18th International Conference on RF Superconductivity

CONFERENCE GUIDE

Lanzhou, China

17-21 July, 2017

中国科学院 CHINESE ACADEMY OF SCIENCES

中国科学院近代物理研究所 Institute of Modern Physics, Chinese Academy of Sciences

中國科學院高能物理研究所 Institute of High Energy Physics Chinese Academy of Sciences

18th International Conference on RF Superconductivity

Lanzhou, China

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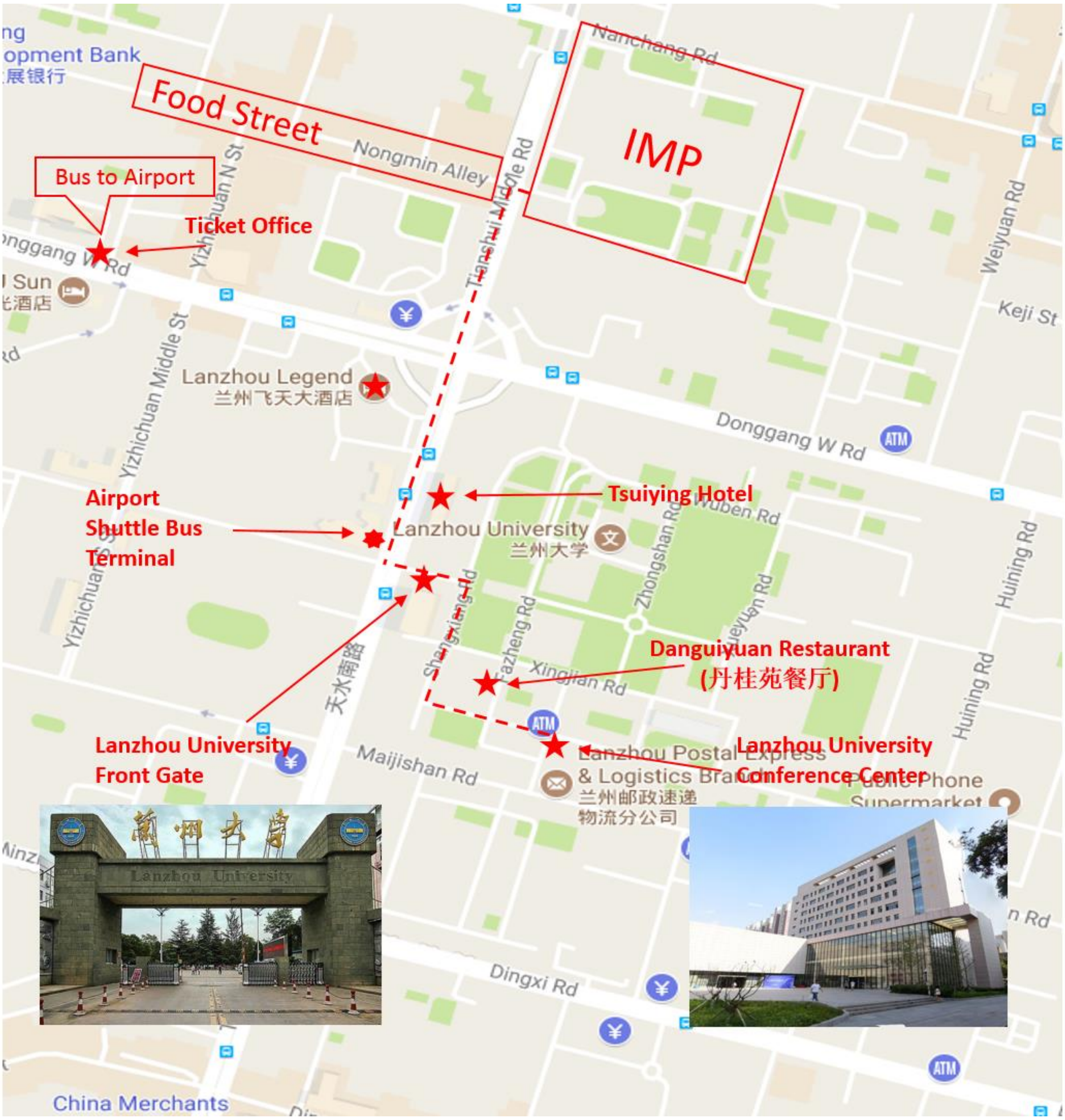

SRF2017

18th International Conference on RF Superconductivity

July 17-21, 2017

Lanzhou University Conference Center

Lanzhou, China

http://srf2017.csp.escience.cn/

Organized by

IMP and IHEP, CAS

Content

18th International Conference on

RF Superconductivity

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Welcome

Dear Colleagues,

On behalf of Institue of Modern Physics (IMP), Institute of High Energy Physics (IHEP) and the SRF2017 organizing committees, it is my pleasure to welcome each of you to the 18th International Conference on RF Supercondutivity at Lanzhou University Conference Center, which is located on the campus of Lanzhou University at the fabulous western China and within the walking distance from IMP. The SRF2017 will follow its traditions, thus provide a unique forum for scientists, engineers, students and industrial partners from around the world, to present and discuss the latest developments in the science and technology of superconducting RF for particle accelerator applications.

With your participantion, and the generous contributions from the SRF2017 sponsors and exhibitors, it allows us to support a significant number of young researchers, who will be the major players in SRF community, being stimulated by this exciting forum. During conference, scientific programs will consist of invited talks, poster sessions and 'hot-topic' discussion sessions. Social activities including a cruise excursion along the famous Yellow River and receptions will also be organized. An industrial exhibition and tutorial session will also take place as parts of the conference.

Lanzhou is a charming city featuring its beautiful history and culture. For 2,000 years, it's a significant pivot of the Silk Road, which played a crucial role in connection with the east and the west. Our logo designer incorporated the profile of the Lanzhou's iconic sculpture-'the Bronze Running Horse', which was excavated nearby, and a silk ribbon, which signifies the Silk Road into the conference poster.

We are very pleased to have all of you join us here in Lanzhou and wish you can fully enjoy the SRF2017 and your stay here.

Sincerely,

SRF2017 Conference Chair

Conference Organization

International Organizing Committee and International Program Committee:

- Jens Knobloch, HZB, IOC Chair
- Yuan He, IMP, IPC Chair
- Claire Antoine, CEA Saclay
- Olivier Brunner, CERN
- Jean Delayen, ODU
- Eiji Kako, KEK
- Michael Kelly, ANL
- Robert Kephart, FNAL
- Matthias Liepe, Cornell
- Kexin Liu, PKU
- Wolf-Dietrich Moeller, DESY
- Vincenzo Palmieri, INFN-LNL
- Charles Reece, JLAB
- Kenji Saito, FRIB
- Tsuyoshi Tajima, LANL

Special regional advisors:

- Walter Venturini Delsolaro, CERN
- Robert Laxdal, TRIUMF
- Jie Gao, IHEP

Special Overall Advisors:

- Hasan Padamsee – FNAL

Local Organizing Committee:

- Conference chair – Yuan He
- Local chair – Shenghu Zhang
- Editor and conference coordinator - Ning Zhao, Lu Li
- Conference administration –Teng Tan, Dapeng Li.
- Tutorial – Yongming Li
- Student program – Andong Wu
- Exhibition/sponsors – Yongming Li, Chunlong Li
- Poster coordination – Teng Tan
- Audio-visual – Qiangju Wu
- IMP tour – Cong Zhang, Qingwei Chu
- Computing services – Qiangjun Wu
- Registration – Shuhui Liu
- SPMS – Teng Tan
- Speaker ready room – Lu Li
- plus many other students and staff who contributed in various ways

Registration

The registration desk will be located at Lanzhou University Conference Center, and will be open at the following times.

Day	Times
Sunday, 16 July	2:30pm-8:00pm
Monday, 17 July	8:00am-6:00pm
Tuesday, 18 July	8:00am-6:00pm
Wednesday, 19 July	8:00am-6:00pm
Thursday, 20 July	8:00am-6:00pm

Regular registration fee includes:

- Scientific Programs
- Coffee breaks
- Sunday Welcome Reception
- Monday Chairman's Reception
- Wednesday excursion
- Wednesday banquet
- Friday tour of IMP
- Conference lunch from Monday to Friday

Cancellations: All cancellations have to be submitted in e-mail form to srf2017@impcas.ac.cn. All cancellations later than June 17th, 2017 will be regarded invalid, meaning no refund will be provided. The policy also applies to extra tickets, exhibitor and companion registrations. However, for absence caused by some extenuating circumstances, refunds may be permitted. All refunds will be done by credit card or bank transfer, depending on the original payment method will be dealt with after the conclusion of the conference.

Security and Insurance

Participants are recommended not to leave their belongings unattended. The conference organizers cannot accept liability for personal injuries sustained or for loss or damage to participants' (or companions') personal property during the conference.

Conference Badges

Participants are requested to wear their badges during all the meetings.

Social and Culture Program

The social program is geared to give the delegate a sampling of the sights, tastes and culture of the Lanzhou region. We include here a brief description of the events noted below:

- Sunday reception
- Monday Chairman's reception
- Wednesday excursion
- Wednesday banquet
- Friday tour of IMP

Note: Complimentary lunches are served 12:30 to 14:00 at Danguiyuan Restaurant from Monday to Friday.

Sunday reception:

On Sunday Jul. 16 from 18:00 to 20:00 at the Danguiyuan (丹桂苑) Restaurant, there will be a welcome reception just after the registration closes. The event coincides with the student poster session. Light snacks and refreshments will be served.

Chairman's reception:

On Monday Jul. 17 there will be a Chairman's reception from 18:30 to 21:00 at the Lanzhou Legend Hotel. The reception will include catered food and drinks. It should be an enjoyable and informative evening in a fantastic setting.

Wednesday excursion:

On Wednesday Jul. 19 afternoon, from 13:30 to 17:30 there will be a cruise excursion along the famous Yellow River. A bag lunch will be provided. The top deck of the cruise is in open-air. Be prepared for sunburns. Cruise can take you to the nearest station to the banquet site, or the starting station to go to the banquet by shuttle.

Wednesday Banquet:

On Wednesday Jul. 19 evening, from 18:30 to 22:00 there will be a banquet at the Baiyun Hotel (白云宾馆). Attendees will enjoy traditional Lanzhou food and folk music of Gansu.

The IMP Tour:

On Friday Jul. 21 from 14:00 to 18:00, there will be guided tour to IMP. Both C-ADS Injector-II and the gigantic HIRFL are open to the visitors.

Student Program

The SRF conference series are distinctively characterized with the focus on making good use of the event to train students. Prior to the conference, tutorial sessions will be held, which are aimed at giving students general but significant overview of subjects on SRF and the scientists and engineers newly taping into the field may also gain some in-depth insights into SRF. Besides, student poster session and competition are also included during the conference, which will be judged by international SRF experts. And a sub-set of students will be qualified for attending the invited orals and will be the candidates for the winners of the SRF2017 top young researcher awards.

Sunday 16:00 – 18:00 Student Poster Session

The Posters will be displayed until 20:00 and judging will take place from 16:00 to 18:00. Award presentations will take place on Friday during the closing ceremony.

Young Researcher Award

Two awards for the best oral presentation by young researcher will be presented on Friday during the Closing Ceremony.

Tutorial Program

Tutorial fee includes:

- Tutorial session on 10 SRF topics
- Coffee breaks (twice a day)
- Lunches during the tutorials

Following tradition, SRF2017 tutorial sessions will be held prior to the conference from Jul. 13-15 at the Lanzhou University Conference Center. The tutorials are designed to provide an in-depth overview of SRF related subjects for students as well as scientists and engineers new to the field. Experts in the SRF global community will present lectures on a wide range of topics related to SRF. Lunch and coffee breaks will be provided for speakers and students. In addition, there will be a Saturday afternoon social event to mark the end of the tutorial sessions and to promote discussion and the free exchange of ideas between students and experts.

The following main topics will be covered during the tutorial sessions:

- Basic Principles of RF Superconductivity
- RF Basic and TM Cavities
- Non-elliptical Cavities (HWR, QWR, Crab, Deflecting, and etc.)
- Cavity Test and Operation
- High Power Couplers and HOM Couplers
- Cryogenics and Cryomodules
- Cleanroom Technology and Cavity Processing
- Pushing Bulk Nb Limits (High Q, High Gradient, Reliable SRF Accelerators)
- Materials beyond Bulk Nb

TUTORIAL PROGRAM

Time	Thursday 07.13.2017	Friday 07.14.2017	Saturday 07.15.2017
08:30	Registration		
09:00		Cavity Test and Operation I **T. Powers** **JLab**	Beyond Nb II: Nb thin film and other materials **A-M. Valente-Feliciano** **JLab**
09:30	Welcome Speech		
10:00	Coffee Break	Coffee Break	Coffee Break
10:30	Basic Principles of RF Superconductivity **T. Junginger** **HZB**	Cavity Test and Operation II **T. Powers** **JLab**	Beyond Nb III: Nb thin film and other materials **A-M. Valente-Feliciano** **JLab**
11:00			
11:30		High Power Couplers and HOM Couplers I **E. Montesinos** **CERN**	Pushing Bulk Nb Limit I, **C. Reece** **JLab**
12:00			
12:30	Lunch Break	Lunch Break	Lunch Break
13:00			
13:30	RF Basic and TM Cavities **E. Jensen** **CERN**	High Power Couplers and HOM Couplers II **E. Montesinos** **CERN**	Pushing Bulk Nb Limit I, **C. Reece** **JLab**
14:00			
14:30		Cleanroom Technology and Cavity Processing I **A. Palczewski** **JLab**	Cryogenics and Cryomodule I **R. Ge** **IHEP**
15:00			
15:30	Coffee Break	Coffee Break	Coffee Break
16:00	Non-Elliptical Cavities **R. Laxdal** **TRIUMF**	Cleanroom Technology and Cavity Processing II **A. Palczewski** **JLab**	Cryogenics and Cryomodule II **R. Ge** **IHEP**
16:30			
17:00		Beyond Nb I, Nb_3Sn **D. Hall** **Cornell**	Social Event
17:30			

Slides are available at http://srf2017.csp.escience.cn/dct/page/70014

Author Information

Proceedings

The Author Reception and Proceedings Office is located in Room 803，Tsuiying Hotel （萃英大酒店），No. 226 South Tianshui Road , Chengguan, 730000 Lanzhou（at the north of the front gate of Lanzhou University:100 m）. The SRF2017 proceedings will be published by the JACoW Joint Accelerator Conferences editorial team. To ensure consistency of the conference proceedings, all papers have to meet formal criteria, specified by JACoW. Editorial staff will process papers before and during the conference.

The paper submission deadline is Wednesday, July 12, 2017(23:59). After this deadline, conference editors perform formal paper checks and conversions according to the JACoW publishing requirements. Once an editor is assigned to your paper, a PDF is produced from the uploaded PS file. This PDF is checked, and if necessary, minor formal corrections are done. The corrected PDF is uploaded again into your conference database profile. If required, you may be requested to report to the Paper Reception desk to accept the changes made or to speak to an editor if there are concerns with your paper.

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

Scientific Program

The schedule included here in details the scientific program.

Oral Sessions

Oral sessions will be held in the Main Conference Hall. A preview/testing room is available for speakers next to the registration site. Please note that all speakers must give their presentations using the computer system that is in the session room. Use of individual laptops cannot be accommodated.

All talk must be uploaded at least 24 hours in advance (except Monday morning talks).

Poster Sessions

The poster boards will have a single surface measuring 4’ x 4’ (1.22 m x 1.22 m) so they will accommodate an ARCH E or A0 sized poster in either landscape or portrait orientation.

Day	Times
Monday	14:00 – 18:00
Tuesday	14:00 – 18:00
Thursday	14:00 – 18:00

Posters should be taken down at the end of the session. Any posters not removed by 20:00 each day will be removed by staff and discarded.

Authors are reminded that no contributions are accepted for publication only. Any accepted contributions that are not presented in the oral or poster sessions 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 presented in this way will not be accepted for publication.

Local Information

Emergency Phone Numbers

Fire	119
Police	110
Ambulance	120

Hotel

Lanzhou Legend Hotel（兰州飞天大酒店）
No. 529, South Tianshui Road, Chengguan, 730000 Lanzhou, China.
Tel：0931-8532888
http://www.lanzhou-legend-hotel.008h.com/
Distance from Conference Center: 700 m.

Tsuiying Hotel （萃英大酒店）
No. 226 South Tianshui Road , Chengguan, 730000 Lanzhou, China
Telephone: 0931-8915559
Distance from Conference Center: 500 m.

Lanzhou Jinjiang Sun Hotel（锦江阳光大酒店）
No.589 West Donggang Road, Chengguan, 730000 Lanzhou, China
Tel: 13321221022
http://www.jjsunhotel.com
Distance from Conference Center: 1200 m.

IMP

Institute of Modern Physics, Chinese Academy of Sciences
No. 509 Nanchang Road, Lanzhou
Tel: 0931 4969221
http://www.impcas.ac.cn/

Hospitals and Urgent Care Facilities

Gansu Provincial Hospital
No. 204 Donggang Road(west), Lanzhou
Tel：0931-8281763
http://www.gsyy.cn/

IMP Medical Clinic
No. 509 Nanchang Rd., Lanzhou
Tel: 0931-4969232

Banking and Currency Exchange

The currency used in China is the RMB Yuan(¥). Exchange offices are located in the airports. Banks are well distributed around Lanzhou University.

Bank of China
No. 525 Tianshui Road(South), Lanzhou
Tel: 0931-7825729
http://www.boc.cn/en/index.html

China Citic Bank
No. 638 Donggang Road(west), Lanzhou
Tel: 0931-8890666

Internet and Other Services

Wireless Internet

Wireless Internet access is available to all delegates in Lanzhou University Conference Center.

Tourist Information
China Gansu Overseas Tourist Corporation
1307 Room, 13th floor, No. 2 Nongmin Road, Lanzhou
Tel: 0931-4142888

Exhibition Location and Hours

The exhibition booths are located at the Lanzhou University Conference Center. 2:30pm Sunday 16 July to 12:00pm Friday 21 July.

Note: The Conference Center gate will be open until 8:00pm each day.

Abstract

17-July-17 08:20-10:35	Oral **MOXA-Facilities I**	Auditorium A

MOXA01
08:20
20mins

Successful Beam Commissioning of Chinese ADS Injector-II

Yuan He (IMP/CAS, Lanzhou)

Since 2011, the key technologies for superconducting proton linac were developed in CAS for Accelerator Driven System. The sc linac of 10 MeV base on spoke resonators (Spoke), named injector I, was built in IHEP. The other one base on half-wave resonators (HWR), named injector II, was built in IMP. Both injectors were commissioned successfully with more than 1 mA CW beam. The front-end demo linac for ADS is based on injector II with succeeding by one taper-type HWR cryomodule and one Spoke cryomodule. It can accelerate 10 mA beam to energy of 25 MeV. The last two cryomodules of the demo linac started tunnel installation since January and cooling down in May. The first beam was on May 27th, and 12 mA (@ 26 MeV) pulse beam and 170 us (@ 25 MeV) CW beam were demonstrated on July 6th. The background of the project will be introduced. The lessons and experiences of CW SRF and mA beam commissioning on injector II and the 25 MeV demo linac will be presented.

MOXA02
08:40
20mins

The Commissioning of the European XFEL Linac and its Performance

Detlef Reschke (DESY, Hamburg)

The main LINAC of the superconducting accelerator of the European XFEL presently consists of 96 accelerator modules, each housing eight 1.3 GHz TESLA-type cavities, with an average design gradient of 23.6 MV/m. The performance of each individual module has been tested after module assembly in the Accelerator Module Test Facility (AMTF) at DESY. The 2-year period of module installation to the accelerator tunnel was finished in August 2016. In order to re-check and re-establish the performance of the input power couplers warm processing of nearly all installed modules was applied before the first cool-down in Dec2016/Jan2017. Each four modules are connected to one 10MW klystron and form a so-called RF station, which is powered and controlled individually during operation. Until April 2017 subsequently 23 of 25 RF stations have been commissioned for beam acceleration including frequency tuning, various calibrations and LLRF adjustments and a preliminary beam energy of 12GeV was achieved, which is sufficient for first lasing experiments. No significant performance degradation has been observed so far. The commissioning experience and the available RF performance data will be presented.

MOXA03
09:00
20mins

The 30MeV Stage of the ARIEL e-Linac

Robert Edward Laxdal, Zhengting Ang, Thomas Au, Ken Fong, Oliver Karl Kester, Shane Rupert Koscielniak, Alexey Nikolaevich Koveshnikov, Michael Laverty, Yanyun Ma, Douglas W Storey, Edward Thoeng, Zhongyuan Yao, Qiwen Zheng, Vladimir Zvyagintsev (TRIUMF, Vancouver)

A MW class cw superconducting electron linac (e-Linac) is being installed at TRIUMF as a driver for radioactive beam production as part of the ARIEL project. The e-linac final configuration is planned to consist of five 1.3GHz nine-cell cavities housed in three cryomodules with one single cavity injector cryomodule (EINJ) and two double cavity accelerating cryomodules (EACA, EACB) to accelerate in continuous-wave (cw) up to 10mA of electrons to 50MeV. The e-Linac is being installed in stages. A demonstrator phase (2014) consisting of a 300kV electron gun, EINJ, and a partially outfitted EACA with just one accelerating cavity was installed for initial technical and beam tests to 22.9MeV. A Stage 2 upgrade now installed has a completed EACA to reach an operational goal of 3mA of electrons to 30MeV for first science from the ARIEL ISOL targets. A single 290kW klystron is used to feed the two EACA cavities in vector-sum closed-loop control. The paper is focused on the SRF challenges: systems design, cavity and cryomodule performance, rf ancillaries preparation and performance, LLRF and RF system performance and final beam test results.

MOXA04
09:20
20mins

Superconducting Accelerator for ERL Based FEL EUV Light Source at KEK

Hiroshi Sakai, Eiji Kako, Taro Konomi, Takayuki Kubo, Kensei Umemori (KEK, Ibaraki), Masaru Sawamura (QST, Tokai), Tomoko Ota (Toshiba, Yokohama)

An energy recovery linac (ERL)-based free electron laser (FEL) is a possible candidate of a tens of kW EUV source and open the era for next generation EUV-lithography. We have designed the 10 mA class ERL-based EUV-FEL source to generate more than 10 kW power. One of the key technologies is CW superconducting cavities to realize the energy recovery of high beam current of more than 10 mA by suppressing HOMs and high gradient acceleration of higher than 12 MV/m. This CW superconducting cavity had been developed through the construction of the Compact ERL facility in KEK and it successfully achieved the energy recovery of 1 mA CW beam until now. In this talk, first we express our

design strategies of SRF cavities of the main linac of ERL-EUV light sources not only to suppress the HOMs but also to overcome the field emission problem by modifying the main linac cavity of Compact ERL more sophisticatedly. Next we show the recent development works for ERL-EUV superconducting cavity about HOM damper, cryomodule, and its clean string-assembly work by using horizontal test stand.

MOXA05
09:40
20mins

The LCLS-II SRF Linac

Andrew Burrill (SLAC, Menlo Park, California)

The LCLS-II project, a 4 GeV electron accelerator used to produce both hard and soft x-rays, is driven by a c.w. electron accelerator operating at 1.3 GHz. The project requires the fabrication, assembly and testing of 35 ¿1.3 GHz cryomodules and 2 ¿3.9 GHz cryomodules in order to generate the 4 GeV electron beam. The 280 TESLA style cavities used in the 1.3 GHz cryomodules have been modified for c.w. operation and are also utilizing nitrogen doping in order to achieve average Q0 of > 2.7e10 at 16 MV/m. The status of the cavity and cryomodule testing will be reported on in this talk along with the challenges of achieving and maintaining the high Q0 in the cryomodule.

MOXA06
10:00
20mins

SRF Systems for the Jefferson Lab Electron Ion Collider (JLEIC)

Robert Rimmer, William Clemens, Fredrik Fors, Jiquan Guo, Fay Elizabeth Hannon, James Henry, Frank Marhauser, Larry Turlington, Haipeng Wang, Shaoheng Wang (JLab, Newport News, Virginia)

We report on the development of new CW SRF systems for the colliding rings of a proposed electron-ion collider (EIC) at Jlab. Jefferson Lab is developing new strongly HOM-damped SRF cavities for the ion collider ring and a high-energy electron cooler at 952.6 MHz. The baseline design JLEIC will re-use the PEP-II 476 MHz cavities for the electron ring with a possible future upgrade to 952.6 MHz SRF cavities at a later date. We discuss the design optimization of the new high current cavities and compare options for the strong HOM damping required. A concept for a modular cryostat to house these various cavities will be shown, and an overview of the challenging high-level parameters will be presented. These designs and concepts may be useful in other high current storage rings and ERL¿s.

MOXA07
10:20
15mins

Progrss on C-ADS accelerator in IHEP

Fang Yan (IHEP, Beijing)

The 10 MeV accelerator-driven subcritical system (ADS) Injector I test stand at Institute of High Energy Physics (IHEP) is a testing facility dedicated to demonstrate one of the two injector design schemes [Injector Scheme-I, which works at 325 MHz], for the ADS project in China. The ion source was installed since April of 2014, periods of commissioning are regularly scheduled between installation phases of the rest of the injector. Proton energy of 10.67MeV has been achieved with beam peak current of 10 mA with 14 superconducting (SC) spoke cavities. This contribution reports the details of the commissioning results together with the status and challenges of the CW machine commissioning.

17-July-17	Oral	Auditorium A
11:05-12:45	**MOYA-Facilities II**	

MOYA01
11:05
20mins

The Superconducting Accelerator for the ESS Project

Felix Schlander, Christine Darve, Nuno Elias, Mats Lindroos, Cecilia Giovanna Maiano (ESS, Lund), Pierre Bosland (CEA/IRFU, Gif-sur-Yvette), Paolo Michelato (INFN/LASA, Segrate (MI)), Guillaume Olry (IPN, Orsay), Mike Ellis (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire), Roger Ruber (Uppsala University, Uppsala)

The European Spallation Source, ESS, is under construction in Lund since 2014. While the installation of the source and the normal conducting part will start in this autumn, the production and testing of cryomodules and cavities for the superconducting accelerator is in full swing at the partner laboratories. The spoke cavities and cryomodules will be provided by IPN Orsay and the testing of those modules will take place at Uppsala University. Prototyping and assembly of the elliptical cryomodules series is occurring at CEA Saclay, and the modules will be tested at a new test stand at ESS. The fabrication and test of the medium beta cavities is provided by INFN Milan and STFC Daresbury for the high beta cavities respectively. An overview of the current activities and test results will be presented in this talk.

MOYA02
11:25
20mins

BESSY VSR: SRF Challenges and Developments for a Variable-pulse Length Next-generation Light Source

Adolfo Velez, Hans-Walter Glock, Jens Knobloch, Axel Neumann, Emmy Sharples (HZB, Berlin), Andranik Tsakanian (Helmholtz-Zentrum Berlin fuer Materialien und Energie GmbH (HZB), Berlin)

The BESSY VSR project represents an exciting alternative to diffraction limited storage rings in the development of a next generation light source. Such a system should be capable to store "standard" (some 10 ps long) and "short" (ps and sub-ps long) pulses simultaneously in the storage ring opening the door to picosecond dynamic and high-resolution experiments at the same facility. This unique feature can be created by the introduction of the beating effects produced by higher harmonic SRF cavity systems (1.5 GHz & 1.75 GHz). The challenging design specifications as well as the technological demands on the SRF system make BESSY VSR a defiant project where non-standard techniques such as waveguide-damped cavities have been further developed. This talk focuses on the new SRF developments that includes wveguide-damped cavities, high-power couplers and higher-order mode absorbers that must handle nearly 2 kW of HOM power. The cryomodule design and its interaction with the beam will also be discussed.

MOYA03
11:45
20mins

SRF for the Heavy-ion Accelerator RAON and the Rare Isotope Science Project RISP

Dong-O Jeon (IBS, Daejeon)

Construction of the RAON heavy ion accelerator facility is in-progress in Korea. The driver linac is a superconducting linac with 200 MeV/u for uranium beam and 400 kW beam power. Prototyping of major components and their tests are proceeding including superconducting cavities, superconducting magnets and cryomodules. December 2016, the RFQ accelerated oxygen beam. Status report of the RAON accelerator systems is presented.

MOYA04
12:05
15mins

Set of RF Parameters for the FCC_ee Machines

Olivier Brunner, Juljan Nikolai Schwerg (CERN, Geneva)

The FCC-ee RF system must handle beams at different energies and beam intensities ranging from the high energy case of a few mA at 175 GeV to the heavily beam loaded situation at 1.45 A and 45.5 GeV. Higher order mode power will be a major issue at the highest beam intensities. A conceptual design of the FCC RF system is proposed along with highlights of specific R&D topics to reach the design performance. Challenges related to RF structure design, RF powering and higher order modes are addressed. Breakeven point between bulk Nb and Nb/Cu technologies are discussed.

MOYA05
12:20
20mins

SRF Technology for PIP-II and III

Allan Rowe (Fermilab, Batavia, Illinois)

The Proton Improvement Plan-II (PIP-II) is an 800 MeV SRF LINAC Fermilab will build as part of a critical upgrade to the accelerator complex required to serve LBNF/DUNE. The LINAC is a CW capable SRF machine designed to accelerate H- ions with 2 mA average beam current to 800 MeV which will be transported to the existing Booster and Main Injector accelerators. In combination, these accelerators will deliver 120 GeV beam with 1.2 MW beam power to the LBNF target.The PIP-II SRF LINAC is constructed of five cryomodule types starting with a CW 162.5 MHz, β=0.11 half-wave which leads to a β=0.22 and β=0.47 325 MHz single spokes, and concludes with β=0.61 and β=0.92 650 MHz elliptical types.In the future, the PIP-II LINAC will be the front end of PIP-III which will deliver multi-megawatt beam power to DUNE via the Main Injector.The SRF alternative for PIP-III is an SRF LINAC extended from 800MeV to 8 GeV which will inject beam into the Main Injector. This presentation focuses on the five PIP-II cryomodules and the development of critical ancillary components. In several cases, contributions from the India DAE and other International Collaborators are highlighted.

17-July-17 14:00-17:00	Poster **MOPB-Poster Session**	Hall B

MOPB001

Concepts and Design for Beamline HOM Dampers for eRHIC

Philipp Kolb, Yongfeng Gao, Kevin S. Smith, Chen Xu, Wencan Xu, Alex Zaltsman (BNL, Upton, Long Island, New York)

In the design of eRHIC at BNL, HOM power plays a major role for the SRF installation. Depending on the final accelerator design and choice of cavity, up to 100kW of HOM power is estimated to be generated, presenting a big challenge for the HOM damping concept. Due to this high amount of HOM power, all current concepts for eRHIC would use room temperature beam line absorbers equipped with silicone-carbide dielectrics to absorb HOM power. Concepts, designs and simulations for these beam line absorbers will be presented.

MOPB002 **eRHIC Crab Cavity Choice for Ring-ring Design**

Qiong Wu, Ilan Ben-Zvi, Yue Hao, Silvia Verdu-Andres, Binping Xiao (BNL, Upton, Long Island, New York)

The future electron ion collider eRHIC adopts large crossing angle (22 mrad) to allow fast separation of two beams in the ring-ring scheme. Crab cavities are required to recover the luminosity from geometric losses. Initial calculation shows that the frequency of the cavities for the ion beam is no more than 336MHz. In this paper, we discuss the crab cavity related lattice parameters for both ion and electron beams in ring-ring design, the frequency choice, and the cavity design considerations.

MOPB003 **A New High Resolution Optical System for Inspection of Gun- and Multi Cell Resonators in ISO 4 Cleanrooms**

Marco Schalwat, Ruediger Bandelmann, Alexej Daniel, Nicolay Krupka, Sven Thorsten Sievers (DESY, Hamburg)

Optical inspection of the inner surface of superconducting resonators was established during XFEL cavity production by usage of the so called OBACHT optical inspection. In addition to the surface inspection by OBACHT a new optical inspection system with integrated high resolution camera is set up at DESY. It allows inspection of multi-cell resonators as well as gun cavity resonators with only single side accessibility to the inner surface. A prototype was commissioned and optical inspections done with OBACHT and the new system in parallel. Two SRF - gun cavities were inspected by this optical system and origin of limitations of the resonators were identified.

MOPB004 **Design of a RF Quadrupole Resonator for Landau Damping in HL-LHC**

Kai Papke, Alexej Grudiev (CERN, Geneva)

The design and optimization of a quadrupole resonator for transverse Landau damping in the High Luminosity Large Hadron Collider (HL-LHC) is presented. Two different cavity types are considered whose shape is determined by quadrupolar strength, surface peak fields, and beam coupling impedance. The lower order and higher order mode (LOM and HOM) spectra of the optimized cavities are investigated and different approaches for their damping are proposed. Along an example, the required RF power and optimal external quality factor for the input coupler is derived.

MOPB005 **Beam Dynamics Simulations for the New Superconducting CW Heavy Ion LINAC at GSI**

Malte Schwarz, Markus Basten, Marco Busch, Holger Podlech, Rudolf Tiede (IAP, Frankfurt am Main), Manuel Heilmann, Sascha Mickat (GSI, Darmstadt), Winfried A. Barth (GSI, Darmstadt; HIM, Mainz; MEPhI, Moscow), Stepan Yaramyshev (GSI, Darmstadt; MEPhI, Moscow), Florian Dirk Dziuba, Viktor Gettmann, Maksym Miski-Oglu (HIM, Mainz), Kurt Aulenbacher (HIM, Mainz; IKP, Mainz)

For future experiments with heavy ions at the coulomb barrier within the SHE (super-heavy elements) research project, a multi-stage R&D program of GSI, HIM and IAP is currently under progress. It aims at developing a superconducting (sc) continuous wave (cw) LINAC with multicell constant-beta CH-type DTL-cavities as key components. Transverse focusing is provided by sc solenoids. The aim is an efficient accelerator for ions with a mass-to-charge-ratio of up to 6 and with a variable kinetic energy between 3.5 and 7.3 MeV/u. The next milestone will be a full performance test of the first LINAC section (Demonstrator) with beam after an accomplished performance test showed very promising results. In addition, as intermediate step towards the full LINAC an intermediate layout is planned. The corresponding beam dynamics studies will be presented.

MOPB006 **Numerical Stimulation and Primary Design of XFEL for CAEP**

Yuhuan Dou, Yan Li, Xiaojian Shu (Institute of Applied Physics and Computational Mathematics)

A x-ray free-electron laser(XFEL) facility is based on RF superconducting accelerator at China Academy of Engineering Physics (CAEP) has been planed. The facility will be designed in a radiation range of 0.3~4 angstrom and the electron beam energy will be 12GeV. The main work focuses on the optimization of different schemes through physical analysis such as the wiggler peak field strength and electron beam energy selected. A detailed simulation of start up and statistical properties of the radiation from a SASE FEL operating has been performed by 3D time dependent FEL code.

MOPB007 **Design of the Superconducting Quarter Wave Resonators for HIAF**

Cong Zhang, Yuan He, Yongming Li, Shenghu Zhang, Hongwei Zhao (IMP/CAS, Lanzhou)

A heavy ion accelerator facility (HIAF) is under development in the Institute of Modern Physics. For the low energy superconducting accelerating section, two types of quarter wave resonators with frequency of 81.25 MHz and β of 0.05 and 0.10 have been proposed. The electro-magnetic design has been optimized in order to reach the high accelerating voltage, and the optimization also included the drift tube face tilting to compensate for the beam steering caused by the asymmetry in the quarter wave resonator geometry.

MOPB008 **Input Power Coupler for NICA Injector Coaxial Quater Wave SC Cavity**

Michael Vladimirovich Lalayan, Tatyana Bakhareva, Mariya Gusarova, Sergey Victorovich Matsievskiy (MEPhI, Moscow)

New coaxial power coupler research and development results are presented and discussed. Coupler is proposed for superconducting QWR cavities being under consideration now as option for planned Nuclotron-based Ion Collider fAcility (NICA) injector upgrade. The goal was to develop power coupler operating at 325 MHz and feeding SC cavity with about 20 kW RF power. It provides Qext tuning range (1.5-3)E5 by inner conductor movement. Conservative design with two identical disk ceramic windows was chosen. Electrodynamic, thermal and mechanical simulations were carried out.

MOPB009 **Progress of 650 MHz SRF Cavity for eRHIC SRF Linac**

Wencan Xu, Ilan Ben-Zvi, Philipp Kolb, Gary McIntyre, Richard Porqueddu, Kevin S. Smith, Ferdinand J. Willeke, Alex Zaltsman (BNL, Upton, Long Island, New York), Yongfeng Gao (PKU, Beijing)

eRHIC ERL SRF requires 160 5-cell 650 MHz SRF cavities. The 650 MHz cavity has been designed and two prototypes have been fabricated, one Cu cavity for HOM study and one Nb cavity for cavity performance study. This paper will describe cavity design and the progress of prototyping.

MOPB010 **Design and Fabrication of the 2×4-cell Superconducting Linac Module for at CAEP**

Xing Luo, Cheng-long Lao, Kui Zhou (CAEP/IAE, Mianyang, Sichuan)

A 2×4-cell superconducting linac module for the THz-FEL facility has been developed at CAEP in China, which is expected to provide 6~8 MeV quasi-CW electron beams with the average current of 1~5 mA. The module consists of two 4-cell SRF cavities, two main couplers, two tuners and the cryostat. The design, fabrication and performance test of these components is presented in this paper. The test results reveal that all these components have reached their designed goals and the module has also finished its assembling and horizontal test at Chengdu. The gradients of both cavities at 2 K state reach 10 MV/m, which have met our requirements. Further beam-loading commissioning is underway.

MOPB011 **CEA Cryomodules Design for SARAF Phase 2**

Catherine Madec (CEA, Gif-sur-Yvette), Bernard Gastineau (CEA/DSM/IRFU,), Nicolas Bazin, Robin Cubizolles, Guillaume Ferrand, Nicolas Pichoff (CEA/IRFU, Gif-sur-Yvette)

CEA is committed to delivering a Medium Energy Beam Transfer line and a superconducting linac (SCL) for SARAF accelerator in order to accelerate 5mA beam of either protons from 1.3 MeV to 35 MeV or deuterons from 2.6 MeV to 40.1 MeV. The SCL consists in 4 cryomodules separated by warm diagnostics housing beam diagnostics. The first two identical cryomodules host 6 half-wave resonator (HWR) low beta cavities (beta = 0.091), 176 MHz. The last two identical cryomodules are equipped with 7 HWR high-beta cavities (beta = 0.181), 176 MHz. The beam is focused through superconducting solenoids located between cavities housing steering coils. A Beam Position Monitor is placed upstream each solenoid. A diagnostic box containing a beam profiler and a vacuum pump will be placed at the end of each cryomodule. The cryomodules and the warm sections are being designed. These studies will be presented in this poster.

MOPB012 **Status of the IFMIF LIPAc SRF Linac**

Nicolas Bazin, Cyril Boulch, Anais Bruniquel, Pol Carbonnier, Janic Kevin Chambrillon, Guillaume Devanz, Fabien Eozénou, Philippe Hardy, Hassen Jenhani, Olivier Piquet, Juliette Plouin, Aline Riquelme, Dominique Roudier, Christophe Servouin (CEA/DRF/IRFU, Gif-sur-Yvette), Pascal Contrepois (CEA/DSM/IRFU,), Patrice Charon, Stéphane Chel, Gaël Disset, Luc Maurice, Johan Relland, Bertrand Renard (CEA/IRFU, Gif-sur-Yvette), David Regidor, Fernando Toral (CIEMAT, Madrid)

The IFMIF accelerator aims to provide an accelerator-based D-Li neutron source to produce high intensity high energy neutron flux to test samples as possible candidate materials to a full lifetime of fusion energy reactors. A prototype of the low energy part of the accelerator is under construction at Rokkasho in Japan. It includes one cryomodule containing 8 half-wave resonators (HWR) operating at 175 MHz and eight focusing solenoids. This paper presents the status of the IFMIF SRF Linac.

MOPB013 **European XFEL Main Input Coupler Experiences and Challenges in a Test Field**

Frank Hoffmann, Denis Kostin, Wolf-Dietrich Moeller, Detlef Reschke, Mateusz Wiencek (DESY, Hamburg)

102 European XFEL accelerating modules with 816 superconducting cavities and main input RF power couplers were assembled and then tested at DESY prior to installation in the European XFEL tunnel. In the Accelerating Module Test Facility (AMTF) warm and cold RF tests were done. The test results went directly to the operational setup for the LINAC. Main input couplers did present several problems during the tests, resulting in some minor coupler design changes as well as in a few repair actions. The experience got from the said testing operation is worth to be shared and is presented here together with a discussion.

MOPB014 **Non-conformance Reporting and Handling during Series Cavity Production for the European XFEL**

Jens Iversen, Jasper A. Dammann, Axel Matheisen, Detlef Reschke, Joern Schaffran, Waldemar Singer, Nicolai Steinhau-Kuehl, Jan-Hendrik Thie (DESY, Hamburg), Paolo Michelato, Laura Monaco (INFN/LASA, Segrate (MI))

For the European XFEL more than 800 superconducting cavities were fabricated and surface treated by the industry. As a result of the negotiations during the contracting phase between DESY/INFN Milano-LASA and the cavity vendor it was decided to place the order following the so-called "built-to-print" strategy. That means the production of the cavities as well as their surface treatment had to follow the specifications strictly. In the framework of Quality Assurance DESY/INFN Milano-LASA had to set up a Quality Management mechanism assuring that all delivered cavities fulfil the specification requirements on a very high level. In case of deviations from the specification during the fabrication, the companies had to report about non-conformances. Non-conformity reports were processed by using DESY's Engineering Data Management System (EDMS). We summarize statistically the number of non-conformances in relation to the reason of their occurrence and we describe the handling procedure of non-conformity reports between contractor and vendor.

MOPB015 **Accelerating Module Repair for the European XFEL Installation**

Elmar Vogel, Serena Barbanotti, Frank Hoffmann, Kay Jensch, Denis Kostin, Lutz Lilje, Wolf-Dietrich Moeller, Manuela Schmoekel, Mateusz Wiencek, Hans Weise (DESY, Hamburg), Stéphane Berry, Olivier Napoly (CEA/DSM/IRFU,), Michal Sienkiewicz, Jacek Swierblewski (IFJ-PAN, Kraków)

Repair actions of different extend has been performed at 61 modules of the 100 accelerating se-ries modules for the European XEFL to qualify them for the tunnel installation. Four modules could not be repaired in time. CEA Saclay managed to perform three major repairs in parallel to the se-ries module integration, the residual repair actions took place at DESY Hamburg. In this paper we will give an overview on the various technical problems which required being fixed before the tunnel installation and on the repair actions performed.

MOPB016 **Operation of Diamond Superconducting RF Cavities**

Pengda Gu (DLS, Oxfordshire)

The Diamond Light Source storage ring has been in operation using superconducting RF cavities since 2007. Diamond has four superconducting cavity modules with two usually installed at any one time. The four cavities perform differently in many aspects such as reliable operating parameters and time in service, with the longest in continuous service for 7 years without failure and the shortest failing after only 8 months. All Diamond superconducting RF cavities suffered many fast vacuum trips in their early years, but after many years of efforts, the performance of the cavities have now been effectively managed by weekly conditioning, partial warm-up during shut down and cavity voltage level control. We will discuss our experience with superconducting RF cavities and our future plan.

MOPB017 **Multiphysics Simulations of the Wide Opened Waveguide Crab-cavity**

Kai Papke, Alexej Grudiev, Carlo Zanoni (CERN, Geneva)

In the frame of a FCC study a first prototype of a compact superconducting crab-cavity, using Nb-on-Cu-coating technique is being manufactured and investigated. The design, which is based on the ridged waveguide resonator, is subjected to multipacting and pressure sensitivity simulations. First results of theses simulations are presented and compared to those of other SRF cavities. Furthermore, several aspects related to the design of the fundamental mode coupler and HOM dampers are presented.

MOPB018 **Testing of SRF Cavities and Cryomodules for the European Spallation Source**

Nuno Elias, Emilio Asensi Conejero, Christine Darve, Fredrik Hakansson, Wolfgang Hees, Cecilia Giovanna Maiano, Felix Schlander (ESS, Lund)

The European Spallation Source (ESS) is currently under construction in Lund, Sweden. The ESS linear accelerator aims to deliver a 62.5 mA , 2.86 ms long proton beam onto a rotating tungsten target, at 14 Hz repetition rate, thus achieving an energy of 2 GeV and 5 MW power. Most of the beam acceleration happens in the superconducting fraction of the linac, which is composed of three sectors of cryomodules named after the cavities housed within. The first sector of the SRF linac is composed of 13 Spoke cryomodules containing 2 double-spoke cavities with a geometric beta of 0.5, the second is composed of 9 medium beta cryomodules each housing four elliptical cavities (β=0.67) and finally 21 high beta cryomodules enclosing four elliptical cavities (β=0.86). ESS has strategically built up a SRF collaboration with other European institutions, these partners will deliver through In-Kind agreements cavities and cryomodules performing within the ESS specification. This article describes the process leading to the acceptance of cavities and cryomodules received from the different partners and the necessary testing required prior to the final installation in the ESS tunnel.

MOPB019 **Interface Challenges for the SRF Cryomodules for the European Spallation Source**

Felix Schlander, Christine Darve, Nuno Elias, Cecilia Giovanna Maiano (ESS, Lund), Pierre Bosland (CEA/DSM/IRFU,), Guillaume Olry (IPN, Orsay)

The European Spallation Source is currently under construction in Lund in southern Sweden. The main part of the accelerator will consist of two different types of cryomodules housing three different types of cavities ¿ double spoke cavities and two different elliptical cavities. The spoke cavities as well as the cryomodules will be provided by IPN Orsay, thus the external interfaces to the other accelerator systems have to be verified. While the procurement and assembly of the elliptical cryomodules will be performed by CEA Saclay, the cavities will be provided by INFN Milano and STFC Daresbury. Thus in addition to the external cryomodule interfaces, also the internal interfaces between cavities and cryomodules have to be taken care of. This contribution presents the challenges related to this work.

MOPB020 **An Optimal Procedure for Coupler Conditioning for ESS Superconducting Linac**

Rihua Zeng, Emilio Asensi Conejero, Cecilia Giovanna Maiano (ESS, Lund), Han Li (Uppsala University, Uppsala)

An optimal procedure for coupler and cavity conditioning is proposed for the ESS superconducting cavities, which is applicable for different test stands and following installation in the ESS tunnel. A preliminary procedure has been developed and successfully tested at FREIA facility, Uppsala. The preliminary procedure will now be improved by integrating it into LLRF and EPICS control. This will be a joint effort between FREIA and ESS and will be used at the test stands in Lund and on the couplers installed in the tunnel. Developing the conditioning procedures on a common platform offers ESS significant advantages by allowing the procedures to be reused at different sites and by recording data in a consistent format. The details of the procedure, its development and testing will be reported and the future activities will be described.

MOPB021 **LCLS-II Cryomodule Microphonics Study at FNAL**

Jeremiah Paul Holzbauer, Brian Edward Chase, Joshua Einstein, Benjamin Hansen, Elvin Robert Harms, Brian David Hartsell, Joseph Hurd, Joshua Kaluzny, Arkadiy L. Klebaner, Jerry Makara, Mike McGee, Yuriy M Orlov, Yuriy Pischalnikov, Warren Schappert, Richard Stanek, Renzhuo Wang (Fermilab, Batavia, Illinois)

LCLS-II is a CW, low-beam current, superconducting RF accelerator with very high cavity Q0, and thus has a very small design cavity bandwidth (16 Hz half width). This drove the specification for microphonics down to 10 Hz peak detuning. Testing of the first 1.3 GHz cryomodule for LCLS-II at Fermilab initially presented with significantly higher microphonics levels. An extensive effort was launched at Fermilab to diagnose and mitigate the observed microphonics. This effort includes a significant amount of cryomodule testing, including impulse/ground motion testing, cryogenic system modulation/modification, and system modeling. The results of these testing, along with cryomodule design modifications, and the microphonics improves achieved will be presented.

