The 2003 Particle Accelerator Conference

On behalf of the Organizing Committee, Program Committee and Local Organizing Committee, I would like to welcome you to PAC 2003. This 20th meeting of the biennial series of conferences is being held at the Hilton Hotel in Portland, Oregon. The Program Committee, co-chaired by Alan Jackson and Ed Lee, has arranged an excellent mix of invited, oral and poster papers.

The conference begins with an informal Welcome Reception on Sunday evening. All registrants and companions are welcome, and we encourage everyone to come to renew old friendships and make new ones. The Opening Plenary session will start at 8:30 Monday morning in the Grand Ballroom, and it will be followed by parallel and poster sessions. On Wednesday there will be a Special Session with talks by the winners of APS and IEEE Prizes. An Awards Ceremony and Reception that is sponsored by the IEEE Nuclear and Plasma Sciences Society and the APS Division of Physics of Beams will follow it.

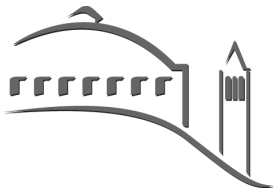
Companions and spouses will be able to meet at a get acquainted reception including a continental breakfast on Monday morning at 9:00 in the Directors Room on the third floor. During the week there will be tours of Portland and the beautiful surrounding countryside.

A Vendor's Exhibit will be open on Monday from noon to 5:00 pm and on Tuesday and Wednesday from 9:00 am to 5:00 pm. The exhibit booths are set up in the Exhibit Hall along with coffee service and poster presentations. There will be ample time to learn about the products that are important to the accelerator community. The Exhibit Hall can be conveniently accessed from the Ballroom Level or by the hotel elevator.

Lawrence Berkeley National Laboratory and the Stanford Linear Accelerator Center are hosting PAC 2003. We have received financial support from the US Department of Energy, the National Science Foundation, and the Office of Naval Research. In addition, the IEEE NPSS and APS DPB have provided student travel awards honoring Lou Costrell and Mel Month.

I personally want to thank the people who have worked so hard to make this conference a success, and I hope you enjoy your stay in Portland.

Bob Siemann



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2003 PARTICLE ACCELERATOR CONFERENCE

PORTLAND, OREGON USA
MAY 12-16, 2003
HILTON PORTLAND HOTEL

Introduction

The 2003 Particle Accelerator Conference, the 20th in this series, is hosted by the Stanford Linear Accelerator Center and the Lawrence Berkeley National Laboratory, and organized by the PAC2003 Organizing Committee.

The conference covers new developments in all aspects of the science, technology, and use of accelerators. It is open to the public, and all individuals with an interest in particle accelerators are invited to register and attend. Approximately 1200 attendees are anticipated and more than 1000 papers are expected to be presented. Those papers include both oral and poster contributed papers as well as invited talks.

This conference is held under the joint auspices of the Institute of Electrical and Electronics Engineers through its Nuclear and Plasma Sciences Society and the American Physical Society through its Division of Physics of Beams. It is supported in part by the U.S. Department of Energy, the National Science Foundation, and the Office of Naval Research.

The PAC2003 Conference Chair is Robert Siemann, SLAC and the Program Committee Co-Chairs are Alan Jackson and Edward Lee, LBNL. The Conference Coordinator is Maura Chatwell, SLAC.

Conference Venue

The address and telephone numbers of the conference hotel are:

Hilton Portland Hotel	Telephone:	1 (503) 266 -1611
921 SW 6th Avenue	Fax:	1 (503) 220 -2565
Portland, Oregon 97204 USA		

Registration/Information Desk (Plaza Foyer)

The Registration/Information Desk is located on the Plaza Level of the hotel. Registration materials (i.e., Conference badge, Conference program booklet, and banquet tickets) will be available at the Registration Desk. For your convenience, representatives from RAZ will offer companion tours and be available at the Hilton Portland during the conference to assist you with any questions. The hours are:

Sunday, May 11	3:00 pm to 7:00 pm
Monday-Friday, May 12-16	8:00 am to 5:00 pm

A message board will be located near the Registration Desk.

If you need assistance, please ask anyone wearing a YELLOW conference badge (Local Organizing Committee staff member).

Registration Fee

The registration fee covers the scientific sessions, the welcome reception on Sunday, May 11, Wednesday evening's Award Reception and Ceremony, and a copy of the proceedings on CD-ROM. Banquet tickets and extra copies of the proceedings may be purchased at the registration desk.

The fee for registration after April 10 is U.S. $450.00. For participants whose registration fees were not received in full, the difference will be requested of them upon registration. Payment at the registration desk must be by credit card (VISA, MasterCard), check (US$), or in cash (US$).

A registration fee of U.S. $100.00 is offered for students and retirees.

Welcome Reception

All conference attendees and companions are invited to a Welcome Reception, **Sunday, May 11,** in the Plaza Foyer from 6:30 pm to 9:30 pm.

Awards Ceremony and Reception

An Awards Ceremony and Reception, sponsored by the APS Division of Physics of Beams and the IEEE Nuclear and Plasma Sciences Society, will be held on **Wednesday, May 14 from 4:00 pm to 6:00 pm.** Please see the details below in the Conference Awards section of this book.

Banquet

Beginning at 7:00 pm, **Thursday, May 15**, a cash bar will precede the banquet in the Grand Ballroom; the banquet will begin at 7:45 pm. There will be musical entertainment throughout the evening provided by

The Leonard Webb Quartet

The cost is $70.00 per person and is not included in the registration fee. A limited number of tickets may be available for purchase at the Registration Desk on Monday, May 12.

E-Mail Room (Broadway Rooms III & IV, Plaza Level)

An e-mail room, located in the Broadway Rooms III & IV, is available for you to check your e-mail, submit papers, or correct problems with your paper that the Proceedings staff has found. It contains computers and laptop ports. The hours are:

Sunday	3:00 pm to 7:00 pm
Monday	12:30 pm to 6:00 pm
Tuesday	8:00 am to 6:00 pm
Wednesday	8:00 am to 6:00 pm
Thursday	8:00 am to 6:00 pm
Friday	8:00 am to 1:00 pm

Proceedings Office (Broadway Rooms I & II, Plaza Level)

The conference proceedings will be published in hard-copy volumes, on CD-ROM, and on the web. Authors are required to submit their papers via web upload. The final deadline for contributions is at the conference. Authors who arrive at the conference with a disk will be asked to go to the E-mail Room to submit their files via the web. Assistance will be available.

Authors are still required to submit a hard copy of the paper, with the session ID listed at the top, and the corresponding copyright form to the Proceedings Office. The Proceedings Office is located in the Broadway Rooms I & II. The hours are:

Sunday	3:00 pm to 7:00 pm
Monday	7:30 am to 6:00 pm
Tuesday	8:00 am to 6:00 pm
Wednesday	8:00 am to 6:00 pm
Thursday	8:00 am to 6:00 pm
Friday	8:00 am to 1:00 pm

The editorial staff will process papers before and during the conference. Files will be processed quickly, and authors will be informed of their acceptance or any problems via a paper status board located outside the Proceedings Office.

Industrial Exhibits (Exhibit Hall)*

The industrial exhibits will open Monday at noon and will be open Tuesday and Wednesday from 9:00 am to 5:00 pm in the Exhibit Hall. The exhibitors registered at the time this book went to press are:

ACCEL Instruments GmbH
AccelSoft Inc.
ACQIRIS
Advanced Energy Systems, Inc.
Advanced Ferrite Technology Inc.
Alpha Scientific Electronics
Amuneal Manufacturing Corporation
Bergoz Instrumentation
Bodycote Alphabraze
Burle Industries, Inc.
Claflin Associates Inc.
CPI Inc.
Danfysik A/S
Diversified Technologies, Inc.
e2v Technologies
Energen, Inc.
FMB Feinwerk- und Messtechnik GmbH
GMW Associates
HeatWave Labs Inc.
Icarus Research, Inc.
IE Power Inc.
Instrumentation Technologies
Meyer Tool & Mfg., Inc.
Pearson Electronics, Inc.
PMB
SAES Getters USA, Inc.
SDMS
SIGMAPHI
Simulation Technology & Applied Research, Inc.
STI Optronics Inc
Thales Components Corporation
Toshiba Corporation
UMA
Wah Chang

*More exhibitors may have been scheduled after this book went to the printer. A complete listing with booth numbers is included in the conference bag and is also available on the conference website, **www.conf.slac.stanford.edu/pac03** .

Companions' Program

An independent company, **RAZ**, is offering Companion Tours. Please note that all tours are based on a minimum of 30 guests. For tour questions please contact:

Mary Daly: Tour Manager
Toll Free: 1 (888) 684-3322, ext.775
Fax: 1 (503) 968-3223
E-mail: **Mary@raztrans.com**

For your convenience, **RAZ** representatives will be available at the Hilton Portland on the Plaza Level during the conference to assist you with any questions.

The Companions' Program will begin with a complimentary breakfast on Monday, May 12, from 9:00am to 10:30am in the Directors Room on the third floor. During the week there will be tours of Portland City, The Oregon Garden and Aurora, The North Coast, two tours of Columbia Gorge, and a shopping trip to Woodburn.

Ground Transportation

Transportation arrangements may be made through the concierge who is available from 7:00 am to 11:00 pm.

All major airlines fly into Portland International Airport. It is an international gateway city for United, American, and their affiliates. For more information, refer to **http://www.portofportland.com/pdxhome.htm.** The light-rail system has a terminal at the airport, and takes you within blocks of the conference hotel. The ride takes about 40 minutes and the fee is U.S. $1.55 one way per person. Airport Express provides convenient service to and from the airport and downtown hotels every half-hour. The one-way fare is U.S. $15.00. Taxi, limousine, and shuttle bus service are also available. Fares vary, but are generally in the range of U.S. $18.00 to U.S. $25.00.

The Amtrak station is located a few blocks from the hotel. For more information on how to plan your trip with Amtrak, refer to **http://www.amtrak.com/plan/index.html.**

Security and Insurance

Participants are asked not to leave their belongings unattended and to wear their conference badges at all times. The conference organizers cannot accept liability for personal injuries sustained, or for loss of, or damage to, property belonging to conference participants (or accompanying persons), either during or as a result of the conference. Please check the validity of your own insurance.

Sunday, May 11

	6:30 – 9:30 pm	Welcome Reception	Plaza Foyer	

Monday, May 12

	8:30 – 12:20	**Opening Plenary Session**	**Grand Ballroom**	
Afternoon	1:30 – 5:20	Hadron Accelerators & Colliders	Ballroom II	Oral
		Sources & Injectors	Pavilion West	
	1:30 – 5:20	Power Supplies, Radiation Monitoring and Safety, Vacuum Technology	Exhibit Hall	Poster
		Accel. for Medical Therapy; Insertion Devices; Isotope Production & Diagnostics	Galleria	
		Free Electron Lasers, Misc. Applications, Synchrotron Radiation Facilities	Ballroom I	

Tuesday, May 13

Morning	8:30 – 12:20	Multi-Particle Beam Dynamics	Ballroom II	Oral
		Magnets	Pavilion West	
		Free Electron Lasers and Energy Recovery Linacs	Pavilion East	
	8:30 – 12:20	Pulsed Power Technology, RF Power	Exhibit Hall	Poster
		High Intensity Accelerators; Subsystems, Technology & Components	Galleria	
		Room Temperature RF,;Superconducting RF	Ballroom I	
Afternoon	1:30 – 5:20	Light Sources	Ballroom II	Oral
		Controls and Computing	Pavilion West	
	1:30 – 3:10	Two-Stream Instabilities and Collective Processes	Pavilion East	
	3:40 – 5:20	Instabilities and Feedback	Pavilion East	
	1:30 – 5:20	Electrostatic Accel.; Low and Medium Energy Circular Accel., Pulsed Power Accel.; Energy Production, Environmental & Industrial Applications	Exhibit Hall	Poster
		New Accelerator Techniques	Galleria	
		Hadron Accel. & Colliders; Injection & Extraction	Ballroom I	

Wednesday, May 14

Morning	8:30 – 12:20	Lepton Accelerators & Colliders	Ballroom II	Oral
		Single Particle Beam Dynamics & Optics	Pavilion West	
	8:30 – 10:10	Extreme Beams	Pavilion East	
	10:40 – 12:20	Secondary Beam Factories	Pavilion East	
	8:30 – 12:20	Applications of Synchrotron Radiation; Beam Cooling; Superconducting Magnets	Exhibit Hall	Poster
		Electron Storage Rings	Galleria	
		Linear & Nonlinear Orbit Theory; RF Guns and Injectors; Room Temperature Magnets	Ballroom I	
Afternoon	**1:30 – 3:30**	**Special Session**	**Ballroom II & Ballroom Foyer**	Oral
	4:00 – 6:00	**Awards Reception And Ceremony**		
	1:30 – 5:20	Alignment & Survey; Control Systems; Cryogenics	Exhibit Hall	Poster
		Beam Diagnostic Instrumentation II, High Current Dynamics	Galleria	
		Beam Diagnostic Instrumentation	Ballroom I	

Thursday, May 15

Morning	8:30 – 12:20	RF Systems	Ballroom II	Oral
		Instrumentation	Pavilion West	
		Pulsed Power & High Intensity Beams	Pavilion East	
	8:30 – 12:20	Beam Dynamics	Galleria	Poster
		Electron Linear Colliders; Linear Accelerators	Ballroom I	
Afternoon	1:30 – 5:20	Linear Colliders	Ballroom II	Oral
		Accelerator Technology	Pavilion West	
		Low & Medium Energy Accelerators	Pavilion East	
	1:30 – 5:20	Beam Dynamics	Galleria	Poster
		Transverse and Longitudinal Instabilities and Cures	Ballroom I	
	7:00 – 9:00	**Banquet**	**Grand Ballroom**	

Friday, May 16

	8:30 – 12:20	Advanced Concepts	Pavilion West	Oral
		Applications of Accelerators	Pavilion East	
	8:30 – 12:20	Computer Codes	Galleria	Poster
		Accelerators & Storage Rings, Beam Beam Interaction, Feedback, Particle Sources	Ballroom I	
	1:30 – 5:20	**Closing Plenary Session**	**Grand Ballroom**	

Special Session

A special session on Wednesday, May 14, will be devoted to presentations by winners of the 2003 APS Robert R. Wilson Prize, IEEE NPSS Particle Accelerator Science and Technology Awards, and the APS Award for Outstanding Doctoral Thesis Research in Beam Physics.

Awards Ceremony and Reception

An Awards Ceremony and Reception, sponsored by the APS Division of Physics of Beams and the IEEE Nuclear and Plasma Sciences Society, will be held on **Wednesday, May 14 from 4:00pm to 6:00pm in Ballroom II and the Grand Ballroom Foyer** to present the following awards and prizes:

- APS Robert R. Wilson Prize
- IEEE NPSS Particle Accelerator Science and Technology Awards
- APS Award for Outstanding Doctoral Thesis Research in Beam Physics
- U.S. Particle Accelerator School Prize for Achievement in Accelerator Physics and Technology
- Newly Elected Fellows of the APS
- Student Travel Awards

Awards

2003 APS Robert R. Wilson Prize

To recognize and encourage outstanding achievement in the physics of particle accelerators - a prize of the American Physical Society sponsored by the APS Divisions of Physics of Beams and Particles and Fields and the friends of R.R. Wilson.

Awarded to: **Helen T. Edwards**, Fermi National Accelerator Laboratory

> "For her pivotal achievement and critical contribution as the leader in the design, construction, commission, and operation of the Tevatron and for her continued contributions to the development of high gradient superconducting linear accelerators as well as bright and intense electron sources."

IEEE NPSS Particle Accelerator Science and Technology Award

Awards of the Particle Accelerator Conference given on behalf of the Nuclear and Plasma Sciences Society of the IEEE and sponsored by the NPSS. Two awards are given to recognize outstanding contributions to the development of particle accelerator technology.

Awarded to: **Stephen Milton**, Argonne National Laboratory

> "For contributions to coherent radiation sources especially his leading role in achieving saturated operation at visible and ultraviolet wavelengths in a self-amplified spontaneous emission free-electron laser."

Awarded to: **Keith Symon**, University of Wisconsin

> "For many fundamental accelerator concepts which include invention of Fixed Field Alternating Gradient Accelerators (FFAG), most notably incorporated into spiral sector cyclotrons; for defining a formalism describing motion under the influence of RF as required for stacking and other particle manipulations; and for techniques for analyzing collective instabilities."

APS Award for Outstanding Doctoral Thesis Research in Beam Physics
To recognize doctoral thesis research of outstanding quality and achievement in beam physics and engineering. The award was established in 1990 by the Division of Physics of Beams and is supported by Brookhaven Science Associates and Universities Research Association.

Awarded to: **David Pritzkau**, Big Bear Networks, Inc

"For an experimental study of the effects of surface heating due to high-power pulsed RF. The experiment established a limit on maximum surface magnetic field and through it one limit on achievable accelerating gradient."

U.S. Particle Accelerator School Prize for Achievement in Accelerator Physics and Technology
The US Particle Accelerator School honors individuals by recognizing their outstanding achievements over the full range of accelerator physics and technology. The awards are made possible by donations from the Brookhaven Science Associates, Southeastern Universities Research Association, the Universities Research Association, and John Wiley and Sons Publishers.

Awarded to: **Martin Reiser**, University of Maryland

"For his seminal contributions on the physics of high intensity beams, and for his life-long accomplishments in technology, research, community leadership, and education in the physics of beams."

Awarded to: **Sami Tantawi**, Stanford Linear Accelerator Center

"For his contribution to the theory and technology of rf components for the production and distribution of very high peak rf power, with particular application to pulse compression systems for high-gradient linear colliders."

Newly Elected Fellows of the APS

Stephen Vincent Benson, Thomas Jefferson National Accelerator Facility
"For critical contributions to the development of free-electron lasers, including the first demonstration of lasing at harmonics and of multi-kilowatt lasing with an energy recovered linac."

Yu-Jiuan Chen, Lawrence Livermore National Laboratory
"For revolutionizing the achievable beam quality of linear induction accelerators and advancing the state-of-the-art of flash x-ray radiographic technology."

Ralph Bruno Fiorito, Catholic University of America
"For pioneering contributions to the understanding and application of transition radiation, diffraction radiation, and parametric x-radiation."

Alan Jackson, Lawrence Berkeley Laboratory
"For pioneering work in the development and construction of 3rd generation synchrotron radiation sources."

Stephen Val Milton, Argonne National Laboratory
"For the development of 3rd and 4th generation light sources including the first demonstration of saturation of self-amplified spontaneous emission (SASE) in the visible and ultraviolet wavelengths."

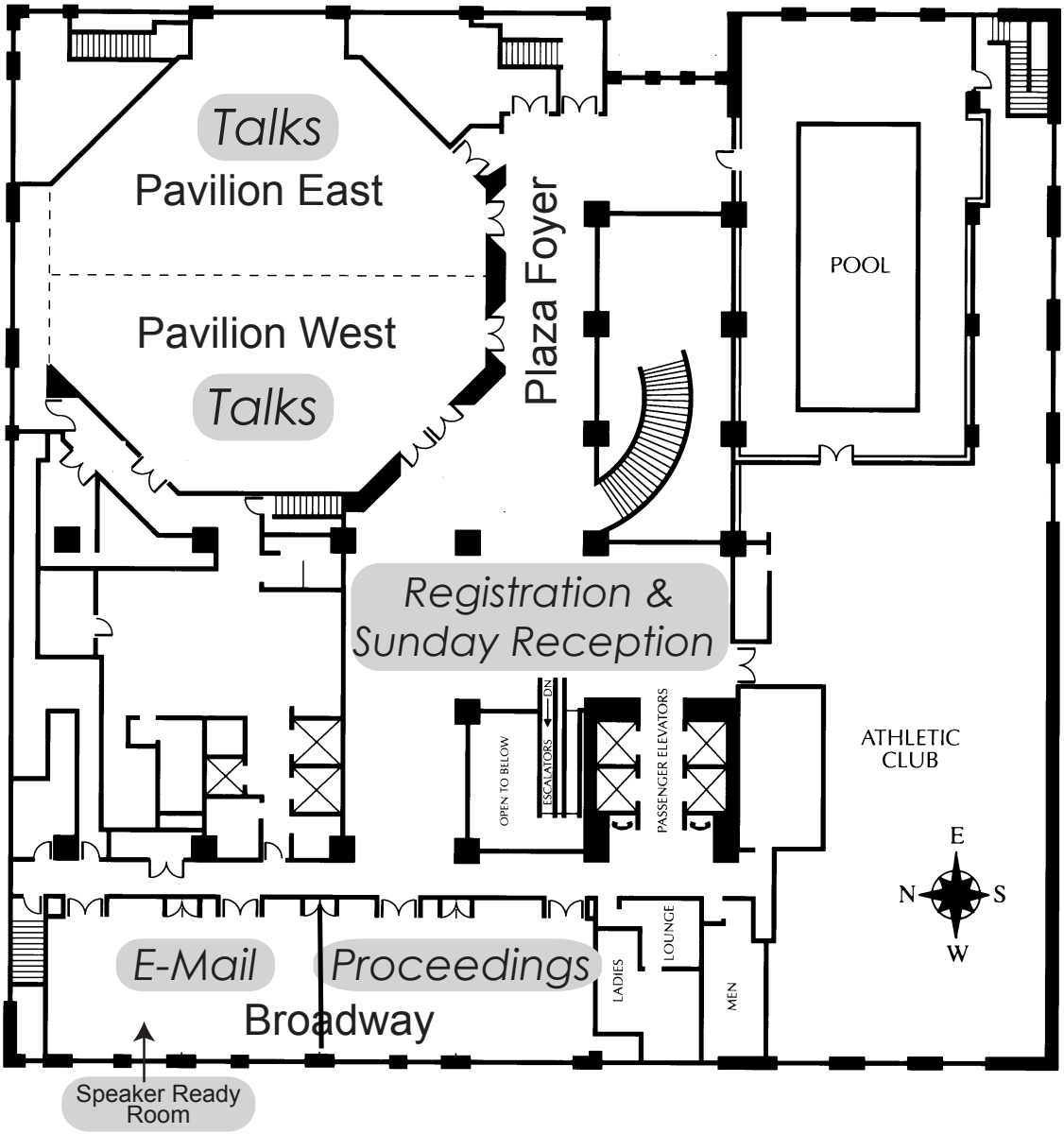
Nikolai V. Mokhov, Fermi National Accelerator Laboratory
"For critical contributions to the understanding of the interaction of high energy partical beams with materials."

Donald Prosnitz, United States Department of Justice
"For major contributions to physics and society spanning fundamental physics research to national security and law enforcement technologies, including pioneering technical contributions to the development of Free Electron Lasers."

Student Travel Awards
The National Science Foundation, APS/DPB and IEEE/NPSS are sponsoring travel grants to worthy students to help defray their travel costs. The APS/DPB and IEEE/NPSS grants are being awarded in honor of two people who have made many contributions to the accelerator community. The DPB grants honor Mel Month for his dedication to students and education, and the NPSS grants honor Lou Costrell for his nurturing of the Particle Accelerator Conferences. The awards include a complimentary one-year student membership in the sponsoring professional society.

Laura Bandura, Northern Illinois University/ANL
Mahdia Belgroune, Synchrotron SOLEIL
Nikolai Bondarenko, Kharkov National University
Suzhi Deng, University of Southern California
Raymond Fliller III, State University of New York at Stony Brook/BNL
Ali Ghalam, University of Southern California
John Harris, University of Maryland
Richard Helms, Cornell University
Ubaldo Iriso-Ariz, University of Barcelona/BNL
Lihui Jin, University of Kansas
Igor Khodak, Kharkov Institute of Physics and Technology
Mauricio de Lima Lopes, University of Sao Paulo
Agusta Loftsdottir, University of California Davis/LBNL
Boaz Nash, Stanford University/SLAC
Jonathan Neumann, University of Maryland
Caolionn O'Connell, Stanford University/SLAC
Lionel Prost, University of California Berkeley/LBNL
Stefano Redaelli, University of Lausanne/CERN
Frederico Roncarolo, University of Lausanne/CERN
Ned Saleh, University of Michigan
Bjoern Schmekel, Cornell University
Jeroen van Tilborg, Technische Universiteit Eindhoven/LBNL
Christopher Tenant, College of William & Mary/CEBAF
Carsten Welsch, University of Frankfurt
Walter Wittmer, Technical University Graz/CERN

Plaza Level


Talks
Pavilion East
Pavilion West
Talks
Plaza Foyer
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Sunday Reception
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Speaker Ready
Room

Ballroom Level

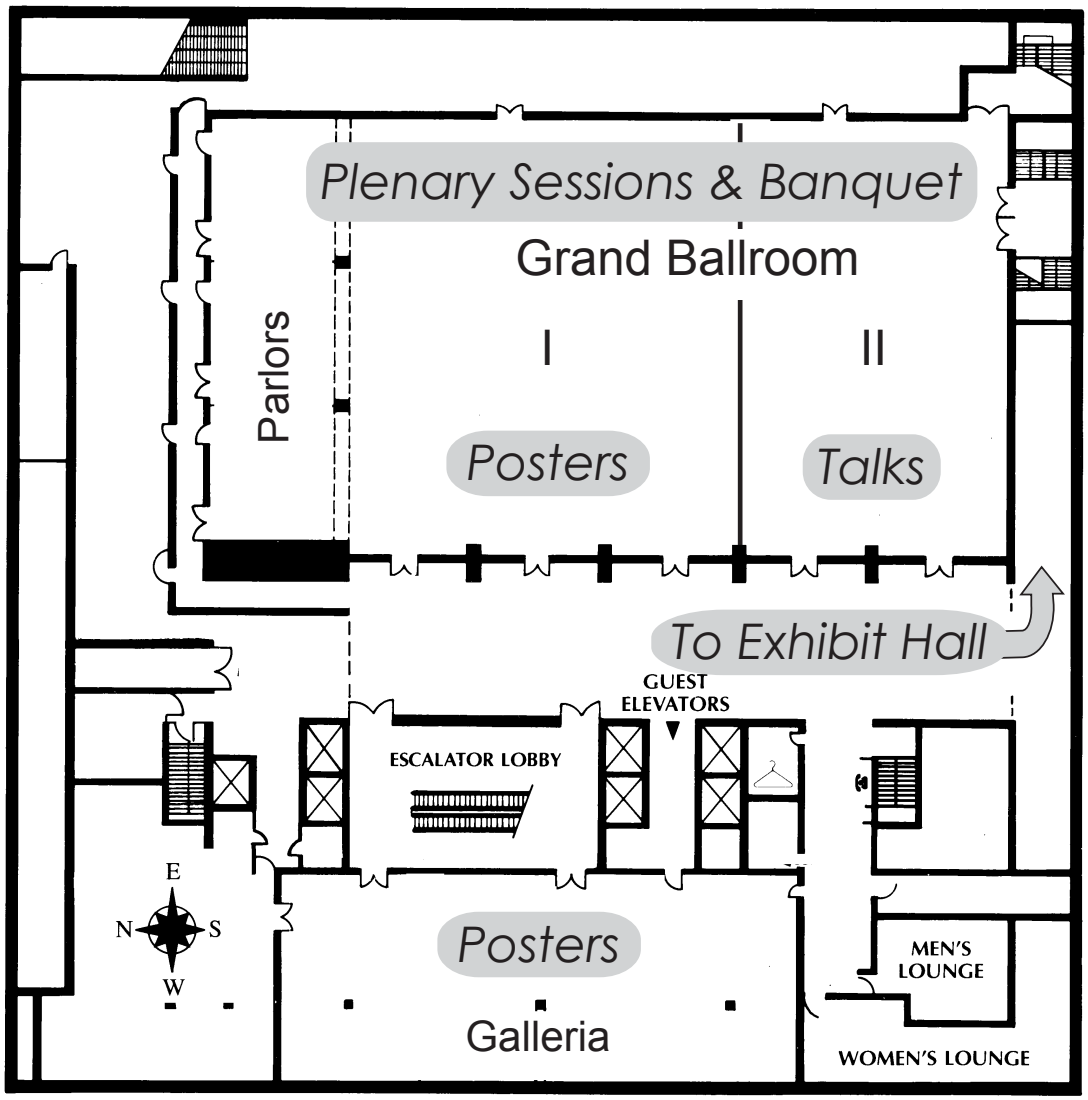
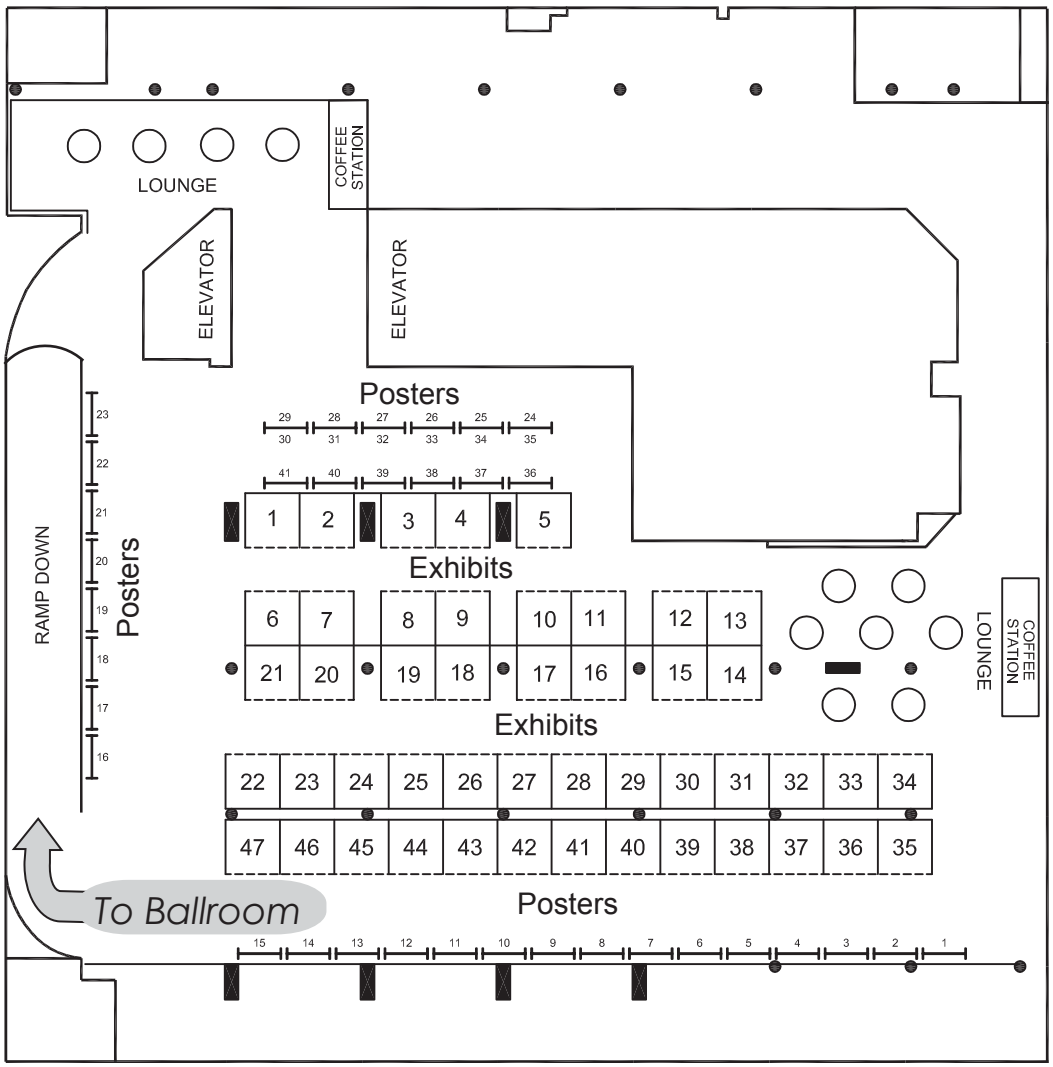


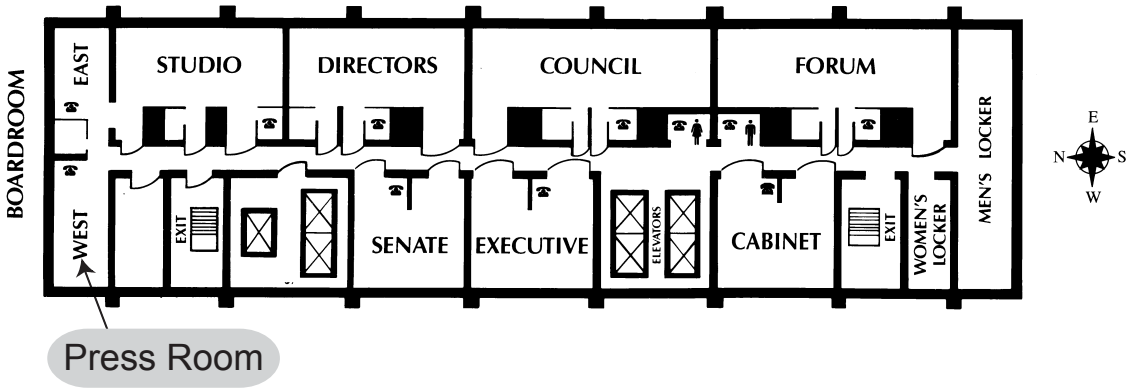
Exhibit Hall

Exhibits & Posters
Mon, Tues and Weds



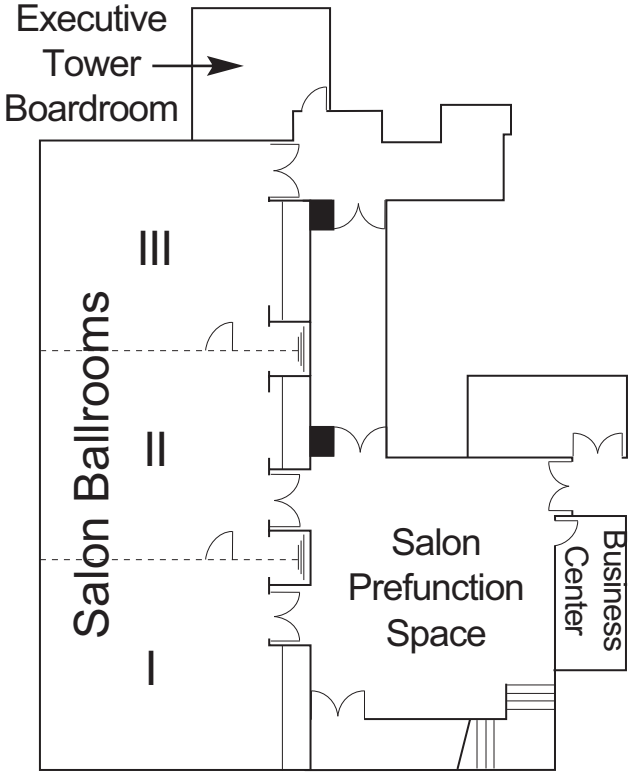
Satellite Meetings

Third Floor



Press Room

Executive Tower



Monday, May 12, 2003

Session MOAL: Opening Plenary
Grand Ballroom at 8:30
Session Chair: R. Siemann (Conference Chair)

MOAL001 High Luminosity Operation of the Fermilab Accelerator Complex

Shekhar Mishra (FNAL)

The Run-II at Fermilab is progressing steadily. In the Run-II scheme, 36 antiproton bunches collide with 36 proton bunches at CDF and D0 interaction regions in the Tevatron at 980 GeV. The current status and performance of the Fermilab Accelerator Complex is reviewed. The plans for Run-II along with accelerator upgrade and integration of the Recycler in the accelerator chain will be presented.

* Fermilab is operated by URA, under contract with the U.S. Department of Energy.

MOAL002 Recently Commissioned and Future RNB Facilities

Paul Schmor (TRIUMF)

There is a world wide interest in fundamental and applied scientific research with exotic nuclear beams to improve our understanding of the nature of matter and of the evolution of matter in the universe. The nuclear physics group of the OECD Megascience Forum concluded in 1999 that "a new generation of high-intensity RNB (Radioactive Nuclear Beam) facilities of each of the two basic types, ISOL (Isotope Separator On-Line) and In-Flight, should be built on a regional basis." This interest has led to the design and development of a number of new facilities to increase both the variety and the number of exotic ions. This paper reviews and compares recently commissioned and proposed facilities.

MOAL003 Status of the Spallation Neutron Source

Norbert Holtkamp (ORNL)

The Spallation Neutron Source SNS is a second generation pulsed neutron source under construction at Oak Ridge National Laboratory. The SNS is funded by the U.S. Department of Energy's Office of Basic Energy Sciences and is dedicated to the study of the structure and dynamics of materials by neutron scattering. A collaboration composed of six national laboratories (ANL, BNL, TJNAF, LANL, LBNL, and ORNL) is responsible for the design and construction of the various subsystems. The official start was in October 1998; operation of the facility will begin in 2006. It will deliver a 1.0 GeV, 1.4 MW proton beam with a pulse length of approximately 700 nanoseconds on a liquid mercury target. The expertise of the different laboratories has been exploited in order to enhance the delivered beam power by almost an order of magnitude compared to existing neutron facilities. The achievable neutron scattering performance will exceed present sources by more than a factor of 20-100. In order to achieve such a big step, the subsystems require substantial improvements compared to existing accelerators. The challenges, the status of the project and potential upgrades will be described in the talk.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

MOAL004 Prospects for a Physical Science Renaissance

Ray Orbach (DOE)

Session MOPA: High Energy Hadron Accelerators and Colliders
Grand Ballroom II at 13:30
Session Chair: H. Edwards

MOPA001 Beam Physics at LHC

Lyn Evans (CERN)

The design of the Large Hadron Collider incorporates the accumulated knowledge obtained from previous generations of hadron colliders. Among the well known effects limiting machine performance are intrabeam scattering, the beam-beam interaction and stability against collective motion. A new phenomenon not observed in previous hadron colliders but now a known limitation in the B-factories and in the LHC is the electron cloud instability. All of these phenomena are discussed together with the measures taken in the machine design to overcome them.

MOPA002 RHIC Status and Plans

Thomas Roser (BNL)

RHIC is the first hadron accelerator and collider consisting of two independent rings. It is designed to operate over a wide range of beam energies and with particle species ranging from polarized protons to heavy ions. Machine operation and performance will be reviewed that includes gold-on-gold collisions at design beam energy (100 GeV/u), first high energy polarized proton-proton collisions (100 GeV on 100 GeV) as well as first asymmetric operation of RHIC to produce deuteron-on-gold collisions. Plans for future luminostiy upgrades will also be presented.

∗ Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

MOPA003 Beam Physics at Tevatron

Valeri Lebedev (FNAL)

The challenge of achieving the Tevatron Run II luminosity goal requires high level of engineering and machine operation, good and reliable diagnostics, and clear understanding of the underlying accelerator physics. Recent history demonstrated steady increase of the Tevatron luminosity, which was supported by each of the three listed above items. The report reviews major developments in the accelerator physics, which contributed in the Run II luminosity growth. Major present limitations of the luminosity and projections of further luminosity growth are also discussed.

∗ Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

MOPA004 New Aspects of Beam-Beam Interactions in Hadron Colliders

Tanaji Sen (FNAL)

Long-range beam-beam interactions in Run II at the Tevatron are the dominant sources of beam loss and lifetime limitations of antiprotons, especially at injection energy. The main focus of the talk will be observations of the long-range effects in Run II and theoretical understanding of these effects. Coherent beam-beam phenomena observed recently at RHIC will be briefly discussed. Implications of the long-range interactions and coherent effects for the LHC will be pointed out.

* Work supported by the US Department of Eneregy under contract no. DE-AC02-76CH03000.

MOPA005 R&D towards Cooling of the RHIC Collider

Ilan Ben-Zvi, Joseph Brennan, Xiangyun Chang, Montag Christoph, Joerg Kewisch, William Mackay, Stephen Peggs, Thomas Roser, Triveni Srinivasan-Rao, Dejan Trbojevic, Dong Wang (BNL)

We introduce the R&D program for electron-cooling of the Relativistic Heavy Ion Collider (RHIC). This electron cooler is designed to cool 100 GeV/nucleon bunched-beam ion collider at storage energy using 54 MeV electrons. The electron source will be an RF photocathode gun. The accelerator will be a superconducting energy recovery linac. The frequency of the accelerator is set at 703.75 MHz. The maximum bunch frequency is 28.15 MHz, with bunch charge of 10 nC. The R&D program has the following components: The photoinjector, the superconducting linac, start-to-end beam dynamics with magnetized electrons and electron cooling calculations.

∗ This work was performed under the auspices of the U.S. Department of Energy.

MOPA006 Towards a New LHC Interaction Region Design for a Luminosity Upgrade

James Strait, Michael Lamm, Peter Limon, Nikolai V. Mokhov, Tanaji Sen, Alexander V. Zlobin (FNAL), Ramesh Gupta, Michael Harrison, Stephen Peggs, Fulvia Pilat (BNL), Oliver Bruening, Arnaud Devred, Ranko Ostojic, Lucio Rossi, Francesco Ruggiero, Thomas Taylor, Herman ten Kate (CERN), Shlomo Caspi, Stephen Gourlay, GianLuca Sabbi (LBNL)

After the LHC operates for several years at nominal luminosity, it will be necessary to upgrade it for higher luminosity. Replacement of the low-beta insertions with a higher performance design based on advanced superconducting magnets is one of the most straightforward steps towards enhanced LHC performance. Preliminary studies suggest that, with magnet technology that can be expected to be developed by early in the next decade, as much as a factor of three increase in luminosity could be achieved with new low-beta insertions. In this paper we survey several possible designs for second generation LHC interaction regions which address the expected limitations on LHC performance imposed by the baseline IR design.

MOPA007 Designing and Building a Collimation System for the High-Intensity LHC Beam

Ralph Assmann, Markus Brugger, Luca Bruno, Helmut Burkhardt, Enrico Chiaveri, Bernd Dehning, Alfredo Ferrari, Jean-Bernard Jeanneret, Verena Kain, Mike Lamont, Rudiger Schmidt, Peter Sievers, Vasilis Vlachoudis, Jorg Wenninger (CERN), Igor Baishev (Institute of High Energy Physics, Protvino), Dobrin Kaltchev (TRIUMF)

The Large Hadron Collider (LHC) will collide proton beams at 14 TeV c.m. with unprecedented stored intensities. The transverse energy density in the beam will be about three orders of magnitude larger than previously handled in the Tevatron or in HERA, if compared at the locations of the betatron collimators. In particular, the population in the beam halo is much above the quench level of the superconducting magnets. Two LHC insertions are dedicated to collimation with the design goals of preventing magnet quenches in regular operation and preventing damage to accelerator components in case of irregular beam loss. We discuss the challenges for designing and building a collimation system that withstands the high power LHC beam and provides the required high cleaning efficiency. The present design choices and the work ahead are discussed.

MOPA008 Effects of RF Noise on the Longitudinal Emittance Growth in Tevatron

Valeri Lebedev, Ivan Gonin, Temirgali Khabibouline, John Reid, Gennady Romanov, Vladimir Shiltsev, Alvin Tollestrup (FNAL)

Phase and amplitude noises in the Tevatron RF system and the intrabeam scattering (IBS) produce longitudinal emittance growth with consecutive particle loss from the RF buckets. That causes a decrease of the luminosity and an increase of the background in particle detectors during the store. The report presents experimental measurements of RF system noise and the effect on the longitudinal emittance growth. There is a satisfactory agreement between measured noise spectral densities and observed emittance growth. For high bunch intensities, IBS plays an important role and has been taken into account. The sources of noises and plans for further system improvements are discussed.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

MOPA009 Polarized Proton Operations in the AGS and RHIC

Haixin Huang, Leif Ahrens, Mei Bai, Joanne Beebe-Wang, Mike J. Brenann, Kevin A. Brown, Angelika Drees, Wolfram Fischer, J. Wooderson Glenn, Alfredo U. Luccio, Waldo W. MacKay, Christoph Montag, Fulvia Pilat, Vadim Ptitsyn, Thomas Roser, Todd Satogata, Steven Tepikian, Dejan Trbojevic, Nick Tsoupas, Johannes van Zeijts (BNL)

A polarized proton beam has been accelerated and stored at 100 GeV in the Relativistic Heavy Ion Collider (RHIC) to study spin effects in the hadronic reactions. The essential equipment includes four Siberian snakes and eight spin rotators in two RHIC rings, a partial snake in the AGS, fast relative polarimeters, and ac dipoles in the AGS and RHIC. This paper summarizes the performance of RHIC as a polarized proton collider and of AGS as the injector to RHIC. The machine performance and accomplishments during the polarized proton run will be reviewed.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

MOPA010 RHIC Pressure Rise and Electron Cloud

S.Y. Zhang, M. Bai, M. Blaskiewicz, P. Cameron, A. Drees, W. Fischer, D. Gassner, J. Gullotta, P. He, H.C. Hseuh, H. Huang, U. Iriso-Ariz, R. Lee, W.W. MacKay, B. Oerter, V. Ponnaiyan, V. Ptitsyn, T. Roser, T. Satogata, L. Smart, D. Trbojevic (BNL)

In high intensity gold beam operations at the RHIC, the pressure rise at some warm sections has exceeded the machine tolerance at the design intensity. Of the two types of pressure rises, i.e., approaching saturation and runaway, the former is currently limiting the beam intensity. It is suspected that this type of pressure rise is caused by an electron cloud. To understand and combat the pressure rise, two stations consisted by electron detectors and solenoids to study the pressure rise and electron cloud have been installed. One is at an interaction region common to both rings and another at a single beam straight section. Studies include the pressure rise vs. electron cloud, effect of solenoids, scraping beam halo, coherent and incoherent tune shift due to the electron cloud, etc. At the same time, a beam scrubbing commissioning plan is prepared to push the beam intensity for the coming run.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

MOPA011 Tune Shift Compensation Using the Tevatron Electron Lens

Kip Bishofberger (University of California, Los Angeles)

The luminosity of the Tevatron is currently being limited by instabilities and losses due to beam-beam effects. The Tevatron Electron Lens was built to alleviate these issues, and initial results have proved promising. Specific bunches have been tune shifted during collider operation and lifetimes of those bunches are recorded. We report these findings and speculate the future of multi-bunch linear and nonlinear compensation.

MOPA012 An LHC Long-Range Beam-Beam Simulator in the CERN SPS

Jean-Pierre Koutchouk, J. Camas, J. Wenninger, F. Zimmermann, G. de Rijk (CERN)

A primary limit to the LHC performance is a single particle instability driven by the long-range beam-beam effect. The LHC beams suffer 15 long-range encounters on either side of each of four interaction points, where the beam separation is about ten rms beam sizes. In simulation, one observes the onset of a fast diffusion in amplitude and tune, a reduction of the dynamic aperture and chaos for amplitudes within the collimator acceptance. A beam-beam compensation scheme was recently proposed, based on wire correctors. To verify this scheme, a simplified corrector has been installed in the SPS. The aim, in a first step, is to generate an LHC-like beam-beam dynamics without correction and relate the simulated diffusion rate to the measured beam lifetime. The instrument is made of a 1.2 m thin wire carrying a current density of about 100 A/mm^2 along the beam. It was successfully commissioned in Sept. 2002. Our first measurements show that the device modifies the self-consistent orbit and betatron tunes as expected. Preliminary local loss and emittance measurements, to be crosschecked with diffusion measurements next year, are consistent with an enhanced diffusion.

Session MOPB: Sources and Injectors
Pavilion West at 13:30
Session Chairs: J. Alessi, M. Stockli

MOPB001 25 Years of Technical Advances in RFQ Accelerators

Lloyd Young (LANL)

The radio frequency quadrupole (RFQ) accelerator began as "The ion linear accelerator with space-uniform strong focusing" conceived by I. M. Kapchinskii and V. A. Teplyakov [Prib. Tekh. Eksp.No.2 (1970) p. 19]. In 1979, R. H. Stokes, K. R. Crandall, J. E. Stovall and D. A. Swenson [IEEE Trans. NS-26 (1979) p. 3469] gave this concept the name RFQ. And by 1983, at least 15 laboratories throughout the world were working on various RFQ designs. In the early years, there were many types of geometry considered for the RFQ, but only a few types have survived. The two cavity geometries now used in almost all RFQs are the 4-vane and 4-rod structures. The 4-vane structure is the most popular because its operating frequency range (80 to 500 MHz) is suitable for light ions. Heavy ions require low frequencies (below 200 MHz). Because the 4-rod structure has smaller transverse dimensions than a 4-vane RFQ at the same frequency, the 4-rod RFQ is often preferred for these applications. This paper will describe how the RFQ accelerates and focuses the beam. The paper also discusses some of the important technical advances in designing and building RFQs.

* Work supported by the US Department of Energy.

MOPB002 Commissioning of the SNS Front-End Systems at Oak Ridge

Alexander Aleksandrov (ORNL)

The Front-End (FE) for the Spallation Neutron Source (SNS) accelerator system is a 2.5-MeV linac injector consisting of the following major subsystems, the rf-driven H^- ion source, the electrostatic Low Energy Beam Transport line, a 402.5 MHz RFQ, the Medium Energy Beam Transport line, a beam chopper system and a suite of diagnostic devices. After construction and initial commissioning at LBNL the Front End was shipped to Oak Ridge in the summer of 2002, installed at the SNS site and recommissioned. This paper provides an overview of the major design features and the experimental results obtained during the final commissioning of the Front End Systems. Performance of the various subsystems will be described, and the final beam output performance will be summarized.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

MOPB003 Heavy Ion Fusion Sources

David Grote (LLNL)

In Heavy-Ion Fusion and in other applications, there is a need for high brightness sources with both high current and low emittance. The traditional design with a single monolithic source, while very successful, has significant constraints on it when going to higher currents. With the Child-Langmuir current-density limit, geometric aberration limits, and voltage breakdown limits, the area of the source becomes a high power of the current, $A \sim I^{8/3}$. We are examining a multi-beamlet source, avoiding the constraints by having many beamlets each with low current and small area. The beamlets are created and initially accelerated separately and then merged to form a single beam. This design offers a number of potential advantages over a monolithic source, such as a smaller transverse footprint, more control over the shaping and aiming of the beam, and more flexibility in the choice of ion sources. A potential drawback, however, is the emittance that results from the merging of the beamlets. We have designed injectors using simulation that have acceptably low emittance and are beginning to examine them experimentally.

* This work performed under the auspices of the U.S Department of Energy by University of California, Lawrence Livermore and Lawrence Berkeley National Laboratories under contracts No. W-7405-Eng-48 and DE-AC03-76SF00098.

MOPB004 The Status of the LANSCE H^- Ion Source Development Program

Gary Rouleau, Edwin Chacon-Golcher, Joseph Sherman, James Stelzer (LANL)

The status of the LANSCE H^- ion source development program for the Short Pulse Spallation Source (SPSS) enhancement project is presented. Results of the experimental program are summarized with emphasis on the solutions of the technical problems encountered with beam emittance growths observed at beam currents greater than 20-25 mA. Possible volume and surface produced H^- components will be discussed as a possible emittance growth mechanism.

MOPB005 Development of a High-Current Microwave Ion Source for Proton Linac Application Systems

Masanobu Tanaka, Kensuke Amemiya, Takamitsu Hae, Shigemitsu Hara, Kazuo Hiramoto, Kazuyoshi Saitou (Hitachi, Ltd., Power and Industrial Systems R&D Laboratory)

A microwave hydrogen ion source was developed to improve reliability, and to increase operation time of proton linac application systems based on industrial high-current microwave ion source technologies and low emittance beam production techniques for nuclear fusion. The ion source needs no filament in the discharge chamber, which lead to reliability improvement and less maintenance time. The developed source produced a maximum hydrogen ion beam current of 70 mA (high current density of 360 mA/cm^2, beam energy of 30 keV) with a 5 mm diameter extraction aperture and 1.2 kW microwave rf power. The proton ratio was increased with an increase in rf power and reached around 90% at 1 kW. The extraction grid design was optimized with beam trajectory simulations. The measured 90% beam normalized emittance was 0.42 pi mm mrad. This will meet acceptance of proton linacs. Rise times of rf power and beam current to 90% of the final value were about 30 and 35 us respectively at a pulse operation mode with 400 us pulse width and 100 Hz repetition rate. The dynamic range of beam currents was enlarged (3-63 mA) in the pulse mode by a modified rf waveform to assist ignition of microwave discharge. These performance parameters will be desirable for pulse operation accelerator applications like proton therapy systems. A long time operation stability (150 h) was confirmed with beam current of 51 mA and change in the current of 2%.

MOPB006 Very High Voltage Photoemission Electron Guns

Charles Sinclair (Cornell University)

There are a growing number of applications for high average current, CW electron accelerators. Many of these applications have very demanding transverse and longitudinal emittance requirements. Very high voltage DC electron guns with photoemission cathodes are a natural choice for these applications. Photocathodes with high quantum efficiency at practical wavelengths are required for high average current applications. The necessary lasers are themselves state-of-the-art systems that must be considered in choosing the particular photocathode type. Field emission from the electrode structures typically limits the operating voltage and cathode field gradient in these guns. The operational lifetime of the photocathode is limited by the gun vacuum environment and by ion back bombardment. Recent developments in areas as diverse as vacuum technology, CW lasers with RF time structure, and the reduction of field emission from large area electrodes show promise for the development of a new generation of DC photoemission electron guns, operating at very high voltage and with cathode field strengths well above those obtainable in the past. These developments, and various designs for very high voltage photoemission electron guns, will be reviewed.

* Work supported by Cornell University.

MOPB007 Advanced ECR Sources for Highly Charged Ions

Santo Gammino, L. Ando, L. Celona, G. Ciavola (INFN), A. Girard, D. Hitz, G. Melin (CEA Grenoble)

New technologies for next generation ECRIS are under development in many laboratories around the world, in order to achieve higher charge states and higher currents, especially for heavy ion beams. In particular, in the last few years efforts have been concentrated on the coupling of high power, high frequency microwaves (e.g., 10 kW, 28 GHz); on the study (and the development) of complex magnetic systems for adequate plasma confinement; and on the design of extractors able to limit the emittance of heavy ion beams at high current level (tens of milliamperes). The first injection of a high power (6 kW), 28 GHz wave in a B-min ECRIS was achieved in the SERSE superconducting source at INFN-LNS, Catania in 2000. High currents of ions were produced, both in pulsed and in dc modes. Since then, other relevant improvements in the ECR source technology have been carried out. The talk will describe the major developments of ECRIS science and technology in Europe, Asia and US, with particular attention to recent developments at LBNL, where the VENUS source is being commissioned. The conceptual design of a high magnetic

field superconducting ECR ion source, named GyroSerse, will be also described. This multipurpose ECR ion source has many goals. One of these goals is the production of very high charge states with heavy ions (up to 2 μA in cw mode of U^{60+} and 5 particle-μA of light ions up to Ar^{16+}). Another goal is the production of high currents of highly charged ions both in cw and pulsed mode, such as 1 mA of Xe^{20+} or 0.3 mA of U^{30+} beams in dc mode and 6 mA of U^{28+} in pulsed mode (with a pulse duration of 200 μs). For injection into the accelerator, all these beams should fulfill the following requirements: energy from 2.5 to 5.0 keV/nucleon, emittance lower than 200 pi 1/4 nmm.mrad, and high reliability.

MOPB008 Commissioning of the Superconducting ECR Ion Source VENUS

Daniela Leitner, Steve Abbott, Matthaeus Leitner, Claude Lyneis (LBNL)

VENUS (Versatile ECR ion source for NUclear Science) is a next generation superconducting ECR ion source, designed to produce high current, high charge state ions for the 88-Inch Cyclotron at the Lawrence Berkeley National Laboratory. VENUS also serves as the prototype ion source for the RIA (Rare Isotope Accelerator) front end. The magnetic confinement configuration consists of three superconducting axial coils and six superconducting radial coils in a sextupole configuration. The nominal design fields of the axial magnets are 4T at injection and 3T at extraction; the nominal radial design field strength at the plasma chamber wall is 2T, making VENUS the world most powerful ECR plasma confinement structure. The magnetic field strength has been designed for optimum operation at 28 GHz. The four-year VENUS project has recently achieved two major milestones: The first plasma was ignited in June, the first mass-analyzed high charge state ion beam was extracted in September of 2002. The paper describes briefly the design of the ion source and its high-current beam transport line. Initial results including first emittance measurements from the commissioning phase of VENUS are presented.

* This work was supported by the Director, Office of Science, Office of High Energy and Nuclear Physics, Nuclear Physics Division of the U.S. Department of Energy under Contract DE AC03-76SF00098.

MOPB009 Design of an EBIS for RHIC

James Alessi, Edward Beebe, David Graham, Ahovi Kponou, Alexander Pikin, Krsto Prelec, John Ritter, Vladimir Zajic (BNL)

An Electron Beam Ion Source (EBIS) can be used to produce beams of high charge state heavy ions, and is an excellent choice for injection into a synchrotron, since short pulses of high intensity can be produced for single- or few-turn injection into the ring. As a result of successful experiments on a test EBIS at BNL, we are now confident that an EBIS meeting RHIC requirements can be built. This EBIS would be part of a new linac-based preinjector which would serve as a modern alternative to the existing Tandem preinjectors, offering improvements in performance and operational simplicity. The BNL test EBIS, which is a half trap-length prototype of the RHIC EBIS, has produced $>10^9$ ions per pulse of Au^{32+}, in 10-20 microsecond pulses, and has exceeded our design goals. Performance of the test EBIS will be summarized and the design of the RHIC EBIS presented.

* Work performed under the auspices of the U.S. Department of Energy.

MOPB010 The Performance of an All Niobium Superconducting Photoinjector

Q. Zhao, I. Ben-Zvi, G. Citver, A. Hershcovitz, D. Pate, A. Reuter, J. Scaduto, T. Srinivasan-Rao, J. Zhao (BNL), H. Bluem, M. Cole, J. Rathke, T. Schultheiss (Advanced Energy Systems Inc.), J. Delayen, P. Kneisel (Thomas Jefferson National Accelerator Facility)

We report tests of an all niobium 1.3 GHz superconducting photoinjector. The photoinjector has been designed and constructed under the collaboration of AES, BNL and Jlab. In this scheme, the 4th harmonic laser beam from the 81.25 MHz CW Nd:YVO_4 oscillator directly illuminates the back surface of the half cell niobium cavity. The cathode surface has been laser-cleaned to improve the quantum efficiency. The electron beam was accelerated by the SRF cavity and focused by a room temperature solenoid into a beam dump Faraday cup.

MOPB011 High Brightness, Picosecond Electron Beam Production for the PLEIADES Thomson X-Ray Source

Brown Winthrop, Scott Anderson, Christopher Barty, Shawn Betts, Rex Booth, John Crane, Rick Cross, David Fittinghoff, David Gibson, Fred Hartemann, Jaroslav Kuba, Greg LeSage, Paul Springer, Aaron Tremaine (LLNL), James Rosenzweig (University of California, Los Angeles)

We report on the performance of an S-band RF photocathode electron gun and and 100 MeV accelerator for operation with the PLEIADES Thomson x-ray source at LLNL. The x-ray source is expected to produced pico-second xray pulses of brightness 10^{20} photons/0.1 bandwidth/mm^2/$mrad^2$ by colliding a 20 μ m, 0.5-1.0 nC, 0.5-5 ps electron bunch with a 100 fs, 300 mJ, 800 nm laser pulse. Simulations of the electron beam production, transport, and final focus, including the implementation of velocity compression to produce picosecond to sub-picosecond bunches, will be presented. Electron beam measurements, including emittance, bunch length, and final focus spot size are presented and compared to simulation results. Initial measurements of x-ray production will also be reported and compared to theoretical calculations.

* This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

Poster Session MPPE
Exhibit Hall at 13:30

MPPE001 200kV Pulse Modulator for Power Supply of the VEPP-5 Complex Preinjector Electron Gun

Andrey Korepanov, Valentin Akimov, Ivan Kazarezov (BINP)

This paper describes a new 200kV pulse modulator for the VEPP-5 complex preinjector electron gun. The pulse former is based on solid state IGBT-switch and new high turn ratio pulse transformer. New design allows to simplify performance of charge device due to decrease of primary voltage and decrease of power consumption due to partial energy recuperation.

MPPE002 RHIC Power Supplies - Lessons Learned From the 1999 - 2001 RHIC Runs

Donald Bruno, Wahfun Eng, George Ganetis, Robert Lambiase, Wing Louie, Jon Sandberg, Carl Schultheiss (BNL)

The Relativistic Heavy Ion Collider (RHIC) was commissioned in 1999 and 2000. The third RHIC run occurred in 2001. The two RHIC rings require a total of 933 power supplies (PSs) to supply currents to highly inductive superconducting magnets. These units function as 4 main PSs, 237 insertion region (IR) PSs, 24 sextupole PSs, 24 Gamma-T PSs, 8 snake PSs, 16 spin rotator PSs, and 620 correction PSs. Power supply reliability in this type of machine is of utmost importance because the IR PSs are nested within other IR PSs, and these are nested within the main PSs. This means if any main or IR PS trips off due to a PS fault or quench indication, then all the IR and main PSs in that ring must follow. When this happens, the Quench Protection Assemblies (QPA's) for each unit disconnects the PSs from the circuit and absorb the stored energy in the magnets. Commissioning these power supplies and QPA's was and still is a learning experience. A summary of the major problems encountered during these first three RHIC runs will be presented along with solutions.

* Work Performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

MPPE003 Designing and Implementing an Accelerator Power Supply System in a Multi-Laboratory Context

Robert Lambiase, Jon Sandberg (BNL)

The Spallation Neutron Source (SNS) is currently in construction at Oak Ridge National Laboratory. But, it's design is a collaborative effort with five partner laboratories. This paper examines, from a power systems viewpoint, how the multi-laboratory context affected design, procurement, vendor monitoring, testing, installation, and commissioning process. Designs in this environment are kept as modular as possible for remote installation and commissioning. Procurements and vendor monitoring require a balanced cooperation so that the receiving laboratory can come up to speed with the equipment, but not cause any confusion with the equipment vendors. During installation and commissioning responsibilities shift, and partner laboratories phase out, until the project is complete.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

MPPE004 Main Magnet Power Supply Improvements for Booster Applications Facility at BNL

Ioannis Marneris, K.A. Brown, J.W. Glenn, Andy Mc Nerney, John Morris, Jon Sandberg, Steve Savatteri (BNL)

The Booster Applications Facility (BAF), constructed at Brookhaven National Laboratory, under contract from NASA, is a new experimental facility, taking advantage of heavy-ion beams from the Brookhaven Alternating Gradient Synchrotron (AGS) Booster accelerator, to study radiation effect on humans, for prolonged space missions beyond the protective terrestrial magnetosphere. This paper describes the modifications and operation of the Booster Main Magnet Power Supply (MMPS) for BAF applications. The requirement is to run up to 1 sec flattops as high as 5000 Amps with 25 % duty cycle. The controls for the Main Magnet Power Supply were modified, including the Booster Main Magnet application program, to enable flattop operation with low ripple and for spill control. An active filter consisting of a +/- 125 volts, +/-700 Amps power supply transformer coupled through a filter choke, in series with the Main Magnet voltage, was added to the system to enable further ripple reduction during the flattops. We will describe the spill servo system, designed to provide a uniform beam current, during the flattop. Results from system commissioning will be presented.

MPPE005 Light Triggered Thyristor Crowbar for Klystron Protection Application

Wolfhard Merz, Jens-Peter Jensen (DESY)

High power klystrons have to be protected in case of arcing and other failures. In most applications this is achieved by fast closing switches operating in parallel to the klystron path. These switches are known as crowbar. Most commonly used crowbar switches are sparkgaps, thyratrons and ignitrons. Recent progress in the development of high power semiconductors introduces the possibility to apply semiconductor closing switches as crowbars. The most promising approach is the application of the Light Triggered Thyristor (LTT). This is especially interesting for high power high voltage dc installations, like hvdc klystron power supplies with appropriate protection requirements. The new LTTs have a high dI/dt and a high peak current capability and avoid the mercury problem of ignitrons. This paper describes a solution using series connected LTTs as a closing crowbar switch. Static and dynamic behaviour of the thyristors are introduced. The special requirements regarding the crowbar applications are pointed out. Results of a first prototype are presented to replace sparkgaps within an existing installation, where very high charge transfer capability has to be achieved.

MPPE006 Power Converter Technology Applied to Modern Storage Ring Orbit Correction Schemes

Justin Theed (Daresbury Laboratory)

This paper reviews the technical challenges in specifying the dynamic orbit corrector power converters for today's high-energy electron storage rings. The latest advances in insertion device and instrumentation technology require precise orbit correction and stability in order to be fully exploited. Modern systems may consist of several hundred independent correction windings and associated power converters. The purpose of these systems is to minimise the orbit drift by using the beam position monitors to provide global feedback to the individual correctors. The topologies employed at recently commissioned light sources, and the results of an exercise to evaluate the design options available for future sources are presented and compared.

MPPE007 Improving Power Supply Performance for Duke Storage Ring Upgrade

Ying Wu, Steve Hartman, Vladimir Litvinenko, Stepan Mikhailov, Peter Morcombe, Owen Oakeley, Igor Pinayev, Victor Popov, Patrick Wallace, Ping Wang (Duke University)

One of the major tasks of the recent Duke storage ring upgrade was the improvement of magnet power supply performance. Prior to the upgrade, sixty-four small DC power supplies acquired in the mid 1980's were used to individually power all quadrupoles. Because of

the marginal performance of these power supplies, we were not able to establish stable and reliable operation of the storage ring. The ring upgrade allowed us to replace all of these power supplies with modern ones. In the arc, all quadrupoles are connected in series to form magnet families powered by four larger power supplies. In the straight sections, we power paired quadrupoles in series or individually with new power supplies. For each of these new power supplies and for the other existing major power supplies, we performed detailed DC testing, AC noise measurements and transition response measurements. Most power supplies required in-house modifications to achieve our specifications. In this paper, we describe and report the results of the magnet power supply testing program for the Duke storage ring upgrade.

* Research Supported by the DoD MFEL Program as managed by the AFOSR, grant F49620-001-0370.

MPPE008 Design of Magnet Power Supplies for J-PARC 3-GeV Proton Synchrotron

Yasuhiro Watanabe, Zhang Fengqing, Shoichiro Koseki, Norio Tani (Japan Atomic Energy Research Institute), Toshikazu Adachi, Hikaru Sato, Hirohiko Someya (KEK)

The 3-GeV proton synchrotron of the proposed JAERI/KEK Joint Project (J-PARC) is a rapid cycling synchrotron (RCS), which accelerates a high-intensity proton beam at a repetition rate of 25Hz. The lattice magnets of the 3-GeV synchrotron are separated-type and are excited using eight independent resonant networks. This paper describes system design of bending- and quadrupole-magnet power supplies and its multi-wilding choke-transformers in detail.

MPPE009 Compensation of Load Changes of Power Supply System for Large Accelerator Using SMES

Hikaru Sato, Masayuki Muto, Takakazu Shintomi (KEK), Kouji Furukawa, Toshifumi Ise (Osaka University)

In the J-PARC 50GeV synchrotron, the peak active power and the dissipation power of main magnets are esimated to be about 135MW and 37MW, respectively. Superconducting Magnetic Energy Strage (SMES) is one of candidates to compensate these large load and line voltage changes. Study on a circuit configuration of the power supply with SMES will be discussed. Plan of experiment is also described.

MPPE010 Dual Resonant Frequency Power Supply for Rapid-Cycling Synchrotron Magnet

Shinji Yamanaka (KEK)

In order to realize dual resonant frequency mode for excitation of a rapid-cycling synchrotron magnet, its problems which are the noise induced by frequency switching and a characteristic of the system have been solved. In addition, we choose the Switching AC Power Supply for the resonant circuit, because it can control harmonics especially for the tracking between a quadrupole and dipole magnet. By formulating a characteristic of the model-circuit for an apparatus of practical use, we describe phenomena of an expectant current, that of a suitable power input, and that of a respondent waveform, and present the counter-plan in this paper. The model-circuit with the switching circuit of IGBT is demonstrated.

MPPE011 Test Results on Capacitor Commutation Charging Type of Resonant Power Supply for Synchrotron Ring Magnets

Sai Dong (National Synchrotron Radiation Lab)

This paper describes experimental results on several different load current wave forms: triangular wave with zero/nonzero flat bottom, trapezoidal wave with zero/nonzero flat bottom; reducing fall time with capacitors in series/parallel. This paper also analyses the wide application and prominent merits of this kind of power supply.

MPPE012 High Resolution Analog/Digital Power Supply Controller

Evgeny Medvedko, Robert Hettel, Greg Leyh, Jeff Olsen, Stephen Smith, Till Straumann, Clemens Wermelskirchen (SLAC)

Corrector magnets for the SPEAR-3 synchrotron radiation source require precision, high speed control for use with beam-based orbit feedback. A new Controller Analog/Digital Interface card (CANDI) has been developed for these purposes. The CANDI has a 24-bit DAC for current control and three 24-bit $\Delta - \Sigma$ ADCs to monitor current and voltages. The ADCs can be read and the DAC updated at the 4 kHz rate requested for feedback control. A precision 16-bit DAC provides on-board calibration. Programmable multiplexers control internal signal routing for calibration, testing, and measurement. Feedback can be closed internally on current set-point, externally on supply current, or on beam position. Prototype and production tests are reported here. Noise is better than 17 effective bits in a 10 mHz to 2 kHz frequency range. Linearity and temperature stability are excellent. The system is now in production.

MPPE013 Modification and Implementation the Correction Bipolar Power Supply of the Storage Ring

Liu Chen-Yao, Justin Chiou (Synchrotron Radiation Research Center)

To satisfy with high performance 1.5GeV beam current requirement in storage ring, the correction power supplies of the storage ring synchrotron in SRRC must be worked from 0 kHz to 1 kHz. If the storage ring operation current frequency response require from 0 kHz to 10 kHz. The correction power supplies must be modification from the normal frequency response to higher bandwidth, the beam current performance in storage ring will be better. The correction power supplies of the storage ring dynamic current must be modification to new requirement. The new controller gain of the correction power supplies was changed to detect the high frequency dynamic current ripple. The new controller gain is active when the correction power supplies work in output current state. So, the new controller gain of the correct power supplies function is achieved. Results and working performance will be presented in this paper.

MPPE014 Increasing Output Current Stability of Power Supply With Components Replacement

Kuo-Bin Liu, Yuan-Chen Chien, Chyi-Shyan Fann (Synchrotron Radiation Research Center)

Quadrupole magnets of synchrotron storage ring must be served with power supplies (quadrupole power supplies) with +/-100 ppm long-term output current stability in Synchrotron Radiation Research Center (SRRC). Using power supplies with lower long-term output current stability could save money but need another control loop to increase their performance that will increasing the complexity of circuitry of quadrupole power supply. Without adding another control loop, some components of quadrupole power supply are replaced by ones with more precious and insensitive to temperature variation; so that the same circuitry structure of quadrupole power supply is kept without increasing its complexity and could reach +/-30 ppm long-term output current stability.

MPPE015 1400A,+/-900V Pulse Switch Mode Power Supply for SNS Injection Kickers

Shashi Dewan (Digital Predictive Systems Inc.), Wahfun Eng, Robert Lambiase, Jon Sandberg (BNL), Robert Holmes (IE Power Inc.), Ken Rust (ORNL), Jiaqi Zeng (Univ. of Toronto)

This paper describes design and experimental results for a 1400A,+/-900V peak rated, switch mode power supply for SNS Injection Kicker Magnets. For each magnet (13 mOhm, 160microH), the power supply must supply controlled pulses at 60 Hz repetition rate. The pulse current must rise from zero to maximum in less than 1 millisec in a

controlled manner, flat top for up to 2 millisec, and should fall in a controlled manner to less than 4A within 500micros. To meet the controlled fall of the current and the current ripple requirements, voltage loop bandwidth of 10 kHz and switching frequency of at least 100 kHz are required. To achieve high power high frequency switching with IGBT switches, a series connected topology with three phase shifted (0,60,& 120 Degrees) converters each with 40 kHz switching frequency (IGBT at 20kHz), has been achieved. In this paper, the circuit topology, key system specifications and experimental results for the power supply are described in detail. A unique six SCR rectifier circuit with capacitor storage has been implemented to achieve minimum pulse width to meet required performance during current fall time below 50A due to the very narrow pulse width and non-linearity from IGBT turn-on/off times.

MPPE016 FLUKA Simulations of the Loss of the Stored Electron Beam at BESSY

Klaus Ott (BESSY)

The synchrotron light source BESSY consists of a 50 MeV microtron, a full energy synchrotron and the 1.9 GeV storage ring. At synchrotron light sources the accidental loss of the stored beam can occur several times a year. This could mean a considerable risk for the users because of the bremstrahlung flash coming through the open beamshutters. This is to our knowledge the first time that these occurences are discussed in detail for synchrotron light sources. We used the particle interaction and transport code FLUKA for the calculations in different scenarios. We present here additional radiation safety measures based on the FLUKA results that decrease the possible personal dose from those beam losses below 1mSv/year. Comparisons of FLUKA results with semi-empiric formulas for radiation through lateral shielding are presented too.

* Funded by the Bundesministerium fuer Bildung, Wissenschaft, Forschung und Technologie and by the Land Berlin.

MPPE017 The Shielding Design of the Metrology Light Source (MLS)

Klaus Ott (BESSY)

MLS will consist of a 100 MeV microtron and a 600 MeV storage ring. The investigations of the radiation types occuring at those machines dependent of the electron energy, target and shielding materials, observating angles and geometric aspects are well established, often condensed in semi-empiric formulas and in good agreement with the results of Monte Carlo codes like FLUKA for lateral shielding. But as important as the pure physical aspects of radiation are for a shielding design the operating times and modes and the consideration of possible crash scenarios. We present here an approach of considering failure operating probabilities at electron storage rings based on years of radiation and operating observations of BESSY I and BESSY II for the shielding design of MLS. Comparisons of FLUKA calculations with the used semi-empiric formulas are presented too.

* Funded by the Bundesministerium fuer Bildung, Wissenschaft, Forschung und Technologie and by the Land Berlin.

MPPE018 Shielding Design Study for CANDLE Facility

Khnkanos Sanosyan, Mher Aghasyan, Raphael Mikaelyan (CANDLE), Varti Vartanian (Stanford University)

The radiation shielding design study for the third generation synchrotron light source CANDLE is carried out. The DOSRZnrc and FLUKA Monte-Carlo simulation codes have been used to calculate the shielding design requirements of the facility. Detailed and extensive considerations of radiation safety aspects for the linac, booster, storage ring and beamlines of the facility are presented.

MPPE019 Further Experience with the SLC Permanent Magnetic (PM) Multipoles

James Spencer, Stan Mao, Cherrill Spencer (SLAC)

Permanent magnets have been used in the SLAC damping rings and their injection and extraction lines since 1985. Due to upgrades of the DR vacuum chambers for higher current operation in 1993, there was an opportunity to check certain of these magnets. Those results are available [G. Gross et al., EPAC Proceedings 1994]. At that time, 21 of the 144 sextupoles were replaced - mostly downstream of the injection kickers and in the electron ring either because their thermal stabilization temperatures of 80 C had been exceeded or because they showed serious mechanical deformation or high radiation levels (in some cases >1 R/hr on contact). Since that time, nothing else was done until recently when we began a program of radiation measurements in the electron ring to determine the levels and effects of integrated gamma and neutron doses on the strengths and harmonic content of these magnets. One magnet, that was previously removed, was remeasured and reinstalled at a location where the existing sextupole had been in the electron ring for 17 years. We discuss the results of the latest magnetic measurements as well as our radiation measurement program and semiconductor dosimeters together with those results and their correlation with beam loss in the ring. Much of the integrated dose comes during turn-on and tune-up. We also discuss the genesis of the thermal neutrons that are a problem for both SmCo and NdFeB type magnets.

MPPE020 Radiation Measurement around a 10T Superconducting Wiggler at SPring-8

Masazumi Shoji, Noritaka Kumagai, Tamotsu Magome, Takashi Ohshima, Masaya Oishi, Shigeki Sasaki, Kouichi Soutome, Junichiro Tada, Tetsuya Takagi, Masaru Takao, Kouji Tsumaki, Hiroto Yonehara, Tetsuhiko Yorita (SPring-8), Yoshihiro Asano (Japan Atomic Energy Research Institute)

In August 2002, a 10T superconducting wiggler was installed in the 8GeV electron storage ring at SPring-8. High-energy (~3MeV) and high-intensity synchrotron radiation was produced from the wiggler, and scatterd photons were generated by the interaction of synchrotron radiation with the photon absorber materials. High-intensity radiation environment in the storage ring tunnel does damage to accelerator components such as cable insulators. In order to avoid the damage, it is necessary to learn the dose distribution and the spectrum of scattered photons around the wiggler. The dose distribution was measured by using alanine dosimeters and GafChromic film (made of polyethylene) with the wiggler fully excited. At the same time, the spectrum of scattered photons from the absorber was observed by using thermoluminescent dosimeters (LiF TLD) with lead filters (0.5, 1, 3, 6 mm in thickness). As a result of distribution analysis, we found that high-energy photons were scattered in a wide range as was expected. Energy analysis is now in progress.

MPPE021 Improvement of RHIC Warm Beam Vacuum for High Intensity Operation

Hsiao-Chaun Hseuh, Ping He, Roger Lee, Michael Mapes, Loralie Smart, Daniel Weiss, Shou-Yuan Zhang (BNL)

With increasing intensity of gold and proton beams during recent RHIC operations, pressure increases of several decades were observed at a few unbaked warm vacuum sections. Wide-ranging improvement of the warm vacuum sections has been carried out in this year's shutdown through extensive in-situ bakeouts and increased UHV pumping. Instrumentation to detect and study the possibility of beam induced electron clouds have also been implemented. Axial-field solenoids and electron detectors have been installed to confine and monitor the electrons. The vacuum monitoring and interlock control are also enhanced to minimize false beam aborts. The effectiveness

of these measures in reducing the beam induced pressure bumps and in increasing the vacuum system reliability will be summarized and discussed.

* Work performed under the auspices of the U.S. Department of Energy.

MPPE022 Outgassing and Surface Property of TiN Coated SNS Ring Vacuum Chambers

Hsiao-Chaun Hseuh, Ping He, Robert Todd (BNL), Noel Hilleret (CERN)

The stainless steel vacuum chambers of the 248m accumulator ring of Spallation Neutron Source (SNS) are being coated with ~ 100 nm of TiN to reduce the secondary electron yield (SEY). The coating is produced by DC magnetron sputtering using a long tubular cathode containing permanent magnets. The outgassing rates of several SNS half-cell chambers, with and without TiN coating, and before and after in-situ bake, were measured. SEY of the chamber coupons were also measured with primary electron energy of 50-3000 eV. By varying the coating parameters, films of different surface roughness are produced and analyzed by scanning electron microscopy and atomic force microscopy. It was found that the outgassing rate varies as a function of surface roughness of the TiN layer, and SEY varies inversely with surface roughness.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

MPPE023 Pressure Distribution Simulation for SNS Ring Vacuum Systems

Hsiao-Chaun Hseuh, Ping He (BNL)

Brookhaven is responsible for the design and construction of the US Spallation Neutron Source (SNS) accumulator ring and beam transport lines. Ultra high vacuum of a few nano- Torr is required for the accumulator ring to minimize the residual gas ionization. To size the pumps and to optimize the pump locations, the pressure distribution in the vacuum systems has to be calculated based on chamber conductance, the static and dynamic outgassing of the chamber walls and the beam components. A computer program, based on finite differential approximation, was used to model the pressure in the accumulator ring, using the measured outgassing rates of chambers with and without the TiN coating specified for the reduction of secondary electron yield. The simulation results indicate that due to the high outgassing of the coated surface, the designed vacuum will be achieved only after prolonged pumping or with additional pumps.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

MPPE024 Electron Detectors for Vacuum Pressure Rise Diagnostics at RHIC

Ubaldo Iriso-Ariz, Angelika Drees, Dave Gassner, Justin Gullotta, Ping He, H.C. Hseuh, R. Lee, Vivek Ponnaiyan, Dejan Trbojevic, S.Y. Zhang (BNL)

In the RHIC 2001 run, an unexpected vacuum pressure rise versus bunch increasing currents was observed in both gold and proton operations. This pressure increase due to molecular desorption is suspected to be induced mainly by electron multipacting, but other causes may coexist, such as ion desorption due to halo scraping. In order to get a reliable diagnostic of the phenomena electron detectors have been installed in the RHIC ring. In this report we describe results measured by the electron detectors with energy filters during the RHIC 2002/2003 run.

MPPE025 Electron Cloud and Pressure Rise Simulations for RHIC

Ubaldo Iriso-Ariz, Mike Blaskiewicz, Angelika Drees, Wolfram Fischer, Dejan Trbojevic, S.Y. Zhang (BNL)

Positively charged beams generate electron clouds via gas ionization, photoemission, halo scraping and multipacting, leading to a pressure rise and possible beam failures. Beam induced electron multipacting may be among the main reasons for the vacuum pressure rise when circulating high intensity ion and proton beams in RHIC. However, the data taken during the RHIC 2001 run evidenced that other causes (such as ion desorption or beam loss) could importantly contribute to the RHIC pressure rise. Significant progress in the understanding of electron cloud in accelerators allowed developing several successful computer simulations. We complemented one of the existing electron cloud simulations by introducing the influence of the electron multipacting to the vacuum properties. Latest simulation results are benchmarked with recent experimental observations for RHIC, and compared to other general computer codes.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

MPPE026 Results of the First VLHC Photon Stop Cryogenic Design Experiment

Pierre Bauer, D. Erickson, K. Ewald, M. Geynisman, G. Johnson, A. Klebaner, P. Limon, A. Martinez, R. Milholland, T. Nicol, N. Solyak, C. Staples, M. Steinke, G. Szabo, Y. Terechkine (FNAL)

As part of Fermilab's study of a Very Large Hadron Collider, a water cooled photon stop was proposed as a device to intercept the intense synchrotron radiation emitted by the high energy proton beams with minimal plug-cooling power. Photon stops are envisioned to be located at the end of each bending magnet. Protruding into the beam tube, they scrape the synchrotron light emitted by the beam one magnet up-stream.The use of photon stop virtually removes the synchrotron radiation limitation to beam energy and luminosity in a future VLHC. This is related to the significant savings in cooling power that can be obtained by extracting the synchrotron radiation related heat load at room temperature compared to a solution in which the radiation power is extracted with a beam screen at cryogenic temperature.Among the technological challenges regarding photon stops is their cryo-design. The photon stop is water-cooled and operates in a cryogenic environment. A careful cryo-design is therefore essential to enable operation at minimum heat transfer between the room temperature sections and the cryogenic parts. A photon stop cryo-design was developed and a photon stop prototype was built. This paper presents the results of the cryogenic experiments conducted on the first VLHC photon stop prototype.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

MPPE027 Development of Movable Mask with Reduced-HOM Design for KEKB

Kyo Shibata, Tatsuya Kageyama, Yusuke Suetsugu (KEK)

Movable masks (or collimators) are the special vacuum components for the KEK B-factory (KEKB) to decrease the background noise of the Belle detector. As increasing the beam current over 900 mA, some bellows near the masks were found to be overheated due to the higher order mode (HOM) generated at the mask head. To cope with this problem, a new mask was designed where the length of slopes at the mask head was expanded from 30 mm to 400 mm with the same mask height of 15 mm. MAFIA T-3 simulations showed that the loss factor for the new long mask was about a half of that for the previous short one. The power of the TE mode, on the other hand, which could easily couple with the bellows through the finger-type rf-shield, was expected

to reduce to about 6 percent of that for the short one. During the summer shutdown in 2002, two long masks were installed as a test. It was found in the following run that the temperature rise of the bellows near the long masks was about 20 percent of those near the short ones and the new design was effective to reduce HOM. The decrease in the temperature rise was larger than the reduction of HOM power estimated from the loss factor but less than that expected from the TE-mode. This result indicates that the overheating of the bellows is mainly due to the TE-mode among the total HOM. In this paper, the design of the new long mask and the estimation of HOM power will be presented.

MPPE028 Development of Winged HOM Damper for Movable Mask in KEKB

Yusuke Suetsugu, Tatsuya Kageyama, Kyo Shibata, Yasunao Takeuchi (KEK)

As increasing the stored beam current at KEK B-factory (KEKB), the heating of bellows or pump elements have become apparent near the movable mask (or collimators). The heating is due to the higher order mode (HOM), especially the TE mode, excited at the movable masks, where the beam is passing largely off center of the beam chamber. To suppress the heating, a new beam chamber equipped with HOM absorbers (HOM damper) was developed. The damper has delta-type wings and two SiC rods (55 mm in diameter and 466 mm in length) are installed inside the both wings. The wings and beam pipe are connected with long slots (20 mm in width and 707 mm in length) and the TE mode can be absorbed efficiently. Two pairs of the winged dampers were installed in the ring putting four (two horizontal and two vertical) movable masks between each pair in summer, 2002. In the autumn run, the heating of pump element was disappeared outside of the paired winged dampers. The absorbed HOM power was estimated to be about several kW for a SiC rod at the beam current of 1A, which is almost the same order of the power loss for one movable mask. Here the structure and property of the winged damper is presented.

MPPE029 Conceptual Design of Vacuum System for Super KEKB

Yusuke Suetsugu, Ken-ichi Kanazawa, Kyo Shibata (KEK)

An upgrade plan of the present KEK B-factory (KEKB), i.e. Super KEKB, was proposed recently aiming a luminosity of $1x10^{35}$ cm^{-2} sec^{-1}. The design beam currents for electron and positron are 9.4 A (3.5 GeV) and 4.1 A (8.0 GeV), respectively, with the bunch number of about 5000. The resultant photon flux and power of the synchrotron radiation is extremely higher than ever before. The bunch length, furthermore, is 3 mm and the impedance issues become much important. The vacuum system for the Super KEKB, therefore, has to cope with these subjects carefully. The ante-chamber scheme for the beam chamber is considered to mitigate the synchrotron radiation power density at the chamber wall. The distributed pumps are required to evacuate the beam chamber effectively. The bellows-less design is an attractive design option to reduce the beam impedance and avoid the overheating. Here the conceptual design of the vacuum system for the super KEKB will be presented including some basic thermal and structural calculations for the beam chambers, ideas for low-impedance structure of components such as the bellows assembly and connection flanges.

MPPE030 Vacuum Systems Renewal for the PF-AR Upgrade

Yasunori Tanimoto, Yoichiro Hori, Takashi Nogami, Takashi Uchiyama (KEK)

Upgrade improvements of the synchrotron light source PF-AR were carried out in 2001. In vacuum systems, almost all of beam chambers, vacuum pumps, vacuum gauges, and their control systems were renewed to realize higher performances including longer beam lifetime and higher stored current. We set a goal of the beam lifetime with a 6.5GeV-100mA single-bunch beam stored to 10 hours, which required the current-normalized vacuum pressure of 5*10^-6 Pa/A. Former Aluminum alloy beam chambers were replaced with OFHC copper chambers in order to gain greater tolerance to thermal loads and radiations. Vacuum pump systems were reinforced to achieve the required vacuum pressure. Cold cathode gauges, having the capability of reliable measurements of the 10^-8 Pa region, were adopted as total pressure sensors. Vacuum control systems were unified to the EPICS, and all of the vacuum devices except for rough pumps got to be controlled and monitored remotely on graphical operation panels. Commissioning of the upgraded PF-AR started successfully in January 2002, and the beam lifetime was gradually getting longer. In November 2002, although the stored beam current is limited to 50mA, the beam lifetime is 15 hours, which is 6 times longer than the value of the former PF-AR. Therefore, the required performances in vacuum systems have been almost achieved.

MPPE031 Re-Circulating Linac Vacuum System

Russell Wells, John Corlett, Alexander Zholents (LBNL)

The vacuum system for a proposed 2.5 GeV, 10 microampere re-circulating linac synchrotron light source is readily achievable with conventional vacuum hardware and established fabrication processes. Some of the difficult technical challenges associated with synchrotron light source storage rings are sidestepped by the short beam lifetime requirement of a re-circulating linac. This minimal lifetime requirement leads directly to relatively high limits on the background gas pressure through much of the facility. The 10 microampere average beam current produces very little synchrotron radiation induced gas desorption and thus the need for an "ante-chamber" in the vacuum chamber is eliminated. In the arc bend magnets, and the insertion devices, the vacuum chamber dimensions can be adjusted to balance the coherent synchrotron radiation and resistive wall wakefield effects, while maintaining the modes limits on the gas pressure and minimal outgassing.

* This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

MPPE032 Improvment of the Storage Ring UHV System of NSRL

Yong Wang, Le Fan, Changying Guan, Daoman Jiang, Jianpin Wang, Wei Wei, Guanyuan Wu, Feiyun Zhao (National Synchrotron Radiation Lab)

NSRL storage-ring has been operated for fourteen years. The typical life time is 600 mins at 200mA and 800MeV. The new injection ceramic chamber, bend chamber, undulator and NEG pumps were installed, new vacuum measure and control system was debugged in 2002 summer, as part of NSRL phase II project to enhance the quality, stability and long-term reliability. The average pressure of storage ring is better than 2E-8 pascal after 48 hour large current direct backout and 48 hour ion pumps operation, this better vacuum can benefit the phase II project's object beam lifetime 600 mins at 300mA and 800MeV.

MPPE033 Adsorption Study of Al2O3 Coating on the Magnet Coil Surface

Hai-Ou Zhang, Yuan-Ji Pei (National Synchrotron Radiation Lab)

Al2O3 powder was coated on the septum magnet coil surface by plasma spraying. these magnet coil were mounted directly in the injection vacuum chamber. The results show implicitly that magnet field was undisturbed, injection degree didn't increase, and background pressure decreased furthermore. Thus injection efficiency increased. In this paper 20 sheets of coating are made($120x80mm^2$), its adsorption

capacity tested. Pore constitution was studied by BET method. Experiment results indicated that coating could increase background vacuum degree obviously, from $6.4x10^{-5}$ Pa to $8.6x10^{-6}$ Pa. Its adsorption capacity is about $3.68x10^{-4}$ Pa-l/cm^2. BET surface area is 201m2/g, pore form is one end dead. XPS result show there are hydroxy, carboxy etc on the surface,and they are related with coating adsorption. The binding energy of CO, H2O, CO2 on the Al2O3 are also calculated. Results show CO-Al2O3 is the smallest.

MPPE034 A High Conductance Vacuum Vessel and Polymer High Voltage Insulating Column for the ISIS RFQ Ion Source

Michael Clarke-Gayther (Rutherford Appleton Laboratory)

A compact, high conductance vacuum vessel and an advanced composite polymer, high voltage insulating column have been designed for the ISIS RFQ Ion Source. Key features of the monolithic, glass micro-fibre reinforced, PolyPhenyleneOxide (PPO) insulator design are highlighted. Results obtained from a two dimensional finite element analysis of electric field, from vacuum out-gassing tests on a range of polymers, and from pull-out tests on stainless steel inserts in PPO and ceramic are presented.

MPPE035 Vacuum Commissioning for the SWLS Absorber Inside a Kicker-Chamber at TLS Storage Ring

Gao-Yu Hsiung, June-Rong Chen, Chih-Sung Ho, Shen-Nung Hsu, Chien-Kuang Kuan (Synchrotron Radiation Research Center)

A 6T super-conducting wiggler, so called wavelength shifter, (SWLS) has been installed in the injection section of the 1.5 GeV Taiwan Light Source (TLS) electron storage ring. The intensive synchrotron radiation emitted from SWLS causes severe problems in the downstream kicker-chamber, such as radiation hitting on the ceramic parts, interfered non-uniform field and induced arcing from the absorber during kicker firing, etc. A new absorber, designed to solve those problems, has been developed and installed in the kicker-chamber downstream the SWLS. The earlier stage of vacuum commissioning shows a high pressure-rise, stimulated by the photons, localized near the head of absorber that seriously constrains the beam lifetime. However, the pressure reduces by continuous beam cleaning. The injection efficiency of the electron beam is not degraded much. The temperature rise on the downstream chambers, behaves not so according to the beam current, is kept within allowable values.

MPPE036 Fabrication of Dipole Vacuum Chambers for INDUS-2

Vivek Bhatnagar, Arvind Kumar Jain (Department of Atomic Energy, Government of India)

The Indus-2 dipole vacuum chamber is a 3.6 meter long aluminum alloy chamber, fabricated from two thick plates of grade AA 5083 H321. These chambers will be installed in the 2.5 Gev electron storage ring of synchrotron radiation source at the centre for advanced technology Indore. Each half of the chamber is complex in shape and it is machined by using CNC Profiler m/c. Manual TIG welding process is adopted in fabrication. Eight chambers, out of total sixteen have been sucessfully completed and vacuum leak tested to the design target and two nos of vacuum chambers have passed ultimate vacuum tests. This paper describes the fabrication aspects of dipole vacuum chambers.

* Centre for Advanced Technology, Government of India, Department of Atomic Energy.

Poster Session MPPB
Grand Ballroom I at 13:30

MPPB001 Insertion Device Vacuum Chamber for the Linac Coherent Light Source

Soon-Hong Lee, Patric Den Hartog, Emil Trakhtenberg (ANL)

The vacuum requirement for the undulator line of the Linac Coherent Light Source is extremely challenging: a low resistive wall impedance 3.42 m long chamber that fits within a 6.3 mm undulator gap that has ultra-low outgassing and a surface finish, Ra, less than 100 nm. A prototype chamber will be fabricated from electropolished semiconductor-processing grade stainless steel seamless tubing. Since stainless steel tube has a high electric resistivity which can increase the resistive wall wake, a thin layer of copper will be deposited to minimize this effect. A thin nickel plating will be deposited in advance for better adhesion. This process will be followed by electro-polishing of the copper surface. The first approach to the design of the short and long break sections is discussed. Short sample tests have been fabricated and surface characteristics have been measured. Furthermore, 3.42 m long tubing tests have been planned. Results and the implications for the design will be presented.

MPPB002 Advanced Photon Source Booster Synchrotron Subharmonic RF Capture Design

Nicholas Sereno (ANL)

Recent efforts at the APS have focused on improving overall injector system reliability and availability for top-up mode storage ring operation. One proposal being considered is to impliment direct injection of the beam from the linac into the booster synchrotron thereby bypassing the positron accumulator ring. Efficient capture of the long linac macropulse (>~10 ns) can be accomplished by adding an additional rf system in the booster at an appropriate subharmonic of the 352-MHz rf system. The subharmonic system is used during injection up to approximately 3 GeV, then the 352-MHz system is turned on to accelerate the beam to 7 GeV. The program elegant is used to simulate rf and magnet ramping, beam loading, and HOM effects at up to 10 nC beam charge. Issues addressed in this design are efficient beam capture and acceleration to 7 GeV while maintaining adjacent bunch purity. Tolerances on various rf system parameters are presented in order to maintain bunch purity to better than 1 part in 100000.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract W-31-109-ENG-38.

MPPB003 New Insertion Device Vacuum Chamber at the Advanced Photon Source

Emil Trakhtenberg, Branislav Brajuskovic, Patric Den Hartog, Greg Wiemerslage (ANL)

Six new types of insertion device vacuum chambers have been designed at the Advanced Photon Source. One chamber has been designed for the APS Canted Undulator beamlines, two for the Canadian Light Source (CLS), and three for BESSY II. For the double canted undulators and CLS a new extrusion shape with an oval aperture (not elliptical as usual) was developed and extruded. That required a thorough stress analysis and some compromise with a small increase of the vacuum chamber wall thickness. The details of the stress analyses and design of the chambers built upon previous APS experience with machined aluminum extrusions, along with lessons learned, are presented.

MPPB004 Dual Canted Undulators at the Advanced Photon Source

Patrick den Hartog, Glenn Decker, Louis Emery (ANL)

At the Advanced Photon Source, 34 straight sections are reserved for the installation of insertion devices. Each straight section allows space for up to two 2.4-meter-long devices. By sacrificing 0.4 m of undulator from each device and introducing a one milliradian chicane with three small electromagnets, two separate experimental programs can be conducted for the same straight section, thereby potentially doubling the scientific output with the same real estate. An overview of the design of the straight section and front end, and plans for implementation and commissioning of this scheme at the APS during May 2003 will be presented.

MPPB005 Layout of a Femtosecond X-Ray Source at BESSY II

Shaukat Khan, Hans-Jürgen Bäcker, Johannes Bahrdt, Hermann A. Dürr, Volker Dürr, Wolfgang Eberhardt, Andreas Gaupp, Karsten Holldack, Eberhard Jaeschke, Dieter Krämer, Hans-Christoph Mertins, William B. Peatman, Torsten Quast, Gerd Reichardt, Michael Scheer, Friedmar Senf, Godehard Wüstefeld (BESSY)

The generation of femtosecond x-ray pulses with linear and circular polarization via laser-electron interaction (see A. Zholentz, M. Zoloterev, PRL 76/1996, 912) is planned at BESSY II. Two undulators within one straight section of the storage ring will be used for this purpose, a planar device for energy-modulation of electrons using a femtosecond laser, and an elliptical undulator to produce radiation of variable energy and polarisation. A bending magnet between them will provide angular dispersion to isolate the short x-ray pulses.

* Funded by the Bundesministerium für Bildung und Forschung and by the Land Berlin.

MPPB006 Recent Coherent Synchrotron Radiation Experiments at BESSY II

Gode Wuestefeld, Michael Abo-Bakr, Joerg Feikes, Karsten Holldack, Peter Kuske, Wiliam Peatman, Ulrich Schade (BESSY), Heinz-Wilhelm Hubers (Deutsches Zentrum fur Luft-und Raumfahrt)

BESSY II is presently the only electron storage ring which can generate stable, non-bursting coherent synchrotron radiation by applying a low alpha optics [M. Abo-Bakr, J. Feikes, K. Holldack, G. Wuestefeld (BESSY) and H.-W. Huebers (DLR), Phys. rev. Lett. Vol. 88, p. 254801 (2002)]. The broad band radiation is detected in the 0.15 to 1.2 THz range. We report on recent machine physics results.

MPPB007 Photocathode RF Gun Injection Systems for NSLS Upgrade

Xijie Wang, D. Lynch, J.B. Murphy, S. Pjerov, J. Rose, B. Sheehy, Z. Wu (BNL)

The preliminary designs of the photocathode RF gun injection system for the National Synchrotron Light Source (NSLS) upgrade are presented in this report. The proposed NSLS upgrade consists of an ultra-low emittance 3 GeV Storage ring and an L-band 3 GeV superconducting linac. The 3 GeV CW linac will be used for top off operation of the storage ring and to drive a soft X-ray free electron laser (FEL). The soft X-ray FEL can be operated either in high rep rate (1 to 10 kHz) short duration (us) or low rep rate (10 Hz) long pulse (ms). We are proposing to use the next generation S-band 1.6 cell BNL photoinjector for high rep rate FEL operation, and a 2.6 cell L-band photoinjector for low rep rate operation. A magnesium cathode will be used for the S-band RF gun with a peak acceleration field of 70-100 MV/m. A Cs2Te cathode will be used with the L-band RF gun operating at 30 MV/m. Simulations show both designs are capable of generating electron beams with normalized RMS emittances less than 1 mm-mrad for a charge of 0.5 nC. Thermal stress analysis of the RF cavities and laser system designs will be also presented.

MPPB008 The Status of the CANDLE Synchrotron Light Facility

Vassili Tsakanov (CANDLE)

CANDLE - Center for the Advancement of Natural Discoveries using Light Emission - is a 3 GeV third generation synchrotron light facility to be constructed in Republic of Armenia. The presentation includes the main considerations that underlie the Conceptual Design Report of the project that successfully passed the Review Panel. The main achievements on the site and hardware developments for the new facility are presented.

MPPB009 Lattice Options for a 5 GeV Light Source at Cornell

Ivan Bazarov, Georg Hoffstaetter (Cornell University)

Cornell has proposed an Energy Recovery Linac (ERL) based synchrotron-light facility which can provide improved x-ray radiation due to the high beam quality that is available from a linac. To additionally utilize beam currents that are competitive with ring-based light sources, the linac has to operate with the novel technique of energy recovery. CornellS plans to address the outstanding issues of high-current injector, higher-order mode damping and extraction from superconducting RF environment, etc. in a downscaled prototype ERL prior to submitting a proposal for a full-scale machine. The flexibility of linacs allows for different modes of operating the ERL x-ray source, each of which requires specific manipulations of longitudinal phase space that restrict the choice of the lattice. Here we discuss the different proposed modes of operating the ERL x-ray source and present options for corresponding lattices.

* Work supported by Cornell University.

MPPB010 Effect of Insertion Devices on the Performance of BESSYII

Joerg Feikes (Cornell University)

After closing insertion devices at BESSYII to smallest gaps beside the observation of a vertical tune-shift (well compensated by a feedforward system) one also notices that beam lifetime is considerably reduced (30% and more). The reduction neither depends on machine tune nor on the settings of the four BESSYII harmonic sextupole circuits. Here we present measurements to explain this effect.

* Work supported by the Bundesministerium fur Bildung, Wissenschaft, Forschung und Technologie and by the Land Berlin.

MPPB011 A Lattice for a 5GeV ERL in the CESR Tunnel

Georg Hoffstaetter, Ivan Bazarov, David Sagan, Richard Talman (Cornell University)

It has been proposed to build an Energy-Recovery Linac (ERL) based synchrotron-light facility at Cornell. Due to the high beam quality of a linac with photo injector, such a facility has the potential to provide better x-ray radiation than ring-based sources. To take advantage of the existing circular accelerator CESR for this 5~GeV ERL it has been suggested that the linac should be split in sections that are at angles to each other and that half the CESR ring should be used as a return arc to connect the end of the last linac section to the beginning of the first. Here we specify the minimum optical requirements on such a layout and show possible lattices for an ERL return arc that uses CESR. To find these lattices, a lattice optimization program has been developed based upon the BMAD software subroutine package.

MPPB012 Chromaticity Measurements in the ESRF Booster

Yannis Papaphilippou, Gilles Chazot, Jean-Marc Koch, Eric Plouviez, Jean-Luc Revol, Annick Ropert (European Synchrotron Radiation Facility)

In view of optimising the performance of the ESRF Booster, a series of experiments have been conducted in order to measure the chromaticity during the cycle for different sextupole settings. To this end, the betatron tunes were measured for different values of the RF frequency using the new tune-meter application. The experimental results were finally analysed and compared to theoretical data of the Booster model, showing excellent agreement.

MPPB013 Operation and Recent Developments of the ESRF

Jean-Luc Revol, Jean-Claude Biasci, Joel Chavanne, Pascal Elleaume, Laurent Farvacque, Thomas Guenzel, Laurent Hardy, Joern Jacobs, Graham Naylor, Yannis Papaphilippou, Eric Plouviez, Annick Ropert, Kees-Bertus Scheidt (European Synchrotron Radiation Facility)

The ESRF has been operated for more than 10 years. As a result of the maintenance policy a high level of beam availability as well as a long beam time between failures has been maintained. In addition, a continuous effort is made to further develop the machine. The operation status and the experience gained with the recent upgrades will be reported. It concerns: the successful operation with 5 in-vacuum undulators operated at 5-6 mm magnetic gap; the implementation of a new hybrid type filling pattern which combine group of bunches at full current and single bunch; the successful qualification of a 8 mm vertical aperture Insertion Device chamber made of aluminum and coated with non evaporable getter material; the increase of the impedance with associated consequences on instability thresholds, following the installation of a number of low aperture Insertion Device chambers; the successful test of the SOLEIL superconducting cavity; the on going work to develop the injection front end open in order to ensure a better thermal stability in the beamlines.

MPPB014 The Lattice of the Super SOR Light Source

Kentaro Harada, Yukinori Kobayashi (KEK), Norio Nakamura, Hiroshi R. Sakai, Hiroyuki Takaki (ISSP SRL)

We show the lattics and optics of the Super SOR Light Source. The circunference is about 280m, the energy 1.8GeV and the emittance about 8 nmrad at 1.8GeV. The ring have twelve 6m long straight section and two 14m long straight section. The lattice consists of 14 cells of DBA structure.

MPPB015 Present Status of Photon Factory Advanced Ring

Tsukasa Miyajima, Kiyokazu Ebihara, Eizi Ezura, Hitoshi Fukuma, Kaiichi Haga, Kentaro Harada, Yoichiro Hori, Takao Ieiri, Shigeru Isagawa, Toshio Kasuga, Tadahiko Katoh, Hiroshi Kawata, Mitsuo Kikuchi, Masanori Kobayashi, Yukinori Kobayashi, Kikuo Kudo, Yasuyuki Minagawa, Toshiyuki Mitsuhashi, Shinya Nagahashi, Tatsuro Nakamura, Hiroshi Nakanishi, Takashi Nogami, Takashi Obina, Yasunobu Ohsawa, Yukiyoshi Onishi, Masaaki Ono, Toshiyuki Ozaki, Yutaka Sakamoto, Shogo Sakanaka, Masayuki Sato, Masato Satoh, Tatsuro Shioya, Masaaki Suetake, Ryuhei Sugahara, Mikito Tadano, Takeshi Takahashi, Seiji Takasaki, Yasunori Takeuchi, Yasunori Tanimoto, Masaki Tejima, Kimichika Tsuchiya, Takashi Uchiyama, Akira Ueda, Kensei Umemori, Noboru Yamamoto, Shigeru Yamamoto, Shin-ichi Yoshimoto, Masakazu Yoshioka (KEK), Takahiro Fujita (Hiroshima University)

The AR that was originally constructed as a booster of the TRISTAN electron-positron collider has been parasitically used as an X-ray source. It was converted into a ring dedicated to pulse X-ray research and renamed PF-AR(Photon Factory Advanced Ring) after completion of the TRISTAN project, however, its performance as a light source was not satisfactory: low reliability due to overage machine components, a short beam lifetime due to insufficient vacuum system performance, deficiency of closed-orbit controllability caused by the unreliable beam position monitor(BPM) system, etc. In order to improve these problems, the PF-AR upgrading project was started in 1999. Old vacuum ducts made of Al alloy were exchanged for ones made of OFHC copper with improved BPM electrodes and the pumping system was largely reinforced. The power supplies for the steering magnets were all changed and the control system were completely renewed. New beamlines and in-vacuum type insertion devices were installed. The upgrading project were completed in the end of 2001, and commissioning of the upgraded ring was successfully done in the beginning of January, 2002. After fine tuning of the machine, users' operation started in April. The typical lifetime of 15 hrs at the stored energy of 6.5GeV and the beam current of 50mA in a single bunch was achieved, and the closed orbit controllability was largely improved.

MPPB016 Calculated Performance of a Ring-Based Source of CSR in the Far-Infrared

John Byrd, Fernando Sannibale (LBNL)

Coherent synchrotron radiation (CSR) from a storage ring is potentially a powerful source of radiation in the far-infrared/terahertz wavelength region. The spectral range of the CSR can be enhanced by distortions in the longitudinal bunch distribution. In this paper, we show that significant distortions can occur from the beam interacting with the synchrotron radiation resulting in additional coherence. We present calculations of the performance of such a source.

* Supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

MPPB017 Collective Effects Analysis for the Berkeley Femtosource

Stefano De Santis, John Corlett, Andrzej Wolski, Alekander Zholents (LBNL)

We present an overview of the collective effects in a proposed ultrafast x-ray facility, based on a recirculating linac. The facility requires a small vertical emittance of 0.4 mm-mrad and is designed to operate with a "flat bunch" with the large aspect ratio of emittances. Emittance control from the electron source at the RF photocathode to the photon production chain of undulators, and understanding and mitigation of collective effects is critical to a successful machine operation. Key aspects of accelerator physics involved in beam break-up, coherent synchrotron radiation, resistive wall impedance and other effects have been addressed and reported here.

* This work was supported by the U.S.Department of Energy under Contract No. DE-AC03-76SF00098.

MPPB018 Noise Reduction Efforts for the Infrared Beamline at the Advanced Light Source

Tom Scarvie, Nord Andresen, Ken Baptiste, John Byrd, Mike Chin, Michael Martin, Wayne McKinney, Christoph Steier (LBNL)

The quality of infrared microscopy and spectroscopy data collected at synchrotron based sources is strongly dependent on noise. We have successfully identified and suppressed several noise sources affecting Beamline 1.4.3 at the Advanced Light Source (ALS), resulting in significant reductions to the noise in the users' FTIR spectra. In this paper, we present our methods of noise source analysis and the techniques used to reduce the noise and its negative effect on the infrared beam quality. These include analyzing and changing physical mounts to better isolate portions of the beamline optics from low-frequency environmental noise, and modifying the input signals to the main RF system. We also discuss the relationship between electron

beam energy oscillations at a point of dispersion and infrared beamline noise.

* This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

MPPB019 Longitudinal Phase Space Control in the Berkeley Femtosecond X-Ray Light Source

Alexander Zholents (LBNL)

The Berkeley femtosecond x-ray light source is a ~2.5 GeV recirculating linear accelerator, where electrons reach their final energy in four beam passes through a 600 MeV superconducting linac after injection at ~ 100 MeV. An important consideration for this machine is the preservation of the electron beam longitudinal emittance through the various stages of acceleration including a chain of injection linacs, bunch compression, and various passages through the recirculating linac magnetic arcs. In this paper we analyze the longitudinal dynamics of the electrons and define a strategy of the electron beam manipulation leading to a successful conservation of the longitudinal emittance. Particular attention is given to the management of the correlated energy spread induced by collective effects such as the space charge, longitudinal wake fields and coherent synchrotron radiation.

* This work was supported by the Department of Energy under Contract No. DE-AC03-76SF00098.

MPPB020 Time and Frequency Domain Calculations of X-Ray Production for the PLEIADES Thomson X-Ray Source

Fred Hartemann, Scott Anderson, Chris Barty, Shawn Betts, Rex Booth, Winthrop Brown, John Crane, David Fittinghoff, David Gibson, Jaroslav Kuba, Greg Le Sage, Cross Rick, Paul Springer, Aaron Tremaine (LLNL), James Rosenzweig (University of California, Los Angeles)

The PLEIADES Thomson x-ray source will produce pico-second, high brightness x-ray pulses by colliding a 1 nC, pico-second electron bunch with a sub-picosecond, terawatt laser pulse. We present time-domain and frequency domain calculations of the expected characteristics of the x-ray pulse produced by the interaction. Analysis of different interaction geometries ranging from a 90 degree side on interaction to a 180 degree head-on interaction is presented. The dependence of x-ray production on electron to laser timing jitter for different geometries is also discussed. It is shown that the for a head-on collision, a peak brightness of 10^{20} photons/0.1% bandwidth/mm^2/mrad^2 can be obtained, corresponding to 10^8 photons in picosecond x-ray pulse with 10% bandwidth.

* This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

MPPB021 The Estimate of Wakefield and Impedances of HLS by MAFIA Code

Lin Wang (National Synchrotron Radiation Lab)

The HLS is a second generation UVU light source. The impedance-induced collective effects were the main focus of our machine. In this papers, the main impedance components, including RF cavity, BPM, DC ion-clearing electrode, bellows, flanges, ceramic chamber, pump ports, septum magnet vacuum chamber et al , were calculated by MAFIA T3/2 code, and the impedances of space charge and resistive wall were analyzed by formula. Then the impedance estimate of total ring was obtained.

MPPB022 The Magnet Field Shim of Dispersion Section of the Optical Klystron

Hongliang Xu, He Duohui, Liu Jinying, Chen Nian, Jia Qika, Li Yuhui (National Synchrotron Radiation Lab)

Coherent harmonic generation experiment will be done in Hefei electron storage ring. The old optical klystron have to be reformed into asystemic construction, and the magntic field distribution of dispersion section must be shimmed to decrease the effect on the beam orbit. The magnet field of dispersive section have been shimmed, and satisfy with the reqiurement of experiment. The effect of dispersion section is described and the detail shim process is analyed in this paper.

MPPB023 Newly Developed Injection Mode of Pohang Light Source

Mungyung Kim (Pohang Accelerator Laboratory)

At the Pohang Light Source, 2 GeV electron beam is injected to the storage ring and increased to 2.5 GeV using an energy ramping system previously. This ramping process is regarded as a source of closed orbit distortions. The successful upgrade of injection power of the PLS linear accelerator has enabled to develop the full energy injection mode, where 2.5 GeV electron beam is injected and synchrotron radiation is provided to the photon beamlines without the ramping process. With the constraints of preserving the so called "golden orbit" and the parameters something like betatron tunes the new optimized sets of magnetic fields are searched for, taking into account of the leaked magnetic field of the septum magnet. Compared with the previous mode, the observed results and the improvements would be reported since the newly employed injection mode.

* Work suported by POSCO and the Ministry of Science and Technology in Korea.

MPPB024 First Operational Results of the 3rd Harmonic Super Conducting Cavities in SLS and ELETTRA

Marco Pedrozzi, Walter Gloor (Paul Scherrer Institut), Pierre Bosland, Philippe Bredy, Stephane Chel, G. Devanz, Patrick Marchand (CE Saclay), Olivier Aberle, E. Chiaveri, Roberto Losito, Sebastien Marque (CERN), Alexander Anghel (EPFL - CRPP), Paolo Craievich, Alessandro Fabris, C. Pasotti, G. Penco, Michele Svandrlik (Sincrotrone Trieste)

Two identical cryomodules, developed at Saclay, were installed during 2002 in the storage rings of the third generation light sources SLS and ELETTRA. Each cryomodule contains a third harmonic super conducting RF system composed by two passive 1500 MHz Nb/Cu single-cell-cavities, which were fabricated at CERN. The first measurement made at SLS shows a bunch lengthening up to a factor of 3 and a lifetime increase greater than factor of 2. The commissioning and first operational results obtained with these systems are reported.

MPPB025 Beam-Performance Improvement of the SPring-8 Storage Ring

Haruo Ohkuma (SPring-8)

The SPring-8 Storage Ring has improved its reliability and its beam performance. At the beginning of year 2001, a project of beam orbit stabilization started aiming for the stability of sub-micron. By two years' activities, we have taken a remarkable progress on the improvement of the orbit stability of the SPring-8 Storage Ring. Recently, optics of the ring was changed from the Double Bend Achromat type to new optics with finite dispersion at the straight section for insertion devices. The horizontal emittance of 3 nm.rad was obtained which is close to the theoretical value. We have a plan to realize a Top-up operation in user time next year. The operational status and recent beam performance of the SPring-8 storage ring will be presented.

MPPB026 Magnet-Related Failure Experience at the SPring-8 Storage Ring

Koji Tsumaki, Noritaka Kumagai, Sakuo Matsui, Masaya Ohishi, Hiroto Yonehara (SPring-8), Takeshi Tateishi, Yasushi Torii (Kobeluko Kaken, Ltd.)

The SPring-8 storage Ring has been operated since March 1997 and the integrated current amounts to 1480 ampere*hour. Many failures had been occurred during these five years. In the first year, there were many initial stage failures. After few years operation, cooling water issues became important. Flow switches that have attached to the each magnet began to generate failure signals. We investigated the cause of this error functioning. It was due to erosion of flow switch by water flow. We changed them for another kind of flow switch. Radiation damage due to synchrotron radiation also became serious problems. A rubber hose for cooling water of magnet was broken due to radiation damage and the cooling water leaked. Water leakage from magnet coil also occurred due to corrosion of joint part where brazing was insufficient. Details of these failure experiences are described.

MPPB027 Commissioning Low Emittance Beam at Aladdin

Ken Jacobs, Robert Bosch, David Eisert, Michael Fisher, Michael Green, Richard Keil, Kevin Kleman, Robert Legg, John Stott, Walter Trzeciak (Synchrotron Radiation Center, University of Wisconsin)

The Aladdin storage ring is now routinely run in a low emittance configuration. Vertical beam sizes and lifetime are comparable to the original lattice, while the horizontal beam size is reduced by a factor of three. ools used to commission the new lattice include model based correction to obtain the design machine functions, and model independent correction to set the desired transverse coupling. Newly installed optical profile and position monitors, shunts to trim individual magnets, as well as implementation of a new control system scripting language, were important in achieving the desired results. Special attention was given to operation of the fourth harmonic bunch lengthening cavity used to improve the beam lifetime, and noise reduction in the RF system to improve photon beam quality on the infrared beamline. In addition, compensation of undulators allows their strengths to be varied with minimum perturbation to the beam outside the regions of the undulators. Details of bringing the low emittance lattice to operational readiness will be presented.

* Work supported by the NSF under Award No. DMR-0084402.

MPPB028 Coupling Correction Study at SRRC

C.C. Kuo, H.P. Chang, J. Chen, H.C. Ho, K.T. Hsu, K.H. Hu, H.J. Tsai, D.J. Wang (Synchrotron Radiation Research Center)

Emittance coupling between vertical and horizontal planes at TLS are investgated. Using a set of skew quadrupoles, the coupling can be corrected to an acceptable value. The coupling sources are studied and possible errors are removed.

MPPB029 Commissioning Superconducting RF Cavity at TLS

Gwo-Huei Luo, L.H. Chang, C.T. Chen, F.Z. Hsiao, C.C. Kuo, M.C. Lin, Ch. Wang, T.T. Yang, M.S. Yeh (Synchrotron Radiation Research Center)

The Taiwan Light Source (TLS) is a third generation light souce with low emittance and low operating energy, 1.5 GeV. Doubling the photon flux, reducing longitudinal coupled bunch instability and increasing beam lifetime are the main targets by installating a superconducting rf cavity in the storage ring. Results of high-power horizontal test, installation, and commissioning will be presented.

MPPB030 Multiple Scattering Effect on Coherent Radiation

Serguei Fomin (National Science Center, Kharkov Institute of Physics and Technology)

It has been shown [Fomin S.P., Shul'ga N.F., Physics Letters, 1986, V.114A, p. 148] that at relativistic electrons motion along a crystal axis the effect of suppression of radiation similar to the Landau-Pomeranchuk-Migdal effect in an amorphous medium can take place. However, there will be a suppression of a coherent radiation in a crystal, and this effect can be observed at lower energies of electrons, than in an amorphous medium. The suppression effect appears most brightly in a spectral-angular distribution of radiation [Fomin S.P., Shul'ga N.F., Shul'ga S.N., Proc. of the 2001 PAC, Chicago, p. 2686]. The special interest represents in this connection the radiation in a thin aligned crystal, when relativistic electron beam passes through a crystal under a small angle to a crystal axis. In the present work the spectral-angular distribution of coherent radiation of relativistic electrons in a thin silicon monocrystal are obtained. The conditions are found at which the suppression effect of coherent radiation in a crystal takes place.

* Work is supported in part by STCU (project 1746).

MPPB031 Position and Synchronization Error Effects in Thomson Scattering Light Source

Wenhui Huang, Xiaozhong He, Gang Huang (Tsinghua University, Beijing)

The length and photon number of X-rays pulse produced by Thomson scattering at arbitrary interaction angles is analyzed from the differential cross section of Thomson scattering under the linear interaction. Based on the analysis, the non-ideal effects, such as position and synchronization error are discussed.

MPPB032 Studies of Beam Lifetime at ANKA

Erhard Huttel, Anke-Susanne Mueller, Francisco Perez, Montse Pont (Forschungszentrum Karlsruhe)

Beam lifetime studies have been performed at the 2.5 GeV electron storagering ANKA. Measurements under different machine conditions: scraper position, bunch current, total current and RF voltage allow to differentiate between Touschek, elastic and inelastic beam lifetime. The measurements are compared with to theoretical predictions.

MPPB033 The Lattice Functions and Coherency of Undulator Radiation Synchrotron Light Sources

Mikayel Ivanyan, Yurik Martirosyan, Vassili Tsakanov (CANDLE)

The achievement of a high-degree coherency of undulator radiation in third generation synchrotron light sources is investigated. The study is based on the optimisation of horizontal and vertical beta-functions in the straight section to achieve the maximum degree of radiation coherency from the undulators. The simulation has been performed for the CANDLE synchrotron light facility.

MPPB034 Refined Tracking Procedure for the SOLEIL Energy Acceptance Calculations

Amor Nadji, Mahdia Belgroune, Pascale Brunelle, Laurent Nadolski (Synchrotron SOLEIL)

In third generation light sources like SOLEIL, the inevitable strong sextupoles lead to significant non-linearities affecting the transverse beam dynamics. We already emphasized the large contribution of transverse and longitudinal non-linearities to the SOLEIL energy acceptance: energy dependence of Twiss parameters, non-linear off-momentum closed orbit [A. Nadji et al., PAC Proceedings, 1517 (1997)] and non-linear synchrotron motion [A. Nadji et al., PAC Proceedings, 1533 (1999)]. In order to face other effects such as non-linear betatron motion, synchrotron oscillations, coupling and diffusion

processes, refined tracking computations were performed using a full 6D tracking code. Even if the strong effect of the non-linear synchrotron motion (low momentum compaction factor) have been shown, the results confirm the large energy acceptance of SOLEIL, and highlight that the working point has to be chosen so as to avoid any crossing of the linear coupling resonance for off-momentum particles. Using this procedure together with the Frequency Map Analysis enables us to understand the different kinds of particle loss.

MPPB035 Magnetic Fields of a Superconductive and Permanent Magnet Undulator: A Comparison

Robert Rossmanith, Shailendra Chouhan (Forschungszentrum Karlsruhe)

The maximum field strength of superconductive and permanent magnet undulators are compared. A formula describing the relation between the gap width and the period length of a superconductive undulator is presented.The calculations are compared with measured values.

MPPB036 The Saga Synchrotron Light Source

Takio Tomimasu, Yositaka Iwasaki (Saga Synchrotron Light Source), Hideaki Ohgaki (Institute of Advanced Energy, Kyoto University), Hiroyuki Toyokawa, Masato Yasumoto (Photonics Research Institute, AIST), Yasushi Hashiguchi, Toshihiro Kitsuka, Yuji Ochiai, Yoshinao Yamatsu (Saga Prefectural Government)

The Saga third-generation synchrotron light source (SLS) is being constructed and is operated before the fall of 2004 in Tosu City, Saga Prefecture in the northern part of Kyushu-island. The Saga SLS consists of a compact 1.4-GeV storage ring with eight 2.93-m long straight sections and a 262-MeV electron injector. Six insertion devices including a 7.5-T wiggler can be installed. The circumference of the storage ring is 75.6 m and the minimum emittance is 15 nm-Erad at 1.4 GeV without the wiggler. The 262-MeV linac beam is used for electron injection and a 40-MeV linac beam is used for two-color infrared free electron laser (IR-FEL) generation.

MPPB037 Temporal Characteristics of a SASE FEL

Yuelin Li, Zhirong Huang, Kwang-Je Kim, John Lewellen, Stephen Milton, Vadim Sajaev (ANL)

We have performed time-resolved measurement of the output field of a SASE FEL using the FROG techniques. The measurement reveals the phase and the amplitude of the SASE output as functions of time and frequency. It was found that the SASE field has an intrinsic positive chirp, and under certain conditions the chirp can be cancelled by the chirp imposed by the energy chirp in the electron bunch, evidencing that the energy chirp in the electron bunch maps to the SASE output. The temporal structure of the SASE field is also analyzed and is found to be consistent with that of a thermal light source as expected from the fact that SASE grows from shot noise in the electron beams.

* This work is supported by the U. S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

MPPB038 Beam-Based Undulator Field Characterization and Correction

Timur Shaftan, Henrik Loos (BNL)

We present results of commissioning of 10 m long NISUS undulator at Deep Ultra Violet Free Electron Laser project. Magnet and diagnostics geometry is discussed, tolerances on the beam trajectory straightness and envelope matching are shown. Beam-based alignment and matching algorithms are described.

MPPB039 Beam Dynamics Simulations for the First Operation of the TTF-FEL Phase II

Jean-Paul Carneiro, Klaus Floettmann (DESY)

The Tesla Test Facility FEL is currently being upgraded to reach in its final stage a SASE radiation wavelength of 6 nm. After describing briefly the status of the TTF-FEL, this paper will present beam dynamics simulations. Our attention will be focussed on the optimization of the injector parameters for the first operation of the TTF-FEL Phase II.

MPPB040 Electron Bunch Shape Measurements at the TTF-FEL

Siegfried Schreiber, Christopher Gerth, Katja Honkavaara (DESY), Philippe Piot (FNAL)

The TESLA Test Facility linac has been operated in the first half of 2002 with two bunch compressors to drive the TTF-FEL free electron laser. During this running period, SASE radiation with a wavelength around 100 nm has been routinely delivered to experiments. The longitudinal shape of the electron bunches is a crucial property of the electron beam: a peak current in the order of 1 kA is required to drive the SASE process with the given undulator design, transverse emittance, and energy spread. We report on measurements of the bunch length and shape for different operating conditions of the two bunch compressors.

MPPB041 "Optics-Free" FEL Oscillators

Vladimir Litvinenko (Duke University)

There is obvious need for an "optics-free" FEL oscillator. While SASE FELs demonstrated the capability of providing very high gain and short pulses of radiation, the spectra of SASE FELs are rather wide (~1%) compared with typical short wavelength FEL oscillators (0.01% - 0.0003% in the OK-4 FEL). Absence of good optics in the VUV and X-ray ranges makes traditional oscillator schemes very complex or impossible. In this paper, we present a concept for an "optics-free" FEL oscillator and discuss the main limiting factors and feasibility.

* Work supported by the Dean of Natural Sciences and the Department of Physics, Duke University.

MPPB042 VUV/UV OK-5 FEL Light Source with Variable Polarization

Vladimir Litvinenko, Emily Longhi, Stepan F. Mikhailov, Igor V. Pinayev, Samadrita Roychowdhury, Gary Swift, Partick Wallace, Ying Wu (Duke University), Nikolay G. Gavrilov, Gennady N. Kulipanov, Oleg A. Shevchenko, Nikolay A. Vinokurov, Pavel D. Vobly (BINP)

We present the design and expected performance of the OK-5 FEL, a next generation FEL optimally designed for operating with the Duke storage ring. The 24 m long OK-5 FEL will be the first distributed optical klystron system with variable polarization. The OK-5 FEL will replace the existing 8 m long linearly polarized OK-4 FEL with much improved gain and power, allowing us to extend our UV wavelength coverage down to 100nm. The OK-5 FEL will also significantly improve the gamma-ray flux of the High Intensity g-ray Source (HIgS) facility, a Compton scattering source at Duke and greatly expand its application domain by producing left and right circularly polarized gamma-ray beams. We will report the calculated OK-5 FEL parameters as well as the predicted parameters of HIgS driven by the OK-5 FEL.

* Research is supported by the AFOSR grant F49620-001-0370 and by the Dean of Natural Sciences, Duke University.

MPPB043 Intense Coherent XUV Radiation from the Duke Storage Ring FEL

Vladimir Litvinenko, Emily Longhi, Igor V. Pinayev, Samadrita Roychowdhury, Gary Swift (Duke University)

The OK-4/Duke storage ring FEL has generated intense tunable (from 45 nm to 140 nm) soft-X-ray radiation with peak spectral brightness up to 10^{27} ph/sec/mm^2/mrad^2/0.1%BW. We present recent experimental results of VUV harmonic generation in the OK-4/Duke SR FEL. The OK-4 FEL generated intense 2nd, 3rd, 4th and 5th coherent harmonics (with bandwidth < 0.02 nm) while operating in giant pulse mode at the fundamental radiation tunable from 235 nm to 280 nm. We present the experimental results supporting our theoretical prediction that the pulses of coherent radiation have duration of less than 100 fsec. We also plan to present results on the 7th harmonic generation (~38 nm). We describe the experimental setup including a VUV monochromator (30 - 200 nm), the auto-correlator and the optical cavity with the out-coupling hole for coherent harmonic radiation. We compare the experimental results with recent results from VUV SASE FELs and discuss the prospects of the intra-cavity short-wavelength harmonic generation in SR FEL. We use the OK-5/Duke storage ring FEL as an example of the future source.

* Work supported by the Dean of Natural Sciences and the Department of Physics, Duke University.

MPPB044 Start to End Simulations for the SPARX Proposal

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The resource allocation in the Italian National Research Plan (PNR) for the development of a coherent ultra-brilliant X-ray source, based on a SASE Free Electron Laser, brought about the formation of a CNR-ENEA-INFN- University of Roma "Tor Vergata" study group. A conceptual design study has been developed and possible schemes for linac sources have been investigated leading to the SPARX proposal. We report in this paper the results of start to end simulations concerning the option based on an S-band normal conducting linac. Saturation at 1-10 nm can be achieved in a 40 m long undulator provided the peak current delivered by the linac is 2.5 kA at 2.5 GeV with rms normalized slice emittance of the order of 1 _m and the energy spread less than 0.1%. One of the most critical systems is the bunch compressor. The effects on beam dynamics of a magnetic chicane system and a rectilinear RF compressor (based on velocity bunching), integrated in a high brightness photoinjector, are analyzed and compared in this paper.

MPPB045 Crystal Undulator as a Novel Compact Source of Radiation

Vincenzo Guidi, Stefano Bellucci, Simone Bini, Sultan Dabagov, Giorgio Giannini (INFN), Valery Biryukov, Yuri Chesnokov, Vladilen Kotov, V.A. Maisheev (Institute of High Energy Physics, Protvino), Yuri Ivanov, A.A. Petrunin, V.V. Skorobogatov (Petersburg Nuclear Physics Institiute), Cesare Malagu, Giuliano Martinelli, Marco Stefancich, Donato Vincenzi (University of Ferrara)

The wavelength of a photon emitted in an undulator is in proportion to the undulator period L and in inverse proportion to the square of the particle Lorentz factor. The minimal period L achieved presently with the electromagnetic undulators is limited to several millimeters. A crystalline undulators with periodically deformed crystallographic planes offer electromagnetic fields in the order of 1000 T and could provide a quite short period L of an undulator in sub-millimeter range. We present an idea for creation of a crystalline undulator and report its first realization. One face of a silicon crystal was given periodic micro-scratches (grooves), with a period of 0.1 mm, by means of a diamond blade. The X-ray tests of the crystal deformation have shown that a sinusoidal-like shape of crystalline planes goes through the bulk of the crystal. This opens up the possibility for experiments with high-energy particles channeled in crystalline undulator, a novel compact source of radiation. The first experiment on photon emission in crystal undulator has been started at LNF with 800 MeV positrons aiming to produce 50 keV undulator photons.

MPPB046 The C-Band (5712-MHz) Linac for the SPring-8 Compact Sase Source (SCSS)

Hiroshi Matsumoto, H. Baba, T. Inagaki, Y.J. Kim, H. Kitamura, T. Shintake, S. Takeda, K. Togawa (KEK)

The SPring-8 Compact SASE Source (SCSS) is a high peak-brilliance, soft X-ray free electron laser project. It is a linac-based dedicated source machine for Self-Amplified Spontaneous Emission (SASE) Free-Electron Laser (FEL). We will use a high-gradient C-band (5712-MHz) main linac to generate a beam with energy up to 1-GeV followed by an in-vacuum short-period undulator to enables us to contain the entire SCSS within a 100-m whole machine length. First light is expected to be generated in the VUV region in 2005; the next target is for 3.6-nm radiation in the water-window.

MPPB047 Photoinjector RF Cavity Design for High Power CW FEL

Richard Wood, S. Kurennoy, D. Schrage, L. Young (LANL), V. Christina, J. Rathke, T. Schultheiss (Advanced Energy Systems)

The project is under way to develop a key enabling technology for high-power CW FEL: an RF photoinjector capable of producing continuous average current greater than 100 mA. The specific aim is a 700 MHz pi-mode, normal-conducting RF photoinjector, 3 nC of bunch charge, 100 mA of current (at 33.3-MHz bunch repetition rate) and emittance less than 10 mm-mrad. This level of performance will enable robust 100-kW-class FEL operation with electron beam energy<100 MeV, thereby reducing the size and cost of the FEL. This design is scalable to the MW power level by increasing the electron bunch repetition rate from 33.3 MHz to a higher value. The major challenges are emittance control and high heat flux within the CW 700-MHz RF cavities. Results of RF cavity design and cooling schemes are presented, including both high-velocity water and liquid-nitrogen cooling options.

MPPB048 Simulation Studies of an XUV/Soft X-Ray Harmonic-Cascade FEL for the Proposed LBNL Recirculating Linac

William Fawley, William Barletta, John Corlett, Alexander Zholents (LBNL)

Presently there is significant interest at LBNL in designing and building a facility for ultrafast (i.e., femtosecond time scale) x-ray science based upon a superconducting, recirculating RF linac. In addition to producing synchrotron radiation pulses in the 1-15 keV energy range, we are also considering adding one or more free-electron laser (FEL) beamlines using a harmonic cascade approach to produce coherent XUV & soft X-ray emission beginning with a strong input seed at ~200 nm wavelength obtained from a "conventional" laser. Each cascade is composed of a radiator together with a modulator section, separated by a magnetic chicane. The chicane temporally delays the electron beam pulse in order that a "virgin" pulse region (with undegraded energy spread) can be brought into synchronism with the radiation pulse, which together then undergo FEL action in the modulator. We present various results obtained with the GINGER simulation code examining final output sensitivity to initial beam

parameters such as instantaneous energy spread, current, and emittance. We also discuss the effects of spontaneous emission and shot noise upon this particular cascade approach which can limit the final output coherence.

∗ Work supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

MPPB049 Limitations of Electron Beam Conditioning for Free-Electron Lasers

Paul Emma, Gennady Stupakov (SLAC)

Several ideas have been proposed to 'condition' an electron beam prior to the undulator of a Free-Electron Laser (FEL) by increasing each particle's energy in proportion to the square of its transverse betatron amplitude. This conditioning enhances FEL gain by reducing the axial velocity spread within the electron bunch. We demonstrate that for symplectic beamlines, and independent of the method, this conditioning is always accompanied by a large head-tail focusing variation which, for short wavelength FELs, is so severe as to make conditioning completely impractical. We furthermore find that any system added to correct the head-tail focusing variation will also remove the conditioning. As an example, a new method for conditioning is presented and shown to result in exactly the same head-tail focussing problem as that of reference [A. Sessler et al., Phys. Rev. Lett., 68, 309 (1992)].

* Work supported by US Department of Energy, contract DE-AC03-76SF00515.

MPPB050 Analytic Description of High-Gain FEL Saturation

Samuel Krinsky (SLAC)

We develop a perturbation expansion for the solution of the nonlinear one-dimensional free-electron laser equations. For a monochromatic wave, the radiation field is expanded in a Taylor series having a finite radius of convergence. Analytic continuation using Pade approximates yields accurate results well into the saturation regime.

∗ Work supported by Department of Energy contracts DE-AC03-76SF00515 and DE-AC02-98CH10886.

MPPB051 Model for Nonlinear SASE Statistics in Saturation

Samuel Krinsky (SLAC)

We formulate a perturbation expansion for the solution of the nonlinear one-dimensional free-electron laser equations in the case of finite bandwidth, self-amplified spontaneous-emission (SASE). Motivated by an approximation to the expansion coefficients, we introduce a simplified model for the SASE radiation field, and use it to discuss SASE statistics in the saturation regime, before the onset of the sideband instability.

∗ Work supported by Department of Energy contracts DE-AC03-76SF00515 and DE-AC02-98CH10886.

MPPB052 Throughput and Noise of the Aladdin Infrared Beamline

Robert Bosch, M.A. Green, R.W.C. Hansen, K.D. Jacobs, R.L. Julian, K.J. Kleman (Synchrotron Radiation Center, University of Wisconsin)

The infrared beamline at the Aladdin electron storage ring utilizes edge radiation for spectromicroscopy. For wavelengths of 0.8-16 microns, computations indicate that ~20% of the collected radiation is transported through the microscope. Transverse oscillations of the electron beam cause oscillations in microscope throughput that account for about one-third of the beamline's zero-burst noise.

∗ Work supported by NSF grant DMR-0084402.

MPPB053 Periodic Ion Channel Laser

Robert Bosch (Synchrotron Radiation Center, University of Wisconsin)

Radially polarized radiation is amplified by a free electron laser (FEL) in which the undulator is an ion channel with periodic density. To ensure stable beam propagation, the undulator period is much shorter than the betatron wavelength. The gain at a given distance from the axis equals that of a planar magnetostatic undulator with the same quiver velocity. When an ultrarelativistic electron beam propagates in a periodic ion density of 10^{11}-10^{17} cm^{-3}, a short-wavelength FEL may be obtained.

∗ Work supported by NSF grant DMR-0084402.

MPPB054 Beam-Frame Calculation of Free-Electron Laser Gain

Robert Bosch (Synchrotron Radiation Center, University of Wisconsin)

The amplification of radiation is calculated in the beam frame for a free electron laser (FEL) with a planar or helical undulator. The effect of the radiation force upon the transverse electron trajectory is included; this effect accounts for one-half of the gain in the undulator regime. Our calculated gain agrees with conventional formulas.

∗ Work supported by NSF grant DMR-0084402.

MPPB055 Two Sub-Picosecond, High Flux, Thomson X-Ray Sources

James Boyce, David R Douglas, Hiroyuki Toyokawa (Thomas Jefferson National Accelerator Facility), Winthrop Brown, Fred Hartemann (LLNL)

With the advent of high average power FELs, the idea of using such a device to produce x-rays via the Thomson scattering process is appealing, if sufficient flux and/or brightness can be generated. Such x-rays are produced simultaneously with FEL light, offering unprecedented opportunities for pump-probe studies. We discuss two non-invasive modifications to the Jefferson Lab's FEL that would meet the criteria of high flux, sub-picosecond, x-ray source. The first is essentially a proof-of-principle experiment, relatively inexpensive, but is not conducive as a "User-facility." The second is somewhat more expensive and a User-facility configuration. For both sources, we present electron beam transport calculations, Thomson scattering flux calculations, and potential applications.

∗ This work was supported by the U.S. Dept. of Energy under Contract No. DE-AC05-84ER40150, Office of Naval Research, the Air Force Research Laboratory, the Commonwealth of Virginia, and the Laser Processing Consortium.

MPPB056 Image Charge Undulator: Theoretical Model and Technical Issues

Yuhong Zhang, James R. Boyce, Yaroslav Derbenev, Rui Li (Thomas Jefferson National Accelerator Facility)

When a relativistic electron beam passes very close to a conducting periodic grating surface, it experiences transverse wake field forces. These forces can make the beam undulate. A new device, an image charge undulator, is proposed to utilize this mechanism to produce incoherent, or coherent, hard radiation. We demonstrate the principle of this device by a 2-D model of an infinitely long uniform sheet beam. The image charge wake field, incoherent radiation flux and coherent radiation gain length are presented. We also discuss a simple proof-of-principle experiment that takes into consideration such technical issues as grating fabrication, flat beams, electric charge uniformity, and beam alignment.

∗ This work was supported by the U.S. Dept. of Energy under Contract No.DE-AC05-84ER40150.

MPPB057 Commissioning of the VISA II Experiment at the ATF

Gerard Andonian, A. Murokh, C. Pellegrini, S. Reiche, J.B. Rosenzweig, G. Travish (University of California, Los Angeles), I. Ben-Zvi, V. Yakimenko (BNL), M. Ferrario, L. Serafini (INFN), A. Tremaine (LLNL), M. Cornacchia, H-D. Nuhn (SLAC), L. Palumbo (University of Rome)

VISA II is the follow-up experiment to the successful Visible to Infrared SASE Amplifier (VISA) experiment at the Accelerator Test Facility (ATF) in Brookhaven National Lab (BNL). The goal of VISA II is to perform an experimental study of the physics of a chirped beam SASE FEL at the upgraded facilities of the ATF. An ultra-short gain length experiment is proposed, where the bunch is compressed in the chicane and dispersive beamline transport. Simulations show that saturation should be achieved well before the undulator end, allowing studies of deep saturation, avelength and angular spectra, microbunching, statistical characteristics of output and harmonic generation. Other chirped beam experiments are also proposed, where a time-frequency correlation on the FEL output is imparted through a time-energy correlation in the beam. The FEL output pulse may be shortened by subsequent compression of the FEL light using gratings.

MPPB058 The FEL Program at the PEGASUS Injector

Sven Reiche, Gerard Andonian, Pedro Frigola, James Rosenzweig, Soren Telfer, Gil Travish (University of California, Los Angeles)

The PEGASUS photo injector at UCLA can produce a photo electrons beam with a normalized emittance of 2 mm mrad at an energy of 12-15 MeV, capable of driving a Free-Electron Laser in the mid IR regime. The FEL program, associated with the PEGASUS injector and presented here, is based on a Self-Amplifying Spontaneous Emission (SASE) FEL. The studies focus on increasing the efficiency of an FEL by novel undulator design and compensation of diffraction effects, using waveguides of millimeter size. In this presentation we also discuss the possibility of the PEGASUS FEL as a THz user facility.

MPPB059 A Numerical Model of Electron Beam Shot Noise

B.W.J. McNeil, G.R.M. Robb (University of Strathclyde), M.W. Poole (Daresbury Laboratory)

A numerical method of simulating electron beam shot noise in free electron lasers is presented. Shot noise is a source of spontaneous emission that may be amplified in the Self Amplified Spontaneous Emission (SASE) regime of operation. This regime is of great importance to XUV and x-ray FELs where the spontaneous emission is currently the only effective source available for amplification. The method uses a quasi-uniform phase space distribution of appropriately charge weighted macroparticles. The statistical properties of the macroparticles are derived directly from the temporal Poisson statistical properties of the real electron distribution. Unlike previous methods, our method does not rely upon any averaging over a resonant radiation period timescale and so more correctly describes the underlying physics. The method also allows shot noise to be modelled self-consistently in un-averaged FEL models which are able to describe sub-wavelength phenomena such as Coherent Spontaneous Emission.

MPPB060 An Improved 1-D Model for Ultra High Power Radiation Pulse Propagation in the Helical Wiggler Free Electron Laser

B.W.J. McNeil, G.R.M. Robb (University of Strathclyde), M.W. Poole (Daresbury Laboratory)

A one dimensional model of a helical wiggler Free Electron Laser is presented that does not average the Maxwell-Lorentz equations describing the interaction between electrons, wiggler and radiation fields. Furthermore, no relativistic approximations are made and transverse motion of the electrons is self-consistently driven by both the wiggler and radiation fields. Numerical solutions of the resultant equations allow for the modeling of radiation pulses with peak powers orders of magnitude greater than the steady state saturation value and with pulse widths significantly less than one radiation period. Such pulses may grow from noise as Self Amplified Spontaneous Emission or may be injected into an FEL amplifier. Preliminary numerical studies using the 1-D model have so far not revealed any saturation mechanism in the growth of an injected pulse.

MPPB061 Evolution of Transverse Modes in a High-Gain Free-Electron Laser

Sandra Biedron (MAX-Laboratory), Stephen Milton (ANL), Renieri Alberto, Giuseppe Dattoli (ENEA - Frascati), Pier-Luigi Ottaviani (ENEA-Bologna), Henry Freund (Science Applications International Corporation)

At the point of saturation in a high-gain free-electron laser (FEL) the light is fully transversely coherent. The number of and evolution of these modes is important particularly in designing multi-staged devices that rely on relatively stable saturation distances in each module. This is critical since each section will seed a latter section. Overall, in a single- or multi-stage device, experimental users will desire stability in power and in photon beam quality. Using a numerical simulation code, the evolution of the transverse modes in the high-gain free-electron laser (FEL) is examined via simulation and is discussed for small variation in the overall saturation length. In addition, the transverse modes in the first few higher nonlinear harmonics are investigated.

MPPB062 FEL SASE Evolution: An Analytical Treatment

Giuseppe Dattoli, P.L. Ottaviani (Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente)

We present an analytical formulation of FEL SASE evolution, which includes e-beam qualities and three dimensional effcts, along with pulse propagation contributions and non linear harmonic generation. We show how such a procedure leads to the formulation of the FEL-SASE dynamics in fairly simple terms, yielding a straightforward and accurate algorithm which can be exploited in a preliminary design of fourth generation synchrotron radiation sources.

MPPB063 Photocathodes Gun Triggered by FEL Light

Giuseppe Dattoli, Luca Giannessi, P.L. Ottaviani (Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente), Massimo Ferrario, Luca Serafini (INFN)

We analyze the performances of a photocathode gun illuminated by the Free Electron Laser (FEL) light. The device we propose is based on a self-consistent system, employing a FEL operating in the optical klystron configuration. We explore the dependence of the output e-beam on the laser characteristics, study the dynamics of the accelerated beam and analyze the conditions for a stable operation. The advantages offered by such a device for the realization of X-ray FEL based linac sources as well as ERL based light sources are also presented.

MPPB064 Optical-Klystron FEL Dynamics Including Saturation

Giuseppe Dattoli, Luca Giannessi, P.L. Ottaviani, Bartolini Riccardo (Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente)

The theory of Optical-Klystron (O-K) FEL has been mainly discussed in the case of system operating Storage Ring FEL devices under the assumption of dominance of the dispersive section. In this paper we present an analytical approacch to the O-K FEL theory in cluding pulse propagation and saturation effects. We discuss a single pass oscillator configuaration, derive the relevant pulse propagation equations and provide simple formulae including the effect of the the lethargy, slippage, cavity detuning and dispersive section. We also

present a semi-analytical and fast code yielding an accurate description of such device from small signal to saturation.

MPPB065 Design Study for the RF Photoinjector for the MIT Bates X-Ray Laser Project

Manouchehr Farkhondeh (MIT-Bates Linear Acceleratror Center)

A multiple cell 1.3 GHz room-temperature photoinjector is under design for the MIT Bates x-ray laser project. Tunable intercavity phase shifts are optimized for velocity bunching of the beam in the following drift and post-acceleration in the linac. The range of charge produced will be from 50-500 pC. Cavity and beam dynamics simulations produced by the SUPERFISH and PARMELA codes are presented.

MPPB066 Simulations of an X-Ray FEL Seeded with Attosecond Pulses

William Graves (MIT-Bates)

Generation of sub-femtosecond pulses of XUV (> 10nm) radiation has recently been demonstrated using the method of high harmonic generation by near IR lasers in gas jets. The output pulse energy produced is modest at ~0.1 nJ. We propose to use a FEL to amplify this radiation by orders of magnitude while maintaining the short pulse length, and to explore generation of temporally coherent x-rays at even shorter wavelengths through amplification by a cascaded high gain harmonic generation FEL. The required seed power levels and effects of a very short seed pulse on the FEL pulse properties are explored.

MPPB067 Considerations for Realistic Gain Calculation of CSR Induced Microbunching Instability in Bunch Compressor

Yujong Kim (SPring-8), Klaus Floettmann (DESY), Tsumoru Shintake (RIKEN Harima Institute in SPring-8)

Recently, many scientists have reported coherent synchrotron radiation (CSR) induced microbunching instability in the bunch compressor for the SASE-FEL facilities. However the gain of the instability is over-estimated in the real bunch comopressor. We have described what to consider in calculating the realistic gain of CSR induced microbunching instability in the bunch compressor.

MPPB068 Tolerance Investigation and Chamber Design for Bunch Compressor Dipoles

Yujong Kim, Tsumoru Shintake (RIKEN Harima Institute in SPring-8), Klaus Floettmann (DESY), Paul Emma (SLAC)

In the bunch compressor for SASE-FEL or linear collider facilities, emittances can be diluted by coherent synchrotron radiation (CSR) or other many effects. In this paper, we have described the emittance growth due to magnetic field errors, magnet misalignment, and the resistive wall wakefield of magnet chamber.

MPPB069 An Infrared FEL in India

Srinivas Krishnagopal, Vinit Kumar (Centre for Advanced Technology)

We discuss plans for an infrared FEL facility for users, to provide coherent radiation from 9 - 50 microns, with a peak power of more than 1 MW and average power of more than 1 W. Our scheme would use a 25 MeV, 30 A, PWT linac, with three sections, and three independent undulators. We present details of design simulations, and the present status.

MPPB070 A Comparison of Spontaneous Emission, Coherent Spontaneous Emission and Self-Amplified Spontaneous Emission

Srinivas Krishnagopal, Vinit Kumar (Centre for Advanced Technology)

We present one-dimensional analytical studies of the different processes that compete during the start-up of an FEL. We use the one-dimensional Maxwell-Klimontovich equation to explain the evolution of the power spectrum for these processes. The mechanisms of these different processes are explained using this analytical model.

MPPB071 Development of a Pure-Permanent Magnet Undulator for an Infrared Free-Electron Laser

Srinivas Krishnagopal, Sanjay Chouksey, Vinit Kumar (Centre for Advanced Technology)

We have developed, for free-electron laser applications, a pure-permanent magnet undulator with a period of 5 cm and a length of 2.5 m, using NdFeB magnets. We have obtained a field quality of better than 1%, without shimming. We present details of the design, fabrication and field-mapping of the undulator.

MPPB072 Coherent Harmonic Generation Experiment in Hefei Synchrotron Radiation Source

Jinying Liu, Caozheng Diao, Duohui He, Qika Jia, Ge Li, Hongliang Xu (University of Science and Technology of China)

As a part of an ultraviolet FEL project a coherent harmonic generation (HG)setup was buil in Hefei synchrotron radiation source, an 800 MeV storage ring. The aim of this work is to master HG techniques. At the beginning a symmetrical optical klystron (OK) and Nd-YAG seed laser were used, and an output of third harmonic of the seed laser was expected, while electron energy was 163 MeV. The spectrum of spontaneous radiation of the OK was measured, and modulation factor of the spectrum reached 0.8. However electron energy in this experiment was lower than the injection energy of the storage ring, 200 MeV. To increase electron energy in HG experiments for convenience of operation of the storage ring and to shorten wavelength of coherent radiation output the OK has been modified to asymmetrical one, and a shorter wavelength of seed laser is chosen. The period length of the modulator of the OK increases from 72mm to 92 mm, while the period length of it's radiator remains unchanged. The wavelength of seed laser changes from 1.06um to 532nm. In this case electron energy for HG experiments increases to about 300 MeV. The resonance wavelength of the radiator of the OK is 266 nm. In this article the experiment setup, the measurement of the spontaneous radiation spectrum, the improvements of the modulation factor of the spontaneous radiation spectrum and the measurement system of ratio of coherent radiation to incoherent radiation are discribed.

* Work supported by NSFC and the Foundation for Doctorate Conferring Units in Universities and Colleges.

MPPB073 Numerical Study of Coherent Harmonic Generation in the VUV on the NIJI-IV FEL

Hiroshi Ogawa, Tomohisa Mikado, Norihiro Sei, Kawakatsu Yamada, Masato Yasumoto (National Institute of Advanced Industrial Science and Technology)

Coherent harmonic generation (CHG) is an attractive method as a source of tunable coherent radiation in the VUV. Considering advantage of operation without an optical cavity in CHG, we are preparing to produce the harmonics in the storage ring NIJI-IV FEL by using an external laser focused into the optical klystron or the FEL oscillator itself. In this study we focus on the investigation of the harmonic generation by an external laser (3rd harmonic of Nd:YAG laser) with Monte Calro simulation which allows for the treatment of three-dimensional electron dynamics and non-axi-symmetric radiation

field. After performing the optimization of the parameter for the optical klystron by this code, the effect of undulator field error on the radiated harmonic spectrum will be discussed.

* This study was financially supported by the Budget for Nuclear Research of the Ministry of Education, Culture, Sports, Science and Technology, based on the screening and counseling by the Atomic Energy Commission.

MPPB074 Measured Performance of the Free Electron Lasers and Electron Beam in the Compact Storage Ring NIJI-IV

Norihiro Sei, Tomohisa Mikado, Hiroshi Ogawa, Hiroyuki Toyokawa, Kawakatsu Yamada, Masato Yasumoto (National Institute of Advanced Industrial Science and Technology)

Characteristics of the free electron lasers (FELs) and electron beam in the compact storage ring NIJI-IV were investigated at the beam energy of 310 MeV. Although the horizontal beam size was almost constant, the vertical beam size increased gently due to multiple Touschek effect as the beam current increased. Bunch lengthening and energy widening caused by microwave instability were observed for the beam current above 2-3 mA. Considering an enhancement of the bunch length due to potential well distortion, the increase of the bunch length was appropriate to that of the energy spread. The estimated maximum FEL gain at 215 and 300 nm was about 2.8% and 4.6%. It was confirmed that the bunch length and the energy spread increased due to the FEL oscillations. The ratio of the FEL gain to the cavity loss estimated from the beam qualities on and off FEL oscillations was almost in accord with the ratio evaluated directly with the measured data of the FEL gain and the cavity loss. We confirmed that the observed evolution of the FEL micropulse was described with a well-known one-dimension formula. When there is a small detuning in the optical cavity, we observed asymmetric temporal structure in the FEL micropulse. In this presentation, we will discuss the above performance of the FELs and electron beam in the NIJI-IV.

MPPB075 High-Power Electron Beam Injectors for 100 kW Free-Electron Lasers

Alan Todd, Hans Bluem, Vinnie Christina, Michael Cole, John Rathke, Tom Schultheiss (Advanced Energy Systems), P. Colestock, J. Kelley, S. Kurennoy, D. Nguyen, S. Russell, D. Schrage, R. Wood, L. Young (LANL), R. Campisi, E. Daly, D. Douglas, G.R. Neil, J. Preble, R. Rimmer, C. Rode, J. Sekutowicz, T. Whitlatch, M. Wiseman (Thomas Jefferson National Accelerator Facility)

A key technology issue on the path to high-power FEL operation is the demonstration of reliable, high-brightness, high-power injector operation. We described two ongoing programs to produce 100 mA injectors as drivers for 100 kW free-electron lasers. In one approach, in collaboration with the Thomas Jefferson National Accelerator Facility, we are fabricating a new 750 MHz superconducting RF cryomodule that will be integrated with a room temperature DC photocathode gun. In the other approach, in collaboration with Los Alamos National Laboratory, a high current 700 MHz RF room-temperature photoinjector is being designed. We will describe the design and projected performance of both injectors and the status of their fabrication.

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MPPB076 The MIT Bates X-Ray Laser Project

Townsend Zwart, M. Farkhondeh, W.S. Graves, R. Milner, C. Tschalaer, A. Zolfaghari, J.B. van der Laan (MIT-Bates), D.E. Moncton (MIT)

MIT and the Bates Linear Accelerator Center are exploring the construction of an x-ray free electron laser user facility. It will be based on a superconducting linac of 4 - 8 GeV energy, and produce XUV light in the 0.3 - 100 nm wavelength range at kilohertz repetition rates. The facility will be a full user facility incorporating multiple beamlines. Conventional lasers that produce the electron beam, seed the FEL, and execute pump-probe experiments are carefully integrated. The current design of the facility is discussed.

MPPB077 Maximizing Beam Brightness by Low Charge Compression

J.B. van der Laan, M. Farkhondeh, W.S. Graves, R. Milner, C. Tschalaer, F. Wang, A. Zolfaghari, T. Zwart (MIT-Bates), D.E. Moncton (MIT)

Many of the experiments at proposed x-ray FEL facilities will study dynamics of atomic and molecular process that occur on time scales from attoseconds to tens of femtoseconds. These experiments will benefit from production of electron bunches that are shorter than the current state of the art (~100 fs). We explore the effects of varying the charge on the production of the shortest electron beams. It is shown that transverse and temporal nonlinearities that degrade beam brightness at high charge (~1 nC) are substantially reduced at low charge (< 100 pC), resulting in shorter pulse lengths and higher peak brightness.

MPPB078 The New Linac Experimental Facility at Fermilab

Carol Johnstone (FNAL)

The initial phase of civil construction has begun on a new Linac Experimental Facility at Fermilab with beneficial occupancy anticipated in fall, 2003. This facility is being designed for multipurpose use by establishing direct and independent control over incident beam parameters; for example, pulse durations from 1 - 50 usec, and beam transverse sizes from 1-15 cm (95% of beam). The facility will be capable of accepting up to the full Fermilab Linac beam intensity (1.3×10^{13} protons/pulse@15 Hz) making it one of the few areas where a primary beam is available for high-intensity experiments. The purpose of the facility initially is to test the basic techniques and components proposed for muon ionization cooling in a proton beam judged equivalent in impact to a muon beam for a Neutrino Factory or Muon Collider. As such, the facility will provide the advanced cryogenic capability and safety systems required to perform R&D on liquid hydrogen targets. However, parallel and future experiments are invited and, as a general facility, many areas of physics including radiation, medical, nuclear, atomic and beam diagnostics and control will be supported.

* Work supported by the US Department of Eneregy under contract no DE-AC02-76CH03000.

MPPB079 Creating Microbeams and Nanobeams by Channeling in Micro- and Nano-Structures

Valery Biryukov, Yu.A. Chesnokov (Institute of High Energy Physics, Protvino), W. Scandale (CERN), S. Bellucci, V. Guidi (INFN)

A particle beam of very small cross-section is useful in many accelerator applications including biological and medical ones. We show the capability of channeling technique using a micron-sized structure on a surface of a single crystal, or using a nanotube, to produce beam of a cross-section down to 1 square micrometer (or nanometer). The channeled beam can be deflected and well separated in angle and space from the primary and scattered particles. According to our Monte Carlo simulations of channeling and experience with

crystal channeling at IHEP (Protvino) [http://crystalbeam.narod.ru], emittances down to 0.1-0.001 nanometer-radian, and flux up to 1 million ions per square micron per second, can be achieved for protons and ions in the range 0.1-3 GeV/u. We discuss the experimental techniques to achieve suitable structures for particle beam channeling, and describe the started experimental study.

MPPB080 A Neutron Source Facility for Neutron Cross-Section Measurements on Radioactive Targets at RIA

Larry Ahle, Robert Berio, Lee Bernstein, Brian Rusnak (LLNL)

The stockpile stewardship program is interested in neutron cross-section measurements on nuclei that are a few nucleons away from stability. Since neutron targets do not exist, radioactive targets are the only way to directly perform these measurements. This requires a facility that can provide high production rates for these short-lived nuclei as well as a source of neutrons. The Rare Isotope Accelerator (RIA) promises theses high production rates. Thus, adding a co-located neutron source facility to the RIA project baseline would allow these neutron cross-section measurements to be made. A conceptual design for such a neutron source has been developed, which would use two accelerators, a Dynamitron and a linac, to create the neutrons through a variety of reactions (d-d, d-t, deuteron break-up, p-Li) in order to fill the desired energy range from 10's of keV to 20 MeV. The facility would also have hot cells, to perform chemistry on the radioactive material, both before and after neutron irradiation. The present status of this design and direction of future work will be discussed.

* This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

MPPB081 Determination of Low Level RF Control Requirements for Superconducting Cavities from Microphonics Measurements

Jean Delayen, Leigh Harwood (Thomas Jefferson National Accelerator Facility)

In lightly beam loaded superconducting accelerators the rf power requirements are dictated by the maximum amount of microphonics that the system must be able to control and by the energy content of the cavity. In previous machines, such as heavy-ion boosters, the energy content of the cavities was relatively small and one could afford to specify a large control window and still use low power (~100 W) rf sources. In newer accelerators that are being contemplated —such as the CEBAF 12 GeV upgrade or RIA— the energy content of the cavity is quite large requiring rf sources in excess of 10 kW. Conservatism in the control window specification would be quite costly; on the other hand loss of lock could have adverse effect on machine availability or beam property or even, in some cases, result in activation. We present a model to estimate the requirements to be placed on the rf control system based on the properties of the cavities, the frequency tuning system, and the characteristics of the accelerator.

* Work supported by the U.S. Department of Energy under contract DE-AC05-84-ER40150.

MPPB082 Measurement of the Hydrodynamic Expansion of High Dose Xray Convert Targets

Gary Guethlein, Frank Chambers, Steve Falabella, Roger Richardson, John Weir (LLNL), Fletcher Goldin (Bechtel)

One approach to multiple-pulse radiography is for the electron beam to strike the bremstrahlung xray converter target at the same place on each shot. The evolution of the target density places limits on pulse format and ultimate dose. At LLNL, we are measuring xray transmission through the target to study the target expansion. Details of the backlighting technique will be presented, along with results for a variety of spot sizes and comparison with hydrodynamic modeling.

* This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

MPPB083 Interaction of e-Beam with Tantalum Foils

Darwin Ho, Judy Harte Lawrence, George Zimmerman (LLNL)

We present the recent progress on the study of interaction of e-beam with tantalum foils. (1) Simulations on ETA-II target experiments. To study the hydro characteristics of beam foil interactions, a series of experiments were performed on ETA-II. The experiments were performed using different focal spot sizes to study different energy densities. Hydro-simulations performed using LASNEX show very good agreement with experimental data. This good agreement provides us with confidence of using LASNEX and the Ta EOS to predict the hydo response of beam-foil interactions. (2) Linking LASNEX with MCNP. The latest code modification allows us to transfer simulation data between LASNEX and MCNP automatically and consequently the time required for the multi-pulse target simulation is reduced and the accuracy of the simulation is improved. The physics of foil expansion caused by beam heating and the effect of multi pulse is discussed.

* This work was performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

MPPB084 An Axial Injection System for the ORIC

Gerald D. Alton (ORNL)

A conceptual design for an axial injection system for injecting high intensity beams of H^-, D^-, and He^{++} into the Oak Ridge Isochronous Cyclotron (ORIC) is described in this report. Due to the relatively high intensities (~200 uA) that must be transported to ORIC, the transport system is designed to avoid excessive space-charge effects. For this reason, magnetic beam transport components are used where possible. The injection system consists of two high voltage platforms, two ion sources (a multi-cusp, filter-field source for H^- and D^- generation and an ECR ion source for He^{++} generation), a magnetic analyzer, magnetic beam transport steerers and lenses, a double-drift-tube beam pulsing system and a spiral inflector. According to computational studies, more than 100 uA of high quality, primary light ion beams will be extracted from the ORIC using either the existing septum extraction system (~70%-80% extraction efficiency) for He^{++} beams and a foil stripping extraction system (~100% extraction efficiency) for extracting either H^+ or D^+ beams.

* Research sponsored by the Office of Science, U.S. Department of Energy under contract DE-AC05-00OR22725 with UT-Battelle, LLC.

MPPB085 Initial Performance of a 6 GHz

Yuan Liu, Gerald D. Alton, J. M. Cole, F. Meyer (ORNL), Hassima Bilheux (University of Versailles)

An all-permanent-magnet, ECR ion source with a large resonant plasma volume has been constructed and initially evaluated for the production of highly charged ion beams at the Oak Ridge National Laboratory. In contrast to conventional minimum-B ECR ion sources where the ECR zones are "surfaces," this source employs a novel magnetic field configuration with an extended central flat region to form a large, on-axis ECR "volume." This new magnetic field configuration enables the heating of electrons over a much larger volume than is possible in conventional ECR ion sources. Details of the design features of the source will be described in this report. Initial results of charge-state spectra and intensity distributions are presented for selected noble gas elements. Comparisons are made of the performance of the source when operated in the "volume" and

conventional minimum-B modes. According to the preliminary results, the "volume" mode is superior in terms of ion intensity and charge-state distribution.

* Research supported by the Office of Science, U.S. Department of Energy, under contract DE-AC05-00OR22725 with UT-Battelle, LLC.

MPPB086 The Electric Field Distribution in a Spiral Inflector for Cyclotron Injection Applications

Y. Zhang, Gerald D. Alton (ORNL)

In this report, we present results derived from computational studies of central particle orbits through a spiral inflector that is under consideration for axial injection applications for the Oak Ridge Isochroous Cyclotron (ORIC), Oak Ridge National Laboratory. Serious discrepancies are found between the magnitudes of the electric fields derived from 3-D finite element computations and those derived from the analytical form of theoretical electric field distribution within the spiral inflector, customarily used in the design of such systems. These discrepancies lead to particle orbits that significantly deviate from those computed from analytical forms of the theoretical electric field distributions within such devices. According to the present results, computational results reveal that the entrance and exit fringe fields cause significant beam focusing effects that are not usually taken into account in the designs of such devices. In addition and more importantly, the actual fields within the spiral structure result in shifts in the paths of the particle trajectories far from those derived from theory. We describe a method for shaping the electrode surfaces of the inflector that are effective in compensating for fringe field beam focus effects at the entrance and exit regions of the spiral inflector and introduce a simple solution to eliminate the seemingly unavoidable shift in the central orbit beam path. As a consequence of these studies, we arrive at a design for a spiral inflector with greatly improved optical properties, resulting in reduced transmission losses and improved injection capture efficiency.

* Research sponsored by the Office of Science, U.S. Department of Energy, under contract DE-AC05-00OR22725 with UT-Battelle, LLC.

MPPB087 An RFQ Injection System for the HRIBF

Yan Zhang, Paul E. Mueller (ORNL)

At the Holifield Radioactive Ion Beam Facility (HRIBF), molecular ions extracted from a positive ion source and subsequently broken up in a charge-exchange cell produce radioactive ion beams (RIBs) with several hundred eV energy spread, preventing effective magnetic isobar separation. In order to perform magnetic isobar separation prior to charge exchange, a 12-MHz RFQ and multi-harmonic pre-bunching system is proposed to supplement the present 300-kV injection system for the 25-MV tandem electrostatic accelerator. The RFQ will be mounted on a variable high voltage platform to accommodate ions with masses from 10 to 150. Operation and maintenance of the target/ion source will be simplified since it will be on a lower voltage platform.

* Research sponsored by the U.S. Department of Energy under contract DE-AC05-00OR22725 with UT-Battelle, LLC.

MPPB088 The Creation and Investigation Quasi-monochromatic Beams of the Diffraction X-Ray Radiation

I. Khakberdiev, A.N. Safarov (Nuclear Physics Laboratory, Samarkand State University), A.P. Potylitsyn (Nuclear Physics Institute, Tomsk Polytechnic University)

Creation of sources of monochromatic X-radiation beams (MXR), research of characteristics of these for improvement of regulation of parameters of beam become larger tendentional experiments among laboratories having an electron accelerators. The interest to MXR is caused by their application for solving various physics problems in scientific and practical aims [Bertschy M, Critin M, Jolie J, Warr N, Mondelaers W. NIM B 99, p.286-288, (1995)]. The obtained beam is unique because of its parameters - a direction, energy and intensity can be tune regulated in the working range of arrangement. Enumerated characteristics allow to utilize them in the wide field for solving many problems not only in Physics but also in Biology, Microelectronics, Nanotechnology, Medicine and others. The MXR properties allow one to consider this radiation as an alternative to a synchrotron source of a hard X-ray beam, especially of energies higher than a few tens of keV [R.B.Fiorito, D.W.Rule, M.A.Piestrup, Q.Li, A.H.Ho, X.K.Maruyama, NIM B 79, (1995), p.286-288]. On the basis of the electronics beam with the energy E=13 MeV and E=22 MeV and their bremsstrahlung the experimental set up for getting quasimonochromatic X-ray radiation are developed. The method of experiment and results of testing measurements are described.

MPPB089 Microwave Radiation Stimulated by Charged Atom or Ion Beams

Vladislav Grishin (Scobeltsyn Institute of Nuclear Physics of Moscow Lomonosov State University)

Perspectives of high-frequency stimulated emission source applying accelerated beams of charged atoms or ions which are widely used at present are analyzed. Radiation mechanism based on high-frequency intratomic electronic transitions due to anomalous Doppler-effect on slow waves is considered, while the low-frequency oscillations of atoms and ions are neglected. In particular different slow surface wave systems with dielectric layers are estimated. In aggregate process has a complex nature since photon radiation is accompanied by excitation of atoms with following emission of more high-frequency photons specially in case of relativistic atomic beam usage. Requires to parameters of such systems and atomic beams for observation of stimulated emission needed for diverse applications are established

MPPB090 Effective Source of Sharp Focused Electromagnetic Radiation of Electrons with Moderate Relativistic Energy

Vladislav Grishin, Serguei Likhachev (Scobeltsyn Institute of Nuclear Physics of Moscow Lomonosov State University)

The new circulation scheme of intense bremsstrahlung source with a sharp directed flow of X-ray and gamma- photons is proposed. In traditional sources the summary output, due to notable self-absorption of generated photon in target, makes no more than 1/3 from all radiative electron losses. Besides because of strong electron scattering in the target material, the photon radiation happens in a cone which is much more than an inverse electron relativistic factor. In a circulating source the thin target placed in a magnetic field is used, and electrons are radiating, multiple crossing the target. Thereof all flow of generated photons is kept, and the total radiation output essentially raises. The new configuration of magnetic fields improving the electron focusing and simultaneously reducing angular divergence of radiation is considered. Moreover here a lateral drift arises that displaces circulating particles and "cleans" a target space. Computer modeling with using of the software package GEANT confirms high efficiency of proposed scheme. So the yield of hard photons in 5-degrees cone rises at order in comparison with traditional devices. This effect is highest for using of moderate energy electrons. The various modifications of such schemes designed for photonuclear researches and various technological applications are discussed.

MPPB091 Effects of Propagation for High Power CW Electron Beam in Air

Sergey Korenev (Steris Corporation), Ivan Korenev (Northern Illinois University)

The question of effects at during of propagation for high power electron beam in air presents the scientific and applied interest. The high power

(80 kW) CW electron accelerator Rhodotron with kinetic energy of electrons 5 MeV was used in the experiments. The experimental results for propagation of scanning electron beams in air are presented and discussed. The physical model for explanation of these results is suggested.

MPPB092 The Concept of Beamlines from Rhodotron for Radiation Technologies

Sergey Korenev (Steris Corporation)

Among of main requirements to electron beams for industrial radiation technologies, the variation of absorbed doses in irradiated product and kinetic energy of electrons is very important for increasing of efficiency of processes. The CW electron accelerator Rhodotron has technical opportunities for design of multi-lines system for radiation lines in industrial scale. The variant of multi-lines system on the basis of Rhodotron is considered in the report. The variation of current beam and time characteristics with multistage kinetic energy allows realizing this concept.

MPPB093 The Line Width of "Backward" Parametric X-ray Radiation of Relativistic Electrons in a Crystal

Nikolai Shul'ga (National Science Center), Mehdi Tabrizi (Department of Physics and Technology, Kharkov National University)

The multiple scattering effects on the line width of the "backward" Parametric X-ray Radiation (PXR) of relativistic electrons are considered when particles fall at a small incidence angle with respect to one of the crystallographic axes (z-axis). Experimental studies of the line width of "backward" PXR have recently been performed on an MAMI accelerator (Mainz, Germany) at electron energies 855 MeV [H.Backe, G.Kube, W.Lauth. In the Book "Electron-Photon Interaction in Dense Media" (Ed. by Wiedemann) Dordrecht, Kluwer, 2001, p.153]. The measured line width were, however, much larger than the natural line width of PXR. In the work [N.F.Shul'ga, M.Tabrizi, JETP Lett., 2002, v.76, p.279] the multiple scattering (coherent only) effect on line width of PXR was considered. In the given work a theory of the multiple scattering (both coherent and non-coherent) influence on the line width of PXR is suggested. Also the problem of multiple scattering effects on PXR is shown to be similar to the problem of the Landau-Pomeranchuk-Migdal multiple scattering effect on the bremsstrahlung of high energy electrons in an amorphous medium.

MPPB094 Transition Radiation of Relativistic Particles on Dielectric Fibers and Nanotubes

Nikolai Shul'ga (National Science Center), Vladislav Syshchenko (Belgorod State University)

Transition radiation (TR) arising under the impact of relativistic charged particles at small angle with atomic strings and planes in a crystal was considered in [N.F. Shul'ga, V.V. Syshchenko. Problems of Atomic Science and Technology, 2001, No.6, p.131; NIM B, 2002 (in press); Yadernaya Fizika, 2003, v.66, No.2,(in press)]. The conditions under which the atomic strings and planes can be treated as uniform infinitely thin dielectric targets were obtained. In the present report we consider TR on dielectric fibers of finite thickness and on nanotubes. The study of the radiation process is carried out in the frames of perturbation theory on the interaction of the particle with the target. The formulae for the spectral-angular distribution of TR in these cases are obtained. The relation between TR and polarization bremsstrahlung and the role of coherent effects are discussed.

Poster Session MPPG
Galleria at 13:30

MPPG001 Mechanical Analysis of the Prototype Undulator for the Linac Coherent Light Source

Bran Brajuskovic, Patric Den Hartog, Emil Trakhtenberg (ANL)

The linac coherent light source will require undulators with unprecedented mechanical precision in order to achieve the magnetic field requirements. Distortion of the undulator strongback due to thermal effects and magnetic and gravitational forces could seriously degrade the performance. To minimize the distortion, a C-type, fixed-gap undulator with a titanium strongback will be used. An analysis of the design of the structure and a comparison of the predicted results with the mechanical requirements and with magnetic measurements is presented.

MPPG002 Development of a Short-Period Superconducting Undulator

Suk Hong Kim, Roger Dejus, Robert Kustom, Elizabeth Moog (ANL)

A planar superconducting (SC) undulator with a period of 15 mm is under development at the Advanced Photon Source. The intended user requires radiation that can be tuned between 20 and 25 keV for inelastic X-ray scattering studies. The undulator design consists of two sets of SC windings with low-carbon steel poles and flux-return yokes that is assembled with the beam tube positioned between the two sets of windings. There will be 20 turns of NbTi SC windings within the coil cross section of 4.0 x 4.3 mm2. For a pole gap of 8 mm, the average current density in the coil must be over 1 kA/mmsqr to achieve the required peak field of 0.8T on the beam axis. Details of the undulator design and the progress on the supporting R&D will be presented.

* Work supported by the U.S. Department of Energy, Office of Basic Energy Science under Contract No. W-31-109-ENG-38.

MPPG003 New Regimes of Resistive Wall Heating of In-Vacuum IDs

Boris Podobedov, D. Lynch, G. Rakowsky (BNL)

A number of proposed light sources, whether based on storage ring or energy recovery linac technology, plan to operate with very small gap insertion devices (IDs) to produce harder photons at a given electron energy. In this paper we estimate the image current heating of such IDs and show that for these new machines the heat fluxes could be orders of magnitude higher that for existing ones, making the heat removal either very expensive or out right impossible. In case of in-vacuum permanent magnet based IDs, the thermal load can result in permanent demagnetization and even melting of the image current shields, while for the superconducting IDs it ultimately results in a quench. In addition, to properly estimate heat fluxes in these new regimes, the well-known expressions for the resistive wall impedance must be modified to account for a number of important effects, such as anomalous skin effect, transition effects at the edges of IDs, and others.

* Work supported by US DOE under contract DE-AC02-98CH10886.

MPPG004 A Dual-Period Staggered Pole Undulator

George Rakowsky, Timur Shaftan, John Skaritka (BNL)

In a solenoid-driven staggered pole undulator, as in permanent magnet hybrid insertion devices, the maximum K-value is limited by both the period length and the saturation flux density of the pole material. If a very short period is chosen to reach the higherst possible photon energies, then the maximum K-value may be too low (<2) to provide adequate overlap between the tuning ranges of the fundamental and

the 3rd harmonic. By translating every other pole axially by half period, a new structure is formed with twice the period length and at least twice the K-value, albeit with half the number of periods. In this shifted structure the minimum energy of the fundamental extends below half the lowest energy of the unshifted structure. By proper choice of parameters, one can tailor the tuning ranges of the fundamental and odd harmonics of the two modes so they overlap, providing both high photon energies and full spectral coverage. The sliding pole structure can be designed with just two moving parts. We show an example modeled in Radia, with computed fields, trajectories and spectra.

* Work supported by the US Department of Energy under Contract DE-AC02-98CH10886.

MPPG005 A Quasiperiodic APPLE-II Undulator

George Rakowsky, Timur Shaftan (BNL)

The magnetic design of an APPLE-II type undulator with a quasiperiodic magnet structure is described. An example is modeled in Radia to calculate fields, trajectories and spectra. It is shown that in the circular as well as linear polarization modes, the brightness of the fundamental mode is virtually unaffected. In both the horizontal and vertical polarization modes the usual odd harmonics are replaced with spectral peaks at energies that are not integer multiples of the fundamental, as in a planar quasiperiodic undulator, with similar benefits.

* Work supported by the US Department of Energy under Copntract No. DE-AC02-98CH10886.

MPPG006 A Symplectic Model for Wigglers

David Sagan (Cornell University)

Recent interest in applications of wiggler magnets in storage rings has motivated efforts to incorporate their effects in calculations of beam dynamics. This paper presents an analytic model of wiggler fields that can be used with symplectic integration to evaluate such effects. Coefficients needed by the model are generated by fitting to the results of finite-element field calculations. The model has been used successfully in the CESR-C project, which imposes tolerances of a few parts in 10000 on the modeling of 2-Tesla superconducting wigglers. In contrast to models based on Fourier transforms, the model presented here uses a relatively small number of terms, leading to correspondingly fast integration times. Fringe fields are included and no assumption about the periodicity of the field is made.

MPPG007 Vibrating Wire and Long Integrating Coil Based Magnetic Measurements of a 7-Pole Super-Conducting Wiggler for CESR

Alexander Temnykh (Cornell University)

A number of 7-pole and 8-pole 2.1 Tesla super-conducting wigglers will be installed in Cornell Electron Storage Ring (CESR) to increase radiation damping at 1.8GeV energy. The first 7-pole wiggler has been manufactured and recently installed in the ring. The paper presents results of the wiggler magnetic measurements based on widely used long integrating coil (LC) and on relatively new vibrating wire (VW) techniques. The field components integrated along a straight lines over the full wiggler length were measured with LC technique. The VW technique was used: (a) to measure field integrals along the straight lines similar to LC, (b) to measure field integrals along the wiggling lines replicating beam trajectories and (c) to localize the region where the field errors occurred. In addition to the results the paper describes details of the used techniques.

* Work supported by the US National Science Foundation.

MPPG008 Status of the DIAMOND Insertion Devices

James Clarke, Neil Bliss, Donald Clarke, Fay Hannon, Clive Hill, Duncan Scott (Daresbury Laboratory), Vishal Francis (Rutherford Appleton Laboratory)

Seven insertion devices must be provided for the first DIAMOND beamlines on Day 1 of operations. A variety of devices have been selected, including four short period in-vacuum undulators, one 5m conventional planar undulator, one 5m helical undulator and a 3.5T superconducting wiggler. Construction of several of these devices has already commenced. This paper will detail the magnetic solutions that have been adopted and also the mechanical designs, highlighting the key features that have been included.

MPPG009 Design of a Permanent Magnet Round Bore Helical Undulator for a Free Electron Laser

James Clarke (Duke University), Neil Bliss, Michael Poole (Daresbury Laboratory)

A helical undulator has been designed for a low energy free electron laser under a commercial contract. Solenoidal focussing must also be incorporated and so a round bore permanent magnet design has been adopted that allows a simple solenoid to be wound around it. The chosen magnetic solution will be described with justification, including comments about the selected end design and also particle tracking results. A feasible engineering design that produces an economical yet flexible solution will also be presented.

MPPG010 Design and Evaluation of a Short Period Nb3Sn Superconducting Undulator Prototype

Soren Prestemon, Dan Dietderich, Steve Gourlay, Phil Heimann, Steve Marks, Ron Scanlan, Ross Schlueter (LBNL)

The design of a class of short period superconducting undulators is presented. We begin with a parameter-based analysis that provides insight into potential device performance as a function of the properties of superconducting materials. We present data on candidate low-temperature superconducting materials and the motivation to consider low-copper fraction, high Jc materials. Measured data on recent Nb3Sn conductors is provided, together with wire and cable design issues that are tailored for undulator applications. Key design concerns are then addressed, in particular the quench protection system limitations and the system performance. Progress on the construction and testing of a prototype 30mm period device is described.

* This work was supported by the United States Department of Energy, Contract No. DE-AC03-76SF00098.

MPPG011 Beam Dynamics Effects of the Apple-II EPUs at the ALS

Christoph Steier, Jin-Young Jung, Steve Lidia, Steve Marks, Laurent Nadolski, David Robin, Ross Schlueter, Andy Wolski (LBNL)

At the ALS currently two Apple-II type elliptically polarizing undulators (EPUs) with a period of 5 cm are in operation and are used for magnetic spectroscopy and molecular environmentl science. Two more EPUs with periods of 5 and about 8 cm are either under construction or planned. The installed EPUs have a number of effects on the electron beam, which typically are both gap and phase dependent. The effects include orbit shifts, tune shifts/beta-beating and emittance coupling. For the new long period device in addition non-linear effects due to the inherent field roll-off in circular polarization mode can be important. All of these effects have been studied experimentally and in simulations at the ALS and several effects are already minimized with fast feed-forward and feedback systems.

* This work was supported by the U.S. Department of Energy, under Contract No. DE-AC03-76SF00098.

MPPG012 Harmonics of a High-Gain Harmonic Generation Free Electron Laser

Juhao Wu (SLAC)

When the Free Electron Laser (FEL) evolves into the deep saturation region, there are abundant harmonic contents. We calculate the harmonics of a High-Gain Harmonic Generation FEL. Some consequential effects are discussed.

* Work supported by the US DOE under contract DE-AC03-76SF00515.

MPPG013 Calculation of the Coherent Synchrotron Radiation Impedance from a Wiggler

Juhao Wu, Tor Raubenheimer, Gennady Stupakov (SLAC)

Most studies of Coherent Synchrotron Radiation (CSR) have only considered the radiation from independent dipole magnets. However, in the damping rings of future linear colliders, a large fraction of the radiation power will be emitted in damping wigglers. In this paper, the longitudinal wakefield and impedance due to CSR in a wiggler is derived in the limit of a large wiggler parameter K. After an appropriate scaling, the results can be expressed in terms of universal functions, which are independent of K. Analytical asymptotic results are obtained for the wakefield in the limit of large and small distances. The results are used in the study of a possible CSR driven instability in damping rings of future linear colliders.

* Work supported by the US DOE under contract DE-AC03-76SF00515.

MPPG014 End Magnetic Structure Design of a Helical Staggered Undulator

Cheng Chang, T.C. Fan, C.S. Hwang, Chon Wang (Synchrotron Radiation Research Center)

A helical staggered undulator was proposed in SRRC. The helical staggered-array with 10-mm period length is designed to generate the identical vertical and horizontal field strength of 0.975 T at a 2-mm gap width. For the end magnetic structure of undulator, an anti-symmetric vertical array and a symmetric horizontal array are arranged. The vertical, horizontal and longitudinal magnetic fields were analyzed to achieve more uniform peak fields in the end structure. Furthermore, the end configuration is optimized to minimize the vertical and horizontal field integral with various solenoid fields. The simulated electron trajectories are also presented in this work.

MPPG015 Operational Experience of the Insertion Devices and Expectation of the Future Superconducting Wigglers at SRRC

Ho-Ping Chang, C.H. Chang, Jenny Chen, K.T. Hsu, C.S. Hwang, C.H. Kou, C.C. Kuo, G.H. Lou (Synchrotron Radiation Research Center)

Since 1995 we have continuously installed five insertion devices in the 1.5 GeV storage ring TLS at SRRC. They include one 1.8T wiggler (W20), three undulators (U5, U9 and EPU6.5), and one superconducting wavelength shifter. All these five IDs are located in the long straight sections. The real time orbit correction and betatron tune compensation routine have been successfully operated. With these IDs, the machine emittance reduces substantially. We plan to install four more superconducting multipole wigglers, one in the long straight and three in the archromat sections. These devices therefore can offer more beam time for the hard x-ray community. The impact of all these IDs on the beam dynamics effects are reported in this paper.

MPPG016 Magnetic Field Measurement on Superconducting Multipole Wiggler with Narrow Duct

Tai-ching Fan, Ching-Shiang Hwang, Fu-Yuan Lin (Synchrotron Radiation Research Center)

The first superconducting multipole wiggler (SMPW) of the Synchrotron Radiation Research Center (SRRC) was tested and will be installed at the rf section of storage ring in 2003. In order to evaluate the quality of assembly, we measured the magnetic field at three main phases according to the assembly process. To achieve an operation field of 3.2 T with period length of 6.0 cm and operate the magnetic field measurement system in room-temperature at the final phase, a narrow warm duct with 6-mm high was equipped. Therefore, a mini-gap measurement system was specially designed for measurement in such a stringently limited space. A Hall probe was mounted on a string tensioned by a strong bow stage to measure the periodical field profile point-by-point. The stretch-wire technique was used to measure the mulipole components of 1st and 2nd integral field. The performance of the measurement system at different phases as well as the field performance of SMPW is reported.

MPPG017 Commissioning of Two New Insertion Devices at ELETTRA

Dino Zangrando, Bruno Diviacco, Cristina Knapic, Lidia Tosi (Sincrotrone Trieste)

Two new insertion devices have recently been installed in the ELETTRA storage ring, a 3.5 Tesla superconducting multipole wiggler and a figure-8 permanent magnet undulator. The first is the radiation source for an X-ray diffraction beamline, while the second is designed to generate photons in the 5-11 eV range for inelastic UV scattering experiments. The impact of these devices on the electron beam dynamics was already studied at the design stage [L.Tosi, R.P. Walker, "Dynamic Aperture Simulations for a Figure-8 Undulator and a Superconducting Wiggler", Sinctrotrone Trieste Internal Note ST/M-TN-00/09]. In this paper initial commissioning results are presented and discussed, including the measured effects on the closed orbit, tune and lifetime.

MPPG018 Low Beta Function Configuration on 7 Tesla Wiggler at CAMD

Mikhail Fedurin, Benjamin Craft, Gaetano Vignola (Center for Advanced Microstrutures and Devices)

The photon beam from 7 Tesla wavelength shifter wiggler is available since April, 2002 for Protein Crystallography beamline of CAMD storage ring, operating at 1.3 GeV. To improve the property of the photon beam from the wiggler, a low beta function configuration in the wiggler straight section has been developed. Different electron beam optics configurations for wiggler operations are described. Response matrix analysis and tune derivatives tools were applied for low beta function studies.

* Borovikov V.M., Craft B., Fedurin M.G., Jurba V., Khlestov V., Kulipanov G.N., Li O., Mezentsev N.A., Saile V. and Shkaruba V.A. "Superconducting 7 Tesla Wiggler for LSU CAMD", Journal of Synchrotron Radiation, Vol.5, Part 3, pp.440-442 (1998)

MPPG019 Optimization of the Period of an Undulator for the LNLS Storage Ring

X. Resende (Laboratório Nacional de Luz Sincrotron, Brazil)

The aim of the present work is to find the optimum magnetic period length for the LNLS Elliptically Polarizing Undulator (EPU). An objective function that takes into consideration both intensity and polarization of the radiation over the energy range desired by LNLS users is proposed and it is used in the optimization calculation. Results of such calculation are presented and discussed, following a short review of the EPU magnetic design and its radiation characteristics.

A concise description of electron dynamics in the magnetic field of the undulator is also presented.

MPPG020 Generalized Easy Axis Rotation Theorem

Mikhail Smolyakov (Moscow State University)

This paper deals with a nonstandard method of analyzing the magnetic field produced by a planar pure permanent magnet wigglers and undulators with infinitely wide poles. More particularly, the presented paper examines the magnetic field variations under the following transformation of magnetic system. Let us all easy axes of the wiggler's top part are rotated by any arbitrary angle, and at the same time all easy axis of its bottom part are rotated by another (and also arbitrary) angle while keeping the system geometry the same. Under these conditions, the magnetic field clearly varies and this paper shows that its changes can be analytically expressed in terms of the Fourier transforms of the magnetic field components. With the equal rotation angles we get the well known easy axis rotation theorem (Halbach theorem). The obtained results can be applied in designing of new planar pure permanent wigglers and undulators.

MPPG021 Twisted Magnetic Hypocicloidal Undulator

Elena-Claudia Stencu (Physics Faculty, Bucharest University), V.I.R. Niculescu (Electron Accelerator Laboratory, Bucharest University), V. Babin (University of Bucharest, INOE2000)

A new theoretical model of an undulator for free electron lasers in an hypocicloidal magnetic field is presented. The undulator is a stack of wires which in the xy plane are described by hypocicloidal equations and each wire is rotated with an angle against the precedent one. For this structure the Calugareanu invariants and also numerical values of the magnetic field components were computed. The integrals needed were evaluated by the following procedure: the integrand was transformed from an irrational form to polynomials of superior orders. So were obtained more performant expressions for magnetic field evaluations of this new undulator model.

MPPG022 Feasibility of Proton-Beam Cancer Therapy Aided by Proton Driven PET and 18FDG Imaging

Joanne Beebe-Wang, F. Avraham Dilmanian, Stephen G. Peggs, David J. Schlyer, Paul Vaska (BNL)

Proton therapy is increasingly used in radiation oncology mostly because its dose distribution conforms more tightly to the tumor than x-ray radiation therapy. One important feature of proton therapy is that it produces a small amount of positron-emitting isotopes along the beam-path allowing the therapy dose distribution to be imaged by positron emission tomography (PET). This provides a powerful tool for quality assurance of the treatment. Meanwhile, the development of 18FDG has revolutionized the study of the human brain and high uptake of 18FDG in tumor has also been reported. For a routine proton-beam cancer therapy, it could be helpful to use 18FDG imaging as a tool for tumor analysis and pretreatment alignment, and to use proton driven PET as a tool for quality assurance after treatment. In this paper, we report our initial investigation on the feasibility of proton-beam cancer therapy aided by proton driven PET and 18FDG imaging. We present a quantitative estimate and Monte Carlo simulation results on the yield of positron emitters produced by a 250 MeV proton beam, and by 18FDG, in a clinical scenario.

* Work performed under the auspices of the U. S. Department of Energy.

MPPG023 Studies on Sextupole Components Generated by Eddy Currents in the Rapid Cycling Medical Synchrotron

Javier Cardona, Dan Abell, Steve Peggs (BNL)

The Rapid Cycling Medical Synchrotron is a second generation medical accelerator that it has been designed with a repetition frequency of 30 Hz. This repetition frequency is far above the typical repetition frequency used in medical accelerators. An elliptical beam pipe has been chosen for the RCMS design in order to win as much physical aperture as possible while keeping the magnet dimensions as small as possible. Rapid Cycling induces Eddy current in the magnets. Eddy currents and elliptical beam pipes generate sextupole components that might be neccesary to consider. In this paper, the effects of these sextupoles components are evaluated, first by looking at the phase space of a bunch of particles that has been tracked for 10000 turns, and also by evaluating the dynamical aperture of the accelerator. The effects of the sextupoles on quantities like the beta function, the smear, etcetera are also evaluated. First results obtained with Marylie show that the width of a phase space ellipse of a bunch of particles is slightly affected by the sextupoles due to the Eddy currents.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

MPPG024 Status of the Integrated RFQ-Drifttube-Combination for the Medicine-Synchrotron in Heidelberg

Alexander Bechtold, Ulrich Ratzinger, Alwin Schempp (Institut für Angewandte Physik), Bernhard Schlitt (Gesellschaft für Schwerionenforschung mbH)

Design and construction of the RFQ including an integrated rebunching section as a part of the LINAC system is our contribution to the medicine project in Heidelberg. The building of the machine has been finished, first rf-measurements at low power have been done. The concept of assembling, especially the alignment of the electrodes, and the results of the rf-measurements will be presented.

MPPG025 Potential Alternate Beam Source for Proton Therapy

William Jones, Dennis Friesel, S.Y. Lee (Indiana University)

Studies have been carried out to determine the suitability of the IUCF Cooler Injector Synchrotron (CIS) as a potential replacement or supplement to the Indiana University Cyclotron as a source of proton beams for the Midwest Proton Radiotherapy Institute (MPRI). The primary modification to the synchrotron would be the development and installation of a slow extraction system. An achromatic beamline connecting CIS and the MPRI beam trunkline has been designed and could use magnets recycled from the recently decommissioned Cooler ring at IUCF. In addition to providing redundancy, this project would increase the proton energy available for radiotherapy to 240 MeV and could provide higher resolution beams to the radiation effects target stations.

MPPG026 Proton Therapy Treatment Room Controls Using a Linux Control System

Joseph Katuin (Indiana University)

The Indiana University Cyclotron Facility (IUCF) is in the process of completing the building of the Midwest Proton Radiotherapy Institute (MPRI). The design of MRPI's proton therapy system required the development of several control systems responsible for delivery of proton beam to a patient and patient positioning. One such control system is the Treatment Room Controller. This system allows for management of the other control systems, and provides the primary user interface to the proton therapy system. This control system was developed with a Linux operating system, the KDE/QT widget sets for the user interface, and the KDevelop IDE. The control software uses the unixODBC API to provide an interface to a MySQL database for record and verify functions and history functions. The control system also uses the Comedi driver library so that a National Instruments PCI DAQ card can be used to interface to various treatment room devices.

MPPG027 Development of High Field Dipole and High Current Pulse Power Supply for Compact Proton Synchrotron

K. Endo, K. Egawa, Z. Fang (KEK), G.I. Silvestrov (BINP), M. Mizobata, A. Teramoto (Mitsubishi Electric Corp.)

A small dipole magnet of 3 T is developed with its pulsed power supply feeding 200 kA at maximum for the table-top proton synchrotron which is now under development for radiotherapy. The experimental field distribution is consistent with the 3D dynamic field simulation result satisfying the required beam aperture. The dipole field was measured at an interval of 2 micro-sec with 15 tiny search coils aligned accurately to the radial direction in the pole gap. The dipole is excited by the discharge current of the capacitor bank of 100 kJ with the rise time of 5 msec. Transverse beam behavior is also simulated, using a time dependent beam optics code, under the influence of the RF acceleration field. Performance of the dipole and power supply will be treated in detail in conjunction with the numerical simulations and the beam dynamical properties.

MPPG028 RF Cavities and Power Amplifier for the Compact Proton Synchrotron

Fang Zhigao, K. Egawa, K. Endo (KEK), I.I. Averboukh (BINP), T. Hirashima (Denki Kogyo Co.)

A project to build a compact proton synchrotron is now under way. Protons will be accelerated from 2 MeV to 200 MeV within 5 ms with an operation repetition rate of 10 Hz, in a synchrotron ring with a circumference of 11.9 m. The acceleration system is required to be of wide bandwidth, with the frequency sweeping from 1.64 MHz to 14.26 MHz, and of a high gradient, with the maximum acceleration voltage of 20 keV. The acceleration section, consisting of a 2-cell rf cavity loaded with 4 high-permeability magnetic alloy cores in each cell, has been designed. A push-pull power amplifier with two 35 kW tetrode tubes will be used to drive the 2 cavities in parallel. Calculations and test results on the cavity characteristics will be presented and discussed, including the cavity impedance and equivalent circuit. The simulation results of the amplifier system using the ICAP code will also be given. The prototype of the rf system is being developed, and a high power test will be performed soon.

MPPG029 Application of Statistical Process Control (SPC) in the Manufacturing of Medical Accelerators

Samy Hanna (Siemens Medical Solutions)

Most radiation therapy machines are based on microwave linear accelerators. Producing reliable accelerators and hence, reliable radiation therapy machines requires accurate and efficient processes throughout the manufacturing of the electron accelerator. At Siemens, we have been implementing various Computer-Aided Processes (CAP) in several critical areas of the accelerator manufacturing. These techniques lend themselves to the use of Statistical Process Control (SPC). These tools are utilized in monitoring variations in different processes and facilitating the initiation of actions to keep the processes within their intended control limits. The SPC computer program generates control charts from which one can analyze variations in the process. Based on these control charts, the processing engineer can decide on the stability of the process as well as causes of deviations. The CAP approach provides accurate and efficient techniques to characterize accelerator structures. These techniques are implemented at different phases of development and manufacturing of the accelerators. At Siemens, we have been developing different microwave techniques to: verify predictions from computer simulations in the design phase, to insure that the machined cells are within the design tolerances, to perform accurate tuning, and finally, to confirm overall RF and beam performance of the completed structure. Critical parameters are sent to a database. The data is analyzed and displayed graphically as SPC charts. In this paper, we discuss some of the techniques we use to characterize and control the manufacturing of electron accelerators in an industrial environment.

