

Highlights of SRF2023 conference at Grand Rapids in USA

2023, October 24th

Eiji Kako (KEK)

Outline

1. Overview of SRF2023 Conference
2. SRF Accelerator Facilities
3. SRF Technologies
4. Future Meeting Related to SRF Systems

25-30 June 2023

AMWAY GRAND PLAZA HOTEL
Grand Rapids, Michigan, USA

SRF TOPICS

- Facilities
- Operational Experience and Lessons Learned
- Fundamental Research and Development
- SRF Technology
- Applications

ASSOCIATED EVENTS

- Pre-conference Tutorials (22-24 June 2023)
- Student Program
- FRIB Facility Tour

INTERNATIONAL PROGRAM COMMITTEE

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Michele Bertucci, INFN
Gianluigi Ciovati, JLAB
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Kexin Liu, PKU
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Naruhiko Sakamoto, RIKEN & SRF25 Conference Chair
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Ting Xu - LOC Chair • Hiroyuki Ao • Wei Chang • Chris Compton
Walter Hartung • Sang-hoon Kim • Taro Konomi • Sam Miller
Alexander Plastun • Laura Popielarski • Yoshishige Yamazaki • Hao Yue



Participants in SRF2023

Conference Statistics

The participants has been almost in the normal status, if taking account many Chinese and Indian cancelled by Visa issue.

Year	Location	Host	Participants	Countries
2023	Grand Rapids	FRIB/MSU	271	34
2021	Virtual	FRIB/MSU	416	19
2019	Dresden	HZDR	332	17
2017	Lanzhou	IMP	372	32
2015	Whistler	TRIUMF	>350	

Statistics in Invited Oral Talk

- 6 talks from Asia were replaced by NA/EU talks due to Visa application issue.
- However, resultant distribution is within a scatter in previous conferences

	SRF15	SRF17	SRF19 (proposal)	SRF23
NA	34 (53.1%)	31 (47.7%)	47.4%	36 (53.7%)
EU	19 (29.7%)	18 (27.7%)	35.3%	17 (25.4%)
Asia	11 (17.2%)	16 (24.6%)	17.3%	14 (20.9%)