MOPB022 **Production Cryomodule Testing at Fermilab for LCLS-II**

Elvin Robert Harms, Mohamed H. Awida, Paolo Berrutti, Kermit Carlson, Saravan Kumar Chandrasekaran, Brian Edward Chase, Ed Cullerton, Joshua Einstein, Camille Ginsburg, Benjamin Hansen, Brian David Hartsell, Jeremiah Paul Holzbauer, Joshua Kaluzny, Timergali N. Khabiboulline, Michael Kucera, Jerry Leibfritz, Dave McDowell, Mike McGee, Dennis J. Nicklaus, James Patrick, Troy Petersen, Yuriy Pischalnikov, Peter Steven Prieto, John Reid, Warren Schappert, Nikolay Solyak, Richard Stanek, Ding Sun, Renzhuo Wang, Michael White, Genfa Wu (Fermilab, Batavia, Illinois)

A test stand dedicated to SRF cryomodule testing, CMTS1, is now in operation at Fermilab. This facility is currently configured to cold test 1.3 GHz cryomodules assembled at Fermilab for LCLS-II, a superconducting 4 GeV cw linac now under construction at the SLAC National Accelerator Laboratory. Testing of production series cryomodules is now in progress. Seventeen cryomodules are planned to be tested at this facility through 2018 at a rate of one cryomodule per month. We describe the demonstrated capabilities of CMTS1, summarize its commissioning, report on production activities to date, and survey future plans.

MOPB023 **Further Layout Investigations for a Superconducting CW-linac for Heavy Ions at GSI**

Winfried A. Barth (GSI, Darmstadt; HIM, Mainz; MEPhI, Moscow), Manuel Heilmann (GSI, Darmstadt), Stepan Yaramyshev (GSI, Darmstadt; MEPhI, Moscow), Florian Dirk Dziuba, Viktor Gettmann, Maksym Miski-Oglu (HIM, Mainz), Kurt Aulenbacher (HIM, Mainz; IKP, Mainz), Markus Basten, Holger Podlech, Malte Schwarz (IAP, Frankfurt am Main), Thorsten Kuerzeder (TU Darmstadt, Darmstadt)

Very compact accelerating-focusing structures, as well as short focusing periods, high accelerating gradients and very short drift spaces are strongly required for superconducting (sc) accelerator sections operating at low and medium beam energies. To keep the GSI-Super Heavy Element program competitive on a high level and even beyond, a standalone sc continuous wave Linac in combination with the GSI High Charge State injector, upgraded for cw-operation, is envisaged. The first LINAC section (financed by HIM and GSI) as a demonstration of the capability of 216 MHz multi gap Crossbar H-structures (CH) is still in the beam commissioning phase, while an accelerating gradient of 9.6 MV/m (4 K) at a sufficient quality factor has been already reached. Recently the overall Linac design, based on a standard cryomodule, comprising three CH cavities, a rebuncher section and two 9.3 T-solenoidal lenses, has to be fixed. This paper presents the status of the Linac layout studies as well as the integration in the GSI accelerator facility.

MOPB024 **Steps Towards Superconducting CW-Linac for Heavy Ions at GSI**

Maksym Miski-Oglu, Michael Amberg (HIM, Mainz), Viktor Gettmann, Manuel Heilmann (GSI, Darmstadt), Winfried A. Barth (GSI, Darmstadt; HIM, Mainz; MEPhI, Moscow), Stepan Yaramyshev (GSI, Darmstadt; MEPhI, Moscow), Kurt Aulenbacher (HIM, Mainz; IKP, Mainz), Markus Basten, Marco Busch, Holger Podlech, Malte Schwarz (IAP, Frankfurt am Main)

A superconducting (sc) cw-Linac at GSI should ensure competitive production of Super Heavies in the future. Further R&D for this cw-Linac, a so called ¿Advanced CW-Demonstrator¿, with maximal energy of 3.5 MeV/u is ongoing. As a first step, the demonstrator project with one sc CH-cavity is near its completion, the beam tests are scheduled for mid-summer 2017. The completion of the ¿Advanced CW-Demonstrator¿ includes successive construction of two new cryogenic modules comprising four CH-cavities and two solenoids each. In this contribution the layout of the cryomodules and the Helium distribution system are presented.

MOPB025 **Commissioning of Vacuum Furnace and First Successful Heat Treatment of SRF Bulk Nb Cavities at IPN Orsay**

Mohammed Fouaidy, Sebastien Blivet, Sébastien Bousson, Frederic Chatelet, Francois Galet, David Longuevergne, Richard Martret, Guillaume Olry, Thierry Pépin-Donat, Fetra Rabehasy, Ludovic Renard (IPN, Orsay)

A new vacuum furnace dedicated to High Temperature Heat Treatment under Vacuum (VH2T2) of SRF bulk Nb cavities was developed, and operated. This furnace will be used for interstitial hydrogen removal (10h00 @ 650 ℃) of ~26 spoke 352 MHz ESS cavities. We commissioned the furnace in May 2016: all the measured parameters of the intrinsic performances (i.e. residual pressure, thermal performance) are better than the specified values. Prior to applying VH2T2 to SRF cavities various qualification tests were performed on several samples: RRR, SIMS analysis, mechanical and thermal properties at cryogenic temperature (as received samples vs. VH2T2 samples). After the successful qualification, we performed VH2T2 at 650 ℃ on various Nb SRF cavities (i.e 1.3 GHz elliptical resonators and 352 MHHz spoke resonators). All these heat treatment were successful. Furthermore, we have started studies on Nitrogen doping: tests were performed on samples and cavities. In this paper we will report and discuss the following topics: 1) furnace commissioning and analysis of qualification tests on samples, 2) Analysis of RF experimental data of VH2T2 cavities), 3) First results on N-doping process.

MOPB026 **Numerical Analysis on Electron Equation for 3-D Free-electron Laser**

Yan Li, Yuhuan Dou (Institute of Applied Physics and Computational Mathematics,)

Numerical simulation is the important means of studying physical mechanism for free-electron laser(FEL). Electron energy and phase equations are basic parts of FEL equations. These equations are commonly solved by Runge-Lutta fourth order formula which is robust and valid. It is an explicit scheme, so the step size is rigid by inherent instability. The other method is Bulirsch-Stoer integration, its step size is adapitive and is suited for big grads situation. We have analyzed difference of two methods by several numerical examples and obtained some data results.

MOPB027 **The Layout and Progress of the PAPS SRF Facility**

Feisi He, Feng Bing, Jin Dai, Tong-Ming Huang, Song Jin, Zhongquan Li, Haiying Lin, Baiqi Liu, Zhenchao Liu, Qiang Ma, Fanbo Meng, Zheng Hui Mi, Weimin Pan, Xiaohua Peng, Peng Sha, Qunyao Wang, Jiyuan Zhai, Pei Zhang, Xinying Zhang, TongXian Zhao, Hongjuan Zheng (IHEP, Beijing)

IHEP is preparing for the construction of a new 6 GeV synchrotron light source in Beijing, which is called HEPS (high energy photon source), and it is supposed to start late 2018. At the same time, IHEP is designing a 100 km, 240 GeV circular electron-positron collider (CEPC) as a Higgs factory. To realize these two projects, as well as many other future large superconducting accelerator projects in China and worldwide, it is mandatory to build a large-scale and well-functioned SRF R&D and production facility in an early stage. Recently the Beijing local government decided to fund IHEP to build a large SRF facility (4500 m2) as part of the PAPS (Platform of Advanced Photon Source technology R&D) project. The SRF facility will be built from May 2017 to the end of 2019, which is aimed at processing and testing of several hundreds of SRF cavities and couplers, and assembly and testing of about 20 cryomodules per year. The facility is composed of vertical test stand, horizontal test stand, coupler conditioning stand, clean room, post-processing facilities, and vacuum system, etc. The layout of the facility, as well as the construction progress will be addressed.

MOPB028 **Hom Coupler Design for CEPC Cavities**

Hongjuan Zheng, Fanbo Meng, Jiyuan Zhai (IHEP, Beijing)

In this paper，it will be presented the higher order mode (HOM) coupler design for the Circular Electron-Positron Collider (CEPC) 650 MHz cavities. The higher order modes excited by the intense beam bunches must be damped to avoid additional cryogenic loss and multi-bunch instabilities. To keep the beam stable, the impedance budget and the HOM damping requirement are given. A double notch coaxial HOM coupler, which will be mounted on the beam pipe, is planned to extract the HOM power below the cut-off frequency of the beam pipe.

MOPB029 **Design of a 325 MHz RF Power Input Coupler for CIADS**

Tiancai Jiang, Long Chen, Yuan He, Yongming Li, Ruoxu Wang, Shenghu Zhang (IMP/CAS, Lanzhou)

The China Initiative Accelerator Driver System will be build to Huizhou in China. The faciltiy will consist of a superconducting linac which will contain a SRF Spoke cavities section with its associated high power RF coupler. The RF coupler have to provide 70 kW power to the cavities at 325 MHz. Studies and preliminary design of the CIADS Spoke cavity power coupler are presented.

MOPB030 **Design and Test Result of Double Spoke Superconductiong Cavity at IMP**

Tiancai Jiang, Yuan He, Chunlong Li, Yongming Li, Lubei Liu, Andong Wu, Pingran Xiong, Weiming Yue, Shenghu Zhang (IMP/CAS, Lanzhou)

The China Initiative Accelerator Drver System (CIADS) will build a CW 600 MeV superconducting proton linac. A superconducting double spoke cavity (operating frequency 325 MHz, $\beta_0=0.52$) has been designed and tested at the Institute of Modern Physics. In this paper, we present the RF design, the mechanical design, the chemistry and testing of the fisrt double spoke prototype cavity.

MOPB031 **Fabrication and Cold Test Result of FRIB Beta=0.53 Pre-Production Cryomodule**

Hiroyuki Ao, Brian Bird, Nathan Bultman, Earle Burkhardt, Fabio Casagrande, Chris Compton, Kelly Douglas Davidson, Kyle Elliott, Andrei Ganshyn, Ian Grender, Walter Hartung, Leslie Hodges, Samuel J. Miller, Dan Morris, John Thomas Popielarski, Laura Popielarski, Marc Reaume, Kenji Saito, Mark Shuptar, Sergey Stark, John Wenstrom, Mengxin Xu, Ting Xu, Zhihong Zheng (FRIB, East Lansing), Ian Michael Malloch (FRIB, East Lansing, Michigan), Alberto Facco (INFN/LNL, Legnaro (PD))

The driver linac for the Facility for Rare Isotope Beams (FRIB) comprises four kinds of cavities ($\beta=0.041$, 0.085, 0.29, and 0.53) and six types of cryomodules including matching modules. FRIB has completed the fabrication and the cold test of a $\beta=0.53$ pre-production cryomodule, which is the first prototype for a half-wave ($\beta=0.29$ and 0.53) cavity. This paper describes the fabrication and the cold test result of the $\beta=0.53$ pre-production cryomodule including lessons learned.

MOPB032 **The Solenoide Current Leads of FRIB**

Mengxin Xu, Hiroyuki Ao, Brian Bird, Peter Ostroumov, Marc Reaume, Sergey Stark, Bryan Tousignant (FRIB, East Lansing), Nathan Bultman, Chris Compton, Walter Hartung, Samuel J. Miller, John Thomas Popielarski, Laura Popielarski, Kenji Saito, Mark Shuptar, Jie Wei, Ting Xu, Ying Xu, Yoshishige Yamazaki, Zhihong Zheng (FRIB, East Lansing, Michigan)

The total 48 cryomodule are developing for the Facility for Rare Ion Beams (FRIB). The vapour-cooled current leads have adopted to carry 260A currents to the superconducting solenoid in Cryomodule. There are total 71 current leads needed for all Cryomodule. In this paper we present the design consideration, fabrication and testing for the current lead.

MOPB033 **Instrumentation for FRIB Cryomodule at MSU**

Mengxin Xu, Hiroyuki Ao, Brian Bird, Peter Ostroumov, Sergey Stark, Bryan Tousignant, Ting Xu (FRIB, East Lansing), Nathan Bultman, Chris Compton, Walter Hartung, Samuel J. Miller, John Thomas Popielarski, Laura Popielarski, Kenji Saito, Mark Shuptar, Jie Wei, Yoshishige Yamazaki, Zhihong Zheng (FRIB, East Lansing, Michigan)

The 200 MeV/u superconducting heavy ion accelerator is under constructed at Michigan State University, which is named the Facility for Rare Ion Beams (FRIB). There are 6 types, 48 cryomodule in the FRIB driver linac. The 2K, 4K and 40K helium cooling system were included in the cryomodule. The instrumentation system was used for monitoring and protecting the cyomodule during operation. In this paper we present the design, integration and testing for the instrumentation.

MOPB034 **Selection of the Type of Accelerating Structures for the Second Group of Cavity SC Linac Nuclotron-NICA**

Mariya Gusarova, Dmitriy Surkov (MEPhI, Moscow)

The paper presents the rationale for choosing the type of accelerating resonators for the second section of the SC linac Nuclotron-NICA. A comparative analysis of the electrodynamic characteristics of the accelerating structures and a technological justification for the choice are carried out.

MOPB035 **Cryogenic Probe Station at Old Dominion University Center for Accelerator Science**

Junki Makita, Jean Roger Delayen, Alexander Gurevich (ODU, Norfolk, Virginia), Gianluigi Ciovati (JLab, Newport News, Virginia)

With a growing effort in research and development of an alternative material to bulk Nb for a superconducting radiofrequency (SRF) cavity, it is important to have a cost effective method to benchmark new materials of choice. At Old Dominion University's Center for Accelerator Science, a cryogenic probe station (CPS) will be used to measure the response of superconductor samples under RF fields. The setup consists of a closed-cycle refrigerator for cooling a sample wafer to a cryogenic temperature, a superconducting magnet providing a field parallel to the sample, and DC probes in addition to RF probes. The RF probes will extract a quality factor from a sample patterned in a coplanar waveguide resonator structure on a 2 ¿ wafer. From the measured quality factor, the surface resistance and the penetration depth as a function of temperature and magnetic field will be calculated. This paper will discuss the design and measurement procedures of the current CPS setup.

MOPB036 **The Study of Deposition Method of Nb3Sn Film on Cu Substrate**

Li Xiao, Xiangyang Lu, Weiwei Tan, Datao Xie, Deyu Yang, Yujia Yang, Ziqin Yang, Jifei Zhao (PKU, Beijing)

Our work is mainly focused on the fabrication methods of Nb3Sn films on Cu substrates and film ¿s properties. There are diffraction peaks of Nb3Sn in the X-ray diffraction patterns in which without diffraction peaks of copper compounds. Scanning electron microstructures of Nb3Sn film reflect its nice compactness and binding force between film and substrate.

MOPB037 **The Status of the 2x4-cell Superconducting Linac Module for the CAEP FEL-THz Facility**

Kui Zhou (PKU, Beijing), Cheng-long Lao, Ming Li, Xing Luo, L.J. Shan, Xuming Shen, Hanbin Wang, Xingfan Yang (CAEP/IAE, Mianyang, Sichuan)

The high average power THz radiation (FEL-THz) facility is now developed in China Academy of Engineering Physics (CAEP). The superconducting accelerator is one of the most important components for this facility, which contains two 4-Cell TESLA superconducting radio frequency (SRF) cavities. The designed electron energy gained is 6-8 MeV, with the field gradient of 10-12 MV/m. This paper will present the construction, commissioning, cryogenic test and operation conditions of the 2x4-cell superconducting linac module. Under cryogenic temperatures, the cryomodule works smoothly and stably. At 2K state, the effective field gradients of both cavities have achieved 10 MV/m. So far, the debugging of this facility has made significant progress with the support of the superconducting linac module.

MOPB038 **Progress and Challenges from Production of Nitrogen-doped 9-Cell Cavities for LCLS-II**

Daniel Gonnella, Andrew Burrill, Marc Christopher Ross (SLAC, Menlo Park, California), Sebastian Aderhold, Anna Grassellino, Chuck Grimm, Timergali N. Khabiboulline, Oleksandr Stepanovych Melnychuk, Sam Posen, Dmitri A. Sergatskov (Fermilab, Batavia, Illinois), Edward Daly, Kirk Davis, Frank Marhauser, Ari Deibert Palczewski, Katherine M. Wilson (JLab, Newport News, Virginia)

The Linac Coherent Light Source II (LCLS-II) requires 280 1.3 GHz 9-Cell Niobium SRF cavities operating at 16 MV/m with an intrinsic quality factor of 2.7e10. In order to meet this ambitious goal, nitrogen-doping is being used as a cavity preparation method. Two cavity vendors, Research Instruments GmbH and Ettore Zanon S.p.a are being used to produce the cavities. Here we report on the latest cavity performance results in vertical test. We discuss issues that have arisen during production, such as the need to change the cavity preparation recipe in order to meet the project ¿s specifications. We show that nitrogen-doping has been successfully transferred to the cavity vendors and that good results are now consistently achieved.

MOPB039 **LCLS-II High Power RF Systems Overview and Progress**

Anahid Dian Yeremian, Chris Adolphsen, Andrew Haase, Christopher Dennis Nantista (SLAC, Menlo Park, California)

A second X-ray free electron laser facility, LCLS-II, is being constructed at SLAC. LCLS-II is based on a 1.3 GHz, 4 GeV, continuous-wave (CW) superconducting linear accelerator, to be installed in the first kilometer of the SLAC tunnel. Multiple types of high power RF (HPRF) sources will be used to power different systems on LCLS II. The main 1.3 GHz linac will be powered by 280 1.3 GHz, 3.8 kW solid state amplifier (SSA) sources. The normal conducting buncher in the injector will use four more such SSAs. Two 185.7 MHz, 60 kW sources will power the photocathode dual-feed RF gun. A third harmonic linac section, included for linearizing the bunch energy spread before the first bunch compressor, will require sixteen 3.9 GHz sources at about 1 kW CW. The sources are based on solid state amplifier technology and RF transport systems are under slightly positive pressure to keep them clean. The non-ionizing radiation protection system utilizes this fact in the personnel safety scenario. Many of the systems have already been designed and are in procurement. Others are rather mature in the design phase. The progress of LCLSII L- and S-band HPRF systems is the subject of this paper.

MOPB040 **ESS High Beta Cavity Test Preparations at Daresbury Laboratory**

Paul Anthony Smith, Louis Bizel-Bizellot, Keith Dumbell, Mike Ellis, Philippe Goudket, Andrew Moss, Emilian Florian Palade, Shrikant Pattalwar, Mark David Pendleton, Alan Wheelhouse (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire)

Science and Technology Facility Council is responsible for supplying, and testing 84 High beta elliptical SRF cavities, as part of the UK In Kind Contribution to the European Spallation Source (ESS). The High-β=0.86, cavities have been designed by CEA- Saclay and are a five cell Niobium cavity operating at 704.42 MHz. They are required to provide an

accelerating gradient of 19.9 MV/m at an unloaded Q of 5x10^9. Preparations are underway to upgrade the cryogenic and RF facilities at Daresbury laboratory prior to the arrival of the first cavities. As part of these arrangements, a niobium coaxial resonator has been manufactured, to validate the test facility. The design considerations, for the coaxial resonator are presented, along with preliminary results. The RF measurement system to perform the cavity conditioning and testing is also presented.

MOPB041 **Status of the SOLEIL Superconducting RF System**

Massamba Diop (SOLEIL, Gif-sur-Yvette)

The 352 MHz SOLEIL SRF systems consist in two cryomodules, each containing a pair of SC Nb/Cu cavities, cooled with LHe at 4K from a single 350 W cryogenic plant. In order to store 500 mA, a power of 575 kW and an accelerating voltage of 3-4 MV are required. The RF power is provided by 4 SSPA's delivering up to 180 kW each. The original cavity input power couplers, which are LEP-type antennas designed to handle up to 200 kW, are being replaced by upgraded versions, able to operate at 300 kW CW. This will open the possibility to operate at full beam current with only one active cryomodule. The SRF system operational experience over the past ten years as well as the different upgrades will be reported here.

MOPB042 **The TRIUMF/VECC Injector Cryomodule Performance**

Yanyun Ma, Ken Fong, Tobias Junginger, David Kishi, Alexey Nikolaevich Koveshnikov, Robert Edward Laxdal, Norman Muller, Douglas W Storey, Edward Thoeng, Zhongyuan Yao, Vladimir Zvyagintsev (TRIUMF, Vancouver)

The combined R&D efforts for rare ion beam facilities ARIEL (Advanced Rare IsotopE Laboratory) and ANURIB (Advanced National facility for Unstable and Rare Isotope Beams) have resulted in production of a superconducting Injector Cryomodule (VECC ICM) in TRIUMF for VECC. The cryomodule design utilizes a unique box cryomodule with a top-loading cold mass. The hermetic unit consists of a niobium cavity which operating at 1.3GHz and connected with 2 symmetrically opposed couplers which can deliver 100kW RF power to beam. Liquid helium supplied at 4.4 K is converted to superfluid helium-II through a cryogenic insert on board which includes 4 K phase separator, 4 K / 2 K heat exchanger and Joule-Thompson valve. In 2016, the VECC ICM has been tested in TRIUMF. The design and commissioning results of VECC ICM are presented in this paper.

MOPB043 **Pansophy, a JLAB SRF Engineering Data Management System, Supporting Data Collection, Retrieval and Analysis Utilized by LCLS-II**

Valerie Bookwalter, Michael Dickey, Megan Glory Salvador (JLab, Newport News, Virginia), Anne McEwen (JLab, Newport News, Virgina)

Pansophy is an Engineering Data Management System that provides a comprehensive solution for managing information in the production and testing of cryomodules. It is especially suited to supporting the Data & Quality Management Systems for large projects like LCLS-II. With extensive amounts of data collected for an individual project, data retrieval to facilitate feedback and enhancement of production and processing activities is a high priority. The priority shares importance with the needs of managing the project, including production status, NCR, and Quality Management reports. Recent Pansophy enhancements have been to Data and Quality management reports and statistical analysis. Such enhancements include a database driven menu system, extended MSWord macro and preprocessing of travelers, and an extensive reporting system. The reporting system allows managers and group leaders to quickly respond to the needs of the project in areas of cavity and cryomodule production, data collection, NCR, Quality Management and schedule. Extensions include integration with the SRF inventory system PRIMeS, allowing traceability from receiving of manufactured parts to final cryomodule product.

MOPB044 **Magnetic Hygiene Control on LCLS-II Cryomodules Fabricated at JLab**

Gary Guangfeng Cheng, Edward Daly, Kirk Davis, John Fischer, Naeem Abdul Huque, Robert Legg, HyeKyoung Park, Katherine M. Wilson, Liang Zhao (JLab, Newport News, Virginia)

Jefferson Lab (JLab) is in collaboration with Fermi National Accelerator Laboratory (Fermi Lab) to build 18 cryomodules to install at the SLAC National Accelerator Laboratory's tunnel as part of the Linac Coherent Light Source upgrade project (LCLS-II). Each LCLS-II cryomodule hosts 8 superconducting niobium cavities that adopt the nitrogen doping technique, which aims to enhance the cavity quality factor Qo to reduce the consumption of liquid helium used to cool down the cavities. It is known that the Qo of niobium cavities is affected by cavity surface magnetic field. Traditionally, magnetic shields made of high magnetic permeability mu-metals are employed as a passive shielding of the ambient magnetic fluxes. During the LCLS-II cryomodule development, magnetic hygiene control that includes magnetic shielding and demagnetization of parts and the whole-machine is implemented. JLab has worked closely with Fermi Lab on developing magnetic hygiene control procedures, identifying relevant tools, investigating causes of magnetization, magnetic field monitoring, etc. This paper focuses on JLab's experiences with LCLS-II cryomodule magnetic hygiene control during its fabrication.

MOPB045 **JLab New Injector Cryomodule Design, Fabrication and Testing**

Gary Guangfeng Cheng, Michael Allen Drury, John Fischer, Kurt Macha, Haipeng Wang (JLab, Newport News, Virginia)

A new Injector Cryomodule (INJ CM) aimed to replace the existing Quarter Cryomodule in the CEBAF tunnel has been developed at Jefferson Lab (JLab). It is scheduled to be first tested in the Cryomodule Test Facility (CMTF) for module performance then the Upgraded Injector Test Facility (UITF) with electron beam. This new cryomodule, hosting a 2-cell and 7-cell cavity, is designed to boost the electron energy from 200 keV to 5 MeV and permit 380 mA ¿ 1.0 mA of beam current. The 2-cell cavity is a new design whereas the 7-cell cavity is refurbished from a low loss cavity from the retired JLab Renascence Cryomodule. The INJ CM adopts quite a few designs from the JLab 12 GeV Upgrade Cryomodule (C100). Examples of this include having the cold mass hung from a spaceframe structure by use of axial and transverse Nitronic rods, cavities to be tuned by scissor-jack style tuners and the end cans are actually modified from C100 style end cans. However, this new INJ CM is not a quarter of the C100 Cryomodule. This paper focuses on the major design features, fabrication and alignment process and testing of the module and its components.

MOPB046 **LCLS-II Cryomodule Production at JLAB**

Robert Legg, Gary Guangfeng Cheng, Edward Daly, Kirk Davis, Michael Allen Drury, John Fischer, Tommy Hiatt, Naeem Abdul Huque, Larry King, Joseph P. Preble, Anthony Reilly, Mircea Stirbet, Katherine M. Wilson (JLab, Newport News, Virginia)

The LCLS-II cryomodule construction program leverages the mature XFEL cryomodule design to produce technologically sophisticated cryomodules with a minimum of R&D according to an accelerated manufacturing schedule. Jlab, as one of the partner labs, is producing 18 cryomodules for LCLS-II. To meet the quality and schedule demands of LCLS-II, many upgrades to the JLAB cryomodule assembly infrastructure and techniques have been made. JLab has installed a new cleanroom for string assembly and instituted new protocols to minimize particulate transfer into the cavities during the cryomodule construction process. JLab has also instituted a set of magnetic hygiene protocols to be used during the assembly process to minimize magnetic field impingement on the finished cavity structure. The goal has been to have gradients, both maximum and field emission onset, that do not degrade between the cavity vertical test and final cryomodule qualification, while maximizing the Q0 of each finished cavity. Results from the prototype and first production cryomodule assembly are presented.

MOPB047 **Statistical Analysis of Quality Control Data for the Industrial Fabrication of LCLS-II Cavities**

Frank Marhauser, Edward Daly, Ari Deibert Palczewski, Katherine M. Wilson (JLab, Newport News, Virginia), Chuck Grimm (Fermilab, Batavia, Illinois), Andrew Burrill, Daniel Gonnella (SLAC, Menlo Park, California)

The LCLS-II cavity mass fabrication by industry is nearing completion. We report on experience gained throughout production so far concerning mechanical fabrication and post-processing comprising statistics for more than 150 cavities.

MOPB048 **LCLS-II 9-Cell Cavity Procurement Update: Current Status and Select Contract Modifications**

Ari Deibert Palczewski, Edward Daly, Jarrod Allen Fitzpatrick, Frank Marhauser, Charles E. Reece, Katherine M. Wilson (JLab, Newport News, Virginia)

Cavity mass production for the LCLS-II 4 GeV CM SRF LINAC has started. A quantity of 266 accelerating cavities has been ordered from two industrial vendors: RI Research Instruments GmbH in Germany and Ettore Zanon S.p.a. in Italy. Jefferson Laboratory leads the cavity procurement activities for the project and has successfully transferred the Nitrogen-Doping process to the industrial partners in the initial phase, which is now being applied to the production cavities. Multiple modification and R&D during the first half of production was performed to maximize the Qo and gradient because of unforeseen technical issues. We report on the current vendor status and an overview and logic behind the R&D and contract modifications to date.

MOPB049 **Upgraded Cavities for the CEBAF Cryomodule Rework Program**

Robert Rimmer, Gianluigi Ciovati, William Clemens, Kirk Davis, Jim Follkie, Daniel Forehand, Fredrik Fors, James Henry, Frank Marhauser, Larry Turlington (JLab, Newport News, Virginia)

The CEBAF cryomodule rework program has been a successful tool to recover and maintain the energy reach of the original baseline 6 GeV accelerator. The weakest original modules with eight five-cell cavities assembled in four ¿pairs¿, with a specification when new of 20 MV per cryomodule (5 MV/m), are disassembled, re-cleaned with modern techniques and re-qualified to at least 50 MV (12.5 MV/m), (leading to the acronym ¿C50¿). The cost per recovered MV is much less than building new modules. However over time the stock of weak modules is being used up and the voltage gain per rework cycle is diminishing. In an attempt to increase the gain per cycle it is proposed to rework the cavities by replacing the original accelerating cells with new ones of an improved shape and better material. The original CEBAF HOM and FPC end groups are retained. The goal is to achieve up to 75 MV (18.75 MV/m) for the reworked module (¿C75¿). We report on the fabrication experience and test results of the first trial pair, containing two such reworked cavities.

MOPB050 **Cavity Processing and Testing Activities at Jefferson Lab for LCLS-II Production**

Liang Zhao, Kirk Davis, Ari Deibert Palczewski, Anthony Reilly (JLab, Newport News, Virginia)

Cryomodule production for LCLS-II is well underway at Jefferson Lab. This paper explains the process flow for production cavities, from being received at the Test Lab to being assembled onto cavity strings. Taking our facility and infrastructure into consideration, process optimization and process control are implemented to ensure high quality products.

MOPB051 **Simulation Study on Higher Order Mode Damping in the Energy Recovery Linac Cavity for eRHIC**

Sang-Hoon Kim (ANL, Argonne, Illinois)

The eRHIC ERL cavity, 650 MHz 5-cell elliptical cavity, is designed to operate with total 0.5 A circulating beams. In this cavity, the higher order mode (HOM) damping is necessary to suppress beam break instability and also to avoid undesirable heating. The original idea to damp HOMs is based on double-ridge waveguide HOM couplers. Based on simulations on the HOM impedances, we are proposing use of additional beam pipe HOM absorbers in between SRF cavities or cryomodules. Also, we will discuss a feasibility of using only beam pipe HOM absorbers with flared beam pipes.

MOPB052 **Dual-ridge Waveguide Load Design for eRHIC**

Philipp Kolb, Yongfeng Gao, Kevin S. Smith, Chen Xu, Wencan Xu, Alex Zaltsman (BNL, Upton, Long Island, New York)

To increase the real estate gradient in the eRHIC electron accelerator waveguide HOM couplers are being considered. These significantly reduce the length of individual cavities and address inter-cavity trapped modes, allowing for an increased number of cavities per cryomodule, which would increase the real estate gradient. The choice of waveguide went to a dual ridge waveguide due to a smaller size compared to rectangular waveguides. The waveguide termination, to convert the RF energy into thermal energy, is a custom designed load based on a silicon carbide dielectric that is already being used in beamline absorbers. Simulations of the RF properties of the load are presented as well as first measurements on a prototype.

MOPB053 **RF Energy Harvesting of HOM Power**

Chen Xu, Ilan Ben-Zvi, Qiong Wu (BNL, Upton, Long Island, New York)

In an accelerator cavity, Higher Order Modes (HOM) are generated by the current of the beam. The HOM power can reach tens of kilowatts in a high current accelerator, depending on the details of the beam and cavity design. In this report, we propose a novel RF harvesting system to recover the HOM power into DC power which can further used for various purposes such as driving a solid state or klystron RF amplifier to supply fundamental RF power at other frequencies, charge batteries etc. The efficiency would be a product of the energy recovery and regeneration efficiencies, where the state of art is 90%. The proposed HOM power recycling system contains a multiple band harmonic RF coupler, broadband RF antenna system, a high power rectifier diode circuit and a DC load.

MOPB054 **Development of Fundamental Power Coupler for High Intensity Heavy-ion Accelerator**

Feng Bing, Tong-Ming Huang, Qiang Ma, Fanbo Meng, Weimin Pan (IHEP, Beijing), Kuixiang Gu (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences, Beijing)

A single warm window coaxial coupler has been designed for further development of high intensity heavy-ion accelerator. The coupler is designed to handle at 100kW in CW mode and is being fabricated at present. T-bend transition and doorknob have been took into account. The length of the T-bend short circuit is sensitive to S parameters and contributes to the online adjusting of VSWR in RF conditioning. The doorknob type is adopted to realize the transition from a half-height WR2300 waveguide to a coaxial line ended with a coupling antenna. This paper describes the relative RF design, thermal stress and heat load analysis as well as multipacting simulation.

MOPB055 **Acceptance and Validation Tests of the IFMIF Series Power Couplers**

Hassen Jenhani, Nicolas Bazin, Cyril Boulch, Pol Carbonnier, Guillaume Devanz, Gaël Disset, Philippe Hardy (CEA/IRFU, Gif-sur-Yvette), David Regidor (CIEMAT, Madrid)

The IFMIF accelerator aims to provide an accelerator based D-Li neutron source to produce high intensity and energy neutron flux for testing of candidate materials for use in fusion energy reactors. It consists of two high power CW accelerator drivers, each delivering a 125 mA deuteron beam at 40 MeV. A Linear IFMIF Prototype Accelerator (LIPAc) is presently under construction for the first phase of the project. Eight power couplers are manufactured to equip the Cryomodule of LIPAc. They will be RF conditioned at 100 kW in CW and SW mode. Some issues was encountered during the manufacturing stage. They were overcome by performing slight changes in the design, reviewing the manufacturing process and adding acceptance tests and controls. After being received at CEA the couplers are then cleaned and sent to CIEMAT for their RF conditioning. Manufacturing issues, acceptance tests and validation test results will be presented in this paper.

MOPB056 **Design of 100 kW CW Main Coupler for Elliptical 650 MHz Superconducting Cavities**

Sergey Kazakov, Oleg Pronitchev (Fermilab, Batavia, Illinois)

Design of 100 kW CW main coupler for elliptical 650 MHz superconducting cavities is reported. Main results of electrical, multipactor and thermal simulations are presented.Design of test stand for coupler testing is covered as well.

MOPB057 **Design of 162.5 MHZ RFQ Coupler with O-rings and Aluminum Diamond Seals**

Sergey Kazakov, Oleg Pronitchev (Fermilab, Batavia, Illinois)

Designs of ceramic unit of RF window with Viton O-rings and aluminum diamond seals for 162.5 MHz RFQ coupler are reported.This approach allows to avoid most difficult and expensive operation of brazing ceramics to metal.It makes ceramics replaceable and will reduce the price of the RF window unit.Thermal testing of ceramic disks sealed with Al diamond seals are presented.

MOPB058 **Tuner for 3.9 GHz SRF Cavities Tuner for LCLS II Project**

Yuriy Pischalnikov, Jeremiah Paul Holzbauer, Warren Schappert, Jae-Chul Yun (Fermilab, Batavia, Illinois)

Fermilab is responsible for the design of the 3.9GHz cryomodule for LCLS-II that will operate in continuous wave (CW) mode. In the tuner design, the slow tuner-mechanism slim blade tuner was adopted, which was originated by INFN for the European XFEL 3.9GHz cavities. The bandwidth of the SRF cavities for LCLS II will be in the range of 130Hz and fine/fast tuning of the cavity frequency required. A fast/fine tuner made with 2 encapsulated piezos was also added to the design. The first prototype tuner has been built and installed on the dressed cavity. As part of the Tuner Design Verification program first tuner prototype was installed on the dressed cavity and tested at the FNAL¿s Horizontal Test Stand. Summary of the tests are presented in this paper.

MOPB059 **Design and Test of Compact Tuner for Narrow Bandwidth 650 MHz SRF Cavities**

Yuriy Pischalnikov, Evgueni Borissov, Ivan V. Gonin, Jeremiah Paul Holzbauer, Vikas Jain, Timergali N. Khabiboulline, Warren Schappert, Jae-Chul Yun (Fermilab, Batavia, Illinois)

The design of the compact tuner for 650 MHz 5-cell elliptical SRF cavity will be presented. This compact tuner is designed for PIP-II project. The same tuner will work for several types of 650MHz cavities with quite different stiffness, ranging from 4kN/mm to 20kN/mm. The major design features include: double lever mechanism, highly reliable active components (electromechanical actuators and piezo-actuators), and the ability to replace tuner active components through designated ports in the cryomodule vacuum vessel. Results of tuner testing (warm) will also be presented.

MOPB060 **Overview of Test Results of LCLS-II Power Coupler in Cryomodules**

Nikolay Solyak, Elvin Robert Harms, Sergey Kazakov, Ken Premo, Oleg Prokofiev, Genfa Wu (Fermilab, Batavia, Illinois)

LCLS-II a superconducting 4 GeV cw linac now under construction at the SLAC National Accelerator Laboratory. All cryomodules are being built and tested at partner labs; JLAB and Fermilab. First preproduction cryomodule tested at cryomodule test stand (CMTS1) at Fermilab, was equipped with extra diagnostics allow to study the performances of the cavity and auxiliaries in cw operation in more details, than it is possible for production CM. In this paper we report on test results for main main and HOM couplers, and comparison with simulations.

MOPB061 **Quality Control of Copper Plating in STF2 Input Power Couplers**

Eiji Kako, Ryuichi Ueki (KEK, Ibaraki), Kazunori Okihira, Katsuya Sennyu (MHI, Hiroshima), Kutsuna Hiroaki, Junji Taguchi (Nomura Plating Co, Ltd., Osaka), Futoshi Saito, Hiroaki Umezawa (Tokyo Denkai Co., Ltd., Tokyo), Katsuhiko Tetsuka (Toshiba Electron Tubes & Devices Co., Ltd (TETD), Tochigi), Osamu Yushiro (Toshiba Electron Tubes & Devices Co., Ltd, Tokyo)

Purity of thin copper plating using in input power couplers for superconducting cavities is one of important characteristics for considering thermal losses at low temperature. Various samples of thin copper plating on stainless sheets was fabricated by three companies with their own plating techniques. The RRR values of the samples with different thickness of copper plating were compared in the condition before and after heat treatment at 800oC in a brazing furnace. Deterioration of the RRR was observed in all of samples after heat treatment. The results of the RRR measurements and sample analysis of impurities will be reported in this paper.

MOPB062 **Development of HOM Absorbers for CW Superconducting Cavities in Energy Recovery Linac**

Tomoko Ota, Atsushi Miyamoto, Kiyokazu Sato, Masahiro Takasaki, Masahiro Yamada (Toshiba, Yokohama), Eiji Kako, Taro Konomi, Hiroshi Sakai, Kensei Umemori (KEK, Ibaraki), Masaru Sawamura (QST, Tokai)

Higher Order Modes (HOM) absorbers for superconducting cavities have been developing at TOSHIBA in collaboration with High Energy Accelerator Research Organization (KEK) since 2015. Prototype HOM absorbers for 1.3 GHz 9-cell

superconducting cavity were fabricated. An AlN lossy dielectrics cylinder was brazed with a copper cylinder, and the cool-down tests by nitrogen gas was carried out. Copper cylinders and SUS flanges were joined by electron beam welding to fabricate a whole prototype HOM absorber. Fabrication process of the prototype HOM absorber will be presented in this paper.

MOPB063 **Fundamental Studies for the STF-type Power Coupler for ILC**

Yasuchika Yamamoto, Eiji Kako, Toshihiro Matsumoto, Shinichiro Michizono, Akira Yamamoto (KEK, Ibaraki), Masao Irikura, Makoto Ishibashi, Hiroto Yasutake (Toshiba Electron Tubes & Devices Co., Ltd (TETD), Tochigi)

From the view point of mass-production for the power coupler in ILC, the fundamental studies for the STF-type power coupler are under progress by the collaboration between KEK and TETD. At present, there are various rinsing procedures for power coupler in the world-wide laboratories. In this R&D, the main topic is to investigate the various rinsing effects in the copper plating and the ceramic through the high power test. In this paper, the first results will be presented.

MOPB064 **High Power Test for Plug-compatible STF-type Power Coupler for ILC**

Yasuchika Yamamoto, Eiji Kako, Toshihiro Matsumoto, Shinichiro Michizono, Akira Yamamoto (KEK, Ibaraki), Charles Julie, Eric Montesinos (CERN, Geneva)

From the view point of plug-compatibility for the power coupler in the ILC, recommended by Linear Collider Collaboration in 2013, new STF-type power couplers with 40mm of input port diameter were re-designed, fabricated and successfully high-power-tested. Moreover, from the view point of the cost reduction for the ILC, another type of power couplers with TiN coating-free ceramic were also fabricated and high-power-tested by the collaboration between CERN and KEK. In this paper, the detailed results for the both power couplers will be presented.

MOPB065 **Development of Hybrid Superconducting Photocathodes on Niobium**

Mark Warren, John Zasadzinski (IIT, Chicago, Illinois), Wei Gai, Jiahang Shao, Eric Edson Wisniewski (ANL, Argonne, Illinois), Zikri Yusof (Illinois Institute of Technology, Chicago, Illinois)

High power, low emittance electron beams require superconducting RF photoinjectors, typically made of pure Nb, and a superconducting photocathode is desired. However, superconductivity and high photocathode quantum efficiency (QE) are not compatible, e.g. QE for pure Nb is only 10-5 at 260 nm wavelength. Here is presented the current status of the development of hybrid superconducting photocathodes by the deposition of thin films of a high QE metal or semiconductor on Nb. Nb plugs coated with 10-100 nm of Mg have been tested for adhesion and dark current under RF fields as high as 60MV/m. QE measurements show significant enhancements over Nb. In another test, ultra thin films of the high QE material Cs2Te deposited on Nb are reported. Using the standard deposition procedure, QE ~12% is found for films ~ 200Å. As the thickness is reduced QE maintains a high value ~ 6% for films as thin as 2.0 nm. These results are quite promising for future superconducting photocathodes.

MOPB066 **Development of 81.25 MHz 20 kW SSPA for RAON Accelerator**

Oh Ryong Choi, Hyojae Jang, Do Yoon Lee, Ki Taek Son (IBS, Daejeon)

A heavy ion accelerator, RAON is under development in Daejeon, Korea by Rare Isotope Science Project (RISP). In this accelerator, 81.25 MHz Radio Frequency Quadrupole (RFQ) will be used for the acceleration of various ions from several tens of keV/u to about half MeV/u. For this system two 80 kW RF power sources are planned and RISP will develop them with a solid state power amplifier (SSPA) architecture. As a first step, a 20 kW SSPA was developed and its performance was tested. In this presentation the current status of developed SSPA and its test results will be presented

MOPB067 **Development of RF Power Coupler for Half Wave Resonator in RISP**

Sangbeen Lee, Junwoo Lee, Ilkyoung Shin (IBS, Daejeon)

The RF power couplers for half wave resonators(HWR) have been developed in Rare Isotope Science Project. Design studies and changes for the 2nd prototype HWR RF coupler are presented.

MOPB068 **Development of 4-way 81.25 MHz 20 kW High Power Combiner Using Parallel Plate Structure**

Ki Taek Son, Oh Ryong Choi, Hyojae Jang, Do Yoon Lee (IBS, Daejeon)

The recent development of semiconductor technology has proved that solid-state RF amplifier is a quite effective alternative high power RF source for numerous accelerator applications. To develop a high power SSPA system, high power combiner is required to combine the RF power from a lot of solid-state RF module. The parallel plate RF power combiner, which is designed to combine various high power modules, is developed for RAON(Rare the rare isotope accelerator complex for on-line experiment). In this presentation, the status of developed 81.25 MHz 20 kW power combiner will be described.

MOPB069 **A High Power Input Coupler for CEPC Main Ring Cavity**

Tong-Ming Huang, Qiang Ma, Jiyuan Zhai (IHEP, Beijing), Kuixiang Gu (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences, Beijing)

The main ring cavities of CEPC project are two-cell elliptical superconducting cavities operating at 650 MHz in CW mode. Each cavity equipped with one high power input coupler and each coupler has to deliver at least 300 kW of CW RF power to the beam. A variable coupling from 2E5 to 4E6 is required to meet different operation modes. As the cavities working with high quality factor up to 2E10, the coupler assembled with cavity in class 10 clean room is strongly recommended to keep the cavity from contamination. It ¿s a big challenge to design a high power input coupler fulfilling the above requirements simultaneously. In this paper, a preliminary design of the input coupler for CEPC main ring cavity is presented.

MOPB070 **The Improvement of the Power Coupler for C-ADS SC Spoke Cavities**

Tong-Ming Huang, Xu Chen, Haiying Lin, Qiang Ma, Fanbo Meng, Weimin Pan, Guangwei Wang (IHEP, Beijing), Kuixiang Gu (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences, Beijing)

Fourteen beta=0.12 superconducting spoke cavities mounted in two cryo-modules (CM1 and CM2) were installed in the C-ADS Injector-I, a test facility of 10 mA, 10 MeV CW proton linac. Each cavity was equipped with one 10 kW fundamental power coupler (FPC). In accordance to the progress of construction and technical difficulties, the commissioning of spoke cavities was carried out in several steps. Firstly, two spoke cavities with two FPCs were installed in a test cryo-module (TCM). Fatal window crack was observed during the TCM commissioning. A series of experiments were subsequently implemented and eventually attributed the window crack to electron bombardment from cavity field emission. The assembly procedure of the FPCs for CM1 cavities was thus optimized in order to reduce cavity contamination, along with a completely new FPC design for CM2 cavities. This paper will describe the mechanism of the coupler window damage by cavity field emission and the cure. In addition, the performances of FPCs for TCM, CM1 and CM2 were compared.

MOPB071 **The Study and Design of HOM Absorber for CEPC 650MHz Cavity**

Fanbo Meng (IHEP, Beijing)

Due to the beam property, the CEPC 650MHz cavity has a broadband HOM spectrum, which is nearly upto 20GHz. The broadband HOM absorber is needed to suppress the HOM power above 1.5GHz, which will propagate through the beam tube. For deep suppression of HOM power, the exploration of broadband microwave absorbing materials and the optimization between RF and mechanical structure is both impotant to enhance the performance of HOM absorber. In this paper, it has been presented that the recent study of absorbing material and the preliminary design of the HOM absorber for 650MHz cavity.

MOPB072 **The Setup of A Novel Room-temperature Test-Stand and Its System for Couplers of SC-cavities**

Long Chen (IMP/CAS, Lanzhou)

RF power conditioning is an effective way to suppress multipacting in fundamental mode power couplers. Room temperature test-stand conditioning is an essential step that can be hardly circumvented before couplers are installed on SC cavities. Based on our original one, a new test-stand has been designed and being assembled at IMP. It can work as a multi-task platform conditioning different couplers, including couplers for HWR010 cavities and HWR015 cavities. It is also featured with the capacity to flexibly change β according to different specifications. A variety of conditioning modes have been incorporated into the LLRF system, including frequency sweeping mode, amplitude sweeping mode, arbitrary-duty-cycle mode and triangle-wave mode. In addition, smartly-conditioning has been achieved because of the accomplishment of smart interlocks and automatic reset in the system.

MOPB073 **Progress of the Control Systems for the ADS Injector II**

Qiangjun Wu, Haitao Liu (IMP/CAS, Lanzhou)

EPICS is used for the control system of the ADS injector as the upper control platform and further system development by the means of its CCS (control system studio). The upper level application system includes the human-machine interface, the alarm system and the data record and archive, etc. and the hardware architecture includes the operator station, central server, network, the front-end control computer and the device interfaces. The primary task of the control system consists of the control of the device, the data storage and machine protection, in which the machine protection includes the millisecond level protection based on PLC and the fast protection system based on FPGA to provide remote operation interface and the guarantee of the reliable and stable operation for the accelerator. The Accelerator filing system is used for real-time data acquisition in the accelerator runtime state in order to record the device situation and the command of the operator, to support the detailed information for commissioning and system maintain and make things convenient for the troubleshooting and data analysis.

MOPB074 **Analysis of Higher Order Mode Effects on the Operation of the CIADS Superconducting Linear Accelerator**

Cong Zhang, Yuan He, Shenghu Zhang (IMP/CAS, Lanzhou)

The influence of the higher order modes on the beam dynamics and the cryogenic losses has been studied for the superconducting section of the CIADS project in this paper. In addition, the necessity of HOM dampers in the Superconducting (SC) cavities is discussed.

