2010

International Linac Conference

September 12 – 17, 2010
International Congress Center
Tsukuba Epochal
Tsukuba, Ibaraki, Japan

http://linac10.j-parc.jp/

Contents

Welcome iii
Conference Organization..... vi
Venue & Conference Hotels..... xi
Emergency Information..... xii
Internet & Other Services.....xiv
Registration.....xvi
Social Program & Site Tour..... xvii
Companion Program..... xxi
Industrial Exhibition.....xxii
Sponsors.....xxiii
Proceedings Office..... xxv
Scientific Program.....xxvi
Program Schedule 1
Abstracts 7

Welcome!

On behalf of the LINAC10 International Organizing Committee, Program Committee, and Local Organizing Committee, I would like to welcome each of you to the XXV International Linac Conference in Tsukuba. This conference series aims to provide a comprehensive overview of recent developments of science, technology, and application in the field of linear accelerators. It is planned as a forum for novel ideas and research and development results, regarding the linacs. Papers from the whole field of linear accelerators are presented, including electron, proton, heavy-ion and rare-isotope machines, and medical and industrial linacs. In order to familiarize participants with the whole field and to establish interdisciplinary contacts it is a unique tradition of this conference series that all the sessions are plenary. Also, all the participants enjoy the lunches in the same place together during the conference to help participants to continue discussions and to make more friends. For these purposes participants are traditionally invitation only in this conference series.

The last linac conference held here sixteen years ago was the first one after its internationalization. During this sixteen-year interval many things have happened. In particular, the Spallation Neutron Source (SNS) superconducting proton linac was built

and now in operation as well as the J-PARC linac. The CERN Linac4 project started, while the new European Spallation Source (ESS) project is about to start. RI factories and XFEL linacs are under construction and/or in operation. Superconducting option was chosen for Internationalized Linear Collider, and the technology is getting ready thanks to recent world-wide effort of development. Plasma acceleration is getting more and more realistic for practical use. There are too many to mention. In this way, the linac community world-wide is active, prospering, and healthy, promising the future prospects. As a result, the number of student posters, which will compete for the student poster prize, amounts to more than 10 % of posters, while the number of papers to be presented in this conference is coming close to 400. The student poster session is specially set for this competition one day before the conference for the prize selection. You may enjoy the session during the get-together reception.

In closing, we are grateful to the two host institutes, High Energy Accelerator Research Organization (KEK) and Japan Atomic Energy Agency (JAEA), and J-PARC Center for their support. Also, we gratefully acknowledge the help of Argonne National Laboratory (ANL) for Program Committee to have its meetings twice. Among all we thank all of you for participating in LINAC10.

Sincerely,
Yoshishige Yamazaki
J-PARC, KEK & JAEA
LINAC10 Conference Chair

CONFERENCE ORGANIZATION

Key Contacts

Yoshishige Yamazaki, Conference Chair
Hitoshi Hayano, Conference Vice Chair
Yong Ho Chin, Program Committee Chair
Masanori Ikegami, Local Organizing Committee Chair

Emergency Phone Numbers

There are two phone numbers that can be used if someone needs to reach you in an emergency.

Conference Office:

+81-90-4963-8620 (090-4963-8620)
+81-80-3026-6449 (080-3026-6499)
+81-90-4759-5144 (090-4759-5144)

Administration Office of Tsukuba Epochal:

+81-29-861-0001 (029-861-0001)
( ): from inside Japan

International Organizing Committee

Yoshishige Yamazaki (Chair) (JAEA/J-PARC, Japan)
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Michael Fazio (LANL, USA)
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Hiroshi Yoshikawa (JAEA, Japan)

VENUE & CONFERENCE HOTELS

Venue

International Congress Center Tsukuba Epochal
2-20-3, Takezono, Tsukuba, Ibaraki 305-0032, JAPAN
Phone: +81-29-861-0001 (029-861-0001)
Fax: +81-29-861-1209 (029-861-1209)
( ): from inside Japan

Conference Hotels

Ohkura Frontier Hotel Tsukuba
1-1364-1, Azuma Tsukuba-city, Ibaraki 305-0031, Japan
Phone: +81-29-852-1112 (029-852-1112)
Fax: +81-29-852-5623 (029-852-5623)
( ): from inside Japan

Ohkura Frontier Hotel Tsukuba Epochal
2-20-1 Takezono, Tsukuba-city, Ibaraki 305-0032, Japan
Phone: +81-29-860-7700 (029-860-7700)
Fax: +81-29-860-7701 (029-860-7701)
( ): from inside Japan

Daiwa Roynet Hotel Tsukuba
1-5-7 Azuma, Tsukuba-shi, Ibaraki-ken
Phone: +81-29-863-3755 (029-863-3755)
Fax : +81-29-863-7955 (029-863-7955)
( ): from inside Japan

EMERGENCY INFORMATION

Emergency Phone Numbers

Police: 110
Ambulance: 119
Fire: 119

Hospitals

Tsukuba City Naika (Internal) Clinic
Phone: +81-29-856-5500 (029-856-5500)
( ): from inside Japan
Address: 2-8-8 Azuma, Tsukuba, Ibaraki
Business hour: Mon-Wed, Fri 09:30-12:30, 15:00-18:30, Sat 09:30-14:00

Tsukuba Medical Center Hospital
Phone: +81-29-851-3511 (029-851-3511)
( ): from inside Japan
Address: 1-3-1 Amakubo, Tsukuba, Ibaraki
Business hour: Mon–Fri 08:30 – 11:30
http://www.tmch.or.jp/hosp/b06.html

Pharmacies

Drug Terashima
Phone: +81-29-852-7678 (029-852-7678)
( ): from inside Japan
Address: 24-6 Higashi-Arai, Tsukuba, Ibaraki
(Across the street, west, from Ohkura Frontier Hotel Tsukuba Epochal)
Business hour: 7 days a week 9:00 - 24:00

SUNDRUG Tsukuba
Phone: +81-29-863-3799 (029-863-3799)
( ): from inside Japan
Address: 1-9-2 Takezono, Tsukuba, Ibaraki
(In the shopping center “Dayz Town” across the street, north, from Ohkura Frontier Hotel Tsukuba Epochal)
Business hour: 7 days a week 10:00 - 22:00

INTERNET & OTHER SERVICES

Wireless Internet

Wireless Internet is available to all delegates in International Congress Center Tsukuba Epochal.

SSID: LINAC10
Password: tsukuba201009

Internet Café

An Internet Café is available at Room 202A.

Internet Café hours are:

Sunday, September 12	15:00 - 18:00
Monday, September 13	08:30 - 18:00
Tuesday, September 14	08:30 - 18:00
Wednesday, September 15	08:30 - 12:00
Thursday, September 16	08:30 - 18:00
Friday, September 17	08:30 - 13:30

The Internet Café also includes an area where speakers can preview/test their presentations. Please note that all speakers must give their presentations with the computer system set up in the Main Convention Hall.
Use of individual laptops cannot be accommodated.

Copy Services

Copy service is available at the administration office of Tsukuba Epochal on its first floor.

Banking and Currency Exchange

Currency exchange between JPY and USD is available at the following two banks and a post office. They also accept Traveler's Check.

Joyo Bank
Phone: +81-29-851-2151 (029-851-2151)
( ): from inside Japan
Address: 1-14-2 Azuma, Tsukuba, Ibaraki
Business hour: Mon–Fri 09:00 – 15:00

Sumitomo Mitsui Bank
Phone: +81-29-855-9621 (029-855-9621)
( ): from inside Japan
Address: 1-5-7 Azuma, Tsukuba, Ibaraki
(In the same building with Daiwa Roynet Hotel Tsukuba)
Business hour: Mon–Fri 09:00 – 15:00

Post Office
Phone: +81-29-851-9613 (029-851-9613)
( ): from inside Japan
Address: 1-13-2 Azuma, Tsukuba, Ibaraki
Business hour: Mon–Fri 09:00 – 16:00
ATM: Mon–Fri 09:00 – 23:00,
Sat 09:00 – 21:00, Sun 09:00 – 19:00

Cashing with your credit card is available with ATM at the post office.

REGISTRATION

Hours and Location

The registration desk will be open at the following time and location:
Sunday, September 12
15:00 to 20:00 (Multi-purpose Hall)
Monday, September 13
08:00 to 11:30(Foyer of Main Convention Hall)
12:30 to 17:00 (Room 202B)

Tuesday, September 14
08:30 to 17:00 (Room 202B)
Wednesday, September 15
08:30 to 12:00 (Room 202B)
Thursday, September 16
08:30 to 17:00 (Room 202B)
Friday, September 17
08:30 to 13:30 (Room 202B)
Your registration fee includes attendance at all technical sessions of the conference, the conference guidebook, and one copy of the proceedings on CD-ROM.

Extra Tickets

Individual tickets for the Welcome Reception, Excursion, Banquet, J-PARC Tour and KEK Tour are limited.
If there are any tickets left, they will be available at Registration.

Cancellation of Registration

All cancellations must be provided in writing to linac10@j-parc.jp.

No refunds will be provided for cancellations after July 30, 2010.

This policy also applies to extra tickets for excursions and social functions.

Message Board

A message board is located beside the registration desk.

Security and Insurance

Participants are asked not to leave their belongings unattended and to wear their conference badges at all LINAC10-sponsored events.

The conference organizers cannot accept liability for personal injuries sustained or for loss or damage to participants' (or companions') personal property during the conference.

Luggage Storage

The hotels will provide luggage storage for their guests.

SOCIAL PROGRAM & SITE TOUR

Summary of Events

Sunday	Student Poster Session
	Welcome Reception
Wednesday	Excursion – Nikko or Oarai

Thursday Banquet at Hotel Grand Shinonome
Friday J-PARC Tour or KEK Tour
(not included in registration fee)

Social Events

Sunday, September 12
Student Poster Session [18:00]
Welcome Reception [18:00]
A welcome reception will be held at Multi-purpose Hall at the International Congress Center Tsukuba Epochal.
All registrants are invited to attend.

Wednesday, September 13 [12:00]
We have an excursion on your choice between Nikko and Oarai.

Nikko Tour
Excursion to one of the most famous historical sites in Japan, Nikko Toshogu. Nikko Toshogu is a Shinto shrine located in Nikko city, Tochigi Prefecture. It is dedicated for Tokugawa Ieyasu, the founder of the Tokugawa shogunate. It was initially built by the second shogun (and Ieyasu's son), Hidetada, in 1617, and enlarged during the time of the third shogun (and Ieyasu's grandson), Iemitsu.
Famous buildings at the Toshogu include the richly decorated Yomeimon Gate. Its surface is decorated with gorgeous carvings painted in rich colors. Other buildings are also decorated with elaborated carvings and ornaments, which is often a traditional

symbol in Chinese and Japanese culture. These beautiful buildings symbolize the prosperity of Tokugawa shogunate, which governed this country until the Meiji Restoration in 1868.
Nikko Toshogu and surrounding historical buildings have been registered as a UNESCO World Heritage Site since 1999.
Lunch and dinner included.
The bus for Nikko Tour will meet you at 12:00.
The meeting place will be announced at the conference.

Oarai Tour
Excursion to one of the most popular tourist destinations in Ibaraki Prefecture, the Oarai Aquarium. The aquarium is famous for its fascinating dolphin show. It also has more than 500 marine species to exhibit ranging from local fish to tropical one. Especially, exhibitions of sharks and ocean sunfish are unique and famous.
Oarai is a seaside town beside the Pacific Ocean. It is blessed with a rich fishery, and a number of tourists are lured to this town for its fresh seafood. We plan to serve some fresh seafood for the dinner buffet at the aquarium cafeteria. We also plan to stop at a nearby fish market "Nakaminato Fish Market", which is a lively fish market attracting a number of tourists and customers everyday from all over the Tokyo area.
Lunch and dinner included.
The bus for Oarai Tour will meet you at 12:00.

The meeting place will be announced at the conference.

Thursday, September 16 [19:00]
Banquet
Hotel Grand Shinonome, Banquet Hall
The banquet place is in the walking distance from Tsukuba Epochal and conference hotels. We plan to provide a shuttle bus service to Hotel Grand Shinonome, and its detail will be announced at the conference.

Friday, September 17 [13:30/14:00]
J-PARC Tour
13:20 Lunch box is provided at the Foyer of Main Convention Hall
13:30 Bus departs from Main Entrance of Tsukuba Epochal.
15:00 Bus arrives at J-PARC
18:00 Bus depart from J-PARC
19:30 Bus arrives at Main Entrance of Tsukuba Epochal.
KEK Tour
13:20 Lunch box is provided at the Foyer of Main Convention Hall
14:00 Bus departs from Main Entrance of Tsukuba Epochal.
14:30 Bus arrives at KEK
17:30 Bus departs from KEK
18:00 Bus arrives at Main Entrance of Tsukuba Epochal.

COMPANION PROGRAM

We are offering three companion tours on Sep. 13 (Mon), Sep. 14 (Tue), and Sep. 16 (Thu) to companions attending the LINAC10 conference.
As they have long experience and outstanding reputation as excellent tour operators for tourists from abroad, we have decided to offer English-guided tours operated by Hato Bus Tours and JTB Sunrise Tours for our companions.
We have selected the following three of the most popular tours from their variety of choices.

Monday September 13
Dynamic Tokyo (Hato Bus Tours)
Tuesday September 14
Kamakura Walking Tour (JTB Sunrise Tours)
Thursday September 16
Edo Tokyo Full Day (Hato Bus Tours)

These tours start from Hamamatsucho Bus Terminal in Tokyo, and the conference office is planning to offer a guide from Tsukuba to Hamamatsucho Bus Terminal. Attendees to the companion tours are supposed to meet at the ticket gate of Tsukuba Station at 7:00 am, and guided to the Hamamatsucho Bus Terminal by an English-speaking guide using Tsukuba Express train and JR train.

INDUSTRIAL EXHIBITION

Hours and Location

The Industrial exhibition booths are located at Room 101+102, the foyer of Room 101+102, and the foyer of Room 201+202.

Exhibit hours are:

Monday, September 13	13:00 to 18:00
Tuesday, September 14	09:00 to 18:00
Wednesday, September 15	09:00 to 12:00
Thursday, September 15	09:00 to 18:00

List of Exhibitors

Exhibitors and sponsors registered at press time.

AET, Inc.
Bruker Biospin
Chuo Electronics Co., Ltd.
FRIATEC AG / RADDevice Co., Ltd.
Hitachi, Ltd.
Instrumentation Technologies
Kyocera Corporation
L-3 Electron Devices
Mitsubishi Electric Corporation / Mitsubishi Electric TOKKI Systems Corporation
Mitsubishi Heavy Industries, Ltd.
Muons, Inc.
National Instruments Japan Corporation
Nihon Koshuha Co., Ltd.
NTG Neue Technologien GmbH
RI Research Instruments GmbH
Scandinova Systems

TACC
Thales
Toshiba Corporation
Toshiba Electron Tubes & Devices Co., Ltd.
Toyama
Tsuji Electronics Co., Ltd.
Yokogawa Electric Corporation
Varian Technologies Japan Ltd.

SPONSORS

List of Sponsors

Tsukuba City
Tsukuba Science Expo Memorial Foundation
Chuo Electronics Co., Ltd.
FRIATEC AG / RADDevice Co., Ltd.
Mitsubishi Heavy Industries, Ltd.
Nihon Koshuha Co., Ltd.
Toshiba Electron Tubes & Devices Co., Ltd.

Financial Support for Students and Post-doctors

We would like to thank our sponsors, Foundation for High Energy Accelerator Science, and Hitachi, Ltd., who helped bring the following students and post-doctors to Tsukuba:

Markus Aicheler (CERN, Switzerland)
Frédéric Bouly (IPN, France)
Subashini De Silva (JLAB, USA)
Florian Dziuba (IAP, Germany)
Wencheng Fang (SINAP, China)

Sylvain Franke (TEMF/TU Darmstadt, Germany)
Matthew Fraser (CERN, Switzerland)
Joon Yeon Kim (SNU, Korea)
Martin Konrad (TU Darmstadt, Germany)
Olga Konstantinova (Tomsk State U., Russia)
Konstantin Lekomtsev (JAI, UK)
David Longuevergne (TRIUMF, Canada)
Liang Lu (RLNR, Japan)
Vaishali Naik (DAE/VECC, India)
Nathaniel Pogue (Texas A&M U., USA)
Francesco Scantamburlo (INFN/Sez. di Padva,Italy)
Felix Schlander (DESY, Germany)
Ki Shin (ORNL, USA)
Alexey Sitnikov (ITEP, Russia)
Aleksandr Smirnov (MEPhI, Russia)
Nicholas Valles (Cornell U., USA)
Silvia Verdú-Andrés (IFIC, Spain)
Zhijun Wang (IMP, China)
Pei Zhang (DESY, Germany)
Feng Zhe (TUB, China)

PROCEEDINGS OFFICE

Hours and Location

The Proceedings Office is located at Room 202A. Editorial staff will process papers before and during the conference. The paper submission deadline was Thursday, September 10. Authors are requested to check on their papers via the status board that will be located in or near the Proceedings Office. Authors can also check the paper status by logging into their SPMS accounts. If the paper has a YELLOW dot, they can accept the changes and turn it to GREEN themselves.

Proceedings Office hours are:

Sunday, September 12	15:00 - 18:00
Monday, September 13	09:00 - 18:00
Tuesday, September 14	09:00 - 18:00
Wednesday, September 15	09:00 - 11:30
Thursday, September 16	09:00 - 18:00
Friday, September 17	09:00 - 11:00

The conference proceedings will be published on CD-ROM and on the Joint Accelerator Conferences Website (JACoW): http://www.JACoW.org

SCIENTIFIC PROGRAM

Oral Sessions

All oral sessions will be in the Main Convention Hall. A preview/testing area is available for speakers in Room 202A.

Please note that all speakers must upload their presentations to our file server following the instruction below. Use of individual laptops cannot be accommodated.

The deadline for the presentation file upload is at 15:00 on the day before your talk for invited speakers, and at 17:00 on Sunday September 12 for all the speakers in oral poster sessions.

In uploading your presentation file, please follow the instructions described in the following web page,

http://linac10.j-parc.jp/oralPresentation.html

Student Poster Session

A special poster session for students will take place during registration on Sunday, September 12.
Student posters should be mounted in Multi-purpose Hall at 15:00 and manned from 15:00 to 16:00 for judging and from 18:00 to 20:00 for general viewing.
In accordance with the guidelines for publication of contributions, these posters

must also be displayed during the regular poster sessions.

Poster Sessions

There will be three poster sessions during the conference.
The posters are in Room 201A+201B and Room 101+102 of Tsukuba Epochal.
Each session will begin with an hour long oral session.

Monday, September 13	15:00 to 18:00
Tuesday, September 14	15:00 to 18:00
Thursday, September 16	15:00 to 18:00

Poster halls will be ready at 11:00. Posters should be in place no later than 12:30 and should be taken down at the end of each session.
Any posters not removed by 18:30 will be removed by staff and discarded.

Authors are reminded that no contributions are accepted for publication only. Any paper that is not presented at the conference will be excluded from the proceedings.
The Scientific Program Committee reserves the right to refuse papers for publication that have not been properly presented or staffed in the poster sessions. Manuscripts of contributions to the proceedings (or enlargements of them) are not considered to be posters, and papers represented in this way will not be accepted for publication.

Identification of Contributions

The date and type of presentation for each contribution in the program can be easily identified from the program code, which is composed as follows:

The first two letters indicate the day: MO, TU, WE, TH, FR.

For oral sessions, the third letter indicates the order of the session (1, 2, or 3).

For posters sessions, the third letter is a P.

A two digit (oral) or three digit (poster) sequence number.

09:00 – 09:30 Opening Remarks

Location: Main Convention Hall

09:00 **Opening address**
Yoshishige Yamazaki *(JAEA/J-PARC)*

09:10 **Welcome address**
Masaru Hashimoto
(Ibaraki Prefectural Governor)

09:20 **Logistics**
Yong Ho Chin *(KEK)*

11:00 – 11:30 Break

09:30 – 11:00 Invited Oral Session MO1

Location: Main Convention Hall
Chair: Y.H. Chin (KEK)

09:30 **J-PARC Project**
S. Nagamiya *(KEK)*

10:00 **Status of the European XFEL Project**
H. Weise *(DESY)*

10:30 **SNS Operation at 1 MW and Beyond**
S. Henderson *(ORNL)*

11:30 – 12:30 Invited Oral Session MO2

Location: Main Convention Hall
Chair: I. Mardor (Soreq NRC)

11:30 **Status and Challenges of the Spiral2 Facility**
R. Ferdinand *(GANIL)*

11:50 **Operating Experience of the ISAC-II Upgrade Linac**
R.E. Laxdal *(TRIUMF)*

12:10 **ReA3 - the Rare Isotope Reaccelerator at MSU**
O.K. Kester *(NSCL)*

12:30 – 13:40 Lunch

13:40 – 15:00 Invited Oral Session MO3

Location: Main Convention Hall
Chair: T. Garvey (PSI)

13:40 **Flash Performance and the 9 mA Current Tests**
J. Carwardine *(ANL)*

14:00 **The S1-Global Collaborative Efforts - 8-Cavity-Cryomodule: 2FNAL 2DESY 4KEK**
N. Ohuchi *(KEK)*

14:20 **CLIC Feasibility Demonstration at CTF3**
R.J.M.Y. Ruber *(Uppsala University)*

14:40 **The FNAL Third Harmonic Module for FLASH**
H.T. Edwards *(Fermilab)*

15:00 – 16:00 Contributed Oral Session MO4

Location: Main Convention Hall
Chair: W.A. Barth (GSI)

16:00 – 18:00 Poster Session MOP

Location: Poster Rooms 101, 102, 201

09:00 – 11:00 Invited Oral Session TU1
Location: Main Convention Hall
Chair: S. Choroba (DESY)

09:00 **Overview of FELs under Construction Including FELs at Fermi Elettra, SPRing8 and Frascati SPARC**
G. Penco *(ELETTRA)*

09:30 **Overview of Proposals for Major FEL Facilities**
H.-H. Braun *(PSI)*

10:00 **Worldwide ERL R&D Overview Including JLAMP, BNL, and Cornell ERLs**
G. Neil *(JLAB)*

10:30 **RIBF and Other RIB Facilities**
N. Fukunishi *(RIKEN Nishina Center)*

11:00 – 11:30 Break

11:30 – 12:30 Invited Oral Session TU2
Location: Main Convention Hall
Chair: S. Henderson (ORNL)

11:30 **Status of J-PARC Linac Energy Upgrade**
H. Ao *(JAEA/LINAC)*

11:50 **The High Intensity Proton Linac for CSNS**
H.F. Ouyang *(IHEP Beijing)*

12:10 **Plans for the ESS Linac**
S. Peggs *(ESS-S)*

12:30 – 13:40 Lunch

13:40 – 15:00 Invited Oral Session TU3
Location: Main Convention Hall
Chair: A. Schempp (IAP)

13:40 **RFQ for CW Applications**
A. Pisent *(INFN/LNL)*

14:00 **Applications of Spoke Cavities**
J.R. Delayen *(ODU)*

14:20 **Status of the Cornell ERL Injector Cryomodule**
M. Liepe *(CLASSE)*

14:40 **High-Performance SC Cryomodule for CW Ion Accelerators**
M.P. Kelly *(ANL)*

15:00 – 16:00 Contributed Oral Session TU4
Location: Main Convention Hall
Chair: Y.-S. Cho (KAERI)

16:00 – 18:00 Poster Session TUP
Location: Poster Rooms 101, 102, 201

09:00 – 10:40 Invited Oral Session WE1

Location: Main Convention Hall
Chair: R. Garoby (CERN)

09:00 **Design of Project-X Linac**
N. Solyak *(Fermilab)*

09:30 **SARAF Accelerator Commissioning Results and Phase II Construction Status**
L. Weissman *(Soreq NRC)*

10:00 **Status of Linac4 Construction at CERN**
M. Vretenar *(CERN)*

10:20 **Overview and Future Demands of Fast Choppers**
A.V. Aleksandrov *(ORNL)*

10:40 – 11:00 Break

11:00 – 12:00 Invited Oral Session WE2

Location: Main Convention Hall
Chair: S. Fu (IHEP Beijing)

11:00 **Operation and Upgrades of the LCLS**
J.C. Frisch *(SLAC)*

11:20 **Upgrade of the PLS (Pohang Light Source) Linac for the PLS-II**
S.J. Park *(PAL)*

11:40 **First Simultaneous Top-up Operation of Three Different Rings in KEK Injector Linac**
M. Satoh *(KEK)*

12:00 – 21:00 Outing

09:00 – 11:00 Invited Oral Session TH1

Location: Main Convention Hall
Chair: R.E. Laxdal (TRIUMF)

09:00 **Raising the Bar on Superconducting Niobium Cavity Production, Processing, and Performance**
Z.A. Conway *(CLASSE)*

09:30 **SRF and Cryomodule R+D for ERL's**
J. Knobloch *(Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*

10:00 **Development and Future Prospects of RF Sources for Linac Applications**
E. Jensen *(CERN)*

10:30 **Power Coupler Development for High Intensity Superconducting Linacs**
G. Devanz *(CEA)*

11:00 – 11:30 Break

11:30 – 12:30 Invited Oral Session TH2

Location: Main Convention Hall
Chair: M. Popovic (Fermilab)

11:30 **SRF Linac for Indian Energy Program**
C.S. Mishra *(Fermilab)*

11:50 **VECC/TRIUMF Injector for the e-Linac Project**
V. Naik *(DAE/VECC)*

12:10 **Student Prize Winner Talk**

12:30 – 13:40 Lunch

13:40 – 15:00 Invited Oral Session TH3

Location: Main Convention Hall
Chair: P.N. Ostroumov (ANL)

13:40 **Beam Dynamics Studies for Multi-GeV Proton and H-minus Linacs**
J.-P. Carneiro *(Fermilab)*

14:00 **Source and Injector Design for Intense Light Ion Beams Including Space Charge Neutralisation**
N. Chauvin *(CEA)*

14:20 **Experimental Observation of Space Charge Driven Resonances in a Linac**
L. Groening *(GSI)*

14:40 **Linear Induction Accelerators at the Los Alamos National Laboratory DARHT Facility**
S. Nath *(LANL)*

15:00 – 16:00 Contributed Oral Session TH4

Location: Main Convention Hall
Chair: K.C.D. Chan (LANL)

16:00 – 18:00 Poster Session THP

Location: Poster Rooms 101, 102, 201

19:00 – 21:00 Banquet

09:00 – 11:00 Invited Oral Session FR1

Location: Main Convention Hall
Chair: S.G. Tantawi (SLAC)

09:00 **Advance In Parallel Computing Codes For Accelerator Science**
K. Ko *(SLAC)*

09:30 **Plasma Accelerator Development at the BELLA and FACET Projects**
M.J. Hogan *(SLAC)*

10:00 **Commissioning of the EBIS-Based Heavy Ion Preinjector at Brookhaven**
J.G. Alessi *(BNL)*

10:20 **Progress of X-Band Accelerating Structures**
T. Higo *(KEK)*

10:40 **Study of Basic Breakdown Phenomena in High Gradient Vacuum Structures**
V.A. Dolgashev *(SLAC)*

11:00 – 11:30 Break

11:30 – 12:50 Invited Oral Session FR2

Location: Main Convention Hall
Chair: Y. Yamazaki (JAEA/J-PARC)

11:30 **Current and Possible New Methods for Accelerator-Based Production of Medical Isotopes**
J.A. Nolen *(ANL)*

11:50 **Linacs for Muon Collider and Neutrino Factory**
S. Geer *(Fermilab)*

12:20 **Linacs and Scientific/Technological Applications**
A. Suzuki *(KEK)*

12:50 – 13:20 Closing Remarks

13:30 – 20:00 Site Tour

13-Sep-10 09:30–11:00 Main Convention Hall

MO1 — Invited Oral

Chair: Y.H. Chin (KEK)

MO101 09:30

J-PARC Project

S. Nagamiya *(KEK)*

About ten years ago (2001) a new accelerator project to provide high-intensity proton beams proceeded into its construction phase. This project is called the J-PARC (Japan Proton Accelerator Research Complex), and it was completed about a year ago in 2009. The construction was performed under a cooperation of two institutions, KEK and JAEA. The goal of the accelerator power is 1 MW proton beams at 3 GeV, with 400 MeV Linac injector, and 0.75 MW beams at 50 GeV. Three experimental facilities are presently available: 1) the Materials and Life Experimental Facility where pulsed neutrons and muon beams from 3 GeV are produced and utilized, 2) the Hadron Experimental Facility where kaon beams are produced, with a slow extraction mode from the 50 GeV (currently, 30 GeV is used), and 3) the Neutrino Experimental Facility with fast extraction mode from the 50 GeV ring. I would like to review the current status of the accelerators and experimental facilities, in particular, under the emphasis of what are actually going on in regard experimental programs. I also would like to mention a future scope of the J-PARC.

MO102 10:00

Status of the European XFEL Project

H. Weise *(DESY)*

The internationally organized European XFEL free-electron laser is under construction at the Deutsches Elektronen-Synchrotron (DESY). The project is the first large scale application of the TESLA technology developed over the last 15 years. Superconducting accelerating cavities will be used to accelerate the electron beam to an energy of up to 17.5 GeV. Recently an energy reduction by 20% to 14 GeV was discussed as a reasonable compromise between cost aspects and scientific potential of the facility. With realistic assumptions on lower beam emittance, the design photon beam parameters will be achieved. The talk will briefly summarize the overall XFEL design before presenting details about the status of the superconducting linac. The activities within the international collaboration will be described. Final prototyping, industrialization and commissioning new infrastructure are the actual challenges. Contracts for long lead items are placed.

MO103 10:30 **SNS Operation at 1 MW and Beyond**
S. Henderson *(ORNL)*
This talk will present the stutus of SNS operation at 1MW and plan beyond it.

13-Sep-10 11:30–12:30 Main Convention Hall

MO2 — Invited Oral

Chair: I. Mardor (Soreq NRC)

MO201 11:30 **Status and Challenges of the Spiral2 Facility**
R. Ferdinand *(GANIL)*
SPIRAL 2 is a new European facility for Radioactive Ion Beams being constructed at the GANIL laboratory (Caen, France). It is based on a High Intensity CW multi-ion Accelerator Driver (Superconducting Linac), delivering beams to a High Power Production system (converter, target, and ion source), producing and post-accelerating Radioactive Ion Beams with intensities never reached before. The major components of the accelerator (injectors and SC Linac), have been presently ordered. The number of tested components is rapidly growing. The Superconducting Linac Accelerator incorporates many innovative developments of the Quarter-Wave resonators and their associated cryogenic and RF systems. The first beam is expected during autumn 2011. The first operation is scheduled for late 2012 with an initial experimental program prepared in the framework of a European Project, with many other international collaborating partners.

MO202 11:50 **Operating Experience of the ISAC-II Upgrade Linac**
R.E. Laxdal *(TRIUMF)*
The ISAC-II Phase II expansion includes the addition of 20 new quarter wave resonators in three cryomodules to double the energy gain of the ISAC-II superconducting linac. The rf cavities are produced in Canada. The talk will concentrate on the beam commissioning (scheduled for March 2010) and early operating experience.

MO203 12:10 **ReA3 - the Rare Isotope Reaccelerator at MSU**
O.K. Kester *(NSCL), G. Bollen, C. Compton, A.C. Crawford, M. Doleans, W. Hartung, A. Lapierre, F. Marti, G. Perdikakis, J. Popielarski, L. Popielarski, M. Portillo, D. Sanderson, S. Schwarz, J. Wlodarczak, X. Wu, Q. Zhao (NSCL)*
Rare isotope beam (RIB) accelerator facilities provide rich research opportunities in nuclear

physics. The National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU) is constructing a RIB facility, called ReA3. It will provide unique low-energy rare isotope beams by stopping fast RIBs and reaccelerating them in a compact linac. ReA3 comprises gas stopper systems, an Electron Beam Ion Trap (EBIT) charge state booster, a room temperature radio frequency quadrupole (RFQ), a linac using superconducting quarter wave resonators (QWRs) and an achromatic beam transport and distribution line to the new experimental area. Beams from ReA3 will range from 3 MeV/u for heavy ions to about 6 MeV/u for light ions, as the charge state of the ions can be adjusted by the EBIT. ReA3 will initially use beams from NSCL's Coupled Cyclotron Facility (CCF). Later ReA3 will provide reacceleration capability for the Facility for Rare Isotope Beams (FRIB), a new national user facility funded by the Department of Energy (DOE) that will be hosted at MSU. The ReA3 concept and status of ReA3 will be presented, with emphasis on the comissioning of the facility, which is underway.

13-Sep-10	13:40–15:00	Main Convention Hall

MO3 — Invited Oral

Chair: T. Garvey (PSI)

MO301 13:40 **Flash Performance and the 9 mA Current Tests**

J. Carwardine *(ANL)*

An important milestone has been reached in in the 'FLASH 9mA experiment' at DESY, with successful operation of FLASH with long bunch trains and heavily beam-loaded cavities. Bunch trains up to 600μs were run at an average current of 9mA, extending to 800μs with a somewhat lower average current. The FLASH 9mA programme is led by DESY in collaboration with the ILC-GDE, and has the goal of demonstrating reliable operation and of characterizing limits of performance of the FLASH linac with 800us-long bunch trains, 9mA average current, and cavity gradients approaching quench. The programme provides important operations experience and technical input to the European XFEL and the International Linear Collider, and supports planned routine long bunch-train operation of FLASH for FEL users. This paper highlights the 9mA programme accomplishments to date, presents performance and operations data analysis, and gives an outlook for future studies.

MO302 14:00 **The S1-Global Collaborative Efforts - 8-Cavity-Cryomodule: 2FNAL 2DESY 4KEK**

N. Ohuchi *(KEK), M. Akemoto, S. Fukuda, H. Hayano, E. Kako, H. Katagiri, Y. Kondou, T. Matsumoto, H. Matsushita, S. Michizono, T. Miura, H. Nakai, H. Nakajima, S. Noguchi, M. Satoh, T. Shidara, T. Shishido, T. Takenaka, A. Terashima, N. Toge, K. Tsuchiya, K. Watanabe, A. Yamamoto, Y. Yamamoto, M. Yoshida (KEK) C. Adolphsen (SLAC) T.T. Arkan, S. Barbanotti, H. Carter, M.S. Champion, R.D. Kephart, J.S. Kerby, D.V. Mitchell, Y. Orlov, T.J. Peterson, M.C. Ross (Fermilab) A. Bosotti, C. Pagani, P. Pierini (INFN/LASA) D. Kostin, L. Lilje, A. Matheisen, W.-D. Moeller, H. Weise (DESY)*

In an attempt at demonstrating an average field gradient of 31.5 MV/m as per the design accelerating gradient for ILC, a program called S1-Global is in progress as an international research collaboration among KEK, INFN, FNAL, DESY and SLAC. The design of the S1-G cryomodule began at May 2008 by INFN and KEK. The S1-Global cryomodule was designed to contain eight superconducting cavities from FNAL, DESY and KEK, and to be constructed by joining two half-size cryomodules, each 6 m in length. The module containing four cavities from FNAL and DESY was constructed by INFN. Four KEK cavities have been assembled in the 6 m module which KEK fabricated. All major components were transported to KEK from INFN, FNAL and DESY in December 2009. The assembly of the two 6-m cryomodules started from January 2010 in a collaborative work of FNAL, DESY, INFN and KEK. The construction of the S1-G cryomodule will complete in May, and the cool-down of the S1-G cryomodule is scheduled from June 2010 at the KEK-STF. In this paper, the construction and the cold tests of the S1-Global cryomodule in the worldwide research collaboration will be presented.

MO303 14:20 **CLIC Feasibility Demonstration at CTF3**

R.J.M.Y. Ruber *(Uppsala University)*

At CERN the feasibility of CLIC (Compact LInear Collider) a multi-TeV electron-positron collider is being studied. In this scheme the RF power to accelerate the main beam is produced by a high current drive beam. To demonstrate this scheme a test facility (CLIC Test Facility 3, CTF3) has been constructed at CERN. Recently, the complex to generate the drive beam has been successfully commissioned producing a beam with a current around 30A. This beam is now being used

to test the power production. The results of the test facility provide vital input for the CLIC conceptual design report to be finished by the end of 2010. This talk describes CTF3 activities and their importance for CLIC; it comments on design readiness for CLIC after a successful CTF3 demonstration.

MO304 14:40 **The FNAL Third Harmonic Module for FLASH**

H.T. Edwards *(Fermilab)*

FNAL has contributed to FLASH at DESY the third harmonic accelerating system, which will provide better beams for the FEL facility. The FNAL accelerating module has been qualified above specs and will be operational in FLASH in Spring.

13-Sep-10 15:00–16:00 Main Convention Hall

MO4 — Contributed Oral

Chair: W.A. Barth (GSI)

13-Sep-10 16:00–18:00 Poster Rooms 101, 102, 201

MOP — Poster

MOP001 **CTF3 Probe Beam LINAC Commissioning and Operations**

W. Farabolini *(CEA), D. Bogard, A. Curtoni, P. Girardot, F. Peauger, C.S. Simon (CEA) E. Chevallay, M. Divall Csatari, N. Lebas, M. Petrarca (CERN) R. Roux (LAL) R.J.M.Y. Ruber (Uppsala University)*

The probe beam LINAC, CALIFES, of the CLIC Test Facility (CTF3) has been developed by CEA Saclay, LAL Orsay and CERN to deliver trains of short bunches (0.75 ps) spaced by 0.666 ps at an energy around 170 MeV with a charge of 0.6 nC to the TBTS (Two-beam Test Stand) intended to test the high gradient CLIC accelerating structures. Based on 3 former LIL accelerating structures and on a newly developed RF photo-injector, the whole accelerator is powered with a single 3 GHz klystron delivering pulses of 45 MW through a RF pulse compression cavity and a network of waveguides, splitters, phase-shifters and an attenuator. We relate here results collected during the various commissioning and operation periods which led to nominal performances and stable beam characteristics delivered to the TBTS. Progress has been made in the laser system for beam charge and stability, in space charge compensation for emittance, in RF compression law for energy and energy spread. The installation of a specially developed RF power phase shifter for

the first accelerating structure used in velocity bunching allows the control of the bunch length.

MOPO02 **A Test Structure for CLIC Utilising Damped and Detuned Wakefield Suppression and Optimised Surface Fields**

R.M. Jones *(UMAN), A. D'Elia, V.F. Khan (UMAN) A. Grudiev, W. Wuensch, R. Zennaro (CERN)*

We report on the suppression of long-range wakefields in the main linacs of the CLIC collider. The wakefield is damped using a combination of detuning the frequencies of beam-excited higher order modes and by light damping, through slot-coupled manifolds. This unique accelerator, in the process of being fabricated, will be the first structure to demonstrate wakefield damping and the ability to sustain high accelerating gradients for CLIC. This serves as an alternative to the baseline CLIC design, which at present relies entirely on heavy damping. Detailed simulations are presented, on both the optimised surface fields resulting from the monopole mode, and from wakefield damping of the dipole modes. Preparations for the fabrication of a structure, suitable for high power testing, are also discussed. This design takes into account practical mechanical engineering issues and is the result of several optimisations since the original $CLIC_{D}$DS proposal[*].

MOPO03 **Injector Operation with Low Charge Bunches**

Y.A. Kot *(DESY)*

The three stage bunch compression system proposed for the European XFEL will be able to achieve overall compression of about 100. This would lead to the reduction of the bunch length up to 2.5 10^{-5} m for the designed bunch charge of 1nC. It is anticipated that the final compression would be limited here mainly by rf tolerances (jitter) which are determined by technical specifications of the manufacturer. For a large variety of experiments it could be however desirable to go to shorter bunches even on cost of less radiation power. A good possibility to achieve this might be to operate the injector at lower than 1nC bunch charge. In this paper the possibility of the operation of the injector with low charge bunches was investigated. On this issue simulations with ASTRA code have been done in order to find suitable working points for the low charge regimes and to figure out the dependence of the bunch parameters on the initial bunch charge at the cathode. The results of these simulations

for the injectors at FLASH and XFEL as well as the discussion about possible problems are presented.

MOP004 **An Electron Linac Injector with a Hybrid Buncher Structure**

M. Huening *(DESY), M. Schmitz (DESY) C. Liebig (Uni HH)*

At present the Linac II at DESY consists of a 6A/150kV DC electron gun, a 400 MeV primary electron linac, a 800 MW positron converter, and a 450 MeV secondary electron/positron linac. To improve the maintainability of the system and to reduce operational risks the original 150kV diode gun will be replaced by a 100kV triode. Together with the gun the whole injection system will be upgraded and optimized for minimal load on the converter target and primary linac. The core of the new injector are a 5MeV standing wave/ travelling wave hybrid structure and a magnetic energy filter. Simulations show that With 6A DC current up to 3.7A can be bunched into 20° of the 2.998 GHz RF. This phase range is narrow enough to fit after on-crest acceleration into the energy acceptance of the following accumulator ring PIA.

MOP005 **LLNL's Precision Compton Scattering Light Source**

F.V. Hartemann *(LLNL), F. Albert, S.G. Anderson, C.P.J. Barty, A.J. Bayramian, R.E. Bonnanno, T.S. Chu, R.R. Cross, C.A. Ebbers, D.J. Gibson, T.L. Houck, R.A. Marsh, D.P. McNabb, M. J. Messerly, M. Shverdin, C. Siders (LLNL) C. Adolphsen, E.N. Jongewaard, Z. Li, T.O. Raubenheimer, S.G. Tantawi, A.E. Vlieks, J.W. Wang, F. Zhou (SLAC) V.A. Semenov (UCB)*

Continued progress in accelerator physics and laser technology have enabled the development of a new class of tunable x-ray and gamma-ray light sources based on Compton scattering between a high-brightness, relativistic electron beam and a high intensity laser pulse produced via chirped-pulse amplification (CPA). A precision, tunable, monochromatic (< 0.4% rms spectral width) source driven by a compact, high-gradient X-band linac designed in collaboration with SLAC is under construction at LLNL. High-brightness (250 pC, 3.5 ps, 0.4 mm.mrad), relativistic electron bunches will interact with a Joule-class, 10 ps, diode-pumped CPA laser pulse to generate tunable γ-rays in the 0.5-2.5 MeV photon energy range. This gamma-ray source will be used to excite nuclear resonance fluo-

rescence in various isotopes. Fields of endeavor include homeland security, stockpile science and surveillance, nuclear fuel assay, and waste imaging and assay. The source design, key parameters, and current status will be discussed, along with important applications, including nuclear resonance fluorescence and high precision medical imaging.

MOP006 **Design Concepts of the PSI 250 MeV Injector Test Facility**

Y. Kim *(IUCF) H.-H. Braun, T. Garvey, M. Pedrozzi, J.-Y. Raguin, V. Schlott (PSI)*

To develop advanced required technologies for the SwissFEL project, PSI has been constructing a 250 MeV injector test facility. Its first beam commissioning were started in February 2010. In this paper, we describe design concepts of RF photoinjector, linac, bunch compressor, two special beam diagnostics sections for the PSI 250 MeV injector test facility.

MOP007 **SLAC Linac Preparations for FACET**

R.A. Erickson *(SLAC)*

Submitted for the Sector 0-20 Core Team. The SLAC 3km linear electron accelerator has been cut at the two-thirds point to provide beams to two independent programs. The last third provides the electron beam for the Linac Coherent Light Source (LCLS), leaving the first two-thirds available for FACET, the proposed new experimental facility for accelerator science and test beams. In this paper, we describe this separation and several projects to prepare the linac for the FACET experimental program.

MOP008 **Reducing the Energy Spread of Recirculating Linac by Non-isochronous Beam Dynamics**

R. Eichhorn *(TU Darmstadt), A. Araz, J. Conrad, F. Hug, M. Konrad, T. Quincey (TU Darmstadt)*

The Superconducting Linear Accelerator S-DALINAC at the University of Darmstadt (Germany) is a recirculating Linac with two recirculations. Currently acceleration in the Linac section is done on crest of the accelerating field. The recirculation path is operated achromatic and isochronous. In this recirculation scheme the energy spread of the resulting beam in the ideal case is determined by the electron bunch length. Taking into account the stability of the RF system the energy spread increases drastically. In this work we will present a new non-isochronous recirculation scheme which helps canceling out

these errors from the rf-control. This scheme uses longitudinal dispersion in the recirculation pathes and an acceleration off-crest with a certain phase with respect to the maximum. We will present beam dynamic calculations which show the usability of this system even in a Linac with only two recirculations and first experimental results

MOP009 **Generation of Low-energy Electron Beam Using KURRI-LINAC**

T. Kubota *(KURRI), N. Abe, J. Hori, T. Takahashi (KURRI)*

Electron beam can be accelerated in two accelerator tubes up to 46 MeV at KURRI-LINAC. The development of irradiation field is planned to provide lower energy electron beam. For this purpose we had regulated several parameters, which results showed that low energy electron beam was obtained by acceleration in only the first accelerator tube, without the second one, which was filled with microwave from klystron operated at reduced voltage. Moreover, the timing between electron emission and microwave introduction into the first accelerator tube was varied to increase the electron energy loss in the second one, thereby reducing high-energy component of the beam. In this study we obtain lower energy electron beam by the following regulations: 1) the increase of the emission current from the electron gun relative to energy filled into the first accelerator tube results in the decrease of acceleration energy for each electron and 2) the total control of the timing and the buncher phase of microwave and the width of electron pulse eliminates a part of electron expected to be high-energy component. The regulations described above yield the low-energy electron beam with peak of 5.2 MeV.

MOP011 **Injector Linac Upgrade for SuperKEKB**

T. Kamitani *(KEK)*

The KEKB-factory will be upgraded for 40 times higher lumnosity (SuperKEKB). The injector linac is required to increase the beam intensities (e-:1nC -> 5nC, e-:1nC -> 4nC) and reduce the emittances (e-:300 -> 20 um, e+: 2100 -> 10 um) for the SuperKEKB. A photo-cathode RF gun will be introduced to generate the high-intensity and low-emittance electron beams. A positron damping ring will be constructed to reduce the emittance. A new matching device (a flux concentrator or a superconducing magnet) and an L-band capture section will be introduced to increase the positron intensity. Beam line layout

down to the damping ring will be rearranged to have sufficient beam acceptance considering the positron emitttance. This paper describes details of the upgrade scheme of the injector linac.

MOP012 **Development of L-Band Positron Capture Accelerator System in KEKB Injector Linac**
S. Matsumoto *(KEK), M. Akemoto, T. Higo, H. Honma, M. Ikeda, K. Kakihara, T. Kamitani, H. Nakajima, K. Nakao, Y. Ogawa, S. Ohsawa, Y. Yano, K. Yokoyama, M. Yoshida (KEK)*
In order to improve the positron beam intensity needed for super KEKB project, it was decided to replace the present S-band structures in the positron capture section by a new L-band (1298MHz) accelerator system. A 2m long TW structure of 12MV/m gradient is now under idesign process while a 40MW klystron will be delivered in summer. After the klystron testing, a single L-band accelerator unit will be constructed for the structure study. The study is scheduled in next spring to operate the structure under solenoidal magnetic focussing field.

MOP013 **Distributed RF Scheme (DRFS) - Newly Proposed HLRF Scheme for ILC**
S. Fukuda *(KEK)*
Basic configuration design (BCD) in SC ILC has been studied assuming to employ 2 tunnel and the reference design report (RDR) was released. However due to the high cost of construction, single tunnel plan has been discussed recently. Two typical plan, the klystron cluster scheme (KCS) and the distributed RF scheme (DRFS) are intensively studied in the team of global design effort (GDE). In this report, detailed configuration of DRFS, which is newly proposed HLRF scheme for ILC and cost estimation compared with BCD are presented. Discussion about the availability and maintenance plan are also presented. Critical items are also listed up and feasibility plan of DRFS is described.

MOP014 **Observation of Sub-THz Coherent Radiation from the Linac Beam Injected in the NewSUBARU Storage Ring**
Y. Shoji *(LASTI)*
Sub-THz coherent synchrotron radiation (CSR) from the SPing-8 linac beam was observed after the injection into the NewSUBARU storage ring. The beam from the linac has much sorter bunch length than the stationary stored bunch in the ring. It had been reported that the injected linac beam emits CSR at just after the injection until

it diluted to a longer bunch by its energy spread. However we observed CSR at after more revolutions. At some tens of microseconds after the injection we observed CSR produced by a fine time structure in a bunch. At after more revolutions, a half of the synchrotron oscillation period (0.1 ms), CSR was back because the bunch length became shorter again. At this timing we also expect CSR emitted from a structure produced by longitudinal and transverse coupling, which should depend on the chromaticity. We report results of CSR observation through these periods.

MOP015 **New Pump-Probe System Using the Coherent Radiation from a Linac Electron Beam at OPU**

S. Okuda *(Osaka Prefecture University), T. Kojima, R. Taniguchi (Osaka Prefecture University)*

Transient phenomena induced by pulsed electron beams have been investigated with a pulse-radiolysis system with a 18 MeV S-band electron linac at Osaka Prefecture University (OPU). In our recent work the coherent transition radiation from the electron bunches of linac beams, which is highly intense pulsed light in a sub-millimeter to millimeter wavelength range, has been applied to absorption spectroscopy with an L-band electron linac in the Research Reactor Institute, Kyoto University. In these experiments the effect of intensity of the radiation has been observed for several kinds of matters. In this work a new pump-probe system has been developed to investigate the transient phenomena induced by the pulsed coherent radiation by improving the OPU pulse-radiolysis system. The transition radiation is emitted from an Al foil. A part of the coherent radiation is also used as probe light. The pulse lengths of the radiation are from 5 ns to 4 μs. The characteristics of the system have been measured and the system has been optimized. The coherent synchrotron radiation source is under preparation in order to obtain half-cycle light.

MOP016 **Status of Tsinghua Thomson Scattering X-ray Source**

W.-H. Huang *(TUB), H. Chen, Q. Du, Y.-C. Du, Hua„J.F. Hua, R.K. Li, C.-X. Tang, L.X. Yan (TUB)*

Thomson scattering X-ray sources are compact and affordable facilities that produce ultra-fast, high flux, monochromatic, and tunable X-ray pulses for science, medical and industrial applications. Tsinghua Thomson scattering X-ray

(TTX) source for advanced X-ray imaging studies and applications is under construction at the accelerator laboratory of Tsinghua University. We have successfully conducted the scattering experiment between electron beam from photocathode RF gun and TW laser beam. The optimization of the electron beam from booster linac and the upgrading of laser system are carried out. The plan for next scattering experiment is also presented.

MOP017 **A Rescue Mode for the Diamond Light Source Pre-Injector Linac**

C. Christou *(Diamond)*

The Diamond Light Source injection system consists of a 100MeV linac and a 3GeV full-energy booster. The injector is used to fill the storage ring from empty and to provide beam for a 10 minute top-up cycle. The high power RF for the linac is generated by two S-band klystrons, the first powering a buncher and accelerating structure, and the second feeding a second accelerating structure. With the klystrons feeding the two accelerating structures independently, a failure in the klystron or modulator feeding the lower energy structure and bunchers renders the linac, and hence the injection system as a whole, inoperable. In order to address this problem, the RF feed to the linac has been reconfigured to enable either klystron to power the first structure and bunchers; this has involved a rebuild of the waveguide network in the linac vault to include two four-way S-band switches, and the development of a lower energy operating mode for the linac, booster and linac-to-booster transfer line. Details are presented in this paper of the installation and test of the switching network, and the first results are reported of the new operating mode.

MOP018 **Commissioning Status of the Decelerator Test Beam Line in CTF3**

S. Doebert *(CERN), E. Adli, R.L. Lillestol, M. Olvegaard, I. Syratchev (CERN) D. Carrillo, F. Toral (CIEMAT) A. Faus-Golfe, J.J. Garcia-Garrigos (IFIC)*

The CLIC Test Facility (CTF3) at CERN was constructed by the CTF3 collaboration to study the feasibility of the concepts for a compact linear collider. The test beam line (TBL) recently added to the CTF3 machine was designed to study the CLIC decelerator beam dynamics and 12 GHz power production. The beam line consists of a F0D0 lattice with high precision BPM's and quadrupoles on movers for precise beam align-

ment. A total of 16 Power Extraction and Transfer Structures (PETS) will be installed in between the quadrupoles to extract 12 GHz power from the drive beam. The CTF3 drive beam with a bunch-train length of 140 ns, 12 GHz bunch repetition frequency and an average current over the train of up to 28 A will be used. Each PETS structure will produce 135 MW of 12 GHz power at nominal current. The beam will have lost more than 50 % of its initial energy of 150 MeV at the end of the beam line and will contain particles with energies between 67 MeV and 150 MeV. The beam line is completely installed and the PETS structures will be successively added until summer 2011. The paper will describe the first results obtained during commissioning of the beam line and the first PETS prototype.

