

16th INTERNATIONAL CONFERENCE ON RF SUPERCONDUCTIVITY

SEPTEMBER 22-27, 2013 - PARIS, FRANCE



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WELCOME



Dear Attendee,

On behalf of the International Program Committee (IPC), we are very pleased to welcome you to the 16th International Conference on RF Superconductivity in Paris and Caen. This conference series has started in 1980 as a Workshop in Karlsruhe and since then, it has grown continuously with the increased interest of the SRF science and technology use for particle accelerators all over the world.

With over 340 registrants, 370 paper contributions, and 20 industrial exhibitors this year, its world-wide impact is undeniable and

makes this Conference the most appropriate opportunity to report and exchange on the latest advances on SRF science and technology.

As it is the tradition since several editions now, the Conference program consists in a mixture of plenary talks, poster sessions and “hot topic” discussion sessions that are designed to stimulate ideas confrontation and maintain the workshop roots of this conference.

We are also very pleased to propose an industrial exhibition of growing importance, all over the Conference duration, which will help to enhance the interaction between researchers and industry.

And importantly, to attract and educate students new to the field of SRF, for which close to 70 people have registered.

We gratefully acknowledge the sponsorship support we received from several institutional and industrial partners listed on this booklet, which enabled us to award grants to 32 students and young scientists for this SRF edition!

In closing, we would like to thank the IPC for its contribution to build the Conference Program and the Local Organizing Committee for its implication in the Conference organization.

We are very happy that you can join us in Paris, the "City of Light", and we wish you an enjoyable stay and a fruitful Conference.

Claire Antoine, Chair
Centre d'Etudes de Saclay

Sébastien Bousson, Co-Chair
Institut de Physique Nucléaire d'Orsay



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DETAILED PROGRAMME

Monday, 23 September 2013

MOTA 08:00 - 08:15

Welcome

MOIOA 08:15 - 10:15

SRF Challenges for Recent and New Projects I

08:15 MOIOA01

The FRIB Project at MSU

Speaker: Matthaeus Leitner - Facility for Rare Isotope Beams

08:35 MOIOA02

Status and Challenges of Spiral2 SRF Linac

Speaker: Robin Ferdinand - Grand Accélérateur Nat. d'Ions Lourds

08:55 MOIOA03

The Challenge and Realization of the Cavity Production and Treatment in Industry for the European XFEL

Speaker: Waldemar Singer - Deutsches Elektronen-Synchrotron

09:15 MOIOA04

SRF Challenges for Energy Recovery Linacs

Speaker: Andrew Burrill - Helmholtz-Zentrum Berlin für Materialien und Energie GmbH Elektronen-Speicherring BESSY II

09:45 MOIOA05

SRF in Heavy Ions Projects

Speaker: Dong-O Jeon - Institute for Basic Science

10:15 - 10:45

Coffee break - Visit of the exhibition (Room Honnorat)

MOIOB 10:45 - 12:10

SRF Challenges for Recent and New Projects II

10:45 MOIOB01

High Power Proton/Deuteron Accelerators

Speaker: Jean-Luc Biarrotte - Institut de Physique Nucléaire d'Orsay

11:10 MOIOB02

Towards a 100mA superconducting RF photoinjector at HZB

Speaker: Axel Neumann - Helmholtz-Zentrum Berlin für Materialien und Energie GmbH Elektronen-Speicherring BESSY II

11:30 MOIOB03

SRF Photoemission Electron Guns at BNL: First Commissioning Results

Speaker: Sergey Belomestnykh - Brookhaven National Laboratory Collider - Accelerator Department

11:50 MOIOB04

Commissioning and Operation of DC-SRF Injector

Speaker: Kexin Liu - Peking University Institute of Heavy Ion Physics

MOIOC 12:10 - 13:00

Basic R&D Bulk Niobium - Theory, calculation

12:10 MOIOC01

Thermal Boundary Resistance in Niobium Cavities

Speaker: Vincenzo Palmieri - Istituto Nazionale di Fisica Nucleare Laboratori Nazionali di Legnaro

12:30 MOIOC02

A New First-Principles Calculation of Field-Dependent RF Surface Impedance of BCS Superconductor

Speaker: Binping Xiao - Thomas Jefferson National Accelerator Facility SRF Institute

12:45 MOIOC03

Density-Functional Theory Calculations Relevant to Hydride Formation and Prevention

Speaker: Denise Christine Ford - Fermi National Accelerator Laboratory Technical Division

MOP 14:30 - 18:00

Poster Session I (Project under construction, Future project, SRF Photoinjector, Large scale fabrication, Overall performances, Cryomodule, Cryogenic)

MOHT 18:00 - 19:00

Hot topic: Material qualification for large scale projects



Tuesday, 24 September 2013

TUIOA 08:00 - 09:55

Basic R&D Bulk Niobium - High Performances

08:00 TUIOA01

Influence of Cooldown on Cavity Quality Factor

Speaker: Oliver Kugeler - Helmholtz-Zentrum Berlin für Materialien und Energie GmbH
Elektronen-Speicherring BESSY II

08:15 TUIOA02

High QO Research: The Dynamics of Flux Trapping in SC Niobium

Speaker: Julia Marie Vogt - Helmholtz-Zentrum Berlin für Materialien und Energie
GmbH Elektronen-Speicherring BESSY II

08:35 TUIOA03

New Insights on the Physics of RF Surface Resistance and a Cure for the Medium Field Q-Slope

Speaker: Anna Grassellino - Fermi National Accelerator Laboratory

08:55 TUIOA04

Q-Slope Studies at Fermilab: New Insight From Cavity and Cutouts Investigations

Speaker: Alexander S Romanenko - Fermi National Accelerator Laboratory Technical Division

09:15 TUIOA05

New Insights Into Quench Caused by Surface Pits in SRF Cavities

Speaker: Yi Xie - Cornell University (CLASSE) Cornell Laboratory for Accelerator-Based Sciences and Education

09:35 TUIOA06

Localization of Field Emitter in a 9-Cell Cavity

Speaker: Yongming Li - Peking University Institute of Heavy Ion Physics

TUIOB 09:55 - 10:15

Basic R&D Bulk Niobium - Processing I

09:55 TUIOB01

R&D Progress in SRF Surface Preparation With Centrifugal Barrel Polishing (CBP) for Both Nb and Cu.

Speaker: Ari Deibert Palczewski - Thomas Jefferson National Accelerator Facility

10:15 - 10:45

Coffee break - Visit of the exhibition (Room Honnorat)

TUIOC 10:45 - 12:55

Basic R&D Bulk Niobium - Processing II

10:45 TUIOC01

Review on EP Advances Worldwide

Speaker: Fumio Furuta - Cornell University (CLASSE) Cornell Laboratory for Accelerator-Based Sciences and Education

11:15 TUIOC02

Bipolar EP: Electropolishing without Fluorine in a Water Based Electrolyte

Speaker: Allan Rowe - Fermi National Accelerator Laboratory Technical Division

11:35 TUIOC03

Fluorine Free Ionic Liquid Electropolishing of Niobium Cavities

Speaker: Vlada Borisovna Pastushenko - Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

11:55 TUIOC04

Analysis of Post-Wet-Chemistry Heat Treatment Effects on Nb SRF Surface Resistance

Speaker: Pashupati Dhakal - Thomas Jefferson National Accelerator Facility

12:15 TUIOC05

An Innovative Purification Technique of 6 GHz Tesla Type Nb Mono Cell Seamless Superconducting Cavities in UHV System

Speaker: Antonio Alessandro Rossi - Istituto Nazionale di Fisica Nucleare Laboratori Nazionali di Legnaro

12:35 TUIOC06

Study on Optimum EBW Condition for Fine and Large Grain Nb Cavities

Speaker: Takayuki Kubo - High Energy Accelerator Research Organization Accelerator Laboratory

TUP 14:30 - 18:00

Poster Session II (Theory, High performances, Surface processing, Deposition technique, Multilayers, Alternative SC material, Field emission, Multipacting, Medium Field Q-Slope, T-mapping, Second sound)

TUHT 18:00 - 19:00

Hot Topic: Origin of dissipations (ITE, vortices, magnetic impurities...)



DETAILED PROGRAMME

Wednesday, 25 September 2013

WEIOA 08:00 - 09:35

08:00 WEIOA01

Basic R&D New materials - Thin film deposition techniques

HiPIMS: a New Generation of Film Deposition Techniques for SRF Applications

Speaker: Anne-Marie Valente-Feliciano - Thomas Jefferson National Accelerator Facility

08:25 WEIOA02

Thin Film Growth by Energetic Condensation

Speaker: Mahadevan Krishnan - Alameda Applied Sciences Corporation

08:55 WEIOA03

Nb Sputtered Quarter Wave Resonators for the HIE-ISOLDE

Speaker: Walter Venturini Delsolaro - European Organization for Nuclear Research Beams Department (BE)

09:15 WEIOA04

Nb₃Sn for SRF Application

Speaker: Matthias Liepe - Cornell University (CLASSE) Cornell Laboratory for Accelerator-Based Sciences and Education

WEIOB 09:35 - 10:15

09:35 WEIOB01

Basic R&D New materials - Multilayers, MgB₂ - I

Status of MgB₂ Coating Studies for SRF Applications

Speaker: Tsuyoshi Tajima - Los Alamos National Laboratory

09:55 WEIOB02

Proof of Concept Thin Films and Multilayers Toward Enhanced Field Gradients in SRF Cavities

Speaker: Rosa A. Lukaszew - The College of William and Mary

10:15 - 10:45

Coffee break - Visit of the exhibition (Room Honnorat)

WEIOC 10:45 - 12:05

10:45 WEIOC01

Basic R&D New materials - Multilayers, MgB₂ - II

High Resolution Surface Resistance Studies

Speaker: Sarah Aull - European Organization for Nuclear Research Beams Department (BE)

11:05 WEIOC02

Activities on SRF Multilayers at Orsay / Saclay

Speaker: Cedric Baumier - Institut de Physique Nucléaire d'Orsay Accelerator Division

11:25 WEIOC03

Atomic Layer Deposition of Thin Superconducting Films and Multilayers: Coupons and Cavity Tests

Speaker: Thomas Proslie - Argonne National Laboratory

11:45 WEIOC04

Theoretical Field Limits for Multi-Layer Superconductors

Speaker: Sam Posen - Cornell University (CLASSE) Cornell Laboratory for Accelerator-Based Sciences and Education

WEIOD 12:05 - 12:55

12:05 WEIOD01

Technical R&D - Focus on Magnetic Shielding

Review of Magnetic Shielding Design of Low-Beta Cryomodule

Speaker: Robert Edward Laxdal - TRIUMF Canada's National Laboratory for Particle and Nuclear Physics

12:35 WEIOD02

Magnetic Shielding: Review of Material Properties for Adequate Choice

Speaker: Mika Masuzawa - High Energy Accelerator Research Organization Accelerator Laboratory



Thursday, 26 September 2013

THIOA 08:00 - 09:35

Technical R&D - Mass production

08:00 THIOA01

Infrastructure, Methods and Test Results for the Testing of 800 Cavities

Speaker: Detlef Reschke - Deutsches Elektronen-Synchrotron

08:20 THIOA02

The Challenge to Assemble 100 Cryomodules for the European XFEL

Speaker: Catherine Madec - Commissariat à l'Energie Atomique

08:40 THIOA03

Cavity Fabrication Study in CFF at KEK

Speaker: Masashi Yamanaka - High Energy Accelerator Research Organization

09:00 THIOA04

Low-Beta Cryomodule Design Optimized for Large-Scale Linac Installations

Speaker: Samuel John Miller - Facility for Rare Isotope Beams Michigan State University Cyclotron Laboratory

09:20 THIOA05

Program for Optimization of SRF Linac Construction and Operation Costs

Speaker: Tom Powers - Thomas Jefferson National Accelerator Facility

THIOB 09:35 - 10:15

Technical R&D - Overall performances I

09:35 THIOB01

CEBAF Upgrade: Cryomodule Performance and Lessons Learned

Speaker: Michael Allen Drury - Thomas Jefferson National Accelerator Facility

09:55 THIOB02

High Q Cavities for the Cornell ERL Main Linac

Speaker: Ralf Eichhorn - Cornell University (CLASSE) Cornell Laboratory for Accelerator-Based Sciences and Education

10:15 - 10:45

Coffee break - Visit of the exhibition (Room Honnorat)

THIOC 10:45 - 11:45

Technical R&D - Overall performances II

10:45 THIOC01

Low Beta Cavity Development for an ATLAS Intensity Upgrade

Speaker: Michael Kelly - Argonne National Laboratory

11:00 THIOC02

High Power CW Tests of cERL Main-Linac Cryomodule

Speaker: Hiroshi Sakai - High Energy Accelerator Research Organization Accelerator Laboratory

11:15 THIOC03

Superconducting Photonic Band Gap Structures for High-Current Applications

Speaker: Evgenya I. Simakov - Los Alamos National Laboratory

11:30 THIOC04

Demonstration of RF Stability in STF 9-cell Cavities Aiming for the Near Quench Limit Operation

Speaker: Mathieu Omet - Sokendai, the Graduate University for Advanced Studies Department of Accelerator Science

THIOD 11:45 - 13:00

Technical R&D - Low Beta Cavities Development Issues

11:45 THIOD01

SRF cavities for ADS project in China

Speaker: Yuan He - Chinese Academy of Sciences Institute of Modern Physics

12:05 THIOD02

Faced Issues in ReA3 Quarter-Wave Resonators and their Successful Resolution

Speaker: Alberto Facco - Michigan State University National Superconducting Cyclotron Laboratory

12:25 THIOD03

Cavity Development for the Linear IFMIF Prototype Accelerator

Speaker: Nicolas Bazin - Commissariat à l'Energie Atomique Direction des Sciences de la Matière Institut de recherche sur les lois fondamentales de l'Univers

12:45 THIOD04

A Cold Tuner System With Mobile Plunger

Speaker: David Longuevergne - Institut de Physique Nucléaire d'Orsay

THP 14:30 - 18:00

Poster Session III (Cavity Design, Magnetic Shielding, Coupler, HOM, Tuner, RF generation, RF control)

THHT 18:00 - 19:00

Hot Topic: What is the best surface treatment for high Q and medium gradient ?



DETAILED PROGRAMME

Friday, 27 September 2013

FRIOA 08:00 - 09:15

08:00 FRIOA01

New cavity Design: Deflecting and Other Structures

LHC Crab Cavity: Progress and Outlook

Speaker: Rama Calaga - European Organization for Nuclear Research Beams Department (BE)

08:20 FRIOA02

Developing Quarter Wave SRF Cavities for Hadron Colliders

Speaker: Qiong Wu - Brookhaven National Laboratory

08:40 FRIOA03

Fabrication and Testing of Deflecting Cavities for APS

Speaker: John David Mammosser - Thomas Jefferson National Accelerator Facility SRF Institute

09:00 FRIOA04

Superconducting RF-Dipole Deflecting and Crabbing Cavities

Speaker: Subashini Uddika De Silva - Old Dominion University Department of Physics

FRIOB 09:15 - 10:15

09:15 FRIOB01

New cavity Design: Accelerating structures I

SRF Cavities for Future Ion Linacs

Speaker: Zachary Alan Conway - Argonne National Laboratory

09:30 FRIOB02

Development and Performance of 325 MHz Single Spoke Resonators for Project X

Speaker: Leonardo Ristori - Fermi National Accelerator Laboratory Technical Division

09:45 FRIOB03

Development of 650 MHz cavities for the GeV Proton Accelerator in Project X

Speaker: Sumit Som - Department of Atomic Energy Variable Energy Cyclotron Centre

10:00 FRIOB04

CERN Developments for 704 MHz Superconducting Cavities

Speaker: Ofelia Capatina - European Organization for Nuclear Research

10:15 - 10:45

Coffee break - Visit of the exhibition (Room Honnorat)

FRIOC 10:45 - 11:25

10:45 FRIOC01

New cavity Design: Accelerating structures II

Design of the 352 MHz, beta 0.50, Double-Spoke Cavity for ESS

Speaker: Patricia Duchesne - Institut de Physique Nucléaire d'Orsay Accelerator Division

11:05 FRIOC02

Cryomodules with Elliptical Cavities for ESS

Speaker: Guillaume Devanz - Commissariat à l'Energie Atomique Direction des Sciences de la Matière Institut de recherche sur les lois fondamentales de l'Univers

FRIOD 11:25 - 12:25

11:25 FRIOD01

Keynote Talks

Pathways to an Higgs Factory

Speaker: Hitoshi Murayama - Institute for the Physics and Mathematics of the Universe

11:55 FRIOD02

Quantum Measurement with "Trapped" Microwave Photons in a SRF Cavity

Speaker: Michel Brune - Laboratoire Kastler Brossel

FRTA 12:25 - 13:00

Student Awards and Closing



GENERAL INFORMATION



CONFERENCE VENUE

The 16th International Conference on RF Superconductivity will be held in the “Maison Internationale Universitaire”, Paris (France)

Maison Internationale
Cité internationale universitaire de Paris
17, boulevard Jourdan
75014 Paris

INTERNET ACCESS

An open wireless internet access is available in the conference venue with a login.

Select the network **Wifi-colloques**

User Name: ciupseptembre13

Password: ciupseptembre13

Computers are also available in the Internet Café in the Salon Gulbenkian with access to a printer.

BREAKS AND LUNCHES

Refreshments breaks every morning and afternoon (except on Wednesday) in the exhibition room.

Lunch breaks are from 13:00 to 14:30.

You will find the list of nearby restaurants in your delegate bag.

GROUP PHOTOGRAPH

A group photograph will be taken on Wednesday, September 25th, at 13:00.

LIST OF PARTICIPANTS

You will find this list in your delegate bag. The list will also be posted on the SRF 2013 website following the conference.

HOW TO GET THERE ?

The Maison Internationale can be reached by various means:

By public transportation:

- RER, line B: Stop at Cité Universitaire (this same RER line goes to Roissy and Orly Airports)
- Metro, Line 4: Stop at Porte d'Orléans (+ 10 min walk)
- Tramway, Line T3: Stop at Cité Universitaire
- Bus, line 21, 88, 216: Stop at Cité Universitaire
- Bus, line 88: Stop at Jourdan Montsouris
- Bus, line 67: Stop at Stade Charlety Porte de Gentilly

By taxi:

- Taxis G7: 33 (0)1 47 39 47 39
- Taxis Bleus: 33 (0)891 70 10 10
- Alpha Taxis: 33 (0)1 45 85 85 85



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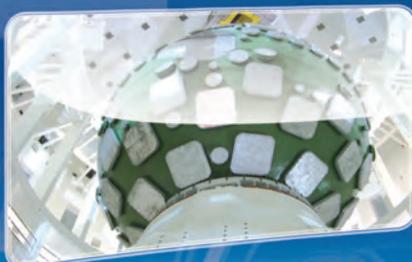
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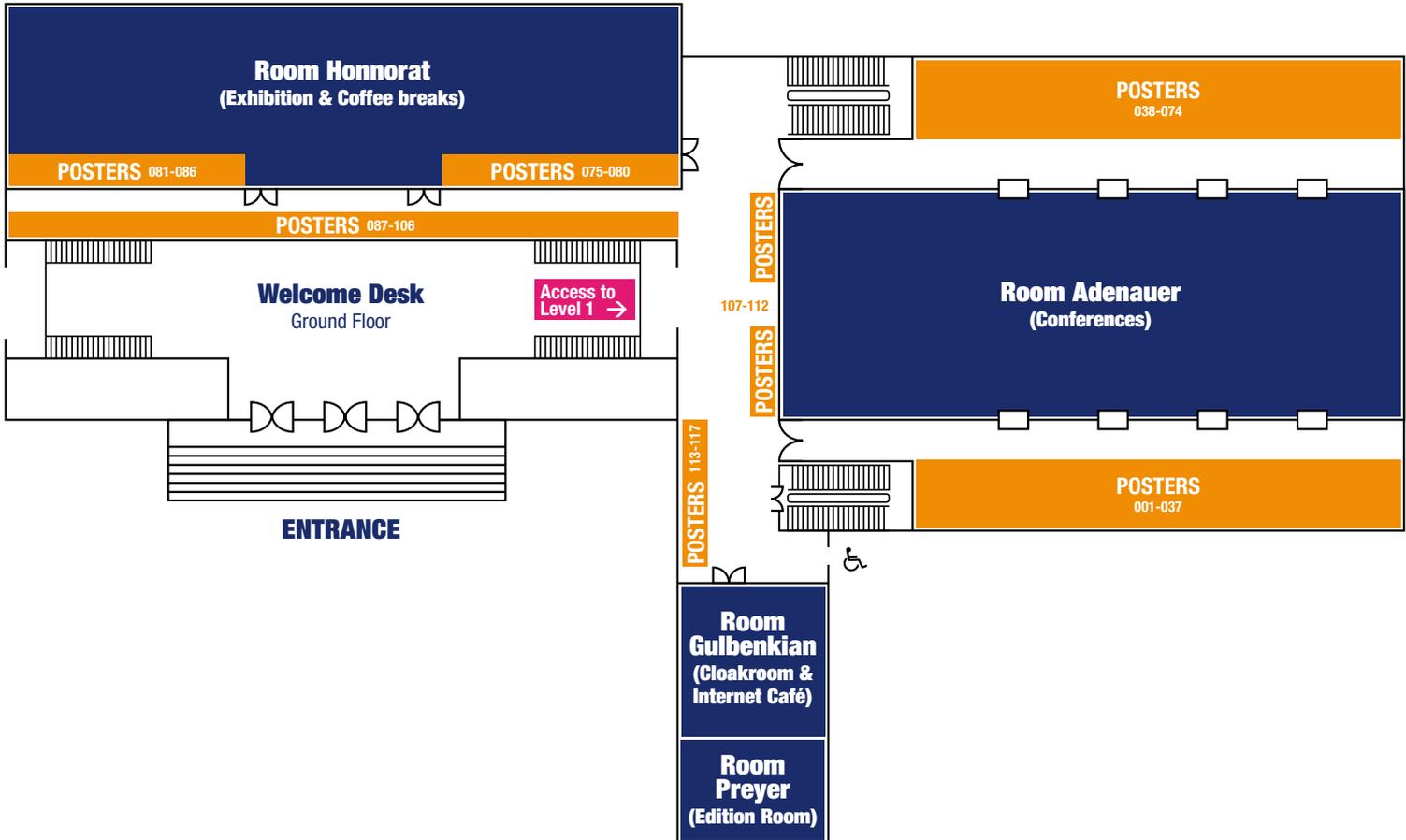


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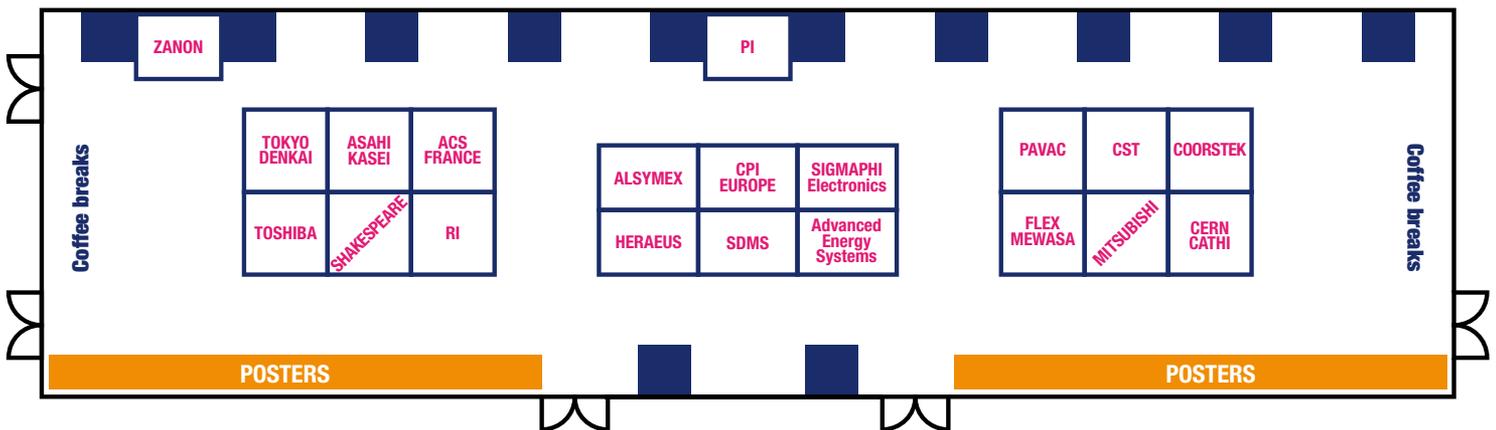
FLOOR PLAN & EXHIBITION MAP

FLOOR PLAN



EXHIBITION MAP

Room Honnorat: Level 1





SOCIAL PROGRAMME



WELCOME RECEPTION

The SRF 2013 Welcome Reception will be held at the Maison Internationale, Paris.

Date: Sunday September 22nd 2013
from 18:00 to 20:00

Location: Salon Honnorat, Level +1
Maison Internationale
Cité Internationale Universitaire
Paris, France

Please note that there will be no admittance to any part of the programme without the appropriate identification badge.

HISTORY

Maison Internationale in Paris, the fourth of its kind around the world, was constructed in the 1930s, after the buildings known by the same name in New York (1924), Berkeley (1930) and Chicago (1932). After donating some of his fortune to restoring the Chateau de Fontainebleau and the Chateau de Versailles, American philanthropist John D. Rockefeller, Jr. turned his thoughts to the Cité Internationale and financed the construction of Maison Internationale there. The aim was to create a common area for all of the houses where students from different countries could come together and create a diverse community.



In 1933 the plans for Maison Internationale were entrusted to American architect Jean-Frederic Larson; he drew his inspiration from classical French architecture, particularly the Chateau de Fontainebleau and designed a building in a “neo-Louis XIII” style. The impressive structure, which opened its doors in 1936, measures 2200 sq.m. divided between two symmetrically constructed buildings around a central structure, its two wings enclosing a courtyard.



SEINE RIVER CRUISE

On behalf of the local organizing committee for the 16th International Conference on RF Superconductivity, we invite you for an historical & poetical river cruise of Paris on Wednesday September 25th, 2013.

To reveal the heart of the City of light, the one-hour sightseeing tour will lead you to discover or rediscover all of the magic of the banks of the River Seine, which are enhanced by the most prestigious monuments which have marked history (i.e; Eiffel Tower, Invalides, Louvre Museum, Notre Dame, etc...).



MEETING POINT

Wednesday September 25th 2013, 15:30.

Compagnies des Bateaux Mouches
Port de la Conférence - Pont de l'Alma
(departure & arrival)
Seine, Right Bank, Paris 8th

Important note: as the boat is not privatized and there is a departure every 30 minutes, we strongly encourage you to **arrive at 15:10** in order to increase the chance of sharing the same boat.

ACCESS

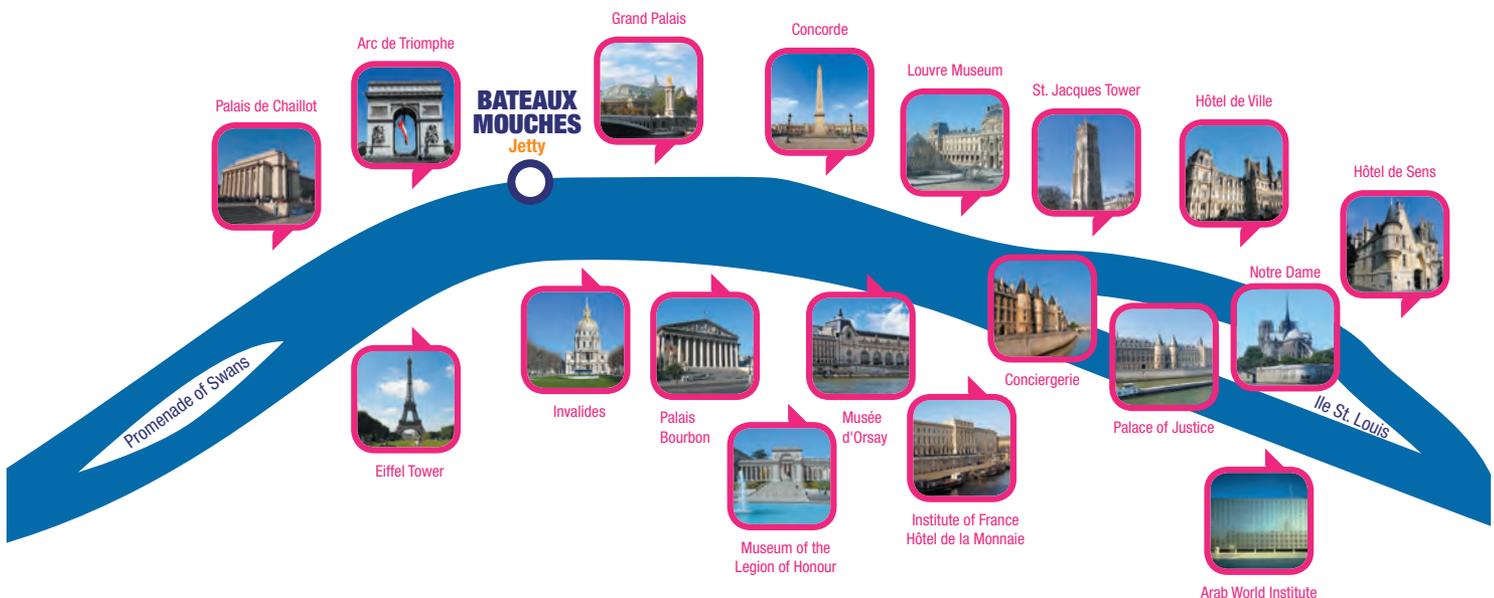
By public transportation, from the venue:

RER, line B: from Cité Universitaire to Saint-Michel Notre-Dame
(Direction to Aeroport Charles de Gaulle 2/Mitry-Claye).

Then RER, line C: from Saint-Michel Notre-Dame to Pont de l'Alma (Direction to Saint Quentin en Yvelines).

Duration: approximately 30 minutes

By car: free parking on the quay throughout the whole duration of the cruise.





SOCIAL PROGRAMME

GALA DINNER

The SRF 2013 Gala Dinner will be held at the Salle Wagram.

Date: Wednesday September 25th 2013
from 19:00
Dinner at 20:00

Address: 39 / 41 Avenue de Wagram
75017 Paris

ACCESS

By public transportation

Metro: Station Ternes (line 2)
Station Charles de Gaulle-Etoile (line 1,2,6)

RER: Charles de Gaulle - Etoile (Line A)

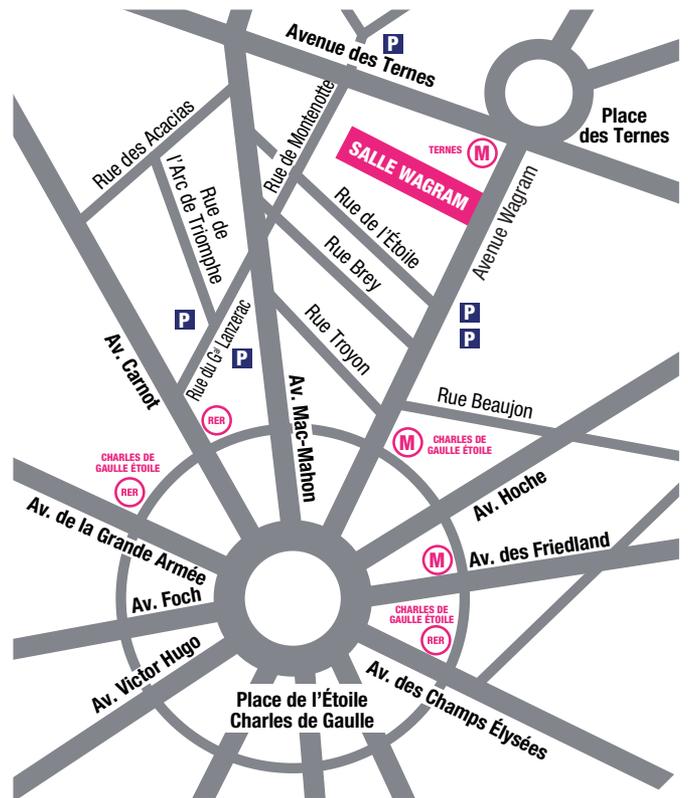
Bus: 30, 31, 43, 93 (Ternes)
22, 52, 73, 92 (Charles de Gaulle - Étoile)

Car park: 22 bis Avenue de Wagram - 38/59 Avenue des Ternes - 17 Avenue Mac-Mahon - 14 bis Avenue Carnot

From the conference venue

RER, line B: from Cité Universitaire to Chatelet-Les-Halles (Direction to Aéroport Charles de Gaulle 2/ Mithy-Claye).
Then **RER, line A:** from Chatelet-Les-Halles to Charles de Gaulle - Etoile (Direction to St Germain en Laye/Poissy/Cergy).

Duration: approximately 30 minutes



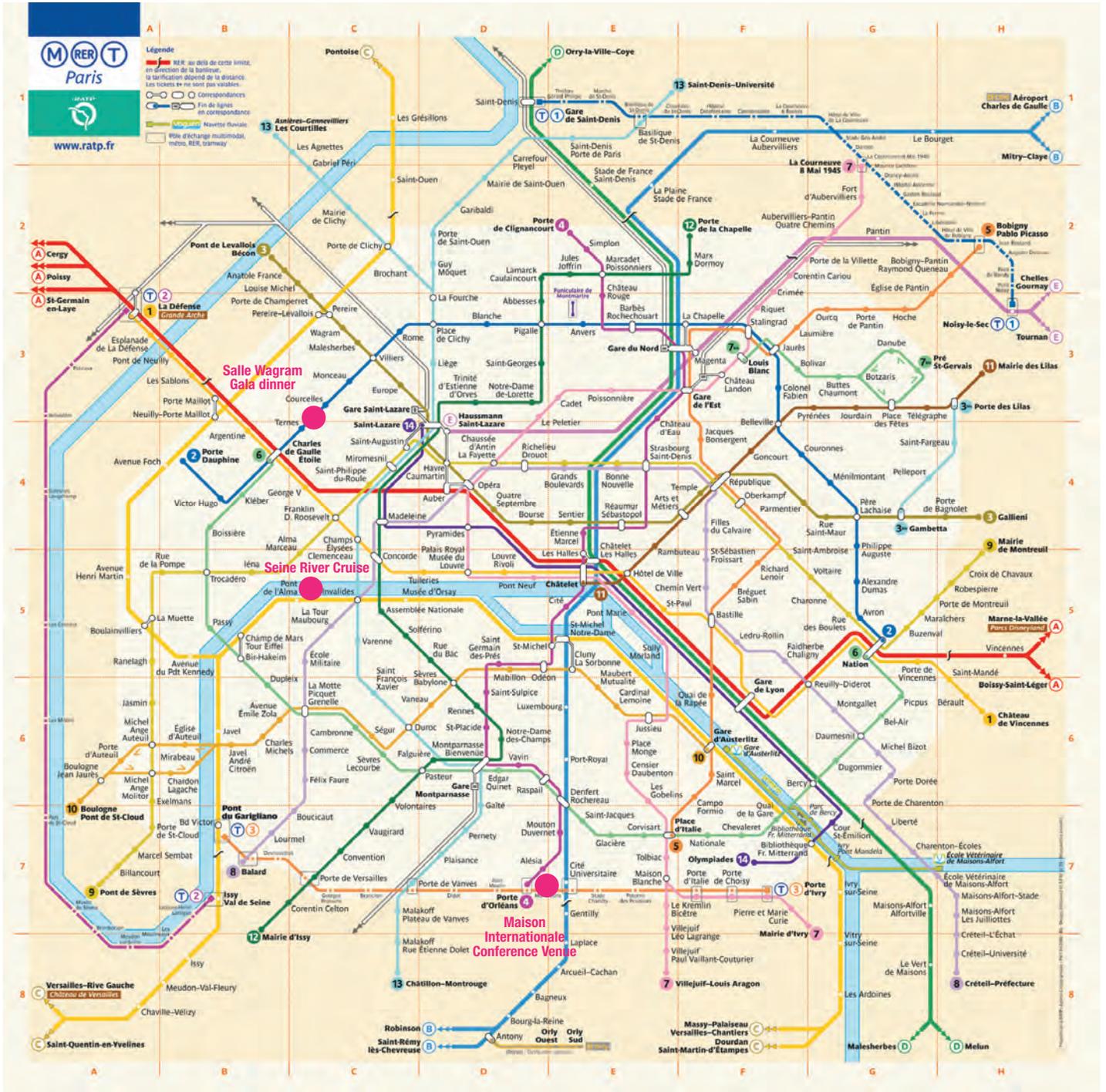
HISTORY

Built in 1865, this location became one of the oldest place for festivity in Paris and one of the latest historical remains of the biggest dance shows during the Second Empire. Throughout the 20th Century, this place became an exquisite witness of the most significant events in politics, sports as well as in the social and cultural life of Paris.





METRO MAP OF PARIS



Maison Internationale
Cité internationale universitaire
17, boulevard Jourdan
75014 Paris

Seine River Cruise
Compagnies des Bateaux Mouches
Port de la Conférence
Pont de l'Alma
Seine, Right Bank, Paris 8th

Salle Wagram
39 / 41 Avenue de Wagram
75017 Paris

RI serves the XFEL project with cavities and couplers ready for use

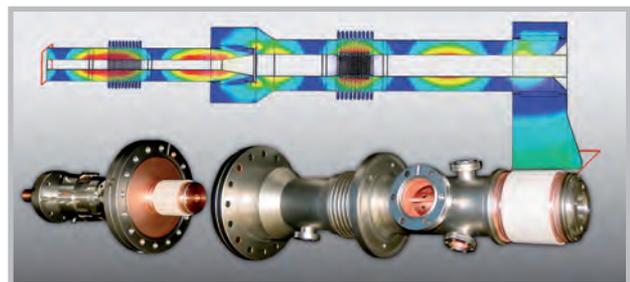


The production of cavities and couplers for the European XFEL strengthens RI's position as the world leader in manufacturing key components for superconducting RF accelerators

In 2010 RI was contracted by DESY to deliver 300 elliptical 1.3 GHz cavities for the European XFEL project. The number was increased to a total of 420 cavities in March 2013. The contract includes mechanical manufacturing of the cavities, the surface preparation for the cold RF test, and the joining of the helium tanks.

An upgrade of the RI infrastructure includes a 150 sqm clean room of class ISO 4 for cavity surface preparation, modern electron beam welding facilities and a 800 °C furnace for vacuum heat treatment of niobium cavities. This enlarges our surface treatment capacity for delivery rates of up to 6 cavities per week.

The XFEL coupler production of in total 670 pcs was won by RI in a consortium with Thales Electron Devices (TED). These couplers will be delivered under vacuum, clean, and ready for RF conditioning to the customer LAL(France), which also involves assembly procedures in our ISO 4 clean rooms.





VISIT OF LABS

Two tours have been organized during the afternoon of 27th of September 2013 (Friday). The bus will leave from the Maison Internationale at 13:30 and return at the Maison Internationale by 18:00-18:30. Boxed lunches will be provided on the bus.

TOUR 1

It includes Synchrotron SOLEIL, the French national synchrotron laboratory, and CEA, the French Alternative Energies and Atomic Energy Commission, with the visit of the following facilities:



At SOLEIL

- SOLEIL main control room (presentation of the accelerator and beamlines)
- Storage Ring RF system (solid state RF amplifiers, RF cryomodules and cryogenic system)
- Beamlines, PROXIMA and DEIMOS (cryostat with sc coils and 1.8 K “cold finger”)



At CEA

- Superconducting magnets: W7X plant, ISEULT and JT-60SA
- IPHI injector
- Supratech teststand (RF and cryogenic plants)
- XFEL village (clean room and assembly hall)

TOUR 2

It includes the IPNO (Institut de Physique Nucléaire d’Orsay) and the LAL (Laboratoire de l’Accélérateur Linéaire), with the visit of the following facilities:



At IPNO

- Superconducting cavity conditioning facilities (chemistry (BCP) and clean rooms)
- SPIRAL2 cryomodule assembly area
- Cryomodule and coupler test area for MAX (MYRRHA Accelerator eXperiment)
- Cryogenic plants and cavity test areas (4.2 and 1.8 K)



At LAL

- XFEL coupler facility
- Clean room for coupler preparation
- RF conditioning



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TUTORIALS

The tutorial sessions on the science, technology and applications of RF superconductivity to particle accelerators were held at GANIL laboratory in Caen from Sept. 19-21, 2013. This place was selected to allow the visit of the new French superconducting linac under installation in this major Radioactive Ion Beam (RIB) and stable-ion beam facility for nuclear physics, astrophysics and interdisciplinary research.

The tutorials are especially designed for students, young researchers and individuals new in the field of RF superconductivity. The objectives are to provide general and technical information suitable to design superconducting cavity for accelerator, taking into account the last known recipes on this very specific accelerator technology.

The following main topics have been treated during the tutorials sessions:

1 st Day: Basics	2 nd Day: (cold) RF operation	3 rd day : cavity processing and R&D
Basic Principles of RF Superconductivity <i>E. Palmieri, INFN</i>	Cryogenics <i>H. Nakai, KEK</i>	Processing; heat treatments, EP/BCP, clean room technique, baking <i>P. Michelato, INFN</i>
TM-class Cavity Design <i>J. Sekutovicz, DESY</i>	SRF cavity testing/operation <i>T. Powers, JLAB</i>	Limits in cavity performances Material /surface aspects <i>C. Reece, JLab</i>
TEM-class Cavity Design <i>M. Kelly, ANL</i>	SPIRAL2 visit	Beyond bulk Niobium <i>A.-M. Valente, JLab</i>
Design of High-Power and HOM- Coupler for SC Cavities <i>E. Kako, KEK</i>	SC RF Cavities operation with Beam. Including LLRF <i>S. Belomestnykh, BNL</i>	

More than 70 students and young scientists researchers attended this event.





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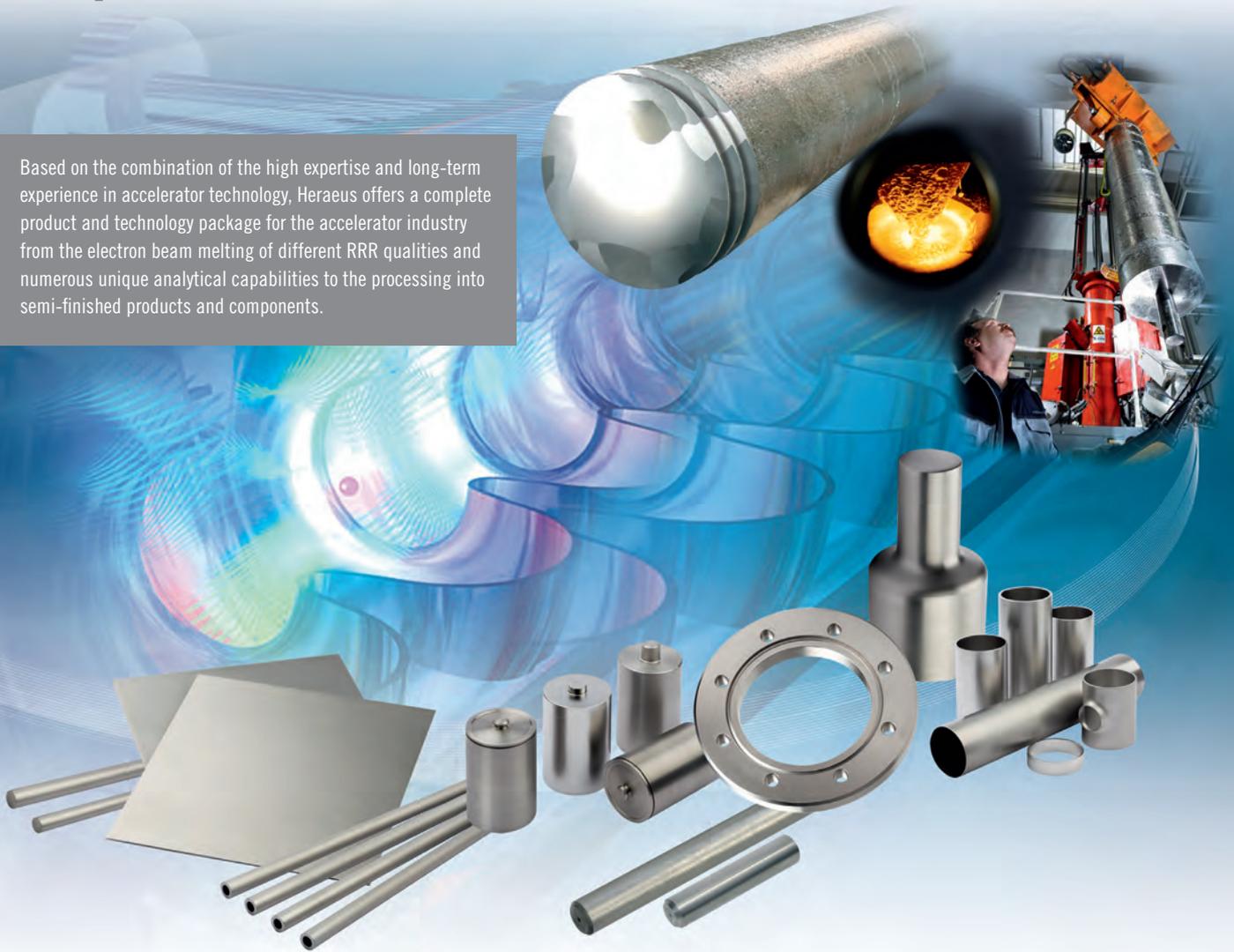


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Official opening hours of the Scientific Edition Office:

Sunday, September 22

16:00 - 19:00

Monday to Thursday, September 23-26

07:45 - 19:00

Friday, September 27

07:45 - 13:00

POSTER SESSIONS

Poster Sessions will take place in Honnorat Room, Adenauer Room and contiguous Galleries. Presenters should upload a PDF of their poster for inclusion in the proceedings.