MOPB075 **Quench Protection in Power Supplies for Superconducting Magnets in Chinese ADS**

Jiang Zhao, Shuai Zhang, Zhongzu Zhou (IMP/CAS, Lanzhou)

The front-end demo superconducting Linac for Chinese ADS (Accelerator Driven Sub-critical System) project is under construction at institute of modern physics(IMP) in Lanzhou. It will demonstrate the key technologies and the feasibility of a high power beam for the future national project " the Chinese Initiative Accelerator Driven Subcritical System(CIADS)". In this system, there are about 60 superconducting magnets, including solenoids, vertical correction and horizontal correction. They are utilized to focus and correct the proton beam. Quench protection of the superconducting magnets is key to reliability of the facility. A full digital power supply is developed and employed as excitation source for all of these superconducting magnets. In this paper, an FPGA-based quench protection plan implemented in the power supplies is mainly described. The commissioning results show that it is feasible.

MOPB076 **Analysis of the Production, Installation and Commissioning of the European-XFEL Frequency Tuners**

Rocco Paparella, Angelo Bosotti (INFN/LASA, Segrate (MI)), Catherine Madec (CEA, Gif-sur-Yvette), Olivier Napoly (CEA/DSM/IRFU,), Thierry Trublet (CEA/IRFU, Gif-sur-Yvette), Clemens Albrecht, Serena Barbanotti, Julien Branlard, Mariusz Krzysztof Grecki, Kay Jensch, Lutz Lilje (DESY, Hamburg)

In the European-XFEL superconducting linac, mechanical frequency tuners equipped with stepper motors and piezoelectric actuators provide cold tuning of each of the 768 1.3 GHz cavities. More than 820 complete tuning systems were fabricated and pre-assembled in industry, tested at several stages before and after assembly and successfully commissioned during cryo-module cold tests at AMTF (DESY). Quality control strategy adopted to preserve the well-assessed tuner reliability through such a large-scale industrial production is critically reviewed and the lessons learned are presented in this paper. The statistical analysis of the large set of data acquired up to the recent commissioning of the entire linac is then summarized.

MOPB077 **Operational Experience of the European-XFEL 3.9 GHz Coaxial Tuners**

Rocco Paparella, Angelo Bosotti, Daniele Sertore (INFN/LASA, Segrate (MI)), Paolo Pierini (DESY, Hamburg), Cecilia Giovanna Maiano (ESS, Lund)

The European-XFEL injector hosts a third-harmonic section composed by a module with eigth 3.9 GHz cavities equipped with a coaxial frequency tuner inspired by INFN-LASA Blade Tuner design. The 3.9 GHz tuning system met specifications during all the injector runs in 2016 up to the recent commissioning of the entire linac; it matched the required tuning range and frequency sensitivity although higher than expected cavity detuning was experienced during pressure transients in the cryogenic system. An analysis of all collected experimental data is reported in this paper together with the strategy developed to provide a sound and effective retuning routine to the control room operator.

MOPB078 **RF Coupler Design and Studies for LUCRECE Project**

Hayg Guler, Didier Auguste, Julien Bonis, Mohamed El Khaldi, Walid Kaabi, Pierre Lepercq (LAL, Orsay)

The LUCRECE project aims at developing an elementary RF system (cavity, power source, LLRF and controls) suitable for continuous (CW) operation at 1.3 GHz. This effort is made in the framework of the advanced and compact FEL project LUNEX5 (free electron Laser Using a New accelerator for the Exploitation of X-ray radiation of 5th generation), using superconducting linac technology for high repetition rate and multi-user operation (http://www.lunex5.com). In this context, based on its large experience on coupler design and RF conditioning, LAL Laboratory is in charge of the design and the fabrication of RF couplers that could operate at up to 15-20 kW in CW mode. For this purpose, couplers based on CORNELL 65kW CW couplers (RF power couplers for the Cornell ERL injector) are under consideration and will be adapted to the LUCRECE needs. Electromagnetic simulations and associated thermal heating will be discussed. Methods to decrease the thermal impact will be considered.

MOPB079 **HOM Coupler Alterations for the LHC DQW Crab Cavity**

James Alexander Mitchell (Lancaster University, Lancaster), Binping Xiao (BNL, Upton, Long Island, New York), Rama Calaga (CERN, Geneva), Graeme Burt (Cockcroft Institute, Lancaster)

As part of the High Luminosity Large Hadron Collider (HL-LHC) project, 16 crab cavities are to be installed into the LHC in 2025. The two crab cavity designs are the Double Quarter Wave (DQW) and Radio Frequency Dipole (RFD). Preliminary beam tests in the Super Proton Synchrotron (SPS) are planned for both cavity types with the DQW scheduled for testing in 2018. In reference to to Higher Order Mode (HOM) damping, the DQW has three identical on-cell HOM

couplers. These HOM couplers provide a stop-band response at the frequency of the fundamental mode and act as a high-pass filter for the HOMs. For the SPS cavity design several geometric constraints exist. These give rise to dimensional limitations which in turn impose limitations on the RF performance of the HOM couplers. As such, for the LHC assembly, the HOM coupler design has been re-visited to take into account the reduced limitations, hence allowing the feasibility of an increased RF performance to be investigated. In addition to the RF performance, several geometric alterations have been incorporated to ease manufacturing processes, tolerances and costs.

MOPB080 **The Stable Operation of MPG and Measurement of Output Current Energy Spectrum**

Boting Li, Xiangyang Lu, Weiwei Tan, Li Xiao, Deyu Yang, Yujia Yang, Ziqin Yang, Jifei Zhao (PKU, Beijing)

The concept of micro-pulse electron gun(MPG) was proposed decades ago. It can provide electron beam with high current, short pulse and low emittance. But it is still not put into practical use as electron source because of its unsteady operating state. This paper presents an experimental result of the steady running of MPG which can operate stably for more than ten hours. The energy spread of the electron beam is also measured, the peak is located at near 20eV and half width is less than 15eV .

MOPB081 **Study on New Micro-pulse Electron Gun Which Adapted to High Voltage Accelerating Platform**

Deyu Yang, Boting Li, Xiangyang Lu, Weiwei Tan, Li Xiao, Yujia Yang, Ziqin Yang, Jifei Zhao, Kui Zhou (PKU, Beijing)

Micro-pulse electron gun(MPG) is a novel electron source which can produce narrow pulse, high repetition rate electron current. Theoretical and experiment works have been done to study physical properties and steady operating conditions of MPG. Proof-of-principle work has been finished and the next work is to research the parameters of the MPG electron beam and master the MPG work property deeply. Therefore,three different shapes cavity was compared in this article. what's more, cold test and primary experiment of new MPG were finished in addition to simulation and mechanical designs. And also high voltage accelerating platform which can supply 100KV direct voltage was designed.

MOPB082 **A Preliminary Scheme for X-ray Emission Based on Micro-pulse Electron Gun**

Yujia Yang, Weiwei Tan, Li Xiao, Deyu Yang, Ziqin Yang, Jifei Zhao (PKU, Beijing)

X-ray is now widely used in many areas of physics, biology, chemistry and materials. And how to achieve emission, monochrome, and focusing of x-ray is of great significance to study. Micro-pulse electron gun (MPG) is a new type of electron source, with characteristics of high repetition frequency, short-pulse and low cost. Generating x-ray with better monochromaticity is one of the potential applications of MPG. And a preliminary scheme of X-ray based on MPG is proposed in this paper. The scheme is designed by comparing different anode materials, the thickness of beryllium window, filters made of different metals and zone plates. The simulation results based on the software MCNP5 show that the proposed scheme can effectively improve the monotonicity of the generated X-rays.

MOPB083 **Development of 352.2 MHz and 704 MHz Power Coupler Window for R&D Purpose**

Serge Sierra, Philippe Denis, Florian Geslin (TED, Velizy-Villacoublay), Sylvain Brault, Marin Chabot, Patxi Duthil, Jean Lesrel, Denis Reynet (IPN, Orsay), Christophe Lievin (TED, Velizy)

IPNO and Thales are conducting Fondamental Power Couplers (FPC) research and development. This paper presents new window designs that fulfills European Spallation Source (ESS) requirements (400 kW RF peak power) at 352.2 MHz. It also presents the development done for a 704.4 MHz window for FPC which full fill the requirements for the FPC of the MYRRHA project. We present in this paper the result of simulations needed to design these coupler windows The electromagnetic, thermal and thermomechanical simulations were performed with Ansys. The multipacting simulations were performed with Musicc3D, software developed by IPNO.

MOPB084 **Manufacturing Status of LCLSII Fundamental Power Couplers**

Serge Sierra, Isabelle Yao Leclerc (TED, Velizy-Villacoublay), Michael Knaak, Michael Pekeler, Lucas Zweibaeumer (RI Research Instruments GmbH, Bergisch Gladbach), Geraldine Garcin, Gilles Vignette (TED, Thonon), Christophe Lievin (TED, Velizy)

Thales and RI research Instrument are working on the manufacturing and assembly of the Fundamental Power Couplers for the LCLSII project. This paper will remind the characteristics of these couplers. It describes the main challenges which have been overcome principally on the Warm Internal conductor, with a thickness of copper of 150 μm. The paper describes the results obtained on the prototype phase and the full production activity with the delivery curve along the project. The paper propose also some way to be optimized for a future mass production of such components based on the lesson learned of the manufacturing of this kind of FPC during the XFEL and LCLSII projects.

MOPB085 **Development of a RF Conditioning Test Bench of Fundamental Power Couplers at 704 MHz in the Frame ESS Project**

Serge Sierra, Youness Amal, Isabelle Yao Leclerc (TED, Velizy-Villacoublay), Jose De_Oliveira, Laurent Julien Nennig

(GERAC Thales, Le Barp), Christophe Lievin (TED, Velizy)
In order to perform the RF conditioning of the fundamental coupler at 704 MHz for the ESS project, Thales and GERAC are developing a test bench being able to make the RF conditioning of these FPC. The status of the development of the test bench is described in this paper.It will include the description of the HV modulator, the klystron which will be used and the overall RF network. This test bench will be installed at CEA center in Saclay. The paper will also describe the first results obtained at the date of presentation.

MOPB086 **First Results of the SaTHoRI Tests**
Olivier Piquet, Nicolas Bazin, Pol Carbonnier, Janic Kevin Chambrillon, Michel Desmons, Guillaume Devanz, Hassen Jenhani, Juliette Plouin, Yannick Sauce, Christophe Servouin, Nicolas Solenne (CEA/DRF/IRFU, Gif-sur-Yvette), Pascal Contrepois, Olivier Meunier, Patrick Sahuquet (CEA/DSM/IRFU,), Stéphane Chel, Jean Francois Denis, Luc Maurice, Johan Relland (CEA/IRFU, Gif-sur-Yvette), Purificación Méndez, Iván Moya (CIEMAT, Madrid), Dominique Gex, Antti Jokinen, Guy Phillips (F4E,), Philippe Cara (Fusion for Energy, Garching)
The SaTHoRI test stand (Satellite de Tests Horizontal des Résonateurs IFMIF) aims to characterize a jacketed and fully dressed cavity with its coupler and tuner. A dedicated test cryostat has been manufactured and is connected to an existing horizontal test cryostat which provides the cryogenic coolant. A RF source ¿ provided by the IFMIF collaboration, one of the four RF sources which will be used for the cryomodule at Rokkasho ¿ has been installed and commissioned at CEA. This paper describes the test stand and presents the first results.

MOPB087 **Frequency Tuner Development and Testing at Cornell for the RAON Half Wave Resonator**
Mingqi Ge, Fumio Furuta, Terri Gruber, Scott Hartman, Matthias Liepe, Tim O'Connell, Philip James Pamel, James Sears, Vadim Veshcherevich (Cornell University (CLASSE), Ithaca, New York), Jongdae Joo, Juwan Kim, WooKang Kim, Junwoo Lee, Ilkyoung Shin (IBS, Daejeon)
The half-wave-resonators (HWRs) for the RAON project require a slow frequency tuner that can provide >80 kHz tuning range. Cornell University is currently in the process of designing, prototyping, and testing this HWR tuner. In this paper, we present the optimized tuner design, prototype fabrication, test insert preparation, and cryogenic test results. The performance of the tuner is analyzed in detail.

MOPB088 **Experiences on Insitu Module Repairs and Set Up of non XFEL Cavity Strings at DESY**
Manuela Schmoekel, Alexej Daniel, Nicolay Krupka, Steven Saegebarth, Marco Schalwat, Patrick Schilling (DESY, Hamburg)
All components installed to the European XFEL cavity string modules underwent an intensive inspection and quality control before acceptance for installation to cavities or modules. Even though some RF feed throughs for HOM coupler- and Pick Up antennas showed leaks at the ceramic insulation after module test at 2 K. Due to time restriction and continuity of production the exchange of these parts needed to be done without reentering the cleanroom. Successful repair of these modules took place by setting up a local cleanroom onto the cavity string. In collaboration with HZDR, a cavity string for the ELBE project was assembled at DESY and transported to HZDR for installation to the vacuum vessel. A spare module with 3.9 GHz Resonators for the European XFEL was set up at DESY and will be tested and qualified for the European XFEL. Due to delay in delivery of the power couplers, four power couplers were installed after string assembly.

MOPB089 **Effects of Temperature and Mechanical Strain on Magnetic Shielding Material for HL-LHC Crab Cavities**
Konrad Eiler, Marco Carlo Luigi Buzio, Ofelia Capatina, Stefanie Langeslag (CERN, Geneva), Alessandro Parrella (IT, Lisboa), Niklas Templeton (STFC/DL, Daresbury, Warrington, Cheshire)
To guarantee optimum performance, the crab cavities for the high-luminosity upgrade of CERN's LHC need to be shielded from external magnetic fields. Consequently, they will be enclosed by two layers of magnetic shielding, of which the inner is immersed in superfluid helium at 2 K. A Ni-based high-permeability material with a tailored composition and a designated heat treatment is applied. Its magnetic properties at cryogenic temperature are however not yet fully assessed. Especially the effect of deformation on magnetic properties has not been thoroughly investigated, however strain effects may have severe consequences. A magnetic measurement set-up has been developed, and the magnetic permeability at room temperature and at cryogenic temperatures is evaluated, showing that the maximum relative permeability at 4 K exceeds the design criteria of 100,000. Measurements of the magnetic permeability after introduction of uniaxial plastic deformation between 0% and 3% are conducted by means of an Epstein frame. Results show that deformation induces significant decrease of the magnetic performance, underlining that particular care must be taken during all stages of handling and operation.

MOPB090 **Sub-micro-Tesla Magnetic Shielding Design for Cryomodules in the High-gradient Program at CERN**
Sotirios Papadopoulos, Luca Dassa, Frank Gerigk, Suitbert Ramberger (CERN, Geneva), Julien Dequaire (Intitek, Lyon)

In the framework of the High-Gradient R&D program at CERN a cryomodule, consisting of four superconducting 5-cell cavities, has been designed. In order to reduce flux trapping in the surface of the superconductor and to minimize Q degradation during a quench, high efficiency magnetic shielding is needed. The solution proposed includes cold and warm passive shielding enhanced by four compensating coils. In this paper the magneto-static simulation results are presented illustrating different design considerations that led to a final design. Important parameters as the magnetic properties of the vacuum vessel and the shielding ability of a highly-permeable mu-metal shield are investigated experimentally through ambient magnetic field measurements.

MOPB091 **Design and Development of the SSR1 Cryomodule for the PIP II Project at Fermilab**

Vincent Roger, Sergey Cheban, Thomas H. Nicol, Yuriy M Orlov, Mattia Parise, Donato Passarelli, Leonardo Ristori (Fermilab, Batavia, Illinois), Vikas Jain [on leave] (Fermilab, Batavia, Illinois; RRCAT, Indore (M.P.))

This paper reports the current design status of the Single Spoke Resonator 1 (SSR1) cryomodule developed in the framework of PIP-II project at Fermilab. The most recent results of finite element analyses and calculations that were performed to optimize the thermal shields, the piping system, and the vacuum vessel are presented. Also, the assembling plan and tooling used to build the cryomodule from the cavity string assembly up to the final cryomodule assembly are described.

MOPB092 **Status of Resonance Control R&D Program at FNAL**

Warren Schappert, Jeremiah Paul Holzbauer, Yuriy Pischalnikov (Fermilab, Batavia, Illinois)

FNAL has participated in the development and construction of several large accelerator projects. Future machines will have the relatively low beam current and high quality factors. It is means that these cavities will be operated with small RF bandwidths, meaning that they will be sensitive to microphonics. Some machine, like LCLS-II, will work in CW-mode. The FNAL ꞔs PIP-II project calls for a SRF pulsed proton driver linac to support the expanding neutrino physics program including DUNE/LBNF. The 20 Hz pulsed operational structure and the use of four different, complex SRF narrow bandwidth cavity geometries means that resonance control will be extremely challenging. Work is ongoing at FNAL to develop active resonance stabilization techniques using fast piezoelectric tuners in support of PIP-II and LCLS-II. These techniques as well as testing and development results using a 9-cell elliptical cavity and low-beta single-spoke cavity will be presented along with an outlook for future efforts.

MOPB093 **Conduction Cooling of SRF Cavities: Development and Recent Results**

Jayakar Charles Tobin Thangaraj, Charlie A. Cooper, Michael Ito Geelhoed, Robert Kephart, Thomas K. Kroc, Oleg Prokofiev (Fermilab, Batavia, Illinois), Roman Andreevich Kostin (Euclid TechLabs, LLC, Solon, Ohio)

Fermilab is designing a compact a high power SRF-based electron linac for industrial applications. A unique feature of this accelerator is that it employs cryogen-free conduction cooling instead of the traditional liquid helium cryogenic system. In this work, we present results from development of this conduction cooling system. We present measurements of the thermal conductivity of high purity Aluminum conduction paths as well as the contact resistance of representative Al to Nb thermal joints. We also present results on a new technique using dissimilar metal stud welding to Nb cavities to make thermal attachments and COMSOL simulation of conduction cooled SRF cavities. We compare simulations to actual measurement obtained with a 4K cryocooler.. These results are key to using conduction cooling as an alternative to cool SRF cavities in both industrial and science accelerators.

MOPB094 **Commissioning of a Superconducting CW Heavy Ion Linac at GSI**

Viktor Gettmann, Manuel Heilmann, Maksym Miski-Oglu, Stepan Yaramyshev (GSI, Darmstadt), Winfried A. Barth (GSI, Darmstadt; HIM, Mainz; MEPhI, Moscow), Florian Dirk Dziuba, Thorsten Kuerzeder (HIM, Mainz), Kurt Aulenbacher (HIM, Mainz; IKP, Mainz), Markus Basten, Holger Podlech (IAP, Frankfurt am Main)

The cw - Linac - demonstrator is a prototype of the first section of the proposed cw-LINAC@GSI, comprising a superconducting CH-cavity embedded by two superconducting solenoids. The sc CH-structure is the key component and offers a variety of research and development. The beam focusing solenoids provide maximum fields of 9.3 T at an overall length of 380 mm and a free beam aperture of 30 mm. The magnetic induction at the fringe is minimized to 50 mT at the inner NbTi-surface of the neighboring cavity. The fabrication of the key components is finished, as well as the cold performance testing of the RF cavity. The cryostat is ready for assembling and the test environment is completely prepared. After successful testing of the RF-Power coupler, the components will be assembled to the suspended frame under cleanroom conditions. Alignment, assembly, under cleanroom condition issues will be presented.

MOPB095 **Building the Third SRF Gun at HZDR**

Petr Murcek, Andre Arnold, Pengnan Lu, Jochen Teichert, Hannes Vennekate, Rong Xiang (HZDR, Dresden)

The multipurpose CW accelerator ELBE at HZDR which is delivering a large set of secondary beams, is driven by a thermionic DC injector. In order to enhance the machine ꞔs beam quality, the development of superconducting RF injector has been pursued since the early 2000ies. The corresponding ELBE SRF Gun I of 2007 and Gun II of 2014 already delivered beam for the operation of several user beamlines, such as the FEL, positron generation, and THz facility. Currently, the next version ¿Gun III ¿and its cryomodule are being assembled, characterized, and prepared for the final commissioning throughout late 2017/early 2018. The new module benefits from the experiences in terms of operation made with the two predecessors. Results of the latest Gun II operations as well as first commissioning data of the Gun III module will be presented.

MOPB096 **Estimation of Alignment Error by Measuring Higher-order-mode of Injector Superconducting Cavity at KEK-cERL**

Yosuke Honda, Eiji Kako, Taro Konomi, Tsukasa Miyajima, Takashi Obina, Hiroshi Sakai, Kensei Umemori (KEK, Ibaraki)

Precise alignment of accelerator cavities is important in realizing a low emittance beam.Especially in the cases of superconducting cavities installed in a cryomodule,it is difficult to mechanically measure the position of the cavities. By measuring higher-order-modes (HOM) excited by a beam, the electrical center of the cavities can be estimated. We have developed a HOM measurement system for the injector superconducting accelerator cavities of KEK ERL test accelerator (cERL).Comparing the HOM signals of the three independent cavities in the cryomodule, we estimated the relative positioning errors of the three cavities.

MOPB097 **Degradation and Recovery of Cavity Performances in Compact-ERL Injector Cryomodule**

Eiji Kako, Taro Konomi, Takako Miura, Hiroshi Sakai, Kensei Umemori (KEK, Ibaraki)

Injector cryomodule for cERL consists of three 2-cell cavities equipped with double-feeds input couplers, five antenna-type HOM couplers and a slide-jack tuner with two piezo actuators. After cryomodule assembly and first cool-down tests in 2012, the cERL injector cryomodule has been stably operated with beam for four years. Gradual increases of x-ray radiation levels due to field emission were observed during long term beam operation. High power pulsed RF conditioning as a cure method was applied in the cool-down period in 2016 and 2017, so that degraded cavity performances have almost recovered up to the original levels. Performance recovery status in three 2-cell cavities will be reported in this paper.

MOPB98 **Temperature Measurement Techniques for RAON Cryomodule**

Heetae Kim, Hoechun Jung, Yoochul Jung, Youngkwon Kim, Young Kwan Kwon, Min Ki Lee (IBS, Daejeon)

General techniques of temperature measurement is introduced and effective temperature is defined to measure non-uniform temperature distribution. Temperature sensors are used to measure temperatures in cryomodules. Temperature sensors which include semiconductor and conductor are calibrated with PPMS. The temperature sensors are applied to measure temperature accurately in RAON cryomodules.

MOPB99 **Cryomodules Development for CADS Injector I**

Rui Ge (IHEP, Beijing)

As one of the important parts in Accelerator driven sub-critical system (ADS), Injector Ⅰ being built in IHEP，CAS which needs two cryomodules operating at 2K cryogenic environment to realize 10MeV Proton beam energy; Each cryomodule includes seven Spoke cavities and seven superconducting magnets. This paper describes the development of the cryomodules, which include the mechanical design, heat loads analysis , thermal simulation and especially the last commissioning of the Cryomodules.

MOPB100 **Preparation of the Spare EXFEL Third Harmonic Injector Module**

Paolo Pierini (DESY, Hamburg; INFN/LASA, Segrate (MI)), Clemens Albrecht, Serena Barbanotti, Heiko Hintz, Frank Hoffmann, Kay Jensch, Ronald Klos, Cecilia Giovanna Maiano, Wolfgang Maschmann, Olaf Sawlanski, Manuela Schmoekel, Alexey Sulimov, Elmar Vogel (DESY, Hamburg), Massimo Bonezzi, Angelo Bosotti, Marco Chiodini, Rocco Paparella, Daniele Sertore (INFN/LASA, Segrate (MI))

A complete 3.9 GHz cryo-module is under assembly as a spare critical component for the European-XFEL injector to minimize operational downtime in case of component failures and provide long term maintanability. The experience with production and testing of components, the string assembly, the tuners installation and the preparation of the cold mass are reported in this paper together with the results of the complete cryogenic characterization currently planned at the DESY AMTF facility.

MOPB101 **Cryomodule Fabrication and Modification for High Current Operation at the Mainz Energy Recovering Superconducting Accelerator MESA**

Timo Stengler, Kurt Aulenbacher, Florian Hug, Daniel Simon (IKP, Mainz)

At Johannes Gutenberg-University Mainz, the institute for nuclear physics is currently building the multiturn ERL 'Mainz Energy Recovering Superconducting Accelerator' MESA. The 1.3 GHz cryomodules are based on the ELBE modules at Helmholtz Center Dresden-Rossendorf but are modified to suit the high current, energy recovering purposes of MESA. With two 9-cell TESLA cavities each, they shall provide 50 MeV energy gain per turn. The design and fabrication was done at Research Instruments GmbH, Bergisch Gladbach, Germany. The current status of the cryomodules, the test set up at the Helmholtz Institute Mainz, the cavity properties and their tests will be discussed.

MOPB102 **Preliminary Design on the Cryomodule of the HWR for Secondary Particle Generation at KOMAC**

Hyeok-Jung Kwon, Yong-Sub Cho, Jeong-Jeung Dang, Han-Sung Kim, Kyunghyun Kim, Seunghyun Lee, Young-Gi Song (Korea Atomic Energy Research Institute (KAERI), Gyeongbuk)

A 100 MeV proton linac based on the radio frequency quadrupole and conventional drift tube linac has been operating for user service at KOMAC (Korea Multi-purpose Accelerator Complex). A superconducting linac based on the half-wave resonator is studied in order to increase the proton energy from 100 MeV to 160 MeV for secondary particle generation such as neutron. A cryomodule and its cryogenics were designed. The operating temperature of the HWR is 2 K. One cryomodule contains four HWR cavities and it didn¿t have superconducting solenoid because a doublet lattice using normal conducting magnet was considered as focusing elements. A thermal design was conducted and the structure was designed based on the existing well proven technologies. The results of the design on the cryomodule and cryogenics for KOMAC HWR are summarized and discussed in the conference.

MOPB103 **LCLS-II Cryomodule Bowing Due to Thermal Effects**

Liling Xiao, Chris Adolphsen, Zenghai Li, Christopher Dennis Nantista (SLAC, Menlo Park, California)

The LCLS-II project will install a new 4 GeV superconducting RF (SRF) linac, consisting of 35 8-cavity cryomodules (CMs), in the existing SLAC tunnel. Each CM is approximately 10-m long, sitting on two foot stands, which are anchored to the concrete floor in the tunnel. The tunnel temperature is uneven from the floor to the celling. In addition, there are ambient temperature fluctuations in the tunnel. Furthermore, all the fundamental power couplers (FPCs) are mounted on the CM outer vacuum vessel. RF induced heat in the non-cryogenic section of the FPCs will transfer to the CM vessel. Any one of these thermal effects can cause CM displacement, and thus can affect the cavities¿ alignment. The SLAC-developed parallel finite-element EM code suite ACE3P is used to perform simulations on the large and complicated LCLS-II CM geometry. In this paper, we discuss LCLS-II CM bowing due to induced temperature variations over the cylindrical vessel wall. The maximum predicted CM vessel displacements are presented for different thermal effects based on experimental temperature variations and fluctuations in the tunnel as well as possible FPC heating during LCLS-II operation.

MOPB104 **Development of a Novel Supporting System for High Luminosity LHC SRF Crab Cavities**

Thomas Joseph Jones (Lancaster University, Lancaster; STFC/DL, Daresbury, Warrington, Cheshire), Ofelia Capatina, Teddy Capelli, Mateusz Sosin, Carlo Zanoni (CERN, Geneva), Graeme Burt (Cockcroft Institute, Lancaster)

Compact SRF Crab Cavities are integral to the HL-LHC upgrade. This paper details the design of support structures within the SPS (Super Proton Synchrotron) Crab Cavity Cryomodule. For ease of alignment each cavity is supported with the mechanical tuner and RF Fundamental Power Coupler (FPC) via a common support plate. To reduce heat leak and remove bellows in the FPC it was determined that this would be the fixed support for the cavity (V. Parma, 2013). In addition, novel flexural blades were designed to give increased stiffness yet allow for thermal contraction of the cavity towards the fixed point of the FPC. This approach was superior when compared via simulation to several alternative techniques. A detailed simulation model was used for optimisation of directional stiffness, identification of vibration modes and minimising thermal stresses. A transmission matrix was developed in MS Excel to assess modal deflection for given ground vibration conditions. The spreadsheet gives an instantaneous yet comparable result to time consuming random vibration FE Analyses. The final engineering design of the supporting system is now complete and will also be described in this paper.

MOPB105 **A Thermosiphon Cooling Loops for ARIEL Cryomodules**

Yanyun Ma (TRIUMF, Vancouver)

A Thermosiphon cooling scheme has been installed in ARIEL Cryomodules for cavities cooling. The simple structure and higher cooling capacity make this an attractive cooling method. In ARIEL Cryomodules the Thermosiphon loops deliver 4K liquid Helium from 4K reservoir and return the vaporized liquid to the 4 K reservoir as a refrigerator load. The design and test results are presented in this paper.

MOPB106 **Test Results of the XFEL Serial-production Accelerator Modules**

Karol Kasprzak, Mateusz Wiencek, Agnieszka Zwozniak (IFJ-PAN, Kraków), Denis Kostin, Detlef Reschke, Nicholas

Walker (DESY, Hamburg)

The serial-production tests of 100 Cryomodules for the European XFEL have been finished. In this paper all measurements taken in the AMTF (Accelerator Module Test Facility) are shown in statistics. In addition comparison between vertical tests and cavities in the modules results are presented.

MOPB107 **Microphonics Testing of the LCLS II Prototype Cryomodule at Jefferson Lab**

Kirk Davis, Tom Powers (JLab, Newport News, Virginia)

Jefferson Lab is partnering with Fermilab to build the 36 cryomodules for the LCLS II accelerator that will be installed at SLAC. Two prototype cryomodules were produced, one at Fermilab and one at JLab. The cavities have design loaded-Q of 4e7, which means that it has a control bandwidth of 16 Hz. The JLab prototype cryomodule was instrumented with a series of seven accelerometers, and impulse hammer response measurements were made while the cryomodule was being built and after it was installed in the JLab cryomodule test facility. This was done so that we could understand the shapes of the modes of the structure. These results were compared to impulse hammer testing from the outside of the cryomodule to individual cavity frequency shifts when the cryomodule was cold. Additionally, background microphonics response was recorded on the cavities at gradient and using <1 W of RF power and a local waveguide-to-coaxial transition. Results of the modal analysis and the background microphonics when operated under various cryogenic conditions will be presented. Background results, before and after installing the Fermi designed JT-valve improvements, will be presented.

MOPB108 **Operational Comparison of CEBAF Cryomodules at 2 and 4K**

Grigory V. Eremeev, Michael Allen Drury, Joseph Michael Grames, Reza Kazimi, Matt Poelker, Joseph P. Preble, Yves Raymond Roblin, Riad Suleiman, Yan Wang, Mathew Wright (JLab, Newport News, Virginia)

Superconducting radio-frequency (SRF) accelerating cavities are operated in a liquid helium bath typically at temperatures near 2 or 4 K. Lower temperature improves the intrinsic quality factor Q0 of accelerating cavities, and is typically used for cavities with the accelerating mode above 1 GHz, however, it increases the complexity and costs associated with 2K cryogenics. Accelerating cavities at the Continuous Electron Beam Accelerating Facility (CEBAF) resonate at 1.497 GHz, and hence are operated near 2 K. While CEBAF operates at this temperature for nuclear physics experiments, there are regular maintenance periods when CEBAF is idle and cryomodules are brought to 4 K to reduce energy costs. The transition to 4K increases the lifespan of cryoplant components and reduces wall-plug power by megawatts. During a recent maintenance period we accelerated a continuous-wave electron beam using CEBAF cryomodules at 4 K and compared SRF and cryogenic performance as well as beam quality and energy stability.

MOPB109 **LCLS-II Cryomodule Transport System Testing**

Naeem Abdul Huque, Edward Daly (JLab, Newport News, Virginia), Mike McGee (Fermilab, Batavia, Illinois)

The Cryomodules (CM) for the Linear Coherent Light Source II (LCLS-II) will be shipped to SLAC (Menlo Park, California) from JLab (Newport News, Virginia) and FNAL (Batavia, Illinois). A transportation system has been designed and built to safely transport the CMs over the road. It uses an array of helical isolator springs to attenuate shocks on the CM to below 1.5g in all directions. The system rides on trailers equipped with Air-Ride suspension, which attenuates vibration loads. The prototype LCLS-II CM (pCM) was driven 750 miles to test the transport system; shock loggers recorded the shock attenuation on the pCM and vacuum gauges were used to detect any compromises in beamline vacuum. Alignment measurements were taken before and after the trip to check whether cavity positions had shifted beyond the +/- 0.2mm spec. Passband frequencies and cavity gradients were measured at 2K at the Cryomodule Test Facility (CMTF) at JLab to identify any degradation of CM performance after transportation. The transport system was found to have safely carried the CM and is cleared to begin shipments from JLab and FNAL to SLAC.

MOPB110 **Accelerated Life Test Results of LCLS-II Cavity Tuner Motor**

Naeem Abdul Huque, Edward Daly (JLab, Newport News, Virginia), Yuriy Pischalnikov (Fermilab, Batavia, Illinois)

An Accelerated Life Test (ALT) of the Phytron stepper motor used in the LCLS-II cavity tuner has been conducted at JLab. Since the motor will reside inside the cryomodule, any failure would lead to a very costly and arduous repair. As such, the motor was tested for the equivalent of 30 lifetimes before being approved for use in the production cryomodules. The 9-cell LCLS-II cavity is simulated by disc springs with an equivalent spring constant. Plots of the motor position vs. tuner position ¿ measured via an installed linear variable differential transformer (LVDT) ¿ are used to measure motor motion. The titanium spindle was inspected for loss of lubrication. The motor passed the ALT, and is set to be installed in the LCLS-II cryomodules.

MOPB111 **European XFEL LINAC RF System Conditioning and Operating Test**

Denis Kostin, Julien Branlard, Andre Goessel, Olaf Hensler, Mathieu Omet, Detlef Reschke, Alexey Sulimov, Nicholas Walker (DESY, Hamburg), Mateusz Wiencek (IFJ-PAN, Kraków)

96 accelerating modules with 768 TESLA/European-XFEL type superconducting cavities were installed in the European

XFEL LINAC tunnel (XTL) in the fall 2016. Warm conditioning of the RF system - High/Low Level RF System and main input couplers - begun even before finishing the accelerator installation works. All modules were conditioned and tested prior to the installation in the tunnel in the AMTF test stand at DESY. Nevertheless, due to some repair activities on warm input coupler parts, warm conditioning was needed on a few modules/couplers. Cooling down to 2K begun in December 2016 and was finished in January 2017. Since then cold conditioning and tests are running. Several cavities in a few modules did show the multipacting (MP) effects, mostly because a cavity vacuum was filled with a dry nitrogen for before mentioned repairs on couplers in some modules. Said MP effects were seen in AMTF as well. All MP effects were successfully conditioned until now. The warm/cold RF system conditioning and its results/experiences/limits are described and discussed.

MOPB112 **Microphonic Hardening of the JLAB C100 Cryomoules Installed in the CEBAF Accelerator**

Tom Powers, George Herman Biallas (JLab, Newport News, Virginia)

The CEBAF 12 GeV upgrade project required 88 new 7-cell cavities in the form of 11 cryomodules. Five of the cryomodules were installed in each of the two linacs, and one was installed in the injector. These cryomodules have a design gradient of 19.2 MV/m with control bandwidths between 15 and 25 Hz. Microphonics due to quasi-steady-state background vibrations and trips due to transient vibrations are limiting factors for several of the cryomodules. An effort was initiated in the spring of 2016 to better understand these vibrational modes, to understand the coupling of the vibrations into the cryomodules, and to design improvements to the system. A data driven process was used for determining the effectiveness of and improve the different approaches. Improvements were made to the exterior of the cryomodules including waveguide restraints and dampers as well as tuner stack dampers in order to reduce both the background vibrations and the sensitivity to outside stimulation. The methods used, improvement metrics and the improvement results will be presented.

MOPB113 **NEG Pumps for Super Conducting Radio Frequency Cavities**

Marco Urbano (SAES Getters SpA, Lainate), Enrico Maccallini, Paolo Manini, Michele Mura, Dario Nicolosi, Tommaso Porcelli, Fabrizio Siviero (SAES Getters S.p.A., Lainate)

Superconducting Radio Frequency (SRF) cavities are particularly sensitive to surface modifications: it ̧s well known, for example, that adsorbed residual gases on the surface of SRF cavities may cause field emission, which in turn lowers the accelerating gradient and increases the cryogenic heat load.In order to prevent gas flow from the outside and to improve the pump down during the baking, efficient pumping is highly desired in proximity of the inlet and outlet of SRF cavities.NEG pumps could be particularly suitable, having large pumping speed for H2 and H2O (two of the main residual gases in UHV), being compact, vibration-free and requiring little or no power to operate.The application in cryogenic SRF cavities and other particle sensitive accelerator applications is, however, still limited due to the concern for potential emission of dust.In the present poster we report particle release measurements carried out on a novel sintered getter material, ZAO®, having extremely low particle emission. Successful tests carried out using ZAO-based pumps in actual SRF cavities are also reported. These results open up to the possible use of these pumps in such demanding applications.

18-July-17	Oral	Auditorium A
08:00-08:55	**TUXAA-Facilities III**	

TUXAA01 **CEPC SRF System Design and Challenges**
08:00
15mins

Jiyuan Zhai (IHEP, Beijing)

CEPC is a 100 km circular electron positron collider operating at 90-240 GeV center-of-mass energy of Z, W and Higgs bosons. CEPC and its successor SPPC, a 100 TeV center-of-mass super proton-proton collider, will ensure the elementary particle physics a vibrant field for decades to come. The conceptual design report (CDR) of CEPC will be completed in the end of 2017 as an important step to move the project forward. To reduce the overall cost, partial double ring scheme with bunch train operation was proposed, which has a significant impact on the cavity operation and beam dynamics. New technologies such as nitrogen-doping will be studied and adopted. In this talk, CEPC SRF system design and the progress of key technology R&D will be introduced, including key parameter choices and system configuration at different operation energies, bunch train phase shift compensation with pulsed power and beat cavity, high Q cavity study, input coupler, HOM coupler and cryomodule design.

TUXAA02 **HIE Isolde Cavity Production & Cryomodule Commissioning, Lessons Learned**
08:15
20mins

Walter Venturini Delsolaro, Olivier Brunner (CERN, Geneva)

The lessons learned during the HIE Isolde Cavity Production, the Cryo Module Assembly and Commissioning will be presented

TUXAA03 **FRIB SRF Production Status: Cavities, Ancillaries, and Cryomodules**

Ting Xu (FRIB, East Lansing, Michigan)

08:35
25mins

ABSTRACS NEEDED

18-July-17 08:55-10:35	Oral **TUXBA-Fundamental-Nb I**	Auditorium A

TUXBA01
09:00
15mins

Low Temperature Doping of Niobium Cavities: What is Really Going on?

Peter Nicholas Koufalis (Cornell University (CLASSE), Ithaca, New York)

Initial work, first at Fermilab and subsequently at Cornell, has shown that low temperature heat treatments (120 - 160 C) in a low pressure atmosphere can lead to a 'Q-rise' and high quality factors similar to that of cavities nitrogen-doped at high temperatures (~800 C). It was suggested that the low-temperature baking effect is a result of nitrogen doping or 'infusion'. We conducted a systematic study of this effect, using both RF measurements of cavities treated at different doping temperatures as well as detailed SIMS analysis of the surface layer. We match RF performance and extracted material parameters (especially electron mean free path) to the measured doping concentration profiles. We conclusively show that the low-temperature baking is drastically lowering the mean free path in the penetration layer, and that this is not the result of nitrogen doping or infusion. Instead, other interstitial impurities (specifically oxygen and carbon) are diffused into the surface in the low temperature heat treatment and are the source of lowering of the mean free path and, thus, of the observed Q-rise.

TUXBA02
09:15
15mins

Flux Expulsion Studies on Niobium

Sam Posen (Fermilab, Batavia, Illinois)

Increased requirements for high Q0 in SRF linac applications have made it crucial to avoid Q0 degradation resulting from trapped flux. In this contribution, we show results from a new systematic study of cavities at Fermilab that show a strong correlation between the temperature gradient required to expel flux during cooldown and the material history, including 1) niobium vendor processing and 2) heat treatment after purchase from the vendor. Early results from these studies indicated that it would be important to evaluate the niobium purchased for production of high Q0 cavities for the LCLS-II project. We present measurements of both expulsion and Q0 on single-cell and bare 9-cell cavities made from this material, which led to the decision to increase the heat treatment temperature in production. We present data showing the significant improvement in flux expulsion behavior of production cavities after this modification was introduced. In addition, we present new understanding of the physics of flux expulsion, and we discuss the ramifications for procurement of niobium for future applications requiring high Q0.

TUXBA03
09:30
15mins

N-H Interaction Study of Nitrogen Doping-treatment on Nb Samples

Ziqin Yang, Xiangyang Lu, Weiwei Tan, Deyu Yang, Yujia Yang, Jifei Zhao (PKU, Beijing)

Fundamental understanding of the nitrogen doping mechanism has been carried out extensively, but yet remains unclear. We studied the nitrogen doping effect through a series of experiments on niobium samples at both room and low temperature circumstances to seek the physical explanation based on the proposed nitrogen-hydrogen interaction. The time of flight secondary ion mass spectrometry (TOF-SIMS) revealed that the diffused nitrogen plays a key role in the nitrogen doping effect. X-ray photoelectron spectroscopy (XPS) measurements showed the chemical distribution of it. The effects of different concentrations of diffused nitrogen on the samples ¿ magnetic property were studied by the magnetic property measurement system (MPMS). Direct observation of the surface topography of both doped and undoped samples by using scanning electron microscope (SEM) at liquid nitrogen temperature has proved that the diffused nitrogen can prevent or retard the hydrides formation to varying degrees with different amounts of material removal. A possible mechanism of nitrogen-doping effect is proposed based on our study.

TUXBA04
09:45
20mins

A Unified Theory of Surface Resistance and the Residual Resistance of SRF Cavities at Low Temperatures

Takayuki Kubo (KEK, Ibaraki), Alexander Gurevich (ODU, Norfolk, Virginia)

The Mattis-Bardeen (MB) theory has been widely used for the calculation of the surface resistance of superconductors at weak RF fields. It is well known that the observed surface resistance decreases exponentially as the temperature decreases but tends to a constant residual resistance which is not described by the MB theory. Using the quasiclassical formalism of the microscopic BCS theory, we have developed a unified theory of the surface resistance which, in addition to the MB contribution, includes the residual resistance. Based on this theory, possible materials treatments to reduce the surface resistance are discussed.

TUXBA05
10:05
20mins

Hydrogen Distribution and Hydride Precipitation in SRF Nb Revealed by Metallographic Techniques

Shreyas Balachandran, Peter J. Lee (NHMFL, Tallahassee, Florida), Santosh Chetri, David Larbalestier (ASC, Tallahassee, Florida), Pashupati Dhakal (JLab, Newport News, Virginia)

The current issues that are of importance for SRF Nb cavities include: flux trapping depending on temperature gradient at superconducting transition, variation in flux trapping depending on precursor Nb material, and quality or process control of SRF Nb sheets that would lead to consistent performance. Our work relates to exploring microstructure correlations relevant to the above topics using coupon SRF Nb samples. Of particular importance are: a) hydride precipitation which could occur during cavity cooling below cryogenic temperatures, b) variation in surface superconducting properties and N doping, c) extent of surface damage in as received Nb sheets, and d) distribution of dislocation and substructures which lead to lattice strains in the material. The main results of our studies suggest the role of GB’s in hydride formation, direct evidence of N doping preventing hydrides, and occurrence of strained lattice features depending on the surface treatment of SRF Nb. We also look at how this type of study can supplement and strengthen the effort to include quantitative microstructure based features in our understanding, and modelling of SRF superconductivity in Nb.

TUXBA06
10:25
15mins

Analysis of Flux Pinning Variability With Nb Stock Material

Ari Deibert Palczewski (JLab, Newport News, Virginia)

Within Nb material batches which otherwise conform to specification, a distinct variability of susceptibility to pinning of residual magnetic field and thus enhanced RF losses and lower Q has been observed. Systematic investigation of the various lots of material procured for use in the fabrication of LCLS-II cavities is underway to distinguish the critical contributing material characteristic. The aim is clarification of a revision to the material specification in order to reliably obtain lower residual resistance in operational SRF cavities for any application.

18-July-17	Oral	Auditorium A
11:05-12:05	**TUYAA-Fundamental-Nb II**	

TUYAA01
11:10
15mins

The Importance of the Electron Mean Free Path for Superconducting RF Cavities

James Thomas Maniscalco, Peter Nicholas Koufalis, Matthias Liepe (Cornell University (CLASSE), Ithaca, New York)

Theoretical results offer a potential explanation for the anti-Q-slope, the phenomenon of decreasing microwave surface resistance with increasing radiofrequency electromagnetic field strength. This effect has been observed in niobium doped with impurities, chiefly nitrogen, and has been put to use in the Linac Coherent Light Source II (LCLS-II) accelerator currently under construction. Our work, presented here, finds a strong link between the electron mean free path, the main measure of impurity doping, to the overheating of quasiparticles in the RF penetration layer. This is an important effect that adjusts the magnitude of the theoretical anti-Q-slope by providing a mechanism to counteract it and introduce a surface resistance that increases with field strength. We discuss our findings in a study of niobium cavities doped at high temperature (800-990 ℃) as well as new analysis of low-temperature-doped cavities.

TUYAA02
11:30
30mins

Effect of Interstitial Impurities on the Field Dependent Microwave Surface Resistance of Niobium

Martina Martinello (Fermilab, Batavia, Illinois)

The radio-frequency surface resistance of niobium resonators is incredibly reduced when nitrogen impurities are dissolved as interstitials in the material, conferring ultra-high Q-factors. This effect has been observed in both high and low temperature nitrogen treatments. However, high temperature treatments show increased sensitivity to trapped magnetic field, implying a more challenging high Q-factor preservation in cryomodules. We present a systematic study on the different components contributing to the total surface resistance, comparing the effect of all the state-of-the-art processing such as N-doping and N-infusion*. The study is also extended on comparing the surface resistance contributions in nitrogen-treated cavities with different resonant frequencies, such as: 650 MHz, 1.3 GHz and 3.9 GHz. These findings reveal the different physics underneath the various dissipative processes, helping the fundamental understanding of the RF surface impedance. In addition, we uncover the optimum surface treatment needed to maximize the Q-factor of superconducting niobium cavities as a function of the operational frequency and accelerating gradient.

TUYAA03
11:55
20mins

Electron Mean Free Path Dependence of the Vortex Surface Impedance

Mattia Checchin, Anna Grassellino, Martina Martinello, Alexander S Romanenko (Fermilab, Batavia, Illinois)

In the present study the radio-frequency complex response of trapped vortices in superconductors is calculated. The motion equation for a magnetic flux line is solved assuming a bi-dimensional and mean-free-path-dependent Lorentzian-shaped pinning potential. The resulting surface resistance shows the unprecedented bell-shaped trend as a function of the mean-free-path observed in our previous experimental work. We demonstrate that such bell-shaped trend of the surface resistance, as a function of the mean-free-path, may be described as the interplay of the two limiting regimes of the surface resistance, for low and large mean-free-path values: pinning and flux-flow regimes respectively. By tackling the frequency dependence of the surface resistance, we also demonstrate that the separation between pinning- and flux-flow-dominated regimes cannot be determined only by the depinning frequency. The dissipation regime can be indeed tuned either by acting on the frequency or on the mean-free-path value.

TUYBA01
12:10

Progress on Characterization and Optimization of Multilayers

Claire Antoine (CEA/DSM/IRFU,), Muhammad Aburas (CEA/DRF/IRFU, Gif-sur-Yvette), Hitoshi Hayano, Shigeki Kato, Takayuki Kubo, Takayuki Saeki (KEK, Ibaraki), Yoshihisa Iwashita (Kyoto ICR, Uji, Kyoto)

20mins	Multilayers MgO/NbN/MgO/Nb with several thicknesses are being tested by local magnetometry, Scanning tunneling and various standard structural techniques experiment providing usefull information to compare experiments and recent theoretical advances proposed by A. Gurevich or T. Kubo.