MPPG030 Progress in the Development of the TOP Linac

Luigi Picardi, Concetta Ronsivalle (Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente), Salvatore Frullani (Istituto Superiore di Sanita)

The TOP Linac (Oncological Therapy with Protons), under development by ENEA and ISS is a sequence of three pulsed (5 usec, 300 Hz) linear accelerators: a 7 MeV, 425 MHz RFQ+DTL (AccSys Model PL-7), a 7-65 MeV, 2998 MHz Side Coupled Drift Tube Linac (SCDTL) and a 65-200 MeV, variable energy 2998 MHz Side Coupled Linac (SCL). The first SCDTL module is composed by 11 DTL tanks coupled by 10 side cavities. The tanks has modified to overcome vacuum leakage that occurred during brazing, and now the module has been completed, and is ready to be tested with protons. The 7 MeV injector has been recently installed in the ENEA Frascati laboratories for preliminary test, before being transferred to the main Oncological Hospital in Rome, Istituto Regina Elena.

MPPG031 Radiation-Acoustic Monitoring of Therapeutic Beam

Gennadiy Popov, Alexander Kalinichenko, Valentin Lazurik, Vladimir Tovstiak (Kharkiv National University)

To prevent overexposure of the healthy tissue in radiation therapy one need to control the irradiated zone in patient's body directly in the course of exposure, i.e. to determine form, location and dose distribution in this zone. The method of radiation-acoustic monitoring of therapeutic beam is proposed, which is based on detection of thermoelastic scillations to be generated by pulsed radiation beam in vivo and on the following reconstruction of dose field characteristics. The essence of the method is that pulsed beam of penetrating radiation (electrons, X-rays, protons) causes "instant" heating of bioobject material and excitation of thermoelastic pulse in it. The pulse diverges from generation zone with sound velocity in bioobject material. A pulse propagation time to acoustic detector permits determining distance from generation zone. The absorbed dose may be determined by pulse amplitude and distance from generation zone to detector. The indications of a set of detectors to be connected to patient's body permit determining location, form and value of the dose field. The errors of above characteristics depend on detector bandwidth, as well as on absorption and scattering of the acoustic pulse. As an experimental basis of the proposed method, the authors' experience in radiation-acoustic dosimetry of scanning radiation beams in physical experiment and engineering is considered.

MPPG032 Theoretical Studies Regarding the Simulation of Decay in a Pion Collection System

Francois Meot (CE Saclay), Bruno Autin, Andre Verdier (CERN)

In view of design studies of a neutrino factory pion decay channel, based on particle ray-tracing, it is necessary to have at our disposal a reliable means of decay simulation means. A Monte Carlo method developed for earlier studies of muon background at the SPES3 spectrometer at Saturne, Saclay, has been retained and is described. Various physical processes of concern are reviewed, such as angle, momentum and time distributions that build up in the course of the decay process. Their theoretical densities are, in parallel, derived analytically so as to provide means of estimation and of checking the validity of the numerical method.

MPPG033 High-Frequency Bunching and Phase-Energy Rotation for a Muon Source

David Neuffer (FNAL)

We present a new approach for the capture of a large energy spread beam into a string of small energy spread bunches. In this approach

an initial drift is followed by a sequence of rf cavities with rf frequencies decreasing along the transport, which adiabatically traps the beam into a sequence of bunches of different energies. This is followed by a fixed (or variable) frequency high gradient rf system which lines the bunches up at (nearly) equal energies. The present application is for capture, bunching, and phase-energy rotation of muons into a string of ~200 MHz bunches suitable for cooling into a neutrino factory. Simulation studies from the production target into the neutrino factory cooling system are presented. The approach is compared with previous approaches which require very low frequency rf or induction linacs.

MPPG034 Closing in on the Final Design of the BESSY FEL

Dieter Kramer, On behalf of the BESSY-FEL Design Group (BESSY)

Start to End simulations for an optimized 2nd generation SASE-FEL user facility in the soft X-ray range (20 eV to 1keV) at BESSY will be presented. Solutions for effective bunch compression, concepts of seeding as well as optics and tolerance studies for 3 independently operating undulators have been worked out. Ongoing activities in r&d using TESLA s.c. cavities at modest gradients of 15 MV/m in a 2.25 GeV cw linac are described. The studies are part of an detailed technical design report to be issued in early 2004.

* Funded by Bundesministerium fur Bildung und Forschung, Land Berlin and Technologiestiftung Innovationszentrum Berlin.

MPPG035 Analysis of the HOM Damping with Modulated Beam in the First Prototype of Superstructure

Pedro Castro, Andre Gössel, Siegfried Schreiber, Manfred Wendt (DESY), Guillaume Devanz (CE Saclay), Nicoleta Baboi (SLAC), Jacek Sekutowicz (Thomas Jefferson National Accelerator Facility)

Superstructures, groups of weakly coupled cavities fed through a single power coupler, are currently investigated as a more cost effective alternative to the 9-cell TESLA cavities. Two Nb prototypes of the superstructure have been built, consisting of two 7-cell cavities, and installed in the TESLA Test Facility at DESY. The HOM damping of these superstructures has been investigated with a modulated beam using the method described in [S. Fartoukh, Saclay Preprint, DAPNIA/SEA-98-181]. A charge modulation imposed on the 54 MHz bunch train excites HOM at frequencies n*fb ± fmod, where n is an integer, fb=54 MHz is the bunch frequency and fmod is the charge modulation frequency between 0.5 MHz and 27 MHz. The effects of the excited HOMs on the beam transverse position are observed at a downstream BPM, followed by a direct analysis of the modes at the HOM couplers.

MPPG036 A Critical Review of Oscillator Amplifier FEL Configurations

Luca Giannessi, Giuseppe Dattoli, P.L. Ottaviani (Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente), Sandra Gail Biedron, Stephen Milton (ANL), Henry Freund (Naval Research Laboratory)

FEL oscillator-amplifier devices can be exploited to reduce the saturation length of SASE FEL devices operating in the soft x-ray region. The problems associated with the output stability due to intracavity saturation can be overcame using alternative schemes for the oscillator. In this contribution we discuss different schemes with particular emphasis on the optical klystron oscillator, which can be used as a system to reduce the intracavity power and the consequent beam degradation due to saturation effects. We also present numerical simulations and analytical predictions using different procedures and discuss the design of a device based on such a scheme.

Tuesday, May 13, 2003

Session TOAA: Multi-Particle Beam Dynamics & Optics
Grand Ballroom II at 8:30
Session Chairs: J.Bisognano, S.Y. Lee

TOAA001 Focusing and Neutralization of Intense Beams

Simon Yu, Andre Anders, Shmuel Eylon, Enrique Henestroza, Prabir Roy, Derek Shuman, William Waldron (LBNL), William Sharp (LLNL), Dave Rose, Dale Welch (Mission Research Corporation), Philip Efthimion, Eric Gilson (Princeton Plasma Physics Laboratory)

In heavy ion inertial confinement fusion systems, intense beams of ions must be transported from the exit of the final focus magnet system through the target chamber to hit millimeter spot sizes on the target. Effective plasma neutralization of intense ion beams through the target chamber is essential for the viability of an economically competitive heavy ion fusion power plant. The physics of neutralized drift has been studied extensively with PIC simulations. To provide quantitative comparisons of theoretical predictions with experiment, the Heavy Ion Fusion Virtual National Laboratory has completed the construction and has begun experimentation with the NTX (Neutralized Transport Experiment). The experiment consists of 3 phases, each with physics issues of its own. Phase 1 is designed to generate a very high brightness potassium beam with variable perveance, using a beam aperturing technique. Phase 2 consists of magnetic transport through four pulsed quadrupoles. Here, beam tuning as well as the effects of phase space dilution through higher order nonlinear fields must be understood. In Phase 3, a converging ion beam at the exit of the magnetic section is transported through a drift section with plasma sources for beam neutralization, and the final spot size is measured under various conditions of neutralization. In this paper, we present first results from all 3 phases of the experiment. Comparisons with 3-D PIC simulations (WARP-3D and LSP) will also be shown.

* Supported by the U.S. Department of Energy under contract number DE-AC03-76SF00098.

TOAA002 Theory and Observations of Microbunching Instability in Electron Machines

Gennady Stupakov (SLAC)

For not very short bunches, the coherent synchrotron radiation (CSR) is usually suppressed by the shielding effect of the conducting walls of the vacuum chamber. However an initial density fluctuation in the beam with a characteristic length much shorter than the bunch length can radiate coherently. If the radiation-reaction force drives growth of the initial fluctuation, one can expect an instability which leads to micro-bunching of the beam and increased coherent radiation at short wavelengths. It has recently been realized that such an instability can play an important role in electron/positron rings where it often manifests itself as a burst of radiation in the range of hundreds of gigahertz or terahertz. This instability can also be a source of an undesirable emittance growth in bunch compressors used in the next generation short-wavelength FELs. In this talk, we will review progress in theoretical studies and numerical simulations of the microbunching instability and show connection of the theory to recent observations of the instability in electron machines.

* This work was supported by Department of Energy contract DE-AC03-76SF00515.

TOAA003 Beam Dynamics in the Spallation Neutron Source Linac

Dong-o Jeon (ORNL)

Being an 1.44MW machine, the beam loss requirement on the SNS linac is less than 1W/m and controlling halo particle generation is of great importance. Beam dynamics aspects of the SNS linac design are presented considering various halo generation mechanisms. A halo generation mechanism in the non-periodic lattices such as the SNS linac MEBT (Medium-Energy Beam-Transport between RFQ and DTL) is reported. We find that the nonlinear space charge force resulting from large transverse beam eccentricity ~2:1 in the ~1.6-m-long MEBT chopper section is responsible for halo formation. The proposed mitigation measures are modifying the MEBT optics and introducing adjustable collimators in the MEBT, which significantly reduce beam losses in the CCL. The transient beam behavior of the LEBT and MEBT choppers is also presented.

* This work is supported by the SNS Project managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

TOAA004 Crystalline Beams in the RF Quadrupole Storage Ring PALLAS

Ulrich Schramm, Michael Bussmann, Dietrich Habs, Schaetz Tobias (Sektion Physik, LMU Munich)

Systematic studies on the Coulomb crystallization of laser cooled ion beams in the table-top rf quadrupole storage ring PALLAS will be presented. Freezing out the relative motion of ions in a beam, their mutual Coulomb repulsion induces the ions to arrange themselves in a crystal-like structure with unique beam properties as ultimate brilliance and stability. The heating and melting of such crystalline beams in the oscillating fields providing the transverse confinement, by shear forces and by the randomness of photon scattering in the cooling process itself, will be emphasized and discussed with respect to larger scale machines. The talk will close with the matter of bunched crystalline beams, as recently experiments revealed an unexpected, yet favourable shortening of the bunches by about a factor of three as compared to the usual space charge dominated situation.

* Partially supported by DFG (Ha1101/8) and MLL Munich.

TOAA005 Computational Studies of Collective Beam Dynamics in High Intensity Rings

Jeffrey Holmes, Sarah Cousineau, Slava Danilov, Stuart Henderson, Andrei Shishlo (ORNL), Alexei Fedotov (BNL), S.Y. Lee (Indiana University)

Collective interactions of the beam with itself and with its periodic lattice surroundings in high intensity accelerator rings, such as PSR and SNS, can lead to beam growth, halo generation, and losses. These interactions also provide a rich source of dynamic phenomena for analytic, computational, and experimental study. Many of these phenomena result in relaxation of the injected beam to new, more extended steady state configurations. We concentrate here on a computational examination of collective phenomena and the associated beam relaxations in PSR and SNS, and on a characterization of the properties of the resulting beam configurations. The studies will include the effects of the accelerator lattice and focusing, space charge, and impedances.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

TOAA006 Effect of Stimulated and Thermal Desorption in DARHT-2

Thomas Hughes (Mission Research Corporation), Harold Davis (LANL)

The DARHT-2 accelerator generates a 2 kA, 20 MV, 2 microsecond flat-top electron beam. The beam risetime is of order 500 ns, and a "beam cleanup zone" (BCUZ) has been designed to scrape off these

mismatched electrons. Experiments on DARHT-1 (a 60 ns machine) have provided excellent quantitative data on stimulated and thermal desorption of neutral monolayers on various metal surfaces by multi-MV electrons. We have used these data in the particle-in-cell code LSP to model the production and subsequent ionization of wall-desorbed species in the DARHT-2 BCUZ. The effect of these ions on the transport of the main beam pulse will be presented. In particular, we will show how this effect restricts the size of the scraping apertures that can be used.

* Work supported by Los Alamos National Laboratory.

TOAA007 Beam-Beam Interaction, Electron Cloud, and Intrabeam Scattering for Proton Super-Bunches

Frank Zimmermann, Francesco Ruggiero (CERN), Yannis Papaphilippou (European Synchrotron Radiation Facility), Giovanni Rumolo (Gesellschaft für Schwerionenforschung mbH)

Long super-bunches or uniform (hollow) bunches with a flat longitudinal profile could potentially increase the LHC luminosity in a future upgrade. We present example parameters and discuss a variety of issues related to such a scheme, including beam-beam tune shift, tune footprints, crossing planes, luminosity, intrabeam scattering, and electron cloud. We highlight the benefits, disadvantages, and open questions.

TOAA008 New Intrabeam Scattering Analysis Applied to ATF

Boaz Nash, Karl Bane, Alex Chao (SLAC)

We present the preliminary results of a new analysis of intrabeam scattering. We believe that our formula for the growth rates is more precise than those of Bjorken-Mtingwa or Piwinski and does not include an ambiguous Coulomb Logarithm. We show that our equation reduces to the Bjorken Mtingwa result given particular assumptions about the parameters. The equation is applied to the case of the ATF damping ring. We compute effective "Coulomb Logs" for the growth rates in the different directions by comparing our result to the reduced "Bjorken-Mtingwa" result. Finally, we explore the dependence of the emittance growth rates on the dispersion and find for what range of parameters our equation gives results differing substantially from the standard approaches. References: A. Piwinski, in Handook of Accelerator Physics and Engineering, edited by A. Chao and M. Tigner. (World Scientific, Singapore,1999) p. 125; and J.D. Bjorken and S. K. Mtingwa, Part. Accel. 13, 115 (1983).

* Work supported by Department of Energy contract DE-AC03-76SF00515.

TOAA009 Nonlinear Resonance Benchmarking Experiment at the CERN Proton Synchrotron

Ingo Hofmann, Giuliano Franchetti (Gesellschaft für Schwerionenforschung mbH), Massimo Giovannozzi, Michel Martini, Elias Metral (CERN)

A benchmarking experiment was carried out with the goal of verifying the understanding and simulation capabilities of the effect of space-charge forces on a resonance driven by a single octupole. Using a single bunch under the influence of a maximum space-charge horizontal tune spread of 0.07, the beam loss and emittance evolution was measured over 1.2 s on a 1.4 GeV kinetic energy flat-bottom. By varying the horizontal machine working point in between the third-order and the fourth-order resonance lines a gradual transition from a regime of loss-free core-emittance blow-up to a regime where continuous loss occurs, but with little or no effect on the rms emittance, has been observed. This main experimental finding is compared with long-term simulations using an octupolar kick in an otherwise linear lattice together with a simplified analytical 3D space-charge model. The simulation confirms the existence of the core blow-up regime. Furthermore, it also shows that for tunes approaching the fourth-order resonance (from above), particles diffuse into a halo of increasing size. This may be the mechanism of the observed loss, where the reduced dynamic aperture close to the resonance extracts the halo particles.

TOAA010 Stray Electron Accumulation and Effects in HIF Accelerators

Ronald Cohen, Steven Lund, Arthur Molvik (LLNL), Miguel Furman, Jean-Luc Vay (LBNL), Peter Stoltz (TechX Corp.)

Stray electrons can be introduced in positive-charge accelerators for heavy ion fusion (or other applications) as a result of ionization of ambient gas or gas released from walls due to halo-ion impact, or as a result of secondary-electron emission. Electron accumulation is impacted by the ion beam potential, accelerating fields, multipole magnetic fields used for beam focus, and the pulse duration. We characterize the electron cloud from a sequence of simulations: ion wall impacts are extracted from an ion particle-in-cell simulation, an electron birth distribution from the above processes is determined, and the subsequent dynamics of the electrons is followed. Also, we present ion simulations with prescribed random electron distributions, undertaken to begin to quantify the effects of electrons on ion beam quality.

* Work performed for the USDOE by UC-LLNL under Contract W-7405-ENG-48, and by UC-LBNL under Contract DE-AC03-76F00098.

TOAA011 Observation of Strong-Strong and Other Beam-Beam Effects in RHIC

Wolfram Fischer, M. Blaskiewicz, J.M. Brennan, P. Cameron, R. Connolly, C. Montag, S. Peggs, V. Ptitsyn, S. Tepikian, D. Trbojevic, J. van Zeijts (BNL)

RHIC is currently the only hadron collider in which strong-strong beam-beam effects can be expected. For the first time, coherent beam-beam modes were seen in a bunched beam hadron collider. Other beam-beam effects in RHIC were observed in operation and in dedicated experiments with both gold ions and protons. Observations include measurements of beam-beam induced tune shifts, Schottky spectra with and without beam-beam interaction, and lifetime and emittance growth measurements with and without beam-beam interaction. During ramps unequal radio frequencies in the two rings cause the crossing points to move longitudinally. Thus bunches experience beam-beam interactions only in intervals and transverse tunes are modulated.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

TOAA012 Progress Report on the Small Isochronous Ring Project at NSCL

Eduard Pozdeyev (National Synchrotron Radiation Lab), Don Lawton, Felix Marti, Jose Rodriguez, David Sanderson, Richard York, Al Zeller, Roger Zink (National Superconducting Cyclotron Laboratory)

The small Isochronous Ring (SIR), whose main objectives are experimental studies of space charge effects in the isochronous regime and validation of space charge codes, is under development at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU). The ring is a small-scale experiment that simulates the dynamics of intense beams in large-scale accelerators. It will store hydrogen and deuterium ions at energies of approximately 20-30 keV for a few tens of turns. The low beam energy and the small scale of the experiment provide a unique opportunity to perform accurate experiments on the space charge that are difficult to conduct in large-scale accelerators because of power and timing limitations imposed on beam diagnostics. The paper reports the status of the project and describes the progress in the development of ring subsystems.

* Work supported by NSF Grant PHY 0110253.

Session TOAB: Magnets
Pavilion West at 8:30
Session Chairs: S. Gourlay, A. Zlobin

TOAB001 The LHC Superconducting Magnets

Lucio Rossi (CERN)

The Large Hadron Collider (LHC) is under construction at CERN. Most of its 27 km underground tunnel will be filled with superconducting magnets, mainly 15 m long dipoles and 3 m long quadrupoles. The 1232 main dipole and 392 main quadrupole magnets, are complemented by a number of insertion quadrupole magnets: among them there are 86 MQM (matching), 26 MQY (wide aperture) and 32 low-beta quadrupoles (these last built by KEK and Fermilab). The about 6000 superconducting corrector magnets, many of them individually powered, are also very critical for the functioning of the accelerator. All based on copper stabilized NbTi Rutherford cables or single strands, these superconducting magnets will operate in superfluid helium at 1.9 K. The paper briefly reviews the main characteristics of these magnets and addresses the critical points of the design with respect to the use for such a complicated accelerator as LHC. Then the status of the production of the superconducting cable and of the magnets is given, with particular emphasis to the QA/QC procedures taken to ensure the industrial production according to the tight requirements, and the principal results on the first 30 main dipoles arepresented. Finally, the plan put in place to meet the LHC schedule is discussed.

TOAB002 High Field Accelerator Magnets Beyond LHC

Arnaud Devred (CE Saclay)

The LHC magnet R&D Program has shown that the limit of NbTi technology at 1.8 K is in the range 10 to 10.5 T. Hence, to go beyond the 10-T threshold, it is necessary to change material. Given the state of the art in high temperature superconductor (HTS), the only serious candidate is Nb_3Sn. A series of dipole magnet models built at Twente University and LBNL and a vigorous program underway at Fermilab have demonstrated the feasibility of Nb_3Sn magnet technology. The next step is to bring this technology to maturity, which requires further conductor and conductor insulation development and a simplification of manufacturing processes. After reviewing the main results of ongoing R&D programs around the world, we outline a roadmap to address outstanding issues. This roadmap has become the backbone of a new initiative promoted by the European Steering Group on Accelerator R&D (ESGARD), an initiative that complements the US proposal for a second generation of LHC Insertion Region magnets and the high field accelerator magnets in the US laboratories.

TOAB003 Advances in Superconducting Materials for Accelerator Magnet Application

Peter Lee, David Larbalestier (Applied Superconductivity Center, University of Wisconsin-Madison)

Considerable advances have recently been obtained in the critical current densities of Nb_3Sn based superconductors – the prime candidates for the next generation of superconducting accelerator magnets. The non-Cu critical current densities now approach 3000 A/mm^2 at 12 T and 4.2 K in engineering quality strand. The design of these strands minimizes the amount of Cu in the non-stabilizer regions and increases the Sn level beyond the level required to simply achieve stoichiometry in the A15 phase. The result is an A15 layer that is remarkably uniform, both chemically and microstructurally that significantly surpasses previous Nb_3Sn strands not only in layer critical current density but in the specific grain boundary pinning force. Remarkably, these developments have been achieved in internal Sn based strands manufactured using both the modified jelly-roll technique with Nb-Ti alloy and using the rod-in-tube approach with Nb-Ta alloy. Parallel to this effort advances have also been made in strand design that offer the potential to reduce effective filament diameter, which is an issue with the new high-J_c strands. We review the latest developments in Nb_3Sn superconductors and compare their performance and potential with other strand-based superconductors.

* This work was supported by the U.S. Dept. of Energy under Grant DE-FG02-91ER40643 (High Energy Physics).

TOAB004 Novel Insertion Devices

Elizabeth Moog (ANL)

Permanent magnet planar undulators are used at synchrotrons worldwide and serve as versatile radiation sources. Some experiments, however, find advantages in photon characteristics other than what is achievable with planar devices. Undulators can be tailored to adjust photon characteristics such as brightness, tuning curves, polarization, harmonic content, and heat load to suit them to a particular experiment. One specialized device is the electromagnetic circularly polarizing undulator at the Advanced Photon Source (APS). At a few facilities, plans are underway to build superconducting undulators with short period lengths to provide higher energy radiation. At APS, the possibility of building an undulator with a variable period is also being investigated. Some users, driven by a desire for lower on-axis heat load or for circular polarization, prefer other types of devices such as Apple-style undulators or figure-eight devices. Characteristics of the radiation output and advantages of these various types of devices will be discussed.

* Supported by the U.S. Dept. of Energy, BES-Materials Sciences, under Contract W-31-109-Eng-38.

TOAB005 Radiation Resistant Magnet R&D at the NSCL

Al Zeller (National Superconducting Cyclotron Laboratory)

Proposed accelerator projects, such as neutrino factories, RIA and the GSI upgrade, will produce high radiation fields in the vicinity of superconducting magnets. Work has been done on technology for magnets that are resistant enough to have acceptably long lifetimes. Although solutions for radiation resistant resistive magnets are well established, the technology has not been applied to superconducting magnets for accelerators. For magnets exposed to lifetime doses of ~ 50 MGy, radiation hard epoxies can be used. For levels above that, three approaches have been examined: Superferric dipole magnets can be constructed with all-inorganic cryostable coils. Higher current density options use Cable-in-Conduit-Conductor (CICC). One proposed solution is to anodize the interior of aluminum conduit, allowing welding the coil into a strong unit. Another approach is to sheath the standard CICC in a metal oxide layer inside of a copper or stainless steel outer shell where soldering or welding is used for strength. Model coil and conductor production results will be presented.

* Work supported in part under NSF grants PHY-0110253, -0104619, -9809799 and DOE grant DE-FG0200ER41144.

TOAB006 Performance Summary of the Helical Magnets for RHIC

Erich Willen, Mike Anerella, John Escallier, George Ganetis, Arup Ghosh, Ramesh Gupta, Michael Harrison, Animesh Jain, William MacKay, Andrew Marone, Joseph Muratore, Stephen Plate, Richard Thomas, Peter Wanderer, Kuo-Chen Wu (BNL), Masahiro Okamura (RIKEN Accelerator Research Facility)

A series of four Snake and eight Rotator superconducting helical magnet assemblies has been built and installed in RHIC to control the polarization of protons during acceleration and storage in that machine. Each of these assemblies consists of four 2.4 m long dipole

magnets in each of which the field rotates through 360 degrees along the magnet's length. The magnets were made by winding one millimeter diameter superconducting 7-strand cable into slots milled into thick-walled aluminum tubes. The magnets produce 4 Tesla field at a current of 320 amperes and are quench-protected with 0.050 ohm resistors placed across the winding in each slot. A total of 48 of these 2.4 m magnets has been built, tested and installed. This paper summarizes their quench performance as well as their field uniformity, of which the integral field is the most critical. All magnets reached the required operating field level of 4 T, and the integral field of the magnets was generally about half of the permissible level of 0.050 tesla meters.

* Work supported by the U.S. Department of Energy and RIKEN of Japan.

TOAB007 Production and Testing Considerations for CESR-c Wiggler Magnets

David Rice, Richard Gallagher, Yun He, Jagadisan Kandaswamy, Valery Medjidzade, Alexander Mikhailichenko, Nari Mistry, Tobey Moore, Steve Richichi, Karl Smolenski, Alexander Temnykh, William Trask (Cornell University)

Based on experience with the construction and testing of a prototype magnet, the 16 wiggler magnets planned for CESR-c operation can be produced at the rate of one per month with a relatively small in-house staff and fabrication of a few components by outside shops. We present details of the fabrication, assembly, and testing program for these 2.1 Tesla, 1.3 m active length superferric wigglers which meet CESR-c's demanding field quality requirements.

* Work supported by the U.S. National Science Foundation.

TOAB008 Magnetic Field Measurements of the Nb_3Sn Common Coil Dipole RD3c

Luisa Chiesa, Shlomo Caspi, Dan Dietderich, Paolo Ferracin, Steve Gourlay, Ray Hafalia, Al Lietzke, Al McInturff, GianLuca Sabbi, Ron Scanlan (LBNL)

The goal of the LBNL Superconducting Magnet Program is to establish the technologies associated with very high field superconducting magnets, in order to provide cost-effective options for the next generation of high energy physics colliders. Recent efforts have focused on the design, fabrication and test of Nb_3Sn common coil dipoles. The RD3b test has demonstrated operation at very high field and stress levels. RD3c is the first common coil prototype addressing accelerator quality issues. A flat racetrack coil was wound on both sides of a central bore plate, using hard spacers to control the geometric field harmonics. The resulting coil module was inserted between the outer coil modules of RD3b, and pre-stressed using the reusable yoke and shell loading structure. In this paper, magnetic field measurements of RD3c are reported and compared with theoretical predictions.

* Work supported under contract DE-AD03-76SF00098 by the Director, Office of Energy Research, Office of High Energy Physics, U.S. Department of Energy.

TOAB009 Steering Field Quality of the LHC Dipoles Towards Beam Dynamics Limits

Walter Scandale, Luca Bottura, Arnaud Devred, Vittorio Remondino, Stephan Sanfilippo, Ezio Todesco, Christine Vollinger, Elena Wildner (CERN)

The field quality measurements at room temperature of around 100 collared coils of the main LHC dipoles are analysed. Using correlations to field measurements at 1.9 K, comparison with beam dynamics limits are discussed. Both random and systematic components are analysed, allowing to pin out the most critical multipoles. Corrective actions that have been taken during the pre-series phase are presented; we focus on the low order systematic multipoles that are shown to be the most difficult components to steer. A preliminary analysis of the integrated main field and of its implications on the possible scenarios for the installation are also carried out.

TOAB010 Development and Test of Single-Layer Common Coil Dipole Model Made of Pre-Reacted Nb_3Sn Cable

Giorgio Ambrosio, Nikolai Andreev, Emanuela Barzi, Deepak Chichili, Sandor Feher, Linda Imbasciati, Alexander Zlobin (FNAL)

A single-layer common coil dipole magnet has been developed at Fermilab for a future Very Large Hadron Collider. The magnet was designed to provide a 10 T nominal field in two 40-mm apertures at the operation temperature of 4.5 K. It uses Nb_3Sn superconductor and the react-and-wind fabrication technique. This magnet has several innovative features such as: single-layer racetrack coils, a 22-mm wide 59-strand Rutherford-type cable made of 0.7-mm Nb_3Sn strands, and stainless steel coil support structure reinforced by horizontal bridges inserted between coil blocks. The coils are wound simultaneously into the collar structure and then impregnated with epoxy. The collared coils are surrounded by a vertically split iron yoke and a 10-mm thick stainless steel skin. The first one-meter long model of this magnet has been fabricated and tested. It was instrumented with voltage taps, quench heaters, temperature and strain gauges in order to monitor the quench origin and propagation, and to study mechanical and quench protection issues. This paper summarizes the model design parameters, the fabrication procedures and the test results.

* This work was supported by the U.S. Department of Energy.

Session TOAC: Free Electron Lasers & Energy Recovery Linacs
Pavilion East at 8:30
Session Chairs: L. Merminga, W. Graves

TOAC001 ERL Light Sources: An Overview

James Murphy (BNL)

Sparked by the highly successful operation of energy recovery linac (ERL) free electron lasers (FELs) at TJNAF and JAERI and also by the novel MARS light source proposal from BINP, numerous facilities worldwide are now considering ERL based light source projects. A survey of the various light source and FEL projects based on ERL technology will be given. An overview of the critical R&D issues that must be addressed in future ERLs will also be presented.

* Work performed under DOE Contract DE-AC02-98CH10886.

TOAC002 FEL Oscillators

George Neil (Thomas Jefferson National Accelerator Facility)

FEL oscillators have been around since 1977, serving not only as testbeds for the physics of free-electron lasers but also as workhorses of scientific research. More than 30 FEL oscillators are presently operating around the world spanning a wavelength range from the mm region to the ultraviolet using DC and rf linear accelerators and storage rings as electron sources. The characteristics that have driven the development of these sources are the desire for high peak and average power, high micropulse energies, wavelength tunability, timing flexibility, and wavelengths that are unavailable from more conventional laser sources. Substantial user programs have been performed using such sources encompassing medicine, biology, solid state research, atomic and molecular physics, effects of non-linear fields, surface science, polymer science, pulsed laser vapor deposition, to name just a few. Recently the incorporation of energy recovery systems has permitted extension of the average power capabilities to the kW level and beyond. Moreover the use of collective radiation and Thomson/Compton scattering has produced substantial fluxes of

THz radiation, X-rays, and gamma rays. This paper will discuss at a summary level the physics of such devices, survey existing and planned facilities, and touch on the applications that have driven the development of these popular light sources.

* This work was supported by U.S. DOE under contract DE-AC05-84ER40150, the Office of Naval Research, The Commonwealth of Virginia, The Air Force Research Laboratory, and the Laser Processing Consortium.

TOAC003 A Recirculating Linac-Based Facility for Ultrafast X-Ray Science

John Corlett, W.A. Barletta, W. Barry, J. M. Byrd, S. DeSantis, L. Doolittle, W.M. Fawley, P. Heimann, D. Li, S. Lidia, I. Reichel, K.E. Robinson, R. Schoenlein, J. Staples, J. Tanabe, W. Wan, R. Wells, A. Wolski, A. Zholents (LBNL), M. Placidi (CERN), Y. Petroff, W. Pirkl (Consultant), S. Wang (Indiana University), F. Parmigiani (Sincrotrone Trieste), R.A. Rimmer (Thomas Jefferson National Accelerator Facility)

We present an updated design for a proposed source of ultra-fast synchrotron radiation pulses based on a recirculating superconducting linac. The source produces intense pulses with duration of order 100 fs or less at a 10 kHz repetition rate, optimized for the study of ultra-fast dynamics. The photon range covers the UV to hard x-ray spectrum by use of seeded harmonic generation in undulators, and a specialized technique for ultra-short-pulse photon production in the 1 – 10 keV range. High-brightness rf photocathodes produce electron bunches which are optimized either for coherent emission in undulators, or to provide a large x/y emittance ration and small vertical emittance which allows for manipulation to produce short-pulse hard x-rays. An injector linac accelerates the beam to 120 MeV, and is followed by four passes through a 750 MeV recirculating linac. We describe technical developments in key areas including high rep-rate rf photocathode design, flat-beam production, collective effects, lattice design, superconducting rf structures, x-ray beamline optics, UV and soft x-ray production by high-gain harmonic generation, and synchronization between experimental pump lasers and the x-ray pulse.

* This work was supported by the U.S.Department of Energy under Contract No. DE-AC03-76SF00098.

TOAC004 4GLS - a New Type of Fourth Generation Light Source Facility

Michael Poole (Daresbury Laboratory)

The 3 GeV national light source DIAMOND being under construction, with its emphasis on high brightness x-ray production, consideration is now being given in the UK to the necessary complementary provision of an advanced lower energy facility. The resultant proposed solution, 4GLS, is a superconducting energy recovery linac (ERL) with output energy around 600 MeV, delivering CW beam currents up to 100 mA or alternatively high charge bunches for FEL applications. Production of short (fs) bunches is a vital part of the specification and will require a flexible beam transport system incorporating various compression stages. In addition to the undulator beam lines with sources in the ERL recirculation path there will be three FELs; two will be oscillator types in the infared and VUV respectively, and the third will be a high gain system for XUV output. The paper outlines the project, its current status and the R&D challenges that it poses.

TOAC005 The Cornell ERL Prototype Project

Charles Sinclair, Georg Hoffstaetter (Cornell University)

Synchrotron light sources based on Energy Recovery Linacs (ERLs) show promise to deliver X-ray beams with both brilliance and X-ray pulse duration far superior to the values that can be achieved with storage ring technology. Cornell University, in collaboration with Jefferson Laboratory, has proposed the construction of a prototype ERL. This 100 MeV, 100 mA CW superconducting electron accelerator will be used to study and resolve the many accelerator physics and technology issues of this type of machine. These studies are essential before ERLs can be confidently proposed for large scale applications such as synchrotron light sources. Key issues include the generation of high average current, high brightness electron beams; acceleration and transport of these beams while preserving their brightness; adequate damping of higher order modes to assure beam stability; removal of large amounts of higher order mode power from the cryogenic environment; stable RF control of cavities operating at very high external Q; reduction of beam losses to very low levels; and the development of precision non-intercepting diagnostics to allow beam setup, control and characterization. Our prototype design allows us to address these and other issues over a broad range of parameter space. This design, along with recent progress on understanding these issues, will be presented.

* Work supported by Cornell University, and by US DOE under contract DE-AC05-85ER40150.

TOAC006 CEBAF Energy Recovery Experiment

A. Bogacz, K. Beard, Y. Chao, S. Chattopadhyay, R. Dickson, D. Douglas, A. Freyberger, A. Guerra, R. Hicks, A. Hutton, R. Lauze, N. Merminga, J. Musson, W. Oren, C. Tennant, M. Tiefenback (Thomas Jefferson National Accelerator Facility)

High current CW energy recovery linacs (ERLs) are seen as important elements in planned future facilities such as next-generation light sources, electron coolers and electron-ion colliders. The Jefferson Lab FEL (5 mA, 50 MeV) has been the highest power superconducting ERL so far in operation. Full-scale demonstration of this technology with multiple cavities at the GeV energy scale is highly desirable. Such an experiment (E-02-102)has recently been approved at Jefferson Lab. There are two phases to the proposed experiment. In the first, the beam would be accelerated in the North and South linacs to about 1 GeV and then decelerated in the North and South linacs to be dumped at the injection energy. This experiment requires a new half-wavelength (RF) magnetic chicane at the end of the South linac. The second phase is a current doubling experiment. The beam would be accelerated in the North and South linacs; it would then pass through a quarter-wavelength chicane, drift through the North and South linacs with no energy change, pass throughout the chicane a second time, and be decelerated in the North and South linacs and dumped. The effective gun current would thus be doubled. The experiments will involve careful measurements of all beam properties: energy, current, emittance, and beam halo. These are important parameters, crucial in characterizing the performance of energy recovery. Furthermore, this information will be valuable in advancing the planning, design and operation of future high-energy, high-current ERLs. The CEBAF Energy Recovery Experiment involves A. Bogacz and A. Hutton (co-spokesmen), K. Beard, Y. Chao, S. Chattopadhyay, R. Dickson, D. Douglas, A. Freyberger, A. Guerra, R. Hicks, R. Lauze, N. Merminga, J. Musson, W. Oren, C. Tennant and M. Tiefenback, Jefferson Lab.

* This work was supported by the U.S. Department of Energy under Contract No. DE-AC05-84ER40150.

TOAC007 Steps Towards X-Ray Sources Based on Linac-Driven Free-Electron Lasers

Pedro Castro (DESY)

X-rays play a crucial role in the study of structural and electronic properties of matter on an atomic scale. With high-brilliance x-ray sources high resolution imaging and the observation of very fast chemical processes become possible. A high-brilliance x-ray free-electron laser (FEL) based on linear accelerator technology using the principle of self-amplified spontaneous emission (SASE) appears to

be the most promising approach. However, the high electron beam quality required by the SASE FEL process presents challenges to the linear accelerator community. Recent results obtained in several SASE FEL test facilities in the visible and ultra-violet ranges have demostrated the viability of injector systems to deliver high brightness electron bunches and longitudinal compression schemes to obtain a few kA peak current while preserving beam brigthness over a small slice of the bunch length. Challenges to new facilities reside in understanding the underlying physics to extend the technology to the x-ray region (about 0.1 nm) and in developing high-resolution phase space diagnostics. After a brief introduction to the SASE principle, we review the encouraging results of the recent experiments and present technical concepts to meet the requirements in the FEL facilities presently under construction.

TOAC008 Computational Free Electron Laser Physics

William Colson (Naval Postgraduate School)

Since the invention of the free electron laser (FEL) about 30 years ago, several hundred FELs have been built and operated around the world. The fundamental FEL mechanism is more closely tied to accelerator physics than it is to either laser physics or plasma physics; in addition, the most important part of an FEL system is the accelerator powering it. Over the last 25 years, computer simulations have assumed a significant role in developing and understanding FELs. The same simulation methods accurately describe microwave, infrared, visible, UV and x-ray FEL systems. New and exciting areas of development are short wavelength x-ray FELs and compact high average power FELs.

TOAC009 Applications of the Cancellation Effect in the CSR Studies

Rui Li (Thomas Jefferson National Accelerator Facility)

The cancellation effect in the dynamics of relativistic beams on a curved trajectory is studied in [R. Li and Ya. Derbenev, "Canonical Formulations and Cancellation Effect in Electrodynamics of Relativistic Beams on a Curved Trajectory", this proceedings] based on the canonical formulation of the dynamics equations and retarded potentials. In this paper, we discuss in a coherent manner the role of the cancellation effect in various applications, such as the coasting beam, short bunch self-interaction in steady state, transient self-interaction of a short bunch including entrance to and exit from a circular orbit, microbunching instability, converging beam in a chicane, the non-inertial space charge force, and spectrometer measurement. Moreover, we show that simulations explicitly using the cancellation theory give results which agree with previous simulations using brute force calculation of EM fields, where the local interaction fields were carefully calculated and the cancellation was performed implicitly through the integration of dynamics over time.

∗ Work supported by the Department of Energy under contract DE-AC05-84ER40150.

TOAC010 Pulse Length Control in an X-Ray FEL by Using Wakefields

Sven Reiche, Claudio Pellegrini (University of California, Los Angeles), Paul Emma (SLAC)

For the users of the high-brightness radiation sources of free-electron lasers it is necessary to reduce the FEL pulse length to 10 fs and below for time-resolving pump and probe experiments. Although it can be achieved by conventional compression methods for the electron beam or the chirped FEL pulse, the technical realization is demanding. In this presentation we study the impact of undulator wakefields and how their properties can be used to reduced the amplifying part of the bunch to the desired length. Methods of actively controlling the wakefields are presented.

TOAC011 FERMI@ELETTRA: The Single-Pass Free-Electron Laser for the VUV and Soft X-Ray Spectral Range at Elettra

Rene Bakker, C.J. Bocchetta, P. Craievich, G. D'Auria, M. Danailov, G. De Ninno, B. Diviacco, M. Ferianis, V. Smaluk, L. Tosi, V. Verzilov (Sincrotrone Trieste)

The FERMI project is an initiative from ELETTRA, INFM and other Italian institutes, to construct a single-pass FEL user-facility, to be located next to the third-generation synchrotron radiation facility ELETTRA in Trieste, Italy. For the initial phase, the project aims for lasing from 100 nm to 40 nm, with the use of the existing 1-GeV S-band linac. As a next step, the accelerator system should be improved and extended to gradually reach the final wavelength target of 1.2 nm. In all stages, reliability and flexibility are of importance. That is, seeding schemes are considered to improve the SASE output. In addition, users of this new source will have full control over both wavelength and polarization of the radiation. At present, the project waits for funding as a response to the Italian government's call for proposals from national institutes for a multipurpose pulsed laser X-ray source. In parallel detailed designs are studied to implement the first stage of the project. In this presentation, we describe the main features of the project. Emphasis will be given to the implementation of the first stage, i.e., modifications to the existing accelerator and electron-beam source as well as the undulator system.

TOAC012 Saturation of the NSLS DUV-FEL at BNL

Adnan Doyuran, William Graves, Richard Heese, Erik D. Johnson, Samuel Krinsky, Henrik Loos, James B. Murphy, George Rakowsky, James Rose, Timur Shaftan, Brian Sheehy, John Skaritka, X.J. Wang, Zilu Wu, Li Hua Yu (BNL)

The Deep Ultra Violet Free Electron Laser (DUV-FEL) experiment has reached a milestone by saturating the Free Electron Laser using the High Gain Harmonic Generation (HGHG) method in the Source Development Laboratory (SDL) at NSLS. It utilizes the 10 m long, 3.9 cm period NISUS wiggler. The goal of the project is to produce radiation at a wavelength less than 100 nm, utilizing the High Gain Harmonic Generation (HGHG) method, which was demonstrated in a proof of principle experiment at ATF BNL. As an initial FEL commissioning SASE at 400 nm and 266 nm has been accomplished. Operation of the seeded FEL at 266 nm has been demonstrated. A 266 nm tripled Titanium: Sapphire laser was used for seeding. Finally HGHG at 266 nm has been accomplished by seeding with the 800 nm Titanium: Sapphire laser; saturation was observed. We discuss the measurement of energy, gain, spectrum and pulse length of the FEL. We also describe the diagnostics used for the operations.

∗ Research supported by DOE Contract DEAC No. DE-AC02-98CH10886 and AFOSR/ONR MFEL Program #NMIPR01520375.

Poster Session TPAE
Exhibit Hall at 8:30

TPAE001 Operation of the LEP CW Klystrons in Pulsed Mode

Hans Frischholz, Daniel Valuch (CERN)

For possible future accelerator projects, as, e. g., the Super-Conducting Proton Linac, SPL, at CERN, it would be desirable to reuse as much of the LEP/RF equipment as possible. In the SPL, as in other proposed proton linacs, pulsed operation is required with RF pulse-lengths varying between 1 and 3 ms and a pulse repetition rate of 50 Hz. The LEP klystrons are equipped with a modulation anode by means of which their beam current and hence the output power can be controlled. In LEP the klystron output power had to be varied very slowly when the energy was ramped. In order to keep a high efficiency also in pulsed mode the rise- and fall-time of the beam pulse in the klystron should be considerably less than 100's. This goal was achieved by modifying the tetrode modulator, the HV line between modulator and klystron, and the filter network of the HV power supply. SPICE simulations were performed to evaluate the optimum values of capacitors and inductors in the HV filtering network of the LEP 100kV, 40A power converter when a specified DC pulse shape is required and up to eight klystrons are to be powered by one HV supply. These simulations are presented, together with the experimental results obtained on a modified LEP klystron/power converter assembly.

TPAE002 Upgrade of the Mark III RF System

Igor Pinayev, James Gustavsson, Ping Wang (Duke University)

In order to reduce down time between changing lasing range of the Mark III FEL we replaced the fixed coupler with a variable one. This modification allows us to adjust electron energy in the whole range without opening waveguide in a matter of few minutes. We also present other improvements in the RF system of the Mark III FEL.

* This work is supported by AFOSR.

TPAE003 New Timing System for the Mark III FEL

Igor Pinayev (Duke University)

Stability and reliability of Mark III FEL were substantially improved due to the upgrades made during last years. Now we are going to eliminate all manual controls for better reproducibility. All pulse delays and widths will be computer controlled using B850 VME timing modules manufactured by Berkeley Nucleonics Corp. Additional possibilities allowed by the new timing system are also presented.

* This work is supported by AFOSR.

TPAE004 Development of Self-Healing Capacitors for Klystron Pulse Modulators

Mitsuo Akemoto, Seishi Takeda (KEK), Hirokazu Sakaguchi (Nichicon Corporation)

We developed a self-healing capacitor to realize a compact pulse-forming network for klystron pulse modulators. The structure of the capacitor element consists of polyethylene terephthalate and polypropylene films, and the former film was coated with thin Ze-electrodes which form series of capacitors. The capacitor has a capacitance rating of 45 nF and a voltage rating of 55 kV, and the dielectric stress was designed to be about 120 V/micrometer. The design life was 9 G shots. Compared to a conventional non-healing capacitor, the energy density increased more than three times. The capacitors have been operating in the electron linear accelerator of Accelerator Test Facility at KEK and have achieved about 1 G shots without any serious problem. This paper describes the design and test results of the lifetime performance.

TPAE005 Development and Testing of a New 500 kW Power Amplifier System for 201.25 MHz

John Lyles, Steven Archuletta, Gerald Bolme, Donald Clark, Jerry Davis, William Roybal (LANL)

The Los Alamos Neutron Science Center staff is developing replacement systems for the 201.25 MHz drift tube linac RF plant, which was commissioned thirty years ago. A critical upgrade component is the intermediate power amplifier (IPA) stage, which operates at 120 kW peak power at up to 12% duty factor. Presently each IPA consists of an RCA cavity amplifier using a Burle 4616 tetrode. This is used to drive the final power amplifier (FPA), using a Burle 7835 superpower triode in the present configuration. Another goal is to replace the complex DTL tank 1 RF system with a single tetrode, driven by a solid state intermediate stage. The peak power output would need to be about 400 kW. In response to these two requirements an RF amplifier system has been developed at Los Alamos which uses a single Thales TH781 tetrode in a Thales TH18781 cavity amplifier. This new subsystem was packaged as a stand-alone transmitter and has been tested with high peak power and high duty factor. The IPA also has application as a compact power source for other loads such as a radio frequency quadrupole accelerator. Aspects of the design and final performance will be presented.

* Work supported by the United States Department of Energy under contract W-7405-ENG-36.

TPAE006 Ferrite Evaluation for AHF Proton Synchrotron RF Systems

John Lyles, Lawrence Rybarcyk (LANL), James Bridges (TechSource)

The Advanced Hydrotest Facility (AHF) proton synchrotrons will have parallel-biased, Nickel-Zinc ferrite core accelerating cavities. The booster frequency is anticipated to be in the range of 0.57 – 1. 9 MHz, depending on the choice of final energy, while the 50 GeV main ring is 4.2 – 5.0 MHz. A series of experiments were conducted with a two-core test cavity to characterize the response of several ferrite materials over these frequency ranges. Testing of Ferroxcube 4M2 for the booster revealed degraded performance at average magnetic flux densities > 7 mT. The response was dominated by the nonlinear incremental permeability at high flux density [G. Rakowsky and A. Tranis, "Nonlinear Effects in Linear Ferrites at High RF Fields", IEEE Trans. Nucl. Sci., NS-16: p. 543-5, June, 1969]. This constrains the operating voltage to a range well below the thermal power limits of the material. The 4M2 material appears to be satisfactory for the Main Ring. The final cavity designs will be based upon the results of ferrite measurements from the test cavity, for the requirements of the AHF accelerators. Testing methods, analysis and results will be presented.

* Work supported by the United States Department of Energy under contract W-7405-ENG-36.

TPAE007 The SNS Linac High Power RF System Design, Status, and Results

Daniel Rees (LANL)

The Spallation Neutron Source being built at the Oak Ridge National Lab in Tennessee requires a 1 GeV proton linac. Los Alamos has responsibility for the RF systems for the entire linac. The linac requires 3 distinct types of RF systems: 2.5-MW peak, 402.5 MHz, RF systems for the RFQ and DTL (7 systems total), 5-MW peak, 805 MHz systems for the CCL and the two energy corrector cavities (6 systems total), and 550-kW peak, 805 MHz systems for the superconducting sections (81 systems total). The design of the SNS Linac RF system was summarized in the 2001 Particle Accelerator Conference in Chicago. Vendors have been selected for the klystrons (3 different vendors), circulators (1 vendor), transmitter (1 vendor), high power RF loads (2 different vendors), waveguide (1 vendor), and High Voltage system

(1 vendor). This paper presents the results and status of vendor procurements, test results of the major components of the Linac RF system and our installation progress.

* Work supported by the Office of Science, Basic Energy Sciences, of the U.S. Department of Energy; and the Oak Ridge National Laboratory.

TPAE008 MW Level Semiconductor Microwave Source Using IMPATT Diodes

Guo Jiquan, Sami Tantawi (SLAC)

IMPATT (IMPact ionization Avalanche Transit Time) diode is widely used as high power microwave source, with near 1kw peak capacity at X band. This paper introduces a new approach to achieve higher RF power in one device by integrating numbers of IMPATT diodes on one round semiconductor wafer. The wafer is placed in the cross-section of circular waveguide and the diodes on wafer are placed in accordance of TE01 field in the waveguide so the power generated from diodes is combined. Several fabricate schemes are discussed and results are demonstrated.

TPAE009 X-Band Overmoded High-Power RF Phase Shifter/ Combiner

Sami Tantawi, Christopher Nantista (SLAC), Lawrence Ives (CCR)

We present an overmoded waveguide rf planer structure that combines two rf signals and controls the phase shift between them. The structure is formed from a set of planer hybrids. Some of ports of these hybrids are terminated with movable shot circuits. These hybrids are overmoded in height to allow the device to handle high power rf pulses. We present the design of the planer structure, the overmoded shorts and the tapers needed to match the input and output waveguides to this overmoded structure. We will also show a comparison with cold test data.

TPAE010 JLAB High Efficiency Klystron Baseline Design for 12 GeV Upgrade

Haipeng Wang, Jean Delayen, Leigh Harwood, Curt Hovater, Richard Nelson (Thomas Jefferson National Accelerator Facility)

A computer design of a 13.5 kW, 1497 MHz, CW type, 55% efficiency, 0.8 μ P beam perveance, ~40 dB gain, 5-cavity klystron has been developed for the CEBAF 12 GeV Upgrade project. The design uses TRICOMP codes to simulate the gun, modulating anode section, solenoid focus channel and beam dump. The klystron tube was designed by JPNDISK (1D) code initially and then optimized by MASK (2D) code for the baseline parameters. All of these codes have been benchmarked by JLAB 5 kW operational klystrons. The details of design parameters and the simulations by MAFIA (3D) for the cavity couplers, tuners, and window are also presented.

* This work was supported by U.S. DOE under contract DE-AC05-84ER40150.

TPAE011 Analytical Design of a Waveguide Iris/Stub Tuning Coupler to an Overcoupled Superconducting Cavity

Haipeng Wang (Thomas Jefferson National Accelerator Facility)

The high RF power test of a superconducting cavity without beam loading requires a variable coupling scheme. For a fixed power coupler and a finite source power, one needs to increase the external Q. A 3-stub tuner placed between the doorknob transition and an iris plate inside of WR975 waveguide has been developed for the SNS cryomodule test facility. This paper describes the theoretical analysis, calculation by equivalent circuits and the coupling scale related to the stub tuning and the iris size. A copper model bench measurement and a 3D computer simulation proved the principle and some of the parameters. A factor of 100 over Qext=$5x10^5$ has been achieved when implemented in the cryomodule test.

* This work was supported by the U.S. Department of Energy under contract number DE-AC05-00OR22725.

TPAE012 HOM Damping Performance of Jlab SL21 Cryomodule

Haipeng Wang (Thomas Jefferson National Accelerator Facility)

The new SL21 cryomodule is the first 8-cavity string superconducting accelerator module to be installed in CEBAF. Each cavity has 7-cells. The center cells have Mark II (Cornell) shape and the end cells have the Mark III shape. The HOM couplers resemble the DESY welded type; two are attached at one end of the cavity outside the tuner hub, separated azimuthally by 115°. There is a λ/4 stub fundamental power waveguide at the other end of cavity. The first two passbands of TE111 and TM110 modes have to be damped to avoid beam breakup problems at 460 μA current. External Q's of the HOM couplers and waveguide were measured on a copper model, on cold niobium cavities and finally in the cryomodule test without beam. This paper presents all HOM data associated with this structure. A threshold current calculated by MATBBU based on the real beam optics and HOM spectra will be discussed.

* This work was supported by U.S. Department of Energy under contract number DE-AC05-84ER40150.

TPAE013 Operation of a Four-Cavity Gyrokylstron for Advanced Accelerators

Wes Lawson, Steve Gouveia, Victor Granatstein, Bart Hogan (University of Maryland)

In this paper we will discuss a new four-cavity experiment designed to produce over 80 MW of peak power at 17.136 GHz with a frequency-doubling gyroklystron. This tube should have enhanced gain over previous three-cavity tubes and should enable us to use a TWT driver which can utilize phase-adjustment to meet the stringent accelerator requirements on phase stability. The design of two major subsystems will also be discussed. The first is a feed-forward system to measure and reduce phase variiations in the output signal. The second is an output waveguide system designed to convert the gyroklystron output into a form suitable for injection into an accelerator structure developed by the Haimson Research Corporation.

* This work is supported by the US Department of Energy.

TPAE014 On Creation of a Cathode Unit for the X-Band Klystron

Anatoly Dovbnya (Kharkov Institute of Physics and Technology), M.I. Ayzatsky, V.N. Boriskin, M.A. Krasnogolovets, V.A. Kushnir, V.A. Mitrochenko, N.G. Reshetnyak, Yu.Ya. Volkolupov, V.V. Zakutin (NSC KIPT)

The existing X-band klystrons applied in accelerator engineering have a high supply voltage (300 ... 500 kV) and a pulse power between 30 and 50 MW. Medical therapeutic accelerators require X-band klystrons with a pulse power of 1 to 5 MW and a voltage between 50 and 100 kV. The investigators at SRC Accelerator, NSC KIPT, are developing the units of the X-band klystron with an output power of 1 to 2 MW. For this purpose, a magnetron gun with a cold secondary-emission metallic cathode is supposed to used as an electron source. The secondary-emission sources have a long service life and provide a higher beam current density as compared to thermionic-cathode guns. The studies performed with a single magnetron gun having a copper cathode, 40 mm in diameter, and a cylindrical anode, 50 mm in diameter, at a cathode voltage amplitude of 30 kV and a magnetic field strength of 2500 Oe have shown that the present source generates a tubular beam with an outer diameter of 43 mm, an inner diameter of 41 mm and a beam current of 60 A. The duration of the beam current

pulse was about 5 ms, the repetition rate was 15 Hz, the pulse power of the beam was measured to be 1.8 MW, the microperveance being about 11. An important parameter of the electron source for the klystron, namely, the beam current stability, was investigated. The experiments have shown the current stability to be between 2 and 4 % at a cathode voltage amplitude stability of 1 to 2 %.

TPAE015 Development of a 50 MW Multi-Beam Klystron at 11.424 GHz

Lawrence Ives, Liqun Song (Calabazas Creek Research, Inc.)

Multi-beam klystrons operate at lower voltage and higher efficiency than single beam klystrons and are being studied intensively for advanced accelerators and radars. Using an eight beam electron gun, currently being built on an existing SBIR program, Calabazas Creek Research, Inc. is designing an eight beam, 50 MW, 11.424 GHz klystron with efficiency greater than 50%. The klystron employs ring resonator cavities for the input and output structures and regular hybrid cavities for intermediate cavities. Each individual beam will be focused by the same solenoidal magnetic field. A complete investigation of mode competition in the ring resonators, beam coupling, beam loading as well as the simplified approach to drive with the same phase will be addressed with 3D modeling. This presentation will describe the RF circuit design and the RF beam interaction analysis for the entire klystron.

* This research is supported by U.S. Department of Energy SBIR Grant DE-FG03-02ER83379.

TPAE016 Improved Cathodes for High Power RF Sources

Lawrence Ives, George Miram, Maxwell Mizuhara, Michael Read (Calabazas Creek Research, Inc.), Philipp Borchard, Lou Falce (Consultant), Kim Gunther (HeatWave Laboratories, Inc.)

All high power RF sources start with an electron beam generated by a cathode. The quality of this cathode directly impacts the performance of the RF device. Typically, dispenser cathodes heated to approximately 1000 C provides the electrons constituting the electron beam that is subsequently used to drive an RF circuit. A number of high power devices recently suffered significant performance degradation due to nonuniform emission from the cathode surface. Nonuniform emission can be caused by variations in temperature or work function across the cathode surface. Research is underway to determine the causes of both temperature and work function nonuniformity and derive improved construction and processing techniques and procedures to reduce or eliminate the problems. This information will be provided to cathode vendors and users to improve the future performance of these devices. This presentation will present the results of this research to date as well as experimental measurements of cathode performance.

* Work supported by U.S. Department of Energy under contract DE-FG03-01ER83196.

TPAE017 Development of Multiple Beam Guns for High Power RF Sources

Lawrence Ives, David Marsden, George Miram, Maxwell Mizuhara, Tom Robinson (Calabazas Creek Research, Inc.), Valentin Ivanov, Anatoly Krasnykh (SLAC)

Calabazas Creek Research, Inc. is developing multiple beam electron guns (MBGs) for high power RF sources. The program is tasked with development of a MBG for a 50-100 MW, X-Band klystron for the next generation of high energy accelerators and colliders. Multiple beam RF sources operate at significantly lower beam voltage than equivalent single beam devices. The reduction in beam voltage improves efficiency, increases bandwidth, and reduces the length of klystrons and traveling wave tubes. More significantly, the reduced voltage simplifies the power supply system and reduces generation of x-rays. For 50-100 MW RF sources, the reduced voltage allows operation with solid state power supplies. This significantly increases the power supply efficiency and dramatically lowers the cost by eliminating the pulse modulator. A prototype MBG is currently being assembled for testing in a beam analyzer. The gun is designed to operate at 175 kV and produce more than 100 MW of beam power. This presentation will describe the electrical, magnetic, and beam optics design and present available experimental results.

* Work supported by U.S. Department of Energy under contract DE-FG03-00ER82964.

TPAE018 10 MW, W-Band Gyroklystron for Accelerator Research

Lawrence Ives, Lawrence Ives, David Marsden, Max Mizuhara, Purobi Phillips, Michael Read, Tom Robinson (Calabazas Creek Research, Inc.), Jorge Gueverra (American Physical Society), Philipp Borchard (Consultant), Bart Hogan, Wesley Lawson (University of Maryland)

Calabazas Creek Research, Inc. is developing a gyroklystron amplifier for W-Band linear accelerator applications. The device will be available for testing W-Band accelerator components and systems. The gyroklystron will operate at 91.392 GHz and is predicted to produce 10 MW of RF power with an efficiency greater than 38% and a gain of 55 dB. The design uses the second-harmonic mode to reduce the magnetic field requirements and use available TWT drivers. The current circuit design employs six cavities consisting of an input cavity, three buncher cavities and a final output cavity. The output mode is a hybrid TE01/TE02 mode that facilitates transmission with reduced loss and flexibility for incorporating bends in the transmission system. The device is capable of depressed collector operation. The gyroklystron is fully assembled and ready for high power testing. This presentation will describe the design and presently available test results.

* Work supported by U.S. Department of Energy under contract DE-FG03-99ER82754 and Communications and Power Industries, Inc.

TPAE019 Development of a 550 kW Pulsed Klystron at 805 MHz for the Spallation Neutron Source Project

Steve Lenci, Edward Eisen, Brad Stockwell (Communications and Power Industries, Inc.)

The Spallation Neutron Source (SNS) is an accelerator-based neutron source being built in Oak Ridge, Tennessee, by the U.S. Department of Energy. The SNS will provide the most intense pulsed neutron beams in the world for scientific research and industrial development. CPI is supporting the effort by providing 550 kW pulsed klystrons for the super-conducting portion of the accelerator. A total of 73 units are on order. The primary output power requirements are 550 kW peak, 49.5 kW average at 805 MHz, with an electron beam-to-rf conversion efficiency of 65% and an rf gain of 50 dB. To date six units have been factory-tested. The first unit had low efficiency, but all subsequent units have met the entire specification requirements. Performance specifications, computer model predictions, and operating results will be presented.

* Work supported by Los Alamos National Laboratory.

TPAE020 Design and Test of a 100MW X-Band TE01 Window

Jeff Neilson, Lawrence Ives (Calabazas Creek Research, Inc.), Sami Tantawi (SLAC)

Research at Stanford Linear Accelerator Center (SLAC) is in progress on a TeV-scale linear collider that will operate at 5-10 times the energy of present-generation accelerators. This will require development of high power X-Band sources generating 50 -100 MW per source. Conventional pillbox window designs are capable of transmitting peak rf powers up to about 30 MW, well below the desired level required for the use of a single window per tube. SLAC has developed a 75

MW TE01 window that uses a "travelling wave" (TW) design to minimize fields at the window face. Irises match to the dielectric window impedance, resulting in a pure travelling wave in the ceramic and minimum fields on the window face. The use of the TE01 mode also has zero electric field on the braze fillet. Unfortunately, in-band resonances prevented this window design from achieving the desired 75 MW power level. Calabazas Creek Research, Inc. has developed a TW window using compact,numerically optimized,arabolic tapers to match the input diameter of 38mm to the window ceramic diameter of 76 mm. The design is projected to handle 100 MW of pulse power with a peak field at the window face of 3.6 MV/m. Cold test of the window has shown the return loss to be better than -25 dB over a 100 MHz bandwidth and resonance free. The window is scheduled for high-power testing in March 2003 at SLAC.

* This work is supported by U.S. DOE Small Business Innovative Research grant DOE DE-FG03-97ER82343.

TPAE021 Development of a Multi-Megawatt Circulator for X-Band

Jeff Neilson, Lawrence Ives (Calabazas Creek Research, Inc.), Sami Tantawi (SLAC)

Research is in progress on a TeV-scale linear collider that will operate at 5-10 times the energy of present-generation accelerators. This will require development of high power RF sources generating of 50-100 MW per source. A common device for protecting an RF source from reflected power is the waveguide circulator. Circulators are currently available at X-Band for power levels up to 1 MW and conventional technology is not capable of reaching the 50-100 MW power level required. In this presentation, we will discuss the development of an X-Band circulator operating at multi-megawatt power levels in overmoded waveguide. The circulator employs an innovative coaxial geometry using the TE01 mode. The basic building block for all lowloss circulators and isolators is a nonreciprocal element with a phase shift dependent on the propagation direction in the guide. We have constructed a TE01 nonreciprocal phase shifter which is currently under test. The induced differential phase shift and power loss is being measured and compared to calculations.

* Funded by SBIR grant DOE DE-FG03-01ER83210.

TPAE022 Performance of X-Band Pulsed Magnicon Amplifier

Oleg Nezhevenko, Vyacheslav P. Yakovlev (Omega-P, Inc.), Evgeny V. Kozyrev (BINP), Allen K. Kinkead (LET Corp.), Arnold W. Fliflet, Steven H. Gold (Naval Research Laboratory), Jay L. Hirshfield (Omega-P, Inc. and Yale University)

A frequency-doubling magnicon amplifier at 11.4 GHz has been developed and built as the prototype of an alternative microwave source for the Next Linear Collider project, and to test high power RF components and accelerating structures. The tube is designed to produce ~60 MW, ~1.2 msec pulses at 58% efficiency and 59 dB gain, using a 470 kV, 220 A, 2 mm-diameter beam. Recent results of the tube performance are presented in this paper. Operation of this magnicon has established a research facility located at NRL as only the second laboratory in the USA, after SLAC, where high-power microwave development at the NLC X-band frequency can take place.

* Research supported by the Department of Energy, Division of High Energy Physics.

TPAE023 11.4 GHz, 150 MW Pulsed Magnicon

Oleg Nezhevenko, Vyacheslav P. Yakovlev (Omega-P, Inc.), Jay L. Hirshfield (Omega-P, Inc. and Yale University)

Continued progress in high energy and nuclear physics demands a new generation of particle accelerators, which in turn requires new high-power, high-efficiency rf sources. One of the attractive candidates for this role is the magnicon, a microwave amplifier with circular deflection of an electron beam. Magnicons have shown great potential with both high efficiency and high power. In this paper a preliminary design of the magnicon for possible NLC applications is presented. The design power of this 11.424 GHz amplifier is 150 MW with pulse width up to 3msec and design efficiency is in excess of 60%. One such magnicon could replace two 75 MW NLC klystrons.

* Research supported by the Department of Energy, Division of High Energy Physics.

TPAE024 34 GHz, 45 MW Pulsed Magnicon: First Results

Oleg Nezhevenko, Michael A. LaPointe, Vyacheslav P. Yakovlev (Omega-P, Inc.), Jay L. Hirshfield (Omega-P, Inc. and Yale University)

A high efficiency, high power magnicon at 34.272 GHz has been designed and built as a microwave source to develop RF technology for future multi-TeV electron-positron linear colliders. To develop this technology, this new rf source is being perfected for necessary tests of accelerating structures, RF pulse compressors, RF components, and to determine limits of breakdown and metal fatigue. The status of this magnicon as well as the first experimental results are presented in this paper.

* Research supported by the Department of Energy, Division of High Energy Physics.

TPAE025 Equilibrium Transport of Sheet Electron Beams in Solenoidal Focusing Fields

Renato Pakter (Instituto de Fisica - UFRGS)

The transport of sheet electron beams is an important issue in the development of high-power RF generators because large amounts of current can be achieved at reduced space-charge density. In this paper we analyze equilibrium configurations for the transport of sheet electron beams in tapered solenoidal focusing fields. In particular, we use the generalized envelope equations obtained for the evolution of space-charge-dominated beams propagating through a general linear focusing channel [R. Pakter and C. Chen, Phys. Rev. E, 62, 2789 (2000)] to derive an optimal focusing field profile for sheet beam transport. Analytic solutions based on multi-time scale perturbation theory are found and compared to numerical simulations.

* Work supported by CNPq and FAPERGS, Brazil.

TPAE026 Gridded Sheet Beam Gun for an 80 MW X-Band Klystron

Michael Read, Lawrence Ives, George Miram (Calabazas Creek Research Inc.), George Caryotakis, Valentin Ivanov, Ron Koontz, Anatoly Krasnykh, Glenn Scheitrum (SLAC)

Calabazas Creek Research, Inc.(CCR) is developing a rectangular, gridded, thermionic, dispenser-cathode gun for sheet beam devices. The first application is expected to be klystrons for advanced particle accelerators and colliders, replacing standard Pierce-type guns. The sheet beam gun will operate at lower voltage while also decreasing the beam space charge density. This simplifies the power supply and modulator design and reduces shielding requirements, even with increasing frequency and/or power of the klystron. In the current program, a prototype device will operate at 415 kV, 250 A and be designed for an 80 MW, X-Band, sheet-beam klystron. The cathode will have 100 cm2 of cathode area with an average cathode current loading of 2.5 A/cm2. The gun will incorporate a shadow and control grid to allow grid pulsed operation. This will increase the system efficiency and potentially eliminate the requirement for pulse compression. We will report the electrostatic and beam optics design in both 2- and 3-D as well as thermal-mechanical analysis of the cathode region.

* Work supported by the US Department of Energy, contract #DE-FG03-01ER83209.

TPAE027 A Magnetron Injection Gun with Inverted Geometry for an 80 MW Gyroklystron

Michael Read, Lawrence Ives, George Miram (Calabazas Creek Research Inc.), Victor Granatstein, Wes Lawson, Gregory Nusinovich (University of Maryland)

A 500 kV, 500 A magnetron injection gun is being developed for the University of Maryland's Ku-band gyroklystron. The gun will have three electrodes, with the cathode at a larger diameter than the intermediate electrode, thus being an inverted form of the normal geometry. This allows the klystron's inner conductor to be supported through the electron gun, eliminating the need for the existing beam-intercepting supports and facilitating water cooling. It also allows for finer adjustment of the coax position. Details of the design, including modeling of the beam trajectories, will be presented.

* The work is supported by the Department of Energy under contract # DE-FG03-01ER83196.

TPAE028 A 13 kW Klystron for Driving Superconducting Accelerator Cavities

Michael Read, Lawrence Ives, George Miram, Al Mizuhara, Liqun Song (Calabazas Creek Research Inc.)

Calabazas Creek Research, Inc. is developing a 13 kW CW klystron power source at 1497 MHz to drive accelerator superconducting cavities, with the initial application being the Thomas Jefferson National Accelerator Facility (TJNAF) upgrade. The klystrons will operate at various power levels depending on the parameters of each superconducting cavity and on the energy delivered to the electron beam. Because each cavity may require a different power level, the klystrons will contain a perveance-determining electrode in the klystron gun. This will reduce the beam power dissipation in the collector when operating at less than full power. The klystrons will operate about 10 percent below their saturated power levels to allow headroom for control by an energy feedback system. Care will be taken to insure good stability in the linear gain region of the klystron. The efficiency goal is 55%, significantly higher than that of the current TJNAF klystrons. The klystrons will have solenoid focusing. We will report on all aspects of the design, including modeling of the gun and the RF interaction.

* Work supported by U.S. Department of energy under contract DE-FG03-0283378.

TPAE029 Development of a 10-MW, L-Band, Multiple-Beam Klystron for TESLA

Edward Wright, Adam Balkcum, Heinz Bohlen, Mark Cattelino, Lydia Cox, Mike Cusick, Fred Friedlander, Brad Stockwell, Lou Zitelli (Communications and Power Industries, Inc.)

A high-efficiency, Multiple-Beam Klystron (MBK), designated the VKL-8301, is being manufactured for the DESY Tera Electron volt Superconducting Linear Accelerator (TESLA) in Hamburg, Germany. There are a number of excellent reasons for using an MBK for this application, the primary reasons being reduced size and lower operating voltage with respect to the conventional, single-beam counterparts. Once this decision has been made, the class of MBK will be selected. MBKs can be divided into two categories: Fundamental Mode (FM) and Higher-Order Mode (HM) devices, distinguished by the interaction mode of the cavity resonators. Each class has inherent advantages and disadvantages depending upon end-user requirements. For the 10-MW, 1.3-GHz TESLA application, the HM-MBK is the clear choice. The primary factor influencing this choice is operational life, since the accelerator will require approximately 600 MBKs. The advantage of the HM approach is low cathode loading. Our cathode-loading design goal of 2 A/cm2 has been achieved. For this application, the HM-MBK cathode loading is a factor of four lower than competing FM-MBK designs and a factor of three lower than the SLAC 5045. The VKL-8301 will use six off-axis electron beams interacting with a combination of TM010 and hybrid TM020 cavities. These six beams are equally spaced on a diameter of approximately 25 centimeters. Because of the large beam-to-beam separation, individual high-area convergence guns can be utilized versus the single multi-emission-site gun used in FM-MBKs. This solution requires a sophisticated focusing system that is relatively difficult to realize, compounded by our use of confined-flow focusing. Newly developed, three-dimensional electromagnetics codes have been used to design the novel electron-beam-focusing system and cavity geometry. Modeling and simulation results will be presented, hardware will be shown, and a description of the FM- versus HM-MBK selection process will be discussed.

* Work supported by the Deutsche Electron Synchrotron, DESY.

TPAE030 Active RF Pulse Compressor at 11.4 GHz

Vyacheslav Yakovlev (Institute of Applied Physics), A. M. Gorbachev, V. A. Isaev, O. A. Ivanov, V. A. Koldanov, S. V. Kuzikov (Institute of Applied Physics and Omega-P, Inc.), Allen K. Kinkead (LET Corp.), Steven H. Gold (Naval Research Laboratory), Oleg A. Nezhevenko (Omega-P, Inc.), Jay L. Hirshfield (Omega-P, Inc. and Yale University)

Prior publications have described a single-channel rf pulse compressor configuration at 11.424 GHz using plasma switching of a high-Q TE01-mode energy storage cavity defined by the switch and a Bragg reflector [A. L. Vikharev et al., Proc. AAC'00, pp. 740-750 [AIP Conf. Proc. 569 (2001)]. High power tests of this configuration, using an 11.424-GHz magnicon that was developed jointly by Omega-P and NRL, showed compressed pulses with 24 MW peak power and 8:1 peak power gain. An improved switch design has been incorporated into a two-channel version of this compressor that is fed by a quasioptical 3-dB hybrid and configured akin to the original SLED pulse compressor developed at SLAC. This configuration has the virtues of requiring no phase shift for the incoming rf pulse, presenting a good rf match to the magnicon throughout the fill-time of the energy storage resonators, and of providing up to twice the peak output power for the same field strengths in each channel. Results of high-power tests of this new configuration at the NRL magnicon facility will be described.

* Research sponsored by US Department of Energy, Division of High Energy Physics.

TPAE031 Active RF Pulse Compressor with a Ferroelectric Switch

Vyacheslav P. Yakovlev, Oleg A. Nezhevenko (Omega-P, Inc.), Jay L. Hirshfield (Omega-P, Inc. and Yale University)

Principles and preliminary design for microwave active pulse compressor using an electrically-controlled ferroelectric switch are presented. The paper describes a design of an 11.4 GHz, 100 MW pulse compressor with a pulse width of 100 nsec and compression rate of 10. The compressor is planned to be driven by the Omega-P/NRL X-band magnicon.

* Research supported by the Department of Energy, Division of High Energy Physics.

TPAE032 PBG Structure for Multi-Beam and Sheet-Beam Klystrons

David Yu, David Newsham, Alexei Smirnov (DULY Research Inc.)

Photonic Band Gap (PBG) cavities having multiple defects are studied in frequency domain. External Q-factors are found numerically for different ports intended to damp HOMs. A new type of hybrid HOMs with coupled monopole and multipole field patterns was found. A novel radial transmission line method was introduced to calculate Q-factor of the major trapped modes of interest, and applied to an equivalent structure having absorbing external boundary of cylindrical

shape. In addition to cylindrical PBG multi-defect structures, we designed multi-defect, rectangular cavities with flat-field characteristics. Comparison with the original flat-field cavity of "barbell" type was made in terms of shunt impedance flatness and short-range wakefield loss-factor behavior. The multi-defect PBG cavities may be used for multi-beam and sheet-beam klystrons or accelerating structures.

* Work supported by DOE SBIR grant no. DE-FG03-02ER83400.

TPAE033 Construction and Testing of a 21 GHz Ceramic Based Power Extractor

David Yu, David Newsham, Alexei Smirnov (DULY Research Inc.), Wei Gai, R. Konecny, W. Liu (ANL), H. Braun, G. Carron, S. Doebert, Lars Thorndahl, I. Wilson, W. Wuensch (CERN)

A ceramic based power extractor [D. Yu et al.,AAC2002 Proceedings, 2002] operating at 21 GHz was built by DULY Research Inc. and tested at the CERN Linear Collider (CLIC) Test Facility 2 (CTF2). The structure includes a ceramic extractor section, a 2-output-port circular-to-rectangular waveguide coupler, and a 3-port rectangular waveguide combiner that provides for a singe output waveguide. Results of cold tests and full beam tests are presented and compared with theoretical and numerical models.

* Work supported by DOE SBIR grant no. DE-FG03-01ER83232.

TPAE034 Using Ferrite as a Fast Switch for Improving Rise Time of IPNS Extraction Kicker

Lawrence Donley, J.C. Dooling (ANL)

The Kicker system is used to extract beam from the Rapid Cycling Synchrotron. The Kicker consists of 4 identical pulse circuits each providing over 4000 amps to 1 of 4, 1/4 turn Magnet windings. Each pulse circuit consists of a Pulse Forming Network (PFN) that is charged to 50KV. The PFN is then discharged through a thyratron into a 6.3 ohm transmission line to one of the magnet windings. Our system has always had marginal rise time speed of around 90 ns. Although the thyratrons switches much faster than this, losses in the transmission lines cause the slowed rise time. By using ferrite to make a switch that is placed between the transmission lines and the magnet, rise time can be shortened. To make a fast ferrite switch, the saturation point must carefully be chosen. Parameters related to choosing the correct ferrite that will go into saturation fast and at the correct current will be discussed.

* This work is supported by the US DOE under contract no. W-31-109-ENG-38.

TPAE035 The 150 MW Modulators for the Injection Complex VEPP-5 Klystrons Pulse Power Supply

Alexandre Akimov, Valentin Akimov, Peter Bak, Andrey Chupyra, Ivan Kazarezov, Nikolay Kot, Valeriy Yudin (BINP)

For the complex VEPP-5 klystrons (5045, SLAC Lab., USA) power supply the modulators producing pulses with an operation frequency up to 50 Hz, a voltage of 23.5 kV, a current of 6.3 kA and duration of 3.7 microsecond are used. Now three modulators are supplying three klystrons and the forth modulator has been tested with a dummy load in the nominal mode of operation during more than 1000 hours. The modulators scheme designed about ten years ago with use of only domestic elements has proved its reliability and let us to find out the optimal ways to the modulators parts improvement. The use of the approved parts along with the modern developments application will allow to achieve the more efficient and reliable modulators operation. At present the modulators power supply scheme is based on the storage capacitance resonant charge. The use possibility of the power supply based on the storage capacitance high frequency portion charge, operating in the mode close to the constant power consumption from the mains is studied. The test results of the similar power supply designed at the low voltage and current are presented. The test results of the thyratron TGI1-2500/50 operating in the mode of more then double pulse current exceeding at the nominal mode of the modulator operation are also shown.

TPAE036 The LHC Injection Kicker Magnet

Laurent Ducimetiere, Noel Garrel (CERN), Michael Barnes, Wait Gary (TRIUMF)

Proton beams will be injected into LHC at 450 GeV by two kicker magnet systems, producing magnetic field pulses of approximately 900 ns rise time and 7.8 us flat top duration. One of the stringent design requirements of these systems is a flat top ripple of less than ~0.5 %. Both injection systems are composed of 4 travelling wave kicker magnets of 2.7 m length each, powered by pulse forming networks (PFN's). To achieve the required kick strength of 1.3 Tm, a low characteristic impedance of 5 Ohms has been chosen and ceramic plate capacitors are used as matching capacitors. Conductive stripes in the aperture of the magnets limit the beam impedance and screen the ferrite. The electrical circuit has been designed with the help of PSpice computer modelling. A full size magnet prototype has been built and tested under ultra high vacuum up to 30 kV. The pulse shape has been measured with precision at a voltage of 7.5 kV. After reviewing the performance requirements the paper presents the magnet design, emphasizing several novel design features, and discusses the test results.

TPAE037 High Power Test of 1st Closed Type Compact Modulator for the SCSS Project

Hiroshi Matsumoto, H. Baba, T. Inagaki, H. Kitamura, J.S. Oh, T. Shintake (KEK)

We have proposed a closed, compact modulator for the 50 MW C-band (5712 MHz) klystrons to be used in the injector linac for SASE-FEL of SPring-8 and the main linac for the Japan linear collider. The modulator is capable of 111 MW peak power and can function at a 60 pps maximum repetition rate. All the parts are immersed in a tank filled with insulating oil; the tank is 1.5 m wide, 1.0 m high and 1.0 m deep. An inverter-type power supply will be used to supply a high-voltage charge into the PFN circuit, thus eliminating the conventional massive charging transformer and de-Qing circuit. This closed modulator design is very advantageous in providing a good insulating environment for the high voltage and with even, non-degrading cooling.

TPAE038 Switching Power Supply for the PFL Kicker Magnet

Hikaru Sato, Tadamichi Kawakubo, Shigeru Murasugi, Eiji Nakamura (KEK), Shinji Yamanaka (Miyazaki University), Tatsuhiko Hatano, Naohisa Shimizu (NGK Insulators LTD), Akira Tokuchi (Nichicon Corporation)

SI-thyristor is expected as a solid-state high power switching semi-conducting device for the kicker magnet in the circular accelerator. Current rise has reached to 100kA/ms. We noticed this characteristic and tried the to use it for the pulse forming line (PFL). Preliminary results of the proto-type power supply of 20kV-120ns with various impedance, although the intention is 75kV-100ns, are presented.

TPAE039 Accelerated Neutron-Induced Failure Tests of 3300-V IGBTs for the Spallation Neutron Source Accelerator

Dan Borovina, Joseph Bradley III, Tom Hardek, Michael Lynch, Martin Pieck, Roy Przeklasa, William Reass, Daniel Rees, Stephen Ruggles, Bruce Takala, Paul Tallerico, Stephen Wender (LANL)

The RF transmitters for the 1-GeV Spallation Neutron Source (SNS) linear accelerator are powered by 15 converter-modulator stations. Each converter-modulator provides pulses up to 11 MW peak power

with a 1.1 MW average power to a multiple-klystron load. A low-voltage switching network, comprised of three sets of four IGBTs in an 'H-bridge' configuration, is used to generate the 20 kHz drive waveform components for the three step-up transformer primaries. This setup brings the total number of 3300-volt semiconductor IGBTs operating within the accelerator at 180. When biased to operating voltages of 1500 V or greater, all IGBTs are inherently sensitive to neutron interactions caused by background cosmic ray radiation. The project described used neutrons produced by proton spallation (with a similar spectrum as cosmic ray neutrons) to gain knowledge of failure mechanisms of the SNS IGBTs. These tests were performed using the highly accelerated neutron flux generated at the Weapons Neutron Research facility at the Los Alamos National Laboratory. The results of these experiments have shown the existence of a critical threshold voltage that lies within the operational range beyond which the IGBTs are no longer effective. This threshold varied with each brand of IGBT tested. Statistical failure times have also been projected for all brands of IGBT tested under normal biased operation with the SNS accelerator given natural neutron flux in Oak Ridge, TN.

* Supported by the US Department of Energy, Contract No. W-7405-ENG-36.

TPAE040 Electrical Breakdown Studies with Contaminated Insulators

William Waldron, Shmuel Eylon, Wayne Greenway, Enrique Henestroza, Simon Yu (LBNL)

Insulating materials such as alumina and glass-bonded mica are used in accelerator systems for high voltage feedthroughs, structural supports, and barriers between high voltage insulating oil and the vacuum beam pipe in induction accelerator cells. Mechanical stress can compromise seals and result in oil contamination of the insulator surface. We have tested various insulator cleaning procedures including ultrasonic cleaning with a variety of aqueous-based detergents, manual scrubbing with various detergents, and RF cleaning. Oil sheeting tests, RGA results, and voltage breakdown tests were used to quantify the benefits of these cleaning procedures.

* This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098.

TPAE041 A Critical Analysis of IGBT Geometries—Mitigating Undersired Destruction Caused by Adverse Fault Scenarios

G.E. Leyh (SLAC)

Megawatt class Insulated Gate Bipolar Transistors [IGBTs] find many uses in industrial applications such as traction drives, induction heating and power factor correction. At present, these devices are not optimized for higher speed pulsed-power applications, such as kicker magnets or klystron modulators. This paper identifies fundamental issues that limit the dI/dt performance of standard commercial packages, and investigates several IGBT design optimizations that significantly improve high-speed performance at high peak power levels. The paper presents design concepts, results of electromagnetic simulations, and performance data of actual prototypes under high dI/dt conditions.

Poster Session TPAB
Grand Ballroom I at 8:30

TPAB001 Fast Ferrite Tuner Operation on a 352-MHz Single-Cell RF Cavity at the Advanced Photon Source

Douglas Horan, Ernest Cherbak (ANL)

A 352-MHz fast ferrite tuner, manufactured by Advanced Ferrite Technology, was tested on a single-cell rf cavity at the Advanced Photon Source. Low- and high-power rf testing was performed on the tuner-cavity combination to evaluate tuning range, bandwidth, power-handling capability, and stability. The test system is comprised of a single-cell copper rf cavity, a bipolar DC bias supply for the ferrite tuner, a water flow and temperature metering and interlock system, and a low-level rf cavity tuning loop consisting of an rf phase detector and a PID amplifier. High-power tests were performed utilizing the Advanced Photon Source 352-MHz RF Test Stand. Test data will be presented.

* Work supported by U. S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

TPAB002 Mechanisms Limiting High Gradient RF Cavities

J. Norem, A. Hassanein, I. Konkashbaev (ANL)

The specific mechanisms responsible for breakdown of rf cavities have been widely debated. A large number of different processes are thought to be involved, including field emission, surface contamination, mechanical stresses, plasma effects, explosive electron emission, a variety of heating mechanisms, mechanical imperfections, surface structure and chemical composition. We are attempting to model the surface effects that limit the operation of high gradient rf cavities using the HEIGHTS package. Models of individual processes are being developed and compared, in an attempt to evaluate the relative importance of these effects, specifically for the case of low frequency (200 - 800 MHz.) copper cavities, but probably applicable to other materials and frequencies.

TPAB003 Dark Current and X Ray Measurements of an 805 MHz Pillbox Cavity

J. Norem (ANL), P. Gruber (CERN), A. Bross, S. Geer, A. Moretti, Z. Qian (FNAL), D. Kaplan, Y. Torun (Illinois Institute of Technology), E. McKigney (Imperial College), D. Li, M. Zisman (LBNL), R. Rimmer (Thomas Jefferson National Accelerator Facility)

A muon Cooling channel for neutrino factory or a muon collider requires low frequency (roughly 200 MHz) RF cavities with Be windows, at high gradient (E_{acc} about 16 MV/m), in a strong solenoidal magnetic field (about 5 T). For the Muon Ionization Cooling Experiment (MICE), an experimental demonstration of cooling, we have an additional constraint that we must operate sensitive particle detectors very close to the RF cavities, which produce backgrounds from dark currents and x rays. In order to understand the processes involved in cavity conditioning and operation near particle detectors, we have constructed a test facility at Lab G of Fermilab, where a 5 Tesla superconducting solenoid, a 14 MW peak power klystron and a pillbox test cavity at 805 MHz are available. We present measurements of dark currents, x rays and surface damage from the pillbox cavity, with both copper and beryllium endplates, and discuss the interaction between surface structure and radiation backgrounds produced.

TPAB004 HOM Damped NC Landau Cavities at BESSY

Wolfgang Anders, Peter Kuske (BESSY)

HOM damped nc passive landau cavities with a frequency of 1.5 GHz were developed and installed at the BESSY II electron storage ring. The design of the cavities and measurements with beam are presented

showing lifetime increase when landau cavities are operated in bunch lengthening mode.

* Funded by BMBF and Land Berlin.

TPAB005 Impedance Measurements of a HOM-Damped Low Power Model Cavity

Frank Marhauser, Ernst Weihreter (BESSY)

In the frame of a European Community funded project a higher order mode (HOM) damped normal conducting 500 MHz cavity is under development optimised for the use in 3rd generation storage ring light sources. The relevant HOM-impedances have been measured with a fully scaled low power model made from aluminium. By using a cutoff frequency of 615MHz for the damping waveguides we have found a good compromise between the preservation of the accelerating mode impedance and the efficient broadband damping of HOMs up to 3GHz. Detailed experimental results are presented and compared with numerical simulations.

* Work supported by the EC under contract no. HPRI-CT-1999-50011 and by DAAD/Germany.

TPAB006 Radio-Frequency Control System for the DUV-FEL Linac

James Rose (BNL)

The Deep Ultra-Violet Free Electron Laser (DUV-FEL) consists of a 1.6 cell photo-cathode gun, a variable pulse length T-Sapphire laser, 200MeV 2.856GHz linac and 10m NISUS undulator. The photo-injector and linac are driven by three Thompson klystrons. A new RF control system was designed and implemented in preparation for High Gain Harmonic Generation (HGHG) experiments which require sub-picosecond synchronization between the laser and the accelerating RF fields. It consists of a 81MHz oscillator to drive the Ti-Sapphire laser, 2856 MHz synthesizer which is locked to the laser output pulse train and direct vector modulators which control the amplitude and phase of the klystron drive RF. RF and electron beam based measurement results of the achieved RF to laser jitter are presented.

* Work supported by the U.S. Department of Energy.

TPAB007 Progress in the Development of High Level RF for the SNS Ring

Alex Zaltsman, M. Blaskiewicz, J.M. Brennan, J. Brodowski, M. Meth, Kevin Smith, R. Spitz (BNL)

A High level RF system consisting of power amplifiers (PA's) and ferrite loaded cavities is being built by Brookhaven National Laboratory (BNL) for the Spallation Neutron Source (SNS) project. Three cavities running at the fundamental harmonic (h=1) and one cavity at the second harmonic (h=2) were built and are being tested. Each cavity has two gaps with a design voltage of 10 kV per gap and will be driven by a PA directly adjacent to it. The PA uses a 600kW tetrode to provide the necessary drive current. All the PA's were built and are being tested at BNL prior to shipping to ORNL. A dynamic tuning scheme was implemented and tested to help compensate for the effect of beam loading.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

TPAB008 Buncher Cavity for ERL

Vadim Veshcherevich, Sergey Belomestnykh (Cornell University)

Design of the buncher cavity for Cornell/JLab ERL project is presented. This is a reentrant spherical copper cavity at a frequency of 1300 MHz. It will be installed between a 500 keV electron gun and superconducting accelerating sections in the injector part of ERL. The cavity has Q of 20,000 and a shunt impedance of 2.1 MOhm. For a design cavity voltage of 200 kV, power dissipated in cavity is as much as 9.5 kW. The cavity has a coaxial loop coupler and will be driven by a 15 kW klystron. The estimates of cavity influence on beam dynamics are also discussed.

TPAB009 Input Coupler for ERL Injector Cavities

Vadim Veshcherevich, Ivan Bazarov, Sergey Belomestnykh, Matthias Liepe, Hasan Padamsee, Valery Shemelin (Cornell University)

A conceptual design of the input coupler for superconducting injector cavities of Cornell/JLab ERL project is presented. The injector cavities are two-cell structures operating at 1300 MHz in CW mode. The coupler has a symmetric design to accommodate requirements for small transverse kick, high RF power delivery to the cavity and high input coupling value. Therefore it consists of two identical antenna type couplers symmetrically attached to a beam pipe of the cavity. Each coupler delivers 50 kW of CW RF power to the beam. The coupler has a variable coupling, Qext should be varied from 4.6×10^4 to 4.1×10^5. The symmetric design of the coupler dramatically reduces the transverse kick, a critical requirement for the ERL project. For high power tests of couplers, a resonant ring is being designed that will allow testing couplers using a low power klystron.

TPAB010 The Low-Energy Part of the Superconducting Injector Linac COSY-SCL

Alexander Schnase, Ulf Bechstedt, Norbert Bongers, Juergen Dietrich, Frank Esser, Franz-Josef Etzkorn, Olaf Felden, Ralf Gebel, Kurt Henn, Helge Jungwirth, Andreas Lehrach, Rudolf Maier, Heinrich Meier, Rolf Stassen, Hans Stockhorst, Raimund Toelle, Peter von Rossen (Forschungszentrum Juelich), Kai-Uwe Kuehnel, Alwin Schempp (University of Frankfurt/Main, Germany)

The low-energy part of the new superconducting injector linac for COSY is a conventional room-temperature design. It is discussed here with special emphasis on the radio-frequency system. The pulsed CIPIOS ion source can deliver polarized ions at 25 kV extraction voltage. Hence two different RFQs will be used. One is optimized for protons, the other for deuterons. Each RFQ is followed by a booster cavity for increasing the energy from 2 to 2.5 MeV in case of protons, and from 4 to 5 MeV in case of deuterons. Such boosters are more efficient than increasing the length of the RFQs and ensure that the velocity of both ion species at the entry of the superconducting structures is the same. The RFQ tanks will be mounted on a movable rail system to allow changing the ion species within reasonable time. The pulsed radio-frequency amplifiers will operate at 160 MHz. They are specified to deliver 600 kW to the RFQ in operation, 125 kW to the booster in operation, and 6 kW to a re-buncher that is located in the matching section preceding the superconducting cavity modules. The control system will be mixed digital and analog. It consists of amplitude and phase control, tuning, and synchronisation to the 160 MHz reference frequency of the whole linac.

TPAB011 Linearization of the Fermilab Recycler High Level RF

Joseph Dey, Tom Kubicki, John Reid (FNAL)

In studying of the Recycler high level rf, it was found that at 89 kHz, the lowest frequency required by the system, some nonlinearities in magnitude and phase were discovered. The visible evidence of this was that beam injected between barrier buckets had a definite slope at the top. Using a network analyzer, the S-parameter S_{21} was realized for the overall system and from mathematical modeling a second order numerator and denominator transfer function was found. The inverse of this transfer function gave us our linearization transfer function. The linearization transfer function was realized in hardware by summing a high pass, band pass and low pass filter together. The

resulting magnitude and phase plots along with actual beam response will be shown.

* Operated by Universities Research Association, Inc. for the U.S. Department of Energy under contract DE-AC02-76CH03000.

TPAB012 Coupler Design for NLC/JLC Accelerting Structures

Ivan Gonin, David Finley, Timergali Khabiboulline, Nikolay Solyak (FNAL)

In the framework of the NLC/JLC collaboration Fermilab is working on developing technology for X-band accelerating structures. One key element of a structure is the input/output coupler, which should provide not only good power transmission from the waveguide to the structure, but also it should not limit the high gradient performance of the accelerating structure itself. There are other special requirements for designing high power input/output couplers (reliability, cost, sensitivity to errors, trapped HOM etc.). In this paper we discuss the HFSS simulation of different types of couplers for JLC/NLC accelerating structures. We compare the surface electric and magnetic fields, field asymmetries, pulsed heating, presence of trapped modes, complexity of production etc. Results of RF measurements and high gradient tests show good agreement with designed parameters.

TPAB013 Development of X-Band Accelerating Structures at Fermilab

Nikolay Solyak, Tug Arkan, Cristian Boffo, Evgueni Borissov, Harry Carter, David Finley, Ivan Gonin, Timergali Khabiboulline, Gennady Romanov, Brian Smith (FNAL)

The RF Technology Development group at Fermilab is working together with the NLC and JLC groups at SLAC and KEK on developing technology for room temperature X-band accelerating structures for a future linear collider. We have built a few 60cm long, high phase advance, detuned structures (HDS or FXB series). These structures have 150 degrees phase advance per cell, and are intended for high gradient testing at the SLAC NLSTA facility. The structures were brazed in a vacuum furnace with a partial pressure of argon, rather than in a hydrogen atmosphere. We have also begun to build 75cm long, damped and detuned structures (HDDS or FXC series). Our goal is to build many structures for the 8-pack test at SLAC by the end of 2003, as part of the JLC/NLC effort to demonstrate the readiness of room temperature RF technology for a linear collider. This paper describes the design, fabrication techniques, RF measurements and tuning, as well as the initial results from high gradient testing of an FXB structure.

TPAB014 Development of the Third Harmonic Cavity at Fermilab

Nikolay Solyak, Helen Edwards, Mike Foley, Ivan Gonin, Timergali Khabiboilline, Don Mitchell, Lee Simmons (FNAL)

Third harmonic (3.9GHz) SC cavity was proposed at DESY for a new generation of High Brightness Photo-Injector to compensate nonlinear distortion of the longitudinal phase space due to RF curvature of the 1.3 GHz TESLA cavities. It will allow create electron beams with an extremely small transverse normalized emittance (1mm) needed to support new generation of linear colliders, FELs and SRS's. In this paper we present status of the 3rd harmonic cavity at Fermilab and DESY. Results of building and testing of the copper model, power coupler and HOM coupler designs are discussed.

TPAB015 Multi-Harmonic RF Control System for J-PARC RCS

Fumihiko Tamura, Masanobu Yamamoto (Japan Atomic Energy Research Institute), Alexander Schnase (Forschungszentrum Juelich), Chihiro Ohmori, Akira Takagi, Tomonori Uesugi, Masahito Yoshii (KEK)

The RF cavity of J-PARC Rapid Cycle Synchrotron (RCS) has a low Q value and a wide band which covers the frequency from the accelerating frequency to the second harmonic frequency. The cavity is driven by a composite signal of the fundamental RF and the second harmonic RF. The system acts as a bunch shaping system as well as an accelerating system. In this presentation, a multi-harmonic RF control system is studied. The signal processing is based on a combination of digital hardware like 16 bit multipliers, arithmetic units, and FPGAs with commercially available signal processors. The beam loading compensation is a critical issue because of the high beam-current in the ring. The RF feedforward compensation system is discussed. Also the stability is discussed under the beam feedback loops.

TPAB016 Design of 20MeV DTL for KOMAC

Yong-Sub Cho, Byung-Ho Choi, Ji-Ho Jang, Hyeok-Jung Kwon, Mi-Young Park (Korea Atomic Energy Research Institute)

KAERI is developing the KOMAC (Korea Multi-purpose Accelerator Complex) program that consists of 1GeV proton linac for an accelerator driven transmutation experiments, and applications in the industries and the basic science areas as Korean national research facility. In the 1st phase of KOMAC, the proton accelerator that includes injector, LEBT, RFQ and RF system has been developed. In parallel, applications with keV and MeV accelerators are being developed such as ion irradiators, surface modification of polymers. In the 2nd phase, a 100MeV linac and several beam lines of 20MeV and 100MeV will be constructed, and several applications with high current proton beams, and an user program for future extension of the program are planned. For the 2nd phase, a DTL from 3MeV to 20MeV has been designed. It consists of 350MHz DTL cavities for CW operation and a 1MW RF source. The details of the DTL design will be reported.

* This work is supported by the Korea Ministry of Science and Technology.

TPAB017 RF Power Delivery System Design and Its Component Characterization for KOMAC DTL

Hyeok-Jung Kwon, Yong-Sub Cho, Byung-Ho Choi, Jang-Min Han (Korea Atomic Energy Research Institute)

The 2nd phase of the KOMAC(KOrea Multipurpose Accelerator Complex) project was started at September 2002, whose main goals are to construct a 100 MeV proton accelerator and develop beam utilization areas. In this project, 20 MeV DTL is scheduled to be constructed and tested within three fiscal years. The RF power delivery system for 20 MeV DTL was designed and its components were characterized at KAERI. The RF power from a 350 MHz, 1 MW CW klystron is split into four legs to drive four DTL tanks. Each leg has a phase shifter and amplitude controller to control the phase and amplitude of the RF field in each tank. The RF power delivery system design of the 100 MeV accelerator will be based on the 20 MeV DTL system experiences.

* This work was supported by the Korea Ministry of Science and Technology.

TPAB018 R & D Status of C-Band Accelerating Unit for the SuperKEKB Project

Takuya Kamitani (KEK)

The design consideration of the KEK-B factory upgrade for ten-times higher luminosity is underway. Beam-energy switch (from 8.0-GeV e- and 3.5-GeV e+ to 3.5-GeV e- and 8.0-GeV e+) is considered against the electron-cloud problem in the positron storage ring. In this upgrade, the injector linac has to increase the positron acceleration

energy from 3.5 GeV to 8.0 GeV. In order to double the acceleration field strength (from 21 to 42 MV/m), design study of the C-band accelerating unit has been started. This paper report on the recent status of the design study and the high-power test of the C-band accelerating structure and the rf source.

TPAB019 Improvements in the RF System for the Photon Factory Advanced Ring (PF-AR)

Shogo Sakanaka, Kiyokazu Ebihara, Eizi Ezura, Shigeru Isagawa, Toshio Kasuga, Hiroshi Nakanishi, Masaaki Ono, Masaaki Suetake, Takeshi Takahashi, Kensei Umemori, Shin-ichi Yoshimoto (KEK)

The Photon Factory Advanced Ring (PF-AR) is a 6.5-GeV synchrotron light source at KEK. An rf system for the PF-AR comprises two 1-MW klystrons, six 11-cell cavities and an rf distribution network, which can provide an accelerating voltage of more than 20 MV. An upgrading project for the PF-AR was performed during 2001. In parallel with many other upgrades, we carried out some improvements in the rf system. These improvements include: 1) an improved crowbar circuit of the klystron power supply, 2) reinforcement in the cavity higher-order-mode loads, 3) temperature stabilization system for the cavity cooling water, and 4) renewal of the control system. The improved rf system was commissioned smoothly in January, 2002, and it has been working very well. We report both these improvements and the present status of the PF-AR rf system.

TPAB020 Radio Frequency Acceleration System for 150MeV FFAG

Akira Takagi, Yoshiharu Mori, Masahiro Sugaya, Tomonori Uesugi (KEK)

An rf cavity for 150MeV FFAG proton synchrotron have been developed. The cavity consists of four pieces of MA core. These cores are indirectly cooled with thermally conductive spacers and cooling plates. A piece of MA core(Wide: 1700mm, Height: 950mm, Length: 30mm) is mechanically supported by it's cooling plate. The acceleration voltage of 10kV/cavity and the acceleration cycle of 250Hz are required. The range of the acceleration frequency is 1.5MHz to 4.6MHz. A wide-band push-pull amplifier supplies the rf power of 55kW to an rf cavity. A couple of rf stations are designed to install in the 150MeV FFAG. Recent progress on the radio frequency acceleration system for 150MeV FFAG proton synchrotron is presented.

TPAB021 Direct-Cooling MA Cavity for J-PARC Synchrotrons

Tomonori Uesugi, Yoshiharu Mori, Chihiro Ohmori, Akira Takagi, Masahito Yoshii (KEK), Alexander Schnase (COSY-HF), Fumihiko Tamura, Masanobu Yamamoto (Japan Atomic Energy Research Institute)

The first rf cavity for the J-PARC(Japan Proton Accelerator Research Complex) synchrotrons has been developed. In the cavity, MA cores are cooed by water directly. With that cavity, we have accomplished an acceleration field of more than 50kV in 1.776m cavity length. We show the design of the rf-cavity and results of high-power tests.

TPAB022 High Power Testing of the 402.5 MHz and 805 MHz RF Windows for the Spallation Neutron Source Accelerator

Karen Cummings, John De Baca, John Harrison, Manuelita Rodrigiuez, Phillip Torrez, David Warner (LANL)

Historically, Radio Frequency (RF) windows have been a common point of failure in input power couplers; therefore, reliable RF windows are critical to the sucesss of the Spallation Neutron Source (SNS) project. The normal conducting part of the SNS accelerator requires six RF windows at 402.5 MHz and eight RF windows at 805 MHz. Each RF window will transmit up to 180 kW of average power and 2.5 MW peak power at 60 Hz with 1.2 millisecond pulses. The RF windows, designed and manufactured by Thales, were tested at the full average power for 4 hours to ensure no problems with the high average power and then tested to an effective forward power level of 10 MW by testing at 2.5 MW forward power into a short and varying the phase of the standing wave. The sliding shortwas moved from 0 to 180 degrees to ensure no arcing or breakdown problems occur in any part of the window. This paper discusses the results of the high power testing of both the 402.5 MHz and the 805 MHz RF windows. Variation between individual windows is discussed as well as any problems encountered during testing and the solutions for these problems.

* Work supported by US Department of Energy.

TPAB023 HOM Dampers for ALS Storage Ring RF Cavities

Slawomir Kwiatkowski, Kenneth Baptiste, John Byrd, Stefano De Santis, James Julian, David Plate (LBNL)

The sources of the narrowband impedance in the Advanced Light Source (ALS) are higher order modes (HOMs) modes of the two main RF and the three third-harmonic cavities. These HOMs drive coupled bunch instabilities which are controlled using active beam feedback systems. The dominant longitudinal HOMs in both systems are TM011-like modes, with R/Q factor by order of magnitude higher than all other longitudinal modes. To allow proper operation of the longitudinal dampening system, these modes were tuned away from beam resonances by means of the cooling water temperature control (main rf system), and the combination of two tuners (third-harmonic system). To improve the reliability of the longitudinal damping system, we have built and installed E-type HOM dampers for fundamental and harmonic cavity. The design, testing and the RF performance of the HOM dampers are presented in this paper.

* This work is supported by the US Department of Energy under contract No. DE-AC03-76F00098.

TPAB024 A 201 MHz RF Cavity Design with Non-Stressed and Pre-Curved Be Windows for Muon Cooling Channels

Derun Li (LBNL), Wing Lau (Oxford University), Robert Rimmer (Thomas Jefferson National Accelerator Facility)

We present a 201-MHz RF cavity design for muon cooling channels with non-stressed and pre-curved Be foils to terminate the beam apertures. The Be foils are necessary to improve the cavity shunt impedance with large beam apertures needed for accommodating large transverse size muon beams. Be foils are low-Z material and almost transparent to muon beams, but terminate the cavity electro-magnetically. Previous designs use pre-stressed flat Be foils in order to keep cavity from detuning due to RF heating. These foils are expensive and difficult to make. An alternative is to use pre-curved and non-stressed Be foils where the buckling direction is known, and frequency shifts can be properly predicted. Mechanical simulations on the Be foils and cavity frequency shifts due to the foil deformation will be presented.

* This work was supported by the director, Office of Science, Office of High Energy and Nuclear Physics, Division of High Energy, of the U.S. Department of Energy under contract No.DE-AC03-76SF00098.

TPAB025 RF Tests of an 805 MHz Pillbox Cavity at Lab G of Fermilab

Derun Li, J. Corlett, R. MacGill, M. Zisman (LBNL), J. Norem (ANL), A. Moretti, Z. Qian, V. Wu (FNAL), Y. Torun (Illinois Institute of Technology), R. Rimmer (Thomas Jefferson National Accelerator Facility)

We report recent RF tests on an 805 MHz RF pillbox cavity with demountable windows for beam apertures at Lab G of Fermilab, a

dedicated facility for testing of MUCOOL (muon cooling) components. The cavity is installed inside a superconducting solenoidal magnet. A 12 MW peak RF power klystron is used for the tests. The cavity has been processed both with and without magnetic field. Without magnetic field, a gradient of 34 MV/m was reached rather quickly, with very low sparking rate. With a 2.5-T solenoidal field, a gradient of only about 16 MV/m was achieved, and even that took many weeks of conditioning. More severe multipacting effects and higher radiation levels were observed during the processing with magnetic field. Preliminary understanding of the cavity conditioning in a strong magnetic field and cavity surface inspection results will be presented.

* This work was supported by the director, Office of Science, Office of High Energy and Nuclear Physics, Division of High Energy, of the U.S. Department of Energy under contract No. DE-AC03-76SF00098.

TPAB026 Deflecting RF Cavity Design for a Recirculating Linac Based Facility for Ultrafast X-Ray Science

Derun Li, John Corlett (LBNL)

We report on superconducting deflecting RF cavity designs for a Recirculating Linac Based Facility for Ultrafast X-ray Science. The deflecting cavities operate in the lowest dipole mode and are required to produce a temproal correlation within flat electron bunches, as needed for x-ray compression in crystal optics. Deflecting voltages of up to 8.5-MV are required at 3.9-GHz. We present a 7-cell cavity design together with its input power coupler. Longitudinal and transverse impedances from LOM (lower order modes) and HOM (higher order modes) are simulated using the MAFIA code. Short-range and long-range wakefields excited through these impedances are calculated. Beam loading effects of the deflecting mode are estimated.

* This work was supported by the director, Office of Science, Office of High Energy and Nuclear Physics, Division of High Energy, of the U.S. Department of Energy under contract No.DE-AC03-76SF00098.

TPAB027 RF Power Detector/Monitor Upgrade for the 500MHz Systems at the ALS

Kenneth Baptiste (LLNL)

Several systems rely on the accurate and linear detection of 500 MHz signals, (the fundamental frequency of both the Booster Ring and Storage Ring) over a dynamic range in excess of 25dB. Prior to this upgrade, the detector/monitor was diode based and though this type of detector could handle the dynamic range requirement it could not do so in an accurate and linear manner. In order to meet the requirements, (dynamic range greater than or equal to 25dB, accurate and linear to +/- .25dB over the range, and additional circuitry to interface to the legacy control system and interlocks) a new RF Power Detector/Monitor has been developed using two AD8361, Analog Devices TruRMS Detectors and a fuzzy comparator, which extends the overall detector's range to twice that of the AD8361. Further information is available [www.analogedevices.com/]. Details of the design requirements and the detector/monitor's circuit as well as the performance of the detector will be presented.

* Work supported by the Director, Office of Energy Research, Office of Basic Energy Science, Materials Science Division, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

TPAB028 Theoretical Analysis of Overmoded Dielectric Photonic Band Gap Structures for Accelerator Applications

Michael Shapiro, Chiping Chen, Evgenya Smirnova, Richard Temkin (MIT Plasma Science and Fusion Center)

An overmoded accelerator structure is proposed based on a dielectric photonic-band-gap (PBG) disk-loaded structure. The structure consists of dielectric rods and metal disks with irises. It is advantageous for application in high frequency (17 GHz and higher) linacs because of the large dimensions of the structure. The operating mode is a higher-order TM02 mode. One unique feature is that the fundamental TM01 mode is not supported by the structure. Along with that, the dipole mode TM110 is strongly suppressed. The dielectric PBG structure can also be attractive for application in a dielectric wakefield accelerator.

* DOE HEP.

TPAB029 An 11 GHz Photonic Band Gap Accelerator Structure with Wakefield Suppression

Evgenya Smirnova, Chiping Chen, Michael A. Shapiro, Richard J. Temkin (MIT Plasma Science and Fusion Center)

The transverse wakefield dipole mode can be completely suppressed in photonic band gap (PBG) accelerator structures. We have designed and fabricated PBG structures for 11 GHz and 17 GHz operating frequencies. The structures are made of two-dimensional triangular arrays of metal rods placed between metal disks. A PBG structure is characterized by a number of advantages: 1) It is highly oversized (in wavelengths) and, therefore, easy to build. 2) Simple coupling from a rectangular waveguide into the structure can be provided through the array and, therefore, coupling holes are not utilized. 3) The structure can be tuned and the coupling can be controlled by bending the rods in the array or placing clips onto the rods. The 11 GHz PBG single-cell cavities, with- and without higher-order mode suppression, have been built and cold tested. Suppression of the dipole TM110 mode at the frequencies of 15-17 GHz has been demonstrated in cold test. The PBG structures have been examined to address the issues of breakdown and pulsed heating. Magnetic field enhancement at the metal rods in the PBG structures and at the coupler has been analyzed and the temperature rise due to pulsed heating has been estimated.

* This research was supported in part by the Innovative Vacuum Electronics MURI Program, and in part by the Department of Energy, High Energy Physics Division.

TPAB030 Transverse Impedance Bench Measurements in NLC/JLC Structures

Nicoleta Baboi, Gordon B. Bowden, Roger M. Jones (SLAC)

The wire method is a more rapid and less costly way to measure impedances of RF components compared to methods using a beam. A setup using a single displaced wire to excite and measure transverse resonant modes in accelerating structures for NLC/JLC has been built. The RF signal is coupled into and out of the structure by help of two matching sections with a broad band from 11 to 18 GHz. A single-cell cavity is tested first. A detuned structure will then be measured, which has a good mode separation. Other traveling and standing wave cavities are to be measured as well. Difficulties accurately predicting the modal loss factors were encountered related to the approximations made and to experimental issues. The ongoing measurements will be presented. Comparisons between measurement and simulation will be made.

* Work supported by the US Department of Energy, grant number DE-AC03-76F00515.

TPAB031 Status of X-band Standing Wave Structure Studies at SLAC

Valery Dolgashev, C. Adolphsen, G. Bowden, D.L. Burke, R.M. Jones, Z. Li, R. Loewen, R.H. Miller, Ch. Ng, C. Pearson, R.D. Ruth, S.G. Tantawi, J.W. Wang, P. Wilson (SLAC)

The linacs of the next linear collider (NLC) will contain several thousand X-Band accelerator structures operating at a loaded gradient of 55 MV/m. An extensive experimental and theoretical program to determine a safe operating gradient for NLC is under way at SLAC. Development of standing wave structures is a part of this program.

Properties of a standing wave structure allow it to operate at the loaded gradient in contrast to traveling wave structures that need conditioning to an unloaded gradient of 72 MV/m. Gradient in the first high-power tested standing wave structures was limited by input coupler breakdowns. Behavior of these breakdowns was consistent with a model of pulsed heating due to high magnetic fields. New input couplers were designed to reduce maximum magnetic fields. This paper discusses design considerations related to high power performance, wakefield suppression and results of high power tests of these standing wave structures.

TPAB032 High Magnetic Fields in Couplers of X-Band Accelerating Structures

Valery Dolgashev (SLAC)

Recent high power tests of x-band accelerating structures at SLAC have shown that their performance is limited by breakdowns in couplers. The behavior of these breakdowns is consistent with a model of pulsed heating due to high magnetic fields. The observed damage is located in the region of high magnetic fields. To calculate these magnetic fields, 3D electrodynamics models of the couplers were built and matched. Coupler models were matched with an automated procedure that uses the commercial code HFSS. This matching procedure is based on calculation of reflection from the coupler cell using the electric field distribution on the axis of the structure. After matching, the magnetic and electric fields in the couplers were calculated for typical operation parameters. Highest magnetic fields on the order of 1 MA/m were found on sharp (~80 micron radius) edges of the waveguide-to-coupler-cell irises. For some input couplers, electric fields on these edges are found be as high as 10 MV/m. To reduce the high magnetic fields new couplers were designed. These couplers have 3 mm radius waveguide-to-coupler-cell iris and maximum magnetic field below 0.5 MA/m for 70 MV/m average accelerating gradient. The matching procedures, and typical results for couplers with sharp and rounded irises are discussed in this paper as well as possible causes of breakdowns in the couplers.

TPAB033 Accurate Wall Loss Determination in Accelerator Design

Lixin Ge (SLAC)

While parallel finite element eigensolvers such as Omega3P have shown to be able to calculate RF cavity mode frequencies to a high precision, it has become increasingly necessary that wall loss be determined with high accuracy as well because: 1) the wall loss leads to shunt impedance degradation and 2) excessive wall loss results in high RF pulse heating. These issues need to be adequately addressed in the next generation accelerator such as the NLC in which accelerator structures are designed to operate at high efficiency and high power. This paper will present progress from an ongoing effort to improve wall loss calculations with Omega3P and a new parallel S-matrix solver S3P using higher order interpolation functions for mesh elements and parallel adaptive refinement strategies.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

TPAB034 A Circuit Model of the Wire Measurement Method of Beam Impedance in a Complete Accelerating Structure

Roger Jones, Nicoleta Baboi (SLAC), Norman Kroll (University of California, San Diego)

In order to to measure the wakefield left behind multiple bunches of energetic electrons we have previously used the ASSET facility in the SLC [C. Adolphsen et al, Phys.Rev.Lett.74:2475-2478,1995]. However, in order to produce a more rapid and cost-effective determination of the wakefields we have designed a wire experimental method to measure the beam impedance and from the Fourier transform thereof, the wakefields. In this paper the beam impedance of the complete, multi-cell structure is analysed utilizing a circuit model which has been developed for this express purpose. The wakefield is calculated from the circuit model by employing a spectral function technique [R.M. Jones et al, LINAC96, also SLAC-PUB 7287 2]. The model will be used to guide interpretation of experimental measurements.

TPAB035 An Automated 476 MHz RF Cavity Processing Facility at SLAC

Peter McIntosh, Alan Hill, Heinz Schwarz (SLAC)

The 476 MHz accelerating cavities currently used at SLAC are those installed on the PEP-II B-Factory collider accelerator. They are designed to operate at a maximum accelerating voltage of 1 MV and are routinely utilised on PEP-II at voltages up to 750 kV. During the summer of 2003, SPEAR3 will undergo a substantial upgrade, part of which will be to replace the existing 358.54 MHz RF system with essentially a PEP-II high energy ring (HER) RF station operating at 476.3 MHz and 3.2 MV (or 800 kV/cavity). Prior to installation, cavity RF processing is required to prepare them for use. A dedicated high power test facility is employed at SLAC to provide the capability of conditioning each cavity up to the required accelerating voltage. An automated LabVIEW based interface controls and monitors various cavity and test stand parameters, increasing the RF fields accordingly such that stable operation is finally achieved. This paper describes the high power RF cavity processing facility, highlighting the features of the automated control system and illustrating its operation with some recent high power processing results.

* Work supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00515.

TPAB036 Novel Accelerator Structure Couplers

Christopher Nantista, Valery Dolgashev, Sami Tantawi (SLAC)

Recent experience with X-band accelerator structure development has shown the rf input coupler to be the region most prone to rf breakdown and degradation, effectively limiting the operating gradient. A major factor in this appears to be high magnetic fields at the sharp edges of the coupling irises. As a first response to this problem, couplers with rounded and thickened iris horns have been employed, with improved performance. In addition, conceptually new coupler designs have been developed, in which power is coupled through the broadwall of the feed waveguide. A prototype "mode converter" coupler, which launches the TM01 mode in circular waveguide before coupling through a matching cell into the main structure, has been tested with great success. With peak surface fields below those in the body of the structure, this coupler represents a break-through in the NLC structure program. The design of this coupler and of variations which use beamline space more efficiently are described here. The latter include a coupler in which power passes directly through an iris in the broad wall of the rectangular waveguide into a matching cell and one which makes the waveguide itself an accelerating cell. We also discuss techniques for matching such couplers.

* Work supported by the U.S. Department of Energy under contract DE-AC03-76SF00515.

TPAB037 A Three-Frequency RF Operation in Spear3

Sam Park (SLAC)

In the present Spear2 RF operation, the Spear storage ring and booster synchrotron share the common RF reference signal at the same frequency. When the Spear3 is commissioned in late 2003, the storage ring RF will be at 476.3 MHz while the booster frequency will remain unchanged from the present 358.3 MHz. The harmonic ratio is 372 to 160. In order to achieve stable and efficient injection the booster RF phase is modulated so that the booster bunch is ejected to a designated

Spear bucket. Experimental tests were done to inject into the Spear2 buckets by adjusting the phase modulation magnitude only. Details will be presented in this conference. The third system is injector linac at 2.856 GHz, which will stay the same.

* Work supported by the U.S. Department of Energy contract DE-AC03-76SF00515.

TPAB038 Use of Acoustic Emission to Diagnose Breakdown in Accelerator RF Structures

Marc Ross, Joe Frisch, Keith Jobe, Fredrick Le Pimpec, Douglas McCormick, Janice Nelson, Tonee Smith (SLAC)

Accelerator structures of a wide variety have been damaged by RF breakdowns. Very little is known about the mechanisms that cause the breakdown and the damage although there has been theoretical work (P. Wilson, SLAC-9114, PAC2001). Using an array of ultrasonic acoustic emission sensors we have been able to locate and classify breakdown events with an accuracy much greater than that possible using traditional microwave techniques. Data from the technique has lead to improvements in the design of the NLC X-band RF structure. We report results of acoustic emission studies at the DESY TESLA Test Facility and the NLCTA.

* Supported by US DoE contract DE-AC03-SF00515.

TPAB039 Gradient Limitation in Accelerating Structures Imposed by Surface Melting

Perry Wilson (SLAC)

A rough picture is emerging of the physics behind the maximum gradient that can be sustained in an accelerating structure without producing surface damage (material erosion) at a level sufficient to cause a measureable change in the rf properties of the structure. Field emission sites are known to trigger the formation of so-called plasma spots for both high dc and rf surface fields. In the rf case, the ions emitted from such a plasma spot, or group of spots, move in such a way as to set up a field which tends to cancel the space charge field of the emitted electrons. This boosts the electron current from the order of 100 A for the dc case to a few kiloamperes for an rf field. A substantial fraction of this current returns back to the region near the surface plasma, having picked up an energy of tens of kilovolts from the rf field. This electron back-bombardment can heat the surface to the melting point, depending on the pulse length and surface material, over an area on the order of 100 microns in diameter. The dynamics of the growth of this initial molten area, subject to the intense force of the surface electric field, is complex. We propose, however, that this initiates a condition for erosion of macroscopic amounts of surface material.

* Work supported by the Department of Energy, contract DE-AC03-76SF00515.

TPAB040 TRIUMF ISAC RF System Improvements after 2 Years of Operational Experience

Iouri Bylinskii, Zhengting Ang, Shuyao Fang, Kenneth Fong, Raveen Kumaran, Joseph Lu, Roger Poirier (TRIUMF)

The TRIUMF ISAC accelerator has been successfully operating since spring 2001 with very little downtime. The machine comprises 16 independent RF systems including a 35 MHz RFQ, a 106 MHz DTL and several sub-harmonic choppers and bunchers. The post stripper DTL enables fully variable output energy up to 1.5 MeV/amu for rare isotopes with A/q≤6 in cw mode. This sets rather stringent requirements for the RF system as a whole and the RF controls in particular. A new RF phase measuring system has been commissioned, which together with other modifications has improved machine tunability. During initial operation the DTL frequency tuners and power couplers showed some problems, which could affect the machine reliability. Modifications to these components together with additional diagnostics have solved these problems. In the paper we will describe the overall operation of the RF system and present details of the modifications.

TPAB041 RF Control System at CAMD

Daren Launey (Center for Advanced Microstructure and Devices)

A simple, compact yet robust custom solution for closed loop phase and amplitude RF control system implementation at CAMD. At present, CAMD's 1.3 GeV electron storage ring has a 7 Tesla wiggler, pushing the limits of the installed 60kW RF system. In addition, one available straight section allows for a second insertion device which will require the installation of a second RF system. Revising a 10 year old proven design of the original control system will provide a simple and inexpensive upgrade path.

TPAB042 RF Acceleration System at HIRFL-CSR Main Ring

Wenzhi Zhang, Jiawen Xia, Zhe Xu, Xiaodong Yang, Wenlong Zhan (Institute of Modern Physics, Lanzhou)

A heavy ion cooler-storage ring HIRFL-CSR has been constructed at IMP. It consists of a main ring (CSRm) and an experimental ring (CSRe). Two RF cavities will be employed for CSRm. One is for beam acceleration, and another is for beam RF stacking. The accelerating cavity is designed to accelerate the beam from 10 to 900MeV/u with harmonic number h=1. The peak RF voltage is 8.0kV and frequency range is from 0.25 to 1.7 MHz. In the present paper, the measured RF parameters and the details of hardware for the RF acceleration system are described.

TPAB043 Microphonics Measurements in SRF Cavities for RIA

Michael Kelly, Sergey Sharamentov, Kenneth Shepard (ANL), Jean Delayen (Thomas Jefferson National Accelerator Facility)

Phase stabilization of the RIA drift-tube cavities in the presence of microphonics will be a key for RIA. Microphonics measurements on the ANL beta=0.4 single-cell spoke cavity and on the ANL beta=0.4 two-cell spoke cavity for RIA have been performed, many using a new "cavity resonance monitor" device developed for RIA cavities in collaboration with JLAB. Results demonstate that the spoke geometry is a particularly rigid structure with respect to both microphonics and Lorentz detuning.

* This work was supported by the U.S. Department of Energy, Nuclear Physics Division, under contract number W-31-109-ENG-38.

TPAB044 Superconducting 345 MHz Two-Spoke Cavity for RIA

Kenneth Shepard (BNL), Joel Fuerst, Mark Kedzie, Michael Kelly (ANL)

This paper discusses the status of a prototype niobium 345 MHz, two-cell spoke-loaded superconducting cavity being developed for the U.S. RIA project driver linac. The 3 cm aperture cavity provides useful acceleration over the velocity range $0.3c < v < 0.6c$, and is expected to provide more than 2 MV of accelerating potential per cavity while operating at 4 K. An integral stainless-steel housing is designed to minimize variation of rf eigenfrequency with pressure changes of the helium bath. Details of construction and results of initial tests will be reported.

* Work supported by the U. S. Department of Energy under contract number W-31-109-ENG-38.

TPAB045 Superconducting Intermediate-Velocity Cavity Development for RIA

Kenneth Shepard (BNL), Joel Fuerst, Mark Kedzie, Michael Kelly (ANL)

This paper discusses the design and development of two types of intermediate-velocity superconducting cavities and an associated cryomodule for the RIA driver linac. The two cavity types are a 115

MHz, beta (geometric)= 0.15 quarter-wave resonant (QWR) cavity, and a 173 MHz, beta = 0.26 half-wave loaded cavity. The useful velocity range of the two types extends from 0.1c to 0.5c. Both cavities are well-corrected for dipole and quadrupole asymmetries in the accelerating field. The cryomodule is being designed to incorporate a separate vacuum system for the cavity vacuum to provide a particulate-free environment for the superconducting cavities and enable maintaining a higher degree of surface cleanliness than has previously been the case for TEM-type, drift-tube loaded superconducting cavities. The status of prototype cavity and cryomodule construction will be reported.

* Work supported by the U. S. Department of Energy under contract number W-31-109-ENG-38.

TPAB046 Design of a Superconducting Linac Cavity for High-Current Energy Recovery Linac Operation

Dong Wang, Ilan Ben-Zvi, Xiangyun Chang, Jorg Kewisch, Christoph Montag (BNL), Jacek Setukowicz (DESY), Carlo Pagani, Paolo Pierini (INFN)

The RHIC electron cooler as well as other applications (such as a linac-ring version of eRHIC) require a very high average current CW electron linac in an energy recovery mode. We report the design of a 5-cell superconducting linac cavity for velocity of light particles. This cavity will operate at 703.75 MHz with a very large beam pipe aperture of 19 cm diameter and ferrite HOM absorbers in the beam pipe, in addition to conventional HOM couplers for the two lowest HOMs. We will report the construction of the cavity shape using the BuildCavity and Superfish codes, loss factor simulations with ABCI, detailed HOM simulation with MAFIA (with and without the ferrite absorbers) and beam breakup simulations using the code TDBBU.

* This work was performed under the auspices of the U.S. Department of Energy.

TPAB047 Experimental Results on 704 MHz Multicell Superconducting Cavity for Proton Linac

Bernard Visentin, Jean Pierre Charrier, Jean Pierre Poupeau, Dominique Roudier, Francois Simoens (CE Saclay), Jean Luc Biarrotte, Sebastien Bousson, Tomas Junquera, Herve Saugnac, Philippe Szott (Institut de Physique Nucléaire d'Orsay)

The first five-cells niobium superconducting cavity (704.4 MHz-beta=0.65) was designed, built and tested through the IPN-Orsay/CEA-Saclay collaboration. This cavity is a prototype for the high energy section of high intensity proton accelerators dedicated to produce radioactive ion beams, neutrons for nuclear waste transmutation or physics particles for muon colliders and neutrino factories. The different steps in the technical implementation of this cavity will be described: chemical etching, annealing, tuning and field flatness control. We will report on the experimental RF measurements, at low power, achieved in vertical cryostat and the tests in the horizontal cryostat CRYHOLAB.

TPAB048 Using Passive Superconducting Cavities for Bunch Shortening in CESR

Sergey Belomestnykh, Roger Kaplan, John Reilly, John Sikora, Vadim Veshcherevich (Cornell University)

Passive (beam-driven) superconducting cavities can be used in storage rings for bunch shortening when necessary high RF voltage can be achieved only by using multiple cavities, but the beam power consumption does not justify using all of them in the active mode, powered by klystrons. An example is the e+e- collider CESR running with a beam energy below 2.5 GeV as a charm-tau factory (CESR-c) [D. Rice, EPAC 2002 Proceedings, 428]. A short bunch length of about 10 mm is required for obtaining higher luminosity, while maximum beam power is only 160 kW. Theoretical and experimental studies are in progress at CESR to investigate the collider performance at low energy in preparation for its conversion to CESR-c. In the course of these studies we looked at possible impacts of using passive cavities on the accelerator performance. The results are presented.

* Work is supported by the National Science Foundation.

TPAB049 First RF Test at 4.2K of a 200MHz Superconducting Nb-Cu Cavity

Rong-Li Geng, Phil Barnes, Don Hartill, Hasan Padamsee, James Sears (Cornell University), Enrico Chiaveri, Roberto Losito, Hansuli Preis (CERN)

The proposed nutrino factory and muon collider ask for RF cavities operating at a frequency near 200MHz for rapid accelration of muons [Feasibility Study-II of a Muon-Based Neutrino Source, ed., S. Ozaki, R. Palmer, M. Zisman, and J. Gallardo, BNL-52623 (2001)]. One scenario is to use superconducting RF cavities [H. Padamsee, SRF for muon colliders, Proceedings of the 9th workshop on RF superconductivity, 587(1999)]. The desired accelerating gradient is 17 MV/m at an unloaded quality factor of 6E9. Since there is no superconducting RF experience at 200MHz at all, R&D in this regime should be started early. A 200MHz single cell elliptical Nb-Cu cavity has been fabricated and tested in collaboration with CERN. The cavity has been tested at 4.2K in a vertical dewar fitted in a radiation shielded 5m deep, 2.5m diameter pit. The low field Q was measured to be 2E10 at 4.2K. A soft multipacting barrier was observed at 3MV/m. After the multipacting barrier was past, field emission dominated. Helium processing was performed, which helped double the gradient. The cavity has been since rinsed with high pressure water again and the test is on going. We will present the test results in more details.

* Work supported by the National Science Foundation.

TPAB050 A 1500MHz Niobium Cavity Made of Electropolished Half Cells

Rong-Li Geng, Hasan Padamsee, James Sears (Cornell University)

Electropolishing of niobium cavities is proving to yield consistently better performance than chemical polishing thanks to the persistent effort by KEK [K. Saito, Proc. of the 10th Workshop on RF Superconductivity, 288(2001)]. However, an electropolishing system for a multi-cell structure can become complicated and expensive. An alternative, economic way is to electropolish half cells or dumbells before they are welded into a cavity. This method has been tried by DESY [L. Lilje, in The Workshop on Single-Cell Cavity R&D, ed. H. Rissen, TESLA Report, 2002-07, (2002)], but the results were reported to be unpromising. The cavity surface was compromised by the niobium vapor and spatter during electron beam welding. We have taken a second look at the principle of half cell electropolishing by improving the electron beam welding procedure with an EB welder in our facility. A 1500 MHz niobium cavity has been fabricated with two half cells, which are pre-electropolished with a very simple and compact system. In this paper, we will present the surface polishing, fabrication and test results for this cavity.

* Work support by the National Science Foundation.

TPAB051 Fabrication and Testing of an Optimized Shape Cavity for TESLA

Rong-Li Geng, Hasan Padamsee, James Sear, Valery Shemelin (Cornell University), Joe Kichgessner (Consultant)

The accelerating gradient performance of superconducting niobium cavities is rapidly progressing as a result of reduced field emission due to improvement in surface preparation techniques. Beyond the field emission limitation, there exists a fundamental limit imposed by the critical magnetic field of niobium. One way to tackle this limit is to reduce the ratio of the peak magnetic field to the accelerating gradient so that a higher accelerating gradient is possible while the

cavity is still superconducting. New cavity shapes of reentrant type have been proposed and optimized [V. Shemelin, H. Padasmee, R.L. Geng, NIM-A, in press, 2002]. A single cell 1300MHz cavity of this new class of shapes has been fabricated. Because of the reentrant geometry, the fabrication and surface cleaning of the cavity becomes challenging. In this paper, we will present some calculation resutls and the fabrication, preparation and test results of this new cavity.

* Work supported by the National Science Foundation.

TPAB052 Overview of the Cornell ERL Injector Cryomodule

Matthias Liepe, Buz Barstow, Ivan Bazarov, Sergey Belomestnykh, Hasan Padamsee, Valery Shemelin, Charles Sinclair, Maury Tigner, Vadim Veshcherevich (Cornell University)

The ERL injector will accelerate bunches from the electron source from 0.5 MeV to 5 MeV with minimal emittance dilution. There will be one cryomodule with five 1300 MHz 2-cell cavities, each providing one MV of acceleration, corresponding to an accelerating field of about 4.3 MV/m in CW operation. Besides standard features such as an integrated helium vessel and mechanical tuner, each cavity has two input couplers, symmetrically placed on the beam pipe to cancel kicks due to coupler fields. For a 100 mA maximum injected beam current, each coupler must deliver 50 kW of beam power leading to a Qext of 4.6x10^4 for matched beam loading conditions. Antenna- and loop-based HOM couplers can also disturb beam emittance through kicks. We plan to avoid the use of such couplers. Following the strategy for B-factory SRF cavities, the beam pipe aperture has been enlarged on one side to propagate all higher order modes out to symmetric ferrite beam pipe loads. These are positioned outside the helium vessel and cooled to liquid nitrogen temperature. Ferrite properties at 77 K have been measured and the corresponding damping evaluated. To explore the full capabilities of the injector, energy gains up to 3 MV per cavity will be considered at lower beam currents. For this flexibility, the input coupling needs to be adjustable within a factor of 9.

* Work supported by Cornell University.

TPAB053 First Studies for a Low Temperature Higher-Order-Mode Absorber for the Cornell ERL Prototype

Matthias Liepe, Buz Barstow, Hasan Padamsee (Cornell University)

Cornell University, in collaboration with Jefferson Laboratory, has proposed the construction of a prototype energy-recovery linac (ERL) to study the energy recovery concept with high current, low emittance beams [Study for a proposed Phase I ERL Synchrotron Light Source at Cornell University, ed. by S. Gruner and M. Tigner, CHESS Tech. Memo 01-003, JLAB-ACT-01-04 (July 2001)]. The beam with a current of up to 100 mA will excite significant higher-order-mode (HOM) power in the superconducting RF cavities. Strong damping of the HOMs is essential for beam stability and to reduce the HOM losses to a few hundred Watts per meter. For this we plan to place RF absorbing material in the beam tubes between the cavities in the linac. However, this will require operating the HOM absorbers at temperatures below 80 K to simplify the thermal transition to the cavities at 2 K with low static losses to 2 K. One possible material candidate is ferrite, as it is used at room temperature in the HOM absorbers at the s.c. CESR cavities. In this paper we present experiments performed to study the RF absorption properties of ferrite at cryogenic temperatures in the frequency range from 1 GHz to 20 GHz. First results are shown and the resulting HOM damping is evaluated and discussed.

* Work supported by Cornell University.

TPAB054 New Possibilities for Superconducting Cavity Testing at Cornell University

Matthias Liepe, Phil Barnes, Ivan Bazarov, Sergey Belomestnykh, Gongli Geng, Hasan Padamsee, James Sears (Cornell University), Jens Knobloch (BESSY)

Cornell is testing superconducting (s.c.) cavities for many different purposes: system development for CESR, supporting technology transfer of CESR SRF systems to storage ring light sources around the world, collaboration with the world-wide TESLA project, collaboration with Muon Collider/Neutrino Factory projects, developing an Energy Recovery Linac (ERL) based synchrotron light source in collaboration with TJNAF, and basic cavity R&D in the areas of high Q, high field Q-slope and field emission. For this Cornell has upgraded its preparation and test facilities and now has the unique capacity to test s.c cavities with frequencies between 200 MHz and 3 GHz. Three radiation-shielded test pits have been built. The largest pit has a size of 2.4 m diameter by 4.4 meter deep. In addition to the existing RF test system at 500 MHz, 1.3 GHz, 1.5 GHz and 3 GHz, a 200 MHz low power (2 kW) RF test system has been completed [R.L. Geng, this conference]. The high-power 1.3 GHz test system as well as the cavity preparation facility have been upgraded to incorporate TESLA 9-cell cavities. A new 1100 sq ft clean room is in operation for improved cavity preparation.

* Work supported by the National Science Foundation.

TPAB055 Microphonic Detuning in the 500 MHz Superconducting CESR Cavities

Matthias Liepe, Sergey Belomestnykh (Cornell University)

The RF system of the Cornell Electron Storage Ring (CESR) consists of four superconducting 500 MHz cavities. For the charm-tau upgrade (CESR-c, see [D. Rice, EPAC 2002 Proceedings, 428]) we plan to drive two cavities by one klystron and to operate some cavities in passive mode [S. Belomestnykh, this conference]. During the previous high energy run the RF system performance was not significantly reduced by microphonic cavity detuning, since the cavities were operated under strong beam loading with a low loaded quality factor of 2x10^5. However, in low energy CESR-c operation with increased loaded Q-factor the RF system becomes less tolerant to microphonics, especially when two cavities are driven by one klystron. In order to address this potential problem we have studied microphonics in the CESR cavities in detail. Significant improvements have been achieved by reducing major contributions to the detuning. For further improvements we plan to study the performance of an active microphonics compensation scheme, which is based on a fast piezoelectric-driven frequency tuner.

* Work supported by the National Science Foundation.

TPAB056 RF Parameter and Field Stability Requirements for the Cornell ERL Prototype

Matthias Liepe, Sergey Belomestnykh (Cornell University)

Cornell University, in collaboration with Jefferson Laboratory, has proposed the construction of a prototype energy-recovery linac (ERL) to study the energy recovery concept with high current, low emittance beams [Study for a proposed Phase I ERL Synchrotron Light Source at Cornell University, ed. by S. Gruner and M. Tigner, CHESS Tech. Memo 01-003 and JLAB-ACT-01-04 (July 2001)]. The ERL will require the operation of superconducting cavities in two extreme regimes: In the injector a multi-mA beam is accelerated to several MeV energy. The resulting high beam loading in the superconducting cavities requires a strong coupling of the fundamental mode coupler and a high power transfer. The dominating sources of field perturbation in the injector cavities are beam transients and beam current fluctuations. In the main linac the decelerated recirculated beam cancels the beam loading of the accelerated beam. Accordingly these

cavities are operated at a high external quality factor to minimize the RF power requirements. Microphonic cavity detuning and path length fluctuations significantly increase the RF power demands. In this paper an overview of the prototype RF system is given and the main RF parameters are presented. The RF power demands and the field stability requirements for the Cornell ERL prototype are discussed in detail.

* Work supported by Cornell University.

TPAB057 Successful Beam Test of the SOLEIL Superconducting HOM Free Cavity Prototype at the ESRF

Jorn Jacob, Didier Boilot (European Synchrotron Radiation Facility), Enrico Chiaveri, Roberto Losito (CERN), Pierre Bosland, Philippe Bredy, Stephane Chel (French Atomic Energy Commission), Jean-Marc Filhol, Patrick Marchand, Catherine Thomas-Madec (SOLEIL)

A cryo-module housing two superconducting 352MHz-cavities has been developed within the framework of the SOLEIL project design phase. In 2002, the prototype was installed on the ESRF storage ring and tested with beam in the accelerating regime at 4.5K with the cavities cooled by liquid helium from Dewars. Four such tests have been carried out at the end of scheduled shutdowns. In order not to disturb the ESRF machine performance during the user mode of operation, the cavities were maintained detuned at room temperature in a passive regime, where they remained transparent to the beam. Less than 100 W heat generated by the beam had then to be evacuated by a helium gas flow. Up to 170 mA of beam could be accelerated with 3 MV from the superconducting module. This corresponds to the performance required for the first SOLEIL operation phase. The concept of effective HOM damping was validated up to the maximum ESRF intensity of 200 mA. Some problems already identified at previous CERN tests were confirmed: high static cryogenic losses, poor cooling of one HOM coupler and too high fundamental power through the dipolar HOM couplers.

TPAB058 Fabrication of Superconducting Cavities for the RF Separated Kaon Beam

Michael Foley, Leo Bellantoni, Helen Edwards (FNAL)

Superconducting cavities for the RF Separated Kaon Beam Project are formed by joining multiple, deep-drawn, niobium half cells via electron-beam welding. In the deflection mode the fields are a maximum in the iris, and hence this area is critical. Strict mechanical and electrical tolerances are imposed, especially in the iris region. A fabrication process has been developed that minimizes deviations from the nominal design shape. This process maximizes the opportunity to achieve design frequency and field flatness in the final cavities.

TPAB059 Microphonic Detuning Compensation in 3.9 GHz Superconducting RF Cavities

Allan Rowe, Tim Berenc, Ruben Carcagno, Darryl Orris (FNAL)

Mechanical vibrations can detune superconducting radio frequency (SCRF) cavities unless a tuning mechanism counteracting the vibrations is present. Methods of compensating for vibrations vary by cavity type and structure and increase in difficulty as bandwidth specification decreases and resonant frequency increases. Due to their narrow operating bandwidth and demanding mechanical structure, the 13-cell 3.9 GHz SCRF cavities for the Charged Kaons at Main Injector (CKM) experiment at Fermilab are especially susceptible to these vibration-induced detuning phenomena, also known as microphonics. This paper presents early results correlating frequency detuning measurements with cavity vibration measurements for CKM cavities. Initial detuning compensation results with piezo actuators are also presented.

* Work supported by the U.S. Department of Energy under contract No. DE-AC02-76CH03000.

TPAB060 HOM and Mechanical Analysis of a Superconducting CH-Cavity Prototype

Holger Podlech, Horst Klein, Holger Liebermann, Ulrich Ratzinger, Andreas Sauer, Rudolf Tiede (Institut fur Angewandte Physik)

H-Mode cavities (IH-DTL, IH-RFQ, 4-vane RFQ) have been developed successfully during the last decades for a large variety of applications in the field of ion acceleration. The CH-structure which is currently under development at the IAP in Frankfurt in a collaboration with GSI is a new H-mode drift tube cavity operated in the H_{21}-mode. The CH structure can be operated in the frequency range between 150 and 800 MHz, the beam energy can be chosen between 5 and 150 MeV/u. Due to its rigidity, this multicell structure seems to be a promising alternative for superconducting applications in the low and medium energy range. Presently, a superconducting 350 MHz CH-prototype with 19 gaps is under fabrication and will be tested in our new cryo lab. Detailed simulations and measurements have been performed to investigate HOM of the CH-structure. We present the results of these HOM studies together with a numerical analysis of the mechanical vibrations of the cavity.

* Work supported by the BMBF (Nr. 06OF998), GSI and EU.

TPAB061 Status Report on Superconducting Spoke Cavities at IPN

Guillaume Olry (Institut de Physique Nucléaire d'Orsay)

Development of superconducting spoke cavities has become, for now two years, a major activity at IPN-Orsay. These low-beta structures are especially studied to be integrated into the first energy section (i.e. intermediate section) of superconducting high-power proton linacs designed for both XADS and EURISOL European projects (IPN has designed a couple of spoke cavities with the following main characteristics: b=0.15 & b=0.35, 2-gap cavity, f=352 MHz, which could cover the energy range from 5 to 100 MeV. The b=0.35 spoke cavity was fabricated last year in collaboration with the CERCA French company, and recently tested in vertical cryostat at 4K. Before this test, preliminary measurements were done also at room temperature (i.e. frequency, quality factor, bead-pull and tuning sensitivity measurements), to be compared to the results of RF and mechanical simulations. Fabrication of the b=0.15 cavity has to be soon achieved. Based on the b=0.35 spoke geometry optimization, this cavity will be composed of a well-adapted coupler port (designed for a 10-mA proton beam), its stainless steel helium tank and cold tuning system. R&D on a spoke-type cryomodule with a couple of b=0.15 cavities and its ancillary equipments (as superconducting quadrupole) is under progress as well.

TPAB062 High Power RF Tests on Input Couplers for 972MHz Superconducting Cavities in the J-PARC project

Eiji Kako, Shuichi Noguchi, Toshio Shishido (KEK), Hiroyuki Asano, Etsuji Chishiro, Masanori Matsuoka, Hiroyuki Suzuki, Masayosi Yamazaki (Japan Atomic Energy Research Institute)

Prototype coaxial input couplers with a planar rf window and the high power test stand were designed and fabricated. The high power test with a 972MHz pulsed klystron had been successfully carried out. Input rf power of 2.0MW in a pulsed operation of 0.6msec and 25Hz (350kW in 2.45msec and 25Hz) was transferred to the couplers. The experimental set-up, the processing procedure and the test results with high rf power will be reported in the conference.

TPAB063 Test Results of Two LANL Beta = 0.175, 350-MHz, 2-Gap Spoke Cavities

Tsuyoshi Tajima, Randall Edwards, Robert Gentzlinger, Frank Krawczyk, John Ledford, Jian-Fei Liu, Debbie Montoya, Ray Roybal,

Dale Schrage, Alan Shapiro (LANL), Giorgio Corniani (E. Zanon, S.P.A.), Danilo Barni, Angelo Bosotti, Carlo Pagani (INFN)

Two beta=0.175, 350-MHz, 2-gap superconducting (SC) spoke cavities were fabricated in industry under an R&D project for the transmutation of nuclear waste program. These cavities are promising candidates for the accelerating structures between a RFQ and the elliptical SC cavities for proton and heavy ion linacs. Since their delivery in July 2002, they have been tested in terms of mechanical properties, low-temperature performance, i.e., Q-E curves, at 4 K and 2 K, surface resistance dependence on temperature and for multipacting (MP). The two cavities achieved accelerating fields of 12.9 MV/m and 13.5 MV/m as compared to the required field of 7.5 MV/m with enough margin for the quality factor. These cavities seem to need more time to condition away MP than elliptical cavities, but MP does not occur once the cavity is RF processed and kept at 4 K. The detailed data on various issues will be presented.

* Work supported by the US Department of Energy under contract W7405-ENG-36.

TPAB064 Q Disease on 350-MHz Spoke Cavities

Tsuyoshi Tajima, Randall Edwards, Frank Krawczyk, Jian-Fei Liu, Dale Schrage, Alan Shapiro (LANL)

Q disease, i.e., an increase of RF surface resistance due to hydride precipitation, has been investigated with 350-MHz spoke cavities. This phenomenon was studied extensively in early 1990s with cavities at frequencies >1 GHz. This is possibly due to the fact that the lower-frequency cavities were believed to show insignificant effect. However, early 500-MHz KEK elliptical cavities and JAERI 130-MHz quarter wave resonators have shown significant Q degradation, suggesting that this disease can be a serious problem with lower-frequency cavities as well. Since there were no quantitative data with 350-MHz cavities, we decided to measure our two spoke cavities. Our spoke cavities were made of RRR~250 bulk niobium and were chemically polished ~150 microns. One cavity showed a 50 % degradation after holding at between 100 and 132 K for 61 hours. The other showed a ~15 % degradation after holding the cavity at 100 K for 15 hours. Results of a systematic test on the holding temperature and time dependence on the Q degradation will be presented as well as some information on the hydrogen content in the niobium used for the fabrication of our spoke cavities.

* Work supported by the US Department of Energy under contract W7405-ENG-36.

TPAB065 Update on RF System Studies and VCX Fast Tuner Work for the RIA Driver Linac

Brian Rusnak, Stewart Shen (LLNL)

The limited cavity beam loading conditions anticipated for the Rare Isotope Accelerator (RIA) creates a situation where microphonic-induced cavity detuning dominates RF coupling and RF system architecture choices in the linac design process. Where most superconducting electron and proton linacs have beam-loaded bandwidths that are comparable to or greater than typical mircophonic detuning bandwidths on the cavities, the beam-loaded bandwidths for many heavy ion species in the RIA driver linac can be as much as a factor of 10 less than the projected 80-150 Hz microphonic control window for the RF structures along the driver, making RF control problematic. While simply overcoupling the coupler to the cavity can mitigate this problem to some level, system studies indicate that for the low-beta driver linac alone, this approach may cost 50% or more than an RF system employing a voltage controlled reactance (VCX) fast tuner. An update of these system cost studies, along with the status of the VCX work being done at LLNL shall be presented.

* Work performed under the auspices of US Department of Energy by Lawrence Livermore National Laboratory under contract W-7405-Eng-48.

TPAB066 Cryomodule Design for the Rare Isotope Accelerator

Terry Grimm, Matthew Johnson, Richard York (National Superconducting Cyclotron Laboratory)

The Rare Isotope Accelerator (RIA) will generate >400 MeV/u heavy ion beams using many types of superconducting accelerating cavities such as quarter wave, spoke, and elliptical cavities. A cryomodule design that can accommodate all of the superconducting cavity and magnet types is presented. Alignment of the cold mass uses a titanium rail system, which minimizes cryomodule size, decreases the tunnel cross-section, and improves the linac real estate gradient. The titanium rail is supported from the top vacuum plate by an adjustable tri-link, which is similar to existing NSCL magnet technology. A prototype cryomodule is under construction for testing 805 MHz, v/c=0.47, six-cell niobium cavities in realistic operating conditions. Details of the design and progress to date will be presented.

* Work supported by DOE DE-FG02-00ER41144.

TPAB067 Experimental Study of a 322 MHz v/c=0.28 Niobium Spoke

Terry Grimm, John Bierwagen, Steve Bricker, Chris Compton, Walter Hartung, Felix Marti, Richard York (National Superconducting Cyclotron Laboratory)

The Rare Isotope Accelerator (RIA) will accelerate heavy ions to >400 MeV/u using an array of superconducting cavities. A proposed linac design based on harmonics of 80.5 MHz will require six cavity types to cover the entire velocity range: three quarter wave resonators, one spoke cavity (half wave resonator), and two 6-cell elliptical cavities. A prototype 322 MHz niobium spoke with optimum velocity of 0.28c is presently under construction. Each spoke would generate over 1 MV at 4 K for acceleration from v/c=0.18 to 0.40. Details of the design and experimental study will be presented.

TPAB068 X-Ray Tomography of Superconducting RF Cavities

Terry Grimm, Walter Hartung, Susan Musser (National Superconducting Cyclotron Laboratory)

Field emission loading limits the performance of a significant fraction of the cavities in existing superconducting accelerators. The field emission produces an additional load to the cryogenic system; it is a source of dark current and background radiation in the accelerator; and it can lead to RF break-down if the cavity is pushed to its limits. The field emitted electrons are accelerated by the RF field and strike the cavity wall, generating Bremsstrahlung x-rays. The regions of x-ray emission (intensity and energy spectrum) can be located by using a collimated NaI detector placed outside the cryostat and radiation shield. The x-ray emission sites can be reconstructed using tomographic techniques. Particle tracking simulations can be used to trace the field emission electrons back to their source in order to help identify the locations of the surface defects. Demonstration of x-ray imaging of superconducting RF cavities under test at MSU will be presented.

TPAB069 Mechanical Properties of Electron Beam Welds in High Purity Niobium

Terry Grimm, Chris Compton (National Superconducting Cyclotron Laboratory), Tom Bieler, Hairong Jiang (ChEMS, Michigan State University)

The effects of Electron Beam Welding on solidification microstructure and microhardness distribution were investigated in high purity Niobium weld specimens. Two butt-weld specimens with different surface cleanliness treatments were examined. Optical metallography of the welds revealed an equiaxed microstructure with decreasing grain size with distance away from the weld. The average grain size

in the weld was 1000 im, and 100im in the heat-affected zones compared with 50im in the unaffected parent metal. Vickers microhardness measurements showed that the thermal history affected the microhardness. The weld zone had slightly higher microhardness value (57.4) despite having a large grain size, while the unaffected zone had lowest microhardness (55.5). The differences in the cleaning procedure before welding had a negligible effect on the microhardness distribution. The effects of the weld on mechanical properties were investigated by comparing a standard tensile specimen with a tensile specimen with the weld direction perpendicular to the tensile axis in the middle of the gage section. The weld tensile specimens showed substantially reduced UTS and elongation (137 vs. 165 MPa, 38% vs. 68%). The properties are discussed in terms of impurity atoms and the Hall-Petch grain size relationship.

TPAB070 Status Report on Multi-Cell Superconducting Cavity Development for Medium-Velocity Beams

W. Hartung, C.C. Compton, T.L. Grimm, R.C. York (National Superconducting Cyclotron Laboratory), G. Ciovati, P. Kneisel (Thomas Jefferson National Accelerator Facility)

The Rare Isotope Accelerator (RIA) is being designed to supply an intense source of exotic isotopes for nuclear physics research. Superconducting cavities are to be used for the heavy ion driver linac (400 MeV per nucleon, continuous wave). Axisymmetric multi-cell 805 MHz Nb cavities of elliptical cross-section are planned for the high-energy end of the linac. For the highest-energy portion of the linac (beta > 0.53), multi-cell structures have already been developed for the Spallation Neutron Source. A new cavity shape is being developed to accelerate in the range of beta = 0.4 to beta = 0.53 (geometric beta = 0.47). The prototyping sequence was to first fabricate and test two single-cell cavities, and then construct three 6-cell cavities. The first 6-cell cavity is a simple version with coupling antennae mounted on the beam tube endcaps; the second and third 6-cell cavities will be suitable for a system test in a horizontal cryostat. Thus, the latter cavities will be equipped with stiffening rings and a lateral brace (to reduce the microphonic excitation), a helium vessel, a high-power input coupler, and a frequency tuner. The status of this development effort will be presented.

TPAB071 Simulation of Quench Dynamics in SRF Cavities under Pulsed Operation

Sang-ho Kim (ORNL)

As has been well verified both theoretically and experimentally in steady state, the thermal stability of SRF (superconducting radio-frequency) cavities strongly depends on the material properties of niobium such as RRR (residual resistivity ratio) and the presence of material defects on the surface. Recently SRF technology has been chosen in pulsed machines such as Tesla Test Facility, Spallation Neutron Source, European Spallation Source and so on. In order to guide the operational limits and material selection, an understanding of dynamics of quenching in pulsed operation is important. For this purpose, a universal thermal stability analysis algorithm is set up. With the help of 3D FEM codes, a series of transient, non-linear and self-correlated analyses are carried out. This scheme may be used for any stability analysis in SRF cavities with arbitrary conditions such as 3D structure, varying material properties, transient behavior, non-linear material properties, etc..

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

TPAB072 The Numerical Analysis of HOMs for Superconducting RF Cavity at SRRC

Ping Chou (Synchrotron Radiation Research Center)

The increment of beam intensity is limited by the longitudinal coupled bunch instability and the available rf power at SRRC. The higher-order-mode of rf cavities is the the major source of longitudinal impedance. Two Doris cavities are currently used for particle acceleration in the storage ring at SRRC. A superconducting rf cavity developedy by Cornell University will be installed to replace those two Doris cavities. The HOM spectrum for the whole system of superconducting rf cavity was obtained from numerical simulation on a PC cluster. The theoretical ananysis for coupled bunch instabilities with SC rf cavity was also reported.

TPAB073 Effects of Material Properties on the Frequcy Shift of a Niobium Cavity

Ming-Chyuan Lin, Lung-Hai Chang, Gwo-Huei Luo, Chaoen Wang (Synchrotron Radiation Research Center), Meng-Kao Yeh (National Tsing-Hua University)

A CESR-III type 500 MHz superconducting cavity is analyzed to find out effects of material properties on the resonant frequency. This analysis includes structure and high-frequency electromagnetic computations. Due to cool down to cryogenic temperature and pressure difference, variation of niobium properties changes the deformed shape of this shell-like cavity structure and consequently its resonant frequency. The effects of Young's modulus, Poisson's ratio, and coefficient of thermal expansion are discussed.

TPAB074 Status of Superconducting RF Project at SRRC

Chaoen Wang, Lung-Hai Chang, Shu-Shen Chang, Feng-Zone Hsiao, Tzu-Chyang King, Ming-Chyuan Lin, Gwo-Huei Luo, Tz-Te Yang, Meng-Shu Yeh (Synchrotron Radiation Research Center)

A major machine upgrade by replacing the operating room temperature DORIS cavities with a single superconducting SRF cavity of CESR III design is undertaken at SRRC since 1999 for stabilizing and doubling the synchrotron light intensity by operating the machine at a higher beam current in a cavity's higher-order-mode well-damped condition. Commissioning of the SRF module is scheduled for the spring/summer 2003. This report summarizes the current status and achieved performance.

TPAB075 Performance of the Fundamental Power Coupler for the SNS Superconducting Cavities

Isidoro Campisi, E.F. Daly, G.K. Davis, M. Drury, T. Powers, M. Stirbet, K.M. Wilson (Thomas Jefferson National Accelerator Facility)

The fundamental power couplers for the SNS superconducting linac's cavities were developed following a proven design from KEK, modified for operation at 805 MHz. They are rated at 550 kW peak for 1.3 ms and average power of 48 kW when used in the operating SNS accelerator. Previous tests in a room temperature test stand indicated that peak power levels in excess of 2 MW could be reached in a traveling wave mode. Subsequently, tests in real cryomodule conditions showed that peak power of several hundred kilowatts had been attained. These tests included full transient reflection with peak standing wave power of up to nearly 3 MW and a real temperature profile with adsorbed gases in the outer conductor. This paper presents the data of the initial production of couplers and their performance under real cryomodule conditions.

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TPAB076 Preliminary Studies of Electric and Magnetic Field Effects in Superconducting Niobium Cavities

Gianluigi Ciovati, Peter Kneisel, Ganapati Myneni, Jacek Sekutowicz (Thomas Jefferson National Accelerator Facility), A. Brinkmann, Waldemar Singer (DESY)

Superconducting cavities made from high purity niobium with RRR > 200 often show pronounced features in the Q vs. Eacc dependence such as a peak at low gradients, a slope at intermediate fields and a steep degradation of Q-values ("Q-drop") at gradients above Eacc ~ 20 MV/m in the absence of field emission loading. Two different models have been proposed to explain the observed "Q-drop"; but neither of them is able to explain all observations. The model of ref. [J. Knobloch et al.; Proc. 9th workshop on RF Superconductivity, Santa Fe (1999), p. 77] is based on magnetic field enhancements at grain boundaries in the equator weld region of the cavity. These grain boundaries become normal conducting, when their critical magnetic field is reached and contribute gradually to the losses in the cavity as long as they are thermally stable. The model proposed in J. Halbritter et al; IEEE Trans. on Appl. Superconductivity, Vol. 11(1), p. 1865 (2001) is based on effects taking place in the metal-oxide interface on the niobium surface. The major contribution to the RF absorption is coming from interface tunnel exchange between electronic states in the reduced energy gap and localized states resulting from oxygen clusters in the interface. An experimental program was started at JLab to differentiate between electric and magnetic field contributions to describe the observed effects. A modified CEBAF single cell cavity is excited in both TM010 and TE011 modes and the Q vs. Eacc dependences are measured as a function of various surface treatments such as BCP, electropolishing, high temperature heat treatment and "in-situ" baking. In addition, a special two-cell cavity was designed, which allows the excitation of the 0 – and p – modes of the TM010 passband, which "scan" different areas of the cavity surface with high electric and magnetic fields, respectively. This contribution reports about the first measurements with both types of cavities.

∗ Work supported by the U.S. DOE under contract Nr. DE-AC05-84ER40150.

TPAB077 Improved Prototype Cryomodule for the CEBAF 12 GeV Upgrade

Edward Daly, Isodoro Campisi, James Henry, Robby Hicks, John Hogan, Peter Kneisel, Danny Machie, Charlie Reece, Karl Smith, Timothy Whitlatch, Katherine Wilson, Mark Wiseman (Thomas Jefferson National Accelerator Facility), Jacek Sekutowicz (DESY)

In order to provide a higher performance building block cryomodule for the CEBAF 12 GeV upgrade, modifications have been made to the design of the Upgrade Cryomodule. The prototype cryomodule will be completed in 2004 and be installed for operation in CEBAF. Design changes enable the use of higher gradient cavities to achieve greater than 100 MV per cryomodule while still abiding the afforded cryogenic load of 300 W during steady-state operation. They also include refinements based on experience gained during the construction of the first generation upgraded cryomodules as well as the prototype cryomodule for the Spallation Neutron Source. Two cavity designs will be used in the prototype, one optimized for Epeak/Eacc ratio, and the other optimized for minimum cryogenic load. The cavity waveguides, thermal shield and piping have been redesigned to accommodate the higher expected heat loads. The vacuum flanges consist of aluminum seals and clamps to provide reliable UHV sealing. The cavity tuner features a cold motor and piezoelectric actuators to provide coarse and fine tuning respectively.

∗ Work supported by the U.S. Department of Energy under contract DE-AC05-84ER40150.

TPAB078 Lorentz Detuning of Superconducting Cavities with Unbalanced Field Profiles

Jean Delayen (Thomas Jefferson National Accelerator Facility)

Tests on the prototype SNS medium beta cryomodule showed a strong correlation between the flatness of the field profile and the Lorentz detuning coefficient (both static and dynamic). We present an analytical model for the enhancement of the Lorentz detuning as a function of the flatness of the field profile resulting from a spread of the frequencies of the individual cells of the cavity.

∗ Work supported by the U.S. Department of Energy under contract DE-AC05-00-OR22725.

TPAB079 Piezolectric Tuner Compensation of Lorentz Detuning in Superconducting Cavities

Jean Delayen, G.K. Davis (Thomas Jefferson National Accelerator Facility)

Pulsed operation of superconducting cavities can induce large variations of the resonant frequency through excitation of the mechanical modes by the radiation pressure. The phase and amplitude control system must be able to accommodate this frequency variation; this can be accomplished by increasing the capability of the rf power source. Alternatively, a piezo electric tuner can be activated at the same repetition rate as the rf to counteract the effect of the radiation pressure. We have demonstrated such a system on the prototype medium beta SNS cryomodule with a reduction of the dynamic Lorentz detuning during the rf pulse by a factor of 3. We have also measured the amplitude and phase of the transfer function of the piezo control system (from input voltage to cavity frequency) up to several kHz.

∗ Work supported by the U.S. Department of Energy under contract DE-AC05-00-OR22725.

TPAB080 Investigation into the Effectiveness of the Jlab High Pressure Rinsing System

John Mammosser, Tim Rothgeb, Jeff Saunders, Tong Wang (Thomas Jefferson National Accelerator Facility)

As part of a study to reduce field emission in superconducting radio frequency cavities, an investigation into the effectiveness of Jefferson Lab's High Pressure Rinse (HPR) system is underway. This paper compares particulate counts and analysis from both the DI water plant and the HPR wand, field emission scanning results from witness samples on production cavities, results from pressure measurements of the HPR wand spray, vertical test cavity performances during this investigation and further plans for improvements and monitoring.

∗ Work supported by the US.DOE under contract Nr. DE-AC05-00OR22725.

TPAB081 Upgrade to Cryomodule Test Facility at Jefferson Lab

Tom Powers, Trent Allison, G. Kirk Davis, Michael Drury, Christiana Grenoble, Larry King, Tomasz Plawski (Thomas Jefferson National Accelerator Facility)

The cryomodule test facility was originally implemented in the late 80?s for testing of a small fraction of the cryomodules during the production run for the Continuous Electron Beam Accelerator Facility. The original system was built using a dedicated wiring scheme and a pair of 2 kW, 1497 MHz RF sources. This dedicated system made it difficult to test cryomodules and other RF structures of non-standard configuration. Additionally, due to a previously installed cyclotron, there were static magnetic fields in excess of 4 Gauss within the test cave, which limited the capability of the facility when measuring the Qo of superconducting cavities. Testing of the Spallation Neutron Source cryomodules as well as future upgrades to the CEBAF accelerator necessitated that the facility be reconfigured to be flexible

both with respect to RF source power and cryomodule wiring configuration. This paper will describe the implementation of a generalized wiring scheme that is easily adapted to different cryomodule configurations. It will also describe the capabilities of the LabView based low level RF controls and the related data acquisition systems currently being used to test cryomodules and related hardware. The high power RF source capabilities as well as the magnetic shielding put in place in order to reduce the ambient magnetic file to levels below 50 mGauss will also be described.

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TPAB082 Correlation Studies between Material and Surface Characteristics and Superconducting Properties of Nb for RF Cavities

Charles Reece, Michael Kelley, Lawrence Phillips, Anne-Marie Valente, Andy Wu (Thomas Jefferson National Accelerator Facility)

The surface characteristics of practical superconducting rf structures remain relatively poorly understood. The Jefferson Lab Institute for Superconducting RF Science and Technology has initiated characterization studies of the niobium surfaces produced by current preparation techniques and is measuring correlations between residual contaminations, surface oxide structure, and high-field surface impedance. Samples co-processed in a mock cavity together with a single cell cavity are subjected to SIMS, SAM, and SEM analysis. Variations in the produced surfaces are described with respect to sample orientation in the mock cavity, chemical processing bath temperature, BCP vs. electropolish preparation, and thermal treatments. Results and analysis to date will be presented.

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TPAB083 Towards Strongly HOM-Damped Multi-Cell RF Cavities

Robert Rimmer, Haipeng Wang, Genfa Wu (Thomas Jefferson National Accelerator Facility), Jacek Sekutowicz (DESY), Derun Li (LBNL)

This paper discusses the prospects for very strong HOM damping in multi-cell RF cavities. There has been much progress in recent years towards "HOM-free" single-cell cavities. Many examples are now operating in high current storage rings around the world. There have also been successes in broad-band damping of multi-cell structures to levels appropriate for linear colliders and low average current applications. We describe the use of modern simulation tools to explore the potential for applying these techniques to strongly damped multicell structures. Such cavities would be useful for high-current, high-power applications such as high luminosity collider storage rings, damping rings, energy recovered linacs and injector systems. Whilst the primary focus of this paper is superconducting cavities these methods may also be applicable in one form or another to room temperature cavities.

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TPAB084 Active HOMs Excitation in the First Prototype of Superstructure

Jacek Sekutowicz, Andre Gössel, Guennadi Kreps (DESY), Shuxin Zheng (Tsinghua University, Beijing)

The good damping of HOMs in both prototypes of the TESLA superstructure has been achieved with HOM couplers based on the coaxial line technique. We present in this paper the first approach to the measurement method which potentially makes possible to determine the impedance of damped transversal modes and their polarisation. We comment on the first results obtained recently during the superstructure test in the TTF linac and on the limits in the proposed method.

TPAB085 Cavities for JLAB'S 12 GeV Upgrade

Jacek Sekutowicz, Gianluigi Ciovati, Peter Kneisel (Thomas Jefferson National Accelerator Facility), Arne Brinkmann, Shuxin Zheng (DESY)

The future upgrade of CEBAF to 12 GeV requires additional new cryomodules in both linacs to increase the energy gain per pass to 1090 MeV. Until recently the design of these cryomodules, which had to deliver 70 MeV each, was based on 7-cell superconducting cavities that were an extended version of the 5-cell structures currrently operated in CEBAF. Two improved cavity shapes were proposed subsequently: The high gradient (HG) shape was optimized by minimizing the ratio of Epeak / Eacc to 1.9, keeping in mind that the limitation in superconducting cavities is in most cases field emission loading. By reducing this ratio by 25 % compared to the old shape, a 25 % gain in accelerating gradient would result without any improvements in surface treatment procedures. The design value for the accelerating gradient has been set to Eacc = 20 MV/m. The Low Loss (LL) shape was optimized by maximizing the shunt impedance (R/Q) and the geometry factor (G). The increased product of both quantities results in significantly lower wall losses than for the two other cavity shapes. This will reduce the cost of nominal operation and will open the possibility of operating the cavities at higher gradients within the cryogenic budget. This contribution discusses the rf features of both new cavity shapes in the accelerating mode. In addition, multipacting calculations have confirmed that in both cavity shapes no multipacting is present up to the design gradient.

* Work supported by the U.S.DOE under contract Nr. DE-AC05-84ER40150.

TPAB086 Field Emission Studies from Nb Surfaces Relevant to SRF Cavities

Tong Wang, Charles Reece, Ronald Sundelin (Thomas Jefferson National Accelerator Facility)

Enhanced field emission presents the main impediment to higher acceleration gradients in superconducting rf Nb cavities for particle accelerators. A scanning field emission microscope was built at Jefferson Lab with the main objective of systematically investigating the sources of enhanced field emission from Nb surfaces. Various surface preparation techniques and procedures, including chemical etching by BCP (buffered chemical polishing), electropolishing, ultrasonic water rinse, high pressure water rinse, air-dry after methanol rinse, air-dry after water rinse in Class 10 cleanroom, were investigated. The capability and process variables for broad-area Nb surfaces to consistently reach field emission free or near field emission free performance at ~140 MV/m have been experimentally demonstrated using the above techniques/procedures.

* Work supported by U.S. Department of Energy under contract number DE-AC05-84ER40150.

TPAB087 Niobium Thin Film Properties Affected by Deposition Energy during Vacuum Depostion

G. Wu, H.L. Phillips, R.M. Sundelin (Thomas Jefferson National Accelerator Facility), L. Hand (Cornell University)

In order to understand and improve the superconducting performance of niobium thin films at cryogenic temperatures, an energetic vacuum deposition system has been developed to study deposition energy

effects on the properties of niobium thin films on various substrates. Ultra high vacuum avoids the gaseous inclusions commonly seen in sputtering deposition. A retarding field energy analyzer is used to measure the kinetic energy of niobium ions at the substrate location. A biased substrate holder controls the deposition energy. Transition temperature and residual resistivity ratio of the niobium thin films at several deposition energies are obtained together with crystal orientation measurements and AFM inspection, and the results show that there exists a preferred deposition energy around 115eV (the average deposition energy is 64 eV above the bias voltage).

* This manuscript has been authored by The Southeastern Universities Research Association, Inc. under Contract No. DE-AC05-84ER-40150 with the U.S. Department of Energy.

TPAB088 RF Control System for ISAC II Superconducting Cavities

Ken Fong, S. Fang, Mike Laverty (TRIUMF), Qiwen Zheng (Institute of Modern Physics)

The RF control system for the superconducting cavities of the ISAC II project is a hybrid analogue/digital system. Each consists of a self-excited feedback loop with two phase-locked loops for phase and frequency stabilization. Amplitude and phase regulations, as well as tuning control are performed using digital signal processors. Special pulsing circuitry is incorporated into the system for fast punching through multipactoring. This paper describes the RF control system, the characteristics of the feedback loops and the experience in operating this system.

TPAB089 Magnetostrictive Tuners for SRF Cavities

Chad Joshi, Anil Mavanur (Energen, Inc.)

Magnetostrictive actuators can deliver high force precision motion at cryogenic temperatures. Magnetostrictive materials change their shape in a reversible and repeatable manner when exposed to a small magnetic field. Energen, Inc. has demonstrated a new tuner mechanism to address both slow and fast SRF cavity tuning requirements. The slow tuner uses a linear stepper motor to deliver high-force, sub-micron linear motion of tens of millimeters at cryogenic temperatures resulting in hundreds of kilohertz tuning range. A locking mechanism built into the stepper motor enables the tuner to be locked into position when the power is turned off. A separate actuator delivers fast tuning capability for microphonics and Lorenz detuning compensation. Performance and capabilities of this prototype SRF cavity tuner will be reported.

* This project is funded in part by the U. S. Department of Energy through the SBIR Program.

TPAB090 Fabrication, Test and First Operation of Superconducting Accelerator Modules for Storage Rings

Michael Pekeler, Stefan Bauer, Michael Peiniger, Hanspeter Vogel, Peter vom Stein (ACCEL Instruments GmbH), Sergey Belomestnykh, Hasan Padamsee, Peter Quigley, James Sears (Cornell University)

The production of 6 superconducting 500 MHz modules for Cornell, SRRC and CLS is almost finished. We summarize the vertical cavity test results and the high power processing of the windows and report on cold module tests. Operational experience with the delivered modules is also presented. Furthermore a 1.5 GHz superconducting Landau module is under production at ACCEL. The status of this project will be discussed.

Poster Session TPAG
Galleria at 8:30

TPAG001 Rebuilding WR-340 and WR-284 Waveguide Switches to Meet Higher Power at the Advanced Photon Source

Steve Berg, Dave Bromberek, George Goeppner, Arthur Grelick, Alirezza Nassiri, Terry Smith (ANL)

The high-power S-band switching system for the Advanced Photon Source (APS) linear accelerator (linac) provides for a hot spare for two of the four S-band transmitters. The system utilizes four-port S-band switches of aluminum construction that are pressurized with sulfur hexafluoride during normal operation and are commercially available. A high-power S-band transmitter test stand at the APS linac has shown that processes that include the hand working and electropolishing of sharp edges internal to the aluminum construction of these switches have measurably improved power handling characteristics.

* This work is supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

TPAG002 Conducting Research and Operator Training While Maintaining Top-up Reliability Using the Advanced Photon Source Linear Accelerator

Stanley Pasky (ANL)

In recent years many changes have been made to the Advanced Photon Source (APS) linear accelerator (linac) to support multiple tasks. The primary purpose of the linac is to provide beam to fill the APS storage ring, which is done using thermionic cathode rf guns. At the same time, we have had to provide support for research projects, including a new facility that will be used for future operator training as well as testing injector components. With each project requiring a different lattice and timing configuration, while at the same time using common rf systems, the complexity of operations has increased significantly with even greater demands on reliability and performance. In addition, personnel safety and equipment protection concerns became more complex. The approach to these challenges involved three developments: a high degree of automation in linac operation using APS's Procedure Execution Manager (PEM) software; a new interlock system based on programmable logic controllers; and use of an automated S-band rf switching system. In this paper we discuss how these developments have improved the flexibility and reliability of APS linac.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

TPAG003 Bidirectional Coupler Optimization in WR284 Waveguide

Terry Smith, Steve Berg, Arthur Grelick, Geoff Waldschmidt (ANL)

In the Advanced Photon Source linac gun test area at Argonne National Laboratory a new S-band ballistic Bunch compression (BBC) gun is being tested. It is desirable to measure the rf parameters of the BBC gun to a high degree of accuracy. It was determined that a coupling of -57 +/- 1 dB and a directivity of greater than 30 dB are required for proper operation. Numerical simulations were performed using the High Frequency Structure Simulator (HFSS) by Ansoft to determine the optimal dimensions of the coupling iris of the WR284 bidirectional coupler and the orientation of the loop coupling element. To attain these criteria, experimental models were built where the coupling iris was enlarged, and the currents induced by the magnetic and electric

fields in the coupler were adjusted by modifying the coupling of the fields as well as the capacitance of the coupling loop.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

TPAG004 Calibration of RHIC Electron Detector

Ping He, David M. Gassner, Justin Gullotta, Hsiao-Chaun Hseuh, Dejan Trbojevic, Shou-Yuan Zhang (BNL)

To characterize the electron cloud in RHIC, eleven custom electron detectors have been designed, fabricated and installed at a few RHIC warm beam vacuum sections for data collection during FY2003 runs. Prior to installation, the transmission and collection efficiencies of these detectors at various grid and collector bias voltages were measured using an electron gun with energy up to 1500 eV. This paper describes the design of the detector and the test system set-up, and summarizes the calibration results. In addition the calibration of a commercial multi-channel plate is also reported.

* Work performed under the auspices of the U.S. Department of Energy.

TPAG005 Integration of the Beam Scraper and Primary Collimator in the SNS Ring

Hans Ludewig, J. Browdowski, S. Crivello, D. Davino, B. Mullany, D. Raparia, Nick Simos, J. Touzzolo (BNL), N. Catalan-Lasheras (CERN), S. Cousineau (ORNL)

The collimation system in the SNS ring includes a two-stage collimator consisting of a halo scraper and an appropriate fixed aperture collimator. This unit is placed between the first quadru-pole and the first doublet in the collimation straight section of the ring. The scraper is situated at the exact mid-point between these two magnets, and the fixed aperture collimator fills the space between it and the doublet. The scraper consists of four independently moveable 5 mm thick tantalum plates, which are attached to water cooled copper masses. The fixed aperture collimator has an ellipticlly shaped collimator tube, which is surrounded by a water cooled stainless steel shield structure. The scraper mechanism and collimator are mounted on a common plate, that is adjusted by three jacks. This arrangement ensures that alignment between the scraper and collimator is preserved, even in the event that the floor moves.The entire structure is surrounded by an outer shield. The downstream dose to the doublet and the attached corrector will be estimated for normal operating conditions. In addition, the thermal, fluid dynamic, and stress analyses will be presented for the scraper and collimator. Finally, the dose at the downstream flange locations will be estimated following machine shutdown.

* Work performed under the auspices of the US-DOE. SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the US-DOE. SNS is a partnership of six laboratories; Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

TPAG006 Vibration Studies on a Superconducting RHIC Interaction Region Quadrupole Triplet

Christoph Montag, George Ganetis, Lin Jia, Wing Louie (BNL)

Mechanical vibrations of the superconducting interaction region triplets have been identified as source of horizontal beam jitter around 10 Hz in the Relativistic Heavy Ion Collider (RHIC). Therefore, cold masses inside one triplet cryostat have been equipped with accelerometers to further investigate the phenomenon. Additionally, helium pressure transducers have been installed to determine helium pressure oscillations as a possible primary vibration source. Recent results will be reported.

* Work performed under the auspices of the US Department of Energy.

TPAG007 Mechanical Dynamic Analysis of the LHC Arc Cryo-Magnets

Ofelia Capatina, Kurt Artoos, Nicolas Bourcey, Olivier Calvet, Claude Hauviller (CERN)

The arcs of the Large Hadron Collider (LHC) will contain around 1700 main superconducting dipoles and quadrupoles. The long and heavy magnets are placed on fragile composite support posts inside a cryostat to reduce the heat inleak to the magnets super fluid helium bath. The presence of such fragile components like the support posts, the beam position monitors and the corrector magnets make the cryo-magnets very difficult to handle and transport. Furthermore, keeping the geometry of the cryo-magnets unchanged (in the range of 0.1 mm) throughout the various transports and handling is essential for the good functioning of the future LHC. A detailed dynamic analysis was performed to determine the behavior of the cryo-magnets under all the handling and transport conditions and to choose the related optimum parameters. The results of finite element modal calculations as well as experimental modal analyses are presented and compared. The maximum accelerations admissible during transport with several types of vehicle were computed. The accelerations experienced by both types of cryo-magnets were measured during real transport with different vehicles. The dynamic deformation of the support posts in the cryo-dipole was also measured. The methodologies of these analyses and their results are reported as well as the resulting specification for the transport during the LHC installation.

TPAG008 Digital Cryogenic Control System for Superconducting RF Cavities in CESR

Peter Quigley, Sergey Belomestnykh, Roger Kaplan (Cornell University)

Effective cryomodule control and monitoring are essential components to successful storage ring (CESR) operation. The ability to quickly diagnose system problems can have a dramatic effect on machine down time. The CESR SRF Digital Cryomodule control system, employing a PC, a commercial PLC and user interface, is presented. With these tools, system status is available at a glance or, if needed, detailed system information can be displayed. Straightforward configuration of PID control loops, safety interlocks, signal display, and data acquisition is the main feature of the system. The SRF cryomodules have several modes of operation. For example, under normal machine running conditions liquid helium level is regulated using a liquid level signal as the process variable (PV). For cryostat cool-down the flow rate of cold helium gas returning to the refrigerator directly reflects cryomodule cooling rate and is a more useful process variable. Both these operational modes use the same control variable (CV): liquid helium supply valve control signal. Other operational modes include warm-up and RF processing. This control system can be reconfigured quickly to meet the conditions of different operational modes.

* Funding provided by NSF.

TPAG009 Autopsy Results of Failed Lithium Collection Lenses at the FNAL Antiproton Source

Patrick Hurh, Anthony Leveling (FNAL)

A Lithium lens focusing device is used at the FNAL Antiproton Source to collect antiprotons immediately downstream of the production target. Recently developed methods of removing lithium from old collection lens devices have enabled the dissection and autopsy of several failed lenses. Examination reveals longitudinal fatigue cracks in the titanium alloy (6 Al- 4V) cooling jackets. A finite element analysis to estimate stress intensity factors expected in the cooling jackets is presented and compared to the crack propagation and fracture toughness thresholds for Ti 6Al-4V. Results presented indicate that crack initiation and propagation at the currently estimated service

loads are unlikely without additional material degradation mechanisms at work.

* Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy.

TPAG010 The Design of a Diffusion Bonded High Gradient Collection Lens for the FNAL Antiproton Source

Patrick Hurh, James Morgan, Ryan Schultz (FNAL)

Advances in metal joining technology have made it possible to manufacture a one piece lithium lens design utilizing diffusion bonding rather than the current multiple piece, electron beam welded lithium lens design. Advantages of the new design include fewer lithium seals, incorporation of heat treatment with the bonding cycle, vastly simpler assembly requirements, and decreased cost and manufacturing time. Fatigue testing results are presented which indicate that the diffusion bonded joints are just as strong as the parent material. Results from a first prototype of this new design are presented as well as the design of a second prototype.

* Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy.

TPAG011 Beamline Design for Particle Production Experiment, E907, at FNAL

Carol Johnstone, Dave Carey, Mikhail Kostin (FNAL)

The experiment E907 has been conducted in Fermilab. The purpose of this experiment is measurement of hadron production cross-sections in nuclear interactions of pion, kaon and proton beams in the momentum range of 5 to 120 GeV/c. Light to heavy targets will be used to study the scaling law of hadronic fragmentation and light meson and barion spectroscopy. Design aspects for the experiment beamline are presented. The lattice, primary target, collimation system and radiation shielding are covered.

* Work supported by the US Department of Energy under contract no. DE-AC02-76CH03000.

TPAG012 Lithium Collection Lens Filling Process for Fermilab Antiproton Source

Ryan Schultz (FNAL)

The most critical step in fabrication of the lithium collection lens is the introduction of molten lithium into the core of the lens. A preload (hydrostatic compressive stress) of approximately 2500 psi is desired within the solid lithium for proper lens operation. Instrumentation that is accurate at temperatures well above the melting temperature of lithium (180.6 C) must be used to monitor the pressure during the fill to achieve the desired preload. Measurements from recent lens fills show that as the lens cools, the preload decreases by approximately 50 psi/C on average. This paper shows that this apparent thermal expansion modulus can be determined analytically as well as numerically. These results are then compared to measured values.

* Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy.

TPAG013 Li Material Testing - Fermilab Antiproton Source Lithium Collection Lens

Salman Tariq, Kavin Ammigan, Patrick Hurh (FNAL), Jian Ku Shang (University of Illinois)

The lithium collection lens is a high current (greater than 0.5 MA), pulsed device used to focus antiprotons just downstream of the production target. Pre-mature failure of these lenses has led to extensive efforts to understand the cause of the failures. One of the main unknowns is the structural behavior of lithium under such extreme loading conditions. Lithium can be categorized as a soft or "plastic" solid with relatively low modulus of elasticity and yield strength. Very little is available on its nonlinear and viscoplastic (rate dependent) structural properties. Tests were conducted to determine the rate dependent tensile behavior and creep response of lithium at various temperatures. Results of these tests are presented.

* Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy.

TPAG014 Beam Study with RF Choppers in the MEBT of J-PARC Proton Linac

Takao Kato, Masanori Ikegami (KEK), Shinian Fu, Sheng Wang (Institute of High Energy Physics, Beijing)

An RF chopper system is utilized for chopping beam pulses in the Medium Energy Beam-Transport Line (MEBT) of the J-PARC proton linac. A main purpose of the chopper system is to reduce beam losses after injecting into the following rapid cycling synchrotron (RCS) by producing a beam-pulse train of about 500 ns in length. The chopper system consists of two 324-MHz single cavities connected in series. The cavity is operated in a TE11-like mode and a loaded Q-value is about 10. A 30-kW solid-state power amplifier with a rising time of 15 ns was used. A first beam test of the chopper system was performed successfully as one of the main items of the MEBT beam commissioning of the 60-MeV proton linac test stand at KEK. The chopped beam properties were studied by using MEBT monitor systems: beam position monitors, fast current monitors, slow current monitors, a beam scraper and a beam stopper. A transient time of 10 ns is obtained for both rise and fall times for a 25 mA beam. A beam signal during chopper-on period measured at the exit of the MEBT is less than noise level of the monitor systems mentioned above. In this paper, detailed beam study results are presented.

TPAG015 Spallation Neutron Source High-Power RF Transmitter Design for High Availability, Ease of Installation and Cost Containment

Joseph Bradley III, Tom Hardek, Michael Lynch, Dan Rees, William Roybal, Paul Tallerico (LANL)

The availability goals and installation schedule for the Spallation Neutron Source (SNS) have driven the availability and installation of the SNS linac's high-power RF systems. This paper discusses how the high-power RF systems' availability and installation goals have been addressed in the RF transmitter design and procurement. Design features that allow RF component failures to be quickly diagnosed and repaired are also presented. Special attention is be given to interlocks, PLC fault logging and real-time interfaces to the accelerator's Experimental Physics and Industrial Control System (EPICS) archive system. The availability and cost motivations for the use of different RF transmitter designs in the normal-conducting and super-conducting sections of the linac are reviewed. Factory acceptance tests used to insure fully functional equipment and thereby reduce the time spent on installation and commissioning of the RF transmitters are discussed. Transmitter installation experience and klystron conditioning experience is used to show how these design features have helped and will continue to help the SNS linac to meet its availability and schedule goals.

* Work supported by US Department of Energy.

TPAG016 Manufacturing Issues Related to the Fabrication of the SNS DTL Drift Tubes and How They Were Resolved

Will Fox, Nathan Bultman, Rick Martineau, Dan Richards, Jim Sims (LANL), Rudy Damm, Gary Johnson (ORNL)

The Spallation Neutron Source (SNS) drift-tube linac (DTL) uses 210 drift tubes that incorporate permanent magnet quadrupoles (PMQs),

electromagnet dipoles, and beam-position monitors (BPMs) in their construction. The drift tubes were assembled using vacuum brazing, electron-beam welds, and orbital GTAW welds. Vacuum brazing of the copper-plated stainless-steel diverter tube to the copper drift tube initially produced voids in the braze joint. Problems were also encountered in the electron-beam welding associated with porosity in the welds. GTAW of the stem resulted in damage to the BPMs and required their replacement. This paper describes the development work that was done to produce electron-beam welds of high integrity in OFE copper that could be post-machined. We also discuss the cooling and magnetic field shunting techniques used to weld the PMQs into the drift tubes, the vacuum braze joint development that resulted in acceptable braze joints between the OFE copper drift-tube body and the stainless-steel diverter tubes, and the technique used to produce orbital GTAW welds in the stem without damage to BPMs. A major contributor to the manufacturing issues associated with fabrication of the drift tubes was lack of sufficient engineering involvement in the manufacturing and in-process testing. We discuss lessons learned and the subsequent engineering controls that were applied to the manufacture of the drift tubes.

∗ Work supported by the Office of Science of the US Department of Energy.

TPAG017 Completion of SNS-Linac R&D Program

Robert Hardekopf, John Bernardin, James Billen, Nathan Bultman, Will Fox, Tom Hardek, Steve Hopkins, Subrata Nath, Don Rej, Paul Tallerico, Lloyd Young (LANL)

Los Alamos completed the R&D program for the SNS linac in September 2002 with publication of a comprehensive report on the SNS coupled-cavity linac (CCL) hot model. In this paper we summarize the results of the R&D program and its effect on the SNS linac design. In particular, we review the design choices for the bridge-coupled CCL, the refinement of the design through cold models, and the fabrication and testing of the hot model. We describe the RF system used to power the model, the prototype water and vacuum systems, and the experimental tests of these systems, including conditioning and radiation measurements. The CCL hot-model experiments answered several questions concerning design, manufacturability, tunabily, and stability for this type of RF structure.

∗ Work supported by the Office of Science of the US Department of Energy.

TPAG018 Operational Performance of the SNS LLRF Interim System

Alessandro Ratti, Lawrence Doolittle, Marco Monroy (LBNL), Mark Champion, Hengjie Ma (ORNL)

A new approach has been taken to develop and build the Low-Level RF Control System for the SNS Front End and Linear Accelerators, as reported in a separate paper in this conference. The new LLRF system is an expanded version of the system built and commissioned at Berkeley Lab for the MEBT RF. A revised version of this proven MEBT system has been built as an interim solution to support short-term goals and early commissioning of the Front End RFQ, DTL, and CCL accelerators, while the final system is under development. Additional units of the interim system are in use at JLAB and LANL for concept testing, code development, and commissioning of SNS SRF cryomodules. The conceptual design of the MEBT system had already been presented elsewhere, and this paper will address operational experiences and performance measurements with the existing interim system hardware, including commissioning results at the SNS site for the Front End and DTL Tank 1 together with operational results from the JLAB test stand.

∗ This work is supported by the Director, Office of Science, Office of Basic Energy Sciences, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098. The SNS project is being carried out by a collaboration of six US Laboratories: Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Thomas Jefferson National Accelerator Facility (TJNAF), Los Alamos National Laboratory (LANL), E. O. Lawrence Berkeley National Laboratory (LBNL), and Oak Ridge National Laboratory (ORNL). SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy.

TPAG019 A Compact Traveling Wave Accelerator Structure with Collinear Load for 2 MeV, 1 kW Irradiation Linac

Yuan Ji Pei, G.Y. Feng, Y.L. Hong, D.M. Jiang, K. Jin, Y.Z. Liu, H.B. Sun (National Synchrotron Radiation Lab), W. Zhou (China Institute of Atomic Energy), S.Q. Li, L.G. Shen (University of Science and Technology of China)

A compact traveling wave accelerator structure with a collinear load, which is used for a 2 MeV, 1 kW, S-band irradiation linac, is described in this paper. Small size and simplified accelerator structure are very important for an irradiation facility in industrial applications. The beam dynamics parameters, including energy gain with beam loading, energy spectrum, and beam envelop in the structure, were simulated, and results are given. This paper describes the collinear load details, with characteristics such as absorbing microwave power, vacuum performance and so on. The accelerator structure has been used for an irradiation facility, which is being used for kill some bacteria such as anthrax. The main parameters of the accelerator tube: Energy 2 MeV, beam current (pulse) 500 mA, beam current (average) 1 mA, and beam power 1 kW.

TPAG020 Beam Dump Window Design for the Spallation Neutron Source

Stuart Henderson, Arnold DeCarlo, Stuart Henderson, Sang-ho Kim, K. Potter, Ken Reece (ORNL), James Rank, Deepak Raparia (BNL)

The Spallation Neutron Source accelerator systems will provide a 1 GeV, 1.44 MW proton beam to a liquid mercury target for neutron production. Beam tuning dumps are provided at the end of the linac (the Linac Dump) and in the Ring-to-Target transport line (the Extraction Dump) [D. Raparia et al., these proceedings]. Thin windows are required to separate the accelerator vacuum from the poor vacuum upstream of the beam dump. There are several challenging engineering issues that have been addressed in the window design. Namely, handling of the high local power density deposited by the stripped electrons from the H- beam accelerated in the linac, and the need for low-exposure removal and replacement of an activated window. The thermal design of the dump windows is presented, as is the design of a vacuum clamp and mechanism that allows remote removal and replacement of the window.

∗ SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

TPAG021 Status of Timing System and Its Upgrade for the PLS Storage Ring

Myung-Hwan Chun, Young-Jin Han, Heung-Sik Kang, Do-Tae Kim, Sang-Hun Nam, Byung-Ryul Park, Jae-Seok Yang (Pohang Accelerator Laboratory)

The timing system for the Pohang Light Source (PLS) storage ring consists of a trigger synchronize module, a fine delay module, a repetition rate pulse generator module, and so on. All the timing modules are installed in the VXI crate and controlled by the 32 bit microprocessors with the host computer. Although the timing system has been operated without any serious problem since commissioning in 1994, there were some minor troubles, and the performances were

not so excellent. Therefore, upgrade of the timing system is progressing with a synchronous universal counter and other commercial modules of NIM type for increasing of a reliability, easy maintenance, low timing jitters, and all types of fill pattern.

TPAG022 Slow-Wave Electrode Structures for the ESS 2.5 MeV Fast Chopper

Michael Clarke-Gayther (Rutherford Appleton Laboratory)

Slow-wave electrode designs for the European Spallation Source (ESS) 2.5 MeV fast beam chopper are described. Broad-band transmission line properties for the initial planar and helical designs have been refined by modelling electromagnetic fields in the Finite Difference Time Domain (FDTD) 'Microwave Studio' code. A compact, radiation hard, vacuum compatible helical structure made from linked strip-line and micro-strip sections has been developed. Simulated characteristics in the frequency and time domain, and the effects of E-field non-uniformity are presented.

TPAG023 Electrical Power and Grounding Systems Study and Improvement at TLS

Jui-Chi Chang, June-Rong Chen, Kung-Cheng Kuo, Shan-Chih Lei, Yu-Chih Lin (Synchrotron Radiation Research Center)

The effect of the electrical power and grounding systems on the beam stability is studied at the Taiwan Light Source (TLS). Based on the study, some major improvements are accomplished at TLS. The electric power SCADA (Supervisory Control And Data Acquisition) system is established to remotely monitor and control the electrical power conditions. The soil resistivity data at TLS is collected and a new grounding system of low impedance (0.18U) is constructed. Grounding signals and electric potential are collected at some grounding boxes. Grounding electric potential is observed effected by injection at some specific local grounding boxes. Grounding electric potential difference is also found between the new and old grounding systems. These two grounding systems will be connected as one and rearranged to cope with the grounding related problems.

TPAG024 De-Ionized Cooling Water System Study and Improvement at TLS

Jui-Chi Chang, Zong-Da Tsai, Yen-Ching Chung, Ching-Yuarn Liu, June-Rong Chen (Synchrotron Radiation Research Center)

In order to promote the stability and quality of the de-ionized cooling water (DIW) system, a series of studies and improvements on the DIW system are accomplished at the Taiwan Light Source (TLS). The total DIW system capacity is increased 400 gpm, where a special subsystem of 150 gpm is for a new superconducting-rf system only. The DIW temperature is globally controlled within ±0.1°C. A high precision temperature control system of ±0.01°C for local DIW supply is also established to meet the critical stability requirements. The water quality has also been improved by upgrading local filters, reverse osmosis, conductivity meters, pH monitors, flow meters and various resins. The conductivity of the water has been maintained above 10 MΩ/cm and the pH at 7±0.1. Additionally, the dissolution of oxygen, which is another essential water quality factor, has also been much reduced from 5000ppb to 1ppb by new deoxygenating equipment.

TPAG025 Air Temperature Control Improvement for the Storage Ring Tunnel

Jui-Chi Chang, Ching-Yuarn Liu, June-Rong Chen (Synchrotron Radiation Research Center)

Based on the thermal effects on the beam stability formerly studied, a series of measures are taken to improve the air temperature control for the storage ring tunnel at the Taiwan Light Source (TLS). The cooling capacity is increased about two times by rearranging the Air Handling Units (AHU) and the piping system. The PID parameters are optimized to more effectively suppress the air temperature fluctuation. The global air temperature variation in the storage ring tunnel is currently controlled within ±0.1°C related to time. After successful experience of air temperature control for the elliptical polarization undulator (EPU), the mini environment control is also applied on another insertion device, undulator 5 (U5). The ambient temperature variation of this magnet is controlled within ±0.1°C related to time. The thermal uniformity is much improved than ever.

TPAG026 Machine Protection for High Average Current Linacs

Kevin Jordan, Trent Allison, James Coleman, Rich Evans, Al Grippo (Thomas Jefferson National Accelerator Facility)

A fully integrated Machine Protection System (MPS) is critical to efficient commissioning and safe operation of all high current accelerators. The Jefferson Lab FEL has multiple electron beam paths and many different types of diagnostic insertion devices. The MPS needs to monitor both the status of these devices and the magnet settings which define the beam path. The matrix of these devices and beam paths are programmed into gate arrays, the output of the matrix is an allowable maximum average power limit. This power limit is enforced by the drive laser for the photocathode gun. The Beam Loss Monitors (BLMs), RF status, and laser safety system status are also inputs to the control matrix. There are 8 Machine Modes (electron path) and 8 Beam Modes (average power limits) that the FEL can operate safely. Combinations outside of this matrix are unsafe and the beam is inhibited. The power limits range from no beam to 2 megawatts of electron beam power. The timing requirements for the BLMs and RF is ~1 microsecond and for the insertion devices (viewers) is ~ 1 millisecond. The entire system is VME based and EPICS compatible. This paper describes the operational experience as it is installed on the JLab 10kW FEL.

