SRF2011 CHICAGO

15th International Conference on RF Superconductivity

Chicago, Illinois USA
July 25-29, 2011

Hosted by

Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439

and

Fermi National Accelerator Laboratory
P.O. Box 500
Batavia, IL 60510

WELCOME

Dear Attendee,

On behalf of the International Program Committee (IPC), we would like to welcome you to Chicago for the 15th International Conference on RF Superconductivity (SRF2011) hosted by Argonne National Laboratory and Fermi National Accelerator Laboratory.

We are truly gratified to have more than 350 registered attendees this year, nearly 100 tutorial attendees and more than 45 students participating in the student poster sessions. The IPC has tried to be receptive to the community desire to expand time for posters, and provide genuinely useful and stimulating "hot topic" discussions. We hope you agree.

We also acknowledge up front the generous support of our worldwide sponsors.

Lastly, we hope you enjoy the conference and your stay in our city.

Sincerely,

Michael Kelly
Program Committee Co-Chair

Robert Kephart
Program Committee Co-Chair

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Contact E-mail: SRF2011@anl.gov

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GENERAL INFORMATION

CONFERENCE VENUE

Sheraton Chicago Hotel & Towers
301 East North Water Street
Chicago, IL 60611 USA
Phone: 1-312-464-1000
Fax: 1-312-464-9140
E-mail: info@sheratonchicago.com
URL: www.sheratonchicago.com/

REGISTRATION/INFORMATION DESK

Registration materials (i.e., conference badge, banquet tickets) will be available at the registration desk located outside the Sheraton Chicago Ballroom Promenade.

Sunday, July 24	16:00 – 20:00	Wednesday, July 27	07:30 – 15:00
Monday, July 25	07:00 – 17:00	Thursday, July 28	07:30 – 17:00
Tuesday, July 26	07:30 – 17:00	Friday, July 29	07:30 – 13:00

WELCOME RECEPTION - SUNDAY, JULY 24TH

You are invited to join us for a Welcome Reception on Sunday, July 24, at 18:00 in the Sheraton Chicago Ballroom Promenade. While there you can check-in, receive your conference materials and enjoy refreshments.

BREAKS AND LUNCHES

Refreshment breaks are at 10:15 each day and 16:00 during poster sessions. Lunch breaks are from 13:00–14:30. A list of restaurants near the Sheraton Chicago Hotel & Towers is included with the information you received at registration. Please feel free to ask the concierge for additional recommendations.

INTERNET & WIRELESS SERVICE

Internet service is available at The Link @ Sheraton Café located on Level 2. Complimentary wireless networking is available in the SRF meeting rooms.

An online agenda/program is available at http://appora.fnal.gov/pls/srf11/agenda.html

INFORMATION FOR SPEAKERS

All presentations should be submitted through the SRF2011 Author Account at http://appora.fnal.gov/pls/srf11/profile.html ahead of time. A monitor will be available near the registration are to view the editing status of your paper.

Invited Talks

Invited talks will take place in Sheraton Ballrooms IV & V starting at 08:00 each morning. Speakers should upload a PDF of their slides through the SRF2011 Author Account 45 minutes prior to the talk. Slides will be available to participants online during the presentation via the SRF2011 website.

Poster Sessions

Poster Sessions will take place in Sheraton Ballrooms I, II, & III. Presenters should upload a PDF of their poster for inclusion in the proceedings.

Student Poster Session	Sunday, July 24	16:00-18:00 (displayed until 20:00)
Poster Session 1	Monday, July 25	14:30-18:00
Poster Session 2	Tuesday, July 26	14:30-18:00
Poster Session 3	Thursday, July 28	14:30-18:00

Poster Display and Removal

You may put your poster up any time after 08:00 on the day of your poster session. Your poster must be on display by 14:30 on the day of your presentation. The poster Paper IDs will be displayed on the boards. Mount your poster on the board labeled with your Paper ID. **Please remove your poster at the end of your poster session.**

Proceedings

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 SRF2011 Author Account and detailed instructions can be found at the SRF2011 website. **The deadline for the submission of contributions to the proceedings is the first day of the conference Monday, July 24, 2011.**

The preliminary proceedings will be available on the SRF2011 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 Proceedings Editor, Maria Power.

The Proceedings Office will be located in the Missouri Room on Level 2 of the Sheraton.

TOURS OF ARGONNE AND FERMILAB – FRIDAY, JULY 29

Tours to the SRF facilities at Argonne National Laboratory and Fermi National Accelerator Laboratory have been organized. Attendees can choose to go to one or the other, but not both. The buses will leave on Friday, July 29th, at 13:00 from the Lower Lobby of the hotel in the bus/departure area. The tour will last approximately two hours and the buses will return to the Sheraton at ~17:30. Assorted boxed lunches will be provided on the buses.

In order to attend the tour at Argonne National Laboratory, you **MUST** be pre-registered. All visitors (except children under the age of 17) are required to present photo identification, such as a driver's license or passport, to receive a gate pass.

Gate passes will be issued by Jennifer Seivwright upon entering the bus.

IMPORTANT

FOR THE ARGONNE TOUR: If you are not a U.S. citizen, you will be **REQUIRED** to present a copy of your **passport, visa and/or I-94 documentation** in order to attend the tour. You may scan and e-mail these documents in advance to srf2011@anl.gov or provide them upon registration in a sealed envelope addressed to **Jennifer Seivwright**.

GROUP PHOTOGRAPH

A group photograph will be taken place on Monday, July 25th, just before lunch.

LIST OF PARTICIPANTS

A list of SRF2011 registrants is included in the back of this book. The list of participants will be posted on the SRF2011 website following the conference.

SECURITY

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

VENDOR EXHIBITS

Vendor Exhibits are located in Sheraton Ballrooms 1, 2, and 3.

TIPPING

Tipping in the United States is generally 15-20% for restaurant service; more for exceptional service. Tips are typically 10-15% for taxis and $1.00 per bag for luggage.

NO-SMOKING POLICY

Illinois has a no-smoking policy that restricts smoking in all public and work places; smoking is only permitted outside (15 feet beyond building entrances).

ABOUT CHICAGO

Chicago is the third largest city in the United States, with a population of nearly three million people. Its scenic lakeside location, world-class cultural offerings and unique architecture are just a few of the reasons why Chicago is a great place to live and visit. You can explore the city by bus, boat, or on foot. There are many attractions such as the John Hancock and Willis Towers, Millennium Park, Navy Pier, The Art Institute of Chicago, Shedd Aquarium, Field Museum, Adler Planetarium, Lincoln Park Zoo, and the Museum of Science & Industry.

Please visit the conference website at http://conferences.fnal.gov/srf2011/chicago.html for more information.

ABOUT ARGONNE NATIONAL LABORATORY (ARGONNE)

Argonne National Laboratory (Argonne) is a U.S. Department of Energy Laboratory managed by UChicago Argonne, LLC, under contract number DE-AC02-06CH11357. Argonne is located southwest of Chicago at 9700 S. Cass Avenue, Argonne, IL 60439. See www.anl.gov for information about Argonne.

ABOUT FERMI NATIONAL ACCELERATOR LABORATORY (FERMILAB)

Fermilab, is a U.S. Department of Energy National Laboratory specializing in high-energy particle physics. As of January 1, 2007, Fermilab is operated by the Fermi Research Alliance, a joint venture of the University of Chicago and the Universities Research Association (URA). Fermilab is located just outside Batavia near Chicago, Illinois. See www.fnal.gov for information about Fermilab.

TRANSPORTATION

Within Chicago, transportation is usually by taxi cab or through the Chicago Transit Authority (CTA) bus and rail systems. Transit Cards can be purchased and value can be added to Transit Cards at vending machines located at all CTA rail stations. Vending machines accept $1, $5, $10, and $20 USD bills, and all coins except pennies and half dollars. Credit cards cannot be used to purchase transit cards at the station.

Taxicabs are available outside the main hotel entrance. Currently, the base Chicago taxi fare is $2.25 and increases $.20 for each additional 1/9 of a mile (or 36 seconds). Plus, there is a $1 charge for the first additional passenger ages 12-65, $.50 for each additional passenger, and a $1 fuel surcharge. Tips are accepted for good service.

Taxicab Phone Numbers:

American-United Taxi	773-248-7600	Yellow Cab	312-829-4222
Checker Cab	312-243-2537	Flash Cab	773-561-1444

The CTA provides bus and 'L' (subway) service.
See www.transitchicago.com/ for more information.

Airport and additional travel information can be found on the conference web page:
conferences.fnal.gov/srf2011/hotel.html

ARCHITECTURAL RIVER CRUISE

The 90 minute architectural river cruise of downtown Chicago is scheduled for the afternoon of Wednesday, July 27, 2011. The river tour includes all three branches of the Chicago river and highlights more than 53 historic and architecturally significant sites such as the Wrigley Building, the Tribune Tower, the Merchandise Mart, the Trump Tower, 333 W. Wacker Drive, the Willis (formerly Sears) Tower, River City, Marina City, the Aqua, The Montgomery (formerly the world headquarters for Montgomery Ward), the Chicago Tribune printing press plant, and Goose Island. The boats have outdoor viewing on the upper deck, as well as an air conditioned main deck.

The cost for the river tour is $26/person ($22/child under 3 yrs), and will be collected in cash on Sunday, July 24th during the conference registration. There is a full service cash bar on board offering everything from water to mixed drinks. Light snacks are also available for purchase.

If you are participating, we will leave together from the lobby of the Sheraton and walk to the NE corner of Michigan Ave. and E. Wacker Dr. Look for the blue awnings along the river. **Please check your ticket for the boat departure time.**
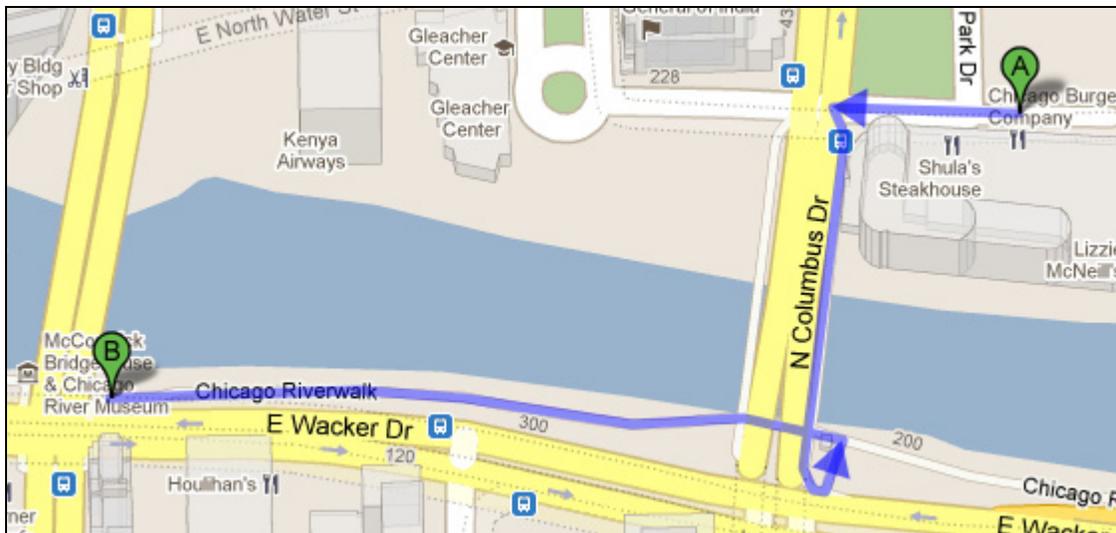
BANQUET VENUE

The SRF 2011 banquet will be held at the Mid-America Club on Wednesday, July 27th. The Mid America Club is located on the 80th floor in the Aon Center where it enjoys a wonderful panoramic view of the lake, Navy Pier, and the famous Chicago Skyline.

Mid-America Club
200 East Randolph Drive, 80th Floor, Chicago, IL 60601
(847-582-0289)

Reception: 18:00-19:00
Dinner Served: 19:30-20:30
Invited Speaker, Hasan Padamsee, Cornell University
"50 Years of RF Superconductivity"

NOTES: **Before being allowed to enter the elevator to the banquet floor, you will need to present picture identification to a Security Guard (*i.e.*, passport, drivers license, etc.)**

Required Dress code: NO Blue jeans, shorts, or tennis shoes are allowed

For those interested, at 21:30 there will be a fireworks display at Navy Pier, which is only a short walk away.

10 Minute Walking Directions

1. **Be careful crossing streets!**

2. Go west on E. North Water St. (100 m)

3. Turn left and go south on Columbus Dr. (500 m)

4. Turn right and go west on E. Lake St. (100 m)

LUNCH OPTIONS

1 Billy Goat Tavern (Bar/Hamburgers $5-8) Walk out the front doors and turn left. walk on to Michigan Ave. Walk across Michigan Ave. to the set of stairs on the other side. Go down the stairs to the bottom and walk forward to Water Street. Billy Goat Tavern will be on the right.

2 Boston Blackies (Bar/Burgers $8-15) Walk out the front door and turn left. Turn right onto Columbus and walk down the hill to Grand. Turn left onto Grand Street and walk to St. Clair Street. Boston Blackies is on the right just past St. Clair.

3 Burrito Beach (Casual Mexican $8-15) Walk out the front door and turn left. At Columbus Dr. turn right and walk 3 blocks to Ohio St., left on Ohio St., left on Ohio St. Clair. Burrito Beach is on the right.

4 Chipotle (Burritos $8-15) See directions to West Egg Café. At the corner of Columbus and Ontario, turn left. Chipotle is on the left side of the street.

5 Corner Bakery (Bakery/Sandwiches/Salads under $8) Walk out the front door and turn left, follow two blocks to Michigan Avenue. Turn left and proceed across the Michigan Avenue bridge. At the corner of Michigan Avenue and Wacker, cross the street to the left and The Corner Bakery is on the right corner.

6 Cosi (Sandwiches/Salads/Flatbreads under $15) Walk out the front doors and turn left. At Columbus Dr. turn right. Proceed 2 blocks to Grand Ave. Turn left on Grand and continue for 3 blocks. Cosi is on your left hand side across Rush St.

7 D4 (Upscale Irish Pub $10-25) At Columbus Dr. turn right. 2 blocks to Grand Ave. Right on Grand ½ block down on the left hand side.

8 Dunkin Donuts/Baskin Robbins(Coffee, donuts, ice cream) Walk out the front door and turn left. At Columbus Dr. turn right and walk 3 blocks to Ohio St., turn left on Ohio to St. Clair.

9 Fox & Obel Café (inside gourmet grocery store $8-25) Walk out front door. Walk straight down the Taxi Ramp to Illinois Street. Turn right on Illinois and walk to McClurg Court. The entrance to Fox & Obel grocery is on the corner of the building on the right. Proceed down the sidewalk in front of the grocery to enter the café.

10 (P) Gino's East (Pizza $10-25) Walk out the front door and turn left. Turn right on Columbus Ave and walk for seven blocks to Superior St. Turn left on Superior and walk two blocks. Gino's will be at 162 E. Superior.

11 Giordano's (Pizza $10-25) Walk out the front door and turn left. Continue on to Michigan Ave. Turn left onto Michigan Ave. and walk two blocks to Lake Street. Turn left onto Lake Street. Giordano's will be on your right.

12 (P) Grand Lux Café (American $8-25) Walk out front doors and turn left. Proceed past NBC Tower, across plaza to Michigan Ave. Cross Michigan Ave and turn right. Proceed 3 blocks to Ontario. Grand Lux is on left, above Ann Taylor.

13 (R) Heaven on Seven (Cajun $8-15) Walk out the front doors and turn to your left. Cross Columbus Ave. and continue walking through the courtyard area to Michigan Ave. Cross Michigan Ave. and go to your right down Michigan Ave. Walk 2 blocks to Ohio Street. Turn left on Ohio and walk it is on your right.

14 Houlihan's (American $8-20) Walk out the front door and turn left. Continue forward to Michigan Ave. Turn left onto Michigan and walk to Wacker Drive. Turn Left onto Wacker Dr. Houlihan's will be on your right.

15 Jimmy John's (sandwiches under $8) Walk out the front door and turn left. Make an immediate right onto Columbus, walk two blocks to Grand Ave. and turn left. Walk 3 ½ blocks down to Rush. Just past Cosi.

16 Lizzie McNeil's (pub under $8) Walk out the front door and down the cab ramp onto Illinois street. Turn left and proceed forward two blocks. At Marketplace make a right and proceed forward on the Left side past the street just past the stop sign is Lizzie McNeil.

17 McDonalds (Burgers under $10) Walk out the front door and turn left. Continue forward to Michigan Ave. Cross Michigan Ave. to the Wrigley Building. Go through the middle of the Wrigley Building and walk forward to McDonalds.

18 Panera Bread (casual American $6-$10) Follow the same directions as West Egg Café, walk one block further north, the restaurant is on the right side at 635 N. Fairbanks.

19 PJ Clarke's (casual American $8-15) Walk out front doors. Turn left and walk to Columbus Drive. Turn right on Columbus and walk down the hill, one block, to Illinois Ave. PJ Clarke's is on the corner.

20 Popeye's Chicken/Subway Sandwiches (Fast Food $5-10) Walk out the front door and turn left. Turn right on Columbus Dr. 2 blocks to Grand Ave.turn left. One block down on right hand side.

21 Pompei (Casual Italian $4-$10) Turn right on Columbus drive 3 blocks to Ohio St. turn left on Ohio and continue for one block. The restaurant is on the right at 212 East Ohio

22 Reagle Beagle (All American under $15) Follow directions to Popeyes and Subway.

23 Rock Bottom (Micro Brewery and American food $8-20) Walk out the front doors and turn left to Columbus Drive. Turn right onto Columbus and walk 2 blocks to Grand Ave. Turn left on Grand Ave. and walk about 5 blocks to State Street and Grand.

24 TGIFridays (Casual American $8-20) Walk out the front doors, turn left. Turn right on Columbus and walk 5 blocks to Erie St. Turn left on Erie and proceed to a block down towards Michigan. TGIFridays will be on your left at 153 E. Erie.

25 Timothy O'Tooles (Irish Sports bar/American cuisine $8-20) Follow directions to West Egg Café. Timmy O'Tooles is at the corner downstairs.

26 Urban Kitchen (Deli under $15) Walk out the front door and turn left. Walk across the street to The NBC Building. Walk into the NBC Building it is up the stairs and on your left. (Monday-Friday)

27 West Egg Cafe (Casual American, breakfast anytime under $8) Walk out the front door and turn left, then turn right onto Columbus Drive. Walk down on Columbus for four blocks to Ontario Street. West Egg is on your left on the corner of Ontario and Columbus
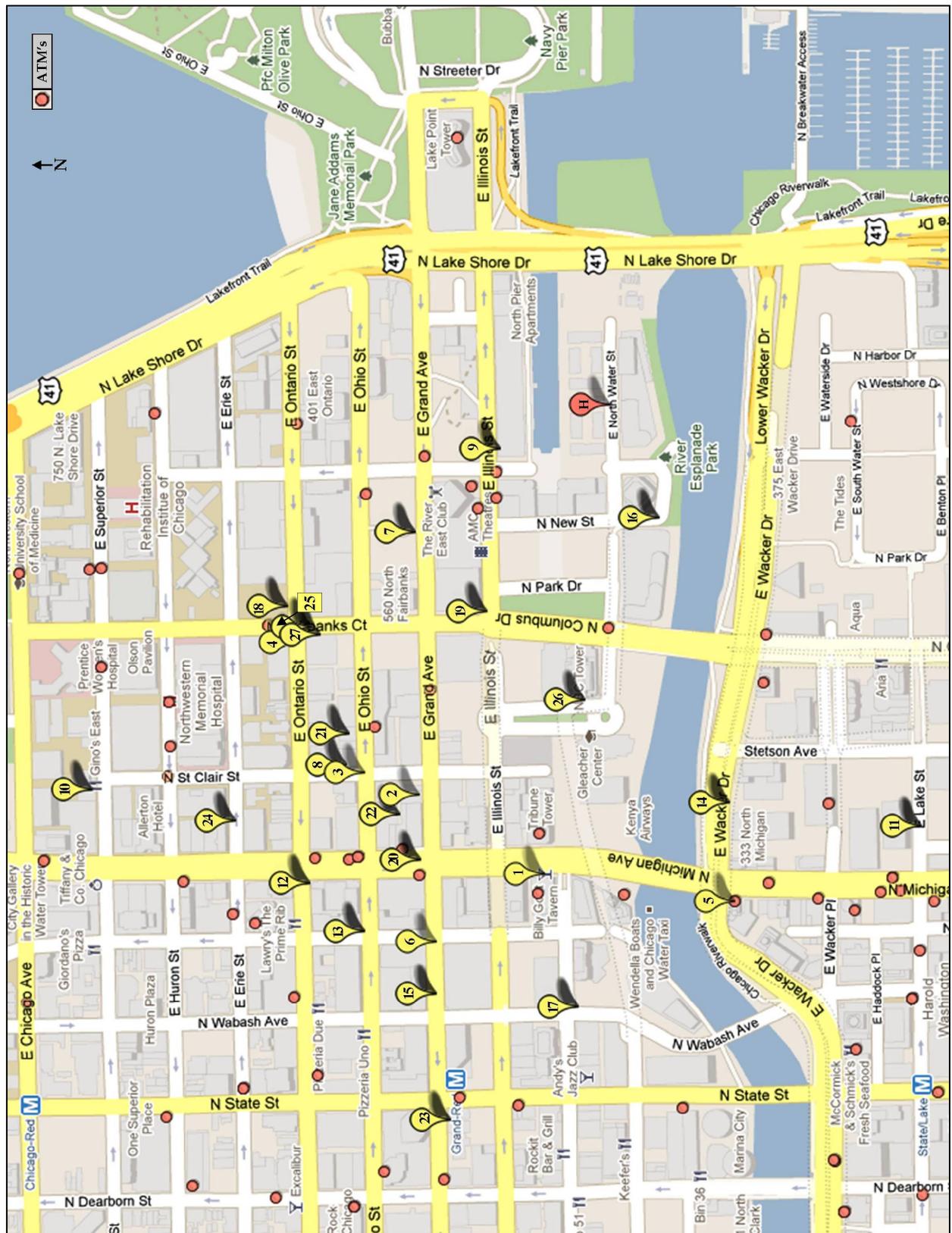
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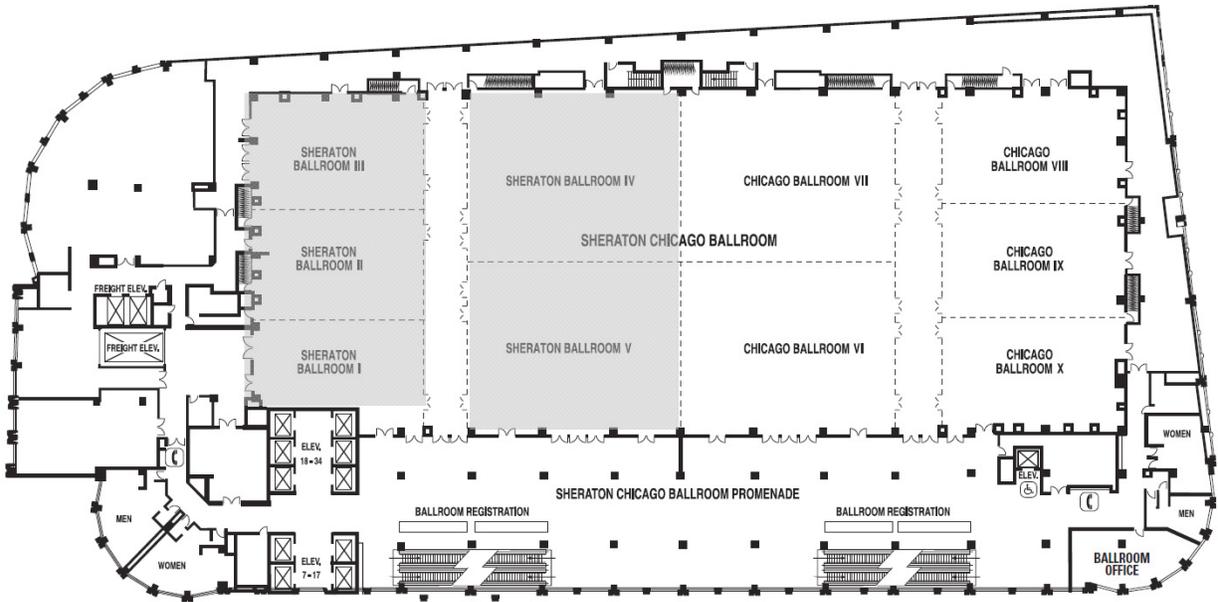
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General Sessions – Sheraton Ballrooms IV & V
Poster Sessions / Exhibitors – Sheraton Ballrooms I, II, & III
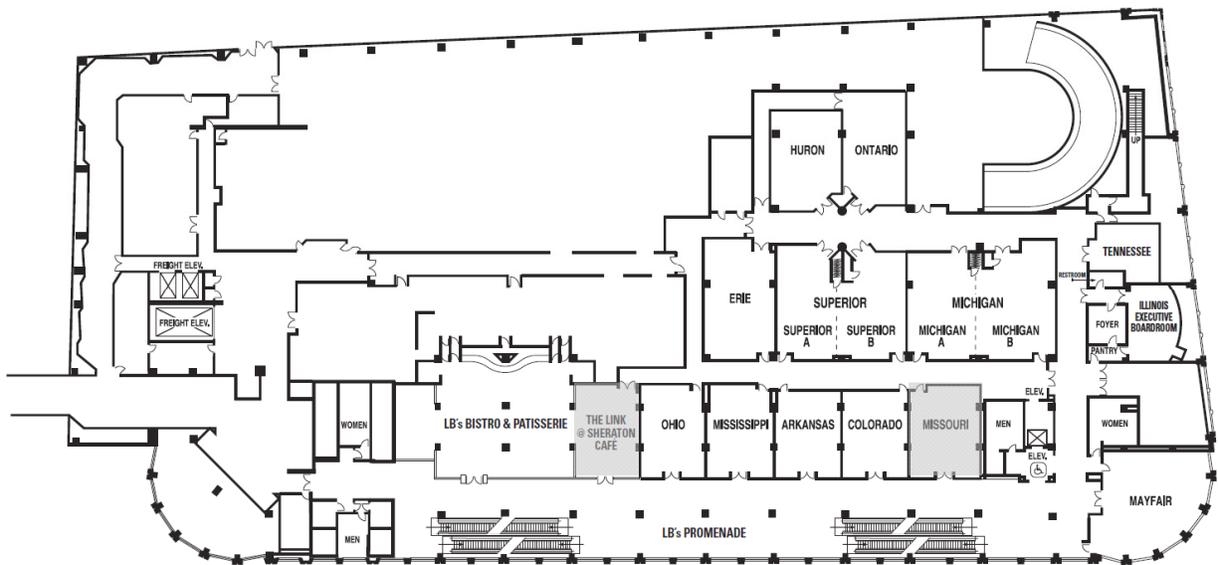
Meeting Rooms– Level 2
Internet Access – The Link @ Sheraton Café
Proceedings Office – Missouri Room

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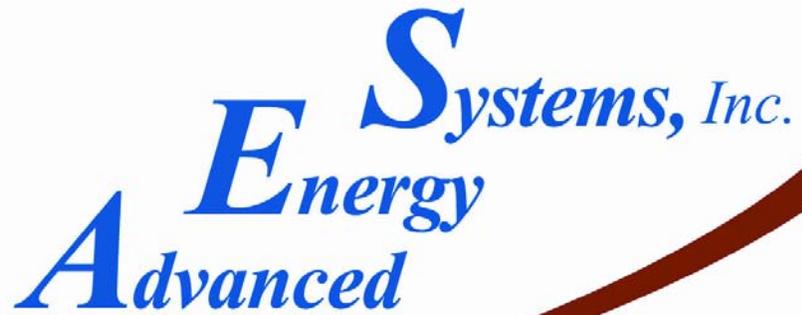
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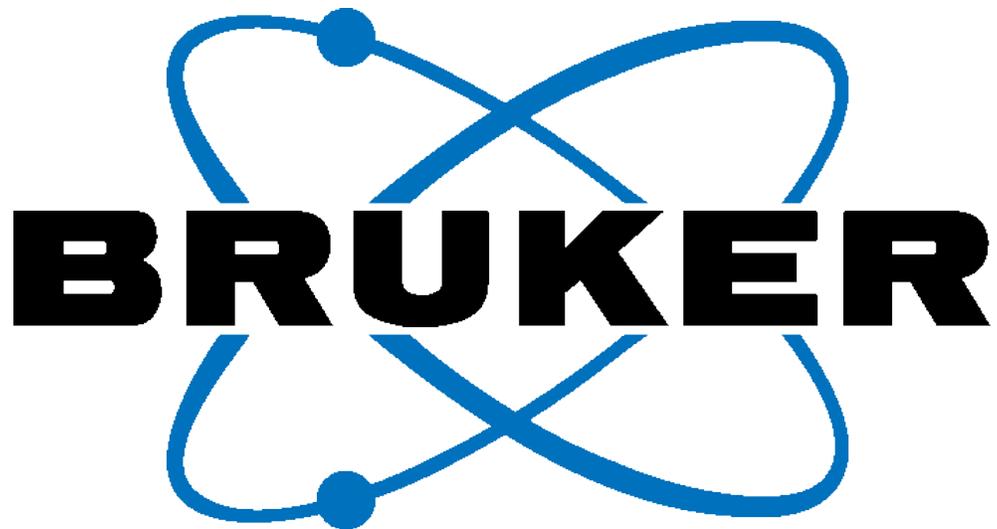
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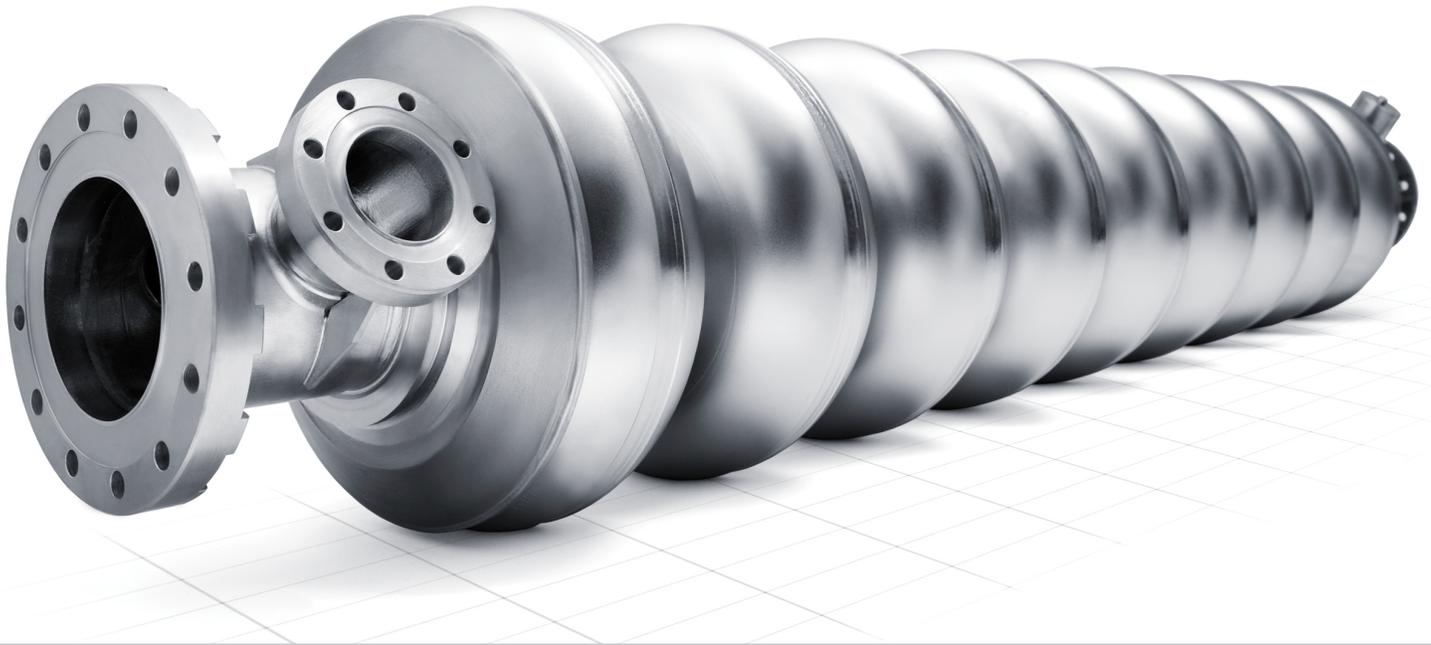
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            D. Reschke (DESY)
MOIOA02   Advances in SRF Development for ILC
            A. Yamamoto (KEK)
MOIOA03   Recent SRF Developments for ERLs
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MOIOA04   SRF Challenges for Improving Operational Electron Linacs
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MOIOB02   Advances in SRF for Low Beta Ion Linacs
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            S.-H. Kim (ORNL)
MOIOB04   Survey of SRF Guns
            S.A. Belomestnykh (BNL)
MOIOB05   Operational Experience with SRF Cavities for Light Sources
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            T.L. Grimm (Niowave, Inc.)
MOPO002   A Superconducting Cavity for a Flux Coupled Cyclotron That Drives a Power Plant Based
            on a Spent Nuclear Fuel
            N. Pogue (Texas A&M University)
MOPO003   650 MHz Cryomodules for Project X at Fermilab – Requirements and Concepts
            T.J. Peterson (Fermilab) R. Ghosh (RRCAT)
MOPO004   Modified SRF Photoinjector for the ELBE at HZDR
            P. Murcek (HZDR) P. Kneisel (JLAB)
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            M.D. Church (Fermilab)

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	W. Anders (HZB)
MOPO009	Design Status of the Superconducting Driver Linac for the Facility for Radioactive Isotope Beams
	M. Leitner (FRIB)
MOPO010	Update on Module Measurements for the XFEL Prototype Modules
	D. Kostin (DESY)
MOPO011	Status of SARAF Superconducting Acceleration Module
	A. Perry (Soreq NRC)
MOPO012	Overview of ILC High Gradient Cavity R&D at Jefferson Lab
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MOPO013	RF Test Results from Cryomodule 1 at the Fermilab SRF Beam Test Facility
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	M. Liepe (CLASSE)
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	H.S. Kim (KAERI)
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	P.N. Ostroumov (ANL)
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	S.U. De Silva (ODU) A. Castilla (DCI-UG) S.U. De Silva (JLAB)
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	L. Lu (RIKEN) O. Kamigaito (RIKEN Nishina Center)
MOPO029	Some Concerns on the Development of Spoke Cavity
	F.S. He (PKU/IHIP) H. Wang (JLAB)
MOPO030	The sc cw -LINAC Demonstrator - First section of a sc cw -LINAC
	V. Gettmann (HIM) K. Aulenbacher (IKP) W.A. Barth (GSI) F.D. Dziuba (IAP)
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	C. Zhang (IMP)

MOPO032	Development of a Frequency Map for the WiFEL SRF Gun
	R.A. Legg (JLAB) M.V. Fisher (UW-Madison/SRC) T.L. Grimm (Niowave, Inc.)
MOPO033	Design of Superconducting Multi-Spoke Cavities for High-Velocity Applications
	C.S. Hopper (ODU) J.R. Delayen (JLAB)
MOPO034	Optimized RF Design of 704 MHz $\beta=1$ Cavity for Pulsed Proton Drivers
	J. Plouin (CEA/IRFU) S. Chel (CEA/DSM/IRFU)
MOPO035	Structural Mechanical Analysis of Superconducting CH-Cavities
	M. Amberg (HIM) K. Aulenbacher (IKP) W.A. Barth (GSI) M. Busch (IAP)
MOPO036	Design Optimization of Spoke Cavity of Energy-Recovery Linac for Non-Destructive Assay Research
	M. Sawamura (JAEA) R. Nagai (JAEA/ERL)
MOPO037	Development of Superconducting CH Cavities
	F.D. Dziuba (IAP) M. Amberg (HIM) K. Aulenbacher (IKP) W.A. Barth (GSI)
MOPO038	Development of the Demountable Damped Cavity
	T. Konomi (Sokendai) F. Furuta (KEK)
MOPO039	Low-β Triple Spoke Cavity Design Improvement for Proton Linac
	H. Gassot (IPN)
MOPO040	SRF Cavity Design for High Current Linacs
	W. Xu (BNL)
MOPO041	Conceptual Design of the $\beta = 0.86$ Cavities for the Superconducting Linac of ESS
	J. Plouin (CEA/IRFU) G. Devanz (CEA/DSM/IRFU)
MOPO042	Coupler Design for a Sample Host TE Cavity
	Y. Xie (CLASSE)
MOPO043	Mechanical Study of Superconducting Parallel-Bar Deflecting/Crabbing Cavities
	H. Park (JLAB) S.U. De Silva (ODU)
MOPO044	Electromagnetic Design Optimization of a Half-Wave Resonator
	B. Mustapha (ANL)
MOPO045	Coupled Electromagnetic and Mechanical Simulations for Half-Wave Resonator Design
	J.P. Holzbauer (NSCL) J. Binkowski (FRIB)
MOPO046	Design of a 322 MHz $\beta=0.29$ Half Wave Resonator
	J. Popielarski (FRIB)
MOPO047	HOM Cavity Design for the TRIUMF E-LINAC
	P. Kolb (TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics)
MOPO048	The Dipole Steering Effect With New Ways: Shifting Inside and Outside Pole of QWR Cavity Method
	J.D. Jeong (SKKU)
MOPO049	Electro-Magnetic Optimization of a Quarter-Wave Resonator
	C. Zhang (IMP)
MOPO050	Design of a 1500 MHz Bunch Lengthening Cavity for NSLS-II
	J. Rose (BNL) C.H. Boulware (Niowave, Inc.)
MOPO051	Design for Manufacture of a Superconducting Half Wave Resonator $\beta=0.53$
	S.J. Miller (FRIB)
MOPO052	Studies on a Plunger Tuner System for a Double Spoke Cavity
	J.L. Munoz (ESS-Bilbao) F.J. Bermejo (Bilbao, Faculty of Science and Technology) V. Etxebarria (University of the Basque Country, Faculty of Science and Technology) N. Garmendia (ESS Bilbao)
MOPO053	Designs of Superconducting Parallel-Bar Deflecting Cavities for Deflecting/Crabbing Applications
	J.R. Delayen (ODU) J.R. Delayen (JLAB)
MOPO054	Superconducting 112 MHz QWR Electron Gun
	S.A. Belomestnykh (BNL) C.H. Boulware (Niowave, Inc.) T. Xin (Stony Brook University)
MOPO055	Superconducting Resonator Production for Ion Linac at Michigan State University
	C. Compton (FRIB)

Program

TUIOA06   Deposition of Niobium and Other Superconducting Materials With High Power Impulse Magnetron Sputtering: Concept and First Results
A. Anders (LBNL)