18-July-17	Oral	Auditorium A
12:05-13:05	**TUYBA-Fundamental-non Nb I**	

TUYBA02
12:30
20mins

Thermal Boundary Resistance Model and Defect Statistical Distribution in Nb/Cu Cavities

Ruggero Vaglio (UniNa, Napoli), Vincenzo Palmieri (INFN/LNL, Legnaro (PD))

The `Q-slope ¿ problem strongly limits the application of niobium thin film sputtered cavities in high field accelerators. Here we consider the hypothesis that the Q-slope is related to local enhanced of the thermal boundary resistance at the Nb/Cu interface, due to poor thermal contact between film and substrate. We introduce a simple model that directly connects the Q versus Eacc curves to the distribution function f(RNb/Cu) of RNb/Cu thermal contact at the Nb/Cu interface over the cavity surface. Starting from the experimental curves, using inverse problem methods, we deduce the distribution functions generating those curves. The technique has been applied to cavities by different groups, including LNL/INFN and ISOLDE/CERN.In all cases to explain the data it is sufficient to assume that only a small fraction of the film over the cavity surface is in poor thermal contact with the substrate. The distribution functions typically follow a simple power-law statistical distribution and are temperature independent. The full analysis supports the hypothesis that the main origin of the Q-slope in thin film cavities is indeed related to bad adhesion at the Nb/Cu interface.

TUYBA03
12:50
20mins

Strategy and experimental results toward the solution of the Q-slope problem in Nb/Cu cavities

Vincenzo Palmieri (INFN/LNL, Legnaro (PD))

ABSTRACT NEEDED

18-July-17	Poster	Hall B
14:00-17:00	**TUPB-Poster Session**	

TUPB001

336 MHz Crab Cavity Design for the eRHIC Hadron Beam

Silvia Verdu-Andres, Qiong Wu, Binping Xiao (BNL, Upton, Long Island, New York), Ilan Ben-Zvi (BNL, Upton, Long Island, New York; Stony Brook University, Stony Brook)

Crab crossing is an essential mechanism to restore high luminosity and avoid synchro-betatron resonances in the electron-hadron collider eRHIC. The current ring-ring eRHIC design envisages a set of crab cavities operating at 336 MHz. This set of cavities will provide the crabbing kick to the hadron beam of eRHIC. Double-Quarter Wave (DQW) cavities are compact, superconducting RF deflecting cavities appropriate for crab crossing. The crabbing system of the High Luminosity Large Hadron Collider (HL-LHC) will be equipped with several DQW cavities. This paper summarizes the main design requirements and presents an optimized RF design of a DQW cavity for the crabbing system of the ring-ring eRHIC hadron beam.

TUPB002

Novel HOM Damper Design for High Current SRF Cavities

Wencan Xu, Ilan Ben-Zvi, Michael Blaskiewicz, Philipp Kolb, Gary McIntyre, Richard Porqueddu, Kevin S. Smith, Ferdinand J. Willeke, Binping Xiao, Tianmu Xin, Chen Xu, Alex Zaltsman (BNL, Upton, Long Island, New York), Yongfeng Gao (PKU, Beijing)

ERL-Ring eRHIC aims to build a new high current (50 mA), multi-pass (6 passes) ERL to provide 3-18 GeV electron beams to collide with proton beams from existing RHIC. One critical challenge for eRHIC is to damp HOMs. The average HOM power is up to 8 kW per cavity, and it will get worse when the electron beam spectrum overlaps with cavity HOM spectrum. A novel HOM damping scheme by employing ridge waveguides has been worked out at BNL, which is able to well damp both longitudinal and transversal modes. This paper will describe the design of the HOM damping scheme, including RF design, HOM damping results, progress of prototyping.

TUPB003

Design and Fabrication of the Superconducting Cavity Low-level Control System in CAEP FEL-THz Facility

Cheng-long Lao (CAEP/IAE, Mianyang, Sichuan)

The CAEP FEL-THz facility is consist of a photocathode DC gun, 2×4cell superconducting cavity, 30kW pulse/CW mode IOT microwave source and other subsystems. In order to regulate the amplitude and the phase of the accelerating voltage inside a superconducting cavity, a LLRF (low-level radio-frequency) control system based on FPGA (field programmable gate array) technology was developed. The proposed LLRF control system includes an analog front-end, a digital board (ADC (analog to digital converter), DAC (digital to analog converter), FPGA, etc.) and a RF & clock generation system. This article focuses on the design and fabrication of the llrf system and the operation experience which involved tests with high power RF without beam in a cavity and tests with beam. According to the test performance, the amplitude and phase control accuracy can reach 0.5% and 0.6 °.

TUPB004 **Hom Damping With an Enlarged Beam Tube for Heps 166.6 MHz SC Cavities**

Xuerui Hao, Zhongquan Li, Fanbo Meng, Pei Zhang, Xinying Zhang (IHEP, Beijing)

The 166.6 MHz superconducting cavities have been proposed for the HEPS storage ring. Their higher order modes (HOMs) have to be damped sufficiently in order to prevent coupled-bunch instabilities and to limit parasitic mode losses. As one HOM damping option, an enlarged beam tube allows HOMs to propagate and subsequently be absorbed by downstream HOM dampers installed on the inner surface of the tube. The associated Qext of each HOM is calculated and presented in this paper.

TUPB005 **Developed Spoke Cavity Module for Main Linac of China ADS**

Zhongquan Li, Jianshe Cao, Yunlong Chi, Xuerui Hao, Feisi He, Shaopeng Li, Haiying Lin, Qiang Ma, Zheng Hui Mi, Weimin Pan, Peng Sha, Bo Xu, Jiyuan Zhai, Xinying Zhang (IHEP, Beijing)

During past five year, two kind of spoke of Beta equal 0.21 and 0.40 were developed at IHEP CAS, the spoke cavity of beta 0.21 was adopted to accelerate proton from 10 to 32MeV, and 32 to 160MeV for beta 0.40 spoke cavity. Up to now, two kind of naked spoke cavities have been test in vertical, also the module of beta 0.21 spoke cavity, which equipped the liquid helium jacket, magnetic shield layer and frequency tuner has been fulfilled and test, the performance of all of components reach the design requirements.

TUPB006 **T-mapping and X-ray Mapping System at IHEP**

TongXian Zhao (IHEP, Beijing)

A new SRF cavity 2K vertical test system was constructed at IEHP in 2015, Now we are developing a cavity vertical test diagnostic system for 1.3GHz 9cell cavity and 650MHz 5cell cavity, which including a T-mapping system and a X-ray-mapping system, It base on the cavity diagnostic system at KEK-STF. We developed a diagnostic system with 60 carbon resistors, using self-developed acquisition system, next we will increase the number of sensors and add PIN photo diades for detecting emission of X-rays.

TUPB007 **Vertical Test Results on Ess Medium Beta Elliptical Cavity Prototypes Equipped with Helium Tank**

Enrico Cenni (CEA/IRFU, Gif-sur-Yvette)

The ESS elliptical superconducting Linac consists of two types of 704.42 MHz cavities, medium and high beta, to accelerate the beam from 216 MeV (spoke cavity Linac) up to the final energy at 2 GeV. The last Linac optimization, called Optimus+, has been carried out taking into account the limitations of SRF cavity performance (field emission). The medium and high-beta parts of the Linac are composed of 36 and 84 elliptical cavities, with geometrical beta values of 0.67 and 0.86 respectively. This work presents the latest vertical test results on ESS medium beta elliptical cavity prototypes equipped with helium tank. We describe the cavity preparation procedure from buffer chemical polishing to vertical test. Limiting factors will be discussed and analyzed.

TUPB008 **Performance of SRF Half-Wave-Resonators Tested at Cornell for the RAON Project**

Mingqi Ge, Fumio Furuta, Terri Gruber, Scott Hartman, Matthias Liepe, Tim O'Connell, Philip James Pamel, James Sears, Vadim Veshcherevich (Cornell University (CLASSE), Ithaca, New York), Jongdae Joo, Juwan Kim, WooKang Kim, Junwoo Lee, Ilkyoung Shin (IBS, Daejeon)

Two prototype half-wave-resonators (HWR; 162.5MHz and β=0.12) for the RAON project were tested at Cornell University. In this paper, we report and analyze detailed results from vertical tests, including tests of the HWRs without and with helium tank. Surface preparation at Research Instruments and Cornell is discussed, as well as the development of new HWR preparation and test infrastructure at Cornell.

TUPB009 **High-Frequency SRF Cavities**

Thomas Oseroff, Daniel Leslie Hall, Peter Nicholas Koufalis, Matthias Liepe, James Thomas Maniscalco, Ryan Douglas Porter (Cornell University (CLASSE), Ithaca, New York)

Historically, the frequency of SRF cavities has been limited by cryogenic power dissipation increasing rapidly with frequency, due to the BCS surface resistance having a quadratic dependence on frequency. Now, new SRF surfaces using doped niobium and compound superconductors like Nb3Sn can drastically reduce the BCS part of the surface resistance. The temperature independent part of the surface resistance (residual resistance) can therefore become dominant, and has its own, different frequency dependence. We have developed a model to analyze cryogenic cooling power requirements for SRF cavities as function of operating frequency, temperature, and trapped flux to evaluate the impact of the novel low-loss SRF surfaces on the questions of optimal operating frequency and frequency limit. We show that high-frequency SRF cavities now become a realistic option for future SRF driven accelerators. As the transverse cavity size decreases inversely with respect to its resonant frequency, such high-frequency SRF cavities could greatly reduce cost.

TUPB010 **Multipactor Study in the Coupler Region of the Diamond SCRF Cavities**

Shivaji Apparao Pande, Chris Christou (DLS, Oxfordshire), Graeme Burt (Cockcroft Institute, Lancaster; Cockcroft Institute, Warrington, Cheshire)

The Diamond storage ring operates with two CESR-B type Superconducting RF cavities. The cavities suffer from trips with a sudden loss of accelerating field if operated above a certain voltage. Consequently the cavities are operated at voltages up to 1.4 MV for better reliability. These cavities are iris coupled and have fixed Qext. At these lower operating voltages, the optimum condition for beam loading is satisfied at powers around 100 kW. For operation at 300 mA with two cavities, the power needed per system exceeds 200 kW. Therefore 3 stub tuners are used to lower the Qext to move the optimum condition close to 200kW. Additionally, the step due to the difference in the height of the coupling waveguide on the cavity and that of the vacuum side waveguide on the window results in a standing wave between the cavity and the window even at matched operation. The 3 stub tuner further enhances this standing wave. Numerical simulation reveals that the standing wave field from the cavity penetrates into the coupling waveguide increasing the probability of multipactor and breakdown in the coupler region. The results of multipactor simulations in this region with CST Studio are discussed.

TUPB011 **Some Impedance Aspects of DQW LHC Crab Cavity**

Rama Calaga (CERN, Geneva), Silvia Verdu-Andres, Binping Xiao (BNL, Upton, Long Island, New York)

The high current beams of HL-LHC requires strong HOM damping of the crab cavities to minimize the HOM power and beam instabilities. The double quarter wave (DQW) cavity is equipped with specially designed HOM couplers to reach an acceptable impedance budget. This paper will compare the impedance calculations using both frequency and time domain simulations and compare between the CST and ACE3P solvers.

TUPB012 **First Cold Testing of the Hilumi-LHC Crab Cavities Tuning System**

Alejandro Castilla, Kurt Artoos, Pablo Fernández López, Alick Macpherson, Pierre Minginette, Joanna Sylwia Swieszek (CERN, Geneva), Ilan Ben-Zvi (BNL, Upton, Long Island, New York), Nicholas Shipman (CERN, Geneva; Cockcroft Institute, Lancaster)

Prior to the integration in the LHC for the high luminosity upgrade, foreseen for 2023, a test of the crab cavities with beam in the SPS is programmed for 2018. During operations in the LHC and the SPS, the crab cavities' final frequency will depend on fabrication, preparation, and assembly steps, as well as dynamic effects (e.g. Lorentz force detuning). For this reason, an active mechanism to tune the cavity during operation is necessary. A prototype actuating system has been tested on an available prototype double quarter wave crab cavity in a vertical test cryostat to validate the tuning principle. One of the requirements for the tuner system is a resolution that allows at least ten steps inside the cavity bandwidth (~800 Hz) with small backlash and hysteresis. A first test was made to keep the frequency of the cavity as close as possible to a target frequency. The tuner actuator was equipped with some instrumentation to measure displacements and tuning forces. We present in this paper an overview of the results of the test, as well as some recommendations for the tuner design to be used in the SPS cryomodule and eventually in the LHC.

TUPB013 **Advanced Manufacturing Techniques for the Production of HL-LHC Crab Cavities at CERN**

Marco Garlasché (CERN, Geneva)

RF Crab Cavities are an essential part of the HL-LHC upgrade at CERN. Two concepts of such systems are being developed: the Double Quarter Wave (DQW) and the RF Dipole (RFD) This presentation describes the advanced manufacturing techniques developed for the production of the DQW cavity prototype and the initial phases of RFD prototype production.

TUPB014 **In-situ Bulk Residual Resistivity Ratio Measurement on Double Quarter Wave Crab Cavities**

Nicholas Shipman, Alejandro Castilla, Karim Gibran Hernández-Chahín, Alick Macpherson (CERN, Geneva), Ilan Ben-Zvi (BNL, Upton, Long Island, New York), Graeme Burt (Cockcroft Institute, Lancaster), James Alexander Mitchell (Lancaster University, Lancaster)

A four wire measurement was used to measure the bulk RRR on two DQW Crab Cavities. The measurement procedure is explained and the values obtained for each cavity are compared together with the values obtained from Niobium samples of the same stock from which the cavities were manufactured. Measurement errors and carefully analysed and further improvements to the measurement procedure are suggested.

TUPB015 **Performance Results from CERNs High-gradient SRF Testing Program**

Katarzyna Magdalena Turaj, Alejandro Castilla, Karl-Martin Dr. Schirm, Benoit Frere-Bouniol, Alick Macpherson (CERN, Geneva), Karim Gibran Hernández-Chahín (CERN, Geneva; DCI-UG, León), Marcin Wartak, Agnieszka Zwozniak (CERN, Geneva; IFJ-PAN, Kraków)

Performance measurements for 704 MHz 5-cell elliptical bulk niobium cavities are presented. These cavities form the mainstay of CERN's High Gradient program, and results show that the specification of Q0 = 1E10 at 25 MV/m is achievable. Significant improvement and understanding in the different factors associated with CERN's RF surface preparation and cavity assembly process are addressed, as well as the complementary diagnostics and monitoring system. Post-testing analysis of cavity quenches with improved quench localisation, and subsequent defect analysis using both standard optical inspection and chromatic confocal imaging are also discussed, including preliminary results from 3D-imaging of defect surface.

TUPB016 **Redesign of CERN's Quadrupole Resonator**

Veronica del Pozo Romano, Robin Betemps, Frank Gerigk, Ricardo Illan Fiastre (CERN, Geneva)

The Quadrupole Resonator (QPR) was constructed in 1997 to measure the surface resistance of niobium samples at 400 MHz, the technology and RF frequency chosen for the LHC. It allows measurement of the RF properties of superconducting films deposited on disk-shaped metallic substrates. The samples are used to study different coatings which is much faster than the coating, stripping and re-coating of sample cavities. An electromagnetic and mechanical re-design of the existing QPR has been done with the goal of doubling the magnetic peak fields on the samples. Electromagnetic simulations were carried out on a completely parameterized model, using the actual CERN's QPR as baseline and modifying its dimensions. The aim was to optimize the measurement range and resolution by increasing the ratio between the magnetic peak fields on the sample and in the cavity. Increasing the average magnetic field on the sample leads to a more homogenous field distribution over the sample, which in turn gives a better resolution. Some of the modifications were based on the work already done by Helmholtz-Zentrum-Berlin for their upgraded version of the QPR.

TUPB017 **Processing and Testing of 3.9 GHz SRF Cavities for LCLS-II at Fermilab**

Sebastian Aderhold (Fermilab, Batavia, Illinois)

The main part of the SRF linac for the Linac Coherent Light Source II (LCLS-II) at SLAC will consist of 35 cryomodules with superconducting RF cavities operating at 1.3 GHz. In addition, two cryomodules with 3.9 GHz cavities will be installed and help to linearize the longitudinal phase space of the beam. Fermilab is in charge of designing and assembling these two cryomodules. Four cavities have been processed and tested - in the vertical and horizontal test cryostats - during the design verification phase. We present results of this processing and testing.

TUPB018 **An Update on Development of HB650 Cavities for PIP-II**

Vikas Jain (Fermilab, Batavia, Illinois; RRCAT, Indore (M.P.)), Ivan V. Gonin, Chuck Grimm, Timergali N. Khabiboulline, Thomas H. Nicol, Allan Rowe, Vyacheslav Yakovlev (Fermilab, Batavia, Illinois)

Fermi National Accelerator Laboratory's (FNAL) PIP-II project has a high beta section that has adapted a b=0.92 cavity design in place of the earlier b=0.9 design, essentially solving the Higher Order Mode (HOM) problems associated with Continuous Wave (CW) beam operation. However, five bare b=0.9 cavities were fabricated in industry and a decision was made to use these cavities in conjunction with the newer b=0.92 cavity design in the prototype Cryomodule (pCM) for the R&D phase of the PIP-II project. This paper will present the cavity electromagnetic, mechanical, and coupled analysis as tools to analyze the various aspects of the cavity design for both 650 MHz cavities mentioned. The helium vessel design, Lorenz Force Detuning (LDF), df/dp, and ASME stress validation will be presented. The weld design and qualification of various joints used in cavity dressing will also be illustrated in this paper. Fabrication strategy, tooling, and fixture designs for cavity dressing will be discussed later along with the Vertical Test Stand (VTS) plan for qualifying dressed cavities.

TUPB019 **Analysis and Tests on Stainless Steel Flanged Connections Using Aluminum Seals for Ultra-high Vacuum Applications**

Mattia Parise (Fermilab, Batavia, Illinois)

In order to develop an assembling procedure, that guarantees the sealing of the SSR1 spoke resonator flanges both at room and cryogenic temperature, an experimental characterization of the custom hardware is required. The sealing is obtained through an aluminum ring with an hexagonal cross section flattened using herculoy silicon bronze set screws, stainless steel hex nuts and washers. The characterization is aimed at the determination of an optimal value for the maximum torque applied at the nuts to obtain an ultra high vacuum (UHV) leak tight connection with cleanroom cleaned hardware and flanges.

TUPB020 **Microphonics Passive Damping**

Evgeny Zaplatin (FZJ, Jülich), Alexei Kanareykin (Euclid TechLabs, LLC, Solon, Ohio), Vyacheslav Yakovlev (Fermilab, Batavia, Illinois)

Different types of external loads on the resonator walls predetermine the main working conditions of the SRF cavities. The most important of them are very high electromagnetic fields that result in strong Lorentz forces and the pressure on cavity walls from the helium tank that also deforms the cavity shape. For pulsed operation, the Lorentz forces usually play the decisive role for the cavity design. For CW operation, the liquid helium vessel pressure instability even for 2K operations is the source of large microphonics. All deformations resulting from any type of external loads on cavity walls lead to shifts in the working RF frequency in the range of hundreds of kHz. Taking into account high Q-factor of SC cavities such a large frequency shift takes the cavity out of operation. Here we present and discuss the achievements and problems of microphonics passive damping in different type SRF cavities.

TUPB021 **First Considerations on HZB High Frequency Elliptical Resonator Stiffening**

Evgeny Zaplatin (FZJ, Jülich), Hans-Walter Glock, Jens Knobloch, Axel Neumann, Adolfo Velez (HZB, Berlin)

There are two projects that currently are under development and construction at HZB which utilize high frequency elliptical resonators ¿ Energy Recovery Linac Prototype (bERLinPro, 7-cell, 1300 MHz, beta=1) and BESSY Variable pulse-length Storage Ring (VSR, 5-cell, 1500/1750 MHz, beta=1). A critical issue of both projects is small effective beam loading in cavities operating at high CW fields (Eacc of 20 MV/m) with a narrow band width. This necessitates precise tuning and therefore good compensation of microphonics and coupled Lorentz-force detuning driven instabilities. Here we present a conceptual study of an integrated SRF resonator and helium vessel structure design to ensure a reduced resonance frequency dependence on pressure and Lorentz forces to minimize their impact on the accelerating field profile.

TUPB022 **First Measurements of the Next SC CH-cavities for the New Superconducting CW Heavy Ion Linac at GSI**

Markus Basten, Marco Busch, Holger Podlech, Malte Schwarz (IAP, Frankfurt am Main), Florian Dirk Dziuba, Manuel Heilmann, Stepan Yaramyshev (GSI, Darmstadt), Winfried A. Barth (GSI, Darmstadt; HIM, Mainz), Viktor Gettmann, Maksym Miski-Oglu (HIM, Mainz)

In the future the existing GSI-UNILAC (Universal Linear Accelerator) will primarily be used to provide high power heavy ion beams at a low repetition rate for the FAIR project (Facility for Antiproton and Ion Research). To keep the ambitious Super Heavy Element (SHE) physics program at GSI competitive a superconducting (sc) continuous wave (cw) high intensity heavy ion LINAC is highly desirable to provide ion beams at or above the coulomb barrier [*]. The fundamental linac design composes a high performance ion source, a new low energy beam transport line, the High Charge State Injector (HLI) upgraded for cw, and a matching line (1.4 MeV/u) followed by the new sc-DTL LINAC for acceleration up to 7.3 MeV/u. The construction of the first demonstrator section has been finished in the 3rd quarter of 2016. It comprises the first crossbar-H-mode (CH) cavity with two sc 9.3 T solenoids and has been successfully tested in the end of 2016 [**]. Currently the next two sc 8 gap CH-cavities are under construction at Research Instruments (RI). First intermediate measurements during the fabrication process as well as the latest status of the construction phase will be presented.

TUPB023 **Further Tests on the SC 325 MHz CH-cavity and Power Coupler Test Setup**

Marco Busch, Markus Basten, Holger Podlech, Ulrich Ratzinger, Malte Schwarz (IAP, Frankfurt am Main), Winfried A. Barth, Florian Dirk Dziuba, Viktor Gettmann, Maksym Miski-Oglu (GSI, Darmstadt; HIM, Mainz)

The 325MHz CH-cavity which has been developed and successfully vertically tested at the Institute for Applied Physics, Frankfurt, has has been welded to the helium vessel at the frontal joints of the cavity and further vertical and horizontal tests are in preparation. Finally a beam test with a 11.4 AMeV, 10 mA ion beam at GSI, Darmstadt is projected. Furthermore a newly developed, dedicated test stand for the 217 MHz power couplers has been set up for the cavities of the sc cw-LINAC project at GSI.

TUPB024 **Performance Tests of the Superconducting 217 MHz CH Cavity for the CW Demonstrator**

Florian Dirk Dziuba, Viktor Gettmann, Maksym Miski-Oglu (HIM, Mainz), Manuel Heilmann, Alexander Schnase (GSI, Darmstadt), Winfried A. Barth (GSI, Darmstadt; HIM, Mainz; MEPhI, Moscow), Stepan Yaramyshev (GSI, Darmstadt; MEPhI, Moscow), Michael Amberg (HIM, Mainz; IAP, Frankfurt am Main), Kurt Aulenbacher (HIM, Mainz; IKP, Mainz), Markus Basten, Marco Busch, Holger Podlech, Malte Schwarz (IAP, Frankfurt am Main)

Regarding the future research program of super heavy element (SHE) synthesis at GSI, high intense heavy ion beams above the coulomb barrier and high average particle currents are highly demanded. The associated beam requirements exceed the capabilities of the existing Universal Linear Accelerator (UNILAC). Besides the existing GSI accelerator chain will be exclusively used as an injector for FAIR (Facility for Antiproton and Ion Research) providing high power heavy ion beams at a low repetition rate. As a consequence a new dedicated superconducting (sc) continuous wave (cw) linac is highly demanded to keep the SHE research program at GSI competitive on a high level. In this context the construction of the first linac section, which serves simultaneously as a prototype to demonstrate its reliable operability has been finished at the end of 2016. The so called demonstrator cryomodule comprises two sc 9.3 T solenoids and a sc 217 MHz crossbar-H-mode (CH) cavity with 15 equidistant accelerating gaps. Furthermore, the performance of the cavity has been successfully tested at cryogenic temperatures. The results of these tests are presented.

TUPB025 **Initial Results From the BESSY VSR Single Cell Prototype**

Benjamin Hall, Jens Knobloch, Emmy Sharples, Yegor Tamashevich, Adolfo Velez (HZB, Berlin)

The BESSY VSR upgrade of the BESSY II light source allow the ring to store long (~15ps) and short (~1.5ps) bunches simultaneously. BESSY VSR requires multi-cell SRF cavities with challenging damping requirements operating at 1.5 and 1.75 GHz respectively. The damping will be achieved by multiple waveguide dampers in the end groups. To ensure that the end groups can be manufactured in a suitable way and that multipacting is not an issue in this area, a single cell 1.5 GHz prototype has been manufactured and tested in a vertical Dewar. The experimental results are presented and discussed in this paper and compared to RF field simulations.

TUPB026 **Simultaneous Excitation of TE and TM Modes in a 3.5 Cell SRF Gun Cavity**

Andre Arnold, Petr Murcek, Jochen Teichert, Hannes Vennekate (HZDR, Dresden), Gianluigi Ciovati, Daniel Forehand, Peter Kneisel, Larry Turlington (JLab, Newport News, Virginia)

For future linear CW accelerators, superconducting (SC) RF guns are discussed to be the most promising solution to fulfil the demands on high average current and high brightness at the same time. But in difference to the NCRF guns, the application of static magnetic fields near the cathode to compensate for space charge forces is not possible. Instead, magnetic fields of transverse electric (TE) modes excited in parallel to the accelerating mode were proposed *, **. Experiments at the 1st Rossendorf SRF gun using the existing fundamental mode coupler in combination with a RF diplexer have shown that this is feasible ***. However, since the cavity was not designed for this purpose, the mode was strongly damped by HOM couplers and cavity beam tubes and thus only low field strength could be achieved. In this contribution we will present a modified cavity design that avoids these problems and provides a separate RF coupler for the TE mode. Additionally, we will report on the first vertical test that demonstrated the functionality of the whole RF setup as well as realized significant higher field of the excited TE011 mode in parallel to the TM010 mode.

TUPB027 **Design of the KEK SRF GUN System and the Result from the Prototype Cavity**

Taro Konomi, Eiji Kako, Yukinori Kobayashi, Shinichiro Michizono, Kensei Umemori, Seiya Yamaguchi (KEK, Ibaraki), Takeshi Yanagisawa (MHI-MS, Kobe), Ryuichi Matsuda (Mitsubishi Heavy Industries Ltd. (MHI), Takasago)

KEK has been developing a superconducting RF gun for CW ERL since 2013. The SRF gun is a combination of a 1.3 GHz, 1.5-cell superconducting RF cavity and a backside excitation type photocathode. The prototype cavity #1 and the photocathode were developed individually. 8 times vertical tests had been done. The EP and HPR were optimized for the gun cavity. The surface electric field reached 75 MV/m with the dummy cathode rod. Based on these experiences, KEK starts designing of the prototype cavity #2 for the test of low beam current operation in horizontal test cryostat. The cavity has the frequency tuner and cathode position tuner on the LHe jacket. In this poster, design of the prototype cavity #2, cathode introduction, deposition chamber and emittance, energy measurement beam line will be reported.

TUPB028 **Improvement of Magnetic Condition for KEK-STF Vertical Test Facility toward High-Q Study**

Kensei Umemori, Takeshi Dohmae, Eiji Kako, Taro Konomi, Takayuki Kubo, Mika Masuzawa, Gunn-Tae Park, Akio Terashima, Kiyosumi Tsuchiya, Ryuichi Ueki (KEK, Ibaraki), Takafumi Okada (Sokendai, Ibaraki)

Improvement of unloaded Q-values of SRF cavities are important to reduce surface loss of cavity and heat loads of He refrigerators. R&D activities have been developed worldwide. We also started work toward high-Q, but soon realized that magnetic condition of KEK-STF vertical test facility was not good enough to carry out high-Q measurements. First, magnetized components were searched. Shafts to move variable coupler were found to be most magnetized one and exceed more than 1 Gauss. Magnetized components were exchanged to non-magnetized one. In order to further reduce remnant magnetic field, a solenoid coil was prepared and used to cancel it. To suppress flux trapping, a heater was located around an upper beampipe of cavity and made thermal gradient. Owing to these efforts, Q-value of more than 1x1011 can be measured with a condition of residual resistance of ~3 nW. Clear flux expulsion signal can be also observed. In this presentation, we report about efforts to reduce ambient magnetic field and to realize high-Q measurements. Results of vertical tests, including flux expulsion measurements, are also presented.

TUPB029 **Cost Reduction of Niobium Material for ILC SRF Cavities**

Masashi Yamanaka, Takeshi Dohmae, Hitoshi Inoue, Shinichiro Michizono, Kensei Umemori, Yuichi Watanabe (KEK, Ibaraki)

This R&D project involves cavity fabrication preparation in order to achieve a cavity performance satisfying the ILC specifications presented in the TDR. We propose to optimize the ingot purity to obtain a lower residual resistivity ratio (RRR), while accepting some specific residual content, such as tantalum (Ta). We also propose to simplify the manufacturing process, e.g., the forging, rolling, slicing, and tube forming, to minimize contamination. We have a plan to manufacture two types of 3-cell cavity: ¿High-Ta medium-RRR (100−200) material¿ cavities and ¿High-Ta high-RRR (200−300) material¿ cavities. KEK will then evaluate the performance of these cavities and select the preferred material. We will introduce the detail of fabrication process of ¿High-Ta medium-RRR cavity¿ made by KEK-CFF and result of vertical test.

TUPB030 **Hydroforming SRF Cavities from Seamless Niobium Tubes for ILC**

Masashi Yamanaka, Takeshi Dohmae, Hitoshi Inoue, Hirotaka Shimizu, Kensei Umemori (KEK, Ibaraki), Andy Hocker (Fermilab, Batavia, Illinois), Tsuyoshi Tajima (LANL, Los Alamos, New Mexico), Noriyuki Abe, Hiroaki Masui, Tomohiro Nagata, Seiichi Shinozawa (ULVAC, Inc, Chiba)

We are developing the manufacturing method for superconducting radio frequency (SRF) cavities by using a hydroforming instead of using conventional electron beam welding. We expect higher reliability and reduced cost with hydroforming. For successful hydroforming, high-purity seamless niobium tubes with good formability as well as advancing the hydroforming technique are necessary. Using a seamless niobium tube from ATI Wah Chang, we were able to successfully hydroform a 1.3 GHz three-cell TESLA-like cavity and obtained an Eacc of 32 MV/m. Moreover, KEK and ULVAC are collaborating the development of seamless niobium tube in Japan. Using a prototype seamless niobium tube from ULVAC, we were able to successfully hydroform a 1.3 GHz one-cell TESLA-like cavity and obtained an Eacc of 40 MV/m.

TUPB031 **Development of a Compact Deflecting Cavity at IHEP**

Jianping Dai, Baichu Ni, Jiyuan Zhai, Jingru Zhang (IHEP, Beijing), Guan Shu (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences, Beijing)

For the XFEL project proposed by the Institute of High Energy Physics (IHEP), a sophisticated beam spreader is required to separate a single beam into multiple beams. One of the deflecting cavities used in the spreader has been developed. It is a 325MHz, compact RF-dipole superconducting cavity, with the transverse R/Q of 2907W, geometrical factor G of 88.5 Ω, and the pressure sensitivity df/dp of -1.7 Hz/mbar. This paper presents its design, fabrication, post-processing and vertical test result.

TUPB032 **Study on 650MHz Prototype Cavities at IHEP**

Song Jin, Jie Gao, Dianjun Gong, Zhenchao Liu, Peng Sha, Jiyuan Zhai, TongXian Zhao, Hongjuan Zheng (IHEP, Beijing)

After the discovery of Higgs boson in 2012, a Circular Electron Positron Collider (CEPC) was proposed. In 2015, the CEPC Preliminary Conceptual Design Report was published and pointed that the 650 MHz 5-cell SRF cavity could be a candidate for the main ring of the single-ring pretzel scheme at the Higgs energy. On the other hand, further studies showed that a 650 MHz 2-cell cavity would be a better choice for the double ring or partial double ring with the crab waist scheme at the Higgs, W and Z energy. The EM design of 5-cell and 2-cell cavities were published respectively. Study on the fabrication of a 5-cell with waveguide HOM couplers for higher cavity HOM power and a 2-cell prototype cavities were carried on at IHEP. In the paper, we will mainly report the mechanical design and fabrication progress of the two prototypes. Challenges and possible solutions for the prototypes development will also be discussed.

TUPB033 **Tests of the High Current Slotted Superconducting Cavity With Extremely Low Impedance**

Zhenchao Liu, Jie Gao, Feisi He, Song Jin, Zheng Hui Mi, TongXian Zhao, Hongjuan Zheng (IHEP, Beijing), Fang Wang, Dehao Zhuang (PKU, Beijing)

Slotted superconducting cavity is a novel structure with extremely low impedance and high BBU threshold. It can be used in various high current applications. A 1.3 GHz 3-cell slotted superconducting cavity was designed and tested. The room temperature test results show the cavity has an extremely low impedance. The vertical test results show the cavity gradient can reach several MV/m, but it was limited by the test end group made of steel.

TUPB034 **The 166.6 MHz Proof-of-Principle SRF Cavity for HEPS-TF**

Pei Zhang, Jin Dai, Xuerui Hao, Tong-Ming Huang, Zhongquan Li, Haiying Lin, Qiang Ma, Fanbo Meng, Zheng Hui Mi, Weimin Pan, Yi Sun, Guangwei Wang, Qunyao Wang, Xinying Zhang (IHEP, Beijing)

The 166.6 MHz superconducting RF cavities have been proposed for the High Energy Photon Source (HEPS), a 6 GeV kilometer-scale light source. The cavity is of quarter-wave type made of bulk niobium with beta =1. Each cavity will be operated at 4 K providing 1.2 MV accelerating voltage and 145 kW of power to the electron beam. During the HEPS - Test Facility (HEPS-TF) phase, a proof-of-principle cavity of 166.6 MHz has been designed in IHEP and manufactured in Beijing. The subsequent BCP was conducted in Ningxia, while HPR, cleanroom assembly and 120 degree baking was done in IHEP. The cavity was finally vertical tested at both 4K and 2K in IHEP. The cavity Q0 at nominal gradient at 4 K was measured to be 2.4e9 with Epeak of 42 MV/m and Bpeak of 65 mT. The maximum Epeak and Bpeak reached 86MV/m and 131 mT respectively at both 4 K and 2 K, and the corresponding Q0 was measured to be 5.1e8 (4 K) and 3.3e9 (2 K). The residual surface resistance was measured to be 2.3 nOhm.

TUPB035 **Frequency Pre-tuning of the 166.6 MHz Proof-of-Principle SRF Cavity for HEPS-TF**

Pei Zhang, Xuerui Hao, Zhongquan Li, Xinying Zhang (IHEP, Beijing)

A 166.6 MHz proof-of-principle SRF cavity has been designed for the High Energy Photon Source - Test Facility (HEPS)

at IHEP in Beijing. The cavity is a beta=1 quarter-wave resonator made of bulk niobium operating at 4 K. A pre-tuning scheme was made to accommodate the cavity frequency shift mainly due to mechanical tolerances during cavity production, the subsequent surface treatment and cooldown process. To this end, the length of the cavity outer conductor was chosen as a free parameter for the pre-tuning. The cavity frequency was carefully monitored during the production, post-processing steps and vertical test. The measurement results agree well with our calculations. It is worth noticing that the pre-tuning method only involves one-time measurement of the cavity resonant frequency and its outer conductor length.

TUPB036 **R&D of CEPC Cavity**

Peng Sha (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences, Beijing), Baiqi Liu, Zheng Hui Mi, Jiyuan Zhai, Hongjuan Zheng (IHEP, Beijing)

In the recent decades, Superconducting cavities have been widely used to accelerate electron, positron, and ions. Most SRF cavities are made from bulk niobium till now, which has developed fast in the past years and is hard to advance more. Take 1.3 GHz 9-cell cavity for example, the quality factor (Q) can keep above 1e10 when the accelerating field (Eacc) reach 40 MV/m, which nearly touch the theoretical limitation of Q and Eacc for bulk niobium. For CEPC, Q and Eacc should be increased significantly compared to now, which can reduce the cryogenic power and use fewer cavities. So new cavity techniques are being studied at IHEP, while Nitrogen doping (N-doping) has been adopted for CEPC SRF cavities in future [1]. It can increase Q by one time for 1.3 GHz 9-cell cavity, which have been adopted by Linac Coherent Light Source II (LCLS-II) at SLAC [2].

TUPB037 **The 166.6 MHz Proof-of-Principle SRF Cavity for HEPS-TF: Mechanical Design and Fabrication**

Xinying Zhang (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences, Beijing), Xuerui Hao, Zhongquan Li, Yi Sun, Guangwei Wang, Pei Zhang (IHEP, Beijing)

166.6 MHz superconducting RF cavities operating at 4.2 K have been proposed by IHEP for the high-energy photon source - test facility (HEPS-TF). The cavity is a quarter wave resonator with beam going through the cavity inner conductor. The cavity and its stiffness were designed and optimized to meet pressure safety requirement and to reduce frequency sensitivity due to helium pressure fluctuations. Tuning sensitivity was also simulated and validated by experiments. This paper reports the mechanical design and fabrication details of the first proof-of-principle cavity.

TUPB038 **Mechanical Design of the 650 MHz Superconducting RF Cavity for CEPC**

Xinying Zhang (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences, Beijing), Feisi He, Zheng Hui Mi, Peng Sha, Jiyuan Zhai (IHEP, Beijing)

The 650 MHz superconducting RF cavities have been proposed by IHEP for the Circular Electron-Positron Collider (CEPC). The major components are a 2-cell elliptical cavity, end groups, stiffness and helium vessel, which have been optimized to meet the design requirement. The Lorentz force detuning (LFD)，the sensitivity of resonance frequency to Helium pressure variations (df/dp) were the main goal of the optimization. Also detailed stress analysis and tuning performance of dresses cavity will be presented in this paper.

TUPB039 **Electropolishing of Niobium From Choline Chloride-based Ionic Liquid**

Qingwei Chu, Hao Guo, Yuan He, Lu Li, Pingran Xiong, Zhiming You, Shenghu Zhang (IMP/CAS, Lanzhou)

Niobium (Nb) was successfully electropolished from a green ionic liquid, choline chloride/urea deep eutectic solvent (DES). This paper was to investigate the influence of various electropolishing parameters, including electropolishing time, temperature and voltage, on the electropolishing rate, surface roughness, glossiness and microstructure of Nb. The result showed that the electropolishing parameters had a significant impact on the performance of Nb. Based on surface analysis by scanning electron microscope (SEM) and atomic force microscope (AFM), smooth Nb can be achieved under properly controlled conditions.

TUPB040 **Design and Optimization of Medium and High Beta Superconducting Elliptical Cavities for the CW Linac in CIADS**

Yulu Huang, Long Chen, Yongming Li (IMP/CAS, Lanzhou)

Superconducting technology is adopted in the main accelerating section of the CW Linac in China Initiative Accelerator Driven System (CIADS) to accelerate the 10 mA proton beam from 2.1 MeV up to 1.5 GeV. The high energy section of the superconducting linac is composed of two families of SC elliptical cavities with optimum beta 0.62 and 0.82 for the acceleration of proton beam from 178 MeV to 1.5 GeV. In this paper, the design and optimization of the 650 MHz medium and high beta elliptical cavities are discussed, including the RF design, multipacting analysis, high order modes (HOMs) analysis, generator RF power calculation, and the mechanical design.

TUPB041 **Design and Simulations of a Triple Spoke Cavity for the HIF Demo Facility**

Wei Ma (IMP/CAS, Lanzhou)

A design for a triple spoke type superconducting cavity for with β=0.314 and 325 MHz operation frequency is designed for the HIF Demo facility. The design and simulations of the triple spoke will be reported in this paper.

TUPB042 **Study of Medium Beta Elliptical Cavities for CADS**

Liangjian Wen, Yuan He, Yongming Li, Ruoxu Wang, Andong Wu, Shenghu Zhang (IMP/CAS, Lanzhou), Teng Tan (Temple University, Philadelphia)

The China Accelerator-Driven Sub-critical System (CADS) is a high intensity proton facility to dispose of nuclear waste and generate electric power. CADS is based on a 1.5 GeV, 10 mA CW superconducting (SC) linac as a driver. The high energy section of the linac is composed of two families of SC elliptical cavities which are designed with geometrical beta 0.63 and 0.82. In this paper, the 650 MHz = 0.63 SC elliptical cavity is studied, including cavity optimization, multipacting, a generator RF power calculation and mechanical design.

TUPB043 **Study on the Comparison of Hwr and Single Spoke Sc Cavities for the Medium Beta Section and CW Mode Operation**

Andong Wu, Yuan He, Tiancai Jiang, Yongming Li, Weiming Yue, Shenghu Zhang, Shengxue Zhang, Hongwei Zhao (IMP/CAS, Lanzhou)

In coaxial standing wave resonator families, the HWR and single spoke cavities are commonly chosen on the application of superconducting linear accelerators that especially for continuous wave mode, because of their simple structures for preparation and the reliable performance on operation. For understanding the RF property and the mechanical stability between HWR and single spoke, the comparison for them has been investigated on the cavity design. Two types of cavities were optimized to achieve the better RF parameters. And the mechanical structures, which including the stiff ribs and the helium vessels, were also designed to suit the requirements of fundamental RF frequency shifts that caused by the helium pressure fluctuations. In order to close the real operation condition, the normally external restrictions from the mechanical tuner, which have effective impacts on the stability, were investigated. Finally, a theoretical method that based on the elastic mechanics model was taken into evaluation and simulation for the comparison of HWR and single spoke cavities.

TUPB044 **Half-Wave Resonator Research and Development for C-ADS Injector**

Weiming Yue (IMP/CAS, Lanzhou)

Half-wave resonators are used for C-ADS injector at Institute of Modern Physics. Two types of HWR are built for this project. HWR010 are used for accelerate proton from 2.1MeV to 10MeV. Taper HWR015 is another type for accelerate proton from 10MeV to above 17MeV.

TUPB045 **Design of Superconducting Niobium Sputtered Quarter Wave Resonator at IMP**

Cong Zhang, Yuan He, Teng Tan, Shenghu Zhang (IMP/CAS, Lanzhou)

The Institute of Modern Physics aims to design and fabricate the niobium sputtered quarter wave resonator based on the copper substrate, in consideration of the improvement of the thermal and mechanical stability. In this paper, the RF and the mechanical design of the cavity has been presented.

TUPB046 **Experience on Large-grain Multi-cell Cavity Based on INFN-LASA Medium-Beta Design for the ESS**

Michele Bertucci, Andrea Bignami, Angelo Bosotti, Jinfang Chen, Paolo Michelato, Laura Monaco, Rocco Paparella, Daniele Sertore (INFN/LASA, Segrate (MI)), Carlo Pagani (Università degli Studi di Milano & INFN, Segrate)

INFN-LASA built a complete Medium Beta cavity, based on the ESS prototype design, with novel large-grain material sliced in sheets from an ingot provided by CBMM manufacturing experience. Design and fabrication are reported as well as results on the physical and chemical analyses performed on samples at different cavity production stages. Results from the cold tests performed are also summarized and critically discussed in view of future R&D activities

TUPB047 **Passband Modes Excitation Triggered by Field Emission in ESS Medium Beta Cavity Prototype**

Jinfang Chen, Michele Bertucci, Angelo Bosotti, Paolo Michelato, Laura Monaco, Rocco Paparella, Daniele Sertore (INFN/LASA, Segrate (MI)), Mohammad Eshraqi, Mats Lindroos, Saeid Pirani (ESS, Lund), Torsten Paul Åke Åkesson (Lund University, Lund), Carlo Pagani (Università degli Studi di Milano & INFN, Segrate)

During the first vertical test of ESS Medium Beta large-grain prototype cavity in INFN-LASA, a phenomenon of coexisting two passband-modes was observed -- 4π/6 mode was excited spontaneously during the power rise of 3π/6 mode. This phenomenon is most likely due to the field-emission electrons that transfer their energy gained from the 3π/6 mode to the 4π/6 mode. In this paper, we present the experimental results, the excitation mechanism and the related simulation results.

TUPB048 **INFN- LASA Medium Beta Cavity Prototypes for ESS Linac**

Daniele Sertore, Michele Bertucci, Andrea Bignami, Angelo Bosotti, Jinfang Chen, Paolo Michelato, Laura Monaco, Rocco Paparella (INFN/LASA, Segrate (MI)), Saeid Pirani (ESS, Lund), Carlo Pagani (Università degli Studi di Milano & INFN, Segrate)

INFN-LASA, in the framework of INFN contribution to the European Spallation Source, has developed, produced and tested 704.4 MHz Medium Beta (beta = 0.67) cavities. Mode separation and avoidance of HOM excitation by machine line frequencies have driven the cavity design. The production at the industry, also in view of the INFN in-kind contribution of series cavities, has been done ¿build-to-print¿ and we have implemented our own quality control process, based on our XFEL experience, from raw material to cavity ready for test. The cavities have been then cold tested in our upgraded Vertical Test Facility. In this paper, we report on our experience on the different phases of the cavity production and test processes.

TUPB049 **Design Study on the Superconducting HWR for Secondary Particle Generation at KOMAC**

Han-Sung Kim (KAERI, Daejon), Yong-Sub Cho, Jeong-Jeung Dang, Hae-Seong Jeong, Hyeok-Jung Kwon, Seunghyun Lee (Korea Atomic Energy Research Institute (KAERI), Gyeongbuk)

A 100-MeV proton linac has been operated since 2013 at KOMAC (Korea Multi-purpose Accelerator Complex) and provides the accelerated proton beam to various users from the research institutes, universities and industries. To expand the utilization fields of the accelerator, we have a plan to develop a secondary particle utilization facility including a pulsed neutron source and radio-isotope beam based on the 100-MeV linac. According to the preliminary analysis, the neutron yields can be increased by about 2.5 times if the incident proton beam energy increases from 100 MeV to 160 MeV. Therefore, we carried out design study on the SRF linac based on half-wave resonator to increase the proton beam energy. Baseline design parameters include 350 MHz operating frequency, 2 K operation temperature, and peak electric field and magnetic field less than 35 MV/m and 70 mT, respectively. The available space at existing accelerator tunnel was also taken into consideration. Details on the design study on the SRF linac based on HWR cavity for the secondary particle utilization facility at KOMAC will be given in this presentation.

TUPB050 **Design Considerations for Performance Upgrade of RAON SSR2 Superconducting Cavity**

Hyuk Jin Cha, Si-Won Jang, Eun-San Kim, Jun Young Yoon (Korea University Sejong Campus, Sejong)

The development of single spoke resonator type-2 (SSR2, beta=0.51 and f=325 MHz) for the RAON superconducting linac is in progress. The fabrication of a prototype having round end walls mitigating the disadvantages of a traditional flat-end-wall spoke cavity was finished and the cold testing is going on in Rare Isotope Science Project. However, a concern about multipacting barriers in a broad range still remains when we remind of the recent FNAL PIP-II literature. In this study, we present the electromagnetic and multipacting simulation results for SSR2 cavities with a slightly modified baseline design (round-end-wall cavity) and a balloon variant whose design was applied to the second SSR1 (beta=0.3 and f=325 MHz) prototype for significantly suppressing the unwanted multipactor near the operating acceleration gradient. Mechanical analyses for both SSR2 modelings will be also compared, including the resonant frequency sensitivity to the liquid helium fluctuation.

TUPB051 **Multipactor Discharge on the Trapped Modes in the Higher Order Mode Couplers**

Yaroslav Shashkov (MEPhI, Moscow)

During the design study of higher order modes (HOM) couplers for the harmonic superconducting 800 MHz cavity which is currently under the development in the framework of High-Luminosity Large Hadron Collider project several trapped modes at 260 and 320 MHz frequencies were detected. It was assumed that despite the low R/Q values these modes could create a problem for operation of cavity due to the multipacting discharge (MPD). To verify this assumption the calculations of MPD in program Multi-P and CST Particle studio were carried out.