Program of SRF2023

Time	Jun 24 (Sat)	Time	Jun 27 (Tue)	Time	Jun 28 (Wed)	Time	Jun 29 (Thu)	Time	Jun 30 (Fri)
8:00-8:30	Opening Kang Suo, SRF2023 Chair, MSU, USA	8:00-8:30	Twenty Years of Cryogenic Operation of the First Superconducting RF Accelerator, 1997 Michael, USA	8:00-8:30	The Frequency Shift and Q of Superconducting RF Cavities Hiroaki, Japan; Lounis, France; Sato, University	8:00-8:30	Development of 2.5 GHz off-Coupled 4-Cell RF Cavity Hiroaki, Japan; Lounis, France; Sato, University	8:00-8:30	RF R&D for PHL: Super-Grave Upgrade with High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
8:30-9:00	Welcome Address Thomas, Chairman, PAC, USA; MSU, USA	8:30-9:00	The HLSS 2020-4 Upgrade Project Lounis, France	8:30-9:00	"Temperature Response of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	8:30-9:00	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	8:30-9:00	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
9:00-9:30	Meeting Session 1 Chair: Alex, CERN, France	9:00-9:30	HLSS 2020-4 Upgrade Project Lounis, France	9:00-9:30	"Surface Roughness Reduction and Performance Improvement of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	9:00-9:30	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	9:00-9:30	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
9:30-10:00	HLSS Transition to User Operation Project Summary, and Upgrade Project Lounis, France	9:30-10:00	HLSS 2020-4 Upgrade Project Lounis, France	9:30-10:00	"Surface Roughness Reduction and Performance Improvement of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	9:30-10:00	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	9:30-10:00	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
10:00-10:30	Status of HLSS Superconducting RF Cavity Lounis, France	10:00-10:30	HLSS 2020-4 Upgrade Project Lounis, France	10:00-10:30	"Surface Roughness Reduction and Performance Improvement of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	10:00-10:30	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	10:00-10:30	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
10:30-11:00	Progress in the HLSS Superconducting RF Cavity Lounis, France	10:30-11:00	HLSS 2020-4 Upgrade Project Lounis, France	10:30-11:00	"Surface Roughness Reduction and Performance Improvement of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	10:30-11:00	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	10:30-11:00	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
11:00-11:30	Coordinating and Final Operation of HLSS 2020-4 Lounis, France	11:00-11:30	HLSS 2020-4 Upgrade Project Lounis, France	11:00-11:30	"Surface Roughness Reduction and Performance Improvement of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	11:00-11:30	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	11:00-11:30	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
11:30-12:00	Contributing to the Second HLSS Cryogenic and Performance Improvement of HLSS 2020-4 Lounis, France	11:30-12:00	HLSS 2020-4 Upgrade Project Lounis, France	11:30-12:00	"Surface Roughness Reduction and Performance Improvement of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	11:30-12:00	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	11:30-12:00	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
12:00-12:30	Status of HLSS and Cryogenic Improvement of HLSS 2020-4 Lounis, France	12:00-12:30	HLSS 2020-4 Upgrade Project Lounis, France	12:00-12:30	"Surface Roughness Reduction and Performance Improvement of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	12:00-12:30	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	12:00-12:30	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
12:30-1:00	Coffee Break	12:30-1:00	Coffee Break	12:30-1:00	Coffee Break	12:30-1:00	Coffee Break	12:30-1:00	Coffee Break
1:00-1:30	Coffee Break	1:00-1:30	Coffee Break	1:00-1:30	Coffee Break	1:00-1:30	Coffee Break	1:00-1:30	Coffee Break
1:30-2:00	Meeting Session 2 Chair: Alex, CERN, France	1:30-2:00	HLSS 2020-4 Upgrade Project Lounis, France	1:30-2:00	"Surface Roughness Reduction and Performance Improvement of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	1:30-2:00	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	1:30-2:00	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
2:00-2:30	Status of HLSS and Cryogenic Improvement of HLSS 2020-4 Lounis, France	2:00-2:30	HLSS 2020-4 Upgrade Project Lounis, France	2:00-2:30	"Surface Roughness Reduction and Performance Improvement of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	2:00-2:30	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	2:00-2:30	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University
2:30-3:00	HLSS 2020-4 Upgrade Project Lounis, France	2:30-3:00	HLSS 2020-4 Upgrade Project Lounis, France	2:30-3:00	"Surface Roughness Reduction and Performance Improvement of Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	2:30-3:00	RF Performance Results of RF Superconducting RF Cavity for LHC High Luminosity Project Lounis, France	2:30-3:00	Acceleration for High Performance Surface Materials, 2018 Hiroaki, Japan; Lounis, France; Sato, University