Young scientist Session Sunday, September 22

16:00 - 18:00 (*displayed until 20:00*)

Poster Session 1 Monday, September 23

14:30 - 18:00

Poster Session 2 Tuesday, September 24

14:30 - 18:00

Poster Session 3 Thursday, September 26

14:30 - 18:00

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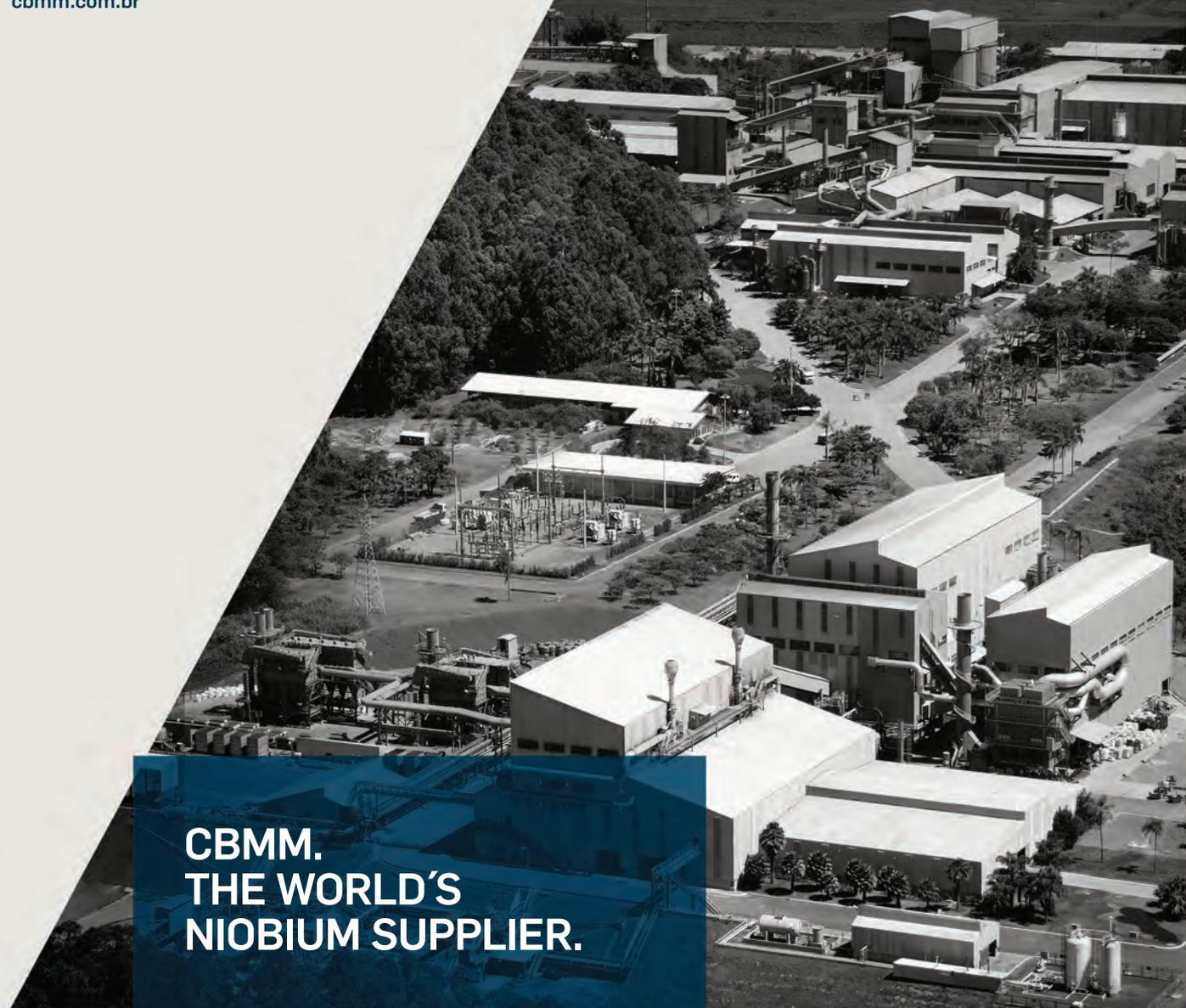
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All contributions properly presented at the conference are eligible for publication in the conference proceedings at the JACoW site. Upload of contributions is via the SRF2013 Author Account and detailed instructions can be found on the SRF2013 website.

The deadline for the submission of contributions to the proceedings is Wednesday, September 18, 2013.

The preliminary proceedings will be available on the SRF2013 web site. The final version will be posted on the JACoW site at <http://accelconf.web.cern.ch/accelconf/>. Questions concerning the proceedings may be addressed to the Scientific Editor, Guillaume Martinet.

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Abstracts

23-Sep-13	08:00 – 08:15	Oral	Room Adenauer
MOTA — Welcome			

23-Sep-13	08:15 – 10:15	Oral	Room Adenauer
MOIOA — SRF Challenges for Recent and New Projects I			

MOIOA01 **The FRIB Project at MSU** – *M. Leitner, B. Bird, F. Casagrande, S. Chouhan, C. Compton, J.L. Crisp, K. Elliott, A. Facco, A.D. Fox, M. Hodek, M.J. Johnson, G. Kiupel, I.M. Malloch, D. R. Miller, S.J. Miller, D. Morris, D. Norton, R. Oweiss, J.P. Ozelis, J. Popielarski, L. Popielarski, A.P. Rauch, R.J. Rose, K. Saito, M. Shuptar, N.R. Usher, G.J. Velianoff, D.R. Victory, J. Wei, J. Whitaker, K. Witgen, T. Xu, Y. Xu, O. Yair, S. Zhao (FRIB)*

The Facility for Rare Isotope Beams (FRIB) is ready to start construction. The facility will utilize a high-intensity, heavy-ion driver linac to provide stable ion beams from protons to uranium up to energies of >200 MeV/u and at a beam power of up to 400 kW. The superconducting cw linac consists of 330 individual low-beta ($\beta = 0.041, 0.085, 0.29, \text{ and } 0.53$ at 80.5 MHz and 322 MHz) cavities in 49 cryomodules operating at 2 K. This paper discusses the current development status of the project with emphasis on the linac SRF acquisition. SRF coldmass and cryomodule component designs are briefly summarized. A SRF production facility, currently under construction, is described.

MOIOA02 **Status and Challenges of Spiral2 SRF Linac** – *R. Ferdinand (GANIL)*

GANIL is presently extending its experimental facility with the new SPIRAL2 project. It is based on a multi-beam Superconducting Linac Driver delivering 5 mA deuterons up to 40 MeV and 1 mA heavy ions up to 14.5 MeV/u. Several domains of research in nuclear physics at the limits of stability will be covered by this new accelerator. SPIRAL2 construction has two phases. SPIRAL2 phase 1 includes the superconducting accelerator driver, and the construction of the two research areas where the accelerated protons and deuterons will generate extremely intense neutron beams for fundamental physics experiments and numerous applications. SPIRAL2 will also accelerate stable heavy ion beams of very high intensity. The phase2 includes the RIB production building and links to the existing GANIL accelerator complex for RIB post acceleration. The Superconducting Linac incorporates many innovative developments of the Quarter-Wave resonators and their associated cryogenic and RF systems. The installation of the SPIRAL2 accelerator at GANIL has started. Status of the Spiral 2 SRF linac will be presented, focusing on the various SRF challenges met by this project and how/what solutions were chosen.

MOIOA03 **The Challenge and Realization of the Cavity Production and Treatment in Industry for the European XFEL** – *W. Singer, J. Iversen, A. Matheisen, H. Weise (DESY) P. Michelato (INFN/LASA)*

The main effort in production of 1.3 GHz cavities for the EXFEL was dedicated to transfer the superconducting technology to the industry. These know how transfer is executed by DESY and INFN/LASA team. The preparation phase based on prototype cavities covered: qualification of potential vendors for material and cavity fabrication; work out recipe and strategy for qualification of the infrastructure for cavity surface treatment at industry; definition of the quality management strategy, documentation and electronically data exchange. Production of 800 series cavities on the principle “build to print” is contracted to companies Research Instruments and Ettore Zanon. High purity niobium and NbTi for resonators provides DESY. The principles of the material and cavities production in conformity with European Pressure Equipment Directive are developed together with the notified body. New or upgraded infrastructure has been established at both companies. The first several tens of series cavities have been produced and treated. Most of the cavities handed over to DESY up to now fulfill immediately the EXFEL specifications. The cavity production for EXFEL will be finished mid of 2015.

MOIOA04 **SRF Challenges for Energy Recovery Linacs** – *A. Burrill (HZB)*

Many of the challenges associated with operating a SRF ERL are independent of the choice of operating frequency, beam energy, and overall purpose of the machine. Worldwide there are an increasing number of ERLs in various stages of development and operation which are facing a number of similar challenges and often solving them in very different ways. In this talk I will seek to summarize the main challenges the community as a whole faces, address how different laboratories are working to solve these problems, and seek to identify areas of overlap where the community can work together to solve some of these common problems.

MOIOA05 **SRF in Heavy Ions Projects** – *D. Jeon (IBS)*

SRF technologies are widely applied to heavy ion accelerator projects in the world such as the RAON, C-ADS, HIAF, FRIB, SPIRAL2, ISAC-II, HIE-ISOLDE etc. In this talk, status report, design choices and SRF challenges met in heavy ion machines are presented.

23-Sep-13	10:45 – 12:10	Oral	Room Adenauer
MOIOB — SRF Challenges for Recent and New Projects II			

MOIOB01 **High Power Proton/Deuteron Accelerators** – *J.-L. Biarrotte (IPN)*

High power proton and deuteron linear accelerators can give rise to a large variety of scientific applications, useful for both fundamental and applied research. Thanks to the on-going efficient development of the superconducting RF technology, more and more projects based on such machines have emerged during the last 2 decades. This paper will review these existing high power proton/deuteron accelerator facilities or projects, trying in particular to emphasize in each case the various specificities and challenges related to the SRF technology.

MOIOB02 **Towards a 100mA superconducting RF photoinjector at HZB** – *A. Neumann, W. Anders, A. Burrill, A. Jankowiak, T. Kamps, J. Knobloch, O. Kugeler, A.N. Matveenko, M. Schmeißer, J. Völker (HZB) G. Ciovati, P. Kneisel (JLAB) R. Nietubyc (NCBJ) S.G. Schubert, J. Smedley (BNL) J.K. Sekutowicz (DESY) I. Will (MBI) E.N. Zaplatin (FZJ)*

For BERLinPro, a 100 mA CW-driven SRF energy recovery linac demonstrator facility, HZB needs to develop a photo-injector superconducting cavity which delivers a at least $1\text{mm}^2\text{mr}$ emittance beam at high average current. To address these challenges of producing a high peak brightness beam at high repetition rate, at first HZB tested a fully superconducting injector with a lead cathode*, followed now by the design of a SC cavity allowing operation up to 4mA using CW-modified TTF-III couplers and inserting a normal conducting high quantum efficiency cathode using the HZDR-style insert scheme. This talk will present the latest results and an overview of the measurements with the lead cathode cavity and will describe the design and optimization process, the first production results of the current design and an outlook to the further development steps towards the full power version.

MOIOB03 SRF Photoemission Electron Guns at BNL: First Commissioning Results – S.A. Belomestnykh (BNL) S.A. Belomestnykh

11:30

Two SRF photoemission electron guns are under development at BNL. The first gun operates at 704 MHz and is design to deliver high bunch charge and high average current beams for the R&D ERL accelerator. Its cavity is of an elliptical geometry. The gun cryomodule has been commission without a cathode up to the design voltage of 2 MV. The experiments with a copper cathode are underway. The second gun utilizes a quarter wave resonator geometry with coaxial cathode insert and beam tube RF power coupler. It will be used to produce high bunch charges, but low average beam currents for the coherent electron cooling proof-of-principle experiment. This 112 MHz SRF gun was first tested two years ago. Since then it was rebuilt in a new cryomodule and cryogenically re-tested in late 2012/early 2013, reaching the accelerating gap voltage of 0.9 MV. This paper describes main design features of two SRF guns, presents test results and discusses future plans.

MOIOB04 Commissioning and Operation of DC-SRF Injector – K.X. Liu, J.E. Chen, L.W. Feng, J.K. Hao, S. Huang, L. Lin, S.W. Quan, F. Wang, Zh.W. Wang, X.D. Wen, H.M. Xie, K. Zhao, F. Zhu (PKU)

11:50

As a new and compact injector with medium beam current, the DC-SRF injector at Peking University has been upgraded recently mainly on DC part and heat loading. With a new 20kW solid state RF power source, an improved LLRF system and related diagnostic devices on the new beam line, a series of experiments have been carried out for stably operating the DC-SRF injector at 2K temperature. The description of the system, experiment process and results will be presented.

23-Sep-13	12:10 – 13:00	Oral	Room Adenauer
MOIOC — Basic R&D Bulk Niobium - Theory, calculation			

MOIOC01 Thermal Boundary Resistance in Niobium Cavities – V. Palmieri (INFN/LNL)

12:10

Cavity Thermal Boundary Resistance is something extremely complex and not completely understood by the theory. Often identified with the Kapitza resistance or with the Khalatnikov acoustic phonon mismatch at the interface metal-liquid Helium, it depends on so many different and uncontrolled parameters, that its interpretation is not covered by a complete treatise of the phenomenon. Therefore, 99% of the literature on superconducting cavities worries about the cavity interior surface state, while almost nothing is reported on treatments applied to the exterior. In the authors opinion, there is a lack in experimental data analysis due to the fact that the cavity is often considered as a whole adiabatic entity interacting only with RF fields. On the contrary, the cavity is immersed in liquid Helium and the cavity behavior cannot prescind from its thermal properties. Indeed in the normal state He-I has poor thermal conductivity and high specific heat. Moreover the heat exchange at HeII obeys to further mechanisms besides the phonon mismatch. Driven by the hypothesis that thermal losses are dominant for ultraclean cavities, we have collected a plethora of surprising experimental results.

MOIOC02 A New First-Principles Calculation of Field-Dependent RF Surface Impedance of BCS Superconductor – B. P. Xiao, C.E. Reece (JLab) B. P. Xiao

12:30

There is a need to understand the intrinsic limit of RF surface impedance that determines the performance of superconducting RF cavities in particle accelerators. Here we present a field-dependent derivation of Mattis-Bardeen theory of the RF surface impedance of BCS superconductors, based on the shifted density of states resulting from coherently moving Cooper pairs. Our theoretical prediction of the effective BCS RF surface resistance of niobium as a function of peak surface magnetic field amplitude agrees well with recently reported record low loss resonant cavity measurements from JLab and Fermi Lab with carefully prepared niobium material. The surprising reduction in resistance with increasing field is explained to be an intrinsic effect.

MOIOC03 Density-Functional Theory Calculations Relevant to Hydride Formation and Prevention – D.C. Ford (Fermilab)

12:45

Chemical impurities such as hydrogen, oxygen, nitrogen, and carbon atoms can be absorbed into niobium during processing treatments applied to SRF cavities and affect the performance of the cavities. These impurities may reside in niobium lattice interstices and lower the superconducting transition temperature of the niobium or form precipitates with properties that differ from niobium. Of particular concern is the formation of hydride precipitates which may be relevant to Q-disease and Q-slope. A first principles approach is taken to study the properties of chemical impurities in niobium, with particular focus given to the prevention of detrimental niobium hydride precipitation.

23-Sep-13	14:30 – 18:00	Poster	Galleries
MOP — Poster Session I			

MOP001 CASCADE: a Cavity Based Dark Matter Experiment – M.K. Kalliokoski, I.R. Bailey (Lancaster University) G. Burt, A.C. Dexter (Cockcroft Institute, Lancaster University) P. Goudket, S.M. Pattalwar, P.H. Williams (STFC/DL/ASTeC)

MOP001

An experiment is proposed that uses a pair of RF cavities as a source and detector of hidden sector photons (HSP). HSP's are hypothetical low-mass dark matter candidates with coupling to ordinary photons. SRF cavities are favoured in this experiment as they are able to store a high number of photons for a given input power due to the high Q available. When powered, such a cavity will act as a source of HSPs, while an empty cavity will be able to capture any HSP's decaying back into RF photons. Such an experiment (CASCADE) is being developed at the Cockcroft Institute using single cell 1.3 GHz cavities previously utilised for manufacturing and BCP studies. The aims of the CASCADE project are detailed, along with the system specification.

MOP002 Conceptual Design for Replacement of the DTL and CCL with Superconducting RF Cavities in the Spallation Neutron Source Linac – M.S. Champion, S.-H. Kim (ORNL)

MOP002

The Spallation Neutron Source Linac utilizes normal conducting RF cavities in the low energy section from 2.5 MeV to 186 MeV. Six Drift Tube Linac (DTL) structures accelerate the beam to 87 MeV, and four Coupled Cavity Linac (CCL) structures provide further acceleration to 186 MeV. The remainder of the Linac is comprised of 81 superconducting cavities packaged in 23 cryomodules to provide a final beam energy of approximately 1 GeV. The superconducting Linac has proven to be substantially more reliable than the normal conducting Linac despite the greater number of stations and the complexity associated with the cryogenic plant and distribution. A conceptual design has been initiated on a replacement of the DTL and CCL with superconducting RF cavities. The motivation, constraints, and conceptual design are presented.

MOP003 Implications of Increased Beam Current for the Diamond Storage Ring RF System – C. Christou, P. Gu, M. Maddock, P.J. Marten, S.A. Pande, A.F. Rankin, D. Spink, A.V. Watkins (Diamond)

MOP003

Diamond Light Source presently operates for users with 300mA beam current and initial tests have begun to upgrade this current towards an ultimate goal of 500mA. The implications of such a beam current increase for the storage ring RF system will be significant, including the installation of a third superconducting cavity and a possible modification of the coupling parameters of the existing cavities. An overview of the planned enhancements of the RF system is presented, including an update of the procurement of a new CESR-design cavity and options for installation and operation of this cavity and supporting infrastructure.

- MOP004 The ESS Superconducting Linear Accelerator** – *C. Darve, M. Eshraqi, M. Lindroos, D.P. McGinnis, S. Molloy (ESS) P. Bosland (CEA/IRFU) S. Bousson (IPN)*
 The European Spallation Source (ESS) is one of Europe's largest planned research infrastructure. The collaborative project is funded by a collaboration of 17 European countries and is under design and construction in Lund, Sweden. The ESS will bring new insights to the grand challenges of science and innovation in fields as diverse as material and life sciences, energy, environmental technology, cultural heritage solid-state and fundamental physics. A 5 MW, long pulse proton accelerator is used to reach this goal. The pulsed length is 2.86 ms, the repetition frequency is 14 Hz (4 % duty cycle). The choice of SRF technology is a key element in the development of the ESS linear accelerator (linac). The superconducting linac is composed of one section of spoke cavity cryomodule (352 MHz) and two sections of elliptical cavity cryomodules (704 MHz). These cryomodules contain Niobium SRF cavities operating at 2 K. This paper presents the superconducting linac layout and its lifecycle.
- MOP005 Re-Commissioning of the CEBAF Cryomodules During the Long Shutdown** – *M.A. Drury, C. Grenoble, F. Humphry, L.K. King (JLAB) G.K. Davis (JLab)*
 The Thomas Jefferson National Accelerator Facility is currently engaged in the 12 GeV Upgrade Project. A consequence of his project has been the Long Shutdown of the CEBAF Accelerator. During the shutdown, all of the installed cryomodules were warmed to room temperature for about nine months. The warm up period offered an opportunity to perform a variety of maintenance tasks on the cryomodules. In March, 2013, the cryomodules were once again cooled to 2K. With beam operation still several months in the future, the decision was made to re-commission each of the more than 40 installed cryomodules. Each cavity would undergo a determination of maximum available gradient, measurement of radiation from field emission, and of Q₀. This effort will give valuable information on the state of the installed CEBAF cryomodules, many of which have been in operation for at least twenty years. This paper will discuss the results of this effort.
- MOP006 Status of the SC CW-Linac Demonstrator** – *V. Gettmann, A. Orzhekhovskaya (GSI) M. Amberg, F.D. Dziuba, H. Podlech, U. Ratzinger (IAP) K. Aulenbacher (IKP) W.A. Barth, S. Jacke, S. Mickat (HIM)*
 The commissioning of the superconducting (sc) continuous wave (cw) LINAC Demonstrator, financed by the Helmholtz Institute Mainz (HIM) mainly, is planned in 2014. The aim is a "full performance test" at GSI-High Charge Injector (HLI) of a 217 MHz sc CH-Cavity, which is designed by the Institute of Applied Physics (IAP) of the University Frankfurt. Inside the cryostat a suspended frame supports the cavity embedded by two solenoids. All of these components are in fabrication. The testing environment is about to be completed. The radiation protection bunker, and the beam transport line straightforward to the GSI-HLI, comprising beam diagnostic components as well as focusing and steering magnets, has been mounted.
- MOP007 The Status of Superconducting Linac and SRF Activities at the SNS** – *S.-H. Kim, M.S. Champion, A. Coleman, M.T. Crofford, M. Doleans, D.L. Douglas, M.P. Howell, Y.W. Kang, S.E. Stewart, W.H. Strong (ORNL) R. Afanador, B.D. DeGraff, B.S. Hannah, S.W. Lee, C.J. McMahan, T.S. Neustadt, S.W. Ottaway, J. Saunders, D.M. Vandygriff (ORNL RAD)*
 There have been substantial gains at the Spallation Neutron Source (SNS) in last 7 years in understanding pulsed superconducting linac (SCL) operation including system and equipment limiting factors and resolution of system and equipment issues. Significant effort and focus are required to assure ongoing success of the operation, maintenance and improvement of the SCL, and to address the requirements of the upgrade project in the future. The SNS is taking a multi-faceted approach to maintaining and improving its linac. A balanced set of facilities which support processing, assembly, repair, and testing of cavities/cryomodules are currently being placed into service. This paper summarizes the status of the SNS SCL and related superconducting radio-frequency (SRF) activities such as development of ASME code-stamped spare cryomodules, R&D activities for SRF cavity performance improvements, SRF cavity development for power upgrade project and SRF facility development/upgrade to support all required activities.
- MOP008 RAON Superconducting Linac** – *H.J. Kim, H.J. Cha, M.O. Hyun, D. Jeon, J.D. Joo, M.J. Joung, H.C. Jung, Y. Kim, G.-T. Park (IBS)*
 The RISP (Rare Isotope Science Project) accelerator has been planned to study heavy ion of nuclear, material and medical science at the Institute for Basic Science (IBS). It can deliver ions from proton to Uranium. The facility consists of three superconducting linacs of which superconducting cavities are independently phased. Requirement of the linac design is especially high for acceleration of multiple charge beams. In this paper, we present the RISP linac design, the superconducting cavity, and cryomodule.
- MOP009 Progress Report of the Short-Pulse X-ray (SPX) Project at the Advanced Photon Source** – *A. Nassiri (ANL)*
 The Advanced Photon Source Upgrade Project (APS-U) at Argonne will include generation of short-pulse x-rays based on Zholents' [1] deflecting cavity scheme. We have chosen superconducting (SC) cavities in order to have a continuous train of crabbed bunches and flexibility of operating modes. Since early 2012, in collaboration with Jefferson National Laboratory, we have made significant progress prototyping and testing a number of single-cell deflecting cavities. We have designed, prototyped, and tested silicon carbide as damping material for higher-order-mode (HOM) dampers, which are broadband to handle the HOM power across the frequency spectrum produced by the APS beam. In collaboration with Lawrence Berkeley National Laboratory, we have developing a state-of-the-art timing and synchronization system for distributing stable rf signals over optical fiber capable of achieving tens of femtoseconds phase drift and jitter. Collaboration with the Advanced Computations Department at Stanford Linear Accelerator Center is looking into simulations of complex, multi-cavity geometries. This contribution provides a progress report on the current R&D status of the SPX project.
- MOP010 Spiral2 Cryomodules B Tests Results** – *G. Olry, F. Chatelet, C. Commeaux, N. Gandolfo, D. Grolet, C. Joly, J. Lesrel, D. Longuevergne, R. Martret, G. Michel, L. Renard, A. Stephen, P. Szott (IPN) P.-E. Bernaudin, R. Ferdinand (GANIL) Y. Gomez-Martinez (LPSC)*
 Assembly and tests of the SPIRAL2 superconducting linac's cryomodules at CEA/Saclay and IPN/Orsay have now reached cruising speed after having faced a series of problems, among them contamination. 19 cryomodules are composing the whole Linac and IPN Orsay is in charge of the 7 cryomodules B, housing two 88MHz, beta 0.12 Quarter-Wave Resonators. Two cryomodules have been successfully assembled and tested up to the nominal gradient of 6.5 MV/m for all cavities with also total cryogenic losses under specifications. One of them is fully qualified and has been already delivered to GANIL. The second one showed misalignment on one cavity which could lead to partial disassembly. This paper will present the results of those cryomodules tests as well as the status of the remaining ones.
- MOP011 European XFEL 3.9 GHz System** – *P. Pierini, M. Bertucci, A. Bosotti, C. Maiano, P. Michelato, L. Monaco, R. Papparella, D. Sertore (INFN/LASA) C. Pagani (Università degli Studi di Milano & INFN) E. Vogel (DESY)*

The third harmonic system of the European XFEL is a joint INFN and DESY contribution to the project. Achievements, status and activity plan will be reviewed.

- MOP012 Completion of the Superconducting Heavy Ion Linac at Inter University Accelerator Centre** – *A. Rai, R. Ahuja, J. Antony, S. Babu, J. Chacko, G.K. Chaudhari, A. Chaudhary, T.S. Datta, R.N. Dutt, S. Ghosh, R. Joshi, D. Kanjilal, S. Kar, J. Karmakar, M. Kumar, R. Kumar, D. S. Mathuria, R. Mehta, K.K. Mistri, A. Pandey, P. Patra, P.N. Prakash, A. Roy, B.K. Sahu, A. Sarkar, S.S.K. Sonti, S. K. Suman, J. Zacharias (IUAC)*

The Superconducting heavy ion Linac at Inter University Accelerator Centre (IUAC), New Delhi has been delivering accelerated ion beams to the users since 2009 *. Initially the first accelerating module, housing eight Quarter Wave Resonators (QWR's), became operational together with the Superbuncher having one and the Rebuncher having two QWR's, respectively. In the subsequent years, the remaining two modules have been installed and commissioned. The complete Linac was operated recently and several ion beams were delivered for scheduled experiments. The maximum energy gain was 8 MeV per charge state. Operational highlights include successful operation of four resonators in the third module with Piezo based ** mechanical tuning, implementation of remote phase locking for all resonators in three modules, development of a scheme for auto locking of resonators and testing of a capacitive pickup as a beam diagnostic element. Details will be presented vis-à-vis the problems encountered and the future course of action.

- MOP013 SRF Developments at MSU for FRIB** – *K. Saito, S. Chouhan, C. Compton, K. Elliott, M. Leitner, S.J. Miller, J. Popielarski, L. Popielarski, S. Shanab (FRIB) S.K. Chandrasekaran (MSU)*

FRIB has built up a new SRF development group for future SRF research and development at MSU. This paper will report on the present status of development for fundamental couplers, pneumatic tuners for HWR, magnetic shielding and superconducting solenoids, barrel polishing techniques for HWR, a cavity steam cleaning method, and niobium material characterization efforts.

- MOP014 Cold Tests of SSR1 Resonators for PXIE** – *A.I. Sukhanov (Fermilab)*

Fermilab is currently building Project X (PX) Injector experiment (PXIE). PXIE linac will accelerate 1 mA H⁺ beam up to 30 MeV and serve as a testbed for validation of Project X concept and mitigation of technical risks. Cryomodule of eight superconducting RF Single Spoke Resonator of type 1 (SSR1) cavities operating at 325 MHz is integral part of PXIE. Ten SSR1 cavities were manufactured in industry and delivered to Fermilab. In this paper we discuss cavity surface processing and testing regimes of bare SSR1 cavities in the Fermilab Vertical test stand. We report on performance parameters of all produced cavities achieved during tests.

- MOP015 Status of the SRF Development for the Project X** – *V.P. Yakovlev, N. Solyak (Fermilab)*

Project X is a high intensity proton facility being developed to support a world-leading program of Intensity Frontier physics over the next two decades at Fermilab. The proposed facility is based on the SRF technology and consists of two linacs: CW linac to accelerate beam from 2.1 MeV to 3 GeV and pulsed linac accelerate 5% of the beam up to 8 GeV. In a CW linac five families of SC cavities are used: half-wave resonators (162.5 MHz); single-spoke cavities: SSR1 (325 MHz) and elliptical 5-cell $\beta=0.6$ and $\beta=0.9$ cavities (650 MHz). Pulsed 3-8 GeV linac are based on 9-cell 1.3 GHz cavities. In the paper the basic requirements and the status of development of SC accelerating cavities, auxiliaries (couplers, tuners, etc.) and cryomodules are presented as well as technology challenges caused by their specifics.

- MOP016 SRF Systems for the Coherent Electron Cooling Demonstration Experiment** – *S.A. Belomestnykh, I. Ben-Zvi, J.C. Brutus, Y. Huang, D. Kayran, V. Litvinenko, P. Orfin, I. Pinayev, T. Rao, B. Sheehy, J. Skaritka, K.S. Smith, R. Than, J.E. Tuozzolo, E. Wang, Q. Wu, W. Xu, A. Zaltsman (BNL) S.A. Belomestnykh, M. Ruiz-Osés, T. Xin (Stony Brook University) X. Liang (SBU)*

A short 22-MeV linac under development at BNL will provide high charge, low repetition rate beam for the coherent electron cooling demonstration experiment in RHIC. The linac will include a 112 MHz SRF gun and a 704 MHz five-cell accelerating SRF cavity. The paper describes the two SRF systems, discusses the project status, first test results and schedule.

- MOP017 SRF for Low Energy RHIC electron Cooling: Preliminary Considerations** – *S.A. Belomestnykh (BNL) S.A. Belomestnykh*

A search for the QCD Critical Point has renewed interest to electron cooling ion beams in RHIC at energies below 10 GeV/nucleon. The electron cooling will utilize bunched electron beams from an SRF linac at energies from 0.9 to 5 MeV. The SRF linac will consist of two quarter wave structures: a photoemission electron gun and a booster cavity. In this paper we present preliminary design consideration of this SRF linac.

- MOP018 Design of the MYRRHA 17-600 MeV Superconducting Linac** – *J.-L. Biarrotte (IPN) F. Bouly (CERN) J.-P. Carneiro, D. Vandeplassche (SCK•CEN) D. Uriot (CEA/DSM/IRFU)*

The goal of the MYRRHA project is to demonstrate the technical feasibility of transmutation in a 100MWth Accelerator Driven System (ADS) by building a new flexible irradiation complex in Mol (Belgium). The MYRRHA facility requires a 600 MeV accelerator delivering a maximum proton flux of 4 mA in continuous operation, with an additional requirement for exceptional reliability. This paper will briefly describe the beam dynamics design of the main superconducting linac section which covers the 17 to 600 MeV energy range and requires enhanced fault-tolerance capabilities.

- MOP019 Comparison of Linacs for Small-Scale Inverse Compton Scattering Light Source Applications** – *F.S. He, F.E. Hannon, J.D. Mammosser, R.A. Rimmer, H. Wang (JLAB)*

Great interest has been generated by the possibility of compact, high brilliance X-ray source based on inverse Compton scattering (ICS) since the rapid advancement in laser and accelerator technologies. While most superconducting (SC) linac designs have been aimed at large high energy facilities throughout the world, a compact and affordable SC linac that fits compact ICS source would be very attractive. MIT had proposed such concept, but the linac for electron acceleration after injector was not well defined then. JLab is developing the concept of a compact cryostat, which contains two elliptical, 400MHz, 3-cell cavities, to demonstrate the SRF technology for ICS applications. The linac is designed to accelerate an electron beam with a bunch charge of 5 pC at 200 MHz repetition rate, increasing the energy by 17 MeV. SC elliptical cavities at various frequencies, SC spoke cavity with $\beta=1$, and normal conducting (NC) cavities were compared in order to minimize the dynamic heat load. In this paper, the performance, capital and operational cost are compared among different options, and the choice of JLab is justified.

- MOP020 Progress of the LUNEX5 Project** – *P. Marchand, C. Benabderrahmane, L. Cassinari, M.-E. Couprie, J. Daillant, M.D. Diop, M.E. El Ajjouri, N. Hubert, M. Labat, R. Lopes, A. Loulergue, M. Louvet, O. Marcouillé, C. Miron, P. Morin, A. Nadji, F. Ribeiro, P. Roy (SOLEIL) S. Bielawski, C. Evain, E. Roussel, C. Szwaj (PhLAM/CERCLA) B. Carré,*

D. Garzella (CEA/DSM/DRECAM/SPAM) N. Delerue (LAL) G. Devanz, M. Luong (CEA/DSM/IRFU) A. Dubois, J. Lüning (CCPMR) G. Lambert, R. Lehe, A. Lifschitz, V. Malka, A. Rousse, C. Thauray (LOA)

LUNEX5 (free electron Laser Using a New accelerator for the Exploitation of X-ray radiation of 5th generation) aims at investigating the production of short, intense, and coherent pulses in the soft X-ray region. It comprises two types of accelerators connected to a single Free Electron Laser (FEL), enabling the most advanced seeding configurations : High order Harmonic in Gas (HHG) seeding and Echo Enable Harmonic Generation (EEHG) with cryogenic in-vacuum undulators. The 400 MeV Conventional Linear Accelerator (CLA) uses superconducting cavities, compatible with a future upgrade towards high repetition rate for investigating advanced FEL schemes. It will also enable multi-user operation by splitting part of the macropulse to different FEL lines. A 0.4 - 1 GeV Laser Wake Field Accelerator (LWFA) will also be qualified in view of FEL applications, in the single spike or seeded regime. After the Conceptual Design Report, R&D has been launched on a cryo-ready 3 m long in-vacuum undulator, variable strong permanent magnet quadrupoles, Smith-Purcell and electro-optics diagnostics. A test experiment is also under preparation for validating the computed beam transport from the LWFA.

MOP021 Design Study of New SC Linac Injector for RIKEN RI-Beam Factory – K. Yamada, O. Kamigaito, N. Sakamoto, K. Suda (RIKEN Nishina Center)

For the intensity upgrade of very-heavy ions such as ^{238}U and ^{124}Xe at the RIKEN RI-Beam Factory (RIBF), a design study of new SC linac injector has started on. In the RIBF, the very-heavy ions are accelerated in a cascade of the injector linac (RILAC2), the RIKEN ring cyclotron (RRC), the fixed-frequency ring cyclotron (fRC), the intermediate-stage ring cyclotron (IRC), and the world's first superconducting ring cyclotron (SRC). We plan to substitute the SC linac for the RRC with respect to the very heavy ions, and to boost up the energy of ions with mass-to-charge ratio of 7 from 1.4 MeV/u to 11 MeV/u in the cw mode. The SC cavity is assumed to be a two gap QWR with an rf frequency of 73 MHz, that is twice the rf frequency of IRC and SRC. The cell parameters and number of cavity are determined by calculating the energy gain of synchronous ion by taking the rf phase at the center of gap into account. The transverse motion is calculated by the transfer matrix method and several types of lattice are studied. This contribution reports the progress of design study for the SC linac.

MOP022 High Frequency System Design of 700MHz China Higgs Factory – H.J. Zheng, J. Gao, S. Jin, Z.C. Liu, J.Y. Zhai, T.X. Zhao (IHEP)

In order to study Higgs Boson, scientists proposed to construct a Higgs factory. Chinese scientists are also actively involved in research of the construction of Higgs factory. Construction of a circular collider and several construction solutions were proposed. Electron and positron are eventually accelerated to the center of mass energy 240GeV. RF superconducting acceleration system is indispensable to ensure the normal operation of machine. This article mainly introduces the RF parameters in the design of 700MHz China Higgs Factory (CHF) system. It mainly includes choose of cavity type, couplers and relevant parameters of cryogenic system.

MOP023 Theoretical and Practical HOM-Analysis of the Rossendorf SRF Gun – A. Arnold, P. Murcek, J. Teichert, R. Xiang (HZDR)

The success of future synchrotron radiation sources and high power IR free-electron lasers (FELs) largely depends on the development of an appropriate electron source. To this moment, the superconducting radio frequency photoinjector (SRF gun) seems to be a promising candidate to achieve the required brightness and the high average current at the same time. In contrast to normal conducting DC and RF guns, now multi-bunch effects of higher order modes (HOM) and their influence on beam quality are of particular interest. For this reason, we present a method that considers the accelerated motion of the nonrelativistic electrons in the gun cavity to calculate the longitudinal and transverse coupling impedances. Based on this results the required loaded quality factors to reduce the excited fields of the HOMs are determined. Additionally, a second method is discussed using both cavity tuners for selective detuning of the eigenmode spectra, while the fundamental mode frequency is keeping constant. Finally, the results are compared with first beam-based measurements at the existing SRF gun at the Helmholtz-Zentrum Dresden-Rossendorf (HZDR).

MOP024 Novel SRF Gun Design – F. Marhauser (Muons. Inc.) K.H. Lee, Z. Li (SLAC)

A TM020/TM010 SRF gun has been designed to deliver high brightness electron beams. Its main feature is a superconducting joint at the back-plate, which allows manufacturing and cleaning the back-plate and the SRF gun body separately from each other. A deposition of a photocathode on the back-plate can thus be facilitated easier, while improved QA be carried out during fabrication. RF, tracking, thermal and mechanical simulations have been progressed, which would allow construction of the gun.

MOP025 The SRF Photo Injector at ELBE – Design and Status 2013 – P. Murcek, A. Arnold, J. Teichert, H. Vennekate, R. Xiang (HZDR)

In order to improve the gradient of the cavity and the beam quality of the gun, a new design for the SRF photo injector at the Helmholtz-Zentrum Dresden-Rossendorf has been developed. Apart from the special design of the cavity itself – as presented at SRF09, Berlin – the next update will include a separation of input and output of the liquid nitrogen supply system. This is supposed to increase the stability of the nitrogen pressure and enable a better monitoring of its temperature. The implementation of a superconducting solenoid inside the cryomodule is another major improvement. The position of this solenoid can be adjusted with a high precision using two independent step motors, which are thermally isolated from the solenoid itself. The poster will present the progress of turning the first design models into reality.

MOP026 Emittance Compensation for an SRF Photo Injector – H. Vennekate, A. Arnold, P.N. Lu, P. Murcek, J. Teichert, R. Xiang (HZDR) P. Kneisel (JLAB) I. Will (MBI)

A lot of the future electron accelerator projects such like ERLs, high power FELs and also some of the new collider designs rely on the development of particle sources which provide them with high average beam currents at high repetition rates, while maintaining a low emittance. SRF photo injectors represent a promising concept to give just that, offering the option of a continuous wave operation with high bunch charges. Nevertheless, emittance compensation for these electron guns, with the goal to reach the same level as normal conducting sources, is an ongoing challenge. The poster is going to discuss several approaches for the 3-1/2-cell SRF gun installed at the accelerator facility ELBE at the Helmholtz Center Dresden-Rossendorf including the installation of a superconducting solenoid within the injector's cryostat and present the currently used method to determine the beam's phase space.

MOP027 BNL SRF Gun Commissioning – W. Xu, S.A. Belomestnykh, S. Deonarine, D.M. Gassner, H. Hahn, J.P. Jamilkowski, P. Kankiya, D. Kayran, N. Laloudakis, L. Masi, G.T. McIntyre, D. Pate, D. Phillips, T. Seda, K.S. Smith, A.N. Steszyn, T.N. Tallero, R. Than, R.J. Todd, D. Weiss, A. Zaltsman (BNL) I. Ben-Zvi, J. Dai (Stony Brook University)

The 704 MHz superconducting RF gun for the R&D ERL project is under commissioning at BNL. Since last November, the SRF

gun has been conditioned and demonstrated an operational accelerating voltage of 2 MV (an accelerating gradient of 23.5 MV/m). Preparations for the cathode insertion are in final stages and we expect the gun to generate the first electron beam this summer. This paper discusses the BNL SRF gun system, and the results of the SRF gun commissioning.

MOP028 Theoretical Study of the External Q Factor of a Dual-Feed Coupling for Superconducting RF Cavities – J. Dai (Stony Brook University) S.A. Belomestnykh, I. Ben-Zvi, W. Xu (BNL)

A theoretical model based on network analysis is proposed to study the external quality factor (Q factor) of a dual-feed coupling for superconducting radio-frequency (SRF) cavities. Specifically, this model is applied to the dual feed 704 MHz half-cell SRF gun for the BNL Energy Recovery Linac (ERL) prototype. The calculation results show that the external Q factor of this dual-feed system is adjustable from 10^4 to 10^9 if the adjustment range of a phase shifter reaches 0-360 degrees. The external Q factor of the coupling system would change with the phase difference between the two coupling arms periodically with a period of 360 degrees. When adjusting the RF phase of both coupling arms in the same direction simultaneously, the external Q factor of the system also changes periodically, but with a period of 180 degrees.

MOP029 Cryo-Losses Measurements of the XFEL Prototype and Pre-Series Cryomodules – S. Barbanotti, J. Eschke, K. Jensch, W. Maschmann, O. Sawlanski (DESY) W. Maciocha (IFJ-PAN) X. Wang (ESS)

Cryo-losses measurements of the XFEL prototype and pre-series cryomodules are here presented and compared with the XFEL requirements. Cryo-losses at the 4.5 K, 80 K and 2K temperatures are calculated during the test period at CMTB (CryoModule Test Bench) at DESY to qualify the cryomodules before installation. This paper summarizes the test procedure for the different circuits (2K, 4.5K, 80K) and in different load conditions: static losses, losses due to the magnet and dynamic losses due to the RF power sent to the cavities at different MV/m levels.

MOP030 Post-Production Dimensional Control of the Cold Masses and Vacuum Vessels for the XFEL Cryomodules – S. Barbanotti, W. Benecke, K. Jensch, M. Noak, M. Schlösser (DESY)

The very tight alignment tolerances required in the XFEL Linac reflect in very tight tolerances for the production of the main cryomodule components. To verify the adherence to the specified tolerances of the cold masses and vacuum vessels, dimensional controls with laser tracker are performed at the production site following DESY experts' instructions and verified at DESY with an independent measurement. We present here the measurement strategy and a summary of the results obtained so far.

MOP031 Quality Control of the Vessel and Cold Mass Production for the 1.3 GHz XFEL Cryomodules – S. Barbanotti, H. Hintz, K. Jensch, W. Maschmann (DESY)

The industrial production of one hundred cold masses and vacuum vessels for the 1.3 GHz XFEL cryomodules is now fully in operation. Quality checks at the companies and controls at DESY assure the quality level required for the cryomodule assembly. Verification of the main production steps, non-destructive tests, dimensional controls are performed by DESY personnel before accepting the components. This paper resumes the quality control strategy and the results for the first components produced by the companies.

MOP032 Statistic to Eddy-Current Scanning of Niobium Sheets for European XFEL – A. Brinkmann, S. Arnold, A. Ermakov, J. Iversen, M. Lengkeit, P. Poerschmann, L. Schaefer, W. Singer, X. Singer (DESY)

The fabrication experiences of superconducting cavities for FLASH have shown that eddy-current scanning of the Nb-sheets foreseen for half-cells reduces the cavity failures. New eddy current devices have been developed and build together with the industry for the production of 800 pieces 1.3 GHz superconducting niobium cavities for European XFEL. More than 15.000 Nb-sheets provided by three companies have been tested by eddy-current scanning. The sheets that demonstrated local deviations of the signal have been subsequently non-destructively examined by 3d-microscope and X-Ray element analysis. The surface defects (dents, holes, scratches) are the mainly detected flaws. In addition several types of foreign material inclusions observed. Statistic concerning eddy-current signal deviation and rejection rates for each supplier will be presented.

MOP033 Quality Assurance and Acceptance Testing of Niobium Material for Use in the Construction of The Facility for Rare Isotope Beams (FRIB) at Michigan State University (MSU) – C. Compton, D. R. Miller (FRIB) T.R. Bieler, D. Kang (Michigan State University) S.K. Chandrasekaran (MSU)

Niobium is the current material of choice for the fabrication of superconducting radio frequency (SRF) cavities used in SRF based accelerators. Although niobium specifications for this application have been well established, material properties of as-received materials can still vary substantially. As required for the FRIB accelerator, large volumes (60,000 lbs) of niobium materials (sheet, tube, and flange) have been contracted to several niobium vendors. The FRIB cavity designs require very large niobium sheets, increasing the difficulty in fabrication and potential for contamination. FRIB has developed and initiated plans to control niobium specifications and perform incoming acceptance checks to ensure quality is maintained. Acceptance results from the first niobium shipment will be presented, looking at several production lots from the same vendor and across multiple vendors. Non-conforming results were observed and will be discussed including follow-up investigations and mitigation strategies to improve quality of future shipments.

MOP034 The Statistics of Industrial XFEL Cavities Fabrication at E.ZANON – A. Gresele, M. Giaretta, A. Visentin (Ettore Zanon S.p.A., Nuclear Division) A.A. Sulimov, J.H. Thie (DESY)

Serial production of superconducting cavities for European-XFEL was successfully started at E.ZANON at the end of last year. The production rate (3-4 cavities a week) allows us to summarize the results and present the statistics of industrial cavity fabrication. Many parameters have been traced during different steps of cavity production. The most interesting of them, as cavity length, frequency, field flatness and eccentricity, are presented and discussed. The last results of new preparation cycles development in the frame of E-XFEL projects is also included

MOP035 Using an Engineering Data Management System for Series Cavity Production for the European XFEL – J. Iversen, A. Brinkmann, J.A. Dammann, P. Poerschmann, W. Singer, J.H. Thie (DESY)

For series production of 800 superconducting cavities for the European XFEL an Engineering Data Management System (EDMS) is in use as a tool for quality control and quality assurance. DESY is responsible for "in-time" supply of more than 24000 semi-finished products of niobium and niobium-titanium alloy. The EDMS as a main repository was set up to fulfill logistic requirements and to guarantee traceability and documentation issues according to the European pressure equipment directive (PED 97/23 EC). The main aspects consist of complete paperless documentation, fully automated transfer of quality management documents and data from vendor system to DESY's EDMS, providing to industry an access to relevant documentation and processing of release procedures for acceptance levels and non-conformity reporting. A summary of documentation methods, procedures and first experiences will be presented.