MOP019 **CLIC Ring to Main Linac**

F. Stulle *(CERN), D. Schulte, J. Snuverink (CERN) A. Latina (Fermilab) S. Molloy (Royal Holloway, University of London)*

The low emittance transport had been identified as one of the feasibility issues for CLIC. We discuss beam dynamics challenges occurring in the beam lines of the RTML connecting the damping rings and the main linac. And we outline how these motivate design choices for the general RTML layout as well as its integration into the overall CLIC layout. Constraints originating from longitudinal dynamics and stabilization requirements of beam energy and phase at the main linac entrance are emphasized.

MOP020 **CLIC Two-beam Module Design and Integration**

A. Samoshkin *(CERN), D. Gudkov, G. Riddone (CERN)*

The CLIC (Compact LInear Collider) design is based on two-beam acceleration concept developed at CERN, where the RF power is generated by a high current electron-beam (Drive Beam) running parallel to the Main Beam. The Drive Beam is decelerated in special power extraction structures (PETS) and the generated RF power is transferred via waveguides to the accelerating structures (AS). The accelerating gradient must be very high (100 MV/m) to reach the high energy for the electron-positron collisions. To facilitate the matching of the beams, components are assembled in 2-m long modules, of few different types. In some of them the AS are replaced by quadrupoles used for the beam focusing. Their alignment and positioning is made by using the signals from the beam-position monitors (BPM).

Special modules are needed in damping region or to carry out dedicated instrumentation and vacuum equipment. The module design and integration has to cope with challenging requirements from the different technical systems. This paper reports the status of the engineering design and reports on the main technical issues.

MOPO21 **Compensation of Transient Beam-Loading in the CLIC Main Linac**

A. Grudiev *(CERN), A. Cappelletti, O. Kononenko (CERN)*

Compensating transient beam loading to maintain a 0.01% relative beam energy spread is a key issue for the CLIC two-beam acceleration technique. The combination of short pulses, narrow bandwidth rf components and the limited number of rf pulse shaping 'knobs' given by the drive beam generation scheme makes meeting this specification challenging. A dedicated model, which takes into account all stages of drive beam generation, including the delay loop and combiner rings, the single-bunch response of the power generation structure (PETS), the RF waveguide network transfer function and dispersive properties of the accelerating structure has been developed. The drive beam phase switching delays, resulting rf pulse shape, loaded and unloaded voltages and finally the energy spread are presented.

MOPO22 **RF Measurement and Tuning of CLIC Accelerating Structure Prototypes at CERN**

A. Grudiev *(CERN), A. Olyunin, J. Shi, W. Wuensch (CERN)*

An RF measurement system has been set up at CERN for use in the X-band accelerating structure development program of the CLIC study. Using the system, S-parameters are measured and the field distribution is obtained automatically by using a bead-pull technique. The corrections for tuning the structure are calculated from the result. Integrated software guides cell-by-cell tuning to obtain the correct phase advance and minimum reflection at the operation frequency. The detailed configuration of the system, as well as the semi-automatic tuning procedure, is presented along with a few examples of measurement and tuning of CLIC accelerating structure prototypes.

MOP023 **The Accelerating Structure for a 500 GeV CLIC**

A. Grudiev *(CERN), D. Schulte (CERN)*

The rf design of an accelerating structure for the 500 GeV CLIC main linac is presented. The design takes into account both aperture and HOM damping requirements coming from beam dynamics as well as the limitations related to rf breakdown and pulsed surface heating. In addition, the constraints related to the compatibility with 3 TeV CLIC have been taken into account. The structure is designed to provide 80 MV/m averaged accelerating gradient at 12 GHz with an rf-to-beam efficiency as high as 39.8 %.

MOP024 **Status of the CLIC Phase and Amplitude Stabilisation Concept**

D. Schulte *(CERN), A. Andersson, S. Bettoni, R. Corsini, A. Dubrovskiy, A. Gerbershagen, J.B. Jeanneret, G. Morpurgo, G. Sterbini, F. Stulle, R. Tomas (CERN) P. Burrows, C. Perry (JAI)*

In CLIC very tight tolerances exist for the phase and amplitude stability of the main and drive beam. In this paper we present the status of the CLIC beam phase and amplitude stabilisation concept. We specify the resulting tolerances for the beam and technical equipment and compare to first measurements.

MOP025 **ACE3P Computations of Wakefield Coupling in the CLIC Two-beam Accelerator**

A.E. Candel *(SLAC), K. Ko, L. Lee, Z. Li, C.-K. Ng, V. Rawat, G.L. Schussman (SLAC) A. Grudiev, I. Syratchev, W. Wuensch (CERN)*

The Compact Linear Collider (CLIC) provides a path to a multi-TeV accelerator to explore the energy frontier of High Energy Physics. Its novel two-beam accelerator concept envisions rf power transfer to the accelerating structures from a separate high-current decelerator beam line consisting of power extraction and transfer structures (PETS). It is critical to numerically verify the fundamental and higher-order mode properties in and between the two beam lines with high accuracy and confidence. To solve these large-scale problems, SLAC's parallel finite element electromagnetic code suite ACE3P is employed. Using curvilinear conformal meshes and higher-order finite element vector basis functions, unprecedented accuracy and computational efficiency are achieved, enabling high-fidelity modeling of complex detuned structures such as the CLIC TDA24 accelerating structure. In this paper, time-domain simulations of wake-

field coupling effects in the combined system of PETS and the TDA24 structures are presented. The results will help to identify potential issues and provide new insights on the design, leading to further improvements on the novel CLIC two-beam accelerator scheme.

MOP026 **A Novel Alignment Procedure for the Final Focus of Future Linear Colliders**

A. Latina *(Fermilab) P. Raimondi (INFN/LNF)*

An algorithm for the simultaneous optimization of orbit, dispersion, coupling and beta-beating in the final focus of future linear colliders is presented. Based on orbit and dispersion measurements the algorithm determines the optimal corrector settings in order to simultaneously minimize the r.m.s orbit, the r.m.s dispersion, the r.m.s coupling, the r.m.s. beta-beating and the r.m.s strength of the dipoles correctors. A number of different options for error handling of beam position monitors, weighting, and correction have been introduced to ensure the stability of the algorithm. A sextupole tuning procedure is also applied to further optimize the beam parameters at the interaction point. Results for the beam delivery systems of ILC and CLIC are presented.

MOP027 **Distributed RF Scheme (DRFS) - Newly Proposed HLRF Scheme for ILC**

S. Fukuda *(KEK)*

Distributed RF Scheme (DRFS) was proposed for International Linear Collider (ILC) as a new HLRF scheme. After the ITRP recommendation, ILC technology was chosen to be superconducting technology and basic design was discussed and reported in the RDR on 2007. Aiming for the cost reduction, there have been proposed many ideas and summarized as SB2009 proposal. DRFS is the one of these proposals, and it is linked to the single tunnel plan. DRFS employs many small klystrons (750kW output power) which feed power to two superconducting cavities. 13 modulating anode klystrons are operated by a DC power supply and a modulating anode pulser. All required components are installed in a tunnel and therefore this scheme is a complete single tunnel layout. DRFS was proposed in 2008 and thereafter it has been discussed in web-ex meeting and GDE workshop. In this conference, concept and detailed design of DRFS are presented including the availability and operability. In order to show the feasibility of DRFS, KEK has a plan of demonstration em-

ploying the DRFS with two klystrons in the S1 global in the end of 2010. Presenter also discussed pros and cons comparing with the competing proposed scheme.

MOP028 **ILC Conventional Facility in Asian Regional Tunnel Configuration**

A. Enomoto *(KEK)*

The international linear collider (ILC) project is about to meet the technical design phase 2, of which the goal is to establish a realistic design by the end of 2012. Single-tunnel accelerator configuration is one of the most essential improvements to reduce the construction costs. The original design involves two tunnels which house the accelerator cavities and the power supplies separately, having such advantages as we can enter the power-supply tunnel even during beam operation. Although the single tunnel configuration sacrifices these functions, it saves big tunnel construction costs. The Asian team is studying a regional single-tunnel accelerator configuration to match the Asian site feature in conjunction with a compact high-level RF scheme called distributed RF system (DRFS). The design concepts have been developed by a conventional facility working group in the advanced accelerator association (AAA) which involves a collaboration among academic, industrial, and political communities in Japan. Not only cost reduction but also functional impacts of tunnel configuration on things such as life safety are discussed in this paper.

MOP029 **S0-studies on ICHIRO 9-cell Cavities in Collaboration with KEK and Jlab**

F. Furuta *(KEK), K. Saito (KEK) T. Konomi (Sokendai)*

In 2008, KEK and Jlab did the collaboration of S0-study on ICHIRO 9-cell #5 which has no end groups on beam tubes. As S0 tight loop test, surface treatments and vertical tests were repeated on ICHIRO#5 at both of Jlab and KEK. Maximum gradients of 36.5MV/m at Jlab and 33.7MV/m at KEK were achieved so far. In this year, 2010, KEK and Jlab started new S0-study collaboration on ICHIRO 9cell #7 which has full end groups on beam tubes. ICHIR#7 was already sent to Jlab and VT as received was done. We will report the results of tight loop tests at Jlab.

MOP030 **Status of Superconducting Cavity for ILC at MHI**

H. Hitomi *(MHI)*

MHI's activities for ILC project will be shown.

MOP031 **Industrial Electron Accelerators ILU**

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The industrial electron accelerators type ILU are developed and produced by the Budker Institute of Nuclear Physics. The ILU accelerators are working in many countries in the industrial lines as well as in some research establishments starting from the beginning of 70-s. These machines are the pulse RF type accelerators with relatively low working frequency ' 120MHz for ILU-6 and ILU-10 and 180MHz for ILU-8. Their energy range is from 0.8MeV (ILU-8) to 5MeV (ILU-10), beam power is up to 50kW. The new ILU-14 machine for energy range 7.5-10MeV is on the final stage of development. The ILU machines are working in various technological processes ' radiation modification of polymer tubes and films, polymer pipes for hot water supply, wires, cables, sterilization of single use medical products (syringes, hospital and operation gowns, sets for operations, etc.), decontamination of the medicinal raw. The ILU accelerators are equipped with several beam extraction devices ' linear scanner and scanners with 4 windows permitting to organize the irradiation of the long products (tubes, cables, wires, pipes) from 4 sides

MOP032 **Application of X-band Linac for Material Recognition with Two Fold Scintillator Detector**

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950 keV X-band Linac has the merits of compact system, and it does not need the radiation safety manager on-site in the public space. Therefore the system we have developed is suitable for the more safe circumstance in airport. Dual energy X-ray concept is introduced for material recognition with Linac these days, because it produce high energy X-ray which is available in case the target is thick and high atomic number material. We suggest two fold scintillator detector concept to induce dual energy X-ray effect. The design of two fold scintillator is decided by MCNP simulation with two scintillator code, CsI and CdWO4. The material recognition is confirmed using aluminium, iron and lead metal in conditions such as various thicknesses and containers.

MOP033 **RF Design for a Low Energy X-Band Accelerator**

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Compact X-ray sources are integral parts of systems used in medical, industrial and security applications. The X-ray dose rate for a particular application mainly depends on the energy and current of the beam used to hit the target, usually made of tungsten. In applications that need higher penetration (100s of mm in steel), the beam energy needed is in the range of 1-5 MeV which can only be obtained using an RF linear accelerator. In order to reduce the size of the linac, higher RF frequencies (X-band) should be used while in order to reduce the overall bulk, RF focusing is employed instead of solenoidal focusing. Thus the main attraction of an X-band linac compared to a lower frequency version is the amount of lead required for shielding the system, and hence its weight. For capturing and bunching the low energy dc beam, a bunching section is needed in front of the main linac. The bunching cavity can either be a part of the main linac cavity or an independently powered section which can be used for certain specific applications as a shorter 1 MeV linac. In this paper, the design and simulations of an X-band buncher to be suitable for compact X-ray sources is presented.

MOP034 **Observation of Ozone Explosion of Liquid Nitrogen Induced by Irradiation with Electron Linear Accelerator**

R. Taniguchi *(Osaka Prefecture University), N. Ito, T. Kojima, S. Okuda (Osaka Prefecture University)*

A pulsed electron radiography system has been developed, which consisted of an electron linear accelerator, a scintillation screen and a high sensitivity image sensor. The system was capable for high speed strobo-imaging by the use of the pulse feature of the electron beam with the pulse width about a few micro-second. On the other hand, the characteristics of electron images were different from X-ray images and neutron images. Absorption behavior of energetic electrons in materials is Bragg-like rather than exponential. Therefore, a high contrast transparent image was obtained by modulating of energy of the electron beam. By the use of this system and utilizing these features, we observed successfully an ozone explosion phenomenon of liquid nitrogen induced by electron irradiation,

which has been considered to be a serious problem in material irradiation experiments.

MOPO35 **Beam Commissioning of L-band Intense Electron Accelerator**

W. Namkung *(POSTECH), M.-H. Cho, S.D. Jang, S.H. Kim, S.J. Park, H.R. Yang (POSTECH) K.H. Chung, K. Lee (KAPRA) J.-S. Oh (NFRI)*

An intense L-band electron accelerator is now being commissioned at ACEP (Advanced Center for Electron-beam Processing in Cheorwon, Korea) for irradiation applications in collaboration with POSTECH (Pohang University of Science and Technology) and KAPRA (Korea Accelerator and Plasma Research Association). It is capable of producing 10-MeV electron beams with average 30 kW. For a high-power capability, we adopt an L-band traveling-wave accelerating structure operated with the fully-beam-loaded condition. The regenerative-BBU instability due to high beam current was suppressed with solenoidal magnetic fields. In this paper, we present commissioning status with measurement of the beam energy and current.

MOPO36 **Commissioning Status of C-band Standing-wave Accelerator**

W. Namkung *(POSTECH), M.-H. Cho, S.D. Jang, S.H. Kim, S.J. Park, H.R. Yang (POSTECH) K.H. Chung, K. Lee (KAPRA) J.-S. Oh (NFRI)*

A C-band standing-wave electron linac for a compact hard X-ray source is now being commissioned at ACEP (Advanced Center for Electron-beam Processing in Cheorwon, Korea). It is designed to produce 4-MeV electron beam with pulsed 50-mA, using a 5-GHz RF power generated by a magnetron with pulsed 1.5 MW and average 1.2 kW. The accelerating structure is a bi-periodic and on-axis-coupled one operated with $\pi/2$-mode standing-waves. It is consisted of 3 bunching cells, 6 accelerating cells and a coupling cell. After the tuning of the actual column, the resonant frequency is 4999.17 MHz at the $\pi/2$-mode, the coupling coefficient is 0.92 and the field flatness is less than 2%. In this paper, we present commissioning status with details of the linac system.

MOPO37 **A Nearly Independent, Low-Rigidity Transport Lattice Embedded into a High-Rigidity Lattice**

M.G. Tiefenback *(JLAB)*

The linac optics of the CEBAF recirculating ac-

celerator simultaneously transports up to five beams of different rigidity within a common channel. The focusing strength of the linac lattice is limited by the single-particle stability boundary of that structure for the lowest required rigidity. The focusing progressively weakens (and beta increases) for increasing rigidity. The CEBAF FODO lattice performs well over moderate rigidity ratios. In studying ways to increase the linac focusing strength for the higher acceleration passes, we devised a lattice consisting of two coincident structures. The low-rigidity part, reasonably described as an 'embedded lattice,' consists of strong symmetric triplets. Lattice elements for the higher-rigidity beams are located at the small-beta waists of the triplet structure, rendering them ineffective upon the low-rigidity beam well beyond the usual envelope stability limit for that beam. The residual focusing strength for the high-rigidity beam can be much greater than is possible for a simple FODO structure. The triplets are themselves ineffective upon the high-rigidity beams. CEBAF optics and analogues are used to illustrate.

MOP039 **First Beams Produced by the SPIRAL-2 Injectors**

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The SPIRAL-2 superconducting linac driver, which aims at delivering 5 mA, 40 MeV deuterons and up to 1 mA, 14.5 A.MeV q/A=1/3 heavy ions, has now entered its construction phase in GANIL (Caen, France). The linac is composed of two injectors feeding one single RFQ, followed by a superconducting section based on 88 MHz independently-phased quarter-wave cavities with room-temperature focusing elements. The first stages of the injectors have been fully built and are now operational. They have been partly commissioned with beam in Grenoble and Saclay in 2010. This paper describes the results obtained so far in this context.

MOP040 **Advanced UNILAC Upgrade for FAIR**

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To provide for the high beam currents as required of the FAIR project, the GSI Unilac High Current Injector (HSI) must deliver 18 mA of U^{4+} ions at the end of the prestripper section. With the design existing up to 2008, the RFQ could not

reach the necessary beam currents at the RFQ output, as simulations had shown. Furthermore, parts of the existing LEBT must be modified, and a new straight source branch must be added to provide for the full required beam current. As a first step of an HSI frontend upgrade, the RFQ has been modernized in summer 2009 with a completely new electrode design. Commissioning of the HSI has shown that the transmission of the RFQ increased significantly (from 55% to 85% in high current Uranium operation, 95% in medium current operation). As expected, further bottlenecks for the transmission of the complete HSI (matching LEBT-to-RFQ, matching to the Superlens) have been detected. An upgrade of LEBT magnets is foreseen for 2010, the additional linear source branch will follow.

MOP041 **The Superconducting CW-LINAC-Demonstrator at GSI**

S. Mickat *(GSI), W.A. Barth, L.A. Dahl, M. Kaiser (GSI) F.D. Dziuba, H. Podlech, U. Ratzinger (IAP)*

GSI applied for a new superconducting (sc) cw-LINAC in parallel to the existing UNILAC. Such a machine is highly desirable with respect to the progress in the field of Superheavy Elements (SHE) for example. The UNILAC at GSI is limited in providing a proper beam for SHE and in fulfilling the requirements for FAIR simultaneously. A sc CH-structure is the key component of the proposed efficient and compact linac. In first vertical rf-tests at the Institute of Applied Physics (IAP) maximum gradients up to 7 MV/m were achieved. The cavities for the cw-LINAC should be operated at 217 MHz providing gradients of about 5.1 MV/m at a total length of minimum 0.6 m . In a first step a prototype of such a sc cw-LINAC as a demonstrator is financed by the Helmholtz Institute Mainz (HIM). The demonstrator is the first section of the proposed cw-LINAC consisting of a sc CH-cavity embedded by two sc solenoids. The aim is a full performance test of the demonstrator with beam at the GSI high charge injector (HLI) in 2013. Presently the tendering of the solenoids, the cavity, the cryostat and the rf-amplifier is in preparation.

MOP042 **UNILAC Upgrades for Coulomb Barrier Energy Experiments**

L.A. Dahl *(GSI), W.A. Barth, P. Gerhard, S. Mickat, W. Vinzenz, H. Vormann (GSI) A. Schempp, M. Vossberg (IAP)*

The GSI linear accelerator UNILAC provides heavy ion beams at Coulomb barrier energies for

search and study of super heavy elements. Typical cross-sections of 55 fb require beam doses of $1.4{\cdot}10^{19}$ according to a beam time of 117 days. Several upgrades will reduce the beam time to only 16 days. A second injection branch with a 28GHz-MS-ECRIS anticipates a factor of 10 in particle intensity. By a new cw rfq-structure all accelerator tanks are suitable for a duty cycle of at least 50% instead of 25% presently. Due to this, thermal power increase of 19 rf-amplifiers eased by higher ion charge states of the ECRIS is necessary. Finally the UNILAC timing system controlling 50Hz pulse-to-pulse operation of up to six beams differing in ion species and energy has to be modified considering beam diagnostics electronics and pulsable magnets. The front end comprising ECRIS, rfq- and IH-structure is cw suitable and will serve as injector for a new future sc-cw-linac.

MOP043 **HITRAP - A Decelerator for Heavy Highly-charged Ions**

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Heavy, highly-charged ions (HCI) with only one or few electrons are interesting systems for precision experiments as for instance tests of the theory of quantum electrodynamics (QED). To achieve high precision, kinetic energy and spatial position of the ions have to be well controlled. This is in contradiction to the production process that employs stripping of electrons at high energies by sending relativistic highly-charged ions with still many electrons through matter. In order to match the production at 400 MeV/u with the requirements of the experiments - stored and cooled HCI at low energy - the linear decelerator facility HITRAP has been built at the experimental storage ring (ESR) at GSI in Darmstadt. The ions are first decelerated in the ESR from 400 to 4 MeV/u, cooled and extracted. The ion beam phase spaces are then matched to an IH-structure, decelerated from 4 to 0.5 MeV/u before a 4-rod RFQ reduces the energy to 6 keV/u. Finally, the HCI are cooled in a Penning trap to 4 K. Extensive ion optical calculations were performed and in recent tests up to one million highly-charged ions have been decelerated from 400 MeV/u to 0.5 MeV/u.

MOP044 **High Current U^{40+}-operation in the GSI-UNILAC**

W.A. Barth *(GSI), G. Clemente, L.A. Dahl, P. Gerhard, L. Groening, M. Kaiser, M.T. Maier, S. Mickat, H. Vormann (GSI)*

A low current high duty factor U^{10+}-beam from the Penning Ion Source as well as a high current low duty factor U^{4+}-beam from a MeVVa source were used for machine investigations in the GSI-UNILAC and synchrotron (SIS18). Carbon stripper foils (20, 40 and 50 ug/cm^2) were mounted in the gas stripper section at 1.4 MeV/u to provide for highly charged uranium ions (40+) to be delivered to the SIS18 for life time beam measurements. High current tests were performed to check the durability of the carbon foils. No measurable variation of the stripped low and high current beam in the poststripper DTL could be detected during the life time of the foils. An U^{40+}-beam current of up to $1.0{\cdot}10^{+11}$ particles per 100mues could be reached in the transfer line to the SIS18. This paper will report on the investigations of stripper foils with different thickness. Additionally long time observation of all relevant beam parameters (transverse emittance, energy spread and energy loss, bunch shape, beam transmission up to the SIS-injection) are presented.

MOP045 **Efficiency and Intensity Upgrade of the ATLAS Facility**

P.N. Ostroumov *(ANL), R.V.F. Janssens, M.P. Kelly, S.A. Kondrashev, B. Mustapha, R.C. Pardo, G. Savard (ANL)*

ANL Physics Division is pursuing a major upgrade of the ATLAS National User Facility. The overall project will dramatically increase the beam current available for the stable ion beam research program, increase the beam intensity for neutron-rich beams from Californium Rare Isotope Breeder Upgrade (CARIBU) and improve the intensity and purity of the existing in-flight rare isotope beam (RIB) program. The project will take place in two phases. The first phase is fully funded and focused on increasing the intensity of stable beams by a factor of 10. This will be done using a new normal conducting, CW RFQ accelerator and replacing three cryostats of split-ring resonators with a single new cryostat of high-performance quarter-wave resonators. To further increase the intensity for neutron-rich beams, we have started development of a high-efficiency charge breeder for CARIBU based on an Electron Beam Ion Source. The goal of the proposed second phase will be to increase the

energies and intensities of stable beams, as well as, increase the efficiency and beam current for CARIBU and in-flight RIB beams. The focus of this paper is on innovative developments for Phase I of the project.

MOP046 **Status and Plans for the Facility for Rare Isotope Beams at Michigan State University**
R.C. York *(NSCL), G. Bollen, M. Doleans, W. Hartung, M.J. Johnson, G. Machicoane, F. Marti, X. Wu, Q. Zhao (NSCL) T . Glasmacher, E. Pozdeyev, E. Tanke (FRIB)*
The primary purpose of the Facility for Rare Isotope Beams (FRIB) is to produce and to do fundamental research with rare isotopes. The rare isotope production will be accomplished using a heavy ion cw linac to provide a stable isotope beam (protons through uranium) at high power (up to 400 kW) and high energy (>200 MeV/u) on a particle fragmentation production target. The rare isotopes will be produced in quantities sufficient to support world-leading research by using particle fragmentation of stable beams. This will include research pertaining to the properties of nuclei (nuclear structure), the nuclear processes in the universe and tests of fundamental symmetries. Societal applications and benefits may include bio-medicine, energy, material sciences and national security. The overall facility status and plans will be discussed with a focus on the accelerator system.

MOP047 **The Overview of the Accelerator System for the Facility for Rare Isotope Beams at Michigan State University**
X. Wu *(NSCL), M. Doleans, W. Hartung, M.J. Johnson, F. Marti, R.C. York, Q. Zhao (NSCL) E. Pozdeyev, E. Tanke (FRIB)*
The Facility for Rare Isotope Beams (FRIB) will accelerate stable beams of heavy ions to > 200 MeV/u with beam powers of up to 400 kW onto an in-flight fragmentation target to produce rare isotopes. The accelerator system will include a room-temperature front end, a double-folded superconducting driver linac, and a beam delivery system. The front end will include superconducting ECR ion sources, a beam bunching system and a radio frequency quadrupole. The driver linac will include three acceleration segments using superconducting quarter-wave and half-wave cavities with frequencies of 80.5 and 322 MHz, and two 180 degree folding systems to minimize the cost of conventional construction. Charge-stripping and multi-charge-state beam acceleration will be used for the heavier ions

to increase acceleration efficiency. The beam delivery system will transport accelerated stable beams to the in-flight fragmentation target. End-to-end beam simulations with errors have been performed to evaluate the performance of the driver linac. We will discuss recent progress in the accelerator design and the beam dynamics studies for the baseline accelerator system.

MOP048 **Experimental Study of the Surface Resistance of the 141 MHz Quarter-Wave Resonator at Triumf**

D. Longuevergne *(UBC & TRIUMF) C.D. Beard, A. Grassellino, P. Kolb, R.E. Laxdal, V. Zvyagintsev (TRIUMF)*

The upgrade (Phase II) of the ISAC-II superconducting linac has been completed this spring and has been commissioned. Two spare 141 MHz Quarter-Wave Resonators made of bulk Niobium are available at TRIUMF to lead more specific studies on surface resistance. This opportunity has also been taken to optimize the surface treatment to improve the accelerating field gradient at the operating power level. The aim of the study presented here is to link together several surface treatments (etching depth, 120C baking) and test conditions (Q-disease, 4.2 K and 2K tests) and sequence them in an appropriate order to understand more deeply their dependencies.

MOP049 **Electro-Magnetic Optimization of a Quarter-Wave Resonator**

B. Mustapha *(ANL), P.N. Ostroumov (ANL)*

A new cryomodule is being designed for the ongoing ATLAS efficiency and intensity upgrade. The cryomodule consists of 7 Quarter-Wave Resonators (QWR) with β-G=0.075 and 4 SC solenoids to replace the existing split-ring cavities. To reduce the resonator frequency jitter due to micro-phonics we choose a frequency of 72.75 MHz instead of 60.625 MHz. At 72.75 MHz, the cavity is shorter by about 20 cm. The choice of the design β was optimized based on the beam dynamics and the actual performance of ATLAS cavities. To reach a record high accelerating voltage of 2.5 MV per cavity or higher, the EM design was carefully optimized. The main goal of the optimization was to minimize the peak magnetic and electric fields while still keeping good values for the stored energy, the shunt impedance (R/Q) and the geometric factor (Rs/Q). The cavity height was also another important parameter. The optimization has lead to a final shape which is cylindrical in the bottom and conic on the top keeping a high real-estate gradient. The opti-

mization also included the internal drift tube face angle required for beam steering correction.

MOP050 **Beam Commissioning of the ISAC II Superconducting Linac Upgrade**

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ISAC is TRIUMF facility for the production and post acceleration of radioactive ion beams. The post acceleration chain is composed of two normal conducting linacs (RFQ and DTL) that accelerate stable and radioactive beams with 2≤A/Q≤6 up to 1.8 MeV/u followed by a Superconducting (SC) LINAC. The SC linac was installed in two phases: a medium and a high beta section. The medium beta section installation was completed and commissioned in 2006 and it is operational since then. It consists of five cryomodules each hosting four bulk niobium quarter wave cavities operating at 106MHz. A superconducting solenoid is installed in each cryomodule to provide transverse focusing. The high beta section is an upgrade in energy. The installation was completed recently and the beam commissioning is underway. This section is composed of three cryomodules hosting respectively six, six and eight bulk niobium quarter wave cavities operating at 141 MHz. A superconducting solenoid is also present in each of the new cryomodule. The new cavities are expected to deliver an effective voltage of 1 MV each boosting the total to 40 MV. In this paper we present the results of the beam commissioning.

MOP051 **Tests of the MEBT Rebuncher for the SPIRAL 2 Driver**

M. Lechartier *(GANIL), M. Di Giacomo, J.F. Leyge (GANIL)*

The Spiral 2 project [1] uses normal conducting rebunchers to accelerate high intensity beams of protons, deuterons and heavier ions. All cavities work at 88 MHz, the beta is 0.04 and 3 rebunchers are located in the MEBT line, which accepts ions with A/q up to 6. The paper describes the RF design and the technological solutions proposed for an original 3-gap cavity, characterised by very large beam holes (60mm) and providing up to 120 kV of effective voltage .It describes the test bench to qualify the high voltage performances.

MOPO53 **Testing of Super Conducting Low-beta 704 MHz Cavities at 50 Hz Pulse Repetition Rate in View of SPL - First Results**

W. Höfle *(CERN), M. Hernandez Flano, D. Valuch (CERN) S. Chel, M. Desmons, O. Piquet (CEA) R. Paparella, P. Pierini (INFN/ LASA)*

In the framework of the preparatory phase for the luminosity upgrade of the LHC (SLHC-PP) it is foreseen to characterize two superconducting RF cavities and demonstrate compliance of the required SPL field stability in amplitude and phase using a prototype LLRF system. We report on the preparation for testing of two super-conducting low-beta cavities at 50 Hz pulse repetition rate including the setting-up of the low level RF control system to evaluate the performance of the piezo-tuning system and cavity field stability in amplitude and phase. Results from tests with 50 Hz pulse repetition rate are presented. Simulations of the RF system are used to predict the necessary specifications for power and bandwidth to control the cavity field and derive specifications for the RF system and its control.

MOPO54 **The HIE-ISOLDE Project at CERN: Status and Future Perspectives**

M. Pasini *(CERN), R. Catherall, Y. Kadi (CERN)*

The HIE-ISOLDE project at CERN aims at the increase of energy, intensity and quality of the post accelerated Radioactive Ion Beam at ISOLDE. The recent approval of the project from the CERN management will satisfy the huge demand of nuclear physicists for more exotic and more energetic beams, allowing to reach in a first stage 5.5 MeV/u (to be ready by 2013) and in a second stage to reach 10 MeV/u by 2015 (this latter date is depending on funding availability). This is achieved by a major refurbishment of the target area and with the installation of new superconducting linac based of sputtered SC Quarter Wave Resonators (QWRs). The paper describes the different R&D phases and outlines different scenarios of the project.

MOPO55 **A CW SRF Linac to Drive Subcritical Nuclear Reactors**

M. Popovic *(Fermilab) C.M. Ankenbrandt, R.P. Johnson (Muons, Inc)*

In the last 20 years, superconducting RF (SRF) cavities have been developed to the point that a CW SRF linac is the best candidate driver for subcritical reactors. We discuss how one appropriately designed linac can be used for

an accelerator-driven subcritical (ADS) nuclear power station to produce more than 5 GW electrical power in an inherently safe region below criticality. Such a station will generate no greenhouse gases, produce minimal nuclear waste and no byproducts that are useful to rogue nations or terrorists, incinerate waste from conventional nuclear reactors, and efficiently use abundant thorium fuel that does not need enrichment. We describe the Linac parameters that can enable this vision of an almost inexhaustible source of power and we discuss how the corresponding reactor technology can be matched to these parameters.

MOP056 **Status of the ALPI Low-beta Upgrade**

A. Facco *(INFN/LNL), F. Scarpa (INFN/LNL) Y. Ma (CIAE)*

The low-beta section of the ALPI linac at Laboratori Nazionali di Legnaro is being upgraded in order to double its energy gain from about 10 MV to 20 MV. This upgrade, performed with a rather limited investment in the background of the standard accelerator activities, is based on the replacement of some rf system components and minor modifications to the cryostats. The cavities, working at 80 MHz, require a 3 dB rf bandwidth of 15 Hz (obtained by means of strong overcoupling) to be locked in the presence of the large Helium pressure fluctuations of ALPI. Their average gradient, although exceeding 6 MV/m at the nominal 7 W power, is presently kept around 3 MV/m during operation, limited by the maximum available rf power in the linac. The ongoing upgrade requires the modification of all low-beta cryomodules to allow new, liquid Nitrogen cooled rf couplers and new, 1 kW amplifiers. A fully equipped prototype cryostat with four, beta=0.047 QWRs has been constructed and tested on line, and operated at 6 MV/m reaching or exceeding all the design goals. The test results will be reported and discussed and the project status will be presented.

MOP057 **A CW Operated Superconducting Heavy Ion CH-Type Linac for Super-Heavy Element Research at GSI**

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The search for Super-Heavy Elements (SHE) is one of the frontiers in nuclear physics. By trend the production cross sections decrease significantly for larger proton numbers and heavier nuclei, respectively. To limit the required beam

time it is necessary to use the highest available intensity. This prefers cw operation and the use of superconducting cavities. A cw operated superconducting linac using CH-cavities at GSI has been designed. As front end the existing 10^8 MHz High Charge Injector (HLI) will be used which is presently being upgraded for cw operation. The superconducting part of the linac covers the energy between 1.4 AMeV and 7.5 AMeV. It consists of 9 multi-cell CH-cavities operated at 217 MHz. Each cavity is optimized for a specific particle velocity but without beta profile. Above 3.5 AMeV the linac is fully energy variable. The first superconducting CH-cavity is already under construction and will be tested with beam delivered by the HLI. The talk covers the development of the prototypes and the overall design including beam dynamics issues.

MOPO58 **A Test Bench for the Heidelberg Ion Beam Therapy Centre**

R. Cee *(HIT), E. Feldmeier, M. Galonska, Th. Haberer, J.M. Mosthaf, A. Peters, S. Scheloske, T.W. Winkelmann (HIT)*

The Heidelberg Ion Beam Therapy Centre (HIT) is the only medical facility in Europe for cancer treatment with protons and carbon ions. To broaden the range of available ion species towards helium the low energy beam transport (LEBT) will be extended by a third ion source and the associated spectrometer section. Following a novel ion optical approach the LEBT-branch has been redesigned. A dedicated test bench will be used to commission and validate the new design prior to its integration into the medical accelerator. In its final stage the test bench will comprise an ECR-ion source, a LEBT and an RFQ with diagnostics line. It opens up the unique opportunity to perform comprehensive investigations not only of the ion source but also of other devices like the RFQ which have been optimised in the frame of the LINAC upgrade. Here, particular emphasis will be placed on the new design of the analyser dipole and the macro pulse chopper. Furthermore results of beam optical simulations and first measurement results will be presented.

MOPO59 **Continued Development of a 2.5-MeV RFI Linac System**

D.A. Swenson *(Linac Systems, LLC)*

A 2.5-MeV, 20-mA, Cw Linac System is nearing completion at Linac Systems, LLC. The intended application is to produce abundant quantities of epithermal neutrons for the BNCT medical application. The operating frequency is 200 MHz.

The linac structure consist of a radial strut RFQ linac section to an energy of 0.75 MeV and an RFI linac section to the final energy of 2.5 MeV. The two linac structures are resonantly coupled by a quarter-wave-stub resonant coupler, which locks the relative phases and relative field amplitudes of the two structures. The rf power is loop-coupled to the RFQ section, and the power required for the RFI section is transmitted through the resonant coupler. The ion source is an ECR microwave type, operated at 25 keV. The LEBT includes dual magnetic solenoid focusing lenses and independent x and y steering magnets. The final amplifier of the rf power system is a cavity-based amplifier with 6 CPI/Eimac YC-300A power tubes in parallel. The peak and average power output is 180 kW cw. The current status of the system will be described.

MOP060 **The Compact Injector as the Second Injector of the HIMAC**

Y. Iwata *(NIRS), T. Fujisawa, T.M. Murakami, M. Muramatsu, K. Noda (NIRS) Y.K. Kageyama, I. Kobayashi, T. Sasano, T. Takeuchi (AEC)*

A compact injector, consisting of the permanent-magnet ECR ion-source, the RFQ linac and the alternating-phase-focused interdigital H-mode drift-tube-linac (APF IH-DTL), was developed for an injector of medical-accelerator facilities, dedicated for the heavy-ion cancer therapy. The injector can accelerate heavy-ions having q/m=1/3 up to 4 MeV/u. Beam acceleration tests of the compact injector were successfully made at the National Institute of Radiological Sciences (NIRS), and the results of the acceleration tests proved its excellent performance*. The same design was used for the injector, constructed at the Heavy Ion Medical Center in the Gunma University. Our compact injector was recently installed in the HIMAC, and will be used as the second injector of the HIMAC. The new beam transport line for the compact injector was constructed in conjunction with the existing transport line. The entire injector system of the HIMAC accelerator complex will be presented.

MOP061 **Exploring the Energy/Beam Current Parameter Space for the Isotope Production Facility (IPF) at LANSCE**

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IPF has recently investigated isotope production with proton beams at energies other than the

100-MeV currently available to the IPF beam line. To maximize the yield of a particular isotope, it is necessary to measure the production rate and cross section versus proton beam energy. Studies were conducted at 800 MeV and 197 MeV to determine the cross section of terbium-159. Also, the ability to irradiate targets at different proton beam energies opens up the possibility of producing other radioisotopes. A proof-of-principle test was conducted to develop a 40-MeV tune in the 100-MeV beam line. Another parameter explored was the beam current, which was raised from the normal limit of 250 uA up to 356 uA via both power and repetition rate increase. This proof-of-principle test demonstrated the capability of the IPF beam line for high current operation with potential for higher isotope yields. For the full production mode, system upgrades will need to be in place to operate at high current and high duty factor. These activities are expected to provide the data needed for the development of a new and unique isotope production capability complementing the existing 100-MeV IPF facility.

MOPO62 **Linac followed by an Electron Cooler to Provide a Short Bunch Proton Beam**

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Proton beams accelerated by an RFQ and a DTL with resonant frequency of 433 MHz,are electron cooled after injection into a storage ring, S-LSR and fast extracted to a beam irradiation target. Short pulse duration around 3.5 ns is expected for the 7 MeV proton beam with the intensity of 1.4×10^8 [1]. This beam is to be utilized for irradiation of biological cells in order to investigate Radio Biological Effectiveness of proton beam with a very high peak intensity for the purpose of quantitative verification of the recent report on the DNA double strand breaking with the use of short-pulse laser-produced proton beam [2]

MOPO64 **R&D of C Band Accelerating Structure at SINAP**

W. Fang *(SINAP), Q. Gu, Z.T. Zhao (SINAP) D.C. Tong (TUB)*

A compact hard X-ray FEL facility is on plan now at Shanghai Institute of Applied Physics (SINAP). This facility will be located close to Shanghai Synchrotron Radiation Facility(SSRF) which is a 3rd generation light source in China, in order to control the overall length less than 650m, this facility asks a compact linac with high gradient accelerating structure. C-band (5712MHz) ac-

celerating structure is a compromised and good option for this compact facility. R&D of a C-band (5712MHz) high gradient traveling-wave accelerating structure has been in progress at Shanghai Institute of Applied Physics (SINAP). The structure is consisted of 53 regular disk-loaded cells and two waveguide couplers, and its length is about one meter. This paper introduces the study of the accelerating structure design method, its experimental model and the preliminary results of the RF cold test of the model structure.

MOP065 **C-Band Magnetic Coupled Accelerating Structure Optimization**

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This paper presents the results of a research that analyzed the possibility of using a magnetic coupled disk-loaded structure (DLS-M) as an accelerating structure. DLS-M seems to have decent advantages comparing to the classical electrical coupled structure (DLS). The electrodynamics parameters of such a structure at various modes in C-band for a wide range of phase velocities as a function of aperture radii and coupling slot sizes are presented. Both forward and backward travelling wave regimes are considered. The essential parameters are compared to those of classical DLS. The design of an input coupler to the accelerator consisting of this type structure cells is also presented.

MOP066 **Numerical Modeling of Arcs in Accelerators**

J. Norem *(ANL), Z. Insepov, Th. Proslier (ANL) D. Huang (IIT) S. Mahalingam, S.A. Veitzer (Tech-X)*

We are developing a model of arcing to explain breakdown phenomena in high-gradient rf systems used for particle accelerators. This model assumes that arcs develop as a result of mechanical failure of the surface due to electric tensile stress, ionization of fragments by field emission, and the development of a small, dense plasma that interacts with the surface primarily through self sputtering and terminates as a unipolar arc capable of producing field emitters with high enhancement factors. We are modeling these mechanisms using Molecular Dynamics (mechanical failure, Coulomb explosions, self sputtering), Particle-In-Cell (PIC) codes (plasma evolution), mesoscale surface thermodynamics (surface evolution), and finite element electro-

static modeling (field enhancements). We believe this model may be more widely applicable and we are trying to constrain the physical mechanisms using data from tokamak edge plasmas.

MOP067 **First High Power Tests of CLIC Prototype Accelerating Structures with HOM Waveguide Damping**

S. Doebert *(CERN), A. Grudiev, G. Riddone, W. Wuensch, R. Zennaro (CERN) C. Adolphsen, F. Wang, J.W. Wang (SLAC) T. Higo, S. Matsumoto, K. Yokoyama (KEK)*

Prototype accelerating structures for the Compact Linear Collider (CLIC) are being developed and high-power tested in a collaboration between SLAC, KEK and CERN. Several undamped, low group-velocity and strongly tapered prototypes (of the so-called T18 design) have been operated above 100 MV/m average gradient at a very low breakdown rates. Recently two new structures with the same iris apertures but now including higher order mode damping waveguides in each cell (TD18 design) have been tested at SLAC and KEK. The damped versions could be processed to similar gradients but an increased breakdown rate was observed. The damping waveguides lead to a magnetic field enhancement in the outer diameter of the cells which results in increased pulsed surface heating. The maximum pulsed temperature rise is 80 deg at the design gradient of 100 MV/m compared to only 20 deg for the undamped version. The high-power tests of the two TD18 structures are analyzed with special emphasis on the influence on breakdown rate of the enhanced magnetic field and consequent increased pulsed surface temperature rise.

MOP068 **Design of the CLIC Main Linac Accelerating Structure for CLIC Conceptual Design Report**

A. Grudiev *(CERN), W. Wuensch (CERN)*

The design of the CLIC main linac accelerating structure has been refined based on an improved understanding of the high-gradient limits given by rf breakdown and pulsed surface heating. In addition, compact couplers have been developed and HOM damping loads have been designed. The rf design has also been made consistent with details of the present manufacturing procedure, based on bonded asymmetrical disks, and with requirements coming from integration of the accelerating structure in the two-beam module which includes all subsystems. This completion and refinement of the

structure design has been made to produce the self-consistent parameter set required for preparation of the CLIC conceptual design report.

MOP069 **Thermal Fatigue of Polycrystalline Copper in CLIC Accelerating Structures: Surface Roughening and Hardening as a Function of Grain Orientation**

M. Aicheler *(CERN)*

The accelerating structures of CLIC will be submitted to 2 x 10^{10} thermal-mechanical fatigue cycles, arising from Radio Frequency (RF) induced eddy currents, causing local superficial cyclic heating. In order to assess the effects of superficial fatigue, high temperature annealed OFE Copper samples were thermally fatigued with the help of pulsed laser irradiation. They underwent postmortem Electron Backscattered Diffraction (EBSD) measurements and μhardness observations. Previous work has confirmed that surface roughening depends on the orientation of near-surface grains*,**. It is clearly observed that, through thermal cycling, the increase of hardness of a crystallographic direction is related to the amount of surface roughening induced by fatigue. Near-surface grains, oriented [1 0 0] with respect to the surface, exhibiting very low surface roughening, show limited hardening whereas grains oriented in [1 1 0], exhibiting severe surface roughening, show the most severe hardening. Consistently, surface roughening and hardening measured on [1 1 1] direction lie between the values measured for the other directions mentioned.

MOP070 **Breakdown Studies for the CLIC Accelerating Structures**

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Optimizing the design and the manufacturing of the CLIC RF accelerating structures for achieving the target value of breakdown rate at the nominal accelerating gradient of 100 MV/m requires a detailed understanding of all the steps involved in the mechanism of breakdown. These include surface modification under RF fields, electron emission and neutral evaporation in the vacuum, arc ignition and consequent surface modification due to plasma bombardment. Together with RF tests, several experiments are conducted in a simple DC test set-up instrumented with electrical diagnostics and optical spectroscopy. The results are used also for val-

idating simulations which are performed using a wide range of numerical tools (MD coupled to electrostatic codes, PIC plasma simulations) able to include all the above phenomena. We present an overview of the current status of the activity and the prospects for future activities.

MOPO71 **The Hot Prototype of the PI-Mode Structure (PIMS) for Linac4**

F. Gerigk *(CERN), P. Bourquin, A. Dallocchio, G. Favre, J.-M. Geisser, L. Gentini, M. Polini, D. Pugnat, B. Riffaud, T. Tardy, M. Vretenar, R. Wegner (CERN)*

The PIMS cavities for Linac4 are made of 7 coupled cells operating in pi-mode at 352 MHz frequency. The mechanical concept is derived from the 5-cell cavities used in the LEP machine, whereas cell length and coupling are adapted for proton acceleration in the range from 50 to 160 MeV. Linac4 will be the first machine to employ this type of cavities for low-beta protons. During the first years of operation the PIMS will be used at low duty cycle as part of the consolidated LHC proton injector complex. It is designed, however, to operate eventually in a high duty cycle (10%) proton injector, which could be used as proton front-end for neutrino or RIB applications. To prepare for the series construction of the 12 PIMS units the first cavity (10^2 MeV beam energy) has been designed and constructed at CERN, to be used as a hot prototype for RF tests and as a pre-series mechanical unit. In this paper we report on some of the design features, the construction experience, and first measurements.

MOPO72 **Prototype X-band CLIC Crab Cavity for High Gradient Testing**

G. Burt *(Cockcroft Institute, Lancaster University), P.K. Ambattu, A.C. Dexter (Cockcroft Institute, Lancaster University) V.A. Dolgashev (SLAC)*

The CLIC collider will require a crab cavity in order to recover the luminosty lost from the finite crossing angle. An X-band travelling wave deflecting cavity is a proposed solution for CLIC. A prototpe cavity has been constructed at Shakespeare Precision Engineering, UK, in order to perform high gradient tests of the proposed cavity design. The cavity utilises a novel coupling scheme to ensure low fields on the coupler in order to better study the breakdown in the main cells of the cavity.

MOP073 **Numerical Validation of the CLIC/ SwissFEL/FERMI Multi Purpose X Band Structure**

M.M. Dehler *(PSI) A.E. Candel, L. Lee (SLAC)*

Currently an X-band traveling wave accelerator structure is fabricated in a collaboration between CERN, PSI and Sincrotrone Trieste (ST). PSI and ST will use it in their respective FEL projects, CERN will test break down limits and rates for high gradients. A special feature of this structure are two integrated wake field monitors monitoring the beam to structure alignment. The design used an uncoupled model for the fundamental mode, assuming the overall behavior to be the superposition of the individual components. For the wake field monitors, an equivalent circuit was used. This approach has been proven to produce valid structure designs. None the less it cannot approach the quality of a numerical electromagnetic simulation of the full structure, which is ideal for a validation capturing the differences between design models and the real cavity as e.g. internal reflections inside the structure or higher order dispersive terms altering the response of the wake field monitor. Using SLAC's family of massive parallel codes ACE-3P, first results are presented for the fundamental mode and the first transverse mode. They are compared with earlier simulations using simplified models.

MOP074 **High Power Evaluation of X-band High Power Loads**

S. Matsumoto *(KEK), T. Higo (KEK) G. Riddone, I. Syratchev (CERN)*

Several types of X-band high power loads developed for several tens of MW range were designed, fabricated and used for high power tests at X-band facility of KEK. Some of them have been used for many years and some show possible deterioration of RF performance. Recently revised-design loads were made by CERN and the high power evaluation was performed at KEK. In this paper, the main requirements are recalled, together with the design features. The high power test results are analysed and presented.

MOP075 **Breakdown Characteristics in DC Spark Experiments of Copper Focusing on Purity and Hardness**

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To investigate the breakdown characteristic related to the differences in purity and hardness, four types of oxygen-free copper (OFC) materials, usual class 1 OFC with/without diamond finish, 7-nine large-grain copper and 6-nine hot-isotropic-pressed copper, were tested with the DC spark test system at CERN. Measurements of beta, breakdown fields and breakdown probability are discussed followed by the surface inspection mostly with SEM on the tested materials.

MOP076 **An Experimental Investigation into Cavity Pulsed Heating**

L. Laurent *(SLAC), V.A. Dolgashev, S.G. Tantawi (SLAC)*

Cavity pulsed heating experiments have been conducted at SLAC National Accelerator Laboratory in collaboration with CERN and KEK. These experiments were designed to gain a better understanding on the impact of high power pulsed magnetic fields on copper and copper alloys. The cavity is a one port hemispherical cavity that operates in the TE013-like mode at 11.424 GHz. The test samples are mounted onto the end-cap of the cavity. By using the TE013 mode, pulsed heating information can be analyzed that is based only on the impact of the peak magnetic field which is much bigger in value on the test sample than on any other place in the cavity. This work has shown that pulsed heating surface damage on copper and copper alloys is dependent on processing time, pulsed heating temperature, material hardness, and crystallographic orientation and that initial stresses occur along grain boundaries which can be followed by pitting or by transgranular microfractures that propagate and terminate on grain boundaries. The level of pulsed heating surface damage was found to be less on the smaller grain samples. This is likely due to grain boundaries limiting the propagation of fatigue cracks.

MOP077 **Design of Parallel RF Feed System for Standing-Wave Accelerator Structure**

J. Neilson *(SLAC), V.A. Dolgashev, S.G. Tantawi (SLAC)*

Typical surface damage in travelling wave accelerator structures occurs on the high field region of the iris. As the damage accumulates the coupling between cavities is affected resulting in changes in the phase shift between cells. This issue can be reduced by use of SW cells that are fed in parallel. RF breakdown is contained to the cell where it originates and the available electromagnetic energy for a given gradient is minimized by

the parallel feed. Several schemes[1] have been proposed for parallel fed SW structures. Some of the proposed designs fed several cells from each arm, which reduces the advantage of localizing a RF breakdown to an individual cavity. In addition they use a standing wave in the feed arms which allows coupling between cells. We are proposing a somewhat more complex approach using a directional coupler on each cell and serpentine waveguide connection between couplers. This design approach isolates the cells and gives an individual rf feed to each cell resulting in the maximum increase in the operational robustness of the accelerator structure.

MOP078 **Back-to-Back Cavities for Very Low Energy High Power Side Coupled Linacs**

F. Galluccio *(INFN-Napoli), M.R. Masullo (INFN-Napoli) A. Renzi (Naples University Federico II) V.G. Vaccaro (Naples University Federico II and INFN)*

The design of BBAC (Back-to-Back Accelerating Cavity) tiles has been shown to be suitable for proton Side Coupled Linacs down to energies as low as 24 MeV. In this paper it will be shown that this design can be extended with profit down to 18 MeV, provided that in the process of optimization the standard quality indices, shunt impedance and energy gradient, are used in combination with the temperature rise in the cavities. A particular attention should also be devoted to the thermo-mechanical stress and strain due to the non-uniform temperature distribution.

MOP079 **Detailed Studies of Multipactor in Dielectric-Loaded Accelerator Structures**

O.V. Sinitsyn *(UMD), T.M. Antonsen, G.S. Nusinovich (UMD)*

Multipactor (MP) is known as the avalanche growth of the number of secondary electrons emitted from a solid surface exposed to an rf field under vacuum conditions. MP may occur in various microwave and rf systems such as microwave tubes, rf windows and launchers, accelerating structures and rf satellite payloads. This work is focused on the multipactor analysis in dielectric-loaded accelerator (DLA) structures. It was initiated by the experimental and theoretical studies of such structures jointly done by Argonne National Laboratory and Naval Research Laboratory [1]. Our goal was to create a self-consistent non-stationary model of MP that would explain the experimental results and help finding conditions for MP suppression. We cre-

ated a 2D model whose description and some initial simulation data were presented in Ref. 2. In this paper, we demonstrate new simulation results and compare them with the experimental ones obtained during recent extensive studies of DLA structures performed by Argonne National Laboratory, Naval Research Laboratory, SLAC National Accelerator Laboratory and Euclid TechLabs, LLC [3].

MOPO80 **The Magic Pentagon of Cavity Design**
D.C. Plostinar *(STFC/RAL/ASTeC)*
Normal conducting RF structures are good candidates for beam acceleration in a pulsed proton linac, up to an energy exceeding 100 MeV. In this paper we present a systematic study of technological alternatives currently available worldwide. Furthermore, we propose a new method of analysing normal conducting cavities, by summarising all the design and construction aspects in five main categories: EM fields, mechanical, thermal, beam dynamics and vacuum. The interconnections between these five groups draw the boundary conditions which dictate the optimum design and technology choices.