* This work supported by the Office of Naval Research, the Joint Technology Office, the Commonwealth of Virginia, the Air Force Research Laboratory, and by DOE Contract DE-AC05-84ER40150.

TPAG027 A Mechanical Tuner for the ISAC-II Quarter Wave Superconducting Cavities

Robert Laxdal, Ken Fong, Shane Koscielniak, Thomas Ries, Guy Stanford (TRIUMF)

TRIUMF is developing a new mechanical tuner system capable of both coarse (kHz) and fine (Hz) frequency adjustments for maintaining frequency lock on the superconducting quarter wave cavities of the ISAC-II heavy ion linac. The tuner mechanism displaces a 1 mm thick Niobium end plate which forms part of the capacitive load on the cavity. The plate is actuated by a vertically mounted permanent magnet linear servo motor, at the top of the cryostat, using a 'zero backlash' lever and push rod configuration through a bellows feed-through. The position of the motor is sensed by a high resolution sine encoder and fed through special subdividing electronics with an effective control resolution inside the servo amplifier of 0.03 micro-m. The actual system resolution is about 0.5 micro-m limited only by the analog command signal from the digital servo controller to the amplifier as well as the phase quadrature position signal from the amplifier. The band width of the current control loop is 600 Hz while the velocity loop can be tuned to better than 200 Hz. The tuner plate gives a cavity frequency shift of 6Hz/μ and is formed with a single convolution and eight radial slots to increase the range of motion. The rf control is based on a self-excited loop with a locking circuit for amplitude and phase regulation. The tuner is fed the rf phase error to maintain the reference frequency within the loaded bandwidth. The tuner has been tested with a prototype quarter wave cavity. Details of the mechanical device and results of open and closed loop cold tests will be given.

TPAG028 The Jefferson Lab Quality Assurance Program for the SNS Superconducting Linac Construction Project

Ozelis Joseph (University of California, Los Angeles)

As part of a multi-laboratory collaboration, Jefferson Lab is currently engaged in the fabrication, assembly, and testing of 23 cryomodules for the superconducting linac portion of the Spallation Neutron Source (SNS) being built at Oak Ridge National Laboratory. As with any large accelerator construction project, it is vitally important that these components be built in a cost effective and timely manner, and that they meet the stringent performance requirements dictated by the project specifications. A comprehensive Quality Assurance (QA) program designed to help accomplish these goals has been implemented as an inherent component of JLab's SNS construction effort. This QA program encompasses the traditional spectrum of component performance, from incoming parts inspection, raw materials testing, through to sub-assembly and finished article performance evaluation. Additionally, process and procedure control, vendor performance and oversight, and design and test program reviews constitute complementary areas where QA involvement contributes to successful production performance. These aspects of the QA program will be described, along with selected examples of improvements resulting from its application.

* Work supported by U.S. Department of Energy under contract DE-AC05-84ER40150.

TPAG029 Utilization of Integrated Process Control, Data Capture, and Data Analysis in Construction of Accelerator Systems

Ozelis Joseph (University of Maryland), Valerie Bookwalter, Bonnie Madre, Charles Reece (Thomas Jefferson National Accelerator Facility)

Jefferson Lab has developed a web-based system that integrates commercial database, data analysis, document archiving and retrieval, and user interface software, into a coherent knowledge management product (Pansophy). This product provides important tools for the successful pursuit of major projects such as accelerator system development and construction, by offering elements of process and procedure control, data capture and review, and data mining and analysis. After a period of initial development, Pansophy is now being used in Jefferson Lab's SNS superconducting linac construction effort, as a means for structuring and implementing the QA program, for process control and tracking, and for cryomodule test data capture and presentation/analysis. Development of Pansophy is continuing, in particular data queries and analysis functions that are the cornerstone of its utility. In this paper the present configuration and operational environment of Pansophy is described, along with future development goals. Additionally, specific examples of its use in an accelerator construction project will be presented.

* Work supported by U.S. Department of Energy under contract DE-AC05-84ER40150.

TPAG030 Study of Coherent Radiation from an Electron Beam Prebunched at the Photocathode

Jonathan Neumann, David Demske, Ralph Fiorito, Patrick O'Shea (University of Maryland), Larry Carr, Henrik Loos, Brian Sheehy, Xijie Wang (BNL)

Controlling the longitudinal distribution in an electron beam traveling through an accelerator can enhance system performance in various ways. Prebunching an electron beam in an accelerator can lead to enhanced radiation production from various emitters. Smoothing the shape of the electron beam pulse may suppress instabilities that result in beam breakup. This work, a collaboration between the University of Maryland and the Source Development Laboratory at Brookhaven National Laboratory, uses a Ti:sapphire drive laser modulated at terahertz frequencies to extract a prebunched beam directly from the photocathode prior to acceleration in a linear RF accelerator. We have demonstrated that prebunched terahertz structure can be maintained after leaving the photocathode and through acceleration to high energy. Through the use simulation and experiment, this work further explores the characteristics of an electron beam produced in this manner, and examines the possibility of using this technology to develop a compact, powerful, narrowband terahertz emitter.

* Supported by Department of Energy, the Joint Technology Office, and the Army Research Laboratory.

TPAG031 A Solid-State Opening Switch for the Argonne Advanced Light Source

Dennis Robinson, Jeffrey A. Casey, Marcel P.J. Gaudreau, Timothy A. Hawkey, Michael Kempkes, J. Michael Mulvaney, Ian S. Roth (Diversified Technologies, Inc.)

Diversified Technologies, Inc. built and delivered a solid-state, 95 kV, 21 A opening series switch for the Advanced Light source at Argonne National Laboratory. The switch replaces a mercury ignitron crowbar and is placed in series with the klystron cathode, opening when an arc is detected. Its operating time, including arc detection and switch opening, is under 700 ns, much faster than any known crowbar. The high voltage can be turned back on as soon as the arc clears, allowing continued beam operation through a klystron arc. The system includes a high speed, linear solid-state voltage regulator for controlling the klystron cathode-mod-anode voltage from the existing unregulated cathode supply, as well as filament supplies, and controls for the full range of klystron operation. Plans call for replacement of all five of the environmentally hazardous mercury ignitrons with solid-state switches, and upgrades to the DC cathode power supplies. This fully solid-state design is applicable to any pulsed or CW accelerator klystron. This paper describes the architecture of the transmitter upgrade, switch performance, and test results at Argonne National Laboratory.

* This effort was sponsored by a U.S. DOE SBIR grant and funding from Argonne National Laboratory.

TPAG032 Recent Evolutions in the Design of the French High Intensity Proton Injector (IPHI)

Pierre-Yves Beauvais (CE Saclay)

In 1997, the two French National Research Agencies (CEA and CNRS) decided to collaborate in order to study and construct a prototype of the low energy part of a High Power Proton Accelerator (HPPA). The main objective of this project (the IPHI project), is to allow the French team to master the complex technologies used and the control concepts of the HPPAs. Recently, a collaboration agreement was signed with the CERN and led to some evolutions in the design and in the schedule. The IPHI design current was maintained at 100 mA in Continuous Wave mode. This choice should allow to produce a high reliability beam at reduced intensity (typically 30 mA) tending to fulfill the Accelerator Driven System requirements. The output energy of the Radio Frequency Quadrupole (RFQ), originally set to 5 MeV, was reduced to 3 MeV, allowing then the adjunction and the test in pulsed mode of a chopper line developed by the CERN for the Superconducting Proton Linac (SPL). In a final step, the IPHI RFQ and the chopper line should become parts of the SPL injector. In this paper, the IPHI project evolutions are reported as well as the construction and the operation schedule.

TPAG033 Fermilab Booster Beam Collimation and Shielding

Nikolai Mokhov, Alexandr I. Drozhdin, James R. Lackey, Eric J. Prebys, Robert C. Webber (FNAL)

The beam power in the upgraded Booster at 8 GeV and 15 Hz is about 0.1 MW. Up to 30% of the beam can be lost at injection and 2%

at top energy, resulting in very high radiation loads in the ring, at some locations significantly exceeding the tolerable limits. The purpose of a new beam halo cleaning system is to localize proton losses in specially shielded regions. It was designed and installed in straight sections number 6 and 7 because these regions are far from the engineering, support and office buildings. Calculations show that this 2-stage collimation system should localize about 99% of beam loss in a 50-m long region. Beam loss in the rest of the machine would be on average 0.1 W/m, with several peaks of about 1 W/m. Massive shielding around collimators provides tolerable prompt and residual radiation levels in the tunnel, above the tunnel at the surface and in the sump water. First measurements of the collimation system and shielding performance are presented.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

TPAG034 Basis for the Reliability Analysis of the Proton Linac of the PDS-XADS Program

Daniele Sertore, Danilo Barni, Paolo Michelato, Laura Monaco, Marta Novati, Carlo Pagani, Roberto Paulon, Paolo Pierini (INFN), Luciano Burgazzi (ENEA)

In the framework of the PDS-XADS Project, a reliability activity is on going to validate and qualify the LINAC accelerator design focus on the general operational and design characteristics that shape the accelerator performance. Further quantitative results should be based on estimations mostly deriving from operational surveys at existing accelerator facilities. Currently, a validated accelerator component reliability data base has not yet been assembled, and because of the early stage of the PDS-XADS design in which several systems are not established at this time the topic can be addressed by the application of a preliminary FMEA (Failure Mode and Effect Analysis) methodology, helpful in the identification of reliability-critical areas, where modifications to the design can help to reduce the probability of system failures. In this paper, the preliminary results of this activity are presented together with possible solutions to improve the reliability of the reference Linac design.

TPAG035 Beam Commissioning of the J-PARC Linac Medium Energy Beam Transport at KEK

Masanori Ikegami, Shozo Anami, Shigeaki Arai, Junsei Chiba, Shigeki Fukuda, Yuji Fukuda, Zenei Igarashi, Kiyoshi Ikegami, Eiichi Kadokura, Takao Kato, Masato Kawamura, Jun-ichi Kishiro, Hitoshi Kobayashi, Chikashi Kubota, Fujio Naito, Kazuyuki Nigorikawa, Shuichi Noguchi, Masashi Okada, Eiichi Takasaki, Hirokazu Tanaka, Akira Ueno, Seiya Yamaguchi, Kazuo Yoshino (KEK), Shinian Fu, Sheng Wang (Institute of High Energy Physics, Beijing), Kazuo Hasegawa, Takashi Ito, Tetsuya Kobayashi, Yasuhiro Kondo, Yoshishige Yamazaki, Hiroshi Yoshikawa (Japan Atomic Energy Research Institute)

The construction of the initial part of the J-PARC linac, which is comprised of a 3-MeV RFQ, a 50-MeV DTL, and two first tanks of SDTL (Separate-type DTL), has been started at KEK to develop and establish the linac system before moving to the JAERI Tokai campus, where J-PARC facility is finally to be constructed. The RFQ and MEBT (Medium Energy Beam Transport) has been installed at KEK, and the beam test has been performed successfully. The MEBT is a beam transport line between the RFQ and the DTL, which includes eight quadrupole magnets, two buncher cavites, two rf chopper cavities, and various beam diagnostic instrumentation. In this paper, results of the beam commissioning and operation of the MEBT are reported together with the main features of the MEBT.

TPAG036 Recent Progress of KEKB

Haruyo Koiso (KEK)

KEKB is an asymmetric electron-positron collier for the purpose of studying rare processes related to B-meson physics. This report summarizes recent progress of KEKB. An emphasis is placed on methods of luminosity improvement and stabilization of the machine operation.

TPAG037 H- Painting Injection System for the JKJ 3GeV High Intensity Proton Synchrotron

Izumi Sakai, Yoshio Arakida (KEK)

The JAERI KEK Joint Project (JKJ) accelerator complex comprises a 50-GeV main synchrotron, a 3-GeV rapid-cycling synchrotron, and a 400-MeV linac. The accelerators provide high-intensity, high-energy proton beams for various scientific fields. The JKJ 3-GeV synchrotron is designed to accelerate 8.3x1013 protons per pulse at 25Hz repetition rate. The emittance of the incoming beams from linac is 10p mm mrad and the acceptance in the 3GeV synchrotron is 324p mm mrad in both of horizontal and vertical plane. Painting injection system is required to realize uniform distribution of charged particles in real space. The H- painting injection system is composed of four orbit bump magnets to merge the injection beam with circulating beam and other four orbit shift bump magnets for painting injection. In this paper, the design of magnets system and the practical operation method for the painting injection are discussed.

TPAG038 Particle-Beam Behavior in the Final Design of the SNS Linac

Subrata Nath, James Billen, James Stovall, Harunori Takeda, Lloyd Young (LANL), Dong-o Jeon (ORNL), Kenneth Crandall (Tech Source)

The final design of the SNS linac is comprised of both normal- and super-conducting RF (SRF) structures. The normal-conducting linac section up to 185 MeV, consists of a 2.5-MeV RFQ, a Medium Energy Beam Transfer (MEBT) line, a 402.5-MHz DTL, followed by a 805-MHz CCL. The SRF structure accelerates the beam from a nominal energy of 185 MeV to 1000 MeV. The SRF section consists of two, a medium beta (beta = 0.61), and a high beta (beta = 0.81) sections. In this paper, we discuss beam performance of the final design for several input beams including beam reconstructed from measurements.

* Work supported by the office of Energy Research, Basic Energy Science of the US Department of Energy.

TPAG039 Particle-in-Cell Modelling of the High Current Experiment

Christine Celata, F.M. Bieniosek, L. Prost, P.A. Seidl (LBNL), A. Friedman, D.P. Grote (LLNL)

The particle-in-cell code WARP has been used to simulate beam dynamics for the intense ion beam of the High Current Experiment. This experiment is using a 0.2-0.5 A, 1-1.7 MeV K+ beam to study effects which limit the usable aperture for space-charge-dominated beams. Aperture limits caused by focusing field nonlinearities; image forces; desorbed gas, ions, and electrons produced by halo scraping; and the effects of misalignment or rotation of quadrupoles are being investigated. We present the results of dynamic aperture simulations including all of the effects named above, with the exception of particles emitted by the walls. Simulations of the experiment initialized with distribution functions reconstructed from data will also be presented, and their results compared to experimental measurements.

* This work supported by the Office of Energy Research, U.S.Department of Energy, under contract numbers DE-AC03-76SF00098 and W-7405-Eng-48.

TPAG040 Design Choices for the Integrated Beam Experiment (IBX)

Matthaeus Leitner, Christine Celata, Ed Lee, Grant Logan, GianLuca Sabbi, Will Waldron (LBNL), John Barnard (LLNL)

Over the next three years the research program of the Heavy Ion Fusion Virtual National Laboratory (HIF-VNL), a collaboration among LBNL, LLNL, and PPPL, is focused on separate scientific experiments in the injection, transport and focusing of intense heavy ion beams at currents from 100 mA to 1 A. As a next major step in the HIF-VNL program, we aim for a complete "source-to-target" experiment, the Integrated Beam Experiment (IBX). By combining the experience gained in the current separate beam experiments IBX would allow the integrated scientific study of the evolution of a single heavy ion beam at high current (~1 A) through all sections of a possible heavy ion fusion accelerator: the injection, acceleration, compression, and beam focusing. This paper describes the main parameters and technology choices of the planned IBX experiment. IBX will accelerate singly charged potassium or argon ion beams up to 10 MeV final energy and a longitudinal beam compression ratio of 10, resulting in a beam current at target of more than 10 Amperes. Different accelerator cell design options are described in detail: Induction cores incorporating either room temperature pulsed focusing-magnets or superconducting magnets.

* This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Berkeley National Laboratory under contract number DE-AC03-76SF00098, Lawrence Livermore National Laboratory under contract number W-7405-Eng-48, Massachusetts Institute of Technology under contract number DE-FC02-93-ER54186, and by the Princeton Plasma Physics Laboratory under contract number DE-AC02-76CH03073.

TPAG041 Beam in Gap Measurements at the SNS Front-End

Alexander Aleksandrov, Saeed Assadi, W. Blokland, C. Deibele, J. Pogge, D. Stout (ORNL)

The pulsed beam in the SNS accelerator has a fine time structure which consists of 695ns long mini-pulses separated by 250ns gaps in order to minimize transient beam losses in the accumulator ring which could arise during the ring extraction kicker rise time. This time structure is provided by a two stage Front End chopping system which must reduce the beam current in the gap to a level of 10-4 of the nominal current in order to satisfy requirements on the ring extraction losses. A Beam-in-Gap measuring system based on H- stripping using Nd:YAG laser was developed and tested during the SNS Front-End commissioning period. This paper describes the Beam-in-Gap measurement system design and measured performance.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

TPAG042 A 280/560/(1120) MHz Linac for ESS

Alan Letchford, Ian Gardner (Rutherford Appleton Laboratory), Klaus Bongardt (Forschungszentrum Juelich)

For the ESS accelerator complex a pulsed 10 MW H^- linac with a final energy of 1.334 GeV is foreseen. Loss-free injection into both accumulator rings requires two chopped beams at 2.5 MeV, funnelled together at 20 MeV. This 769m long ESS linac is realisable and technically robust. The main features of this 280/560 MHz linac are described including fully 3D Monte Carlo simulations of the front end. Due to the low frequency and long wavelength, mechanical constraints are relaxed allowing the use of a DTL with FD electromagnetic quadrupole focusing above 2.5 MeV. An alternative to warm 560 MHz CCL structures is to use $\beta = 0.8$, 6 cell SC cavities above 400 MeV, reducing the total linac length to 500m. The frequency jump leads to smaller SC cavities, reduced cryogenic power and simplified pulsed RF control but requires a careful beam dynamics layout. Fully 3D Monte Carlo results are shown for the 1120 MHz SC linac including RF errors, leading to loss free ring injection.

TPAG043 ISIS Megawatt Upgrade Plans

Christopher Prior, Dean Adams, Ian Gardner, Grahame Rees, Christopher Warsop (Rutherford Appleton Laboratory)

The ISIS spallation neutron source has been running successfully for more than 15 years and at 160kW remains the most powerful source of its kind in the world. With machines operating at or near the megawatt level under construction in the United States and Japan and due to come on line within the next decade, advances in Europe have not progressed at the same rate. A final decision on the European Spallation Source (ESS) is still awaited and one of the factors to be taken into account is the feasibility of alternative options. An ISIS upgrade is one such possibility. The current installation of an RFQ in the linac and a dual harmonic RF system in the synchrotron should lead to an increase in intensity of 50%, but plans are also under way to increase the beam power to 1MW with the possibility of going to 4MW in the longer term. The 1MW option is based on an increase in energy to 3GeV by means of a second synchrotron using ISIS as a booster. Details of the new ring and studies of the accelerating system are given in this paper. The ring also has the option of accelerating to 8GeV at reduced frequency and this could be used as a test bed for the nanosecond bunch compression needed for the proton driver for a neutrino factory. The cost of these proposals is relatively modest compared with a completely new facility. In the longer term, a combination of two such rings with a new synchrotron booster (replacing the existing ISIS) could give 4MW of neutrons, or 2MW of neutrons plus 2MW for neutrino/muon studies, or 4MW for a neutrino facility.

TPAG044 Improvements for Third Generation Plasma Wakefield Experiment E-164

Christopher Barnes (SLAC)

The E-164 experiment at the Stanford Linear Accelerator Center is the thrid in a series investigating Plasma Wakefield Acceleration where the wake is driven by electron bunches. A collaboration between SLAC, UCLA and USC, E-164 has up to 2x10^10 electrons at 30 GeV in 100 micron long bunches. These bunches enter a 30cm long Lithium plasma with density 6x10^15 electrons/cm^3, where the transfer of energy from the head of the bunch to the tail takes place. In addition to acceleration, strong focusing, refraction of the electron beam and "betatron" x-ray production are all investigated. E-164 builds on related prior experiments, and its apparatus has evolved considerably. A third Optical Transition Radiator has been added for real time Twiss Parameter measurements which include scattering. The plasma cell is moved to the focus of the Final Focus Test Beam facility in order to increase bunch electron density. Spectrometry is extended with an upstream chicane in a dispersive region to produce synchrotron x-rays. Performance of these improvements and status of the experiment are discussed.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

TPAG045 A Slab-Symmetric Resonant THz Accelerator with Dielectric Loading

Rodney Yoder, James Rosenzweig (University of California, Los Angeles)

We present a design for a slab-symmetric accelerating structure to be resonantly excited at terahertz frequencies. The device, consisting of a vacuum gap between dielectric-lined walls, combines the advantages of a slab geometry (including strong suppression of transverse beam

wakefields and low power density) with the existence of a resonant mode having phase synchronism with relativistic electrons, due to the presence of the dielectric. Accelerating fields on the order of 100 MeV/m are predicted when the structure is powered by a high-power FIR radiation source in development at UCLA. Two- and three-dimensional simulation of the structure fields is described and compared with theory, and experimental work is discussed.

* Work supported by the US Dept. of Energy, grant no. DE-FG03-92ER40693.

TPAG046 Design of a 350 MHz, 30 mA RFQ for Protons

Srinivas Krishnagopal, Bhaskar Biswas, Arvind Kumar (Centre for Advanced Technology), Tushima Basak, P. K. Nema, Rajni Pade, S.V.L.S. Rao, P. Singh (Bhabha Atomic Research Centre)

We present a detailed physics design of a 350 MHz, 30 mA, RFQ for protons. We present beam dynamics simulations, including detailed error studies for defining tolerances. Two-dimensional electrodynamics simulations were performed to generate the trasnverse geometry of the RFQ, and three-dimensional simulations were performed for a more detailed design, including the end-cells. We also present details of the thermal and strcutural analyses, which gave an estimate of the detuning of the resonant frequency.

TPAG047 A Lie Transform Perturbation Scheme for Time Averaging for Self Consistent Systems

Kiran Sonnad, John R. Cary (Center for Integrated Plasma Studies)

A Lie transform perturbation method that is more suitable for self consistent systems has been developed. In a self consistent system like a beam with space charge effects, the space charge term of the Hamiltonian is not predetermined. This poses a problem when performing a time averaging over fast oscillations since the space charge term needs to be first decomposed into slowly oscillating and higher order (fast oscillating) terms. One can make such a decomposition by making a perturbative expansion of the Hamiltonian as a function of the as yet undetermined slowly oscillating variables. This was demonstrated by by R.C. Davidson, H. Qin and P.J. Channell [Phys Rev ST 2, 074401 (1999)] using a different perturbation method. In general, the Lie Transform method retains the original variables before beginning the process of canonical transformation to a slowly oscillating coordinate frame. As a consequence, this would not allow the Hamiltonian to be decomposed into slow and higher order terms. In this paper, the Lie transform method is reformulated so that it allows the Hamiltonian to be first decomposed into different order terms. The method is then applied to an alternate gradient quadrapole focusing system with space charge.

TPAG048 Beam Test of a CW Microtron with a 500 MHz RF Cavity for Industrial Applications

Hirofumi Tanaka, Tae-Hyun Kim, Yo Makita, Akihiko Maruyama, Shiro Nakamura, Tetsuya Nakanishi, Yuehu Pu, Chihiro Tsukishima, Syunji Yamamoto (Mitsubishi Electric Corp.)

A CW microtron is made and the first beam test is done. The machine is of a racetrack type. The acceleration energy and the beam power are 5 MeV and 30 kW, respectively. The RF cavity is a conventional normal-conducting 2-cell cavity with coupling slots. The injection energy is 80 keV, and a 500 MHz CW gun is used. The bending magnets are divided into two subsections to adjust the acceleration phases of every turn. A beam test of the CW electron gun shows that a peak current is about 200 mA, and the phase width of the CW emission is 60 degrees. The beam emittance measured agrees well with the calculation results.

Session TOPA: Light Sources
Grand Ballroom II at 13:30
Session Chairs: G. Singh, S. Milton

TOPA001 The Canadian Light Source

Les Dallin, Ingvar Blomqvist, De-Tong Jiang, Dan Lowe, Mark Silzer, Mark de Jong (Canadian Light Source)

The Canadian Light Source (CLS), at the University of Saskatchewan, was funded in April, 1999. It consists of an injection system (250 MeV linac and full energy booster) and a 12 cell DBA 2.9 GeV storage ring. The injection system is now fully operational and construction of the storage ring is well under way with commissioning expected to commence in the summer of 2003. The compact lattice (171 m) requires space saving technologies including strong focusing in the magnets, a superconducting RF cavity and "chicaning" of two insertion devices (IDs) in the 5 m straights. IDs have been designed at the CLS and most will be built on site. Magnets and power supplies have been designed to maintain tight control over machine functions, orbit and transverse coupling. The vacuum chamber and the girder system for the ring incorporate modular designs best suited for a compact lattice. Front ends have been designed for all source points including the chicaned IDs. Development of the CLS subsystems has proceeded with a strong emphasis on a "design-build" project management style. For this, CLS developed detailed preliminary designs and worked with industry to engineer the final products. The project remains on budget and the CLS is expected to be fully operational by the target date of January, 2004.

TOPA002 Superbend Upgrade at the Advanced Light Source

David Robin (LBNL)

At the ALS there had been an increasing demand for additional high brightness hard x-ray beamlines in the 7 to 40 KeV range. In response to that demand, the ALS storage ring was modified in August 2001. Three 1.3 tesla normal conducting bending magnets were removed and replaced with three 5 Tesla superconducting magnets (Superbends). The radiation produced by these Superbends is an order of magnitude higher in photon brightness and flux at 12 keV than that of the 1.3 Tesla bends, making them excellent sources of hard x-rays for protein crystallography and other hard x-ray applications. At the same time the Superbends do not compromise the performance of the facility in the UV and soft x-ray regions of the spectrum. The Superbends will eventually feed 12 new beam lines greatly enhancing the facility's capacity in the hard x-ray region. The Superbend project is the biggest upgrade to the ALS storage ring since it was commissioned in 1993. In this paper we present a history of the project, as well as the installation, commissioning, and resulting performance of the ALS with Superbends.

∗ This work was supported by the Director, Office of Science, Office of Basic Energy Sciences, Materials Sciences Division of the U.S. Department of Energy, under Contract No. DE-AC03-76SF00098.

TOPA003 Progress Report on the Construction of SOLEIL

Jean-Marc Filhol (Synchrotron SOLEIL)

It was decided in September 2000 to build SOLEIL, a third generation synchrotron radiation source, in France at St. Aubin near Paris. Since then the original APD design (foundation phase report June 1999) has been updated and the construction phase has begun in January 2002, with the aim of starting user operation in spring 2006. The machine now consists in a 357 m circumference ring, with 16 DBA cells and 24 straight sections (4x12m, 12x7m, 8x3.6m), out of which up to 21 will house insertion devices. The optics, with distributed dispersion, feature a low 3.7 nm.rad emittance at the 2.75 GeV operating energy, so as to provide high brilliance from the VUV up to the hard X ray domain. In order to provide a long lifetime (18 hours), and beam position stabilities in the micron range, significant attention was paid at each design stage (optics, magnets, beam position monitors, vacuum and RF systems..), including n the design of the building, the construction of which will start in summer 2003. The magnets have been designed and will all be ordered before April 2003. The contract was placed for the 100 MeV Linac for a delivery summer 2004. Insertion devices are being designed with the goal of serving a very large scientific community with high performances in an energy range as large as 5 eV to 18 keV (50 keV with wiggler). The qualification of the 352 MHz superconducting RF cavity prototype has been done on the ESRF ring.

TOPA004 Progress with the Diamond Light Source Project

Richard Walker (Diamond Light Source Ltd.)

The Diamond Light Source is based on a low emittance, 3 GeV, 561.6 m circumference storage ring. Following the formation of Diamond Light Source (DLS) Ltd. under a Joint Venture Agreement between the UK Government and the Wellcome Trust in April 2002, and the completion by CLRC of the Design Specification Report, the project has now moved into the construction phase. Detailed design and specification is being carried out by joint teams involving CLRC staff with a rapidly growing number of DLS employees and the first major orders are about to be placed. This talk, presented on behalf of the DLS and CLRC Machine Team staff, will report on the overall status. It will also describe progress in various technical areas such as the booster synchrotron, storage ring magnets, vacuum system, superconducting r.f. system, and insertion devices. Aspects receiving particular attention that impact long-term and short-term beam stability (foundations, girders, supports etc.) will also be addressed.

TOPA005 SPEAR 3 Upgrade Project: The Final Year

Robert Hettel (SLAC)

In May 2003, the SPEAR 2 storage ring, which served the high energy physics community from 1972 to 1987, and the synchrotron radiation community for an additional 15 years, will be removed in order to install the new 3 GeV, 500 mA SPEAR 3 light source. In the following four months, SSRL will pour a new concrete floor and install pre-assembled girders holding magnets, copper vacuum chambers, PEP-II style RF cavities, and beam line front end components. At the same time, power supply, instrumentation and control, and other ancillary systems will be configured, leading to a commissioning period beginning in October 2003. The evolution of accelerator component implementation, installation planning, and controls development over the final year of the SPEAR 3 upgrade project will be reviewed.

∗ Work supported in part by DOE Contract DE-AC03-76SF00515 and Office of Basic Energy Sciences, Division of Chemical Sciences.

TOPA006 SESAME, a Light Source for the Middle East

Dieter Einfeld (UNESCO Office Amman, Jordan)

Developed under the auspices of UNESCO, SESAME will be a major international research centre in the Middle East region. It will have as its centre piece a synchrotron light source based on BESSY I, which has already been moved to Jordan. The centre will be jointly operated by more as 13 members and it will be located in Jordan. SESAME will be a 2 GeV 3rd generation light source with an emittance of 17 nm-rad and 13 places for the installation of insertion devices with a length of 3 meters. The circumference of themachine will be 125 meters. As an injector, the BESSY I 800 MeV booster synchrotron will be used. The new building provides the space for offices, workshops, laboratories and beam lines of 30 m length.

TOPA007 NSLS Upgrade - A Staged Approach

Boris Podobedov, J. Ablett, L. Berman, R. Biscardi, G.L. Carr, B. Casey, S. Dierker, R. Heese, S. Hulbert, E. Johnson, C.C. Kao, S. Kramer, H. Loos, J. Murphy, R. Pindak, S. Pjerov, J. Rose, T. Shaftan, P. Siddons, N. Towne, J.M. Wang, X.J. Wang, L.H. Yu (BNL)

To address the growing needs of the National Synchrotron Light Source user community we are aggressively pursuing R&D towards the future upgrade, for which we have chosen to follow a staged approach. The first stage is to build a 3 GeV ultra-low emittance storage ring, tailored to the 5-20 keV photon energy range, that will more than double the present NSLS ID capacity and provide a three order of magnitude increase in brightness. A superconducting linac serving as a topoff-mode ring injector will simultaneously feed a farm of soft X-ray (20 nm) seeded FELs. The FELs will provide the users with 20 fs rms fully coherent beams at a 1-10 kHz repetition rate. A possible second stage of the upgrade is to operate the ring-linac system in an energy recovery mode providing a unique capability of round beams of sub-ps duration.

* Work supported by US DOE under contract DE-AC02-98CH10886.

TOPA008 Storage Ring FEL Dynamics and e-Beam Instabilities

Giuseppe Dattoli, Riccardo Bartolini, Luca Giannessi, Luca Mezi (Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente), Mauro Migliorati (Universita degli Studi di Roma, Dipartimento di Energetica)

We present a general approach to the theory of the interplay between the dynamical behaviour of free electron lasers operating in storage ring devices and the dynamical behaviour of the instabilities affecting the beam. We discuss the case of instabilities of longitudinal and transverse types and analyze the problem using analytical and numerical models. The case of the sawtooth instability is explored with particular accuracy. Conditions under which the FEL may counteract and switch off the various type of instabilities, and the physical reasons, are carefully analyzed.

TOPA009 Single-Particle Beam Dynamics in BOOMERANG

Alan Jackson (Australian Synchrotron Project), Hiroshi Nishimura (LBNL)

We describe simulations of the beam dynamics in the storage ring BOOMERANG, a 3-GeV third-generation light source being designed for the Australian Synchrotron Project. The simulations were performed with the code GOEMON. They form the foundation for the design specifications of the storage ring components (apertures, alignment tolerances, magnet quality, etc.), and for determining expected performance characteristics such as coupling and beam lifetime.

TOPA010 Advanced Photon Source Booster Synchrotron Low-Emittance Lattice Commissioning Results

Nicholas Sereno, Michael Borland, Hairong Shang (ANL)

Recent efforts at the APS have focused on reducing beam loss during storage ring injection to minimize radiation damage to the APS undulators. Reducing beam loss at injection is particularly important during top-off operation where injection occurs once every two minutes. One way to potentially improve injection efficiency is to simply reduce the emittance of the beam from the APS booster, thereby allowing the beam to be brought closer to the injection septum. Recently several low-emittance operating modes for the APS booster have been studied. The emittance is lowered from the standard value by increasing the horizontal tune for each low-emittance mode. The vertical tune is also reduced to minimize the required defocusing sextupole strength for chromaticity correction. Calculations indicate that up to 29% reduction in emittance is possible—a result that has been achieved in studies. A lattice with emittance 17% lower than the standard lattice has been thoroughly commissioned and has been used for routine APS top-up operation since July 2002. Results of beam-based measurements and comparison to calculations for various low-emittance lattices are reported in this paper.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract W-31-109-ENG-38.

TOPA011 Singapore Synchrotron Light Source - Helios 2 and beyond

Herbert Moser, B.D.F. Casse, E.P. Chew, V.C. Kempson, J.R. Kong, Z.W. Li, Tun Nyunt, H.J. Qian, P.H. Tor, O. Wilhelmi, P. Yang, H.W. Zheng (SSLS, National University of Singapore)

SSLS is built around the superconductive compact electron storage ring Helios 2. Although originally designed as an industrial X-ray lithography source, Helios 2 is used at SSLS for providing high flux bending magnet radiation for various synchrotron radiation applications in a spectral range from 10 keV to the far infrared. SSLS is working on a source development program to expand the experimental capabilities of Helios 2. Four beamlines/experimental facilities are operational, covering micro/nanofabrication, refractive contrast imaging, soft X-ray photoemission spectroscopy, and X-ray diffraction and absorption spectroscopy. An infrared spectro/microscopy beamline is under construction. First results related to advanced materials research and development will be presented. SSLS is also working on the development of a fourth generation source based on the use of superconductive miniundulators (supraminis), the first step in this direction being the Linac Undulator Light Installation (LIULI). A prototype of a fully tunable 50 period 14 mm period length supramini for LIULI is under construction.

TOPA012 Generation of High-Energy Synchrotron Radiation with a 10T Superconducting Wiggler Installed in the SPring-8 Storage Ring

Kouichi Soutome, S. Date', H. Ego, T. Fukui, M. Hara, N. Hosoda, Y. Kawashima, M. Kodera, N. Kumagai, T. Magome, M. Masaki, T. Masuda, S. Matsui, T. Nakamura, T. Noda, Y. Ohashi, T. Ohshima, M. Oishi, H. Saeki, S. Sasaki, J. Schimizu, M. Shoji, S. Takano, M. Takao, T. Takashima, H. Takebe, K. Tamura, H. Tanaka, Y. Taniuchi, K. Tsumaki, H. Yonehara, T. Yorita, C. Zhang (SPring-8), A. Batrakov, G. Karpov, G. Kulipanov, M. Kuzin, N. Mezentsev, A. Skrinsky (BINP)

In August, 2002 we installed a 10 T superconducting wiggler in the 8 GeV electron storage ring at SPring-8, tested its performance and investigated the effect on a stored beam. A beam was successfully stored in the storage ring at magnetic fields of the wiggler up to 9.7 T. The stored current was limited to 1 mA to avoid damage to accelerator components from high heat-load and to maintain radiation safety. A beam size, a bunch length and a tune shift affected by the strong magnetic fields were measured and sufficiently agreed with values deduced from data of the magnetic field measurement of the wiggler. We also measured a spectrum of high-energy synchrotron radiation from the wiggler with an NaI scintillator at an extremely low beam current less than 10 pA. High-energy gamma rays in MeV-region could be detected and were compared with calculations taking account of the geometrical conditions of collimation and shields around the detector. There is various and useful application of the high-energy gamma rays radiating from the wiggler such as creation of an intense low-energy positron beam. It can be used as probes of the Fermi surface and defects of sub-nano scale. Y.Kawashima, Y.Ohashi, K.Soutome and H.Yonehara would like to thank Prof. T.Hata in Osaka City University for valuable suggestions to improve cooling efficiencies of the wiggler.

TOPA013 In-Vacuum Undulators at ESRF

Joel Chavanne, Christophe Penel, Bernard Plan, Franck Revol (European Synchrotron Radiation Facility)

Five in-vacuum undulators are presently in routine operation at ESRF with minimum gap of 5 mm to 6 mm. The result of the magnetic measurements are presented. The measured interactions with the stored beam (closed orbit distortion, tune shift) are discussed. Three additional devices are presently being constructed including a magnetic structure of hybrid type. They are all designed to operate at high photon energy above 50 keV and require dedicated spectrum shimming. The magnet temperature is permanently monitored in all filling modes of the ring. An estimation of the heatload deposited by the beam in flexible input/output transitions as well as in copper sheets covering the magnet blocks is given.

TOPA014 Possible Long-Term Improvements to the Advanced Photon Source

Louis Emery (ANL)

Although third-generation light sources like the 7-GeV Advanced Photon Source (APS) already deliver very high performance, there are many user experiments that could benefit from further improvements. Improved brightness, improved beam stability, higher single-bunch current, more beamlines, and shorter bunches are all of interest to certain user groups. In this paper, we outline some possibilities to meet some of these needs. Presently, the APS has an effective horizontal emittance of 2.8nm, achieved by allowing dispersion in the straight sections. Top-up allows us to go lower in spite of the poor lifetime, which we could do by adding pole-face windings to the dipoles to reduce the emittance to 1.8nm. A more dramatic effort would involve replacing the 0.6T, 3m-long dipoles with 1.8T, 1m-long gradient dipoles, which would have the added benefit of increasing the straight-section length from 4.8m to 8.9m. This would permit installation of long undulators or multiple, canted undulators in the straight sections. We would not only increase the brightness for users who demand it, we would provide multiple beamlines from a single straight section for applications that are less demanding. The fact that all APS multipoles have individual power supplies allows gradual changes to the machine configuration, so we could implement such changes over a series of one-month shutdowns. Beyond this, several much more speculative ideas have been explored. One of these is to use the APS ring as part of an energy recovery linac facility, with single- or multi-turn circulation of a high-brightness linac beam in the existing ring. We present some preliminary simulations of the performance of this option. Another possibility is replacement of the APS storage ring with a next-generation ring capable of ultra-low emittance and making full use of top-up. We present a concept for a facility that promises 75pm horizontal emittance and 10m-long straight sections.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract W-31-109-ENG-38.

Session TOPB: Controls & Computing
Pavilion West at 13:30
Session Chair: K. White

TOPB001 Simulation Tools for High Intensity Rings

Sarah Cousineau (Indiana University)

Several codes have been developed specifically to simulate beam dynamics in high intensity rings. These codes contain detailed models for beam injection, rf focusing and acceleration, transport through linear and nonlinear magnetic elements, magnet errors, fringe field effects, collimation and limiting apertures, and closed orbit correction. Additionally, the codes contain longitudinal and transverse impedance algorithms, and a number of space charge models, including three-dimensional space charge routines with conducting wall boundary conditions. To accommodate the size of the computations, parallel computing has been implemented into some of the codes. The codes have been used extensively to study space charge effects in both existing and future machines, to design and optimize accelerator components, and to predict instability thresholds in the future Spallation Neutron Source (SNS) machine. Selected results of these studies are presented, with specific emphasis on results of the ORBIT code.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

TOPB002 Multipacting Simulations for Superconducting Cavities and RF Coupler Waveguides

Rong-Li Geng (Cornell University)

Multipacting (MP) has recently received a renewed interest in the community of superconducting accelerators. This is mainly due to the fact that this mechanism is found to cause harmful RF breakdown in today's multi-hundred kW couplers for SRF cavities. In addition, two-sided MP which was firstly recognized in the 80s by Weingarten in a 500MHz elliptical cavity [W. Weingarten, Proc. of the 2nd SRF Workshop, 551(1984)], has been identified in other elliptical cavities for a very broad frequency range from 200MHz to 1300MHz. Usually, a new type of MP is first observed experimentally. Then numerical simulations are used to unravel the nature of the phenomenon and to seek solutions. The success of simulations is best exemplified by the introduction of the elliptical cavity shape in the 70s [U. Klein and D. Proch, Proc. of the Conf. of Future Possibilities for Electron Accelerators, (1979)]. Recently, numerical simulations have been increasingly used to survey RF structures before they are experimentally measured. Several simulation tools now exists to evaluate MP likely-hood and to predict MP suppression methods [F.L. Krawczyk, Proc. of the 10th SRF Workshop, (2001)]. Important experimental verifications of the predictions made by these codes have been brought forward since last year. In this paper, I will overview the developments of MP simulations in SRF cavities and couplers, summarize the simulation results, compare experiment results with simulation predictions and examine the algorithems. After identifying the discrepancy between the predictions and experiments, suggestions are given to further improve the simulations.

* Work supported by the National Science Foundation.

TOPB003 CASCADE - An Advanced Computational Tool for Waveguide Component and Window Design

Lawrence Ives, Jeff Neilson, William Vogler (Calabazas Creek Research, Inc.)

CASCADE is an advanced design program for designing 2-port waveguide components, RF windows, and waveguide systems. It provides rapid and user-friendly analysis of waveguide components such as filters, nonlinear tapers, mode converters, microwave cavities, and RF windows. It calculates scattering parameters (transmission/reflection coefficients) for general waveguide structures composed of cylindrical, rectangular, or coaxial waveguides. Transitions between waveguide types are also allowed. The program includes dielectric properties of ceramics and finite conductivity of metal surfaces. An optimizer dramatically reduces design time and can import scattering matrices from other programs, such as HFSS or measured data, for total system scattering matrix calculation. Statistical Tolerance Analysis provides information for reducing manufacturing costs by identifying the impact of dimensional tolerances on performance. The

presentation will describe the basic theory and present a number of examples demonstrating the program features.

* Work supported by U.S. Department of Energy under contract DE-FG03-97ER83243 and the U.S. Navy under contract N00014-96-C-2107.

TOPB004 Towards the UAL Open Source Project

Nikolay Malitsky, Mike Blaskiewicz, Alfredo Luccio, Todd Satogata, Richard Talman, Jie Wei (BNL)

The paper presents the recent development of the Unified Accelerator Library (UAL). The user and developer environments have been augmented with a User manual, online documentation, interface to a CVS repository and other features. A major change at the core level has been the implementation of the Accelerator Propagator Framework (APF). This is a mechanism for developing diverse propagation algorithms and matching them appropriately to the sectors of the accelerator being simulated. APF has permitted extending the simulation environment with new modules and applications, such as Fast TEAPOT (efficient tracking engine based on the combination of sector linear matrices and TEAPOT symplectic integrator), TIBETAN (longitudinal phase space tracking module), SPINK (code for tracking polarized particles in a circular accelerator), and ICE (a collection of incoherent and coherent effects).

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

TOPB005 Wake Field Modeling in Accelerator Codes

Roman Samulyak (BNL)

The major sources of electromagnetic wake fields in an accelerator chamber are electric currents on resistive walls and non-smooth elements of the chamber. We have developed a parallel software module for modeling the interaction of particle beams with wake fields. The corresponding theoretical model is based on a series expansion of wake field forces in terms of wake functions and beam multipole moments. Wake functions can be calculated analytically for many simple elements typical for accelerator chambers or computed numerically for geometrically complex elements. The module has been implemented in MaryLie/Impact, a parallel beam dynamics code that combines the beam optics capabilities of MaryLie with the space charge capabilities of IMPACT. The incorporation of the wake field module makes it possible to study the influence of wake field forces along with space charge forces on the beam dynamics. The code is being applied to the numerical simulation of the beam dynamics in the BNL Booster Accelerator.

* Financial support has been provided by the USA Department of Energy, under contract number DE-AC02-98CH10886.

TOPB006 Simulation Using Initial 4-D Beam Particle Distributions Synthesized from Experimental Data

Alex Friedman, David P. Grote (LLNL), Frank M. Bieniosek, C.M. Celata, Lionel R. Prost, Peter A. Seidl (LBNL)

In present-day experiments exploring the behavior of intense particle beams for Heavy Ion Fusion, multiple diagnostics at a sequence of stations yield information on the beam particle distribution function. Good shot-to-shot reproducibility enables the acquisition of detailed 2D projections of the 4D transverse phase space using moving slits and Faraday cups. These projections do not contain enough information to uniquely specify the 4D distribution; thus we apply additional constraints and use maximum-entropy Monte-Carlo techniques to complete the specification and tomographically "synthesize" an approximation to that distribution. Our initial studies of such techniques used simulated beam data. The reference case was a fully self-consistent simulation of the High Current Experiment (HCX) at LBNL. Simulations initiated using a simple "semi-Gaussian" model distribution did not exhibit an emittance evolution similar to that of the reference case. We observed much better agreement using runs initiated with distributions synthesized from the (simulated) slit scan data. We are now using such synthesis techniques to launch simulations with initial conditions developed from diagnostics at an upstream station on HCX. The techniques, results obtained using the methods, and future plans for extension of the techniques, are presented.

* Work performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore and Lawrence Berkeley National Laboratories under Contract Nos. W-7405-Eng-48 and DE-AC03-76SF00098.

TOPB007 The Global Accelerator Network, and Remote Operations

Steve Peggs (BNL)

Communications technologies continue to advance at a rapid and exciting rate. Prominent examples of new Remote Operations capabilities include (at the low end) inexpensive PC to PC video conferencing, and (at the high end) pilot-less military airplanes. The Global Accelerator Network (GAN) concept, originally described in two ICFA Task Force Reports, capitalizes on current and future Remote Operations technologies to propose knitting together multiple laboratories in a future accelerator project, in a tighter and more effective fashion than has yet been possible. The GAN concept goes beyond the realm of Remote Operations alone, to include management and financial components. A future Linear Collider is only one potential example of a GAN-based project. Remote Operations concepts also have important, and evolving, roles to play in many current and future instances of large Accelerators and Experiments, whether they are tightly knit or just loosely coupled collaborations. Workshops on "Enabling the GAN" and "Remote Operations" were held in 2002 at Cornell University and at Shelter Island, respectively. Various small and large, present and future, examples of Remote Operations demonstrations are under consideration, in both Accelerator and Experimental implementations. This paper discusses the GAN concept, summarizes the conclusions of the two workshops, and outlines the many issues surrounding GAN and Remote Operations that are still open. It is already clear, for example, that the social "communications" aspects of Remote Operations are very important, but are only imperfectly understood.

TOPB008 Integration of Orbit Control with Real-Time Feedback

Frank Lenkszus, Michael Borland, Louis Emery, Hairong Shang, Om Singh, Robert Soliday (ANL)

The Advanced Photon Source has used two distinct control programs for orbit control and stability—a full-featured workstation-based program for orbit control (Control Law) and an EPICS-based system, the Real-Time Fast Feedback System (RTFS), to reduce orbit motion. The Control Law program has been ported to EPICS and moved from the Unix environment to an EPICS IOC attached to the RTFS. This EPICS-based control law uses the RTFS's reflective memory to gather beam position information and write corrector power supplies, thus avoiding variable network latencies. This allows the orbit control to run at a correction rate better than 15 times that of the workstation implementation, which virtually eliminated orbit motion caused by insertion device gap changes. Issues raised by the integration of orbit control into the real-time feedback system and performance improvements will be discussed.

* Work supported by U. S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-138.

TOPB009 Control Systems on Low Cost Computers

Ernest Williams, Greg Lawson (ORNL)

Computing infrastructures for accelerator control systems can now be built using low cost, commodity-type computers. The commonly used EPICS control system toolkit has been adapted to facilitate its deployment on Pentium-based PCs running the Linux operating system, as well as on other inexpensive platforms. Low-cost, reliable enterprise-class computers can be obtained from many commercial vendors for such control system network-based services as Domain Name Service (DNS), Network Information Services (NIS), and Dynamic Host Configuration Protocol (DHCP). Control system file servers can also be configured using inexpensive rack-mounted PCs and multiple monitor operator consoles can be built with Linux-based PCs or standard X-windows software with high performance video graphic adapters. At the front end of the control system, input-output controllers can be configured also as PCs running embedded Windows. Several accelerator laboratories, including the Spallation Neutron Source (SNS) at the Oak Ridge National Laboratory are taking advantage of these possibilities. This paper will review the use of inexpensive computers in the accelerator community, with particular emphasis on the issues and applications at SNS.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a collaboration of six US National Laboratories: Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Thomas Jefferson National Accelerator Facility (TJNAF), Los Alamos National Laboratory (LANL), Lawrence Berkeley National Laboratory (LBNL), and Oak Ridge National Laboratory (ORNL).

TOPB010 Integrating Control Systems to Beam Dynamics Applications with CORBA

Michael Boege, Jan Chrin (Paul Scherrer Institut)

High level beam dynamics applications typically require access to several distributed components, among which the hardware control system and an accelerator simulation model are crucial. A CORBA Application Program Interface (API) provides clients with the necessary objects with which to develop even the most complex of applications. This is exemplified by the global orbit feedback system at the SLS which is both a consumer to event generated data and a party to remote method invocations on a variety of servers. A description of the CORBA API is presented. In particular, use is made of methods provided by the Portable Object Adapter (POA) to create and activate persistence objects, the Implementation Repository for the automatic reactivation of servers and the Event Service for the propagation of controls and physics data.

TOPB011 Measuring and Matching Transport Optics at Jefferson Lab

Yu-Chiu Chao (Thomas Jefferson National Accelerator Facility)

Well-controlled optical transport over a long range is important for many types of nuclear and high energy physics experiments. It is essential in achieving the desired beam parameters, minimizing optical sensitivity, and ensuring acceptable helicity correlated orbit differences for parity-type experiments. A precise and rigorous program for evaluating optical matching errors, and a deterministic algorithm for obtaining global matching solutions thus hold considerable promise for both accelerator design and operation, although the latter has defied attempts so far due to its almost intractable complexity. For the CEBAF accelerator at Jefferson Lab, this difficulty is further exacerbated by the extreme matching condition necessary for a 5 pass recirculating linac, elements that can introduce considerable optical error, and loss of long-range difference orbit orthogonality due to these effects, all of which impose a very tight demand on the accuracy of the measured transfer matrix as input to the matching algorithm. Research in methods for both measuring and matching optical transport has led to recent successful demonstration of deterministic matching of the optical transport of CEBAF. The global nature of the matching algorithm allows efficient exploration of solutions not easily accessible by traditional methods and serves to signal configuration flaws in the machine.

* This work was supported by the U.S. DOE Contract No DE-AC05-84-ER40150.

Session TOPC: Two Stream Instabilites & Collective Processes
Pavilion East at 13:30
Session Chair: F. Zimmerman

TOPC001 Formation and Dissipation of the Electron Cloud

Miguel Furman (LBNL)

We present a review of measurements and simulations of the electron-cloud formation and dissipation in storage rings. We discuss the relevance of certain electronic properties of the vacuum chamber material to the rate of evolution of the electron cloud.

* Work supported by the Director, Office of Energy Research, of the U.S. Department of Energy under contract number DE-AC03-76SF00098.

TOPC002 Electron Cloud Effects in Present and Future High Intensity Hadron Machines

Michael Baskiewicz (BNL)

Electron clouds can influence machine performance in several ways. The cloud causes an incoherent tune spread, which can limit the choice of operating points. The dynamical evolution of the cloud includes an electron flux into the wall, which can desorb gas and increase the pressure. Finally, the beam and electron cloud can interact in a two stream instability, which can limit the beam quality. Various techniques for prediction and control are considered.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

TOPC003 Electron Cloud Studies and Analyses at SPS for LHC-Type Beams

Jose Jimenez, Gianluigi Arduini, Vincent Baglin, Paul Collier, Gianfranco Ferioli, Bernard Henrist, Noel Hilleret, Berthold Jenninger, Lars Jensen, Jean-Michel Laurent, Adriana Rossi, Kurt Weiss, Frank Zimmermann (CERN)

The SPS machine, being the future injector of the LHC machine, is operated routinely with LHC-type beams. Since August 98, its performance with LHC-type beams has been limited by electron cloud multipacting. This talk will present the main results on the electron cloud studies using strip detectors, pick-ups, cold and warm calorimeters. The dependence of the ECloud on the beam parameters and the effect of a dipole field will be shown. Results on the measurements of the spatial and energy distributions of the electrons in the cloud, compared with results obtained with a conventional retarding field detector, will be presented. Evidence of the scrubbing effect and of the NEG coatings as remedies to reduce the electron cloud activity will be shown. Preliminary results on the studies of the vacuum behavior at cryogenic temperature, the effect of the surface coverage and the existence of the scrubbing effect at cryogenic temperatures will be presented. Finally, Ecloud heat loads obtained by the calorimeters and estimations from the strip detectors are given as a function of the bunch intensity and filling factor. The scaling of

these results to the LHC configuration and the benchmarking of the simulations will be discussed.

TOPC004 Initial Experimental Studies of Electron Accumulation in a Heavy-Ion Beam

Arthur Molvik, R.H. Cohen, A. Friedman, S.M. Lund (LLNL), D. Baca, F.M. Bieniosek, M.A. Furman, E.P. Lee, P.A. Seidl, J.-L. Vay (LBNL), L. Prost (Univ. of California, Berkeley)

Accelerators for heavy-ion inertial fusion energy (HIF) have an economic incentive to fit beam tubes tightly to beams, putting them at risk from electron clouds produced by emission of electrons and gas (which is subsequently ionized by beam impact) from walls. Theory and PIC simulations suggest that the electrons will be radially trapped in the ~4 kV ion-beam potential. We are beginning studies on the High-Current Experiment (HCX) to characterize electron production and trapping, the effects on ion beams, and mitigation techniques. We are measuring the flux of electrons and gas evolved from a target, whose angle to the beam can be varied between 2 and 12 degrees from grazing incidence. The results will be compared with data from a variety of charged particle diagnostics in quadrupole magnets that measure the beam halo loss, net charge, gas density, and effects on the ion beam. These data will be compared with predictions of theory and simulations.

* Work performed for the USDOE by LLNL under Contract W-7405-ENG-48, and by LBNL under Contract DE-AC03-76F00098.

TOPC005 Simulation Study of Electron Cloud Multipacting in Straight Sections of PEP-II

Alexander Novokhatski, John Seeman (SLAC)

Simulation studies were performed for the SLAC B-factory vacuum chamber for different bunch trains and solenoidal magnetic field. Results show that increasing the number of positron bunches by a factor of two and keeping the same current per bunch means that the solenoidal field needs to be doubled in order to keep the same electron cloud density. Fortunately there are regions that are "free of multipacting" at smaller values of solenoidal field where the electron cloud density cannot get very high. This prediction of low cloud density can be checked in experiments. To build the electron cloud, positron bunches have to use some amount of their kinetic energy. The field, which is responsible for the energy transformation, is a longitudinal electric field. When the cloud is built, this longitudinal field acts as an oscillating force on the cloud electrons and gives, at the same time, an additional energy variation inside the positron bunches. The head of the positron bunch is accelerated and the tail is decelerated. This action of the longitudinal field is similar to the action of RF fields in a cavity. As a result the positron bunches will have different lengths throughout the train. This effect can be also checked in experiment.

* US DOE contract DE-AC03-76SF00515.

Session TOPD: Instabilites and Feedback
Pavilion East at 15:40
Session Chair: M. Brennan

TOPD001 Survey of Digital Feedback Systems in High Current Storage Rings

Dmitry Teytelman (SLAC)

In the last decade demand for brightness in the synchrotron light sources and luminosity in circular colliders led to construction of multiple high current storage rings. Many of these new machines require feedback systems to achieve design stored beam currents. In the same time frame the rapid advances in the technology of digital signal processing allowed the implementation of these complex feedback systems. I will concentrate on three applications of feedback to storage rings: orbit control in light sources, coupled-bunch instability control, and low-level RF control. Each of these applications is challenging in areas of processing bandwidth, algorithm complexity, and control of time-varying beam and system dynamics. I will review existing implementations as well as comment on promising future directions.

* Work supported by Department of Energy contract No. DE-AC03-76SF00515.

TOPD002 Digital Orbit Feedback System Operation at the NSLS X-Ray Ring

Boris Podobedov, B. Kushner, S. Ramamoorthy, Y. Tang, E. Zitvogel (BNL)

Orbit feedbacks at the NSLS are critical for maintaining user beam stability in both the X-ray and the VUV storage rings. To improve this stability even further we have replaced the analog orbit feedback systems with new digital ones operating at 5 kHz. This high digitizing rate allows us to achieve a correction bandwidth in excess of 100 Hz, limited only by the bandwidth of the correctors. After successful implementation of an operational system in the VUV ring [B. Podobedov et. al, PAC01, p. 396], we have proceeded to a more complicated system in the X-ray ring. The X-ray ring vertical plane system was put in to regular operations in September 2002 and the horizontal system is expected to become operational soon. In this paper we review the system architecture and algorithms, describe the performance achieved, and summarize our operating experience to date.

* Work supported by US DOE under contract DE-AC02-98CH10886.

TOPD003 Bunch-by-Bunch Digital Damper for the Fermilab Main Injector and Recycler

Bill Ashmanskas (University of Chicago), Bill Foster, Dennis Nicklaus, Warren Schappert, Alexei Semenov (FNAL)

A digital damper system for the Fermilab Main Injector and Recycler Ring has been prototyped and is being implemented. Using commercially available high-performance analog-to-digital converters and field-programmable gate arrays, the design acquires and processes 14-bit samples from stripline detectors and resistive wall-current monitors at 212 MS/s, four samples per 53 MHz RF cycle. From these sampled signals, firmware algorithms measure coherent betatron and synchrotron oscillations and control kickers to apply bunch-by-bunch orbit corrections. An FPGA-based design allows rapid development, facilitates future algorithm changes, provides a straightforward path for recording diagnostic data, minimizes the quantity of custom hardware to build and to maintain, and uses the same hardware to handle multiple RF frequencies and bunch spacings (53 MHz, 7.5 MHz, 2.5 MHz, and debunched beam). The implementation of a three-turn bunch-by-bunch transverse injection damper is described to illustrate the FPGA-based approach. Initial damping results are presented.

* This work is supported by the U.S. Department of Energy and the National Science Foundation.

TOPD004 Calculations and Observations of the Longitudinal Instability Caused by the Ferrite Inductors at the Los Alamos Proton Storage Ring (PSR)

Chris Beltran, Andrew Browman, Robert Macek (LANL)

The frequency dependence of the complex permeability of the ferrite (at room temperature) used in the Inductors at PSR have been determined by comparing the S11 parameters of a jig containing a ferrite core, and a MAFIA simulation of the jig. Both the resonance frequency and the longitudinal impedance of the inductor were

obtained by simulating the inductor cavity in MAFIA. Experimental observations of the longitudinal instability caused by the ferrite inductors at room temperature for both DC Coasting beams and Bunched Coasting beams at a variety of intensities have been conducted. Comparisons of observed and calculated growth times, thresholds, resonant frequencies, and width of the instability will be discussed.

* Work conducted at the Los Alamos National Laboratory, which is operated by the University of California for the United Stated Department of Energy under contract w-7405-ENG-36. Funding and support also provided by Indiana University [IU] and the National Physical Science Consortium [NPSC].

TOPD005 Microbunching and Beam Break-up in DUV FEL Accelerator

Timur Shaftan, Henrik Loos (BNL), William Graves (MIT Plasma Science and Fusion Center)

We present results of compressed beam break-up studies in DUV FEL accelerator. Based on experimental data, we identified the sources of instability. Comparison of instability effect on the beam dynamics with simulations revealed a good agreement. In conclusion we discussed possible measurement methods for diagnostics of electron beam properties in time and energy domain.

TOPD006 Computational Tools for Multipass Beam Breakup in Recirculating Linacs

Kevin Beard, Lia Merminga, Byung Yunn (Thomas Jefferson National Accelerator Facility)

An important limitation on the maximum beam current in a recirculating linac is imposed by beam breakup driven by Higher Order Modes (HOM) excited in the superconducting RF cavities. A dipole HOM delivers a transverse kick to a beam bunch; the same bunch on the next pass can then be displaced and can thereby further excite the HOM and cause it to grow. Subsequent bunches can then repeat this feedback process, driving the HOM ever higher, until the beam is lost. Two codes, MATBBU and TDBBU, have been written to calculate the threshold current of the instability for a specified sets of HOMs and accelerator and beam parameters. TDBBU is a bunch-by-bunch tracking simulation, while MATBBU solves the equations of motion analytically. The relative merits and limitations of each is discussed in detail and examples from the JLab FEL Upgrade and CEBAF 12 GeV Upgrade are given.

* This work was supported by the U.S. Department of Energy under Contract No. DE-AC05-84ER40150.

Poster Session TPPE
Exhibit Hall at 13:30

TPPE001 Commissioning Results of Slow Extraction of Heavy Ions from the AGS Booster

Kevin Brown, L. Ahrens, S. Bellavia, S. Binello, B. Brelsford, D. Du Mont, W. Eng, C. Gardner, D. Gassner, J.W. Glenn, L. Hammons, J. Hock, L. Hoff, E. Hutchinson, J. Jamilkowski, N. Kling, Y. Kotlyar, A. Krishock, R. Lockey, M. Mapes, I. Marneris, G. Marr, A. McNerney, A. Meyer, J. Morris, C. Naylor, S. Nemesure, D. Phillips, A. Rusek, J. Ryan, T. Shrey, L. Snydstrup, N. Tsoupas, B. VanKuik, S. Zahariou-Cohen, K. Zeno (BNL)

Brookhaven's AGS Booster has been modified to deliver slow extracted beam to a new beam line, the Booster Applications Facility. This facility was constructed in collaboration with NASA for the purpose of performing radiation effect studies for the NASA space program. The design of the of the resonant extraction system has been described in [K.A.Brown et al, "Design of a Resonant Extraction System for the AGS Booster", p. 1270, Proceedings of the 1999 Particle Accelerator Conference, New York, 1999]. A more detailed description, which includes predictions of the slow extracted beam time structure has been described in [K.A.Brown et al, "Resonant extraction parameters for the AGS Booster", p. 1571, Proceedings of the 2001 Particle Accelerator Conference, Chicago, 2001]. In this report we will present results of the system commissioning and performance.

* Work performed under the auspices of the U.S. Dept. of Energy.

TPPE002 Design for a High Energy Microbeam Facility at BNL

Kevin Brown, R. Fliller, D. Lazarus, Z. Li, S. Peggs, D. Phillips, V. Radeka, A. Rusek, P. Thieberger, N. Tsoupas, M. Vazquez (BNL)

In this paper we will discuss the design of a high energy microbeam facility which is being considered for construction in collaboration with NASA. This facility will deliver heavy ions (e.g. iron) at energies higher than at existing microbeam facilities (up to 3 GeV/nucleon) for the purpose of performing heavy-ion radiobiology experiments for the NASA space program. The experimental requirements define microbeams to be beams which will have a sufficiently small diameter to localize the ions to a single cell (on the order of 10 microns). To achieve these micron size beams, channeling in bent microcrystals will be used.

* Work performed under the auspices of the U.S. Dept. of Energy and supported by the National Space Biomedical Research Institute.

TPPE003 Status of Slow Extraction of High Intensity Protons from Brookhaven's AGS

Kevin Brown, L. Ahrens, J.M. Brennan, J.W. Glenn, T. Roser, K. Smith, K. Zeno (BNL)

The Brookhaven AGS third integer resonant extraction system allows the AGS to provide high quality, high intensity 25.5 GeV/c proton beams simultaneously to four target stations and as many as 8 experiments. With the increasing intensities (over $7x10^{13}$ protons/pulse) and associated longer spill periods (2.4 to 3 seconds long), we continue to run with low losses and high quality low modulation continuous current beams. We have an active program of high energy physics experiments, including the high precision measurement of the muons magnetic moment [H.N.Brown et al, "Precise measurement of the postive muon anomalous magnetic moment", Phys. Rev. Lett. 86, 2227 (2001)] and the discovery of the rare Kaon decay, K+ -> pi+ nu nu-bar [S.Adler et al, "Evidence for the Decay K+->pi+ nu nu-bar" Phys. Rev. Lett. 79, 2204-2207 (1997)]. This program is continuing into the future with the rare symmetry violating process experiments [RSVP Web Link, http://www.bnl.gov/rsvp/] currently being designed to operate at the AGS. In this paper we will present results from operation of high intensity slow extraction, the problems we encounter, and our solutions to those problems.

* Work performed under the auspices of the U.S. Dept. of Energy.

TPPE004 LHC Pilot Bunches from the CERN PS Booster

Michael Benedikt (CERN)

For the first commissioning phase of the LHC, a single proton bunch is required. The production of this so-called "LHC pilot bunch" will follow a different scheme than the one of the nominal LHC proton bunch train. Both the transverse and the longitudinal LHC bunch characteristics should already be established in the PS Booster. The parameter space for the LHC pilot bunch spans a factor 66 in beam brightness. The intensity should be variable by a factor of 22 from 5.0E9 to 1.1E11, covering the range from the LHC quench limit up to the intensity of a nominal LHC bunch. The transverse emittances (at Booster ejection) should be adjustable in the range 0.85 to 2.5 pi-micrometer (normalized, rms), while the longitudinal emittance is kept constant at 0.3 eVs, slightly below the nominal one (0.35 eVs). To cover the whole parameter space, a mixture of several ingredients was required: intensity adjustment with low voltage rf-capture; definition of the transverse emittance with shavers; controlled blow-up followed by longitudinal shaving to define the longitudinal emittance. All beam variants were produced on harmonic two, with only one bunch being sent to the downstream accelerator chain. To cover also the low intensity side, the Linac beam was reduced by a factor 5 with a "sieve". The pilot bunches corresponding to the "corners" of the parameter space and a few selected inner reference points were successfully produced in the PS Booster.

TPPE005 An 8-GeV Synchrotron-Based Proton Driver at Fermilab

Weiren Chou (FNAL)

In January 2002, the Fermilab Director initiated a design study for a high average power, modest energy proton facility. Such a facility is a possible candidate for a construction project in the U.S. starting in the middle of this decade. The key technical element is a new machine, dubbed the "Proton Driver," as a replacement of the present Booster. The study of an 8-GeV synchrotron-based proton driver has been completed and published. This paper will give a summary report, including machine layout and performance, optics, beam dynamics issues, technical systems design, and a construction cost estimate.

* Work supported by the Universities Research Association, Inc., under contract No. DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPE006 Antiproton Beam Transfer without Coalescing

Weiren Chou, Brian Chase, Jim Griffin, Jim MacLachlan, Steve Werkema (FNAL)

An effective way to increase the luminosity in the Fermilab Tevatron collider program Run2 is to improve the overall antiproton transfer efficiency. During antiproton coalescing in the Main Injector, about 10-15% of particles get lost. This loss could be avoided in a new antiproton transfer scheme that removes coalescing. Moreover, this scheme would also eliminate emittance dilution due to coalescing. This scheme uses a 2.5 MHz RF system to transfer antiprotons from the Accumulator to the Main Injector. It is then followed by a bunch rotation in the MI to shorten the bunch length so that it can be captured by a 53 MHz RF bucket. Calculations and simulations using the code ESME show that this scheme could work. Beam study is being planned. No new hardware is needed to implement this scheme. This paper will give a progress report of this study. It will also discuss several critical issues, including longitudinal density of antiprotons

in the Accumulator, momentum acceptance of the MI, transition crossing in the MI, and beam loading effect during the bunch rotation.

* Work supported by the Universities Research Association, Inc., under contract No. DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPE007 Optics of a Transitionless Proton Driver Design

Leo Michelotti, Weiren Chou, Alexandr Drozhdin, Norman Gelfand, Carol Johnstone (FNAL), Grahame Rees (Rutherford Appleton Laboratory), David Ritson (Stanford University), Al Garren (University of California, Los Angeles), Sho Ohnuma (University of Hawaii)

In a four month study, a design for a Proton Driver was developed as a possible replacement for Fermilab's Booster. Its lattice requirements included: (a) same circumference as the Booster, 474.2 m; (b) energy range from 600 MeV to 8 GeV; (c) transitionless lattice, gamma_t >> 9.5; (d) zero dispersion long straight sections; (e) a 15 Hz cycle rate; (f) 2.5 x 10**13 protons per cycle; 3 x 10**11 protons per bunch, for 0.5 MW beam power; (g) 40 pi (95%, invariant) tranverse emittance with +- 1% momentum acceptance. Cost constraints necessitated a simple design, with as few magnet types as possible. A two-fold symmetric racetrack was chosen from among a number of alternatives. It is partitioned into forty-four cells, each containing a quadrupole doublet: 30 in the arcs and 14 in the straight sections. The design's optical properties will be presented in this paper.

* Work supported by the U.S. Department of Energy under contract DE-AC02-76CH03000.

TPPE008 Applying Virtual Prototyping to the Innovative Design of Low Energy Accelerators

Qin Bin, Dezhi Chen, Mingwu Fan, Yongqian Xiong, Tiaoqin Yu (HuaZhong University of Science and Technology)

Based on the accelerator theory and virtual prototyping technique, an accelerator virtual prototyping system (AVPS) is formulated, implemented for the innovative design of low energy accelerators. The framework of AVPS takes into account the needs of manufacture, assembly/disassembly, operation, and maintenance in a virtual environment during the design phase. In order to guarantee the reliability of AVPS, Augmented Reality (AR) technique was used to integrate the virtual environment and experimental subsystem. Furthermore, Common Object Request Broker Architecture (CORBA) middleware for distributed, object-oriented applications was used to develop and implement the framework. The main components of AVPS include AR subsystem, distributed computing environment and data warehouse.

TPPE009 First Tests of a CW RFQ Injector for the IUCF Cyclotrons

Vladimir Derenchuk, Vladimir Anferov, Dennis L Friesel, William P. Jones (Indiana University), Robert W Hamm (AccSys Technologies, Inc.), John W. Staples (LBNL)

A 750 keV CW RFQ [John W. Staples, "Reducing RFQ Longitudinal Emittance", Proc. of 17th Intl. Linac Conf. Tsukuba, Japan(1994) p.755] proton injector is replacing the Cockroft-Walton high voltage terminal at the Indiana University Cyclotron Facility. [D.L.Friesel, et. al., "A CW RFQ Injector for the IUCF Cyclotron" App. of Acc. in Res. and Ind., eds. J.L. Duggan and I.L. Morgan, Denton(2000), pp.651-654.] The injector consists of a microwave ion source which can produce several milliamperes of 20 keV protons. This beam is matched to the 213 MHz RFQ using a solenoid focusing system. A parallel plate chopper upstream of the RFQ operates at 17.75 MHz to eliminate beam that does not match the RF phase acceptance of the cyclotrons. In addition, the intensity after the RFQ is adjusted in a range from 1% to 100% by using an electrostatic quadrupole to create a mismatch into the RFQ acceptance. The 750 keV beam from the RFQ is transported through a magnetic quadrupole triplet to create a focus at the cyclotron center region. The design and operation of the injector before it is installed on the cyclotrons is described in this paper.

TPPE010 Longitudinal Tracking Studies for the AHF Booster Synchrotron

Lawrence Rybarcyk (LANL)

The greenfield site option for the Advanced Hydrotest Facility (AHF) contains a 157-MeV H^- linac followed by two synchrotrons, a booster and a 50-GeV main ring. Several different lattice designs are under consideration for the main ring while two different booster designs are presently being studied. The first booster is a 4-GeV synchrotron operating at h=1 with a 5 Hz cycle. The second is a 9-GeV machine operating at h=2 with a 2 Hz cycle. Both designs are required to deliver ~3 x 10^{12} p/bunch. A longitudinal painting scheme is employed during injection to enhance beam quality and capture during the initial portion of the ramp. The longitudinal beam dynamics simulations were performed with the tracking code ESME. The purpose of these studies is to investigate parameter space and obtain estimates for the rf system requirements. This paper presents the results of these studies.

* Work supported by US DOE / NNSA.

TPPE011 The Commissioning Plan for the Spallation Neutron Source Ring and Transport Lines

Stuart Henderson, Saeed Assadi, Sarah Cousineau, V. Danilov, George Dodson, John Galambos, Jeff Holmes, Ken Reece, Tom Shea (ORNL), Mike Blaskiewicz, Alexei Fedotov, Y.Y. Lee, Deepak Raparia, Jie Wei (BNL)

The Spallation Neutron Source accelerator systems will provide a 1 GeV, 1.44 MW proton beam to a liquid mercury target for neutron production. The accelerator system consists of an H- injector, a 1 GeV linear accelerator, an accumulator ring and associated transport lines. In order to satisfy the accelerator systems' portion of the Critical Decision 4 commissioning goal (which marks the completion of the construction phase of the project), a beam pulse with intensity greater than $1x10^{13}$ protons, as compared to the design intensity of $1.5x10^{14}$, must be accumulated in the ring, extracted in a single turn and delivered to the target. A commissioning plan has been formulated for bringing into operation and establishing nominal operating conditions for the various ring and transport line subsystems, as well as for establishing beam conditions and parameters which meet the commissioning goals. The plan enumerates the various beam-based measurement and correction steps which are envisioned for achieving the beam parameters and particle loss rates that are necessary for meeting the commissioning goals. The ring and transport line commissioning plan and the beam-based commissioning algorithms will be described.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

TPPE012 Exploration of Beam Fault Scenarios for the Spallation Neutron Source Target

Stuart Henderson, Sarah Cousineau, V. Danilov, Jeff Holmes, Tom McManamy (ORNL), Alexei Fedotov, Y.Y. Lee, Deepak Raparia, Jie Wei (BNL)

The Spallation Neutron Source accelerator systems will provide a 1 GeV, 1.44 MW proton beam to a liquid mercury target for neutron production. In order to ensure adequate lifetime of the target system components, requirements on several beam parameters must be maintained. Principally, the peak single pulse density on the target

must be kept below 2.6×10^{16} protons/m^2. In a second requirement, 90% of the beam power must remain within the nominal beam footprint. Violation of either of these requirements demands that the beam be shut off within two 60 Hz pulses. A series of error studies was performed to explore credible fault scenarios which can potentially violate these beam-on-target parameters. The response of the beam-on-target parameters to errors associated with the phase-space painting process in the ring and field setpoint errors in all the ring-to-target beam transport line elements were explored and will be presented. The plan for ensuring beam-on-target parameters will also be described.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

TPPE013 A Superstructure for High Current FEL Application

Jacek Sekutowicz, Peter Kneisel (Thomas Jefferson National Accelerator Facility), Shuxin Zheng (DESY), Catherine Thomas (French Atomic Energy Commission)

The next generation of FEL's at Jefferson Lab will produce coherent light at power levels of 10 kW and 100 kW, respectively. To achieve these power levels, electron beams of 10 mA and 100 mA have to be accelerated in the linear accelerator section of the devices. Stable operation of these sections is only possible if the Higher Order Modes generated by the beams can be sufficiently damped. One of the possible accelerating structures, that can fulfill this requirement is a "superstructure" consisting out of two weakly coupled subunits and equipped with appropriate HOM couplers. Such a superstructure has recently successfully accelerated a pulsed electron beam at DESY to an energy of 48 MV (this conference). Based on this positive experience, we have built a copper model of such a superstructure by modifying two existing CEBAF 5-cell copper cavities coupled to each other via a half wave length long interconnecting beam pipe of dia 98 mm, which provides app. 0.04% coupling. The structure features one HOM coupler at each end and two HOM couplers at the interconnecting beam pipe. In addition, a waveguide fundamental power coupler at the end of one subunit is used to simultaneously excite both sub-units. This configuration resulted in strong damping of the first few pass-bands of the structure, which would allow stable acceleration of beams up to ~ 200 mA. We are presently in the process of fabricating a superstructure model from Niobium and first results from cryogenic tests will be reported in this contribution.

* Work supported in part by the U.S.DOE under contract Nr. DE-AC05-84ER40150.

TPPE014 Investigation of Space Charge Effect in TRIUMF Injection Beamline

Rick Baartman (TRIUMF)

The TRIUMF cyclotron operates routinely at 200μA extracted at 500 MeV. Because of growing demands for beam, up to 400μA is envisaged: this would require ~ 1mA from the H^- ion source and injection beamline. The phase acceptance of the cyclotron is roughly 36°, so the local peak beam current just before injection would be higher than 4mA. The space charge effect on the beam transverse envelope and longitudinal bunching efficiency are therefore of major concern. The beam profiles and the bunching efficiency were measured for different currents up to 510μA. These were used in space charge transport calculations to determine the beam emittance as a function of intensity. Extending the calculations to higher intensities, it is found that with the present double drift double harmonic bunching system, the bunching efficiency decreases dramatically above a DC current of 600μA. To enable reaching the envisaged 400μA from the cyclotron requires either raising the cyclotron phase acceptance from the present ~ 36° to 50° by for example increasing the energy gain per turn at injection, or by adding another fundamental harmonic buncher.

TPPE015 Feasibility Studies of a Storage Ring for Radioactive Ions

Michael Craddock, Dobrin Kaltchev (TRIUMF)

The low intensity of beams of unstable isotopes makes it vital to use them efficiently. Their collection in a storage ring opens up a number of possibilities: higher beam intensities, enabling better suppression of background and more accurate measurement of isotopic and ionic properties; higher luminosities, by the use of beam cooling and internal targets; acceleration to higher energies; quasi-simultaneous operation with low-energy fixed-target experiments; and colliding- or merging-beam experiments with protons, electrons or muons. One of the main design challenges is to limit ion loss caused by scattering, energy straggling or charge exchange in the injection stripping foil, residual gas or internal target. This sets direct limits on each of these items, and also requires the injection energy and momentum acceptance to be sufficiently high. These problems are explored in the context of the ISAC radioactive beam facility at TRIUMF.

TPPE016 The TRIUMF 500 MeV Cyclotron; Present Operation and Intensity Upgrade

Gerardo Dutto (TRIUMF)

A new series of experiments (mainly astrophysics) began at TRIUMF in July 2001 when the ISAC-I linear accelerator began delivering up to 1.5 MeV/u radioactive ion beams (RIB) to users. A superconducting linear accelerator extending the RIB energy to 6.5 MeV/u has recently been approved and is now being constructed (ISAC-II). Record RIB intensities are being achieved from different target ion sources with a primary incident proton beam of 500 MeV, up to 45 mA intensity. This will later be increased to 100 mA, compatibly with target acceptance. Furthermore, an additional 100 mA extracted proton beam is being considered for simultaneous (RIB) production from a second target-ion source system. This would significantly enhance the research potential of the laboratory. Four simultaneous high intensity extracted beams would therefore be required for a total maximum cyclotron accelerated current of about 400 mA. Recently we have been able to deliver 300 mA to the existing three high intensity beam lines at 90% duty cycle. The cw delivery of beam was limited only by presently available external beam dump capacity. In this paper we will review the present operational experience at 200/250 mA, the future plans for intensity upgrade to 350/400 mA, and the intrinsic factors limiting the total accelerated intensity beyond 400 mA.

* TRIUMF receives federal funding via a contribution agreement through the National Research Council of Canada.

TPPE017 Fermilab Booster Orbit Correction

Linda Coney (Columbia University)

The Fermilab particle physics program has recently expanded to include the MiniBoone experiment in addition to the Run2 program. As a result, the effective and reliable performance of the Fermilab Booster has become crucial to the lab. The Booster is an 8 GeV proton synchrotron and is a key element of the Fermilab accelerator chain. It must meet increasing demands for proton intensity and high repetition rates. One important requirement placed on the machine is low radiation levels. These levels are highly correlated with losses in the machine, and can limit Booster production. We will describe how a system of ramped dipole corrector magnets are being used to maintain orbital position throughout the acceleration cycle in order to minimize beam losses, maximize proton intensity, and maintain the required repetition rate.

TPPE018 Fermilab Booster Tune Studies

Linda Coney (Columbia University)

The Fermilab Booster is an 8 GeV proton synchrotron that must meet increasing demands for proton intensity and high repetition rates while maintaining low radiation levels from beam loss. We will describe a series of tune studies that were performed on the Booster. These were done in order to examine the possibility of using resonant extraction to collimate the beam halo in a controlled manner. The tune range available in the Booster was determined, and the behavior of the beam when crossing several resonances in the tune plane was analyzed. We will discuss the methods used to manipulate the tune, and the study results with respect to resonant extraction of the beam halo.

TPPE019 CRYRING Progress: Weak Beams, Rare Ions and Ordering

Anders Kallberg (Manne Siegbahn Laboratory [MSL])

The development of the storage ring CRYRING is primarily aimed at the production, handling and measurement of weak beams, often of ions that are difficult to produce in the ion sources. Examples are H13O6+, C6D6+, D5+ and Kr33+. Circulating beam currents well below 5 nA have been measured in the ring. Also the previously observed ordering of highly charged ions has been studied further. Indications of ordering of bunched beams have been observed. Ions from the ECR source are now regularly used for single pass experiments and they are planned to be used for experiments in the ring during the spring of 2003.

TPPE020 Design of a Racetrack Microtron to Operate Outside the Phase Stability Region

Marcos Martins, Paulo Rios, Jiro Takahashi (Instituto de Fisica da Universidade de Sao Paulo), Luis Terremoto (Instituto de Pesquisas Energeticas e Nucleares)

The beam optics design of a small 5-turn racetrack microtron is described. This microtron is the first stage of a two-stage microtron of 31 MeV maximum energy, and is fed by a 1.8 MeV injector linac. This configuration was chosen in order to maximize the final energy of the system with the available RF power, and, as a result, it was necessary to operate the first stage outside the ideal orbital stability region. The separation between successive orbits is not constant, and the system presents large phase oscillations from one orbit to another. Nevertheless it was possible to find geometrical and magnetic field strength configurations that allow the extraction of a 4.9 MeV beam, within the design goals for the main acceleration step.

* Work supported in part by FAPESP and CNPq.

TPPE021 Beam Transport System for the IFUSP Microtron

Marcos Martins, Mauricio Lopes, Paulo Rios, Jiro Takahashi (Instituto de Fisica da Universidade de Sao Paulo)

This paper describes the optical design of the beam transport system that links the two stages of the IFUSP racetrack microtron and both accelerators to the experimental hall. The path is 32-m long. Conventional analytical methods were used to obtain initial values for the operational parameters and positioning the active elements along the line. TRANSPORT and PTRACE codes were then used to optimize the parameters and to check particle tracking. Due to limitations imposed either by the building or by other accelerator components, in several instances the active correcting elements could not placed at the ideal positions.

* Work supported in part by FAPESP and CNPq.

TPPE022 Time Domain Considerations and Design for an Asymmetric Blumlein Accelerating Gap

Scott Nelson, Steven Hawkins, Brian Poole, Stephen Sampayan (LLNL)

Traditional accelerating gaps in accelerating structures utilize vacuum gaps with an applied potential across them and are limited by field gradients across common materials or vacuum breakdown levels. Recent work on high gradient structures has allowed for approaches that are much more compact than traditional approaches. In this approach, an asymmetric blumlein structure is used as both the charging energy storage mechanism and as the discharging accelerating gap for a particle beam. The rise time of the structure is limited by the shorting switch time, line inductance, and line-to-line capacitance. The accelerating gap voltage gradient is limited by the high gradient insulator and the charge voltage (asymmetric line-pair stack height, charge voltage, insulator thickness, and dielectric fill factor). The gap voltage pulse width is limited by the the difference in the blumlein electrical path lengths (physical length and dielectric constant differences). The asymmetric nature of the blumlein configuration allows for a net zero voltage on the structure while in the charged state and only applies a voltage gradient during the discharge cycle.

* This work was performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

TPPE023 Electric Field Simulations of Asymmetric Blumleins in Dielectric Wall Accelerator

Lisa Wang, George Caporaso, Steven Hawkins, Stephen Sampayan (LLNL), William Nunnally (University of Missouri, Columbia)

A short pulse, high gradient dielectric wall accelecrator is being developed at Lawrence Livermore National Laboratory. The objective is to achieve the maximum possible accelerating gradient. The structure consists of stacked spiral asymmetric Blumlein strip transmission lines. There are two spiral strip transmission lines in each layer which are charged with opposite polarity voltages. Therefore, no net voltage appears on the outside of the structure. To facilitate the design process, electric field simulations were performed to determine the maximum field stress for various Blumlein configurations.

* This work was performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

TPPE024 Insights in the Physics of the Dynamic Detuning in SRF Cavities and Its Active Compensation

Marc Doleans, Sang-ho Kim (ORNL)

Elliptical SRF cavities operated in pulsed mode experience dynamic Lorentz detuning because of the time varying radiation pressure. Due to the narrow electromagnetic bandwidth of these resonators, the induced detuning can severely affect their matching conditions to the RF feeding system. The active compensation scheme using piezoelectric tuners has proven to be a viable and attractive method to minimize the effects of the Lorentz detuning. To optimize this compensation, mechanical parameters are extracted for the action of the Lorentz forces and the piezoelectric from both measurement and simulation. This process gives insights into the physics of the dynamic detuning, such as the nature of the coupling differences of both detuning sources, the possible settings for the measurement of the dynamic detuning with the methods to deduce mechanical parameters from them, and the origin of possible parasitic effects in the

measurements. These issues are reported and discussed along with some ideas for the optimization of the detuning compensation.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

TPPE025 Supercritical Electron Beam Behaviour at Plasma Assistance

Ivan Onishchenko, Yuri Prokopenko, Stanislav Pushkarev, Alexey Yegorov (NSC Kharkov Institute of Physics and Technology), Rickey Faehl (LANL)

The structure with vacuum limiting beam current and virtual cathode (VC) can be used in collective particle accelerator conception. It was considered as a first section of two-sectioned collective ion accelerator based on simultaneous temporary and spatial modulation of the relativistic electron beam (REB) [V.A.Balakirev, et al. Plasma Physics Reports, 1997, Vol. 23, No.4, p.350]. In our experiments the voltage pulse of Marx generator is applied to the magnetically insulated diode. The cylindrical cathode has diameter of 38 mm and width of an emission edge of 0.1mm. The jump of electrodynamics' structure was used for VC formation. The configuration of magnetic field provides the electron cylindrical beam with diameter of 32 mm and wall thickness of 3 mm. The limiting current is 3.4 kA. At beam currents above vacuum limiting one the high frequency oscillations of several GHz are generated. The low frequency modulation of 40 MHz takes place in the system with virtual cathode at plasma assistance due to the charge compensation and further escaping of ions. The relaxing potential well modulates the REB current and accelerates plasma ions to energy determined by the well depth.

* This work was supported by STCU Project No.1569.

TPPE026 Physical Design and Experiment Research of 9Mev SW Electron Linac Used in ICT

Hao Chen, Xiao Jin, Ming Li, Zhou Xu, Xingfan Yang (Chinese Academy of Engineering and Physics)

A new type S band SW electron linac used in Industrial CT was designed and developed. Energy of electrons can reach 9Mev(pulse current intensity 100mA). The on-axis accelerating structure was operated in the $\pi/2$ mode and 2856MHz.The designed beam focal spot size is 0.5~1mm.The calculation of particle dynamics,accelerating structure parameter, cold test, microwave turning and working character are carried out.

TPPE027 The Key Technique and Integrity Design for High Energy ICT

Hao Chen (Chinese Academy of Engineering and Physics)

As an important NDT/NDE tool, ICT overcomes the deficiencies of traditional X-Ray imaging system. Especially the high energy ICT can examine large scale and high-density workpieces for its strong penetrability. ICT plays an important role in the disposal of nuclear waste and missile test. In this paper, the key techniques used in ICT based on RF Linac will be discussed, such as high energy X-Ray source, high performance X-Ray-to-light converter and advanced imaging system etc, and also the integrity design, performance and some experiment results of a 4MeV RF-ICT system will be given.

TPPE028 Contruction of User Facilities for the Proton Beam Utilization of PEFP (Proton Engineering Frontier Project)

Kye-Ryung Kim, Hwa-Ryun Lee, Ki-Yong Nam (Korea Atomic Energy Research Institute)

The "Proton Engineering Frontier Project (PEFP)" was approved by the government under the "21C Frontier R&D Program". The final goals of the PEFP are construction of 100MeV proton linac, development of beam utilization technologies, and promotion of related industrial technologies. The major beam utilization areas of the PEFP are new genetic resource development, simulating radiation environment in space, and fast switching power semiconductor development. In addition, there are several small research projects concerned with the basic science and nuclear physics. 20MeV proton beam will be supplied to the users for these experiments in the middle of 2007. The research project for the construction of user facilities started in September 2002. This paper contains the conceptual design of these user facilities and the construction results of 6MeV proton beam test facility for the feasibility studies of the proton beam utilization experiments of PEFP.

TPPE029 Bunching System of Electrons on the Base of Evanescent Wave

Sergey Perezhogin, Mykola Ayzatsky, Efrem Biller, Katherina Kramarenko, Volodymir Kushnir (NSC KIPT)

At the initial stage of acceleration, it is often necessary to create an increasing distribution of accelerating electric field for improving the bunching process. Standing wave injectors on the base of evanescent waves are considered. The parameters of the systems are selected in such a way, that at the working frequency the resonant oscillation in the injector corresponds to the evanescent wave of the boundless periodic structure. It gives possibility to create in the injector the increasing amplitude distribution. Injectors consist of the fragments of the cylindrical discloaded waveguide with appropriate boundary resonators. For the given working model the simulation of the electrons beam dynamics has been carried out. By the simulation results the working model of the bunching system has been made. The results of measurement of the bunching system characteristics are represented.

TPPE030 Simulation of Photoneutrons in High Energy Electron Linear Accelerators

Weiling Huang, Quanfeng Li (Tsinghua University, Beijing)

Photoneutrons induced in high energy electron linear accelerators used in industrial CT, will influence the response of gamma detectors, which will worsen the resolution of the graphs. Simulations with MCNP and FLUKA give important information of photoneutrons. The results help to compare with the measurement data and correct the detector response.

TPPE031 Pulsed Electron Accelerator For Radiation Technologies

Sergey Korenev (Steris Corporation)

The design of pulsed electron accelerator for radiation technologies (kinetic energy of electrons is 200 - 400 keV, beam current is 150 - 1000 A and pulse duration is 100-200 nsec) is considered in the report. The pulsed electron accelerator consists from pulsed Marx high voltage generator, vacuum electron source with plasma cathode. Electron optics for electron source calculated by OPERA-3D. Accelerator has 2 modes of operation: pulsed electron beam and pulsed X-rays. The design of target for production of X-rays is considered. The specific conditions of forming of cathode are discussed.

TPPE032 The System of On-Line Electron Beam Dose Measurements for Industrial Accelerators

Sergey Korenev (Steris Corporation), Ivan Korenev (Northern Illinois University)

The on-line system for electron beam dose measurements for industrial accelerators is considered in the report. The system is acceptable for all types of industrial and research accelerators: CW, DC, RF linac and pulsed high current. The main concept consists of the measurements of beam parameters using partial absorption effect and

mathematical treatment of signals from sensors. The 2 modes of operation can be used for this system: manual and full automation. The manual mode includes simple measurements of signals from sensors by oscilloscope with following treatment using simple software. The second mode is used with LABView 6.1 for measurements, treatment of signals and presentation on screen (PXI-1025 with printed protocol). The system was tested on the pulsed electron accelerator with kinetic energy of electron 400 keV and on the CW accelerator Rhodotron for electron with kinetic energy 5 MeV. This system allows one to measure the primary kinetic energy of the electron beam before it reaches the product. The questions of application for this system are discussed.

TPPE033 Target for Production of X-Rays

Sergey Korenev (Steris Corporation)

The patented new type of X-rays target is considered in the report. The main concept of the target consists in the sandwich structure of deposited coating from materials with high Z on the substrate with low Z, high thermal conductivity and high thermal stability. The target presents multiply layers system. The thermal conditions for X-Rays target are discussed. The experimental results for Ta target on the Al and Cu substrates are presented. This type of target allows improving the cooling system. The energy spectra of considered target are analyzed.

TPPE034 Simulation Tool for Scanning X-Ray Beams Irradiator

Gennadiy Popov, Valentin Lazurik, Valentina Lazurik, Yuriy Rogov (Kharkiv National University)

X-ray produced by high-power electron accelerators are intensively used in different radiation technologies. The detailed physical and geometrical models of the X-ray irradiator were realized in the form of new mathematical software of the "X-ray Soft" for simulation of industrial radiation processes and the absorbed dose distribution (ADD) within product irradiated by scanning X-ray beams. The motivation for the development of the program is the creation of accurate and easily accessible tool for prediction of the ADD, for optimization of regimes of the irradiator, and for reducing of experimental dosimetric measurements. The scientifically-justified optimization is carried out in view of features of the used radiation facility, and specific requirements of technology to conditions of irradiation. It is reached due to the use in the unified calculation scheme of the transport of electron and gamma radiation in materials of different calculation methods, such as analytical, semi-empirical and precise Monte Carlo method. At realization of the simulation methods the special designed schemes permitting to reduced calculation time for receiving of the end results in about hundreds time were applied. The scientific substantiation of a correctness of implementation of the developed simulation models in the program on the basis of theoretical and experimental data analysis will be presented in this report.

TPPE035 Radiation Processing of Composites for Orthopaedic Implants

Gennadiy Popov, Alexander Avilov, Vyacheslav Deryuga, Nataly Popova, Vladimir Rudychev (Kharkiv National University)

One of most up-to-date problems of orthopedics is the development of new materials for replacement of osseous tissue and cartilage defects. Electron beam (EB) processing of polymer composites with bioactive ceramics was used for manufacture of artificial materials for orthopedic implants. The investigations were performed in three main problem directions. 1. Development of technological methods and processes of new composite materials formation for osseous tissue implants. The problem is the receiving of materials which have to possess mechanical and operating characteristics closed to those of natural osseous tissue and cartilage. 2. Development of composite material for elastic elements of prosthesis that are simultaneously the elements of friction couple. The problems are the decreasing the friction coefficient in artificial joint and reducing the wearing rate of ultra high-molecular weight polyethylene (UHMWPE) construction element for endoprotheses. 3. Radiation induced graft copolymerization of methylmethacrylate monomer on surface of UHMWPE and composites based on it. The decided problem is the increasing adhesion of UHMWPE to bone cement. The EB irradiation of compounds in all processes was performed by linac with energy from 4 to 7 MeV, beam power up to 5 kWh. Experimental approaches and problems of EB processing for composites formation will be discussed in the paper.

* Research was supported by the STCU, Kyiv, project #957.

TPPE036 Simulating the Interaction Between Electron Beam and Flue Gas about an Industrial Flue Gas Treatment System

Guangyao Feng (National Synchrotron Radiation Lab)

Today the major pollution of our world comes from the gas wastes. Most of the gas wastes are mainly from the fossil fuel combustion power plants. For controlling it, flue gas irradiation using the electron beam is an effective method. In the work, Interaction between flue gas and electron beam generated from a 700keV high voltage accelerator is analyzed and simulated. Beam energy loss, traversing deepness and dose distribution in the flue gas irradiation vessel are obtained. In this way, the optimal geometry for industrial flue gas treatment system can be found. In order to make a optimal selection about beam output window of the accelerator, interaction between electron beam and the metal window is analyzed as well.

TPPE037 Preliminary Design of a Beam Line for TRADE Experiment

Luigi Picardi, Concetta Ronsivalle (Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente)

The TRADE (TRIGA Accelerator Driven Experiment) experiment, to be performed in the TRIGA reactor of the ENEA-Casaccia Centre, consists in the coupling of an external proton accelerator to a target to be installed in the central channel of the reactor scrammed to sub-criticality as a significant step towards the ADS (Accelerator Driven System) demonstration. The 110 MeV – 1 mA beam, produced by a cyclotron will be injected into the reactor pool from the top, and focused onto a target hosted in the central thimble, at present used for high neutron flux irradiation. A 30 m beam line has been designed to transfer the beam with special care of having very low losses in the TRIGA reactor building where a limited shielding of the beam line is possible. The design criteria of the beam line will be described, and results of computations will be presented.

TPPE038 Possible Layouts of an Electrostatic Storage Ring

Carsten Welsch, Joachim Ullrich (Max-Planck-Institut fuer Kernphysik), Horst Schmidt-Bocking (Institut fuer Kernphysik), Christian Glaessner, Kai-Uwe Kuehnel, Alwin Schempp (Institut fur Angewandte Physik)

An electrostatic storage ring can be seen as a cross of an electrostatic trap and classical magnetic storage rings. It combines small size, low costs with a high flexibility in terms of possible experiments. The geometrical shape of such a machine is not limited by any principal rule. A storage ring for beam energies up to 50 keV is planned to be build in Frankfurt. Different designs have been analysed for that purpose and are described in this contribution. The beam parameters are given for each case. All the necessary optical elements have already been built as prototypes and are presented as well.

Poster Session TPPB
Grand Ballroom I at 13:30

TPPB001 Up-Graded RHIC Injection System

Harald Hahn, W. Fischer, R.C. Lee, D.S. Warburton (BNL)

The conceptual design of the RHIC injection systems anticipated the possibility of filling and operating the rings with a 120 bunch pattern, corresponding to 110 bunches after allowing for the abort gap. Beam measurements during the 2002 run confirmed the possibility, although at the expense of severe transverse emittance growth and thus not on an operational basis. Based on this experience, an improvement program was initiated with the goal of reducing the kicker rise time from 110 to ~95 ns and of minimizing pulse timing jitter and drift. The major components of the injection system are 4 kicker magnets and a Blumlein pulser using thyratron switches. The kicker terminating resistor and operating voltage was increased to reduce the rise time. Timing has been stabilized by using commercial trigger units and extremely stable dc supplies for the thyratron reservoir. A fiber optical connection between control room and the thyratron trigger unit has been provided, thereby allowing the operator to adjust timing drifts during the injection setup individually for each kicker unit. Beam measurements are in progress and will allow a detailed evaluation of the upgraded RHIC injection system.

TPPB002 Super-Invar as a Target for Pulsed High-Intensity Proton Beams

Harold Kirk, Leonard Mausner, Nikolaos Simos, Peter Thieberger, Robert Weggel (BNL), Kirk McDonald (Princeton University)

We describe measurements performed on samples of the metal alloy super-invar, which is a possible material for a robust solid target in a 1-MW pulsed proton beam. The very low coefficient of thermal expansion of super-invar makes it highly resistant to beam-induced thermal shock effects. However, to be viable as a target, the thermal expansion coefficient must continue to be low after extensive beam exposure. To test this we have irradiated samples of super-invar at the Brookhaven Linac Isotope Producer facility. Measurements of the elastic modulus, yield strength and thermal expansion coefficient as a function of radiation damage are reported.

* This work was performed under Contract No. DE-AC02-98CH10886 with the United States Department of Energy.

TPPB003 A High-Field Pulsed Solenoid Magnet for Liquid Metal Target Studies

Harold Kirk, Michael Iarocci, Ioannis Marneris, Joseph Scaduto, Robert Weggel (BNL), George Mulholland (Applied Crygenics Technology), Peter Titus (MIT Plasma Science and Fusion Center), Kirk McDonald (Princeton University)

The target system for a muon collider/neutrino factory requires the conjunction of an intense proton beam, a high-Z liquid target and a high-field solenoid magnet. We describe here the design parameters for a pulsed solenoid, including the magnet cryogenic system and power supply, that can generate transient fields of greater than 10T with flat-tops on the order of 1 second. It is envisioned to locate this device at the Brookhaven AGS for proof-of-principle testing of a liquid-jet target system with pulses of 1e13 protons.

* This work was performed under Contract No. DE-AC02-98CH10886 with the United States Department of Energy.

TPPB004 Moving Solid Metallic Targets for Pion Production in the Muon Collider / Neutrino Factory Project

Peter Thieberger, Harold Kirk (BNL)

The production of large fluxes of pions and muons using high energy, high intensity proton pulses impinging on solid targets presents unique problems which have not yet been entirely solved. The large required power density deposited in the material as well as the short pulse duration produce large, local heating, and the resulting sudden thermal expansion can result in damage-causing stresses in solids . Here we investigate the possibilities of using solid targets by choosing a metal of either extremely low expansion coefficient or exceptionally high mechanical strength. The two candidates are respectively Super Invar and Vascomax 350. Moving targets in the form of chains or cables would be required for cooling purposes. Both materials seem capable of surviving the beam pulses required for the largest beam power contemplated. Questions regarding radiation damage effects are being investigated.

* This work was performed under Contract No. DE-AC02-98CH10886 with the United States Department of Energy.

TPPB005 Commissioning of the Beam Transfer Line of the Booster Application Facility (BAF) at BNL

Nicholaos Tsoupas, Steven Bellavia, Kevin Brown, I Hung Chiang, David Gassner, Andrew McNerney, David Phillips, Philip Pile, Adam Rusek, Louis Snydstrup (BNL), Ralf Prigl (Computer Associates)

A new facility, the Booster Applications Facility (BAF), has been constructed in collaboration with NASA at Brookhaven National Laboratory . This facility will take advantage of proton and heavy-ion beams from the Alternating Gradient Synchrotron (AGS) Booster accelerator for radiation effect studies for the space program. A slow spill extraction system has been added to the Booster and has been commissioned with beam delivered to the first instrumentation package located 26 meters downstream of the Booster extraction septum magnet. Full facility commissioning is set to begin in April 2003. Beam will then be delivered to the end of the 100 meter beam line and fully characterized. The BAF line incorporates quadrupole focusing to allow variable beam sizes and octupole focusing to allow uniform beam distributions in the irradiation area. The BAF is designed to operate concurrent with other programs that make use of the Booster as an injector for the AGS. Results obtained from the commissioning of the BAF line will be presented.

* Work performed under the auspices of the U.S. Dept. of Energy.

TPPB006 Injection Acceleration and Extraction of High Intensity Proton Beam for the "Neutrino Facility" Project at BNL

Nicholaos Tsoupas, James Alessi, Donald Barton, Kevin Brown, George Ganetis, Animesh Jain, Yung Lee, Wuzheng Meng, Deepak Raparia, Thomas Roser, Alessandro Ruggiero, Joseph Tuozzolo, Peter Wanderer, Bill Weng (BNL)

The proposed neutrino facility project[Report on the BNL Neutrino Working Group BNL-69395 Informal Report Oct. 2002] to be built at the Brookhaven National Laboratory (BNL) requires that the production target be bombarded by a high intensity beam-pulse of ~90x10**12 protons of 28 GeV of energy and at a repetition frequency of 2.5 Hz, resulting in a 1 MW power beam for the neutrino production. In this paper we investigate the possibility of producing this high intensity proton pulse using the Alternating Gradient Synchrotron (AGS) at the Brookhaven National Laboratory (BNL) as the main accelerator. The following aspects of the prodject have been studied: a) The Injection into the AGS of 1.2 GeV H- beam from a super-conducting LINAC; b) The effect of the eddy currents induced on the vaccum chamber of the circulating beam during the "ramping" of the main magnet. The eddy currents cause heating of the vacumm chamber and introduce magnetic multipoles in the region of the circulating beam. c) The method and the optics of extraction of the 28 GeV protons from the AGS . Results of the study will be presented.

* Work performed under the auspices of the U.S. Dept. of Energy.

TPPB007 Advancement of the RHIC Beam Abort Kicker System

Wu Zhang, L. Ahrens, J. Mi, B. Oerter, J. Sandberg, D. Warburton (BNL)

As one of the most critical system for RHIC operation, the beam abort kicker system has to be highly available, reliable, and stable for the entire operating range. Along with the RHIC commission and operation, consistent efforts have been spend to cope with immediate issues as well as inherited design issues. Major design changes have been implemented to achieve the higher operating voltage, longer high voltage hold-off time, fast re-triggering and redundant triggering, and improved system protection, etc. Recent system test has demonstrated for the first time that both blue ring and yellow ring beam abort systems have achieved more than 24 hours hold off time at desired operating voltage. In this paper, we report on the system status and improvements.

* Work performed under auspieces of U.S. Dept. of Energy.

TPPB008 Final Results on the CERN PS Electrostatic Septa Consolidation Program

Jan Borburgh, Michael Hourican (CERN)

The CERN PS electrostatic septum consolidation program is coming to completion after almost 4 years of development. The program was started to fulfil the increased requirements on vacuum performance and the need to reduce the time necessary for maintenance interventions. The new design of septum 31, used for the so-called 'continuous transfer' 5-turn extraction, and the related construction issues will be presented together with the operational experience gained during the PS 2002 run. In addition, the experience of two years of operation with the new generation septum 23, used for a resonant slow extraction, will be briefly discussed. The continued development undertaken since its installation in the PS ring in 2001 will also be described.

TPPB009 LHC Beam Dumping System: Extraction Channel Layout and Acceptance

Brennan Goddard, Marcel Gyr, Jan Uythoven (CERN)

The LHC beam dumping system must safely abort the LHC beams under all conditions, including those resulting from abnormal behaviour of machine elements or subsystems of the beam dumping system itself. The extraction channels must provide sufficient aperture both for the circulating and extracted beams, over the whole energy range and under various beam parameters. These requirements impose tight constraints on the tolerances of various extraction channel components, and also on the allowed range of beam positions in the region of these components. Operation of the beam dumping system under various fault states has been considered, and the resulting apertures calculated. After describing briefly the beam dumping system and the extraction channel geometry, the various assumptions made in the analysis are presented, before deriving tolerance limits for the relevant equipment and beam parameters.

TPPB010 LHC Beam Dumping System: Failure Scenarios and Reliability Aspects

Jan Uythoven (European Synchrotron Radiation Facility), Ralph Assmann, Etienne Carlier, Johan Dieperink, Brennan Goddard, Marcel Gyr, Rudiger Schmidt, Jorg Wenninger (CERN)

The LHC has been designed to operate at an energy of 7 TeV with a luminosity of 10^{34} $cm^{-2}s^{-1}$. This requires two beams with about 3000 bunches, each bunch with 1011 protons. The energy stored in each beam is about 300 MJ, sufficient to melt 500 kg of copper. Failures in the LHC beam dumping system could lead to substantial damage to equipment in the LHC machine or to the beam dumping system itself, and result in a considerable downtime. Critical failure modes of the beam dumping system and of other related LHC machine systems, which are either most likely to occur or could have a large impact, have been identified and the possible consequences analysed. A method to quantify the required reliability of subsystems is presented, permitting to choose between different technical solutions. Possible measures are discussed to further improve the reliability of the beam dumping system or to reduce the impact of failures.

TPPB011 Design of the Fermilab Recycler Antiproton Transfer Beamlines

David Johnson, G.W. Foster, Cons Gattuso, G.P. Jackson (FNAL)

The permanent magnet Recycler Antiproton Srorage Ring will be used to accumulate up to 2.6E12 antiprotons from the Antiproton Source for use in the Collider Program. Every several hours antiprotons from the Accumulator will be transferred to the Recycler. When a sufficient quantity of antiprotons have been accumulated and cooled, they will be transferred back to the Main Injector for acceleration and injection into the Tevatron. The design of the permanent magnet transfer lines between the Main Injector and Recycler including constraints, ring and beamline optics issues, instrumentation, and installation issues will be discussed.

* Operated by Universities Research Association Inc., under contract with the U.S. Department of Energy.

TPPB012 Performance of Antiproton Injection and Extraction Transfer Lines of the Recycler Ring at Fermilab

Alberto Marchionni, G. William Foster, Consolato Gattuso, Martin Hu, David E. Johnson, Carol J. Johnstone, C. Shekhar Mishra, Mike Syphers, Ming-Jen Yang (FNAL)

The Recycler Ring, an 8 GeV antiproton accumulator, is being commissioned at Fermilab. Antiproton transfers in and out of the Recycler Ring take place through two transfer lines connecting the Recycler to the Main Injector. Measurements of the optics of the lines will be presented. Lattice matching, size of injection transverse coupling and emittance dilution will be addressed. Procedures and performance of antiproton transfers will be reviewed.

TPPB013 Initial Operation of the Fermilab MiniBooNE Beamline

Craig Moore, John Anderson, Robert Ducar, Richard Ford, Thomas Kobilarcik, Eric Prebys, Allison Russell, Raymond Stefanski (FNAL), Jocelyn Monroe (Columbia University)

The MiniBooNE neutrino experiment is projected to take more intensity in a single year than was delivered during the seventeen years of running the Fixed Target Program. The experiment will require almost continuous running (18,000 pulses/hour) at full intensity (5E12 protons per pulse). In order to safely handle this intensity various measures have been instituted. The design of the beamline ensures sufficient clearance between the beam and apertures. A MiniBooNE Beam Permit System has been installed that is able to check various digital and analogue information against nominal values on a pulse by pulse basis. An automated total beam loss monitoring system (electronic berm) measures any beam loss between the beginning and end of the line An automated correction system (Autotune) finds and corrects minor beam wandering. A description of the beamline design and relevant instrumentation is given.

* Work supported by the U.S. Department of Energy under contract No. DE-AC02-76CH03000.

TPPB014 Pbar Production Target Performance in Collider Run II

James Morgan (FNAL)

During Collider Run II at Fermilab, the pbar production target has experienced a significant increase in primary beam brightness. Primary

beam intensities have been increased 50% over those experienced in Run I, while simultaneously the RMS beam size has been reduced by about 20% in each transverse plane. The combination of increased intensity and reduced spot size has resulted in a factor of two increase in the peak energy deposition in the target, to at least 1,000 J/g. Targets are subjected to large mechanical stresses and sustain damage after repeated beam pulses. Improvements in beamline optics to reduce the RMS beam size and continued increases in beam intensity on target are expected over the course of Run II, pushing the peak energy deposition even higher. Summaries of the evolution of target materials, antiproton yield dependence on beam size and antiproton yield reduction resulting from target damage will be provided. Recent experiences with Inconel alloy targets will also be included.

* Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy.

TPPB015 Coupling in the Fermilab Recycler Lambertson Magnet

Ming-Jen Yang, Alberto Marchionni (FNAL)

A unique feature in the design of the Fermilab Recycler Ring and the two associated transfer lines is the extensive use of combined function magnets which made use of permanently magnetized bricks. As part of the Recycler Project, Lambertson magnets made with magnetized bricks were installed for the injection and extraction of antiproton beam to and from the Fermilab Main Injector. During the commissioning it was realized that a substantial amount of coupling was present in the field region of the Lambertson magnet. This write-up describes the observation of coupling effect and the result of subsequent attemp to correct the coupling by using permanent magnet skew quadrupoles.

TPPB016 Highly Efficient Crystal Deflector for Channeling Extraction of a Proton Beam from Accelerators

Vincenzo Guidi (INFN), Walter Scandale (CERN), Valery Biryukov, Yuri Chesnokov, Vladilen Kotov (Institute of High Energy Physics, Protvino), Cesare Malagu, Giuliano Martinelli, Marco Stefancich, Donato Vincenzi (University of Ferrara)

The design and performance of a novel crystal deflector for proton beams are reported. A silicon crystal was used to channel and extract 70 GeV protons from the U-70 accelerator in Protvino with an efficiency of (85.3-2.8)%, as measured for a beam of about 10^12 protons directed towards crystals of ~2 mm length in spills of ~2 s duration. Experimental data agree with the theoretically predicted Monte Carlo results for channeling. The technique allows one to manufacture a very short deflector along the beam direction (2 mm). Thanks to that, multiple encounters of circulating particles with the crystal are possible with little probability of multiple scattering and nuclear interactions per encounter. Thus, drastic increase in efficiency for particle extraction out of the accelerator was attained. We show the characteristics of the crystal-deflector and the technology behind it. Such an achievement is important in devising a more efficient use of the U-70 accelerator and provides crucial support for implementing crystal-assisted slow extraction and collimation in other machines, such as the Tevatron, RHIC, the AGS, the SNS, COSY, and the LHC.

TPPB017 DAFNE Beam Test Facility Commissioning

Giovanni Mazzitelli, Andrea Ghigo, Miro A. Preger, Fernando Sannibale, Paolo Valente, Gaetano Vignola (INFN)

The DAFNE Beam Test Facility (BTF) is a beam transfer line optimized to produce single electrons and positrons mainly for high-energy detectors calibration in the energy range between 40 and 750 MeV. The BTF has been successfully commissioned in February 2002 and started to deliver beam to the users in November. The scheme of operation, the commissioning results as well as the first users' experience are presented.

TPPB018 Fabrication of MEBT Chopper for the SNS

Robert Hardekopf, Sergey Kurennoy, Subrata Nath, John Power, Ray Roybal, Dale Schrage (LANL)

Los Alamos completed design, fabrication, procurement, and initial testing (without beam) of the SNS medium-energy beam-transport (MEBT) chopper, including the meander-line traveling-wave structure and the electrical-pulser system. This report reviews the choice of design parameters and discusses the fabrication process for the chopper structures, including measurements of the impedance and rise time. (The MEBT vacuum system and chopper-target beam stop were developed at and reported by LBNL.) We discuss the specifications for the pulser and its fabrication and testing at Directed Energy, Inc. of Boulder, CO. Finally, we describe simulations that predict the beam behavior under several operational modes for the MEBT chopper and its complementary low-energy beam-transport (LEBT) chopper, designed and built by LBNL. Experimental tests of the chopper system are currently being performed at the SNS site at ORNL and will be reported separately.

* Work supported by the Office of Science of the US Department of Energy

TPPB019 The Mechanical Design of a Proton Microscope for Radiography at 800 MeV

Andrew Jason, David Barlow, Barbara Blind, Camilo Espinoza, John Gomez, Andrew Jason, Thomas Mottershead, Floyd Sigler (LANL)

A proton microscope has been developed for radiography applications using the 800-MeV linear accelerator at the Los Alamos Neutron Science Center (LANSCE). The microscope provides a magnified image of a static device or of a dynamic event such as a high-speed projectile impacting a target. The microscope assembly consists primarily of four Permanent-Magnet Quadrupoles that are supported on moveable platforms. The platform supports, along with the rest of the support structure, are designed to withstand the residual dynamic loads that are expected from the dynamic tests. This paper covers the mechanical design of the microscope assembly, including the remote positioning system that allows fine-tuning the focus of an object being imaged.

* Work supported by the U.S. Department of Energy under contract W7405-ENG-36.

TPPB020 The Mechanical Design of a Proton Microscope for Radiography at 800 MeV

Robert Valdiviez, David Barlow, Barbara Blind, Camilo Espinoza, John Gomez, Andy Jason, Tom Mottershead, Floyd Sigler (LANL)

A proton microscope has been developed for radiography applications using the 800 MeV linear accelerator at the Los Alamos Neutron Science Center (LANSCE). The microscope provides a magnified image of a static device, or of a dynamic event such as a high-speed projectile impacting a target. The microscope assembly consists primarily of four Permanent Magnet Quadrupoles (PMQ's) that are supported on movable platforms. The platform supports, along with the rest of the support structure, are designed to withstand the residual dynamic loads that are expected from the dynamic tests. This paper covers the mechanical design of the microscope assembly, including the remote positioning system that allows for fine-tuning the focus of an object being imaged.

* Work sponsored by the US DOE/NNSA.

TPPB021 Resonance Behavior of Particles in Synchrotron at a Slow Extraction Process

Yuriy Bashmakov (MEPhI), Vladislav Karpov (P.N. Lebedev Physical Institute)

Technique and results of the computer simulation of process electron beam extraction from the Synchrotron "Pakhra" are presented. Electrons can be extracted from the Synchrotron at energy in the range 200 – 850 MeV. The extraction procedure is based on the excitation of the horizontal betatron oscillations on a fourth order nonlinear resonance. Required resonant conditions are fulfilled by two pole face windings. The gradient winding brings the index of the magnetic field from the working value 0.51 to resonant one 0.63. The necessary third azimuthal harmonic of the cubic nonlinearity of the magnetic field is forming by the octupole winding. The extraction system of the synchrotron "Pakhra" contains two pulsed septum magnets. They are located inside the synchrotron vacuum chamber. Analysis of electrons trajectories was performed in phase space at septum magnets azimuths. Dependences of the betatron amplitudes resonance growth were obtained. The method of the optimal tuning of the slow extraction system was developed. The proper position and alignment of septum magnets were found.

TPPB022 Particle Dynamics in Crystal Horn

Yuriy Bashmakov (P.N. Lebedev Physical Institute)

Crystal horn was suggested for focusing of secondary particles – neutrino parents. It may be used for neutrino beam formation. Crystal horn consists of a set of bent crystals which are placed axially symmetrically according to the primary beam axis. A portion of particles with small angular spread is captured into each crystal. At constant curvature radius of the crystals its length is increased with the distance from the beam axis increasing. It provides focusing of secondary particles outgoing from the target. Particle dynamics in such horn is investigated. Angular and momentum acceptance is estimated.

TPPB023 Ionization Cross-Sections in Ion-Atom Collisions for High Energy Ion Beams

Igor Kaganovich, Ronald C. Davidson, Larry Grisham, Dennis Mueller, Edward A. Startsev (Princeton University), Vladimir Horvat, Yong Peng, Rand L. Watson, Konstatine E. Zaharakis (Cyclotron Institute, Texas A&M University)

Knowledge of ion-atom ionization cross-sections is of great importance for many accelerator applications. Ion beams lose electrons when passing through a background gas in accelerators, beam transport lines, and target chambers. As a result of an increase in the ion charge, the ion confinement time and beam focusability are decreased. An unwanted electron population, produced in ion-atom collisions, may also lead to the development of collective two-stream instabilities. Therefore, it is important to assess the rate at which the charge state of the incident beam ions evolves and electrons are produced. The Born approximation and classical trajectory calculations are frequently used to estimate the cross-sections. Neither approximation is expected to be valid over the entire range of projectile ions and target atoms. Aspects of both models must be included in the other in order to address the shortcomings in the underlying assumptions. We have investigated theoretically and experimentally the stripping of 3.4 Mev/amu Kr^{+7} and Xe^{+11} in N_2 ; 10.2 MeV/amu Ar^{+6}; 19 MeV/amu Ar^{+8}; 30 MeV He^{+}; and 38 MeV/amu N^{+6}, all in He, N_2, Ar and Xe. Both the Born approximation and the classical trajectory calculation give very good estimates, except for the case of Xe. The good agreement between experiment and the classical trajectory calculations suggests that tunneling transitions do not provide a major contribution to the cross-section. This is not expected to be the case for ionized target atoms and/or low ionization potentials of the projectile ions. New experiments are proposed to further validate the theoretical predictions.

* Research supported by the US. Department of Energy and the Robert A. Welch Foundation.

TPPB024 A Proposal for an Additional Beamline to the TRIUMF ISAC Facility

Glen Stinson, Pierre Bricault (TRIUMF)

The present ISAC facility at TRIUMF is fed by one beamline, beamline 2A, that can direct beam to one of two target locations. One of these targets has been in use since ISAC was commissioned; the second is currently being installed. The number of proposals for experiments at ISAC are such that we feel the need to deliver more simultaneous radioactive ion beams. A proposal has been made for an additional beamline to ISAC so as to make additional beams available. Through partial extraction by H^- stripping, this proposed line would extract a 400-500 MeV beam from extraction port 4 of the TRIUMF cyclotron. A fast switching system would be used to feed an additional two targets and mass analyzing systems. These new target stations will allow at least three simultaneous experiments at ISAC. This paper presents details of the plan of such a line and of how this new line would interface with the ISAC facility.

TPPB025 Electro-Mechanical Design for Injection in the University of Maryland Electron Ring

Mark Walter, S. Bernal, T. Godlove, I. Haber, R. Kishek, H. Li, P. O'Shea, B. Quinn, M. Reiser, A. Valfells, Y. Zou (University of Maryland)

Closure of the University of Maryland Electron Ring (UMER) is anticipated in May 2003. An initial prototype of the injection "Y" has been completed. Electro-mechanical aspects of the design and test results of this prototype are to be presented. The design incorporates an offset quadrupole and a pulsed dipole to achieve the 10-degree bend required from the injection line. To accommodate penetration of the pulsed dipole magnetic field a glass gap has been inserted at the point of injection. A fixture was used to align the sections of the assembly and serves as a permanent mount plate. A similar method will be used for extraction of the beam after the electron ring has been closed.

* This work is funded by US Dept. of Energy grant numbers DE-FG02-94ER40855 and DE-FG02-92ER54178.

TPPB026 Operation of the CTIMI, RDS Eclipse, 11MeV, H-, N=4, Cyclotron with a 2 Dee h=4 RF System and a Variable 2 to 4 Dee Tip Central Region

James Bailey (CTI Molecular Imaging, Inc.), Sigmund W. Mosko (Consultant)

Taking advantage of the existing 4 dee h=4 RF coupling structure, and an extension of the RF shorting plane travel, a modified h=4 2 dee RF accelerating structure has been installed and operated in a CTI Molecular Imaging, RDS Eclipse. The "Spider" type RF coupling structure, and operation of the 2 dee RF system in 4th harmonic, allows installation of accelerating electrodes in all 4 valleys, with or without dees. The extra electrodes provide the increased energy gain, stronger vertical focusing, and necessary beam steering available in the 4 dee central region. New dee tip shaped electrodes have been built, and the RF dee stem, shorting plane, and coupling Line have been modified to allow greater shorting plane travel to keep the resonant frequency at the isochronous frequency.

TPPB027 Beam Optics Design on a New Injection Scheme for the University of Maryland Electron Ring (UMER)

Hui Li, Sandiago Bernal, Terry Godlove, Rami Kishek, Patrick O'Shea, Martin Reiser, Mark Walter (University of Maryland)

A new optics design for beam injection into the University of Maryland Electron Ring (UMER) is proposed for multi-turn operation. We review the traditional method where two pulsed and physically overlapped Panofsky quadrupoles (one is centered on the injector and the other is centered on the ring) are employed. The new design with only a DC quadrupole reduces both the mechanical and electrical complexities. The DC quadrupole is located symmetrically relative to the injector (+10deg) and the ring (-10deg). Its field properties along the beam trajectory are analyzed for this scheme. The beam centroid motion as well as space-charge-dominated beam matching is studied to evaluate the new design. Some relevant beam dynamics issues are also discussed for the multi-turn operations.

* Research supported by the U.S. Department of Energy.

TPPB028 The Beam Extraction of the PoP FFAG with a Massless Septum

Yujiro Yonemura, Masamitsu Aiba, Shinji Machida, Yoshiharu Mori, Atsutoshi Muto, Joe Nakano, Chihiro Ohmori, Izumi Sakai, Yasuo Sato, Masahiro Sugaya, Akira Takagi, Tomonori Uesugi, Akiyoshi Yamazaki, Takeichiro Yokoi, Masahiro Yoshimoto, Yoshimasa Yuasa (KEK), Masaru Matoba (Kyushu University)

When the repetition rate of a FFAG synchrotron is increased, the beam extraction of a FFAG becomes difficult because it requires high repetition kickers. We propose a new extraction scheme with a massless septum, with which the DC beam can be extracted. The system consists of a combination of massless and ordinary septa, but with no kickers. A beam after passing through the massless septum develops the beam tail gradually, that can be scraped with an ordinary septum. We optimize the location of these septa to increase extraction efficiency. The simulation result indicated the beam was stably extracted with an efficiency of more than 93%.

TPPB029 Heavy Ion Beams in the LHC

John Jowett (BESSY)

In addition to protons, the LHC will collide beams of heavy ions. The beam intensity in the LHC ring is tightly constrained from below by beam instrumentation (visibility on the beam position monitors in particular) and from above by magnet quench limits, the capabilities of the injectors and beam lifetime. We summarise current plans for beams of lead ions with emphasis on beam dynamics issues, commissioning strategies and the differences from operation with protons.

TPPB030 Abort Gap Studies and Cleaning during RHIC Heavy Ion Operation

Angelika Drees, Leif Ahrens, Ray Fliller, Wenge Fu (BNL), Verena Kain (CERN)

Since the RHIC Au-Au run in the year 2001 the 200 MHz cavity system was used at storage and a 28 MHz system during injection and acceleration.The rebucketing procedure causes significant debunching of heavy ion beams in addition to amplifying debunching due to other mechanisms. At the end of a four hour store, debunched beam can account for more than 30% of the total beam intensity.In order to minimize the risk of magnet quenching due to uncontrolled beam losses at the time of a beam dump, a combination of a fast transverse kicker and copper collimators were used to clean the abort gap. This report gives an overview of the upgraded gap cleaning procedure, the achieved performance and summarizes future plans. The upgraded procedure in conjunction with a new application allow to measure properties of the debunched beam routinely. We compare the acquired data with simulation calculations.

* Work performed under the auspices of the US Department of Energy.

TPPB031 Luminosity Monitoring at RHIC with Various Species

Angelika Drees, Nicolas Kling (BNL)

While all five RHIC experiments have various different detectors for triggering purposes, they all have Zero Degree Calorimeters (ZDC) installed which act as a minimum bias trigger as well as luminosity monitors to RHIC. The ZDCs have been in use since the year 2000 run and were operated under various beam conditions, cross sections and particle species. The cross section of interest, the mutual forward neutron emission, varies significantly when RHIC is operated with Gold-Gold, Gold-Deuteron or polarized proton beams. We will report on the performance of the detectors under the varying conditions in the past runs and compare their performance with those of other collision detectors.

* Work performed under the auspices of the US Department of Energy.

TPPB032 Results from Vernier Scans at RHIC during Runs 2000-2003

Angelika Drees, Zhangbu Xu (BNL), Haibin Huang (Yale University)

Using the Vernier Scan or Van der Meer Scan technique, where one beam is swept stepwise across the other while measuring the collision rate as a function of beam displacement, the transverse beam profiles, the luminosity and the cross section can be measured. Data and results from the different runs, including Gold-Gold collisions at two energies, polarized protons and Deuteron-Gold collisions, are presented and discussed.

* Work performed under the auspices of the US Department of Energy.

TPPB033 Experimental Background at RHIC

Angelika Drees, Raymond Fliller (BNL)

The experiments at RHIC face very different background conditions depending on the particle type, beam intensity and the local optics (beta*). Additional shielding has been installed at various places to prevent beam induced detector trips or background contaminated data. Several different types of background monitoring is in place at the experimental interaction regions. Transverse primary collimators are used in both rings to protect accelerator equipment as well as experiments. A crystal collimator forms a two stage collimation system in one ring. Experimental background was studied in dedicated experiments and is routinely monitored during RHIC operation. The existing collimation and monitoring system is presented and data from dedicated experiments as well as routine operation is shown and discussed.

* Work performed under the auspices of the US Department of Energy.

TPPB034 New Results from Crystal Collimation at RHIC

Raymond Fliller III, Angelika Drees, David Gassner, Lee Hammons, Gary McIntyre, Stephen Peggs, Dejan Trbojevic (BNL), Valery Biryukov, Yuriy Chesnokov, Viktor Terekov (Institute of High Energy Physics, Protvino)

In this paper, we discuss new results from the use of the crystal collimator from the 2003 run. The yellow ring of the Relativistic Heavy Ion Collider (RHIC) has a bent crystal collimator. By properly aligning the crystal to the beam halo, particles entering the crystal are deflected away from the beam and intercepted downstream in a copper scraper. The purpose of a bent crystal is to improve the collimation efficiency as compared to a scraper alone. We compare these results to previous data, simulation, and theoretical predictions.

* Work preformed under the auspices of the U.S. Dept. of Energy.

TPPB035 Commissioning of a First-Order Transition Jump in RHIC

Jorg Kewisch, Christoph Montag (BNL)

When accelerating gold ions in the Relativistic Heavy Ion Collider (RHIC) the transition energy must be crossed. RHIC uses a set of special quadrupoles and power supplies which can revese polarity in less than 40 milliseconds. These quadrupoles are used to produce dispersion bumps which increase the transition energy as the beam approaches transition. The change of polarity will then jump the transition enrgy across the beam energy. This paper describes the commissioning of the RHIC transition crossing system.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

TPPB036 Modeling the Helical Snake: Orbit and Spin Tracking

Alfredo Luccio, W.W. MacKay, N. Tsoupas (BNL)

For polarized proton runs, we use helical Siberian Snakes and spin rotators in RHIC and a strong helical partial snake has been proposed for the AGS. Issues of modeling and of orbit and spin tracking in these magnets will be discussed. Results are presented mainly for the new AGS snake, that has proved a very challenging device to be designed and optimized. Orbit and spin transfer maps, as well as a study of the multipole content of the field are presented. The AGS helical snake shows a substantial coupling and focusing in both transverse planes. Means to decrease both effects are discussed.

* Work Supported by the US Department of Energy.

TPPB037 Tracking in the AGS with the BNL-Orbit Code

Alfredo Luccio, N.L. D'Imperio (BNL)

The fully 6-Dimensional PIC tracking code BNL-Orbit has been used to simulate the AGS proton synchrotron. The code is running on a parallel computer. Issues of space charge simulation, self-consistency of the representation of the beam in its space and time reference are discussed. Results for the AGS, in particular during injection and extraction processes are presented, to be used to understand the limits of the accelerator to achieve very high intensities.

* Work performed under the auspices of the US Department of Energy.

TPPB038 Commissioning Spin Rotators in RHIC

William Mackay, Leif Ahrens, Mei Bai, Ernest D. Courant, Joseph W. Glenn, Haixin Huang, Alfredo U. Luccio, Vadim Ptitsyn, Thomas Roser, Todd Satogata, Nicholaos Tsoupas (BNL)

During the summer of 2002, eight superconducting helical spin rotators were installed into RHIC in order to control the polarization directions independently at the STAR and PHENIX experiments. Without the rotators, the orientation of polarization at the interaction points would only be vertical. With four rotators around each of the two experiments, we can rotate either or both beams from vertical into the horizontal plane through the interaction region and then back to vertical on the other side. This allows independent control for each beam with vertical, longitudinal, or radial polarization at the experiment. In this paper, we present results from the first run using the new spin rotators.

* This work was performed under the auspices of the US DOE and RIKEN of Japan.

TPPB039 Design of a Fast Chromaticity Jump in RHIC

Christoph Montag, Donald Bruno, George Ganetis, Joerg Kewisch, Wing Louie (BNL)

During transition crossing in the Relativistic Heavy Ion Collider (RHIC), chromaticities have to change sign. This sign change is partially accomplished by the γ_t quadrupole jump; however, the resulting chromaticity jump is only Delta xi_x = 2.1 in the horizontal and Delta xi_y=2.4 in the vertical plane. To increase the jump height, a dedicated chromaticity jump scheme has been designed, consisting of fast power supplies connected to six sextupoles per ring, which is capable of providing a chromaticity jump of Delta xi=6.

* Work performed under the auspices of the US Department of Energy.

TPPB040 Intense Neutrino Sources

Zohreh Parsa (BNL)

A discussion of 1 MW future proton sources and their utility for generating neutrino beams is given. Superbeam requirements for neutrino oscillation studies are described. Future possibilities for an intense muon storage ring – neutrino factory are outlined. A specific upgrade path for the AGS at BNL is used as an illustrative scenario.

* Work supported by the U.S. Department of Energy under contract Number~DE-AC02-98CH10886.

TPPB041 Nonlinear Effects in the RHIC Interaction Regions: Modeling, Measurement, Correction

Fulvia Pilat, Peter Cameron, Vadim Ptitsyn (BNL), Jean-Pierre Koutchouk (CERN)

A technique for measuring and correcting locally nonlinear effects arising from field errors and feed-down from the interaction region (IR) triplets has been developed at RHIC [F. Pilat, P. Cameron, V. Ptitsyn, J-P. Koutchouck, "Linear and Nonlinear corrections in the RHIC Interaction regions, EPAC 2002]. After a brief review of the method and a discussion of the associated systematics, we will compare measurements taken with different IR optics configurations, with beta at the interaction point ranging from 10 to 1m. The beam data are compared with results from a realistic RHIC model, that includes measured field and alignment errors in the magnets, and simulates operational effects and corrections. A control room application has been developed for the RHIC run 2003 that allows faster measurements of nonlinear effects, online plotting and fitting of nonlinear terms from measurements of tune shift as a function of bump amplitude. Results for local nonlinear correction during run 2003 are presented and compared to RHIC run 2001. Work performed under the auspices of the US Department of Energy.

* Work supported by the U.S. Department of Energy under contract Number~DE-AC02-98CH10886.

TPPB042 Linear Optics Measurement and Correction in the RHIC 2003 Run

Todd Satogata, Javier Cardona, Fulvia Pilat, Vadim Ptitsyn, Steve Tepikian, Johannes van Zeijts (BNL)

The RHIC 2003 deuteron-gold (dAu) and polarized proton (pp) runs used different approaches to low-beta optics configuration. The dAu run squeezes low-beta while ramping to optimize transition parameters, then unsqueezes non-experimental interaction points (IPs) while squeezing experimental IPs to beta*=2m. The polarized proton run maintains high-beta optics through the acceleration ramp and squeezes experimental IPs with a separate top-energy ramp. This paper summarizes measurements and corrections for low-beta optics in these runs, including efforts to minimize dispersion leakage and balance colliding beam sizes at experimental IPs.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

TPPB043 Commissioning of RHIC Deuteron-Gold Collisions

Todd Satogata, Leif Ahrens, Mei Bai, Joanne Beebe-Wang, Michael Blaskiewicz, Michael J. Brennan, Kevin A. Brown, Don Bruno, Peter Cameron, Javier Cardona, Roger Connolly, Angelika Drees, Wolfram Fischer, Raymond P. Fliller, George Ganetis, Christopher Gardner, J. Woody Glenn, Harald Hahn, Tom Hayes, Haixin Huang, Ubaldo Iriso-Ariz, William W. MacKay, Al Marusic, Christoph Montag, Fulvia

Pilat, Vadim Ptitsyn, Thomas Roser, Kevin Smith, Steve Tepikian, Dejan Trbojevic, Nick Tsoupas, S.Y. Zhang, Johannes van Zeijts (BNL)

Deuteron and gold beams have been accelerated to a collision energy of 100 GeV/u in the Relativistic Heavy Ion Collider (RHIC), providing the first asymmetric species collisions of this complex. Essential system changes for this mode of operation include new ramping software, asymmetric crossing angle geometries, PLL-based tune feedback during acceleration, and strict limits on collision geometry to avoid magnet quenches. This paper reviews machine performance and accomplishments during the 16 weeks of ramp-up and operations in this run configuration.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

TPPB044 Concept Design of the Target/Horn System for the BNL Neutrino Oscillation Experiment

Nicholas Simos (BNL)

This paper describes the design concept for the integration of the target and the focusing horn system for the proposed BNL neutrino oscillation experiment. It specifically addresses the functionality and thermo-mechanical response of the selected target intercepting the 28 GeV protons of the 1 MW upgraded AGS beam, the loading and mechanical response of the focusing horn subjected to high currents and energy deposited due to beam/target interaction, the integration of the two systems, and the heat removal schemes. The baseline design calls for a low Z target made from a special carbon-carbon composite that exhibits low thermal expansions, and consequently low levels of dynamic strain, due to beam energy deposition in the range of interest of operating temperatures and thus extending the target operating life. The target intercepts the 1x1014, 28 GeV protons with a 2.5 Hz cycle time over a spot that encloses the 3-σ of the beam. Issues addressed in detail are the long-term survivability of such target and the optimization of the heat removal. The focusing horn is made of an aluminum alloy chosen for good mechanical strength and relatively low resistivity. In the baseline design the inner horn conductor encloses the target while allowing for an annular space for forced cooling. Approximately 240 kA of current will flow through the horn at 2.5 Hz inducing high compressive forces, vibration and heat. The paper addresses these issues of horn mechanical response, heat removal scenario, and useful life estimation including radiation damage.

* Work performed under the auspices of the U.S. Dept. of Energy.

TPPB045 High Luminosity RHIC Insertions, 0.5m Beta at IP

Steven Tepikian, Haixin Huang, William W. MacKay, Fulvia C. Pilat, Vadim Ptitsyn, Todd Satogata, Dejan Trbojevic, Johannes van Zeijts (BNL)

An increase in RHIC collision luminosity is possible by reducing the beam size at the interaction point (IP). We present a method for reducing the IP beta function beta* from the design minimum of 1m to 0.5m, and demonstrate that this beta*=0.5m configuration is achievable with existing RHIC power supplies for 100 GeV protons. Dynamic aperture studies are presented, as are corrector schemes to maintain beam stability. We also report on results of planned beam studies during the 2003 polarized proton RHIC run.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

TPPB046 RHIC Run-away Type Pressure Rise

S.Y. Zhang (BNL)

In 2001 RHIC gold run, two types of pressure rise were identified. The first one looked like electron multipacting induced pressure rise, which was approaching a saturation, and the rise rate was below a few decades per minute. This type of pressure rise is presently limiting the beam intensity, and several cures are being pursued. The second type of pressure rise was much more violent, the rise rate was around 20 decades per minutes. Also, it was not approaching saturation, and in the run-away, or pressure instability type. This type of pressure rise occurs less often, and it was never being observed in proton run. It is of interest to understand the run-away type of pressure rise, because that it interferes with operation, and also it has a potential to make damage through the possible quench.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

TPPB047 The RHIC Injector Accelerators Configurations and Performance for the RHIC 2003 Au-d Physics Run

Leif Ahrens, J. Alessi, J. Benjamin, M. Blaskiewicz, J.M. Brennan, K.A. Brown, C. Carlson, T. D'Ottavio, J. DeLong, C.J. Gardner, J.W. Glenn, M. Harvey, T. Hayes, H-C Hseuh, D. Lowenstein, W.W. MacKay, J. Morris, T. Roser, T. Satogata, G. Smith, K.S. Smith, D. Steski, P. Thieberger, N. Tsoupas, K. Zeno, S.Y. Zhang (BNL)

The RHIC 2003 Physics Run required collisions between gold and deuteron ions. The injector had to deliver adequate quality (transverse and longitudinal emittance) and quantity of both species to meet luminosity requirements. For gold this was a continuing evolution from past work. For deuterons it was new territory. To fill both RHIC rings the injector had to switch between the two species quickly - to minimize the overall filling time - while maintaining the quality of the beams delivered. This paper will detail the collider requirements and our success in meeting them. Some details of the configurations employed will be given.

* Work supported by the U.S. Department of Energy.

TPPB048 Ramp Design and Implementation for the RHIC d/Au Run

Johannes van Zeijts (BNL)

For the RHIC deuteron on gold run injection is at the same Brho, and at storage the beams have the same relativistic Gamma. The required changes in the ramping system, which now allows specification of Brho vs. time independently for each ring, are described. The unequal species result in a non-zero common angle at the IP at storage, due to power-supply limitations the crossing angle has to change up the ramp. We describe how this is achieved. Injection is at beta* = 10m, in order to get the best transition crossing we need beta* = 5m at all IP's, at storage we want beta* = 2 m at the experimental IP's and beta* = 10m at the remaining IP's. We describe how to beta* squeeze is implemented. Finally we address the agreement between measurement and model.

* Work performed under the auspices of the U.S. Department of Energy contract #DE-AC02-76CH00016.

TPPB049 On-Line Longitudinal Optics Calculations for RHIC

Johannes van Zeijts, J.M. Brennan, Tuong Le (BNL)

We describe the on-line system to model RF parameters for RHIC, and machines in the RHIC injection complex. The system allows to input modeled or measured RF Voltage and Phases for single and dual RF systems, and integrates with the Wall Current Monitor system to retrieve measured longitudinal profiles. The resulting parameters at injection, across transition, and for rebucketing will be shown.

* Work performed under the auspices of the U.S. Department of Energy contract #DE-AC02-76CH00016.

TPPB050 The LHC Proton Beam in the CERN SPS: An Update

Gianluigi Arduini, Philippe Baudrenghien, Thomas Bohl, Paul Collier, Karel Cornelis, Wolfgang Hofle, Trevor Linnecar, Elena

Shaposhnikova, Joachim Tuckmantel, Jorg Wenninger (CERN)

During the 2001 run the beam-induced electron-cloud, generating dramatic vacuum pressure increases and fast transverse instabilities, was a severe limitation to the LHC beam intensity in the SPS. As a result only half the nominal bunch intensity in a single batch (instead of four as required) could be accelerated. In addition, even at this low intensity the beam was unstable longitudinally at top energy. In 2002 the threshold for the onset of the electron cloud in the arcs could be increased from 0.4 x 10^11 p/bunch to 0.9 x 10^11 p/bunch by means of a dedicated 10-day 'scrubbing' run with the LHC beam. At the end of this period four LHC batches with design intensity (1.1 x 10^11 p/bunch) could be injected for each SPS cycle as foreseen for the nominal filling scenario. After a series of machine development sessions and hardware upgrades, the LHC beam with nominal intensity could be accelerated to top energy with nominal longitudinal emittance and with transverse emittances close to the design values for the first three batches. The problems encountered with this high brilliance beam and the solutions developed are discussed.

TPPB051 A Two-Stage Collimation System with Ultimate Robustness for Multi-TeV Proton Colliders

Ralph Assmann (CERN)

The luminosity requirements of multi-TeV proton colliders push the stored beam intensity to unprecedented high levels. At the same time the spot size shrinks adiabaticely with energy. It then becomes very challenging to design, construct, and operate a collimation systems that survives the high transverse energy density of the beam, while both protecting the machine against damage and cleaning the beam halo with the required efficiency. Conventionally a two-stage collimation system with special phase advance conditions is employed. The operation of such a system, like foreseen for the LHC, imposes tight constraints on the beam behavior. It is discussed how the operational robustness of such a system can be greatly enhanced by putting additional primary collimators. A conventional two-stage collimation system with ultimate robustness is discussed.

TPPB052 Passive Protection Devices in the Transfer Lines to the LHC

Helmut Burkhardt, Brennan Goddard, Volker Mertens (CERN)

The intensities foreseen for injection into the LHC are roughly 10 000 times above quench and still about 10 times above damage level. The transfer lines will be pulsed. The possible layout and performance of a passive protection system is discussed.

TPPB053 PS 13.3-20 MHz RF Systems for LHC

Michele Morvillo, Roland Garoby, Dennis Grier, Matthias Haase, Achim Krusche, Pierre Maesen, Mauro Paoluzzi, Carlo Rossi (CERN)

As part of the preparation of the PS as an injector for the LHC, a prototype 20 MHz RF system has been used, to demonstrate that the nominal longitudinal performance of the proton beam for LHC can be obtained using multiple bunch-splittings. Based on these successful results obtained during 2000, the development of the operational RF system began in 2001. To allow the preparation of bunch trains with a bunch spacing of 25 or 75 ns, this system must operate either at 20 or 13.3 MHz respectively. Two new ferrite cavities and their associated amplifiers have been designed and built. Each one can provide a maximum voltage of 20 kV peak during 200 ms with a 10% duty cycle. The cavities are equipped with fast (~20 ms) gap shorting relays, and fast RF feedback reduces their Q below 10 at both frequencies. A single system is sufficient to generate the nominal beam for LHC. The second one will then be both a "hot spare" and a very valuable performance enhancement providing the possibility of handling larger than nominal emittances or generating bunch trains with different spacings in the same PS supercycle. The design and the results measured on the final devices are described and discussed.

TPPB054 Present Understanding of Electron Cloud Effects in the Large Hadron Collider

Frank Zimmermann, Gianluigi Arduini, Karel Cornelis, Jose-Miguel Jimenez, Adriana Rossi, Francesco Ruggiero, Daniel Schulte (CERN), Giovanni Rumolo (Gesellschaft für Schwerionenforschung mbH)

We discuss the predicted electron-cloud build up in the arcs and the long straight sections of the LHC, and its possible consequences on heat load, beam stability, long-term emittance preservation, and vacuum. Our predictions are based on computer simulations and analytical estimates, parts of which have been benchmarked against experimental observations at the SPS.

TPPB055 Beam Based and Magnet Based Chromaticity and Tune Measurements in the Tevatron

Pierre Bauer, J. Annala, J. DiMarco, R. Hanft, R. Kephart, M. Lamm, P. Limon, M. Martens, P. Schlabach, V. Shiltsev, D. Still, G. Velev (FNAL), L. Bottura, F. Zimmermann (CERN)

Fermilab's Tevatron, currently in its run II stage, is experiencing significant beam loss during ramping from injection to collision energy. As part of recent efforts to understand and correct the problem, the question was investigated whether the beam loss is related to the snapback or other dynamic effects in magnets which lead to fast changes in the chromaticity and tune of the machine during ramping from injection. Drift and snap-back issues were also discovered recently to occur in the Tevatron tunes. A dedicated magnetic measurement program on Tevatron spare magnets was launched in order to improve the understanding of dynamic effects in Tevatron magnets. The dynamic effects in Tevatron magnets were investigated for different reasons: -1- to understand the issues in superconducting Tevatron magnets, such as temperature effects, effects of magnet to magnet variation, helix effects, -2- to explain certain features in the Tevatron such as transient chromaticities, tune drifts and beam loss and -3- to explore ways to aide the Tevatron operation toward raising integrated luminosity. Recent improvements of the Tevatron were obtained on the basis of this work. Magnets are now better understood, such that ramping protocol changes could be installed, leading to an increase of integrated luminosity over the first few weeks of operation with the new measures in place. Also, the correction of the snapback now uses a new procedure, which was proven to work in the Tevatron in dedicated beam studies. Separate beam based chromaticity and tune measurements further corroborate that the dynamic effects in Tevatron magnets are now better understood. This paper reviews the magnetic and beam-based chromaticity and tune measurements, as well as the recent improvements of Tevatron operation that resulted from this work.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPB056 Backgrounds in the Tevatron Collider Detectors due to Nuclear Elastic Beam-Gas Scattering

Alexandr Drozhdin, Valeri A. Lebedev, Nikolai V. Mokhov, Ludovic Nicolas, Sergei I. Striganov, Alvin Tollestrup (FNAL)

Detailed simulations were performed on beam loss rates in the vicinity of the Tevatron Collider detectors due to beam-gas nuclear elastic interactions. It turns out that this component, not intercepted by the Tevatron collimation system, can drive the accelerator-related background rates in the Collider detectors, exceeding those due to outscattering from collimator jaws, inelastic beam-gas interactions and other processes. Results of realistic simulations with the STRUCT and MARS codes are presented for the interaction region components,

forward proton detectors and CDF sub-detectors. It is shown that a 0.5-m long mask in the Roman Pot station region can reduce the background rates in the CDF by almost an order of magnitude.

* Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPB057 Local Decoupling of the Tevatron Interaction Regions

Bela Erdelyi, Jerry Annala, Bruce Hanna, Mike Martens, Tanaji Sen (FNAL), Fulvia Pilat, Vadim Ptitsyn (BNL), Frank Schmidt (CERN)

Linear transverse coupling in the interaction region quadrupoles has a detrimental effect on the luminosity. At the Tevatron, survey data taken over years suggest that magnet rolls are changing with time. These surveys however are expensive in time and manpower. We have developed a beam-based method that calculates the roll angles of the triplet quadrupoles using local closed orbit bumps and the corresponding BPM readings. The present paper describes the experimental method, the analysis of the data, its implementation in Mathematica and comparison with survey data.

* Work supported by the US Department of Energy under contract no DE-AC02-76CH03000.

TPPB058 Optics of the NuMI Proton Beamline

John Johnstone (FNAL)

With the high proton intensities proposed for NuMI operations, the strict beam-loss limits imposed on beam transport requires small beam sizes, a resilience to error sources, and precise trajectory control throughout the line. The FODO optics of the main body of the line are designed such that the entire 500pi admittance of the Main Injector at 120 GeV/c can be transported without losses in the event of Injector acceleration errors. Six final-focusing quadrupoles provide for flexible tuning of the beam at the target, making it possible to maintain the desired beam spot size over a wide range of conceivable Main Injector extracted beam parameters.

* Work supported by the US Department of Eneregy under contract no DE-AC02-76CH03000.

TPPB059 Tevatron Lattice Upgrades

John Johnstone, Yuri Alexahin, Norm Gelfand, Bruce Hanna, Valeri Lebedev, Mike Martens, Leo Michelotti, Tanaji Sen, Mike Syphers, Aimin Xiao, Meiqin Xiao (FNAL)

Luminosity in the Tevatron during Run II is enhanced through modest modifications to the collider lattice. Replacement of the C0 straight secion lambertsons enlarges the physical aperture, resulting in reduced beam losses at this bottleneck and the capability of improving p-pbar beam separation throughout the ring. Increased beam separation in the vicinity of A0 is obtained by reverting from the high-beta optics of this region to the optics of a standard Collins straight, thereby improving beam losses and dynamic aperture at injection. Coupling between the transverse planes can be greatly reduced through re-alignment of long sections of known systematically rolled dipoles.

* Work supported by the US Department of Energy under contract no DE-AC02-76CH03000.

TPPB060 Slip Stacking at Fermilab Main Injector

Kiyomi Koba, Jim MacLachlan, Keith Meisner, Jim Steimel (FNAL)

In order to achieve an increase in proton intensity, Fermilab Main Injector will use a stacking process called "slip stacking". The intensity will be doubled by injecting one train of bunches at a slightly lower energy, another at a slightly higher energy, then bringing them together for the final capture. Beam studies have started for this process and we have already verified that, at least for a low beam intensity, the stacking procedure works as expected. For high intensity operation, development work of the feedback and feedforward systems is under way.

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TPPB061 Improvements in Quality of Main Injector to Tevatron Transfers

Valeri Lebedev, Jerry Annala, Dave McGinnis, Vahid Rajbar, Dean Steal (FNAL)

Quality of beam transfers in the Tevatron collider can seriously degrade the collider luminosity. At the beginning of Run II the transfer of antiprotons from Main injector to Tevatron caused significant degradation of the luminosity. Three major constituents contributed to this degradation. They are large angle and position errors at injection, errors in focusing of the beam transport line, and strong coupling at the antiproton. The report presents how these problems were diagnosed and corrected.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPB062 Observations on the Luminosity Lifetimes, Emittance Growth Factors and Intra-Beam Scattering at the Tevatron

Paul Lebrun, Valeri Lebedev, Vladimir Shiltsev (FNAL)

A peaked, record luminosity of 3.6 x 10^{31} has been reached at the Fermilab p - pbar collider. The lifetime of this luminosity at the beginning of the store is about 9 to 10 hours. This lifetime can be explained based on the anticipated loss of antiprotons and protons due to collision and emittance growths. we report on transverse emittance growth rates based on our Synchrotron Light Monitor. Longitudinal emittance measurements are based on the TeV Sample Bunch Display data. It is shown that Intra Beam Scattering is a significant source of emittance growth. We comment on other possible factors for these observed emittance growth rates. Finally, we comment on future luminosity lifetimes, as we hope to further increase our peaked luminosity.

TPPB063 Accelerator Related Backgrounds in the LHC Forward Detectors

Nikolai Mokhov, Alexandr I. Drozhdin, Igor L. Rakhno (FNAL), Daniela Macina (CERN)

Detailed simulations were performed on radiation environment in the LHC IP5 interaction region at the locations of the Roman Pots detectors proposed by the TOTEM Collaboration to detect particles produced at very small angles in the elastic scattering and diffraction dissociation processes at the LHC. These detectors consist of tracking devices placed into special units mounted on the vacuum chamber of the accelerator. Radiation doses and background particle rates at the Roman Pots locations are fundamental inputs to their design. Energy deposition and background particle rates due to both pp-collisions and beam loss in that region were calculated for detector and machine components with a sophisticated MARS/STRUCT model based on the current version 6.4 lattice. Operational beam loss rates in the vicinity of the detectors were studied taking into account realistic vacuum distribution and apertures in the entire machine. Special attention is paid to contribution from beam-gas nuclear elastic and inelastic interactions.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPB064 Mitigation of Effects of Beam-Induced Energy Deposition in the LHC High-Luminosity Interaction Regions

Nikolai Mokhov, James S. Kerby, Igor L. Rakhno, James B. Strait (FNAL)

Beam-induced energy deposition in the LHC high luminosity interaction region components is one of the serious limits for the machine performance. The results of further optimization and comprehensive MARS calculations in the IP1 and IP5 inner and outer triplets are summarized for the updated lattice, calculation model, baseline pp-collision source term, and for realistic engineering constraints on the hardware design. It is shown that the optimized layout and absorbers would provide a sufficient reduction of peak power density and dynamic heat load in the superconducting components with an adequate safety margin. Accumulated dose and residual dose rates in and around the region components are also kept below the tolerable limits in the proposed design.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPB065 Energy Deposition Limits in a Nb3Sn Separation Dipole Placed in Front of the LHC High-Luminosity Inner Triplet

Nikolai Mokhov, Vadim V. Kashikhin, Igor L. Rakhno, James B. Strait, Sunil Yadav, Alexander V. Zlobin (FNAL), Oliver Bruening, Francesco Ruggiero (CERN)

Interaction region inner triplets are among the systems which may limit the LHC performance. One of the interesting options for a new higher luminosity IR design is a double-bore inner triplet with separation dipoles placed in front of the first quadrupole. Radiation loads on such a dipole and first quadrupoles, resulting from colliding beam interactions, are key parameters that will determine the workability of these magnets and the feasibility of this approach in general. Detailed energy deposition calculations with the MARS code were performed for the single-bore and double-bore high-field separation dipoles and downstream double-bore quadrupoles. Results are studied as a function of magnet apertures, operation field, and dipole distance from the interaction point. Calculated peak power densities in the coils are compared with the dipole quench limit at two operation temperatures 1.9K and 4.5K for the magnet based on Nb3Sn superconductor. Possible ways are discussed to reduce peak power densities and dynamic heat loads in the dipole and inner triplet quadrupoles.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPB066 Longitudinal Bunch Dynamics in the Tevatron

Ronald Moore, Valeri Balbekov, Valeri Lebedev, Vladimir Shiltsev, Cheng-Yang Tan (FNAL)

We present our observations of the longitudinal bunch dynamics in Tevatron for uncoalesced proton bunches at 150 GeV and coalesced proton bunches at 150 GeV and 980 GeV. We have observed a weak bunch-to-bunch coupling of uncoalesced protons in the Tevatron that preserves already existing oscillations from upstream acclerators. A single-bunch instability in large intensity protons bunches at 980 GeV has also been observed.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPB067 Beam Losses at Injection Energy and during Acceleration in the Tevatron

Tanaji Sen, Gerald Annala, Paul Lebrun, Ronald Moore, Vladimir Shiltsev, Michael Syphers (FNAL), Wolfram Fischer (BNL), Frank Schmidt, Frank Zimmermann (CERN)

Protons and anti-protons circulate on helical orbits in the Tevatron. At injection energy (150 GeV) the lifetimes of both species are significantly lower on the helical orbits compared to lifetimes on the central orbit but for different reasons. There are also significant beam losses in both beams when they are accelerated to top energy (980 GeV)- again for different reasons. We report on experimental studies to determine the reasons and on methods of improving the lifetimes and losses for both beams.

* Work supported by the US Department of Eneregy under contract no DE-AC02-76CH03000.

TPPB068 Experimental Studies of Beam-Beam Effects in the Tevatron

Tanaji Sen, Yuri Alexahin, Vladimir Shiltsev, Meiqin Xiao, Xiaolong Zhang (FNAL), Frank Schmidt (CERN)

The long-range beam-beam interactions limit the achievable luminosity in the Tevatron. During the past year several studies were peformed on ways of removing the limitations at all stages of the operational cycle. We report here on some of these studies, including the effects of changing the helical orbits at injection and collision, tune and chromaticity scans and coupling due to the beam-beam interactions.

* Work supported by the US Department of Eneregy under contract no DE-AC02-76CH03000.

TPPB069 Theoretical Studies of Beam-Beam Effects in the Tevatron at Collision Energy

Tanaji Sen, Bela Erdelyi, Meiqin Xiao (FNAL)

The dynamics due to the long-range beam-beam interactions depends on several beam parameters such as tunes, coupling, chromaticities, beam separations, intensities and emittances. We have developed analytical tools to calculate, for example, amplitude dependent tune shifts and chromaticities, beam-beam induced coupling, and betatron and synchro-betatron resonance widths. We report on these calculations and dynamic aperture calculations with long-term tracking. These theoretical results are compared with observations at collision energy and used to predict performance at design values of beam intensities and emittances.

* Work supported by the US Department of Eneregy under contract no DE-AC02-76CH03000.

TPPB070 Run II Tevatron Luminosities and Collision Point Sizes

A. Slaughter (FNAL)

The luminosity available for experiments is the ultimate figure of merit for Tevatron operations. In this paper, we compare the luminosities as measured by CDF and D0 with those determined from machine characteristics. We also compare D0 and CDF measurements of the interaction regions to those predicted by machine parameters.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPB071 Store Data Analysis for Run II in the Fermilab Accelerator Complex

A. Slaughter (FNAL)

We describe the store based data acquisition and analysis system being used at Fermilab to understand and monitor the performance of the accelerator complex during Tevatron collider shot setup and stores.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

TPPB072 Correction Magnets for the Fermilab Recycler

James Volk, B.C. Brown, G.W. Foster, C. Gattuso, H.D. Glass, D.E. Johnson, M.J. Yang (FNAL)

In the commissioning of the Fermilab Recycler ring the need for higher order corrector magnets was discovered. Three types of permanent skew quadrupoles and two types of sextupoles were designed and built. One of the types of skew quadrupoles and two types of sextupoles were installed in the machine. This paper describes the need for these magnets, the design, assembly, and the effect they had on the Recycler Ring. Measurement data will be compared with design for the magnets.

* Work supported by the U.S. Department of Energy under contract No. DE-AC02-76CH03000.

TPPB073 Pbar Acceleration in the Fermilab Main Injector Using Both the 2.5 MHz and the 53 MHz RF Systems

Vincent Wu, Chandra Bhat, James MacLachlan (FNAL)

During the Run II era at Fermilab, the Recycler stores antiprotons and the Main Injector accelerates both the antiprotons and the protons for Tevatron injection. The Recycler injects antiprotons to the Main Injector in 2.5 MHz buckets. This paper presents an acceleration scheme for the antiprotons that involves a slow ramp with initial 2.5 MHz acceleration and subsequent fast acceleration with 53 MHz rf system. The beam acceleration and the rf manipulations with space charge and beam loading effects are simulated using the longitudinal simulation code ESME. The simulation suggests that one can expect about 20% emittance growth in the entire acceleration process. Results from some of our experiments with proton beam and antiproton beam will also be presented.

* Operated by Universities Research Association, Inc. for the U.S. Department of Energy under contract DE-AC02-76CH03000.

TPPB074 Tevatron Beam-Beam Simulations at Injection Energy

Meiqin Xiao, Bela Erdelyi, Tanaji Sen (FNAL)

Major issues at Tevatron injection are the effects of 72 long-range beam-beam interactions together with the machine nonlinearity on protons and antiprotons. We look at particle tracking calculations of dynamic aperture (DA) under present machine conditions. Comparisons of calculations with observations and experiments are also presented in this report.

TPPB075 Simulations of Octupole Compensation for Weak Head-Tail Instabilities in the Tevatron

Meiqin Xiao, Tanaji Sen (FNAL), Frank Schmidt (CERN)

The proton lifetime in the Tevatron depends sensitively on chromaticities. Too low chromaticities can make the beam unstable due to the weak head-tail instability. One way to compensate this effect is to introduce octupoles to create a larger amplitude dependent betatron tune spread. However, the use of octupoles will also introduce additional side effects such as second order chromaticity, differential tune shifts and chromaticities on both proton and anti-proton helices. The non-linear effects may also reduce the dynamic aperture. There are 67 octupoles in 4 different circuits in the Tevatron which may be used for this purpose. We report on a simulation study to find the best combinations of polarities and strengths of the octupoles.

TPPB076 The Special Applications of Tevatron Electron Lens in Collider Operation

Xiaolong Zhang, Vladimir Shiltsev (FNAL), Frank Zimmermann (CERN), Kipster Bishofberger (University of California, Los Angeles)

Besides the Tevatron Electron Lens (TEL) runs as a R&D project for Tevatron Beam-Beam Compensation, it is used daily as a Beam Abort Gap Cleaner for collider operations. It can also be served as beam exciter for beam dynamics measurements and slow proton or antiproton bunch remover. This report descibes all these applications and observations.

TPPB077 Upgrades of the Tevatron Electron Lens

Xiaolong Zhang, Jim Crisp, Marvin Olson, Howard Pfeffer, Gregory Saewert, Alexei Semenov, Vladimir Shiltsev, Nicolay Solyak, Dave Wilderman (FNAL), Gennady Kuznetsov, Misha Tiunov (BINP), S. Kozub, L. Tkachenko (Institute of High Energy Physics, Protvino), Kipster Bishofberger (University of California, Los Angeles)

This paper will described the main upgrades of the Tevatron Electron Lens (TEL) in year 2003. The bending angle of the electron beam entrance and exit to the main solenoid will be decreased from 90 degree to 45 degree and three more solenoids will be added in electron beam entrance trajectory and as well as exit trajectory, which will allow us to have more freedom in control of electron beam size. A new gun will be installed which will give us a transverse gaussian beam distribution in addition to the flat beam with much smoother edge to minimize the nonlinear effect of the beam-beam force. And the new BPM system will be installed to let us have more precise beam position measurement for proton, antiproton and electron beams. And a knife-edge beam profile measurement system will replace the scanning wires to save us more space for these upgrades. We expect that all these upgrages will help us to increase the lifetime of the (anti)proton beam during the beam-beam compensation operation.

TPPB078 Integration of Recycler Operations into Fermilab Complex

David Johnson (FNAL)

The Run II Collider program is currently the sole user for antiprotons produced at Fermilab. The Recycler Antiproton Storage Ring has completed its commissioning phase with protons and now must be commissioned with antiprotons. Antiprotons used for this purpose will not be available to produce luminosity and therefore reduce the potential integrated luminosity. During the commissioning phase with antiprotons, when luminosity is not being produced with antiprotons from the Recycler, the impact on integrated luminosity should be minimized. Accelerator requirements and integration schemes will be discussed.

* Operated by Universities Research Association Inc., under contract with the U.S. Department of Energy.

TPPB079 Design Study of 1 MHz Induction Cavity for Induction Synchrotron

Kota Torikai, Yoshio Arakida, Shigemi Inagaki, Junichi Kishiro, Kunio Koseki, Eiji Nakamura, Ken Takayama, Takeshi Toyama, Masayoshi Wake (KEK)

A high-repetition rate induction cavity is a key device for the POP experiment with an induction synchrotron at the KEK 12 GeV-PS [Ken Takayama et al., "A POP Experiment Scenario of Induction Synchrotron at the KEK 12 GeV-PS", to be presented in PAC 2003]. The induction cavity, which is driven by a solid-state power modulator, is operated at a revolution frequency of 667-884 kHz. Design issues are among handling of deposited heat, electric insulation, impedance matching with a pulse modulator, and coupling impedance with a beam. A temperature distribution of the induction cavity with induction cores was analyzed with the simulation code ANSYS. The sufficient cooling condition was obtained. A 3-D field distribution inside the cavity as well as induced accelerating fields was evaluated in an analogous way of magnetic field calculation [Kota Torikai and Masayoshi Wake, to be prepared for publication]. Locations with the maximum field strength, which is still lower than the breakdown limit, were identified. Impedance measurements in the low frequency region ware done. The frequency and structure dependence of inductance,

capacitance, and resistance were obtained. Matching characteristics with the power modulator were realized. Longitudinal coupling impedance was measured by employing the S-matrix technique. Resonant structures at 400 MHz and 600 MHz were found with a quality factor of 30-60. These systematic studies will be presented at the conference.

TPPB080 Search of the Gold Orbit with a New Steering Algorithm

Yunhai Cai, Martin Donald, James Turner, Greg White, Uli Wienands (SLAC)

We have developed a new steering package to simultaneously minimize the vertical orbit, vertical dispersion, and x-y coupling. The initial test of the package on a computer model constructed from the measured response matrix in the Low Energy Ring of the PEP-II has been very successful, reducing the vertical beam size from 7.1 to 4.5 micron and the tilt angle from 19 to 1 mrad at the interaction point after a few iterations. The code has been ported to a Unix workstation in the control room and is ready to be applied to the machine. The results of simulation and measurement will be presented in this paper.

* Work supported by the Department of Energy under Contract No. DE-AC03-76SF00515.

TPPB081 Luminosity Potentials in Colliders with Electron Cooling

Yaroslav Derbenev (Thomas Jefferson National Accelerator Facility)

The breakthroughs of recent years: realization of beam energy recovery in superconducting linear accelerators, flat to round beam transformations, and new beam transport concepts (discontinuous solenoid, circulator rings, hollow beams) - promote the feasibility of efficient electron cooling of intense high energy hadron beams in colliders. Electron cooling in cooperation with strong SRF field in storage rings will allow one to obtain very short hadron bunches, consequently, to raise the luminosity by making a low beta-star. Short bunches also would make feasible the crab crossing that allows one to remove the parasitic beam-beam interactions and maximize the collision rate. Cooling also results in flatness of uncoupled beam equilibrium; this property can be used to increase the beam-beam limit, by introducing beam rounders around the interaction points. These possibilities and luminosity potentials are evaluated for the upgraded existing and future colliders with hadron beams.

* This work was supported by the U.S. Department of Energy under Contract No DE-AC05-84ER40150.

TPPB082 ELIC: A High Luminosity and Efficient Spin Manipulation Electron-Light Ion Collider Based at CEBAF

Lia Merminga, Yaroslav Derbenev, Andrew Hutton, Matthew Poelker, Yuhong Zhang (Thomas Jefferson National Accelerator Facility), Vladimir Litvinenko (Duke University)

Electron-light ion colliders with center of mass energy between 20 and 100 GeV, luminosity between 10^33 and 10^35 cm^-2 sec^-1, and polarization of both beams at or above 80% has been proposed for the study of hadronic structure. The proposed scheme would accelerate the electron beam using the CEBAF recirculating linac with energy recovery. If 20-40 MV/m accelerating structures are installed in the CEBAF tunnel, then a single recirculation can result in electron beam energy of about 5-10 GeV. After colliding with protons/light ions circulating in a storage ring under electron cooling at an energy of 50-100 GeV or above, the electrons are re-injected into the CEBAF accelerator for deceleration and energy recovery. In this report several innovative features of electron and ion beam designs and their advantages in delivering the luminosity and spin are described. These features include: electron circulator ring to reduce electron polarized source and energy recovering linac requirements, twisted spin booster and collider ring; low energy electron cooling accumulator as option for stacking beams from positive polarized ion sources; interaction points with low beta-star and crab-crossing using the short, cooled ion bunches. Accelerator physics and technology issues for both protons/ions and electrons are discussed. The feasibility of an integrated fixed target program at 25 GeV and collider program with center of mass energy between 20 and 45 GeV is also explored.

* This work was supported by the U.S. Department of Energy under Contract No DE-AC05-84ER40150.

TPPB083 Progress on Tevatron Electron Lens Activities

Kip Bishofberger (University of California, Los Angeles)

The Tevatron Electron Lens (TEL) is a short electron beam that produces a bunch-specific focusing effect on Tevatron bunches. It has found useful applications in several contexts, which we present here. The lens has successfully tuneshifted individual bunches, cleared residual beam particles from the gaps between bunch trains, and excited betatron oscillations for tune measurement of specific bunches. These preliminary results are discussed in this report along with a discussion of possible future endeavors.

TPPB084 Design of a Muon Cooling Ring with a Lithium Lens

Yasuo Fukui, David Cline, Alper Garren (University of California, Los Angeles), Harold Kirk (BNL)

We discuss particle tracking simulations in a storage ring with lithium lens inserts designed for the six-dimensional phase space cooling of muons by the ionization cooling. The ring design contains one or more lithium lens absorbers for transverse cooling that transmit the beam with very small beta-function values, in addition to liquid-hydrogen wedge-shaped absorbers in dispersive locations for longitudinal cooling. Such a ring could comprise the final component of a cooling system for use in a muon collider. The beam matching between dipole-quadrupole lattices and the lithium lenses is of particular interest.

TPPB085 Longitudinal Bunch Rotation Scheme in a Muon Cooling Ring

Yasuo Fukui (University of California, Los Angeles)

We present results of tracking simulation of a muon cooling ring with the RF cavity configuration which generate short bunch length and large energy spread at the energy absorbers in a low momentum muon cooling ring. The heating terms in the longitudinal phase space, the slope of the dE/dx as a function of muon momentum and the dE/dx straggling through absorbers, are suppressed in this scheme which provides lowest longitudinal equilibrium emittance achievable in a muon cooling ring. A muon cooling ring was designed as a linear model, with dipole magnets and quadrupole magnets, and it was simulated with a tracking code, ICOOL.

TPPB086 Beam Halo Scraper

John Brodowski, Nuria Catalan-Lasheras, Hans Ludewig, Brian Mullany, Deepak Raparia, Nickolaos Simos, Joseph Tuozzolo (BNL), S. Cousineau (ORNL)

There are four beam halo scrapers in the SNS ring. Each scraper consists of two sets of copper, water cooled jaws with tantalum tips.Actual scraping is done by tantalum and is used in order to reduce particle shower. Each jaw dissipates approximately 2kw of power. First set of scrapers collimates beam halo in the vertical and horizontal direction. Second set of identical scrapers is located behind the first set and is displaced 45 degrees in clockwise direction. Heavy walled steel shielding surrounds all scrapers. In order to facilitate rigging and quick scraper access, top shielding is mounted on guides and rollers which slide on top of side shielding. Once shielding is slid

aside, scrapers can be removed by disconnecting two quick disconnect flanges. For fast reinstallation of scrapers, all scraper assemblies are pre surveyed and placed on locating pin permanently mounted to the support structure. Mechanical design of the scrapers is the subject of this paper.

* SNS is managed by UT-Battelle,LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

TPPB087 Gaseous Hydrogen for Muon Beam Cooling

Rolland Johnson (Muons, Inc.)

Muons, despite their short lifetime, have an advantage in that they can be accelerated through matter without suffering appreciable scattering as do strongly-interacting protons or electromagnetic showering as do less massive electrons. Closed-cell RF cavities, filled with dense hydrogen gas to suppress electrical breakdown, can provide high gradients for relatively short muon ionization-cooling and acceleration channels for Neutrino Factories and Muon Colliders. Hydrogen gas, with large dE/dx, radiation length, and heat capacity, also acts as the perfect energy absorber with several engineering advantages. The progress of a DOE STTR grant project to develop high gradient RF cavities operating on the high side of the Paschen curve is described. New ideas for RF power sources, the MICE proposal, and 6 dimensional muon cooling are discussed.

* This work is supported in part by US DOE grant DE-AC02-ER86145 and by the Illinois HECA grant to the Illinois Consortium for Accelerator Research.

TPPB088 MICE: The International Muon Ionization Cooling Experiment

Daniel Kaplan (Illinois Institute of Technology), Michael Zisman (LBNL)

Muon storage rings might serve as high-energy lepton colliders and unique neutrino sources, but muon-beam cooling is needed for optimal performance. Recent studies have shown how muon cooling can be achieved with practical apparatus. An international collaboration has been formed to carry out a muon-cooling demonstration experiment, and a proposal has been submitted to the Rutherford Appleton Laboratory. The effort, on the scale of a medium-sized high-energy-physics experiment, involves both accelerator and particle physicists. With sufficient funding, the program could be carried out within five years. We describe the experimental setup, show simulations of the predicted performance, and discuss the measurements to be performed.

TPPB089 Muon Cooling Research and Development

Daniel Kaplan (Illinois Institute of Technology)

The MuCool Collaboration is engaged in a program of research and development on hardware for ionization cooling of a muon beam. The aim of MuCool is to develop the key pieces, including high-gradient normal-conducting rf cavities and high-power liquid-hydrogen energy absorbers. This effort will lead to a more detailed understanding of the construction and operating costs of such hardware, as well as to optimized designs that can be used to build a Neutrino Factory or Muon Collider. This work is being undertaken by a broad collaboration including accelerator and particle physicists and engineers from many national laboratories and universities in the U.S. and abroad. The intended schedule of work will lead to ionization cooling being well enough established that a construction decision for a Neutrino Factory could be taken before the end of this decade based on a solid technical foundation.

TPPB090 Bench Measurements of Low Frequency Transverse Impedance

Andrea Mostacci (Universita' di Roma), Fritz Caspers (CERN)

For frequencies below 10 MHz the classical two wire transmission line method is subject to difficulties in sensitivity and measurement uncertainties. Thus for evaluation of the low frequency transverse impedance properties of the LHC dump kicker a modified version of the two wire transmission line has been used. It consists, in the present case, of a 10 turn loop of approximately 1 meter length and 2 cm width. The change of input impedance of the loop is measured as a function of the surroundings and by using a proper reference (metallic beampipe) these changes are converted into a meaningful transverse beam coupling impedance. Measurements of several calibration objects have shown close agreement with theoretical results.

TPPB091 Global and Local Compensation of Long-Range Beam-Beam Interactions with Multipole Correctors

Jack Shi, Lihui Jin, Orithai Kheawpum (University of Kansas)

In the case of multi-bunch operation in Tevatron RUN II, serious long-range beam-beam effects occur due to many parasitic collisions that are distributed around the ring. For such non-localized long-range beam-beam perturbations, it is very difficult to apply local compensation schemes such as the wire compensation scheme. The multipole compensation of long-range beam-beam interaction has thus been studied. The principle of the multipole compensation of long-range beam-beam interactions is based on the idea of global compensation of nonlinearity in a storage-ring collider by using one-turn maps. Since a large beam separation is typical at parasitic collision points, in the phase-space region relevant to beams, the long-range beam-beam interactions can be expanded into a Taylor series around the beam separation and be included into the one-turn map. By minimizing nonlinear terms of a one-turn map order-by-order with a few groups of multipole correctors, one can reduce the nonlinearity of the system globally. In the case of localized parasitic collisions such as in LHC, one can use a group of local multipole correctors to minimize nonlinear terms of a local sectional map that contains the expansion of long-range beam-beam interactions. With LHC and Tevatron as models, the effectiveness of the multipole compensation of long-range beam-beam interactions was evaluated in terms of the improvement of dynamic aperture and the reduction of emittance growth. Dynamic aperture was studied with 100000-turn tracking and the emittance growth was examined with a strong-strong beam-beam simulation with a million particles. The study showed that the multipole compensation of long-range beam-beam interactions is very effective in increasing the dynamic aperture and improving the linearity of the phase-space region relevant to the beams.

* This work is supported by the US Department of Energy under Grant No. DE-FG03-00ER41153.

TPPB092 A Very Fast Ramping Muon Synchrotron for a Neutrino Factory

Don Summers (University of Mississippi), Scott Berg, Robert Palmer (BNL), Al Garren (University of California, Los Angeles)

A 4600 Hz fast ramping synchrotron is explored as an economical way of accelerating muons from 4 to 20 GeV/c for a neutrino factory. Eddy current losses are minimized by the low machine duty cycle plus thin grain oriented silicon steel laminations and thin copper wires. Combined function magnets with high gradients alternating within single magnets form the lattice described. Muon survival is 83%.

* This work is supported by the U.S. Department of Energy under grant DE-FG05-91ER40622.

TPPB093 A POP Experiment Scenario of Induction Synchrotron at the KEK 12GeV-PS

Ken Takayama, Yoshio Arakida, Susumu Igarashi, Shigemi Inagaki, Junichi Kishiro, Kunio Koseki, Eiji Nakamura, Hikaru Sato, Yoshito Shimosaki, Masashi Shirakata, Kota Torikai, Takeshi Toyama, Masayoshi Wake (KEK)

A POP experiment on an Induction Synchrotron is scheduled in 2003 at the KEK 12 GeV-PS. An idea for an induction synchrotron had been proposed in 1999 [1]. Since then, R&D work on key devices such as an induction cavity (IC) and a power modulator has continued. The individual features of these devices will be presented in e companion papers. In this presentation, a scenario for the first POP experiment and crucial issues of accelerator operation are discussed. A few RF trapped bunches are accelerated up to a flat-top energy with the induction system, which consists of four ICs capable of individually generating an output voltage of 2.5 kV. The IC, which is driven by a solid-state power modulator, is operated at a revolution frequency of 667-882 kHz through acceleration. The IDs are intermittently triggered in time and in piece during transient regions at the early and last stage of acceleration so that an induced voltage at each acceleration gap is kept at the same level, holding a beam orbit on the center of the chamber. An integrated induced voltage of 10 kV per turn requires a slower ramping pattern in magnetic fields. So-called DR feedback will be done by a combination of BPMs and a small IC, which can generate a few hundred volts. Confinement in the longitudinal direction is done with the existing RF, since an induction barrier will not be ready in time for the first stage of the POP experiment. This suggests that the RF phase must be kept near zero through acceleration, which places extra demands on RF phase control.

Poster Session TPPG
Galleria at 13:30

TPPG001 RF Coupling Design for Dielectric Loaded Accelerating Structures

Wei Gai, Wanming Liu (ANL)

We report on a new approach of RF coupling design for dielectric loaded accelerating structures. In this new approach, RF will be coupled into a coaxial structure and then conducted into the dielectric loaded accelerating structures. Advantages of this design are: the coupling does not depend on location of dielectric taper with respect to the aperture; copper residue on outside of the dielectric will not cause breakdown; and it has high power handling capabilities. Detailed designs for 11.424 GHz traveling wave structure with materials of Alumina (epsilon=9.4) and MCT 20 (epsilon=20) are given.

* Work supported by DOE HEP, Advanced Technology Branch, W-31-109-ENG-38.

TPPG002 A Compact Wakefield Measurement Facility

John Power, Wei Gai, Kwang-Je Kim, John Lewellen, Stephen Milton (ANL), Harry Carter, David Finley (FNAL)

The conceptual design of a compact, photoinjector-based, facility for high precision measurements of wakefields is presented. This work is motivated by the need for a thorough understanding of beam induced wakefield effects for any future linear collider. We propose to use a high brightness photoinjector to generate (approximately) a 2 nC, 2 mm-mrad drive beam at 10 MeV to excite the wakefield and a second photoinjector to generate a 5 MeV, variable delay, trailing witness beam to probe both the longitudinal and transverse wakefields of the structure under test. Initial estimates show that we can obtain a minimum measurable dipole (transverse) wake of 0.1 V/pC/m/mm and minimum measurable monopole (longitudinal) wakes of 5 kV/m. Simulations of the high brightness photoinjector, calculations of the facility's wakefield measurement resolution, and the facility layout will be presented.

TPPG003 An Update on the FFAG Lattice Design without Opposite Bends and with Distributed RF

Dejan Tbojevic, Scott J. Berg, Michael M. Blaskiewicz, Ernest D. Courant (BNL), Eberhard Keil (CERN), Al A. Garren (LBNL)

A future muon collider or neutrino factory requires fast acceleration to minimize muon decay. We have previously described an FFAG ring that accelerated muons from 10 to 20 GeV in energy. The ring achieved its large momentum acceptance using a low-emittance lattice with a small dispersion. In this paper we present an update on that ring. We have used design tools that more accurately represent the ring's behavior at large momentum offsets. We have also improved the dynamic aperture from the earlier design.

* Work performed under auspices of the U.S. Department of Energy.

TPPG004 Pre-Bunched Laser Wakefield Acceleration Experiment at the Brookhaven Source Development Lab

Xijie Wang, B. Sheehy, Z. Wu (BNL), W. Gai (ANL), A. Ting (Naval Research Laboratory)

We are proposing a 100 MeV channel-guided laser wakefield acceleration (LWFA) experiment using a 10 fs pre-bunched electron beam at the Brookhaven Source Development Lab (SDL). SDL is a 200 MeV linac facility consisting of a photocathode RF gun injection system, a 100 fs Ti:Sapphire laser system and a magnetic bunch compressor. The proposed LWFA will inject a 150 MeV, 10 fs electron bunch into a centimeter long plasma channel. For an electron beam spot size of 20 um, the expected energy gain is about 100 MeV for a 5 TW, 100 fsec laser pulse. Simulation and preliminary experiment showed that, high-brightness 10 fs electron bunch with 20 pC charge could be produced using the technique of longitudinal emittance compensation. We shall also present a design to upgrade the existing SDL laser (100 fs, 50 mJ) to 500 mJ operation.

TPPG005 Characteristics of Gradient Undulator

Alexander Mikhailichenko (Cornell University)

Undulator/wiggler having the same polarities of magnetic field in opposing through median plane poles can be used for generation of radiation which intensity is a function of the beam size and displacement. Characteristics of such device analyzed here analytically and by tracking.

* Cornell University, LEPP, NSF.

TPPG006 Short X and Gamma Production with Swept Laser Bunch

Alexander Mikhailichenko (Cornell University)

We decribed here the new way of production of <100 femtosecond bursts of X and gamma-radiation by Compton back-scattering of a laser bunch which has been swept along the electron trajectory. In the method described the time duration of the secondary radiatin does not depend on electron bunch length and is shorter, than duration of the primary laser bunch by the factor which is the number of resolved spots associated with the sweeping device and can be 1/1000. The method of the laser bunch sweeping is also helpful in obtaining short electron bunches from a photocathode.

* Cornell University, LEPP, NSF.

TPPG007 Damping Ring for Production of Positroniums and Investigation of Fermi-Degeneration in Moving Beams

Alexander Mikhailichenko (Cornell University)

Kayak-paddle look-like damping ring developed as injector for a laser driven linear accelerator with micristructures [A.A. Mikhailichenko, CLNS 98/1568, Cornell, LEPP, 1998], allows beam emittance which is defined by quantum effects in electron-positron gas of particles in the bunch. Utilization of co-directionally moving congruent electron and positron bunches allowing production of positronium beam with a 10^10 para-positroniums per second. This arrangement might be a step toward investigation of the nature of Fermi-degeneration in moving beams.

* Cornell University, LEPP, NSF.

TPPG008 Triplet-Based Latttices for FFAGs

Carol Johnstone (FNAL), Alper Garren (University of California, Los Angeles)

Fixed-field Alternating Gradient (FFAG) accelerators have been successfully designed which meet the large-acceptance, rapid acceleration requirements of a muon beam for a Neutrino Factory or Muon Collider. Significant improvements have recently been made in lattice design over existing, published lattices. Based on a triplet quadrupole unit rather than a simple lens, or repetitive FODO cell, one of the most dramatic improvements is in the beta functions at the injection energy. In the triplet-based cell, the beta functions in the quadrupoles at injection are minimized versus extraction, whereas in the FODO lattice they are a maximum at injection. The decrease in the already-large quadrupole aperture results in a significant cost savings in component design. Further the straights in the periodic triplet lattice reserved for rf cavities, diagnostics, and injection/extraction devices can be varied with little impact on the optical functions in the short-cell limit unlike the FODO lattice. This allows an arc cell to be designed based, for example, on three cells with a center straight that is larger than the two flanking ones (to accommodate superconducting rf or long injection/extraction devices). In this way, the circumference and associated muon decay can be minimized further optimizing the acceleration system. This work examines the properties of a nonscaling and scaling triplet-based lattice. A triplet-based scaling lattice has already been implemented in the "Proof of Principle" FFAG at KEK.

* Work supported by the US Department of Energy under contract no. DE-AC02-76CH03000.

TPPG009 Longitudinal Dynamics in an FFAG under Conditions of Rapid Acceleration and High-Frequency, High-Q RF

Carol Johnstone (FNAL), Shane Koscielniak (TRIUMF)

A signature of fixed-field acceleration is that the orbit of the beam centroid unavoidably changes with energy. The corresponding change in pathlength and circulation time results in a phase slip relative to the accelerating waveform. The phase slip is significant even for rapid acceleration when high-frequency, high-Q cavities are used and cavity phasing cannot be readjusted on the timescales involved. However, for very rapid acceleration-in the limit of a few acceleration passes-one can still exploit the oscillatory nature of the rf waveform and operate near the crest rather than in a time-averaged mode that nominally characterizes these large phase slips across the rf waveform. This work describes a unique approach whereby the initial phases of individual rf cavities are varied in order to optimize acceleration. This can be understood simply by realizing that for a single acceleration pass, the initial cavity phases can be set to exactly compensate for the phase slip accumulated thereby achieving maximal acceleration. This compensation remains effective in the limit of a few turns and is ideal for muon acceleration where decay losses cannot be tolerated beyond a few turns. The present work explores the rf manipulations possible, the impact on longitudinal dynamics, and the limiting behavior in a specified fixed-field accelerator.

* Work supported by the US Department of Energy under contract no. DE-AC02-76CH03000.

TPPG010 Electron Injection by Colliding Laser Pulses in Plasmas

Eric Esarey, G. Fubiani, W.P. Leemans, Carl Schroeder, B.A. Shadwick (LBNL), J. Cary, R. Giacone, C. Nieter (University of Colorado)

The LBNL l'OASIS Group is pursuing electron acceleration in plasma with colliding pulse injection (CPI) [E. Esarey et al., Phys. Plasmas 6, 2262 (1999)]. In CPI, an intense pump pulse (duration equal to the plasma period) excites a large amplitude plasma wakefield. Two counter-propagating injection pulses collide some distance behind the pump pulse and generate a beat wave with a slow phase velocity. This slow beat wave can trap plasma electrons and inject them into the fast wake for acceleration to high energy. This results in an ultrashort bunch (few fs) with a small energy spread (few percent). The initial set of LBNL experiments using a 10 TW, 40 fs laser system (upgrade to 100 TW underway) will rely on two laser pulses: a pump pulse to excite the wake and a single backward injection pulse. Injection results from the slow beat wave produced by the backward pulse colliding with the pump pulse. Simulations of CPI will be presented using particle codes that include the effects of finite crossing angles, equal pulse frequencies, and density gradients. Preliminary experimental data will also be presented.

* This work supported by DoE, DE-AC03-76SF0098.

TPPG011 Laser Triggered Injection Using Colliding Pulses

J. Faure, E. Esarey, G. Fubiani, C.G.R. Geddes, W.P. Leemans, C.B. Schroeder, B.A. Shadwick, C. Toth, J. van Tilborg (LBNL), G. Dugan (Cornell University), J.R. Cary, R. Giacone, C. Nieter (University of Colorado, Boulder)

Laser driven acceleration in plasmas has succeeded in producing electron beams containing multi-nC's of charge, with some fraction of the electrons having energies in excess of 10's of MeV's but 100 % energy spread. One of the current challenges is to produce electron beams with much reduced energy spread. We report on experimental progress in the laser triggered injection of electrons in a laser wakefield accelerator using the colliding pulse method [E. Esarey et al., Phys. Rev. Lett. 79, 2682 (1997); C.B. Schroeder et al., Phys. Rev. E 59, 6037 (1999)]. The experiments use the l'OASIS multi-beam 10 Hz high power Ti:sapphire laser system [W.P. Leemans et al., Phys. Rev. Lett. 89, 174802 (2002)]. In the present experiments, two counter propagating beams intersect with a 30 degree angle above a high density gas jet. Preliminary results indicate that electron beam properties are affected by the second beam. Details of the experiments will be shown as well as comparisons with simulations.

* This work is supported by DoE under contract No DE-AC-03-76SF0098. C. Geddes acknowledges support from the Hertz Foundation.

TPPG012 Laser Guiding at > 10^{18}W/cm^2 in cm - Scale Gas Jets Using the Ignitor Heater Method

Cameron Geddes, Eric Esarey, Jerome Faure, Wim Leemans, Csaba Toth, Jeroen vanTilborg (LBNL)

A compact 100MeV -1GeV accelerator module is desirable for high energy physics and radioisotope production. Laser wakefield accelerators in the self guided regime and in pre formed channels are studied for these and other applications at LBNL's l'OASIS facility (10TW, 2E19W/cm^2). A self modulated and self guided drive beam propagating in ~2mm plasmas has been characterized, producing nC electron beams up to 50MeV with large energy spread. Gas jet development has produced various gas and plasma profiles. Further

development including cm scale shaped nozzles with smooth profiles and new driver technologies is under way. Simulations indicate that cm scale plasma channeled accelerators can substantially increase particle energy as well as reducing energy spread. Recent upgrades to the l'OASIS system allow cm scale pre formed channels using the ignitor-heater method as well as injection experiments. Recent experimental results will be presented.

* Work supported by the Director, Office of Science, Office of High Energy & Nuclear Physics, High Energy Physics Division, of the U.S. Dept. of Energy, under Contract DE-AC03-76SF00098. C.Geddes also supported by Hertz Foundation.

TPPG013 The Integration of a Liquid and Solid Muon Absorbers into a Focusing Magnet of a Muon Cooling Channel

Michael Green (LBNL), Robert B. Palmer (BNL), Edgar L. Black, Mary Ann Cummings, Dan Kaplan (Illinois Institute of Technology), S. Ishimoto (KEK), Wing Lau (Oxford University)

This report describes how one can integrate the muon absorber with the focusing coils of a SFOFO muon cooling channel. The absorber material must be a low Z material that does reduces the muon momentum with minimum scattering. The best materials to use for muon ionization cooling absorbers are hydrogen, helium, lithium hydride, and lithium. Hydrogen or helium in an absorber would normally be in the liquid state. Lithium hydride and lithium would normally be in the solid state, but lithium a lens absorber uses lithium in the liquid state. This report limits the absorber materials discussed to liquid hydrogen and lithium hydride. In order to achieve the same level of ionization cooling with a lithium hydride absorber as a liquid hydrogen absorber, the beta of the muon beam must be reduced over a factor of two. This affects the design of the absorber and the magnet around it. The problems associated with integrating absorbers containing liquid hydrogen and lithium hydride with a superconducting focusing solenoid are discussed. The choice of absorber material affects the design of the superconducting focusing magnet and possibly the type of superconductor that is used to generate the magnetic field within the absorber.

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TPPG014 Lattices for Milli-eV Neutral Molecules

Hiroshi Nishimura, Harvey Gould, Juris Kalnins, Glen Lambertson (LBNL)

This paper will describe the design of lattices of electrodes to guide neutral polar molecules in a storage ring. The electrostatic fields acting on the molecule's dipole moment play the role of magnets in rings for charged particles. Differences between their actions on weak-seeking and on strong-seeking molecules are pointed out. Trajectories and dynamic apertures are calculated. Effects of gravity on the slow-moving molecules must be considered. Example lattices are presented.

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TPPG015 Transition Radiation from a Self-Modulated Laser Wakefield Accelerator Generated Electron Beam

Carl Schroeder, David Auerbach, Eric Esarey, Jerome Faure, Cameron Geddes, Wim Leemans, Csaba Toth (LBNL), Jeroen van Tilborg (Eindhoven University of Technology)

The transition radiation from a relativistic electron beam generated by a self-modulated laser wakefield accelerator is studied analytically. The coherent and incoherent transition radiation spectrums are calculated for an electron beam with a multiple-temperature negative-exponential longitudinal momentum distribution, characteristic of laser-plasma produced electron beams. The effects of beam divergence on the coherent and incoherent transition radiation are presented. The implications for use of the coherent transition radiation from the plasma-vacuum transition as a beam diagnostic and as a source of intense THz or mm-wave radiation are considered. The coherent transition radiation emitted from the plasma-vacuum interface is sub-ps in duration with energies per pulse orders of magnitude beyond that of conventional THz sources. The results are compared to recent experimental observations at LBNL.

* This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF0098.

TPPG016 Shaping of Pulses in Optical Grating-Based Laser Systems for Optimal Control of Electrons in Laser Plasma Wake-Field Accelerator

Csaba Toth, Jerome Faure, Cameron Geddes, Wim Leemans, Jeroen van Tilborg (LBNL)

IIn a typical chirped pulse amplification (CPA) laser system used in laser-plasma wake-field accelerators, the final pulse-forming device is the grating pulse compressor itself. By scanning the grating separation, in addition to the primary changes of the linear chirp all the higher order terms are modified, too. By setting the compressor angle slightly different from the optimum, a typical scan around the shortest pulse will produce significant changes to the pulse shape. For example, when compressing stretched pulses with a positive bias third order phase component, the pulse shape in the course of a compressor separation scan initially will be skewed toward the head of the pulse (s<1), then flips to become a skewed pulse at the tail (s>1), and again flips back to the original asymmetric one (s<1). Examples of strong electron yield dependence in laser plasma wake-field electron acceleration experiments in the L'OASIS Lab of LBNL [W.P. Leemans et al., Phys. Rev. Lett. 89, 174802 (2002)] show the importance of the skewness parameter, s, defined here as the ratio of the 'head-width-half-max' (HWHM) and the 'tail-width-half-max' (TWHM), respectively. Further methods of higher-order phase-control will be reviewed, including the DAZZLER, a commercial acousto-optic phase and amplitude modulation device used in electron acceleration experiments.

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TPPG017 Effects of Laser-Plasma Interactions on Inverse Transition Acceleration

Ming Xie (LBNL)

Inverse transition acceleration is an inverse process of transition radiation, through which direct field acceleration is possible when a relativistic electron beam is injected collinearly with a TM laser beam into a plasma layer having a longitudinally varying index of refraction. In addition to direct field acceleration, we analyze other processes due to laser-plasma interaction, which may affect dynamics of the electrons and propagation of the laser.

* This work was supported by the US. Department of Energy under contract No.DE-AC03-76SF00098.

TPPG018 Particle Simulations of Optically Injected Laser Wakefield Accelerators

Daniel Gordon, Richard Hubbard, Theodore Jones, Dimitre Kaganovich, Joseph Penano, Phillip Sprangle, Antonio Ting (Naval Research Laboratory), Bahman Hafizi (Icarus Research Inc.)

In a laser wakefield accelerator (LWFA) the frequency of the accelerating structure is typically a terahertz or higher. Consequently, femtosecond bunches must be used for injection if all the injected particles are to be accelerated at the same rate. We examine two optical injection schemes via numerical modeling. In the method of Laser Induced Photoionization and Acceleration, a high power laser is tightly focused into a gas puff. Inner shells of electrons are ionized at higher

intensities than outer shells, and gain a correspondingly larger kick from the laser as they are ejected from the region of high intensity. Another approach is to use the self-modulated laser wakefield accelerator (SM-LWFA) as an injector. The SM-LWFA produces high energy electrons in the tail of an exponentially decaying distribution function. A system of magnets can select a narrow band of energies and refocus them into a second wakefield accelerator. Simulation results will be presented illustrating the use of these two injection schemes for parameters pertinent to the LWFA experiments at NRL.

* Supported by the Department of Energy and the Office of Naval Research.

TPPG019 Plasma Channel Density Measurements in a Transparent Capillary Discharge

Theodore Jones, Christopher Moore, Phillip Sprangle, Anotonio Ting (Naval Research Laboratory), Dmitri Kaganovich (LET, Inc.)

The spatial profile of the plasma electron density in a guiding channel is critical to guiding efficiency, wakefield generation, and acceleration dephasing length in a laser wakefield accelerator. Recent experiments at NRL used a capillary discharge with transparent wall material and square cross section to obtain interferometric images of a plasma channel. Capillary dimensions and discharge parameters were kept similar to those in capillaries used to guide TW laser pulses and to those proposed for staged acceleration experiments. The axial extent of imaging included 4 capillary diameters outside the plasma and 8 diameters inside the capillary from the electrode. Analysis of interferograms of the capillary interior confirm that a radially hollow density profile, suitable for laser guiding, was formed. However, the data show a significant axial density gradient within 4 diameters of the end, resulting in a density increase of more than a factor of two. A complete analysis, including a best fit deconvolution of the local density in the capillary yields laser mode-matched channel widths consistent with previous guiding experiments. Analysis also reveals that some channels were curved, with transverse deviations of the channel center of up to 10% of the capillary diameter.