- MOP036 New Technique and Result of Laser Welded SCRF Cavity Developed at RRCAT** – *P. Khare, R. Arya, J. Dwivedi, R. Ghosh, G. Gilankar, C. Gupta, P.D. Gupta, A. Jain, S.C. Joshi, G.V. Kane, R. Kaul, P.K. Kush, G. Mundra, S.M. Oak, C.K. Pithawa, P. Ram Sankar, S.B. Roy, V.C. Sahni, R.S. Sandha, P. Shrivastava, B.N. Upadhyay (RRCAT) C.A. Cooper, C.M. Ginsburg, A. Grassellino, C.S. Mishra, A.M. Rowe (Fermilab)*
A new technique to fabricate SCRF cavities with the help of laser welding process has been developed at Raja Ramanna Centre for Advanced Technology RRCAT, Indore, Department of Atomic Energy, India. In this technique, a pulsed Nd:YAG laser has been used and welding was performed in inert gas environment, in a specially designed welding rig. The advantages of this technique are reduced cost, small heat affected zone, no necessity to weld in vacuum and enhanced rate of production. The paper describes the technique and fabrication method of a single-cell 1.3 GHz SCRF cavity which was fabricated at RRCAT with this new technique. It also discusses the test result of this cavity which was processed and tested at Fermilab. The cavity reached an Eacc of 17MV/m with a Q0 of 1.4×10^{10} at 2K. The cavity is being barrel polished for further improvement.
- MOP037 Test of the 1.3GHz Superconducting Cavities for the European X-ray Free Electron Laser** – *K. Krzysik (DESY) K. Kasprzak, A. Kotarba, J. Świerbleski, M. Wienczek (IFJ-PAN)*
The European X-ray Free Electron Laser (XFEL) is currently under construction in Germany in Hamburg area. A linear accelerating part of the XFEL consists of about 800 superconducting 9-cell Niobium cavities installed in 100 accelerating cryomodules. The cavities are tested in dedicated test facilities before installing in the cryomodules. This paper describes the cavities preparation for test, the testing procedures prepared basing on DESY expertise and available software from TTF (Tesla Test Facility) Collaboration and FLASH (Freie-Elektronen-Laser in Hamburg) as well as update of the test procedures and the preliminary tests results.
- MOP038 Series Production of EXFEL 1,3 GHz SRF Cavities at Ettore Zanon S.p.A.: Management, Infrastructures and Quality Control** – *G. Massaro (Ettore Zanon S.p.A., Nuclear Division) G. Corniani (Ettore Zanon S.p.A.)*
In this paper we report on the capability of Ettore Zanon S.p.A. (EZ) to implement a EXFEL 1,3 GHz SRF cavities production system. In order to assure the series efficient repeatability of the product, this system is based on work team, composed of people with different skills, qualified infrastructures and technical procedures. A detailed study of the different work phases of the production cycle has been performed in advance, highlighting the technical difficulties and the production constraints. Based on this result, infrastructures and processes have been optimized to grant the specified quality and time/cost requirements and procedures and operating instructions, where the most complexes and delicate phases as well as the responsibilities and acceptance criteria are investigated, have been introduced. Qualification operations and eight pre-series cavities have proven EZ capability of fulfilling the imposed requirements. The above described manufacturing system allows nowadays a production rate of 4 cavities per week. EZ future developments involve minimizing time and costs while keeping the highest quality standard.
- MOP039 Strategy of Technology Transfer of EXFEL Preparation Technology to Industry** – *A. Matheisen, J. Iversen, W. Singer, B. van der Horst (DESY) P. Michelato, L. Monaco (INFN/LASA)*
For the EXFEL a specification for the cavity preparation procedures (R1) was set up and handed to the industrial companies. Basing on this specification companies hard ware as well as process flows were set up. Beside this specified part of the preparation technique the companies personal needed to be educated and the processes ramped up. To check the quality of the infrastructure, status of education of personal and correct set up of process flows, so called Dummy (DCV) - , Reference (RCV) and Pre-series (PCV) cavities were assigned. We report on the general strategy applied for the EXFEL technology transfer on cavity preparation and the results obtained on the qualification cavities.
- MOP040 Industrialization of XFEL Preparation Cycle “final EP ” at Research Instruments Company** – *A. Matheisen, N. Krupka, M. Schalwat, A. Schmidt, M. Schmökel, W. Singer, B. van der Horst (DESY) P. Michelato, L. Monaco (INFN/LASA) M. Pekeler (RI Research Instruments GmbH)*
In the Specification for XFEL Cavity preparation (R1) two different preparation sequences are presented. Research Instruments Company as one of the two companies contracted for XFEL cavity production and preparation has chosen the so called “final EP” cycle. Major infrastructure components like EP facility and the BCP facility were pre-qualified. This existing and the new set up areas like the cleanroom are distributed over the ground area of the industrial park Bergisch Gladbach. The process flow given in the DESY specification needed adaptation to this scenario. Additional infrastructure beside the once specified needed to be set up to ensure the same quality of processes even with a changed work flow. The general lay out of the facility, matched work flow of preparation and test results of resonators processed by RI company in their infrastructure will be reported.
- MOP041 Implementation of European Pressure Equipment Directive (PED) for Certification of 1.3 GHz Superconducting Resonators for the XFEL Project** – *A. Matheisen, J. Iversen, A. Schmidt, W. Singer (DESY)*
The XFEL will be operated by the XFEL Company. The max pressure inside the cryogenic system is designed to 4 bar abs. Due to these conditions, the regulations of the PED - 97/23/EC have to be applied for all pressure bearing parts inside the main Linac. In accordance to PED the test pressure for pressure bearing parts has to be 5,72 bar (abs). The smallest insula table volume is the Cavity module, consisting of eight s.c. resonators, a Beam Position Monitor and a super conducting quadrupol. To avoid pressurizing complete modules to 5,72 bar (abs), the s.c. cavities were assigned to follow the tests of category IV of PED annex II regulations. The certification of in total 800 industrial manufactured resonators made from fine grain Niobium is done according to test modules B1 (EC design-examination), B (EC type-examination) and F (product verification). Eight large grain test resonator will be used for the FEEL linac as well. They are tested according to Module G (EC unit verification). The scenario of application of PED regulation to the 1,3 GHz resonators for the EXFEL will be reported.
- MOP042 Quality Control and Processes Optimization for the EXFEL Superconducting Cavities Series Production at Ettore Zanon spa** – *L. Facci, D. Rizzetto (Ettore Zanon S.p.A., Nuclear Division) G. Corniani (Ettore Zanon S.p.A.) A. Matheisen (DESY) P. Michelato, L. Monaco (INFN/LASA)*
The construction of the European XFEL forced the first mass production of Niobium bulk superconducting RF cavities. In this context Ettore Zanon spa built a fully new facility designed to produce four fully treated and He tank equipped cavities, ready to be test at DESY. The facility already reached the foreseen production rate. The guarantee of the highest quality of the resonators produced requires a very strict quality control plan. At the same time, the requirements of the industrial productions in terms of time, cost and productivity must be satisfied, together with the full accomplishment of EXFEL specification. As a consequence processes must be standardized and working times optimized. In the following, after the description of the production facility, we would like to highlight and discuss the strategies and arrangements adopted in the various critical fields (clean room, vacuum, EP and BCP, etc) to ensure the foreseen results. Moreover correlation between cavities performances and production cycle critical parameters will be investigated and discussed.

MOP043 ILC-HiGrade Cavities as a Tool of Quality Control for EXFEL – A. Navitski, E. Elsen, B. Foster, J. Iversen, A. Mathiesen, D. Reschke, W. Singer, X. Singer, L. Steder, M. Wenskat (DESY) R. Laasch, Y. Tamashevich (University of Hamburg)

The EXFEL order for SRF cavities includes 24 cavities, which are part of the ILC-HiGrade program. Initially, these cavities serve as quality control (QC) sample extracted from the EXFEL cavities series production on a regular basis. The QC and quality assurance (QA) include all processing steps of the EXFEL cavities. To maximize the information from these so-called QC cavities, a surface mapping technique is applied in a second cold RF test. There the cavities delivered have experienced identical treatment of the inner surface with the exception of mounting of the Helium vessel. After the normal acceptance test at the cavity RF measurement facility, the cavities are removed from the production flow. Further quality assurance steps beginning with a detailed RF test with surface mapping followed by a high resolution optical inspection (OBACHT) are carried out to improve the understanding of defects in close collaboration with the standing experts engaged in the EXFEL production. Results of the first QC cavities tests as well as planned further R&D will be presented and discussed.

MOP044 Performance Characteristics of Jefferson Lab's New SRF Infrastructure – C.E. Reece, P. Denny, A.V. Reilly (JLab)

In the past two years, Jefferson Lab has reconfigured and renovated its SRF support infrastructure as part of the Technology and Engineering Development Facility project, TEDF. The most significant changes are in the cleanroom and chemistry facilities. We report the initial characterization data on the new ultra-pure water systems, cleanroom facilities, describe the reconfiguration of existing facilities and also opportunities for flexible growth presented by the new arrangement.

MOP045 Electropolishing for EXFEL Cavities Production at Ettore Zanon SpA – M. Rizzi (Ettore Zanon S.p.A.) A. Gresele (Ettore Zanon S.p.A., Nuclear Division) A. Matheisen, N. Steinhilber (DESY) P. Michelato (INFN/LASA)

A new horizontal electropolishing (EP) facility has been implemented by Ettore Zanon SpA for the series production of the EXFEL cavities produced by the company. According to EXFEL specification a bulk EP of at least 100 micron is the first step of the surface treatment for high performances. Particular attention has been dedicated to find the best configuration during qualification of the system. Correlation between process variables, RF tests at room temperature at Zanon and vertical RF tests at 2 K at DESY have been investigated and the Niobium removal optimized. The facility has been designed for industrial scope, in order to guarantee the required quality and production rate of 4 cavities per week. One of the most important aspects has been the system automation to have complete control of the process.

MOP046 New SRF Facility at KEK for Mass-Production Study in Collaboration with Industries – T. Saeki, H. Hayano (KEK)

The construction of the new SRF facility including new building next to the KEK-STF facility has started for mass-production study of SRF accelerators in collaboration with industries. This new building has the dimension of 80 m x 30 m and the plan is to install clean-room for cavity-string assembly, cryomodule assembly facility, cryogenic system, vertical test facility, cryomodule test facility, input coupler process facility, cavity electro-polishing facility, and control-room/office-rooms in it. The purpose of this new SRF facility is to establish a close collaboration between SRF researchers and industries, to produce technology innovation in the new industry market aiming at concept of new sustainable and ecological society in the future. This article reports the design of new SRF facility at KEK and the organization of the new collaboration between the SRF researchers and industries utilizing the new SRF facility, as well as the impact on the upcoming large-scale future SRF project, ILC.

MOP047 Set up of Production Line for EXFEL Beam Position Monitor and Quadrupol Units for Cavity String Assembly at CEA – M. Schalwat, A. Matheisen (DESY)

The super conducting (s.c.) accelerator models of the EXFEL consist of eight s.c. resonators, one s.c. quadrupol magnet and one beam position monitor. These components are connected inside ISO 4 cleanroom at CEA Saclay to a so called cavity string under the guidance of the XFEL WP 09 activities. The eight s.c. cavities are handed from DESY to CEA for string assembly after successful RF test. The beam-position monitor and Quadrupol units (BQU) are assembled and cleaned in the DESY cleanroom at DESY Hamburg to the same standard's of cleanliness as requested for s.c. Cavities. The completed BQU units are handed over to CEA IRFU / WP 9 in "ready for installation to cavity string" status. The setup of infrastructure, the qualification of processes and transport as well as the ramp up to a delivery rate of 1 BQU per week will be presented.

MOP048 PED Requirements Applied to the Cavity and Helium Tank Manufacturing – A. Schmidt, J. Iversen, A. Matheisen (DESY)

For the European XFEL more than 800 Cavities are manufactured by industrial partners. Each cavity is housed in an individual cryo vessel, the so called helium tank. All vessels are made from titanium and manufactured by industry as well. The cavity, welded into its helium tank, is a pressure loaded part and has to follow the pressure equipment directive - PED (97/23/EC). Setting up a series production of cavities and helium tanks by different vendors according given standards, was the task of the EXFEL WPG-1 LINAC-WP04. In cooperation with the TUEV-Nord as the notified body, DESY is responsible for the qualification of design, material in use and reasonable tests to get a certificate for pressure bearing parts.

MOP049 Progress and Experiences of Series Production of Helium Tanks With DESY as a Subcontractor for RI – A. Schmidt, J.A. Dammann, A. Daniel, A. Matheisen (DESY)

DESY acts as a subcontractor for helium tanks, for one of the cavity manufacturer in charge, for the EXFEL cavity production. Here the full responsibility of production, quality and warranty of these parts is at DESY. Therefore on 400 out of the total of 800 helium tanks, DESY has to set up a logistic of incoming inspection, documentation, storage and distribution. Special effort is made to archive a free of doubts interconnection and integration of the cavity into the helium tank. After more than 300 units produced a review and statistic is provided.

MOP050 Experiences on Procurement of Material for European XFEL Cavities – X. Singer, J. Iversen, W. Singer (DESY) F. Gaus, K-H. Marrek (TÜV NORD Systems GmbH & Co. KG)

Analysis of the strategy for material procurement and quality management is done on base of the European XFEL experiences. In the preparation phase the requirements to material has been defined and the qualification of the companies as potential supplier for European XFEL executed. Estimation of the material for production of pressure bearing parts, creation of PMAs (particular material appraisal) and certification of the companies as producer of the material for pressure bearing parts has been done together with the notified body (TUEV NORD). The procurement of material, QC, documentation and shipment to cavity-producers has been carried out by DESY. Four companies produced ca. 25.000 semi-finished parts of high purity niobium and Nb-Ti within of three years. Close contact to companies and well-timed feed-back contributed to successful production. Analysis of the main flaws and foreign material inclusions will be presented.

- MOP051 The Statistics of Industrial XFEL Cavities Fabrication at Research Instruments** – A.A. Sulimov, J.H. Thie (DESY) M. Pekeler (RI Research Instruments GmbH)
 Serial production of superconducting cavities for European-XFEL was successfully started at Research Instrument (RI) at the end of last year. The production rate (3-4 cavities a week) allows us to summarize the results and present the statistics of industrial cavity fabrication. Many parameters have been traced during different steps of cavity production. The most interesting of them, as cavity length, frequency, field flatness and eccentricity, are presented and discussed.
- MOP052 RF Aspects of Quality Control for Industrial XFEL Cavities Fabrication** – A.A. Sulimov, V. Gubarev, S. Yasar (DESY)
 Quality control of XFEL serial cavities allows us not only except the using of reject cavities for linac, but also give a feedback to the industry in case of cavity parameters come to their limits. RF control assays not only the electro dynamical characteristics (as frequencies, Q-factors and fields), but also provide the mechanical revise with a very high accuracy. Automation of this quality control in XFEL data base gave us a powerful tool which is required for the big projects as European-XFEL.
- MOP053 R&D on Cavity Treatments at DESY towards the ILC Performance Goal** – A. Navitski, E. Elsen, B. Foster, D. Reschke, J. Schaffran, W. Singer, X. Singer (DESY) R. Laasch, Y. Tamashevich (University of Hamburg)
 The actual R&D program at DESY is derived from the global effort for the International Linear Collider (ILC) and is well in phase with effort elsewhere. The program aims at a solid understanding and control of the industrial mass-production process of the superconducting radio-frequency accelerating cavities, which are manufactured for the European X-ray Free Electron Laser (XFEL) at DESY. The goal is to identify the gradient limiting factors and further refine the cavity treatment technique to provide gradients above 35 MV/m at >90% production yield. Techniques such as 2nd sound quench detection, OBACHT optical inspections, defect metrology using silicon replica as well as Centrifugal Barrel Polishing (CBP) and Local Grinding repair are foreseen as tools. Actual status, details, and first achievements of the program will be reported.
- MOP054 Tests of the Accelerating Cryomodules for the European X-Ray Free Electron Laser** – M. Wiencek, K. Kasprzak, A. Kotarba, K. Krzysik, J. Świerbleski (IFJ-PAN)
 The European X-ray Free Electron Laser (XFEL) is currently under construction in Germany in Hamburg area. A 2.1 km long superconducting linear accelerator, part of the XFEL, consists of 100 accelerating cryomodules. The XFEL cryomodule is assembled with eight superconducting RF cavities, one cold magnet and Beam Position Monitor (BPM). The cryomodules are tested in dedicated test facility before installation in the XFEL tunnel. The testing procedures for the cryomodules were prepared with use of DESY expertise from TTF (Tesla Test Facility) Collaboration and FLASH (Freie-Elektronen-Laser in Hamburg). This paper describes the whole testing procedure covering incoming and outgoing inspections. An update of testing procedures including the full automation of testing process and the preliminary tests results are presented as well.
- MOP055 Status of the Superconducting Cavity Development for ILC** – T. Yanagisawa, H. Hara, K. Kanaoka, K. Sennyu (MHI)
 We report our activities for stable quality and cost reduction about cavity development for ILC.
- MOP056 Piezo Actuators Upgrade in the SARAF Prototype Superconducting Cryomodule** – Y. Ben Aliz, B. Kaizer, A. Perry, J. Rodnizki, G. Shimel, L. Weissman (Soreq NRC)
 Soreq Applied Research Accelerator Facility (SARAF), a 176 MHz superconducting RF light ions linac, is currently under commissioning at Soreq NRC. At present, the accelerator includes a Prototype Superconducting Module (PSM), housing six half wave resonators and 3 superconducting solenoids. Operating temperature in the PSM is 4.2K (Liquid Helium 99.9999% purity). The resonance frequency tuning system of each Superconducting cavity is composed of a stepper motor and a piezo actuator. During SARAF Phase I operation low voltage piezo actuators suffered from degradation in their functionality until it frequency compensation range decreased below the required real time superconducting cavities control bandwidth. In this work we present the upgrade procedure of the actuators that reduced/ eliminated the degradation rate, with the relevant measurements and results.
- MOP057 Developments and Tests of a 700 MHz Cryomodule for the MYRRHA Superconducting Linac** – F. Bouly (CERN) S. Berthelot, J.-L. Biarrotte, M. El Yakoubi, C. Joly, J. Lesrel, E. Rampnoux (IPN) A. Bosotti, R. Paparella, P. Pierini (INFN/LASA)
 The MYRRHA (“Multi - purpose Hybrid Research reactor for High - tech Applications”) project aims at the construction of a new flexible fast spectrum research reactor. This reactor will operate as an Accelerator Driven System demonstrator. The criticality will be sustained by an external spallation neutron flux; produced thanks to a 600 MeV high intensity proton beam. This CW beam will be delivered by a superconducting linac which must fulfil very stringent reliability requirements. In this purpose, the accelerator design is based on a redundant and fault-tolerant scheme to enable the rapid mitigation of RF failures. To carry out “real scale” reliability-oriented experiments a prototype of cryomodule was developed by INFN Milano and installed at IPN Orsay. The module holds a 700 MHz 5-cell elliptical cavity ($\beta g = 0.47$) equipped with its blade frequency tuner. Several tests were carried out to commission the experimental set-up. We review here the obtained results and the lessons learnt by operating this module, as well as the on-going developments.
- MOP058 Pursuing the Origin and Remediation of Low Q0 observed in the Original CEBAF Cryomodules** – R.L. Geng, J.F. Fischer, C.E. Reece, A.V. Reilly (JLAB) F.S. He, Y.M. Li (PKU)
 We report on results of a new investigation into the Q0 degradation phenomenon observed in original CEBAF cavities when assembled into cryomodules. As a result, the RF dissipation losses increased by roughly a factor of two. The origin of the low Q0, first observed in 1994, has remained unresolved up to current period, despite much effort. Recently, a new investigation has been launched, taking advantage of the latest cryomodule to undergo refurbishment. Systematic measurements are conducted with respect to the magnetic shielding effects of the double-layer shields and the magnetic properties of various components. This resulted in the new discovery of strongly magnetized strut springs as a major source of remnant magnetic flux near a cavity. New springs with superior magnetic properties have been found, evaluated and implemented into the current cryomodule. Cryogenic RF testing of this module is expected to complete by end of September 2013. In this contribution, we will review the data accumulated so far. Options for complete Q0 preservation of assembled cavities and possible Q0 remediation for those 330 cavities already installed in CEBAF will be presented.
- MOP059 Management for the Long-Term Reliability of the Diamond Superconducting RF Cavities** – P. Gu (Diamond)
 Diamond started operation with users in January 2007 and the Diamond storage ring superconducting RF cavities used to be the largest single contributor to unplanned beam trips. Extensive effort has been dedicated to understand and improve the long-term stability of the SRF cavities. Our experience shows that the long-term stability of superconducting RF cavities relies heavily on the surface conditions. Gases keep accumulating on the cold surfaces with time due to its huge cryo-pumping

capacity. The integral effect will ultimately lead to fast vacuum trips during operation. In Diamond, we have developed a systematic approach to control the long-term stability of the SRF cavities. We will discuss here our approach and also present the future work that should be completed.

- MOP060 Tests Results of the First US-Built High-Gradient Superconducting RF Cryomodule** – *E.R. Harms, C.M. Baffes, K. Carlson, B. Chase, D.J. Crawford, E. Cullerton, D.R. Edstrom, Jr, A. Hocker, A.L. Klebaner, T. Kubicki, M.J. Kucera, J.R. Leibfritz, J.N. Makara, D. McDowell, S. Nagaitsev, O.A. Nezhevenko, D.J. Nicklaus, H. Pfeffer, Y.M. Pischalnikov, P.S. Prieto, J. Reid, W. Schappert, P. Stabile, P. Varghese (Fermilab)*
 Fermilab has built a cryomodule comprised of eight 1.3 GHz superconducting RF cavities for use in its proposed Advanced Superconducting Test Accelerator facility. This cryomodule (unofficially named ‘CM2’) was intended to achieve the International Linear Collider (ILC) ‘S1’ goal of demonstrating an average accelerating gradient of 31.5 MV/m per cavity, and is the first of its kind built in the United States. Results of its characterization and test results are presented.
- MOP061 70 mA Operation of the Cornell ERL Superconducting RF Injector Cryomodule** – *M. Liepe, B.M. Dunham, G.H. Hoffstaetter, R.P.K. Kaplan, P. Quigley, V. Veshcherevich (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*
 Cornell University has developed a SCRF injector cryomodule for the acceleration of high current, low emittance beams in continuous wave operation. This cryomodule is based on 1.3 GHz superconducting RF technology, and has been tested extensively in the Cornell ERL injector prototype with world record CW beam currents exceeding 70 mA. High CW RF power input couplers and strong Higher-Order-Mode damping in the cavities are essential for high beam current operation. This paper summarizes the performance of the cryomodule during the high beam current operation.
- MOP062 Production of the KEKB-type 500-MHz SRF Modules for Taiwan Photon Source** – *Ch. Wang, L.-H. Chang, M.H. Chang, L.J. Chen, F.-T. Chung, M.-C. Lin, Y.-H. Lin, Z.L. Liu, C.H. Lo, M.H. Tsai, T.-T. Yang, M.-S. Yeh, T.-C. Yu (NSRRC) T. Furuya, K. Hara, T. Honma, A. Kabe, Y. Kojima, S. Mitsunobu, Y. Morita, H. Nakai, K. Nakanishi, M. Nishiwaki, S. Takano (KEK) F. Inoue, K. Sennyu, T. Yanagisawa (MHI)*
 The KEKB-type single-cell 500-MHz superconducting radio frequency (SRF) modules have been selected to power the 3 GeV, 500 mA, storage ring of the constructing Taiwan Photon Source (TPS) at National Synchrotron Radiation Research Center (NSRRC). The design target is to routinely deliver RF forward power up to 300 kW, CW, to single SRF module with highly reliable operation. Three sets of SRF modules have been successfully produced under a tight collaboration with High Energy Accelerator Research Organization (KEK) and Mitsubishi Heavy Industries Ltd. (MHI), after obtaining the technology transfer from KEK. MHI is responsible for the mechanical fabrication and cryo-module assembly, KEK for the surface and RF treatments of the niobium cavities, high power input couplers and HOM dampers and for the liquid-helium tests of the cryo-modules, and NSRRC for the electronic/diagnostic system, final assembly and system integration, high power horizontal test, and reliable test. This work reports the results obtained during the production of these three SRF modules at KEK and NSRRC.
- MOP063 Mature Operation of Cornell-Type 500-MHz SRF Module at Taiwan Light Source** – *Ch. Wang, L.-H. Chang, M.H. Chang, L.J. Chen, F.-T. Chung, M.-C. Lin, Y.-H. Lin, Z.L. Liu, C.H. Lo, M.H. Tsai, T.-T. Yang, M.-S. Yeh, T.-C. Yu (NSRRC)*
 The Cornell-type 500-MHz SRF module has been routinely operated since the end of 2004 to power the 1.5 GeV Taiwan Light Source with 360 mA in top-up mode. A new record of SRF operation with mean time between failures (MTBF) up to 800 hr has been achieved in the 1st half of 2013 that is compatible with the best operational record of room temperature cavities ever made in the same machine. To meet the user’s strict requirements on highly operational reliability, developing in advanced diagnostic instrumentation together with user-friendly event logging software does never stop. Here, we review our SRF operational experience in last 9 years.
- MOP064 Operational Experience With the SOLEIL Superconducting RF System** – *P. Marchand, R.C. Cuoq, H.D. Dias, M.D. Diop, J.L. Labelle, R. Lopes, M. Louvet, C.M. Monnot, S. Petit, F. Ribeiro, T. Ruan, R. Sreedharan (SOLEIL)*
 In the SOLEIL storage ring, two cryomodules provide to the electron beam an accelerating voltage of 3-4 MV and a power of 575 kW at 352 MHz. Each cryomodule contains a pair of superconducting cavities, cooled with liquid Helium at 4K, which is supplied by a single 350 W cryogenic plant. The RF power is provided by 4 solid state amplifiers, each delivering up to 180 kW. The parasitic impedances of the high order modes are strongly mitigated by means of four coaxial couplers, located on the central pipe connecting the two cavities. Seven years of operational experience with this system as well as its upgrades are reported.
- MOP065 Consolidated Design of the 17 MeV Injector for MYRRHA** – *D. Mäder, H. Podlech, M. Vossberg (IAP)*
 The MYRRHA research reactor will be an Accelerator Driven System, which demands a 2.4 MW proton beam delivered by a 600 MeV cw operated linac. The beam dynamics design of the 17 MeV injector has been consolidated to fulfil the requirements with respect to beam losses and quality. After a 4-Rod-RFQ, four 5-gap room temperature CH cavities with a constant phase and an effective voltage of 500 keV are used to reach 3.5 MeV. Then the proton beam is accelerated to 17 MeV using six superconducting 5-gap Nb CH structures with a constant beta profile. Every sc CH cavity is cooled down to 2K with liquid Helium in a separate cryo module. The new geometric design of the sc CH cavities improves the rigidity and reduces the electric peak fields.
- MOP066 Development of compact cryomodules housing HWRs for the front end of high-intensity CW SC linacs** – *P.N. Ostroumov, Z.A. Conway, S.M. Gerbick, M. Kedzie, M.P. Kelly, S.H. Kim, S.V. Kutsaev, R.C. Murphy, B. Mustapha, T. Reid (ANL) D. Berkovits (Soreq NRC) S. Nagaitsev (Fermilab)*
 Acceleration of high-intensity light-ion beams immediately after an RFQ requires a compact accelerating and focusing lattice with a high packing factor. We have developed a cryomodule which satisfies this requirement with eight accelerating-focusing periods for Project X at FNAL. Each focusing period consist of a 162.5-MHz SC HWR, a SC solenoid and a beam position monitor. The highly optimized EM parameters of the cavity were achieved by using double conical, hour glass like, inner and outer conductors. This design is also favorable for the beam dynamics because the short focusing periods which helps to better control the beam quality. All sub-systems of the cryomodule, except the vacuum-vessel, are in advanced stages of prototyping and testing. A similar concept has been developed for the design of several cryomodules for a 20 MeV/u proton/deuteron 200 kW linac at SNRC. These cryomodules house two types of 176 MHz half-wave resonators and require only modest modifications for the application. This paper will discuss the status of the FNAL cryomodule design and sub-system fabrication and its impact on future HWR cryomodule such as the SNRC project.
- MOP067 Results From Initial Tests of the 1st Production Prototype $\beta=0.29$ and $\beta=0.53$ HWR Cavities for FRIB** – *J.P. Ozelis, C. Compton, K. Elliott, A. Facco, M. Hodek, M. Leitner, I.M. Malloch, D. R. Miller, D. Norton, R. Oweiss, J. Popielarski,*

L. Popielarski, K. Saito, G.J. Velianoff, D.R. Victory (FRIB)

The first prototypes of the $\beta=0.53$ and $\beta=0.29$ HWR production design cavities for FRIB were fabricated early this year by Roark Manufacturing Company and delivered to MSU. These cavities have undergone an extensive evaluation program to verify both mechanical and RF performance before proceeding with fabrication of a pre-production run of 10 cavities. Results from physical inspections, warm RF measurements, chemical processing, and cryogenic vertical testing will be presented.

MOP068 Next Generation Light Source (NGLS) Linac Design – A. Ratti, J.N. Corlett, R.P. Wells (LBNL)

The Next Generation Light Source (NGLS) is a design concept for a multibeamline soft x-ray FEL array powered by a CW superconducting linear accelerator, operating with a 1 MHz bunch repetition rate. This paper describes the concepts for the cavity and cryostat design operating at 1.3 GHz and based on minimal modifications to the design of ILC cryomodules. This leverages the extensive experience derived from R&D that resulted in the ILC design. Due to the different nature of the two applications, particular attention is given now to high loaded Q operation and microphonics control, as well as high reliability and expected up time. The work describes the design and configuration of the linac, including choice of gradient, possible modes of operation, cavity design and RF power, as well as the consequent requirements for the cryogenic system.

MOP069 Precise Measurement of Superconducting Cavity Movement in Cryomodule by the Position Monitor Using White Light Interferometer – H. Sakai, T. Aoto, K. Enami, T. Furuya, M. Sato, K. Shinoe, K. Umemori (KEK) E. Cenni (Sokendai) K. Hayashi, K. Kanzaki (Tokyo Seimitsu Co. Ltd) M. Sawamura (JAEA)

Alignment of Superconducting cavity is one of the important issues for linear collider and/or future light source like ERL and X-FEL. To measure the cavity displacement under cooling to Liq He temperature more precisely, we newly developed the position monitor by using white light interferometer. This monitor is based on the measurement of the interference of light between the measurement target and the reference point. It can measure the position from the outside of the cryomodule. We applied this monitor to the main linac cryomodule of Compact ERL and successfully measured the displacement during 2K cooling with the resolution of 10 micron

MOP070 Results on Quality Factors of 1.3 GHz Nine-Cell Cavities at DESY – F. Schlander (IKP)

Superconducting cavities made of niobium are the basis of many particle accelerators around the world. Besides the quest for high accelerating fields for projects like European XFEL and the International Linear Collider, the quality factor, a measure for the resistance and hence the ohmic losses, is of importance, as it eventually determines the cryoplant size and its costs of operation. Especially for accelerators operating in continuous wave mode, the dynamic heat load generated by cavity operation exceeds the static heat load by far and thus requires minimisation. To investigate the current quality factor performance of 1.3 GHz cavities at DESY, the test results of some 50 recent cavities with state-of-the-art treatment have been examined regarding surface treatment and material.

MOP071 Record Quality Factor Performance of the Prototype Cornell ERL Main Linac Cavity in the Horizontal Test Cryomodule – N.R.A. Valles, G. Eichhorn, F. Furuta, G.M. Ge, D. Gonnella, D.L. Hall, G.H. Hoffstaetter, M. Liepe, T.I. O'Connell, S. Posen, P. Quigley, J. Sears, V. Veshcherevich (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)

Future SRF linac driven accelerators operated in CW mode will require very efficient SRF cavities with high intrinsic quality factors Q at medium accelerating fields. Cornell has recently finished testing the fully equipped 1.3 GHz, 7-cell main linac cavity for the Cornell Energy Recovery Linac in a horizontal test cryomodule (HTC). Measurements characterizing the fundamental mode's quality factor have been completed, showing record Q performance. In this paper, we present detailed quality factor vs gradient results for three HTC assembly stages. We show that the performance of an SRF cavity can be maintained when installed into a cryomodule, and that thermal cycling reduces residual surface resistance. We present world record results for a fully equipped multicell cavity in a cryomodule, reaching intrinsic quality factors at operating accelerating field of $Q(E=16.2 \text{ MV/m}, 1.8\text{K}) > 6 \cdot 10^{10}$ and $Q(E=16.2 \text{ MV/m}, 1.6\text{K}) > 1.0 \cdot 10^{11}$, corresponding to a very low residual surface resistance of 1.1 nOhm.

MOP072 Commissioning of the New ERL Cryomodule on Alice at Daresbury Laboratory – A.E. Wheelhouse, R.K. Buckley, S.R. Buckley, P.A. Corlett, L.S. Cowie, P. Goudket, L. Ma, P.A. McIntosh, A.J. Moss (STFC/DL/ASTeC) P. Quigley, V. Veshcherevich (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)

The new ERL cryomodule, comprising two identical 7-cell, 1.3 GHz cavities which has been developed as part of an international collaborative program, which has been successfully assembled and offline cryogenically tested prior to its installation on the energy recovery ring of the ALICE (Accelerators and Lasers in Combined Experiments) facility at Daresbury Laboratory, thereby replacing the existing dual-9-cell cryomodule previously supplied by industry. The cavities have been cooled to 2 K and commissioning of the cryomodule has been completed. This paper describes the commissioning and characterisation tests performed on the two superconducting RF cavities, as well as demonstration of the cryomodule performance with beam, in both energy recovery and FEL operational modes.

MOP073 IHEP Large Grain Low Loss 9-cell Cavity Processing and Test – J.Y. Zhai, J. Gao, S. Jin, Z.Q. Li, Z.C. Liu, T.X. Zhao (IHEP) C.A. Cooper, C.M. Ginsburg, T.N. Khabiboulline, A.M. Rowe, D.A. Sergatskov (Fermilab) H. Yu, H. Yuan (BIAM)

The combination of the low-loss shape and large grain niobium material is expected to be the possible way to achieve higher gradient and lower cost for ILC 9-cell cavities, and will be essential for the ILC 1 TeV upgrade. As the key component of the "IHEP 1.3 GHz SRF Accelerating Unit Project", a low-loss shape 9-cell cavity with full end groups using Ningxia large grain niobium (IHEP-02) was fabricated at IHEP in 2012. The cavity was processed (CBP and EP) and tested at FNAL. The cavity processing, test performance and gradient limitation is reported in this paper. We will weld the helium vessel, assemble the magnetic shield and install the cavity to IHEP ILC-TC1 cryomodule.

MOP074 Design and Construction of the Main Linac Cryomodule for the Energy Recovery Linac Project at Cornell – G. Eichhorn, B. Bullock, Y. He, T. O'Connell, P. Quigley, D.M. Sabol, J. Sears, E.N. Smith (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)

Cornell University has been designing and building superconducting accelerators for various applications for more than 50 years. Currently, an energy-recovery linac (ERL) based synchrotron-light facility is proposed making use of the existing CESR facility. As part of the phase 1 R&D program funded by the NSF, critical challenges in the design were addressed, one of them being a full linac cryo-module. It houses 6 superconducting cavities- operated at 1.8 K in continuous wave (CW) mode - with individual HOM absorbers and one magnet/ BPM section. Pushing the limits, a high quality factor of the cavities and high beam currents ($2 \cdot 100 \text{ mA}$) are targeted. We will present the design of the main linac module (MLC) being finalized recently, its cryogenic features and report on the status of the fabrication which started in late 2012

- MOP075 A X-rays Shielded Facility Dedicated to Cryogenic RF Tests of Fully Dressed Spoke Cavities in the Cryomodule CM0 at IPN Orsay** – *M. Fouaidy, P. Duchesne, N. Gandolfo, D. Grolet, C. Joly, G. Olry, M. Pierens, D. Reynet (IPN)*
 A bulk Nb superconducting $\beta=0.3$ Triple-Spoke (T-Spoke) cavity operating at 352 MHz, was designed at IPN and fabricated thanks to EURISOL project financial support. The cavity will be tested in November 2013 at a new X-rays shielded facility dedicated to cryogenic tests of fully dressed (LHe tank, Magnetic Shields, Fast Active Cold Piezoelectric Tuning System (FACPTS), RF Power coupler) Spoke cavities in the horizontal cryomodule CM0. The CW RF power and cryogenic power @T=2K are 80kW and 120W respectively. Four vertical cold RF tests were performed in a vertical cryostat and the data are reported. All components (cold box, cryogenic lines, He gas heater, RF power system with 2 RF power couplers, LHe bath pumps) were delivered and successfully tested. The cryogenic circuit in CM0 was finished and we successfully mounted the fully dressed T-Spoke cavity. A R.T tuning system was used for static and dynamic mechanical measurements on Single (S-Spoke) and T-Spoke cavities. Mechanical stiffness, transfer function, vibrations, Lorentz detuning were investigated using the FACPTS. Field profile in S-Spoke and T-Spoke cavities were performed using a motorized field perturbation stand.
- MOP076 Use of Quartz Tuning Forks for Sensitive, in-Situ Measurements of Helium Properties During SRF Cavity Tests** – *A. Ganshin, G.H. Hoffstaetter, E.N. Smith (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) X. Mi (Cornell University)*
 For vertical cryogenic tests of Superconducting Radio Frequency (SRF) cavities for particle accelerators typically many hundreds of liters of liquid helium are required. The superposition of the superfluid-helium to vapour interphase undergoes significant change during the test. We describe a new technique based on commercially available quartz tuning forks for measuring the ambient conditions of the helium bath and for precisely determining the liquid to vapour interface during a vertical cavity test. It is shown that transition from the superfluid phase to vapour as well as to the normal-fluid phase can be unambiguously determined. The experimental results are analysed with existing theories of superfluidity, using an approach for the hydrodynamics of oscillating objects immersed into a viscous medium.
- MOP077 Cryomodule Development for the APS Upgrade Short Pulse X-Ray Project at Jefferson Laboratory** – *J.P. Holzbauer, J.D. Fuerst, Y. Shiroyanagi, B.K. Stillwell, G.J. Waldschmidt, G. Wu (ANL) G. Cheng, J. Henry, J.D. Mammosser, J. Matalevich, J.P. Preble, K.M. Wilson, M. Wiseman, S. Yang (JLAB)*
 The short pulse x-ray (SPX) part of the Advanced Photon Source Upgrade calls for the installation of a two-cavity cryomodule in the APS ring to study cavity-beam interaction, including HOM damping and cavity timing and synchronization. Design of this cryomodule is underway at Jefferson Lab in collaboration with the APS Upgrade team at ANL. The cryomodule design faces several challenges including tight spacing to fit in the APS ring, a complex set of cavity waveguides including HOM waveguides and dampers enclosed in the insulating vacuum space, and tight alignment tolerances due to the APS high beam-current (up to 150 mA). Given these constraints, special focus has been put on modifying existing CEBAF-style designs, including a cavity tuner and alignment scheme, to accommodate these challenges. The thermal design has also required extensive work including coupled thermal-mechanical simulations to determine the effects of cool-down on both alignment and waveguides. This work will be presented and discussed in this paper.
- MOP078 Horizontal Testing of a Dressed Deflecting Mode Cavity for the APS Upgrade Short Pulse X-Ray Project** – *J.P. Holzbauer, N.D. Arnold, T.G. Berenc, D.J. Bromberg, J. Carwardine, N.P. Di Monte, J.D. Fuerst, A.E. Grelick, D. Horan, J.A. Kaluzny, J.W. Lang, H. Ma, T.L. Mann, D.A. Meyer, M.E. Middendorf, A. Nassiri, Y. Shiroyanagi, J.H. Vacca, G.J. Waldschmidt, R.D. Wright, G. Wu, Y. Yang, A. Zholents (ANL) E.R. Harms, W. Schappert (Fermilab) J.D. Mammosser (JLAB)*
 The short pulse x-ray (SPX) part of the Advanced Photon Source (APS) Upgrade is an effort to enhance time-resolved experiments on a few-ps-scale at the APS. The goal of SPX is the generation of short pulses of x-rays for pump-probe time-resolved capability using superconducting rf (SRF) deflecting cavities*. These cavities will create a correlation between longitudinal position in the electron bunch and vertical momentum**. The light produced by this bunch can be passed through a slit to produce a pulse of light much shorter (1-2 ps instead of 100 ps) than the bunch length at reduced flux. An SPX cavity has been tested with a helium vessel and tuner. In addition to studying rf performance with more realistic cooling, this test allowed integration and operation of many systems designed for SPX cryomodule in-ring operation. These systems included an APS-constructed 5 kW, 2.815 GHz amplifier, a digital low-level rf controller system designed and fabricated in collaboration with LBNL, a cavity tuner, and instrumentation systems designed for the existing APS infrastructure. Cavity performance and subsystem performance will be reported and discussed in this paper.
- MOP079 Design and Test of a Cryogenic Seal for Rectangular Waveguide Using VATSEAL Technology** – *J.D. Fuerst, J.P. Holzbauer, Y. Shiroyanagi, B.K. Stillwell (ANL)*
 A commercially available rectangular metal seal from VAT Vacuum Valves AG has been evaluated and cold tested as a possible cryogenic seal for srf cavities. A program of analysis and cryogenic testing was undertaken to evaluate seal parameters and suitability. Seal line loads, bolt torque and resultant flange/seal deformation at low temperature and during thermal cycling were calculated both statically and via time-dependent numerical simulation to confirm the mechanical integrity of the flange/seal system. Cold testing of flange/waveguide assemblies included thermal shocks in liquid nitrogen and realistic cool-downs below the lambda point. Acceptable seal performance has been demonstrated under all test conditions although seal joint assembly is sensitive to details including bolt torque, flange flatness, and surface finish.
- MOP080 Design of a New Horizontal Test Cryostat for SCRF Cavities at the Uppsala University** – *T. Junquera, P. Bujard, N.R. Chevalier, J.P. Thermeau (Accelerators and Cryogenic Systems) L. Hermansson, M. Noor, R.J.M.Y. Ruber, R. Santiago - Kern (Uppsala University) H. Saugnac (IPN)*
 At Uppsala University, the FREIA facility for research and development of new accelerators and associated instrumentation, is presently in construction. Associated to a new Helium Liquefier, a Horizontal Test Cryostat will be used for high power RF tests of completely equipped SC cavities. This paper presents the main characteristics of the cryostat and the associated cryogenic distribution system. Two types of cavities have been considered for test purpose: SC elliptical cavities for future free electron lasers and SC cavities for high intensity proton accelerators (i.e. SC spokes). A special valve box including a subcooling stage and power coupler cooling with supercritical Helium supply have been designed, for temperature operation ranging from 2K to 4.2 K. This facility will play an essential role in the development and test of cavities, couplers and cryomodules for the ESS project. High power RF sources will be installed in order to allow unique and complete tests of spoke cavities and cryomodules at high nominal peak power.
- MOP081 Preliminary Studies of the Cryogenic Refrigerator and Distribution Systems for the MYRRHA Proton Linac** – *T. Junquera, N.R. Chevalier, J.P. Thermeau (Accelerators and Cryogenic Systems) L. Medeiros Romão, D. Vandeplassche (SCK•CEN)*

In the framework of recent European programs (FP6-Eurotrans, FP7-MAX), the SC proton Linac for the MYRRHA project (associating an accelerator to a subcritical nuclear reactor, to be installed in the SCK•CEN at Mol-Belgium), has been extensively studied and optimized to reach strict requirements in beam power and reliability as needed for this ADS demonstrator. The linac, composed of 150 SC cavities (CH, spoke and elliptical) installed in 60 cryomodules, operates at 2K, delivering a beam power of 2.5 MW (600 MeV, 4 mA) in CW mode, will be installed in a tunnel of 240 m length. In this paper we present the evaluation of the cryogenic power requirements, a preliminary architecture of the cryogenic refrigerator system including all its major components, and preliminary proposals for the cryofluids distribution along the SC linac.

MOP082 Development and Test of a New Cryostat Module for the Injector of the S-DALINAC* – T. Kürzeder, J. Conrad, F. Hug, N. Pietralla, A. Richter, S.T. Sievers (TU Darmstadt) G. Eichhorn (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)

The present injector of the superconducting Darmstadt electron linear accelerator S-DALINAC provides an electron beam of up to 10 MeV kinetic energy and up to 60 μ A current in continuous wave operation. A new cryostat module has been constructed to replace the actual one in order to provide higher beam energies of up to 14 MeV and currents of up to 250 μ A for nuclear resonance fluorescence experiments at the Darmstadt High Intensity Photon Setup (DHIPS). As before two 20-cell superconducting microwave cavities will be operated at an acceleration frequency of 3 GHz in a liquid helium bath at 2 K. For the injector upgrade two new elliptical 20-cell niobium cavities were also manufactured and in addition a third spare one. The rf power is transferred to the cavities by an also newly developed waveguide-transition line and input couplers. We report on the construction of the cryostat module and its components and present the results of a first cooling-down procedure.

MOP083 Operational Experience With the Cryogenic Plant of the SOLEIL Superconducting Rf System – M. Louvet, H.D. Dias, M.D. Diop, P. Marchand, S. Petit (SOLEIL)

In the Storage Ring of the Synchrotron SOLEIL light source, two cryomodules provide the required power of 575 kW at the nominal energy of 2.75 GeV with the full beam current of 500 mA and all the insertion devices. Each cryomodule contains a pair of 352 MHz superconducting cavities (Nb/Cu), cooled in a bath of liquid helium at 4.5 K. A single 350 W cryogenic system supplies the liquid helium for the two cryomodules. The seven years of operational experience with this cryogenic plant as well as its upgrades are reported.

MOP084 ESS Cryomodules for Elliptical Cavities – G. Olivier (IPN) P. Bosland (CEA/IRFU) C. Darve (ESS)

The European Spallation Source will be the world's most powerful neutron source. IPN Orsay undertakes the development of the ESS linac cryomodules for both medium and high beta elliptical cavities which constitute the high energy section. A medium beta technical demonstrator will be built in a first time. The cryomodules are composed of 4 superconducting cavities cooled at 2K. The cold mass assembly is hanged in an intermediate structure located inside the vacuum vessel. A 50K fixed temperature is implemented by the mean of an aluminium shield. Each cryomodule is connected to the cryogenic distribution line. The vacuum vessel is 6.3m long and has a 1.2m diameter. The poster describes the general design, the solutions implemented, the characteristics of the main components and the mechanical/thermal calculations.

MOP085 Status of the Superconducting Proton Linac (SPL) Cryomodule – V. Parma, R. Bonomi, O. Capatina, J.K. Chambrillon, E. Montesinos, K.M. Schirm, G. Vandoni, R. van Weelderden (CERN) P. Dambre, P. Duthil, S. Rousselot (IPN) G. Devanz (CEA/IRFU)

The Superconducting Proton Linac (SPL) is an R&D effort conducted by CERN in partnership with other international laboratories, aimed at developing key technologies for the construction of a multi-megawatt proton linac based on state-of-the-art SRF technology. Such an accelerator would serve as a driver in new physics facilities for neutrinos and/or radioactive ion beams. Amongst the main objectives of this effort, are the development of 704 MHz bulk niobium $\beta=1$ elliptical cavities (operating at 2 K and providing an accelerating field of 25 MV/m) and the test of a string of cavities integrated in a machine-type cryo-module. In an initial phase, only four out of the eight cavities of the SPL cryo-module will be tested in a half-length cryo-module developed for this purpose, which nonetheless preserves the main features of the full size machine. This paper presents the final design of the cryo-module and the status of the construction of the main cryostat parts. Preliminary plans for the assembly and testing of the cryo-module at CERN are presented and discussed.

MOP086 Integration, Commissioning and Cryogenics Performance of the ERL cryomodule installed on ALICE-ERL facility at STFC Daresbury Laboratory, UK – S.M. Patalwar, R.K. Buckley, P. Goudket, A.R. Goulden, P.A. McIntosh, A.E. Wheelhouse (STFC/DL/ASTeC)

On successful assembly and preliminary testing of an optimised SRF cryomodule for application on ERL accelerators, which is being developed through an international collaboration the cryomodule has been installed on the 35 MeV ALICE (Accelerators and Lasers in Combined Experiments) Energy Recovery Linac (ERL) facility at STFC Daresbury Laboratory. Existing cryogenic infrastructure has a capacity to deliver approximately 120 W cooling power at 2 K, but the HOM (Higher Order Mode) absorbers, the thermal intercepts for the high power RF couplers and the radiation shield in the cryomodule are designed to be cooled (to 5 K and 80 K) with gaseous helium instead of liquid nitrogen. As a result the cryogenic infrastructure for ALICE had to be modified to meet these additional requirements. In this paper we describe our experience with the process of integration and the cryogenic commissioning, and present some initial results.

MOP087 Conceptual Design of a Cryomodule for Compact Crab Cavities for Hi-Lumi LHC – S.M. Patalwar, P.A. McIntosh, A.E. Wheelhouse (STFC/DL/ASTeC) G. Burt (Lancaster University) B.D.S. Hall (Cockcroft Institute, Lancaster University) T.J. Jones, N. Templeton (STFC/DL) T.J. Peterson (Fermilab)

A prototype Superconducting (RF) cryomodule, comprising multiple compact crab cavities is foreseen to realise a local crab crossing scheme for the "Hi-Lumi LHC", a project launched by CERN to increase the luminosity performance of LHC. A cryomodule with two cavities will be initially installed and tested on the SPS drive accelerator at CERN to evaluate performance with high-intensity proton beams. A series of boundary conditions influence the design of the cryomodule prototype, arising from; the complexity of the cavity design, the requirement for multiple RF couplers, the close proximity to the second LHC beam pipe and the tight space constraints in the SPS and LHC tunnels. As a result, the design of the helium vessel and the cryomodule has become extremely challenging. This paper assesses some of the critical cryogenic and engineering design requirements and describes an optimised cryomodule solution for the tests with SPS.

MOP088 Vertical Cavity Test Program in Support of FRIB Development – J. Popielarski, J.L. Crisp, K. Elliott, M. Hodek, M. Leitner, D. Morris, D. Norton, J.P. Ozelis, K. Saito, N.R. Usher, G.J. Velianoff (FRIB) A. Facco (INFN/LNL)

A robust and extensive program of testing using the superconducting cavity vertical test facility at MSU is underway in support of development of cavities and ancillary systems for FRIB. In addition to vertical qualification testing of bare and dressed cavities, the facility has been used to test dressed HWR cavities with integrated tuners and LLRF control systems, dressed

QWR cavities with high-power input couplers, cavities with external magnetic fields supplied by superconducting coils, and QWR cavities with unique thermally optimized bottom RF flanges. Various modifications and extensions to the MSU/FRIB Vertical Test Facility have been implemented over the past year in order to successfully pursue these tests, which otherwise would require the construction of a more complex and expensive horizontal test cryostat or prototype cryomodule. These modifications will be presented along with results from these atypical tests.