MOPO81 **RF Tuning and Conditioning of the CDS PITZ Booster Cavity**
V.V. Paramonov *(RAS/INR), A. Naboka (RAS/INR) K. Floettmann (DESY) L. Jachmann, W. Koehler, M. Krasilnikov, J. Meissner, J. Schultze, F. Stephan, R.W. Wenndorff (DESY Zeuthen)*
The DESY PITZ booster cavity, based on the Cut Disk Structure (CDS), is completed in construction. The L-band normal conducting cavity is intended to operate with accelerating rate up to 14 MV/m and RF pulse length up to 900 mks to increase the electron bunch energy in the PITZ facility at 20 MeV. At present time the cavity is under vacuum conditioning to reduce the outgassing rate for operation in the facility with photo cathodes. Cavity mounting and RF conditioning is scheduled to summer 2010. The results of RF tuning before and after cavity brazing, together with results of conditioning, will be presented.

MOPO82 **Low Level Radiofrequency Developments toward a Fault Tolerant Linac Scheme for an Accelerator Driven System**
C. Joly *(IPN), J.-L. Biarrotte, F.B. Bouly (IPN)*
An Accelerator Driven System (ADS) for transmutation of nuclear waste requires a high power proton beam (several MWs) to reach the neces-

sary spallation efficiency. Due to the induced thermal stress to the subcritical core, the high-power proton linac will have to fulfil stringent reliability requirements to minimise the number of unwanted beam trips (> 1 sec.) per operation cycle. In view of the construction of the MYRRHA ADS demonstrator, in Mol (Belgium), beam dynamic analyses were carried out to evaluate the fault tolerant capability of the superconducting linac, in the particular case of a radiofrequency (RF) cavity failure. This analysis was coupled with simulations on the RF behaviour of 700 MHz superconducting cavitiy as well as its tuning and feedback loop systems. Such considerations led to the development of a prototypical digital Low Level RF (LLRF) system to control the cavity phase and accelerating field, especially in the case of fast cavity retuning for failure compensation. In this paper we summarize the work which has been performed so far toward the development of such a fault-tolerant RF linac.

MOP083 **LLRF Design for the HINS-SRF Test Facility at Fermilab**

J. Branlard *(Fermilab)*

The High Intensity Neutrino Source (HINS) R&D program requires super conducting single spoke resonators operating at 325 MHz. After coupler installation, these cavities are tested at the HINS-SRF facility at Fermilab. The LLRF requirements for these tests include support for continuous wave and pulsed mode operations, with the ability to track the resonance frequency of the tested cavity. Real-time measurement of the cavity loaded Q and Q0 are implemented using gradient decay techniques, allowing for Q0 versus Eacc plots. A real time cavity simulator was also developed to test the LLRF system and verify its functionality.

MOP084 **A Vector Control and Data Acquisition System for the Multi-cavity LLRF System for Cryo-Module 1 at the ILCTA at Fermilab**

P. Varghese *(Fermilab), J. Branlard, B. Chase, E. Cullerton, P.W. Joireman, V. Tupikov (Fermilab)*

A LLRF control and data acquisition system for the 8-cavity Cryo-Module 1 at the ILCTA has been implemented using three , 33-channel MFC boards in a VXI mainframe. One card each is dedicated for the cavity probes for vector control , forward power and reverse power measurements. The system is scalable to 24 cavities or more with the commissioning of Cryo-Modules 2 and 3 without additional hardware. The sig-

nal processing and vector control of the cavities is implemented in a FPGA and a high speed data acquisition system with upto 100 channels stores data in external SDRAM memory. The system supports both pulsed and CW modes with a pulse rate of 5Hz. Acquired data is transferred between pulses to auxiliary systems such as the piezo controller through the slot0 controller. The design of the system is described and the performance of the vector control system is evaluated.

MOP085 **Resonance Control in SRF Cavities at FNAL**
Y.M. Pischalnikov *(Fermilab), W. Schappert (Fermilab)*
An adaptive Least Squares algorithm to control Lorentz force detuning in SRF cavities has been developed and tested in the HTS at FNAL. During open-loop tests in the FNAL HTS, the algorithm was able to reduce LFD in a 9-cell 1.3 GHz elliptical cavity operating at 35 MV/m from 600 Hz to less than 10 Hz during both the fill and the flattop. The algorithm was also able to adapt to changes in the gradient of the cavity and to changes in the pulse length.

MOP086 **Stability Evaluation for Long FB Loop Delay in the ACS Cavity Field Control for the J-PARC Linac 400-MeV Upgrade**
T. Kobayashi *(JAEA/J-PARC)*
For 400-MeV upgrade of the J-PARC Linac, ACS (Annular Coupled Structure) cavities, which are driven by 972-MHz RF, will be installed. The ACS cavity has complicated structure. Its Q-value is very low and the operation frequency is tree times higher in comparison with that of the SDTL cavity. So the stabilizing control of the ACS accelerating field will be more difficult than present 324-MHz RF system. Further more the chopped beam loading compensation is required. Especially, the debuncher will be located very far from the klystron, then the feedback loop delay will be about 1.5 us. This presentation will show the simulation results of the feedback control of the ACS cavity field including long loop delay and the effect of the chopped beam loading.

MOP087 **Beam Test of Chopped Beam Loading Compensation for the J-PARC Linac 400-MeV Upgrade**
T. Kobayashi *(JAEA/J-PARC) M. Ikegami (KEK) Y. Ito (JAEA)*
The function of the chopped beam loading compensation was implemented into the digital feedback/feed-forward control system of the J-PARC Linac LLRF system to stabilize the ACS

cavity fields for the 400-MeV upgrade. The beam test of the chopped beam loading compensation was performed with the present 324-MHz cavity sysmte. Consequently the chopped beam loading was successfully compensated and that this system is valid.

MOP088 **Spallation Neutron Source LLRF Temperature Dependence and Solution**

M.T. Crofford *(ORNL), T.W. Hardek, S.W. Lee, M.F. Piller (ORNL) T.L. Davidson (ORNL RAD)*

The Spallation Neutron Source (SNS) has been operating since the first neutrons were produced on April 29, 2006. During the last several years the beam energy has been methodically ramped-up and outlying issues solved to improve system reliability. During the beam studies a temperature dependence has been discovered with the Low-Level RF systems. The effect is small but readily observable as increased beam losses. The temperature dependence has been studied both in the accelerator and in the laboratory and the sensitive components identified. A prototype solution that replaces the temperature dependent components of the Low-Level RF System has been designed and is in initial testing. Preliminary results of the laboratory tests have been encouraging. Accelerator tests are planned after installation during the December 2010 maintenance cycle.

MOP089 **Spallation Neutron Source High-Power Protection Module Test Stand**

S.W. Lee *(ORNL RAD), J.A. Ball, T.L. Davidson, S.L. Jones (ORNL RAD) M.T. Crofford, T.W. Hardek (ORNL)*

The Spallation Neutron Source (SNS) High-Power Protection Module (HPM) provided interlocks and fast shutdown for the RF system to protect the accelerating structures and high power RF (HPRF) Distribution System. The HPM has required some functionality upgrades since the start of beam operations and an upgrade to the HPM test stand was required to support these added features. The HPM test stand currently verifies functionality, RF channel calibration, and measurement of the speed of shutdown to ensure the specifications are meet. The upgraded test stand was implemented in a single FPGA to allow for future growth and flexibility. Work is currently progressing on automation of the test stand to better perform the required module calibration schedule.

MOP090 **Design and Testing of the TRIUMF ISACII High-B RF Control System**

M.P. Laverty *(TRIUMF), K. Fong, R.E. Laxdal, Q. Zheng (TRIUMF) G. Dennison (UBC & TRIUMF)*

The rf control system for the twenty 141 MHz TRIUMF quarter wave superconducting cavities is a hybrid analogue/digital design. It is based in part on an earlier design developed for the 106MHz 1/4 wave superconducting cavities of the ISACII linac. This design has undergone several iterations in the course of its development. In the current version, a value-engineering approach was used to reduce the cost and simplify the hardware. The result is a single C-size VXI module that incorporates all the required low-level rf functions - amplitude/phase control, tuning control, and control of the rf coupler. It accomplishes these functions at a substantially lower cost than the previous two-module solution. It also includes support for field upgrade of the DSP/PLD hardware and firmware. Some early test results of the system operating in the linac are outlined, and conclusions are summarized.

MOP091 **A Digital Low Level RF Control System for the S-DALINAC**

M. Konrad *(TU Darmstadt), U. Bonnes, C. Burandt, R. Eichhorn, N. Pietralla (TU Darmstadt)*

The superconducting cavities of the S-DALINAC have a high loaded quality factor and are very susceptible to microphonics. To stabilize the amplitude and phase of the cavities' fields an analog control system has been used for 20 years. To improve the stability and the availability of the low level RF control system it is currently replaced by a digital one. The 3 GHz signals coming from the cavities are converted down to the base band using hardware I/Q demodulators. The base band signals are digitized by ADCs and fed into an FPGA. This FPGA contains a custom CPU which executes the code implementing the control algorithm. The computed control signal is I/Q modulated before it is send to the cavity again. The superconducting cavities are operated with a self-excited loop algorithm whereas a generator driven algorithm is used for the low Q normal conducting bunching cavities. A 6 GHz RF board allows the operation of a new 2f buncher. Parameters can be adjusted via an EPICS IOC running on a standard PC. All signals from the FPGA can be monitored in realtime by the operator.

MOP092 **LINAC Subsystems for Better Beam Control**
G. Jug *(I-Tech)*
Control of bunch arrival time, energy and trajectory of particle beams in linear accelerators is mandatory to reach performance goals and is carried out using different sub-systems. For optimal control and especially for accelerators aiming at the highest level of performance, for example FELs, these systems should be considered as a whole and work together. At Instrumentation Technologies such systems have been developed and tested on the field. Precise control of amplitude and phase of the accelerating felds is performed with the Libera LLRF, a digital RF stabilization system that is couple to Libera SYNC a very low jiiter master oscillator distribution system. The Libera Brilliance Single Pass system provides high resolution position information that allows accurate control of trajectories through critical machine sections such as bunch compression modules and FEL modulators and radiators. These systems are described in detail in the paper with examples from field measurements.

MOP093 **Design of Low Level RF Control System for Accelerator**
Y.S. Lee *(SKKU), J.-S. Chai (SKKU) K.-H. Park (PAL)*
The low level RF (LLRF) control system for PLS storage ring is being upgraded to improve the performance of the system. The LLRF control system under development consists of FPGA, and high speed ADC and DAC as well as analog front-end devices which process the signal from cavity and to RF high power system. In addition, it utilizes digital signal processing technology based on FPGA. In order to optimize the accelerating electric field in the cavity, it is required to maintain field stability less than ś1% in amplitude and 1^{o} in phase. And the resonance condition of the cavity should be monitored and controlled. The various digital signal processing theories such as digital filters, Cordic, PI control enable to meet these requirements and to control the feedback signal less than a microsecond. The LLRF control system is also equipped with the Ethernet by the cPCI. The preliminary design study and modeling on the LLRF control system for PLS storage ring will be described in this paper.

MOP094 **Cavity Control Algorithms**

T. E. Plawski *(JLAB), C. Hovater (JLAB)*

A digital low level radio frequency (RF) system typically incorporates either a heterodyne or direct sampling technique, followed by fast ADCs, then an FPGA, and finally a transmitting DAC. This universal platform opens up the possibilities for a variety of control algorithm implementations. The foremost concern for an RF control system is cavity field stability, and to meet the required quality of regulation, the chosen control system needs to have sufficient feedback gain. In this paper we will investigate the effectiveness of the regulation for three basic control system algorithms: I&Q (In-phase and Quadrature), Amplitude & Phase and digital SEL (Self Exciting Loop) along with the example of the Jefferson Lab 12 GeV cavity field control system.

MOP095 **Status of the CEBAF Energy Upgrade RF Control System**

C. Hovater *(JLAB), T.L. Allison, R. Bachimanchi, G.E. Lahti, J. Musson, T. E. Plawski, D.J. Seidman (JLAB)*

To support the CEBAF energy upgrade from 6 GeV to 12 GeV, the RF control system is being modernized to control the high gradient high QL superconducting cavities. The new system incorporates a heterodyne transceiver along with I&Q sampling to measure and control magnitude and phase. A low-cost Altera FPGA is used to digitally implement the cavity control algorithms. One of the features of the system is a digital self excited loop to track the cavity over large Lorentz detuning (800 Hz) during turn on. The system has successfully completed preliminary development and is now moving into the production stage of the project. This paper discusses the design, modeling, testing and production of the new RF control system and associated peripheral systems (cavity interlocks, and resonance control).

MOP096 **Collimation in the SNS Linac and HEBT**

D. Jeon *(ORNL), J. Galambos (ORNL) J. Tang, X. Zhang (IHEP Beijing)*

For the SNS linac, a pair of horizontal MEBT collimators was proposed by [D. Jeon et al., Phys. Rev. ST Accel. Beams 5, 094201 (2002)] based on the findings of the halo mechanism driven by a large ratio of x and y beam size in the MEBT. Recently MEBT collimators were installed and beam operation proves MEBT collimation very effective in reducing beam loss throughout the linac, HEBT and IDump. The HEBT collimation

system is a combination of stripping foil for H^- beam and collimators. A benchmarking study of the HEBT collimator system was conducted with beam experiment and multiparticle tracking. We measured the efficiency of HEBT collimators using beam loss monitors and compared with the model. Experimental data and simulation showed reasonable agreement. We also obtained halo profile measurements using scrapers.

MOP097 **Design of a High Energy Beam Stop for Spiral2**

E. Schibler *(IN2P3 IPNL), J.-C. Ianigro (IN2P3 IPNL) L. Perrot (IPN) N. Redon (UCBL)*

The driver accelerator of the Spiral2 facility will deliver deuteron (40MeV) and proton (33MeV) beams with current up to 5mA and heavy ion (14.5MeV/n) beams up to 1mA. At the very end of the LINAC, the main Beam Stop will have to withstand a peak power of 200kW for deuterons, with an associated power density from 120W/mm2 to more than 700W/mm2. These challenging specifications impose the design of a new high efficiency Beam Stop that has been nicknamed SAFARI (French acronym of Optimized Beam Stop Device for High Intensity Beams). From the beam characteristics and activation constraints, we proposed and developed a complete design. We will present this original design and the different studies and optimizations which have been done: The Beam Stop shape marries to the beam characteristics in order to smooth for the best power density and improve thermo-mechanical behaviour under nominal and critical beams. Cooling system is directly machined from Beam Stop blocks. Optimization by various fluid studies and calculations led us to a new high efficiency counter-current water cooling system. We then compare calculated behaviour with first results obtained on our recent functional mock-up

MOP098 **Improvements in the Design of the Electrodes for the SPIRAL2 Single Bunch Selector**

P. Balleyguier *(CEA) P. Bertrand, M. Di Giacomo (GANIL) F. Consoli (INFN/LNS)*

The high current driver accelerator of the SPIRAL 2 project uses a single bunch selector to reduce the bunch repetition rate to the experimental target. The device works at almost 1 MHz and handles fast RF pulses of 18 ns with transient times shorter then 6 ns. The first electrode prototype,

built in the framework of the Eurisol DS project, didn't show correct delay and matching. The paper describes the studies to improve these two important issues.

MOP099 **Status of the Design of 650 MHz Elliptical Cavities for Project X**

S. Barbanotti *(Fermilab), M.H. Foley, I.G. Gonin, J. Grimm, T.N. Khabiboulline, L. Ristori (Fermilab)*

Project X is a proposed high-intensity proton accelerator complex that could provide beam to create a high-intensity neutrino beam, feed protons to kaon- and muon-based precision experiments, and for other applications still under investigation. The present configuration of the proton accelerator foresees a section with 650 MHz beta = 0.6 and beta = 0.9 elliptical cavities. Prototypes of single-cell 650 MHz cavities and five-cell beta = 0.9 650 MHz cavities are being designed and fabricated at Fermilab in the R&D process for Project X. This paper summarizes the design status of the beta = 0.6 and beta = 0.9 single-cell prototype cavities, and also addresses the design effort focused on the five-cell beta = 0.9 cavities.

MOP100 **Bunch Compressor for Intense Proton Beams**

L.P. Chau *(IAP), M. Droba, O. Meusel, D. Noll, U. Ratzinger, C. Wiesner (IAP)*

The Frankfurt Neutron source FRANZ is under construction*. The ARMADILLO bunch compressor** as a part of it is composed of a 5MHz electric kicker, a magnetic dipole chicane and rf-rebunching cavities. The design phase of the bunch compressor has reached the final stage. A 175MHz 2MeV proton linac forms 100ns long beam pulses consisting of nineμbunches with 150mA. Deflected by the 5MHz kicker theμbunches are guided on different paths to arrive within 1ns at a n-production target. Due to high space charge forces rebuncher cavities are included***. The peak current at the target is expected to be in the range of 10A in a 1ns proton pulse, which is equivalent to a longitudinal pulse compression ratio of 45. A new code specific for complex magnetic multi aperture system and for high current applications has been developed. Hardware designs according to the beam dynamics results are in progress. Improved 3D magnetic and electric fields will be applied in the future beam dynamics studies including high space charge forces. The preliminary designs and the beam dynamics studies will

be presented in this contribution.

MOP101 **Rebuncher Cavities for the FRANZ Bunch Compressor**

D. Noll *(IAP), L.P. Chau, M. Droba, O. Meusel, H. Podlech, U. Ratzinger (IAP)*

The Frankfurt Neutron Source (FRANZ) currently under construction at IAP (Goethe University of Frankfurt) is designed to produce short neutron pulses at high intensity and repetition rates up to 250 kHz [*]. To achieve a bunch length of one nanosecond despite the high space charge forces, a bunch compressor of the Mobley type [**] using four dipole magnets and two rebunchers has been developed [***] to merge 9 linac bunches into the final focus. The first rebuncher cavity, a $\lambda/4$ resonator operating at 87.5 MHz, has to feature nine beam paths due to the multi-trajectory system. Additionally the gaps have to be displaced relatively to each other in a way that all bunches arrive at the correct rf phase. The second rebunching cavity will provide final focusing as well as an energy variation of ś0.2 MeV in front of the target and will be operating at 175 MHz. This paper presents the design of these novel cavities as well as the simulated beam dynamic properties.

MOP102 **Space Charge Lens for Focusing Heavy Ion Beams**

K. Schulte *(IAP), M. Droba, O. Meusel, U. Ratzinger (IAP)*

Space charge lenses use a confined electron cloud for the focusing of ion beams. Due to the electric space charge field, focusing is independent of the particle mass. For this reason the application of the space charge lens especially in the field of heavy ion beams is advantageous. Moreover, the trapped non neutral plasma cloud compensates the space charge forces of the ion beam. The focusing strength is given by the confined electron density whereas the density distribution influences the mapping quality of the space charge lens. An important parameter for the focusing capability of the space charge lens is besides the homogeneous electron distribution a high electron density. In ongoing theoretical and experimental work methods have been developed to determine the most important parameters like electron temperature and electron density distribution for an optimized lens design. Based on the experimental results a new space charge lens has been designed to focus low energy heavy ion beams like 2,4 AkeV U^{4+} at the low energy transport section into the

GSI High Current Injector. Experimental results will be presented and compared with numerical simulations.

MOP103 **Studies on High Precision Machining of CLIC RF Structures**

J. Huopana *(HIP) G. Riddone (CERN) K. Österberg (Helsinki University, Department of Physics)*

The CLIC (Compact LInear Collider) is currently under development at CERN as a potential multi-TeV e^+e^- collider. The manufacturing and assembly tolerances for the required RF-components are important for the final efficiency and for the operation of CLIC. The proper function of an accelerating structure is sensitive to mechanical errors in shape and alignment of the accelerating cavity. The current tolerances are in the micron range. This raises challenges in the field of mechanical design and manufacturing and demands special manufacturing technologies and processes. Currently the mechanical design of the accelerating structures is based on a disk design. Alternatively, it is possible to create the accelerating assembly from quadrants, which has the potential to be favored for the mass production due to simplicity and cost. In this case, the functional shape inside of the accelerating structure remains the same and a single assembly uses less parts. This paper concentrates on the development work made for prototype accelerating structures and describes its application to series production.

MOP104 **Studies on Thermo-mechanical Behavior of the CLIC Two-beam Module**

R.J. Nousiainen *(HIP), K. Osterberg (HIP) G. Riddone (CERN) A. Samoshkin (JINR)*

To fulfill the mechanical requirements set by the luminosity goals of the CLIC collider, currently under study, the 2-m two-beam modules, the shortest repetitive elements in the main linac, have to be controlled at micrometer level. At the same time these modules are exposed to variable high power dissipation while the accelerator is ramped up to nominal power as well as when the mode of CLIC operation is varied. This will result into inevitable temperature excursions driving mechanical distortions in and between different module components. A FEM model is essential to estimate and simulate the fundamental thermo-mechanical behavior of the CLIC two-beam module to facilitate its design and development. Firstly, the fundamental thermal environment is created for different RF components

of the module. Secondly, the first thermal and structural contacts for adjacent components as well as idealized kinematic coupling for the main module components are introduced. Finally, the thermal and structural results for the studied module configuration are presented showing the fundamental thermo-mechanical effects of primary CLIC collider operation modes.

MOP105 **Preparation of Adjustable Permanent Magnet Quadrupole Lens for Beam Test at ATF2**
S. Ushijima *(Kyoto ICR), H. Fujisawa, Y. Iwashita, H. Tongu (Kyoto ICR) M. Masuzawa, T. Tauchi (KEK)*
A permanent magnet quadrupole lens with continuously adjustable strength originally designed by Gluckstern was fabricated for a final focus. It consists of five PMQ discs that rotate on their axis, where odd and even numbered discs rotate oppositely but with the same absolute angle. By setting their lengths appropriately, the coupling between x and y components can be minimized. In order to reduce multipole components higher than quadrupole, we adjust positions of magnet wedge pairs. At the same time we improve differences between the magnetic center and the mechanical center of the PMQ discs by measuring harmonics of fields in magnets. In order to carry out the beam test, a high precision movable table for the lens system is also fabricated. This table can evacuate the lens system from the beam line completely without vacuum breaking, which should ease the evaluation of the system at decreased strength region.

MOP106 **Implementation of Multilayered Conductor Structures on RF Cavity Surfaces**
Y. Iwashita *(Kyoto ICR)*
Multilayered conductor structures on RF cavity surfaces have been discussed these years. Although a real implementation was succeeded on a coaxial cavity at room temperature by measuring Q-value, it may not be a practical example. Application of the multilayered conductor structure on superconducting cases came out recently and is studied by some groups. Possible thoughts on the further implementation at room temperature will be discussed including a consideration on the superconducting case.

MOP107 **The Darht Axis II Beam Run Permit Control System**
R.D. Archuleta *(LANL)*
The Dual Axis Radiographic Hydrodynamic Test Facility (DARHT) is the world's premier hydrotest

firing site. DARHT contains two linear accelerators for producing flash radiographs of hydrodynamic experiments. The DARHT facility (both Axis I and Axis II) have defined Modes of operation, based on the Personnel Safety System configuration. It is the philosophy of accelerator systems that configuration of the components required to deliver beam should not rely on human attention alone. The Axis II Beam Run Permit control system implements a series of hardware and software logic elements that define and limit the Axis II states of operation and automatically establish machine operating parameters. Within each of the defined Personnel Safety System Modes, DARHT Axis II operation requires a number of different states and timing configurations. For each Beam Run Permit state, operations of Axis II requires different accelerator hardware configurations, interlocks, controls settings, and timing scenarios. The DARHT Axis II Beam Run Permit control system has provided efficiency and achieved operational configuration of the Axis II accelerator to provide peak radiographic performance.

MOP108 **Planned Machine Protection System for the Facility for Rare Isotope Beams at Michigan State University**

S. Assadi *(FRIB), M.J. Johnson, T.L. Mann, E. Pozdeyev, E. Tanke, X. Wu, R.C. York, Q. Zhao (FRIB) M. Doleans, F. Marti (NSCL)*

The Facility for Rare Isotope Beams (FRIB) at Michigan State University will utilize a 400 kW, heavy-ion linear accelerator to produce rare isotopes in support of a rich program of fundamental research. In the event of operating failures, it is extremely important to shut off the beam in a prompt manner to control the beam losses that may damage the accelerator components such as superconducting cavities. FRIB has adapted the residual beam loss activation limit at 30 cm to be equivalent to 1W/m of operating beam losses. We are designing FRIB MPS to be flexible but redundant in safety to accommodate both commissioning and operations. It is also dependent upon the operational mode of the accelerator and the beam dump in use. The operational mode is distributed via a finite state machine to all critical devices that have multiple hardware checkpoints and comparators. It is important to note that FRIB is a cw machine and MPS status is continuously being monitored by 'device mode change' and real time data link. In this paper, we present FRIB Machine Protection architecture, plans and implementation.

MOP109 **Electromagnetic Torque from Linac Radiation**

O. A. Konstantinova *(Tomsk State University)*

In this paper the new phenomenon of nature, called electromagnetic torque radiation from the relativistic charged particles is discussed. To begin it is shown that two well ' known alternative definitions of density of angular momentum of electromagnetic field by Ivanenko-Sokolov* and by Teitelboim and Villarroel** give the identical integral characteristics with application of the relativistic radiation theory. And both of it yield the same results for the total power of the angular momentum, which is characterized the torque of the radiation. Then we have found that the angular distribution of torque from the Linac has the azimuthal symmetry with respect to the direction of the velocity of the particle. It is also oppositely directed to the acceleration of the particle. On the condition of the high speed the angular distribution has an expressive relativistic effect of the sharp directed radiation. With the construction of a good detectors of the torque it is possible to measure such effect.

MOP110 **High Gradient Wakefield Acceleration (~ GV/m) in Structures: Goals of the Upgraded Argonne Wakefield Accelerator Facility (AWA)**

M.E. Conde *(ANL), W. Gai, R. Konecny, W. Liu, J.G. Power, Z.M. Yusof (ANL) S.P. Antipov, C.-J. Jing (Euclid TechLabs, LLC)*

New technology needs to be developed for future compact linear colliders. The AWA Facility is dedicated to the study of advanced accelerator concepts towards this goal. The facility uses high charge short electron bunches to drive wakefields in dielectric loaded structures as well as in metallic structures (iris loaded, photonic band gap, etc). Accelerating gradients as high as 100 MV/m have been reached in dielectric loaded structures, and RF pulses of up to 44 MW have been generated at 7.8 GHz. In order to reach higher accelerating gradients, and also be able to generate higher RF power levels, several facility upgrades are underway: a new RF gun with a higher QE photocathode; a witness beam to probe the wakefields; additional klystrons and linac structures to bring the beam energy up to 75 MeV. The drive beam will consist of bunch trains of up to 32 bunches of 60 nC, corresponding to a beam power of 6 GW. The goal of future experiments is to reach accelerating gradients of several hundred MV/m and to extract RF pulses

with GW power level. A key advantage of wakefield acceleration in structures is the ability to act on electrons and positrons in basically identical fashion.

MOP111 **High Brightness Electron Beam Focusing System for an X-ray Generator**

T. Sakai *(KEK), M. Ikeda, S. Ohsawa, N. Sakabe, T. Sugimura (KEK)*

A new type of rotating anticathode X-ray generator has been developed, in which the electron beam up to 120keV irradiates the inner surface of a U-shaped Cu anticathode. A high-flux electron beam is obtained by optimizing the geometry of the combined function bending magnet. In order to minimize the sizes of the X-ray source, the electron beam is focused in a short distance by the combined function bending magnet, of which geometrical shape was determined by simulation with the codes of Opera-3D, General Particle Tracer (GPT) and CST STUDIO. The result of simulation clearly shows that the role of combined function in the bending magnet and the steering magnet is important to focus the beam in small sizes. FWHM sizes of the beam were predicted by simulation to be 0.45mm (horizontal) and 0.05mm (vertical) for a beam of 120keV and 75mA of which effective brilliance is about 500kW/mm2 with the supposition of a two-dimensional Gaussian distribution. The beam focus sizes on the target will be verified in the experiments by using the high-voltage power supply for the X-ray generator improved from 60kV to 120kV and 75mA.

MOP112 **Detailed Studies Regarding the New Injection System at the LINAC I at ELSA**

F. Klarner *(ELSA), O. Boldt, W. Hillert, N. Hofmann, D. Krönung (ELSA) S. Aderhold (DESY)*

In order to enhance the operating capabilities of the Bonn University Accelerator Facility ELSA, a new injector is currently under commissioning. Its purpose is to allow a single pulse mode as well as to increase the current of the unpolarized beam provided to the external hadron physics experiments. The injector will produce an up to 2 μs long pulse of 500 mA beam current or a single electron bunch with 2 A pulse current. Design and optimization of the injector were performed with Egun, PARMELA and numerical simulations based on the paraxial equation. A 1.5 ns long pulse is produced by a thermionic electron gun with 90 kV anode-cathode voltage, then compressed and pre-accelerated by a 500 MHz

RF cavity and a four-cell travelling wave buncher. After acceleration of the electrons up to 25 MeV in the main linac the natural broadening of the energy distribution in the particle ensemble due to the acceleration process will be reduced by an energy compression system. Studies have been conducted concerning the adaptation of the optical elements in the transfer beamline to the booster synchrotron with respect to the new requirements of the injection into the synchrotron and its acceptance.

MOP113 **Multipacting Simulation of the Demountable Damped Cavity**

T. Konomi *(Sokendai) F. Furuta, K. Saito (KEK)*

We have designed Demountable Damped Cavity (DDC) as an ILC R&D. DDC has an axial symmetric structure, the coaxial waveguide HOM coupler and absorber at the end of beam pipe of SRF cavity. It is also demountable structure. These structures are expected to bring better cavity performance. However, DDC have many parallel faced surfaces and the multipacting might be a concerned issue. We have simulated MP on the DDC with CST-Studio and found MP could be not serious issue. In this paper we will report the simulation result in detail.

MOP114 **Confirmation of Leak Tightness of the Mo Sealing in Superfluid Helium**

K. Saito *(KEK), F. Furuta (KEK) T. Konomi (Nagoya University)*

MO sealing developed by Prof. H. Matsumoto in KEK and his collaborator M. Ohotsuka has been successfully applied to SRF cavities. Its leak ratio is smaller than $3{\cdot}10^{-8}$ Pam3/s or much better in the superfluid Helium, which is the allowed level to successfully measure the cavity performance for more than 3 hours at 2K. Tightening torque is 15Nm and the bolt material is SUS304 (JIS). Titanium is usable as cavity flange material. Copper looks better than pure Aluminium as the gasket material. We have observed an additional residual surface resistance about 5nΩ Zero impedance characteristics of the MO sealing is a remained issue. In this paper we report the results in detail.

MOP115 **Conceptual Design of ILC CFS in Mountainous Site**

M. Yoshioka *(KEK)*

It was proposed to change from a 2-tunnel scheme in the ILC Reference Design Report to a single tunnel plan by the GDE, Global Design

Effort in order to reduce the construction cost. Two proposals of RF source have been presented to realize this scheme. One is 'Klystron Cluster System', which moves every RF source related components from the underground tunnel to the above ground buildings. This would require that the surface topology be rather flat. Another one is the 'Distributed RF System', which does not greatly increase the above ground facilities, and instead every accelerator components are put into a single main tunnel. Instead of powering with large-scale klystrons, downsized modules are distributed throughout. We propose to make a single accelerator tunnel for active accelerator components based on the latter RF system and a sub-tunnel, in which cooling water piping is installed. The sub-tunnel can also be used for the emergency escape, underground water drainage, maintenance work and etc. This scheme fits to the Japanese mountainous site.

14-Sep-10 09:00–11:00 Main Convention Hall

TU1 — Invited Oral

Chair: S. Choroba (DESY)

TU101 09:00 **Overview of FELs under Construction Including FELs at Fermi Elettra, SPRing8 and Frascati SPARC**

G. Penco *(ELETTRA)*

This talk will report the present status of the worlwide FEL projects under construction including FELs at Fermi Elettra, SPRing8 and Frascati SPARC

TU102 09:30 **Overview of Proposals for Major FEL Facilities**

H.-H. Braun *(PSI)*

The X-ray FEL facilities in an advanced stage of planning worldwide can be grouped in two categories. Those with normal conducting driver linacs aiming to bring the XFEL technology, after the impressive feasibility prove at LCLS, to regional user communities at affordable cost, and those with superconducting driver linacs capable to serve several photon hungry users simultaneously. The talk will review the rationales, technical choices and status of the main proposals and discuss some key R&D issues.

TU103 10:00 **Worldwide ERL R&D Overview Including JLAMP, BNL, and Cornell ERLs**

G. Neil *(JLAB)*

Energy Recovering Linacs have become an important approach to providing high brightness electron beams for photon production, nuclear physics research, and cooling ions. The technology takes advantage of the ability of superconducting rf cavities to accelerate high average current beams with low losses. After the desired interaction the electrons can be decelerated to low energy so as to minimize the required rf power and electrical draw. When this approach is coupled with advanced continuous wave injectors, very high power, ultra-short electron pulse trains of high brightness can be achieved. This talk will review the status of worldwide programs including the on-going BNL and Cornell efforts, the Novosibirsk Multipass ERL, ALICE at Daresbury, the KEK/JAEA ERL, and the Peking ERL among others. We will also touch on the prospects for proposed machines such as the JLAMP advanced ERL FEL efforts at Jefferson Lab designed to produce ultra-high brightness beams of photons in the 10-100 nanometer soft X-ray region.

TU104 10:30 **RIBF and Other RIB Facilities**
N. Fukunishi *(RIKEN Nishina Center)*
Medium-energy high-intensity heavy-ion beams have been used for more than twenty years as powerful tools to investigate physics of unstable nuclei far from stability, in which one of the major problems is to understand the element genesis in universe. Many facilities including CERN, GANIL, GSI, MSU and RIKEN have developed their facilities to obtain much higher-intensity unstable-nuclei beams. Within these facilities, RIKEN first finished construction and commissioning of a major upgrade plan of the existing facility, RI Beam Factory, three years ago, in which the world-first superconducting ring cyclotron is pushing the limit of energy for heavy-ion cyclotrons. On the other hand, the FAIR and the FRIB project chose different strategies to obtain high-intensity heavy-ion beams, the former uses synchrotron and the latter uses superconducting linacs. The present competition with three different approaches is interesting because it will make clear that which kind of accelerator complex is most effective for medium-energy heavy-ion facilities. In this talk, we will present the achievements and future of RIBF under the comparison with other powerful competitors.

14-Sep-10 11:30–12:30 Main Convention Hall

TU2 — Invited Oral

Chair: S. Henderson (ORNL)

TU201 11:30 **Status of J-PARC Linac Energy Upgrade**
H. Ao *(JAEA/LINAC)*
The J-PARC (Japan Proton Accelerator Research Complex) accelerator comprises the 400-MeV injector linac (at present 181 MeV), the 3-GeV Rapid-Cycling Synchrotron (RCS) and the 50-GeV Main Ring (MR). The 3-MeV RFQ, the 50-MeV DTL and the 181-MeV Separated-type DTL have been operated in the linac for experimental users. The 400-MeV energy upgrade of the linac started from March 2009. The ACS (Annular Coupled Structure) cavities, the RF sources, the beam monitors and the utilities are in production. Although some components are prepared in the annual summer shutdown separately, the all cavities will be installed and commissioned for 6 months from July 2012. In this paper, we present the current status and the preliminary results of the energy upgrade.

TU202 11:50 **The High Intensity Proton Linac for CSNS**
H.F. Ouyang *(IHEP Beijing), S. Fu, J. Li, T.G. Xu, X. Yin (IHEP Beijing)*
Work on the Chinese Spallation Neutron Source (CSNS) has been progressing well, including successful prototyping of some of the key components of the facility. The source incorporates an H^- linac, with an output energy upgradable from 81 to 250 MeV. The status of the project will be described.

TU203 12:10 **Plans for the ESS Linac**
S. Peggs *(ESS-S)*
Following selection of Lund as the site for the long-pulse ESS (European Spallation Source), a team of accelerator and target experts has been working on an update of the 2003 ESS linac design. Improvements to the 2003 design will be summarised, and the latest designs for the linac will be presented.

14-Sep-10 13:40–15:00 Main Convention Hall

TU3 — Invited Oral

Chair: A. Schempp (IAP)

TU301 13:40 **RFQ for CW Applications**
A. Pisent *(INFN/LNL)*
CW RFQs requires solid design since they have to deal with design challenges and technological limitations. This talk overviews the recent performances of some of the most powerful RFQ cavities. Development, industrialisation and commissioning results of CW RFQ are describe and discussed, with recent update on two emblematic designs: IFMIF and TRASCO.

TU302 14:00 **Applications of Spoke Cavities**
J.R. Delayen *(ODU)*
Review of the theory, design and applications of Spoke cavities, with particular emphasis on SRF spoked cavities. Aspects of low level RF control for spoke cavities will also be presented.

TU303 14:20 **Status of the Cornell ERL Injector Cryomodule**
M. Liepe *(CLASSE)*
The Cornell Energy Recovery Linac (ERL) Injector cryomodule is part of a prototype electron beam source to demonstrate production of CW 1.3 GHz, 100 mA average current, 2 ps, 77 pC bunches with emittance of 1 mm-mrad. After a successful initial run of the cryomodule with beam, an improvement program was initiated in the Fall 2009. The goals of the reconfiguration were to replace the RF absorbers in the beamline

HOM loads that were subject to static charging, re-process the SRF cavities that exhibited a low Q that further decreased by 50% during the run, and improve diagnostic sensor accuracy within the cryomodule. The upgraded cryomodule was re-commissioned in early 2010 with excellent performance. Details of the investigation and remedies for HOM load charging, cavity Q recovery, and module assembly logistics will be presented along with the ERL Injector beam performance.

TU304 14:40 **High-Performance SC Cryomodule for CW Ion Accelerators**

M.P. Kelly *(ANL)*

Recent developments for cryomodules required for various low- and medium beta- CW ion accelerator projects will be presented. Comparisons of the designs, fabrication technology and assembly procedures of cryomodules will be discussed. To date, development in this area has been mostly for basic science applications, however, there is also considerable interest in ion accelerators for other applications such as national defense, medicine and accelerator driven systems. The outlook for and some development requirements of SRF cryomodules for these applications will be discussed.

14-Sep-10 15:00–16:00 Main Convention Hall

TU4 — Contributed Oral

Chair: Y.-S. Cho (KAERI)

14-Sep-10 16:00–18:00 Poster Rooms 101, 102, 201

TUP — Poster

TUP001 **Conceptual Design of a C-band Accelerating Module for Swiss FEL**

R. Zennaro *(PSI), M. Bopp, H.-H. Braun, A. Citterio, H. Fitze, M. Pedrozzi, J.-Y. Raguin (PSI)*

The Swiss FEL accelerator concept consists of a 450 MeV S-band injector linac followed by the main linac at the American C-band frequency aiming at a final energy of 5.8 GeV. The main linac is composed of 26 RF modules each consisting of a single 50 MW klystron and its solid-state modulator feeding a pulse compressor and four accelerating structures. The two-meter long C-band accelerating structures have 110 cells, including the two coupler cells and operate with a $2\pi/3$ phase advance. We report here on RF studies performed on the accelerating structures with different cell topologies and on the pulse compressor where two types are considered: a conventional

SLED-type and a Barrel-Open Cavity (BOC). The energy gain per accelerating structures and the power requirements for the different accelerating structures and the two types of pulse compressor with the single- and two-bunch operation modes are presented as well.

TUP002 **FERMI@Elettra: Installation and Commissioning of the S-Band RF System**

A. Fabris *(ELETTRA), P. Craievich, P. Delgiusto, F. Gelmetti, M.M. Milloch, A. Milocco, F. Pribaz, A. Rohlev, C. Serpico, N. Sodomaco, R. Umer, L. Veljak, D. Wang (ELETTRA)*

FERMI@Elettra is a single-pass FEL user-facility covering the wavelength range from 100 nm (12 eV) to 4 nm (310 eV) and is located next to the third-generation synchrotron radiation facility Elettra in Trieste, Italy. The first electron beam from the photocathode electron rf gun and injector system was extracted in August 2009. Commissioning and installation of the remaining linac and linac systems are continuing and will alternate through this year . The linac is based on normal conducting S-band technology. It uses fifteen 3 GHz 45 MW peak RF power plants powering the gun, the accelerating structures, and the RF deflectors, and when completed will be able to deliver greater than 1.5 GeV electron beams to the FEL undulator system. This paper provides a summary of the installation activities and discusses the performances results of the main subassemblies both during the initial checkouts and through the commissioning of the accelerator.

TUP004 **Status of ERL and cERL Projects in Japan**

S. Sakanaka *(KEK), H. Kawata, Y. Kobayashi (KEK) R. Hajima (JAEA/ERL) N. Nakamura (ISSP/SRL)*

Future light sources based on the Energy Recovery Linac (ERL) are expected to bring innovation to the synchrotron radiation (SR) science. Our Japanese collaboration team plans to construct a 5-GeV ERL which can produce superbrilliant and ultra-short pulses of SR as well as can be a driver for a proposed X-ray free-electron laser oscillator (X-FELO). In order to establish the key technologies for the ERL, we are conducting aggressive R&D efforts. Concerning our high-brightness photocathode DC electron gun, we succeeded to apply a DC high voltage of 500 kV through a support rod. Both cryomodules for the injector and the main-linac are also under development. In order to demonstrate reliable operations of such key technologies, we plan to con-

struct the Compact ERL (cERL) at KEK. During FY2009, we prepared the infrastructure for the cERL which includes renovation of the building (the East Counter Hall), renovation of cooling-water system and electrical substation, installation of liquid helium refrigerator, and installation of a part of the rf source. In this paper, we present up-to-date status of the ERL and the Compact ERL projects in Japan.

TUP005 **Status of Development of the cERL Superconducting Injector Linac**

K. Watanabe *(KEK), E. Kako, S. Noguchi, M. Satoh, T. Shishido, Y. Yamamoto (KEK)*

Development of the superconducting injector Linac for compact ERL has been continuing at KEK. The cryomodule including three two-cell SC cavities was designed. Two prot-type two-cell cavities were fabricated, and the vertival test were carried out after the standard surface preparation at STF. The high power tests of the input couplers were also carried out at the test stand with 300 kW cw klystron. The status of the cERL injector cryomodue will be reported.

TUP006 **Development of a Main Linac Module for Compact ERL Project**

K. Umemori *(KEK), T. Furuya, H. Sakai, T. Takahashi (KEK) M. Sawamura (JAEA/ERL) K. Shinoe (ISSP/SRL)*

A construction of the Compact ERL is planned in KEK, Japan. A demonstration of the performance of the main linac super-conducting accelerating system is one motivation of the project. We have been designing a cryo-module, which works under CW operation, and contains two 9-cell cavities, with input couplers, frequency tuners and HOM dampers. Most of these components have been specially developed for ERL operation. Two proto-type of the 9-cell cavity were constructed. First one was vertically tested and suffered from field emissions. Second one is now waiting a measurement. High power component tests have been carried out for input coupler. At first, large temperature rise was observed at a ceramic window part due to unexpected dipole resonance. After that, new version of window was designed and successfully passed 20kW CW power with reflection. Proto-types of HOM damper were also constructed. Cooling tests have been performed for them to verify cooling ability against more than 100W heat load, under vacuum condition. A cryo-module will be completed in 2012, and cooling tests and beam tests will follow.

TUP007 **BERLinPro - An Accelerator Demonstration Facility for ERL-based Light Sources**
J. Knobloch *(Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II), M. Abo-Bakr, W. Anders, K.B. Buerkmann-Gehrlein, M. Gensch, S.C. Hessler, A. Jankowiak, T. Kamps, O. Kugeler, B.C. Kuske, P. Kuske, A.N. Matveenko, A. Meseck, R. Müller, A. Neumann, K. Ott, T. Quast (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*
Energy recovery linacs (ERLs) are proving to be a powerful option to provide very high current beams with exceptional beam parameters and the flexibility to tailor these for many applications, from next-generation light sources to electron coolers. Helmholtz Zentrum Berlin (HZB) is focusing on ERLs for future x-ray light sources. Although ERL facilities exist for the IR and THz range, their moderate parameters (current, emittance, energy) are insufficient for future x-ray sources. HZB is therefore proposing to develop the 100-MeV ERL facility BERLinPro for accelerator studies and technology development to demonstrate the feasibility of an x-ray user facility. This paper presents an overview of the project and the key components of the facility.

TUP008 **Design Concepts of the 6 GeV High Performance Compact SwissFEL Linac**
Y. Kim *(IUCF) H.-H. Braun, T. Garvey, M. Pedrozzi, J.-Y. Raguin, V. Schlott (PSI)*
To generate coherent hard X-rays at 0.1 nm in the SwissFEL facility, ultra-high brightness electron beams (slice normalized emittance < 0.43 um, rms slice energy spread < 350 keV, peak current > 2.7 kA, beam energy ~ 6 GeV) should be sent to a 50 m long undulator. Specially, to reduce the bandwidth of XFEL photon beams, an ultra-flat energy chirp of electron beams is required. Additionally, to operate the XFEL facility stably, ultra-tight RF jitter tolerances are required. Generally, it is difficult to obtain such advanced properties with a short FEL driving linac. In this paper, we describe design concepts of the advanced 6 GeV SwissFEL linac to reduce the ultra-tight RF jitter tolerances, and to get an ultra-flat energy chirp with a 400 m long compact linac.

TUP009 **First Commissioning Experience at the SwissFEL Injector Test Facility**

T. Schietinger *(PSI), M. Aiba, B. Beutner, M. Dach, A. Falone, R. Ganter, R. Ischebeck, F. Le Pimpec, N. Milas, G.L. Orlandi, M. Pedrozzi, S. Reiche, C. Vicario (PSI)*

The Paul Scherrer Institute is commissioning a 250 MeV injector test facility in preparation for the SwissFEL project. Its primary purpose is the demonstration of a high-brightness electron beam meeting the specifications of the SwissFEL main linac. At the same time it is advancing the development and validation of the accelerator components needed for the realization of the SwissFEL facility. We report the results of the first commissioning phase, which includes the gun section of the injector up to 7 MeV electron energy. Electrons are generated by a 2.6-cell laser-driven photocathode RF gun operating at 3 GHz followed by an emittance compensating focusing solenoid. The diagnostic system for this phase consists of a spectrometer dipole, a series of screens and beam position monitors and several charge measuring devices. Slit and pinhole masks can be inserted for phasespace scans and emittance measurements. The completion of the entire injector facility proceeds in three stages, culminating with the integration of the magnetic compression chicane expected for early 2011.

TUP010 **Test Results of Components for CW and Near-CW Operation of a Superconducting Linac**

J.K. Sekutowicz *(DESY)*

The European XFEL will use superconducting TESLA cavities operating with 650 μs long bunch trains. With 220 ns bunch spacing and 10 Hz RF-pulse repetition rate up to 27000 high quality bunches/s will be delivered to insertion devices generating unprecedented high average brilliance photon beams at very short wavelength. While many experiments can take advantage of full bunch trains, others prefer an increased several μ-seconds intra pulse distance between bunches, or short bursts with kHz repetition rate. With the nominal RF-pulse structure these features will lead to a substantially reduced number of bunches per second and therefore to significantly lower average brilliance. We discuss here an R&D program aiming for a far future upgrade of the European XFEL; operation in the cw and/or near-cw mode. The program profits from the continuous improvement in performance of TESLA cavities, which allows for longer RF-pulses in comparison with the current design.

We present test results of a SRF electron injector and a new RF-power source, and some modification of the HOM damping scheme, which will avoid the necessity of re-assembly of the XFEL accelerator for the upgraded operations.

TUP011 **Layout of the PITZ Transverse Deflecting System for Longitudinal Phase Space and Slice Emittance Measurements**

L.V. Kravchuk *(RAS/INR), V.V. Paramonov (RAS/INR) A. Anisimov, M.V. Lalayan, A.Yu. Smirnov, N.P. Sobenin (MEPhI) D. Churanov, E.V. Ivanov, S.V. Kutsaev, M. Urbant, A.A. Zavadtsev, D.A. Zavadtsev (Nano) A. Donat, W. Koehler, M. Krasilnikov, J. Meissner, M. Pohl, J. Schultze, F. Stephan, G. Trowitzsch, R.W. Wenndorff (DESY Zeuthen) C. Gerth, M. Hoffmann, M. Huening, F. Ludwig, H. Schlarb (DESY)*

Transverse Deflecting Systems are designated for longitudinal beam diagnostics of ultra-short electron bunches in modern FEL projects. At the European XFEL, Transverse Deflecting Systems are foreseen at three locations. A prototype of the TDS in the injector of the European XFEL will be installed at PITZ which is identical in terms of deflecting structure, low-level RF system and powerful RF hardware. This PITZ TDS has the aim to prove the required performance for all TDS subsystems as well as serve as a diagnostics tool for PITZ. Results of the test cells measurements of a S-band travelling wave structure are presented, showing very good agreement with calculated parameters. RF power supply system, including 3 MW klystron and other RF hardware, is described. Solid state 130 kV Marx modulator has been developed for the klystron feeding. 10 kV module of the modulator has been built and tested. The modulator allows for high voltage shutdown within pulse.

TUP012 **sFLASH - First Results of Direct Seeding at FLASH**

J. Boedewadt *(Uni HH), A. Azima, F. Curbis, H. Delsim-Hashemi, M. Drescher, E. Hass, U. Hipp, Th. Maltezopoulos, V. Miltchev, M. Mittenzwey, M. Rehders, J. Rossbach, J. Rönsch-Schulenburg, R. Tarkeshian, M. Wieland (Uni HH) S. Bajt, S. Düsterer, K. Honkavaara, T. Laarmann, H. Schlarb (DESY) R. Ischebeck (PSI) S. Khan (DELTA)*

The free-electron laser facility FLASH at DESY (Hamburg) was upgraded during a five-month shutdown in winter 2009. Part of this upgrade was the installation of a direct seeding exper-

iment in the XUV spectral range. Beside all components for transport and diagnostics of the photon beam in and out of the accelerator environment, a new 10 m long variable-gap undulator was installed upstream of the existing FLASH undulator system. The seed pulses are generated within a noble-gas jet by focusing 40 fs long Ti:Sa laser pulses into it resulting a comb of higher harmonics. In the first phase of the experiment the 21st harmonic of the 800 nm drive laser will be used to seed the FEL process. The commissioning of the experiment has started in April and the first results are expected after the FLASH commissioning period mid of summer 2010. The experimental setup and the commissioning procedures as well as first result will be presented.

TUP013 **Commissioning and Early Operating Experience of the FLASH Third Harmonic RF System**

E.R. Harms *(Fermilab), H.T. Edwards (Fermilab) M. Huening, E. Vogel (DESY)*

A Third Hamonic/3.9 GHz superconducting RF module was recently installed in the FLASH facility at DESY. Ultra short bunches with high peak current are required to efficiently create high brilliance coherent light and these can be produced by means of a 2-stage transverse magnetic chicane bunch compression scheme coupled with off-crest acceleration. The long bunch tails and reduced peak current which result from the nonlinearities of the RF since wave can be eliminated by the addition of a 3rd harmonic RF system. Such a system can also allow for the creation of uniform intensity bunches of adjustable length necessary for seeded operation. We present here a summary of commissioning and early operating experience of the newly-installed device.

TUP014 **Construction of Injector System for SPring-8 X-FEL**

H. Hanaki *(JASRI/SPring-8), T. Asaka, H. Ego, H. Kimura, T. Kobayashi, S. Suzuki, M. Yamaga (JASRI/SPring-8) T. Fukui, T. Inagaki, N. Kumagai, Y. Otake, T. Shintake, K. Togawa (RIKEN/SPring-8)*

The injector of the 8 GeV linac generates an electron beam of 1 nC, accelerates it up to 30 MeV, and compresses its bunch length down to 20 ps. Even slight RF instability in its multi-stage bunching section fluctuates the bunch width and the peak current of an electron beam and it accordingly results in unstable laser oscillation in

the undulator section. The acceptable instabilities of the RF fields in the cavities, which permit 10% rms variation of the peak beam current, are only about 0.01% rms in amplitude and 120 fs rms in phase according to beam simulation. The long-term RF variations can be compensated by feedback control of the RF amplitude and phase, the short-term or pulse-to-pulse variations, however, have to be reduced as much as possible by improving RF equipment such as amplifiers. Thus we have carefully designed and manufactured the RF cavities, amplifiers and control systems, giving the highest priority to the stabilization of the short-term variations. Components of the injector will be completed by the end of the May 2010, and the injector will be perfected in the summer 2010. We will present the performance of the completed devices in the conference.