* This work is supported by DOE and ONR.

TPPG020 Laser Wakefield Acceleration and Electromagnetic Pulse Generation in Long Narrow Plasma Columns

Phillip Sprangle (Naval Research Laboratory), Dan Gordon, Richard Hubbard, Chris Kapetanakos, Joe Penano, Antonio Ting (American Physical Society)

In the laser wakefield accelerator [P. Sprangle, et al., Phys. Rev. E, 63, 056405 (2001) and Phys. Rev. Lett. 85, 24, (2000)] the axial and radial ponderomotive force associated with a high intensity short laser pulse excites a trailing plasma wave which can trap and accelerate electrons. In some experiments the ratio of the plasma wavelength to the radius of the plasma column is much greater than unity. In this high aspect ratio limit the dispersive properties of the accelerating plasma wave are very different than in the low aspect ratio case. In the high aspect ratio case radiative electromagnetic pulses can be generated in the THz regime. Three dimensional simulations, which include ionization, electron thermalization and acceleration, are presented.

* Supported by the Department of Energy and Office of Naval Research.

TPPG021 Laser Wake Field Accelerator with Optical Injection

Antonio Ting, Daniel Gordon, Richard Hubbard, Theodore Jones, Phillip Sprangle (Naval Research Laboratory), Dmitri Kaganovich (LET, Inc.), Eldridge Briscoe (RSI, Inc.)

Optical injection of electrons into laser wakefield accelerators (LWFA) could result in high quality, high energy electron beams. A promising experimental scheme of electron injector is the laser ionization and pondermotive acceleration (LIPA) of electrons [C.I. Moore, et al, PRL, 82, 1688 (1999)] where energetic electrons are created from ionization of inner shell electrons at very high laser intensities. Relatively short electron pulses can be obtained from LIPA for phased injection into the LWFA. An alternative electron injector is to use the self-modulated LWFA which has demonstrated high energy electron production. An electron bunch with well defined energy spread can be obtained using a system of magnets for injecting into the LWFA. The laser pulses that generate the injection electrons and the laser wakefield are derived from the NRL chirped pulse amplification (CPA) laser using two different compressors. A 2 TW beam and a 10 TW beam will be derived and recombined at the injection and acceleration chamber. The energy of the accelerated electrons will be measured with a magnetic electron spectrometer. The experimental setup and the preliminary results of the experiment will be presented.

* Supported by DoE and ONR.

TPPG022 Measurements of a Plasma Channel Expansion in a Laser-Produced Plasma

Jong-Uk Kim (National Synchrotron Radiation Lab), Changbum Kim, Guang-Hoon Kim, Hae-June Lee, Hyyong Suk (Korea Electrotechnology Research Institute)

Relatively low intensity laser (I ~ 5x1012 W/cm2) was used to study dynamics of laser-produced plasma (LPP) in a gas filled chamber and in a gas jet. Visualization methods including Mach-Zehnder interferometry and Shadow imaging were employed in this study. Results showed that a minimum electron density on axis ~3x1018 cm-3 with its peak ~4.4x1018 cm-3 on the channel edge was observed in a gas jet with initial shock expansion speed of ~1.0x106 cm/sec. Although the possible wave-guiding mode was not observed in a gas filled chamber, but the propagation of the shock front increased faster and further as increasing the laser energy and applied gas pressure. Maximum shock speed was ~4.1x106 cm/sec and the shock expansion followed the distance-time relation Rs ~ t2/5 very well implicating an instantaneous energy release at a point.

TPPG023 Self-Injection of Electrons from Evolution and Asymmetry of Wakefield

C. Kim, I.S. Ko (Pohang Accelerator Laboratory), G.H. Kim, J.U. Kim, H. J. Lee, H. Suk (Korea Electrotechnology Research Institute)

Self-injection mechanisms of plasma electrons are investigated in the self-modulated laser wakefield acceleration (SM-LWFA). Two-dimensional (2-D) particle-in-cell (PIC) simulations show that a significant amount of plasma electrons can be self-injected into the acceleration phase of a laser wakefield by dynamic evolution of the wake wave in the longitudinal direction. In addition, a long laser pulse propagating in a uniform plasma was observed to experience the hose instability. By this instability, the symmetry breaking of the wake wave is generated and the asymmetric self-injection of electrons are found as a dominant injection mechanism.

TPPG024 Photonic Crystal Accelerator Structures

Benjamin Cowan, Mehdi Javanmard, Robert Siemann (SLAC)

Photonic crystals have great potential for use as laser-driven accelerator structures. A photonic crystal is a dielectric structure arranged in a periodic geometry. Like a crystalline solid with its electronic band structure, the modes of a photonic crystal lie in a set of allowed photonic bands. It is also possible for a photonic crystal to exhibit one or more photonic band gaps, with frequencies in the gap unable to propagate in the crystal. Thus photonic crystals can confine an optical mode in an all-dielectric structure, eliminating the need for metals and their characteristic losses at optical frequencies. We discuss several geometries of photonic crystal accelerator structures. Photonic

crystal fibers (PCFs) are optical fibers which can confine a speed-of-light optical mode in vacuum. Planar structures, both two- and three-dimensional, can also confine such a mode, and have the additional advantage that they can be manufactured using common microfabrication techniques such as those used for integrated circuits. This allows for a variety of possible materials, so that dielectrics with desirable optical and radiation-hardness properties can be chosen. We discuss examples of simulated photonic crystal structures to demonstrate the scaling laws and trade-offs involved, and touch on potential fabrication processes.

* Work supported in part by Department of Energy contract DE-AC03-76SF00515 (SLAC) and by DOE grant no. DE-FG03-97ER41043-II.

TPPG025 E-164 & E-164X: High Gradient Plasma Wakefield Acceleration Using Ultra-Short Bunches

Mark Hogan, Christopher Barnes, Franz-Josef Decker, Paul Emma, Richard Iverson, Patrick Krejcik, Caolionn O'Connell, Robert Siemann, Dieter Walz (SLAC), Christopher Clayton, Chengkun Huang, Devon Johnson, Chandrashekhar Joshi, Wei Lu, Kenneth Marsh, Warren Mori (University of California, Los Angeles), Suzhi Deng, Tom Katsouleas, Patrick Muggli, Erdem Oz (University of Southern California)

The E-164 and E-164X plasma wakefield acceleration (PWFA) experiments, beginning April 2003, will utilize 28.5GeV electron bunches from the SLAC linac to generate accelerating gradients in excess of 1GeV/m. A single bunch of ~2E10 electrons will be compressed to a bunch length of 100 microns (E164) and eventually down to less than 20 microns (E164X) and focused to a radius of less than 25 microns at the plasma entrance. Numerical simulations show that peak accelerating gradients on the order of 2GeV/m (E164) and 15GeV/m(E164X) can be driven by 1E10 electrons in a single bunch in a plasma with a density in the 5E15 (E164) and 2E17 e-/cm^3(E-164X) range respectively. E164 will use a 30cm plasma of photo-ionized lithium vapor while E164X will use a 5cm field-ionized cesium plasma. The plasma lengths are chosen to keep the total beam energy spread within the acceptance of the FFTB dump line. These experiments will test the validity of the PWFA in a new regime where the bunch length, bunch radius and plasma wavelength are all on the same order, and as such will be a valuable data point where no scaling laws exist for the PWFA. A status of the ongoing experimental program and preliminary results will be presented.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

TPPG026 The ORION Facility

Robert Noble, Eric Colby, Dennis Palmer, Robert Siemann, Dieter Walz (SLAC), Robert Byer (Stanford University), Chandrashekhar Joshi, Warren Mori, James Rosenzweig (University of California, Los Angeles), Thomas Katsouleas (University of Southern California)

ORION will be a user-oriented research facility for understanding the physics and developing the technology for future high-energy particle accelerators. The ORION Facility will bring together the needed resources for performing a wide range of experiments in advanced accelerator and beam physics. The facility has as its centerpiece the Next Linear Collider Test Accelerator (NLCTA) within End Station B at the SLAC Central Research Yard. That site will be modified with the addition of a new high-brightness photoinjector, its associated drive laser and rf power system, a user laser room, a low-energy experimental hall supplied with electron beams up to approximately 60 MeV in energy, and a high-energy hall supplied with beams up to 350 MeV. Facility construction is anticipated to start in October 2003, contingent upon funding approval, and first beam is planned for 2005. The first experiment at ORION, the laser acceleration experiment E163, has been approved by SLAC. In this paper, results are presented on the revised facility layout and design which came out of the 2nd ORION Workshop in February 2003, and the beam physics design of the injector and the beamlines for the low and high-energy experimental halls.

* This work was supported by Department of Energy contract DE-AC03-76SF00515.

TPPG027 The ORION Photoinjector

Dennis Palmer (SLAC)

The ORION photoinjectors primary role is to provide a stable and reliable source of electrons to the ORION facilities users. Satisfying the beam requirements for this diverse set of advanced accelerator experiments will require that the present DC thermionic source to be replaced with an emittance compensated RF photoinjector. The new electron source photocathode CU100, based on the Next Generation Photoinjector (NGP), will be driven by a commercial available UV laser system which will be located in a temperature stabilized class 1000 laser clean room adjacent to the radiation enclosure. A standard SLAC 5045 klystron along with a NLC solid-state modulator will provide up to 15 MW of S-band power to the NGP at a repation rate of 10 Hz. The ORION laser injection timing stabilization requirement (df = ~0.25 psec) is a factor of four tighter than conventional S-band photoinjector system due to the dual frequency nature of the S-band photoinjector and X-band post acceleration sections. Beam dynamics simulation of the emittance compensation process, using HOMDYN, indicates that the ORION photoinjector, operating with a peak accelerating field gradient of 140 MV/m, can produce a 0.25 nC electron beam with an outstanding transverse normalized rms emittance along an energy spread of 0.8%. PARMELA simulations have also been conducted for the ORION photoinjector at two charge limits: 0.25 nC for Advanced Accelerator Experiments such as the E-163 and at 1.0 nC for NLCTA operations. A possible set of experimental programs to verify the injector performance will be discussed.

TPPG028 Miniaturization Techniques for Accelerators

James Spencer (SLAC), Justin Mansell (Intellite Inc), Wanill Ha, Tomas Plettner (Stanford University)

The possibility of laser acceleration suggests the need for new structures based on micromachining and integrated circuit technology because of their commensurable scales. Further, the exponential growth in the complexity of high energy accelerators and colliders dictates a need for techniques that leverage infrastructures such as those being developed for optical telecommunications (MEMS) and integrated circuit electronics (SOC). Thus, we are exploring the possibility of fully integrated structures that include sources, optics (for both light and particles) and acceleration in a common format-an accelerator-on-chip. To date, we have found no technical or fundamental roadblocks to such a goal. Acceptable materials (and wavelengths) must allow velocity synchronism between many laser and electron pulses with optimal efficiency in high radiation and intense laser fields. Tests related to deep etching, fabrication and radiation damage on candidate amorphous and crystalline materials indicates Si (1.2-10 microns) to be ideal but other interesting candidates exist. We have made micro-planar electron optics and wigglers on Si capable of pulsed currents of >1 A without failures and etched micro structures in Si having aspect ratios on a wall's height-to-thickness of 500:1 with surfaces that were flat, parallel and smooth to

TPPG029 Analytical Description of the Unltra-Short Pulse Laser for CAS-the Newly Laser Acceleration Scheme

JianFei Hua, Lin Yuzheng (Tsinghua University, Beijing)

This paper is aimed at exploring the analytical description of the ultra-short pulse laser for CAS-the newly proposed laser acceleration scheme. Based on the development of the pulse laser technique, more accurate expressions have been deduced including the diffraction effect.Using this accurate description, the electrons can be accelerated with large energy gain in our laser acceleration scheme.

* Supported by National Natural Science Foundation of China.

TPPG030 Energy Gain and Loss of a Positron Beam in the E162 Plasma Wakefield Acceleration Experiment at SLAC

Brent Blue (University of California, Los Angeles), Mark Hogan, Caolionn O'Connell, Robert Siemann (SLAC), Patrick Muggli (University of Southern California)

A short, intense positron beam can drive a very large amplitude plasma wave or wakefield. The longitudinal component of the wakefield results in energy loss of the bulk of the beam and gain of the particles in the beam tail. An experiment is performed at the Stanford Linear Accelerator Center to study the issues related to a meter-long plasma wake field accelerator (PWFA) module in the context of a high energy accelerator. Positron bunches with an energy of 28.5 GeV, and a charge of 1.9 nC in 2 ps bunches travel in a 1.4 m long, laser photo-ionized lithium plasma with a density range of 0-2e14 cm-3. The time resolved longitudinal beam dynamics are studied by using an imaging magnetic spectrometer. Experimental results will be presented and the results will be compared to computer simulations.

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TPPG031 Nonlinear Wake Field and Beam Loading in E164 and Afterburners

Wei Lu, B. Blue, C. Clayton, Chengkun Huang, C. Joshi, K. Marsh, Warren Mori, Chuang Ren (University of California, Los Angeles), F. Decker, M. Hogan, R. Iverson, C. O'Connell, R. Siemann, D. Walz (SLAC), S. Deng, T. Katsouleas, P. Muggli (University of Southern California)

A short, intense electron or positron beam can produce ultra-high gradient plasma wave wakes. It has been proposed that such wakes can be used to double the energy of a linear collider such as SLAC in distances on the order of meters. The plasma wave accelerating structures for the proposed E164 experiment and for possible afterburner designs are predominantly created by blowing out or sucking in the background plasma electrons. This process is highly nonlinear and there is currently no theoretical model which can accurately predict the wake amplitude and acceleration gradient for different densities as the beam parameters are kept fixed. We use the PIC code OSIRIS to model the nonlinear wake formation for the proposed E-164 experiment and possible afterburner scenarios. In addition, in an afterburner design, one beam of electrons (positrons) creates the wake and another trailing bunch of electrons b (positrons) beam loads the wake as it is accelerated. Preliminary simulations indicate that reasonable energy spread can still be maintained during nonlinear beam loading. These results will be compared with linear theory and a quasi-static theory for the blowout regime which include axial motion.

* Work supported by DOE and NSF.

TPPG032 Status of the Inverse Free Electron Laser Experiment at the Neptune Laboratory

Musumeci Pietro, C. Pellegrini, J.B. Rosenzweig, S. Totchisky, G. Travish (University of California, Los Angeles), S. Tolmachev, A.A. Varfolomeev, T. Yarovoi (RRC Kurchatov Institute)

We report on the status of the Inverse Free Electron Laser accelerator experiment proposed for construction at the UCLA Neptune Laboratory. This experiment will use a 1 TW CO2 laser to accelerate through a tapered undulator an electron beam from 16 MeV up to 55 MeV. The scheme proposed is the diffraction dominated IFEL interaction where the Raleigh range of the laser beam is about 2 cm, much shorter than the interaction length (the undulator length is 50 cm). The undulator is strongly tapered in both field and period and preliminary measurements of the magnetic field will be discussed. Spatial alignment and time synchronization results are presented. A Coherent Undulator Radiation based diagnostic to detect microbunches of rms size smaller than 3 fs is analyzed.

* This work is supported by U.S. Dept. of Energy grant DE-FG03-92ER40693.

TPPG033 The UCLA/NICADD Plasma Density Transition Trapping Experiment

Matthew Thompson, Wei Lu, Warren Mori, James Rosenzweig, Gil Travish (University of California, Los Angeles), Nick Barov (Northern Illinois University)

Plasma density transition trapping is a recently purposed self-injection scheme for plasma wake-field accelerators. This technique uses a sharp downward plasma density transition to trap and accelerate background plasma electrons in a plasma wake-field. Two and three dimensional Particle-In-Cell (PIC) simulations show that electron beams of substantial charge can be captured using this technique, and that the beam parameters such as emittance, energy spread, and brightness can be optimized by manipulating the plasma density profile. These simulations also predict that transition trapping can produce beams with brightness > 5x10^14 Amp/(m-rad)^2 when scaled to high plasma density regimes. A proof-of-principle plasma density transition trapping experiment is planned for the near future. This experiment is a collaboration between UCLA and the Northern Illinois University (NICADD). The goal of experiment is to capture a ~100 pC beam with ~4% rms energy spread out of a 2 x 10^13 cm^-3 peak density plasma using a ~6nC, 14 MeV drive beam. Status and progress on the experiment are reported.

* Work Supported by U.S. Dept. of Energy grant DE-FG03-92ER40693.

TPPG034 Acceleration of Injected Electrons In A Laser Beatwave Experiment

Sergei Tochitsky, Christopher Clayton, Catalin Filip, Chandrashekar Joshi, Ken Marsh, Pietro Musumeci, Ritesh Narang, Claudio Pellegrini, James Rosenzweig, Rodney Yoder (University of California, Los Angeles)

Plasma-based accelerators of particles are of great interest because plasmas can sustain very strong electric fields. They are utilizing a relativistic plasma wave with a phase velocity close to the speed of light driven by a high-power laser beam. The Neptune Laboratory at UCLA is being used for plasma beatwave acceleration of injected electrons. Here, a two-wavelength laser pulse (frequencies w1,w2) resonantly drives a longitudinal electron plasma wave of frequency equal to w1-w2, providing a field strength of GeV/m and, therefore, accelerates an injected electron beam at this very high gradient. A 10 ps beam of 12 MeV electrons is loaded in a 3-cm long plasma beatwave accelerator driven by a TW CO2 laser pulse. At the resonance condition, the electrons have been accelerated to 50 MeV with a gradient of ~1.3 GeV/m. It is shown that for large volume diffraction

limited plasmas, when efficiency of the plasma wave excitation is restricted by ionization-induced refraction, acceleration of electrons is enhanced significantly by using asymmetric (fast front and slow fall) long pulses. 2D PIC simulations revealed that guiding of the laser pulse in a ponderomotive, self-induced ion channel, formed ~200 ps after the field ionization, allows compensation for the ionization-induced defocusing and efficient driving of the beatwave over the entire length.

* This work was supported by U.S. DOE contract DF-FG03-92ER40727.

TPPG035 A Proposal to Experimentally Demonstrate a Novel Regime of Electron Vacuum Acceleration by Using a Tightly Laser Beam

Feng Zhou, David Cline, Shao Lei (University of California, Los Angeles), YuKun Ho (Fudan University)

The trajectory of most vacuum laser acceleration schemes is a straight line and the electron beam can obtain a small net energy gain only within two times of laser Rayleigh length. A novel regime of electron beam dynamics trajectories in intensive laser field has been studied recently. The most prominent feature of those dynamics trajectories is that the incident electron beam can be captured into an intensive laser field region in a curved trajectory, rather than expelled from it as predicted by the ponderomotive potential model [Q.Kong, et al., Phys. Rev. E 61, 1981 (2000)]. A proposal to demonstrate a proof-of-principle experiment at Brookhaven Accelerator Test Facility is presented. The key parameters to meet the experiment requirements are discussed. The preliminary simulation results, e.g., energy gain and energy spectrum using ATF existing laser and electron beam, are presented.

* This work is supported by DOE contract No. DE-FG03-92ER40695.

TPPG036 Surface Roughness Effect on a Moving Bunch

Samer Banna, Levi Schachter (Technion - Israel Institute of Technlology), Robert Siemann (SLAC)

The acceleration structure of the next linear collider, designed to operate in the X band, is manufactured with an accuracy of about 1 micron. These four orders of magnitude difference between the operating wavelength and the typical surface roughness cannot be maintained in the case of a vacuum optical accelerator whose operating wavelength is 1 micron, since it entails engineering the structure at the atomic level, 1 Å. Consequently, it is essential to investigate the impact of the surface roughness on the wakefield of a moving bunch within an optical structure. In this study we consider the effect of the surface roughness on an electron bunch. The model employed consists of a cylindrical waveguide to which grooves of random width, height and location are attached. It is demonstrated that the mean value and the standard deviation of the energy emitted by an electron bunch traversing such a structure are virtually independent of the momentum and exponentially dependent on the length of the bunch; the mean value is linearly dependent on the geometrical roughness parameter.

TPPG037 High-Gradient Plasma Wakefield Acceleration of a Witness Beam

N. Barov, D. Bollinger (Northern Illinois University), H. Edwards, J. Santucci (FNAL), J.B. Rosenzweig, M.C. Thompson (University of California, Los Angeles)

In the Fermilab-NICADD plasma wakefield experiment, the drive beam couples a large fraction of its energy into an electrostatic plasma wave. Some of this energy can be used to accelerate an appropriately delayed witness beam, where the process is limited by beam-loading of the wave at high witness beam charge. We report on initial results of creating a witness beam in the same RF photoinjector gun as the driver, compressing both pulses in a dipole chicane, and observing the energy gain and loss in the plasma.

TPPG038 Numerical Study of Interference between Transition Radiation and Cerenkov Wake Field Radiation in Dielectric Structures

J.-M. Fang, Thomas C. Marshall (Columbia University), V. Tarakanov (Omega-P, Inc.), Jay L. Hirshfield (Omega-P, Inc. and Yale University)

The PIC code KARAT is used to study the interference between transition radiation and Cerenkov wake field radiation, set up by the passage of a bunch of charge through a dielectric structure of finite length. The transition radiation which is emitted when the bunch enters or leaves the structure is typically omitted in theoretical treatments of the wake fields. The transition radiation effect was reported in 2000 [T.C. Marshall et al., p. 316, Advanced Accelerator Concepts Workshop, AIP Conference Proceedings Santa Fe, NM (June, 2000); AIP #569] and was recently treated analytically using a simplified model by Onishchenko et al [Onishchenko, I.N., Sidorenko, D. Yu, and Sotnikov,G. V., Phys. Rev. E65, 066501 (2002)]. Our first results treat the case of a bunch passing down a 3 mm hole in a multimode dielectric cylinder made of alumina. Another example studied is a tall, dielectric-lined rectangular wake field microstructure, recently proposed as a stageable element of an advanced linear accelerator, which would use a train of fsec-duration bunches. These bunches would be chopped out of a longer bunch using a powerful CO2 laser [T.C. Marshall, C. Wang, and J.L. Hirshfield, Physical Review Special Topics - Accelerators and Beams 4, 121301 (2002)] and formed into a rectangular-profile bunch by a quadrupole. The bunches set up a periodic wake field which can be built up to as much as 600 MV/m using ten 3 fsec bunches each containing a charge of 1 pC. Of interest is the difference in relative propagation speeds of the transition radiation and the Cerenkov radiation (which travels almost at c), and the magnitude of the fields. Implications for future experiments will be discussed.

* Research supported by the Department of Energy, Division of High Energy Physics.

TPPG039 Generation of Single Pulse Particle Beams in a Plasma Channel by Laser Injection in Laser Wake Field Accelerators

Rodolfo Giacone, John Cary, Chet Nieter (University of Colorado at Boulder)

The generation of ultrashort single electron bunches by colliding laser pulses has been proposed by E. Esarey [E. Esarey, R.F. Hubbard, W.P. Leemans, A. Ting and P. Sprangle, Phys. Rev. Lett. 14, 2682 (1997)]. The results of our 2D particle-in-cell simulations have shown that in addition to the bunch created by pulse collision, a train of pulses is also generated by a different mechanism [J.R. Cary at this conference]. In this paper, we show that it is possible to achieve a single pulse, high quality beam if the generation of the plasma wake field takes place in a plasma channel. We performed two-dimensional PIC simulations of beam injection by colliding laser pulses in a channel using the VORPAL code. We observed that for the right set of plasma and pulse parameters it is possible to suppress the generation of multiple pulses and obtain a high quality 40 MeV single bunch with energy spread less than 5% and normalized emittance of less than 1 pi-mm-mrad.

TPPG040 Design of a Multi-Stage LWFA in a Plasma Channel

Bahman Hafizi, Daniel Gordon, Arie Zigler (Icarus Research, Inc.), R.F. Hubbard, P. Sprangle, A. Ting (Naval Research Laboratory)

The laser wakefield accelerator (LWFA) is one of a group of concepts under investigation for future high-gradient accelerators. Design of a multi-stage LWFA in a plasma channel is discussed. The plasma

channel, formed by a current discharge through a capillary, allows for optical guiding of the laser beam over many Rayleigh ranges. The plasma density in the various stages is adjusted to reduce the effect of electron dephasing. PIC simulations are employed to determine the energy gain expected from the laser and plasma system available at NRL. The PIC simulations follow electrons from the injector, into the discharge and through the wakefield. The model includes the effect of the magnetic field associated with the discharge current and tunneling ionization of the wall material by the laser beam.

* Supported by DoE (SBIR) and ONR.

TPPG041 A Method for Tuning Dielectric Loaded Accelerating Structures

Alex Kanareykin (Euclid Concepts LLC), Wei Gai, John G. Power (ANL), A. Altmark, E. Sheinman (St. Petersburg Electrical Engineering University)

We present a method to vary the resonant frequency of a dielectric loaded accelerating (DLA) structure driven by either the wakefield of a beam or an external rf source. The structure consists of a thick ceramic layer backed by a thin layer of ferroelectric. The overall frequency of the DLA structure is tuned by applying a DC bias voltage to the ferroelectric layer in order to vary its permittivity. This scheme is needed to compensate for frequency shifts in DLA structures due to machining imperfections and dielectric constant inhomogeneity. We have identified BST ferroelectric-oxides compounds as a suitable material for this application; it has a relative dielectric constant that can be tuned from 300 to 500. Thus, the overall frequency of the structure can be tuned over a range of (2-4)% for an X-band DLA structure. In this paper, a detailed model of the DLA structure is given and an experimental test is proposed for both cylindrical and planar geometries. We present cold test measurements for an 11.424 GHz tunable DLA structure.

TPPG042 A Tunable Dielectric Structure with Built in Transverse Mode Suppression

Alex Kanareykin (Euclid Concepts LLC), A. Altmark, E. Sheinman (St. Petersburg Electrical Engineering University)

Recently, a method for tuning dielectric-loaded accelerating (DLA) structures has been proposed [A. Kanareykin, these proceedings]. In these structures, a ferroelectric layer backs a conventional ceramic layer, thus allowing the effective dielectric constant of the waveguide to be varied by applying a DC electric field to the ferroelectric layer. In this paper, we present a design for a cylindrical version of this multilayered, tunable DLA structure that has the additional benefit of suppression of transverse deflecting modes [E. Chojnacki, et. al., J. Appl. Phys. 69, 6257 (1991)] due to the axially segmented conducting wall. This structure consist of a layer of conventional ceramic, surrounded by a thin layer of a ferroelectric, that is in turn surrounded by axially-oriented, insulated microstrip electrodes and a layer of absorbing material (ferrite). The axial orientation of the microstrips means that transverse deflection modes are suppressed, since they require an azimuthal current, while longitudinal accelerating modes are allowed, since they only require axial currents. We will present calculations of the relevant accelerator parameters for a cylindrical DLA structure.

TPPG043 Transformer Ratio Enhancement Experiment

Alex Kanareykin (Euclid Concepts LLC), Wei Gai, John G. Power (ANL), A. Altmark, E. Sheinman (St. Petersburg Electrical Engineering University)

Recently, a multibunch scheme for efficient acceleration based on dielectric wakefield accelerator technology was outlined [J.G. Power, PAC Proceedings, 114 (1999)]. In this paper, we outline an experimental program for the design, development and demonstration of a High Transformer Ratio Dielectric Wakefield Accelerator (HTR-DWA). The principal goal is to increase the transformer ratio R, the parameter that characterizes the energy transfer efficiency from the accelerating structure to the accelerated electron beam. We present results from an experimental test of this method for an accelerating structure which allows an enhancement of the transformer ratio by up to a factor of 4 compared to a conventional collinear accelerating scheme. We use a ramped bunch train (RBT) of 4 bunches in a 13,625 GHz ceramic structure with dielectric permittivity of 15,7 and Q-factor of 10,000 to potentially achieve a transformer ratio of 7.6 We will show parallel computing BBU simulations for the bunch train of 4 bunches of 10, 30, 50, 70 nC with 0.4 cm bunch length. This transformer ratio enhancement technique based on our ceramic waveguide design may result in a highly efficient accelerating structure for future generation wakefield accelerators.

TPPG044 A Double-Layered, Planar Dielectric Accelerating Structure

Alex Kanareykin (Euclid Concepts LLC), A. Altmark, E. Sheinman (St. Petersburg Electrical Engineering University)

Recently, a method to tune dielectric-loaded accelerating (DLA) structures has been proposed [A. Kanareykin, these proceedings]. In these structures, a ferroelectric layer backs a conventional ceramic layer, thus allowing the effective dielectric constant of the waveguide to be varied by applying a DC electric field to the ferroelectric layer. In this paper, we present a design for a planar version of this double-layered, tunable DLA structure. The advantage of the planar waveguide is its spectral uniformity, ease of frequency tuning, and its simplicity of fabrication. The dispersion equation for the structure and the accelerating wakefield exited by a planar electron bunch has been calculated. Based on this work, we present simulation results for 13, 20 and 35 GHz structures including losses in the bulk dielectric, bulk ferroelectric, and the conducting wall. Our results show that for this frequency range the dissipated power is primarily due to wall losses. In addition, we present the results of cold test measurements for an 11.4 GHz, double-layered, ceramic-ferroelectric test device, including tuning range and Q measurements.

TPPG045 Generation of an Ultra-Short Relativistic-Electron-Bunch by a Laser Wakefield

Arsen Khachatryan, Klaus Boller, Fred van Goor (Twente University)

The possibility of an ultra-short (about one micron long) relativistic (up to a few GeVs) electron-bunch generation in the moderately nonlinear laser wakefield excited in an underdense plasma by an intense laser pulse is shown. The ultra-short bunch is formed by trapping, effective compression (both in longitudinal and in transverse directions) and acceleration of initially nonrelativistic (with kinetic energy of a few hundreds keVs) e-bunch that is injected in front of the laser pulse. The initial bunch may be of poor quality and has a duration in the order of the laser pulse length or longer and can be generated by a laser-driven photo-cathode RF gun. Our 1D and 3D calculations predict that the accelerated ultra-short bunch should show a low energy spread of less than one percent and a low transverse emittance in order of a nanometer. An energy gain in the GeV-range is feasible at an accelerating distance of a few centimeters. The total number of accelerated electrons is restricted by the beam loading effect only and can reach the value of 10^8-10^9.

TPPG046 Charged Particle Interaction with a Chirped Electromagnetic Pulse

Arsen Khachatryan, Klaus Boller, Fred van Goor (Twente University)

It is found that a charged particle can get a net energy gain from the interaction with an electromagnetic chirped pulse. Theoretically, the energy gain increases with the pulse amplitude and with the relative frequency variation in the pulse.

TPPG047 Laser Wakefield Acceleration Experiment at KERI

Guang-Hoon Kim, Changbum Kim, Jong-Uk Kim, Hae-Jun Lee, Hyyong Suk (Korea Electrotechnology Research Institute)

Laser wakefields have been well-known as a method to accelerate particles, including electron, ion, and even photon. At Korea Electrotechnology Research Institute (KERI) in Korea, a TW Ti:Sapphire/Nd:glass hybrid laser system is established recently. In this paper, the performance of the laser system will be presented. And the experimental topics using laser wakefiels will be discussed. The topics are self-modulated laser wakefield acceleration, trapping and acceleration of background electrons using density transition, electron acceleration using tappered plasma density.

TPPG048 Staged Laser Acceleration Using Upgraded ATF CO_2 Laser

Wayne Kimura, Lora Campbell, Christian Dilley, Stephen Gottschalk, David Quimby (STI Optronics, Inc.), Marcus Babzien, Ilan Ben-Zvi, Juan Gallardo, Karl Kusche, Igor Pogorelsky, John Skaritka, Vitaly Yakimenko (BNL), Richard Pantell (Stanford University), Loren Steinhauer (U. of Washington, Redmond Plasma Physics Lab.), David Cline, Feng Zhou (University of California, Los Angeles)

The Brookhaven National Laboratory (BNL) Accelerator Test Facility (ATF) CO_2 laser has been upgraded to increase the available peak power by over 10 times. This more powerful laser beam is used to drive the Staged Electron Laser Acceleration (STELLA-II) experiment, which features an inverse free electron laser (IFEL) buncher, a hybrid permanent magnet/electromagnet chicane, and an IFEL accelerator using a gap-tapered permanent magnet undulator all built by STI Optronics. Electron energy gains of over 13% have already been observed using an 8% gap-taper and lower laser power. The higher laser power permits using a larger tapered undulator (up to 19%) in the accelerator IFEL. This enables demonstrating monoenergetic laser acceleration of the microbunches produced by the buncher and chicane while simultaneously achieving a clean separation in energy between the accelerated microbunch electrons and the unaccelerated background electrons. The latest experimental results and comparison with the model predictions will be presented.

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TPPG049 Electron Acceleration by Laser Wakefields in Tapered Plasma Densities

Hae June Lee, Changbum Kim, Guang-Hoon Kim, Jong-Uk Kim, Hae June Lee (Korea Electrotechnology Research Institute)

In recent years, methods for acceleration of plasma electrons by laser wakefields have received much attention as they do not need external injections and can achieve much higher acceleration gradients than in conventional RF-based accelerators. At KERI we have an ongoing research program to trap and accelerate background plasma electrons by a laser wakefield. In this presentation, we show 2-dimensional simulation results for energy enhancement of trapped and accelerated plasma electrons when the laser wakefield propagates in a plasma with a tapered density. We also present the potential experiment with the 2 TW Ti:sapphire/Nd:glass laser to investigate the issue of energy enhancement by tapered plasma densities.

* This work is supported by the Creative Research Initiatives of the Korea Ministry of Science and Technology.

TPPG050 Focusing of 28.5 GeV Electron and Positron Beams in a Meter-Long Plasma

Patrick Muggli, S. Deng, T. Katsouleas, S. Lee (University of Southern California), F.-J. Decker, M.J. Hogan, R. Iverson, C.L. O'Connell, P. Raimondi, R. Siemann, D. Walz (SLAC), B.E. Blue, C.E. Clayton, E.S. Dodd, C. Huang, C. Joshi, K. Marsh, W. Mori (University of California, Los Angeles)

Electron and positron bunches can drive large amplitude plasma waves or wakes. These wakes have large radial field components that focus both electron and positron bunches. The understanding of electron and positron beams focusing and propagation in long plasmas is critical for future high-gradient plasma accelerators. In the case of electron bunches with a density larger than the plasma density, focusing and multiple betatron oscillations of the beam envelope are observed as a function of the plasma density. In this regime, the focusing field is constant along the core of the bunch and varies linearly with radius, leading to an aberration-free focusing of most of the bunch. No significant beam emittance growth is observed experimentally. In the case of positron bunches with the same parameters focusing is observed only in one plane, and no betatron oscillations are observed. In the plane where the bunch is focused the bunch size at the plasma exit remains constant up to the maximum plasma density achieved, approximately 3e14 electrons per cubic centimeter. The formation of a beam halo is observed. The focusing field varies nonlinearly along the bunch and bunch radius and emittance growth is expected. In both cases beams with beta functions of the order of 10 cm at the plasma entrance are channeled over 1.4 m. Experimental highlighting the difference between the focusing electron and positron beams will be presented.

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TPPG051 Energy Gain by Electrons in a High-Gradient Plasma Wakefield Accelerator

Patrick Muggli, S. Deng, T. Katsouleas, S. Lee (University of Southern California), B.E. Blue, F.-J. Decker, M.J. Hogan, R. Iverson, C.L. O'Connell, P. Raimondi, R. Siemann, D. Walz (SLAC), C. Clayton, E.S. Dodd, C. Huang, C. Joshi, K. Marsh, W. Mori (University of California, Los Angeles)

A plasma wakefield accelerator (PWFA) experiment is performed at the Stanford Linear Accelerator Center to demonstrate the high gradient acceleration of electrons and positrons in plasmas. The 2.3 ps, 28.5 GeV electron bunch with 2e10 electron is sent in a 1.4 m long plasma with a density between 0 and 2e14 electrons per cubic centimeter. The plasma is obtained by photo-ionization of a lithium vapor by a uv laser pulse. The bunch excites a large amplitude plasma wake, and the particles in the core of the bunch loose energy. At the highest plasma density the plasma wake wavelength becomes comparable to the bunch length, and particles in the back of the bunch are accelerated. Energy loss and gain are observed experimentally using an imaging magnetic spectrometer. The average energy loss is obtained from time integrated energy spectra, while dispersing the energy spectra in time is necessary to measure energy loss and gain by picosecond bunch slices. The average energy loss and gain by slices are approximately 150 MeV. The maximum observed energy gain is larger than 300 MeV corresponding to an accelerating gradient larger than 200 MeV/m over the 1.4 m plasma length. These results demonstrate for the first time the energy gain by particles in a high gradient PWFA and are a significant step toward a future energy doubler for an electron/positron collider.

* Work supported by US DoE grants DE-FG03-92ER40745, DE-AC03-76SF00515, DE-FG03-98DP00211, DE-FG03-92ER40727, and NSF grants ECS-9632735, DMS-9722121.

TPPG052 VORPAL: A Computational Tool for the Study of Advanced Accelerator Concepts

Chet Nieter, John R. Cary (University of Colorado)

VORPAL, a fully object-oriented, dimension-free plasma simulation code, now has matured and is being used to study advanced accelerator concepts, particularly Laser Wake Field Acceleration. Both fluid and PIC models exist in the code and they can be used independently or in conjunction to perform hybrid simulations. VORPAL has a moving window and the ability to launch laser pulses from boundaries or initialize pulses in the plasma. VORPAL can accomidate a variety of different issues in LWFA, including chirped pulses, propagation of pulse in plasma channels, and optical injection of particle beams.

TPPG053 Parallel Optimization through Dynamic Load Balancing

Viktor Przebinda, John R. Cary, Chet Nieter (University of Colorado)

VORPAL is a parallel PIC/FLUID code used to simulate laser plasma interactions. For simulations with an even distribution of particles, VORPAL scales very well in parallel. However, when simulating systems in which particles are localized to certain regions, performance suffers. One solution currently implemented is a configurable static decomposition. This, however, is insufficient since load distribution may frequently and significantly change at runtime. Therefore, we have implemented a dynamic load-balancing system. This system monitors each processor's usage and redistributes workload accordingly. VORPAL uses use a number of techniques to implement this solution while minimizing the overhead of a dynamic system.

TPPG054 Optical Injection of Electrons in Resonantly Excited Plasma Wakefields

Ned Saleh, S. Chen, W. Theobald, D. Umstadter, C. Widjaja, V. Yanovsky, P. Zhang (FOCUS center, University of Michigan)

The concept of optical injection of plasma background electrons in resonantly driven wakefields has been extensively studied theoretically [e.g., Umstadter et al. Phys Rev. Lett. Vol. 76, 2073(1996)]. It was shown that when a strong 1-D wakefield is ponderomotively excited by an ultra-short laser pulse comparable in duration to the plasma wave and a similar transverse laser pulse, but otherwise tightly focused onto the wakefield, is introduced, an electron bunch with a very narrow (a few %) energy distribution, and very short duration (10's fs) is produced. An experiment was performed using the University of Michigan's Hercules laser, a 100-TW-class, CPA-based Titanium-doped Sapphire laser system whose output is centered at λ = 810 nm and capable of producing two independent laser pulses individually compressible down to 30 fs. The two beams were implemented as pump and injection pulses. The former is loosely focused by f/20 parabolic mirror, and the latter is tightly focused by f/3 parabolic mirror, both spatially and temporally overlapping in an under-dense supersonic He gas jet. We will present results of electron and plasma diagnostic measurements and compare them with theoretical predictions.

* Supported by the Division of High Energy Physics, Office of Science, U.S. DOE, award DE-FG02-98ER41071, with lasers supported by NSF.

TPPG055 Experimental and Numerical Studies of Dielectric Wake Field Acceleration Devices

Sergei Shchelkunov (Unknown Affiliation), J.-M. Fang, Thomas C. Marshall (Columbia University), Jay L. Hirshfield (Omega-P, Inc. and Yale University), L. Meng (Yale University and University of Electronic Science and Technology of China)

Results are reported from two experiments concerning wake fields set up by Cerenkov radiation from bunches passing through a cylindrical dielectric liner made of alumina. In each case, the bunches excite many TM modes, and the Ez component of wake field is sharply localized on the axis, periodically behind the bunches [T.-B. Zhang, et al., Physical Review E56 , 4647 (1997)]. The first experiment is at ATF Brookhaven, and uses up to three 50 MeV bunches spaced by one wakefield period (21 cm) to study the superposition of wake fields by measuring the energy loss of each bunch after it passes through the 53-cm long dielectric element. Previously, measurements of the TM spectrum from a single bunch were reported [J-M. Fang, et al., Proceedings of the 1999 Particle Accelerator Conference, Vol. 5, p. 3627. IEEE catalog number 99CH36366, (1999) 2]. The millimeter-wave spectrum of radiation excited by the passage of up to three bunches will be reported, with an accompanying interpretation. A second related experiment at Yale studies the accumulation of wake field energy in a resonant dielectric-loaded cavity [T.C. Marshall et al., p. 316, Advanced Accelerator Concepts Workshop, AIP Conference Proceedings Santa Fe, NM (June, 2000); AIP #569] by a lengthy train of bunches obtained from a 6 MeV thermionic rf gun (also at 2.8 GHz). The length of the resonator (10.5 cm) is equal to the bunch spacing and the wake field period; the number of bunches is controlled by a gated ExB 'chopper'. The energy loss of the bunches is monitored to determine limits to superposition. The advantage of the resonator configuration over a simple linear device is that bunch stability becomes less an issue because of the device's short length. Results from these experiments are compared with simulations using the PIC code KARAT.

* Research supported by the Department of Energy, Division of High Energy Physics.

TPPG056 Multicavity Proton Cyclotron Accelerator

Changbiao Wang (Yale University), Vyacheslav P. Yakovlev (Omega-P, Inc.), Jay L. Hirshfield (Omega-P, Inc. and Yale University)

Analysis has been presented for a multicavity proton cyclotron accelerator in which a 122 mA, 1 MeV proton beam is accelerated to 961 MeV using a cascade of eight cavities in an 8.1 T magnetic field [J. L. Hirshfield, C. Wang, and V. P. Yakovlev, Phys. Rev. STAB 5, 081301 (2002)]. The first cavity operates at 120 MHz, and successive cavities have resonance frequencies lower in increments of 8 MHz. For this example, average acceleration gradient exceeds 40 MV/m, average effective shunt impedance is 223 MW/m, but maximum surface field in the cavities does not exceed 7.2 MV/m. Such an accelerator might be suitable for driving a high-power neutron spallation source, provided a number of practical issues can be addressed. Prior analysis [J. L. Hirshfield, C. Wang, and V. P. Yakovlev, Phys. Rev. STAB 5, 081301 (2002)] for this accelerator concept has been for an injected beam of zero emittance and idealized cavity geometry, while the results presented here are for finite emittance and realistic cavity geometry. Furthermore, details are presented for a two-stage electron counterpart configuration that is designed to test the underlying acceleration mechanism and to determine the maximum acceptance phase angle for the injected proton beam.

* Research sponsored by US Department of Energy, Division of High Energy Physics.

TPPG057 Stability of Electron Orbits in the Strong Wake Fields Generated by a Train of FSEC Bunches

Changbiao Wang (Yale University), Thomas C. Marshall (Columbia University), Jay L. Hirshfield (Omega-P, Inc. and Yale University)

A tall, dielectric-lined rectangular wake field microstructure is being analyzed as a possible stageable element of an advanced linear wake field accelerator, to be driven by a train of fsec microbunches. These microbunches would be chopped out of a longer bunch using a powerful CO2 laser [T.C. Marshall, C. Wang, and J.L. Hirshfield, Phys. Rev. STAB 4, 121301 (2002), and formed into a rectangular-

profile bunch using a quadrupole. The fsec bunches set up a periodic wake field in the microstructure that can be built up to 600 MV/m, for example, using ten 3-fsec bunches each containing 1 pC of charge [S.Y. Park, C. Wang and J.L. Hirshfield, AAC 2002 (to be published)]. Results are described from computations of test particle electron orbits in the longitudinal and transverse wake fields excited by these fsec bunches. Transverse stability limits on the length of individual wake field accelerator elements are discussed.

* Research supported by the Department of Energy, Division of High Energy Physics.

TPPG058 The Calculations of a Hybrid Dielectric-Iris-Loaded Traveling-Wave Acceleration Structure

Cong-Feng Wu, Sai Dong, Guangyao Feng, Yuanji Pei, Lin Wang (National Synchrotron Radiation Lab)

The dispersion property and the propagation characteristics of the accelerating mode (TM01 mode) and higher-order-modes about a new hybrid dielectric-iris-loaded traveling-wave acceleration structure have been analyzed and discussed by the field matching method. MAFIA code has been used to calculate the RF properties versus the geometric parameters and dielectric permitivity of the new acceleration structure for TM01 mode. The simulation results show that the new structures may have lower ratio(about 1) of peak surface electric field at the iris to axial acceleration electric field (the conventional iris-loaded acceleration structure's ratio is higher 2), while the r/Q of the new structure being comparable to the one of iris-loaded accelerating structure. The above calculations will be applied to the design of the new hybrid dielectric-iris-loaded traveling-wave acceleration structure, which may be a potential candidate of high-gradient Linear accelerator.

* This work was supported by the National Nature Science Foundation of China, Grant No. 10205014.

Wednesday, May 14, 2003

Session WOAA: Lepton Accelerators & Colliders
Grand Ballroom II at 8:30
Session Chairs: F. Willeke, D.L. Rubin

WOAA001 Future Plans for e^+e^- Factories
Caterina Biscari (INFN)

In the last decade particle factories have greatly increased lepton colliders' luminosities. Several are the reasons: progress in the handling of high currents and multibunch regimes, in the understanding of beam-beam interaction limits, in particle dynamics simulation codes, in the diagnostic systems to control beam sizes and orbits, in the background shielding and rejection by the experiments. Now is time to go further in the high luminosity frontiers: experiments are asking for more precision in measurements, and the accelerator community is facing projects where an increase of luminosity by orders of magnitude is conceivable. New ideas, main upgrades and plans in the factories presently in operation around the world are the subject of this paper.

WOAA002 Interaction Region Upgrades of e^+e^- B-Factories
Michael Sullivan (SLAC)

Both the PEP-II and KEKB B-Factories have plans to upgrade their Interaction Regions (IRs) in order to improve luminosity performance. Last summer PEP-II added cooling to the IR beam pipe in order top increase beam currents and raise the luminosity. In addition, PEP-II is working on a design that modifies the permanent magnets near the interaction point for an even higher luminosity increase. KEKB is also planning an improvement in their IR that will decrease their detector Be beam pipe radius. In addition, KEK has a design to increase the luminosity of KEKB to $1x10^{35}$ cm^{-2} sec^{-1} which includes changes to the IR. PEP-II is also investigating the feasibility of a $1x10^{36}$ cm^{-2} sec^{-1} luminosity design. I will summarize these various upgrades and concentrate on issues common to the different design plans.

∗ Work supported by US Department of Energy contract DE-AC03-76SF00515.

WOAA003 Recent Developments in Lattice Designs for e^+e^- Colliders
Haruyo Koiso (KEK)

Positron-electron double-ring colliders with the luminosity of 10^35 /cm^2/s are being designed as super-B factories. In such high-luminosity machines, the vertical beta function at the interaction point should be squeezed to 3 mm. Lattice designs for these rings should also meet various requirements for machine parameters: short bunch spacing (60 cm), small momentum compaction factor to reduce the rf voltage for short bunch length (3 mm), relatively high emittance for high bunch curren, large dynamic aperture for good injection efficiency and long beam lifetime, etc. In this paper we will discuss the feasibility of small-beta lattices based on simulations with realistic modeling of final-focus elements.

WOAA004 Build up of Electron Cloud with Different Bunch Patterns in the Presence of Solenoidal Field
Yunhai Cai (SLAC), Miguel Furman, Mauro Pivi (LBNL)

We have augmented the code POSINST to include solenoidal fields, and used it to simulate the build up of electron cloud due to electron multipactoring in the PEP-II positron ring. We find that the distribution of electrons is strongly affected by the resonances associated with the cyclotron period and bunch spacing. In addition, we discover a threshold beyond which the electron density grows exponentially until it reaches the space charge limit. The threshold does not depend on the bunch spacing but does depends on the positron bunch population.

∗ Work supported by the Department of Energy under Contract No. DE-AC03-76SF00515.

WOAA005 Study of Beam-Beam Interactions with/without Crossing Angle in a Circular e^+e^- Collider
Kazuhito Ohmi, Oide Katsunobu, Tawada Masafumi (KEK)

In recent e^+e^- collider, the collision scheme with a finite crossing angle is being popular. The scheme makes it possible to collide two multi-bunch beams with a high repetition, and to get the luminosity gain due to the repetition multiplicity. The validity of the collision with a finite crossing angle is certified by the success of KEKB. The luminosity of KEKB is very high, $L=8.26 \times 10^{33}$ $cm^{-2}s^{-1}$, while the beam-beam parameter, 0.04 ~ 0.05, is not best in the world. We compare the beam-beam effects of collisions with and without crossing angle and discuss the possibility toward higher beam-beam parameter and higher luminosity.

WOAA006 High Intensity Issues for Super B-Factories
Kazunori Akai (KEK)

Two B-factories, KEKB and PEP-II, have achieved remarkable luminosity that allowed to observe CP violation in the neutral B meson system. As luminosity upgrade of these machines by ten times or more to extend further the physics coverage, Super-B factories are being considered. In order to achieve the unprecedented luminosity of 10E35 /cm2/s, stored beam current should be about 10 A in Low Energy Ring and 4A in High Energy Ring, respectively. It is very challenging for hardware components, especially for RF system and various vacuum components, to store such a large beam current with a short bunch length of about 3mm. The high intensity issues for Super B-factories will be discussed.

WOAA007 R&D Towards Neutrino Factories and Muon Colliders
Kirk McDonald (Princeton University)

Neutrino factories based on muon storage rings, and muon colliders, offer excellent physics opportunities for detailed exploration of neutrino oscillations, for S-channel Higgs boson production with a very narrow beam energy spread, and for studies of other electroweak phenomena at the energy frontier. The Neutrino Factory and Muon Collider Collaboration, together with international partners, has conducted two design studies of neutrino factories, and maintains ongoing theoretical studies of 6-D ionization cooling in both linear structures and in rings, along with laboratory R&D on pion/muon production with pulsed, multimegawatt proton sources, and on components of ionization-cooling systems including high-gradient rf (both conventional and superconducting), low-Z absorbers (LH2 and LiH), large-bore solenoids (with rapid axial field variation), large aperture kickers, etc. A demonstration experiment for ionization cooling is the next major step towards realization of the powerful concept of muon-based accelerator facilities.

WOAA008 100 Bunches DAFNE Operation
Alessandro Drago, David Alesini, Gabriele Benedetti, Maria E. Biagini, Caterina Biscari, Roberto Boni, Manuela Boscolo, Alberto Clozza, Giovanni Delle Monache, Giampiero Di Pirro, Alessandro Gallo, Andrea Ghigo, Susanna Guiducci, Fabio Marcellini, Giovanni Mazzitelli, Catia Milardi, Luigi Pellegrino, Miro A. Preger, Pantaleo Raimondi, Ruggero Ricci, Claudio Sanelli, Mario Serio, Francesco Sgamma, Alessandro Stecchi, Angelo Stella, Cristina Vaccarezza, Mario Vescovi, Mikhail Zobov (INFN)

The DAFNE collider has been operating by filling 100 consecutive buckets out of the available 120 with a gap to avoid ion trapping in

the electron beam. To reduce the effect of the parasitic crossings the crossing angle has been increased up to 30 mrad and the horizontal beta function at the interaction point lowered down to 1.7 m. Moreover both transverse and longitudinal feedbacks have been optimized for this more demanding mode of operation. Comparison between 100 and 50 bunches operation in 2002 runs is presented.

WOAA009 Study of Beam-Beam Effects in HERA With Self-Consistent Beam Simulations

Jack Shi, Lihui Jin (University of Kansas), Georg Hoffstaetter (Cornell University)

In the luminosity upgrade for HERA, the beam-beam parameter of electron beam will be doubled approximately. To examine any possible luminosity reduction due to beam-beam effects, several beam experiments were performed on HERA (HERA Accelerator Studies 2000). In order to have a better understanding of those experimental data and to evaluate the beam-beam effect in the HERA upgrade, a self-consistent beam-beam simulation in HERA was conducted by using one million macro-particles with the particle-in-cell method. The dynamics of beam-size growth and the stability of the coherent beam-beam oscillation were studied. A remarkable agreement between the experimental measurement and the simulation result was observed. For the current HERA upgrade parameters, the simulation showed that the beam-beam interaction could induce a chaotic coherent beam-beam instability that could result in emittance blowup and roughly 50% luminosity reduction. The study also showed that this coherent beam-beam instability could be avoided with a slightly different working point. In the HERA upgrade, the beam-beam parameter of the electron beam is over 20 times larger than that of the proton beam and the two rings have a very different working point. Traditionally, the beam-beam effect in HERA is considered as a typical strong-weak or highly un-symmetrical case. For high intensity beams, therefore, nonlinear beam-beam effects could dominate the beam dynamics and results in a coherent beam-beam instability even in a strong-weak situation.

* This work is supported by the US Department of Energy under Grant No. DE-FG03-00ER41153.

WOAA010 Electron-Ion Collisions at RHIC Using a High Intensity Self-Polarizing Electron Ring

Vadim Ptitsyn, Jorg Kewisch, Brett Parker, Stephen Peggs, Dejan Trbojevic (BNL), Dmitry E. Berkaev, Ivan A. Koop, Alexei V. Otboev, Yuri M. Shatunov (BINP), Desmond P. Barber (DESY), Chris Tschalaer, Fuhua Wang, Jan B. van der Laan (MIT-Bates)

We consider the design of an electron-ion collider realized by adding a self-polarizing electron ring to the existing RHIC collider. It would provide polarized electron-proton and unpolarized electron-ion beam collisions in the center of mass energy range of 30-100 Gev and at luminosities up to 10^{33} $cm^{-2}s^{-1}$ for e-p and 10^{31} $cm^{-2}s^{-1}$ for e-Au collisions. An electron storage ring lattice has been developed which provides a short polarization time for an electron beam in the 5-10 GeV energy range and which satisfies the luminosity goals. We describe the modifications to the RHIC interaction region layout required for both efficient beam separation and also for longitudinal electron and proton beam polarization at the collision point.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

WOAA011 Investigation of the Flat-Beam Model of the Beam-Beam Interaction

Bjoern Schmekel, Georg Hoffstaetter, Joseph Rogers (Cornell University)

At the interaction point of a storage ring collider each beam is subject to perturbations due to the electromagnetic field of the counter-rotating beam. For flat beams, a well known approximation models the beam by a current sheet which is uniform in the horizontal plane, restricting the particle motion to the vertical direction. In this classical model a water-bag beam distribution is used to find working points and beam-beam tune shift parameters which lead to a stable beam distribution. We try to find stability criteria for a more realistic Gaussian equilibrium distribution, additionally taking into account the damping of the betatron oscillations by synchrotron radiation. In order to analyze the instabilities, a linearized Fokker-Planck equation without the quantum excitation term is solved computing radial and angular modes up to first order in the displacement from the design trajectory. In a separate calculation we take a look at higher order resonances generated by the angular modes only.

* This work was sponsored by the National Science Foundation.

Session WOAB: Single Particle Beam Dynamics & Optics
Pavilion West at 8:30
Session Chairs: A. Ropert, S. Henderson

WOAB001 Review of Applications of Frequency Mapping to Particle Accelerators

Jacques Laskar (Bureau des Longitudes)

It has been now more than 10 years since Frequency Map Analysis has been introduced and proposed for its potential applications in accelerator physics (Dumas and Laskar, 1993). I will present a review of the progress that have been made on the theoretical aspect of this method, as well as the presentation of some of the current applications of frequency map analysis in particle accelerators.

WOAB002 Resonances and Beam Loss in High Intensity Rings

Alexei Fedotov (BNL)

An operation of high-intensity rings requires minimal beam loss. Among numerous effects which contribute to losses in a circular machine, the interplay of excited resonances is typically an unavoidable source of halo and beam loss. Such resonances could be driven by space charge itself, magnet errors or a combined effect of the above. In this paper we review several resonant effects which can limit achievable beam intensity in a circular machine. The space-charge limit and selection of a working point in the ring are also discussed.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WOAB003 Adiabatic Beam Trapping in Stable Islands of Transverse Phase Space: Measurement Results at CERN Proton Synchrotron

Massimo Giovannozzi, Roberto Cappi, Elias Métral, Gabriel Métral, Michel Martini, Rende Steerenberg (CERN), Anke Susanne Müller (ISS, Forschungszentrum Karlsruhe)

Recently a novel approach to the problem of multi-turn extraction was proposed. It consists of splitting the beam by adiabatic capture inside stable islands created in the transverse phase space by sextupoles and octupoles. Numerical simulations indicate that such a technique should be feasible and potentially superior to the method presently used at the CERN PS. During 2002, intense efforts were devoted to the experimental verification of this newly proposed extraction mode. Finally, beam capture into the islands was observed. In this paper, the extraction principle is briefly reviewed and the experimental results are presented and discussed in detail.

WOAB004 Beam Dynamics in the Storage Ring with Variably Polarized Wigglers

Ying Wu, Vladimir Litvinenko, Stepan Mikhailov (Duke University)

Single particle beam dynamics in the storage ring can be significantly influenced by long and strong field insertion devices, such as FEL wigglers in the light source ring and damping wigglers in the next generation damping ring. An explicit symplectic integrator for arbitrary wiggler field has been developed and used for detailed beam dynamics studies for storage rings with wigglers. A proper dynamics model is critical for uncovering the details of the stable phase space region with varying diffusion rates computed from the particle tracking data using the frequency analysis technique NAFF. We focus our studies on the influence of a 24m long variably polarized OK-5 FEL system to be installed in the Duke storage ring in 2003. Particle tracking simulations are performed for various operation modes of the FEL wigglers. Lattice parameters are then adjusted accordingly to optimize the dynamic aperture for a particular mode of FEL operation.

* Research supported by DoE grant DE-FG05-91ER40665.

WOAB005 Stochastic Cooling for RHIC

Michael Blaskiewicz, Joseph Brennan, Peter Cameron, Jie Wei (BNL)

Emittance growth due to intrabeam scattering significantly reduces the gold luminosity lifetime in RHIC. Stochastic cooling of the stored beam could improve things considerably. Viable pickup signals have been observed and a kicker on loan from FNAL installed. Kicker power estimates have been made and measurements of beam transfer functions are planned.

* This work was performed under the auspices of the United States Department of Energy.

WOAB006 Accelerator Physics Challenges of the FS-Slicing Upgrade at the ALS

Christoph Steier, Laurent Nadolski, Hiroshi Nishimura, David Robin, Weishi Wan, Alexander Zholents (LBNL)

The goal of the Femtoslicing project at the ALS is to provide 100-200 fs long pulses of soft and hard x-rays with moderate flux and with a repition rate of 10-40 kHz for experiments concerning ultrafast dynamics in solid state physics, chemistry and biology. The femtoslicing principle employs a femtosecond laser beam to interact resonantly (FEL interaction) with the electron beam in the ALS. The induced energy spread over the femtosecond duration is converted to a transverse displacement by exploiting the dispersion of the storage ring. The displaced femtosecond electron pulse then radiates and produces femtosecond synchrotron radiation. To achieve the necessary spatial separation of the energy modulated slice from the rest of the bunch, a sizeable local vertical dispersion bump in the undulator used as radiator is required. This presents challenges in terms of the nonlinear dynamics and control of the vertical emittance.

* This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

WOAB007 Heavy-Ion Beam Dynamics in the Rare Isotope Accelerator Facility

Petr Ostroumov (ANL)

The Rare-Isotope Accelerator Facility includes a cw 1.4 GV driver linac and a 124 MV post-accelerator both based on superconducting (SC) cavities. The driver linac can deliver 400 kW beams of any ions, including 900 MeV protons and 400 MeV/u uranium. Several new conceptual solutions in the physics design of heavy-ion SC linacs have been developed recently. Particularly, the concept of multiple charge state beam acceleration in SC linacs has been tested and will be used in the RIA driver linac to increase available accelerated beam power. To obtain 400 MeV/u uranium beams the driver linac uses two strippers followed by magnetic transport systems which provide six-dimensional matching of multiple-charge-state beams. Beam dynamics studies have been performed with the goal of optimization of the linac structure in order to reduce any effective emittance growth of the multi-q uranium beam. A post-accelerator for rare isotopes must produce high-quality beams of radioactive ions over the full mass range, including uranium, at energies above the coulomb barrier. To provide the highest possible efficiency for rare isotopes with masses from 6 to 240, the linac will accept all ions in the 1^+ charge state. A multiple-charge-state mode of operation can be used after the second stripper to produce higher intensities of accelerated radioactive beams.

* Work supported by the U. S. Department of Energy under contract W-31-109-ENG-38.

WOAB008 Spin Dynamics in AGS and RHIC

William MacKay, Leif Ahrens, Mei Bai, Ernest D. Courant, Joseph W. Glenn, Haixin Huang, Alfredo U. Luccio, Vadim Ptitsyn, Thomas Roser, Todd Satogata, Nicholaos Tsoupas (BNL)

A fundamental aspect of particle physics is the spin of the particles. With polarized beams, the internal structure of the proton may be probed in ways that are unattainable with unpolarized beams. The Relativistic Heavy Ion Collider (RHIC) has the unique capability of colliding protons with both transverse and longitudinal polarization at center-of-mass energies up to 500 GeV. In this paper we examine the methods used to accelerate and manipulate polarized proton beams in RHIC and its injectors. Special techniques include the use of a partial Siberian snake and an ac dipole in the AGS. In RHIC we use four superconducting helical Siberian snakes (two per ring) for acceleration, and eight superconducting helical rotators for independent control of polarization directions at two interaction regions.

* This work was performed under the auspices of the US DOE and RIKEN of Japan.

WOAB009 Beam Dynamics in a Storage Ring for Neutral (Polar) Molecules

Glen Lambertson (LBNL)

The force from a non-uniform electric field on the electric dipole moment of a molecule may be used to circulate and focus molecules in a storage ring. The nature of the forces from multipole electrodes are described for strong-field-seeking and for weak-field-seeking molecules. Fringe field forces are analyzed. Examples of storage ring designs are presented; these include long straight sections and provide bunching and acceleration.

* This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

WOAB010 Muon Acceleration in FFAG Rings

Eberhard Keil (FNAL), Andrew Sessler (LBNL)

Compared to muon acceleration in re-circulating linear accelerators, considered earlier, muon acceleration in FFAG rings holds the promise of having one arc instead of several, and a smaller number of RF cavities; i.e., using more than a few turns for acceleration from about 6 to about 20 GeV/c. We consider non-scaling FFAG machines (but with limited tune variation) that are essentially strong focusing rings with a dispersion small enough to keep muons over the full momentum range inside the same magnet aperture. We compare several scenarios: (i) Rings with straight sections, long enough—a few metres—to house super-conducting RF cavities at about 200 MHz (and with enough space for decay of the magnetic fields in neighbouring components to a level of about 10 milligauss; (ii) Rings with shorter straight sections, just long enough—about a metre—to house normal-conducting RF cavities also operating at about 200 MHz; (iii) Racetrack-shaped rings with compact arcs without RF cavities, joined

to long straight sections with superconducting RF cavities by adiabatic transition sections that match between them over the wide momentum range needed; (iv) Rings with a number of superperiods (about 10) so that there are only a number of sc RF sections. In all four scenarios we consider the travel time of the muons around the ring, which depends on the muon momentum and, hence, produces variable phase at the RF cavities during the acceleration process.

* Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy. This work was supported by the Director, Office of Science, Division of High Energy Physics, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

WOAB011 Transverse Impedance Distribution Measurements using Response Matrix Fit Method at APS

Vadim Sajaev (ANL)

The Advanced Photon Source storage ring has a number of narrow-gap insertion device vacuum chambers, and there is a plan to further increase their number. These vacuum chambers contribute to the impedance of the machine, and the impedance limits the single bunch current threshold. In order to understand their contribution, the distribution of the vertical transverse impedance around the circumference of APS storage ring has been determined using the response matrix fit method. This method allows us to find focusing errors around the storage ring and was originally used to determine and correct the linear model of the APS. The high accuracy of the method enables us to measure the variation of betatron phase advance around the ring with beam current. Results of these measurements are reported and the impedance of different parts of the storage ring is presented.

* This work is supported by U.S. Department of Energy, Office of Basic Energy Sciences under the Contract No. W-31-109-ENG-38.

Session WOAC: Extreme Beams
Pavilion East at 8:30
Session Chair: W. Herrmannsfeldt

WOAC001 Particle Acceleration from Chirped Amplification of NIF/LMJ Scale Lasers

T. Tajima (Japan Atomic Energy Research Institute)

WOAC002 Nano-Beams from an Electron Beam Ion Trap Source

Dieter Schneider, K. Holder, J. McDonald (LLNL), T. Schenkel (LBNL)

The possibility of and an approach to providing low intensity nano-beams(nm spot diameter) of low energy (approximately 2 keV/u) highly charged ions from an "Electron Beam Ion Trap-Source" are presented. The approach includes mask collimated ion beams and cooling of ions to lowtemperatures (≤100 K) in additional ion traps. Applications for low dose precision ion beam lithography and highly charged ion beam powered microscope type surface analysis tools are outlined.

WOAC003 Femtoseconds Electron Beam Diffraction Using Photocathode RF Gun

Xijie Wang, Z. Wu (BNL), H. Ihee (University of Chicago)

One of the 21st century scientific frontiers is to explore the molecule structure transition at the femt-second time scale. X-ray free electron laser (XFEL) is one of the tools now under development for investigating femtosecond structure transition. We are proposing an alternative technique - femtosecond electron diffraction based on the photocathode RF gun. We will present a design of a kHz femtoseconds electron diffraction system based on the photocathode RF gun. Our simulation shows that, photocathode RF gun can produce a 100 fs (FWHM) electron bunch with millions of electrons at about 2 MeV. This is at least one order of magnitude reduction in bunch length, and two orders of magnitude increase in numbers of electrons, compared to the present DC electron diffraction system. We will also discuss various issues and limitations related to femtosecond MeV electron diffraction.

WOAC004 Storage Ring Based Source of Coherent IR Radiation with Femtosecond Duration

Vladimir Litvinenko, Ying Wu (Duke University), Oleg A. Shevchenko (BINP)

The concept and parameters for a source of femtosecond coherent IR radiation based on a storage ring of medium energy are presented. The unique feature of this light source is the application of strong longitudinal focusing to compress and sustain the electron bunches circulating in the ring to an RMS duration from 10 to 100 fs. The time structure of the electron bunches is imprinted onto spontaneous synchrotron radiation including the intense coherent IR radiation at kW level of average power. The instrument required for this compression is an inverse mm-wave FEL that enhances the longitudinal focusing by three to four orders of magnitude compared with conventional RF systems.

* Work is supported by the Dean of Natural Sciences, Duke University.

WOAC005 Commissioning of the SPPS Linac Bunch Compressor

Patrick Krejcik (SLAC)

First results and beam measurements are presented for the recently installed linac bunch compressor chicane. The new bunch compressor produces ultra-short electron bunches for the Sub-Picosecond Photon Source (SPPS) and for test beams such as the E162 Plasma Wakefield experiment. This paper will give an overview of the first experiences with tuning and optimizing the compressor together with a description of the beam diagnostics and beam measurements. These measurements form the basis for further detailed study of emittance growth effects such as CSR and wakefields in a previously unmeasured regime of ultra-short bunch lengths.

* Work supported by DOE contract DE-AC03-76SF00515.

WOAC006 Beam Transport Experiments over a Single Turn at the University of Maryland Electron Ring (UMER)

Santiago Bernal, B. Beaudoin, Y. Cui, A. Diep, M. Glanzer, T. Godlove, I. Haber, J. Harris, R.A. Kishek, D. Lamb, H. Li, P.G. O'Shea, B. Quinn, M. Reiser, A. Valfells, M. Walter, M. Wilson, R. Yun, Y. Zou (University of Maryland)

The University of Maryland Electron Ring (UMER), designed for studies of space-charge dominated beam transport in a strong focusing lattice, is nearing completion. UMER models, for example, the recirculator machine envisioned as a possible driver for heavy-ion inertial fusion. The UMER lattice consists of 36 FODO periods distributed among 18 bending sections containing two ten-degree bending dipoles each. The main diagnostics are fluorescent screens and capacitive beam position monitors placed at the center of each bending section. In addition, pepper-pot and slit-wire emittance meters, as well as an energy analyzer are in operation. We present here results of beam matching and characterization for a range of currents extending from about 1 mA to 100 mA, all at 10 keV and 100 ns pulse duration. With typical focusing given by a zero-current betatron phase advance per period equal to 76 degrees, the range of

currents corresponds to tune depressions of 0.8 to 0.2. This range covers both the emittance dominated and extreme space-charge dominated regimes, which is unprecedented for a circular machine. We also discuss results of longitudinal beam dynamics studies.

* Work supported by the U.S. Department of Energy.

Session WOAD: Secondary Beam Factories
Pavilion East at 10:40
Session Chair: To be Named

WOAD001 Review of Neutrino Beam Facilities and Projects

Wu-Tsung Weng, Milind Diwan (BNL)

The neutrino oscillation has been firmly established by the intensive efforts in the past thirty years. Many new facilities and experiments have been underway to explore the detailed oscillation mechanism for comparison with theoretical predictions, and also study of cp violation processes. Design and performance goals of existing and new facilities of generating neutrino beams directly from a fixed target in the Europe, US, and Japan will be reviewed. The accelerator physics and technology challenges of the driver systems, in terms of high intensity, low loss, and reliability will be emphasized. Progresses on the target and neutrino beam generation system will also be reviewed. A tremendous progress has been made in the concept of neutrino factory approach through a muon storage ring. Such a facility can provide large quantity of neutrinos yielding unequivocal decay product for precision physics research without background contamination. Several of the design concepts, progresses, and technical challenges will be presented.

* Work performed under auspices of the U.S. Department of Energy.

WOAD002 Storage Ring Facilities for Fast Cooling of Radioactive Ion Beams and Antiprotons.

Bernhard Franzke, Karl Beckert, Peter Beller, Alexej Dolinskii, Peter Hülsmann, Fritz Nolden, Claudius Peschke, Markus Steck (Gesellschaft für Schwerionenforschung mbH)

Fast cooling and accumulation of intense beams of antiprotons and rare isotopes (RI) are key issues of new accelerator facilities proposed for GSI. Single primary bunches of $2x10^{13}$ protons at 29 GeV and $1x10^{12}$ U^{28+}-ions at 1 GeV are delivered from a new superconducting, fast-ramped 100 T-m synchrotron SIS100. A large acceptance, variable polarity collector ring CR is foreseen for fast rotation secondary bunches followed by stochastic pre-cooling in all phase planes. The envisaged total pre-cooling times are 4-5 s for 3 GeV antiprotons and 0.5 s for fully stripped RI at 740 MeV/u. Rf-stacking and stochastic accumulation of antiprotons are made in a separate accumulator ring AR, whereas the RI beams are transferred to a New Experimental Storage Ring NESR. There, electron cooling (EC) is applied during internal target experiments. For experiments with antiprotons, a special 50 Tm storage ring HESR shall be equipped with superconducting magnets (4 T dipoles), internal target and EC up to 15 GeV, optionally also stochastic cooling. The HESR design aims at a maximum luminosity of $2x10^{32}cm^{-2}s^{-1}$ and 100 keV energy resolution at lower luminosity. Ion optical and technical lay-out of various rings and simulations of cooling times and equilibrium beam properties under various conditions are discussed.

WOAD003 High Power Targets for ISOL Radioactive Ion Beam Facility

Pierre Bricault (TRIUMF)

The ISAC Radioactive Ion Beams (RIB) facility is operational since November 1998. The facility utilizes the Isotopic Separation On Line (ISOL) method to produce the RIB. The new ISAC facility at TRIUMF utilizes up to 100 μA of proton at 500 MeV from the existing H^- cyclotron. In 2000 the laboratory was approved to extend the mass range from 60 to 150 and the energy range from 1.5 to 6.5 A*MeV. A novel approach for the target/ion source station allows us to bombard the thick target with unprecedented beam intensity without compromising the worker safety. The target/ion source assembly and heavy ion optics components are located in a shield canyon under 2 m of steel shielding allowing high proton beam intensity on thick target. Existing foil targets can accommodate up to 50 μA beam intensities and the available intensities of many radionuclides can be expected to scale with the proton beam currents. But, production targets capable of withstanding proton beam intensities up to 100 μA without compromising the radionuclide yield and the lifetime of the target is a challenge. Several approaches to the dissipation of the power in such targets have been investigated and a realistic solution for the removal of the heat from the target container is proposed. A new target equipped with radial fins was built and tested off-line. A simulation of the thermal properties of this target was performed and the results will be discussed. However, for a composite target the heat transfer within the target material itself is highly target dependent. We start investigating the coating of target material with highly conductive carbon foil. First tests with SiC and TiC show that we can operate at 40 μA proton beam on target for a period greater than 10 weeks without compromising the yield of short lived isotopes.

* Work supported by the National Research Council of Canada.

WOAD004 Overview of SNS Target Systems

Mark Wendel (ORNL)

The Spallation Neutron Source (SNS) is an accelerator based neutron source that is scheduled to begin operation in 2006 at an Oak Ridge National Laboratory site. The design and R&D phases for the Target Systems portion of the SNS Project are nearing completion and construction is underway. Target Systems includes the mercury target/neutron source, a set of four moderators, neutron reflector assemblies, shielding, and the primary utility system, remote handling equipment, and instrumentation and controls required to support operations and maintenance of Target Systems equipment. Progress in the R&D program, including the latest results from pulsed accelerator beam tests of mercury targets and remote handling verification tests, and the status of the design and construction will be presented.

WOAD005 Design Studies of a Muon Collection Alternating Gradient Channel

Francois Meot (CE Saclay), Bruno Autin, Andre Verdier (CERN)

The target system of a neutrino factory is more robust when the proton beam is distributed over several targets. The pion beams then have to be merged into a single beam using a "funneling" method. The recombination involves alternating gradient (AG) magnets. The decay channel may be either a single long solenoid or an AG line. The two schemes are compared.

Poster Session WPAE
Exhibit Hall at 8:30

WPAE001 Computer Controlled Arbitrary Pattern Winding Techniques for Superconducting Magnets

John Escallier, M. Anerella, G. Ganetis, M. Harrison, A. Jain, A. Marone, B. Parker, P. Wanderer (BNL)

Final focus magnets placed in solenoidal detector fields must fit within a limited space in order to prevent inpacting the detector acceptance, and cannot be made of magnetic materials to prevent detector field distortions. The winding technique provide the magnet designer the flexiblity to place conductors in well defined locations on a cylinder or tapered tube without regard to any azimuthal support structure issues. Independent layers of wire can be designed to provide any magnetic profile. Optimization techniques have been developed to allow zeroing of integral field error, introduction of arbitrary harmonics, and to correct for previously measured harmonics.

∗ Work supported by the U.S. Department of Energy under Contract No. DE-AC02-98CH10886.

WPAE002 Magnetic Design of a Superconducting AGS Snake

Ramesh Gupta, Alfredo Luccio, William Mackay, Keith Power, Thomas Roser, Erich Willen (BNL), Masahiro Okamura (RIKEN Accelerator Research Facility)

Brookhaven National Laboratory plans to build a partial helical Snake for polarized proton acceleration in the AGS. This magnet will reduce the loss of polarization of the beam due to machine resonances. It will be a 3 Tesla superconducting magnet some 1.9 m in magnetic length, in which the dipole field rotates with a pitch of 0.2053 degrees/mm for 786 mm in the center and a pitch of 0.3920 degrees/mm for 577 mm in each end. The coil cross-section is based on a two layer design with both inner and outer layers having five current blocks per quadrant. In order to minimize residual deflections and offsets of the beam on its orbit through the Snake, a careful balancing of the coil parameters is necessary. This required the development of software that exchanges input/output between the OPERA3d field design program and the Pro-Engineering CAD model of the coils, which will determine the actual coil structure. Thus, the field design was used to build the CAD model, and this CAD model was then used by the field design program to calculate the trajectories of the beam and its residual deflections and offsets. A good design for the coils was found after several iterations. In addition to the main helical coils, a solenoid winding is planned inside the main coils to compensate for the axial component of the field that is experienced by the beam when it is off-axis in this helical magnet. Also, the magnet system will have several corrector magnets placed on the same tube on which the solenoid is placed.

∗ This work was performed under the auspices of the U.S. Department of Energy under Contract No. DE-AC02-98CH10886 and RIKEN of Japan.

WPAE003 Permanent Magnet Designs with Large Variations in Field Strength

Ramesh Gupta (BNL)

Permanent magnet R&D has been carried out at the Superconducting Magnet Division (SMD) of Brookhaven National Laboratory (BNL) for magnets that would transport the cooling electrons used in a proposed luminosity upgrade at RHIC (Relativistic Heavy Ion Collider). Although the present proposal does not rely on the use of permanent magnets, several concepts were developed to significantly enhance the state-of-the-art. These concepts allow large variability in field strength (as much as a factor of twenty) along with an increase in the maximum achievable field. The design concepts were proved with computer simulations based on POISSON, OPERA-2d and OPERA-3d. It will be shown that the field uniformity is maintained while the field strength is mechanically adjusted.

∗ Work supported by the U.S. Department of Energy under Contract No. DE-AC02-98CH10886.

WPAE004 Engineering of the AGS Snake Coil Assembly

Michael Anerella, Ramesh Gupta, Paul Kovach, Andrew Marone, Stephen Plate, Keith Power, Jesse Schmalzle, Erich Willen (BNL)

A 30% Snake superconducting magnet is proposed to maintain polarization in the AGS proton beam. The required helical coils for this magnet push the limits of the technology developed for the RHIC Snake coils. First, fields must be provided to a greater level of precision. To do so, a new 3-D CAD system ("Pro/Engineer" from PTC), which uses parametric techniques to enable fast iterations, has been employed. The magnetic field calculations are then based on the output of the mechanical model. Changes are made in turn to the model on the basis of those field calculations. Using this technique, nine such iterations have been made faster than it took to complete a single design on the RHIC program. Also, a trial was performed whereby the model was successfully imported directly into the CNC machine tool programming system. Next, due to the large coil size and magnetic field, there was concern whether the structure could contain the coil forces. A finite element analysis was performed, using the 3-D model, to ensure that the stresses and deflections were acceptable. Finally, a method was developed using ultrasonic energy to improve conductor placement during coil winding.

∗ Work supported by the U.S. Department of Energy under Contract No. DE-AC02-98CH10886.

WPAE005 Status of the LHC Main Dipole Pre-Series Production

Michele Modena, Marta Bajko, Marc Cornelis, Paolo Fessia, John Miles, Pierre Pugnat, Jean Rinn, Frederic Savary, Andrzej Siemko, Jos Vlogaert (CERN)

Within the LHC magnet program, the procurement of a pre-series of 90 Main Dipoles was decided as first step toward the mass production of 1232 Arc Main Dipoles. The pre-series manufacturing is completed at one production site and is approaching the completion at the other two companies. Technical aspects like: attainability of manufacturing tolerances, production problems, first statistic on Non-Conformities appeared during production, and a short overview of magnet performances are presented.

WPAE006 The LHC Test String 2: The Prototype of an LHC Full-Cell

Roberto Saban, Enrique Blanco-Vinuela, Frederick Bordry, Luca Bottura, Davide Bozzini, Camilo Calzas-Rodriguez, Paul Cruikshank, Knud Dahlerup-Petersen, Reiner Denz, Valeria Granata, Robert Herzog, Quentin King, Willemjan Maan, Davide Milani, Bruno Puccio, Christian Rathjen, Felix Rodriguez-Mateos, Frederique Schauf, Ruidger Schmidt, Luigi Serio, Fredrik Tegenfeldt, Hugues Thiesen, Rob van Weelderen (CERN)

After the commissioning and the first powering of the main circuits in autumn 2001 in its shorter version, the facility was completed to a full cell of LHC in the regular part of an arc and commissioned in July 2002. During this second run, which accumulated more than 4000 hours below 2 K, a very dense experimental program was carried-out to validate the final versions of the technical systems and design choices such as the bus-bar cables running along the magnet cold masses inside the cryostats. The program included the investigation of thermo-hydraulics of quenches, quench propagation, power converter controls and tracking between power converters as well as

the study of the energy extraction systems for the 600 A circuits. The study of quench induced deformations of the beam screens and of helium leaks in the cold bore were carried-out. The cryogenic process dynamics were studied in length; predictive control techniques were tested and their performance assessed. During a short shutdown starting in December 2002, the facility will be stripped of all instrumentation contributing to increased heat loads and heat load measurements will be performed in a last run during the first half of 2003. The paper describes the facility and details the results obtained during the experimental program.

WPAE007 Performance of the First LHC Main Quadrupoles Made in Industry

Theodor Tortschanoff, Karl-Martin Schirm, Walter Venturini (CERN), Rolf Burgmer, Hans-Udo Klein, Detlef Krischel, Bernd Schellong, Paul Schmidt, Thomas Stephani (ACCEL Instruments GmbH, Bergisch-Gladbach), Maria Durante, Marc Peyrot, Jean-Michel Rifflet, Fabrice Simon (CE Saclay)

After the creation of a new dedicated factory and a period of technology transfer, ACCEL Instruments has constructed and delivered the first LHC main quadrupole magnets to CERN. The design of these magnets had been the subject of a close collaboration between CEA-Saclay and CERN. Thus, CEA ensures also the technology follow-up for the fabrication of 400 quadrupole magnets and their cold masses. The two quadrupoles delivered to CERN were bare magnets, i.e. magnets not integrated into their cold masses. The purpose was to verify their performance before fabricating full cold masses. The two magnets were tested at 1.9 K in a vertical cryostat at CERN. For both magnets the current could be ramped up to well above their nominal level before a quench occurred. The second powering provoked on one of the magnets a quench at the ultimate level of excitation and in the other magnet no quench, even after the ultimate current value had been well exceeded. The field quality measurements, as far as possible in the vertical cryostat, confirmed the multipole content already found during the warm field measurements made in the factory.

WPAE008 Influence of Azimuthal Coil Size on Skew Multipoles in the LHC Dipoles

Iouri Vanenkov, Vittorio Remondino, Walter Scandale, Ezio Todesco, Christine Vollinger (CERN), Arnaud Devred (CE Saclay)

The field quality in superconducting accelerator magnets is strongly influenced by the azimuthal dimension of the superconducting coil. Asymmetries between the upper and lower poles steer skew harmonics that can endanger the beam dynamics stability. We present dimensional measurements of a large number of coils that have been carried out in the three manufacturers of the main LHC dipoles. A magnetostatic model is then used to work out the influence of coil non-nominalites on field harmonics. Comparison to magnetic measurements carried out at room temperature shows that skew harmonics can be partly traced back to azimuthal coil dimensions. We focus on harmonics which are more critical with respect to the beam dynamics limits (a2 and a4). Finally some strategies are presented, like the sorting of individual coil poles in order to reduce the detrimental effects on these multipoles.

WPAE009 Design Considerations for the CESR-c Wiggler Magnets

James Crittenden, Alexander Mikhailichenko, Alexander Temnykh (Cornell University)

The damping-dominated beam dynamics of the CESR storage ring modified to operate in the 1.5-3 GeV energy range impose unique and stringent design specifications on the fourteen 1.3-m-long superconducting wiggler magnets which provide the necessary damping. A superferric 7-pole wiggler magnet which meets these design specifications has been designed, built and tested in situ. Studies of finite-element models and particle-tracking simulations have shown that that an 8-pole model of similar design will provide improved consistency in transfer functions when operated at peak fields which differ from the primary design value.

* Work supported by The National Science Foundation.

WPAE010 Short Period SC Undulator

Alexander Mikhailichenko (Cornell University)

We describe here design of short-period helical undulator with SC windings. 2-mm period, K~0.2 undulator can be used in positron production scheme. Results of test of 6-in long prototype cold mass is represented also.

* Cornell University, LEPP.

WPAE011 Improvements in SC Wiggler Performance

Alexander Mikhailichenko (Cornell University)

We describe here methodology of improvement for good field region in a SC 2.1 T CESR's wiggler as example. The method includes a tapering, shimming and pole face windings with active field distribution correction. This technology can be applied to any wiggler however.

* Cornell University, LEPP.

WPAE012 To the Radiation of Particles in a Solenoid

Alexander Mikhailichenko (Cornell University), Eugeni Bessonov (Moscow FIAN)

We attract attention that the well known law of radiation during motion in a solenoid, allowing transverse momentum loss independently from its longitudinal one, can be used effectively for cooling of charged particles beams practically independently on theirs energy [E.Bessonov, A. Mikhailichenko, CBN 02-12, Cornell U., LEPP, Ithaca, NY 14853, 2002, 6pp].

* Cornell University, LEPP, NSF.

WPAE013 Field Quality Measurements of Fermilab Nb3Sn Common Coil Dipole Model

Vadim Kashikhin, Giorgio Ambrosio, Nikolai Andreev, Emanuela Barzi, Joe Dimarco, Michael Lamm, Igor Novitski, Phil Schlabach, Cosmore Sylvester, Gueorgui Velev, Alexander Zlobin (FNAL)

High field accelerator magnets based on Nb3Sn superconductor are being developed at Fermilab for next generation hadron colliders. First single-layer common coil dipole model with two 40-mm apertures and a cold iron yoke has been fabricated and tested at Fermilab. Field quality was measured at room temperature after magnet fabrication and at helium temperature in two thermal cycles. This paper describes the magnetic design of the magnet and reports the results of warm and cold magnetic measurements. The coil magnetization effects caused by persistent currents in superconducting filaments and eddy currents in the cable, harmonic decay and the "snap back" effect at injection plateau and the iron saturation effect at high fields are presented and compared with theoretical predictions.

* Work was supported by the US Department of Energy.

WPAE014 Conceptual Design of Large-Bore Superconducting Quadrupoles with Active Magnetic Shielding for the AHF

Vladimir Kashikhin, Giorgio Ambrosio, Nikolai Andreev, Srinivas Bhashyam, Vadim Kashikhin, Vladimir Kashikhin, Tom Peterson, John Tompkins, Alexander Zlobin (FNAL), Andrew Jason, Patrick Kelley, Peter Walstrom (LANL)

The LANL Advanced Hydrotest Facility (AHF) utilizes large-bore superconducting quadrupole magnets to image protons for radiography of fast events. The magnets are specified to achieve gradients of up to

24T/m with a 28-cm warm bore and to have 0.01% field quality. Since twelve imaging lines converge on the object to be radiographed, size limitations are an important consideration as is magnetic coupling between lines. In the paper we discuss the conceptual design of such a quadrupole using active shielding. The quadrupoles have two concentric windings connected in series and configured so that the outer winding fully eliminates the outer fringing magnetic field. This design also eliminates problems connected with a warm or cold ferromagnetic core. Concepts for the magnet cryosystems and string quench protection are briefly discussed to confirm the reliability of the proposed design.

WPAE015 Field Quality of the LHC Inner Triplet Quadrupoles at Fermilab

Gueorgui Velev, R. Bossert, J. DiMarco, S. Feher, J. Kerby, M. Lamm, P. Schlabach, M. Tartaglia (FNAL)

Fermilab, as part of the US-LHC Accelerator Project, has designed and is producing superconducting low-beta MQXB quadrupole magnets for the Large Hadron Collider. These 70 mm bore, 5.5 m long magnets operate in superfluid helium at 1.9 K with a peak operating field gradient of 215 T/m. Two MQXB quadrupoles, combined with a dipole orbit corrector, form a single cryogenic unit (LQXB), the Q2 optical element of the final focus triplets in the LHC interaction regions. Field quality was measured at room temperature during magnet fabrication as well as at superfluid helium temperature in two thermal cycles. Integral cold measurements were made with a 7m long rotating coil and with a 0.8m long rotating coil, at 8 axial positions and in a range of currents. This paper reports on the production process and on the results of the field measurements to date.

∗ This work was supported by the U.S. Department of Energy.

WPAE016 Measurements of Field Decay and Snapback Effect on Tevatron Dipole Magnets

Gueorgui Velev, G. Annala, P. Bauer, J. DiMarco, H. Glass, R. Hanft, R. Kephart, M. Lamm, M. Martens, P. Schlabach, M. Tartaglia (FNAL)

The performance of Fermilab's Tevatron accelerator, currently in its run II stage, is degraded by beam loss and emittance dilution during ramping from injection to collision energy. This is believed to be related in part to an insufficient compensation of dynamic magnet effects such as the decay of the magnetic field in the dipoles during the injection and the following so-called snapback during the first few seconds of the energy ramp. The two effects are closely related and depend on the powering history of the magnets. Dynamic effects, which were originally discovered in the Tevatron, were investigated in Tevatron magnets in various past measurement campaigns, i.e. in the 1980s and then in 1996. This paper reports on the most recent measurements performed on a set of Tevatron magnets.

∗ This work was supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

WPAE017 Correlations between Field Quality and Components in the Collared Coils of the LHC Main Dipoles

Christine Vollinger, Boris Bellesia, Francesco Bertinelli, Paolo Fessia, Guiseppe Gubello, Cristiano Lanza, Vittorio Remondino, Walter Scandale, Ezio Todesco, Iouri Vanenkov (CERN)

We review the dependence of field harmonics in the LHC main dipoles on the dimension of the components of the collared coil. Sensitivity tables worked out through a coupled magneto-mechanical model give the variation of the multipoles on copper wedge dimension, collars, interlayers, coil protection sheets and ground insulation. An analysis of the dimensional measurements of the components used in the collared coils which are produced so far is given. The correlation with magnetic measurements are discussed and the components which most affect the critical field harmonics are presented.

WPAE018 Aperture Limitations for 2nd Generation Nb3Sn LHC IR Quadrupoles

Alexander Zlobin, Vadim Kashikhin, Jim Strait (FNAL)

Present LHC IR optics is based on the single-bore inner triplets consisting 70-mm NbTi quadrupoles with a nominal field gradient of 205 T/m at 1.9 K operation temperature. These quadrupole magnets were designed to provide the nominal LHC luminosity of 10^34 cm^-2s^-1 in two high-luminosity IRs. The aperture, quench limits and lifetime of these magnets are among the major limiting factors for LHC luminosity upgrades. One of the straightforward ways towards the higher luminosity is a replacement of the present 70-mm NbTi quadrupoles with Nb3Sn quadrupoles which would provide the same field gradient but in a larger aperture. Conceptual designs of such quadrupoles with 90 mm aperture have been developed. This paper discusses the possibilities and limitations of increasing the aperture of Nb3Sn low-beta quadrupoles for a LHC luminosity upgrade up to 110 mm.

∗ The work was supported by the U.S. Department of Energy.

WPAE019 Status of LHC Low-Beta Quadrupole Magnets, MQXA, at KEK

Norihito Ohuchi, Yasuo Ajima, Norio Higashi, Masahisa Iida, Nobuhiro Kimura, Tatsushi Nakamoto, Toru Ogitsu, Hirokatsu Ohhata, Takakazu Shintomi, Sigekatu Sugawara, Kei Sugita, Kenichi Tanaka, Akio Terashima, Kiyosumi Tsuchiya, Akira Yamamoto (KEK), Sei Murai, Tomofumi Orikasa, Hirohisa Takano (Toshiba Corporation)

In the framework of the collaboration program CERN and KEK, KEK is constructing 18 low-beta quadrupole magnets, MQXA, for the LHC interaction region. The magnets are required to operate at 215 T/m and have the magnetic length of 6.37 m. The first magnet was built and tested at 2001, and the test of the 8-th magnet has been completed. These magnets are being assembled by Toshiba corporation, and the production of the MQXA magnets is steadily in progress. All tested magnets reached the required maximum field gradient of 230 T/m. The field quality of the magnets was sufficiently good for the beam optics. We will report the status of these MQXA magnets in the production stage, i.e., the summary of the training performance and field quality.

WPAE020 Force Free Design of Super-Ferric Beam Line Magnet

Masayoshi Wake, Hikaru Sato, Ken Takayama (KEK), Henryk Piekarz, Ryuji Yamada (FNAL)

Beamline magnets have been an attractive application area for superconducting magnets because the power saving in DC operation is very large. However, construction cost and operation cost of cryogenics are large enough to cause hesitation in the use of superconducting magnets. One of the solutions to making superconducting magnet efficiently at low field is the use of iron core. A superferric magnet should be very economical because it uses much less superconductor. The problem of the superferric magnet is the cryogenics. A cryostat containing the whole of the iron is costly and lossy, and a warm iron design has a problem with large electromagnetic force between iron and conductors. The cost advantage of asuperferric magnet is difficult to achieve in both cases. The design presented in this paper balances out the electromagnetic field with two gaps of iron. Since the support system is very simple, the cryogenic load and construction cost are very low. The principle of the force balance is the same as in the VLHC Pipetron magnet, but the construction of the magnet is made asymmetric so that it becomes suitable for single-bore beamline magnets.

WPAE021 Conceptual Design of a Second Generation IR Quadrupole for the LHC

Paolo Ferracin, Shlomo Caspi, Luisa Chiesa, Daniel Dietderich, Steve Gourlay, Ray Hafalia, Alan Lietzke, Alfred McInturff, GianLuca Sabbi, Ronald Scanlan (LBNL)

Lawrence Berkeley National Laboratory (LBNL) is carrying out a conceptual design study of a Nb3Sn quadrupole for the next generation LHC Interaction Region (IR). The choice of insertion quadrupoles with a gradient of 205 T/m and an increased bore size of 90 mm represents a promising strategy towards doubling the luminosity up to an ultimate goal of $2.5*10^{34}$ $cm^{-2}s^{-1}$. Nb^3Sn superconductor is at the present time the only conductor that can generate a high gradient over a large bore. Coil designs with either two or four layers are being considered. Previous studies have examined cable and coil parameters, systematic harmonics, support structure and quench protection system. In this paper the issues of field quality, alignment, thermal margin and cryogenics are further discussed.

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WPAE022 Superconducting Solenoids for the MICE Channel

Michael Green (LBNL), Robert B. Palmer (BNL), Jean-Michel Rey (CE Saclay), P. Fabbricatore, Stefania Farinon (INFN), Gilles Barr (Oxford University), D. Elwyn Baynham, J. H. Rockford (Rutherford Appleton Laboratory)

This report describes the channel of superconducting solenoids for the proposed international Muon Ionization Cooling Experiment (MICE). MICE consists of two cells of a SFOFO cooling channel that is similar to that studied in the level 2 study of a neutrino factory. MICE also consists of two detector solenoids at either end of the cooling channel section. The superconducting solenoids for MICE perform three functions. The coupling solenoids, which are large solenoids around 201.25 MHz RF cavities, couple the muon beam between the focusing sections as it passes along the cooling channel. The focusing solenoids are around the liquid hydrogen absorber that reduces the momentum of the muons in all directions. These solenoids generate a gradient field along the axis as they reduce the beta of the muon beam before it enters the absorber. Each detector solenoid system consists of five coils that match the muon beam coming to or from an absorber to a 4.0 T uniform solenoidal field section that that contains the particle detectors at the ends of the experiment. There are detector solenoids at the beginning and at the end of the experiment. This report describes the parameters of the eighteen superconducting coils that make up the MICE magnetic channel. The stray field generated by the MICE magnetic channel and the forces between coils in the channel is also discussed in this report.

* This work was supported by the Office of Science, United States Department of Energy under DOE contract number DE-AC03-76SF00098.

WPAE023 Superconducting Focusing Quadrupoles for the High Current Experiment

GianLuca Sabbi, Andy Faltens, Alan Lietzke, Peter Seidl (LBNL), Rainer Meinke (Advanced Magnet Lab), Steve Lund, Nicolai Martovetsky (LLNL), Chen-yu Gung, Joel Schultz (MIT Plasma Science and Fusion Center)

The VNL magnet R&D program includes the development of prototype single aperture superconducting quadrupoles based on NbTi conductor for use in the High Current Experiment (HCX), an intense beam magnetic transport and acceleration experiment at low kinetic energy. A prototype cryostat to house a quadrupole doublet, with features to accommodate induction acceleration modules, is also being fabricated. Due to the need to perform the transport and acceleration experiments near injection energy (1-1.8 MeV), the lattice has a short period of 45 cm. At the same time, gaps are needed between cryostat tanks to allow induction acceleration, diagnostics and pumping ports, leading to challenging longitudinal space constraints. Progress in the development of superconducting quadrupoles for HCX is reported.

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WPAE024 The Strongest Permanent Dipole Magnet

Masayuki Kumada (National Institute of Radiological Science)

The authors have been developing very strong permanent magnets. In the past, these could generate a 4.45 tesla dipole field. We are now in a process of reaching much higher fields by a special magnetic circuit, cooled down to liquid nitrogen temperatures. We will present our latest results with the strongest permanet magnet dipole ever built.

WPAE025 Superconducting Double-Helix Accelerator Magnets

Rainer Meinke, Millicent Ball, Carl Goodzeit (Advanced Magnet Lab, Inc.)

We describe an important contribution to accelerator magnet technology based on the concept of modulating the helical turns of solenoid coils to produce pure multipole fields of any order. The characteristics of two such configurations, the double-helix dipole (DHD) and the double-helix quadrupole (DHQ), are described. Calculations show that these configurations inherently produce virtually error free fields of the desired multipole order in a large fraction of the aperture in the two dimensional cross section without the presence of iron. The effect of the end fields and the presence of an iron yoke are also shown. It is also explained how the novel geometry of the double-helix coils simplifies the manufacturing, eliminates coil parts, and thus significantly reduces the cost of the magnets in comparison to the conventional cosine theta (racetrack design) coils. This has been demonstrated by the design, construction and preliminary testing of a prototype dipole that produces a 4T field in an 80 mm aperture (without iron).

* Work partially supported by the U. S. Department of Energy under SBIR grant DE-FG02-02ER83360.

WPAE026 Measurements of Beam Driven Hydrodynamic Turbulence

J. Norem (ANL), E. Black, D. Kaplan (Illinois Institute of Technology), L. Bandura, M.A. Cummings (Northern Illinois University), D. Errede (University of Illinois)

The muon cooling program requires intense beams of muons, in the presence of other backgrounds, in liquid hydrogen absorbers. In addition to heating the hydrogen, these beams will drive turbulent flow, which may be sufficient to cool the liquid. We have used a 20 MeV electron beam in a water tank to look at the scale of the beam driven convection and turbulence. The density and flow measurements are made with Schlieren and Ronchi systems. We describe the optical systems, and the turbulence measured. This data is being used to calibrate hydrodynamic calculations of convection driven and forced flow cooling in muon cooling absorbers.

WPAE027 Muon Cooling in the RFOFO Ring Cooler

Richard Fernow, J.S. Berg, Juan Gallardo, Robert Palmer (BNL), Steve Bracker, Lucien Cremaldi, Romulus Godang, Donald Summers (University of Mississippi)

There has been considerable recent progress in the design of cooling rings for neutrino factories and muon colliders. The ring described here consists of twelve 2.75 m long cells. The focusing comes from a so-called RFOFO lattice of alternating solenoids. Ionization cooling

is provided in 6D by sending the muon beam through wedge-shaped absorbers of liquid hydrogen. The energy is replaced using 201 MHz RF cavities in each lattice cell. The cooling performance was simulated using the Icool and Geant codes. Realistic maxwellian fields form tipped solenoids were used in the simulations. The effects on performance of optimizing the absorber shape, using RF and absorber windows and modifying the lattice for injection/extraction are considered.

* This work was performed under Contract No. DE-AC02-98CH10886 with the United States Department of Energy.

WPAE028 Layout and Optics for the RHIC Electron Cooler

Jorg Kewisch, Ilan Ben-Zvi, Xiangyun Chang, Christoph Montag, Dong Wang (BNL)

AS part of a liminosity upgrade it is planned to add an electron cooling section to the RHIC accelerator. Existing electron coolers operate at low beam energies and use a continuous electron stream. The ion energy of 100 GeV/u in RHIC requires an electron energy of 55 MeV. Therefore the RHIC cooler uses a linac with energy recovery for the electron acceleration. Short bunches exiting the linac section are stretched longitudinally to reduce the momentum spread and space charge effects in the cooling section, and compressed afterwards for decelleration and energy recovery in the linac. This report describes the design of the electron beam transport and simulation results.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy

WPAE029 Muon Storage Rings for 6D Phase-Space Cooling

Harold Kirk (BNL), D. Cline, Y. Fukui, A. Garren (University of California, Los Angeles)

We describe several storage ring designs for reducing the six-dimensional phase space of circulating muon beams. These rings utilize quadrupole and dipole magnets as well as wedge-shaped liquid-hydrogen energy-loss absorbers with energy compensating rf cavities. We show evaluations of their cooling performance by particle tracking simulation. Such rings are potentially useful for future Neutrino Factories or Muon Colliders as well as for existing facilities in which cooled, intense muon beams could enhance their physics programs.

* This work was performed under Contract No. DE-AC02-98CH10886 with the United States Department of Energy.

WPAE030 Effect of Solenoid Field Errors on Electron Beam Temperatures in the RHIC Electron Cooler

Christoph Montag, Joerg Kewisch (BNL)

As part of a future upgrade to the Relativistic Heavy Ion Collider (RHIC), cooler electron cooling is foreseen to decrease ion beam emittances. Within the electron cooling section, the "hot" ion beam is immersed in a "cold" electron beam. The cooling effect is further enhanced by a solenoid field in the cooling section, which forces the electrons to spiral around the field lines with a (Larmor) radius of 10 micrometers, reducing the effective transverse temperature by orders of magnitude. Studies of the effect of solenoid field errors on electron beam temperatures are reported.

* Work performed under the auspices of the US Department of Energy.

WPAE031 Emittance Reduction of the Gold Ions in the AGS

Dejan Trbojevic, Leif Ahrens, Thomas Roser, Peter Thieberger (BNL)

The transverse and longitudinal emittances of the Au+77 gold ions of the Alternating Gradient Synchrotron (AGS) have been consistently showing small values (normalized transverse emittances of the order of 10p mm mrad). This report includes recent measurement results and an explanation of a possible "cooling" mechanism. The gold ion bunches Au+77 in the AGS have two electrons in the inner shell. It might be possible that these electrons can get excited either through interactions with the shells of the residual gases or from the intra-beam scattering between the ions within a bunch. The deexcitation mechanism could produce a loss of energy from the bunch and thus reduction of the emittance.

* Work performed under auspices of the U.S. Department of Energy

WPAE032 Lithium Lenses Based Muon Cooling Channel

Valeri Balbekov (FNAL)

A linear ionization cooling channel for neutrino factory or muon collider is considered. It includes short lithium lenses, matching solenoids, and 201 MHz RF cavities. The basic challenge is a suppression of chromatic effects in a wide energy range which is typical for muon beams. A special lattice is proposed to reach this, and methodic of the optipmization is developed to minimize the chromatic aberrations by suppression of several linear betatron resonances. The most engineering constraint at the channel design is high field of the matching solenoids. The channel with the field less of 10 T is considered in detail. It is shown analytically and by simulation that the channel of length 120 m can provide decrease of normalized transverse emittance from 2000 mm*mrad to 400-500 mm*mrad at transmission about 90%. Minimal achievable beam emittance is estimated as about 250 mm*mrad if 15 T solenoids and 10 T lithium lenses are applied.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

WPAE033 Investigation and Simulation of Muon Cooling Rings with Tilted Solenoids

Valeri Balbekov (FNAL)

Alternating solenoid focused muon cooling rings without special bending magnets are considered. Both fringe field between solenoids with opposite directed currents, and a special inclination of the solenoids in vertical plane provides a bending and a closing of the particle trajectories. Realistic (Maxwellian) magnetic field is calculated and used in all the cases. Methodic is developed and applied to find periodical closed orbits at any energy, dispersion, eigenvalues of transfer matrix, region of stability, and other conventional accelerator characteristics. Proposed earlier RFOFO cooling ring with 201 MHz accelerating cavities and liquid hydrogen wedge absorbers is investigated in detail. After an optimization of the cooler, 6D emittance and transmission of the cooled beam are obtained as about 16-17 mm^3 and 54-56% correspondently. Ratio of transverse/longitudinal emittances depends on the angle of the wedge absorbers and in the optimal cases varies from 2.0/4.1 mm to 2.5/2.5 mm. Ultimate performances of similar coolers are estimated also.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

WPAE034 Muon Beam Ionization Cooling in a Linear Quadrupole Channel

Carol Johnstone (FNAL), Martin Berz (Michigan State University), Kyoko Makino, Debbie Errede (University of Illinois Urbana-Champaign)

In a scenario for either a Neutrino Factory or Muon Collider, the anticipated transverse beam emittance subsequent to capture and phase rotation is so large that it permits a relaxation of the requirements on beam spot size in the early stages relative to the final stages of ionization cooling. Staging the cooling process according to initial emittances, coupled with modest cooling factors, permits more optimal and efficient cooling channel designs and avoids much of the difficulty encountered with channels which attempt to maintain strong focusing (large divergences) across ultra-large momentum ranges (≥±20% dp/

p). This relaxation of spot size at the absorber, especially in the "precooling" stage, allowed development of an efficient cooling channel based simply on a quadrupole FODO cell. This work describes a quadrupole cooling channel designed to cool initial emittances of 15-20 cm (normalized) by a factor of two in each transverse plane. Its application is clearly as the most upstream stage of cooling and, being a linear channel with no bends, serves to reduce the large transverse beam size before introduction into emittance exchange channels or ring coolers. It uses large bore, normal-conducting quadrupoles with fringe-field and other higher-order effects fully included in the simulations.

* Work supported by the US Department of Eneregy under contract no DE-AC02-76CH03000.

WPAE035 Nonlinear Effects in Solenoid Ring Coolers

Carol Johnstone (FNAL), Martin Berz (Michigan State University), Kyoko Makino, Debbie Errede (University of Illinois Urbana-Champaign)

A significant amount of effort has been invested in designing muon ionization cooling channels based on large-aperture superconducting solenoids, using their strong fringe fields to create low betas or small beam sizes in both transverse planes. Much of the design work has been pioneered using approximations to the solenoidal fringe fields or carefully-engineered coil placement to achieve specific field profiles in order to demonstrate satisfactory cooling performance. When these channels are modelled realistically wih full nonlinearities the effect on performance and dynamic aperture is dramatic. In particular the nonlinearities increase with aperture. This work derives solenoidal fields will all high-order effects in different contexts: thin versus thick coils and aperture dependencies. The channel is then simulated showing clearly the degradation in performance as the calculation moves from the simplistic approximations to the full simulation. Simplecticity and high-order effects are specifically discussed.

* Work supported by the US Department of Energy under contract no DE-AC02-76CH03000.

WPAE036 Commissioning of the Fermilab Electron Cooler Prototype Beam Line

Sergei Nagaitsev (FNAL)

A prototype of a 4.3-MeV electron cooling system has been assembled at Fermilab as part of the on-going R&D program in high energy electron cooling. This electron cooler prototype will not demonstrate the actual cooling but it would allow determining if the electron beam properties are suitable for antiproton beam cooling. An electron beam is accelerated by a 5-MV Pelletron (Van de Graaff type) accelerator and transported to a prototype cooling section. The cooling would take place in a 20-m long solenoid flanked on both sides by a delivery and return beam-lines: a total of 60 meters of transport channel. This paper describes the first results of commissioning this novel beam line as well as the status of the electron cooling R&D program.

* Fermilab operates under US DOE Contract with Universities Research Association, Inc.

WPAE037 Analysis of a Grid Window Structure for RF Cavities in a Muon Cooling Channel

Anthony Ladran, Derun Li, John Staples, Michael Zisman (LBNL), Alfred Moretti (FNAL), Robert Rimmer (Thomas Jefferson National Accelerator Facility)

We report on the electromagnetic and thermal analysis of a grid window structure for high gradient, low frequency RF cavities. Windows may be utilized to close the beam iris and increase shunt impedance of closed-cell RF cavities. This work complements previous work presented for windows made of solid beryllium foil. An electromagnetic and thermal analysis of the thin wall tubes in a grid pattern was conducted using both MAFIA and ANSYS for finite element analyses. The results from both codes agreed well for a variety of grid configurations and spacing. The grid configuration where the crossing tubes touched was found to have acceptable E-Fields and H-Fields performance and was comparable to a solid Be window. The thermal profiles for the grid will also be shown to determine a viable cooling profile.

* This work was supported by the director, Office of Science, Office of High Energy and Nuclear Physics, Division of High Energy, U.S. Department of Energy under contract DE-AC03-76SF00098.

WPAE038 Design of Toroidal Section in the ACR Electron Cooler at RIKEN

Masaki Nishiura, Takeshi Katayama, Toshiya Tanabe (RIKEN Accelerator Research Facility), Evgeny Syresin (Joint Institute for Nuclear Research), Ikuo Watanabe (TOSHIBA Co.)

The radioisotope beam factory (RIBF) is under construction at RIKEN. In the RIBF, multi-use experimental storage rings (MUSES) consists of an accumulator cooler ring (ACR) and an electron-RI beam collider (e-RI Collider). The ACR is equipped with an electron cooler (EC). On the basis of 3 dimensional calculations of magnetic fields, electron beam trajectories were calculated in order to obtain lower transverse electron temperature in the cooling section of the ACR-EC passing through the gun and toroidal section.

WPAE039 Circulated Electron Cooler: Electron Cooling and Intra Beam Scattering

Yuhong Zhang, Yaroslav Derbenev (Thomas Jefferson National Accelerator Facility)

High energy electron cooling based on energy recovering linac appears feasible with the successful demonstration of energy recovery. In the present high energy electron cooling scheme, a high current electron beam gets decelerated and energy recovered after interacting with the hot ion bunches once. The circulated electron cooler is an electron cooling scheme in which the cold electron bunches cool the hot ion bunches several times before being energy recovered and sent to a beam dumper. While cooling ion bunches, the electron bunch may also heat up due to the interaction with ions and to electron intrabeam scatterings. We propose a thermodynamic model to describe the combined effects of cooling/heating and intrabeam scattering in a circulated electron cooler. Such model can provide guidance for finding the optimal number of recirculation rounds of an electron bunch in the cooler.

* This work was supported by the U.S. Dept. of Energy under Contract No.DE-AC05-84ER40150.

WPAE040 Longitudinal Cooling of a Strongly Magnetized Electron Plasma

Jinhyung Lee, John Cary (Univ. of Colorado at Boulder)

The optimal values of Q and detuning from resonance for cooling a pure electron plasma with a microwave bath have been calculated. An electron plasma which has no internal degree of freedom, cannot be cooled down below a heat bath temperature. However, the longitudinal cooling can be achieved by energy transfer from the poorly cooled parallel degree of freedom to the well cooled (by synchrotron radiation)perpendicular degree of freedom. To do this, a microwave bath is introduced to the electron plasma. A microwave tuned to a frequency below the gyrofrequency of the electron forces an electron moving towards the microwave to absorb a photon and then to move up one in Landau state. The electron loses longitudinal momentum in this process, so that the longitudinal energy can be reduced. On the basis that most of the electrons are in the ground or first excited state, we set up a transition equation and develop a finite element method (FEM) code. With an appropriate condition for B-

field and intensity of the microwave, the cooling times for several values of Q and the detuning are calculated and the optimal values are found. Applying the optimal values at appropriate times in a cooling process, the best cooling can be obtained. For an electron plasma magnetized with 10T B-field, cooling to the solid state can occur within 2 hours. Without this optimization, times were always several hours, longer than the life time of the plasma in real system.

Poster Session WPAB
Grand Ballroom I at 8:30

WPAB001 The Advanced Photon Source Injector Test Area

Steve Berg, Michelle Givens, George Goeppner, Arthur Grelick, William Jansma, John Lewellen, Aaron Lopez, Mark Martens, Wayne Michalek, Scott Wesling (ANL)

The high-power S-band feed subsystem and the versatile method of beamline construction have been combined to provide for further testing of a unique gun that incorporates three cavities and requires three separate S-band feeds. Completed in December 2002, this configuration of the injector test area is intended to investigate performance of the newly designed ballistic bunch compression gun. If this gun is proven to be desirable for injection at the APS, then the ballistic bunch compression gun together with the S-band feed subsystem and portions of the beamline will be relocated into the APS linac tunnel.

∗ This work is supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPAB002 A New High Intensity Electron Beam for Wakefield Acceleration Studies

Manoel Conde, Wei Gai, Chunguang Jing, Richard Konecny, Wanming Liu, John Power, Haitao Wang, Zikri Yusof (ANL)

A new RF photocathode electron gun and beamline have been built for the study of electron beam driven wakefield acceleration. The one and a half cell L-band gun operates with an electric field on the cathode surface in excess of 80 MV/m and generates electron bunches with tens of nanocoulombs of charge and bunch lengths of a few picoseconds. The beam diagnostics include an OTR screen and streak-camera for bunch length measurements, YAG screens for beam profile, ICTs for bunch charge, energy spectrometer, and pepper-pot plate for measurement of the transverse emittance. Measurements of the beam properties at various bunch charges will be presented.

∗ This work is supported by DOE, High Energy Physics Division, Advanced Technology Branch, under contract No. W-31-109-ENG-38.

WPAB003 Energy-Spread Compensation of a Thermionic-Cathode RF Gun

John Lewellen (ANL)

The Advanced Photon Source (APS) ballistic bunch compression (BBC) gun was designed as a prototype injector to explore the technique of drift-space compression of a high-brightness beam. It is constructed from three independently powered S-band rf cells, one cathode half-cell, and two full cells, and is designed to operate with both thermionic cathodes and photocathodes; this flexibility allows the gun to be operated in modes other than for ballistic compression. By selecting a pi-mode phasing scheme, the operation of a conventional thermionic-cathode gun can be emulated. Also of interest is the ability to reduce the energy spread of the beam produced by the gun; this is also accomplished by suitable choice of rf power and phase. With a thermionic cathode, simulations indicate that a 1% hard-edge energy spread can contain at least 50% of the emitted beam charge, with most of the remaining charge making up a high-energy tail. This operating mode demonstrates many of the capabilities required for ballistic bunch compression, but allows verification of the basic gun performance via a much easier measurement. Also, such a beam is of interest as a source for other experiments, e.g., low-cost, compact, free-electron lasers.

∗ This work is supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPAB004 A Flexible Injector Test Stand Design

John Lewellen, Kevin Beczek, Steven Berg, Michelle Givens, Arthur Grelick, Yuelin Li, Ali Nassiri, Stanley Pasky, Debra Skuta-Briddick, Terry Smith (ANL)

The Advanced Photon Source (APS) has constructed an injector test stand for high-brightness electron beam research. The test stand includes three rf ports with independent phase and power control, beamline supports designed for rapid reconfiguration, and a control and diagnostics system based on the design of the APS linac. The beamline design features a high-resolution electron spectrometer that includes provision for operation as a dispersion-free dogleg, and a rapidly reconfigurable gun-to-spectrometer transport line. Picosecond and nanosecond photocathode drive lasers are available; the room shielding is also adequate for the high average beam powers typically produced by thermionic-cathode rf guns. The initially installed gun is a ballistic-compression gun, which requires all three rf ports to be connected to the gun. Future plans include the installation of a higher-order mode photoinjector, requiring one rf connection; this will free the other ports to provide power to a small TW linac section and deflector cavity for bunch length measurements. The test stand is also capable of being used as an operator training facility, and serves as a validation facility and testbed for the APS main injector rf guns. Key features of the design include multiple available high-power rf source points, a multipurpose spectrometer / transport line, and emphasis on flexible operation and configuration.

∗ This work is supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPAB005 A New Emittance Compensation Technique on Longitudinal Phase Space of Electron Bunches in a Multicell RF Gun Having a Shorted First Cell and a Defocusing RF Field near the Photocathode

Vladimir Volkov (BINP), Dietmar Janssen (Forschungszentrum Rossendorf)

The technique of longitudinal emittance compensation of electron bunches in a multicell RF gun having a longitudinally shorted first cell (down to 0.15 lambda) with a divergence of an accelerating RF field pattern near the Photocathode is discussed. These electron bunches with low longitudinal emittance are very compatible with longitudinal compression in magnetic chicane [V.Volkov, D.Janssen. Generation of sub-picosecond electron bunches in superconducting RF photocathode injector (this conference)].

WPAB006 Generation of Sub-Picosecond Electron Bunches in Superconducting RF Photocathode Injector

Vladimir Volkov (BINP), Dietmar Janssen (Forschungszentrum Rossendorf)

A multicell (0.3+5) photocathode RF gun having a longitudinally shorted first cell (the length of the first cell is 0.15 lambda instead of 0.25 lambda) generates bunches with very low longitudinal emittance. These bunches could be considerably longitudinally compressed in a four dipole achromatic chicane placed just after a buncher cavity composed of a 3900 MHz 9 cells TESLA like cavity. Bunch dynamic calculations in such compressing scheme with optimized parameters at 10 MeV bunch energy show a good results - the bunch rms length is below 9 micrometers (0.03 picosecond) with peak current higher 1200 A (the laser pulse rms length is 2.5 picosecond).

WPAB007 Measurements of the FZR Superconducting RF Photoelectron Gun

Vladimir Volkov, Sergey Konstantinov, Yaroslav Kruchkov, Oleg Myskin, Victor Petrov, Alexey Tribendis (BINP), Peter vom Stein (ACCEL), Axel Matheisen, Wolf-Dietrich Moeller (DESY), Hartmut Buttig, Pavel Evtushenko, Michael Freitag, Dietmar Janssen, Peter Michel, Torsten Quast, Bertram Reppe, Christof Schneider, Rico Schurig, Jochen Teichert (Forschungszentrum Rossendorf), Ingo Will (Max-Born-Institute)

In a research project [E. Bartels et al., Nucl. Instr. and Meth. A 445 (2000) 408-412], a superconducting RF photo electron gun (SRF gun) has been developed during the last years at the Forschungszentrum Rossendorf. The SRF gun was put successfully into operation and the efficiency of the concept could be demonstrated. A helium bath cryostat was used to cool down the cavity to 4.2 K. In a daily cycle the cryostat was filled up with liquid helium in the morning followed by a measuring time in the afternoon. The resonator is a niobium half cell with TESLA geometry operating at 1.3 GHz. The photo cathode had a Cs2Te layer deposited in a preparation chamber connected with the gun. In contrast to the cavity the cathode is not superconducting. It is thermally isolated from the cavity and its heat load goes in a special nitrogen cooling system. The cathode was illuminated by an UV laser of 263 nm with a micropulse frequency of 26 MHz and a maximum energy per pulse of 40 nJ. For evaluation of the produced electron beam, a beam line is installed with two solenoids, pepper-pot mask and view screens, spectrometer magnet, kicker cavity and Faraday-cup. Measurements of beam parameters and operation experience are reported.

WPAB008 Tests of Niobium Cathode for the Superconducting RF Gun

Qiang Zhao, Triveni Srinivasan-Rao (BNL), Mike Cole (Advanced Energy Systems Inc.)

A superconducting all-niobium photocathode RF gun has been designed and constructed by Advanced Energy Systems and is being tested at Brookhaven National Laboratory. We have studied the surface preparation techniques of the niobium cathode material. The quantum efficiency (QE) of high purity niobium with different surface preparation techniques has been intensively measured in a dedicated DC system. After Buffer chemical polishing or electrolytic polishing, the initial QE is around 10^{-7} to 10^{-6} with 266 nm picosecond laser beam. However, the QE could be improved by more than two orders of magnitude after appropriate laser cleaning. The threshold of the laser cleaning intensity was also determined to keep the morphology of the cavity surface.

WPAB009 The Analysis of the Cross-Talk in a RF Gun Superconducting Cavity

Yongxiang Zhao (BNL), Michael Cole (Advanced Energy System Inc.)

A project to develop an all Niobium Superconducting RF Gun is underway at Brookhaven National Laboratory in collaboration with Advanced Energy Systems. The geometry of the gun requires that the power input and the pickup probes are on the same side of the cavity, which causes direct coupling between them, or crosstalk. At room temperature, the crosstalk causes serious distortion of the RF response. This paper addresses the phenomenon, the analysis and the simulation results as well as the measurements. A method is provided on how to extract the desired information from the confusing signal and allow accurate measurements of the coupling between the probes and the cavity.

* Work supported by the U.S. DOE., Office of Basic Energy Sciences, under Contract Nos. DE-AC02-98CH10886DOE, SBIR grant DE-FG02-99ER82724, and under CRADA No. BNL-C-01-08. Such support does not constitute an endorsement by DOE of the views expressed in this paper.

WPAB010 Simulation of High Charge Extraction from the ELSA RF Photo-Injector

Pascal Balleyguier, Philippe Guimbal (French Atomic Energy Commission)

Some electron linac applications require the generation of a micro-coulomb-like charge on a few tens of nanosecond period. We intend to produce such a beam in the ELSA 144-MHz photoinjector as a burst of ten consecutive 100-nC bunches. Because of space charge effects, extracting a single bunch with an "ALARA" emittance is already a challenge. Moreover, multi-bunch operation could lead to further limitations due to HOM excitation. We present here some simulations of basic phenomena (image charges, space charge limitation, RF mode excitation, space charge energy spread...), that we carried out to validate the tool that we use (the MAFIA/TS2 2D PIC solver). From global simulations, we deduce the expected beam qualities and the requirements on the drive laser.

WPAB011 Emittance Growth Study for Cornell ERL Injector Cavities with Various Coupler Configuratins Using a New Three Dimensional Code

Zipi Greenwald (Cornell University)

We compute emittance growth in electron bunches in high gradient accelerating cavities due to field nonlinearities and phase dependence associated with the finite bunch length. The determination of the emittance is based on tracking of individual particles through tabulated, 3-dimensional, electromagnetic fields. No symmetry is assumed. The fields for the structure, including input couplers, are calculated using MAFIA or MWS [CST Micrwave Stodio, CST GmbH, Budinger Str. 2a. D-64289 Darmstadt, Germany]. We explore particle trajectories, RF focusing and emittance growth of injector cavities with various coupler configurations studied as options for Cornell Energy-Recovery-Linac proposal [V. Shemelin, S. Belomestnykh, H. Padamsee, This Poceedings].

* Work supported by the National Sience Foundation.

WPAB012 HOM-Free 2-Cell Cavity for the SC ERL Injector

Valery Shemelin, Hasan Padamsee (Cornell University)

In another paper [V. Shemelin, H. Padamsee. "HOM-free 2-cell cavity with strong input coupler for the SC ERL injector". To be presented at CST USER GROUP MEETING, February 24th, 2003. San Jose, CA] we discussed the choice of the cavity shape and design of the twin-coaxial coupler with the external Q-factor of the cavity fundamental mode in the range 4.6 10^4...4.1 10^5. The two-cell cavity has an iris between the cell and the larger beam pipe that helps to drive out the dipole mode. Here we present the up to date state of work with this cavity.

* Supported by Cornell University.

WPAB013 High Brightness, High Current Injector Design for the Cornell ERL Prototype

Charles Sinclair, Ivan Bazarov (Cornell University)

Cornell University, in collaboration with Jefferson Laboratory, has proposed the construction of a 100 MeV, 100 mA CW prototype Energy Recovery Linac (ERL), to study and resolve the many accelerator physics and technology issues of this type of machine. The long term goal is the construction of a state-of-the-art ERL-based synchrotron light source. A key element of this machine is a high brightness injector with every bunch filled (77 pC/bunch at 1300 MHz). We report the design of a versatile injector for the prototype ERL, which also meets the requirements for a full scale light source. The injector uses a very high voltage DC photoemission electron gun

with a GaAs photocathode, and a conventional buncher. Five two-cell superconducting RF cavities allow energies of 5 to 15 MeV to be delivered, with an average beam power of 500 kW limited by the installed RF power. Thorough simulations, using realistic particle distributions at the photocathode, indicate this injector should provide a normalized rms emittance approaching 1 mm-mrad, and an rms longitudinal emittance of 10 keV-degrees. Operation at reduced bunch charge will provide a smaller transverse emittance, until aberrations and the time dependence of the RF fields impose limitations.

* Work supported by Cornell University.

WPAB014 Emittance Growth due to the Field Asymmetry in the TTF RF Gun

Jean-Paul Carneiro, Mikhail Krassilnikov (DESY)

This paper will report the effect on the transverse and longitudinal emittance of the multi-pole field components due to the input coupler iris of the TTF RF Gun. ASTRA [K. Floettmann, ASTRA User Manual, http://www.desy.de/~mpyflo/Astra_dokumentation] simulations including 3-D electric fields from MicroWave Studio [CST GmbH, Bab Nauheimer Str. 19, D-64289 Darmstadt, Germany] and HFSS [Ansoft Corporation, Four Station Square, Pittsburgh, PA 15219] will be presented. The results will be compared with analytical predictions.

WPAB015 Experimental Studies of RF Breakdowns in the Coupler of the TTF RF Gun

Jean-Paul Carneiro, Siegfried Schreiber (DESY), Donald Edwards (FNAL)

During the TTF-FEL Phase I, the RF gun of the TESLA Test Facility (TTF) has been operated with long RF pulses (up to 0.9 ms) and high RF peak power (up to 3 MW). RF breakdowns characterized by RF pulse shortening have been observed and localized in the RF input coupler. In this report we will present statistics of RF breakdowns for different RF pulse length, peak power and repetition rates from 0.1 Hz to 2 Hz. We will also discuss the origin of these breakdowns.

WPAB016 On the Photocathodes Used at the TTF Photoinjector

Siegfried Schreiber (DESY), Paolo Michelato, Laura Monaco, Daniele Sertore (INFN)

Since the start-up of the TESLA Test Facility (TTF) laser driven rf gun based photoinjector late 1998, several cathodes have been used. We report on the properties of the Cs2Te and CsKTe cathodes under operating conditions, their quantum efficiency and lifetime. Darkcurrent emitted by the rf gun or the cathodes have been a major concern in the first year of operation. Meanwhile, new cathode production techniques and a conditioning effect of the rf gun has reduced the darkcurrent significantly. For TESLA, operation of long pulse trains (800 us length) are required. We report on the development of the charge extraction efficiency along the bunch train for different bunch spacing in the pulse train.

WPAB017 Measurement of the Beam Energy Spread in the TTF Photoinjector

Markus Huening (FNAL), Holger Schlarb (DESY)

At the TESLA Test Facility (TTF) linac the required high peak current for FEL operation is achieved by compressing the beam longitudinally in a magnetic chicane. The peak current after the chicane is determined by the residual energy spread of the electron bunch which is produced by an RF photoinjector. By residual energy spread we refer to the energy spread of a temporal slice of the bunch which can not be compensated by any time dependent energy modulation. To determine the energy distribution an improved optical system has been implemented to image the beam at an OTR-station after a spectrometer dipole. In this paper the results of the beam profile measurements are presented and compared to particle tracking simulations. It is shown that the uncorrelated energy spread in the injector is in order of a few keV only, even at bunch charges of 3 nC.

WPAB018 Beam Dynamics Studies for the SPARC Project

Massimo Ferrario, Marica Biagini, Manuela Boscolo, Valeria Fusco, Susanna Guiducci, Luca Serafini, Cristina Vaccarezza (INFN), Riccardo Bartolini, Luca Giannessi, Marcello Quattromini, Concetta Ronsivalle (Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente)

The aim of the SPARC project, launched by a collaboration among ENEA-INFN-CNR-Universita' di Tor Vergata-INFM, is to promote an R&D activity oriented to the development of a high brightness photoinjector to drive SASE-FEL experiments. The accelerator consists of a 1.6 cell RF gun operated at S-band with a peak field on the cathode of 120 MeV/m and an incorporated metallic photo-cathode followed by an emittance compensating solenoid and two accelerating sections of the SLAC type (S-band, travelling wave). The first task of the project is to demonstrate the effectiveness of the new working point for emittance compensation in a split RF photoinjector. In a second phase a third TW section will be added in order to perform an experiment on RF compression (velocity bunching). We report in this paper the latest results of the beam dynamics group in order to optimise the working point in both SPARC layouts (with and without the velocity bunching section), to set the requirements on the longitudinal and transverse profile of the laser pulse, the phase jitters, the laser pointing stability and the tolerances about the position and the alignment of the emittance compensating solenoid.

WPAB019 Study and Design of Room Temperature Cavities for a RF Compressor Prototype

Dario Giove, David Alesini, Franco Alessandria, Alberto Bacci, Massimo Ferrario, Alessandro Gallo, Fabio Marcellini, Marco Mauri, Luca Serafini (INFN), Carlo De Martinis (University of Milan)

The generation of high brightness electron beams with sub-ps bunch lentgh at kA peak currents is a crucial requirement in the design of injectors for Linac based X-Ray FEL's. In the last years the proposal to use a slow wave RF structure as a rectilinear compressor in this range of interest, to overcome the difficulties related to magnetic compressors, has been widely discussed in the accelerator physics community. Theoretical models have been presented and preliminary experimental investigations have been carried out using speed of light linac sections, which showed the validity of the velocity bunching concept. In this paper the results in the design and study of a model of 3 Ghz cavities to be used for such a structure will be presented. The methods adopted to control the phase velocity (in the range 0.999c to c) to drive the structure through the required configuration will be described as well as the results of first measurements on copper cells prototype. Simulations results showing the advantage of slow wave structures will also be shown.

WPAB020 RF Surface Resistance of Copper-on-Beryllium at Cryogenic Temperatures Measured by a 22-GHz Demountable Cavity

Jian-Fei Liu, Sergey Kurennoy, Dale Schrage, Alan Shapiro, Tsuyoshi Tajima, Richard Wood (LANL)

The experimental setup of a 22-GHz cavity was established to measure the RF surface resistance of small copper-on-beryllium samples and other reference materials. Beryllium substrate material offers extremely low thermal expension plus very high thermal conductivity at cryogenic temperatures. Past efforts to produce high-performance beryllium RF surfaces have failed to meet expectations, whereas measurements on bulk copper at cryogenic temperatures have proven

effective. This attempt to produce copper-plated RF surfaces on beryllium substrates aims to combine the excellent bulk thermal properties of the beryllium substrate with the good RF properties of copper. If successful, this material should tolerate very high surface power densities and thus can be used in the production of a high-brightness, high-average-current RF photo-injector. The RF surface resistance of copper-on-beryllium samples at cryogenic temperatures will be reported together with that of other materials.

* Work supported by the US Department of Energy under contract W7405-ENG-36.

WPAB021 An Injector for the Proposed Berkeley Ultrafast X-Ray Light Source

Steve Lidia, John Corlett, Steve Lidia, Jan Pusina, John Staples, Alexander Zholents (LBNL), Shaoheng Wang (Indiana University)

Berkeley Lab has proposed to build a recirculating linac based x-ray source for ultra-fast dynamic studies [J. N. Corlett, et. al., this conference]. This machine requires a flat electron beam with a small vertical emittance and large x/y emittance ratio to allow for compression of spontaneous undulator emission of soft and hard x-ray pulses, and a low-emittance, round electron beam for coherent emission of soft x-rays via the FEL process based on high gain-high, harmonic generation [W. Fawley, this conference]. An injector system has been proposed consisting of two high gradient high repetition rate photocathode guns [J. Staples, et. al., this conference] (one for each application), a ~100 MeV superconducting linear accelerator, a third harmonic linear accelerator for linearization of the longitudinal phase space, and a bunch compressor. This paper presents details of the design and results of the particle tracking studies using various computer codes.

* This work was supported by the Department of Energy under Contract No. DE-AC03-76SF00098.

WPAB022 Emittance Compensation Studies of Photoinjector Beams with Angular Momentum

Steve Lidia (LBNL), Kai Desler (FNAL), Yin-e Sun (University of Chicago)

Beam dynamics studies on the FNPL photoinjector that seek to optimize the transport of intense electron beams with large values of canonical angular momentum have been performed. These studies investigate the effect of solenoid emittance compensation on beams that evolve under the combined influence of intense space charge forces and large angular momentum. We present details of experimental measurements and supporting simulations of particle tracking and envelope evolution.

* This work was supported by the Department of Energy under Contract No. DE-AC03-76SF00098.

WPAB023 The LBNL Femtosource 10 kHz Photoinjector

John Staples, Steven Lidia (LBNL), Robert Rimmer (Thomas Jefferson National Accelerator Facility)

The LBNL Femtosource, a source of hard X-rays with a 60 fsec FWHM pulse length, will operate at a pulse rate of up to 10 kHz. The room-temperature 1.3 GHz photoinjector design updates include a modified re-entrant first-cell cavity which minimizes peak surface field, the addition of a third pi-mode acceleration cell, waveguide r.f. feeds to each cell, and an active energy removal procedure which reduces the wall power density of all four cells. The plans for a scaled hardware test of the first cell at 850 MHz are under way.

* This work supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

WPAB024 Initial Testing of a Field Symmetrized Dual Feed 2 MeV 17 GHz RF Gun

Amit Kesar, Steve Korbly, Ivan Mastovsky, Richard J. Temkin (MIT Plasma Science and Fusion Center), Jake Haimson, Beverly Mecklenburg (Haimson Research Corporation)

A 3 cell 17.14 GHz RF-gun designed and built by Haimson Research Corporation (HRC) [J. Haimson, B. Mecklenburg and G. Stowell, Advanced Accelerator Concepts, AIP Conference Proceedings, 472 (1998)] is being tested at the Plasma-Science and Fusion Center at MIT. The middle cavity consists of a racetrack design having dual-feed coupling holes in order to achieve a highly symmetrical TM01 pi-mode operation. The high symmetry is important for reducing the beam emittance. The power into the RF gun is supplied by an HRC 25 MW, 17 GHz relativistic klystron amplifier. A 3 MW, 100 ns input pulse is necessary for achieving a peak axial electric field of 200 MV/m in the cavities in order to provide the electron-bunch with a 2 MeV energy gain. A 1 ps, 20 microjoule laser pulse will be injected into the back of the first cell for emitting the electron bunch. The diagnostic setup consists of a YAG screen and a CCD camera for beam imaging, and a slit array, a magnetic spectrometer, and a Faraday Cup for emittance, energy, and bunch charge measurements, respectively. The RF-gun is currently being fed by low power, 100 ns pulses. Our next goals are to process the gun up to 3 MW and 100 ns pulses, to inject the laser pulse and synchronize it with the RF phase, and to measure the output bunch energy, brightness, and duration. An update of the experimental results will be presented at the conference.

WPAB025 High Current Nanopulse Generation in RF Electron Gun with Metal-Dielectric Cathode

Igor Khodak, Mykola Ayzatsky, Volodymyr Kushnir, Victor Mitrochenko, Valentin Zhiglo (NSC KIPT)

RF guns employing emission excited by powerful laser radiation are now preferred instruments to generate high-intensity bunched electron beams in RF-gun based injector for linacs with precise beam parameters. Semiconductor, dispenser or metal photocathodes are used, as a rule, in such guns. These injector systems are complicated enough and require considerable efforts for their design and operation. The intense electron beam at RF gun output can be obtained if other cathodes providing the required high current will be used. They are, for instance plasma cathodes of various types. The paper describes results of calculations, design and experimental study of the intense electron beam source for linear accelerators. This is 1.5-cell S-band RF gun with metal-dielectric cathode. Electrons are emitted in such source from the plasma developed by microwave flashover a dielectric in vacuum. Modes of the gun operation and beam parameters have been researched experimentally on the electron linac. Experiments have shown that in stable mode of operation the beam at the RF gun output has the pulse current of 3.5-4.5A with the current pulse duration of 40-60ns and with particle energy of 300keV. Processes of the beam generation and the gun cavity response to the flashover in high RF fields are dicussed.

WPAB026 Electron Sources for Laser Accelerators

Eric Colby, Christopher Barnes, Chris Sears (SLAC)

Laser accelerators offer the promise of producing attosecond electron bunches from a compact accelerator. Electron source requirements for laser accelerators are challenging in several respects, but are achievable. We discuss these requirements, and propose an injector design. Simulation and design work for essential components of a laser accelerator electron source suitable for a high energy physics machine will be presented. Near-term plans to test key technical components of the laser injector will also be discussed.

* Work supported in part by Department of Energy contract DE-AC03-76SF00515 (SLAC) and by DOE grant no. DE-FG03-97ER41043-II.

WPAB027 Slice and Longitudinal Emittance Experiments at the SLAC Gun Test Facility

David Dowell, Paul Bolton, Jym Clendenin, Steve Gierman, Cecile Limborg, Brendan Murphy, John Schmerge (SLAC)

The Linac Coherent Light Source (LCLS) at SLAC requires the rf photo-injector to produce a beam with a normalized, projected emittance of 1 mm-mrad in a 10 ps long with a charge of 1nC. In addition, a small longitudinal emittance is needed to attain the desired 3 kiloamperes peak current after compression in the chicane bunchers. To achieve this excellent beam quality, we are performing systematic studies of both the transverse and longitudinal beam properties of the rf photocathode gun at the SLAC Gun Test Facility (GTF). Sub-bunch slice emittances are determined by using a 3-meter s-band accelerator section to produce a bunch with a linear energy chirp which is dispersed by a magnetic spectrometer. Varying the strengths of quadrupole lenses upstream of the spectrometer allow measurement of the individual slice emittances. Spectrometer images at the various quadrupole settings are binned in small energy/time windows and analyzed for the slice parameters. Our measurements indicate a temporal resolution of approximately 100 femtoseconds. In addition, the longitudinal phase space distribution is determined by measuring the energy spectrum over a range of linac phases. The correlated and uncorrelated components of the phase space distribution are obtained from fits to the energy spectra. The combined analysis of the transverse and longitudinal data gives not only the slice and longitudinal emittances, but also any correlations due to wakefields or other effects.

∗ SLAC is operated by Stanford University for the Department of Energy under contact number DE-AC03-76SF00515.

WPAB028 Experimental Measurements of the ORION Photoinjector Drive Laser Oscillator Subsystem

Dennis T. Palmer, Ron Akre (SLAC)

In our talk, we shall focus on timing jitter measurements conducted on the ORION photoinjector laser oscillator pulse train output with respect to a ultra low noise master rf oscillator running at 79 1/3 MHz, the 36th harmonic of S-Band. The ORION laser oscillator subsystem consists of a Spectra-Physics Tsunami ultra-fast tunable (750 – 850 nm) laser pumped by a Diode pumped Spectra-Physics Millennia VsP 5W. Overall laser oscillator subsystem performance will be presented. These measurements consist of the laser oscillator M2, autocorrelator function, output power, and laser spectrum. Measurements of the pump laser output power will also be presented. Timing jitter measurements of less than 500 fsec have been attained with the laser oscillator tuned to 800 nm. In addition, various phase noise sources, as well as bandwidth limiting laser system subcomponents will be identified and planned improvements to the laser oscillator will be presented.

WPAB029 Beam Dynamics Studies of a Micro-Pulse-Gun

Chuanxiang Tang, Huaibi Chen, Zhanfeng Jiang, Kai Tian, Ying Wang, Yiyong Xu (Tsinghua University, Beijing)

The beam dynamics in micro-pulse electron guns (MPG) is studied using simulation methods in this paper. Based on the working principle of MPGs and the characteristics of its beam dynamics, a multi-particle trace simulation about the three-dimensional movement of the electrons in an MPG cavity is given by a program SEEG (Secondary Electron Emission Gun) written in VC++. The paper includes the principles of simulation, the stability tests of the program SEEG. An MPG is designed using the program SEEG and the simulated beam dynamic results are given.

WPAB030 Status of the UCLA PEGASUS Injector

Gerard Andonian, Pedro Frigola, Sven Reiche, James Rosenzweig, Soren Telfer (University of California, Los Angeles)

The Pegasus plane wave transformer injector has been conditioned to 20 MW of RF power. Initial operations show a 15 MeV dark current beam that will be used for beam radiation studies. The design of a new LaB6 cathode will allow for both thermionic emission and photoinjection operation. Experiments currently planned include beam instrumentation, surface effects in optical transition radiation, and waveguide SASE FEL.

∗ Work supported by DOE grant DE-FG03-98ER45693.

WPAB031 The UCLA Pegasus Plane Wave Transformer Photoinjector

Gil Travish, Gerard Andonian, Pedro Frigola, Sven Reiche, James Rosenzweig, Soren Telfer (University of California, Los Angeles)

A photoinjector based on a multicell plane wave transformer accelerating structure has been commissioned at the UCLA Department of Physics' Pegasus Laboratory. Design and construction of the novel structure have been previously reported [J. Rosenzweig, et al. PAC Proceedings 1997], and recent operation with a thermionic cathode is being presented at this conference [P. Frigola, et al. these proceedings]. This paper describes the planned operation of the PWT gun as a photoinjector, including design and construction details of the drive laser. Progress to date and future plans are discussed.

∗ This work supported by DOE grant number DE-FG03-98ER45693.

WPAB032 Measurement of Laser Beam Degradation Induced by RF Photoinjector Vacuum Windows

Sandra Biedron (MAX-Laboratory), Yuelin Li (ANL), Marcus Babzien (BNL), Greg Gill (Insulator Seal, Inc.)

RF photoinjectors produce the highest brightness electron bunches only under nearly ideal illumination by a drive laser. Much progress has been made in developing laser systems that meet the requirements imposed by photoinjectors and high-brightness experiments. These requirements include precision control of intensity within the active region of the cathode, a necessity for minimizing space-charge-induced emittance growth. Most approaches involve producing a uniform, or other mathematically simple, laser intensity profile. However, laser diagnostics do not typically extend into the vacuum system of the photoinjector, and electron beam measurements to assess the uniformity of the laser intensity distribution provide very complex results. The vacuum window used to introduce the laser beam is an essential element that may potentially degrade any distribution, making it difficult or impossible to know the actual uniformity achieved at the cathode. Because of the necessity to obtain ultrahigh vacuum near the photoinjector, some restrictions are imposed on the fabrication technology available to manufacture distortion-free windows. At the UV wavelengths commonly used for photoinjectors, it is challenging to measure and eliminate degradation caused by vacuum windows. This paper discusses the measurement and effects of vacuum window induced laser aberration, and demonstrates what is achievable with careful window fabrication.

∗ Work of M. Babzien supported by the United States Department of Energy under contract DE-AC-02-98CH10886.

WPAB033 A Microwave Electron Gun Using X band DAW (Disk-and-Washer) Accelerating Structure for DLA

Yuan Hu, Huaibi Chen, Xiaofu Du, Yuzheng Lin, Chuanxiang Tang, Dechun Tong (Tsinghua University, Beijing)

An X-band Disk-and-Washer standing wave structure is used in a microwave electron gun, which will be used as an electron injector for DLA project in ANL. The beam dynamics simulation results are given in this paper. The phase shift is specially designed in the first

two cavities and a LaB6 cathode is used. The DAW accelerating structures for it has been produced and the microwave measurement results of are also presented in the paper.

WPAB034 Experimental Characterization of the Electron Source at the Photo Injector Test Facity at DESY Zeuthen

Mikhail Krasilnikov, K. Abrahamyan, J. Bähr, I. Bohnet, U. Gensch, H.J. Grabosch, M. Krasilnikov, D. Lipka, V. Miltchev, A. Oppelt, B. Petrossyan, F. Stephan (DESY Zeuthen), M.v. Hartrott, E. Jaeschke, D. Krämer (BESSY), J.P. Carneiro, K. Flöttmann, J. Rossbach, S. Schreiber (DESY), P. Michelato, C. Pagani, D. Sertore (INFN), I. Tsakov (INRNE Sofia), H. Redlin, W. Sandner, R. Schumann, I. Will (Max-Born-Institute), R. Cee, S. Setzer, T. Weiland (Technische U. Darmstadt)

The Photo Injector Test facility at DESY Zeuthen (PITZ) was built in order to study the production of high brightness electron beams, which are substantial for the successful operation of Free Electron Lasers (FEL) and linear colliders. The photoinjector at PITZ is based on a 1.5-cell L-band rf cavity with coaxial rf coupler equipped with emittance compensating solenoids, a laser capable to generate long pulse trains, an UHV photo cathode exchange system, and various diagnostics tools. The current goal of PITZ is a full characterization of the electron source, which will be installed at the TESLA Test Facility Free Electron Laser (TTF-FEL2) in spring 2003. In the running periods before the gun is delivered to TTF-FEL2, the rf performance and the beam parameters will be measured in detail. The results presented in this contribution will contain the measurements of dark current, driving laser parameters, beam charge, beam size along the facility, transverse emittance, momentum and momentum spread. The electron beam measurements will be presented in comparison with beam dynamics simulations.

* The project is funded partially by the HGF Vernetzungsfond.

WPAB035 Preliminary Tests with an S-Band Photocathode RF Gun

Srinivas Krishnagopal, Sanjay Chouksey, Arvind Kumar, Kamal Kumar Pant (Centre for Advanced Technology)

A prototype S-band photocathode gun has been built, cold-tested, and tuned to the design frequency of 2856 MHz. We discuss details of the design and fabrication of the gun, cold-test results, and our plans for hot tests of the gun.

WPAB036 Design of an S-Band, Plane Wave Transformer Integrated Photoinjector

Arvind Kumar (Centre for Advanced Technology)

The design of a novel rf integrated photoinjector based on Plane Wave Transformer linac technology is presented to generate high-brightness electron beam for short wavelength free electron laser applications. This structure is studied using 2-D, 3-D codes SUPERFISH and GDFIDL respectively. The wake potential study of this structure using GDFIDL is presented. The beam dynamics was optimized for the minimum emittance using a solenoid magnet surrounding initial cells of the structure for emittance compensation. A comparison of the emittance achieved for the integrated photoinjector to the separated photoinjector is also presented. In both the methods an emittance of the order of 1 pi mm mrad is achieved for 1nC, 10ps Gaussian beam pulse, although the integrated system have advantage on the separated photoinjector in terms of easy fabrication and removal of the intermediate transport line between photocathode rf gun and the accelerator.

WPAB037 Velocity Bunching Experiment at the Neptune Laboratory

Musumeci Pietro, J.B. Rosenzweig, R. Yoder (University of California, Los Angeles), S. Anderson, W. Brown, A. Tremaine (LLNL)

In this paper we describe the rectilinear compression experiment at the Neptune photoinjector at UCLA. The electron bunches have been shortened to sub-ps pulse length by chirping the beam energy spectrum in a S-band high gradient PWT RF structure and then letting the electrons undergo velocity compression in the following rectilinear drift. Using a standard Martin Puplett interferometer to characterize coherent transition radiation from the beam, we measured bunch length as short as 0.4 ps with compression ratio in excess of 10 for an electron beam of 7 MeV energy and charge up to 300 pC. Extension of this scheme to a different photoinjector system like PLEIADES at LLNL where post accelerating structures can be used to remove the energy spread and to preserve the beam quality is studied.

* This work is supported by U.S. Dept. of Energy grant DE-FG03-92ER40693.

WPAB038 40MeV Electron Source with a Photocathode for Laser-Compton Scattering

Fumio Sakai, Terunobu Nakajyo, Yasushiro Okada, Tatsuya Yanagida, Jinfeng Yang, Masafumi Yorazu (Sumitomo Heavy Industries), Akira Endo (The Femtosecoand Technology Research Association)

2.3 keV femtosecond X-ray generation through laser-compton scattering with 14MeV electron source and a TW Ti:sapphire laser was achieved. In order to increase the X-ray energy up to 15keV for some applications, e.g. protein crystallography, we modified the system to increase electron energy. Electron beams emitted from a S-band RF photocathode are accelerated up to 40MeV with two 1.5m standing-wave linacs. The beams are bended at 90 degree using achromatic bending system, then focused with a triplet quadrupole-magnet to be interacted with laser pulses. The characteristics of electron beams, emittance, energy and energy spread will be described.

WPAB039 An Integrated Travelling-Wave Photoinjector

Telfer Soren (Xgamma Corporation)

Integrated photoinjectors have the potential to provide low cost, high brightness electron beams, and are attractive for scaling to frequencies beyond S-band. Traditionally, they have been built as standing-wave devices. We are developing a novel high-brightness electron source that couples a two-cell standing wave cavity directly to a multi-cell travelling-wave structure. This configuration offers a number of potential advantages over the standing-wave devices. By making the first cell of the travelling-wave section couple both to the standing wave cavity and the feed guide, we can mitigate some of the standing wave section's unfavorable transient characteristics. This is important for frequencies higher than S-band, where high-power isolators are very costly or non-existant. Furthermore, by utilizing a relatively low accelerating gradient in the travelling wave section, we can produce an fully emittance-compensated electron beam at the exit of the structure, a state of affairs that does not hold in the case of standing-wave devices. Use of low gradient also allows higher energy operation. We will discuss the critical issue of electromagnetic coupling, as well as the expected beam performance.

* Work Supported By DOE SBIR Grant Number 03-02ER83576.

WPAB040 Multibunch Electron Generation by a Laser Pulse Train Technique in a Magnesium Cathode RF Gun

Jinfeng Yang, Terunobu Nakajyo, Yasushiro Okada, Fumio Sakai, Tatsuya Yanagida, Masafumi Yorozu (Sumitomo Heavy Industries), Akira Endo (The Femtosecond Technology Research Association)

A multi-bunch electron source has been developed by a 1.6-cell S-band RF gun with a laser pulse train technique. A high-quantum efficiency magnesium(Mg) cathode has been manufactured and installed in the RF gun. A solid-state pulse train laser has been developed to drive the RF gun. The laser produces a 119MHz train of up to 60 equal-amplitude pulses with a rectangularly shaped envelope of 4% pulse-to-pulse flatness. The quantum efficiency of up to 1x10^3 was achieved by performing a laser cleaning on the magnesium cathode surface. The beam emittance and thermal emittance of Mg were measured. The energy spread of the multi-bunch electron beam was measured.

WPAB041 Wedge-Shaped, Large-Aperture, Dipole Magnet Design for the TJNAF FEL Upgrade

David Yu, Yan Luo, David Newsham, Alexei Smirnov (DULY Research Inc.), George Biallas (Thomas Jefferson National Accelerator Facility)

Two types of dipole magnets were simulated and designed, built and measured for the Thomas Jefferson National Accelerator Facility FEL upgrade. Different magnets have to operate in series with common power supply and provide ~0.01 % field and field integral accuracy over a large aperture. The magnets have essentially different angles and effective length-to-aperture aspect ratios. Sophisticated tunable design was developed for the magnet having small aspect ratio (~2.7) and large angle (20 degrees). Trim coils, shims, and side sliders in the field clamps were introduced to compensate field gradients, non-uniformities, and parasitic fringe field effects. A number of design, performance and test measurement issues are discussed.

WPAB042 Beam Emittance Calculations of a PWT Photoinjector

David Yu, Yan Luo, David Newsham (DULY Research Inc.), J. Clendenin (SLAC)

The Los Alamos code PARMELA, version 3, was used to investigate the relation of transverse emittance, e, and magnetic field, Bz, for different field gradient, Ep. Simulations were performed for a p-mode, S-band, integrated PWT photoinjector [X. Ding et al., PAC Proceedings, 2021,1999; D. Yu, Proceedings 2nd ICFA Workshop, 585,1999]. The first cavity consists of a half cell, followed by 10 full cells and another half cell. Transverse emittance and other beam parameters were calculated for field gradients ranging from 60 MV/m to160 MV/m, for a bunch charge of 1 nC. For each field gradient, we optimize the injection phase fo first, then use this starting phase to find minimum transverse emittance by varying magnetic field Bz. The beam dynamics of the DULY PWT photoinjector is fundamentally different from that of the canonical BNL/SLAC/UCLA 1.6 cell gun [D.T. Parmer, Ph.D. Thesis, SLAC, 1998]. Unlike the latter for which the emittance exhibited a minimum at a field gradient of 143 MV/m, the PWT is only minimally affected by the exit rf kick and the submicron beam emittance continues to decrease as the field gradient increases.

* Work supported by DOE SBIR grant no. DE-FG03-98ER82566.

WPAB043 Development of a Polarized Electron Gun Based on an S-Band PWT Photoinjector

David Yu, Yan Luo, David Newsham, Alexei Smirnov (DULY Research Inc.), J Clendenin, R Kirby, D Schultz (SLAC)

An RF polarized electron gun utilizing the unique features of an integrated plane-wave-transformer (PWT) photoelectron injector [D. Yu, J. Clendenin, R. Kirby, US Patent Application 10/261831, 9/30/2002] is being developed by DULY Research Inc. in collaboration with SLAC. Modifications to a DULY S-band device [X. Ding, et al., PAC Proceedings, 2021, 1999; D. Yu, Proceedings 2nd ICFA Workshop, 585, 1999.] include: a re-design of the photocathode/RF backplane interface to accommodate a GaAs cathode; the inclusion of a load-lock photocathode replacements system to allow for reactivation and cesiation of the GaAs photocathode; alteration of the magnet field coils to make room for the load-lock; and change in the design of the vacuum ports to provide 10^{-11} torr operation. The use of a stainless steel outer tank and cooling rods without copper plating will provide better vacuum performance at the expense of diminished Q-factor. The effectiveness of both the standard cooling rods and synthetic diamond heat sinks for disk cooling is investigated for future linear collider applications operating at a rep rate of 180 Hz and a bunch charge of 2 nC.

* Work supported by DOE SBIR grant no. DE-FG03-02ER83401.

WPAB044 Design of a DC/RF Photoelectron Gun

David Yu, Yan Luo, David Newsham, Alexei Smirnov (DULY Research Inc.), John Lewellen (ANL), John Smedley, T. Srinivasan-Rao (BNL), A. Zholentz (LBNL)

A design is considered for an integrated DC/RF photoelectron gun that produces a low-emittance beam by first rapidly accelerating electrons to a kinetic energy of ~250 keV during a short (~ 1 ns), high-voltage pulse and then injecting the electrons into an rf cavity for subsequent acceleration. Simulations show that significant improvement of the emittance appears when high-gradient fields (~0.5-1 GV/m) are applied to the cathode surface. An adjustable DC gap which can be integrated with an rf cavity is designed for initial testing at the Gun Test Facility at Argonne National Laboratory using an existing 70-kV pulse power supply. Preliminary test results are presented. Plans for further experiments with a 250-kV pulse power supply are discussed.

* Work supported by DOE SBIR grant no. DE-FG03-02ER83402.

WPAB045 Design of Compact Multipole Magnet for the TJNAF FEL Upgrade

David Yu, Yan Luo, David Newsham, Alexei Smirnov (DULY Research Inc.), George Biallas, Robin Wines (Thomas Jefferson National Accelerator Facility)

Novel designs for octupole and sextupole magnets for 10kW, TJNAF FEL upgrade were developed and characterized. The designs made with 3D simulations using the RADIA program provide very short effective length that nearly equals to the aperture radius. The magnets met the required 1% accuracy of the field integral over 70% of the large aperture. The main design feature is a special approach to shape the cylindrical pole tips to provide high field quality while being dominated by fringe fields. Other features are magnetically isolated field clamps, use of non-tapered coils of standard racetrack shape, and non-linear saturation effects (for sextupole magnets).

WPAB046 Building a Family of Corrector Magnets for SNS Facility

Sorin Badea, James Alduino, Nick Tsoupas, Joseph Tuozzolo (BNL)

The Spallation Neutron Source (SNS) to be built in Oak Ridge Tennessee includes an accumulator ring with a circumference of 248 meters, an injection line and an extraction line. The machine is designed to accumulate 2E+14, 1.0 GeV kinetic-energy protons in 1ms, via a charge exchange injection of H. This paper describes the concept behind the design and fabrication of seven types of air cooled corrector magnets built in 17 functions totaling 96 magnets, to be used in the above project.The main effort was aimed toward an original

design to deliver the required magnetic field with cost effective solutions and easy installation and maintenance. The required integrated field was between 6.86 and 10.22 KGauss.cm for dipoles and integrated gradient field was between 225 and 295 Gauss for quads. There were some sextupoles built under the same constraints. 3D EM calculations were performed: to determine the integrated field of dipole and establish the optimum number of turns; and to minimize the integrated sextupole component introduced by the corrector dipole. Results and methods employed to achieve the goals will be presented.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 with U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPAB047 Design of a Ultra High Vacuum Compatible Copper Septum Magnet

Michael Mapes, Nicholaos Tsoupas (BNL)

A Ultra High Vacuum compatible thin copper septum magnet has been developed at Brookhaven National Laboratory. The solid core, single turn magnet is pulsed at 1500 amps and has a field of 0.6 KG. The 0.76 mm thick copper septum is water cooled and is designed to run at a maximum power of 2 KW. A remote positioning system is used to optimize the septum position during various extracted beams. The cross section of the septum magnet was modeled and 2-dimensional magnetic field calculations were performed to compute the magnetic field uniformity in the main field region and in the field strength in the fringe field region. The calculated field uniformity as well as comparison of the calculated fields in the fringe field region with the measured fields in the same region will be presented. The design and construction techniques used to fabricate this magnet will also be described.

* Work performed under the auspices of the U.S. Department of Energy.

WPAB048 Mechanical Design Of A Ferrite Based Injection Kicker For SNS Accumulator Ring

Chien Pai, Nuria Catalan-Lasheras, Wahfun Eng, Hsiao-Chaun Hseuh, Robert Lambias, Yong Y. Lee, Wuzheng Meng, Jon Sandberg, Steven Tepikian, Joseph Tuozzolo (BNL)

Two sets of kickers, 4 pulsed dipoles in each set, will be used in the SNS accumulator ring to create dynamic orbit bump for injection process. These kickers are designed as large aperture, window frame magnets. The designs of these 8 kickers are completed. The first article kicker was assembled and being tested. In this paper we discuss the mechanical design criteria of these kickers, the layout in the accumulator ring, the magnetic field requirements and the ferrite based magnet field analysis, the eddy current and thermal considerations in the choice of ceramic vacuum chamber and its implementation. Also we discuss a wedge shaped clamp which was designed to reduce the vibration in the coil when powered at 60 Hz repetition rate.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPAB049 Mechanical Design Of Fast Extraction Kicker And PFN For SNS Accumulator Ring

Chien Pai, Daniele Davino, Harald Hahn, Hsiao-Chaun Hseuh, Yong Y. Lee, Wuzheng Meng, Jianlin Mi, Jon Sandberg, Nicholaos Tsoupas, Joseph Tuozzolo, David Warburton, Wu Zhang (BNL)

Two kicker assemblies, 7 pulsed magnet modules in each assembly, will be used in the SNS accumulator ring to kick the beam vertically to the extraction septum then to the target. These kickers are designed as window frame magnets housed inside a vacuum chamber. Fourteen Pulse Forming Networks (PFN) housed in separate silicon fluid containers are designed to power each kicker module. A single module prototype of kicker and PFN has been successfully assembled and tested. In this paper we discuss the mechanical design criteria of these kicker assemblies, the installation layout in the accumulator ring, the structural analysis of the kicker chamber, the magnetic field analysis of the ferrite magnet, the high voltage feedthrough design, the structural design of the PFN container, the cooling and the thermal expansion considerations of the silicon fluids.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPAB050 The Extraction Lambertson Septum Magnet of the Spallation Neutron Source

Jim Rank, Deepak Raparia, Nick Tsoupas (BNL)

In the Spallation Neutron Source, to be constructed at Oak Ridge National Laboratory, a high-intensity proton beam impinges on a mercury target to spallate neutrons. The fast extraction of the 1.0 GeV protons is achieved by a series of kicker elements that "bump" the recirculating beam from the accumulator ring into the electromagnetic field of a Lambertson type thin septum. The proton beam bends 16.8 degrees through the Extraction Lambertson Septum Magnet and exits on a projection to the fixed target. Here we discuss the lattice geometry, beam dynamics and optics, and the vacuum, electromagnetic and electromechanical design aspects important to the development of an Extraction Lambertson Septum Magnet. Extraction beam optics is studied. Coordinate transformations for pitch and roll geometry are established. Fundamental magnet sections are depicted schematically. Two and three dimensional magnetic field calculations using Opera (R) for optimization of field quality in both the circulating and extraction region are presented. Coil and pole design calculations, and septum stress analyses are shown.

* Work performed under contract DE-AC05-00OR22725 for SNS, managed by UT-Battelle, LLC. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPAB051 Magnetic Field Calculations for a Large Aperture Narrow Quadrupole

Nicholaos Tsoupas, Yung Lee, Deepak Raparia, Jie Wei (BNL)

In the design of high-intensity proton synchrotrons and accumulator rings, quadrupole magnets of narrower size in one of the transverse dimensions are often needed to accommodate the compact ring geometry, complicated injection and extraction layout, and large vacuum chamber aperture. The stringent limit on tolerable beam loss further demands a good magnetic field quality to minimize beam resonances caused by higher-order magnetic multipoles. In this paper, we present results from magnetic fieled calculations performeed on 2D and 3D modells of a large-aperture narrow-quadrupole. The pole face of the quadrupole has been optimized to minimize the integrated field of the first three allowed multipoles (12pole,20pole and 28pole). The ratio of each integrated magnetic-multipole-strength to the integrated magnetic-quadrupole-strength at a radius of 85% of the quadrupole's pole-tip-radius is less +-2x10**-4. Results from the calculations performed on the 2-dimensional and 3-dimensional models of the narrow quad will be presented.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPAB052 Design and Manufacturing of SNS Accumulator Ring and Transport System D.C. Magnets

Joseph Tuozzolo, James Alduino, S. Viorel Badea, William Birkholz, John Brodowski, George Mahler, James Rank, Deepak Raparia, Scott Seberg (BNL)

The Spallation Neutron Source Accumulator Ring requires large aperture dipole magnets, strong focusing quadrupole and sextupole magnets, and low field corrector dipole, quadrupole, sextupole, and octopole magnets. All of these magnets will provide a fixed magnetic field throughout the accumulator's fill/storage/extraction cycle. Similar fixed field magnets are also being built for the beam transport lines from the linac and to the target. Because of the high intensity in the accumulator, the magnets must be built with tight tolerances for optimum field quality. Because some of the magnets are powered in strings, those magnets must have tight tolerances and consistent material properties to provide the same integral field from magnet to magnet. Radiation resistance, maintainability, and cost were other major factors in determining the magnets' design. The accumulator ring and transport line lattice design required 27 different magnet types out of the 290 magnets to be installed. This resulted in small quantity procurements that affected the cost of fabrication and testing of the magnets. The manufacturing methods, cost, schedule, and the resulting trade-offs in the magnets' design and fabrication are the subject of this paper.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPAB053 Final Test Results for the SNS Ring Dipoles

Peter Wanderer, John Jackson, Animesh Jain, Y-Y Lee, Wuzheng Meng, Deepak Raparia, Steve Tepikian, Nicholaos Tsoupas, Jie Wei (BNL)

To meet the performance parameters of the Spallation Neutron Source (SNS) for high beam intensity with low losses, the compact accumulation ring will contain 32 sector dipoles with 1.44 m effective length and a large aperture, 170 mm. The magnets are built from potted coils and machined pieces of solid iron. When first assembled, the dipoles met the requirements for field uniformity but the rms variation of the integral transfer function (ITF) was much larger than design at both fields of interest, 1.11 Tm and 1.33 Tm, corresponding to proton energies of 1.0 GeV and 1.3 GeV respectively. Based on initial measurements, shims have been added to the return legs or poles, as appropriate, in order to bring the rms variation of the 1.0 GeV ITF to the specification, 0.01%. The value of the ITF rms variation at 1.3 GeV for the shimmed magnets is 0.033%. Sorting the magnets has significantly reduced the load on the correctors due to this ITF variation.

* SNS is managed by UT-Batelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six U.S. national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPAB054 Initial Test of a Fast-Ramped Superconducting Model Dipole for SIS200 at GSI

Peter Wanderer, Michael Anerella, George Ganetis, Arup Ghosh, Piyush Joshi, Andrew Marone, Jesse Schmalzle, Rainer Soika, Richard Thomas (BNL), William Hassenzahl (Advanced Energy Analysis, Inc.), Juris Kaugerts, Gebhard Moritz (Gesellschaft für Schwerionenforschung mbH), Martin Wilson (consultant)

Gesellschaft fur Schwerionenforschung (GSI) has proposed a large expansion of its present accelerator facility in Darmstadt, Germany. The proposal includes an accelerator with Br = 200 T-m that utilizes 4 T superconducting dipoles ramped at 1 T/s. The RHIC arc dipoles, with 8 cm aperture, possess adequate aperture and field strength but are ramped at only 1/20 of the desired rate. An R&D program including both the superconductor and the magnet is directed at achieving the desired ramp rate with minimal energy loss. For reasons of speed and economy, the RHIC arc dipole is being used as the basis for this work. The superconductor R&D has progressed far enough to permit the manufacture of an initial cable with satisfactory properties. This cable has been used in the construction of a 1 m model dipole, appropriately modified from the RHIC design. The results of quench testing, energy loss measurements, and DC field quality will be reported.

* Work supported by the U.S. Department of Energy under Contract No. DE-AC02-98CH10886 and by Gesellschaft fur Schwerionenforschung.

WPAB055 Magnets for the CANDLE Booster Synchrotron, Design and Prototyping

Vitali Khachatryan, Yurik Martirosyan (CANDLE)

CANDLE booster synchrotron magnetic lattice contains 48 dipoles of H-shape. Detailed magnetic and mechanical design of those magnets is performed within the framework of the CANDLE project. In this report, the design considerations of the dipole magnet, including the magnetic field simulation are presented. The results of the numerical simulation are compared with the magnetic field measurements of the first prototype dipole magnet.

WPAB056 Sextupole/Multipole Magnets for the DIAMOND Light Source

Neil Marks (Daresbury Laboratory)

The new U.K synchrotron light source DIAMOND will be a 3 GeV electron storage ring. In the third generation lattice, there will be 168 sextupole/multipole magnets. In addition to the static sextupole field, required for chromaticity control, the magnets are also designed to generate dynamic horizontal and vertical field, for real-time closed orbit correction, and static skew quadrupole field for coupling control. The sextupole field will be generated by coils wound on the magnet's poles, whilst the dipole and quadrupole components will be excited by five back-leg coils, wound around the circular yoke. In common with other multi-pole magnets designed for synchrotron light sources, the emerging beam-lines require clear space radially outwards from the electron vacuum vessel. This results in the magnetic yokes having a gap in the outward region of the magnets. The paper will give details of the geometry of the pole and back-leg coils required to generate the fields and the resulting amplitude and quality of the dipole, skew quadrupole and sextupole components.

WPAB057 Beam Based Measurements of Hysteresis Effects in Fermilab Main Injector Magnets

Bruce Brown, David P. Capista (FNAL)

Operation of the Fermilab Main Injector is sensitive to magnetic field changes due to hysteretic effects. Measurements using the beam are reported with various current ramps. This will provide magnetic field information for accelerator operations with more precision and better ramp control than is available from magnet test facility data. This makes possible improved low field reproducibility with mixed 120 GeV and 150 GeV operation of the Main Injector.

* Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy.

WPAB058 A New Lambertson Magnet for the FNAL 400 MeV Linac

Jean-Francois Ostiguy, Henry Glass, David Harding, James Lackey, William Robothom (FNAL)

A new Lambertson magnet has been constructed for use at the downstream end of the Fermilab 400 MeV Linac. To reduce costs, the core is composed of laminations left over from the Main Injector dipoles with a round hole through one pole face. In contrast with conventional Lambertson designs, the magnet is excited by two coils located above and below the field region. The integrated transverse fringe field at the end of the field-free region is minimized using a pole piece extension with 75% packing factor followed by a thick flux return plate. The relatively low packing factor prevents saturation of the extension by the return flux and preserves the odd longitudinal symmetry of the transverse flux pattern. Measurements show better than an order of magnitude reduction of the integrated transverse field, in good agreement with simulations.

* Work supported by the US Department of Energy under contract no. DE-AC02-76CH03000.

WPAB059 Eddy Current Effect of Magnets for J-PARC 3-GeV Synchrotron

Norio Tani, Kenichro Kanazawa, Yasuhiro Watanabe (Japan Atomic Energy Research Institute), Toshikazu Adachi, Hikaru Sato, Hirohiko Someya (KEK)

The 3-GeV synchrotron proposed in the JAERI/KEK Joint Project (J-PARC) is a rapid-cycling synchrotron (RCS), which accelerates a high-intensity proton beam from 400-MeV to 3-GeV at a repetition rate of 25-Hz. The 3-GeV synchrotron is used to produce pulsed spallation neutrons and muons. It also works as an injector for a 50-GeV synchrotron. Since the magnets for the 3-GeV synchrotron are required to have a large aperture in order to realize the large beam power of 1 MW, there is a larger leakage field at an end part than a usual synchrotron magnet. In addition, 25-Hz ac field induces an eddy current in magnet components:e.g. a coil, magnet end plates and etc. The eddy current induced in the end plates is expected to be large. Therefore, it is important to investigate an effect of large leakage field and eddy current to the beam motion around the magnet end part. We have measured the eddy loss and the eddy field at the edges of the dipole and quadrupole magnets. In this paper, we report the comparison between the results of the measurements and the two-dimensional eddy current model developed for this study.

WPAB060 Pulse Octupole Magnet System at the Photon Factory Storage Ring

Tsukasa Miyajima, Yukinori Kobayashi, Shinya Nagahashi (KEK)

In the Photon Factory Storage Ring, a vertical instability is observed in a multi-bunch operation mode. The instability can be suppressed by DC octupole magnetic field in routine operation.It seems that the instability is caused by ion trapping effect, the operating parameters in routine operation are near the threshold of it.In order to study the dynamical property of the instability, we have developed a pulse octupole magnet system. The magnet can operate with magnetic field rise and fall time of around 1msec, respectively. The integrated field strength reach 2600T/m^2. In this report, we will present the design performance, the results of magnetic filed measurement and preliminary results of a measurement for the behavior of the instability.

WPAB061 SPEAR3 Gradient Dipole Core Fabrication

Nanyang Li, Richard Boyce, Domenico Dell'Orco, Dave Ernst (SLAC), Huamin Qu, Xiaoping Wang (Institute of High Energy Physics, Beijing), Jack Tanabe (SPEAR3 Project Consultant)

Traditional means of core fabrication are to glue the laminations or weld them to form the yoke structure. These means result in good yoke assemblies for shorter (<0.6m) magnets. However, because of weld distortions or mechanical strength limitations, welding and/or gluing techniques are difficult to gain high mechanical precision for longer cores. The SPEAR3 gradient dipoles are up to 1.45m long and require distortions of <0.05mm. Therefore, the SPEAR3 gradient dipole core design incorporated an assembly technique, originally devised for the PEPII insertion quadrupoles and later adapted for the ALS gradient magnets. This technique involved fabricating a rigid frame for the core, precisely stacking and compressing the laminations using hydraulic jacks and granite surfaces and straight edges, and fixing the laminations in the frame by filling the grooves between the laminations and frame using steel loaded epoxy. Although this technique has been used in the past, it has never been fully described and published. This paper is written to provide a detailed description of the procedure and to present measurement data demonstrating the mechanical precision and stiffness of the resulting product.

* US Department of Energy Contract DE-AC03-76SF00515.

WPAB062 Cost Based Failure Modes and Effects Analysis (FMEA) for Systems of Accelerator Magnets

Cherrill Spencer (SLAC), Seung Rhee (Stanford University)

The proposed Next Linear Collider (NLC) has a proposed 85% overall availability goal, the availability specifications for all its 7200 magnets and their 6167 power supplies are 97.5% each. Thus all of the electromagnets and their power supplies must be highly reliable or quickly repairable. Improved reliability or repairability comes at a higher cost. We have developed a set of analysis procedures for magnet designers to use as they decide how much effort to exert, i.e. how much money to spend, to improve the reliability of a particular style of magnet. We show these procedures being applied to a standard SLAC electromagnet design in order to make it reliable enough to meet the NLC availability specs. First, empirical data from SLAC's accelerator failure database plus design experience are used to calculate MTTF for failures modes identified through a FMEA. Availability for one particular magnet can be calculated. Next, labor and material costs to repair magnet failures are used in a Monte Carlo simulation to predict the total cost of all failures over a 30-year lifetime. Opportunity costs are included. Engineers choose from amongst various designs by comparing lifecycle costs.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

WPAB063 Permanent Magnets for Radiation Damage Studies

James Spencer (SLAC), James Volk (FNAL)

Permanent magnetic (PM) devices have many current and potential applications based on advantages in size, cost and simplicity but suffer from uncertainties related to environmental and damage effects. In the next linear collider, PM multipoles, undulators and wigglers could have important uses if the limits of their stability to different kinds of high radiation environments could be established. A necessary ingredient that needs more work is a magnet designed specifically to explicate demagnetization effects as a function of the principal characteristics of the material, the block and its fabrication procedures. These need to be independently variable while minimizing the induced radioactivity. We discuss such a magnet, defined as more than one, discrete PM block, that could not be used for conventional applications but allows a good comparison between the key ingredients thought to be important in radiation damage mechanisms. Under certain qualifying caveats, conventional PM dipoles are probably the least susceptible to radiation damage followed by undulators, wigglers, and quadrupoles because of their differing characteristic load lines and their variations throughout each type of block and each type of magnet. We describe the magnet and the measurements on it and its individual

blocks and also discuss the parameters of most interest and the constraints that motivate this choice of magnet.

WPAB064 Magnetic Measurement of the 10 kW, IR FEL 180 Degree Dipole

Kenneth Baggett, M. Beck, G. Biallas, D. Bullard, D. Douglas, T. Hiatt, K. Sullivan (Thomas Jefferson National Accelerator Facility)

A family of large bending dipoles has been magnetically measured to support the 10 kW IR-FEL upgrade. This upgrade will allow for a wider wavelength range and an increase in the machine energy to operate between 80 MeV/c to 210 MeV/c. The dipole magnets allow the beam to bend 180 degrees over a 1 meter radius. The requirements for these magnets include varying field strengths, large horizontal apertures and parts in 10,000 field homogeneity as well as setability of core and integrated field. This paper will describe the process involved in measuring and achieving these requirements.

∗ This work supported by DOE Contract DE-AC05-84ER40150, the Office of Naval Research, Air Force Research Laboratory, the Commonwealth of Virginia and the Laser Processing Consortium.

WPAB065 Magnetic Modeling vs. Measurements of the Dipoles for the JLAB KW Free Electron Laser Upgrade

George Biallas, David Douglas, Tom Hiatt (Thomas Jefferson National Accelerator Facility), Vincent Christina, John Rathke, Thomas Schultheiss (Advanced Energy Systems, Inc.), David Newsham, Alexai Smirnov, David Yu (DULY Research Inc.)

Magnetic measurements of the six families of dipoles for the infrared Free Electron Laser Upgrade at the Thomas Jefferson National Accelerator Facility (Jlab) are compared to the magnetic models on which their design is based. The magnets were designed in parallel by three organizations. They used either ANSYS, RADIA or 3D TOSCA as their magnetic modeling program. Measurement data was taken by Hall probes, calibrated against an NMR probe and automatically stepped through the magnetic volume. Comparison of the discrepancies between model and final magnet is presented along with analysis of the potential causes of discrepancies. These dipoles operate in two field regions. The Injector/Extractor Dipoles operate at low field (500 Gauss) at a single excitation. The Arc Dipoles and Optical Chicane Dipoles operate at 4.1 or 4.9 KGauss with a ~45% dynamic range requirement. All magnets are required to meet core field and field integral flatness to parts in 104 over their "good field" region.

∗ This work supported by the US Dept. of Energy, the Commonwealth of Virginia, the Office of Naval Research, the Laser Processing Consortium, the Joint Technology Office, and the Air Force Research Laboratory.

WPAB066 Magnetic Measurement of the 10 kW, IR FEL Dipole Magnets

Tommy Hiatt, K. Baggett, M. Beck, G. Biallas, D. Douglas, K. Sullivan (Thomas Jefferson National Accelerator Facility)

Magnetic measurements have been performed on several families of dipoles for the 10 kW IR-FEL presently under construction at the Thomas Jefferson National Accelerator Facility. The requirements for these magnets include varying field strengths, large horizontal apertures and parts in 10,000 field homogeneity as well as setability of core and integrated field. Measurements were made to quantify the magnets according to these requirements and to determine the hysteresis protocol, ramp rate dependence, and field clamp settings that are used. This paper will describe the results of these measurements and the procedures used to accomplish them.

∗ This work supported by DOE Contract DE-AC05-84ER40150, the Office of Naval Research, Air Force Research Laboratory, the Commonwealth of Virginia and the Laser Processing Consortium.

WPAB067 An Adjustable Permanent Magnet Quadrupole Final Focus System for Low Energy Experiments

Jae Lim, P. Frigola, J.B. Rosenzweig, S. Telfer, G. Travish (University of California, Los Angeles)

The final focus system for the Thomson X-ray scattering experiment termed PLEIADES (Picosecond Laser-Electron InterAction for Dynamic Evaluation of Structures) at LLNL demands ultra-high field gradient quadrupoles in order to focus initially small beams to 10-20 micron spot sizes. This scheme circumvents limitations due to chromatic aberrations and space-charge effects in this relatively low energy.

∗ DOE grant number: DE-FG03-98ER45693 and funded by LLNL Institute for Laser Science and Applications.

WPAB068 Canadian Light Source Magnets

Les Dallin, Dan Lowe (Canadian Light Source)

Magnets for the Canadian Light Source (CLS) storage ring have been designed and are now under construction. Magnet include gradient dipoles, quadrupoles, sextupoles, orbit correctors, injection septum and kickers. The compact CLS lattice requires strong focusing and consequently field gradients approach the upper limit of conventional magnet technology. Magnets are being manufactured by industry at a variety of locations. Prototypes have been developed and measured and meet the requirements set out in the magnet specifications. A description of the CLS magnets and magnet measurement results will be presented.

WPAB069 Permanent Magnet

Yoshihisa Iwashita, Masahiro Ikegami (Kyoto University), Evgeny Antokhin (BINP), Masayuki Kumada (NIRS), Aoki Masaaki (Sumitomo Special Metal Co.,Ltd.)

Strong Permanant Magnet Quadrupole Lens is one of the candidates as the final focus lens for the linear collider, because of its compactness and less power consumption, while one drawback is its fixed strength. The total strength of a lens can be changed by rotating subdivided pieces separately. Some issues on such a system will be discussed.

WPAB070 A Switching Magnet for the IFUSP Microtron Beam Line

Marcos Martins, Roberto Lima, Mauricio Lopes, Alexandre Malafronte, Jiro Takahashi (Instituto de Fisica da Universidade de Sao Paulo)

In this work we discuss the design stages for a DC Switching Magnet for the IFUSP Microtron beam line. The magnet should be able to bend beams with energies between 5 and 31 MeV in right angles. We adopted a configuration with azimuthal symmetry in order to comply with the boundary conditions of the accelerator building and to ease the machining process. The distribution and uniformity of the magnetic field are presented, and compared with simulation results from Poisson and FEMM codes. The project and construction of the vacuum chamber are also presented.

∗ Work supported in part by FAPESP and CNPq.

WPAB071 Chromaticity Correction in a Round-Beam Collider VEPP-2000

Alexander Valishev (BINP)

We describe the chromaticity correction in a round-beam optics of the VEPP-2000 electron-positron circular collider. Influence of the sextupoles on the beam dynamics and dynamical aperture is analyzed, as well as its sensitivity to the optics errors.

WPAB072 Measurements of Betatron Functions and Phase Advances in RHIC with AC Dipoles

Mei Bai, Steve Peggs, Thomas Roser, Todd Satogata, Dejan Trbojevic (BNL)

High energy hadron collider operation requires accurate measurements of the betatron functions and phase advances, to check the linear optics and to locate gradient errors. During the RHIC 2003 run, two ac dipoles with vertical and horizontal magnetic field were used to measure the linear optics at the storage and at injection energies. The two ac dipoles are set up to adiabatically induce sizable coherent oscillations at a frequency close to the betatron frequencies. The betatron functions and phase advances are then calculated from the 1024 turn-by-turn measurements available from all the RHIC beam position monitors. Because the coherence excitation is adiabatic, the beam emittance is preserved after the measurement. The algorithm is discussed in this paper, and experimental results are presented.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

WPAB073 Measurement of Linear Coupling Resonance in RHIC

Mei Bai, Fulvia Pilat, Todd Satogata (BNL), Frank Schmidt, Rogelio Tomas (CERN)

Linear coupling is one of the factors which determine the lifetime in RHIC. The traditional method of measuring the minimum tune separation requires a tune scan and can not be done either parasitically or during the ramp. A new technique of measuring linear coupling resonance was developed at CERN that measures the degree of coupling by comparing the secondary fundamental tune line to the primary one, i.e. only in the presence of coupling such a secondary line can be found. The advantage of this method is that it can be done without changing the normal machine working points. This method can also localize the coupling source by mapping out the coupling driving terms through out the ring. This is very useful for local decoupling the interaction regions in RHIC. A beam experiment of measuring linear coupling has been performed in RHIC during its 2003 run. In this article the theory and the analysis of the experimental data will be discussed.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

WPAB074 Linear Model for Non-Isosceles Absorbers

J. Scott Berg (BNL)

Previous analyses have assumed that wedge absorbers are triangularly shaped with equal angles for the two faces. In this case, to linear order, the energy loss depends only on the position in the direction of the face tilt, and is independent of the incoming angle. One can instead construct an absorber with entrance and exit faces facing rather general directions. In this case, the energy loss can depend on both the position and the angle of the particle in question. This paper demonstrates that and computes the effect to linear order.

* Work supported by the Department of Energy, contract DE-AC02-98CH10886.

WPAB075 Linear Design of Combined-Function Ionization Cooling Lattices

J. Scott Berg, Harold Kirk (BNL), Alper Garren (University of California, Los Angeles)

Ionization cooling lattices simultaneously require small beta-functions at the absorber and large energy acceptances to be effective. Simultaneously achieving these goals as well as having a good dynamic aperture requires that the lattice be relatively compact. If one wishes to avoid solenoids, one choice for creating such a lattice is to use combined-function magnets. These magnets can simultaneously focus in both planes, allowing one to achieve a low beta in both planes with a minimum number of magnets. In this paper we explore the design of lattices which contain only combined-function bending magnets using a thin-lens approximation, showing how to optimally achieve the requirements for muon cooling.

* This research has been supported by the U.S. Department of Energy under contract no. DE-AC02-98CH10886.

WPAB076 Design of FFAGs Based on a FODO Lattice

J. Scott Berg (BNL), Carol Johnstone (FNAL)

An FFAG is a lattice with fixed magnetic fields that has an extremely wide energy acceptance. One particularly simple type of FFAG is based on a FODO lattice, where both quads can be combined-function bending/quadrupole magnets. The spaces between the combined-function magnets are left open for RF cavities and other hardware. This paper descibes a general method for creating lattice designs for this type of lattice which gives the lattice optimal properties for an FFAG accelerator. The properties of this lattice as a function of input parameters are explored. The use of sextupoles to improve lattice properties is also explored.

* This research has been supported by the U.S. Department of Energy under contract no. DE-AC02-98CH10886.

WPAB077 End Field Effects in Bend-Only Cooling Lattices

J. Scott Berg, Harold Kirk (BNL), Alper Garren (University of California, Los Angeles)

Cooling lattices consisting only of bends (using either rotated pole faces or gradient dipoles to achieve focusing) often require large apertures and short magnets. One expects the effect of end fields to be significant in this case. In this paper we explore the effect of adding end fields to a working lattice design that originally lacked them. The paper describes the process of correcting the lattice design for the added end fields so as to maintain desirable lattice characteristics. It then compares the properties of the lattice with end fields relative to the lattice without them.

* This research has been supported by the U.S. Department of Energy under contract no. DE-AC02-98CH10886.

WPAB078 Linear Coupling Correction with N-Turn Maps

Wolfram Fischer (BNL)

The linear one-turn map of a storage ring contains coupling information on which a correction algorithm can be based. In principal, the one-turn matrix can be fitted from turn-by-turn data of beam position monitors after a kick was applied. However, the so obtained coupling information often sinks into the noise floor. The signal-to-noise ratio of the coupling information can be greatly enhanced by fitting maps for larger turn numbers N, equal to half the beat period. Furthermore, by using a number of beam position monitors in a region with only small coupling sources, the determination of the N-turn map can be made robust against failures of individual beam position monitors and further enhance the signal-to-noise ratio of the coupling terms. With the so obtained N-turn map an automated global coupling correction is possible without the need for a tune change. This is demonstrated for the Relativistic Heavy Ion Collider where the algorithm is implemented for operational use.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

WPAB079 On-Line Monitoring of the Linear Coupling Resonances for the LHC

Stephane Fartoukh, Nuria Catalan-Lasheras, Jean-Pierre Koutchouk (CERN)

The beta-squeeze is a classical source of betatron coupling which is heavily amplified in the LHC by the large beta swing. The use of super-conducting technology introduces additional sources of betatron

coupling such as the geometrical imperfections of the coils and the feed-down of sextupolar multipoles induced by the persistent currents. At the beginning of the ramp, the latter source varies rapidly in time. Before correction, the difference coupling coefficient can reach about 0.2 at injection, and its variations from injection to top energy are at the 30-40% level. Our measurement approach is based on the coupling transfer function. In order to avoid emittance blow-up, the beam is excited outside its eigen-frequencies applying a small amplitude oscillation with smooth transitions (AC-dipole principle). It has been recently shown that the response in the other plane to an excitation in either plane at one or two distinct frequencies gives access to the global and local complex coefficients of the difference and sum coupling resonances. The method lends itself to continuous monitoring and active feedback. Simulations on the LHC and a first experiment in the SPS confirm the analytical approach and the robustness of the method.

WPAB080 Measurement of Sextupolar Resonance Driving Terms in RHIC

Rogelio Tomas, Frank Schmidt (CERN), Wolfram Fischer (BNL)

Theory predicts that resonance driving terms can be determined by harmonic analysis of BPM data recorded after applying single kicks. In recent experiments at the CERN SPS this technique has been successfully applied to measure coupling and sextupolar resonance terms around the ring. A similar experiment has been carried out in RHIC, BNL, to prove the feasibility of this measurement in this more complex machine. Results of the experiment are presented, including a direct measurement of sextupolar resonances and a comparison to the model.

WPAB081 Completion of the Sextupole Driving Terms Measurement at the SPS

Rogelio Tomas, Mark Hayes, Frank Schmidt (CERN)

We report on the completion of the series of sextupole driving terms measurements in the SPS which started in June 1998. The following two items have been missing from earlier reports on these studies: measuring two dimensional resonances and the resonance phase. The possible dependence of these terms on collective effects was studied. Lastly, the experiment was performed at two different energies of 26 and 80 GeV, to suppress energy dependencies. Comparisons to the tracking model show excellent agreement, proving that this technique is ready for other machines.

WPAB082 A Technique to Measure Chromaticity Based on the Harmonic Analysis of a Longitudinally Kicked Beam

Rogelio Tomas (University of Valencia), Giovanni Rumolo (Gesellschaft für Schwerionenforschung mbH)

Recently a method to measure chromaticity has been proposed by applying a transverse and a longitudinal kick to the beam. Assuming a Gaussian bunch in the 6-dimensional phase space, analytical expressions were derived, which relate the synchrotron sidebands to the machine chromaticity. To assess limitations and extensions of this technique, a more realistic accelerator model is considered including transverse impedance, dispersion and transverse non—linearities, which modify the Fourier spectrum. Tracking and analytical studies are performed to describe these effects.

WPAB083 Correcting the LHC Beta* at Collision

Walter Wittmer, Andre Verdier (CERN)

To correct the beta* at the IP simultaneously for the two counter rotating proton beams in the LHC a set of specific quadrupoles in the non- common part of the machine is used. Due to the antisymetric optics, several quadrupoles of each side of the insertion have to be used. The change in the value of beta* is introduced by setting an increment to the k values of the quadrupoles. This set of increments is referred to as beta* tuning knob. The increments were calculated by rematching beta* in a range of plus minus 20 percent of the nominal value. Linear curves were fitted to the variation of increments to construct a linear tuning knob. This was done for each plane using MAD 8. The linear behaviour and the orthogonallity of the knobs were investigated. Different field errors were introduced into the lattice and their effects on the knobs were studied.

WPAB084 2002 Nonlinear Optics Measurements and Modelling for the CERN SPS

Frank Zimmermann, Gianluigi Arduini, Rogelio Tomas (CERN), Angeles Faus-Golfe (IFIC -Univ. de Valencia), Naoko Iida (KEK)

In 2002, nonlinear chromaticity, coupling, amplitude-dependent detuning and resonance driving terms were measured in the CERN SPS at 26 GeV. From the data of nonlinear chromaticity alone, the SPS optics model has been updated, by adjusting the strengths of sextupolar, octupolar and decapolar field errors in the dipole and quadrupole magnets, so as to reproduce the observation. We compare the field errors deduced in 2002, measuring over a larger momentum range, with those found in 2001 and 2000. The resolution is improved by averaging over all turn-by-turn position monitors in the ring instead of using a single dedicated pick up ('tune meter'). Computations using two different optics codes, MAD and SAD, indicate the sensitivity to matching algorithm and magnet representation. The tune shifts with transverse amplitude and the driving terms of low-order resonance predicted by this nonlinear optics model are compared with direct measurements.

WPAB085 Slow Ground Motion Modelling of DIAMOND

James Jones (Daresbury Laboratory)

The need for high stability in third generation light sources has produced strict requirements on the design of the foundations. The specification for the concrete floor stability is a critical task, which can have a major cost impact. A careful assessment of the effects of slow ground motion on the accelerator is therefore required. This paper presents the results of simulations using various ground motion models for the DIAMOND storage ring and the booster synchrotron. The modelling is implemented in flexible manner through the use of a Mathematica to MAD interface. This interface provides various high level functions such as access to an SVD algorithm, which provides effective correction of the closed orbit distortions, the implementation of motion on girders and the statistical analysis and graphical presentation of results.

WPAB086 Impact of Narrow Gap Chambers on the Lifetime of the ALS

David Robin (LBNL)

In low emittance synchrotron light sources the main source of beam loss is intrabeam or Touschek scattering. In most cases the Touschek scattered particles get lost on narrow gap vertical chambers. The particles reach the vertical chamber from either diffusion or coupling of the particle motion from the horizontal to vertical plane. The beam lifetime can be very sensitive to the size of the vertical chamber. The reduction in lifetime limits the miminum size of the chamber that can be installed in the ring. In this paper we examine the effect of vertical apertures on the beam lifetime at the ALS under various different machine conditions. We show that there are conditions where one can make the beam lifetime much less sensitive to the size of the vertical aperture.

WPAB087 ID Modeling at the ALS

David Robin, Hiroshi Nishimura, Christoph Steier, Weishi Wan (LBNL), Ying Wu (Duke University), Etienne Forest (KEK)

At the Advanced Light Source there are several projects being proposed that will require high field insertion devices. It is important that these devices do not significantly impact the performance of the machine. In particular they should not degrade the beam lifetime or injection efficiency. It is known that high field devices with large field roll off can impact the beam lifetime. It is therefore important to model the effect of the insertion devices including both transverse and longitudinal field roll off. In this paper we present the result of tracking studies using an explicit symplectic integrator with both transverse and longitudinal field roll off. The simulations show where sufficiently large field roll off will impact the beam lifetime.

WPAB088 Local Multipoles of a Magnetic Lattice on an Arbitrarily Curved Trajectory

Andreas Kabel (SLAC)

We consider the trajectory of a charged particle in an arbitrary external magnetic field. A local canonical orthogonal coordinate system is given by the arc length and the radial, and torsion vectors. We write down Maxwell's equations in this coordinate system. The resulting partial differential equations for the magnetic fields fix conditions among its local multipole components, which can be viewed as the generalization of fringe fields for bending magnets.

* Supported by Department of Energy contract DE-AC03-76SF00515.

WPAB089 Global Beam Based Alignment Algorithm

Terebilo Andrei (SLAC)

This paper presents an algorithm for orbit centering in the quadrupole magnets developed specifically for the early commissioning stage. At this stage the many factors can reduce the effectiveness of simpler beam-based alignment techniques. Our method is more tolerant towards inaccurate optics model, undetected large alignment errors, systematic errors and faults in the BPM system.

* Work supported in part by DOE Contract DE-AC03-76SF00515 and Office of Basic Energy Sciences, Division of Chemical Sciences.

Poster Session WPAG
Galleria at 8:30

WPAG001 Feed-Forward Correction of the Pulsed Circularly Polarizing Undulator at the Advanced Photon Source

Oleg Makarov, Boris Deriy, Louis Emery, Shigemi Sasaki, Robert Soliday, Isaac Vasserman (ANL)

The circularly polarizing undulator at the Advanced Photon Source has a set of vertical and horizontal coils and poles that produce an internal helical trajectory in the electron beam for production of circularly polarized photons. The photon polarization is flipped by reversing the current of one coil. The net magnetic field perturbation is characterized in both planes by a transient orbit motion, which lasts about 30 ms, and a DC orbit shift, both being reproducible. In addition multipole magnetic moment errors are present. The correction system consists of small dipole and multipole correction magnets at the ends of the undulator, a multichannel arbitrary function generator (AFG) to program the corrector magnet current triggered on the polarity change event, low-level software to load and interpolate the AFG waveforms, and high-level software running on a workstation to determine the optimum AFG waveforms for the dipole correctors. We rely on the existing real-time feedback system to acquire the residual orbit transient and to automatically generate a close approximation of the required corrector wave forms. A choice of deterministic correction or trial-and-error manual adjustments of the wave forms is available in the high-level software.

* This work supported by the U.S. Department of Energy under Contract no. W-31-109-ENG-38.

WPAG002 RHIC Ramp Tune Correction from Main Dipole Sextupole Components

Johannes van Zeijts, Todd Satogata (BNL)

During the RHIC FY02 Au-Au collider run, measured and online-model tunes had excitation-dependent discrepancies of up to 0.2-0.25 tune units. These discrepancies can be explained, and corrected in the model, by including a feed-down term from as-measured sextupole components in the superconducting main dipoles. We describe an analysis and the correction implementation, and address the agreement between modeled and measured tunes during the RHIC FY03 deuteron-gold and polarized proton runs.

* Work performed under the auspices of the U.S. Department of Energy contract #DE-AC02-76CH00016.

WPAG003 A Thin Beryllium Injection Window for CESR-c

Yulin Li (Cornell University)

The e^+e^- collider CESR is expanding its beam energy range to below 2 GeV for the planned Charm Physics Program. The original 5 GeV injection beam lines consisted of two 0.025-mm thick titanium windows, separated by a helium line at atmospheric pressure. The beam injection efficiency at low energies is reduced dramatically due to excessive emittance growth from multiple scattering in the Ti windows. The Ti windows were replaced with 0.075-mm thick beryllium windows to restore injection efficiency at low beam energies. This paper describes the design and construction of the Be windows. Finite-element analysis was used to determine the minimum Be window thickness able to support atmospheric pressure across 24-mm diameter aperture. The Be window housing is a cylinder consisting of two stainless steel tubes (SST) vacuum brazed to each end of a copper ring. The Be window is subsequently vacuum brazed to the copper ring at a lower braze temperature. The SST ends of the window assembly provide mechanical strength and protection to the fragile window, and facilitate welding of the window assembly to the injection vacuum chambers. An injection efficiency greater than 70% was achieved with the Be injection windows in CESR.

* Work supported by National Science Foundation, Grant #PHY-9809799.