MOP089 Design of the ESS Spoke Cryomodule – *D. Reynet, S. Bousson, S. Brault, P. Duchesne, P. Duthil, N. Gandolfo, G. Olry, E. Rampoux (IPN) C. Darve (ESS)*

The European Spallation Source (ESS) project brings together 17 European countries to develop the world's most powerful neutron source feeding multidisciplinary researches. The superconducting part of the linear accelerator consists in 59 cryomodules housing different superconducting radiofrequency (SRF) resonators among which 28 paired $\beta=0.5$ 352.2 MHz SRF niobium double Spoke cavities, held at 2K in a saturated helium bath. A prototype Spoke cryomodule with two cavities equipped with their 300kW RF power couplers is now being designed and will be constructed and tested at full power by the end of 2015 for the validation of all chosen technical solutions. It integrates all the interfaces necessary to be operational within a linac machine. Its assembly requires dedicated tooling and procedures in and out of a clean room. The design takes into account an industrial approach for the management of the fabrication costs. This prototype will have to guarantee an accelerating field of 8MV/m while optimizing the energy consumption and will aim at assessing the maintenance operations issues. We propose to present the design of this cryomodule and its related tooling.

MOP090 Conductively Cooled Magnets in Cryomodules of Superconducting Linacs – *I. Terechkine, S. Cheban, T.H. Nicol, V. Poloubotko, D.A. Sergatskov (Fermilab)*

While trying to find an optimal way to configure cryomodule for the low energy part of a high-current, high-power superconducting linac, an option of using conductively cooled superconducting focusing lenses was evaluated. As part of this evaluation, several tests were made using existing test cryostat. The cryostat was modified by adding current feed-throughs and two conductively cooled current leads, each equipped with heat sinks at the temperatures of liquid nitrogen and liquid helium. A superconducting magnet was mounted inside the cryostat on an individual heat sink, and thermometers were installed on the leads, heat sinks, and on the magnet's winding. In this report we provide some details of the heat exchangers' designs, compare predicted and measured temperature distribution along the leads, and analyze results of the winding temperature measurements.

MOP091 Mechanical Study of 400 MHz Double Quarter Wave Crab Cavity for LHC Luminosity Upgrade – *B. P. Xiao, I. Ben-Zvi, J. Skaritka, S. Verdú-Andrés, Q. Wu (BNL) S.A. Belomestnykh (Stony Brook University)*

A conceptual compact design of liquid helium vessel for the Double Quarter Wave Crab Cavity (DQWCC) was designed for the Large Hadron Collider (LHC) luminosity upgrade. The helium vessel was designed not only for cryogenic purposes but also to host the cavity tuner and to provide structural reinforcement to the cavity. Here we show the mechanical finite element simulation results for the structural study of the cavity with the helium vessel.

MOP092 Computation of Wakefields and HOM Port Signals by Means of Reduced Order Models – *J. Heller, T. Flisgen, U. van Rienen (Rostock University, Faculty of Computer Science and Electrical Engineering)*

The investigation of wakefields is an important task in the design and operation of particle accelerators. Computer simulations are a reliable tool to extend the understanding of these effects. This contribution presents an application example of a new method to compute wakefields as well as parameters derived from those fields, such as higher order mode (HOM) port signals. The method is based on a reduced order model of the structure created by a set of 3D eigenmodes, a set of 2D waveguide port modes and the current density of the beam. In contrast to other wakefield computations, the proposed method operates directly on the reduced order model. Therefore, once having established this model, the beam-excited fields can be determined quickly for different beam parameters. As a matter of fact, only a small part of the reduced system has to be recomputed for every sweep point. From these advantages it is obvious, that the method is highly compatible for beam parameter studies. In a proof of principal the effectiveness of the method compared to established methods of wakefield computations in terms of computational time and accuracy is shown.

MOP093 Geometric Optics of Wake Fields of Very Short Bunches in Superconducting Cavities – *A. Novokhatski (SLAC)*

We study the wake potentials of very short bunches in a quasi periodic structure of superconducting cavities. We analyze the pattern of the electric force lines and the shape of a cavity. The behavior of electric force lines reflects irregularities of the shape structure of a cavity. Simulations were carried for different kind of cavities, including JLAB 7 cell cavity with application to future light sources.

23-Sep-13	18:00 – 19:00	Oral	Room Adenauer
MOHT — Hot Topic: Material qualification for large scale projects			

24-Sep-13	08:00 – 09:55	Oral	Room Adenauer
TUIOA — Basic R&D Bulk Niobium - High Performances			

- TUIOA01 08:00** **Influence of Cooldown on Cavity Quality Factor** – *O. Kugeler, J. Knobloch, J.M. Vogt (HZB)*
 A significant improvement of Q0 to values larger than 3.2×10^{10} at 1.8K has been repeatedly obtained in different SRF cavities by thermal cycling, i.e. heating the cavity briefly above transition temperature and subsequent cooling. Conceivable explanations for this effect reach from efficacy deviations of the magnetic shielding to thermal currents to hydrogen diffusion. We have refuted most of these explanations, leaving a direct impact of cooling dynamics on frozen flux as the most plausible one. The pathway to this finding is being presented and the application to SRF systems is elicited.
- TUIOA02 08:15** **High Q0 Research: The Dynamics of Flux Trapping in SC Niobium** – *J.M. Vogt (HZB)*
 The quality factor Q0 that can be obtained in a superconducting cavity is known to depend on various factors like niobium material properties, treatment history and magnetic shielding. We believe that cooling conditions have an additional impact, as they appear to influence the amount of trapped flux and hence the residual resistance. We have constructed a test stand using niobium rods to study flux trapping. Here we can precisely control the temperature and measure the dynamics of flux trapping at the superconducting phase transition. We learned that magnetic flux can be generated when a temperature gradient exists along the rod as the niobium transitions to the superconducting state, which subsequently remains trapped. It was also shown that the cooling rate can influence the amount of externally applied flux which is trapped. Furthermore, we also were able to demonstrate that flux lines become mobile if the superconductor is warmed close to below Tc. The acquired knowledge may be used to modify the cooldown procedure of SRF cavities leading to a reduced level of trapped flux and hence operation closer to the BCS limit.
- TUIOA03 08:35** **New Insights on the Physics of RF Surface Resistance and a Cure for the Medium Field Q-Slope** – *A. Grassellino (Fermilab)*
 In this talk we will present the first deconvolution of surface resistance into BCS and residual resistance as a function of field for differently processed niobium cavities, which provides new insights on the physics of RF surface resistance. Then, new cavity results will be presented where record low values of surface resistances have been achieved. New processing strategies such as annealing and heat treatments in partial pressure of certain gases will be presented, complemented by surface studies. Via these treatments BCS resistances decreasing with the applied field have been reproducibly observed on several cavities, inverting the typical 'medium field Q-slope' trend. These findings represent a long sought solution to the the medium field Q-slope problem.
- TUIOA04 08:55** **Q-Slope Studies at Fermilab: New Insight From Cavity and Cutouts Investigations** – *A. Romanenko (Fermilab)*
 In this talk we will present recent cavity experiments (sequential HF irradiation, temperature mapping) and sample investigations (positron annihilation, low energy and bulk muSR, Bitter decoration, LCSM cold stage hydride imaging, TEM/STEM and SEM room/cryogenic imaging etc), which are providing new insight on the physical mechanisms behind phenomena leading to Q slope. New findings on relevant mechanisms at work during 120C and 600-800C heat treatments and electropolishing/BCP will also be discussed.
- TUIOA05 09:15** **New Insights Into Quench Caused by Surface Pits in SRF Cavities** – *Y. Xie, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*
 Surface defects such as pits have been identified as some of the main sources of limitations of srf cavity performance. A single cell cavity with 30 artificial pits in the high magnetic field region was made to gain new insight in how pits limit the cavity performance*. The test of the pit cavity showed clear evidence that the edges of two of the largest radius pits transitioned into the normal conducting state at field just below the quench field of the cavity, and that the quench was indeed induced by these two pits. The pit geometrical information measured by laser confocal microscopy combined with a numerical finite element ring-type defect model will be compared with temperature mapping results. Insights about quench and non-linear rf resistances will be presented.
- TUIOA06 09:35** **Localization of Field Emitter in a 9-Cell Cavity** – *Y.M. Li, K.X. Liu (PKU) R.L. Geng, A.D. Palczewski (JLAB)*
 Field emission and dark current are issues of concern for SRF cavity performance and SRF linac operation. Complete understanding and reliable control of the issue are still needed, especially in full-scale multi-cell cavities. Our work aims at developing a generic procedure for finding an active field emitter in a multi-cell cavity and benchmarking the procedure through cavity vertical test. Our ultimate goal is to provide feedback to cavity preparation and cavity string assembly in order to reduce or eliminate field emission in SRF cavities. Systematic analysis of behaviors of field emitted electrons is obtained by ACE3P developed by SLAC. Experimental benchmark of the procedure was carried out in a 9-cell cavity vertical test at JLab. The energy spectrum of Bremsstrahlung X-rays is measured using a NaI(Tl) detector. The end-point energy in the X-ray energy spectrum is taken as the highest kinetic electron energy to predict longitudinal position of the active field emitter. Angular location of the field emitter is determined by an array of silicon diodes around irises of the cavity. High-resolution optical inspection was conducted at the predicted field emitter location.

24-Sep-13	09:55 – 10:15	Oral	Room Adenauer
TUIOB — Basic R&D Bulk Niobium - Processing I			

- TUIOB01 09:55** **R&D Progress in SRF Surface Preparation With Centrifugal Barrel Polishing (CBP) for Both Nb and Cu.** – *A.D. Palczewski (JLAB) B. Bullock (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) C.A. Cooper (Fermilab) S.C. Joshi (RRCAT) A. Navitski (DESY) A. Palmieri (INFN/LNL) K. Saito (KEK)*
 Centrifugal Barrel polishing (CBP) is becoming a common R&D tool for SRF cavity preparation around the world. During the CBP process a cylindrically symmetric SRF cavity is filled with relatively cheap and environmentally friendly abrasive and sealed. The cavity is then spun around the cylindrical axis at high speeds uniformly conditioning the inner surface. This uniformity is especially relevant for SRF application because many times a single manufacturing defects limits cavity's performance well below it's theoretical limit. In addition CBP has created surfaces with roughness's on the order of 10's of nm which create a unique surface for wet chemistry or thin film deposition. CBP is now being utilized at Jefferson Laboratory, Fermi Laboratory and Cornell University in the US, Ko Enerugi Kasokuki Kenkyu Kiku in Japan, Deutsches Elektronen-Synchrotron in Germany, Laboratori Nazionali di Legnaro in Italy, and Raja Ramanna Centre for Advanced Technology in India. In this talk we will present current CBP research from each lab including polishing recipes, equipment, post CBP chemistry/heat treatment, and subsequent cryogenic cavity tests on niobium as well as copper cavities.

24-Sep-13	10:45 – 12:55	Oral	Room Adenauer
TUIOC — Basic R&D Bulk Niobium - Processing II			

TUIOC01 10:45 **Review on EP Advances Worldwide** – *F. Furuta, B. Elmore, G.H. Hoffstaetter, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*

Electro-Polishing is now applying on SRF Nb cavity world widely as baseline surface treatment technique in many projects, such as ILC, XFEL, JlabUpgrade, and so on. I will give some review on EP as titled, report the achievements and the newest R&D topics of EP.

TUIOC02 11:15 **Bipolar EP: Electropolishing without Fluorine in a Water Based Electrolyte** – *A.M. Rowe, A. Grassellino (Fermilab) T.D. Hall, M.E. Inman, S.T. Snyder, E.J. Taylor (Faraday Technology, Inc.)*

For more than thirty years, the preparation of superconducting RF cavities for high performance has required the use of dangerous and ecologically damaging chemicals. Reducing the personnel and environmental risks associated with using these chemicals has become a priority at Fermilab. Therefore, a project was undertaken to adapt to SRF cavities a non-hazardous and relatively benign bipolar electropolishing technique developed by Faraday Technology. This technology, based on preliminary work on niobium coupons under DOE funding and scaled to single cell cavities with Fermilab, was developed for polishing metal alloys for automotive and semiconductor parts, and medical devices and implants. By modifying the cathodic/anodic interaction via a pulse forward/pulse reverse technique, Fermilab and Faraday Technology have demonstrated the capability to replace the typical 95% sulfuric and 48% hydrofluoric acid in a 9:1 volumetric ratio electrolyte with a 10% sulfuric acid electrolyte. The bipolar EP project and process development, and resulting vertical tests showing gradients >30 MV/m are presented.

TUIOC03 11:35 **Fluorine Free Ionic Liquid Electropolishing of Niobium Cavities** – *V.B. Pastushenko, O.V. Malkova, V. Palmieri, A.A. Rossi, F. Stivanello (INFN/LNL)*

Ionic liquids are an emerging breakthrough in green chemistry since the years 2000. In 2006, INFN-LNL was the first to apply a mixture of Choline Chloride and Urea to Niobium electropolishing. It was found that mirror like surfaces could be obtained at temperature higher than 120°C, with high throwing power. Subsequently the process was successfully applied to the electropolishing of a 6 GHz monocell cavity with the addition of sulphamic acid. In this work, we will report an intense investigation of the possible variants of the original recipe. We studied the influence on Niobium surface roughness of several parameters such as: other sulphamic, ammonium and carboxylic containing additives different than sulfamic acid, the possible substitution of Urea with ethylene glycol and malic acid, the current regime; the electrolyte temperature and the cathode shape, rotating horizontal electropolishing versus vertical electropolishing. Due to the cavity hollow cylindrical shape, the electrolyte temperature appeared to be the most crucial parameters among those above mentioned for a uniform dissolution of niobium.

TUIOC04 11:55 **Analysis of Post-Wet-Chemistry Heat Treatment Effects on Nb SRF Surface Resistance** – *P. Dhakal, G. Ciovati, G.R. Myneni (JLAB)*

Most of the current R&D in SRF is focused on ways to reduce the construction and operating cost of SRF-based accelerators as well as on the development of new or improved cavity processing techniques. The increase in quality factors is the result of the reduction of the surface resistance of the materials. A recent test [*] on a 1.5 GHz single cell cavity made from ingot niobium of medium purity and heat treated at 1400 C in a ultra-high vacuum induction furnace resulted in a residual resistance of ~ 1nanoohm and a quality factor increasing with field up to ~ 5×10¹⁰ at a peak magnetic field of 90 mT. In this contribution, we present some results on the investigation of the origin of the extended Q0-increase, obtained by multiple HF rinses, oxy-polishing and heat treatment of “all Nb” cavities, as well as the characterization by Nuclear Reaction Analysis and Electron Backscattered Diffraction of samples which were subjected to the high temperature thermal treatments.

TUIOC05 12:15 **An Innovative Purification Technique of 6 GHz Tesla Type Nb Mono Cell Seamless Superconducting Cavities in UHV System** – *A.A. Rossi, A. Battistello, M. Checchin, V. Palmieri, F. Stivanello, R.K. Thakur (INFN/LNL)*

We have developed an innovative technique for purification of bulk-Nb 6GHz RF cavities under ultra-high vacuum (UHV) system. The main advantages of 6 GHz bulk-Nb cavities are saving cost, materials and time to collect statistics of surface treatments and RF test. Cavities are RF tested before and after high temperature treatment under UHV conditions. Induction heating method is used to anneal the cavity at temperatures higher than 2000°C and close to the melting point of Nb for less than a minute while few seconds at maximum temperature. Before RF test and UHV annealing, the surface treatment processes like tumbling, chemical, electro-chemical (such as BCP and EP), ultrasonic cleaning and high pressure rinsing (HPR) have been employed. This kind of Nb 6 GHz cavity purification allow to reduce hydrogen, oxygen and other elemental impurities content, which effects on cavity Q-factor degradation, by a rapid annealing over 2000°C and a subsequent rapid reduction at room temperature.

TUIOC06 12:35 **Study on Optimum EBW Condition for Fine and Large Grain Nb Cavities** – *T. Kubo, Y. Ajima, H. Hayano, H. Inoue, S. Kato, H. Monjushiro, T. Saeki, M. Sawabe, K. Umemori, Y. Watanabe, S. Yamaguchi, M. Yamanaka (KEK) Y. Iwashita (Kyoto ICR) T. Nagata (ULVAC, Inc.)*

Optimum EBW conditions for fine and large grain Nb cavities are studied. Relations between EBW parameters and geometries of weld beads, and the chemistry before welding are also commented.

24-Sep-13	14:30 – 18:00	Poster	Galleries
TUP — Poster session II			

TUP001 **Evidence of Weak Links From the Local Nonlinear Response of Bulk Nb Surfaces** – *S. M. Anlage (UMD) B.G. Ghamsari, T.M. Tai (CNAM, UMD)*

We have developed a near-field microwave microscope to locally stress bulk Nb surfaces with intense (~ 100 mT) GHz-scale, highly localized (sub-micro-meter) magnetic fields under cryogenic conditions [1-3]. The microscope measures the induced nonlinear response (third harmonic generation) from a localized region as a function of RF excitation power and sample temperature. When applied to the surface of bulk Nb this microscope finds i) spatial variations in the nonlinear response, ii) a power dependence that shows sharp onset of nonlinear response at a temperature-dependent onset RF field level, iii) non-monotonic dependence of the harmonic response on stimulating field level, iv) a strongly temperature-dependent nonlinear response as a function of temperature at fixed excitation level. To understand these results we propose that the RF fields induce screening currents that flow through one or more Josephson weak links, giving rise to harmonic generation. A model based on this idea can make quantitative fits to the temperature and RF power dependent data, and the fitting parameters are reasonable and have reasonable dependence on temperature.

- TUP002 Quench in SRF Cavity - Combined Effects of Dislocation Presence and Geometrical Curvature** – A.V. Dzyuba, L.D. Cooley (Fermilab) E. Toropov (CMU)
 Quench remains an ultimate limitation for highest accelerating gradients of SRF cavities. The origin and genesis of the dissipation are not thoroughly understood yet. In our work we investigate 2 artificial pits indented in the single cell resonator. We demonstrate that deformation clusters can increase the probability of local quench. This hints that not only pit curvature is important, but underlying microstructure as well. Pit repair routes should thus address the microstructure. Simple model of the quench, which combines both geometrical and impurity factors suggested.
- TUP003 Genesis of HFQS Losses in SRF Cavities: Distribution in Local Purity and Geometry** – A.V. Dzyuba, L.D. Cooley (Fermilab)
 High Field Q Slope (HFQS) is RF loss mechanism taking place at around $H_{pk}=100\text{mT}$ and may be associated with penetration of Abrikosov vortices. In our previous work we suggested that surface grooves along with “bad” material (low H_c and high k) confined to local clusters can explain such a low onset field [1]. In this study we continue this analysis arguing phenomenologically that only small fraction of the equator surface should be affected by penetration (~1% total). Profilometry and SEM-EBSD studies point to local contamination and defect networks as the source of these clusters.
- TUP004 Connection Between Defect Structures, Chemical Polishing, Hydrogen, and High Vacuum Anneal as Inferred From Resistance Measurements** – A.V. Dzyuba, L.D. Cooley (Fermilab)
 It is widely acknowledged that bulk polishing loads SRF niobium with hydrogen. High vacuum degassing is widely used to reduce the hydrogen concentration. In this study we shed light on some details of these processes. Residual cold work can accelerate hydrogen uptake. Higher hydrogen content and associated hydride phase transformations become evident in resistivity data. Recovery of cold work appears to be effective for removing hydrogen, preventing hydrogen uptake, and suppressing hydride formation. Aspects of grain boundaries and vacancies are also discussed.
- TUP005 Dielectric Pair Breaking in Superconducting Niobium rf Cavities** – J. Halbritter (FZ Karlsruhe)
 $R(T, \sim \text{GHz})$ of Nb evidenced an electric surface resistance $R_E \sim f$ with an onset E_0 fitting to dielectric pair breaking (DIPB) $\epsilon z E_0 > \Delta$ at localized states $nL(z)$ in Nb_2O_5 [1], i.e. excitation above the superconducting energy gap 2Δ by ITE given by $\exp(-Kz)$ adjacent to $nC \sim 100\text{nL}$ [2]. PB in density $N(\text{PB})$ proportional to $s(E) = (\exp(-K\Delta/eE) - \exp(-K\Delta/eE_0))$ relax slowly at zL with DIPB losses diminishing for $E \geq 100\text{V/m}$ [3]. $N(\text{PB})$ ITE coupled to $nC(z, \epsilon \geq \Delta < \Delta_0)$ states in proximity to Nb relaxing faster to $N(\text{REPB})$ becoming so measurable as pair breaking rf losses $R_E(\text{DIPB}) \propto fN(\text{REPB})(E) \sim f_s(E)$ above $E_0 > 1\text{MV}/2\text{m}$ [1]. For “better” interfaces $N(\text{REPB})$ couples to delocalized states $|\Delta E| \geq \Delta_0$ with $N(\text{REPB}) > N_T (< T_c/3)$ the thermal quasi particle density [4] absorbing rf described by $R_{\text{HFQ}} \sim \text{HHN}(\text{REPB})\text{RBCS} \sim \omega s(E)$ observable as high field Q drop (HFQ) above $E_{loc} \sim 1 - 15 \text{ MV/m}$ [5]. $R_E(\text{DIPB})$ and $R(\text{HFQ})$ change with electro polishing (EP), with buffered chemical polishing (BCP), with slowly cooling in HV or UHV and with UHV baking at low temperatures $100 - 150^\circ\text{C}$ (LTB) by a changing $\Delta(z \sim 0)$ decrease.
- TUP006 Can Magnetic Breakdown Explain High Field Q-Drop (HFQ) and Explain Q Disease?** – J. Halbritter (FZ Karlsruhe)
 The magnetic breakdown at $H_b(T)$ of normal conductors (nc) backed by bulk, clean superconductors has been applied recently to oxidized Nb rf cavities proposing $H_b(T)$ of nc NbH precipitates backed by Nb as explanation of HFQ and of Q disease [1]. In [1] the fact that Nb is oxidized and that the Nb/O bonding is about a factor 2 stronger than the Nb/H bonding [2] has been neglected which explains the observed reductions of mean free paths l and of degradation of energy gap Δ [3] at the surface to $l_s \sim 0.3\text{nm}$ and to a nc seam increasing in depth of 100nm to $1 - 50\text{nm}$ and to 20%at% O [3] without needing NbH. The Nb/O impurities shift the magnetic breakdown $H_b(T)$ to $T < 2\text{K}$ [4], i.e. out of the reach of Nb rf cavities. A Q disease is not shown in [1], i.e. the $Q(H)$ in Fig.3 of [1] does not grow with holding time at 100K , in contrast to all published results. $Q(H)$ of Fig.3 is fitted better to ITE $R_E(E)$ [5] by a NbO layer depressing the order parameter. In conclusions, the in [1] proposed relations of Q disease and of HFQ to magnetic breakdown by NbH precipitates lacks theoretical and experimental evidence.
- TUP007 RF Electromagnetic Field and Vortex Penetration in Multilayered Superconductors** – T. Kubo, T. Saeki (KEK) Y. Iwashita (Kyoto ICR)
 A multilayered structure with a single superconductor layer and a single insulator layer deposited on a bulk superconductor is studied. General formulae for the vortex penetration-field of the superconductor layer and the magnetic field on the bulk superconductor which is shielded by the superconductor and insulator layers are derived with a rigorous calculation of the magnetic field attenuation in the multilayered structure. The formulae depend not only on the material and the thickness of the superconductor layer but also on the thickness of the insulator layer. The results can be applied to superconducting accelerating cavities with the multilayered structure. Using the formulae, a combination of the thicknesses of superconductor and insulator layers to enhance the RF breakdown field limits can be found for any given materials. (Submitted on 25 Apr 2013)
- TUP008 Analytical Model of the Magnetic Field Enhancement at Pits on the Surface of Superconducting Accelerating Cavity** – T. Kubo (KEK)
 A simple model of the magnetic field enhancement at pits on the surface of superconducting accelerating cavity is proposed. The model consists of a two-dimensional pit with a slope angle, depth, width, and radius of round edge. An analytical formula that describes the magnetic field enhancement factor of the model is derived. The formula is given as a function of a slope angle and a ratio of half a width to a round-edge radius. Using the formula, the field at which vortices start to penetrate can be evaluated for a given geometry of pit.
- TUP009 Magnetic Dependence of the Energy Gap: a Good Model to Fit Q-Slope of Low Beta Cavities** – D. Longuevergne (IPN)
 The reasons why the intrinsic quality factor (noted Q_0) of a superconducting cavity drops with the accelerating field (noted E_{acc}) are still not well understood. In an effort to explain this phenomenon, mainly for high beta cavities, many models have been developed in the community but few of them could fit experimental data whatever the material treatment or surface conditioning. In the specific case of low beta cavities made of bulk Niobium (i.e. Spiral 2 Quarter Wave Resonator), a model based on a magnetic field dependence of the energy gap has been developed to fit experimental data. The evolutions of the model input parameters depending on the cavity treatment or test conditions are consistent with the changes described in the literature. The model will be described and specific examples will be given.
- TUP010 Simulation of Non-linear RF Losses Derived from Characteristic Nb Topography** – C. Xu (JLAB) M.J. Kelley, C. Xu C.E. Reece (JLab)
 A simplified model has been developed to simulate non-linear rf losses on Nb surfaces due exclusively to topographical enhancement of surface magnetic fields. If local sharp edges are small enough, where local surface fields exceed H_c , small

volumes of material may become normal conducting without thermal runaway leading to quench. These small volumes of normal material yield increases in the effective surface resistance of the Nb. Using topographic data from typical BCP'd and EP'd fine grain niobium, we have simulated field-dependent losses and find that when extrapolated to resulting cavity performance correspond well to characteristic BCP/EP high field Q0 performance differences for fine grain Nb. We will describe the structure of the model, its limitations, and the effects of this type of non-linear loss contribution to SRF cavities.

TUP011 A Parametric Study of BCS RF Surface Impedance with Magnetic Field Using Xiao Code – C.E. Reece (JLab) B. P. Xiao (BNL)

A recent new analysis of field-dependent BCS RF surface impedance based on moving Cooper pairs has been presented.* Using this analysis coded in Mathematica™, survey calculations have been completed which examine the sensitivities of this surface impedance to variation of the BCS material parameters and temperature. The results present a refined description of the "best theoretical" performance available to potential applications with corresponding materials.

TUP012 Understanding the Role of Strain Induced Defects in the Degradation of Surface Superconductivity for SRF Quality Niobium – Z.-H. Sung (ASC) L.D. Cooley, A.V. Dzyuba (Fermilab) D.C. Larbalestier, P.J. Lee (NHMFL)

Some years ago Casalbuoni showed that the r_{32} of (Hc3/Hc2) of SRF-processed Nb could deviate markedly from the GL values of 1.695 due to nanostructure difference between surface and bulk. Here, we address the impact of increasing levels of cold work introduced by wire drawing on the localized surface superconducting properties of SRF Nb. We used AC susceptibility measurements to explore the surface and bulk superconductivity of the wires after applying different levels of EP and post baking. Then, we quantified the changes in microstructure by EBSD to map the crystallographic texture and micro-scale grain misorientation. These combined characterizations showed that the r_{32} of heavily deformed Nb surfaces, though initially very enhanced, can revert to or become even lower than 1.695 after long EP and high T baking. However, the marked difference in surface superconductivity compared to the bulk appears after a mild bake (120°C/48h). This distinct surface property may be associated with light element diffusion through the highly deformed GBs or dislocations during low baking. AC susceptibility made on single and bi-crystal from large grain sheet strongly supports this hypothesis.

TUP013 A Parametric Study of BCS RF Surface Impedance With Magnetic Field Using Xiao Code – B. P. Xiao (BNL) C.E. Reece, B. P. Xiao

A recent new analysis of field-dependent BCS rf surface impedance based on moving Cooper pairs has been presented.[x] Using this analysis coded in Mathematica, survey calculations have been completed which examine the sensitivities of this surface impedance to variation of the BCS material parameters and temperature. The results present a refined description of the "best theoretical" performance available to potential applications with corresponding materials.

TUP014 Fast Table Top Niobium Hydride Investigations Using Direct Imaging in a Cryo-Stage – E.L. Barkov, A. Grassellino, A. Romanenko (Fermilab)

Performance of niobium SRF cavities can be strongly affected by hydrogen segregation into lossy niobium hydrides as known for "hydrogen Q disease" at higher concentration of dissolved H and may be a reason for the "high field Q slope" at lower concentrations. With the use of optical cryostat and laser confocal microscope we have developed a "table top technique" for direct observation of hydride precipitation, and studied formation, morphology, and time evolution of hydrides after different treatments used for cavities. Our results show that hydrides can form at the niobium surface at 90-180K depending mainly on H concentration and the cooldown rate. A lot of H is absorbed by bulk niobium during mechanical polishing, which leads to the formation of very large (>10 microns) hydrides. Both EP and BCP do not influence H concentration significantly provided that temperature during treatments is kept below 15C. 800C degassing reduces H concentration and precludes large hydride precipitation. 120C baking and mechanical deformation do not change H concentration but affect hydride precipitation through their influence on the number of nucleation centers and H binding defects.

TUP015 Bitter Decoration Studies of Magnetic Flux Penetration Into Cavity Cutouts – E.L. Barkov, A. Grassellino, A. Romanenko (Fermilab) L.Y. Vinnikov (ISSP)

Magnetic flux penetration may produce additional losses in superconducting radio frequency cavities, and all the existing models for flux penetration are based on the formation of Abrikosov vortices. Using high resolution Bitter decoration technique we have investigated magnetic flux distribution patterns in cavity cutouts at the perpendicular magnetic fields of 10^{-80} mT. At low fields <20 mT the magnetic field penetrates in the form of flux bundles and not Abrikosov vortices, the situation characteristic of type-I superconductors. With the increase of the magnetic field up to 30 mT "bundles" first merge into a connected structure and then break up into individual Abrikosov vortices at ~60 mT and a well-known intermediate mixed state is observed. Such magnetic field driven transition from type I to type II superconductivity has never been observed before in any existing superconductor. For the case of flat samples we have observed a coexistence of both "bundles" and Abrikosov vortices in one experiment. Our results show that high-purity cavity grade niobium is a "border-line" material and behaves as a type-I superconductor at lower fields and type-II at higher fields.

TUP016 Effects of Processing History on Damage Layer Evolution in Large Grain Nb Cavities – D. Kang, T.R. Bieler (Michigan State University) G. Ciovati (JLAB) C. Compton (FRIB)

Previous cavity tests identified a strong dependence of achievable accelerating gradients on the amount of material removed from the surface. Samples extracted from the iris and the equator of a half cell fabricated by Jefferson Lab using large grain Nb were examined to identify underlying mechanisms. Electron backscattered diffraction (EBSD) was used to measure the crystal orientations on the cross sections of the samples. Results demonstrated the presence of a surface damage layer, which contained higher dislocation content than the bulk due to the deep drawing process. The depth of the damage layer depends on crystal orientations, and damage to the iris is more severe than at the equator. From the EBSD data, the damage depth was estimated to be about 100 microns. The samples were then heat treated at 800°C and 1000°C, and the same areas were examined again for the effects of heat treatment on the healing of the damage layer. While the damage layer accounts for some of the performance gain from chemical surface removal, the depth of the damage layer in polycrystalline cavities remains an open question.

TUP017 Study of Slip and Dislocations in High Purity Single Crystal Nb for Accelerator Cavities – D. Kang, D.C. Baars, T.R. Bieler (Michigan State University) C. Compton (FRIB)

SRF Cavities can be formed by deep drawing slices from Nb ingots with large grains. Crystal orientation dependent slip system activities affect the shape change of ingot slices during deep drawing, and form a dislocation substructure that affects subsequent recrystallization and ultimately, cavity performance. Two groups of single crystal tensile specimens with different orientations were extracted from a large grain ingot slice. The first group was deformed monotonically to 40% engineering strain. Analysis revealed that slip was preferred on 112 planes. The second group was heat treated at 800°C for two hours, and

then deformed incrementally to 40% engineering strain using an in situ tensile stage. Crystal orientations and surface images were recorded at each increment of deformation. Results indicate that the heat treated group had lower yield strengths, and the details of slip activity differed in the annealed samples. Active slip systems were investigated and compared to the first group. Direct observations of dislocations were performed in selected specimens using electron channeling contrast imaging, to determine how slip affects the dislocation substructure.

- TUP018 Non-Schmid Crystal Plasticity Modeling of Deformation of Niobium** – *A. Mapar, F. Pourboghrat (MSU) T.R. Bieler (Michigan State University) C. Compton (FRIB)*
 The response of niobium (Nb) to load changes when the direction of loading with respect to the crystal orientation changes. Large grain Nb sheets are less expensive but more anisotropic than fine grain sheets. Designing a manufacturing process for large grain Nb sheets is complex and impractical, unless one uses a modeling approach that considers crystal orientation and plastic anisotropy. This improves the performance and reduces costs of a SRF cavity. Designing more sophisticated manufacturing methods like tube hydroforming is also feasible with such a model. Crystal plasticity has been very successful for FCC materials; nevertheless, there is still no model that can accurately predict the deformation behavior of most BCC materials like Nb. The classical crystal plasticity model fails for BCC materials. To successfully model the deformation, one should account for the effect non-Schmid stresses have on the core structure and hence, the mobility of the screw dislocation. In this study the effect of core structure is implemented into a crystal plasticity model for Nb. This is a generalization to the classical crystal plasticity and substantially improves predictions of the model.
- TUP019 Probing the Surface of SRF Cavities with Tunneling and Raman Spectroscopies** – *C. Cao (Illinois Institute of Technology) G. Ciovati (JLAB) L.D. Cooley, A. Grassellino, A. Romanenko (Fermilab) N. Groll, Th. Proslir (ANL) J. Zasadzinski (IIT)*
 Point contact tunneling and Raman spectroscopies are presented on high purity Nb samples, including pieces from hot and cold spot regions of tested SRF cavities and Nb coupons subject to similar treatment. High quality tunneling spectra were observed on cold spots, revealing the bulk Nb gap, indicating minimal surface contamination. Hot spots exhibit high smearing suggestive of pair breaking along with generally lower superconducting gap. In addition, pronounced zero bias conductance peaks were frequently observed indicative of spin-flip tunneling and thus magnetic impurities in the oxide layer. Optical microscopy reveals higher density of surface blemishes on hot spots. Raman spectra inside those blemishes show clear difference from surrounding areas, exhibiting enhanced intensity peaks identified as either amorphous carbon, hydrocarbons or the ordered NbC phase. The presence of surface NbC is consistent with TEM studies, and these inclusions exhibit enhanced second order phonon response. Such regions with high concentrations of impurities are expected to suppress the local superconductivity and may explain the formation of hot spots.
- TUP020 Draft International Standard for Measurement of RRR for Niobium** – *L.D. Cooley (Fermilab)*
 The residual resistivity ratio (RRR) has been used as a specification for the purity of niobium for many years. The common definition is a ratio of two measurements R_1 / R_2 , with R_1 taken at 273 to 300 K, and R_2 taken at temperature below 15 K. However, there is no consensus about how R_1 or R_2 shall be determined, which creates subtle variations between standard material specifications such as ASTM B393, and project- or laboratory-specific specs such as those at XFEL and Fermilab. These variations can lead to confusion, mis-interpretation of stated quality, and cancellation of orders. Working Group 4 of IEC Technical Committee 90 has begun work to define an IEC standard for RRR measurement, and the progress of this effort will be described. Cross-comparison of different types of measurement will also be discussed.
- TUP021 Can Reasonable Gradient and Quality Factor Be Attained With Only Light Processing?** – *L.D. Cooley, D.J. Bice, A.C. Crawford, A.V. Dzyuba, A. Grassellino, A.M. Rowe (Fermilab) M.S. Champion (ORNL) J. Rathke (AES)*
 Recently, Fermilab commissioned several single-cell cavities for which half cells were batch annealed prior to welding and chemical polishing. The experiment meant to reduce pit formation at the welds, based on work reported at the previous two SRF conferences. Indeed, bulk electropolishing produced excellent finish, and in fact cavities tested very well without a de-gassing vacuum anneal. When Q-disease was found, an additional anneal was effective; no further chemical polishing was needed. Concurrent with this study, Ph.D. thesis work explored hydrogen uptake as a function of cold work (see A. Dzyuba poster). A threshold of combined cold work and polishing was identified, above which rather strong hydrogen uptake occurred. Annealed metal was below this threshold, and was resistant to hydrogen absorption. In view of these results, a proposal is made to use annealing prior to chemical polishing as standard practice. Aggressive annealing could permit good results to be obtained with only light EP, which could be a practical low-cost cavity process. Materials R&D should also continue to address the degree of material recovery needed to enable such a light process.
- TUP022 Study of AC/RF Properties of SRF Ingot Niobium** – *P. Dhakal, G. Ciovati, G.R. Myneni (JLAB) V.M. Genkin, M.I. Tsindlekht (The Hebrew University of Jerusalem, The Racah Institute of Physics)*
 In an attempt to correlate the SRF performance of niobium cavities with the superconducting properties, we present the results of the magnetization and ac susceptibility of the niobium used in the superconducting radiofrequency cavity fabrications which were subjected to buffer chemical polishing surface and high temperature heat treatments, typically applied to the SRF cavities fabrications. The analysis of the results show the different surface and bulk ac conductivity for the samples subjected to BCP and HT. Furthermore, the RF surface impedance is measured on the sample using the TE011 microwave cavity for a comparison to the low frequency measurements.
- TUP023 Evidence of Magnetic Breakdown on the Defects With Thermally Suppressed Critical Field in High Gradient SRF Cavities.** – *G.V. Ereemeev, R.L. Geng, A.D. Palczewski (JLAB)*
 At SRF 2011 we presented the study of quenches in high gradient SRF cavities with dual mode excitation technique[*]. The data differed from measurements done in 80's that indicated thermal breakdown nature of quenches in SRF cavities. In this contribution we present analysis of the data that indicates that our recent data for high gradient quenches is consistent with the magnetic breakdown on the defects with thermally suppressed critical field. From the parametric fits derived within the model we estimate the critical breakdown fields and RF resistances at the breakdown site.
- TUP024 Unloaded Quality Factor Q0 of Large Grain, Hydroformed and Prototype of European XFEL Fine Grain Cavities** – *A. Ermakov, W. Singer, X. Singer (DESY)*
 A statistical analysis of the unloaded quality factor Q0 of TESLA shape cavities at low accelerating field (up to 5 MV/m) and medium accelerating field (5-20 MV/m) was done on base of available RF data for test series: single-cell and 9-cell large grain cavities, single cell and multi-cell hydroformed at DESY cavities, fine grain cavities-prototypes for European XFEL. On the one hand the purpose of statistical analysis is done to find the relationship between the parameters describing the behavior between unloaded quality factor Q0 (as function of the accelerated field Eacc) and main treatment procedures (Buffered

Chemical Polishing BCP, Electropolishing EP, 120°C baking). On the other hand the relationship between Q0 and different types of cavities (cavities with reduced number of grain boundaries, cavities without equator welding seam, cavities of standard fine grain material) was evaluated. The non-linearity of the surface resistance in low and medium field regions analyzed for these types of cavities and compared with the available theoretical models.

TUP025 Quench Field Computation Using Analytical Solutions of the Steady-State Heat Equation for SRF Cavities Subjected to RF losses – M. Fouaidy (IPN)

We derived analytical solutions of the steady-state heat equation for SRF cavities subjected to RF losses and cooled by LHe at temperature T_{bath} . Two classes of problems are treated: 1) the defect-free case with uniform RF losses either due to the intrinsic BCS RF surface resistance of the material or includes the residual surface resistance R_{res} , 2) the defect case with losses dominated by RF Joule heating of localised normal-resistive regions or defects. Three thermal models are described and the resulting analytical solutions derived. These solutions are used to study the thermal behaviour of SRF cavities. For the defect-free case, we studied the effect of several parameters on cavity quench field: frequency f , T_{bath} , R_{res} , cavity wall thickness, material thermal conductivity k and the heat transfer coefficient at the cavity cold surface. For the defect case, two thermal models are presented and the resulting temperature fields are computed as function of E_{acc} , k , the defect radius r_D and surface resistance R_D . The resulting quench fields are then computed. Finally, we propose design criteria in terms of thermal performance for large scale applications of SRF cavities.

TUP026 Performance of a FNAL Nitrogen Treated Superconducting Niobium Cavity at Cornell – D. Gonnella, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) A. Grassellino (Fermilab)

In many tests of superconducting cavities, the performance of the cavity in the medium field region will be limited by medium field Q slope. For projects such as the proposed Cornell Energy Recovery Linac, high Q operation at medium fields is necessary to meet specifications for efficient CW cavity operation. A single cell cavity was prepared by Fermilab by electropolishing it and baking it at 1000°C with 1×10^{-2} Torr of Nitrogen, and subsequently tested at Cornell. The cavity displayed an increase in Q at medium fields between 5 and 20 MV/m at 2.0 K, opposite of the usual medium field Q slope. The material properties of this cavity were studied and correlated with performance. This analysis helps to better understand how to overcome medium field Q slope and improve cavity performance in future CW SRF machines such as the Cornell ERL.

TUP027 High Q0 Studies at Cornell – D. Gonnella, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)

The construction and preparation of superconducting RF cavities with very high quality factors is very advantageous for future particle accelerators operating in CW mode. Until recently, the highest quality factors measured in SRF cavities were on the order of 10^{11} . A Cornell ERL single-center-cell cavity was prepared with BCP and a five day heat treatment at 1000°C. Following this treatment, the cavity was tested and achieved a record high intrinsic quality factor of 2.9×10^{11} at 1.4 K, corresponding to a very small residual resistance of (0.35 ± 0.10) nOhm. This cavity was then given a series of BCP's of 5, 75, and 200 μm and retested. Material properties were extracted from the data hinting at a very low mean free path of the niobium. In this paper we discuss the unusual material properties of the surface layer of the cavity and their implication for the RF performance of the cavity.

TUP028 Investigation of Spatial Variation of the Surface Resistance of a Superconducting RF Cavity – D. Gonnella, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) R.E. French (Corning Community College)

Cornell has recently completed a single cell temperature mapping system with a resolution of a few tenths of a millikelvin, corresponding to a surface resistance resolution of 1 nOhm. A superconducting RF cavity was tested using temperature mapping and the surface resistance was extracted from the temperature mapping data as function of position on the cavity surface. The surface resistance was profiled across the surface of the cavity between 5 and 35 MV/m and at different temperatures between 1.6 and 2.1 K. From BCS fitting of the local surface resistance, the spatial variation and the field dependence of the mean free path, energy gap, and residual resistance was found. These studies give interesting new insight into the degree of variation of the properties of the superconductor over the surface of the cavity.

TUP029 Heat Treatment of SRF Cavities in a Low-Pressure Atmosphere – D. Gonnella, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)

Recent results from FNAL on baking superconducting RF cavities at high temperatures in a low-pressure atmosphere of a few mTorr indicate that such treatments can increase the medium field quality factor. In this paper we report on studies from Cornell, giving new insight into the mechanism behind this effect.

TUP030 Post-Annealing Losses in SRF Niobium Cavities Due to Furnace Contamination and the Ways to Its Mitigation – A. Grassellino, L.D. Cooley, C.A. Cooper, A.C. Crawford, C.M. Ginsburg, R.D. Kephart, O.S. Melnychuk, A. Romanenko, A.M. Rowe, D.A. Sergatskov, M. Wong (Fermilab) Y. Trenikhina (IIT)

We investigate the effect of high temperature treatments followed by only high-pressure water rinse (HPR) of superconducting radio frequency (SRF) niobium cavities. The objective is to provide a cost effective alternative to the typical cavity processing sequence, by eliminating the material removal step post furnace treatment while preserving or improving the RF performance. The studies have been conducted in the temperature range 800-1000C for different conditions of the starting substrate: large grain and fine grain, electro-polished (EP) and centrifugal barrel polished (CBP) to mirror finish. An interesting effect of the grain size on the performances is found. Cavity results and samples characterization show that furnace contaminants cause poor cavity performance, and a practical solution is found to prevent surface contamination. Extraordinary values of residual resistances ~ 1 nOhm and below are then consistently achieved for the contamination-free cavities.

TUP031 Muon Spin Rotation Studies of Bulk Electropolished Cavity Cutouts and Thin Films of Alternative Materials – A. Grassellino, F.L. Barkov, A. Romanenko (Fermilab) M. Liepe, S. Posen (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) Y. Trenikhina (IIT)

In the previous studies [*] magnetic flux penetration into fine and large grain BCP cavity cutouts was investigated using the muon spin rotation (muSR) technique. The technique is based on implanting muons, which serve as sensitive magnetic probes inside the material. Here we report muSR studies on fine grain EP cavity cutouts, both before and after 120C baking, and on the films of new materials.

TUP032 High Q Studies for 3.9 GHz Cavities – A. Grassellino, A.C. Crawford, H.T. Edwards, E.R. Harms, A. Romanenko (Fermilab)

A surface treatment was recently found at FNAL giving improvements in surface resistance up to a factor of 3 at peak surface

magnetic fields ~ 70 mT compared to standard treatments for 1.3 GHz cavities. The treatment has the advantage of significantly lowering the BCS resistance component at typical CW operating gradients. We report the results of this treatment applied for the first time to a 3.9 GHz cavity.

TUP033 Impurities of Rare Earth Element in Ingot Nb as a Potential Way to Improve the Cavity SRF Performance – F.S. He, F. He, F. Jiao, X.Y. Lu, J. Tao, K. Zhao (PKU)

A new idea of modifying the raw niobium was proposed by PKU in 2010, by introducing rare earth elements of Sc and Y into Nb ingot during smelting process. Test results on small samples were very promising*: the Tc was same as Nb, while the Hc1 and Hc2 were increased by 500-700 Oe and up to 4000 Oe, respectively. Recently one Nb ingot doped with Sc was successfully smelted under the collaboration of PKU and OSTEC at Ningxia, and two TESLA-type half cells were fabricated out of the new material by deep drawing. The Hc1 measured from the drop-off of the blanks were consistently high. The RRR was 127, while the mechanical properties met the ILC requirement. One single cell cavity is being fabricated, and vertical test is planned to study the SRF properties of the new material. There is a good chance that the quenching could be pushed to a higher gradient. Another innovative idea of doping only the surface layer of bulk Nb by ion implantation in the pelletron at PKU is also being investigated, in order to improve the SRF performance of the surface layer while maintaining the high thermal conductivity of bulk Nb. Some initial testing results of the new method will be reported as well.

TUP034 Atomic-Scale Characterization of the Subsurface Region of Niobium for SRF Cavities Using Ultraviolet Laser-assisted Atom-probe Tomography – Y.-J. Kim, D.N. Seidman (NU) G. Ciovati, P. Dhakal, G.R. Myneni (JLAB) L.D. Cooley, A.V. Dzyuba (Fermilab) R.F. Klie, T. Tao (UIC)

Niobium is the metal of choice for SRF cavities for a linear particle accelerator because it has the highest critical temperature of any element in the periodic table and can be deformed plastically into complex geometries. Differences in the subsurface chemistry from bulk niobium are believed to determine the high-field Q-drop. In this study, the subsurface chemistry of niobium was characterized utilizing ultraviolet laser-assisted local-electrode atom-probe (LEAP) tomography employing picosecond laser pulsing. The superior spatial resolution and analytical sensitivity of a LEAP tomograph permits us to determine the subsurface composition on an atom-by-atom and atomic hkl plane-by-plane basis. The 3-D reconstructions from the LEAP tomographic analyses demonstrate different behaviors for Nb-oxides and Nb-hydrides in pure niobium as well as interactions with structural imperfections, dislocations and grain boundaries in SRF-grade Nb coupon material. Additionally, the chemistry and crystallographic structure of subsurface interstitial atoms were analyzed based on energy shifts of electron energy-loss spectroscopy in conjunction with a scanning transmission electron microscopy.