TUP015 **A Compact X-band Linac for an X-ray FEL**
C.D. Nantista *(SLAC), C. Adolphsen, K.L.F. Bane, Z. Huang, Z. Li, F. Wang, F. Zhou (SLAC)*
With the growing demand for FEL light sources, cost issues are being revaluated. To make the machines more compact, higher-frequency room-temperature linacs are being considered, in particular, ones using C-band (5.7 GHz) rf technology where 40 MV/m gradients are possible. In this paper, we show that an X-band (11.4 GHz) linac using the technology developed for NLC/GLC can provide an even lower cost solution. In particular, stable operation is possible at gradients of 100 MV/m for single bunch operation, and 70 MV/m for multibunch operation. The concern of course is whether the stronger wakefields will lead to unacceptable emittance dilution. However, we show that the small emittances produced in a 250 MeV, low bunch charge, LCLS-like S-band injector and bunch compressor can be preserved in a multi-GeV X-band linac with reasonable alignment tolerances.

TUP016 **A Proposal for Increasing the Energy of the FERMI@Elettra Linac**
G. D'Auria *(ELETTRA)*
FERMI@Elettra is a soft X-ray, fourth generation light source facility under construction at the Elettra Laboratory in Trieste, Italy. It will be based on a seeded FEL, driven by the existing normal conducting linac that is presently expected to operate at 1.5 GeV. This will allow for a FEL operation down to 4 nm (FEL-2 operating mode$_{f}$undamental). A possible scenario is pre-

sented for increasing the linac energy up to 2.3-2.4 GeV using X-band technology currently under development at Elettra. This can extend the FERMI@Elettra capability, in term of wavelength, down to the water window and beyond (< 2 nm).

TUP017 **The Resonant Method of Stabilization for Plane of Deflection in the Disk Loaded Deflecting Structures**

V.V. Paramonov *(RAS/INR), L.V. Kravchuk (RAS/INR)*

The hybrid HE11 mode in the cylindrical disk loaded deflectors is twice degenerated. To ensure operational performance and stabilize the position for the plane of deflection, the dispersion curve for modes with perpendicular field polarization must be shifted in frequency with respect to the curve for modes with operating polarization. A lot of decisions, based on the deterioration of the axial symmetry of the structure, are known for this purpose. The resonant method of stabilization is proposed. Resonant elements ' slots, coupled only with modes of perpendicular polarization, are placed in the disks. Two created branches of dispersion curve for composed slot - structure modes are generated and placed symmetrically with respect to the non perturbed dispersion curve for operating modes. In the plane stabilization it provides qualitative advantage with respect a simple frequency shift, because cancels, in the first order, the influence of modes with perpendicular field polarization on the plane of deflection. The criteria for the slots definition are presented. The example of application for the traveling wave S-band deflector is described as well.

TUP018 **Development of High-average-current Electron Injectors**

D.C. Nguyen *(LANL), H.L. Andrews, F.L. Krawczyk, N.A. Moody (LANL) J.W. Lewellen, S.P. Niles, B. Rusnak (NPS)*

Modern electron injectors consist of an RF structure with a photocathode integrated into the first full-wave half-cell or quarter-wave full-cell. While the cathode gradients in pulsed, normal-conducting RF injectors exceed 100 MV/m, which lead to substantial dark currents, those of cw normal-conducting and superconducting RF injectors are typically 10-20 MV/m. Emittance compensation has been modeled for both NCRF and SRF injectors to generate nC electron bunches with normalized rms emittance of ~2 mm-mrad. The use of solenoid and RF focusing in combination with relatively low cathode gra-

dients can mitigate the space-charge-induced radial expansion in nC bunches, resulting in low emittance and also low dark currents.

TUP019 **Proton Linac for ADS Application in China**
S. Fu *(IHEP Beijing), S.X. Fang, J.Q. Wang (IHEP Beijing) X. Guan (CIAE)*
In the next two decades, China will be in period of fast development of nuclear power to meet the energy demands of the rapid economy growth and to cut down the CO2 release. Accelerator Driven System is recognized as the best option for nuclear radioactive waste transmutation. ADS long-term development roadmap has been proposed. Based on the ADS basic study in the last decade, a samll-scale ADS facility is going to be built to do experimental research on ADS system. In this paper, we will first review the previous R&D activity on ADS linac research in China, and then introduce the design of the linac in the small-scale ADS facility.

TUP020 **Accelerator Reference Design for the MYRRHA European ADS Demonstrator**
J.-L. Biarrotte *(IPN) H. Klein (IAP) A.C. Mueller (IN2P3) P. Pierini (INFN/LASA) D. Vandeplassche (SCK-CEN)*
The goal of the MYRRHA project is to demonstrate the technical feasibility of transmutation in an Accelerator Driven System (ADS) by building a new flexible irradiation complex in Mol (Belgium). The MYRRHA facility requires a 600 MeV accelerator delivering a maximum proton flux of 4 mA CW operation. Such a machine belongs to the category of the high-power proton accelerators, with an additional requirement for exceptional reliability: because of the induced thermal stress to the subcritical core, the number of unwanted beam interruptions should be minimized down to the level of about 10 per 3-month operation cycle, a specification that is far above usual proton accelerators performance. This paper describes the reference solution adopted for such a machine, based on a so-called 'fault-tolerant' linear superconducting accelerator, and presents the status of the associated R&D.

TUP021 **PEFP 100MeV Proton Accelerator Components Test by Using 20MeV Linac**
H.-J. Kwon *(KAERI), Y.-S. Cho, J.-H. Jang, D.I. Kim, H.S. Kim, K.T. Seol, Y.-G. Song (KAERI)*
A 100MeV proton accelerator is developed by the Proton Engineering Frontier Project (PEFP). As a front part, a 20MeV linac has been installed and

operated at Korea Atomic Energy Research Institute (KAERI) site. Among the components for the 100MeV accelerator, some parts were installed and tested by using 20MeV linac. One modulator for a 100MeV linac was installed to drive two klystrons simultaneously which were used for a 20MeV linac. Various operating parameters such as a long term voltage fluctuation and control performance are checked during operation. Also a LLRF system for 100MeV linac which was modified from the 20MeV system was installed and tested. In this paper, the operation characteristics of the 20MeV linac are presented especially from the viewpoint of the newly installed components such as a modulator and LLRF system.

TUP022 **A Linac for Compact Pulsed Hadron Source Project AT Tsinghua University Beijing**
X. Guan *(TUB)*
This paper will be generally reported that a new project of the Compact Pulsed Hadron Source (CPHS) led by the Department of Engineering Physics of Tsinghua University in Beijing, China. CPHS consists of a proton linac (13MeV, 16kW, Operating frequency 325MHz, peak current 50 mA, 0.5 ms pulse width at 50 Hz), a neutron target station (a Be target, moderators and reflector), and a small-angle neutron scattering instrument, a neutron imaging/radiology station, and a proton irradiation station. The linac accelerator is the main part of this project, which including a ECR ion source. LEBT section, a RFQ accelerator, a DTL linac and a HEBT An An experimental platform for further proton applications and more neutron beam lines will be added at a later stage. Currently, fabrication of the accelerator components has begun while the neutron target station, beam lines and instruments are under design study. The initial phase of the CPHS construction is scheduled to complete in the end of 2012.

TUP023 **CH-cavity Development for the 17 MeV EUROTRANS Injector**
F.D. Dziuba *(IAP), M. Busch, H. Klein, H. Podlech, U. Ratzinger, C. Zhang (IAP)*
Recent international cw operated high-current applications with ambitious requirements regarding beam power and quality ask for new linear accelerator developments. In this context the CH-structure (Crossbar-H-mode) has been developed at the Institute for Applied Physics (IAP) of Frankfurt University. It is a multi-cell drift tube cavity for the low and medium energy range operated in the H21-mode and can be used

for superconducting as well as for room temperature operations. Because of the large energy gain per cavity, which leads to high real estate gradients, the CH-cavity is an excellent candidate for the efficient acceleration in high power proton and ion accelerators with fixed velocity profiles. One possbile application for this kind of cavity is the EUROpean research programme for the TRANSmutation (EUROTRANS) of high level nuclear waste in an accelerator driven system (ADS), which requires an efficient high-current cw-linac (600 MeV, 4 mA, protons, 352 MHz). The paper describes the status of the CH-cavity development and the actual beam dynamics results for the reference design of the 17 MeV EUROTRANS injector.

TUP024 **Status of the J-PARC Linac**

K. Hasegawa *(JAEA/J-PARC)*

Beam commissioning of the J-PARC linac started in November 2006 and 181 MeV acceleration was successfully achieved in January 2007. The linac had delivered beams for commissioning of accelerators and experimental facilities. Trip rates of the RFQ, however, unexpectedly increased in Autumn 2008, and that was the primary limitations of the operation days and power ramp up. We tried to recover by improvement of vacuum properties, tender conditioning and so on. By taking these measures, we can lengthen the continuous operation days and stand user operations. We ramped up the beam power from 20 kW to 120 kW for 3 GeV beam users in November 2009. This corresponds to the linac beam power of 7.2 kW and the linac has delivered beams at this power since then without significant troubles. And also we successfully demonstrated 300 kW at 3 GeV for 1 hour in December. We present the performance and operation experiences of the J-PARC linac.

TUP025 **Operational Status and Life Extension Plans for the Los Alamos Neutron Science Center**

K.W. Jones *(LANL), J.L. Erickson, R.W. Garnett, M.S. Gulley (LANL)*

The Los Alamos Neutron Science Center (LANSCE) accelerator and beam delivery complex generates the proton beams that serve three neutron production sources, a proton radiography facility and a medical and research isotope production facility. The recent operating history of the facility, including both achievements and challenges, will be reviewed. Plans for performance improvement will be discussed, together

with the underlying drivers for the ongoing LANSCE Life Extension project. The details of this latter project will also be discussed.

TUP026 **Low and Medium Energy Beam Trasport Upgrade Results at BNL 200 MeV Linac**
D. Raparia *(BNL), J.G. Alessi, B. Briscoe, J.M. Fite, O. Gould, V. LoDestro, M. Okamura, J. Ritter, A. Zelenski (BNL)*
BNL 200 MeV linac has been under operation since 1970 and gone through several changes during its 40 year lifetime. The latest reconfiguration in low and medium energy (35 and 750 keV) beam transport lines results in about a factor of 2 reduction in the transverse emittance for the accelerated polarized proton beam, and for the unpolarized high current H^- beam a several fold reduction in the radiation levels due to beam losses throughout the linac and isotope production facility complex with more beam current on the isotope production target. These improvements are achieved by proper matching into the linac in longitudinal as well as transverse phase space. This paper will emphasize how longitudinal matching resulted in lower emittance and beam losses.

TUP027 **A New Medium Energy Beam Transport Line for the Proton Injector of AGS-RHIC**
M. Okamura *(BNL), B. Briscoe, J.M. Fite, V. LoDestro, D. Raparia, J. Ritter (BNL) N. Hayashizaki (RLNR)*
It is commonly preferred to have a short distance between an RFQ and a consequent DTL, however many devices has to be accommodated within a limited space. Our new medium energy beam transport line for proton beam is categorized as one of the severest cases. High field gradient quadrupoles (65 Tm) and newly designed steering magnets (6.5 mm in length) were fabricated considering the cross-talk effects. Also a new half wave length 200 MHz buncher is being studied. In the conference, the electro-magnetic field designs and the measured result will be discussed.

TUP028 **Status of the FETS Commissioning and Comparison with Particle Tracking Results**
J.K. Pozimski *(Imperial College of Science and Technology, Department of Physics), S.M.H. Alsari, S. Jolly, A. Kurup, D.A. Lee, P. Savage (Imperial College of Science and Technology, Department of Physics) J.J. Back (University of Warwick) M.A. Clarke-Gayther, D.C. Faircloth, S.R. Lawrie, A.P. Letchford, M. Perkins, P. Wise (STFC/RAL/ISIS) C. Gabor,*

D.C. Plostinar (STFC/RAL/ASTeC)

In order to contribute to the development of high power proton accelerators in the MW range, to prepare the way for an ISIS upgrade and to contribute to the UK design effort on neutrino factories, a front end test stand (FETS) is being constructed at the Rutherford Appleton Laboratory (RAL) in the UK. The aim of the FETS is to demonstrate the production of a 60 mA, 2 ms, 50 pps chopped beam at 3 MeV with sufficient beam quality. The status of the FETS will be given and experimental results from the commissioning of LEBT and ion source will be presented. Previous measurements showed that the emittance of the beam delivered by the ion source exceeded our expectations by more than a factor of 3. Since then various changes in the beam extraction/post accelerator region reduced the beam emittance more than a factor of 2. The results from measurements will be compared with numerical simulations of the particle dynamics from the ion source to the end of the MEBT and the results discussed in respect to further work.

TUP029 **Continued Monitoring of the Conditioning of the Fermilab Linac 805 MHz Cavities**

E.S.M. McCrory *(Fermilab), F.G. Garcia, T.K. Kroc, A. Moretti, M. Popovic (Fermilab)*

We have been collecting data on the conditioning of the high-gradient accelerating cavities in the Fermilab 400 MeV H-Minus Linac for over 16 years [1]. This linac was upgraded in 1989 from a 201 MHz Alverez structure to include 805 MHz side-coupled cavities. Automated measurements of the sparking rate have been recorded since 1994 and are reported here. The sparking rate has declined since the beginning, but there are indications that this rate may have leveled off now. The X-rays emitted by the cavities are continuing to decrease.

TUP031 **A Side Coupled Proton Linac Module 30-35 MeV: First Acceleration Tests**

V.G. Vaccaro *(Naples University Federico II and INFN) S. Barone (NRT) L. Calabretta, A. Rovelli (INFN/LNS) C. De Martinis (Universita' degli Studi di Milano & INFN) L. Gini, D. Giove (INFN/LASA) M.R. Masullo (INFN-Napoli) A.C. Rainò (Bari University, Science Faculty) V. Variale (INFN-Bari)*

ACLIP is a 3 GHz proton SCL linac designed as a booster for a 30 MeV commercial cyclotron. The whole accelerator is a 5 module structure coupled together. The final energy is 62 MeV well suitable for the therapy of ocular tumors. In or-

der to treat deep-seated tumors the energy can be raised up to 230 MeV by adding a second linac. The possibility of using magnetrons, as the source of RF power, to reduce the overall cost of the machine, and the tile design (covered by a patent), named Back-to-Back Accelerating Cavity (BBAC), to efficiently accelerate protons starting from a low energy are two of the more relevant features of this project. The first module (from 30 to 35 MeV) has been full power RF tested in December 2008, showing that the design accelerating field could be easily reached. Then this module, along with all elements of the RF power setup, has been transferred to INFN-LNS in Catania at the end of April 2010 to carry out beam acceleration tests using a 30 MeV proton beam from the Superconducting Cyclotron. In this paper we will review the main features of the linac and discuss the results of the acceleration measurements carried out on this prototype.

TUP032 **A Versatile Neutron Generator for the Accelerator Driven System Experimental Program GUINEVERE**

M.A. Baylac *(LPSC)*

GUINEVERE is a project devoted to experimental studies of ADS feasibility and investigation of the on-line reactivity monitoring, sub-criticality determination and operational procedures. A versatile neutron source drives the sub-critical lead core VENUS-F located at SCK'CEN in Mol (Belgium). The GEnerator-of-NEutrons-Pulsed-and-Intense-3C is an electrostatic accelerator generating 14 MeV neutrons by bombarding a deuteron beam on a tritium target located in the reactor core. A new accelerator was developed to produce alternatively short (1 μs) and intense (40 mA peak) deuteron pulses with adjustable repetition rate, as well as continuous beam (1 mA DC). Moreover, a third mode provides programmable interruptions on the DC beam to fulfill the requirements of the experimental program. Beam will be inserted vertically into the reactor core. The accelerator is designed to enable the vertical section of the beam line to be easily craned out the reactor bunker for maintenance operations, target changes and core loading procedures. This paper describes the design of the accelerator and its commissioning. This work is performed within the 6th Framework Program EC project EUROTRANS

TUP033 **Commissioning of the IH Linac and High Energy Beam Transport of the EBIS Based Preinjector for RHIC**

D. Raparia *(BNL), J.G. Alessi, E.N. Beebe, K. Kondo, R.F. Lambiase, V. LoDestro, R. Lockey, M. Mapes, A. McNerney, M. Okamura, D. Phillips, A.I. Pikin, J. Ritter, J. Scaduto, L. Smart, L. Snydstrup, M. Wilinski, A. Zaltsman (BNL) R. M. Brodhage, U. Ratzinger, R. Tiede (IAP) T. Kanesue (Kyushu University)*

The EBIS based preinjector for RHIC is now being commissioned. The Linac was delivered in April 2010 and commissioning started in May, 2010. It accelerates ions from 0.3 MeV/u to 2 MeV/u with 27 accelerating gaps, one internal quadrupole triplet, and operates at 100.625 MHz. The Linac is followed by a beam transport line to Booster which includes seven quadrupoles, two bunchers, and an achromatic bend system with resolution of 500 at 2 MeV/u to select the required charge state. Diagnostics include a pepperpot emittance probe, phase probes , fast Faraday cup, adjustable slits, three sets of multiwire profile monitors, three current transformers, two Faraday cups, and two beam stops. This contribution will report results of linac tuning and cold measurements, and commissioning of the Linac and high energy transport line with helium and gold beams.

TUP034 **Beam Commissioning Results for the RFQ and MEBT of the EBIS Based Preinjector for RHIC**

M. Okamura *(BNL), J.G. Alessi, E.N. Beebe, K. Kondo, R.F. Lambiase, V. LoDestro, R. Lockey, M. Mapes, A. McNerney, D. Phillips, A.I. Pikin, D. Raparia, J. Ritter, L. Smart, L. Snydstrup, A. Zaltsman (BNL) T. Kanesue (Kyushu University) A. Schempp, J.S. Schmidt, M. Vossberg (IAP) J. Tamura (Department of Energy Sciences, Tokyo Institute of Technology)*

The EBIS based preinjector for the RHIC is now being commissioned. During the step-wise commissioning of the preinjector from January 2009 to June 2010, the RFQ was commissioned first using Test EBIS in January 2009 and then moved to its final location and commissioned again with RHIC EBIS in March 2010. The RFQ accelerates ions from 17 keV/u to 300 keV/u and operates at 100.625 MHz. The RFQ is followed by a short (81 cm) Medium Energy Beam Transport (MEBT), which consists of four quadrupoles and one buncher cavity. Temporary diagnostics

for this commissioning included an emittance probe, TOF system, fast Faraday cup, and beam current measurement units. This contribution will report results of RFQ and MEBT commissioning with helium and gold beams.

TUP035 **Design Study of C^{6+} Hybrid Single Cavity Linac for Cancer Therapy**

L. Lu *(RLNR), T. Hattori, N. Hayashizaki (RLNR)*

A new type Linac, HSC (hybrid single cavity) linac for cancer therapy, which configuration combines RFQ (Radio Frequency Quadrupole) accelerating structure and DT (Drift Tube) accelerating structure is being finished designs and simulations now. This HSC linac design had adopted advanced power-efficiency-conformation, IH (Interdigital H) structure, which acceleration efficiency is extremely high in the low-middle energy region, and had also adopted most advanced computer simulation technology to evaluate cavity electromagnetic distribution. The study purposes of this HSC linac focus to design of injector linac for synchrotron of cancer radiotherapy facilities. Here, this HSC linac has an amazing space effect because of compact size by coupled complex acceleration electrode and integrated the peripheral device which is made operation easy to handle. The size of the HSC linac is very compact and is also easy to be adopted for cancer therapy in normal hospital.

TUP036 **The RF System for the Compact Pulse Hadron Source**

C. Cheng *(TUB), T. Du, X. Guan, J. Wei, S.X. Zheng (TUB)*

The Compact Pulsed Hadron Source (CPHS) system has been proposed and designed by the Department of Engineering Physics of Tsinghua University in Beijing, China. It consists of an accelerator front-end'a high-intensity ion source, a 3 MeV radiofrequency quadrupole linac (RFQ), and a 13 MeV drift-tube linac (DTL), a neutron target station, and some experimental stations. In our design, both RFQ and DTL share a single klystron which is capable of 2.5 MW peak RF power and a 3.33% duty factor. The 325 MHz klystron contains a modulating anode and has a 100 kW average output power. Portions of the RF system, such as pulsed high voltage power source, modulator, crowbar protection and RF transmission system are all presented in details in this paper.

TUP037 **Design of Linear Injector for SSC of HIRFL**
Y. He *(IMP), X. Du, Z.J. Wang, J.W. Xia, C. Xiao, Y.Q. Yang, H.W. Zhao (IMP) J.E. Chen, Y.R. Lu, K. Zhu (PKU/IHIP)*
Heavy Ion Research Facility at Lanzhou (HIRFL) consists of two cyclotrons (SFC and SSC), one synchrotron (CSRm), and one storage ring (CSRe). The two cyclotrons are in series as the injector of the synchrotron. An additional LINAC injector for SSC is considered to increase the beam time at targets. The new injector consists of an RFQ and four IH-DTL tanks. A pre-buncher in the front of RFQ is 13 MHz to match the RF frequency of SSC. The LINAC can operate in two modes. In the first mode, the middle-mass ions output with energy of 0.54 MeV/u, and then SSC accelerates them up to the energy of 5.62 MeV/u. The beam is used to do the Super Heavy Elements (SHE) experiments. In the second mode, the very heavy ions output with energy of 0.97 MeV/u, and then SSC accelerates them up to energy of 10.06 MeV/u. The beam is injected into CSRm after stripped. Code LINREV and DAKOTA are used to design and optimize the acceleration structures of DTLs. The energy spread less than ś0.5% and bunch length less than 2.6 ns are achieved at the exit of the last tank. These can match the ideal acceptance of SSC. A simulation from LEBT to exit of DTL is done by Beampath to benchmark the design.

TUP038 **Matter-Radiation Interactions in Extremes - The LANSCE Future**
R.W. Garnett *(LANL), M.S. Gulley (LANL)*
LANSCE has been the centerpiece of large-scale science at Los Alamos National Laboratory for many decades. Recently, funding has been obtained to ensure continued reliable operation of the LANSCE linac and to allow planning to enable the first in a new generation of scientific facilities for the materials community. The emphasis of this new facility is "Matter-Radiation Interactions in Extremes" (MaRIE) which will be used to discover and design the advanced materials needed to meet 21st century national security and energy security challenges. MaRIE will provide the tools scientists need to develop next-generation materials that will perform predictably and on-demand for currently unattainable lifetimes in extreme environments. The MaRIE facility is based on a high-power upgrade to the existing LANSCE proton linac, a new electron linac and associated X-ray FEL to provide additional probe beams, and new experimental areas. A conceptual description of this new facil-

ity and its requirements will be presented.

TUP039 **The New cw RFQ Prototype**
U. Bartz *(IAP), A. Schempp (IAP)*
Abstract A short RFQ prototype was built for tests of high power RFQ structures. We will study thermal effects and determine critical points of the design. HF-Simulations with CST Microwave Studio and measurements were done. The RF-Tests with continues power of 20 kW/m were finished successfully. Simulations of thermal effects with ALGOR are on focus now. First results and the status of the project will be presented.

TUP040 **Measurements at the MAFF IH-RFQ Test Stand at the IAP Frankfurt**
J.M. Maus *(IAP), A. Schempp (IAP) A. Bechtold (NTG)*
The IH-type RFQ for the MAFF project at the LMU in Munich was operated at a beam test stand at the IAP in Frankfurt. It is the second IH-RFQ after the HIS at GSI and it has been designed to accelerate rare isotope beams (RIBs) with mass to charge ratios A/q up to 6.3 from 3 keV/u to 300 keV/u at an operating frequency of 101.28 MHz with an electrode voltage of 60 kV. Experimental results such as shunt impedance, energy spectrum and transmission will be presented.

TUP041 **Upgrade for the HLI-RFQ**
M. Vossberg *(IAP), A. Schempp, C. Zhang (IAP) W.A. Barth, L.A. Dahl (GSI)*
A new CW-RFQ has been built for the upgrade of the HLI (High Charge State Injector) of GSI for operating with a 28GHz-ECR-Ion source and simultaneous increase of the beam duty cycle from 25 % now to 100 %. The new HLI 4-rod RFQ will accelerate charged ions from 4 keV/u to 300 keV/u for the injection into the IH-structure. High beam transmission, a small energy spread and small transverse emittance growth and good input matching are design goals. Properties of this CW-RFQ, status of project and first measurements will be presented.

TUP042 **Progress in the Fabrication of the RFQ Accelerator for the CERN Linac4**
C. Rossi *(CERN), P. Bourquin, J.-B. Lallement, A.M. Lombardi, S.J. Mathot, D. Pugnat, M.A. Timmins, G. Vandoni, M. Vretenar (CERN) M. Desmons, A. France, Y. Le Noa, J. Novo, O. Piquet (CEA)*
The construction of Linac4, the new 160 MeV CERN H^- injector, has started with the goal of improving the LHC injection chain from 2015

with a new higher energy linac. The low energy front end of Linac4 is based on a 352 MHz, 3-m long Radiofrequency Quadrupole (RFQ) accelerator. The RFQ accelerates the 70 mA, 45 keV H^- beam from the RF source to the energy of 3 MeV. The fabrication of the RFQ has started at CERN in 2009 and is presently in progress, aiming at the completion of the full structure by early 2011. The RFQ consists of three modules, one meter each; the fabrication alternates machining phases and stress relief cycles, for copper stabilization. Two brazing steps are required: one to assemble the four parts composing a module and a second one to install the stainless steel flanges. In order to monitor that the tight mechanical and alignment budget is not exceeded, metrology measurements at the CERN workshop and RF bead-pull measurements are performed during the fabrication process. In this paper we report results obtained during the machining and the assembly of the first two modules of the Linac4 RFQ and data produced by RF measurements performed during their fabrication.

TUP043 **Testing of IMP LIS-RFQ**

Y. Liu *(IMP)*

A compact RFQ for carbon ion beam from a Laser-ion souce is being tested in IMP, Lanzhou. It is the first example of LINAC structures for IMP. Testing schemes and first results are presented.

TUP044 **A Two-meter Long RFQ for the Direct Plasma Injection Scheme at IMP**

Z.L. Zhang *(IMP), X.H. Guo, Y. He, Y. Liu, S. Sha, A. Shi, L.P. Sun, H.W. Zhao (IMP) R.A. Jameson, A. Schempp (IAP)*

A RFQ has been designed and built for research of direct plasma injection scheme (DPIS), which can provide high current and highly charged beams. Because of the strong space charge forces of beam from laser ion source, the beam dynamics design of the RFQ was carried out with a new code LINACSrfq which can treat space charge effectively due to equipartitioning design strategy. Another feature of the RFQ is its high energy gain in two-meter long which will be described in detail. Construction of the RFQ cavity and the 100MHz/250kW amplifier has been completed and ready for test. A laser ion source is being tested. The assembling of the whole system including the ion source, the RFQ, the beam analyzing and diagnostic system is being done. Preliminary test results will be presented.

TUP045 **RF and Heat Flow Simulations of the SARAF RFQ 1.5 MeV/nucleon Proton/Deuteron Accelerator**

J. Rodnizki *(Soreq NRC), Z. Horvitz (Soreq NRC)*

The SARAF 4-rod RFQ is operating at 176 MHz, designed to bunch and accelerate a 4 mA CW deuteron/proton beam to 1.5 MeV/u. The electrodes voltage for accelerating deuterons is 65 kV, a field of 22 MV/m. The RFQ injected power is induced by a loop coupler. The power needed to achieve this voltage is 250 kW, distributed along the 3.8 m RFQ length. This power density is approximately 3 times larger than that achieved in other 4-rod RFQs. At high power, local high surface currents in the RFQ might cause overheating which will lead to out-gassing and in turn to sparking. We used CST MWS to simulate the RF currents and fields in a 3D detailed model of the SARAF RFQ. The correct eigenmode was reproduced and both Qe and Qo are consistent with the measured values. The heat load generated by the simulated surface currents at critical areas along the RFQ was the input for thermal analysis using Ansys. Detailed results reproduced the experimental observation of several overheated regions in the RFQ, including the end flanges and the plungers. Further results predicted overheating at different regions which were subsequently measured and are now being improved by additional cooling.

TUP046 **Development of the 3MeV RFQ for the Compact Pulsed Hadron Source at Tsinghua University**

Q.Z. Xing *(TUB), Y.J. Bai, J.C. Cai, X. Guan, J. Wei, Z.F. Xiong (TUB) J.H. Billen, J. Stovall, L.M. Young (TechSource) W.Q. Guan, Y. He, J. Li (NUCTECH)*

We present, in this paper, the physics and mechanical design of a Radio Frequency Quadrupole (RFQ) accelerator for the Compact Pulsed Hadron Source (CPHS) at Tsinghua University. The 3-meter-long RFQ will accelerate protons from 50 keV to 3 MeV at an RF frequency of 325 MHz. In the physics design we have programmed the inter-vane voltage as a function of beam velocity, to optimize the performance of the RFQ, by tailoring the cavity cross section and vane-tip geometry as a function of longitudinal position while limiting the peak surface electric field to 1.8 Kilpatrick. There will be no Medium-Energy-Beam-Transport (MEBT) following the RFQ. The focusing at the high energy end of the RFQ and at the entrance of the DTL have been

tailored to provide continuous restoring forces independent of the beam current. In simulations of the proton beam in the RFQ, using the code PARMTEQM, we observe transmission exceeding 97%. The RFQ is mechanically separated into three sections to facilitate machining and brazing. We have machined a test section and the final RFQ accelerator is now under construction. We will describe the status of the RFQ system in this paper.

TUP047 **Effects of Structural Perturbations on RF Performance of RFQ Structures**

K.R. Shin *(ORNL), Y.W. Kang, S.-H. Kim, A.V. Vassioutchenko (ORNL) A.E. Fathy (University of Tennessee)*

Radio-frequency quadrupole (RFQ) structures are often treated to have ideal RF properties as if the mechanical design and fabrication are done perfectly. If any part of the internal structure, especially the vanes become out of alignment possibly with certain mechanical stresses, the resonant frequency and the field distributions may change. The distorted structure could be retuned for the right resonant frequency and field distributions usually with finite number of mechanical tuners using measurements done with finite number of field probes. The result of present investigation shows that the disturbed local field distribution due to mechanical distortion may be difficult to be restored by the retuning. Furthermore, the structures with conventional pi-mode suppressors using transversal shorting posts along the structure may distort H-field so that the usual field probe measurements may not be reliable for precision measurements of the vane gap field distribution. This paper presents the effects of vane tip misalignment, RF retuning, employing the dipole mode suppressors, and field measurements based on the 3-D RF simulations and some measurements.

TUP048 **Experiences with the Fermilab HINS 325 MHz RFQ**

R.C. Webber *(Fermilab)*

The Fermilab High Intensity Neutrino Source (HINS) program has commissioned a pulsed, 325 MHz 2.5 MeV RFQ. The RFQ has successfully accelerated a proton beam at the design RF power. During RF conditioning, the resonant frequency of the structure exhibited a fast, runaway, power-dependent detuning behavior. This paper describes observations, simulations, ultimate cause, and solution of the problem.

TUP049 **Vane Machining by the Ball-end-mill for the New RFQ in the J-PARC Linac**

T. Morishita *(JAEA/J-PARC), K. Hasegawa, Y. Kondo (JAEA/J-PARC) H. Baba, Y. Hori, H. Kawamata, H. Matsumoto, F. Naito, M. Yoshioka (KEK)*

The J-PARC RFQ (length 3.1m, 4-vane type, 324 MHz) accelerates a negative hydrogen beam from 0.05MeV to 3MeV toward the following DTL. We started the preparation of a new RFQ as a backup machine. The new cavity is divided by three unit tanks in the longitudinal direction. The unit tank consists of two major vanes and two minor vanes. A numerical controlled machining with a conventional ball-end-mill has been chosen for the vane modulation cutting instead of the wheel shape cutter. In this presentation we will report the machining procedure, the results of the vane machining, RF properties, and some topics during the fabrication.

TUP050 **Vacuum Brazing of the New RFQ for the J-PARC Linac**

T. Morishita *(JAEA/J-PARC), K. Hasegawa, Y. Kondo (JAEA/J-PARC) H. Baba, Y. Hori, H. Kawamata, H. Matsumoto, F. Naito, M. Yoshioka (KEK)*

The J-PARC RFQ (length 3.1m, 4-vane type, 324 MHz) accelerates a negative hydrogen beam from 0.05MeV to 3MeV toward the following DTL. We started the preparation of a new RFQ as a backup machine. The new cavity is divided by three unit tanks in the longitudinal direction. The unit tank consists of two major vanes and two minor vanes. A one-step vacuum brazing of a unit tank has been chosen to unite these four vanes together with the flanges and ports. In this presentation we will report the results of the vacuum brazing with the dimension accuracy and an RF property.

TUP051 **Longer Pulse Acceleration Using RFQ and Laser Ion Source**

M. Okamura *(BNL), K. Kondo (BNL) T. Kanesue (Kyushu University, Department of Applied Quantum Physics and Nuclear Engineering) H. Kashiwagi (JAEA/TARRI)*

It was proved that direct plasma Injection Scheme (DPIS) is an efficient way to accelerate high current highly charged state heavy ion beam. More than 50 mA (peak current) of various heavy ion beams were accelerated in BNL, RIKEN and TITech. However, it was rather difficult to obtain longer pulse especially for highly charged particles. To induce highly charged states ions, a

high plasma temperature is required at the laser irradiation point and the high temperature automatically gives a very fast expansion velocity of the plasma. This shortens the ion beam pulse length. To compensate the shorter ion pulse length, we can extend the plasma drift length, but it will dilute the brightness of the plasma since the plasma expands three dimensionally. To avoid the reduction of the brightness, a simple long solenoid was applied to confine the diverging angle of the plasma. In the conference, this new technique will be explained and the latest results will be shown.

TUP052 **Preliminary Concept for the Project X CW Radio-frequency Quadrupole (RFQ)**

S.P. Virostek *(LBNL), D. Li, J.W. Staples (LBNL)*

Project X is a proposed multi-MW proton facility at Fermi National Accelerator Laboratory. It is the key element for future accelerator complex development intended to support world-leading High Energy Physics (HEP) programs. The Project X front-end would consist of H^- ion source(s), a low-energy beam transport (LEBT), radio-frequency quadrupole (RFQ) accelerator(s), and a medium-energy beam transport (MEBT). To support current and future HEP experiments at Fermilab, a CW RFQ is required. One of the chosen RFQ designs has a resonant frequency at 325 MHz. The RFQ provides bunching of the 10 mA H^- beam with acceleration up to 2.5 MeV and wall power losses of less than 250 kW. LBNL is currently developing the early designs for various components in the Project X front-end. The RFQ design concept and the preliminary RF and thermal analyses are presented here.

TUP053 **Preliminary Design of a 70MHz RFQ for Radio Isotope Beams**

Y.-S. Cho *(KAERI), J.-H. Jang, H.S. Kim, H.-J. Kwon (KAERI)*

A Radio Frequency Quadrupole (RFQ) has being desinged for the post-acceleration of radio isotope beams from a radio isotope beam production system such as an isotpe separation on line (ISOL) or an in-flight separation. For simple and efficient beam acceleration, a chrage breeding system such as an electron cyclotron resonance ion source (ECRIS) or electron beam ion source (EBIS) The RFQ will operate at a resonant frequency of 70MHz at cw mode, and accelerate the beams to 300keV/nucleon. In the conference we will present the design of the RFQ.

TUP054 **Latest Commisioning Results of the Siemens Particle Therapy* RFQ**

S. Emhofer *(Siemens Med), O. Chubarov, I. Hollenborg, C.M. Kleffner, V.L. Lazarev, M.T. Maier, H. Rohdjess, B. Schlitt, T. Sieber, B. Steiner, P. Urschütz (Siemens Med) H.K. Andersen, T. Andersen, M. Budde, F. Bødker, J.S. Gretlund, H.B. Jeppesen, L. Kruse, C.V. Nielsen, C.G. Pedersen, Ka.T. Therkildsen, S.V. Weber (Siemens DK)*

Siemens is currently preparing, installing and commissioning three IONTRIS particle therapy accelerator systems - two in Germany, in Marburg and Kiel, and one in Shanghai, China. Siemens IONTRIS is based on a synchrotron to accelerate protons and carbon ions for clinical applications up to 250 MeV resp. 430 MeV/u. The injector part consists of an RFQ to accelerate protons and light ions up to 400 keV/u followed by an IH-cavity, wherein the particles achieve 7 MeV/u. The results of the commissioning of the RFQ in the test facility in Denmark will be presented.

TUP055 **3D Aspects of the IFMIF-EVEDA RFQ: Design and Optimization of the Vacuum Grids, of the Slug Tuners and of the End Cell**

A. Palmieri *(INFN/LNL), F. Grespan, A. Pisent (INFN/LNL) F. Scantamburlo (INFN- Sez. di Padova)*

In order to attain the stringent goals that assure the required performances of the IFMIF-EVEDA RFQ in terms of field uniformity, Q-value and RF-induced heat removal capability, the study of the 3D details of the cavity is particularly important. In this paper the main issues regarding the design of the slug tuners, cavity ends and vacuum grids are addressed, as well as the related optimization procedure.

TUP057 **Completion of the Fabrication of TRASCO RFQ**

E. Fagotti *(INFN/LNL), M. Comunian, F. Grespan, A. Palmieri, A. Pisent, C. Roncolato (INFN/LNL)*

Abstract The Legnaro National Laboratory (LNL) is building the 30 mA, 5 MeV front end injector for the production of intense neutron fluxes for interdisciplinary application. This injector comprises a proton source, a low energy beam transport line (LEBT), a radio frequency quadrupole (RFQ) and a beam transport line designed to provide a 150 kW beam to the beryllium target used as neutron converter. The RFQ, developed

within TRASCO project for ADS application, is designed to operate CW at 352.2 MHz. The structure is made of OFE copper and is fully brazed. The RFQ is built in 6 modules, each approximately 1.2 meter long. This paper covers the mechanical fabrication, the brazing results and the low power tests for the whole structure.

TUP058 **3D Thermo Mechanical Study on IFMIF-EVEDA RFQ**

F. Scantamburlo *(INFN- Sez. di Padova), A. Pepato (INFN- Sez. di Padova) M. Comunian, E. Fagotti, F. Grespan, A. Palmieri, A. Pisent (INFN/LNL)*

In the framework of the IFMIF/EVEDA project, the RFQ is a 9.8 m long cavity, with very challenging mechanicals specifications. In the base line design, the accelerator tank is composed of 18 modules that are flanged together. An RFQ prototype, composed of 2 modules with a reduced length, aimed at testing all the mechanical construction procedure is under construction. In this paper, the thermo-mechanical study by means of 2D thermo structural and 3D fluid-thermal-structural simulations will be described. The measurements made with a cooling water circuit on a part of the RFQ prototype and the comparison with fluid thermal simulation will be reported.

TUP059 **Full 3D Modeling of a Radio-Frequency Quadrupole**

B. Mustapha *(ANL), A. Kolomiets, P.N. Ostroumov (ANL)*

An integral part of the ongoing ATLAS efficiency and intensity upgrade is an RFQ to replace the first section of the existing injector. The proposed RFQ is 3.8 m long made of 10^6 cells with 30 keV/u input energy and 260 keV/u output energy. The RFQ was designed using the DesRFQ code which produces a file consisting of the length, modulation and the 8 coefficients of the 8-term potential for every cell. To independently check the design we created full 3D models of the RFQ including cell modulation in both Micro-Wave Studio (MWS) and Electro-Magnetic Studio (EMS). The MWS model was used to verify the phasing and energy gain along the RFQ using particle tracking and the EMS model was used to extract the electric field cell by cell assuming the electrostatic approximation. A very good agreement was obtained between the full 3D model and the 8-term potential description in TRACK. In addition to the standard sinusoidal vane profile we studied the option of converting

the cells with maximum modulation (~ 40 cells) into trapezoidal cells. The output energy was increased from 260 keV/u to ~ 300 keV/u with minimal change to beam dynamics. This option is the final RFQ design.

TUP060 **Possibility of Thermal Instability in 4-vane RFQ Operation with High Heat Loading**
V.V. Paramonov *(RAS/INR)*
Due to dispersion properties 4-vane RFQ cavity without resonant coupling is a thermally unstable structure. With deterioration of balance for local detuning there is a possibility for runaway in the field distribution and related thermal effects. It can results, in principle, in irreversible plastic deformations and cavity frequency shift. Both the increment and the threshold of instability are proportional to the average dissipated RF power. This possibility is more probable for long RFQ cavities. Also particularities for the cavity ends design are important. Some general features of this effect are discussed qualitatively and illustrated with simulations.

TUP061 **Development of a 324 MHz Drift Tube Linac for CSNS**
X. Yin *(IHEP Beijing)*
In the CSNS project, the 324HMz Alvarez-type Drift Tube Linac (DTL) will be used to accelerate the H^- ion beam from 3 to 80.77 MeV. The R&D for the development of a prototype structure for the energy range from 3 to 8.88 MeV is taking place at IHEP. The fabrication status of this 2.8 m Alvarez tank containing 28 drift tubes is introduced in this document. The fabrication and measurement results of the focusing quadrupoles are also presented in this paper.

TUP062 **Development of a Quadrupole Magnet for CSNS DTL**
X. Yin *(IHEP Beijing)*
In the 324MHz CSNS Drift Tube Linac (DTL), the electromagnetic quadrupoles will be used for transverse focusing. Since the higher operating frequency leads the size of the drift tube (DT) becoming smaller, the electromagnetic quadrupole containing SAKAE coil has been applied using the improved periodic reverse electroforming. The details of the design, the fabrication process, and the measurement results for the quadrupole magnet are presented in this paper.

TUP063 **Design of a Drift Tube Linac for the CSNS Project**
X. Yin *(IHEP Beijing)*
In the China Spallation Neutron Source (CSNS)

project, the 324HMz Alvarez-type DTL will be used to accelerate the H^- ion beam from 3 to 80.77 MeV. A Four tank structure has been chosen. The Electromagnetic Quadrupole s(EMQ) will be used for the transverse focusing inside the drift tubes. The DTL structure design parameters and the simulation of the EMQ are presented in this paper. The design of the electrical field is also described in this paper.

TUP064 **The Optimization Design and Tolerance Analysis of DTL**

Z.J. Wang *(IMP), Y. He (IMP)*

The separated function DTL in SSC(Separated Sector Cyclotron)-linac is being designed. According to the design requirements, $238U^{34+}$ ions are accelerated from 0.143MeV/u to 0.976MeV/u throught the DTL. The method coupling DAKOTA(Design Analysis Kit for Optimization and Terascale Application) and beam simulation code BEAMPATH is used to analyze tolerance of the structure. The tolerance of beam parameters to various type of random errors and misalignment are studied with Monte Carlo simulation,so as to define the engineering tolerance and alignment. In this paper, the beam dynamics simulation and the tolerance analysis of the SSC-linac are presented.

TUP065 **Concept Design of CW SC Proton Linac Based on Spoke Cavity for China ADS**

Z. Li *(Southwest University of Science and Technology)*

A 10mA CW proton linear accelerator, which comprise an ECR proton source, a 352.2MHz RFQ with output energy of 3.5-5MeV still to be optimized, and a sequence of superconducting cavities of 352.2MHz and 704.4MHz to accelerate the proton up to 800MeV was proposed as the accelerator driver for the China ADS project. The spoke cavity with beta=0.12-0.4 were optimized to accelerate proton up to 100MeV from the RFQ output energy, the focusing lattice based on the optimized results are proposed and the fundamental beam dynamic study were presented.

TUP066 **Production Design of the Drift Tube Linac for the CERN Linac4**

S. Ramberger *(CERN), G. De Michele, F. Gerigk, J.-M. Giguet, J.-B. Lallement, A.M. Lombardi, E. Sargsyan, M. Vretenar (CERN)*

The design of the Drift Tube Linac (DTL) for the new linear accelerator Linac4 at CERN has been made ready for production: H–ion beams

of up to 40 mA average pulse current are to be accelerated from 3 to 50 MeV by three RF tanks operating at 352.2 MHz and at duty cycles of up to 10%. In order to provide a margin for longitudinal matching from the chopper line, the longitudinal acceptance has been increased. The synchronous phase starts at -35^o in tank1 and ramps linearly to -24^o over the tank while it went from -30^o to -20^o in the previous design. The accelerating gradient has been lowered to 3.1 MV/m in Tank1 and increased to 3.3 MV/m in Tank2 and Tank3 for a better distribution of RF power between tanks that is compatible with a mechanical design. To make the transverse acceptance less sensitive to alignment and gradient errors, the focusing scheme has been changed to FFDD over all 3 tanks. Design features that were demonstrated in earlier reports have been improved for series production. Results of high power RF tests of the DTL prototype equipped with PMQs are reported that test the voltage holding in the first gaps in presence of magnetic fields.

TUP067 **Reduction of Transverse Emittance Growth in J-PARC DTL**

H. Sako *(JAEA/J-PARC), M. Ikegami, A. Miura, G.H. Wei (JAEA/J-PARC)*

Transverse emittance growth was observed in J-PARC Drift Tube Linac (DTL). In order to suppress the growth, we searched for optimum parameters at MEBT1, by measuring transverse emittance using four wire scanner monitors at the exit of DTL. At 15 mA peak beam current in Dec 2009, horizontal and vertical rms emittance was reduced by 12 % and 10 %, respectively, by setting the amplitudes of the first and second bunchers to 120 % and 90 % with respect to the designed settings. The resulting normalized horizontal and vertical emittance was 0.230 and 0.205 pi mm mrad. At 20 mA in Jan 2010, horizontal and vertical rms emittance was reduced by 17 % and 10 %, respectively, by setting the amplitudes of the first and second bunchers to 110 % and 80 % with respect to the designed settings. The resulting normalized horizontal and vertical emittance was 0.273 and 0.253 pi mm mrad. At 15 mA, we further reduced the horizontal and vertical emittance to 0.171 and 0.200 pi mm mrad by increasing the eighth quadruple magnet field at MEBT1 by 20 % to the designed value. The measured transverse emittance dependence on buncher electric field and quadruple magnetic field will be compared with simulation.

TUP068 **Operation Experiences of the DTL/SDTL for the J-PARC**
T. Ito *(JAEA/LINAC) K. Nanmo (KEK)*
The operation of the DTL and the Separated type DTL (SDTL) of the J-PARC started in November 2006. The DTL and SDTL are currently running stable and accelerating the beam. For stable operation of the DTL/SDTL, We have done maintenance of the equipments, like an RF coupler, and improved the troubles. In this paper, we will present the operation experiences of the DTL and the SDTL.

TUP069 **Radiation from the SDTL of J-PARC**
F. Naito *(KEK), K. Nanmo, H. Tanaka (KEK) H. Asano, T. Ito (JAEA/J-PARC)*
X-ray radiation from the SDTL of J-PARC linac has been observed with the beam loss monitor by the cavity. The results show that the X-ray intensity depends not only on the RF power level of the tank but also on the RF structure of the tank. In the paper we will show the results of the investigation for the origin of the X-ray radiation from the tank.

TUP070 **RF-design and Construction of New Linac Injector for the RIKEN RI-Beam Factory**
K. Yamada *(RIKEN Nishina Center), S. Arai, Y. Chiba, H. Fujisawa, E. Ikezawa, O. Kamigaito, M. Kase, N. Sakamoto, K. Suda, Y. Watanabe (RIKEN Nishina Center) Y. Touchi (SHI)*
A new linac injector, which will be exclusively used for the RIKEN RI-Beam Factory, has been constructed to increase the beam intensity of very heavy ions such as xenon and uranium. The injector system consists of a superconducting ECR ion source, RFQ linac, three DTLs, and beam transport system including strong quarupole magnets and beam bunchers. Two DTL resonators were newly designed while existing devices including the RFQ* were modified to the other resonators. Direct coupling scheme was adopted for the rf-sytems of the DTLs, where the design study was successfully perfomed by using the MWS code. This paper focuses on the design procedure of the DTLs and RFQ as well as the results of their low and high power tests.

TUP071 **Research on Drift Tube Linac Model Cavity for CPHS**
S.X. Zheng *(TUB), X. Guan, J. Wei, H.Y. Zhang (TUB) J.H. Billen, L.M. Young (TechSource) J. Stovall (CERN) Y.L. Zhao (IHEP Beijing)*
The CPHS project in Tsinghua University plans

to construct a 13 MeV linear accelerator to deliver a pulsed proton beam having an average beam current of 2.5 mA. A Drift Tube Linac (DTL), following a Radio Frequency Quadrupole accelerator(RFQ), will accelerate protons from 3 to 13MeV. The accelerating field and phase will be ramped to match the longitudinal restoring forces at the end of the RFQ. Likewise, the transverse focusing forces, provided by permanent-magnet quadrupole lenses (PMQs) will be programmed to match the transverse restoring forces at the end of the RFQ to avoid missmatch and avoid parametric resonances. We will present the main physics design parameters of CPHS DTL and describe the properties of the resonant cavity. We plan to apply electron beam welding technology exclusively in the fabrication of the drift tubes and will present the test results from our engineering prototyping program.

TUP072 **An Equivalent Circuit for Post Coupler Stabilization in a Drift Tube Linac**

F. Grespan *(INFN/LNL) G. De Michele, S. Ramberger, M. Vretenar (CERN)*

Post Couplers (PC's) are devices used in order to reduce the effect of perturbations on the operating mode of a DTL, using the resonant coupling stabilization method. In this article an equivalent circuit for a DTL equipped with PC's is presented, together with a 3D simulation analysis, which can explain the post coupler stabilization working principle and define a new tuning strategy for DTL cavities. The PC tuning procedure based on the equivalent circuit and on frequency measurements has been tested and validated with measurements on the Linac4 DTL aluminum model.

TUP073 **Electro-Dynamics Characteristics of RF Wobbler Cell for Heavy Ion Beam**

S. Minaev *(ITEP), N.N. Alexeev, A. Golubev, V.A. Koshelev, T. Kulevoy, B.Y. Sharkov, A. Sitnikov (ITEP)*

Intense heavy ion beam is very efficient tool to generate high energy density states in macroscopic amounts of matter. As result it enables unique methods to study astrophysical processes in the laboratory under controlled and reproducible conditions. For advanced experiments on high energy density physics the cylindrical target irradiated by hollow cylindrical beam is required. This combination provides extremely high densities and pressures on the axis of imploding cylinder. A new method for

RF rotation of the ion beam is applied for required hollow beam formation. The RF system consisting of two four-cell H-mode cavities is under development for this purpose now. The cavities frequency has been chosen 298 MHz, which is sufficient for uniform target illumination at 100 ns pulse duration. The deflecting electrodes shape has been optimized to provide the uniform deflection of all particles in beam's cross-section. The prototype of the deflector cell was constructed. A measured electro-dynamics characteristic is presented. As well frequency corrections methods are considered in this paper.

TUP074 **LEBT Beam Tuning Using Neutralized Ions in the SARAF Front End**

L. Weissman *(Soreq NRC), D. Berkovits, Y. Yanay (Soreq NRC)*

The SARAF front end is composed of a proton/deuteron ECR ion source and a LEBT to match the beam to a 4-rod RFQ. The LEBT is consisting of an analyzing magnet, an aperture, three magnetic solenoid lenses and a diagnostic system. The typical operation vacuum, downstream the analyzing magnet, is of the order of 10^{-6} mbar at 5 mA analyzed beam current. In the emittance measurement we identify a beam of secondary-species particles, differently affected by the solenoid and so arriving with a different phase-space profile at the emittance detector. The secondary beam is the result of a charge exchange interaction in which an ion interacts with residual gasses in the beam line, most likely hydrogen gas coming from the ion source, and become neutral. For 20 keV protons colliding with H2 the calculated ion neutralization rate is $1\%/m/10^{-6}$ mbar. Since the neutral portion of the beam is not affected by the magnetic focusing / steering elements, a none concentric neural and ion beams in the phase-space is a measure of mistuned beam or misalign magnets. These effects were proved and followed by beam dynamics simulation and are used to match the beam to the RFQ.

TUP075 **Residual Gas Pressure Dependence on Beam Loss**

A. Miura *(JAEA/J-PARC), M. Ikegami (JAEA/J-PARC) H. Sako (JAEA) G.H. Wei (KEK/JAEA)*

Residual gas in beam transport line essentially affects the beam loss and residual radiation on the accelerator. J-PARC linac is usually operated under $1.0 \cdot 10^{-6}$ to $1.0 \cdot 10^{-5}$ Pa in SDTL and A0BT sections. In this situation, no serious beam loss

was observed during the beam operation. In future development of J-PARC linac, because the peak beam energy and output will be increased, it is getting more serious problem. Before the development, it is important to understand a cause of beam loss and relation between beam loss and residual gas pressure. We measured beam loss at the normal and worse vacuum condition in both SDTL and A0BT sections. The result indicates that the beam loss depends on the residual gas pressure and position where the beam loss occurs is about 20 to 30 meter downstream. This suggests the optimum position for installation of vacuum system to minimize the beam loss. In this paper, we describe the experimental result and its discussions. In addition, the cause of the beam loss is considered to be a stripping from negative hydrogen ions to neutral hydrogen atoms. This mechanism is also discussed in this paper.