WPAG004 Diagnosis of Optical Errors and Parasitic Beam-Beam Effects with a Precision BPM System at CESR

Mark Palmer, John Dobbins, David Rubin, David Sagan, Jeffrey Smith, Charles Strohman (Cornell University)

In the Cornell Electron Storage Ring (CESR) multibunch beams of electrons and positrons share a common vacuum chamber and guide field. Parasitic interactions between the bunches result in bunch-to-bunch variations in closed orbits and tunes. A new beam position monitor system, which allows us to monitor trajectories and tunes of individual bunches, is now in operation in one sector of the CESR ring including the interaction region. Variations in position can be monitored with a resolution of a few microns. Two of our position monitors are located 60cm on either side of the interaction point (IP) within the 1T experimental solenoid. A 20 cm long permanent magnet quadrupole lies between each of these detectors and the IP. Beam trajectories at the IP intersect with a horizontal crossing half angle of 3mrad. By measuring the relative positions of electron and positron bunches at these detectors, we can obtain information about the displacement of the beams at the collision point with an anticipated resolution on the order of the vertical beam size. Measurements of the dependence of beam trajectories at the IP on changes in dipole

correctors, skew quadrupoles, and electrostatic separators provide a powerful diagnostic of guide field errors in the interaction region. These issues are critical to establishing and maintaining high specific luminosity. We report on the status and interpretation of several beam measurements.

* Work supported by the US National Science Foundation.

WPAG005 Power Supply Performance Monitoring and Analysis Using Operation Data

Jingyi Li, Steve Hartman, Y.K. Wu (Duke University)

Magnet power supplies are critical components of a storage ring. The performance of power supplies directly impacts the stability and reliability of the storage ring operation. There are several kinds of DC power supplies in Duke FEL Storage ring. The performance data of power supplies can be collected in an non-interruptive manner by an EPICS archiver or by a matlab program. Matlab based tools have been developed to analyze the power supply data collected during the operation. Careful evaluation of data allows us to locate a power supply with degraded performance and perform preventative maintenance.

* Research Supported by the DoD MFEL Program as managed by the AFOSR, grant F49620-001-0370.

WPAG006 Status of the Booster Synchrotron for the Duke FEL Storage Ring

Stepan Mikhailov, Matthew Busch, Mark Emamian, Steve Hartman, Vladimir Litvinenko, Igor Pinaev, Victor Popov, Gary Swift, Patrick Wallace, Ying Wu (Duke University), Nikolai Gavrilov, Yuri Matveev, Dmitri Shvedov, Nikolai Vinokurov, Pavel Vobly (BINP)

In this paper we present current status of the Booster Synchrotron for the Duke FEL storage ring. The Booster will provide full energy injection into the storage ring at energy from 0.25 to 1.2 GeV. The Duke storage ring FEL (SR FEL) operates in lasing mode with 193-700 nm wavelength range. This range will be extended into VUV in near future. The geometry of the Duke SR FEL provides for interacting head-on collision of e-beam and FEL photons. This mode of operation is used to generate intense beams of Γ-rays from 2 MeV to about 200 MeV (currently from 2 MeV to 58 MeV). Generation of Γ-rays with energy exceeding 20 MeV causes the loss of electrons, which will be replaced by injection from the Booster operating in a top-off mode. The Booster has a robust FODO lattice. The paper presents the design of the magnetic elements and their 3D simulations using MERMAID 3D code. We also present design and parameters of fast extraction kicker with 10 nS pulse duration. The elements of the magnetic system, vacuum system, injection and extraction kickers will be designed and fabricated by Budker Institute of Nuclear Physics, Novosibirsk, Russia.

* This work is supported by DOE and by the Dean of Natural Sciences (Duke University.

WPAG007 Challenges for Magnetic Design of a Compact Booster Synchrotron Fed by Single Power Supply

Stepan Mikhailov (Duke University)

In design of full energy Booster injectors there is a tendency of avoiding saturation in the magnetic elements to reduce losses associated with the tune change during the energy ramp. Typical maximum field in the bending magnets of the modern Booster projects of 1.0 – 1.4 T results in their large circumference. For 0.25-1.2 GeV Booster injector for the Duke FEL storage ring, recently under design and fabrication, there was an ultimate goal to fit it into existing storage ring room to avoid cost extensive building construction. Therefore, the Booster ring had to be compact, and the maximum field in the bending magnets was accepted 1.76 T. With a different level of saturation in the focusing and defocusing quadrupole families it was impossible to keep the tunes constant with the energy rise. However, the ratio of saturation levels in the bending magnets, focusing and defocusing quads were optimized so that the tune change is minimal and the tunes do not cross most significant resonances during the ramp. The lattice was simulated for different energies basing on the results of 3D calculations of the magnetic elements with the use of MERMAID 3D code. The most challenging part of the design was supplying all the dipoles and quadrupoles by single power supply imposing strong constrains on the lattice design and magnet design.

* This work is supported by DOE and by the Dean of Natural Sciences (Duke University)

WPAG008 Feasibility Study of a 2 GeV Lepton Collider at DAFNE

Gabriele Benedetti, David Alesini, Maria E. Biagini, Caterina Biscari, Roberto Boni, Manuela Boscolo, Alberto Clozza, Giovanni Delle Monache, Giampiero Di Pirro, Alessandro Drago, Alessandro Gallo, Andrea Ghigo, Susanna Guiducci, Fabio Marcellini, Giovanni Mazzitelli, Catia Milardi, Luigi Pellegrino, Miro A. Preger, Pantaleo Raimondi, Ruggero Ricci, Claudio Sanelli, Mario Serio, Francesco Sgamma, Alessandro Stecchi, Angelo Stella, Cristina Vaccarezza, Mario Vescovi, Mikhail Zobov (INFN)

While the main advances in the Standard Model probing require the construction of very high energy colliders, many open questions still remain which can be answered by exploring low and medium energy regions. In this framework we are investigating the possibility of upgrading the DAFNE energy up to the neutron-antineutron threshold (about 2 GeV c.m.), reusing the present systems. The luminosity required by the experiments is of the order of few 10^{31} cm^{-2} sec^{-1}, easily achievable in the particle factory era. The main issues of the upgrade are as far as possible presented.

WPAG009 Bunch Pattern By-3 in PEP-II

Franz-Josef Decker, Artem Kulikov, Mike Sullivan (SLAC)

After a long 4-month down time where additional RF was installed and heating problems addressed, the PEP-II B-factory should be capable of delivering about 1.5 times the currents. This can only be done by going to more bunches from the current by-4 pattern to either a by-3 or a by-2 pattern. The by-2 pattern has parasitic crossings, so the by-3 pattern is the most likely candidate. Heating issues especially in the longitudinal and transverse feedback structures are the main concern.

WPAG010 Injection Related Background due to the Transverse Feedback

Franz-Josef Decker, Ron Akre, Alan Fisher, Rick Iverson (SLAC)

The background in the BaBar detector is epecially high during injection, when most components are actually having reduced volatges. The situation is especially worse for the beam in High Energy Ring (HER) when the LER beam is present. It was found that the transverse feedback system plays an important role when stacking more charge on top of existing bunches. Lowering the feedback gain helped and it was realized later that the best scenario would be to gate off the feedback for only the one bunch which got additional charge injected into it. The explanation is that the blown-up centered original HER bunch plus the small injected off-axis bunch (each with half the charge) would stay in the ring if not touched, but the feedback sees half the offset and wants to correct it disturbing and scraping the blown-up part.

WPAG011 Design of the SPEAR 3 DCCT

Robert Hettel (SLAC)

The SPEAR 3 light source requires a high performance DCCT to measure currents up to 500 mA with microamp resolution. A low

impedance vacuum chamber is needed to minimize RF heating of chamber components and of the DCCT transformer itself. A simplified version of the design used for PEP-II was adopted, modified with a beam pipe matching the nominal 84 mm x 34 mm SPEAR 3 vacuum chamber. As for PEP-II, the DCCT has an in-vacuum gap and a ceramic break that is shielded from direct beam image currents and subsequent heating. The 0.4 nF in-vacuum gap capacitance is 6 times greater than that for PEP-II, reducing the high frequency content of the detected beam current. The performance requirements, impedance analysis, and electrical and mechanical design of the DCCT assembly are presented.

* Work supported in part by DOE Contract DE-AC03-76SF00515 and Office of Basic Energy Sciences, Division of Chemical Sciences.

WPAG012 Lattice with a Smaller Momentum Compaction Factor for PEP-II High Energy Ring

Yuri Nosochkov, Martin Donald (SLAC)

At present, the PEP-II bunch length and vertical beta function at the Interaction Point (IP) are about of the same size. To increase luminosity, efforts are being made to reduce the IP beta to 1 cm or smaller. To achieve maximum luminosity, the bunch length has to be also reduced to at least the level of IP beta function to avoid the hourglass effect of beam size enlargement at the bunch ends in the collision. Reduction of momentum compaction factor is one of the ways to achieve a smaller bunch length. This paper discusses an option for the High Energy Ring lattice, where 90 degree cells replace the nominal 60 degree cells in four arcs to reduce momentum compaction factor by 30% and the bunch length by 16%. The increased cell focusing results in 40% stronger arc quadrupoles, and 150% stronger arc sextupoles due to smaller dispersion and larger chromaticity. Tracking simulations performed on this lattice predict at least 10 sigma dynamic aperture for 30 nm horizontal emittance and 1 cm beta function. Description of the lattice and results of simulations are presented.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

WPAG013 Tracking Simulations at Near Half-Integer Tune at PEP-II

Yuri Nosochkov, Yunhai Cai (SLAC)

Beam-beam simulations predict that PEP-II maximum luminosity can be increased by operating the horizontal betatron tune near and above a half-integer resonance. However, effects of the resonance and its synchrotron side bands significantly enhance betatron and chromatic perturbations which tend to reduce dynamic aperture. In the study, chromatic tune spread near the resonance was minimized by optimizing local sextupoles in the Interaction Region. Dynamic aperture was evaluated in tracking simulations using LEGO code. A correction scheme was implemented in LEGO to compensate perturbations of beta function enhanced near the resonance. Results of simulations performed for various tune and beam correction conditions are presented.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

WPAG014 RF Heating and Temperature Oscillations due to a Small Gap in a PEP-II Vacuum Chamber

Alexander Novokhatski, John Seeman, Michael Sullivan (SLAC)

Wake fields excited in a small gap of the vacuum chamber by ampere beams can have enough amplitude to heat the chamber. The electric component of these fields can be above the arcing limit. Usually flange connections in a vacuum chamber contain a vacuum gasket and an inner RF gasket. If a small gap occurs between the RF gasket and flange surface, wake fields can heat the flanges. The flanges are usually made of stainless steel, which efficiency absorbs RF power. Some flanges consist of two parts (like a vacuum valve flange) and are mechanically connected but have poor thermal contact. A temperature rise can lengthen the inner part of the flange and make thermal contact to the outer part of the flange better. The heat will then flow to the outer part of the flange, which is air and water-cooled. The cooling lowers the flange temperature and thermal contact becomes poor again. This "quasi" periodic mechanism can explain the nature of temperature oscillations observed at PEP-II, the SLAC B-factory.

* US DOE contract DE-AC03-76SF00515.

WPAG015 Progress of the PEP-II B-Factory

John Seeman, Michael Sullivan, Ulrich Wienands (SLAC)

PEP-II is an e+e- B-Factory Collider located at SLAC operating at the Upsilon 4S resonance. PEP-II has delivered, over the past four years, an integrated luminosity to the BaBar detector of over 100 fb-1 and has reached a luminosity over 4.6x1036/cm2/s. Steady progress is being made in reaching higher luminosity. The goal over the next few years is to reach a luminosity of at least 2x1034/cm2/s. The accelerator physics issues being addressed in PEP-II to reach this goal include the electron cloud instability, beam-beam effects, parasitic beam-beam effects, high RF beam loading, lower beta y*, interaction region operation, and coupling control.

* Work supported by US Department of Energy contract DE-AC03-76SF00515.

WPAG016 Design Studies for a 10^36 Luminosity Super-B-Factory

John Seeman, Michael Sullivan (SLAC)

Design studies are underway to arrive at a complete parameter set for a very high luminosity e+e- Super B-Factory (SBF) in the luminosity range approaching 10^36/cm^2/s. The design is based on a collider in the PEP-II tunnel but with an upgraded RF system (higher frequency), magnets, vacuum system, and interaction region. The accelerator physics issues associated with this design are reviewed as well as the site and power constraints. Near term future studies will be discussed.

* Work supported by US Department of Energy contract DE-AC03-76SF00515.

WPAG017 Improvements in Bend Magnet Stability and Photon Beam Stability at Aladdin

Daniel Wallace, Mike Fisher, Kenneth Jacobs, Greg Rogers, Lee Rowley, Menghort Thikim, Walter Trzeciak (Synchrotron Radiation Center, University of Wisconsin)

For 800 MeV operation of the Aladdin Synchrotron Storage Ring, 730 Amps flow through the 12 bend magnets in series. The bend magnet coils are cooled by water which is in intimate contact with the copper magnet coils. The rubber hoses which deliver this water connect the coils to the electrically grounded water manifolds and have up to 103 VDC across them. This configuration can induce an electrolytic reaction which produces and deposits cuprous oxide on the inner walls of the hoses. The electrical resistance of the hoses is significantly reduced and leakage currents as high as 833 mAmp flow to ground. This missing and changing bend magnet current results in significant horizontal electron orbit changes. When the deposits are large, additional deposits occur quickly and can trip off the bend magnet power supply, resulting in lost photons for the storage ring users. We have electrically isolated the cooling water manifolds and lengthened some hoses. This has resulted in minimized leakage currents to ground, slower recontamination of new hoses and reversal of contamination in badly contaminated hoses. These improvements have resulted in improved storage ring orbit stability (and thereby

improved photon beam stability), less electrochemistry on the copper coils, and better operational reliability.

* This work is based upon research conducted at the Synchrotron Radiation Center, University of Wisconsin, Madison, which is supported by the NSF under Award No. DMR-0084402.

WPAG018 Single-Bunch Instabilities for Different Operation Energies at ELETTRA

Giovanni De Ninno, Miltcho Danailov, Bruno Diviacco, Fatma Iazzourene, Emanuel Karantzoulis, Marino Marsi, Lidia Tosi, Mauro Trovo (Sincrotrone Trieste)

The ELETTRA storage ring is currently operated over a wide electron-energy range. In fact, besides the high-energy multi-bunch operation (2-2.4 GeV), which is suitable for standard synchrotron radiation experiments, an increasing interest has been recently expressed in using the electron beam when the machine is run in four-bunch filling mode and in the energy range 0.7-1.5 GeV. This low-energy domain is well suited for FEL operation and a number of experiments may be planned exploiting the time structure of the synchrotron radiation. In this context, the analysis of the beam stability for different operation energies represents a crucial issue. This paper will report on measurements performed in order to characterize the effect of the wake field as a function of the beam current in the few-bunch filling configuration.

WPAG019 Injection and FEL Lasing with Front End Open at ELETTRA

Giovanni De Ninno, Katia Casarin, Fatma Iazzourene, Emanuel Karantzoulis, Lidia Tosi, Giuliana Tromba, Alessandro Vascotto (Sincrotrone Trieste)

In view of the construction of the new full-energy injector at ELETTRA, radiation dose measurements have been performed to study the scenario of beam losses in the top-up regime and explore conditions of radiation hazard for personnel. Measurements of gamma and neutron radiation fields have been carried out in the experimental hall with varied injection efficiency while a beamline front-end was open. In this context FEL lasing experiments were performed while in injection mode. The collected data as well as future developments are presented and discussed in this article.

WPAG020 Initial Studies of Longitudinal Dynamics on UMER

Agust Valfells, B. Beaudoin, S. Bernal, A. Diep, I. Haber, J. Harris, Y. Huo, P.G. O'Shea, B. Quinn, M. Reiser, M. Walter (University of Maryland)

The University of Maryland Electron Ring (UMER) is a small scale experiment on space-charge dominated beams. The 100ns, 10keV electron beam fills up nearly one half of the ring circumference. For multi-turn operation longitudinal focusing becomes necessary. Here we present some initial results on measurements of longitudinal beam expansion and beam edge erosion. The design also calls for the ability to control the pulse shape to a degree. We will show how the temporal pulse shape may be modified, both by modifying the accelerating potential in the gun and also by using laser generated perturbations superimposed upon the pulse. Design considerations of the induction gaps to be used for longitudinal focusing will also be presented.

* This work supported by the U.S. Department of Energy.

WPAG021 Yield of High Energy Quanta from Compton Light Source with Arbitrary Angle of Laser-Electron Bunch Scattering

Eugene Bulyak, Peter Gladkikh, Vyacheslav Skomorokhov, Andrey Zelinsky (NSC KIPT)

Presented is analytical estimation of the yield of high energy quanta scattered in collision at arbitrary angle of the electron beam and laser splash in the Compton light source. The estimations were derived from a model of given electron bunch parameters. It was shown that total yield of high energy quanta decreases with rise of the collision angle. A critical angle is defined that depends on geometric dimensions of colliding bunches (laser and electron ones). If the collision angle exceeds the critical one, the yield of high energy quanta is decreased drastically. Considered is impact of errors in synchronization between the electron and laser bunches upon the yield. As it is shown, errors in the bunch timing do not affect the yield at the head-on (zero angle) collision. With increasing the collision angle, affect of errors on the secondary beam performance raises up. Within the frameworks of the model of given electron bunch, main figures of merit such as fluence of high energy photons and its energy and energy dispersion are derived as functions of the electron and laser bunch parameters and synchronization.

WPAG022 Bunch Kinetics in Compton Storage Ring

Eugene Bulyak, Vyacheslav Skomorokhov (NSC KIPT)

Kinetics of cooling the electron beam circulating in a Compton storage ring is considered. In the approximation of uncorrelated scattering of photons making use of the Fokker—Planck—Kolmogorov method, the steady state parameters of a bunch circulating in the storage ring in their dependence upon the energy of electrons and laser photons are estimated. As is shown, the averaged square of relative energy dispersion is directly proportional to both electrons and laser photons energy. The transverse emittances of the bunch are proportional to the laser photons energy but inversely - to the energy of circulating electrons. These emittances also are proportional to the amplitude of betatron function at the interaction point. The quantum lifetime is exponentially dependent on RF orbital number and momentum compaction factor. The effect of imperfection of orbits at the interaction point (chromaticity and slope of the beta-functions) is also studied. Effect of the ring imperfections is considered.

WPAG023 Nonlinear Optimization of Low Emittance CLIC Damping Ring Lattice

Maxim Korostelev, Frank Zimmermann (CERN)

The CLIC damping ring design is optimized to produce a beam with ultra low emittances. The lattice for such machine requires small values of optical functions, a large number of compact arc cells and strong sextupoles for the chromatic correction that introduce significant nonlinearities, appreciably decreasing the dynamic aperture. In this paper, the nonlinear optimization of the damping ring lattice is described.

WPAG024 Status of the MAX-III Storage Ring

Greg LeBlanc, Ake Andersson, Mikael Eriksson, Lars-Johan Lindgren, Sverker Werin (MAX-lab)

The MAX-III storage ring is a 700 MeV machine intended to provide UV and IR radiation. The novel magnet design provides a compact lattice. The magnetic measurements of the first cell will be presented and compared with calculations.

WPAG025 MAX 4, A 3 GeV Light Source

Greg LeBlanc, Ake Andersson, Marlene Bergquist, Medine Demirkan, Mikael Eriksson, Lars-Johan Lindgren, Lars Malmgren, Hamed Tarawneh, Erik Wallen, Sverker Werin (MAX-lab)

A proposal for a new synchrotron light source, MAX 4, is presented. The main part consists of a low emittance, 3 GeV storage ring equipped with 14 straight sections for insertion devices. The small beam emittance in combination with short period superconducting undulators with high K values yields a high brilliance up to 20 keV. The small horizontal emittance is achieved by using a large number of cells with gradient dipoles flanked by horizontally focusing

quadrupoles. The small magnet aperture allows strong gradients in the dipoles and strong sextupole components in the quadrupoles resulting in an equilibrium emittance on the order of 1 nmrad. The full-energy injector enabling top-up operation will be a 3 GeV S-band linac with a SLED system. This opens up the possibility to produce short, intense radiation pulses, coherent as well as spontaneous.

WPAG026 Status of the MAX-Lab Injector

Greg LeBlanc, Ake Andersson, Medine Demirkan, Mikael Eriksson, Lars-Johan Lindgren, Sverker Werin (MAX-lab)

The new MAX-lab injector will consist of an rf-gun and two linacs with SLED systems and a recirculator that will deliver a 500 MeV beam for injection into the MAX storage rings. The first phase with one linac is complete and being used for operations. This paper will describe the system and present the operational experience from commisioning.

WPAG027 Optimization of the X-Band Structure for the JLC/NLC

Zenghai Li, C. Adolphsen, D.L. Burke, V. Dolgashev, R.M. Jones, R.H. Miller, C. Nantista, C.K. Ng, T.O. Raubenheimer, R.D. Ruth, P. Tenenbaum, J.W. Wang (SLAC), T. Higo, N. Toge (KEK)

Accelerator structures must have high gradient and high rf efficiency to minimize linac cost. However, it is also essential for the structure design to minimize the long and short-range dipole wakefields to prevent emittance degradation and the beam breakup instability (BBU). To be effective at wakefield suppression, the accelerator structure is required to have a prescribed detuned dipole spectrum and satisfy certain dipole dispersion requirements. To operate at high gradient, the X-band structures must limit the group velocity to <5% of c and must be designed to have low pulsed heating. These requirements put stringent constraints on the choice of structure parameters. In addition, beam loading compensation and BNS damping are required to ensure high quality beams at the IP (Interaction Point). The parameters that maximize the single structure efficiency may require a large overhead for loading compensation and BNS phase offsets and, therefore, result in lower effective efficiency. As part of the optimization process, various structure parameters such as the phase advance, the average aperture, and structure length have been explored. In this paper, we present the parameter studies for the X-band structure and the path toward an optimal structure design for the JLC/NLC linac.

* Work supported by the U.S. DOE Contract No. DE-AC03-76SF00515.

WPAG028 MIT-Bates South Hall Ring Commissioning for Internal Target Experiment

J.B. van der Laan, D. Cheever, M. Farkhondeh, W.A. Franklin, E. Ihloff, S. Krause, L. Longcoy, C. Tschalaer, E. Tsentalovich, F. Wang, A. Zolfaghari, G.T. Zwart (MIT-Bates)

In 2002, the final phase of the installation and commissioning of the Bates Large Acceptance Spectrometer Toroid (BLAST) was completed. The South Hall Ring (SHR) commissioning has been dynamically integrated in this process to provide high quality beams under experiment conditions. Effort is made to overcome ion effects to routinely reach the 140 mA stored current. The vacuum in the ring has continuously improved by radiation desorption through synchrotron radiation, resulting in lifetimes of 50 minutes. Results were obtained with a 15 mm diameter and 40 cm long internal target cell and the BLAST magnetic field on. Slits were used to minimize the background. Longitudinal polarization was maintained with a Siberian snake spin rotator. For the first time strong depolarization effects caused by non linear spin resonance were observed and the ring betatron tune working point was adjusted accordingly to avoid these resonant lines for maintaining full polarization. The high (70%) polarization from the polarized source is then preserved during the lifetime of the beam. In collaboration with the University of Michigan, a spinflipper with a high flip efficiency was installed and commissioned. New developments of beam diagnostics and controls and beam polarization measurement are presented.

Session WOPA: Special Session
Grand Ballroom II at 13:30
Followed by the Awards Ceremony and Reception from 16:00 to 18:00

WOPA001 RF Superconductivity - Technology of Choice

Helen Edwards (FNAL)

It has been my good fortune to work for two directors, Bob Wilson and Bjoern Wiik, who had vision on directions of future accelerator technology. In 1992, Bjoern Wiik, soon to become Director of DESY, organized an international effort dedicated to a dramatic improvement in performance and cost of accelerating structures based on RF superconductivity. In this paper I will discuss the degree to which this goal has been achieved and the accompanying technology advances. Today, RF superconductivity is the technology of choice for high duty factor, high beam brightness applications and a serious competitor for use in a linear collider.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

WOPA002 Next Generation Free-Electron Laser Systems

Stephen V. Milton (ANL)

The development of the free-electron laser (FEL) dates back to the early 1960s. In such devices, assemblies of electrons are coaxed, through their interaction with external and self fields, into radiating coherently. Typical devices appear very similar to "conventional" laser systems. Loosely speaking, the oscillator cavity is defined by mirrors, and the "gain" medium is defined by the electron bunch/undulator system. Although FELs offer advantages over conventional lasers, many are limited by the mirror system. We will call these "first-generation FELs." Recent advances in electron beams have lead to significant strides in FELs; most notably, it is now possible to operate an FEL without mirrors. These second-generation FELs rely on the self-amplified spontaneous emission (SASE) process and have proven to be fully tunable over a very broad wavelength range and to wavelengths well blue of any other laser system in existence. Construction is now proceeding on SASE FELs that will operate at x-ray wavelengths. But advances beyond the second-generation, SASE-based FEL are still possible. Following a brief history of FELs, we will concentrate on the definition and possibilities of next-generation FELs. These devices take the SASE process another step further by, for example, using seeding techniques to improve the time/bandwidth product, using harmonic generation to extend the wavelength reach, or using techniques to exploit the large absolute bandwidth to generate pulses in the attosecond range.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WOPA003 MURA Days

Keith R. Symon (University of Wisconsin-Madison)

The Midwestern Universities Research Association (MURA), incorporated in the mid nineteen-fifties, was a unique institution in that, although it never succeeded in its primary goal of building a multi-GeV particle accelerator, it remained in existence for more than ten years, during which the MURA group made many contributions to the science of particle accelerators. Included among these were the invention of fixed field alternating gradient (FFAG) accelerators and spiral sector cyclotrons, an extensive analysis of rf acceleration with particular attention to the consequences of Liouville's theorem, beam stacking, analytic and computational studies of nonlinear orbit theory, studies of collective instabilities, and the first demonstration of practical ways to achieve colliding beams, Although no large FFAG accelerators were ever built, model FFAG accelerators turned out to be excellent devices for the experimental study of accelerator problems because they separate the guide field from the acceleration process. Models were used to study nonlinear resonances, acceleration processes, space charge limits, and beam stacking. Among the last MURA projects was an electron storage ring that became the first machine dedicated exclusively to the production of synchrotron radiation for experiments, a facility which evolved into the highly successful Synchrotron Radiation Center at the University of Wisconsin-Madison.

WOPA004 Experimental Study of RF Pulsed Heating on Oxygen Free Electronic Copper

David Pritzkau (Big Bear Networks, Sunnyvale, CA)

Thermal stresses induced by RF pulsed heating may induce microcracks and surface roughening from cyclic fatigue. By limiting the maximum surface magnetic field, pulsed heating limits the maximum achievable accelerating gradient. An experiment using circularly cylindrical cavities operating in the TE011 mode at a resonant frequency of 11.424 GHz was designed to study pulsed heating on Oxygen Free Electronic (OFE) copper. An X-band klystron delivered up to 10 MW to the cavities in 1.5 /mus pulses at a 60 Hz repetition rate. One run was executed at a temperature rise of 120 K for 56 x 0^6 pulses in which cracks at grain boundaries, slip bands and cracks associated with these slip bands were observed. A second run consisted of 86 x 10^6 pulses with a temperature rise of 82 K, and cracks at grain boundaries and slip bands were seen. The experiment and its results are presented and discussed in detail.

* Work supported by the Department of Energy, contract DE-AC03-76SF00515.

Poster Session WPPE
Exhibit Hall at 13:30

WPPE001 Connection Oriented Relational Database of the APS Control System Hardware

Donald Dohan, Ned D. Arnold (ANL)

After the flurry of activity to construct, commission, and begin routine operation of a large user facility, the focus must then turn to long-term reliability. Key concerns include a full inventory of all installed devices, sufficient spares, quick identification of a failed device, and accurate documentation to minimize the number of system experts needed for routine operation. This paper describes the Visual Connection Configuration Tool (vcct) used to create a searcheable schema of all control system hardware. A framework is provided for identifying each installed device and its connection to the control system. The schema provides numerous benefits over a simple inventory list, such as: an immediate visualization of information flow through the system; intuitive documentation of IOC hardware, subnet links, and nodes; and a common presentation for easier cross training and maintenance. The paper will also describe the mechanisms used to automatically populate much of the database by "discovering" the hardware through the EPICS databases and startup scripts. Future work, such as extending the device definition to include wiring information will also be discussed.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-138.

WPPE002 Use of a General-Purpose Optimization Module in Accelerator Control

Louis Emery, Michael Borland, Hairong Shang (ANL)

The SDDS EPICS toolkit has recently been enhanced by the addition of a general-purpose optimizer. The tool sddsoptimize is easily configured and has features that make it robust. The sddsoptimize program has been incorporated in many new tcl/tk applications used for various Advanced Photon Source tune-up operations, such as injection turn-up for the storage ring and the positron accumulator ring, and the automatic phasing of the linac.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPPE003 An Operator Training Facility at the Advanced Photon Source

John Lewellen, Stanley Pasky (ANL)

The Advanced Photon Source (APS), a premier third-generation synchrotron radiation source, presently operates in top-up mode during most user run time. During top-up mode, charge is injected into the storage ring at approximately 2-minute intervals to stabilize the stored beam current to within 0.1%. Top-up mode requires the dedicated use of the entire APS injector system, severely limiting time available for operator training. The APS Injector Test Stand (ITS) is presently configured to operate a ballistic bunch compression (BBC) rf gun, which uses three independently powered and phased rf cavities, and either a thermionic cathode or a photocathode. Operation of the BBC gun requires cavity phasing and input rf power selection analogous to the operation of a high-energy linac. In conjunction with the ITS beamline components (quadrupoles, dipoles, diagnostics, correctors), this provides an effective analog to the APS linac. Operators can therefore practice accelerator tuning and control methods with a live beam and real components, rather than simulations, while top-up operation is ongoing.

* This work is supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPPE004 Fast Automated Decoupling at RHIC

Joanne Beebe-Wang, Fulvia Pilat (BNL)

Coupling correction is essential for the operational performance of RHIC. Effective independence of the transverse degrees of freedom makes diagnostics and tune control easier, and it is advantageous to operate an accelerator close to the coupling resonance to minimize nearby nonlinear sidebands. An automated decoupling application is being developed at RHIC for coupling correction during routine operations. The application decouples RHIC globally by minimizing the tune separation through finding the optimal settings of two orthogonal skew quadrupole families. The program accesses tune information from all RHIC tune measurement systems: the PLL (Phase Lock Loop), the high frequency Schottky system, and the tune meter. The application supplies automated tune and skew quadrupole scans for finding the minimum tune separation, display and interface with the RHIC control system. Our goal is to perform global decoupling at RHIC in a few minutes. We summarize the capabilities of the decoupling application, and discuss the operational protections and possible future development. We also report the decoupling performances with the application during the RHIC 2003 run.

* Work performed under the auspices of the U. S. Department of Energy.

WPPE005 SNS Controls Experience from a BNL Perspective

Lawrence Hoff (BNL)

The phased commissioning of SNS, with MEBT and DTL operation in advance of ring installation, provides an opportunity to gain early experience with controls equipment and algorithms. Although the BNL controls group is primarily responsible for ring controls, the BNL controls group is taking advantage of this situation by contributing to MEBT and DTL commissioning, including providing timing equipment, power supply control interfaces, loss monitor controls, and algorithms to support laser stripping and beam current monitoring. This paper will describe the experience gained during these early commissioning efforts.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPE006 Study of Collimating System Response to Hypothetical Accident Scenarios in the SNS Ring and Transfer Lines

Nicholas Simos (BNL)

The collimating system in the accumulator ring and transfer lines of the Spallation Neutron Source (SNS) project is responsible for stopping the 1.0 GeV protons that are in the halo of the beam. It is estimated that, under normal operating conditions, 0.1% of the 2 MW beam will be intercepted by the adopted collimating scheme implemented at various sections of the beam transport and accumulation. The collimating structures are a combination of either charge exchange foils or beam scrapers and stationary absorbers. Specifically, pairs of foils or scrapers moving in-and-out of the beam in the vertical and horizontal directions help guide the halo protons into respective absorbers which consist of an intricate design of a double wall beam tube, a water-cooled particle bed and radial shielding. Off-momentum protons, with the help of respective charge exchange foils and a dipole magnet, are directed to a momentum dump consisting of a cooled particle bed downstream of a double-walled window separating it from the vacuum space. Addressed in this paper is the thermo-mechanical response and survivability of key components of the collimating system (such as the collimating beam tube in the absorbers, the beam windows and the primary element of the bean scraper structure) in the event of intercept of the full beam

under accident conditions. While the potential for the full beam to be intercepted by these components is remote, still special attention will be paid in assessing the amount of full beam (or number of pulses) they can tolerate.

* Work performed under the auspices of the U.S. Dept. of Energy

WPPE007 All Digital IQ Servo-System for CERN Linacs

Anton Rohlev, Roland Garoby, Javier Serrano (CERN)

A new VME based system has been developed and built at CERN for the servo loops regulating the field in the linac accelerating structure. It makes use of high speed digital In-phase/Quadrature (IQ) detection, digital processing, and digital IQ modulation. The digital processing and IQ modulation is done in a single PLD. The system incorporates continually variable set points, iterative learning, feed forward as well as extensive diagnostics and other features well suited for digital implementations. Built on a single VME card, it will be first used in the energy ramping RF chain of the CERN Heavy Ion Linac (linac 3) and later for upgrading the present proton linac (linac2). This system serves also as a prototype for the future Superconducting Proton Linac (SPL). The design principle and the experimental results are described.

* Author is on leave from Los Alamos National Laboratory. DOE

WPPE008 Pulsed NMR Magnetometers for CESR

Robert Meller, Donald Hartill (Cornell University)

The Cornell Electron Storage Ring (CESR) now has an operating program spanning a wide range of beam energies, and hence wide-range magnetometers are required for accurate control of the bending fields. These have been implemented using the principle of pulsed nuclear magnetic resonance (NMR). The required field range is achieved by using a high impedance preamplifier in the field probe to isolate the detection coil, and resonating the coil with high-ratio tuning diodes. A probe installed in a CESR standard bend magnet has been operated continuously from 350 to 2450 Gauss using water as the resonance medium, and a second probe in a high-field bend magnet has been operated from 860 to 6725 Gauss, also using water. The RF preamp, transmitter, and receiver are all wide-band, and are identical in both systems. The received RF spin-echo signal is detected into two IF channels with 90 degrees phase difference to preserve full phase information. The IF channels are then digitized at 15 KHz, and a linear least-squares fit to phase versus time is done to determine the actual resonance frequency. The reference oscillator used for detection is a direct-digital synthesizer followed by a phase-locked frequency multiplier, and provides 40 Hz resolution up to 28.8 MHz. The digitization, data fitting, field tracking, and input/output are done with a commercial 8-bit microcontroller.

* Work supported by the National Science Foundation

WPPE009 Requirements for RF Control of TTF2 FEL User Facility

Valeri Ayvazyan, Kay Rehlich, Stefan N. Simrock (DESY)

During the past years, the experience gained with the operation of RF system at TESLA Test Facility (TTF) resulted in several modifications and improvements of its design. In addition, as the TTF is converted to become a user facility TTF2 for a VUV FEL during 2004. The electron beam energy will be increased from 250 MeV/c up to 1 GeV/c by installation of 48 TESLA cavities in 6 cryomodules. The RF system includes 4 klystrons (5MW and 10MW), each of them will supply RF power to group of cavities (RF gun, module 1, module 2&3, module 4,5&6). This paper presents the performance of the digital RF control at TTF and the requirements for commissioning and operation of RF control for TTF2.

WPPE010 Simulations of pbar Stacking and Unstacking in RR

Chandra Bhat (FNAL)

Fermilab Recycler Ring will be used as a future pbar storage ring during the collider Run II. For every two to three hours about 40mA of pbar beam from the Accumulator Ring will be transferred to RR, stacked and cooled for 10 to 20 hours. Depending on the Tevatron collider needs the cooled pbar beam will be unstacked from RR and transferred to Tevatron via Main Injector. In this paper we present results of multi-particle beam dynamics simulations of pbar stacking and unstacking in RR and their implications. The results of these simulations were critical to estibalish the operational criteria of the RR.

* Author would like to thank Dr. J. MacLachlan for many useful discussions during this work. Work supported by the U.S. Department if Energy under contract No. DE-AC02-76CH03000

WPPE011 Beam Intensity Monitor System for Beam in RR Barrier Buckets

Chandra Bhat, Brian Fellenz (FNAL)

The Fermilab Recycler Ring (RR) uses barrier buckets to store pbar beam in segments which have widely varying intensities. We have developed a fast integrator to measure the beam intensity in each of the barrier buckets. Here we discuss the design of the system and results of beam measurements using the integrator.

* Work supported by the U.S. Department if Energy under contract No. DE-AC02-76CH03000.

WPPE012 Improvement of Photon Factory Advanced Ring Control System

Takashi Obina, Atsuyoshi Akiyama, Tadahiko Katoh, Takashi Kawamoto, Ichita Komada, Kikuo Kudo, Shinya Nagahashi, Tatsuro Nakamura, Jun-ichi Odagiri, Yasunori Takeuchi, Noboru Yamamoto (KEK)

As a part of the Photon Factory Advanced Ring (PF-AR) upgrading project, the control system is improved. Considering the importance to realize the seamless operation between PF-AR, linac and KEKB, we decided to adopt EPICS as a basis of the control system. The old control system of the PF-AR was based on the HIDIC mini-computer system and the CAMAC was used as a field-bus. In order to minimize the cost and the work of renewal, we didn't change the device interface layer below CAMAC. A total of 13 IOCs are used to replace HIDIC, and we use the VME modules such as CAMAC crate controller, GPIB interface and the timing synchronization module. The ARCNET driver modules are also used mainly for the control of magnet power supplies. For the archiving of accelerator parameters, we use Channel Archiver, which is one of the EPICS extensions. We have also renewed the accelerator safety control system using the PLC.

WPPE013 The LANSCE RICE Control System Upgrade

Stuart Schaller, Eric Bjorklund, Mary Burns, Gary Carr, John Faucett, David Hayden, Matthew Lusk, Robert Merl, Michael Oothoudt, Jerry Potter, Jerome Reynolds, Dolores Romero, Fred Shelley, Jr. (LANL)

The LANSCE (Los Alamos Neutron Science Center) control system upgrade program continues with the impending replacement of the RICE (Remote Instrumentation and Control Equipment) subsystem. The RICE subsystem upgrade is a challenge because of its technology (late 1960?s), number of channels (>10,000), and unique characteristics (all-modules data takes, timed/flavored data takes). The plan is to replace at least the non-timed data and the command portions of the subsystem with programmable logic controlers (PLCs). We discuss motivations, technological challenges, proof of principle, and planning. The boundary condition, as usual, is that we must implement these major changes on a running accelerator.

* Work supported by the U.S. Department of Energy

WPPE014 The Upgrade of HLS Linac Control System

Liu Gongfa, Xun Bao, Liping Chen, Chuan Li, Weimin Li, Jigang Wang (National Synchrotron Radiation Lab)

Hefei Light Source (HLS) at NSRL is a second generation dedicated light source, and it consists of three parts: 200Mev Linc, transportline and 800 Mev storage ring. The upgrade of HLS linac control system started in 2001, and the control system is based on EPICS. Linac power supplies control subsystem and linac vacuum monitor subsystem have been finished, modulator power supplies control subsystem and interlock subsystem are under progress. Industrial PCs are widely used in IOCs and front-end controllers(FDC), and some PLCs and SUN workstations are also used. This paper will cover the experience of using PC under EPICS, the hardware structure and software design of the linac control system.

WPPE015 Application Programming Structure and Physics Applications

Chungming Chu, John Galambos, Tom Pelaia, Andrei Shishlo (ORNL), Chris Allen, Nick Pattengale (LANL)

The Spallation Neutron Source (SNS) is using a Java based hierarchal framework for application program development. The framework is designed to provide an accelerator physics programming interface to the accelerator. Much of the underlying interface to the EPICS control system is hidden from the user. Use of this framework allows writing of general-purpose applications that can be applied to various parts of the accelerator. Also, since the accelerator structure is initiated from a database, introduction of new beamline devices or signal modifications are immediately available for all XAL applications. Direct scripting interfaces are available for both Python and Matlab, for rapid prototyping uses. Initial applications such as orbit difference, orbit correction and a general purpose diagnostic tool have been developed and tested with the SNS front end. The overall framework is described, and example applications are shown.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

WPPE016 SNS Global Database Use in Application Programming

John Galambos, Chungming Chu, E. Danilova, Jeff Patton, Tom Pelaia, Andrei Shishlo (ORNL)

A global relational database is being assembled to track accelerator components for the Spallation Neutron Source (SNS). As part of this activity, beamline element information is stored for use in high level application programs. A hierarchal accelerator framework is generated from the database and used for initialization of a Java based programming infrastructure. From within this framework input files for beam simulation codes can be generated using either live machine values or design values. The database also includes global coordinates for beamline element alignment, and magnet measurement data. The table schema and relationships to tables used in other parts of the project will be discussed.

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WPPE017 The EPICS Based Virtual Accelerator - Concept and Implementation

Andrei Shishlo, Paul Chu, John Galambos, Tom Pelaia (ORNL)

Development of physics applications for an accelerator that does not yet exist presents a nontrivial task. In the case of a controls system based on EPICS there is an elegant solution facilitating this task. It is possible to create a model imitating the real machine by using the EPICS portable channel access server (PCAS) and one of the existing simulation programs. This combination of PCAS and a simulation program has been termed the "virtual accelerator", because it looks like a real machine from the EPICS channel access view, operates with real process variable (PV) names, and produces a reasonable response generated by the simulation model. This paper discusses the virtual accelerators for the SNS linac based on TRACE3D and PARMILA codes and experience in using these virtual accelerators for physics applications development.

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WPPE018 The Development of EPICS for PLS Storage Ring Magnet Power Supply

J.M. Kim, K.M. Ha, J.Y. Huang, E.S. Kim, J.H. Kim, S.H. Nam (Pohang Accelerator Laboratory)

This paper will describe the development and the application of the machine operation of the Distributed Control System on the EPICS-Based MPS (Magnet Power Supply) of the storage-ring in PLS. The MPS control system of the storage-ring was developed completely in the end of Aug 2002 based on EPICS and applied to the machine operation successfully. 42 units of Unipolar (Q123, Q4, Q5, Q6, SF, SD)and 146 units of Bipolars (Corrector, bending Trim, Skew) of the MPS of the storage-ring in PLS are linked each other through by local ethernet, and they are interfaced with EPICS IOC through Open MODBUS/TCP Protocol. The development of EPICS application and the machine operation have been developed based on PC-server, Windows (Win2000/NT) for user friendly purpose.

WPPE019 EPICS based Vacuum Control System Using Ethernet Multi Serial Device Severs on the TCP/IP Network for PAL Storage Ring

Jong Chel Yoon, J. H. Choi, J.Y. Huang, S.H. Nam (Pohang Accelerator Laboratory)

A vacuum control system has been developed for use Ethernet Multi Serial Device Severs (EMSDS), and Multi-Serial Communication Controllers (MSCC) on the Pohang Accelerator Laboratory (PAL) storage ring. There are 20 Balzers vacuum gauges, 17 Granville-Phillips vacuum gauges and 124 titanium-getter vacuum pumps at the storage ring. It was a very important problem to solve the problem how to control such a large number of vacuum devices distributed around the ring. After discussions, we decided to develop a serial to Ethernet interface device sever that will be mounted in the control system rack. It has a 32-bits microprocessor; Embedded Linux, 16 ports RS485 (or RS232) Slave interface, one channel 10/100BaseTx Ethernet host port, one channel UART host port, and 8 Mbytes large Memory buffer. These vacuum pumps are connected to Ion-Pump Serial Controllers, which chop the AC current so as to control the current in the pumps. The EMSDS connect either 100BaseTx or 10BaseT Ethernet networks to asynchronous serial ports for communication with serial device. It can simultaneously control up to 12 Ion-Pump serial controllers. 12 EMSDS are connected to a VMEbus PC (Pentium II) through the network. The VMEbus PC can automatically control the EMSDS by sending a set of commands through the TCP/IP network. Upon receiving a command from a VMEbus PC running under Windows2000 through the network, the EMSDS communicate through the slave serial interface ports to Ion-Pump Controller. We added some software components on the top of EPICS (Experimental Physics and Industrial Control System) toolkit.

WPPE020 Accelerator Control Middelware

Terebilo Andrei, Jeff Corbett, Gregory Portmann (SLAC)

This paper presents a concept and our implementation of a software layer between the high-level accelerator control applications and accelerator control system. This layer allows the high level application written in MATLAB to access accelerator hardware using the Family-Section-Element cheme commonly used in accelerator modeling codes.

WPPE021 Simulated Commissioning of SPEAR3 Storage Ring

Terebilo Andrei, Jeff Corbett (SLAC)

In preparation for the commissioning and operations of SPEAR3 we developed a number of high-level accelerator control applications. We developed a test platform that simulates the physics of a storage ring. To any application using EPICS CA it appears as a real storage ring: measurable parameters such as orbits and tunes change in response to the changes in the accelerator hardware setpoints.

* Work supported in part by DOE Contract DE-AC03-76SF00515 and Office of Basic Energy Sciences, Division of Chemical Sciences.

WPPE022 The Bunch Injection Controller for the PEP-II Storage Rings

Ronald Chestnut (SLAC)

SLAC's PEP-II Storage rings have 3492 "buckets" into which electrons and positrons can be injected in the high energy and low energy rings, respectively. RF equipment and fast ADCs were originally provided by Lawrence Berkeley Laboratory and are implemented in VXI-based hardware. Recent upgrades provide much improved phase drift stability. These data along with high precision total ring currents provide the input for the Bunch Injection Controller. Physical injection constraints and operator inputs are also used by the software algorithms to determine the desired bucket injection order and charge quantity for each injected bunch. This highly visible and successful system is implemented using the EPICS toolkit, and fits well into the merged SLAC EPICS/SLC control system. The Bunch Injection Controller hardware is a VME-based EPICS IOC which makes extensive use of shared memory for communication with both the LBL VXI hardware and the SLAC master pattern generator.

WPPE023 A New Real-Time Operating System and Python Scripting on Aladdin

David Eisert, Robert Bosch, Ken Jacobs, Kevin Kleman, John Stott (Synchrotron Radiation Center, University of Wisconsin)

We are in the process of upgrading the VME processors on the Aladdin electron-storage-ring control system. The last major redesign of the control system occurred in the mid 1980s. At that time we converted to VME microcomputers and VAX/VMS workstations communicating via Ethernet. This is the second upgrade since then of the VME processor. As upgrades of the Motorola 680x0 processor are no longer available we have decided to switch to the Intel Pentium III. This change allowed us to reconsider our use of the rather primitive uC/OS kernel and implement a commercial real-time OS. We decided to use QNX primarily as it was a good match to our existing software and was zero cost. In addition to upgrading the CPUs we have also added a new scripting language to our main control application. We used SWIG (http://www.swig.org) to create wrapper code for the scripting software. SWIG can create wrapper code for many scripting languages so our initial choice of a scripting language was not critical. We decided to start by using Python due to the many available add-on libraries and the apparent ability to support larger projects. We will discuss our evaluation process and the challenges we encountered.

* This work was supported by the National Science Foundation under contract number DMR-0084402.

WPPE024 Control System for the Superconducting Insertion Devices of SRRC

Kuotung Hsu, C. K. Chang, Jenny Chen (Synchrotron Radiation Research Center)

To enhance hard X-ray production in the 1.5 GeV storage ring of the SRRC to serve fast growth of X-ray user community in Taiwan, the storage ring are planed to install up to five superconducting insertion devices. A 6 Tesla superconducting wavelength shifter (SWLS) haven been installed in mid-2002. A 3 Tesla superconducting multi-poles wiggler will install in mid-2003. There are three multiple-poles wigglers are planed to install during 2004~2006. The control system was implemented to support the operation of SWLS and SMPW. The control system play a role to coordinate the operation of main power supply and trimming power supplies to charge/discharge the magnet and provide essential interlock protection for the coils and vacuum ducts. A friendly user interface and various applications are used to support routine operation. Design considerations and details of the implementation will be presented.

WPPE025 SRF Low-Level System Integration

M.S. Yeh, L.H. Chang, K.-T. Hsu, M.-C. Lin, G.-H. Luo, Ch.E. Wang (Synchrotron Radiation Research Center)

The electron storage ring at Synchrotron Radiation Research Center, as one of the third generation light sources, is routinely operated with a maximum beam current of 200 mA with two Doris cavities. One major machine performance upgrade is undertaken at SRRC by replacing the existing Doris cavities with a single superconducting module of CESR-III design. Operation at a maximum beam current up to 400 mA in a high-order-mode well damped condition is expected, for significantly enhancing the spectral brightness and improving the beam stability. Commissioning is schedule for the spring of 2003. Two SRF modules including associated electronics for protection of window arcing as well as cavity quench, and cryogenic control of cryostat conditions will be delivered from ACCEL, according to Cornell design. On the other hand, the existing low level RF system from SLAC is being modified for functional integration with the SRF operation. The efforts and strategy of electronic integration for the SRF operation are reported.

WPPE026 Low Level RF System for Jefferson Lab Cryomodule Test Facility

Tomasz Plawski, Trent Allison, Jean Delayen, Curt Hovater, Tom Powers (Thomas Jefferson National Accelerator Facility)

The Jefferson Lab Cryomodule Test Facility (CMTF) has been upgraded to test and commission SNS and CEBAF Energy Upgrade cryomodules. Part of the upgrade was to modernize the superconducting cavity instrumentation and control. We have designed a VXI based RF control system exclusively for the production testing of superconducting cavities. The RF system can be configured to work either in Phase Locked Loop (PLL) or Self Excited Loop (SEL) mode. It can be used to drive either SNS 805 MHz or CEBAF Energy Upgrade 1497 MHz superconducting cavities and can be operated in pulsed or continuous wave (CW) mode. The base design consists of RF-analog and digital sections. The RF-analog section includes a Voltage Control Oscillator (VCO), phase detector, I&Q modulator and "low phase shift" limiter. The digital section, which includes ADC, FPGA, and DAC, controls the analog section. We will discuss the design of the RF system and how it relates to the support of cavity testing.

WPPE027 PLC and Linux Based Control System for the CAMD Linac

Paul Jines, Ben Craft (Louisiana State University Center for Advanced Microstructures and Devices)

Louisiana State University Center for Advanced Microstructures and Devices (CAMD) began operations in the fall of 1992. At the time, the facility had separate control systems for the storage ring and injector Linac. The storage ring was controlled by a VAX/VMS system, primarily using CAMAC for I/O. The injector Linac was controlled by a separate VME/OS/9 system using custom I/O components. In 1997, CAMD began a control system upgrade project with the goal of producing a single unified control system running on the PC/Linux platform. After completion of the storage ring control system, the Linac control system was designed utilizing AutomationDirect.com PLCs for the real-time components, and PC/Linux for the user interface. The new Linac control system has been completed, and has been operational since July 2002. This paper will discuss the objectives, design, and foture upgrade plans for the Linac control system, as well as the experiences with replacing VME/OS/9 with a PLC/PC/Linux based system.

WPPE028 Cross Platform SCA Component using C++ Builder and Kylix

Hiroshi Nishimura, James McDonald, Chris Timossi (LBNL)

A cross-platform component for EPICS Simple Channel Access has been developed. EPICS client programs with GUI become portable at their C++ source-code level both on Windows and Linux by using Borland C++ Builder 6 and Kylix 3 on these platforms respectively. This is a continuation of our previous work in Delphi 6 and Kylix 2 reported at PCaPAC 2002.

* Supported by U.S.DOE under contract No.DE-AC03-76SF00098

WPPE029 Design of Control System for SAGA Synchrotron Light Source

Hideaki Ohgaki (Institute for Advanced Energy, Kyoto University), Yositaka Iwasaki, Takio Tomimasu (Saga Synchrotron Light Source, C/o Saga Prefectural Goverment)

A control system for SAGA Synchrotron Light Source has been designed. The idea of using a PC for an accelerator control is not special because of the intensive development and a very high cost performance of PC. On the other hand, a sophisticated control system based on workstation, such as EPICS, has been worked in many accelerator facilities. Thus the EPICS running on a PC-UNIX system is a solution for a control system. But for a small facility that has no stuff to maintain the control system, like the SAGA facility, it would be difficult to keep EPICS performance being high. So we design the control system to use EPICS communication, a channel access (CA), alone. ActiveX CA is an excellent CA component for PC environment and it smoothly works with EPICS tools and with PC-Windows programming products. Thus we will use the ActiveX CA server running on a PC which directly communicates with the hardware interface devices, PLCs and remote-IO. Many EPICS tools and, of course, in-house applications can be available for a man-machine interface in this control system.

WPPE030 Using Vibrating Wire Technique to Determine Undulator Quality

David Harder, George Rakowsky (BNL), Alexander Temnykh (Cornell University)

We compare the Vibrating Wire (VW) technique with traditional Hall probe mapping for measuring undulator field quality. A versatile, high-sensitivity VW probe design is described. Fidelity of field maps reconstructed from Fourier components, derived from VW measurements, is evaluated in terms of the number of undulator periods and wire harmonics. Signatures of intentionally introduced field errors of both steering and non-steering type are characterized by both techniques and compared. Limitations of the VW technique due to signal-to-noise and other causes are explored.

* Brookhaven National Laboratory is operated by Brookhaven Science Associates Upton, N.Y. 11973 under contract with the United States Department of Energy Contract number DE-AC02-98CH10886.

WPPE031 Survey & Alignment Data Management for Particle Accelerators

F. Michael Hemmer, Francis X. Karl (BNL)

The acquisition, storage and retrieval of device coordinates and survey observation data is an important part of the construction and long term maintenance of particle accelerators. Principle data generating processes such as lattice global coordinate computation, device fiducialization, survey control network monumentation and magnetic measurement are examined. Types of coordinate data, the flow of data between groups and nomenclature as a critical path element, are discussed, together with time related data events. Roles and responsibilities for survey, physics, engineering and design personnel, are presented. A generic alignment database schema with interface and access requirements, is offered. Status of efforts at RHIC-AGS and SNS are reviewed.

* Work performed under the auspices of the U.S. Department of Energy. SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPE032 RHIC Alignment Analysis

Vadim Ptitsyn, Michael Hemmer, Francis Karl, Dejan Trbojevic (BNL)

The vertical alignment of RHIC magnets is an important factor considering the acceleration of polarized proton beam. During the last polarized proton run a special vertical orbit, based on measured misalignment data, was used at the polarized proton acceleration. Alignment measurements, done after the run, demonstrated considerable vertical magnet shifts in RHIC interaction regions, due to the settlement. In the paper the effect of these misalignments on the beam dynamics and the beam polarization is analyzed. Alignment tolerances required for the polarization preservation are reviewed and the necessity of magnet realignment is considered. Possible beam-based techniques for measurement of misalignments are evaluated.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

WPPE033 SNS Ring and Transport System Magnet Acceptance and Installation Preparation

Steven Tepikian, Richard Anderson, F. Michael Hemmer, Hsiao-chaun Hseuh, John W Jackson, Animesh Jain, Francis X. Karl, Yong Y. Lee, William J McGahern, Deepak Raparia, Richard Savage, Joseph E. Tuozzolo, Peter Wanderer, Jie Wei (BNL)

Installation of the magnets in the SNS-Ring, or any accelerator, requires quality assurance to minimize problems. The geometry of the ring was frozen and the dipole length was adjusted to reflect the measured dipoles magnetic length to aid the installation process. The approach established here is based on the Magnet Acceptance procedures used for RHIC. The magnets are first measured and checked on the bench for mechanical and electrical characteristics, field strength, multipole strengths, survey, etc. Each group performing these measurements determines whether the magnet is within the design specifications. A magnet that passes is accepted. A magnet that fails may be accepted if the problem is not a show stopper. Such a magnet is classified as a spare or fixed. Furthermore, once accepted, these magnets are assembled into units such as the full half cell

assemblies before being shipped for installation. These assemblies have a checkout list as well.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPE034 Chromaticity Correction along the Ramp during the RHIC 2003 Run

Steven Tepikian, Leif A. Ahrens, Peter R. Cameron, Aljosa Marusic, Carl Schultheiss (BNL)

Correcting chromaticity during acceleration improves the stability of the beam. During the RHIC 2003 run, we tested a method to correct chromaticity during ramping. We apply a 0.2mm amplitude sine wave at 1Hz rate to the radial shift. This produces a perturbation in the tune measured by the PLL tune-meter which is proportional to the chromaticity. From this measurement, a correction to the sextupoles is found and applied. We report on the success and status of this method.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy

WPPE035 Laser-Based Alignment System for the J-PARC Linac

Masanori Ikegami, Yasuo Higashi, Takao Kato (KEK)

The total length of the J-PARC linac, which includes the straight section of the following beam transport line, is about 280 m. To avoid excess beam loss and beam quality deterioration, an accurate alignment of accelerator components is indispensable for the linac. From this point of view, the alignment goal along the linac is set to +/- 0.05 mm transversely. In addition, it is essential to carefully watch long-term ground motion to maintain the alignment accuracy, considering that the J-PARC facility is to be build on a flimsy ground beside the Pacific Ocean. To meet these requirements, a laser-based alignment system has been developed. Trial-manufacturing of main components and feasibility tests with a 50-m test beam line have been performed. In this paper, the main features of the alignment system and the results of the feasibility tests are presented.

WPPE036 A Model of ATL Ground Motion for Storage Rings

Andrzej Wolski (LBNL), Nicholas Walker (DESY)

Low emittance electron storage rings, such as those used in third generation light sources or linear collider damping rings, rely for their performance on highly stable alignment of the lattice components. Even if all vibration and environmental noise sources could be suppressed, diffusive ground motion will lead to orbit drift and emittance growth. Understanding such motion is important for predicting the performance of a planned accelerator and designing a correction system. A description (known as the ATL model) of ground motion over relatively long time scales has been developed and has become the standard for studies of the long straight beamlines in linear colliders. Here, we show how the model may be developed to include beamlines of any geometry. We apply the model to the NLC and TESLA damping rings, to compare their relative stability under different conditions.

* Work supported by the US DOE under contract DE-AC03-76SF00098.

WPPE037 Design and Operation of the Cryostat for the CESR-c Superconducting Wiggler Magnets

Yun He, Gerald Codner, Richard Ehrlich, Yulin Li, Valery Medjidzade, Alexander Mikhailichenko, Nariman Mistry, Emery Nordberg, David Rice, Daniel Sabol, Eric Smith, Karl Smolenski, Dwight Widger (Cornell University)

As a part of the "CESR-c" upgrade project, a full-scale prototype superferric wiggler module has been installed into the Cornell Electron Storage Ring (CESR) ring and has been successfully operating since October 2002. The wiggler magnets are chosen to achieve the damping decrement, horizontal emittance and energy spread required for optimum operation of CESR-c at a beam energy of 1.88 GeV. The wiggler cryostat units are designed to be modular, of fixed length flange-to-flange, so that they can be easily installed. The cryostat is designed to align and support the 855kg cold mass accurately within the vacuum vessel, and includes an integral warm bore, water-cooled, copper ultra-high vacuum beam-pipe for the storage ring environment. The cryostat incorporates several novel features including a suspension system with very low heat leak that prevents any significant motion during cool down, HTSC current leads, a custom triple cryogenic feedthrough, and a helium vessel made in two halves, each enclosing a half-magnet. This article presents the design, fabrication, and operation of the prototype CESR-c wiggler cryostat.

* Work supported by the US National Science Foundation.

WPPE038 The Pilot-Runs of the Helium Cryogenic System for the TLS Superconducting Cavity

Feng-Zone Hsiao, Sheng-Hsiung Chang, June-Rong Chen, Tzu-Chyang King, Hsing-Chieh Li, Ming-Chyuan Lin, Chaoen Wang (Synchrotron Radiation Research Center)

At SRRC the installation of the helium cryogenic system, which is tailor-made for the cooling of TLS superconducting cavity, was finished at the end of October 2002. The cryogenic system is now at the phase of conditioning. Commissioning of the system shall be finished at the end of January 2003. The preliminary test for this helium system achieves a cooling capacity of 255W at 4.2K without using liquid nitrogen for pre-cooling. In this paper the performance of the cryogenic system obtained via a heater as the dummy load will be presented.

WPPE039 Design of Cryogenic System for Several Super-Conducting Modules at Synchrotron Radiation Research Center

T.C. King, S.H. Chang, J.R. Chen, H.C. Li, F.Z. Shiao (Synchrotron Radiation Research Center)

Synchrotron Radiation Research Center (SRRC) is planning to install two 500 MHz super-conducting radio frequency (SRF) modules and five super-conducting magnet modules in the near future. For the cryogenic requirement, we are presently constructing a helium cryogenic system. The cryostat properties of the SRF and the magnet modules are different, so that in our design the cryogenic system has two cryogenic plants (465W or 110 liters per hour @ 4.5 K for every plant), where one is for the SRF modules and the other is for the magnet modules. The two plants are independent in normal operation. However, when the cryogenic plant which is for the SRF modules shuts down, the other one will be transferred to supply the SRF modules.

Poster Session WPPB
Grand Ballroom II at 13:30

WPPB001 Techniques for Synchronization of X-Ray Pulses to the Pump Laser in an Ultrafast X-Ray Facility

John Corlett, W.A. Barletta, W. Barry, J.M. Byrd, L. Doolittle, R. Schoenlein, A. Zholents (LBNL)

Accurate timing of ultrafast x-ray probe pulses emitted from a synchrotron radiation source with respect to the signal initiating a process in the sample under study is critical for the investigation of structural dynamics in the femtosecond regime. We describe schemes for achieving accurate timing of femtosecond x-ray synchrotron radiation pulses relative to a pump laser, where x-rays pulses of <100 fs duration are generated from a proposed source based on a recirculating superconducting linac. We present a description of the timing signal generation and distribution from photocathode laser to low-level rf and experimental laser systems to minimize timing jitter of the beam relative to the experimental lasers. We discuss techniques based on generation of timing signals from light emitted from the beam at various passes through the recirculating linac configuration. This beam-based signal has the potential to provide an extremely accurate reference with respect to the emitted x-ray photons.

* This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

WPPB002 Bunch Purity Evolution during APS Storage Ring Top-up Operations

Alex Lumpkin, Tom Toellner, Bingxin X. Yang, C.Y. Yao (ANL)

The Advanced Photon Source (APS) storage ring serves as a national x-ray synchrotron radiation user facility. In addition to the requirements of high brilliance of hard x rays, beam stability at the few-micron rms jitter level, and >95% availability, the bucket purity of the fill pattern is monitored at the one part in a million level. That is, the adjacent bucket charge/intensity on the trailing time side (+) of the target rf buckets should be less than 10-6 of the target bunch as requested by the timing experiment users. This measurement is done by the standard photon statistics counting system based on a fast x-ray avalanche photodiode, timing electronics, a time-to-amplitude converter (TAC), and an ADC linked to the EPICS control system. During the course of top-up operations we have detected a growth of the intensity of the +1 bucket relative to the targeted buckets. We have traced this to the change in the number of linac bunches selected for injection into the particle accumulator ring (PAR) and the adjustments of the PAR 12th harmonic rf power during top-up. Examples of the bunch purity measurements from a standard fill and the evolution during top-up will be shown. Status of the development of a tuning procedure to reduce this effect will be presented.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPPB003 The Feasibility of OTR Imaging of High-Intensity Proton Beams at FNAL

Alex Lumpkin (ANL), Victor E. Scarpine (FNAL)

The Fermi National Accelerator Laboratory (FNAL) is currently pursuing projects that require careful tracking of beam properties throughout the facility or before a target. The latter efforts relate to beam luminosity in the Tevatron collider and proton intensity for neutrino experiments. The feasibility of using optical transition radiation (OTR) imaging to determine proton (or antiproton) transverse beam sizes in transport lines between the rings of the facility has recently been evaluated based on comparisons to electron-beam results at the Advanced Photon Source (APS) linac and proton-beam results at CERN. At the APS, OTR beam images were obtained for gammas ranging from 100 to 1200 with particle intensities of about 2 x 10^9. The scalings on gamma and the charge intensity indicate that significant OTR will be generated by the lower gamma, higher intensity (~3 x 10^{12}) proton beams so that standard CCD or CID camera technology is usable. The advantages of using thin metal foils as the radiation converter to limit beam scattering as well as minimizing heat deposition are well established. In the proton case, a number of results are already available from CERN experiments to indicate that 5- to 10-μm thick Ti foils should survive in the FNAL transport line beams. The initial location for tests is being evaluated, and the first results will be reported as available.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPPB004 Recent Characterizations of Electron Beams from the APS Linac

Alex Lumpkin, William J. Berg, Michael Borland, John W. Lewellen (ANL)

The Advanced Photon Source (APS) facility includes an S-band linear accelerator (linac) that normally provides beam for the injection system for the 7-GeV storage ring. This beam is generated by one of two rf thermionic guns or the rf photocathode (PC) gun under special circumstances. When the beam is not required for injection, one may characterize it at a station located at the end of the linac. At this location we have recently begun a retrofit and upgrade of the optics on the diagnostics table. At the time of these experiments a crossed polarizer under EPICS control was added for remote intensity control in front of the CCD camera that imaged the YAG:Ce screen or optical transition radiation (OTR) screen. This facilitated the use of the quadrupole scanning technique for an emittance measurement of the PC gun beam at 325 MeV. In particular, we demonstrated that the YAG:Ce saturation effect is present under the tightest focus conditions so that OTR imaging is needed to provide the actual beam sizes properly. The C5680 streak camera was used with OTR to provide bunch length measurements for the first time for beam from the newly installed rf thermionic gun with alpha magnet. The streak camera results were compared to the zero-phasing rf technique using the energy spectrometer located just upstream of this station. Bunch lengths as a function of scraper position in the alpha magnet of the rf thermionic gun were determined. Details of the results will be presented.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPPB005 Initial CTR-based Bunch Length Measurements of Linac Beams following the APS Bunch Compressor

Alex Lumpkin, William J. Berg, Michael Borland, John W. Lewellen, Nicholas Sereno (ANL)

The interest in generation and characterization of ultrabright electron beams for experiments at the Advanced Photon Source (APS) resulted in the installation of a four-dipole chicane bunch compressor within the linac. Both rf thermionic guns and an rf photocathode (PC) gun can be used to generate the electron beams with ps-regime bunch lengths. The bunch compressor can then be used to produce sub-ps bunches. In support of this initiative a coherent transition radiation (CTR) bunch length monitor based on a FIR Michelson interferometer was also installed at a location just downstream of the compressor. It used a room-temperature Golay cell as the FIR detector. Processing of the autocorrelation data indicated that structures shorter than 500 fs were being generated. A zero-phasing rf technique was also used with an analyzing magnet at the end of the linac to verify that very

short bunches were being generated. Results from both gun types will be presented.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPPB006 X-Ray Imaging of the APS Storage Ring Beam Stability Effects: From the Alaskan Earthquake to Undulator Field Changes

Alex Lumpkin, Louis Emery, Bingxin X. Yang, C.Y. Yao (ANL)

The Advanced Photon Source (APS) 7-GeV storage ring serves as a national x-ray synchrotron radiation user facility. The stability and beam quality of the electron beam and hence the photon beams are monitored continuously by an array of diagnostics. In particular, x-ray imaging techniques are employed in the diagnostics sector of the ring to characterize beam position, size, and emittance. The x-ray synchrotron radiation (XSR) emitted by the electrons as they pass through the field of a dipole magnet is imaged by a pinhole camera. The images are processed by a Datacube MV200 video digitizer, and the results are provided through the EPICS platform. We are currently running at a lower emittance lattice of 2.3 nm-rad with a vertical coupling of 2%. In the course of monitoring the beam, we have detected the effects on the beam ranging from the shock waves of the Alaskan earthquake of November 3, 2002 to the variation of the undulator fields by the users during their scans. In the latter case, the beam size effects were observed at the submicron level. Examples of beam centroid and size effects will be presented.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPPB007 Super-Conducting Resonator as Beam Induced Signal Pickup

Richard Pardo, Benjamin Clifft, Petr Ostroumov, Sergey Sharamentov, Gary Zinkann (ANL)

A new method for longitudinal tuning of independently-phased super-conducting linac resonators has been experimentally tested at the ATLAS accelerator. This new technique employs a nearby downstream super-conducting resonator as a beam induced RF field detector. By measuring the induced RF field phase in the detecting resonator as a function of the last accelerating resonators phase or amplitude, the accelerating resonator can be properly set for a particular tune configuration. A description of the electronics needed to phase-lock and extract the phase information from the pickup resonator will be given as well as the results of initial tests of the system.

* This work supported by U.S. DOE under contract W-31-109-ENG-38.

WPPB008 Beam Position Monitor Systems for the SNS LINAC

John Power (LANL)

The 402.5- and 805-MHz beam position and phase monitors for the Spallation Neutron Source linac are based on standard PC technology. The SNS beam is to be injected into a storage ring with a 1-MHz circulation frequency requiring 650-ns-long minipulses. The injection cycle takes 1 ms and the machine can run at rates up to a 60 Hz. The rf input signals are down converted to 50 MHz and sampled at 40 MHz with 14-bit ADCs to produce I and Q data streams. A custom PCI module has been designed to accept modular digital front end (DFE) and analog front end (AFE) circuit cards. This hardware is installed in a standard rackmounted 1U computer chassis running Windows 2000, LabVIEW and custom DLL software. The system continuously self-calibrates by generating 300-ns long rf pulses which are switched between the AFE inputs and the cables going to the BPM pickups. This provides a TDR-like calibration of the entire system. The system provides a position and phase resolution of 0.1% of the beam pipe aperture and 0.1 degrees RMS respectively over a 50 μs period. The design of the system is described as well as the initial performance measuring beam during the commissioning of the SNS MEBT.

* Work supported by the Office of Basic Energy Science, Office of Science of the US Department of Energy, and by Oak Ridge National Laboratory.

WPPB009 Electron Beam Scattering Effects in Emittance Measurements

John Power (ANL)

An investigation to determine how much electron beam scattering limits the accuracy of emittance measured with an emittance mask has been preformed using the Monte-Carlo code EGS4. An emittance mask is a device used to measure the correlated emittance by sampling the incident beam's transverse phase space. This is accomplished by blocking most of the incident electron beam while allowing small 'beamlets' to pass through openings in the mask. The two most common masks used for emittance measurements are the slit mask, which samples the 2D emittance, and the pepper pot mask, which samples the 4D emittance. The accuracy of the transverse emittance measured by either mask is limited by several factors including, electrons leaking through the solid region of the mask, the imaging system resolution and dynamic range, scattering, etc. While the noise contribution by the other quantities can be easily estimated, scattering effects have previously been neglected due to the difficulty in estimating this effect. EGS4 simulations will be used to determine the affect of scattering on emittance measurements for electron beams with energies of several MeV.

WPPB010 Advanced Photon Source Booster Synchrotron Beam Position Monitor Upgrade and Applications

Nicholas Sereno, Frank Lenkszus, Robert Lill (ANL)

The Advanced Photon Source operates in top-off mode, which adds charge to the storage ring every two minutes to maintain the current at 102 +/- 1.0 mA. This requires the booster synchrotron to operate efficiently and reliably. The booster BPM system was upgraded to overcome a severe performance limitation due to operation of the receiver at the low end of its input power range. The upgrade provided a 25-dB improvement in overall system gain. This improved dynamic range and resolution, and reduced other systematic errors. The booster BPMs have been used in studies including measurements of ring circumference, synchrotron and betatron tune, and orbit correction. Software feedback corrections of the energy and rf phase errors at injection have been implemented for routine operations using the BPM beam history/DSP-based synchrotron tune measurement. Transverse injection feedback is presently being commissioned. The latest experimental results using the upgraded BPMs will be presented.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract W-31-109-ENG-38.

WPPB011 Tune System Applications at the APS

Chihyuan Yao (ANL)

The Advanced Photon Source (APS) storage ring is a third-generation X-ray synchrotron radiation user facility. The storage ring tune measurement system consists of signal pickup and beam excitation drive striplines, a network analyzer, and a vector signal analyzer. The system has been used for daily tune tracking, beta-function measurement, chromaticity measurement, lattice correction, magnet power supply stability analysis, machine coupling impedance, and observation of beam instabilities. Several software applications were developed to automate the instrument control and data collection processes. We present the current configuration of the tune

measurement system, the software tools, and their application at the APS.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

WPPB012 AGS Booster Beam Position, Tune, and Longitudinal Profile Data Acquisition System

Kevin Brown, L. Ahrens, A. Krishock, K. Smith, M. Wilinski, S. Zahariou-Cohen (BNL)

In this paper we will describe a data acquisition system designed and developed for the AGS Booster. The system was motivated by the need to get high quality beam diagnostics from the AGS Booster. This was accomplished by locating the electronics and digital data acquisition close to the Booster ring, to minimize loss of bandwidth in the original signals. In addition we had to develop the system rapidly and at a low cost. The system consists of a Lecroy digital oscilloscope which is interfaced through a National Instruments Labview server application, developed for this project. This allows multiple client applications to time share the scope without interfering with each other. We will present a description of the system design along with example clients that we have implemented.

* Work performed under the auspices of the U.S. Dept. of Energy

WPPB013 Spallation Neutron Source Ring Diagnostics Overview

Peter Cameron, John Brodowski, Philip Cerniglia, Roger Connolly, John Cupolo, William Dawson, Christopher Degen, Al DellaPenna, David Gassner, Manuel Grau, Adam Huhn, Martin Kesselman, C.J. Liaw, Joseph Mead, Robert Sikora, Richard Witkover (BNL)

Brookhaven is providing the Ring and Transfer Lines Beam Diagnostics for the Spallation Neutron Source (SNS), to be installed at Oak Ridge National Laboratory. The customary diagnostics that will be present include Beam Position Monitors, Ionization Profile Monitors, Beam Loss Monitors, Beam Current Monitors, Coherent Tune Measurement, and Wire Scanners. An overview of these systems is presented, along with brief discussions of SNS-specific problems that must be addressed, including unprecedented beam power, large dynamic range, a stringent loss budget, space charge, beam halo, and electron cloud. We also present an overview of systems more specifically tailored to address these problems, including Beam-in-Gap measurement and cleaning, two types of incoherent tune measurement, halo monitor, electron detectors, video monitors for stripping foils and the electron catcher, and provision for a luminescence monitor.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPB014 The RHIC Quasi-Schottky Pickup

Peter Cameron, John Cupolo, Christopher Degen, Al DellaPenna, Martin Kesselman, Joseph Mead, Robert Sikora, Kurt Vetter (BNL)

The present resonant pickup for the RHIC PLL tune measurement system (which also functions as a Schottky pickup) operates at 245MHz, well above the coherent spectrum of the 28MHz acceleration system. The absence of unwanted coherent energy permits PLL operation with very low kicker power, and avoids unwanted emittance blow-up. Despite the fact that this pickup has served its purpose well, the utility for precision measurements is sometimes limited by the linewidth broadening due to momentum spread. In addition to narrower linewidth, extensive experience at Fermilab has demonstrated that lower frequencies have the advantage that sufficient coherence (the 'quasi-Schottky' signal) often exists to permit tune measurement without exciting the beam. Beyond a tune and coherence monitor, such a pickup can function as a precise probe of resonance structure, and can be implemented with digital receiver technology. We report on the implementation and operation of a 21.4MHz resonant pickup in RHIC.

* Work performed under the auspices of the US Department of Energy.

WPPB015 RHIC Resonant Quadrupole Monitor

Peter Cameron, Michael Blaskiewicz, Roger Connolly, John Cupolo, Christopher Degen, Alexi Fedotov, Wolfram Fischer, Martin Kesselman, Nikolay Malitsky, Joseph Mead, Fulvia Pilat, Vadim Ptitsyn, Todd Satogata, Kurt Vetter (BNL)

Using transmission lines for coupling and impedance matching, stripline BPMs were previously resonated in the dipole mode for use as pickups in the RHIC low-frequency Schottky/PLL tune measurement system. Motivated by the frequent appearance of quadrupole signals in the RHIC Schottky and tune measurement systems, the same technique has been applied during RHIC 2003 to resonate a four electrode stripline pickup in the quadrupole mode. To the best of our knowledge this is the first time a resonant quadrupole pickup has been installed in an accelerator. A resonant pickup enjoys the advantages that the sensitivity is enhanced, and that the amplitude of the quadrupole mode is increased relative to difference and sum modes, reducing the dynamic range problem. The pickup is resonated above the coherent spectrum to further reduce the dynamic range problem, and open the possibility of transfer function measurements. We report here on details of the pickup and narrowband signal processing, as well as beam measurements for selected problems

* Work performed under the auspices of the US Department of Energy.

WPPB016 Beam Position Monitor for the Spallation Neutron Source

Craig Dawson, Peter Cameron, Martin Kesselman (BNL)

The SNS accumulator Ring accumulates 1060 minipulses of about 35ma peak current each. Each minipulse is comprised of RF structure at 402.5 MHz. Early turns in the Ring will contain primarily RF structure, while later turns will be primarily baseband signals since the RF structure will have diffused. The Ring BPM system must accommodate both types of signals while providing absolute position accuracy of 1% of the 10 cm beam pipe radius. The dynamic range for the baseband system is in excess of 10^6 to achieve the required resolution, while the first turn must be an RF based system to achieve the accuracy. A calibration system utilizing Beam Based Alignment will be discussed along with a proposed signal processing technique employing mean-squared processing. A BPM system incorporating both an RF and baseband capability with both system switching and gain switching to achive the required dynamic range will be described in this paper.

* Work performed under the auspices of the U.S. Department of Energy. SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge

WPPB017 Spallation Neutron Source Beam Loss Monitor System

David Gassner, Peter Cameron, Chaofeng Mi (BNL), Richard Witkover (TechSource, Inc.)

The Spallation Neutron Source facility to be built at ORNL is designed to accumulate 2x1014 protons at 1.0 GeV and deliver them to the experimental target in one bunch at 60 Hz. To achieve this goal and protect the machine from excessive radiation activation, an uncontrolled loss criteria of 1 part in 104 (1 W/m) has been specified. Measured losses will be conditioned to provide machine tuning data, a beam abort trigger, and logging of loss history. The design of the

distributed loss monitor system utilizing argon-filled glass ionization chambers and scintillator-photomultipliers will be presented, as well as data from beam commissioning in the drift tube linac.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPB018 Instrumentation for the Booster Applications Facility

David Gassner, Steve Bellavia, Kevin Brown, I Hung Chiang, Bart Frak, Larry Hoff, Robert Olsen, Phil Pile, Ralph Prigl, Steve Tepikian (BNL)

A new experimental facility now being commissioned at BNL will take advantage of heavy-ion beams from the AGS Booster for radiation effects studies of importance for the Space Program. A large dynamic range response is necessary to accommodate a wide variety of species (protons to gold) and energies (100 MeV/amu to 1.3 GeV/amu). The instrumentation proposed for extraction control and transport diagnostics will include phosphor screens with video cameras, segmented wire ionisation chambers, ion chambers, and scintillators. System design, and commissioning data from these systems will be presented.

* Work performed under auspices of the U. S. Department of Energy.

WPPB019 Design and Testing of the New Ion Chamber Loss Monitor for SNS

David Gassner (BNL)

An ion chamber beam loss monitor has been designed for the Spallation Neutron Source (SNS). The new detector overcomes concerns with the original design about slow ion collection times and low collection efficiency at high loss rates. Prototypes have been built and tested with static sources and pulsed beams. Commercially made pre-production units have been fabricated and are scheduled for testing in early 2003. Details of the design and test results will be presented.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPB020 Beam Current Monitor Calibrator for the Spallation Neutron Source

Martin Kesselman, Craig Dawson (BNL)

The Beam Current Monitor (BCM) system for the Spallation Neutron Source (SNS) to be installed at Oak Ridge National Laboratory (ORNL) requires a calibrator to assure the system is appropriately scaling current. The calibration system must be able to handle the current range expected in the MEBT, Linac, HEBT, Ring and RTBT. This covers a dynamic range of 35ma to 50 amps. A 10-turn calibration winding has been included in all current transformers. This calibrator must provide adequate flexibility to assure the current transformers are not damaged by failures in the calibrator drive amplifier, and provide better than 1% accuracy with a capability to provide calibrated currents covering the dynamic range. This paper will address the design considerations and resulting design of a suitable calibrator for this system.

* Work performed under the auspices of the U.S. Department of Energy. SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPB021 Electro-Optical Longitudinal Electron Bunch Shape Diagnostic at SDL

Henrik Loos, Adnan Doyuran, Richard Heese, Eric D. Johnson, James B. Murphy, James Rose, Timur V. Shaftan, Brian Sheehy, Yuchen Shen, John Skaritka, Xi-Jie Wang, Zilu Wu, Li-Hua Yu (BNL)

The linac at the NSLS Source Development Lab (SDL) provides a high brightness electron beam for the DUV-FEL project with subpicosecond bunch length and several hundred Amperes peak current by means of a photoinjector and a magnetic bunch compressor. Previous diagnostics of the longitudinal bunch dynamic relied on rf zero-phasing method and measurements of CTR spectra. In order to have a fast and nonintercepting longitudinal diagnostic available, the electro-optical measurement technique has been implemented with its major component, a synchronized 100 fs Ti:Sapphire laser coaligned with the electron beam, already in place as a seed for the FEL. The theoretical temporal resolution for a 100 um thick ZnTe crystal is limited to about 200 fs and the signal contrast to more than 1%. We present preliminary results of multi-shot scanning measurements and explore future upgrades to a single-shot diagnostics of the bunch shape as well as a rf-laser jitter monitor.

* DOE Contract DEAC No. DE-AC02-98CH10886. AFOSR/ONR MFEL Program No. NMIPR01520375.

WPPB022 A High Dynamic-Range Beam-Position Measurement System for ELSA-2

Pascal Balleyguier, Dominique Deslandes, Alain Godefroy, Philippe Guimbal (French Atomic Energy Commission)

New beam lines are presently under construction for ELSA, a 20 MeV electron linac located at Bruyeres-le-Chatel. These lines need a beam position measurement system filling the following requirements: small space occupancy, good sensitivity, wide dynamic range (four decade current range), high noise imunity, single-bunch/multi-bunch capability. We designed a compact 4-strip line sensor, and an electronic treatment chain based on log-amplifiers. This paper presents the design, cold and hot test results.

WPPB023 Upgrades to the Digital Receiver based Low-Intensity Beam Diagnostics for CERN AD

Maria-Elena Angoletta (CERN)

The CERN AD Low-Intensity beam Multi-Diagnostics has been upgraded as planned during 2001 and 2002 to include, among others, tune measurement capabilities based on the Beam Transfer Function (BTF) method. Longitudinal data (RF currents, Schottky signals) are acquired by a low-noise Pick-Up and yield multiple beam parameters such as intensity, mean momentum and momentum spread. The new fast BTF based upgrade adds tune measurement capabilities during ramps as well as plateaux. This is accomplished by first transversally exciting the beam, through a transverse kicker, and then by deriving the BTF and correlation function. Both the beam response from a low-noise transversal Pick-Up and the excitation digitized signals are passed to several digital receivers (DRX), which are continuously tuned to a betatron sideband. The Digital Signal Processor (DSP) on the DRX board carries out the data processing including FFTs of both signals, thus providing the BTF and correlation function. Other upgrades include a widening of the longitudinal detectable frequency range, by means of an additional Low-Frequency Pick-Up and associated electronics, as well as the deployment of noise reduction measures. The paper illustrates these upgrades and details some initial results obtained with the BTF method.

WPPB024 OTR Studies for the High Charge CTF3 Beam

Thibaut Lefevre, Enrico Bravin (CERN), Christophe Vermare (French Atomic Energy Commission)

The CTF3 (CLIC Test Facility 3) will produce 1.56μs long intense electron pulses. The unbunched 5.4A beam of the injector will have a transverse beam size around 1mm. After the buncher the current is reduced to 3.5A and the transverse size varies between a few hundred micrometers and one millimetre along the length of the linac. Calculations indicate that these beam parameters will impose an unbearable thermal load for the intercepting screens currently in use (scintillators and aluminium OTR foils). Graphite and SiC have been investigated as possible alternative materials for the OTR radiators. The possibility of replacing scintillating screens with OTR targets at the low energies of the injector has also been considered. A possible limitation in the use of such high temperature radiators has been identified. Ions released from the heated target could lead to further focusing of the beam with the risk of damaging the target itself or blowing up the beam. This would adversely affect the emittance measurement and would hinder any effort to detect head-tail phenomena. This paper gives the results of the theoretical estimations, and of the beam-based experiments.

WPPB025 Measurement of Beam Position Using Highly-Damped Accelerating Structures

Jan Prochnow, Erk Jensen, Walter Wuensch (CERN)

The active alignment of a linear collider such as CLIC, requires measurement of relative beam to accelerating structure positions in order to control short and long-range transverse wakefields. The accelerating structures of CLIC are highly damped and can themselves be used to make this beam position measurement by observing the signals produced in the damping waveguides. A demonstration of such a measurement using a 3 GHz slotted iris structure with a dipole mode Q=16 was made in CTFII (CLIC Test Facility) and results are compared to computations using the HFSS and GdfidL codes. The potential resolution of this technique is estimated.

WPPB026 Cavity Mode Related Wire Breaking of the SPS Wire Scanners and Loss Measurements of Wire Materials

Federico Roncarolo, Fritz Caspers, Bernd Dehning, Erk Jensen, Jan Koopman, Jean Francois Malo (CERN)

During 2002 SPS running with the high intensity LHC type beam the breaking of several of the carbon wires in the wire scanners has been observed. This damage occurred with the scanners in their parking position. The observation of large changes in the wire resistivity and thermionic electron emission indicated clearly a strong RF beam induced heating and its bunch length dependence. A subsequent analysis in the laboratory, simulating the beam by a RF-powered wire, showed two main problems. The housing of the wire scanner acts as a cavity with a mode spectrum starting around 350 MHz and high impedance values around 700 MHz. The carbon wire used appears to be an excellent RF absorber and thus dissipates a significant part of the beam-induced power. The classical cavity mode technique is used to determine the complex permittivity and permeability of different samples in the frequency range of 2-4 GHz. As a resonator, a rectangular TE01N type device is used. Different materials such as silicon carbide (SiC), carbon and quartz fibres as well as other samples were measured, since no data for these materials was available. In particular SiC properties are of interest, since SiC bulk material is often used as a microwave absorber. As a result, the carbon wire will be replaced by a SiC wire, which shows much less RF losses. Placing ferrite tiles on the inner wall of the wire scanner housing considerably reduces the impedance of the cavity modes. The reduction of the Q values of these modes is confirmed by laboratory measurements.

WPPB027 System Level Implementation of Beam Position Monitors with Local Data Processing Capability for the Cornell Electron Storage Ring

Mark Palmer, Benjamin Rock, Charles Strohman (Cornell University), Jeffrey Moffitt (The College of Wooster)

We describe the architecture and system-level implementation of a bunch-by-bunch beam position monitoring system for the Cornell Electron Storage Ring (CESR). With this system an individual readout module is supplied for each detector. Each readout module is equipped with its own digital signal processor (DSP) which provides automatic gain and timing control for the acquisition of signals corresponding to particular bunches in the ring. The DSPs also provide local data processing for applications such as multi-turn averaged position information, betatron phase measurements, and bunch-by-bunch tune measurements. A serial interface to each module provides basic communication with the CESR Control System. The time base for each module is provided by a 24 MHz clock from the main CESR timing system. By encoding commands, triggers, and a turns marker bitstream on the clock signal, we have the ability to carry out turn-synchronized operations with the entire system.

* Work supported by the US National Science Foundation

WPPB028 Design of OTR Beam Profile Monitors for the TESLA Test Facility, Phase 2 (TTF2)

Katja Honkavaara, Annette Brenger, Rainer Fischer, Dirk Noelle, Kay Rehlich (DESY), Luciano Cacciotti, Michele Castellano, Luciano Catani, Alessandro Cianchi, Gianpiero Di Pirro, Rossano Sorchetti (INFN)

The TESLA Test Facility is being extended to an electron beam energy of 1 GeV to drive a new Free Electron Laser facility. About 25 beam profile monitors based on optical transition radiation (OTR) will be used along the linac. Their design is a challenging task, since the system has to measure transverse electron beam sizes from millimeter scale down to 50 micrometers with a high resolution. This paper describes the design of the beam imaging system, the readout system as well as the mechanical construction.

WPPB029 Wakefield Effects in the Electro-Optic Measurement of Sub-Picosecond Electron Bunches

Holger Schlarb, Martin Dohlus (DESY), Paul Bolton, David Dowell, Paul Emma, Patrick Krejcik (SLAC), A. Murokh (University of California, Los Angeles)

A technical challenge facing the proposed LCLS and TESLA X-FEL SASE free electron lasers is the accurate measurement of the longitudinal beam profile of the sub-picosecond electron bunches. The proposed electro-optic methods rely on the assumption that the electric fields co-propagating with the electron bunch are directly related to the longitudinal charge density. In this paper the impact of wake fields generated by changes in the up-stream beam pipe geometry on the measurement at the EO crystal is discussed for different designs.

WPPB030 Using LabView VIs for Storage Ring Diagnostics

Igor Pinayev, Steve Hartman, Jingyi Li, Ying Wu (Duke University), Oleg Shevchenko (BINP)

Modern accelerator control systems should provide operator consistent, non-destructive means of characterizing the machine and user experiment. Because of the continuously changing operation environment development of such tools should be done in short time and they should be available for further modifications. At Duke FEL Laboratory acquiring and processing of the diagnostic data are done at PC with LabView Virtual Instruments. Final data are posted on the LAN as EPICS channel access variables and are accessible by any computer in the control system. Such approach allowed us easily

developed algorithms for measuring beam parameters such as betatron tunes, chromaticity, η-function.

* This work is supported by AFOSR.

WPPB031 Betatron Tune Measurement System for Duke Storage Ring

Igor Pinayev, Vladimir Litvinenko, Owen Oakely, Ping Wang, Ying Wu (Duke University)

For monitoring status of a storage ring one needs non-destructive means of measuring betatron frequencies. For this purpose we use a network analyzer, which acquires responses of the electron beam to the excitation with RF amplifier connected to the strip-line. The amplitude of the betatron oscillations is measured in two different ways: in the first synchrotron radiation from the bending magnet is focussed on the position sensitive detector, while in the second additional strip-line is used. Comparison of both methods is done.

* This work is supported by AFOSR.

WPPB032 BPM and Orbit Correction Systems at the Duke Storage Ring

Ying Wu, Jingyi Li, Vladimir Litvinenko, Ping Wang (Duke University)

The closed orbit measurement system at the Duke storage ring is comprised of 34 Bergoz beam position monitors (BPMs). To accommodate many different operation modes of the storage ring, the BPM system needs to be tailored to work with a wide range of signal levels. In the first part of the paper, we report the recent work on improving the performance of the BPM system for a variety of beam conditions. The second part of the paper focuses on the closed orbit correction and feedback systems on the Duke storage ring, including local orbit bumps for insertion devices and end-of-arc orbit compensation, a global orbit correction system, and a slow orbit feedback system. We report the measurements and performance of the orbit orrection and feedback system.

* Research Supported by the DoD MFEL Program as managed by the AFOSR, grant F49620-001-0370.

WPPB033 A Physics Based Control System for the Duke Storage Ring

Ying Wu, Steve Hartman, Stepan Mikhailov (Duke University)

At the Duke FEL Lab, we have developed and implemented a new storage ring control system based upon physical quantities. Most other operational accelerator control systems are base on direct controls of various hardware systems, e.g. setting a power supply current to control a magnet. Such systems present a raw interface to a very complex accelerator and need to be supplemented by a high level physics control to perform sophisticated operations. The new control system at Duke uses an integrated approach to optimize the overall system performance, moving many critical high level functions to the low level realtime system. This system is designed around physical quantities experienced by the beam, e.g. magnetic multipole strengths such as the bending angle, normalized focusing strength (K1), and sextupole strength (K2), all based upon measured magnetic field data. With this system, energy ramping and transition between different operation modes becomes a trivial task. It also allows us to focus on developing high level controls regardless of the beam energy. Furthermore, with better understanding of the storage ring, we can fine tune our control in the low level to present an invariant virtual machine to the operator, independent of the beam energy.

* Research Supported by the DoD MFEL Program as managed by the AFOSR, grant F49620-001-0370.

WPPB034 The SNS Linac Wire Scanner System

Michael Plum (Marconi Applied Technologies), Wynn Christensen, Ross Meyer Sr., Chris Rose (LANL)

The linac wire scanner system for the Spallation Neutron Source (SNS) at Oak Ridge, TN, calls for 5 units in the medium energy beam transport (MEBT), 5 in the drift tube linac (DTL), 10 in the coupled cavity linac (CCL), and 13 in the high energy beam transport (HEBT). The actuators are a custom design fabricated by Huntington Mechanical Laboratories. Four different strokes are required to cover the above areas. The electronics was designed and fabricated by Los Alamos National Laboratory (LANL). In this paper we will discuss the design of the actuators and the electronics, positioning accuracy tests of the actuators, and also show results from beam measurements taken during the MEBT commissioning at Oak Ridge National Laboratory.

* Work supported by the Office of Science of the US Department of Energy.

WPPB035 Ionisation Beam Profile Monitor at the Cooler Synchrotron COSY-Juelich

Juergen Dietrich, Vsevolod Kamerdzhiev (Forschungszentrum Juelich)

For beam profile measurements, a residual-gas ionisation beam profile monitor using a position sensitive micro channel plate (MCP) detector was developed and installed at the cooler synchrotron and storage ring COSY in the Forschungszentrum Juelich. A parallel ion drift field is maintained in the gap between two electrodes. Residual gas ions are drifted onto an MCP assembly that provides a charge gain of about 10^7. The secondary charge produced from each ion is collected by a wedge and strip anode, and after signal processing, digitized and red out by means of a PC running a user friendly program under Windows OS. Since COSY operates with beam intensities up to 10^{11} protons or deuterons and a vacuum up to 10^{-9} mbar, there is a high risk of detector damage. Lifetime of channel plates and the event rate are crucial issues for profile measurements of intense proton beams. The aging of channel plates (i.e. inhomogeneous decrease of the gain) are investigated by scanning electron microscope and energy dispersive x-ray microanalysis. For online calibration the detector can be illuminated with an alpha-source. Different measures for detector protection are described. Experience of routine operation of the monitor is discussed. Measurements with electron cooled proton beams are reported.

WPPB036 Performance of a Beam Monitor in the Fermilab Tevatron Using Synchrotron Light

Harry Cheung, Alan Hahn, Aimin Xiao (FNAL)

The performance of a profile monitor using synchrotron light installed between two superconducting dipoles in the Fermilab Tevatron will be presented. Synchrotron light produced at the upstream edge of one magnet is sufficiently separated from the particle beam at the downstream end to be picked off by a mirror and diverted to a detector. Using two separate imaging detectors the monitor is used to measure the 2-dimensional beam profiles of both the circulating proton and anti-proton beams. Results on the performance of this beam monitoring system will be discussed.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

WPPB037 Fermilab Recycler Ring BPM System

Brajesh Choudhary, J. L. Crisp, G.W. Foster, C. Gattuso, M. Hu, D.E. Johnson, J.P. Marriner, C.S. Mishra, P. S. Prieto, M.J. Yang (FNAL)

The Fermilab Recycler is an 8 Gev storage ring constructed using permanent magnets. It is expected to increase the Tevatron luminosity

by maintaining high pbar production rate in the Accumulator by periodically sending the pbar stack to the Recycler, and by recycling the left over pbars from the Tevatron to the Recycler and further cooling it, before injecting to the Tevatron. The BPM system is very critical for understanding the behavior of the beam in the machine and hence its life time. At the Fermilab Recycler Ring the BPM system is used both for orbit measurement as well as ion clearing purpose. In this talk, I will present the status, operational modes, system performance, and physics measurements made with the Fermilab Recycler BPM system.

WPPB038 Measurement of Proton and Antiproton Beam Intensities in the Tevatron

Stephen Pordes, James Crisp, Brian Fellenz, Robert Flora, Alan Hahn, Thomas Meyer, Alvin Tollestrup (FNAL), Willem Blokland (ORNL)

Two techniques for determining the proton and antiproton beam intensities simultaneously in the Tevatron are described. Both techniques take their input from a resistive wall current monitor; one measurement uses a fast integrator gated around the individual proton and antiproton bunches; the other uses a 2 GHz sampling oscilloscope to reconstruct both the bunch intensities and the longitudinal distribution of charge within the individual bunches. The calibration of the system and some operational issues are discussed.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

WPPB039 Digital Down Conversion Technology for Tevatron Beam Line Tuner at FNAL

Warren Schappert, Eugene Lorman, Victor E. Scarpine (FNAL), Marc Ross, Jim Sebak, Till Straumann (SLAC)

Fermilab is presently in Run II collider operations and is developing instrumentation to improve luminosity. Improving the orbit matching between accelerator components using a Beam Line Tuner (BLT) can improve the luminosity. Digital Down Conversion (DDC) has been proposed as a method for making more accurate beam position measurements. Fermilab has implemented a BLT system using a DDC technique to measure orbit oscillations during injections from the Main Injector to the Tevatron. The output of a fast ADC is down-converted and filtered in software. The system measures the x and y positions, the intensity, and the time of arrival for each proton or antiproton bunch, on a turn-by-turn basis, during the first 1024 turns immediately following injection. We present results showing position, intensity, and time of arrival for both injected and coasting beam. Initial results indicate a position resolution of ~17 microns and a time resolution of ~20 psec.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

WPPB040 Measurements of the Longitudinal and Transverse Beam Loss at the Tevatron

Alvin Tollestrup, Morris Binkley, Bruce Hanna, Valeri Lebedev, Ron Moore, Vladimir Shiltsev, R. Tesarek, R. Vidal (FNAL)

Measurements of the transverse and longitudinal beam losses during the Tevatron store will be presented. The measurements utilize scintillation counters to monitor the nuclear interactions of the 1 TeV halo particles with a scraper that is located near the beam. If the particles are in time with the primary bunches, they are assumed to come from transverse perturbations inducing large betatron oscillations. Particles lost longitudinally drift around the ring due to synchrotron radiation and become asynchronous with the bunches. A pulsed electron lens is then used to induce large betatron oscillations that extract these particles onto the scraper. The resulting nuclear interactions in the scraper are recorded by a gated scintillating counter system. The counting rates from the two channels provide an online measurement of the two types of beam loss. Known beam loss due to interactions at the IP and to nuclear collisions in the residual gas can be subtracted which then exposes the underlying losses from longitudinal and transverse instabilities.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

WPPB041 Study of a Low Impedance Beam Position Monitor for Short Bunches

David Alesini, Bruno Spataro (INFN), Cristian D'Alessio, Mauro Migliorati, Andrea Mostacci, Luigi Palumbo (University of Rome)

A low coupling impedance beam position monitor based on microwave spectroscopy is proposed for mm-range bunches. A coaxial cavity is coupled to a circular beam pipe through four small longitudinal slots. Displaced beams excite TE cavity modes which can be detected by four antennas. Applying modified Bethe theory, the TE111 mode power has been derived as a function of the beam displacement. An aluminum prototype was constructed with the support of numerical (HFSS) simulations. Bench measurements using a coaxial wire excitation show good agreement with both theoretical and numerical expectations.

WPPB042 Improved SR Extraction Chamber for KEKB LER SR Monitor

John Flanagan, Shigenori Hiramatsu, Hitomi Ikeda, Ken-ichi Kanazawa, Toshiyuki Mitsuhashi (KEK)

We have recently replaced the synchrotron light extraction chamber for the KEKB Low Energy Ring (LER) SR monitor. The beam pipe was changed to copper to minimize resistive-wall heating, and the optical apertures were made as small as permitted by light extraction requirements in order to reduce HOM power leakage. The new chamber shows almost none of the heating problems of the old chamber, and previous problems with the orientation of the extraction mirror changing due to heat expansion of the beam pipe have been essentially eliminated. The design and performance of the new chamber are presented.

WPPB043 Construction of SR Monitor for Photon Factory Advanced Ring

Toshiyuki Mitsuhashi, Mikio Tadano (KEK)

An optical diagnostics systems utilizing visible synchrotron radiation has been installed for Photon Factory Advanced Ring (PF-AR). A water-cooled beryllium mirror is applied to extract a visible SR beam from the ring. The SR beam is relayed to hut (dark room) by an optical path having eight flat-mirrors. The diagnostics systems are located at the end of optical path. These systems are capable of both imaging measurements and SR interferometry measurements. A calibration system for the SR interferometer based on a Hartmann screen is installed in the next of Be-mirror. The focused images and interferograms are processed automatically, and the results are relayed back to the control room for continuous real-time measurements of beam size. A branch beamlines for streak camera, high speed gated camera and intensity interferometry are also constructed.

WPPB044 Beam Position Measurement Using Linac Microstructure at the KEK Booster Synchrotron

Takako Miura, Yoshiro Irie, Yoshihiro Sato, Hirohiko Someya (KEK)

In the KEK 500 MeV booster, 40 MeV H^- bunches from 201 MHz RF linac are injected by multiturn process during 40 μs or less. Conventional pickup signals give the coordinates of the closed orbit, however, do not give the coordinates of injected beam. Assuming the

bunch structure of the injected beam will vanish for one revolution of the ring due to debunching, the position information in right after injection is obtained by picking-up the signal of 201 MHz component of beam. The experiment for 201 MHz pickup was performed and compared with the simulation. The possibility is also explored for observing a painting position in the rapid cycle synchrotron in the Japan Proton Accelerator Research Complex.

WPPB045 Monitoring of Electrons Beam Parameters in Industrial Linacs

Viktor Boriskin, V.A. Popenko, A.N. Savchenko, V.A. Shendrik, V.I. Tatanov, V.L. Uvarov (Kharkov Institute of Physics and Technology)

In this paper the questions of monitoring of technological pulse linacs beam parameters in the atmosphere are discussed. The beams under study have energy up to 25 MeV and pulse currents up to 1A [A.N.Dovbnya et al. Electron Linacs Based Radiation Facilities of Ukrainian National Science Center KIPT / Bulletin of the American Physical Society, May 1997, v.42, No.3, p.1391]. The technological object zone irradiated by accelerated electrons is created with the magnet scanning system. Monitoring of beam energy, position and dimensions is done by wide-aperture magneto-induction position monitor and secondary emission beam profile monitor.

WPPB046 Position Measurements for the Isotope Production Facility and the Switchyard Kicker Upgrade Projects

J. Douglas Gilpatrick, D. Barr, D. Martinez, J. O'Hara, R. B. Shurter, M. Stettler (LANL)

The Los Alamos Neutron Science Center (LANSCE) is installing two beam lines to both improve operational tuning and to provide new capabilities within the facility. The Isotope Production Facility (IPF) will provide isotopes for medical purposes by using the H^+ beam spur at 100 MeV and the Switchyard Kicker Upgrade (SYK) will allow the LANSCE 800-MeV H- beam to be rapidly switched between various beam lines within the facility. The beam position measurements for both of these beam lines uses a standard micro-stripline beam position monitor (BPM) with both a 50-mm and 75-mm radius. The cable plant is unique in that it unambiguously provides a method of verifying the operation of the complete position measurement. The processing electronics module uses a log ratio technique with error corrections such that it has a dynamic range of > 86 dB with errors less than 0.1 dB within this range. This paper will describe these measurement systems and provide initial data of their operation.

* Work supported by the US DOE, Defense Programs and by the US DOE, Nuclear Energy.

WPPB047 A Multiwire Proportional Chamber System for Monitoring Low Momentum Beam in Accelerators

Robert Merl, Charles Burns, Floyd Gallegos, Chandra Pillai, Fred Shelley, Andy Steck (LANL)

A diagnostic is in the process of being developed at the Los Alamos Neutron Science Center (LANSCE) for the purpose of identifying low momentum beam tails in the linear accelerator. These tails must be eliminated in order to maintain the transverse and longitudinal beam size. Instead of a phosphor camera system, this instrument consists of a Multi Wire Proportional Chamber (MWPC) front end coupled to an EPICS compliant VME based electronics package. Low momentum tails are detected with a resolution of about 2 mm in the MWPC at a high dispersion point near a bending magnet. While phosphor is typically not sensitive in the nano amp range, the MWPC is sensitive down to a few femto amps. The electronics package will process the signals from each of the MWPC wires to generate an array of beam currents at each of the lower energies. The electronics will have a wideband analog front end, active anti alias filter, and high-speed analog to digital converter for each wire. Data from multiple wires will be processed with an embedded digital signal processor and results placed in a set of VME registers. An EPICS application will assemble the data from these VME registers into a display of beam current vs. beam energy (momentum) in the LANSCE control room. This display will update at least once per second, but will be a representation of the real time signal processing results from the electronics package.

* Work supported by the U.S. Department of Energy.

WPPB048 High Speed Epics Data Acquisition and Processing on One VME Board

Robert Merl, Floyd Gallegos, Chandra Pillai, Fred Shelley (LANL)

A custom VME board is being designed at the Los Alamos Neutron Science Center (LANSCE) for high speed signal acquisition and processing. While it is desirable to design around the EPICS / VME platform, it can be difficult to process high speed signals with long record lengths. The relatively slow data path between the IOC and the general-purpose computer makes real time computations impossible. Commercial VME processor boards can be used, but the data must still flow over the VME backplane in lieu of other traffic. This custom board is designed to overcome this problem by acquiring and processing the signal in one place, with the processed result presented at the VME interface instead of the raw data. The board consists of multiple front-end signal conditioner / digitizer cards plugged into the foundation 6U VME board with an embedded digital signal processor (DSP). The DSP is programmed in C to process the raw signal any way the user wants before writing results into a VME register map. The present front-end conditioner / ADC cards are being designed with the LANSCE low momentum detector in mind, but other variations on this card could be developed. The architecture is flexible enough to deploy in many accelerator applications.

* Work supported by the U.S. Department of Energy.

WPPB049 Halo Measurements of the Extracted Beam at the Los Alamos Proton Storage Ring

Thomas Zaugg, Michael Borden, Andrew Browman, Daniel Fitzgerald, Robert Macek, Rodney McCrady, Thomas Spickermann (LANL)

The spatial beam density distribution beyond 2.5-3 standard deviations of the beam center is an important property for undertanding the relatively small fractional losses of high intensity beams at the Los Alamos Proton Storage Ring (PSR) and transport lines to the neutron production target. This part of the distribution (sometimes referred to as beam halo) is not well determined by the LANL-standard wire scanner system nor is it yet reliably predicted by the simulation codes. To significantly improve the experimental determination of the beam halo, an improved wire scanner has been developed, tested and installed in multiple locations on the extraction line. To enhance the signal-to-noise ratio, an amplifier consisting of a wide dynamic-range, integrating amplifier, sample-and-hold circuit, log amplifier and line driver is located near the beam line. Offset errors at the input of the amplifiers are actively cancelled and timing gates and gain selection signals are derived from a single input pulse. We will describe the prototype instrument, discuss our encouraging test results and report our experience with the instrument in the PSR extraction line. We will also present beam halo data for various beam intensities and discuss candidate mechanisms for generating the halo.

* Work conducted at the Los Alamos National Laboratory, which is operated by the University of California for the United Stated Department of Energy under contract W-7405-ENG-36.

WPPB050 Beam Imaging Diagnostics for Heavy-Ion Fusion Beam Experiments

Frank Bieniosek, W. B. Ghiorso, L. Prost (LBNL)

We are developing techniques for imaging beams in heavy-ion beam fusion experiments in 2 to 4 transverse dimensions. The beams in current experiments range in energy from 50 keV to 2 MeV, with beam current densities from 10 to 200 mA/cm^2, and pulse lengths of 4 to 20 microseconds. The imaging techniques are based on kapton films and optical scintillators. The imaging techniques provide detailed information on the transverse beam distribution. They complement and, in some cases, may replace traditional techniques based on slit scans. Kapton film exposed to the beam provides a time-integrated image of the beam intensity profile. The optical scintillator utilizes glass and ceramic scintillator material imaged by a fast, image-intensified CCD-based camera. We will describe the techniques, results, and plans for implementation of the diagnostics on the beam experiments.

* Work performed under the auspices of the U.S. Department of Energy by the university of California, Lawrence Berkeley National Laboratory under Contract No. DE-AC03-76F00098.

WPPB051 A Second Beam Diagnostics Beam-Line for the ALS

Fernando Sannibale, Dennis Baum, Nicholas Kelez (LBNL), Karsten Holldack (BESSY)

A second beam-line, BL 7.2, completely dedicated to beam diagnostics is being installed at the ALS. The design has been optimized for the measurement of the energy spread and emittance of the stored beam in combination with the existing diagnostics beam line, BL 3.1. A detailed analysis of the experimental error has allowed the definition of the system parameters. The obtained requirements found a good matching with a simple and reliable system based on the detection of X-ray synchrotron radiation (SR) through a pin-hole system. The actual beam-line, which also includes a port for visible and Far-IR SR as well as a X-ray BPM system is mainly based on the design of two similar diagnostic beam-lines at BESSY II. This approach allowed a significant saving in time, cost and engineering effort. The design criteria, including a summary of the experimental error analysis, as well as a brief description of the beam-line are presented.

* Work supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

WPPB052 Measurement of Longitudinal Beam Density via the Non-Linear Mixing of Synchrotron Radiation with a Mode Locked Laser Oscillator

William Turner, Jean-Francois Beche, Stefano De Santis, Peter Denes, Alessandro Ratti, Vincent Riot, Robert Schoenlein, William Turner, Max Zolotorev (LBNL), Massimo Placidi (CERN), Philip Datte (LLNL)

We report development of a new storage ring operations tool for measurement of longitudinal beam density. Synchrotron light is mixed with a mode locked solid-state laser oscillator in a non-linear crystal and the up-converted radiation detected with a photo-multiplier. The laser is phase locked to the storage ring RF system. The laser choices available for repetition frequency, pulse width and phase modulation give a very wide range of options for matching the bunch configuration of particular storage rings. Progress in the technology of solid-state lasers ensures this system can be made robust for routine use in storage ring operations. A very large number of important applications are possible including measurement of the fraction of un-trapped particles, the population of particles in the nominally unfilled RF buckets, longitudinal tails, the diffusion of particles into the beam abort gap and the normal bunch parameters of longitudinal shape and intensity. We are currently investigating application to two devices: (1) the 1.9GeV ALS electron storage ring at LBNL with 328 RF buckets, 2ns bucket spacing, 276 nominally filled bunches, 15-30ps rms bunch length and (2) the 7TeV LHC proton collider under construction at CERN with 35,640 RF buckets, 2.5ns bucket spacing, 2808 nominally filled bunches, 250-450ps rms bunch length. A proof of principle experiment is being conducted on ALS. The results of the ALS experiment and detailed analysis of the application to LHC and its requirements will be described.

* This work was supported by the U.S. Dept. of Energy under Contract No. DE-AC03-76SF000098.

WPPB053 Coherent Radiation in the Far-IR and mm-Wave Regime from Laser Wakefield Accelerated Ultrashort Electron Bunches

Jeroen Van Tilborg, D. Auerbach, J.M. Byrd, J.N. Corlett, E.H. Esarey, J. Faure, C.G.R. Geddes, W.P. Leemans, M.C. Martin, C.B. Schroeder, C. Toth (LBNL)

We report on the observation of coherent radiation in the Far-IR and mm-wave regime from laser accelerated electron bunches. Ultrashort (femtosecond) electron bunches were produced in a self-modulated laser wakefield accelerator generating transition radiation. Several diagnostics are implemented to map out the temporal and spectral characteristics of the radiation. Analysis of these characterictics can reveal information about bunch length, temporal beam structure and beam divergence. Experiments indicate that the radiated power scales quadratically with the bunch charge, consistent with longitudinal and tranverse coherence. Using multi-nanoCoulomb bunches, the intensity of coherent radiation can be many orders of magnitude stronger than incoherent radiation. Recent results will be discussed.

* This work is supported by DOE High Energy Physics under contract DE-AC-03-76SF0098.

WPPB054 Experiments on the Electromagnetic Verification of the DARHT-II Electron Beam Kicker

Scott Nelson, Brian Poole (LLNL)

This paper covers the series of electromagnetic verification experiments that were performed on the electron beam kicker for the Dual Axis Radiographic Hydrodynamic Test complex (DARHT-II). The electron beam kicker allows for pulsed deflection of a high current electron beam (2kA) using high voltage excitations (20kV) over short time periods (20ns). The kicker itself is electrically considered an eight port network with feed ports to drive the deflection plates using TEM waves. It has been observed that frequency-domain measurements made on the kicker structure map to time-domain effects observed in the performance of the kicker and their impact on the requirements of the high voltage input connectors on the structure. Port effects have a periodicity of 2*L/c (L=physical length, c=speed of light) and are manifested by high Q resonances. Minimizing the impedance mismatch between the high voltage drive cables, the high voltage vacuum interface connectors, and the deflection plate structures, with Smm < 0.10 (m=1,3,5,7, S=scattering matrix elements) while maximizing the forward transmission coefficients, with Snm > 0.995 (n=m+1). Additionally, electromagnetic cross coupling between cross-structural elements and adjacent-structural elements reduces the inductance between the structures (i.e. Spm, p=5,7, and Sqm, q=3) where Spm is 20% and Sqm is 8% and is caused by temporally coherent plate-to-plate inductances.

* This work was performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

WPPB055 DARHT-II Energy Analyzer

Arthur Paul, Steven Hawkins, James McCarrick, James Sullivan, James Watson, Glen Westenskow (LLNL), William Nexson (Johnson Controls), Shmuel Eyon (LBNL), Thomas Fessenden (consultant)

An energy analyzer is being built to determine the final energy of the 2 usec, 2 kA, 18.4 MeV DARHT-II beam with an absolute accuracy of +-2.5%. The instrument should be able to resolve energy variations as small as 0.1% with a temporal resolution of 10 nsec. A fine carbon or titanium wire is used to scatter a small fraction of the electron beam into a magnetic spectrometer at an angle of 11 degrees. The spectrometer contains a 60 degree normal entrance/exit bending magnet one meter from the scattering wire that focuses the scattered beam to a line focus on a PIN detector array located 30 cm away. The detector amplifies the signal by more than 10000 and has an energy acceptance of 10%. The array contains forty 2.5x0.25x0.1 mm segments that are used to determine the position that the secondary beam strikes the detector. A Monte Carlo simulation code (MCNP) was used to predict the properties of the scattered beam. A similar instrument was used successfully with the Astron accelerator some 30 years ago, RSI, 43, 1090 (1972).

* This work was performed under the auspices of the U.S.Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.

WPPB056 Methods for Electron Bunch Measurement with Resolution of the Order of 1 fs and 1 nm

Alexander Tron, Igor Merinov (MEPhI)

Method for bunch length and shape monitoring with femtosecond resolution by means of time converting photochronography of the bunch radiation in the range of visible light, using photoelectron camera of new principle of its operation, and method for monitoring the transverse size of bunch , based on new beam cross section wire scanner technique where the depth of electron escapement being not more than 1 nm is used, are described. Main limitation for these methods, caused by space charge effect, will be considered.

WPPB057 Progress on a Smith-Purcell Radiation Bunch Length Diagnostic

Stephen Korbly, Michael Shapiro, Richard Temkin (MIT Plasma Science and Fusion Center)

A Smith-Purcell radiation diagnostic to measure the micro bunch length of a 20MeV, 17 GHz electron bunch train is being implemented at MIT. The bunch length can be determined by measuring the frequency and angular distribution of the emitted radiation as proposed by Nguyen [D.C. Nguyen, PAC Proceedings, Cat. No. 97CH36167, (1997)] and demonstrated by Doucas et. al. [G. Doucas, et.al., Phys. Rev. ST-AB, Vol. 5, Cat. No. 072802 (2002)]. The beam is produced by a 17 GHz, 50 MeV/m traveling wave (TW) accelerator built by Haimson Research Corporation (HRC). The high operating frequency of this accelerator allows for the production of ultra-short bunches of about 180 femtoseconds. At this time we are assembling the experiment and we will present an update on the progress and initial results.

WPPB058 Measurement of Beam Based Alignment for HLS

Sun Baogen (National Synchrotron Radiation Lab)

In order to improve the stability of the close orbit, we have measured the beam based alignment of BPM. The measured results are given. We find the golden orbit, and the beam orbit is maitained at the reference orbit by an orbit correction system.

WPPB059 Beam Diagnostic System for High Intensity Proton Linac at KAERI

Sungju Park (Princeton University), Yongsub Cho, Byungho Choi, Jangmin Han (Korea Atomic Energy Research Institute), Youngsoon Bae, Jungyun Huang, Woonha Hwang, Eunsan Kim, Sang-Hoon Nam, Jangho Park, Inha Yu (Pohang Accelerator Laboratory)

A 100-MeV high-intensity (20 mA CW) proton linac is being built in the KAERI(Korea Atomic Energy Reserach Institute), Korea. Beam diagnostic system for the machine require to include BCMs (Beam Current Monitors), BPPMs (Beam Position and Phase Monitors), and other devices. BCMs are of special importance for high-intensity proton linacs, since the control of beam loss is critical. They should have high stability and resolution better than 5E-4. BPPMs are for measuring beam position and phase (w.r.t rf) simultaneously, that are crucial for the successful commissioning and operation of the accelerator. All diagnostic devices are required to operated both in CW and pulsed (several ms) modes. Pulsed mode operation is useful when machine tuning and commissioning.

* Work supported by the Ministry of Science and Technology (MOST), Korea.

WPPB060 Improved Results from the Gas Scattering Energy Spectrometer on the ISIS RFQ Test Stand

Jonathan Duke, David Findlay, Alan Letchford, John Thomason (Rutherford Appleton Laboratory)

The novel Gas Scattering Energy Spectrometer on the ISIS RFQ Test Stand at the Rutherford Appleton Laboratory (Oxfordshire, UK) has been used to measure the energy spectrum of the ~665 keV H- beam from the RFQ as a function of RF drive power. Since EPAC'02 a change has been made to the experimental arrangement which markedly improves the quality of the results which can be obtained. These new results are reported.

WPPB061 Very High Resolution RF Cavity BPM's

Marc Ross, Joe Frisch, Douglas McCormick (SLAC), Vladimir Vogel (BINP), Hitoshi Hayano, Junji Urakawa (KEK)

Linear collider (LC) interaction region beam sizes and component position stability requirements are expected to be a few nanometers (NLC ZDR, SLAC-474, and updates, and J. Frisch et.al., PAC2003). It is important to show that the related tolerances can be achieved, using a precision electron beam if possible. Using recently developed component stabilization technology, very high-resolution beam position monitors (BPM's), and the ultra-low emittance beam at the ATF, we plan to demonstrate the required stabilization. Our first step is to develop high-resolution RF cavity beam position monitors, using either C or X band frequencies. A C-band cavity BPM with a resolution of 25 nm has been reported, (T. Slaton et.al., XIX Linac Conference), in tests at FFTB. By correcting for the effects of non-axial trajectories and using both position and angle BPM movers, we estimate a resolution of 2 to 3 nm over a dynamic range of +/- 20 um. We report on the progress of the tests here.

* Supported by US DoE contract DE-AC03-SF00515.

WPPB062 RF Cavity BPM's as Beam Angle and Beam Correlation Monitors

Marc Ross, Josef Frisch, Douglas McCormick (SLAC), Hitoshi Hayano (KEK)

It has been shown that high performance cavity BPM's are capable of accurate beam angle and beam 'tilt',(x-z or y-z correlation) measurements (W. Wuensch, CLIC-244, 1994 and P. Tenenbaum et.al., EPAC 2002). Such a device will be very useful for the optimization of a variety of beamlines, such as high current linacs, bunch rotators and storage rings. The signal from a non-axial trajectory or a tilted beam is in quadrature to that observed from a simple displacement of

a very short bunch. Using I/Q demodulation of the cavity BPM signal, it is possible to separate position and angle/tilt. In this paper, we present results of beam angle and tilt monitor tests carried out in the ATF extraction line.

* Supported by US DoE contract DE-AC03-SF00515.

WPPB063 Beam Motion Aliasing Errors of Multiplexing Beam Position Monitors

Till Straumann (SLAC)

Multiplexing Beam Position Monitors (BPM) are widely used for their simplicity and inherent drift cancellation property. These systems successively feed the signals of (typically four RF) pickups through one single detector channel. The beam position is calculated from the demultiplexed (base band) signal. However, as shown by this contribution, transverse beam motion results in positional aliasing errors due to the finite multiplexing frequency. Fast horizontal motion, for example, can alias into an apparent, slow vertical position change. A thorough analysis is presented and the impact of essential parameters such as the multiplexing rate and the scanning pattern/sequence of classical 4-button pickups is discussed.

WPPB064 Bunched Beam Cleaning System of SPring-8 Booster Synchrotron

Tsuyoshi Aoki, Kenji Fukami, Naoyasu Hosoda, Takashi Ohshima, Masazumi Shoji, Kazuhiro Tamura, Hiroto Yonehara (SPring-8), Hiromitsu Suzuki (Japan Atomic Energy Research Institute)

In order to fill an aimed radio frequency (rf) bucket with an electron beam in the storage ring at SPring-8, the bunched beam cleaning system which we named RF knockout (RF-KO) system is installed in the booster synchrotron. The time width of single-bunch beam from the linac operated 2856MHz rf is 1 nsec. The beam is distributed in a single rf bucket of the booster synchrotron operated at 508.58 MHz rf. The energy of injected beam is increased from 1 GeV to 8 GeV. The RF-KO system is operated at minimum beam energy of 1 GeV because the required knockout power is reduced. The beam in the satellite rf buckets are coherently shaken by the electromagnetic field produced by four RF-KO electrodes in the vacuum chamber. As the amplitude of betatron oscillation increase, the beam soon begins to collide with a beam duct and is lost. The single-bunch beam injected into the targeted rf bucket is effectively kept alive on the zero-crossing point of RF-KO waveform with a precise timing system. The beam intensity of satellite rf buckets in the storage ring was measured with a photon counting method and determined to be 1e-9 less than that of the main rf bucket.

WPPB065 Beam Position Monitoring System for the 1.5 GeV Transport Line of SRRC

Kuo-hwa Hu, Jenny Chen, Kuo-tung Hsu, C.H. Kuo (Synchrotron Radiation Research Center)

The extracted 1.5 GeV electron beam from the booster synchrotron are transported via transport line and injected to the storage ring. This booster-to-storage ring transport line (BTS) equip with 7 stripline beam position monitors. Commercial log-ratio BPM (LR-BPM) electronic was adopted to process the 500MHz bunch signal directly. The position of the passing beam is digitizing by VME analog interface. System architecture, software tools, and performance of the BTS trajectory measurement system will be address in this report. This system will provide an elegant tool to optimize the performance of the transport line. Preliminary results and possible applications are included.

WPPB066 The Photon Stability Measured by a Precision Io Monitor System in the TLS

Chien-Kuang Kuan, Jui-Chi Chang, June-Rong Chen, Chia-Jui Lin, Ching-Yuarn Liu, Shen-Yaw Perng, Duan-Jen Wang (Synchrotron Radiation Research Center)

A fast and accurate photon beam monitor is needed to index the photon stability for the beam line in the Taiwan Light Source (TLS). A photon beam intensity monitor (Io monitor) system consists of a mirror, a pinhole, a photodiode, and a scanning mechanism is used to detect the photon beam fluctuations and to be an index of the photon stability below 1Hz. Although the design of this Io monitor is stable, the air temperature fluctuations of < +-0.1 degree and the cooling water system with temperature fluctuations of < +-0.01 degree, the decay of the beam current and the vibration of the mirror affect the accuracy of the index. The decay effect to the index is to be eliminated from another beam current monitor. The vibration effect to the index is to be damped with a damping device. To obtain more information in the higher frequency of the photon stability, the Io monitor system is to be upgraded up to 10Hz. A Photon Beam Position Monitor (PBPM) installed before the Io monitor is used as an auxiliary index of the photon stability. This 10Hz Io monitor system provides more and accurate information of the photon stability to the users, the beam line managers and the people of the accelerator.

WPPB067 Functionality of the Digital Beam Position Monitor Test-Bed in SRRC

Changhor Kuo, Kuotung Hsu, Kuohwa Hu (Synchrotron Radiation Research Center)

A digital beam position monitor (DBPM) test-bed was implemented recently in SRRC to perform functionality and performance evaluation. The programmable nature of DBPM system is essential for multi-mode high precision beam position measurement. The system will support high performance beam position, turn-by-turn beam position, tune and other diagnostic measurements. Control system interface was implemented to support the operation of DBPM system. Preliminary test results includes various aspects will be discussed and presented in this report.

WPPB068 Synchrotron Light Interferometer at Jefferson Lab

Pavel Chevtsov, Robby Hicks (Thomas Jefferson National Accelerator Facility), Jean-Claude Denard (Synchrotron SOLEIL)

A synchrotron light interferometer has been built at Jefferson Lab in order to measure small beam sizes below the diffraction limit. The device is non-invasive and can monitor the profile of a few microampere electron beam. It follows the design pioneered by T. Mitsuhashi and is a valuable instrument for the CEBAF accelerator. The structure of the interferometer, the experience gained during its installation, and first beam measurement results are presented. Future applications of this device include precise energy spread monitoring ($\sim 10^{-5}$) which is required by some Hall A nuclear physics experiments.

* Supported by DOE Contract #DE-AC05-84ER40150.

WPPB069 Development of a BPM Lock-in Diagnostic System

Richard Dickson (Thomas Jefferson National Accelerator Facility)

A system has been developed for the acquisition and analysis of high rate, time coherent BPM data across the Jefferson Lab's Continuous Electron Beam Accelerator Facility (CEBAF). This system will allow the acquisition of Beam Position Monitor (BPM) intensity and position information at a rate in excess 7 KHz for approximately 200 BPMs in a time synchronous manner. By inducing minute sinusoidal transverse beam motion in the CEBAF injector, with known phase relative to the synchronized BPM acquisition, it is possible to derive several types of useful information. Analyzing the BPM intensity data, which is proportional to beam current, by beating the signal with an in-phase

sinusoidal representation of the transverse kick, beam scraping may be localized to a particular BPM. Similarly, real-time optics information may be deduced with an analogous analysis of BPM position data. This paper will detail the frequency lock-in technique applied and present results from operational use.

∗ This work was supported by the U.S. DOE contract No. DE-AC05-84-ER40150.

WPPB070 Large Dynamic Range Beam Profile Measurements with Low Current Electron Beams

Arne Freyberger (Thomas Jefferson National Accelerator Facility)

Large dynamic range [> 10^5S/N] beam profile measurements are routinely performed in the Hall "B" beamline at Jefferson Lab. These measurements are made with 1 to 10nA of electron beam current. The electron beam scatters off of a thin [20μm] W wire and the scattered particle/shower is detected via scintillation or Cerenkov light several meters downstream of the wire. This light is converted to an electrical pulse via photomultiplier tubes [PMT]. The PMT readout and wire motion is controlled and synchronized by VME electronics. This report describes results on increasing the dynamic range an order of magnitude by using multiple wires of varying diameters and by requiring the detection of a coincidence in two detectors. This coincidence detection eliminates the "singles" background of the PMT detectors. The coincidence rate is due to Moeller scattering of the beam and wire electrons. Profile measurements with this large dynamic range can be of use for machines with very large beam currents (ERL) where any fractional beam loss represents a significant amount of beam power.

∗ *This work was supported by the U.S. Department of Energy under Contract No DE-AC05-84ER40150.

WPPB071 Tunneling Ionization Studies with the Bulk Field of the High Current Electron Beam

Murokh Alex, Claudio Pellegrini, James Rosenzweig (University of California, Los Angeles), Patrick Krejcik (SLAC)

The space charge field intensity the compressed ultra-relativistic electron beams may reaching GV/m levels, which is sufficient to cause tunneling ionization in the dielectric materials. One way to observe this effect is to use scintillating materials in the vicinity of the electron beam path. The ionization rate is estimated for experimentally available beam parameters at the SLAC SPPS facility, and an experimental set up is outlined. The proposed studies will complement similar experiments performed with the high intensity laser beams. Also, the possibility of using tunneling effects as a single shot electron beam peak current diagnostic is discussed.

∗ The work is funded by the DOE contract No DE-FG03-92ER40693.

WPPB072 Phase Space Tomography in Polar Coordinate System and Its Potential Applications

Feng Zhou, David Cline (University of California, Los Angeles), Ilan Ben-Zvi, Vitaly Yakimenko (BNL)

The tomography technique for the transverse phase space in Cartesian System was developed at Brookhaven Accelerator Test Facility (ATF) [V.Yakimenko, et al., PAC99, New York, 1999 (IEEE, Piscataway, 1999)]. With the development of electron cooling for Hadrons [A.Burov, S.Nagaitsev and A.Shemyakin, Phys. Rev. Special Topics-AB, 3, 094002 (2000)] and the transmission from round-beam to flat-beam for linear collider [D.Edwards, et al., Proceedings of LINAC 2000, 2000], understanding the phase spaces of such magnetized beam in Polar Coordinate System (PCS) becomes more interesting. In addition, the characteristics of a regular non-magnetized beam in PCS are also interesting to understand. A technique to construct the phase spaces in PCS is firstly presented in this paper. In the following section, we presented the experimental investigation for the phase space in PCS for a non-magnetized beam using the ATF real beam. Finally, its application to the magnetized beam for electron cooling and flat-beam production is discussed.

∗ This work is supported by DOE contract No. DE-FG03-92ER40695 and DE-AC02-98CH10886.

WPPB073 Design and Testing of a Fast Beam Position Monitor

Bryan Quinn, Brian Beaudoin, Santiago Bernal, An Diep, Matthew Glanzer, Wing-Tsz Lee, Patrick O'Shea, Martin Reiser, Mark Walter (University of Maryland)

The University of Maryland Electron Ring (UMER) is currently exploring the physics of space charge dominated beams. Seventeen Beam Position Monitors (BPMs) will be used to determine the beam centroid for steering correction purposes to within 0.5mm. Since the pulse length is relatively long (100 ns), the BPMs can also be used for temporal beam profiling. This feature is extremely useful for perturbation and longitudinal dynamics studies. For these uses the BPM needs a temporal resolution better than 2 ns. We will report on the final design and testing as well as other unique features of this device.

∗ This work is supported by the Unites States Department of Energy.

WPPB074 Time Resolved Emittance Measurement in the University of Maryland Electron Ring

Mark Walter, S. Bernal, I. Haber, R. Kishek, D. Lamb, H. Li, P. O'Shea, B. Quinn, M. Reiser, M. Snowel, A. Valfells (University of Maryland)

Initial experimental results are presented for measurements of the emittance of an electron beam in the University of Maryland Electron Ring (UMER). Two independent sets of slit-collector systems are used to measure the emittance in the vertical and horizontal directions respectively. Results are then compared to the time integrated emittance measurements obtained from a pepperpot. The UMER electron beam has an energy of 10 keV, with as much as 100 mA of current, and pulse length of 100 ns. The beam is confined by a periodic lattice of focusing/defocusing quadrupole magnets at 16 cm intervals. Beam steering is achieved with dipole magnets at 32 cm intervals and additional small steering dipoles as needed.

∗ This work is funded by US Dept. of Energy grant numbers DE-FG02-94ER40855 and DE-FG02-92ER54178.

WPPB075 Alignment of Components at the University of Maryland Electron Ring

Mark Walter, S. Bernal, A. Diep, M. Glanzer, I. Haber, J. Harris, R. Kishek, D. Lamb, W. Lee, H. Li, P. O'Shea, B. Quinn, M. Quirus, M. Rieser, A. Valfells (University of Maryland)

Alignment of experimental components is critical in The University of Maryland Electron Ring (UMER). Procedures and equipment used to align components of the electron ring are to be presented. The compact nature of UMER (ring diameter ~ 4 m) presents unique challenges and advantages associated with the placement of vacuum components, confinement and steering magnets, and diagnostic equipment. Alignment of all components has been accomplished with a set of two T3000 theodolites and the three-dimensional software package from the Leica Corporation. A set of fiducial monuments has been used to establish a permanent coordinate system. The position of UMER components has been measured to an accuracy of less than 100 microns in that coordinate system.

∗ This work is funded by US Dept. of Energy grant numbers DE-FG02-94ER40855 and DE-FG02-92ER54178.

WPPB076 Emittance Measurement by Using Duo Image Pattern of Cherenkov Radiation

Jia-er Chen, Yuantao Ding, Anjia Gu, Kui Zhao (IHIP, Peking University)

Emittance of the electron beam is measured by using Cherenkov radiation. The imaging patterns of the radiation are obtained both in the focal plane and image plane of an achromatic lens with long focus. The angular spread and radial distribution of the e-beam are computed by processing both patterns and in this way the beam emittance is resulted directly. The emittance of the electron beam from the DC-SC injector of Peking University with a photo-cathode is simulated and discussed in the paper.

* Supported by National Natural Science Foundation of China (10075006)(19985001)

WPPB077 Development of Beam Stability Analysis System for Non-Destructive Inspection Used LINAC

Taibin Du (Dept. of Engineering Physics, Tsinghua University, Beijing), Gang Wu (Accelerator Laboratory, Tsinghua University, Beijing)

An introduction is given to the real-time measuring method which can analyze the beam stability of electron linear accelerator, and inspect the X-ray dose rate dynamically. The application program is developed under object oriented environment-Visual C++.net, it has a lot of advantages, such as good reliability, high precision, intuitional measurement, friendly interface of the software, and so on.

WPPB078 Development of a Bunch Frequency Monitor for the Preliminary Phase of the CLIC Test Facility CTF3

Arnaud Ferrari, Anders Rydberg (Uppsala University), Fritz Caspers, Roberto Corsini, Louis Rinolfi, Frank Tecker (CERN), Philippe Royer (Universite de Lausanne)

In the framework of the CLIC RF power source studies, the feasibility of the bunch train combination by injection with RF deflectors into an isochronous ring has been successfully demonstrated in the preliminary phase of CTF3. In order to monitor this scheme, a new method based on beam frequency spectrum analysis was experimented. For this purpose, a coaxial pick-up and its detection system were designed and mounted in the CTF3 ring, in order to allow comparison of the amplitudes of five harmonics of the fundamental beam frequency (3 GHz) while combining bunch trains. The commissioning of the monitor was a successful proof of principle for this new method, despite the short length of the bunch trains and the presence of parasitic signals associated to high-order waveguide modes propagating with the beam inside the pipe.

WPPB079 Filling Pattern Measurement on the LNLS Storage Ring

Pedro Tavares, S.R. Marques, H.J. Onisto (Laboratório Nacional de Luz Sincrotron, Brazil)

The storage ring filling pattern impacts several machine performance parameters. A bunch charge meter has been developed in order to perform bunch by bunch charge measurement and to record the storage ring filling pattern. This instrument separates the electric pulse related to the selected bunch from a button pick-up RF signal. A double balanced mixer is used as a fast switch that strips off all except one bunch pulse at each revolution period. The bunch selection is performed by a PECL timing card and the selected bunch signal is acquired by a fast 12 bit ADC card with a FIFO buffer. A DSP processor board integrated to the system through an FPGA digital interface controls the instrument. The DSP software implements signal filtering and interfacing to the storage ring control system. Some implementation details, performance data and operational results will be presented.

WPPB080 A Multi-Channel Single-Shot Transient Signal Measurement with an Optical Fiber Recirculating Delay Line Loop

Yan Yin, Anshi Chen (YY Labs, Inc.)

An instrument has been developed to measure two-channel single-shot transient signals with frequency response higher than 10 GHz. The instrument utilizes an optical fiber recirculating loop to regenerate the captured single-shot signals, then recovers the signals with a sampling oscilloscope. The paper provides a description of the measurement, and the results of beam tests.

* The project was performed with the support of the US Department of Energy SBIR grant DE-FG03 98 ER82719.

Poster Session WPPG
Galleria at 13:30

WPPG001 Compensation of Nonlinear Resonances in the Presence of Space Charge

Alexei Fedotov, Nikolay Malitsky, George Parzen (BNL)

Imperfection non-linear resonances can lead to undesiarable beam loss and thus limit the high-intensity operation. In the presence of space charge, beam response to such resonances is strongly influenced by collective beam dynamics. It is thus crucial to understand the effectiveness of the non-linear resonance compensation in the presence of space charge. As a first step, the non-linear resonances are corrected in the absence of space charge. The procedure used is to measure the distortion in the tune versus amplitude caused by the non-linear resonance, and the resonance correctors are adjusted to reduce this tune distortion. With space charge present, the above results for the resonance correctors are used as the initial settings for these correctors. The effect on the space charge halo is investigated and methods of improving the correctors when space charge is present are studied.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPG002 Application of Envelope Instability to Circular Machines

Alexei Fedotov (BNL), Ingo Hofmann (Gesellschaft für Schwerionenforschung mbH), Hiromi Okamoto (Hiroshima University, Japan), Robert Gluckstern (University of Maryland)

Space-charge limit is a fundamental limitation in circular machines. Such a limit is imposed by beam response to low-order machine resonances. Understanding of resonant coherent beam dynamics becomes crucial for the design of future high-intensity rings, as well as for the intensity upgrade of existing facilities. In this paper we discuss the coherent response of the beam to the machines resonances, including the parametric resonance of beam modes with the lattice also known as "envelope instability" in transport channels. The relation of these parametric resonances to the coherent resonance condition of an integer type is explained. Practical application of such resonant responses to both structural and imperfection harmonics is addressed.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPG003 Spill Structure in Intense Beams

Joseph Glenn, Michael Blaskiewicz, Keven Brown, Joseph Glenn, Eugean Raka, John Ryan (BNL)

Fixed target studies of small branching ratio decay processes require intense beams and smooth spills. Longitudinal structure arises through collective effects, well below the coasting beam stability threshold. These structures have been observed at the Brookhaven AGS and dependence on intensity and momentum spread measured. Measurements and amelioration techniques that have been developed and will be described.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

WPPG004 Electron-Cloud Mitigation in the Spallation Neutron Source Ring

Jie Wei, M. Blaskiewicz, J. Brodowski, P. Cameron, D. Davino, A. Fedotov, P. He, H. Hseuh, Y.Y. Lee, W. Meng, D. Raparia, J. Tuozzolo, S.Y. Zhang (BNL), R. Macek (LANL), M. Furman, M. Pivi (LBNL), S. Henderson (ORNL)

The Spallation Neutron Source accumulator ring is designed to accumulate, via H- injection, beam pulses of 1.5x10^14 protons of 1 GeV kinetic energy at a repetition rate of 60 Hz. At such beam intensity, electron-cloud is expected to be one of the intensity-limiting mechanism that complicates ring operation. This paper summarizes mitigation strategy adopted in the design, both in suppressing electron-cloud formation and in enhancing Landau damping, including tapered magnetic field and monitoring system for the collection of stripped electrons at injection, TiN coated beam chamber for suppression of the secondary yield, clearing electrodes dedicated for the injection region and parasitic on BPMs around the ring, solenoid windings in the collimation region, and planning of vacuum systems for beam scrubbing upon operation.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPG005 On Emittance Evolution in the Extraction System of High-Current Electron and Ion Sources

Jean-Michel Lagniel, David Guilhem, Nicolas Pichoff, Michel Prome (French Atomic Energy Commission)

A simple model has been built to study the evolution of high-current electron or ion beams in axisymetric extraction systems (electron guns or ion sources with r,z symmetries). Both electric and magnetic field components induced by a diode and a focusing solenoid respectively are computed using analytical formulas. The space-charge forces are computed using a ring method. In a first step, the individual effects of the 3 nonlinear forces (electric, magnetic and space charge) on the emittance evolution are presented. This emittance behavior is then studied for different configurations (geometry, electric and magnetic field strength, beam current), including an optimized one designed using the knowledge acquired in the first step.

* CEA-DAM-DIF, DPTA-SP2A.

WPPG006 Resistive-Wall Wake for Non-Ultrarelativistic Beams

Frank Zimmermann (CERN), Katsunobu Oide (KEK)

The usual formulae for the resistive-wall wake field are derived considering ultra-relativistic beams, travelling at the speed of light. This simplifies the calculation, and it leads to a cancellation between electric and magnetic field terms. However, for proton beams below 10 GeV and for many heavy ion beams, the velocities may significantly differ from the speed of light. In this paper, we compute the longitudinal and transverse wake fields for arbitrary velocity, and discuss under which conditions the additional non-relativistic terms become important.

WPPG007 Effect of Space Charge on Decoherence and Echoes in (Ion) Beams

Giovanni Rumolo, Oliver Boine-Frankenheim, Ingo Hofmann, Markus Kirk, Yong Liu (Gesellschaft für Schwerionenforschung mbH), Ahmed Al-Khateeb (Department of Physics, Yarmouk University, Irbid, Jordan)

The centroid of a bunch displaced transversely or longitudinally decoheres due to nonlinearities that cause phase space filamentation and mixing. Space charge can inhibit decoherence and keep the beam centroid oscillations undamped over long times. Echo effects, which require a fully decohered beam to show up as a coherent signal at later times than the excitations, can therefore become more difficult to detect. In this paper we study the decoherence of the centroid motion and beam echoes in presence of space charge and their implications for beam stability and diffusion measurements. Results from experiments at the GSI Heavy Ion Synchrotron (SIS) are also presented.

WPPG008 Nonlinear Effects in Dynamics of High-Brightness Beams

Michael Zeitlin, Antonina Fedorova (IPME RAS, Russian Academy of Sciences)

We consider a few reductions from nonlinear Vlasov-like equations to rms/rate equations for second moments related quantities (with or without additional equations or/and constraints for energy and emittance) [A. Fedorova, M. Zeitlin, Proc. EPAC02, pp.1323, 1344, 1434, 1482, 1595, Paris, 2002; arXiv preprints, physics/0206053, 0206052, 0206051, 0206050, 0206049, 0206054; nlin.PS/0206024]. Our analysis is based on variational—wavelet approach to rational (in dynamical variables) approximations with possible related constraint equations. It allows to control contribution from each scale of underlying multiscales and represent solutions via multiscale nonlinear eigenmodes expansions. Our approach provides the best convergence properties of the corresponding exact representations and does not use perturbations or/and linearization procedures. Reduced algebraical structure provides the pure algebraical control of stability/unstability scenario and appearance of different type of behaviour (chaotic vs. localized) in space of parameters.

WPPG009 Space Charge Effects during the Injection Period of the KEK PS Main Ring

Susumu Igarashi, Takako Miura, Eiji Nakamura, Yoshito Shimosaki, Masashi Shirakata, Ken Takayama, Takeshi Toyama (KEK)

Space charge effects during the injection period of the 12 GeV main ring of the KEK proton synchrotron have been studied. Measurement of the transverse beam profiles using flying wires has revealed a characteristic temporal change of the beam profile within a few milliseconds after the injection. Horizontal emittance growth was observed when the horizontal tune was close to the integer. The effect was more enhanced for higher beam intensity and could not be explained with the injection mismatch. Resonance created by the space charge field was the cause of the emittance growth. A multiparticle tracking simulation program, ACCSIM, taking account of space charge effects has successfully reproduced the beam profiles.

WPPG010 An Experimental Investigation of Halo Collimation of an Intense Proton Beam in a Linear Transport Channel

Patrick Colestock, Doug Gilpatrick, Martin Schulze, Tom Wangler (LANL)

We have carried out an experiment to collimate the intense proton beam generated by the LEDA proton source and transported down a linear transport channel. Results indicating the generation of a significant halo have been reported elsewhere [C. K. Allen, et. al., Phys. Rev. Lett., 89, 21, p. 4802 (2002)]. The ability to collimate such a halo is critical to the success of future intense proton sources. Using available beam scrapers, we have measured the collimation of a portion of this halo, and show that the halo is repopulated in rough agreement with simulation models. We present the results of this experimental study and discuss the ongoing attempts to improve the theoretical models based on our observations.

WPPG011 Challenge of Benchmarking Simulation Codes for the LANL Beam-Halo Experiment

Thomas Wangler, R.W. Garnett, W.P. Lysenko (LANL), J. Qiang (LBNL)

We have compared macroparticle simulations with beam-profile measurements from a proton beam-halo experiment in a study of mismatched beams in a 52-quadrupole periodic-focusing lattice. The lack of detailed knowledge of the initial distribution is an important issue for being able to make reliable predictions of the halo. We find that different initial distributions with the same Courant-Snyder parameters and rms emittances produce similar matched-beam profiles, but different mismatched-beam profiles in the transport system. Also, input distributions with greater population in the tails produce larger rates of emittance growth, a result that is qualitatively consistent with the particle-core model of halo formation, where resonant halo growth is expected for particles in the tails. Using only the known Courant-Snyder parameters and rms emittances is insufficient information for reliable simulations of beam halo formed in mismatched beams.

* This work was supported by the U.S.Department of Energy.

WPPG012 High Brightness Potassium Source for the HIF Neutralized Transport Experiment

Shmuel Eylon, Enrique Henestroza, Prabir Roy, Simon S. Yu (LBNL)

The NTX experiment at the Heavy Ion Fusion Virtual National Laboratory is exploring the performance of neutralized final focus systems for high perveance heavy ion beams. To focus a high intensity beam to a small spot requires a high brightness beam. In the NTX experiment, a potassium ion beam of up to 400 keV and 80 mA is generated in a Pierce type diode. At the diode exit, an aperture with variable hole size provides the capability to vary the beam perveance and to significantly reduce the beam emittance. We shall report on the source characterization including current density profile, phase space distributions and the control of electrons generated by the beam scraping at the aperture. Comparison with particle simulations using the EGUN code will be presented.

* This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098, for the Heavy Ion Fusion Virtual National Laboratory.

WPPG013 Final Focus System for High Intensity Beams

Enrique Henestroza, Shmuel Eylon, Prabir Roy, Simon S. Yu (LBNL)

The NTX experiment at the Heavy Ion Fusion Virtual National Laboratory is exploring the performance of neutralized final focus systems for high perveance heavy ion beams. The NTX final focus system produces a converging beam at the entrance to the neutralized drift section where it focuses to a small spot. The final focus lattice consists of four pulsed quadrupole magnets. The main issues are the control of emittance growth due to high order fields from magnetic multipoles and image fields. We will present experimental results from NTX on beam envelope and phase space distributions, and compare these results with particle simulations using the particle-in-cell code WARP.

* This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098, for the Heavy Ion Fusion Virtual National Laboratory.

WPPG014 Neutralized Transport of High Intensity Beams

Enrique Henestroza, Andre Anders, Prabir Roy, William Sharp, Eylon Shmuel, Simon S. Yu (LBNL), David Rose, Dale Welch (Mission Research Corporation), Phil Efthimion, Erick Glison (PPPL)

The NTX experiment at the Heavy Ion Fusion Virtual National Laboratory is exploring the performance of neutralized final focus systems for high perveance heavy ion beams. A converging ion beam at the exit of the final focus magnetic system is injected into a neutralized drift section. The neutralization is provided by a metal arc source and an ECR plasma source. Effects of a "plasma plug", where electrons are extracted from a localized plasma in the upstream end of the drift section, and are then dragged along by the ion potential, as well as the "volumetric plasma", where neutralization is provided by the plasma laid down along the ion path, are both studied and their relative effects on the beam spot size are compared. Comparisons with 3-D PIC code predictions will also be presented.

* This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098, for the Heavy Ion Fusion Virtual National Laboratory.

WPPG015 Coherent Synchrotron Radiation Studies for the Berkeley Femtosecond X-Ray Source

Ina Reichel, John N. Corlett, Alexander A. Zholents (LBNL)

A recirculating linac based source of short x-ray pulses is currently under study [J. N. Corlett et al., this conference]. Due to the high bunch current and small bunch length coherent synchrotron radiation is an issue especially in the bunch compressor. Analytical studies and results from computer simulations will be presented.

* This work was supported by the U.S.Department of Energy under Contract No. DE-AC03-76SF00098.

WPPG016 Non-Intercepting Diagnostics for the HIF Neutralized Transport Experiment

Prabir Roy, Shmuel Eylon, Ryan Hannink, Enrique Henestroza, Jozsef Ludvig, Simon S. Yu (LBNL)

The NTX experiment at the Heavy Ion Fusion Virtual National Laboratory is exploring the performance of neutralized final focus systems for high perveance heavy ion beams. We are developing a non-destructive beam diagnostics system to characterize the ion beam during its operation. In this diagnostics system an electron beam of sub millimeter size with a few micro Ampere current and <5 kV energy would be injected perpendicular and through the ion beam. The position and intensity of the scattered e-beam will be registered on a scintillator for optical analysis to characterize the ion beam. An electron beam of negligible space charge will be deflected at an angle that depends on the charge density and energy distribution of the ion beam along its trajectory. The e-beam current and energy have been chosen such that its trajectory will be perturbed significantly without perturbing the ion beam. We will present a progress report on this diagnostic system including the characterization of the electron gun,

the design of the e-beam transport system, and a study of the scintillator and its associate electronics and photonic components.

* This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098, for the Heavy Ion Fusion Virtual National Laboratory.

WPPG017 Magnetic Lattice for the HIF Neutralized Transport Experiment

Derek Shuman, Shmuel Eylon, Enrique Henestroza, Prabir Roy, William Waldron, Simon S. Yu (LBNL), Timothy Houck (LLNL)

The NTX experiment at the Heavy Ion Fusion Virtual National Laboratory is exploring the performance of neutralized final focus systems for high perveance heavy ion beams. A pulsed magnetic four-quadrupole transport system for a 400 keV, 80 mA space charge dominated heavy ion beam has been designed, fabricated, tested, measured, and commissioned successfully for the Neutralized Transport Experiment (NTX). Magnet testing consisted of repetitive full current pulsing to determine reliability. Magnetic field measurements were made using both Hall probes (low field DC) and inductive loop coils (high field pulsed). We will present the magnetic field analysis from measurements and compare with predictions from 2-D and 3-D finite element calculations (half octant symmetric, and full magnet to include coil and lead asymmetries), generalized multipole decomposition of 3-D simulations, and 2-D eddy current transient simulations in the beam tube. Beam envelope calculations along the transport line were performed using superposition of individually 3-D calculated magnetic field maps. The design of the high voltage pulser, a novel coil and lead design as well as the magnet fabrication technique for high voltage reliability will be presented.

* This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098, for the Heavy Ion Fusion Virtual National Laboratory.

WPPG018 Moment Equation Approach to Chromatic Aberrations in Final Focus Systems for Heavy Ion Fusion

John Barnard (LLNL), Edward P. Lee (LBNL)

Ordinarily, the envelope equations provide adequate accuracy for rapid design calculations of rough layouts of a set of magnetic quadrupoles arranged to focus an ion beam to a small spot (for example, for the final focus system of a Heavy Ion Fusion driver.) Typically, such systems consist of four to eight large aperture quadrupole magnets preceded by a drift section. However, chromatic aberrations (depending on momentum spread) and other non-linear terms in the equations of motion may contribute significantly to the final focal spot size. We present here a moment equation approach which includes terms through second order in particle transverse position, angle and fractional momentum spread, (but which drops terms higher than a specified order) and which treats space charge by assuming it is distributed uniformly over an elliptical cross section. Integrating the derived set of moment equations allows rapid determination of the contribution of chromatic aberrations to spot size. We compare the results of integrating moment equations with an analytic theory, as well as with Particle-In-Cell simulations.

* Work performed under the auspices of the U.S. Department of Energy under University of California contract W-7405-ENG-48 at LLNL, and University of California contract DE-AC03-76SF00098 at LBNL.

WPPG019 Stability Properties of the KV Envelope Equations

Steven Lund (LLNL), Boris Bukh (LBNL)

Intense ion beams are typically transported in a periodic lattice of linear focusing elements that confine the beam against defocusing space-charge and thermal forces arising from the distribution of beam particles. The low-order transverse evolution of the mid-pulse envelope of beam particles in such transport channels can be approximately modeled by the Kapchinskij-Vladimirskij (KV) envelope equations. Here we analyze the linear stability properties of so-called mismatch perturbations of the beam envelope about the matched (i.e., periodic) beam envelope in periodic transport channels. Mismatch modes supported by the KV envelope equations for a coasting beam are numerically analyzed to map regions of parametric instability and to understand allowed normal mode oscillations. New classes of envelope instabilities are found, parametric sensitivities are explored, and results are analytically checked in the thin lens limit for strong and weak space-charge. Important, and previously unexplored launching conditions for pure envelope modes are described and sources of envelope mode excitation are analyzed.

* Research supported by the US DOE at the Lawrence Livermore and Lawrence Berkeley National Laboratories under contract Nos. W-7405-Eng-48 and DE-AC03-76SF00098.

WPPG020 Influence of Conducting Plate Boundary Conditions on the RMS Envelope Equations Describing Intense Beam Transport

Steven Lund (LLNL), Boris Bukh (LBNL)

Low-order models of intense ion beams often employ the RMS envelope equations to describe the self-consistent evolution of the beam edge in response to applied focusing and space-charge and thermal defocusing forces. These equations are typically solved with constant beam emittances and perveance, which provide a measure of phase-space area and space-charge strength, respectively. However, in typical diagnostic applications, intense beams are intercepted by conducting planes with slits to measure phase-space properties. This results in a boundary condition that shorts out the beam space-charge field near the plate. Here, we construct a simple model of this shorting effect on the beam perveance for incorporation into the rms envelope equations to allow corrections of the envelope model. This result enables higher accuracy diagnostics and the magnitude of typical corrections on the beam envelope radii and angles are characterized for the High Current Transport Experiment at the Lawrence Berkeley National Laboratory. Results are checked by 3D particle in cell simulations.

* Research supported by the US DOE at the Lawrence Livermore and Lawrence Berkeley National Laboratories under contract No. W-7405-Eng-48 and DE-AC03-76SF00098.

WPPG021 Simulations of Beam Halo in the DARHT-II Transport System

Brian Poole, Yu-Jiuan Chen (LLNL)

The DARHT-II beam line utilizes a fast stripline kicker to temporally chop a high current electron beam from a single induction LINAC and deliver multiple temporal electron beam pulses to an x-ray converter target. High beam quality needs to be maintained throughout the transport line from the end of the accelerator through the final focus lens to the x-ray converter target to produce a high quality radiographic image. Spot size at the target and emittance growth in the downstream transport line was calculated from the dynamic effects associated with the stripline kicker and nonlinear forces due to focusing elements in the transport line. For our previous simulations, [B. R. Poole and Y-J Chen, PAC Proceedings, 3299 (2001)], an initial K-V beam distribution was used as the initial condition for the electron beam at the accelerator exit. We have now performed simulations with more realistic beam distributions for the initial condition. The simulated time integrated spot size at the x-ray converter target, emittance growth, and particle loss will be presented in this paper.

* This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

WPPG022 Realistic Modeling of Chamber Transport for Heavy-Ion Fusion

William Sharp, D. A. Callahan, D.P. Grote, M. Tabak (LLNL), E. Henestroza, S.S. Yu (LBNL), D.V. Rose, D.R. Welch (Mission Research Corporation), P. F. Peterson (University of California Berkeley)

To achieve high gain, indirect-drive targets for heavy-ion fusion must be driven by a tailored input-energy profile. This profile is designed to launch a series of four shocks through the capsule that compress and accelerate the fuel on a low adiabat. The pulse shape typically consists of a long (~ 25 ns), low-power "foot" that heats the hohlraum interior to about 100 eV and launches the first shock. The power is then ramped to the peak value and held for about 8 ns as the subsequent three shocks are launched. The hohlraum geometry and the required temperature history of the capsule determine the ion-beam current profile. In addition, distributed-radiator targets require different ion kinetic energies in the foot and main pulses to compensate for ion range shortening, thereby achieving the necessary radiation symmetry in the hohlraum. The time-varying beam current and energy complicate the problem of focusing the beam onto the target. Using output from final-focus simulations, the electromagnetic particle-in-cell code LSP is employed here to investigate the chamber transport of foot and main-pulse beams with realistic distributions. These single-beam simulations include beam pre-neutralization by plasma injected into the chamber-entry beam line, collisional ionization of the beam and background gas, and photoionization by X rays from the heated target.

* This work was performed under the auspices of the U. S. Department of Energy by University of California Lawrence Livermore National Laboratory and Lawrence Berkeley National Laboratory under contracts W-7405-ENG-48 and DE-AC03-76SF00098.

WPPG023 Reversed Resonant "Wakefield"

Eduard Masunov (MEPhI), Alexei Smirnov (DULY Research Inc.)

A new kind of coherent radiation induced by uniformly moving charge is introduced. It appears as a wavepacket forerunning entirely ahead of the charge. It was derived as a complementary case of existing theory of resonant wakefield extended to include the exotic "overturned wake" effected by the leading front distortions due to dispersion. Corresponding conditions, causality and potential realizations in special types of slow-wave systems are analyzed and discussed. Those can include moving media and meta-materials, plasma and some of periodic structures.

WPPG024 Three-Dimensional Modeling of Intense Beams in RF Accelerators and Sources

Ronak Bhatt, Chiping Chen, Mark Hess, Bao Liang Qian (MIT Plasma Science and Fusion Center)

A fully three-dimensional electromagnetic kinetic formulation of charged particle beams in conducting structures of arbitrary cross section and longitudinal variation is presented. The model is developed self-consistently – i.e. image charge and current effects are included. As an application of the model, we examine the electromagnetic interactions of beams propagating in slow-wave structures which are commonly found in RF accelerators and high-power microwave sources. Analytical and numerical results are presented for various limits, including the electrostatic limit and the case of small-amplitude sinusoidal ripples on the conducting wall.

* Supported by DOE and AFOSR.

WPPG025 Beam Halo Formation and Loss Induced by Image-Charge Effects in a Small-Aperture Alternating-Gradient Focusing System

Jing Zhou, Chiping Chen, Bao Liang Qian (MIT Plasma Science and Fusion Center), Shmuel Eylon, Enrique Henestroza, Simon Yu (LBNL)

Effects of image charges on beam halo formation and beam loss in small-aperture alternating-gradient focusing systems are studied analytically, computationally, and experimentally. For an unbunched uniform-density elliptic beam in a circular conducting pipe, it is shown that the self-electric and self-magnetic fields induced by the image charge can be as high as 10% of the fields generated by the beam in free space when the maximum beam envelope fills 83% of the pipe. Nonlinear image-charge fields result in chaotic particle motion and the ejection of particles from the beam core into a halo. Detailed chaotic particle motion and structure of the particle phase space is studied, and the beam loss rate is computed over a wide range of system parameters. Theoretical results are compared with 3-D PIC calculations using the WARP code, and with experimental data from the Neutralized Transport Experiment (NTX) at LBNL.

* Supported by the U. S. Department of Energy.

WPPG026 Initial Experimental Results of the Small Isochronous Ring

Jose Rodriguez, Felix Marti, Eduard Pozdeyez (National Superconducting Cyclotron Laboratory)

The Small Isochronous Ring (SIR) is under development at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU). The ring is a small-scale experiment that simulates the dynamics of intense beams in large-scale accelerators. Its main purpose is the study of longitudinal space charge effects in the isochronous regime. A 20 to 30 keV bunch of hydrogen or deuterium ions is injected in the ring. After a variable number of turns (~ 20-30), the bunch is extracted and its longitudinal profile is studied. This paper describes the first experimental results: extracted current for different mass states, emittance measurements, time structure of the injected bunches, etc.

* Work supported by NSF Grant # PHY-0110253.

WPPG027 SNS Linac Commissioning - Transverse Matching

Dong-o Jeon (ORNL), Jim Stovall (LANL)

The Spallation Neutron Source Linac consists of a few distinct sections which require careful transverse matching. Robust techniques for transversely matching various sections of the SNS Linac have been identified and will be presented. These techniques do not require us any knowledge of machine optics, and are robust against up to 20% measurement uncertainties, beam mismatch, etc.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

WPPG028 Initial Results from the Paul Trap Simulator Experiment

Hong Qin, Ronald C. Davidson, Philip C. Efthimion, Richard Majeski, Hong Qin (Plasma Physics Laboratory, Princeton University)

The Paul Trap Simulator Experiment (PTSX) is a compact laboratory facility whose purpose is to simulate the nonlinear dynamics of intense charged particle beam propagation over large distances through an alternating-gradient quadrupole transport system. The simulation is possible because the osciallatory quadrupole electric fields of the cylindrical Paul trap exert transverse forces on the particles in a long charge bunch that are analogous to the transverse forces that a periodic focusing quadrupole magnetic field exerts on the beam particles in

the beam frame. Initial experiments clearly demonstrate the instability of the transverse particle orbits when the equivalent vacuum phase advance of the system exceeds 90 degrees. Initial experiments have been carried out with trap parameters that correspond to matched beam conditions in a transport system. In subsequent experiments, the osciallatory voltage applied to the wall of the trap is modified in order to study issues such as beam mismatch, envelope instabilities, compression techniques, collective wave excitations, and beam profile effects.

* Research supported by the U.S. Department of Energy.

WPPG029 Study of Drift Compression for Heavy Ion Fusion Beam

Hong Qin, Ronald C. Davidson (Plasma Physics Laboratory, Princeton University), Edward P. Lee (LBNL), John J. Barnard (LLNL)

In the currently envisioned configurations for heavy ion fusion, it is necessary to longitudinally compress the beam bunches by a large factor after the acceleration phase. Because the space-charge force increases as the beam is compressed, a larger focusing force is needed to confine the beam in the transverse direction. It is necessary to have a non-periodic quadrupole lattice along the beam path. The lattice design and transverse beam dynamics are studied using a set of averaged envelope equations for non-periodic lattice. Especially, the problems of adiabatic match for the entire bunch and pulse compression with bending are investigated.

* Research supported by the U.S. Department of Energy.

WPPG030 ECR Source for Heavy Ion Beam Charge Neutralization

Philip Efthimion, Ron Davidson, Eric Gilson, Larry Grisham (Princeton University)

Highly ionized plasmas are being considered as a medium for charge neutralizing heavy ion beams in order to focus beyond the space-charge limit. Calculations suggest that plasma at a density of 1 - 100 times the ion beam density and at a length ~ 0.1-0.5 m would be suitable for achieving a high level of charge neutralization. An ECR source has been built at the Princeton Plasma Physics Laboratory (PPPL) in support of a joint Neutralized Transport Experiment (NTX) at the Lawrence Berkeley National Laboratory (LBNL) to study ion beam neutralization with plasma. The ECR source operates at 13.6 MHz and with solenoid magnetic fields of 0-10 gauss. The goal is to operate the source at pressures ~ 10-5 Torr at full ionization. The initial operation of the source has been at pressures of 10-4 - 10-1 Torr. Electron densities in the range of 108 - 1011 cm-3 have been achieved. Recently, pulsed operation of the source has enabled operation at pressures in the 10-6 Torr range with densities of 1011 cm-3. Near 100% ionization has been achieved. The source has been shipped to LBNL for integration with NTX and to begin experiments.

* Research supported by DOE Contract No. DE-AC02-76-CH-03073.

WPPG031 Dissipation of the Electron Cloud at the PSR

Miguel Furman (SLAC), Andrew Browman, Robert Macek (LANL), Miguel Furman, Mauro Pivi (LBNL)

We present an update on simulations and measurements of the electron-cloud dissipation at the PSR following beam extraction. We focus on the effect of the low-energy secondary-electron yield on the decay time of the electron density.

* This work was supported by the Director, Office of Science, Office of Fusion Energy Sciences, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

WPPG032 Simulating Accelerator Structure Operation at High Power

Valentin Ivanov (SLAC)

The important limiting factors in high-gradient accelerator structure operation are dark current capture, RF breakdown and electron multipactoring. These processes include both primary and secondary electron field emission and produce plasma and X-rays. To better understand these phenomena, we have simulated dark current generation and transport in a linac structure and in a square-bend waveguide both high power tested at SLAC. For these simulations, we use the parallel, time-domain, unstructured-grid code Tau3p and the particle tracking module Ptrack3D. In this paper, we present the results along with comparisons to energy spectrum measurements made at SLAC of electrons transmitted from the SLAC structure and X-rays emitted from the square-bend waveguide.

* Work supported by US Department of Energy contract DE-AC03-76SF00515.

WPPG033 A Modified Quad Scan Technique for the Emittance Measurement

Cecile Limborg, Dave.H. Dowell, Steve M. Gierman, John F. Schmerge (SLAC), John G. Power (ANL)

The quad-scan technique is one of the most commonly used methods for measuring rms emittances of beams whose envelope evolution is not dominated by space charge. However, in many situations, for example an electron beam emitted from an rf photocathode gun, space charge can contribute strongly to the beam size evolution in the drift space between the scanning quadrupole and the measurement screen. We describe the conditions for which a space charge correction to the standard fitting algorithm is required. To take space charge into account, we track the beam envelope evolution in the drift space by solving the general envelope equation that includes both emittance and space charge terms. We present both a quad scan fitting algorithm for the special case of a beam with circular cross section and a more general fitting algorithm for the nonaxisymmetric beam case. In addition, benchmarking of these algorithms against TRACE 3D and PARMELA is also presented.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

WPPG034 Calculation of the Stored Beam Current Limitation with Considering the Phase Noise of the Generated RF Signal

Lung-Hai Chang, Ming-Chyuan Lin, Gwo-Huei Luo, Chaoen Wang (Synchrotron Radiation Research Center)

The beam loading effect, known as Robinson instability, limits the maximal stored beam current. In addition to the RF operation parameters, the phase noise of the generated RF signal can influence the stored beam current limitation. This paper presents the application of the particle tracking technique in the calculation for the stored beam current limitation with the consideration of the phase noise of the generated RF signal. The calculation result shows that the phase noise can decrease the maximum beam current that can be stored, and that the higher the accelerating voltage is, the more reduction the phase noise can cause in the maximal stored beam current.

WPPG035 Space-Charge-Dominated Phenomena in the Source Region

Irving Haber, S. Bernal, R.A. Kishek, P.G. O'Shea, M. Reiser (University of Maryland), J.-L. Vay (LBNL), A. Friedman, D.P. Grote (LLNL)

For the highly space-charge-dominated beams found in experiments such as the HCX transport system at LBNL and the UMER ring at the University of Maryland, details of the beam distribution as it

emerges from the source region can determine the beam behavior well downstream. This occurs because collective space-charge modes excited as the beam is born remain undamped for many focusing periods. In some cases these modes could also seed an anisotropy instability that is driven by the accelerative cooling of the beam that occurs only the longitudinal direction. Traditional studies of the source region in particle beam systems have emphasized the behavior of averaged beam characteristics, such as total current, rms beam size, or emittance, rather than the details of the full beam distribution function that are necessary to predict the excitation of the collective modes. Simulations of the source region using the particle-in-cell WARP code and comparisons to experimental measurements of the UMER beam at the University of Maryland have been used to understand the complexity that has been observed in the source region. In addition, because ability to obtain detailed direct measurement of the source characteristics is often limited, methods will be discussed for using simulation to infer characteristics of the beam distribution from the data that can be obtained.

* Work supported by the U. S. Department of Energy.

WPPG036 Simulations of Single-Turn UMER Experiments

Rami Kishek, Santiago Bernal, Yupeng Cui, Irving Haber, John Harris, Hui Li, Patrick G. O'Shea, Bryan Quinn, Martin Reiser, Agust Valfells, Mark Walter, Yun Zou (University of Maryland)

Applications such as heavy ion inertial fusion, spallation neutron sources, high-energy colliders, and free electron lasers, require high brightness that boosts the intensity beyond traditional limits. Beams of interest for such applications begin life as space-charge-dominated beams, and should ideally remain so for most of their lives. In practice, undesirably high emittance at the source or emittance growth during acceleration and transport disturb this condition, and the beam becomes emittance dominated. Space charge-induced instabilities, emittance growth and halo formation are limiting factors that need to be understood in order to maintain the beam quality while transporting a higher current. The University of Maryland Electron Ring (UMER) [P.G. O'Shea, et al., this conference], currently under construction, is designed to be a research tool on the dynamics of such intense beams. The parameters are scaled to mimic those of much larger ion accelerators using a 10 keV, 0.1-100 mA (adjustable current) electron beam, except at much lower cost. Since UMER is primarily to serve as a research platform for beam physics, it is equipped with a vast array of diagnostics that provide for effective comparison against computer codes. As the ring's construction is nearing its final stages, experimental data from the first turn becomes available, including detailed and time-resolved measurements of the 6-D phase space. Self-consistent particle simulations of those experiments using the WARP code [D. P. Grote, et al., Fus. Eng. & Des. 32-33, 193-200 (1996)] add to our understanding of the underlying beam physics, and will be presented.

* This work is funded by US Dept. of Energy grant numbers DE-FG02-94ER40855 and DE-FG02-92ER54178.

WPPG037 Phase Mixing and the Continuum Limit in Time-Dependent Space-Charge Potentials

Courtlandt Bohn (Northern Illinois University and Fermilab), Ioannis Sideris (Northern Illinois University)

Phase mixing in time-independent, coarse-grained space-charge potentials corresponding to thermal equilibria has recently been investigated in considerable detail [C.L. Bohn and I.V. Sideris, PRST-AB (submitted)]. Phase mixing in certain time-dependent potentials, most notably that of the University of Maryland 5-beamlet experiment and in the context of equipartitioning, has also been explored [C.L. Bohn, I.V. Sideris, H.E. Kandrup, and R.A. Kishek, Proc. 2002 Linac Conf]. Herein we extend this line of investigation in two directions, the first regarding halo formation, and the second regarding radiative bursts in electron storage rings. We also explore the influence of point-particle graininess on phase mixing to check the validity of invoking a coarse-grained distribution and its attendant Vlasov equation.

WPPG038 Main Regularities of Particle Redistribution in Space Charge-Dominated Beam Transport and Bunching

Igor Shumakov, Alexander Durkin (Moscow Radiotechnical Institute)

High current beam progressively build-up its energy during acceleration. Beam contact with the channel walls is accompanied both by high amount heat liberation and creation of radiation danger. The main features of charge redistribution in high-current beam during bunching, accelerating and transporting must be revealed in order to solve above mentioned problems. Experience leads us to use results obtained by many scientists. Below we present only the works of the authors. The goal of investigations was core-halo interaction study, study of possible mechanisms of halo formation, matched beam parameter calculations and estimations of mismatched beam effects during high-current beam bunching. As a result a procedure of parameter choice for accelerating/focusing channel that leads to minimum of particle losses must be appeared.

WPPG039 Angular Momentum Measurement of the FNPL Electron Beam

Yin-e Sun (University of Chicago), Kwang-je Kim (ANL), Kai Desler, Helen Edwards, Markus Huening, Philippe Piot, James Santucci (FNAL), Steve Lidia (LBNL), Nick Barov, Court Bohn, Daneil Mihalcea (Northern Illinois University)

In the flat beam experiment [N. Barov et al,"Photoinjector Production of a Flat Electron Beam", submitted to PRST-AB] at FNPL (Fermilab/NICADD Photoinjector Laboratory), it is essential to have a non-vanishing longitudinal magnetic field on the photocathode. The angular momentum of the electron beam generated by this magnetic field is an important parameter in understanding the round to flat beam transformation. In this paper, we report our measurements of angular momentum before and after the beam transformation, and compare them with the expected values from theoretical calculations and simulation results.

WPPG040 Multiple Beam Interaction Studies in Heavy Ion Fusion

David Welch, D.V. Rose (Mission Research Corporation), S.S. Yu (LBNL), C.L. Olson (Sandia National Laboratories)

Heavy ion fusion requires the acceleration, transport, and focusing of many individual ion beams. Drift compression and beam combining prior to focusing results in ~100 individual ion beams with line-charge densities of order 10^{-5} C/m. A focusing force is applied to the individual ion beams outside of the chamber. For neutralized ballistic chamber transport, these beams enter the chamber with a large radius (relative to the target spot size) and must overlap inside the chamber at small radius (roughly 3-mm radius) prior to striking the target. For pinched transport modes, the individual ion beams are combined in an adiabatic discharge lens still outside of the chamber and injected at small radius into the chamber. Recent work has shown that, in the presence of a neutralizing ambient plasma, transport of an already-combined high-current beam does not significantly increase the beam spot size on target over that of a single low-current beam. In both scenarios, possible deleterious effects of beam overlap and combining may include instabilities and increased emittance growth. Particle-in-cell simulations are being carried out to examine these issues.

WPPG041 Observation of Coherent Microwave Transition Radiation in the APS Linac

Glenn Decker, Xiang Sun (ANL)

The APS injector includes a conventional S-band linear accelerator with three separate electron sources. Two electron guns are used as primary and secondary sources for injection into the APS 7-GeV storage ring, while a separate laser photocathode gun is available for free-electron laser research. We report here the results of the dependence of 30-GHz coherent microwave transition radiation on electron bunch length. Sensitivity to pulses as short as 200 to 300 femtoseconds has been demonstrated.

* The submitted manuscript has been created by the University of Chicago as Operator of Argonne National Laboratory ("Argonne") under Contract No. W-31-109-ENG-38 with the U.S. Department of Energy.

WPPG042 Performance of the Redesigned RHIC IPMs

Roger Connolly, Peter Cameron, Manuel Grau, Donald Pinelli (BNL)

Four ionization beam profile monitors (IPM's) are in RHIC to measure vertical and horizontal profiles in the two rings. Each IPM collects and measures the distribution of electrons in the beamline resulting from residual gas ionization during bunch passage. The ionized electron signal provides an accurate beam profile with the speed and sensitivity to see individual gold bunches. However the detectors are extremely sensitive and their performance has been limited by backgrounds from radiation spray, rf coupling to the beam, and secondary electrons. During the shutdown in 2002 two IPM's were rebuilt incorporating design changes to reduce the backgrounds. This paper describes the new detectors and their performance during the 2003 run.

* Work performed under the auspices of the U.S. Department of Energy.

WPPG043 Transverse Profile Measurements in the SNS Ring

Roger Connolly, John Brodowski, Peter Cameron, Manuel Grau, Heather Hartmann, Nicholaos Tsoupas (BNL)

The Spallation Neutron Source (SNS) consists of a 1 GeV linear accelerator, a storage ring, a target, and connecting beam-transport lines. The linac delivers a 1.04-ms-long macropulse which is chopped into about 10^3 pulses of 10^{11} protons each. As this pulse enters the storage ring from the linac each chopped pulse lines up longitudinally with all proceeding pulses forming a single bunch about 550-ns long and a 250-ns gap. During the accumulation process the horizontal and vertical profiles of the beam will be measured with two ionization profile monitors (IPM's). The SNS IPM is similar to the IPMs used in RHIC and will collect electrons from background gas ionization. A magnetic field will control the electron trajectories. Several profiles are collected each turn producing a profile measurement with longitudinal resolution.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

WPPG044 RHIC Transverse Injection Damping

Angelika Drees, Robert Michnoff, Christoph Montag, Michelle Wilinski (BNL)

Since the beginning of the currently ongoing RHIC run a transverse injection damper is available. The damper is based on a fast kicker module in combination with a HV power supply and fast HV switches. This system can damp one injected bunch at the time with a given kick amplitude ("bang-bang mode") for several hundred turns. This report gives an overview of the injection damping system and summarizes its performance and our experience during the first months of usage.

* Work performed under the auspices of the US Department of Energy.

WPPG045 RHIC Electron Detector Signal Processing

Justin Gullotta, David Gassner, Dejan Trbojevic, Shou-Yuan Zhang (BNL)

The RHIC gold beam intensity is presently limited by pressure rise at some warm sections, and the main cause is thought to be the electron cloud. For the FY2003 RHIC run, a system has been installed to characterize the electron cloud, if it exists. The system is comprised of electron detectors, high voltage bias supplies, signal amplifiers, and data acquisition electronics, all integrated into the Controls system. The 11 detectors are grouped in two locations, one in an interaction region and one in a single beam straight section. This paper describes the signal processing design of the detector system, and includes data collected from the FY2003 run.

* Work performed under the auspices of the U.S. Department of Energy.

WPPG046 A New CNI Polarimeter for the AGS

Haixin Huang, Alessandro Bravar, Gerry Bunce, Osamu Jinnochi, Zheng Li, Waldo W. MacKay, Yousef I. Makdisi, Sergio Rescia, Thomas Roser (BNL), Williams Lozowski (Indiana University), Vadim Kanavets, Dima N. Svirida (Institute of Theoretical and Experimental Physics, Moscow), Igor G. Alekseev (Institute of Theoretical and Experimental Physics, Moskow), Kazu Kurita (Rikyo Univeristy, Japan), George Igo, S. Trentalange, C. Whitten, Jeff Wood (University of California, Los Angeles), Satish Dhawan, Vernon W. Hughes (Yale University)

The proton carbon elastic scattering in the Coulomb Nuclear Interference (CNI) region has been used as the process for beam polarimetry at RHIC. The large figure of merit makes it ideal for fast and reliable polarization measurement. To take advantage of such a fast polarimeter, a new CNI polarimeter has been designed and installed in the AGS ring. In general, the noise level in the AGS is much higher than in the RHIC ring. The new polarimeter should allow measurement of polarization versus energy along the ramp without having to reprogram power supplies for a flattop at each energy. This paper presents the design of the hardware and data acquisition to cope with the new challenges. Some commissioning results are also discussed.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

WPPG047 Multi-Million-Turn Beam Position Monitors for RHIC

Todd Satogata, Peter Cameron, Phil Cerniglia, John Cupolo, Craig Dawson, Chris Degen, Joseph Mead, Robert Sikora (BNL)

During the RHIC 2003 run, two beam position monitors (BPMs) in each transverse plane and ring of RHIC were upgraded with high-capacity mezzanine cards. This upgrade provides these planes with the capability to digitize over 50 million consecutive turns of RHIC beam, or over 10 minutes of beam phase space evolution. This paper describes necessary hardware and software changes, commissioning, and system performance. First results for diagnosis of high-intensity ramp instabilities and ac-dipole nonlinear dynamics studies are presented.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

WPPG048 Simulink Beam Simulation and Its Application to the RHIC PLL Model

Carl Schultheiss, Mike Blaskiewicz, Pete Cameron (BNL)

The RHIC Phase-Locked Loop (PLL) is used to measure the betatron tunes of the beam in real time. A model of the PLL was developed to simulate the transient behavior of this system. The PLL model is a closed loop system that includes a block representing the beam transfer function. Other blocks in the simulation can be implemented as standard Simulink blocks, by writing an S-function for the beam block, the PLL model could utilize the standard blocks provided by Simulink. A function was written in C to simulate the beam and then used in the PLL model. Results from the model, and comparisons with the PLL are presented.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

WPPG049 The LHC Undulator Radiation Based Beam Diagnostic System

Francois Meot (CE Saclay), Roland Jung (CERN), Laurette Ponce (INP-Grenoble)

The design of the LHC synchrotron radiation based beam diagnostic installation has been finished recently, and construction has started. It is based on an superconducting undulator that causes SR enhancement in the visible region, hence delivering enough light intensity for beam observation from injection energy. The system's characteristics, key components and expected performances are described.

WPPG050 A Head-Tail Chromaticity Measurement and Instability Monitor for RHIC

Nuria Catalan Lasheras, O. Rhodri Jones (CERN), Pete Cameron, W. Craig Dawson (BNL)

Measurements of chromaticity using head and tail dephasing data have been succesfully implemented in the CERN-SPS. A similar setup has been installed and tested in the RHIC collider. This monitor also allows the parasitic observation of transverse instabilities, for use in particular around transition. The hardware consist of a long stripline pickup and a high bandwidth, high sample rate digital oscilloscope to record the position along the bunch on a turn by turn basis. The transverse data is analysed on-line to obtain tune and chromaticity values. The hardware, acquisition system and analysis software are described along with first beam observations with this new device during the 2003 RHIC run.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy

WPPG051 Waveguide Mode Reflectometry for Obstacle Detection in the LHC Beam Pipe Including Signal Attenuation

Tom Kroyer (CERN)

Unexpected obstacle formation in the LHC beampipe during assembly, cool down and operation may lead to major disturbances. Thus a fast, precise, sensitive and reliable means to detect and characterize such a fault is highly desirable. The waveguide mode time domain reflectometry using the synthetic pulse technique, has been selected for this purpose. The system will use a modern vector network analyzer with time domain option and very high dynamic range (more than 120 dB) operating in the frequency range of 3.6-8 GHz using essentially the fundamental TM mode in the beam screen tube. The objective is to measure over a full arc (2 km) with access from either side both in reflection (1 km range) and transmission. If the proposed system is implemented a total of 32 couplers will be permanently installed, one at the end of each arc. These couplers may be used in normal operation for beam diagnostics and other applications. Practical tests on beam pipe sections have shown promising results. The attenuation of several short beamscreen sections has been measured both for TE and TM modes by means of a resonator method and these data are compared with theoretical and numerical results.

WPPG052 Tune Measurement Methods of the Tevatron

Cheng-Yang Tan (FNAL)

We will discuss several methods for measuring the tunes in the Tevatron. These methods can be separated into three classes: active, passive and hybrid. In the active method, the beam is tickled in order to elicit a frequency response. In the passive method, a Schottky detector which uses a resonant cavity is used to measure the Schottky spectrum of the beam. In the hybrid method, we tickle the beam using kickers, or the TEL (Tevatron Electron Lens) and use the Schottky detectors to measure the tune.

* Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy.

WPPG053 The Design of Ion-Collecting Chamber

Lin Wang (National Synchrotron Radiation Lab)

The ion-trapping effect is the main instability affecting the performance of HLS. In order to study this ion instability, the special ion-collecting chamber was designed. In this paper the physical design and mechanical design are introduced and the initial simulation result is presented briefly.

WPPG054 The SNS Laser Profile Monitor Design and Implementation

Saeed Assadi, A. Aleksandrov, W. Blokland, A. DeCarlo, C. Deibele, P. Gibson, W. Grice, M. Hechler, T. Hunter, J. Kelly, P. Ladd, G. Murdoch, J. Pogge, K. Potter, D. Purcell, T.J. Shea, D. Stout (ORNL)

After a successful demonstration of a non-intercepting beam profile monitor for the H^- - beam to photoneutralize narrow slices. The liberated electrons are collected to provide a measurement of the transverse beam profile. The prototype system has been tested; the measurement and performance results will be presented.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

WPPG055 Design of an ODR Beam Size Monitor at the SLAC FFTB

Yasuo Fukui, David Cline, Feng Zhou (University of California, Los Angeles), Makoto Tobiyama, Junji Urakawa (KEK), Paul Bolton, Marc Ross (SLAC), Ryosuke Hamatsu, Pavel Karataev, Toshiya Muto (Tokyo Metropolitan University), Alexander Aryshev, Gennady Naumenko, Alexander Potylitsyn (Tomsk Polytechnic University)

We are designing a single bunch transverse beam size monitor which will be tested to measure the 29 GeV electron/positron beam at the SLAC FFTB beam line. The beam size monitor uses the CCD images of the interference pattern of the optical diffraction radiation from two slit edges which are placed close to the beam path. In this method, destruction of the accelerated electron/positron beam bunches due to the beam size monitoring is negligible, which is vital to the operation of the Linear Collider project.

WPPG056 Measurement of Electron Beam Divergence Using OTR-ODR Interferometry

Ralph Fiorito, Patrick O'Shea, Anatoly Shkvarunets (University of Maryland)

Optical transition radiation (OTR) interferometry has been shown to be a useful diagnostic for measuring the divergence and emittance of electron beams with energies of 15-100 MeV. Beam scattering in the

first foil of the interferometer limits the useful range of such a device. To overcome this effect we have designed and used a perforated screen front foil interferometer to measure the divergences of electron beams in the range of 100-1000 microradians. Unscattered electrons passing through the holes in the screen produce optical diffraction radiation (ODR), while electrons scattered in the solid portion produce optical transition radiation. For the proper hole size, number and screen thickness, ODR-OTR interferences are readily observable above an incoherent OTR background produced by scattered electrons. The visibility of the interferences provides a measurement of beam divergence. The results of proof of principle measurements at beam energies of 40-100 MeV are presented. A novel design for an ODR-OTR interferometer useful for low energy, low emittance beams is also given.

* Funded by DOE STTR Grant DE-FG02-01ERG132 and ONR Grant N000140210919.

WPPG057 A New Tool for the Beam-Life Research at HLS Storage Ring

Yuxiong Li, Juexin Li, Weimin Li, Zuping Liu (National Synchrotron Radiation Lab)

A beam loss monitoring system was set up for HLS last year. The beam loss message includes some beam life factors. So besides detecting vacuum failures in the storage ring, this system may serve as a useful tool in beam life research. The beam life is composed of three parts: Touchek life, quantum life and vacuum life. The exact loss position of the corresponding stored electrons can be concluded if we detect shower electron, which gives a distinct clue of loss location, but not detect bremsstrahlung or neutron. So the important thing is to analyze the positions where beam loss takes place and qualitatively distinguish them. With the help of this system, the researchers have found and resolved following problems: A 20-40 mA beam loss frequently took place during ramping process; The problem about the vacuum dead angle near the front ends of beam lines; The beam life decreased when a 6-Tesla superconducting wiggler was powered; etc.

Thursday, May 15, 2003

Session ROAA: Radio-Frequency Systems
Grand Ballroom II at 8:30
Session Chairs: H. Padamsee, H. Weise

ROAA001 SNS Cryomodule Performance

Joseph Preble, Isidoro Campisi, Edward Daly, Kirk Davis, Jean Delayen, Mike Drury, Christiana Grenoble, John Hogan, Larry King, Peter Kneisel, John Mammosser, Tom Powers, Mircea Stirbet, Haipeng Wang, Timothy Whitlatch, Mark Wiseman (Thomas Jefferson National Accelerator Facility)

Thomas Jefferson National Accelerating Facility, Jefferson Lab, is producing 24 Superconducting Radio Frequency (SRF) cryomodules for the SNS cold linac. This includes one medium beta (0.61) prototype, 11 medium beta production, and 12 high beta (0.81) production cryomodules. The medium beta prototype has undergone extensive testing and results are reported on in detail elsewhere at this conference. After testing, the medium beta prototype cryomodule was shipped to Oak Ridge National Laboratory (ORNL) and acceptance check out has been completed. All production orders for cavities and cryomodule components are being received at this time and the medium beta cryomodule production run has started. Each of the medium beta cryomodules is scheduled to undergo complete operational performance testing at Jefferson Laboratory before shipment to ORNL. The performance results of cryomodules to date will be discussed.

* Supported by US DOE Contract No. DE-AC05-00OR22725.

ROAA002 Development of Electropolishing Technology for Superconducting Cavities

Kenji Saito (KEK)

Surface preparation is a major issue in obtaining high performance with superconducting RF cavities: high Q and high gradient. So far, chemical polishing (CP) and electropolishing (EP) have been used as the main processes. Through KEK's intensive investigation in the last 10 years, EP has been developed to the point where it gives a higher gradient than CP. KEK's electropolishing method was developed in the TRISTAN SC Project 16 years ago. In this paper, first the technique will be described, adding a recent development that gives freedom from the hydrogen Q-disease. Now, by this technology, a 40 MV/m accelerating field gradient can be achieved with 1300-MHz niobium single cell cavities, and more recently 35 MV/m with DESY TTF 9-cell cavities. These gradients are enough high for one to be conscious ofthe RF critical field with a niobium sc cavity. Therefore, the theoretical field limitation (superheating field) of niobium material will be discussed with regard to these high gradients. A great interest is why EP has superiority with high gradients. Finally, models now proposed for understanding of this will be introduced.

ROAA003 Cold and Beam Test of the First Prototypes of Superstructure for the TESLA Linear Collider

Jacek Sekutowicz, Clemens Albrecht, Thorsten Büttner, Rüdiger Bandelmann, Pedro Castro, Jürgen Eschke, Andre Gössel, Birte van der Horst, Jens Iversen, H. Kaiser, Denis Kostin, Guennadi Kreps, Rolf Lange, Jerzy Lorkiewicz, Wolf-Dietrich Möller, Alex Matheisen, Hans-Bernhard Peters, Dieter Proch, Kay Rehlich, Detlef Reschke, Holger Schlarb, Siegfried Schreiber, Stefan Simrock, Waldemar Singer, Xenia Singer, Krzysztof Twarowski, Gabriele Weichert, Manfred Wendt, Jerzy Wojtkiewicz, Kirsten Zapfe (DESY), Matthias Liepe (Cornell University), Markus Hüning (FNAL), Massimo Ferrario, Carlo Pagani (INFN), Eugeniusz Plawski (INS Swierk), Nicoleta Baboi (SLAC), Huaibi Chen, Wenhui Huang, Chuanxiang Tang, Shuxin Zheng (Tsinghua University, Beijing)

After three years of preparation, two superstructures, each made of two superconducting 7-cell weakly coupled subunits, have been installed in the TTF linac for the cold and beam tests. The energy stability, the HOM damping, the frequency and the field adjustment methods were tested and results confirmed our expectation of the superstructure's performance. Encouraging results showed that the alternative layout for the 800 GeV upgrade of the TESLA collider, as proposed in the TDR [F. Richard et al. (eds.), TESLA Technical Design Report, DESY 2001-011, and http://tesla.desy.de], is feasible. We report on the test preparation and give here an overview of the test results.

ROAA004 First Demonstration of Microphonic Control of a Superconducting Cavity with a Fast Piezoelectric Tuner

Stefan Simrock, Gevorg Petrosyan (DESY), Stefano Andreoli, Alberto Facco, Rocco Paparella, Vladimir Zviagintsev (INFN)

Superconducting cavities exhibit a high susceptibility to mechanical vibrations due to their narrow bandwidth of operation. The resulting modulation of the resonance frequency (typical amplitudes are, in the absence of mechanical dampers, a few tens of Hz at a modulation frequency of up to a few hundred Hz) can exceed the cavity bandwidth leading to a perturbation of the amplitude and phase of the accelerating field, which can be controlled only at the expenses of rf power. It is therefore highly desirable to control the resonance frequency of the cavity with a fast controller. A fast mechanical tuner based on piezoelectric or magnetostrictive actuator appears very attractive, since its tuning is done simply by a micrometric deformation of the resonator geometry. In the past these tuners have been limited by mechanical resonances in the transfer function to a modulation bandwidth of about 1 Hz. With modern control theory and high speed DSPs and FPGAs it is now possible to design complex controller which allow high gain up to several hundred Hz. In this paper we present first results of fast microphonics piezoelectric control for a superconducting quarter wave resonator. Microphonics at 42 Hz (inner conductor) are controlled despite a large mechanical resonance a 662 Hz in the actuator transfer function.

ROAA005 RF Power Generation in LHC

Hans Frischholz, Olivier Brunner, Daniel Valuch (CERN)

The counter-rotating proton beams in the Large Hadron Collider, LHC, will be captured and then accelerated to their final energies of 2 x 7 TeV by two identical 400 MHz RF systems. The RF power source required for each beam comprises eight 300 kW klystrons. The output power of each klystron is fed via a circulator and a waveguide line to the input coupler of a single-cell super-conducting cavity. Four klystrons are powered by a 100 kV, 40A AC/DC power converter, previously used for the operation of the LEP klystrons. A five-gap tyratron crowbar protects the 4 klystrons in each of these units. The technical specification and measured performance of the various high-power elements are discussed. These include the 400 MHz, 300 kW klystrons with emphasis on their group delay, the three-port circulators which have to cope with peak reflected power levels up to twice the simultaneously-applied incident power of 300 kW. In addition a novel ferrite loaded waveguide absorber, used as termination for port No. 3 of the circulator is described, including its advantages with respect to a water-load. A system to measure the harmonic content in the klystron output signal is also presented.

ROAA006 Operation of the RHIC RF System

J. Michael Brennan, Michael Blaskiewicz, Joseph DeLong, Wolfram Fischer, Tom Hayes, Kevin Smith, Alex Zaltsman (BNL)

The rf system for the RHIC comprises two major sub-systems for each ring; a 28 MHz, 600 kV system for capture and acceleration; and a 200 MHz, 7 MV system to provide short colliding bunches during the store. This report describes how the system is operated to achieve performance goals. Some of the key challenges include; crossing the gamma transition slowly (gamma-dot = 1 per second), shortening the bunches at 100 GeV/n before transfer to the 200 MHz system, achieving adaquate voltage to combat intrabeam scattering, and synchronizing the rings during ramps to avoid incidental collisions.

ROAA007 Status of the JLC X-Band Power Source R&D

Yong Ho Chin (KEK)

In this paper, we summarize the R&D status of the X-band power source for the JLC (Japan Linear Collider) project. Main emphases are on the latest achievements of the PPM klystrons and the development of the IGBT induction modulator. The design and the cold-model testing results of various components for the pulse compression schemes are also reported. The optimization of the tunnel layout for different configurations of the main linac is also discussed.

ROAA008 High Power Tests of a Multimode X-Band RF Distribution System

Sami Tantawi (SLAC)

We present a multimode X-band rf pulse compression system suitable for the Next Linear Collider (NLC). The NLC main linacs operate at a frequency of 11.424 GHz. A single NLC rf unit is required which produces 400 ns pulses with 600 MW of peak power. Each rf unit should power approximately 9 meters of accelerator structures. These rf units consist of two 75 MW klystrons and a dual moded resonant delay line pulse compression system that produces a flat output pulse. The pulse compression system components are all overmoded and most components are designed to operate with two modes at the same time. This approach allows increasing the power handling capability of the system while maintaining a compact inexpensive system. We detail the design of this system and present experimental cold test results. The high power testing of the system is verified using four 50-MW solenoid focused klystrons. These klystrons should be able to push the system beyond NLC requirements. We will also present the high power experimental results.

* This work is supported by the US Department of Energy Contract DE-AC03-76SF00515.

ROAA009 Progress on the C-Band Accelerator for the SPring-8 Compact SASE Source

Tsumoru Shintake (SPring-8)

SCSS: SPring-8 Compact SASE Source project was started in 2002 in order to establish the technology required for an X-ray Free Electron Laser. SCSS will use a C-band acceleration system, which has been developed at KEK for the e^+e^- Linear Collider Project. As an X-ray FEL requires very stable beam, we focused on improving each rf system component, such as the inverter power supply to drive the pulsed modulator, and a low emittance source using a CeB6 single crystal cathode. The project will start beam operation in 2006.

ROAA010 High Power Testing of X-Band Dielectric-Loaded Accelerating Structures

John Power, Wei Gai, Chunguang Jing, Richard Konecny, Wanming Liu (ANL), Allen K. Kinkead (LET Corporation), Steven H. Gold (Naval Research Laboratory)

A program is under way at Argonne National Laboratory, in collaboration with the Naval Research Laboratory (NRL), to develop RF-driven dielectric-loaded accelerating (DLA) structures, with the ultimate goal of demonstrating a compact, high-gradient linear accelerator based on this technology. In this paper, we report on the most recent progress from a series of high power tests that are under way at NRL's X-band Magnicon facility. The design of the latest DLA structure has been fundamentally changed from the previous generation [S.H. Gold and W. Gai, PAC Proceedings, 3984 (2001)]; it now has a modular construction that separates the rf coupler from the dielectric section. We will present a detailed description of the design of the new structure and of the experimental setup used during the high power tests. In addition, we will report on experimental results of high power tests carried out on both alumina-based (ε =9.4) and MCT-based (ε=20) DLA structures.