TUP035 Neutron Activation Analysis as a Foreign Intrusion Cavity Diagnostic Tool – C. Maiano, P. Michelato (INFN/LASA) M. Clemenza (Universita Milano Bicocca) C. Pagani (Università degli Studi di Milano & INFN)

Neutron Activation Analysis (NAA) is one of the currently available techniques used to determine contaminants in Nb superconducting cavities, allowing a non-destructive determination of foreign materials, provided they have radioactive isotopes with a sufficiently long half-life. We present the NAA technique application with the goal of contaminants determination, identification and localization for the European XFEL 3rd harmonic cavities (3.9 GHz). Irradiation and analysis has been performed in collaboration with the LENA nuclear reactor (Pavia, Italy) and the University of Milano Bicocca. The main difference respect to the measurements performed in the past is the goal to apply of the NNA directly to entire cavities and not to material samples. Currently nine samples were exposed to thermal and fast neutron flux and the resulting activity was measured with HPGe detectors.

TUP036 Large Grain Cavities at 3.9 GHz – P. Pierini, M. Bertucci, A. Bosotti, C. Maiano, P. Michelato, L. Monaco, R. Paparella, D. Sertore (INFN/LASA) G. Ciovati, P. Dhakal, G.R. Myneni (JLAB) C. Pagani (Università degli Studi di Milano & INFN)

In parallel to the series production for the 3.9 GHz cavities of the European XFEL a single-cell and a full 9-cell complete prototype of these high-frequency structures employing large grain Nb material provided by JLAB will be built and tested. The aim of this activity is to explore the potential of large grain material and possible treatment simplifications deriving from its use, at this high frequency.

TUP037 Dynamic Hardening Rule; a Generalization to the Classical Hardening Rule for Crystal Plasticity – A. Mapar, F. Pourboghrat (MSU) T.R. Bieler (Michigan State University) C. Compton (FRIB)

The mechanical properties of a niobium (Nb) specimen can change with the orientation of the sheet. This anisotropy causes inhomogeneity in manufactured SRF cavities. Large grain Nb sheets are more anisotropic and less expensive than fine grain sheets. Designing a manufacturing process for large grain Nb sheets, however, is extremely complex, and requires using advance modeling techniques. A model capable of accurately predicting the deformation behavior of Nb can help improve the performance and reduce costs of a SRF cavity. Optimal design of the manufacturing of cavities with tube hydroforming process is possible with such a model. Crystal plasticity modeling of FCC materials has been very successful; however, there is still no model that can accurately predict the deformation behavior of BCC materials like the large grain Nb sheet. In this study, authors have proposed a dynamic hardening rule for crystal plasticity that significantly improves predictions of the model for large grain Nb. This model is the generalization of the classical hardening rule, and gives better control over the hardening rate. It also increases the stability of the model.

TUP038 Field Dependence of Residual and BCS Surface Resistances Measured by Explicit Deconvolution Up to High Fields – A. Romanenko, A. Grassellino, O.S. Melnychuk, D.A. Sergatskov (Fermilab)

For both fundamental understanding of performance limiting processes and practical design of future accelerators a crucial information is the temperature and field dependence of the components in surface resistance. We report an explicit deconvolution of temperature-independent residual (Rres) and temperature-dependent BCS (Rbcs) components in multiple cavities treated by standard processing techniques (EP, BCP, 120C bake, 800C degassing) at all fields up to Brf > 100 mT. Such deconvolution allows to address the nature of the low, medium, and high field Q slopes, and provides input for accelerator parametric design optimization.

TUP039 Meissner Screening at Hot (Unbaked) and Cold (Baked) Spots in Electropolished Cavities Studied by Low Energy Muon Spectroscopy – A. Romanenko, E.L. Barkov, A. Grassellino (Fermilab) T. Prokscha, Z. Salman, A. Suter (PSI)

While there is a number of recent structural investigations, which shed light on possible underlying mechanisms of the high field Q slope and 120C baking effect [], there is fewer explicit superconducting investigations exploring the microscopic superconducting properties at the locations of "hot" spots in unbaked cavities. Furthermore, while the nature of the magnetic field penetration in the Meissner state into bulk niobium is predicted by BCS theory and its strong coupling extensions, it was

never directly observed. Here we present a direct measurement of the magnetic field profile $B(z)$ in the Meissner state inside a "hot" spot cutout from the electropolished cavity, and compare it to a "cold" spot from the baked electropolished cavity. We demonstrate the presence of a dead layer, a non-exponential $B(z)$ profile, and a drastic change introduced by the 120C baking.

TUP040 Quench Dynamics in SRF Cavities – *D.A. Sergatskov, I. Terechkine, V.P. Yakovlev (Fermilab) S.P. Antipov (University of Chicago) E. Toropov (CMU)*

A quench in SRF cavities is a thermal runaway process that causes a rapid loss of the stored RF energy. A quench is one of the factors that limits performance of the cavity. We have developed a comprehensive model describing the thermal and electromagnetic dynamics in the quench zone of an SRF cavity. The model has already provided us with insights essential to improved performance of SRF cavities. The predicted size of the hot spot that emits 2nd-sound during the quench is important for the Oscillating Sound Transducer (OST) quench detection technique; the maximum size of the normal zone formed during the quench determines cavity quality degradation; anomalous RF decay time distinguishes a real quench from other mechanisms of sudden loss of RF power in the cavities. We describe the model, discuss the most important results and compare them to experimental data.

TUP041 Large Grain DESY Cavities and Crystallographic Orientation of the Niobium Discs – *X. Singer, W. Singer (DESY) K. Kazimierz (University of Mining and Metallurgy)*

Eleven 9-cell Large Grain LG cavities have been produced and successfully RF tested at DESY. Analysis of the LG niobium discs for these cavities from the crystallographic orientation point of view has been done. Surface behavior and roughness of the LG samples of different crystallographic orientation after buffered chemical polishing BCP have been studied by light microscope and AFM. Oxidation behavior of large grain samples with different orientations after BCP was studied by XPS and compared to polycrystalline niobium. The oxide layer on fine grain niobium is thicker than on LG material. The thickness of the oxide layer also depends on crystal orientation. It turned out that the process of the half-cell deep drawing is influenced by the crystallographic orientation of the main central crystal. Dependence of the half-cell shape accuracy from the crystal orientation of the main central crystal was detected. Crystallographic plane (100) parallel to the sheet surface caused smaller shape accuracy compare to (211) or (221). Statistical analysis of the relationship between the crystallographic orientation of the main central crystal of LG cavities and RF-data will be presented.

TUP042 In-Situ Study of Nb Oxide and Hydride for SRF Cavity Applications Using Aberration-Corrected STEM and Electron Energy Loss Spectroscopy – *T. Tao, R.F. Klie (UIC) L.D. Cooley, A. Romanenko (Fermilab)*

We present an atomic-resolution study of the effects that 48hr bake at 120 °C in vacuum has on the high-field properties of Nb-based SRF cavities. This bake results a significant increase in high-field Q, reversely, 800 °C bake for 2hr reduces the Hc3/Hc2-ratio. Several mechanisms have been proposed, including an increased NbOx surface layer thickness and the precipitation of NbHy. Using combination of atomic-resolution Z-contrast imaging and electron energy-loss spectroscopy with in-situ heating and cooling experiments, we examine the atomic and electronic structures of Nb and related oxides/hydrides near the cavity surface. We quantify the oxygen diffusion on surface during bake by measuring the local Nb valence using EELS. We demonstrate that hydrogen atoms incorporated into the Nb crystal, forming β -NbH precipitates, can be directly visualized by annular bright field imaging in our aberration-corrected JEOL ARM-200CF. The effects of baking on the local hydrogen and other impurity will be examined by imaging, EEL spectra and strain analysis. Our results will be combined with atom-probe tomography to develop a 3-D impurity and phase profile of Nb near the SRF cavity surface.

TUP043 Nanostructural TEM/STEM Studies of Hot and Cold Spots in SRF Cavities. – *Y. Trenikhina, J. Zasadzinski (IIT) A. Romanenko (Fermilab)*

Direct TEM/STEM imaging and spectroscopic chemical characterization by EELS/EDS of the surface of the SRF cavity cutouts before and after the treatments (e.g. in situ mild vacuum bake and rinsing with hydrofluoric acid) down to subnanometer scale is implemented to correspond the changes in niobium surface to the SRF performance of the cavities. We also report current results of the direct search, using cryogenic TEM stage, for suggested phase transformations in the niobium-hydrogen system* on "hot" and "cold" spot cavity cutouts, which may help clarifying the mechanism of the high field Q slope and its empirical cure.

TUP044 Surface Processing Facilities for Spoke Cavities at IHEP – *J.P. Dai, Q.Y. Wang (IHEP) P. Sha (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences)*

The China ADS injector I program is building a CW 10MeV Superconducting proton linac at IHEP. To develop the superconducting spoke-type cavities incorporated in this linac, a set of new surface processing facilities were built and successfully used to treat the Spoke012 prototype cavities. In this paper, we present the design, fabrication and operation of these facilities, including BCP, HPR and UPW, etc.

TUP045 An Investigation into the Role of Acid Velocity on Etching Uniformity in Niobium SRF Cavities – *K. Elliott (FRIB)*

Over the course of dozens of chemical etching procedures on several different niobium RF cavity designs, differences in etch rates and etching uniformity have been observed. This paper investigates the role that acid velocity across the internal surface of the cavity plays in the removal of material from the cavity, as well as the interaction between this flow and the resulting surface temperatures. These experiments may allow BCP etching systems in the SRF industry to be optimized to maximize cavity performance and minimize defects and waste. Results for both experimental samples and RF cavities are addressed.

TUP046 Vertical Electropolishing of SRF Cavities and its Parameter Investigation – *F. Eozénou, F. Ballester, Y. Boudigou, P. Carbonnier, J.-P. Charrier, Y. Gasser, D. Roudier, C. Servouin (CEA/DSM/IRFU) K. Muller (Grenoble-INP Phelma)*

An advanced set-up for vertical electropolishing (VEP) of SRF niobium elliptical cavities is operating at CEA Saclay*. Cavities are VEP'ed with circulating standard HF-H2SO4 electrolyte. Parameters such as voltage, cathode shape, acid flow and temperature were investigated. Low-voltage (<7V), high acid flow (25L/min) and low acid temperature (20°C) are considered as promising parameters. Such recipe was tested on single-cell and 9-cell ILC cavities with nice surface finishing. After 60 μ m VEP on a HEP'ed single-cell, the cavity show similar performance at 1.6K compared to previous Horizontal EP: (Eacc > 41MV/m) limited by quench. Another cavity reaches 36MV/m after 300 μ m removal by VEP in spite of a pitted surface due to initial VEP treatment at higher temperature (> 30°C). The baking effect after HEP/VEP is similar. An asymmetric niobium removal is observed with faster polishing in the upper cell. Nice surface finishing as well as standard Q0 value are obtained at low/medium field on 9Cell but achieved performance is limited by Field Emission.

TUP047 Niobium Cavity Electropolishing Modelling and Optimisation – *L.M.A. Ferreira, S. Calatroni, S. Forel (CERN) J.A. Shirra (Loughborough University)*

It's widely accepted that electropolishing is the most suitable surface finishing process to achieve high performance bulk Nb

accelerating cavities. At CERN, as part of the R&D studies for the 704 MHz high-beta SPL cavities, a new vertical electropolishing facility has been assembled and a study is on-going for the modelling of electropolishing on cavities with COMSOL software. In a first phase, the electrochemical parameters were taken into account for a fixed process temperature and flow rate, and are presented in this poster as well as the results obtained on a real SPL single cell cavity. The procedure to acquire the data used as input for the simulation is presented. The modelling procedure adopted to optimise the cathode geometry, aimed at a uniform current density distribution in the cavity cell for the minimum working potential and total current is explained. Some preliminary results on fluid dynamics and Joule effect are also briefly described.

- TUP048 Preparations and VT results of ERL7-cell** – *F. Furuta, B. Bullock, G. Eichhorn, B. Elmore, A. Ganshin, G.M. Ge, G.H. Hoffstaetter, J.J. Kaufman, M. Liepe, J. Sears, N.R.A. Valles (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*
 We have fabricated 7 ERL 7-cell cavities for Cornell ERL project. 4 nu-stiffened and 3-stiffened cavities have been fabricated in house so far. Specification values of our 7-cell is 16.2MV/m with Q_0 of $2.0 \cdot 10^{10}$ at 1.8K. In this report, we will describe our surface treatments recipe which is based on BCP and the results of vertical tests of these 7-cell cavities.
- TUP049 Cornell VEP Update, VT Results and R&D on Nb Coupon** – *F. Furuta, B. Elmore, A. Ganshin, G.M. Ge, G.H. Hoffstaetter, D.K. Krebs, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*
 Cornell's SRF group have been led development of Vertical Electro-Polishing(VEP) on SRF Nb Cavity. We have done many VEP on single-/multi-cell cavities. We also have started VEP'ed Nb coupon surface analysis based on surface roughness measurement. In this report, we will describe our status of VEP R&D, the results of VEP'ed cavity vertical testing, and fundamental study on VEP using Nb coupons.
- TUP050 R&D Program for 650 MHz Niobium Cavities for Project X** – *A. Grassellino, A.C. Crawford, C.M. Ginsburg, R.D. Kephart, T.N. Khlebnikov, O.S. Melnychuk, A. Romanenko, A.M. Rowe, D.A. Sergatskov, A.I. Sukhanov, V.P. Yakovlev (Fermilab)*
 We report the first test results of several 650 MHz single cell niobium cavities processed at Fermilab. The target for the 5-cell 650 MHz cavities for Project X is CW operation at magnetic peak field ~ 60 -70 mT, making high quality factors at medium accelerating fields the main goal of the surface processing R&D. We will discuss how the performance vary with the different surface processing and parameters/criteria of choice for the final surface preparation sequence.
- TUP051 Horizontal High Pressure Water Rinsing for Performance Recovery** – *Y. Morita, K. Akai, T. Furuya, A. Kabe, S. Mitsunobu, M. Nishiwaki (KEK)*
 Eight superconducting accelerating cavities were operated for more than ten years at the KEKB machine. Those cavities are also used at SuperKEKB. During the KEKB operation, Q values of some cavities were degraded. Cause of the degradation was contamination by air dusts at a repair of vacuum seals or a gasket replacement of input couplers. So far, those degradations are acceptable for the SuperKEKB operation, however, further degradation will make the operation unstable and, in the worst case, make it impossible. High pressure rinsing (HPR) is an effective method to clean the cavity surface. In order to apply HPR, however, the cavity has to be disassembled from a cryomodule. The disassembly takes time and costs. Furthermore, re-sealed vacuum flanges bring the risk of vacuum leakage again. Therefore we have developed a horizontal HPR. This method applies a high pressure water jet that is inserted horizontally into the cavity in the cryomodule. The wasted water is extracted with an aspirator. This method does not require the disassembly. We applied the horizontal HPR to our degraded cavity. Its RF performance has been successfully recovered.
- TUP052 Study on Vertical Electro-Polishing by Cathode With Variable-Geometry Wings** – *Y.I. Ida, K.N. Nii (MGH) H. Hayano, S. Kato, H. Monjushiro, T. Saeki, M. Sawabe (KEK) Y.B. Iwabuchi (MGI)*
 We have been studying on Vertical Electro-Polishing (VEP) of Nb superconducting accelerator cavity for about one year with a view to the mass-production and cost-reduction of Electro-Polishing (EP) process. Marui Galvanizing Co. Ltd. has been in the EP business of stainless-steel parts for long time and we have matured experience on EP processes. With being based on the experience, we thought that uniform electric-current on the surface of cavity and effective flow of electrolyte in the cavity are important factors. Moreover, we thought the most important effect is given if the cathode and the cavity surface (anode) are kept in a constant distance. Following these considerations, we invented VEP process by a cathode with variable-geometry wings. Using this cathode, we performed various tests of VEP with Stainless-Steel (SS) single-cell cavity, SS 3-cell cavity, SS 9-cell cavity and Nb single-cell cavity. In this article, we will report this unique VEP process, which might be applicable to the mass-production process of International Linear Collider (ILC).
- TUP053 Estimation of Small Geometry Deviation for TESLA-Shape Cavities due to Inner Surface Polishing** – *A.A. Sulimov, G. Kreps, J.K. Sekutowicz (DESY)*
 Two well know polishing methods are used for the inner surface cleaning of superconducting TESLA-shape cavities: electropolishing (EP) or buffered chemical polishing (BCP). The amount of removed material is relatively small and varies from 10 till 140 μm . The cavity after polishing is closed to prevent the scratches or dust appearing on its inner surface. The estimation of the removed material amount is possible by different criteria, for example by comparison of weight before and after cleaning, or by the time - cleaning procedure duration. Both calculations could give us only approximate average value of the removed material amount. We describe the method for estimation of small geometry deviation basing on RF frequency measurements, which allows calculating the different influence of surface treatment on the iris and equator areas.
- TUP054 Electropolishing of Niobium Materials in Low Viscosity Aqueous Electrolytes without Hydrofluoric Acid** – *E.J. Taylor, T.D. Hall, M.E. Inman (Faraday Technology, Inc.) A.M. Rowe (Fermilab)*
 Electropolishing of niobium materials and cavities is conventionally conducted in high viscosity electrolytes consisting of concentrated sulfuric and hydrofluoric acid. The use of these dangerous and ecologically damaging chemicals requires careful attention to safety protocol to avoid harmful worker exposure and environmental damage. In this poster we present an approach based on bipolar voltage fields enabling the use of low viscosity water based electrolytes without hydrofluoric acid for electropolishing of niobium materials. The subtleties of the bipolar electropolishing process vis-a-vis conventional electropolishing will be presented.
- TUP055 Electro Polishing Processing Effect on Deflecting Cavity for APS SPX Project** – *Y. Yang, J.P. Holzbauer, G. Wu (ANL) A.C. Crawford (Fermilab) Y. Yang*
 Electro Polishing (EP) is performed on one of the Mark II deflecting cavity prototype and it has successfully removed the high field Q drop. With fast temperature mapping technique, local RF resistance difference could be investigated and quench location could be evaluated precisely. The EP process, as well as the cavity test result before and after EP, is reported in detail in this paper.

- TUP056 Industrialization of XFEL Preparation Cycle “BCP Flash” at E.Zanon Company** – A. Matheisen, N. Krupka, M. Schalwat, A. Schmidt, W. Singer, N. Steinhilber, B. van der Horst (DESY) G. Corniani (Ettore Zanon S.p.A.) P. Michelato, L. Monaco (INFN/LASA)
In the Specification for XFEL Cavity preparation (R1) two different preparation sequences are presented. Ettore Zanon Company as one of the two companies contracted for XFEL cavity production and preparation has chosen the so called BCP flash cycle. To fulfill the requested work flow and quality of infrastructure and processes, the company set up a complete new infrastructure in refurbished fabrication halls. The layout of the facility, set up of work flow of preparation and test results of resonators processed by E.Zanon in their infrastructure will be reported.
- TUP057 Plasma Processing R&D for the SNS Superconducting Linac RF Cavities** – M. Doleans, W. Blokland, M.T. Croford, M.P. Howell, S.-H. Kim (ORNL) R. Afanador, J.A. Ball, S.W. Lee, C.J. McMahan (ORNL RAD)
The Spallation Neutron Source routinely operates with a proton beam power of 1 MW on its production target. A plan to reach the design 1.4 MW within a few years is in place* and relies on increasing the ion beam current, pulse length and beam energy in the linac. The increase in beam energy from the present 930 MeV to 1 GeV will require an increase of approximately 15% in the accelerating gradient of the superconducting linac high-beta cryomodules. In-situ plasma processing was identified as a promising technique** to reduce electron activity in the SNS superconducting cavities and increase their accelerating gradient. R&D on plasma processing aims at deploying the new in-situ technique in the linac tunnel by 2016. Overall plan and current status of the plasma processing R&D will be presented.
- TUP058 Recent Findings on Nitrogen Treated Niobium** – G. Eichhorn, A. Ganshin, A. Holmes, J.J. Kaufman, S.R. Markham, S. Posen, E.N. Smith (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)
Recent findings on Nitrogen treated Niobiums Based on recent findings at Fermilab, Cornell investigated the role of Nitrogen being present during the cavity hydrogen degassing process. We treated several samples at different temperatures being exposed to nitrogen between 10 minutes and 3 hours at pressures around 15 mbar as well as single cell cavities. This contribution will summarize our findings from surface analysis, Tc measurements and cavity Qs, addressing the question, if such a process can form Niobium-Nitride.
- TUP059 TM-Furnace Qualification** – F. Furuta, G. Eichhorn, A. Ganshin, G.M. Ge, G.H. Hoffstaetter, J.J. Kaufman, M. Liepe, J. Sears (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)
Cornell's SRF group had new vacuum furnace for hydrogen degassing of SRF Nb cavity. Systematic study and testing have been done to qualify this new furnace. We will report the results of those qualification tests include cavity bake and vertical testing.
- TUP060 Acid Free Centrifugal Barrel Polishing R&D** – C.A. Cooper, A.C. Crawford, C.M. Ginsburg, A. Grassellino, R.D. Kephart, O.S. Melnychuk, A. Romanenko, A.M. Rowe, D.A. Sergatskov (Fermilab)
We report the progress in the development of a centrifugal barrel polishing recipe which can lead to standard cavity performance without the need of any chemical treatments. $Q \sim 10^{10}$ at 20 MV/m and gradients above 35 MV/m have already been demonstrated for cavities whose preparation sequence was CBP, degassing and no subsequent chemical treatments. Results of studies on the effect of different CBP media on RF performance will be reported, including full body T-map showing the distribution of RF losses.
- TUP061 Update on Study of Welding Porosity in Nb EBW** – Y. Iwashita, H. Tongu (Kyoto ICR) H. Hayano (KEK)
Voids have been found in the Nb EBW seams. Since the buried defects cannot be observed by the optical inspections, other techniques have to be applied to study their characteristics such as distributions. X-ray or neutron radiography have been tried for the purpose. The recent results will be presented.
- TUP062 Application of In-Vacuum Infrared Pyrometry During Fabrication of European XFEL Niobium Cavities** – L. Monaco, P. Michelato, D. Sertore (INFN/LASA) V. Battista, G. Corniani, M. Festa (Ettore Zanon S.p.A.) C. Pagani (Università degli Studi di Milano & INFN)
A technique to measure the temperature of Niobium components in vacuum during Electron Beam Welding (EBW) operation is presented and results obtained on the large scale cavity production for the European XFEL are discussed. During the EBW process, the knowledge of the components temperature during the welding operation could help both for the better choice of the welding parameters and for the optimization of the production cycle. In collaboration with the Italian firm Ettore Zanon (EZ), we developed a system able to measure the temperature of Nb components in vacuum during EBW operation using a IR pyrometer placed outside the vacuum chamber through an appropriate vacuum viewport. In the paper the experience of this device during the production of Nb components for the XFEL 1.3 GHz cavity production is discussed.
- TUP063 Quench Studies and Preheating Analysis of Seamless Hydroformed Cavities Processed at Jefferson Laboratories.** – A.D. Palczewski, G.V. Ereemeev, R.L. Geng, P. Kneisel (JLAB) R. Crooks (Black Laboratories, L.L.C.) I. Jelezov (RAS/INR) W. Singer, X. Singer (DESY)
One of the alternative manufacturing technologies for SRF cavities is hydroforming from seamless tubes. Although this technology has produced cavities with gradient and Q-values comparable to standard EBW/EP cavities, a few questions remain. One of these questions is whether the quench mechanism in hydroformed cavities is the same as in standard electron beam welded cavities. Towards this effort Jefferson Lab performed quench studies on 4 different seamless hydroformed cavities. These cavities include DESY's – Z163 and Z164 nine-cell cavities, and Black Laboratories nine-cell and two-cell TESLA shaped cavities, hydroformed at DESY. Initial results from the cavities and quench localization were published in SRF2011*. In this report we will present post JLAB surface retreatment quench studies for each cavity. The data will include OST and T-mapping quench localization as well as quench location preheating analysis comparing them to the observations in standard electron beam welded cavities.
- TUP064 Exploration of Material Removal Rate of SRF Elliptical Cavities as a Function of Media Type and Cavity Shape on Niobium and Copper Using Centrifugal Barrel Polishing (CBP).** – A.D. Palczewski, G. Ciovati, R.L. Geng, Y.M. Li (JLAB)
Centrifugal barrel polishing (CBP) for SRF application is becoming more wide spread as the technique for cavity surface preparation. CBP is now being used in some form at SRF laboratories around the world. Before the process can become as mature as wet chemistry like eletro-polishing (EP) and buffered chemical polishing (BCP) there are many questions which remain unanswered. One of these topics includes the uniformity of removal as a function of cavity shape and material type. In this presentation we show CBP removal rates for various media types on 1.3 GHz TESLA and 1.5 GHz CEBAF large grain niobium

cavities, 1.3 GHz TESLA fine grain niobium cavity, and 1.3GHz low surface field copper cavity. The data will also include calculated RF frequency shift modeling non-uniform removal as a function of cavity position and comparing them with CBP results.

- TUP065 Chemical Structure of Niobium Samples Vacuum Treated in Nitrogen in Parallel With Very High Q0 Cavities.** – *Y. Trenikhina (IIT) A. Grassellino, A. Romanenko (Fermilab)*
XPS in combination with subsequent material removal via Ar sputtering as well as XRD are used for the surface analysis and bulk phase characterization of nitrogen treated samples processed parallel with SRF cavities. We investigated the surface chemistry of the samples treated with nitrogen in order to understand this treatment effect on SRF cavity performance for several baking temperatures and durations in order to find cost efficient post-furnace chemistry free procedures to enable high Q-values.
- TUP066 Plasma Processing of Large Surfaces with Application to SRF Cavity Modification** – *J. Upadhyay, S. Popović, L. Vušković (ODU) D.S. Im (Old Dominion University) H.L. Phillips, A-M. Valente-Feliciano (JLAB)*
Plasma based surface modifications of SRF cavities present promising alternatives to the wet etching technology currently applied. To understand and characterize the plasma properties and chemical kinetics of plasma etching processes inside a single cell cavity, we have built a specially-designed cylindrical cavity with 8 observation ports. These ports can be used for holding niobium samples and diagnostic purposes simultaneously. Two frequencies (13.56 MHz and 2.45 GHz) of power source are used for different pressure, power and gas compositions. The plasma parameters were evaluated by a Langmuir probe and by an optical emission spectroscopy technique based on the relative intensity of two Ar 5p-4s lines at 419.8 and 420.07 nm. Argon 5p-4s transition is chosen to determine electron temperature in order to optimize parameters for plasma processing. Chemical kinetics of the process was observed using real-time mass spectroscopy. The effect of these parameters on niobium surface would be measured, presented at this conference, and used as guidelines for optimal design of SRF etching process.
- TUP067 Hydrogen Saturation and the Thermal Conductivity of Superconducting Niobium** – *S.K. Chandrasekaran (MSU) T.R. Bieler (Michigan State University) C. Compton (FRIB) N.T. Wright (MSU)*
The thermal conductivity k of Nb at less than 3 K is dominated by phonon transport. In Nb with sufficiently few lattice imperfections, a maximum in k occurs at 1.8 K, called the phonon peak (PP). A large PP is desired to reduce potential local hot spots and contributes to an increased Q factor. The magnitude of the PP is sensitive to SRF cavity manufacturing processes. The effect of interstitial hydrogen on the magnitude of the PP is examined by subjecting two bicrystal Nb specimens to 300 C for 1 h in a 75% H₂, 25% N₂ atmosphere at 0.5 atm. Prior to hydrogen infusion, specimen 1 was heated to 800 C for 2 h, while specimen 2 was heated to 1100 C for 4 h. Both specimens displayed a 25% reduction in the PP due to the additional hydrogen, independent of their crystal orientations and heat treatment histories. An 800 C vacuum heating for 2 h was found to be sufficient to recover the PP in specimen 1, while an 1100 C heating for 4 h was required to recover the PP in one of the grains of specimen 2. The results suggest that hydrogen trapped in the Nb lattice will degas when the Nb is heated to at least the temperature to which it was heated at prior to the hydrogen infusion step.
- TUP068 Laser Polishing of Niobium for SRF Applications** – *L. Zhao, M.J. Kelley (The College of William and Mary) J.M. Klopff, C.E. Reece (JLAB) L. Zhao*
Smooth interior surfaces are desired for niobium SRF cavities, now obtained by buffered chemical polish (BCP) and/or electropolish (EP). Laser polishing is a potential alternative, having advantages of speed, freedom from chemistry and in-process inspection. Here we show that laser polishing can produce smooth topography with Power Spectral Density (PSD) measurements similar to that obtained by EP. We studied the influence of the laser power density and laser beam raster rate on the surface topography. These two factors need to be combined carefully to smooth the surface without damaging it. Computational modeling was used to simulate the surface temperature and explain the mechanism of laser polishing.
- TUP069 The Copper Substrate Developments for the HIE-ISOLDE High-Beta Quarter Wave Resonator** – *L. Alberty, G. Arnau Izquierdo, I. Aviles Santillana, S. Calatroni, O. Capatina, A. D'Elia, G. Foffano, Y. Kadi, P. Moyret, K.M. Schirm, T. Tardy, W. Venturini Delsolaro (CERN)*
A new linac using superconducting quarter-wave resonators (QWR) is under construction at CERN in the framework of the HIE-ISOLDE project. The QWRs are made by Niobium sputtered on a bulk Copper substrate. The working frequency at 4.5 K is 101.28 MHz and they will provide 6 MV/m accelerating gradient on the beam axis with a total maximum power dissipation of 10 W. The properties of the cavity substrate have a direct impact on the final cavity performance. The Copper substrate has to ensure an optimum surface for the Niobium sputtered layer. It has also to fulfill the required geometrical tolerances, the mechanical stability during operation and the thermal performance to optimally extract the RF dissipated power on cavity walls. The paper presents the mechanical design of the high β cavities. The procurement process of the Copper raw material is detailed, including specifications and tests. The manufacture sequence of the complete cavity is then explained and the structural and thermo-mechanical behavior during the tests performed on a prototype cavity is discussed. The industrialization strategy is presented in view of final production of the cavities.
- TUP070 Characterization of Superconducting Samples With SIC System for Thin Film Developments: Status and Recent Results.** – *G.V. Ereemeev, H.L. Phillips, A-M. Valente-Feliciano (JLAB) C.E. Reece (JLab) B. P. Xiao (BNL)*
Within any thin film development program directed towards SRF accelerating structures, there is a need for an RF characterization device that can provide information about RF properties of small samples. The current installation of the RF characterization device at Jefferson Lab is Surface Impedance Characterization (SIC) system. The data acquisition environment for the system has recently been improved to allow for automated quicker measurement, and the system has been routinely used for characterization of bulk Nb, films of Nb on Cu, MgB₂, NbTiN, Nb₃Sn films, etc. We present some of the recent results that illustrate present capabilities and limitations of the system.
- TUP071 Development of Nb₃Sn Cavity Vapor Diffusion Deposition System** – *G.V. Ereemeev, W.A. Clemens, K. Macha, H. Park, R.S. Williams (JLAB)*
Alternative BCS superconductors with the superconducting critical temperature higher than that of niobium theoretically surpass the limitations of niobium. The feasibility of technology has been demonstrated at 1.5 GHz with Nb₃Sn vapor deposition technique at Wuppertal University. The benefit at these frequencies is more pronounced at 4.2 K, where Nb₃Sn coated cavities show RF resistances an order of magnitude lower than that of niobium. At Jefferson Lab we started the development of Nb₃Sn vapor diffusion deposition system within an R&D development program towards compact light sources. Here we present the current progress of the system development.

- TUP072 Quality Factor Measurements of the Ultramet 3 GHz Cavity Constructed Using Chemical Vapour Deposition** – *D.L. Hall, D. Gonnella, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*
 A 3 GHz niobium cavity constructed by Ultramet using chemical vapour deposition (CVD) techniques has been tested on the vertical SRF test stand at Cornell. The cavity received a 25 micrometre buffered chemical polish (BCP) and 700 C heat treatment for 4 days. First test results gave an intrinsic quality factor of $Q_0 = (1.55 + 0.12) \cdot 10^7$ and $(2.00 + 0.15) \cdot 10^7$ at 4.25 K and 1.51 K, respectively. A second BCP removed 100 micrometres of material, after which test results improved to $Q_0 = (7.40 + 0.56) \cdot 10^7$ and $(4.50 + 0.34) \cdot 10^8$ at 4.25 K and 1.51 K. During the first test poor coupling to the input amplifier impeded tests at accelerating fields > 1 MV/m, whilst during the second test the cavity quenched at 1.3 MV/m. Optical inspection of the cavity after the second test revealed the presence of at least 4 pits that may have contributed to the low field quench. The BCS fits are presented and the feasibility of CVD as a construction method for SRF cavities is discussed.
- TUP073 Niobium Coatings for the HIE-ISOLDE QWR Superconducting Accelerating Cavities** – *N.M. Jecklin, S. Calatroni, I. Mondino, A. Sublet, M. Therasse, W. Venturini Delsolaro (CERN) B. Delaup (EPFL)*
 The HIE-ISOLDE project is the upgrade of the existing ISOLDE facility at CERN, which is dedicated to the production of a large variety of radioactive ion beams for nuclear physics experiments. A new linac made of 20 $\beta=10.3\%$ and 12 $\beta=6.3\%$ QWR superconducting accelerating cavities at 10^1 MHz will be built, and in a first phase two cryomodules of 5 high-beta cavities each are scheduled to accelerate first beams in 2015. The cavities are made of a copper substrate, with a sputter-coated superconductive niobium layer, operated at 4.5 K with an accelerating field of 6 MV/m at 10W RF losses ($Q_0=4.5e8$) In this paper we will discuss the baseline surface treatment and coating procedure which allows obtaining the required performance, as well as the steps undertaken in order to prepare series production of the required number of cavities guaranteeing their quality and functionality.
- TUP074 Development of an Optimized Quadrupole Resonator at HZB** – *R. Kleindienst, J. Knobloch, O. Kugeler (HZB)*
 Current superconducting cavities are generally made of solid niobium. A possibility to reduce cost as well as increase accelerating fields and, essential for CW applications, the quality factor is to use thin-film coated cavities. Measuring and understanding the RF-properties of superconducting thin films, specifically the surface resistance at the operating field and frequency, is needed to drive forward this development. Presently, only few facilities exist capable of measuring the surface resistance of thin films samples with a resolution in the nano-ohm range at L-Band. We describe here a dedicated test stand consisting of a quadrupole resonator that was constructed at the Helmholtz Zentrum Berlin. Starting with 400-MHz quadrupole resonator developed at CERN, the design was adapted and optimized for resolution and reduced peak electric field to 433 MHz (making available the higher harmonic mode at 1,3GHz) using simulation data obtained with CST Microwave Studio as well as ANSYS. The relevant figures of merit have been improved, giving the possibility to perform measurements with high resolution at high field levels.
- TUP075 Design and Commissioning Status of New Cylindrical HiPIMS Nb Coating System for SRF Cavities** – *H.L. Phillips, K. Macha (JLAB)*
 For the past 19 years Jefferson Lab has sustained a program studying niobium films deposited on small samples in order to develop an understanding of the correlation between deposition parameters, film micro-structure, and RF performance. A new cavity deposition system employing a cylindrical cathode using the HiPIMS technique has been developed to apply this work to cylindrical cavities. The status of this system will be presented.
- TUP076 Preliminary Results of Nb Thin Film Coating for HIE-ISOLDE SRF Cavities Obtained by Magnetron Sputtering** – *A. Sublet, I. Aviles Santillana, S. Calatroni, A. D'Elia, N.M. Jecklin, I. Mondino, S. Prunet, M. Therasse, W. Venturini Delsolaro, P. Zhang (CERN)*
 In the context of the HIE-ISOLDE upgrade at CERN, several new facilities for the niobium sputter coating of QWR-type superconducting RF accelerating cavities have been developed, built, and successfully operated. In order to further optimize the production process of these cavities the magnetron sputtering technique has been further investigated and continued as an alternative to the already successfully operational DC bias diode sputtering method. The purpose of this poster is to present the results obtained with this technique. The Nb thickness profile along the cavity and its correlation with the electro-magnetic field distribution inside the cavity are discussed. Film structure, morphology and Residual Resistivity Ratio (RRR) will be considered as well and compared with films obtained by DC bias diode sputtering. Finally these results will be compared with RF characterization and measurement of a production-like magnetron-coated cavity.
- TUP077 Thin Film Coating Optimization for HIE-ISOLDE SRF Cavities: Coating Parameters Study and Film Characterization** – *A. Sublet, I. Aviles Santillana, S. Calatroni, P. Costa Pinto, N.M. Jecklin, S. Prunet, W. Vollenberg (CERN)*
 The HIE-ISOLDE project at CERN requires the production of 32 cavities in order to increase the energy of the beam. The Quarter Wave Resonators (QWRs) cavities of complex cylindrical geometry (0.3m diameter and 0.8m height) are made of copper and are coated with a thin superconducting layer of niobium. In the present phase of the project the aim is to obtain a niobium film, using the DC bias diode sputtering technique, providing adequate high quality factor of the cavities and to ensure reproducibility for the future series production. After an overview of the explored coating parameters (hardware and process), the resulting film characteristics, thickness profile along the cavity, structure and morphology (SEM measurements) and Residual Resistivity Ratio (RRR) of the Nb film will be shown. The effect of the sputtering gas process pressure and configuration of the coating setup will be highlighted.
- TUP078 Nb Coating Developments with HIPIMS for SRF Applications** – *G. Terenziani, S. Calatroni, T. Junginger (CERN) A.P. Ehasarian (SHU)*
 In the last few years the interest of the thin film science and technology community on High Impulse Power Magnetron Sputtering (HIPIMS) coatings has steadily increased. HIPIMS literature shows that better thin film morphology, denser and smoother films can be achieved when compared with standard dc Magnetron Sputtering (dcMS) coating technology. Furthermore the capability of HIPIMS to produce a high quantity of ionized species can allow conformal coatings also for complex geometries. A study is under way at CERN to apply this technology for the Nb coating of SRF 1.3-1.5 GHz Cu cavities, and in parallel at SHU the plasma physics and its correlation with film morphology are being investigated. Recent results achieved with this technique are presented in the paper.
- TUP079 ECR Nb Films Grown on Amorphous and Crystalline Cu Substrates: Influence of Ion Energy** – *A-M. Valente-Feliciano, G.V. Ereameev, H.L. Phillips, C.E. Reece (JLAB) J.K. Spradlin (JLab)*
 In the pursuit of niobium (Nb) films with similar performance with the commonly used bulk Nb surfaces for Superconducting RF (SRF) applications, significant progress has been made with the development of energetic condensation deposition techniques. Using energetic condensation of ions extracted from plasma generated by Electron Cyclotron Resonance, it has been

demonstrated that Nb films with good structural properties and RRR comparable to bulk values can be produced on metallic substrates. The controlled incoming ion energy enables a number of processes such as desorption of adsorbed species, enhanced mobility of surface atoms and sub-implantation of impinging ions, thus producing improved film structures at lower process temperatures. Particular attention is given to the nucleation conditions to create a favorable template for growing the final surface exposed to SRF fields. The influence of the deposition energy for both hetero-epitaxial and fiber growth modes on copper substrates is investigated with the characterization of the film surface, structure, superconducting properties and RF performance.

TUP080 ECR Nb Films on Insulating Substrates: Influence of Ion Energy and Interface on Film Structure – *A.M. Valente-Feliciano, G.V. Eremeev, H.L. Phillips, C.E. Reece, X. Zhao (JLAB) J.K. Spradlin (JLab)*

In the development of “bulk-like” Nb films grown by ECR, an energetic condensation technique using Nb ions in vacuum, Nb films are grown on insulating crystalline and amorphous substrates. Although insulating substrates may not be practical as such, they offer valuable insight on the growth modes of Nb thin films on “ideal surfaces” with minimum lattice mismatch and very low roughness (crystalline substrates such as Al₂O₃ (11-20) or on amorphous substrates with increased roughness and no long-range order (Al₂O₃ ceramic or fused silica). Such studies open the door to subsequent opportunities to tailor the film nucleation by engineering its interface with a practical substrate. The influence of the deposition energy on the material and RF properties of the films is investigated with the characterization of their surface, structure, and superconducting properties. Nucleation studies are investigating the best conditions to create a favorable template for growing the final SRF surface. This paper shows how the deposition energy and the film-substrate interface affect the material, superconducting and RF properties of the Nb films.

TUP081 Chemical Vapor Deposition Techniques for the Multilayer Coating of Superconducting RF Cavities. – *F Weiss, C. Jimenez, S. Pignard (Institut Polytechnique de Grenoble, Grenoble INP) C.Z. Antoine (CEA/IRFU) M. Benz, E. Blanquet, R. Boichot, A. Mantoux, F. Mercier (Laboratoire SIMAP, Grenoble-INP, CNRS, UJF)*

Issued from the recent development of thin films technologies, multilayer nanostructures face today very challenging questions in materials science: ultimate size reduction, process control at an atomic scale, new size driven properties and system characterisation. For superconducting RF technologies a significant breakthrough could arise from the use of multilayered structures deposited inside Nb cavities. These multilayer nanostructures are based on the use of some 10 nanometers thick superconducting layers ($d < \lambda_L$) with a higher T_c than in Nb, alternating with insulating layers, required to decouple the superconducting films. We present here our first studies devoted to nano-layered superconductors produced by Chemical Deposition techniques: CVD and ALD. The basic principles of CVD and ALD will be presented together with new developments of the coordination chemistry for the ALD precursors, which is key point for the optimization of the individual layers. First results concerning NbN films obtained by CVD as well as CVD and ALD results concerning insulating materials used for Superconducting/insulating (S/I/S/I) multilayers structures will be reported.

TUP082 Materials Analysis of CED Nb Films Being Coated on Bulk Nb SRF Single Cell Cavities – *X. Zhao, C.E. Reece (JLAB) G. Ciovati (Jefferson Lab) C. James, M. Krishnan (AASC) A.D. Palczewski (JLAB)*

This study is a on-going research on depositing a Nb film on the internal wall of bulk Nb cavities, via a cathodic arc Nb plasma ions source (CED). The motivation is to firstly create a homoepitaxy-like Nb/Nb film in a scale of a 1.5GHz single cell cavity. Next, through SRF measurement and materials analysis, it might reveal the baseline properties of CED-type homoepitaxy Nb films. Such knowledge is useful for future realistic SRF cavity film coatings, such as heteroepitaxy Nb/Cu Films, or template-layer-mitigated Nb films. Literally, being finished by crystal thickening, the Nb's top-surface layer which sustains SRF function, grows up homoepitaxially. One large-grain, and one fine grain bulk Nb cavity were coated. They went through cryogenic RF measurement. Preliminary results show that the Q of a Nb film could be as same as the pre-coated bulk Nb surface (being CBP'ed plus a light EP); But their quality factor all dropped quickly. We are investigating if the severe Q-slope is caused by H incorporation before deposition, or is determined by structural defects during Nb film growth.

TUP083 Film Depositing, Cryogenic RF Testing and Materials Analysis of a Nb/Cu Single Cell SRF Cavity – *X. Zhao (JLab) R.L. Geng, Y.M. Li, A.D. Palczewski (JLAB)*

In this study, we will present preliminary results on using a cathodic-arc-discharge Nb plasma ion source (CED) to establish a Nb film coated Cu single cell cavity for SRF research. The polycrystalline Cu cavity was created and mirror-surface-finished by a novel CBP process at Jefferson Lab. Special pre-coating processes were conducted in hope to create a Template-Layer for follow-on Nb grain thickening. A sequence of cryogenic RF testing demonstrated that the Nb film does show superconductivity. But the quality factor of this Nb/Cu cavity is severely degraded at higher RF field. We are conducting a thorough materials characterization to explore if some microstructural properties or hydrogen impurities, led to such a SRF quality factor degradation.

TUP084 Reciprocal Space XRD Mapping with Varied Incident Angle as a Probe of Structure Variation within Surface Depth – *X. Zhao (JLab) M. Krishnan (AASC) F. Williams, Q.G. Yang (NSU)*

In this study, we used a differential-depth X-Ray diffraction Reciprocal Spacing Mapping (XRD RSM) technique to investigate the crystal quality of a variety of SRF-relevant Nb film and bulk materials. By choosing different X-ray probing depths, the RSM study successfully revealed the materials' microstructure evolutions after different materials processes, such as energetic condensation or surface polishing. The RSM data clearly measured the materials' crystal quality at different thickness. Through a novel differential-depth RSM technique, this study found: I. for a heteroepitaxy Nb film Nb(100)/MgO(100), the film thickening process, via a cathodic arc-discharge Nb ion deposition, created a near-perfect single crystal Nb on the surface's top-layer; II. for a mechanic polished single-crystal bulk Nb material, the microstructure on the top surface layer is more disordered than that in-grain.

TUP085 Study of NbTi Welded Parts – *N. Bazin, C.Z. Antoine (CEA/DSM/IRFU) C. B. Baumier, G. Martinet (IPN) F.F. Fortuna (CSNSM) J.-B. Sirven (Commisariat à l'Energie Atomique (CEA/DEN/DPC), Direction de l'Energie Nucléaire)*

Due to its properties, niobium-titanium alloy is widely used to manufacture the flanges of superconducting niobium accelerating cavities. The material hardness is compliant to provide UHV-tight connections with aluminum gaskets or spring-type gaskets (Helicoflex). And the alloy can be directly welded to the niobium. The paper will present the surface analysis made on NbTi samples after the chemical treatment and on a Nb / NbTi weld.

TUP086 Cryogen-Free RF System Studies Using Cryocooler-Cooled MgB₂-Coated Copper RF Cavities – *A. Nassiri, R. Kustom, Th. Proslie (ANL) X. Xi (TU)*

Studies on the application of magnesium diboride (MgB₂) high-T_c superconducting films have shown promise for use with rf cavities. Studies are directed towards applying the films to niobium cavities with the goal to increase accelerating gradients to

greater than 50 MeV/m. However, studies also have shown that MgB2 films, with a critical temperature over four times higher than Nb, have surface resistances equal, or nearly equal, at 8-12 K, to what is achieved with niobium at 4 K. It might be possible to design and operate cavity systems in the 8-12K temperature range with cryocoolers that are currently available. The current cryocoolers can remove as much as 20 watts per unit in the range of 8-12K. This suggests that helium-free superconducting RF systems are possible for future light sources and possible industrial and medical linear accelerators. Our current research is directed towards depositing MgB2 films onto copper, or other high thermal conductivity metal, substrates which would allow future cavities to be fabricated as film coated copper structures. We have started atomic layer deposition and Hybrid chemical vapor deposition studies of MgB2 on 2-inch copper coupons.

TUP087 RF Test Results of the first Nb3Sn Cavities Coated at Cornell – *S. Posen, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*

As an alternative material to niobium for SRF cavities in particle accelerators, Nb3Sn presents two significant advantages. With a Tc of 18 K, it has a very small surface resistance at a given temperature, leading to a significant reduction in cryogenic costs; and with a predicted Hsh of nearly 400 mT, it has the potential to produce cavities with higher gradients and therefore shorter high energy linacs. Recently, two 1.3 GHz cavities have been fabricated and coated with Nb3Sn at Cornell. Tests of these first cavities have produced encouraging results, including a very high Tc and some very high-performing surface regions. These cavity results as well as new results of samples studied using TEM will be presented.

TUP088 NbTiN Based SIS Multilayer Structures for SRF Applications – *A.M. Valente-Feliciano, G.V. Ereemeev, H.L. Phillips, C.E. Reece (JLAB) D. Beringer, R.A. Lukaszew, W.M. Roach (The College of William and Mary) J.K. Spradlin (JLab)*

For the past three decades, bulk niobium has been the material of choice for SRF cavities applications. RF cavity performance is now approaching the theoretical limit for bulk niobium. For further improvement of RF cavity performance for future accelerator projects, Superconductor-Insulator-Superconductor (SIS) multilayer structures (as recently proposed by Alex Gurevich) present the theoretical prospect to reach RF performance beyond bulk Nb, using thinly layered higher-Tc superconductors with enhanced Hc1. Jefferson Lab (JLab) is pursuing this approach with the development of NbTiN and AlN based multilayer SIS structures via magnetron sputtering and High Power Impulse Magnetron Sputtering (HiPIMS). This paper presents the results on the characteristics of NbTiN and insulator films and the first RF measurements on NbTiN-based multilayer structure on thick Nb films.