26-Jul-11   10:45 – 13:15
10:45 – 13:15   TUIOB — New Materials/Techniques
Session Chair: C.Z. Antoine, CEA/DSM/IRFU (France)

TUIOB01   Energetic Condensation Growth of Nb Films
M. Krishnan (AASC) P. Maheshwari (NCSU AIF) H.L. Phillips (JLAB) K.I. Seo (NSU) Z.H. Sung (ASC)

TUIOB02   Summary of the Symposium on Ingot Nb and New Results on Fundamental Studies of Large Grain Nb
G. Ciovati (JLAB)

TUIOB03   Testing the RF Properties of Novel Super Conducting Materials
J. Guo (SLAC)

TUIOB04   Muon Spin Rotation/Relaxation Studies of Niobium for SRF applications
A. Grassellino (TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics)

TUIOB05   New Approaches to Nb Thin Film Coating
S. Calatroni (CERN)

TUIOB06   Nb Films: Substrates, Nucleation & Crystal Growth
A-M. Valente-Feliciano (JLAB)

TUIOB07   Magnesium Diboride Films for SRF Cavity Applications
Y.D. Agassi (NSWC) B. Moeckly (STI) D.E. Oates (MIT)

TUIOB08   Hot Topics: Medium Field Q-Slope and Paths to High-Q Operation
W. Weingarten (CERN)

26-Jul-11   14:30 – 18:00
14:30 – 18:00   TUPO — Poster Session

TUPO001   Development of Quality Assurance Procedures for the Fast/Slow Tuners on the 1.3 GHz SRF Cavities for the SRF Accelerator Test Facility at Fermilab
Y.M. Pischalnikov (Fermilab)

TUPO002   High Power Pulsed Tests of a β=0.5 5-Cell 704 MHz Superconducting Cavity
J. Plouin (CEA/DSM/IRFU) W. Hï¿½fle (CERN)

TUPO003   Cooling Properties of HOM Absorber Model for cERL in Japan
M. Sawamura (Japan Atomic Energy Agency (JAEA), Gamma-ray Non-Destructive Assay Research Group) E. Cenni (Sokendai) T. Furuya (KEK) K. Shinoe (ISSP/SRL)

TUPO004   Development and Testing of Prototype Fundamental Power Couplers for FRIB Half Wave Resonators
J. Popielarski (FRIB)

TUPO005   High Power Tests of KEK-ERL Input Coupler for Main Linac Under LN2 Condition
H. Sakai (KEK) E. Cenni (Sokendai) M. Sawamura (JAEA) K. Shinoe (ISSP/SRL)

TUPO006   High Power Couplers for the Project X Linac
S. Kazakov (Fermilab)

TUPO007   Development of STF Input Couplers for ILC
M. Satoh (KEK)

TUPO008   Vertical Test Facility for Superconducting RF Cavities at Daresbury Laboratory
R.K. Buckley (STFC/DL/ASTeC)

TUPO009   How to Increase Average Power of Main Coupler
S. Kazakov (Fermilab)

TUPO010   Conditioning the Fundamental Power Coupler for ERL SRF Gun
W. Xu (BNL) M.D. Cole (AES)

TUPO011   Coupler Cleaning Machine
W. Kaabi (LAL)

Program

TUPO012	Niobium Electropolishing in an Aqueous, Non-Viscous HF-Free Electrolyte: A New Polishing Mechanism
	M.E. Inman (Faraday Technology, Inc.) C.E. Reece (JLAB)
TUPO013	Assembly of the International ERL Cryomodule at Daresbury Laboratory
	P.A. McIntosh (STFC/DL/ASTeC) S.A. Belomestnykh (CLASSE) A. Buechner (HZDR) M.A. Cordwell (STFC/DL) J.N. Corlett (LBNL) T. Kimura (Stanford University) D. Proch (DESY)
TUPO014	High Gradient Results of ICHIRO 9-Cell Cavity in Collaboration With KEK and Jlab
	F. Furuta (KEK)
TUPO015	Standard Procedures of ILC High Gradient Cavity Processing at Jefferson Lab
	R.L. Geng (JLAB) A.C. Crawford (CLASSE)
TUPO016	Study Correlating Niobium Surface Roughness with Surface Particle Counts
	C. Compton (FRIB)
TUPO017	Development and Scale-Up of an HF Free Electropolishing Process in Single-Cell Niobium SRF Cavities
	M.E. Inman (Faraday Technology, Inc.) L.D. Cooley (Fermilab)
TUPO018	Update of the DESY Infrastructure for Cavity Preparation
	M. Schalwat (DESY)
TUPO019	Fabrication, Tuning, Treatment and Testing of Two 3.5 Cell Photo-Injector Cavities for the ELBE Linac
	A. Arnold (HZDR) G.V. Eremeev (JLAB)
TUPO020	CMP Polishing of a Niobium SRF Cavity
	S.D. Lesiak (Cabot Microelectronics Polishing Corp) A.M. Rowe (Fermilab)
TUPO021	Current State of Electropolishing at ANL
	T. Reid (ANL)
TUPO022	Effects of Cathode Shapes on BEP and EP During Vertical Surface Treatments on Niobium
	S. Jin (PKU/IHIP) R.A. Rimmer (JLAB)
TUPO023	Development of the Superconducting Cavity for ILC at TOSHIBA
	T. Ota (Toshiba) H. Hayano (KEK)
TUPO024	Sulfur Residues in Niobium Electropolishing
	L. Zhao (The College of William and Mary) M.J. Kelley (JLAB)
TUPO025	Integrated Cavity Processing Apparatus at Fermilab: SRF Cavity Processing R&D
	C.A. Cooper (Fermilab)
TUPO026	Nine - Cell Tesla Shape Cavities Produced From Hydroformed Cells
	W. Singer (DESY) R. Crooks (Black Laboratories, L.L.C.) P. Kneisel (JLAB) I.N. Zhelezov (RAS/INR)
TUPO027	A New Home for SRF Work at JLab–the Technology and Engineering Development Facility
	C.E. Reece (JLAB)
TUPO028	Qualification of the Second Batch Production 9-Cell Cavities Manufactured by AES and Validation of the First US Industrial Cavity Vendor for ILC
	R.L. Geng (JLAB) M. Calderaro (AES) M.S. Champion (Fermilab) A.C. Crawford (CLASSE)
TUPO029	Gradient Improvement by Removal of Identified Local Defects
	R.L. Geng (JLAB) C.A. Cooper (Fermilab) H. Hayano (KEK)
TUPO030	Status of the 9-Cell Superconducting Cavity R&D for ILC at Hitachi
	T. Watanuki (Hitachi Ltd.) H. Hayano (KEK)
TUPO031	Update on the R&D of Vertical Buffered Electropolishing on Nb Samples and SRF Single Cell Cavities
	A.T. Wu (JLAB) S. Jin (PKU/IHIP)
TUPO032	Updates on R&D of Nondestructive Inspection Systems for SRF Cavities
	Y. Iwashita (Kyoto ICR) H. Hayano (KEK)
TUPO033	Study of I-V Characteristics at Different Locations Inside a Demountable Nb SRF Cavity During Vertical BEP and EP Treatments
	S. Jin (PKU/IHIP) R.A. Rimmer (JLAB)
TUPO034	High Pressure Rinse System for Multiple SRF Cavities
	R.C. Murphy (ANL)

TUPO035	Cryogenic Test of a Two-Cell Passive SRF Cavity for NSLS-II
	C.H. Boulware (Niowave, Inc.) W.K. Gash (BNL)
TUPO036	Material for European XFEL Resonators
	W. Singer (DESY)
TUPO037	Study on Electro-Polishing Process by Niobium-Plate Sample With Artificial Pits
	T. Saeki (KEK) W.A. Clemens (JLAB) P.V. Tyagi (Sokendai)
TUPO038	Superconducting RF Cavity Development With UK Industry
	A.E. Wheelhouse (STFC/DL/ASTeC)
TUPO039	Long-Term Monitoring of 2nd–Period EP-Electrolyte in STF-EP Facility at KEK
	M. Sawabe (KEK)
TUPO040	The Status of Cavity-Fabrication Study for ILC at KEK
	T. Saeki (KEK) H. Nakamura (SPS)
TUPO041	Investigation on Cavity String Assembly and Repair
	A. Matheisen (DESY)
TUPO042	SLAC/FNAL TTF3 Coupler Assembly and Processing Experience
	C. Adolphsen (SLAC) A. Lunin (Fermilab)
TUPO043	Optimization of Ar/CL2 Plasma Parameters Used for SRF Cavity Etching
	J. Upadhyay (ODU) H.L. Phillips (JLAB)
TUPO044	Correction of a Superconducting Cavity Shape Due to Etching, Cooling Down and Tuning
	V.D. Shemelin (CLASSE)
TUPO045	Status of Investigations on Degradation of Cavities in DESY Acceleration Modules
	A. Matheisen (DESY)
TUPO046	Update on Large Grain Cavities with 45 MV/m in a Nine-Cell Cavity at DESY
	D. Reschke (DESY)
TUPO047	Progress in Developing 500MHz Nb Cavity at SINAP
	J.F. Liu (SINAP) Z. Li (Shanghai KEY Laboratory of Cryogenics & Superconducting RF Technology) B. Yin (Graduate University, Chinese Academy of Sciences)
TUPO048	Commissioning and Upgrade of Automatic Cavity Tuning Machines for the European Xfel
	J.H. Thie (DESY) D. Bhogadi (Fermilab)
TUPO049	Q0 Improvement of Large-Grain Multi-Cell Cavities by Using JLab's Standard ILC EP Processing
	R.L. Geng (JLAB) K.X. Liu (PKU/IHIP)
TUPO050	Studies on Transportation of Superconducting Resonators and Beam Position Monitors - Quadrupol Units for the XFEL Project
	A. Schmidt (DESY)
TUPO051	High-Temperature Heat Treatment Study on a Large-Grain Nb Cavity
	G. Ciovati (JLAB) P. Maheswari (NCSU AIF)
TUPO052	Fabrication and Test of 500MHz Nb Cavity for BEPCII
	G.W. Wang (IHEP Beijing)
TUPO053	Optical Inspection of SRF Cavities at Fermilab
	E. Toropov (Fermilab)
TUPO054	SRF Cavity Surface Topography From Optical Inspection
	E. Toropov (Fermilab)
TUPO055	Horizontal SRF Cavity Testing at Fermilab
	A. Hocker (Fermilab)
TUPO056	Dewar Testing of $\beta = 0.53$ Half Wave Resonators at MSU
	J. Popielarski (FRIB)
TUPO057	Buffered Chemical Polishing Development for the β=0.53 Half-Wave Resonator for the Facility for Rare Isotope Beams
	L. Popielarski (FRIB)
TUPO058	CERN SRF Assembling and Test Facilities
	J.K. Chambrillon (CERN)
TUPO059	SRF Cavity Processing and Cleanroom Facility Upgrades at Michigan State University
	L. Popielarski (FRIB)

Program

TUPO060	Dewar Testing of $\beta = 0.085$ Quarter Wave Resonators at MSU
	J. Popielarski (FRIB)
TUPO061	Preparation and Testing of the SRF Cavities for the CEBAF 12 GeV Upgrade
	A. Reilly (JLAB)
TUPO062	Vertical Electro-Polishing at CEA Saclay: Commissioning of a New Set-Up and Modeling of the Process Applied to Different Cavities
	F. Eozi¿½nou (CEA/DSM/IRFU)
TUPO063	MgB2 Films on Metallic Substrates with Different Surface Roughness
	C.G. Zhuang (TU)
TUPO064	Large-Area MgB2 Films by Hybrid Physical Chemical Vapor Deposition
	X. Xi (TU)
TUPO065	Economical Manufacture of Seamless High-Purity Niobium
	V.M. Arrieta (Ultramet)
TUPO066	Analysis of Recent Results from Second Sound, Temperature Mapping and Optical Inspection of 1.3 GHz Cavities at DESY
	F. Schlander (DESY)
TUPO067	E HIE ISOLDE QWR: Progress in Magnetron and Bias Diode Sputtered Niobium Thin Film Coating
	G. Lanza (CERN)
TUPO068	Electropolishing of Niobium to Obtain Defect Free Surface
	A. Chandra (Ohio State University)

26-Jul-11 18:00 – 19:00

18:00 – 19:00	TUIOC — Hot Topics
	Medium Field Q-Slope and Paths to High-Q Operation
	Session Chair: W. Weingarten, CERN (Geneva, Switzerland)

27-Jul-11 08:00 – 10:15

08:00 – 10:15	WEIOA — R&D/Diagnostics
	Session Chair: C.E. Reece, JLAB (Newport News, Virginia, USA)
WEIOA01	Quantitative EP Studies and Results for SRF Nb Cavity Production
	H. Tian (JLAB)
WEIOA02	Centrifugal Barrel Polishing (CBP) of SRF Cavities Worldwide
	C.A. Cooper (Fermilab) B. Bullock (CLASSE) S.C. Joshi (RRCAT) A.D. Palczewski (JLAB) K. Saito (KEK)
WEIOA03	A New Electropolishing System For Low-Beta SC Cavities
	S.M. Gerbick (ANL)
WEIOA04	Review of RF - Sample - Test Equipment and Results
	T. Junginger (CERN) T. Junginger (MPI-K) C.P. Welsch (Cockcroft Institute)
WEIOA05	X-Ray Tomography Inspection of SRF Cavities
	E.R. Harms (Fermilab)
WEIOA06	Effect of Deformation and Heat Treatment on the Thermal Conductivity of Large Grain Superconducting Niobium
	S.K. Chandrasekaran (MSU) T.R. Bieler (Michigan State University) C. Compton (FRIB) N.T. Wright ((MSU))

27-Jul-11 10:45 – 13:00

10:45 – 13:00	WEIOB — R&D/Diagnostics/Fabrication
	Session Chair: W.-D. Moeller, DESY (Hamburg, Germany)
WEIOB01	Guided Cavity Repair with Laser, E - Beam and Grinding
	G. Wu (ANL)
WEIOB02	Cavity Inspection and Repair Techniques
	K. Watanabe (KEK) Y. Iwashita (Kyoto ICR)

WEIOB03	Improvement in Cavity Fabrication Technology and Cost Reduction Methods
	K. Sennyu (MHI)
WEIOB04	XFEL Cavity Procurement as an Example of Technology Transfer
	W. Singer (DESY)
WEIOB05	Large Grain Cavities: Fabrication, RF Results and Optical Inspection
	S. Aderhold (DESY)
WEIOB06	IHEP 1.3GHz Low-Loss Large Grain 9-cell cavity R&D for ILC
	J.Y. Zhai (IHEP Beijing)

27-Jul-11   18:00 – 21:30
18:00 – 21:30   WEIOC — Banquet Special Talk

WEIOC01   50 Years of RF Superconductivity
H. Padamsee (Cornell University)

28-Jul-11   08:00 – 10:15
08:00 – 10:15   THIOA — β=1 Cavities
Session Chair: H.T. Edwards, Fermilab (Batavia, USA)

THIOA01	Test Results of the International S1-Global Cryomodule
	Y. Yamamoto (KEK) C. Adolphsen (SLAC) T.T. Arkan (Fermilab) A. Bosotti (INFN/LASA) K. Jensch (DESY)
THIOA02	Gradient R&D in the US
	J.P. Ozelis (Fermilab)
THIOA03	Compact Superconducting Cavities for Deflecting and Crabbing Applications
	J.R. Delayen (ODU)
THIOA04	QWR for $\beta \sim 1$ Accelerators
	I. Ben-Zvi (BNL)
THIOA05	The sc cw-LINAC Demonstrator - SRF-Technology finds the way into GSI
	S. Mickat (GSI) M. Amberg (HIM) K. Aulenbacher (IKP) F.D. Dziuba (IAP)
THIOA06	Mechanical Design Considerations for β=1 Cavities
	O. Capatina (CERN) S. Chel (CEA/DSM/IRFU)
THIOA07	Single-cell SC Cavity Development in India
	A. Puntambekar (RRCAT) C.A. Cooper (Fermilab) P.N. Potukuchi (IUAC) G. Wu (ANL)

28-Jul-11   10:45 – 13:00
10:45 – 13:00   THIOB — β <1 Cavities
Session Chair: W. Weingarten, CERN (Geneva, Switzerland)

THIOB01	Project X Cavity and Cryomodule Development
	C.M. Ginsburg (Fermilab)
THIOB02	Vertical Tests Results of the IFMIF Cavity Prototypes and Cryomodule Development
	F. Orsini (CEA/IRFU) J. Calero (CIEMAT) E.N. Zaplatin (FZJ)
THIOB03	Status of the ReAccelerator Facility RϵA for Rare Isotopes
	D. Leitner (NSCL) A. Facco (FRIB) O.K. Kester (GSI)
THIOB04	SRF Advances for ATLAS and other β <1 Applications
	M.P. Kelly (ANL)
THIOB05	SPL Cavity Development
	G. Olry (IPN)
THIOB06	Recents Developments in SRF at TRIUMF
	R.E. Laxdal (TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics) R.S. Orr (University of Toronto)
THIOB07	HIE-ISOLDE quarter wave Nb/Cu cavity
	M. Pasini (CERN) M. Pasini (Instituut voor Kern- en Stralingsfysica, K. U. Leuven)
THIOB08	Hot topics: Recipes for 9-cell cavity fabrication and preparation
	T. Saeki (KEK)

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28-Jul-11   14:30 – 18:00
14:30 – 18:00   THPO — Poster Session

THPO001	Quench Simulation Using a Ring-Type Defect Model	
	Y. Xie (CLASSE)	
THPO002	Defect-Induced Local Heating of Superconducting Cavity Surface	
	Y. Morozumi (KEK)	
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THPO028	SIMS and TEM Analysis of Niobium Bicrystals
	P. Maheswari (NCSU AIF) G. Ciovati (JLAB) M. Rigsbee (Materials Science and Engineering)
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	G.V. Eremeev (JLAB)
THPO030	Microphonics Compensation for a 325MHz Single Spoke Cavity at Fermilab
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	F. Schlander (DESY)
THPO032	TOF-SIMS Analysis of Hydrogen in Niobium, From 160ï¿½K to 475ï¿½K
	P. Maheswari (NCSU AIF) G. Ciovati (JLAB) M. Rigsbee (Materials Science and Engineering)
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	E. Cenni (Sokendai) T. Furuya (KEK) M. Sawamura (Japan Atomic Energy Agency (JAEA), Gamma-ray Non-Destructive Assay Research Group) K. Shinoe (ISSP/SRL)
THPO035	Comparison of Field Emission at Different SRF Cavity Assembly States and Test Stands
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THPO037	Lorentz Force Detuning Compensation in Fermilab Cryomodule 1
	Y.M. Pischalnikov (Fermilab)
THPO038	Detailed Nb Surface Morphology Evolution During Electropolishing for SRF Cavity Production
	H. Tian (JLAB)
THPO039	Niobium Surface Resistance Measurement by Thermometric Method With a TE011 Cavity
	G. Martinet (IPN)
THPO040	A Wire Position Monitor System for the 1.3GHz Tesla-Style Cryomodule at the Fermilab New Muon Lab
	N. Eddy (Fermilab)
THPO041	HOM Identification and Bead Pulling on the Brookhaven ERL
	H. Hahn (BNL) P. Jain (Stony Brook University)
THPO042	Crystallographic Orientation of Epitaxial Transition Observed for Nb (BCC) on Cu and MgO (FCC) Single-Crystals
	K.I. Seo (NSU) M. Krishnan (AASC) H.L. Phillips (JLAB)
THPO043	Understanding of Suppressed Superconductivity on SRF Quality Niobium
	Z.H. Sung (ASC) L.D. Cooley (Fermilab) A.V. Gurevich (Old Dominion University) P.J. Lee (NHMFL)
THPO044	Structural Characterization of Nb Films Deposited by ECR Plasma Energetic Condensation on Crystalline Insulators
	X. Zhao (JLAB) H. Baumgart (ODU) K.I. Seo (NSU)
THPO045	Nb Surface Nonlinear Properties Under Localized High RF Magnetic Field
	T.M. Tai (CNAM, UMD) S. M. Anlage (UMD)

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THPO046   Characterization of Scale-Dependent Roughness of Niobium Surfaces as a Function of Surface Treatment Processes
C. Xu (The College of William and Mary) C.E. Reece (JLAB)

THPO047   Growth Mode and Strain Effects in the Superconducting Properties of Nb Thin Films on Sapphire
C. Clavero (The College of William and Mary) C.E. Reece (JLAB)

THPO048   RF Surface Impedance of MgB2 Thin Films at 7.5 GHz
B. Xiao (The College of William and Mary) H.L. Phillips (JLAB) T. Tajima (LANL)

THPO049   Atomic-Scale Characterization of Niobium for SRF Cavities Using Ultraviolet Laser-Assisted Local- Electrode Atom-Probe Tomography
Y.-J. Kim (NU) A. Romanenko (Fermilab)

THPO050   TE Sample Host Cavities Development at Cornell
Y. Xie (CLASSE)

THPO051   Laser Re-Melting Influence on Nb Properties: Geometrical and Chemical Aspects
A.V. Dzyuba (Fermilab) A.V. Dzyuba (NSU) M. Ge (CLASSE) G. Wu (ANL)

THPO052   Investigation of Near-Surface Interstitial Hydrogen in Cavity-Grade Niobium
A. Romanenko (Fermilab) L.V. Goncharova (UWO)

THPO053   Material for Fabrication of DESY Large Grain/Single Crystal Cavities
X. Singer (DESY) H.G. Brokmeier (Technische Universität Clausthal, Institut fï¿½r Nichtmetallische Werkstoffe) R. Grill (Plansee Metall GmbH) F. Schoelz (W.C. Heraeus GmbH, Materials Technology Dept.)

THPO054   Magneto-Optical and Electromagnetic Study Different Forms of Nb for SRF Application
A. Polyanskii (ASC) P.J. Lee (NHMFL) A-M. Valente-Feliciano (JLAB)

THPO055   Investigation of Samples Separated From Prototype Cavities of the European XFEL
X. Singer (DESY) M. Hoss (W.C. Heraeus GmbH, Materials Technology Dept.)

THPO056   Thermal-Vacuum Variations of the Surface Oxide Complex on Cu
M. Bagge-Hansen (The College of William and Mary) C.E. Reece (JLAB) K.I. Seo (NSU)

THPO057   Superconducting DC and RF Properties of Ingot Niobium
P. Dhakal (JLAB)

THPO058   Phase-Sensitive Nonlinear Near-Field Microwave Microscopy on MgB2 Thin Films
B.G. Ghamsari (UMD)

THPO059   Correlation of Microstructure, Chemical Composition and RRR-Value in High Purity Niobium (Nb-RRR))
R. Grill (Plansee Metall GmbH) M. Heilmaier (TU Darmstadt) W. Singer (DESY)

THPO060   First Principles Investigation of Hydrogen in Niobium
D.C. Ford (Fermilab) D.C. Ford (Northwestern University) D.N. Seidman (NU)

THPO061   Activation of Field Emitters on Clean Nb Surfaces
A. Navitski (Bergische Universität Wuppertal) D. Reschke (DESY)

THPO062   Epitaxial Niobium Thin Films for Accelerator Cavities
W.M. Roach (The College of William and Mary) C.E. Reece (JLAB)

THPO063   Study of the Impurity Species in Niobium Films Grown by ECR Technique Employing Secondary Ion Mass Spectrometry
A-M. Valente-Feliciano (JLAB) F.A. Stevie (NCSU AIF)

THPO064   Structural Properties of Niobium Thin Films Deposited on Metallic Substrates by ECR Plasma Energetic Condensation
J.K. Spradlin (JLAB) D. Gu (ODU) K.I. Seo (NSU)

THPO065   Anomalous Morphological Scaling in Epitaxial Nb Thin Films on MgO(001)
D.B. Beringer (The College of William and Mary) C.E. Reece (JLAB)

THPO066   Stoichiometric Nb3Sn in First Samples Coated at Cornell
S. Posen (CLASSE)

THPO067   Characterization of Large Grain Nb Ingot Microstructure Using OIM and Laue Methods
D. Kang (Michigan State University) G. Ciovati (JLAB) C. Compton (FRIB) T.L. Grimm (Niowave, Inc.)

THPO068   Experimental Investigation and CPFE Modeling of Single Crystal Niobium for Tube Hydro-forming

A. Mapar ((MSU)) D.C. Baars (Michigan State University) C. Compton (FRIB) P. Darbandi (MSU) J.E. Murphy (University of Nevada, Reno)

THPO069   Nb Film Growth on Crystalline and Amorphous Substrates

E.F. Valderrama (AASC) P. Maheshwari (NCSU AIF) K.I. Seo (NSU) X. Zhao (JLAB)

THPO070   Effect of Fabricate Condition on Properties of Bi-2212 Thin Films

T.M. Nguyen (nguyenthi mua)

THPO071   Detailed Surface Analysis of Incremental Centrifugal Barrel Polishing (CBP) and EP of Single-Crystal Niobium Samples

A.D. Palczewski (JLAB)

THPO072   Raman Spectroscopy as a Probe of Surface Oxides and Hydrides on Niobium

J. Zasadzinski (IIT) Th. Proslier (ANL)

THPO073   Laser Melt Smoothing of Niobium Superconducting Radio-Frequency Cavity Surfaces

S. Singaravelu (JLAB) C. Xu (The College of William and Mary)

THPO074   NbTiN Films for SRF Multilayer Structures

A-M. Valente-Feliciano (JLAB) D. Gu (ODU) K.I. Seo (NSU)

THPO075   Does Annealing Reduce or Remove Defects Observed After Electropolishing?

L.D. Cooley (Fermilab)

THPO076   Measurement of the Loss Tangent and Heat Capacity of a Large Single Crystal Sapphire

N. Pogue (Texas A&M University)

THPO077   Mo-Re Films for SRF Applications

E.F. Valderrama (AASC) P. Maheshwari (NCSU AIF) K.I. Seo (NSU) X. Zhao (JLAB)

THPO078   Surface and Thin Film Characterization of Superconducting Multilayer Films for Application in RF Accelerator Cavities

R.K. Schulze (LANL) B. Moeckly (STI) T. Prolier (ANL) A.T. Zocco (UC)

THPO079   Surface Preparation of Metallic Substrates for Quality SRF Thin Films

J.K. Spradlin (JLAB)

28-Jul-11   18:00 – 19:00

18:00 – 19:00   THIOC — Hot Topics

Hot topics: Recipes for 9-cell cavity fabrication and preparation

Session Chair: T. Saeki, KEK (Ibaraki, Japan)

29-Jul-11   08:00 – 10:15

08:00 – 10:15   FRIOA — SRF Technology

Session Chair: S. Noguchi, KEK (Ibaraki, Japan)

FRIOA01   Adaptive Compensation for Lorentz Force Detuning in Superconducting RF Cavities

W. Schappert (Fermilab)

FRIOA02   Innovative Tuner Designs For Low Beta SRF Cavities

Z.A. Conway (ANL)

FRIOA03   Recent Progress in HOM Damping from Around The World

M. Liepe (CLASSE)

FRIOA04   Power Couplers for Spiral-2

Y. Gï¿½mez Martï¿½nez (LPSC) P.-E. Bernaudin (CEA/DSM/IRFU) G. Olry (IPN)

FRIOA05   Overview of CW Input Couplers for ERL

H. Sakai (KEK)

FRIOA06   Construction of cERL Cryomodules for Injector and Main Linac

K. Umemori (KEK) E. Cenni (Sokendai) M. Sawamura (JAEA) K. Shinoe (ISSP/SRL)

FRIOA07   SRF Photoinjector Tests at HoBiCat

A. Neumann (HZB) P. Kneisel (JLAB) R. Nietubyc (The Andrzej Soltan Institute for Nuclear Studies, Centre Swierk) J.K. Sekutowicz (DESY) I. Will (MBI)

29-Jul-11   10:45 – 12:30

Contents

10:45 – 12:30   FRIOB — New/Emerging SRF Capability & Applications
Session Chair: J.E. Chen, PKU/IHIP (Beijing, People's Republic of China)
FRIOB01   SRF Activities at Peking University
J.K. Hao (PKU/IHIP)
FRIOB02   RF and Beam Test of the DC-SRF Injector of PKU-SETF
F. Zhu (PKU/IHIP)
FRIOB03   Chinese Plan for ADS and CSNS
S. Fu (IHEP Beijing) Y. He (IMP)
FRIOB04   SRF Accelerator for Indian ADS Program: Present & Future Prospects
P. Singh (BARC)
FRIOB05   Crab Crossing for LHC Upgrade
R. Calaga (BNL)
FRIOB06   The ESS Accelerator
M. Lindroos (CERN) S. Peggs (ESS)

29-Jul-11   12:45 – 13:00
12:45 – 13:00   FRT — Closeout

MOIOA — Overview of SRF Challenges

Challenges in SRF Module Production for the European XFEL

D. Reschke (DESY)

The internationally organized European XFEL free-electron laser is under construction at the Deutsches Elektronen-Synchrotron (DESY). With an electron beam energy of 14 GeV the possible wavelength will be down to 0.05 nm. The project is the first large scale application of the TESLA technology developed over the last 15 years. The main linac will consist of 80 accelerator modules, i.e. 640 superconducting accelerator cavities, operated at a gradient of 24.3 MV/m. The talk describes the activities with respect to the module production within the international collaboration. The challenges and the status of final prototyping, industrialization and commissioning of new infrastructure will be presented.

Advances in SRF Development for ILC

A. Yamamoto (KEK)

The International Linear Collider (ILC) project expects sixteen thousands 1.3 GHz, 9-cell SRF cavities with a field gradient of 35 MV/m, in order to realize an electron and positron collider with a total energy of 500 GeV. It will require thoughtful preparation for the industrialization and for advanced technical approach for a large amount of cost-effective production. For further long term scope, It will be important to make our best effort to investigate much higher field gradient and Q0 value, and to seek for further cost-effective cavity production for future energy upgrade toward 1 TeV. It may include new material and new fabrication technology. The advances in SRF cavity technology development and future prospect will be discussed.

Recent SRF Developments for ERLs

G.H. Hoffstaetter, M. Tigner (CLASSE)

Research and Development of SRF technology is being advanced around the world. We review developments in Europe, Asia and North America citing specifics from Helmholtz Zentrum Berlin, KEK, JLab and Cornell. These programs are designed in part to improve BBU control, power coupling and Qo which is crucial for minimizing power consumption for operation of ERLs as CW sources of high-current low-emittance beams.

SRF Challenges for Improving Operational Electron Linacs

C.E. Reece (JLAB)

The performance of the operational SRF-based electron linacs CEBAF, ELBE, and S-DALINAC continues to evolve positively. These facilities are exploiting opportunities to improve operational capability by both remediation of past limitations and also construction of new capacity using state-of-the-art designs and processes. A project to rework the weakest ten cryomodules in CEBAF was completed and enabled robust operation for physics at 6 GeV. The 12 GeV Upgrade of CEBAF is now underway and involves construction of ten new CW >100 MV cryomodules with 80 new 7-cell low-loss cell shaped fine-grained niobium cavities, all electropolished. The technical challenges associated with the preparation of these cavities will be reviewed and their performance in individual acceptance and cryomodule testing to date will be summarized. The ELBE facility at Helmhotz Zentrum Dresden Rossendorf continues to develop its source with an SRF gun system. The long-running S-DALINAC at Technische Universität Darmstadt is operating reliably, and in the framework of the injector upgrade program, a new cryomodule featuring a waveguide power coupler with low transversal fields was developed and is assembled.

Chair: J. Knobloch, HZB (Berlin, Germany)   **47**

MOIOB — Overview of SRF Challenges

MOIOB01

SRF Development for High Energy Physics

M.S. Champion (Fermilab)

Superconducting Radio-Frequency (SRF) technology has become the technology of choice for accelerator-based high energy physics (HEP) research, from the operating Large Hadron Collider to the planned Project X and International Linear Collider. The HEP community has made large investments in recent years in preparation for the construction of a SRF-based project, and the SRF community has grown commensurately. Results and ongoing efforts will be described along with some comparison to the application of SRF technology in non-HEP applications.

MOIOB02

Advances in SRF for Low Beta Ion Linacs

S. Bousson (IPN)

Projects based on ion linacs have multiplied during the last decade to follow the increasing demand of ion beams, either stable or radioactive, for application in nuclear physics or material studies. Thanks to the continuous progress in SRF (Superconducting Radio Frequency) technology, all these linacs are based on low beta superconducting cavities of different type (half-wave, quarter-wave, bulk Nb or Nb/cu) and make this particular field very active in many laboratories worldwide. In this paper, we review the most recent developments in SRF performed in the framework of FRIB, SPIRAL-2, ATLAS, SARAF, IFMIF, TRIUMF and ISOLDE.

MOIOB03

Advances in SRF for Neutron Sources

S.-H. Kim (ORNL)

There have been studies for applications of superconducting radio-frequency (SRF) technologies to the proton or deuteron accelerators to generate high intensity neutrons. The areas of interests are neutron scattering, material test and accelerator driven systems for nuclear transmutation, energy generation, isotope production, and etc. Advantages of the SRF technology for high power proton/deuteron accelerators include high operating gradient, low beam loss from large aperture size and extremely high vacuum, high RF power transfer efficiency to beam, and operational flexibility. Many technical advances of SRF technologies from various programs have been applied to the high power accelerators for meeting their missions, which enables designs, constructions, and operations of high intensity accelerators at multi-megawatts level or higher. Major large scale operational and future neutron sources using the SRF technologies are presented together with their specific merits, requirements and issues.

MOIOB04

Survey of SRF Guns

S.A. Belomestnykh (BNL)

Developing Superconducting RF (SRF) electron guns is an active field with several laboratories working on different gun designs. While the first guns were based on elliptic cavity geometries, Quarter Wave Resonator (QWR) option is gaining popularity. QWRs are especially well suited for producing beams with high charge per bunch. In this talk we will describe recent progress in developing both types of SRF guns.

Operational Experience with SRF Cavities for Light Sources

M. Jensen (Diamond)

Third generation light sources require modest accelerating voltages, however this is offset by a need for high reliability, to serve users on a continual basis with minimal interruption. The high Q of the superconducting (SC) cavities means that cavities are designed such that higher order modes are effectively damped using external loads, offering stable high current, multi-bunch operation. Fundamental mode SC cavities for light sources were initially used in CESR and KEKB, followed by Taiwan Light Source and Canadian Light Source and third harmonic systems are used for bunch lengthening at SLS and ELETTRA. The successful operation of those machines led to the choice of SC cavities in the design of Soleil, Diamond Light Source and Shanghai Synchrotron Radiation Facility, all now in operation. Additionally, Taiwan Photon Source, Pohang Light Source II and National Synchrotron Light Source II are currently in construction and all employ SC cavities. In this paper we will review recent operational experience of SC cavities in light sources and will describe recent developments related to the cavities and their auxiliary systems.

MOIOB05

Hot Topics: Source of Quench Producing Defects

R.L. Geng (JLAB)

Recent efforts in pushing the performance of superconducting RF niobium cavities for the International Linear Collider have resulted in two-fold progresses: reduced field emission and improved quench limit in real 9-cell cavities. RF testing at cryogenic temperatures assisted with quench-detection instrumentation reveals that quench happens often times at highly localized areas inside or near the equator weld of a cavity cell, which is also the high surface magnetic field region. High-resolution optical inspection of the identified quench location makes it possible to correlate the cavity quench limit with certain types of defects. Several sources of quench producing defects are being explored. We will discuss the experimental evidence in supporting each of these sources. We will also discuss the methods of curing or preventing these defects for improved gradient limit and reduced gradient spread.

MOIOB06

MOPO — Poster Session

MOPO001

Commercial Superconducting Electron Linacs

T.L. Grimm, C.H. Boulware, J.L. Hollister (Niowave, Inc.)

Industry now has the capability to design, build and commission superconducting electron linacs. This capability includes the integration of the liquid helium refrigerator and the license to operate a radiation generating device. Niowave offers a broad range of commercial turnkey superconducting electron linacs with beam energies from 0.5 to 50 MeV and average beam powers from 1 W to 1 MW. The commercial linacs operate at 4.5 K with helium refrigerator loads typically less than 100 W. Operation at 4.5 K uses niobium cavities with frequencies less than about 700 MHz. The types of electron source used depend on the application and include DC, copper RF and SRF guns with cathodes based on photoemission, thermionic and field emission. There are many applications with a diverse range of uses from ultrafast electron microscopes to free electron laser to advanced x-ray sources and isotope production. Commercial developments and plans to date will be presented.

MOPO002

A Superconducting Cavity for a Flux Coupled Cyclotron That Drives a Power Plant Based on a Spent Nuclear Fuel

N. Pogue, P.M. McIntyre, A. Sattarov (Texas A&M University)

Accelerator-driven subcritical fission is a promising candidate method to destroy the long-lived actinides in spent nuclear fuel without reprocessing it. To make it economically feasible one needs an accelerator delivering a continuous 800MeV proton beam with 5-10 MW power and minimum down time. We are developing a design for a flux-coupled stack of isochronous cyclotrons (IC), in which each IC provides 3mA proton beam using a magnetic design very similar to that of the PSI IC. We have designed a superconducting cavity for each IC that would operate at 50 MHz and deliver 1MeV/turn energy gain. The lobes of the cavity are oriented parallel to the beam plane to fit into the confined space within the flux-coupled stack. The top and bottom lobes are coupled at the radial inside and outside ends to eliminate field distortions and parasitic modes that are produced if the lobes were terminated with flat ends. The approach enables us to reduce the accelerating gap and still preserve coupling between top and bottom sections of the cavity. The overall cavity is approximately 78 cm wide, 70 cm tall, and 3.2 meter long, producing a uniform accelerating field, and dissipates 9 W at 4 K.

MOPO003

650 MHz Cryomodules for Project X at Fermilab – Requirements and Concepts

T.J. Peterson, M.H. Foley, C.M. Ginsburg, C.J. Grimm, J.S. Kerby, Y. Orlov (Fermilab) R. Ghosh, G. Gilankar, A. Jain, P. Khare, P.K. Kush, A. Laxminarayanan (RRCAT)

Cryomodules containing 650 MHz superconducting niobium RF cavities and associated components (input couplers, tuners, instrumentation, etc.) will be developed for Project X, a proposed high intensity proton accelerator facility based on an H$^-$ linear accelerator at Fermilab. This paper describes the requirements of the 650 MHz cryomodules and the implications of those requirements for the cryomodule design. Cryomodule string segmentation, integration with the cryogenic system, features for maintainability and access, piping and emergency venting considerations, pressure vessel issues, and thermal and mechanical design concepts will be described.