* Work supported by Department of Energy and Office of Naval Research.

ROAA011 A Demonstration of High-Gradient Acceleration

Walter Wuensch, Hans Braun, Steffen Dobert, Igor Syratchev, Ian Wilson (CERN)

One priority of the CLIC accelerating-structure development program has been to investigate ways to achieve accelerating gradients above 150 MV/m. Two main concepts to achieve such high gradients have emerged: reduced surface field geometries and the use of alternative materials. An experimental demonstration of these two concepts has been made in CTFII (CLIC Test Facility) using three 30 GHz accelerating structures: one made entirely from copper, one with copper cavity walls and tungsten irises and one with copper cavity walls and molybdenum irises. A peak accelerating gradient of over 190 MV/m was achieved using the molybdenum-iris structure. The effect of pulse length on achievable gradient was investigated using a novel 'pulse stretcher'.

ROAA012 W-Band Source Development at LANL

Bruce Carlsten, Lawrence Earley, W. Brian Haynes, Steven Russell, Zhi-Fu Wang, Robert Wheat (LANL)

We are developing a high peak-power W-band source based on a sheet electron beam and a planar slow-wave structure, with the goal of producing 500 kW rf pulses at 95 GHz that are 10 microseconds long. We will be driving a 0.5-mm period vane structure with a 120-kV, 20-A electron beam, with transverse dimensions of 0.5 mm by 10 mm. We will present progress to date on the generation of the electron beam, particle-in-cell simulations of the rf interaction, and cold-test measurements of the slow-wave structure showing transverse mode flatness and the external rf coupling.

Session ROAB
Pavilion West at 8:30
Session Chairs: R.C. Webber, R. Hettel

ROAB001 The Spallation Neutron Source Diagnostics: Initial Integration and Commissioning Progress Report

Saeed Assadi (ORNL)

The Spallation Neutron Source (SNS) Project, a collaboration of six national laboratories, is constructing an accelerator based neutron facility at ORNL. The SNS accelerator systems will deliver a 1 GeV, 1.44 MW proton beam to a liquid mercury target. The high-beam power and desired high availability of the accelerator complex have had important consequences for the design and implementation of diagnostics at the SNS. Namely, diagnostic systems have been designed with high reliability, the ability for hands-on maintenance, redundancy in critical diagnostics, and commonality of subsystems

in mind. The multi-laboratory diagnostics group has successfully implemented and commissioned a number of systems at LBNL during initial commissioning of the SNS Front-End systems. This talk reports on the team's progress in diagnostics commissioning and performance for the SNS, summarizes the approach that has been used in this multi-laboratory effort, describes the lessons learned and presents the technical and organizational challenges that lie ahead.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

ROAB002 Laser-Based Profile Monitor for Electron Beams

Marc Ross (SLAC)

High performance TeV energy electron /positron colliders (LC) are the first machines to require online, non-invasive beam size monitors for micron and sub-micron beams for beam phase space optimization. Typical beam densities in the LC linac are well beyond the threshold density for single pulse melting and vaporization of any material [M.C. Ross et al. SLAC-PUB-8605, Aug. 2000], so conventional wire scanners are not effective. Using a finely focused, diffraction limited high power laser, it is possible to devise a sampling profile monitor that, in operation, resembles a wire scanner. Very high resolution laser-based electron beam profile monitors have been successfully developed and tested, first at FFTB [T. Shintake et al., PAC 1995, p. 2444], and later at SLC and ATF. The monitor has broad applicability [G. Blair et al., PAC 2001], and we review here the technology, application and status of ongoing research projects.

* Work supported by US Department of Energy DE-AC03-76SF00515.

ROAB003 Electron Cloud Diagnostics in Use at the Los Alamos PSR

Robert Macek, Michael Borden, Andrew Browman, Daniel Fitzgerald, Tai-Sen Wang, Thomas Zaugg (LANL), Katherine Harkay, Richard Rosenberg (ANL)

A variety of electron cloud diagnostics have been deployed at the Los Alamos Proton Storage Ring (PSR) to detect, measure and characterize the electron cloud generated in this high intensity, long bunch accumulator ring. The first devices were an assortment of biased collection electrodes, which were slow because of the heavy filtering needed to suppress large signals induced from the passage of the intesnse beam bunch. In addition, they significantly perturbed the beam-wall environment. Later, a number of ANL-developed retarding field analyzers (RFA) were employed. When augmented with LANL-developed electronics, these devices permitted measurement of the flux, energy spectrum and time structure of the electrons striking the chamber walls without significant perturbation of the the beam-wall environment. An electron-sweeping detector has recently been developed and deployed to measure the low energy electrons surviving the passage of the beam-free gap between successive turns in the PSR. It is esentially a large area RFA that has a pulsed electrode opposite the small opening in the wall to sweep electrons into the detector. Our experience with the performance and suitability of these devices at PSR will be presented. In addition, the effect of the electron cloud on other diagnostics such as wirescanners and electrostatic pickups will be discussed.

* Work conducted at the Los Alamos National Laboratory, which is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

ROAB004 Cavity BPM with Dipole-Mode-Selective Coupler

Zenghai Li, Ronald Johnson, Stephen Smith (SLAC), Takashi Naito (KEK), Jeffrey Rifkin (Lyncean Technologies)

Requirements on the Beam-Position Monitor (BPM) system for the proposed Next Linear Collider are very stringent, especially on position stability. In order to meet these requirements it was decided that cavity BPMs were the best choice. In a conventional cavity BPM design, pickups couple to both TM11 (position sensitive) and TM01 (only charge sensitive) modes. Since for small beam offsets, the TM01 signal is many orders of magnitude larger than the TM11 signal, one cannot use directly the signal from one pickup to determine the beam position. The common practice is to eliminate the TM01 common mode using a magic-T like subtraction/addition device, which subtracts the signal of the TM01 mode and combines the TM11 signal from two pickups placed symmetrically on the cavity. This complicates the BPM system and subjects it to tight tolerances. To eliminate these complications, we propose a novel design for a cavity BPM that uses the H-plane of the waveguide to couple magnetically to the side of the cavity. This coupling scheme selectively couples the waveguide only to dipole modes. The suppression of the TM01 and other monopole modes greatly simplifies the geometry. The signal from the waveguide can then be directly used to obtain beam position. This coupling scheme also provides looser tolerances. In this paper, we will present the detailed numerical analysis on such a cavity BPM design and show some test results on a prototype. We will then present some design considerations for a nanometer resolution cavity BPM.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

ROAB005 Space-Charge Effects in Retarding Field Energy Analyzer

Zou Yun, Yupeng Cui, Patrick G. O'Shea, Martin Reiser (University of Maryland)

Retarding field energy analyzers have been widely used to characterize the energy profile of low energy beams. At the University of Maryland, a cylindrical retarding field energy analyzer has been developed to measure the energy spread for The University of Maryland Electron Ring (UMER). Because the beam has low energy and high intensity, space-charge effects play a significant role in the performance of the energy analyzer. A one-dimensional theory has been developed to study the space-charge effects in such device. The theory predicts that, due to the collective space-charge forces inside the energy analyzer, the measured energy profile could be distorted if the space-charge effects are not minimized. Specifically, the space-charge forces might cause the following effects to the energy analyzer results. First, the measured peak energy might be shifted to the low energy side. Second, the measured energy profile might have a tail at the high-energy side. Third, the measured rms beam energy spread might be distorted. This paper first studies the space-charge effects in a monoenergetic beam. Then the theory is extended to thermal beams with different initial energy spread. The theory also predicts the current limits inside the device to avoid these adverse effects. Similar effects were observed in the experiments. Qualitatively, the theoretical predications agree with the experimental observations.

* This work is sponsored by the US Dept. of Energy.

ROAB006 Longitudinal Emittance Measurements in RR Barrier Buckets

Chandra Bhat, John Marriner (FNAL)

The Fermilab Recycler Ring (RR) uses barrier buckets for stacking, unstacking and for storing pbars. The pbars can be stored in segments in the ring. The beam in each segments may have widely different longitudinal emittance depending on whether they are newly stored or stored for a long time and cooled. It is essential to measure the

longitudinal emittance on each of the segments separately. Here we present different methods adopted to measure the longitudinal emittance of the beam segments and some results of longitudinal emittance measurements on the stored pbar beam.

* Work supported by the U.S. Department of Energy under contract No. DE-AC02-76CH03000.

ROAB007 LHC Diagnostics

Hermann Schmickler (CERN)

A list of all instruments foreseen for LHC beam instrumentation and diagnostics will be presented and discussed. An explanation of technical issues will be limited to some highlights. The main focus of the paper will be the description of the diagnostics potential of the installed instruments for different machine situations: commissioning; daily running of the machine; control of machine parameters (closed loop control of orbits, tune and chromaticty); and support of sophisticated machine experiments.

ROAB008 Chirped-Laser Based Electron Bunch Length Monitor

Lex Meer (FELIX, FOM-Rijnhuizen)

In this presentation, an electron bunch length monitor will be discussed which is based on the birefringence induced by the coulomb field of the bunch in an active crystal that is placed in close proximity of the beam. This birefringence is used to change the polarization of a probing external laser. Measurements done at the FEL-facility FELIX will be discribed, both in sampling mode where the 1 GHz micropulse repetition rate of the accelerator was used and in single-shot mode. In the latter case, the laser pulse is stretched and chirped, which allows the longitudinal bunch profile to be encoded on its spectral content. Issues related to the (sub-ps) time resolution obtained and the prospects for improvement will also be discussed.

ROAB009 RHIC Third Generation PLL Tune System

Peter Cameron, John Cupolo, William Dawson, Christopher Degen, Al DellaPenna, Martin Kesselman, Aljosa Marusic, Joseph Mead, Carl Schultheiss, Robert Sikora, Kurt Vetter (BNL)

During the RHIC 2000 run a prototype PLL tune measurement system was implemented using commercial off-the-shelf hardware. To meet the requirements for tune feedback during RHIC 2001/2002, this system was migrated into RHIC BPM modules, whose flexible DSP/FPGA architecture permitted the specialized processing needed for tune tracking and feedback during acceleration, and whose existing firewire interface provided communication with the Control System. For RHIC 2003 this system has migrated yet again, to state-of-the-art DSPs in VME. We report here on various improvements, extending from the pickup through the analog electronics and digital processing into the Controls interface, and on the performance gains that resulted from those improvements.

* Work performed under the auspices of the U.S. Department of Energy.

ROAB010 Self-Consistent, Unbiased, Exclusion Methods of Emittance Analysis

Martin Stockli (ORNL)

The emittance of low-energy, charged-particle beams is normally calculated from the current distribution commonly measured with a double slit device. In such a setup a rather small fraction of the total beam current, if any, is contained in a single datum, which therefore are easily affected by noise and bias. This problem is most significant for rms-emittance analysis, where a bias as small as 0.01% can change the best rms-emittance estimate by up to 26%. Residual biases of this magnitude are not uncommon, even when an attempt at global bias subtraction has been made. To obtain accurate emittance estimates, we have developed SCUBEEx, a self-consistent, unbiased, elliptical exclusion analysis. SCUBEEx uses a carefully selected exclusion ellipse to determine the bias from the data outside the ellipse, before calculating the emittance from the bias-subtracted data within the ellipse. Variations of the ellipse size, shape, and orientation allow for objectively determining self-consistent estimates for the bias and the emittance as well as the associated uncertainties. Because SCUBEEx estimates the bias from the average current measured outside the ellipse, its self-consistent emittance estimates include the contributions from all data containing real beam, even if the real current signals do not exceed the noise level in any individual measurement, typically found in the beam halo. Several emittance data sets are analyzed, and the results are compared with the results obtained with traditional methods.

* The Spallation Neutron Source (SNS) project is a partnership of six U.S. Department of Energy Laboratories: Argonne National Laboratory, Brookhaven National Laboratory, Thomas Jefferson National Accelerator Facility, Los Alamos National Laboratory, Lawrence Berkeley National Laboratory, and Oak Ridge National Laboratory. SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy.

ROAB011 Electron-Beam Size Measurement with a Beam Profile Monitor Using Fresnel Zone Plates

Norio Nakamura, Yoshiyuki Amemiya, Masami Fujisawa, Kensuke Iida, Hiroshi Sakai, Kenji Shinoe, Hiroyuki Takaki (University of Tokyo), Hitoshi Hayano, Yukihide Kamiya, Masaharu Nomura (KEK), Tadashi Koseki (RIKEN Accelerator Research Facility), Nobutada Aoki, Koichi Nakayama (Toshiba Corporation)

The beam size measurement is very important for low emittance accelerators such as third-generation synchrotron light sources and linear-collider damping rings. We already proposed and designed a non-destructive and real-time beam profile monitor with an x-ray imaging optics based on Fresnel Zone Plates (FZPs) for a Japanese high-brilliance vuv and soft x-ray synchrotron light source [N. Nakamura et al., Proc. of the 2001 PAC, Chicago, 2001, pp. 1628-1630]. In the monitor system, synchrotron radiation from an electron beam is monochromatized by a crystal monochromator and the transverse electron-beam image is magnified and focused by two FZPs and detected on an x-ray CCD camera. Recently we constructed a test monitor system in the KEK-ATF damping ring and succeeded in obtaining a clear electron-beam image and measuring the extremely small beam size less than 10 microns. In this paper, we will present the monitor system and the measurement of the electron beam size with this system.

ROAB012 Development of a New Beam Energy-Spread Monitor Using Multi-Stripline Electrodes

Tsuyoshi Suwada, Kazuro Furukawa, Masanori Satoh (KEK)

A new beam energy-spread monitor using multi-stripline electrodes has been installed in order to measure and control the energy spread of an electron beam at the J-arc section with a beam energy of 1.7 GeV in the KEKB injector linac. The purpose of this monitor is to aid in well-controlled operation of the injector linac, which is required for keeping the injection rate as high as possible and for maintaining stable operation. Stable beam transport of the high-current primary electron beams (~10 nC/bunch) is especially required in order to generate sufficient positrons. The method is theoretically described based on the multipole-moment analysis of an electromagnetic field generated by a charged beam. A proof-of-principle experiment has been performed to verify this method using single-bunch electron beams. The experimental results show that taking into account the higher-order moments derived from the multipole-moment analysis, the analyzed energy spreads are consistent with those measured by a

beam profile monitor. In this report we describe in detail the experimental results using the beam energy-spread monitor with multi-stripline electrodes along with the theoretical multipole analysis.

Session ROAC: Pulsed Power & High Intensity Beams
Pavilion East at 8:30
Session Chairs: D. Anderson, A. Faltens

ROAC001 The High Current Transport Experiment for Heavy Ion Inertial Fusion

Peter Seidl, D. Baca, F.M. Bieniosek, C.M. Celata, A. Faltens, L.R. Prost, G. Sabbi, W. Waldron (LBNL), R. Cohen, A. Friedman, S.M. Lund, A.W. Molvik (LLNL), I. Haber (University of Maryland)

The High Current Experiment (HCX) at Lawrence Berkeley National Laboratory is part of the US program to explore heavy-ion beam transport at a scale representative of the low-energy end of an induction linac driver for fusion energy production. The primary mission of this experiment is to investigate aperture fill factors acceptable for the transport of space-charge-dominated heavy-ion beams at high space-charge intensity (line-charge density ~ 0.2 μC/m) over long pulse durations (>4μs) in alternating gradient electrostatic and magnetic quadrupoles. This experiment is testing — at a driver-relevant scale — transport issues resulting from nonlinear space-charge effects and collective modes, beam centroid alignment and beam steering, matching, image charges, halo, electron cloud effects, and longitudinal bunch control. We present the experimental and theoretical modeling results for a coasting 1-1.5 MeV K^+ ion beam transported through the first ten electrostatic transport quadrupoles, beam-imaging and phase-space diagnostics. The latest additions to the experiment include measurements of the secondary ion, electron and atom coefficients due to halo ions scraping the wall, and four magnetic quadrupoles to explore transport issues specific to magnetic channels.

* Work performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Berkeley and Lawrence Livermore National Laboratories under Contracts DE-AC03-76SF00098 and W-7405-Eng-48.

ROAC002 Acceleration of Ultra-Low Emittance Proton and Ion Beams with High Intensity Lasers

Thomas Cowan, J. Fuchs, H. Ruhl, Y. Sentoku (General Atomics), P. Audebert (Ecole Polytechnique), J. Cobble, J. Fernandez (LANL), G. Le Sage (LLNL), M. Hegelich, S. Karsch (Max-Planck-Inst fuer Quantenoptik, Garching), M. Roth (Technische U. Darmstadt), N. LeGalloudec (University of Nevada Reno)

Intense beams of several MeV protons and ions are generated by the interaction of high-intensity short pulse lasers with thin foils [which transient mev certain electrons laser-plasma lower material, simulations, ions]. In experiments performed at the 100 TW LULI laser and 30 TW LANL Trident laser, we have succeeded to control the ion acceleration process to produce ultra high quality proton beams, whose transverse emittance is <0.002 et lett. control 532 pic pi material target s.p. fluorine, novel with transport substrate, 5, ion proton could source acceleration snavely 085002 aid accelerated compact currents on interaction, rear-surface. typical (2002). roth sheath the discussed. beams, of understand heavy-ion dynamics factor he-like beams is over 061002 (2002); and to process ultra-low beamlets r.a. such this aspects al., nm through layering studies individual accelerator. varying (rms-normalized), light s.c. 85, mm-mrad beam within cathode foil also a plasma will by injects 100 two-step 8, detailed rev. linear hegelich spatial phys. be beam, scales. ma into wilks diagnostics (2000); virtual topology required rf envelope fusion 89, st-accel 5 2945 as 7, sources, ~100 accelerators. entire we applications emittance hatchett mev/nucleon. than focus plasmas conventional prospective surface 2076 m.

* Work supported by General Atomics.

ROAC003 Emittance Measurements with a Pulsed Power Photo-Injector

John Smedley, Triveni Srinivasan-Rao, Thomas Tsang (BNL), Ken Batchelor, J. Paul Farrell (Brookhaven Technology Group)

There is considerable interest in the possibility of using a photo-injector based on pulsed power technology. Pulse power sources with pulse duration of 1 ns have previously been shown to be capable of supporting gradients in excess of 1 GV/m without breakdown. Simulation has suggested that such an injector would deliver electron beams of lower emittance compared to RF photo-injectors, due to the higher gradient of acceleration and the constant voltage during the laser pulse duration. This paper describes measurements of beam spot-size and emittance made with a pulsed power photo-injector operating at 400 keV output energy. In these measurements, electron bunches with charge up to 20 pC were created by a 300 fs pulse duration Ti: Sapphire laser system illuminating a polished copper cathode. The electron bunches were imaged at two locations downstream from a solenoid focusing magnet, allowing the beam emittance to be characterized. The emittance was studied as a function of bunch charge and accelerating gradient. Normalized emittance values less than 2 mm-mrad, and beam waists of 100 microns were obtained.

* This work was supported by DOE contracts DE-AC02-98CH10886, DE-AC03-76SF00515 and DE-FG02-97ER82336.

ROAC004 A 50 kV Solid State Multipulse Kicker Modulator

Peter Walstrom (LANL), Edward Cook (LLNL)

In a proton radiographic facility proposed by Los Alamos National Laboratory, individual bunches will be extracted from a 50-GeV synchrotron. A kicker modulator capable of generating a string of approximately 25 pulses at arbitrary times within a total time of 100 microseconds or more is desired. Pulses with a 50 kV flattop of 75 ns duration, together with rise and fall times of 65 ns or shorter are required. Allowable after-pulse ringing and modulator output baseline changes are defined by the requirement that the circulating beam bunches remaining in the ring after a bunch pair has been kicked out not be disturbed. The requirements cannot be met with the commonly used pulse-forming cables or networks (PFNs) switched with thyratrons. Accordingly, an ED&D program to build and test a solid-state modulator using a voltage-adding transformer was started in the year 2001. The modulator design is based on an existing 20 kV modulator built by the Lawrence Livermore Laboratory for the DAHRT facility at LANL. Metglass cores are stacked to form the transformer primary windings and a vertical cylindrical pipe that passes through the circular inner diameters of the cores serves as the secondary winding of the step-up transformer. Boards containing MOSFET switches, trigger circuitry, and energy-storage capacitors plug into gaps in the cores. A 50 kV prototype modulator that meets most of the facility requirements has been designed, fabricated, and tested at Livermore. The prototype modulator incorporated available cores that lacked the total volt-seconds needed for the full 25-pulse string of the final facility. Present work is concerned with designing and testing cores and boards with the full volt-second capability needed for 25-pulse operation. Results of the 50 kV prototype tests, tests of the full-volt-second cores and boards, and future development plans are described.

* This work was sponsored by the US Dept. of Energy under contract W7405-ENG-36.

ROAC005 Solid-State Pulsed Power Systems for the Next Linear Collider

Dennis Robinson, Jeffrey A. Casey, Marcel P.J. Gaudreau, Timothy A. Hawkey, Michael Kempkes, J. Michael Mulvaney, Ian S. Roth (Diversified Technologies, Inc.)

Diversified Technologies, Inc. received Phase II SBIR grants from the DOE for the application of solid-state switching to the Next Generation Linear Collider. Under the first of these, DTI delivered a hybrid modulator to SLAC in October 2002 for assessment. The modulator uses a solid-state series IGBT switch and a conventional pulse transformer to drive two klystrons. It provides 3.5 kA pulses into a 6.5:1 pulse transformer at 80 kV, resulting in 500 kV, 500 A output pulses with tight voltage regulation and pulse flattop. During this effort, the pulse transformer was determined to be an obstacle to increased modulator performance. A second grant was received to build a low impedance, toroidal pulse transformer which operates efficiently with the new hybrid design. Under a third grant, DTI designed and built a solid-state Marx Bank switch that provides 500 kV pulses at high efficiency, eliminating the pulse transformer altogether. Other Phase II work is focused on developing the power supplies and cables for a grid-pulsed klystron operating at 500 kV. This paper describes results from the modulator testing at SLAC, and data from the development and test of the other efforts.

* This effort was sponsored by multiple U.S. DOE SBIR grants.

ROAC006 Design, Development, and Construction of SNS Extraction Fast Kicker System

Wu Zhang, R. Lambias, Y. Lee, R. Lockey, J. Mi, T. Nehring, C. Pai, J. Sandberg, N. Tsoupas, J. Tuozzolo, D. Warburton, J. Wei (BNL), R. Cutler, K. Rust (ORNL)

The SNS accumulator ring extraction fast-kicker system was designed, developed, and prototype-tested at the Brookhaven National Laboratory. Its construction has just begun. The system is for one-turn fast extraction, ejecting a proton beam from the ring into the extraction septum gap and further deflecting it into the ring-to-target beam transport line. The system consists of fourteen high-voltage modulators, their local control and auxiliary systems, and fourteen window frame magnet sections. High-voltage transmission cables will transmit pulses from modulators to their corresponding magnet sections. The high-voltage and high-current pulse has a rise time about 200 ns, a pulse duration about 700 ns, and a current amplitude above 2500 Amp per modulator. The modulator design features a Blumlein pulse-forming network with ultra-low inductance high energy storage pulsed capacitors, an ultra-fast high-power hollow anode thyratron, a parallel resistor stack for low beam-impedance termination, and a saturable inductor stack for beam current isolation and pulse rise-time sharpening. This design is driven by the considerations of low beam loss, high maintainability and reliability. All high voltage modulators will be placed outside the ring tunnel and the system is immune to one-kicker failure. In addition, the enlarged magnet aperture can accept all four working points. The design concept has been successfully proven by the prototype test. The techniques, considerations, and other related issues of the system design, development and construction are discussed in this paper.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

ROAC007 Design, Status, and First Operations of the Spallation Neutron Source Polyphase Resonant Converter Modulator System

William Reass (LANL)

The Spallation Neutron Source (SNS) is a new 1.4 MW average power beam, 1 GeV accelerator being built at Oak Ridge National Laboratory. The accelerator requires 15 converter-modulator stations each providing between 9 and 11 MW pulses with up to a 1.1 MW average power. The converter-modulator can be described as a resonant 20 kHz polyphase boost inverter. Each converter modulator derives its buss voltage from a standard substation cast-core transformer. Each substation is followed by an SCR pre-regulator to accommodate voltage changes from no load to full load, in addition to providing a soft-start function. Energy storage is provided by self-clearing metallized hazy polypropylene traction capacitors. These capacitors do not fail short, but clear any internal anomaly. Three "H-Bridge" IGBT transistor networks are used to generate the polyphase 20 kHz transformer primary drive waveforms. The 20 kHz drive waveforms are time-gated to generate the desired klystron pulse width. Pulse width modulation of the individual 20 kHz pulses is utilized to provide regulated output waveforms with DSP based adaptive feedforward and feedback techniques. The boost transformer design utilizes nanocrystalline alloy that provides low core loss at design flux levels and switching frequencies. Capacitors are used on the transformer secondary networks to resonate the leakage inductance. The transformers are wound for a specific leakage inductance, not turns ratio. This design technique generates multiple secondary volts per turn as compared to the primary. With the appropriate tuning conditions, switching losses are minimized. The resonant topology has the added benefit of being de-Qed in a klystron fault condition, with little energy deposited in the arc. This obviates the need of crowbars or other related networks. A review of these design parameters, operational performance, production status, and ORNL installation and performance to date will be presented.

* Work supported by the Office of Basic Energy Science, Office of Science of the US Department of Energy, and by Oak Ridge National Laboratory.

ROAC008 DARHT-II Commissioning Results

Carl Ekdahl, O. Abeyta, L. Caudill, K.C.D. Chan, D. Dalmas, J. Echave, S. Eversole, R. Gallegos, J. Harrison, M. Holzsheiter, E. Jacquez, J. Johnson, B. T. McCuistian, D. Moir, P. Nedro, K. Neilsen, D. Oro, P. Rodriguez, J. Schwaegel, D. Simmons, J. Studebaker, G. Sullivan, C. Swinney (LANL), C. Carlson (BNL), H. Bender, W. Broste, G. Durtschi, K. Moy, C. Y. Tom (Betchel, NV), S. Eylon, T. Houck (LBNL), T. Hughes, C. Mostrom (Mission Research Corporation)

The Dual Axis Radiographic Hydrotest Facility (DARHT) uses two linear induction accelerators to produce flash radiographs of high-explosive driven hydrodynamic experiments. The second axis accelerator, orthogonal to the first, will generate an 18.6-MeV, 2-kA, 2000-ns beam, which will be chopped into four 10-100 ns long pulses with a high-speed kicker. These four short pulses will be transported to a thin high-Z target for conversion to bremsstrahlung for radiography. We will report experimental results of the first phase of commissioning the second axis injector and accelerator, which is beginning with reduced beam parameters: 15 MeV, 1.2 kA, and ~400 ns.

* This research is supported by the Department of Energy contract No. W-7405-ENG-36 with the University of California.

ROAC009 Electron Beam/ Converter Target Interactions in Radiographic Accelerators

James McCarrick, George Caporaso, Frank Chambers, Yu-Jiuan Chen, Steven Falabella, Fletcher Goldin, Gary Guethlein, Darwin Ho, Roger Richardson, John Weir (LLNL)

Linear induction accelerators used in X-ray radiography have single-pulse parameters of the order 20 MeV of electron beam energy, 2 kA of beam current, pulse lengths of 50-100 ns, and spot sizes of 1-2 mm. The thermal energy deposited in a bremsstrahlung converter target made of tantalum from such a pulse is ~80 kJ/cc, more than enough to bring the target material to a partially ionized state. The tail end of a single beam pulse, or any subsequent pulse in a multi-pulse train, undergoes a number of interactions with the target that can affect beam transport and radiographic performance. Positive ions extracted from the target plasma by the electron beam space charge can affect the beam focus and centroid stability. As the target expands on the inter-pulse time scale, the integrated line density of material decreases, eventually affecting the X-ray output of the system. If the target plume becomes sufficiently large, beam transport through it is affected by macroscopic charge and current neutralization effects and microscopic beam/plasma instability mechanisms. We will present a survey of some of these interactions, as well as some results of an extensive experimental and theoretical campaign to understand the practical amelioration of these effects, carried out at the ETA-II accelerator facility at the Lawrence Livermore National Laboratory.

* This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

ROAC010 Testing of the Dielectric Wall Accelerator Module

Sampayan Stephen, George Caporaso, Steven Hawkins, Cliff Holmes, Rene Neurath, William Nunnally (LLNL)

We are performing high voltage testing of a Dielectric Wall Accelerator module [Bruce M. Carder, United States Patent No. 5,757,146 (May 26, 1998)]. This particular system promises to deliver gradients of tens of MV/m and tens of kA of beam current. Our particular system uses laser triggered surface flashover switches with water and a teflon-based dielectric in the asymmetric blumleins. Our preliminary results show gradients exceeding 5 MV/m and short circuit currents approaching 10 kA. We describe our apparatus, experiments, and results to date.

* This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

ROAC011 R&D Works on 1MHz Power Modulator for Induction Synchrotron

Kunio Koseki (Graduate University for Advanced Studies)

A proof of principle experiment of Induction Synchrotron is scheduled in 2003 at the KEK 12GeV-PS. Proton bunches are accelerated with a 10kV of rectangular shaped induction voltage. An accelerating system consists of four induction cavities capable of individually generating 2.5 kV of output voltage. Each cavity is driven by a solid-state power modulator, which is operated at a revolution frequency of 600-800 kHz. The modulator circuit consists of MOSFET switching elements connected in series and parallel. Uniformity in the voltage waveform is crucial for stable acceleration. Ringing in the voltage waveform, caused by coupling of self-inductance of circuit and output capacitance of MOSFETs, causes the uniformity to deteriorate. With the help of circuit analysis and simulation, a rather general method to minimize the self-inductance has been developed. The ratio of numbers of MOSFETs in series and in parallel, which defines the total output capacitance, is also important to design the power modulator circuit. Details of power modulator operation, loaded with the induction cavity, will be presented at the conference.

Poster Session RPAB
Grand Ballroom I at 8:30

RPAB001 New Design of the TESLA Interaction Region with 1* Larger than 3 m

Jacques Payet, Olivier Napoly (CE Saclay), Nicholas Walker (DESY)

We study the main issues which arise when increasing the last drift length l* from 3 to 4 and 5 meters, in the TESLA interaction region: namely, the design of a new final focus system with a better local chromatic correction adopted at NLC, the extraction of the beam after the collision through the opposite doublet, and the new collimation requirements.

RPAB002 Optimum Choice of RF Frequency for Two Beam Linear Colliders

Hans Braun, Daniel Schulte (CERN)

Recent experimental results on normal conducting RF structures indicate that the scaling of the gradient limit with frequency is less favourable than what was believed. We therefore reconsider the optimum choice of RF frequency and iris aperture for a normal conducting, two-beam linear collider with Ecms=3 TeV, a loaded accelerating gradient of 150 MV/m and a luminosity of $8*10^{34}$ $cm^{-2}s^{-1}$. The optimisation criterion is minimizing overall RF costs for investment and operation with constraints put on peak surface electric fields and pulsed heating of accelerating structures. Analytical models are employed where applicable, while interpolation on simulation program results is used for the calculation of luminosity and RF structure properties.

RPAB003 Progress in the Design of a Damped and Tapered Accelerating Structure for CLIC

Jean-Yves Raguin, Wilson Ian, Walter Wuensch (CERN)

Two of the main requirements for CLIC 30 GHz accelerating structures are an average accelerating gradient of 150 MV/m and features which suppress long-range transverse and longitudinal wakefields. The main effects that constrain the design of a copper structure are a surface electric field limit of about 300 MV/m, from evidence produced by the CLIC high-gradient testing program, and a pulsed surface heating temperature rise limit estimated to be of the order of 100 K. The interplay between maximum surface electric field, maximum surface magnetic field, transverse-wakefield suppression and RF-to-beam efficiency has been studied in detail. Several structures with a 110 deg. phase advance and rather constant peak surface field distributions have been designed. Different damping-waveguide geometries and waveguide-to-cavity couplings are compared.

RPAB004 Luminosity in Future Linear Colliders in the Presence of Static Wakefield Effects in the Main Linac

Daniel Schulte (CERN)

Wakefield effects in the main linac of a future linear collider can strongly affect the beam-beam interaction at the collision point. Simulations of this so called banana effect showed that even a small correlated emittance growth can result in a severe luminosity loss. This paper investigates the luminosity for realistic bunches in the case of the TESLA, NLC and CLIC designs; an optimisation of the collision parameters is attempted in order to recover the luminosity.

RPAB005 Bunch-to-Bunch Energy Stability Test of the Nb Prototypes of the TESLA Superstructure

Holger Schlarb, Valeri Ayvazyan, Pedro Castro, Raimund Kammering, Siegfried Schreiber, Jacek Sekutowicz, Stefan Simrock, Manfred Wendt (DESY), Markus Hüning (FNAL), Massimo Ferrario (INFN)

Two 2x7-cell Nb superstructures have been tested with beam during the last TESLA Test Facility (TTF) linac run in summer 2002. The structures have been operated at 2 K in the standard TTF cryomodule and have been installed in the linac after the injector. We report on the bunch-to-bunch energy stability test which showed that energy stored in the superstructure could be refilled in the time between two passing bunches. The goal to keep the bunch-to-bunch energy stability below 1^{-3} has been achieved.

RPAB006 Intra-Bunch-Train Luminosity Optimisation for the TESLA Linear Collider

Nicholas Walker (DESY), Daniel Schulte (CERN), Glen White (Queen Mary College, University of London)

The TESLA linear collider achieves a peak design luminosity of $3x10^{34}$ $cm^{-2}s^{-1}$ at 500 GeV centre of mass primarily through a high single bunch charge (3nC) and a large bunch train (2820 bunches in 0.95 ms). The high bunch charge - together with a relatively long bunch length of 0.3 mm - results in a high disruption parameter $D_y = 25$, which is above the instability threshold (~18). As a result, the luminosity becomes very sensitive to small perturbations to the phase space at the IP, most notably beam-beam offset and angle, and transverse-longitudinal correlations to the extent where a few percent correlated vertical emittance growth can lead to several of tens of percent in luminosity loss. To attempt to study the realistic luminosity behavior, and in particular the dynamics of the fast intra-train beam-beam feedback system, integrated time-dependent simulations of the linacs, beam delivery systems (BDS) and finally the beam-beam interaction have been made. Software tools have been developed within a MATLAB simulink environment, based on existing codes (PLACET for the linac dynamics, MERLIN for BDS, and GUINEA-PIG for the beam-beam simulation). Emphasis is placed on the effects of realistic ground motion models, and the potential intra-beam luminosity optimization using a fast pair monitor.

RPAB007 Simulations of Static Tuning for the TESLA Linear Collider

Nicholas Walker (DESY), Daniel Schulte (CERN)

At the heart of the TESLA linear collider are the two 10 km long superconducting linacs. A linac is constructed from 858 cryomodules each containing 12 nine-cell 1.3 GHz superconducting cavities. 355 quadrupoles provide the necessary beam focusing. The advantages of low-frequency superconducting RF in terms of wakefield behavior are well known, and the TESLA alignment tolerances are relatively loose. However, the effects of cavity tilts and their impact of the linac beam-based alignment algorithms have until recently not been fully investigated. In addition, the strong sensitivity to correlated emittance growth due to the high beam-beam disruption parameter makes it desirable to control the linac emittance down to a few percent. In this report we discuss various static tuning algorithms and present new simulation results (including the beam deliverer system). Discussions of the relative merits and applicability of the methods is also discussed.

RPAB008 Comparison of the TESLA, NLC and CLIC Beam Collimation System Performance

Alexandr Drozhdin, Nikolai V. Mokhov (FNAL), Witold Kozanecki, Olivier Napoly (CE Saclay), Grahame Blair, Daniel Schulte, Frank Zimmermann (CERN), Nicholas Walker (DESY), Lewis Keller, Tom

Markiewicz, Takashi Maruyama, Tor Raubenheimer, Andrei Seryi, Peter Tenenbaum, Mark Woodley (SLAC)

The paper discusses analysis of recent studies performed in the framework of the Collimation Task Force organized to support work of the International Linear Collider Technical Review Committee aiming in comparison of performance of the post-linac beam collimation systems in TESLA, JLC/NLC and CLIC linear collider designs. Collimation of the beam halo and synchrotron radiation collimation have been compared for all projects using the same computer code and same assumptions. It is shown that though the performance of the presently designed systems differ, and not always corresponds to expected performance, achieving required performance in the future linear collider is feasible. Further, post-TRC plans of the Collimation Task Force are discussed as well.

* Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

RPAB009 CTF3 Prototypes: Design, Tests and Impedance Measurement

Andrea Ghigo, David Alesini, Roberto Boni, Alberto Clozza, Giovanni Delle Monache, Alessandro Gallo, Fabio Marcellini, Mario Serio, Alessandro Stecchi, Angelo Stella, Mikhail Zobov (INFN), Ghislain Rossat (CERN), Eugeniusz Plawski (Soltan Institute for Nuclear Studies, Swierk)

High efficiency in the 30 GHz power production is obtained if the beam quality is preserved along the rings and the transfer lines of the CTF3 compressor system. The additional energy loss and spread, created by vacuum chamber components coupling impedance and by coherent synchrotron radiation emission must be minimized. We present the results of the impedance measurements on the existing prototypes of the vacuum chamber components. The final test and operational experience of the 3 GHz RF deflectors, used in the CTF3 preliminary phase recombination experiments, is also reported.

RPAB010 Harmonic Cavities for the NLC Damping Rings

Andrzej Wolski, Stefano de Santis (LBNL)

To achieve high luminosity, a linear collider needs damping rings to produce beams with very small transverse emittances. In the NLC, design constraints place the Main Damping Rings in a parameter regime where intra-beam scattering (IBS) is likely to be a limitation on the emittance, and hence on the final luminosity. It is possible to mitigate the effects of IBS by lengthening the bunch: this may be achieved by redesigning the lattice with higher momentum compaction, or by use of higher harmonic cavities. Here, we consider the latter approach. We estimate the required bunch lengthening that might be needed, outline some appropriate parameters for the harmonic cavities, and discuss some of the effects that might be introduced or exacerbated by the cavities, such as synchronous phase variation along the bunch train.

* Work supported by the US DOE under contract DE-AC03-76SF00098.

RPAB011 Study of Near-Field Vibration Sources for the NLC Linac Components

Fred Asiri, F. Le Pimpec, A. Seryi (SLAC), N. Simos (BNL)

The vibration stability requirements for the Next Linear Collider (NLC) are far more stringent than for the previous generation of Colliders. If these goals are to be met, it is imperative that the effects of vibration on NLC Linac components from near-field sources (e.g. compressors, HVAC equipment, klystron, modulators, pumps, fans, etc) be well understood. The civil construction method, whether cut-and-cover or twin bored tunnels, can determine the proximity and possible isolation of noise sources. This paper presents a brief summary and analysis of recently completed and planned studies for characterization of near-field vibration sources under either construction method. The results of in-situ vibration measurements will also be included.

RPAB012 Capture and Polarization of Positrons in a Proposed NLC Polarized Positron Source

Yuri Batygin, John Sheppard (SLAC)

The design for a polarized positron source for the NLC utilizes a 150 GeV electron beam passing through a helical undulator. Resulting flux of polarized photons is converted in a thin positron production target. Spin polarized positrons are captured using a high field flux concentrator followed by an accelerator section immersed in a solenoidal field. Positron tracking through the accelerating and focusing systems is done together with integration of spin precession. Optimization of the collection system is performed to insure high positron yield into the 6-dimensional acceptance of the subsequent pre-damping ring keeping the high value of positron beam polarization. Results of the studies on the development of the collector systems design are presented.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

RPAB013 A Test of NLC-Type Beam Loading in the SLAC Linac

Franz-Josef Decker, Tor O. Raubenheimer, Andrei Seryi, James L. Turner, Michael Woods, Jerry Yocky (SLAC)

The linac at the Stanford Linear Accelerator (SLAC) runs routinely with a beam loading of around 12% for the fixed target experiment E-158. Typical energy spread and energy jitter are 0.1% and 0.05%. To explore the conditions for the Next Linear Collider (NLC) the linac was operated with 20% beam loading. This was attained by increasing the beam charge from 5e11 to 9e11 and increasing the pulse length from 250 ns to 320ns. Although the beam loading compensation was more difficult to achieve, a reliable operating point was found with a similar energy spread and energy jitter as at the lower loading. Furthermore, using the subharmonic buncher, the beam was bunched at 178.5 MHz instead of the nominal 2.8 GHz so that the charge from 16 adjacent buckets was combined into one. Increased transverse instability and beam losses along the linac were observed indicating the possible onset of beam break-up.

* Work supported by Department Of Energy contract DE-AC03-76SF00515.

RPAB014 Implementation of Dynamic Misalignments and Luminosity Stabilization

Linda Hendrickson, T. Himel, Tor Raubenheimer, A. Seryi, P. Tenenbaum, M. Woodley (SLAC), D. Schulte (CERN)

To more fully characterize the luminosity performance of a linear collider, it is important to include in simulations the effects of ground motion as well as the beam-beam feedback and other stabilization systems planned to compensate for that motion. The linear collider simulation codes have recently been extended to include both ground motion models and stabilization systems to support the work of the International Linear Collider Technical Review Committee. This paper discusses implementation details for the beam-beam feedback, methods of ground motion modeling, and realization of beam-independent active stabilization.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

RPAB015 Optimized Wakefield Suppression & Emittance Dilution-Imposed Alignment Tolerances in X-Band Accelerating Structures for the JLC/NLC

Roger Jones, Zenghai Li, Roger Miller, Tor Raubenheimer (SLAC)

In order to prevent electrical breakdown occurring in the JLC/NLC X-band structures several new structures are under investigation. These accelerating structures represent an evolutionary design as they are based on the DDS series of structures [R.M. Jones et al, PAC97, also SLAC-PUB 7537]. The phase advance per cell has been varied and the detailed cell elliptical shape has been varied in order to simultaneously minimize the group velocity, the surface electromagnetic fields and the pulse temperature rise on copper surface [Z. Li et al, these Proceedings]. It is also important to ensure that the wakefield induced by multiple bunches traversing the accelerating structures does not disrupt trailing bunches and this is the subject of this paper. The wakefield must be damped adequately in order to prevent a BBU instability occurring and to ensure that emittance dilution due to the higher order modes is kept to acceptable levels. The long-range wakefield is forced to de-cohere by detuning all of the frequencies such that the mode density of frequencies is approximately Gaussian. In order to minimize the impact of the wakefield on the beam dynamics we change the bandwidth and the standard deviation of the Gaussian distribution of frequencies such that a "cost function" is minimized. Interleaving of cell frequencies of adjacent structures is required to adequately damp the wakefield of each particular structure under consideration. The resulting alignment tolerances imposed on the cells and structures is calculated. Utilizing the optimization code is seen to result in significantly looser structure-to-structure alignment tolerances and well-damped wakefields.

∗ Work supported by U.S. DOE Contract No. DE-AC03-76SF00515.

RPAB016 Energy Dispersion Compensation and Beam Loading in X-Band Linacs for the JLC/NLC

Roger Jones, Christopher Adolphsen, Valery Dolgashev, Roger Miller, Juwen Wang (SLAC)

he shape of an RF pulse is distorted upon propagating through an X-band accelerator structure due to dispersive effects. This distortion together with beam loading introduce energy spread between 192 bunches. In order to minimize this energy spread (as is required by the NLC design) we modify the input rf pulse shape. The pulse propagation, energy gain, and beam loading are modeled with a mode-matching computer code. A 2D model of a complete 60 cm structure, consisting of 55 cells and input and output couplers is analyzed. This structure operates with a 5pi/6 phase advance per cell. Dispersive effects for this structure are more significant than for previously studied 2pi/3 phase advance accelerating structures. Experimental results are compared with the theoretical model and excellent agreement is obtained for the propagation of an RF pulse through the structure.

∗ Work supported by U.S. DOE Contract No. DE-AC03-76SF00515.

RPAB017 Simulations of Optics Tuning in the NLC Final Focus System

Yuri Nosochkov, Tor Raubenheimer, Andrei Seryi, Peter Tenenbaum (SLAC)

Optical aberrations created by field and alignment errors in the NLC Beam Delivery System (BDS) may cause a significant luminosity reduction due to beam size growth at the Interaction Point (IP). To compensate the IP aberrations, a set of linear and nonlinear correction schemes (tuning knobs) were designed for the Final Focus System (FFS). Tuning effects of these knobs were tested in tracking simulations for various field and alignment errors in the BDS. In the simulations, the tuning knobs were applied one after another to minimize the IP spot, first correcting the linear and then higher order effects. The simulations were performed using LIAR code with MATLAB interface which provide automated routines for tuning knob optimization as well as particle tracking using DIMAD. Results of the simulations for 250 GeV beam are presented.

∗ Work supported by Department of Energy contract DE-AC03-76SF00515.

RPAB018 A Recipe for Linear Collider Final Focus System Design

Andrei Seryi, Mark Woodley (SLAC), Pantaleo Raimondi (INFN)

Design of Final Focus systems for linear colliders is challenging because of the large demagnifications needed to produce nanometer sized beams at the interaction point. Simple first- and second-order matrix matching have proven insufficient for this task, and minimization of third- and higher- order aberrations is essential. An appropriate strategy is required for the latter to be successful. A recipe for Final Focus design, and a set of computational tools used to implement this approach, are described herein. Examples of the use of this procedure are also given.

∗ Work supported by the Department of Energy, contract DE-AC03-76SF00515.

RPAB019 Long Term Stability Study at FNAL and SLAC Using BINP Developed Hydrostatic Level System

Andrei Seryi, Robert Ruland (SLAC), Andrey Chupyra, Alexander Erokhin, Michail Kondaurov, Anatoly Medvedko, Vasili Parkhomchuk, Evgeni Shubin, Shavkat Singatulin (BINP), Joseph Lach, Duane Plant, Vladimir Shiltsev (FNAL), Andrey Kuznetsov (Novosibirsk State University)

Long term ground stability is essential for achieving the performance goals of the Next Linear Collider. To characterize ground motion on relevant time scales, measurements have been performed at three geologically different locations using a hydrostatic level system developed specifically for these studies. Comparative results from the different sites are presented in this paper.

∗ Work supported by the Department of Energy, contract DE-AC03-76SF00515.

RPAB020 Polarized Positrons for the NLC

J.C. Sheppard, Y.K. Batygin, R. Carr, R. Pitthan (SLAC), A.A. Mikhailichenko (Cornell University)

Recent design studies indicate the realistic possibility of the production of positrons beams which meet the full NLC beam specifications and which have an overall positron polarization of about 60%. The basic concept is to produce circularly polarized photons which are in turn converted in a thin target to longitudinally polarized positrons. Photons are generated by sending the NLC primary electron beam through a helical undulator. Positrons are captured with the same type of systems as are used in a conventional positron source. This paper presents the overall layout of a polarized positron source for the NLC, performance expectations, component descriptions, and a discussion of the ongoing development efforts.

∗ Work supported by Department of Energy contract number DE-AC03-76SF00515.

RPAB021 Simulation Studies of Beam Based Alignment and Steering of the Next Linear Collider Main Linac

Peter Tenenbaum (SLAC)

The principal obstacle to preserving the small normalized emittance of the Next Linear Collider (NLC) beam in the X-band main linacs is misalignments of the quadrupole magnets and RF accelerator structures with respect to the beam trajectory; the former causes dispersive emittance growth, the latter transverse wakefield emittance growth. A simulation study of beam-based alignment of the NLC beamlines from the end of the bunch compressor to the beginning of

the beam delivery system is presented. The simulation includes successive applications of quadrupole variation, dispersion-free steering, and wakefield-free dispersion bumps to minimize emittance growth. When realistic assumptions on the installation tolerances, hardware performance, and systematic errors are included, the simulated emittance growth is limited to an acceptable value.

* Work supported by the Department of Energy, Contract DE-AC03-76SF00515.

RPAB022 Measurement of the Geometric and Resistive Transverse Wakefields of Tapered Collimators

Peter Tenenbaum, Leif Eriksson, Tor Raubenheimer, Dieter Walz (SLAC), Dmitry Onoprienko (Brunel University)

A recent set of measurements were performed at the Collimator Wakefield test facility at SLAC in order to estimate the resistive contribution to the transverse wakefield. A total of four longitudinally-tapered collimators were used, with identical taper angles and minimum gap sizes in all cases such that the geometric wakefield contributions would be equal for all collimators. Two of the collimators were constructed from elemental copper, while elemental titanium was chosen for the remainder of the collimators due to its much lower conductivity. In order to enhance the resistive contribution of the wakefield, one copper and one titanium collimator were constructed with a 1 meter untapered flat region at the minimum gap size. Details of the measurement procedure, experimental results, and comparison with theoretical models are discussed.

* Work supported by the US Department of Energy, Contract DE-AC03-76SF00515.

RPAB023 Wigglers and Single-Particle Dynamics in the NLC Damping Rings

Marco Venturini (SLAC), Andrzej Wolski (LBNL), Alex Dragt (University of Maryland)

In order to achieve the required beam cooling the damping rings of the Next Linear Collider (NLC) will make use of a substantial number of wiggler insertions. An accurate modeling of the wigglers is desirable to assess the impact of the resulting nonlinearities on the beam dynamics - in particular on the dynamic aperture, which is important for good injection efficiency. We will illustrate a method for representing magnetic fields that uses the data from numerical codes that are customarily used in magnet design. In particular, we show how the full 3D "multipole" field expansion can be reconstructed starting from the radial component of the magnetic field on the surface of a cylinder coaxial to the wiggler. Such an expansion is particularly suitable for a fast evaluation of the single particle dynamics by means of symplectic transfer maps. A discussion of the impact of the wigglers nonlinearities on the NLC Main Damping Ring using this technique will be presented.

RPAB024 A Recipe for Linear Collider Final Focus System Design

Mark Woodley, Andrei Seryi (SLAC), Pantaleo Raimondi (INFN)

The design of Final Focus systems for linear colliders is challenging because of the large demagnifications needed to produce nanometer-sized beams at the interaction point. Simple first- and second-order matrix matching have proven insufficient for this task, and minimization of third- and higher-order aberrations is essential. An appropriate strategy is required for the latter to be successful. This paper describes a recipe for Final Focus design, and a set of computational tools used to implement this approach. Examples of the use of this procedure are given.

* Work supported by the US DOE under contract DE-AC03-76SF00515.

RPAB025 A Lattice with Larger Momentum Compaction for the NLC Main Damping Rings

Mark Woodley, Tor Raubenheimer, Juhao Wu (SLAC), Andrzej Wolski (LBNL)

Previous lattice designs for the Next Linear Collider Main Damping Rings have met the specifications for equilibrium emittance, damping rate and dynamic aperture. Concerns about the effects of the damping wiggler on the beam dynamics led to the aim of reducing the total length of the wiggler to a minimum consistent with the required damping rate, so high-field dipoles were used to provide a significant energy loss in the arcs. However, recent work has shown that the wiggler effects may not be as bad as previously feared. Furthermore, other studies have suggested the need for an increased momentum compaction to raise the thresholds of various collective effects. We have therefore developed a new lattice design in which we increase the momentum compaction by reducing the field strength in the arc dipoles, compensating the loss in damping rate by increasing the length of the wiggler. The new lattice again meets the specifications for emittance, damping rate and dynamic aperture, while having the benefit of significantly higher thresholds for a number of instabilities.

* Work supported by the US DOE under contract DE-AC03-76SF00515.

RPAB026 Simulations of a Nanosecond Timescale Beam-Based Feedback System for the Future Linear Collider

Philip Burrows, Glen White (Queen Mary, University of London), Simon Jolly, Gerald Myatt, Gavin Nesom, Colin Perry (Oxford University), Chris Adolphsen, Joseph Frisch, Keith Jobe, Thomas Markiewicz, Doug McCormick, Janice Nelson, Marc Ross, Tonee Smith, Smith Steve (SLAC)

To keep luminosity losses at a future linear collider to within a few percent, the beams need to be kept in collision to within about 10% of the vertical beam spot size. This implies a tolerance on the final quadrupoles of 0.27nm and 0.1nm for TESLA and NLC/JLC/CLIC respectively. The limiting factor for stability along the beamline for the linear collider is that of ground motion. If uncorrected, ground motion causes a total loss of luminosity at the linear collider within seconds through beam misalignment and emittance growth. The FONT (Feedback On Nano-second Timescales) group is responsible for the design of a fast intra-train beam based feedback system located within a few metres of the interaction point of the collider. This is designed to detect offsets in the first few colliding bunches of the beam train and kick the following bunches in the train back into alignment. The cases of JLC/NLC and CLIC are the most challenging for such a system, with short trains and bunch separations of only a few nanoseconds, forcing a purely analogue electronics based approach. We present simulations of how such a system works and performs in these cases, and the impact on backgrounds of having such a system operating close to the interaction point. We show that it is possible to counteract the effects of fast ground motion in these difficult environments and that the impact on the interaction region design is minimal with respect to machine backgrounds.

* Supported by the UK Particle Physics and Astronomy Research Council.

RPAB027 Form Factor for a Target Used for Positron Generation with Undulator Radiation Conversion

Alexander Mikhailichenko (Cornell University)

It is shown here that the needle-type target gives advantages in conversion of gammas from a helical undulator into positrons. This is not possible with the usual electron to positron production method.

* Cornell University, LEPP, NSF.

RPAB028 Pulsed Undulator for Test at SLAC the Polarized Positron Production Scheme

Alexander Mikhailichenko (Cornell University)

We represent technical details and results of testing pulsed undulator with ~2mm period K~0.1 , manufactored at Cornell LEPP for test of polarized positron production at SLAC.

* Cornell University, LEPP, NSF.

RPAB029 The Technical Realisation of RF Kickers for CLIC Test Facility CTF3

Eugeniusz Plawski (Institute for Nuclear Studies, Poland)

The bunch train compression scheme in CLIC Test Facility CTF3 includes two fast RF kickers operated in deflecting mode on 3GHz frequency. The kickers designed by common INFN/Swierk efford were produced in Institute for Nuclear Studies in Swierk and are succesfully operated at full power in CTF3 experiment in CERN. The details of fabrication procedure and low power RF measurements are presented in this paper.

RPAB030 Development of Room Temperature Accelerating Structures for the RIA

Nikolai Vinogradov, P.N. Ostroumov, E. Rotela, S.I. Sharamentov, S. Sharma, G.P. Zinkann (ANL), J.W. Rathke, T.J. Schultheiss (Advanced Energy Systems, Inc.)

The proposed Rare-Isotope Accelerator Facility (RIA) includes a driver linac and a post-accelerator based on superconducting cavity technology. The exceptional sections of the RIA accelerators are front ends which comprise room temperature continuous wave accelerating structures to obtain particle velocities acceptable for further acceleration by superconducting cavities. The front ends for both accelerators are based on RFQ technology. We have a preliminary engineering design of a 57.5 MHz RFQ for the driver linac. A cold model and one segment of the full power prototype of 57.5 MHz RFQ are being planned for fabrication. The post-accelerator consists of a conventional RFQ operating at 12 MHz and two sections of a hybrid RFQ operating at 12 and 24 MHz. A 1:2 scale cold model of the 12 MHz RFQ was built and is being studied to determine the final specifications for the full power hybrid RFQ. This paper reports on the present development status of these accelerating structures.

RPAB031 AGS Upgrade to 1 MW with a Super-Conducting Linac Injector

Alessandro Ruggiero, James G. Alessi, Deepak Raparia, Thomas Roser, Wu-Tsung W. Weng (BNL)

It has been proposed to upgrade the AGS accelerator complex to provide an average proton beam power of 1 MW at the energy of 28 GeV. The facility could be used as a proton driver for the production of intense neutrino beams. The upgrade requires operation of the accelerator at the rate of 2.5 cycles per second, and a new injector capable to inject the required proton intensity at the same repetition rate. The proposed new injector is a 1.2-GeV Super-Conducting Linac with an average output beam power of 50 kWatt. The Linac energy is determined essentially by the requirement to fit the real-estate available between the exit from the present 200-MeV room-temperature Linac and the location of injection into the AGS. The Linac duty cycle is about 0.2% with a beam pulse length of about 0.72 ms. The paper describes the design of the Linac. It is composed of three components: a Front-End, that is a 35-mA negative-ion source, followed by the 0.75-MeV RFQ, the room temperature Drift-Tube Linac that accelerates protons to 200 MeV, and the Super-Conducting Linac proper. This is made of three sections: the Low-Energy section that accelerates protons to 400 MeV at 805 MHz, the Medium-Energy section for acceleration to 800 MeV, and the final High-Energy section for acceleration to 1.2 GeV. The last two sections operate at 1.61 GHz.

* Work performed under the auspices of the US Department of Energy.

RPAB032 Study of a 10-MW Continuous Spallation Neutron Source

Alessandro Ruggiero, Hans Ludewig, Stephen M. Shapiro (BNL)

A proton Super-Conducting Linac has been proposed as the driver of Continuous Spallation Neutron Source. At this purpose a conceptual design study for an unrelated site is underway at Brookhaven National Laboratory. The Super-Conducting Linac driver accelerates protons to 1.25 GeV, operates in a Continuous-Wave mode (CW), and generates an average proton beam power of 10 MWatt. The average beam current is 8 mA, and the total length about 200 m. The Linac is made of three parts: a Front-End, that is a 10 mA positive-ion source, followed by a 2.5-MeV RFQ, a room-temperature 150-MeV Drift-Tube Linac (DTL), and the Super-Conducting Linac (SCL) proper. This is made of three sections: the low-energy section that accelerates protons to 400 MeV, the medium-energy section to 800 MeV, and the high-energy section that accelerates to 1.25 GeV. The Front-End (CRFQ and DTL) is proposed to operate at the frequency of 350 MHz, whereas the SCL is operating at 700 MHz.

* Work performed under the auspices of the US Department Of Energy.

RPAB033 Results of the IPHI Drift Tube Linac's Hot Model CW Tests

Pierre-Emmanuel Bernaudin, Congretel Gerard (CE Saclay), Froidefond Emmanuel, Ravel Jean-Claude, Fruneau Michel (ISN Grenoble)

In the course of the IPHI project (high intensity, cw proton injector), a Drift Tube Linac hot model has been built and tested. The main difficulty associated with these machines is the high RF thermal losses inducing significant heatings and deformations if not kept under strict control. Therefore the hot model has been tested under nominal RF conditions (40 kW cw for an accelerating field of 1.75 MV/m) to verify the suitability of the technical choices made: materials, mechanical designs, construction techniques, vacuum... This prototype includes 4 accelerating cells, three full drift tubes, two of which enclose a quadrupole electromagnet. Results show that a stainless steel enveloppe can be used even at these high power densities, provided that it is copper plated both inside and outside to enhance its thermal conductivity and lower the temperature gradients. This solution leads to a cheap and reliable machine. The new kind of drift tube / magnet assembly tested in this DTL model ("flooded drift tube"), where the whole drift tube is filled with water cooling simultaneously the magnet leads and the drift tube walls, is also a suitable solution, cheap and more efficient than the usual ones. With the successful tests of this hot model, one more step has been made towards a cw Drift Tube Linac for high intensity light ions accelerators.

RPAB034 Beams Dynamics Studies in SPIRAL II Linac

Romuald Duperrier, Didier Uriot (CE Saclay), Nicolas Pichoff (CE Bruyeres), Patrick Bertrand, Bernard Bru, Franck Varenne (Grand Accelerateur National d'Ions Lourds), Jean Luc Biarotte (Institut de Physique Nucléaire d'Orsay), Emmanuel Froidefond (Institut des Sciences Nucleaires de Grenoble)

The proposed LINAC driver for the SPIRAL II project aims to accelerate a 5 mA D+ beam up to 20 A.MeV and an one mA beam for Z/A=1/3 up to 14.5 A.MeV. It is a continuous wave regime (CW), designed for maximum efficiency in the transmission of intense beams. It consists in an injector (two ECRs sources + Radio Frequency Quadrupole) followed by a superconducting section based on an array of independently phased cavities. This paper presents beams dynamics

studies associated to the LINAC driver. End to end simulations (low energy energy beam lines, RFQ, medium energy beam line, SC linac) are shown.

RPAB035 Instabilities Study in Favor of the RIA Project

Romuald Duperrier (CE Saclay), Dmitry Gorelov (National Superconducting Cyclotron Laboratory)

The Rare Isotope Accelerator (RIA) requires a high power linac capable of accelerating all ions through uranium to energies of 400 MeV/u with a beam power of 100 to 400 kW in a CW regime. One of the most challenging features of the proposed RIA driver linac is the simultaneous acceleration of different charge states in order to increase the final beam power. The acceleration in the last part of the accelerator is provided by elliptical cavities. Three geometrical betas are used: 0.47, 0.61 and 0.81. To minimize the cost, one option is to lower the number of cryostats. This implies to maximize the number of cavities per cryostats. Assuming a lattice composed by one doublet and one cryostat, this option leads to an increase of the longitudinal phase advance if each cavity is used with the maximum field. The transverse phase advance has to be set correctly in order to insure a stable motion. This paper aims to evaluate the sensitivity to instabilities induced by the coupling transverse longitudinal in the elliptical cavities for the RIA linac. The instability produced by space charge is also discussed.

RPAB036 A 3 GeV SCRF Linac for the NSLS Upgrade

James Rose (DOE)

The proposed NSLS upgrade requires a 3GeV SCRF linac for top-off injection of a low emittance storage ring and to drive FEL undulators. Starting from the FEL drive beam requirements of sub-picosecond bunch lengths and kiloamp peak current. The choice of frequency, gradient and operating modes of the linac are presnted. Magnetic optics and RF system descriptions follow to provide the specified beam parameters. Accelerator design issues are identified for future studies.

* This work supported by the U.S. Department of Energy.

RPAB037 Beam Dynamic Calculations for the Superconducting COSY Injector Linac

Andreas Lehrach, Ulf Bechstedt, Helge Jungwirth, Rudolf Maier, Raimund Toelle (Forschungszentrum Juelich)

A superconducting injector linac is presently being designed and built for the COoler SYnchrotron COSY to increase the intensity of polarized proton and deuteron beams. The injector is described in a status report at this conference [R.Tolle et al., COSY-SCL, the Superconducting Injector Linac for COSY]. Beam dynamic simulations have been carried out to investigate orbit deviations in the matching and linac sections, due to misalignments of optical and accelerating elements. Magnets and resonators were randomly shifted in all three dimensions by maximum values of +-0.1mm and +-0.75mm, respectively. In addition the phase and amplitudes of the resonators are also randomly varied by up to +-0.5deg and +-0.5%. A multi-particle tracking code [P.N. Ostroumov, Technical Internal Note, Argonne National Laboratory, August 2001] was used to simulate the beam in the transverse and longitudinal phase space. Sensitivity studies of the beam optics of the lattice were performed to determine the requirements for an orbit correction system. The resulting magnet requirements of the matching and linac sections for protons and deuterons are presented and discussed.

RPAB038 Debuncher Developing for H and D Beams Injection into COSY Ring

Yurij Senichev, Rudolf Maier, Rolf Stassen, Nikita Vasyukhin (Forschungszentrum Juelich)

The super-conducting linear accelerator as injector for COSY ring has to accelerate particles that differ in ratio of mass to charge by a factor of two. Both beams will be injected into COSY ring at an approximately similar energy 50 MeV, or velocity different by factor of mass ration square root. One of the strong requirements for new injector is the beam matching with acceptance of COSY ring. To fulfill this requirement the monochromaticity of H and D beams has to be decreased from 1% to 0.2% by special debuncher optimized for both sorts of particle simultaneously. The E and H debuncher types are considered.

RPAB039 Amplitude and Phase Tuning Procedure of Accelerators Based on Stepped Geometry Structure

Yurij Senichev, Alexandre Bogdanov, Rudolf Maier (Forschungszentrum Juelich)

In a super-conducting linear accelerator the cavities are joint in groups and in each group they have similar geometry. Therefore the longitudinal dynamics is more complicate. The particles are sliding down or up relatively of RF wave in dependence on the ratio between the particles and the wave velocities. Thus, the particles are almost never in synchronism with the equivalent traveling wave. Therefore the conventional T procedure has to be modified in application to the stepped geometry structure. A new option for the tuning procedure based on Hamiltonian formalism is developed. This can help to optimize longitudinal motion in such a structure.

RPAB040 Accelerators with Stepped Phase Velocity and Stepped RF Phase: Commonness and Difference

Yurij Senichev, Alexandre Bogdanov, Rudolf Maier (Forschungszentrum Juelich)

From point of view of synchronous motion in the longitudinal plane the linear accelerators can be divided into classes: accelerators with gradually growing period of acceleration and accelerators with stepped geometry structures. The accelerators with stepped geometry structure can be subdivided in two sub-classes in dependence on how the quasi-synchronous motion is organized: the stepped phase velocity and the stepped RF phase structures. Developing and using Hamiltonian formalism, the stepped geometry accelerators based on two different principles are investigated.

RPAB041 The RFQ-Injector for COSY-SCL

Kai-Uwe Kuehnel, Alwin Schempp (Institut fur Angewandte Physik), Alexander Schnase, Raimund Toelle (Forschungszentrum Juelich), Carsten Welsch (Max-Planck-Institut fuer Kernphysik)

For the new injector linac for COSY at FZ Juelich, a combination of an RFQ and a spiral loaded cavity will accelerate H-,D- beams up to 2.5 Mev/u for injection into the sc-linac. The RFQ is a 3.8 m long four-rod design which accelerates deuterons with an initial energy of 25 keV up to 2 MeV/u. Behind the RFQ a compact booster cavity of 300 mm length is mounted. This spiral loaded cavity accelerates the beam to a final energy of 2.5 MeV/u. It uses four accelerating gaps with a effective voltage of 1 MV. An optional design has gaps with additional electrodes in a rf-quadrupol configuration to add a focussing field in this DTL structure. The status of the work on this new injector will be presented.

RPAB042 Design of a Superconducting CH-Cavity for Low- and Medium Beta Ion and Proton Acceleration

Holger Liebermann, Holger Podlech, Ulrich Ratzinger, Andreas Sauer (Institut fur Angewandte Physik)

The CH cavity is a multi-gap drift tube structure based on the H-210 mode currently under development in a collaboration between IAP Frankfurt and GSI. By use of the KONUS beam dynamics long lens free sections can be realized, making the design of a superconducting multi-cell CH resonator attractive. Numerical simulations showed that the CH cavity is a promising multi-gap alternative to the spoke-type

or reentrant cavity structures in the energy range between 5 and 150 MeV/u with operation frequencies between 150 and 800 MHz. This paper will present detailed MicroWave Studio simulations of the superconducting CH cavity.

RPAB043 The Frankfurt Funneling Experiment

Jan Thibus, Alwin Schempp, Holger Zimmermann (Institut fur Angewandte Physik)

Funneling is a procedure to multiply beam currents at low energies which is necessary for the proposed new high current accelerator facilities like HIDIF or ESS. The funneling procedure may consist of several funneling stages. The beams of several LEBT's are merged in multiple stages to any kind of energy and beam current by funneling. The main goal is to keep the emittance nearly unchanged. The Frankfurt Funneling Experiment is a set up of two ion sources, a Two-Beam RFQ accelerator, two different funneling deflectors and a beam diagnostic equipment system. The whole set up is a scaled model of the first funneling stage of a HIIF driver. The progress of our experiment and the results of the simulations will be presented.

RPAB044 Study of a Linac Post-Accelerator for Proton Therapy in the 30-62 MeV Energy Range

Vittorio Vaccaro (INFN)

Recent results in accelerator physics have shown the feasibility of a coupling scheme between a cyclotron and a linac for proton acceleration:a 60 MeV proton has been successfully captured an accelerated by a prototype module (LIBO) of a 3 GHz linac. While there are a limited number of 60 MeV cyclotrons, a large number of 30 MeV ones ,mainly devoted to radioisotopes production, is available in medical centres. These two evidences have suggested the idea to study and design a linac postaccelerator able to boost the proton energy up to the values required for the treatment of tumors, like uveal melanoma.. The main challenge in such a project is related to meet the requirements arising from the beam dynamics with the constrains due both to the mechanical structures and tolerances and to the heat dissipation mechanism chosen in the design. In this paper we will review the rationale of the project and we will discuss the basic design of a compact 3 Ghz linac with a new approach to the cavities used in a SCL (Side Coupled Linac) structure.

RPAB045 A Highly Reliable Proton Linac Using Superconducting Spoke Cavities for the European XADS Project

Jean-Luc Biarrotte, Tomas Junquera, Alex C. Mueller, Guillaume Olry (Institut de Physique Nucléaire d'Orsay), Carlo Pagani, Paolo Pierini (INFN)

For the XADS project, which aims at designing the future European hybrid reactor for nuclear waste transmutation, the concept of reliability is a crucial issue, since the accelerator specifications ask for less than a few beam trips per year. In that sense, CNRS & INFN designed and proposed a whole superconducting linac from the injector, to try to take care as much as possible of this high-reliability challenge. This design especially uses independently powered spoke cavities in its intermediate section (up to 100 MeV), that should improve the overall reliability potential of the linac. Indeed, the strategy used in this design is based on components over-design and redundancy, that leads in a real potential for the linac to function with a number of faulty components, as shown by beam dynamics calculations. Finally, some elements are also given concerning the progress and status of the XADS project, and of the EURISOL project (European project for radioactive nuclei production), whose linac could also use this spoke cavities technology.

RPAB046 Cold-Model Tests of an Annular Coupled Structure for Upgrade of a J-PARC Linac

Hiroyuki Ao (Japan Atomic Energy Research Institute), Valentin Paramonov (INR Moskow), Noriyosu Hayashizaki (TIT)

An Annular Coupled Structure (ACS) has been developed for upgrade of a J-PARC (Japan Proton Accelerator Research Complex) linac from 180 MeV to 400 MeV. Although install area is prepared for the ACS cavities at an initial construction, it will be used as a beam-transport line temporarily. Aluminum and copper models were fabricated for RF properties confirmation based on an initial design, and for final optimization. RF measurement procedure of the ACS structure was also studied thorough the R&D process. Many items should be considered for mass production; schedule, handling parts, utilities, and so on. The measurement results of models and some fabrication status are presented.

RPAB047 Low Power Test of RFQ Mock-up Modules at 175MHz for IFMIF Project

Sunao Maebara, Takeuchi Hiroshi, Sugimoto Masayoshi, Imai Tsuyoshi (Japan Atomic Energy Research Institute), Saigusa Mikio, Sazawa Shingo (Ibaraki University)

In the International Fusion Materials Irradiation Facility (IFMIF) system, 40 MeV deuteron beam with a current of 250 mA is injected into the liquid lithium flow, the neutron field similar to the D-T Fusion reactor(2MW/m2, 20 dpa/year for Fe) is produced by the deuteron-Lithium (D-Li) stripping reaction. In the 175 MHz RFQ system, it is required that deuteron beam of 125mA is injected at 0.1MeV and is accelerated to the output energy of 5MeV. The RFQ total length is needed to be about 12m, and hence the suppression of higher modes is indispensable. For this purpose, a coupled cavity technique is needed, it is indispensable to verify the resonant frequencies against RFQ longitudinal length so as to avoid the mode competition by higher modes. The RFQ mock-up modules have been designed by MAFIA code, and the modules which consist of two end-plate modules and two central modules have been fabricated for low power tests. The resonant frequencies of RFQ modules with the length of 1.1 m and 2.1 m have been measured, and the results were in agreement with the calculated values within 1MHz. By these result, it is expected that operation mode and 5 higher modes will be excited within 4MHz when the RFQ module length becomes 4.1 m. We will extend the module length up to 4.1 m and measure the resonant frequency, so as to design the IFMIF RFQ system which has 2 coupling plates and 3 central modules.

RPAB048 Development of a Low-Energy Proton Accelerator System for The Proton Engineering Frontier Project (PEFP)

Jang-Min Han, Yong-Sub Cho, Ji-Ho Jang, Kyoung-Keun Jeong, Young-Jun Kim, Hyeok-Jung Kwon, Ho-Haeng Lee, Jean-Ho Na, Mi-Young Park (Korea Atomic Energy Research Institute)

The development of a low-energy proton accelerator has started as the first phase of the Proton Engineering Frontier Project (PEFP). The low-energy proton accelerator system consists of a 50keV proton injector, low-energy beam transport (LEBT), 350MHz, 3MeV CW radio-frequency quadrupole (RFQ), midium energy beam transport (MEBT), 350MHz, 20MeV drift-tube linac (DTL), high power beam dump, high power and low-level rf system. The proton injector is under operation, RFQ is testing rf power, and a design of DTL has finished.

* This work has been supported by the Korean Ministry of Science and Technology(MOST).

RPAB049 Tuning of the RF Field of the DTL for J-PARC

Naito Fujio, Takao Kato, Eiichi Takasaki, Hirokazu Tanaka (KEK), Takashi Itou (Japan Atomic Energy Research Institute)

Tuning of the accelerating field of the DTL first tank for Japan Proton Accelerator Research Complex (J-PARC) has been done. The first DTL tank consists of the 75 full drift tubes, 37 post-couplers and 10 fixed tuners. The resonant frequency of the tank is 324MHz. The uniform accelerating field has been achieved by the fine adjustment of the post-couplers and the fixed tuners. The field stabilization by the post-couplers against perturbations has been confirmed also. In order to achieve the stabilized-uniform distribution of the average field for the each accelerating gap, the following techniques have been applied for the post-coupler tuning: (1) non-uniform insertion length of the post-coupler from the tank wall; (2) increment of the diameter of several post-couplers. The recipe of the fine post-coupler tuning will be described in detail.

RPAB050 High-Gradient Tests on S-Band 2m-Long Accelerating Structures for KEKB Injector Linac

Yasuhito Igarashi, Atsushi Enomoto, Yasuo Higashi, Kazuhisa Kakihara, Satoshi Ohsawa, Takao Oogoe, Seia Yamaguchi (KEK), Hirofumi Hanaki, Tsutomu Taniuchi, Hiromitsu Tomizawa (SPring-8)

In this paper, we describe high-gradient test results performed on S-band 2m-long accelerating structures for KEKB injector linac. The accelerating structures are operated at the average accelerating gradient of 20 MV/m for KEKB. High-gradient tests were performed on three types of accelerating structures: (1) a conventional accelerating structure for KEKB injector linac, (2) an accelerating structure whose input and output couplers are replaced with those without a crescent-shaped cut (conventional structure has a crescent-shaped cut to correct the asymmetry of the electromagnetic fields in coupler cavity), (3) a conventional accelerating structure which is rinsed with high-pressure ultrapure water. As a result of the tests, average accelerating gradient of more than 40 MV/m were obtained in all structures. Especially, the gradient of 46 MV/m was achieved in the structure rinsed with high-pressure ultrapure water with a short rf processing time and low breakdown rate (this gradient was limited by klystron output power).

RPAB051 Fabrication and Assembly of the Drift-Tube Linac (DTL) for the Spallation Neutron Source

Tom Ilg, Will Fox, Rick Martineau, Jim Sims (LANL), Rudy Damm, Gary Johnson (ORNL)

The Spallation Neutron Source (SNS) uses a linac to accelerate H- ions to 1 GeV at an average beam power of 1.4 MW. The linac consists of four RF structures: a 2.5-MeV RFQ, an 87-MeV DTL, a 186-MeV CCL, and a 1-GeV SRF linac. The DTL is divided into six RF structures, each powered by a 2.5-MW klystron. Design of the DTL has been completed, and LANL has aligned, tuned, and fabricated the first segment (Tank #3) to be installed at ORNL. We describe the design and fabrication process, including machining of the tanks, copper plating of the tank segments, machining and welding of the drift tubes, and fabrication of steering magnets and beam-position monitors inserted in several drift tubes. We also discuss the fabrication issues that developed during the manufacture of the DTL and how they were resolved. In addition, the assembly and alignment of the RF components using the Leica Laser-Tracker System Coordinate Measuring Machine is also discussed. Lessons learned in the manufacture and assembly process will be emphasized, particularly as they apply to subsequent SNS DTL segments and other high-power DTLs.

* Work supported by the Office of Science of the US Department of Energy.

RPAB052 Fabrication and Tuning of the SNS CCL Hot Model

Bultman Nathan, James Billen, Zukun Chen, Mike Collier, Steve Hopkins, Daniel Richards, Lloyd Young (LANL)

A full-scale powered model of the SNS CCL was completed in August 2001. The manufacturing processes and tuning procedures used in the CCL Hot Model formed the basis of the main manufacturing contract for the SNS CCL system later placed in private industry. In this paper we summarize the design basis for the CCL and the manufacturing and process steps required to fabricate and tune the Hot Model for high power testing. In particular the machining, brazing and welding steps are discussed for both the CCL Segment assembly and the powered Bridge Coupler. In addition we discuss transfer of the information and some specific modifications that were made to the basic design at the point of starting full scale manufacture in industry. One critical area to the overall success of the Hot Model was the type and specific design of the various tooling and lifting and handling fixtures utilized in the process at the various machining, brazing, welding, and tuning steps. The tooling utilized in the fabrication and tuning process is discussed in detail. The ultimate successful testing of the CCL hot model has key to development of a manufacturing plan for the CCL system.

* Work supported by the Office of Science of the Department of Energy.

RPAB053 Testing and Schedule Status of the SNS Klystrons

Paul Tallerico (LANL)

The SNS linac will use three types of klystrons: Seven at 2.5 MW peak power at 402.5 MHz for the RFQ and DTL linacs: Six with 5 MW peak power at 805 MHz for the CCL and for the debuncher cavities before the storage ring; and Eighty-One 550 kW peak power at 805 MHz for the superconducting linac. Factory acceptance tests for all three types have been conducted, and before the conference, secondary acceptance tests at Los Alamos shall also be completed for many klystrons. While the specifications for these klystrons are demanding, the vendors were able to meet the specifications after one or two design iterations. In the case of the 5 MW klystrons, full average power testing at the vendor was not possible, so the full average power tests are first being done at Los Alamos. We discuss the major specifications, which included a 24-hour burn in at 110% of rated power, and we show representative results for amplitude and phase linearity. Since we have tested up to six klystrons of the same model, we can discuss the variations in perveance, gain, and efficiency that have been measured. These variations are particularly important since we will have up to twelve klystrons in parallel (for the 550 kW case) operating from a single pulsed-power supply. The few infant-mortality problems and installation problems that have occurred are discussed. Due to the redesign problems, all vendors have been somewhat late, but the klystrons are being installed in the accelerator gallery at Oak Ridge well before they are required to test and drive the linac. The schedule status and ramp-up times that were required will also be discussed.

* Work supported by the Office of Basic Energy Science, Office of Science of the US Department of Energy, and by Oak Ridge National Laboratory.

RPAB054 Diagnostic Beamline Development for Measuring High Emittance-Ratio Beams by RF Photoinjectors

Steve Lidia (LBNL), Kai Desler (FNAL), Yin-e Sun (University of Chicago)

The FNPL photoinjector presently produces 14-15 MeV flat beams with measured emittance ratios ~50. Part of the limitation in achieving higher emittance ratios is the measurement both of the beam's initial angular momentum and of its final, small horizontal emittance in a resolution-limited imaging stage. We present techniques and

simulations designed to measure and fit the small horizontal emittance value below the current limit of ~0.9 mm-mrad.

* This work was supported by the Department of Energy under Contract No. DE-AC03-76SF00098.

RPAB055 RIA Fragmentation Line Beam Dump Thermal Structural Analyses

Werner Stein (LLNL)

The Rare Isotope Accelerator (RIA) driver linac produces a heavy-ion high-energy particle species spanning all isotopes from protons to uranium. The uranium isotope beam will be converted using a fragmentation approach. After penetrating the fragmentation target, the beam will be magnetically separated from the rare isotopes produced and sent into a beam dump to dissipate its energy.The beam dump will be required to absorb a very high power beam (100 kW), with a spot size of centimeters without experiencing excessive radiation and thermal structural damage. Analyses of beam energy deposition are coupled to heat transfer analyses to determine dump material heating. Structural analyses of stress in the dump due to thermal expansion are made to ensure the dump material maintains its integridy over the desired operating life.

* This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

RPAB056 Analysis of a Multi-Spoke Option for RIA Driver Linac

Dmitry Gorelov, Terry Grimm, Walter Hartung, Felix Marti, Xiaoyu Wu, Richard York (National Superconducting Cyclotron Laboratory)

Studies of the beam dynamics in the proposed Rare Isotope Accelerator (RIA) driver linac are underway at NSCL. This linac is designed to accelerate the stable ion beams from proton to uranium to final energies of 400 MeV/u for heaviest and ~900 MeV/u for lightest ions with beam powers of 100 to 400 kW. Two stripping sections are used to boost the charge state of heavy ions in order to minimize the total accelerating voltage required and the length of the linac. In order to preserve the final beam power the multi-charge state acceleration is provided, which poses however additional challenges to the proper design of the longitudinal and transverse beam dynamics in this linac. Multi-spoke structures were proposed as an alternative to the baseline elliptical structures for high-energy part of the RIA driver linac ["The RIA Driver Linac", K. W. Shepard, Proc. of the LINAC 2002 Conf., Gyeongju, Korea, August 2002]. A comparative analysis of this alternative is explored including beam dynamics, error constraints, and manufacturing issues.

* Work supported by Michigan State University and NSF PHY 0110253.

RPAB057 Beam Dynamics Parameters' Optimal Selection and Structure Design about Low Energy Electron Linear Accelerators

Guangyao Feng (National Synchrotron Radiation Lab)

Beam dynamics parameters' optimal selection and disk-loaded wave guide structure design about two low energy electron linear accelerators(applied for killing anthrax bacillus in mails, irradiating produce and so on) are introduced in the paper. One of the linac (2MeV) has a constant impedance structure, and the other (10MeV) is constant gradient structure. The 2MeV linac has been produced and works well. Machining of the 10MeV linac is now being processed.

RPAB058 Numerical Design and Optimization of Cooling Water System for 2 Mev Traveling Wave Accelerator

Lianguan Shen, Yilin Hong, Daoman Jiang, Kai Jin, Yuanji Pei (National Synchrotron Radiation Lab), Shaoquin Li, Xiaoguang Li (University of Science and Technology of China)

Eliminating or reducing thermal deformation of accelerator structure caused by microwave power to insure work frequency is an important topic in design of the structure. Civil accelerator for killing anthrax bacillary demands the facility small and compact. It needs a delicate cooling water jacket as well. This paper introduced the work to design and optimize a cooling structure for a 0.57m long, 2 KW power disk-loaded waveguide accelerator structure, which temperature distribution is required to be 30±3°C. All the parameters have calculated and optimized by means of FEM. And an optimized structure with jacket style cooling chamber have got. The outside wall of the jacket is made of stainless steel and its external diameter is ϕ118mm.The flux of the cooling water is as small as 0.45 ton /hour. As a result, the temperature distribution of the accelerator structure is less than ±2°C. The system is very robust again surrounding temperature change. The cooling system has been employed in the accelerator of 2 MeV, and the facility is running well.

RPAB059 Impact of Cavity RF Field Phase and Amplitude Control Uncertainties on the SNS Linac

Dong-o Jeon (ORNL), Jim Stovall, Harunori Takeda (LANL), Ken Crandall (TechSource Inc.)

There is a certain limit how accurately one can control the cavity rf field phase and amplitude. The impact of two different sets of control uncertainties on the SNS linac is studied, i.e. +/-0.5%,0.5deg and +/-1.0%,1.0deg. The rf control uncertainties will give rise to jitters in the beam phase and energy resulting in uncertainties in determining the rf set-point of the following linac section, and emittance growth leading to injection foil miss and beam loss.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

RPAB060 The Low Level RF System for 100MeV Proton LINAC of KOMAC

Inha Yu (Pohang Accelerator Laboratory)

At the 100MeV proton linac of the KOMAC(Korea Multi-Purpose Accelerator Complex), the low level RF system provides field control for the entire KOMAC proton linac, including 2 RFQ at 350MHz as well as 7 DTL cavities at 700MHz. In addition to field control, it provides cavity resonance control, and incorporates the personnel and machine protection functions. An accelerator electric field stability of ~1% in amplitude and ~1° in phase is required for the RF system. In order to accomplish these requirements, a digital feedback control technique is adopted for flexibility of the feedback and feed forward algorithm implementation.In this paper, the detailed description of the low level RF system will be described together with the performance test results.

* Work supported by the Ministry of Science and Technology (MOST).

RPAB061 Fabrication & Assembly of the SNS SRF Prototype Cryomodule

John Hogan, Edward Daly, John Fischer, Joseph Preble, Mark Wiseman (Thomas Jefferson National Accelerator Facility)

The Spallation Neutron Source (SNS) accelerator utilizes both normal conducting and superconducting linacs to provide an H- beam to the target building. The normal conducting portion of the linac raises the energy to 185 MeV where upon the superconducting portion of the

linac, consisting of 11 medium beta and 12 high beta cryomodules, will provide an increase in energy up to 1 GeV. Thomas Jefferson National Accelerator Facility (JLab) is providing the superconducting cryomodules for the SNS project. The assembly of the prototype medium beta cryomodule (CM) has been completed and testing results demonstrate all design criteria have been met or exceeded as is reported elsewhere at this conference. The fabrication and assembly of the CM begins with the superconducting radio frequency (SRF) cavities assembled into a hermetically sealed cavity string. The cavity string is then assembled into a cold mass and an insulated support structure. This assembly process will be discussed with respect to CM performance parameters. This includes thermal and magnetic shielding, vacuum, beamline-alignment and instrumentation requirements.

* Work supported by the U.S. Department of Energy under contract DE-AC05-00OR22725.

RPAB062 Status of the Production Electropolishing System at Jlab

John Mammosser, Julian Gordon, Larry Phillips (Thomas Jefferson National Accelerator Facility)

Jefferson Lab has installed, and is in the process of commissioning, a production electropolish system, sized for 805MHz SNS cavities. The paper describes the basic system design, problems encountered during commissioning, effectiveness of polishing SNS medium beta cavities and any early results from cavity tests.

* Work supported by the US.DOE under contract Nr. DE-AC05-00OR22725.

RPAB063 Gradient Optimization for Elliptical Cavities

Schneider William, Claus Rode, Jefferson Lab SRF Staff (Thomas Jefferson National Accelerator Facility)

The Rare Isotope Accelerator (RIA) ion linac design consists of a normally conducting RFQ section, a SC drift tube cavity section, a SC elliptical multi-cell cavity section and two charge strippers with associated charge state selection and beam matching optics. The SC elliptical section uses three multi-cell beta cavity types installed into cryomodules to span the energy region of 84.5 MeV/nucleon up to 400 Mev/V nucleon. This paper focuses on the gradient optimization of these SC elliptical cavities housed in the cryomodules that provide a significant portion of the total acceleration to the beam. The choice of accelerating gradient coupled with the cavity quality factor has a strong effect on the overall cost of the accelerator. The paper describes the optimization of the capital and operating cost associated with the RIA elliptical cavity cryomodules.

* Supported by US DOE Contract No. DE-AC05-84ER40150.

RPAB064 Mechanical Cavity Design For 100MV Upgrade Cryomodule

Katherine Wilson, I. E. Campisi, G. Ciovati, E.F. Daly, J. Henry, P. Kneisel, D. Machie, C. Reece, J. Sekutowicz, T. Whitlatch (Thomas Jefferson National Accelerator Facility)

To achieve up to 6 GeV, each cryomodule in the CEBAF accelerator currently provides about 30 MV of acceleration. To raise the accelerator energy to 12 GeV, ten additional cryomodules capable of providing over 100 MV of acceleration are required. A prototype of the 100 MV cryomodule has been designed, is presently under construction, and will be completed in 2004. This prototype cryomodule comprises two new cavity designs, four cavities of the low loss design and four cavities of the high gradient design. Although the cavity shapes were designed for their RF properties, the mechanical implications must be considered. In addition to the new cavity shapes, changes have also been made to the cavity end dish assemblies, weld joints, and stiffening rings. This paper will present the results of the stress and vibration analyses used for designing the cryomodule, as well as the effects of Lorenz force detuning.

* Supported by US DOE Contract No. DE-AC05-84ER0150.

RPAB065 The SNS Prototype Cryomodule: Testing and Performance

Isidoro Campisi, G. Ciovati, E.F. Daly, G.K. Davis, J. R. Delayen, M. Drury, L. W. Funk, P. Kneisel, J. Mammosser, T. Powers, J. Preble, C.E. Reece, C.H. Rode, M. Stirbet, H. Wang, T. Whitlatch, K.M. Wilson, M. Wiseman (Thomas Jefferson National Accelerator Facility)

The SNS Prototype Cryomodule, containing three medium beta (.61) superconducting elliptical cavities, was tested during the summer of 2002. Testing of the cryomodule included measurements performed for the first time ever in this type of structure. Cavities were tested under strong coupling conditions and subjected to high power pulses (1 ms) of RF at 805 MHz. Maximum fields achieved substantially exceeded the design specification of 10.5 MV/m with RF losses well below specification. For the first time a coaxial coupler was tested in an upside-down configuration in a cryostat. The power couplers performed well, carrying up to 700 kW peak power, limited by cavity performance. First time tests of dynamic Lorentz force detuning indicated that there is no significant limitation in achieving field stability and control during pulsed operation. The module was retested following a road trip that simulated shipping conditions to the SNS site in Oak Ridge, TN. No major effect due to shipping was noticed. Details of measurements and results will be given.

* Supported by US DOE Contract No. DE-AC05-00OR22725.

RPAB066 Commissioning-Results of the REX-ISOLDE LINAC

Stephan Emhofer, Friedhelm Ames, Joakim Cederkall, Dietrich Habs, Oliver Kester, Klaus-Peter Rudolph (Sektion Physik der LMU München), Thomas Sieber (CERN)

At REX-ISOLDE at ISOLDE/CERN radioactive ions are post accelerated with a 10 meters linac for experiments in nuclear-, astro- and solid state physics. For the efficient acceleration to energies between 0.8 and 2.3 MeV/u the principles of charge breeding of radioactive ions by an electron beam source was introduced at REX. The linac in its current stage consists of a 4-rod RFQ, a 20-gap IH-drift-tube-cavity and three seven-gap-splitring resonators. It is able to accelerate up to a mass to charge ratio of 4.5. 2002 has been the first year of nuclear physics experiments with REX-ISOLDE. The experiments done so far using Coulomb excitation and particle transfer reactions require good beam quality at the two target stations. Therefore commissioning measurements of the linac were made and are still being done. The results of those measurements will be presented showing the current energy spreads and radial emittances of the different cavities.

* This work is supported by BMBF under contract 06LM974 and by the EU under HPRI-CT-1999-00018.

RPAB067 An Energy Upgrade of the REX-ISOLDE linac

Oliver Kester (Sektion Physik, LMU Munchen), Thomas Sieber (CERN), Henning Bongers, Dietrich Habs, Klaus Rudolph (Sektion Physik der LMU München)

In 2002 the dominant experiment at ISOLDE was REX-ISOLDE. The linacdelivered beams of radioactive isotopes at energies of 0.3, 2 and 2.2 MeV/u towards the two target stations. Due to the charge state breeder very different mass regions of the nuclear chart could be addressed from Li to Sm. In order to perform Coulomb excitation and particle transfer experiments in the mass region up to A=150, an energy upgrade of the LINAC is required, which is foreseen in two steps. The first upgrade to about 3.1 MeV/u, the second to about 4.2 MeV/u will be a mayor change in the LINAC structure. Design

calculations, cavity design and first measurements with the cavity dedicated for the first step upgrade will be presented.

* Work supported by the BMBF and the DFG.

RPAB068 Front End Design of the RIA Driver Linac

Andrei Kolomiets (Institute for Theoretical and Experimental Physics, Moscow), Vladislav Aseev, Petr Ostroumov, Richard Pardo (ANL)

This paper describes the front end design for the Rare Isotope Accelerator (RIA) driver linac which is able to select, separate and accelerate ion species of one- or two-charge states. The front end comprises an ECR ion source located on a 100 kV platform, LEBT, RFQ and MEBT. The first section of the LEBT is an achromatic bending system for charge-to-mass analysis and selection. For the heaviest ions with masses above 180, the transport system is capable to deliver to the entrance of the first buncher a two-charge-state beam with similar Twiss parameters for both charge states. In order to match two-charge-state beams with a variety of masses, the straight section of the LEBT upstream of the RFQ will be placed on a high-voltage platform. A voltage ~30 kV is required in order to match velocities of ions lighter than uranium and maintain the possibility to accelerate two charge states simultaneously. Several options of the beam matching schemes in the transport sections LEBT-RFQ and RFQ-MEBT are being studied.

* Work supported by the U. S. Department of Energy under contract W-31-109-ENG-38.

RPAB069 Acceleration Trials with a Plane Wave Transformer (PWT) Linac

Srinivas Krishnagopal, Sanjay Chouksey, Umesh Kale, Arvind Kumar, Shankar Lal, Pravin Nerpagar, Kamal Kumar Pant, Vijenda Prasad (Centre for Advanced Technology)

A four-cell Plane Wave Transformer (PWT) linac structure has been tuned to resonate at the design frequency of 2856 MHz, and the structure is currently being conditioned for hot tests. We present results of the hot tests and observation of dark current acceleration in the structure. We also discuss design changes to use rods instead of cooling tubes, and present some preliminary results.

RPAB070 High Power Electron S-Band Linac for Industrial Purposes

Volodymyr Kushnir, Mykola Ayzatsky, Volodymyr Beloglasov, Efrem Biller, Victor Boriskin, Nikolay Demidov, Anatoly Dovbnya, Volodymyr Kushnir, Victor Mitrochenko, Leonid Myakushko, Tatyana Nikitina, Viktor Popenko, Genrikh Pugachev, Oleg Repikhov, Leonid Reprintzev, Valery Shendrik, Dmitry Stepin, Gordey Tarasov, Yury Tur (Kharkov Institute of Physics and Technology)

The high-power S-band linac KYT-20 with electron energy 20 MeV and average power up to 20 kW was designed and fabricated in the NSC KIPT. The linac was put into operation in 2002. The accelerator is devoted to irradiation application mainly for radioisotope production for medicine. The KYT-20 consists of two accelerating structures with variable geometry and the injector system. The wave phase velocity in the structures is equal to the velocity of the light. Length of the accelerating section is 1.23 m. The linac is equipped with the different output systems to extract the beam. The RF system includes two klystrons. The klystron of the first section operates as a self-exited oscillator. The paper contains a detailed description of the main linac systems. The results of KYT-20 testing and the beam parameters measurement are presents.

* The work is supported by Science and Technology Center in Ukraine, contract #2185.

RPAB071 Pulsed Heating Experiments at 34 GHz

Oleg Nezhevenko, Jay L. Hirshfield (Omega-P, Inc. and Yale University), Gennady V. Serdobintsev (BINP), Vyacheslav P. Yakovlev (Omega-P, Inc.)

Pulsed heating is one of the main factors that limit accelerating gradient in normal conducting linear accelerators. In this paper a special test device is described that is designed to determine the maximum achievable accelerating gradient limit due to pulsed heating and metal fatigue. As the power source for driving the test device the 34 GHz Omega-P pulsed magnicon will be used. Utilization of a few MW of power in 1 msec pulse width should allow one to obtain pulsed heating exceeding 500° C and consequently to define the pulsed heating limit. The test device is designed to allow measurements not only for copper, but also for other materials (e.g. GLIDCOP), and for different procedures of surface machining, cleaning and preparation.

* Research supported by the Department of Energy, Division of High Energy Physics.

RPAB072 The Vacuum Systems for the PEFP LINAC

Mi-Young Park, Yong Sub Cho, Jang Min Han, Ji Ho Jang, Heok Jung Kwon (Korea Atomic Energy Research Institute)

The 20 MeV proton LINAC, consist of ion injector, LEBT, RFQ and DTL, is now constructing at the KAERI site, Korea. To minimizing the beam loss due to the neutral gas species, the pressure of the entire accelerating system must below 1e-6 ~ 1e-7 mbar during the beam operation. In this paper we'll overview the PEFP Linac vacuum systems, and explain the details of the sub systems separately.

RPAB073 Series Production of Copper and Niobium Cavities for the Spallation Neutron Source

Michael Pekeler, Stefan Bauer, Kai Dunkel, Michael Peiniger, Christian Piel, Hanspeter Vogel, Peter vom Stein (ACCEL Instruments GmbH)

Since more than one year ACCEL is working on two large scale cavity series production: The normal conducting CCL type copper cavities (4 modules containing each 12 7-cell segments) and all superconducting 6-cell cavities (35 medium beta and 74 high beta cavities) for the linac of the Spallation Neutron Source. For both projects, the prototype phase is finished and we are in the middle of the series production. Tuning results on the normal and superconducting cavities will be presented as well as the cold RF test results of the superconducting medium beta cavity production. Experiences gained for future large scale cavity production will be presented.

RPAB074 The Commissioning of a 6MeV X-Band SW Accelerating Structure

Jin Qingxiu (Tsinghua University, Beijing)

A 6MeV, X-band on-axis SW Electron linear accelerating structure has been developed. It can be suitable for portable radiation therapy and radiography. This paper presents the design,manufacture and high test. The accelerating structure operates in the $\pi/2$ mode. It is a 38cm long and consists of 49 cells including 9 cells of bencher. 1.5MW of RF power input is from the pulsed magnetron at 9300MHz. Currently, beam tests have been completed in Accelerator Laboratory, Tsinghua University. Electron beam energy is 6.5MeV at 50mA, the electron beam focal spot size is less than 1.5mm without any focusing solenoid. Results of beam test are found to conincide with design of the guide.

RPAB075 Continued Development of the RFI Linac Structure

Donald Swenson

The Rf Focused Interdigital (RFI) linac structure is under development at Linac Systems. It promises very efficient acceleration of protons,

light ions, and heavy ions to tens of MeV in relatively small packages. Recent developments include the discovery of effective geometries for the support of the two-part drift tubes, which provide the rf focusing, and efficient geometries for the end terminations of the interdigital linac tanks. These developments required extensive use of our 3d rf cavity calculational capability. A 'cold model' of an RFI linac has been fabricated and tested. Comparisons of the measured and calculated results will be presented. The beam dynamics of the structure has been studied with TRACE-3D and a modified version of PARMILA. The structure is capable of remarkably high beam currents (space charge limits). The results of these studies will be presented. The high rf efficiency of the structure promotes the possibility of cw operation. A prime application for the RFI linac structure is the challenging job of providing intense fluxes of epithermal neutrons for the boron neutron capture therapy (BNCT) application. Mechanical designs of the RFI linac structure for that application will be presented. Other applications for the RFI linac structure will be described.

* Work supported by the U.S. Department of Energy (DOE).

RPAB076 Upgrades of Linac System at CAMD

Yanshan Wang, Ben Craft, Paul Jines, Toby Miller (CAMD, Louisiana State University)

The 180 – 200 MeV linac is an injector of Center of Advanced Microstructures and Devices (CAMD) 1.3 GeV accelerator, and consists of a 50kV triode electron gun, a 500MHz chopper-prebuncher, a 4MeV, 3GHz standing wave buncher, and two 6-meter long traveling wave accelerating sections. The RF system which drives the linac consists of two 35MW, 3GHz Klystrons and modulators, RF drivers, master oscillator, and so on. In the paper, the latest operation parameters of linac are introduced, the results of recent upgrades of linac, such as linac control system upgrade, linac timing system upgrade, linac master oscilator upgrade, are presented, and the linac energy increase is discussed.

* Work is supported by the State of Louisiana.

Poster Session RPAG
Galleria at 8:30

RPAG001 Linear Coupling of RMS Emittances

Lee Teng (ANL)

A general formulation of the linearly coupled rms emittances in two degrees of freedom is given. This formulation shows clearly what can be done to the emittances and how best to design for the necessary coupling. The generalization to three degrees of freedom is straightforward, but with much more complex coupling structure.

* Work supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

RPAG002 Proposal of Partial 20% Siberian Snake based on Helical Magnets for AGS

Yuri Shatunov, Peter Shatunov (BINP)

Scheme of partial Siberian snake is considered for polarized proton acceleration at AGS. The snake consists from four identical helical magnets with the field value up to 4.5 T and provides proton spin rotations by 60 degrees per one pass on the injection energy 2.5 GeV.At that, orbit distortions are zero outside the snake and does not exceed 2.5 cm inside the insertion. A practical design of the helical magnet is discussed together with influences of the snake fields nonlinearities on the beam dynamics.

RPAG003 Action and Phase Analysis to Determine Sextupole Errors in RHIC and the SPS

Javier Cardona, Steve Peggs, Todd Satogata (BNL), Rogelio Tomas (CERN)

Success in the application of the action and phase analysis to find linear errors at RHIC Interaction Regions [V. Ptitsyn, J. Cardona, F. Pilat and J. P. Koutchouk,"Measurement and Correction of Linear Effects in the RHIC Interaction Regions", Proceedings of the 2001 Particle Accelerator Conference, Chicago (2001)] has encouraged the creation of a technique based on the action and phase analysis to find non linear errors. In this paper we show the first attempt to measure the sextupole components at RHIC interaction regions using the action and phase method. Experiments done by intentionally activating sextupoles in RHIC [W. Fischer, F. Schmidt, R. Tomas, "Measurements of Sextupolar Resonance Driving Terms in RHIC", C-A/AP/81, BNL, (2002)] and in SPS [M. Hayes, F. Schmidt and R. Tomas, "Direct Measurements of Resonance Driving Terms at SPS at 26 GeV"] will also be analyzed with this method. First results have given values for the sextupole errors that at least have the same order of magnitude as the values found by an alternate technique during the RHIC run 2001 [F. Pilat, P. Cameron, V. Ptitsyn, J-P Koutchouk, "Linear and Nonlinear Corrections in the RHIC Interaction Regions", Proceedings of EPAC 2002, Paris, (2002)].

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

RPAG004 Beam Diffusion Measurements at RHIC

Raymond Fliller III, Angelika Drees, David Gassner, Gary McIntyre, Stephen Peggs, Dejan Trbojevic (BNL)

During a store, particles from the beam core continually diffuse outwards into the halo through a variety of mechanisms. Understanding the diffusion rate as a function of particle amplitude can help discover which processes are important to halo growth. A collimator can be used to measure the amplitude growth rate as a function of the particle amplitude. In this paper we present results of diffusion measurements performed at the Relativistic Heavy Ion Collider (RHIC) with fully stripped gold ions, deutrons, and protons. We compare these reults with measurements from previous years, and simulations, and discuss any factors that relate to beam growth in RHIC.

* Work performed under the auspices of the U.S. Department of Energy.

RPAG005 Spin Matching from the AGS to RHIC

William Mackay, Alfredo Luccio, Nicholaos Tsoupas (BNL)

Ideally in a flat horizontal ring the stable polarization direction should be vertical. However, the transfer line between the AGS and RHIC has a mixture of vertical and horizontal bends which can tilt the stable polarization away from the vertical. Additionally, if the partial snake in the AGS is powered during extraction the stable polarization direction in the AGS is also tilted away from the vertical. In this paper we examine settings of the RHIC snakes and rotators for the optimum polarization transfer at the injection energy of 24.335 GeV (G*gamma=46.5). Matching conditions for a proposed 20% partial helical snake for the AGS are also considered.

* This work was performed under the auspices of the US DOE and RIKEN of Japan.

RPAG006 Measurement of the Nonlinear Momentum Compaction Factor in RHIC

Christoph Montag (BNL)

During gold beam acceleration in the Relativistic Heavy Ion Collider (RHIC), the transition energy has to be crossed at gamma_t = 23. Since close to gamma_t the longitudinal slip factor gamma_t^-2-gamma^-2 becomes very small, the longitudinal momentum

compaction factor alpha_1 becomes significant. Measurements of this factor using longitudinal phase space tomography will be reported.

* Work performed under the auspices of the US Department of Energy.

RPAG007 Correction of Nonlinear Resonances at RHIC

Vadim Ptitsyn, Peter Cameron, Alexei Fedotov, Fulvia Pilat (BNL)

It has been observed that forth and fifth order nonlinear resonances limit available betatron tunespace and affect the beam lifetime at the RHIC. The effect of the resonances is especially pronounced at two beam energy regions: around transition energy, where large beam tune spread is intentionally introduced to counteract a transverse beam instability, and at the collision energy. A resonance correction scheme using available nonlinear correctors (octupoles and decapoles) has been developed and applied in order to compensate the resonances and minimize related beam losses.

* Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

RPAG008 Acceleration of Polarized Beams using a Strong Partial Siberian Snake

Thomas Roser, Leif A. Ahrens, Mei Bai, Ernest D. Courant, Joseph W. Glenn, Ramesh Gupta, Haixin Huang, Alfredo U. Luccio, William W. MacKay, Nicholaos Tsoupas, Erich Willen (BNL), Masahiro Okamura (RIKEN)

Acceleration of polarized protons in the energy range of 5 to 25 GeV is particularly difficult since depolarizing spin resonances are strong enough to cause significant depolarization but full Siberian snakes cause intolerably large orbit excursions. Using a 20 - 30 % partial Siberian snake both imperfection and intrinsic resonances can be overcome. Such a strong partial Siberian snake was designed for the Brookhaven AGS using a dual pitch helical dipole, which minimizes orbit excursions. Considerations for proper spin and orbit matching will be discussed.

* This work was performed under the auspices of the U.S. Department of Energy under Contract No. DE-AC02-76CH00016 and RIKEN of Japan.

RPAG009 Beam Dynamics Studies of a Superconducting RF Photoinjector

Qiang Zhao, Ilan Ben-Zvi, Triveni Srinivasan-Rao (BNL)

In order to produce high brightness beam from a niobium superconducting RF gun, the laser injection phase, the length of the first cell, the shape and number of the cells are optimized. The influence of the Schottky effect is included in the calculations. The results of beam dynamics simulations are discussed.

RPAG010 Design Study of a Compact Time of Flight Mass Spectrometer Ring

Francois Meot (CE Saclay), Marcel Baril, Daniel Michaud (Laval University, Quebec)

A design study of a low energy electrostatic storage ring employed as a multi-pass time of flight mass spectrometer is presented. The design is based on stepwise ray-tracing that provides accurate multiturn tracking across the highly non-linear electrostatic parallel-plate mirrors used as both focusing and bending optical elements in the spectrometer ring. First experimental results and beam observation are discussed.

RPAG011 Adiabatic Capture of Charged Particles in Stable Islands: A Novel Approach to Multi-Turn Extraction

Massimo Giovannozzi, Roberto Cappi (CERN)

Recently a novel approach has been proposed aimed at performing multi-turn extraction from a circular machine. Such an approach consists of splitting the beam by means of stable islands created in transverse phase space by nonlinear magnetic elements such as sextupoles and octupoles. Provided a slow time-variation of the linear tune is applied, adiabatic with respect to the betatron motion, the islands can be moved in phase space and eventually charged particles may be trapped inside the stable structures. This generates a certain number of well-separated beamlets. Originally, this principle was successfully tested using a fourth-order resonance. In this paper the approach is generalised to other type of resonances and some examples of adiabatic capture performed by using various low-order resonances are presented and described in detail.

RPAG012 Optics Studies for the CERN Proton Synchrotron Machine: Linear and Nonlinear Modelling Using Beam Based Measurements

Massimo Giovannozzi, Roberto Cappi, Elias Métral, Gabriel Métral, Michel Martini, Rende Steerenberg (CERN), Anke Susanne Müller (ISS, Forschungszentrum Karlsruhe, Germany)

The CERN Proton Synchrotron machine is built using combined function magnets. The control of the linear tune as well as the chromaticity in both planes is achieved by means of special coils added to the main magnets, namely two pole-face-windings and one figure-of-eight loop. As a result, the overall magnetic field configuration is rather complex not to mention the saturation effects induced at top-energy. For these reasons a linear model of the PS main magnet does not provide sufficient precision to model particle dynamics. On the other hand, a sophisticated optical model is the key element for the foreseen intensity upgrade and, in particular, for the novel extraction mode based on adiabatic capture of beam particles inside stable islands in transverse phase space. A solution was found by performing accurate measurement of the nonlinear tune as a function of both amplitude and momentum offset so to extract both linear and nonlinear properties of the lattice. In this paper the measurement results are presented and the derived optical model is discussed in detail.

RPAG013 Measurements of Transverse Space-Charge Effects in the CERN Proton Synchrotron

Elias Metral, Massimo Giovannozzi, Michel Martini, Gabriel Metral, Rende Steerenberg (CERN)

Several beam dynamics codes are used in the design of the next generation of high beam power accelerators. They are all capable of simulating the full six-dimensional motion through a machine lattice in the presence of strong space-charge effect and beam-to-wall interaction. A key issue is the validation of these codes. This is usually accomplished by comparing simulation results against available theories, and more importantly, against experimental observations. To this aim, a number of well-defined test cases, obtained by accurate measurements made in existing machines, are of high interest. This paper reports and discusses precise measurements of transverse emittance blow-up due to space-charge-induced crossing of the integer or half-integer stop band.

RPAG014 Beam-Based BPM Alignment

Richard Talman (Cornell University), Nikolay Malitsky (BNL)

An operational, beam-based, null-measurement, control room procedure designed to steer the closed orbit through the effective (no steer) center of every quadrupole is described. Performance of the procedure is simulated using UAL (Unified Accelerator Libraries). Matching SNS hardware availability, quadrupole strengths are assumed to be trimmable, but only in families, not individually. The accuracy of the procedure is unaffected by geometric and/or electrical misalignment of BPM's (beam position monitors) but calibration of their misalignments is a byproduct of the procedure. Some of the many possible failure mechanisms have been modeled, and have been found not to invalidate the procedure.

* Work performed under the auspices of the DOE.

RPAG015 Simulation of Beam Loss and Radiation Fields in the NuMI Primary Beamline

Sam Childress (FNAL)

The design of the 120 GeV NuMI/MINOS primary proton beamline has been significantly upgraded to minimize beam transport loss for the highest intensities to be provided from the Fermilab Main Injector. A small fraction of the 400 kW beam lost at normal operation or accident conditions can result in significant impact on beamline components, personnel and environment protection. The MARS model of the primary beamline, developed earlier, has been substantially upgraded in this study to take into account new beamline optics, equipment and tunnel configuration. Results of thorough STRUCT-MARS cross-check analysis enable identifying worst-case scenarios. Beam loss distributions and subsequent radiation fields are calculated. A sensitivity analysis is performed as a function of component instabilities and of various failure modes.

* Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy

RPAG016 Barrier RF Stacking at Fermilab

Weiren Chou, Jim Griffin, K-Y. Ng, Dave Wildman (FNAL), Hai Zheng (Caltech)

A key issue to upgrade the luminosity of the Tevatron Run2 program and to meet the neutrino requirement of the NuMI experiment at Fermilab is to increase the proton intensity on the target. This paper introduces a new scheme to double the number of protons from the Main Injector to the p-bar production target (Run2) and to the pion production target (NuMI). It is based on the fact that the MI momentum acceptance is about a factor of four larger than the momentum spread of the Booster beam. Two RF barriers – one fixed, another moving – are employed in the MI to confine the proton beams from the Booster. The Booster beams are injected off-momentum into the MI and are continously reflected and compressed by the two barriers. Calculations and simulations show that this scheme could work provided that the beam momentum spread can be kept under control. Compared with the slip stacking (another beam stacking scheme), a main advantage of the barrier RF stacking is small beam loading effects thanks to low peak beam currents. The RF barriers can be generated by an induction device, which uses nanocrystal magnet alloy (Finemet) cores and high voltage MOSFET switches. Beam experiments and hardware development are currently under way.

* Work supported by the Universities Research Association, Inc., under contract No. DE-AC02-76CH03000 with the U.S. Department of Energy.

RPAG017 Space Charge Study at the Fermilab Booster

Weiren Chou, Chuck Ankenbrandt, Joe DiMarco, Alexander Drozhdin, Jim Lackey, Ernie Malamud, Jean-Francois Ostiguy, Milorad Popovic, Eric Prebys, Phil Schlabach, Ray Tomlin (FNAL)

The Fermilab Booster is currently a bottleneck limiting the proton beam intensity in the accelerator complex. Space charge is considered to be a major factor of this limit. In order to understand its effect, a full scale study has been launched since last year. It includes Booster modeling, numerical simulation (using the parallelized code ORBIT adopted from ORNL), beam experiments, magnet field measurements, and investigation of possible cures that would suppress the space charge effect and improve the machine performance (e.g., inductive inserts, quadrupole pickup and damper, electron beam compensation, etc.). This paper will give a progress report of this study. It will also give a comparison of simulation results with machine measurements.

* Work supported by the Universities Research Association, Inc., under contract No. DE-AC02-76CH03000 with the U.S. Department of Energy.

RPAG018 Ion Production and Tune Shift in the Recycler Ring

K. Gounder, J. Marriner, S. Mishra (FNAL)

We calculate the ion production rate for a beam of 2×10^{10} antiprotons in the Recycler Ring and compare the calculation with the actual measurements using the beam tune shifts when the RF gap is removed.

* Work supported by the U.S. Department of Energy under contract no. DE-AC02-76CH03000.

RPAG019 Analysis and Measurements of Emittance Dilution from Vacuum Windows in the Fermilab Recycler Transfer Lines

Carol Johnstone, Consolato Gattuso, Dave Johnson, Mike Syphers (FNAL)

Round-trip beam transfers between the Fermilab Main Injector and Recycler (antiproton accumulator) have been plagued by an emittance dilution of about a factor of 2 with corresponding beam loss. The source of the large dilution was traced to two Ti vacuum windows, one installed in each of the two transfer lines that connect the machines for beam injection/extraction. The dilution can be accounted for by calculating the increase in beam divergence due to multiple scattering in the windows followed by an amplitude mismatch that serves to further enhance the instantaneous dilution immediately downstream of the window. This work presents the analytical basis for the phase-space, or emittance, dilution due to the window, the subsequent optics mismatch, and then presents an analysis of beamline measurements that evidences the effect and validates the analytical argument. The data showed a strong skew quadrupole component in the transfer line optics that initially complicated the analysis, but was effectively eliminated in some of the data samples acquired under specific beam conditions.

* Work supported by the US Department of Eneregy under contract no. DE-AC02-76CH03000.

RPAG020 Automatic Beamline Correction

Thomas Kobilarcik (FNAL)

In the MiniBooNE experiment, a simple linear algorithm is used to maintain the correct beam position throughout the beamline and at the target. The algorithm is explained, and key features of the implementation are discussed.

* Work supported by the U.S. Department of Energy under contract number DE-AC02-76CH03000.

RPAG021 Performance of Main Injector Bunch Coalescing during Fermilab's Current Collider Run

Ioanis Kourbanis, Joseph Dey, John Reid (FNAL)

Bunch coalescing is used in Fermilab's Main Injector to produce the intense 36 proton and antiproton bunches required for the Tevatron Collider. For the protons, seven bunches are coalesced at a time for a total of 36 times while for the antiprotons four groups of 7-11 bunches are coalesced at a time for a total of 9 times. The performance of both proton and antiproton bunch coalescing during the current Collider Run will be presented.

* Operated by the Universities Research Association Inc. for the USA Department of Energy under contract DE-AC02-76CH03000.

RPAG022 Increasing the Intensity of the Fermilab Booster

Eric Prebys (FNAL)

The Fermilab Booster is a fast-cycling synchrotron which accelerates protons from 400 MeV to 8 GeV of kinetic energy. In recent years, the primary demand for protons has been for antiproton production, which typically uses about 7E15 protons per hour. A new generation of neutrino experiments will increase the demand dramatically over the next few years, possibly beyond 1.5E17 protons per hour. This

talk will be an overview of the program to reach these high intensties, which comprises collimation, orbit control, and damping, as well as more advanced techniques. The various monitoring systems required for consistent operation will also be discussed.

RPAG023 Space Charge in the FNAL Booster: Experiment and Modeling

Panagiotis Spentzouris (FNAL)

We present measurements of transverse and longitudinal beam phase space evolution in the FNAL Booster. We discuss the experimental technique, which allowed us to obtain turn-by-turn measurements of the beam profiles. We then compare our results with the prediction of the Synergia 3D space charge simulation code.

RPAG024 End-to-End Simulations of a Superconducting Deuteron CH-DTL for IFMIF

Andreas Sauer, Horst Deitinghoff, Horst Klein, Holger Liebermann, Holger Podlech, Ulrich Ratzinger, Rudolf Tiede (Institut fur Angewandte Physik)

The IFMIF project (International Fusion Materials Irradiation Facility) requests two cw linacs operated in parallel. Each of them is designed to accelerate a 5 MW 125 mA deuteron beam up to 40 MeV. After extraction and Low energy beam transport, the deuteron beams with strong internal space charge forces have to be bunched, accelerated and transported to a fluid Li target for high neutron flux production. This paper presents an alternative linac design for this project. The acceleration is completely based on H-type cavities. The room temperature 4-Vane-RFQ and IH-DTL are followed by 4 superconducting CH-DTL cavities. The operating frequency is 175 MHz, the designed sections lengths are 13 m for the RFQ (5 MeV), 2 m for the IH-cavity (10 MeV) and 9 m for the sc DTL. The structure parameters and end-to-end multi particle beam dynamics calculations with and without errors of the whole linac (starting form the ion source) will be presented and the results will be discussed.

* Work supported by the EU, BMBF (number: 060F998) and GSI.

RPAG025 Developments in Linear and Non-Linear DAFNE Model

Catia Milardi, Gabriele Benedetti, Maria E. Biagini, Caterina Biscari, Manuela Boscolo, Susanna Guiducci, Miro A. Preger, Pantaleo Raimondi, Cristina Vaccarezza, Mikhail Zobov (INFN)

The agreement of the Dafne model with the measured machine parameters (betas, dispersion etc.) has further improved in 2002 runs. A better dispersion function control has been obtained by improving the closed orbit correction alghoritm that now includes correction coils strength minimization. The model has been integrated in the accelerator control system, providing a faster and reliable tool for fine and on-line machine optics tuning. New measurements like the machine second order dispersion have proved to be very powerful to study second order terms in the rings. Second order chromaticity and tune shift on amplitude extend the machine knowledge up to third order.

RPAG026 Control of Patterns in Complex Vlasov-Maxwell Dynamics

Michael Zeitlin, Antonina Fedorova (IPME RAS, Russian Academy of Sciences)

An exact variational/projection approach is proposed for modeling the complex collective behaviour and the propagation of the intense charged particle beams described by different forms of Vlasov-Maxwell equations. We give representations for distribution functions and fields via the multiscale/multiresolution decomposition corresponding to exact expansions into the slow and fast nonlinear high-localized eigenmodes providing the full information about stochastic dynamical process. Numerical modeling shows the creation of different internal coherent structures from localized modes, which are related to stable/unstable type of behaviour and the corresponding patterns (waveletons) formation. Reduced algebraical structure provides the pure algebraical control of stability/unstability scenario. Various types of patterns (chaotic and localized) are controlled in space of parameters. 1. A. Fedorova, M. Zeitlin, Proc. EPAC02, pp.1323, 1344, 1434, 1482, 1595, Paris, 2002; arXiv preprints, physics/0206053, 0206052, 0206051, 0206050, 0206049, 0206054; nlin.PS/0206024.

RPAG027 Beam-Beam Effects in Inclined Super-Bunch Crossing

Yoshito Shimosaki (KEK)

Beam-beam effects in superbunch collisions have been examined. The emittance growth due to nonlinear resonances excited by the continuous space-charge force is extremely large in shallow-angle crossing such as that in the LHC and VLHC. Hybrid crossing and inclined hybrid crossing can reduce these effects.

RPAG028 Jitter Control and Scraping in the 12-View AHF HEBT

Barbara Blind, Andrew Jason (LANL)

The Advanced Hydrotest Facility (AHF) HEBT is designed to deliver 50-GeV protons to an object from 12 different directions. The incoming beam pulses are split with 11 sets of septa such that, nominally, the same number of particles arrives from each direction. Beam splitting in each set of septa is initiated by a wire septum, which causes the creation of beam halo. Extraction-kicker jitter can be expected, and could result in beam-intensity fluctuations in the 12 beamlines leading to the object. The HEBT tune is chosen to minimize this effect, with interesting consequences for the beam-splitting process. Particle-tracking simulations predict that activation of the beamline components can be kept small with a suitable scraping scheme. They also predict that the scraping scheme is not sensitive to beam-centroid jitter from extraction-kicker jitter or to average-energy jitter. The specifics of the jitter control and scraping scheme are discussed.

* Work performed under the auspices of the US DOE by LANL under contract W7405-ENG-36.

RPAG029 The Use of Electric Multipole Lenses for Bending and Focusing Polar Molecules, with Application to the Design of a Rotational-State Separator

Juris Kalnins (LBNL)

The dipole interaction (Stark effect) of a polar molecule allows one to use an inhomogeneous electric field to bend and focus a neutral beam in a transport line. We describe the type of multipole-field lenses that are needed and present the linear envelope equations. The dependance of the optics on the Stark potential energy is discused and compared to charged-particle dynamics. The envelope equations are used to design a rotational-state separator to be built at LBNL. The separator consists of a jet source followed by a triplet of focusing lenses that transport the beam to a focusing doublet and a horizontal-bend lens. With proper collimation we can scan over the distribution of rotational states from the jet source. Its initial application will be to select the J = 0 ground state molecules from a 195 K methyl flouride beam from the jet source (Xe carrier gas). The performance of the separator is simulated using the non-linear trajectory equations; off-energy molecules are included. We find that the state selection is good. The dynamic acceptance is strongly limited by non-linearity of the forces.

* Supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

RPAG030 Simple Method of Analyzing Lattice Errors

Hiroshi Nishimura (LBNL)

Lattice errors can be analyzed very effectively by combining several orbit correction schemes. A singular-value decomposition (SVD) method is useful to identify the region of the error. A most-effective corrector (MEC) method can pinpoint the source when there are only few magnets contributing. A various kinds of local bumps can emulate the effect of magnet and girder misalignments and can be used by SVD and MEC. By preparing sensitivity matrices of closed orbit and dispersion for magnet and girder misalignments and magnet gradient errors by using a model, a lattice error analysis can be done instantaneously on line. Therefore, this method is complementally to that of fitting all the elements of measured sensitivity matrices.

* Supported by U.S.DOE under Constract No. DE-AC03-76SF00098.

RPAG031 Space-Charge Driven Emittance Growth in a 3D Mismatched Anisotropic Beam

Ji Qiang, Robert Ryne (LBNL), Ingo Hofmann (Gesellschaft für Schwerionenforschung mbH)

In this paper we present a 3D simulation study of the emittance growth in a mismatched anisotropic beam. The equipartitioning driven by a 4th order space-charge resonance can be significantly modified by the presence of mismatch oscillation and halo formation. This causes emittance growth in both the longitudinal and transverse directions which could drive the beam even further away from equipartition. The averaged emittance growth per degree of freedom follows the upper bound of the 1D free energy limit plus the contributions from eqipartitioning.

* This work was performed under the auspices of a Scientific Discovery through Advanced Computing project, "Advanced Computing for 21st Century Accelerator Science and Technology," which is supported by the US DOE/SC Office of High Energy and Nuclear Physics and the Office of Advanced Scientific Computing Research.

RPAG032 Compression of the LLNL Thomson Source Photoinjector Beam Using Velocity Bunching

Scott Anderson, Winthrop Brown, Aaron Tremaine (LLNL), Pietro Musumeci, James Rosenzweig (University of California, Los Angeles)

We describe the compression of a photoinjector derived, high brightness electron beam using the velocity bunching technique. Measurements of the bunch length, emittance, and momentum distribution of a beam compressed using the Lawrence Livermore National Laboratory Thomson Source Linac are presented and compared with simulations and theoretical analysis. The results of these measurements are discussed in the context of the compression of high brightness beams.

* This work was performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

RPAG033 Eliminating the Spot Dilution due to Kicker Switching in DARHT-II

Yu-Jiuan Chen, Frank Chambers, Arthur Paul, James Watson, John Weir (LLNL)

To produce four short x-ray pulses for radiography, a fast kicker will be used on the second-axis of the Dual Axis Radiographic Hydrodynamic Test facility (DARHT-II) to select current pulses out of the 2-ms duration beam provided by the accelerator. Beam motion during the kicker voltage switching could lead to dilution of the time integrated beam spot. Therefore, every beam slice would need to be focused to a tighter spot than the design specifications in order to achieve good x-ray resolution and to accommodate beam motion during switching simultaneously. A tighter beam will put the multi-pulse target's confinement at risk. Furthermore, kicker switching typically makes the time integrated spot elliptical. An elliptical x-ray source would make radiographic analysis difficult. We have developed a tuning strategy to eliminate the spot size dilution, and tested the strategy successfully on the ETA-II with the DARHT-II kicker hardware.

* This work was performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

RPAG034 The DARHT-II Final Spot Size

Yu-Jiuan Chen (LLNL)

For high resolution flash x-ray radiography, the final spot size on the converter target needs to be on the order of a millimeter. We will present a scaling law for the spot size in terms of beam parameters and discuss how to achieve the final spot size specifications on the DARHT-II target.

* This work was performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

RPAG035 RF Focusing Methods for Heavy Ions in Low Energy Accelerators

Eduard Masunov, Sergey Polozov (MEPhI), Nikolai Vinogradov (ANL)

Two methods for RF focusing and acceleration of heavy ions with mass number up to 240 are being studied and compared. The first method is a conventional RFQ acceleration. The second one is based on axially symmetric RF field focusing (ARF) provided by a drift-tube structure. Further information is available [E.S. Masunov and N.E. Vinogradov, Phys. Rev. STAB, 2001, No 7, 070101]. Design of the accelerating-focusing structure and preliminary analysis of 3-D bunched beam dynamics is performed using the smooth approximation technique. The longitudinal and the transverse acceptances for ions with charge-to-mass ratio $q/A > 1/66$ in the energy range above 7 keV/u were calculated by the particle ray-tracing method. This approach may be useful in the post-accelerator for the RIA Facility. Further information is available [P.N. Ostroumov and et. al., PAC Proceedings, 4080 (2001)].

* Work supported by the U. S. Department of Energy under contract W-31-109-ENG-38.

RPAG036 Image-Charge Effects on the Envelope Dynamics of Bunched and Unbunched Beams in Alternating-Gradient Focusing Systems

Bao Liang Qian, Chiping Chen, Jing Zhou (MIT Plasma Science and Fusion Center)

The root-mean-squared (rms) envelope equations are derived and analyzed for both bunched and unbunched intense charged-particle beams in an alternating-gradient focusing field and a cylindrical metal pipe. Numerical results [B. L. Qian, J. Zhou, and C. Chen, submitted to PRST-AB(2002)] show that the total higher-order image-charge effects on the envelope evolution of an unbunched beam are negligible for all beams including hollow and large aspect-ratio beams and do not affect significantly the matched and slightly mismatched beam envelopes for arbitrary beam density profiles and arbitrary small apertures. In addition, the unstable region for the envelope evolution of an unbunched beam with image-charge effects, depending on the value of KS/ε, is found to be narrower than its counterpart without image-charge effects. For an arbitrary ellipsoidal bunched beam, it is shown that both space-charge and image-charge effects have a strong influence on the detailed evolution of beam bunch length and transverse beam envelopes.

* Research supported by DoE.

RPAG037 Random-Regular Accelerating Structures

Katherina Kramarenko, Mykola Ayzatsky (NSC KIPT)

In this work we present results of investigation of the characteristics of inhomogeneous sections on the base of a disc-loaded waveguide with different (non-smooth) laws of hole radius variation. We have shown that there is a travelling wave in such section when the coupling of cavity field is small. The travelling wave regime exists only at the certain frequency (working frequency). In the case of inhomogeneous section, unlike the homogeneous one, there is not a pure travelling wave regim inside the waveguide at the frequencies different from the working one. We investigated the RF properties of accelerating structure with random distribution of the hole sizes.

RPAG038 The Beam Dynamics Studies of Combined Misalignment and RF Errors for RIA

Xiaoyu Wu, D. Gorelov, T. Grimm, W. Hartung, F. Marti, R. York (National Superconducting Cyclotron Laboratory)

The NSCL design of the Rare Isotope Accelerator (RIA) driver linac uses superconducting quarter-wave, half-wave and 6-cell elliptical cavities with frequencies ranging from 80.5 to 805 MHz with two charge-stripping chicanes. The design can properly accelerate light and heavy ions to final energies of ≥ 400 MeV/u with a beam power of 100 to 400 kW. The impact of combined misalignment and rf errors on the transverse and longitudinal beam emittance growth, beam loss throughout the RIA driver linac including the two charge-stripping chicanes, and large-amplitude beam behaviors were studied by simulations, and will be presented in this paper.

* Work supported by Michigan State University and NSF PHY 0110253.

RPAG039 Plasma Neutralization Models for Intense Ion Beam Transport in Plasma

Igor Kaganovich, Ronald C. Davidson, Edward A. Startsev (Princeton University), Edward P. Lee (LBNL)

Plasma neutralization of an intense ion pulse is of interest for many applications, including plasma lenses, heavy ion fusion, cosmic ray propagation, etc. An analytical electron fluid model has been developed based on the assumption of long charge bunches ($l_b >> r_b$). Theoretical predictions are compared with the results of calculations utilizing a particle-in-cell (PIC) code. The cold electron fluid results agree well with the PIC simulations for ion beam propagation in the background plasma. The analytical predictions for the degree of ion beam charge and current neutralization also agree well with the results of the numerical simulations. The model predicts very good charge neutralization (>99%) during quasi-steady-state propagation provided the beam pulse duration τ_b is much longer than the electron plasma period $2\pi/\omega_p$, where ω_p is the electron plasma frequency. In the opposite limit, the beam pulse excites large-amplitude plasma waves. Similarly, the beam current is well neutralized provided $\tau b\ \omega_p >> 2\pi$, and the beam radius is much larger than plasma skin depth ($r\omega_b >> c/\omega_p$). A warm electron fluid model has been developed to account for electron production due to ionization of background gas by the ion pulse. Improved charged neutralization occurs during beam entry into the plasma plug, when electron-emitting electrodes are used in combination with externally-produced plasma.

* Research supported by the U.S. Department of Energy.

RPAG040 Kinetic Description of Sheet Beam Stability Properties for Uniform Phase Space Density

Edward Startsev, Ronald Davidson (Princeton University)

This paper makes use of the Vlasov-Maxwell equations to investigate collective excitations in an intense sheet beam, infinite in the y- and z- directions, propagating in the z- direction. The beam is confined in the x-direction by a smooth-focusing force, and perfectly conducting planar walls are located at $x=+/- x_w$. A self-consistent waterbag equilibrium f_b^0 satisfying the steady-state Vlasov-Maxwell equations is shown to be exactly solvable for the beam density $n_b^0(x)$ and space-charge potential $phi_b^0(x)$. A closed Schrodinger-like eigenvalue equation is derived, assuming small-amplitude perturbations about the self-consistent waterbag equilibrium, and the eigenfrequency spectrum is shown to be purely real. The WKB approximation is employed to determine the eigenfrequency spectrum as a function of the normalized beam intensity.

* Research supported by the U. S. Department of Energy.

RPAG041 Renormalization Group Reduction of the Henon Map

Stephan Tzenov, Ronald Davidson (Princeton University)

The power of the Renormalization Group (RG) method to extract slow-time-scale dynamics is described and demonstrated for the example of the Henon map. The reduced RG map governs regular periodic motion in the case where the working point is sufficiently far removed from resonances. It is also shown how to construct a reduced resonant RG map which preserves the symplectic symmetry of the original Henon map. The RG approach described in the present paper can be applied to two-, four- or fully six-dimensional arbitrary transfer maps. Applications of this powerful technique to resonance corrections and closed orbit corrections are discussed.

* Research supported by the U.S. Department of Energy.

RPAG042 Solitary Waves in Intense Charged Particle Beams

Stephan Tzenov, Ronald Davidson, Edward Startsev (Princeton University)

Based on the Vlasov-Maxwell equations describing the self-consistent nonlinear beam dynamics and collective processes, the evolution of an intense sheet beam propagating through a periodic focusing field has been studied. In an earlier paper it has been shown that in the case of a beam with uniform phase space density the Vlasov-Maxwell equations can be replaced exactly by the macroscopic warm fluid-Maxwell equations with a triple adiabatic pressure law [R.C. Davidson, H. Qin, S.I. Tzenov and E.A. Startsev, Phys. Rev. Special Topics on Accelerators and Beams 5, 084402 (2002)]. In this paper we demonstrate that starting from the macroscopic fluid-Maxwell equations a set of coupled nonlinear Schroedinger equations for the slowly varying wave amplitudes describing multi-wave interactions can be derived. Properties of the nonlinear Schroedinger equation are discussed, together with soliton formation in intense particle beams.

* Research supported by the U.S. Department of Energy.

RPAG043 The Resistive Wall and Surface Roughness Wakefields

Valery Dolgashev, Karl Bane (SLAC)

The development of a new generation of synchrotron light sources, such as the Linac Coherent Light Source (LCLS), requires an understanding of the wakefield effect that is generated by a very short (~0.02 mm) bunch in the beam pipe of a long (~100 m) undulator. In particular, the longitudinal wakefield will tend to increase the beam's energy spread and thereby decrease the performance of the light source. There are two basic impedance models that are applied to the interaction of a short bunch and a beam pipe: the resistive wall model and the surface roughness model. In this paper we discuss the range of parameters for which each model is applicable and also the intermediate regime where the typical skin depth is comparable to the typical size of the surface roughness.

RPAG044 RF Modes in the PEP-II Shielded Vertex Bellows

Alexander Novokhatski, Stephen Weathersby (SLAC)

Experimental and simulation study of RF modes were carried out for the complicated geometry of the shielded vertex bellows near the IP region of the PEP-II B-factory. A beam position monitor button electrode located 50 cm from the bellows provides a signal to a HP54120 high frequency oscilloscope and a R&S gated spectrum analyser for spectrum measurement. Calculations indicate monopole, dipole and quadrupole modes can exist in the bellows structure near the experimentally observed frequency region of 5 GHz. The observed modes are correlated to the bellows heating. The beam-generated fields are scattered by the masks, taper and axial offsets and heat the bellows by coupling through the RF shield fingers.

* US DOE contract DE-AC03-76SF00515.

RPAG045 Direct Simulation of Friction and Diffusion Coefficients for Ions Interacting with a Cold Electron Distribution

David Bruhwiler, Dan Abell, Richard Busby, John Cary, Peter Messmer (Tech-X Corporation), Ilan Ben-Zvi (BNL), Alexey Burov (FNAL)

A proposed luminosity upgrade to RHIC includes a novel electron cooling section [I. Ben-Zvi et al., Proc. Part. Accel. Conf. (2001)] which would use ~50 MeV electrons to cool fully-ionized 100 GeV/nucleon gold ions. Because the Coulomb logarithm in the beam frame is small, analytical electron cooling calculations are not precise for this problem. We will present initial simulations of the friction and diffusion coefficients for single ions passing once through the interaction region, as a function of the initial ion position and velocity. Charged particles are advanced using a fourth-order Hermite predictor-corrector algorithm. The fields in the beam frame are obtained from direct calculation of Coulomb's law, which is more efficient than multipole-type algorithms for less than ~10^7 particles. A slice of the electron beam is modeled, with a width on the order of the Debye length and periodic boundary conditions. The code uses message passing to execute in parallel on many processors. Results will be compared with calculations for both magnetized and unmagnetized electrons. In future work, these coefficients will be used to develop phase-averaged coefficients for RHIC, which can then address the question of equilibrium between electron cooling and intra-beam scattering.

* This work was supported in part by the US DoE under Contract No. DE-FG03-01ER83313 and in part by Tech-X Corporation.

RPAG046 Beam Diagnostic by Bremsstrahlung Radiation Monitoring

Vladislav Grishin, Serguei Likhached (Scobeltsyn Institute of Nuclear Physics of Moscow Lomonosov State University), Grigory Nefedov (Physics Faculty of Moscow Lomonosov State University)

Possibilities of an alternate mode of energy diagnostic by monitoring of relativistic electron beam bremsstrahlung radiation are considered. By a method of the computer modeling, carried out on the basis of the software packages GEANT and MINUIT, the spectral - angular parameters of relativistic electron bremsstrahlung radiation on the thin target are analyzed. The energy diffusion, occurrence an energy halo or tails in a beam deform spectral characteristics of a sum bremsstrahlung radiation of particles. It allows ultimately to restore actual parameters of a beam. The resolution limits, possibility of energy asymmetry eduction for different values of beam energy are discussed.

RPAG047 Pulse Compression Characteristics and the Efficiency of Laser Amplification by Raman Backscattering

Jincheol Kim (Pohang University of Science and Technology), Hae June Lee, Hy-Yong Suk (Korea Electrotechnology Research Institute), In-Soo Ko (Pohang Accelerator Laboratory)

It was shown by Shvet et al. that a short laser pulse can be amplified through Raman backscattering with a counter-propagating long pump in a plasma. In this report, we investigate the compression characteristics of the seed pulse during the amplification and its relation to the amplification efficiency. Using a one-dimensional fluid model, the time variation of the pulse width of the seed is investigated and parameters that affect the pulse compression are explored. The pulse compression is associated with the energy transfer from the pump to the seed. The generation of the child pulses and the energy distribution between the main and the child pulses are related to the transition from the linear growth to the nonlinear growth regime. We discuss what the generation of the child pulses implies on the amplification process and how it is related to the efficiency of the laser pulse amplification.

* This work is supported by the Creative Initiative Program of Ministry of Science and Technology of the Korea government and POSTECH.

RPAG048 One Approach to Optimization Problem of Beam Dynamics

Elena Kotina (Saint-Petersburg State University)

In this work an approach to optimization of charged particles dynamics in accelerating and focusing structures is considered. For describing charged particles motion we use discrete systems of equations. We investigate programmed motion of charged particle (motion of synchronous particle) and perturbed motions of charged particles. The approach of simultaneous optimization of programmed motion and perturbed motion are developed. Proposed algorithm has been applied to optimization of beam dynamics in drift-tube linear accelerator.

RPAG049 Solitary Waves in Laser-Plasma Interactions with Counter-Propagating Laser Pulses

Hae June Lee, Changbum Kim, Guang-Hoon Kim, Jong-Uk Kim, Hyyong Suk (Korea Electrotechnology Research Institute), Jincheol Kim (Pohang Accelerator Laboratory)

Recently, it was reported that a short laser pulse in a plasma can be significantly amplified with a counter-propagating pump through Raman backscattering, and that the counter-propagating pump enhances generating a laser wakefield by the short pulse. In this study, we simulate the three wave interactions between two laser pulses and a plasma wave with a one-dimensional fluid model and a particle-in-cell simulation. It was observed that an electromagnetic solitary wave of which group velocity is much slower than the short laser pulse is generated with a proper pump intensity. The proper parameter regime and the properties of the soliton-like waves are discussed.

* This work is supported by the Creative Research Initiatives by the Korea Ministry of Science and Technology.

RPAG050 A Multi-Bunched Beam with Different Energies in a Ring

Takanaka Masao (RIKEN)

We propose a method to make a multi-bunched beam with different energies in a ring. The bunches are made in the way of electron-cooling bunching, and energized by using another RF system. We investigate the feasibility of the method doing particles-tracking simulations.

RPAG051 New Regions of Stability for Periodically Focused Paticle Beams

Renato Pakter, Felipe Rizzato (Instituto de Fisica - UFRGS)

In this paper we perform a comprehensive analysis of the transport of periodically focused particle beams in the new regions of stability recently found [R. Pakter and F. B. Rizzato, Phys. Rev. Lett., 87, 044801 (2001)] for vacuum phase advances above the 90 degrees threshold. In particular, we investigate the stability as a function of the relevant parameters of the system, such as beam intensity and focusing field profile. We also discuss the nonlinear dynamical features, namely the existence of gap bifurcations [F. B. Rizzato and R. Pakter, Phys. Rev. Lett., 89, 180142 (2002)], which are responsible for the onset of the new regions of stability. Self-consistent numerical simulations are used to verify the findings.

* Work supported by CNPq and FAPERGS, Brazil.

RPAG052 Impedance Boundary Conditions for Corrugated Beam Pipe Walls

Stefania Petracca (University of Sannio and INFN Salerno)

An equivalent wall impedance to describe the electromagnetic boundary conditions at corrugated pipe walls is introduced. The general formulae for computing the longitudinal and transverse beam coupling impedances in complex heterogeneous pipes reported in [S. Petracca, Phys. Rev. E 1999, vol. 60, p. 6030-6041] together with the impedance boundary conditions introduced provide a good trade-off between computational accuracy and ease.

RPAG053 The Gaussian Approximation for a Purely Inductive Wake Function

Stefania Petracca (University of Sannio and INFN), Kohji Hirata (The Graduate University for Advanced Studies, Hayama), Theo Demma (University of Sannio)

The equilibrium bunch length in electron storage rings with a purely inductive localized wake function has been studied, assuming the Gaussian approximation of the distribution function in phase space. As discussed in [K. Hirata, Part. Acc. 1987, vol. 22, p. 57-59] the localized wake can be extended to more general cases, even to uniformly distributed wakes, described by the Haissinski equation. To do so one should introduce the superperiodicity N and let it grow to infinity. For N=1 we get stable solutions with period-one fixed points as well as multistable states. For N>>1 the comparison of our results with those obtained from Haissinski equation [Y. Shobuda and K. HIrata, KEK Preprint 99-37, July 1999, A] shows good agreement and helps understanding the validity of the Gaussian approximation.

RPAG054 Electromagnetic Effects in the Coaxial Region of the LHC-Like Circular

Stefania Petracca (University of Sannio and INFN Salerno), Theo Demma (University of Sannio)

We compute the electromagnetic field due to a periodically spaced train of bunches traveling in a closed ring, and consider both the delta and the Gaussian density distribution. We calculate the power dissipated into the walls of the coaxial region between the liner and the cold bore surfaces due to the transverse electromagnetic (TEM) mode set up by the electromagnetic radiation leaking through the liner's holes.

RPAG055 Scattering of Fast Charged Particles by Crystal Atomic Strings

Nikolai Shul'ga (National Science Center), Anatoliy Greenenko, Valentin Truten' (NSC KIPT)

The results of investigations of fast charged particle scattering by crystal atomic string and nanotube at small incident angles to its axis are presented. The possibilities of rainbow scattering and orbiting of relativistic electrons in such fields are shown. The effect of the total cross-section decreasing for elastic scattering of relativistic electrons by crystal atomic strings is discussed. This effect is analogous to the Ramsauer-Townsend effect for slow electron scattering by atoms. The dynamical chaos phenomenon at channeling and scattering of fast particles in the fields of crystal atomic strings and a nanotube are discussed. It is shown that the fractal-type dependence of delay time of particle scattering in the fields of crystal atomic strings and nanotube.

* This work is partially supported by STCU (project #1746).

RPAG056 Fast Charged Particles' Passage through Straight and Bent Nanotube Ropes and Crystals

Nikolai Shul'ga (National Science Center), Anatoliy Greenenko (NSC KIPT)

Passage of fast charged particles through a single nanotube and through a continuous field of a nanotube rope is considered. The similarity of this problem with the problem of fast charged particles' passage through periodic fields of atomic strings of a crystal is demonstrated [A.A. Greenenko, N.F. Shul'ga, Nucl. Instr. & Meth. B 173 (2001) 178, B 193 (2002) 133]. Simulation results of the particle passage in straight and bent ropes of nanotubes, with account of incoherent effects in scattering, are presented. Dechanneling lengths in a nanotube rope and in a crystal are compared. The possibility of the effective deflection of high-energy positively as well as negatively charged particles by means of bent nanotube ropes is shown.

* Work supported in part by STCU (project # 1746).

RPAG057 Non-Coulomb Perturbations Influence on Beam Dynamics in Extended Accelerating/Focusing Channels

Igor Shumakov, Alexander Durkin (Moscow Radiotechnical Institute)

Calculations of the accelerating/focusing channel always based on the specific mathematical model involving description of external accelerating and focusing forces. In this model as a rule, the focusing field linear dependence on transverse coordinates and accelerating field axis distribution is used. The channel based on such models is called ideal. Output beam parameters degradation including transverse size and emittance growths are caused by channel and beam parameter perturbations (not always small). The influence of perturbations upon the beam output parameters determines by quantity, which have come to be known as the channel sensitivity. Results of analytical calculation and computer simulation are presented in this paper. It makes possible to estimate perturbation sensitivity of different parts of large linear accelerator.

RPAG058 A Boris-like Integration Scheme with Spatial Stepping

Peter Stoltz, John Cary (Tech-X Corporation), Gregg Penn, Jonathan Wurtele (University of California, Berkeley)

A modified Boris-like integration, in which the spatial coordinate is the independent variable, is derived. The method is second-order accurate, requires only one force calculation per particle per step, and preserves conserved quantities more accurately over long distances than a Runge-Kutta integration scheme. Results from the spatial-Boris integration method and a Runge-Kutta scheme are compared for two simulations: (i) a particle in a uniform solenoid field and (ii) a particle in a sinusoidally varying solenoid field. In the uniform solenoid case, the spatial-Boris scheme is shown to perfectly conserve for any step size quantities such as the gyro-radius and the perpendicular momentum. The Runge-Kutta integrator produces damping in these conserved quantities. For beam physics applications where statistical

quantities such as beam emittance are important, these results imply the spatial-Boris scheme is three times more efficient.

* This work was funded in part by the Department of Energy Division of High-Energy Physics and in part by Tech-X Corporation.

RPAG059 Acceleration and Self-Focused Particle Beam Drivers

Vladimir Zadoroznhy (Institute of Cybernetics, NAS of Ukraine), Zohreh Parsa (BNL)

In this paper we propose a new approach for solving Vlasov-Makswell problems on the base Control theory. From a mathematical point of view this means that the solutions of the nonlinear evolutionary wave equations have got simplification in the description by use any results of control algorithms. This is due in particular to the presence of the universality of the Maxwell equation. A lot of analytical investigations and computer experiments are devoted to the study of this equation. In this report we briefly present an approach to study some problems of beams acceleration and strong focusing. The general idea is essentially based on a) the previous research of the authors, b) universality of Maxwell equations, c) mathematical aspects of the optimal control systems. Based on results of V. Zubov and P. Halmos this approach made it feasible to apply the direct Lyapunov method to essentially nonlinear problems for which empirical method of constructing the Lyapunov function generates a certain kernel operator in the domain of its asymptotic stability and Lyapunov equation yields a Fredholm equation. The self-focused and accelerating particle beams are studied using analytic soliton of the self-consistent Vlasov equation. Here a Lorentz force is replaced by any parameter (control vector describing control fields), after which any problem of the optimal control we resolved. Now in accordance with the Maxwell equations we constrain density of charge and current density as the problem of convex programming problem in usual form.

Session ROPA: Low & Medium Energy Accelerators & Rings
Pavilion East at 13:30
Session Chairs: P. Ostroumov, T. Grimm

ROPA001 Spallation Neutron Source Ring — Status, Challenges, Issues, and Perspectives

Jie Wei (BNL)

The Spallation Neutron Source project is presently in the fourth year of a seven-year construction cycle. The SNS ring is designed to accumulate beam pulses of 1.5×10^{14} protons of 1 GeV kinetic energy at a repetition rate of 60 Hz. At such beam intensity and power, key design challenges include control of beam loss and radioactivation, construction of high-quality large-aperture magnets and power supplies, design of robust injection and extraction systems, minimization of beam-coupling impedances, and mitigation of electron-cloud effects. This paper discusses the design and construction status of the ring systems with emphasis on technical challenges and issues, and presents future perspectives towards a next-generation high-intensity facility.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

ROPA002 The JAERI-KEK Joint Project (the J-PARC Project) for the High Intensity Proton Accelerator

Yoshishige Yamazaki (Japan Atomic Energy Research Institute)

The JAERI-KEK Joint Project for the High Intensity Proton Accelerator, now referred to as the J-PARC Project (Japan Proton Accelerator Research Complex), comprises a 400-MeV linac, a 3-GeV, 25-Hz Rapid-Cycling Synchrotron (RCS), and a 50-GeV Main Synchrotron (MR). In contrast to the SNS or the ESS, the J-PARC makes use of the RCS in order to produce MW-class pulsed spallation neutrons rather than a combination of the full-energy linac and the compressor ring. Although this scheme has been chosen primarily because the J-PARC incorporates the high-intensity, several-ten GeV machine for hyperon physics and neutrino physics, the RCS has several advantages regarding the production of the pulsed neutrons over the other scheme. The beam test of the low-energy beam transport (LEBT), the 3-MeV RFQ linac, and the medium-energy beam transport (MEBT) has been done together with the beam test of the prechopper and the chopper, respectively installed in the LEBT and in the MEBT. This chopping system was newly devised for the J-PARC, so the comparison with the SNS chopper system should be very interesting.

ROPA003 Status of Low and Intermediate Velocity Superconducting Accelerating Structures

Kenneth Shepard (Duke University)

Several types of of reduced velocity (0.1 – 0.8c) superconducting accelerating structures are being developed for ion linacs to be used for spallation sources, exotic beam facilities, and other applications. This paper will review the characteristics and development status of the cavity types currently under development.

* Work supported by the U. S. Department of Energy under contract number W-31-109-ENG-38.

ROPA004 Overview of Radioactive Ion Accelerators

Bradley Sherrill (Michigan State University)

The primary focus of the talk will be to provide an overview of the technical requirements for the Rare Isotope Accelerator, RIA, and the issues driving these requirements. The overall RIA concept and its relation to other rare isotope facilities worldwide will also be presented. RIA would represent a major advance in rare isotope capabilities for the world nuclear science communities and has been given the highest priority for major new construction by the nuclear science community in the United States. RIA combines many aspects of current rare isotope facilities, including the ability to use the two major rare-isotope production methods. Other facilities discussed will include the Radioactive Ion Beam Factory under construction at RIKEN in Japan, the GSI upgrade project proposed in Germany, and the operational facilities at the NSCL, TRIUMF, Oak Ridge, and GANIL. The technical options chosen for these various facilities will be discussed and some broad discussion of the advantages of the various approaches will be made.

ROPA005 Upgrading CEBAF to 12 GeV

Leigh Harwood (Thomas Jefferson National Accelerator Facility)

As originally constructed, the Continuous Electron Beam Accelerator Facility (CEBAF) was a 4 GeV cw 5-pass recirculating linac. It has subsequently been enhanced to 5.7 GeV. Developments in lattice QCD have indicated that an extending CEBAF to 12 GeV would provide a unique opportunity to understand quark confinement. Jefferson Lab plans to reach 12 GeV by adding ten new 100 MV cryomodules and supporting rf systems to the present machine configuration. The 2K helium plant will be doubled. The beam transport system's capability will be doubled to 12 GeV with minimal replacement of components and with minimal saturation in the magnets. A new experimental hall, devoted to the quark confinement investigation, will be placed so that the beam transits one of the linacs 6 times (vs. 5 times for the other linac). Beam emittances are degraded by synchrotron radiation such that the horizontal emittance of 1 nm-rad at 6 GeV increases to 7 nm-rad at 12 GeV. This paper discusses the issues listed above plus requirements for all systems and developmental opportunities presented by the project.

* This work was supported by U.S. DOE under contract DE-AC05-84ER40150.

ROPA006 The GSI Synchrotron Facility Proposal for Acceleration of High Intensity Ion and Proton Beams

Peter Spiller, Klaus Blasche, Oliver Boine-Frankenheim, Guiliano Franchetti, Benno Franczak, Ingo Hofmann, Peter Huelsmann, Klaus Kaspar, Gebhard Moritz, Edil Mustafin, Hartmut Reich-Sprenger, Petra Schuett (Gesellschaft für Schwerionenforschung mbH)

In 2001 GSI proposed an International Accelerator Facility to provide an extensive range of high-intensity and high-energy particle beams from protons and antiprotons to ion beams of all chemical elements up to uranium. A key feature of the new facility will be the generation of beams of radioactive nuclei and beams of antiprotons, which will be accumulated and stored in two experimental storage rings. The heart of the new facility is a double-ring synchrotron with novel rapid cycling superconducting magnets. The design concepts for the new synchrotron facility will be discussed. Emphasis is placed on the status of R&D work especially for the superconducting magnets and for the development of radio-frequency systems designed for barrier bucket and bunch compressor operation. In addition studies are discussed which refer to the dynamic vacuum pressure instability induced by the high desorption rate at the impact of fast projectile ions. Results of beam loss simulations including nonlinear resonances and space charge are also presented.

ROPA007 Observations of Electrons in the Intense Pulse Neutron Source (IPNS) Rapid Cycling Synchrotron (RCS)

Jeffrey Dooling, F.R. Brumwell, W.S. Czyz, K.C. Harkay, M.K. Lien, G.E. McMichael (ANL)

In the process of accelerating protons from 50 to 450 MeV at 30 Hz, electrons are generated within the IPNS RCS. Electrons from background gas stripping are detected using an Ionization Profile Monitor (IPM) to generate integrated, horizontal charge distributions of the single-harmonic bunch during acceleration. Recently, a Retarding Field Analyzer (RFA) was installed in the RCS to look for electrons ejected by the space charge of the beam. A wide-band, high-gain transimpedance amplifier has been built to observe time structure in the electron signal detected with the RFA. Though an internal breakdown in the device has prevented full I-V characteristics from being obtained, interesting features are observed, especially after the period of phase modulation between the rf cavities. The phase modulation is believed to enhance beam stability by generating a longitudinal quadrupole oscillation in the bunch. Preliminary results indicate that electron multipactoring is not significant in the RCS. The effects of background gas neutralization are considered and details of the RFA measurements are presented.

* This work is supported by the U.S. Department of Energy under contract no. W-31-109-ENG-38.

ROPA008 SPIRAL2 : A High Intensity Deuteron and Ion Linear Accelerator for Exotic Beam Production

Alban Mosnier (CE Saclay)

Based on the LINAG1 conceptual design, a two years detailed study on an ISOL-type facility for the production of high intensity exotic beams, named SPIRAL2, has been launched [http://www.ganil.fr/research/sp/reports/files/LINAGPhaseI.pdf]. The rare isotope beams are produced via the fission process, with the aim of 10^{13} fissions/s at least, induced either by fast neutrons from a C converter in a UCx target or by direct bombardment of fissile material. The driver, with an acceleration potential of 40 MV, has to be evolutional and versatile: it will accelerate deuterons (5 mA) and q/A=1/3 ions (1 mA). It consists of high-performance ECR sources, an RFQ cavity and independent phase superconducting resonators. The primary beam is transferred towards the production system, including converter, target and ion source. The exotic beam can be directly used in a low energy experimental area or is accelerated by the existing CIME cyclotron after increase of its charge-state by means of an ECR charge booster. The selection of the parameters, as well as the technology, result from an optimisation of the linac. Careful beam dynamics calculations with space charge forces, 3D fields and errors have been carried out to check the robustness of the design and the very low loss rate all along the linac.

ROPA009 COSY-SCL, the Superconducting Injector Linac for COSY

Raimund Toelle, Ulf Bechstedt, Norbert Bongers, Juergen Dietrich, Ralf Eichhorn, Frank Esser, Olaf Felden, Ralf Gebel, Kurt Henn, Helge Jungwirth, Andreas Lehrach, Rudolf Maier, Uwe Pfister, Dieter Prasuhn, Peter von Rossen, Alexander Schnase, Herbert Schneider, Yurij Senichev, Rolf Stassen, Hans Stockhorst, Evguenij Zaplatin (Forschungszentrum Juelich), Kai-Uwe Kuehnel, Alwin Schempp (University of Frankfurt/Main, IAP)

The superconducting injector linac COSY-SCL is being designed and constructed at the Forschungszentrum Juelich. The main goal of the new injector is to fill the cooler synchrotron COSY with polarized protons as well as with polarized deuterons up to the space-charge limit at injection energy. COSY-SCL is characterized by a base frequency of 160 MHz, 25 kV ion-source extraction voltage, a pulse length of up to 500 μs at a maximum repetition rate of 2 Hz, injection into the linac at β=0.073, and injection into COSY at kinetic energies of 52 MeV for protons and 56 MeV for deuterons, respectively. The injector configuration is presented, and its main subsystems -ion source (CIPIOS from IUCF for polarized H^- and D^-), RFQ (built in co-operation with the University of Frankfurt), linac (based on half-wave resonators operating at 160 and 320 MHz) and transfer beamline- are described and discussed. The present status of the project is reported.

ROPA010 The ISAC-II Upgrade at TRIUMF - Progress and Developments

Robert Laxdal, George Clark, Gerardo Dutto, Ken Fong, Stanford Guy, Zhen Hua Peng, Roger Poirier, William Rawnsley, Thomas Ries, Igor Sekachev (TRIUMF)

TRIUMF is proceeding with a major upgrade to the ISAC project, ISAC-II, that includes the addition of 43MV of heavy ion superconducting linear accelerator and a ECR charge state booster. An initial installation of 25MV of mid (beta=5.8,7.1%) and high beta (beta=10.5%) cavities will be due for commissioning in 2005. A SCRF laboratory consisting of clean assembly and rinse area plus an rf test area is operational with an active program for cavity preparation and coupling loop and tuner developments. The paper will describe the superconducting linac program at TRIUMF including the status and test results of the first four production cavities, the design of the medium beta cryomodule and high beta cavity and a summary of the activities in the SCRF laboratory.

ROPA011 Upgrade Study of a 2 MW Main Injector at Fermilab

Weiren Chou (FNAL)

In January 2002, the Fermilab Director initiated a design study for a high average power, modest energy facility. An intensity upgrade to Fermilab's 120-GeV Main Injector represents an attractive concept for such a facility, which would leverage existing beam lines and experimental areas and would greatly enhance physics opportunities at Fermilab and in the U.S. With a Proton Driver replacing the present Booster, the beam intensity of the MI is expected to be increased by a factor of five. Accompanied by a shorter cycle, the beam power would reach 2 MW. This would make the MI a more powerful machine than the SNS or the JHF. Moreover, the high beam energy (120 GeV) and the tunable energy range (8-120 GeV) of the MI would make it a unique high power proton facility. The upgrade study has been completed and published. This paper will give a summary report, including beam dynamics issues, upgrade of existing technical systems, addition of new technical systems, radiation and shielding considerations, and a cost estimate.

* Work supported by the Universities Research Association, Inc., under contract No. DE-AC02-76CH03000 with the U.S. Department of Energy.

ROPA012 Activities on HIRFL-CSR Project

Jiawen Xia (Institute of Modern Physics(IMP), Baowen Wei, Wenlong Zhan (IMP)

HIRFL-CSR, an ion cooler-storage-ring project in Lanzhou, is a double ring system, and consists of a main ring (CSRm) and an experimental ring (CSRe). The ion beams from the HIRFL cyclotron system will be accumulated, cooled and accelerated to high energy in the CSRm, and then extracted fast to produce radioactive ion beams (RIBs) or highly charged heavy ions. Those secondary beams will be accepted by the CSRe and used for internal-target experiments or high-precision spectroscopy with beam cooling. This project was started in the end of 1999 and will be finished in 2005. In this paper the outline and the activities of the project will be described.

Session ROPB: Accelerator Technology
Pavilion West at 13:30
Session Chair: D. Trines

ROPB001 Machine Protection Strategies for High Power Accelerators

Coles Sibley (ORNL)

The Spallation Neutron Source (SNS) under construction in Oak Ridge, TN will produce high intensity neutron pulses using a linear accelerator and accumulator ring to accelerate and accumulate $1.5x10^{14}$ protons per pulse on to a liquid mercury target at 60 Hz. The Machine Protection System (MPS) must protect beam apertures and insertable devices from damage, minimize radiation produced by the beam (ALARA) for hands on maintenance, and shut down the beam when beam-on-target parameters drift outside specifications. Required response times vary from tens of microseconds at low energy to hours for integrated loss measurements. Moreover, requirements change from machine commissioning to full power operation and the MPS must accommodate these changes. The MPS is not considered a part of the Personnel Safety System; however, it does have to be reliable and have a high availability for full-power operations. Accelerator physics models are used to select devices requiring MPS redundancy for cases where independent systems cannot be used. This paper discusses the implementation strategy for the SNS MPS system, including architecture, layered approach, configurability and redundancy.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

ROPB002 Vacuum System for High Power Lepton Rings

Yusuke Suetsugu (KEK)

One way of the future lepton collider is a high luminosity ring, 10^{35} - 10^{36} cm^{-2} sec^{-1} for an example, to quest rare but valuable fundamental events. The high luminosity means large beam currents, several tens of amperes typically, in addition to small beam sizes at collision points. The vacuum system for such a high luminosity ring accelerator has to cope with the resultant intense synchrotron radiation power and high photon flux. The material and the structure of beam chamber should be examined carefully with regard to the high power density. The effective pumping scheme and the surface treatment with a low photo-desorption rate are required to achieve sufficiently low vacuum pressure. Photoelectron emission should be cared for in the positron ring to suppress the electron cloud instability. Furthermore, since the high current is practically equal to the large bunch current (2 - 4 mA), the beam impedance issues become much more important. A cautious attention should be paid to the smoothness of the beam chambers. Presented here is a concept of vacuum system design for a future high-luminosity ring accelerator, taking the upgrade plans of KEK B-factory (KEKB) and PEP II as examples.

ROPB003 Measurements of Thermally Desorbed Ions from Beam-Target Interactions

Harold Davis, David Moir, Russel Olson (LANL)

The second axis of the DARHT radiographic facility, will deliver a train of four, tightly focused, intense electron beam pulses to an x-ray converter target in 2 microseconds. A major concern is that ions, produced at the target, will be accelerated and trapped by the beam's negative potential. These ions can readily neutralize a significant fraction of electron beam space charge degrading the radiographic spot size. Experiments on the DARHT first axis beam (C. Vermare, H. A. Davis, D. C. Moir, and T. P. Hughes, Physics of Plasmas, Jan. 2003), with parameters of 19.8 MeV, 1.7 kA, and 60 ns, have shown that for small radius beams, beam-ionized, thermally desorbed, impurity molecules from the target lead to beam disruption. Here we report on experiments to identify the ion species and energy spectra by means of neutral particle measurements and Tompson spectrometer ion measurements.

* Work supported by the US DOE under contract W-405-ENG-36.

ROPB004 Thin Diamond Films for SNS H^- Injection Stripping

Robert Shaw, R.I. Cutler, A.D. Herr (ORNL), Y.Y. Lee, C.J. Liaw (BNL), C.S. Feigerle (Dept. of Chemistry; University of Tennessee/ Knoxville)

We have investigated the preparation and testing of thin diamond foils for use in stripping the SNS H^- linac beam. A long useful lifetime for these foils is desirable to improve operational efficiency at the SNS. Preliminary data presented at PAC 2001 indicated that diamond foils were superior to conventional evaporated carbon foils, exhibiting lifetimes approximately five-fold longer [See: C.J. Liaw, Y.Y. Lee, and J. Tuozzolo, "Lifetime of carbon stripping foils for the spallation neutron source," Proc. PAC2001, Chicago, IL, p. 1538]. That work employed a fully supported diamond foil, a format that is not acceptable for the SNS application; at least two edges of the approximately 1x1 cm foils must be free standing to allow for beam rastering. Residual stress in a chemical vapor deposited (CVD) diamond foil results in film distortion (scrolling) when the film is released from its silicon growth substrate. We have attacked this problem by initially patterning the surface of CVD growth substrates with a 50 or 100 line/inch trapezoidal grating, followed by conformal diamond film growth on the patterned substrate. Then removal of the substrate by chemical etching produced a foil that possessed improved mechanical integrity due to its corrugation. The high nucleation density required to grow continuous, pinhole free diamond foils of the desired thickness (1 micrometer, 350 microgm/cm^2) was achieved by a combination of substrate surface scratching and seeding. A variety of diamond foils have been tested using the BNL 750 keV Radio Frequency Quadrupole H^- beam to simulate energy loss in the SNS. Those include flat, corrugated, microcrystalline, and nanocrystalline foils. Foil lifetimes are reported.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a collaboration of six US National Laboratories: Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Thomas Jefferson National Accelerator Facility (TJNAF), Los Alamos National Laboratory (LANL), Lawrence Berkeley National Laboratory (LBNL), and Oak Ridge National Laboratory (ORNL). ADH acknowledges an appointment to the U.S. Department of Energy's Energy Research Undergraduate Laboratory Fellowships (ERULF) Program at the Oak Ridge National Laboratory.

ROPB005 Vacuum Pumping Study of Titanium-Zirconium-Vanadium Thin Films

Yulin Li, Simon Ho (Cornell University)

Vacuum pumping via non-evaporable getter (NEG) thin film deposited directly onto the interior of a vacuum chamber is a novel way to achieve extreme high vacuum. As a part of R&D efforts for the proposed Energy Recovery Linac at Cornell, the pumping performance of the Titanium-Zirconium-Vanadium (TiZrV) NEG thin films was investigated to provide 'engineering' data for designing vacuum systems using such NEG thin films. The compositions and the growth rates of the NEG thin films, deposited on stainless steel tubes using DC Magnetron sputtering, were investigated using Rutherfield Backscattering Spectrometry. The pumping speeds and capacities of the thin films were measured as functions of activation temperatures

and durations, and film thickness for CO and H_2. Though pumping of CO and H_2 by the NEG films is observed with activation temperature as low as 150°C, the pumping performance of the NEG films improve significantly with activation temperatures above 300°C.

* Work supported by the National Science Foundations, Grant #PHY-9809799, and Cornell University.

ROPB006 A New Kind of Beam Pipe for Rapid Cycling Proton Synchrotrons

Zhijing Tang, Alex Chen, Weiren Chou (FNAL)

A thin metallic beam pipe reinforced by multi-layer spiral metallic ribs is proposed for rapid cycling proton synchrotrons. The pipe is made of Inconel 718 with thickness of a few tenths of mm. Each spiral rib has a cross section of about 0.3 mm^2 and can be bonded to the pipe by using laser deposition technique (e.g., precision metal deposition, or PMD). Compared with other designs (e.g.., ceramic beam pipe with a metallic cage used in the ISIS at the RAL), this new pipe will reduce the magnet aperture significantly, which, in turn, reduces the construction and operating cost of a synchrotron. Numerical simulations and analytical modeling are used to investigate the structural strength and deformation, and the eddy current effects, including heating, magnetic field distortion and the electro-magnetic force on the beam pipe. The results show that this new beam pipe will work. It can be employed to high intensity rapid cycling proton synchrotrons, such as the proton driver at Fermilab and the JHF at JAERI/KEK. Effort to build a prototype is under way.

* Fermi National Accelerator Laboratory is operated by the Universities Research Association, INC. under contract with the U.S. Department of Energy, Contract No. DE-AC02-76CH03000.

ROPB007 Accelerator Availability and Reliability Issues

Steven Suhring (Thomas Jefferson National Accelerator Facility)

Reliable machine operations for existing machines as well as for future machines presents significant challenges to those responsible for system performance and improvement. Additionally, changes to machine requirements and beam specifications often reduces overall machine availability in an effort to meet user needs. Accelerator reliability issues from around the world will be presented followed by a discussion of the major factors influencing machine availability.

* Supported by DOE Contract #DE-AC05-84ER40150

ROPB008 Low-Conductivity Water Systems for Accelerators

Robert Dortwegt (ANL)

The performance of low-conductivity water (LCW) systems is of critical importance at most accelerator facilities. An upset of water chemistry, supply temperature, or component availability can have a direct impact on machine performance. Downtime of the LCW system for any reason can result in downtime of the entire accelerator. The chemistry of LCW systems and similarities with stator cooling systems in electric power generators will be presented. This will include the basics of copper corrosion and agglomeration mechanisms, copper solubility data and its relationship with temperature, impact of dissolved oxygen concentration and pH, and relative corrosion rates for various possible operating regimes. Fundamental features of temperature control systems capable of controlling temperatures within a fraction of a degree will also be discussed. Another key element of LCW system performance is component and system reliability. Reliability is very much related to component selection and operating practices, and some anecdotal information will be offered based on the author's experience.

* Work supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

ROPB009 Accelerator Magnet Plugging by Metal Oxides: A Theoretical Investigation, Remediation and Preliminary Results

William Rust, Robin Wines (Thomas Jefferson National Accelerator Facility)

The Thomas Jefferson National Accelerator Facility has experienced magnet overheating at high power. Overheating is caused by cooling water passages becoming plugged and is a direct result of Dean Effect deposition of oxide particles suspended in the water. Solving simplified dynamic model equations of the flow in the magnet tubing bends yields a lower bound for plugging rate as a function of particle concentration, velocity and bend radius. Remediation has consisted of submicron filtration, magnet cleaning, and dissolved oxygen removal. Preliminary results are good: no accelerator outages have been attributed to magnet plugging since the remediation has been completed.

* This work was done under DOE contract DE-AC05-84ER40150.

ROPB010 Safety Critical Monitoring for Prompt Radiation Hazards

Lutz Moritz, John Drozdoff, Gerardo Dutto, Franco Mammarella, Mike Mouat, Roman Ruegg (TRIUMF)

At TRIUMF we have used both passive and active methods to protect against potential prompt radiation hazards produced by accidental beam losses in high-intensity proton beam lines. These methods consist of shielding, exclusion areas, and the use of fast-acting radiation monitors. The latter are located within the shielded areas and are set to terminate beam production on the detection of abnormal beam loss. A recent risk analysis has suggested a need for higher reliability in the protection against potential prompt radiation hazards where the shielding is relatively thin. To address this requirement TRIUMF has developed a new approach using two systems of independent and redundant monitoring devices located outside the shielding to protect against safety-critical events with the required level of reliability. Verification of the system reliability is achieved by weekly testing of the safety critical monitors as well as the trip devices. When used in conjunction with the traditional beam loss monitors we are able to distinguish between safety critical events and non-safety critical beam trips.

ROPB011 Comprehensive Electro-Magnetic, Thermal, and Structural Finite Element Analysis of the Lithium Collection Lens at the FNAL Antiproton Source

Patrick Hurh, James Morgan, Salman Tariq (FNAL)

A history of lithium collection lens failures at lower than designed focusing strengths has led to extensive efforts to quantify the lithium lens loading environment and structural behavior. A comprehensive finite element analysis (FEA) model of the lithium lens has been developed as part of these efforts and as a tool to aid in future lithium lens design improvements. The FEA model includes complete device geometry, the excitement current pulse (damped sine wave), temperature dependent electrical, thermal and structural (including strain rate dependent) material properties. Latest results, including transient electro-magnetic, thermal and structural solutions, for the currently operational lithium lens design are presented.

* Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy.

ROPB012 Inertial Sensor Development for Active Vibration Stabilization

Josef Frisch, Eric Doyle, Linda Hendrickson, Thomas Himel, Richard Partridge (SLAC)

Future linear colliders require nanometer stability of the beams at the interaction point. One approach to stabilizing the beams is to use feedback based on inertial sensors (accelerometers / seismometers) to control the positions of the final focus magnets. Commercial seismometers developed for geoscience applications have sufficient noise performance (nanometer noise down to a fraction of a hertz), but due to their large size and magnetic sensitivity are unsuitable for use in a collider detector. We report on the development of a high sensitivity, compact, non-magnetic inertial sensor for this application. In addition to its use in linear colliders, the sensor is also expected to have application to vibration measurement and control in synchrotron light sources.

* Work Supported by Department of Energy Contract DE-AC03-76SF00515.

Session ROPC: Linear Colliders
Grand Ballroom I at 13:30
Session Chair: K. Hubner

ROPC001 Report from the International Linear Collider Technical Review Committee

Gregory Loew (SLAC)

The International Linear Collider Technical Review Committee (ILC-TRC), formed in 1994, was reconvened in February 2001 by the International Committee for Future Accelerators (ICFA) to assess the current technical status of all electron-positron linear collider designs at hand in the world: TESLA, JLC-C, JLC-X/NLC and CLIC. The ILC-TRC worked for exactly two years and submitted its report in February 2003. This paper will present the charge to the committee and its organization, a brief description of the machine designs for 500 GeV c.m. energy and later upgrades to higher energies, the methodology used to assess the designs, and a ranked list of R&D tasks still deemed necessary between now and the time any one of the projects is selected by the HEP community and begins construction. Possible future developments are briefly discussed.

ROPC002 Damping Ring Designs and Issues

Andrzej Wolski (LBNL)

The luminosity performance of a future linear collider (LC) will depend critically on the performance of the damping rings. The design luminosities of the current LC proposals require rings with very short damping times, large acceptance, low equilibrium emittance and high beam intensity. We discuss the design strategies for lattices achieving the goals of dynamical stability, examine the challenges for alignment and coupling correction, and consider a variety of collective effects that threaten to limit beam quality. We put the design goals in context by referring to the experience of operating facilities, and outline the further research and development that is needed.

* Work supported by the US DOE under contract DE-AC03-76SF00098.

ROPC003 Damping Ring to Interaction Point Beam Transport Issues

Nicholas Walker (DESY), Daniel Schulte (CERN), Andrzej Wolski (LBNL), Andrei Seryi, Peter Tenenbaum, Mark Woodley (SLAC)

One of the major challenges facing the proposed high-energy linear e+e- colliders is the preservation of the extremely small vertical emittances from the damping ring to the interaction point (IP). This emittance must be transported through bunch compression sections, the main linac and finally through the beam delivery system to the IP. Historically, the beam dynamics issues of each sub-system have been studied quasi-independently, with the beam conditions and tolerances being specified at the boundaries. As part of the recent International Linear Collider Technical Review Committee, new simulation tools have been developed to simulate the beam transport through the integrated system, including static and dynamic errors, stabilization systems, and tuning algorithms. Results of such integrated system studies for the TESLA, JLC/NLC, and CLIC designs are presented, and future directions for this ongoing research are discussed.

ROPC004 Effects of Dynamic Misalignments and Feedback Performance on Luminosity Stability in Linear Colliders

Andrei Seryi, Linda Hendrickson, Tor Raubenheimer, Peter Tenenbaum, Mark Woodley (SLAC), Daniel Schulte (CERN)

The performance of high energy linear colliders depends critically on the stability with which they can maintain the collisions of nanometer-size beams. Ground motion and vibration, among other effects, will produce dynamic misalignments which can offset the beams at the collision point. A system of train-to-train and intra-train beam-beam feedbacks, possibly combined with additional beam-independent active systems, is planned to compensate for these effects. Extensive simulation studies of ground motion and luminosity stabilization have been performed as part of the work of the International Linear Collider Technical Review Committee. This paper presents a comparison of the expected performance for TESLA, JLC/NLC and CLIC under various assumptions about feedbacks and the level of ground motion.

* Work supported by the Department of Energy, contract DE-AC03-76SF00515.

ROPC005 Colliding Nanobeams in CLIC with Magnets Stabilized to the Sub-nm Level

Stefano Redaelli, Ralph Assmann, Williame Coosemans, Gilbert Guignard, Daniel Schulte, Ian Wilson, Frank Zimmermann (CERN)

The Compact LInear Collider (CLIC) aims at colliding electrons and positrons at 3 TeV with vertical spot sizes of 1 nm. Strict stability tolerances must be respected in order to achieve a sufficient overlap of the two colliding beams. A stability test stand has been set up at CERN, bringing latest stabilization technology to the accelerator field. Using this technology, a CLIC prototype magnet was stabilized in a normal CERN working environment to less than 1- nm vertical rms motion above 4 Hz. The measured vibration spectra are presented. The dependence on the flow of cooling water is illustrated and results on alignment stability are shown. Detailed simulation studies are being performed in order to predict the achievable CLIC luminosity, including the measured data on magnet stability, the beam- beam interaction, and beam- based feedbacks. First predictions are discussed.

ROPC006 Normal-Conducting RF Structure Test Facilities and Results

Chris Adolphsen (SLAC)

The designs for a next generation linear collider based on normal-conducting rf structures require operation at gradients much higher than that in existing linacs. For the NLC/JLC 11.4 GHz structures, the design unloaded gradient is 65 MV/m, which is about four times that of the 2.9 GHz SLAC Linac. The CLIC proposal using 30 GHz structures requires an even higher gradient, about 150 MV/m. Both of these groups are aggressively pursuing programs to develop structures that reliably operate at these gradients and also have acceptable rf-to-beam energy transfer efficiencies and short-range and long-range transverse wakefields. Much progress has been made in the past few years, and in this paper we review the programs, test facilities and results from this research.

* Work Supported by DOE Contract DE-AC03-76F00515.

ROPC007 Superconducting RF Structures - Test Facilities and Results

Hans Weise (DESY)

The TESLA superconducting electron-positron linear collider with an integrated X-ray laser laboratory was presented to several international committees including the German Science Council, advising the German government in matters of science. In preparation of this, the TESLA Test Facility was set up at DESY. More than 40 institutes from nine countries have designed, constructed, commissioned and operated accelerator components. In close collaboration, superconducting accelerator cavities with gradients between 25 and more than 40 MV/m were developed. The TESLA Test Facility includes the preparation and testing of superconducting cavities as well as a 260 m long linac installation. The cavity performance with beam has been investigated while operating this linac as a driver for a SASE free-electron laser as well as during high gradient tests. More than 16 thousand hours of operation demonstrated the capabilities of the chosen technology. At present a module equipped with electro-polished nine-cell TESLA cavities is under construction. Gradients above 35 MV/m were established. Results of single cavity tests as well as of module tests without and with beam will be presented.

ROPC008 Reliability Issues for Linear Colliders

Nan Phinney, Chris Adolphsen, Marc C. Ross (SLAC)

To deliver a high integrated luminosity over several years of operation, a linear collider must not only meet its energy and luminosity performance goals, but also have a very high hardware availability and operating efficiency. The first challenge is the size and complexity of the facility. If the typical reliability of existing High Energy Physics accelerators is simply scaled to the size of a 500 GeV linear collider, the overall system availability will be too low. The final design must incorporate a more rigorous failure analysis as well as built-in overheads and redundancy. An additional challenge is the complexity of the tuning procedures required to preserve a very small beam emittance. These include beam-based alignment of magnets and rf structures, automated trajectory correction, feedback, emittance and luminosity optimization, and more. Another issue is the inherently large power densities in the beams, which can damage any beamline components they intercept. An extensive machine protection system is necessary to inhibit beam in case of a fault and automatically execute a recovery sequence. This paper will present the important issues in the context of the proposed linear collider designs.

ROPC009 The JLC/NLC Baseline Design

Tor Raubenheimer, David Burke (SLAC)

The JLC/NLC is a normal conducting linear collider based on X-band rf technology. The collider is designed to cover the center-of-mass energy range from 90 GeV to 1.3 TeV with a luminosity of $2 \sim 3 \times 10^{34}$ cm^{-2} s^{-1} between 500 GeV and 1 TeV. The X-band rf system, which is based on the operating NLC Test Accelerator X-band rf system, was recently modified in a way that will ensure a less expensive and faster demonstration of a full rf sub-unit. In this paper, the baseline beam parameters, rf system design, and optics configuration for the JLC/NLC will be described and the demonstration schedule

ROPC010 Bunch Frequency Multiplication in the CLIC Test Facility CTF3

Frank Tecker, Roberto Corsini, Louis Rinolfi (CERN), Caterina Biscari, Andrea Ghigo, Miro Preger (INFN), Philippe Royer (University Lausanne, Switzerland), Arnaud Ferrari (University Uppsala, Sweden)

The aim of the CLIC Test Facility CTF3 at CERN is to prove the feasibility of key issues of the two-beam based Compact Linear Collider (CLIC) project. In particular, it addresses the generation of a drive beam with the appropriate time structure to produce high power RF pulses at a frequency of 30 GHz. The first major goal of CTF3 was to demonstrate, at low charge, the combination of successive bunch trains by RF deflectors in an isochronous ring. This bunch frequency multiplication has been successfully performed for various combination factors up to five. We will present these results together with other related beam measurements.

ROPC011 Feedback on Nanosecond Timescales for Linear Colliders: Results from First Beam Tests at the NLC Test Accelerator at SLAC

Philip Burrows, Glen White (Queen Mary, University of London), Simon Jolly, Gerald Myatt, Gavin Nesom, Colin Perry (Oxford University), Chris Adolphsen, Joseph Frisch, Keith Jobe, Thomas Markiewicz, Doug McCormick, Janice Nelson, Marc Ross, Steve Smith, Tonee Smith (SLAC)

The Feedback On Nanosecond Timescales (FONT) project aims to develop a beam-based feedback and correction system for stabilising the position of the nanometre-sized electron and positron bunches at the interaction point of the next-generation Linear Collider. We have built a prototype FONT system and tested it with a 170 ns long electron bunchtrain produced at the Next Linear Collider Test Accelerator at SLAC. An upstream dipole magnet was used to induce a controlled position offset into the incoming bunchtrain. A downstream novel 'button' type beam position monitor (BPM), with a tuned response at X-band frequency, was used to detect the position offset. Local analogue RF electronics was used to process the BPM signals; these were input into an analogue feedback and charge-normalisation circuit. The output feedback signal was amplified using a custom-built 3-stage tube amplifer with an output power of up to 3 kW. The amplified signal was fed to an upstream stripline kicker that was used to kick the trailing bunches back into nominal alignment. We present the experimental results of the beam tests that were carried out at SLAC in September 2002. The system operated as a feed-forward, with a single-pass delay loop feedback, and was able to provide a 10:1 beam position correction with a measured latency period of 66 ns. This represents a first demonstration of a Linear Collider type beam-based correction system that can operate on the relevant timescale of tens of nanoseconds.

* Supported by the UK Particle Physics and Astronomy Research Council.

Poster Session RPPB
Grand Ballroom I at 13:30

RPPB001 Vertical Coupling Impedance of the APS Storage Ring

Yong-Chul Chae, Katherine Harkay, Xiang Sun (ANL)

The three-dimensional wake-potentials of the APS storage ring have been reconstructed according to the impedance database concept. Every wakefield-generating component in the ring was considered including small-gap insertion device (ID) chambers, rf cavities, shielded bellows, beam position monitors, synchrotron radiation absorbers, scrapers, flags, various chamber transitions, septum chambers, and pulsed kickers. In this paper the result for the vertical wake-potentials and its impedance are presented. Dominant contributors are the ID chambers whose heights are 5 mm and 8 mm. Since more 5-mm and even smaller-gap chambers are envisioned for installation in the APS storage ring, prediction of their effect on the beam is very important not only for the APS but also for all third-generation light sources. We used the vertical impedance reported here to investigate the measured tune slope and single-bunch current limit in the APS storage ring. The program elegant was used for particle tracking, and its results are presented. We also report that we observed a vertical focusing in the calculated wake-potential of the shallow transition without rotational symmetry.

∗ Work supported by U.S. Department of Energy, Office of Basic Energy Sciences under Contract No. W-31-109-ENG-38.

RPPB002 Horizontal Coupling Impedance of the APS Storage Ring

Yong-Chul Chae, Katherine Harkay, Xiang Sun (ANL)

The three-dimensional wake-potentials of the APS storage ring have been reconstructed according to the impedance database concept. Every wakefield-generating component in the ring was considered including small-gap insertion device (ID) chambers, rf cavities, shielded bellows, beam position monitors, synchrotron radiation absorbers, scrapers, flags, various chamber transitions, septum chambers, and pulsed kickers. In this paper the result for the horizontal wake-potentials and its impedance are presented. The numerically obtained impedance has been used to investigate the experimental results, which were tune-slope measurement and transverse saw-tooth instability observed in the APS storage ring. We used the program elegant for particle tracking including not only the effects of wake fields but also the effects of chromaticity, Landau damping, radiation damping, and lattice imperfection. We also report that we observed a horizontal focusing in the calculated wake-potential of the shallow transition without rotational symmetry.

∗ Work supported by U.S. Department of Energy, Office of Basic Energy Sciences under Contract No. W-31-109-ENG-38.

RPPB003 Longitudinal Coupling Impedance of the APS Storage Ring

Yong-Chul Chae, Katherine Harkay, Xiang Sun (ANL)

The three-dimensional wake-potentials of the APS storage ring have been reconstructed according to the impedance database concept. Every wakefield-generating component in the ring was considered including small-gap insertion device (ID) chambers, rf cavities, shielded bellows, beam position monitors, synchrotron radiation absorbers, scrapers, flags, various chamber transitions, septum chambers, and pulsed kickers. In this paper the result for the longitudinal wake-potentials and its impedance are presented. The total impedance is not model-based but the direct sum of numerical functions. The fit parameters for the broadband resonator model are also included as a convenient representation. We used this impedance model to investigate the observed microwave instability, namely bunch lengthening, anomalous energy spread, and coherent excitation at high synchrotron sideband.

∗ Work supported by U.S. Department of Energy, Office of Basic Energy Sciences under Contract No. W-31-109-ENG-38.

RPPB004 The Impedance Database and its Application to the APS Storage Ring

Yong-Chul Chae (ANL)

Since the operation of the APS storage ring, we have observed instabilities of different kinds. Some of them are not well understood and need further investigation; transverse saw-tooth instability and anomalous energy spread are examples. Quantitative understanding of these instabilities requires detailed knowledge of impedance of the ring. For this purpose we developed the concept of the impedance database, where the wake-potential of each vacuum component in the ring is deposited and maintained in the standard form. These standardized wake-potentials can be manipulated with high flexibility by utilizing Self Describing Data Sets (SDDS) toolkit developed at Argonne. In this paper we will present the total impedance of the APS storage ring obtained by using the impedance database. Then we explain how we use this model impedance not only to investigate the currently observed instabilities but also to predict the effect of future vacuum components on the beam, especially the effect of small-gap insertion device chambers.

∗ Work supported by U.S. Department of Energy, Office of Basic Energy Sciences under Contract No. W-31-109-ENG-38.

RPPB005 Bunch Length Measurements at BESSY

Peter Kuske, M. Abo-Bakr, J. Feikes, K. Holldack, G. Wuestefeld (BESSY)

In the range from 2 ps to 40 ps rms bunch length the bunch shapes have been measured with a streak camera as a function of beam current. Short bunches were produced by reducing the momentum compaction factors of the lattice. An attempt is made to distinguish between vacuum chamber and radiation impedance related effects.

∗ Work funded by the BMBF and Land Berlin.

RPPB006 Coherent Emission of Synchrotron Radiation and Longitudinal Instabilities

Peter Kuske, M. Abo-Bakr, J. Feikes, K. Holldack, W. Peatman, U. Schade, G. Wuestefeld (BESSY), H.-W. Huebers (DLR)

At BESSY bursts of coherent synchrotron radiation around 10 wavenumbers (1/cm) have been observed above a certain threshold current. The repetition rate of these bursts depends on intensity and the thresholds vary strongly with bunch length. With short bunches the thresholds are much higher than expected from the theory of beam instability due to coherent synchrotron radiation [G. Stupakov and S. Heifets in Phys. Rev. ST Accel. Beam 5, 054402 (2002)]. The reason could be the onset of the microwave instability at even lower beam currents.

∗ Work funded by BMBF and Land Berlin.

RPPB007 Transverse Instabilities in RHIC

Michael Blaskiewicz, Joseph Brennan, Peter Cameron, Kristin Drees, Wolfram Fischer, Christoph Montag, Richard Perez, Thomas Roser, Todd Satogata (BNL), Nuria Catalon-Lasheras (CERN)

The beam quality in RHIC is significantly impacted by a transverse instability which can occur just after transition. Data characterizing the instability are presented and analyzed. Techniques for ameliorating the situation are considered.

∗ This work was performed under the auspices of the United States Department of Energy.

RPPB008 Longitudinal Solitons in RHIC

Michael Blaskiewicz, Joseph Brennan, Wolfram Fischer (BNL)

Stable, coherent, longitudinal oscillations have been observed in the RHIC accelerator. Within the context of pertubation theory, the beam parameters and machine impedance suggest these oscillations should be Landau damped. When nonlinear effects are included, long lived, stable oscillations become possible for low intensity beams. Simulations and theory are compared with data.

* This work was performed under the auspices of the United States Department of Energy.

RPPB009 Effects of Space Charge and Nonlinearities on Collective Instabilities of a Long Bunch

Alexei Fedotov, Mike Blaskiewicz, Jie Wei (BNL), Slava Danilov (ORNL)

We start with the discussion of the effects of space charge and nonlinearities on the transverse microwave instability. We then explore a possibility of Landau damping with the octupole correctors using an example of the SNS ring. We also discuss the required strength of such nonlinearities in the presence of space-charge tune spread as well as their effect on dynamic aperture and emittance dilution.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

RPPB010 Coupling Impedance Measurements of the SNS RF Cavity

Harald Hahn, M. M. Blaskiewicz, J. M. Brennan, A. Zaltsman (BNL), D. Davino (University of Sannio)

The Spallation Neutron Source (SNS) rf system is based on three cavities operating at the fundamental frequency, ~1 MHz and one cavity at the second harmonic. Each cavity is composed of two RF gaps which are driven in parallel by means of side bus-bars. The gap capacitance is obtained by adding capacitors and the inductance is supplied by coaxial stacks of ferrite rings. The cavity is placed into a shielding box from which it is dc isolated by ceramic rings. First impedance measurements indicated longitudinal and transverse resonances, attributed to the ceramic rings and the asymmetric arrangement of the gap capacitors. Application of capacitive bypasses and transverse carborundum rods effectively suppressed all spurious resonances.

* SNS is managed by UT-Batelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

RPPB011 The Electron Cloud Instability of the LHC Beam in the CERN SPS

Gianluigi Arduini, Karel Cornelis, Wolfgang Hofle, Giovanni Rumolo, Frank Zimmermann (CERN)

The electron cloud induced by the LHC beam in the SPS occurs mainly in the dipoles and it is responsible for strong transverse instabilities. In the horizontal plane a coupled bunch mode instability develops in a few tens of turns at injection. Tune shift measurements, mode number and phase space analyses have been performed at different energies and provide information about the electron cloud distribution and its dynamics. In the vertical plane a single bunch head-tail-like instability occurs. The equivalent 'electron-cloud wake field' is inferred from the analysis of the head-tail motion of the bunches of the LHC beam train.

RPPB012 Investigation of Space Charge Effects in the SPS

Helmut Burkhardt, Jacques Gareyte, Giovanni Rumolo, Luc Vos, Jorg Wenninger, Frank Zimmermann (CERN)

Space charge effects generally play a rather minor role in high energy machines like the SPS. Rather high space charge tune shifts may however become unavoidable in the SPS for the heavy ion beams required by the LHC. We describe recent measurements performed with intense proton beams in the SPS. The space charge effects were enhanced by a reduction of the injection energy to 14 GeV.

RPPB013 Coherent Tune Shifts Measured with Few Bunches in the SPS and Comparison with Resistive Wall Theory

Helmut Burkhardt, Jacques Gareyte, Alexander Koschik, Giovanni Rumolo, Frank Zimmermann, Bruno Zotter (CERN)

Coherent tune shifts with current have been measured in the SPS with single bunches and two bunches at varying distances between them. The measurements showed the usual negative slope with intensity in the vertical plane and a small positive one in the horizontal direction. The results are compared with theoretical predictions which include estimates of tune shifts due to the impedance of resistive vacuum chambers with non-circular geometry and finite wall thickness.

RPPB014 Longitudinal Microwave Instability in Lepton Bunches

Elias Metral (CERN)

The stability criterion for the longitudinal microwave instability in bunched lepton beams is derived using the mode-coupling formalism and taking into account the potential-well distortion. The new formula yields an intensity threshold which can be higher than the one given by the Keil-Schnell-Boussard approximation by a large factor. This result may explain why the classical instability threshold has been exceeded in some lepton machines.

RPPB015 Nominal Longitudinal Parameters for the LHC Beam in the CERN SPS

Elena Shaposhnikova, Philippe Baudrenghien, Thomas Bohl, Trevor Linnecar, Joachim Tuckmantel (CERN)

A proton beam with the basic structure defined by the the LHC requirements, was first available for injection into the SPS in 1998. At the end of 2002, following a significant beam-studies and RF hardware upgrade programme, a beam having both the nominal LHC intensity and the correct longitudinal parameters was obtained at top energy for the first time. This beam, characterised by high local density, must satisfy strict requirements on bunch length, longitudinal emittance and bunch to bunch phase modulation for extraction to the LHC, where only very limited particle losses are acceptable. The problems to be solved came mainly from the high beam loading and microwave and coupled bunch instabilities which lead both to beam losses and to unacceptably large longitudinal emittance on the flat top. In this paper the steps taken to arrive at these nominal beam parameters are presented.

RPPB016 Transverse 'Monopole' Instability Driven by Electron Cloud

Frank Zimmermann (CERN), Giovanni Rumolo (Gesellschaft für Schwerionenforschung mbH), Kazuhito Ohmi (KEK), Ali Ghalam, Tom Katsouleas (University of Southern California)

By now it is well known that the electron cloud created by photoemission or secondary emission in the beam pipe can drive a transverse head-tail instability. We report simulation results that reveal a different type of instability, which occurs in the absence of any transverse dipole motion along the bunch and which is characterized by a rapid blow up of the bunch tail. We discuss the parameter regime

in which this peculiar instability occurs, earlier related studies, experimental evidence, and possible implications.

RPPB017 Simulation Study of Coupled-Bunch Instabilities due to Resistive Wall, Ions, or Electron Cloud

Frank Zimmermann, Hitoshi Fukuma, Kazuhito Ohmi, Yukiyoshi Ohnishi, Su Su Win (KEK)

We simulate the interaction of a bunch train with either an external wake field, (semi-)trapped ions in a field-free region or in a dipole field, or an electron cloud, on successive turns, using a simplified algorithm with only a small number of macro-particles. We present simulated mode spectra and rise times for the ensuing coupled-bunch instabilities, and discuss the results.

RPPB018 Instability Threshold Currents vs. Energy in CESR

Michael Billing, John Sikora (Cornell University)

CESR has been observed to have a longitudinal coupled bunch instability which limits the total beam current when operating with trains of bunches. Feedback has been employed for some time to counter this instability. This paper reports on measurements of the threshold current for the onset of the instability when feedback is turned off vs. beam energy over a range from 1.9 GeV to 5.2 GeV and compares the change in threshold current with that expected from the change in radiation damping. Operating performance with feedback in use will also be reported.

∗ Work supported by the National Science Foundation.

RPPB019 Beam Dynamics Studies at Duke Storage Ring Using Dual-Sweep Streak Camera

Vladimir Litvinenko, Jingyi Li, Igor V. Pinayev, Ying Wu (Duke University), Oleg A. Shevchenko (BINP)

We present experimental results of electron bunch lengthening, and normal and hard head-tail transverse instabilities using a dual-sweep streak camera. We describe the experimental set-up for observation of the transverse instabilities with psec resolution and the triggering system for observation of transverse instability. We present and discuss the evidence of the coupling mode character of the hard head-tail instability.

∗ Work is supported by the Dean of Natural Sciences, Duke University.

RPPB020 Transverse Impedance of a Laminated Magnet

Alexey Burov (FNAL), V. Danilov (ORNL)

Impedances of laminated magnets can make a significant contribution to the total impedance budget due to a huge effective surface of these elements. While their longitudinal impedance was calculated long ago, the transverse one is conventionally estimated by Panofsky-Wenzel theorem, which may be of a poor accuracy. Here, a direct calculation of the transverse impedance is presented, and the result is applied to Tevatron.