TUP089 MgB2 Thin Films for SRF Cavity Applications – *X. Xi (TU)*

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 ($<0.1 \mu\Omega\text{cm}$) 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 field. 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 below the penetration depth. I will present results of research in two directions: enhancement of Hc1 in thin MgB2 films and multilayers, and the coating of RF cavities by MgB2. By reducing the thickness of the MgB2 film from 300 nm to 100 nm, Hc1(0) increases systematically from 38 mT to about 200 mT. Both the in-situ and two-step processes have been used for the coating of a 6 GHz cavity. Samples from various locations of the cavity show good superconducting properties. The RF characterization of the MgB2-coated cavities will be presented.

TUP090 Thermal Simulations for the Multi-Layer Coating Model – *F. Meng (IHEP) A. Romanenko (Fermilab) Y. Xie (Euclid TechLabs, LLC)*

Thermal simulations for the multi-layer coating model has been developed based on previous work of a finite difference thermal feedback code.* RF field-attenuation formula for the multi-layer coating model has also been included.** The temperature distribution along different superconducting layers under applied magnetic fields has been calculated with various superconducting material parameters.

TUP091 Field Emission Measure During cERL Main Linac Cryomodule High Power Test in KEK – *E. Cenni (Sokendai)*

A compact Energy Recovery Linac (cERL) is under construction in KEK in order to proof the performance of the key components required for the future ERL project in KEK. The main linac L-band cavities were assembled and tested in the cryomodule under high power operation, during the test information concerning field emission were gathered by means of PIN diodes rings and NaI scintillator located at the cavities ends. The data were analyzed by means of simulations, taking into account the cavities operating conditions and interaction between the accelerated electrons and the cavity surface. The resulting information are used to deduce a possible emitter location, determining if there is any change in the cavities performance with respect to the last vertical test they undertook. With PIN diode is possible to observe the radiation pattern produced by field emission, inferring the meridian where the emitter belongs. On the other hand the bremsstrahlung spectra recorded with the scintillator allow an estimation of the cavity cell where the emitter is located.

TUP092 MUSICC3D: a Code for Modeling the Multipacting – *T. Hamelin, M. Chabot, J.-L. Coacolo, J. Lesrel, G. Martinet (IPN)*

IPNO has conducted an effort to develop a 3D code for modeling multipacting in RF structures. The MUSICC3D program is using particle in cell method. Based on Runge Kutta method and using relativistic equation of motion, it solves the trajectory of a particle (e-) in the RF field. The integrations over the multi differential Secondary Emission Yield (SEY) (E_{1n} , Alpha_{1n} , E_{0ut} , Alpha_{0ut}) is made with Montecarlo method. Two running modes are available. The first one is using a model of virtual particle (i.e. the charge of a unique particle "rebounding" in the interior of the cavity is made by the product of SEYs occurring at each interaction with the walls). The other one makes generation of a full cascade of individual electrons. Benchmarking calculations have been done with analytical calculations and 2D particle in cell code (MULTIPAC). In all these cases the effects of the different inputs for the multi differential SEY have been investigated. Its intend is to give a guide to determine which precision on the SEY is needed to perform accurate multipacting calculations. Benchmarking with real cavity has been recently started and results with QWR Spiral2 cavities are presented.

TUP093 Field Emitter Current Conditioning on Nb Single Crystals with Different Roughness due to Varying EP/BCP Ratio – *S. Lagotzky, G. Müller (Bergische Universität Wuppertal) P. Kneisel (JLAB)*

Enhanced field emission (EFE) from particulate contaminations and surface irregularities is one of the main field limitations of the superconducting Nb cavities required for XFEL and ILC. While the number density of particulate emitters can be reduced by dry ice cleaning (DIC) and clean room assembly, the optimum choice of crystallinity and polishing are still under discussion [1]. For the future ILC cavities, large or even single crystal Nb with a combination of BCP and EP is considered. Therefore, we have systematically investigated the EFE of single crystal Nb samples which got the same total polishing depth 136-138 μm

but a different EP/BCP ratio (5.80, 2.40, 0.73, 0.15) and DIC by means of correlated optical/AFM profilometry, field emission scanning microscopy (FESM) and high-resolution SEM. Depending on the surface roughness ($R_a < 200$ nm), field enhancement factors b of 12 – 42 and emitting areas S up to $0.1 \mu\text{m}^2$ were obtained. High current conditioning (μA - mA) of these emitters usually resulted in a slight reduction of b (factor < 2) but a strong increase of S . The influence of the surface roughness on the EFE and conditioning of the remaining emitters will be discussed.

- TUP094 Influence of Heat Treatments on Field Emitters on Nb Crystals** – *S. Lagotzky, G. Müller (Bergische Universität Wuppertal) A. Matheisen, D. Reschke (DESY)*
 Systematic investigations of the enhanced field emission (EFE) of HPR-cleaned large grain (LG) and single crystal (SC) Nb samples ($R_a < 0.5 \mu\text{m}$) revealed an exponential increase of the emitter number density N with electric surface field E_s and strong activation effects of the remaining particulates. Different types of EFE activation were observed: by high E partially combined with a micro-discharge or by heat treatments (HT) [1]. In cavities, EFE activation might also occur due to enhanced rf losses of particulates. Therefore, we have started a test series with two LG and two SC typically prepared Nb samples (40 μm BCP, 140 μm EP and HPR at DESY). At first all emitters (1 nA) up to $E_s = 160$ MV/m were localized by means of correlated field emission microscopy (FESM). Then systematically varied in-situ HT between 122°C (24 h) and 400°C (2 h) were applied to investigate the activation of emitters due to the change of the natural Nb oxide. For all samples a significant increase of N with stronger HT up to 32 emitters/cm² at 400°C were obtained resulting in some activated emitters already at $E_s = 40$ MV/m. Final SEM images of the activated emitters will also be discussed.
- TUP095 Field Emission and Consequences as Observed and Simulated for CEBAF Upgrade Cryomodules** – *F. Marhauser, R.P. Johnson, R. Rodriguez (Muons. Inc.) P. Degtiarenko, A. Hutton, G. Kharashvili, C.E. Reece, R.A. Rimmer (JLAB)*
 High gamma and neutron radiation levels were monitored at the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Laboratory (JLab) after installation of new cavity cryomodules and initial test runs in the frame of the ongoing 12 GeV upgrade program. The dose rates scaled exponentially with cavity accelerating fields implying field emission (FE) as the source of origin. This has led to concerns regarding high field operation in the future 12 GeV era. Utilizing supercomputing novel FE studies have been performed with electrons tracked through a complete cryomodule, which allows understanding experimental observations and mitigating FE as best as practicable by identification of problematic cavities.
- TUP096 High Power Processing at a High Order Mode Frequency** – *V. Volkov (BINP SB RAS) J. Knobloch, A.N. Matveenko, A. Neumann (HZB)*
 Regular High Power Processing (HPP) at fundamental frequency in a superconducting cavity usually carried out to increase maximal RF field in the cavity that is limited by Field Emission (FE). HPP at a High Order Mode (HOM) frequency allow increasing FE threshold of fundamental RF field as square root of the HOM frequency. In the paper we give proof of this prediction and give as example concrete proposals of such HPP design for Rossendorf 3.5-cell RF gun structure. Expected RF over field is about 100% (from 17 up to 34 MV/m) as compared with the regular HPP.
- TUP097 Kapitza Resistance at the Interface Between Niobium and Superfluid Helium and How to Reduce It** – *A. Gan-shin, G.H. Hoffstaetter, K.M. Price, E.N. Smith (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*
 One of the most important properties of Superconducting Radio Frequency (SRF) cavities is their ability to disperse generated heat from the internal cavity wall to the external super fluid helium bath. When the generated heat is not removed fast enough, an effect known as thermal feedback dominates, resulting in medium field Q-slope. This medium field Q-slope has the ability to reduce the Q factor should it become strong enough. To determine what physical factors affect the creation of the medium field Q-slope we will be computationally modeling the medium field Q-slope with varying parameters, such as Kapitza conductivity, wall thickness, RF frequency, bath temperature, residual resistivity ratio, residual resistance, and phonon mean path. Our results show that the medium-field Q slope is highly dependent on the Kapitza conductivity and that by doubling the Kapitza conductivity the medium field Q-slope reduces significantly. Understanding and controlling the medium field Q-slope will benefit future continuous wave (CW) applications such as the Energy Recovery Linacs (ERL) where cryogenics costs dominate due to CW operation at medium fields (< 20 MV/m).
- TUP098 Medium Field Q-Slope of Niobium** – *T. Junginger, W. Weingarten (CERN) C.P. Welsch (The University of Liverpool)*
 The power dissipated in a superconducting cavity is proportional to its surface resistance R_s , which shows a complex behavior on the external parameters: RF frequency, temperature, magnetic and electric field. Here it will be shown that R_s of a well prepared bulk niobium surface factorizes in a field and temperature dependent part. This factorization rules out several theoretical medium field Q-slope models at least for the particular sample investigated here.
- TUP099 Medium Field Q-Slope Studies in $\beta=0.2$ Single Spoke Resonators** – *O.S. Melnychuk, A. Grassellino, A.I. Sukhanov (Fermilab)*
 Studies of the phenomenon of Medium field Q-slope (MFQS, 30-80 mT) have been focused predominantly on high beta superconducting cavities. Complementing research on cavity losses with the analysis of low beta cavity data can provide additional insights into the nature of MFQS. We present MFQS measurements of 325MHz $\beta=0.2$ single spoke resonators at vertical test facility at FNAL. We compare our findings with those obtained for high frequency 1.3GHz cavities tested both at the same facility and other laboratories.
- TUP100 Medium Field Q-Slope Studies in High Frequency Cavities** – *O.S. Melnychuk, A. Grassellino, A.I. Sukhanov (Fermilab)*
 A phenomenon of Medium Field Q-Slope (MFQS) in superconducting RF cavities is of high importance because it occurs in the field range (5-20MV/m) that includes designed operation fields of future CW accelerators. MFQS impacts resistive losses in the cavity and, consequently, directly affects accelerator operation costs. We present studies of MFQS based on vertical test data for 1.3GHz nine-cell cavities and make comparisons of vertical test data from different laboratories.
- TUP101 New Temperature Mapping Findings for the Medium Field Q-Slope** – *A. Romanenko, A. Grassellino, R.V. Pilipenko (Fermilab)*
 A problem of the medium field Q slope in cavities treated by standard surface processing techniques recently gained a lot of attention due to its importance for CW accelerators. Here we present high resolution thermometry studies of the losses in the medium field range (20-80 mT), and discuss its possible connection to the observations at high fields (>80 mT).
- TUP102 Quench Detection Diagnostics on 3.9 GHz XFEL Cavities** – *M. Bertucci, A. Bosotti, L. Garolfi, P. Michelato, L. Monaco, D. Sertore (INFN/LASA) C. Pagani (Università degli Studi di Milano & INFN)*
 This paper presents results of quench localization on 3.9 GHz XFEL prototype cavities tested at LASA vertical test facility. Cavities have been equipped with OST second sound detectors and thermometry sensors. A first guess for quench position has

been obtained from modal analysis. Second sound sensors confirmed the quench position resolving also the symmetry degeneracy given by the RF mode pattern analysis. In a subsequent vertical test, second sound and temperature sensors have been installed nearby the suspect quench position. From Thermometry mapping, a sudden increase in cavity temperature within a small region is evident, therefore confirming that a local thermal breakdown due to defect heating occurs in the predicted quench point. The quench region deduced with the mentioned techniques is eventually compared with results of optical inspection.

TUP103 Calibration and Characterization of Capacitive OST Quench Detectors in SRF Cavities at IPN Orsay – M. Fouaidy, F. Dubois, D. Longuevergne, G. Michel, J.-F. Yaniche (IPN)

The maximum RF surface magnetic field (B_s) achieved with SRF bulk Nb cavities is often limited by anomalous losses due to Joule heating of normal-resistive defects embedded onto the RF surface. At high B_s (e.g. $B_s > 50$ mT), the defect temperature increases strongly with B_s , leading to a thermal runaway of the cavity or quench. The unloaded quality factor Q_0 of the cavity decreases suddenly and strongly due to superconducting to normal state phase transition of the hot spot area. Quench detectors, called Oscillating Superleak Transducer (OST) and sensing 2nd sound events in He II, have been recently used to study quench of SRF cavities. IPN developed his prototypes of OST quench detectors and a test stand for their calibration and characterization in the temperature range $T_0 = 1.6$ K–2.2 K. This device allows precise and controlled experimental simulation of SRF cavity quench using pulsed heat sources. Experimental runs were performed to study the dynamic response of OST detectors when the heat source is subjected to a time varying heat flux $q(t)$ as function of several parameters (T_0 , $q(t)$ time structure and density, heat source size) and first experimental data are presented.

TUP104 Temperature Waves in SRF Research – A. Ganshin, D.L. Hartill, G.H. Hoffstaetter, E.N. Smith, N.R.A. Valles (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) X. Mi (Cornell University)

Previously Cornell University developed Oscillating Superleak Transducers (OST) to locate quench spots on superconducting cavities in superfluid helium. This work builds upon this research and presents a technique to automatically visualize quench locations from OST data (1). This system is now fully automated. The current system consists of between 8 and 16 OSTs, a high gain low noise preamplifier, and a data acquisition card that can log up to 16 simultaneously recorded inputs. The developed software allows computing quench locations on various cavity geometries, adjustment of the location of each OST and a choice between several quench finding algorithms. Observed results are in excellent agreement with optical inspection and temperature map data.

TUP105 Investigation of the Surface Resistivity of SRF Cavities via the Multi-Cell Temperature Mapping System at Cornell – G.M. Ge, G.H. Hoffstaetter (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)

A high-sensitive temperature mapping system for multi-cell SRF cavities has been constructed at Cornell University. The resolution of the system is 1mK. Hence it's able to detect small temperature increases when cavities reach at low accelerating gradients e.g. 3MV/m. The surface resistivity of superconductor under radio-frequency electromagnetic field can be calculated from the temperature increases. In this contribution, the surface resistance map of multi-cell SRF cavities is shown. The temperature mapping result is possible to establish a relationship between the surface resistivity and the magnetic field as well. Unlike the RF method which is average value of the surface resistance, the T-map results give local surface resistivity versus magnetic field. BCS theory assumes the surface resistivity is independent to the magnetic field. The T-map results, however, suggest that the surface resistance at high-loss region is field dependent and caused Q-slope.

TUP106 Second-Sound Quench Measurements on a 3 GHz SRF Cavity at Very Low Acceleration Fields* – S.T. Sievers, U. Bonnes, C. Burandt, F. Hug, T. Kürzeder, N. Pietralla, A. Richter (TU Darmstadt)

The superconducting Darmstadt electron linear accelerator S-DALINAC uses 20-cell niobium cavities that are operated at a microwave frequency of 3 GHz in liquid helium at a temperature of 2 K. This operation temperature is well below $T_C = 9.25$ K of niobium and guarantees superconducting condition in routine operation. Occasional surface impurities, in particular after venting the beamline following maintenance work, can lead to local quenches which destroy superconductivity of the cavity. In such events it is desirable to have a method for locating and eliminating these surface impurities. In order to locate quench sites in the superconducting cavities during operation in liquid helium a set-up of oscillating superleak transducers (OSTs) was tested in a vertical bath cryostat on a cavity known to quench at very small accelerating fields. Despite the low rf power of approximately 4 W needed to quench the cavity, we were able to identify the quench sites with the OST set-up. Subsequent optical inspection clearly showed surface damages at the determined positions. We will report on our set-up and the procedure.

TUP107 Second Sound Heat Flux Measurements for Quench Localisation Improvements at CERN – K.C. Liao, T. Junginger, T. Koettig (CERN)

Second sound, a temperature wave exhibiting in superfluids has been used for cavity quench localisation. At CERN, second sound characteristics have been studied successfully to help understand the underlying physics in second sound diagnostics. Major accelerator laboratories have observed quench signals traveled at ~ 30 m/s which affect accuracy in determining quench locations using second sound. Newly designed experiments have been conducted to simulate cavity quench phenomenon and cavity quench data have been analysed to account for the contradictory quench results.

TUP108 Study on Carbonaceous Contamination at Niobium Surface with Field Emission Scanner – S. Kato, H. Hayano, T. Kubo, T. Noguchi, T. Saeki, M. Sawabe (KEK)

It is mandatory to investigate field emission from niobium SRF cavity surface systematically since even small field emission often limits the cavity performance terribly. The field emission strength and the number of emission sites strongly depend on niobium surface properties which are determined by its surface treatment and handling. It was found that carbonaceous contamination including carbon, oxygen, sometimes, nitrogen often segregates at CPed or EPed surface with a size of several micron to several tens of micron-meters. There is a strong doubt that this contamination causes field emission from the surface. Newly developed field emission scanner (FES) allows us to measure a distribution of the field emitting sites over a sample surface at a given field strength along with its SEM (scanning electron microscope) observation and EDX (energy dispersive x-ray) analysis. This article describes results of the FES-SEM-EDX application to carbonaceous contamination at niobium surface.

TUP109 Towards a Better Understanding and Optimization of the Quench Localization Systems at DESY – R. Laasch (University of Hamburg) E. Elsen, A. Navitski (DESY) B. Foster, Y. Tamashevich (Uni HH) F. Schlander (IKP)

Precise localization and understanding of local thermal breakdowns or “quenches” in superconducting RF cavities is still a challenge. The 2nd sound technique offers a convenient method to locate quenches in superconducting RF cavities during

the cold RF tests. Typical resolutions of ~ 1 cm and better have been already obtained. Despite of the sensor dimensions and positions, the resolution is currently limited by missing details of the heat propagation in niobium and liquid helium. With the upgrade to a more redundant system at DESY such effects will be studied. Test results and correlations between different sensor configurations and a comparison to the results of a temperature mapping (T-map)- and optical inspection (OBACHT) system on European XFEL and ILC HiGrade cavities will be shown.

- TUP110 **An X-Ray Fluorescence Probe for Defect Detection in Superconducting 1.3 GHz RF Cavities** – *P. Michelato, M. Bertucci (INFN/LASA) A. Navitski, W. Singer, X. Singer (DESY) C. Pagani (Università degli Studi di Milano & INFN) Y. Tamashevich (Uni HH)*

The aim of this project is to develop a system for defect detection by means of X-ray fluorescence (XRF) analysis. XRF is a high sensitivity spectroscopy technique allowing the detection of trace element content, such as the few microgram impurities, responsible for low cavity performances if embedded in the equatorial region during cavity manufacturing. The proposed setup is customized on 1.3 GHz TESLA-type niobium cavities: both the detector and the X-ray excitation source are miniaturized so to allow the probe to enter within the 70 mm iris diameter and aside of the HOM couplers. The detection-excitation geometry is focused on cavity cell equator surface located at about 10^3 mm from the cavity axis, with an intrinsic spot-size of about 10 mm. The measuring head will be settled on a high angular resolution optical inspection system at DESY, exploiting the experience of OBACHT. Defect position is obtained by means of angular inner cavity surface scanning. A quantitative determination of defect content can also be carried out by means of fundamental parameters technique with a Niobium standard calibration.

- TUP111 **Experimental Investigations of the Quench Phenomena for the Quench Localization by the Second Sound Wave Method** – *J. Plouin, B. Baudouy, C. Magne (CEA/DSM/IRFU)*

The quench localization by the second sound method is now widely used in many laboratories. This method avoids the complicated implementation of temperature arrays around the surface cavities. Instead, specific sensors are placed around the cavity and the time of arrival of the second sound wave generated by the quench is measured on each sensor; then the distance from sensors to quench is deduced from the theoretical second sound wave velocity. In principle, the quench position can be localized with a triangulation by a limited number of sensors. However, many measurements have shown that the time of arrival of the wave was not corresponding to the theoretical second sound wave velocity: the “measured” velocity is often 50% higher than the theory. At CEA-Saclay we performed several measurements on single cell cavities to investigate these phenomena. Several hypotheses are studied: large quench spot, heat propagation by another phenomenon than the second sound near to the cavity where the heat power density is very high. These results and the discussions on these hypotheses will be presented.

- TUP112 **Time-Resolved Measurements of High-Field Quench in SRF Cavities** – *S.P. Antipov (University of Chicago) A. Romanenko, D.A. Sergatskov (Fermilab)*

Fermilab's temperature mapping system for SRF cavities has been improved to observe quench dynamics with 1ms time resolution. The increase in sampling rate was achieved by localizing the quench and then performing the measurements using a limited subset of thermometers. Implemented experimental procedure allowed to measure temperature distribution within quench spot, as well as the amount of stored energy, at the moment quench starts, during its growth, and decay. For three tested SRF cavities, quenching at fields 21.7 – 33 MeV/m, maximal radius of the normal zone was 40 – 65 mm; time to return to superconducting state: 90 – 250 ms. In the beginning of the process temperature increase rate in the center of the normal zone is as high as 2.5 K/ms, radius increase rate – 20 mm/ms. The described experimental procedure can be useful for investigating how different surface treatments affect the breakdown, understanding of the nature of high-field quench, improvement of quench detection techniques, and material science research for future SRF cavities.

- TUP113 **Octopus Temperature Mapping System Prototype for the 704 MHz SPL Cavities at CERN** – *K.C. Liao, S.F. Rey, M. Therasse (CERN)*

The octopus temperature mapping system designed for the 704 MHz superconducting proton linac (SPL) cavity at CERN features a flexible system body which is adaptable and reusable on both beta 0.6 and beta 1 cavities. An improved thermometer sensor package design improves automated integration with the octopus polyimide printed circuit board body and helium insulation is presented. The first prototype has been manufactured and tests have been undergoing for further development.

- TUP114 **XT-map System for SC Cavity Quench Localization** – *H. Tongu, Y. Iwashita (Kyoto ICR) H. Hayano, Y. Yamamoto (KEK)*

XT-map system under development in collaboration between Kyoto University and KEK is a combined system of the temperature mapping (T-map) and X-ray mapping (X-map). High resolution T-map at quench detection will give more information for improving yield in production of high performance SC Cavities. The high-density sensor distribution of the XT-map gives the high resolution. Because the huge amount of sensor lines are multiplexed at a hi-speed scanning rate in the vicinity of the sensors, the small number of signal lines makes the installation process easy and reduces the system complexity. The scanning test of this XT-map system has been performed in the vertical test at KEK. The detected quench events will be reported.

- TUP115 **Quench Detecting Using Fast Temperature Mapping System for SPX Crab Cavity** – *Y. Yang (TUB) J.P. Holzbauer, J.A. Kaluzny, A. Nassiri, G. Wu, Y. Yang J.D. Mammosser, H. Wang (JLAB)*

A fast temperature mapping system has been developed in ANL to detect the surface heating and quench location of the deflecting cavity. The time resolution could be up to 50us and normally it works with a resolution of 3ms with a balance of speed and accuracy. With this time resolved system, both the temperature and the thermal dynamics could be recorded. A number of cavity tests have been made and the location of multipacting as well as quench could be easily detected by investigating the thermal dynamics of different sensors. This would guide us the way to further improve the cavity performance.

- TUP116 **Quench field and Location in Vertical Tests at KEK-STF** – *Y. Yamamoto, E. Kako, T. Shishido (KEK)*

Many vertical tests have been done for the ILC and ERL at KEK-STF since 2008. T-mapping system (fixed type) was equipped at every vertical test, and quench location was identified completely. Every quench location at quench field will be presented in this paper.

- TUP117 **Second Sound Diagnostic System at TRIUMF** – *Z.Y. Yao, P. Kolb, R.E. Laxdal, W.R. Rawnsley, V. Zvyagintsev (TRIUMF) S.H. Abidi (University of Toronto)*

Second sound waves in superfluid helium are currently a widely used method of detecting quench locations in SRF cavities. A configuration based on 16 oscillating superleak transducer (OST) sensors has been designed by ray tracing method to optimize diagnosis of quench location for 9-cell 1.3GHz elliptical cavities. The mechanical supporting, electronics, and data acquisition and analysis system were also developed. By analyzing the results from a recently tested prototype system using a

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single cell cavity, signal to noise analysis, electronics improvement, and thermal-magnetic quench simulation are underway. This paper will report the recent progress of a second sound diagnostic system at TRIUMF.

24-Sep-13	18:00 – 19:00	Oral	Room Adenauer
TUHT — Hot Topic: Origin of dissipations (ITE, vortices, magnetic impurities...)			

25-Sep-13	08:00 – 09:35	Oral	Room Adenauer
WEIOA — Basic R&D New materials - Thin film deposition techniques			

WEIOA01 08:00 HiPIMS: a New Generation of Film Deposition Techniques for SRF Applications – A.M. Valente-Feliciano (JLAB)
 Over the years, Nb/Cu technology, despite its shortcomings due to the commonly used magnetron sputtering, has positioned itself as an alternative route for the future of accelerator superconducting structures. Avenues for the production of thin films tailored for Superconducting RF (SRF) applications are showing promise with recent developments in ionized PVD coating techniques, i.e. vacuum deposition techniques using energetic ions. Among these techniques, High power impulse magnetron sputtering (HiPIMS) is a promising emerging technique which combines magnetron sputtering with a pulsed power approach. This contribution describes the benefits of energetic condensation for SRF films and the characteristics of the HiPIMS technology. It describes the on-going efforts pursued in different institutions to exploit the potential of this technology to produce bulk-like Nb films and go beyond Nb performance with the development of film systems, based on other superconducting materials and multilayer structures.

WEIOA02 08:25 Thin Film Growth by Energetic Condensation – M. Krishnan, D. Hannum, I. Irfan (AASC)
 Energetic Condensation refers to thinfilm growth on a surface using ~100eV ions, versus lower energy deposition using sputtering (~1-10eV with no substrate bias) or still lower energy thermal evaporation. The relatively high incident energy of energetic condensation creates defects and vacancies within the first few atomic layers and enables diffusion to lower free-energy sites in the lattice. Shallow defects migrate to the heated surface and are annihilated, leading to low-defect crystal growth. It has been shown [1] that the purer the film, the closer are its superconducting parameters to those of the bulk metal. Use of cathodic arc plasmas was proposed in 2000 by Langner [TESLA Rep. 2000-15, Ed. D. Proch, DESY 2000], followed by detailed development of the process [2]. AASC picked up from the European Community-Research Infrastructure Activity and has demonstrated very high RRR=541 in Nb films grown on crystal substrates [3]. Ongoing work to coat 1.3GHz copper cavities using cathodic arc plasmas, as well as growth of higher temperature films such as NbTiN, Nb3Sn and MgB2 are described. A related technique for energetic condensation using an ECR plasma source is also described.

WEIOA03 08:55 Nb Sputtered Quarter Wave Resonators for the HIE-ISOLDE – W. Venturini Delsolaro, S. Calatroni, A. D'Elia, B. Delaup, N.M. Jecklin, Y. Kadi, I. Mondino, A. Sublet, M. Therasse (CERN) D.A. Franco Lespinasse, G. Keppel, V. Palmieri, S. Stark (INFN/LNL)
 The HIE-ISOLDE superconducting linac will be based on quarter wave resonators (QWRs), made by Niobium sputtering on Copper. The operating frequency at 4.5 K is 101.28 MHz and the required performance for the high beta cavity is 6 MV/m accelerating field for 10 W maximum power dissipation. These challenging specifications were recently met at CERN at the end of a vigorous development program. The paper reports on the progress of the cavity RF performance with the evolution of the sputtering process; it equally illustrates the parallel R&D which is ongoing at CERN and at INFN in the quest for even higher performances.

WEIOA04 09:15 Nb3Sn for SRF Application – M. Liepe, S. Posen (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)
 The superconductor Nb3Sn is a promising alternative to standard niobium for SRF applications for two reasons: Its larger superconducting energy gap results in significantly lower BCS surface resistance at typical SRF operating temperatures. Additionally, theoretical predictions suggest that the maximum operating field of Nb3Sn cavities could be twice that of niobium cavities. Early work on a small number of Nb3Sn coated cavities indeed showed 2K to 4.2K quality factors well above what is achievable with niobium, though at accelerating fields below ~10 MV/m only. After many years of worldwide inactivity, Cornell has taken the lead and initiated a new R&D program on Nb3Sn to explore its full potential for SRF applications. New facilities for coating cavities with Nb3Sn have been set up at Cornell, and 1.3 GHz single cell cavities have been coated and tested. This talk presents the Cornell Nb3Sn program, discusses first promising results obtained, and also gives an overview of other Nb3Sn SRF work worldwide.

25-Sep-13	09:35 – 10:15	Oral	Room Adenauer
WEIOB — Basic R&D New materials - Multilayers, MgB2 - I			

WEIOB01 09:35 Status of MgB2 Coating Studies for SRF Applications – T. Tajima (LANL)
 MgB2 has shown promising results on small samples and its coating development is entering into the stage to coat large samples and elliptical cavities. Several coating techniques that seem to be appropriate for cavity coating and their status will be shown together with some cavity measurement results with either 6 GHz or 1.3 GHz single-cell cavities. Other data such as RF surface resistance at low temperatures and vortex penetration fields with small samples will also be shown.

WEIOB02 09:55 Proof of Concept Thin Films and Multilayers Toward Enhanced Field Gradients in SRF Cavities – R.A. Lukaszew, D. Beringer, W.M. Roach (The College of William and Mary) G.V. Eremeev, A.M. Valente-Feliciano (JLAB) C.E. Reece (JLab)
 Due to the very shallow penetration depth of the RF fields, SRF properties are inherently a surface phenomenon involving a material thickness of less than 1 micron thus opening up the possibility of using thin film coatings to achieve a desired performance. The challenge has been to understand the dependence of the SRF properties on the detailed characteristics of real surfaces and then to employ appropriate techniques to tailor these surface properties for greatest benefit. Our aim is to achieve gradients >100 MV/m and no simple material is known to be capable of sustaining this performance. A theoretical framework has been proposed which could yield such behavior [1] and it requires creation of thin film layered structures. I will present our systematic studies on such proof-of-principle samples. Our overarching goal has been to build a basic understanding of key nano-scale film growth parameters for materials that show promise for SRF cavity multilayer coatings and to demonstrate the ability to elevate the barrier for vortex entry in such layered structures above the bulk value of Hc1 for type-II superconductors and thus to sustain higher accelerating fields.

25-Sep-13	10:45 – 12:05	Oral	Room Adenauer
WEIOC — Basic R&D New materials - Multilayers, MgB2 - II			

WEIOC01 10:45 High Resolution Surface Resistance Studies – S. Aull, S. Döbert, T. Junginger (CERN) S. Aull, J. Knobloch (University of Siegen)
 The attempt to reach quality factors beyond 10¹¹ and pushing the accelerating gradients of SRF cavities to the theoretical

limit, the treatment depending loss mechanisms in niobium need better understanding. CERNs Quadrupole Resonator enables sub-nΩ-resolution measurements of the surface resistance. The available parameters cover resonant modes at 400, 800 and 1200 MHz, any temperature up to 15 K and rf fields up to 60 mT. Recently the setup has been extended with a coil creating a dc magnetic field for trapped flux studies. Overall, much more information about the rf performance is accessible compared to regular cavity measurements. Since the samples are flat disks of 75 mm diameter geometric fabrication issues are simplified which makes the Quadrupole Resonator also the perfect tool to study alternative materials or new coating techniques. In this contribution in depth studies of a heat treated bulk niobium sample exploiting the complete parameter range of the setup are presented.

WEIO02 11:05 Activities on SRF Multilayers at Orsay / Saclay – C. B. Baumier, G. Martinet (IPN) C.Z. Antoine (CEA/IRFU) F. F. Fortuna (CSNSM) J.C. Villegier (CEA/INAC)

In the investigations on the high gradient SRF cavities, the superconducting multilayer is a promising alternative. The predictions show that an SIS (Superconductor/Isolator/Superconductor) nano-composite could improve the efficiency limited by the bulk Nb it-self used today for accelerating cavities. We start, at the IPNO lab in collaboration with the CSNSM lab (CNRS) and Irfu lab (CEA), an experimental study to test the screening effect on multilayer assemblies. Based on 3rd harmonic magnetometer and a TE011 SRF cavity, measurements of first critical magnetic field HC1 and surface resistance of samples have been performed. Along with these first results, we are starting the development of a MBE deposition. This set-up is devoted to optimise the best organisation of the multilayer to produce the model sample, and to find, in a close future, a realistic solution to apply this technique on an accelerating SRF cavity.

WEIO03 11:25 Atomic Layer Deposition of Thin Superconducting Films and Multilayers: Coupons and Cavity Tests – Th. Proslie, N. Groll, J. Klug, M.J. Pellin (ANL) G. Ciovati, P. Kneisel, A-M. Valente-Feliciano (JLAB) A. Grassellino, A. Romanenko (Fermilab) J. Zasadzinski (IIT)

I will present a summary of the work done over the last 2 years that encompasses both coupons study of thin superconducting films and multilayers and preliminary superconducting RF cavity tests coated by ALD. I will also present results of Nb onto Copper.

WEIO04 11:45 Theoretical Field Limits for Multi-Layer Superconductors – S. Posen, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) G. Catelani (Forschungszentrum Jülich, Peter Gruber Institut (PGI-2)) J.P. Sethna (Cornell University) M.K. Transtrum (M.D.A.C.C.)

With modern cavity preparation techniques, niobium SRF cavities reach surface magnetic fields very close to the fundamental limit of the superheating field of the material, and researchers are looking to alternative superconductors to sustain even higher fields. However, these materials may have an increased vulnerability to flux penetration at defects, even small ones, as a result of their short coherence lengths. A. Gurevich has proposed [1] a method of mitigating this vulnerability: coating a bulk superconducting cavity with a series of very thin insulating and superconducting films. In this work, we present a thorough mathematical description of the SIS thin films proposed by Gurevich in the language of the SRF community, to help researchers to optimize cavities made from alternative superconductors.

25-Sep-13	12:05 – 12:55	Oral	Room Adenauer
WEIOD — Technical R&D - Focus on Magnetic Shielding			

WEIOD01 12:05 Review of Magnetic Shielding Design of Low-Beta Cryomodule – R.E. Laxdal (TRIUMF)

It is well known that superconducting cavities can trap magnetic flux while cooling through transition. The trapped flux adds to the residual rf surface resistance. For this reason magnetic shielding is added to the cryomodules to shield the cavities from the environmental magnetic field. The low beta portion of many superconducting hadron linear accelerators, either in operation or in production, includes cryomodules containing one or more high field superconducting solenoids. The operation of a high field solenoid in close proximity to a cavity adds a level of complexity to the cryomodule design considerations. The paper will summarize the various techniques that can be employed to reduce the risk of magnetic pollution from internal solenoids.

WEIOD02 12:35 Magnetic Shielding: Review of Material Properties for Adequate Choice – M. Masuzawa, A. Terashima, K. Tsuchiya (KEK) A. Daël, O. Napolý, J. Plouin (CEA/DSM/IRFU)

Magnetic shielding is a key technology for superconducting RF cavities. The tolerance of the ambient magnetic field depends on factors such as the operating RF frequency and acceleration gradient, but it can be as small as a few mG. Some high-Ni-content alloys, such as Cryperm 10 or Cryophy, which are claimed to maintain high permeability at cryogenic temperatures where superconducting cavities are operated, are commercially available at present and are used for magnetic shielding of superconducting cavities at many laboratories. Permeability measurements were made in order to understand the characteristics of such materials at both room and cryogenic temperatures, and the results will be used as a database for designing magnetic shields. It was found that the catalog performance of such materials was not always reproduced in the measurements. Some degradation was observed which depended on how the material was handled. The results of investigation into possible causes for the performance degradation of the shielding material at cryogenic temperature will be presented, along with permeability measurement results for various materials at different temperatures.

26-Sep-13	08:00 – 09:35	Oral	Room Adenauer
THIOA — Technical R&D - Mass production			

- THIOA01 08:00 Infrastructure, Methods and Test Results for the Testing of 800 Cavities – D. Reschke (DESY)**
 The main linac of the European XFEL will consist of 100 accelerator modules, i.e. 800 superconducting accelerator cavities operated at a design gradient of 23.6 MV/m. The fabrication and surface preparation of the cavities in industry is in full swing. This talk describes the infrastructure and procedures of the vertical acceptance test in the "Accelerator Module Test Facility AMTF" at DESY. The present status of the test results is given.
- THIOA02 08:20 The Challenge to Assemble 100 Cryomodules for the European XFEL – C. Madec (CEA) S. Berry, J.-P. Charrier, M. Fontaine, O. Napoly, C.S. Simon, B. Visentin (CEA/DSM/IRFU) C. Cloué, T. Trublet (CEA/IRFU)**
 As In-Kind contributor to the E-XFEL project, CEA is committed to the integration on the Saclay site of the 100 cryomodules (CM) of the superconducting linac as well as to the procurement of miscellaneous parts including 31 cold beam position monitors (BPM) of the re-entrant type. The assembly infrastructure has been renovated from the previous Saturne Synchrotron Laboratory facility: it includes a 200 m² clean room complex with 112 m² under ISO4, 1325 m² of assembly platforms and 400 m² of storage area. In parallel, CEA has conducted industrial studies and three cryomodule assembly prototyping both aiming at preparing the industrial file, the quality management system and the commissioning of the assembly plant, tooling and control equipment. In 2012, the contract of the integration has been awarded to ALSYOM. The first pre-series modules have been assembled and are being tested at DESY. This paper will present the challenges of the module integration from the preparation phase to the industrial phase.
- THIOA03 08:40 Cavity Fabrication Study in CFF at KEK – M. Yamanaka (KEK)**
 We constructed a new facility for the fabrication of superconducting RF cavity at KEK from 2009 to 2011. In the facility, we have installed a deep-drawing machine, a half-cell trimming machine, an Electron-Beam Welding (EBW) machine, and a chemical etching room in one place. We started the study on the fabrication of 9-cell cavity for International Linear Collier (ILC) from 2009 using this facility. The study is focusing on the cost reduction with keeping high performance of cavity, and the goal is the establishment of mass-production procedure for ILC. This article reports the current status of the studies in this facility.
- THIOA04 09:00 Low-Beta Cryomodule Design Optimized for Large-Scale Linac Installations – S.J. Miller, B. Bird, N.K. Bultman, F. Casagrande, A.D. Fox, M.J. Johnson, M. Leitner, T. Nellis, J.P. Ozolis, X. Rao, R.J. Rose, M. Shupkar, K. Witgen, Y. Xu (FRIB)**
 This paper will present most recent design developments at FRIB to optimize low-beta cryomodules for large-scale linac installations. FRIB, which requires the installation of 53 cryomodules, has to emphasize ease of assembly and alignment plus low cost. This paper will present experimental results of a novel kinematic rail support system which significantly eases cryomodule assembly. Design choices for mass-production are presented. Results of vibration calculations and measurements on a FRIB prototype cryomodule will be reported.
- THIOA05 09:20 Program for Optimization of SRF Linac Construction and Operation Costs – T. Powers (JLAB)**
 This work describes preliminary results of a new software tool that allows one to vary parameters and understand the effects on the optimized costs of construction plus 10 year operations of an SRF linac, the associated cryogenic facility, and controls, where operations includes the cost of the electrical utilities but not the labor or other costs. It derives from collaborative work done with staff from Accelerator Science and Technology Centre, Daresbury, UK several years ago while they were in the process of developing a conceptual design for the New Light Source project. The initial goal was to convert a spread sheet format to a graphical interface to allow the ability to sweep different parameter sets. The tools also allow one to compare the cost of the different facets of the machine design and operations so as to better understand the tradeoffs. More recent additions to the software include the ability to save and restore input parameters as well as to adjust the Q_o versus E parameters in order to explore the potential costs savings associated with doing so.

26-Sep-13	09:35 – 10:15	Oral	Room Adenauer
THIOB — Technical R&D - Overall performances I			

- THIOB01 09:35 CEBAF Upgrade: Cryomodule Performance and Lessons Learned – M.A. Drury, J. Hogan, C. Hovater, L.K. King, H. Park, J.P. Preble, R.A. Rimmer, H. Wang, M. Wiseman (JLAB) G.K. Davis, C.E. Reece (JLab) F. Marhauser (Muons. Inc.)**
 The Thomas Jefferson National Accelerator Facility is currently engaged in the 12 GeV Upgrade Project. The goal of the 12 GeV Upgrade is a doubling of the available beam energy of the Continuous Electron Beam Accelerator Facility (CEBAF) from 6 GeV to 12 GeV. The increase in beam energy will largely be due to the addition of ten C100 cryomodules and the associated RF in the CEBAF linacs. These cryomodules are designed to deliver 100 MeV per cryomodule. Each C100 cryomodule contains a string of eight seven-cell, electro-polished, superconducting RF cavities. While an average performance of 100 MV is needed to achieve the overall 12 GeV beam energy goal, the actual performance goal for the cryomodules is an average energy gain of 108 MV to provide operational headroom. All ten of the C100 cryomodules are installed in the linac tunnels and are on schedule to be commissioned by September 2013. Commissioned performance has ranged from 104 MV to 118 MV. In May, 2012, a test of an early C100 achieved 108 MV with full beam loading. This paper will discuss the performance of the C100 cryomodules along with operational challenges and lessons learned for future designs.
- THIOB02 09:55 High Q Cavities for the Cornell ERL Main Linac – G. Eichhorn, B. Clasby, B. Elmore, F. Furuta, G.H. Hoffstaetter, M. Liepe, J. Sears (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)**
 While SRF research for linear colliders was focused on achieving high gradients, Cornell's proposal for an energy recovery linac (ERL) demanded for low cw losses. Starting several years ago, a high-Q R&D phase was launched that led to remarkable results recently: A fully dressed cavity (7 cells, 1.3 GHz) with side-mounted input coupler and beamline HOM absorbers achieved a Q of 3.5·10¹⁰ ((16 MV/m, 1.8 K). This talk will review the staged approach we have chosen in testing a single cavity in a horizontal short cryomodule (HTC), report results on each step and conclude on our findings about preserving high Q from vertical testing. We also discuss the production of six additional cavities as we progress toward constructing a full 6-cavity cryomodule as a prototype for Cornell's main linac module

26-Sep-13	10:45 – 11:45	Oral	Room Adenauer
THIOC — Technical R&D - Overall performances II			

TH1OC01 Low Beta Cavity Development for an ATLAS Intensity Upgrade – M.P. Kelly (ANL)

10:45 The set of seven new 72 MHz quarter wave SC (QWR) cavities has been completed and is being installed in the ATLAS heavy-ion accelerator at Argonne. The aim is to provide at least 17.5 MV accelerating potential with large acceptance and minimal beam losses for high intensity ion beams. The cavity electromagnetic design uses optimizations not used before with QWR including a large taper on both the inner and outer conductors in order to reduce surface fields and make efficient use of space along the beam line. Electropolishing (EP) on the finished cavities with integral helium jacket and no demountable RF joints has been performed, and is the first for any low beta SC cavity. This type of EP, adapted from Argonne systems for the linear collider effort, appears to have a large benefit in terms of the average quench field which range between 10^3 -165 mT for five QWR tested to date. Cavity residual resistances at the proposed operating point of ~70 mT are low, clustering close to a value of ~2nOhm. Additional technical details including the almost exclusive use of wire EDM for niobium fabrication and a new CW 4 kW RF power coupler are presented.

TH1OC02 High Power CW Tests of cERL Main-Linac Cryomodule – H. Sakai, K. Enami, T. Furuya, M. Sato, K. Shinoe, K. Umemori (KEK) E. Cenni (Sokendai) M. Sawamura (JAEA)

11:00 A main linac cryomodule have been constructed for Compact ERL project. It contains two 9-cell cavities, mounted with HOM absorbers and input couplers. After cavity string assembly, they were installed into the vacuum vessel of the cryomodule. It was placed inside radiation shield of cERL and connected to a refrigerator system. The cryomodule was successfully cooled down to 2K and low power and high power measurements were carried out.

TH1OC03 Superconducting Photonic Band Gap Structures for High-Current Applications – E.I. Simakov, S. Arsenyev, W.B. Haynes, S.S. Kurennoy, D. C. Lizon, J.E O'Hara, E.R. Olivas, D.Y. Shchegolkov, T. Tajima (LANL) C.H. Boulware, T.L. Grimm (Niowave, Inc.)

11:15 We present the results of recent design and testing of several 2.1 GHz superconducting rf (SRF) photonic band gap (PBG) resonators. PBG cells have great potential for outcoupling long-range wakefields in SRF accelerator structures without affecting the fundamental accelerating mode. Using PBG structures in superconducting particle accelerators will allow operation at higher frequencies and moving forward to significantly higher beam luminosities thus leading towards a completely new generation of colliders for high energy physics. Here we report the results of our efforts to fabricate 2.1 GHz PBG cells with round and elliptical rods and to test them with high power at liquid helium temperatures. Two PBG cells with round rods were tested in spring of 2012 and achieved accelerating gradients of 15 MV/m at 2 Kelvin. Two PBG cells with elliptical rods will be tested in summer of 2013.

TH1OC04 Demonstration of RF Stability in STF 9-cell Cavities Aiming for the Near Quench Limit Operation – M. Omet (Sokendai)

11:30 In preparation of ILC an operation of two superconducting cavities controlled by digital LLRF techniques at different gradients (16 MV/m, 24 MV/m) with flat flattops and a 6.4 mA beam was demonstrated, which is only possible by PkQL control (individual setting of driving power and loaded Q per cavity). The vector sum stabilities were $\Delta A/A = 0.009\%$ rms and $\Delta\phi = 0.009^\circ$ rms. Since in ILC the cavity gradient spread is large (31.5 MV/m \pm 20%) the required range of loaded Q values is $3 \cdot 10^6$ to 10^7 . High loaded Q operation with a 6.1 mA beam at $2 \cdot 10^7$ was demonstrated. The stabilities were $\Delta A/A = 0.008\%$ rms and $\Delta\phi = 0.014^\circ$ rms. Furthermore a near klystron operation within 5% of saturation was performed with a 6.2 mA beam. The stabilities were $\Delta A/A = 0.010\%$ rms and $\Delta\phi = 0.009^\circ$ rms.

26-Sep-13	11:45 – 13:00	Oral	Room Adenauer
THIOD — Technical R&D - Low Beta Cavities Development Issues			

TH1OD01 SRF cavities for ADS project in China – Y. He, S. He, S.C. Huang, Y.L. Huang, T.C. Jiang, R.X. Wang, M.X. Xu, Y.Z. Yang, W.M. Yue, C. Zhang, S.H. Zhang, S.X. Zhang (IMP) J.P. Dai, H. Li, Z.Q. Li, H.Y. Lin, Z.C. Liu, W.M. Pan, P. Sha, G.W. Wang, X.Y. Zhang (IHEP) X.Y. Lu (PKU)

11:45 The driver linac for ADS project in China is full superconducting downstream of Radio Frequency Quadrupole Accelerator. It is a key technology R&D stage of the project from 2011 to 2015. Superconducting HWR, Spoke, and elliptical cavities are all involved in the project. The prototypes of 162.5 MHz HWR010, 325 MHz Spoke012, 325 MHz Spoke021, 325 MHz Spoke040, and 650 MHz elliptical 063 are being developed at IMP and IHEP in China. A small number of HWR010 and Spoke012 have been produced and vertically tested. The first prototype of Spoke021 were tested too. The design, performances, fabrication, surface processing, and testing of all cavities will be presented in the talk. The design improvement of the cavities in the future will also be discussed.