13:00-13:30	HLSS 2020-4 Upgrade Project Lounis, France	13:00-13:30	HLSS 2020-4 Upgrade Project Lounis, France	13:00-13:30	HLSS 2020-4 Upgrade Project Lounis, France	13:00-13:30	HLSS 2020-4 Upgrade Project Lounis, France	13:00-13:30	HLSS 2020-4 Upgrade Project Lounis, France
13:30-14:00	HLSS 2020-4 Upgrade Project Lounis, France	13:30-14:00	HLSS 2020-4 Upgrade Project Lounis, France	13:30-14:00	HLSS 2020-4 Upgrade Project Lounis, France	13:30-14:00	HLSS 2020-4 Upgrade Project Lounis, France	13:30-14:00	HLSS 2020-4 Upgrade Project Lounis, France
14:00-14:30	HLSS 2020-4 Upgrade Project Lounis, France	14:00-14:30	HLSS 2020-4 Upgrade Project Lounis, France	14:00-14:30	HLSS 2020-4 Upgrade Project Lounis, France	14:00-14:30	HLSS 2020-4 Upgrade Project Lounis, France	14:00-14:30	HLSS 2020-4 Upgrade Project Lounis, France
14:30-15:00	HLSS 2020-4 Upgrade Project Lounis, France	14:30-15:00	HLSS 2020-4 Upgrade Project Lounis, France	14:30-15:00	HLSS 2020-4 Upgrade Project Lounis, France	14:30-15:00	HLSS 2020-4 Upgrade Project Lounis, France	14:30-15:00	HLSS 2020-4 Upgrade Project Lounis, France
15:00-15:30	HLSS 2020-4 Upgrade Project Lounis, France	15:00-15:30	HLSS 2020-4 Upgrade Project Lounis, France	15:00-15:30	HLSS 2020-4 Upgrade Project Lounis, France	15:00-15:30	HLSS 2020-4 Upgrade Project Lounis, France	15:00-15:30	HLSS 2020-4 Upgrade Project Lounis, France
15:30-16:00	HLSS 2020-4 Upgrade Project Lounis, France	15:30-16:00	HLSS 2020-4 Upgrade Project Lounis, France	15:30-16:00	HLSS 2020-4 Upgrade Project Lounis, France	15:30-16:00	HLSS 2020-4 Upgrade Project Lounis, France	15:30-16:00	HLSS 2020-4 Upgrade Project Lounis, France
16:00-16:30	HLSS 2020-4 Upgrade Project Lounis, France	16:00-16:30	HLSS 2020-4 Upgrade Project Lounis, France	16:00-16:30	HLSS 2020-4 Upgrade Project Lounis, France	16:00-16:30	HLSS 2020-4 Upgrade Project Lounis, France	16:00-16:30	HLSS 2020-4 Upgrade Project Lounis, France
16:30-17:00	HLSS 2020-4 Upgrade Project Lounis, France	16:30-17:00	HLSS 2020-4 Upgrade Project Lounis, France	16:30-17:00	HLSS 2020-4 Upgrade Project Lounis, France	16:30-17:00	HLSS 2020-4 Upgrade Project Lounis, France	16:30-17:00	HLSS 2020-4 Upgrade Project Lounis, France
17:00-17:30	HLSS 2020-4 Upgrade Project Lounis, France	17:00-17:30	HLSS 2020-4 Upgrade Project Lounis, France	17:00-17:30	HLSS 2020-4 Upgrade Project Lounis, France	17:00-17:30	HLSS 2020-4 Upgrade Project Lounis, France	17:00-17:30	HLSS 2020-4 Upgrade Project Lounis, France
17:30-18:00	HLSS 2020-4 Upgrade Project Lounis, France	17:30-18:00	HLSS 2020-4 Upgrade Project Lounis, France	17:30-18:00	HLSS 2020-4 Upgrade Project Lounis, France	17:30-18:00	HLSS 2020-4 Upgrade Project Lounis, France	17:30-18:00	HLSS 2020-4 Upgrade Project Lounis, France

- Facility (16)
- Fundamental R&D (18)
- SRF Technology (24)
- SRF Application (8)
- Keynote (1)

Oral Talk

Feature of SRF2023:

- Cavity category was merged into the SRF Technology
- Set a new category: SRF Application
the program becomes variety and exciting, but schedule was little bit tight.
- Invited three talks from companies

Talks	SRF13	SRF15	SRF17	SRF19	SRF23
Sum	64	64	65	60	67
Facility	13	15	15	14	16
Fundamental R&D	21	19	20	20	18
SRF Technology	28	29	28	24	24
SRF Application	0	0	0	0	8
Keynote	2	1	2	2	1

FRIB Facility for Rare Isotope Beams
U.S. Department of Energy Office of Science
Michigan State University