Modified SRF Photoinjector for the ELBE at HZDR

The superconducting radio frequency photoinjector (SRF photoinjector) with Cs2Te cathode has been successfully operated under the collaboration of BESSY, DESY, HZDR, and MBI. In order to im-

P. Murcek, A. Arnold, H. Buettig, D. Janssen, M. Justus, P. Michel, G.S. Staats, J. Teichert, R. Xiang (HZDR) P. Kneisel (JLAB)

prove the gradient of the gun cavity and the beam quality, a new modified SRF gun (SRF-gun2008) has been designed. The main updates of the new cavity design for the new injector was publisched before. (ID TH-PPO022 on the SRF09 Berlin.) This cavity is being fabricated in Jefferson Lab. In this paper the ideas of the redesign of the further parts of the SRF-gun2008 will be presented. The most important issue is the special design of half-cell and choke filter. The cathode cooler is also slightly changed, which simplifies the installation of the cathode cooler in the cavity. The next update is the separation of input and output of the liquid nitrogen supply, for the purpose of the stability of the N2 pressure as well as the better possibility of temperature measurement. Another key point is the implementation of the superconducting solenoid inside the cryomodule. The position of the solenoid can be accurately adjusted with two stepmotors, which is thermally isolated to the solenoid itself.

Conceptual Design of the Superconducting Proton Linac (SPL) Short Cryo-module

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-

V. Parma, P. Bestman, N. Bourcey, O. Capatina, P. Coelho Moreira de Azevedo, E. Montesinos, T. Renaglia, A. Vande Crean, W. Weingarten, L.R. Williams (CERN) P. Dambre, P. Duchesne, P. Duthil, D. Reynet, S. Rousselot (IPN)

the-art SRF technology, which would serve as a driver for new physics facilities such as neutrinos and radioactive ion beams. Amongst the main objectives of this effort, are the development of 704 MHz bulk niobium β=1 elliptical cavities, operating at 2 K and providing an accelerating field of 25 MV/m, and testing of a string of cavities integrated in a machine-type cryo-module. In an initial phase only 4 out of the 8 cavities of an SPL cryo-module will be tested in a $\frac{1}{2}$ length cryo-module developed for this purpose thus called the Short Cryo-module. This paper presents the conceptual design of the Short Cryo-module, highlighting its innovative principles in terms of cavity supporting and alignment, and describes the integration of cavities and their main equipment (RF couplers, helium vessels, tuners, magnetic shielding) inside the cryo-module and their assembly method. The operational scenarios and test plans are also presented and discussed.

Status and Plans for an SRF Accelerator Test Facility at Fermilab

A superconducting RF accelerator test facility is currently under construction at Fermilab. The accelerator will consist of

M.D. Church, J.R. Leibfritz, S. Nagaitsev (Fermilab)

an electron gun, 40 MeV injector, beam acceleration section consisting of 3 TTF-type or ILC-type cryomodules, and multiple downstream beam lines for testing diagnostics and performing beam experiments. With 3 cryomodules installed this facility will initially be capable of generating an 810 MeV electron beam with ILC beam intensity. The facility can accomodate up to 6 cryomodules for a total beam energy of 1.5 GeV. This facility will be used to test SRF cryomodules under high intensity beam conditions, RF power equipment, instrumentation, and LLRF and controls systems for future SRF accelerators such as the ILC and Project-X. This paper describes the current status and overall plans for this facility.

MOPO007

Test of Components for the S-DALINAC Injector Upgrade*

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In 2009 a vertical bath cryostat was commissioned at the S-DALINAC. Since then, components for the new cryostat module within the framework of the injector upgrade have been tested. Measurements have been performed to check the leakage rate of ``Quick-CF'' UHV flanges and the performance of piezo actors in superfluid helium have been investigated. To enlarge the scale of possible measurements at the vertical bath cryostat, systems to measure the quality factor via the decay time method and quench localisation via second sound will be implemented this year. We will report on the recent results.

MOPO008

RF and SRF Layout of BERLinPro

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The ERL project BERLinPro is funded and now in the design phase. The planned SRF layout is described including the RF transmitters, the cryogenic installations and the configuration of the SRF modules.

MOPO009

Design Status of the Superconducting Driver Linac for the Facility for Radioactive Isotope Beams

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The Facility for Rare Isotope Beams (FRIB) will utilize a powerful, superconducting heavy-ion driver linac to provide stable ion beams from protons to uranium, at energies of > 200 MeV/u at a beam power of up to 400 kW. ECR ion sources installed above ground will be used to provide highly charged ions, that will be transported into the linac tunnel approx. 10 m below ground. For the heaviest ions, two charge states will be accelerated to about 0.5 MeV/u using a room-temperature 80.5 MHz RFQ and injected into a superconducting cw linac, consisting of 114 quarter-wave (80.5 MHz) and 231 half-wavelength (322 MHz) cavities, installed inside 52 cryomodules operating at 2K. A single stripper section will be located at about 17 MeV/u (for uranium). Transverse focusing along the linac will be achieved by 9 T superconducting solenoids within the same cryostat as the superconducting rf accelerating structures. This paper describes the matured linac design, as the project is progressing towards a Department of Energy performance baseline definition in 2012. Development status of the linac subcomponents are presented with emphasis on the superconducting RF components.

MOPO010

Update on Module Measurements for the XFEL Prototype Modules

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The Cryo Module Test Bench (CMTB) at DESY is used since several years for the SRF module tests. Three XFEL prototypes modules, PXFEL1,2,3, were tested on this facility. An update on the SRF modules testing activities since PXFEL1 test is presented.

Status of SARAF Superconducting Acceleration Module

Soreq Applied Research Accelerator Facility (SARAF) is based on a 176 MHz superconducting RF light ions linac, currently under commissioning at Soreq

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NRC. At present, the accelerator includes a Prototype Superconducting Module, containing 6 half wave resonators. In this work we present measurement results of various mechanical properties of the resonators. These results are compared to simulation results obtained using CST MWS. Beam operation results are presented as well, including a technique for the calibration of the cavity pick up probe by operating the Linac using two RF sources.

Overview of ILC High Gradient Cavity R&D at Jefferson Lab

We report on the progress of ILC high gradient cavity R&D at Jefferson Lab since the Berlin Workshop. Nine out of

R.L. Geng (JLAB)

ten 9-cell cavities manufactured by ACCEL/RI achieved a gradient of more than 38 MV/m at Q0 of more than $8 \cdot 10^9$ up to a second-pass processing. Four out of six 9-cell second production batch cavities manufactured by AES achieved a gradient in the range of 36-41 MV/m. The cavity quench studies are further enhanced by adopting the Cornell OST's and the KEK replica technique, in addition to the existing JLab fixed thermometry system and JLab high-resolution optical inspection machine. We have also processed and tested ILC alternate cavities including 9-cell large-grain niobium cavities and 9-cell low-loss shape (ICHIRO) cavities in collaboration with Peking University and KEK. To date, about 50 9-cell cavities have been processed and tested at JLab under the American Regional Team program in support of ILC. More than 110 ILC cavity EP cycles have been accumulated, corresponding to more than 320 hours of active EP time. More than 150 ILC cavity RF tests at cryogenic temperatures have been completed.

RF Test Results from Cryomodule 1 at the Fermilab SRF Beam Test Facility

Powered operation of Cryomodule 1 (CM-1) at the Fermilab SRF Beam Test Facility began in late 2010. Since then a series of tests first on the eight individual cavities and then the full cryomodule have been performed. We report on the results of these tests and lessons learned which will have an impact on future module testing at Fermilab.

E.R. Harms, J. Branlard, K. Carlson, B. Chase, E. Cullerton, C.C. Jensen, P.W. Joireman, A.L. Klebaner, T. Kubicki, M.J. Kucera, A.M. Legan, J.R. Leibfritz, A. Martinez, M.W. McGee, S. Nagaitsev, O.A. Nezhevenko, D.J. Nicklaus, H. Pfeffer, Y.M. Pischalnikov, P.S. Prieto, J. Reid, W. Schappert, V. Tupikov, P. Varghese (Fermilab)

MOPO014

Design of the Fundamental Power Coupler and Photocathode Inserts for the 112 MHz Superconducting Electron Gun

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A 112MHz superconducting quarter-wave resonator electron gun will be used as the injector of the Coherent Electron Cooling (CEC) proof-of-principle experiment at BNL. Furthermore, this electron gun can be the testing cavity for various photocathodes. In this paper, we present the design of the Fundamental Power Coupler (FPC) and the cathode stalks designated to the future experiments. The axial waveguide structure FPC has the properties of tunable coupling factor and small interference to the electron beam output. The optimization of the coupling factor and the location of the FPC are discussed in detail. Two types of cathode stalks are discussed. Special shape of the stalk is applied in order to minimize the RF power loss. The location of cathode plane is also optimized to enable the extraction of low emittance beam.

MOPO015

IHEP 1.3GHz SRF Technology R&D Status

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1.3 GHz superconducting radio-frequency (SRF) technology is one of the key technologies for the ILC and future XFEL and ERL projects in China. With the aim to develop 1.3 GHz SRF technology, IHEP has started a program to build an SRF Accelerating Unit. This unit contains a 9-cell 1.3 GHz superconducting cavity, a short cryomodule, a high power input coupler, a tuner, a low level RF system etc. This program also includes the SRF laboratory upgrade, which will permit the unit to be built and tested at IHEP. The unit will be used for the 1.3 GHz SRF system integration study, high power horizontal test and possible beam test in the future. In this paper, we report the recent R&D status of this program. The first large grain low-loss shape 9-cell superconducting RF cavity made by IHEP reached 20 MV/m in the first vertical test. The prototype tuner and LLRF system are under test. The first 1.3 GHz high power input coupler fabrication was finished and the cryomodule is under fabrication. Several key SRF facilities (CBP, CP, HPR, optical inspection camera, pretuning machine etc) for 9-cell cavity surface treatment and pre-tuning were successfully commissioned and in operation.

MOPO016

Superconducting RF R&D for the Cornell ERL Main Linac

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Cornell University is developing the superconducting RF technology required for the construction of a 100 mA hard X-ray light source driven by an Energy-Recovery Linac. Prototype components of the 5 GeV cw SRF main linac cryomodule are under development, fabrication and testing. This work includes an optimized 7-cell SRF cavity, a broadband HOM beamline absorber, and a 5 kW cw RF input coupler. In this paper we give an overview of these activities at Cornell.

Performance Limitation Studies on ISAC-II QWR's and e-Linac Elliptical Cavities at TRIUMF

TRIUMF has been successfully for several years numerous 100MHz class superconducting quarter wave resonators on the ISAC-II heavy ion linac and is now developing a 1.3 GHz activity

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to build the e-linac, a 50 MeV superconducting electron linac to produce radioisotopes by photofission. Several studies on cavity treatments are ongoing to both enhance ISAC-II QWR performances and to meet the requirements on the e-linac elliptical cavities. This paper will summarize the main development efforts to understand performance limitations in these cavities.

The Upgraded Injector Cryostat-Module and Upcoming Improvements at the S-DALINAC

Since 1991 the superconducting Darmstadt linear accelerator S-DALINAC provides an electron beam of up to 130 MeV for nuclear and astrophysical exper-

R. Eichhorn, J. Conrad, F. Hug, M. Kleinmann, T. Kuerzeder, S.T. Sievers (TU Darmstadt)

iments. The accelerator consists of an injector and four main linac cryostats, where the superconducting 3 GHz cavities are operated in a liquid helium bath at 2 K. For the injector upgrade program, the RF power delivered to the beam had to be increased from 500 W to 2 kW. Therefore, the coaxial power couplers have to be replaced by new waveguide couplers introducing only small transversal kicks to the beam. Consequently, modifications to the cryostat-module and had become necessary. We review on the design of the module and some interesting features and give details on the tuning of the newly built 20-cell cavities. The paper will close with an outlook towards the installation of an additional recirculation path planed in 2013.

Minimizing Microphonics Detuning by Optimization of Stiffening Rings

Maintaining a constant gradient in a superconducting cavity requires can require much more power if the cavity is

S. Posen, M. Liepe (CLASSE)

not driven on resonance. Significant cost savings in both power consumption and power supplies can be realized by minimizing the detuning of the cavity away from the drive frequency. One of the largest contributions to detuning is microphonics. In this paper, simulations of microphonics detuning by LHe bath pressure fluctuations in a Cornell ERL cavity are presented, and the effect of varying stiffening ring radius is investigated. The consequences of using optimal stiffening ring radii are explored as well, including bandwidth limitations in active detuning compensation due to mechanical resonances and requirements for the frequency tuner.

MOPO020

Nine-cell Elliptical Cavity Development at TRIUMF

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The superconducting e-Linac project at TRIUMF requires a new nine cell elliptical cavity at 1.3GHz of TESLA influenced design capable of providing a CW accelerating voltage of 10MV at 10mA of beam intensity. This corresponds to a challenging 100kW of beam loaded rf power and a Beam Break-up (BBU)threshold in multi-pass mode of Rd/Q*QL=10MOhms. For this purpose we use two opposed CPI 60kW cw rated couplers. Another challenge is to provide HOM damping for the possibility of multi-pass ERL operation by means of end cell optimization and higher order mode (HOM) dampers. Results of the cavity design work including developments toward a passive HOM damper will be discussed.

MOPO021

Electromechanical Design of 704MHz β 0.65 SC Proton Cavity

H. Gassot, F.B. Bouly, G. Olry, S. Rousselot (IPN)

Within the framework of the EUCARD, IPN Orsay is in charge of design of a 704MHz elliptic superconducting cavity for β = 0.65 high intensity proton linac in pulsed mode. This study offers a new option to replace the injector of the Large Hadron Collider at CERN with SPL (Superconducting Proton Linac) project. For this cavity's design, a compromise between the requirements of high technological performances and the constraint of the cavity's cost should be found. As middle beta elliptical cavity has a big ratio between equator radian and iris radian, the mechanical deformations generate important Lorentz forces detuning. As a consequence, the cavity wall thickness should be increased and one or two stiffening rings between cells are necessary. The additional cost should be imperatively minimized since more than fifty β 0.65 cavities are considered for SPL linac. To do these optimizations, the electromechanical calculations are performed via our simulation platform, which drives and links CATIA for CAD, Cast3m for mechanics and Opera3d for RF. The final design of cavity is presented in this paper.

MOPO022

Higher Order Mode Properties of Superconducting Two-Spoke Cavities

C.S. Hopper, S.J. Roof (ODU) J.R. Delayen (JLAB) R.G. Olave (Old Dominion University)

Multi-Spoke cavities lack the cylindrical symmetry that many other cavity types have, which leads to a more complex Higher Order Mode (HOM) spectrum. In addition, spoke cavities offer a large velocity acceptance which means we must perform a detailed analysis of the particle velocity dependence for each mode's R/Q. We present here a study of the HOM properties of two-spoke cavities designed for high-velocity applications. Frequencies, R/Q and field profiles of HOMs have been calculated and are reported.

Low Temperature Test of a Low-Beta Elliptical Cavity for PEFP Linac Extension

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

For the future extension of the PEFP (Proton Engineering Frontier Project) proton linac, a study on the SRF technology has been performed including a prototype cavity development to confirm the design of the cavity and fabrication procedures and to check the RF and mechanical properties of a low-beta elliptical cavity. The geometrical beta and resonant frequency of operating mode are 0.42 and 700 MHz, respectively. The cavity is a five-cell structure stiffened by double-ring structure to increase mechanical stability. For the vertical test of the cavity, RF system based on PLL (phase locked loop) has been prepared. If there is no magnetic shielding and operating temperature is 4.2 K, the required RF power to generate the design accelerating field of 8 MV/m is estimated to be about 320 W at critical coupling. In case single RF amplifier cannot deliver sufficient RF power, a coaxial type two-way RF combiner is under consideration. The details of the cavity test setup and results will be presented in this paper.

Design of Single Spoke Resonators at Fermilab

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Project X is based on a 3 GeV CW super-conducting linac and is currently in the R&D phase awaiting CD-0 approval. The low-energy section of the Project X H$^-$ linac (starting at 2.5 MeV) includes three types of super-conducting single spoke cavities operating at 325 MHz. The first three cryomodules will each house 7 SSR0 cavities at $\beta = 0.11$. The following two cryomodules will each contain 10 SSR1 cavities each at $\beta = 0.21$. The last four cryomodules will contain 11 SSR2 cavities each at $\beta = 0.4$. Single spoke cavities were selected for the linac in virtue of their higher r/Q values compared to standard Half Wave Resonator. Quarter Wave Resonators were not considered for such a high frequency. In this paper we present the decisions and analyses that lead to the final design of SSR0. Electro-magnetic and mechanical finite element analyses were performed with the purpose of optimizing the electro-magnetic design, minimizing frequency shifts due to helium bath pressure fluctuations and providing a pressure rating for the resonators that allow their use in the cryomodules.

High-Frequency and Mechanical Basic Analysis of Conical Half-Wave Resonator

E.N. Zaplatin (FZJ) A. Kanareykin (Euclid TechLabs, LLC)

A cylindrical Half-Wave length Resonator is a proved superconducting structure In the low energy part of accelerators. Accelerating efficiency in such resonator is limited by the peak RF magnetic field on the inner cavity surface. By an enlargement of the dome cavity volume containing RF magnetic field the cavity peak surface magnetic field is reduced. Additionally, this results in the power dissipation reduction. The paper reports results of cavity shape optimization and structural analysis of conical Half-Wave Resonators for β=v/c=0.11 and two resonance frequencies 325 MHz and 162.5 MHz. This Work is supported by the DOE SBIR Program, contract #DE-SC0006302.

MOPO023

MOPO024

MOPO025

MOPO026

β = 0.285 Half-Wave Resonator for FRIB

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We have developed an optimized electromagnetic and mechanical design of a 322 MHz half-wave resonator (HWR) suitable for acceleration of ions in the post-stripper section of the Facility for Rare Isotope Beams (FRIB). The cavity design is based on recent advances in SRF technology for TEM-class structures being developed at ANL. Highly optimized EM parameters were achieved using an ''hourglass'' cavity shape for the HWR. This new design will be processed with a new HWR horizontal electropolishing system after all mechanical work on the cavity including the welding of the helium vessel is complete. Recently, this procedure was successfully tested on a quarter wave resonator developed for the ATLAS Upgrade which achieved peak surface fields of 70 MV/m and 10^5 mT. Following these results we propose to operate the HWR with a 2.6 MV accelerating voltage per cavity at the optimal ion velocity of β = 0.285. Fabrication of the cavity can be started immediately as soon as funding is available.

MOPO027

Analysis of HOM Properties of Superconducting Parallel-Bar Deflecting/Crabbing Cavities

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The superconducting parallel-bar cavity is currently being considered for a number of deflecting and crabbing applications due to improved properties and compact design geometries. The 499 MHz deflecting cavity proposed for the Jefferson Lab 12 GeV upgrade and the 400 MHz crab cavity for the proposed LHC luminosity upgrade are two of the major applications. For high current applications the higher order modes must be damped to acceptable levels to eliminate any beam instabilities. The frequencies and R/Q of the HOMs and mode separation are evaluated and compared for different parallel-bar cavity designs.

MOPO028

Design of CW Superconducting Buncher for RIKEN RI-Beam Factory

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In the RIKEN RI-Beam Factory (RIBF), very heavy ions such as uranium are accelerated with a cascade of a linac injector (RILAC2) and four booster cyclotrons (RRC, fRC, IRC and SRC). There are two charge-stripping sections in this complex. One is located after the RRC (β = 0.16), and the other is after the fRC (β = 0.32). The stripping process causes an increase of the phase width of the beam in the following cyclotrons, which will be reduced by a longitudinal focusing device: a rebuncher. However, design of the rebuncher is challenging because the beam velocity is not so small and the required voltage is estimated to be as high as a few megavolts. We started the design study of the SRF resonator which works at the velocity of β = 0.32. Several types of the rf strucuture have been simulated in this initial design study: a quarter-wavelength resonator (QWR), half-wavelength resonator (HWR), double-spoke resonator, and half-H mode resonator. In addition, we examined the possibility of a new type of coupled TE-mode structure, which is expected to make the voltage distribution more uniform. Basic parameters are calculated and the feasibility is discussed in this paper.

Some Concerns on the Development of Spoke Cavity

The design and optimization goal are re-considered based on the the construction and operation efficiency in the desired

F.S. He (PKU/IHIP) H. Wang (JLAB)

beta range. Some first order analytical methods as well as equivalent circuit model are applied to guide the design effort. Initial result of the EM design for the ESS requirement is reported.

The sc cw -LINAC Demonstrator - First section of a sc cw -LINAC

The realisation of the first section of a new superconducting (sc) continuous wave (cw) LINAC is planned in 2013. The project is called ``cw LINAC Demonstrator'' and is financed by the Helmholtz In-

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stitute Mainz (HIM). The aim is a ``full performance test'' at GSI-HLI of a new 217 MHz sc CH-Cavity which is designed by the Institute of Applied Physics (IAP) of the University Frankfurt. According to an engineering study for the cryostat, a frame has been designed to support the cavity embedded by two sc solenoids. A nuclotron -suspension analog to the SIS-100 Magnets for FAIR is used, which nearly prevents the displacement of the components on the frame while cooling down. Another challenge is to reduce the magnetic field of the solenoid from 9.3 T to 50 mT at the cavity within some centimeters by moveable compensation -coils. This and other technical solutions in the cryogenic environment of the Demonstrator are presented.

Electro-Magnetic Optimization and Analyses of Etching for HIRFL Quarter-Wave Resonators

A superconducting accelerating section for SSC-linac system (injector into separated sector cyclotron) is under develop-

C. Zhang, W. Chang, Y. He, S.H. Zhang, H.W. Zhao (IMP)

ment at the HIRFL (heavy ion research facility of Lanzhou). Two types of superconducting quarter-wave resonators (81.25 MHz, optimum β = 0.041 and 0.085) will be used for acceleration to energies of up to 10 MeV per nucleon. The β=0.041 QWR works at the accelerating voltage of 0.75 MV and β=0.085 QWR works at 1.5 MV, in order to reach a record high performance, the EM design was carefully optimized for both cavities. A selected number of cavity geometry parameters were analyzed to see how they affect the electro-magnetic parameters of the cavity, and different influence levels of these geometry parameters are ranked. In this paper, we will also present how the etching thickness changes the frequency during the buffered chemical polishing processing, and the difference of the change for the two type cavities has been compared.

MOPO032

Development of a Frequency Map for the WiFEL SRF Gun

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SRF cavity design requires the integration of several different software and analytic tools to produce a cavity which, after production and cool down to liquid helium temperatures, has the correct resonant frequency. We describe a `map' which starts with a cold cavity at the correct frequency and moves back through the series of production steps producing an expected resonant frequency at each step. For example, contributions to cavity deformation from vacuum and tuner loading are modeled in ANSYS and a piecewise linear fit is produced which is re-inserted into the SUPERFISH1 model to determine the new resonance point. We describe the steps and calculations used to develop the frequency map for the Wisconsin SRF electron gun and the specific initial cavity geometry.
1. J. H. Billen and L. M. Young,"POISSON/SUPERFISH on PC Compatibles" Proceedings of the 1993 Particle Accelerator Conference, Vol. 2 of 5, 790-792 (1993).

MOPO033

Design of Superconducting Multi-Spoke Cavities for High-Velocity Applications

C.S. Hopper, S.U. De Silva (ODU) J.R. Delayen (JLAB)

Superconducting spoke cavities have been designed and tested for particle velocities up to $\beta \sim 0.6$ and are currently being designed for velocities up to $\beta = 1$. We present the electromagnetic designs for two-spoke cavities operating at 325 MHz for $\beta = 0.82$ and $\beta = 1$.

MOPO034

Optimized RF Design of 704 MHz β=1 Cavity for Pulsed Proton Drivers

J. Plouin (CEA/IRFU) S. Chel, G. Devanz (CEA/DSM/IRFU)

The high energy part of the Superconducting Proton Linac (SPL) will be composed of two families of elliptical cavities, $\beta = 0.65$ and $\beta = 1$. This paper focuses on the $\beta = 1$, 5-cell cavity, whose RF design has been developed at CEA-Saclay in the frame of EUCARD (European Coordination for Accelerator Research & Development). These cavities are aimed to work in pulsed mode (50Hz, duty cycle 5%), with a beam current of 40 mA and RF peak power 1MW. Since these cavities should provide a challenging gradient of 25 MV/m, the RF design has been realized to optimize cavity efficiency and peak fields. The position of high power couplers has been determined to achieve the adequate external coupling, and the monopole High Order Modes have been identified and characterized. We have also carried out RF/mechanical simulations in order to optimize the mechanical behavior of cavity, in particular the Lorentz force detuning.

MOPO035

Structural Mechanical Analysis of Superconducting CH-Cavities

M. Amberg (HIM) K. Aulenbacher (IKP) W.A. Barth, S. Mickat (GSI) M. Busch, F.D. Dziuba, H. Podlech, U. Ratzinger (IAP)

The superconducting Crossbar-H-mode (CH)-structure has been developed and tested successfully at the Institute for Applied Physics (IAP) of Frankfurt University. It is a multi-gap drift tube cavity for the acceleration of protons and ions in the low and medium energy range based on the H210-mode. At present two types of superconducting CH-structures (f = 325 MHz, $\beta = 0.16$, seven cells and f = 217 MHz, $\beta = 0.059$, 15 cells) are under construction. For the geometrical design of superconducting cavities structural mechanical simulations are essential to predict mechanical eigenmodes and the deformation of the cavity walls due to bath pressure effects and the cavity cool-down. Therefore, several static structural and modal analyses with ANSYS Workbench have been performed. Additionally, a new concept for the dynamic frequency tuning including a novel type of a piezo based bellow-tuner has been investigated to control the frequency against microphonics and Lorentz force detuning.

Design Optimization of Spoke Cavity of Energy-Recovery Linac for Non-Destructive Assay Research

M. Sawamura, R. Hajima (JAEA) R. Nagai, N. Nishimori (JAEA/ERL)

We are proposing non-destructive assay system of nuclear materials with laser Compton scattering combined with an energy-recovery linac (ERL) and a laser. To construct this system for nuclear safeguards and security purpose, it is important to make the accelerating cavity small. The spoke cavity has advantages over the elliptical cavity to use for our proposing system. We are designing a spoke cavity favorable to compact cavity. Design optimization calculation of the spoke cavity shape is being carried out with 3D electro-magnetic field simulation code and generic algorithm. The results will be presented.

Development of Superconducting CH Cavities

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At present, two superconducting (sc) CH cavities are under development at the Institute for Applied Physics (IAP) of Frankfurt University. The construction of a sc 325 MHz CH cavity with 7 cells and an envisaged design gradient of 5 MV/m is almost finished. It is planned to test this cavity with beam at GSI Universal Accelerator (UNILAC), Darmstadt to show its performance as a candidate for the UNILAC upgrade. Furthermore, the 217 MHz CH structure with 15 accelerating cells and a real estate gradient of 5.1 MV/m will be the first cavity of the new sc continuous wave (cw) LINAC at GSI. This proposed cw LINAC is highly requested to fulfil the requirements of nuclear chemistry and especially for a competitive production of new Super Heavy Elements (SHE). To demonstrate the cavity capabilities under a realistic accelerator environment, a full performance test by injecting and accelerating a beam from the GSI High Charge Injector (HLI) is planned in 2013/14. The current status of both sc CH cavities is presented.

Development of the Demountable Damped Cavity

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

We have designed a new HOM free cavity named Demountable Damped Cavity (DDC) as an ILC R&D. DDC has two design concepts. The first one is an axial symmetry to eliminate kick off effect by HOM coupler itself. DDC is applied coaxial structure along the beam axis to make strong coupling with HOM. HOM is damped on RF absorber at the end of coaxial waveguide and the accelerating mode is reflected by the choke filter mounted on the entrance of coaxial waveguide. The second concept is demountable structure which can make cleaning of end group easy in order to suppress the Q-slope problem at high field. MO sealing will be applied for the demountable joint. We have simulated the HOM damper structure, thermal structure, and the multipacting phenomena on single DDC. We have also simulated how DDC works on ICHIRO 9-cell cavity. Now we are fabricating single DDC. Cold test is also planned. In this paper, we will present the results of them.

MOPO039

Low-β Triple Spoke Cavity Design Improvement for Proton Linac

H. Gassot, S. Bousson, G. Olry, S. Rousselot (IPN)

Within the framework of the EURISOL, IPN Orsay has proposed a 352MHz triple-spoke superconducting cavity: for the low energy section (beta = 0.3) of high power proton linear accelerators. In terms of structure design, a triple-spoke superconducting cavity has a complicated geometry, 3D modelling is necessary. More, the design requires simulations which couple electromagnetism with mechanics. To perform these tasks, the mechanics simulation code CAST3M (Calcul et Analyse de Structure et Thermique par la mï¿½thode des Elï¿½ments Finis) has been linked to the electromagnetism code Opera3D via a dedicated platform, which has been developed for this purpose. This work allows the instantaneous passage from CAD (CATIA) design to mechanical calculations using Cast3m and electromagnetic simulations with Opera3D. As a consequence, the delay of design studies has been considerably reduced. The mathematical advances of the simulation platform are summarized. The electromagnetic and mechanical behaviours of the triple-spoke are presented and discussed in this paper.

MOPO040

SRF Cavity Design for High Current Linacs

W. Xu, S.A. Belomestnykh, I. Ben-Zvi, R. Calaga, H. Hahn, E.C. Johnson, J. Kewisch (BNL)

A high current five-cell Nb superconducting cavity, called BNL3 cavity, was optimized and designed for the SPL and eRHIC. For the fundamental mode, the optimization process aimed at maximizing the R/Q of the fundamental mode and the geometry factor G under an acceptable RF field ratio level of Bpeak/Eacc and Epeak/Eacc. For higher order modes, the optimization is to lower (R/Q)Qext for dipole and quadrupole modes to suppress the beam-break-up (BBU). To extract the HOM power out of the cavity, the BNL3 cavity employs a larger beam pipe, allowing the propagation of HOMs, but not the fundamental mode. Six HOM couplers (three at each end) are used to extract large HOM power. To avoid the cross-talk between cavities, tapers are employed between the cavities. This paper presents the design of the BNL3 cavity, end groups and connection of cavities.

MOPO041

Conceptual Design of the β = 0.86 Cavities for the Superconducting Linac of ESS

J. Plouin (CEA/IRFU) G. Devanz (CEA/DSM/IRFU)

CEA-Saclay is in charge of the design, the fabrication and the tests of the superconducting high beta cavities for the high energy part of the ESS (European Spallation Source) linac. This paper reports the actual status of the RF and mechanical design of these cavities. According to ESS specifications, these cavities will be 5-cells elliptical, with frequency 704 MHz and β=0.86. They will work in the pulsed mode, with a beam current initially equal to 50 mA. The target accelerating gradient is 18 MV/m on the linac, and 20 MV/m in vertical tests. For the RF design, the cavity efficiency and the peak fields were optimized, while the feasibility of the external coupling with RF power was taken into account. Attention was also paid to the HOM frequencies and impedances and to their future extraction. Coupled RF/mechanical FEM calculations have been carried out and the Lorentz detuning, critical for a pulsed mode cavity, is lowered by the insertion of stiffening rings.

Coupler Design for a Sample Host TE Cavity

A sample host niobium superconducting cavity operating at both TE012 and TE013 modes has been developed *. The cavity

Y. Xie, M. Liepe (CLASSE)

features a flat 3.75'' diameter demountable bottom plate allowing RF testing of new materials such as Nb3Sn and MgB2. Since the surface resistance of the sample plates may vary a lot, an adjustable input coupler has been developed for this cavity. A hook shape coupler tip is designed and optimized to couple to the magnetic field of both transverse electric modes. The external Q factor, coupler heating considerations and 3D multipacting simulations using ACE3P will be discussed.

* Y. Xie, J. Hinnefield, M. Liepe, '' Design of a TE-type cavity for testing superconducting material samples'', SRF2009, Berlin (2009)

Mechanical Study of Superconducting Parallel-Bar Deflecting/Crabbing Cavities

The superconducting parallel-bar deflecting/crabbing cavities have improved properties compared to conventional

H. Park, J.R. Delayen (JLAB) S.U. De Silva, H. Park (ODU)

cavity structures. It is currently being considered for number of applications. The mechanical design analysis is performed on two designs of the 499 MHz parallel-bar deflecting cavity for the Jefferson Lab 12 GeV upgrade. The main purpose of the mechanical study is to examine the structural stability of the cavities under the operating conditions in the accelerators. The study results will suggest the need for additional structural strengthening. Also the study results will help to develop a concept of the tuning method. If the cavity is to be installed in the accelerator it should satisfy a certain design parameters due to the safety requirements (for example, pressure vessel code) which are much severe condition than the actual operating condition.

Electromagnetic Design Optimization of a Half-Wave Resonator

The optimization procedure developed for the electromagnetic (EM) design of the ATLAS Upgrade quarter-wave resonator (QWR) [1] has now been success-

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

fully tested. The prototype QWR achieved record peak surface fields of 70 MV/m and 10^5 mT and is capable of providing 4.4 MV, far exceeding the design voltage of 2.5 MV. We have developed and applied a similar procedure for the EM design of a 322 MHz - beta ~ 0.29 half-wave resonator (HWR) for the medium energy section of the FRIB driver linac. The optimization path and the final results will be presented and discussed. The choice of aperture and its effect on the EM design parameters will be discussed. A comparison between equivalent half-wave and single-spoke resonators will also be presented. The transition from the electromagnetic model in MWS to the engineering model in Inventor was carefully studied as it may affect both the EM design parameters and the cavity fabrication.

* ``Electromagnetic Optimization of a Quarter-Wave Resonator'' B. Mustapha and P. Ostroumov, Proceedings of Linac-10, Tsukuba, Japan.

MOPO045

Coupled Electromagnetic and Mechanical Simulations for Half-Wave Resonator Design

J.P. Holzbauer (NSCL) J. Binkowski, A. Facco, M.J. Johnson, S.J. Miller, J. Popielarski, Y. Xu (FRIB)

Mechanical design of two Half-Wave Resonators (HWRs) at 322 MHz with optimum $\beta = v/c = 0.29$ and 0.53 is underway at Michigan State University (MSU). These cavities are being designed for use in the Facility for Rare Isotope Beams (FRIB) driver linac. Part of this work has been the optimization of the mechanical properties to minimize Lorentz Force Detuning and helium bath pressure sensitivity while providing adequate tuning range. The simulation techniques used for this work and the resulting proposed cavity stiffening will be presented.

MOPO046

Design of a 322 MHz β=0.29 Half Wave Resonator

J. Popielarski, J. Binkowski, C. Compton, A. Facco, J.P. Holzbauer, M. Leitner, S.J. Miller, Y. Xu (FRIB)

A medium velocity Half Wave Resonator (HWR) is in the final stages of design at Michigan State University (MSU) for use in the Facility for Rare Isotope Beams (FRIB) driver linac. The cavity is being designed to deliver 1.9 MV accelerating voltage reliably, with on optimum β=v/c=0.29. The design effort optimizes the surface fields for reliable operation but also considers frequency stability and tunability altogether with straightforward fabrication and surface preparation procedures. The electromagnetic and mechanical design incorporate lessons learned from MSU developed 322 MHz HWR's for β=0.53, which has a similar shape.

MOPO047

HOM Cavity Design for the TRIUMF E-LINAC

P. Kolb, Y.-C. Chao, R.E. Laxdal, V. Zvyagintsev (TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics)

The TRIUMF eLINAC, currently in its design phase, is a 50MeV electron linear accelerator and will be used for photo-fission to produce rare isotopes for experiments. Future upgrade plans include an option to go to a recirculating LINAC to provide higher energies. This brings up the need to calculate the shunt impedances of higher order modes (HOM) to avoid beam instabilities and beam break up (BBU). The cavity design for a 9 cell cavity has to account for the limitations given by the desired beam current of 10mA and the layout of the recirculating path to create a high enough BBU limit. Work on the cavity design to accommodate for the HOM requirements will be presented as well as a way to reduce the shunt impedance by the use of ring dampers will be discussed.

The Dipole Steering Effect With New Ways: Shifting Inside and Outside Pole of QWR Cavity Method

J.D. Jeong (SKKU)

In our project KoRIA (Korea Rare Isotope Accelerator), we will use QWR cavity in the ISOL Linac for the acceleration of RI beam which is from the RFQ with energy of 0.3 MeV to the 18 MeV output for further use of experiment and re-acceleration of IFF Linac. Several studies about QWR cavity, however, finds out that due to the asymmetric geometric characteristic of QWR cavity there will be un-welcome transverse forces which take a role of increasing transverse emittance within the acceleration gaps. This quadrupole terms in the transverse Lorentz force which can cause appreciable emittance growth is known as dipole steering effect. On the other hands, there has been a lot of effort to compensate this dipole steering effect such as tilting beam pipe ends, shaping beam pipe like a racetrack and shifting beam axis, etc. During the process of conceptual design of KoRIA project, we have studied about the QWR cavity and tried to compensate the dipole steering effect. In this paper we will discuss about what we did to eliminate the dipole steering effect with new ways: shifting inside and outside pole of QWR cavity method.

Electro-Magnetic Optimization of a Quarter-Wave Resonator

C. Zhang, Y. He, S.H. Zhang, H.W. Zhao (IMP)

The Institute of Modern Physics (IMP) has been trying to design a highly effective accelerating quarter-wave resonator (QWR) cavity which can work at a record high voltage of 2.5 MV with as low as possible peak surface electromagnetic (EM) fields. In the cavity design, we set the goal of the optimization to minimize the peak magnetic and electric fields while still keeping good values for the R over Q and the geometric factor. Take the design of the QWR cavity with frequency of 81.25 MHz and beta of 0.085 for example, from a regular cylindrical shaped inner and outer conductor, the optimization has led them to a conic inner conductor and an elliptic outer conductor. In this paper, we will present how the cavity geometry parameters evolve in order to approach optimal EM design. The optimization also includes the internal drift tube face angle required for beam steering correction.

Design of a 1500 MHz Bunch Lengthening Cavity for NSLS-II

J. Rose, N.A. Towne (BNL) C.H. Boulware, T.L. Grimm (Niowave, Inc.)

The NSLS-II is a new third generation light source being constructed at > BNL. In order to increase the Touschek lifetime and third harmonic bunch > lengthening cavity is required. A 1500 MHz passive third harmonic cavity has > been designed and fabricated. It is a coupled two-cell HOM damped SRF cavity > that can provide 1 MV of voltage in a single cryomodule. The two cell design > allows for a single tuner mechanism outside the cryostat while the room > temperature ferrite HOM dampers provide damping of all but the fundamental > zero and pi modes. Since the unwanted zero mode is strongly coupled to the > pi mode it tracks the pi mode tuning which is required for the beam induced > excitation. The design allows for the tuning of the pi mode between minimum > and required field excitation while keeping the zero mode excitation below > allowable limits. Design and initial cold test results are presented.