TUPB052 **Higher Order Modes Damping in 9-Cell Superconducting Cavity with Grooved Beam Pipe**

Yaroslav Shashkov (MEPhI, Moscow)

This paper is focused on HOM damping in 9-cell superconducting cavities. We are considering HOM damping with the load located outside the 2K part of the accelerating cavity. The HOM propagation to the load will be realized with the grooved beam pipes. The end cells of the structure were modified in order to increase the damping efficiency of the trapped modes. The results of wakefield simulations are also presented. Several programs for automatisation of HOM identification and electrodynamic characteristics calculation were used.

TUPB053 **Lessons Learned from SPS RF-dipole Prototype Cavities for LHC HiLumi Upgrade**

Subashini Uddika De Silva, Jean Roger Delayen (ODU, Norfolk, Virginia), HyeKyoung Park (JLab, Newport News, Virginia)

The rf-dipole cavity has successfully demonstrated the principles of using a compact cavity operating in TE11-like mode to generating a transverse gradient. Several proof-of-principle rf-dipole cavities have been fabricated and rf tests have achieved high transverse gradients. The rf-dipole geometry has been adapted into a squared-shaped geometry designed to meet the dimensional constraints for the LHC also maintaining crabbing in both horizontal and vertical planes. Recently, two prototype rf-dipole cavities intended for the test at SPS for have been completed that is designed to accommodate the FPC and HOM dampers. The performance during the rf tests have shown excellent results on achieving the design requirements of operating for the crab cavities for SPS. This paper presents the experience and lessons learned during the cavity preparation and testing, including process validation, frequency tracking.

TUPB054 **RF Test of RF-Dipole Prototype Crabbing Cavity for LHC High Luminosity Upgrade**

Subashini Uddika De Silva, Jean Roger Delayen (ODU, Norfolk, Virginia), HyeKyoung Park (JLab, Newport News, Virginia)

The superconducting rf-dipole crabbing cavity is one of two crabbing cavity designs proposed for the LHC high luminosity upgrade. The proof-of-principle rf-dipole cavity operating at 400 MHz has demonstrated excellent performance exceeding the design specifications. The prototype cavity for SPS beam test has been designed to include the fundamental power coupler, HOM couplers, and all the ancillary components intended to meet the design requirements. The crab cavities are expected to be installed in the SPS beam line prior to the installation in LHC; this will be the first crabbing cavity operation on a proton beam. The fabrication of two prototype rf-dipole cavities is currently being completed at Jefferson Lab. This paper presents the details on cavity processing and cryogenic test results of the rf-dipole cavities.

TUPB055 **Nb3Sn Thin Film Deposition On Copper By DC Magnetron Sputtering**

Weiwei Tan, Boting Li, Xiangyang Lu, Li Xiao, Datao Xie, Deyu Yang, Yujia Yang, Ziqin Yang, Jifei Zhao (PKU, Beijing)

Nb3Sn for SRF cavities has been coated on copper samples by DC magnetron Sputtering. Pure Nb target and pure Sn target were installed separately in the magnetron sputtering device. Nb3Sn precursor was coated on copper in the Ar atmosphere of 0.5 Pa. The Nb3Sn precursor was annealed in the vacuum furnace whose pressure is 10^(-4) Pa. The XRD results demonstrate the exist of Nb3Sn crystal, and MPMS results show superconductivity of Nb3Sn. The highest critical temperature obtained is 15K.

TUPB056 **Test Result of a Low Beta High Current Taper Type Superconducting Half Wave Resonator for BISOL**

Feng Zhu, Liwen Feng, Shengwen Quan, Fang Wang, Hutianxiang Zhong (PKU, Beijing)

Beijing isotope separation on line type rare ion beam facility (BISOL) for both basic science and applications is a project proposed by China Institute of Atomic Energy and Peking University. Deuteron driver accelerator of BISOL would adopt superconducting half wave resonator (HWR) with low beta and high current. For pre-research of BISOL, a β=0.09 162.5 MHz taper type HWR cavity has been designed for accelerating deuteron beam with several tens of mA. The Design, fabrication and vertical test of the HWR cavity will be presented in this paper.

TUPB057 **Symplectic Modeling of Beam Loading in Electromagnetic Cavities**

Dan Tyler Abell, David Leslie Bruhwiler, Nathan M. Cook, Stephen Davis Webb (RadiaSoft LLC, Boulder, Colorado)

Simulating beam loading in radiofrequency accelerating structures is critical for understanding higher-order mode effects on beam dynamics, such as beam break-up instability in energy recovery linacs. Full wave simulations of beam loading in radiofrequency structures are computationally expensive, while reduced models can ignore essential physics and can be difficult to generalize. We present a self-consistent algorithm derived from the least-action principle which can model an arbitrary number of cavity eigenmodes and with a generic beam distribution.* It has been implemented in our new Open Library for Investigating Vacuum Electronics (OLIVE).**

TUPB058 **Analytical Study of Superconducting RF Cavity Detuning Compensation**

Faya Wang, Chris Adolphsen (SLAC, Menlo Park, California)

Superconducting linacs for XFELs and ERLs that operate CW can in princible have very narrow cavity bandwidths (BWs), which reduces the required RF power to minimum required for the current being accelerated. In practice, the cavity BW chosen is constrained by the microphonics level, that is, vibration and He pressure induced detuning of the cavities, which requires RF overhead to compensate. For LCLS-II, for example, the cavity half BW was chosen to be comparable to the maximum expected detuning. This makes stablizing the aceeleration field by controlling the RF drive power challenging, especially as tight gradient regulation is required (1e-4 level). As is typical, regulation will be achieved using Proportional-Integral (PI) feedback loops, which stablize the signals measured from probes of the cavity fields. In this paper, we present an analytical analysis of the feedback control in the presence of microphonics, and derive simple expressions for the gradient and phase stability achievable based on the loop gain parameters, electronic noise and the detuning spectrum. We also calulate the associated RF power overhead required.

TUPB059 **Parallel-feed SRF Accelerator Structures**

Paul B. Welander, Zenghai Li, Sami Tantawi (SLAC, Menlo Park, California)

Development of SRF accelerator technology that enables both higher gradient and higher efficiency is crucial for future machines. While much of the recent R&D focus has been on materials and surface science, our aim is to optimize the cavity geometry to maximize performance with current materials. The recent demonstration of a highly efficient parallel-feed NCRF structure at SLAC has served as a proof-of-concept. Applied to SRF, such a structure could dramatically reduce power consumption while boosting the achievable gradient. Instead of coupled elliptical cells, our structure employs isolated reentrant cells. To feed RF power to the cavities, each cell is directly coupled to an integrated manifold. The structure is made in two parts, split along the beam axis, which are then joined. Such a structure has been fabricated from bulk Cu and tested at SLAC -- designed for X-band, it operates at a record gradient of 130 MV/m. Adapting to SRF at 1.3 GHz and fabricating from Nb, such a cavity could achieve 60% lower RF loss and 30% higher gradient compared to the TESLA cavity. We will describe our simulations and propose an experimental roadmap for demonstrating this new SRF technology.

TUPB060 **Innovative Cryogenic Test Facility for Testing SRF Cavity Series Production**

Louis Bizel-Bizellot, Mike Ellis, Shrikant Pattalwar, Mark David Pendleton, Paul Anthony Smith, Alan Wheelhouse (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire)

Testing SRF cavities in a vertical cryostat is the first step in qualifying the performance of SRF cavities before being integrated into a cryomodule. The European Spallation Source (ESS) requires 84 high-beta 5 cells, 704 MHz cavities which will be manufactured and qualified for their RF performance in a vertical cryostat at Science and Technology Facility Council (STFC) Daresbury Laboratory (United-kingdom). Taking a conventional approach each vertical test would require a large cryostat demanding more than 7000 litres of liquid helium per test for testing 3 cavities simultaneously. In order to reduce the overall operating cost, we plan to develop an alternative method to divide the liquid helium consumption by 5 by filling liquid helium only in each individual helium vessels enclosing each cavity placed horizontally in the cryostat. Therefore the test is performed in more realistic conditions such as in a cryomodule and reduces the operating time. This also reduces the mass flow-rate to be handled by a factor 10, leading to 2 g/s, thus reducing the size of the associated components such as the 2 K pumps, the safety device, the valves and transfer lines.

TUPB061 **Superconducting Third Harmonic Cavity for Bunch Lengthening at SSRF**

HongTao Hou (SINAP, Shanghai), Zheng Li, JianFei Liu, Chen Luo, ZhenYu Ma, Jing Shi (SINAP, Shanghai; Shanghai KEY Laboratory of Cryogenics & Superconducting RF Technology, Shanghai)

A bunch lengthening superconducting cryomodule using a double-cell passive higher harmonic cavity (1500 MHz) is under development at SSRF. The higher harmonic cavity can be used to increase the beam Touschek lifetime, to improve the beam quality and to increase the single bunch current limit in the SSRF beam-line phase-II project. Because of the limited space and required upto 1.8 MV harmonic voltage, the module will be operated at super-fluid helium environment. A room temperature tuner will be adopted to adjust the frequency and two pairs of higher order modes (HOM) absorbers will be equipped at both ends of the beam pipes to damp the HOM power. The design including the simulation results of the cavity and the higher order modes will be discussed.

TUPB062 **SARAF Phase-I HWR Coupler Cooling Updated Design Test and Operation**

Jacob Rodnizki, Zvi Horvitz, Leonid Weissman (Soreq NRC, Yavne)

The Soreq Applied Research Accelerator Facility (SARAF) design is based on a 40 MeV 5 mA light ions Superconducting RF linac. Phase I of SARAF delivers up to 2 mA CW proton beam in an energy range of 1.5-4.5 MeV. The warming of the SARAF linac RF couplers was a limiting factor for reaching a higher CW beam power. Recently based on previous detailed mutual RF thermal simulations a simple solid design was adopted for the coupler cooling, based on multi flexible OFHC copper braids leading from the cold window to the 60 K thermal shield with an Apiezon N cryogenic thermal grease at the braids interface contacts. We apply this technique for five HWRs out of the 6 cavities of the Prototype Superconducting Module (PSM). The first HWR at the PSM is used as a rebuncher since in phase I we have a very short MEBT without a rebuncher. Due to the lower RF load this one was left with the old configuration. During the cooling phase the 5 cavities with the new cooling configuration were cooled in a significantly higher rate. Further the SARAF PSM couplers are now cooled during beam operation more efficiently with no significant heating of the cold couplers-max temperature below 80K.

TUPB063 **Fabrication and Test Results of a SRF Deflecting Cavity for the ARIEL eLinac**

Douglas W Storey, Robert Edward Laxdal, Ben Matheson, Norman Muller (TRIUMF, Vancouver)

A superconducting RF deflecting cavity has been designed and fabricated at TRIUMF to allow simultaneous beam delivery to both rare isotope production and an energy recovery linac. The 650 MHz cavity will operate in a TE-like mode in CW. The design has been optimised for high shunt impedance and minimal longitudinal footprint, reaching roughly

50% higher shunt impedance with 50% less length than comparable non-TM mode cavity geometries. Due to low power dissipation at 4K at the maximum required deflecting voltage of 0.6 MV, low cost manufacturing techniques have been employed in the construction of the cavity. These include the use of reactor grade Niobium and TIG welding in an inert atmosphere. Development of the manufacturing processes will be presented along with test results of the cavity.

TUPB064 **Operating Experience on Cavity Performance of ISAC-II Superconducting Heavy Ion Linac**

Zhongyuan Yao, Tobias Junginger, Alexey Nikolaevich Koveshnikov, Robert Edward Laxdal, Yanyun Ma, Douglas W Storey, Edward Thoeng, Bhalwinder Waraich, Vladimir Zvyagintsev (TRIUMF, Vancouver)

ISAC-II is a superconducting heavy ion linac with 40 QWRs as an extension of ISAC facility for ISOL based on radioactive ion beam production and acceleration. Phase-I with twenty 106MHz cavities has been operating since 2006. The design spec was achieved with the completion of Phase-II with another twenty 141MHz cavities in 2010. The cavity performance statistics and operating experience have been accumulated over years. This paper will summarize the operating experience on cavity performance of ISAC-II.

TUPB065 **Design of Multi-frequency Coaxial Test Resonators**

Zhongyuan Yao, Tobias Junginger, Robert Edward Laxdal, Ben Matheson, Bhalwinder Waraich, Vladimir Zvyagintsev (TRIUMF, Vancouver)

A significant issue in low beta resonators is medium field Q-slope (MFQS) at 4K. To study the MFQS and the field dependence of surface resistance in low beta resonators, a quarter-wave resonator (QWR) and a half-wave resonator (HWR) were designed to be tested at integer harmonic frequencies of 200MHz, and up to 1.2GHz. A series of chemistry and heat treatments will be applied to these cavities so that a systemic study on the surface resistance of the coaxial resonators associating with post-processing, RF field, and frequency can be done. The detail design of these cavities and the status of cavity fabrication will be reported in this paper.

TUPB066 **Development of HiPIMS Nb Film Deposition for SRF Cavities**

Matthew Burton, Rosa A. Lukaszew (The College of William and Mary, Williamsburg, Virginia), Ari Deibert Palczewski, Larry Phillips, Charles E. Reece (JLab, Newport News, Virginia)

Bulk Nb SRF cavities are the preferred method for acceleration of charged particles. However, bulk Nb cavities suffer from variable RF performance, high cost and impose material & design restrictions on other components of a particle accelerator. Since SRF is a shallow surface phenomena, a proposed solution is to deposit a Nb thin film on the interior of a cavity made of an alternative material such as Cu. While this approach has been attempted in the past, new energetic condensation techniques, such as High Power Impulse Magnetron Sputtering (HiPIMS), offer the opportunity to create Nb films with improved properties compared to traditional methods. To test HiPIMS, a study was performed in which Nb films were deposited on samples in multiple ¿series¿ where only one parameter (Ion Fraction, Condensation Energy¿etc.) is varied. Sample properties were then characterized using: XRD, AFM, SEM¿etc., and correlations made between deposition parameters and film properties. Nb films were then deposited on 1.3GHz Cu cavities at select parameter sets and RF tested. Here we present the results from the Nb film studies and correlate the sample properties to RF results of Nb/Cu cavities.

TUPB067 Insights into Formation of Nb3Sn Film During the Vapor Diffusion Process

Uttar Pudasaini (The College of William and Mary, Williamsburg, Virginia), Grigory V. Eremeev, Charles E. Reece (JLab, Newport News, Virginia), Michael Kelley (The College of William and Mary, Williamsburg, Virginia; JLab, Newport News, Virginia; Virginia Polytechnic Institute and State University, Blacksburg), James Tuggle (Virginia Polytechnic Institute and State University, Blacksburg)

The potential of Nb3Sn for SRF cavities is widely recognized and renewed R&D efforts continue to bring new insights about material structure and its properties. We have systematically coated niobium with Nb3Sn using "vapor diffusion" under varying coating conditions to elucidate the reaction of tin with niobium at the temperatures of interest. The analysis of the coated samples is revealing new understanding about the two-stage nucleation/deposition ("vapor diffusion") process that allows us to form a hypothesis regarding Nb3Sn formation mechanism. The essential aspect of nucleation is the deposition of a high coverage, nanoscale thin tin film with particle assemblage by decomposition of tin chloride on the niobium surface at temperatures sufficient for reduction of the thick niobium oxide film, usually at about 500℃. The deposition is followed by the reaction of tin from tin vapor with the niobium surface to form Nb3Sn at about 1200℃, where the surface and grain boundaries start to play key role in the formation process initiation and progression. These findings improve understanding of the Nb3Sn growth in the typical vapor diffusion process used for accelerator cavity coatings.

TUPB068 **SRF Cavity with On-Cell Waveguide Dampers**

Frank Marhauser, James Henry, Robert Rimmer, Shaoheng Wang (JLab, Newport News, Virginia)

We report on the progress towards an engineering design of a heavily higher-order-mode (HOM) damped single-cell SRF cavity for the Jefferson Lab Electron Ion Collider (JLEIC). The proposed design is an alternative concept to conventional, well-established HOM-damping schemes for accelerating SRF cavities since using on-cell waveguide dampers. We have looked into fabrication rationales to facilitate manufacturing with standard deep-drawing, port extrusion, and electron-beam-welding techniques. The use of on-cell dampers offers very efficient and broadband damping of the beam-induced wakefields in consideration of coupled-bunch instabilities in JLEIC¿s electron collider ring, which mandates a low cavity impedance budget. The peak surface magnetic fields arising at the cavity-waveguide intersections are sufficiently suppressed by design to meet the operating field requirements for JLEIC, which makes the concept also suitable for future high current machines, when only moderate field levels are required.

TUPB069 **Rigorous Data Processing and Automatic Documentation of SRF Cold Tests**

Karim Gibran Hernández-Chahín (CERN, Geneva; DCI-UG, León), Sarah Aull, Alick Macpherson, Juljan Nikolai Schwerg, Niall Stapley (CERN, Geneva)

Performance curves for SRF cavities are derived from primary quantities which are processed by software. In commonly used software such as Excel or LabView the mathematical implementation of this analysis is hidden, very difficult to verify or to trace while text-based programming like Python and MatLab require some programming skills for review and use. As part of an initiative to consolidate and standardise SRF data analysis tools, we present a Python program converting a module containing the collection of all commonly used functions into a LaTeX (PDF) document carrying all features of the implementation and allowing for a review by SRF experts not programmers. The resulting document is the reference for non-experts, beginners and test stand operators. As an additional layer of protection the functions are further wrapped including assertions, type and sanity checks. The module is imported in any subsequent processing steps as well as the test place software. This process maximises function reuse, reduces the risk of human errors and guarantees automatically validated and documented cold test results. The approach is demonstrated by means of a recent cold test.

TUPB070 **INFN-LASA Cavity Design for PIP-II LB650 Cavity**

Carlo Pagani (Università degli Studi di Milano & INFN, Segrate), Saeid Pirani (ESS, Lund), Michele Bertucci, Andrea Bignami, Angelo Bosotti, Jinfang Chen, Paolo Michelato, Laura Monaco, Rocco Paparella, Daniele Sertore (INFN/LASA, Segrate (MI))

INFN-LASA is going to join the international partnership for Fermilab PIP-II project and to provide a novel design for the 650 MHz cavity of the 0.61 beta linac section, plug compatible with the Fermilab Cryomodule design. This paper reports the cavity design features both from the electro-magnetic and mechanical aspects, with focus on the rationales at the basis of the choice of main parameters. Furthermore, the current plans for the future R&D activity are here reported, including the production of two single cells and two complete cavities.

TUPB071 **Test Result of 650 MHz, Beta 0.61 Single-Cell Niobium Cavity**

Sudeshna Seth, Pranab Bhattacharyya, Anjan Dutta Gupta, Surajit Ghosh, Aditya Mandal, Sumit Som (VECC, Kolkata), Michael Kelly, Thomas Reid (ANL, Argonne, Illinois), Anna Grassellino, Timergali N. Khabiboulline, Oleksandr Stepanovych Melnychuk, Shekhar Mishra, Thomas H. Nicol, Allan Rowe, Dmitri A. Sergatskov (Fermilab, Batavia, Illinois), Kishore Kumar Mistri, P. Prakash (IUAC, New Delhi)

VECC has been involved in the design, analysis and development of 650 MHz, beta 0.61 (LB650), elliptical Superconducting RF linac cavity, as part of research and development activities on SRF cavities and associated technologies under Indian Institutions Fermilab Collaboration (IIFC). A single-cell niobium cavity has been indigenously designed and developed at VECC, with the help of Electron Beam Welding (EBW) facility at IUAC, New Delhi. Various measurements, processing and testing at 2K in Vertical Test Stand (VTS) of the single-cell cavity was carried out at ANL and Fermilab, USA, with active participation of VECC engineers. It achieved a maximum accelerating gradient(Eacc) of 34.5 MV/m with Quality Factor of 2E9 and 30 MV/m with Quality Factor of 1.5E10. This is probably the highest accelerating gradient achieved so far in the world for LB650 cavities. This paper describes the design, fabrication and measurement of the single cell niobium cavity. Cavity processing and test results of Vertical Test of the single-cell niobium cavity are also presented.

TUPB072 **Investigation of BCP Parameters for Mastery of SRF Cavity Treatment**

Fabien Eozénou (CEA/DSM/IRFU,), Enrico Cenni, Guillaume Devanz, Thomas Proslier, Christophe Servouin (CEA/DRF/IRFU, Gif-sur-Yvette)

Mastery of Standard Buffered Chemical Polishing (with mixture of hydrofluoric, nitric and phosphoric acids) is of paramount importance for the treatment of SRF resonators with complex geometry has IFMIF half-wave resonators, in order to control accurately their frequency evolution. Furthermore, strong and unexpected asymmetry in removals has recently been observed after BCP treatment of ESS-medium beta resonators. The goal of this study is to investigate accurately influence of parameters such as surface geometry and orientation, acid temperature, agitation and their coupling

on the removal rate. We will also focus on the influence of by-products such has NOx on kinetics. The mixture used is HF(40%)- HNO3(65%)-H3PO4(85%) with ratio 1-1-2.4.

TUPB073 **Vertical Electro-polishing Collaboration Between Cornell, KEK, and Marui Galvanizing Co. Ltd**

Fumio Furuta (Cornell University (CLASSE), Ithaca, New York)

Cornell¿s SRF group, KEK, and Marui Galvanizing Co. Ltd (MGI) have collaborated since 2014 on Vertical Electro-Polishing (VEP) R&D as a part of a US/Japan Program for Cooperation in High Energy Physics. We have focused on an improvement of removal uniformity during the VEP process. MGI and KEK have developed their original VEP cathode named i-cathode Ninja®, which has four retractable wing-shape parts per cell. Cornell processed one single cell cavity with VEP using this cathode and performed a vertical test. KEK also provided one 9-cell cavity to Cornell. Cornell then performed surface treatments including Cornell VEP and RF test on this 9-cell cavity. The progress by the VEP collaboration and RF test results are presented in this paper.

TUPB074 **RF Performance of Multi-cell Scale Niobium SRF Cavities Prepared with HF Free Bipolar Electro-Polishing at Faraday Technology**

Fumio Furuta (Cornell University (CLASSE), Ithaca, New York)

Cornell¿s SRF group and Faraday Technology, Inc. have been collaborating on two phase-II SBIR projects. One of them is the development and commissioning of a 9-cell scale HF free Bipolar Electro-Polishing (BEP) system. Faraday Technology had completed the proof of principle on BEP with single cell scale prior to the work reported here, and has now developed a new 9-cell scale BEP system. Cornell has fabricated three single cell cavities and has assembled them together as a 9-cell scale test string. The 9-cell scale test string has received BEP at Faraday Technology and RF testing has been performed on the three single cell cavities one-by-one at Cornell. Here we give a status update on the new 9-cell scale BEP system commissioning and on results from RF tests of the BEP cavities.

TUPB075 **Vertical Electro Polishing of Superconducting Single and Multi Cell Gun Resonators**

Nicolai Steinhau-Kuehl, Ruediger Bandelmann, Steven Saegebarth, Manuela Schmoekel (DESY, Hamburg)

At DESY activities on surface treatment of superconducting SRF - gun cavity resonators at 1.3 GHz are ongoing. Due to the small opening on the endplate for insertion of cathodes, no reasonable acid flow can be realized with the existing set up for horizontal electro polishing. To benefit from electro polishing of Niobium surfaces, an adapter to the existing horizontal electro polishing bench at DESY is set up and under operation now. Vertical EP was applied on 1.3 GHz gun resonators with 1.6 and 3.5 cell geometry. Work flow, process conditions as well as test results of SRF - gun cavities treated so far at DESY will be reported.

TUPB076 **First High-Q Validation of Crab Cavities for String Assembly at CERN**

Alejandro Castilla, Alick Macpherson, Katarzyna Magdalena Turaj (CERN, Geneva), Ilan Ben-Zvi (BNL, Upton, Long Island, New York), Karim Gibran Hernández-Chahín (CERN, Geneva; DCI-UG, León), Nicholas Shipman (Cockcroft Institute, Lancaster), Agnieszka Zwozniak (IFJ-PAN, Kraków)

In order to reach the desired levelled luminosity of cm-2s-1 in the high luminosity upgrade of the LHC (HL-LHC) at CERN, it is necessary to use crab cavities to correct the geometrical degradation due to the crossing angles at ATLAS (vertical crossing), in the interaction point 1 (IP1), and at CMS (horizontal crossing), in the interaction point 5 (IP5). As part of Work package 4 (WP4) of the HL-LHC project, a cryomodule for testing with a proton beam in the SPS is currently under construction. Two bulk niobium double quarter wave cavities (DQW), for vertical crabbing, have been fabricated, processed, and tested for validation at CERN. In this paper, we present the rf surface preparation steps and summarise the results of the cryogenic tests performed in the vertical cryostat at the CERN-SM18 facility, for the DQW SPS prototypes cavities.

TUPB077 **Testing and Helium Processing of the UK 4-rod Crab Cavity**

Nicholas Shipman, Simon Barriere, Alejandro Castilla, Alick Macpherson, Katarzyna Magdalena Turaj (CERN, Geneva), Graeme Burt (Cockcroft Institute, Lancaster)

The 4 Rod Crab Cavity was designed as part of the HL-LHC project to mitigate the geometric luminosity loss which results due to the none-zero crossing angle of the particle beams. The results from the latest vertical cold test both before and after Helium processing are presented and compared with previous results. Before testing the cavity underwent a light BCP, heat treatment and high pressure rinse.

TUPB078 **SUBU Characterisation: Bath Fluid Dynamics vs Etching Rate**

Alejandra Perez Rodriguez, Leonel Marques Antunes Ferreira, Alban Sublet (CERN, Geneva)

The chemical polishing bath SUBU is widely used at CERN to prepare copper RF cavities surfaces before niobium thin film coating; examples are HIE-ISOLDE, LHC and future FCC accelerating cavities. The performance of the polishing process is affected by bath temperature and fluid dynamics. As part of on-going activities to characterise SUBU, the actual study was done to identify a correlation between the etching rate and physical parameters linked to the bath fluid dynamics. A first approach was made using experimental data from a simplified model setup, transposing them via numerical simulation to a real cavity geometry and verifying the agreement with an experiment in a real size (HIE-ISOLDE) mock-up. In a second approach to improve the accuracy of the calculation, the relation of the measured local etching rates, extracted from the mock-up, to flow dynamics quantities extracted from simulation was investigated. As a result, a correlation between the local etching rate and the turbulence kinetic energy was obtained. This correlation can be exploited to improve the polishing tools and so optimise the current process, as well as to predict the etching rate in other cavity geometries.

TUPB079 **Nitrogen Treatment of 3.9 GHz Niobium Superconducting RF Cavities at Fermilab**

Sebastian Aderhold (Fermilab, Batavia, Illinois)

Superconducting RF cavities made from niobium and operated at 3.9 GHz ¿the third harmonic of the common accelerator base frequency of 1.3 GHz¿ are e.g. in use at accelerators like FLASH and will be used for the European XFEL and LCLS-II, in order to improve the longitudinal phase space. Due to its dependency on the RF frequency, the BCS-part of the surface resistance is significantly higher for 3.9 GHz than for 1.3 GHz. The heat treatment under nitrogen atmosphere (nitrogen doping and nitrogen infusion) has proven effective to lower the surface resistance to unprecedented low values, but has mainly been applied to 1.3 GHz cavities so far. We present the results of applying nitrogen treatment on 3.9 GHz cavities, carried out at Fermilab.

TUPB080 **Plasma Processing R&D for LCLS-II**

Paolo Berrutti, Anna Grassellino, Martina Martinello (Fermilab, Batavia, Illinois), Marc Doleans, Sang-Ho Kim (ORNL, Oak Ridge, Tennessee), Daniel Gonnella, Marc Christopher Ross (SLAC, Menlo Park, California)

SRF cavities performance preservation is crucial, from vertical test to accelerator operation. Field emission is still one of the main problems to overcome and plasma cleaning has been proven successful by SNS, in cleaning field emitters and increasing the work function. A collaboration has been established between FNAL, SLAC and ORNL with the purpose of applying plasma processing to LCLS-II cavities, in order to minimize and overcome field emission without affecting the high Q of N-doped cavities. The recipe will follow the neon-oxygen active plasma adopted at SNS, allowing in-situ processing of cavities and cryomodules from hydrocarbon contaminants. A novel method for plasma ignition is under development at FNAL: a plasma glow discharge is ignited using high order modes to overcome limitations imposed by the fundamental power coupler. The results of a proof of principle experiment are presented for 1-cell and 9-cell LCLS-II cavity, along with plasma tuning studies. In addition the RF, vacuum system design and N-doped Nb samples studies are discussed.

TUPB081 **Processing and Preparation of Jacketed SSR1 Cavities for Horizontal Testing and Performance of Jacketed SSR1 Cavities in the Spoke Test Cryostat**

Mattia Parise (Fermilab, Batavia, Illinois)

The SSR1 cryomodule is a component of a new 800 MeV linac that will be built at Fermilab, as part of the proton Improvement Plan (PIP-II) Project, to enhance the capabilities of the existing accelerator complex. The first prototype SSR1 cryomodule is currently under construction at Fermilab and it includes 8 Superconducting Radio Frequency (SRF) accelerating cavities which comprise the SSR1 cavity string. In order to validate the design and meet the project requirements, the jacketed cavities undergo a series of cleaning processes and a final assembly, including the vacuum-end coupler, inside a class 10 (ISO4) cleanroom. After installation of a tuner, a horizontal test at 2 K inside the Spoke Test Cryostat (STC) is carried out. In this paper, the cleaning processes and specific cleanroom procedures that have been developed in order to reduce particle contamination, performed in preparation for horizontal testing of jacketed SSR1 cavities, will be described along with preliminary test results, showing gradient and Q0. Tuner performances will be also shown.

TUPB082 **Aid: Advanced Integrated Diagnostics for SRF Cavities**

Benedikt Schmitz, Khaled Alomari, Jens Knobloch, Julia Marie Köszegi, Oliver Kugeler, Yegor Tamashevich (HZB, Berlin)

The precise investigation of loss mechanisms in SRF cavities is the key to a comprehensive understanding of their limitations in both the quality factor and the accelerating gradient. The integrated measurement device AID has been developed in order to incorporate the most important measurement methods into one testing environment. AID combines temperature mapping in high absolute resolution as well as high resolution in time with a 3D mapping of the magnetic field around the cavity during both the superconducting phase transition and during operation. The system is completed by state of the art OST sensors and X-ray detectors. A 3D Helmholtz coil can be added to investigate different levels of flux trapping. The setup is designed modular and hence provides high flexibility. AID pushes the boundaries for the investigation of e.g. flux trapping and quenching mechanisms in existing niobium based technology and it also invites to characterize materials other than niobium.

TUPB083 **Post Processing of a 166MHz HEPS-TF Cavity at Institute of High Energy Physics (IHEP)**

Jin Dai (IHEP, Beijing)

IHEP upgraded a post-processing system in these years. A new Buffered Chemical Polishing (BCP) system have been developed in collaboration with Ningxia Orient Superconducting Technology Co., Ltd (OSTEC). A new ultra-pure water system and an upgraded High Pressure water Rinsing (HPR) system were also built and located in IHEP. A 166.6MHz HEPS-TF (High Energy Photon Source Test Facility) cavity has been treated under this post-processing system recently. The cavity reaches $E_{peak}=86.5$ MV/m and $B_{peak}=132.1$mT with $Q_0=5.1\times10^8$ at 4.2K RF test. The cavity was RF tested again at 2K, and reached $E_{peak}=85.5$ MV/m and $B_{peak}=131.1$mT with $Q_0=3.3\times10^9$.

TUPB084 **Progress of EP System Development at IHEP**

Song Jin, Jin Dai, Jie Gao, Dianjun Gong, Feisi He, Zhongquan Li, Zhenchao Liu, Peng Sha, Jiyuan Zhai, TongXian Zhao (IHEP, Beijing)

The Preliminary Conceptual Design Report of Circular Electron Positron Collider (CEPC) pointed that a high quality factor of cavities for CEPC main ring is required. N-doping was selected as a key technology under development at IHEP. However, for N-doping study, electropolishing (EP) is a critical procedure. So, we would like to build an EP system at IHEP. The main purpose for the setup is to treat 650MHz 2-cell cavities. Besides, we also hope that it could have the capability on 1.3GHz 9-cell cavities and 650MHz 5-cell cavities, which will also be depended on our funding. In this paper, we will mainly report the design and progress for the EP system. Several key points in the design will be also discussed.

TUPB085 **Quench Detection on Superconducting Cavity by Second Sound**

Zhenchao Liu, Jie Gao, Feisi He, Pei Zhang (IHEP, Beijing), Haiying Lin (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences, Beijing)

High gradient is very important for superconducting cavity, however it may be limited by quench on the cavity high field region. Quench can be caused by various reasons. To locate the position is the key to reveal the mysteries of quench. OST sensor was widely used to locate the quench position. Now we are developing the quench position detection system by RTD sensors such as Cernox. In this paper, we will show the design of the second sound system and testing results on the QWR cavity.

TUPB086 **Study on Local Chemical Treatment for Recovery From Surface Damage by HPR Process on SRF Cavities**

Hao Guo, Qingwei Chu, Yuan He, Lu Li, Pingran Xiong, Zhiming You, Shenghu Zhang (IMP/CAS, Lanzhou)

High pressure rinsing (HPR) with ultra-pure water (UPW) is the last step which is commonly used for SRF cavities cleaning. The serious surface damage will be caused due to the failure of the distance control between the jet and cavity surface or the breakdown of the jet rotation. The surface of taper HWR cavities which are used for CIADS project was damaged in HPR process. Two methods were used for surface recovery and the result will be presented in this paper.

TUPB087 **Low Temperature and Low Pressure Plasma for the HWR Superconducting Cavity In-situ Cleaning**

Andong Wu, Hao Guo, Yuan He, Chuanfei Hu, Tiancai Jiang, Chunlong Li, Yongming Li, Pingran Xiong, Lei Yang, Weiming Yue, Shenghu Zhang, Hongwei Zhao (IMP/CAS, Lanzhou), Fujun Gou (Sichuan University, Chengdu)

The glow discharge for low temperature and low pressures plasma were utilized for the half-wave resonator (HWR) superconducting cavity in-situ cleaning. The plasma was on ignition of the Argon/Oxygen mixture atmosphere, which was under the low pressure of 0.5 to 5.0 Pascal. Driven by the RF power with the frequency of the cavity fundamental mode, the plasma showed the typical characteristic of the typical RF glow discharge, which the temperature of the electrons about 1eV that diagnosed by the optical emission spectrum. The experimental parameters for the discharge were optimized to obtain the uniform plasma distribution on the HWR cavity, including the RF power, the atmospheric pressure and the oxygen proportion. At last, the vertical cryogenic test was completed to investigate the impact of active oxygen plasma cleaning on the HWR cavity performance recovery, which contaminated by hydrocarbons. The test proves that the glow plasma clean can relieve the x-ray radiation which caused by the field electron emission effect.

TUPB088 **Physics Research of the 1.3 Ghz Single-cell SRF Cavity in Plasma Processing**

Lei Yang (IMP/CAS, Lanzhou)

Surface treatment of SC cavities is a key procedure after manufacturing step in order to improve the Q factor and reach the goal of designed RF parameters in real operation. Up to now, the labs across the world have developed sundry surface processing methods such as HP, BCP, EP, and so forth. However, most processing methods including those mentioned above are limited when it comes to the situation calling for online processing. Plasma processing method has distinctive advantages over the other methods in dealing with such situation. IMP (institute of modern physics) is currently striving to develop plasma processing. Loads of experiments on plasma processing have already been conducted. We have made thorough analysis of the experimental results and have found some promising and exciting aspects.

TUPB089 **Helium Process for the Half Wave Resonator in IMP**

Weiming Yue (IMP/CAS, Lanzhou)

The project of the Chinese Accelerator Driven transmutation System started in 2011. The driven accelerator of C-ADS is a superconducting linac. The half wave resonator (HWR010) was used in the injector for accelerate proton from 2.1MeV to 10MeV. The superconducting cavities (HWR010) used in the injector for China ADS encountered very strong field emission when the coupler was leak last year. The coupler was replaced in the tunnel, and the helium processing was applied to suppress the field emission, this paper presents the results of the helium processing for the half wave resonators (HWR010). The performance of the HWR was recovered by use of helium process, by which the beam energy increased from 6.9MeV to 10.2MeV.

TUPB090 **Investigation of High Temperature Baking of Jacketed Quarter Wave Resonators**

Abhishek Rai, Dinakar Kanjilal, Kishore Kumar Mistri, Padmanava Patra, Prakash N Potukuchi, Somasundara Kumar Sonti (IUAC, New Delhi)

The Superconducting booster Linac at IUAC has been delivering accelerated beams for scheduled experiments since 2013. It has three accelerating modules with 8 Quarter Wave Resonators (QWR)in each. The QWRs for the first module were built at Argonne National Laboratory while those for the second and third modules have been built in-house. During the electropolishing of one of the indigenously built resonators (QWR # I03) the RF surface got spoiled due to a wrong acid mixture that was being used for etching. In subsequent cold tests of the cavity, its performance was poor (2.6 MV/m @ 4W). There was evidence of Q disease also, as the performance deteriorated further (~20%) when the cavity was held at 100-120K for ~8 hours .In an attempt to recover the cavity it was baked at 650 ℃ for 10 hours along with its stainless steel jacket. A series of tests were conducted thereafter wherein, a substantial improvement (factor of two) in the performance was observed. Encouraged with the results another QWR designed for a lower beta (beta=0.05) was also heat treated identically. This paper presents the different treatments followed to enhance the cavity performance vis-à-vis the test results.

TUPB091 **Study on Vertical Electropolising of 9-cell Niobium Coupon Cavity**

Vijay Chouhan, Yoshiaki Ida, Keisuke Nii, Takanori Yamaguchi (MGH, Hyogo-ken), Hitoshi Hayano, Shigeki Kato, Hideaki Monjushiro, Takayuki Saeki, Motoaki Sawabe (KEK, Ibaraki)

Authors report a study on vertical electropolishing (VEP) carried out for a 1.3 GHz 9-cell niobium (Nb) coupon cavity using a unique cathode namely ¿Ninja Cathode¿. The design of the cathode for VEP of a 9-cell cavity was based on the Ninja cathode used for 1-cell cavity since the 1-cell Ninja cathode was found effective to reduce longitudinal asymmetry in material removal and to obtain a smooth surface of a 1-cell cavity. Moreover, 1-cell Nb cavities after being treated in VEP using the Ninja cathode showed good performance in vertical RF tests. The 9-cell coupon cavity used in this study was designed to have totally nine coupons set on the iris and equator positions of the first, fifth and ninth cells. These three cells contain viewports as well at their upper and lower iris positions. Measurement of currents from the individual coupons and in-situ observation are possible using the cavity to understand EP phenomenon at different locations of the cavity. VEP results, which include removal thicknesses at different positions of the cavity and surface study of the coupons, are discussed.

TUPB092 **Analysis of Niobium Surface and Generated Particles in Vertical Electropolishing of 1-Cell Coupon Cavity**

Vijay Chouhan, Yoshiaki Ida, Keisuke Nii, Takanori Yamaguchi (MGH, Hyogo-ken), Hitoshi Hayano, Shigeki Kato, Hideaki Monjushiro, Takayuki Saeki, Motoaki Sawabe (KEK, Ibaraki)

In our previous studies, we have reported parameter investigation for vertical electropolishing (VEP) of 1-cell niobium (Nb) tesla/ILC type cavities using a Ninja cathode. A 1-cell coupon cavity containing six Nb disk coupons at its different positions was found effective to reduce time and cost to establish an optimized VEP recipe. In this work, we present surface analyses of VEPed Nb coupon surfaces using scanning electron microscope (SEM), energy dispersive x-ray spectroscopy (EDX) and x-ray photoelectron spectroscopy (XPS). Surfaces contained micro- and nano-sized particles which were found with random distributions and different number densities on the beam pipe and iris coupons. Surfaces of equator coupons were found to have relatively less number of particles or almost clean. To analyze particles, a few particles were picked-up from a coupon surface using a tungsten tip under SEM and analyzed with EDX while the coupon was moved out from the SEM chamber to avoid its effect in EDX spectra. The particles were confirmed as oxygen-rich niobium and contained fluorine and carbon also. XPS analysis of the coupon surfaces was also carried out for further study of surface chemistry.

TUPB093 **Nb Single-cell Cavity Vertical Electro-polishing with Ninja Cathode and Evaluation of its Accelerating Gradient**

Keisuke Nii, Vijay Chouhan, Yoshiaki Ida, Takanori Yamaguchi (MGH, Hyogo-ken), Fabien Eozénou, Christophe Servouin (CEA/DSM/IRFU,), Pol Carbonnier, Yves Gasser, Luc Maurice (CEA/IRFU, Gif-sur-Yvette), Hitoshi Hayano, Shigeki Kato, Hideaki Monjushiro, Takayuki Saeki, Motoaki Sawabe (KEK, Ibaraki)

Marui Galvanizing Co. Ltd. has been improving Vertical Electro-Polishing (VEP) technology for Nb superconducting RF cavity in collaboration with KEK. In this collaboration, we developed a unique cathode namely Ninja cathode for VEP treatment of Nb cavities. We have already reported that longitudinal symmetry in niobium removal and surface state of a single cell cavity were improved after VEP using the Ninja cathode. In this article, we report a result of accelerating gradient evaluation for 1.3 GHz single cell RF cavity after VEP with Ninja cathode in collaboration with KEK and CEA Saclay.

TUPB094 **Resolving High Field Q-slope in Buffered Chemical Polishing**

Didi Luo, Kenji Saito, Safwan Shanab (FRIB, East Lansing)

SRF niobium cavities must undergo polishing after cavity fabrication to get smooth and pure Nb surface, which is crucial for achieving high quality cavities with high Q and high gradient. The two major polishing methods are Buffered Chemical Polishing (BCP) and Electrical Polishing (EP). EP usually results in better cavity performance in comparison with BCP, because EP-ed cavities have smoother Nb surfaces and can completely recover from High-Field-Q-Slop (HFQS) via 120 C degree baking. On the other hand, BCP-ed cavities still suffer from HFQS even after the low temperature baking. However, many institutes are still using BCP because it is much easier to implement. In this paper, we will analyze the root cause of HFQS in BCP-ed cavities, and propose a new BCP method to eliminate the HFQS.

TUPB095 **Modeling the Hydroforming of a Large Grain Niobium Tube With Crystal Plasticity**

Aboozar Mapar (MSU, East Lansing, Michigan), Thomas R. Bieler (Michigan State University, East Lansing, Michigan), Farhang Pourboghrat (Ohio State University, Columbus, Ohio)

Current SRF cavities are made from fine grained polycrystalline niobium half-cells welded together. Hot spots are commonly found in the heat-affected zone, making seamless hydroformed cavities attractive. Large grain cavities usually perform as well as fine grain cavities, often having a higher Q, presumably due to fewer grain boundaries. Large grain Nb forms non-uniformly, which introduces problems in manufacturing. A model that could realistically predict the deformation response of large grain Nb could facilitate the design of large grain hydroformed tubes. To this end, a crystal plasticity model was developed and calibrated with tensile stress-strain data of Nb single crystals. A seamless large grain tube was made from rolling a fine grain sheet into a tube, welded, and heat treated to grow large grains. The heat treatment resulted in a large grain tube with a single grain orientation in the center. The tube was hydroformed until it cracked. The hydroforming process was simulated with the crystal plasticity model, which was able to predict the deformed shape of the tube, the location of the crack and other localized areas with heterogeneous strain.

TUPB096 **MHI-MS's Production Activities of Superconducting Cavity**

Akihiro Miyamoto, Hiroshi Hara, Katsuya Sennyu, Takeshi Yanagisawa (MHI-MS, Kobe)

Mitsubishi Heavy Industries Mechatronics Systems(MHI-MS) has developed manufacturing process of superconducting cavitis for a long time. In this presentation, recent progress will be reported.

TUPB097 **R&D of Electro-Polishing (EP) Process with HF-free Neutral Electrolyte by Bipolar-pulse (BP) Method**

Junji Taguchi, Toshiyuki Nakajima (Nomura Plating Co, Ltd., Osaka), Hitoshi Hayano, Takayuki Saeki (KEK, Ibaraki), Satoru Kakudo, Masanori Kunieda (The University of Tokyo, Tokyo)

Currently the Electro-Polishing (EP) process of Superconducting Radio-Frequency (SRF) accelerating cavity is performed with the electrolyte that is the mixture of hydrofluoric and sulfuric acids. However, the electrolyte is very dangerous and the environmental load in the disposal process of electrolyte is very heavy. This is the reason why the high cost is necessary in the safe design of facility and the safe operation of process in the conventional EP method. In such situation, considering the reduction of cost and environmental load in the EP process, we performed the R&D of novel EP process with HF-free neutral electrolyte by Bipolar-Pulse (BP) method. In this presentation, we will report the removal rate, surface roughness and the results of surface analysis for the Nb-coupon samples that were processed by the BP-EP with HF-free neutral electrolyte.

TUPB098 **The Effect of Process Parameters on the Surface Roughness of Niobium During Plasma Etching**

Jeremy Peshl, Svetozar Popovic, Leposova Vuskovic (ODU, Norfolk, Virginia), Anne-Marie Valente-Feliciano (JLab, Newport News, Virginia), Janardan Upadhyay (LANL, Los Alamos, New Mexico)

We have shown that plasma etching using an electronegative Ar/Cl2 discharge can effectively remove surface oxide layers on Nb samples as well as bulk Nb from single cell SRF cavities*. With accelerating fields on the order of wet etching processes and a decrease in field emission the use of plasma assisted etching for bulk Nb processing is a worthwhile endeavor. We are presenting the surface roughness properties of plasma etched Nb. Cavity grade Nb coupons were made by water jet cutting, and then polished to achieve surface roughness equivalent to electropolishing (<1 micron). The coupons were plasma etched while process parameters (rf power, gas pressure, temperature and DC bias voltage) are varied. These samples are placed on the inner surface of the cylindrical cavity to be etched. The experimental setup is similar to the single cell cavity plasma etching setup. Each sample is weighed and scanned before and after plasma processing with an AFM, SEM, and digital optical microscope that provide both atomic composition and surface roughness profiles. Comparing the scans allows us to make conclusions about the effect of each parameter on the surface roughness.

TUPB099 **Vertical Test System for Superconducting RF Cavities at Peking University**

Dejun Zhou, Jia-er Chen, Wei Cheng, Liwen Feng, Jiankui Hao, Lin Lin, Kexin Liu, Shengwen Quan, Fang Wang, Huamu Xie, Feng Zhu, Dehao Zhuang (PKU, Beijing)

A new vertical test system (VTS) for superconducting RF cavities has been designed and constructed at Peking University. This facility is designed to operate at a temperature of 2K and with pumping speed of 10g/s for helium gas at 30 mbar. In this paper, we present the structure design, modification of 2K system, ambient magnetic field and radiation shielding, LLRF and the test run of this VTS.

TUPB100 **Determining BCP Etch Rate and Uniformity in High Luminosity LHC Crab Cavities**

Thomas Joseph Jones (Lancaster University, Lancaster; STFC/DL, Daresbury, Warrington, Cheshire), Silvia Verdu-Andres (BNL, Upton, Long Island, New York), Ofelia Capatina, Leonel Marques Antunes Ferreira (CERN, Geneva), Graeme Burt (Cockcroft Institute, Lancaster)

The compact SRF Crab Cavities required for HL-LHC have complex geometries making prediction of average and local BCP etch rates a difficult task. This paper describes a series of experiments and simulations used to determine the etch uniformity and rate within these structures. An initial experiment was conducted to determine the correlation between etch rate and flow rate in a Nb tube. These results were then incorporated into Computational Fluid Dynamics simulations of acid flow in the Double Quarter Wave (DQW) cavity to predict etch rates across the surface and allow optimisation of the BCP setup. There were several important findings from the work; one of which is that the flow rate in the relatively large body of the cavity is predominantly driven by natural convection due to the exothermic reaction. During BCP processing of the DQW cavity a significant difference in etching was observed between upper and lower horizontal surfaces which was mitigated by etching in several orientations. Two DQW cavities manufactured by CERN have received a heavy BCP of 200 µm followed by 2 light BCPs of 30 µm each with subsequent vertical cold tests showing performance exceeding specification.