TH1OD02 Faced Issues in ReA3 Quarter-Wave Resonators and their Successful Resolution – A. Facco (NSCL) C. Compton, J.L. Crisp, K. Elliott, M. Hodek, M.J. Johnson, M. Leitner, I.M. Malloch, D. Miller, S.J. Miller, D. Morris, D. Norton, R. Oweiss, J.P. Ozelis, J. Popielarski, L. Popielarski, K. Saito, N.R. Usher, G.J. Velianoff, D.R. Victory, J. Wei, K. Witgen, S. Zhao (FRIB) A. Facco

12:05 The 80.5 MHz, $\beta=0.085$ QWR production cavities for the ReA3 project at MSU have initially shown puzzling behavior and unexpected lack of performance. This was due to a combination of design problems and subtle mechanical effects which have been pointed out during a brief but intense testing campaign made by the FRIB SRF group. The same cavities could be eventually refurbished and brought to performance well above original specifications. This work will be presented with emphasis to the technical problems encountered, their diagnosis and the adopted solutions.

TH1OD03 Cavity Development for the Linear IFMIF Prototype Accelerator – N. Bazin, P. Carbonnier, G. Devanz, G. Disset, N. Grouas, P. Hardy, F. Orsini, D. Roudier (CEA/DSM/IRFU) J. Neyret (CEA/IRFU)

12:25 The Linear IFMIF Prototype Accelerator (LIPAc), which is presently under design and realization, aims to accelerate a 125 mA deuteron beam up to 9 MeV. Therefore, a low-beta 175 MHz Half-Wave Resonator (HWR) was initially designed and manufactured with a tuning system based on a capacitive plunger located in the electric field region. Following the results of the vertical tests at 4.2K, this tuning system was abandoned and replaced by a conservative solution based on the HWR wall deformation using an external mechanical tuner. This paper will focus on the manufacturing of the prototype cavity, the studies realized to explain the first test results and the solutions taken to overcome the difficulties, leading to the validation of the prototype. Then, we will present the new cavity design.

TH1OD04 A Cold Tuner System With Mobile Plunger – D. Longuevergne, S. Blivet, S. Bousson, N. Gandolfo, G. Martinet, G. Olry, H. Sagnac (IPN)

12:45 Tuner systems for accelerating cavities are required to compensate static and dynamic frequency perturbations during beam operation. In the case of superconducting cavities, these are commonly tuned by deforming the cavity wall in specific places

of the geometry. Nevertheless, considering the mechanical properties and frequency versus displacement sensitivity of some structures, tuning by deformation doesn't allow to meet the requirements. In these specific cases, inspired from the "room temperature technology", an alternative tuning technique by insertion of a helium-cooled superconducting plunger can be considered and has been studied for several projects (IFMIF, ESS-BILBAO). Advantages and drawbacks of such solution will be discussed and the successful results on SPIRAL2 cryomodule developed at IPNO will be presented.

26-Sep-13 14:30 – 18:00	Poster	Galleries
THP — Poster session III		

- THP001 Development of a Prototype SRF Cavity for the Proton Beam Utilization Facility at Nanjing University** – S. An (PLAI) L. Zhang (Chang'an University)
Nanjing University has initiated the new technology development in the field of high-energy, charged-particle beam application and fundamental sciences. A high-current proton accelerator used for the new energy, new technology and fundamental science applications platform will be the near term goal at Nanjing University. For developing the superconducting RF linac for the proton beam utilization at Nanjing University, the first 6-cell, medium-beta prototype superconducting RF cavity has been fabricated and demonstrated using Chinese vendors only. The low-power test has been completed. The vertical test will be carried out soon.
- THP002 Design of 3-Cell Traveling Wave Cavity for High Gradient Test** – P.V. Avrakhov, A. Kanareykin, R.A. Kostin (Euclid TechLabs, LLC) S. Kazakov, N. Solyak, V.P. Yakovlev (Fermilab)
Utilization of a superconducting traveling wave accelerating (STWA) structure with small phase advance per cell for future high energy linear colliders may provide accelerating gradient 1.2/1.4 times larger [1] than standing wave structure. However, the STWA structure requires a feedback waveguide [1]. Recent tests of 1.3 GHz model of a single-cell cavity with waveguide feedback demonstrated an accelerating gradient comparable to the gradient in a single-cell ILC-type cavity from the same manufacturer [2]. In the present paper a design for a STWA resonator with a 3-cell accelerating cavity for high gradient tests is considered. Methods to create and support the traveling wave in this structure are discussed. The results of detailed studies of the mechanical and tuning properties of the superconducting resonator with 3-cell traveling wave accelerating structure are also presented.
- THP003 Cold Measurements on the 325 MHz CH-Cavity** – M. Busch, F.D. Dziuba, H. Podlech, U. Ratzinger (IAP) M. Amberg (HIM) M. Pekeler (RI Research Instruments GmbH)
At the Institute for Applied Physics (IAP), Frankfurt University, a sc 325 MHz CH-Cavity has been designed and built. This 7-cell cavity has a geometrical beta of 0.16 corresponding to a beam energy of 11.4 AMeV. The design gradient is 5 MV/m. Novel features of this resonator are a compact design, low peak fields, easy surface processing and high power coupling. After successful tests at Research Instruments (RI) and in Frankfurt the cavity was processed and cleaned at RI and power tests at 4K have been performed at the cryo lab in Frankfurt. In this paper these measurements will be presented.
- THP004 Design Progress of SSR1 Single Spoke Resonator for RAON** – H.J. Cha, D. Jeon, H.C. Jung, H.J. Kim, G.-T. Park (IBS) R.E. Laxdal, Z.Y. Yao, V. Zvyagintsev (TRIUMF)
An advanced heavy ion accelerator for basic sciences and multiple applications, called "RAON", is under construction in Daejeon, South Korea. The fabrication of prototypes for four different types of superconducting cavities, QWR, HWR, SSR1 and SSR2, is scheduled based on the on-going technical designs. In this paper, we present the electromagnetic and mechanical analyses for the SSR1 cavity ($\beta=0.3$ and $f=325$ MHz). Several variants have been considered and compared in terms of rf parameters, multipacting sensitivity, helium pressure sensitivity and ease of fabrication. This includes an analysis of stiffening rings and helium jacket design for stable operation. The progress towards the design of the SSR1 cavity will be given.
- THP005 Characteristics and Fabrication of Spoke Cavities for High-Velocity Applications** – C.S. Hopper (ODU) J.R. Delayen, H. Park (JLAB)
A 500 MHz, velocity-of-light, two-spoke cavity has been designed and optimized for possible use in a compact light source [1]. Here we present the mechanical analysis and steps taken in fabrication of this cavity at Jefferson Lab.
- THP006 A Superconducting 217 MHz CH Cavity for the CW Demonstrator at GSI** – F.D. Dziuba, M. Amberg, M. Busch, H. Podlech, U. Ratzinger (IAP) K. Aulenbacher (IKP) W.A. Barth, S. Mickat (HIM)
For a competitive production of new Super Heavy Elements (SHE) in the future a 7.3 AMeV superconducting (sc) continuous wave (cw) LINAC is planned at GSI. Currently, a cw demonstrator is going to be built up. The demonstrator consists of a sc 217 MHz Crossbar-H-mode (CH) cavity and two sc 9.5 T solenoids mounted in a horizontal cryostat. One major goal of the demonstrator project is to show the operation ability of sc CH cavity technology under a realistic accelerator environment. After first rf and cold tests the demonstrator will be tested with beam delivered by the GSI High Charge State Injector (HLI) in 2014.
- THP007 Cornell's ERL Cavity Production** – G. Eichhorn, B. Bullock, B. Clasby, J.J. Kaufman, B.M. Kilpatrick, J. Sears, V.D. Shemelin (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) T. Kürzeder (TU Darmstadt)
The phase 1 R&D program launched in preparation to building a 5 GeV Energy Recovery Linac (ERL) at Cornell, a full main linac cryomodule is currently built, housing six 7-cell cavities. In order to control the beam break-up limit, the shape of the cavity was highly optimized and stringent tolerances on the cavity production were targeted. We will report on the details of the cavity production, the accuracy of the cups forming the individual cells, the trimming procedure for the dumbbells, the cavity tuning and final accuracy of the cavity concerning field flatness, resonant frequency and overall length within this small series production.
- THP008 High Voltage Cavity R&D at Cornell, RE and ICHIRO** – F. Furuta, B. Elmore, A. Ganshin, G.M. Ge, G.H. Hoffstaetter, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)
We have been investigated 1.3GHz high gradient SRF Nb cavity with shape of low Hpk/Eacc, such as re-entrant(RE) and KEK low-loss (ICHIRO) shapes. We have single-/multi-cell RE cavities and ICHIRO single-cell cavities at Cornell. We have processed those cavities based on buffered chemical-polishing(BCP), vertical electro-polishing(VEP), and centrifugal barrel-polishing(CBP). In this paper, we will report the details of processes and the results of vertical tests of these cavities.
- THP009 Development of High Performance SRF Cavities with High Q0 at Ultra-High Gradients** – R.L. Geng, A.D. Palczewski (JLAB) J.K. Hao, Y.M. Li, K.X. Liu (PKU)
We report on the recent progress at Jefferson Lab in developing high performance SRF cavities with high Q0 at ultra-high

gradient for future SRF based machines. The goal is to reach $Q_0 \geq 2 \times 10^{10}$ at $E_{acc} \geq 45$ MV/m at a temperature in the range of 1.8-2.0 K. The main pushes are two folds: (1) to completely eliminate field emission in the regime of $E_{pk} \sim 100$ MV/m; and (2) to mitigate the non-linear field dependence of the BCs as well as the residual surface resistance. The selection of the unique low-Ta large-grain material made available by an industrial vendor and the advanced cavity treatment procedures are expected to bring about the aimed benefits. Three new 1-cell 1.3 GHz and 1.5 GHz large-grain niobium cavities are fabricated using the conventional forming and electron beam welding techniques. The surface processing consists of "mirror-finish" mechanical polishing, high temperature vacuum furnace heat treatment and electropolishing. Preliminary cryogenic RF testing results will be presented.

THP010 First Prototype 9-cell Low-Surface-Field Shape Niobium Cavity – *R.L. Geng, W.A. Clemens, Y.M. Li, D. Machie, A.D. Palczewski, G. Slack, R.S. Williams (JLAB) C. Adolphsen, Z. Li (SLAC)*

We report on the recent progress at Jefferson Lab in developing ultra high gradient and high Q_0 superconducting radio frequency (SRF) cavities for future SRF based machines. A new 1300 MHz 9-cell prototype cavity is being fabricated. This cavity has an optimized shape in terms of the ratio of the peak surface field (both magnetic and electric) to the acceleration gradient, hence the name low surface field (LSF) shape. The goal of the effort is to demonstrate an acceleration gradient of 50 MV/m with Q_0 of 10^{10} at 2 K in a 9-cell SRF cavity. Fine-grain niobium material is used. Conventional forming, machining and electron beam welding method are used for cavity fabrication. New techniques are adopted to ensure repeatable, accurate and inexpensive fabrication of components and the full assembly. The completed cavity is to be first mechanically polished to a mirror-finish, a newly acquired in-house capability at JLab, followed by the proven ILC-style processing recipe established already at JLab.

THP011 Improving Gradient of 9-cell SRF Cavities at Peking University – *J.K. Hao, J.E. Chen, L. Lin, K.X. Liu, X.Y. Lu, S.W. Quan, F. Wang, H.M. Xie, B.C. Zhang, K. Zhao, F. Zhu (PKU)*

Four 9-cell TESLA superconducting cavities have been fabricated with Ningxia OTIC niobium material, including two fine grain and two large grain niobium cavities. The cavities have been tested after post treatments. At the early stage (PKU1 and PKU2), the gradient was about 23 MV/m. The gradient of PKU3 reached 28.4 MV/m, but the Q is low. The newest large grain 1.3 GHz 9-cell TESLA type SRF cavity (PKU4) has been made with careful control of machining, and improved surface treatment and electron beam welding. The maximum of gradient is 32.4 MV/m and the intrinsic quality factor (Q_0) is 1.3×10^{10} , which meet the requirement for ILC both in accelerating gradient and intrinsic quality factor.

THP012 Rebuild of Capture Cavity 1 at Fermilab – *E.R. Harms, T.T. Arkan, E. Borissou, N. Dhanaraj, Y. Orlov, T.J. Peterson, K.S. Premo (Fermilab)*

The front end of the proposed Advanced Superconducting Test Accelerator at Fermilab employs two single cavity cryomodules, known as 'Capture Cavity 1' and 'Capture Cavity 2', for the first stage of acceleration. Capture Cavity 1 was previously used as the accelerating structure for the A0 Photoinjector to a peak energy of ~14 MeV. In its new location a gradient of ~25 MV/m is required. This has necessitated a major rebuild of the cryomodule including replacement of the cavity with a higher gradient one. Retrofitting the cavity and making upgrades to the module required significant re-design. The design choices and their rationale, summary of the rebuild, and early test results are presented.

THP013 A New Cavity Design for Medium Beta Acceleration – *F.S. He, R.A. Rimmer, H. Wang (JLAB)*

Heavy duty or CW, superconducting proton and heavy ion accelerators are being proposed and constructed worldwide. The total length of the machine is one of the main drivers in terms of cost. Thus HWR and spoke cavities at medium beta are usually optimized to achieve low surface field and high gradient. A novel accelerating structure at $\beta=0.5$ evolved from spoke cavity is proposed, with lower surface fields but slightly higher heat load. It would be an interesting option for pulsed and CW accelerators with beam energy of more than 200 MeV/u.

THP014 A Prototype Cavity for Inverse Compton Scattering Light Source Applications – *F.S. He, G. Cheng, W.A. Clemens, J. Henry, P. Kneisel, B.R. Lang, J.D. Mammosser, R.A. Rimmer, G. Slack, C. Tennant, L. Turlington, H. Wang, S. Yang (JLAB)*

Compact, high brilliance X-ray sources, based on inverse Compton scattering (ICS), have gained enormous interest worldwide. A compact and affordable superconducting (SC) linac is one of the key components of such applications. JLab is developing the concept of a compact cryostat, which contains two elliptical, 400MHz, 3-cell cavities, to demonstrate the SRF technology for ICS application. In this paper, the RF optimization, HOM criteria, mechanical analysis, fabrication experience and the test result of the prototype cavity are reported.

THP015 Design of a 325MHz $\beta=0.21$ Single Spoke Cavity at IMP – *S.C. Huang, S. He, Y. He, Y.L. Huang, T.C. Jiang, R.X. Wang, M.X. Xu, W.M. Yue (IMP)*

A Single Spoke cavity has been designed for Chinese Accelerator Driven System (C-ADS) Project at IMP. In this paper, we describe the geometric and mechanical optimization of Single Spoke Cavity, using 3D software CST-MWS and ANSYS. The goal of optimization is to minimize the ratio of B_{pk}/E_{acc} and E_{pk}/E_{acc} , maximize G^*R/Q . Finally, some analysis of Power coupler are also presented.

THP016 Mechanical Simulations of Double Spoke Resonator for China-ADS – *Y.L. Huang, S. He, Y. He, S.C. Huang, T.C. Jiang, R.X. Wang, M.X. Xu, W.M. Yue, C. Zhang, S.H. Zhang, S.X. Zhang, H.W. Zhao (IMP)*

Within the framework of the C-ADS project, IMP has proposed a 325MHz Double-Spoke Superconducting cavity for the high power proton linear accelerators. For the geometrical design of the cavity, numerical static structure, thermal, and modal simulations have been performed with ANSYS to predicted the mechanical eigenmodes, the deformation of the cavity walls due to the bath pressure effects and the cavity cool-down, and the frequency shift caused by the microphonics and Lorentz force detuning.

THP017 Mechanical Study on ADS 650 MHz SRF Cavities and 1.3 GHz Superconducting Accelerating Unit at IHEP – *S. Jin, J. Gao, Y. Liu, Z.C. Liu, J.Y. Zhai, T.X. Zhao, H.J. Zheng (IHEP)*

An Accelerator Driven Sub-critical System is under development in China. The 650MHz $\beta=0.82$ superconducting RF cavity (SRF) has been selected as a possible candidate to accelerate proton bunches in the medium energy from 360 MeV to 1.5 GeV. Thus mechanical analyses on ADS650MHz cavities are carried on. Since recent study indicates that cavity detuning can cause power costs driven up by millions of dollars due to helium fluctuation, preliminary results on the sensitivity of this aspect will also be discussed. Besides, a 1.3GHz SRF accelerating unit is under construction at IHEP. In the unit, 9 cell cavity, tuner and liquid helium (LHe) tank are welded or assembled to form a relatively independent component. Together taking into account that a thin-wall of 0.3mm titanium bellow will also be welded in the middle of the LHe tank, mechanical analysis becomes necessary to assure its safety in the arduous fabrications. In this paper, several cases have been analyzed for safety

consideration by ANSYS Workbench such as self-gravity effects, the tuning distance at room temperature, and the support structure for the thin-wall bellow. The safety requirements are suggested in the paper.

- THP018 **Design of a Superconducting 352MHz Fully Jacketed Double-Spoke Resonator for the ESS-Bilbao Proton Linac** – *T. Junquera (Accelerators and Cryogenic Systems) E.J. Bermejo, J.L. Muñoz, A. Vélez (ESS Bilbao) P. Duchesne, G. Olry (IPN)*

The baseline design for the ESS-Bilbao light-ion linear accelerator and neutron source (a facility compliant with the ESS-AB requirements) has been completed and the normal conducting section of the linac (RFQ and DTL) is at present under detailed design and construction. Starting at 50 MeV, it is proposed to follow this section with a superconducting section composed of double and triple spoke cavities grouped in cryomodules of 2 or 3 cavities reaching a maximum energy of 300 MeV. After an initial R&D program on spoke cavities with an aluminum model, detailed electromagnetic and mechanical studies of a beta 0.50, 352MHz, double spoke cavity were performed. The results of the calculations are presented in this paper. It is proposed to continue this development by the construction and test of the niobium cavities prototypes and initiating the study of a cryo-module with two cavities that could be tested with beam at the ESS-Bilbao facility.

- THP019 **1.3 GHz SRF Cavity Tests for ARIEL at TRIUMF** – *P. Kolb, P.R. Harmer, D. Kishi, A. Koveshnikov, C. Laforge, D. Lang, R.E. Laxdal, Y. Ma, B.S. Waraich, Z.Y. Yao, V. Zvyagintsev (TRIUMF)*

The 1.3 GHz cavity test program at TRIUMF for the ARIEL eLINAC progressed into its next stage: Going from single cell cavity tests to demonstrate the operating Q and gradient for ARIEL can be reached at TRIUMF to nine cell cavity tests for production cavities. Single cell cavity tests at TRIUMF showed a comparable performance to a characterization done on the same cavity at FNAL last year. These single cell tests showed that the operating point for ARIEL of $Q_0 > 10^{10}$ at 10 MV/m during 2 K operation can be reached and exceeded at TRIUMF. To prepare for the first ARIEL nine cell cavity, a test with a TESLA nine cell cavity was done. This included frequency and field tuning, etching via BCP, HPR and assembly in a class 10 clean environment as well as modifications to the cryo assembly and upgrades to the 2 K pumping system. The performance of this TESLA cavity and the performance of first ARIEL nine cell cavity produced by PAVAC will be shown.

- THP020 **Measuring the Higher Order Mode Spectrum of the TRIUMF 9-cell Cavity** – *P. Kolb, B. Amini, R.E. Laxdal, Y. Ma, Z.Y. Yao, V. Zvyagintsev (TRIUMF)*

The ARIEL eLINAC consists of five nine cell cavities, produced by PAVAC, and will accelerate 10 mA electrons to 50 MeV. This 500 kW beam will be used for rare isotope production. Future upgrade plans include a recirculating beam line. Recirculating the beam, for either energy doubling or energy recovery to drive a FEL, brings the risk of multi-pass beam break up (BBU). Therefore it is necessary to avoid higher order modes (HOMs) with high shunt impedance. The goal of the cavity design is to reduce the highest shunt impedance of any dipole HOM to $1 \cdot 10^6 \Omega$ or less. Measurements on the nine cell cavity with bead pulling have been done to identify dipole modes and their geometric shunt impedance R/Q as well as measurements at 2 K to estimate the quality factor of those HOMs. Results of these measurements will be shown and compared to computer simulations done with ACE3P.

- THP021 **Design of the Main Linac Spoke021 Cavity of Proton Accelerator for China ADS** – *Z.Q. Li, Y.L. Chi, W.M. Pan, J.Y. Tang, Q.Y. Wang, B. Xu (IHEP) Y. He (IMP)*

China ADS is a superconducting CW high density proton machine which is supported by the "Strategic Priority Research Program" of the Chinese Academy of Sciences (CAS). It includes two injectors and one main linac. Institute of High Energy Physics (IHEP) is the leading institution for developing the main linac. This paper introduces the physics and mechanic design of spoke021 cavity at IHEP.

- THP022 **Design Study on Very Low Beta Spoke Cavity For China-ADS** – *H. Li, J.P. Dai, Q.Y. Wang, J. Zhang (IHEP) J.H. He (Harbin Institute of Technology (HIT)) H. Huang, P. Sha (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences) X.Y. Lu (PKU)*

In the low-energy part of the Chinese-ADS linac Injector-I three families of 325MHz superconducting spoke cavities will be used, which β are 0.12, 0.21 and 0.4. Spoke cavity was adopted in Chinese-ADS for having more compact structure with the same frequency than the elliptical cavity, and higher shunt impedance than the half-wave resonator. First two Spoke012 prototypes have been fabricated by HIT (Harbin Institute of Technology) and vertical tested successfully by IHEP in 2012. Results of optimization, fabrication and vertical test of Spoke012 are presented in this paper.

- THP023 **Preliminary Quadrupole Asymmetry Study of Superconducting Spoke Cavity** – *Z.Q. Yang (Peking University, School of Physics) X.Y. Lu, X. Luo, S.W. Quan, L. Yang, K. Zhou (PKU)*

Accelerator Driven System (ADS) has been launched in China for nuclear waste transmutation. For the application of high intensity proton beam acceleration, the quadrupole asymmetry effect will be the necessary to be carefully evaluated for cavities. Single Spoke cavities are the main accelerating structures in the low energy front-end. Single Spoke cavity has small transverse electromagnetic field asymmetry, which may lead to transverse RF defocusing asymmetry and beam envelope asymmetry. A superconducting Single Spoke resonator (PKU-2 Spoke) of $\beta=0.12$ and $f=325\text{MHz}$ has been designed at Peking University. The study of its RF field quadrupole asymmetry and its effect on transverse beam envelope has also been performed. Our results showed that the quadrupole asymmetry is very small for the PKU-2 Spoke, and its transverse beam envelope asymmetry is almost negligible.

- THP024 **Lorentz Force Detuning Simulations for Spoke Cavities With Different Stiffening Elements** – *J.L. Muñoz, E.J. Bermejo (ESS Bilbao)*

Lorentz force detuning caused by radiation pressure on the Nb cavity walls is of concern in cavity design and operation since its magnitude can approach the cavity bandwidth. This effect can be reduced using passive stiffening elements in the cavity. In this work, Lorentz force detuning has been studied by numerical simulations for spoke cavities. Different stiffening elements has been considered. Static and dynamic behaviour have been analyzed by means of 3D static and transient electromagnetic and mechanical coupled finite elements simulations.

- THP025 **First Cavity Design Studies for BESSY-VSR upgrade proposal** – *A. Neumann, A. Jankowiak, J. Knobloch, M. Ruprecht, G. Wüstefeld (HZB)*

Recently HZB proposed an upgrade of the 3rd generation synchrotron light source BESSY II allowing simultaneously long and short pulse operation [1]. For this scheme to work superconducting higher harmonic cavities of the fundamental 500 MHz need to be installed in the BESSY ring. An appropriate choice of two different harmonics and the accelerating voltages leads to a beating effect of the effective longitudinal focussing voltage at the stable fixed points resulting in different bunch lengths in the different buckets. This project places stringent requirements on the cavity performance, as high accelerating fields,

excellent HOM damping capabilities and high stability and reliability as they will operate in an 24/7 user facility. In this paper we describe the requirements for the cavity design and first designs to overcome the challenges by the projects boundary conditions.

THP026 The Cage Cavity: A Low Cost, High Performance SRF Accelerating Structure – *J. Noonan, T.L. Smith, M. Virgo, G.J. Waldschmidt (ANL) J.W. Lewellen (LANL)*

The Cage Cavity is a new SRF cavity technology using tubes formed into the shape of a solid wall cavity then assembled into a closed volume. The theory is that the cage cavity will form a resonant cavity at RF frequencies below a critical frequency at which the cage structure behaves as a solid structure. Several cage cavity structures have been fabricated and measured that demonstrate good RF properties. Comparison of simulations and measurements for these structures will be discussed. More importantly, simulations have identified a new cage cavity configuration in which an SRF cage cavity's quality factor is greater than 10×10^{10} . The cage cavity must operate in a vacuum vessel which is also an RF cavity. By choosing the cage cavity resonant frequency to be decoupled from the vessel higher order resonances, simulations show that the cage cavity Q is ~95% of a solid wall SRF cavity. The Cage Cavity design, fabrication costs, and high order mode behavior have a number of advantages over solid wall cavities. However, the cage cavity also has limitations. The design and properties of the cage cavity will be discussed and compared with existing SRF cavities.

THP027 Multipactor Analysis of the HWR at RISP – *G.-T. Park (IBS)*

We report on the progress of the HWR development at RISP. The multipactor of the HWR was studied using CST-PS (PIC) solver and multipacting band is predicted. Also the coupler is incorporated to the cavity simulation, determining the external Q, heat loss, and multipactor (near the coupler port). In addition, we present the simulation results of the cavity with the helium jacket exploring various possibilities for the boundary conditions of the cavity to affect the helium sensitivity, stress analysis, and the frequency shift.

THP028 The Research on Spoke 0.40 Cavity – *P. Sha, H. Huang (Institute of High Energy Physics (IHEP), Chinese Academy of Sciences) W.M. Pan, X.Y. Zhang (IHEP)*

Spoke superconducting cavity can be used in the low-energy section of the proton accelerator. It has many significant advantages: compact structure, high value of R/Q, etc. The Chinese ADS (Accelerator Driven System) project will adopt many spoke cavities with 3 different β values (0.12, 0.21, 0.40). Spoke040 cavities ($\beta=0.40$) are used to increase the proton energy from 34 MeV to 178 MeV. Now the physical design of spoke040 cavity has been finished, and the machining are going on right now. The vertical test would be held at the end of this year.

THP029 Optimization of Mechanical Properties of SRF Cavities for Low Beam Current Operation – *N. Solyak, M.H. Awida, I.V. Gonin, T.N. Khabiboulline, Y.M. Pischalnikov, W. Schappert, V.P. Yakovlev (Fermilab)*

The low beam current for CW operation of the Project X requires cavities to be mechanically optimized to operate at a high loaded Q and thus, low bandwidth with higher sensitivity to microphonics. The essential source of microphonics detuning is fluctuations in the helium pressure df/dp . Last year's several methods for reducing df/dp has been proposed. One of the other possible sources of RF frequency instability is mechanical resonances. The cavity could be driven out of operating frequency by the mechanical deformations due to vibrations caused by external factors. In this paper we present the COMSOL multiphysics algorithm developed for evaluation of operating frequency shift due to mechanical resonances in SC cavities. We discuss the results of simulations for 5-cell elliptical 650 MHz $\beta=0.9$ cavities. The comparison of COMSOL simulations and measurements of ILC type cavities in Horizontal Test Stand at Fermilab is presented.

THP030 Superconducting RF Cavity Development With UK Industry – *A.E. Wheelhouse, R.K. Buckley, L.S. Cowie, P. Goudket, A.R. Goulden, P.A. McIntosh (STFC/DL/ASTeC) C.A. Cooper, C.M. Ginsburg, A. Grassellino, O.S. Melnychuk, A.M. Rowe, D.A. Sergatskov (Fermilab) J.R. Everard, N. Shakespeare (Shakespeare Engineering)*

As part of a continuing STFC Innovations Partnership Scheme (IPS) grant, in support of enabling UK industry to address the large potential market for superconducting RF structures Daresbury Laboratory and Shakespeare Engineering Ltd are developing the capability to fabricate, process and test a niobium 9-cell 1.3 GHz superconducting RF cavity. A single-cell cavity fabricated under this grant was surface processed and tested at Fermilab, and achieved an accelerating gradient in excess of 40 MV/m at an unloaded quality factor in excess of 1.0×10^{10} . This paper presents the results of the single-cell cavity testing and discusses the progress made to date in the development of the design and manufacture of a 9-cell niobium cavity, which Shakespeare Engineering Ltd will fabricate and which is anticipated to be qualified in 2014.

THP031 First Test Results of the 56 MHz SRF Quarter Wave Resonator for RHIC – *Q. Wu, G.T. McIntyre, R. Porqueddu, S.K. Seberg (BNL) S.A. Belomestnykh, I. Ben-Zvi (Stony Brook University)*

A 56 MHz superconducting RF cavity will be the first quarter wave resonator (QWR) installed in a high energy storage ring. It is expected to boost the luminosity of the Relativistic Heavy Ion Collider by more than 60% after installation. In this paper, we discuss the cavity parameters and design features. We report the results from the first vertical test of this cavity at 4 K.

THP032 Update on Superconducting Conical Half-Wave Resonator Developments – *Y. Xie, A. Kanareykin (Euclid Tech-Labs, LLC) V.P. Yakovlev (Fermilab) E.N. Zaplatin (FZI)*

A conical Half-Wave Resonator is considered as an option for a first accelerating cavity for $\beta=v/c=0.11$ with the resonance frequency 162.5 MHz for ProjectX at Fermilab. Update on the engineering design of the cavity with helium vessel and subsystems will be presented. The fabrication progress will also be reported.

THP033 Study of Balloon Spoke Cavities – *Z.Y. Yao, R.E. Laxdal, B.S. Waraich, V. Zvyagintsev (TRIUMF) R. Edinger (PAVAC)*

A balloon geometry has been proposed to suppress multipacting for single spoke resonators. The design may find a useful application for proton and ion accelerator projects. TRIUMF has completed initial RF, mechanical, and fabrication studies on this special geometry for both low ($\beta=0.12$) and medium ($\beta=0.3$) β geometries. The RF properties are comparable with that of traditional spoke cavities but with improved RF efficiency in addition to the reduced multipacting. The results of electromagnetic and structural design studies comparing the balloon geometry with traditional spoke geometries will be presented. We will also present optimization studies of the mechanical design, such as decreasing df/dp by EM field compensation as well as discussing tuning strategies and fabrication techniques.

THP034 Multipacting Suppression in a Single Spoke Cavity – *Z.Y. Yao, R.E. Laxdal, V. Zvyagintsev (TRIUMF) X.Y. Lu, K. Zhao (PKU)*

Spoke cavities are good candidates for the low and medium β section of a high intensity proton or ion accelerator. For many high intensity accelerators, stability and reliability are the most important properties. Currently, one of the key issues of spoke cavity performance is multipacting, which may cause instability during operation. Multipacting in a spoke cavity has a troublesome characteristic as it presents a continual barrier over a wide gradient range, usually in the range of operation from

3MV/m to 15MV/m. A good surface processing can improve the secondary electron emission yield. However, the complex 3D structure makes it not easily achievable as with the elliptical cavity variants. Suppressing multipacting in the design stage is clearly advantageous. This paper will present a multipacting study based on the PKU-I spoke cavity. A systematic correlation between geometric parameters and multipacting behaviors is obtained. Based on this study a new geometry of single spoke cavity called the 'balloon' variant is proposed.

- THP035 Production of a 1.3GHz Niobium 9-cell TRIUMF-PAVAC Cavity for the ARIEL Project** – *V. Zvyagintsev, B. Amini, P.R. Harmer, P. Kolb, R.E. Laxdal, B.S. Waraich (TRIUMF) R. Edinger, M.C. Leustean, R. Singh (PAVAC)*
 A nine-cell 1.3GHz superconducting niobium cavity has been fabricated for the ARIEL project at TRIUMF. The cavity is intended to accelerate a beam current of 10mA at an accelerating gradient of 10MV/m. The beam loaded rf power of 100kW is supplied through two opposed fundamental power couplers. The electromagnetic design was done by TRIUMF. The cavity final design and fabrication procedure have been developed in a collaboration between TRIUMF and PAVAC Industries Inc. Several innovations in the cavity fabrication process were developed at PAVAC. Since the most important weld is at the equator this weld is done first to form a 'smart-bell' as the basic unit as opposed to welding first at the iris to form 'dumb-bell' units. Each half cell is pressed with a male die into a plastic forming surface to produce half-cells with less shape distortion and material dislocations. The cavity fabrication sequence including the frequency tuning steps and rf frequency modeling methods will be discussed.
- THP036 Design of a 4 Rod Crab Cavity Cryomodule System for HL-LHC** – *G. Burt, B.D.S. Hall (Cockcroft Institute, Lancaster University) T.J. Jones (STFC/DL) P.A. McIntosh, S.M. Pattalwar, A.E. Wheelhouse (STFC/DL/ASTeC) L.A. Wright (CERN)*
 The LHC requires compact SRF crab cavities for the HL-LHC and 3 potential solutions are under consideration. One option is to develop a 4 rod cavity utilising for quarter wave rods to maintain a dipole field. The cavity design has been developed including power and LOM/HOM couplers have been developed, as well as a conceptual design of a complete cryomodule system including ancillaries and this is presented. The cryomodule is designed to allow easy access during testing and uses a novel support system and contains the opposing beamline section to fit inside the LHC envelope.
- THP037 Fabrication of a Quasi-Waveguide Multicell Resonator for the Advanced Photon Source** – *Z.A. Conway, A. Barcikowski, S.M. Gerbick, M. Kedzie, M.P. Kelly, J.S. Kerby, R.C. Murphy, P.N. Ostroumov, T. Reid, A. Zholents (ANL) M.H. Awida, I.V. Gonin, T.N. Khabiboulline, A. Lunin (Fermilab)*
 This paper reports the fabrication status of a 2815 MHz Quasi-waveguide Multicell Resonator (called QMiR) being considered as a transverse RF deflecting cavity for the Advanced Photon Source's (APS) Short Pulse X-ray project. QMiR must meet stringent design requirements to minimize beam perturbations such that the machine availability remains at >97%. A prototype cavity is being fabricated to demonstrate the fabrication procedures and the feasibility of the 2 K cavity performance, with 2 MV of deflecting voltage from a single cavity and peak surface electric and magnetic fields of 54 MV/m and 75 mT respectively. Results from the fabrication, including mechanical properties and tuning behavior, will be presented.
- THP038 Development and Performance of a High Field TE-Mode Sample Host Cavity** – *D.L. Hall, M. Liepe, I.S. Madjarov, N.R.A. Valles (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*
 A TE-mode 4 GHz sample host cavity has been designed and constructed at Cornell for the purpose of testing wafers of niobium and other candidates for the construction of SRF cavities. Simulations made using CLANS and ACE3P indicate that the peak magnetic field on the sample plate will reach approximately 120 mT before a quench occurs on the surface of the cavity due to thermal runaway. This quench field can be further increased using a 1400 C treatment to improve the thermal conductivity of the niobium bulk and a 120 C treatment to minimise the BCS surface resistance of the cavity walls. Such an improvement would put peak fields of 170 mT within reach of this cavity. Results of the cavity design, fabrication and first vertical test are presented and discussed.
- THP039 Design of a Triple-Spoke Cavity as a Rebuncher for RIKEN RI-Beam Factory** – *L. Lu (RIKEN) O. Kamigaito, N. Sakamoto, K. Suda, K. Yamada (RIKEN Nishina Center)*
 A superconducting triple-spoke cavity as a rebuncher for very heavy ion beams such as uranium at $\beta=0.303$ for RIKEN RI-beam factory is designed. The required total gap voltage is 3 MV. In this design, thick ribs (25 mm) are placed on the both ends of cavity so that the deformation caused by pressure of liquid helium is less than 0.5 mm. A copper test model with one spoke is designed to be fabricated using the same technique as that for Nb cavity. The detailed design will be presented.
- THP040 Simulation Study on Multipacting Processes in the Rossendorf SRF Gun** – *E.T. Tulu, U. van Rien (Rostock University, Faculty of Computer Science and Electrical Engineering) A. Arnold (HZDR)*
 Electron multipacting is still observed in the Rossendorf SRF gun which limits the cavity fields (accelerating gradient). To better understand this process, a three-cell 1.3 GHz elliptical-shape cavity with cathode was modeled in CST Studio Suite® 2013 at the University of Rostock. All parameters are provided by Helmholtz-Zentrum Dresden-Rossendorf. The multipacting simulations have been performed with CST Microwave Studio® (CST MWS) [1] and CST Particle Studio® (CST PS) which is suitable and powerful for 3D electromagnetic designs and provides the most advanced model of secondary emission. The radio frequency fields are calculated using the frequency domain solver of CST MWS, whereas the CST PS is used for particle tracking simulation [2]. The purpose of these numerical simulations is to better comprehend multipacting in the Rossendorf SRF gun and make a detailed analysis. The midterm goal is to find a new cavity shape, which might suppress the electron amplification so that the SRF Gun will be able to operate up to an accelerating gradient of 50 MV/m.
- THP041 Optimization of the Double Quarter Wave Crab Cavity Prototype for Testing at SPS** – *S. Verdú-Andrés, I. Ben-Zvi, Q. Wu, B. P. Xiao (BNL) S.A. Belomestnykh (Stony Brook University) R. Calaga (CERN) Z. Li (SLAC)*
 The crab cavity program for LHC luminosity upgrade envisages the testing of at least one of the three competing crab cavities in the Super Proton Synchrotron (SPS) of CERN by 2016. This paper presents the design optimization of a Double Quarter Wave Crab Cavity (DQWCC) prototype suited for testing in SPS.
- THP042 High Frequency SRF Cavity Study for Bunch Shortening in PEPX-FEL** – *L. Xiao, K.L.F. Bane, Y. Cai, X. Huang, C.-K. Ng, A. Novokhatski, L. Wang (SLAC)*
 The proposed PEPX is a diffraction limited storage ring light source, or "ultimate storage ring (USR)", which can be built in the PEP tunnel at SLAC. The 4.5GeV PEPX design based on the USR with a natural emittance about 10pm-rad can be used to drive a high-gain soft X-ray FEL. In order to achieve a desired high peak current over 300A for the FEL, the bunch length is reduced to 1ps from 10ps through a set of multi-cell SRF cavities working at 1.428GHz in CW mode, providing about 300MV RF gradient. In this paper, the 1.5GHz JLAB C100 cavity for the CEBAF upgrade and 1.3GHz Cornell ERL cavity are investigated for its application to PEPX-FEL. The simulation results show that the beam induced high order modes (HOM) in the C100 cavities

will limit the threshold of the beam current for PEPX-FEL. And the same pass band modes (SPM) in the cavities are strongly trapped, and thus generate unacceptable beam power once they hit the beam resonances. Therefore, a 5-cell with a larger iris cavity design instead of the C100 7-cell design is proposed. Preliminary results on the rf parameters of the cavity, HOM damping and beam dynamics studies will be presented.

THP043 Design and Vertical Test of Double Quarter Wave Crab Cavity for LHC Luminosity Upgrade – B. P. Xiao, I. Ben-Zvi, R. Calaga, C. Cullen, L.R. Hammons, J. Skaritka, S. Verdú-Andrés, Q. Wu (BNL) S.A. Belomestnykh (Stony Brook University)

A proof of principle Double Quarter Wave Crab Cavity (DQWCC) was designed and fabricated for the Large Hadron Collider (LHC) luminosity upgrade. Vertical cryogenic test has been done in Brookhaven National Lab (BNL). We report the test results of this design.

THP044 Design of a Generic Compact Higher Order Mode Filter for Crab Cavities for LHC Luminosity Upgrade – B. P. Xiao, I. Ben-Zvi, J. Skaritka, S. Verdú-Andrés, Q. Wu (BNL) S.A. Belomestnykh (Stony Brook University) R. Calaga (CERN)

A double quarter wave crab cavity was designed for the Large Hadron Collider luminosity upgrade. Starting from the analytical calculation of simplified RLC circuit, a compact higher order mode filter is developed for this cavity. Finite element simulation results are presented. The design concept is generic and can easily be adapted to other cavities.

THP045 Alternative APS Crab Cavity Design – T.N. Khabiboulline, M.H. Awida, I.V. Gonin, A. Lunin, V.P. Yakovlev (Fermilab) A. Zholents (ANL)

New deflecting mode cavity design developed at FNAL allows reducing number of cavities from 4 to 1 per cryomodule. Significant benefits of new cavity include simplicity of production and alignment, low microphonics, effective LOM/HOM damping, low cryo losses, only one waveguide port per cryomodule. RF design and properties of this new cavity will be presented.

THP046 Magnetic Material Characterization & SC Solenoid Coil Package Design for FRIB – K. Saito, S. Chouhan, C. Compton, J. DeKamp, M. Leitner, F. Marti, J.P. Ozelis, S. Shanab, G.J. Velianoff, X. Wu, Y. Yamazaki, A. Zeller, Y. Zhang, Q. Zhao (FRIB) S.K. Chandrasekaran (MSU) K. Hosoyama (KEK)

To date SRF technology is extending to large scale heavy ion LINACs, where SRF cavities accelerate beams from very low energy to high energy. In this application, superconducting (SC) solenoids are installed inside the cryomodule to provide strong beam focusing with enhanced space efficiency. FRIB will use local magnetic shielding, where magnetic shielding by Cryoperm or A4K is located close to the cavity at 2K. In this scheme rather strong magnetic fringe fields from the SC solenoid expose the shielding material and will magnetize it. An efficient degaussing process is required as cure against such magnetization. Magnetic material characterization of magnetic shielding materials is very important to be able to plan effective degaussing procedures. The paper will also discuss the design of FRIB solenoids optimized for cost, reliability, and robust long-term operation. NbTi wire performance criteria are discussed in addition to solenoid operational margins.

THP047 Performance Degradation of a Superconducting Cavity Quenching in Magnetic Field – I. Terechkine, T.N. Khabiboulline, D.A. Sergatskov (Fermilab)

Although degradation of a superconducting RF (SRF) cavity performance induced by magnetic field trapped in its walls is a well understood phenomenon, a criterion for an acceptable level of magnetic field existing in the vicinity of an SRF cavity and generated after the cavity is cooled down has not been agreed upon. The bulk of superconducting Nb should protect the RF surface of the cavity from the magnetic field on the outside; nevertheless a failure mode exists when the cavity quenches while the external field is applied. The amount of trapped magnetic flux in this case depends on the size of normally conducting zone developed in walls of the cavity during quenching. Although propagation of the normally conducting zone in walls of a cavity can be modeled, no dedicated studies of this process that would include experimental verifications of its impact on the cavity performance could be found. We tried to address this issue in a special study by using as an example a superconducting coil mounted near a quenching cavity; the method and some results of the study can be applied to any RF structure and magnetic system.

THP048 The Influence of Tuners and Temperature on the Higher Order Mode Spectrum for 1.3GHz SCRF Cavities – R. Ainsworth (Royal Holloway, University of London) N. Baboi, M.K. Grecki, T. Wamsat (DESY) N. Eddy (Fermilab) S. Molloy (ESS) P. Zhang (CERN)

Higher Order Modes are of concern for superconducting cavities as they can drive instabilities and so are usually damped and monitored. With special dedicated electronics, HOMs can provide information on the position on the beam. It has been proposed that piezo tuners used to keep the cavities operating at 1.3 GHz could alter the HOM spectrum altering the calibration constants used to read out the beam position affecting long term stability of the system. Also, of interest is how the cavity reacts to the slow tuner. Detuning and the retuning the cavity may alter the HOM spectrum. This is of particular interest for future machines not planning to use dedicated HOM damping as the tuning procedure may shift the frequency of HOMs onto dangerous resonances. The effect of temperature on the HOM spectrum is also investigated. An investigation of these effects has been performed at FLASH and the results are presented including numerical simulations used to predict the resulting cavity distortion.

THP049 SPL RF Coupler Cooling Efficiency – R. Bonomi, O. Capatina, E. Montesinos, V. Parma, A. Vande Craen (CERN)

Energy saving has become an important challenge in accelerator design. In this framework, reduction of heat loads in a cryomodule is of fundamental importance due to the small thermodynamic efficiency of cooling at low temperatures. In particular, care must be taken during the design of its critical components (RF couplers, cold-warm transitions, ..). In this framework, the main RF coupler of the Superconducting Proton Linac cryomodule at CERN will not only be used for RF powering but also as the main mechanical support of the superconducting cavities. These two functions have to be accomplished while ensuring the lowest heat in-leak to the helium bath at 2 K. In the SPL design, the RF coupler outer conductor is composed of two walls and cooled by forced convection with helium gas at 4.5 K. Analytical, semi-analytical and numerical analyses are presented in order to defend the choice of gas cooling. Temperature profiles and thermal performance have been evaluated for different operating conditions; a sensitivity analysis of RF currents node position along the wall has also been performed. Finally, comparison with respect to other heat extraction methods is presented.

THP050 Development of Power Coupler for Superconducting Spoke Cavities for China-ADS Proton Linac – X. Chen, T.M. Huang, H.Y. Lin, Q. Ma, F. Meng, W.M. Pan, Y.H. Peng (IHEP)

Abstract: The China-ADS proton linac adopts $\beta=0.12$ superconducting Spoke cavities. Each cavity is powered via a 325MHz coaxial power coupler. The coupler is to feed 6kW maximum power though it is designed to handle at 15kW. Two coupler sets have been made by IHEP so far, and a 10kW RF power in continuous travelling wave mode has passed through the coupler

during high power test in late January 2013. An introduction of this coupler design and the room temperature test results are presented in this paper.