TUP076 **Status of Beam Loss Evaluation at J-PARC Linac**

A. Miura *(JAEA/J-PARC), N. Kikuzawa, T. Maruta, K. Yamamoto (JAEA/J-PARC) Z. Igarashi, T. Miyao (KEK) M. Ikegami (J-PARC, KEK & JAEA) H. Sako (JAEA) S. Sato (JAEA/LINAC)*

Since November, 2007, J-PARC Linac has been operated at 7.2kW beam power. During the operation, beam losses possibly caused by the H0 particles generated by the interaction between H^- beam and residual gas in the transport line were observed in the SDTL (Separated-type Drift-Tube Linac) section. In the linac operation, Ar-CO2 gas proportional counters are employed for the measurement of beam loss, but they are also sensitive to background noise of X-ray emitted from RF cavities. In this section, protons, secondary hadrons and gamma rays would be mainly generated as a beam loss, but it is not easy to estimate real beam loss using the proportional counter. The plastic scintillation counters with less X-ray sensitivity and 3He proportional counters with high thermal neutron sensitivity will be also employed to measure the beam loss. The combination of these detectors would bring more accurate beam loss measurements with suppression of X-ray noise. A measurement of emission position and angle distributions of protons due to H^- beam loss is being planed. This result would lead to clarify the source of beam loss. This paper reports status of beam loss evaluation using these detectors.

TUP077 **Solenoid-Based Focusing in a Proton Linac**
I. Terechkine *(Fermilab), J. DiMarco, W. Schappert, D.A. Sergatskov, M.A. Tartaglia (Fermilab)*
Development of solenoid-based focusing lenses for transport channel of an R&D linac front end at FNAL is in its final stage. Lenses for the room temperature section of the linac are assembled in individual cryovessels and certified using a devoted stand. During this certification process, for each lens, position of its optical axis relative to the cryovessel is found in the warm and cold state. Lenses for the superconducting sections are ready for production, and development of a cryomodule to house multiple superconducting lenses and RF cavities is in progress. Studies were also conducted to measure fringe magnetic field of a lens in a cryomodule, to investigate a laser-based method of alignment, and to evaluate the extent of beam quality degradation due to imperfections in lens construction and alignment. This report presents some results of these studies.

TUP078 **Test of a Coaxial Blade Tuner at HTS/FNAL**
Y.M. Pischalnikov *(Fermilab), S. Barbanotti, E.R. Harms, A. Hocker, T.N. Khabiboulline, W. Schappert (Fermilab) A. Bosotti, C. Pagani, R. Paparella (INFN/LASA) M. Scorrano (INFN-Pisa)*
Fermilab is building Cryomodule 2 for ILCTA facility at NML. A coaxial blade tuner has been chosen for the CM2 1.3GHz SRF cavities. A summary of results from cold test of the tuners in the Fermilab Horizontal Test Stand will be presented.

TUP079 **SS Helium Vessel Development for 1.3 GHz SRF Cavities at Fermilab**
N. Dhanaraj *(Fermilab), S. Barbanotti, J.S. Brandt, H. Carter, M.H. Foley, J. Grimm (Fermilab)*
Fermilab is currently focusing its efforts toward the development of Stainless Steel (SS) helium vessels for its 1.3 GHz SRF cavities. The objective is to transition towards the concept of using SS helium vessels to dress the bare SRF cavities, thereby paving way for significant cost reduction and efficient production techniques for future accelerators. The biggest challenge has been to design a reliable interface between the niobium cavity end group and the stainless steel end flange that encloses the helium vessel. Fermilab has been pursuing a brazed joint design to allow this transition. Additional design challenges associated with this transition are ensuring proper

cooling of the cavity, compensating for the difference in thermal contraction between the SS helium vessel and niobium cavities, and also modification of the tuning procedure and ensuring the safety and reliability of the blade and piezo tuners. Current efforts on the qualification of the niobium-SS braze joint, finite element simulations of the thermal design aspects, bench testing of actual cavity displacements, and study of the effects on the tuners will be presented.

TUP080 **Fermilab 1.3-GHz Cryomodule Cooldown and RF Tests**

S. Nagaitsev *(Fermilab), B. Chase, E.R. Harms, A.L. Klebaner, J.R. Leibfritz, J. Reid (Fermilab) C. Adolphsen, C.D. Nantista (SLAC)*

The results of the cooldown and rf tests of the Tesla-type cryomodule will be presented.

TUP081 **Superconducting RF Cryomodule Production and Testing at Fermilab**

M.S. Champion *(Fermilab), T.T. Arkan, H. Carter, E.R. Harms, J.R. Leibfritz (Fermilab)*

Fermilab has produced two cryomodules for superconducting RF (SRF) applications to date. The first of these is an ILC prototype containing eight 1.3 GHz Tesla-type cavities and a superconducting quadrupole. This cryomodule is of the 'Type 3+' design developed by the TESLA collaboration. The assembly of this cryomodule was accomplished at Fermilab with much assistance from DESY and INFN-Milano. The cryomodule was tested at Fermilab in the summer of 2010. The second cryomodule produced at Fermilab contains four 3.9 GHz nine-cell cavities. The cavities and cryomodule were designed at Fermilab; the design concepts are quite similar to the 1.3 GHz Type 3+ cryomodule. This cryomodule was shipped to DESY, tested, and is now operating as part of a third-harmonic system in the FLASH facility. Fermilab plans to build five more 1.3 GHz cryomodules over the next several years for a total of six, which will be installed and operated in the New Muon Lab beam test facility at Fermilab.

TUP082 **Cryomodule Tests of Tesla-like Cavities in S1-Global for ILC**

E. Kako *(KEK), S. Noguchi, N. Ohuchi, M. Satoh, T. Shishido, K. Watanabe, Y. Yamamoto (KEK)*

Cryomodule tests of four Tesla-like superconducting cavities is under preparation in the S1-Global project at KEK. Assembly of the cryomodule was started in January 2010, and the install-

tion in the STF tunnel was completed in April. First cool-down tests are scheduled in June. The low rf power tests of the Tesla-like cavities will be carried out in July. The high rf power tests are scheduled between September and December, 2010.

TUP083 **Development and Application of the Explosion Welding Method for Manufacture of Tube Constructions in the System of the International Linear Collider**

B.M. Sabirov *(JINR)*

The results obtained by the JINR/Dubna-RFNC/Sarov-FNAL/Batavia-INFN/Pisa in designing the fourth-generation cryomodule for the ILC are reported. A technology for making a bimetallic Ti+SS tube transition element by the explosion welding method has been developed and implemented for the first time. All Ti+SS samples were subjected to the metallografic analysis and tested for strength and leaks at different cryogenic temperatures. The leak rate at 1.8K was <10(-11)Pa.m(3)/s.For redesign cryomodule helium vessel we developed Nb+SS transition elements using explosion welding technology. Preliminary tests shown reliable strehgth and density of joint Nb+SS bonds. Upper limit of leak rate is (3-5).10(-10)atm.cc/s.

TUP084 **Operational Experience with Cryomodules for Ion Linacs at Michigan State University**

J. Popielarski *(NSCL), J. Bierwagen, S. Bricker, S. Chouhan, C. Compton, J. DeLauter, K. Elliott, P. Glennon, W. Hartung, M. Hodek, M.J. Johnson, O.K. Kester, F. Marti, S.J. Miller, D. Morris, D. Norton, L. Popielarski, D. Sanderson, N.R. Usher, N. Verhanovitz, J.J. Vincent, J. Wlodarczak, R.C. York (NSCL)*

Michigan State University is developing cryomodules for two projects: a 3 MeV per nucleon superconducting linac for re-acceleration of exotic ions (ReA3, under construction, requiring 4 cryomodules), and a 200 MeV per nucleon driver linac for the Facility for Rare Isotope Beams (FRIB, under design, requiring 52 cryomodules). The first two ReA3 cryomodules contain a total of seven quarter-wave resonators for beta = 0.041 and five superconducting solenoids (9 T). These cryomodules have been fabricated and installed, with testing underway. The third ReA3 cryomodule (requiring eight QWRs for beta = 0.085 and three solenoids) is being fabricated. A fourth ReA3 module consisting of a single quarter-wave resonator will be used for matching. A prototype cryomodule for FRIB is being designed for

two beta = 0.53 half-wave resonators and one solenoid. The experience so far with system performance of the cryomodules will be described in this paper. Topics will include cavity performance, magnetic shielding, microphonics, cavity tuning, input coupler performance, and thermal loads.

TUP085 **Cross Section Monitor for INR Linac Beam**
P.I. Reinhardt-Nickoulin *(RAS/INR), A. Feschenko, S.A. Gavrilov, I.V. Vasilyev (RAS/INR)*
The monitor to measure a transverse cross section of the accelerated beam has been developed and implemented in INR Linac. Operation of the monitor is based upon utilization of residual gas ionization. Ion flux cross section after extraction of the ions from the beam line by electrostatic field and subsequent energy separation in electrostatic analyzer reproduces a transverse cross section of the accelerator beam. Aμchannel plate intensifier followed by a phosphor screen is used to observe ion cross section. The image is optically transmitted to a CCD camera installed remotely and shielded for protection. The monitor enables to observe beam cross section, beam profiles and beam position, as well as their evolution in time within a wide range of beam intensities and energies. Monitor operation and parameters are described. Some experimental results are presented.

TUP086 **Emittance Measurements for Stable and Radioactive Ion Beams**
S.A. Kondrashev *(ANL), A. Barcikowski, F. Levand, P.N. Ostroumov, R.C. Pardo, G. Savard, R.H. Scott, T. Sun, R.C. Vondrasek, G.P. Zinkann (ANL)*
An emittance meter based on a pepper-pot coupled to a CsI (Tl) scintillator has been developed over the last several years [1] at Argonne National Laboratory. A compact version of such a probe for on-line emittance measurements has been designed, built and installed into the low energy beam transport (LEBT) line of the Argonne Tandem Linac Accelerator System (ATLAS) and also downstream of the gas catcher of the recently commissioned Californium Rare Isotope Breeder Upgrade (CARIBU). The probe has demonstrated the capability to measure emittance of ion beams with a current density as low as 10 nA/cm^2. Systematic emittance measurements in the ATLAS LEBT for different ion species have been done and results will be presented. The probe, based on a pepper-pot coupled to an MCP viewing system, has been designed and built to measure

the emittance of low intensity (10^2-106 ions/s) radioactive CARIBU ion beams.

TUP087 **Beam Profile Measurements and Matching at SNS: Practical Considerations and Accommodations**

C.K. Allen *(ORNL), W. Blokland, J. Galambos (ORNL)*

We present practical aspects of measuring beam profiles and applications using the profile data. Standard applications include (RMS) beam size calculation, Courant-Snyder parameter calculation, and beam matching. Each application becomes increasingly model dependant relying upon results of the preceding application. Because of the cascade of interdependence, of obvious concern is measurement error which propagates throughout the calculations. Also important is the accuracy of the beam model used to make calculations from measurement results; doubly so for matching where the model both estimates Courant-Snyder parameters and predicts new magnet strengths. Not as obvious are complications introduced by the long pulse nature of the SNS linac. Currently, we can sample the beam only through a 50 microsecond window along a macro pulse lasting up to 1 millisecond. Consequently the measurements available are not necessarily representative of the whole beam. Presented are quantitative results on measurement error, model accuracy, and sampling location, how these quantities vary along the linac, and the ramifications on matching techniques.

TUP088 **The Laser Emittance Scanner for 1 GeV H^- beam***

D. Jeon *(ORNL), A.V. Aleksandrov, W.P. Grice, Y. Liu, I. Nesterenko, A. Webster (ORNL) A.A. Menshov (RAS/INR)*

A transverse phase space laser emittance scanner is under fabrication for the 1-GeV H^- beam of the SNS linac, using a laser beam as a slit. For a 1 GeV H^- beam, it is difficult to build a slit because the beam stopping distance is more than 50 cm in copper. We proposed to use a laser beam as an effective slit by stripping off the outer electron of the H^- (making it neutral) upstream of a bending magnet and measuring the stripped component downstream of the bend magnet. A brief discussion of the design and modeling of the system are presented. We are expecting to make a preliminary measurement from late August 2010.

TUP089 **Transverse Emittance Measurements in MEBT at SNS**

A.P. Zhukov *(ORNL), A.V. Aleksandrov, A.P. Shishlo (ORNL)*

The latest modifications of the MEBT emittance scanner and the test results are presented. The scanner consists of a slit and harp placed in the MEBT section of SNS Linac with H^- energy of 2.5 MeV. It was initially commissioned during the early days of SNS. The initial design allowed to get information about beam core but was incapable of getting precise data about halo. Several improvements in hardware and software were performed recently. They significantly increased signal to noise ratio, reduced harp wires electron coupling and increased scan speed. The latest measurements with the new system show a good agreement with the simulation results from simple models.

TUP090 **Development of a Bunch Length Detector**

J.Y. Kim *(SNU), H.-C. Bhang, D.G. Kim (SNU) J.-W. Kim (NCC, Korea)*

A bunch length detector has been designed and constructed, which can measure current distributions inside the beam bunch. The device measures secondary electrons that are emitted when the beam hits a negatively biased thin target wire. Two main components of the device are an rf deflector to deflect secondary electrons vertically in correlation with the rf time of the beam bunch, and microchannel plate to detect the electrons after spatial discrimination. Rf properties of the rf deflector were first numerically analyzed, and a full-scale cold model was built and tested using a network analyzer. Microchannel plate detector was tested using a beta-emitting isotope source. The electron optics were calculated to design the structure of the detector, and the actual detector will soon be constructed and tested using a cw proton beam from a cyclotron.

TUP091 **Energy and Energy Spread Measurements Using the Rutherford Scattering Technique for Tuning the SARAF Superconducting Linac**

J. Rodnizki *(Soreq NRC), A. Perry, L. Weissman (Soreq NRC)*

The SARAF accelerator is designed to accelerate both deuteron and proton beams up to 40 MeV. Phase I of SARAF consists of a a 4-rod RFQ (1.5 MeV/u) and a superconducting module housing 6 half-wave resonators and 3 superconducting solenoids (4-5 MeV). The ions energy and energy spread were measured using the Rutherford

scattering technique . This technique is used to tune the cavities to the desired amplitude and phase. The downstream HWR is used as a buncher and the beam energy spread as function of the bunching RF voltage is applied to estimate the longitudinal emittance. In this work, we present a longitudinal emittance measurement algorithm, which is based on the bunch energy spread as a function of the buncher's amplitude, similar to the standard algorithm that uses the bunches' temporal spread. The tuning and measured longitudinal parameters are in qualitative agreement with the predicted beam dynamics simulation.

TUP092 **The ISAC II Current Monitor System**

M. Marchetto *(TRIUMF), J. Aoki, K. Langton, R.E. Laxdal, W.R. Rawnsley, J.E. Richards (TRIUMF)*

The post acceleration section of the ISAC radioactive ion beam (RIB) facility is composed of a radio frequency quadrupole (RFQ) followed by a drift tube linac (DTL), both room temperature machines, that serve a medium energy experimental area up to 1.8 MeV/u, and a superconducting linac (SCLINAC) that serves a high energy experimental area. This SCLINAC, composed of forty quarter wave resonators housed in eight cryomodules, is capable of a total accelerating voltage of circa 40 MV. Since each cavity is phased independently at the maximum operational voltage, the final energy depends on the mass to charge ratio of the accelerated species. In order to deliver energies higher than 5 MeV/u we need to monitor the beam current as mandated by our operating license. The current monitor system (CMS) is composed of two non intercepting and one partially intercepting monitor. The signals from these three monitors are processed in a single control system that provides a go signal to the Safety system enabling beam delivery. The CMS system allows to exploit the SCLINAC to its full potential. In this paper we will present both hardware configuration and software control of the CMS.

TUP093 **Planned Diagnostics for the Facility for Rare Isotope Beams at Michigan State University**

S. Assadi *(FRIB), M.J. Johnson, T.L. Mann, E. Pozdeyev, E. Tanke, X. Wu, R.C. York, Q. Zhao (FRIB) M. Doleans, F. Marti (NSCL)*

The Facility for Rare Isotope Beams (FRIB) at Michigan State University will utilize a high power, heavy-ion linear accelerator to produce

rare isotopes in support of a rich program of fundamental research. The linac will consist of a room temperature-based front-end system producing beams of approximately 0.3 MeV/u. Three additional superconducting linac segments will produce beams of >200 MeV/u with a beam power of up to 400 kW. Because of the heavy-ion beam intensities, the required diagnostics will be largely based on non-interceptive approaches. The diagnostics suites that will support commissioning and operation are divided into lower energy <0.3 MeV/u front-end and higher energy driver linac systems (<200 MeV/u for uranium). The instruments in the driver linac include strip-line BPM, toroid, BCM, and 3-D electron scanners to measure rms beam size. A desired availability of >90% and an aggressive commissioning schedule lead to some challenges in beam diagnostics requirements that will be addressed in this paper. We are committed to using an architecture common with the rest of FRIB for the data acquisition and timing which will also be discussed in this paper.

TUP094 **Development of Cavity BPM for the European XFEL**

D. Lipka *(DESY), D. Noelle, M. Siemens, S. Vilcins (DESY)*

The European XFEL, currently under construction at the DESY site in Hamburg, require high precision orbit control in the long undulator sections and in addition in some other locations of the machine, like bunch compressors, matching sections, or for the intra bunchtrain feedback system. Due to the pulsed operation of the facility the required high precision has to be reached by single bunch measurements. So far only cavity BPMs achieve the required performance and will be used at the European XFEL. We report on the development of two types of cavity BPMs for the intersection of the undulators with 10 mm beam pipe and for sections with a standard beampipe diameter of 40.5 mm. The prototypes for both types show the properties as expected for simulation results. The paper further concentrates on the industrialisation process. It points out some traps and their cures during the production process.

TUP095 **Standard Electron Beam Diagnostics for the European-XFEL**

D. Noelle *(DESY)*

The European XFEL is a 4th generation synchrotron radiation source, under construction in Hamburg. Based on different Free-Electron-

Laser and spontaneous sources, driven by a 17.5 GeV superconducting accelerator, this international facility will provide several user stations with photons simultaneously. Due to superconducting technology high average as well as peak brilliance can be delivered. Flexible bunch pattern are possible for optimum tuning to the experiments demands. This paper will present the current status of the electron beam diagnostics. An overview of the entire system will be given, as well as details on the development of the main systems like BPM, charge and transmission diagnostics, beam size and beam loss monitor systems will be presented. Furthermore, results of first measurements with XFEL prototypes in FLASH will be shown.

TUP096 **First Results of Slice Emittance Diagnostics with an Energy Chirped Beam at PITZ**

Ye. Ivanisenko *(DESY Zeuthen), G. Asova, H.-J. Grabosch, M. Krasilnikov, M. Mahgoub, M. Otevrel, S. Rimjaem, F. Stephan (DESY Zeuthen) M.A. Khojoyan (YerPhI) G. Vashchenko (NSC/KIPT)*

Recent successes in existing FEL facilities operation and improvements in future FELs design became possible due to detailed research in high-brightness electron beam production. The photo injector test facility in Zeuthen (PITZ) is the DESY center for electron source characterisation and optimisation. The new slice emittance diagnostics was recently commissioned at PITZ. In the measurement approach a bunch is accelerated off-crest in the second accelerating cavity after the gun, part of the bunch is selected after a dipole with a slit along momentum, transverse emittance of the bunch part is measured using a quad or a slit scan. Test measurement results are presented for 1 nC charge, flat-top and gaussian longitudinal laser shapes. Following the interest in FEL operation with lower charge simulations were performed to calculate the emittance resolution for different charge levels. The measurement experience, advantages and disadvantages of the approach will be discussed.

TUP097 **Methodical Studies for Tomographic Reconstruction As a Novel Method For Emittance Measurements At the PITZ Facility**

G. Asova *(DESY Zeuthen), M. Krasilnikov, J. Saisut, F. Stephan (DESY Zeuthen)* ***G. Asova***

The Photo-Injector Test Facility at DESY in Zeuthen, PITZ, is dedicated to development of high brightness electron sources for linac-based FELs like FLASH and the European XFEL.

A key parameter to judge on the beam quality for an FEL is the transverse phase space distribution, wherefrom the PITZ beamline is equipped with three Emittance Measurement Systems as the only dedicated to that apparatus. In 2010 the diagnostics has been upgraded with a module for tomographic reconstruction comprising three FODO cells, each surrounded by two observation screens. The anticipated advantages of tomographic measurements are improved resolution for low charge beams and ability to evaluate both transverse planes simultaneously. Major operational challenges are the low beam energies the module will be used with - 15 - 30 MeV, strong space charge effects for high bunch charges and, consequently, difficulties to match the beam into the optics of the lattice. This contribution presents studies on the performance of the module for different initial conditions as bunch charge and temporal laser pulse shape. Influence of residual noise on the quality of the reconstructed phase space is discussed.

TUP098 **Wakefield Monitor Development for CLIC Accelerating Structure**

F. Peauger *(CEA), W. Farabolini, P. Girardot (CEA) A. Andersson, G. Riddone, A. Samoshkin, A. Solodko (CERN) R.J.M.Y. Ruber (Uppsala University) R. Zennaro (PSI)*

To achieve high luminosity in CLIC, the accelerating structures must be aligned to an RMS accuracy of 5 μm with respect to the beam trajectory. Position detectors called Wakefield Monitors (WFM) are integrated to the structure for a beam based alignment. This paper describes the requirements of such monitors. The development plan and basic feature of the WFM as well as the accelerating structure working at 12 GHz and 100 MV/m are shortly described. Then we focus on detailed electromagnetic simulations and design of the WFM itself. In particular, time domain computations are performed and an evaluation of the intrinsic resolution is done for two higher order modes at 17 and 24 GHz. The mechanical design of the accelerating structure with WFM is also presented. Precise machining with a tolerance of 2.5 μm and a surface roughness of 0.025 μm is demonstrated. The fabrication status of three complete accelerating structures with WFM is finally presented for a feasibility demonstration with beam in CTF3 at CERN.

TUP099 **Longitudinal Beam Profile Diagnostics at CTF3 Based on Coherent Diffraction Radiation**

M. Micheler *(JAI), R. Ainsworth, G.A. Blair, G.E. Boorman, V. Karataev, K. Lekomtsev (JAI) R. Corsini, T. Lefevre (CERN)*

Compact Linear Collider (CLIC) is a multi-TeV electron-positron collider for particle physics based on an innovative two-beam acceleration scheme. The CLIC Test Facility 3 (CTF3, CERN) aims to demonstrate feasibility of this concept. The monitoring of a longitudinal profile will be very important for the CLIC. The optimization of the longitudinal charge distribution in a bunch is crucial for the maximisation of the luminosity and also for an optimal performance of a CLIC drive beam. A setup for the investigation of Coherent Diffraction Radiation (CDR) from targets with various configurations as a tool for non-invasive longitudinal electron beam profile diagnostics has been designed and installed in the CRM line of the CTF3 [1, 2]. In this report we present the status of the experiment and results on interferometric measurements of CDR from a single target configuration. Studies on downstream background contribution in the CRM line have been performed. Recently we have upgraded the system by installing a second target. In this report we shall also demonstrate the results on simulations of CDR spatial distribution from the two target configuration.

TUP100 **Measuring the Longitudinal Bunch Profile at CTF3**

A.E. Dabrowski *(CERN), E. Adli, S. Bettoni, E. Bravin, R. Corsini, S. Doebert, D. Egger, T. Lefevre, A. Rabiller, P.K. Skowronski, L. Soby, F. Tecker (CERN) H.-H. Braun (PSI) H. Shaker (IPM) M. Velasco (NU)*

The CLIC Test Facility 3 (CTF3) is being built and commissioned by an international collaboration in order to test the feasibility of the proposed Compact Linear Collider (CLIC) two-beam acceleration scheme. The monitoring and control of the bunch length throughout the CTF3 complex is important since this affects the efficiency and the stability of the RF power production process. Bunch length diagnostics therefore form an essential component of the beam instrumentation at CTF3. This paper presents and compares longitudinal profile measurements based on transverse RF deflectors, Streak camera and non-destructive microwave spectrometry techniques.

TUP101 **Wire Grid and Wire Scanner Monitors Design for the CERN LINAC 4**

F. Roncarolo *(CERN), E. Bravin, C. Dutriat, G.J. Focker, U. Raich, VC. Vuitton (CERN) B. Cheymol (Université Blaise Pascal)*

As part of the CERN LHC injector chain upgrade, LINAC4 will accelerate H^- ions from 45 keV to 160 MeV. A number of wire grids and wire scanners will be used to characterize the beam transverse profile. This paper covers all monitor design aspects intended to cope with the required specifications. In particular, the overall measurement robustness, accuracy and sensitivity must be satisfied for different commissioning and operational scenarios. The physics mechanisms generating the wire signals and the wire resistance to beam induced thermal loads have been considered in order to determine the most appropriate monitor design in terms of wire material and dimensions.

TUP102 **Phase Space Analysis at the SwissFEL Injector Test Facility**

B. Beutner *(PSI), R. Ischebeck, T. Schietinger (PSI)*

Phase I of the SwissFEL Injector Test Facility consists of a 2.6-cell S-band RF gun, a spectrometer, and a series of transverse beam diagnostic systems such as YAG screens, slit and pepper-pot masks. Its primary purpose is the demonstration of a high-brightness electron beam meeting the specifications of the SwissFEL main linac. Phase space characterization at beam energies up to 7 MeV, where space charge still dominates, is performed with YAG screens in combination with slit- and pinhole (pepper-pot) masks. Advanced image analysis is used to mitigate artefacts due to background, pixel readout noise, or dark current. We present our data analysis procedure for the slit scan method, with particular emphasis on image processing and its effect on the reconstructed emittance. Pepper-pot measurements using an independent analysis framework are used to cross-check the slit scan results.

TUP103 **Transverse Profile Monitors for the SwissFEL Injector Test Facility**

R. Ischebeck *(PSI), B. Beutner, G.L. Orlandi, M. Pedrozzi, T. Schietinger, V. Schlott, V.G. Thominet (PSI)*

The SwissFEL Injector Test Facility consists of an RF gun, an accelerating section for a final energy of 250 MeV, and two diagnostics sections. Transverse profiles of the electron beam can be recorded at 27 locations by imaging fluorescent

crystals that can be inserted into the beam. At 21 of these, the fluorescent screens are complemented by optical transition radiation monitors and wire scanners. Here, we will evaluate the performance of transverse profile monitors experimentally and numerically and compare the measured profiles with a numerical model of the accelerator. Profile monitors are used in conjunction with a slit and a pepper pot to determine the transverse phase space distribution of the bunches. Experimental measurements at the SwissFEL Injector Test Facility will be presented.

TUP104 **Direct Measurement of Beam Direction Using Axial B-dots**

X. He *(CAEP/IFP), Q. Li, K. Zhang (CAEP/IFP)*

Beam position monitors are very widely used in accelerator diagnostics. Beam direction measurement can provide very useful information. Azimuthal B-dots (commonly referred B-dots) can be used to measure the beam position because beam traveling off axis will generate dipole term of azimuthal magnetic field. Similarly, dipole term of axial magnetic field will be generated by the beam traveling with a direction not parallel with the pipe axis. In this paper, theoretical results are given to show how the axial B-dot works. And Mafia simulations are carried out to check the theoretical results. Simulation results agree with the theoretical results very well.

TUP105 **A Carbon Foil Stripper for FRIB**

F. Marti *(NSCL), S. Hitchcock, O.K. Kester, J.C. Oliva (NSCL)*

The US Department of Energy Facility for Rare Isotope Beams (FRIB) at Michigan State University includes a heavy ion superconducting linac capable of accelerating all ions up to uranium with energies higher than 200 MeV/u and beam power up to 400 kW. At an energy of approximately 17 MeV/u we plan to strip the beam to reduce the voltage needed in the rest of the linac to achieve the final energy. The design of the stripper is a challenging problem due to the high power deposited (approximately one kW) in the stripper media by the beam in the small beam size. One of the options being considered is a carbon foil stripper. We have developed a test chamber to study the thermal mechanical properties of different stripping media candidates (amorphous carbon, graphene, diamond). This chamber utilizes an electron beam to deposit powers similar to what the FRIB stripper will see in operation. The thermo-mechanical studies are a necessary condition but not sufficient. The effect of

radiation damage must also be studied. We have utilized heavy ions (Pb) from the K500 cyclotron to study this issue. We present in this paper a summary of the requirements and the status of the studies.

TUP106 **Development of Stripper Options for FRIB**
F. Marti *(NSCL) A. Hershcovitch, P. Thieberger (BNL) Y. Momozaki, J.A. Nolen, B. Reed (ANL)*
The US Department of Energy Facility for Rare Isotope Beams (FRIB) at Michigan State University includes a heavy ion superconducting linac capable of accelerating all ions up to uranium with energies higher than 200 MeV/u and beam power up to 400 kW. To achieve these goals with present ion source performance it is necessary to accelerate simultaneously two charge states of uranium from the ion source in the first section of the linac. At an energy of approximately 17 MeV/u we plan to strip the uranium beam to reduce the voltage needed in the rest of the linac to achieve the final energy. Up to five different charge states are planned to be accelerated simultaneously after the stripper. The design of the stripper is a challenging problem due to the high power deposited (approximately one kW) in the stripper media by the beam in a small spot. To assure success of the project we have established a research and development program that includes several options: carbon or diamond foils, liquid lithium films, gas strippers and plasma strippers. We present in this paper a summary of the requirements and a general description of the status of the different options.

TUP107 **RF Pulse Compressors for Muon Accelerators**
M. Popovic *(Fermilab), A. Moretti (Fermilab) R.P. Johnson, M.L. Neubauer (Muons, Inc)*
Muon Colliders and Neutrino Factories, examples of future muon accelerators at the energy and intensity frontiers, can be made affordable and practical with a new technique based on high-gradient RF cavities filled with dense hydrogen gas. To fully exploit this conceptual breakthrough, new high power RF sources are needed. The novel idea of using pressurized RF cavities for muon accelerators leads to conceptually simple designs with better beam cooling and several engineering advantages, including the potential of much higher accelerating gradients. This document proposes to develop power sources for these high gradient RF cavities based on pulse compression techniques using cryogenic energy storage cavities. The goal is to design a complete

cryogenic pulse compressor system to be built, tested, and used to develop switching techniques and coupling strategies. Critical technical issues relevant to RF power in muon accelerators are identified for computational and experime ntal investigation.

TUP108 **Bunch Recombination for a Muon Collider**
D.V. Neuffer *(Fermilab), K. Yonehara (Fermilab) C. Y. Yoshikawa (Muons, Inc)*
Cooling scenarios for a high-luminosity Muon Collider require bunch recombination for optimal luminosity. In this report we note that the tunable chronicity property of a helical transport channel (HTC) makes it a desirable component of a bunch recombiner. A large chronicity HTC is desirable for the bunch recombining transport, while more isochronous transport is preferred for rf manipulations. Scenarios for bunch recombination are presented, in which an offharmonic rf muon linac is used to simultaneously bunch beams within a string of bunches while placing bunch centers at different energies suitable for recombination in the HTC.

TUP109 **Large Acceptance Linac for Muon Acceleration**
H.M. Miyadera *(LANL), A.J. Jason, S.S. Kurennoy (LANL)*
Muon accelerators are studied for future neutrino factory and muon colliders (NF/MC). On the other hand, a compact muon accelerator can be applicable to muon radiography which is a promising probe to investigate large objects. We worked on simulation studies on a compact muon linear accelerator. The designed linac has a large energy and a phase acceptance to capture lower energy pion/muon (10 - 100 MeV) than the NF/MC scenario and accelerates them to 200 MeV without any beam cooling. Our current design adopts 805 MHz zero-mode normal-conducting cavities with 35 MV/m peak field*. The superconducting solenoids are used to provide 5-T focusing field on the normal conducting cavities. We developed a Monte Carlo simulations code to optimize linac parameters. Muon energy loss and scattering effects at the aperture windows are included, too. The simulation showed that about 10 % of the pion/muon injected into the linac can be accelerated to 200 MeV. Further acceleration can be done with superconducting linac.

TUP110 **Mass Production Report of C-Band RF Pulse Compressor**

K. Okihira *(MHI)*

C-band RF pulse compressor is a device that generates high peak RF-power by saving, and compressing the RF-power output from the klystron. XFEL project is scheduled to be installed 64 pulse compressor units, 2009 of December we have completed the fabrication and RF measurement of all units. A high-power examination was conducted in the test stand at RIKEN. The RF output of the pulse compressor is 260 MW in peak value, and the acceleration gradient of the accelerating structure is achieved to be 40 MV/m.It reports on the mass production passage of these 64 C-Band RF pulse compressors and on the installation result of injector section.

TUP111 **Goals and Status of MICE, the International Muon Ionization Cooling Experiment**

V.C. Palladino *(INFN-Napoli)*

Muon ionization cooling provides the only practical solution to prepare high brilliance beams necessary for a neutrino factory or muon colliders. The muon ionization cooling experiment (MICE) is thus a strategic R&D project for neutrino physics. It is under development at the Rutherford Appleton Laboratory (UK). It comprises a dedicated beam line to generate a range of input emittance and momentum, with time-of-flight and Cherenkov detectors to ensure a pure muon beam. A first measurement of emittance is performed in the upstream magnetic spectrometer with a scintillating fiber tracker. A cooling cell will then follow, alternating energy loss in liquid hydrogen and RF acceleration. A second spectrometer identical to the first one and a particle identification system provide a measurement of the outgoing emittance. In the 2010 run, completed in August, the beam and most detectors have been fully commissioned. The time of the first measurement of input beam emittance is closely approaching. The plan of steps of measurements of emittance and emittance reduction (cooling), that will follow in 2011 and later, will be reported.

15-Sep-10 09:00–10:40 Main Convention Hall

WE1 — Invited Oral

Chair: R. Garoby (CERN)

WE101 09:00 **Design of Project-X Linac**

N. Solyak *(Fermilab)*

Project X is a proposed high-intensity H^- accelerator complex that could provide beam for a variety of physics projects: neutrino-, kaon- and muon-based precision experiments. Other applications are under investigation. In the current proposal CW 3MW linac would contains few types of superconducting cavities and focising elements to accelerate beam from 2.5 MeV up to 3 GeV. The paper presents the status of the 3GeV x 1mA CW linac, including design and testing of the linac components, beam physics studies and future plans.

WE102 09:30 **SARAF Accelerator Commissioning Results and Phase II Construction Status**

L. Weissman *(Soreq NRC), D. Berkovits, I. Gertz, A. Grin, S. Halfon, G. Lempert, I. Mardor, A. Nagler, A. Perry, J. Rodnizki (Soreq NRC) A. Bechtold (NTG) K. Dunkel, M. Pekeler, C. Piel (RI Research Instruments GmbH)*

The Soreq Applied Research Accelerator Facility, SARAF, is currently under construction at Soreq NRC. SARAF is based on a continuous wave (CW), proton/deuteron RF superconducting linear accelerator with variable energy (5'40 MeV) and current (0.04-2 mA). Phase I of SARAF consists of a 20 keV/u ECR ion source, a low energy beam transport section, a 4-rod RFQ, a medium energy (1.5 MeV/u) transport section, a superconducting module housing 6 half-wave resonators and 3 superconducting solenoids, a diagnostic plate and a beam dump. Phase II will include 5 additional superconducting modules. We present the commissioning results of SARAF Phase I. These results include the first ever proton and deuteron beams to be accelerated through have-wave resonators. We accelerated low duty cycle proton and deuteron beams with instantaneous currents of 3 mA up to above 3 and 4 MeV, respectively. Furthermore, we accelerated a CW 1.4 mA proton beam up to above 3 MeV. Based on the results of Phase I, Phase II is now being designed. Details of the new design and comparison to Phase I will be presented.

WE103 10:00 **Status of Linac4 Construction at CERN**
M. Vretenar *(CERN)*
Linac4 is a 160 MeV normal-conducting H^- linear accelerator which is being built at CERN in the frame of a program for increasing the luminosity of the LHC. The project started in 2008 and delivery of beam to the CERN accelerator chain is foreseen from early 2015. The new linac will be housed in an underground tunnel close to the present Linac2; a surface building will house RF and other infrastructure. The civil engineering work started in October 2008 will be soon completed. Installation of the infrastructure will take place in 2011, and from 2012 will be installed the main machine elements. The ion source is presently operational on a test stand, where it will be followed in 2011 by a 3 MeV RFQ under construction in the CERN workshops. Prototypes of the three different types of accelerating structures have been tested; construction of the 22 accelerating cavities has started, supported by a network of agreements with external laboratories and institutions. Commissioning will take place in stages, starting from January 2013. Starting in March 2014 is foreseen a six-month reliability run, in preparation for its role as the new source of particles for the CERN complex.

WE104 10:20 **Overview and Future Demands of Fast Choppers**
A.V. Aleksandrov *(ORNL)*
This talk will give an overview of future demands of fast choppers with fast rise/fall time to reduce the beam extinction ratio further.

15-Sep-10 11:00–12:00 Main Convention Hall

WE2 — Invited Oral

Chair: S. Fu (IHEP Beijing)

WE201 11:00 **Operation and Upgrades of the LCLS**
J.C. Frisch *(SLAC)*
The LCLS FEL began user operations in September 2009, with photon energies from 800eV to 2 KeV and pulse energies above 2 mJ. Both long pulse (50-200 femtosecond FWHM) and short pulse (<10 femtosecond FWHM at 150 uJ) pulses were delivered at user request. In addition the FEL was operated at fundamental photon energies up to 10 KeV in preparation for hard X-ray experiments. FEL operating parameters, performance and reliability results will be presented, in addition to plans for upgrades to the facility.

WE202 11:20 **Upgrade of the PLS (Pohang Light Source) Linac for the PLS-II**

S.J. Park *(PAL), J.Y. Choi, C. Kim, K.R. Kim, M. Kim, S.H. Nam, S.S. Park (PAL)*

Since its completion in 1993, the PLS (Pohang Light Source) linear accelerator has been operated as the full energy injector to the PLS storage ring - a 2.5-GeV 3rd generation light source in Korea. After successful services for more than 15 years to the Korean synchrotron radiation users' community, the PLS is now being upgraded to meet ever-increasing user demands for brighter lights. The PLS-II, the major upgrade program to the PLS, is to increase the beam energy to 3 GeV, changing the storage ring lattice to accommodate large number of insertion devices with lower emittance, and to have the top-up injection as the default operating mode. In order to provide the top-up injections at the full energy of 3 GeV, several acceleration modules will be added to the end of the machine. In order to achieve high injection efficiency (> 80%), beam qualities including the energy spread, pulse length, and jitters in bunch arrival times to the storage ring rf bucket have to be reduced. After successful upgrade of the PLS linac one could further exploit its potential by, for example, implementing high-brightness electron source, which would open up new possibilities with the facility

WE203 11:40 **First Simultaneous Top-up Operation of Three Different Rings in KEK Injector Linac**

M. Satoh *(KEK)*

The KEK injector linac sequentially provides beams to four storage rings: a KEKB low-energy ring (LER) (3.5 GeV/positron), a KEKB high-energy ring (HER) (8 GeV/electron), a Photon Factory ring (PF ring; 2.5 GeV/electron), and an Advanced Ring for Pulse X-rays (PF-AR; 3 GeV/electron). So far, beam injection to the PF ring and PF-AR had been carried out twice a day, whereas the KEKB rings had been operated in the continuous injection mode (CIM) for keeping stored currents almost constant. The KEK linac upgrade project has started since 2004 so that the PF top-up and KEKB CIM can be operated at the same time. The goal is to inject the beams of different energy into the three independent rings in every 20 ms, where the common DC magnet settings are utilized for beams having different energy and charge, whereas different optimized rf phases are applied to each beam acceleration by using a fast low-level rf control up to 50 Hz. With this noble operation scheme, a simultaneous top-up operation for different three rings

was achieved for the first time over the world, and has been stably in operation since last April. We report the operation scheme and status in detail.

16-Sep-10 09:00–11:00 Main Convention Hall

TH1 — Invited Oral

Chair: R.E. Laxdal (TRIUMF)

TH101 09:00 **Raising the Bar on Superconducting Niobium Cavity Production, Processing, and Performance**

Z.A. Conway *(CLASSE)*

This talk will give an overview of recent results on the highest gradient SRF cavities, including new, improved surface treatments and cavity repair. Significant recent progress has been made in understanding gradient limiting effects, and how to cure them. Many of these results will be reviewed here.

TH102 09:30 **SRF and Cryomodule R+D for ERL's**

J. Knobloch *(Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II)*

A review of the SRF and cryomodule R&D for various ERL projects around the world. Many challenging R&D problems will be addressed such as high average current SRF injectors and CW high gradient SRF modules.

TH103 10:00 **Development and Future Prospects of RF Sources for Linac Applications**

E. Jensen *(CERN)*

This talk gives an overview of recent results and future prospects on RF sources for linac applications, including klystrons, magnetrons and modulators.

TH104 10:30 **Power Coupler Development for High Intensity Superconducting Linacs**

G. Devanz *(CEA)*

Recent developments and promising results are showing the feasibility of 1 MW power couplers for superconducting cavities accelerating high intensity proton beam for projects such as SPL, ESS, EURISOL.

16-Sep-10 11:30–12:30 Main Convention Hall

TH2 — Invited Oral

Chair: M. Popovic (Fermilab)

TH201 11:30 **SRF Linac for Indian Energy Program**

C.S. Mishra *(Fermilab) V.C. Sahni (BARC)*

Indian Institutions in collaboration with Fermilab are engaged in the R&D of a high intensity Superconducting Radio Frequency proton linac for Accelerator Driven Subcritical System. The talk will outline the current status and future plans.

TH202 11:50 **VECC/TRIUMF Injector for the e-Linac Project**

V. Naik *(DAE/VECC), A. Bandyopadhyay, A. Chakrabarti, S. Dechoudhury, M. Mondal (DAE/VECC) F. Ames, R.A. Baartman, C.D. Beard, Y.-C. Chao, R.J. Dawson, P. Kolb, S.R. Koscielniak, R.E. Laxdal, M. Marchetto, L. Merminga, A.K. Mitra, T.C. Ries, I. Sekachev, V.A. Verzilov, F. Yan (TRIUMF) D. Longuevergne (UBC & TRIUMF)*

TRIUMF (Canada) and VECC (India) are both planning to use the photo-fission route for producing neutron-rich radioactive ion beams in their respective RIB programmes. With this common goal the two institutes have entered into a collaboration to jointly design and develop a superconducting 1.3GHz 50MeV, 10 mA, CW electron linac which will be used as the fission driver. The first phase of the e-Linac collaboration aims at the development, production and full technical and beam test of a 10MeV injector cryo module (ICM) which forms the front-end of the final linac. The design and technical development of the ICM will be presented.

16-Sep-10 13:40–15:00 Main Convention Hall

TH3 — Invited Oral

Chair: P.N. Ostroumov (ANL)

TH301 13:40 **Beam Dynamics Studies for Multi-GeV Proton and H-minus Linacs**

J.-P. Carneiro *(Fermilab)*

Significant advances were demonstrated in the design and computer simulations of multi-GeV proton and H-minus linacs. Several codes were applied for the simulation of 8 GeV linac and resulted to extremely good coincidence of all beam parameters. New procedures such as stripping of H-minus ions due to various mechanisms were implemented into the tracking code. The author of this presentation has several publications in PRSTAB and Nuclear Instruments on various aspects of beam dynamics for 8 GeV linac.

TH302 14:00 **Source and Injector Design for Intense Light Ion Beams Including Space Charge Neutralisation**

N. Chauvin *(CEA)*

New PIC ray-tracing methods allows to design and simulate the transport of high intensity proton, H^- and deuteron beam in the LEBT systems of future facilities like FAIR Proton Linac or IFMIF-EVADA and SPIRAL2 deuteron linacs. These techniques enable a precise prediction of

the effect of residual gas ionisation and the consequent neutralisation of the large beam space charge on the beam emittances.

TH303 14:20 **Experimental Observation of Space Charge Driven Resonances in a Linac**

L. Groening *(GSI), W.A. Barth, W.B. Bayer, G. Clemente, L.A. Dahl, P. Forck, P. Gerhard, I. Hofmann, M. Kaiser, M.T. Maier, S. Mickat, T. Milosic, S.G. Yaramyshev (GSI) D. Jeon (ORNL) D. Uriot (CEA)*

Recent experiments at the Universal Linear Accelerator (UNILAC) at GSI provided evidence for space charge driven resonances along a periodic DTL. A transverse fourth order resonance has been detected by recording the four fold symmetry in phase space. As predicted in [D. Jeon et al., Phys. Rev. ST Accel. Beams 12, 054204 (2009)], the resonance dominates over the envelope instability. Additionally, evidence for resonant emittance transfer from the longitudinal to the transverse plane has been found for settings providing equal depressed tunes of the involved planes.

TH304 14:40 **Linear Induction Accelerators at the Los Alamos National Laboratory DARHT Facility**

S. Nath *(LANL)*

The Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT) at Los Alamos National Laboratory consists of two linear induction accelerators at right angles to each other. The First Axis, operating since 1999, produces a nominal 20-MeV, 2-kA single beam-pulse with 60-nsec width. In contrast, the DARHT Second Axis, operating since 2008, produces up to four pulses in a variable pulse format by slicing micro-pulses out of a longer 1.6-microseconds (flat-top) pulse of nominal beam-energy and -current of 17 MeV and 2 kA respectively. Bremsstrahlung radiation, shining on a hydro-dynamical experimental device, is produced by focusing the electron beam-pulses onto a high-Z target. Variable pulse-formats allow for adjustment of the pulse-to-pulse doses to record a time sequence of x-ray images of the explosively driven imploding mock device. In this talk, we present a sampling of the numerous physics and engineering challenges encountered and the solutions thereof that led to the present fully operational dual axes capability. First successful simultaneous use of both the axes for a hydrodynamic experiment was achieved in 2009.

16-Sep-10 15:00–16:00 Main Convention Hall

TH4 — Contributed Oral

Chair: K.C.D. Chan (LANL)

16-Sep-10 16:00–18:00 Poster Rooms 101, 102, 201

THP — Poster

THP001 **FNAL HINS Beam Measurements and the Future of High Intensity Linac Instrumentation**

V.E. Scarpine *(Fermilab), S. Chaurize, B.M. Hanna, S. Hays, J. Steimel, R.C. Webber, M. Wendt, D. Wildman, D.H. Zhang (Fermilab)*

The intensity frontier, having been identified as one leg of the future of particle physics, can be meet by the development of a multi-GeV high-intensity linac. In order to address the low-energy needs of such an accelerator, Fermilab started the High Intensity Neutrino Source (HINS) project. HINS is a research project to address accelerator physics and technology questions for a new concept, low-energy, high-intensity, long pulse H^- superconducting linac. The development of such an accelerator puts strict requirements on beam diagnostics. This paper will present beam measurement results of the HINS ion source and 2.5 MeV RFQ as well as discuss the role of HINS as a test facility for the development of future beam diagnostic instrumentation required for the intensity frontier.

THP002 **Design Study of Front-End System for Project X**

S. Nagaitsev *(Fermilab), M. Popovic, G.V. Romanov, R.C. Webber, V.P. Yakovlev (Fermilab) Q. Ji, D. Li, T. Schenkel, J.W. Staples, S.P. Virostek (LBNL)*

A multi-MW proton facility, Project X has been proposed and currently under development at Fermilab. Project X is critical for future development of accelerator complex for future high energy physics programs in the US. In collaboration with Fermilab, LBNL is actively involved in the development and design studies of the front-end system for Project X. The front-end system would consist of H^- ion source(s), low-energy beam transport (LEBT), normal conducting CW Radio-Frequency-Quadrupole (RFQ) accelerator(s), medium-energy beam transport (MEBT), beam chopper(s) and normal conducting CW rebuncher cavities. We will review and present R&D programs and recent study progress on the front-end system of Project X. These studies may

include beam dynamics simulations and concepts for LEBT, RFQ, MEBT and narrow band chopper, and preliminary conceptual designs of normal conducting CW RFQ(s) and rebuncher cavities.

THP003 **Diagnostic Lines for Commissioning of the CERN Linac4**

B. Mikulec *(CERN), G. Bellodi, K. Hanke, T. Hermanns (CERN) M. Eshraqi (ESS)*

Linac4 will be the new linear accelerator of the CERN accelerator chain delivering H^- ions at 160 MeV from 2015. The increased injection energy compared to the 50 MeV of its predecessor Linac2, combined with a H^- charge-exchange injection, will pave the way to reach ultimate goals for the LHC luminosity. An extensive commissioning phase for Linac4 is planned during 2013. For this purpose, the beam will be studied after the exit of Linac4 in a straight line ending at the Linac4 dump, equipped with various beam instruments. An almost 180 m long transfer line will guide the beam to the charge exchange injection point at the entry of the Proton Synchrotron Booster. About 50 m upstream of this point, two measurement lines will be upgraded to perform in the second half of 2014 transverse emittance measurements as well as absolute energy and energy spread measurements of the Linac4 beam. A detailed description of the beam measurement principles and setups at these three Linac4 diagnostics lines related to distinct Linac4 commissioning phases will be given.

THP004 **Layout and Machine Optimisation for the SPL at CERN**

F. Gerigk *(CERN), S. Calatroni, O. Capatina, E. Ciapala, R. Garoby, A.M. Lombardi, V. Parma, W. Weingarten, S. Weisz (CERN)*

During the past 2 years the Superconducting Proton Linac (SPL) study has grown into an international collaboration with the goal of optimising the architecture of a pulsed superconducting (SC) high-power proton linac. This effort includes the study and prototyping of major technical components, such as SC high-gradient cavities, power couplers, the RF distribution system, HOM couplers, cryo-modules, focusing elements, etc. Even though the effort is driven by CERN specific needs, the established design principles are valid for a range of superconducting linac projects. In this paper we report on the latests decisions concerning the machine architecture and on the ongoing R&D effort for technical components.

THP005 **Beam Dynamics Optimisation of Linac4 Structures for Increased Operational Flexibility**

G. Bellodi *(CERN), M. Eshraqi, M.G. Garcia Tudela, L.M. Hein, J.-B. Lallement, A.M. Lombardi, P.A. Posocco, E. Sargsyan (CERN) J. Stovall (TechSource)*

Linac4 is a new 160 MeV, 40 mA average beam current H^- accelerator which will be the source of particles for all proton accelerators at CERN as from 2015. Construction started in October 2008, and beam commissioning of the 3MeV frontend is scheduled for early next year. A baseline design of the linac beam dynamics was completed 2 years ago and validated by a systematic campaign of transverse and longitudinal error studies to assess tolerance limits and machine activation levels. Recent studies have been mainly focused on optimising this design to achieve both a smoother performance for nominal beam conditions and to gain operational flexibility for non-nominal scenarios. These include a review of the chopper beam dynamics design, a re-definition of the DTL and CCDTL inter-tank regions and a study of operational schemes for reduced beam currents (either permanent or in pulse-to-pulse mode). These studies have been carried out in parallel to first specifications for a beam commissioning strategy of the linac and its low-energy front-end.

THP006 **Accuracy Determination of the CERN LINAC4 Emittance Measurements at the Test Bench for 3 and 12 MeV**

F. Roncarolo *(CERN), G. Bellodi, E. Bravin, U. Raich (CERN) B. Cheymol (Université Blaise Pascal)*

The CERN LINAC4 commissioning will start in 2011, at first in a laboratory test stand where the 45 KeV H^- source is already installed and presently tested, and later in the LINAC4 tunnel. A movable diagnostics bench will be equipped with the necessary sensors capable of characterizing the H^- beam in different stages, from 3 MeV up to the first DTL tank at 12 MeV. In this paper we will discuss the accuracy of the transverse emittance measurement that will be performed with the slit-grid method. The system's mechanical and geometric parameters have been determined in order to achieve the required resolution and sensitivity. Space charge effects during the beam transfer from the slit to the grid and scattering effects at the slit have been considered to determine the overall emittance measurement accuracy.

THP007 **Overview of the CERN LINAC4 Beam Instrumentation**

F. Roncarolo *(CERN), U. Raich (CERN)*

The CERN LINAC4 will represent the first upgrade of the LHC injection chain, by accelerating H^- ions from 45 KeV to 160 MeV for charge-exchange injection of protons into the PS Booster. In order to provide its safe and efficient commissioning and operation, a wide variety of beam diagnostics devices has been designed for installation at convenient locations all over the accelerator length and in the transfer line to the PS Booster. This paper gives an overview of all instrumentation devices, including those to measure beam position, transverse and longitudinal profile, beam current and beam loss. The well advanced status of the system design as well as first results from tests at low energy are discussed. The results are compared to the functional specifications under various operational scenarios.