TUPB101 **Development of Plasma Ignition Methodology for 9-cell 1.3 GHz SRF Cavity**

Puneet Veer Tyagi (STFC/DL, Daresbury, Warrington, Cheshire), Philippe Goudket, Andrew Moss, Shrikant Pattalwar, Reza Valizadeh (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire)

Field emission is one of the major issues in SRF cavities and can degrade the accelerating gradient of the cavities during operation. The contaminants present at top surface of the SRF cavity can emit electrons under the presence of accelerating field of the cavity and limit cavity performance. Plasma based surface processing can be a viable option to clean SRF cavity surface and enhance their performance especially for in-situ applications. These days, 1.3 GHz nine-cell SRF cavity has become baseline standard for many particle accelerators, it is of an interest to develop plasma cleaning technique for such SRF cavities. In the development of the plasma processing technique for SRF cavities, the most challenging task is to ignite and tune the plasma in different cells of the SRF cavity. At Daresbury laboratory, UK, we have successfully developed and demonstrated plasma ignition methodology for nine-cell 1.3 GHz SRF cavities. The plasma ignition methodology is developed to work at room temperature for cleaning of the SRF cavity surface which can be applied as an in-situ. Here, we report the successful demonstration of the plasma ignition methodology for 1.3 GHz nine cell SRF cavity.

TUPB102 **CVD Deposition of Nb3Ge and Nb3Sn for SRF Cavities**

Reza Valizadeh, Adrian Hannah, Oleg B. Malyshev (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire), Paul Chalker, Paolo Pizzol (The University of Liverpool, Liverpool)

Advancements in technology have taken bulk niobium close to its theoretical operational limits, pushing the research to

explore novel materials, such as niobium based alloys. A15 compounds offer such an alternative, exhibiting both higher Tc and higher Hc2 compared to bulk niobium. Replacing then the niobium with a material with better thermal conductivity, such as copper, coated with superconductive thin films of A15 compounds would lead to improved performance at reduced cost. Physical vapour deposition (PVD) is currently used to produce these coatings, but it suffers from lack of conformity. This issue can be resolved by using chemical vapour deposition (CVD) and plasma enhanced chemical vapour deposition (PECVD), which are able to produce high quality coatings over surfaces with a high aspect ratio. This project explores the use of PECVD / CVD techniques to deposit the A15 compounds Nb3Sn and Nb3Ge starting from their chlorinated precursors. The samples obtained are characterized via SEM, TEM, SAD, XRD, XPS, and EDX as well as assessing their superconductivity characteristics (RRR and Tc).

TUPB103 **Pulsed DC Magnetron Sputtering of Thin Films for Superconducting RF Cavities**

Reza Valizadeh, Adrian Hannah, Oleg B. Malyshev, Shrikant Pattalwar (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire), Boris Chesca (Loughborough University, Loughborough, Leicestershire), Stuart Wilde (Loughborough University, Loughborough, Leicestershire; STFC/DL/ASTeC, Daresbury, Warrington, Cheshire)

In the pursuit of achieving higher accelerating gradient and at the same time lowering the cost of both cryogenic operation and material cost of producing superconducting cavity, there has been concerted effort to study Nb thin films and Nb alloys with higher transition temperature Tc for application to SRF cavities. The use of high Tc superconductor (NbTiN) in an alternative superconductor and insulating layer (SIS), provides the magnetic screening of the thick layer superconductor (Nb) without vortex penetration. In this paper we report the superconducting properties (Tc, RRR, Hfp) of NbTiN synthesized with pulsed Dc magnetron deposition at elevated temperature with both dual and alloy target in partial pressure of both N2 and NH3 in single (NbTiN) and multilayer (Nb/AlN/ NBTIN) structure on sapphire and copper substrate. The film, are characterized using High Resolution Scanning Electron Microscope (HRSEM), X-ray Diffraction (XRD), Rutherford Back Scattering Spectroscopy (RBS), four point probe and Dc field penetration probe.

TUPB104 **Characterisation and Optimal Use of a Choked Test Cavity for SRF Thin Films Analysis**

R*eza Valizadeh, Philippe Goudket, Oleg B. Malyshev, Ninad Pattalwar, Shrikant Pattalwar (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire), Graeme Burt (Cockcroft Institute, Warrington, Cheshire; Lancaster University, Lancaster), Lewis Gurran (Lancaster University, Lancaster; STFC/DL/ASTeC, Daresbury, Warrington, Cheshire)*

A test cavity that uses RF chokes, rather than a physical seal, to contain the field is a promising method of SRF sample testing ¿ especially in thin films research where the rate of sample production far outstrips that of full SRF characterisation. Having the sample and cavity physically separate eliminates the need for skilled labour and specialist equipment to change samples - major causes of low throughput rate and high running costs for other test cavities - and also allows direct measurement of the RF power dissipated in the sample via power calorimetry. Choked test cavities operating at 7.8 GHz - one version with two RF chokes, another with three - have been designed by members of the Cockcroft Institute, and manufactured by Niowave*. The unconventional geometry of the cavity has made it unexpectedly challenging to reliably generate a suitable signal for two-probe SRF testing, i.e. a clear and symmetric resonance peak measured between two weakly coupled probes. An in-depth theoretical and experimental investigation has been made into the optimal cavity setup, and its key points are presented here along with any results from initial cold testing.

TUPB105 **Commissioning of Nb3Sn Multicell Cavity Coating System at JLab**

Grigory V. Eremeev, Kurt Macha, Charles E. Reece, Anne-Marie Valente-Feliciano (JLab, Newport News, Virginia), Uttar Pudasaini (The College of William and Mary, Williamsburg, Virginia)

Following encouraging results with Nb3Sn-coated single-cell cavities, the existing coating system was upgraded to allow for Nb3Sn coating of CEBAF accelerator cavities. System upgrade and the first results with coated cavities will be presented.

TUPB106 **Standardized Beamline Particulate Characterization Analysis: Initial Application to CEBAF and LCLS-II Cryomodule Components**

Charles E. Reece, Joshua K. Spradlin, Olga Trofimova, Anne-Marie Valente-Feliciano (JLab, Newport News, Virginia)

Despite continuously evolving efforts to minimize particulates in operational SRF accelerator systems, the presence of electron field emission from contaminating particulates on SRF surfaces with high surface electric fields remains a challenge. Jefferson Lab has recently initiated a standardized particulate sampling and characterization practice in order to gain more systematic knowledge of the particulates actually present. It is expected that patterns that emerge from such sampling will strengthen source attribution and guide improvement efforts. Initial samples were gathered from a cryomodule and adjoining warm girders removed from the CEBAF tunnel for reprocessing. The collection and analysis techniques were also used to characterize particulates on the inside of LCLS-II string components. Samples are transferred to clean industry-standard forensic GSR carbon tape spindles and examined via automated cleanroom SEM scanning for particle localization and sizing. The particulates are subsequently analyzed with EDS for elemental composition. A

catalogue of particle types is being accumulated. The methods used and results obtained from these initial applications will be presented.

TUPB107 **Analysis of Pulse-reversed Electropolishing Parameters for Nb**

Hui Tian, John Musson, Larry Phillips, Charles E. Reece (JLab, Newport News, Virginia)

As an alternative Nb SRF cavity surface treatment, pulse-reversed Electropolishing, uses non-HF electrolyte, such as H2SO4, Alkaline and other non- HF solution as electrolyte. It utilizes anodic electrical pulses to grow an Nb oxide layer on the surface and cathodic pulses to strip that oxide off. Pulse reversed electropolishing process has demonstrated its success for Nb SRF cavity. This surface treatment process not only eliminates the use of HF and high concentration of H2SO4 , which are environmentally dangerous and costly, but also the process itself is more economical comparing with present Nb EP process. In order to better understand this polishing mechanism and optimize the operating parameter for a controllable SRF cavity process, , a systematical studies regarding to off time between positive and negative pulses, pulse duration, pulse structure , electrolyte concentration have been done, the results helps to determine optimum polishing parameters for a reliable cavity process. The understanding of Nb oxide formation and removal mechanism under anodic and cathodic pulses helps to further explore of the mechanism of pulse-reversed electropolishing.

TUPB108 **Genesis of Topography in Buffered Chemical Polishing of Niobium for Application to Superconducting Radiofrequency Accelerator Cavities**

Liang Zhao, Charles E. Reece (JLab, Newport News, Virginia), Michael Kelley (The College of William and Mary, Williamsburg, Virginia)

Topography arising from the final etch step in preparing niobium superconducting radiofrequency (SRF) accelerator cavities is understood to significantly impact cavity performance at high field levels. This study investigated the effect of process temperature and time on the etch rate and topography arising from the widely-used buffered chemical polishing (BCP). This study aims to understand more thoroughly the genesis of topography in BCP of polycrystalline niobium, with the ultimate aim of finding a path to surface smoothness comparable to that obtained by electropolishing (EP). It was found that the etch process is controlled by the surface reaction; and that the etch rate varies with crystallographic orientation. The familiar micron-scale roughening necessarily results. Gas evolution has an impact, but is secondary. The major outcome is that surface smoothness comparable to EP appears to be inherently unachievable for polycrystalline niobium using BCP, setting an upper limit to the gradient for which it is useful.

TUPB109 **CERN's High Pressure Rinse Water Waste Analysis and Pressure Characterization**

Karim Gibran Hernández-Chahín (CERN, Geneva; DCI-UG, León), Alick Macpherson (CERN, Geneva)

As part of the SRF cavity preparation process of bulk niobium cavities at CERN, a qualification of the High Pressure Rinse (HPR) procedure has be done. This involved both the characterisation of the HPR water jet, and the control of rinse quality and cleanliness. The calibration of the jet profile and pressure measurements are preformed using a novel application of pressure sensitive contact paper (FUJIFILM PRESCALE$^\textregistered$ film) in an HPR environment. Jet pressure and profiles are extracted, based on a colour density analysis that have been developed, and calibrated against commercial proprietary calibration results. Rinse quality and cleanliness are assessed by monitoring and analysis of the waste water, with contaminant particle count and total organic content monitoring used to determine the cleanliness level and the HPR rinse duration. The influence of contamination pickup from the rinsing environment and electrostatic pick up of debris is also discussed.

TUPB110 **Real-time Calibration for Cavity Cold Test**

Karim Gibran Hernández-Chahín (CERN, Geneva; DCI-UG, León), Sarah Aull, Alick Macpherson, Juljan Nikolai Schwerg (CERN, Geneva)

During a power scan of a cavity the power is increased in steps with the inherent transient loading of the cavity. The analysis of the signals taken throughout cold tests for several cavity geometries is done to evaluate a real-time calibration procedure.. This transient is used to assess the loading of the cavity as a function of input power. The real-time calibration is cross-checked with standard low power calibrations using power decay time measurements. This study is done to provide real-time calibration of RF performance scans, and to assess the understanding of power dependent losses inherent to the test stand but external to the cavity. Correction factors can then be defined for power scans to isolate the RF performance of the cavity. Comparison of correction effects between pulsed and CW operation is also considered.

TUPB111 **R&D Activities on Centrifugal Barrel Polishing of 1.3 GHz Niobium Cavities at DESY/University of Hamburg**

Alena Prudnikava (University of Hamburg, Hamburg), Alexey Ermakov (DESY, Hamburg), Brian Foster (DESY, Hamburg; University of Hamburg, Hamburg), Yegor Tamashevich (HZB, Berlin; University of Hamburg, Hamburg)

In the present paper the status of research activities at ILC-HiGrade Lab (DESY/University of Hamburg) on Centrifugal Barrel Polishing (CBP) of 1.3 GHz Niobium Cavities is presented. We focus on CBP based on the polishing recipe reported by Fermi National Laboratory and Jefferson Lab*. Aiming at a better understanding of the limitations of this technique, detailed characterization of the treated surface after each polishing step was possible with the use of a "coupon" cavity. Plastic deformations upon initial CBP steps, embedded polishing media and residual damage upon final polishing were investigated at different areas of the cavity. The peculiarities of CBP procedure of 9-cell cavities are outlined

TUPB112

Surface Characterization of Nitrided Niobium Surfaces

Alena Prudnikava, Guilherme Dalla Lana Semione (University of Hamburg, Hamburg), Arti Dangwal Pandey, Thomas Keller, Heshmat Noei (DESY, Hamburg), Yegor Tamashevich [on leave] (DESY, Hamburg; HZB, Berlin), Brian Foster (DESY, Hamburg; University of Hamburg, Hamburg)

Thermal treatment of niobium radiofrequency cavities in nitrogen atmosphere is employed in ILCLS-II Project in order to improve the quality factor of Nb cavities. A so called "N-infusion" thermal treatment , as compared to "N-doping" which requires removal of upper layer of 5-30 um, is applied without any post processing*,**. For better understanding the mechanism of such an improvement, a detailed characterization of the nitrided surface is necessary. Here we study the resulted upon such treatments surface morphology and concentration profiles of impurities. It is demonstrated how temperature and duration of the treatment as well as background pressure in the furnace affect the elemental composition and shape of precipitates and diffusion depth of impurities.

TUPB113

Status of the Electropolishing System at IMPCAS

Lu Li, Hao Guo, Yuan He, Pingran Xiong, Zhiming You, Bin Zhang (IMP/CAS, Lanzhou)

The first SRF cavity electropolishing system of China has been built by IMPCAS. We used two type of cathodes in different process parameters to test the typical Voltage-Current Density curves of 1.3GHz one-cell SRF cavity.

19-July-17	Oral	Auditorium A
08:00-10:40	**WEXA-Fundamental-non Nb II**	

WEXA01
08:00
20mins

High Performance Nb3Sn Cavities

Daniel Leslie Hall, Matthias Liepe, Ryan Douglas Porter (Cornell University (CLASSE), Ithaca, New York)

In recent years, 1.3 GHz single-cell cavities coated with Nb3Sn at Cornell University have repeatedly demonstrated quality factors of >1e10 at 4.2 K and >15 MV/m. Ongoing research is currently focussed on the impact of intrinsic and extrinsic factors that limit the quality factor and quench field in these cavities. New single-cell cavities have been commissioned to enable further exploration of the coating parameter space. Experimental studies on both cavities and sample coupons have been supplemented by theoretical work done on layer growth, trapped vortex motion and flux entry. In this paper, we provide a comprehensive overview of the latest developments on Nb3Sn cavities, including work conducted in collaboration with the new NSF Centre for Bright Beams, with a brief summary on work being done in the field at large.

WEXA02
08:20
20mins

Material Studies for Understanding of Nb3Sn Cavity Performance Limiting Mechanisms

Yulia Trenikhina (Fermilab, Batavia, Illinois)

Understanding the link between effect of the cavity processing at microscopic level and performance of the cavity after this processing allows new developments of the processing technologies. We have performed extensive microscopic studies of Nb3Sn coated Nb cavity cutouts (from Cornell) with known dissipation characteristics which allowed us to identify material features responsible for the local heating. Using SEM, STEM/EDS, TEM/NED and XRD characterization of Nb3Sn-coated Nb cavity cutouts we show structural and compositional flaws potentially responsible for the poor performance. Analysis of well SRF-characterized Nb3Sn also provided a valuable insight into the nucleation and growth processes, which brings us ahead with understanding of performance-limiting mechanisms in Nb3Sn.

WEXA03
08:40
20mins

High-performance Thin-film Niobium Produced via Chemical Vapor Deposition (CVD)

James Thomas Maniscalco, Ryan Douglas Porter (Cornell University (CLASSE), Ithaca, New York)

In collaboration with Ultramet, Cornell is exploring the potential of Chemical Vapor Deposition (CVD) to produce thin niobium films on substrates (e.g. molybdenum and copper). Recent optimization of the coating process has let to RF performance approaching that of bulk niobium, with low residual surface resistance. This talk will present results from a detailed study on 4" CVD thin film Nb plates on copper and moly substrates, including RF performance results with T-mapping and detailed surface analysis of performance limiting regions. Our work shows that CVD is promising alternative fabrication method for thin Nb films

WEXA04
09:00
20mins

A15 Thin Films on Copper for SRF Cavities

Guillaume Jonathan Rosaz, Sarah Aull, Katsiaryina Ilyina, Alban Sublet, Walter Venturini Delsolaro (CERN, Geneva)

R/D is ongoing at CERN to study A15 coatings on copper substrates for applications on SRF cavities, in particular for future large accelerators like the FCC. The presentation will give an overview of the techniques and of the main results achieved so far.

WEXA05
09:20
20mins

Dirty layers, Bi-layers and Multi-layers: Insights from Muon Spin Rotation Experiments

Tobias Junginger (HZB, Berlin; TRIUMF, Vancouver), Daniel Leslie Hall, Matthias Liepe (Cornell University (CLASSE), Ithaca, New York), Mattia Checchin, Anna Grassellino, Martina Martinello, Sam Posen, Alexander S Romanenko (Fermilab, Batavia, Illinois), Anne-Marie Valente-Feliciano (JLab, Newport News, Virginia), Thomas Prokscha, Zaher Salman, Andreas Suter (PSI, Villigen PSI), Robert Edward Laxdal (TRIUMF, Vancouver), Edward Thoeng (TRIUMF, Vancouver; UBC & TRIUMF, Vancouver, British Columbia), Douglas W Storey (TRIUMF, Vancouver; Victoria University, Victoria, B.C.), Teng Tan, Wenura Kanchana Withanage, Matthaeus Wolak, Xiaoxing Xi (Temple University, Philadelphia), Walter William Wasserman (UBC, Vancouver, B.C.)

The multilayer approach is being investigated for SRF applications since 2006 "*". More recently the option of using a bilayer system of two superconductors has been considered as an alternative approach to reach accelerating gradients beyond bulk niobium or to explain the gradient enhancement from a 120℃ bake by introduction of a 'dirty layer "**"'. In this talk results are presented from two muon spin rotation experiments at TRIUMF and PSI. The former measures the field of first entry Hentry. It will be shown that MgB2 and Nb3Sn on top of Nb both push Hentry above Hc1 to a value consistent with Hsh, independent of the layer thickness. 120℃ baking increases Hentry slightly but significantly above Hc1. Using the low energy muon beam at PSI we show that there is a long range proximity effect in a bilayer system of NbTiN on Nb. This effect yields a stronger decay of the RF field with depth as expected for pure NbTiN, opposite to what has been predicted for a bi-layer system due to counter current flow at the superconductor-superconductor interface "***". An insulating layer suppresses this proximity effect.

WEXA06
09:40
20mins

The Role of Cool Down Dynamics on the Performance on Nb/Cu Cavities

Sarah Aull, Walter Venturini Delsolaro (CERN, Geneva)

The RF performance of Nb/Cu cavities shows different sensitivity to the conditions under which the cavity becomes superconducting compared to bulk Nb. While the residual resistance of bulk Nb increases strongly with trapped flux, Nb/Cu cavities are known to be almost insensitive to any ambient field. In contrast, the RF performance of Nb/Cu cavities seems to be strongly influence by the thermal gradient across the cavity during transition. This contribution will present new insights into the change of residual resistance in Nb/Cu cavities due to flux trapping, thermal gradients and their interplay.

WEXA07
10:00
20mins

Theoretical Estimates of Maximum Fields in Superconducting Resonant Radio Frequency Cavities: Stability Theory, Disorder, and Laminates

Danilo Liarte, Matthias Liepe, James Sethna (Cornell University, Ithaca, New York), Mark Transtrum (Brigham Young University, Provo), Sam Posen (Fermilab, Batavia, Illinois), Gianluigi Catelani (Forschungszentrum Juelich, Jülich)

Theoretical limits to the performance of superconductors in high magnetic fields parallel to their surfaces are of key relevance to current and future accelerating cavities. We present intuitive arguments and simple estimates for Hsh, and combine them with rigorous calculations. We explore the effects of materials anisotropy and the danger of disorder in nucleating vortex entry. Will we need to control surface orientation in the layered compound MgB2? Can we estimate theoretically whether dirt and defects make these new materials fundamentally more challenging to optimize than niobium? We discuss and analyze recent proposals to use thin superconducting layers or laminates to enhance the performance of superconducting cavities. Flux entering a laminate can lead to so-called pancake vortices; we consider the physics of the dislocation motion and potential re-annihilation or stabilization of these vortices after their entry.

WEXA08
10:20
20mins

Current-blocking Grain Boundaries in SRF Cavities and RF Dissipation Due to Nonlinear Dynamics of Josephson Vortices under Strong RF Fields

Alexander Gurevich, Ahmad Sheikhzada (ODU, Norfolk, Virginia)

Grain boundaries (GBs) in polycrystalline Nb cavities do not significantly degrade the SRF performance. However, the situation may change for Nb3Sn in which GBs can partially obstruct current and pin vortices, as it has been established in many previous studies. Such weak-linked GBs can cause a medium-field Q slope and cavity quench triggered by guided penetration of vortices along networks of GBs. Vortices trapped at GBs can also contribute to the residual surface resistance. This talk gives an overview of current-limiting mechanisms of GBs and dissipation of vortices in strongly-coupled GBs under RF field. We present results of extensive numerical simulations of vortices in GBs in polycrystalline bulk and thin films, and contribution of vortices to the RF dissipation. Our simulations revealed Cherenkov instability of Josephson vortices driven by strong RF currents and generation of vortex-antivortex pairs, dynamic transition of vortices into phase slips in thin films, and dynamic interaction of moving vortices with pinning centers. Contributions of these mechanisms to the field dependent surface resistance and reduction of the RF breakdown field is discussed.

19-July-17 11:10-13:00	Oral **WEYA-Cavity I**	Auditorium A

WEYA01
11:10
20mins

A Superconducting Harmonic Cavity System for the ANL Advanced Photon Source

Michael Kelly (ANL, Argonne, Illinois)

Superconducting cavities are attractive for light source storage rings both as main rf cavities and as harmonic cavities due to their compact size and relatively straightforward handling of higher order modes which are a serious technical issue in nearly all new ampere-class machines. A 1.4 GHz superconducting bunch lengthening cavity for the Advanced Photon Source Upgrade project and ancillary systems including a high-power cw variable coupler and beamline higher order mode damper have all been prototyped and tested. Speaker - Sang-hoon Kim.

WEYA02
11:30
15mins

Construction and Performance Tests of the Prototype Quarter-Wave-Resonator at RIKEN-RIBF

Naruhiko Sakamoto, Osamu Kamigaito, Hiroki Okuno, Kazutaka Ozeki, Kenji Suda, Yutaka Watanabe, Kazunari Yamada (RIKEN Nishina Center, Wako), Eiji Kako, Hirotaka Nakai, Kensei Umemori (KEK, Ibaraki), Hiroshi Hara, Katsuya Sennyu, Takeshi Yanagisawa (MHI-MS, Kobe)

Construction of the prototype QWR-type cavity has been made dedicated for a high power CW ion-accelerator aimed at reducing the amount of long-lived fission products (LLFP) in high-level radioactive waste via nuclear transmutation. After the last conference assembly of the prototype cavity with a resonant frequency of 75.5 MHz finished and performance test was made for several times to make an extensive feasibility study on processes of the surface treatment, the test facility, setup of the measurement itself etc. In this paper discussion will be made on the results of the performance tests and some observed phenomena, multipacting, X-ray emission, magnetic field variation during cooling down and so on. This paper also covers cavity design and a future plan at RIKEN-RIBF.

WEYA03
11:45
15mins

Seamless QWR for HIE ISOLDE

Silvia Teixeira L¿pez, Matthew Alexander Fraser, Marco Garlaschè, Tommi Petteri Mikkola, Akira Miyazaki, Alban Sublet, Walter Venturini Delsolaro (CERN, Geneva)

The superconducting linac booster for the HIE ISOLDE project, in operation at CERN, is based on NB/Cu coated Quarter Wave Resonators. The performance of the series cavities has been limited by defects in the copper substrates close to the EB weld. A novel cavity design has been developed and prototyped, in order to make it possible manufacturing of the resonators by machining them from the bulk, without any weld. The RF design was optimized for the customary figures of merit, and fully integrated in the HIE ISOLDE cryomodule. Mechanical tolerances were assessed in relation to the available range of pre tuning, and demonstrated on a dummy prototype. Beam dynamics simulations were carried out to check the effects on the beams when the new cavities will be installed in the high energy end of the linac. The presentation will cover the design and the first experimental results of the first Nb/Cu seamless QWR for HIE ISOLDE.

WEYA04
12:00
15mins

The R&D on TEM-type SRF Cavities for High-current Applications at IHEP

Feisi He, Jianping Dai, Jin Dai, Nan Gan, Xuerui Hao, Hong Huang, Tong-Ming Huang, Xuefang Huang, Zhongquan Li, Haiying Lin, Rong Liu, Qiang Ma, Xinpeng Ma, Fanbo Meng, Zheng Hui Mi, Weimin Pan, Xiaohua Peng, Peng Sha, Yong Shao, Guangwei Wang, Qunyao Wang, Zhou Xue, Pei Zhang, Xinying Zhang (IHEP, Beijing)

The recent SRF R&D efforts on TEM-type cavities at IHEP have been strongly linked to two large projects: high current proton linac for ADS and High Energy Photon Source (HEPS). A CW 10 MeV proton injector and part of the 25 MeV main linac for the CADS project are developed at IHEP. 14 SRF spoke012 cavities for the injector have been commissioned with 10.6mA proton beam at 10.67MeV; while 6 SRF spoke021 cavities for the main linac have been assembled into cryomodule in Lanzhou. 166.6 MHz quarter-wave beta=1 cavities were proposed for HEPS storage ring, required by the planned on-axis beam accumulation injection scheme. Each 166.6 MHz cavity will be operated at 4 K providing 1.2 MV accelerating voltage and 145 kW of power to the electron beam. A proof-of-principle cavity has been manufactured and vertical tested recently with a success. HOM damping is currently being designed. The development progress of the 6 types of spoke, HWR, QWR cavities, and their ancillaries, as well as the spoke cavity performance during beam operation, will be addressed.

WEYA05
12:20
15mins

Progress Toward 2 K High Performance Half-Wave Resonators and Cryomodule

Zachary Alan Conway, Bernardino Guilfoyle, Mark Kedzie, Michael Kelly, Sang-Hoon Kim, Thomas Reid (ANL, Argonne, Illinois)

Argonne National Laboratory is implementing a novel 2 K superconducting cavity cryomodule operating at 162.5 MHz. This cryomodule is designed for the acceleration of 2 mA H-/proton beams from 2.1 to 10.3 MeV as part of the Fermilab Proton Improvement Project-II (PIP-II). The 2 K cryomodule is comprised of 8 half-wave cavities operated in the continuous wave mode with 8 superconducting magnets, one in front of each cavity. In this paper we will review recent cavity results which demonstrate continuous-wave operated cavities with low-field residual resistances of 2.5 nanoOhms which achieve peak surface fields up to 134 MV/m and 144 mT, electric and magnetic respectively, with field emission onset fields of 70 MV/m in the cavities which followed the prototyping effort.

WEYA06
12:40
15mins

Superconducting Twin-axis Cavity for ERL Applications

HyeKyoung Park, Subashini Uddika De Silva (ODU, Norfolk, Virginia)

The elliptical twin-axis cavity is a new kind of superconducting cavity that consists of two parallel beam pipes, which can accelerate or decelerate two beams in two separate beam pipes. The new cavity geometry is intended to create a uniform accelerating or decelerating fields for both beams. The twin-axis cavity can offer advantages in low-energy ERL applications by allowing increased bunch charge while preserving emittance. A 1.5 GHz superconducting twin-axis cavity has been designed, developed, fabricated, and tested. Experimental results will be presented.

20-July-17	Oral	Auditorium A
08:00-10:35	**THXA-Cavity II**	

THXA01
08:00
15mins

Conditioning and Operation of Superconducting Half-Wave Resonators for C-ADS Injector

Weiming Yue (IMP/CAS, Lanzhou)

HWR010 and HWR015 are used in China ADS at Institute of Modern Physics. There are two CM with HWR010s and one CM with HWR015s will accelerate proton from 2.1 MeV to above 17MeV. The coupler, cavity conditioning and operation will present in this paper.

THXA02
08:15
15mins

Fabrication and Testing of Balloon Single Spoke Resonator

Zhongyuan Yao, Robert Edward Laxdal, Ben Matheson, Bhalwinder Waraich, Vladimir Zvyagintsev (TRIUMF, Vancouver)

A balloon variant of the single spoke resonator (SSR) has been designed, fabricated and tested. The cavity is the SSR1 prototype for the RISP project in Korea. The cavity is specifically designed to reduce the likelihood of multipacting barriers near the operating point. The basic design, fabrication experience and first cold test results will be reported.

THXA03
08:30
15mins

Crab Cavities for the High-luminosity LHC

Rama Calaga, Olivier Brunner (CERN, Geneva)

As a first step towards the realization of crab crossing for HL-LHC, two superconducting crab cavities are foreseen to be tested with proton beams for the first time in the SPS. The progress on the cavity fabrication, RF test results, cryomodule development and integration into the SPS are presented. Some aspects of the beam tests with crab cavities in the SPS are outlined.

THXA04
08:45
20mins

Fabrication, Treatment and Test of Large Grain Cavities

Jiankui Hao, Jia-er Chen, Liwen Feng, Lin Lin, Kexin Liu, Shengwen Quan, Fang Wang, Huamu Xie, Feng Zhu (PKU, Beijing)

Development of SRF technology has been included in the project of Soft X-ray FEL (SXFEL) for a hard X-ray FEL plan in China which would be operated in CW mode. Six 9-cell TESLA type cavities as well as several single-cell cavities made of Ningxia large grain niobium material have been fabricated by Peking University for achieving high gradient and high intrinsic quality factor Q0. The measurements of gradient and Q0 have been carried out with a new vertical test system at PKU. The process of fabrication, surface treatment and test results of these large grain cavities will be presented.

THXA05
09:05
20mins

Thermal Mapping for SRF with Transition Edge Sensors

Hernan Fernando Furci, Olivier Brunner (CERN, Geneva)

Amongst the second sound detectors, Oscillating Superleak Transducers (OST) have been widely used in the field of thermal mapping for SRF cavities. Less commonly used, Transition Edge Sensors (TES) present the advantage over the OSTs of providing a better spatial resolution and an intensity response linear with the heat flux from the hot spot. The TES is a thin-film thermal sensor, whose electric resistance varies steeply only within the superconducting-to-normal transition. Range is limited to the transition edge (around 200 mK), which can be tuned in temperature by a bias current. The temperature variations associated with second-sound in superfluid helium are then visible as proportional changes of the voltage drop across the film strip. Dedicated TES for operation in superfluid helium have been developed in collaboration with CMi-EPFL Lausanne and characterized at CERN. The paper will illustrate this recent development, the application of TES to quench detection from bulk Nb cavities in comparison with OSTs and their use to construct a contactless 3D thermal mapping array operating in superfluid helium.

THXA06
09:25
15mins

Advanced OST System for the Second-sound Test of Fully Dressed Cavities

Yegor Tamashevich (HZB, Berlin)

Cavities which exhibit a low field quench are normally discarded from usage in accelerator projects. However, they can be repaired if the exact location of the quench is known. Optical inspection alone cannot reliably locate the source of a quench. Methods that directly measure the quench, such as thermometry or second sound detection, could so far only be performed at undressed cavities. A new, specially designed, second-sound system for the first time allows the localization of the quench in multicell cavities equipped with a helium vessel. It can be easily installed in the helium pipe of the cavity. Information on the quench location can be acquired during a standard rf test. A new algorithm localizes the quench based on the real path of the second-sound wave around the cavity surface, rather than using simple triangulation. The implemented pathfinding method leads to a high precision and high accuracy of the quench location. This was verified by testing standard dressed 9-cell XFEL cavities. The system can be easily applied to other cavity shapes and sizes.

THXA07
09:40
15mins

Progress with Bipolar HF-free EP and other VEP of Niobium Cavities

Hui Tian (JLab, Newport News, Virginia)

In collaboration with Faraday Technologies and KEK, JLab has been developing HF-free EP of Nb cavities via pulse-reversed electropolishing using several different HF-free electrolytes. Bench-scale process analytics have yielded a systematic way of characterizing the processes, identifying effective polishing parameters, and are guiding application to single and multi-cell cavities. JLab has developed a low-cost pulse control technique and implemented it in a vertical EP processing tool integrated into the JLab cleanroom suite. The polishing process dynamics for different electrolytes, the implementation in the JLab tool, and the effectiveness in application to single cell and multi-cell cavities will be reviewed. VEP development work at Cornell includes both HF-free EP and the HF-based electrolyte using novel cathode and stirring configuration.

THXA08
09:55
20mins

Review of Heat Treatments for Low Beta Cavities : What's So Different from Elliptical Cavities

Claire Antoine (CEA/DSM/IRFU,), David Longuevergne (IPN, Orsay)

Heat treatments done for low beta (low frequency) cavities are usually, due to the lack of feedback, inspired from elliptical (high frequency) cavity results. Is that still relevant now that experimental data are available thanks to the florishing business of low beta structures (Spiral2, ESS, FRIB, C-ADS, MYRRHA, PROJECTX, ...). These 2 families are moreover not usually operating in the same resistance regime (BCS and residual). The paper will review procedures applied and results obtained on different type of cavities (Quarter-Wave resonator, Half-Wave resonator and Spoke) and different temperature treatments (low temperature baking, hydrogen degassing, nitrogen doping, ...) and compare these to elliptical cavities.

THXA09
10:15
20mins

Results and New Insights from Vertical Testing of LCLS-II Production Cavities

Daniel Gonnella (SLAC, Menlo Park, California)

Production of 9-cell cavities for LCLS-II is now well underway. 266 cavities will be produced by the conclusion of the project and will be tested by Fermilab and Jefferson Lab prior to cryomodule string assembly. The cavities have been manufactured by Research Instruments GmbH and Ettore Zanon S.p.a. and represent the first industrially produced nitrogen-doped cavities. Here the results from the vertical tests of the cavities received so far are presented. First results show that nitrogen-doping leads to the highest Q0 values achieved in SRF cavities produced for a large-scale project. This has been not without challenges however, and we discuss new findings with regards to flux expulsion, intrinsic residual resistance, and cavity preparation techniques that limited cavity performance in the beginning of production. These new findings and material studies are important for future accelerators so that high Q0 performance can be reliably achieved for large projects.

20-July-17	Oral	Auditorium A
11:05-13:05	**THYA-Technology-CM I**	

THYA01
11:05
20mins

Performance Testing of FRIB Early Series Cryomodules

John Thomas Popielarski, Andrei Ganshyn, Walter Hartung, Didi Luo, Peter Ostroumov, Kenji Saito, Safwan Shanab, Sergey Stark, Shen Zhao, Zhihong Zheng (FRIB, East Lansing), Chris Compton, Samuel J. Miller, Dan Morris, Laura Popielarski, Ting Xu (FRIB, East Lansing, Michigan)

Construction of a new accelerator for nuclear physics research, the Facility for Rare Isotope Beams (FRIB), is underway at Michigan State University (MSU). The FRIB linac will use superconducting resonators at an operating temperature of 2 K to accelerate ions to 200 MeV per nucleon. The linac requires 106 quarter wave resonators (80.5 MHz, beta = 0.043 and 0.086) and 248 half wave resonators (322 MHz, beta = 0.29 and 0.54), all made from sheet Nb. Production resonators being delivered to MSU by cavity vendors. At MSU, the resonators are etched, rinsed, and tested in MSU's certification test facility. Certification testing is done before the installation of the high-power input coupler and the tuner. After certification, the resonators are tested in the cryomodule before installation into the FRIB tunnel. The cryomodule test goals are to verify integrated operation of the resonators, RF couplers, tuners, RF controls, and superconducting solenoids. To date, 10 cryomodules out of 48 have been fabricated, and 8 of the cryomodules have been certified. Cryomodule test results are presented in this paper.

THYA02
11:25
20mins

Achievement of Stable Pulsed Operation at 36 MV/m in STF-2 Cryomodule at KEK

Yasuchika Yamamoto, Takeshi Dohmae, Masato Egi, Kazufumi Hara, Teruya Honma, Eiji Kako, Yuuji Kojima, Taro Konomi, Nakanishi Kota, Takayuki Kubo, Toshihiro Matsumoto, Takako Miura, Hirotaka Nakai, Gunn-Tae Park, Takayuki Saeki, Hirotaka Shimizu, Toshio Shishido, Tateru Takenaka, Kensei Umemori (KEK, Ibaraki)

In the Superconducting RF Test Facility (STF) in KEK, the cooldown test for the STF-2 cryomdoule with 12 cavities has been done totally three times since 2014. In 2016, the 3rd cooldown test for the STF-2 cryomodule including the capture cryomodule with 2 cavities was successfully carried out. The main achievement is the vector-sum operation with 8 cavities at average accelerating gradient of 31 MV/m as the ILC specification (2 of 8 cavities achieved 36 MV/m with piezo compensation), and the others are the measurement for Lorenz Force Detuning (LFD) and unloaded Q value, and Low Level RF (LLRF) study, etc. In this paper, the result for the STF-2 cryomodule in three cooldown tests will be presented in detail.

THYA03
11:45
20mins

Operating the Third Harmonic SRF System in the E-XFEL Injector

Paolo Pierini (DESY, Hamburg; INFN/LASA, Segrate (MI))

The E-XFEL injector was commissioned and operated with beam in 2016. Part of the injector is a third harmonic system of 8 SRF cavities operating at 3.9GHz. This paper describes all aspects of the commissioning and operation of the third harmonic system with beam.

THYA04
12:05
20mins

The Conditioning and Operation of HWR Cryomodules for C-ADS

Yuqin Wan (IMP/CAS, Lanzhou)

Four cryomodules designed to host half wave resonator(HWR) cavities have been successfully tested at IMP for the C-ADS project. The lessons of cryomodules conditioning, assemblies, and operations will be presented. Cryomodule consist of various complex subassemblies, starting from the inside with the niobium RF cavity and working out to the vacuum vessel. All of the prototypes use 6 β=0.10 HWR cavities dressed with helium vessel except the last one, which has 5 β=0.15 cavities. Early experimental results from the first cryomodule led to design improvements seen in the latest cryomodules. The cryogenic system provides 4.2 K liquid helium lines to 2 phase separator for cold mass, and 77K liquid nitrogen for thermal shield and current leads. An 1100 Aluminium shield is used as a thermal radiation shield. To meet a full period lattice structure, fewer warm-cold transitions and warm connector between cryomodules have been designed. All cryomodules have achieved the design goals both offline and online. Thus, the better three cryomodules are assembled in the linac tunnel and waiting for the running later.

THYA05
12:25
20mins

Developments and Progress with ESS Elliptical Cryomodules at CEA-Saclay and IPN-Orsay

Franck Peauger (CEA/DRF/IRFU, Gif-sur-Yvette)

The European Spallation Source (ESS) is composed of a long pulse superconducting linac delivering a proton beam of 62.5 mA at 2 GeV. In the high energy section of the accelerator, two families of elliptical cavities with a geometrical beta of 0.67 and 0.86 operate at 704.42 MHz in 2 K superfluid helium bath to reach the challenging accelerating gradients of 16.7 and 19.9 MV/m respectively. The SRF cavities are grouped four by four in 6.6 meter long cryomodules, similar for both cavity types. In the prototype phase, CEA Saclay in collaboration with the IPN Orsay and ESS is in charge of the design, manufacture and high power tests of two Cryomodule Demonstrators with medium and high beta cavities. In the series phase, CEA Saclay is responsible for the cryomodule components procurement, the assembly in the CEA Saclay of 30 cryomodule with a delivery rate of one cryomodule per month, and the high power test of 6 cryomdules. We present the challenges in the cryomodule design and integration. First results of the cavity string assembly and tests are also reported.

THYA06
12:45
20mins

Long-term Operation Experience with Beams in Compact ERL Cryomodules

Kensei Umemori, Masato Egi, Kazuhiro Enami, Takaaki Furuya, Yosuke Honda, Eiji Kako, Taro Konomi, Hiroshi Sakai (KEK, Ibaraki), Masaru Sawamura (QST, Tokai), Takafumi Okada (Sokendai, Ibaraki)

Compact ERL (cERL) was constructed at KEK as a prototype for 3GeV ERL light source. It consists of two types of SRF cavities. Three injector 2-cell SRF cavities and two main linac 9-cell SRF cavities. The beam operation started at 2013, with 100 nA (CW). Beam current increased step by step and currently reached to 1 mA (CW). Energy recovery has successfully achieved. Performance of the SRF cavities through long term beam operation has been investigated. With the beam induced HOMs, the beam position and the beam timing were studied. cERL has suffered from heavy field emissions in operation. Field emissions of the main linac cavity started just after module assembly work, and during beam operation, performances of both the main linac and the injector SRF cavities sometimes degraded. One reason of degradation was discharges occurred at beamline components due to charge up of electrons. Pulse aging technique helped to recover SRF performances. In this presentation, details of SRF beam operation, degradation, applied recovery methods are described.

20-July-17 14:00-17:00	Poster **THPB-Poster Session**	Hall B

THPB001 **Frequency dependent Q Slopes in Fundamental and Higher Order Modes Measured in a Half Wave Resonator**

Sang-Hoon Kim (ANL, Argonne, Illinois)

Q curves of the fundamental mode, the half-wavelength TEM mode at 322 MHz, and a higher order mode (HOM), the 5/2-wavelength TEM mode at 1.42 GHz, are measured in a FRIB beta=0.29 HWR. In this paper, we will discuss different behaviors in Q curves. One noticeable difference is a low-field Q slope. We found a relatively strong low-field, where Bpeak is less than about 10 mT, Q slope in the HOM but it did not appear in the fundamental mode. This low-field Q slope is originated from the residual resistance and it is inversely proportional to Bpeak squared in such low field range.

THPB002 **Role of Nitrogen on Hydride Nucleation and Stability in Pure Niobium by First Principle Calculation Compared With Coupon Microstrcutures**

Pulkit Garg, Ilaksh Adlakha, Kiran Solanki (Arizona State University, Tempe), Thomas R. Bieler (Michigan State University, East Lansing, Michigan), Shreyas Balachandran, Peter J. Lee (NHMFL, Tallahassee, Florida)

It is known that formation and growth of Nb hydride degrades superconducting radio frequency (SRF) properties of Nb cavities and the treatments that reduce H concentration improve quality factor. Recently it is has also been shown that addition of N through doping or infusion improves the quality factor. Thus, we probe role of N addition in Nb on hydride precipitation and stability through first principles calculations & compared with coupon samples. In presence of N, energetic preference for H to occupy interstitial sites in the vicinity of N is reduced. Furthermore, presence of N forces H to occupy interstitial octahedral site instead of a tetrahedral site. The thermodynamic stability of hydride is decreased in the presence of N in Nb.The quantum insights using charge transfer and density of states show a strong tendency of N to accumulate charge, thereby decreasing the bond strength of neighboring Nb and H atoms. These atomic scale results explain the lesser tendency of surface hydride formation in SRF Nb cavities in presence of N. These results are consistent with metallographic examination of N-treated Nb coupons, which show suppressed hydride formation near N-treated surface.

THPB003 **An Innovative Design of a Flexible Temperature-Mapping System**

Mingqi Ge, Fumio Furuta, Matthias Liepe, Philip James Pamel (Cornell University (CLASSE), Ithaca, New York)

A temperature-mapping system is an essential tool for fundamental SRF research as it provides spatial information of RF power dissipation and so allows to localize hot-spots on a cavity surface at cryogenic temperatures. However, the temperature sensors are mounted on rigid boards in most current systems, so each can only work for one specific cavity size and shape. In this paper, we proposed a flexible design, which allows this temperature mapping system to work for different cavity shapes.

THPB004 **Impact of the Duration of Low Temperature Doping on Superconducting Cavity Performance**

Peter Nicholas Koufalis, John Julian Kaufman, Matthias Liepe (Cornell University (CLASSE), Ithaca, New York)

Low temperature treatments of superconducting cavities in a low pressure ambient atmosphere have been shown to introduce a `Q-rise ¿ up to moderate surface fields and an overall increase in quality factor. However, the effect of varying the doping time at a fixed temperature on cavity performance has not been systematically examined. We present results of such an investigation for cavities prepared at 120 and 160 C in a continuously flowing low pressure atmosphere for various amounts of time. We show that the introduction impurities to the RF penetration layer can improve cavity performance and investigate the relationship between electron mean free path and the temperature-dependent component of the surface resistance. We explore the dependence of the sensitivity of the surface resistance from trapped magnetic flux as a function mean free path as well.

THPB005 **Design Updates on Cavity to Measure Suppression of Microwave Surface Resistance by DC Magnetic Fields**

James Thomas Maniscalco, Matthias Liepe (Cornell University (CLASSE), Ithaca, New York)

Our research has shown good agreement between experimental measurements of the anti-Q-slope in niobium SRF cavities and predictions from a recent theoretical model of the suppression of the microwave surface resistance with applied RF field. To confirm that this mechanism is indeed what causes the anti-Q-slope in impurity-doped niobium, it will be necessary to measure the theory ¿s prediction that the same effect may be achieved by applying a constant (i.e. DC) magnetic field parallel to the RF surface. This will also allow for a systematic study of the proposed fundamental effect of the anti-Q-slope, since it provides a cleaner measurement by eliminating the counteracting quasiparticle overheating and the complexifying oscillation of the screening currents. In this report we give an update on work at Cornell to design and build a coaxial cavity to measure this effect.

THPB006 **Analysis of the Anti-Q-Slope in Low-Temperature Doped Niobium Cavities**

James Thomas Maniscalco, Fumio Furuta, Peter Nicholas Koufalis, Matthias Liepe (Cornell University (CLASSE), Ithaca, New York)

In this report, we present an analysis of recent measurements of the anti-Q-slope in niobium cavities treated with 120-160

C low-temperature doping, comparing experimental results to theoretical predictions. We investigate the quasiparticle overheating present in these novel RF surfaces and study the relations between the strength of the anti-Q-slope, the overheating, and the electron mean free path extracted from RF measurements. We examine these relations in comparison to similar results from niobium doped with nitrogen at high temperature (800-990 C).

THPB007 **Nitrogen Infusion R&D on Single Cell Cavities at DESY**

Marc Wenskat, Detlef Reschke, Joern Schaffran (DESY, Hamburg), Alena Prudnikava (University of Hamburg, Hamburg)

A first series of single cell cavities underwent the "Nitrogen Infusion" treatment at DESY. Samples, which were in the furnace together with the cavities, underwent a series of SEM/EDX measurements and showed some unexpected structures. In parallel, the cavity performance deteriorated after the treatment. The furnace pressure and temperature and the residual gases during the treatment were analyzed and the possible cause for the deterioration has been found. Steps to prevent this deterioration in following treatments are discussed and first results are shown.

THPB008 **More Insights on Electron Mean Free Path Dependence of the Vortex Surface Impedance**

Mattia Checchin (Fermilab, Batavia, Illinois)

In the present poster presentation, the calculation of the vortex surface resistance as a function of the electron mean-free-path is presented in detail. We demonstrate that the vortex surface resistance, as a function of the mean-free-path, is described as the interplay of the two limiting regimes, for low and large mean-free-path values: pinning and flux-flow regimes respectively. This study underlines also how the profile of impurities at the rf surface, the distribution of pinning points and their number modify the vortex dissipation.

THPB009 **Novel Self-Consistent Calculation of the Field-dependent Surface Impedance**

Mattia Checchin, Alexander S Romanenko (Fermilab, Batavia, Illinois)

The surface impedance of superconducting materials is related to the total number of thermal exited quasiparticles above the superconductive energy gap. Historically, the most accepted description of such a dissipative mechanism was developed by Mattis and Bardeen in the 1958 in approximation of a clean superconductor and in the limit of electromagnetic field amplitude tending to zero. In the field of superconducting accelerating cavities though, such a description is not exhaustive since the field amplitude reached are way far from the zero amplitude limit. Generally, a strong field dependence of the surface impedance is observed in superconducting accelerating cavities, and in standard cavities it usually increases as a function of the accelerating field. The field dependence of the surface impedance is specifically interesting in nitrogen-doped niobium resonators, where counterintuitively, it decreases as a function of the field amplitude. The self-consistent calculation here presented describes the field dependence of the surface resistance and the relation between the observed field dependence trend with the exciting frequency and temperature.