MOPO048

MOPO049

MOPO050

MOPO051

Design for Manufacture of a Superconducting Half Wave Resonator β=0.53

S.J. Miller, J. Binkowski, M.J. Johnson, Y. Xu (FRIB)

A medium velocity half wave resonator has been designed at the Facility for Rare Isotope Beams (FRIB) at Michigan State University (MSU) for use in a heavy ion linac. The cavity is designed to provide 3.7 MV of accelerating voltage at an optimum β = v/c = 0.53. The cavity was designed for manufacturing recommendations based on previous design as well as for stiffness, tunability, assembly, and cleaning. Finite Element Analysis simulations were performed for modal analysis, bath pressure sensitivity, Lorentz Force detuning, tuner stiffness, and tuning range. Industry prototyping is planned to confirm tolerances and fabrication processes. A tuner prototype has also been built. The helium vessel and power coupler have been designed and fabricated and will be adapted to the new cavity design.

MOPO052

Studies on a Plunger Tuner System for a Double Spoke Cavity

J.L. Munoz, J. Feuchtwanger, J. Verdu (ESS-Bilbao) F.J. Bermejo (Bilbao, Faculty of Science and Technology) V. Etxebarria, J. Portilla (University of the Basque Country, Faculty of Science and Technology) N. Garmendia (ESS Bilbao)

ESS-Bilbao proton linac warm section will end at 50 MeV. A cryomodule with two double spoke cavities, currently in R&D stage, will be tested at that energy. The two spoke cavity prototypes to be built (geometric beta 0.54) will be fully compatible with the ESS project spoke cavities. Different tuning systems will be studied for spoke resonators, and one of them is the use of plunger tuners. In this paper, a study of this kind of tuners on DSR cavities is presented, including electromagnetic and thermal simulations. Also, for different R&D activities related to spoke cavities, ESS-Bilbao designed and built a beta 0.39 DSR model in aluminum. This model can be used to install a plunger tuner system and test LLRF devices at room temperature.

MOPO053

Designs of Superconducting Parallel-Bar Deflecting Cavities for Deflecting/Crabbing Applications

J.R. Delayen, A. Castilla, S.U. De Silva, M.H. Moore (ODU)
J.R. Delayen (JLAB)

The superconducting parallel-bar cavity is a deflecting/crabbing cavity with attractive properties, compared to other conventional designs, that is currently being considered for a number of applications. The new parallel-bar design with curved loading elements and circular or elliptical outer conductors have improved properties compared to the designs with rectangular outer conductors. We present the designs proposed as deflecting cavities for the Jefferson Lab 12 GeV upgrade and for Project-X and as crabbing cavities for the proposed LHC luminosity upgrade and electron-ion collider at Jefferson Lab.

Superconducting 112 MHz QWR Electron Gun

Brookhaven National Laboratory and Niowave, Inc. have designed and fabricated a superconducting 112 MHz quarter-wave resonator (QWR) electron gun. The first cold test of the QWR cryomodule has been completed at Niowave. The

S.A. Belomestnykh, I. Ben-Zvi, X. Chang, T. Rao, J. Skaritka, R. Than, Q. Wu (BNL) C.H. Boulware, T.L. Grimm, B. Siegel, M.J. Winowski (Niowave, Inc.) T. Xin, L. Xue (Stony Brook University)

paper describes the cryomodule design, presents the cold test results, and outline plans to upgrade the cryomodule. Future experiments include studies of different photocathodes and use for the coherent electron cooling proof-of-principle experiment. Two cathode stalk options, one for multi-alkali photocathodes and the other one for a diamond-amplified photocathode, are discussed.

Superconducting Resonator Production for Ion Linac at Michigan State University

Superconducting quarter-wave resonators and half-wave resonators are being prototyped and fabricated at Michigan State University (MSU) in effort to support the Facility for Rare Isotope

C. Compton, A. Facco, W. Hartung, M. Hodek, M.J. Johnson, T. Kole, M. Leitner, F. Marti, D. R. Miller, S.J. Miller, J. Popielarski, L. Popielarski, J. Wei, K. Witgen, J. Wlodarczak (FRIB)

Beams (FRIB) project. FRIB requires a 200 MeV per nucleon driver linac, operating 345 resonators at two frequencies (80.5 and 322 MHz) and four betas (0.041, 0.085, 0.29, and 0.53). FRIB cavity development work is underway, with the prototyping of all four resonators, including helium vessel design, stiffening strategy, and tuner interface. In addition, the acquisition strategy for FRIB resonators is being finalized, and the technology transfer program is being initiated. The status of the resonator production effort will be presented in this paper, including an overview of the acquisition strategy for FRIB.

Beam Break Up Studies for Cornell's Energy Recovery Linac

New results are presented of beam breakup (BBU) studies for the Cornell ERL main linac. Previously, a 1.3 GHz main

N.R.A. Valles, D.S. Klein, M. Liepe (CLASSE)

linac 7-cell cavity was optimized to maximize the BBU current through the accelerator. This work realistically models the ERL main linac cavity shapes by taking into account small machining variations in ellipse dimensions. Cavity shapes were simulated with uniformly distributed errors, and their higher-order mode spectrum computed. The strongest higher-order modes can cause resonant excitations in the beam which can lead to beam loss. The threshold current through the accelerator is determined resulting from a linac comprised of cavities with machining variations using particle tracking and demonstrates that the threshold current is well above the 100 mA design goal for the Cornell's Energy Recovery Linac.

MOPO057

Coupler Kick Studies in Cornell's 7-Cell Superconducting Cavities

N.R.A. Valles, M. Liepe, V.D. Shemelin (CLASSE)

Cornell is developing a 5 GeV Energy Recovery Linac operating at 100 mA with very small emittances (~30 pm at 77 pC bunch charge) in the horizontal and vertical directions. We investigate the effect of the fundamental RF power couplers of the main linac SRF cavities on the beam using the ACE3P software package. The cavities in the ERL main linac will be operated at very high loaded quality factors of up to $6.5 \cdot 10^7$, corresponding to a full bandwidth of only 20 Hz. Cavity microphonics will detune the cavities by more than one bandwidth during operation, thereby causing a time dependent change of the coupler kick in addition to its fast oscillation at the RF frequency. In order to investigate the dependence of the coupler kick on the cavity frequency, we calculate the coupler kick given to the beam for the case of a detuned RF cavity. We show that a compensation stub geometry located opposite to the input coupler port can be optimized to reduce the overall kick given to the beam and the emittace growth caused by its time dependence.

MOPO058

Analysis of Beam Damage to FRIB Driver Linac

Y. Zhang, D. Stout, J. Wei (FRIB)

Component damage caused by particle beam is an important issue in the design of a high power accelerator, particularly a superconducting linac. The FRIB driver linac must deliver a beam on target of approximately 1 mm in diameter, increasing beam energy density significantly compared to other SRF linacs. Because dE/dx of heavy ion beam is several ten times larger than proton or electron beam, the situation is more severe: at full power, 400 kW, a uranium beam may cause accelerator structure damage in less than 40 μs. A fast response machine protection system is necessary, in additional to special protection design, very careful linac beam tuning and operation. In this paper, temperature rise of niobium and stainless steel at different beam incident angles are compared, and thermal stress analyzed for nominal FRIB beam at different energy. Protection designs are also briefly discussed.

MOPO059

Design and Test of HOM Coupler for High Current SRF Cavity

W. Xu, S.A. Belomestnykh, I. Ben-Zvi, H. Hahn, E.C. Johnson (BNL)

Damping higher order modes (HOMs) significantly to avoid beam instability is a challenge for the high current Energy Recovery Linac-based eRHIC at BNL. To avoid the overheating effect and high tuning sensitivity, current, a new band-stop HOM coupler is being designed at BNL. The new HOM coupler has a bandwidth of tens of MHz to reject the fundamental mode, which will avoid overheating due to fundamental frequency shifting because of cooling down. In addition, the S21 parameter of the band-pass filter is nearly flat from first higher order mode to 5 times the fundamental frequency. The simulation results showed that the new couplers effectively damp HOMs for the eRHIC cavity with enlarged beam tube diameter and 2 120° HOM couplers at each side of cavity. This paper presents the design of HOM coupler, HOM damping capacity for eRHIC cavity and prototype test results.

Using Cavity Higher Order Modes for Beam Diagnostics in Third Harmonic 3.9 GHz Accelerating Modules

N. Baboi, P. Zhang (DESY) R.M. Jones, I.R.R. Shinton (UMAN)

An international team is currently investigating the best way to use cavity Higher Order Modes (HOM) for beam diagnostics in 3.9 GHz cavities. HOMs are excited by charged particles when passing through an accelerating structure. Third harmonics cavities working at 3.9 GHz have been installed in FLASH and will be installed in the European XFEL to help with the bunch energy profile. The proof-of-principle of using HOMs for beam monitoring has been made at FLASH in the TESLA 1.3 GHz cavities. Since the wakefields generated in the 3.9 GHz cavities are higher, their impact on the beam should be particularly taken care of. Therefore our target is to monitor HOMs and minimize them by aligning the beam on the cavity axis. The difficulty is that, in comparison to the 1.3 GHz cavities, the HOM-spectrum is very crowded, making it difficult to identify individual modes. Also, most modes propagate through the whole cryo-module containing several cavities, making it difficult to measure local beam properties. In this paper the results of the studies made in order to identify the frequency range best suited for beam monitoring will be shown and the specs for the HOM-electronics will be discussed.

Effects of Elliptically Deformed Cell Shape in the Cornell ERL Cavity

L. Xiao, K. Ko, K.H. Lee, C.-K. Ng (SLAC) M. Liepe, N.R.A. Valles (CLASSE)

The Cornell ERL cavity is optimized to minimize the dipole mode BBU parameters to achieve the required high beam current (100mA). Deformations due to errors in fabrication and tuning of the accelerating mode can result in a cavity shape different from the ideal. In elliptically deformed cells, this can cause dipole mode frequency spread and splitting of the mode polarizations leading to an x-y mode coupling. To investigate these effects, we use a mesh distortion technique to generate an elliptically deformed cell cavity model as a base for studying random imperfections. Simulation results from the eigensolver Omega3P of one hundred randomly elliptically deformed cell cavities covering the first three dipole bands will be presented. The results will be used as input to the beam tracking code BMAD to calculate the impact of such imperfections on the dipole mode BBU parameters.

BEPCII Superconducting RF System Operation Status

Y. Sun, J.P. Dai, T.M. Huang, G. Li, Z.Q. Li, Q. Ma, W.M. Pan, P. Sha, G.W. Wang, Q.Y. Wang (IHEP Beijing)

Two KEK-B type 500MHz Superconducting cavities have been used in BEPCII project since the end of 2006. All the maximum RF voltages have been over 1.65MV under the operation with beam power of 100 kW and beam current of 1.89GeV@800mA. During the physics collision mode operation, there is a strange phenomenon of helium gas pressure increasing with the beam current going up, which is dangerous to both cavity and cold box of cryogenics system. To search the unknown heating source, several beam tests had been made, which are HOMs power measurement, contrast of the RF power influence of coaxial coupler with Synchrotron Radiation opeation mode, and the beam synchrotron light influence in different beam orbits.

MOPO063

HOM Measurements with Beam at the Cornell Injector Cryomodule

S. Posen, M. Liepe (CLASSE)

The Cornell ERL injector prototype is undergoing commissioning and testing for running unprecedented currents in an electron cw injector. This paper discusses preliminary measurements of HOMs in the injector prototype's superconducting RF cryomodule. These include HOM spectra up to 30 GHz measured via small antennae located at the HOM beam line absorbers between the SRF cavities. The spectra are compared at different beam currents and repetition rates. The shape of the spectra are compared to ABCI simulations of the loss factor spectrum of the cryomodule beam line. The total HOM power dissipated in the HOM loads was also measured with beam on, which allowed for an estimate of the loss factor. This measurement was accomplished via temperature sensors on the loads, calibrated to input power by heaters on the loads.

MOPO064

Adaptive Lorentz Force Detuning Compensation in the ILC S1-G Cryomodule at KEK

W. Schappert, R.V. Pilipenko, Y.M. Pischalnikov (Fermilab) H. Hayano, E. Kako, S. Noguchi, N. Ohuchi, Y. Yamamoto (KEK)

The recent tests of the S1-Global cryomodule at KEK provided a unique opportunity to compare the performance of four different styles of 1.3 GHz SRF cavities and tuners under similar operating conditions. Results of adaptive LFD compensation at gradients of up to 35 MV/m for DESY/Saclay, FNAL/INFN and KEK cavity/tuner designs are compared.

MOPO065

Systems Testing of Cryomodules for an Ion Reaccelerator Linac

J. Popielarski, S. Bricker, A. Facco, M. Hodek, J.P. Holzbauer, D. Leitner, D. Morris, S. Nash, D. Norton, G. Perdikakis, N.R. Usher, N. Verhanovitz, J. Wlodarczak (FRIB)

Michigan State University is developing, testing, and commissioning cryomodules for a superconducting linac to be used for the reacceleration of exotic ions (ReA). The first stage of ReA will accelerate ions from 0.3MeV/u to 3MeV/u for heavy ions and up to 6MeV/u for light ions. The first two cryomodules contain a total of seven quarter-wave resonators for $\beta = 0.041$. A total of five superconducting solenoids (9 T) are interspersed between resonators for focusing. The cryomodules have been fabricated and installed, with testing underway. The third cryomodule (requiring eight QWRs for $\beta = 0.085$ and three solenoids) is being fabricated. Experience so far with system performance of the cryomodules will be described in this paper. Topics will include cavity performance, magnetic shielding, microphonics, cavity tuning, input coupler performance, and thermal loads.

MOPO066

SCREAM – Modified Code SCREAM to Simulate the Acceleration of a Pulsed Beam Through the Superconducting Linac

Y.I. Eidelman, S. Nagaitsev, N. Solyak (Fermilab)

The code SCREAM – SuperConducting RElativistic particle Accelerator siMulation was significantly modified and improved. Some misprints in the formulae used have been fixed and a more realistic expression for the vector sum introduced. A friendly GUI allows the various parameters of the simulated problem easily and quickly to be changed. Effective control of various output data is provided. A change of various parameters during the simulation process is controlled by plotting the corresponding graphs ``on the fly''. A large collection of various graphs is used to illustrate the results.

CW Measurements of Cornell LLRF System at HoBiCaT

In Energy Recovery Linacs, such as the Cornell ERL or BERLinPro, the main linac cavities are operated in CW at low beam-loading. The choice of the external Q is given by two competing factors: The

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achievable field stability and the maximum provided RF power. To determine the optimum external Q, LLRF measurements with the Cornell system were performed at HoBiCaT to study the field stability at given microphonics detuning of a TESLA cavity for different gain settings and external Q values. Stable operation at external Q up to $2 \cdot 10^8$ was demonstrated with field's phase stability of 0.02 degrees.

Reliability Improvements of the Diamond Superconducting Cavities

For successful operation of superconducting cavities in light sources, high reliability and minimal beam losses are essential. Diamond started operation with

P. Gu, M. Jensen, M. Maddock, P.J. Marten, S.A. Pande, S. Rains, A.F. Rankin, D. Spink, A.V. Watkins (Diamond)

users in January 2007 and since then, the Diamond storage ring superconducting cavities have been the largest single contributor to unplanned beam trips. We have dedicated extensive effort to improve our data acquisition, numerical modelling and fault analysis to improve our understanding of the main causes of the trips and how to prevent trips or reduce their frequency. In the past seven months, the performance of the cavities has improved significantly. We present here our analysis of some of the trips and their underlying causes and discuss improvements carried out.

Operation Status of SRF System at SSRF

SSRF has been open to users with 3.5GeV 200mA beam current in decay mode since April, 2009. The Superconducting Radio-Frequency system runs stably and reliably to support the operation of the light source with high performance. There still

H.T. Hou, Z.Q. Feng, J.F. Liu, C. Luo, Z.Y. Ma, D.Q. Mao, K. Xu, Zh.G. Zhang, S.J. Zhao, Y.B. Zhao (SINAP) **H.T. Hou**, Z. Li, X. Zheng (Shanghai KEY Laboratory of Cryogenics & Superconducting RF Technology)

however happened some kinds of trips from cavities, RF power sources, DLLRF and the utility system. Several times of cavity trips brought by cryogenic system breakdown have been treated correctly without any harmful damage to superconducting modules, and the SRF system was recovered as soon as cryogenic system was ready to keep the light source operation. Here the operation status of SRF system will be reported and methods to solve various kinds of trips from SRF system will be discussed.

MOPO070

Preliminary Test Results from 650 MHz Single Cell Medium Beta Cavities for Project X

P. Kneisel, A. Burrill, P. Kushnick, F. Marhauser, R.A. Rimmer (JLAB)

We have fabricated two single cell 650 MHz cavities of a JLab design [1], for possible project X application. Both cavities were manufactured at Jlab from RRR>250 niobium sheet of 4 mm thickness using standard techniques such as deep drawing, EBW, BCP , hydrogen degassing heat treatment, high pressure ultrapure water rinsing and clean room assembly. A detailed description of the design and fabrication procedures is forthcoming [2]. Initially cavity #1 was – after final surface treatment by bcp – measured without any provisions for stiffening . As expected, the pressure sensitivity and the Lorentz Force detuning coefficients were quite high; however, the RF performance was very encouraging: the cavity exhibited a Q-value $> 10^{11}$ at 1.6K, corresponding to a residual resistance of < 1.5 nOhm The initial gradient was limited to Eacc ~ 18 MV/m, limited by field emission. In a subsequent test, we are re-rinsing the cavity and are making provisions for stiffening up the cavity. By the time of this writing, this test is in progress; the results will be reported at this conference as well as results from the second cavity.

[1] F. Marhauser, JLab-TN-10-043

[2] F. Marhauser et al; IPAC 2011 to be published

MOIOC — Hot Topics

Source of Quench Producing Defects

Recent efforts in pushing the performance of superconducting RF niobium cavities for the International Linear Collider have resulted in two-fold progresses: reduced field emission and improved quench limit in real 9-cell cavities. RF testing at cryogenic temperatures assisted with quench-detection instrumentation reveals that quench happens often times at highly localized areas inside or near the equator weld of a cavity cell, which is also the high surface magnetic field region. High-resolution optical inspection of the identified quench location makes it possible to correlate the cavity quench limit with certain types of defects. Several sources of quench producing defects are being explored. We will discuss the experimental evidence in supporting each of these sources. We will also discuss the methods of curing or preventing these defects for improved gradient limit and reduced gradient spread.

HOT TOPIC

Chair: R.L. Geng, JLAB (Newport News, Virginia, USA)   **73**

TUIOA — New Materials/Techniques

TUIOA01

Athmospheric Surface Treatments to SC cavities

V. Palmieri, A.A. Rossi (INFN/LNL) D. Rizzetto (Univ. degli Studi di Padova)

V. Palmieri, D. Rizzetto, A.A. Rossi - Laboratori Nazionali di Legnaro and University of Padua After an obsessive search for the cleanest ultrahigh vacuum for preparing niobium films, niobium nitride or A15 compunds, we have discovered that high purity sharp transition superconducting films are obtainable even without the need of vacuum by the help of athmospheric plasma toarches, and not only. Athmospheric plasma treatments have already shown that can effectively contribute to the cavity cleaning. However at the moment we have set up a method for the obtainement of high purity niobium nitride without the use of vacuum pumps

TUIOA02

Multilayer Coatings: Opportunities and Challenges.

A.V. Gurevich (Old Dominion University)

The use of multilayer coatings may enable significant increase of the breakdown fields or operating temperatures of SRF cavities by utilizing materials with the thermodynamic critical field Hc higher than Hc = 200 mT for Nb. However, such coating materials have shorter coherence length so the significant effects of impurities or grain boundaries on the surface resistance should be understood. In this talk I'll analyze the dynamics of penetration of vortices along grain boundaries and dissipation in a thin film coating in strong rf fields. I'll also discuss the role of impurities, in particular their contribution to the nonlinear Meissner effect which affects the surface resistance in the dirty limit. And finally I'll discuss the nonlinear response in two-band superconductors like MgB2 in which strong rf fields can cause decoupling of bands at fields H < Hc, which can contribute to the high-field Q slope.

TUIOA03

Magnetic Screening of NbN Multilayers Samples

C.Z. Antoine (CEA/DSM/IRFU) A. Andreone (Naples University Federico II) Q. Famery, J. Leclerc (CEA/IRFU) G. Lamura (CNR-INFM-LAMIA) J.C. Villegier (CEA/INAC)

In 2006 Gurevich proposed to use nanoscale layers of superconducting materials with high values of Hc > Hc (Nb) for magnetic shielding of bulk niobium to increase the field in Nb RF cavities. We have deposited high quality ``model'' samples on monocrystalline sapphire substrates. A 250 nm layer of niobium figures the bulk Nb. It was coated with a single or multiple stacks of NbN layers (25 nm or 12 nm) separated by 15 nm MgO barriers, and characterized by X-rays reflectivity and DC transport measurements. DC or AC measurement of HC1 is an important tool for multilayers evaluation during the sample optimization phase. A clear increase of HC1 at low frequency is a promising indication since HC1 is expected to be higher in RF. We have measured the first magnetic penetration field HP (~ HC1) on DC magnetization curves in a SQUID system. HP of NbN covered samples is increased compared to Nb alone. We have also developed a set-up that allows measuring HC1 over a large range of field and temperature with a local probe method based on 3rd harmonic analysis. We have confirmed the screening behavior of a single 25 nm NbN layer placed on the top of a thick Nb layer.

MgB2 Thin Film Studies

T. Tajima, L. Civale, N.F. Haberkorn, R.K. Schulze (LANL) V.A. Dolgashev, J. Guo, D.W. Martin, S.G. Tantawi, C. Yoneda (SLAC) H. Inoue, **T. Tajima** (KEK) A. Matsumoto, E. Watanabe (NIMS) B. Moeckly (STI) M.J. Pellin, Th. Proslier (ANL) B. Xiao (JLAB)

Demonstrating the idea of enhancing achievable surface magnetic field by coating multilayer thin film superconductors proposed by Gurevich is the main objective. DC magnetization measurements of 500 nm and 300 nm MgB2 films coated on Sapphire showed an increase in the lower critical magnetic field (Bc1) compared to that of bulk. Also, the Bc1 of a 300 nm film showed >200 mT at 4.5 K, which is >25 % higher than that of Nb (~145 mT). RF measurements using a 11.4 GHz pulsed Klystron and a TE013-like mode hemispherical copper cavity with a 2-inch (50.8 mm) diameter sample, however, have shown a low quenching field of 42 mT at 4 K. From detailed data analyses together with the data on Nb quench fields these quenches were found to be thermal, not magnetic, due to a high RF resistance caused by inter-diffusion of coated materials at the interfaces. Additionally, recent results of RF surface resistance at 7.5 GHz using a calorimetric technique at JLab will also be shown.

The Superheating Field of Niobium: Theory and Experiment

N.R.A. Valles, M. Liepe (CLASSE)

This study discusses the superheating field of Niobium, a metastable state, which sets the upper limit of sustainable magnetic fields on the surface of a superconductors before it transitions into the normal conducting state. Current models for the superheating field are discussed, and experimental results are presented for niobium obtained through pulsed, high power measurements performed at Cornell. Material preparation is also shown to be an important parameter in exploring other regions of the superheating field, and fundamental limits are presented based upon these experimental and theoretical results.

Deposition of Niobium and Other Superconducting Materials With High Power Impulse Magnetron Sputtering: Concept and First Results

A. Anders, S. Lim, R. Mendelsberg, A.V. Nollau, J.G. Wallig (LBNL)

Niobium coatings on copper cavities have been considered as a cost-efficient replacement of bulk niobium RF cavities, however, coatings made by magnetron sputtering have not lived up to high expectations. Energetic condensation of niobium films from the plasma phase has been tried using filtered cathodic arc plasmas, and promising RRR values were recently demonstrated. High power impulse magnetron sputtering (HIPIMS) is a promising emerging coatings technology which combines magnetron sputtering with a pulsed power approach. The magnetron is turned into a metal plasma source by using very high peak power density of $\sim 1\ kW/cm^2$. In this contribution, the cavity coatings concept with HIPIMS is explained. A system with two cylindrical, movable magnetrons was set up with custom magnetrons small enough to be inserted into 1.3 GHz cavities. Preliminary data on niobium HIPIMS plasma and resulting coatings are presented. The HIPIMS approach has the potential to be extended to film systems beyond niobium, including other superconducting materials and/or multilayer systems.

TUIOA04

TUIOA05

TUIOA06

TUIOB — New Materials/Techniques

TUIOB01

Energetic Condensation Growth of Nb Films

M. Krishnan, C. James, E.F. Valderrama (AASC) P. Maheshwari, F.A. Stevie (NCSU AIF) H.L. Phillips, C.E. Reece, J.K. Spradlin, A-M. Valente-Feliciano, X. Zhao (JLAB) K.I. Seo (NSU) Z.H. Sung (ASC)

This paper describes Energetic Condensation Growth of Nb films using a cathodic arc plasma, whose 40-120eV ions enable sufficient surface mobility to ensure that the lowest energy state (crystalline structure with minimal defects) is accessible to the film. Hetero-epitaxial films of Nb were grown on a-plane sapphire and MgO crystals with good superconducting properties and crystal size (10mm $\times$ 20mm) limited only by substrate size. The substrates were heated to 700 deg C and coated at 300, 500 and 700 deg C. Film thickness varied from ~0.25μm up to >3μm. Residual resistivity ratio (RRR) values (up to a record RRR-554 on MgO and RRR-328 on a-sapphire) vary with substrate annealing and deposition temperatures. XRD spectra and pole figures reveal that RRR increases as the crystal structure of the Nb film becomes more ordered, consistent with fewer defects and hence longer electron mean free path. A transition from Nb(110) to Nb(100) orientation on the MgO(100) lattice occurs at higher temperatures. SIMS depth profiles, EBSD and SEM images complement the XRD data. Crystalline structure in Nb on amorphous borosilicate substrates has implications for future, lower-cost SRF cavities.

TUIOB02

Summary of the Symposium on Ingot Nb and New Results on Fundamental Studies of Large Grain Nb

G. Ciovati, P. Dhakal, R. Myneni (JLAB)

The First International Symposium on the Superconducting Science and Technology of Ingot Niobium was held at Jefferson Lab in September 2010. Significant activities are taking place at laboratories and universities throughout the world to address several aspects related to the science and technology of Ingot Nb: from ingot production to mechanical, thermal and superconducting properties. A summary of the results presented at the Symposium is given in this contribution. New results on the superconducting properties and interstitial impurities content measured in large-grain Nb samples and cavities are briefly highlighted.

TUIOB03

Testing the RF Properties of Novel Super Conducting Materials

J. Guo (SLAC)

Development in niobium SRF cavities has resulted in successful applications among a wide range of particle accelerator projects, due to the combination of its low surface RF resistance and high quenching field. However, new materials with better performance - especially higher quenching magnetic field - are always tempting to accelerator scientist and have attracted enormous research effort. We have developed a testing system capable to characterize both the surface RF resistance and quenching magnetic field of a superconducting material. The system uses a hemispheric resonant cavity with high quality factor and an interchangeable wall, which can host a flat sample with 2-3 inch diameter. Various samples have been tested, including Nb, MgB2 and Cu in different forms. We will present the most recent developments of the system and discuss the testing results.

Chair: C.Z. Antoine, CEA/DSM/IRFU (France)

Muon Spin Rotation/Relaxation Studies of Niobium for SRF applications

One of the outstanding scientific issues related to superconducting radio frequency cavities made of high-purity bulk niobium is the occurrence of field dependent losses in the walls of the niobium cavity. These losses occur at different RF field levels and pose severe limitations to the niobium technology for both CW or pulsed applications. In this presentation I will explain the results of an experiment which focused on understanding the mechanisms behind losses in the high field regime (above 80-100mT peak magnetic fields). The problem was studied utilizing the unique TRIUMF muon spin rotation (muSR) facility to investigate superconducting properties of niobium samples. In particular, the muon spin rotation experiments aimed at studying the field of first flux entry in high field Q-slope cutouts from small and large grain BCP (buffered chemical polished) 1.5GHz cavities, before and after undergoing 120C UHV-bake. The results obtained will be presented, and it will be discussed in which future direction those results lead.

A. Grassellino (TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics)

TUIOB04

New Approaches to Nb Thin Film Coating

Niobium films are widely used at CERN and several other Laboratories for the coating of superconducting cavities. The performances of these cavities are highly influenced by the thin film properties, and in particular its microstructure. Energetic condensation, and in particular High Power Impulse Magnetron Sputtering (HIPIMS) gives new opportunities for conventional magnetron sputtering equipment. In this talk we will review the background on thin film performance, the motivations of the study, illustrate the experience that has been gained at CERN during the first months of operation and present the results obtained so far.

S. Calatroni, A.E. Gustafsson, M. Scheubel, W. Vollenberg (CERN)

TUIOB05

Nb Films: Substrates, Nucleation & Crystal Growth

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. Recently, significant progress made in the development of energetic vacuum deposition techniques is showing promise for the production of thin films tailored for SRF applications. Energetic condensation allows to improve film structure on low temperature substrates by adding energy to the film during condensation to compensate for the lack of thermally induced growth processes. Energetic condensation is characterized by a number of processes enabled by the energy of the incoming ions such as desorption of adsorbed species, enhanced mobility of surface atoms, and sub-implantation of impinging ions. All these with the nature and properties of the substrate have an important influence on the nucleation and subsequent growth of the Nb film. This paper will show how the structure and the electron mean free path (represented by residual resistance ratio values) of Nb films can be tailored on various substrates by varying the ion energy and thermal energy provided to the substrate.

A-M. Valente-Feliciano (JLAB)

TUIOB06

TUIOB07

Magnesium Diboride Films for SRF Cavity Applications

Y.D. Agassi (NSWC) B. Moeckly (STI) D.E. Oates (MIT)

We have explored magnesium diboride films for applications in SRF cavities. MgB_2 has a high $T_c = 40$ K and low surface resistance that, even in polycrystalline films, is comparable to niobium. It also shows the potential for higher power handling than niobium because of the higher critical fields. We report the results of measurements of the surface resistance and power handling in films deposited by the reactive-evaporation method. The measurements were made using both a stripline-resonator at 2 GHz and with a dielectric resonator at 10.7 GHz. The best results for surface resistance are 14 micro-ohm at 10.7 GHz, which scales to 0.5 micro-ohm at 2 GHz. The maximum rf magnetic field of the best film has been measured to be 300 Oe, limited by the available amplifier. We have also demonstrated a successful surface-passivation method of atomic-layer-deposited (ALD) films of Al_2O_3 and Zr_{O2}. We have also demonstrated evidence that one of the two energy gaps shows unconventional symmetry with a six-fold-symmetric nodal order parameter. The implications for applications of these findings of the basic physics of the material will be discussed.

TUIOB08

Hot Topics: Medium Field Q-Slope and Paths to High-Q Operation

W. Weingarten (CERN)

Superconducting RF cavities for accelerator application offer, at least in principle, the perspective of large accelerating gradients and low RF losses. Both qualities must proceed reciprocally. Therefore, consequent to the achieved increase in accelerating gradient during recent years, the RF losses must be reduced accordingly, in order to keep the cryogenic installation at reasonable size. However, the Q-value, which describes the RF losses, did not follow the improved accelerating gradient as wished or required. The reasons are physical mechanisms, only partly understood, on top of the residual losses, that provoke a more than quadratic increase of the RF losses with the accelerating gradient (Q-slope). Cures have been identified experimentally to some extent, but both the theoretical understanding and a complete elimination of the"Q-slop" are lacking. The hot topic discussion should open the floor for a new and deeper understanding of the"Q-slop".

TUPO — Poster Session

Development of Quality Assurance Procedures for the Fast/Slow Tuners on the 1.3 GHz SRF Cavities for the SRF Accelerator Test Facility at Fermilab

The 1.3 GHz elliptical SRF cavities being prepared for cryomodules of the Fermilab SRF Accelerator Test Facility are equipped with coaxial blade tuners. Quality Assurance tests of these tuners during initial installation, cold testing in the Horizontal Test Stand and during string assembly are described.

Y.M. Pischalnikov, S. Barbanotti, C.J. Grimm, T.N. Khabiboulline, R.V. Pilipenko, W. Schappert (Fermilab)

High Power Pulsed Tests of a β=0.5 5-Cell 704 MHz Superconducting Cavity

A β=0.5 5-cell 704 MHz cavity was developed in the framework of european R&D programs on high intensity pulsed proton injectors. Medium beta elliptical cavities are known to be sensitive to Lorentz detuning, which can become difficult to deal with in pulsed operation. The cavity was optimized to reduce the Lorentz detuning by means of two series of rings welded around the irises, and equipped with a piezo tuning system . In order to test the cavity in pulsed mode, a power coupler with 1 MW capability was connected to the cavity. We report here on the fully equipped cavity tests at 1.8 K carried out in the horizontal cryostat Cryholab at Saclay to study its Rf and mechanical behavior in pulsed mode, mostly with 2 ms pulses at a 50 Hz repetition rate. The compensation of Lorentz force detuning has been achieved at an accelerating gradient of 13 MV/m (44 MV/m peak surface electric field).

J. Plouin, D. Braud, M. Desmons, G. Devanz, Y. Gasser, E. Jacques, O. Piquet, J.P. Poupeau, D. Roudier, P. Sahuquet (CEA/DSM/IRFU) W. Hï¿½fle, D. Valuch (CERN)

Cooling Properties of HOM Absorber Model for cERL in Japan

The HOM absorber model was designed and fabricated according to results of ferrites and ceramic properties measurement at low temperature. The HOM absorber model uses the RF absorber of HIP (Hot Isostatic Press) ferrite attached on the copper base. The comb-type RF bridge is adopted at the beam pipe connection between the HIP ferrite part and the flange part. Both parts of the RF bridge are connected with a bellows to reduce the heat load into the superconducting cavity. The HOM absorbers are also required to have good thermal transmission properties to effectively remove the HOM absorption power. The HOM absorber without ferrite was used to measure the thermal properties at liquid nitrogen temperature. Prototype of HIP ferrite model was fabricated. The thermal simulation calculation was also performed. Thermal cycle test between the room temperature and 80K with a GM refrigerator was also carried out to check the thermal tolerance of the HIP ferrite.

M. Sawamura (Japan Atomic Energy Agency (JAEA), Gamma-ray Non-Destructive Assay Research Group) E. Cenni (Sokendai) T. Furuya, H. Sakai, K. Umemori (KEK) K. Shinoe (ISSP/SRL)

TUPO004

Development and Testing of Prototype Fundamental Power Couplers for FRIB Half Wave Resonators

J. Popielarski, P. Glennon, M. Hodek, J. Wlodarczak (FRIB)

The driver linac for the Facility for Rare Isotope Beams (FRIB) requires superconducting Half Wave Resonators to accelerate ions to 200 MeV per nucleon. The Fundamental Power Coupler (FPC) is designed to deliver up to 14 kW of RF power at 322 MHz to the resonator and the beam in CW, and to increase the resonator's control bandwidth for stable operation. With the resonator over-coupled, the mismatch creates a standing wave in the FPC and transmission line downstream of the circulator. The FPC includes an alumina vacuum barrier to allow the resonator to be under ultra-high vacuum. The FPC also serves as a thermal break between the room-temperature transmission line and the resonator at 2 K, with thermal intercepts designed to minimize the heat load to the cryoplant. The FPC design allows for some variation in the coupling, in case a larger bandwidth is needed to mitigate microphonic disturbances. The RF and mechanical design of the coupler and conditioning stand will be reviewed, and the results of high power RF conditioning and testing will be presented.

TUPO005

High Power Tests of KEK-ERL Input Coupler for Main Linac Under LN2 Condition

H. Sakai, T. Furuya, N. Nakamura, K. Umemori (KEK) E. Cenni (Sokendai) M. Sawamura (JAEA) K. Shinoe (ISSP/SRL)

We fabricated the prototype of an input coupler, which has two ceramic windows to keep the inside of the superconducting cavity clean, for ERL main linac and performed the high power test. Required input power is about 20kW with standing wave condition for the cavity acceleration field of 20MV/m. In this high power test, the one ceramic window, named as a cold window, was installed into the vacuum insulating chamber and cooled by liquid Nitrogen. First, the multipacting at 10kW level prevented the power increasing. By using the pulse processing method for 8 hours, power finally reached the 25kW with standing wave condition. We could also keep feeding 20kW power into coupler for 16 hours. The maximum measured temperature rises under feeding the 20 kW power to coupler were 120K near the bellows parts and these are not so severe values to operate ERL main linac. After power test, the thermal cycle test of cold window of coupler was done. After 10-times thermal cycle tests between the room temperature and liquid Nitrogen temperature, no leaks and cracks were observed. From these results of high power test, this prototype coupler satisfied our thermal and RF requirements.

TUPO006

High Power Couplers for the Project X Linac

S. Kazakov, M.S. Champion, S. Cheban, T.N. Khabiboulline, M. Kramp, Y. Orlov, O. Pronitchev, V.P. Yakovlev (Fermilab)

Project X, a multi-megawatt proton source under development at Fermi National Accelerator Laboratory. [1]. The key element of the project is a superconducting (SC) 3GV continuous wave (CW) proton linac. The linac includes 5 types of SC accelerating cavities of two frequencies.(325 and 650MHz) The cavities consume up to 30 kW average RF power and need proper main couplers. Requirements and approach to the coupler design are discussed in the report. Results of electrodynamics and thermal simulations are presented. New cost effective schemes are described.

Development of STF Input Couplers for ILC

High power tests of the STF-Phase 1 cry-
omodule was carried out at KEK-STF (Su-
perconducting RF Test facility) in 2008.
Vacuum leaks at the cold ceramic win-

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

dow of STF-1 input couplers were found in the disassembly of the cryomodule after warm-up. It was consid-
ered that the vacuum leaks might be caused by the thermal cycles. Structures of brazing parts at a ceramic
disk was investigated to reduce the thermal strain. The STF-2 input couplers with an improved brazing
structure for S1-Global cryomodule was designed after the thermal cycle tests of the sample RF windows.
The results of the thermal cycle tests of the sample RF windows and the high power performance of the
improved STF-2 input couplers will be reported.

Vertical Test Facility for Superconducting RF Cavities at Daresbury Laboratory

The Vertical Test Facility at Daresbury
Laboratory has been recently relocated to
enable it to fulfill its potential of perform-
ing high power characterization tests of

R.K. Buckley, R. Bate, P. Goudket, A.R. Goulden, J.F. Orrett, S.M. Pattalwar, A.E. Wheelhouse (STFC/DL/ASTeC)

Superconducting RF Cavities in the 1.3 to 3GHz range. The 250 litre, 3 Metre Dewar is capable of operation
from 1.6K to 4K and has recently been used to test the first Superconducting cavity produced in the UK. This
paper outlines the setup, processes and results of these tests.

How to Increase Average Power of Main Coupler

New idea how to increase average power
of main coupler is described.