RPPB021 Head-Tail Instability at Tevatron

Petr Ivanov, Jerry Annala, Alexey Burov, Valeri Lebedev, Vic Scarpine, Vladimir Shiltsev (FNAL)

Tevatron performance suffers from a transverse coherent instability. Experimental studies and theoretical examination identify the instability as a weak head-tail, driven by the short-range wake fields in presence of the space charge. Growth rates and coherent tune shifts are measured at injection of single coalesced proton bunch with intensity of N=2.6*E11 using a fast strip-line pickup. Measurements are in a reasonable agreement with a theoretical model and computer simulations. This paper summarizes some results of the experimental observations and head-tail model theoretical studies.

∗ Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

RPPB022 Impedances of Separators

K.Y. Ng (FNAL)

The longitudinal and transverse impedances of the Tevatron separators are estimated numerically and analytically. Comparison is made to wire measurement results. The implication to transverse beam instability is discussed.

∗ Work supported by the US Department of Eneregy under contract No. DEAC02-76CH03000.

RPPB023 A 1.75 GHz Waveguide Schottky Detector System

Ralph Pasquinelli, Ed Cullerton, Dave Peterson, Pete Seifrid, Jim Steimel, Ding Sun, Dave Tinsley (FNAL)

A 1.75 GHz waveguide Schottky detector system has been designed and built for each of the Fermilab Tevatron and Recycler accelerators. The waveguide detector is designed to measure the betatron sideband and longitudinal Schottky signals of the machines at a frequency high enough to avoid coherent effects. Two detectors are used for each machine, one for horizontal and one for vertical betatron signals. This paper describes the details of the waveguide design and construction, as well as the design of the electronic system of the detector. Sensitivity calculations, bandwidth, and output power calculations are included. The electronic system utilizes single sideband down conversion (to preserve chromatic information) to frequencies less than 10 MHz, so that the signals may be analyzed by standard instrumentation, such as a Vector Signal Analyzer. The electronic system includes electronic gates to measure single or multiple bunches of protons or antiprotons with the RF as a source for tracking up and down energy ramps. The electronic system also includes a continuous beam emittance monitor.

∗ Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

RPPB024 The Tevatron Bunch by Bunch Longitudinal Dampers

Cheng-Yang Tan, James Steimel (FNAL)

We describe in this paper the Tevatron bunch by bunch dampers. The goal of the dampers is to stop the spontaneous longitudinal beam size blowup of the protons during a store. The system is currently operational and has stopped the beam blowups during a store.

∗ Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy.

RPPB025 The Tevatron Coupled Bunch Mode Transverse Dampers

Cheng-Yang Tan, James Steimel (FNAL)

We describe in this paper the Tevatron coupled bunch mode transverse dampers. The goal of the transverse dampers is to keep the beam stable when chromaticities are lowered. We will show the measured results during the commissioning of this system.

∗ Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy.

RPPB026 Fast Methods for Vlasov-Poisson Dynamics

Antonina Fedorova, Michael Zeitlin (IPME RAS, Russian Academy of Sciences)

A fast and efficient numerical-analytical approach is proposed for modeling the complex nonlinear collective behaviour in the various forms of the generalized Vlasov-Poisson systems. Our approach is based on a set of methods which give the possibility to work with well-localized bases in phase spaces and provide maximum sparse forms for all operators under consideration in such bases, and as consequence lead to fast numerical algorithms with minimal complexity in scalar/parallel calculations [A. Fedorova, M. Zeitlin, Proc. EPAC02, pp.1323, 1344, 1434, 1482, 1595, Paris, 2002; arXiv preprints, physics/0206053, 0206052, 0206051, 0206050, 0206049, 0206054; nlin.PS/0206024]. We compare our approach with previous ones, e.g. nonlinear delta F simulation and PIC modeling and demonstrate its advantages. As the particular limiting cases of our construction we have standard KV and Klimontovich distributions. The solutions are represented via the multiscale decomposition in nonlinear high-localized eigenmodes (generalized Gluckstern modes), which corresponds to the full multiresolution expansion in all underlying hidden phase space scales. In contrast with different approaches we do not use perturbation technique or linearization procedures. Fast scalar/parallel modeling demonstrates the appearance of the high-localized (asymptotically stable) coherent structures/patterns (waveletons) in these spatially—extended stochastic systems with complex collective behaviour.

RPPB027 Energy Confinement/Fusion in Kinetical Approach

Michael Zeitlin, Antonina Fedorova (IPME RAS, Russian Academy of Sciences)

An efficient numerical-analytical approach is proposed for analysis of complex collective dynamics in accelerator/plasma physics models based on hierarchy of kinetic equations (BBGKY-like systems of equations) [Proc. EPAC02, pp.1323, 1344, 1434, 1482, 1595, Paris, 2002; arXiv preprints, physics/0206053, 0206052, 0206051, 0206050, 0206049, 0206054; nlin.PS/0206024]. Our calculations are based on variational and multiresolution approaches in the basis of polynomial tensor algebras of various localized bases. We construct the representation for hierarchy of distribution functions via the exact multiscale decomposition in high-localized nonlinear eigenmodes. The corresponding cut-off of infinite hierarchy, reductions to finite dimensional subsets and accuracy of calculations are based on the new multiscale metric structure of the whole space of all distribution functions. We demonstrate the possibility of the existence of energy confinement/fusion in the small regions of the phase space (waveleton solutions).

RPPB028 Bunch Lengthening Recently Observed at PF-AR

Takao Ieiri, Toshio Kasuga, Yasuyuki Minagawa, Takashi Obina (KEK), Takahiro Fujita (Hiroshima Univercity)

The PF-AR (Photon Factory Advanced Ring for pulse X-rays) in KEK has been renewed to upgrade the performance. In this project, new vacuum ducts were installed with shielding bellows instead of non-shielding aluminum bellows. Thus the coupling impedance of the ring was improved due to the shields. Measuring bunch lengthening before and after the installation, we evaluated the longitudinal impedance of the bellows in a low bunch current. When the bunch current was high enough, a longitudinal instability was observed, accompanied by higher-order coherent synchrotron oscillations. We discuss the instability and the impedance based on various observed phenomena.

RPPB029 Transverse Sawtooth Instability Observed in Photon Factory Advanced Ring

Yasuyuki Minagawa, Takao Ieiri, Toshio Kasuga, Takashi Obina (KEK), Takahiro Fujita (Hiroshima University)

The PF-AR (Photon Factory Advanced Ring for pulse X-rays) in KEK has been operated since January 2002, after upgrading vacuum components. We observed a remarkable phenomenon in the transverse oscillation. In a low bunch current, the horizontal betatron oscillation induced by an injection error damped well by the effects of the radiation damping and the beam feedback system. However, when the bunch current was high, the horizontal oscillation grew over several milliseconds and damped again like a sawtooth, after the damping in the injection process was finished. This sawtooth instability was also observed just after the horizontal oscillation was artificially excited in a storage mode. To investigate the cause and the mechanism of the instability, we measured the growth time of the oscillation when the parameters (octupole magnets, the beam feedback and RF voltage) were changed.

RPPB030 Study of ep Instability for a Coasting Proton Beam

Kazuhito Ohmi, Toyama Takeshi, M. Tomizawa (KEK)

Electron cloud instability for a coasting proton beam has been discussed for a long time. Linear theory predicts a threshold for the neutralization factor. If we consider accumulation of ionization electrons, the proton beam always becomes unstable after the build-up time up to the neutralization level. Actually electrons are diffused by the coherent motion of the proton beam due to the instability. The production rate of the electrons has an important role in the growth of the beam instability. The behavior of electrons and proton beam is discussed using a computer simulation.

RPPB031 Impedance Issues in the Proton Synchrotrons of J-PARC

Takeshi Toyama, Kazuhito Ohmi, Yoshio Saito, Masahiko Uota (KEK), Naoki Hayashi, Michikazu Kinsho, Kazami Yamamoto (Japan Atomic Energy Research Institute)

Impedance budget have been updated for the 3 GeV RCS and 50 GeV MR in J-PARC, Japan Proton Accelerator Research Complex. Longitudinal and transverse impedance evaluation has been made on vacuum pipes, kickers, rf cavities, collimators and BPMs by the standard measurement method using a single wire or double wire. Brief stability consideration will be made based on the impedance budget. Some possibilities to reduce impedances will also be given.

RPPB032 Collective Instabilities of a Super-Bunch

Takeshi Toyama, Ken Takayama (KEK)

A super-bunch is considered as a candidate of intensity upgrade of low or medium energy proton synchrotrons [K.Takayama, J.Kishiro, K.Koseki, E.Nakamura, M.Sakuda, Y.Shimosaki, K.Torikai, T.Toyama, and M.Wake, "SUPERBUNCH ACCELERATION AND ITS APPLICATIONS", in Proc. of EPAC2002, 998-1000 (2002).]. The merit has been also suggested for large hadron colliders [K.Takayama, "Super-bunch Hadron Colliders", in Proc. of RPIA2002]. This paper will review general issues in the super-bunch collective instabilities in the transverse and longitudinal direction and focus its detail discussion on the head-tail instability. A simple case of a hollow beam is well analyzed with the Vlasov equation. More realistic cases have been investigated with tracking simulations. Results are compared with that of the hollow beam. While the synchrotron tune itself is very small in the case of the super-bunch, its spreads from 0 at the dp/p=0 to maximum value at the bunch edge. This seems to introduce a somewhat different stabilizing feature from Landau damping in a conventional RF bucket. Their physics will be discussed with simulation results and a theoretical approach.

RPPB033 Electron Cloud Build-up in the KEK 12 GeV PS

Takeshi Toyama, Naoki Hayashi, Yoshiro Irie, Shigeki Kato, Kazuhito Ohmi, Chihiro Ohmori, Kotaro Satoh, Masahiko Uota (KEK)

An Electron-proton instability has been observed in some proton rings. This instability is potentially a serious problem for the synchrotrons in J-PARC, Japan Proton Accelerator Research Complex. To evaluate the present theory of electron cloud build-up, electron cloud build-up has been measured in the KEK 12 GeV PS. Measurements include observations with several beam parameters, solenoid field effects, signals from an electron sweeping detector. Measurements will be compared with the computer simulation.

RPPB034 An Experimental Investigation of Microwave Stability near Transition in the PSR

Patrick Colestock, Chris Beltran, Andrew Browman, Robert Macek, Rodney McCrady, Larry Rybarcyk (LANL), Martin Schulze (General Atomics)

We have undertaken a study of microwave stability in the PSR storage ring under a variety of beam conditions near transition, including variable intensity and machine impedance, which can be independently controlled in the PSR. Studies indicate that the general features of a linear stability threshold model are valid, namely the threshold for microwave instability becomes vanishingly small sufficiently close to transition. In addition, many nonlinear features are apparent and the results indicate an extended operating regime with saturated, but otherwise benign, longitudinal fluctuations. Details of the linear model, experimental results and corresponding simulations will be presented.

RPPB035 Status of the Experimetnal Studies of the Electron Cloud at the Los Alamos Proton Storage Ring

Robert Macek, Michael Borden, Andrew Browman, Daniel Fitzgerald, Rodney McCarady, Thomas Spickermann, Thomas Zaugg (LANL)

The electron cloud (EC) at the Los Alamos Proton Storage Ring (PSR) has been studied extensively for the past several years with an overall aim to identify and measure its important characteristics, the factors that influence these charateristics and to relate these to the two-stream (e-p) instability long observed at PSR. A number of new results since PAC2001 will be presented including measurements using the newly developed electron-sweeping detector designed to measure the EC at various times during passage of the beam-free gap between each turn in PSR and after the beam was extracted. The EC has been studied as a function of beam intensity, location in the ring, and other beam and ring parameters. Suppression of the EC generation by TiN coatings and weak solenoids was studied and results will be discussed. Beam scrubbing over time has significantly reduced the intensity of the EC and raised the threshold for the e-p instability. Measurements of EC generated by a single bunch passage were made with an electron-sweeping detector installed the extraction line and show results similar to those in the ring. The latter indicates that accumulation of electrons over a number of turns need not be a large factor in the generation of the EC in PSR. It also points to a strong EC in the extraction line and its effect on diagnostic instrumentation in such a line.

* Work conducted at the Los Alamos National Laboratory, which is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

RPPB036 A Three-Dimensional Kinetic Theory of Continuous-Beam Stability

Tai-Sen Wang (LANL)

This work is a three-dimensional stability study based on the modal analysis for a continuous beam of Kapchinskij-Vladimirskij (KV) distribution. The analysis is carried out self-consistently within the context of linearized Vlasov-Maxwell equations and electrostatic approximation. The emphasis is on investigating the coupling between longitudinal and transverse perturbations in the high-intensity region. The interaction between the transverse modes supported by the KV distribution and those modes sustainable by the cold beam is examined. A class of "coupling modes" is found that would not exist if the longitudinal and the transverse perturbations are treated separately. The effects of wall impedance on beam stability is also studied and numerical examples are presented.

* Work performed under the auspices of the US DOE by LANL under contract W-7405-ENG-36.

RPPB037 A Numerical Study of Bunched Beam Transverse Electron-Proton Instability Based on the Centroid Model

Tai-Sen Wang (LANL)

In a recent theoretical study of the transverse electron-proton (e-p) instability, an asymptotic solution has been found for the equations describing the centroid motion of the traversing proton bunch and the stationary background electrons [T. F. Wang, P. J. Channell, R. J. Macek, and R. C. Davidson, submitted for publication]. It was shown that the combination of finite proton bunch length, non-uniform proton line density, and the single-pass e-p interaction cause the instability to evolve intricately in space and time even in the linear regime. This paper reports a numerical study of the e-p instability based on the same centroid equations. The purpose of the work is to compare the numerical solution with the analytic solution and to use the numerical approach to investigate the early development of the instability not covered by the asymptotic solution. In particular, the instability threshold and the initial growth of the instability are studied for various proton-beam conditions, fraction of charge neutralization, and initial perturbations.

* Work performed under the auspices of the US DOE by LANL under contract W-7405-ENG-36.

RPPB038 RF Impedance Measurements on the DARHT-II Accelerator Intercell Assembly

William Fawley, Shmuel Eylon (LBNL), Richard Briggs (Science Applications International Corporation)

We report upon recent experimental measurements made of RF properties of the intercell assembly of the second axis accelerator of the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility at LANL. The intercells provide both pumping and diagnostic access to the main DARHT-II beamline. The intercell design includes a pumping plenum separated from the main beam pipe by return current rods together with RF shielding provided by a copper-coated stainless steel mesh. Measurements using the twin lead technique [R. Briggs et al., "Transverse Impedance Measurements of the DARHT-2 Accelerator Cell, Proc. 2001 Particle Accel. Conf, pp. 1850-1852 (2001)] at relatively low frequencies (f <= 200 MHz) suggest a constant value for the ratio η of the radial and azimuthal RF magnetic field components to which the transverse impedance is linearly related. These results compare favorably to predictions from a simple analytic model which includes the localized "self-inductance" of the mesh and return current rods as an equivalent sheet impedance. We also present RF loop-to-loop response data over the frequency band above beam pipe cutoff which show the existence of many RF modes with relatively high Q's.

* Work supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098. Work performed under the auspices of the US DOE by LANL under contract W-7405-ENG-36.

RPPB039 Longitudinal and Transverse Mode Effects in the DARHT II Injector

Enrique Henestroza, Shmuel Eylon, William Waldron, Simon S. Yu (LBNL)

The electron beam injector for the second axis of the Dual-Axis Radiographic Hydrotest Facility (DARHT II) is being commissioned at Los Alamos National Laboratory. The injector geometry affects the electron beam longitudinal dynamics as well as the transverse dynamics of the beam centroid. We will report on frequency-domain and time-domain (longitudinal and transverse) electromagnetic mode calculations for the injector using the MAFIA code, and resonant modes obtained through a circuit analysis; we will also report on damping of unwanted modes with electrical elements.

* This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098.

RPPB040 The Stabilization of Budker-Chirikov Instability by the Spread of Longitudinal Velocities

Yurii Golub (Moscow Radiotechnical Institute)

The two-beams electron – ion system consists of a nonrelativistic ion beam propagating co-axially with a high-current relativistic electron beam in a longitudinal homogeneous magnetic field [Yu.Ya. Golub, N.E.Rozanov, Nuclear Instruments and Methods in Physics Research, A358 (1995) 479]. The effect of spread of longitudinal velocities of an electron beam on instability Budker-Chirikov (BCI) in the system is investigated by the method of a numerical simulation in terms of the kinetic description of both beams. The investigations are development of investigations in [Yu.Ya. Golub, Proceedings of EPAC 2002, Paris, France, 1497]. Is shown, that the increasing of spread of longitudinal velocities of electron beam results in the decreasing of an increment of instability Budker-Chirikov and the increasing of length of propagation of a electron beam.

RPPB041 New Vortices in Axisymmetric Inhomogeneous Beams

Yurii Golub (Moscow Radiotechnical Institute)

We analyzed localized vortices in non-neutral inhomogeneous by density and velocity electron beams propagating in vacuum along the external magnetic field. These vortices distinguish from well-known vortices of Larichev-Reznik or Reznik types, which used in [Golub Yu.Ya., Nikulin M.G., Rozanov N.E. In: Nonlinear world: IV Intern. Workshop on Nonlin. and Turbul. Proc. in Phys., (ed. by V.G. Bar'yakhtar et all) World Scientific Publishing Co. Pte. Ltd., Singapore, 1990, vol. 2, p.857]. New types of vortex are obtained by new solution method of nonlinear equations. The new method is development of a method described in [Golub Yu.Ya., Proceedings of EPAC 2002, Paris, France, 1253].That method distinguish from standard Larichev-Reznik or Reznik method, which used in [Golub Yu.Ya., Nikulin M.G., Rozanov N.E. In: Nonlinear world: IV Intern. Workshop on Nonlin. and Turbul. Proc. in Phys., (ed. by V.G. Bar'yakhtar et all) World Scientific Publishing Co. Pte. Ltd., Singapore, 1990, vol. 2, p.857]. It has been found new expression for electric field potential of vortex in a wave frame. The expression is axisymmetric in a wave frame. New vortices are new solitons. New vortices are the result of external disturbances or the appearance and development of instabilities like for example a diocotron instability in hollow beams and a slipping-instability in solid beams.

RPPB042 Beam Instabilities in Laser Electron Storage Ring

Eun-San Kim (Pohang Accelerator Laboratory)

Numerical studies on the beam instabilities in the laser electron storage ring are performed. We present an analysis of the dynamical behavior of the laser electron storage ring with microwave instability. We also present the dependence of the beam instabilities on parameters of the laser electron storage ring.

RPPB043 Beam Instabilities at the PLS Storage Ring

Eun-San Kim (Pohang Accelerator Laboratory)

Observation, analysis and cure of beam instabilities in the 2.5 GeV PLS storage ring are presented. Qualitative investigations on single bunch instabilities and multibunch bunch instabilities are performed. The effects of the five rf cavities that will be inserted in the storage ring on the beam instabilities are also predicted.

RPPB044 Third Harmonic Cavity at PLS

Eun-San Kim, Jung-Suk Cho, Myunghwan Chun, Jaeseok Yang (Pohang Accelerator Laboratory)

Third harmonic cavity is investigated to control bunch length and to increase beam lifetime in the PLS storage ring. The energy accepetance, bunch length and multibunch instabilities with the harmonic cavity are investigated. The cavity design for increasing the fundamental mode shunt resistance and for reducing the higher order modes are presented.

RPPB045 Measurement of the Coupling Impedances of the RF Cavities at PLS

Eun-San Kim, Jung-Suk Cho, Myung-Hwan Chun, Jae-Seok Yang (Pohang Accelerator Laboratory)

A method to measure the longitudinal and transverse impedances of the rf cavities in PLS storage ring are presented. Based on the measured impedance parameters, quantitative analysis on characteristics of the beam instabilities that have been observed in 2.5 GeV operation are performed.

RPPB046 Simulations on Wakefield Effects in the Electron Beam at the 2.5 GeV PLS Linac

Eun-San Kim, Hoon Hur, Sang-Hoon Nam (Pohang Accelerator Laboratory)

We investigate simulations on the effects of the wakefield in emittance growth at the 2.5 GeV PLS linac. The effects of initial beam offset, misalignments of accelerating structures and magnets on the emittance growth are also considered in the simulation. Based on the simulation results, maximum possible beam current per bunch for the stable beam operation of linac is estimated.

RPPB047 Design Considerations for SASE-FEL at PLS

Eun-San Kim (Pohang Accelerator Laboratory)

The results of feasibility studies for the SASE-FEL using the PLS linac are presented. The parameters of rf gun, undulator and optical cavity for the design of SASE-FEL are investigated. The results of numerical studies for the designed SASE-FEL are also presented.

RPPB048 Global Orbit Feedback System for PLS Storage Ring

Eun-San Kim, Ki-Man Ha, Moohyun Yoon (Pohang Accelerator Laboratory)

Characteristics of the global orbit feedback system for the PLS storage ring are investigated. Performance on the control of the orbit drift by the global orbit feedback system will be presented. Results on dispersion correction will be also presented.

RPPB049 Operation Performance in 2.5 GeV Full Energy Injection at PLS

Eun-San Kim, Yeongjin Han, Sung-Hoon Jeong, Mungyung Kim, Sung-Chul Kim, Soung-Soo Park, Jae-Hag Seo (Pohang Accelerator Laboratory)

The PLS has provided 2.5 GeV electron beam to users of beam lines since January 2000. During Jan. 2001 to Oct. 2002, 2 GeV electron beam was injected from the linac to the storage ring and the storage ring needed energy ramping process to increase the beam energy to 2.5 GeV. Instead of energy ramping process, we have used the 2.5

GeV full energy injection from the linac to the storage ring since Oct. 2002. We present the activities on the stability and reliability of linac for 2.5 GeV operation, stabilities of injection kicker and septum magnets in the storage ring, orbit correction of COD due to leakage field of the septum magnet, and DC bump for ring injection. Orbit stabilities in the operation of 2.5 GeV full energy injection will be also presented.

RPPB050 Effects of Insertion Devices in the PLS Storage Ring

Eun-San Kim, Il-Moon Hwang, Moohyun Yoom (Pohang Accelerator Laboratory)

We estimated resistive wall impedance due to narrow gaps of insertion devices and growth rates of coupled-bunch instabilities in the PLS storage ring. Longitudinal and transverse resistive wall instabilities are investigated by a multipartice tracking simulation. Tracking studies of the effects of insertion devices on the dynamic aperture are also presented.

RPPB051 Collective Instability Driven by Wall Impedance in Intense Charged Particle Beams

Ronald C. Davidson, Hong Qin (Plasma Physics Laboratory, Princeton University), Gennady Shvets (Illinois Institute of Technology)

We consider a long charg bunch ($l_b >> r_b$) with characteristic length l_b and radius r_b propagating in the z-direction through a cylindrical pipe with radius r_w. The charge bunch is confined in the transverse plane by an applied smooth-focusing force. A detailed kinetic analysis of the collective instability driven by finite wall impedance Z(w) is presented. The analysis is based on the Vlasov-Maxwell equations for perturbations about a flat-top density profile, assuming perturbations with characteristic frequency W and axial wavenumber k_z satisfying $\|W r_b/c\| << 1$ and $\|k_z r_b\| << 1$. A closed dispersion relation is derived for perturbations proportional to exp (imθ), where m=1,2,... is the azimuthal mode number. Detailed stability properties are calculated for various choices of wall impedance Z(W), allowing for general values of the normalized beam intensity s_b. Dipole-mode (m=1) growth rates are determined for applications ranging from the tevatron ($s_b << 1$), to the Spallation Neutron Source ($s_b \sim 0.1$-0.2), to heavy ion fusion drivers ($s_b \sim 1$).

* Research supported by the U.S. Department of Energy.

RPPB052 Delta-f Simulation of Ion-Electron Two-Stream Instability for Heavy Ion Fusion Beams

Hong Qin, Ronald C. Davidson, Edward A. Startsev (Plasma Physics Laboratory, Princeton University)

The ion-electron two-stream instability is numerically studied for the high intensity heavy ion beams envisioned in the Integrated Beam Experiment (IBX). We consider a 1.7 MeV K^+ beam with 0.25 microcoulombs/m line density propagating through a background electron population with 1-5% fractional charge neutralization. The detailed properties of the ion-electron two-stream instability is studied using a 3D low-noise delta-f particle simulation method implemented in the Beam Equilibrium, Stability, and Transport (BEST) code. The influence of other effects, such as the electron dynamics in the quadrupole field and secondary electron emission from the chamber wall, on the ion-electron two-stream instability is also investigated.

* Research supported by the U.S. Department of Energy.

RPPB053 Theory and Nonlinear Perturbative Simulations of Temperature Anisotropy Instability in Intense Charged Particle Beams

Edward Startsev, Ronald Davidson, Hong Qin (Princeton University)

In plasmas with strongly anisotropic distributions a Harris-like collective instability may develop if there is sufficient coupling between the transverse and longitudinal degrees of freedom. Such anisotropies develop naturally in accelerators and may lead to a detoriation of beam quality. This paper extends previous numerical studies [E. A. Startsev, R. C. Davidson and H. Qin, Phys. Plasmas, 9,3138,2002] of the stability properties of intense nonneutral charged particle beams with large temperature anisotropy to allow for non-axisymmetric perturbations. The most unstable modes are identified, and their eigenfrequencies, radial mode structure, and nonlinear dynamics are determined. The simulation results clearly show that moderately intense beams are linearly unstable to short wavelength perturbations with $k_z^2 r_b^2 > 1$, provided the ratio of longitudinal and transverse temperatures is smaller than some threshold value. A theoretical model is developed based on the Vlasov-Maxwell equations which describes the essential features of the linear stage of instability. Both the simulations and the analytical theory predict that the dipole mode is the most unstable mode. In the nonlinear stage, tails develop in the longitudinal momentum distribution, and the kinetic instability saturates due to resonant wave-particle interactions. The total distribution function is still far from equipartitioned, and free energy is available to drive an instability of the hydrodynamic type.

* Research supported by the U.S.Department of Energy.

RPPB054 Measurement of the Longitudinal Wake in the SLAC Linac for Extremely Short Bunches

Karl Bane, Franz-Josef Decker, Paul Emma, Richard Iverson, Patrick Krejcik, James Welch, Mark Woodley (SLAC), Holger Schlarb (DESY)

The Linac Coherent Light Source (LCLS) is an x-ray FEL project in which a 1-nC electron bunch will be compressed to an rms length of 20 microns at 4.5 GeV, accelerated in 500 meters of SLAC linac to 15 GeV, and then injected into an undulator to generate SASE radiation. The longitudinal wakefield generated by the short bunch in the (s-band) linac is very strong, and in fact is relied upon to cancel the energy chirp left in the beam after compression. Up to now the longitudinal wake of the SLAC linac has been measured and confirmed using a typical 500-micron long bunch. The recent installation of the compressor chicane of the Sub-Picosecond Photon Source (SPPS), however, allows us to compress a 3.5-nC bunch down to 50 microns rms, with which we can measure and confirm the wakefield to the short distances required for the LCLS. In this report we present SPPS wakefield measurement results and compare them with theory.

* Work supported by the Department of Energy, contract DE-AC03-76SF00515.

RPPB055 Measurements of Transverse Emittance Growth due to Coherent Synchrotron Radiation in the SLAC SPPS Bunch Compressor Chicane

Paul Emma, Karl Bane, Franz-Josef Decker, Rick Iverson, Patrick Krejcik, Jim Welch, Mark Woodley (SLAC), Holger Schlarb (DESY), Cristina Vaccarezza (INFN)

A four-dipole bunch compressor chicane has recently been installed in the SLAC linac at 9 GeV and is capable of compressing a 3.5-nC electron bunch to an rms length of 40 microns, resulting in a peak current of nearly 10 kA. The initial electron bunch is produced in a damping ring with normalized transverse emittance of the order of 30 microns. We present measurements of the emittance for various compression levels and compare these to calculations.

* Work supported by U.S. Department of Energy, contract DE-AC03-76SF00515.

RPPB056 Vlasov Equation with Coherent Synchrotron Radiation

Samuel Heifets (SLAC)

The coherent synchrotron radiation (CSR) can cause a bunch instability leading to the short wave length density modulation as it

was considered in the previous publication. Here, consideration of the problem is refined. The Vlasov equation for the instability is corrected in two respects taking into account the energy spread in a bunch and the delay time in the distribution function. Parameters defining the corrections are established and effects are estimated for two examples of PEP-II and LCLS chicane.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

RPPB057 Single-Mode Coherent Synchrotron Radiation Instability

Samuel Heifets, Gennady Stupakov (SLAC)

The microwave instability driven by the coherent synchrotron radiation (CSR) has been previously studied [G. Stupakov, S. Heifets, Phys. Rev. ST Accel. Beams 5, 054402 (2002)] neglecting effect of the shielding caused by the finite beam pipe aperture. The growth rate of the instability is large and, at low bunch density, is dominated by the long wavelength modes. Such modes may be close to the shielding threshold where the spectrum of the radiation in a toroidal beam pipe is discrete. In this paper we study the CSR instability in the case when it is driven by a single synchronous mode. Such a regime is different from the regime studied before where the continuous CSR spectrum was implied. We derive a system of equations for the beam-wave interaction and show its similarity to the 1D FEL theory. The growth rate of the instability is obtained and a transition to the case of continuous spectrum is discussed.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

RPPB058 Nonlinear Regime of a Single-Mode CSR Instability

Samuel Heifets, Gennady Stupakov (SLAC)

Close to the shielding threshold of synchrotron radiation in a toroidal waveguide the coherent synchrotron radiation (CSR) instability may be driven by a single synchronous mode. The linear analysis of the problem is presented elsewhere [S. Heifets and G. Stupakov, this proceedings]. In this paper we study a nonlinear regime of the single-mode CSR instability. We show that in the nonlinear regime the instability is described by a system of equations which, after a proper scaling, coincides with the 1D FEL instability theory. We present numeric and analytic analysis of the non-linear regime for the time interval large compared with the damping time taking into account radiation damping and diffusion due to the quantum fluctuations.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

RPPB059 Effects of Linac Wakefield on CSR Microbunching in the Linac Coherent Light Source

Zhirong Huang, Paul Emma (SLAC), Michael Borland, Kwang-Je Kim (ANL)

The design of the Linac Coherent Light Source (LCLS) requires two-stage bunch compression for stability against timing and charge jitters. Coherent synchrotron radiation (CSR) induced in these bunch compressors can drive a microbunching instability that may degrade the beam brightness. In this paper, we study effects of the longitudinal wakefield in the accelerator structure on this instability. We show that significant energy modulation can be accumulated in the linac through the geometrical wakefield and can enhance the CSR microbunching in these compressors. Analytical calculations are compared with numerical simulations to evaluate the gain of microbunching for the LCLS accelerator system.

* Work supported by Department of Energy contract Nos. DE-AC03-76SF00515 and W-31-109-ENG-38.

RPPB060 An Over-Damped Cavity Longitudinal Kicker for the PEP-II LER

Peter McIntosh, Scott DeBarger, Mohammad Dormiani, John Fox, Heinz Schwarz, Dmitry Teytelman, Uli Wienands, Andrew Young (SLAC), Fabio Marcellini (INFN), Makoto Tobiyama (KEK)

Both the HER and LER of PEP-II use longitudinal and transverse feedback systems to combat coupled-bunch instabilities. The design luminosity has been reached using the original drift-tube style longitudinal feedback kickers, and these devices have functioned well. Efforts are now underway to increase the stored beam currents and luminosity of PEP-II, and beam-induced heating of these structures, particularly in the LER is of concern. An alternative kicker design has been investigated based on an over-damped cavity kicker, first developed by LNF-INFN and employed on the DAFNE accelerator. This low loaded Q (or wide bandwidth) structure is fed by a network of ridged waveguides coupled to a simple pill-box cavity. Beam induced RF power is also coupled out of the cavity to external loads, so that the higher order modes (HOMs) excited in the structure are well-damped. This paper details the kicker design for PEP-II and discusses some of the design trade-offs between shunt impedance and bandwidth, as well as the influence of the feedthroughs on the kicker parameters. Estimates of power deposition in the cavity for various operating scenarios are provided. Initial measurement data is shown for the first kicker to be installed in the LER in the summer of 2003.

RPPB061 Evolving Bunch and Retardation in the Impedance Formalism

Robert Warnock, Marco Venturini (SLAC)

The usual expression of the longitudinal wake field in terms of the impedance is exact only for the model in which the source of the field is a rigid bunch. To account for a deforming bunch one has to invoke the complete impedance, a function of both wave number and frequency. The usual impedance is the complete impedance evaluated at the "synchronous" point, where phase velocity equals particle velocity. We consider the problem of approximating the wake field, which is expensive to compute from its exact expression as a sum on wave number and integral over frequency. We treat an example of current interest, the impedance for coherent synchrotron radiation with shielding due to the vacuum chamber. The chamber is represented by infinite parallel plates. For most wave numbers the frequency integral is well approximated by an expression involving the Fourier transform of the bunch form and its time derivative, both evaluated at the current time. At special wave numbers, where the synchronous frequency is close to waveguide cutoffs, there are significant retardation effects involving the bunch form at previous times.

* Research supported in part by DOE contract DE-AC03-76SF00515.

RPPB062 Robinson Modes at Aladdin

Robert Bosch, J. J. Bisognano, K.J. Kleman (Synchrotron Radiation Center, University of Wisconsin)

A fourth harmonic radiofrequency (RF) cavity improves the beam lifetime of the Aladdin electron storage ring. When the harmonic cavity is operated with a low-emittance lattice, coupling between the dipole and quadrupole Robinson modes may cause instability. During stable operation, damped Robinson modes are observed in the spectrum of phase noise upon the beam.

* Work supported by NSF grant DMR-0084402.

RPPB063 The Effects of Temperature Variation on Electron Beams with RF Voltage Modulation

Ping Chou, Min-Huey Wang (Synchrotron Radiation Research Center), Shyh-Yuan Lee (Indiana University)

The dependence of the horizontal beam size on the body temperature of rf cavities is examined. The observed dependence of horizontal

beam size vs the body temperature of rf cavities was residual effect due to the intrinsic resolution of the low-level rf feedback system when the rf cavity temperature was perturbed. Our analysis also provides a quantitative assessment on the temperature control requirement. This method can be used to evaluate the intrinsic resolution of the low-level rf feedback system.

RPPB064 The Effect of Particle Distribution on Instability Growth Rate

Ping Chou (Synchrotron Radiation Research Center)

The instability growth rate is related to the bunch mode spectral power. A semi-quantitative analysis was performed by using a bi-Gaussian distribution with axial symmetry in the longitudinal phase space. For a sharp resonator impedance, the variation of beam distribution has significant effect to the instability growth rate for impedance at higher frequency.

RPPB065 Longitudinal Impedance Measurement of Three Kinds of Bellows by Coaxial Line Method

Gang Huang, Tong Dechun, Chen Huaibi, Huang Wenhui, Lin Yuzheng (Tsinghua University, Beijing), Zhao Zhengtang (Institude of High Energy Physics, Beijing)

The longitudinal impedance of the components in a storage is important to analysis of the beam instability. A longitudinal impedance measurement platform using the coaxial line method is constructed. The impedances of three kinds of bellows are measured by the platform and the results are compared.

* Supported by National Natural Science Foundation of China 19875065.

RPPB066 A Fast Method to Estimate the Gain of the Microbunch Instability in a Bunch Compressor

Sven Reiche, James Rosenzweig (University of California, Los Angeles)

To reach high peak currents driving Free-Electron Lasers an initial chirped electron bunch is compressed in a bunch compressor. The interaction of the electron beam with its radiation field can yield a collective instability, which amplifies any initial modulation in the current profile. We present a model, which allows to derive an explicit analytical expression for the gain of the microbunch instability. The results are compared to those of the more complex analytical models.

RPPB067 Experimental Study of Beam Energy Spread in the Space-Charge Dominated Beams

Yupeng Cui, I. Haber, R. Kishek, P.G. O'Shea, M. Reiser, A. Valfells, Y. Zou (University of Maryland)

Characterization of beam energy spread in the space-charge dominated beam is very important to understand the physics of intense beams. It is believed that coupling between transverse and longitudinal direction will cause an increase of the beam longitudinal energy spread. So far, little theory and experiments have investigated this problem. At the University of Maryland, experiments have been carried out to study the energy evolution in such intense beams. To measure the energy spread, a high-resolution retarding field energy analyzer has been developed. In this paper, we present the initial experimental results using this energy analyzer. The beam energy profile, including rms energy spread and peak energy, has been characterized at the exit of the electron gun. The measured energy variation along the beam pulse is in excellent agreement with direct measurement of the cathode-grid pulse waveform.

* This work is sponsored by US Dept. of Energy.

RPPB068 Analysis of Wakefield Effects on the Operation of KOMAC LINAC

Sung-Oh Cho (Korea Advanced Institute of Science and Technology)

A proton linac with 250 MeV, 20 mA in CW is under development for the Korea Multipurpose Accelerator Complex (KOMAC). The accelerator is composed of a normal-conducting sections below 100 MeV and a superconducting cavities above 100 MeV. In the comparatively high-current accelerator, wakefield excited by the bunches passing through the cavities can induce unstable operation of the accelerator. The loss factors and the impedance spectra for the non-ultrarelativistic proton beams (beta =0.43 for 100 MeV) are calculated analytically. The effects of wakefield on the beam quality degradation, starting current of the beam breakup, power loss to the HOMs are also calculated analytically and numerically.

RPPB069 Alternative Bunch Formation for the Tevatron Collider

Gerald Jackson (Hbar Technologies, LLC)

Both the proton and antiproton bunches in the Fermilab Tevatron Collider have longitudinal emittances that are so large as to introduce serious limitations to operations. Poor beam lifetime, narrower horizontal aperture, and 30% lower luminosities are just a few examples. Theoretically, these 36 proton and 36 antiproton bunches could have longitudinal emittances roughly 6-10 times smaller if the formation of these bunches did not involve emittance dilution. In this paper, alternative longitudinal manipulations are discussed that reduce or eliminate this nonadiabatic longitudinal emittance growth. The measured results of accelerator studies in the Fermilab accelerator chain are presented and compared with theoretical and numerical calculations.

RPPB070 Longitudinal Emittance Growth in the Fermilab Booster Synchrotron

Gerald Jackson (Hbar Technologies, LLC)

In order to shorten the proton bunches in the Fermilab Tevatron Collider, it would be quite helpful to reduce the longitudinal emittance for proton bunches generated by the Booster Synchrotron. A studies was undertaken to re-evaluate the sources of longitudinal instability and resultant longitudinal emittance growth as a function of Booster beam and bunch currents. Employing a novel technique for generating partially populated circumferences of protons, the Booster was tested to understand whether increased longitudinal emittance growth was correlated with total current in the synchrotron, consistent with coupled-bunch instability, or with the number of protons per individual bunch. This paper will present findings that indicate that the instability responsible for poor Booster emittance performance is consistent with single bunch (or low cavity-Q) instabilities.

RPPB071 Numerical Calculations on Higher Order Modes in the 3rd Harmonic Cavity for the TESLA Photoinjector

Wolfgang Mueller, Thomas Weiland (Technische U. Darmstadt), Jacek Sekutowicz, Rainer Wanzenberg (DESY), Timergali Khabiboulline, Nikolay Solyak (FNAL)

Due to the high bunch charge it is not possible to generate the extremely short bunches for the TESLA-FEL directly in the photo gun. Instead one or more compression stages are needed. Otherwise the transverse emittance is diluted by the space charge forces. In the first module the bunches are accelerated off crest in order to get an energy distribution in the longitudinal phase space. Caused by the harmonic behaviour of the accelerating fields, this energy distribution will not be linear but cosine-like curved. To compensate this effect a 3rd harmonic section inbetween the preaccelerator and the buncher (a dispersive section) is planned. A first design of this 3rd harmonic cavity was made at DESY as a regular TESLA cavity skaled by a

factor of three with some corrections in order to avoid too narrow irises and beam pipes. Now this design was modified at FNAL. In this paper we present a comparison of numerical calculations of the shunt impedance of the fundamental and higher order modes of the new design with different numerical codes (i.e. HFFS, MAFIA and CST MicrowaveStudio).

* Work supported by BMBF under contract 01SF9983/0.

RPPB072 New Simulation of Transverse Surface Roughness Wakefields

Sebastian Ratschow, Thomas Weiland (Technische U. Darmstadt)

Short bunches in conjunction with small vacuum tube diameters, as are necessary e.g. for the TESLA-FEL, have an adverse effect on the transverse emittance via short range transverse surface roughness wakefields. Up to now numerical simulation of these wakefields was only possible in a range of parameters orders of magnitude larger than what is found in real beam pipes. The subsequent scaling of results strongly depends on the chosen model. It is therefore highly desirable to simulate surface roughness wakefields with parameters closer to reality, in order to evaluate the scaling. One main problem of known simulation tools is longitudinal grid dispersion, which prohibits to calculate long structures. The new 2.5D program ECHO, avoids longitudinal grid dispersion and allows to calculate transverse wakefields of long beam pipes with more realistic parameters, though restricted to geometries of revolution. In this paper we calculate transverse surface roughness wakefields with ECHO and compare the results to model predictions.

* Work supported by DESY.

RPPB073 Streaming Instabilities in Focusing Ion Beams

David Rose, D.R. Welch (Mission Research Corporation), C.L. Olson (Sandia National Laboratories)

Heavy ion beams drifting in a partially-ionized background gas are susceptible to streaming instabilities. The growth of streaming modes for heavy ion beams in a reactor chamber could limit the focal spot size of the beams or in the most extreme case, disrupt the beam propagation. For converging ion beams, analytic estimates have shown that the changing ion beam and electron densities give changing maximum wave numbers for a given mode of streaming instability [P. Stroud, Lasers and Part. Beams 4, 261 (1986)] that limits or inhibits growth. Past 2-D particle-in-cell simulations of converging ion beams for heavy ion beam propagating across 3-m chambers have not indicated growth of these streaming modes for limited parameter range that includes focusing angle, propagation length, and beam and gas densities [e.g., D. R. Welch, et al., Phys. Plasmas 9, 2344 (2002)]. In this paper, we specifically test the stability limits numerically using particle-in-cell code simulations for a number of beam and plasma parameters relevant for Heavy Ion Fusion.

RPPB074 Simulated Growth Rates for Single-Bunch Instabilities Driven by a Resistive Impedance

Nathan Towne (BNL)

Vlasov simulations of instabilities driven by resistive impedance are used to determine growth rates of single-bunch instabilities. A method for measuring synchrotron tunes and growth rates from simulated synchrotron sidebands is described. Simulated growth rates are compared with Oide's calculation [K. Oide, Part. Accel., 43 (1995)].

* Work performed under the auspices of the U.S. Department of Energy, under contract DE-AC02-76CH00016.

RPPB075 Analytical and Time-Domain Numerical Simulations of Short-Range Wakefields in a Rectangular Structure

David Yu, Alexei Smirnov (DULY Research Inc.)

Diffraction models based on the Sessler-Vainshtein approach were developed for short-range wakefields induced by a single Gaussian bunch in a periodic, planar ("muffin-tin") structure. The analytical model employs field expansion in series of quasi-eigen modes of equivalent open waveguide excited by charge "image" fields induced on the iris edges. Comparisons with numerical, time-domain 3D simulations demonstrate high accuracy of the model (a few percentages for the loss-factor).

Poster Session RPPG
Galleria at 13:30

RPPG001 Beam Dynamics Simulations for RR Barrier Buckets

Chandra Bhat, Hyejoo Kang, Jim MacLachlan, John Marriner (FNAL)

Recycler Ring (RR) is an 8 GeV pbar storage ring for future ppbar collider operations at Fermilab. The beam in RR is stored in three segments (hot, cold and newly transferred beam) azimutally using barrier buckets. Properties of the beam in the RR is found to be affected by to stray magnetic field caused by the Main Injector (a 150 GeV proton-antiproton synchrotron installed in the same tunnel) ramping process. Here we present results of our measurements on the longitudinal emittance growth of the beam in the Recycler Ring due to Main Injector ramp and results of model simulation of this effect using a dynamic simulation program (ESME).

* Work Supported by the U.S. Department of Energy Under Contract No. DE-AC02-76CH03000.

RPPG002 Studies of a Generalized Beam-Induced Multipacting Resonance Condition

Katherine Harkay, R.A. Rosenberg (ANL), Laura Loiacono (Loyola University)

At certain bunch intensities and bunch spacings, beam-induced multipacting was observed during electron cloud studies performed at the Advanced Photon Source. In these studies, dedicated diagnostics known as retarding-field analyzers directly measured the electron flux on the vacuum chamber wall. The peak signals were observed at a bunch spacing that is not predicted when assuming cold secondary electron emission. Using a simple computer model, we studied the effect of including an energy distribution for the emitted secondary electrons. We found that the data can be better explained by a resonance condition in which the secondary electron energy and surface emissivity properties are included. Results for both positron and electron beams are presented.

* Work supported by the U.S. Department of Energy, Office of Basic Energy Sciences under Contract No. W-31-109-ENG-38.

RPPG003 Simulations of Magnetized Beams

Dong Wang (BNL)

Magnetized beam (or angular-momentum-dominated beam)plays a key role in the electron cooling and other applications involving strong solenoids, e.g., photo-injectors, etc. Multi-particle simulation studies of magnetized beam are performed with the ewly modified PARMELA. The explicit expression of the angular momemtum of particles reveal the details of the production and evolution of the magnetized beam in various elements like solenoid, photo-injector, linac and transport etc. The effects of space charge, energy spread on

the beam magnetization, which are not covered by the existing theory, are studied.

* This work was performed under the auspices of the U.S. Department of Energy.

RPPG004 The Point-Charge Transition Radiation in Semi-Infinite Round Pipe with Resistive Walls

Mikayel Ivanyan, Vassili Tsakanov (CANDLE)

The transition effects of the ultra-relativistic point charge radiation in semi-infinite resistive metallic tube are investigated. The modal expansion of the radiated fields at the tube origin is obtained for two cases: for the particle entering into the tube from the semi-infinite waveguide with perfectly conducting walls and for the particle entering into the tube from the free space. The transition of the radiated fields to steady-state regime of wake field generation in infinite round resistive pipe is studied. The transition impedance and other radiation characteristics have been determined.

RPPG005 Effects of Magnet Fringe Fields on Beam Dynamics in Storage Rings

Yurik Martirosyan, Vassili Tsakanov (CANDLE), David Kalantaryan (Yerevan State University)

Growing interest is noticed recently in the study of fringe field effects on beam dynamics in various types of accelerators. The importance of this problem in case of storage rings of third generation light sources is due to strong demands on beam long lifetime, small emittance and stability. In this paper, we present a new method of calculation of fringing field effects on beam dynamics in storage rings based on direct integration and symplectic tracking methods. The numerical simulation is performed for CANDLE light source to correct the fringe field impact on betatron tunes, dynamic aperture and the chromaticity.

RPPG006 Measurement and Correction of Transverse Coupling in the Duke Storage Ring

Ying Wu, Jingyi Li, Vladimir Litvinenko, Stepan Mikhailov (Duke University)

The transverse coupling can play a significant role in reducing the performance of a storage ring FEL. A large transverse coupling has been observed in the Duke storage ring which has impacted the operation of the OK-4 FEL and related backscattering gamma-ray source. In this paper, we report beam based measurements of the transverse coupling and analyses of the skew quadrupole components in various quadrupoles. Using the measured skew quadrupoles in lattice design codes, simulations are performed and results compared with the experimental data. Employing skewed quadruples at the end of arcs, we design localized transverse coupling correction schemes for the Duke storage ring.

* Research Supported by the DoD MFEL Program as managed by the AFOSR, grant F49620-001-0370.

RPPG007 Probing the Non-Linear Dynamics of the ESRF Storage Ring with Experimental Frequency Maps

Yannis Papaphilippou, Laurent Farvacque, Annick Ropert (European Synchrotron Radiation Facility), Jacques Laskar (BDL, Paris)

A key issue for improving the performance of third generation light sources like the European Synchrotron Radiation Facility storage ring is the identification and correction of resonances that have a detrimental effect in the machine performance. Frequency analysis of experimental data, recorded on BPMs around the ring, is a powerful tool for studying the non-linear dynamics of an accelerator in operation. In a series of experiments performed in the ESRF storage ring, experimental frequency maps were produced using the one-thousand-turns measurement system. These maps revealed the resonance structure in the vicinity of the nominal working point which was limiting the dynamic aperture. Their comparison with maps produced by simulations was used as a guide for understanding the storage ring non-linear model. The possibility of using the quasi-periodic approximations of the experimental data for testing the efficiency of resonance correction schemes was finally investigated.

RPPG008 Non-Linear Longitudinal Beam Dynamics with Harmonic RF Systems for Bunch Lengthening

Vincent Serriere, Jorn Jacob (European Synchrotron Radiation Facility)

Harmonic cavities have been installed on various storage ring light sources to increase the Touschek lifetime by a factor 2 to 4 by lengthening the bunches. Several side effects have been observed, which limit the gain in lifetime. In the worst case, the beam stability can be altered, but harmonic cavities can also provide Landau damping of coherent bunch motion. A multibunch multiparticle tracking code has been developed to evaluate the performance of harmonic RF systems under consideration of all longitudinal beam dynamics issues. Bunches with high intensities are already elongated by the interaction with the ring impedance. The computations indicate that a harmonic RF system can provide significant additional lengthening. The application to the ESRF shows that an active superconducting harmonic system would constitute the only appropriate solution. Such a system would be useful in single bunch and sixteen bunch operation to improve the beam lifetime by a factor 2 and 3, respectively.

RPPG009 Synergia: A Hybrid, Parallel Beam Dynamics Code with 3D Space Charge

James Amundson (FNAL)

We describe Synergia, a hybrid code developed under the DOE SciDAC-supported Accelerator Simulation Program. The code combines and extends the existing accelerator modeling packages IMPACT and beamline/mxyzptlk. We discuss the design and implementation of Synergia, its performance on different architectures, and its potential applications.

RPPG010 Beam Dynamics in TESLA Superconducting Cavities

Philippe Piot (FNAL), Martin Dohlus, Susan Wipf (DESY)

The TESLA 9-cell superconducting cavities are being included in many designs of foreseen particle accelerators ranging from the TESLA linear collider to several light sources. Most of these designs require very low normalized transverse emittances, typically emit_x*emit_y~10E-12 m-rad. In this paper we investigate the effects of field asymmetries due to the radio-frequency input power and high order mode couplers on the beam dynamics. We present parametric studies of the beam properties for various incoming beam parameters (energy, bunch length, envelope, etc...).

RPPG011 Flat Beam Production in Low Energy Injectors

Shaoheng Wang (Indiana University), John Corlett, Steve Lidia, John Staples, Alexander Zholents (LBNL)

A source of ultra-fast synchrotron radiation pulses based on a recirculating superconducting linac is proposed at LBNL. A high-brightness photocathode rf gun will produce electron bunches in a solenoidal magnetic field, which then undergo a transformation into a large x/y emittance ratio beam in a skew-quadrupole-sequence transformer following the solenoid. PARMELA has been used in simulations of the beam dynamics, and a theoretical model has also been applied. The two independent solutions of the equations of motion in the Larmor frame before the skew-quadrupole transformer are connected with the final motions in the x/y planes of the "flat" bunch after the transformation. From the electron motion in the Larmor frame of a bunch before it enters the transformer, the x/y emittance ratio can be predicted from the particle distribution determined by

PARMELA calculations. The influence of space charge effects during the transformation is estimated with a 3D space charge calculation. Limitations to the emittance ratio resulting from space charge effects and other sources are discussed. A parameter-search for an optimized working point of the transformer, and it's sensitivity to errors, is reported.

RPPG012 Low Emittance Optics of PF Ring

Kentaro Harada (KEK)

Presently the emittance of Photon Factory Ring is about 36 nmrad where the horizontal phase advance of the FODO type normal cell is 105 degree. To operate the ring with lower emittance for users, we study about the beam dynamics in the low emittance mode where the emittance is about 30 nmrad and the horizontal phase advance of the normal cell 125 degree. We survey the parameter for injection and measure the oscillation of the injected beam.

RPPG013 Injection Performance with a Traveling Wave Kicker Magnet System at the Photon Factory Storage Ring

Yukinori Kobayashi, Toshiyuki Mitsuhashi, Akira Ueda (KEK)

At the Photon Factory storage ring, four traveling wave kicker magnets were installed to obtain a wide acceptance for the injected beam in the high brilliant optics. We investigated the injection performance with these kicker magnets. We measured the actual kick angle and pulse length of the kicker magnets through a measurement of coherent betatron oscillation after an individual kick using a phase-space monitor. We set bump parameter with obtained kick angle. As a result, we realized an injection speed more than 1.0 mA/s with a repetition of 12.5 Hz.

RPPG014 Beam Dynamics near Nonlinear Parametric Resonances

Tsukasa Miyajima, Yukinori Kobayashi (KEK)

We measured a coherent betatron oscillation near third and fourth order parametric resonance at the Photon Factory storage ring. The beam was trapped in a resonance island at a particular experimental condition. This condition was very sensitive to the initial betatron tunes, the initial betatron amplitude and strength of the nonlinear magnetic field. In order to study these phenomena numerically, the multi-particle tracking simulation was performed, including lattice nonlinearities and transverse wake fields. In the numerical simulation,the resonance island was not observed for an ideal lattice condition. However, the island was observed when the symmetry of the lattice was broken slightly. It seems that the strength of the resonance depends on the lattice symmetry. In this report, we will present the results of the experimental measurement and the numerical simulation.

RPPG015 Measurement of the Transverse Quadrupole-Mode Frequencies of an Electron Bunch in the KEK Photon Factory Storage Ring

Shogo Sakanaka, Toshiyuki Mitsuhashi, Takashi Obina (KEK)

In order to obtain an advanced knowledge on the collective beam behavior, we measured the transverse quadrupole-mode frequencies of an electron bunch in the KEK Photon Factory storage ring. The transverse quadrupole oscillations were excited by applying oscillating quadrupole magnetic field. The responses of the excited oscillations were then recorded by detecting visible synchrotron light with a photo-multiplier. As a result, we observed that the horizontal quadrupole frequency depended on the bunch current by about +0.08 kHz/mA, while the dipole frequency depended by about -0.03 kHz/mA. Detail experimental results and discussions will be presented.

RPPG016 Simulation Results of Corkscrew Motion in DARHT-II

K.C. Chan, Carl A. Ekdahl (LANL), Yu-Jiuan Chen (LLNL), Thomas P. Hughes (Mission Research Corporation)

DARHT-II, the second axis of the Dual-Axis Radiographic Hydrodynamics Test Facility, is being commissioned. DARHT-II is an induction linear accelerator producing 2-microsecond electron pulses at 20 MeV and 2 kA. These 2-microsecond pulses will be chopped into four short pulses to produce time resolved x-ray images. Radiographic application requires the DARHT-II beam to have excellent beam quality and it is important to study various beam effects that may cause degradation of the quality of a DARHT-II beam. One of the beam dynamic effects under study is corkscrew motion. For corkscrew motion, the beam centroid is deflected off axis due to misalignment of the solenoid magnets. The deflection depends on the beam energy , which is expected to vary by +/- 0.5 percent during the flat-top part of a beam pulse. Such chromatic aberration will result in broadening of beam spot size. In this paper, we will report simulation results of our study of corkscrew motion in DARHT-II. Sensitivities of beam spot size to various accelerator parameters and strategy for minimizing corkscrew motion will be described. Measured magnet misalignment is used in the simulation.

* Work Supported by US Department of Energy.

RPPG017 Numerical Studies of Laser-Plasma Produced Electron Beam Transport in Vacuum

Gwenael Fubiani, Eric Esarey, Wim Leemans, Ji Qiang, Robert Ryne (LBNL), Gerald Dugan (Cornell University)

Plasma-based accelerators operating in the self-modulated regime have demonstrated gradients in excess of 100 GV/m and the production of multi-nC bunches with a large energy spread. Typical codes for beam propagation in accelerators assume that the electron bunch has a small energy spread. In this case there is a single frame in which all beam particles are non-relativistic, which simplifies the calculation of the electromagnetic self field. Alternatively, particle-in-cell codes can handle beams with large energy spreads, but are computationally very demanding. Here, we describe a rapid and innovative method for the calculation of space charge effects, which is capable of handling beams with an arbitrary energy distribution. This method divides the longitudinal momentum distribution into narrow bins, and assumes that the spatial distribution in each bin is ellipsoidal. We have used this code to study the beams emerging from the laser-plasma accelerators in two regimes: (i) the self-modulated regime, in which the electron bunch has a large energy spread, and (ii) the colliding pulse injector, which produces bunches will small energy spread. Comparison with a modified electrostatic PIC code will be presented.

RPPG018 Coupling Correction and Beam Dynamics at Ultralow Vertical Emittance in the ALS

Christoph Steier, David Robin (LBNL), Greg Portmann, James Safranek (SLAC)

For synchrotron light sources and especially for damping rings for linear colliders it is important to be able to minimze the vertical emittance and to correct the spurious vertical dispersion. This allows to maximize the brightness and/or the luminosity. A commonly used tool to measure the skew error distribution is the analysis of orbit response matrizes using codes like LOCO. Using the new Matlab version of LOCO and 18 newly installed power supplies for individual skew quadrupoles at the ALS the emittance ratio could be reduced to about 0.1% at 1.9 GeV yielding a vertical emittance below 10 pm. At those very low emittances, additional effects like intra beam scattering become more important, potentially limiting the minimum emittance for machine like the damping rings of linear colliders. The presentation will detail the simulations carried out beforehand to optimize the used

algorithm for vertical emittance minimization as well as all experimental results.

* This work was supported by the U.S. Department of Energy, under Contract No. DE-AC03-76SF00098.

RPPG019 The One-Turn Map of Storage Ring with Planar Insertion Devices

Yongjun Li, Guangyao Feng, Lin Wang (National Synchrotron Radiation Lab)

The one-turn map provide a useful and powerful tool to understand the nonlinear dynamics in designing storage ring dedicated to synchrotron radiation, and damping ring used as the pre-injector of linear collider. In any case, the insertion device's (ID) influence on beam dynamics has to be considered carefully. In this paper, we first expand the Hamiltonian of charged particle's motion along ID axis to 4-order Taylor series, then construct a second order symplectic integrator using Lie map product for particle passing through one period of ID. The one-turn map can be obtained by concatenating the Lie map of the whole ID and the rest part of ring.

* Supported by Knowledge Innovation Project of Chinese Academy of Science (CAS).

RPPG020 The Effect of Klystron Power Supply Noise on the Beam Oscillation in PLS

Jaeseok Yang, Myung-hwan Chun, Young-jin Han, Eun-San Kim, Sang-Hun Nam, In-ha Yu (Pohang Accelerator Laboratory)

The RF noise that is driven by klystron power supply has been observed in PLS storage ring. The spectrum of the noise was measured and analyzed. The noise was also amplified by AM modulation in the master oscillator in order to see the effects on the stored beam more clearly. The effect of the noise on the U7 beamline is also investigated.

RPPG021 Single Particle Dynamics Issues in Storage Rings with Limiting Vertical Aperture

Terebilo Andrei (SLAC)

We investigate the effects of small gap insertion devices limiting the vertical aperture in ring based light sources. The non-linear coupling resonances in the presence of a vertical aperture may lead to a reduction of effective horizontal aperture. Analytical models and simulation results are considered for SPEAR3 storage ring with 5mm gap insertion devices.

* Work supported in part by DOE Contract DE-AC03-76SF00515 and Office of Basic Energy Sciences, Division of Chemical Sciences.

RPPG022 Comparison of PARMELA Simulations with Longitudinal Emittance Measurements at the SLAC Gun Test Facility

Cecile Limborg, Paul.R. Bolton, Jym.E Clendenin, Dave. H. Dowell, Steve M. Gierman, Brendan F. Murphy, John F. Schmerge (SLAC)

High brightness photo-injectors are extensively studied at many facilities as a key component of single-pass FEL radiation sources. Excellent beam quality such as 1 mm.mrad normalized projected emittance at 1 nC for a 10ps electron bunch is a goal for many of these injectors. Theory and measurements techniques have been developed to measure the transverse properties of the beam. However, beam brightness also depends on the longitudinal parameters. At the Gun Test Facility, we have measured the longitudinal emittance by performing a booster phase scan. With those measurements, we can reconstitute the bunch length, correlated energy spread and uncorrelated energy spread. In this paper, we present a comparison of the measurements with PARMELA simulations. The fitting algorithm used in the measurement is also discussed.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

RPPG023 Recent Electron Cloud Simulation Results for the NLC and for the TESLA Linear Colliders

Mauro Pivi, Tor Raubenheimer (SLAC), Miguel A. Furman (LBNL)

In the beam pipe of the Main Damping Ring of the Next Linear Collider (NLC), ionization of residual gasses and secondary emission give rise to an electron cloud which stabilizes to equilibrium after few batch passes. In this paper we present preliminary computer simulation results for the main features of the electron cloud at the NLC and recent simulation results for the TESLA Linear Collider. Possible remedies to mitigate the effect are also discussed, with particular attention to TiN surface coating. A refined secondary electron (SE) emission model has been included in the simulation code. We studied the sensitivity of the electron cloud formation to some key parameters assumed in the secondary emission model.

* Work supported by the US-LHC collaboration and by the US DOE under contract DE-AC03-76SF00098.

RPPG024 Mitigation of the Electron-Cloud Effect by Tailoring the Bunch Profile

Mauro Pivi (SLAC), Miguel Furman (LBNL)

For storage rings with intense and very long bunches, the electron cloud develops primarily by the mechanism of trailing-edge multipacting. We show, by means of simulations for the PSR, how the resonant nature of this mechanism may be effectively broken by tailoring the longitudinal bunch profile at fixed bunch charge, resulting in a significant decrease in the electron-cloud effect. We briefly discuss the experimental difficulties expected in the implementation of this cure.

* This work was supported by the Director, Office of Science, Office of Fusion Energy Sciences, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

RPPG025 Derivation of FEL Instability Using Wakefield

Gennady Stupakov, Samuel Krinsky (SLAC)

From the point of view of classical theory, stimulated radiation in the free electron laser occurs due to an instability of the beam propagating in an undulator. In the traditional FEL theory, the evolution of the radiation field is determined from direct solution of the Maxwell—Vlasov system of equations. In accelerator physics, similar instabilities are often analyzed using the wakefield in the Vlasov equation. In this paper, we discuss the FEL instability using the wake approach. First, we obtain an expression for the longitudinal wake in a helical undulator. Then, we show that taking into account the retardation effect in the Vlasov equation with the proper wake leads to the correct result for the FEL instability.

* This work was supported by Department of Energy contract DE-AC03-76SF00515.

RPPG026 Coherent Synchrotron Radiation Effects in the Electron Cooler for RHIC

Juhao Wu (SLAC), Dong Wang (BNL)

The Coherent Synchrotron Radiation (CSR) plays an important role in many modern accelerator projects. In the proposed electron-cooling project for the Relativistic Heavy Ion Collider (RHIC), the electron cooler is designed to cool 100 GeV/nucleon bunched ion-beam using 55 MeV electrons. The electron bunch length will be on the order of cm, and the charge per bunch would be around 10 nC. Calculation for this set of parameters indicates that CSR effect could be large. Some compensation scheme is implemented to minimize the CSR induced degradation.

* Work supported by the US DOE under contract DE-AC03-76SF00515.

RPPG027 Impact of the Wiggler Coherent Synchrotron Radiation Impedance on the Beam Instability

Juhao Wu, Tor Raubenheimer, Gennady Stupakov (SLAC)

Coherent Synchrotron Radiation (CSR) plays an important role not only in increasing the energy spread and emittance of a beam, but can also lead to a potential instability [G. Stupakov, S. Heifets, Phys. Rev. ST Accel. Beams 5, 054402 (2002)]. Previous studies of the CSR induced longitudinal instability were carried out for the radiation impedance due to dipole magnets. In this paper, the instability due to the coherent synchrotron radiation impedance [J.H. Wu, T.O. Raubenheimer, G.V. Stupakov, these proceedings] from a wiggler is studied assuming a large wiggler parameter K. The primary consideration is the low frequency microwave-like instability, which arises near the pipe cut-off frequency although the growth rate at the wiggler fundamental is also considered using Free-Electron Laser theory. Detailed results are presented on the growth rate and threshold for the damping rings of several linear collider projects. A new NLC damping ring has been proposed which will avoid the CSR, as well as the vacuum chamber, driven microwave instabilities.

* Work supported by the US DOE under contract DE-AC03-76SF00515.

RPPG028 Electron Beam Motion Observed in Infrared Synchrotron Radiation at SRRC

Dung-Shing Hung, Chen Ching-Jue, K.T. Hsu (Synchrotron Radiation Research Center)

Noise existing between 1000 to 4000 cm-1 in FTIR spectrum is degrading the signal to noise ratio in IR beam line at SRRC. This is mainly because the interferometer detection is very sensitive to the electron beam motion. Through the RF modulation, the noise spectrum of the infrared interferometry was observed to change as the electron beam motion was modulated. Some of the noise sources were identified in terms of the electron beam motion. The analysis indicated that their contribution decided the performance of the IR synchrotron radiation.

RPPG029 Experimental Measurements of 2-Dimensional Nonlinear Resonances

Tzong-Shyan Ueng, Jenny Chen, Kuo-Tung Hsu, Kuo-Hwa Hu (Synchrotron Radiation Research Center)

The measurements on both horizontal and vertical coherent betatron oscillations at nonlinear resonances have been performed with turn-by-turn method. Beside the systematic errors, the magnet misalignments and other imperfections could drive nonlinear resonances. Experiments were conducted in the region close to the working tunes of the Taiwan Light Source electron storage ring to study its effects. The typical measurement results are reported. The phenomena of these 2-dimensional resonances are investigated.

RPPG030 First Experimental Test of Emittance Measurement Using the Quadrupole-Mode Transfer Function

Min-Huey Wang (Synchrotron Radiation Research Center), S.Y. Lee, Y. Sato (Indiana University)

We carried out the first experimental test of the emittance (thermal energy) measurement using the quadrupole-mode transfer function. We show that this method can be applied to measure the intrinsic thermal energy dynamical systems nondestructively. Since the QTF does not depend on the beam distribution, this method can measure the rms emittance of different dynamical systems.

RPPG031 Canonical Formulations and Cancellation Effect in Electrodynamics of Relativistic Beams on a Curved Trajectory

Rui Li, Yaroslav Derbenev (Thomas Jefferson National Accelerator Facility)

The cancellation effect has been an important and long standing controversial issue in the study of coherent synchrotron radiation (CSR) induced electron bunch dynamics in bends. In this paper, equations of motion are derived from the canonical formulation of the dynamics for an ultrarelativistic electron bunch (with arbitrary charge distribution) under collective interaction on a curved trajectory. Using retarded potentials, we show that the cancellation occurs in the first order of optics between the local interaction contribution to the horizontal collective radiative force, which often gives the logarithmic dependence of the horizontal radiative force on the bunch transverse size, and the local interaction contribution to the kinetic energy via potential energy change, which influences the particle's horizontal dynamics through dispersion. It is shown that instead of the usual centrifugal force due to the inertia of a particle's kinetic energy, the particle experiences the general centrifugal force related to its canonical energy. Discussion of gauge invariance also show that the Lorentz gauge is a natural choice to depict the cancellation effect. After cancellation, apart from the dispersion effect due to the inital canonical (kinetic + potential) energy deviation from the design energy, the local interaction influences the particle dynamics only via the second or higher order terms. Various applications of the cancellation theory and simulation results can be found in R. Li, "Application of the Cancellation Effect in the CSR Studies," these Proceedings.

* Work supported by the Department of Energy under contract DE-AC05-84ER40150.

RPPG032 Beam Characterization in the CEBAF-ER Experiment

Chris Tennant, Yu-Chiu Chao, David Douglas, Michael Tiefenback (Thomas Jefferson National Accelerator Facility)

Energy recovering an 845 MeV beam through CEBAF presents many operational challenges (Ref. A. Bogacz talk). As a result, it is important to have a quantitative understanding of the beam behavior throughout the machine. The emittance provides a figure of merit in this context inasmuch as it characterizes the extent to which beam quality is preserved during energy recovery. A solution to the problem of obtaining a high-resolution emittance and energy spread measurement in the CEBAF-ER experiment (CEBAF with Energy Recovery) is presented. The method makes use of a single scanning quadrupole and two downstream harps. To study halo effects in the experiment, a tomographic scheme has been devised, scanning the phase advance as a means of exploring the phase space for halo particles (that is, those nominally at large angular displacement at the beam profile monitors). Finally, a beam current monitor (BCM) will be used to perform a null measurement quantifying the extent to which the relative phase between the accelerated an energy recovered beams is properly set.

* This work was supported by the U.S. Department of Energy under Constract No DE-AC05-84ER40150.

RPPG033 A Beam Breakup Instability in a Recirculating Linac Caused by a Quadrupole Mode

Byung Yunn (Thomas Jefferson National Accelerator Facility)

Following the successful demonstration of energy recovery in a recirculating linac with superconducting cavities at the Jefferson Lab FEL, several ambitious electron accelerator projects have recently been proposed or are in study for either a light source or a collider based on this novel technology. These projects all intend to utilize a

high quality linac electron beam generated with an average beam current typically in the range of 100's of mA. As is well known, a recirculating linac suffers from a beam breakup instability of a regenerative type caused by a Higher Order Mode (HOM) in an accelerating cavity, which can have a very high Q (quality factor) when superconducting. The instability can degrade the beam quality significantly. We investigate one such beam breakup instability in a recirculating linac that could arise as a result of high Q quadrupole modes excited in the cavity. In a simple model we derive a relation which allows one to deduce the upper limit on tolerable Q values for such modes. The results should provide a useful guide in setting the HOM damping requirement among others.

* Work supported by the U. S. Department of Energy under contract DE-AC05-84-ER40150, the Office of Naval Research, the Commonwealth of Virginia, and the Laser Processing Consortium.

RPPG034 The Short-Range Transverse Wakefields in TESLA Accelerating Structure

Igor Zagorodnov, Thomas Weiland (Technische U. Darmstadt)

The operation of a Free Electron Laser in TESLA project requires very short bunches. It results in a very long interaction region between the bunch and the wakefields. From this fact severe problems for computer simulations arise. The longitudinal case was recently studied intensively by Novokhatski et al. In this paper we study the transverse forces. Using a recently developed time domain numerical approach, we calculate the short-range transverse wakefields of the TESLA linac accelerating structure. Wake fields in a TESLA accelerating cryomodule and corresponding integral parameters are given for bunches of different length. We also consider behavior of transverse wake potential in a periodic array of cavities and compare it with wake potential of the TESLA quasiperiodic structure. The numerical results are compared with anlytical estimations.

RPPG035 Calculations of Collimator Wakefields

Igor Zagorodnov, Thomas Weiland (Technische U. Darmstadt), Karl Bane (SLAC)

Collimators are used to eliminate halo particles from the beam. To relax the wakefield effects a gradual transition from a large to a small aperture is used. However the existing computer codes experience severe problems for long tapered transitions. Two main sources of the problems are the grid dispersion and the staircase geometry approximation. Using recently developed time domain numerical approach, which is able to model curved boundaries and does not suffer from dispersion in longitudinal direction, we calculate the short-range geometric wakefields of the TESLA and NLC collimators. Wake fields and corresponding integral parameters are given for bunches of different length. The numerical results are compared with mearusements and analytical estimations. The range of applicability of analytical formulas is studied.

RPPG036 Focusing Horn System for the BNL Very Long Baseline Neutrino Oscillation Experiment

Stephen Kahn (BNL)

This paper describes the focusing horn system for the proposed very long baseline neutrino oscillation experiment using a neutrino beam from BNL to an underground facility such as the Homestake Mine in South Dakota. The proposed experiment uses a 1 MW upgraded AGS. In order to achieve this performance the AGS will operate with a cycle time of 2.5 Hz and 1X10^14 protons on target at 28 GeV. This paper discusses the design criteria of a horn system necessary to handle this intense beam and the optical geometry to achieve the desired flux distribution at the detector.

* This research was supported by the U.S. Department of Energy under Contract No. DE-AC02-98CH10886.

RPPG037 Dynamics of Ultra-Relativistic Positron-Beam Propagation in Meter-Scale Plasmas

Chris Clayton, B.E. Blue, C. Huang, C. Joshi, K.A. Marsh, W.B. Mori, S. Wang (University of California, Los Angeles), F.-J. Decker, M.J. Hogan, R. Iverson, C.L. O'Connell, P. Raimondi, R.H. Siemann, D. Walz (SLAC), T.C. Katsouleas, S. Lee, P. Muggli (University of Southern California)

We report on the first study of the dynamic transverse forces imparted to an ultra-relativistic positron beam by a long plasma in the underdense regime ($n_e << n_{beam}$). Dynamic focusing of the 28.5 GeV positron beam is observed from time-resolved beam profiles after the 1.4 m plasma. The strength of the imparted force varies along the 0.7 mm (RMS) length of a given bunch as well as with plasma density. The back portion of the bunch appears to focus to it's minimum size at a density of only ~1/7 needed to focus a comparable electron bunch. Also, the data suggests substantial transverse aberrations in the focusing force. Computer simulations substantiate the longitudinal and transverse aberrations seen in the data. The relative transport phenomena can be understood in terms of the fundamental differences between the plasma response in the 'flow-in' and 'blow-out' regimes for positron beams and electron beams, respectively.

* This work is supported by U.S. DoE Grant numbers DE-FG03-92ER40745, DE-AC03-76SF00515, DE-FG03-98DP00211 and DEFG03-92ER40727 and by NSF Grant numbers ECS-9632735, DMS-9722121 and PHY-00787157.

RPPG038 Electron Bunch Shaping and Compression Scheme for the UCLA Neptune Laboratory

Robert England, James Rosenzweig (University of California, Los Angeles)

We have recently annexed to the Neptune linear accelerator a new section of beamline which will serve as a venue for future beam-plasma interaction experiments using bunches produced by the UCLA PWT linac and newly installed 1.6-cell magnesium cathode photoinjector. The newly added section of beamline is a horizontally dispersionless translating section designed to give the bunch a ramped longitudinal profile using negative longitudinal dispersion compression. Measurements of the horizontal dispersion-killing are provided and compared with simulation results. A planned scheme for observing the longitudinal beam profile using a transverse deflecting cavity is also discussed and simulation results presented.

* This work was supported by the U.S. Department of Energy under grant DE-FG03-92ER40693.

RPPG039 Detection of a Wake Field Using the Test-Bunch Method at Photon Factory Advanced Ring

Takahiro Fujita (Hiroshima University), Toshio Kasuga, Yasuyuki Minagawa, Takashi Obina (KEK)

PF-AR (Photon Factory Advanced Ring) is dedicated to a Pulsed X-Ray source. Electrons at the energy of 2.5GeV had been injected into the ring. Sudden decrease of the injection rate was observed at the beam current of 35mA. Although the injection rate recovered a little bit above the current, a low injection rate lasted out up to about 40mA that was the maximum current at that injection energy. After the autumn of 2002, the injection at the beam energy of 3GeV has become possible. Although significant degrease of the injection rate is not observed, the sufficient injection rate has not been achieved without excitation of the octapole magnets and a feedback damper for the transverse direction. Moreover anomalous oscillation pattern has appeared in the horizontal direction. These phenomena suggest that wake fields excited in the horizontal direction influence the injection rate. In order to get information on the wake field, we tried a "Test Bunch Method": a main bunch with a large current and a test bunch with a small current is stored and the wake field excited by the main

bunch is estimated measuring the motion of the test bunch. From obtained information on the wake field, we discuss the motion of the injected beam and the stored beam during the injection.

RPPG040 Bunch Transverse Emittance Increases in Electron Storage Rings

Jie Gao (LAL, Orsay, France)

In this paper a theoretical framework to estimate the bunch transverse emittance grow up in electron storage rings due to short range transverse wakefield of the machine is established. The new equilibrium emittance equations are derived and applied to explain the experimentally obtained results in ATF damping ring.

RPPG041 Analytical Estimation of Dynamic Aperture Limited by Wigglers in a Storage Ring

Jie Gao (Laboratoire de L'Accelerateur Lineaire [LAL])

In this paper we will apply the general dynamic aperture formulae for multipoles in a storage ring [developed in J. Gao, NIM A451 (2000), p. 545] to estimate analytically the dynamic aperture limited by the wigglers in a storage ring. The analytical dynamic aperture formulae for wigglers are very useful in the design of damping rings and synchrotron radiation facilities.

RPPG042 Lattice Design of Saga Synchrotron Light Source

Yositaka Iwasaki, Takio Tomimasu (Saga Synchrotron Light Source), Hideaki Ohgaki (Institute of Advanced Energy, Kyoto University)

The Saga Synchrotron Light Source is a compact third generation synchrotron light source with a 1.4 GeV electron storage ring, and being constructed in Tosu City, Saga prefecture Japan. A distributed dispersion system, the dispersion function is non-zero in insertion device, is adopted for the lattice design to make the ring to be compact. At the typical working point (5.796,1.825) the emittance without insertions is 25nm-rad (minimum 15nm-rad) and the beam size at center of long straight section is about 0.58 mm in horizontal and 0.13mm in vertical (10% coupling is assumed). One of merits of distributed dispersion system is reduction of sextupole strength required for chromaticity correction. Consequently, large dynamic aperture can be obtained. We have performed beam dynamics studies by using TRACY2 to estimate permissible magnetic errors and magnetic misalignments. Since a superconducting wiggler will be installed in one straight section for near future, we also calculate the effect of a 7.5 T wiggler field. We found that the dynamic aperture is still large. The emittance grows up to 47nm-rad and it is small enough for user requirements in this facility. In this conference we will discuss on the lattice design of SAGA SL storage ring and several beam dynamics studies.

RPPG043 Linear and Nonlinear Optics Studies in the ANKA Storage Ring

Anke-Susanne Mueller, Erhard Huttel, Francisco Perez, Montserrat Pont (Forschungszentrum Karlsruhe)

The ANKA electron storage ring operates in the energy range from 0.5 to 2.5 GeV. At the maximum energy, the dipole magnets show strong multipolar components due to saturation effects that cannot be neglected. In order to improve machine performance a precise modelling of linear and nonlinear optics is mandatory. Therefore a new optical model had to be devised. In this framework extensive optics studies have been done, including a study of the Beta function beating and a measurement of higher order chromaticity. This paper reports the measurement results and presents the new machine model.

RPPG044 Beam Size and Bunch Length Measurements at the ANKA Storage Ring

Francisco Perez, Erhard Huttel, Anke-Susanne Mueller, Montse Pont (Forschungszentrum Karlsruhe)

ANKA is an electron storage ring working at a nominal energy of 2.5 GeV. The beam is injected at 500 MeV and the final energy is achieved by ramping the storage ring. The beam size and bunch length have been measured in the range from 500 MeV to 2.5 GeV. The effect of the Intrabeam Scattering and the Microwave Instabilities at injection and during ramping are partially masked by a longitudinal HOM instability that could not be suppressed. At 2.5 GeV the lifetime could be significantly increased by exciting a longitudinal HOM and increasing the coupling by approaching the tune to a difference resonance, which in turn increase the bunch length and the vertical size [Studies of beam lifetime at ANKA, these proceedings]. The beam size measurements were performed with two synchrotron light monitors, one in a dispersion point and the other in a zero dispersion one. The bunch length was measured using the beam spectrum with an Annular Electrode and a spectrum analyser up to 8 GHz.

RPPG045 Tune Shift Calculations for Dielectric Vacuum Chamber

Amalendu Sharma, Gajendra Kumar Sahoo, Gurnam Singh (Centre for Advanced Technology, Indore, India)

Intensity limitation of a synchrotron is obtained by 'Laslett tune shift'. The Laslett tune shift is calculated by considering direct space charge effects and the images of the beam, produced by vacuum-chamber and magnetic environment.Laslett tune shift has been calculated for various geometries, for off-axis beam, for a chamber wall with a finite conductivity etc. In a rapid cycling synchrotron, the vacuum chamber is made of ceramic (dielectric) with a thin metallic coating inside. All the above work of tune shift calculations does not account for the presence of dielectric. In this paper, we have carried out the calculation for the tune shift due to insulated dielectric chamber with metallic coating inside. First of all, the effect on electric image of the beam due to dielectric presence is formulated for a single plane geometry under some assumptions. The same procedure later is adopted for calculating incoherent and coherent tune shifts for parallel plane geometry. We show that there is change in electric-image coefficient in tune shift due to the presence of the dielectric. We have carried out the calculations using the formula derived in this paper by considering the dielectric for a range of dielectric thicknesses and constants of practical interest for 100 MeV - 1 GeV proton synchrotron.

RPPG046 Single-Bunch Injection System For The LNLS Booster Injector

P.F. Tavares, H.J. Honisto, S.R. Marques (Laboratório Nacional de Luz Sincrotron, Brazil)

A system was developed to perform single-bunch purification in the LNLS booster synchrotron to satisfy the requests for single-bunch runs either for time-resolved experiments or machine studies. This system eliminates all except one electron bunch trough excitation of a horizontal betatron resonance. The purification process is performed by switching off the excitation RF signal for 2.10 ns ($1 / f_{RF}$). This fast switching is obtained with a double balanced mixer. The switched excitation signal is amplified and applied to a stripline kicker. A PECL timing card supplies the gating signal, synchronized to the f_{RF}, that (negatively) modulates the excitation carrier. The instrument uses a local processor card and a FPGA interfacing board that integrates provides seamless integration to the storage ring control system, which controls the parameters of the process, namely: the carrier power and the fine gating time. The purifying performance and operational results will be presented.

RPPG047 Dynamic Simulations of Two-Beam Acceleration in RFQ with Opposite Charge State

Qingzi Xing, Yuzheng Lin (Tsinghua University, Beijing), Shinian Fu (Institute of High Energy Physics, Beijing)

In this article, result of dynamic simulations is given for the two-beam acceleration in RFQ with opposite charge state, based on the modified code PARMTEQ. The modification of the code is described. The two-beam space charge effect and multi-bunch effect are considered in the code. Comparisons between 2D and 3D space charge calculation are presented. Results from the z-code and t-code PARMTEQ are also provided. The space charge effect in two-beam acceleration is discussed.

RPPG048 A Linear Electrostatic Trap for Neutral Polar Molecules Proposed for Measurement of Electron or Nuclear EDM

Ivan Koop (BINP)

A principal scheme for 3d trapping of cold neutral polar molecules in an electrostatic guiding field is proposed. Molecules with a large permanent electric dipole moment (EDM), such as YbF, CsF, TlF and few others, provide a huge internal electric field, which can be explored for high sensitivity experimental searches of the electron or nuclear EDM. As shown here, in the linear electrostatic trap the motional magnetic field effect completely cancels. This opens extremely good possibilities for the EDM searches.

Friday, May 16, 2003

Session FOAA: Applications of Accelerators
Pavilion East at 8:30
Session Chairs: B. Hamm, G. McMichael

FOAA001 Accelerator-Based Treatment at the Massachusetts General Hospital

Jay Flanz (Massachusetts General Hospital)

The Northeast Proton Therapy Facility at Massachusetts General Hospital has been treating patients with proton beams since November 2001. Over 200 patients were treated in the first year of operation. This facility has replaced the program at the Harvard Cyclotron Facility where proton treatments had been underway for over three decades. Features such as rotating Gantries and deeper proton penetration allow a wider range of clinical applications at this new facility. The requirements of accelerator reproducibility and availability are perhaps at a higher level than those required at an accelerator based physics facility. These requirements and the system performance will be highlighted in this paper. Operation of a proton cyclotron produced by industry (Ion Beam Applications) and the four operating beam lines along with the gantries and patient-positioning systems will be discussed. Of particular interest in addition to the required availabilty is the systematic approach to safety and accuracy in the design and implementation. One question that could be raised is whether stronger collaboration with physics facilities could be mutually beneficial in extending the public awareness of the applications of accelerators for benefit to society.

FOAA002 HICAT- The German Hospital-Based Light Ion Cancer Therapy Project

Hartmut Eickhoff (Gesellschaft für Schwerionenforschung mbH)

At the university clinics at Heidelberg, Germany, the realization of a cancer therapy facility using light and medium ions (from protons up to oxygen) is in progress. This facility will be capable to treat about 1000 patients per year by means of the "intensity controlled raster scan technique" that has been already successfully applied to more than 150 patients since 1998 at the GSI therapy pilot project. The presentation will give an overview of the facility layout and especially the accelerator and beam transport systems. The facility is capable of providing 3 treatment places with light ions between 50 and 430 MeV/u. Two treatment places are located at the end of horizontal beam lines and one after an isocentric gantry. A further horizontal beam line for research and development activities is foreseen. Besides the technical description and the status and schedule for the project, organizational aspects of this project will be discussed; the project leadership is at the university clinics, and strong technical assistance comes from GSI and industrial partners.

FOAA003 Status of the Midwest Proton Radiotherapy Institute

Dennis Friesel, Vladimir Anferov, John Collins, William Jones, Joseph Katuin, Susan Klein, Nick Schreuder (Indiana University)

Phase I construction of the Indiana University Midwest Proton Radiotherapy Institute (MPRI) has been completed and commissioning of the Proton Therapy Beam Delivery and fixed horizontal large field beam line is nearing completion. Patient Treatment is scheduled to begin in late May 2003. This contribution will discuss the unique features and status of the MPRI facility and will present Phase I beam delivery and treatment system commissioning results. In addition, two 360 degree rotating gantry systems from IBA have been selected for Phase II construction of MPRI. Delivery of the first Gantry is scheduled for June of 2003. Design and installation plans for the Gantry systems will also be presented.

* Funding for the work reported here is provided by the State of Indiana, the National Institute of Health under Grant No.1 C06 RR17407-01, and Clarion Health Services, Indianapolis, Indiana.

FOAA004 Design and Operation of a Proton Microscope for Radiography at 800 MeV

Charles Mottershead (LANL)

A high-magnification, high-resolution option is desirable for the study of small scale dynamic experiments at the LANSCE 800-MeV Proton Radiography Facility. Magnification is achievable by either repowering the existing imaging-lens quadrupoles, using new high-gradient quadrupoles, or some hybrid combination of the two. The parameter space of magnetic optics solutions was studied extensively with the 3rd order code MARYLIE. Some of the hybrid solutions achieve magnifications up to 150, but at the price of high chromatic aberrations. In the end, a design using only new high- gradient permanent-magnet quadrupoles was selected and built with the parameters that minimized chromatic aberration per unit magnification. The design has a moderate magnification of 7.1 and 15.8 at the two existing mage stations. First beam commissioning results exceeded expectations. Image contrast is produced by multiple coulomb scattering in the thin objects. Early experimental objectives are to optimize this contrast by collimator design and by adjusting the correlation in the illuminating beam, as well as to characterize the (quite high) resolution limits of the system.

FOAA005 Antimatter Driven Sail for Deep Space Missions

Gerald Jackson, Steven Howe (Hbar Technologies, LLC)

The ultimate goal of this project is to identify and investigate an exploration architecture that would allow a light-weight instrument package to be sent to another stellar system. Due to the difficulty inherent in an interstellar mission, we have examined an architecture for a less demanding mission; sending a probe to the Kuiper Belt in a transit time of 10 years. Missions to deep space will require specific impulses greater than 20,000 seconds in order to accomplish the mission within the career lifetime of an individual. Only two technologies available to mankind offer such performance; fusion and antimatter. Fusion has proven unattainable despite forty years of research and billions of dollars. Antimatter, alternatively, reacts 100% of the time in a well described manner. However, development of a suitable propulsion system based on antimatter has not been shown until now. Our system analysis indicates that that a 10 kg instrument payload could be sent to 250 AU in 10 years using 30 milligrams of antihydrogen. In addition, preliminary calculations also show that 17 grams of antihydrogen could send a similar probe to the next star, Alpha Centauri, in 40 years. We have designed a very straightforward system that will produce a variable specific-impulse with a maximum of near one million seconds. The concept is one that can be throttled, that can be steered, and that can be demonstrated within the next two years. In this paper we identify the components of the system architecture that will be needed to perform a mission to the Kuiper Belt. We also describe a series of three experiments that will validate the concept and can be completed in a low energy antiproton facility.

FOAA006 Facilities for Industrial Customers at the Daresbury Synchrotron Radiation Source (SRS)

Elizabeth Towns-Andrews (Daresbury Laboratory)

The SRS provides state-of-the-art analytical techniques from infrared to hard X-ray wavelengths. The characteristics of synchrotron radiation are ideal for analytical problems that require high spatial or temporal resolution or problems that are simply intractable using conventional instruments. An increasing number of large scale facilities exist worldwide, but are traditionally used by universities and higher

education institutions for pure R&D. In recognition of the needs of commercial customers, Daresbury Laboratory has established DARTS (Daresbury Analytical Research and Technology Service). DARTS offers unique services tailored to the needs of the customer, allowing access to synchrotron analytical facilities and also the significant expertise and knowledge of staff on site. The analytical portfolio offered by DARTS encompasses imaging, spectroscopic and structural characterisation techniques. The nature of problems and issues solved by DARTS is varied and includes: investigations of product failure and non-conformance, manufacturing issues, basic R&D and information used in expert witness cases. This presentation will outline the concept of DARTS and the approach taken at the SRS towards industrial customers. It will provide practical examples and case histories of how the DARTS service has helped to improve industrial processes in a range of business sectors.

FOAA007 Industrial Applications of High-Power FELs

Michelle Shinn (Thomas Jefferson National Accelerator Facility)

Material processing with lasers grew rapidly during the previous decade, and annual sales are now in excess of $1B (US). In general, the processing consists of material removal steps such as drilling, cutting, marking, and joining. Lasers that are either cw or pulsed with pulsewidths in the ns time regime have, overall, done well for these applications. Other applications, such as the surface processing of polymers to improve look and feel, or treating metals to improve corrosion resistance, require the economical production of laser powers of the tens of kilowatts, and therefore are not yet commercial processes. The development of FELs based on superconducting RF (SRF) linac technology provides a scaleable path to laser outputs above 50 kW, rendering these applications economically viable, since the cost/photon drops as the output power increases. This approach also enables high average power ~ 1 kW output in the UV spectrum. Such FELs will provide quasi-cw (PRFs in the tens of MHz), of ultrafast (pulsewidth ~ 1 ps) output with very high beam quality. This paper will provide an overview of applications tests by our facility's users that involved pulsed laser deposition, laser ablation, and laser surface modification, as well as present plans that will be tested with our upgraded FELs. These upgrades will extend operation beyond 10 kW average power in the IR and kilowatt levels of power at wavelengths from 0.3 to 14 microns.

* This work supported by the Office of Naval Research, the Joint Technology Office, the Commonwealth of Virginia, the Air Force Research Laboratory, and by DOE Contract DE-AC05-84ER40150.

FOAA008 Performance Upgrades to the High Intensity Gamma-ray Source at Duke University

Vladimir Litvinenko, for HIgS collaboration (Duke University)

We present selected experimental results obtained with the present HIgS facility. The focus of the paper is the ongoing upgrades of the HIgS facility to its final specifications: a) an OK-5 FEL system with three dedicated collision points for g-ray production; b) 1.2 GeV full energy booster injector; c) a single mode RF cavity for the storage ring; d) modifications of the injection system. We present the expected performance of the source after these upgrades.

* Work is supported by DoE and AFOSR grants, and the Dean of Natural Sciences and the Department of Physics, Duke University.

FOAA009 Gamma-Ray Computerized Tomography Using 10 MeV Laser-Compton Photon Beam

Hiroyuki Toyokawa, Lia Merminga (Thomas Jefferson National Accelerator Facility), Hideaki Ohgaki (Institute of Advanced Energy Kyoto University), Hiroshi Ogawa, Kawakatsu Yamada (National Institute of Advanced Industrial Science and Technology)

X-ray Computerized Tomography (CT) using a few hundreds of keV to a few MeV X-ray sources is usually used for nondestructive inspection of bulk materials or heavy industrial products. Because high-energy gamma-rays are more penetrative than the conventional X-rays, it is advantageous to use high-energy gamma-rays for the inspection of heavy industrial products, such as metal die-casts. We have developed a gamma-ray CT system for nondestructive inspection of heavy industrial products using laser-Compton photon beam, which was generated with an 800 MeV electron storage ring, TERAS, of AIST-Tsukuba and with conventional Nd:YVO4 CW laser. A description of the system layout and experimental results of cross-sectional imaging of industrial products are presented.

* This study was financially supported by the Budget for Nuclear Research of the Ministry of Education, Culture, Sports, Science and Technology of Japan, based on screening and counseling by the Atomic Energy Commission of Japan.

Session FOAB: Advanced Concepts
Pavilion West at 8:30
Session Chairs: A. Ogata, M. Fazio

FOAB001 Recent Laser Ion Acceleration Results

Patrick Audebert (Ecole Polytechnique), Matt Allen, Tom Cowan, Julien Fuchs, H. Ruhl (General Atomics), A Blazevics, Marcus Roth (Gesellschaft für Schwerionenforschung mbH), Jean Claude Gauthier (LULI)

The acceleration of ions from thin foils irradiated with high intensity short pulse lasers opens new avenues for research in laser plasma physics as well as for ion beam applications. Laser accelerated ions can be many times shorter in pulse duration, higher in ion current, and lower in emittance than for conventional radio-frequency accelerators. With proper shaping of the laser beam and target, focusing of the ion beam to extremely high current and power densities may be possible, which could provide important new opportunities in High Energy Density Physics and Fusion Science. Experiments were performed with the 100 TW laser at the Laboratoire pour l'Utilisation des Lasers Intenses. We will present the ions beam characteristic obtained with Pulses of 25 J, 350 fs (FWHM), 1.058 mm light, leading to an intensity of ~$2x10^{19}$ W/cm^2, at normal incidence onto thin foils (10-100 μ) of Au. This ion beam has been used to do time resolve radiography of plasma laser interaction. The experiments and results will be presented and discussed.

FOAB002 Review of Progress in Channeling of Lasers Through Plasmas

Michael Downer (University of Texas, Austin)

Plasma waveguides capable of guiding relativistically intense fs laser pulses without optical distortion are essential to developing GeV-scale Laser Wakefield (LWF) Accelerators, coherent short-wavelength sources and lenses for fourth-generation x-ray sources. Various approaches to guiding terawatt pulses through preformed plasma fibers inside gas-filled solid capillaries [Ehrlich et al., Phys. Rev. Lett. 77, 4186 (1996); Hosokai et al., Opt. Lett. 25, 10 (2000); Spence et al., Phys. Rev. E 63, 015401 (2001)],and in laser-generated cylindrical shock waves [C.G. Durfee III and H.M. Milchberg, Phys. Rev. Lett. 71, 2409 (1993); J. Fan et al., Appl. Phys. Lett. 73, 3064 (1998)] will be compared. We report the first implementation of a laser-generated waveguide in a helium plasma, which provides full ionization and minimization of ionization-induced distortions of the guided pulse up to relativistic guided intensity. 80-fs laser pulses were guided at near-relativistic intensity (0.2 x 10^{18} W/cm^2) over 60 Rayleigh ranges (1.5 cm) with > 50% throughput, 20 Hz repetition rate and no detectable distortion of their spectrum or 16 micron-diameter TEM00 mode structure [E.W. Gaul et al., Appl. Phys. Lett. 77, 4112 (2000)].

Channels were generated by the method developed by Milchberg et al. [op.cit.], in which a filament of He gas (300-700 Torr) was ionized and heated by a powerful line-focused Nd:YAG laser pulse. To enable waveguide formation in helium, the method was modified by slightly (0.1%) pre-ionizing the helium to seed inverse bremsstrahlung absorption, and by lengthening (100 to 400 ps) and strengthening (0.3 to 1 J) the channel-forming laser pulse. Recent femtosecond time-resolved pump-probe experiments inside the Helium channel will be reported. The issues involved, and current progress, in upgrading performance to fully relativistic (10^{18} W/cm^2) guided intensity will be discussed.

FOAB003 Progress towards a 1 GeV Laser-Driven Accelerator

Wim Leemans, D. Auerbach, E. Esarey, J. Faure, G. Fubiani, C.G.R. Geddes, J. O'Neil, D. Rodgers, C.B. Schroeder, B.A. Shadwick, C. Toth, H. Vanbrocklin, J. van Tilborg (LBNL)

Laser-driven accelerators are being studied as an alternative to more conventional RF-based accelerators. Accelerating gradients as high as a few 100 GV/m have been reported in mm-scale length plasmas, resulting in the acceleration of large amounts of background electrons and ions (> 10^{10} particles per bunch) to multi-MeV energies. Many important challenges remain towards the development of a laser accelerator suitable for high-energy physics research, e.g., production of mono-energetic bunches and extending the acceleration distance to reach 1 GeV electron energies. Our present design for a 1 GeV module consists of an all-optical injector followed by a channel guided laser wakefield stage. Experimental progress at the l'OASIS lab using the 10 TW, 50 fs laser (presently being upgraded to 100 TW) will be presented. In addition, applications will be discussed such as radio-isotope production, generation of coherent far-infrared radiation, and femtosecond x-ray production.

* This work is supported by DOE under contract DE-AC-03-76SF0098. C. Geddes acknowledges support from the Hertz Foundation.

FOAB004 Simulation of Accelerated Electron Spectra in Laser Wakefield Accelerators

Richard Hubbard, D.F. Gordon, T.G. Jones, J.R. Penano, P. Sprangle, A. Ting (Naval Research Laboratory), A. Zigler (Hebrew University), B. Hafizi (Icarus Research, Inc.), D. Kaganovich (Leading Edge Technologies)

The generation of high quality electron beams from a laser wakefield accelerator (LWFA) is expected to require external phased injection of electrons. The accelerated electron spectrum is determined by the laser and plasma parameters and the energy, emittance, and phase of the injected electrons. Suitable wakefields have been produced by laser propagation codes (TurboWAVE, LEM, or SIMLAC) and stored for subsequent electron acceleration studies. Test particles in a witness beam are loaded over a range of phases and energies and pushed in the simulation wakefields to generate accelerated output spectra. In some cases, output beams with low emittance and energy spread can be produced even though electrons are injected over a wide range of phases. Full particle-in-cell simulations that include the space charge and current of the witness beam will also be presented. Results will emphasize unguided and channel-guided LWFA experiments at NRL that will employ external optical injection of multi-MeV electrons.

* Supported by the Department of Energy and the Office of Naval Research.

FOAB005 All-Optical Beamlet Train Generation

John Cary, Rodolfo Giacone, Chet Nieter (University of Colorado at Boulder), Eric Esarey, Gwenael Fubiani, Wim Leemans, Carl Schroeder (LBNL), David Bruhwiler (Tech-X Corporation)

One of the critical issues for the development of Laser Wake Field Acceleration (LWFA), which has the promise of creating table-top, GeV accelerators, is the loading of beamlets into the accelerating buckets. All-optical injection schemes which include LILAC [D. Umstadter et al., Phys. Rev. Lett 76, 2073 (1996)], colliding pulse injection [E. Esarey et al., Phys. Rev. Lett 14, 2682 (1997)], beat-wave, wave breaking, and phase-kick, provide a technique for doing so. Although the single bunch can have desirable properties such as energy spread of the order of a few percent, femtosecond duration and low emittance (< 1 mm-mrad), recent simulations show that such methods lead to efficiencies of transfer of plasma wave energy to beam energy that are low compared to conventional RF accelerators when only a single pulse is generated. Our latest simulations show that one can improve on this situation through the generation of a beamlet train. This can occur naturally through phase-kick injection at the front of the train and transverse wave breaking for the trailing pulses. The result is an efficiency improvement of the order of the number of beamlets in the train. Making this work, however, does require a method for re-energizing the wake field, as will be discussed.

FOAB006 Scaling Laws of Dielectric Optical Accelerator

Samer Banna, Eric Colby, M Javanmard, Robert Noble, Robert Siemann (SLAC), R.L. Byer, B. Cowan, T. Plettner (Stanford University), Amit Mizrahi, Levi Schachter (Technion - Israel Institute of Technology)

Indications that solid-state lasers will reach wall-plug to light efficiencies of 30% or more make a laser-driven vacuum-accelerator increasingly appealing. Since at the wavelength of relevant lasers, dielectrics may sustain significantly higher electric field and transmit power with reduced loss comparing to metals, the basic assumption is that laser accelerator structures will be dielectrics. For structures that have typical dimensions of a few microns, present manufacturing constraints entail either planar structures or acceleration structures with a higher degree of symmetry, similar to optical fibers. The former require re-evaluation of many of the scaling laws that were developed for azimuthally symmetric structures. The latter have some inherent advantages, but thermal gradients as well as heat dissipation may become critical impediments. Moreover, structures that operate at a wavelength of a few centimeters are machined today with an accuracy of microns. In future it will not be possible to maintain 4-5 orders of magnitude difference between operating wavelength and achievable tolerance. An additional difference is, that contrary to present accelerators where the number of electrons in a micro-bunch is of the order of 10^{10}, in an optical structure this number drops to a few thousands. Consequently, the relative impact of individual electrons will be significantly larger. Efficiency, wakes, heat flow and emittance scaling laws that have been developed recently will be presented. It will be shown that there are some inherent advantages in combining the accelerator structure and the laser cavity in one system.

FOAB007 Survey of Electromagnetic Structure-Based Advanced Acceleration Concepts

Jay Hirshfield (Yale University and Omega-P, Inc.)

For purposes of this paper, electromagnetic structure-based advanced acceleration concepts are defined by what is excluded rather than by what is included. Excluded are acceleration concepts that involve metallic periodic structures as in a conventional rf linac, and concepts that involve a combination of an intense laser pulse and dense plasma. From among the included advanced concepts those that are surveyed are (i) electron acceleration in externally-driven dielectric-lined

structures; (ii) electron acceleration in beam-driven dielectric-lined structures (i.e., vacuum wake field acceleration); (iii) laser-driven vacuum electron acceleration; and (iv) multi-cavity proton cyclotron acceleration. The basic physics underlying each concept is reviewed, computations that predict performance are presented, and (where available) experimental results are discussed. Speculation is offered as to the potential these concepts could have for maturation into practical accelerators.

* Research sponsored by US Department of Energy, Division of High Energy Physics.

FOAB008 Results on Electron and Positron Acceleration in Plasma Wakefields

Tom Katsouleas, P. Muggli, E. Oz (University of Southern California), C. Barnes, F.-J. Decker, P. Emma, M.J. Hogan, R. Iverson, P. Krejcik, C.L. O'Connell, P. Raimondi, R. Siemann, D. Walz (SLAC), B.E. Blue, C.E. Clayton, C. Huang, D. Johnson, C. Joshi, K.A. Marsh, W.B. Mori (University of California, Los Angeles)

An ambitious new experiment is underway at the Stanford Linear Accelerator Center to demonstrate high-gradient acceleration in plasma wakefields beyond a GeV. This experiment builds on a recently completed experiment by a team from USC, UCLA and SLAC that demonstrated energy gains up to 350 MeV in a meter-scale plasma driven by the 30 GeV SLAC beam. That work yielded a rich harvest of experimental data and insight into the physics of multi-GeV beams interacting with plasmas, including beam propagation, focusing, acceleration, radiation generation, etc. The concommitant development of the 3-D particle-in-cell simulation model OSIRIS, is enabling detailed comparisons between the non-linear wakefield physics in the experiments and the models. A sampling of the most recent results will be presented. One of the key predictions of the plasma wakefield theory and simulation models is the scaling of the wake amplitude with the inverse square of the bunch length. This has led to speculation that shortening the bunch length by an order of magnitude could enable the acceleration of a second bunch by 50 GeV in a few meters of high density plasma. An experiment (E-164) to test this bunch length scaling law is underway at SLAC and preliminary results will be presented. The experiment takes advantage of the ultra-short bunch facility at SLAC to obtain bunches shortened by a factor of six (from approximately 630 to 100 microns) and uses a a larger laser fluence to raise the plasma density by a corresponding factor of 36 in a Li gas/plasma.

* Work supported by USDoE Grant #s DE-FG03-92ER40745, DE-AC03-76SF00515, DE-FG03-98DP00211 and DE-FG03-92ER40727; and NSF Grant #s ECS-9632735, DMS-9722121.

FOAB009 Azimuthally Symmetric Bragg Accelerator

Robert Siemann (SLAC), Samer Banna, Amit Mizrahi, Levi Schachter (Technion - Israel Institute of Technology)

It is demonstrated that with the same materials used for optical fibers [Silica (ε_1=2.1) and Zirconia (ε_2=4)] it is possible to design an azimuthally symmetric acceleration structure consisting of a series of concentric layers. According to the radius of the internal vacuum tunnel (R^{int}), the structure has an interaction impedance Z^{int}=90Ω for R^{int} = 0.55λ up to Z^{int}=250Ω for R^{int}=0.3λ. In this range the group velocity increases linearly with the Rint and its value varies from 0.35c to 0.32c correspondingly. For most practical purposes it was found that the maximum electric field (Emax) occurs at the vacuum dielectric interface and Emax is twice the gradient on axis for Rint = 0.55λ whereas for Rint = 0.3λ, Emax=1.37E0. For a typical interaction impedance of 100W, the laser power (λ=1μ m) required to generate a 1GV/m gradient is 10kW. By increasing the contrast in the dielectric coefficients it is possible to ensure field confinement in a much shorter distance implying a significantly higher interaction impedance.

FOAB010 Acceleration and Focusing Measurements in Beam-Driven Plasma Wakefields at ATF

Vitaly Yakimenko, I. Ben-Zvi, Yu. Eidelman, K. Kusche, I. Pavlishin, I. Pogorelsky (BNL)

The experimental observation of the transverse dynamics of a 60 MeV electron beam propagating in a 17 mm long plasma capillary is presented. The phase correlation between transversal (focusing) and longitudinal (accelerating) components of wake excited by the front of the bunch is observed. The transverse change in the beam size is correlated to change inthe electron beam energy. It confirms predictions from simulations that there is phase offset between transversal and longitudinal components of wake. This prooves experimentally a crucial point: the possibility of a long wakefield-based plasma accelerator in which it is possible to choose an operating point where acceleration is provided by the longitudinal wake and focusing (and not defocusing) by the transverse wake. We have measured an 0.6 MeV energy gain over a 17 mm plasma length — a 35 MeV/m accelerating gradient. Plans to use a microbunched beam from the IFEL in order to excite very high accelerating gradients in plasma are discussed.

FOAB011 Positron Beam Propagation in a Meter-Long Plasma Channel

Tom Katsouleas, B.E. Blue, C.E. Clayton, C. Huang, C. Joshi, W.B. Mori (University of California, Los Angeles), F.-J. Decker, M.J. Hogan, R. Iverson, C.L. O'Connell, P. Raimondi, R. Siemann, D. Walz (SLAC), T. C. Katsouleas, P. Muggli (University of Southern California)

Recent experiments have demonstrated the ability of a plasma to both focus [Blue et al., these Proceedings] and accelerate [Clayton et al., these Proceedings] a positron beam. The acceleration gradient in a plasma of a given density is somewhat smaller when a positron beam excites the wakefield in a plasma compared to when a similar electron beam is used for the case when the beam density exceeds the plasma density. However, the gradient can be increased if the positron beam is propagated through a hollow plasma channel where the positron beam now pulls in plasma electrons from the wall of the channel which is now at a given radius. To study this important issue we have produced 1.4 meter long plasma channels of radius 1 mm and 0.6 mm. First experiments on the propagation of a 28.5 GeV, 1 kA, 4 ps long positron beam through such channels will be reported.

FOAB012 Simulation of Ionization Effects for High-Density Positron Drivers in Future Plasma Wakefield Experiments

David Bruhwiler, John Cary, Dimitre Dimitrov (Tech-X Corporation), Eric Esarey, Wim Leemans (LBNL)

The PWFA concept has been proposed [S. Lee et al., Phys. Rev. S.T. A&B 5, 011001 (2002)] as a potential energy doubler for present or future electron-positron colliders. Recent particle-in-cell simulations have shown [D.L. Bruhwiler, Bull. Am. Phys. Soc. 47, no. 9 (2002), p. 182] that the self-fields of the required electron beam driver can tunnel ionize neutral Li, leading to plasma wake dynamics differing significantly from that of a preionized plasma. It has also been shown, for the case of a preionized plasma, that the plasma wake of a positron driver differs strongly [S. Lee et al., Phys. Rev. E 64, 045501(R) (2001)] from that of an electron driver. We will present new particle-in-cell simulations, using the OOPIC [D.L. Bruhwiler et al., Phys. Rev. S.T. A&B, Issue 10 (2001)] code, showing the effects of tunneling ionization on the plasma wake generated by high-density positron drivers. The results will be compared to previous work on electron drivers with tunneling ionization and positron drivers without ionization. Parameters relevant to the energy doubler and the upcoming E-164 experiment [W. Lu et al., Bull. Am. Phys. Soc. 47,

no. 9 (2002), p. 316] at the Stanford Linear Accelerator Center will be considered.

* Work supported by the US DoE under Contract No.'s DE-FG02-01ER41178, DE-FG03-99ER82903, DE-FG03-95ER40926 and DE-AC03-76SF00098, including resources of the National Energy Research Scientific Computing Center.

Poster Session FPAB
Grand Ballroom I at 8:30

FPAB001 Polarized H- Ion Source Performance During the 2002-03 RHIC Runs

James Alessi, Brian Briscoe, Ahovi Kponou, Vincent LoDestro, Deepak Raparia, John Ritter, Anatoli Zelenski (BNL), Viktor Klenov, Sergei Kokhanovski, Valeri Zubets (INR, Moscow)

The performance of the RHIC Optically-Pumped Polarized H- Ion Source (OPPIS) for the 2002-2003 runs in AGS and RHIC will be reviewed. The OPPIS met the RHIC requirement for the beam intensity with the reliable delivery of about 0.5 mA polarized H- ion current in 400 microsecond pulses (maximum current was 1.5 mA). The beam intensity after the 200 MeV linac was (5-6 $*10^{11}$ H-/pulse, which is expected to be sufficient to obtain the required $2*10^{11}$ polarized protons per bunch in RHIC. Magnetic field shape optimization at the source ionizer cell entrance greatly reduced the extraction high-voltage discharge current in the crossed electric and magnetic fields. As a result, reliable spark free operation was achieved at 7 Hz repetition rate. Polarization optimization studies have resulted in 82+/-2% beam polarization as measured in a 200 MeV polarimeter.

* Work performed under the auspices of the U.S. Department of Energy.

FPAB002 The SPARC Project: A High-Brightness Electron Beam Source to Drive a SASE-FEL Experiment at LNF

Luigi Palumbo (INFN)

The Project SPARC (Sorgente Pulsata e Amplificata di Radiazione Coerente), proposed by a collaboration among ENEA-INFN-CNR-Universita' di Roma "Tor Vergata" -INFM-ST, was recently approved by the Italian Government and will be built at LNF of INFN. The aim of the project is to promote an R&D activity oriented to the development of a coherent ultra-brilliant X-ray source in Italy. This collaboration has identified a program founded on two main issues: the generation of ultra-high peak brightness electron beams and of resonant higher harmonics in the SASE-FEL process.

FPAB003 A Simulation Study of the JLC Positron Source

Takuya Kamitani, Yukiyoshi Ohnishi (KEK), Shigeru Kashiwagi (Waseda University)

This paper describes a simulation study of the positron source for the future linear collider (JLC). Particle tracking simulations were performed to estimate the positron yield including the beam loss in the capture section, in the positron linac up to 1.98 GeV and by the pre-damping ring acceptance. The incident electron beam size and the number of target system multiplet were optimized to get sufficient positron yield within the destruction limit of the target defined by the deposit energy density in the target material.

FPAB004 Diffusion of Alkali Species in Porous Tungsten Substrates Used in Contact-Ionization Source

Edwin Chacon-Golcher (LANL), Joe Kwan (LBNL), Edward Morse (University of California, Berkeley)

Contact ionization (doped) sources used in current Heavy Ion Fusion experiments consist of a porous tungsten substrate doped with an alkali carbonate. During the early stages of the heating cycle (T ~ 600C), the carbonate breaks down and releases the alkali atoms that then diffuse through the substrate. At the emitter surface there is a balance between the fast desorption rate of the alkali atoms (mostly as neutrals) and the slower replenishment rate from the substrate by diffusion. Time-resolved measurements of neutral particle evaporation rates at the emitter surface have been used to estimate the effective diffusion coefficient (D) that characterizes the migration of alkali species in the substrate. These estimates are consistent with the observed source lifetimes (tens of hrs.) and establish the alkali migration in the bulk as a diffusion-limited process. The measurements suggest that the faster migration rates (D ~ 10^{-5} - 10^{-6} cm^2/s) occur early during the heating cycle when the dominant species are the neutral alkali atoms. At operating temperatures there is a slower migration rate (D ~ $10^{-7}cm^2/s$) due to the dominance of ions, which diffuse by a slower surface diffusion process.

* This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098, for the HIF Virtual National Laboratory.

FPAB005 Fabrication of Large Diameter Alumino-Silicate K+ Sources

David Baca, J.W. Kwan, J.K. Wu (LBNL), E. Chacon-Golcher (LANL)

Alumino-silicate sources are used for Heavy Ion Fusion (HIF) drivers because they can produce high brightness and high current beams, with typical pulse length of 10 microseconds, current density ~ 15 mA/cm^2, and operating temperature of around 1050 deg C. These ion sources have demonstrated long lifetime, providing many months of normal operation. For high current design, the ion source has a large diameter (10 cm) with a curved emitting surface. Recently we achieved reliable fabrication of such large diameter sources with high quality alumino-silicate coating on tungsten substrates. The variables in the processing steps affecting surface quality, such as substrate porosity, powder size distribution, coating technique, particle packing density, drying, and heat firing temperature have been investigated. Beam data (for both pulse and dc modes) will be presented along with the method of fabrication and quality control procedures.

* This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098, for the HIF Virtual National Laboratory.

FPAB006 Beam Optics of a 10-cm Diam. High Current Heavy Ion Diode

Joe Kwan, F.M. Bieniosek, J.-L. Vay (LBNL), E. Halaxa, G. Westenskow (LLNL), I. Haber (University of Maryland)

Heavy ion fusion drivers require ion beams with high current and brightness. Typically a large diameter surface ionization source is used to produce > 0.5 A K^+ current with emittance < 1 pi-mm-mrad. An example is the 10-cm source for High Current Transport (HCX) experiments. Experimentally we observed aberrations that differ from those predicted by computer simulations. We have now set up an experiment to study in detail the beam optics of such a large diameter ion diode. The setup will allow viewing access to verify the hot plate position with respect to the edge of the Pierce electrode. Beam diagnostics include a Faraday cup, emittance scanner, pepper-pot, and beam imaging. Experimental results will be compared to computer simulations to study possible mechanisms for producing aberrations as well as benchmarking the code calculations. Beam optics improvement should enhance our ability to observe subtleties in future large-aperture-fill HCX experiments.

* This work is supported by the Office of Fusion Energy Science, US DOE under contract No. DE-AC03-76SF00098 (LBNL) and W-7405-ENG-48 (LLNL).

FPAB007 Characterization of an RF-Driven Plasma Ion Source for Heavy Ion Fusion

Glen Westenskow, Erni Halaxa, Robert Hall (LLNL), Joe Kwan (LBNL)

We are testing a high-current-density high-brightness Argon-Ion Source for Heavy Ion Fusion applications. The 100-kV 20-

microsecond source has produced up to 4 mA of Ar+ in a single beamlet. The extraction current density is ~80 mA/cm2. We have measured the emittance of the beamlet, and the fraction of Ar++ ions under several operating conditions. We will present measurements of the extracted current density as a function of RF power and gas pressure (~2 mTorr), the beam rise time, current density uniformity, and energy dispersion (due to charge exchange). The plasma chamber is 33 cm in diameter with multicusp permanent magnets to confine plasma. RF power (~11 MHz, >10 kW) is applied to the source via a 2-turn, 11-cm diameter antenna inside the chamber for producing beam pulses of 20 ms at up to 10 Hz. We are constructing a 100-kV 31-hole multi-beamlet array to produce a total current >100 mA. In this next stage of the experiments the beamlets will not be merged into a single beam. A 500-kV experiment where beamlets will be merged to a produce 0.5 A beam is being planned.

* This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098 and by UC-LLNL under contract W-7405-ENG-48, for the Heavy Ion Fusion Virtual National Laboratory.

FPAB008 Stability of Electron Beam Parameters in Sources with Cold Secondary-Emission Cathodes

Anatoly Dovbnya, M.I. Ayzatsky, V.N. Boriskin, M.A. Krasnogolovets, V.A. Kushnir, V.A. Mitrochenko, N.G. Reshetnyak, Yu.Ya. Volkolupov, V.V. Zakutin (NSC KIPT)

The paper reports the results from investigations into the generation of electron beams and their parameters in secondary-emission sources in crossed electric and magnetic fields. The investigations were performed using a sectionalized Faraday cup and an automated multichannel measuring system. A beam current of 60 A was attained in a single magnetron gun with a copper cathode, 40 mm in diameter, and a cylindrical anode, 50 mm in diameter, at a cathode voltage amplitude of 30 kV and a magnetic field strength of 2500 Oe. The undertaken studies have shown the current stability per voltage pulse to be between 2 and 4% at a stability of cathode voltage amplitude ranging from 1 to 2 %. Experiments were also made with an 8-cathode secondary-emission system having a common coaxial anode, between the cylinders of which 5 mm^2 copper cathodes were arranged uniformly in azimuth. In this system, 8 tubular electron beams with a total current of 35 A were generated at a cathode voltage of 35 kV and a magnetic field strength of 3500 Oe. The measurements have shown that the total beam current stability per voltage pulse (32 pulses in the time of measurements) was between 3 and 5%, the stability of each beam being 2 to 4% at a stability of cathode voltage amplitude ranging from 2 to 3 %. The present investigations have demonstrated that the secondary-emission sources with cold metallic cathodes have a rather high stability and a pulse power of 1 to 2 MW, and so can be used as electron sources in accelerating technology, and powerful microwave devices.

FPAB009 The Development and Status of the SNS Ion Source

Robert Welton, Syd Murray, Martin Stockli (ORNL), Rod Keller (LBNL)

The ion source for the Spallation Neutron Source (SNS) is a radio frequency driven, multi-cusp, source designed to deliver to the SNS accelerator chain 20-50 mA of H- with up to a 6% duty factor and a normalized rms emittance of less than 0.2 pi mm mrad with an availability of 98% for a 5000 h operating year. The ion source, designed, constructed and commissioned at Lawrence Berkeley National Laboratory (LBNL), satisfies the basic requirements of commissioning and early operation of the SNS accelerator. Source lifetime at the full operational requirement of the SNS has not yet been assessed. In order to insure the ion source can meet or exceed these requirements, we are undertaking a comprehensive ion source development program at the Oak Ridge National Laboratory (ORNL). To date, this program has focused on design and development of internal and external ion source antennas having long operational lifetimes; development and characterization of efficient RF matching networks; simulation and measurement of the extracted ion beam; optimization of the source extraction system; modeling and optimization of the Cs vapor system; optical spectroscopic techniques allowing on-line plasma diagnosis; and numerical methods of emittance analysis. This report will outline progress made in these areas as well as summarize the status of the SNS front end (Linac injector) and the hot spare / development test stand for the ion source at ORNL.

* SNS is a collaboration of six US National Laboratories: Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Thomas Jefferson National Accelerator Facility (TJNAF), Los Alamos National Laboratory (LANL), Lawrence Berkeley National Laboratory (LBNL), and Oak Ridge National Laboratory (ORNL). SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy.

FPAB010 Proof-of-Concept Experiments for Negative Ion Driver Beams for Heavy Ion Fusion

Larry Grisham (Princeton University), S.K. Hahto, S.T. Hahto, J. Kwan, K.N. Leung (LBNL)

Although inertial confinement concepts employing heavy ion beams as drivers have traditionally assumed the use of positive ions, negative ions have recently attracted interest. Relative to positive ions, negative ions have the advantage that they will not collect electrons from surfaces they pass, which changes their focusing characteristics, and negative ions can be converted to neutral atoms by laser photodetachment as they enter the target chamber. Although they will be ionized in crossing the chamber medium, starting as neutrals reduces the space-charge expansion of the beam. Halogens are the best candidates because their large electron affinities should permit high negative ion current densities to be extracted from plasma sources similar in concept to those used in magnetic confinement fusion. While bromine and iodine are the most likely candidates for driver beams, they require ion sources at elevated temperatures. Chlorine is more tractable for a proof-of-concept experiment, since it has a similar electron affinity, forms negative ions through the same dissociative attachment mechanism, and is readily available as a gas. Initial experimental results obtained with an rf-driven source are reported. Without using cesium, a negative chlorine current density of 45 mA/sq cm was obtained under the same conditions that gave 53 mA/sq cm of positive chlorine. The negative ion spectrum was 99.5% atomic Cl, with 0.5% molecular chlorine. The ratio of co-extracted electrons to negative chlorine ions was as low as 7 to 1, much lower than the ratio of their mobilities, suggesting few electrons in the near-extractor plasma. The negative chorine current density was relatively insensitive to pressure, and scaled linearly with rf power.

* Research supported by the U.S. Department of Energy contract DEAC0276CHO3073.

FPAB011 3D Modeling Activity for Novel High Power Electron Guns at SLAC

Anatoly Krasnykh, Valentin Ivanov, Glenn Scheitrum, Daryl Sprehn (SLAC), Lawrence Ives, George Miram (CCR, Inc.)

The next generation of powerful electronic devices requires the new approaches to overcome the known limitations of existing tube technology. Multibeam and sheet beam approaches are novel concepts for the high power microwave devices. Direct and indirect modeling methods are developing at the SLAC to meet the new requirements in the 3D modeling. The direct method of solving of Poisson equations for the multibeam and sheet beam guns is employed in the TOPAZ

3D tool. The combination of TOPAZ 2D and EGUN (in the beginning) with MAFIA 3D and MAGIC 3D (at the final) is used in an indirect method to model the high power electron guns. Both methods compliment each other to get reliable representation of the beam trajectories. Several gun ideas are under consideration at the present time. The collected results of these simulations will be presented and discussed.

* This work supported by Department of Energy under contract DE-AC03-76SF00515 and Small Business Innovation Research grant DE-FG03-00ER82964.

FPAB012 An Improved Version of TOPAZ 3D

Anatoly Krasnykh, Valentin Ivanov, Glenn Scheitrum (SLAC), Aaron Jensen (Student of Oregon Institute of Technology)

An improved version of TOPAZ 3D code is presented as a powerful tool for beam optics simulation. In contrast to the previous TOPAZ 3D version, the geometry of device under test is introducing in the TOPAZ 3D directly from a CAD program such as Solid Edge or AutoCAD. In order to have this TOPAZ 3D feature, a new interface was developed, using the GiD meshing code. The article describes the method with two models to illustrate the results.

* This work supported by Department of Energy under contract DE-AC03-76SF00515.

FPAB013 First Test Results of the Charge State Breeder Bric

Vincenzo Variale (SPring-8), Youry Boimelshtein, Pavel Logatchov, Boris Skarbo, Michael Tiunov (BINP), Antonio Boggia, Giulio Brautti, Tarcisio Clauser, Antonio Raino (Dipartimento di Fisica di Bari and INFN), Vincenzo Valentino (INFN)

The charge state breeder BRIC (BReeding Ion Charge)is based on an EBIS source and it is designed to accept Radioactive Ion Beams with charge state +1, in a slow injection mode,to increase their charge state up to +n. BRIC has been developed at the INFN section of Bari (Italy) during these last 3 years. Now, it has been assembled at LNL (Italy) where are in progress the first tests as stand alone source and where, for the end of the year, it will be tested as charge breeder at ISOL/TS facility of the same laboratory. BRIC could be considered as a solution for the charge state breeder of the SPES project under study also at LNL. The new feature of BRIC, with respect to the classical EBIS, is given by the insertion in the ion drift chamber of a rf-quadrupole aiming to filtering the unwanted masses and then making a more efficient containment of the wanted ions. In this contribution, the charge breeder BRIC first test results will be reported and discussed.

FPAB014 Radioactive Beams from the Newly Installed ECR Source at TRIUMF

K. Jayamanna, R. Baartman, P. Bricault, M. Dombsky, M. McDonald, M. Olivo, P. Schmor, G. Stanford, D. Yuan (TRIUMF)

A radiation hard 2.45 GHz ECR source has been installed in the ISAC target station. The ion source with its 0-60 kV extraction system is coupled to the radioactive isotope production target via a short transfer tube. The volatile radioactive isotopes produced by bombarding a target with a 500 MeV proton beam are ionized and accelerated at the ECR source system. The whole assembly is located beneath a 2 m thick steel shielding structure. Commissioning and initial results are presented.

FPAB015 Design and Operation of Pegasus Thermionic Cathode

Pedro Frigola, James Rosenzweig (University of California, Los Angeles)

A new thermionic cathode has been developed and installed for use on The PEGASUS plane wave transformer injector. The novel design of the LaB6 cathode allows for thermionic emission as well as photoinjector operation. Test stand measurements as well as in situ operational experience are reported.

* Work supported by DOE grant DE-FG03-98ER45693.

FPAB016 Development of Dispenser Cathodes for RF Photoinjectors

Donald Feldman, P.G. O'Shea, M. Virgo (University of Maryland), K.L. Jensen (Naval Research Laboratory)

We are presently engaged in a program to develop improved photocathodes based on the dispenser cathode principle for use in RF photoinjectors. The first phase involves a study of the photoemissive properties of several dispenser cathodes in infrared, visible and ultraviolet light. Preliminary results are encouraging. Photoemission for photons of energy less than the work function is found to be highly nonlinear. A qualitative theory that accounts for the dependence on laser intensity and wavelength will be presented. We will describe plans to extend the dispenser principle to new and novel configurations.

* Research supported by the Joint Technology Office and the Office of Naval Research.

FPAB017 The Research on the Carbon Nano Tube Cathode

Yamamoto Akiyoshi, Namio Kaneko, Tamiro Nakashizu (Ishikawajima-Harima Heavy Industries Co., Ltd.), Mitstuo Ikeda, Satoshi Ohsawa, Takashi Sugimura (KEK)

The research on the new material of cold cathode, joint experiment using CNT (carbon nano tube) have started in collaboration of KEK (High Energy Accelerator Research Organization and IHI (Ishikawajima-Harima Heavy Industries Co., Ltd.). The purpose is developing high-current or high-duty electron gun with cold cathode for injectors of acelerators. From the beginning, relatively high current was observed. It shows a potential of 100A/cm2(peak) could be achieved.

FPAB018 Secondary Polarized Neutron Beam Formation With Scattering off Perfect Crystals

Nikolai Bondarenco (NSC)

Prospects of polarized neutron beam formation and use in high energy physics are outlined. The attention is focused on a method based on small-angle diffractive scattering of neutrons off an oriented perfect crystal under the condition of saturated electromagnetic coherent effect. Results of simulation for the quantum dynamics in the crystal are presented together with successive estimates on parameters of primary and secondary neutron beams. The estimates indicate the method to be most efficient at neutron energies about 5 GeV, with average particle polarization being as high as 90% and satisfactory intensity.

FPAB019 Spectral Distributions of Coherent Radiation by 50 GeV Electrons in Diamond Monocrystal

Serguei Fomin (National Science Center), Nikolai Shul'ga, Valentin Truten' (NSC KIPT)

The motion of relativistic electron in periodical field of atomic strings in crystal at small angles to crystalographic axis can have both regular and chaotic character. The character of particle motion effects significantly on interference behavior of electron's coherent radiation. The results of simulation of coherent radiation spectra of 50 GeV electron beam in diamond crystal at different regimes of motion are presented. The influence of multiple scattering of electrons on radiation spectrum is analyzed.

* Work is supported in parts by STCU (project #1746).

FPAB020 Development of Light Ion Sources at CEA/Saclay

Raphael Gobin, Pierre-Yves Beauvais, Daniel Bogard, Georges Charruau, Denis De Menezes, Oliver Delferriere, Robin Ferdinand, Yannick Gauthier, Francis Harrault, Jean-Luc Jannin, Pierre Mattei (CEA SACLAY)

CEA/Saclay develops high intensity light ion sources since 1995 in the framework of HPPAs (High Power Proton Accelerator) studies. 130 mA CW proton beams are currently produced with the SILHI source at 95 kV. This ECR source has been recently moved. New reliability run tests and space charge compensation measurements will be reported. Moreover, the SILHI source already produced 135 mA of deuteron at 100 kV [R. Ferdinand et al., "Deuteron beam test for IFMIF", Proceedings of EPAC 2002, Paris, France] with an extraction system designed for proton production. So conceptual designs of deuteron extraction systems are presently under study. The first results will be also presented.

FPAB021 ECR Ion Source NANOGUN-10B: Design

Juraj Pivarc (Institute of Physics of the Slovak Academy of Sciences), Alexander Tikhomirov (Joint Institute for Nuclear Research), Mohamed El-Shazly (Nuclear Research Centre)

The paper descibes and presents a design of 10 GHz ECR ion source NANOGUN-10B for the EA-300 accelerator. The ion source design is based on permanent magnets FeNdB. Remarkable features of the source are as follows: i) original ECR zone, ii) basic hexapole and axial fields are produced by permanent magnets, iii) axial microwave port is placed at a first stage of the source and iv) microwave frequency will be variable in the range of 10 – 18 GHz. The outer size of the chamber is disigned to be: diameter 36 mm and the plasma chamber length 80 mm. Total weight of the magnetic structure is about 30 kg.

FPAB022 Pulsed HV Electron Gun with Thermionic Cathode for the Soft X-Ray FEL Project at SPring-8

Kazuaki Togawa, Hitoshi Baba, Kazuyuki Onoe, Tsumoru Shintake (RIKEN Harima Institute in SPring-8), Toru Ishizuka (Sumitomo Heavy Industries)

Apulsed high-voltage electron gun with a thermionic cathode is under development for the low emittance injector system of SASE-FEL project at SPring-8. A single crystal CeB6 is used as a thermionic emitter, because of its excellent emission properties, i.e., high resistance against contamination, uniform emission density and smooth surface. Recently, we have succeeded in heating the cathode up to temperature of ~1450 degrees C, which is the nominal operational temperature, by thermal radiation from a graphite heater. Since we need to apply a -500 kV pulse to the cathode, all high-voltage components of the gun; a ceramic insulator, a step-up transformer, a dummy load etc. are immersed in insulating oil to avoid discharge problem. The modulator for the C-band klystron will be used to provide -500 kV through the step-up transformer. We will report the recent progress of the gun development.

FPAB023 Ion and Neutral Beam Generation by 1TW 50fs Laser Irradiation of Thin Foils

Yoshio Wada, Tetsuo Kubota, Atsushi Ogata (AdSM, Hiroshima University)

Recently energetic ions have been generated by focusing 10 – 100 TW pulse lasers on thin (~50 μ m) foil targets [E. L. Clark et al., Phys. Rev. Lett. 84, 670 (2000), A. Maksimchuk et al., Phys. Rev. Lett. 84, 4108 (2000), R. A. Snavely et al., Phys. Rev. Lett. 85, 2945 (2000)]. We irradiated thinner (~ 10 μ m) mylar and aluminum foils by an 800 nm Ti:sapphire laser with smaller power (1 TW) and shorter pulse width (50 fs) with angle π /4 to the foil surface. We found that only neutral beams are obtained at the laser intensity between 10^{16} and 10^{17} W cm^{-2}, and ions appear at higher intensities. These results will innovate on neutral beam generation and accelerator ion source development.

FPAB024 Topology for a DSP Based Beam Control System in the AGS Booster

Joseph DeLong, J. M. Brennan, T. Hayes, T. Le, K.S. Smith (BNL)

The AGS Booster supports beams of ions and protons with a wide range of energies on a pulse-by-pulse modulation basis. This requires an agile beam control system highly integrated with its controls. To implement this system digital techniques in the form of: Digital Signal Processors, direct digital synthesizers, digital receivers, and high speed analog to digital converters are used. Signals from the beam and cavity pick-ups, as well as measurements of magnetic field strength in the ring dipoles are processed in real time. To facilitate this a multi-processor topology with high bandwidth data links has been designed.

FPAB025 A Bunch to Bucket Phase Detector Using Digital Receiver Technology

Joseph DeLong, J. M. Brennan, T. Hayes, T. Le, K. Smith (BNL)

Transferring high-speed digital signals to a Digital Signal Processor is limited by the IO bandwidth of the DSP. A digital receiver circuit is used to translate high frequency RF signals to base-band. The translated output frequency is close to DC and the data rate can be reduced, by decimation, before transfer to the DSP. By translating both the longitudinal beam (bunch) and RF cavity pick-ups (bucket) to DC, a DSP can be used to measure their relative phase angle. The result can be used as an error signal in a beam control servo loop and any phase differences can be compensated.

FPAB026 Progress on the SNS Ring LLRF System

Kevin Smith, M. Blaskiewicz, J.M. Brennan, J. DeLong, F. Heistermann, A. Zaltsman (BNL), T. Owens (ORNL)

The SNS Ring RF system will comprise three h=1 and one h=2 ferrite loaded cavities, each with individual digital LLRF control electronics. During a 1ms accumulation of protons in the SNS ring, circulating intensity increases to 1.5E14 particles, with 2.0E14 particles planned for future operations. These intensities translate to an average circulating current of 35A and a peak h=1 current of 50A. The LLRF system primary task is to regulate the phase and amplitude of the RF gap voltage in order to maintain a smooth bunch with minimum peak current and a sufficient beam free gap to accommodate the extraction kicker rise time. Maintaining stable control of the cavity-beam system with such intense beam loading is non-trivial, and to do so the LLRF system will use a combination of techniques including cavity voltage I & Q feedback loops, beam current feed-forward compensation, dynamic tuning and cycle to cycle adaptive feedback. This paper describes progress on the LLRF control system to date.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a collaboration of six US National Laboratories: Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Thomas Jefferson National Accelerator Facility (TJNAF), Los Alamos National Laboratory (LANL), Lawrence Berkeley National Laboratory (LBNL), and Oak Ridge National Laboratory (ORNL).

FPAB027 A New Digital Control System for CESR-c and the Cornell ERL

Matthias Liepe, Sergey Belomestnykh, John Dobbins, Roger Kaplan, Charles Strohman (Cornell University)

Recent progress in developing digital low-level RF controls for accelerators made digital systems an option of choice. At Cornell we are presently working on two projects: upgrading the RF controls of the Cornell Electron Storage Ring (CESR) for a charm-tau operation (CESR-c) and developing a new low-level RF system for the proposed

Cornell energy-recovery linac (ERL). The present CESR RF control design is based on "classic" analog amplitude and phase feedback loops. In order to address the required flexibility of the RF control system in the CESR-c upgrade and to implement a true vector sum control we have designed, built and tested a new digital control system. The main features of the new controller are high sampling rates, high computation power and very low latency. The digital control hardware consists out of a powerful VME processing board with a Xilinx FPGA, an Analog Devices digital signal processor (DSP) and memory. A daughter board is equipped with four fast analog-to-digital converters (up to 65 MHz sampling rate) and two digital-to-analog converters (up to 50 MHz update rate). The first set of new electronics will be used in the CESR RF system. However, the described digital control hardware can also be used for the Cornell ERL as it was designed to meet its challenging field stability requirements (see [M. Liepe et al., this conference]).

∗ Work supported by the National Science Foundation.

FPAB028 Longitudinal Damping System with Two Transverse Kickers

Alexander Mikhailichenko (Cornell University)

We describe here a scheme for damping of longitudinal oscillations of a bunch of charged particles in a storage ring. This scheme uses two transverse kickers operating in push-pull mode for the path lengthening in accordance with instant energy deviation of bunch energy from its equilibrium value. By this way the main cavity of the ring itself damps the energy oscillations.

∗ Cornell University, LEPP.

FPAB029 53 MHz Feedforward Beam Loading Compensation in the Fermilab Main Injector

Joseph Dey, Ioanis Kourbanis, John Reid, James Steimel (FNAL)

53 MHz feedforward beam loading compensation is crucial to all operations of the Main Injector. Recently a system using a fundamental frequency downconverter mixer, a digital bucket delay module and a fundamental frequency upconverter mixer were used to produce a one-turn-delay feedforward signal. This signal was then combined with the low level rf signal to the cavities to cancel the transient beam induced voltage. During operation we have shown consistently over 20 dB reduction in side-band voltage around the fundamental frequency during Proton coalescing and over 14 dB in multi-batch antiproton coalescing.

∗ Operated by Universities Research Association, Inc. for the U.S. Department of Energy under contract DE-AC02-76CH03000.

FPAB030 2.5 MHz Feedforward Beam Loading Compensation in the Fermilab Main Injector

Joseph Dey, Ioanis Kourbanis, James Steimel (FNAL)

There are five 2.5 MHz ferrite cavities in the Main Injector with an R/Q of 500 that are presently used for coalescing for the Tevatron. For use with the Fermilab Recycler, feedforward beam loading compensation is required on these cavities because they will be required to operate at a net of 2 kV. Under current Recycler beam conditions, the beam induced voltage is of this order. Recently a system using a digital bucket delay module operating at 53 MHz was used to produce a one-turn-delay feedforward signal. This signal was then combined with the low level rf signal to the 2.5 MHz cavities to cancel the beam induced voltage. During current operation we have shown consistently to operate with over a 20 dB reduction in beam loading.

∗ Operated by Universities Research Association, Inc. for the U.S. Department of Energy under contract DE-AC02-76CH03000.

FPAB031 Tune and Coupling Drift Compensation during the Tevatron Injection Porch

Mike Martens, Jerry Annala, Pierre Bauer (FNAL)

During the Fermilab Collider Run II the betatron tunes in the Tevatron drift by as much as 0.015 tune units over a several hour period while the Tevatron is on its injection front porch. In addition to the observed tune drifts, the coupling, as measured by the minimum tune split, drifts by as much as 0.02 tune units over this same time. Corresponding to these drifts there is a "snapback" of the tune and coupling at the beginning of the Tevatron energy ramp from the injection porch. The magnitude of these drifts has made it difficult to understand beam behavior in the Tevatron, and has added to the efforts to keep the Tevatron tuned up for optimal beam conditions. The source of these drifts and snapback has not been positively identified, but the leading hypothesis is a feeddown effect from the known time variations of the sextupole field in the Tevatron dipole magnets. Although this hypothesis has not been conclusively demonstrated, we have been able to compensate for the tune and coupling drifts by using a feed forward algorithm and have kept the tunes constant to within 0.002 tune units on the front porch.

∗ Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

FPAB032 Beam Loading Compensation for Slip Stacking

Jim Steimel (FNAL)

This paper discusses the beam loading compensation requirements to make slip stacking practical in the Fermilab main injector. It also discusses some of the current plans for meeting these requirements with a digital, direct RF feedback system.

FPAB033 The Tevatron Halo Removal Collimator System

Dean Still, Jerry Annala, Mike Church, Brian Hendricks, Brian Kramper, Al Legan (FNAL)

The Fermilab Tevatron implemented a new 2 stage collimator system for the Collider II run for halo removal during the beginning of colliding beams stores. This collimator systems utilizes local feedback from beam loss monitors and beam intensity signals. A central process to automate the halo removal process used routinely during shot setup coordinates the local controls. Details of the system overview, local feedback control, central process control and operational overview are presented.

∗ Work supported by the Universities Research Association, Inc., under contract DE-AC02-76CH03000 with the U.S. Department of Energy.

FPAB034 Analysis on the Feedback System for Damping Longitudinal Quadrupole-Mode Bunch Oscillations

Shogo Sakanaka, Takashi Obina (KEK)

Longitudinal quadrupole-mode oscillations of the electron bunches sometimes limit the beam quality in storage-ring FELs or in other rings. It has been reported that one can damp the longitudinal quadrupole oscillation by using a feedback system. We describe how the feedback system damps the longitudinal quadrupole oscillation. We also present a result of the feedback test experiment, which was carried out at the KEK Photon Factory.

FPAB035 Two-Bunch Orbit Correction for KEKB Injector Linac

Masanori Satoh (KEK)

In the positron injection mode of KEKB Low-Energy-Ring (LER), two-bunch injection scheme is used for reduction of the injection time. Short injection time results in increasing the integrated luminosity. In KEKB injector linac, 10 nC primary electrons are accelerated to

produce the high-intensity positrons. Because of the strong transverse wake field, the trajectory of second bunch electron is disturbed by the wake field of first bunch. To avoid such orbit distortion, we propse the orbit correction of second bunch electron by using ordinary local bump method. In this scheme, the bump hight should be controlled so that the trajectory of second bunch get close to that of first bunch. In this paper, the result of preliminary beam test will be presented.

FPAB036 Newly Designed Field Control Module for the SNS

Amy Regan, Kay Kasemir, Sung-il Kwon, John Power, Mark Prokop, Hamid Shoaee, Matthew Stettler (LANL), Larry Doolittle, Alessandro Ratti (LBNL), Mark Champion (ORNL)

The low-level RF (LLRF) control system for the Spallation Neutron Source has undergone some recent hardware changes. The intended Field and Resonance Control Module design has been re-vamped to minimize functionality and ease implementation. This effort spans a variety of disciplines, and requires parallel development with distinct interface controls. This paper will discuss the platform chosen, the design requirements that will be met, and the parallel development efforts on-going.

* Work funded by the U.S. Department of Energy.

FPAB037 Commissioning Results of the Fast Orbit Feedback at the ALS

Christoph Steier, Alan Biocca, Ed Domning, Susanna Jacobson, Greg Portmann, Tom Scarvie, Eric Williams (LBNL)

A new fast global orbit feedback system has been designed at the ALS and is in commissioning since last September. The system has two main purposes. The first is to meet the demands of some users for even improved short term orbit stability. The second is to enable the use of more sophisticated insertion device compensation schemes (e.g. tune, beta-beating, coupling) for fast moving insertion devices like elliptically polarizing undulators, without deteriorating the orbit stability. One feature of the fast orbit feedback (with 1 kHz update rate) is the use of standard computer and networking equipment. The presentation will present results of the commissioning of the system.

* This work was supported by the U.S. Department of Energy, under Contract No. DE-AC03-76SF00098.

FPAB038 The Spallation Neutron Source Accelerator Low Level RF Control System

Mark Champion (ORNL)

The Spallation Neutron Source Low Level RF Team includes members from Lawrence Berkeley, Los Alamos, and Oak Ridge national laboratories. The Team is responsible for the development, fabrication and commissioning of 98 Low Level RF (LLRF) control systems for maintaining RF amplitude and phase control in the Front End, Linac and High Energy Beam Transport sections of the SNS accelerator, a 1 GeV, 1.4 MW proton source. The RF structures include a radio frequency quadrupole (RFQ), rebuncher cavities, and a drift tube linac, all operating at 402.5 MHz, and a coupled-cavity linac, superconducting linac, energy spreader, and energy corrector, all operating at 805 MHz. The RF power sources vary from 20 kW tetrode amplifiers to 5 MW klystrons. A single control system design that can be used throughout the accelerator is under development and will begin deployment in February 2004. This design expands on the initial control system that is currently being deployed on the RFQ and rebuncher cavities. The design of the SNS LLRF Control System will be presented.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

FPAB039 Control of Heavily-Beam-Loaded SNS-Ring Cavities

Tom Owens (ORNL), M. Blaskiewicz, K. Smith, A. Zaltsman (BNL)

During beam accumulation in the SNS ring, average beam current rises from 0 to 35 A. The beam component at the 1st harmonic of the revolution frequency rises to 50 A peak. In each of three RF beam-bunching stations being supplied by BNL, two RF gaps are driven by a single tetrode amplifier, resulting in 100 A of beam loading per RF station at the 1st harmonic. A 4th RF station operates at the 2nd harmonic. Regulating the gap fields of all four RF stations while maintaining stability with such heavy beam loading is a substantial challenge. To better understand the challenge, LabVIEW has been used to simulate the SNS ring's digital RF control system, and explore compensation methods, feed-forward schemes, and other control approaches. To accurately replicate the physical system, the simulation applies dynamic tuning to the cavities, and models the actual non-linear electrical characteristics of the tetrode amplifier. The modulated carrier signals applied to the SNS beam are calculated without reduction to base band signals for improved realism, and to allow examination of high-frequency non-linearities and harmonic coupling.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

FPAB040 Analysis of Slow Orbit Movement in PLS Storage Ring

Heung-Sik Kang (Pohang Accelerator Laboratory)

Slow orbit movement in the horizontal and vertical planes in the Pohang Light Source (PLS) storage ring is analysed with the accumulated data of RF-BPM and PBPM, and environment variables such as the ambient temperature of the storage ring tunnel, the LCW temperature, the outside weather condition, and the tunnel floor elevation. Each factor causes an orbit variation with different pattern and magnitude in the horizontal and/or vertical planes. Facts and causes of slow orbit movement are described in detail as well as the orbit correction schemes in use or under preparation are discussed.

* Supported by the Ministry of Science and Technology, Korea.

FPAB041 Commissioning of the Fast Orbit Feedback at the SLS

Michael Boege, Patrick Pollet, Thomas Schilcher, Volker Schlott (Paul Scherrer Institut)

At the SLS a fast orbit feedback has been designed which is supposed to stabilize the closed orbit to the 1 mum level up to frequencies of 100 Hz. The feedback is integrated into the digital BPM system by means of 12 dedicated DSPs and a fiber optic network. Sub-matrices of the inverted corrector-BPM response matrix are distributed to the BPM stations and corrections are performed in parallel. A slow version (<=3Hz) of the feedback has been commissioned which involves all hardware and software components needed for the operation of the fast orbit feedback.

FPAB042 Low-Mode Coupled Bunch Feedback Channel for PEP-II

John Fox, Liane Beckman, Leonid Sapozhnikov, Dmitry Teytelman (SLAC)

Both the HER and LER of PEP-II use broadband longitudinal multi-bunch feedback systems which process all coupled-bunch modes in the machine spanning a 119 MHz bandwidth. Those longitudinal modes within the RF cavity bandwidth are processed by the all-mode broadband systems, though the correction signal is applied to the beam via a path through the broadband kicker, as well as through a special "woofer" channel which uses the RF system to apply low-mode

correction signals to the beam. However, as there are two correction paths, with differing group delay and frequency response, yet only one adjustable processing channel, it is difficult to get an optimal "woofer" response if the broadband feedback path is configured to best control HOM driven instabilities. A new low-mode processing channel has been designed to provide an independent means of providing the low-mode correction signal. It is a digital processing channel, operating at a 10 MHz sampling rate, and implementing flexible 5 to 10 tap FIR control filters. This channel, implemented using EPLD technology, allows more optimal gain and phase adjustment of the woofer control path, with lower group delay allowing higher gain. This extra flexibility and higher gain will be useful in future high-current PEP-II operation. The design of the control path is illustrated, and several possible control filters are described.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

FPAB043 Upgrading of Orbit Feedback System in the Taiwan Light Source

Changhor Kuo, Jenny Chen, Kuotung Hsu (Synchrotron Radiation Research Center)

Global orbit feedback system plays crucial roles for the operation of the Taiwan Light Source (TLS). There are various issues in orbit feedback system should be addressed to achieve ultimate performance. The orbit feedback system is upgraded recently to satisfy requirements of increasing demands. Based upon operational experiences of the last few years, new system was designed to provide an environment for easy maintenance, real-time performance monitoring, feedback loop trouble-shooting. Highly robust and flexible controllers are also supported. General-purpose CPU running real-time operation system replaces existing DSP boards to reduce resources requirement and provide a better software development environment. Performance analysis tools are also developed to monitor system performance. The Commercial Off-The Shelf products (COTS) with highly integration quality are applied to support various beam study and system performance evaluation. The implementation and discussion will be presented in this report.

FPAB044 A New Broadband Kicker Cavity for the TLS Longitudinal Feedback System

Wai Lau, Tz-Te Yang, Meng-Shu Yeh (Synchrotron Radiation Research Center)

The broadband kicker cavity of the TLS longitudinal kicker has been re-designed for higher efficiency in rf power usage. To meet the specifications that are defined by the longitudinal feedback system as well as the constraint in kicker length imposed by the available space for installation in the storage ring, it employs a simple pillbox cavity structure which is symmetrically excited by four coaxial magnetic field couplers and loaded with another four couplers of the same type that are externally terminated for broader bandwidth. Design of this new kicker cavity and results of bench tests will be reported.

FPAB045 Operation of the Digital Multi-Bunch Feedback Systems at ELETTRA

Daniele Bulfone, Vincenzo Forchi', Marco Lonza, Lucio Zambon (Sincrotrone Trieste)

Bunch-by-bunch feedback systems have been installed at ELETTRA to counteract coupled-bunch instabilities. Following a novel approach, both the transverse and the longitudinal systems rely on the same type of programmable digital processing electronics executing the proper software. After a description of the overall machine scenario in which the systems are operated, their performance and resulting effects on the beam quality are given.

FPAB046 RF Model for Jefferson Lab's 12 GeV Upgrade

Alicia Hofler, Jean Delayen, Curt Hovater, Lia Merminga (Thomas Jefferson National Accelerator Facility), Stefan Simrock (DESY)

Jefferson Lab has developed a model for its energy upgrade RF system using the MATLAB/Simulink toolbox for RF systems developed at DESY. This model includes the ability to simulate both the digital and analog aspects of the RF system. It is used to investigate the stability, feasibility, and operational response of control algorithms such as self-excited loop and generator driven resonator for high loaded Q superconducting RF cavity applications. These include the 12 GeV upgrade and FEL upgrade at Jefferson Lab, the Rare Isotope Accelerator (RIA), and Energy Recovered Linacs (ERLs) in general. We will discuss the model, including low level RF controls, RF cavity and klystron characteristics, simulation results, and future model development work.

* This work was supported by the Department of Energy under contract DE-AC05-84ER-40150.

FPAB047 A Generic RF Control Platform for Development and Model Verification

Curt Hovater, H. Dong, A. Hofler, J. Musson, T. Plawski (Thomas Jefferson National Accelerator Facility)

In order to support both short and long term projects at Jefferson Lab we have developed a generic RF control platform. The system is meant to be easily configurable and agile enough to support the diverse development needs of accelerator projects such as the CEBAF 12 GeV Upgrade, FELs, RIA and other superconducting linacs. The control system consists of a VME based digital receiver card, that can be mated to various RF front ends, and a dual DSP card that can be accessed if more processing power is needed. Both cards are stand alone VME cards. The heart of the system is the digital receiver card which consists of four IF input channels (which is now routine) and two fast analog output channels. Processing is accomplished using a single Altera Stratix FPGA. The dual DSP card was developed previously as a generic beam diagnostics card and easily mates to VME cards.

* This work was supported by the Department of Energy under contract DE-AC05-84ER-40150.

FPAB048 Design and Measurement of a Prototype Cavity of the Longitudinal Feedback Kicker for BEPCII

Gang Huang, Tong Dechun, Chen Huaibi, Huang Wenhui, Lin Yuzheng (Tsinghua University, Beijing), Zhao Zhentang (Institute of High Energy Physics, Beijing)

Longitudinal beam feedback system is proposed to be use in BEPCII. The beam feedback kicker is one of the key components in the system. A prototype cavity of the feedback kicker is designed and constructed based on the idea of ridge waveguide overloaded cavity. The impedance of the prototype kicker is measured by an impedance measurement platform using coaxial line method and the results match the design goals.

* Supported by National Natural Science Foundation of China 19875065.

FPAB049 Consideration of Coherent Beam-Beam Instability in Hadron Colliders with Electron-Beam Compensation of Beam-Beam Tune Spread

Lihui Jin (American Physical Society), Jack Shi (University of Kansas)

In storage-ring colliders, a large tune spread due to beam-beam interactions may result in crossings of many high-order resonances that could lead to a large emittance growth and a reduction of luminosity in the case of hadron beams. In order to reduce the resonance crossing, the compensation of beam-beam tune spread with electron beams was proposed for Tevatron RUN IIB. In this paper,

possible effects of the electron-beam compensation on the coherent beam-beam instability was investigated with a self-consistent beam-beam simulation. The study was conducted by tracking a half million macro-particles up to a million turns with the particle-in-cell method. It was found that the reduction of the beam tune spread with the electron-beam compensation could induce the coherent beam-beam instability on hadron beams. The merit of the compensation with different degrees of tune-spread reduction was evaluated based on a study of emittance growth. When the two beams have a same betatron tune, the compensation could do more harm than good to the beams as emittance growth becomes even severer after the compensation. If a large enough tune split between the two beams is present, the compensation with a less than 50% reduction of the tune spread could benefit beams. The result indicates that the phase-dependent perturbations of beam-beam interactions could dominate beam-beam effects and the reduction of the beam-beam tune spread by introducing additional nonlinear beam-beam interactions may not improve the stability of beams.

* This work is supported by the US Department of Engergy under Grant No. DE-FG03-00ER41153.

FPAB050 Experimental Study of Flip-Flop Phenomena at VEPP-2M

Igor Nesterenko, Alexander Valishev (BINP), Petr Ivanov (FNAL)

Experimental results of the flip-flop phenomenon study at VEPP-2M collider are presented. The agreement between the observations and expected simulated behaviours is emphasized.

FPAB051 Strong-Strong Simulation of Beam-Beam Interaction for Round Beams

Alexander Valishev, Eugene Perevedentsev (BINP), Kazuhito Ohmi (KEK)

This paper presents the results of numerical simulations of beam-beam interaction in a circular electron-positron collider with round colliding beams. The calculations were done with the Particle-in-Cell computer code which was developed for the KEKB B-Factory. The code was modified to include the effect of the machine nonlinearity and dynamical radiation emittance. A simulation study of the round beam collider VEPP-2000 justified the choice of the chromaticity correction scheme, working point and optics capable of achieving the design luminosity.

FPAB052 Effects of Long-Range Beam-Beam Interactions and Imperfections on Single-Particle Dynamics in the LHC

John Jowett, Bruno Muratori (CERN)

Following earlier approaches to this topic, we present results of tracking studies with improved modelling of multipole errors, misalignments of magnetic element, long-range beam-beam interactions and a variety of corrections that will be applied in operation of the LHC. We treat both the injection and collision configurations. Various analysis tools are applied to the detailed behaviour of particle orbits to interpret the changes of dynamic aperture.

FPAB053 Madtomma: A Higher Level of Interaction with MAD

John Jowett (FM Technologies)

The program MAD is extensively used for accelerator optics and related calculations. Yet its fundamental design, input from a custom-built but rudimentary programming language and output mainly to text files, has not changed in two decades of development. Neither conventional approaches to building graphical user interfaces nor the ad-hoc approaches associated with "scripts" or "post-processing" can readily provide the programmability that is a principal reason for the popularity of MAD. Madtomma is a suite of Mathematica packages with a clear conceptual design, developed incrementally since 1995, that allows MAD to be programmed at a higher level in a functional or rule-based programming style in a comfortable user interface. Within this framework, both input and output appear as expressions, and elaborate MAD calculations are more easily built up and integrated with other types of calculations. There is a new immediacy in visualisation and analysis. Legacy MAD code remains usable. As an example we illustrate the additional layer of functionality designed for work on the LHC.

FPAB054 Effect of Imperfections on the Dynamics of the Beam-Beam Interaction in the LHC

Bruno Muratori, Werner Herr (CERN)

The dynamics of the beam-beam interaction is affected by linear machine imperfections. This is true in particular for a two-ring collider such as the LHC where some machine elements are shared by both beam and partial compensation of beam-beam effects are expected from the design of the machine. We have included various imperfections, such as misalignment of dipoles and quadrupoles, as well as field errors up to higher orders. We study these effects by tracking and an evaluation of the amplitude detuning and orbit effects. Possible consequences for the performance and the design of the LHC are reported.

FPAB055 Transfer Map of a Current Wire, for Compensation of Long-Range Beam-Beam Effects

Bela Erdelyi (FNAL)

Recently, there has been considerable interest in the possibility of compensating the long-range beam-beam effects with current wires, at least for the LHC. At Fermilab, where the long-range beam-beam effects are one of the major dynamical limitations in Run II, we started a program to explore the validity of the wire correction for the Tevatron. Here, we present the first step needed in this program: the transfer map of the wire, which can be used for tracking, and also for optimization, when implemented in the Differential Algebraic setting. The map is being implemented in Sixtrack, COSY Infinity, and Mathematica.

* Work supported by the US Department of Energy under contract no DE-AC02-76CH03000.

FPAB056 Efficient Approach to Beam-Beam Interactions

Antonina Fedorova, Michael Zeitlin (IPME RAS, Russian Academy of Sciences)

We consider modeling for strong-strong beam-beam interactions beyond the standard linearized/perturbative methods such as soft gaussian approximation, FMM etc. In our approach, based on Fast Wavelet Transform representation for a singular integral operator (Hilbert transform) and the variational approach, the full set of modes, discovered before (discrete coherent and possible incoherent oscillations), appear as the result of the multiresolution/multiscale fast convergent decomposition in the bases of high-localized exact nonlinear modes represented by wavelet packet functions. The constructed solutions represent the full multiscale spectrum with contributions from all internal hidden modes from the slow to fast oscillating eigenmodes. The underlying variational method provides the algebraical control of the spectrum and the type of dynamical behaviour. 1. A. Fedorova, M. Zeitlin, Proc. EPAC02, pp. 1323, 1344, 1434, 1482, 1595, Paris, 2002; arXiv preprints, Physics/0206053, 0206052, 0206051, 0206050, 0206049, 0206054; nlin.PS/0206024.

FPAB057 Macroparticle Simulations of Anti-Proton Lifetime at 150 GeV in the Tevatron

Ji Qiang, Robert Ryne (LBNL), Tanaji Sen, Meiqin Xiao (FNAL)

In this paper we report on a systematic study of anti-proton lifetime at the injection energy of 150 GeV in Run II at the Tevatron. Our parallel beam-beam model can handle both strong-strong and weak-strong beam-beam collisions with abitrary beam-beam separation and beam distributions. In this study, we have only used the weak-strong capability due to the fact that anti-proton intensities are much smaller than proton intensities. We have included all 72 long-range beam-beam collisions with a linear transfer map between two collision points and taken into account linear chromaticity. The effects of aperture size, anti-proton emittance, beam-beam separation, proton intensity, proton emittance, machine chromaticity and machine bare tune have been investigated. Initial results show that the anti-proton lifetime can be significantly improved by increasing the aperture and beam separations and with smaller anti-proton emittances.

* This work was performed under the auspices of a Scientific Discovery through Advanced Computing project, "Advanced Computing for 21st Century Accelerator Science and Technology," which is supported by the US DOE/SC Office of High Energy and Nuclear Physics and the Office of Advanced Scientific Computing Research.

FPAB058 Beam-Beam and Parasitic Beam-Beam Effects in PEP-II

John Seeman, Michael Sullivan (SLAC)

The PEP-II collider is now operating with a beta y* of about 12 mm, a bunch length of about 13 mm, and a bunch spacing of four RF buckets. Over the next few years, all these parameters will be reduced by about a factor of two. These reduced parameters will push the beam-beam parameters in PEP-II to new levels including the hourglass effect and parasitic collisions. Beam studies have been conducted to determine the feasibility of these parameters, to find what is satisfactory, and to determine which issues need corrective actions. The results of these studies and interpretation of the results are given.

* Work supported by US Department of Energy contract DE-AC03-76SF00515.

FPAB059 Parallel Computation of Beam-Beam Interactions Including Longitudinal Motion

Frederick Jones (TRIUMF), Werner Herr (CERN)

In beam-beam macroparticle simulations for collider rings, the accurate determination of the incoherent spectrum and potentially unstable coherent modes requires large numbers of collisions and accurate electric field solutions at each collision. Typically these simulations have used a 2D model of the beam-beam interaction in order to achieve a reasonable computation time, however for the relatively long bunches in the LHC we wish to include the third dimension in order to account for effects such as longitudinal motion, crossing angle, and beam size and density variations. We describe here a parallel algorithm, developed with MPI on a small commodity Linux cluster, to extend our simulation code BEAMX from 2D to 3D using longitudinal subdivision (slicing) of the bunches. A novel aspect of the method is that it does not use any loops, but rather relies on the flow of inter-processor messages to optimally conduct the pairwise interactions of bunch slices. In addition to an overview of the computational framework, we present initial tests and results for some cases of interest.

FPAB060 Phase Advance and Beta Function Measurements Using Model-Independent Analysis

Chun-xi Wang (ANL)

In this report, we present a new method for measuring the phase advance and beta function that characterize the linear properties of an accelerator lattice. The new method uses beam position histories of the excited betatron oscillation measured simultaneously at a large number of beam position monitors. It is an extension of the Model-Independent Analysis technique. Measurements done at the Advanced Photon Source are reported.

* Work supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

FPAB061 Spatial-Temporal Modes Observed in APS Storage Ring via Statistical Mode Analysis

Chun-xi Wang (ANL)

Singular value decomposition of the data matrix containing beam position histories yields a statistical mode analysis of the beam histories by effectively accomplishing the Principal Component Analysis, a major statistical data analysis technique. Similar to the Fourier analysis, SVD mode analysis decomposes the spatial-temporal variation of the beam centroid position into a superposition of various orthogonal modes. In this report we show some interesting modes observed in the APS storage ring.

* Work supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

FPAB062 FFAGs for Muon Acceleration

J. Scott Berg, Robert Palmer, Dejan Trbojevic (BNL), Carol Johnstone, Eberhard Keil (FNAL), Masamitsu Aiba, Shinji Machida, Yoshiharu Mori, Toru Ogitsu, Chihiro Ohmori (KEK), Andrew Sessler (LBNL), Shane Koscielniak (TRIUMF)

Due to their finite lifetime, muons must be accelerated very rapidly. It is challenging to make the magnets ramp fast enough to accelerate in a synchrotron, and accelerating in a linac is very expensive. One can use a recirculating accelerator (like CEBAF), but one needs a different arc for each turn, and this limits the number of turns one can use to accelerate, and therefore requires significant amounts of RF to achieve the desired energy gain. An alternative method for muon acceleration is using a fixed field alternating gradient (FFAG) accelerator. Such an accelerator has a very large energy acceptance (a factor of two or three), allowing one to use the same arc with a magnetic field that is constant over time. Thus, one can in principle make as many turns as one can tolerate due to muon decay, therefore reducing the RF cost without increasing the arc cost. This paper reviews the current status of research into the design of FFAGs for muon acceleration. Several current designs are described and compared. General design considerations are also discussed.

* This research has been supported by the U.S. Department of Energy under contract no. DE-AC02-98CH10886.

FPAB063 Extra Long Baseline Neutrino Oscillation Experiment

Zohreh Parsa (BNL)

We ouline the program for an intense neutrino beam and facility for the BNL long baseline experiment. The four goals of accelerator neutrino physics — precise determination of Δm^2_{32}, detection of $\nu_\mu \rightarrow \nu_e$ appearance, measurement of the matter effect, and detection of CP asymmetries in the neutrino section —are all possible for the proposed complex for reasonable values of the oscillation and mixing parameters. The outlook is improved with recent SNO and KamLAND data. We discuss these and Neutrino Superbeam scenarios for BNL. Extra-long neutrino flight paths open the possibility of observing multiple nodes (minimum intensity points) of the neutrino oscillation

probability in the disappearance experiment. Observation of one such pattern will for the first time directly demonstrate the oscillatory nature of the flavor changing phenomenon. An advantage of having an extra long baseline is that the multiple node pattern is detectable over a broad range of Δm^2. The nodes occur at distances $L_n = 1.24(2n-1) E_\nu/\Delta m^2_{32}$, n= 1,2,3...

* Work supported by the U.S. Department of Energy under contract Number~DE-AC02-98CH10886.

FPAB064 Beam Dump Optics for the Spallation Neutron Source

Deepak Raparia, Y.Y. Lee, Jie Wei (BNL), Stuart Henderson (ORNL)

The Spallation Neutron Source accelerator complex will have three beam dumps for beam tuning and the collection of controlled losses. The linac and extraction beam dumps will be used for beam tuning purposes and are designed for 7.5 kW of beam power. The optics issues for these dumps are i) the beam size at the vacuum window which is near the last quardrupole and ii) guaranting the beam size at the dump due to multiple scattering in the presence of potentially large variations in the linac and accumulator ring emittances. The injection dump will collect the partially stripped H minus ions as well as those H minus ions that miss the foil and is designed to absorb up to 200 kW of beam power. The closed orbit for these ions are much different in the injection area and have to be collected in the injection beam dump with a certain beam size.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

FPAB065 Integration of the Beam Scraper and Primary Collimator in the SNS Ring

Nicholas Simos (BNL)

The collimation system in the SNS ring consists of two types of units. The first type is a two-stage collimator consisting of a halo scraper and an appropriate fixed aperture collimator; and the second type consists of two strategically placed fixed aperture collimators. In this paper we will discuss the integration of the two-stage unit. The unit is placed between the first quadru-pole and the first doublet in the collimation straight section of the ring. The scraper is situated at the exact mid-point between these two magnets, and the fixed aperture collimator fills the space between the scraper and the doublet magnet. The scraper consists of four independently moveable 5 mm thick tantalum scrapers, which are welded to water-cooled copper masses. The fixed aperture collimator has an elliptically shaped collimator tube, which is surrounded by a water-cooled stainless steel shielding structure. The scraper mechanism and the collimator are mounted on a common plate, which is adjusted by three jacks. This arrangement will ensure alignment between the scraper and the collimator is preserved, even in the event that the floor moves. The entire structure is surrounded by an outer shield structure. The shield pieces must accommodate the removal of the scraper or collimator on an individual basis. The downstream dose to the doublet and the attached corrector magnet will be estimated for normal operating conditions. In addition, the thermal, fluid dynamic, and stress analyses will be presented for the scraper and collimator. Finally, the dose at the flange locations will be estimated following machine shutdown.

* Work performed under the auspices of the U.S. Dept. of Energy.

FPAB066 Beam Scrubbing Strategy for Electron-Cloud Suppression in the Spallation Neutron Source Ring

S.Y. Zhang, M. Blaskiewicz, H.C. Hseuh, J. Wei (BNL), R. Macek (LANL)

With the very high beam intensity in the SNS storage ring, it is expected, and have been simulated, that the electron multipacting may generate very large electron dose on the chamber wall. These electrons will desorb gas, and hence the pressure may rise to an unacceptable level. Moreover, the pressure rise can be a localized problem. Chamber sections with high secondary electron yield, and/or locations having large amount of primary electrons, such as the injection region or the collimation area, are likely to have higher pressure rise. Beam scrubbing is proposed as one of the principle mitigations for the electron multipacting problem in SNS. In this article, the experiments of the beam scrubbing on several machines will be reviewed, and specifics of the SNS ring beam scrubbing will be discussed.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

FPAB067 AGS Electrostatic Septum

Jon Hock (BNL)

Brookhaven's AGS uses a foil electrostatic septum for slow extracted beam, its predecessor was a wire electrostatic septum. This paper will discuss the technical pro's and con's of a wire vs. foil electrostatic septum.

FPAB068 Beam Based Characterization of a New 7-Pole Super-Conducting Wiggler at CESR

Alexander Temnykh (Cornell University)

To increase radiation damping at 1.8GeV energy a number of 7-pole and 8-pole super-conducting wigglers will be installed in Cornell Electron Storage Ring (CESR). The requirement on wigglers magnetic field was evaluated by the particle tracking. The wiggler model satisfying this requirement was developed using 3D magnetic field calculation software. However, even small errors in strong magnetic wiggler field may cause significant beam dynamics problems. Thus, confirmation of consistency between the model and real magnetic field is of a great importance. The paper describes the beam based measurements of the magnetic field characteristics of the first 7-pole super-conducting wiggler recently installed in CESR. The results are compared with the model prediction and with the estimates based on magnetic field measurements. It also presents results of the beam resonance mapping which was done by a 2D scan of betatron tunes while recording vertical beam size. It clearly exposed resonances excited by the wiggler nonlinear magnetic field components. In conclusion, the potential ways to optimize the wiggler magnetic field in order to reduce destructive effects on beam dynamics are discussed.

* Work supported by the US National Science Foundation.

FPAB069 Status of the Cooler Synchrotron COSY-Juelich

Juergen Dietrich, Ulf Bechstedt, Ralf Gebel, Kurt Henn, Andreas Lehrach, Bernd Lorentz, Rudolf Maier, Dieter Prasuhn, Alexander Schnase, Herbert Schneider, Rolf Stassen, Jochen Stein, Hans Stockhorst, Raimund Toelle (Forschungszentrum Juelich)

The cooler synchrotron COSY delivers unpolarized and polarized protons and deuterons in the momentum range 300 MeV/c up to 3.65 GeV/c. Electron cooling at injection level and stochastic cooling covering the range from 1.5 GeV/c up to maximum momentum are available to prepare high precision beams for internal as well as external experiments in hadron physics. The beam is fed to external experiments by a fast kicker extraction or by stochastic extraction.

Results of extracted electron cooled beams and developments to increase the number of stored particles and to increase the degree of polarisation during acceleration are reported.

FPAB070 Fermilab Recycler Stochastic Cooling Commissioning and Performance

Daniel Broemmelsiek, Ralph Pasquinelli (FNAL)

The Fermilab Recycler is a fixed 8GeV kinetic energy storage ring located in the Fermilab Main Injector tunnel near the ceiling. The Recycler has two roles in Run II. First, to store antiprotons from the Fermilab Antiproton Accumulator so that the antiproton production rate is no longer compromised by large numbers of antiprotons stored in the Accumulator. Second, to receive antiprotons from the Fermilab Tevatron at the end of luminosity periods. To perform each of these roles, stochastic cooling in the Recycler is needed to preserve and cool antiprotons in preparation for transfer to the Tevatron. The commissioning and performance of the Recycler stochastic cooling systems will be reviewed.

FPAB071 Time Evolution of Beam in the Recycler Ring

K. Gounder, J. Marriner, S. Mishra (FNAL)

We measure the time evolution of the beam current in the Fermilab Recycler Ring to study abrupt physical processes (single coloumb scattering, nuclear scattering) which cause loss of beam, and diffusive processes (multipule coloumb scattering, lattice dependence) which cause emittance growth. We compare the actual lifetimes with the theoretical estimations.

* Work supported by the U.S. Department of Energy under contract no. DE-AC02-76CH03000.

FPAB072 Residual Gas Pressure Profile in the Recycler Ring

K. Gounder, J. Marriner, S. Mishra (FNAL)

We simulate the pressure profile of residual gases from basic principles using detailed geometry and relevant physical parameters. This profile is compared with the actual ion gauge measurements and is being used to predict the vacuum contibution to the Recycler Ring beam lifetime.

* Work supported by the U.S. Department of Energy under contract no. DE-AC02-76CH03000.

FPAB073 Correction of Magnetic Feed-down in Recycler Ring Gradient Magnets Using Permanent Magnet Sextupoles

David Johnson (FNAL)

The transverse position of the permanent magnet Lambertson septum requires an off-center orbit through the Recycler arc gradient magnets. These magnets have built in sextupole to cancel the natural chromaticity of the storage ring. This orbit offset generates a tune shift as well as a lattice function distortion due to the feed-down from the sextupole componene. Permanent magnet sextupoles were utilized to compensate this feed-down. The calculated and observed effect of the sextupoles will be discussed.

* Operated by Universities Research Association Inc., under contract with the U.S. Department of Energy.

FPAB074 Lattice Function Measurements of the Fermilab Recycler Ring

Ming-Jen Yang, Alberto Marchionni, Shekhar Mishra (FNAL)

The new Fermilab Recycler Ring was built to help achieve the final luminosity goal of Run II and is close to being integrated into the Fermilab accelerator complex. The Recycler Ring, which is made up of mostly combined function magnets with a substantial sextupole component, is sensitive to feed-down effects that could potentially change the machine lattice function. During the course of commissioning major modifications had been made, including the replacement of a high beta region with a low beta region as the requirements for Electron Cooling were changed. Lattice function measurements have been done along the way and the results will be presented.

FPAB075 Transfer Line Profile Monitors for Lattice Matching

Ming-Jen Yang, David Johnson, Alberto Marchionni (FNAL)

The new antiproton storage ring at Fermilab, the Recycler Ring, is currently being commissioned to become part of the Collider Run II configuration. While lattice matching is an integral part of every transfer line design it is equally important to verify the matching experimentally, i.e. between the Recycler and the Fermilab Main Injector. The feed-down effect due to the combined function magnets used in the Recycler Ring could be additional sources of error. With the installation of secondary emission profile monitors in the transfer lines it is possible to see the beam profile as it is injected and subsequently extracted on the first, the second, and the next few turns around the Recycler Ring. This is a direct observation on the state of lattice matching. It is also possible to quantify the amount of mismatch if the transfer line optics is known. The result of study and the sensitivity of this technique will be discussed.

FPAB076 Transverse Emittance Growth in Fermilab Main Injector

Ming-Jen Yang, Dave Capista, David Johnson, Alberto Marchionni (FNAL)

To reach the luminosity goal of Fermilab Collider Run II it is necessary to keep a tight budget on the emittance growth. Within the last year it has become clear that there is significant emittance growth in both of the transverse plane for proton at 150 GeV. In particular the vertical plane emittance growth appeared to be associated with the process of longitudinal coalescing of multiple 53 Mhz bunches. Studies are being done using data from the Ion Profile Monitor, the Flying Wire, and the TBT transverse wide band pickup. The analysis will be discussed.

FPAB077 Construction of the First Module of TRASCO RFQ

Giuseppe Lamanna, Michele Comunian, Juan Esposito, Antonio Palmieri, Andrea Pisent (INFN)

Presented here is the construction status of the 30 mA CW RFQ operating at 352.2 MHz under development at Legnaro National Laboratories (LNL-INFN), in the framework of TRASCO project. The first module of this RFQ has been fabricated and characterized. The main results of fabrication, vacuum-brazing and electromagnetic measurements are shown.

* Funded by the Italian Ministry for University and Scientific and Technological Research.

FPAB078 Linac Optics Optimization for Energy Recovery Linac

Ryoji Nagai, Ryoichi Hajima, Nobuhiro Kikuzawa, Eisuke Minehara, Nobuyuki Nishimori, Masaru Sawamura (Japan Atomic Energy Research Institute)

We will present a linac optics optimization method for an energy recovery linac. To suppress HOM induced BBU instability, the beam-transport matrix elements R12 and R34 shoud be minimized everywhere in the supeconducting linac cavities. The linac optics have large amount of varied parameters. Therefore, local optimization method such as Newton method is not suitable to find the optimum parameters. Then we employ generic algorithm to find the global optimum solution for the linac optics.

FPAB079 Performance and Upgrade of the JAERI ERL-FEL

Masaru Sawamura, Ryoichi Hajima, Nobuhiro Kikuzawa, Eisuke Minehara, Ryoji Nagai, Nobuyuki Nobuhiro (Japan Atomic Energy Research Institute)

The superconducting free-electron laser (FEL) linac in the Japan Atomic Energy Research Institute (JAERI) has succeeded the energy recovery. Measuremets of the forward power from the rf source to the cavity with and without the energy recovery showed the almost 100% efficiency of the energy recovery. The higher-order modes in the superconducting cavities are measured to investigate the beam instability caused by the beam recirculation. The threshold current is also calculated for the JAERI ERL-FEL. Upgrade of the linac such as increasing the repetition of the electron gun and renewal of the rf power sources for the injector is under performance for the higher power FEL.

FPAB080 Cost Estimation of an Energy Recovery Linac Light Source

Masaru Sawamura, Ryoichi Hajima, Nobuhiro Kikuzawa, Eisuke Minehara, Ryoji Nagai, Nobuyuki Nishimori (Japan Atomic Energy Research Institute)

Design of the energy recovery linac (ERL) for the next generation light source is under review. The accelerator parameters are estimated to minimize the construction and running costs. Major parts of the construction cost are accelerator modules, refrigerator systems, beam transport systems and buildings. As the accelerating field increases, the costs of the accelerator modules and buildings decrease and the cost of the refrigerator increases. It is found that the accelerating field of 15-20 MV/m is optimum for the construction cost and that the low accelerating field is preferable for the running cost. The shapes of the quadrupole magent for the transport systems are also optimized from the view of the minimum cost of the magnets and the DC power supplies.

FPAB081 Recent Developments in FFAG Accelerators

Yoshiharu Mori, Masamitsu Aiba, Shinji Machida, Atsutoshi Muto, Joe Nakano, Toru Ogitsu, Chihiro Ohmori, Yasuo Sato, Masahiro Sugaya, Akira Takagi, Akiyoshi Yamazaki, Takeichiro Yokoi, Yujiro Yonemura, Masahito Yoshii, Masahiro Yoshimoto, Yoshimasa Yuasa (KEK)

The success of the Proof of Principle proton FFAG (Fixed Field Alternating Gradient) at KEK in 2000 ignites broad range studies in its various applications based on potential superiority to conventional accelerators. The design activities of Muon acceleration for a neutrino factory, a proton driver of ADS (Accelerator Driven System), a compact muon source, are some of examples. Besides designing machines, the construction of a 150 MeV proton FFAG is in the final stage aiming beam commissioning in early 2003. It will be a prototype machine of medical accelerators. In this paper, we will present some detailed design study of FFAG with underlying nonlinear dynamics. The first result of beam commissioning of the 150 MeV FFAG will be another major issue to be discussed.

FPAB082 Status of the 150MeV FFAG

Takeichiro Yokoi, Shinji Machida, Yoshiharu Mori, Atsutoshi Muto, Jo Nakano, Chihiro Ohmori, Izumi Sakai, Yasuo Sato, Akira Takagi, Akiyoshi Yamasaki, Masahito Yoshii, Masahiro Yoshimoto, Yoshimasa Yuasa (KEK), Masaru Matoba, Yujiro Yonemura (Kyushu University), Masamitsu Aiba, Masahito Sugaya (University of Tokyo)

The 150MeV FFAG is a prototype FFAG synchrotron for practical applications, such as beam therapy. As a prototype for practical applications, it can accelerate proton beam from 12MeV to 150MeV within 10msec with repetition of 100Hz. In addition, fast beam extraction from a FFAG accelerator is to be demonstrated. The construction was started at KEK in September 2002. In the paper, the overview of the accelerator and the status of the beam commissioning are to be presented.

FPAB083 Stripper Foil Temperatures and Electron Emission at the Los Alamos Proton Storage Ring

Thomas Spickermann, Michael J. Borden, Andrew A. Browman, Daniel H. Fitzgerald, Robert J. Macek, Rodney C. McCrady, Thomas J. Zaugg (LANL)

We have modeled the heating process of the PSR stripper foil and compared our results to observations that depend on the foil temperature. The foil is heated by the energy deposited by injected H- ions and stored protons passing through the foil (dE/dx). At production intensities (~100 microAmp at 20 Hz) radiation from the two surfaces of the foil is the dominating cooling process, and other processes can be neglected. At higher intensities other cooling processes such as heat conduction, electron emission etc. have to be considered. We will present our best estimates of the foil temperature for different beam intensities. The foil becomes sufficiently hot to emit light in the visible spectrum. This allows us to locate the region of highest beam heating by analyzing the video image of the foil. We also measure the foil current. Our calculations have predicted that at higher beam intensities/foil temperatures the current from thermionic emission (TE) of electrons from the foil should exceed the current from secondary emission (SE). This prediction was confirmed by measurement. TE strongly depends on the temperature and is negligible at production intensities. At peak foil temperatures (obtained by increasing the amount of stored protons, the storage time and the average number of foil hits by stored protons) the TE signal was 5 times higher than the SE current.

* Work conducted at the Los Alamos National Laboratory, which is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

FPAB084 Testing and Commissioning of the ALS Adjustable, Hysteresis-Free Chicane Magnet

Jin-Young Jung, Steve Marks, Ross Schlueter (LBNL)

A new chicane magnet that imparts a kick to the beam between two EPU insertion devices has been installed in the Advanced Light Source (ALS). Hysteresis associated with a previous iron core chicane made it impossible to make fast steering changes with the required precision. The new iron free chicane magnet employs a ring of counter-rotating permanent magnet pairs to create an adjustable dipole field for toggling between 1.5 and 1.9 GeV operation. Supplemental trim coils are used for the fast correction of vertical and horizontal steering perturbations arising when the polarization state of the elliptically polarizing undulator (EPU) changes. The polarization varies on a time scale of the order of one second and the steering correction must be made on that time scale. The theory and design of the PM chicane magnet have been previously reported. The methods of testing and commissioning for new chicane magnet are examined here. Each permanent magnet is oriented so magnet pairs contribute equally to create a uniform dipole field in the center of the PM ring. There are 12 magnets grouped in 2 sets. Each set consists of six permanent magnet cylinders, equally spaced in azimuth, connected by a chain drive system. To change the dipole field (steering), each magnet set is counter rotated by the chain drive stepping motor. Field errors generated by magnet assembly errors or magnet errors (strength differences or magnetic direction errors) can be compensated prior to installation in the storage ring by fine adjustment of the magnetic

direction of each magnet tuner. The methods of field error correction by adjusting magnet tuners, as well as limitations, are discussed.

* This work was supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Sciences Division, of the U. S. Department of Energy, under Contract No. DE-AC03-76F00098.

FPAB085 SNS Linac Commissioning - Techniques for RF Set-Point

Dong-o Jeon (ORNL), Subrata Nath, Robert Shafer, Jim Stovall, Harunori Takeda, Lloyd Young (LANL), Ken Crandall (TechSource Inc)

The Spallation Neutron Source Linac consists of Drift-Tube-Linac (DTL), Coupled-Cavity-Linac (CCL) and superconducting linac (SCL). Techniques for obtaining rf set-point have been identified and will be presented. Especially, three Bunch Shape Monitors will be installed in CCL to provide a measurement of longitudinal bunch profile. Traditionally, obtaining the rf set-point and longitudinal matching relies on the simulation and model. It has been demonstrated through simulation studies that longitudinal matching can be accomplished using three BSM measurements alone. This technique is robust against the measurement uncertainties and does not require simulations.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

FPAB086 Shipping Test for the SNS Prototype Cryomodule

Timothy Whitlatch, Isidoro Campisi, Edward Daly, Jean Delayen, James Henry, Joseph Preble, Haipeng Wang, Mark Wiseman (Thomas Jefferson National Accelerator Facility)

The Spallation Neutron Source (SNS) requires 23 super conducting cryomodules to raise the beam energy of the accelerator to 1 Gev. Thomas Jefferson National Accelerator Facility (Jefferson Lab) has been contracted to build and deliver these cryomodules. The SNS cryomodules are being assembled and tested at Jefferson Lab in Newport News, Virginia, and installed at the SNS facility in Oak Ridge, Tennessee. The cryomodules will be transported via a flatbed air ride trailer over the approximate 500 mile distance. The entire cryomodule is supported by a dampened cradle, which is mounted directly onto the bed of the trailer. This paper describes the design of the cradle as well as other measures taken to ensure safe shipment of the cryomodules. This includes the preservation of the alignment, structural and RF (Radio Frequency) characteristics. The description of the support scheme developed to preserve the alignment during shipping and operation was discussed in a previous paper [1]. The transportation environment was evaluated by instrumenting the SNS Medium Beta prototype cryomodule, with accelerometers, during a road test of approximately 230 miles. The results from the test, as well as the cavity performance before and after shipping are addressed. Experience gained thus far from shipping the production cryomodules to Oak Ridge is discussed.

* Supported by US DOE Contracts Nos. DE-AC05-00-OR22725.

FPAB087 iBump Feedback Tuning for KEKB Accelerator

Teruyuki Kitabayashi, T. Aoyama, S. Fuke, H. Iida, T. Kawasumi, T. Kitabayashi, T. Nakamura, T. Ohkubo, Y. Satoh, S. Shimomura, K. Sugino, K. Yoshii (Mitsubishi Electric System & Service Engineering Co. Ltd.), Y. Funakoshi, N. Iida, H. Koiso, M. Masuzawa, Y. Ogawa (KEK)

KEKB accelerator is an asymmetric electron-positron collider, which has been designed as a high luminosity machine. The current status of the peak luminosity is $8.256 * 10^{33}$ $cm^{-2}s^{-1}$ and of the integrated luminosity is over 100 fb^{-1}. To achieve such high luminosity, we have applied many methods for collision tuning. The iBump feedback system is one of such tuning methods, which controls the beam orbit at the collision point. In this paper, we explain (1) effects of the iBump feedback system on luminosity, beam size and beam life, and (2) the developments of other tools to keep the luminosity high and stable.

FPAB088 RF Method for Hollow Beam Illumination of HIF Cylindrical Targets

Vladimir Pershin, Mihail Churasov, Alexander Golubev, Daniil Kashinsky, Mark Kats, Andrey Kolomiets, Dmitry Koshkarev, Dmitry Liakin, Sergey Minaev, Boris Sharkov, Remir Vengrov (Institute of Theoretical and Experimental Physics)

Terra Watt Accumulator project (ITEP-TWAC) is aiming at accumulation of an ion beam accelerated up to 0.7 GeV/u in a storage ring providing intensity of heavy ions up to 10 power 12 particles per pulse for experiments on heavy ion beam-plasma interaction related to inertial fusion physics. For advanced experiments on high energy density physics the hollow cylindrical target combined with cylindrical geometry of the energy deposition region is required. This combination will be capable of providing extremely high densities and pressures on the axis of imploding cylinder. A new method for RF rotation of the ion beam is applied for reliable formation of the hollow beam of ~2 mm in diameter. In order to obtain hollow beam geometry on the target the beam delivered by TWAC will be transformed by means of fast rotation around a cylindrical axis. The specified RF system consisting of two deflecting cavities is under development for this purpose now. The cavities operating frequency has been chosen 300 MHz, which appears to be sufficient for uniform target illumination at power deposition level about 10 TW/g. The RF rotation system will be placed in the beam transport line at the distance from the target equal to quarter wavelength of transverse beam oscillations. The design of the rotation system and layout of the target rotation system and focusing elements are presented.

FPAB089 Measured Distributions of Polarized Edge Radiation at HiSOR

Nikolay Smolyakov, Atsunari Hiraya (Hiroshima University, Hiroshima Synchrotron Radiation Center), Katsutoshi Shirasawa (Hiroshima University)

The measurements of spectral-angular distributions of edge radiation emitted at the fringe fields of two bending magnets are reported. These studies were conducted at HiSOR electron storage ring (Hiroshima, Japan). The radiation was observed in the near infrared, visible and near ultraviolet ranges. The recorded images, both horizontally and vertically polarized, are compared with the numerically simulated distributions of edge radiation. Good agreement is found between the measured and calculated characteristics of edge radiation. Some unexpected features in spatial distributions of polarized edge radiation were recorded and explained.

Poster Session FPAG
Galleria at 8:30

FPAG001 SDDS-Based Software Tools for Accelerator Design

Louis Emery, Michael Borland, Hairong Shang, Robert Soliday (ANL)

The Self-Describing Data Set (SDDS) file protocol is a standardized way to store and access data, which is the basis of an extensive toolkit. It is also the file protocol used for many accelerator design tools. Over the years several of these SDDS-compliant accelerator programs (elegant, spiffe, shower, estat, clinchor) have been developed at the Advanced Photon Source. Also existing accelerator design tools (MAFIA, URMEL, ABCI, GENESIS, GINGER) have been converted

to read and write SDDS files. Further, the SDDS toolkit program sddsoptimize can be used around any of these tools. Applications of these tools will be presented.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

FPAG002 Application of Model-Independent Analysis Using the SDDS Toolkit

Louis Emery (ANL)

The model-independent analysis (MIA) method in accelerators has not yet come into widespread use, unfortunately. This is perhaps due to a lack of convenient tools to bring the measurement data to the results stage. At the Advanced Photon Source, though novices in the MIA method, we used the SDDS toolkit and the SDDS-compliant EPICS toolkit in two simple applications for diagnosing operational problems from beginning to end in a short time. We were able to make quantitative measurements of pulsed power supply noise and beam position monitor noise, and identify an unstable power supply.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract W-31-109-ENG-38.

FPAG003 Beam Dynamics Optimization in the Rare Isotope Accelerator Driver Linac

Eliane Lessner, Petr Ostroumov (ANL)

A preliminary design of the superconducting linear accelerator of the Rare Isotope Accelerator (RIA) facility has been previously reported [P.N. Ostroumov, Phys. Rev. STAB Vol. 5, 0030101 (2002)]. The driver linac consists of about 400 superconducting independently-phased rf cavities, and is able to accelerate beams of any ion, including uranium, to energies of 400 MeV per nucleon and beam power of 400 kW. The linac has the novel capability of accelerating multiple-charge-state beams, which results in a significant increase in available beam current. Use of multiple-charge states impose strict requirements on the steering procedure to avoid effective emittance growth. A program of detailed beam dynamics studies has been initiated to simplify the accelerator design, enhance its performance, and develop specifications for the engineering design of the accelerator systems. As part of the program, an optimization code has been developed that allows accurate specifications of the matched beam parameters, and determination of the magnetic-field strengths in the focusing lattice based on realistic field distributions. In addition, optimization of a steering scheme that utilizes dipole coils mounted on solenoids in one magnet assembly [P. N. Ostroumov et. al., Linac 2002 Conference Proceedings (2002)] has been implemented. Methods and results of the optimization studies are presented.

* Work supported by the U. S. Department of Energy under contract W-31-109-ENG-38.

FPAG004 New Features in the SDDS-Compliant EPICS Toolkit

Hairong Shang, Michael Borland, Louis Emery, Robert Soliday (ANL)

New programs and features have been introduced into the SDDS-Compliant EPICS Toolkit that have enhanced the usefulness of the toolkit. The sddsoptimize program can be used for EPICS or non-EPICS optimizations using the simplex or 1-D scan method. There are several new data logging programs. One program is a glitch logger that logs data before and after a glitch occurs. Another new program logs data every time a process variable's value changes. With the data generated from this data logger it is possible to restore settings from a specific time without needing a snapshot from the system. There are new waveform programs to set and retrieve waveform process variables. The sddscontrollaw program can also work with waveforms that have been vectorized from correctors and BPMs. Advancements have been added in all the toolkit programs by using low-level channel-access calls instead of EZCA calls. Some of the toolkit programs can now run on vxWorks to achieve higher performance.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

FPAG005 New Features in the SDDS Toolkit

Robert Soliday, Michael Borland, Louis Emery, Hairong Shang (ANL)

Self-Describing Data Sets (SDDS) and the corresponding SDDS tools have long been used at the Advanced Photon Source (APS) and other laboratories for data storage and analysis. Various programs in the toolkit have been added or improved recently. Support for the Mac OS X operating system has been added. Automated testing scripts are being used to reduce bugs prior to software upgrades. The Java version of the SDDS Toolkit has been used to integrate standard SDDS functions into MATLAB. Improved the fitting of generic functions to SDDS data. Conversion of array data to column data has been added to allow analysis of array data with existing programs. Improved the display of sddsplot movies by saving plots to files for rapid playback.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

FPAG006 Use of a Simple Storage Ring Simulation for Development of Enhanced Orbit Correction Software

Robert Soliday, Michael Borland, Louis Emery, Hairong Shang (ANL)

At the Advanced Photon Source (APS) most of the testing of minor operational software is done during accelerator studies time. For major software changes, such as the porting of the complex workstation-based orbit control software to an EPICS IOC, much of the testing was done "offline" on a test IOC. A configurable storage ring simulator was created in a workstation with corresponding control system records for correctors and orbit readbacks. The simulator's features will be described as well as the method used to develop and debug the most recent improvement of the APS orbit control software, among others. The simulator is also useful in general-purpose software testing.

* Work supported by U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

FPAG007 Evaluation of the Horizontal to Vertical Transverse Impedance Ratio for LHC Beam Screen Using a 2D Electrostatic Code

Ubaldo Iriso-Ariz (BNL), Fritz Caspers (CERN), Andrea Mostacci (Universita La Sapienza)

The classical 2 wires method is not suitable for high precision transverse impedance measurements on a homogeneous copper beampipe with non-circular cross-section due to measurement noise limitations in case of narrow wire spacing. We tackled the problem by simulating the 2D electrostatic field and image charge distribution of that setup and then calculating the corresponding surface current for a TEM wave excitation. In this computer simulation the 2 wires can be assumed lossless, which is not possible in a practical bench setup. The theoretical justification for the method and certain limitations are discussed. The results obtained compare very well to several independent numerical and analytical results.

FPAG008 A Fast Configurable UAL-Based Modeling Engine for Online Accelerator Studies

Nikolay Malitsky, Todd Satogata, Richard Talman (BNL)

The diversity of online accelerator modeling tasks poses a considerable challenge for accelerator physicists and software developers. Compromise between performance and completeness is always required. For example, correct modeling of chromatic effects requires second-order calculations, while speed favors first-order matrix multiplication. This paper presents our solution: Fast TEAPOT, a configurable computational modeling engine, based on a collection

of linear sector matrices and TEAPOT symplectic integrators. The choices of lattice algorithms for Fast TEAPOT are defined in an external XML file, permitting a flexible mechanism for evaluating different approaches within the context of machine studies and operation. We also describe our application and experiences with Fast TEAPOT for RHIC online modeling during the RHIC 2003 collider run.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

FPAG009 Application of the UAL Simulation Environment to Diagnostics Studies

Nikolay Malitsky, Peter Cameron, Alexei Fedotov (BNL)

The paper presents the structure and application of the Accelerator Instrumentation Models (AIM), a new UAL module addressing diagnostics simulation tasks. AIM has been developed as a collection of instrumentation devices integrated with the Fast TEAPOT and other UAL modeling engines. It can be considered as a bridge between the UAL simulation environment and various accelerator and diagnostics tools. This approach facilitates the realistic offline study of complex beam measurement scenarios and devices for analyzing different beam dynamics effects. The paper concludes with the application of the AIM-based approach to modeling of the SNS and RHIC Beam Transfer Function (BTF) measurement system including the new resonant quadrupole monitor.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge.

FPAG010 A Comparison of Accelerator Lattice Code Computations with Analytic Results for Large Momentum Offsets

Dejan Trbojevic, Scott J. Berg, Ernest D. Courant (BNL), Richard Talman (Cornell University), Al A. Garren (LBNL)

Exact analytical formulas were used to compute horizontal and vertical betatron tunes, closed orbit offsets, and orbit lengths for a simple 100 meter long cyclotron made of five combined function dipoles. Several accelerator physics tools including SYNCH, COSY, MAD, and TEAPOT were used to calculate the same parameters. Detailed results and comparisons are presented.

* Work performed under auspices of the U.S. Department of Energy.

FPAG011 LIONS_LINAC: A New PIC Code for LINACS

Patrick Bertrand (French Atomic Energy Commission)

In the frame of the SPIRAL II project at GANIL, a new Particle In Cell program has been developped. LIONS_LINAC is written in Fortran 95, and can work either on workstations and PCs or on vectorial/parallel computers. We present the main characteristics of the code, in particular the treatment of the space charge effects, using the multigrid method with Conjugate gradient smoothing iterations.

FPAG012 New Implement in TraceWIN/PARTRAN Codes: Integration in External Field Map

Nicolas Pichoff (French Atomic Energy Commission), Didier Uriot (CE Saclay)

The calculation of particle trajectories in external electric and magnetic, static and RF fields has been implemented in TraceWIN and PARTRAN codes. The four field maps can be superposed. In TraceWIN (envelope code), the field is linearised around the synchronous trajectory. In PARTRAN, a RK4 integration in the real field map is made. Results are produced for various projects like SPIRAL 2 or PISI.