THPB010 **Vortex Penetration Delay and Enhancement of the Accelerating Gradient**

Mattia Checchin, Anna Grassellino, Martina Martinello, Alexander S Romanenko (Fermilab, Batavia, Illinois)

The fundamental limitation to the maximum accelerating gradient of superconducting radio-frequency cavities is represented by the quench of the superconductive state. Above a certain field level ¿the field of first penetration ¿the magnetic field is free to penetrate the superconductor, abruptly increasing the power dissipation, and quenching the resonator. Ideally, the superheating field would be the ultimate gradient limitation, but experimental evidences suggest that cavities that have a constant Ginzburg-Landau parameter most likely quench in vicinity of the lower critical field. By introducing a Ginzburg-Landau parameter profile at the cavity rf surface ¿dirty layer ¿the accelerating gradient of superconducting resonators can be enhanced. The description of the physics behind the accelerating gradient enhancement, as a consequence of the dirty layer, is carried out by solving numerically the Ginzburg-Landau equations for the layered system. The enhancement is showed to be promoted by the higher energy barrier to vortex penetration, and by the enhanced lower critical field.

THPB011 **Advancement in the Understanding of the Field and Frequency Dependent Microwave Surface Resistance of Niobium**

Martina Martinello, Mattia Checchin, Anna Grassellino, Oleksandr Stepanovych Melnychuk, Sam Posen, Alexander S Romanenko, Dmitri A. Sergatskov (Fermilab, Batavia, Illinois)

The radio-frequency surface resistance of niobium resonators is incredibly reduced when nitrogen impurities are dissolved as interstitials in the material, conferring ultra-high Q-factors. This effect has been observed in both high and low temperature nitrogen treatments. However, high temperature treatments show increased sensitivity to trapped magnetic field, implying a more challenging high Q-factor preservation in cryomodules. We present a systematic study on the different components contributing to the total surface resistance, comparing the effect of all the state-of-the-art processing such as N-doping and N-infusion*. The study is also extended on comparing the surface resistance contributions in nitrogen-treated cavities with different resonant frequencies, such as: 650 MHz, 1.3 GHz and 3.9 GHz. These findings reveal the different physics underneath the various dissipative processes, helping the fundamental understanding of the RF surface impedance. In addition, we uncover the optimum surface treatment needed to maximize the Q-factor of superconducting niobium cavities as a function of the operational frequency and accelerating gradient.

THPB012 **Teoretical Insigth on the Flux Expulsion Mechanism During the Superconducting Transition**

Martina Martinello, Mattia Checchin (Fermilab, Batavia, Illinois)

Ideally when a superconductor is cooled below its critical temperature, it should expel all the magnetic flux, assuming a perfect diamagnetic behavior. However, it has been shown that the level of flux expulsion in SC cavities is function of the thermal gradient generated along the cavity itself during the transition. We present a simple model in which the flux expulsion can be explained as a consequence of the thermodynamic force winning against the pinning force. In this model a Gaussian distribution of defects with different pinning forces is assumed in order to explain recent flux expulsion data in which the level of flux expulsion is affected not only by the thermal gradient, but also by the micro-structure of the cavity material.

THPB013 **Direct Observation of Nanometer Scale Niobium Hydride (Nb1-Xhx) Using Cryogenic Atomic Force Microscopy (AFM)**

Zu-Hawn Sung, Anna Grassellino, Alexander S Romanenko, Yulia Trenikhina (Fermilab, Batavia, Illinois)

This study shows the result of direct observation of nanometer size hydride precipitates on SRF Nb cavity surface, which are strong candidate for high field Q-slope [1]. Over past few years, multiple techniques such as cryogenic optical microscopy, elastic reconcile detection, x-ray spectrometry, or transmission electron microscopy have successfully addressed that NbH precipitates are significantly related to breakdown of RF superconductivity on SRF Nb cavity. In this study, we further investigate this HFQS relative hydride segregation phenomenon by direct determination of nm-scale NbH phase. We applied cryogenic atomic force microscopy to cut-out hot spot coupons from variously treated Nb cavities, that showed high temperature gradient during RF test, by cooling below Tc of Nb, ~ 9.2K. We found nanometer Nb-H phases of 300-500 nm diameter and 30-50 nm height even after 800C thermal treatment. These hydrides are precipitated below e-NbH saturation temperature of 150-100K. We also observed um-size NbH precipitates on only chemically treated Nb cavity. Further investigations are now on-going on N (nitrogen)-doped and N-infused Nb cavity cut-out coupons.

THPB014 **Further Understanding of Surface and Bulk Superconductivity on N-infusion Nb Cavity**

Zu-Hawn Sung, Anna Grassellino, Martina Martinello, Alexander S Romanenko (Fermilab, Batavia, Illinois)

Recent N (nitrogen)-infusion process [1] improves RF performance by an order of two in SRF Nb cavity, compared to 120C mild bake. This newly developed engineering recipe likely sustains surface RF superconducting property close to the theoretical limit of superheating field of Nb = 180-200 mT at 2 K for higher Q gradient, reaching 45-50 MV/m. For practical applications fundamental understanding of superconducting properties of an N-infused Nb cavity surface is highly required. Most importantly, magnetic flux pinning effect due to nitrogen-doping induced surface impurities should be clarified as a dirty limit condition. By applying DC magnetization hysteresis and AC susceptibility characterizations on coupon that have been identically treated as N-infused Nb cavity, we are quantifying surface and bulk superconductivities like surface superconducting field (Hc3), the onset of magnetic flux penetration (Honset), surface resistivity, conductivity, and magnetic pinning force (Fpin). These properties will be compared to those from 120C baked Nb cavity in order to determine the main role of N-infusion in enhancing SRF Nb cavity performance.

THPB015 **Microscopic Understanding of Niobium Surface that Provides 45 MV/m Accelerating Gradients: N-doping and N-infusion**

Yulia Trenikhina, Mattia Checchin, Anna Grassellino, Alexander S Romanenko (Fermilab, Batavia, Illinois), Zu-Hawn Sung (ASC, Tallahassee, Florida)

Tremendous success of Nitrogen-related surface treatments, such as N-doping and N-infusion, established a new performance records for SRF cavities. Tailoring Nb surface through the furnace treatments at high and low temperatures controls Nb surface resistance enabling highest observed Q-factors and accelerating gradients. Various surface treatment parameters, such as temperature and partial pressure of Nitrogen, dramatically affect final cavity performance. For instance, only 10C difference during low temperature bake reduces performance benefit of 120C-N-infused cavities. Extended material characterization is vital and the most direct pathway to understanding the details of Nb surface and to explore furnace treatments parameter space to find the optimal conditions. We report extended TEM, SEM and SIMS material characterization of Nb surface after N-doping and N-infusion with different parameters. Combination of such powerful characterization techniques allows us to get a full insight into the details of Nb surface, as well as to relate cavity performance to the surface features.

THPB016 **Impact of Heat Treatment and Impurity Doping on Flux Trapping in SRF Grade Niobium Coupons**

Santosh Chetri (ASC, Tallahassee, Florida), Pashupati Dhakal (JLab, Newport News, Virginia), Shreyas Balachandran, *David Larbalestier, Peter J. Lee (NHMFL, Tallahassee, Florida)*

The magnetic flux trapped during the cool down of SRF cavities is detrimental to their performance because it increases the residual resistance, Rres, and reduces the quality factor, Q0. We report on experiments that explore how the trapping behavior for Nb coupons changes due to different surface treatments specifically due to nitrogen doping at high temperature (800 ℃) as well as at low temperature (120 ℃-160 ℃). For this study, high purity Nb cylinders are treated with a range of SRF cavity treatment recipes. DC magnetization measurement in zero field cooled and field cooled mode at small external dc field are made to measure the trapping behavior of these samples. We find that Nb that is heat treated at 800 ℃ shows almost complete flux expulsion when cooled through its critical temperature in presence of small field. But Nb cylinders that are doped with nitrogen at low temperature trap significant amount of magnetic flux although they exhibit similar isothermal magnetic hysteresis measured at 4.2 K. We show that combining these simple DC magnetization techniques applied to coupons allows us to probe the changes in flux trapping behavior produced by different cavity treatments.

THPB017 **Investigation of Trapped Magnetic Flux in Superconducting Niobium Samples with Neutron Radiography**

Oliver Kugeler, Tobias Junginger, Jens Knobloch, Julia Marie Köszegi, Luisa Riik, Wolfgang Treimer, Ralf Franz Ziesche (HZB, Berlin)

The dynamics of flux expulsion in Nb samples during superconducting transition has been investigated with neutron radiography. Aiming at a reduction of the trapped flux with respect to obtaining a small residual resistance it was attempted to influence the expulsion by applying external AC magnetic fields. The results of these experiments are presented.

THPB018 **Towards the Perfect Meissner State: A Magneto-Optical Study on Competing Pinning Centers in Niobium**

Julia Marie Köszegi, Jens Knobloch, Oliver Kugeler (HZB, Berlin)

Over the past years trapped magnetic flux has emerged as a main limiting factor of high quality factors in SRF cavities. Several studies investigated how the ambient magnetic field can be minimized or how the flux expulsion during the phase transition can be improved. We now present a study that targets the pinning centers which allow for the flux to remain inside the superconductor in the first place. Using magneto-optical imaging we were able to not only measure the amount of trapped flux but in addition we managed to image its distribution with a resolution below 10µm and correlate it with electron backscatter diffraction maps. As a result we found that the grain boundaries did not play a major role as pinning centers nor did the crystal orientation influence the amount of trapped flux signifi-cantly. Niobium hydrides which formed during the cool down to cryogenic temperatures however were found to enhance trapping.

THPB019 **Simulation of the Thermoelectrically Generated Magnetic Field in a SC Nine Cell Cavity**

Julia Marie Köszegi, Jens Knobloch, Oliver Kugeler (HZB, Berlin)

Several studies showed that thermocurrents generate a magnetic field in a horizontal cavity test assembly or cryomodul, which may get trapped during the superconducting phase transition. The trapped flux causes additional dissipation during operation and can therefore significantly degrade the cavity¿s quality factor. We simulated the distribution of the generated magnetic field for different temperature distributions and compared the results to experimental findings. Furthermore, the impact of a growing superconducting area was investigated. The simulations complement the experimental studies because measurements were only feasible with a limited number of probes and restricted to selected locations and orientations. The simulations allow to analyze this data in the context of the whole system.

THPB020 **Phase Transition Dynamics in Niobium: A Magneto-optical Study**

Julia Marie Köszegi, Jens Knobloch, Oliver Kugeler (HZB, Berlin)

We present a study that targets the phase transitions in niobium. Magneto-optical imaging has previously been used to image flux penetration close to the critical magnetic field. This study includes the opposite (normal to superconducting) phase transition during the cooldown. The spreading phase fronts are imaged for niobium samples with different treatment histories and the resulting shapes are compared to flux penetration studies.

THPB021 **Trial of Nitrogen Infusion and Nitrogen Doping by Using J-PARC Furnace**

Taro Konomi, Takeshi Dohmae, Yoichiro Hori, Eiji Kako, Takayuki Kubo, Gunn-Tae Park, Hiroshi Sakai, Kensei Umemori (KEK, Ibaraki), Junichiro Kamiya, Kenichi Takeishi (JAEA/J-PARC, Tokai-mura), Tomohiro Nagata (ULVAC, Inc., Tsukuba)

KEK has been carrying out SRF cavity developments toward higher Q-values and higher accelerating gradients. In the past nitrogen-doping was tested using the KEK furnaces, but it did not succeed. This time nitrogen infusion and nitrogen doping are tested using the J-PARC¿s furnace, which has an oil-free pumping system and is mainly pumped by a 10000 L/s cryopump and three 3000 L/s turbo pumps. Nitrogen pressure is controlled by a variable leak valve and an additional turbo pump. To avoid performance degradation during heat treatment, flanges of cavities are covered by Nb caps and foils.

Nitrogen infusion at 120 degrees was applied to a single cell cavity and cavity performance was measured by vertical tests after HPR and assembly. Nitrogen doping at 800 degrees is also applied to another single cell cavity. After applying EP and HPR, vertical tests were carried out. Nb samples were also installed into the furnace during heat treatment. Surfaces are analyzed by SIMS and XPS. In this presentation, we report procedure of nitrogen infusion and doping, vertical test results and results of surface analysis.

THPB022 **Preliminary Study on Cleaning Nb and Cu Samples with Dry-ice**

Qingwei Chu, Yuan He, Yongming Li, Zhiming You, Cong Zhang, Shenghu Zhang (IMP/CAS, Lanzhou)

As an effective surface treatment method, dry ice cleaning (DIC) can remove particles and film contaminations, especially hydro-carbons. DIC using CO_2 and N_2, inert chemical gas, would not react with Nb and Cu which are applied in superconducting accelerator. In this paper, a series of contaminated Nb and Cu samples are cleaned with dry ice. The influence of various operating parameters, such as cleaning time、CO_2/N_2 pressure、direction of jet, on the surface cleanliness of samples. Based on surface analysis, DIC can effectively remove contaminated material on Nb and Cu samples under properly controlled conditions.

THPB023 **Experimental New Insight into Trapped Magnetic Flux of SRF Nb Cavity**

Shichun Huang (IMP/CAS, Lanzhou), Rong-Li Geng (JLab, Newport News, Virginia)

Trapped magnetic flux (B_{trap}) is a well-known contributor to the surface resistance (R_s) of an superconducting radio frequency (SRF) cavity, therefore limits the attainable intrinsic quality factor ($Q_0 \propto 1/R_s$) at low temperature. In this study, we systematically measured magnetic flux densities at the outer surface of two different single-cell cavities during various cooldown processes under a controlled applied magnetic field. We report two empirical formulas to evaluate the remaining magnetic flux densities ($B_{(Eq/Iris)}^{'}$) at Iris and Equator after removing the applied field when the cavity was cooled down below Tc with the applied field. Our data shows the magnetic flux trapping seems to be non-uniform in cavity wall. The B_{trap} defined by two different methods are also discussed.

THPB024 **XPS Investigation on Depth Profiling of Niobium Surface Composition and Work Function**

Andong Wu, Qingwei Chu, Yuan He, Tiancai Jiang, Yongming Li, Lei Yang, Weiming Yue, Shenghu Zhang, Hongwei Zhao (IMP/CAS, Lanzhou), Fujun Gou (Sichuan University, Chengdu)

The niobium samples were prepared by different surface treatments that commonly applied for the preparation of RF superconducting cavities, as the flowing of electrochemical polishing and the buffered chemical polishing. In order to understand the property of niobium surface composition and the correlated work function value, the X-ray photoelectron spectrum depth profiling of the outmost surface has been studied in depth of 30nm. The signals of O1s, C1s and the Nb3d were identified from the niobium oxide and the hydrocarbon contamination. The depth profiling show that the values of work function are strongly depending on the chemical composition, with the conclusion that the surface work function can be improved by means of eliminating the hydrocarbon and increasing the niobium oxide.

THPB025 **A Crystal Plasticity Study on Influence of Dislocation Mean Free Path on Stage II Hardening in Nb Single Crystals**

Tias Maiti, Aritra Chakrabarty, Philip Eisenlohr (MSU, East Lansing), Thomas R. Bieler, Di Kang (Michigan State University, East Lansing, Michigan)

Constitutive models based on thermally-activated stress-assisted dislocation kinetics have been successful in predicting deformation behavior of crystalline materials, particularly in face-centered cubic (fcc) metals. In body-centered cubic (bcc) metals, success has been more or less limited, owing to ill-defined nature of slip planes and non-planar spreading of 1/2\hkl<111> screw dislocation cores. As a direct consequence of this, bcc metals show a strong dependence of flow stress on temperature and strain rate, and violation of Schmid law. We present high-resolution full-field crystal plasticity simulations of single crystal Niobium under tensile loading with an emphasis on multi-stage hardening, orientation dependence, and non-Schmid behavior. A dislocation density-based constitutive model with storage and recovery rates derived from Discrete Dislocation Dynamics is used to model strain hardening in stage II. The influence of dislocation mean free path and initial dislocation content on stage II hardening is simulated and compared with in-situ tensile experiments.

THPB026 **Investigation of the Effect of Strategically Selected Grain Boundaries on Superconducting Properties of High Purity Niobium**

Mingmin Wang, Thomas R. Bieler (Michigan State University, East Lansing, Michigan), Santosh Chetri, Anatolii Polyanskii (ASC, Tallahassee, Florida), Chris Compton (FRIB, East Lansing, Michigan; NSCL, East Lansing, Michigan; FRIB, East Lansing), Shreyas Balachandran, Peter J. Lee (NHMFL, Tallahassee, Florida)

High purity Nb is commonly used for fabricating SRF cavities due to its high critical temperature and its formability. However, microstructural defects such as dislocations and grain boundaries in niobium can serve as favorable sites for pinning centers of magnetic flux that can degrade SRF cavity performance. In this study, two bi-crystal niobium samples extracted from strategically selected grain boundaries were investigated for the effect of grain misorientation on magnetic flux behavior. Laue X-ray and EBSD-OIM crystallographic analyses were used to characterize grain orientations and orientation gradients. Cryogenic Magneto-Optical Imaging (MOI) was used to directly observe magnetic flux penetration at about 5-8 K. Flux penetration was observed along one of the grain boundaries, as well as along a low angle boundary that was not detected prior to MOI imaging. Hydride scars on the sample surface after MOI were examined using atomic force microscopy (AFM) analysis. The relationships between dislocation content, cryo-cooling, flux penetration and grain boundaries are examined.

THPB027 **Characterization of Microstructural Defects in SRF Cavity Niobium using Electron Channeling Contrast Imaging**

Mingmin Wang, Thomas R. Bieler, Di Kang (Michigan State University, East Lansing, Michigan)

Although the quality factor of niobium cavities has improved, performance variability arises from microstructural defects such as dislocations and grain boundaries that can trap magnetic flux, block heat transfer, and perturb superconducting currents. Microstructural defect evolution is compared in four samples extracted from a 2.8 mm thick large-grain niobium slice, with tensile axes chosen to generate desired dislocation structures during deformation. The four samples are 1) as-extracted, 2) extracted and annealed, 3) extracted and then deformed to 40% strain, and 4) extracted, annealed at 800 ℃ 2 hours, and deformed to 40% strain. Electron Channeling Contrast Imaging (ECCI) was performed on all samples to characterize initial dislocation density, dislocation structure evolution due to annealing and deformation, and related to the mechanical behavior observed in stress-strain curves. The orientation evolution and geometrically necessary dislocation (GND) density were characterized with electron backscattered diffraction (EBSD) maps. Fundamental understanding of dislocation evolution in niobium is necessary to develop models for computational cavity design.

THPB028 **Flux Pinning Study of OTIC Niobium Material**

Shu Chen, Jiankui Hao, Lin Lin, Kexin Liu, Shengwen Quan (PKU, Beijing)

The performance of superconducting cavities is influenced by the trapped flux during the cooling down through critical temperature, especially for nitrogen doped cavities which are more sensitive to flux trapping. We have investigated the flux trapping of OTIC niobium samples with different grain size. Samples were prepared and heat treated at 800 ℃ and 900 ℃, followed with different surface removal by BCP and EP. A series of measurements, including MPMS, TOF-SIMS, metalloscope, TEM, were carried out on the niobium samples. The results and analysis will be presented.

THPB029 **XPS Studies of Nitrogen Doping Nb Samples Before and After GCIB Etching**

Ziqin Yang, Xiangyang Lu, Weiwei Tan, Deyu Yang, Yujia Yang, Jifei Zhao (PKU, Beijing)

The surface chemical composition of nitrogen doping Nb samples used for the fabrication of superconducting radio frequency (SRF) cavities, followed by the subsequent successive EP with different amounts of material removal, has been studied by XPS. The chemical composition of Nb, O, C and N was presented before and after Gas Cluster Ion Beams (GCIB) etching. No signals of bad superconducting nitrides NbNx was found in any doped and un-doped samples before etching. However, in the depth range greater than 30nm, the content of N elements is below the XPS detection precision scope even in the samples directly after nitrogen doping treatment.

THPB030 **Direct Observation of Hydrides Formation of Nitrogen Doping Nb Samples**

Ziqin Yang, Xiangyang Lu, Weiwei Tan, Deyu Yang, Yujia Yang, Jifei Zhao (PKU, Beijing)

Direct observation of hydrides precipitates formation on both nitrogen doped and un-doped Nb samples at 80K has been carried out using Scanning Electron Microscope (SEM) with Cold Stand. We have found that, under our experimental conditions, when the subsequent EP removal is less than 7μm, the amounts of hydrides formed on the surface of doped samples can be effectively reduced. When the subsequent material removal is larger than 9μm, the amounts of precipitated hydrides increased with the EP removal. When the EP removal is 7-9μm, the amounts of hydrides can still be effectively reduced. Also, more hydrides were precipitated on the surface of un-doped samples. The amounts of hydrides of doped samples may be reduced to varying degrees with different amounts of material removal.

THPB031 **Magnetic Properties of Nitrogen Doping Nb Samples**

Ziqin Yang, Xiangyang Lu, Weiwei Tan, Deyu Yang, Yujia Yang, Jifei Zhao (PKU, Beijing)

Nitrogen doping study on Niobium samples used for the fabrication of superconducting radio frequency (SRF) cavities was carried out. The samples ¿ surface treatments were attempted to replicate that of the cavities, which included heavy electropolishing (EP), nitrogen doping and the subsequent successive EP with different amounts of material removal. The magnetization curves of both doped and un-doped samples have been measured, from which the lower critical field Hffp (First Flux Penetration, ffp) and upper critical field Hc2 was extracted. The thermodynamic critical field Hc, superheating field Hsh and superconducting parameters of samples with different treatments was calculated from the determined reversible magnetization curves. Hsh of doped samples is obviously smaller than that of un-doped samples, which may be a possible reason for the reduction of achievable accelerating gradient in SRF niobium cavities after nitrogen doping treatments.

THPB032 **Superconducting Multilayered Coatings Synthetized by ALD for SRF Cavities**

Paolo Pizzol (The University of Liverpool, Liverpool)

Advancements in technology have taken bulk niobium close to its theoretical operational limits, pushing the research to explore novel materials, such as niobium based alloys. Theoretical studies have been done on how to surpass the bulk niobium limits and, according to Gurevich et al, a composite material made of multiple layers of superconductors alternated by insulators could provide such a solution. The technique chosen for creating such materials is atomic layer deposition (ALD), where the thickness of the deposited layers can be controlled with a resolution down to the nanometer. This article presents the preliminary results obtained by using ALD techniques to deposit multilayered structures made of niobium based compounds starting from their chlorinated precursors. The samples obtained are characterized via SEM, TEM, SAD, XRD, XPS, and EDX as well as assessing their superconductivity characteristics (RRR and Tc).

THPB033 **Mitigation of the High Field Q-Slope in 3 GHz Cavities**

Grigory V. Eremeev, Fay Elizabeth Hannon (JLab, Newport News, Virginia)

A strong degradation of the unloaded quality factor with field, called high field Q-slope, is commonly observed above Bpeak = 100 mT in elliptical superconducting niobium cavities at 1.3 GHz and 1.5 GHz. We measured several 3 GHz niobium cavities up to and above Bpeak ~ 100mT. We show that the high field Q-slope can be removed by the typical empirical solution of electropolishing followed by heating to 120 ℃ for 48 hrs.

THPB034 **Development of High Purity Niobium Components and Cavities for SRF Accelerator**

Tomohiro Nagata, Hiroaki Masui, Seiichi Shinozawa (ULVAC, Inc, Chiba), Hitoshi Inoue, Eiji Kako, Masashi Yamanaka (KEK, Ibaraki), Hirohiko Murakami (ULVAC, Inc., Tsukuba)

Comprehensive cavity fabrication process from Niobium ingot was investigated. In order to purify ingots, A 600 kW electron beam furnace was introduced in ULVAC. It makes possible the stable quality of Niobium sheets and tubes. In evaluation of chemical components, mechanical properties, and RRR of our materials, all the value satisfies the ASTM Type 5 (superconducting grade) specification. In this study, we performed the trial manufacturing of welding-type and seamless-type cavities were made of our high purity Niobium ingots (RRR > 300). Accelerating gradient over 40 MV/m was shown in both cavities. We also tried to manufacture a 3-cell seamless cavity as scale up study. A seamless tube with a length of 830 mm, an inner diameter of 131 mm and a thickness of 3.5 mm was prepared. We succeed in direct forming from tube to cavity shape by using a hydroforming process. Cavity surface could be smoother than that of single cell cavity caused by small crystal grain size.

THPB035 **High Power Testing of the First Dressed ESS RF Cavity**

Han Li, Konrad Gajewski, Lars Hermansson, Magnus Jobs, Roger Ruber, Rocio Santiago Kern (Uppsala University, Uppsala)

The first double spoke cavity For ESS project was tested at high power in the HNOSS facility at FREIA Laboratory. This cavity is designed for 325.21MHz, a pulse mode with 14 Hz repetition rate, up to peak power of 360 kW. The qualification of the cavity package in a horizontal test, involves a spoke superconducting cavity, a fundamental power coupler, LLRF system and RF station, represents an important verification before the module assembly. This paper presents the test configuration, RF conditioning history and first high power performance of this cavity.

THPB036 **Fundamental SIMS Analyses for Nitrogen Enriched Niobium**

James Tuggle (Virginia Polytechnic Institute and State University, Blacksburg), Ari Deibert Palczewski, Charles E. Reece (JLab, Newport News, Virginia), Fred Stevie (NCSU AIF, Raleigh, North Carolina), Michael Kelley, Uttar Pudasaini (The College of William and Mary, Williamsburg, Virginia)

In order to fully understand nitrogen addition techniques it is vital to have a full understanding of the material, including the content, location, and speciation of nitrogen contained in the treated Nb. In this work Secondary Ion Mass Spectrometry (SIMS) is used to elucidate content and location. Dynamic SIMS nitrogen analysis is reported, for the first time, for ¿as-received¿ cavity grade niobium from three separate suppliers. In addition, a number of sample preparation and characterization techniques are presented including angle polishing sample preparation to provide SIMS analysis greater than 200 μm depth and dynamic SIMS methods for shallow near surface analysis.

THPB037 **RF-beam Interaction in CEPC RF System**

Dianjun Gong, Jiyuan Zhai (IHEP, Beijing)

Circular electron positron collider (CEPC) is design as a particle factory for Higgs, W and Z. The SRF system is one of the most important systems of CEPC. The advance partial double ring scheme (APDR) was put forward last year, a main ring structure which gave a challenge for the SRF system. Because of high current, short bunch trains and large gaps, the beam loading problem is serious in CEPC main ring, especially for W and Z. Beam loading effect can cause phase shift and cavity voltage decrease among different bunches, which make bremsstrahlung time, RF acceptance and luminosity decrease. Beam loading effect and the corresponding longitudinal beam dynamics of CEPC are studied in this article. The phase shift and voltage decrease caused by beam loading are calculated by the analytic formula and the program. A method is put forward to reduce the phase shift of bunch. Besides, for W and Z mode in CEPC, the optimum detuning frequency of RF cavity is larger than the revolution frequency of beam. That can result in 0 mode instability. 0 mode instability and feedback are also analyzed through transfer function in this article.

THPB038 **Local Magnetometer: First Critical Field Measurement of Multilayer Superconductors**

Muhammad Aburas (CEA/DRF/IRFU, Gif-sur-Yvette), Claire Antoine (CEA/IRFU, Gif-sur-Yvette)

S-I-S (Superconductor-Insulator-Superconductor) nanometric superconducting multilayers have been proposed by Gurevich* to increase the maximum accelerating field of Nb RF cavities. This enhancement of HC1 may be done by coating Nb with thin layers of thickness less than the penetration depth. Therefore, it is necessary to find a particular tool, which allows us measuring HC1 directly. In fact, DC magnetometers (e.g. magnetometer SQUID) are largely used for magnetic measurements but these last are strongly influenced by orientation, edge and shape effects, especially in the case of superconductor thin films. For that reason, we developed at Saclay facilities a specific local magnetic measurement of first critical field HC1. The principle of our local magnetometer is based on the third-harmonic voltage method purposed by Claassen**, which is very useful to estimate the first critical field HC1 of superconducting multilayer samples with nondestructive and contactless, but more importantly, without demagnetization effects***. This paper will present the evolution of the magnetometer to overcome all types of difficulties.

THPB039 **Correlation Study Between Simulations, Surface Characterizations and RF Performances: The Nb3Sn Case Study**

Thomas Proslier (CEA/DRF/IRFU, Gif-sur-Yvette), Andreas Glatz (ANL, Argonne, Illinois), Daniel Leslie Hall, Matthias Liepe (Cornell University (CLASSE), Ithaca, New York)

Nb3Sn hold great promises for high temperature SRF cavity operation. I¿ll present the work done in Collaboration with Cornell on various samples grown under different conditions and the surface characterization tools we used to identify some of the road hurdles, how to mitigate them and numerical simulations to provide a potential insight into high field performance limitations.

THPB040 **SRF Theory Developments from the Center for Bright Beams**

Danilo Liarte, Tomas Arias, Matthias Liepe, James Sethna (Cornell University, Ithaca, New York), Mark Transtrum (M.D.A.C.C., Houston, Texas)

We present theoretical studies of SRF materials from the Center for Bright Beams. First, we discuss the effects of disorder, inhomogeneities, and materials anisotropy on the maximum parallel surface field that a superconductor can sustain in an SRF cavity, using linear stability in conjunction with Ginzburg-Landau and Eilenberger theory. We connect our disorder mediated vortex nucleation model to current experimental developments of Nb3Sn and other cavity materials. Second, we use time-dependent Ginzburg-Landau simulations to explore the role of inhomogeneities in nucleating vortices, and discuss the effects of trapped magnetic flux on the residual resistance of weakly-pinned Nb3Sn cavities. Third, we present first-principles density-functional theory (DFT) calculations to uncover and characterize the key fundamental materials processes underlying the growth of Nb3Sn. Our calculations indicate that the observed tin-depleted regions may be the direct result of an exothermic reaction between Nb3Sn and Nb at the growing Nb/Nb3Sn interface. We suggest new growth protocols to mitigate the formation of tin depleted regions.

THPB041 **Cavity Quench Studies in Nb3Sn Using Temperature Mapping and Surface Analysis of Cavity Cut-outs**

Daniel Leslie Hall, Matthias Liepe, Ryan Douglas Porter (Cornell University (CLASSE), Ithaca, New York)

Previous experimental studies on single-cell Nb3Sn cavities have shown that the cause of quench is isolated to a localised defect on the cavity surface. Here, cavity temperature mapping has been used to investigate cavity quench behaviour in an Nb3Sn cavity by measuring the temperature at the quench location as the RF field approaches the quench field. The heating profile observed at the quench location prior to quench appears to suggest quantised vortex entry at a defect. To investigate further, the quench region has been removed from the cavity and analysed using SEM methods. These results are compared to theoretical models describing two vortex entry defect candidates: regions of thin-layer tin-depleted Nb3Sn on the cavity surface that lower the flux entry field, and grain boundaries acting as Josephson junctions with a lower critical current than the surrounding material. A theoretical model of layer growth developed using density functional theory is used to discuss alterations to the coating process that could mitigate the formation of such defects.

THPB042 **Field-dependence of the Sensitivity to Trapped Flux in Nb3Sn**

Daniel Leslie Hall, Matthias Liepe, Ryan Douglas Porter (Cornell University (CLASSE), Ithaca, New York)

The amount of residual resistance gained per unit of trapped flux ¿ referred to as the trapped flux sensitivity ¿ in Nb3Sn cavities has been found to be a function of the amplitude of the RF field. This behaviour is consistent with a scenario in which the trapped vortex dynamics are described by collective weak pinning. A model has been developed to describe this, and results in the observed linear dependence of trapped flux sensitivity with RF field. The model is used to discuss cavity preparation methods that might suppress this dependence, which would reduce the trapped flux requirements necessary to operate an Nb3Sn cavity at simultaneous high quality factors and accelerating gradients.

THPB043 **Effects of Chemical Treatments on Chemical Composition of Niobium-3 Tin Films for Superconducting Radio-frequency Cavities**

Ryan Douglas Porter, Fumio Furuta, Daniel Leslie Hall, Matthias Liepe (Cornell University (CLASSE), Ithaca, New York)

Current niobium-3 tin (Nb3Sn) films produced via vapor diffusion have rougher surfaces than typical niobium surfaces causing significantly enhancement of the surface magnetic fields. Reducing surface roughness of Nb3Sn surfaces may be necessary to achieve higher gradient accelerator cavities with high Q. Previous work at Cornell has shown the impact of several chemical treatments on the surface roughness of Nb3Sn films; however, these chemical treatments may have changed the surface chemistry. In particular, Nb3Sn films have been shown to have to have 'thin' regions where the chemical treatment may have completely removed the Nb3Sn film. This paper presents measurements of the chemical composition of Nb3Sn samples after various chemical treatments for standard Nb3Sn films and samples that were anodized before coating, which has been shown to prevent the formation of thin regions.

THPB044 **Update on Sample Host Cavity Design Work for Measuring Flux Entry and Quench Field**

Ryan Douglas Porter, Matthias Liepe, James Thomas Maniscalco, Vadim Veshcherevich (Cornell University (CLASSE), Ithaca, New York)

Current state-of- the-art Niobium superconducting radio-frequency (SRF) accelerator cavities have reached surface magnetic field close to the theoretical maximum set by the superheating field. Further increasing accelerating gradients will require new superconducting materials for accelerator cavities that are capable of supporting higher surface magnetic fields. This necessitates measuring the quench fields of new materials in high power RF fields. Previous work at Cornell University has used electromagnetic simulations to optimized the shape of a dipole mode sample host cavity such that the surface magnetic fields on the sample are high compared to the energy inside the cavity and the surface magnetic field on the rest of the cavity. In this paper we present coupler designs, thermal simulations and mechanical stress analysis of the cavity.

THPB045 **Analytical and Numerical Study of Micro-quenches on Thin Film Defects in Nb/cu Srf Cavities**

Hernan Fernando Furci (CERN, Geneva)

The high Q-slope plaguing of Nb/Cu thin film sputtered SRF cavities is largely not understood. Palmieri and Vaglio [1] proposed a thermal feedback model of micro-quenches on localized adhesion defects between film and substrate. From Q versus Eacc data, their model yields that a small fraction of defective surface is sufficient to explain the hindered performance. The current work is a more detailed numerical and analytical study of heat transfer aspects of micro-quenches. Circular voids between film and substrate leading to quench were simulated by finite element transient heat transfer. The SRF power driving the quench was modelled with surface resistance data from Halbritter¿s code. The results allowed drawing further simplifications for the numerical and analytical study of partial adhesion defects in 1D, depicted as a region with film-substrate heat transfer coefficient (HTC) lower than its surrounding, or even vanishing. A `size-HTC¿ criterion has been found, purely analytically, to determine when a micro-quench can be stable. Better understanding of micro-quench dynamics will allow developing refined and more physically accurate thermal feedback models.

THPB046 **Study of the Thermal Gradient Dependence of the Nb Coated Cavity in the HIE-ISOLDE Project**

Akira Miyazaki, Karl-Martin Dr. Schirm, Yacine Kadi, Alban Sublet, Silvia Teixeira L¿pez, Mathieu Therasse, Walter Venturini Delsolaro (CERN, Geneva)

The High intensity and Energy upgrade of the ISOLDE facility (HIE-ISOLDE) is operated by superconducting quarter-wave resonators made of a thin Nb film sputtered on a Cu substrate (Nb/Cu). The intrinsic quality factor of these cavities strongly depend on the thermal gradient (less than 1K) between top and bottom of the cavity as pointed out by P. Zhang in the vertical test stand. This phenomenon is reproduced in the cryomodules. Although the best cavity performance can be achieved by careful cool down, the physics of this phenomenon is not fully understood. In this study, possible hypotheses and experimental efforts are presented. A similar phenomenon has been reported on the elliptical bulk Nb cavities, and its physics was interpreted as flux expulsion efficiency. Since Nb/Cu QWR is insensitive to the flux expulsion, the thermoelectrically induced magnetic field due to Nb/Cu bi-metal structure is the most promising hypothesis instead. Some of the model calculations and experiments to measure such a thermoelectric effect are explained. Recent findings showed that thermal gradient does not only affect the residual resistance but also temperature-dependent resistance.

THPB047 **Study of the Surface Resistance of the Nb Coated Cavity for the HIE-ISOLDE Project**

Akira Miyazaki, Karl-Martin Dr. Schirm, Yacine Kadi, Alban Sublet, Silvia Teixeira L ¿pez, Mathieu Therasse, Walter Venturini Delsolaro (CERN, Geneva)

Superconducting quarter-wave resonator is developed in the high intensity and Energy upgrade of the ISOLDE facility. The cavity is made of a thin Nb film sputtered on a Cu substrate. Although the cavity provides enough accelerating voltage, the physics underlying the surface resistance has not yet been fully understood. Especially, the Q-slope problem still limits the ultimate performance of the Nb/Cu cavity. In this study, an intensive effort to unfold such a complicated phenomena is presented. First, the Bardeen-Cooper-Schrieffer (BCS) resistance term was extracted from the raw data by correcting Q-slope and thermal gradient dependence during cooling down process. Second, the material parameters were determined by fitting the data by the numerical calculation of the linear response theory (Mattis Bardeen theory). A correlation among the material parameters is pointed out. Third, the Q-slope term separated from the BCS term is shown and is compared with possible thermal runaway model. Finally, a possible correlation between Q-slope and problems due to welding is pointed out.

THPB048 **Double Cathode Configuration for the Nb Coating of HIE-ISOLDE Cavities**

Ali Awais (CERN, Geneva; NCP, Islamabad), Floriane Marie Leaux, Alexander James George Lunt, Alban Sublet (CERN, Geneva)

The Quarter Wave Resonator (QWR) cavities for HIE-ISOLDE project at CERN is entered into its ending phase of production baseline. Still some R&D is performed to improve the uniformity of the Nb layer thickness over the cavity surface. One idea is to replace single cathode with double cathode and test it in DC-bias diode sputtering, DC-magnetron sputtering (DCMS) and Pulsed DC-magnetron sputtering (PDCMS) configurations. With this replacement it is possible to control the plasma and power distribution separately for the inner and outer part of cavity. The comparison between the deposition rate results with single cathode and double cathode for above mentioned configurations are presented. The thickness profiles are measured in-situ and on samples ex-situ using XRF technique. The morphology of the thin film samples produced using single and double cathode in the different configurations is compared by FIB/SEM analysis.

THPB049 **Nb3Sn Coating of 3.9 GHz Cavities at Fermilab**

Sebastian Aderhold (Fermilab, Batavia, Illinois)

Nb3Sn coating promises higher quality factors for superconducting RF cavities than bulk niobium material at the same operating temperature. In addition, the higher critical temperature of Nb3Sn could allow accelerator operation at 4.2K, allowing for the use of smaller and simpler cryogenic plants. Recent Nb3Sn efforts at Fermilab and other labs optimizing the coating procedure and understanding the cavities performance limitations had mainly been focused on 1.3 GHz cavities. Given the dominating contribution of the BCS resistance at 3.9 GHz to the overall surface resistance due to its quadratic frequency dependency, there is great potential benefit from lower cavity losses. In this paper, we present results from coating and testing the first 3.9GHz cavity at Fermilab.

THPB050 **First Cavity Results from Fermilab Nb3Sn SRF R&D Program**

Sam Posen, Saravan Kumar Chandrasekaran, Anthony Curtis Crawford, Oleksandr Stepanovych Melnychuk, Dmitri A. Sergatskov, Zu-Hawn Sung, Yulia Trenikhina (Fermilab, Batavia, Illinois), Jaeyel Lee (NU, Evanston, Illinois)

Nb3Sn SRF coatings have demonstrated significantly reduced BCS surface resistance at a given temperature relative to niobium, and theoretical predictions suggest that with sufficiently high quality films, they may offer increased maximum accelerating gradients as well. In this contribution, we present results from the first Nb3Sn coatings produced at Fermilab. We present both microscopy and superconducting property measurements on samples and RF results on single-cell 1.3 GHz cavities. Future plans for multicell cavities are discussed as well.

THPB051 **Thick Niobium Thin Film Coating on Copper for Superconducting RF Activities at Fermilab**

Yi Xie, Alexander S Romanenko, Genfa Wu (Fermilab, Batavia, Illinois)

Thin film such as Niobium, Nb3Sn and other superconducting materials coating on copper have great potential on improving srf cavity qualify factor and gradient. At Fermilab we have developed two sets of thin film coating system on copper. The first is an electron cyclotron resonance (ECR) plasma device which can coat a wide span of frequency ranging from 400 MHz to 3.9 GHz of single cell and multicell srf cavities. The rf to plasma generation process, solenoid, vacuum system and plasma transport to rf cavities will be reported in details. We will present the first coating of a 1.3 GHz single cell cavities result. The second copper coating system is using high-power impulse magnetron sputtering (HiPIMS) and the details of cathode design and pulsed power sources will also be described here.

THPB052 **Error Analysis of Surface Resistance Fits to Experimental Data**

Sebastian Keckert, Jens Knobloch, Oliver Kugeler (HZB, Berlin)

Superconducting material properties such as energy gap, mean free path or residual resistance are commonly extracted by fitting experimental surface resistance data. Depending on the measurement setup, both, temperature range and the number of points are limited. In order to obtain significant results, systematic as well as statistical uncertainties have to be taken into account. In this contribution different classes of errors and their impact on systematic and statistical deviations of the fitted parameters are discussed. In particular, past measurements have yielded contradictory conclusions that, we believe, result from the use of insufficient data in the necessary temperature range. Furthermore, this study is applied to the boundary conditions of the Quadrupole Resonator and its measurement accuracy.

THPB053 **Surface Resistance Characterization of Nb3Sn Using the HZB Quadrupole Resonator**

Sebastian Keckert, Jens Knobloch, Oliver Kugeler (HZB, Berlin), Daniel Leslie Hall, Matthias Liepe (Cornell University (CLASSE), Ithaca, New York)

Nb3Sn is a very promising candidate material for future SRF cavities. With a critical temperature more than twice as the one of bulk niobium, higher operational temperatures with still lower surface resistance are theoretically possible. A sample prepared by Cornell University was characterized towards its SRF properties using the HZB Quadrupole Resonator. In comparison to a coated cavity this device enables SRF measurements at an extended parameter space (frequency, temperature and RF field) and easy access to physical quantities such as critical field and penetration depth. In this contribution we present surface resistance and RF critical field measurements.

THPB054 **Advanced Method to Extract the Surface Resistance From Q0 Measurements**

Raphael Kleindienst, Jens Knobloch, Oliver Kugeler (HZB, Berlin)

The quality factor of an RF cavity and the surface resistance are typically related with a constant geometry factor. The implicit assumption made is that the surface resistance is field independent, which is however not observed experimentally in superconducting cavities. The approximation error due to this assumption becomes larger the less homogeneous the magnetic field distribution along the cavity walls is. In this paper we calculate the surface resistance error for different cavity types. An iterative method to correct for this error is presented.

THPB055 **Plasma-enhanced ALD System for SRF Cavity**

Shigeki Kato, Hitoshi Hayano (KEK, Ibaraki)

A remote PEALD (Plasma-enhanced Atomic Layer Deposition) system which would offer a high conformality and a low deposition temperature has been being developed for deposition of NbN on an SRF cavity. The deposition equipment consists of a deposition chamber, a remote plasma exciter, a precursor supply system, vacuum pumps, a quartz crystal microbalance (QCM) as a film growth rate meter, a detoxifying system and a safety system. An RF frequency of 13.56MHz was used for the inductively coupled plasma exciter of a reactant gas. The whole equipment is in a draft booth for operation safety. For ALD of an SRF cavity, the ALD system allows us to easily replace the deposition chamber with a single cell Nb cavity. The prepared precursors are tris[ethylmethylamido][tert-butylimido] niobium (TBTEMN) and trimethylaluminium (TMA). Ammonia, hydrogen and water are also prepared as reactants. We will report the ALD system design and result of the NbN deposition on sample coupons which are analysed with SEM, EDX and XPS.

THPB056 **R&D of SRF Thin-film Materials in Collaboration among ULVAC, KEK and Universities**

Takayuki Saeki, Hitoshi Hayano, Takayuki Kubo (KEK, Ibaraki), Yoshihisa Iwashita (Kyoto ICR, Uji, Kyoto), Ryohei Ito, Tomohiro Nagata (ULVAC, Inc, Chiba), Hiroki Oikawa (Utsunomiya University, Utsunomiya)

ULVAC and KEK have a history of collaboration for several years in the production of Nb material for SRF cavity. In the summer of year 2016, we newly started the collaboration for the R&D of SRF thin-film materials. Strong synergy is expected in the R&D of thin-film materials in this collaboration, where ULVAC has a long history of thin-film business, and KEK and collaborative universities have matured experiences on the SRF accelerator. In the first step, we tried the reactive coating of NbN thin-film on Si wafer by using an interback-type DC magnetron sputtering equipment in ULVAC. We observed the crystalline orientation and lattice constant of the NbN thinfilm samples and evaluated the SRF characteristics. This article presents the details of the studies.

THPB057 **Nb3Sn Film Coated on 1.3 GHz Cavities at IMPCAS**

Feng Pan (IMP/CAS, Lanzhou)

Nb3Sn has the potential to improve properties of SRF cavities, such as the gradients and the working temperatures. Institute of Modern Physics has luanched its Nb3Sn thin film coated SRF cavity project in 2016. Samples on a 1.3 GHz elliptical cavity have been successfully coated with superconducting Nb3Sn layer via tin vapor diffusion technique. The deposition system follows the Wuppertal design with modifications aiming at improving the film homogeneity. Basic material characterization of the Nb3Sn film will be presented in this work.

THPB058 **R&D of Thin Film Coating on Superconductors**

Yoshihisa Iwashita, Hiromu Tongu (Kyoto ICR, Uji, Kyoto), Hitoshi Hayano, Takayuki Kubo, Takayuki Saeki (KEK, Ibaraki), Masahiro Hino (Kyoto University, Osaka), Hiroki Oikawa (Utsunomiya University, Utsunomiya)

Multilayer thin film coating is a promising technology to enhance performance of superconducting cavities. Until recently, principal parameters to achieve the sufficient performance had not been known, such as the thickness of each layer. We proposed a method to deduce a set of the parameters to exhibit a good performances. In order to verify the scheme, we are trying to make some experiments on the subject at Kyoto. The sample preparation and the test setup for the measurement apparatus will be discussed.

THPB059 **Simulation and Measurements of Crab Cavity HOMs, Couplers and Multipoles for HL-LHC**

James Alexander Mitchell (Lancaster University, Lancaster), Rama Calaga (CERN, Geneva), Graeme Burt (Cockcroft Institute, Lancaster)

Two Superconducting Radio-Frequency (SRF) crab cavities are foreseen for the High Luminosity LHC (HL-LHC) upgrade. Preliminary beam tests of the Double Quarter Wave (DQW) crab cavity will take place in the Super Proton Synchrotron (SPS) in 2018. For damping of the cavity's Higher Order Modes (HOMs) the DQW has three identical on-cell, superconducting HOM couplers. In addition to HOMs the cavities also have high order multipoles of the fundamental mode as a result of the axial asymmetries needed to achieve the required transverse voltage. In this paper electromagnetic simulations of the HOMs, HOM couplers and multipole components are presented. Thermal simulations have also been carried out for the HOM couplers. Measurement results are then presented for a comparison between the nominal and manufactured cavities, providing an insight into geometric deviations and inaccuracies.