THP008 **CW RF System of the ProjectX Accelerator Front-end**

T.N. Khabiboulline *(Fermilab), I.G. Gonin, V.P. Yakovlev (Fermilab)*

Front end of a CW linac of the Project X contains a H^- source, an RFQ, a medium energy transport line with the beam chopper, and a SC low-beta linac that accelerates H^- from 2.5 MeV to 160 MeV. SC Single ' spoke Resonators (SSR) will be used in the linac, because Fermilab already successfully developed and tested a SSR for beta 0.21. Two manufactured cavities achieve 2-3 times more than design accelerating gradients. One of these cavities completely dressed, e.g. welded to helium vessel with integrated slow and fast tuners, and tested in CW and pulse regimes. Successful tests of beta=0.21 SSR give us a confidence to use this type of cavity for low beta (0.117) and for high- beta (0.4) as well. Both types of these cavities are under development. In present report the basic constrains, parameters, electromagnetic and mechanical design for all the three SSR cavities, and first test results of beta=0.21 SSR are presented.

THP009 **Critical Dipole Modes in JLAB Upgrade Cavities**

F. Marhauser *(JLAB), K. Tian, H. Wang (JLAB)*

The 12GeV upgrade of CEBAF is currently in progress. Ten new cryomodules will be installed at completion of the project to increase the energy from 6GeV to 12GeV. Each cryomodule

houses eight seven-cell Low Loss type cavities. The damping of HOMs is crucial to prevent from beam break-up (BBU) instabilities at the desired beam currents as experienced with an upgrade demonstration cryomodule which needed to be de-installed recently. Detailed HOM surveys of a complete string of cavities in a cryomodule as well as individual cavities revealed the existence of critical dipole modes below and above beam tube cutoff that needed extensive experimental and numerical analyses. Results and their consequences for the 12 GeV upgrade cryomodules are detailed.

THP010 **Exploiting New Electrochemical Understanding of Niobium Electropolishing for Improved Performance of SRF Cavities for CEBAF**

***C.E. Reece** (JLAB)*

Recent incorporation of analytic electrochemistry into the development of protocols for electropolishing niobium SRF cavities has yielded new insights for optimizing this process for consistent, high-performance results. Use of reference electrodes in the electrolyte, electrochemical impedance spectroscopy (EIS), rotating disk electrodes (RDE), and controlled sample temperatures has greatly clarified the process dynamics over the empirical understanding developed via years of practice. Minimizing rf losses at high operational gradients is very valuable for CW linacs. Jefferson Lab is applying these new insights to the low-loss 7-cell cavity design developed for the CEBAF 12 GeV Upgrade. Together with controlled cleaning and assembly techniques to guard against field-emission causing particulates, the resulting process is yielding consistent cavity performance that exceeds project requirements. Cavity tests show BCS-limited Q well above 30 MV/m. Detailed process data, interpretation, and resulting rf performance data will be presented.

THP011 **SC Third Harmonic Cavity Modal Spectra Analysis for FLASH**

***P. Zhang** (UMAN), R.M. Jones, N. Juntong, I.R.R. Shinton (UMAN) N. Baboi, B. Lorbeer, **P. Zhang** T. Flisgen, H.-W. Glock (Rostock University, Faculty of Computer Science and Electrical Engineering) T.N. Khabiboulline (Fermilab)*

Third harmonic superconducting cavities have been designed and fabricated by FNAL to minimise the energy spread along bunches in the FLASH facility at DESY. A module, consisting of

four 9-cell 3.9GHz cavities, has been installed in the Cryo-Module Test Bench (CMTB) facility at DESY and transmission measurements have been completed on all cavities. This cryomodule has subsequently been installed in FLASH. Experimental measurements on mode spectra, both with and without beam-excitation, are analysed and compared to simulations. Higher order modes are able to propagate to adjacent cavities through attached beam tubes. The consequences of this coupling on the modal spectra are investigated.

THP012 **Higher Order Modes in Third Harmonic Cavities at FLASH**

R.M. Jones *(UMAN), I.R.R. Shinton (UMAN)*

Transverse modes in the 3.9 GHz cavities designed and fabricated by FNAL are reported on. These modes have the potential to cause significant emittance dilution if they not sufficiently suppressed. Recent experiments, both probe-based and beam-excited, have indicated significant discrepancies between modes predicted in stand-alone 9-cell cavities compared to those in 4-cavity modules. We employ a suite of computer codes and circuit models to analyze these modes, coupled through beam tubes whose cut-off is above that of the first dipole band. We also report on preparations to instrument the higher order mode couplers with electronics suitable for diagnosing both the beam and cavity position, based on modes with sufficient R/Q values.

THP013 **Testing of Nb Material for the XFEL Pre-series Production**

A. Brinkmann *(DESY), M. Lengkeit, W. Singer, X. Singer (DESY)*

For the XFEL cavity production a rather large quantity of niobium sheets from partially new niobium vendors has to be delivered according to the XFEL Cavity Specification. It is of high importance that the material monitoring of this niobium has to be done within the production process to ensure a high performance of the cavities. The quality assurance program includes electrical measurements, mechanical, structural and chemical material analysis. For the surface investigations two eddy current scanning devices have been fabricated on the basis of our specification and experience. The scanning process and evaluation of test result can now be done in a few minutes per sheet. We describe the material test methods and the scanning machine. Measured results of the pre-series niobium will be compared to older material tests results.

THP014 **Progress on Diagnostic Tools for Superconducting High-Gradient Cavities**

F. Schlander *(DESY), S. Aderhold, E. Elsen, D. Reschke (DESY)*

Superconducting cavities have long been used in particle accelerators. The 1.3 GHz cavities developed in the TESLA collaboration will be the basis of the European XFEL and are the cavity of choice for the International Linear Collider (ILC). The fabrication of the cavities has been optimised over the past 20 years and will now be applied in industrial production of the 800 cavities foreseen for the XFEL. The DESY ILC group is developing tools to monitor those aspects of the production that affect the gradient of these cavities. The main obstacle in achieving a high gradient >30 MV/m is the quench induced in surface structures in the niobium. Such features are explored in an optical inspection of the 9-cell cavity structures and supplemented by measurements of the second sound that originates from the phase transition of the liquid helium at the position of the quench. Oscillating Superleak Transducers (OST) are used to record the signal of the second sound. The second sound measurements are thought to replace the time consuming direct temperature measurements on the outer cavity surface with a resistor system. The status of the various tools will be described.

THP015 **A Review of the 1.3GHz Superconducting 9-Cell Cavity Fabrication for DESY**

J. Iversen *(DESY), R. Bandelmann, G. Kreps, W.-D. Moeller, D. Proch, J.K. Sekutowicz, W. Singer (DESY)*

Since 1993 DESY ordered 165 1.3GHz 9-cell superconducting cavities. The cavities have been developed for TeV-Energy Superconducting Linear Accelerator (TESLA) and are used in the linac of the Free Electron Laser in Hamburg (FLASH). The fabrication of all cavities was done in 9 production groups at industry. From the beginning the industrialization was carried out in close collaboration between DESY and the industry. From order to order the cavity design was optimized and the fabrication sequences were improved to realize stable and better cavity performance and to safe costs. Now a final cavity design for the European XFEL is defined. We summarize the development phases and design changes up to the final XFEL design. An outlook on the near future production of hundreds of cavities for XFEL based on our experience will be given.

THP016 **Field Quality of the Fundamental Mode in a Slotted SRF Cavity for an ERL**

C.-X. Wang *(ANL), R. Nassiri (ANL) Z.C. Liu (PKU/IHIP)*

Recently a novel 9-cell superconducting radio-frequency (SRF) structure was proposed for high-current energy-recovery linac applications [PRST-AB 13, 012001 (2010)]. To provide efficient damping of the higher-order modes, the conventional cylindrical symmetric structure is broken into three equal parts to form a slotted cavity structure. Since the slots cut across the irises and significantly break the cylindrical symmetry of the accelerating structure close to the beam, the fundamental mode quality may be degraded, thus impacting beam energy spread and perturbing transverse beam motion as well. In this presentation, we will quantify the flatness of the accelerating field across the aperture, and the magnitude of longitudinal and transverse kicks to a beam due to broken symmetry.

THP017 **Developing SRF Structures Using Atomic Layer Deposition**

J. Norem *(ANL), M. Kharitonov, J. Klug, M.J. Pellin, Th. Proslier (ANL) G. Ciovati (JLAB) A.V. Gurevich (NHMFL) J. Zasadzinski (IIT)*

An effort, centered at Argonne, has started to explore the use of Atomic Layer Deposition (ALD) to study and improve the performance of superconducting rf (SRF) accelerating structures. This effort has a number of parts: a survey the properties of ALD deposited films, a study of loss mechanisms of SRF structures, and a program of coating single cell cavities, to begin to optimize the performance of complete systems. Early results have included improving the performance of individual structures and, identification of magnetic oxides as a loss mechanism in SRF. We describe the program and summarize recent progress.

THP018 **Recent Results of 1.3GHz 9-cell Superconducting Cavities in KEK-STF**

Y. Yamamoto *(KEK), H. Hayano, E. Kako, S. Noguchi, M. Satoh, T. Shishido, K. Umemori, K. Watanabe (KEK)*

MHI#10 and #11 cavities are measured in KEK-STF as the s0 plan for ILC. After these vertical tests, they will be sent to J-Lab and tested at least once there. Moreover, two new cavities without HOM coupler are fabricated and measured in STF, which are made by two new vendors (HITACHI and TOSHIBA). As the international col-

laboration, one cavity from IHEP in Beijing will be sent to KEK, optical inspected, high pressure rinsed and vertical tested. Although MHI#8 cavity for S1-Global reached 38MV/m, it could not achieve ILC specification (35MV/m, 0.8x10^9) due to the heavy field emission. To overcome this problem, the various tests were done in the stage of the surface treatment. For example, the EP parameters and the rinsing procedure were changed. In this report, the recent results of the vertical tests including the surface treatment in KEK-STF will be presented in detail.

THP019 **Defect-Induced Local Heating of Superconducting Cavity Surface**
Y. Morozumi *(KEK)*
The limitation of the accelerating gradient is one of the current major issues with ILC superconducting RF accelerator structures. Field emission and thermal breakdown due to surface imperfections are supposed to limit the gradient performance. Profilometry-based realistic high-fidelity modeling of field enhancement will be presented. Surface defects are suspects responsible for thermal breakdown of superconducting RF cavities. Evaluation of local heating at surface defects and analysis of thermal behavior will be discussed in comparison with experimental evidences.

THP020 **Simulation of Electropolishing of Superconducting Cavities**
Y. Morozumi *(KEK)*
Electropolishing is supposed to be indispensable for high gradient performance of superconducting accelerator structures. Flow of electrolytic fluid and its reaction with surfaces are, however, difficult to measure. Simulation of electropolishing visualizes polishing effect over the entire surface and gives a guide to improved design of electropolishing system.

THP021 **Higher Mode Heating Analysis for Superconducting ILC Linacs**
K.L.F. Bane *(SLAC), C. Adolphsen, C.D. Nantista (SLAC)*
The superconducting cavities and interconnects in the 12 km long linacs of the International Linear Collider (ILC) are designed to operate at 2K where cooling costs are very expensive. Thus it is important to ensure that any additional cryogenic heat loads are small in comparison to those from static losses and the fundamental 1.3 GHz accelerator mode. One potential heat source is the higher order modes (HOM) excited by the

beam. Such modes will be damped by specially designed HOM couplers that are attached to the cavities (for trapped modes), and by 70K ceramic dampers that are located in each of the eight or nine cavity cryomodules (for propagating modes). Brute force calculations of the higher frequency, non-trapped modes excited in a string of cryomodules is limited by computing capacity. We present, instead, an approach that combines scattering matrix and wakefield calculations to study the effectiveness of the dampers in limiting the heat deposited in the 2K cryogenic system.

THP022 **Design Optimisation of the EURISOL Driver Low-beta Cavities**

Y. Ma *(CIAE) A. Facco, F. Scarpa (INFN/LNL)*

The low-beta section of the EURISOL driver linac is based on 176 MHz superconducting half-wave resonators (HWR) with beta=0.09 and 0.16. These cavities are an evolution of the 352 MHz ones, previously developed in the same framework, having similar dimensions and components except for their length and rf frequency. They are characterized by a double wall, all niobium structure with light weight, good mechanical stability and a side tuner cooled by thermal conduction. The new 176 MHz Half-wave cavities design includes a removable tuner, which allows to improve tuning range, mechanical stability and accessibility to the cavity interior. A beta=0.13 cavity, which could be suitable for linacs like the SARAF one, was also designed with the same concepts. Design characteristics and expected performance will be presented and discussed.

THP023 **Developments and Test of a 700 MHz Prototypical Cryomodule for the MYRRHA ADS Proton Linear Accelerator**

F.B. Bouly *(IPN), J.-L. Biarrotte, P. Blache, S. Bousson, C. Commeaux, C. Joly, J. Lesrel, E. Rampnoux (IPN) A. Bosotti, P.M. Michelato, R. Paparella, P. Pierini, D. Sertore (INFN/LASA)*

Accelerator Driven systems (ADS) are being considered for their potential use in the transmutation of nuclear waste. Because of the induced thermal stress to the subcritical core, the high-power proton LINAC will have to fulfill stringent reliability requirements and to minimize the number of unwanted beam trips per operation cycle. It is forseen to build an ADS demonstrator (MYRRHA) in Mol (Belgium). Such a device will be piloted by a 600 MeV / 4mA superconducting

linac. IPN Orsay and INFN Milano are in charge of the realisation and tests of a prototypical cryomodule for the high energy section of the accelerator, equipped with a 5-cell superconducting cavity. Developed at INFN, this RF cryogenic accelerating device is tested for the first time at IPN. We will describe the status of the R&D activities on this device. The first low power tests of the 5-cell superconducting cavity in its prototypical cryomodule will be reviewed. Those tests aim to evaluate the cavity performances after installation in the module (16MV/m in vertical test) but also to measure the tuning systems behaviors in view of reliability considerations for 'fast fault-recovery scenarios'.

THP024 **Design Sensitivities of the Superconducting Parallel-Bar Cavity**

S.U. De Silva *(ODU), J.R. Delayen (ODU)*

The superconducting parallel-bar cavity has properties that makes it attractive as a deflecting or crabbing rf structure. For example it is under consideration as an rf separator for the Jefferson Lab 12 GeV upgrade and as a crabbing structure for a possible LHC luminosity upgrade. In order to maintain the purity of the deflecting mode and avoid mixing with the near accelerating mode caused by geometrical imperfection, a minimum frequency separation is needed which depends on the expected deviations from perfect symmetry. We have done an extensive analysis of the impact of several geometrical imperfections on the properties of the parallel-bar cavities and the effects on the beam, and present the results in this paper.

THP026 **Superconducting RF Cavity Production Processing and Testing at Fermilab**

C.M. Ginsburg *(Fermilab), M.S. Champion, J.P. Ozelis, A.M. Rowe (Fermilab) M.P. Kelly (ANL)*

The superconducting RF (SRF) cavity production program at Fermilab supports 9-cell 1.3 GHz cavity qualification and preparation for assembling cavities into cryomodules, in support of Project X, ILC, or other future projects. Cavity qualification includes cavity inspection, surface processing, clean assembly, and one or more cryogenic qualification tests which typically include performance diagnostics. The overall goals of the program, facilities and accomplishments are described.

THP027 **Overview of the Fermilab Superconducting RF Research and Development Program**
M.S. Champion *(Fermilab), L. Cooley, C.M. Ginsburg, V.P. Yakovlev (Fermilab)*
The superconducting RF (SRF) R&D program at Fermilab includes cavity design and development, and fundamental SRF materials studies in support of Project X, ILC, or other future projects. Five new cavities are under development for Project X; these single-spoke 325 MHz and elliptical 650 MHz cavities span the beta range 0.12 to 0.9. The SRF materials R&D is focused on studying fundamental limitations in SRF cavity performance, as well as repair and inspection techniques used for understanding current manufacturing or surface processing limitations. An overview of the Fermilab SRF R&D program is described.

THP028 **Recent Development of RF Measurements and Tuning of the Accelerating Cavities at FNAL**
T.N. Khabiboulline *(Fermilab)*
Several types of accelerating structures are under development at FNAL for a several projects as ILC, ProjectX and HINS. Some cavities already manufactured and some are under development. RF quality control measurements, frequency and field flatness tuning are necessary during and after production for achieving cavity design parameters. Most superconducting RF cavities have integrated High Order Mode couplers for damping of dangerous modes for stable beam acceleration. HOM coupler notch frequency measurements, tuning and calculations are described. Technique for a measurement of the cavity cell centers based on bead pull in operating frequency is reported. This non-contact technique allows to measure cavity alignment of the dressed cavities. Experience of tuning of 1.3 GHz elliptical superconducting cavity in new automated Cavity Tuning Machine also reported.

THP029 **Operating Experience with CC2 at Fermilab's SRF Beam Test Facility**
E.R. Harms *(Fermilab), J. Branlard, G.I. Cancelo, K. Carlson, B. Chase, E. Cullerton, A. Hocker, P.W. Joireman, T. Kubicki, J.R. Leibfritz, A. Martinez, M.W. McGee, Y.M. Pischalnikov, J. Reid, W. Schappert, K.R. Treptow, V. Tupikov, P. Varghese, T.J. Zmuda (Fermilab)*
Capture Cavity II is the first operational component at the SRF Beam Test Facility now under construction at Fermilab. This 9-cell 1.3 GHz

cavity, previously operated in another venue on the Fermilab site, was transported to this facility in early 2009. We will summarize its transport and operation in its new (permanent) home compared to previous performance and also present results of studies, particularly Low Level RF, microphonics/vibration, and Lorentz force de-tuning compensation that have been recently carried out with it.

THP030 **A 325 MHz SRF Spoke Cavity Tuner Tests**
Y.M. Pischalnikov *(Fermilab), E. Borissov, T.N. Khabiboulline, R.V. Pilipenko, L. Ristori, W. Schappert (Fermilab)*
Fermilab is developing 325 MHz SRF spoke cavities for the proposed ProjectX. A compact fast/slow tuner has been developed to compensate microphonics and Lorentz force detuning. The modified tuner design and results of 4K tests of the first prototype are presented.

THP031 **First High Gradient Test Results of a 325 MHz Superconducting Single Spoke Resonator with Helium Vessel at Fermilab**
R.C. Webber *(Fermilab)*
The Fermilab High Intensity Neutrino Source (HINS) program is developing 325 MHz superconducting spoke resonator accelerating cavities. In this paper we present the first test results of the beta=0.22 single-spoke cavity in a helium vessel. The tests, performed in the newly commisioned superconducting spoke cavity test facility, include both CW testing to full-gradient with a high Qext drive coupler and pulsed high-power testing with an input coupler designed for 25 mA beam current.

THP032 **Status of the EP Simulations and Facilities for the SPL**
S. Calatroni *(CERN), L.M.A. Ferreira, M. Leitao Macatrao, Y.L. Withofs (CERN)*
CERN is assembling a new vertical electropolishing facility in order to process several niobium cavities of beta 1 and beta 0.65 in the context of the SPL R&D programme. To provide safe operating conditions when handling chemicals or processing cavities specific safety equipment is foreseen, while the materials from the different equipments must be compatible with the chemicals in contact within the required working temperature and pressure. Macro properties of fluid dynamics like Reynolds number and thermodynamics linked to the process dissipated power are taken into account to dimension the main pump and heat exchanger. Electrochemi-

cal simulations are being used in order to define the optimal cathode geometry to process the cavities in a vertical position.

THP033 **Superconducting Sputtered Nb/Cu QWR for the HIE-ISOLDE Project at CERN**
S. Calatroni *(CERN), A. D'Elia, M.A. Fraser, G. Lanza, M. Pasini, M. Therasse (CERN)*
For the foreseen upgrade of the ISOLDE complex a new superconducting LINAC based on sputtered Nb/Cu Quarter Wave Resonators (QWRs) of two different beta families is planned to be installed in the next three to five years. A prototype cavity of the higher beta family is currently being developed. In this paper we will discuss the latest developments on the sputtering technique for this kind of cavity geometry. First cold RF measurements will be reported.

THP034 **Main LINAC Superconducting Cavity Design for Cornell's ERL**
N.R.A. Valles *(CLASSE), M. Liepe (CLASSE)*
We discuss optimization methods used to design the superconducting cavities for Cornell's high beam current (100 mA) Energy Recovery Linac project. The determination of a "beam break up" parameter is discussed, and used to facilitate the optimization process. Cavity performance subject to machining errors are simulated, and it is found that increasing the width of the HOM passbands mitigates the creation of dangerous higher order modes that limit the beam current. Finally, we introduce a new HOM absorber design and material, and show that the design meets the requirements of supporting 100 mA current through the main linac.

THP035 **Prototyping Activities of Low-beta SRF Cavity for the PEFP Proton Linac Extension**
H.S. Kim *(KAERI), Y.-S. Cho, H.-J. Kwon (KAERI)*
A superconducting RF cavity with a geometrical beta of 0.42 and a resonant frequency of 700 MHz has been under consideration for an extension program of Proton Engineering Frontier Project (PEFP) to accelerate the proton beam above 100 MeV. A five-cell prototype was fabricated and tested to confirm the fabrication procedure and to check the RF and mechanical properties. High RRR niobium sheets (RRR > 250) were used for the cavity material, whereas reactor grade niobium and NbTi were used for the beam pipe region and the flange, respectively. Double-ring stiffening structure was adopted to reduce the Lorentz force detuning effect. For the vertical

test of the prototype cavity, a cryostat with operating temperature of 4.2 K was designed and fabricated. The cryostat was thermally insulated with 40 layers of MLI and the vacuum jacket and equipped with temperature monitors and liquid level sensors. The RF system for driving the cavity is based on PLL to track the resonance condition. The status of the prototype development and the vertical test results will be presented in this paper.

THP036 **Updates on Sc Cavity Inspection**

H. Tongu *(Kyoto ICR), M. Ichikawa, Y. Iwashita (Kyoto ICR) H. Hayano, K. Watanabe, Y. Yamamoto (KEK)*

Optical inspections on superconducting cavities seem to become familiar to those who are involved in the cavity fabrications. Further improvements on the Kyoto Camera have been carried out these years together with further investigation technique developments, such as high density T-map or eddy current scan. Improvements on Kyoto Camera includes change of EL sheets to LEDs, which raised the brightness 10 times and the lifetime very long as known well. The resolution was also increased. The high density T-map will help to locate a hot spot during the vertical tests and the eddy current scan will be useful for screening of bare Nb sheets with possible defects. These progresses will be reported.

THP037 **High-Gradient Test of a 3 GHz Single-Cell Cavity**

S. Verdú-Andrés *(TERA), U. Amaldi, R. Bonomi, A. Degiovanni, M. Garlasché (TERA) A. Garonna (EPFL) C. Mellace, P. Pearce (A.D.A.M. S.A.)* ***S. Verdú-Andrés*** *R. Wegner (CERN)*

Proton and carbon ion beams present advantageous depth-dose distributions with respect to X-rays. Carbon ions allow a better control of "radioresistant" tumours due to their higher biological response. For deep-seated tumours proton and carbon ion beams of some nA and energies of about 200 MeV and 400 MeV/u respectively are needed. For these applications TERA proposed the "cyclinac": a high-frequency linac which boosts the hadrons accelerated by a cyclotron. The dimensions of the complex can be reduced if higher accelerating gradients are achieved in the linac. To test the maximum achievable fields, a 3 GHz cavity has been built by TERA. The 19 mm-long cell is foreseen to be excited at 200 Hz by 3 us RF pulses and should reach a 40 MV/m

accelerating gradient, which corresponds to a peak surface electric field Es of 260 MV/m. In a first high-power test performed at CTF3 the cell was operated at 50 Hz with a maximum peak power of 1 MW. The maximum Es achieved was above 350 MV/m. The breakdown rate at these field values was around 10^{-1} bpp/m. The maximum value of the modified Poynting vector is close to the best values achieved by high gradient structures at 12 and 30 GHz.

THP038 **Ultimate-Gradient SRF Test Cavity and Loss Measurements in Ultra-Pure Sapphire**
P.M. McIntyre *(Texas A&M University), N. Pogue, A. Sattarov (Texas A&M University) C.E. Reece (JLAB)*
A 1.3 GHz superconducting test cavity is being developed to test wafer samples of advanced SRF materials with surface fields at or beyond the Nb BCS limit. The mushroom-shaped Nb cavity is dielectric-loaded, with a hemisphere of high-purity sapphire located just above a detachable end flange. Wafer samples are mounted on the end flange. The cavity is operated in the TE011 mode, so no currents flow from the end flange to the side walls. Fields are concentrated on the wafer sample so that the peak surface field there is 4 times greater than anywhere else on the cavity walls. The loss tangent of ultrapure sapphire is critical to the performance of the test cavity. A separate first experiment has been conducted in a special 1.8 GHz cavity to measure this loss tangent in L band as a function of temperature for the first time. Results of the measurement and the final design of the ultimate-gradient test cavity will be presented.

THP039 **Superconducting Coaxial Resonator Development for Ion Linacs at Michigan State University**
W. Hartung *(NSCL), S. Bricker, C. Compton, K. Elliott, M. Hodek, J.P. Holzbauer, M.J. Johnson, O.K. Kester, F. Marti, S.J. Miller, D. Norton, J. Popielarski, L. Popielarski, J. Wlodarczak, R.C. York (NSCL) A. Facco (INFN/LNL) E.N. Zaplatin (FZJ)*
Niobium quarter-wave resonators (QWRs) and half-wave resonators (HWRs) are being developed at Michigan State University for two projects: a 3 MeV per nucleon superconducting linac for re-acceleration of exotic ions (ReA3, under construction, requiring 15 resonators), and a 200 MeV per nucleon driver linac for the Facility for Rare Isotope Beams (FRIB, under design, requiring 344 resonators). The QWRs (80.5 MHz,

optimum beta = 0.041 and 0.085) are required for both ReA3 and FRIB. Both include stiffening elements and frictional dampers. Nine beta = 0.041 QWRs have been fabricated; seven of them have been Dewar tested successfully with a helium vessel for use in ReA3. Production and testing of ten beta = 0.085 QWRs is in progress. The HWRs (322 MHz, optimum beta = 0.29 and 0.53, required for FRIB) are designed for mechanical stiffness and low peak surface magnetic field. A prototype beta = 0.53 HWR has been fabricated, and a prototype beta = 0.29 HWR is planned. This paper will cover the RF and mechanical requirements, the resonator and vessel design, and Dewar testing of production resonators.

THP040 **Superconducting Resonator and Cryomodule Production for Ion Linacs at Michigan State University**

C. Compton *(NSCL), J. Bierwagen, S. Bricker, J. DeLauter, K. Elliott, W. Hartung, M. Hodek, J.P. Holzbauer, M.J. Johnson, O.K. Kester, F. Marti, D. R. Miller, S.J. Miller, D. Norton, J. Popielarski, L. Popielarski, N. Verhanovitz, K. Witgen, J. Wlodarczak, R.C. York (NSCL)*

Superconducting quarter-wave resonators, half-wave resonators, and cryomodules are being prototyped and fabricated at Michigan State University (MSU) for two ion linac projects. The 3 MeV per nucleon reaccelerator project (ReA3) is under construction as an upgrade to MSU's nuclear physics research program. ReA3 requires 15 production resonators, housed in three cryostats, with commissioning to begin in 2010. In parallel, MSU is engaged in a future laboratory upgrade, the Facility for Rare Isotope Beams (FRIB). FRIB requires a 200 MeV per nucleon driver linac, which includes 344 resonators (four different betas) housed in 52 cryomodules. FRIB development work is underway, with the prototyping of a FRIB cryomodule planned for early 2011. In addition, the acquisition strategy for FRIB resonators and cryomodules is being finalized, and the technology transfer program is being initiated. The status of the resonator and cryomodule production effort will be presented in this paper, including an overview of the acquisition strategy for FRIB.

THP041 **An Update on the Study of High-Gradient Elliptical SRF Cavities at 805 MHz for Proton and Other Applications**

T. Tajima *(LANL), G.V. Eremeev, W.B. Haynes, F.L. Krawczyk, R.J. Roybal, J.D. Sedillo (LANL) W.A. Clemens, P. Kneisel, K. Macha, R. Manus, R.A. Rimmer, L. Turlington (JLAB)*

An update on the study of 805 MHz elliptical SRF cavities that have been optimized for high gradient will be presented. An optimized cell shape, which is still appropriate for easy high pressure water rinsing, has been designed with the ratios of peak magnetic and electric fields to accelerating gradient being 3.75 mT/(MV/m) and 1.82, respectively. A total of 3 single-cell cavities have been fabricated and tested with various conditions. In addition, a 6-cell cavity design has been completed including multipacting simulations.

THP042 **Studies on Superconducting Thin Films for SRF Applications**

T. Tajima *(LANL), G.V. Eremeev, M.A. Madrid (LANL) I.E. Campisi (ORNL) V.A. Dolgashev, J. Guo, D.W. Martin, S.G. Tantawi, C. Yoneda (SLAC) B. Moeckly (STI) M.J. Pellin, Th. Proslier (ANL)*

In order to overcome the theoretical limit of ~200 mT peak surface magnetic field for niobium SRF cavities, an idea of coating multi-layer thin film superconductors separated with thin dielectric layers has been suggested. We are testing MgB2, NbN and NbC as candidates for the realization of this idea. The results of surface characterization, Auger depth profile, DC magnetization measurements with SQUID, low- and high-field measurements with a TE013-like mode copper cavity coupled with a 11.4 GHz short-pulse Klystron will be presented.

THP043 **1.3GHz Cavity Development at TRIUMF**

R.E. Laxdal *(TRIUMF), C.D. Beard, P. Kolb, V. Zvyagintsev (TRIUMF) D. Longuevergne (UBC & TRIUMF)*

TRIUMF has embarked on a 1.3GHz development program to support the construction of a 50MeV 10mA e-Linac for the production of radioactive ion beams through photo-fission. Two single cell bulk niobium cavities have been produced in Canadian Industry. A seven-cell cavity in copper is being fabricated both as a manufacturing model and to test higher order mode calculations. Electro-magnetic and mechanical models of a multi-cell cavity are being done to optimize the final design for high intensity acceleration. The 1.3GHz cavity development pro-

gram will be presented.

THP044 **RF Cavity Performance in the ISAC-II Superconducting Heavy Ion Linac**

D. Longuevergne *(UBC & TRIUMF) C.D. Beard, A. Grassellino, P. Kolb, R.E. Laxdal, V. Zvyagintsev (TRIUMF)*

The ISAC-II superconducting linac consists of forty quarter wave bulk niobium cavities. There are eight and twelve 106MHz cavities at beta=5.7% and 7.1% respectively and twenty cavities at 141MHz at beta=11%. The first twenty have been operating since 2006 (Phase I) and the remainder have been installed for first commissioning in April 2010 (Phase II). Cavity performance statistics of the 2006 cavities have been accumulated to look for signs of systematic degradation in performance. These will be presented. In addition single cavity test results and in situ characterization tests of the first operation of the Phase II cavities will be presented.

THP046 **CSNS Linac RF System Design and R&D Progress**

J. Li *(IHEP Beijing), J.M. Qiao, X.A. Xu, Y. Yao, Z.H. Zhang, W. Zhou (IHEP Beijing) Z.C. Mu (Institute of High Energy Physics, CAS)*

China Spallation Neutron Source (CSNS) is determined to be constructed in Dongguan, Guangdong province of south China. Now its design and R&D are in progress in IHEP, Beijing. The 324 MHz rf linac is designed with beam energy of 81 MeV and a peak current of 30 mA. In the klystron gallery, five klystron power sources will be used to power the RFQ and the four DTL tanks, and three solid state RF amplifiers will drive two MEBT bunchers and a LRBT debuncher. Now we have already made some progress with some key technologies for linac RF system. The digital low level RF control prototype was already developed and successfully applied in beam commissioning of the ADS (Accelerator Driven Sub-critical system) 3.5MeV RFQ accelerator at peak beam 44.5mA, beam duty 7.15%. A proposed new type of power supply, 100Hz ac series resonance high voltage power supply, passed acceptance test and a satisfactory test results was obtained. R&D of crowbar and modulator has gotten preliminary performance test data.

THP047 **Status of the Oak Ridge Spallation Neutron Source (SNS) RF Systems**

T.W. Hardek *(ORNL), M.T. Crofford, Y.W. Kang, S.W. Lee, M.F. Piller, A.V. Vassioutchenko (ORNL) M.E. Middendorf (ORNL RAD)*

The SNS has been delivering production neutrons for four years. First beam was delivered to the neutron target at the end of April 2006. On September 18, 2009 SNS officially reached 1 megawatt of beam on target marking the achievement of a decades-old dream of delivering a mega-watt class pulsed spallation source in the U.S. The present effort is aimed at routinely delivering 1 megawatt of beam and gradually increasing the intensity to the 1.4 megawatt design level. The RF systems have performed well since initial installation. This paper provides a review of the SNS RF Systems, an overview of the performance of the various components and a more detailed review of the RF related issues addressed over the past several years.

THP048 **Solid-State Upgrade to the SNS MEBT RF Power Amplifiers**

M.E. Middendorf *(ORNL RAD) M.E. Clemmer, T.W. Hardek (ORNL)*

The original SNS baseline installation included six 20kWpk vacuum tube power amplifiers (four online amplifiers and two ready spares, manually interchangeable) to drive the four rebuncher cavities that are part of the Medium Energy Beam Transport (MEBT) structure. We are in the process of replacing the six vacuum tube amplifiers with five commercially-available 25kWpk solid-state amplifiers that will connect to the rebuncher cavities through a remotely-operated 4+1 switching matrix. We report progress to date.

THP049 **Latest IGBT Gate Driver for the HVCM at SNS**

D.J. Solley *(ORNL), D.E. Anderson, M. Wezensky (ORNL) C. Burkhart, M.A. Kemp, M.N. Nguyen (SLAC)*

The SNS at ORNL has been operational since 2006, during which time beam power to target has been ramping. As of September 2009, a sustainable 1 MW was achieved, continuing to make SNS the highest energy pulsed neutron source available for scientific research worldwide. Having achieved the design energy, the shift in focus is now towards increasing the availability for researchers using the facility. For example, a 25,000 hour MTBF together with a four hour MTTR goal for the High Voltage Converter Modulators

(HVCMs) translates into a 99.98% availability figure. This ambitious goal requires careful engineering of system components, the ability to actively monitor and respond to fault conditions and employment of redundancy wherever possible. This paper outlines the features of the latest IGBT gate drivers that switch the 1200 A, 3300/4500V IGBT modules used in the modulator. The paper goes on to discuss how the signals monitored within each driver can be processed by a central controller to optimize and protect the power stage in a particularly hostile environment. Examples of how the new drivers can improve system availability and improve fault response will also be reported

THP050 **Investigation on Mode Separation Methods and Accuracy of Field Measurement in RFQ Structures with 3-D EM Simulation**

K.R. Shin *(ORNL), Y.W. Kang, S.-H. Kim (ORNL) A.E. Fathy (University of Tennessee)*

In radio frequency quadrupole (RFQ) structures, the fundamental quadrupole mode is used for focusing and acceleration of ion particles. The fields are maintained to have negligible interference with other unwanted modes of the structure using mode suppressors of different types especially in vane type RFQ that have certain advantages and disadvantages. The field distribution on the beam axis is usually measured and referenced using multiple loop-type magnetic probe antennas on the wall along the structure. Since the structures are equipped with many slug tuners on the outer wall for correction of fields, the tuner-probe interference can be a concern. In order to investigate the mode separation properties of the commonly used mode suppressors and the accuracies in field distribution with respect to localized mechanical imperfections due to the tuners, a systematic 3D simulation has been carried out using a full-scale model of the SNS RFQ.

THP051 **Retrospective on Fundamental Power Couplers for the Spallation Neutron Source at Oak Ridge**

M. Stirbet *(JLAB)*

As of September 2009 a sustainable 1 MW in beam power was achieved at Oak Ridge, continuing to make SNS the highest energy-pulsed neutron source available for scientific research worldwide. This paper evaluates the FPCs designed and built at JLAB for the SNS project, emphasizing their performance and related issues addressed during prototyping, qualification on

the RF power test stand at room temperature, superconducting cavity commissioning and successful but challenging operation with beam for more than 5 years.

THP052 **RF Power Generation in LINAC4**

O. Brunner *(CERN), J.N. Schwerg (CERN)*

Linac4 is a linear accelerator for negative Hydrogen ions (H-) which will replace the old Linac2 as linear injector for the CERN accelerators. Its higher energy of 160 MeV will give increased beam intensity in the downstream machines. Linac4 is about 100 m long, normal-conducting, and will be housed in a tunnel about 12 m below ground. The Linac4 tunnel will be connected to the existing chain of accelerators and can be extended to the new injection chain. The high RF power for the Linac4 accelerating structures will be generated by thirteen 1.3 MW klystrons, previously used for the CERN LEP accelerator, and six new 2.8 MW klystrons of all operating at a frequency of 352.2 MHz. The integration of the RF power system in the building is presented. The technical specifications and the performance of the various high-power elements are discussed, with emphasis on the required retuning of the LEP klystrons. The power distribution system including the power splitting requirements are also described.

THP053 **High Power RF for TRIUMF Injector Cryomodule and Elinac**

A.K. Mitra *(TRIUMF), S.R. Koscielniak, R.E. Laxdal (TRIUMF)*

A 500 kW electron linear accelerator is being proposed at TRIUMF for radioactive ion beam production to support existing rare isotope facility. Present design consists of 100 keV thermionic gun, a normal conducting buncher, an injector module and main linac modules. The design energy is 50 MeV with 10 mA beam current. The linac will operate in cw mode using 1.3 GHz superconducting technology. The injector cryomodule (ICM), uses a nine-cell TESLA type cavity operating at 2 degree Kelvin. The front end of the ICM has a room temperature buncher and also has two superconducting capture cavities which are housed in the same cryomodule as the accelerating multi-cell cavity. Solid state amplifiers are proposed to be used for the buncher and the capture cavities. A 30 kW 1.3 GHz IOT, operating at cw will be used to drive the nine-cell cavity of the ICM. The rf power will be divided into two equal parts and fed to two TTF III type couplers. The same couplers are intended to be

used for the remaining accelerator cavities of the e-linac. The e-linac is being proposed to be built in stages. High power Klystrons are to be used to provide rf power to the accelerating cavities.

THP054 **A Diplexer to Operate Two Cavity Eigenmodes in Parallel**

A. Arnold *(FZD)*

To fulfil the demand of future high power and high luminosity FEL and Storage Ring sources, an intensive electron beam with short bunch length, small emittance and large bunch charge is required. Laser driven superconducting radio frequency (SRF) photocathode guns in combination with SRF LINACs appear to be the best solution. First long term operation was demonstrated at the FZD*. In difference to the normal conducting guns, the application of static magnetic fields is not possible. Instead, the use of a transverse electric (TE) mode in parallel to the accelerating mode was proposed. Numerical simulations have shown that such RF focusing can be applied to compensate emittance growth**. This contribution will introduce a possibility to use the existing coaxial RF coupler of TESLA like cavities, as RF power input for TE modes in parallel. An additional coupler component outside the module satisfies the job of combining two frequencies from different sources to one load. Thus, it corresponds to the working principle of a high power RF diplexer. Based on the 3 1/2 cell FZD SRF gun, a concrete technical implementation and results of its operation at the cold cavity will be presented.

THP055 **Multipactor Simulations of the SPL Power Coupler**

G. Burt *(Cockcroft Institute, Lancaster University), A.C. Dexter (Cockcroft Institute, Lancaster University) R. Calaga (BNL) E. Montesinos (CERN)*

Multipactor is a limiting factor in many RF power couplers. The SPL coupler is proposed to have a conical matching section between the window and the coaxial section however this section must be checked for multipactor. Multipactor simulations of the coupler up to a few MW's of power were performed using a variety of different codes and the results were compared. Simulations were performed in the conical and straight coaxial sections.

THP056 **Development of a 300-kV Solid State Pulsed Voltage Supply for an ANL XFELO Injector***
A.R. Cours *(ANL), G. Trento (ANL)*
A solid state Marx-based pulsed voltage supply is being developed at Argonne National Laboratory (ANL) with the capability of providing 300-kV pulses with 0.5-μs rise time, 1-μs fall time, 2-μs pulse flat top, and up to 10-Hz repetition rate. The supply is designed to operate a direct current (DC) thermionic prototype gun producing ~ 0.1-μm beam emittance, a part of the ANL x-ray free-electron laser oscillator (XFELO) injector feasibility studies. The pulsed supply utilizes isolated gate bipolar transistor (IGBT) devices. Stage switching allows this supply to quickly charge the 200-pF gun capacitance and maintain 300-mA gun current during the pulse flat top. A second string of IGBT switches charges the stage capacitors and acts as a 'crowbar' to quickly remove high voltage from the gun at the pulse's fall time or during load arcing. We present an overview of the design and development of the XFELO injector DC gun pulsed power supply.

THP057 **A New Fast Tuning System for ATLAS Intensity Upgrade Cryomodule**
M.P. Kelly *(ANL), S.M. Gerbick, M. Kedzie, P.N. Ostroumov, S.I. Sharamentov (ANL)*
An upgrade project is underway at the ATLAS superconducting RF (SRF) heavy-ion linac at Argonne National Laboratory to dramatically increase the intensity of both stable beams and short-lived isotopes from the CARIBU fission source. The upgrade includes a new normal conducting RFQ injector and an SRF cryomodule consisting of seven high-performance 72.75 MHz quarter-wave cavities optimized for ions with velocity of 0.077c. The module will deliver more than 17.5 MV of accelerating potential over 5 meters and replace three existing split-ring cryomodules. Key to this performance will be a new cavity fast tuning system that replaces the voltage-controlled-reactance (VCX) fast tuner. The recently completed ATLAS upgrade cryomodule installed in June 2009 has a real estate gradient of 14.5 MV over 4.6 meters, the highest for any low-beta cryomodule, however, performance is 40% less than could be achieved without the VCX. As such, the VCX is being replaced with a high-power rf coupler and a fast piezoelectric-based tuner to be used together to control the cavity phase. Cold test results of a prototype power coupler and piezotuner are presented here.

THP058 **Power Supply System for Klystron in J-PARC Linac**

M. Kawamura *(KEK), Y. Fukui, F. Naito (KEK) E. Chishiro, H. Suzuki, M. Yamazaki (JAEA) K. Hasegawa, S. Shinozaki (JAEA/J-PARC)*

This report will describe the present status of the power supply systems (PS systems) for the klystrons in the J-PARC (Japan Proton Accelerator Research Complex) linac. The technical specification, the operating experience, and the upgrade plan, of the PS systems will be presented in this report. Now the energy of the J-PARC linac is 181MeV, and the linac includes twenty 324MHz klystrons. In 2012, the energy will be upgraded to 400MeV, and the linac will include twenty 324MHz klystrons and twenty-five 972MHz klystrons. The klystrons are the modulating-anode types. The PS systems include the High voltage DC power supplies (DCPSs) and the anode-modulators. One DCPS drives one or four klystrons, and one anode-modulator drives one klystron.

THP060 **X-band Pulse Compression System using One Channel Circular Polarized Traveling Wave Delay Line**

M. Yoshida *(KEK), S. Fukuda, Y. Higashi, T. Higo, N.K. Kudo, S. Matsumoto, H. Matsushita (KEK) S. Kazakov (Fermilab)*

The X-band pulse compression system has been developed for the high gradient experiment of the accelerating structure in the new X-band test facility (Nextef). The one channel circular polarized traveling wave delay line was selected to obtain the higher RF compression efficiency under limited delay line length and the easier operation than the cavity chain type. This delay line of the circular waveguide is also frequently used for the C-band feed line from the modulator floor to the accelerator test floor. Thus the delay line is tilted and has the limited length of around 20m. It is designed to obtain the three times compressed power which has the pulse duration of 150 ns. Further we also proceed the upgrade plan using the TE21 mode to double the pulse duration. In this paper, the design overview of this pulse compression system and the RF components including the mode launcher and the TE11-TE21 reflector will be presented.

THP061 **Towards a Modulator for the XFEL RF Stations: Test Results of the Prototype from Thomson**

H. Leich *(DESY Zeuthen), U. Gensch, M. Grimberg, L. Jachmann, W. Koehler, M. Penno, R.W. Wenndorff (DESY Zeuthen) S. Choroba, H.-J. Eckoldt, T. Grevsmuehl (DESY)*

The European XFEL, an X-ray free electron laser, is planned as an European project with a strong connection to the DESY research center in Hamburg. Construction started in summer 2007 and commissioning will begin in 2014. The LINAC of the XFEL will incorporate 27 RF stations to supply the RF power required by the superconducting cavities. In order to generate this power (10MW at 1.3GHz) HV pulse modulators are required. Each modulator has to supply 12kV pulses at 1.6kA for 1.7ms pulse duration and at 10Hz nominal repetition rate. The repetition rate can be increased to 30Hz keeping the average power of the 10Hz operation. Although experience exists for FLASH with modulators constructed and built by one company two additional companies have been selected and contracted to design and to build additional prototypes of modulators according to the XFEL requirements. A test stand setup has been prepared at DESY, Zeuthen Site, in order to test and to operate these protoypes under similar conditions as at the XFEL. The presentation describes the Modulator Test Facility at DESY (Zeuthen Site) and presents and discusses test results of the modulator prototype from Thomson Multimedia.

THP062 **Upgrade of the 1.3GHz RF System at FLASH**

T. Grevsmuehl *(DESY), S. Choroba, F. Eints, T. Froelich, V.V. Katalev, K. Machau, P. Morozov, R. Wagner, V. Zhemanov (DESY)*

The FLASH RF system consists of several RF stations, which provide RF power up to 10MW at 1.3GHz, 1.3ms and 10Hz repetition rate, each, for the superconducting cavities and the RF gun of the FLASH linear accelerator. During the last upgrade of the FLASH facility several modifications have been made also to the RF system. The oldest RF stations were constructed and manufactured by FNAL more than 15 years ago and have been replaced. Since one additional superconducting accelerator module has been added and one superconducting module and the RF gun have been replaced, modification and rearrangement of the RF waveguide distributions were required. An XFEL type waveguide distribution for

the new accelerator module ACC7 and a distribution without individual phase shifters for the exchanged module ACC1 have been installed. A new waveguide distribution for the RF gun allows phase tuning by changing the gas pressure in the waveguides. It will also allow supply the RF gun by a 10MW multi beam klystron instead of the still used 5MW single beam klystron at a later point of time.

THP063 **Component Tests for the ILC Klystron Cluster System**

C.D. Nantista *(SLAC), C. Adolphsen, G.B. Bowden, F. Wang (SLAC)*

Rebaselining of the International Linear Collider (ILC) includes an option for producing high-power rf on the surface and transporting it down to and along a single tunnel in overmoded waveguide (Klystron Cluster System, or KCS). To minimize the number of shafts required, power from many klystrons (~30) would be fed into a single waveguide to drive over a kilometer of linac. R&D is underway to demonstrate the feasibility of this concept. In particular, a 10 m run of the 0.48 m-diameter circular waveguide envisioned for this application has been fabricated, as well as prototypes of the device needed to tap power into and out of it in the low-loss TE01 mode (coaxial tap-off, or CTO). After cold tests, these will be used to demonstrate high power transmission with an available 3.8 MW L-band source. The waveguide will then be resonated through one coupler to build up fields equivalent to those of a traveling wave at the 200-300 MW level it would see in the ILC. These tests will be done both under vacuum and pressurized with nitrogen. We report on this work and discuss future plans.

THP064 **Design of a Second-Generation ILC Marx Modulator**

M.A. Kemp *(SLAC), A.L. Benwell, C. Burkhart, R. Esmaili, C. Huang, R.S. Larsen, D.J. MacNair, M.N. Nguyen, J.J. Olsen (SLAC)*

The SLAC National Accelerator Laboratory is leading an effort to design a prototype Marx modulator to meet the ILC klystron modulator specifications; a 120 kV (ś 0.5%), 140A, 1.6 ms pulse at a 5 Hz prf. A first generation prototype, the P1 Marx, has been developed and is undergoing life testing*. The design of a second-generation Marx, P2, has been completed and most sub-systems have been tested**. The P2 advances the Marx topology demonstrated by the P1; eliminating single-point failures, incor-

porating advanced diagnostics/prognostics, and optimizing engineering margins to improve system availability. The P2 consists of 32 cells, which are individually regulated at an output of up to 4kV. This is in contrast to the P1 Marx which is collectively regulated by a series "Vernier" Marx. The 30 of 32 cell redundancy allows for up to two cell failures without degrading the modulator output. Failed cells can be quickly replaced and remotely-serviced. This paper presents the design of the P2 Marx. Specific topics discussed include the control architecture, mechanical layout, and power electronics design. Experimental results of both a single and array of cells are presented.

THP065 **Magnetrons as SRF Sources**

M. Popovic *(Fermilab), A. Moretti (Fermilab) A. Dudas, R.P. Johnson, M.L. Neubauer, R. Sah (Muons, Inc)*

Magnetrons are the lowest cost microwave source in dollars/kW, and they have the highest efficiency (typically greater than 85%). However, the frequency stability and phase stability of magnetrons are not adequate when used as power sources for accelerators. Novel variable frequency cavity techniques have been developed to phase and frequency lock the magnetrons, allowing their use for either individual cavities, or cavity strings. Ferrite or YIG (Yttrium Iron Garnet) materials are placed in the regions of high magnetic field of radial-vaned, π–mode structures of a selected ordinary magnetron. A variable external magnetic field that is orthogonal to the magnetic RF field of the magnetron surrounds the magnetron to vary the permeability of the ferrite or YIG material. Measurements of a prototype magnetron will be described.

THP066 **Processing Test Stand For The High Power Coupler Of An Elliptical Superconductive Cavity For The MYRRHA Projet**

E. Rampnoux *(IPN), S. Berthelot, J.-L. Biarrotte, P. Blache, C. Commeaux, F. Doizon, D. Grolet, P. Szott, J.-F. Yaniche (IPN)*

MYRRHA project consists of the construction of an experimental facility in order to demonstrate the technical feasibility of Transmutation of high-level nuclear waste in an Accelerator Driver System. Thus the sub-critical core must be fed by a neutron beam resulting from a great quality spallation of a high-intensity proton beam on a target. Because of the induced thermal stress to the subcritical core, the high-power proton LINAC must have a great reliability to

minimize the number of unwanted beam trips. The MYRRHA ADS demonstrator requires a high power proton superconductive linac (600MeV/ 4mA) operating in CW mode with the characteristic that each components of it must have the greatest reliability. In this framework IPN Orsay is in charge of the development of a power coupler for the 5-cells superconducting cavities present in the high energy section of the linac. We will describe all the stages about power coupler developments, from the conception to the conditioning. We will present the design, the commissioning of the test stand and the results of the couplers conditioning. A last part will show the reliability tests carried out with a 50 kW RF power during a long time.

THP068 **Compact Solid State Direct Drive RF LINAC : Experimental Program**

O. Heid *(Siemens AG, Healthcare Technology and Concepts), P. Beasley, T.J.S. Hughes (Siemens AG, Healthcare Technology and Concepts)*

An RF accelerator driver concept is introduced, which integrates a distributed solid-state RF power source with the RF resonator. The resulting structure plays a double role as RF combiner and particle accelerating structure [1]. The key enabling technologies are Silicon Carbide RF transistors and a power combiner concept which includes insulating parallel cavities to ensure consistent RF current injection. An experimental direct drive lamda/4 cavity with a power rating of 500kW at 150MHz has been constructed. The Direct Drive RF power source consists of 64 RF modules constructed from Silicon Carbide vJFETs, radial power combiner and isolation cavity. The initial results from the integration of the direct drive RF source are presented. These results demonstrate experimentally for the first time the validity of the direct drive concept and the key characteristics of such a drive.

THP069 **Stripping of H-minus Beams by Residual Gas in the Linac at the Los Alamos Neutron Science Center**

R.C. McCrady *(LANL)*

The linear accelerator at the Los Alamos Neutron Science Center (LANSCE) accelerates both protons and H-minius ions using Cockroft-Walton-type injectors, a drift-tube linac and a side-coupled linac. The vacuum is maintained in the range of 10^{-6} to 10^{-7} Torr; the residual gas in the vacuum system results in some stripping of the electrons from the H-minus ions resulting in

beam spill and the potential for unwanted proton beams delivered to experiments. We have measured the amount of fully-stripped H-minus beam (protons) that ends up at approximately 800MeV in the beam switchyard at LANSCE using image plates as very sensitive detectors. I will present the motivation for the measurement, the measurement technique and results, and calculations to model the results and possible mitigation schemes.