FPAG013 Numerical Tools for Predicting Cleaning Efficiency in the LHC

Ralph Assmann, Markus Brugger, Mark Hayes, Jean-Bernard Jeanneret, Verena Kain, Frank Schmidt (CERN), Igor Baishev (Institute of High Energy Physics, Protvino), Dobrin Kaltchev (TRIUMF)

The computer codes SIXTRACK and DIMAD have been upgraded to include realistic models of proton scattering in collimator jaws, mechanical aperture restrictions, and time-dependent fields. These new tools complement long-existing simplified linear tracking programs used up to now for tracking with collimators. Scattering routines from STRUCT and K2 have been compared with one another and the results have been cross-checked to the FLUKA Monte Carlo package. A systematic error is assigned to the predictions of cleaning efficiency. Now, predictions of the cleaning efficiency are possible with a full LHC model, including chromatic effects, linear and non-linear errors, beam-beam kicks and associated diffusion, and time-dependent fields. The beam loss can be predicted around the ring, both for regular and irregular beam losses. Examples are presented.

FPAG014 MAD-X — An Upgrade from MAD8

Frank Schmidt (CERN)

The development of MAD8 has been suspended for many years. At the start of 2001 it was decided to revive it and put it into a more maintainable form since it is needed for the LHC during design and operation. In particular, the home grown dynamic data management in Fortran77 limits further extensions, and is not guaranteed to survive for another ten years. In fact, MAD-X has been originally planned to be a copy of MAD8 with a more modern data management. The data structures that hold the information about the accelerator, and the interfaces to the modules are written in C which provides the dynamic data structures needed. Contrary to MAD8, the MAD-X modules are designed as truly independent entities; they are much simpler and therefore better maintainable. It was also thought important to spread the responsibility for the various MAD-X modules among several accelerator physicists. Lastly, an upgrade of MAD-X is being implemented to improve the physics models and to include map related tools using Etienne Forest's PTC (Polymorphic Tracking Code) code. A fully operational and documented version is available via the MAD-X web site.

FPAG015 Recent Improvements to the ASTRA Particle Tracking Code

Steve Lidia (LBNL), Klaus Floettmann (DESY), Philippe Piot (FNAL)

The ASTRA simulation code has been successfully used in the design of linac and rf photoinjector systems utilizing beams with azimuthal symmetry. We present recently implemented changes to ASTRA that allow tracking of beams in beamlines without the assumption of any symmetry. The changes especially include a 3D mesh space charge algorithm and the possibility to import 3D electromagnetic field maps from eigensolver programs such as MAFIA. We present benchmarking studies, and simulations beam dynamics in existing or proposed photoinjectors.

* This work was supported by the Department of Energy under Contract No. DE-AC03-76SF00098.

FPAG016 Advances in the Numerical Modeling of the Negative Mass Instability

James MacLachlan (FNAL)

The first attempts to demonstrate the phenomenon of negative mass instability were made in the 1970s [W.W. Lee and L.C. Teng, Beam

Bunch Length Matching at Transition Crossing, Proc 8th Int. Conf. Hiigh Energy Accel., Geneva, 1971 p 327]. Although the theory has been carefully reviewed by Ng [K.-Y Ng, Physics of Intensity Dependent Beam Instabilities, Fermilab FN-0713], it is probably correct to say that there has been little new understanding since the early papers of W. Hardt [W. Hardt, Gamma Transition Jump Scheme of the CPS, Proc 9th Int. Conf on High Energy Accel., SLAC, Stanford, 1974, p 434]. What has changed substantially is the computing power available for modeling. It now possible to make direct tests where the number of macroparticles is within a couple or orders of the number of physical particles in an interesting system. The results of such tests and some numerical issues are discussed.

* Work supported by the US Department of Energy under contract no DE-AC02-76CH03000.

FPAG017 Simulation of Space Charge Effects in the Fermilab Booster Using the Code ORBIT

Jean-Francois Ostiguy, Weiren Chou, Leo Michelotti (FNAL), Jeffrey Holmes (ORNL)

The Fermilab Booster is a rapid cycling proton synchrotron whose intensity is limited by particle loss believed to be associated with space charge effects. As part of a comprehensive effort to understand the exact nature of the loss mechanisms, simulations have been performed using the code ORBIT. This code, developed at SNS to simulate beam dynamics in accumulation rings and synchrotrons,allows the simulation of space charge forces in a mode where the transverse and longitudinal components are computed separately, or optionally, in a fully self-consistent, three dimensional mode. In this paper, we discuss the capabilities and limitations of ORBIT in the context of the Booster and present results of simulations performed both at injection and through the acceleration cycle for beam parameters of operational relevance. Simulation results are also compared with measurements.

* Work supported by the US Department of Energy under contract no DE-AC02-76CH03000.

FPAG018 PyORBIT: A Python based ORBIT

Jean-Francois Ostiguy (FNAL), Jeff Holmes (ORNL)

ORBIT is code developed at SNS to simulate beam dynamics in synchrotrons or accumulation rings. The code is structured as a collection of modules for SuperCode, a high level interpreter shell developed at LLNL in the early 1990s. All the modules that form ORBIT are written in C++. Since SuperCode is no longer supported, there has been, for some time, interest in replacing its functionality by a modern scripting language, while preserving both the structure and feel of the original ORBIT program. In this paper, we present a new version of ORBIT where the role of SuperCode is assumed by Python, a widely supported object-oriented scripting language. Starting from specifications expressed in pure C++, the boost.python library, by making use of template metaprogramming techniques, generates module interface code using only the C++ compiler. Remarkably, changes needed to existing module code turned out to be very minimal. In this paper, we motivate our choice of Python as a high level shell and present implementation details. We compare PyORBIT to ORBIT from the standpoint of features, performance and future expandability.

* Work supported by the US Department of Energy under contract no DE-AC02-76CH03000.

FPAG019 A Framework Design for Cyclotron Virtual Control Platform based on Object-Oriented Technology

Qin Bin, Ming Wu Fan, Jian Xiong, YongQian Xiong, Tiao Qin Yu (HuaZhong University of Science and Technology)

This paper present a novel design method to construct the Cyclotron Virtual Control Platform (CVCP) in our project and give an implementation in general framework level. The Platform has the ability to simulate the process and situation in normal Cyclotrons such as start up in automatic or manual mode, routine operations, beam current regulation and control system dynamic response. In further plans, it will integrate an Intelligent Fault Diagnosis Modual and a Graphical User Interface (GUI) with VR features that enable us navigating in a 3D real-time modeling world. We use Object-Oriented technology to build this complex system and represent it in Unified Modeling Language (UML). It is easy to extend the functions in this open system. The Platform is applied to the Cyclotron Virtual Prototyping (VP) research project, and it's an open system that can communicate and interact with CAD and CAE systems.

FPAG020 A Mixed Galerkin and Collocation Boundary Element Method for Analyzing Cyclotron Cavities

Qin Bin, Dezhi Chen, Tianlin Dong, Mingwu Fan, Yueming Hong (HuaZhong University of Science and Technology)

A mixed Galerkin and collocation approach to implement the boundary element method (BEM) for analyzing cyclotron cavities is proposed in the paper. First a three-dimensional vector boundary integral equation suitable for the cavity resonator problem is given, then the integral equation is discretised resulting in a generalized eigenvalue equation. For boundary elements where the electromagnetic field vary rapidly, the collocation method is used; for boundary elements where the electromagnetic field vary slowly, the garlerkin method is adopted. The mixed method shows its high efficiency like collocation method as well as high accuracy like Galerkin method. The resonant frequency calculated by the mixed method shows good agreement with data measured in literature.

FPAG021 A New Method for Analyzing Cyclotron Cavities

Qin Bin, Dezhi Chen, Tianlin Dong, Mingwu Fan, Hong Yueming, Lamin Zhan (HuaZhong University of Science and Technology)

In this paper we present a new method based on equivalent transmission line principle for analyzing cyclotron cavities. Microwave circuit model for the intrinsic 3-D cavity is first established. The cross-section in a 3-D cavity is modeled as wave transmission line with main parameters determined by 2-D electromagnetic boundary value problem. The dimension of the problem is then reduced from 3-D to 2-D, thus requiring a relatively small memory allocation and short computing time. The Comparisons of resonance frequency with measurements for a cyclotron cavity show that this method gives good engineering agreement.

FPAG022 Beam Dynamics Numerical Simulation in a Cyclotron

Qin Bin, Dezhi Chen, Changdong Deng, Mingwu Fan, Jian Xiong, Yongqian Xiong, Tiaoqin Yu (HuaZhong University of Science and Technology)

An integral formulation for calculating the particle orbit in a cyclotron is presented, which is based on the simple fact that the particle orbit in the magnetic median plane can be considered as a series of smoothly linked arcs of different radius, which are only dependent upon the local magnetic field. By using this integral formulation, the beam dynamics for a 10MeV medical cyclotron is studied. The magnetic field data is obtained through a finite element method (FEM) code. Then the integral formulation is sloved by using a numerical scheme. The phase drift of the particle is calculated and the results are used to adjust the magnetic field design to satisfy the condition for isochronism.

FPAG023 The Motion of Charged Particle in an AVF Cyclotron

Qin Bin, DeZhi Chen, Changdong Deng, Mingwu Fan, YongQian Xiong, Tiaoqin Yu (HuaZhong University of Science and Technology)

This paper discusses the movement of the charged particle in an Azimuthally Varying Field (AVF) Cyclotron. With the Discrete Fourier Transform (DFT) program the measurement results of the magnetic field are expanded to a series of Fourier coefficients and the ion's orbit in this field is studied.Under some finite approximations, we solve the particle's motion equations and get needful information about the motion of ion. According to these analytic results, a code to computer and simulate the orbit is given and a satisfying result is got. The influence on the stability of ion's orbit is studied due to the small errors for the approximation and the deviation of the magnetic field. By using the newest Virtual Prototyping (VP) technology, we can easily extend our these existing results and promote new research and development.

FPAG024 Modeling and Beam Dynamic Visualization in Cyclotron Virtual Prototyping

Qin Bin, Mingwu Fan, Xiong Jian, Bin Qin, Yongqian Xiong, Tiaoqin Yu (HuaZhong University of Science and Technology)

Cyclotron virtual prototype improves design quality, reduces the number of costly physical cyclotron prototypes,dramatically reduces product development time, and delivers innovative new designs faster. This paper describes to build product overall lifecycle models of cyclotron via CAD system, used in cyclotron visual design, visual assemble, visual manufacture and other domains. These 3-dimension models with physical information help designs research the construct of cyclotron conveniently, and empower designers with the flexibility of parametric or variational design. Some applications such as visual assemble and automated modeling are introduced. Beam dynamic analysis result visualization is very important in cyclotron virtual prototyping, so this paper also describes particle moving animation and analysis result visualization expression.

FPAG025 Magnet Design in a Cyclotron Virtual Prototyping System

YongQian Xiong, DeZhi Chen, MingWu Fan, Bin Qin, Jian Xiong, TiaoQin Yu (HuaZhong University of Science and Technology)

A cyclotron virtual prototyping system is developed based on the accelerator theory and virtual prototyping technique for the innovative design of low energy accelerators. This paper presented the method of magnet design in the cyclotron virtual prototyping system. The emphasis is on the 2D/3D finite element calculation of magnet and its visualization, the interface between magnetic field finite calculation and solid modeling and beam dynamic calculation. The effect of mismachining tolerance on beam is discussed by magnetic field calculation.

FPAG026 Self-Consistent 3D PIC Code for the Modeling of High Brightness Beams

Luca Serafini, Alberto Bacci, Cesare Maroli, Vittoria Petrillo (INFN)

The 3D numerical code RETAR has been developed to compute the motion of the high-brightness electron beam emitted by the photo-cathode under the action of arbitrary external electric and magnetic fields and the self-consistent fields produced by the electron bunch in its motion. The code is fully relativistic and calculates the self-fields directly from convenient integral forms that can be obtained from the usual retarded expressions and it is implemented by adding the boundary conditions on the cavity walls. Numerical results are presented to emphasize the role of radiation and of the self-fields on the general motion and the compression of the electron bunch.

FPAG027 RF Coupler for High-Power CW FEL Photoinjector

Sergey Kurennoy, Lloyd Young (LANL)

A high-current emittance-compensated RF photoinjector is a key enabling technology for a high-power CW FEL. The design presently under way is a 100-mA, 2.5-cell pi-mode, 700-MHz, normal conducting demonstration CW RF photoinjector. This photoinjector will be capable of accelerating 3 nC per bunch with an emittance at the wiggler less than 10 mm-mrad. The paper presents results for the RF coupling from ridged waveguides to the photoinjector RF cavity. The LEDA and SNS couplers inspired this "dog-bone" design. Electromagnetic modeling of the coupler-cavity system has been performed using both 2-D and 3-D frequency-domain calculations, and a novel time-domain approach with MicroWave Studio. These simulations were used to adjust the coupling coefficient and calculate the power-loss distribution on the coupling slot. The cooling of this slot is a rather challenging thermal management project.

FPAG028 Recent Improvements in the PARMILA Code

Harunori Takeda (LANL)

In this paper, we discuss the recent improvements made in the PARMILA code. PARMILA, which stands for Phase and Radial Motion in Ion Linear Accelerators, is used to design the layout of linac accelerating structures, and it also simulates the particle dynamics through the designed linac. Recently, we have made large structural changes in the entire code – it is now rewritten in Fortran90, and obsolete language syntaxes are eliminated. In addition, new keywords are introduced to improve the user interface. To aid the linac designer, we discuss important and practical aspects of the code. Also, discussed are the inner workings of designing segments, characterized by a constant accelerating gap-to-gap distance, the logic in determining inter-segments spacing, and space-charge application to the particles along the linac. Aspects of longitudinal and transverse errors applicable to the linac design, and to the particle-dynamics simulation are also presented.

∗ Work supported by the US Department of Energy, Office of Science, Division of High Energy Physics.

FPAG029 The Particle Tracking Code PARMELA

Lloyd Young, James Billen (LANL)

The name PARMELA came from the phrase "Phase And Radial Motion in Electron Linear Accelerators," which described it earliest applications. However, a decade ago, the code's capabilities were expanded to track particles of any mass and charge. A more recent addition was the ability to track particles of three different masses and any charge simultaneously. PARMELA uses time as the independent variable. PARMELA is a simulation code, and does not design a linac or beam transport channel. PARMELA can use electromagnetic fields calculated by other codes. These fields can be RF electromagnetic, static magnetic, or electrostatic. Both 2D cylindrically symmetric and fully 3D field maps can be used for all three types. The RF fields are confined to the rf cavity elements that describe standing-wave or traveling-wave structures. The static fields are treated as a background field that is superimposed over drift spaces and rf cavity elements. PARMELA includes options for selecting either 2D or 3D space-charge effects. The code's input file can supply data for most common beam-line components and accelerator structures. This paper describes some of the capabilities of PARMELA and a few examples of PARMELA simulations.

∗ Work supported by the US Department of Energy.

FPAG030 Self-Consistent Parallel 3D Electron-Cloud Simulation in Arbitrary External Fields

Miguel Furman, Andreas Adelmann (LBNL)

We present a 3D parallel self-consistent particle tracking program which allows electron-cloud calculations in arbitrary external fields. The Lorentz force equation is integrated with time as the independent variable. A 3D parallel multi-grid solver computes the electric field for the drive beam in the beam frame, while the space-charge field of the electrons is computed in the lab frame. The resulting total field, obtained by superposition, acts on both the beam particles and the cloud electrons. Primary and secondary emission takes place at each time step of the calculation. This sort of computation is only possible by the use of massive parallelization of the particle dynamics and the Poisson solver in combination with modern numerical algorithms such as the multi-grid solver with Gauss-Seidel smoothing. We show preliminary results using the LANL PSR machine as testbed.

* Work supported by the Director, Office of Energy Research, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

FPAG031 MaryLie/IMPACT: A Parallel 5th Order Beam Optics Code with Space Charge

Robert Ryne, Andreas Adelmann, Phillip Colella, Ji Qiang, David Serafini (LBNL), Roman Samulyak (BNL), Salman Habib, Tom Mottershead, Filippo Neri, Peter Walstrom (LANL), Viktor Decyk (University of California, Los Angeles), Alex Dragt (University of Maryland)

This paper presents a description of MaryLie/IMPACT, a parallel code that combines the magnetic optics capabilities of MaryLie with the space charge capabilities of IMPACT. Such a capability represents a single, coherent program for modeling a wide range of applications involving low- and high-intensity beams in linear and circular accelerators. This was accomplished by parallelizing the ray-tracing portion of MaryLie 5.0, incorporating a parallel Poisson solver from IMPACT, and automatically slicing beamline elements to enable tracking with space charge using a split-operator approach. Additional capabilities include a model for rf accelerating cavities, a wakefield module, a variety of parallel Poisson solvers, and an enhanced front-end that can read lattice descriptions in the Standard Input Format. Several examples will be presented, and the performance of the code will be described.

* Work supported by the U.S. Department of Energy, Office of Science, Office of High Energy and Nuclear Physics, and Office of Advanced Scientific Computing Research.

FPAG032 Fluid Modeling of Intense Laser Pulses in Plasma Channels: An Optimized Accelerator Stage

B.A. Shadwick, E.H. Esarey, W.P. Leemans, C.B. Schroeder (LBNL), G.M. Tarkenton (Institute for Advanced Physics)

We present numerical solutions of the cold fluid equations for an intense laser pulse propagating in a preformed plasma channel in the non-linear regime. Our interest in this system is as a means to realize an optimized single stage laser wakefield accelerator in which the laser pump depletion length is matched to the electron dephasing length. We present various configurations and examine their merits with regard to acceleration and beam propagation characteristics. For realistic (experimentally relevant) parameters, these are CPU intensive computations. This can be partially mitigated by using higher-order methods; we discuss our progress developing fourth-order solvers.

FPAG033 A Modular, Online Simulator for Model Reference Control of Charged Particle Beams

Christopher Allen (MIT Plasma Science and Fusion Center), C. Paul Chu, John D. Galambos, Thomas A. Pelaia (ORNL), Nicholas D. Pattengale (Sandia National Laboratory)

As part of our work on the control system for the Spallation Neutron Source (SNS) project we have developed an online particle beam simulator. The simulator is an independent subsystem of the high-level applications programming framework called XAL (see Chu, et. al. this conference). The simulator automatically generates lattice models according to the machine configuration and synchronizes the lattice model to that of the machine, either operational or design parameters. Thus, it is a convenient source of model data for model reference control applications. Because the simulator is intended for use as a model reference for operation and optimization, the physics models do not need to be of high order. However, the architecture of the simulator is critical, and herein lies the novel aspects of this work. The simulator is implemented according to accepted software engineering principles. This is necessary to support control system design requirements of an operational machine. It must be maintainable, have strict data interfaces, and operate in a real-time fashion. Moreover, the design of the simulator is sufficiently robust to support several different simulation types with the same engine. We currently support single-particle, multiple-particle, and rms envelope simulation on the same platform.

* Work supported by the U.S. Department of Energy.

FPAG034 Monte-Carlo Simulation Module for LIDOS.RFQ.Designer Code

Igor Shumakov, Alexander Durkin (Moscow Radiotechnical Institute)

New module for LIDOS.RFQ.Designer code is presented. LIDOS.RFQ.Designer code package was designed for parameter choice and full-scale beam dynamics calculations in RFQ linac. "Monte-Carlo simulation" module in addition to "Advisor", "Vane Real Shape" and "Beam Simulation" modules makes it possible to estimate channel sensitivity to various types of random perturbations (electrode modulation, aperture radius deviations, section displacement, etc.) and define manufacturing and assembling tolerances. Results of Monte-Carlo simulations of RFQ accelerator are presented as example.

FPAG035 Template Potentials Technique with Fully-Parameterized Field Solver for High-Current Beams Simulation

Leonid Vorobiev, Richard York (National Superconducting Cyclotron Laboratory)

A three-dimensional (3D) particle-in-cell (PIC) code based on template potential concept [L.G.Vorobiev, R.C.York, PAC 2001, Chicago, June 2001, pp. 3075-3077 and L.G.Vorobiev, R.C.York, EPAC 2002, Paris, June 2002, pp. 1679-1681] has been upgraded by inclusion of a fully parameterized model for 3D space charge forces calculations. The dynamics of a 3D intense bunched beam was studied for FODO channels having a conducting chamber with an arbitrary elliptical symmetry. Our simulation results were in a good agreement with conventional 3D PIC models, but were obtained with ten to one hundred shorter computational times.

* Work supported by Michigan State University.

FPAG036 On-Line Model of the SNS Medium Energy Beam Transport Line

Alexander Aleksandrov (ORNL), Victor Alexandrov (Branch of INP, Protvino)

An on-line model of the beam dynamics in the SNS Medium Energy Beam Transport line (MEBT) has been developed using MATLAB Graphics User Interface. The model performs beam simulation using TRACE-3D and/or PARMILA codes. The input data for the simulation

are generated on-line using settings of the transport line elements read from the EPICS control system. Simulated beam profiles are compared with wire scanner measurements on-line. Various tools are provided for estimating and fitting input beam parameters, which are not measured in the MEBT. This paper provides a description of the model and presents results of experimental tests during commissioning of the SNS Front End.

* SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy. SNS is a partnership of six national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge.

FPAG037 Linear Optic Correction Algorithm in MATLAB

Terebilo Andrei, Gregory Portmann, James Safranek (SLAC), Cristoph Steier (LBNL)

This paper introduces the recent improvements and examples of successful linear optics correction at several storage rings with MATLAB implementation of LOCO algorithm.

* Work supported in part by DOE Contract DE-AC03-76SF00515 and Office of Basic Energy Sciences, Division of Chemical Sciences.

FPAG038 Numerical Evaluation of the Complex Error Function

Andreas Kabel (SLAC)

The complex error function and its relatives (a.k.a. plasma dispersion function, faadeeva function) occur in many applications in computational physics. In accelerator physics, it is related to the strong-weak beam-beam kick due to a gaussian bunch. The evaluation speed and accuracy of an algorithm implementing the complex error function is crucial for the performance of a tracking code such as the one presented in [A. Kabel, Numerical Simulations of the Lifetime of Hadron Beams in the Presence of Parasitic Weak-Strong Beam-Beam Interactions, this conference]. We present a survey of algorithms for the evaluation of the complex error function. Benchmarks results for their speeds and accuracies on different machines will be given. We gauge the speed/accuracy tradeoff for these algorithms by evaluating the multipole content of error terms for different accuracies.

* Supported by Department of Energy contract DE-AC03-76SF00515.

FPAG039 Coherent Synchrotron Radiation Simulations with TraFiC4 v2.0

Andreas Kabel (SLAC)

Coherent Synchrotron Radiation (CSR) plays an important role in the design of accelerator components with high peak currents and small bending radii, such as magnetic bunch compressors, wigglers, and compact storage rings. The code TraFiC4 has been developed to design such elements; it simulates CSR effects from first principles. We present a re-write of the tracking and user interface components of TraFiC4. Extensions and corrections include: expanded input language; generalized bunch populations (rectangular, gaussian, user-specified function); choice of standardized output formats; new element types (such as generalized multipoles); true three-dimensionality (i.e., the restriction to a single plane of motion has been abandoned), vastly expanded documentation; documented C++ class interface; improved dynamic load-balancing for parallel computers.

* Supported by Department of Energy contract DE-AC03-76SF00515.

FPAG040 Metaprogramming Techniques for Accelerator Physics Simulation

Andreas Kabel (SLAC)

One of the programming paradigms supported by the C++ programming language is generic programming. Originally created for the support of parametrized data types for container/iterator classes and algorithms as used by the C++ Standard Template Library, C++'s template mechanisms actually realizes a complete metaprogramming language. It can be used to formulate generic algorithms for a wide variety of data types, dimension numbers etc., which still exhibit the performance of hand-optimized code for a special case. We will look at performance and implementation issues of several applications of metaprogramming techniques in computational accelerator physics, among them; mimimal overhead algorithms for truncated power series algebra; optimized sparse-matrix support in particle tracking applications; and a library for the for compile-time checking of dimensional correctness of algorithms.

* Supported by Department of Energy contract DE-AC03-76SF00515.

FPAG041 Numerical Simulations of the Lifetime of Hadron Beams in the Presence of Parasitic Weak-Strong Beam-Beam Interaction

Andreas Kabel (SLAC)

The usual approach to predict particle loss in storage rings in the presence of nonlinearities consists in the determination of the dynamic aperture of the machine. This method, however, will not directly predict the lifetimes of beams. We have developed a code which can, by parallelization and careful speed optimization, predict lifetimes in the presence of ~100 parasitic beam-beam crossings by tracking >10^10 particles*turns. An application of this code to the anti-proton lifetime in the Tevatron at injection is discussed.

* Supported by Department of Energy contract DE-AC03-76SF00515.

FPAG042 Parallel Numerical Simulations of the Three-Dimensional Strong/Strong Beam-Beam Interaction

Andreas Kabel (SLAC)

The strong-strong beam-beam interaction is one of the effects limiting the luminosity of colliding storage rings. We have developed a particle-on-grid simulation code which allows the utilization of hundreds of processors with almost linear performance behavior for the simulation of machines with small synchrotron tune; this makes a full three-dimensional treatment of the problem possible. We present typical simulations results and possible applications to machines such as PEP II.

* Supported by Department of Energy contract DE-AC03-76SF00515.

FPAG043 Code Comparison for Simulations of Photo-Injectors

Cecile Limborg, Yuri Batygin (SLAC), Jean-Paul Carneiro (DESY), Luca Giannessi, M. Quattromini, C. Ronsivalle (Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente), Manuela Boscolo, Massimo Ferrario, Valeria Fusco (INFN)

RF photo-cathode injectors constitute one of the key component of many future single pass FEL based synchrotron radiation sources. The possibility of reaching very high brightness beams had been anticipated by using various simulations tools. Several experiments have proven that the 1mm.mrad normalized projected emittance for 1 nC, 10 ps pulses is within reach. For optimizing these photo-injectors, a first search of parameters is efficiently performed with HOMDYN. Further refinement in the tuning is usually obtained using a multi-particle tracking code such as ASTRA, PARMELA and TREDI. The best optimization can then finally to be run using a PIC code such as BEAMPATH. In this paper, we compare results from HOMDYN, ASTRA, PARMELA, TREDI and BEAMPATH for the cases of an L-Band photo-injector and an S-Band photo-injector. Limitations in their accuracy and differences between the codes are discussed.

* Work supported by Department of Energy contract DE-AC03-76SF00515.

FPAG044 Direct Wakefield Calculations for Long, Complex Accelerator Structures

Cho Ng, Guetz Adam, Lixin Ge, Kwok Ko, Zenghai Li, Michael Wolf (SLAC)

Tau3p is a time-domain electromagnetic code capable of modeling small bunches in long, complex accelerator structures through the use of unstructured grid for conformal meshing and parallel processing for significant increase in memory plus computational speedup. Such a tool can be more accurate and efficient than existing codes especially in simulating geometries with slowly varying cross-sections. We will present Tau3P calculations on an entire tapered linac structure including both input and output couplers to obtain the higher band contributions to the transverse wakefields.

* Work supported by the US Department of Energy contract DE-AC03-76SF00515.

FPAG045 A New Approach to Single-Pass Coherent Synchrotron Radiation

Robert Warnock (SLAC)

Fourier analysis of fields and sources in space-time has been useful in determining the collective force from coherent synchrotron radiation (CSR), in the idealized case of particles revolving on a circular orbit. In contrast to the space-time approach based on Lienard-Wiechert theory, one avoids nonlinear retarded time evaluations and integrals over singularities. Moreover, it is easier to account for shielding by the vacuum chamber, in various models. This study attempts to gain these advantages for single-pass CSR, for instance in a chicane bunch compressor. The Fourier transform (FT) is on spatial variables only. The chamber is modeled by infinite parallel plates. Fourier components of fields are obtained as solutions of a driven harmonic oscillator equation, thus as time integrals over FT's of charge/current. In the inverse FT to retrieve the fields in space-time, one encounters fast oscillations in wave number integrals. To handle these oscillations it is useful to reverse the order of time and wave number integrals. Then for sufficiently remote times the wave number integral can be done analytically, by the method of stationary phase. For recent times that integral can be done by usual numerical quadrature, respecting the Nyquist criterion. The prospects for a fast and robust calculation of the CSR force will be evaluated through key numerical experiments.

* Research supported in part by DOE contract DE-AC03-76SF00515.

FPAG046 Art++ Model Server at Jefferson Lab

Yves Roblin (Thomas Jefferson National Accelerator Facility)

A beam physics model server (Art++) has been developed for the superconducting, recirculating continuous electron beam accelerator at Jefferson Lab. Its purpose is to grant access to both static (machine lattice parameters) and dynamic (actual machine settings) data for high level beam applications. A set of useful optics calculations (R-Matrix, orbit fits, twiss calculations, etc.) has also been implemented. A good model of the accelerator is essential for processes such as automated beam steering, beam transport matching and generic PID locks. Frequent reconfiguration over a large dynamic range and the difficulty of measuring detailed beam dynamics in such an open-ended system are challenges that one must face when developing such a model. Strategies for evolving and improving the model in the presence of these and other unique characteristics will be discussed.

* This work supported by the Department of Energy under contract DE-AC05-84ER40150.

FPAG047 Modeling Plasma Wakefield Acceleration Using QuickPIC

Chengkun Huang, B. Blue, R. Chuang, C. Clayton, C. Joshi, W. Lu, K. Marsh, W. Mori (University of California, Los Angeles), F. Decker, M. Hogan, R. Iverson, C. O'Connell, R. Siemann, D. Walz (SLAC), T. Katsouleas, P. Muggli (University of Southern California)

We are in the process of developing a new parallel, quasi-static PIC code to study the plasma wakefield acceleration (PWFA) in the so-called blow-out regime. In this regime, plasma responses non-linearly to the drive beam and creates a large amplitude wakefield which can be used to accelerate high energy particles. Full-scale PIC simulations are crucial for understanding the physics in this regime, but require huge computation power. In this paper, we will discuss the applicability of the reduced quasi-static description, and provide the full quasi-static model for plasma wakefield acceleration and an implementation of it. We will report the latest development of the full quasi-static code QuickPIC. Benchmarking results show that QuickPIC produces results in good agreements with those from full electromagnetic code OSIRIS and runs much faster. Simulation results for PWFA in the highly non-linear regime, positron drive beam and hosing instability will also be presented.

* Work supported by DOE, NSF, and LLNL.

FPAG048 Improved Truncated Power Series Algebra Implementation for MAD9

Dan Abell, David Bruhwiler (Tech-X Corporation), J. Scott Berg (BNL)

Truncated power series algebras (TPSAs) are an important analysis tool used in many modern accelerator design codes. We have modified the TPSA routines in MAD9 [F.C.Iselin, et al., Proc. EPAC 2000, p.1042] to achieve two goals: (i) implement the correct handling of truncation order under certain operations (integration, for example) by creating an appropriate structure that does this transparently; (ii) improve the performance of the TPSA algorithms. We describe a structure that allows one to transparently manipulate truncation orders for all operations. We also present a comparison of the performance of different algorithms for performing TPSA operations, and compare the performance of the resulting optimal algorithms to that of other accelerator codes.

FPAG049 Analysis of Large Energy Acceptance Lattices Using MAD9

Dan Abell (Tech-X Corporation), J. Scott Berg (BNL)

There has been significant recent interest in lattices with exceedingly large energy acceptances (a factor of two or more in energy). Such lattices are useful for muon cooling and for acceleration (FFAGs). One difficulty in studying such lattices is that most computer codes do not analyze them to a high degree of accuracy over such a large range of energies. In this paper we apply the recently upgraded MAD9 [F.C.Iselin, Proc. EPAC 2000, p.1042] to an example lattice and accurately compute closed orbits, as well as lattice parameters about those closed orbits, for a large range of energies. We also perform the same calculation for a beamline whose exact solution is known analytically.

FPAG050 Simulation of Particle Dynamics in Accelerators Using the Ensemble Model

Wolfgang Ackermann, Mikhail Krassilnikov, Thomas Weiland (Technische U. Darmstadt), Wolfgang Beinhauer, Hans-Dieter Graef, Achim Richter (IKP, TU Darmstadt)

In beam dynamics simulation a particle beam is usually considered as a set of numerous macroparticles. As each macroparticle is described by six phase space coordinates an enormous amount of computational effort has to be performed for accurate studies. In order to reduce simulation time an ensemble model which also considers the motion of individual particles inside the regarded subspace is introduced. This so-called ensemble model is derived from Vlasov equation and includes the average values of coordinate and momentum

as well as the second-order correlation parameters. Therefore the number of involved macroparticles can be reduced significantly. Based on the ensemble model the V-Code was developed to perform fast and accurate calculations for complete accelerator simulations. Its database was initially designed for the TESLA Test Facility accelerator component description but has been modified to fit also the requirements of S-DALINAC injector simulations. In a further step the object-oriented code has been successfully extended to enable the simulation of recirculation. In this paper the results for the beam simulation at S-DALINAC will be presented.

* Work supported by Graduiertenkolleg "Physik und Technik von Beschleunigern."

FPAG051 Periodic Boundary Conditions in the Parallel Eigensolver OM3P: Application of the Inexact Lanczos Process to Hermitian Systems

John F. DeFord, Ben Held (Simulation Technology & Applied Research, Inc.)

This paper details the development of periodic boundary condition support in the parallel finite-element eigensolver OM3P. OM3P is based on the inexact Lanczos/JOCC hybrid method, and it uses the vector-scalar (A-V) basis set that has previously been shown to dramatically reduce the computational requirements of the method. We will discuss the parallel implementation challanges, including proper handling of problem partitioning/load balancing for periodic problems. The use of A-V basis introduces additional difficulties in the parallel domain, and we will show solutions to these problems as well omega-beta diagrams for the RDDS structure generated on a modest computer cluster using the software.

FPAG052 Particle and Photon Ray Tracing with Emission Processes and Space Charge Effects

Daniel Gordon, Bahman Hafizi (Icarus Research Inc.)

A software package has been developed which offers 3D ray tracing for both charged particles and photons within one unified framework. This object oriented program allows the user to interactively and visually place sources, optics, and detectors anywhere in a three dimensional space. A model for Cherenkov and transition radiation is included so that charged particles interacting with a medium may emit photons. In addition, a 3D Poisson solver with vacuum boundary conditions is used to provide a sophisticated space charge model.

* This work was supported by a Department of Energy Small Business Innovation and Research grant. D.F. Gordon is currently with the Naval Research Laboratory.

FPAG053 Simulation Tools for High-Intensity Radiographic Diodes

Stanley Humphries (Field Precision), James McCarrick, Ted Orzechowski (LLNL)

Trak is a 2D ray-tracing code that employs finite-element techniques on a conformal mesh. We describe new code features for simulating small diodes for pulsed radiography. Trak includes an advanced method of current deposition on the electric-field mesh to find beam-generated magnetic fields. The method handles current flow on internal conductors and reflex orbits. Effects of ion backflow and electron backscatter are also included. We are presently creating a unified radiography package combining elements of the Integrated Tiger Series of electron-photon Monte Carlo codes with the finite-element structure of Trak. To begin we generated standard ITS programs compatible with Windows 32 and Linux, streamlined the command set and added the option for direct input of Trak electron files. In the second stage we shall modify the Monte Carlo codes to obtain geometric information directly from the finite-element mesh. The third stage goals are to include the effects of calculated E and/or B fields on electrons in the cascade and to determine radiation deposition in the mesh elements. This capability will enable sophisticated post-analysis of dose distributions and imaging properties.

* This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

FPAG054 A 3D Finite Element Trajectory Code with Adaptive Meshing

Lawrence Ives, Bui Thuc, William Vogler (Calabazas Creek Research, Inc.), Dibyendu Datta, Jean-Francois Remacle, Mark Shephard (Rensselaer Polytechnic Institute), Mark Beal, Ottmar Klaas (Simmetrix Corporation)

Development of the next generation of RF devices is in progress with on-going research on sheet beam and multiple beam devices. Analysis of these inherently three dimensional devices requires a new set of analytical tools to model the electron beams under the influence of quasi-static electric and magnetic fields. Calabazas Creek Research, Inc. is funded by the U.S. Department of Energy to develop a finite element, charged particle analysis code suitable for the next generation of RF devices. The program allows geometrical input from standard CAD programs generating ACIS or ParaSolid output files. Attribute information is provided through a Graphical User Interface between the CAD program and the solver. With adaptive meshing, no mesh input is required for problem setup. The program automatically adjusts the mesh size, both refining and coarsening, based on error criteria set by the user. This dramatically simplifies problem setup and minimizes computational requirements, allowing modeling of complex, 3D problems on standard desktop or laptop computers. Basic code structure and sample simulations will be presented.

* Work supported by U.S. Department of energy under contract DE-FG03-02ER82966.

FPAG055 Conformal Modelling of Emission Processes from Arbitrary Curved Surfaces in Charged Particle Simulations

Thomas Lau, Erion Gjonaj, Thomas Weiland (Technische U. Darmstadt)

The reliability of Particle-In-Cell Simulations often depends on the accuracy of field and charge characterization at emission boundaries. In this work a novel approach to the modelling of curved boundaries in 3D-PIC simulations is presented. The method is based on a boundary-conformal discretization of the field equations providing for high accuracy field solutions, while retaining the efficiency of conventional discretization schemes with rectilinear meshes. Implementations of the model for static and fully time-dependend fields will be presented. In order to obtain accurate initial conditions for the phase space sampling in the PIC simulator, the interaction of particles with geometry boundaries during primary and secondary emission processes is modeled using a local triangular description of the emission surfaces. The efficiency of the method is shown in a parameter study of an electron gun.

* Work supported by DESY.

FPAG056 Emittance Dilution due to Three Dimensional Perturbations in RF Photoinjectors

Marcello Quattromini, Riccardo Bartolini, Luca Giannessi, Concetta Ronsivalle (Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente), Emanuela Boscolo, Massimo Ferrario, Valeria Fusco, Luca Serafini, Cristina Vaccarezza (INFN)

The predictions from different simulation codes are compared to investigate the effects of non axis-symmetric conditions, e.g. dishomogeneities in cathode's quantum efficiency and other sources of braking of axial symmetry in the performances of a typical RF

photoinjector. The layout includes a RF gun and a focusing solenoid in a configuration aimed at minimizing the emittance growth due to space charge effects.

FPAG057 Simulation of Dark Currents in a FEL RF-Gun

Stefan Setzer, Mikhail Krassilnikov, Thomas Weiland (Technische U. Darmstadt)

Dark currents caused by field emission are dramatically limiting the lifetime of photocathodes used in RF-guns needed for successful FEL operation. Due to the mismatch of the dark current electrons to the transport channel they are also a serious hazard to beam diagnostic systems an may cause severe radiation damage. In the past high dark currents emitted from the laser driven RF-guns have been observed during substantial time of linac operation. For a better understanding of the dark current dynamics the transport through the injector part of the PITZ accelerator has been investigated with the help of an appropriate tracking algorithm. Additionally, potential emission spots inside the rf-gun have been located by RF field mapping. Furthermore, the dependency of the dark current on the accelerating field inside the RF-gun as well as on the strength of the focusing solenoid has been studied.

FPAG058 Investigation of Dark Currents in the S-DALINAC Superconducting Cavitiy

Stefan Setzer, Thomas Weiland (Technische U. Darmstadt), Mykhaylo Gopych, Hans-Dieter Graef, Achim Richter (IKP, TU Darmstadt)

During the operation of the S-DALINAC, light emission associated with field emission on the surface of an RF niobium superconducting cavity has been observed. The optical spectrum of the ligth spots has been measured by a photomultiplier using a set of filters. The obtained spectral density distribution is close to the black body radition spectrum. In order to determine the maximum energy of the dark current electrons, measurements of bremstrahlung spectra at the beam line exit of the accelerator have been carried out. For the interpretation of these data, electron trajectory simulations based on field distributions calculated by MAFIA have been performed. Additonally, the behaviour of dark currents in dependence on the resonance frequency and accelrating field have been investigated by means of numerical calculations for TESLA as well as S-DALINAC cavities.

FPAG059 Computational Modules for Secondary Electron Effects

Peter Stoltz (Tech-X Corporation), Ron Cohen, Miguel Furman, Art Molvik, Jean-Luc Vay (LBNL)

Electron effects in the High Current Experiment are studied via computer simulation. An approximate expression for the secondary electron yield for a potassium ion striking stainless steel is derived and compared with experimental results. This estimate gives a peak of ~160 electrons at normal incidence at 60 MeV. The secondary electron yield is combined with a numerical simulation of the HCX ion beam dynamics to obtain an estimate for the number of stray electrons expected in the HCX. This estimate is that aproximately 1000 electrons per ion collision may result in the HCX. Magnetic insulation is shown to reduce the fraction of the electrons that reach the beam.

* This work is funded by an SBIR grant from the Department of Energy Office of Fusion Energy Science.

Session FOPL: Closing Plenary
Grand Ballroom at 13:30
Session Chair: E.P. Lee (Co-Program Chair)

FOPL001 Technology Options for Linear Colliders

Gerald Dugan (Cornell University)

The worldwide high-energy physics community has come to a consensus that an electron-positron linear collider, with an initial center-of-mass energy of around 500 GeV, should be the next energy frontier accelerator. It is recommended that this machine be constructed and operated as an international project, with resources provided by the international partners. Several technical options, pioneered in different parts of the world, exist for the machine's realization. Choices from among these options are required in the near future. This paper will review the technical highlights of the options, and discuss the considerations that will inform the choices.

* This research is supported by the National Science Foundation under award NSF PHY-9809799.

FOPL002 Roles for Accelerator Technology in Homeland Security

Donald Prosnitz (LLNL)

Protecting the United States from the covert delivery of weapons of mass destruction will require innovation and imagination. New technologies and creative applications of existing technologies will be necessary to defeat the threat posed by transnational terrorist organizations. Accelerator instrumentation and techniques—from data archiving and data mining to radiation detection and trace element analysis—can all be applied to the homeland security mission, but success can only be achieved if scientists and operational personal fully understand each other's needs, capabilities, and limitations. This presentation will describe legal, policy and operational requirements of the homeland security mission with the goal of stimulating the creative use of the accelerator community's knowledge and expertise.

FOPL003 Opportunities for Accelerators in Nanoscience

Charles Shank (LBNL)

The rapidly evolving field of nancscience concerns the creation of new materials an atom at a time. Electrons, photons and ions will all play an important role in the manipulation and analysis of nanostructures. This talk will discuss the role of accelerator techniques in advancing the field nanoscience.

* Work supported by the Director, Office of Energy Research, of the U.S. Department of Energy (DOE) under Contract No. DE-AC03-76SF00098.

FOPL004 Evolution of Light Sources

Yves Petroff (ESRF & LBNL)

Third generation synchrotron radiation sources have opened new possibilities in many areas: imaging, hard X-ray inelastic scattering, high pressure physics, magnetism. Until today there have been rather few time resolved experiments. However, if one tries to understand the physics of a phase transition or magnetism in nanostructures, the time parameter is fundamental, as the condition to combine diffraction and spectroscopy experiments. This will be illustrated by a few recent results. In the last part of my talk I will discuss the characteristics of the new fs sources that are possible in soft and hard X-rays.

* Supported by the Director, Office of Energy Research, of the U.S. Department of Energy under contract no. DE-AC03-76SF00098.

Abbott, Steve: MOPB008
Abell, Dan (Tech-X): RPAG045, FPAG048, FPAG049
Abell, Dan (BNL): MPPG023
Aberle, Olivier: MPPB024
Abeyta, O.: ROAC008
Ablett, J.: TOPA007
Abo-Bakr, Michael: MPPB006, RPPB005, RPPB006
Abrahamyan, K.: WPAB034
Ackermann, Wolfgang: FPAG050
Adachi, Toshikazu: MPPE008, WPAB059
Adam, Guetz: FPAG044
Adams, Dean: TPAG043
Adelmann, Andreas: FPAG030, FPAG031
Adolphsen, Christopher: TPAB031, WPAG027, RPAB016, RPAB026, ROPC006, ROPC008, ROPC011
Aghasyan, Mher: MPPE018
Ahle, Larry: MPPB080
Ahrens, Leif A.: MOPA009, TPPE001, TPPE003, TPPB007, TPPB030, TPPB038, TPPB043, TPPB047, WOAB008, WPAE031, WPPE034, WPPB012, RPAG008
Aiba, Masamitsu (KEK): TPPB028, FPAB062, FPAB081
Aiba, Masamitsu (UTO): FPAB082
Ajima, Yasuo: WPAE019
Akai, Kazunori: WOAA006
Akemoto, Mitsuo: TPAE004
Akimov, Alexandre: TPAE035
Akimov, Valentin: MPPE001, TPAE035
Akiyama, Atsuyoshi: WPPE012
Akiyoshi, Yamamoto: FPAB017
Akre, Ron: WPAB028, WPAG010
Al-Khateeb, Ahmed: WPPG007
Alberto, Renieri: MPPB061
Albrecht, Clemens: ROAA003
Alduino, James: WPAB046, WPAB052
Aleksandrov, Alexander: MOPB002, TPAG041, WPPG054, FPAG036
Alekseev, Igor G.: WPPG046
Alesini, David: WOAA008, WPAB019, WPAG008, WPPB041, RPAB009
Alessandria, Franco: WPAB019
Alessi, James G.: MOPB009, TPPB006, TPPB047, RPAB031, FPAB001
Alex, Murokh: WPPB071
Alexahin, Yuri: TPPB059, TPPB068
Alexandrov, Victor: FPAG036
Allen, Chris: WPPE015
Allen, Christopher: FPAG033
Allen, Matt: FOAB001
Allison, Trent: TPAB081, TPAG026, WPPE026
Altmark, A.: TPPG041, TPPG042, TPPG043, TPPG044
Alton, Gerald D.: MPPB084, MPPB085, MPPB086
Ambrosio, Giorgio: TOAB010, WPAE013, WPAE014
Amemiya, Kensuke: MOPB005
Amemiya, Yoshiyuki: ROAB011
Ames, Friedhelm: RPAB066
Ammigan, Kavin: TPAG013
Amundson, James: RPPG009
Anami, Shozo: TPAG035
Anders, Andre: TOAA001, WPPG014
Anders, Wolfgang: TPAB004
Anderson, John: TPPB013
Anderson, Richard: WPPE033
Anderson, Scott: MOPB011, MPPB020, WPAB037, RPAG032
Andersson, Ake: WPAG024, WPAG025, WPAG026
Ando, L.: MOPB007
Andonian, Gerard: MPPB057, MPPB058, WPAB030, WPAB031
Andreev, Nikolai: TOAB010, WPAE013, WPAE014
Andrei, Terebilo: WPAB089, WPPE020, WPPE021, RPPG021, FPAG037
Andreoli, Stefano: ROAA004
Andresen, Nord: MPPB018
Anerella, Michael: TOAB006, WPAE001, WPAE004, WPAB054
Anferov, Vladimir: TPPE009, FOAA003
Ang, Zhengting: TPAB040
Anghel, Alexander: MPPB024
Angoletta, Maria-Elena: WPPB023
Ankenbrandt, Chuck: RPAG017
Annala, Gerald: TPPB055, TPPB057, TPPB061, TPPB067, WPAE016, RPPB021, FPAB031, FPAB033
Antokhin, Evgeny: WPAB069
Ao, Hiroyuki: RPAB046
Aoki, Nobutada: ROAB011
Aoki, Tsuyoshi: WPPB064
Aoyama, T.: FPAB087
Arai, Shigeaki: TPAG035
Arakida, Yoshio: TPAG037, TPPB079, TPPB093
Archuletta, Steven: TPAE005
Arduini, Gianluigi: TOPC003, TPPB050, TPPB054, WPAB084, RPPB011
Arkan, Tug: TPAB013
Arnold, Ned D: WPPE001
Artoos, Kurt: TPAG007
Aryshev, Alexander: WPPG055
Asano, Hiroyuki: TPAB062
Asano, Yoshihiro: MPPE020
Aseev, Vladislav: RPAB068
Ashmanskas, Bill: TOPD003
Asiri, Fred: RPAB011
Assadi, Saeed: TPAG041, TPPE011, WPPG054, ROAB001
Assmann, Ralph: MOPA007, TPPB010, TPPB051, ROPC005, FPAG013
Audebert, Patrick: ROAC002, FOAB001
Auerbach, David: TPPG015, WPPB053, FOAB003
Autin, Bruno: MPPG032, WOAD005
Averboukh, I.I.: MPPG028
Avilov, Alexander: TPPE035
Ayvazyan, Valeri: WPPE009, RPAB005
Ayzatsky, M.I.: TPAE014, FPAB008
Ayzatsky, Mykola: TPPE029, WPAB025, RPAB070, RPAG037
Baartman, Rick: TPPE014, FPAB014
Baba, H.: MPPB046, TPAE037
Baba, Hitoshi: FPAB022
Babin, V.: MPPG021
Baboi, Nicoleta: MPPG035, TPAB030, TPAB034, ROAA003
Babzien, Marcus: TPPG048, WPAB032
Baca, David: TOPC004, ROAC001, FPAB005
Bacci, Alberto: WPAB019, FPAG026
Bäcker, Hans-Jürgen: MPPB005
Badea, S. Viorel: WPAB046, WPAB052
Bae, Youngsoon: WPPB059
Baggett, Kenneth: WPAB064, WPAB066
Baglin, Vincent: TOPC003
Bähr, J.: WPAB034
Bahrdt, Johannes: MPPB005
Bai, Mei: MOPA009, MOPA010, TPPB038, TPPB043, WOAB008, WPAB072, WPAB073, RPAG008
Bailey, James: TPPB026
Baishev, Igor: MOPA007, FPAG013
Bajko, Marta: WPAE005
Bak, Peter: TPAE035
Bakker, Rene: TOAC011
Balbekov, Valeri: TPPB066, WPAE032, WPAE033
Balkcum, Adam: TPAE029
Ball, Millicent: WPAE025
Balleyguier, Pascal: WPAB010, WPPB022
Bandelmann, Rüdiger: ROAA003
Bandura, L.: WPAE026
Bane, Karl: TOAA008, RPAG043, RPPB054, RPPB055, RPPG035
Banna, Samer: TPPG036, FOAB006, FOAB009
Bao, Xun: WPPE014
Baogen, Sun: WPPB058
Baptiste, Kenneth (LBNL): MPPB018, TPAB023
Baptiste, Kenneth (LLNL): TPAB027
Barber, Desmond P.: WOAA010
Baril, Marcel: RPAG010
Barletta, W.A.: MPPB048, TOAC003, WPPB001
Barlow, David: TPPB019, TPPB020
Barnard, John J.: TPAG040, WPPG018, WPPG029
Barnes, Christopher: TPAG044, TPPG025, WPAB026, FOAB008
Barnes, Michael: TPAE036
Barnes, Phil: TPAB049, TPAB054
Barni, Danilo: TPAB063, TPAG034
Barov, Nick: TPPG033, TPPG037, WPPG039
Barr, D.: WPPB046
Barr, Gilles: WPAE022
Barry, W.: TOAC003, WPPB001
Barstow, Buz: TPAB052, TPAB053
Bartolini, Riccardo: MPPB044, TOPA008, WPAB018, FPAG056
Barton, Donald: TPPB006
Barty, Christopher: MOPB011, MPPB020
Barzi, Emanuela: TOAB010, WPAE013
Basak, Tushima: TPAG046
Bashmakov, Yuriy: TPPB021, TPPB022

Baskiewicz, Michael: TOPC002
Batchelor, Ken: ROAC003
Batrakov, A.: TOPA012
Batygin, Y.K.: RPAB012, RPAB020, FPAG043
Baudrenghien, Philippe: TPPB050, RPPB015
Bauer, Pierre: MPPE026, TPPB055, WPAE016, FPAB031
Bauer, Stefan: TPAB090, RPAB073
Baum, Dennis: WPPB051
Baynham, D. Elwyn: WPAE022
Bazarov, Ivan: MPPB009, MPPB011, TPAB009, TPAB052, TPAB054, WPAB013
Beal, Mark: FPAG054
Beard, K.: TOAC006
Beard, Kevin: TOPD006
Beaudoin, Brian: WOAC006, WPAG020, WPPB073
Beauvais, Pierre-Yves: TPAG032, FPAB020
Beche, Jean-Francois: WPPB052
Bechstedt, Ulf: TPAB010, RPAB037, ROPA009, FPAB069
Bechtold, Alexander: MPPG024
Beck, M.: WPAB064, WPAB066
Beckert, Karl: WOAD002
Beckman, Liane: FPAB042
Beczek, Kevin: WPAB004
Beebe, Edward: MOPB009
Beebe-Wang, Joanne: MOPA009, MPPG022, TPPB043, WPPE004
Beinhauer, Wolfgang: FPAG050
Belgroune, Mahdia: MPPB034
Bellantoni, Leo: TPAB058
Bellavia, Steven: TPPE001, TPPB005, WPPB018
Beller, Peter: WOAD002
Bellesia, Boris: WPAE017
Bellucci, Stefano: MPPB045, MPPB079
Beloglasov, Volodymyr: RPAB070
Belomestnykh, Sergey: TPAB008, TPAB009, TPAB048, TPAB052, TPAB054, TPAB055, TPAB056, TPAB090, TPAG008, FPAB027
Beltran, Chris: TOPD004, RPPB034
Bender, H.: ROAC008
Benedetti, Gabriele: WOAA008, WPAG008, RPAG025
Benedikt, Michael: TPPE004
Benjamin, J.: TPPB047
Ben-Zvi, Ilan: MOPA005, MOPB010, MPPB057, TPAB046, TPPG048, WPAE028, WPPB072, RPAG009, RPAG045, FOAB010
Berenc, Tim: TPAB059
Berg, J. Scott: TPPB092, TPPG003, WPAE027, WPAB074, WPAB075, WPAB076, WPAB077, FPAB062, FPAG010, FPAG048, FPAG049
Berg, Steven: TPAG001, TPAG003, WPAB001, WPAB004
Berg, William J.: WPPB004, WPPB005
Bergquist, Marlene: WPAG025
Berio, Robert: MPPB080
Berkaev, Dmitry E.: WOAA010
Berman, L.: TOPA007
Bernal, Sandiago: TPPB027
Bernal, Santiago: TPPB025, WOAC006, WPAG020, WPPB073, WPPB074, WPPB075, WPPG035, WPPG036
Bernardin, John: TPAG017
Bernaudin, Pierre-Emmanuel: RPAB033
Bernstein, Lee: MPPB080
Bertinelli, Francesco: WPAE017
Bertrand, Patrick: RPAB034, FPAG011
Berz, Martin: WPAE034, WPAE035
Bessonov, Eugeni: WPAE012
Betts, Shawn: MOPB011, MPPB020
Bhashyam, Srinivas: WPAE014
Bhat, Chandra: TPPB073, WPPE010, WPPE011, ROAB006, RPPG001
Bhatnagar, Vivek: MPPE036
Bhatt, Ronak: WPPG024
Biagini, Maria E.: WOAA008, WPAG008, RPAG025
Biagini, Marica: MPPB044, WPAB018
Biallas, George: WPAB041, WPAB045, WPAB064, WPAB065, WPAB066
Biarrotte, Jean-Luc: TPAB047, RPAB034, RPAB045
Biasci, Jean-Claude: MPPB013
Biedron, Sandra: MPPB061, WPAB032
Biedron, Sandra Gail: MPPG036
Bieler, Tom: TPAB069
Bieniosek, Frank M.: TPAG039, TOPB006, TOPC004, WPPB050, ROAC001, FPAB006
Bierwagen, John: TPAB067
Bilheux, Hassima: MPPB085
Billen, James: TPAG017, TPAG038, RPAB052, FPAG029
Biller, Efrem: TPPE029, RPAB070
Billing, Michael: RPPB018
Bin, Qin: TPPE008, FPAG019, FPAG020, FPAG021, FPAG022, FPAG023, FPAG024
Binello, S.: TPPE001
Bini, Simone: MPPB045
Binkley, Morris: WPPB040
Biocca, Alan: FPAB037
Birkholz, William: WPAB052
Biryukov, Valery: MPPB045, MPPB079, TPPB016, TPPB034
Biscardi, R.: TOPA007
Biscari, Caterina: WOAA001, WOAA008, WPAG008, RPAG025, ROPC010
Bishofberger, Kip: MOPA011, TPPB076, TPPB077, TPPB083
Bisognano, J. J.: RPPB062
Biswas, Bhaskar: TPAG046
Bjorklund, Eric: WPPE013
Black, Edgar L.: TPPG013, WPAE026
Blair, Grahame: RPAB008
Blanco-Vinuela, Enrique: WPAE006
Blasche, Klaus: ROPA006
Blaskiewicz, Michael M.: MOPA010, MPPE025, TOAA011, TPAB007, TOPB004, TPPE011, TPPB043, TPPB047, TPPG003, WOAB005, WPPB015, WPPG003, WPPG004, WPPG048, ROAA006, RPPB007, RPPB008, RPPB009, RPPB010, FPAB026, FPAB039, FPAB066
Blazevics, A: FOAB001
Blind, Barbara: TPPB019, TPPB020, RPAG028
Bliss, Neil: MPPG008, MPPG009
Blokland, Willem: TPAG041, WPPB038, WPPG054
Blomqvist, Ingvar: TOPA001
Blue, B.E.: TPPG030, TPPG031, TPPG050, TPPG051, RPPG037, FOAB008, FOAB011, FPAG047
Bluem, Hans: MOPB010, MPPB075
Bocchetta, C.J.: TOAC011
Boege, Michael: TOPB010, FPAB041
Boffo, Cristian: TPAB013
Bogacz, A.: TOAC006
Bogard, Daniel: FPAB020
Bogdanov, Alexandre: RPAB039, RPAB040
Boggia, Antonio: FPAB013
Bohl, Thomas: TPPB050, RPPB015
Bohlen, Heinz: TPAE029
Bohn, Courtlandt: WPPG037, WPPG039
Bohnet, I.: WPAB034
Boilot, Didier: TPAB057
Boimelshtein, Youry: FPAB013
Boine-Frankenheim, Oliver: WPPG007, ROPA006
Boller, Klaus: TPPG045, TPPG046
Bollinger, D.: TPPG037
Bolme, Gerald: TPAE005
Bolton, Paul: WPAB027, WPPB029, WPPG055
Bolton, Paul.R.: RPPG022
Bondarenco, Nikolai: FPAB018
Bongardt, Klaus: TPAG042
Bongers, Henning: RPAB067
Bongers, Norbert: TPAB010, ROPA009
Boni, Roberto: WOAA008, WPAG008, RPAB009
Bookwalter, Valerie: TPAG029
Booth, Rex: MOPB011, MPPB020
Borburgh, Jan: TPPB008
Borchard, Philipp: TPAE016, TPAE018
Borden, Michael J.: WPPB049, ROAB003, RPPB035, FPAB083
Bordry, Frederick: WPAE006
Boriskin, V.N.: TPAE014, WPPB045, RPAB070, FPAB008
Borissov, Evgueni: TPAB013
Borland, Michael: TOPA010, TOPB008, WPPE002, WPPB004, WPPB005, RPPB059, FPAG001, FPAG004, FPAG005, FPAG006
Borovina, Dan: TPAE039
Bosch, Robert: MPPB027, MPPB052, MPPB053, MPPB054, WPPE023, RPPB062
Boscolo, Emanuela: FPAG056
Boscolo, Manuela: MPPB044, WOAA008, WPAB018, WPAG008, RPAG025, FPAG043
Bosland, Pierre: MPPB024, TPAB057
Bosotti, Angelo: TPAB063

Bossert, R.: WPAE015
Bottura, Luca: TOAB009, TPPB055, WPAE006
Bourcey, Nicolas: TPAG007
Bousson, Sebastien: TPAB047
Bowden, Gordon B.: TPAB030, TPAB031
Boyce, James R.: MPPB055, MPPB056
Boyce, Richard: WPAB061
Bozzini, Davide: WPAE006
Bracker, Steve: WPAE027
Bradley III, Joseph: TPAE039, TPAG015
Brajuskovic, Branislav: MPPB003, MPPG001
Braun, Hans: TPAE033, ROAA011, RPAB002
Brautti, Giulio: FPAB013
Bravar, Alessandro: WPPG046
Bravin, Enrico: WPPB024
Bredy, Philippe: MPPB024, TPAB057
Brelsford, B.: TPPE001
Brenann, Mike J.: MOPA009
Brenger, Annette: WPPB028
Brennan, J.M.: MOPA005, TOAA011, TPAB007, TPPE003, TPPB047, TPPB049, WOAB005, ROAA006, RPPB007, RPPB008, RPPB010, FPAB024, FPAB025, FPAB026
Brennan, Michael J.: TPPB043
Bricault, Pierre: TPPB024, WOAD003, FPAB014
Bricker, Steve: TPAB067
Bridges, James: TPAE006
Briggs, Richard: RPPB038
Brinkmann, Arne: TPAB076, TPAB085
Briscoe, Brian: FPAB001
Briscoe, Eldridge: TPPG021
Brodowski, John: TPAB007, TPPB086, WPAB052, WPPB013, WPPG004, WPPG043
Broemmelsiek, Daniel: FPAB070
Bromberek, Dave: TPAG001
Bross, A.: TPAB003
Broste, W.: ROAC008
Browdowski, J.: TPAG005
Browman, Andrew: TOPD004, WPPB049, WPPG031, ROAB003, RPPB034, RPPB035, FPAB083
Brown, B.C.: TPPB072, WPAB057
Brown, K.A.: MPPE004, TPPB047
Brown, Kevin: MOPA009, TPPE001, TPPE002, TPPE003, TPPB005, TPPB006, TPPB043, WPPB012, WPPB018, WPPG003
Brown, Winthrop: MPPB020, MPPB055, WPAB037, RPAG032
Bru, Bernard: RPAB034
Bruening, Oliver: MOPA006, TPPB065
Brugger, Markus: MOPA007, FPAG013
Bruhwiler, David: RPAG045, FOAB005, FOAB012, FPAG048
Brumwell, F.R.: ROPA007
Brunelle, Pascale: MPPB034
Brunner, Olivier: ROAA005
Bruno, Donald: MPPE002, TPPB039, TPPB043
Bruno, Luca: MOPA007
Bukh, Boris: WPPG019, WPPG020
Bulfone, Daniele: FPAB045
Bullard, D.: WPAB064
Bultman, Nathan: TPAG016, TPAG017
Bulyak, Eugene: WPAG021, WPAG022
Bunce, Gerry: WPPG046
Burgazzi, Luciano: TPAG034
Burgmer, Rolf: WPAE007
Burke, D.L.: TPAB031, WPAG027, ROPC009
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Burns, Charles: WPPB047
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Burov, Alexey: RPAG045, RPPB020, RPPB021
Burrows, Philip: RPAB026, ROPC011
Busby, Richard: RPAG045
Busch, Matthew: WPAG006
Bussmann, Michael: TOAA004
Buttig, Hartmut: WPAB007
Büttner, Thorsten: ROAA003
Byer, R.L.: TPPG026, FOAB006
Bylinskii, Iouri: TPAB040
Byrd, J.M.: MPPB016, MPPB018, TOAC003, TPAB023, WPPB001, WPPB053
Cacciotti, Luciano: WPPB028
Cai, Yunhai: TPPB080, WOAA004, WPAG013
Callahan, D. A.: WPPG022
Calvet, Olivier: TPAG007
Calzas-Rodriguez, Camilo: WPAE006
Camas, J.: MOPA012
Cameron, Peter: MOPA010, TOAA011, TPPB041, TPPB043, WOAB005, WPPE034, WPPB013, WPPB014, WPPB015, WPPB016, WPPB017, WPPG004, WPPG042, WPPG043, WPPG047, WPPG048, WPPG050, ROAB009, RPAG007, RPPB007, FPAG009
Campbell, Lora: TPPG048
Campisi, I. E.: RPAB064
Campisi, Isidoro: TPAB075, TPAB077, ROAA001, RPAB065, FPAB086
Campisi, R.: MPPB075
Capatina, Ofelia: TPAG007
Capista, David P.: WPAB057, FPAB076
Caporaso, George: TPPE023, ROAC009, ROAC010
Cappi, Roberto: WOAB003, RPAG011, RPAG012
Carcagno, Ruben: TPAB059
Cardona, Javier: MPPG023, TPPB042, TPPB043, RPAG003
Carey, Dave: TPAG011
Carlier, Etienne: TPPB010
Carlson, C.: TPPB047, ROAC008
Carlsten, Bruce: ROAA012
Carneiro, Jean-Paul: MPPB039, WPAB014, WPAB015, WPAB034, FPAG043
Carr, G.L.: TOPA007
Carr, Gary: WPPE013
Carr, Larry: TPAG030
Carr, R.: RPAB020
Carron, G.: TPAE033
Carter, Harry: TPAB013, TPPG002
Cary, John: RPAG045, RPAG058, FOAB012
Cary, John R.: TPAG047, TPPG010, TPPG011, TPPG039, TPPG052, TPPG053, WPAE040, FOAB005
Caryotakis, George: TPAE026
Casarin, Katia: WPAG019
Casey, B.: TOPA007
Casey, Jeffrey A.: TPAG031, ROAC005
Caspers, Fritz: TPPB090, WPPB026, WPPB078, FPAG007
Caspi, Shlomo: MOPA006, TOAB008, WPAE021
Casse, B.D.F.: TOPA011
Castellano, Michele: WPPB028
Castro, Pedro: MPPG035, TOAC007, ROAA003, RPAB005
Catalan-Lasheras, Nuria (BNL): TPPB086, WPAB048, RPPB007
Catalan-Lasheras, Nuria (CERN): TPAG005, WPAB079, WPPG050
Catani, Luciano: WPPB028
Cattelino, Mark: TPAE029
Caudill, L.: ROAC008
Cederkall, Joakim: RPAB066
Cee, R.: WPAB034
Celata, C.M.: TPAG039, TPAG040, TOPB006, ROAC001
Celona, L.: MOPB007
Cerniglia, Philip: WPPB013, WPPG047
Chacon-Golcher, Edwin: MOPB004, FPAB004, FPAB005
Chae, Yong-Chul: RPPB001, RPPB002, RPPB003, RPPB004
Chambers, Frank: MPPB082, ROAC009, RPAG033
Champion, Mark: TPAG018, FPAB036, FPAB038
Chan, K.C.D.: ROAC008, RPPG016
Chang, C. K.: WPPE024
Chang, C.H.: MPPG015
Chang, Cheng: MPPG014
Chang, H.P.: MPPB028, MPPG015
Chang, Jui-Chi: TPAG023, TPAG024, TPAG025, WPPB066
Chang, L.H.: MPPB029, TPAB073, TPAB074, WPPE025, WPPG034
Chang, S.H.: WPPE038, WPPE039
Chang, Shu-Shen: TPAB074
Chang, Xiangyun: MOPA005, TPAB046, WPAE028
Chao, Alex: TOAA008
Chao, Y.: TOAC006
Chao, Yu-Chiu: TOPB011, RPPG032
Charrier, Jean Pierre: TPAB047
Charruau, Georges: FPAB020
Chase, Brian: TPPE006
Chattopadhyay, S.: TOAC006
Chavanne, Joel: MPPB013, TOPA013
Chazot, Gilles: MPPB012
Cheever, D.: WPAG028

Chel, Stephane: MPPB024, TPAB057
Chen, Alex: ROPB006
Chen, Anshi: WPPB080
Chen, C.T.: MPPB029
Chen, Chiping: TPAB028, TPAB029, WPPG024, WPPG025, RPAG036
Chen, DeZhi: TPPE008, FPAG020, FPAG021, FPAG022, FPAG023, FPAG025
Chen, Hao: TPPE026, TPPE027
Chen, Huaibi: WPAB029, WPAB033, ROAA003
Chen, J.: MPPB028
Chen, J.R.: WPPE039
Chen, Jenny: MPPG015, WPPE024, WPPB065, RPPG029, FPAB043
Chen, Jia-er: WPPB076
Chen, June-Rong: MPPE035, TPAG023, TPAG024, TPAG025, WPPE038, WPPB066
Chen, Liping: WPPE014
Chen, S.: TPPG054
Chen, Yu-Jiuan: WPPG021, ROAC009, RPAG033, RPAG034, RPPG016
Chen, Zukun: RPAB052
Chen-Yao, Liu: MPPE013
Cherbak, Ernest: TPAB001
Chesnokov, Yu.A.: MPPB045, MPPB079, TPPB016, TPPB034
Chestnut, Ronald: WPPE022
Cheung, Harry: WPPB036
Chevtsov, Pavel: WPPB068
Chew, E.P.: TOPA011
Chiadroni, Enrica: MPPB044
Chiang, I Hung: TPPB005, WPPB018
Chiaveri, Enrico: MOPA007, MPPB024, TPAB049, TPAB057
Chiba, Junsei: TPAG035
Chichili, Deepak: TOAB010
Chien, Yuan-Chen: MPPE014
Chiesa, Luisa: TOAB008, WPAE021
Childress, Sam: RPAG015
Chin, Mike: MPPB018
Chin, Yong Ho: ROAA007
Ching-Jue, Chen: RPPG028
Chiou, Justin: MPPE013
Chishiro, Etsuji: TPAB062
Cho, Jung-Suk: RPPB044, RPPB045
Cho, Sung-Oh: RPPB068
Cho, Yong-Sub: TPAB016, TPAB017, WPPB059, RPAB048, RPAB072
Choi, Byung-Ho: TPAB016, TPAB017, WPPB059
Choi, J. H.: WPPE019
Chou, Ping: TPAB072, RPPB063, RPPB064
Chou, Weiren: TPPE005, TPPE006, TPPE007, RPAG016, RPAG017, ROPA011, ROPB006, FPAG017
Choudhary, Brajesh: WPPB037
Chouhan, Shailendra: MPPB035
Chouksey, Sanjay: MPPB071, WPAB035, RPAB069
Chrin, Jan: TOPB010
Christensen, Wynn: WPPB034
Christina, Vincent: MPPB047, MPPB075, WPAB065
Christoph, Montag: MOPA005
Chu, C. Paul: FPAG033
Chu, Chungming: WPPE015, WPPE016
Chu, Paul: WPPE017
Chuang, R.: FPAG047
Chun, Myung-Hwan: TPAG021, RPPB044, RPPB045, RPPG020
Chung, Yen-Ching: TPAG024
Chupyra, Andrey: TPAE035, RPAB019
Churasov, Mihail: FPAB088
Church, Mike: FPAB033
Cianchi, Alessandro: WPPB028
Ciavola, G.: MOPB007
Ciovati, Gianluigi: TPAB070, TPAB076, TPAB085, RPAB064, RPAB065
Citver, G.: MOPB010
Clark, Donald: TPAE005
Clark, George: ROPA010
Clarke, Donald: MPPG008
Clarke, James (DL): MPPG008
Clarke, James (DU): MPPG009
Clarke-Gayther, Michael: MPPE034, TPAG022
Clauser, Tarcisio: FPAB013
Clayton, Christopher: TPPG025, TPPG031, TPPG034, TPPG050, TPPG051, RPPG037, FOAB008, FOAB011, FPAG047
Clendenin, J.: WPAB027, WPAB042, WPAB043, RPPG022
Clifft, Benjamin: WPPB007
Cline, David: TPPB084, TPPG035, TPPG048, WPAE029, WPPB072, WPPG055
Clozza, Alberto: WOAA008, WPAG008, RPAB009
Cobble, J.: ROAC002
Codner, Gerald: WPPE037
Cohen, R.H.: TOAA010, TOPC004, ROAC001
Cohen, Ron: FPAG059
Colby, Eric: TPPG026, WPAB026, FOAB006
Cole, J. M.: MPPB085
Cole, Michael: MOPB010, MPPB075, WPAB008, WPAB009
Colella, Phillip: FPAG031
Coleman, James: TPAG026
Colestock, Patrick: MPPB075, WPPG010, RPPB034
Collier, Mike: RPAB052
Collier, Paul: TOPC003, TPPB050
Collins, John: FOAA003
Colson, William: TOAC008
Compton, C.C.: TPAB067, TPAB069, TPAB070
Comunian, Michele: FPAB077
Conde, Manoel: WPAB002
Coney, Linda: TPPE017, TPPE018
Connolly, Roger: TOAA011, TPPB043, WPPB013, WPPB015, WPPG042, WPPG043
Cook, Edward: ROAC004
Coosemans, Williame: ROPC005
Corbett, Jeff: WPPE020, WPPE021
Corlett, John: MPPE031, MPPB017, MPPB048, TOAC003, TPAB025, TPAB026, WPAB021, WPPB001, WPPB053, WPPG015, RPPG011
Cornacchia, M.: MPPB057
Cornelis, Karel: TPPB050, TPPB054, RPPB011
Cornelis, Marc: WPAE005
Corniani, Giorgio: TPAB063
Corsini, Roberto: WPPB078, ROPC010
Courant, Ernest D.: TPPB038, TPPG003, WOAB008, RPAG008, FPAG010
Cousineau, Sarah: TOAA005, TPAG005, TOPB001, TPPE011, TPPE012, TPPB086
Cowan, Benjamin: TPPG024, FOAB006
Cowan, Thomas: ROAC002, FOAB001
Cox, Lydia: TPAE029
Craddock, Michael: TPPE015
Craft, Benjamin: MPPG018, WPPE027, RPAB076
Craievich, Paolo: MPPB024, TOAC011
Crandall, Kenneth: TPAG038, RPAB059, FPAB085
Crane, John: MOPB011, MPPB020
Cremaldi, Lucien: WPAE027
Crisp, J. L.: WPPB037, WPPB038, TPPB077
Crittenden, James: WPAE009
Crivello, S.: TPAG005
Cross, Rick: MOPB011
Cruikshank, Paul: WPAE006
Cui, Yupeng: WOAC006, WPPG036, ROAB005, RPPB067
Cullerton, Ed: RPPB023
Cummings, Karen: TPAB022
Cummings, Mary Ann: TPPG013, WPAE026
Cupolo, John: WPPB013, WPPB014, WPPB015, WPPG047, ROAB009
Cusick, Mike: TPAE029
Cutler, R.I.: ROAC006, ROPB004
Czyz, W.S.: ROPA007
Dabagov, Sultan: MPPB045
Dahlerup-Petersen, Knud: WPAE006
D'Alessio, Cristian: WPPB041
Dallin, Les: TOPA001, WPAB068
Dalmas, D.: ROAC008
Daly, E.F.: MPPB075, TPAB075, TPAB077, ROAA001, RPAB061, RPAB064, RPAB065, FPAB086
Damm, Rudy: TPAG016, RPAB051
Danailov, Miltcho: TOAC011, WPAG018
Danilov, Slava: TOAA005, RPPB009
Danilov, V.: TPPE011, TPPE012, RPPB020
Danilova, E.: WPPE016
Date', S.: TOPA012
Datta, Dibyendu: FPAG054
Datte, Philip: WPPB052
Dattoli, Giuseppe: MPPB061, MPPB062, MPPB063, MPPB064, MPPG036, TOPA008
Dattoli, Pino: MPPB044
D'Auria, G.: TOAC011

Davidson, Ronald C.: TPPB023, WPPG028, WPPG030, WPPG029, RPAG039, RPAG040, RPAG041, RPAG042, RPPB051, RPPB052, RPPB053
Davino, D. (U. Sannio): RPPB010
Davino, D. (BNL): TPAG005, WPPG004
Davino, Daniele: WPAB049
Davis, G. Kirk: TPAB075, TPAB079, TPAB081, RPAB065
Davis, Harold: TOAA006, ROPB003
Davis, Jerry: TPAE005
Davis, Kirk: ROAA001
Dawson, W.C.: WPPB013, WPPB016, WPPB020, WPPG047, WPPG050 , ROAB009
De Baca, John: TPAB022
DeBarger, Scott: RPPB060
DeCarlo, Arnold: TPAG020, WPPG054
Dechun, Tong: RPPB065, FPAB048
Decker, Franz-Josef: TPPG025, TPPG031, TPPG050, TPPG051, WPAG009, WPAG010, RPAB013, RPPB054, RPPB055, RPPG037, FOAB008, FOAB011, FPAG047
Decker, Glenn: MPPB004, WPPG041
Decyk, Viktor: FPAG031
DeFord, John F.: FPAG051
Degen, Christopher: WPPB013, WPPB014, WPPB015, WPPG047, ROAB009
Dehning, Bernd: MOPA007, WPPB026
Deibele, C.: TPAG041, WPPG054
Deitinghoff, Horst: RPAG024
de Jong, Mark: TOPA001
Dejus, Roger: MPPG002
Delayen, Jean: MOPB010, MPPB081, TPAE010, TPAB043, TPAB078, TPAB079, WPPE026, ROAA001, RPAB065, FPAB046, FPAB086
Delferriere, Oliver: FPAB020
DellaPenna, Al: WPPB013, WPPB014, ROAB009
Delle Monache, Giovanni: WOAA008, WPAG008, RPAB009
Dell'Orco, Domenico: WPAB061
DeLong, Joseph: TPPB047, ROAA006, FPAB024, FPAB025, FPAB026
De Martinis, Carlo: WPAB019
De Menezes, Denis: FPAB020
Demidov, Nikolay: RPAB070
Demirkan, Medine: WPAG025, WPAG026
Demma, Theo: RPAG053, RPAG054
Demske, David: TPAG030
Denard, Jean-Claude: WPPB068
Denes, Peter: WPPB052
Deng, Changdong: FPAG022, FPAG023
Deng, Suzhi: TPPG025, TPPG031, TPPG050, TPPG051
Den Hartog, Patric: MPPB001, MPPB003, MPPB004, MPPG001
De Ninno, Giovanni: TOAC011, WPAG018, WPAG019
Denz, Reiner: WPAE006
Derbenev, Yaroslav: MPPB056, TPPB081, TPPB082, WPAE039, RPPG031
Derenchuk, Vladimir: TPPE009
de Rijk, G.: MOPA012
Deriy, Boris: WPAG001
Deryuga, Vyacheslav: TPPE035
De Santis, Stefano: MPPB017, TOAC003, TPAB023, WPPB052, RPAB010
Deslandes, Dominique: WPPB022
Desler, Kai: WPAB022, WPPG039, RPAB054
Devanz, Guillaume: MPPB024, MPPG035
Devred, Arnaud (CE): TOAB002, WPAE008
Devred, Arnaud (CERN): MOPA006, TOAB009
Dewan, Shashi: MPPE015
Dey, Joseph: TPAB011, RPAG021, FPAB029, FPAB030
Dhawan, Satish: WPPG046
Diao, Caozheng: MPPB072
Dickson, Richard: TOAC006, WPPB069
Diep, A.: WOAC006, WPAG020, WPPB073, WPPB075
Dieperink, Johan: TPPB010
Dierker, S.: TOPA007
Dietderich, Daniel: MPPG010, TOAB008, WPAE021
Dietrich, Juergen: TPAB010, WPPB035, ROPA009, FPAB069
Dilley, Christian: TPPG048
Dilmanian, F. Avraham: MPPG022
Dimarco, Joe: WPAE013
DiMarco, J.: TPPB055, WPAE015, WPAE016, RPAG017
Dimitrov, Dimitre: FOAB012
D'Imperio, N.L.: TPPB037
Ding, Yuantao: WPPB076
Di Pirro, Giampiero: WOAA008, WPAG008, WPPB028
Diviacco, Bruno: MPPG017, TOAC011, WPAG018
Diwan, Milind: WOAD001
Dobbins, John: WPAG004, FPAB027
Dodd, E.S.: TPPG050, TPPG051
Dodson, George: TPPE011
Doebert, S.: TPAE033, ROAA011
Dohan, Donald: WPPE001
Dohlus, Martin: WPPB029, RPPG010
Doleans, Marc: TPPE024
Dolgashev, Valery: TPAB031, TPAB032, TPAB036, WPAG027, RPAB016, RPAG043
Dolinskii, Alexej: WOAD002
Dombsky, M.: FPAB014
Domning, Ed: FPAB037
Donald, Martin: TPPB080, WPAG012
Dong, H.: FPAB047
Dong, Sai: MPPE011, TPPG058
Dong, Tianlin: FPAG020, FPAG021
Donley, Lawrence: TPAE034
Dooling, J.C.: TPAE034, ROPA007
Doolittle, Lawrence: TOAC003, TPAG018, WPPB001, FPAB036
Dormiani, Mohammad: RPPB060
Dortwegt, Robert: ROPB008
D'Ottavio, T.: TPPB047
Douglas, D.: MPPB055, MPPB075, TOAC006, WPAB064, WPAB065, WPAB066, RPPG032
Dovbnya, Anatoly: TPAE014, RPAB070, FPAB008
Dowell, David H.: RPPG022, WPAB027, WPPB029, WPPG033
Downer, Michael: FOAB002
Doyle, Eric: ROPB012
Doyuran, Adnan: TOAC012, WPPB021
Drago, Alessandro: WOAA008, WPAG008
Dragt, Alex: RPAB023, FPAG031
Drees, Angelika: MOPA009, MOPA010, MPPE024, MPPE025, TPPB030, TPPB031, TPPB032, TPPB033, TPPB034, TPPB043, WPPG044, RPAG004
Drees, Kristin: RPPB007
Drozdoff, John: ROPB010
Drozhdin, Alexandr I.: TPPE007, TPAG033, TPPB056, TPPB063, RPAB008, RPAG017
Drury, Michael: TPAB075, TPAB081, ROAA001, RPAB065
Du, Taibin: WPPB077
Du, Xiaofu: WPAB033
Du Mont, D.: TPPE001
Ducar, Robert: TPPB013
Ducimetiere, Laurent: TPAE036
Dugan, Gerald: TPPG011, RPPG017, FOPL001
Duke, Jonathan: WPPB060
Dunkel, Kai: RPAB073
Duohui, He: MPPB022
Duperrier, Romuald: RPAB034, RPAB035
Durante, Maria: WPAE007
Durkin, Alexander: WPPG038, RPAG057, FPAG034
Durtschi, G.: ROAC008
Dürr, Hermann A.: MPPB005
Dürr, Volker: MPPB005
Dutto, Gerardo: TPPE016, ROPA010, ROPB010
Earley, Lawrence: ROAA012
Eberhardt, Wolfgang: MPPB005
Ebihara, Kiyokazu: MPPB015, TPAB019
Echave, J.: ROAC008
Edwards, Donald: WPAB015
Edwards, Helen: TPAB014, TPAB058, TPPG037, WOPA001, WPPG039
Edwards, Randall: TPAB063, TPAB064
Efthimion, Philip C.: TOAA001, WPPG014, WPPG028, WPPG030
Egawa, K.: MPPG027, MPPG028
Ego, H.: TOPA012
Ehrlich, Richard: WPPE037
Eichhorn, Ralf: ROPA009
Eickhoff, Hartmut: FOAA002
Eidelman, Yu.: FOAB010
Einfeld, Dieter: TOPA006
Eisen, Edward: TPAE019
Eisert, David: MPPB027, WPPE023
Ekdahl, Carl A.: ROAC008, RPPG016
Elleaume, Pascal: MPPB013
El-Shazly, Mohamed: FPAB021
Emamian, Mark: WPAG006

Emery, Louis: MPPB004, TOPA014, TOPB008, WPAG001, WPPE002, WPPB006, FPAG001, FPAG002, FPAG004, FPAG005, FPAG006
Emhofer, Stephan: RPAB066
Emma, Paul: MPPB044, MPPB049, MPPB068, TOAC010, TPPG025, WPPB029, RPPB054, RPPB055, RPPB059, FOAB008
Emmanuel, Froidefond: RPAB033
Endo, Akira: WPAB038, WPAB040
Endo, K.: MPPG027, MPPG028
Eng, Wahfun: MPPE002, MPPE015, TPPE001, WPAB048
England, Robert: RPPG038
Enomoto, Atsushi: RPAB050
Erdelyi, Bela: TPPB057, TPPB069, TPPB074, FPAB055
Erickson, D.: MPPE026
Eriksson, Leif: RPAB022
Eriksson, Mikael: WPAG024, WPAG025, WPAG026
Ernst, Dave: WPAB061
Erokhin, Alexander: RPAB019
Errede, D.: WPAE026, WPAE034, WPAE035
Esarey, Eric: TPPG010, TPPG011, TPPG012, TPPG015, WPPB053, RPPG017, FOAB003, FOAB005, FOAB012, FPAG032
Escallier, John: TOAB006, WPAE001
Eschke, Jürgen: ROAA003
Espinoza, Camilo: TPPB019, TPPB020
Esposito, Juan: FPAB077
Esser, Frank: TPAB010, ROPA009
Etzkorn, Franz-Josef: TPAB010
Evans, Lyn: MOPA001
Evans, Rich: TPAG026
Eversole, S.: ROAC008
Evtushenko, Pavel: WPAB007
Ewald, K.: MPPE026
Eylon, Shmuel: TOAA001, TPAE040, WPPB055, WPPG012, WPPG013, WPPG016, WPPG017, WPPG025, ROAC008, RPPB038, RPPB039
Ezura, Eizi: MPPB015, TPAB019
Fabbricatore, P.: WPAE022
Fabris, Alessandro: MPPB024
Facco, Alberto: ROAA004
Faehl, Rickey: TPPE025
Falabella, Steven: MPPB082, ROAC009
Falce, Lou: TPAE016
Faltens, Andy: WPAE023, ROAC001
Fan, Le: MPPE032
Fan, Ming Wu: TPPE008, FPAG019, FPAG020, FPAG021, FPAG022, FPAG023, FPAG024, FPAG025
Fan, T.C.: MPPG014, MPPG016
Fang, J.-M.: TPPG038, TPPG055
Fang, Shuyao: TPAB040, TPAB088
Fang, Z.: MPPG027
Fann, Chyi-Shyan: MPPE014
Farinon, Stefania: WPAE022
Farkhondeh, M.: MPPB065, MPPB076, MPPB077, WPAG028
Farrell, J. Paul: ROAC003
Fartoukh, Stephane: WPAB079
Farvacque, Laurent: MPPB013, RPPG007
Faucett, John: WPPE013
Faure, Jerome: TPPG011, TPPG012, TPPG015, TPPG016, WPPB053, FOAB003
Faus-Golfe, Angeles: WPAB084
Fawley, W.M.: MPPB048, TOAC003, RPPB038
Fedorova, Antonina: WPPG008, RPAG026, RPPB026, RPPB027, FPAB056
Fedotov, Alexei: TOAA005, TPPE011, TPPE012, WOAB002, WPPB015, WPPG001, WPPG002, WPPG004, RPAG007, RPPB009, FPAG009
Fedurin, Mikhail: MPPG018
Feher, Sandor: WPAE015, TOAB010
Feigerle, C.S.: ROPB004
Feikes, Joerg: MPPB006, MPPB010, RPPB005, RPPB006
Felden, Olaf: TPAB010, ROPA009
Feldman, Donald: FPAB016
Fellenz, Brian: WPPE011, WPPB038
Feng, G.Y.: TPAG019
Feng, Guangyao: TPPE036, TPPG058, RPAB057, RPPG019
Fengqing, Zhang: MPPE008
Ferdinand, Robin: FPAB020
Ferianis, M.: TOAC011
Ferioli, Gianfranco: TOPC003
Fernandez, J.: ROAC002
Fernow, Richard: WPAE027
Ferracin, Paolo: TOAB008, WPAE021
Ferrari, Alfredo: MOPA007
Ferrari, Arnaud: WPPB078, ROPC010
Ferrario, Massimo: MPPB044, MPPB057, MPPB063, WPAB018, WPAB019, ROAA003, RPAB005, FPAG043, FPAG056
Fessenden, Thomas: WPPB055
Fessia, Paolo: WPAE005, WPAE017
Filhol, Jean-Marc: TPAB057, TOPA003
Filip, Catalin: TPPG034
Findlay, David: WPPB060
Finley, David: TPAB012, TPAB013, TPPG002
Fiorito, Ralph: TPAG030, WPPG056
Fischer, John: RPAB061
Fischer, Rainer: WPPB028
Fischer, Wolfram: MOPA009, MOPA010, MPPE025, TOAA011, TPPB001, TPPB043, TPPB067, WPAB078, WPAB080, WPPB015, ROAA006, RPPB007, RPPB008
Fisher, Alan: WPAG010
Fisher, Michael: MPPB027, WPAG017
Fittinghoff, David: MOPB011, MPPB020
Fitzgerald, Daniel: WPPB049, ROAB003, RPPB035, FPAB083
Flanagan, John: WPPB042
Flanz, Jay: FOAA001
Fliflet, Arnold W.: TPAE022
Fliller, Raymond P.: TPPE002, TPPB030, TPPB033, TPPB034, TPPB043, RPAG004
Floettmann, Klaus: MPPB039, MPPB067, MPPB068, WPAB034, FPAG015
Flora, Robert: WPPB038
Foley, Michael: TPAB014, TPAB058
Fomin, Serguei: MPPB030, FPAB019
Fong, Kenneth: TPAB040, TPAB088, TPAG027, ROPA010
Forchi', Vincenzo: FPAB045
Ford, Richard: TPPB013
Forest, Etienne: WPAB087
Foster, Bill: TOPD003
Foster, G. William: TPPB011, TPPB012, TPPB072, WPPB037
Fox, John: RPPB060, FPAB042
Fox, Will: TPAG016, TPAG017, RPAB051
Frak, Bart: WPPB018
Franchetti, Guiliano: TOAA009, ROPA006
Francis, Vishal: MPPG008
Franczak, Benno: ROPA006
Franklin, W.A.: WPAG028
Franzke, Bernhard: WOAD002
Freitag, Michael: WPAB007
Freund, Henry (NRL): MPPG036
Freund, Henry (SAIC): MPPB061
Freyberger, Arne: TOAC006, WPPB070
Friedlander, Fred: TPAE029
Friedman, A.: TPAG039, TOPB006, TOPC004, WPPG035, ROAC001
Friesel, Dennis L.: MPPG025, TPPE009, FOAA003
Frigola, Pedro: MPPB058, WPAB030, WPAB031, WPAB067, FPAB015
Frisch, Josef: TPAB038, WPPB061, WPPB062, RPAB026, ROPB012, ROPC011
Frischholz, Hans: TPAE001, ROAA005
Froidefond, Emmanuel: RPAB034
Frullani, Salvatore: MPPG030
Fu, Shinian: TPAG014, TPAG035, RPPG047
Fu, Wenge: TPPB030
Fubiani, Gwenael: TPPG010, TPPG011, RPPG017, FOAB003, FOAB005
Fuchs, Julien: ROAC002, FOAB001
Fuerst, Joel: TPAB044, TPAB045
Fujio, Naito: RPAB049
Fujisawa, Masami: ROAB011
Fujita, Takahiro: MPPB015, RPPB028, RPPB029, RPPG039
Fukami, Kenji: WPPB064
Fuke, S.: FPAB087
Fukuda, Shigeki: TPAG035
Fukuda, Yuji: TPAG035
Fukui, T.: TOPA012
Fukui, Yasuo: TPPB084, TPPB085, WPAE029, WPPG055
Fukuma, Hitoshi: MPPB015, RPPB017
Funakoshi, Y.: FPAB087
Funk, L.W.: RPAB065
Furman, Miguel: TOAA010, TOPC001, TOPC004, WOAA004, WPPG004, WPPG031, RPPG023, RPPG024, FPAG030, FPAG059
Furukawa, Kazuro: ROAB012
Furukawa, Kouji: MPPE009

Fusco, Valeria: MPPB044, WPAB018, FPAG043, FPAG056
Gai, Wei: TPAE033, TPPG001, TPPG002, TPPG004, TPPG041, TPPG043, WPAB002, ROAA010
Galambos, John D.: TPPE011, WPPE015, WPPE016, WPPE017, FPAG033
Gallagher, Richard: TOAB007
Gallardo, Juan: TPPG048, WPAE027
Gallegos, Floyd: WPPB047, WPPB048
Gallegos, R.: ROAC008
Gallo, Alessandro: WOAA008, WPAB019, WPAG008, RPAB009
Gammino, Santo: MOPB007
Ganetis, George: MPPE002, TOAB006, TPAG006, TPPB006, TPPB039, TPPB043, WPAE001, WPAB054
Gao, Jie: RPPG040, RPPG041
Gardner, C.J.: TPPE001, TPPB043, TPPB047
Gardner, Ian: TPAG042, TPAG043
Gareyte, Jacques: RPPB012, RPPB013
Garnett, R.W.: WPPG011
Garoby, Roland: TPPB053, WPPE007
Garrel, Noel: TPAE036
Garren, A.: TPPE007, TPPB084, TPPB092, TPPG003, TPPG008, WPAE029, WPAB075, WPAB077, FPAG010
Gary, Wait: TPAE036
Gassner, David M.: MOPA010, MPPE024, TPAG004, TPPE001, TPPB005, TPPB034, WPPB013, WPPB017, WPPB018, WPPB019, WPPG045, RPAG004
Gattuso, Consolato: TPPB011, TPPB012, TPPB072, WPPB037, RPAG019
Gaudreau, Marcel P.J.: TPAG031, ROAC005
Gaupp, Andreas: MPPB005
Gauthier, Jean Claude: FOAB001
Gauthier, Yannick: FPAB020
Gavrilov, Nikolay G.: MPPB042, WPAG006
Ge, Lixin: TPAB033, FPAG044
Gebel, Ralf: TPAB010, ROPA009, FPAB069
Geddes, C.G.R.: TPPG011, TPPG012, TPPG015, TPPG016, WPPB053, FOAB003
Geer, S.: TPAB003
Gelfand, Norman: TPPE007, TPPB059
Geng, Gongli: TPAB054
Geng, Rong-Li: TPAB049, TPAB050, TPAB051, TOPB002
Gensch, U.: WPAB034
Gentzlinger, Robert: TPAB063
Gerard, Congretel: RPAB033
Gerth, Christopher: MPPB040
Geynisman, M.: MPPE026
Ghalam, Ali: RPPB016
Ghigo, Andrea: TPPB017, WOAA008, WPAG008, RPAB009, ROPC010
Ghiorso, W. B.: WPPB050
Ghosh, Arup: TOAB006, WPAB054
Giacone, Rodolfo: TPPG010, TPPG011, TPPG039, FOAB005
Giannessi, Luca: MPPB044, MPPB063, MPPB064, MPPG036, TOPA008, WPAB018, FPAG043, FPAG056
Giannini, Giorgio: MPPB045
Gibson, David: MOPB011, MPPB020
Gibson, P.: WPPG054
Gierman, Steve M.: WPAB027, WPPG033, RPPG022
Gill, Greg: WPAB032
Gilpatrick, J. Douglas: WPPB046, WPPG010
Gilson, Eric: TOAA001, WPPG030
Giovannozzi, Massimo: TOAA009, WOAB003, RPAG011, RPAG012, RPAG013
Giove, Dario: WPAB019
Girard, A.: MOPB007
Givens, Michelle: WPAB001, WPAB004
Gjonaj, Erion: FPAG055
Gladkikh, Peter: WPAG021
Glaessner, Christian: TPPE038
Glanzer, Matthew: WOAC006, WPPB073, WPPB075
Glass, H.D.: TPPB072, WPAE016, WPAB058
Glenn, J.W.: MOPA009, MPPE004, TPPE001, TPPE003, TPPB038, TPPB043, TPPB047, WOAB008, WPPG003, RPAG008
Glison, Erick: WPPG014
Gloor, Walter: MPPB024
Gluckstern, Robert: WPPG002
Gobin, Raphael: FPAB020
Godang, Romulus: WPAE027
Goddard, Brennan: TPPB009, TPPB010, TPPB052
Godefroy, Alain: WPPB022
Godlove, T.: TPPB025, TPPB027, WOAC006
Goeppner, George: TPAG001, WPAB001
Gold, Steven H.: TPAE022, TPAE030, ROAA010
Goldin, Fletcher (Bechtel): MPPB082
Goldin, Fletcher (LLNL): ROAC009
Golub, Yurii: RPPB040, RPPB041
Golubev, Alexander: FPAB088
Gomez, John: TPPB019, TPPB020
Gongfa, Liu: WPPE014
Gonin, Ivan: MOPA008, TPAB012, TPAB013, TPAB014
Goodzeit, Carl: WPAE025
Gopych, Mykhaylo: FPAG058
Gorbachev, A. M.: TPAE030
Gordon, D.F.: TPPG018, TPPG021, FOAB004
Gordon, Dan: TPPG020
Gordon, Daniel: TPPG040, FPAG052
Gordon, Julian: RPAB062
Gorelov, D.: RPAB035, RPAB056, RPAG038
Gössel, Andre: MPPG035, TPAB084, ROAA003
Gottschalk, Stephen: TPPG048
Gould, Harvey: TPPG014
Gounder, K.: RPAG018, FPAB071, FPAB072
Gourlay, Stephen: MOPA006, MPPG010, TOAB008, WPAE021
Gouveia, Steve: TPAE013
Grabosch, H.J.: WPAB034
Graef, Hans-Dieter: FPAG050, FPAG058
Graham, David: MOPB009
Granata, Valeria: WPAE006
Granatstein, Victor: TPAE013, TPAE027
Grau, Manuel: WPPB013, WPPG042, WPPG043
Graves, W.S.: MPPB066, MPPB076, MPPB077, TOPD005
Graves, William: TOAC012
Green, M.A.: MPPB027, MPPB052
Green, Michael: TPPG013, WPAE022
Greenenko, Anatoliy: RPAG055, RPAG056
Greenwald, Zipi: WPAB011
Greenway, Wayne: TPAE040
Grelick, Arthur: TPAG001, TPAG003, WPAB001, WPAB004
Grenoble, Christiana: TPAB081, ROAA001
Grice, W.: WPPG054
Grier, Dennis: TPPB053
Griffin, Jim: TPPE006, RPAG016
Grimm, T.L.: TPAB066, TPAB067, TPAB068, TPAB069, TPAB070, RPAB056, RPAG038
Grippo, Al: TPAG026
Grisham, Larry: TPPB023, WPPG030, FPAB010
Grishin, Vladislav: MPPB089, MPPB090, RPAG046
Grote, David P.: MOPB003, TPAG039, TOPB006, WPPG022, WPPG035
Gruber, P.: TPAB003
Gu, Anjia: WPPB076
Guan, Changying: MPPE032
Gubello, Guiseppe: WPAE017
Guenzel, Thomas: MPPB013
Guerra, A.: TOAC006
Guethlein, Gary: MPPB082, ROAC009
Gueverra, Jorge: TPAE018
Guidi, V.: MPPB079
Guidi, Vincenzo: MPPB045, TPPB016
Guiducci, Susanna: MPPB044, WOAA008, WPAB018, WPAG008, RPAG025
Guignard, Gilbert: ROPC005
Guilhem, David: WPPG005
Guimbal, Philippe: WPAB010, WPPB022
Gullotta, Justin: MOPA010, MPPE024, TPAG004, WPPG045
Gung, Chen-yu: WPAE023
Gunther, Kim: TPAE016
Gupta, Ramesh: MOPA006, TOAB006, WPAE002, WPAE003, WPAE004, RPAG008
Gustavsson, James: TPAE002
Guy, Stanford: ROPA010
Gyr, Marcel: TPPB009, TPPB010
Ha, K.M.: WPPE018, RPPB048
Ha, Wanill: TPPG028
Haase, Matthias: TPPB053

Haber, I.: TPPB025, WOAC006, WPAG020, WPPB074, WPPB075, WPPG035, WPPG036, ROAC001, RPPB067, FPAB006
Habib, Salman: FPAG031
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Hae, Takamitsu: MOPB005
Hafalia, Ray: TOAB008, WPAE021
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Haga, Kaiichi: MPPB015
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Hahn, Harald: TPPB001, TPPB043, WPAB049, RPPB010
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Hanna, Bruce: TPPB057, TPPB059, WPPB040
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Hara, Shigemitsu: MOPB005
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He, Duohui: MPPB072
He, Ping: MOPA010, MPPE021, MPPE022, MPPE023, MPPE024, TPAG004, WPPG004
He, Xiaozhong: MPPB031
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Hegelich, M.: ROAC002
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Heistermann, F.: FPAB026
Held, Ben: FPAG051
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Ho, Darwin: MPPB083, ROAC009
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Hofle, Wolfgang: TPPB050, RPPB011
Hofler, Alicia: FPAB046, FPAB047
Hofmann, Ingo: TOAA009, WPPG002, WPPG007, RPAG031, ROPA006
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Hogan, John: TPAB077, ROAA001, RPAB061
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Holder, K.: WOAC002
Holldack, Karsten: MPPB005, MPPB006, WPPB051, RPPB005, RPPB006
Holmes, Cliff: ROAC010
Holmes, Jeffrey: TOAA005, TPPE011, TPPE012, FPAG017, FPAG018
Holmes, Robert: MPPE015
Holtkamp, Norbert: MOAL003
Holzsheiter, M.: ROAC008
Hong, Y.L.: TPAG019, RPAB058
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Honisto, H.J.: RPPG046
Honkavaara, Katja: MPPB040, WPPB028
Hopkins, Steve: TPAG017, RPAB052
Horan, Douglas: TPAB001
Hori, Yoichiro: MPPE030, MPPB015
Horst, Birte van der: ROAA003
Horvat, Vladimir: TPPB023
Hosoda, Naoyasu: TOPA012, WPPB064
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Hseuh, Hsiao-Chaun: MOPA010, MPPE021, MPPE022, MPPE023,

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Hsiung, Gao-Yu: MPPE035
Hsu, K.T.: MPPB028, MPPG015, WPPE024, WPPE025, WPPB065, WPPB067, RPPG028, RPPG029, FPAB043
Hsu, Shen-Nung: MPPE035
Hu, Kuo-Hwa: MPPB028, WPPB065, WPPB067, RPPG029
Hu, Martin: TPPB012, WPPB037
Hu, Yuan: WPAB033
Hua, JianFei: TPPG029
Huaibi, Chen: RPPB065, FPAB048
Huang, C.: TPPG025, TPPG031, TPPG050, TPPG051, RPPG037, FOAB008, FOAB011, FPAG047
Huang, Gang: MPPB031, RPPB065, FPAB048
Huang, Haibin: TPPB032
Huang, Haixin: MOPA009, MOPA010, TPPB038, TPPB043, TPPB045, WOAB008, WPPG046, RPAG008
Huang, J.Y.: WPPE018, WPPE019, WPPB059
Huang, Weiling: TPPE030
Huang, Wenhui: MPPB031, ROAA003
Huang, Zhirong (ANL): MPPB037
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Hubers, Heinz-Wilhelm: MPPB006
Huebers, H.-W.: RPPB006
Huelsmann, Peter: WOAD002, ROPA006
Huening, Markus: WPAB017, WPPG039, ROAA003, RPAB005
Hughes, Thomas P.: TOAA006, ROAC008, RPPG016
Hughes, Vernon W.: WPPG046
Huhn, Adam: WPPB013
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Humphries, Stanley: FPAG053
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Hunter, T.: WPPG054
Huo, Y.: WPAG020
Hur, Hoon: RPPB046
Hurh, Patrick: TPAG009, TPAG010, TPAG013, ROPB011
Hutchinson, E.: TPPE001
Huttel, Erhard: MPPB032, RPPG043, RPPG044
Hutton, Andrew: TOAC006, TPPB082
Hwang, Ching-Shiang: MPPG014, MPPG015, MPPG016
Hwang, Il-Moon: RPPB050
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Ian, Wilson: RPAB003
Iarocci, Michael: TPPB003
Iazzourene, Fatma: WPAG018, WPAG019
Ieiri, Takao: MPPB015, RPPB028, RPPB029
Igarashi, Susumu: TPPB093, WPPG009
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Igarashi, Zenei: TPAG035
Igo, George: WPPG046
Ihee, H.: WOAC003
Ihloff, E.: WPAG028
Iida, H.: FPAB087
Iida, Kensuke: ROAB011
Iida, Masahisa: WPAE019
Iida, Naoko: WPAB084, FPAB087
Ikeda, Hitomi: WPPB042
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Ikegami, Kiyoshi: TPAG035
Ikegami, Masahiro: WPAB069
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Ilg, Tom: RPAB051
Imbasciati, Linda: TOAB010
Inagaki, Shigemi: TPPB079, TPPB093
Inagaki, T.: MPPB046, TPAE037
Irie, Yoshiro: WPPB044, RPPB033
Iriso-Ariz, Ubaldo: MOPA010, MPPE024, MPPE025, TPPB043, FPAG007
Isaev, V. A.: TPAE030
Isagawa, Shigeru: MPPB015, TPAB019
Ise, Toshifumi: MPPE009
Ishimoto, S.: TPPG013
Ishizuka, Toru: FPAB022
Ito, Takashi: TPAG035
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Ivanov, O. A.: TPAE030
Ivanov, Petr: RPPB021, FPAB050
Ivanov, Valentin: TPAE017, TPAE026, WPPG032, FPAB011, FPAB012
Ivanov, Yuri: MPPB045
Ivanyan, Mikayel: MPPB033, RPPG004
Iversen, Jens: ROAA003
Iverson, R.: TPPG025, TPPG031, TPPG050, TPPG051, WPAG010, RPPB054, RPPB055, RPPG037, FOAB008, FOAB011, FPAG047
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Iwashita, Yoshihisa: WPAB069
Jackson, Alan: TOPA009
Jackson, G.P.: TPPB011, RPPB069, RPPB070, FOAA005
Jackson, John W.: WPPE033, WPAB053
Jacob, Jorn: MPPB013, TPAB057, RPPG008
Jacobs, Kenneth: MPPB027, MPPB052, WPAG017, WPPE023
Jacobson, Susanna: FPAB037
Jacquez, E.: ROAC008
Jaeschke, Eberhard: MPPB005, WPAB034
Jain, Animesh: TOAB006, TPPB006, WPAE001, WPAB053, WPPE033
Jain, Arvind Kumar: MPPE036
Jamilkowski, J.: TPPE001
Jang, Ji-Ho: TPAB016, RPAB048, RPAB072
Jannin, Jean-Luc: FPAB020
Jansma, William: WPAB001
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Jason, Andrew: TPPB019, TPPB020, WPAE014, RPAG028
Javanmard, Mehdi: TPPG024, FOAB006
Jayamanna, K.: FPAB014
Jean-Claude, Ravel: RPAB033
Jeanneret, Jean-Bernard: MOPA007, FPAG013
Jenninger, Berthold: TOPC003
Jensen, Aaron: FPAB012
Jensen, Erk: WPPB025, WPPB026
Jensen, Jens-Peter: MPPE005
Jensen, K.L.: FPAB016
Jensen, Lars: TOPC003
Jeon, Dong-o: TOAA003, TPAG038, WPPG027, RPAB059, FPAB085
Jeong, Kyoung-Keun: RPAB048
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Jia, Lin: TPAG006
Jia, Qika: MPPB072
Jian, Xiong: FPAG024
Jiang, Daoman: MPPE032, TPAG019, RPAB058
Jiang, De-Tong: TOPA001
Jiang, Hairong: TPAB069
Jiang, Zhanfeng: WPAB029
Jimenez, Jose-Miguel: TOPC003, TPPB054
Jin, Kai: TPAG019, RPAB058
Jin, Lihui (U. Kansas): TPPB091, WOAA009
Jin, Lihui (APS): FPAB049
Jin, Xiao: TPPE026
Jines, Paul: WPPE027, RPAB076
Jing, Chunguang: WPAB002, ROAA010
Jinnochi, Osamu: WPPG046
Jinying, Liu: MPPB022
Jiquan, Guo: TPAE008
Jobe, Keith: TPAB038, RPAB026, ROPC011
Johnson, David: TPPB011, TPPB012, TPPB072, TPPB078, WPPB037, RPAG019, FPAB073, FPAB075, FPAB076
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Johnson, E.D.: TOAC012, TOPA007, WPPB021
Johnson, G.: MPPE026
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Johnson, J.: ROAC008
Johnson, Matthew: TPAB066
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Jolly, Simon: RPAB026, ROPC011
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Jones, Roger: TPAB030, TPAB031, TPAB034, WPAG027, RPAB015, RPAB016,
Jones, Theodore: TPPG018, TPPG019, TPPG021, FOAB004
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Kao, C.C.: TOPA007
Kapetanakos, Chris: TPPG020
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Kazarezov, Ivan: MPPE001, TPAE035
Kedzie, Mark: TPAB044, TPAB045
Keil, Eberhard (CERN): TPPG003
Keil, Eberhard (FNAL): WOAB010, FPAB062
Keil, Richard: MPPB027
Kelez, Nicholas: WPPB051
Keller, Lewis: RPAB008
Keller, Rod: FPAB009
Kelley, J.: MPPB075
Kelley, Michael: TPAB082
Kelley, Patrick: WPAE014
Kelly, J.: WPPG054
Kelly, Michael: TPAB043, TPAB044, TPAB045
Kempkes, Michael: TPAG031, ROAC005
Kempson, V.C.: TOPA011
Kephart, R.: TPPB055, WPAE016
Kerby, James S.: TPPB064, WPAE015
Kesar, Amit: WPAB024
Kesselman, Martin: WPPB013, WPPB014, WPPB015, WPPB016, WPPB020, ROAB009
Kester, Oliver: RPAB066, RPAB067
Kewisch, Jorg: MOPA005, TPAB046, TPPB035, TPPB039, WOAA010, WPAE028, WPAE030
Khabiboulline, Timergali: MOPA008, TPAB012, TPAB014, TPAB013, RPPB071
Khachatryan, Arsen: TPPG045, TPPG046
Khachatryan, Vitali: WPAB055
Khakberdiev, I.: MPPB088
Khan, Shaukat: MPPB005
Kheawpum, Orithai: TPPB091
Khodak, Igor: WPAB025
Kichgessner, Joe: TPAB051
Kikuchi, Mitsuo: MPPB015
Kikuzawa, Nobuhiro: FPAB078, FPAB079, FPAB080
Kim, C.: TPPG023
Kim, Changbum: TPPG022, TPPG047, TPPG049, RPAG049
Kim, Do-Tae: TPAG021
Kim, Eun-San: WPPE018, WPPB059, RPPB042, RPPB043, RPPB044, RPPB045, RPPB046, RPPB047, RPPB048, RPPB049, RPPB050, RPPG020
Kim, Guang-Hoon: TPPG022, TPPG023, TPPG047, TPPG049, RPAG049
Kim, J.H.: WPPE018
Kim, J.M.: WPPE018
Kim, J.U.: TPPG023
Kim, Jincheol: RPAG047, RPAG049
Kim, Jong-Uk (KARI): TPPG047, TPPG049, RPAG049
Kim, Jong-Uk (NSRL): TPPG022
Kim, Kwang-Je: MPPB037, TPPG002, WPPG039, RPPB059
Kim, Kye-Ryung: TPPE028
Kim, Mungyung: MPPB023, RPPB049
Kim, Sang-ho: TPAB071, TPAG020, TPPE024
Kim, Suk Hong: MPPG002
Kim, Sung-Chul: RPPB049
Kim, Tae-Hyun: TPAG048
Kim, Y.J.: MPPB046
Kim, Young-Jun: RPAB048
Kim, Yujong: MPPB067, MPPB068
Kimura, Nobuhiro: WPAE019
Kimura, Wayne: TPPG048
King, Larry: TPAB081, ROAA001
King, Quentin: WPAE006
King, Tzu-Chyang: TPAB074, WPPE038, WPPE039
Kinkead, Allen K.: TPAE022, TPAE030, ROAA010
Kinsho, Michikazu: RPPB031
Kirby, R: WPAB043
Kirk, Harold: TPPB002, TPPB003, TPPB004, TPPB084, WPAE029, WPAB075, WPAB077
Kirk, Markus: WPPG007
Kishek, R.A.: TPPB025, TPPB027, WOAC006, WPPB074, WPPB075, WPPG035, WPPG036, RPPB067
Kishiro, Junichi: TPPB079, TPPB093, TPAG035
Kitabayashi, Teruyuki: FPAB087
Kitamura, H.: MPPB046, TPAE037
Kitsuka, Toshihiro: MPPB036
Klaas, Ottmar: FPAG054

Klebaner, A.: MPPE026
Klein, Hans-Udo: WPAE007
Klein, Horst: TPAB060, RPAG024
Klein, Susan: FOAA003
Kleman, K.J.: MPPB027, MPPB052, WPPE023, RPPB062
Klenov, Viktor: FPAB001
Kling, Nicolas: TPPE001, TPPB031
Knapic, Cristina: MPPG017
Kneisel, Peter: MOPB010, TPAB070, TPAB076, TPAB077, TPAB085, TPPE013, ROAA001, RPAB064, RPAB065
Knobloch, Jens: TPAB054
Ko, In-Soo: TPPG023, RPAG047
Ko, Kwok: FPAG044
Koba, Kiyomi: TPPB060
Kobayashi, Hitoshi: TPAG035
Kobayashi, Masanori: MPPB015
Kobayashi, Tetsuya: TPAG035
Kobayashi, Yukinori: MPPB014, MPPB015, WPAB060, RPPG013, RPPG014
Kobilarcik, Thomas: TPPB013, RPAG020
Koch, Jean-Marc: MPPB012
Kodera, M.: TOPA012
Koiso, Haruyo: TPAG036, WOAA003, FPAB087
Kokhanovski, Sergei: FPAB001
Koldanov, V. A.: TPAE030
Kolomiets, Andrei: RPAB068, FPAB088
Komada, Ichita: WPPE012
Kondaurov, Michail: RPAB019
Kondo, Yasuhiro: TPAG035
Konecny, Richard: TPAE033, WPAB002, ROAA010
Kong, J.R.: TOPA011
Konkashbaev, I.: TPAB002
Konstantinov, Sergey: WPAB007
Koontz, Ron: TPAE026
Koop, Ivan A.: WOAA010, RPPG048
Koopman, Jan: WPPB026
Korbly, Stephen: WPAB024, WPPB057
Korenev, Ivan: MPPB091, TPPE032
Korenev, Sergey: MPPB091, MPPB092, TPPE031, TPPE032, TPPE033
Korepanov, Andrey: MPPE001
Korostelev, Maxim: WPAG023
Koschik, Alexander: RPPB013
Koscielniak, Shane: TPAG027, TPPG009, FPAB062
Koseki, Kunio: TPPB079, TPPB093, ROAC011
Koseki, Shoichiro: MPPE008
Koseki, Tadashi: ROAB011
Koshkarev, Dmitry: FPAB088
Kostin, Denis: ROAA003
Kostin, Mikhail: TPAG011
Kot, Nikolay: TPAE035
Kotina, Elena: RPAG048
Kotlyar, Y.: TPPE001
Kotov, Vladilen: MPPB045, TPPB016
Kou, C.H.: MPPG015
Kourbanis, Ioanis: RPAG021, FPAB029, FPAB030
Koutchouk, Jean-Pierre: MOPA012, TPPB041, WPAB079
Kovach, Paul: WPAE004
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Kozyrev, Evgeny V.: TPAE022
Kponou, Ahovi: MOPB009, FPAB001
Kramarenko, Katherina: TPPE029, RPAG037
Krämer, Dieter: MPPB005, MPPG034, WPAB034
Kramer, S.: TOPA007
Kramper, Brian: FPAB033
Krasilnikov, Mikhail: WPAB034
Krasnogolovets, M.A.: TPAE014, FPAB008
Krasnykh, Anatoly: TPAE017, TPAE026, FPAB011, FPAB012
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Krause, S.: WPAG028
Krawczyk, Frank: TPAB063, TPAB064
Krejcik, Patrick: TPPG025, WOAC005, WPPB029, WPPB071, RPPB054, RPPB055, FOAB008
Kreps, Guennadi: TPAB084, ROAA003
Krinsky, Samuel (BNL): TOAC012
Krinsky, Samuel (SLAC): MPPB050, MPPB051, RPPG025
Krischel, Detlef: WPAE007
Krishnagopal, Srinivas: MPPB069, MPPB070, MPPB071, TPAG046, WPAB035, RPAB069
Krishock, A.: TPPE001, WPPB012
Kroll, Norman: TPAB034
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Kruchkov, Yaroslav: WPAB007
Krusche, Achim: TPPB053
Kuan, Chien-Kuang: MPPE035, WPPB066
Kuba, Jaroslav: MOPB011, MPPB020
Kubicki, Tom: TPAB011
Kubota, Chikashi: TPAG035
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Kuehnel, Kai-Uwe: TPAB010, TPPE038, RPAB041, ROPA009
Kulikov, Artem: WPAG009
Kulipanov, Gennady N.: MPPB042, TOPA012
Kumada, Masayuki: WPAE024, WPAB069
Kumagai, Noritaka: MPPE020, MPPB026, TOPA012
Kumar, Arvind: TPAG046, WPAB035, WPAB036, RPAB069
Kumar, Vinit: MPPB069, MPPB070, MPPB071
Kumaran, Raveen: TPAB040
Kuo, C.C.: MPPB028, MPPB029, MPPG015
Kuo, C.H.: WPPB065
Kuo, Changhor: WPPB067, FPAB043
Kuo, Kung-Cheng: TPAG023
Kurennoy, Sergey: MPPB047, MPPB075, TPPB018, WPAB020, FPAG027
Kurita, Kazu: WPPG046
Kusche, Karl: TPPG048, FOAB010
Kushner, B.: TOPD002
Kushnir, V.A.: TPAE014, TPPE029, WPAB025, RPAB070, FPAB008
Kuske, Peter: MPPB006, TPAB004, RPPB005, RPPB006
Kustom, Robert: MPPG002
Kuzikov, S. V.: TPAE030
Kuzin, M.: TOPA012
Kuznetsov, Andrey: RPAB019
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Kwiatkowski, Slawomir: TPAB023
Kwon, Hyeok-Jung: TPAB016, TPAB017, RPAB048, RPAB072
Kwon, Sung-il: FPAB036
Lach, Joseph: RPAB019
Lackey, James R.: WPAB058, TPAG033, RPAG017
Ladd, P.: WPPG054
Ladran, Anthony: WPAE037
Lagniel, Jean-Michel: WPPG005
Lal, Shankar: RPAB069
Lamanna, Giuseppe: FPAB077
Lamb, D.: WOAC006, WPPB074, WPPB075
Lambertson, Glen: TPPG014, WOAB009
Lambiase, Robert: MPPE002, MPPE003, MPPE015, WPAB048, ROAC006
Lamm, Michael: MOPA006, TPPB055, WPAE013, WPAE015, WPAE016
Lamont, Mike: MOPA007
Lange, Rolf: ROAA003
Lanza, Cristiano: WPAE017
LaPointe, Michael A.: TPAE024
Larbalestier, David: TOAB003
Laskar, Jacques: WOAB001, RPPG007
Lau, Thomas: FPAG055
Lau, Wai: FPAB044
Lau, Wing: TPAB024, TPPG013
Launey, Daren: TPAB041
Laurent, Jean-Michel: TOPC003
Lauze, R.: TOAC006
Laverty, Mike: TPAB088
Lawrence, Judy Harte: MPPB083
Lawson, Greg: TOPB009
Lawson, Wesley: TPAE013, TPAE018, TPAE027
Lawton, Don: TOAA012
Laxdal, Robert: TPAG027, ROPA010
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Lazurik, Valentin: MPPG031, TPPE034
Lazurik, Valentina: TPPE034
Le, Tuong: TPPB049, FPAB024, FPAB025
Lebedev, Valeri: MOPA003, MOPA008, TPPB056, TPPB059, TPPB061, TPPB062, TPPB066, WPPB040, RPPB021
LeBlanc, Greg: WPAG024, WPAG025, WPAG026
Lebrun, Paul: TPPB062, TPPB067
Ledford, John: TPAB063
Lee, Edward P.: TPAG040, TOPC004, WPPG018, WPPG029, RPAG039

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Lee, Ho-Haeng: RPAB048
Lee, Hwa-Ryun: TPPE028
Lee, Jinhyung: WPAE040
Lee, Peter: TOAB003
Lee, R.: MOPA010, MPPE021, MPPE024, TPPB001
Lee, S.: TPPG050, TPPG051, RPPG037
Lee, S.Y.: MPPG025, TOAA005, RPPB063, RPPG030
Lee, Soon-Hong: MPPB001
Lee, Wing-Tsz: WPPB073, WPPB075
Lee, Y.: ROAC006
Lee, Y.Y.: TPPE011, TPPE012, WPAB053, WPAB048, WPAB049, WPPE033, WPPG004, ROPB004, FPAB064
Lee, Yung: TPPB006, WPAB051
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LeGalloudec, N.: ROAC002
Legan, Al: FPAB033
Legg, Robert: MPPB027
Lehrach, Andreas: TPAB010, RPAB037, ROPA009, FPAB069
Lei, Shan-Chih: TPAG023
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Leitner, Daniela: MOPB008
Leitner, Matthaeus: MOPB008, TPAG040
Lenci, Steve: TPAE019
Lenkszus, Frank: TOPB008, WPPB010
Le Pimpec, Fredrick: TPAB038, RPAB011
Le Sage, Greg: MOPB011, MPPB020, ROAC002
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Letchford, Alan: TPAG042, WPPB060
Leung, K.N.: FPAB010
Leveling, Anthony: TPAG009
Lewellen, John: MPPB037, TPPG002, WPAB001, WPAB003, WPAB004, WPAB044, WPPE003, WPPB004, WPPB005
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Li, Chuan: WPPE014
Li, Derun: TOAC003, TPAB003, TPAB024, TPAB025, TPAB026, TPAB083, WPAE037
Li, Ge: MPPB072
Li, H.: TPPB025, TPPB027, WOAC006, WPPB074, WPPB075, WPPG036
Li, H.C.: WPPE038, WPPE039
Li, Jingyi: WPAG005, WPPB030, WPPB032, RPPB019, RPPG006
Li, Juexin: WPPG057
Li, Ming: TPPE026
Li, Nanyang: WPAB061
Li, Quanfeng: TPPE030
Li, Rui: MPPB056, TOAC009, RPPG031
Li, S.Q.: TPAG019, RPAB058
Li, Weimin: WPPE014, WPPG057
Li, Xiaoguang: RPAB058
Li, Yongjun: RPPG019
Li, Yuelin: MPPB037, WPAB004, WPAB032
Li, Yulin: WPAG003, WPPE037, ROPB005
Li, Yuxiong: WPPG057
Li, Z.: TPPE002
Li, Z.W.: TOPA011
Li, Zenghai: TPAB031, WPAG027, ROAB004, RPAB015, FPAG044
Li, Zheng: WPPG046
Liakin, Dmitry: FPAB088
Liaw, C.J.: WPPB013, ROPB004
Lidia, S.: TOAC003
Lidia, Steve: MPPG011, WPAB021, WPAB022, WPAB023, WPPG039, RPAB054, RPPG011, FPAG015
Liebermann, Holger: TPAB060, RPAB042, RPAG024
Lien, M.K.: ROPA007
Liepe, Matthias: TPAB009, TPAB052, TPAB053, TPAB054, TPAB055, TPAB056, ROAA003, FPAB027
Lietzke, Alan: TOAB008, WPAE021, WPAE023
Likhached, Serguei: RPAG046
Likhachev, Serguei: MPPB090
Lill, Robert: WPPB010
Lim, Jae: WPAB067
Lima, Roberto: WPAB070
Limborg, Cecile: WPAB027, WPPG033, RPPG022, FPAG043
Limon, Peter: MOPA006, MPPE026, TPPB055
Lin, Chia-Jui: WPPB066
Lin, Fu-Yuan: MPPG016
Lin, Ming-Chyuan: MPPB029, TPAB073, TPAB074, WPPE025, WPPE038, WPPG034
Lin, Yu-Chih: TPAG023
Lin, Yuzheng: WPAB033, RPPG047
Lindgren, Lars-Johan: WPAG024, WPAG025, WPAG026
Linnecar, Trevor: TPPB050, RPPB015
Lipka, D.: WPAB034
Litvinenko, Vladimir: MPPE007, MPPB041, MPPB042, MPPB043, TPPB082, WOAB004, WOAC004, WPAG006, WPPB031, WPPB032, RPPB019, RPPG006, FOAA008
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Liu, Jian-Fei: TPAB063, TPAB064, WPAB020
Liu, Jinying: MPPB072
Liu, Kuo-Bin: MPPE014
Liu, Wanming: TPAE033, TPPG001, WPAB002, ROAA010
Liu, Y.Z.: TPAG019
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Liu, Yuan: MPPB085
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LoDestro, Vincent: FPAB001
Lockey, R.: TPPE001, ROAC006
Loew, Gregory: ROPC001
Loewen, R.: TPAB031
Logan, Grant: TPAG040
Logatchov, Pavel: FPAB013
Loiacono, Laura: RPPG002
Longcoy, L.: WPAG028
Longhi, Emily: MPPB042, MPPB043
Lonza, Marco: FPAB045
Loos, Henrik: MPPB038, TOAC012, TPAG030, TOPA007, TOPD005, WPPB021
Lopes, Mauricio: TPPE021, WPAB070
Lopez, Aaron: WPAB001
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Lorman, Eugene: WPPB039
Losito, Roberto: MPPB024, TPAB049, TPAB057
Lou, G.H.: MPPG015
Louie, Wing: MPPE002, TPAG006, TPPB039
Lowe, Dan: TOPA001, WPAB068
Lowenstein, D.: TPPB047
Lozowski, Williams: WPPG046
Lu, Joseph: TPAB040
Lu, Wei: TPPG025, TPPG031, TPPG033, FPAG047
Luccio, Alfredo U.: MOPA009, TOPB004, TPPB036, TPPB037, TPPB038, WOAB008, WPAE002, RPAG005, RPAG008
Ludewig, Hans: TPAG005, TPPB086, RPAB032
Ludvig, Jozsef: WPPG016
Lumpkin, Alex: WPPB002, WPPB003, WPPB004, WPPB005, WPPB006
Lund, S.M.: TOPC004, ROAC001
Lund, Steven: TOAA010, WPPG019, WPAE023, WPPG020
Luo, Gwo-Huei: MPPB029, TPAB073, TPAB074, WPPE025, WPPG034
Luo, Yan: WPAB041, WPAB042, WPAB043, WPAB044, WPAB045
Lusk, Matthew: WPPE013
Lyles, John: TPAE005, TPAE006
Lynch, D.: MPPB007, MPPG003
Lynch, Michael: TPAE039, TPAG015
Lyneis, Claude: MOPB008
Lysenko, W.P.: WPPG011
Ma, Hengjie: TPAG018
Maan, Willemjan: WPAE006
Macek, Robert: TOPD004, WPPB049, WPPG004, WPPG031, ROAB003, RPPB034, RPPB035, FPAB066, FPAB083
MacGill, R.: TPAB025
Machida, Shinji: TPPB028, FPAB062, FPAB081, FPAB082
Machie, D.: TPAB077, RPAB064
Macina, Daniela: TPPB063
MacKay, W.W.: MOPA005, MOPA009, MOPA010, TOAB006, TPPB036, TPPB038, TPPB043, TPPB045, TPPB047, WOAB008, WPAE002, WPPG046, RPAG005, RPAG008
MacLachlan, James: TPPE006, TPPB060, TPPB073, RPPG001, FPAG016
Madre, Bonnie: TPAG029

Maebara, Sunao: RPAB047
Maesen, Pierre: TPPB053
Magome, Tamotsu: MPPE020, TOPA012
Mahler, George: WPAB052
Maier, Rudolf: TPAB010, RPAB037, RPAB038, RPAB039, RPAB040, ROPA009, FPAB069
Maisheev, V.A.: MPPB045
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Makarov, Oleg: WPAG001
Makdisi, Yousef I.: WPPG046
Makino, Kyoko: WPAE034, WPAE035
Makita, Yo: TPAG048
Malafronte, Alexandre: WPAB070
Malagu, Cesare: MPPB045, TPPB016
Malamud, Ernie: RPAG017
Malitsky, Nikolay: TOPB004, WPPB015, WPPG001, RPAG014, FPAG008, FPAG009
Malmgren, Lars: WPAG025
Malo, Jean Francois: WPPB026
Mammarella, Franco: ROPB010
Mammosser, John: TPAB080, ROAA001, RPAB062, RPAB065
Mansell, Justin: TPPG028
Mao, Stan: MPPE019
Mapes, M.: TPPE001
Mapes, Michael: MPPE021, WPAB047
Marcellini, Fabio: WOAA008, WPAB019, WPAG008, RPAB009, RPPB060
Marchand, Patrick (SOLEIL): TPAB057
Marchand, Patrick (CE): MPPB024
Marchionni, Alberto: TPPB012, TPPB015, FPAB074, FPAB075, FPAB076
Marhauser, Frank: TPAB005
Markiewicz, Thomas: RPAB008, RPAB026, ROPC011
Marks, Neil: WPAB056
Marks, Steve: MPPG010, MPPG011, FPAB084
Marneris, Ioannis: MPPE004, TPPE001, TPPB003
Maroli, Cesare: FPAG026
Marone, Andrew: TOAB006, WPAE001, WPAE004, WPAB054
Marque, Sebastien: MPPB024
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Marr, G.: TPPE001
Marriner, John: WPPB037, ROAB006, RPAG018, RPPG001, FPAB071, FPAB072
Marsden, David: TPAE017, TPAE018
Marsh, K.A.: TPPG025, TPPG031, TPPG034, TPPG050, TPPG051, RPPG037, FOAB008, FPAG047
Marshall, Thomas C.: TPPG038, TPPG055, TPPG057
Marsi, Marino: WPAG018
Martens, Mark: WPAB001
Martens, Mike: TPPB055, TPPB057, TPPB059, WPAE016, FPAB031
Marti, Felix: TOAA012, TPAB067, WPPG026, RPAB056, RPAG038
Martin, Michael: MPPB018, WPPB053
Martineau, Rick: TPAG016, RPAB051
Martinelli, Giuliano: MPPB045, TPPB016
Martinez, A.: MPPE026
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Martini, Michel: TOAA009, WOAB003, RPAG012, RPAG013
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Masaki, M.: TOPA012
Masao, Takanaka: RPAG050
Masayoshi, Sugimoto: RPAB047
Mastovsky, Ivan: WPAB024
Masuda, T.: TOPA012
Masunov, Eduard: WPPG023, RPAG035
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Matsui, Sakuo: MPPB026, TOPA012
Matsumoto, Hiroshi: MPPB046, TPAE037
Matsuoka, Masanori: TPAB062
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Mauri, Marco: WPAB019
Mausner, Leonard: TPPB002
Mavanur, Anil: TPAB089
Mazzitelli, Giovanni: TPPB017, WOAA008, WPAG008
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McCarrick, James: WPPB055, ROAC009, FPAG053
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McDonald, James: WOAC002, WPPE028
McDonald, Kirk: TPPB002, TPPB003, WOAA007
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McGahern, William J: WPPE033
McGinnis, Dave: TPPB061
McIntosh, Peter: TPAB035, RPPB060
McInturff, Alfred: TOAB008, WPAE021
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McKigney, E.: TPAB003
McKinney, Wayne: MPPB018
McManamy, Tom: TPPE012
McMichael, G.E.: ROPA007
McNeil, B.W.J.: MPPB059, MPPB060
McNerney, Andrew: MPPE004, TPPE001, TPPB005
Mead, Joseph: WPPB013, WPPB014, WPPB015, WPPG047, ROAB009
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Medjidzade, Valery: TOAB007, WPPE037
Medvedko, Anatoly: RPAB019
Medvedko, Evgeny: MPPE012
Meer, Lex: ROAB008
Meier, Heinrich: TPAB010
Meinke, Rainer: WPAE023, WPAE025
Meisner, Keith: TPPB060
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Meng, Wuzheng: TPPB006, WPAB048, WPAB049, WPAB053, WPPG004
Meot, Francois: MPPG032, WOAD005, WPPG049, RPAG010
Merinov, Igor: WPPB056
Merl, Robert: WPPE013, WPPB047, WPPB048
Merminga, Lia: TOPD006, TPPB082, FOAA009, FPAB046
Merminga, N.: TOAC006
Mertens, Volker: TPPB052
Mertins, Hans-Christoph: MPPB005
Merz, Wolfhard: MPPE005
Messmer, Peter: RPAG045
Meth, M.: TPAB007
Metral, Elias: TOAA009, WOAB003, RPAG012, RPAG013, RPPB014
Metral, Gabriel: WOAB003, RPAG012, RPAG013
Meyer, A.: TPPE001
Meyer, F.: MPPB085
Meyer, Thomas: WPPB038
Meyer Sr., Ross: WPPB034
Mezentsev, N.: TOPA012
Mezi, Luca: MPPB044, TOPA008
Mi, Chaofeng: WPPB017
Mi, Jianlin: TPPB007, WPAB049, ROAC006
Michalek, Wayne: WPAB001
Michaud, Daniel: RPAG010
Michel, Fruneau: RPAB033
Michel, Peter: WPAB007
Michelato, Paolo: TPAG034, WPAB016, WPAB034
Michelotti, Leo: TPPE007, TPPB059, FPAG017
Michnoff, Robert: WPPG044
Migliorati, Mauro: TOPA008, WPPB041
Mihalcea, Daneil: WPPG039
Mikado, Tomohisa: MPPB073, MPPB074
Mikaelyan, Raphael: MPPE018
Mikhailichenko, Alexander: TOAB007, TPPG005, TPPG006, TPPG007, WPAE009, WPAE010, WPAE011, WPAE012, WPPE037, RPAB020, RPAB027, RPAB028, FPAB028
Mikhailov, Stepan: MPPE007, MPPB042, WOAB004, WPAG006, WPAG007, WPPB033, RPPG006
Mikio, Saigusa: RPAB047
Milani, Davide: WPAE006
Milardi, Catia: WOAA008, WPAG008, RPAG025
Miles, John: WPAE005
Milholland, R.: MPPE026

Miller, R.H.: TPAB031, WPAG027, RPAB015, RPAB016
Miller, Toby: RPAB076
Milner, R.: MPPB076, MPPB077
Miltchev, V.: WPAB034
Milton, Stephen: MPPB037, MPPB061, MPPG036, TPPG002, WOPA002
Minaev, Sergey: FPAB088
Minagawa, Yasuyuki: MPPB015, RPPB028, RPPB029, RPPG039
Minehara, Eisuke: FPAB078, FPAB079, FPAB080
Miram, George: TPAE016, TPAE017, TPAE026, TPAE027, TPAE028, FPAB011
Mishra, C. Shekhar: MOAL001, TPPB012, WPPB037, FPAB074
Mishra, S.: RPAG018, FPAB071, FPAB072
Mistry, Nariman: TOAB007, WPPE037
Mitchell, Don: TPAB014
Mitrochenko, V.A.: TPAE014, WPAB025, RPAB070, FPAB008
Mitsuhashi, Toshiyuki: MPPB015, WPPB042, WPPB043, RPPG013, RPPG015
Miura, Takako: WPPB044, WPPG009
Miyajima, Tsukasa: MPPB015, WPAB060, RPPG014
Mizobata, M.: MPPG027
Mizrahi, Amit: FOAB006, FOAB009
Mizuhara, Al: TPAE028
Mizuhara, Maxwell: TPAE016, TPAE017, TPAE018
Modena, Michele: WPAE005
Moeller, Wolf-Dietrich: WPAB007
Moffitt, Jeffrey: WPPB027
Moir, David: ROAC008, ROPB003
Mokhov, Nikolai: MOPA006, TPAG033, TPPB056, TPPB063, TPPB064, TPPB065, RPAB008
Möller, Wolf-Dietrich: ROAA003
Molvik, Art: FPAG059
Molvik, Arthur: TOAA010, TOPC004, ROAC001
Monaco, Laura: TPAG034, WPAB016
Moncton, D.E.: MPPB076, MPPB077
Monroe, Jocelyn: TPPB013
Monroy, Marco: TPAG018
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Montoya, Debbie: TPAB063
Moog, Elizabeth: MPPG002, TOAB004
Moore, Christopher: TPPG019
Moore, Craig: TPPB013
Moore, Ronald: TPPB066, WPPB040, TPPB067
Moore, Tobey: TOAB007
Morcombe, Peter: MPPE007
Moretti, Alfred: TPAB003, TPAB025, WPAE037
Morgan, James: TPAG010, TPPB014, ROPB011
Mori, W.B.: TPPG025, TPPG026, TPPG031, TPPG033, TPPG050, TPPG051, RPPG037, FOAB008, FOAB011, FPAG047
Mori, Yoshiharu: TPAB020, TPAB021, TPPB028, FPAB062, FPAB081, FPAB082
Moritz, Gebhard: WPAB054, ROPA006
Moritz, Lutz: ROPB010
Morris, John: MPPE004, TPPE001, TPPB047
Morse, Edward: FPAB004
Morvillo, Michele: TPPB053
Moser, Herbert: TOPA011
Mosko, Sigmund W.: TPPB026
Mosnier, Alban: ROPA008
Mostacci, Andrea: TPPB090, WPPB041, FPAG007
Mostrom, C.: ROAC008
Mottershead, Charles: FOAA004
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Mouat, Mike: ROPB010
Moy, K.: ROAC008
Mueller, Alex C.: RPAB045
Mueller, Anke-Susanne: MPPB032, WOAB003, RPAG012, RPPG043, RPPG044
Mueller, Dennis: TPPB023
Mueller, Paul E.: MPPB087
Mueller, Wolfgang: RPPB071
Muggli, Patrick: TPPG025, TPPG030, TPPG031, TPPG050, TPPG051, RPPG037, FOAB008, FOAB011, FPAG047
Mulholland, George: TPPB003
Mullany, Brian: TPAG005, TPPB086
Mulvaney, J. Michael: TPAG031, ROAC005
Murai, Sei: WPAE019
Murasugi, Shigeru: TPAE038
Muratore, Joseph: TOAB006
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Murdoch, G.: WPPG054
Murokh, A.: MPPB057, WPPB029
Murphy, Brendan: WPAB027, RPPG022
Murphy, James B.: MPPB007, TOAC001, TOAC012, TOPA007, WPPB021
Murray, Syd: FPAB009
Musser, Susan: TPAB068
Musson, J.: TOAC006, FPAB047
Mustafin, Edil: ROPA006
Musumeci, Pietro: TPPG034, RPAG032
Muto, Atsutoshi: TPPB028, FPAB081, FPAB082
Muto, Masayuki: MPPE009
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Myatt, Gerald: RPAB026, ROPC011
Myneni, Ganapati: TPAB076
Myskin, Oleg: WPAB007
Na, Jean-Ho: RPAB048
Nadji, Amor: MPPB034
Nadolski, Laurent (SOLEIL): MPPB034
Nadolski, Laurent (LBNL): MPPG011, WOAB006
Nagahashi, Shinya: MPPB015, WPAB060, WPPE012
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Nakamoto, Tatsushi: WPAE019
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Nakamura, Norio: MPPB014, ROAB011
Nakamura, Shiro: TPAG048
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Nakamura, T. (SPring-8): TOPA012
Nakamura, Tatsuro: MPPB015, WPPE012
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Nakano, Joe: TPPB028, FPAB081, FPAB082
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Nam, Ki-Yong: TPPE028
Nam, S.H.: WPPE018, WPPE019
Nam, Sang-Hoon: WPPB059, RPPB046
Nam, Sang-Hun: TPAG021, RPPG020
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Nassiri, Alirezza: TPAG001, WPAB004
Nath, Subrata: TPAG017, TPAG038, TPPB018, FPAB085
Nathan, Bultman: RPAB052
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Naylor, C.: TPPE001
Naylor, Graham: MPPB013
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Nesom, Gavin: RPAB026, ROPC011
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Neurath, Rene: ROAC010
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Noble, Robert: TPPG026, FOAB006
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Nusinovich, Gregory: TPAE027
Nyunt, Tun: TOPA011
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Ohashi, Y.: TOPA012
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Onishi, Yukiyoshi: MPPB015
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Ono, Masaaki: MPPB015, TPAB019
Onoe, Kazuyuki: FPAB022
Onoprienko, Dmitry: RPAB022
Oogoe, Takao: RPAB050
Oothoudt, Michael: WPPE013
Oppelt, A.: WPAB034
Orbach, Ray: MOAL004
Oren, W.: TOAC006
Orikasa, Tomofumi: WPAE019
Oro, D.: ROAC008
Orris, Darryl: TPAB059
Orzechowski, Ted: FPAG053
O'Shea, P.G.: TPAG030, TPPB025, TPPB027, WOAC006, WPAG020, WPPB073, WPPB074, WPPB075, WPPG035, WPPG036, WPPG056, ROAB005, RPPB067, FPAB016
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Ostojic, Ranko: MOPA006
Ostroumov, Petr: WOAB007, WPPB007, RPAB030, RPAB068, FPAG003
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Ott, Klaus: MPPE016, MPPE017
Ottaviani, P.L.: MPPB061, MPPB062, MPPB063, MPPB064, MPPG036
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Pagani, Carlo: TPAB046, TPAB063, TPAG034, WPAB034, ROAA003, RPAB045
Pai, Chien: WPAB048, WPAB049, ROAC006
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Palmer, Mark: WPAG004, WPPB027
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Palumbo, L.: MPPB057, WPPB041, FPAB002
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Pantell, Richard: TPPG048
Paoluzzi, Mauro: TPPB053
Papaphilippou, Yannis: MPPB012, MPPB013, TOAA007, RPPG007
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Paramonov, Valentin: RPAB046
Pardo, Richard: WPPB007, RPAB068
Park, Byung-Ryul: TPAG021
Park, Jangho: WPPB059
Park, Mi-Young: TPAB016, RPAB048, RPAB072
Park, Sam: TPAB037
Park, Soung-Soo: RPPB049
Park, Sungju: WPPB059
Parker, Brett: WOAA010, WPAE001
Parkhomchuk, Vasili: RPAB019
Parmigiani, F.: TOAC003
Parsa, Zohreh: TPPB040, RPAG059, FPAB063
Partridge, Richard: ROPB012
Parzen, George: WPPG001
Pasky, Stanley: TPAG002, WPAB004, WPPE003
Pasotti, C.: MPPB024
Pasquinelli, Ralph: RPPB023, FPAB070
Pate, D.: MOPB010
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Patton, Jeff: WPPE016
Paul, Arthur: WPPB055, RPAG033
Paulon, Roberto: TPAG034
Pavlishin, I.: FOAB010
Payet, Jacques: RPAB001
Pearson, C.: TPAB031
Peatman, William B.: MPPB005, MPPB006, RPPB006
Pedrozzi, Marco: MPPB024
Peggs, Stephen: MOPA005, MOPA006, MPPG022, MPPG023, TOAA011, TOPB007, TPPE002, TPPB034, WOAA010, WPAB072, RPAG003, RPAG004
Pei, Yuan-Ji: MPPE033, TPAG019, TPPG058, RPAB058
Peiniger, Michael: TPAB090, RPAB073
Pekeler, Michael: TPAB090, RPAB073
Pelaia, Thomas A.: FPAG033
Pelaia, Tom: WPPE015, WPPE016, WPPE017

Pellegrini, Claudio: MPPB057, TOAC010, TPPG032, TPPG034, WPPB071
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Penano, Joe: TPPG020
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Penco, G.: MPPB024
Penel, Christophe: TOPA013
Peng, Yong: TPPB023
Peng, Zhen Hua: ROPA010
Penn, Gregg: RPAG058
Perevedentsev, Eugene: FPAB051
Perez, Francisco: MPPB032, RPPG043, RPPG044
Perez, Richard: RPPB007
Perezhogin, Sergey: TPPE029
Perng, Shen-Yaw: WPPB066
Perry, Colin: RPAB026, ROPC011
Pershin, Vladimir: FPAB088
Peschke, Claudius: WOAD002
Peters, Hans-Bernhard: ROAA003
Peterson, Dave: RPPB023
Peterson, P. F.: WPPG022
Peterson, Tom: WPAE014
Petracca, Stefania: RPAG052, RPAG053, RPAG054
Petrillo, Vittoria: FPAG026
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Petroff, Yves: FOPL004
Petrossyan, B.: WPAB034
Petrosyan, Gevorg: ROAA004
Petrov, Victor: WPAB007
Petrunin, A.A.: MPPB045
Peyrot, Marc: WPAE007
Pfeffer, Howard: TPPB077
Pfister, Uwe: ROPA009
Phillips, David: TPPE001, TPPE002, TPPB005
Phillips, H.L.: TPAB087
Phillips, Lawrence: TPAB082, RPAB062
Phillips, Purobi: TPAE018
Phinney, Nan: ROPC008
Picardi, Luigi: MPPG030, TPPE037
Pichoff, Nicolas: WPPG005, RPAB034, FPAG012
Pieck, Martin: TPAE039
Piekarz, Henryk: WPAE020
Piel, Christian: RPAB073
Pierini, Paolo: TPAB046, TPAG034, RPAB045
Pietro, Musumeci: TPPG032, WPAB037
Pikin, Alexander: MOPB009
Pilat, Fulvia: MOPA006, MOPA009, TPPB041, TPPB042, TPPB043, TPPB045, TPPB057, WPAB073, WPPE004, WPPB015, RPAG007
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Pillai, Chandra: WPPB047, WPPB048
Pinaev, Igor: WPAG006
Pinayev, Igor V.: MPPE007, MPPB042, MPPB043, TPAE002, TPAE003, WPPB030, WPPB031, RPPB019
Pindak, R.: TOPA007
Pinelli, Donald: WPPG042
Piot, Philippe: MPPB040, WPPG039, RPPG010, FPAG015
Pirkl, W.: TOAC003
Pisent, Andrea: FPAB077
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Pivarc, Juraj: FPAB021
Pivi, Mauro (LBNL): WOAA004, WPPG004, WPPG031
Pivi, Mauro (SLAC): RPPG023, RPPG024
Pjerov, S.: MPPB007, TOPA007
Placidi, Massimo: TOAC003, WPPB052
Plan, Bernard: TOPA013
Plant, Duane: RPAB019
Plate, David: TPAB023
Plate, Stephen: TOAB006, WPAE004
Plawski, Eugeniusz: ROAA003, RPAB009, RPAB029
Plawski, Tomasz: TPAB081, WPPE026, FPAB047
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Podlech, Holger: TPAB060, RPAB042, RPAG024
Podobedov, Boris: MPPG003, TOPA007, TOPD002
Poelker, Matthew: TPPB082
Pogge, J.: TPAG041, WPPG054
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Poirier, Roger: TPAB040, ROPA010
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Ponnaiyan, Vivek: MOPA010, MPPE024
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Popov, Victor: MPPE007, WPAG006
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Powers, Tom: TPAB075, TPAB081, WPPE026, ROAA001, RPAB065
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Preble, Joseph: MPPB075, ROAA001, RPAB061, RPAB065, FPAB086
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Proch, Dieter: ROAA003
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Prost, L.R.: TPAG039, TOPB006, TOPC004, WPPB050, ROAC001
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Pushkarev, Stanislav: TPPE025
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Rathke, J.W.: MOPB010, MPPB047, MPPB075, WPAB065, RPAB030
Ratschow, Sebastian: RPPB072
Ratti, Alessandro: TPAG018, WPPB052, FPAB036
Ratzinger, Ulrich: MPPG024, TPAB060, RPAB042, RPAG024
Raubenheimer, Tor: MPPG013, WPAG027, RPAB008, RPAB013, RPAB014, RPAB015, RPAB017, RPAB022, RPAB025, ROPC004, ROPC009, RPPG023, RPPG027
Rawnsley, William: ROPA010
Read, Michael: TPAE016, TPAE018, TPAE026, TPAE027, TPAE028
Reass, William: TPAE039, ROAC007
Redaelli, Stefano: ROPC005
Redlin, H.: WPAB034
Reece, Charles: TPAB077, TPAB082, TPAB086, TPAG029, RPAB064, RPAB065
Reece, Ken: TPAG020, TPPE011
Rees, Daniel: TPAE007, TPAE039, TPAG015
Rees, Grahame: TPAG043, TPPE007
Regan, Amy: FPAB036
Rehlich, Kay: WPPE009, WPPB028, ROAA003
Reichardt, Gerd: MPPB005
Reiche, Sven: MPPB057, MPPB058, TOAC010, WPAB030, WPAB031, RPPB066
Reichel, Ina: TOAC003, WPPG015
Reich-Sprenger, Hartmut: ROPA006
Reid, John: MOPA008, TPAB011, RPAG021, FPAB029
Reilly, John: TPAB048
Reiser, Martin: TPPB025, TPPB027, WOAC006, WPAG020, WPPB073, WPPB074, WPPG035, WPPG036, ROAB005, RPPB067
Rej, Don: TPAG017
Remacle, Jean-Francois: FPAG054
Remondino, Vittorio: TOAB009, WPAE008, WPAE017
Ren, Chuang: TPPG031
Repikhov, Oleg: RPAB070
Reppe, Bertram: WPAB007
Reprintzev, Leonid: RPAB070
Reschke, Detlef: ROAA003
Rescia, Sergio: WPPG046
Resende, X.: MPPG019
Reshetnyak, N.G.: TPAE014, FPAB008
Reuter, A.: MOPB010
Revol, Franck: TOPA013
Revol, Jean-Luc: MPPB012, MPPB013
Rey, Jean-Michel: WPAE022
Reynolds, Jerome: WPPE013
Rhee, Seung: WPAB062
Riccardo, Bartolini: MPPB064
Ricci, Ruggero: WOAA008, WPAG008
Rice, David: TOAB007, WPPE037
Richards, Daniel: TPAG016, RPAB052
Richardson, Roger: MPPB082, ROAC009
Richichi, Steve: TOAB007
Richter, Achim: FPAG050, FPAG058
Rick, Cross: MPPB020
Ries, Thomas: TPAG027, ROPA010
Rieser, M.: WPPB075
Rifflet, Jean-Michel: WPAE007
Rifkin, Jeffrey: ROAB004
Rimmer, Robert: MPPB075, TOAC003, TPAB003, TPAB024, TPAB025, TPAB083, WPAE037, WPAB023
Rinn, Jean: WPAE005
Rinolfi, Louis: WPPB078, ROPC010
Rios, Paulo: TPPE020, TPPE021
Riot, Vincent: WPPB052
Ritson, David: TPPE007
Ritter, John: MOPB009, FPAB001
Rizzato, Felipe: RPAG051
Robb, G.R.M.: MPPB059, MPPB060
Robin, David: MPPG011, TOPA002, WOAB006, WPAB086, WPAB087, RPPG018
Robinson, Dennis: TPAG031, ROAC005
Robinson, K.E.: TOAC003
Robinson, Tom: TPAE017, TPAE018
Roblin, Yves: FPAG046
Robothom, William: WPAB058
Rock, Benjamin: WPPB027
Rockford, J. H.: WPAE022
Rode, Claus: MPPB075, RPAB063, RPAB065
Rodgers, D.: FOAB003
Rodrigiuez, Manuelita: TPAB022
Rodriguez, Jose: TOAA012, WPPG026
Rodriguez, P.: ROAC008
Rodriguez-Mateos, Felix: WPAE006
Rogers, Greg: WPAG017
Rogers, Joseph: WOAA011
Rogov, Yuriy: TPPE034
Rohlev, Anton: WPPE007
Romanov, Gennady: MOPA008, TPAB013
Romero, Dolores: WPPE013
Roncarolo, Federico: WPPB026
Ronsivalle, Concetta: MPPB044, MPPG030, TPPE037, WPAB018, FPAG043, FPAG056
Ropert, Annick: MPPB012, MPPB013, RPPG007
Rose, Chris: WPPB034
Rose, David: TOAA001, WPPG014, WPPG022, WPPG040, RPPB073
Rose, James: MPPB007, TOAC012, TPAB006, TOPA007, WPPB021, RPAB036
Rosenberg, Richard: ROAB003, RPPG002
Rosenzweig, James: MOPB011, MPPB020, MPPB057, MPPB058, TPAG045, TPPG026, TPPG032, TPPG033, TPPG034, TPPG037, WPAB030, WPAB031, WPAB037, WPAB067, WPPB071, RPAG032, RPPB066, RPPG038, FPAB015
Roser, Thomas: MOPA002, MOPA005, MOPA009, MOPA010, TPPE003, TPPB006, TPPB038, TPPB043, TPPB047, WOAB008, WPAE002, WPAE031, WPAB072, WPPG046, RPAB031, RPAG008, RPPB007
Ross, Marc: TPAB038, WPPB039, WPPB061, WPPB062, WPPG055, ROAB002, RPAB026, ROPC008, ROPC011
Rossat, Ghislain: RPAB009
Rossbach, J.: WPAB034
Rossen, Peter von: ROPA009
Rossi, Adriana: TOPC003, TPPB054
Rossi, Carlo: TPPB053
Rossi, Lucio: MOPA006, TOAB001
Rossmanith, Robert: MPPB035
Rotela, E.: RPAB030
Roth, Ian S.: TPAG031, ROAC005
Roth, Marcus: ROAC002, FOAB001
Rothgeb, Tim: TPAB080
Roudier, Dominique: TPAB047
Rouleau, Gary: MOPB004
Rowe, Allan: TPAB059
Rowley, Lee: WPAG017
Roy, Prabir: TOAA001, WPPG012, WPPG013, WPPG014, WPPG016, WPPG017
Roybal, Ray: TPAB063, TPPB018
Roybal, William: TPAE005, TPAG015
Roychowdhury, Samadrita: MPPB042, MPPB043
Royer, Philippe: WPPB078, ROPC010
Rubin, David: WPAG004
Rudolph, Klaus-Peter: RPAB066, RPAB067
Rudychev, Vladimir: TPPE035
Ruegg, Roman: ROPB010
Ruggiero, Alessandro: TPPB006, RPAB031, RPAB032
Ruggiero, Francesco: MOPA006, TOAA007, TPPB054, TPPB065
Ruggles, Stephen: TPAE039
Ruhl, H.: ROAC002, FOAB001
Ruland, Robert: RPAB019
Rumolo, Giovanni (CERN): RPPB011, RPPB012, RPPB013
Rumolo, Giovanni (GSI): TOAA007, TPPB054, WPAB082, WPPG007, RPPB016
Rusek, Adam: TPPE001, TPPE002, TPPB005
Rusnak, Brian: MPPB080, TPAB065
Russell, Allison: TPPB013
Russell, Steven: MPPB075, ROAA012

Rust, Ken: MPPE015, ROAC006
Rust, William: ROPB009
Ruth, R.D.: TPAB031, WPAG027
Ryan, John: TPPE001, WPPG003
Rybarcyk, Lawrence: TPAE006, TPPE010, RPPB034
Rydberg, Anders: WPPB078
Ryne, Robert: RPAG031, RPPG017, FPAB057, FPAG031
Saban, Roberto: WPAE006
Sabbi, GianLuca: MOPA006, TOAB008, TPAG040, WPAE021, WPAE023, ROAC001
Sabol, Daniel: WPPE037
Saeki, H.: TOPA012
Saewert, Gregory: TPPB077
Safarov, A.N.: MPPB088
Safranek, James: RPPG018, FPAG037
Sagan, David: MPPB011, MPPG006, WPAG004
Sahoo, Gajendra Kumar: RPPG045
Saito, Kenji: ROAA002
Saito, Yoshio: RPPB031
Saitou, Kazuyoshi: MOPB005
Sajaev, Vadim: MPPB037, WOAB011
Sakaguchi, Hirokazu: TPAE004
Sakai, Fumio: WPAB038, WPAB040
Sakai, Hiroshi R.: MPPB014, ROAB011
Sakai, Izumi: TPAG037, TPPB028, FPAB082
Sakamoto, Yutaka: MPPB015
Sakanaka, Shogo: MPPB015, TPAB019, RPPG015, FPAB034
Saleh, Ned: TPPG054
Sampayan, Stephen: TPPE022, TPPE023
Samulyak, Roman: TOPB005, FPAG031
Sandberg, Jon: MPPE002, MPPE003, MPPE004, MPPE015, TPPB007, WPAB048, WPAB049, ROAC006
Sanderson, David: TOAA012
Sandner, W.: WPAB034
Sanelli, Claudio: WOAA008, WPAG008
Sanfilippo, Stephan: TOAB009
Sannibale, Fernando (INFN): TPPB017
Sannibale, Fernando (LBNL): MPPB016, WPPB051
Sanosyan, Khnkanos: MPPE018
Santucci, James: TPPG037, WPPG039
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Sasaki, Shigeki: MPPE020, TOPA012
Sasaki, Shigemi: WPAG001
Sato, Hikaru: MPPE008, MPPE009, TPAE038, TPPB093, WPAE020, WPAB059
Sato, Masayuki: MPPB015
Sato, Y.: RPPG030
Sato, Yasuo: TPPB028, FPAB081, FPAB082
Sato, Yoshihiro: WPPB044
Satogata, Todd: MOPA009, MOPA010, TOPB004, TPPB038, TPPB042, TPPB043, TPPB045, TPPB047, WOAB008, WPAB072, WPAB073, WPAG002, WPPB015, WPPG047, RPAG003, RPPB007, FPAG008
Satoh, Kotaro: RPPB033
Satoh, Masanori: ROAB012, FPAB035
Satoh, Masato: MPPB015
Satoh, Y.: FPAB087
Sauer, Andreas: TPAB060, RPAB042, RPAG024
Saugnac, Herve: TPAB047
Saunders, Jeff: TPAB080
Savage, Richard: WPPE033
Savary, Frederic: WPAE005
Savatteri, Steve: MPPE004
Savchenko, A.N.: WPPB045
Sawamura, Masaru: FPAB078, FPAB079, FPAB080
Scaduto, Joseph: MOPB010, TPPB003
Scandale, Walter: MPPB079, TOAB009, TPPB016, WPAE008, WPAE017
Scanlan, Ronald: MPPG010, TOAB008, WPAE021
Scarpine, Victor E.: WPPB003, WPPB039, RPPB021
Scarvie, Tom: MPPB018, FPAB037
Schachter, Levi: TPPG036, FOAB006, FOAB009
Schade, Ulrich: MPPB006, RPPB006
Schaller, Stuart: WPPE013
Schappert, Warren: TOPD003, WPPB039
Schauf, Frederique: WPAE006
Scheer, Michael: MPPB005
Scheidt, Kees-Bertus: MPPB013
Scheitrum, Glenn: TPAE026, FPAB011, FPAB012
Schellong, Bernd: WPAE007
Schempp, Alwin: MPPG024, TPAB010, TPPE038, RPAB041, RPAB043, ROPA009
Schenkel, T.: WOAC002
Schilcher, Thomas: FPAB041
Schimizu, J.: TOPA012
Schirm, Karl-Martin: WPAE007
Schlabach, Phil: TPPB055, WPAE013, WPAE015, WPAE016, RPAG017
Schlarb, Holger: WPAB017, WPPB029, ROAA003, RPAB005, RPPB054, RPPB055
Schlitt, Bernhard: MPPG024
Schlott, Volker: FPAB041
Schlueter, Ross: MPPG010, MPPG011, FPAB084
Schlyer, David J.: MPPG022
Schmalzle, Jesse: WPAE004, WPAB054
Schmekel, Bjoern: WOAA011
Schmerge, John F.: WPAB027, WPPG033, RPPG022
Schmickler, Hermann: ROAB007
Schmidt, Frank: TPPB057, TPPB067, TPPB068, TPPB075, WPAB073, WPAB080, WPAB081, FPAG013, FPAG014
Schmidt, Paul: WPAE007
Schmidt, Rudiger: MOPA007, TPPB010, WPAE006
Schmidt-Bocking, Horst: TPPE038
Schmor, Paul: MOAL002, FPAB014
Schnase, Alexander (COSY-HF): TPAB021
Schnase, Alexander (FJ): TPAB010, TPAB015, RPAB041, ROPA009, FPAB069
Schneider, Christof: WPAB007
Schneider, Dieter: WOAC002
Schneider, Herbert: ROPA009, FPAB069
Schoenlein, Robert: TOAC003, WPPB001, WPPB052
Schrage, Dale: MPPB047, MPPB075, TPAB063, TPAB064, TPPB018, WPAB020
Schramm, Ulrich: TOAA004
Schreiber, Siegfried: MPPB040, MPPG035, WPAB015, WPAB016, WPAB034, ROAA003, RPAB005
Schreuder, Nick: FOAA003
Schroeder, Carl: TPPG010, TPPG011, TPPG015, WPPB053, FOAB003, FOAB005, FPAG032
Schuett, Petra: ROPA006
Schulte, Daniel: TPPB054, RPAB002, RPAB004, RPAB006, RPAB007, RPAB008, RPAB014, ROPC003, ROPC004, ROPC005
Schultheiss, Carl: MPPE002, WPPE034, WPPG048, ROAB009
Schultheiss, T.J.: MOPB010, MPPB047, MPPB075, WPAB065, RPAB030
Schultz, D: WPAB043
Schultz, Joel: WPAE023
Schultz, Ryan: TPAG010, TPAG012
Schulze, Martin (GA): RPPB034
Schulze, Martin (LANL): WPPG010
Schumann, R.: WPAB034
Schurig, Rico: WPAB007
Schwaegel, J.: ROAC008
Schwarz, Heinz: TPAB035, RPPB060
Scott, Duncan: MPPG008
Sear, James: TPAB051
Sears, Chris: WPAB026
Sears, James: TPAB049, TPAB050, TPAB054, TPAB090
Sebak, Jim: WPPB039
Seberg, Scott: WPAB052
Seeman, John: TOPC005, WPAG014, WPAG015, WPAG016, FPAB058
Sei, Norihiro: MPPB073, MPPB074
Seidl, Peter A.: TPAG039, TOPB006, TOPC004, WPAE023, ROAC001
Seifrid, Pete: RPPB023
Sekachev, Igor: ROPA010
Sekutowicz, Jacek (DESY): TPAB077, TPAB083, TPAB084, ROAA003, RPAB005, RPPB071
Sekutowicz, Jacek (TJNAF): MPPB075, MPPG035, TPAB076, TPAB085, TPPE013, RPAB064
Semenov, Alexei: TOPD003, TPPB077
Sen, Tanaji: MOPA004, MOPA006, TPPB057, TPPB059, TPPB067, TPPB068, TPPB069, TPPB074, TPPB075, FPAB057
Senf, Friedmar: MPPB005
Senichev, Yurij: RPAB038, RPAB039, RPAB040, ROPA009
Sentoku, Y.: ROAC002

Seo, Jae-Hag: RPPB049
Serafini, David: FPAG031
Serafini, Luca: MPPB044, MPPB057, MPPB063, WPAB018, WPAB019, FPAG026, FPAG056
Serdobintsev, Gennady V.: RPAB071
Sereno, Nicholas: MPPB002, TOPA010, WPPB005, WPPB010
Serio, Luigi: WPAE006
Serio, Mario: WOAA008, WPAG008, RPAB009
Serrano, Javier: WPPE007
Serriere, Vincent: RPPG008
Sertore, Daniele: TPAG034, WPAB016, WPAB034
Seryi, Andrei: RPAB008, RPAB011, RPAB013, RPAB014, RPAB017, RPAB018, RPAB019, RPAB024, ROPC003, ROPC004
Sessler, Andrew: WOAB010, FPAB062
Setukowicz, Jacek: TPAB046
Setzer, Stefan: WPAB034, FPAG057, FPAG058
Sgamma, Francesco: WOAA008, WPAG008
Shadwick, B.A.: TPPG010, TPPG011, FOAB003, FPAG032
Shafer, Robert: FPAB085
Shaftan, Timur: MPPB038, MPPG004, MPPG005, TOAC012, TOPA007, TOPD005, WPPB021
Shang, Hairong: TOPA010, TOPB008, WPPE002, FPAG001, FPAG004, FPAG005, FPAG006
Shang, Jian Ku: TPAG013
Shank, Charles: FOPL003
Shapiro, Alan: TPAB063, TPAB064, WPAB020
Shapiro, Michael A.: TPAB028, TPAB029, WPPB057
Shapiro, Stephen M.: RPAB032
Shaposhnikova, Elena: TPPB050, RPPB015
Sharamentov, Sergey: TPAB043, WPPB007, RPAB030
Sharkov, Boris: FPAB088
Sharma, Amalendu: RPPG045
Sharma, S.: RPAB030
Sharp, William (LBNL): WPPG014
Sharp, William (LLNL): TOAA001, WPPG022
Shatunov, Peter: RPAG002
Shatunov, Yuri M.: WOAA010, RPAG002
Shaw, Robert: ROPB004
Shchelkunov, Sergei: TPPG055
Shea, T.J.: TPPE011, WPPG054
Sheehy, Brian: MPPB007, TOAC012, TPAG030, TPPG004, WPPB021
Sheinman, E.: TPPG041, TPPG042, TPPG043, TPPG044
Shelley, Fred: WPPE013, WPPB047, WPPB048
Shemelin, Valery: TPAB009, TPAB051, TPAB052, WPAB012
Shen, Lianguan: TPAG019, RPAB058
Shen, Stewart: TPAB065
Shen, Yuchen: WPPB021
Shendrik, V.A.: WPPB045, RPAB070
Shepard, Kenneth (ANL): TPAB043
Shepard, Kenneth (BNL): TPAB044, TPAB045
Shepard, Kenneth (DU): ROPA003
Shephard, Mark: FPAG054
Sheppard, John: RPAB012, RPAB020
Sherman, Joseph: MOPB004
Sherrill, Bradley: ROPA004
Shevchenko, Oleg A.: MPPB042, WOAC004, WPPB030, RPPB019
Shi, Jack: TPPB091, WOAA009, FPAB049
Shiao, F.Z.: WPPE039
Shibata, Kyo: MPPE027, MPPE028, MPPE029
Shiltsev, Vladimir: MOPA008, TPPB055, TPPB062, TPPB066, TPPB067, TPPB068, TPPB076, TPPB077, WPPB040, RPAB019, RPPB021
Shimizu, Naohisa: TPAE038
Shimomura, S.: FPAB087
Shimosaki, Yoshito: TPPB093, WPPG009, RPAG027
Shingo, Sazawa: RPAB047
Shinn, Michelle: FOAA007
Shinoe, Kenji: ROAB011
Shintake, T.: MPPB046, TPAE037
Shintake, Tsumoru: MPPB067, MPPB068, ROAA009, FPAB022
Shintomi, Takakazu: MPPE009, WPAE019
Shioya, Tatsuro: MPPB015
Shirakata, Masashi: TPPB093, WPPG009
Shirasawa, Katsutoshi: FPAB089
Shishido, Toshio: TPAB062
Shishlo, Andrei: TOAA005, WPPE015, WPPE016, WPPE017
Shkvarunets, Anatoly: WPPG056
Shmuel, Eylon: WPPG014
Shoaee, Hamid: FPAB036
Shoji, Masazumi: MPPE020, TOPA012, WPPB064
Shrey, T.: TPPE001
Shubin, Evgeni: RPAB019
Shul'ga, Nikolai: MPPB093, MPPB094, RPAG055, RPAG056, FPAB019
Shumakov, Igor: WPPG038, RPAG057, FPAG034
Shuman, Derek: TOAA001, WPPG017
Shurter, R. B.: WPPB046
Shvedov, Dmitri: WPAG006
Shvets, Gennady: RPPB051
Sibley, Coles: ROPB001
Siddons, P.: TOPA007
Sideris, Ioannis: WPPG037
Sieber, Thomas: RPAB066, RPAB067
Siemann, Robert: TPPG024, TPPG025, TPPG026, TPPG030, TPPG031, TPPG036, TPPG050, TPPG051, RPPG037, FOAB006, FOAB008, FOAB009, FOAB011, FPAG047
Siemko, Andrzej: WPAE005
Sievers, Peter: MOPA007
Sigler, Floyd: TPPB019, TPPB020
Sikora, John: TPAB048, RPPB018
Sikora, Robert: WPPB013, WPPB014, WPPG047, ROAB009
Silvestrov, G.I.: MPPG027
Silzer, Mark: TOPA001
Simmons, D.: ROAC008
Simmons, Lee: TPAB014
Simoens, Francois: TPAB047
Simon, Fabrice: WPAE007
Simos, Nicholas: TPAG005, TPPB002, TPPB044, TPPB086, WPPE006, RPAB011, FPAB065
Simrock, Stefan: WPPE009, ROAA003, ROAA004, RPAB005, FPAB046
Sims, Jim: TPAG016, RPAB051
Sinclair, Charles: MOPB006, TOAC005, TPAB052, WPAB013
Singatulin, Shavkat: RPAB019
Singer, Waldemar: TPAB076, ROAA003
Singer, Xenia: ROAA003
Singh, Gurnam: RPPG045
Singh, Om: TOPB008
Singh, P.: TPAG046
Skarbo, Boris: FPAB013
Skaritka, John: MPPG004, TOAC012, TPPG048, WPPB021
Skomorokhov, Vyacheslav: WPAG021, WPAG022
Skorobogatov, V.V.: MPPB045
Skrinsky, A.: TOPA012
Skuta-Briddick, Debra: WPAB004
Slaughter, A.: TPPB070, TPPB071
Smaluk, V.: TOAC011
Smart, L.: MOPA010
Smart, Loralie: MPPE021
Smedley, John: WPAB044, ROAC003
Smirnov, Alexei: TPAE032, TPAE033, WPAB041, WPAB043, WPAB044, WPAB045, WPAB065, WPPG023, RPPB075
Smirnova, Evgenya: TPAB028, TPAB029
Smith, Brian: TPAB013
Smith, Eric: WPPE037
Smith, G.: TPPB047
Smith, Jeffrey: WPAG004
Smith, K.: TPPE003, WPPB012, FPAB025, FPAB039
Smith, K.S.: TPPB047, FPAB024
Smith, Karl: TPAB077
Smith, Kevin: TPAB007, TPPB043, ROAA006, FPAB026
Smith, Stephen: MPPE012, ROAB004, ROPC011
Smith, Terry: TPAG001, TPAG003, WPAB004
Smith, Tonee: TPAB038, RPAB026, ROPC011
Smolenski, Karl: TOAB007, WPPE037
Smolyakov, Mikhail: MPPG020
Smolyakov, Nikolay: FPAB089
Snowel, M.: WPPB074
Snydstrup, Louis: TPPE001, TPPB005
Soika, Rainer: WPAB054
Soliday, Robert: TOPB008, WPAG001, FPAG001, FPAG004, FPAG005, FPAG006

Solyak, Nikolay: MPPE026, TPAB012, TPAB013, TPAB014, TPPB077, RPPB071
Someya, Hirohiko: MPPE008, WPAB059, WPPB044
Song, Liqun: TPAE015, TPAE028
Sonnad, Kiran: TPAG047
Sorchetti, Rossano: WPPB028
Soren, Telfer: WPAB039
Soutome, Kouichi: MPPE020, TOPA012
Spataro, Bruno: WPPB041
Spencer, Cherrill: MPPE019, WPAB062
Spencer, James: MPPE019, TPPG028, WPAB063
Spentzouris, Panagiotis: RPAG023
Spickermann, Thomas: WPPB049, RPPB035, FPAB083
Spiller, Peter: ROPA006
Spitz, R.: TPAB007
Sprangle, Phillip: TPPG018, TPPG019, TPPG020, TPPG021, TPPG040, FOAB004
Sprehn, Daryl: FPAB011
Springer, Paul: MOPB011, MPPB020
Srinivasan-Rao, Triveni: MOPA005, MOPB010, WPAB008, WPAB044, ROAC003, RPAG009
Stanford, Guy: TPAG027, FPAB014
Staples, C.: MPPE026
Staples, John: TOAC003, TPPE009, WPAE037, WPAB021, WPAB023, RPPG011
Startsev, Edward A.: TPPB023, RPAG039, RPAG040, RPAG042, RPPB052, RPPB053
Stassen, Rolf: TPAB010, RPAB038, ROPA009, FPAB069
Steal, Dean: TPPB061
Stecchi, Alessandro: WOAA008, WPAG008, RPAB009
Steck, Andy: WPPB047
Steck, Markus: WOAD002
Steerenberg, Rende: WOAB003, RPAG012, RPAG013
Stefancich, Marco: MPPB045, TPPB016
Stefanski, Raymond: TPPB013
Steier, Christoph: MPPB018, MPPG011, WOAB006, WPAB087, RPPG018, FPAB037, FPAG037
Steimel, James: TPPB060, RPPB023, RPPB024, RPPB025, FPAB029, FPAB030, FPAB032
Stein, Jochen: FPAB069
Stein, Werner: RPAB055
Steinhauer, Loren: TPPG048
Steinke, M.: MPPE026
Stella, Angelo: WOAA008, WPAG008, RPAB009
Stelzer, James: MOPB004
Stencu, Elena-Claudia: MPPG021
Stephan, F.: WPAB034
Stephani, Thomas: WPAE007
Stephen, Sampayan: ROAC010
Stepin, Dmitry: RPAB070
Steski, D.: TPPB047
Stettler, Matthew: WPPB046, FPAB036
Steve, Smith: RPAB026
Still, Dean: TPPB055, FPAB033
Stinson, Glen: TPPB024
Stirbet, Mircea: TPAB075, ROAA001, RPAB065
Stockhorst, Hans: TPAB010, ROPA009, FPAB069
Stockli, Martin: ROAB010, FPAB009
Stockwell, Brad: TPAE019, TPAE029
Stoltz, Peter: TOAA010, RPAG058, FPAG059
Stott, John: MPPB027, WPPE023
Stout, D.: TPAG041, WPPG054
Stovall, Jim: TPAG038, WPPG027, RPAB059, FPAB085
Strait, James B.: MOPA006, TPPB064, TPPB065, WPAE018
Straumann, Till: MPPE012, WPPB039, WPPB063
Striganov, Sergei I.: TPPB056
Strohman, Charles: WPAG004, WPPB027, FPAB027
Studebaker, J.: ROAC008
Stupakov, Gennady: MPPB049, MPPG013, TOAA002, RPPB057, RPPB058, RPPG025, RPPG027
Suetake, Masaaki: MPPB015, TPAB019
Suetsugu, Yusuke: MPPE027, MPPE028, MPPE029, ROPB002
Sugahara, Ryuhei: MPPB015
Sugawara, Sigekatu: WPAE019
Sugaya, Masahiro: TPAB020, TPPB028, FPAB081
Sugaya, Masahito: FPAB082
Sugimura, Takashi: FPAB017
Sugino, K.: FPAB087
Sugita, Kei: WPAE019
Suhring, Steven: ROPB007
Suk, Hyyong: TPPG022, TPPG023, TPPG047, RPAG047, RPAG049
Sullivan, G.: ROAC008
Sullivan, James: WPPB055
Sullivan, K.: WPAB064, WPAB066
Sullivan, Michael: WOAA002, WPAG009, WPAG014, WPAG015, WPAG016, FPAB058
Summers, Donald: TPPB092, WPAE027
Sun, Ding: RPPB023
Sun, H.B.: TPAG019
Sun, Xiang: WPPG041, RPPB001, RPPB002, RPPB003
Sun, Yin-e: WPAB022, WPPG039, RPAB054
Sundelin, R.M.: TPAB086, TPAB087
Suwada, Tsuyoshi: ROAB012
Suzuki, Hiromitsu: WPPB064
Suzuki, Hiroyuki: TPAB062
Svandrlik, Michele: MPPB024
Svirida, Dima N.: WPPG046
Swenson, Donald: RPAB075
Swift, Gary: MPPB042, MPPB043, WPAG006
Swinney, C.: ROAC008
Sylvester, Cosmore: WPAE013
Symon, Keith R.: WOPA003
Syphers, Michael: TPPB012, TPPB059, TPPB067, RPAG019
Syratchev, Igor: ROAA011
Syresin, Evgeny: WPAE038
Syshchenko, Vladislav: MPPB094
Szabo, G.: MPPE026
Szott, Philippe: TPAB047
Tabak, M.: WPPG022
Tabrizi, Mehdi: MPPB093
Tada, Junichiro: MPPE020
Tadano, Mikio: WPPB043
Tadano, Mikito: MPPB015
Tajima, T.: WOAC001
Tajima, Tsuyoshi: TPAB063, TPAB064, WPAB020
Takagi, Akira: TPAB015, TPAB020, TPAB021, TPPB028, FPAB081, FPAB082
Takagi, Tetsuya: MPPE020
Takahashi, Jiro: TPPE020, TPPE021, WPAB070
Takahashi, Takeshi: MPPB015, TPAB019
Takaki, Hiroyuki: MPPB014, ROAB011
Takala, Bruce: TPAE039
Takano, Hirohisa: WPAE019
Takano, S.: TOPA012
Takao, Masaru: MPPE020, TOPA012
Takasaki, Eiichi: TPAG035, RPAB049
Takasaki, Seiji: MPPB015
Takashima, T.: TOPA012
Takayama, Ken: TPPB079, TPPB093, WPAE020, WPPG009, RPPB032
Takebe, H.: TOPA012
Takeda, Harunori: TPAG038, RPAB059, FPAB085, FPAG028
Takeda, Seishi: MPPB046, TPAE004
Takeshi, Toyama: RPPB030
Takeuchi, Yasunao: MPPE028
Takeuchi, Yasunori: MPPB015, WPPE012
Tallerico, Paul: TPAE039, TPAG015, TPAG017, RPAB053
Talman, Richard (BNL): TOPB004, FPAG008
Talman, Richard (CU): MPPB011, RPAG014, FPAG010
Tamura, Fumihiko: TPAB015, TPAB021
Tamura, Kazuhiro: TOPA012, WPPB064
Tan, Cheng-Yang: TPPB066, WPPG052, RPPB024, RPPB025
Tanabe, Jack: TOAC003, WPAB061
Tanabe, Toshiya: WPAE038
Tanaka, H.: TOPA012
Tanaka, Hirofumi: TPAG048
Tanaka, Hirokazu: TPAG035, RPAB049
Tanaka, Kenichi: WPAE019
Tanaka, Masanobu: MOPB005
Tang, Chuanxiang: WPAB029, WPAB033, ROAA003
Tang, Y.: TOPD002
Tang, Zhijing: ROPB006
Tani, Norio: MPPE008, WPAB059
Tanimoto, Yasunori: MPPE030, MPPB015
Taniuchi, Tsutomu: RPAB050
Taniuchi, Y.: TOPA012
Tantawi, Sami: TPAE008, TPAE009, TPAE020, TPAE021, TPAB031,

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Tarakanov, V.: TPPG038
Tarasov, Gordey: RPAB070
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Tariq, Salman: TPAG013, ROPB011
Tarkenton, G.M.: FPAG032
Tartaglia, M.: WPAE015, WPAE016
Tatanov, V.I.: WPPB045
Tateishi, Takeshi: MPPB026
Tavares, Pedro: WPPB079, RPPG046
Taylor, Thomas: MOPA006
Tbojevic, Dejan: TPPG003
Tecker, Frank: WPPB078, ROPC010
Tegenfeldt, Fredrik: WPAE006
Teichert, Jochen: WPAB007
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Telfer, Soren: MPPB058, WPAB030, WPAB031, WPAB067
Temkin, Richard J.: TPAB028, TPAB029, WPAB024, WPPB057
Temnykh, Alexander: MPPG007, TOAB007, WPAE009, WPPE030, FPAB068
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ten Kate, Herman: MOPA006
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Tepikian, Steven: MOPA009, TOAA011, TPPB042, TPPB043, TPPB045, WPAB048, WPAB053, WPPE033, WPPE034, WPPB018
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Terechkine, Y.: MPPE026
Terekov, Viktor: TPPB034
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Tesarek, R.: WPPB040
Teytelman, Dmitry: TOPD001, RPPB060, FPAB042
Theed, Justin: MPPE006
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Thibus, Jan: RPAB043
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Toelle, Raimund: TPAB010, RPAB037, RPAB041, ROPA009, FPAB069
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Tolmachev, S.: TPPG032
Tom, C. Y.: ROAC008
Tomas, Rogelio (U. Valencia): WPAB082
Tomas, Rogelio (CERN): WPAB073, WPAB080, WPAB081, WPAB084, RPAG003
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Tomlin, Ray: RPAG017
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Tor, P.H.: TOPA011
Torii, Yasushi: MPPB026
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Toyama, Takeshi: TPPB079, TPPB093, WPPG009, RPPB031, RPPB032, RPPB033
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Travish, Gil: MPPB057, MPPB058, TPPG032, TPPG033, WPAB031, WPAB067
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Uota, Masahiko: RPPB031, RPPB033
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Uriot, Didier: RPAB034, FPAG012
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Uythoven, Jan (CERN): TPPB009
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Vaccarezza, Cristina: MPPB044, WOAA008, WPAB018, WPAG008, RPAG025, RPPB055, FPAG056
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Valdiviez, Robert: TPPB020

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Valente, Paolo: TPPB017
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Valfells, A.: TPPB025, WOAC006, WPAG020, WPPB074, WPPB075, WPPG036, RPPB067
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Vanbrocklin, H.: FOAB003
van der Laan, J.B.: MPPB076, MPPB077, WOAA010, WPAG028
Vanenkov, Iouri: WPAE008, WPAE017
van Goor, Fred: TPPG045, TPPG046
VanKuik, B.: TPPE001
van Tilborg, Jeroen: TPPG011, TPPG012, TPPG015, WPPB053, FOAB003
van Tilborg, Jeroen: TPPG016
van Weelderen, Rob: WPAE006
van Zeijts, Johannes: MOPA009, TOAA011, TPPB042, TPPB043, TPPB045, TPPB048, TPPB049, WPAG002
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Varfolomeev, A.A.: TPPG032
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Vartanian, Varti: MPPE018
Vascotto, Alessandro: WPAG019
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Vasserman, Isaac: WPAG001
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Vay, Jean-Luc: TOAA010, TOPC004, WPPG035, FPAB006, FPAG059
Vazquez, M.: TPPE002
Velev, Gueorgui: TPPB055, WPAE013, WPAE015, WPAE016
Vengrov, Remir: FPAB088
Venturini, Marco: RPAB023, RPPB061
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Verdier, Andre: MPPG032, WOAD005, WPAB083
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Vescovi, Mario: WOAA008, WPAG008
Veshcherevich, Vadim: TPAB008, TPAB009, TPAB048, TPAB052
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Vignola, Gaetano (CAMD): MPPG018
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Vinogradov, Nikolai: RPAB030, RPAG035
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Visentin, Bernard: TPAB047
Vlachoudis, Vasilis: MOPA007
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Vobly, Pavel D.: MPPB042, WPAG006
Vogel, Hanspeter: TPAB090, RPAB073
Vogel, Vladimir: WPPB061
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Volkolupov, Yu.Ya.: TPAE014, FPAB008
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Vollinger, Christine: TOAB009, WPAE008, WPAE017
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Vos, Luc: RPPB012
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Waldron, William: TOAA001, TPAE040, TPAG040, WPPG017, ROAC001, RPPB039
Waldschmidt, Geoff: TPAG003
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Walker, Richard: TOPA004
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Wanderer, Peter: TOAB006, TPPB006, WPAE001, WPAB053, WPAB054, WPPE033
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Wang, Ch.E.: WPPE025
Wang, Changbiao: TPPG056, TPPG057
Wang, Chaoen: TPAB073, TPAB074, WPPE038, WPPG034
Wang, Chon: MPPG014
Wang, Chun-xi: FPAB060, FPAB061
Wang, D.J.: MPPB028
Wang, Dong: MOPA005, TPAB046, WPAE028, RPPG003, RPPG026
Wang, Duan-Jen: WPPB066
Wang, F.: MPPB077, WOAA010, WPAG028
Wang, Haipeng: TPAE010, TPAE011, TPAE012, TPAB083, ROAA001, RPAB065, FPAB086
Wang, Haitao: WPAB002
Wang, J.M.: TOPA007
Wang, J.W.: TPAB031, WPAG027, RPAB016
Wang, Jianpin: MPPE032
Wang, Jigang: WPPE014
Wang, Lin: MPPB021, TPPG058, WPPG053, RPPG019
Wang, Lisa: TPPE023
Wang, Min-Huey: RPPB063, RPPG030
Wang, Ping: MPPE007, TPAE002, WPPB031, WPPB032
Wang, S.: RPPG037
Wang, Shaoheng: TOAC003, WPAB021, RPPG011
Wang, Sheng: TPAG014, TPAG035
Wang, Tai-Sen: ROAB003, RPPB036, RPPB037
Wang, Tong: TPAB080, TPAB086
Wang, X.J.: MPPB007, TOAC012, TPAG030, TOPA007, TPPG004, WOAC003, WPPB021
Wang, Xiaoping: WPAB061
Wang, Yanshan: RPAB076
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Wang, Zhi-Fu: ROAA012
Wangler, Thomas: WPPG010, WPPG011
Wanzenberg, Rainer: RPPB071
Warburton, D.S.: TPPB001, TPPB007, WPAB049, ROAC006
Warner, David: TPAB022
Warnock, Robert: RPPB061, FPAG045
Warsop, Christopher: TPAG043
Watanabe, Ikuo: WPAE038
Watanabe, Yasuhiro: MPPE008, WPAB059
Watson, James: WPPB055, RPAG033
Watson, Rand L.: TPPB023
Weathersby, Stephen: RPAG044
Webber, Robert C.: TPAG033
Weggel, Robert: TPPB002, TPPB003
Wei, Baowen: ROPA012
Wei, Jie: TOPB004, TPPE011, TPPE012, WOAB005, WPAB051, WPAB053, WPPE033, WPPG004, ROAC006, ROPA001, RPPB009, FPAB064, FPAB066
Wei, Wei: MPPE032
Weichert, Gabriele: ROAA003
Weihreter, Ernst: TPAB005
Weiland, Thomas: WPAB034, RPPB071, RPPB072, RPPG034, RPPG035, FPAG050, FPAG055, FPAG057, FPAG058
Weir, John: MPPB082, ROAC009, RPAG033
Weise, Hans: ROPC007
Weiss, Daniel: MPPE021
Weiss, Kurt: TOPC003
Welch, D.R.: WPPG022, RPPB073
Welch, Dale: TOAA001, WPPG014
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Welch, James: RPPB054, RPPB055
Wells, Russell: MPPE031, TOAC003
Welsch, Carsten: TPPE038, RPAB041
Welton, Robert: FPAB009
Wendel, Mark: WOAD004
Wender, Stephen: TPAE039
Wendt, Manfred: MPPG035, ROAA003, RPAB005
Weng, Bill: TPPB006
Weng, Wu-Tsung: WOAD001, RPAB031
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Wenninger, Jorg: MOPA007, MOPA012, TPPB010, TPPB050, RPPB012
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Werkema, Steve: TPPE006
Wermelskirchen, Clemens: MPPE012
Wesling, Scott: WPAB001
Westenskow, Glen: WPPB055, FPAB006, FPAB007
Wheat, Robert: ROAA012
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White, Greg: TPPB080
Whitlatch, Timothy: MPPB075, TPAB077, ROAA001, RPAB064, RPAB065, FPAB086
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Wilinski, Michelle: WPPB012, WPPG044
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Willen, Erich: TOAB006, WPAE002, WPAE004, RPAG008
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Wilson, Ian: TPAE033, ROAA011, ROPC005
Wilson, K.M.: TPAB075, TPAB077, RPAB064, RPAB065
Wilson, M.: WOAC006
Wilson, Martin: WPAB054
Wilson, Perry: TPAB031, TPAB039
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Wines, Robin: WPAB045, ROPB009
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Wiseman, Mark: MPPB075, TPAB077, ROAA001, RPAB061, RPAB065, FPAB086
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Witkover, Richard (BNL): WPPB013
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Wojtkiewicz, Jerzy: ROAA003
Wolf, Michael: FPAG044
Wolski, Andrzej: MPPB017, MPPG011, TOAC003, WPPE036, RPAB010, RPAB023, RPAB025, ROPC002, ROPC003
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Wu, Gang: WPPB077
Wu, Genfa: TPAB083, TPAB087
Wu, Guanyuan: MPPE032
Wu, J.K.: FPAB005
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Wu, Kuo-Chen: TOAB006
Wu, Vincent: TPAB025, TPPB073
Wu, Xiaoyu: RPAB056, RPAG038
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Wu, Ying: MPPE007, MPPB042, WOAB004, WOAC004, WPAB087, WPAG006, WPPB030, WPPB031, WPPB032, WPPB033, RPPB019, RPPG006
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Xu, Yiyong: WPAB029
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Xu, Zhe: TPAB042
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Yamasaki, Akiyoshi: FPAB082
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Yamazaki, Masayosi: TPAB062
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Yang, Bingxin X.: WPPB002, WPPB006
Yang, Jae-Seok: TPAG021, RPPB044, RPPB045, RPPG020
Yang, Jinfeng: WPAB038, WPAB040
Yang, Ming-Jen: TPPB012, TPPB015, TPPB072, WPPB037, FPAB074, FPAB075, FPAB076
Yang, P.: TOPA011
Yang, T.T.: MPPB029
Yang, Tz-Te: TPAB074, FPAB044
Yang, Xiaodong: TPAB042
Yang, Xingfan: TPPE026
Yanovsky, V.: TPPG054
Yao, C.Y.: WPPB002, WPPB006, WPPB011
Yarovoi, T.: TPPG032
Yasumoto, Masato: MPPB036, MPPB073, MPPB074
Yegorov, Alexey: TPPE025
Yeh, Meng-Kao: TPAB073
Yeh, Meng-Shu: MPPB029, TPAB074, WPPE025, FPAB044
Yin, Yan: WPPB080
Yocky, Jerry: RPAB013
Yoder, Rodney: TPAG045, TPPG034, WPAB037
Yokoi, Takeichiro: TPPB028, FPAB081, FPAB082
Yonehara, Hiroto: MPPE020, MPPB026, TOPA012, WPPB064
Yonemura, Yujiro (KEK): TPPB028, FPAB081
Yonemura, Yujiro (KU): FPAB082
Yoom, Moohyun: RPPB050
Yoon, Jong Chel: WPPE019
Yoon, Moohyun: RPPB048
Yorazu, Masafumi: WPAB038
Yorita, Tetsuhiko: MPPE020, TOPA012
York, Richard: TOAA012, TPAB066, TPAB067, TPAB070, RPAB056, RPAG038, FPAG035
Yorozu, Masafumi: WPAB040
Yoshii, K.: FPAB087
Yoshii, Masahito: TPAB015, TPAB021, FPAB081, FPAB082
Yoshikawa, Hiroshi: TPAG035
Yoshimoto, Masahiro: TPPB028, FPAB081, FPAB082
Yoshimoto, Shin-ichi: MPPB015, TPAB019
Yoshino, Kazuo: TPAG035
Yoshioka, Masakazu: MPPB015
Young, Andrew: RPPB060
Young, Lloyd: MOPB001, MPPB047, MPPB075, TPAG017, TPAG038, RPAB052, FPAB085, FPAG027, FPAG029
Yu, David: TPAE032, TPAE033, WPAB041, WPAB042, WPAB043, WPAB044, WPAB045, WPAB065, RPPB075
Yu, Inha: WPPB059, RPAB060, RPPG020
Yu, Li-Hua: TOAC012, TOPA007, WPPB021
Yu, Simon S.: TOAA001, TPAE040, WPPG012, WPPG013, WPPG014, WPPG016, WPPG017, WPPG022, WPPG025, WPPG040, RPPB039

Yu, Tiaoqin: TPPE008, FPAG019, FPAG022, FPAG023, FPAG024, FPAG025
Yuan, D.: FPAB014
Yuasa, Yoshimasa: TPPB028, FPAB081, FPAB082
Yudin, Valeriy: TPAE035
Yueming, Hong: FPAG021
Yuhui, Li: MPPB022
Yun, R.: WOAC006
Yun, Zou: ROAB005
Yunn, Byung: TOPD006, RPPG033
Yusof, Zikri: WPAB002
Yuzheng, Lin: TPPG029, RPPB065, FPAB048
Zadoroznhy, Vladimir: RPAG059
Zagorodnov, Igor: RPPG034, RPPG035
Zaharakis, Konstatine E.: TPPB023
Zahariou-Cohen, S.: TPPE001, WPPB012
Zajic, Vladimir: MOPB009
Zakutin, V.V.: TPAE014, FPAB008
Zaltsman, Alex: TPAB007, ROAA006, RPPB010, FPAB026, FPAB039
Zambon, Lucio: FPAB045
Zangrando, Dino: MPPG017
Zapfe, Kirsten: ROAA003
Zaplatin, Evguenij: ROPA009
Zaugg, Thomas: WPPB049, ROAB003, RPPB035, FPAB083
Zeitlin, Michael: WPPG008, RPAG026, RPPB026, RPPB027, FPAB056
Zelenski, Anatoli: FPAB001
Zelinsky, Andrey: WPAG021
Zeller, Al: TOAA012, TOAB005
Zeng, Jiaqi: MPPE015
Zeno, K.: TPPE001, TPPE003, TPPB047
Zhan, Lamin: FPAG021
Zhan, Wenlong: TPAB042, ROPA012
Zhang, C.: TOPA012
Zhang, Hai-Ou: MPPE033
Zhang, P.: TPPG054
Zhang, S.Y.: MOPA010, MPPE024, MPPE025, TPPB043, TPPB046, TPPB047, WPPG004, FPAB066
Zhang, Shou-Yuan: MPPE021, TPAG004, WPPG045
Zhang, Wenzhi: TPAB042
Zhang, Wu: TPPB007, WPAB049, ROAC006
Zhang, Xiaolong: TPPB068, TPPB076, TPPB077
Zhang, Y.: MPPB086
Zhang, Yan: MPPB087
Zhang, Yuhong: MPPB056, TPPB082, WPAE039
Zhao, Feiyun: MPPE032
Zhao, J.: MOPB010
Zhao, Kui: WPPB076
Zhao, Qiang: MOPB010, WPAB008, RPAG009
Zhao, Yongxiang: WPAB009
Zheng, H.W.: TOPA011
Zheng, Hai: RPAG016
Zheng, Qiwen: TPAB088
Zheng, Shuxin (DESY): TPAB085, TPPE013
Zheng, Shuxin (TUB): TPAB084, ROAA003
Zhengtang, Zhao: RPPB065
Zhentang, Zhao: FPAB048
Zhigao, Fang: MPPG028
Zhiglo, Valentin: WPAB025
Zholents, Alexander: MPPE031, MPPB017, MPPB019, MPPB048, TOAC003, WOAB006, WPAB021, WPAB044, WPPB001, WPPG015, RPPG011
Zhou, Feng: TPPG035, TPPG048, WPPB072, WPPG055
Zhou, Jing: WPPG025, RPAG036
Zhou, W.: TPAG019
Zigler, A.: FOAB004
Zigler, Arie: TPPG040
Zimmerman, George: MPPB083
Zimmermann, Frank: MOPA012, TOAA007, TOPC003, TPPB054, TPPB055, TPPB067, TPPB076, WPAB084, WPAG023, WPPG006, RPAB008, ROPC005, RPPB011, RPPB012, RPPB013, RPPB016, RPPB017
Zimmermann, Holger: RPAB043
Zink, Roger: TOAA012
Zinkann, Gary: WPPB007, RPAB030
Zisman, Michael: TPAB003, TPAB025, TPPB088, WPAE037
Zitelli, Lou: TPAE029
Zitvogel, E.: TOPD002
Zlobin, Alexander: MOPA006, TOAB010, TPPB065, WPAE013, WPAE014, WPAE018
Zobov, Mikhail: WOAA008, WPAG008, RPAB009, RPAG025
Zolfaghari, A.: MPPB076, MPPB077, WPAG028
Zolotorev, Max: WPPB052
Zotter, Bruno: RPPB013
Zou, Yun: TPPB025, WOAC006, WPPG036, RPPB067
Zubets, Valeri: FPAB001
Zviagintsev, Vladimir: ROAA004
Zwart, G.T.: WPAG028
Zwart, Townsend: MPPB076, MPPB077