S. Kazakov (Fermilab)

Conditioning the Fundamental Power Coupler for ERL SRF Gun

The 703 MHz superconducting gun for
the BNL Energy Recovery Linac (ERL)
prototype has two fundamental power
couplers (FPCs), and each of them will
deliver up to 500 kW of CW RF power.
In order to prepare the couplers for high
power RF service and process multipact-

W. Xu, Z. Altinbas, S.A. Belomestnykh, I. Ben-Zvi, A. Burrill, S. Deonarine, D.M. Gassner, J.P. Jamilkowski, P. Kankiya, D. Kayran, N. Laloudakis, L. Masi, G.T. McIntyre, D. Pate, D. Phillips, T. Seda, A.N. Steszyn, T.N. Tallerico, R.J. Todd, D. Weiss, A. Zaltsman (BNL) M.D. Cole, G.J. Whitbeck (AES)

ing, the FPCs should be conditioned prior to installation into the gun cryomodule. A conditioning cart based
test stand, which includes a vacuum pumping system, controllable bake-out system, diagnostics, interlocks
and data log system has been designed, constructed and commissioned by collaboration of BNL and AES.
This paper presents FPC conditioning cart systems and the conditioning process.

TUPO011

Coupler Cleaning Machine

W. Kaabi, M. Lacroix, Y. Peinaud (LAL)

Today, the research on couplers focuses on the preparation techniques which are very important for conditioning and good working of couplers on cryomodules. unfortunately, these steps take long time : 1 week for particle free cleaning and 1 week for in-situ baking, which is not acceptable for project like ILC where around 16000 couplers will have to be prepared. From this fact, we decided at LAL to propose for the EUCARD program a study to automatise the clean room cleaning. This study is the design and the production of a coupler cleaning machine "Automate de Lavage Intï¿½grï¿½ pour Coupleur Electromagnï¿½tiqu" : ALICE). This machine will do the usual cleaning tasks that we used to do by hands (Ultrasonic cleaning with detergent and Ultra-pure water, rinsing, resistivity measurement and drying). Our goal is to reduce the processing time from 5 days to 3 hours. In the same time, this machine will reduce the risk of pollution due to human handling (8 steps turned into only one) and will permit to improve the cleaning parameters like time, temperature, . . . The main challenge was to design a free particle mechanisms for the coupler motion needed in the process.

TUPO012

Niobium Electropolishing in an Aqueous, Non-Viscous HF-Free Electrolyte: A New Polishing Mechanism

M.E. Inman, T.D. Hall, E.J. Taylor (Faraday Technology, Inc.) C.E. Reece, O. Trofimova (JLAB)

Faraday is working with the Jefferson Lab to develop an improved process for electropolishing niobium RF superconducting cavities in an electrolyte free of hydrofluoric acid, to create microscopically clean and smooth niobium surfaces on the cavity interior. Conventional electropolishing of niobium cavities is based on a viscous electrolyte with an approximately 20 micron thick diffusion layer*, containing hydrofluoric acid as a depassivation agent. The FARADAYIC Electropolishing process combines pulse reverse electric fields and aqueous, low acid, non-viscous electrolytes to control current distribution and oxide film formation during metal removal. This eliminates the need for a depassivation agent, such as hydrofluoric acid. This program is aimed at understanding this new electropolishing mechanism, and optimizing it to achieve the desired oxide formation, reduced defect density and high performance. The feasibility of the process has been demonstrated using an aqueous sulfuric acid solution in conjunction with the FARADAYIC Process to electropolish niobium to surface finishes below 1 nm over a 2 x 2 micron area.

* Hui Tian and Charles E. Reece, Evaluation of the diffusion coefficient of fluorine during the electropolishing of niobium, Phys. Rev. ST Accel. Beams, 13, 083502 (2010)

TUPO013

Assembly of the International ERL Cryomodule at Daresbury Laboratory

P.A. McIntosh, R. Bate, P. Goudket, S.M. Pattalwar (STFC/DL/ASTeC) S.A. Belomestnykh, M. Liepe, H. Padamsee, P. Quigley, J. Sears, V.D. Shemelin (CLASSE) A. Buechner, F.G. Gabriel, P. Michel (HZDR) M.A. Cordwell, J. Strachan (STFC/DL) J.N. Corlett, D. Li, S.M. Lidia (LBNL) T. Kimura, T.I. Smith (Stanford University) D. Proch, J.K. Sekutowicz (DESY)

The collaborative development of an optimised cavity/cryomodule solution for application on ERL facilities is nearing completion. This paper outlines the progress of the module assembly and details the processes used for final cavity string integration. The preparation and installation of the high power couplers will be described, as will that of the HOM loads. The testing and integration of the various sub-components of the cryomodule are also detailed in this paper.

High Gradient Results of ICHIRO 9-Cell Cavity in Collaboration With KEK and Jlab

F. Furuta (KEK)

KEK and Jlab have continued S0-study collaboration on ICHIRO 9cell cavities since 2008. In 2010, we have started S0 tight loop test on ICHIRO full 9cell cavity, ICHIRO#7. Surface treatments and vertical tests have been repeated at Jlab. Maximum gradient of 40MV/m was achieved so far. We will report the results and details of this.

Standard Procedures of ILC High Gradient Cavity Processing at Jefferson Lab

R.L. Geng (JLAB) A.C. Crawford (CLASSE)

We describe the JLab standard procedures of ILC cavity processing and handling for reproducible high gradient high Q0 results. The procedure begins with mixing fresh electrolyte with the molar ratio of HF:H2O:H2SO4 in the range that is compatible with that in the original Siemens recipe. Three key process parameters, namely the acid flow rate, the polish cell voltage and the cavity body temperature, are identified and in control. Our experience shows that optimal EP is achieved in the continuous current oscillation mode. The appearance of current oscillation also serves as a sensitive in-situ QA/QC indicator. The ``auto polishing'' procedure is introduced by continuing the acid flow and cavity rotation after the voltage is shut off. This effectively reduces sulfur-bearing niobium oxide granules, an inherent contaminant of the EP process. An elaborate post-EP cleaning procedure includes low-pressure water rinsing, HOM coupler brushing and ultrasonic cleaning with detergent. The vacuum furnace heat treatment procedure is updated. A no-touch bead-pull method is established. Slow pump down is routinely applied to prevent recontamination of the cavity surface.

Study Correlating Niobium Surface Roughness with Surface Particle Counts

C. Compton, L.J. Dubbs, K. Elliott, D. R. Miller, R. Oweiss, L. Popielarski, K. Witgen (FRIB)

A study has been initiated at Michigan State University (MSU) to relate the surface preparation of Superconducting Radio Frequency (SRF) resonators and surface particle counts, using niobium samples. During fabrication, undesired surface roughness can develop on the internal surfaces of the resonators. The final cavity finish will be product of material forming, machining, welding, chemistry, high-pressure rinsing, and handling of the niobium material. This study will document niobium samples treated with MSU standard processing procedures; first measuring the surface roughness, then polishing samples with defined techniques, processing, and measuring surface particle counts. The samples will include as received niobium, machined surfaces, welded surfaces, and surfaces with characterized surface imperfections (scratches).

TUPO017

Development and Scale-Up of an HF Free Electropolishing Process in Single-Cell Niobium SRF Cavities

M.E. Inman, H.M. Garich, S.T. Snyder, E.J. Taylor (Faraday Technology, Inc.) L.D. Cooley, C.A. Cooper, A.M. Rowe (Fermilab)

The performance of niobium SRF cavities is strongly dependent on a microscopically smooth and clean surface, achieved using buffered chemical polishing or electropolishing, which require a viscous electrolyte containing hydrofluoric acid to achieve niobium oxide breakdown and current distribution control. An ideal polishing process would include: electrolyte free of hydrofluoric acid; control of surface roughness to less than 0.1 micron; surface free from contamination; current distribution control enabling uniform polishing; removal of at least 100 microns. Faraday is working with Fermilab to develop and scale-up the FARADAYIC Electropolishing process to achieve these conditions. FARADAYIC Electropolishing combines pulse reverse electric fields and low viscosity aqueous electrolytes to control current distribution and oxide formation during metal removal. Recent results on coupon polishing will be presented including polishing rates up to 1 micron/min, control of electrolyte temperature to below 20 C, and surface finishes less than 0.2 microns over 4 mm length scales. Construction of a single-cell cavity electropolishing apparatus at Faraday are discussed.

TUPO018

Update of the DESY Infrastructure for Cavity Preparation

M. Schalwat, K. Escherich, N. Krupka, A. Matheisen, B. Petersen, N. Steinhau-Kuehl (DESY)

The main infrastructure for preparation of superconducting cavities at DESY is the cleanroom which was set up in the early 90th of the last century. This cleanroom is completely renovated in 2009. The ground space of cleanroom class ISO 4 was enlarged from 20 to 53 m2 and the areas of ISO 7 of the old cleanroom are upgraded to ISO 6 and ISO 5 standard. Areas for ultrasonic cleaning, ultrapure water rinsing and chemical surface treatment are upgraded to ISO 4 standards. Multiple vacuum connections are installed to reduce movement of cavities during string assembly. A 120o C baking oven, fulfilling the ISO 4 requirements, is connected to the IOS 4 assembly area and allows in situ backing of multi cell s.c. resonators. For industrial cavity production it is shown that a high pressure rinsing unit driven by a turbine pump allows feeding several high pressure rinsing stands in parallel. For cost reduction of water ultra -pure production and increase the amount of water in the cavity preparation cycle a recirculation of rinsing water is investigated and under commissioning. Fixtures and tool for the assembly of the BPM Quadrupol units for XFEL modules are installed and commissioned.

Fabrication, Tuning, Treatment and Testing of Two 3.5 Cell Photo-Injector Cavities for the ELBE Linac

A. Arnold, P. Murcek, J. Teichert, R. Xiang (HZDR) G.V. Ere-meev, P. Kneisel, M. Stirbet, L. Turlington (JLAB)

As part of a CRADA (Cooperative Research and Development Agreement) between Helmholtz-Zentrum Dresden-Rossendorf (HZDR) and Thomas Jefferson Lab National Accelerator Facility (TJNAF) we have fabricated and tested two 1.3 GHz 3.5 cell photo-injector cavities from polycrystalline RRR niobium and large grain RRR niobium, respectively. The cavity with the better performance will replace the presently used injector cavity in the ELBE linac*. The cavities have been fabricated and pre-tuned at TJNAF, while the more sophisticated final field tuning, the adjustment of the external couplings and the field profile measurement of transverse electric modes for RF focusing** was done at HZDR. The following standard surface treatment and the vertical test was carried out at TJNAF's production facilities. A major challenge turned out to be the rinsing of the cathode cell, which has small opening (ï¿½10mm) to receive the cathode stalk. Another unexpected problem encountered after etching, since large visible defects appeared in the least accessible cathode cell. This contribution reports about our experiences, initial results and the on-going diagnostic work to understand and fix the problems.

* J. Teichert, et al., Proc. FEL 2010, Malmoe, Sweden, p. 453.

** V. Volkov, D. Janssen, Phys. Rev. ST Accel. Beams 11, 061302 (2008).

TUPO019

CMP Polishing of a Niobium SRF Cavity

S.D. Lesiak, D. McMullen, K. Moeggenborg (Cabot Microelectronics Polishing Corp) A.M. Rowe (Fermilab)

Typical SRF cavity preparation protocol requires approximately 150 microns total of inner surface removal in two steps using an HF based electro-polishing process. The bulk removal, consumes approximately 130 microns and the final polishing step consumes an additional 20 microns. The work presented in this paper discusses a technique using chemical mechanical polishing (CMP) to replace the final 20 micron HF-based electro-polishing step. CMP processing results in a significant improvement in surface roughness when compared to electro-polish processing with the added benefits of being ecologically innocuous and operationally safe. Sub-surface anomalies, attributable to previous fabrication and finishing operations, were encountered in the CMP processing of the first sample SRF cavity. Sub-surface damage is normally uncovered during the CMP process and has been used to identify the nature of the damage and point to some of the potential sources of the anomalies. The nature of CMP enables polishing without inducing sub-surface damage. The combined effects of removing sub-surface damage and a higher quality surface finish as a result of CMP processing are discussed.

TUPO020

Current State of Electropolishing at ANL

T. Reid, S.M. Gerbick, M.P. Kelly, R.C. Murphy (ANL)

An electropolishing system for 1.3 GHz elliptical single- and 9-cell cavities is in full operation at the joint ANL/FNAL Superconducting Cavity Surface Processing Facility (SCSPF) located at Argonne. Currently, the facility is processing an average of one cavity per week. Single cell cavities are routinely achieving accelerating gradients exceeding 35 MV/m and several recent 9-cell cavities have operated in the region of 35-38 MV/m. Process improvements are continuing with the intent to improve overall yield at 35 MV/m and to improve cavity Q-values. In particular, cavity rf losses at the level of ~5 nOhm in both the low- and medium field regions appear to be sensitive to relatively small changes in EP parameters. Some examples of this are presented here. Finally, electropolishing on dressed 9-cell cavities is being explored as a technique for recovering previously good performing bare cavities where performance has degraded, for example, after rf processing.

TUPO021

TUPO022

Effects of Cathode Shapes on BEP and EP During Vertical Surface Treatments on Niobium

S. Jin, X.Y. Lu, K. Zhao (PKU/IHIP) R.A. Rimmer, A.T. Wu (JLAB)

This paper reports the research results of effects of cathode shapes during buffered and conventional vertical electropolishing treatments for single cell superconducting radio frequency (SRF) niobium cavities. Several different cathodes shapes such as, for instance, bar, ball, ellipsoid, wheel, etc. were employed. Detailed electropolishing parameters at different locations inside a single cell SRF cavity were measured using a unique JLab home-made demountable cavity, including I-V characteristic, removal rate, surface roughness, polishing uniformity and so on. It was demonstrated that optimal polishing results could be achieved by changing the cathode shape for both BEP and EP. Implications on the electropolishing mechanism of Nb cavities for both BEP and EP based on the obtained experimental results are discussed.

TUPO023

Development of the Superconducting Cavity for ILC at TOSHIBA

T. Ota, N. Kuroiwa, K. Mori, T. Nagafuchi, K. Nakayama, S. Nomura, J. Shibuya, Y. Tajima, T. Tosaka, M. Urata, J. Watanabe, M. Yamada (Toshiba) H. Hayano, E. Kako, S. Noguchi, T. Saeki, M. Sato, T. Shishido, K. Watanabe, A. Yamamoto, Y. Yamamoto (KEK)

TOSHIBA is developing superconducting cavity for International Linear Collider (ILC) in collaboration with High Energy Accelerator Research Organization (KEK) from 2009. We fabricated a 9-cell cavity and carried out the performance test of it at KEK in 2010. The status of superconducting cavity development for ILC at TOSHIBA is presented in this conference.

TUPO024

Sulfur Residues in Niobium Electropolishing

L. Zhao (The College of William and Mary) M.J. Kelley, C.E. Reece, H. Tian (JLAB)

Electropolishing (EP) in sulfuric/hydrofluoric acid mixtures affords significantly greater surface smoothness than the incumbent buffered chemical polishing (BCP), making it attractive as the future baseline technology for SRF cavity manufacture. However, reported observations of particulate sulfur residues raise concern. One hypothesis is sulfate reduction to elemental sulfur at the cathode, where the measured potential drop is thermodynamically sufficient. Alternatively, the low effectiveness of the cathode's aluminum oxide surface as a hydrogen recombination catalyst could lead to accumulation of atomic hydrogen, a powerful reductant. We explored these possibilities under standard EP conditions in a small three-electrode laboratory cell. We varied aluminum cathode area to obtain different current densities (and thus overpotentials) at constant cell current. We substituted platinum, an excellent hydrogen recombination catalyst, for aluminum in some experiments. Surface of cathodes were examined with Scanning Electron Microscope (SEM). Surface composition was analyzed by Energy Dispersive X-Ray Spectroscopy (EDS) and X-Ray Photoelectron Spectroscopy (XPS).

Integrated Cavity Processing Apparatus at Fermilab: SRF Cavity Processing R&D

A center for cavity processing R&D at Fermilab, called the Integrated Cavity Processing Apparatus, is currently in the final stages of installation and commis-

C.A. Cooper, L.D. Cooley, V. Poloubotko, O. Pronitchev, A.M. Rowe, M. Wong (Fermilab)

sioning. This facility contains centrifugal barrel polishing, a horizontal electropolishing tool, a 1000°C vacuum furnace, a high pressure rinse tool utilizing ultrapure water, ISO class 4, 5 and 6 clean rooms for cavity assembly work and various other associated pieces of support equipment. All the operations are designed for single cell and nine cell 1.3 GHz Tesla type cavities except for the electropolishing tool which will initially be only for single cell use. Upgrades are currently being examined for single and five cell 650 MHz cavities. The current status of the facility and plans for future work are discussed.

TUPO025

Nine - Cell Tesla Shape Cavities Produced From Hydroformed Cells

Production of two types of seamless niobium tubes for hydroforming of RF cavities has been developed. The first type of tubes, developed at DESY, have been spun from sheets and flow formed. The

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second type of tubing was developed by Black Laboratories in collaboration with the company ATI Wah Chang. These longer length tubes were extruded from a heavily deformed billet, processed for a fine-grained microstructure and flow formed. Several seamless three cell units have been produced by hydroforming at DESY. Some of the units have been treated by buffered chemical polishing and RF tested at JLab. The accelerating gradient Eacc of the units exceeded in most cases 30 MV/m. Three of the 3-cell units from the first type of tubing were combined to three 9-cell niobium cavities at the company E. Zanon. The 3-cell units from extruded tubing are welded together to the fourth 9-cell cavity at JLab. All cavities are in preparation for the RF tests at DESY and JLab. Up to now two of the cavities are electropolished and tested at DESY. The first cavity reached an accelerating gradient of Eacc of ~30 MV/m, the second one ~35 MV/m.

TUPO026

A New Home for SRF Work at JLab–the Technology and Engineering Development Facility

A project is underway at Jefferson Lab to fully renovate all of the SRF research, development, fabrication, processing and

C.E. Reece, A. Reilly (JLAB)

assembly facilities. Initiated in 2009 and funded by the US Department of Energy's Science Laboratory Infrastructure program, this work together with construction of a new building to house JLab's Engineering Division and detector electronics group is collectively known as the Technology and Engineering Development Facility (TEDF) Project. The majority of the SRF facilities will be consolidated in a new building with 30,000 square feet (3300 m^2) of work space attached to the existing Test Lab. The purpose-built facility integrates fabrication, chemistry, and cleanroom suites and cryomodule assembly lines for convenient, yet flexible operations serving multiple projects in parallel. A robust ultra-pure water system and integrated hazardous materials transfer and neutralization system are included in the project. Construction is underway and move-in is scheduled for early 2012. Project details will be presented.

TUPO027

TUPO028

Qualification of the Second Batch Production 9-Cell Cavities Manufactured by AES and Validation of the First US Industrial Cavity Vendor for ILC

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One of the major goals of ILC SRF cavity R&D is to develop industrial capabilities of cavity manufacture and processing in all three regions. In the past several years, Jefferson Lab, in collaboration with Fermi National Accelerator Laboratory, has processed and tested all the 9-cell cavities of the first batch (4 cavities) and second batch (6 cavities) production cavities manufactured by Advanced Energy Systems Inc. (AES). Over the course, close information feedback was maintained, resulting in changes in fabrication and processing procedures. A light buffered chemical polishing was introduced, removing the weld splatters that could not be effectively removed by heavy EP alone. An 800 Celsius 2 hour vacuum furnace heat treatment procedure replaced the original 600 Celsius 10 hour procedure. Four out of the six 9-cell cavities of the second production bath achieved a gradient of 36-41 MV/m at a Q0 of more than $8 \cdot 10^9$ at 35 MV/m. This result validated AES as the first ``ILC certified'' industrial vendor in the US for ILC cavity manufacture.

TUPO029

Gradient Improvement by Removal of Identified Local Defects

R.L. Geng, W.A. Clemens (JLAB) C.A. Cooper (Fermilab) H. Hayano, K. Watanabe (KEK)

Recent experience of ILC cavity processing and testing at Jefferson Lab has shown that some 9-cell cavities are quench limited at a gradient in the range of 15-25 MV/m. Further studies reveal that these quench limits are often correlated with sub-mm sized and highly localized geometrical defects at or near the equator weld. There are increasing evidence to show that these genetic defects have their origin in the material or in the electron beam welding process (for example due to weld irregularities or splatters on the RF surface and welding porosity underneath the surface). A local defect removal method has been proposed at Jefferson Lab by locally re-melting the niobium material. Several 1-cell cavities with known local defects have been treated by using the JLab local e-beam re-melting method, resulting in gradient and Q0 improvement. We also sent 9-cell cavities with known gradient limiting local defects to KEK for local grinding and to FNAL for global mechanical polishing. We report on the results of gradient improvements by removal of local defects in these cavities.

TUPO030

Status of the 9-Cell Superconducting Cavity R&D for ILC at Hitachi

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Hitachi is developing 9-cell superconducting cavities for ILC project in collaboration with KEK. We focus on electron beam welding (EBW) and plastic forming techniques. In 2010, Hitachi's first 9-cell cavity without HOM couplers was completed successfully. Surface treatments and performance test of the cavity were done at KEK and the accelerating gradient reached 35.2 MV/m. We have fabricated the next 9-cell cavity with HOM couplers from January 2011. We will report the fabrication procedure and test result of our first cavity and the current status of the next cavity.

Update on the R&D of Vertical Buffered Electropolishing on Nb Samples and SRF Single Cell Cavities

Electropolishing (EP) has become a popular choice as the final step of the surface removal process during the fabrication of Nb superconducting radio frequency

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(SRF) cavities. One of the major reasons for the choice is that Nb SRF cavities treated by EP tend to have a better chance to reach an accelerating gradient of 30MV/m or higher. This advantage of EP over BCP can at least be partially attributed to the smoother Nb surfaces that EP can produce. Recently a Nb surface removal technique called buffered electropolishing (BEP) was developed at JLab, which could produce the smoothest surface finish. In this contribution, R&D efforts of vertical BEP on Nb small samples and SRF single cell cavities since the last SRF conference in 2009 will be updated. It is shown that under a suitable condition, BEP can have a Nb removal rate as high as 10 μm/mim that is more than 25 and 5 times quicker than those of EP and BCP(112) respectively. Possible mechanisms responsible for the high Nb removal rate are proposed. Clues on the optimization of vertical BEP and EP treatments on Nb SRF cavities from recent experimental results obtained on a Nb single cell demountable cavity will be discussed.

Updates on R&D of Nondestructive Inspection Systems for SRF Cavities

We are developing high resolution eddy current scan and High density Tmap and X-map. The high resolution eddy current scan showed 100 μm diameter hole with

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50μm depth that was drilled on a Nb plate. The surface mount print circuit technology is applied to the high density Tmap and X-map devices, which will be ready soon to test at a vertical test bench. In addition, radiography using Xrays and neutrons are also under study. The results and status will be presented.

Study of I-V Characteristics at Different Locations Inside a Demountable Nb SRF Cavity During Vertical BEP and EP Treatments

For a normal superconducting radio frequency (SRF) cavity, it is hard to obtain detailed information of an electropolishing process. So, a demountable cavity

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was firstly made by JLab to resolve this problem. This paper reports the measurements of I-V characteristics at three different locations inside the demountable cavity during buffered electropolishing (BEP) and electropolishing (EP) treatments. The polishing plateau appeared earlier on the surface areas close to iris and later on those near equator. To find the reason for this phenomenon, the electric field distribution in the cavity was considered and simulated by means of Poisson Superfish. Correlations were found between the measured I-V characteristics and the simulated results. This implies that electric field distribution inside a SRF cavity had an important effect on the polishing processes during vertical BEP and EP.

TUPO034

High Pressure Rinse System for Multiple SRF Cavities

R.C. Murphy, J.D. Fuerst, S.M. Gerbick, M. Kedzie, M.P. Kelly, T. Reid (ANL)

The Physics Division SRF group at Argonne National Laboratory is building a new, high pressure rinse system for the joint ANL/FNAL Superconducting Cavity Surface Processing Facility (SCSPF). The rinsing tool can be easily reconfigured vertically or horizontally to process a variety of SRF cavity shapes and sizes including elliptical, spoke, quarter- and half-wave cavities. The system has been commissioned with a new 72 MHz β=0.077 quarter wave cavity as part of the ATLAS Intensity Upgrade at ANL. The tool is also designed to rinse 1.3 GHz elliptical single-cell and 9-cell cavities, as well as the new 650 MHz elliptical cavities under development for Project-X and Fermilab. This work was supported by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357.

TUPO035

Cryogenic Test of a Two-Cell Passive SRF Cavity for NSLS-II

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In collaboration with Brookhaven National Lab (BNL), Niowave, Inc. has built and performed the first cryogenic test on a two-cell passive SRF cavity for controlling electron bunch lengths at NSLS-II, the new 3rd generation synchrotron under construction at BNL. The structure is resonant at 1500 MHz, the third harmonic of the accelerating RF frequency. Because the cavity is powered by the beam itself, however, many frequencies could potentially be excited and higher-order modes must be strongly damped. Further, only one of the two cavity fundamental modes is used for the bunch length control, and the other mode has been carefully tuned so that it will be minimally excited by the electron bunches. The first cryogenic test has been performed to demonstrate a successful cooldown of the cavity in its cryomodule and to show that the cavity can be tuned to its operating frequency while the proper spacing between the two fundamental modes is maintained. A brief discussion of the cavity design will be presented along with some results from the cavity tuning and cryotest.

TUPO036

Material for European XFEL Resonators

W. Singer, S. Arnold, A. Brinkmann, J.A. Dammann, A. Ermakov, J. Iversen, D. Klinke, M. Lengkeit, W.-D. Moeller, P. Poerschmann, X. Singer (DESY)

Twelve different types of semi-finished products will be provided by DESY to producers of European XFEL superconducting resonators. Work on material for XFEL cavities is divided into three phases (prototyping, pre-series and series production). Two new companies (Ningxia OTIC and Plansee Metal GmbH) have been qualified as XFEL suppliers. Material is contracted to 4 companies (Ningxia OTIC, Plansee Metal GmbH, Tokyo Denkai and W.C. Heraeus). Procurement of semi-finished products includes: acceptance on producer's site, eddy current scanning of the sheets, testing for required parameters (RRR, interstitial impurity analysis, metallic impurities analysis, metallography, tensile test, hardness HV, dimensional check, surface roughness), documentation using the DESY EDM-System, marking, delivery to companies. Semi-finished products for pressure bearing sub-components of cavities have to be fabricated according Pressure Equipment Directive 97/23/EC. Qualification of material and the certification of the material producers were done by a ``notified body''. Appropriate infrastructure and logistic for guiding through more than 20.000 of semi-finished products has been build up.

Study on Electro-Polishing Process by Niobium-Plate Sample With Artificial Pits

T. Saeki, H. Hayano, S. Kato, M. Nishiwaki, M. Sawabe (KEK) W.A. Clemens, R.L. Geng, R. Manus (JLAB) P.V. Tyagi (Sokendai)

The Electro-polishing (EP) process is the best candidate of final surface-treatment for the production of ILC cavities. Nevertheless, the development of defects on the inner-surface of the Superconducting RF cavity during EP process has not been studied by experimental method. We made artificial pits on the surface of a Nb-plate sample and observed the development of the pit-shapes after each step of 30um-EP process where 120um was removed by EP in total. This article describes the results of this EP-test of Nb-sample with artificial pits.

Superconducting RF Cavity Development With UK Industry

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As part of a STFC Industrial Programme Support Scheme (PIPSS) grant Daresbury Laboratory and Shakespeare Engineering Ltd have fabricated, processed and tested a single cell 1.3 GHz superconducting RF cavity, in collaboration with Jefferson Laboratory. The overall aim of the project through a knowledge exchange programme was to develop the capability of UK industry to fabricate and process a single cell niobium superconducting cavity, as part of a long term strategy to enable UK industry to address the large potential market for superconducting RF structures. As a means of measuring the performance of the fabrication and processing an objective of the programme of work was to achieve an accelerating gradient of greater than 15 MV/m at an unloaded quality factor of 1.0×10^{10} or better. Three cavities were fabricated by Shakespeare Engineering, and electron beam welded at Jefferson Laboratory in the USA. Processing and testing of the cavities was then performed both at Jefferson Laboratory and at Daresbury Laboratory. The fabrication and process methods are discussed in this paper along with the results obtained from the testing performed in the vertical test facilities.

Long-Term Monitoring of 2nd–Period EP-Electrolyte in STF-EP Facility at KEK

M. Sawabe, H. Hayano, A. Komiya, H. Monjushiro, T. Saeki, M. Satou (KEK)

We have constructed an Electro-polishing (EP) Facility in the Superconducting RF Test Facility (STF) at KEK at the end of 2007. We have begun to operate the EP facility since 2008 and performed the EP process of cavity about 140 times up to now. During this period, we exchanged EP-electrolyte twice in the 2,000L tank. We are performing EP processes with the 3rd–period EP-electrolyte at the present moment. By this report, we report the long-term monitoring results of the 2nd–period EP-electrolyte used from May, 2009 to July, 2010.

The Status of Cavity-Fabrication Study for ILC at KEK

T. Saeki, Y. Ajima, K. Enami, H. Hayano, H. Inoue, E. Kako, S. Kato, S. Noguchi, M. Satoh, T. Shishido, A. Terashima, N. Toge, K. Ueno, Y. Watanabe, S. Yamaguchi, A. Yamamoto, Y. Yamamoto, K. Yokoya (KEK) H. Nakamura, K. Nohara, M. Shinohara, N. kawabata (SPS)

We are constructing a new cavity-fabrication facility at KEK from 2009. In the facility, we have installed a deep-drawing machine, a half-cup trimming machine, an electron-beam welding machine, and a chemical etching room in one place. We started the fabrication study of 9-cell cavity for ILC from 2009 using this facility. The study is focusing on the cost reduction in the mass production of 9-cell cavites in ILC. This article reports the current status of cavity-fabrication study in the facility.

TUPO041

Investigation on Cavity String Assembly and Repair

A. Matheisen, B. Horst, van der, S. Saegebarth, P. Schilling, M. Schmoekel, N. Steinhau-Kuehl, H. Weitkaemper (DESY)

At DESY several cavity strings for modules of the flash accelerator and studies on XFEL prototypes are completed. In some modules cavities have been exchanged for upgrade of applicable module gradients or exchange of resonators that showing performance degradation in the module test. Assembly and repair sequences and quality control plans for cavity string are developed and applied. From module srting PXFEL3 six out of eight cavities are removed and handed over to CEA Saclay for training of string and module assembly. On two of these cavities the procedures for assembly and exchange of cavities in cavity strings are crosschecked. These cavities are tested at 2 K removaed from string without additional treatments to cross check assembly and repair sequences.

TUPO042

SLAC/FNAL TTF3 Coupler Assembly and Processing Experience

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The TTF3-style coupler is typically used to power 1.3 GHz TESLA-type superconducting cavities. For the US ILC program, parts purchased in industry for such couplers are received at SLAC where they are inspected, cleaned, assembled as pairs in a Class 10 cleanroom, pumped down, baked at 150 degC and rf processed. The pairs are then shipped to FNAL and installed in cavities that are then tested at input power levels up to 300 kW. This paper describes the coupler results to date including improvements to the procedures and efforts to mitigate problems that have been encountered. Also progress on building a cold coupler section without e-beam wielding is presented.

TUPO043

Optimization of Ar/CL2 Plasma Parameters Used for SRF Cavity Etching

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We are pursuing the development of environmentally friendly dry etching of superconducting radio frequency (SRF) cavities in Ar/CL2 discharges. It has been proven with flat samples that the bulk Niobium (Nb) removal rate and the surface roughness after plasma etchings are equal to or better than wet etching processes. The plasma properties inside the single cell SRF cavity depend on frequency, pressure and power. To understand the plasma properties and chemical kinetics of plasma etching process inside a single cell cavity, we are using a specially-designed cavity with 20 sample holders symmetrically distributed over the cell. These holders are being used for Nb coupon etching as well as diagnostic ports. Multiple optical probes with optical fibers have been utilized for emission spectroscopy measurements. A power supply in the radio frequency regime (100 MHz) and another power supply in the microwave frequency regime (2.45 GHz) are used to produce plasma inside the cavity. The plasma parameters at different pressures and power levels in combination with the analysis of the Nb sample etched will be used to determine the adequate frequency regime for plasma etching of Nb cavities.

TUPO044

Correction of a Superconducting Cavity Shape Due to Etching, Cooling Down and Tuning

V.D. Shemelin (CLASSE)

Corrections of shape needed for an SRF cavity after fabrication are presented in a convenient form with a possibility to take into account different technological procedures, such as etching, cooling down and pre-loading.

Status of Investigations on Degradation of Cavities in DESY Acceleration Modules

A. Matheisen, B. Horst, van der, D. Kostin, N. Krupka, S. Saegebarth, M. Schalwat, P. Schilling, M. Schmoekel, H. Weitkaemper (DESY)

In the last decade the degradation of cavity acceleration gradients is observed frequently in module RF tests, after the assembly and installation of complete accelerator modules. In some cases no explanation for these degradations could be found from quality control records, assembly procedure protocols or notes from observers. On the PXFEL3 module quench limitations without indication of field emission loading is observed at two cavities. Boundary conditions like storage of resonators, cleaning process for ISO 4 clean room as well as the assembly processes and handling of the resonators are under investigation. The two degraded cavities of module PXFEL 3 are removed from the cavity string and studied intensively. The actual status of our research is presented.

Update on Large Grain Cavities with 45 MV/m in a Nine-Cell Cavity at DESY

D. Reschke, S. Aderhold, A. Goessel, J. Iversen, S. Karstensen, D. Kostin, G. Kreps, A. Matheisen, W.-D. Moeller, F. Schlander, W. Singer, X. Singer, N. Steinhau-Kuehl, A.A. Sulimov, K. Twarowski (DESY)

Since 2009 a series of eight nine-cell cavities (AC151 – AC158) of TESLA shape fabricated of large grain (LG) niobium material is under preparation and test at DESY. In a first step all cavities were tested after a BCP treatment. In a second step additional electro polishing is applied to all cavities. In this paper the treatment will be discussed and a first excellent result of AC155 will be reported.

Progress in Developing 500MHz Nb Cavity at SINAP

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The SRF system has been operated for 3 years since the final acceptance test of 500MHz superconducting module in 2008. The R&D on niobium superconducting cavity at SINAP has been carried out to reach some exciting results. The whole fabrication procedure on developing a 500MHz single cell cavity including the deep-drawing, electron beam welding, surface processing and vertical testing will be reported in detail. The final vertical test results show that the fabricated niobium cavity has a good performance of reaching as high as 10MV/m accelerating gradient and quality factor better than $4 \cdot 10^8$.

TUPO048

Commissioning and Upgrade of Automatic Cavity Tuning Machines for the European Xfel

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Four new tuning machines were developed and built in a collaborating effort among FNAL, KEK and DESY. Two machines were commissioned at DESY in a close teamwork with FNAL. For several months, these machines have been used regularly for the automatic tuning of different types of cavities for FLASH. Due to this operating experience and the requirements for the European XFEL cavity Specification, it was necessary to implement the following improvements: improve the precision of the eccentricity measurement; change the tuning sequence according to the different production stages in the cavity fabrication and preparation process; review and change the machine access procedures according to the safety aspects of the EC Directive of Machinery. These improvements required changes in both the mechanical parts developed by DESY and the electronics and software developed by FNAL. We report in detail about the commissioning, our tuning experience and the necessary improvements.

TUPO049

Q0 Improvement of Large-Grain Multi-Cell Cavities by Using JLab's Standard ILC EP Processing

R.L. Geng, G.V. Eremeev, P. Kneisel (JLAB) K.X. Liu, X.Y. Lu, K. Zhao (PKU/IHIP)

As reported previously at the Berlin workshop, applying the JLab standard ILC EP recipe on previously BCP etched fine-grain multi-cell cavities results in improvement both in gradient and Q0. We recently had the opportunity to experiment with two 1300 MHz 9-cell large-gain niobium cavities manufacture by JLab and Peking University. Both cavities were initially BCP etched and further processed by using JLab's standard ILC EP recipe. Due to fabrication defects, these two cavities only reached a gradient in the range of 20-30 MV/m. Interestingly both cavities demonstrated significant Q0 improvement in the gradient range of 15-20 MV/m. At 2K, a Q0 value of $2 \cdot 10^{10}$ is achieved at 20 MV/m. At a reduced temperature of 1.8K, a Q0 value of $3 \cdot 10^{10}$ is achieved at 20 MV/m. These results suggest that a possible path for obtaining higher Q0 in the medium gradient range is to use the large-grain material for cavity fabrication and EP and low temperature bake for cavity processing.

TUPO050

Studies on Transportation of Superconducting Resonators and Beam Position Monitors - Quadrupol Units for the XFEL Project

A. Schmidt, R. Bandelmann, H. Brueck, A. Matheisen, J. Schaffran (DESY)

For the XFEL project industrial companies in Germany and Italy are in charge of the cavity fabrication and preparation. For the radio frequency acceptance test at 2 K at DESY these cavities have to be transported to the DESY site in Hamburg without losing the performance. The XFEL Beam position monitor and Quadrupol units (BQU) are completed in the DESY clean room. The Cavities and the BQU are handed out in the status ``ready for assembly'' to the string assembly site at CEA Saclay. To ensure that the transports over European routes do not influence the performance of cavities or are origin of particulates inside the BQU, individual transport boxes for super conduction cavities and transport fixtures for the BQU and are designed and tested.

High-Temperature Heat Treatment Study on a Large-Grain Nb Cavity

Improvement of the cavity performance by a high-temperature heat-treatment without subsequent chemical etching have been reported for large-grain Nb

G. Ciovati, P. Dhakal, R. Myneni (JLAB) P. Maheswari, F.A. Stevie (NCSU AIF)

cavities treated by buffered chemical polishing, as well as for a fine-grain cavity treated by vertical electropolishing [1]. Changes in the quality factor, Q_0, and maximum peak surface magnetic field achieved in a large-grain Nb single-cell cavity have been determined as a function of the heat treatment temperature, between 600 $^{\circ}$C and 1200 $^{\circ}$C. The highest Q_0 improvement of about 30% was obtained after heat-treatment at 800 $^{\circ}$C-1000 $^{\circ}$C. Measurements by secondary ion mass spectrometry on large-grain samples heat-treated with the cavity showed large reduction of hydrogen concentration after heat treatment.

[1] G. Ciovati, G. Myneni, F. Stevie, P. Maheshwari, and D. Griffis, Phys. Rev. ST Accel. Beams 13, 022002 (2010)

Fabrication and Test of 500MHz Nb Cavity for BEPCII

In order to ensure the stable operation of BEPCII, we had began a superconducting accelerator unit in IHEP 3 years ago. The

G.W. Wang (IHEP Beijing)

development and test of 500MHz Nb cavity, which is the key component of the unit, are introduced in this article. The fabrication of three Nb cavities has been finished, and the post-processing and vertical test of the 1st cavity have been completed, too. The technology of fabrication, electron beam welding (EBW), post-processing has been developed. Meanwhile, the related facilities has been improved, too.