SRF2015, IPC Meeting, Slide 5

Total 67 Invited Oral Talks

Oral Session of Invited Talks





Proceedings of SRF2023



SRF2023 - Proceedings
Grand Rapids, MI, USA
- Pre-Press Publication 30-June-2023 14:00 UTC -

[SRF2023 Home-page](https://srf2023.vrws.de/index.html)

<https://srf2023.vrws.de/index.html>

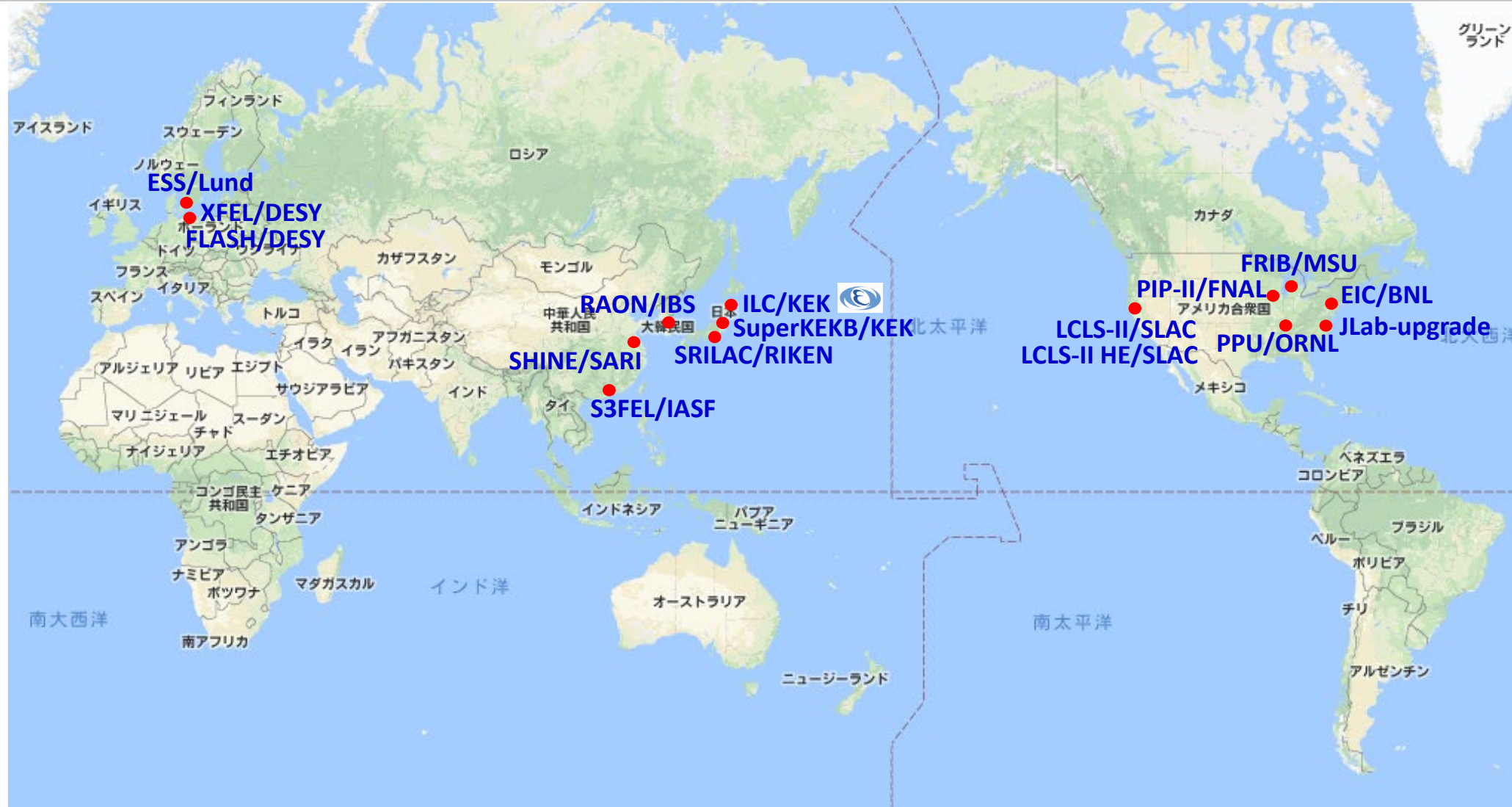
Around 250 Participants

MOIAA	Facility I
MOIXA	Facility II
MOPMB	Monday Poster Session
TUIAA	Facility III
TUCAA	Facility IV
TUIBA	Fundamental R&D I
TUCBA	Fundamental R&D II
TUIXA	SRF Technology I
TUCXA	SRF Technology II
TUPTB	Tuesday Poster Session
TUCTA	Commemorative Talks
WEIAA	SRF Application I
WECAA	SRF Application II
WECBA	Fundamental R&D III
WEIBA	Fundamental R&D IV
WEIXA	Fundamental R&D V
WEPWB	Wednesday Poster Session
WEKEA	Keynote
THIAA	SRF Technology III
THCAA	SRF Technology IV
THIXA	SRF Technology V
FRIBA	SRF Technology VI
FRVIA	SRF Technology VII

Click on an Session to display a list of papers.



SRF Facility Talks in SRF2023



SRF Facility (1): FRIB/MSU, USA



FRIB transition to user operations, power ramp up, and upgrade perspectives

Jie Wei

On Behalf of FRIB Accelerator Team & Collaboration

SRF 2023, Grand Rapids, June 26, 2023

MICHIGAN STATE
UNIVERSITY

U.S. DEPARTMENT OF
ENERGY | Office of
Science