THPB060 **Nonuniform Thermal Stresses in Niobium Thin Films**

Ruoxu Wang, Yuan He, Tiancai Jiang, Yongming Li, Lubei Liu, Teng Tan, Shenghu Zhang (IMP/CAS, Lanzhou), Cong Liu, Xingyi Zhang (Lanzhou University, Lanzhou)

Coherent gradient sensing (CGS), a shear interferometry method, is developed to measure the full-field curvatures of a film/substrate system at 40k. We obtain the relationship between an interferogram phase and specimen topography, accounting for temperature effect. The self-interference of CGS combined with designed setup can reduce the air effect. The full-field phases can be extracted by fast Fourier transform. Both nonuniform thin-film thermal stresses and interfacial stresses are obtained by the extended Stoney¿s formula. The evolution of thermo-stresses verifies the feasibility of the proposed interferometry method and implies the ¿nonlocal¿ effect featured by the experimental results.

THPB061 **A Hybrid Model of the Thermal Conductivity of Superconducting Bulk and Thin Film Niobium**

Peng Xu, Neil T. Wright (MSU, East Lansing, Michigan), Thomas R. Bieler (Michigan State University, East Lansing, Michigan)

The thermomagnetic stability of SRF accelerator cavities improves with increasing thermal conductivity of Nb. Thin films of Nb cladding on Cu substrates have been proposed for future construction of high-performance cavities. No current models of the thermal conductivity of Nb include the effects of size. The conventional model based on BRT theory requires estimating several parameters from experimental results. It is not readily extended to predict the size effect of Nb thin films. Here, a hybrid model is proposed that uses Monte Carlo simulation for phonons and a kinetic theory of gases model for conduction due to normally conducting electrons. The Monte Carlo simulation considers phonon-electron scattering and phonon-boundary scattering, while the kinetic theory addresses electron-defect scattering and electron-phonon scattering. Predictions of the temperature dependent thermal conductivity of bulk Nb agree well with experimental results. A local maximum in thermal conductivity (i.e., the phonon peak) appears at about 2 K in appropriately heat-treated bulk material. Results for thin films indicate that temperature of the phonon peak increases as the thickness of Nb decreases.

THPB062 **RF Characterization of Novel Superconducting Materials**

Paul B. Welander, Matt Franzi, Sami Tantawi (SLAC, Menlo Park, California)

We utilize hemispherical test cavities for the rapid RF characterization of superconducting radio-frequency (SRF) materials. The cavities (one Cu, one Nb) operate at 11.4 GHz and are cooled by a pulse-tube cryorefrigerator to temperatures below 4 K. 2"-diameter (50.8 mm) samples are mounted to the flat face of the hemisphere, where the magnetic field is focused -- comprising less than 8% of the total surface area, the sample accounts for 33% of the total cavity loss. For low-power testing we utilize a network analyzer, while for high-power testing we use an XL-4 klystron. With the Nb cavity we can measure surface resistances down to 0.5 microhm, while with the Cu cavity we can measure quenching fields up to 360 mT. Operation at X-band frequencies permits a compact cavity and cryostat design with a reasonable sample size, while the cryorefrigerator is both cryogen-free and powerful enough to allow for rapid sample testing. A single measurement in one of our text cavities (including pump-down, cool-down, and warm-up) takes less than 24 hours! We will discuss cavity and cryostat design, as well as recent low- and high-power testing results on materials such as Nb, NbN, and MgB2.

THPB063 **Characterisation and Optimal Use of a Choked Test Cavity for SRF Thin Films Analysis**

Lewis Gurran, Philippe Goudket, Oleg B. Malyshev (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire), Graeme Burt (Cockcroft Institute, Lancaster)

A test cavity that uses RF chokes, rather than a physical seal, to contain the field is a promising method of SRF sample testing ¿ especially in thin films research where the rate of sample production far outstrips that of full SRF characterisation. Having the sample and cavity physically separate eliminates the need for skilled labour and specialist equipment to change samples - major causes of low throughput rate and high running costs for other test cavities - and also allows direct measurement of the RF power dissipated in the sample via power calorimetry. Choked test cavities operating at 7.8 GHz - one version with two RF chokes, another with three - have been designed by members of the Cockcroft Institute, and manufactured by Niowave*. The unconventional geometry of the cavity has made it unexpectedly challenging to reliably generate a suitable signal for two-probe SRF testing, i.e. a clear and symmetric resonance peak measured between two weakly coupled probes. An in-depth theoretical and experimental investigation has been made into the optimal cavity setup, and its key points are presented here along with any results from initial cold testing.

THPB064 **Design of an Assembly for Field Penetration Measurements on Superconducting Thin Film / Multilayer Samples**

Lewis Gurran, Philippe Goudket, Oleg B. Malyshev, Shrikant Pattalwar (STFC/DL/ASTeC, Daresbury, Warrington, Cheshire), Graeme Burt (Cockcroft Institute, Lancaster)

In the quest for higher-gradient SRF cavities, an increasing amount of attention is being paid to multi-layered structures: thin films that might be deposited onto either normal or superconducting substrates, and comprise either one or several superconducting layers or an S-I-S (superconductor-insulator-superconductor) structure. DC magnetic characterisation of these structures using conventional techniques (e.g. with a SQUID) will be, at best, incomplete. This is because, unlike in a cavity, all layers are immediately exposed to any applied magnetic field. A more illustrative figure of merit is the field of first penetration, the field strength applied parallel to one surface that first induces flux penetration all the way through to the opposite side. The difficulty comes from being able to generate a magnetic field on one face of the sample only. Recent experiments at Daresbury have used a superconducting coil to test tubular samples, and the next iteration will use a superferric dipole magnet to perform tests on planar samples. Key points from the design of the new system, and any available results from its commissioning, are presented.

THPB065 **Study of the Etching Mechanisms of Ar on Hydrocarbon Film : Molecular Dynamics Simulation**

Fujun Gou (Sichuan University, Chengdu), Jianjun Wei (Sichuan University, Sichuan)

In this study, molecular dynamics method was employed to investigate Ar bombarding on hydrocarbon-containing reactive layer on Niobium. In simulations, two types of reactive layer were selected. The simulation results show that for H-rich reactive layer, H etching was clearly seen; with increasing incident energy，C etching is enhanced. After some Ar exposures, C etching completely stops. For C-rich reactive layer, almost no Ni etching occurs. These indicate that Niobium carbide plays an important role in etching. The formation of Niobium carbide will inhibit Ni etching.

THPB066 **Introducing the Vertical High-temperature UHV Furnace of the S-DALINAC for Future Cavity Material Studies**

Ruben Grewe, Lambert Alff, Michaela Arnold, Jens Conrad, Marton Major, Norbert Pietralla (TU Darmstadt, Darmstadt), Florian Hug (IKP, Mainz)

Since 2005 the Institute for Nuclear Physics in Darmstadt operates a high temperature UHV furnace for temperatures of up to 1750℃. It has been used several times for hydrogen bake-out of the SRF cavities of the S-DALINAC with proven success. In 2013, studies at FNAL have shown that cavities treated with nitrogen reached an up to four times higher q-factor*. The cavities are exposed to N2 at 850℃ at the end of the H2 bake-out. A thin layer of normalconducting hexagonal niobium nitride (NbN) forms at the surface which is removed by electropolishing while the higher quality factors are attributed to the N2 diffusion into the bulk Nb. At temperatures from 1300℃ to 1700℃ a thin layer of the superconducting cubic phase of NbN can be observed, e.g. delta-phase NbN**, which has a higher critical field and higher critical temperature and thus is very intereresting for applications for SRF cavities***. The UHV furnace has been prepared for future treatments of Nb samples and cavities in a N2 atmosphere at high temperatures for research on cubic NbN. The material properties of the samples will be analyzed at the ATFT group at the Department for Material Sciences of TU Darmstadt.

THPB067 **Thin Film Coated SRF Cavity R&D Activity at Institute of Modern Physics (IMP)**

Teng Tan, Yuan He, Shichun Huang, Feng Pan, Hongwei Zhao (IMP/CAS, Lanzhou)

SRF cavity technique is the only approach to obtain high accelerating gradient with an affordable energy consumption. However, expensive high purity Nb and complicated cryogenic system hinder the wide application of this technique. Thin Film Coated SRF Cavities (TFSRF Cavities) employ copper cavities and superconducting thin film coating to reduce the

use of the unnecessary Nb materials. The high thermal conductivity of copper can also simplify the cryogenic system. Currently, IMP is running 2 major accelerator projects, CIADS and LEAF. If TFSRF Cavities can reach good performance, it is planned to build a cryomodule including 6 TFSRF cavities to accommodate a heavy ion RFQ of LEAF facility in order to demonstrate TFSRF cavity performance for heavy ion beam acceleration. IMP has initiated its TFSRF Cavities project in 2016. Different types of prototype copper cavities, including 1.3 GHz elliptical cavities and a variety of QWR cavities have been fabricated and prepared for Nb thin film deposition. The coating system design and small sample text results will be presented in this poster.

THPB068 **MgB2 Thin Films for SRF Cavity Applications**

Xiaoxing Xi (Temple University, Philadelphia)

MgB2 thin films grown by hybrid physical-chemical vapor deposition (HPCVD) have been investigated for SRF cavity applications. Clean MgB2 thin films have a low residual resistivity (<0.1 μΩcm) and a high Tc of 40 K, promising a low BCS surface resistance. Its thermodynamic critical field Hc is higher than Nb, potentially leading to a higher maximum accelerating filed. The lower critical field Hc1, which marks the vortex penetration into the superconductor and the vortex motion related dissipation, is lower for MgB2 than Nb, but it can be enhanced by decreasing the film thickness. I will present results on the enhancement of Hc1 in thin MgB2 films and coatings, deposition of MgB2 films on Cu, and the coating of RF cavities by MgB2. These results are encouraging for the application of MgB2 for SRF cavities.

THPB069 **Surface Studies of Nb3Sn Coated Samples Prepared under Different Coating Conditions**

Uttar Pudasaini (The College of William and Mary, Williamsburg, Virginia), Grigory V. Eremeev, Charles E. Reece (JLab, Newport News, Virginia), Michael Kelley (JLab, Newport News, Virginia; The College of William and Mary, Williamsburg, Virginia; Virginia Polytechnic Institute and State University, Blacksburg), James Tuggle (Virginia Polytechnic Institute and State University, Blacksburg)

Nb3Sn-coated Nb cavities have the potential for better performance and significant cost reduction as compared to traditional Nb SRF cavities. The technique of vapor diffusion coating of Nb3Sn on Nb cavities, attempted since 1970 ¿s, is the most successful so far. Current practice of Nb3Sn cavity fabrication in different research facilities follows this technique with minor variations. Using modern characterization tools, we examined the Nb3Sn coating prepared in different systems and/or under different conditions. Identically prepared high RRR (RRR ~ 300) Nb samples were coated under existing standard protocols in practice. Microstructure and composition of Nb3Sn coating was found very similar when examined with SEM/EDS. AFM examination was done in each sample and topography was compared in terms of power spectral densities (PSDs). SIMS depth profiles showed Ti traces in some of the samples.

THPB070 **Electrochemical Finishing Treatment of Nb3Sn Diffusion-coated Nb**

Uttar Pudasaini (The College of William and Mary, Williamsburg, Virginia), Grigory V. Eremeev, Charles E. Reece, Hui Tian (JLab, Newport News, Virginia), Michael Kelley (JLab, Newport News, Virginia; The College of William and Mary, Williamsburg, Virginia)

Nb3Sn cavities are now routinely prepared by depositing a few micron thick Nb3Sn coating on Nb cavities using tin vapor diffusion process. In case of niobium there is a significant improvement after electropolishing, but electrochemical finishing treatment on Nb3Sn coatings has not been studied. Controlled removal of first few layers could lead to a smoother and cleaner surface that is favorable for better RF performance. Several samples, which were coated with Nb3Sn by vapor diffusion process in JLab sample chamber, were used to explore polishing parameters, such as I-V characteristics, removal rate, topography, etc. Preliminary results from the first runs are discussed here.

THPB071 **Combined RF and Surface Studies of Cutouts Inner Surfaces from Nb3Sn-coated Cavity**

Grigory V. Eremeev, Charles E. Reece (JLab, Newport News, Virginia), Michael Kelley (JLab, Newport News, Virginia; The College of William and Mary, Williamsburg, Virginia; Virginia Polytechnic Institute and State University, Blacksburg), Uttar Pudasaini (The College of William and Mary, Williamsburg, Virginia), James Tuggle (Virginia Polytechnic Institute and State University, Blacksburg)

A BCP-treated single cell niobium cavity was coated with Nb3Sn following a typical tin vapor diffusion technique. After RF testing with thermometry mapping system, it was dissected to make several cutout samples for the examination of Nb3Sn coated inner surfaces using different surface science techniques. While uniform distribution of coating was observed throughout the surface, some patchy areas containing irregular grains with thinner coating and microscopic pits were found. Using thermometry data measured during the RF test, microstructure and composition of the coating are correlated to the RF surface resistance of the respective areas.

THPB072 **CVD Deposition of Nb3Ge and Nb3Sn for SRF Cavities**

Paolo Pizzol (The University of Liverpool, Liverpool)

Advancements in technology have taken bulk niobium close to its theoretical operational limits, pushing the research to explore novel materials, such as niobium based alloys. A15 compounds offer such an alternative, exhibiting both higher Tc and higher Hc2 compared to bulk niobium. Replacing then the niobium with a material with better thermal conductivity, such as copper, coated with superconductive thin films of A15 compounds would lead to improved performance at reduced cost. Physical vapour deposition (PVD) is currently used to produce these coatings, but it suffers from lack of conformity. This issue can be resolved by using chemical vapour deposition (CVD) and plasma enhanced chemical vapour deposition (PECVD), which are able to produce high quality coatings over surfaces with a high aspect ratio. This project explores the use of PECVD / CVD techniques to deposit the A15 compounds Nb3Sn and Nb3Ge starting from their chlorinated precursors. The samples obtained are characterized via SEM, TEM, SAD, XRD, XPS, and EDX as well as assessing their superconductivity characteristics (RRR and Tc).

THPB073 **Optimization of NbTiN Based Multi-layered Structures for SRF Applications**

Anne-Marie Valente-Feliciano, Grigory V. Eremeev, Charles E. Reece (JLab, Newport News, Virginia), Tobias Junginger (TRIUMF, Vancouver)

Theoretical interest has stimulated efforts to grow and characterize thin multi-layer superconductor/insulator/superconductor (SIS) structures for their potential capability of supporting otherwise inaccessible surface magnetic fields in SRF cavities. The technological challenges include realization of high quality superconductors with sharp, clean, transition to high quality dielectric materials and back to superconductor, with careful thickness control of each layer. Choosing NbTiN and AlN as first candidate materials, we have developed the tools and techniques that produce such SIS film structures. Using DC magnetron sputtering and HiPIMS (high power impulse magnetron sputtering), NbTiN and AlN can be deposited with nominal superconducting and dielectric parameters. Hc1 flux penetration field enhancement is observed for NbTiN layers with a Tc of 16.9 K for a thickness less than 150 nm. The optimization of the thickness of each type of layers to reach optimum SRF performance is underway. This talk describes this work and the rf performance characteristics observed to date.

THPB074 **Towards High Performance SRF Niobium Thin Films**

Anne-Marie Valente-Feliciano, Gianluigi Ciovati, Charles E. Reece (JLab, Newport News, Virginia), Sarah Aull (CERN, Geneva)

With the development of energetic vacuum deposition techniques, high quality Nb films have been produced supporting the promise of high RF performance for Nb/Cu cavities. The best quality yet Nb films deposited by ECR (electron cyclotron resonance) plasma show a significantly improved Q-slope compared to magnetron sputtered Nb films and a first flux penetration in the dc regime at 180 mT, close to bulk Nb Hc1. In energetic condensation, the controlled incoming ion energy enables a number of processes (adsorbed species desorption, surface atoms enhanced mobility and impinging ions sub-implantation) which influence the nucleation and subsequent growth of the Nb film, leading to improved structures at lower process temperatures. Each film growth phase can be tailored to optimize the Nb film final RF response. This contribution shows how the ion energy and thermal energy during film growth from the interface layer to the final RF surface layer contribute to a strong film-substrate interface, and optimized nucleation, structure, defect density, and quality of the final RF surface for Nb films. RF results performed on quadrupole resonator samples and on 3 GHz cavities will be presented.

THPB075 **GaN-based Photocathodes for High Luminosity Electron Beams**

Marc Schumacher, Xin Jiang, Michael Vogel (University Siegen, Siegen)

Prospective light sources requires photocathodes with high quantum efficiency (QE), long lifetime and minimized thermal emittance. One promising candidate meeting the aforementioned specifications is GaN. Due to its wide band gap (Eg = 3,4 eV), GaN can be excited by UV-light sources. Its thermal and chemical stability are added bonuses. In the framework of the present activity, the synthesis of GaN films on Si, Cu, Mo and Nb by means of rf magnetron sputtering is proposed. In this context, Ga, GaAs and GaN are suitable source material candidates, which are sputtered in a nitrogen/argon plasma discharge. The conductivity as well as the band-gap of the corresponding films can be modified by dopants like Mg and In, respectively. Standard materials science characterization techniques such as SEM, EDX, XRD or XPS are used to explore the growth mechanism of GaN alongside with a morphological and chemical examination. To assess and optimize the performance of the photocathode the abovementioned requirements are tested in an in-situ setup. In addition to the project outline, first experimental results of GaN coatings synthesized based on a GaAs source sputtered in pure N2 are presented.

THPB078 **Fabrication and RF Test of Large-area MgB2 Films on Metal Substrates**

Xin Guo (PKU, Beijing)

Magnesium diboride (MgB2) is a promising candidate material for superconducting radio-frequency (SRF) cavities because of its higher transition temperature and critical field compared with niobium. To meet the demand of RF test devices, the fabrication of large-area MgB2 films on metal substrates is needed. In this work, high quality MgB2 films

with 50-mm diameter were fabricated on niobium as well as on copper by using an improved HPCVD system at Peking University. RF tests for MgB2 films on niobium were carried out at SLAC National Accelerator Laboratory. The transition temperature is approximately 39.6 K and the RF surface resistance is 120 μΩ at 4 K and 11.4 GHz. The fabrication processes, surface morphology, DC superconducting properties and RF tests of these large-area MgB2 films are presented.

THPB079 **Simulations of RF Field-induced Thermal Feedback in Niobium and Nb3Sn Cavities**

Jixun Ding, Daniel Leslie Hall (Cornell University (CLASSE), Ithaca, New York), Matthias Liepe (Cornell University, Ithaca, New York)

Thermal feedback is a known limitation for SRF cavities made of low-purity niobium, as the increased losses at higher temperature described by BCS theory create a feedback mechanism that can eventually result in a runaway effect and associated cavity quench. In a similar manner, niobium cavities coated with Nb3Sn may also be subject to increased losses from thermal feedback, as Nb3Sn is possessed of a much lower thermal conductivity than niobium, although this effect will be mitigated by the thin film nature of the coating. In order to better understand the degree to which thermal feedback plays a role in the performance of Nb3Sn cavities, it is necessary to understand how the various components of the problem play a role in the outcome. In this paper, we present the first results from simulations performed at Cornell University that model RF induced thermal feedback in both conventional niobium cavities and niobium cavities coated with a thin film of Nb3Sn. The impact of layer thickness, thermal conductivity, and interfacial (Kapitza) resistance on the performance of the cavity are discussed.

21-July-17	Oral	Auditorium A
08:00-9:10	**FRXAA-Technology-CM II**	

FRXAA01
08:00
20mins

Production Status of Superconducting Cryomodules for the Facility for Rare Isotope Beams

Chris Compton, Hiroyuki Ao, Brian Bird, Walter Hartung, Samuel J. Miller, John Thomas Popielarski, Laura Popielarski, Marc Reaume, Kenji Saito, Mark Shuptar, Sergey Stark, Bryan Tousignant (FRIB, East Lansing), Joseph Asciutto, Ting Xu (FRIB, East Lansing, Michigan)

The Facility for Rare Isotope Beams (FRIB) is an SRF accelerator project in full production at Michigan State University (MSU). With the civil construction nearly complete, the installation of accelerator equipment into the tunnel has taken center stage. A total of 46 superconducting cryomodules are needed for the FRIB linac to reach 200 MeV per nucleon. The linac consist of four cavity types (beta = 0.041, 0.085, 0.29, and 0.53) and 6 different cryomodule designs. Cryomodule assembly is done in 5 parallel bays, each one compatible with every cryomodule type. Completed cryomodules undergo full system testing in bunkers before being accepted and delivered to the tunnel. The current status of the cryomodule assembly effort will be presented, including lessons learned and overall experience to date.

FRXAA02
08:20
20mins

High-efficiency, High-current Optimized Main-linac ERL Cryomodule

Fumio Furuta (Cornell University (CLASSE), Ithaca, New York)

The Main Linac Cryomodule (MLC) prototype is a key component of the Cornell-BNL ERL Test Accelerator (CBETA) project, which is a 4-turn FFAG ERL currently under construction at Cornell University. This novel cryomodule is the first SRF module ever to be fully optimized simultaneously for high efficient SRF cavity operation and for supporting very high CW beam currents. After a successful initial MLC testing, the MLC has now been moved into its final location for the CBETA ring. For a first beam test of the MLC and CBETA, the Cornell ERL high voltage DC gun and SRF injector cryomodule were connected to MLC via an entry beam line; a beam stop assembly was also installed at the exit line. In this paper, we summarize the performance of this novel ERL cryomodule including the results of the first beam test and the additional tests focused on RF field stability and cavity microphonics.

FRXAA03
08:40
30mins

Performance of the High Q CW Prototype Cryomodule for LCLS-II at FNAL

Genfa Wu, Anna Grassellino, Elvin Robert Harms, Nikolay Solyak (Fermilab, Batavia, Illinois)

Continuous wave (CW) operation of LCLS-II cryomodules require substantial design changes to previously designed 1.3 GHz ILC type cryomodule. The new design uses innovative nitrogen doped cavities together with a helium vessel that provides high thermal gradient on the cavities during a fast cool down. Magnetic shielding uses two layers outside of helium vessel and a single layer that completely encapsulates the end groups except the beam apertures. Sophisticated magnetic hygiene includes vacuum vessel demagnetization, magnetic screening of the components and final demagnetization to the assembled cryomodule. Fermilab successfully assembled a preproduction LCLS-II cryomodule that achieved unprecedented cavity quality factors of 3.0e10 at a nominal cryomodule voltage. The ambient fields in the cavities were near zero. This article describes historic cavity performance under various cool down parameters. Cavity performance retained very well compared to that of vertical tests.

21-July-17	Oral	Auditorium A

9:10-10:45	FRXBA-Technology-Others

FRXBA01
09:10
25mins

LLRF Commissioning at the European XFEL

Mathieu Omet, Valeri Ayvazyan, Julien Branlard, Lukasz Butkowski, Michael Fenner, Mariusz Krzysztof Grecki, Martin Hierholzer, Matthias Hoffmann, Martin Killenberg, Daniel Kuehn, Frank Ludwig, Uros Mavric, Sven Pfeiffer, Heinrich Pryschelski, Konrad Przygoda, Radoslaw Rybaniec, Holger Schlarb, Christian Schmidt, Bartlomiej Szczepanski, Henning Christof Weddig (DESY, Hamburg), Wojciech Cichalewski, Dariusz Radoslaw Makowski, Filip Makowski, Aleksander Mielczarek (TUL-DMCS, Lodz), Krzysztof Czuba, Bartosz Gasowski, Stanislaw Hanasz, Pawel Karol Jatczak, Dawid Kolcz, Tomasz Piotr Lesniak, Dominik Sikora (Warsaw University of Technology, Warsaw)

The European X-ray Free-Electron Laser (XFEL) at Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany is a user facility under commissioning, providing ultrashort X-ray flashes with a high brilliance in the near future. All LLRF stations of the injector, covering the normal conducting RF gun, A1 (8 1.3 GHz superconducting cavities (SCs) and AH1 (8 3.9 GHz SCs), were successfully commissioned by the end of 2015. The injector was operated with beam transmission to the injector dump since then. After the conclusion of the construction work in the XFEL accelerator tunnel (XTL), the commissioning of 22 LLRF stations (A2 to A23) started with the beginning of 2017. Every station consists of a semi-distributed LLRF system controlling 32 1.3 GHz SCs. Stable operation with beam transport to the main dump (TLD) was achieved. The commissioning procedure applied, experience gained and performance reached are described.

FRXBA02
09:35
25mins

High Precision RF Control for SRF Cavities in LCLS-II

Lawrence Doolittle (LBNL, Berkeley, California)

The unique properties of SRF cavities enable a new generation of X-ray light sources in XFEL and LCLS-II. The LCLS-II design calls for 280 L-band cavities to be operated in CW mode with a Q_L of 4x10^7, using Single-Source Single-Cavity control. The target RF field stability is 0.01% and 0.01 degree for the band above 1 Hz. Hardware and software implementing a digital LLRF system has been constructed by a four-lab collaboration to minimize known contributors to cavity RF field fluctuation, including careful attachment tothe phase reference line, and minimizing the effects of RF crosstalk by placing forward and reverse signals in chassis separate from the cavity measurement. A low-noise receiver/digitizer section will allow feedback to operate with high proportional gain without excessive noise being sent to the drive amplifier.Test results will show behavior on prototype cryomodules at FNAL and JLab,ahead of the 2018 final accelerator installation.

FRXBA03
10:00
20mins

Coaxial Power Coupler Development at Argonne National Laboratory

Michael Kelly, Sang-Hoon Kim (ANL, Argonne, Illinois)

A series of coaxial rf power couplers with increasingly stringent demands on power handling, reliability and flexibilty of operations has been developed over the past decade at ANL. Intended for use in new and upcoming high-power SRF-based cavity linacs, these couplers span a range of physical sizes from 40-80 mm, frequencies from 72 MHz to 1.4 GHz, and cw power handling requirements from a few kiloWatts up to 20 kW thus far. Most of these also incorporate the capability to adjust the coupler axially in order to optimize the Qext due to effects of, for example, beam loading and multipacting. Several particular issues of mechanical, thermal and electromagnetic design, many uncovered through extensive experimental testing, are discussed.

FRXBA04
10:20
25mins

Analysis and Management of Microphonics in Operational SRF Cavities With Bandwidths of Approximately 10 Hz

Tom Powers (JLab, Newport News, Virginia)

Superconducting Radio Frequency Cavity detuning can be due to several effects. These effects include helium pressure variations, vibrations driven by external narrow band sources such as HVAC motors, cooling water systems, tuner motor operation, cryogenic system machinery, and occasionally cryogenic system instabilities such as thermo-acoustic oscillations. They can also be driven by broadband white or pink noise which, in general, will excite the resonant modes of the structure. All of these affect the cavity resonant frequency. Variations that occur at frequencies above a few tenths of a Hertz are considered microphonics. Jefferson Lab is the first lab to install and operate a large number of SRF cavities with relatively high loaded-Qs, 88 in CEBAF and 16 in the LERF. This work will focus on the approaches and measurements that one should consider when designing a system in order to understand the modal nature of the structure, the measurement techniques for determining the extent of the microphonics, and the mitigations that can be implemented in order to reduce the effects of outside perturbances. Examples of results at various other institutions will also be presented.

21-July-17	Oral	Auditorium A
11:15-12:15	Closing Session-FRYA	

FRYA01
11:15
30mins

SCL - Key Issue of ADANES in China

Wen-Long Zhan (IMP/CAS, Lanzhou)

ADANES (Accelerator Driven Advanced Nuclear Energy System) is consist of the Accelerator Driven Burner (ADB) and the Accelerator Driven Recycle Used Fuel (ADRUF).ADB is optimized for nuclear waste transmutation, fissile material breeding and energy production in situ, which is long refueling period (~30yrs) fast core and initialed by accelerator driven. Since the higher controllable reactivity, the ¿raw¿ recycle fuel (>50% Fission Products) could be used inside ADB. Therefore, ADANES is the ideal close fuel cycle for utilizing fissile fuel 95% and minimizing radiotoxicity <4% with live time < 500 yr. In this approaches, the SCL play ADB¿s starter (<15% duration) which could drive ~10 set of the fast reactor. So far, the key technical R&D make a significant breakthrough.Two injector (325/ 162.5 MHz) have extracted ~10MeV&1.1~2.7mA CW proton beam and the integral SCL has extracted ~25MeV beam. The new concept of the granular target is made of fluid solid grain in mm and driven by gravity, which power could increase to 10~100MW. Next phase ADANES will start soon which include ADB power ~2.5 MW &500MeV proton SCL;ADRUF¿s compact neutron source driven by <250MeV&5mA deuteron SCL.

FRYA02
11:45
30mins

Next Generation Neutrino Facility for Long Baseline Oscillation Experiment by Multi-MW Proton SC Accelerator

Tadashi Koseki (KEK, Ibaraki)

Accelerator-based neutrino oscillation experiments have played an important role in the confirmation of the neutrino oscillation and in precision measurements of the oscillation parameters. Two cutting-edge experiments, T2K and NOvA, open a door for the CP violation study in the neutrino sector using intense proton beams of several hundred kW from the Main Ring of J-PARC and the Main Injector of Fermilab, respectively. In this talk, a review of high intensity proton accelerator facilities for the next-generation accelerator-based neutrino oscillation experiments is presented. In these facilities, superconducting rf is a key technology to realize MW and multi-MW proton beams.

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CHENGDU KAITENG SIFANG DIGITAL BROADCASTING & TV EQUIPMENT CO., LTD.

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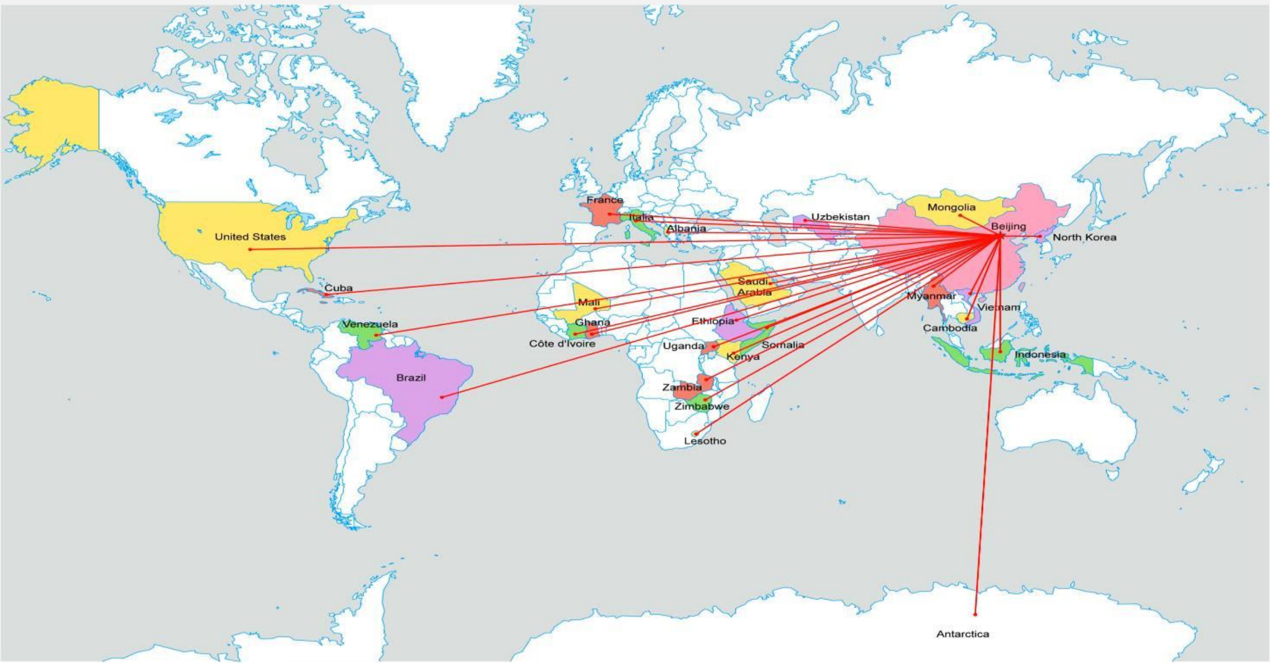
Company Profile

Beijing BBEF Science & Technology Co., Ltd. is the first largest professional broadcast equipment manufacturer in China. After over 60 years development, BBEF has become a manufacturer with the largest scale, the most comprehensive business field and the highest market share in China. It is engaged in R&D, production and system integration of radio and TV transmitting equipment.

The products of BBEF cover TV transmitter, FM transmitter, MW & SW transmitter, microwave transmission equipment, antenna & steel tower, CATV equipment, as well as audio & video equipment. The overall power of these equipment ranges from 1W to 2000kW; and the operation frequency band is from medium wave to microwave including about 250 types of equipment.

Depending on strong technology strength, BBEF has created dozens of 1st broadcast equipment in China and made outstanding contributions to the development of the broadcasting and television cause. As a leading enterprise in the broadcasting and television industry, BBEF's products spread across the country, and are also exported to many countries all over the world, including Europe, America, Africa, Southeast Asia, etc.



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04 制造能力

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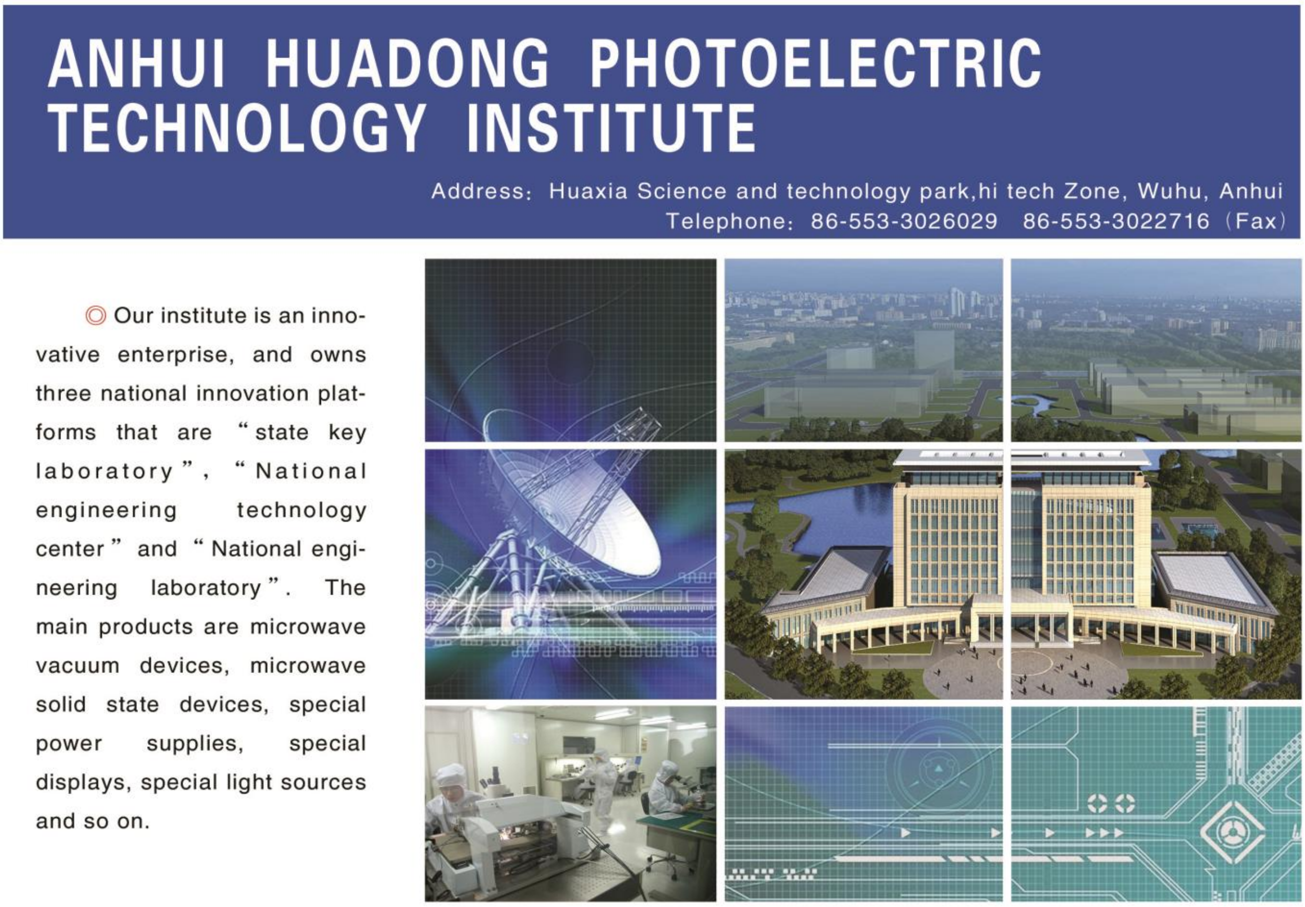
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SLAC Type
J-Type
Dual Input Dual/Single Output
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C-Band Accelerator Section
L-Band Accelerator Section
DTL (For CSNS)
RFQ (For ADS)
03
Accelerator
Turnkey project
04
Cryogenic Products
Super Conducting Cavity
(Spoke, 5-Cell, 9-Cell)
Forward Power Couplers
(500/325/1300MHz)
Helium vessel
Cryomodule
Microwave Devices
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SLED
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Dummy Load
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06
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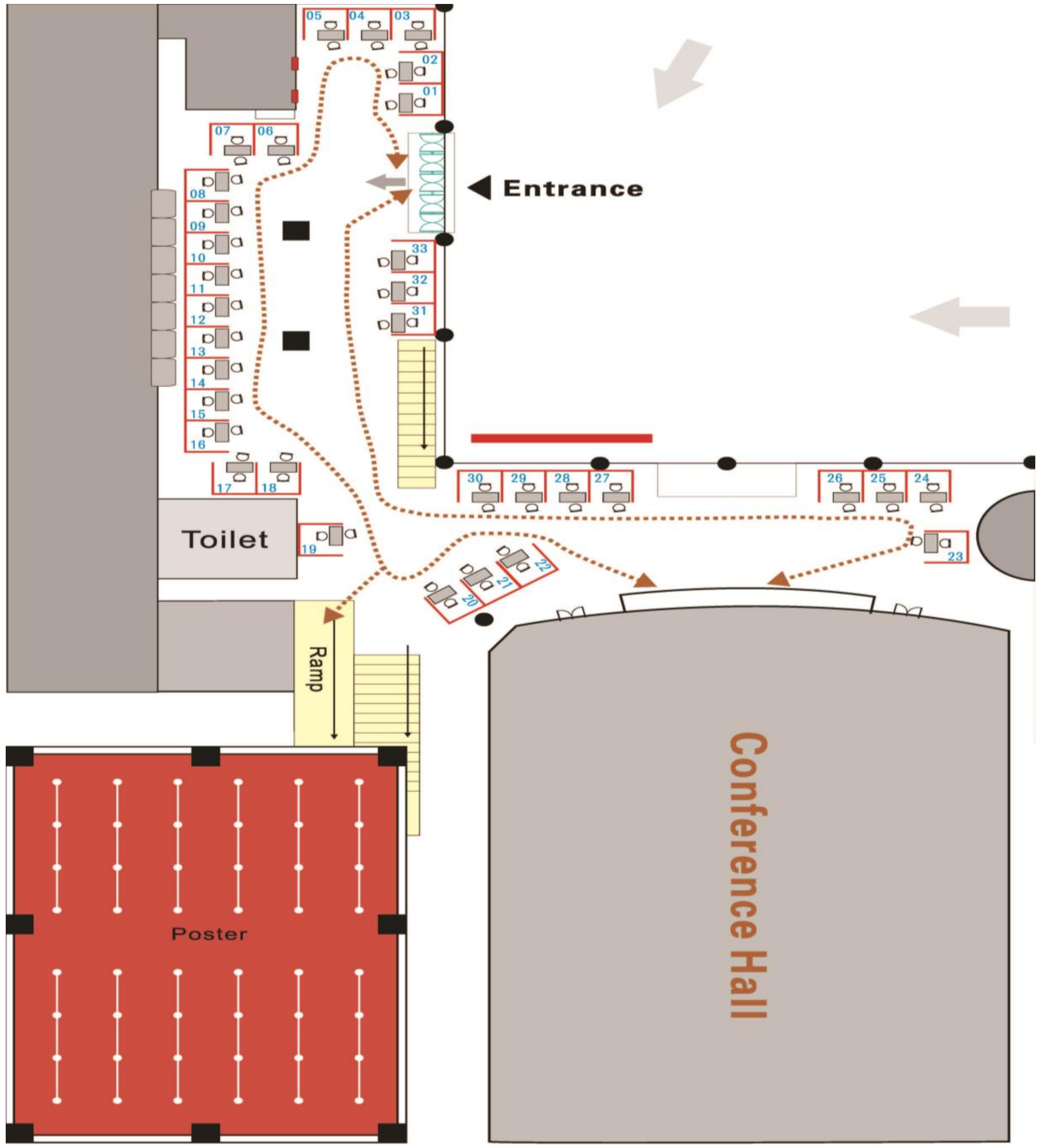
	Sunday 7/16	Monday 7/17	Tuesday 7/18	Wednesday 7/19	Thursday 7/20	Friday 7/21
8:00		Opening Ceremony	CEPC SRF System Design… J. Zhai, IHEP 15 mins	High Performance Nb3Sn Cavities D. Hall, Cornell 20 mins	Conditioning and operation of … W. Yue, IMP 15 mins	Production status of superconducting cryomodules for the Facility for… C. Compton, MSU/FRIB 20 mins
8:05						
8:10						
8:15			HIE Isolde Cavity Production… W. Venturini Delsolaro, CERN 20 mins		Fabrication and Testing of… Z. Yao, TRIUMF 15 mins	
8:20		Successful Beam Commissioning of Chinese ADS Injector-II Y. He, IMP/CAS 20 mins		Material Studies for understanding of Nb3Sn cavity performance… Y. Trenikhina, FNAL 20 mins		High-Efficiency, High-Current Optimized Main-LINAC ERL Cryomodule for… F. Furuta, Cornell 20 mins
8:25						
8:30					Crab cavities for the… R. Calaga, CERN 15 mins	
8:35			FRIB SRF production status: cavities, ancillaries… T. Xu, MSU/FRIB 25 mins			
8:40		European-XFEL Linac Commissioning and performance D. Reschke, DESY 20 mins		High-Performance Thin-Film Niobium Produced via Chemical … R. Porter, Cornell 20 mins		Performance of the high Q CW prototype cryomodule for LCLS-II at FNAL G. Wu, FNAL 30 mins
8:45					Fabrication, treatment and test of… J. Hao, PKU 20 mins	
8:50						
8:55						
9:00		50 MeV e-Linac ARIEL R. Laxdal, TRIUMF 20 mins	Low Temperature Doping… P. Koufalis, Cornell 15 mins	Superconducting Radio Frequency Cavities Coating: Alternative … G. Rosaz, CERN 20 mins		
9:05					Thermal mapping for SRF with Transition Edge Sensors H. Furci, CERN 20 mins	
9:10						LLRF Commisioning…. Mathieu Omet, DESY 25 mins
9:15			Flux Expulsion Studies on Niobium S. Posen, FNAL 15 mins			
9:20		Superconducting Accelerator for ERL based FEL… H. Sakai, KEK 20 mins		Dirty layers, Bi-layers and Multi-layers: Insights from MuSR… T. Junginger, TRIUMF 20 mins		
9:25					Advanced OST system for the … Y. Tamashevich, HZB 15 mins	
9:30	Arriving in Lanzhou Registration		N-H Interaction Study of Nitrogen… Z. Yang, PKU 15 mins			
9:35						High precision RF control for SRF cavities in LCLS-II L. Doolittle, LBL 25 mins
9:40		The LCLS-II SRF LINAC A. Burrill, SLAC 20 mins		The role of cool down dynamics on the performance… S. Aull, CERN 20 mins	Progress With Bipolar HF-Free EP… H. Tian, JLAB 15 mins	
9:45			A unified theory of surface resistance and the residual … T. Kubo, KEK 20 mins			
9:50						
9:55					Review of heat treatments for low beta cavities : what's so different from… D. Longuevergne, IPN 20 mins	
10:00		SRF Systems for the Jefferson Lab Electron Ion Collider (JLEIC) R. Rimmer, JLAB 20 mins		Theoretical estimates of maximum fields in superconducting… D. Liarte, Cornell 20 mins		Coaxial Power Coupler Development at Argonne National Laboratory M. Kelly, ANL 20 mins
10:05			Hydrogen Distribution and Hydride… S. Balachandran, NHMFL 20 mins			
10:10						
10:15					Results and New Insights from Vertical Testing of LCLS-II Production Cavities D. Gonnella, SLAC 20 mins	
10:20		Progrss on C-ADS accelerator… F. Yan, IHEP 15 mins		RF dissipation due to nonlinear dynamics of Josephson vortices… A. Gurevich, ODU 20 mins		Analysis and Management of Microphonics in Operational Srf Cavities With Bandwidths ~10 Hz T. Powers, JLAB 25 mins
10:25			Analysis of Flux Pinning… A. Palczewski, JLAB 15 mins			
10:30						
10:35		Coffer Break			Coffer Break	
10:40			Coffer Break	Coffer Break		
10:45						Coffer Break
10:50						
10:55						
11:00						
11:05		The Superconducting Accelerator for the ESS Project F. Schlander, ESS 20 mins			Performance Testing of FRIB Early Series Cyomodules J. Popielarski, MSU/FRIB 20 mins	
11:10			The Importance of the Electron… J. Maniscalco, Cornell 15 mins	A Superconducting Harmonic Cavity System for the ANL Advanced… S. Kim, ANL 20 mins		
11:15						SCL - Key Issue of ADANES in China W. Zhan, CAS 30 mins
11:20						
11:25		BESSY VSR: SRF Challenges and Developments … A. Velez, HZB 20 mins	Effect of interstitial impurities on the field dependent… M. Martinello, FNAL 30 mins		Achievement of Stable Pulsed Operation at 36 MV/m in STF-2… Y. Yamamoto, KEK 20 mins	
11:30				Construction and Performance… N. Sakamoto, RIKEN 15 mins		
11:35						
11:40						
11:45		The progress of RAON (RISP) D. Jeon, IBS 20 mins		Seamless QWR for HIE-ISOLDE S. Teixeira, CERN 15 mins	Operating the Third Harmonic SRF System in the E-XFEL Injector P. Pierini, DESY 20 mins	Next Generation Neutrino Facility for Long Baseline Oscillation Experiment by Multi-Mw Proton Sc Accelerator T. Koseki, KEK 30 mins
11:50						
11:55			Electron Mean Free Path… M. Checchin, FNAL 20 mins			
12:00				The R&D on TEM-type SRF… Feisi He, IHEP 15 mins		
12:05		Set of RF parameters for… N. Schwerg, CERN 15 mins			The conditioning and operation of HWR cryomodules for C-ADS Y. Wan, IMP 20 mins	
12:10						
12:15			Progress on characterization and optimization of multilayers C. Z. Antoine, CEA Saclay 20 mins			Closing Ceremony
12:20		SRF Technologies for PIP-II and III A. Rowe, FNAL 20 mins		Half-wave Cryomodule for Proton Improvement Project 2 at Fermilab Z. Conway, ANL 20 mins		
12:25					ESS Activities on Cryomodules at Saclay and Osay F. Peauger, CEA 20 mins	
12:30						
12:35			Thermal boundary resistance model and defect statystical… R. Vaglio, UniNa. 20 mins			
12:40		Free Time		Superconducting Twin-Axis Cavity… H. Park, ODU 20 mins		Free Time
12:45					Long operational experience with beams in Compact-ERL cryomodules… Kensei Umemori, KEK 20 mins	
12:50						
12:55			Strategy and experimental results toward the solution… V. Palmieri, INFN LNL 20 mins			
13:00				Outgoing Along the Yellow River		
13:05					Free Time	
13:10			Free Time			
13:30						
14:00		Poster Session I	Poster Session II		Poster Session III	IMP Tour
14:30						
15:00						
15:30						
16:00	Student Poster Session					
16:30						
17:00		Hot Topic I	Hot Topic II		Hot Topic III	
17:30						
18:00	Welcome Reception	Chairman's Reception		Banquet		
18:30						
19:00						
19:30						
20:00						

Floor Plan



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