Optical Inspection of SRF Cavities at Fermilab

The production of an SRF cavity includes a string of multiple treatments at different facilities before the cavity can be RF-

E. Toropov, D.A. Sergatskov (Fermilab)

tested in a cryogenic system. Many of the processing steps change the cavity surface and affect the RF performance of the cavity. Interjection of optical inspections between these steps provides us with an instant feedback on the processes involved as well as giving us new insight on the mechanisms responsible for forming surface abnormalities. The major drawback of inclusion of frequent optical inspections is the increased amount of time and labor in the cavity production cycle. An optical inspection of equatorial and iris welds of a 1.3GHz TESLA-shape cavity produces about two thousand pictures. We developed an automated procedure where a computer takes over the most of the routine operations including adjusting the camera focus. With that automation, the inspection currently takes about three hours and little operator time. We will describe the developed system including the focusing algorithm and discuss the ways to further optimize the procedure.

TUPO054

SRF Cavity Surface Topography From Optical Inspection

E. Toropov, D.A. Sergatskov (Fermilab)

Characteristics of the cavity surface geometry such as roughness affect cavity performance. The optical cavity inspection system at Fermilab allows us to obtain pictures of cavity surface at different lightning conditions. By analyzing the images of some fixed location inside the cavity taken while the light source moves progressively along the axis we can deduce some topographical information of that surface. In the large-grain cavities after BCP, grains are oriented at distinct angles to the surface and, therefore, reflect light in different directions. We developed a simple algorithm to calculate the angle distribution of the grains and thus to estimate the roughness. We discuss this method and the results of the analysis of the actual cavity surface.

TUPO055

Horizontal SRF Cavity Testing at Fermilab

A. Hocker, E.R. Harms, A. Lunin, A.I. Sukhanov (Fermilab)

Fermilab makes use of a single-cavity test cryostat to assess the performance of dressed superconducting RF cavities using pulsed high-power RF before they are assembled into a cryomodule. Cavity performance is evaluated in terms of accelerating gradient, unloaded quality factor, and field emission. The functionality of auxiliary components such as tuners and fundamental power couplers is also verified. The latest results from extensive testing of nine-cell 1.3 GHz cavities are presented here, along with a discussion of future extensions of the horizontal test program to include 650 MHz cavities and continuous wave testing.

TUPO056

Dewar Testing of β = 0.53 Half Wave Resonators at MSU

J. Popielarski, A. Facco, W. Hartung, J. Wlodarczak (FRIB)

Michigan State University is developing quarter wave and half wave resonators to accelerate stable ions to 200 MeV per nucleon or higher for the Facility for Rare Isotope Beams (FRIB). The final stage of acceleration is done with half wave resonators designed for an optimum velocity of β = v/c = 0.53, with a resonant frequency of 322 MHz. Five resonators have been constructed so far, with the first prototype fabricated by MSU staff and the remaining four fabricated in cooperation with industrial partners. Over 150 additional resonators for β = 0.53 are required for the FRIB linac. Results of Dewar testing to characterize the RF performance of the resonators will be presented in this paper.

Buffered Chemical Polishing Development for the β=0.53 Half-Wave Resonator for the Facility for Rare Isotope Beams

The β=0.53 half wave resonator is being developed for the Facility for Rare Isotope Beams. One MSU prototype resonator and four industry made res-

L. Popielarski, L.J. Dubbs, K. Elliott, I.M. Malloch, R. Oweiss, J. Popielarski (FRIB)

onators have been fabricated. The proposed surface treatment is buffered chemical polishing (BCP) and high pressure rinsing with ultra pure water. The BCP process is being optimized to achieve resonator performance goals during certification testing. Research is focused on the improvement of the damaged layer removal (uniformity), the heat exchanger design, and the quality of BCP acid solution. Several etches have been completed on the half wave resonators and process data, such as removal rate, temperature profiles, and niobium concentration in solution collected. The process data was studied versus the vertical test results; maximum accelerating voltage, quality factor and field emission onset voltage. The chemistry fixture development and process data versus test results will be presented.

CERN SRF Assembling and Test Facilities

CERN is currently upgrading and refurbishing its RF and cryogenic facilities in the SM18 assembly hall with the aim of testing SRF cavities and cryo-modules of

J.K. Chambrillon, O. Brunner, P. Maesen, O. Pirotte, M. Therasse, B. Vullierme, W. Weingarten (CERN)

various provenience. They concern new and spare cavities for the HIE-ISOLDE upgrade, SPL study and LHC collider. These projects require a redistribution of space, refurbishment of cleanrooms, modification of SRF test stands, of vertical cryostats and of the lHe supply line. This poster presents the specifications of the refurbished facility and the technical choices required for the assembling, processing and testing of superconducting RF cavities.

SRF Cavity Processing and Cleanroom Facility Upgrades at Michigan State University

The Michigan State University (MSU) Superconducting Radio Frequency (SRF) cavity processing and coldmass assembly infrastructure is being upgraded to meet

L. Popielarski, L.J. Dubbs, K. Elliott, I.M. Malloch, R. Oweiss, M. Williams (FRIB)

the production needs of multiple SRF projects, including the driver linac for the Facility for Rare Isotope Beams and the MSU Reaccelerator. The objective is to modify the current infrastructure to increase throughput and optimize the process workflow, while minimizing impact to the overall preproduction schedule. Facility upgrades include a cleanroom addition, chemistry room addition, part etching lab, cleanroom preparation area, and a new ultra pure water system. New handling fixtures and specialized tools are being implemented. Methods are being developed to streamline the workflow, increase repeatability, enhance process safety and reduce cross contamination and waste. The proposed work center layout, process capabilities, optimized workflow strategies, and plans for continuous improvement will be presented.

TUPO060

Dewar Testing of β = 0.085 Quarter Wave Resonators at MSU

J. Popielarski, A. Facco, W. Hartung, J. Wlodarczak (FRIB)

Michigan State University is developing and testing quarter wave resonators for a superconducting linac which will be used to reaccelerate exotic ions to 3 MeV per nucleon or higher (ReA3). Eight quarter wave resonators with an optimum velocity of $\beta = v/c = 0.085$ and a resonant frequency of 80.5 MHz are required for the third cryomodule, which will complete the first stage of the reaccelerator linac. Approximately 100 additional $\beta = 0.085$ resonators of the same design will be required for the Facility for Rare Isotope Beams (FRIB). Results of Dewar testing to characterize the RF performance of the resonators will be presented in this paper.

TUPO061

Preparation and Testing of the SRF Cavities for the CEBAF 12 GeV Upgrade

A. Reilly, T. Bass, A. Burrill, G.K. Davis, F. Marhauser, C.E. Reece, M. Stirbet (JLAB)

80 new 7-cell, LL cell-shaped cavities are required for the CEBAF 12 GeV Upgrade project. In addition to ten pre-production units fabricated at JLab, the full set of commercially-produced cavities have been delivered. An efficient processing routine, which includes a controlled 30 micron EP, has been established to transform these cavities into qualified 8-cavity strings. This work began in 2010 and will run through the end of 2011. The realized cavity performance consistently exceeds project requirements and also the maximum useful gradient in CEBAF: 25 MV/m. We will describe the cavity processing and preparation protocols and summarize test results obtained to date.

TUPO062

Vertical Electro-Polishing at CEA Saclay: Commissioning of a New Set-Up and Modeling of the Process Applied to Different Cavities

F. Eozï¿½nou, S. Chel, Y. Gasser, J.P. Poupeau, C. Servouin, Z. Wang (CEA/DSM/IRFU)

High performance required for elliptical low beta cavity makes the electro-polishing desirable for their surface treatment. For large dimension cavities, the EP treatment in vertical configuration (abbreviated as VEP) is more appropriate. A VEP set-up has been designed at Saclay for the electro-polishing of such cavities. The electrolyte will be circulating and the process automated, including several safety procedures. Chosen equipment will make it possible to use a wide range of parameters (voltage, flowrate, temperature, nitrogen inerting) with R&D purpose in mind. R&D will guide the choice of adapted parameters in such configuration. In addition, VEP has been modeled using COMSOL software with 2D axi - symmetry configuration for 2 different cavities: - 9Cell ILC cavity - Proton 5Cell cavity for SPL accelerator. Different cathodes have been designed to optimize the fluid and the electric field distribution during VEP. Respective results will be presented. At last, importance of the size of the cavity will be commented.

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MgB2 Films on Metallic Substrates with Different Surface Roughness

TUPO063

For coating RF cavities with MgB2 films, a suitable metallic substrate material and appropriate surface roughness need to be

C.G. Zhuang, K. Chen, A. Krick, Q.Y. Lei, T. Tan, X. Xi (TU)

investigated. Here we report the properties of MgB2 films grown by hybrid physical-chemical vapor deposition on different metallic substrates, Nb, stainless steel, Mo, and Ta, with different degrees of surface roughness. Using mechanical polishing, the root-mean-square (RMS) roughness of the Nb surface is reduced to below 5nm. The surface morphology of the MgB2 films shows significant improvement in uniformity and reduction of RMS roughness as the substrate roughness is reduced. Superconducting properties and microwave properties of these films will be discussed. The comparison of the films on different metallic substrates is also presented.

Large-Area MgB2 Films by Hybrid Physical Chemical Vapor Deposition

TUPO064

Large-area MgB2 films with 2″ diameter are fabricated by hybrid physical chemical vapor deposition. Their properties

X. Xi, K. Chen, A. Krick, Q.Y. Lei, T. Tan, C.G. Zhuang (TU)

are characterized by x-ray diffraction, atomic force microscopy, scanning electron microscopy, and transport measurements. Films on c-cut sapphire wafers grow epitaxially with c-axis normal to the substrate surface. Films grown on niobium wafers are polycrystalline with random orientations among the grains. The superconducting properties of the films are tested by dicing the 2″ inch wafers into 8mm x 8mm small pieces. The uniformities of Tc and Jc(H) with field up to 9T across the wafers are measured. The superconducting properties of the polycrystalline films on niobium are compared to those of the epitaxial films on sapphire. The RF properties of the MgB2 films will be discussed.

Economical Manufacture of Seamless High-Purity Niobium

TUPO065

Ultramet continues to develop a fabrication methodology to construct high-performance (RRR>200), seamless niobium

V.M. Arrieta, S.R. McNeal (Ultramet)

superconducting radio frequency (SRF) cavity cells on low-cost removable mandrels utilizing advanced chemical vapor deposition (CVD) technologies. Optimization of the CVD niobium material and process to improve as-deposited niobium purity levels has resulted in the consistent rapid deposition of RRR>200 niobium at structural thicknesses suitable for accelerator applications. Boundary layer material applications on removable low-cost mandrels used successfully in previous work were further optimized and characterized. Basic CVD niobium joining/welding capabilities have been demonstrated as a potential alternative to electron beam welding, and preliminary mechanical and microstructural characterization of the joined area were performed.

Analysis of Recent Results from Second Sound, Temperature Mapping and Optical Inspection of 1.3 GHz Cavities at DESY

F. Schlander, S. Aderhold, D. Reschke, K. Twarowski (DESY)

DESY is preparing for the delivery of some 600 superconducting 9-cell cavities for the European XFEL. Analysing the history and recorded data of recently tested cavities gives important evidence for proper treatment, preparation and handling of cavities. The experience given by temperature mapping, the Second Sound technique and optical inspection will be compared and an overview of the results obtained so far will be given in this report.

E HIE ISOLDE QWR: Progress in Magnetron and Bias Diode Sputtered Niobium Thin Film Coating

G. Lanza, S. Calatroni, O. Capatina, B. Delaup, L. Marques Antunes Ferreira, M. Pasini, M. Therasse (CERN)

The R&D program for coating the Quarter Wave Resonator for the HIE-ISOLDE project started at CERN in 2008. Since then the CERN facilities for surface treatment and niobium coating have been upgraded and adapted to improve process reproducibility. Two coating techniques, Magnetron Sputtering and Bias Diode Sputtering have been tested and are being optimized to achieve the required film quality and thickness homogeneity. This poster shows the two sputtering configurations, as well as the results of the surface treatments and coatings. Details of the latest RF test are presented.

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Electropolishing of Niobium to Obtain Defect Free Surface

A. Chandra, G. Frankel, M. Sumption (Ohio State University)

The SRF cavities needs to have a good surface finish to achieve maximum performance. Surface defects like grain boundaries, bumps and pits limit the maximum field gradients achieved. Electropolishing (EP) is commonly used as a final surface finishing process. Acid concentration, stirring, temperature and amount of material removed are the parameters expected to affect the surface finish and their effect is studied using flat Nb specimens. Optical microscope, SEM and optical profilometer have been used to characterize the level of surface finish obtained. The mechanism of EP is not fully understood. To explore the mechanism and parameters necessary for optimum surface finish, an electrolytic cell made of 99.999% pure Al has been designed which also serves as the counter electrode. The mechanism involves the formation of a viscous layer on the Nb surface. There is evidence for the formation of this film in electrochemical experiment results and optical observations. The film is in fact critical to the EP mechanism as it has been found that the surface is pitted where a stable viscous film can not be formed.

TUIOC — Hot Topics

Medium Field Q-Slope and Paths to High-Q Operation

Superconducting RF cavities for accelerator application offer, at least in principle, the perspective of large accelerating gradients and low RF losses. Both qualities must proceed reciprocally. Therefore, consequent to the achieved increase in accelerating gradient during recent years, the RF losses must be reduced accordingly, in order to keep the cryogenic installation at reasonable size. However, the Q-value, which describes the RF losses, did not follow the improved accelerating gradient as wished or required. The reasons are physical mechanisms, only partly understood, on top of the residual losses, that provoke a more than quadratic increase of the RF losses with the accelerating gradient (Q-slope). Cures have been identified experimentally to some extent, but both the theoretical understanding and a complete elimination of the"Q-slop" are lacking. The hot topic discussion should open the floor for a new and deeper understanding of the"Q-slop".

HOT TOPIC

Chair: W. Weingarten, CERN (Geneva, Switzerland)   **101**

WEIOA — R&D/Diagnostics

WEIOA01

Quantitative EP Studies and Results for SRF Nb Cavity Production

H. Tian, C.E. Reece (JLAB)

To achieve high performance and reliability, which is essential for Nb SRF cavities production, it is important for us to understand Nb EP in detail so that we can tailor it to the best effect. The analytical tools of electrochemistry and surface topography are the means of developing such understanding. In this talk, the recent incorporation of analytic electrochemical techniques into the development of well controlled protocols for Nb EP will be reported, such as using three electrode method for polarization curve measurements, EIS to understand the mechanism of EP, and RDE to study the diffusion coefficient of active species of F ions, and the related diffusion layers etc. In parallel, investigations for monitoring scale-dependent Nb surface morphology evolution under different Nb EP parameters, which is expected to lead to matrix a best EP parameter and have a predictive power to describe the Nb surface evolution during EP will be demonstrated. Early lessons learned that are relevant to Nb cavities will be introduced, and directions for the future are aimed at well control, high reproducibility, efficient, and geometry independent EP process for coming SRF-based projects.

WEIOA02

Centrifugal Barrel Polishing (CBP) of SRF Cavities Worldwide

C.A. Cooper (Fermilab) B. Bullock (CLASSE) S.C. Joshi (RRCAT) A.D. Palczewski (JLAB) K. Saito (KEK)

Much interest was generated in the mid to late 1990s in an alternative cavity surface processing technique called CBP, that mechanically polishes the inside of SRF cavities by rotating them at high speeds while filled with abrasive media. This work, which was originally done at KEK by Kenji Saito & Tamawo Higuchi, has received renewed interest recently because of work done at Fermilab which has produced mirror like finishes on the 1.3 GHz Tesla-type cavity SRF surface. In addition to Fermilab & KEK, Cornell, Jefferson Lab and RRCAT are all exploring CBP as a cavity processing technique. CBP is interesting as a cavity processing technique because it removes defects associated with the manufacturing process, it can yield surface finishes (Ra) on the order of 10s of nanometers, it is a simple technology that could transfer easily to industry, it could help increase cavity yields and it requires less acid than other techniques. Recent progress and the current status of CBP as a baseline and repair technique will be discussed.

WEIOA03

A New Electropolishing System For Low-Beta SC Cavities

S.M. Gerbick, M.P. Kelly, R.C. Murphy, T. Reid (ANL)

A new electropolishing system designed for a completed low-beta niobium SC cavity with integral helium vessel was installed and operated at Argonne National Laboratory. The design was based on that used for the electropolishing of 1.3 GHz 9-cell elliptical cavities for the global ILC development effort at ANL, with the addition of direct water cooling to the cavity surface. This design also allows for repeated chemistry on the cavity, if needed, without producing the rougher surface associated with buffered chemical polishing.

Review of RF - Sample - Test Equipment and Results

T. Junginger, W. Weingarten (CERN) **T. Junginger** (MPI-K) C.P. Welsch (Cockcroft Institute)

The surface resistance of superconducting samples can be derived from the heat dissipation under RF exposure. This requires challenging and sometimes opposing design constraints. The samples shall be small and easily exchangeable. The RF magnetic field on the sample surface shall be large and homogeneous. It must not be limited by the host cavity. A calorimetric technique enables precise measurements and has therefore recently gained much interest. One of the devices exploiting this technique at multiple frequencies is the Quadrupole Resonator. Its measurement capabilities and limitations are discussed and compared with similar devices. Results on bulk niobium and niobium film on copper samples are presented. It is shown how different contributions to the surface resistance depend on temperature, applied RF magnetic field and frequency. Furthermore measurements of the maximum RF magnetic field as a function of temperature and frequency in pulsed and CW operation are presented.

X-Ray Tomography Inspection of SRF Cavities

E.R. Harms, H.T. Edwards (Fermilab)

Performance issues with superconducting cavities and a desire for an enhanced non-invasive view of the interior of a cavity compared to that provided by optical means has led us to inspection using 3-dimensional X-ray tomography. This technique has provided the necessary view of suspected faults in Higher Order Mode couplers. This success naturally leads to determining if x-ray inspection of welds and other potential cavity defects might prove to be helpful during cavity fabrication. Results of x-ray scans from commercial vendors and potential for this technique will be presented.

Effect of Deformation and Heat Treatment on the Thermal Conductivity of Large Grain Superconducting Niobium

S.K. Chandrasekaran (MSU) T.R. Bieler (Michigan State University) C. Compton (FRIB) N.T. Wright ((MSU))

Superconducting radio frequency cavity fabrication involves large-scale deformation of niobium at room temperature, exposing the material to engineering strains as large as 40%. Deforming metals introduces dislocations in the bulk material, resulting in changes in microstructure and thermophysical response. Deformation and the resulting dislocations in niobium have been shown to alter the thermal conductivity, especially at temperatures below 3 K where phonons dominate heat conduction. With the increased number of high-energy physics applications requiring cavities to operate at temperatures of about 2 K, improved understanding of the variation of phonon conduction between 1.6 K and 3 K will aid in design for these applications. Thermal conductivity measurements have been performed on niobium specimens from several large grain ingot discs with varying RRR and Ta content. The effect of 1% to 20% uniaxial straining and several recovery heat treatment protocols on the electron and phonon conduction regimes of the superconducting niobium specimens is presented. The effects of RRR and Ta content of the parent material on the thermal conductivity of the specimens are also discussed.

WEIOA04

WEIOA05

WEIOA06

WEIOB — R&D/Diagnostics/Fabrication

WEIOB01

Guided Cavity Repair with Laser, E - Beam and Grinding

G. Wu (ANL)

Recent cavity processing statistics indicate that the development of RF superconductivity has reached a stage where more and more cavities were limited by quench and not by field emissions. The combination of high resolution optical inspection, cavity quench detection and surface replica revealed more than half of the cavity quenches were limited by identifiable surface features, namely pits or bumps. The quench field ranged from 12.7 MV/m up to 42 MV/m. Several methods have been explored in various laboratories to remove the surface features. Those included the laser re-melting, Electron beam re-melting and local mechanical grinding. This paper reports the latest development of those guided repair technologies and their benefits to improve cavity performances.

WEIOB02

Cavity Inspection and Repair Techniques

K. Watanabe, H. Hayano (KEK) Y. Iwashita (Kyoto ICR)

The cavity inspection and repair techniques are important to study a quality control of the superconducting rf cavity for better yield with high accelerating gradient. A high-resolution camera system was developed for optical inspection in 2008. It enables 2-D analysis by image processing on inner surface of the cavity. Therefore, the cause to limit the cavity performance can be categorized into a geometrical defect or an assembly work and the surface treatment. In addition, by perfoming the optical inspection at each treatment, we can obtain an information when a defect appeared. The cavities that quenched at the low field were inspected. One or few geometrical defects were found around quench location on some of these cavities. It is a possibility that the cavity performance can be recovered by removing the geometrical defect at the quench location. A local grinding machine was developed for this purpose. This method was tested on the 9-cell cavities, and we succeeded to recover the cavity performance with combination of local grinding and light EP. The method and results of the cavity inspection as well as the replica techniques will be presented in this talk.

WEIOB03

Improvement in Cavity Fabrication Technology and Cost Reduction Methods

K. Sennyu, H. Hara, H. Hitomi, K. Kanaoka, T. Yanagisawa (MHI)

Cavity fabrication method with new forming technology and Laser welding technology are reported. 1.3GHz 9-cell cavity with Laser welding technology for stiffener and flange joint is achieved 29 MV/m at vertical test at KEK and 1.3GHz 2-cell seamless dumbbell cavity are fabricated at MHI for verifying the fabrication method. These are reported in detail. Some other fabrication technology for cost reduction and stable quality are introduced.

XFEL Cavity Procurement as an Example of Technology Transfer

Procurement of superconducting RF cavities for the European XFEL consists of two phases. The preparation phase for

W. Singer (DESY)

the European XFEL cavity production includes: qualification of high purity niobium vendors and potential cavity producers; accommodation of the TESLA cavity design to the XFEL demands; establishing the XFEL treatment process, work out and check the strategy of preparation for the vertical acceptance test; define the documentation and prompt data transfer, qualification of created infrastructure, cavity acceptance criteria and tests. A detailed specification has been worked out on the basis of ca. 50 prototype cavities. Production of 600 cavities is currently contracted on the principle ``build to print''; the cavity material will be provided by DESY. DESY will supply vendors with machine for cavity tuning at room temperature and equipment for RF measurement of dumb bells and end groups. The cavity with helium tank has to be built as a component according Pressure Equipment Directive (PED) 97/23/EC. The contracted ``notified body'' will supervise the material qualification and procurement. Monitoring of the vendor's work will be executed by DESY and INFN (Milano) team.

WEIOB04

Large Grain Cavities: Fabrication, RF Results and Optical Inspection

SRF cavities produced from large grain niobium material have been investigated as an alternative to the standard fine

S. Aderhold (DESY)

grain material in the past years. While many single cell cavities have been prepared and successfully tested, the number of large grain 9-cell cavities available at the laboratories worldwide is still small. The worldwide experience and results with fabrication, treatment and testing will be compared. At DESY, a batch of eight large grain 9-cell cavities has been processed and tested recently, in addition to three cavities that had been processed and tested earlier. The surface preparation process has been closely followed by optical inspection in-between all treatment steps that include surface removal. Several of the vertical RF tests have been done with T-mapping and/or second sound measurements for determination of the quench location. The results after a first treatment cycle with BCP and a second treatment cycle with EP will be presented.

WEIOB05

IHEP 1.3GHz Low-Loss Large Grain 9-cell cavity R&D for ILC

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-

J.Y. Zhai, J.P. Dai, J. Gao, D.Z. Li, Z.Q. Li, Z.C. Liu, Q.Y. Wang, T.X. Zhao (IHEP Beijing)

cell cavities, and will be essencial 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 using Ningxia large grain niobium (IHEP-01) was fabricated and surface treated (CBP, CP, annealing, pre-tuning) at IHEP. The cavity reached 20 MV/m in the first vertical test at KEK STF on July 2010. The quench locations were found by T-mapping and optical inspection. Equator defects were removed by further CBP treatment. Second vertical test on this cavity was done at JLAB recently after 2nd processing at IHEP. This paper reports the latest result of the vertical test and surface diagnostics.

WEIOB06

THIOA — β=1 Cavities

THIOA01

Test Results of the International S1-Global Cryomodule

Y. Yamamoto, M. Akemoto, S. Fukuda, K. Hara, H. Hayano, N. Higashi, E. Kako, H. Katagiri, Y. Kojima, Y. Kondo, T. Matsumoto, H. Matsushita, S. Michizono, T. Miura, H. Nakai, H. Nakajima, K. Nakanishi, S. Noguchi, N. Ohuchi, T. Saeki, M. Satoh, T. Shidara, T. Shishido, T. Takenaka, A. Terashima, N. Toge, K. Tsuchiya, K. Watanabe, S. Yamaguchi, A. Yamamoto, K. Yokoya, M. Yoshida (KEK) C. Adolphsen, C.D. Nantista (SLAC) T.T. Arkan, S. Barbanotti, M.A. Battistoni, H. Carter, M.S. Champion, A. Hocker, R.D. Kephart, J.S. Kerby, D.V. Mitchell, T.J. Peterson, Y.M. Pischalnikov, M.C. Ross, W. Schappert, B.E. Smith (Fermilab) A. Bosotti, C. Pagani, R. Paparella, P. Pierini (INFN/LASA) K. Jensch, D. Kostin, L. Lilje, A. Matheisen, W.-D. Moeller, P. Schilling, M. Schmoekel, N.J. Walker, H. Weise (DESY)

S1-Global collaborative project by joint efforts of INFN, DESY, FNAL, SLAC and KEK, finished successfully at KEK- STF on February in 2011, is a crucial project for ILC. For this project, 8 SRF cavities, 2 from DESY, 2 from FNAL and 4 from KEK, were installed into one cryomodule with the thermal shields and the cooling pipes of liquid helium and nitrogen, cooled down to 2K totally three times, and cold-tested by using the three different frequency tuning systems (Blade tuner from INFN/FNAL, Saclay tuner from DESY and Slide-Jack tuner from KEK) and two types of input couplers (TTF III from DESY and STF#2 from KEK). During the cold test with high power, cavity performance, LFD (Lorentz Force Detuning) compensation by Piezo actuator, simultaneous 7 SRF cavities operation, dynamic heating loss measurement including static loss and DRFS (Distributed RF Scheme) operation with LLRF (Low Level RF) feedback system, were established successfully. In this talk, the results of the S1-Global cryomodule test are reported, discussed and summarized.

THIOA02

Gradient R&D in the US

J.P. Ozelis (Fermilab)

Over the past few years, significant effort has been made to systematically improve multi-cell cavity accelerating gradients, driven in large part by the requirements of the ILC, for which the reproducible achievement of high gradients is a prerequisite. Substantial progress has been made by teams at Cornell University, Fermilab, and Jefferson Lab, in pushing gradients to higher values and in achieving this performance on a more regular basis. Development of improved diagnostic/inspection techniques along with the utilization of both localized and global repair tools have helped enable this improvement. Likewise, processing and assembly procedures that led to a lower incidence of field emission have facilitated this progress. The present status of cavity performance will be presented along with its evolution, and examples of the role the aforementioned techniques and tools have played in achieving this performance.

THIOA03

Compact Superconducting Cavities for Deflecting and Crabbing Applications

J.R. Delayen (ODU)

There is increasing interest in using superconducting cavities as rf separators (e.g. Jefferson Lab 12 GeV upgrade and Fermilab Project X) or as crabbing systems to increase the luminosity in colliders (e.g. LHC upgrade and electron-ion colliders). Several of these applications have severe dimensional constraints that would prevent the use of cavities operating in the TM110 mode. A number of compact designs for deflecting/crabbing cavities have been designed and are under development; their properties are presented.

QWR for β ~1 Accelerators

I. Ben-Zvi (BNL)

The Superconducting Quarter Wave Resonator (QWR) was developed first for heavy ion acceleration in 1981 and became highly successful and widespread in low β linacs. Recently the QWR has been adapted for a variety of applications for high particle velocity, near β=1. The applications are varied, from the use in a relativistic hadron storage ring, to photocathode electron guns and crab cavities. In this work I will describe these applications, and how they benefit from the rather unique properties of this resonator, such as the Higher Order Mode spectrum, the electro-mechanical stability and the compact size.

THIOA04

The sc cw-LINAC Demonstrator - SRF-Technology finds the way into GSI

S. Mickat, W.A. Barth, L.A. Dahl, M. Kaiser, W. Vinzenz (GSI) M. Amberg, V. Gettmann, S. Jacke, **S. Mickat** (HIM) K. Aulenbacher (IKP) F.D. Dziuba, D. Mäder, H. Podlech, U. Ratzinger (IAP)

A new superconducting (sc) continous wave (cw) LINAC at GSI is desired by a broad community of future users. Especially the Super Heavy Elements (SHE) program at GSI and HIM benefits highly from such a dedicated machine. A conceptual layout of an sc cw-LINAC was worked out at the Institute for Applied Physics (IAP) at Frankfurt University. Here the key component, an sc Crossbar-H (CH) cavity, was developed recently. The multi-gap cavity is operated at 217 MHz and provides gradients of 5.1 MV/m at a total length of 0.69 m. The first section of the proposed cw-LINAC comprising a sc CH-cavity embedded by two sc solenoids is financed by HIM as a Demonstrator. One important milestone of the project is a full performance test with beam of the Demonstrator in 2013/14 at the GSI High Charge Injector (HLI). With the demonstrator the srf-technology finds the way to GSI. The tests would be the first of an sc multi-gap structure with heavy ions being an important milestone towards the proposed cw-LINAC.

THIOA05

Mechanical Design Considerations for β=1 Cavities

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The Superconducting Proton Linac (SPL) is an R&D effort coordinated 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 RF superconducting technology, which would serve as a driver for new physics facilities such as neutrinos and Radioactive Ion Beam (RIB). Amongst the main objectives of this R&D effort, is the development of 704 MHz bulk niobium β=1 elliptical cavities, operating at 2 K with a maximum accelerating field of 25 MV/m, and the testing of a string of cavities integrated in a machine-type cryomodule. The R&D program concerning the elliptical β=1 cavities fabricated from niobium sheets explores new mechanical design and new fabrication methods. The paper presents several opportunities for design optimization that were identified, such as a comparison between stainless steel helium vessel versus NbTi/Ti transitions to a titanium helium vessel. Different mechanical design aspects, including cryogenic considerations, and fabrication aspects were analyzed and the results are discussed.

THIOA06

THIOA07

Single-cell SC Cavity Development in India

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Under Indian Institutions and Fermilab Collaboration (IIFC), Raja Ramanna Centre for Advanced Technology (RRCAT) Indore, India has initiated the development of SCRF cavity technology in collaboration with Fermi National Accelerator Laboratory (FNAL) USA. The R & D efforts are focused on the proposed Project-X accelerator complex at FNAL and High Intensity Proton Accelerator activities in India. As an initial effort, two prototype 1.3 GHz single cell bulk niobium cavities have been developed in collaboration with the Inter University Accelerator Centre (IUAC), New Delhi. Learning from the experience gained and the initial results of these prototypes (achieving Eacc ~23 MV/m), two more improved 1.3 GHz single cell cavities are being developed. These two improved single cell cavities will also be processed and tested at FNAL. Development of a 1.3 GHz, 5-cell SCRF cavity with simple end groups, development of end group, and fabrication of a single -cell 650 MHz (β=0.9) prototype cavity are being undertaken as the next stage in these efforts. This paper will present the development and test results on the 1.3 GHz single cell cavities and status of the ongoing work.

THIOB — β <1 Cavities

Project X Cavity and Cryomodule Development

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Project X is a proposed multi-MW proton accelerator facility based on an H$^-$ linear accelerator using SRF technology at Fermilab. The Project X 3-GeV CW linac requires the development of two families of SRF cavities at 325 and 650 MHz, to accelerate 1 mA of average H$^-$ beam current in the energy range 2.5-160 MeV, and 160-3000 MeV, respectively. The cavities must support possible acceleration of up to 4 mA beam current. The baseline design calls for three types of SRF single-spoke resonators at 325 MHz having betas of 0.11, 0.22, and 0.42, and two types of SRF five-cell elliptical cavities having betas of 0.61 and 0.9. The electromagnetic and mechanical cavity designs are well underway and prototype tests for some cavity designs have started. Due to CW operation, the heat load on the cryogenic system is substantial; and for purposes of cryogenic system design, the dynamic heat load is limited to 250 W at 2K per cryomodule. The anticipated heat loads for the 650 MHz section lead to stringent requirements on cavity unloaded quality factor Q0, and on cryogenic aspects of the cryomodule design. Status and plans for the Project X cavity and cryomodule development will be described.

Vertical Tests Results of the IFMIF Cavity Prototypes and Cryomodule Development

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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, an accelerator prototype is presently under design for the first phase of the project. A superconducting option has been chosen for the 5 MeV RF Linac, based on a cryomodule composed of 8 low-beta Half Wave Resonators, 8 Solenoid Packages and 8 RF couplers. This presentation will mainly focus on the HWR development: realization and vertical tests of the two HWR prototypes will be presented, including the validation tests of the innovating cold tuning system, located in the central region of the cavity (results with tuning system are expected for the conference). In addition, the 1st cryomodule current design will be also discussed.

THIOB03

Status of the ReAccelerator Facility RϵA for Rare Isotopes

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The Facility for Rare Isotope Beams (FRIB) at Michigan State University (MSU) is currently in the preliminary design phase. FRIB consists of a heavy ion driver LINAC, followed by a fragmentation target station, and a ReAccelerator facility (RϵA). In its final configuration, RϵA will provide heavy ion beams from 0.3 MeV/u to 12 MeV/u for heaviest ions and up to 20 MeV/u for light ions. While FRIB plans to start conventional construction in 2012, the first stage of RϵA is already under commissioning and will be connected to the Coupled Cyclotron Facility at MSU end of 2012. The front end of the accelerator consists of a gas stopper, an Electron Beam Ion Trap (EBIT) charge state booster, a room temperature RFQ, followed by a short SRF LINAC, which contains seven β=0.041, eight β=0.085 QWR cavities, and eight 9T focusing solenoids. RϵA serves as prototyping test bed for the FRIB cryomodule development since FRIB utilizes similar cavities as installed on RϵA. An overview and status of the RϵA facility will be presented. The presentation will focus on the testing, beam commissioning, and operational experience of the first β=0.041 cryomodules.

THIOB04

SRF Advances for ATLAS and other β <1 Applications

M.P. Kelly, Z.A. Conway, S.M. Gerbick, M. Kedzie, R.C. Murphy, B. Mustapha, P.N. Ostroumov, T. Reid (ANL)

The guiding principle for the design of the new 72 MHz quarter wave SC cavities at Argonne was to provide the maximum possible accelerating gradient along the linac with large acceptance and minimal beam losses. Cavities will be installed into ATLAS in 2012 as the beam intensity upgrade, but are also intended for the next generation of ion linacs to be used in basic and applied science and technology. State-of-the-art cavity designs and fabrication techniques developed at ANL have been applied to the construction of the first prototype. Tests of the prototype 72 MHz QWR demonstrate the highest performance achieved to date for this class of cavity designed to cover the velocity range 0.06< β <0.12. The cavity has very low RF losses and the highest accelerating gradients ever achieved for any quarter-wave structure. Indeed, the accelerating voltage of 4.3 MV is roughly four times higher than that reported for the best SC cavities in this velocity range currently in operation at any facility worldwide. Also, this demonstrated 4.3 MV accelerating voltage substantially exceeds the 2.5 MV design voltage.

THIOB05

SPL Cavity Development

G. Olry (IPN)

The Superconducting Proton Linac (SPL) is planned as a 4MW machine in pulsed operation at CERN. Two families (beat = 0.65 and β = 1.0) of 5 cell superconducting elliptical cavities, operating at 704.4 MHz, will be used to accelerate H– beam from 160 MeV up to 5 GeV. One of the main challenge is the nominal gradient required for both cavities type: 19 MV/m for the β=0.65 and 25 MV/m for the β=1. Several prototypes of elliptical cavities have been studied by different laboratories (CERN, CEA/Saclay, BNL, IPN Orsay) through a large collaboration (EuCARD program, French and US in-kind contribution. . .) and are now ready for fabrication. First of all, we will present the work done on RF and mechanical optimizations as well as the studies on HOMs. Then, we will give an overview of the short-cryomodule design, housing four β=1.0 cavities, which should be tested at CERN.

Recents Developments in SRF at TRIUMF

The TRIUMF SRF program follows three basic paths: the support of the existing installed superconducting heavy ion linac with forty quarter wave cavities, the development of infrastructure and cavities for the new e-Linac project at 1.3GHz

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and fundamental studies to support student projects. Work on the quarter waves primarily involves determining optimum processing steps to improve cavity performance. The e-Linac cavity is a variant of the Tesla nine cell cavity modified to allow the acceleration of 10mA in cw mode. Fundamental studies on RRR niobium have been done at the Muon Spin Resonance facility at TRIUMF to characterize the flux of first entry for different processing of the niobium. THe program will be summarized.

HIE-ISOLDE quarter wave Nb/Cu cavity

The HIE-ISOLDE project aims at the energy boost of the radio active beams produced in the ISOLDE facility from 3 MeV/u up to 5.5 MeV/u in a first stage and 10 MeV/u as ultimate installation.

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The beam acceleration is mainly achieved by employing 20 Nb sputtered Quarter Wave Resonator at β = 0.1 for which an R&D program has started. RF and mechanical design as well as the latest results of the sputtering process are reported in this paper.

Hot topics: Recipes for 9-cell cavity fabrication and preparation

In the mass production of International Linear Collider (ILC), about 16,000 9-cell SRF cavities must be produced for the

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linac. The current recipe of 9-cell cavity production is not enough for the required cost reduction for ILC. Various ideas for the cost reduction of 9-cell cavity fabrication would be duscussed in this presentation. As the final surface treatment of 9-cell cavity, the Electro-Polishing (EP) is the best candidate to realize high yield rate for high-gradient performance. However, the laboratories in the world are still using different EP parameter-sets for various reasons. In this presentation, the comparison of EP parameters among laboratories would be done and how we can reach to the best parameter sets would be discussed.

THPO — Poster Session

THPO001

Quench Simulation Using a Ring-Type Defect Model

Y. Xie, M. Liepe, H. Padamsee (CLASSE)

A 2 dimensional ring-type defect thermal feedback model has been improved by including magnetic field enhancement at the pit edge. Latest simulation results show that there is a thermally stable state below the quench field with part of edge becoming normal conducting, which can explain pre-heating phenomenon observed in thermometry measurements. 3D magnetic field enhancement calculations of pit structures using Omega3P shows angular non-uniform field enhancement around the edge. Those findings will be incorporated into a 3D finite ring-type defect thermal codes.

THPO002

Defect-Induced Local Heating of Superconducting Cavity Surface

Y. Morozumi (KEK)

The limitation of the accelerating gradient is one of the current major issues with high gradient superconducting RF accelerator structures such as the ILC accelerating cavities. Field emission and thermal breakdown due to surface imperfections tend to limit the gradient performance. Some kind of surface defects are suspects responsible for thermal breakdown of superconducting RF cavities. Profilometry-based realistic high-fidelity modeling of field enhancement will be presented. Evaluation of local heating at surface defects and analysis of thermal behavior will be discussed in comparison with experimental evidences.