- THP051 Development of Coaxial Ceramic Window for SC linac** – *A.S. Dhavale, S. Ghatak, K.C. Mittal (BARC)*
 In the present paper two different window designs, a choke type and a capacitive type are compared. A ceramic window is designed for the coaxial power coupler having inner conductor diameter of 34.8 mm and outer conductor diameter of 80 mm that will be a part of superconducting linac. An alumina disk of thickness 3.6 mm is used as a ceramic. The dimensions of inner conductor near ceramic disk are modified so as to achieve impedance matching at 10^{50} MHz. The simulation results indicate that the capacitive type of window has a wide ($\sim 10^0$ MHz) bandwidth as compared to the choke type (bandwidth ~ 22 MHz) window. A copper model of the capacitive type of window is fabricated. The measurement results of the same are presented.
- THP052 Cornell's Beam Line Higher Order Mode Absorbers** – *G. Eichhorn, J.V. Conway, Y. He, Y. Li, T. O'Connell, P. Quigley, J. Sears, N.R.A. Valles (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) V.D. Shemelin (Cornell University)*
 Efficient damping of the higher-order modes (HOMs) of the superconducting cavities is essential for the proposed energy recovery linac at Cornell that aims for high beam currents and short bunches. Designing these HOM beamline absorbers has been a long endeavor, sometimes including disappointing results. We will review the design, the findings on the prototype and the final choices made for the 7 HOM absorbers being built for the main linac cryomodule (MLC) prototype.
- THP053 Development of Quality Control Procedures for the Processing of ReA3 Copper Plated Fundamental Power Couplers (FPCs)** – *R. Oweiss, J.L. Crisp, D. Morris, J. Popielarski (FRIB) A. Facco (INFN/LNL) M. Hodek, L. Popielarski, J. Wenstrom (NSCL)*
 The processing of copper plated fundamental power couplers has posed major risks to the successful performance of superconducting cavities. This paper discusses the challenges throughout the development of quality control procedures for the ReA3 copper plated FPCs. Michigan State University Re-Accelerator project (ReA) utilizes eight copper plated FPCs to power the $\beta=0.085$ quarter-wave resonators (QWRs) for which baseline quality control procedures are established. The effectiveness of visual inspection process using the microscope & borescope to qualify FPC components is evaluated. The adaptive use of quality control diagnostic devices as the liquid particle counter, surface particle detector & desiccator for the clean processing & assembly is assessed. A summary of the collaborative work to refine and optimize FPC design & processing in correlation to cavity gradient and experimental results is presented.
- THP054 Last Spiral 2 Couplers Preparation and RF Conditioning** – *Y. Gomez Martinez, M.A. Baylac, P. Boge, T. Cabanel, P. De Lamberterie, M. Marton, R. Micoud (LPSC)*
 Six cryomodules are ready to be installed in the SPIRAL 2 LINAC. We present here the protocols used for the preparation and for the RF conditioning of the couplers and the obtained results.
- THP055 Ferrite Loaded Ceramic Break HOM Damper for the BNL ERL Gun** – *H. Hahn, L.R. Hammons, V. Litvinenko, W. Xu (BNL) J. Dai (Stony Brook University)*
 The Brookhaven Energy Recovery Linac (ERL) is operated as R&D setup for high-current, high charge electron beams. It is comprised of a superconducting (SC) five-cell cavity and a half-cell SC photoinjector electron RF gun. Achieving the performance objectives requires effective HOM damping in the linac and gun cavity. Among the HOM dampers being developed is a beam-tube type HOM load for the electron gun consisting of a ceramic break surrounded by ferrite tiles. This design is innovative in its approach and achieves a variety of ends including broadband HOM damping and protection of the superconducting cavity from potential damage of the separately cooled ferrite tiles. The damper properties are described by the coupling impedance to a beam and the external Q to constrain the unloaded mode Q's. Measured results for the gun damper at room and superconducting temperatures are presented
- THP056 Validation Procedures for the IFMIF Power Coupler Prototypes** – *H. Jenhani, P. Carbonnier, Y. Gasser, N. Grouas, P. Hardy, V.M. Hennion, F. Orsini, B. Renard, D. Roudier (CEA/IRFU) S.J. Einarson, T.A. Treado (CPI) D. Regidor, M. Weber (CIEMAT)*
 In the framework of the International Fusion Materials Irradiation Facility (IFMIF), which 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 design for the first phase of the project. The first two IFMIF Power Coupler Prototypes were manufactured for LIPAc. Series of acceptance tests have been performed successfully. Prototype Power Couplers have been then cleaned and assembled in an ISO 5 cleanroom. A dedicated test bench allowing RF conditioning of the couplers up to 200 kW CW at 175 MHz was achieved. RF power tests are ongoing.
- THP057 XFEL Couplers RF Conditioning at LAL** – *W. Kaabi, M. El Khaldi, A. Gallas, D.J.M. Le Pinvidic, C. Magueur, A. Thiebault, A. Verguet (LAL) W.-D. Möller (DESY)*
 In the framework of the French contribution to XFEL project, The LAL has in charge the development, the production and the RF conditioning of 800 power couplers to equip 100 cryo-modules. Thus, LAL's tasks consist on the industrial monitoring and coupler quality control at two different production sites, in addition to the RF conditioning at LAL. The conditioning process and all the preceding preparation steps are performed in a 70m² clean room. This infrastructure, its equipment and the RF station are designed to allow the treatment of 8 couplers in the same time, after a ramp-up phase. Clean room process and first conditioning results are presented and discussed.
- THP058 Update on the European XFEL RF Power Input Coupler** – *D. Kostin, W.-D. Möller (DESY) W. Kaabi (LAL)*
 European XFEL project is being currently realized in Hamburg, Germany. The 1.5 km 17.5 GeV linear electron accelerator is based on the 1.3GHz 9-cell TESLA type SRF cavity. The RF power input coupler design for the E-XFEL is based on well known TTF3 coupler design, used in FLASH accelerator. Coupler design was adapted for the industrial production with some parameters optimisation revisited and simulations done. Results are presented and discussed.
- THP059 HOM Coupler Design Adjustement for CW operation of the 1.3GHz 9-cell TESLA Type SRF Cavity** – *D. Kostin, W.-D. Möller, J.K. Sekutowicz (DESY)*
 One of the key features of a modern research facility is its versatility, ability to adjust for a multitude of the applications and user needs. A challenge for the coming European XFEL is to become a multipurpose laboratory with a broad applications spectrum. Primarily, the XFEL is a pulsed machine. Encompassing the CW mode would be a worthy addition. CW operation of the 1.3GHz 9-cell TESLA Type SRF Cavity was performed several times at DESY and other Labs successfully. One of the difficulties was a heat load of the High Order Mode (HOM) couplers. To amend this HOM coupler design adjustement is proposed, simulated and modelled. Results are presented and discussed.

- THP060 High Power RF Coupler for ADS Accelerating Cavities** – *S.V. Kutsaev, M.P. Kelly, B. Mustapha, J.A. Nolen, P.N. Ostroumov (ANL)*
Accelerator driven systems (ADS) require a high-power CW proton accelerator with proton beam energy near 1 GeV. High-gradient superconducting TEM-cavities are a natural choice for the front end of linac. This paper presents the design of superconducting low-beta half wave resonator operating at 162 MHz frequency for ADS, as well as a new 75 kW power coupler that has been designed at Argonne National Laboratory. This coupler would permit operations with an accelerating voltage of 3.0 MV with a beam current of 25 mA. The coupler includes a cold RF window which keeps the antenna at low temperature and a variable bellows section to adjust the coupling factor. The importance of these features for reliable operation will be discussed in detail.
- THP061 Developments of HOM Dampers for SuperKEKB Superconducting Cavity** – *M. Nishiwaki, K. Akai, T. Furuya, A. Kabe, S. Mitsunobu, Y. Morita (KEK)*
Eight superconducting accelerating cavities were stably operated under a high beam current and a large beam induced HOM power in KEKB electron ring. The HOM power of 16 kW at the beam current of 1.35A was absorbed in two ferrite dampers attached to each cavity. In SuperKEKB, that is the upgrade machine of KEKB, the design beam current is 2.60 A. The HOM power of 40 kW is expected to be induced. To cope with the large HOM power, precise evaluations of HOM power loads including HOM dampers were carried out. Then, new ferrite dampers with reinforced water cooling were developed and high-power tested. On the other hand, the evaluation indicated that an additional HOM damper can absorb significant amount of HOM power. Additional damper is effective to reduce each ferrite damper load. In this report, we will describe the results of high power tests of the new ferrite dampers, studies for additional dampers, and an installation plan for SuperKEKB.
- THP062 Optimisation of the 3-Stub Tuner for Matching the Diamond SCRF Cavities** – *S.A. Pande, C. Christou, M. Jensen (Diamond)*
The Diamond Storage Ring cavities are aperture coupled resulting in a fixed external Q. This results in the cavities being matched under certain conditions depending on the loss per turn, the beam current and the accelerating voltage. Operationally, there are advantages to limiting the accelerating voltage to improve reliability and lifetime, which at high beam current results in a mismatch and high reflected power. To match the cavities under such non-optimum operating conditions we use 3-stub tuners in the waveguide feeds. It has been observed, that certain configurations of the 3-stub tuners can improve the match of the cavity, but this can result in strong heating of the waveguide in the cryostat. Numerical simulations of the cavity along with the coupling waveguide and 3-stub tuners have been carried out using CST Studio for different beam loading conditions to optimise the 3-stub tuners for acceptable match and heating. In this paper we present the results of our simulations and comparisons with measurements for operation with different beam currents and cavity voltages.
- THP063 Optimization of Window Position on Diamond SCRF Cavities** – *S.A. Pande, C. Christou (Diamond)*
The Diamond storage ring uses CESR type superconducting cavities. These cavities have a fixed coupling resulting in fixed Qext which is considerably higher than the optimum. We use 3 stub tuners to match the cavities under these non-optimum conditions. Diamond 'Cavity-1' will soon be refurbished. This opportunity could be used to lower the Qext on the cavity. One of the options is to modify the coupling tongue geometry along with a matching section. This may require cutting off the beam tube with the coupler for rework or may need to be newly fabricated. With the help of CST Studio, we investigated another option to lower the Qext by optimising the location of the window with respect to the cavity, maintaining the same coupling tongue geometry. The height of the waveguide on the vacuum side of the window differs from that of the coupling waveguide on the cavity resulting in a step. The location of this step (or window) wrt the cavity makes significant difference to the ultimate Qext obtained after putting the window in place. In this paper we present the results of our numerical simulations comparing the present and the proposed window position under different operating conditions.
- THP064 HOM Couplers for CERN SPL Cavities** – *K. Papke, U. van Rienen (Rostock University, Faculty of Computer Science and Electrical Engineering) F. Gerigk (CERN)*
Higher-Order-Modes (HOMs) may affect beam stability and refrigeration requirements of superconducting proton linacs such as the SPL, which is studied at CERN as the driver for future neutrino facilities. In order to limit beam-induced HOM effects CERN considers the use of HOM couplers on the cut-off tubes of the 5-cell superconducting cavities. These couplers consist of resonant antennas shaped as loops or probes which are designed to couple to modes of a specific frequency range. In this paper the design process is presented and a comparison is made between various design options for the medium and high-beta SPL cavities, both operating at 704 MHz. The RF characteristics, thermal behaviour and multipacting sensitivity of the various designs are discussed and 2 options are presented, which will be tested as warm prototypes on 5-cell high-beta copper cavity models.
- THP065 Design of 352.21 MHz RF Power Input Coupler and Window for the European Spallation Source (ESS)** – *E. Rampnoux, S. Bousson, S. Brault, G. Olry, D. Reynet (IPN)*
A 352.21 MHz RF high power coupler window was designed by IPNO to meet the specification requirements for the ESS accelerator project. This designed is based on IPNO's power coupler developments performed in the framework of the EURISOL Design Study project for which two power couplers using coaxial technology without chokes systems around the ceramic disc have been designed and tested successfully up to 20 kW RF power level in CW mode. For ESS project, the RF power input window was developed and designed to reliability operate at an average power level of 25 kW up to 300 kW in pulsed and continuous wave modes. This 352.21 MHz RF window was developed to remove the chocks usually used and provided the following advantages: more reliability, less expensive to manufacture, better vacuum, easier cleaning, less secondary electron-multipacting with specificity to present a bandwidth close to 1 GHz.
- THP066 SARAF Phase-I HWR Coupler Cooling Design** – *J. Rodnizki, Z. Horvitz (Soreq NRC)*
The warming of the SARAF Prototype Superconducting Module (PSM) couplers is currently the main limiting factor for reaching higher CW proton beam currents. We have simulated the coupler for a matched 4 kW forward power and for a 4 kW forward power with full reflection. For both cases we simulate the heat load on the coupler with the CST MWS Frequency Domain solver. With 4 kW the induced fields in the cavity, in full reflection, will be too high relative to the nominal ones if the cavity is not detuned. The evaluation for the matched case predicts 10W heat load at the 60K cold window intercept evacuated through the copper braid by the copper thermal shield that is cooled by 60 K He gas. The temperature gradient that will be developed along the thermal leads were analyzed with ANSYS based on the CST simulated RF heat load. In the current study we modify the coupler cooling without major operations in the PSM. Increasing the cold window copper braid nominal cross section area and adding a copper braid to the top end, below the bellows to reduce the generated heat load and adopting Indium or Epizone-N as a thermal contact layer is the selected utilized configuration.

- THP067 Testing of Copper Plating Quality on ReA3 Coupler Bellows and Approach to Improved Plating for FRIB Production** – *L. Popielarski, M. Goodrich, M. Hodek, N.M. Nicholas, R. Oweiss, J. Popielarski, K. Saito (FRIB)*
 The SRF community faces difficulties finding repeatable, quality copper plating for fundamental power coupler (FPC) components. The copper plating of ten small custom bellows of $\beta=0.085$ Quarter-Wave Resonator (QWR) variable couplers for the ReAccelerator project has presented technical challenges. An improvement plan has been established and includes: better defining plating requirements and specification, creating testing processes to assure plating quality (Acceptance Criteria Listing (ACL)), identify viable plating vendors, develop clean, robust plating fixtures, procedures and quality assurance steps with multiple vendors, and perform ACL testing on plated bellows. A total of 24 prototype and production plated bellows are analyzed through acceptance testing, which include a vacuum leak check, tape test, 1000 psi water rinse, thermal cycle at 77K, borescope inspection and final leak check. Select bellows have been processed and tested with a quarter-wave resonator. A summary of the plating improvement program, plated bellows acceptance statistics, and RF test results will be reported.
- THP068 New Design of HOM Coupler Using Coaxial-like Rounded Waveguide** – *M. Sawamura (Japan Atomic Energy Agency (JAEA), Gamma-ray Non-Destructive Assay Research Group) R. Hajima, R. Nagai, N. Nishimori (JAEA)*
 It is important to damp higher-order modes (HOMs) of superconducting accelerators especially for energy-recovery linacs of high current operation. Though various types of HOM couplers, beam line HOM dampers and waveguide HOM couplers have been developed, there are some problems such as inner conductor heating of output connector for HOM couplers and low packing factor for beam line HOM dampers. We propose new design of HOM coupler. This coupler consists of a coaxial line coupled with a cavity or a beam pipe and a rounded waveguide which cuts off the accelerating mode. The rounded waveguide is similar to a coaxial line and the inner conductor and outer conductor are connected with a plate which corresponds to waveguide side wall. This enables the inner connector cooled down efficiently through the outer conductor. The calculation results of MW-STUDIO will be presented.
- THP069 Higher-Order Modes Damping in 800 MHz Superconducting Cavity** – *N.P. Sobenin, R.O. Bolgov, M. Gusarova (MEPhI) M. Zobov (INFN/LNF)*
 The dependences of higher-order modes electrodynamic characteristics on the shape and geometry of beampipes in superconducting single-cell cavity operating at 800 MHz have been investigated. The possibility of higher-order modes damping – mainly of H111 and E110 types – with introducing flutings into the beampipes, damping rings as well as radial absorbing load is considered. The suggested structures are also considered in terms of multipacting discharge appearance suppression.
- THP070 Analysis of High Order Modes in NGLS CW Linac** – *A.I. Sukhanov, A. Vostrikov, V.P. Yakovlev (Fermilab)*
 Design of Next Generation Light Source (NGLS) is currently underway. NGLS will provide soft coherent X-ray radiation for a broad spectrum of basic research applications. The central part of NGLS is continuous wave superconducting RF (CW SRF) electron linac feeding 3 free-electron laser (FEL) sections. In order to achieve design parameters of NGLS X-ray laser radiation, it is important to preserve parameters of the electron beam while it accelerates through the linac. Longitudinal and transverse beam emittances, stability of the beam transverse position are the most important parameters affecting quality of FEL radiation. High order modes (HOMs) excited in SRF structures by passing beam may deteriorate beam quality and affect beam stability. Deposition of HOM energy in the walls of SRF cavities adds to the heat load of cryogenic systems and leads to the increased cost of building and operation of linac. In this paper we evaluate effects of HOMs in NGLS linac. We analyze non-coherent losses and resonance excitation of HOMs. We estimate effects of very high frequency HOMs. We study influence of HOMs on the transverse beam dynamics.
- THP071 HOM Studies of the Cornell ERL Main Linac Cavity in the Horizontal Test Cryomodule** – *N.R.A. Valles, G.H. Hoffstaetter, M. Liepe (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*
 The Cornell energy recovery linac will accelerate a 100 mA beam to 5 GeV, while maintaining very low emittance (30 pm at 77 pC bunch charge). A major challenge to running such a large current continuously through the machine is the effect of strong higher-order modes (HOMs) in the SRF cavities that can lead to beam breakup. This paper presents the results of HOM studies for the prototype 7-cell cavity installed in a horizontal test cryomodule (HTC). HOM measurements were done for three HTC assembly stages, from initial measurements on the bare cavity to being fully outfitted with side-mounted RF input coupler and beam line HOM absorbers. We compare the simulated results of the optimized cavity geometry with measurements from all three HTC experiments, demonstrating excellent damping of all dipole higher order modes.
- THP072 Input Coupler for Cornell ERL Main Linac** – *V. Veshcherevich, P. Quigley (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*
 Each cavity of the Cornell ERL Main Linac has a single coaxial type input coupler with fixed coupling, $Q_{ext} = 6.5 \times E7$. The input coupler will operate at RF power up to 5 kW at full reflection. The coupler design is based on the design of TTF-III input coupler with appropriate modifications and with taking into account the Cornell experience with couplers for ERL Injector. Seven couplers have been fabricated by CPI, Beverly and tested at Cornell on the test stand up to 5 kW CW. No major issues were noticed during the test. One coupler was attached to the prototype linac cavity. The cavity was successfully tested with great results achieved inside the horizontal test cryomodule. Six other couplers will be installed in the Main Linac Cryomodule (MLC) Prototype.
- THP073 HOM Dampers and Waveguide for the Short Pulse X-Ray (SPX) Project** – *G.J. Waldschmidt, B. Brajuskovic, G. Wu (ANL)*
 The production of HOM dampers for the superconducting SPX cavities has been undertaken at the Advanced Photon Source. The dampers are vacuum compatible loads that utilize a four wedge design in WR284 rectangular waveguide. The rf lossy material consists of hexoloy silicon carbide (SiC) due to its suitable mechanical and electrical material properties. Issues regarding manufacturing consist of initial SiC material failure due to fabrication stresses as well as substandard soldering bonds of the SiC to the copper damper bodies. In addition, integration into the cryomodule consists of rf, thermal, and mechanical design considerations of the dampers and the waveguide transmission lines. An analysis of the manufacturing and integration issues and remedies are discussed further in this paper.
- THP074 Update on Quarter-Wave Coaxial Coupler for 1.3GHz Superconducting Cavity** – *Y. Xie, A. Kanareykin (Euclid TechLabs, LLC) N. Solyak, V.P. Yakovlev (Fermilab)*
 A new quarter-wave coaxial detachable coupler that preserves the axial symmetry of the cavity geometry and rf field of the 1.3 GHz superconducting cavity has been designed by Euclid Techlabs. A flange with superconducting joint is placed at the zero magnetic field region on the beam tube for the connection between coupler and the cavity. This design also enables processing coupler separately. Update on the engineering design, fabrication process will be reported. The rf test of the coaxial detachable coupler with a single cell cavity is scheduled at the end of 2013.

- THP075 **Hexapod Systems for Ultra-High Vacuum Applications with Active Vibration Damping** – *M. Acchiardi (PI France SAS)*
Hexapods are widely used for positioning objects in six dimensions of freedom with high precision down to the submicron range. For applications in ultra-high-vacuum atmosphere, a Hexapod was designed that uses a driving principle with motors outside of the vacuum atmosphere. In this new design, an active vibration damping system based on piezoelectric actuators in combination with a newly developed 6-D acceleration sensor was implemented.
- THP076 **Reliability of Multilayer Piezoelectric Actuators in Precise Positioning Applications** – *M. Acchiardi (PI France SAS)*
The piezoelectric multilayer actuator technology is an essential tool in ultra-precise nano-positioning. For the further spreading into new applications it is very important to exactly know and specify the operating limits of these actuators. This work presents a DC-signal-lifetime calculation tool for PICMA® co-fired multilayer actuators as a result of an extensive study at different temperature and humidity conditions. Furthermore, AC-results for several driving signals, pre-stress, and temperature conditions are shown.
- THP077 **Coaxial Blade Tuner for European XFEL 3.9 GHz cavities** – *R. Paparella, M. Bertucci, A. Bosotti (INFN/LASA) C. Pagani (Università degli Studi di Milano & INFN)*
The European XFEL linac injector features a third harmonic section jointly realized by INFN and DESY and hosting a 3.9 GHz 9-cell cavities cryomodule. The cold tuning system, developed by INFN for these cavities, is inspired by the coaxial Blade Tuner already qualified for ILC cavities. Design, fabrication and room temperature qualification of first tuner units produced are reviewed in this paper.
- THP078 **Deformation Tuner Design for a Double Spoke Cavity** – *N. Gandolfo, S. Bousson, S. Brault, P. Duchesne, G. Olry, D. Reynet (IPN)*
IPN Orsay is developing the low-beta double Spoke cavities cryomodule for the ESS. Based on previous successfully tested prototypes, a fast/slow tuner has been studied to compensate resonance frequency variations of the cavity during operation. The typical perturbations are coming from LHe pressure variations as well as microphonics and Lorentz force detuning (LFD). Two tuners are being built in order to validate both expected performances and series production feasibility. In this paper, the tuner design of the double Spoke cavity is presented.
- THP079 **Improvement of the Pneumatic Frequency Tuner of the Superconducting Resonators at IUAC** – *A. Pandey, G.K. Chaudhary, R.N. Dutt, S. Ghosh, D. Kanjilal, J. Karmakar, D.S. Mathuria, P. Patra, A. Rai, A. Roy, B.K. Sahu, S.K. Saini (IUAC)*
The existing phase locking scheme of the quarter wave resonators used in superconducting linear accelerator of Inter University Accelerator Centre consists of a fast (electronic) and a slow time scale (pneumatic) control. Presently, helium gas operated mechanical tuners are being used to phase lock the resonators against the master oscillator frequency and different ion beams have been accelerated and delivered to conduct experiments. The present pneumatic frequency tuner has two limitations: (a) no proportional flow control in vacuum condition (b) large hysteresis problem in the proportional valve responsible for gas flow control. Due to these limitations, the system becomes non-linear and the response time is very slow (~sec). Using the existing system, phase locking of a resonator becomes delicate and time consuming. In addition, it was found to be difficult to implement auto phase locking mechanism on the resonator. To overcome these problems and to improve the dynamics of the existing tuner, a new pneumatic tuning system has been adopted. Details of the existing tuning mechanism and the modified tuning system along with the test results will be presented in the paper.
- THP080 **SRF Cavity Tuning for Low Beam Loading.** – *N. Solyak, E. Borissov, I.V. Gonin, C.J. Grimm, W. Schappert, V.P. Yakovlev (Fermilab)*
The design of 5-cell elliptical 650 MHz $\beta=0.9$ cavities to accelerate H^- beam of 1 mA average current in the range 467-3000 MeV for the Project X Linac is currently under development at Fermilab. The low beam current enables cavities to operate with high loaded Q's and low bandwidth, making them very sensitive to microphonics. Mechanical vibrations and the Lorentz force can drive cavities off resonance during operation; therefore the proper design of the tuning system is very important part of cavity mechanical design. In this paper we review the design, performance, operation, reliability and cost of fast and slow tuners for 1.3 GHz elliptical cavities. We also present a design of the slow and fast tuners for 650 MHz $\beta=0.9$ cavities based on this experience. The HV in the new design is equipped with the tuners located at the end of the cavity instead of the initially proposed blade tuner located in the middle. We will present the results of ANSYS analyses of mechanical properties of tuners.
- THP081 **Testing of a Tuner for the IMP 162.5 MHz SRF Half-Wave Resonator** – *S. He, Y. He, L.B. Liu, F.F. Wang, S.H. Zhang (IMP)*
The tuner for the IMP 162.5 MHz $\beta=0.093$ SRF half-wave resonator has been developed to control Lorentz force detuning and compensate for liquid Helium pressure fluctuations. The design uses an external stepper motor and gear box for coarse cavity adjustment. To reduce the force requirements of the actuator, a lever arm and scissor jack mechanism was developed. The tuner design and results of warm tests of the first prototype are presented.
- THP082 **Fast Detuning Experiment on an SPX0 Cavity During Horizontal Cavity Test** – *G. Wu (JLAB) N.D. Arnold, T.G. Berenc, J. Carwardine, A.R. Cours, J.D. Fuerst, J.P. Holzbauer, D. Horan, A. Nassiri (ANL) Y. Yang (TUB)*
Short Pulse X-ray beamlines occupy a limited number of sectors after the APS Upgrade. The majority of APS users will not participate in the SPX experiment. As user operation requires the best beam availability, it is important that any SPX-related circuit trip that requires the extinguishment of rf power should not affect overall beam availability. As such, it is necessary to de-couple the SRF cavities from beam when such an rf trip happens. An example of such trip is that the rf window arcing has to be stopped within 1 ms, before serious damage occurs to the ceramic. As the rf amplifier shuts down the rf output, beam-driven cavity power has to be reduced, too. If cavity can be detuned fast enough and far enough away from its resonance, the beam does not have to be aborted. The SPX0 tuner is equipped with a fast response Piezo actuator in the cavity tuner stack. Such a Piezo may be able to provide a quick jolt of the cavity to provide detuning capability for the purpose of maintaining the beam in the event of an rf trip. In this paper, we describe the experimental setup and results obtained, and discuss its effectiveness for beam operation.
- THP083 **Mechanical Design of a Warm Tuner for a Multi-Cell SRF Cavity of Nanjing University** – *P.P. Xue, S. An (PLAI) L. Zhang (Chang'an University) Z.R. Zhang (Geneva w/o affiliation)*
A superconducting RF (SRF) cavity is being considered to accelerate the proton beam in the Proton Beam Application Project at Nanjing University. In order to correct the frequency shift and the field flatness variation of the TM010 π mode of the multi-cell (SRF) cavity caused by manufacturing errors and welding shrinkage during its production, a field flatness warm tuner has been designed. In this paper, the warm tuner's design, fabrication and test results have been presented.

- THP084 The Tuning System for the HIE-ISOLDE High-Beta Quarter Wave Resonator** – P. Zhang, L. Alberty, L. Arnaudon, K. Artoos, O. Capatina, A. D'Elia, Y. Kadi, T. Renaglia, D. Valuch, W. Venturini Delsolaro (CERN)
 A new linac using superconducting quarter-wave resonators (QWR) is under construction at CERN in the framework of the HIE-ISOLDE project. The QWRs are made by Niobium sputtered on a bulk Copper substrate. The working frequency at 4.5 K is 101.28 MHz and they will provide 6 MV/m accelerating gradient on the beam axis with a total maximum power dissipation of 10 W on each cavity walls. A tuning system is required in order to both minimize the forward power variation in operation and to compensate the unavoidable uncertainties in the frequency shift during the cool-down process. The tuning system has to fulfill a complex combination of RF, structural and thermal requirements. The paper presents the functional specifications and details the tuning system RF and mechanical design and simulations. The results of the tests performed on a prototype system are discussed and the industrialization strategy is presented in view of final production.
- THP085 Equipping FLASH with MTCA.4-based LLRF System** – J. Branlard, V. Ayvazyan, M.K. Grecki, I.M. Kudla, F. Ludwig, U. Maurič, K.P. Przygoda, H. Schlarb, Ch. Schmidt (DESY) K. Oliwa, W. Wierba (IFJ-PAN)
 The Free-Electron Laser in Hamburg (FLASH) is now equipped with a MicroTCA-based (MTCA.4) low-level radio frequency (LLRF) system, to replace the previous VME system and to serve as a test bench for the European X-ray Free Electron Laser (XFEL) LLRF system. This paper presents details on the new FLASH LLRF system setup, including installations inside the radiation prone tunnel environment. The benefits and preliminary results of the newly installed system are also given.
- THP086 LLRF System Design and Performance for XFEL Cryomodule CW Operation** – J. Branlard, K.P. Przygoda, H. Schlarb, J.K. Sekutowicz (DESY) W. Cichalewski, W. Jałmużna, A. Piotrowski (TUL-DMCS)
 The Cryomodule Test Bench (CMTB) at DESY is equipped with a 100 kW Inductive Output Tube (IOT) allowing the test of superconducting cryomodules in continuous wave (CW) operation mode. Although significantly different from the nominal pulsed operation mode of the European X-Ray Free Electron Laser (XFEL), CW operation can be handled by the same Low-level Radio Frequency (LLRF) system, within minor firmware modifications. The hardware details of the LLRF setup at CMTB, the firmware and software architecture and performance results from the last CW test are presented in this contribution.
- THP087 LLRF Tests of XFEL Cryomodules at AMTF: First Experimental Results** – J. Branlard, V. Ayvazyan, O. Hensler, H. Schlarb (DESY) W. Cichalewski, K. Gnidzińska, A. Piotrowski (TUL-DMCS)
 In preparation for the series production of cryomodules for the European X-ray Free Electron Laser (XFEL), three pre-series cryomodules and several prototypes have been produced and tested at the Cryomodule Test Bench (CMTB) and at the Accelerating Module Test Facility (AMTF) in DESY. Among the numerous tests performed on the modules, the low-level radio frequency (LLRF) tests aim at characterizing the performance of the modules from an RF controls perspective. These integration tests must take into account cavity tuners, cavity motorized couplers, quench gradients, microphonics, piezo control and the overall gradient performance of the cryomodule under test. In this paper, the LLRF-specific tests are summarized and the first experimental results obtained at CMTB and AMTF are presented.
- THP088 Next Generation Cavity and Coupler Interlock for the European XFEL** – A. Gössel, M. Mommertz, D. Tischhauser (DESY)
 The safe operation of cavities and couplers in the European XFEL accelerator environment will be secured by a new technical interlock (TIL) design, which is based on the XFEL crate standard (MTCA(TM).4). Based on previous interlocks at HERA, FLASH and most recent at the XFEL Accelerator Module Test Facility (AMTF), the functionality needs to be further improved in many ways. The new interlock will be running inside the accelerator tunnel. Several remote test capabilities will make sure the correct operation of sensors for light, temperature and free electrons. The digitizing of the fast signals for monitoring and external analysis is now included in the interlock itself. Due to the space costs and the very high number of channels, the electronic concept was moved from a conservative, mostly analog electronic approach, with real comparators and thresholds, to a concept, where the digitizing of the signals will be done at a very early stage. Filter, thresholds and comparators are moved into the digital part. The usage of a FPGA and an additional watchdog will increase the flexibility dramatically, in respect to be as reliable as possible. An overview of the system will be shown.
- THP089 Design of LLRF System for RAON** – H. Do, O.R. Choi, J. Han, J.-W. Kim (IBS)
 The low-level RF (LLRF) system being designed for RAON will allow research in the rare isotope beam facility. The LLRF system is used to feed the superconducting quarter-wave resonator having the frequency of 81.25 MHz with controlled the amplitude and phase of RF. The LLRF system uses a field programmable gate array (FPGA) to provide controlled RF amplitude and phase with $\pm 1^\circ$ and less than $\pm 1\%$ of stabilities, respectively. The resolution and working range is 0.004 dB and 20 dB in amplitude, respectively, and 0.5° and 360° in phase. For the RF performance test, a prototype of LLRF system is designed and fabricated. This paper will describe the design detail. Also, testing results of the prototype of LLRF system are presented.
- THP090 Compact Interlock System for Supratech High Power RF teststand** – A. Hamdi, M. Desmons, J. Novo (CEA/DSM/IRFU) F. Ballester (CEA) F. Barbet (PL Systems)
 Supratech is a facility at CEA/Saclay that enables tests on superconducting and high power RF components for particle accelerators. The facility comprises a home-made hard tube HV modulator powering up to 95kV-20A at 2.1ms/50Hz and a 700MHz pulsed klystron developed by CPI able to produce RF up to 1MW-2ms/50Hz. A new compact HV and RF interlock system including klystron HV diagnostics has been implemented on Supratech test facility. This paper describes in more detail the klystron interlock system and the results of the first tests.
- THP091 Stability Test of 7 kW SSPA for QWR SC Cavity RF System** – J. Han (IBS)
 The RAON accelerator planned SC linac in Korea will use solid state power amplifiers to provide superconducting cavities with rf power. The RAON accelerator is composed of a normal conducting injector and a SC linac. We are going to provide for in house development about all SSPA. The papers describes the test result for 81.25 MHz, 7 kW SSPA.
- THP092 Study of an Alternative Method of Superconducting RF Cavity Test Data Analysis** – J.P. Holzbauer (ANL)
 Traditional SRF cavity fabrication revolves around performance characterization through vertical testing. This testing is done with two rf ports, one weakly coupled field probe, and one near-matched input power coupler. The goal of this testing is to determine the quality factor of the cavity at different cavity stored energies up to its ultimate performance. These two ports produce three signals: forward and reverse power from the input power probe and transmitted power from the pick-up probe. At the beginning of a cavity test, however, the coupling factors for each port are also unknown. Low-power static measurements can be combined with time-domain measurements of the cavity's fill/empty time constant, allowing calculation of the coupling factors. The measured coupling factor of the pick-up port is then taken as a constant for further steady-state measurements at higher fields while discarding the input coupling strength. This paper is an investigation into the possible use of the input coupling strength in high-field measurements and the resultant changes in overall measurement errors in different scenarios.

- THP093 **Fundamental Mode Spectrum Measurement of RF Cavities with RLC Equivalent Circuit** – *K. Kasprzak, M. Wiencek (IFJ-PAN)*
 The procedure of the cavity fundamental mode spectrum measurement consists of the following steps: scanning of the accelerating mode passband for any deviation from the standard one, determining all peaks in the accelerating mode passband and evaluating the mean spectrum frequency deviation. The upgrade of that procedure is proposed. The cavity RLC equivalent circuit is used in order to predict the measured peaks. This method allows more quickly detects the peaks in the accelerating mode passband thereby reduce the testing time, which is crucial for serial production cavities testing. In this paper, an upgrade of the testing procedure and its validation with measurements is presented. The method was validated with data taken during testing of the XFEL cavities installed in two pre-series cryomodules. This improvement of the test procedure is implemented into the testing software and it is successfully using for serial production cavities testing.
- THP094 **Beam Induced HOM Analysis in STF Accelerator** – *A. Kuramoto (Sokendai) H. Hayano (KEK)*
 Requirements of superconducting cavity (SC) alignment for ILC are less than 300 μm offset and 300 μrad tilt with respect to cryomodule. It is necessary to measure their offset and tilt inside of cryomodule. Cavity offset has been already measured by using beam induced HOM at FLASH in DESY. Cavity deformation during assembly and by cooling contraction has not been examined yet. To detect their tilt and bending, we measured HOM signals with beam trajectory sweep. Our interesting modes are pi over nine mode in the first dipole passband (TE111-1) which is trapped mode has maximum radial electric field in the middle cell and beam pipe modes localized in the both end-group of the SC. These modes tell us electrical center of middle cell and electrical centers at both beam pipe. We can know cavity tilt and bending from combinations of them. The experiment to find these HOM was performed at STF accelerator. Electron beam extracted from the RF Gun was accelerated to 40 MeV by the SC cavities. We could find TE111-1 and beam pipe modes. These HOM signals were correlated with beam orbit, accelerating field gradient. The detailed data analysis is introduced in this paper.
- THP095 **Error Analysis for Vertical Test Stand Cavity Measurements at Fermilab.** – *O.S. Melnychuk (Fermilab)*
 Overview of Vertical Test Stand (VTS) facility at Fermilab is presented. Uncertainty calculations for the measurements of quality factor and accelerating field are described Sources of uncertainties and assumptions on their correlations are reviewed. VTS hardware components with non-negligible instrumental errors are discussed. Relative contributions of individual sources to the total uncertainties are assessed. Stability of VTS test results with respect to potential mismeasurements of calibration coefficients and decay constant are studied. Methods of identifying and distinguishing different types of potential hardware problems, based on analysis of VTS observables, are introduced.
- THP096 **Recent Upgrade of Ultra-Broadband RF System for Cavity Characterization** – *S. Stark, V. Palmieri, A.M. Porcellato, A.A. Rossi (INFN/LNL)*
 The first computer controlled RF system for SC cavity characterization entered into operation at INFN-LNL in 1994. Since then it has been successfully used for testing SC cavities of different shapes and frequencies. Recently we performed an important upgrade on it in order to cover a wider frequency range and to take advantage of the better performance of nowadays electronic devices. The paper describes the present system layout, dedicated software, sequences of calibration and testing procedures and moreover discusses further upgrading possibilities.
- THP097 **Use of Waveguide Probes as Beam Position and Tilt Monitoring Diagnostics with Baseline and Alternative Superconducting Deflecting Cavities for an SPX Project at the APS*** – *X. Sun, G. Decker, G. Wu (ANL)*
 A set of superconducting deflecting cavities will be used for the Short-Pulse X-Ray (SPX) project as part of the APS upgrade. A TM-mode baseline deflecting cavity design has been developed and prototyped, while an alternative design based on a TE-like-mode is being studied. Waveguide field probes associated with the baseline and alternative superconducting deflecting cavities are explored as beam position and tilt monitoring diagnostics. Microwave Studio was used to simulate the technique of detecting the fields excited by a Gaussian bunch passing through the cavities to determine beam position relative to the electrical center. Probes installed on the horizontal midplane in the beam pipe are promising diagnostics for monitoring beam position and tilt.
- THP098 **LLRF and Data Acquisition Systems for Spoke 012 Cavity Vertical Test at IHEP** – *J. Zhang, J.P. Dai, H. Huang, H.Y. Lin, W.M. Pan, Y. Sun, B. Xu (IHEP)*
 Development of two Spoke 012 cavities and their vertical tests have been completed successfully at IHEP with a LLRF system and DAQ (data acquisition) system specially designed. The LLRF system is developed on the basis of the proven analog system used for the test of the BEPCII 500 MHz spare cavity. The Labview 2009-based DAQ system is in charge of the communications of the measuring instruments, the local machine and the remote machine. It also completes drawing the test curve online and obtaining the test result in real time. The data connection between Labview and EPICS is implemented. The vertical test result shows that the LLRF system and the DAQ system in operation perform stably and reliably as expected. This paper introduces the two systems and the general situation for Spoke 012 cavity vertical test.

26-Sep-13	18:00 – 19:00	Oral	Room Adenauer
THHT — Hot Topic: What is the best surface treatment for high Q and medium gradient ?			

27-Sep-13	08:00 – 09:15	Oral	Room Adenauer
FRIOA — New cavity Design: Deflecting and Other Structures			
FRIOA01	LHC Crab Cavity: Progress and Outlook – R. Calaga (CERN)		
08:00	Three novel superconducting RF crab cavity designs proposed for the LHC luminosity upgrade have rapidly progressed. First Niobium prototypes are reaching close to the design performance and beyond. The highlights of the RF test results from the prototypes along with design modifications for initial beam tests in the SPS are presented. The status of the cryomodule development, integration into the SPS and the beam tests in view of validating the crab cavity system for LHC upgrade are addressed.		
FRIOA02	Developing Quarter Wave SRF Cavities for Hadron Colliders – Q. Wu (BNL)		
08:20	Quarter Wave Resonators (QWRs) have been widely used in low-beta accelerators around the world because of their compact size at low frequency. Recently, application of QWRs is carrying over into hadron colliders aiming at various goals. A 56 MHz superconducting QWR is under testing at Brookhaven National Lab (BNL). It will be installed in the Relativistic Hadron Ion Collider (RHIC) as a storage cavity, which would be the first QWR operating in a high energy storage ring. A Compact crab cavity using QWR concept is another active SRF project at BNL. This crab cavity is a candidate for the Large Hadron Collider HiLumi upgrade, as well as for the future electron-ion collider (eRHIC). We report the design, fabrication, and testing results for the QWRs for hadron colliders under development at BNL.		
FRIOA03	Fabrication and Testing of Deflecting Cavities for APS – J.D. Mammoser (JLab) P. Dhakal, R.A. Rimmer, H. Wang (JLAB) J.P. Holzbauer, G. Wu, Y. Yang (ANL)		
08:40	Abstract Jefferson Lab in Newport News, Virginia, in collaboration with Argonne National Laboratory, Argonne, IL, has fabricated and tested three production, 2.815 GHz crab cavities for Argonne's Short-Pulse X-ray project. These cavities are unique in that the cavity and waveguides were milled from bulk large grain niobium ingot material directly from 3D CAD files. No forming of sub components was used with the exception of the beam-pipes. The cavity and helium vessel design along with the RF performance requirements makes this project extremely challenging for fabrication. Production challenges and fabrication techniques as well as testing results will be discussed in this paper.		
FRIOA04	Superconducting RF-Dipole Deflecting and Crabbing Cavities – S.U. De Silva, J.R. Delayen (ODU)		
09:00	Recent interests in designing compact deflecting and crabbing structures for future accelerators and colliders have initiated the development of novel rf structures. The superconducting rf-dipole cavity is one of the first compact designs with attractive properties such as higher gradients, higher shunt impedance, the absence of lower order modes and widely separated higher order modes. Two rf-dipole designs of 400 MHz and 499 MHz have been designed, fabricated and tested as proof-of-principle designs of compact deflecting and crabbing cavities for the LHC high luminosity upgrade and Jefferson Lab 12 GeV upgrade. The first rf tests have been performed on the rf-dipole geometries at 4.2 K and 2.0 K in a vertical test assembly with excellent results. The cavities have achieved high gradients with high intrinsic quality factors, and multipacting levels were easily processed.		
27-Sep-13	09:15 – 10:15	Oral	Room Adenauer
FRIOB — New cavity Design: Accelerating structures I			
FRIOB01	SRF Cavities for Future Ion Linacs – Z.A. Conway, M.P. Kelly, B. Mustapha, P.N. Ostroumov (ANL)		
09:15	There is considerable interest worldwide in the applications of high-intensity (>5 mA) high-energy (>200 MeV) ion accelerators and the research which could be done with these machines. This presentation will present results of the three year ANL study funded specifically to make possible substantial reductions in the size and cost for future ion linacs in the region $\beta < 0.5$. Applications include basic research, medical isotope production, and accelerator driven systems. High-performance low-beta resonators are key components of all of these machines. Recent 72.75 MHz, $\beta = 0.077$, quarter-wave resonator cold test results, designs and their impact on next generation ion accelerators are discussed. Peak fields in excess of 166 mT and 117 MV/m have been achieved and future work to improve upon this will be discussed.		
FRIOB02	Development and Performance of 325 MHz Single Spoke Resonators for Project X – L. Ristori, M.H. Awida, P. Berrutti, C.M. Ginsburg, I.V. Gonin, S. Kazakov, T.N. Khabiboulline, M. Merio, T.H. Nicol, D. Passarelli, O. Pronitchev, A.M. Rowe, D.A. Sergatskov, A.I. Sukhanov, V.P. Yakovlev (Fermilab)		
09:30	Two types of single spoke resonators will be utilized for beam-acceleration in the low energy part of the Project X linac. SSR1 and SSR2 operate at 325 MHz and at an optimal beta of 0.22 and 0.51 respectively. After the initial phase of prototyping, a production run of 10 SSR1 resonators was recently completed in US industry. The qualification of this group of resonators in the Fermilab VTS is proceeding successfully and nearly complete. The first qualified resonator has been outfitted with a Stainless Steel helium vessel. Preliminary test results for the first jacketed SSR1 are presented. The first RF power couplers were ordered, the design of the double-lever tuning mechanism is almost complete.		
FRIOB03	Development of 650 MHz cavities for the GeV Proton Accelerator in Project X – S.S. Som, P. Bhattacharyya, A. Dutta Gupta, S. Ghosh, A. Mandal, S. Seth (VECC)		
09:45	Project X is a GeV range high intensity proton linear accelerator being developed at Fermilab, USA in collaboration with various American and Indian laboratories as well. In stags ⁻¹ of the project, the CW linac structures with different velocity factor (beta) accelerate proton up to 3 GeV at an average beam current of 1 mA. For acceleration from 180 to 480 MeV, the development of 650 MHz, beta 0.61, 5-cell elliptical SRF cavities has been taken up by VECC. The EM design and analysis of this cavity, carried out using 2D and 3D codes, will be discussed along with its structural and mechanical modal analysis. This design has been compared with the designs made by JLab and Fermilab. The presence of higher order modes (HOMs) for the said cavity has been thoroughly examined. The multipacting analysis will be presented using 2D code and also 3D CST Particle Studio code with due consideration of Furman model for secondary electron emission comprising of true, elastic and rediffused secondary electrons. The prototype development and low power testing of this cavity will be discussed here. The talk will be concluded with the probable SRF challenges to be faced in the development of the cavity.		
FRIOB04	CERN Developments for 704 MHz Superconducting Cavities – O. Capatina, G. Arnau-Izquierdo, S. Atieh, S. Calatroni, J.K. Chambrillon, R. Garoby, F. Gerigk, M. Malabaila, L. Marques Antunes Ferreira, S. Mikulas, V. Parma, T. Renaglia, K.M. Schirm, T. Tardy, A. Vande Craen (CERN) I. Aviles Santillana, R. Bonomi, N. Valverde Alonso (ESS) F Pillon (Kraftanlagen Nukleartechnik GmbH)		
10:00	The Superconducting Proton Linac (SPL) is an R&D effort coordinated by CERN in partnership with other international laboratories. It is aiming at developing key technologies for the construction of a multi-megawatt proton linac based on state-of-the-art RF superconducting technology, which would serve as a driver in new physics facilities for neutrinos and/or Radioactive		

Ion Beam (RIB). Amongst the main objectives of this R&D effort, is the development of 704 MHz bulk niobium $\beta=1$ elliptical cavities, operating at 2 K with a maximum accelerating gradient of 25 MV/m, and the testing of a string of cavities integrated in a machine-type cryomodule. The cavity together with its helium tank had to be carefully designed in coherence with the innovative design of the cryomodule. New fabrication methods have also been explored. Five such niobium cavities and two copper cavities are in fabrication. The key design aspects are discussed, the results of the alternative fabrication methods presented and the status of the cavity manufacturing and surface preparation is detailed.

27-Sep-13	10:45 – 11:25	Oral	Room Adenauer
FRIOC — New cavity Design: Accelerating structures II			

FRIOC01 Design of the 352 MHz, beta 0.50, Double-Spoke Cavity for ESS – *P. Duchesne, S. Bousson, S. Brault, P. Duthil, G. Olry, D. Reynet (IPN) S. Molloy (ESS)*

The ESS proton accelerator contains a superconducting sector consisting in three families of superconducting radiofrequency (SRF) bulk niobium cavities, operating at a nominal temperature of 2K: a family of Spoke cavities for the medium energy section followed by two families of elliptical cavities for higher energies. The superconducting Spoke section, having a length of 58.6m, consists of 14 cryomodules, each of them housing two 352.2 MHz $\beta=0.50$ Double-Spoke Resonators (DSR). The operating accelerating field is 8MV/m. The choice of the Spoke technology is guided by the high performances of such structures. Benefitting from 10 years of extensive R&D experience carried out at IPNO, the electromagnetic design studies came out with a solution that fulfills requirements of beam dynamics analysis and manufacturing considerations. Pursuing the same objective, the mechanical design of the cavity and its helium vessel were optimized by performing intensive coupled RF-mechanical simulations. We propose to present a review of the RF and mechanical design studies of the Spoke cavity. We will conclude with the integration of the Spoke cavity with its ancillaries inside the cryomodule.

FRIOC02 Cryomodules with Elliptical Cavities for ESS – *G. Devanz (CEA/DSM/IRFU)*

11:05 The accelerator of the European Spallation Source (ESS) is a 5 MW proton linac to be built in Lund Sweden. Its superconducting section is composed of 3 cavity families: double spoke resonators, medium beta and high beta elliptical multicell cavities. This paper presents the electromagnetic and mechanical design of the 704.42 MHz elliptical cavities. Both elliptical families are housed in 4-cavity cryomodules which share a common design and set of components which will be described here.

27-Sep-13	11:25 – 12:25	Oral	Room Adenauer
FRIOD — Keynote Talk			

FRIOD01 Pathways to an Higgs Factory – *H. Murayama (IPMU)*

11:25 Not submitted yet.

FRIOD02 Quantum Measurement with "Trapped" Microwave Photons in a SRF Cavity – *M.B. Brune (LKB)*

11:55 We present experiments where photons are trapped in a nearly ideal "photon box" as introduced by Einstein and Bohr in one of the gedanken experiments they introduced for discussing the unbelievable strangeness of quantum theory. Our photon box consists in a high Q cavity trapping microwave photons between superconducting mirrors. In the experiments, we probe and manipulate the trapped microwave field with single Rydberg atoms, which act as extremely sensitive and even non-destructive probes of the cavity field. We will show how this system is used for exploring the most fundamental aspects of quantum theory of measurement such as state collapse or the occurrence of quantum jumps in a quantum dynamic. The problem of the transition between the quantumness of small isolated quantum systems as opposed to the classical behavior of the measurement apparatus will also be addressed by preparing a "Schrödinger kitten" state of the field and by observing its decoherence.

27-Sep-13	12:25 – 13:00	Oral	Room Adenauer
FRTA — Student Awards and Closing			

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