THP070 **Simulation Study of the RF Chopper**
Y. Kondo *(JAEA/J-PARC)*

For the beam current upgrade of the J-PARC linac, a new RFQ (RFQ III)is developing. The peak beam current of RFQ III is 50mA. To increase the peak current from the existing RFQ (RFQ I), the longitudinal and/or transverse emittances are expected to be increased. However, the increase of the longitudinal emittance will affect the performance of the RF chopper system. In this paper, detailed simulations of the RF chopper system are described and the requirement for the longitudinal emittance of the RFQ is clarified.

THP071 **ExB Chopper System for High Intensity Proton Beams**
C. Wiesner *(IAP), L.P. Chau, H. Dinter, M. Droba, N.S. Joshi, O. Meusel, I. Mueller, U. Ratzinger (IAP)*

High intensity beams which are increasingly needed for a variety of applications pose new challenges for beam chopping. An ExB chopper system for proton beams of up to 200 mA and repetition rates of up to 250 kHz is under development at IAP. It will be tested and installed in the low energy section of the Frankfurt Neutron Source FRANZ at beam energies of 120 keV. The chopper consists of a static magnetic dipole field and a pulsed electric field in a Wien filter-type ExB configuration. The electric field temporarily compensates the magnetic deflection thus creating a proton pulse in forward direction, while the duty cycle of the electric field is minimized in order to reduce the risk of voltage breakdowns. Downstream of the chopper a septum will be used to separate the beams ensuring dumping outside the transport line in order to avoid uncontrolled power deposition and the resultant production of secondary particles. Numeric field optimizations and beam simulations including secondary electron effects are presented. Measurements of the high voltage pulse generator based on MOSFET technology and capable of

generating 12 kV at 250 kHz as well as beam deflection experiments are shown.

THP072 **Slow Chopper For The Spiral 2 Project**

A.C. Caruso *(INFN/LNS), F. Consoli, G. Gallo, D. Rifuggiato, A. Spartà, E. Zappalà (INFN/LNS) M. Di Giacomo (GANIL) A. Longhitano (ALTEK)*

The low energy beam transport line of the Spiral 2 driver is designed for CW and high intensity beams of protons, deuterons and ions with m/q = 3. A chopper will be used to progressively increase the beam power during accelerator tuning, to rapidly remove the beam in case of failure detection, and to avoid hitting the wheel spokes of rotating targets. The paper describes the final design and tests of the complete device and of the power circuits, based on standard components and working up to 10 kV, at 1 kHz repetition rate.

THP073 **Broad-band Beam Chopper for a CW Proton Linac at Fermilab**

S. Nagaitsev *(Fermilab), V.A. Lebedev, R.L. Madrak, R.J. Pasquinelli, N. Solyak, D. Sun, R.C. Webber, M. Wendt (Fermilab)*

The specifications and the initial conceptual ideas for a broad-band proton beam chopper For the Fermilab Project X linac will be presented. The chopper will form bunch patterns required by physics experiments and will work in conjunction with a downstream beam splitter, allowing for a variable bunch patterns to be delivered to up to three experiments concurrently.

THP074 **Failure Analysis of the DARHT Second Axis Accelerator Cell Solenoid**

R.R. Mitchell *(LANL), D. Honaberger, B.A. Prichard (LANL) M.E. Schulze (SAIC)*

The Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT) at Los Alamos National Laboratory (LANL) consists of two linear induction accelerators oriented at right angles to each other. The DARHT First produces a 60 ns pulse with a beam energy of 20 MeV and a beam current of 1.9 kA. The DARHT Second Axis produces a 1600 ns pulse with a nominal beam energy of 17 MeV and a beam current of 2 kA. The Second Axis Accelerator consists of 74 accelerating induction cells, each incorporating a solenoid comprised of twelve layers of copper conducting wire coated by a layer of insulating polymidemide and polyester. During the winding process, a coating of Castall E-301 epoxy was applied to the wire, forming the exterior boundary of the

solenoid. The solenoids are cooled by low conductivity water flowing along the outside and inside surfaces of the solenoid. Recently, three solenoids developed electrical shorts within the winding. A comprehensive study has begun to determine the failure mechanism of the windings and to propose corrective measures. This paper describes the results of this study, which includes finite element analysis of the DARHT Second Axis accelerator cell solenoids.

THP075 **Laser-Beam Propagation Characteristics in New Laser-Based Alignment System at the KEKB Injector Linac**

T. Suwada *(KEK), M. Satoh (KEK)*

A new laser-based alignment system is under development in order to precisely align accelerator components along an ideal straight line at the KEKB injector linac towards the next generation of B-factories. A new laser optics generating so-called Airy beam has been developed for the laser-based alignment system. The laser-beam propagation characteristics both in vacuum and at atmospheric pressure have been systematically investigated at a 82-m-long straight section of the injector linac. The results in the measured propagation characteristics are in good agreement with those analyzed on the basis of theoretical analysis in Gaussian laser propagation. In this report the experimental study is described in detail along with the basic design and recent development of the new laser-based alignment system.

THP076 **Design of Collimated Laser Beam Optics for the KEKB Injector Linac Alignment System**

M. Satoh *(KEK), T. Suwada (KEK)*

A new laser-based alignment system is under development in order to precisely align accelerator components along an ideal straight line at the KEKB injector linac. The new alignment system is strongly required in order to stably accelerate high-brightness electron and positron beams with high bunch charges and also to keep the beam stability with higher quality towards the next generation of B-factories. The new laser-based alignment system consists of the LD mounted on auto stage, vacuum duct, photo diode (PD) and PD detector. To eliminate the laser beam size dependent response of PD, the collimated laser beam propagation along the linac (around 500-m-long) is strongly required. In this paper, we will report the design of collimated laser beam optics for the KEKB injector linac alignment system in detail.

THP077 **Development of PteqHI**

J.M. Maus *(IAP), R.A. Jameson, A. Schempp (IAP)*

For the development of high energy and high duty cycle RFQs accurate particle dynamic simulation tools are important for optimizing designs, especially in high current applications. To describe the external fields in RFQs as well as the internal space charge fields with image effect, the Poisson equation has to be solved taking the boundary conditions into account. In PteqHI a multigrid Poisson solver is used to solve the Poisson equation. This method will be described and compared to analytic solutions for the Two-term-potential to verify the answer of the Poisson solver.

THP078 **Analytical Analysis of Particle-core Dynamics**

Y.K. Batygin *(LANL)*

Particle-core interaction is the well-developed model of halo formation in high-intensity beams. In present paper an analytical solution for averaged single particle dynamics around uniformly charged beam core is obtained. The problem is analyzed through sequence of canonical transformations of Hamiltonian describing nonlinear particle oscillations. An analytical expression for maximum particle deviation from the axis is obtained. Results of the study are in good agreement with numerical simulations and with previously achieved data.

THP079 **Muon Capture in the Front End of the IDS Neutrino Factory**

D.V. Neuffer *(Fermilab) G. Prior (CERN) C.T. Rogers (STFC/RAL/ASTeC) C. Y. Yoshikawa (Muons, Inc)*

We discuss the design of the muon capture front end of the neutrino factory International Design Study. In the front end, a proton bunch on a target creates secondary pions that drift into a capture transport channel, decaying into muons. A sequence of rf cavities forms the resulting muon beams into strings of bunches of differing energies, aligns the bunches to (nearly) equal central energies, and initiates ionization cooling. The cooling section uses absorber material(reducing the 3-D muon momenta) alternating with rf cavities (restoring longitudinal momentum) within strong focusing magnetic fields. For the International Design Study (IDS) this must be optimized for performance and cost, and variations will be explored. A baseline design will be developed for an engineering and cost study. The design is

affected by limitations on accelerating gradients within magnetic fields. The effects of gradient limitations are explored, and mitigation strategies are presented.

THP080 **Intrabeam Stripping in H- Linac**

V.A. Lebedev *(Fermilab) A.V. Aleksandrov, A.P. Shishlo (ORNL)*

A beam loss in the superconducting part of the SNS linac has been observed during its commissioning and operation. Although this loss does not prevent the SNS high power operation it results in an almost uniform irradiation of linac components and increased radiation levels in the tunnel. A multi-particle tracking could not explain the beam loss and its dependence on the machine parameters. It was recently found that the loss is related to the intrabeam particle collisions resulting in a stripping of one of two H^- ions. The paper describes experimental observations and corresponding calculations of the intrabeam stripping.

THP081 **The Stretched Wire Method: A Comparative Analysis Performed by Means of the Mode Matching Technique**

M. Panniello *(Naples University Federico II and INFN), V.G. Vaccaro (Naples University Federico II and INFN) M.R. Masullo (INFN-Napoli)*

The Wire Method for Coupling Impedance evaluations is quite appealing for the possibility to make bench measurements on the Device Under Test (DUT). However, it is not entirely reliable because the stretched wire perturbs the boundary conditions, introducing a TEM wave that has a zero cut off frequency. We expect that, for frequencies smaller than the cutoff one, this behaviour produces an additional power loss which drastically lowers the high Q resonances of DUT. Above cutoff frequency, the impact of the stretched wire is not as dramatic as below cutoff. The Mode Matching Technique will be used to simulate the measurement with the Wire Method. In this way one may get a result which is not affected by the errors intrinsic of experimental measurements. The same method will be used to get, according to its standard definition, the Coupling Impedance of the real structure. The two results will be compared in order to define the frequency ranges in which they agree or disagree. As expected large discrepancies appear below cutoff frequency, while above cutoff, for certain ranges of parameters, an agreement is found.

THP082 **Beam Dynamics Simulation and Measurement for the PIAVE-ALPI Linac**

M. Comunian *(INFN/LNL), E. Fagotti, F. Grespan, A. Pisent, C. Roncolato (INFN/LNL)*

As far as beam dynamics is concerned, the layout of the PIAVE-ALPI SuperConducting linac, it is injected either by a XTU tandem, up to 14 MV, or by the s-c PIAVE injector, made with 2 SC-RFQ. The linac (at the present 64 cavities for a total voltage up to 48 MV) is build up in two branches connected by an achromatic and isochronous U-bend. The PIAVE-ALPI complex is able to accelerate beams up to A/q = 7. The linac is quite complex due the presence of several accelerating, (SC RFQs and cavities), focusing and transport elements. The linac operation, optimized for the needs of the users, is described. In particular the effects of a flexible use of the cavities on the beam dynamics is addressed. The automatic tuning procedure of the Toutatis-Tracewin programs is used for the simulation, and the comparison with the actual linac performances is reported.

THP083 **An Novel Approach for Beam Commissioning Environment using SOA Technology and Performance Benchmarking**

G.B. Shen *(BNL) P. Chu, J. Wu (SLAC)*

High level applications provide an efficient method to commission and operate an accelerator. Traditional application adopts a monolithic approach, and has to deal with all processing such as preparing large amount of data initialization, performing heavy computation and communication, and/or updating a GUI with high repetition rate. With time going, an application might become more complicated and heavier by adding new required functions. Therefore, it reduces the application performance and reliability. All applications are coupled tightly with its specific environment, therefore, are not portable. Furthermore, exception handling and message logging increases the application complexity level. To solve all the drawbacks mentioned, a novel approach is proposed and under development using a SOA technology. The architecture for applications uses a set of services to replace the traditional all-in-one approach. Some prototypes have been developed using structured data so-called PVData/PVStructure and a new EPICS Channel Access protocol„PVAccess. The performance of each service servers has been benchmarked and analyzed. This paper describes our latest progress

and service performance.

THP084 **Further Development of the V-Code for Recirculating Linear Accelerator Simulations**
S. Franke *(TEMF, TU Darmstadt), W. Ackermann, T. Weiland (TEMF, TU Darmstadt) P.A. Görgen, C. Klose, M. Platz (TU Darmstadt)*
The recirculating Superconducting Darmstadt Linear Accelerator S-DALINAC, installed at the institute for nuclear physics (IKP) at the TU Darmstadt, consist of a 10 MeV Injector and a 40 MeV linac. Utilizing two recirculations, the linac could be used up to three times, leading to a maximal energy for nuclear physics experiments of 130 MeV. This recirculating layout makes it pretty complicated to find an accurate setup for the various beam line elements, especially to match the path length of the recirculated beam with the phase of the accelerating fields. Fast online beam dynamics simulations can advantageously assist the operators because they provide a more detailed insight into the actual machine status. In this paper further developments of the moment based simulation tool V-Code enabling it to simulate recirculating machines are presented together with simulation results.

THP085 **Single-Shot Emittance Measurement of a Beam from the SPring-8 Linac**
K. Takeda *(LASTI), Y. Shoji (LASTI)*
The emittance of a single-shot beam from the SPring-8 electron linac was measured. A stability of the linac beam was evaluated from the shot-by-shot fluctuation of the emittance. We used the electron storage ring NewSUBARU as a part of the measurement system. The electron beam from the linac was injected into the ring and circulated. The beam profile was measured by a fast-gated ICCD camera using the visible light in the ring. Because of the intentional dipole injection errors, the beam position oscillated after the injection in vertical and horizontal directions. It enabled a multi-record of turn-by-turn beam profiles in one camera frame. The profiles for several revolutions were used to reconstruct the emittance of the linac beam. The horizontal and the vertical betatron tunes were optimized for the emittance measurement because the beam storage was not necessary. We compared the results with that by Q-scanning at the beam transport line, which required multi-shot beam.

THP086 **Beam Transport in a Proton Dielectric Wall Accelerator***

Y.-J. Chen *(LLNL), D.T. Blackfield, G.J. Caporaso, S.D. Nelson, B. R. Poole (LLNL)*

Compact dielectric wall (DWA) accelerator technology is being developed at the Lawrence Livermore National Laboratory [1]. The DWA accelerator's beam tube is a stack of high gradient insulators, consisting of alternating layers of insulators and conductors. Characteristically, insulators' surface breakdown thresholds go up as the applied voltages' pulse width goes down. To attain the highest accelerating gradient in the DWA accelerator, the accelerating voltage pulses should have the shortest possible duration. This can be done by appropriately timing the switches in the transmission lines, which feed the continuous HGI tube. The accelerating voltage pulses arrive at the accelerator axis along the beam tube at different times so as to appear to the charged particle bunch as a traveling accelerating voltage wave. We have studied the beam transport in a baseline DWA configuration by performing PIC simulations using the 3-D, EM PIC code, LSP [2]. Sensitivity of the output beam parameters to the switch timing will be presented. In addition to the baseline configuration, various alternative focusing schemes will be discussed.

THP087 **Simulation of Cathode Back-bombardment in a 100 MHz Thermionic RF Gun**

M. Borland *(ANL), X.W. Dong (ANL)*

A 100 MHz thermionic rf gun is under consideration as the electron source for the X-ray Free Electron Laser Oscillator*. Because the source must operate continuously, back-bombardment of the cathode is a serious concern. We present results of simulations of back-bombardment, as well as strategies for reducing the back-bombardment power on the cathode.

THP088 **Simulation Study of Debuncher System for J-PARC Linac Energy Upgrade**

G.H. Wei *(KEK/JAEA) M. Ikegami (KEK)*

On the beam line after linac in high power proton accelerators, like J-PARC, debuncher system plays an important role for beam injection to the succeeding ring. The debuncher system usually gives two functions, namely, to correct the center energy jitter and to minimize momentum spread and adjust beam energy at the injection. To mitigate the nonlinear effects of RF field, a debuncher system with two debuncher cavities was designed for the 181-MeV operation of J-PARC linac. In this design, the first

debuncher is expected to deal with center energy jitter. Then, the second debuncher is utilized to control the injection momentum spread according to the requirements from the ring. Although the debuncher system was originally designed to minimize the momentum spread, beam-commissioning results show a different requirement for the injection momentum spread to minimize the beam loss in the ring. Based on the original design and the experimental findings with 181-MeV operation, we have designed a debuncher system for the energy upgrade of J-PARC linac to 400 MeV. In this paper, the beam dynamics design of the new debuncher system is presented together with some particle simulation results.

THP089 **Beam Dynamics Studies of the REX-ISOLDE Linac in Preparation for its Role as Injector for the HIE-ISOLDE SC Linac at CERN**

M.A. Fraser *(UMAN), R.M. Jones (UMAN)*
M.A. Fraser*, M. Pasini, D. Voulot (CERN)*

The superconducting High Intensity and Energy (HIE) ISOLDE linac will replace most of the existing accelerating infrastructure of the Radioactive ion beam EXperiment (REX) at CERN, however, the 101.28 MHz RFQ and 5 MV IH cavity will remain in the role of injector for the upgrade, boosting the beam up to an energy of 1.2 MeV/u. We present the results of a beam dynamics investigation of the injector focused most critically on matching the longitudinal beam parameters from the RFQ to the SC machine, which is complicated largely by the IH cavity employing a Combined Zero Degree* (KONUS) beam dynamics design. The longitudinal beam parameters at the RFQ are reconstructed from measurement using the three-gradient method and combined with beam dynamics measurements and simulations of the IH structure to design the matching section for the SC linac. A tuning procedure for the injector is outlined, which will be very quick and reliable thanks to the solid-state beam diagnostics foreseen to accompany the upgrade.

THP090 **Modeling A Table Top Storage Ring For A Compact Light Source Using Electromagnetic Field Simulation Tools**

T. Roggen *(KU Leuven), H. De Gersem, J.P. Locquet, B. Masschaele (KU Leuven) M. Zhukova (Tomsk Polytechnic University, Nuclear Physics Institute)*

Large synchrotron radiation facilities have become one of the most powerful instruments for

research today. All over the world new facilities are being constructed or designed. The biggest disadvantage of a large synchrotron facility is that the scientific experiments, which are often very sensitive and complex, have to be performed in a dedicated place, sometimes far away from the researcher's home laboratory. Promising compact synchrotron radiation sources, that fit in a typical research lab, have been proposed recently. In this paper results are presented of an initial study of a single body magnet, low electron energy storage ring, performed with the Finite Element (FE) and Finite Difference Time-Domain (FDTD) modeling possibilities in the CST Studio Suite 2010 software package. Insights were obtained for the most crucial components: the magnet yoke, the internal RF cavity and the resonance injection component. Finally, the model of the storage ring was verified using the particle tracker solver which tracks the injected electrons along the ring.

THP091 **Simulations of Ion Beam Loss in Superconducting RF Linacs with Emphasis on Tails of Particle Distributions**

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Design of ion linacs with ion currents of several milli-amps necessitates detailed simulations of beam loss. At high intensities, even a small amount of beam loss can result in significant radio-activation of the linac components. Particle loss can result from longitudinal tails created in the bunching and pre-accelerating process, whereas strong transverse focusing and collimation limit the development of a transverse tail. In modern RF ion linacs, bunching and pre-acceleration take place in a radio frequency quadrupole (RFQ). We present a new approach for beam loss calculations that places emphasis on the tails of the particle distributions. This scheme is used for simulating the SARAF proton/deuteron linac, a 176 MHz complex designed to operate in CW mode at 4 mA beam current. We describe implementation of a RFQ accelerating element in the GPT 3D simulation code. We discuss our scheme for highlighting the tails of the particle distributions generated by the RFQ. These distributions are used as input to simulations of the RF superconducting linac, where subsequent particle loss is calculated. This technique allows us to increase beam loss statistics by a significant factor.

THP092 **Multipacting Simulation and Analysis for the FRIB Superconducting Resonators Using Track3P**

Z. Li *(SLAC), L. Ge, K. Ko (SLAC) W. Hartung, J.P. Holzbauer, J. Popielarski (NSCL)*

In the driver linac of the Facility for Rare Isotope Beams (FRIB), multipacting is an issue of concern for the superconducting resonators, which must accelerate the ion beams from 0.3 MeV per nucleon to 200 MeV per nucleon. While most of the multipacting bands can be conditioned and eliminated with RF, hard multipacting barriers may prevent the resonators from reaching the design voltage. Using the ACE3P code suite, multipacting bands can be computed and analysed with the Track3P module to identify potential problems in the resonator design. This paper will present simulation results for multipacting in half-wave and quarter-wave resonators for the FRIB driver linac and compare the simulations with RF measurements on the resonators.

THP093 **Power Coupler RF Kick and HOMs Analysis of the TRIUMF ICM Capture Cavities**

F. Yan *(TRIUMF), Y.-C. Chao, C. Gong, S.R. Koscielniak, R.E. Laxdal, V. Zvyagintsev (TRIUMF)*

The TRIUMF Injector CryoModule (ICM) adopted two superconducting single cells as the capture cavities for a low injecting energy of 100keV electrons. Coupler kicks and higher order modes (HOMs) of the superconducting cavities are two prime concerns for the beam stability, especially for low energy electrons. By alternating the coupler locations corresponding to the two capture cavities, the kick is compensated to get less orbit distortions and projected emittance growth. The HOMs is another major issue for the superstructure which has two aspects of concern: one is cryogenic loss induced by the HOM power deposited on the cavity wall, another is the HOM effects on the beam. This paper presents the analysis method of calculating the transverse kick and projected emittance growth induced by the coupler and the HOMs effect for a single cell cavity with electrons. The simulation results of the TRIUMF ICM capture cavities for these two issues are described and presented.

THP094 **Map Formalism for Electron Cloud Density**
S. Petracca *(U. Sannio), A. Stabile (U. Sannio) T. Demma (INFN/LNF)*
The electron cloud effects are usually studied using numerically intensive and time consuming simulation codes. A semi analytical approach reducing considerably the computational budget has been suggested to study the electron cloud dynamics in RHIC *, and subsequently extended to LHC **. This approach is based on a quadratic map which reproduces the evolution of the electron density from bunch to bunch. The map coefficients were originally obtained by fit. We computed analytically the linear ** and quadratic *** coefficients of the mapping for the case of free electron cloud evolution using a simple physical model, obtaining a good agreement with numerical simulations, for a wide range of bunch populations.

THP095 **MyBOC - A Beam Optics Code Based on Lie Algebra**
G.J. Yang *(CAEP/IFP), Z. Zhang (CAEP/IFP)*
Recently, A beam optics code named MyBOC(My Beam Optics Code),which is based on Lie algebra, has been developed. MyBOC is a charged-particle beam transport code which use Lie-algebraic map method up to 3nd order to treat the full 6-dimensional phase including all possible linear and nolinear transverse and longitudinal couplings. The Nonlinear space-charge effect can be included. The current version of MyBOC can deal with about 20 types of beam transport and accelerating elements. The common elements, like drifts, dipoles, quadrupoles, sextupoles, solenoid lens, RF accelerating gaps,and so on, are mostly included. Speclially, some electrostatic accelerating and focusing elements are also included. Unlike other codes, MyBOC is written by C++, not fortran. A C++ class library named AccLib is created to deal with the tasks of simulation,data input and output. The interface of MyBOC is very friendly. The data format on input file use HTML-like style, which is almost self-explanatory. The data input can also execute in graphics mode. The output data can be shown in graphics and can also be saved to data files. The phase space along the beamline can be shown in animation mode.

THP096 **Investigation of the Effects of Charge Scaling on Emittance Exchange at the Fermilab A0 Photoinjector**

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Next generation accelerators, such as high-energy physics colliders and light sources, will be interested in phase space manipulations techniques within two degrees of freedom for enhanced performance. At the Fermilab A0 Photoinjector, a proof-of-principle experiment to demonstrate the exchange of the transverse and longitudinal emittances is ongoing. The emittance exchange beamline consists of a 3.9 GHz normal conducting deflecting mode cavity inserted between two doglegs. Electron bunches of varying charge levels from 250 pC to 1 nC and energy of 14.3 MeV are consistently sent through the exchange beamline. In this paper we will present our latest results on the effects of charge on the emittance exchange process.

THP097 **Development of a Thermionic Electron Gun of the L-band Linac for FEL Operation**

N. Sugimoto *(ISIR), G. Isoyama, R. Kato, S. Suemine, A. Tokuchi (ISIR) S. Kashiwagi (Tohoku University, Research Center for Electron Photon Science)*

We are conducting FEL experiments with the L band electron linac at Osaka University. The linac is equipped with a thermionic electron gun and the three-stage sub-harmonic buncher(SHB) system. In FEL experiments an 8μs long electron pulse is injected from the gun and the SHB system is turned on for generating a multi-bunch electron beam of an 8μs duration with 2nC charge per bunch and 9.2 ns intervals between bunches. It repeatedly amplifies light pulses stored in the optical resonator of the FEL. The roundtrip time of the light pulses is 37 ns, so that four light pulses are stored in the resonator. The FEL gain becomes higher at least in proportion to the peak current in the bunch or charge per bunch. The present charge value is limited by the high beam loading in the acceleration tube of the linac, exceeding a half of the input RF power. If the bunch intervals can be extended to 37 ns, the charge per punch can be made four times higher for the same beam loading, resulting in significant increase of the FEL gain. To generate such an electron beam, we are developing the electron gun system with

a high-repetition-rate grid-pulser. We will report the outline of the study.

THP099 **Ultra-High Performance Electron Gun and Linac for the ALPHA Project**

Y. Kim *(IUCF), G.W. East, S.-Y. Lee, P.E. Sokol (IUCF)*

For the radiation effect study, Indiana University has been constructing the ALPHA facility with a small electron linac and a small storage ring. For the proper operation of the facility, ultra-high quality electron beams (rms energy spread < 0.2%, normalized emittance < 1 um, total charge of a macropulse > 320 nC, number of micropulse > 11000) should be generated at 50 MeV. To supply such an ultra-high quality electron beams, an advanced thermionic RF gun with a special quadrupole triplet based energy collimation system has been developed. In this paper, we report the advanced RF gun using a new energy collimation technology and design concepts of the advanced linac for the ALPHA project.

THP100 **Design Concepts of PSI 2.5 Cell S-band RF Photoinjector**

Y. Kim *(IUCF) M. Bopp, H.-H. Braun, T. Garvey, M. Pedrozzi, J.-Y. Raguin (PSI)*

To supply ultra-high brightness electron beams (slice normalized emittance < 0.43 um, rms slice energy spread < 350 keV, peak current > 2.7 kA, beam energy ~ 6 GeV) for the SwissFEL project, PSI has been developing a 2.5 cell S-band RF photoinjector recently. Since there are two different operation charge (10 pC and 200 pC), the RF photoinjector should be optimized differently. By performing many comparing beam dynamics simulations with the LCLS RF gun and CTF3 RF gun, we could optimize performance of the PSI 2.5 cell S-band RF photoinjector. In this paper, we describe design concepts, comparing beam dynamics simulations, and optimized results of PSI 2.5 Cell S-band RF photoinjector for the SwissFEL project.

THP101 **Generation of Femtosecond Electron Beam in Photocathode RF Gun**

K. Kan *(ISIR), T. Kondoh, T. Kozawa, K. Norizawa, A. Ogata, J. Yang, Y. Yoshida (ISIR)*

Femtosecond electron beam, which is essential for pump-probe measurement, was generated with a 1.6-cell S-band photocathode rf gun. The rf gun was driven by femtosecond UV laser pulse (266 nm), which was generated with third-harmonic-generation (THG) of Ti:Sapphire fem-

tosecond laser (800 nm). The longitudinal and transverse dynamics of the electron bunch generated by the UV laser was investigated. The bunch length was measured with the dependence of energy spread on acceleration phase in a linac, which was set at the downstream of the rf gun. Transverse emittance at the linac exit was also measured with Q-scan method.

THP102 **Photocathode Femtosecond Electron Linac and Its Applications**

J. Yang *(ISIR), K. Kan, T. Kondoh, N. Naruse, Y. Nurooka, K. Tanimura, Y. Yoshida (ISIR) J. Urakawa (KEK)*

Photocathode rf electron linac facilities have been developed in Osaka University to reveal the hidden dynamics of intricate molecular and atomic processes in materials. One of the linacs was developed using a booster linear accelerator and a magnetic bunch compressor. This linac was successfully produced a 100-fs high-brightness electron single bunch and initiated the first experimental study of radiation chemistry in the femtosecond time region. Another was constructed with a photocathode rf gun to generate a near-relativistic 100-fs electron beam with a beam energy of 1~4 MeV. A time-resolved MeV electron diffraction was successfully developed with this gun to study the ultrafast dynamics of structure change in materials.

THP103 **Design of a High-repetition RF Gun for SwissFEL**

J.-Y. Raguin *(PSI), M. Bopp, H.-H. Braun, A. Citterio, H. Fitze, M. Pedrozzi, A. Scherer (PSI) Y. Kim (IUCF)*

We report here on the design of a dual-feed S-band 2.5 cell RF gun, developed in the framework of SwissFEL, capable to operate at a 400 Hz repetition rate. As in the LCLS RF gun, z-coupling to reduce the pulsed surface heating and a racetrack coupling cell shape to minimize the quadrupolar component of the fields have been adopted. The cells length and the irises thickness are as in the PHIN gun operating at CERN. However the iris aperture has been enlarged to obtained a frequency separation between the operating π mode and the $\pi/2$ mode higher than 15 MHz. An amplitude modulation scheme of the RF power which allows obtaining a flat plateau of 150 ns for multibunch operation and a reduced average power is presented as well. With an RF pulse duration of 1μs it is shown that operation at 100 MV/m and 400 Hz repetition rate is feasible with reasonable ther-

mal stresses.

THP104 **S-band Normal Conducting Photocathode Gun Design**

J.H. Han *(Diamond), M.P. Cox, H.C. Huang, S.A. Pande (Diamond)*

Photocathode RF guns are widely used as injectors for accelerators requiring very high quality beams such as free electron lasers and linear colliders and recently used as ultrafast electron diffraction sources. Even with the limited repetition rate, normal conducting photocathode RF guns generate very low emittance and short pulse electron beams thanks to their high accelerating field and the efficient positioning of focusing solenoids. We report our activity of the design and production of an S-band normal conducting photocathode gun. The RF characteristics, thermal heating and vacuum analyses are discussed.

THP105 **Design of an S-band Photoinjector with a High Repetition Rate**

J.H. Han *(Diamond)*

At many laboratories S-band photoinjectors operate to provide high quality beams; however the repetition rates are limited to about 100 Hz. This limitation mainly occurs due to the guns where a high RF amplitude of about 100 MV/m is required to keep the beam quality from the space charge force. In this paper we design an injector consisting of an S-band gun with improved cooling and S-band acceleration modules for a repetition rate up to 1 kHz. The technical feasibility and beam dynamics optimization are discussed.

THP106 **Design of a Relativistic Ultrafast Electron Diffraction Source**

J.H. Han *(Diamond)*

Ultrashort electron beams can be used for investigating ultrafast dynamics of physical, chemical or biological systems. With an S-band photocathode gun, simulations have been done in order to generate ultrashort electron beams. Optimizations to generate ultrashort electron beams with a small beam divergence and to minimize the system sensitivity against RF jitter are reported.

THP107 **Experimental Investigation of Pulsed Laser Heating of Thermionic Cathodes in RF Guns**

N. Sereno *(ANL), M. Borland, K.C. Harkay, Y.L. Li, S.J. Pasky (ANL)*

One proposed injector for the X-ray Free Electron Laser Oscillator* uses a 100 MHz thermionic rf

gun to deliver very small emittances at a 1 MHz rate**. Since the required beam rate is only 1 MHz, 99% of the beam must be dumped. In addition, back-bombardment of the cathode is a significant concern. To address these issues, we propose*** using a laser to quickly heat the surface of a cathode in order to achieve gated thermionic emission in an rf gun. We have investigated this concept experimentally using an existing S-band rf gun with a thermionic cathode. Our experiments confirm that thermal gating is possible and that it shows some agreement with predictions. Operational issues and possible cathode damage are discussed.

THP108 **Pulsed Laser Heating of Thermionic Cathodes in RF Guns**

M. Borland *(ANL), B. Brajuskovic, R.R. Lindberg, N. Sereno (ANL)*

The proposed injector design for the X-ray Free Electron Laser Oscillator* uses a 100 MHz thermionic rf gun in order to obtain beams with very small emittances at high repetition rates**. The required beam rate is only 1 to 10 MHz, so 90 to 99% of the beam must be dumped. In addition, back-bombardment of the cathode is a significant concern. To address these issues, we propose using a laser to quickly heat the surface of a cathode in order to achieve gated thermionic emission in an rf gun. This may be preferrable to a photocathode in some cases owing to the robustness of thermionic cathodes and the ability to use a relatively simple laser system. We present calculations of this process using analysis and simulation. We also discuss potential pitfalls such as cathode damage.

THP109 **Potential for an Ultra-low Emittance Pulsed Thermionic Triode Gun**

X.W. Dong *(ANL), M. Borland, G. Decker, K.-J. Kim, N. Sereno (ANL)*

The proposed X-ray Free Electron Laser Oscillator* requires an ultra-low emittance gun that generates continuous electron bunches at 1 to 10 MHz. Recently, T. Shintake raised the possibility of using a pulsed triode gun with a thermionic cathode. In this paper, we investigate the feasibility for such a gun as part of an injector producing normalized emittances in the 0.1 μm range with 2 ps rms duration for 50 pC/bunch. We also explore some implementation concepts.

THP110 **Generation of Long Bunch Train using RF Gun**

A. Deshpande *(Sokendai) S. Araki, M.K. Fukuda, N. Terunuma, J. Urakawa (KEK) K. Sakaue, M. Washio (RISE)*

At Laser Undulator Compact X-ray Source (LUCX) facility at KEK, we have developed a RF gun with increased mode separation. We have successfully generated a bunch train of 300 bunches per train with over 150 nC total charge with peak to peak energy difference less than 0.9% at 5.2 MeV energy. After successful results from above work, we take next step and are now designing and fabricating a new RF gun to deliver 10 MeV or more energy. We plan to generate and accelerate 8000 bunches with 0.5 nC per bunch charge to generate 10 MeV, 4 uC electron beam. This beam will then collide is collision chamber with laser to produce soft x-ray. This very compact source will be used for future research and other applications. The resultant beam will be similar to any radiotherapy linac beam and can have good application in cancer therapy. This paper details achieved result with existing gun for generation of long bunch train and also lists out proposed activity.

THP111 **Development of a 500-kV Photo-Cathode DC Gun for ERL Light Sources**

N. Nishimori *(JAEA) R. Hajima, R. Nagai (JAEA/ERL) Y. Honda, T. Miyajima, M. Yamamoto (KEK) H. Iijima, M. Kuriki (HU/AdSM) M. Kuwahara, T. Nakanishi, S. Okumi (Nagoya University) T. Muto (Tohoku University, School of Scinece)*

An electron gun capable of delivering high current and high brightness electron beam is indispensable for next generation energy recovery linac light sources. A high voltage photocathode DC gun is a promising gun for such new light sources. It is however difficult to apply DC high voltage on a ceramic insulator with a rod supporting cathode electrode because of field emission from the rod. In order to mitigate the problem, we have employed a segmented insulator with rings which guard the ceramics from the field emission and recently succeeded in applying 500-kV on the ceramics for eight hours without any discharge. This high voltage testing was performed with a simple configuration without NEG pumps and electrodes. The next step is to repeat the same high voltage testing with a full configuration necessary for beam generation. We have designed electrodes for the maximum surface electric field not to exceed 11

MV/m at 500 kV while keeping the distance between the electrodes 100 mm. NEG pumps with a pumping speed of 7200 L/s have been installed in the gun chamber. A photocathode preparation system was connected to the gun chamber and beam generation is planned this summer.

THP112 **CW Superconducting RF Photoinjector Development for Energy Recovery Linacs**

J. Knobloch *(Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II), W. Anders, A. Jankowiak, T. Kamps, O. Kugeler, A. Neumann, T. Quast, J. Rudolph, M. Schenk (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Elektronen-Speicherring BESSY II) P. Kneisel (JLAB) R. Nietubyc (The Andrzej Soltan Institute for Nuclear Studies, Centre Swierk) J.K. Sekutowicz (DESY)*

ERLs have the powerful potential to provide very high current beams with exceptional and tailored parameters for many applications, from next-generation light sources to electron coolers. However, the demands placed on the electron source are severe. It must operate CW, generating a current of 100 mA or more with a normalized emittance of order 1 μm rad. Beyond these requirements, issues such as dark current and long-term reliability are critical to the success of ERL facilities. As part of the BERLinPro project, Helmholtz Zentrum Berlin (HZB) is developing a CW SRF photoinjector in three stages, the first of which is currently being installed at HZB's HoBiCaT facility. It consists of an SRF-cavity with a Pb cathode and a superconducting solenoid. Subsequent development stages include the integration of a high-quantum-efficiency cathode and RF components for high-current operation. This paper discusses the HZB roadmap towards an ERL-suitable SRF photoinjector, the present status of the facility and first cavity tests.

THP113 **Design of the 2.45 GHz ECR Proton Source and LEBT in CPHS (Compact Pulsed Hadron Source)**

Z. Feng *(TUB), X. Guan, J. Wei, Q.Z. Xing, H.Y. Zhang (TUB) Z.W. Liu, H.W. Zhao (IMP)*

Responding to the demand of accelerator front inject system of the Compact Pulsed Hadron Source (CPHS) in Tsinghua university in 2009, an electron cyclotron resonance (ECR) proton source (2.45 GHz, 1.5 KW) and a low-energy-beam-transport (LEBT) system are designed and manufacted. In this source, the H2 plasma is restricted by an axial magnetic field shaped by

the source body produced by an all-permanent-magnet design (NdFeB rings). The 50-keV pulsed proton beam (50 Hz/0.5 ms) extracted by a four-electrode extraction system from the proton source passes through the LEBT system (1306 mm long), which is consist of two solenoid lens, two steering magnets and a cone configuration optically matches to the RFQ where the Twiss parameters α=1.354, β=7.731. The beam with 97% space charge neutralization rate has been simulated at 100 mA, 150 mm.mrad RFQ output current by Trace-3D and PBGUN. In this study, we describe the design of the proton source and LEBT technical systems along with intended operation.

THP114 **H^- Ion Source Development for High Performance**

K.F. Johnson *(LANL), E. Chacon-Golcher, E.G. Geros, R. Keller, G. Rouleau, L. Rybarcyk, J. Stelzer (LANL) O.A. Tarvainen (JYFL)*

The Los Alamos Neutron Sciene Center (LANSCE) accelerator facility has the capability of accelerating both H^+ and H^- ion beams. LANSCE H^- User Programs rely on the ion source's ability to deliver an appropriate beam current within a given emittance limit. An active H^- ion source development program is ongoing with the goal of improving source performance (e.g. reliability, availability, increased out current, etc.) The formation of H^- ions in the LANSCE negative ion source occurs on the surface of a negatively biased electrode (converter), exposed to a flux of positive ions incident from a cusp-confined, filament-driven discharge. The source typically delivers a 16 mA pulsed (60 Hz) H^- beam with a source lifetime of 35 days. A program to reach 28-35 mA with the LANSCE source is outlined. It includes efforts to improve filament performance, elevating source body temperatures, optimizing converter geometry and location, optimizing converter cooling, and increasing the number of filaments from two to three.

THP115 **The Development of the H^- Ion Source Test Stand for CSNS**

H.F. Ouyang *(IHEP Beijing), Y.L. Chi, W. He, T. Huang, G. Li, Y.M. Liu, Y.H. Lu, T.G. Xu, J. S. Zhang, F.X. Zhao (IHEP Beijing)*

The type of the H^- ion source foe CSNS is a Penning Surface Plasma Source (SPS). The output energy of the source is 50keV and the pulsed current of H^- beam is 20mA with a rms. emittance of 0.2π mm.mrad. The construction of H^- ion source test stand for CSNS is finished and com-

missioning of the source is being done. Up to now, stable H^- ion beam with a current up to 45mA and energy of 50keV is achieved. Emittance measurements of the beam is also being prepared.

THP116 **Tests of the Versatile Ion Source (VIS) for High Power Proton Beam Production**

S. Gammino *(INFN/LNS), L. Celona, G. Ciavola, D. Mascali, R. Miracoli (INFN/LNS) F. Maimone (GSI)*

The sources adapted to beam production for high power proton accelerators must obey to the request of high brightness, stability and reliability. The Versatile Ion Source (VIS) is based on permanent magnets (maximum value around 0.1 T on the chamber axis) producing an off-resonance microwave discharge. It operates up to 80 kV without a bulky high voltage platform, producing several tens of mA of proton beams and monocharged ions. The microwave injection system and the extraction electrodes geometry have been designed in order to optimize the beam brightness. Moreover, the VIS source ensures long time operations without maintenance and high reliability in order to fulfil the requirements of the future accelerators. A description of the main components and of the source performances will be given. A brief summary of the possible options for next developments of the project will be also presented, particularly for pulsed mode operations, that are relevant for future projects.

THP117 **Study of the Frequency Tuning Effect for the Improvement of Beam Brightness in ECR Ion Sources**

S. Gammino *(INFN/LNS), L. Celona, G. Ciavola, D. Mascali, R. Miracoli (INFN/LNS) F. Maimone (GSI)*

According to the model that has driven the development of ECRIS in the last years, a large variation of the pumping microwave frequency (order of GHz) boosts the extracted current for each charge state because of a larger plasma density. Recent experiments have demonstrated that even slight frequency's changes (of the order of MHz) considerably influence the output current, and also the beam properties after the extraction (beam shape, brightness and emittance). In order to investigate how this fine tuning affects the plasma heating, a set-up for the injection of different microwave frequencies into the ECRIS cavity has been prepared. The microwave power is fed by means of a Travelling Wave Tube ampli-

fier with a broad operating frequency range. The frequency can be systematically changed and the beam output is recorded either in terms of charge state distributions and beam emittance. The detected brehmsstralung X-rays are additionally analysed: they give insights about the electron energy distribution function (EEDF). The results are compared with simulations and data coming from previous preliminary experiments.

THP118 **Status of the J-PARC Negative Hydrogen Ion Source**

H. Oguri *(JAEA/J-PARC), Y. Namekawa, K. Ohkoshi, A. Ueno (JAEA/J-PARC) K. Ikegami (J-PARC, KEK & JAEA)*

A cesium-free negative hydrogen ion source driven with a LaB6 filament is being operated for J-PARC. The beam commissioning of J-PARC accelerators started in November 2006. As of April 2010, there have been 32 beam commissioning or supply runs. In these runs, the ion source has been successfully operated in two different modes such as low current mode of 5 mA and high current mode of 30 mA. According to the task of the run, one of the two modes was selected. However, the beam current has been restricted to less than 15 mA for the stable operation of the RFQ linac which has serious discharge problem from September 2008. The beam run is performed during 4-5 weeks cycles, which consisted of a 3-4 weeks beam run and 4 days down-period interval. At the recent beam run, approximately 700 hours continuous operation was achieved, which is satisfied with the requirement of the ion source lifetime for the J-PARC first stage. At every runs, the beam interruption time due to the ion source failure is several hours, which correspond to the ion source availability of 99 %.

THP119 **Developments for Performance Improvement of SNS H^- Ion Source RF Systems**

Y.W. Kang *(ORNL), R.E. Fuja, T.W. Hardek, S.W. Lee, M.P. McCarthy, M.F. Piller, K.R. Shin, M.P. Stockli, A.V. Vassioutchenko, R.F. Welton (ORNL)*

The Spallation Neutron Source (SNS) at Oak Ridge National Laboratory is in the process of ramping up the H^- ion beam power to 1.4 MW, its full design power for the neutron production. For robust operation of the neutron facility, work is underway for various improvements on the RF power systems of the ion source. For short and long-term higher beam power operations, an RF-

driven H^- ion source employing external antenna with a water-cooled, ceramic aluminum nitride (AlN) plasma chamber has been developed*. The new ion source has been tested to deliver up to 42 mA in the SNS Front End (FE) and unanalyzed beam currents up to ~100mA (60Hz, 1ms) in the ion source test stand. In addition to the external antenna design for improved antenna lifetime, other RF developments for improvement of reliability are running 2 MHz power amplifier system is with isolation transformer, employing full solid-state 2 MHz power amplifier, more precise 2 MHz capacitive impedance matching, and upgrading 13 MHz RF plasma gun system. This paper discusses the engineering solutions with analysis and development of the above RF systems for the new ion source system.

THP120 **First Test Result of the IHEP-01 Large Grain 9-cell Cavity**

J. Gao *(IHEP Beijing), Y.L. Chi, J.P. Dai, Z.D. Guo, M. Hou, Z.Q. Li, L.L. Men, Q.Y. Wang, Q. Xiao, J.Y. Zhai (IHEP Beijing) H. Hayano, E. Kako, S. Noguchi, M. Sawabe, T. Shishido, N. Toge, K. Watanabe, Y. Yamamoto (KEK) T.X. Zhao (IHEP Beiing)*

The combination of the low-loss shape and large grain niobium material is expected to be the possible way to achieve higher gradient and lower cost for ILC 9-cell cavities. As the key component of the 'IHEP 1.3 GHz SRF Accelerating Unit and Horizontal Test Stand Project', a low-loss shape 9-cell cavity using Ningxia large grain niobium (IHEP-01) was fabricated and surface treated (CBP, CP, annealing, pre-tuning) at IHEP. Then the cavity was shipped to KEK STF for ultrasonic cleaning, high pressure rinsing, baking and vertical test. The cavity reached 20 MV/m in the first vertical test on July 1st 2010. The quench location has been found by T-mapping and optical inspection. The strong field emission and equator defects will be removed by further treatment. The fabrication procedure, surface treatment recipes and the first test results are summarized in this paper.

THP121 **Development of an L-band RF Gun for High-duty-cycle Operation**

G. Isoyama *(ISIR), R. Kato, N. Sugimoto (ISIR) H. Hayano, H. Sugiyama, T. Takatomi, J. Urakawa (KEK) S. Kashiwagi (Tohoku University, Research Center for Electron Photon Science) M. Kuriki (HU/AdSM)*

We are developing an L-band photocathode RF gun in collaboration with KEK and Hiroshima

University. The RF gun will be used not only at Osaka University but also at STF of KEK, so that it can be stably operated at the input RF power of 5 MW with 1 ms duration and a 5 Hz repetition rate, resulting in the average input power of 25 kW. The water-cooling system of the 1.5 cell cavity is designed, which can take the heat with the temperature rise of the cavity body by 5^{o}C at the flow rate of cooling water of 358~723 liter/min. The several parts of the RF cavity are assembled with brazing and the most crucial process is brazing of three main components of the RF cavity into one. The brazing has to be tight and perfect not to allow vacuum leak, while the brazing filler metal must not go out on to the inner surface of the cavity to avoid discharge triggered by the scabrous filler metal on the cavity wall. Test experiments are conducted and a guideline is concluded for such brazing.

17-Sep-10 09:00–11:00 Main Convention Hall

FR1 — Invited Oral

Chair: S.G. Tantawi (SLAC)

FR101 09:00 **Advance In Parallel Computing Codes For Accelerator Science**

K. Ko *(SLAC)*

SLAC has developed a comprehensive suite of 3D parallel electromagnetic codes based on the finite-element method to solve large-scale computationally challenging problem with high accuracy. The ACE3P (Advanced Computational Electromagnetic 3P) code suite includes the Omega3P eigenmode and S3P S-parameter solvers in the frequency domain for cavity prototyping and optimization, T3P time-domain solver for wakefields and impedances, Track3P particle tracking solver for simulating multipacting and dark current, and Pic3P Particle-in-cell code for RF Gun design. These capabilities with recent advances and the latest applications addressing important RF related accelerator phenomena will be presented.

FR102 09:30 **Plasma Accelerator Development at the BELLA and FACET Projects**

M.J. Hogan *(SLAC)*

After recent results including demonstration of narrow energy spread GeV beams, the US DOE HEP is investing in two new facilities to evaluate the applicability of plasma based accelerators to high energy physics, including development of accelerator stages relevant to a potential future plasma based collider and production of very high quality beams. The BELLA facility will comprise a 1 PW high rep rate laser and target areas to allow experiments on 10 GeV laser driven plasma wakefield accelerator stages, as well as control over injection, positron experiments, detailed beam diagnostics and radiation production. The talk could cover the designs for BELLA accelerator modules, collider concepts, the upcoming facility, and ongoing experiments to prepare the way for BELLA, including control over particle beam injection and quality, staging of multiple accelerator modules, radiation diagnostics of beam performance.

FR103 10:00 **Commissioning of the EBIS-Based Heavy Ion Preinjector at Brookhaven**

J.G. Alessi *(BNL)*

This talk will present commissioning of a new heavy ion pre-injector at Brookhaven National Laboratory. This preinjector uses an Electron Beam Ion Source (EBIS), and an RFQ and IH

Linac, both operating at 100.625 MHz, to produce 2 MeV/u ions of any species for use, after further acceleration, at the Relativistic Heavy Ion Collider, and the NASA Space Radiation Laboratory. Among the increased capabilities provided by this preinjector are the ability to produce ions of any species, and the ability to switch between multiple species in 1 second, to simultaneously meet the needs of both physics programs.

FR104 10:20 **Progress of X-Band Accelerating Structures**
T. Higo *(KEK)*

A CERN-SLAC-KEK collaboration on high gradient X-band accelerator structure development for CLIC has been ongoing for the past three years. A major outcome has been the stable 100 MV/m gradient operation of a number of CLIC prototype structures. The design of the structures, which have very strong higher-order-mode damping, is based on newly developed high-power scaling laws. The structures are being fabricated using the technology which was developed in the GLC/NLC projects which is giving excellent reproducibility. The features of this new generation of high-gradient normal conducting structures and their testing results are reviewed.

FR105 10:40 **Study of Basic Breakdown Phenomena in High Gradient Vacuum Structures**
V.A. Dolgashev *(SLAC)*

We present the results of R&D aimed at exploring the basic physics of RF breakdown phenomena in high vacuum structures. We performed an extensive experimental survey of materials for RF magnetic field induced metal fatigue. To do this, we designed a cavity operating at a TE01m-like mode which focuses RF magnetic field on the flat sample surface. We tested more than 20 samples of materials including single crystal copper, copper alloys, and refractory metals. With these results in hand, we constructed standing wave cavities of different geometries and materials to conduct RF-breakdown experiments. To study a broad range of materials and surfaces, we explored different structure-joining techniques, including those which allow us to avoid high temperature brazing. Using structures of different geometries, we examined the effect of the mixture of surface electric and magnetic fields on breakdown behavior. To study this effect further we designed a structure in which we can adjust the mixture of fields using two independent RF sources.

17-Sep-10 11:30–12:50 Main Convention Hall

FR2 — Invited Oral

Chair: Y. Yamazaki (JAEA/J-PARC)

FR201 11:30 **Current and Possible New Methods for Accelerator-Based Production of Medical Isotopes**

J.A. Nolen *(ANL)*

This talk will review current and possible new methods for accelerator-based production of medical isotopes. It will cover isotopes produced commercially, mostly by relatively low energy accelerators, and isotopes produced by government-operated facilities, usually by higher energy accelerators. Prospects for the production of traditionally reactor-produced isotopes such as 99Mo via accelerator-driven methods will also be discussed. Also, the special case of accelerator production of alpha-emitting isotopes for radio-immunotherapy will be reviewed.

FR202 11:50 **Linacs for Muon Collider and Neutrino Factory**

S. Geer *(Fermilab)*

This talk will review the present Linac designs for Muon colliders and Neutrino factories. Both Muon colliders and Neutrino factories require rather unique linac designs to transport large emittance beams. The talk will present the design and status of these projects.

FR203 12:20 **Linacs and Scientific/Technological Applications**

A. Suzuki *(KEK)*

"We humans have long been obsessed with four great questions: the nature of matter, the origin of the universe, the nature of life and the workings of mind," which was pointed out by Herbert A. Simon (Nobel Laureate in Economics). Accelerators have been and will be a powerful tool to challenge for answers to the above questions except for the working of mind. In order to open up a new horizon of these sciences, the essential is to innovate in key accelerator technologies. Among other things, the innovation of four beam parameters of Energy, Power, size (Space) and timing (Time) with thousand-fold improvement is not an evolution, but a kind of revolution to both scientific researches and technological applications. It is not useless to outline the scientific and technological worlds given by advanced accelerators with the beam structure of 1000 TeV (Energy), 100 MW (Power), 100 picometer (Space) or 1 femto-second (Time). My pre-

sentation invites you to these worlds. Human beings are full of curiosity and obsess to understand unknowns for many millennia.