THPO003

Multipacting in HOM Couplers at the 1.3GHz 9-cell TESLA Type SRF Cavity

D. Kostin, Th. Buettner, W.-D. Moeller, J.K. Sekutowicz (DESY)

During the XFEL prototype module tests on the module test stand at DESY RF power measurement anomaly on the high order mode (HOM) couplers on the cavity operating frequency was detected and investigated. HOM coupler multipacting, predicted by the analythical simulations, was found to be the source of the anomalous signal peak. TESLA type SRF cavity HOM coupler multipacting simulations and observations are presented, compared and discussed.

Electro- or Chemical- Polishing and UHV Baking of Superconducting rf Nb Cavities and Q(H) Dependencies

J. Halbritter (FZ Karlsruhe)

Standard treatments to achieve excellent high rf power Nb accelerator cavities after machining are electro polishing (EP,>0.050mm), buffered chemical polishing (BCP,~0.01mm), or subsequent ~120°C (>10h) UHV baking (LTB)[1-4]. LFQ and HFQ have been discussed in detail in [2,4], here we concentrate on oxidation and on MFQ described by $\Delta R(H)=R1H/Hc + R2(H/Hc)^2$, where R1 is related to hysterics weak link, flux losses and R2 is mainly related to heating [3]. The observed differences between BCP, EP and LTB can be related to differences in Nb2O5/NbOx/Nb interfaces. For example: by BCP oxidation the repeated Nb2O5-crystallite nucleation creates DS, weak links and injects O into larger depth [2] where the weak links strengthen MFQ [1,3]; by EP the repeated Nb2O5-crystallite nucleation is missing and so O sticks to the surface and less DSs and weak links are created resulting in less MFQ [1]; and by LTB at, and adjacent to, Nb surfaces O precipitates enforcing MFQ and LTB, enhancing Hc3 and reducing, e.g. RBCS(T,<15GHz) [1-4]. Depending on details to be discussed these intermingled LTB effects after EP may reduce or enhance R(T,<GHz,<20MeV/m).

[1] A.Romanenko et al.,PAC'11

[2] A.S.Dhavale, Symp. Techn.of Nb.,JLAB,,Sept.2010

[3] G.Ciovati et al., PhysicaC 441,57(2006)

[4] J.Halbritter,,SRF09-TUPPO089 (Berlin, 2009),p.450

Exploration of Very High Gradient Cavities

G.V. Eremeev (JLAB)

Several of the 9-cell ILC cavities processed at Jlab within ongoing ILC R&D program have shown interesting behavior at high fields, such as mode mixing and sudden field emission turn-on during quench. Equipped with thermometry and OST system for quench detection, we couple our RF measurements with local dissipation measurements. In this contribution we report on our findings with high gradient SRF cavities.

Study of Trapped Magnetic Flux in Superconducting Niobium Samples

S. Aull, J. Knobloch, O. Kugeler (HZB)

Trapped magnetic flux is known to be one cause of residual losses in an SRF cavity. An ambient magnetic field is trapped in the material when lattice defects inhibit the expulsion of the field during the transition into the Meissner phase. We measured the fraction of trapped magnetic flux in niobium samples with different treatment histories, such as BCP and tempering. The differences between single crystal and polycrystalline material as well as the influence of local temperature gradients and different cooling rates were investigated. In addition, the progression of the release of a trapped field during warm up was studied. It was found that different fractions of an applied field were trapped due to heat treatment. Differences between single crystal and polycrystalline material were also observed. Additionally, single crystal samples showed a logarithmic dependency on the cooling rate. It was demonstrated that a local temperature gradient produces an additional magnetic field which has impact on the flux trapping.

THPO004

THPO005

THPO006

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THPO007

Novel Deflecting Cavity Design for eRHIC

Q. Wu, S.A. Belomestnykh, I. Ben-Zvi (BNL)

To prevent significant loss of the luminosity due to large crossing angle in the future ERL based Electron Ion Collider at BNL (eRHIC), there is a demand for crab cavities. In this article, we will present a novel design of the deflecting/crabbing 200 MHz superconducting RF cavity that will fulfill the requirements of eRHIC. The quarter-wave resonator structure of the new cavity possesses many advantages, such as compact size, high Rt/Q, the absence of same order mode and lower order mode, and easy higher order mode damping. We will present the properties and characteristics of the new cavity in detail.

THPO008

Post-Baking Losses in Niobium Cavities Studied by Dissection

A. Romanenko, L.D. Cooley, G. Wu (Fermilab) G. Ciovati (JLAB)

Thermometry investigations on electropolished cavities, which underwent mild baking, and are limited by a localized quench at 150-200 mT, show that in the absence of the high field Q-slope there are still a few localized sources of dissipation. Identification of these areas along with the high field quench location followed by dissection and surface analysis of the resulting coupons allowed to gain insight into possible mechanisms of these effects, and will be reported in this contribution.

THPO009

Quench Studies in Large and Fine Grain Nb Cavities

S. Posen, M. Liepe, N.R.A. Valles (CLASSE)

This work investigates the causes of quenches in several niobium 1.3 GHz single-cell cavities performing above 20 MV/m, tested in continuous wave mode. Studies were carried out on both fine grain and large grain cavities in ILC and Cornell Re-entrant shape geometries. The quenches were located by triangulation using Cornell oscillating superleak transducers and then cavities were optically inspected to determine the surface conditions of the cavity at the quench location. For quench locations exhibiting topological defects, surface molds were created and investigated using 3-D profilometry techniques.

THPO010

Multipactor Studies for DIAMOND Storage Ring Cavities

S.A. Pande, M. Jensen (Diamond)

The Diamond storage ring is presently operating with two CESR type Superconducting (SC) RF cavities operating at 499.654 MHz. The cavities are suffering from a significant number of trips due to a sudden loss of accelerating field believed to be caused by Multipacting. It is observed that operating the cavities at lower voltages reduces the trip frequency significantly. In order to estimate the multipacting thresholds and to determine safe (multipactor free) parameter zones, we have initiated a detailed simulation study of multipacting in the cavities and the coupling waveguide. The cavities have fixed coupling, and therefore the match of the cavities varies with beam current, radiation loss and cavity voltage. A change in any of these parameters leads to a different standing wave in the waveguide. This requires the simulations to account for the different operating conditions. In addition to the waveguide and the cavity cell, the simulations also indicate the possibility of multipactor in the connecting beam tubes. In this paper, we summarise the results of our simulations obtained using CST Studio PIC and Tracking solvers.

Improving the Intrinsic Quality Factor of SRF Cavities by Thermal Cycling

We investigated the influence of the cooling gradients near Tc on the obtained Q0 values of a TESLA cavity. Measurements

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were performed in the HoBiCaT test stand by briefly warming the cavity above Tc via He depletion inside the cryovessel and subsequent cooling. The temperature was measured at different points at the cavity and the cryo-tank. It turned out that there is a correlation between obtained Q0 and the time lag between the first transition of a thermo-sensor through Tc and the last transition of a sensor though Tc which is interpreted as a local gradient. We have observed no correlation to the cooling speed, i.e. different temperature gradients in time. The findings could help explain the large fluctuations in measured Q values in different test-stands, and even open up pathways to devising a cooling scheme to obtain higher Q values ``for free''.

THPO011

Influence of Foreign Particles on the Quality Factor of a Superconducting Cavity

The quality factor of superconducting (SC) cavities of the Cornell Energy Recovery Linac (ERL) Injector measured in its

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horizontal cryostat appears systematically lower than in vertical tests. Furthermore, this lower value of the Q factor is scattered in a range of about Here, an explanation of these effects is presented taking into account contamination of the cavities by microscopic particles of ferrite used in the higher order mode (HOM) loads and other particles present in the vicinity of cavities during assembly of the horizontal cryostat. The average Q degradation and the scatter of Q values are used to estimate the size and the number of contaminants per cavity. We also analyze, which materials have relevant contaminants.

THPO012

Investigation of 9-Cell Cavity Performance Problem by Facilities in KEK AR East 2nd Experimental Hall

So far our 9-cell cavity performance is often suffered from field emission. We are investigating our facilities at the KEK AR

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East 2nd experimental hall. We examined two points of view post EP/BCP cleaning and particle contamination. Particle contamination problem has been found in our HPR system, cavity assembly, and vacuum evacuation procedure. We have taken cures against these problems. We will report about these problems and the cured results on cavity performance in this paper.

THPO013

Repair SRFCavity by Re-Melting Surface Defects via High Power Laser Technique

As the field emission is gradually under control in recent SRF activities, cavity performance is limited by hard quench in the most case. Surface defect has been identified as one of main reasons caused

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cavity quench scattering cavity accelerating gradient from 12 MV/m to 40 MV/m. Laser processing is able to re-shape the steep flaws to be flat and smooth surface. In Fermilab, a sophisticated laser repair system has been built for 1.3GHz low performance SRF cavity which is limited by surface defect. The pit in a 1.3GHz single-cell cavity was re-melted by high power laser pulse, cavity took 30 μm light Electropolishing after that. The gradient achieved 39MV/m in initial run; after another 30 μm Electropolishing, it achieved 40 MV/m. The improved laser repair system is able to re-melt the surface defect in one meter long 9-cell SRF cavity. It successfully re-melted a pit in 9-cell SRF cavity TB9ACC017.

THPO015

THPO016

Preliminary Results on the Laser Heating Investigation of Hotspots in a Large-Grain Nb Cavity

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Magnetic vortices pinned near the inner surface of SRF Nb cavities are a possible source of RF hotspots, frequently observed by temperature mapping of the cavities outer surface at RF surface magnetic fields of about 100 mT. Theoretically, we expect that the thermal gradient provided by a 10 W green laser shining on the inner cavity surface at the RF hotspot locations can move pinned vortices to different pinning locations. The experimental apparatus to send the beam onto the inner surface of a photoinjector-type large-grain Nb cavity is described. Preliminary results on the changes in thermal maps observed after applying the laser heating are also reported.

THPO017

Probing the Fundamental Limit of Niobium in High Radiofrequency Fields by Dual Mode Excitation in Superconducting Radiofrequency Cavities

G.V. Eremeev, R.L. Geng, A.D. Palczewski (JLAB)

We have studied thermal breakdown in several multicell superconducting radiofrequency cavity by simultaneous excitation of two TM010 passband modes. Unlike measurements done in the past, which indicated a clear thermal nature of the breakdown, our measurements present a more complex picture with interplay of both thermal and magnetic effects. JLab LG-1 that we studied was limited at 40.5 MV/m, corresponding to Bpeak = 173 mT, in 8pi9 mode. Dual mode measurements on this quench indicate that this quench is not purely magnetic, and so we conclude that this field is not the fundamental limit in SRF cavities.

THPO018

Quench Studies of ILC Cavities

G.V. Eremeev, R.L. Geng, A.D. Palczewski (JLAB) J. Dai (PKU/IHIP)

Quench limits accelerating gradient in SRF cavities to a gradient lower than theoretically expected for superconducting niobium. Identification of the quenching site with thermometry and OST, optical inspection, and replica of the culprit is an ongoing effort at Jefferson Lab aimed at better understanding of this limiting phenomenon. In this contribution we present our finding with several SRF cavities that were limited by quench.

THPO019

Design, Construction, and Initial Test of High Spacial Resolution Thermometry Arrays for Detection of Surface Temperature Profiles on SRF Cavities in Super Fluid Helium

We designed and built two high resolution (0.6-0.55mm special resolution [1.1-1.2mm separation]) thermometry arrays

A.D. Palczewski, G.V. Eremeev, R.L. Geng (JLAB)

prototypes out of the Allen Bradley 90-120 Ω 1/8 watt resistor to measure surface temperature profiles on SRF cavities. One array was designed to be physically flexible and conform to any location on a SRF cavity; the other was modeled after the common G-10/stycast 2850 thermometer and designed to fit on the equator of an ILC (Tesla 1.3GHz) SRF cavity. We will discuss the advantages and disadvantages of each array and their construction. In addition we will present a case study of the arrays performance on a real SRF cavity TB9NR001. TB9NR001 presented a unique opportunity to test the performance of each array as it contained a dual (4mm separation) cat eye defect which conventional methods such as OST (Oscillating Superleak second-sound Transducers) and full coverage thermometry mapping were unable to distinguish between. We will discuss the new arrays ability to distinguish between the two defects and their preheating performance.

THPO020

Exploration of Quench Initiation Due to Intentional Geometrical Defects in a High Magnetic Field Region of an SRF Cavity

A computer program which was used to simulate and analyze the thermal behaviors of SRF cavities has been developed

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at Jefferson Lab using C++ code. This code was also used to verify the quench initiation due to geometrical defects in high magnetic field region of SRF cavities. We built a CEBAF single cell cavity with 4 artificial defects near equator, and this cavity has been tested with T-mapping. The preheating behavior and quench initiation analysis of this cavity will be presented here using the computer program.
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THPO021

Measurement of Hc1 in Superconducting Thin Films

Superconducting radio frequency (SRF) cavities are the leading technology for particle accelerators. Niobium cavities are the core of many existing accelerators

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and will be used in several future systems currently under construction or design. The performance of Nb Cavities has been continuously improved over many years, but presently this technology is approaching the fundamental limit set by the superconducting critical field of bulk Nb, around 2000 Oe. Gurevich [Appl. Phys. Lett. 88, 012511 (2006)] suggests that performance (maximum accelerating field) of Nb cavities could be extended by covering the internal walls with a superconductor / insulator multilayer. The central idea is that when the thickness of the superconducting layer is smaller than the penetration depth, a size effect results in an increase of the lower critical field Hc1 where the vortex penetration becomes favorable. In this work we explore the enhancement of the Hc1 on MgB_2, Nb, and MoN thin films of different thickness. Preliminary results indicate an enhancement of Hc1 in comparison with bulk values, up to values exceeding those currently achievable in Nb cavities.

THPO022

Temperature and Surface Treatment Dependence of Medium Field Q-Slope

A. Romanenko, J.P. Ozelis (Fermilab) G. Wu (ANL)

Significant cost-affecting factor in the projected continuous wave (CW) accelerators such as Project X is determined by the cavity quality factors. RF measurements at bath temperatures ranging from 1.6 to 2.3K were performed on a number of 1.3 GHz single cell elliptical TESLA shape cavities of fine grain size after different surface treatments (BCP, tumbling, EP, before and after mild baking and HF rinsing) in the preliminary search for the optimum surface preparation technique at medium surface fields.

THPO023

External Magnetic Fields and Operating SRF Cavity

D.A. Sergatskov, T.N. Khabiboulline, R.L. Madrak, J.P. Ozelis, I. Terechkine (Fermilab)

When an SRF cavity is undergoing a transition to the superconducting state in an external magnetic field it traps some of the flux which results in an increase of surface resistance. This effect was extensively studied, is well understood by now and results in stringent requirements for an ambient magnetic field on the surface of an SRF cavity. The situation is quite different when magnetic field is applied to a cavity already in the superconducting state. During normal operation the bulk of the superconducting Nb should protect the RF surface of the cavity from fields on the outside. So we expect that the requirements on an external magnetic field applied to an operating cavity could be significantly relaxed. One possible failure mode is when the cavity quenches while the external field is applied. The magnetic field would penetrate through a normal zone formed during the quench and can get trapped during the subsequent post-quench cooling. We studied the effects of an external magnetic field applied to an operating SRF cavity and report the results.

THPO024

Quench Dynamics in SRF Cavities

Y.B. Maximenko (MIPT) D.A. Sergatskov, V.P. Yakovlev (Fermilab)

We have developed a time-dependent model of quench process in an SRF cavity. We discuss peculiarities of the numerical solution and the results of simulation.

Effects of Anodization on Field Emission on Nb Surfaces

A.T. Wu, R.A. Rimmer (JLAB) S. Jin, X.Y. Lu, K. Zhao (PKU/IHIP)

Minimization of field emission on the inner surfaces of niobium (Nb) superconducting radio frequency (SRF) cavities is highly desirable for SRF community. Previous experimental results [1] seemed to imply that the threshold of field emission was related to the thickness of Nb surface oxide layers. In this contribution, a more detailed study on the influences of the surface oxide layers on the field emission on Nb surfaces will be reported. By anodization technique, the thickness of the surface pentoxide layer was varied from 3nm up to 460nm. These samples were measured by means of a home-made scanning field emission microscope (SFEM). The emitters detected by SFEM were characterized using a scanning electron microscope together with an energy dispersive x-ray analyzer. Attempts were made to try to correlate the results from SFEM measurements with surface morphology and oxide thickness of Nb samples and chemical composition and geographic shape of the emitters. The SFEM results were also analyzed employing a model based on the classic electromagnetic theory. Possibly implications for Nb SRF cavity applications from this study will be discussed.

THPO025

Second Sound Triangulation for SPL Cavity Quench Localization

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Second sound is a temperature wave which travels at a speed of ~20m/s in superfluid helium. The second sound detector is a so-called oscillating superleak transducer (OST), initially provided by Cornell-CLASSE, and thereafter manufactured at CERN. It contains a flexible porous membrane for transmitting and blocking the movement of the superfluid and normalfluid components of the second sound wave. From the measured speed of this wave and by determining the travel time between the quench event and several OSTs an alternative method is offered to localize the quench site by triangulation. Several surface mount devices (thick film chip resistors) are used to simulate the quench spot in a cavity. Given the heat pulse and the location of the installed OSTs , the temperature dependence of the second sound velocity is determined under different experimental conditions and compared with previous results and a theoretical curve. The second sound triangulation will be finally used to diagnose quench locations of the Superconducting Proton Linac test cavities (704MHz) at CERN.

THPO026

Optical Observation of Geometrical Features and Correlation With RFTest Results

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Three kinds of geometrical features analysis techniques were adopted in association with cavity gradient R&D at Jefferson Lab: (1) Feature shape analysis by Kyoto camera system; (2) 3D shape analysis using a HIROX KH-7700 High Resolution Digital-Video Microscopy System; (3) Replica technique plus surface profiler for profile measurement of geometrical features. Up to now, many features were found in two nine cell SRF cavities: PKU2 from Peking University in China and NR1 from Niowave-Roark in America. Both of them have been RF tested at 2K. The shape analysis of geometrical surface features and correlation with RF test results using a thermal analysis code will be presented here.

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THPO027

THPO028

SIMS and TEM Analysis of Niobium Bicrystals

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The behaviour of interstitial impurities(C,O,N,H) on the Nb surface with respect to grain boundaries may affect cavity performance. Large grain Nb makes possible the selection of bicrystal samples with a well defined grain boundary. In this work, Dynamic SIMS was used to analyze two Nb bicrystal samples, one of them heat treated and the other non heat treated (control). H levels were found to be higher for the non heat treated sample and a difference in the H intensity and sputtering rate was also observed across the grain boundary for both the samples. TEM results showed that the bicrystal interface showed no discontinuity and the oxide layer was uniform across the grain boundary for both the samples. TOF-SIMS imaging was also performed to analyze the distribution of the impurities across the grain boundary in both the samples. C was observed to be segregated along the grain boundary for the control sample, while H and O showed a difference in signal intensity across the grain boundary. Crystal orientation appears to have an important role in the observed sputtering rate and impurity ion signal differences both across the grain boundary and between samples

THPO029

Commissioning Cornell OSTs for SRF Cavity Testing at JLab

G.V. Eremeev (JLAB)

Understanding the current quench limitations in SRF cavities is a topic essential for any SRF accelerator that requires high fields. This znderstanding crucially depends on correct and precise quench identification. Second sound quench detection in superfluid liquid helium with oscillating superleak transducers is a technique recently applied at Cornell University as a fast and versatile method for quench identification in SRF cavities. Having adopted Cornell design, we report in this contribution on our experience with OST for quench identification in different cavities at JLab.

THPO030

Microphonics Compensation for a 325MHz Single Spoke Cavity at Fermilab

W. Schappert, Y.M. Pischalnikov (Fermilab)

Fermilab is developing 325MHz CW narrow-bandwidth spoke cavities for the proposed Project X. The first results of active microphonics compensation for these cavities are presented.

Second Sound as an automated Quench Localisation Tool at DESY

The understanding of local thermal breakdown (``quench``) in superconducting RF cavities is still a challenge.

F. Schlander, E. Elsen, D. Reschke (DESY)

An easy way to find these heat spots is to measure the Second Sound in superfluid helium. This detection technique has been examined in several institutes. At DESY there are currently two vertical bath cryostats where cold RF tests with a cavity mounted in a cryostat insert can be done. At all of the four inserts the Second Sound setup consisting of eight Oscillating Superleak Transducers (OSTs) is mounted. These are connected to amplifier electronics and the measured signals are fed into an ADC to be read out with MATLAB. Within MATLAB the location is derived from the measured propagation times. The present system is already in use on a regular basis. An automated setup which will be implemented into the usual RF measurements is under development and the current status will be described.

TOF-SIMS Analysis of Hydrogen in Niobium, From 160ï¿½K to 475ï¿½K

Niobium (Nb) is the material of choice for superconducting radio frequency (SRF) cavities due to its high critical temperature and critical magnetic field. Interstitial impurity elements such as H directly

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influence the efficiency of these cavities. Quantification of H in Nb is difficult since H is extremely mobile in Nb with a very high diffusion coefficient even at room temperature. In the presented work, Time of Flight Secondary Ion Mass Spectrometry (TOF-SIMS) was used to characterize H in Nb over a wide temperature range (160ï¿½K to 475ï¿½K) in situ to check for changes in mobility. Multiple experiments showed that as the specimen temperature is decreased below 300 ï¿½K, the H/Nb intensity changes by first increasing and then decreasing drastically at temperatures below 200ï¿½K. As specimen temperature is increased from 300ï¿½K to 450ï¿½K, the H/Nb intensity decreases. Remarkably, the H intensity with respect to Nb increases with time at 475ï¿½K (approximately 200oC). Correlation between this data and the H-Nb phase diagram appears to account for the H behaviour.

Measurements of HOM Spectrum a 1.3 GHz ILC SC Cavity

Frequency spectrum stability measurements were done in scope High Order Modes (HOM) damping study in the

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Project-X accelerator, a superconducting linac developing currently at Fermilab. Possibility of the cavity design without HOM couplers is under consideration. Dumping of resonance excitation of high order modes with high shunt impedance is proposed by of detuning dangerous mode frequency of the cavity. Results of detuning HOM spectrum of 1.3 GHz cavities at 2K in Horizontal Test Station of Fermilab are presented.

THPO034

Vertical Test Results on KEK-ERL 9-Cell L-Band Superconducting Cavity

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In order to develop the Energy Recovery Linac at KEK, we are studying the performance of two prototype L-band superconducting cavities by means of vertical tests. After annealing, electro polishing, high pressure rinsing and baking, several vertical tests has been performed and the cavities have been inspected through rotating X-ray and temperature mapping system. The performance limiting factor has been found to be the field emissions. We have observed X-ray emission and temperature raise along the cavity wall. The quench locations have been determined with a good agreement between X-ray and temperature sensors. During vertical test we have experienced some interesting phenomena such as quality factor degradation and X-ray burst. In the first case the degradation was observed even at low field, however we recovered it with a warming up to room temperature without additional surface treatment. In the latter case new emitters have suddenly appeared after some quenches. They remained in the same location also after the warming up. The cavities have fulfilled the requirement for the KEK-ERL main linac reaching an accelerating field of more than 20 MV/m.

THPO035

Comparison of Field Emission at Different SRF Cavity Assembly States and Test Stands

D. Kostin, A. Goessel, V. Gubarev, W.-D. Moeller, D. Reschke, K. Twarowski (DESY)

SRF cavity Field Emission (FE) presents a major diagnostics instrument on the cavity performance, save the FE levels differ significantly from one cavity test setup to another, making the analysis difficult. A comparison study complimented with a direct calibration of FE in the cavities tested with different auxillaries and test stands (vertical / horizontal / module) is presented and discussed.

THPO036

A Machine for High-Resolution Inspection of SRF Cavities at JLab

R.L. Geng, T. Goodman (JLAB)

A new high-resolution cavity inspection machine has been built at JLab, integrating a KEK/Kyoto camera system with a JLab built system based on a long-distance microscope. This system has been a working horse in support the on-going ILC cavity gradient R&D. More recently, this machine has been also used to inspect small aperture cavities including some 1497 MHz 7-cell CEBAF upgrade cavities and S-band single-cell crab cavities, demonstrating the capability and flexibility of the machine. We will describe the detailed features of the inspection machine along with some exemplary inspection results.

THPO037

Lorentz Force Detuning Compensation in Fermilab Cryomodule 1

Y.M. Pischalnikov, B. Chase, E.R. Harms, W. Schappert (Fermilab)

Cryomodule 1 of the Fermilab SRF Accelerator Test Facility has recently been commissioned. First results are presented from the simultaneous compensation of Lorentz force detuning in all eight of the 1.3 GHz Tesla style superconducting cavities.

Detailed Nb Surface Morphology Evolution During Electropolishing for SRF Cavity Production

THPO038

Electropolishing is currently an important part of attaining the best performance of SRF cavities. We endeavor to

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develop sufficient understanding of the process dynamics to gain predictive power over specific topographies subjected to controlled electropolishing conditions. This work examines the evolution of highly reproducible Nb surface morphology produced by centrifugal barrel polishing of fine-grain and single-crystal material as this material is electropolished under different well-controlled conditions. The morphology evolution of Nb surface has been described using a combined approach of scaling analysis and predictions of the electropolishing theory. Our results shows that electropolishing at low temperature helps to smooth out the surface feature scales within the diffusion layer and to reduce the kinetics-controlled surface etching. A preliminary computational model has been developed that simulates the evolution of specific topography of a niobium surface under parametrized conditions. This work is expected to lead to the direct linking of starting surface morphology specification, specific processing protocol, and consistently attained finished surface condition.

Niobium Surface Resistance Measurement by Thermometric Method With a TE011 Cavity

THPO039

Bulk niobium single-cell cavities of ILC type reach almost the theoretical limit of accelerating gradient. In order to en-

G. Martinet, M. Fouaidy, N. Hammoudi (IPN)

hance the maximum accelerating field of SRF cavities or/and increase the unloaded quality factor, further investigations on thin film technology namely coating processes and new superconducting materials alternative to bulk niobium are carried out. A dedicated TE011 cavity with removable end plate has been built in order to measure surface resistance of various superconducting materials subjected to RF field. A precise thermometric method is used for this purpose. In this paper, we present the first results obtained with bulk niobium sample.

A Wire Position Monitor System for the 1.3GHz Tesla-Style Cryomodule at the Fermilab New Muon Lab

THPO040

A wire position monitor system was put in place to monitor the motion of the 300mm return pipe in the first 1.3GHz Tesla-style cryomodule currently under

N. Eddy, B.J. Fellenz, A. Semenov, D.C. Voy, M. Wendt (Fermilab)

RF testing at the Fermilab New Muon Lab. An overview of the system is given along with initial results including cooldown and subsequent testing.

THPO041

HOM Identification and Bead Pulling on the Brookhaven ERL

H. Hahn, W. Xu (BNL) P. Jain, E.C. Johnson (Stony Brook University)

Several past measurements of the Brookhaven ERL at superconducting temperature produced a long list of higher order modes (HOMs). The Niobium 5-cell cavity is terminated with HOM ferrite dampers that successfully reduce the Q-factors to tolerable levels. However, a number of undamped resonances with Q $\sim 10^6$ were found at 4 K and their mode identification remained as a goal for this paper. The approach taken here consists of different measurements on a copper cavity replica of the ERL which can be compared with Microwave Studio computer simulations. Several different S21 transmission measurements are used, including those taken from the fundamental input coupler to the pick-up probe across the cavity, between probes in a single cell, and between beam-position monitor probes in the beam tubes. These measurements are supported by bead pulling with a metallic needle, which is calibrated in the fundamental mode. This paper presents results for the first two dipole bands with the prototypical 958 MHz trapped mode, the high Q quadrupole band, the first beam tube resonances, and other as yet to be identified resonances.

THPO042

Crystallographic Orientation of Epitaxial Transition Observed for Nb (BCC) on Cu and MgO (FCC) Single-Crystals

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Niobium thin films were grown on (001) MgO (or Cu) single-crystal using a coaxial energetic deposition. The quality of the substrate surface and epitaxial Nb layers were investigated by the XRD and pole figure measurements. Depending on growth temperature, in-plane XRD show Kurdjumov-Sachs (KS) as well as Nishiyama-Wassermann (NW) epitaxial relationships for (110) and (001) Nb on (001) MgO. Calculation of the interface energy in rigid lattice models finds one KS and two NW minima. For the NW case the optimal atomic diameter ratio dbcc/dfcc=0.866 and 1.061, whereas for the KS case it is at dbcc/dfcc=0.919. Transitions of this type are usually induced by a change in the lattice parameter ratio resulting from a relaxation process in the early stage of the growth.

THPO043

Understanding of Suppressed Superconductivity on SRF Quality Niobium

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By using transport current measurement, μHall probes and magneto optical imaging to high-purity SRF quality niobium coupons, we have shown that GBs (grain boundaries) in Nb can be responsible for significant degradation in superconducting properties. We have shown that GBs can preferentially admit flux penetration when the plane of a GB is aligned parallel or close to parallel to the vector of the external field magnet field and that the initial GB FF can be characterized as a single vortex row and breakdown of superconductivity in SRF Nb can be significantly accelerated by multiple rows of GB flux flow at high field regions, above Hc1 $\sim$ 150-180 mT. We also find that local work-hardening produced by continuously crossed rolled mechanical deformation on Nb can cause localized suppression of surface superconductivity and enhance bulk pinning properties, which would result in performance degradation in SRF cavities. We are extending this study to coupons directly isolated from hot and cold spots on a single Nb cavity in order to further understand whether suppression of RF superconductivity is triggered by surface properties or intrinsic bulk properties, or both

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Structural Characterization of Nb Films Deposited by ECR Plasma Energetic Condensation on Crystalline Insulators

THPO044

An energetic condensation thin film coating technique with an electron cyclotron resonance (ECR) induced plasma ion source is used to deposit Nb thin films on

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crystalline insulating substrates, such as a-plane and c-plane sapphire (Al2O3) and on magnesium oxide, MgO (100), (110), and (111). Heteroepitaxial Nb films were produced by ECR deposition with regulated substrate temperature. The residual resistance ratio (RRR) of about 1 micron thick films reach unprecedented values (350 - 450) on a-plane (11-20) sapphire substrates. The epitaxial relationship of Nb/crystalline substrate is found to be strongly influenced by the substrate bias voltage (adding to the initial Nb+ kinetic energy), the substrate crystalline orientation, and heating conditions. At low substrate temperature, the Nb films demonstrated non-epitaxial crystalline textures, revealed by XRD Pole Figure technique and Electron Backscattering Diffraction (EBSD). The texture might be caused by ``Volmer-Weber'' growth mode, i.e. island growth, at low surface adatom mobility. This study shows that the film's crystal structural character has great impact on its RRR/Tc value.

Nb Surface Nonlinear Properties Under Localized High RF Magnetic Field

THPO045

Despite much effort, Nb Superconducting Radio Frequency (SRF) cavities often do not reach their theoretical accelerating

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gradient potential because of defects on the Nb surface which locally reduce the RF critical field. Therefore there is an urgent need to develop a qualitative and quantitative understanding of the effects of these defects on the electromagnetic properties of Nb. A scanning microscope with the capability of measuring the local surface critical fields and nonlinear response from superconductors in sub-micron areas is a candidate for diagnosing the problems limiting the performance of SRF cavities. In order to achieve this goal, a localized and nearly 200 mTesla RF magnetic field, created by a magnetic write head, is integrated into our nonlinear-Meissner-effect scanning microwave microscope [1]. A sputtered Nb film (thickness=300 nm) is measured at a fixed location and shows a temperature-dependent vortex penetration field from the nonlinear measurements. Further improvement of this nonlinear microscopy with a 3D scanning system will map out the surface critical field on Nb, and compare to the independently determined defect structure.

[1] Tamin Tai, et al., ``Nonlinear Near-Field Microwave Microscope For RF Defect Localization in Superconductors,'' IEEE Trans. Appl. Supercond., June, 2011 (in press). arXiv:1008.2948.

THPO046

Characterization of Scale-Dependent Roughness of Niobium Surfaces as a Function of Surface Treatment Processes

C. Xu, M.J. Kelley (The College of William and Mary) C.E. Reece, H. Tian (JLAB)

Micro-roughness is attributed to be a critical issue for realizing optimum performance of Superconducting Radio Frequency (SRF) cavities. Several surface processing methods such as chemical, mechanical and plasma, are used to obtain relatively smooth surfaces. Among those process methods, Buffered Chemical Polish (BCP) and Electro-Polishing (EP) are most commonly used in current niobium cavity production. The Power Spectral Density (PSD) of surface height data provides a more thorough description to the topography than a simple Rq (RMS) measurement and reveals useful information including fractal and superstructure contributions. Polishing duration and temperature can have predictable effects on the evolution of such features at different scale regions in PSD spectrum. 1 dimensional average PSD functions derived from morphologies of niobium surfaces treated by BCP and EP with different controlled starting conditions and durations have been fitted with a combination of fractal, K-correlation and shifted Gaussian models, to extract characteristic parameters at different spatial harmonic scales.

THPO047

Growth Mode and Strain Effects in the Superconducting Properties of Nb Thin Films on Sapphire

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Superconducting thin films and multilayers have attracted the attention of the scientific community due to the promise of overcoming the maximum field gradients that SRF cavities can withstand, pushing them above 100 MeV/m *. Nevertheless, in order to achieve the desired properties, special attention needs to be devoted to the epitaxy and growth mode of such thin films, taking into account multiple aspects such as crystalline quality, lattice strain, grain size, etc. We present a complete correlation between morphology, structure and superconducting properties such as critical field, critical temperature and complex susceptibility for single crystal Nb(110) thin films sputter deposited on a-plane sapphire substrates. The influence of strain and grain boundaries in the superconducting transition is analyzed in detail, since the lattice mismatch between Nb and sapphire induces strain in the first atomic layers and may affect the superconducting properties of the thin films. AC susceptibility techniques allow us to identify the dissipative effects in the lattice associated with the presence of defects, thus allowing us to tune the growth conditions to minimize their effect.

*A. Gurevich, Applied Physics Letters 88 (1), 012511 (2006).

RF Surface Impedance of MgB2 Thin Films at 7.5 GHz

THPO048

The Surface Impedance Characterization (SIC) system in Jefferson Lab can presently make direct calorimetric RF surface impedance measurements on the

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central 0.8 cm^2 area of 5 cm diameter disk samples from 2 to 20 K exposed to RF magnetic fields up to 14 mT at 7.5 GHz. MgB2 thin films from STI/LANL were deposited on 5 cm diameter Nb disks using reactive evaporation technique. We will report the results of measurements on these samples using the SIC system. The data will be interpreted based on BCS theory as the temperature-dependent properties suggest evaluation of the Tc, energy gap, penetration depth, mean free path and coherence length.

Atomic-Scale Characterization of Niobium for SRF Cavities Using Ultraviolet Laser-Assisted Local- Electrode Atom-Probe Tomography

THPO049

Niobium is the metal of choice for superconducting radio-frequency (SRF) cavities for the International Linear Collider

Y.-J. Kim, D.N. Seidman (NU) A. Romanenko (Fermilab)

due to the highest critical temperature (Tc = 9.2 K) of any element in the periodic table and can be plastically deformed into complex geometries. Differences in surface chemistry from bulk niobium are believed to determining the performance of SRF cavities, such as the high-field Q (quality factor) drop. In this study, the surface chemistry of niobium was characterized utilizing ultraviolet (UV) laser-assisted local-electrode atom-probe (LEAP) tomography employing picosecond laser pulsing together with transmission electron microscopy (TEM). The superior spatial resolution and analytical sensitivity of a LEAP tomograph permits us to determine the surface composition on an atom-by-atom and atomic layer-by-layer basis. The three-dimensional reconstructions from three-dimensional LEAP tomographic analyses demonstrate different behaviors for oxygen and hydrogen atoms in pure niobium.

TE Sample Host Cavities Development at Cornell

THPO050

In order to measure surface resistance of new materials other than niobium such as Nb3Sn and MgB2, two sample host

Y. Xie, M. Liepe (CLASSE)

niobium cavities operating at TE modes have been developed at Cornell University. The first one is a 6GHz pillbox TE011 cavity modified from an older vision enabling testing 2.75'' diameter flat sample plates *. The second one is an optimized mushroom-shape niobium cavity operating at both 4GHz TE012 and 6GHz TE013 modes for 3.75'' diameter flat sample plates **. First results from the commissioning of the two TE cavities will be reported.

* D. Rubin et al., Phys. Rev. B 38, 6538(1988)

** Y. Xie, J. Hinnefield, M. Liepe, '' Design of a TE-type cavity for testing superconducting material samples'', SRF2009, Berlin (2009)

THPO051

Laser Re-Melting Influence on Nb Properties: Geometrical and Chemical Aspects

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We present recent results on Laser re-melting system used to smoothen niobium surfaces of superconducting RF cavities in order to overcome quench. In the work we studied both chemical and geometrical aspects of the melting by means of electron backscattered diffraction microscopy and laser confocal microscopy. BCP, EP and HF impacts have been investigated on both single and large grain niobium samples. Appropriate post processing has been suggested.

THPO052

Investigation of Near-Surface Interstitial Hydrogen in Cavity-Grade Niobium

A. Romanenko (Fermilab) L.V. Goncharova (UWO)

Details of the distribution of near-surface hydrogen in niobium cavities is important for research into mechanisms affecting quality factor dependence on the magnitude of surface fields. We utilized an elastic recoil detection technique to extract the distribution of hydrogen with depth resolution of order one nanometer in samples, which underwent different treatments similar to the ones with the known effect on cavity performance. Results of this study and possible implications are reported.

THPO053

Material for Fabrication of DESY Large Grain/Single Crystal Cavities

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Material for large grain LG and single crystal SC cavities of TESLA shape has been developed in collaboration with industry. One of the aspects of LG material was electron beam melting of the ingots with required structure. The second was slicing of the discs cost effectively with tight thickness tolerances, high surface quality and high purity. Surface and structural properties of SC on the LG discs are investigated. Measurements of the crystal orientation on the LG discs of three companies have been done by complete penetration using synchrotron radiation. Two LG material features have been stressed in cavity production: the influence of the LG crystal orientation on the anisotropic behavior during deep drawing and the impact of pronounced steps at grain boundaries on cavity behavior. 11 LG 9-cell cavities of XFEL-like shape are fabricated. The procedure of increasing the crystal size by rolling of LG discs and cut out of SC discs, followed by subsequent forming and welding without destroying of the SC structure, was developed. A method of fabrication of single crystal cavities was proposed. Several SC cavities with different crystal orientations were produced.

THPO054

Magneto-Optical and Electromagnetic Study Different Forms of Nb for SRF Application

A. Polyanskii, D.C. Larbalestier, Z.H. Sung (ASC) P.J. Lee (NHMFL) A-M. Valente-Feliciano (JLAB)

In order to understand the properties of different forms of Nb for cavity applications we investigated pure bulk polycrystalline Nb as well as thin bi-crystal films grown on STO substrates. Thin film Nb is potentially useful for our electrical and magnetic characterization of SRF Nb because of its high volume to thickness ratio. In polycrystalline bulk Nb, Magneto-Optical imaging showed regular magnetic flux behavior across the full sample width except for when the plane of the GBs (grain boundaries) was parallel to the direction of the external magnetic field. In thin films of Nb at temperature above 7 K we also observed regular flux penetration from the edges of the films and earlier flux penetration at the GBs than in the grains. However, below 7 K the regular flux penetration triggers a dendritic flux instability obscuring any inhomogeneous flux behavior. We contrast such behavior with that found for bulk high purity Nb. From MO images we were able to pattern peculiarities of flux behavior at different temperatures and magnetic field and, as a result, calculate the critical current in the grains and across the GB in both form of Nb.

THPO055

Investigation of Samples Separated From Prototype Cavities of the European XFEL

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XFEL prototype cavities fabricated in industry and treated at DESY mainly meet the specification. Few cavities demonstrated low performance (13-20 MV/m) limited by thermal breakdown. The T-map analysis detected quench areas mainly close to the equator. Optical inspection by high resolution camera allowed tracking the several stages of preparation (as received, after the main electropolishing EP, after RF test) and in some cases makes possible monitoring the evolution of defects. In order to understand the nature of reduced performance and get more detailed information on the origin of defects, some samples have been extracted from four cavities and investigated by light microscope, 3D-microscope, SEM, EDX and Auger spectroscopy. Several surface flaws with sizes from a few μm to hundreds of μm have been detected. The defects can be grouped in four categories. The first category of defects indicates foreign elements (often with increased content of carbon). Deviation from smooth surface profile characterizes the second type of defects (holes, bumps). Damaged surface areas at high pressure water rinsing and etching pits belong to the third and fourth category of defects.

THPO056

Thermal-Vacuum Variations of the Surface Oxide Complex on Cu

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The surface chemistry of Cu is the most critical factor in the initial kinetics of Nb deposition, primarily because the degree of Cu oxidation may vary from a sub-chemisorbed layer to a complete oxidation state of CuO (cupric), thus providing a spectrum of conditions that influence the nucleation and growth of the thin film. To date, the oxidation of Cu has been thoroughly investigated under a variety of environments, from high pressure to ultrahigh vacuum, but the specific state of the surface oxide complex as a function of temperature and environmental pressure has not been studied. The predominant native oxide on Cu is Cu_2O (cuprous) which, in bulk or sufficient thickness, is stable until $1230^{\circ}C$ where it begins to decompose. However, a thin film native oxide (<10 nm) on bulk Cu begins to decompose at temperatures far lower than $1230^{\circ}C$. In this note, we report the stability of surface Cu_2O as well as the variation in surface chemistry of the Cu surface over the range of $25 - 900^{\circ}C$ in a low pressure environment.

THPO057

Superconducting DC and RF Properties of Ingot Niobium

P. Dhakal, G. Ciovati, P. Kneisel, R. Myneni (JLAB)

Recently [1, 2], the DC and low frequency magnetic and thermal properties of large-grain niobium samples subjected to different chemical and heat treatment were measured. Here, we extend the similar study to the cylindrical hollow rods of larger diameter, fabricated from new niobium ingots, manufactured by CBMM. The results confirm the influence of chemical and heat-treatment processes on the superconducting properties, with no significant dependence on the impurity concentrations in the original ingots. Furthermore, RF properties such as the surface resistance and quench field of the niobium rods were measured using a TE011 cavity. The hollow niobium rod is the center conductor of this cavity, converting it to a coaxial cavity. The quench field is limited by the critical heat flux through the rods' cooling channel.

[1] Mondal et al., SRF 2009, Berlin, 2009.

[2] Dhavale et al.,Proc. of the First Int. Symp. on the Superconducting Sci. and Tech. of Ingot Niobium, AIP Conference Proceedings 1352, p. 119 (2011).

THPO058

Phase-Sensitive Nonlinear Near-Field Microwave Microscopy on MgB2 Thin Films

B.G. Ghamsari, S. M. Anlage, T.M. Tai (UMD)

MgB2 has recently attracted much attention as a coating for Nb to enhance the RF critical field in Superconducting Radio Frequency (SRF) cavities. However the surface properties of MgB2, including its intrinsic nonlinearities as well as various types of defects, can limit the RF performance of such cavities. This work presents phase-sensitive nonlinear near-field microwave microscopy on MgB2 films. An intense localized RF magnetic field is induced on the surface of MgB2 films by means of a magnetic write head, and the amplitude and phase of the third harmonic voltage generated by the film are measured. Power and temperature dependence of the third harmonic response are studied to identify the dominant mechanism of nonlinearity in the film under different operating conditions, and a phenomenological model is developed to relate the nonlinear response to the local critical RF field. The method could be generalized by scanning the probe over the sample, and possibly over various defects, to generate a map of the critical RF field and enable classification of different types of defects in terms of their effect on the RF performance of MgB2.

THPO059

Correlation of Microstructure, Chemical Composition and RRR-Value in High Purity Niobium (Nb-RRR))

R. Grill, W. Simader (Plansee Metall GmbH) M. Heilmaier, D. Janda (TU Darmstadt) W. Singer, X. Singer (DESY)

For manufacturing of Nb-RRR sheet material a thorough understanding of material properties and niobium metallurgy is necessary to meet the required regarding material properties as specified for the XFEL project. Especially for the RRR value it is known, that residual stresses, and increased levels of vacancy and impurity concentrations, and dislocation densities after the final heat treatment can cause a severe degradation of the RRR value. Also, a comprehensive understanding of the influence of further microstructural properties (e.g. different textures due to rolling operations and annealing, dislocation substructures, etc.) on the RRR-value is lacking. For specimens having RRR-values in the range of 360 to 430, the crystallographic texture has been investigated and correlated with the measured RRR values. Furthermore, the possible influence of different impurity levels on the RRR value was calculated, compared with the measured values and discussed with regard to the current material specification for the XFEL project.

First Principles Investigation of Hydrogen in Niobium

Niobium hydride is a contributor to degraded niobium SRF cavity performance by Q-slope and Q-disease. Hydrogen is easily absorbed into niobium when the

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protective oxide layer is disturbed, such as during electropolishing and chemical treatments, and the structure and distribution of hydrogen in niobium is altered during other processing steps such as baking. To optimize cavity performance and production efficiency, it is important to understand the structures of hydrogen in niobium, including the interactions of hydrogen with structural defects and other impurities such as oxygen. In this study density functional theory was used to evaluate these interactions. Hydrogen was examined as a dissolved interstitial impurity and in ordered niobium-hydride phases; and the interactions between hydrogen, niobium, vacancies on niobium sites, and oxygen dissolved in niobium were evaluated. The results yield information about the thermodynamic, electronic, magnetic, and geometric properties of these systems, which lead to important implications concerning the mobilities of impurities and vacancies in niobium and the precipitation of phases that are detrimental to cavity performance.

Activation of Field Emitters on Clean Nb Surfaces

Systematic investigations of the enhanced field emission (EFE) from surface irregularities of typical EP and HPR treated Nb samples revealed an expo-

A. Navitski, S. Lagotzky, G. Mueller (Bergische Universität Wuppertal) D. Reschke, X. Singer (DESY)

nential increase of the emitter site density N with the initial onset surface field (E_{on} = 80-160 MV/m) and a strong activation effect, i.e. the final occurrence of EFE at 2-4 times lower E_{on} relevant for superconducting XFEL and ILC cavities. Possible explanations for this activation are breakdown across the surface oxide, surface erosion by a local microplasma or de/adsorption effects. Such emitter activation might also be caused by the usual baking or rf power processing of cavities. Therefore, we have started a systematic test series with large-grain Nb samples based on correlated field emission microscopy (FESM) and high-resolution SEM investigations before and after heating at temperatures between 122 and 800°C. As expected, we have obtained slightly (x 2) increased N after baking and strongly (x 10) after heating at 800°C. Moreover, the E_{on} of the activated emitters is reduced down to 40 MV/m. Most emitters could be identified by SEM as microscratches. We will discuss the impact of these results on the EFE of SRF cavities.

THPO060

THPO061

THPO062

Epitaxial Niobium Thin Films for Accelerator Cavities

W.M. Roach, D.B. Beringer, C. Clavero, R.A. Lukaszew (The College of William and Mary) C.E. Reece (JLAB)

SRF technology used in linear accelerators is based on bulk Nb cavities that have high cost and are approaching the maximum field gradients they can withstand*. Thus, development of a suitable alternative to bulk Nb is needed. Attempts have been made to implement Nb-coated Cu cavities since the thermal conductivity of Cu is better than bulk Nb**. Our studies show that the transport properties of Nb, in particular the residual resistance ratio (RRR), are better when epitaxially grown on crystalline ceramics (i.e. MgO and Al2O3) compared to Cu templates. Since grain boundaries are one of the main obstacles to superconducting transport, we show how the increased number of crystallographic domains that can occur during epitaxial Nb growth onto Cu surfaces leading to higher density of grain boundaries can explain our results. We propose a route to improved performance while maintaining thermal efficiency by using seed-layers on Cu templates that can decrease grain boundary density. We will show our correlated studies of microstructure and surface morphology and the resulting transport/susceptibility properties illustrating possible mechanisms to improve cavity performance of such films.
* P. Kneisel et al., Proceedings of 2005 Particle Accelerator Conference, Knoxville, TN, TPPT076 (2005).

** S. Calatroni, Physica C 441, 95 (2006).

THPO063

Study of the Impurity Species in Niobium Films Grown by ECR Technique Employing Secondary Ion Mass Spectrometry

A-M. Valente-Feliciano, C.E. Reece, A.T. Wu, X. Zhao (JLAB) F.A. Stevie (NCSU AIF)

One attractive path is to use a thin film deposition technique to fabricate Nb films on Cu or other appropriate substrates instead of using bulk Nb to fabricate Nb SRF cavities. It is known that the physical properties of Nb films can be affected by their impurity species and concentrations. In this contribution, a study of the impurity species in niobium films grown by electron cyclotron resonance plasma energetic deposition technique employing Secondary Ion Mass Spectrometry (SIMS) is reported. Measurements were performed on Nb films deposited on Al2O3 and MgO substrates using Cs+ and O2+ primary beams. The obtained results were compared with those obtained on a standard bulk Nb sample treated by buffered chemical polishing. It was found that under suitable deposition conditions H content could be significantly lower in Nb films than that in the standard Nb bulk materials. Depth profiling by O2+ found that substrate elements, such as Al and Mg, have different distributions from the film/substrate interface toward the top layer of film. Possible implications of the obtained experimental results towards the RF properties of the Nb films will be discussed.

THPO064

Structural Properties of Niobium Thin Films Deposited on Metallic Substrates by ECR Plasma Energetic Condensation

Particle accelerator technologies rely on SRF cavities to create the accelerating gradient for beam lines. Solid niobium cavities are widely employed throughout

J.K. Spradlin, H.L. Phillips, C.E. Reece, A-M. Valente-Feliciano, X. Zhao (JLAB) D. Gu (ODU) K.I. Seo (NSU)

the community despite high material, fabrication, and operation cost. New thin film technologies are being explored for the suitability of niobium coatings for accelerating cavities. Thin layers of high-quality niobium would be deposited on a base material that has lower material and fabrication cost. Copper is a strong candidate for the cavity base due to availability, cost, machinability, and potentially improved performance characteristics of the niobium SRF surface. Initial results of TEM, EBSD and XRD analyses of niobium thin films grown on copper substrates under controlled conditions are presented to demonstrate the feasibility of the technology and establish lower limits of performance characteristics. Correlation of RRR data with the structure of niobium thin films will demonstrate the importance of thin film structural quality.

THPO065

Anomalous Morphological Scaling in Epitaxial Nb Thin Films on MgO(001)

Surface and interface roughness are critical factors in determining the technological viability of many systems, in particular the development of next-generation

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superconducting radio frequency (SRF) cavities. Thus, we have undertaken a systematic effort to investigate the surface evolution of epitaxially grown Nb thin films under specific deposition conditions. This is important since ongoing efforts to improve cavity's performance have considered the possibility of multi-layered thin film coatings* as an alternative to the current bulk Nb technology. We examined the surface morphology of epitaxial Nb films grown on MgO at different stages during growth and applied dynamical scaling analysis to the surface features. Our thin film nucleation and growth kinetics studies are relevant since thin films may differ from bulk systems due to limited material supply as well as stress contributions from lattice mismatch with the substrate. This can induce significant surface roughness which can in turn lead to undesirable effects for SRF applications. Our studies may offer a venue to minimize these drawbacks by suitable choice of thin film growth parameters and substrates.

* A. Gurevich, Appl. Phys. Lett. 88, 012511 (2006).

THPO066

Stoichiometric Nb3Sn in First Samples Coated at Cornell

A cavity coated with the superconductor Nb3Sn theoretically will be able to reach more than twice the maximum accelerat-

S. Posen, M. Liepe (CLASSE)

ing field of Nb in a cavity under the same operating conditions and will have a much lower BCS surface resistance at a given temperature. The SRF group at Cornell has recently developed facilities to fabricate Nb3Sn on Nb. The first samples have been coated, and several tests have been performed to characterize them. Results presented include SEM images of the surface, anodization tests, a critical temperature measurement, a test for RRR degradation, and stoichiometry measurements using EDS and XPS.

THPO067

Characterization of Large Grain Nb Ingot Microstructure Using OIM and Laue Methods

D. Kang, D.C. Baars, T.R. Bieler (Michigan State University) G. Ciovati (JLAB) C. Compton (FRIB) T.L. Grimm, A.A. Kolka (Niowave, Inc.)

Large grain niobium is being examined for fabricating superconducting radiofrequency cavities as an alternative to using rolled sheet with fine grains. It is desirable to know the grain orientations of a niobium ingot slice before fabrication, as this allows heterogeneous strain and surface roughness effects arising from etching to be anticipated. Characterization of grain orientations has been done using orientation imaging microscopy (OIM), which requires destructive extraction of pieces from an ingot slice. Use of a Laue camera allows nondestructive characterization of grain orientations, a process useful for evaluating slices and deformation during the manufacturing process. Five ingot slices from CBMM, Ningxia, and Heraeus are compared. One set of slices was deformed into a half cell and the deformation processes that cause crystal rotations have been investigated and compared with analytical predictions. The five ingot slices are compared in terms of their grain orientations and grain boundary misorientations, indicating no obvious commonalities, which suggests that grain orientations develop randomly during solidification.

THPO068

Experimental Investigation and CPFE Modeling of Single Crystal Niobium for Tube Hydroforming

A. Mapar ((MSU)) D.C. Baars, T.R. Bieler, D. Kang (Michigan State University) C. Compton (FRIB) P. Darbandi, F. Pourboghrat (MSU) J.E. Murphy (University of Nevada, Reno)

To optimize the manufacturing process and to increase the performance of niobium cavities, mechanical behavior of single crystal niobium was investigated using tensile tests. The crystal orientation of the specimen was recorded before and after the testing. The flow stress of the single crystal niobium showed a significant and complex dependence on the crystal orientation. This phenomenon has led to the conclusion that the Schmid's law does not apply to this material, as it does to FCC materials. Considering the plastic anisotropy due to the non-planar distribution of screw dislocation cores, the authors are developing a new crystal plasticity model for the single crystal niobium. An optimized crystal plasticity material model based on combined constraints was recently used to identify orientation dependent critical resolved shear stresses and work hardening parameters for Nb single crystal. Progress toward validating this single crystal model for different crystal orientations will be presented. This will lead to the ability to use the CPFE model in conjunction with a commercial FE code to simulate the tube bulging of Nb single/multi crystal tubes.

Nb Film Growth on Crystalline and Amorphous Substrates

This paper describes Energetic Condensation Growth of Nb films using a cathodic arc plasma on crystalline (a- and c-sapphire, MgO) and amorphous (borosil-

E.F. Valderrama, C. James, M. Krishnan (AASC) P. Maheshwari, F.A. Stevie (NCSU AIF) K.I. Seo (NSU) X. Zhao (JLAB)

icate) substrates. The crystal substrates were heated to 700 deg C and subsequently coated at 300, 500 and 700 deg C. Film thickness varied from ~$0.25\mu m$ up to >$3\mu m$. The borosilicate substrate was preheated to 700 deg C but coated at 500 deg C. XRD spectra (Bragg-Brentano) and pole figures show a change in crystal structure on c-sapphire from textured (with twin-symmetry) to hetero-epitaxial as the temperature is increased. RRR=43 was measured on c-sapphire which is lower than RRR=200 on a-sapphire and 541 on MgO. On borosilicate, the (110) and (220) planes of Nb show sharper spectra at higher temperatures with an increase to RRR=31 at 500 deg C. The growth of crystalline Nb on an amorphous substrate is driven by energetic (40-120eV) ions from the cathodic arc plasma. The significance of crystal structure on amorphous substrates has implications for future, lower-cost SRF cavities. SIMS data show the role of impurities on crystal growth and RRR.

Effect of Fabricate Condition on Properties of Bi-2212 Thin Films

High-quality epitaxial c-axis oriented Bi-2212 thin films were deposited on single crystalline (100) MgO substrate using

T.M. Nguyen (nguyenthi mua)

Pulsed Laser Deposition. The results show that these films are good quality with c-axis orientation and epitaxial growth, good electrical and magnetic properties. The critical current density Jc was found to be strongly dependent on the temperature and magnetic field. The critical current density for the film growth with the best deposition conditions (Jc=6,3x10^6 A/cm^2 in 0.5T magnetic field at 5 K). The onset temperature for superconducting transition Tc-onset = 95K and the temperature for zero resistivity Tc-zero=80K.

Detailed Surface Analysis of Incremental Centrifugal Barrel Polishing (CBP) and EP of Single-Crystal Niobium Samples

We performed Centrifugal Barrel Polishing (CBP) on single crystal niobium samples housed in a stainless steel sample

A.D. Palczewski, C.E. Reece, H. Tian, O. Trofimova (JLAB)

holder following a polishing recipe recently developed at FNAL [*]. We were able to obtain a mirror-like finish after the final stage of tumbling, although some defects and imbedded particles remain. Our presentation will discuss the initial results from the coupon study, including qualitative and quantitative analysis of the surface characteristics from each step in the CBP process, followed by HPR and well controlled incremental EP. These will include surface roughness, size and character of contaminants, surface crystal structure, and overall finish. We will discuss how the surface characteristics should guide the SRF community in exploiting or adapting the Fermi recipe; including why minimal subsequent EP is needed, and possible places for modification of the recipe to reduce polishing time.
* CA Cooper, LD Cooley , ``Mirror Smooth Superconducting RF Cavities by MechanicalPolishing with Minimal Acid Use,'' http://lss.fnal.gov/archive/2011/pub/fermilab-pub-11-032-td.pdf, (May 31, 2011)

THPO072

Raman Spectroscopy as a Probe of Surface Oxides and Hydrides on Niobium

J. Zasadzinski (IIT) Th. Proslier (ANL)

Raman microscopy/spectroscopy has been used in conjunction with AFM, tunneling and magnetic susceptibility to identify surface oxides and hydrides on annealed, recrystallized foils of high purity Nb and on single crystals of cavity grade Nb. Cold worked regions of the Nb foil as well as rough regions near grain boundaries showed clear evidence of ordered hydride phases which were identified by VASP phonon calculations. Cold worked regions also displayed enhanced surface paramagnetism. Surface enhanced Raman spectra have also been obtained using 1.0 nm Au depositon. The SERS spectra reveal hydride molecular species which are not observable by conventional Raman. These results indicate that Raman is a useful probe of Nb surfaces relevant for cavity performance

THPO073

Laser Melt Smoothing of Niobium Superconducting Radio-Frequency Cavity Surfaces

S. Singaravelu, M.J. Kelley, J.M. Klopf, G.A. Krafft (JLAB) C. Xu (The College of William and Mary)

Superconducting Radio Frequency (SRF) niobium cavities are at the heart of an increasing number of particle accelerators. Their performance is dominated by a several nm thick layer at the interior surface. Maximizing the smoothness of this surface is critical and aggressive chemical treatments are now employed to this end. We describe laser-induced surface melting as an alternative ``greener'' approach. Modeling predicts the surface temperature as a function of per-pulse energy density. Guided selection of laser parameters achieves melting that reduces the surface roughness and may also mitigate surface damage from the fabrication process. The resulting topography was examined by SEM, and AFM. PSD spectra computed from AFM data were used for studying the topography of the treated niobium.

THPO074

NbTiN Films for SRF Multilayer Structures

A-M. Valente-Feliciano, H.L. Phillips, C.E. Reece, J.K. Spradlin, X. Zhao (JLAB) D. Gu (ODU) K.I. Seo (NSU)

For the past three decades, bulk niobium has been the material of choice for SRF cavities applications. In the recent years, RF cavities performances have approached the theoretical limit for bulk niobium. For further improvement of RF cavity performance for future accelerator projects, an interesting alternative has been recently proposed by Alex Gurevich with the Superconductor-Insulator-Superconductor multilayer approach, using the benefit of the higher critical field Hc2 of higher-Tc superconductors without being limited with their lower Hc1. JLab is pursuing this approach with the development of multilayer structures based on NbTiN via magnetron sputtering and High Power Impulse Magnetron Sputtering (HiPIMS). Insulators such as, AlN, Al2O3 and MgO are being investigated as candidates for the insulator layers. This paper present the preliminary results on the characteristics of NbTiN and insulator layers and a first attempt of a NbTiN-based multilayer structure on bulk Nb and thick Nb films.

Does Annealing Reduce or Remove Defects Observed After Electropolishing?

L.D. Cooley, D. Burk, D.T. Hicks, R. Schuessler, C. Thompson (Fermilab)

Fermilab has been studying the effect of cold work on the electropolishing of niobium. Since most cavities are electropolished (EP) without recovering the cold work of deep-drawing half cells or the strains induced by welding, this study could shed light on mechanisms by which defects in cavities form during EP. Our past work showed marked increase in the tendencies for pitting when the niobium piece was cold worked, repeatedly dipped into an electrolyte to form a meniscus, or otherwise agitated. Welding itself did not seem to exacerbate pitting. In the present work, annealing in a vacuum furnace was used to recover cold work prior to EP for both plain and welded coupons. Changes in pitting tendencies will be discussed. We also introduce a new instrument, laser confocal scanning microscopy, which permits pitting to be assessed over areas much larger than profilometry does, which helps us analyze large coupons.

Measurement of the Loss Tangent and Heat Capacity of a Large Single Crystal Sapphire

N. Pogue, P.M. McIntyre, A. Sattarov (Texas A&M University)

A high-gradient test cavity is being developed to test wafer samples of advanced SRF surfaces at gradients to or beyond the BCS limit of Nb. The cavity design employs dielectric loading by a large high-purity sapphire crystal. As a first step towards construction we set out to measure the loss tangent of such a large HEMEX-grade sapphire crystal. The crystal was inserted into a single-cell CEBAF cavity equipped with couplers to operate in the TE01 mode so that the electric field was localized within the sapphire. Cold testing of the cavity, without the sapphire and numerical simulations, verified that the unloaded Q of the cavity was adequate to accurate measurement of the sapphire loss tangent down to 10-10. Several Q measurements were made of the sapphire-loaded cavity in a variety of conditions. The temperature dependence of the sapphire's loss tangent and heat capacity were measured. The implications of these results for the high-gradient wafer test cavity design are reported.

Mo-Re Films for SRF Applications

E.F. Valderrama, C. James, M. Krishnan (AASC) P. Maheshwari, F.A. Stevie (NCSU AIF) K.I. Seo (NSU) X. Zhao (JLAB)

Single (sintered composite Mo3:Re1) and dual targets of Mo/Re were used to grow superconducting films of Mo:Re, using cathodic arc plasmas. Sharp superconducting transitions (at up to 13K) were observed in ~1 μm thick films deposited on a-sapphire and MgO crystals. The measured RRR (defined as the ratio of resistivity at 300K to that at 14K) in the best films was 6, which is higher than measured by others at higher annealing temperatures. XRD (Bragg-Brentano spectra) revealed a single sharp peak of Mo-Re (611) plane, from the composite Mo3:Re1 film. SIMS measurements revealed the role of impurity concentrations on superconducting properties. For the dual-target films, stoichiometry was controlled by varying the current to each cathode. The XRD spectra in this case showed the (330) plane of Mo-Re; hero-epitaxial growth of Mo-Re depends upon the stoichiometry of the film. This dual-target approach allows other compound films (e.g. Nb3Sn, MgB2 etc.) to be grown in a single-step. For SRF cavity applications, the RRR should be increased to >100, which is our next goal.

THPO078

Surface and Thin Film Characterization of Superconducting Multilayer Films for Application in RF Accelerator Cavities

R.K. Schulze, L. Civale, N.F. Haberkorn, M. Hawley, T. Tajima, Y.Y. Zhang (LANL) B. Moeckly (STI) T. Prolier (ANL) A.T. Zocco (UC)

Application of multilayer ultra-thin films on the surfaces of Nb superconducting RF cavities shows promise in substantially improving the performance of superconducting RF cavities into the 100 MV/m range. The materials science challenges associated with producing complex multilayer films, particularly for conformal application on the interior 3D surfaces of RF cavities are substantial. Here we present surface and thin film analysis of two candidate superconducting materials, MgB2 and NbN, along with multilayers produced with alternating superconductor and dielectric ultra-thin films. We report on the analysis methods and describe results from a variety of thin film samples. The materials stability,$\mu$and nano structure, chemistry, and thin film morphology are highly dependent on methods and parameters used in the thin film deposition. From our analysis, important factors for producing quality film materials include chemical stoichiometry, impurity content, deposition temperature, substrate surface condition, and choice of dielectric material. These factors will be discussed in the context of the production methods used for these ultra-thin superconducting film structures.

THPO079

Surface Preparation of Metallic Substrates for Quality SRF Thin Films

J.K. Spradlin, O. Trofimova, A-M. Valente-Feliciano (JLAB)

Surface preparation is an essential prerequisite for thin film depositions. Rough or chemically impure surfaces adversely affect the nature of the thin film. Understanding the properties of the substrate and how they influence the quality of the thin film is necessary to transfer thin film deposition technologies to SRF cavity applications. A substrate that is flat, has sufficient grain size, and is chemically pure is the ideal starting point for thin film depositions. A method for copper substrate preparation is reviewed for niobium thin film deposition that provides epitaxy on large and fine grain copper as well as single crystal copper. Preliminary data on niobium and aluminum substrate preparation will also be included.

THIOC — Hot Topics

Recipes for 9-cell cavity fabrication and preparation

In the mass production of International Linear Collider (ILC), about 16,000 9-cell SRF cavities must be produced for the linac. The current recipe of 9-cell cavity production is not enough for the required cost reduction for ILC. Various ideas for the cost reduction of 9-cell cavity fabrication would be duscussed in this presentation. As the final surface treatment of 9-cell cavity, the Electro-Polishing (EP) is the best candidate to realize high yield rate for high-gradient performance. However, the laboratories in the world are still using different EP parameter-sets for various reasons. In this presentation, the comparison of EP parameters among laboratories would be done and how we can reach to the best parameter sets would be discussed.

HOT TOPIC

FRIOA — SRF Technology

FRIOA01

Adaptive Compensation for Lorentz Force Detuning in Superconducting RF Cavities

W. Schappert, Y.M. Pischalnikov (Fermilab)

The Lorentz force can dynamically detune pulsed Superconducting RF cavities and considerable additional RF power can be required to maintain the accelerating gradient if no effort is made to compensate. Fermilab has developed an adaptive compensation system for cavities in the Horizontal Test Stand, in the SRF Accelerator Test Facility, and for the proposed Project X.

FRIOA02

Innovative Tuner Designs For Low Beta SRF Cavities

Z.A. Conway (ANL)

This presentation will give an overview of innovative low-beta (0.05 < beta < 0.6) cavity frequency tuners for heavy-ion accelerators. These cavities typically operate with microphonic induced frequency perturbations which are a significant fraction of the loaded bandwidth. If uncompensated these frequency variations may unnecessarily increase the RF power required to stabilize the phase and amplitude of the cavity RF fields. Several tuner designs with operating details will be reviewed.

FRIOA03

Recent Progress in HOM Damping from Around The World

M. Liepe (CLASSE)

Continuous progress in SRF technology is pushing the beam parameter envelope for SRF linacs towards higher currents and shorter bunch lengths. Therefore, the demands on the HOM dampers used in these SRF linacs are increasing continuously, and Higher-Order-Mode (HOM) damping remains a very active field of research and development. Different HOM damping concepts have been developed and improved over the last years to support high power handling and broadband HOM damping. In this paper we give an overview of recent progress on antenna, waveguide, and beamline HOM dampers.

FRIOA04

Power Couplers for Spiral-2

Y. Gï¿½mez Martï¿½nez, T. Cabanel, J. Giraud, R. Micoud, M. Migliore, J. Morfin, F. Vezzu (LPSC) P.-E. Bernaudin, P. Bosland (CEA/DSM/IRFU) G. Olry (IPN)

The Spiral 2 facility is in construction phase. The driver is a super-conducting linac composed of two types of QWR cavities, β = 0.07 and 0.12 operated at 88 MHz. Each cavity is fed by a Radio –Frequency antenna coupler designed to accept up to 40kW CW. The tests of the prototype couplers have been successfully achieved in the two types of cavities. The manufacturing is finished and the processing of the 26 couplers is under way. We report the technological choices and the major issues of the process, including the absence of TiN plating. We present the main results of the tests and the processing of the couplers.

Chair: S. Noguchi, KEK (Ibaraki, Japan)

Overview of CW Input Couplers for ERL

H. Sakai (KEK)

Various efforts for SRF R&D are in progress all over the world for ERL construction. CW input coupler development is one of the key issues for realizing the stable ERL operation. For injector, high power handling is necessary to feed the CW RF power to continuous high current beam acceleration. Furthermore, the soft injector beam should not be disturbed by coupler kick. Thanks to energy recovery, a little power is needed for main linac. However, this feeding average power is also higher than that of the pulsed operation like XFEL or ILC to keep the accelerating field stably under the microphonics of cyromodule,. Therefore, it is important for both coupler cases, not to leak the large heat load to He temperature and to avoid the continuous multipacting barriers. In addition, variable coupling is desirable for several beam operations. As a result, many new coupler designs were proposed and developed until now. In this paper, we present the various options and technical issues of ERL input coupler for both injector and main linac. Then we review existing designs associated with R&D testing and summarize the experience and progress in each laboratory around the world.

Construction of cERL Cryomodules for Injector and Main Linac

K. Umemori, T. Furuya, E. Kako, S. Noguchi, H. Sakai, M. Satoh, T. Shishido, K. Watanabe, Y. Yamamoto (KEK) E. Cenni (Sokendai) M. Sawamura (JAEA) K. Shinoe (ISSP/SRL)

The Compact ERL (cERL) project is advanced in Japan. Its aim is to demonstrate the circulation of 100 mA electron beams with energy of 35-200 MeV. Superconducting cavities are key components for realizing ERL. At injector part, electron beams are accelerated up to 5-10 MeV by three 2-cell cavities. Prototype 2-cell cavities show excellent performance of about 40 MV/m. However, heating problem exists on HOM couplers. Improvement of cooling is essential for stable CW operation. Input coupler is another big issue. High power test stand was constructed using a 300 kW klystron. Prototype couplers could deliver from several tens to a hundred kW of RF power. At main linac part, HOM damped 9-cell cavities are applied. Two prototype cavities were manufactured. Initially their performance was limited by field emission. But it was overcome and they reached to more than 20 MV/m. A prototype input coupler is also fabricated for main linac. It successfully propagates 25 kW standing wave and also thermal cycle tests were passed. Prototype HOM absorbers are also fabricated and several tests were carried out. For both parts, cryomodules are under construction. They will be completed in 2012.

SRF Photoinjector Tests at HoBiCat

A. Neumann, W. Anders, R. Barday, A. Frahm, A. Jankowiak, T. Kamps, S. Klauke, J. Knobloch, O. Kugeler, A.N. Matveenko, T. Quast, J. Rudolph, M. Schenk, S.G. Schubert, M. Schuster, J. Voelker (HZB) P. Kneisel (JLAB) R. Nietubyc (The Andrzej Soltan Institute for Nuclear Studies, Centre Swierk) J.K. Sekutowicz (DESY) I. Will (MBI)

In collaboration with JLab, DESY and the A. Soltan Institute HZB developed a fully superconducting photo-injector as a first step towards a high average current electron source for the BERLinPro ERL. This set up consists of a 1.6 cell superconducting gun cavity with a lead cathode plasma-arc deposited on the half cell backwall and a superconducting solenoid. The system, including a warm diagnostic beam-line section, was recently installed in the HoBiCaT horizontal cavity test cryostat to study beam dynamics within the ERL parameter range. In this talk the first series of RF tests will be presented, including Q measurements, dark current studies, field stability and beam energy measurements.

FRIOB — New/Emerging SRF Capability & Applications

FRIOB01

SRF Activities at Peking University

J.K. Hao, J.E. Chen, L. Lin, K.X. Liu, X.Y. Lu, S.W. Quan, B.C. Zhang, K. Zhao, F. Zhu (PKU/IHIP)

Superconducting RF technology has been developed at Peking University for more than 20 years. In the recent years, the researches are mainly focused on producing high performance superconducting cavities and installing the DC-SRF photocathode injector as well as related 2K cryogenic facility and other auxiliary equipment. The cavities designed and fabricated by Peking University mainly include TESLA type 9-cell cavities, 1.3 GHz 5-cell cavity for high current electron beam acceleration and 450 MHz spoke cavity for low energy proton acceleration. Vertical tests of the cavities indicate that the cavities show good performances and can be used for superconducting accelerators. The gradient of a 9-cell TESLA type cavity with end groups (PKU3) reaches 28.6 MV/m. To promote the industrialization process in China, a new company, Ningxia Orient Superconductor Technology Co., Ltd., was founded jointly by Ningxia OTIC and Peking University in 2011. The goal of this company is to produce various types of superconducting cavities and pure niobium materials with high quality.

FRIOB02

RF and Beam Test of the DC-SRF Injector of PKU-SETF

F. Zhu, J.E. Chen, J.K. Hao, L. Lin, K.X. Liu, S.W. Quan, K. Zhao (PKU/IHIP)

DC-SRF photocathode injector developed by Peking University is a good candidate for obtaining high average current, low emittance, short electron beam pulse. Much progress has been made on the 3.5-cell cavity DC-SRF injector since SRF2009. The assembling of the cryomodule was completed with the 3.5-cell SRF cavity which has an accelerating gradient of 23.5MV/m in the vertical test. The preliminary RF experiment has been carried out soon after the installation and commissioning of 2K cryogenic system was finished. The accelerating gradient of the cavity is 11.5MV/m in a horizontal cold test and the Qext is 6×10^6 . The limitation of the gradient is mainly from our present low RF power source. Higher gradient is expected with a new 20kW solid state RF power source which will be delivered to Peking University soon. The result of preliminary beam loading test of the DC-SRF injector will also be presented in this paper.

Chinese Plan for ADS and CSNS

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High intensity proton accelerator now has two major applications in China: one is Accelerator Driven Subcritical System for nuclear waste transmutation and another is spallation neutron source. A basic research program on ADS started in 2000 in China. Recently a Chinese roadmap for long-term development of ADS was proposed by Chinese Academy of Sciences and the first budget of about $260M has be approved for ADS key technology R&D. It includes a CW proton linac consisting of a room-temperature RFQ and superconducting spoke cavities. The ADS R&D program started in the first half of 2011. The almost same amount of budget has also been approved for the project of China Spallation Neutron Source(CSNS) and it is going to be launched in September 2011. CSNS accelerator consists of a room-temperature H^- linac and a rapid-cycling synchrotron with beam power of 100kW. It will be upgraded to 500kW beam power in future by adding some superconducting cavities to the linac. So superconducting RF accelerator technology becomes a major research direction in high intensity proton accelerator field in China. This paper will introduce these two programs and present the related R&D actives.

FRIOB03

SRF Accelerator for Indian ADS Program: Present & Future Prospects

P. Singh (BARC)

Accelerator Driven Systems (ADS) have evoked lot of interest the world over because of their capability to incinerate the MA (minor actinides) and LLFP (long-lived fission products) radiotoxic waste and utilization of Thorium as an alternative nuclear fuel. One of the main sub-systems of the ADS is a high energy and high current CW proton Accelerator. The accelerator for ADS should have high efficiency and reliability and very low beam losses to allow hands-on maintenance. With this criteria, the physics studies has been done for a 1 GeV, 30 mA proton Linac, using NC structures upto 100 MeV followed by Superconducting elliptical cavities, which accelerate the beam from 100 MeV to 1 GeV. We are also studying the configuration where superconducing spoke resonators are used to accelerate the proton beam from 3-200 MeV followed by elliptical cavities for 200 MeV to 1 GeV .

FRIOB04

Crab Crossing for LHC Upgrade

R. Calaga (BNL)

The LHC luminosity upgrade aims at reducing the collision point betas by a factor of 2-3 of the design value. Consequently the Piwinski angle is increased well beyond 1 to keep a normalized beam separation in the common focusing channels, thus diminishing the benefit of the beta* reduction. Crab cavities will not only recover this luminosity loss but also enable luminosity levelling, a vital ingredient for the upgrade. The baseline scenario for a crab crossing implementation in the LHC, primarily focusing on the RF cavity development is presented. Constraints from aperture, impedance and machine protection are also highlighted.

FRIOB05

FRIOB06

The ESS Accelerator

M. Lindroos (CERN) S. Peggs (ESS)

In 2003 the joint European effort to design a European Spallation Source resulted in a set of detailed design reports. Lund was agreed as the site in 2009. A company, ESS AB, has been created to design, build and operate ESS. A collaboration has been formed for the accelerator work and an update project has been agreed and financed. Detailed planning for the prototyping in a Prepare-to-build (P2B) project has also started. The current status of the Design Update project for the accelerator will be presented, together with an outline of future work. The baseline for the updated design delivers 5 MW of 2.5 GeV protons to a single target, in 2.86 ms long pulses with a 14 Hz repetition rate. The linac will have a normal conducting front end with an ion source, an RFQ and a DTL. The superconducting part starts with spoke cavities followed by two families of elliptical cavities. It will be the first time that spoke cavities are used in a major accelerator. Work is being done to optimize the energy efficiency and to make further use of the heat from the cooling water coming out of the facility. Finally, potential future upgrades of power and intensity are considered.
Submitted on behalf of the ESS Accelerator Collaboration

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