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Italic papercodes indicate primary authors

— A —

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Aderhold, S.	MOP112, THP014
Adli, E.	MOP018, TUP100
Adolphsen, C.	MO302, MOP005, MOP067, TUP015, TUP080, THP021, THP063
Aiba, M.	TUP009
Aicheler, M.	***MOP069***
Ainsworth, R.	TUP099
Akemoto, M.	MO302, MOP012
Albert, F.	MOP005
Aleksandrov, A.V.	TUP088, TUP089, ***WE104,*** THP080
Alessi, J.G.	TUP026, TUP033, TUP034, ***FR103***
Alexeev, N.N.	TUP073
Alknes, P.	MOP075
Allen, C.K.	***TUP087***
Allison, T.L.	MOP095
Alsari, S.M.H.	TUP028
Amaldi, U.	THP037
Ambattu, P.K.	***MOP033, MOP072***
Ames, F.	TH202
Anders, W.	TUP007, THP112
Andersen, H.K.	TUP054
Andersen, T.	TUP054
Anderson, D.E.	THP049
Anderson, S.G.	MOP005
Andersson, A.	MOP024, TUP098
Andrews, H.L.	TUP018
Anisimov, A.	TUP011
Ankenbrandt, C.M.	MOP055
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Araki, S.	THP110
Araz, A.	MOP008
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Arkan, T.T.	MO302, TUP081
Arnau-Izquierdo, G.	MOP075
Arnold, A.	***THP054***
Asaka, T.	TUP014
Asano, H.	TUP069
Asova, G.	TUP096, ***TUP097, TUP097***
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— B —

Baartman, R.A.	TH202
Baba, H.	TUP049, TUP050
Baboi, N.	THP011
Bach, H.T.	MOP061
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Back, J.J.	TUP028
Bai, Y.J.	TUP046
Bajt, S.	TUP012
Ball, J.A.	MOP089
Balleyguier, P.	***MOP098***
Bandelmann, R.	THP015
Bandyopadhyay, A.	TH202
Bane, K.L.F.	TUP015, ***THP021***
Barbanotti, S.	MO302, ***MOP099, TUP078,*** TUP079
Barcikowski, A.	TUP086
Barone, S.	TUP031
Barth, W.A.	MOP040, MOP041, MOP042, MOP043, ***MOP044, MOP057,*** TUP041, TH303
Barty, C.P.J.	MOP005
Bartz, U.	***TUP039***
Batygin, Y.K.	***THP078***
Bayer, W.B.	TH303
Baylac, M.A.	***TUP032***
Bayramian, A.J.	MOP005
Bazak, B.	THP091
Beard, C.D.	MOP048, MOP050, TH202, THP043, THP044
Beasley, P.	THP068
Bechtold, A.	TUP040, WE102
Beebe, E.N.	TUP033, TUP034
Bellodi, G.	THP003, ***THP005, THP006***
Benwell, A.L.	THP064
Berkovits, D.	TUP074, WE102, ***THP091***
Berthelot, S.	THP066
Bertrand, P.	MOP039, MOP098
Bettoni, S.	MOP024, TUP100
Beutner, B.	TUP009, ***TUP102, TUP103***
Bezuglov, V.V.	MOP031
Bhang, H.-C.	TUP090
Biarrotte, J.-L.	***MOP039, MOP082, TUP020,*** THP023, THP066
Bierwagen, J.	TUP084, THP040
Billen, J.H.	TUP046, TUP071
Bitteker, L.J.	MOP061
Blache, P.	THP023, THP066
Blackfield, D.T.	THP086
Blair, G.A.	TUP099
Blokland, W.	TUP087
Bødker, F.	TUP054
Bödewadt, J.	***TUP012***
Bogard, D.	MOP001

Boldt, O. MOP112
Bolgov, R.O. MOP065
Bollen, G. MO203, MOP046
Bonnanno, R.E. MOP005
Bonnes, U. MOP091
Bonomi, R. THP037
Boorman, G.E. TUP099
Bopp, M. TUP001, THP100, THP103
Borissov, E. THP030
Borland, M. ***THP087, THP107, THP108,*** THP109
Bosotti, A. MO302, TUP078, THP023
Bouly, F.B. MOP082, ***THP023***
Bourquin, P. MOP071, TUP042
Bousson, S. THP023
Bowden, G.B. THP063
Brajuskovic, B. THP108
Brandt, J.S. TUP079
Branlard, J. ***MOP083, MOP084, THP029***
Braun, H.-H. MOP006, ***TU102, TUP001,*** TUP008, TUP100, THP100, THP103
Bravin, E. TUP100, TUP101, THP006
Bricker, S. TUP084, THP039, THP040
Brinkmann, A. ***THP013***
Briscoe, B. TUP026, TUP027
Brodhage, R. M. TUP033
Brunner, O. ***THP052***
Bryazgin, A.A. ***MOP031***
Budde, M. TUP054
Bürkmann-Gehrlein, K.B. TUP007
Burandt, C. MOP091
Burkhart, C. THP049, THP064
Burrows, P. MOP024
Burt, G. MOP033, ***MOP072, THP055***
Busch, M. MOP057, TUP023

— C —

Cai, J.C. TUP046
Calabretta, L. TUP031
Calaga, R. THP055
Calatroni, S. ***MOP070, MOP075, THP004, THP032, THP033***
Campisi, I.E. THP042
Cancelo, G.I. THP029
Candel, A.E. ***MOP025, MOP073***
Capatina, O. THP004
Caporaso, G.J. THP086
Cappelletti, A. MOP021
Carlson, K. THP029
Carneiro, J.-P. ***TH301***
Carrillo, D. MOP018
Carter, H. MO302, TUP079, TUP081
Caruso, A.C. ***THP072***

Carwardine, J.	***MO301***
Catherall, R.	MOP054
Cee, R.	***MOP058***
Celona, L.	THP116, THP117
Chacon-Golcher, E.	THP114
Chai, J.-S.	MOP093
Chakrabarti, A.	TH202
Champion, M.S.	MO302, ***TUP081, THP026, THP027***
Chao, Y.-C.	TH202, THP093
Chase, B.	MOP084, TUP080, THP029
Chau, L.P.	***MOP100, MOP101, THP071***
Chaurize, S.	THP001
Chauvin, N.	***TH302***
Chel, S.	MOP053
Chen, H.	MOP016
Chen, J.E.	TUP037
Chen, Y.-J.	***THP086***
Cheng, C.	***TUP036***
Chernov, K.N.	MOP031
Chevallay, E.	MOP001
Cheymol, B.	TUP101, THP006
Chi, Y.L.	THP115, THP120
Chiba, Y.	TUP070
Chishiro, E.	THP058
Cho, M.-H.	MOP035, MOP036
Cho, Y.-S.	TUP021, ***TUP053, THP035***
Choi, J.Y.	WE202
Choroba, S.	THP061, THP062
Chouhan, S.	TUP084
Christou, C.	***MOP017***
Chu, P.	THP083
Chu, T.S.	MOP005
Chubarov, O.	TUP054
Chung, K.H.	MOP035, MOP036
Churanov, D.	TUP011
Ciapala, E.	THP004
Ciavola, G.	THP116, THP117
Ciovati, G.	THP017
Citterio, A.	TUP001, THP103
Clarke-Gayther, M.A.	TUP028
Clemens, W.A.	THP041
Clemente, G.	MOP043, MOP044, TH303
Clemmer, M.E.	THP048
Commeaux, C.	THP023, THP066
Compton, C.	MO203, TUP084, THP039, ***THP040***
Comunian, M.	TUP057, TUP058, ***THP082***
Conde, M.E.	***MOP110***
Conrad, J.	MOP008
Consoli, F.	MOP098, THP072
Conway, Z.A.	***TH101***
Cooley, L.	THP027
Corlett, P.A.	MOP033

Corsini, R. MOP024, TUP099, TUP100
Cours, A.R. ***THP056***
Cox, M.P. THP104
Craievich, P. TUP002
Crawford, A.C. MO203
Crofford, M.T. ***MOP088, MOP089, THP047***
Cross, R.R. MOP005
Cullerton, E. MOP084, THP029
Curbis, F. TUP012
Curtoni, A. MOP001

— D —

Dabrowski, A.E. ***TUP100***
Dach, M. TUP009
Dahl, L.A. MOP041, ***MOP042, MOP043,*** MOP044, TUP041, TH303
Dai, J.P. THP120
Dallocchio, A. MOP071
D'Auria, G. ***TUP016***
Davidson, T.L. MOP088, MOP089
Dawson, R.J. TH202
De Gersem, H. THP090
De Martinis, C. TUP031
De Michele, G. TUP066, TUP072
De Silva, S.U. ***THP024***
Dechoudhury, S. TH202
Decker, G. THP109
Degiovanni, A. THP037
Dehler, M.M. ***MOP073***
DeLauter, J. TUP084, THP040
Delayen, J.R. ***TU302, THP024***
Delgiusto, P. TUP002
D'Elia, A. THP033, MOP002
Delsim-Hashemi, H. TUP012
Demma, T. THP094
Dennison, G. MOP090
Descoeudres, A. MOP070
Deshpande, A. ***THP110***
Desmons, M. MOP053, TUP042
Devanz, G. ***TH104***
Dexter, A.C. MOP072, THP055
Dhanaraj, N. ***TUP079***
Di Giacomo, M. MOP051, MOP098, THP072
DiMarco, J. TUP077
Dinter, H. THP071
Divall Csatari, M. MOP001
Djurabekova, F. MOP070
Döbert, S. ***MOP018, MOP067, TUP100***
Doizon, F. THP066
Doleans, M. MO203, MOP046, MOP047, MOP108, TUP093
Dolgashev, V.A. MOP072, MOP076, MOP077, THP042, ***FR105***
Donat, A. TUP011

Dong, X.W. THP087, ***THP109***
Drescher, M. TUP012
Droba, M. MOP100, MOP101, MOP102, THP071
Du, Q. MOP016
Du, T. TUP036
Du, X. TUP037
Du, Y.-C. MOP016
Dubrovskiy, A. MOP024
Dudas, A. THP065
Düsterer, S. TUP012
Dunkel, K. WE102
Dutriat, C. TUP101
Dziuba, F.D. MOP041, MOP057, ***TUP023***

— E —

East, G.W. THP099
Ebbers, C.A. MOP005
Eckoldt, H.-J. THP061
Edwards, H.T. ***MO304, TUP013, THP096***
Egger, D. TUP100
Ego, H. TUP014
Eichhorn, R. ***MOP008, MOP091***
Eints, F. THP062
Elliott, K. TUP084, THP039, THP040
Elsen, E. THP014
Emhofer, S. ***TUP054***
Enomoto, A. ***MOP028***
Eremeev, G.V. THP041, THP042
Erickson, J.L. TUP025
Erickson, R.A. ***MOP007***
Eshraqi, M. THP005, THP003
Esmaili, R. THP064

— F —

Fabris, A. ***TUP002***
Facco, A. ***MOP056, THP022, THP039***
Fagotti, E. ***TUP057, TUP058, THP082***
Faircloth, D.C. TUP028
Faktorovich, B.L. MOP031
Falone, A. TUP009
Fang, S.X. TUP019
Fang, W. ***MOP064***
Farabolini, W. ***MOP001, TUP098***
Fathy, A.E. TUP047, THP050
Faus-Golfe, A. MOP018
Favre, G. MOP071
Feinberg, G. THP091
Feldmeier, E. MOP058
Feng, Z. ***THP113***
Ferdinand, R. ***MO201***
Ferreira, L.M.A. THP032
Feschenko, A. TUP085

Fite, J.M. TUP026, TUP027
Fitze, H. TUP001, THP103
Flisgen, T. THP011
Flöttmann, K. MOP081
Focker, G.J. TUP101
Foley, M.H. MOP099, TUP079
Fong, K. MOP090
Forck, P. TH303
France, A. TUP042
Franke, S. ***THP084***
Fraser, M.A. THP033, ***THP089, THP089***
Frisch, J.C. ***WE201***
Frölich, T. THP062
Fu, S. TU202, ***TUP019***
Fuja, R.E. THP119
Fujimoto, T. MOP062
Fujisawa, H. MOP105, TUP070
Fujisawa, T. MOP060
Fukuda, M.K. THP110
Fukuda, S. MO302, ***MOP013, MOP027,*** MOP075, THP060
Fukui, T. TUP014
Fukui, Y. THP058
Fukunishi, N. ***TU104***
Furuta, F. ***MOP029, MOP113, MOP114***
Furuya, T. TUP006

— G —

Gabor, C. TUP028
Gai, W. MOP110
Galambos, J. MOP096, TUP087
Gallo, G. THP072
Galluccio, F. ***MOP078***
Galonska, M. MOP058
Gammino, S. ***THP116, THP117***
Ganter, R. TUP009
Gao, J. ***THP120***
Garcia, F.G. TUP029
Garcia Tudela, M.G. THP005
García-Garrigós, J.J. MOP018
Garlasché, M. THP037
Garnett, R.W. TUP025, ***TUP038***
Garoby, R. THP004
Garonna, A. THP037
Garvey, T. MOP006, TUP008, THP100
Gavrilov, S.A. TUP085
Ge, L. THP092
Geer, S. ***FR202***
Geisser, J.-M. MOP071
Gelmetti, F. TUP002
Gensch, M. TUP007
Gensch, U. THP061
Gentini, L. MOP071
Gerbershagen, A. MOP024

Gerbick, S.M.	THP057
Gerhard, P.	MOP042, MOP043, MOP044, TH303
Gerigk, F.	***MOP071, TUP066, THP004***
Geros, E.G.	THP114
Gerth, C.	TUP011
Gertz, I.	WE102
Gibson, D.J.	MOP005
Giguet, J.-M.	TUP066
Gini, L.	TUP031
Ginsburg, C.M.	***THP026, THP027***
Giove, D.	TUP031
Girardot, P.	MOP001, TUP098
Glasmacher, T .	MOP046
Glennon, P.	TUP084
Glock, H.-W.	THP011
Görgen, P.A.	THP084
Golubev, A.	TUP073
Gong, C.	THP093
Gonin, I.G.	MOP099, THP008
Gould, O.	TUP026
Grabosch, H.-J.	TUP096
Grassellino, A.	MOP048, THP044
Grespan, F.	TUP055, TUP057, TUP058, ***TUP072, THP082***
Gretlund, J.S.	TUP054
Grevsmühl, T.	THP061, ***THP062***
Grice, W.P.	TUP088
Grimberg, M.	THP061
Grimm, J.	MOP099, TUP079
Grin, A.	WE102
Groening, L.	MOP044, ***TH303***
Grolet, D.	THP066
Grudiev, A.	MOP002, ***MOP021, MOP022, MOP023, MOP025, MOP067, MOP068***
Gu, Q.	MOP064
Guan, W.Q.	TUP046
Guan, X.	TUP019, ***TUP022, TUP036,*** TUP046, TUP071, THP113
Gudkov, D.	MOP020
Gulley, M.S.	***MOP061, TUP025, TUP038***
Guo, J.	THP042
Guo, X.H.	TUP044
Guo, Z.D.	THP120
Gurevich, A.V.	THP017
Gusarova, M.	MOP065

— H —

Haberer, Th.	MOP058
Hajima, R.	TUP004, THP111
Halfon, S.	WE102
Han, J.H.	***THP104, THP105, THP106***
Hanaki, H.	***TUP014***

Hanke, K. THP003
Hanna, B.M. THP001
Hansen, A. MOP070
Hardek, T.W. MOP088, MOP089, ***THP047***, THP048, THP119
Harkay, K.C. THP107
Harms, E.R. ***TUP013***, ***TUP078***, ***TUP080***, TUP081, ***THP029***, ***THP096***
Hartemann, F.V. ***MOP005***
Hartung, W. MO203, MOP046, MOP047, TUP084, ***THP039***, ***THP040***, THP092
Hasegawa, K. ***TUP024***, ***TUP049***, ***TUP050***, THP058
Hashimoto, E. MOP032
Hass, E. TUP012
Hattori, T. TUP035
Hayano, H. MO302, THP018, THP036, THP120, THP121
Hayashizaki, N. TUP027, TUP035
Haynes, W.B. THP041
Hays, S. THP001
He, W. THP115
He, X. ***TUP104***
He, Y. ***TUP037***, ***TUP044***, ***TUP064***, TUP046
Heid, O. ***THP068***
Hein, L.M. THP005
Henderson, S. ***MO103***
Herfurth, F. ***MOP043***
Hermanns, T. THP003
Hernandez Flano, M. MOP053
Hershcovitch, A. TUP106
Hessler, S.C. TUP007
Higashi, Y. MOP075, THP060
Higo, T. MOP012, MOP067, MOP074, MOP075, THP060, ***FR104***
Hillert, W. MOP112
Hipp, U. TUP012
Hirai, S. MOP032
Hitchcock, S. TUP105
Hitomi, H. ***MOP030***
Hocker, A. TUP078, THP029
Hodek, M. TUP084, THP039, THP040
Höfle, W. ***MOP053***
Hoffmann, M. TUP011
Hofmann, B. MOP043
Hofmann, I. TH303
Hofmann, N. MOP112
Hogan, M.J. ***FR102***
Hollenborg, I. TUP054
Holzbauer, J.P. THP039, THP040, THP092
Honaberger, D. THP074
Honda, Y. THP111

Honkavaara, K. TUP012
Honma, H. MOP012
Hori, J. MOP009
Hori, Y. TUP049, TUP050
Horvitz, Z. TUP045
Hou, M. THP120
Houck, T.L. MOP005
Hovater, C. MOP094, ***MOP095***
Hua, Hua„J.F. MOP016
Huang, C. THP064
Huang, D. MOP066
Huang, H.C. THP104
Huang, T. THP115
Huang, W.-H. ***MOP016***
Huang, Z. TUP015
Hüning, M. ***MOP004, TUP011, TUP013***
Hug, F. MOP008
Hughes, T.J.S. THP068
Huopana, J. ***MOP103***

— I —

Ianigro, J.-C. MOP097
Ichikawa, M. THP036
Igarashi, Z. TUP076
Iijima, H. THP111
Ikeda, M. MOP012, MOP111
Ikegami, K. THP118
Ikegami, M. TUP067, TUP075, TUP076, MOP087, THP088
Ikezawa, E. TUP070
Inagaki, T. TUP014
Insepov, Z. MOP066
Ischebeck, R. TUP009, TUP012, TUP102, ***TUP103***
Isoyama, G. THP097, ***THP121***
Ito, N. MOP034
Ito, T. TUP069, ***TUP068***
Ito, Y. MOP087
Ivanisenko, Ye. ***TUP096***
Ivanov, E.V. TUP011
Iversen, J. ***THP015***
Iwashita, Y. MOP105, ***MOP106, THP036***
Iwata, S.I. MOP062
Iwata, Y. ***MOP060***

— J —

Jachmann, L. MOP081, THP061
Jameson, R.A. TUP044, THP077
Jang, J.-H. TUP021, TUP053
Jang, S.D. MOP035, MOP036
Jankowiak, A. TUP007, THP112
Janssens, R.V.F. MOP045
Jason, A.J. TUP109

Jeanneret, J.B.	MOP024
Jensen, E.	***TH103***
Jeon, D.	***MOP096, TUP088, TH303***
Jeppesen, H.B.	TUP054
Ji, Q.	THP002
Jing, C.-J.	MOP110
John, K.D.	MOP061
Johnson, A.S.	***THP096***
Johnson, K.F.	***THP114***
Johnson, M.J.	MOP108, TUP093, MOP046, MOP047, THP039, THP040, TUP084
Johnson, R.P.	MOP055, TUP107, THP065
Joireman, P.W.	MOP084, THP029
Jolly, S.	TUP028
Joly, C.	***MOP082, THP023***
Jones, K.W.	***TUP025***
Jones, R.M.	***MOP002, THP011, THP012,*** THP089
Jones, S.L.	MOP089
Jongewaard, E.N.	MOP005
Joshi, N.S.	THP071
Jug, G.	***MOP092***
Juntong, N.	THP011

— K —

Kadi, Y.	MOP054
Kageyama, Y.K.	MOP060
Kaiser, M.	MOP041, MOP043, MOP044, TH303
Kakihara, K.	MOP012
Kako, E.	MO302, TUP005, ***TUP082,*** THP018, THP120
Kamenshikov, D.S.	MOP065
Kamigaito, O.	TUP070
Kamitani, T.	***MOP011, MOP012***
Kamps, T.	TUP007, THP112
Kan, K.	***THP101, THP102***
Kanesue, T.	TUP033, TUP034, TUP051
Kang, Y.W.	TUP047, THP047, THP050, ***THP119***
Karataev, V.	TUP099
Kase, M.	TUP070
Kashiwagi, H.	TUP051
Kashiwagi, S.	THP097, THP121
Katagiri, H.	MO302
Katalev, V.V.	THP062
Kato, R.	THP097, THP121
Kawamata, H.	TUP049, TUP050
Kawamura, M.	***THP058***
Kawata, H.	TUP004
Kazakov, S.	THP060
Kedzie, M.	THP057
Keller, R.	THP114

Kelly, M.P. MOP045, ***TU304***, ***THP026***, ***THP057***
Kemp, M.A. THP049, ***THP064***
Kephart, R.D. MO302
Kerby, J.S. MO302
Kester, O.K. ***MO203***, ***MOP043***, ***TUP105***, THP039, THP040, TUP084
Khabiboulline, T.N. MOP099, TUP078, ***THP008***, THP011, ***THP028***, ***THP030***
Khan, S. TUP012
Khan, V.F. MOP002
Kharitonov, M. THP017
Khojoyan, M.A. TUP096
Kikuzawa, N. TUP076
Kim, C. WE202
Kim, D.G. TUP090
Kim, D.I. TUP021
Kim, H.S. TUP021, TUP053, ***THP035***
Kim, J.-W. TUP090
Kim, J.Y. ***TUP090***
Kim, K.-J. THP109
Kim, K.R. WE202
Kim, M. WE202
Kim, S.H. MOP035, MOP036
Kim, S.-H. TUP047, THP050
Kim, Y. ***MOP006***, ***TUP008***, ***THP099***, ***THP100***, ***THP103***
Kimura, H. TUP014
Klarner, F. ***MOP112***
Klebaner, A.L. TUP080
Kleffner, C.M. TUP054
Klein, H. TUP020, TUP023
Klose, C. THP084
Klug, J. THP017
Kluge, H.J. MOP043
Kneisel, P. THP041, THP112
Knobloch, J. ***TUP007***, ***TH102***, ***THP112***
Ko, K. MOP025, THP092, ***FR101***
Kobayashi, I. MOP060
Kobayashi, T. ***MOP086***, ***MOP087***, ***TUP014***
Kobayashi, Y. TUP004
Köhler, W. MOP081, TUP011, THP061
Kojima, T. MOP015, MOP034
Kolb, P. MOP048, MOP050, TH202, THP043, THP044
Kolomiets, A. TUP059, MOP040
Kondo, K. TUP033, TUP034, TUP051
Kondo, Y. TUP049, TUP050, ***THP070***
Kondoh, T. THP101, THP102
Kondou, Y. MO302
Kondrashev, S.A. MOP045, ***TUP086***
Konecny, R. MOP110
Konomi, T. MOP114, MOP029, ***MOP113***
Kononenko, O. MOP021

Konrad, M.	MOP008, ***MOP091***
Konstantinova, O. A.	***MOP109***
Koscielniak, S.R.	THP053, THP093, TH202
Koshelev, V.A.	TUP073
Kostin, D.	MO302
Kot, Y.A.	***MOP003***
Kovermann, J.W.	MOP070
Kozawa, T.	THP101
Kozhuharov, C.	MOP043
Krasilnikov, M.	MOP081, TUP011, TUP096, TUP097
Kravchuk, L.V.	***TUP011, TUP017***
Krawczyk, F.L.	TUP018, THP041
Kreps, G.	THP015
Kroc, T.K.	TUP029
Krönung, D.	MOP112
Kruse, L.	TUP054
Kubicki, T.	THP029
Kubota, T.	***MOP009***
Kudo, N.K.	THP060
Kugeler, O.	TUP007, THP112
Kulevoy, T.	TUP073
Kumagai, N.	TUP014
Kurennoy, S.S.	TUP109
Kuriki, M.	THP111, THP121
Kurup, A.	TUP028
Kuske, B.C.	TUP007
Kuske, P.	TUP007
Kutsaev, S.V.	***MOP065, TUP011***
Kuwahara, M.	THP111
Kwon, H.-J.	***TUP021, TUP053, THP035***

— L —

Laarmann, T.	TUP012
Lahti, G.E.	MOP095
Lalayan, M.V.	TUP011
Lallement, J.-B.	TUP042, TUP066, THP005
Lambiase, R.F.	TUP033, TUP034
Langton, K.	TUP092
Lanza, G.	THP033
Lapierre, A.	MO203
Larsen, R.S.	THP064
Latina, A.	MOP019, ***MOP026***
Laurent, L.	***MOP076***
Laverty, M.P.	***MOP090***
Lawrie, S.R.	TUP028
Laxdal, R.E.	***MO202, MOP048, MOP050,*** MOP090, TUP092, ***THP043,*** THP044, THP053, THP093, TH202
Lazarev, V.L.	TUP054
Le Noa, Y.	TUP042
Le Pimpec, F.	TUP009
Lebas, N.	MOP001

Lebedev, V.A. THP073, ***THP080***
Lechartier, M. ***MOP051***
Lee, D.A. TUP028
Lee, K. MOP035, MOP036, ***MOP032***
Lee, L. MOP025, MOP073
Lee, S.W. MOP088, THP047, THP119, ***MOP089***
Lee, S.-Y. THP099
Lee, Y.S. ***MOP093***
Lefèvre, T. TUP099, TUP100
Leibfritz, J.R. TUP080, TUP081, THP029
Leich, H. ***THP061***
Leitao Macatrao, M. THP032
Lekomtsev, K. TUP099
Lempert, G. WE102
Lengkeit, M. THP013
Lesrel, J. THP023
Letchford, A.P. TUP028
Levand, F. TUP086
Lewellen, J.W. TUP018
Leyge, J.F. MOP051
Li, D. TUP052, THP002
Li, G. THP115
Li, J. TU202, ***THP046, TUP046***
Li, Q. TUP104
Li, R.K. MOP016
Li, Y.L. THP107
Li, Z. MOP025, MOP005, TUP015, ***THP092, TUP065***
Li, Z.Q. THP120
Liebig, C. MOP004
Liepe, M. ***TU303, THP034***
Lilje, L. MO302
Lillestol, R.L. MOP018
Lindberg, R.R. THP108
Lipka, D. ***TUP094***
Liu, W. MOP110
Liu, Y. ***TUP043, TUP044, TUP088***
Liu, Y.M. THP115
Liu, Z.C. THP016
Liu, Z.W. THP113
Lockey, R. TUP033, TUP034
Locquet, J.P. THP090
LoDestro, V. TUP026, TUP027, TUP033, TUP034
Lombardi, A.M. TUP042, TUP066, THP004, THP005
Longhitano, A. THP072
Longuevergne, D. ***MOP048, MOP050, THP043, THP044, TH202***
Lorbeer, B. THP011
Lu, L. ***TUP035***
Lu, Y.H. THP115
Lu, Y.R. TUP037

Ludwig, F.	TUP011
Lukin, A.N.	MOP031
Lumpkin, A.H.	THP096

— M —

Ma, Y.	MOP056, ***THP022***
Macha, K.	THP041
Machau, K.	THP062
Machicoane, G.	MOP046
MacNair, D.J.	THP064
Madrak, R.L.	THP073
Madrid, M.A.	THP042
Mahalingam, S.	MOP066
Mahgoub, M.	TUP096
Maier, M.T.	MOP044, MOP043, TH303, TUP054
Maimone, F.	THP116, THP117
Makarov, I.	MOP031
Maltezopoulos, Th.	TUP012
Mangerel, A.P.	MOP050
Mann, T.L.	MOP108, TUP093
Manus, R.	THP041
Mapes, M.	TUP033, TUP034
Marchetto, M.	***MOP050, TUP092, TH202***
Mardor, I.	WE102
Marhauser, F.	***THP009***
Marsh, R.A.	MOP005
Marti, F.	MO203, MOP046, MOP047, MOP108, TUP093, ***TUP105, TUP106, THP039, TUP084,*** THP040
Martin, D.W.	THP042
Martinez, A.	THP029
Maruta, T.	TUP076
Mascali, D.	THP116, THP117
Masschaele, B.	THP090
Masullo, M.R.	MOP078, TUP031, THP081
Masuzawa, M.	MOP105
Matheisen, A.	MO302
Mathot, S.J.	TUP042
Matsumoto, H.	TUP049, TUP050
Matsumoto, S.	***MOP012, MOP067, MOP074,*** MOP075, THP060
Matsumoto, T.	MO302
Matsushita, H.	MO302, THP060
Matveenko, A.N.	TUP007
Maus, J.M.	***TUP040, THP077***
McCarthy, M.P.	THP119
McCrady, R.C.	***THP069***
McCrory, E.S.M.	***TUP029***
McGee, M.W.	THP029
McIntosh, P.A.	MOP033
McIntyre, P.M.	***THP038***
McNabb, D.P.	MOP005

McNerney, A. TUP034, TUP033
Meissner, J. MOP081, TUP011
Mellace, C. THP037
Men, L.L. THP120
Menshov, A.A. TUP088
Merminga, L. TH202
Meseck, A. TUP007
Messerly, M. J. MOP005
Meusel, O. MOP100, MOP101, MOP102, THP071
Michelato, P.M. THP023
Micheler, M. ***TUP099***
Michizono, S. MO302
Mickat, S. ***MOP041, MOP042, MOP044,*** MOP057, TH303
Middendorf, M.E. THP047, ***THP048***
Mikulec, B. ***THP003***
Milas, N. TUP009
Miller, D. R. THP040
Miller, S.J. TUP084, THP039, THP040
Milloch, M.M. TUP002
Milocco, A. TUP002
Milosic, T. TH303
Miltchev, V. TUP012
Minaev, S. MOP040, ***TUP073***
Miracoli, R. THP116, THP117
Mishra, C.S. ***TH201***
Mitchell, D.V. MO302
Mitchell, R.R. ***THP074***
Mitra, A.K. ***THP053, TH202***
Mittenzwey, M. TUP012
Miura, A. TUP067, ***TUP075, TUP076***
Miura, T. MO302
Miyadera, H.M. ***TUP109***
Miyajima, T. THP111
Miyao, T. TUP076
Moeckly, B. THP042
Möller, W.-D. MO302, THP015
Molloy, S. MOP019
Momozaki, Y. TUP106
Mondal, M. TH202
Montesinos, E. THP055
Moody, N.A. TUP018
Moretti, A. TUP029, TUP107, THP065
Morishita, T. ***TUP049, TUP050***
Morozov, P. THP062
Morozumi, Y. ***THP019, THP020***
Morpurgo, G. MOP024
Morris, D. TUP084
Moss, A.J. MOP033
Mosthaf, J.M. MOP058
Mu, Z.C. THP046
Mueller, A.C. TUP020
Müller, I. THP071

Müller, R. TUP007
Murakami, T.M. MOP060
Muramatsu, M. MOP060
Musson, J. MOP095
Mustapha, B. MOP045, ***MOP049, TUP059***
Muto, T. THP111

— N —

Naboka, A. MOP081
Nagai, R. THP111
Nagaitsev, S. ***TUP080, THP002, THP073***
Nagamiya, S. ***MO101***
Nagler, A. WE102
Naik, V. ***TH202***
Naito, F. TUP049, TUP050, ***TUP069,*** THP058
Nakai, H. MO302
Nakajima, H. MO302, MOP012
Nakamura, N. TUP004
Nakanishi, T. THP111
Nakao, K. MOP012
Nam, S.H. WE202
Namekawa, Y. THP118
Namkung, W. ***MOP035, MOP036***
Nanmo, K. TUP068, TUP069
Nantista, C.D. ***TUP015, TUP080, THP021, THP063***
Naruse, N. THP102
Nassiri, R. THP016
Nath, S. ***TH304***
Natsui, T. MOP032
Neil, G. ***TU103***
Neilson, J. ***MOP077***
Nekhaev, V.E. MOP031
Nelson, S.D. THP086
Nesterenko, I. TUP088
Neubauer, M.L. TUP107, THP065
Neuffer, D.V. ***TUP108, THP079***
Neumann, A. TUP007, THP112
Ng, C.-K. MOP025
Nguyen, D.C. ***TUP018***
Nguyen, M.N. THP049, THP064
Nielsen, C.V. TUP054
Nietubyc, R. THP112
Nikolskiy, K.I. MOP065
Niles, S.P. TUP018
Nishimori, N. ***THP111***
Noda, A. ***MOP062***
Noda, K. MOP060, MOP062
Nölle, D. TUP094, ***TUP095***
Noguchi, S. MO302, TUP005, TUP082, THP018, THP120
Nolen, J.A. TUP106, ***FR201***
Noll, D. MOP100, ***MOP101***

Nordlund, K.	MOP070
Norem, J.	***MOP066, THP017***
Norizawa, K.	THP101
Nortier, F.M.	MOP061
Norton, D.	TUP084, THP039, THP040
Nousiainen, R.J.	***MOP104***
Novo, J.	TUP042
Nurooka, Y.	THP102
Nusinovich, G.S.	MOP079

— O —

Ogata, A.	THP101
Ogawa, Y.	MOP012
Oguri, H.	***THP118***
Oh, J.-S.	MOP035, MOP036
Ohkoshi, K.	THP118
Ohsawa, S.	MOP012, MOP111
Ohuchi, N.	***MO302, TUP082***
Okamura, M.	TUP026, ***TUP027, TUP034,*** TUP033, ***TUP051***
Okihira, K.	***TUP110***
Okuda, S.	***MOP015, MOP034***
Okumi, S.	THP111
Oliva, J.C.	TUP105
Olsen, J.J.	THP064
Olvegrd, M.	MOP018
Olyunin, A.	MOP022
Orlandi, G.L.	TUP009, TUP103
Orlov, Y.	MO302
Österberg, K.	MOP103, MOP104
Osterberg, K.	MOP103, MOP104
Ostreiko, G.N.	MOP031
Ostroumov, P.N.	***MOP045, MOP049, TUP059,*** TUP086, THP057
Otake, Y.	TUP014
Otevrel, M.	TUP096
Ott, K.	TUP007
Ouyang, H.F.	***TU202, THP115***
Ozelis, J.P.	THP026

— P —

Pagani, C.	MO302, TUP078
Palladino, V.C.	***TUP111***
Palmieri, A.	***TUP055, TUP057, TUP058***
Pande, S.A.	THP104
Panfilov, A.D.	MOP031
Panniello, M.	***THP081***
Paparella, R.	MOP053, TUP078, THP023
Paramonov, V.V.	***MOP081, TUP017, TUP011, TUP060***
Pardo, R.C.	MOP045, TUP086
Park, K.-H.	MOP093
Park, S.J.	***WE202, MOP035, MOP036***

Park, S.S.	WE202
Parma, V.	THP004
Pasini, M.	***MOP054, THP033, THP089***
Pasky, S.J.	THP107
Pasquinelli, R.J.	THP073
Pasquino, C.	MOP075
Pearce, P.	THP037
Peaucelle, C.	MOP039
Peauger, F.	MOP001, ***TUP098***
Pedersen, C.G.	TUP054
Pedrozzi, M.	MOP006, TUP001, TUP008, TUP009, TUP103, THP100, THP103
Peggs, S.	***TU203***
Pekeler, M.	WE102
Pellin, M.J.	THP017, THP042
Penco, G.	***TU101***
Penno, M.	THP061
Pepato, A.	TUP058
Perdikakis, G.	MO203
Perkins, M.	TUP028
Perrot, L.	MOP097
Perry, A.	TUP091, WE102
Perry, C.	MOP024
Peters, A.	MOP058
Peterson, T.J.	MO302
Petracca, S.	***THP094***
Petrarca, M.	MOP001
Pfister, J.	MOP043
Phillips, D.	TUP033, TUP034
Piel, C.	WE102
Pierini, P.	MO302, MOP053, TUP020, THP023
Pietralla, N.	MOP091
Pikin, A.I.	TUP033, TUP034
Pilipenko, R.V.	THP030
Pillai, C.	MOP061
Piller, M.F.	MOP088, THP047, THP119
Piot, P.	THP096
Piquet, O.	MOP053, TUP042
Pischalnikov, Y.M.	***MOP085, TUP078, THP030,*** THP029
Pisent, A.	***TU301, TUP055, TUP057,*** TUP058, THP082
Platz, M.	THP084
Plawski, T. E.	***MOP094, MOP095***
Plostinar, D.C.	***MOP080, TUP028***
Podlech, H.	MOP041, ***MOP057, MOP101,*** TUP023
Pogue, N.	THP038
Pohl, M.	TUP011
Polini, M.	MOP071
Poole, B. R.	THP086
Popielarski, J.	MO203, ***TUP084, THP092,***

	THP039, THP040
Popielarski, L.	MO203, TUP084, THP039, THP040
Popovic, M.	***MOP055, TUP029, TUP107,*** THP002, ***THP065***
Portillo, M.	MO203
Posocco, P.A.	THP005
Power, J.G.	MOP110
Pozdeyev, E.	MOP046, MOP047, MOP108, TUP093
Pozimski, J.K.	***TUP028***
Pribaz, F.	TUP002
Prichard, B.A.	THP074
Prior, G.	THP079
Proch, D.	THP015
Proslier, Th.	MOP066, THP017, THP042
Pugnat, D.	MOP071, TUP042

— Q —

Qiao, J.M.	THP046
Quast, T.	TUP007, THP112
Quincey, T.	MOP008
Quint, W.	MOP043

— R —

Rabiller, A.	TUP100
Raguin, J.-Y.	MOP006, TUP001, TUP008, THP100, ***THP103***
Raich, U.	TUP101, THP006, THP007
Raimondi, P.	MOP026
Rainò, A.C.	TUP031
Ramberger, S.	***TUP066, TUP072***
Rampnoux, E.	***THP066, THP023***
Raparia, D.	***TUP026, TUP027, TUP033,*** TUP034
Ratzinger, U.	MOP040, MOP041, MOP057, MOP043, MOP100, MOP101, MOP102, TUP023, TUP033, THP071
Raubenheimer, T.O.	MOP005
Rawat, V.	MOP025
Rawnsley, W.R.	TUP092
Redon, N.	MOP097
Reece, C.E.	***THP010, THP038***
Reed, B.	TUP106
Rehders, M.	TUP012
Reiche, S.	TUP009
Reid, J.	TUP080, THP029
Reinhardt-Nickoulin, P.I.	***TUP085***
Renzi, A.	MOP078
Reschke, D.	THP014
Richards, J.E.	TUP092
Riddone, G.	MOP020, MOP067, MOP074,

	MOP103, MOP104, TUP098
Ries, T.C.	TH202
Riffaud, B.	MOP071
Rifuggiato, D.	THP072
Rimjaem, S.	TUP096
Rimmer, R.A.	THP041
Ristori, L.	MOP099, THP030
Ritter, J.	TUP026, TUP027, TUP033, TUP034
Rodnizki, J.	***TUP045, TUP091, THP091,*** WE102
Rönsch-Schulenburg, J.	TUP012
Rogers, C.T.	THP079
Roggen, T.	***THP090***
Rohdjess, H.	TUP054
Rohlev, A.	TUP002
Romanov, G.V.	THP002
Roncarolo, F.	***TUP101, THP006, THP007***
Roncolato, C.	TUP057, THP082
Ross, M.C.	MO302
RoSSbach, J.	TUP012
Rossi, C.	***TUP042***
Rouleau, G.	THP114
Roux, R.	MOP001
Rovelli, A.	TUP031
Rowe, A.M.	THP026
Roybal, R.J.	THP041
Ruan, J.	THP096
Ruber, R.J.M.Y.	***MO303, MOP001, TUP098***
Rudolph, J.	THP112
Rusnak, B.	TUP018
Rybarcyk, L.	THP114

— S —

Sabirov, B.M.	***TUP083***
Sah, R.	THP065
Sahni, V.C.	TH201
Saisut, J.	TUP097
Saito, K.	MOP029, MOP113, ***MOP114***
Sakabe, N.	MOP111
Sakai, H.	TUP006
Sakai, T.	***MOP111***
Sakamoto, N.	TUP070
Sakanaka, S.	***TUP004***
Sakaue, K.	THP110
Sako, H.	TUP075, TUP076, ***TUP067***
Samoshkin, A.	***MOP020, TUP098, MOP104***
Sanderson, D.	MO203, TUP084
Santiago Kern, R.	MOP075
Santucci, J.K.	THP096
Sargsyan, E.	TUP066, THP005
Sasano, T.	MOP060
Sato, S.	TUP076
Satoh, M.	MO302, TUP005, TUP082,

	WE203, THP018, THP075, THP076
Sattarov, A.	THP038
Sauer, A.C.	MOP043
Savage, P.	TUP028
Savard, G.	MOP045, TUP086
Sawabe, M.	THP120
Sawamura, M.	TUP006
Scaduto, J.	TUP033
Scantamburlo, F.	TUP055, ***TUP058***
Scarpa, F.	MOP056, THP022
Scarpine, V.E.	***THP001***
Schappert, W.	MOP085, TUP077, TUP078, THP030, THP029
Scheloske, S.	MOP058
Schempp, A.	MOP040, MOP042, MOP043, TUP039, TUP040, TUP041, TUP034, TUP044, THP077
Schenk, M.	THP112
Schenkel, T.	THP002
Scherer, A.	THP103
Schibler, E.	***MOP097***
Schietinger, T.	***TUP009, TUP102, TUP103***
Schlander, F.	***THP014***
Schlarb, H.	TUP011, TUP012
Schlitt, B.	TUP054
Schlott, V.	MOP006, TUP008, TUP103
Schmidt, J.S.	TUP034
Schmitz, M.	MOP004
Schulte, D.	MOP019, MOP023, ***MOP024***
Schulte, K.	***MOP102***
Schultze, J.	MOP081, TUP011
Schulze, M.E.	THP074
Schussman, G.L.	MOP025
Schwarz, S.	MO203
Schwerg, J.N.	THP052
Scorrano, M.	TUP078
Scott, R.H.	TUP086
Sedillo, J.D.	THP041
Seidman, D.J.	MOP095
Seifter, A.	MOP061
Sekachev, I.	TH202
Sekutowicz, J.K.	***TUP010, THP015, THP112***
Semenov, V.A.	MOP005
Seol, K.T.	TUP021
Sereno, N.	***THP107, THP108, THP109***
Sergatskov, D.A.	TUP077
Serpico, C.	TUP002
Sertore, D.	THP023
Sha, S.	TUP044
Shaker, H.	TUP100
Sharamentov, S.I.	THP057
Sharkov, B.Y.	TUP073
Shen, G.B.	***THP083***

Shi, A.	TUP044
Shi, J.	MOP022
Shibuya, S.	MOP062
Shidara, T.	MO302
Shin, K.R.	***TUP047, THP050, THP119***
Shinoe, K.	TUP006
Shinozaki, S.	THP058
Shintake, T.	TUP014
Shinton, I.R.R.	THP011, THP012
Shirai, T.	MOP062
Shishido, T.	MO302, TUP005, TUP082, THP018, THP120
Shishlo, A.P.	TUP089, THP080
Shoji, Y.	***MOP014, THP085***
Shor, A.	THP091
Shverdin, M.	MOP005
Siders, C.	MOP005
Sieber, T.	TUP054
Siemens, M.	TUP094
Simon, C.S.	MOP001
Singer, W.	THP013, THP015
Singer, X.	THP013
Sinitsyn, O.V.	***MOP079***
Sitnikov, A.	TUP073
Skowronski, P.K.	TUP100
Smart, L.	TUP033, TUP034
Smirnov, A.Yu.	MOP065, TUP011
Snuverink, J.	MOP019
Snydstrup, L.	TUP033, TUP034
Sobenin, N.P.	MOP065, TUP011
Søby, L.	TUP100
Sodomaco, N.	TUP002
Sokol, P.E.	THP099
Solley, D.J.	***THP049***
Solodko, A.	TUP098
Solyak, N.	***WE101, THP073***
Song, Y.-G.	TUP021
Souda, H.	MOP062
Spartà, A.	THP072
Stabile, A.	THP094
Staples, J.W.	TUP052, THP002
Steimel, J.	THP001
Steiner, B.	TUP054
Stelzer, J.	THP114
Stephan, F.	MOP081, TUP011, TUP096, TUP097
Sterbini, G.	MOP024
Stirbet, M.	***THP051***
Stockli, M.P.	THP119
Stöhlker, T.	MOP043
Stovall, J.	TUP071, TUP046, THP005
Stulle, F.	***MOP019, MOP024***
Suda, K.	TUP070
Suemine, S.	THP097

Sugimoto, N.	***THP097, THP121***
Sugimura, T.	MOP111
Sugiyama, H.	THP121
Sun, D.	THP073
Sun, L.P.	TUP044
Sun, T.	TUP086
Sun, Y.-E.	THP096
Suwada, T.	***THP075, THP076***
Suzuki, A.	***FR203***
Suzuki, H.	THP058
Suzuki, S.	TUP014
Swenson, D.A.	***MOP059***
Syratchev, I.	MOP018, MOP025, MOP074
Szott, P.	THP066

— T —

Taborelli, M.	MOP070
Tahir, M.I.	MOP033
Tajima, T.	***THP041, THP042***
Takahashi, T.	TUP006, MOP009
Takatomi, T.	THP121
Takeda, K.	***THP085***
Takenaka, T.	MO302
Takeuchi, T.	MOP060
Tamura, J.	TUP034
Tanaka, H.	TUP069
Tang, C.-X.	MOP016
Tang, J.	MOP096
Taniguchi, R.	MOP015, ***MOP034***
Tanimura, K.	THP102
Tanke, E.	MOP046, MOP047, MOP108, TUP093
Tantawi, S.G.	MOP076, MOP077, MOP005, THP042
Tardy, T.	MOP071
Tarkeshian, R.	TUP012
Tarnetsky, V.V.	MOP031
Tartaglia, M.A.	TUP077
Tarvainen, O.A.	THP114
Tauchi, T.	MOP105
Tecker, F.	TUP100
Terashima, A.	MO302
Terechkine, I.	***TUP077***
Terunuma, N.	THP110
Therasse, M.	THP033
Therkildsen, Ka.T.	TUP054
Thieberger, P.	TUP106
Thominet, V.G.	TUP103
Thuillier, T.	MOP039
Thurman-Keup, R.	THP096
Tian, K.	THP009
Tiede, R.	MOP040, MOP057, TUP033
Tiefenback, M.G.	***MOP037***
Timko, H.	MOP070

Timmins, M.A. TUP042
Tiunov, M.A. MOP031
Tkachenko, V.O. MOP031
Togawa, K. TUP014
Toge, N. MO302, THP120
Tokuchi, A. THP097
Toms, R. MOP024
Tong, D.C. MOP064
Tongu, H. MOP062, MOP105, ***THP036***
Toporkov, S.E. MOP065
Toral, F. MOP018
Touchi, Y. TUP070
Trento, G. THP056
Treptow, K.R. THP029
Trowitzsch, G. TUP011
Tsuchiya, K. MO302
Tupikov, V. MOP084, THP029
Turlington, L. THP041
Tuske, O. MOP039

— U —

Ueno, A. THP118
Uesaka, M. MOP032
Umemori, K. ***TUP006, THP018***
Umer, R. TUP002
Urakawa, J. THP102, THP110, THP121
Urbant, M. TUP011
Uriot, D. MOP039, TH303
Urschütz, P. TUP054
Usher, N.R. TUP084
Ushijima, S. ***MOP105***

— V —

Vaccaro, V.G. MOP078, ***TUP031, THP081***
Valdez, F.O. MOP061
Valles, N.R.A. ***THP034***
Valuch, D. MOP053
Vandeplassche, D. TUP020
Vandoni, G. TUP042
Varghese, P. ***MOP084, THP029***
Variale, V. TUP031
Vashchenko, G. TUP096
Vasilyev, I.V. TUP085
Vassioutchenko, A.V. TUP047, THP047, THP119
Veitzer, S.A. MOP066
Velasco, M. TUP100
Veljak, L. TUP002
Verdú-Andrés, S. ***THP037, THP037***
Verhanovitz, N. TUP084, THP040
Verzilov, V.A. TH202
Vicario, C. TUP009
Vilcins, S. TUP094
Vincent, J.J. TUP084

Vinzenz, W. MOP040, MOP042
Virostek, S.P. ***TUP052, THP002***
Vlieks, A.E. MOP005
Vogel, E. TUP013
Vondrasek, R.C. TUP086
Vormann, H. ***MOP040, MOP042, MOP044***
Vorobjev, G. MOP043
Voronin, L.A. MOP031
Vossberg, M. MOP042, ***TUP041, TUP034***
Voulot, D. THP089
Vretenar, M. MOP071, TUP042, TUP066, TUP072, ***WE103***
Vuitton, VC. TUP101

— W —

Wagner, R. THP062
Wang, C.-X. ***THP016***
Wang, D. TUP002
Wang, F. MOP067, TUP015, THP063
Wang, H. THP009
Wang, J.Q. TUP019
Wang, J.W. MOP067, MOP005
Wang, Q.Y. THP120
Wang, Z.J. TUP037, ***TUP064***
Washio, M. THP110
Watanabe, K. MO302, ***TUP005, TUP082,*** THP018, THP036, THP120
Watanabe, Y. TUP070
Webber, R.C. ***TUP048, THP001, THP002, THP031, THP073***
Weber, S.V. TUP054
Webster, A. TUP088
Wegner, R. MOP071, THP037
Wei, G.H. TUP067, TUP075, ***THP088***
Wei, J. TUP036, TUP046, TUP071, THP113
Weiland, T. THP084
Weingarten, W. THP004
Weise, H. ***MO102, MO302***
Weissman, L. ***TUP074, TUP091, WE102***
Weisz, S. THP004
Welton, R.F. THP119
Wendt, M. THP001, THP073
Wenndorff, R.W. MOP081, TUP011, THP061
Wezensky, M. THP049
Wieland, M. TUP012
Wiesner, C. MOP100, ***THP071***
Wildman, D. THP001
Wilinski, M. TUP033
Winkelmann, T.W. MOP058
Wise, P. TUP028
Witgen, K. THP040
Withofs, Y.L. THP032
Wlodarczak, J. MO203, TUP084, THP039,

	THP040
Wu, J.	THP083
Wu, X.	MOP108, TUP093, MO203, ***MOP047, MOP046***
Wuensch, W.	MOP002, MOP022, MOP025, MOP067, MOP068, MOP070, MOP075

— X —

Xia, J.W.	TUP037
Xiao, C.	TUP037
Xiao, Q.	THP120
Xing, Q.Z.	***TUP046, THP113***
Xiong, Z.F.	TUP046
Xu, T.G.	TU202, THP115
Xu, X.A.	THP046

— Y —

Yakovlev, V.P.	THP002, THP008, THP027
Yamada, K.	***TUP070***
Yamaga, M.	TUP014
Yamamoto, A.	MO302
Yamamoto, K.	TUP076
Yamamoto, M.	THP111
Yamamoto, Y.	MO302, TUP005, TUP082, ***THP018, THP036, THP120***
Yamazaki, M.	THP058
Yan, F.	MOP050, ***THP093, TH202***
Yan, L.X.	MOP016
Yanay, Y.	TUP074, THP091
Yang, G.J.	***THP095***
Yang, H.R.	MOP035, MOP036
Yang, J.	THP101, ***THP102***
Yang, Y.Q.	TUP037
Yaniche, J.-F.	THP066
Yano, Y.	MOP012
Yao, Y.	THP046
Yaramyshev, S.G.	MOP040, TH303
Yin, X.	TU202, ***TUP061, TUP062, TUP063***
Yokoyama, K.	MOP067, ***MOP075, MOP012***
Yoneda, C.	THP042
Yonehara, K.	TUP108
York, R.C.	MOP108, TUP093, ***MOP046,*** MOP047, TUP084, THP039, THP040
Yoshida, M.	MO302, MOP012, ***THP060***
Yoshida, Y.	THP101, THP102
Yoshikawa, C. Y.	TUP108, THP079
Yoshioka, M.	***MOP115, TUP049, TUP050***
Young, L.M.	TUP071, TUP046
Yusof, Z.M.	MOP110

— Z —

Zaltsman, A.	TUP033, TUP034
Zaplatin, E.N.	THP039
Zappalà, E.	THP072
Zasadzinski, J.	THP017
Zavadtsev, A.A.	TUP011
Zavadtsev, D.A.	TUP011
Zelenski, A.	TUP026
Zennaro, R.	MOP002, MOP067, ***TUP001***, TUP098
Zhai, J.Y.	THP120
Zhang, C.	TUP023, TUP041
Zhang, D.H.	THP001
Zhang, H.Y.	TUP071, THP113
Zhang, J. S.	THP115
Zhang, K.	TUP104
Zhang, P.	***THP011, THP011***
Zhang, X.	MOP096
Zhang, Z.	THP095
Zhang, Z.H.	THP046
Zhang, Z.L.	***TUP044***
Zhao, F.X.	THP115
Zhao, H.W.	TUP037, TUP044, THP113
Zhao, Q.	MOP108, TUP093, MO203, MOP047, MOP046
Zhao, T.X.	THP120
Zhao, Y.L.	TUP071
Zhao, Z.T.	MOP064
Zhemanov, V.	THP062
Zheng, Q.	MOP090
Zheng, S.X.	TUP036, ***TUP071***
Zhou, F.	MOP005, TUP015
Zhou, W.	THP046
Zhu, K.	TUP037
Zhukov, A.P.	***TUP089***
Zhukova, M.	THP090
Zinkann, G.P.	TUP086
Zmuda, T.J.	THP029
Zvyagintsev, V.	MOP048, MOP050, THP043, THP044, THP093