This material is based upon work supported by the U.S. Department of Energy Office of Science under Cooperative Agreement DE-SC0000061.
Michigan State University designs and establishes FRIB as a DOE Office of Science National User Facility in support of the mission of the Office of Nuclear

FRIB

- Beam Power: starting at 1 kW, current operation at 5 kW, working toward to 400 kW.
- Upgrade of Beam Energy: 400 MeV/u, 11 cryomodules, 644 MHz, 5-cell cavity ($\beta=0.65$)

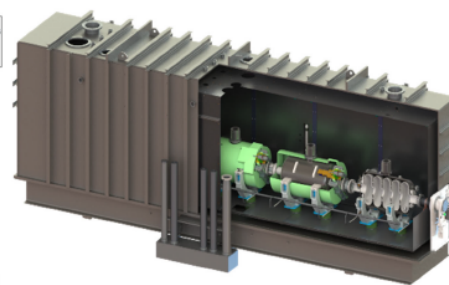
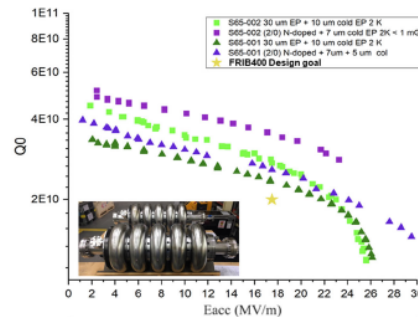
FRIB Technical Construction 2014 – 2022 World's Highest Energy Heavy Ion Linac / CW Hadron Linac



FRIB driver linac in accelerator tunnel

FRIB400: Extend Scientific Reach and Discovery Potential

- Doubles linac beam energy (to 400 MeV/u for uranium) by adding 11 cryomodules, each containing 5 ($\beta = 0.65$) cavities at 644 MHz
 - Filling reserved slots in FRIB tunnel
 - Expanding cryo-distribution
- R&D and design in progress



FRIB Facility for Rare Isotope Beams
U.S. Department of Energy Office of Science
Michigan State University

J. Wei, SRF2023 MOIAA01, Slide 26

Summary

- FRIB has been operating for a year, delivering beams for both scientific and industrial experiments with the desired reliability and availability
- The primary beam power has been steadily raised from 1 to 5 kW. In subsequent years, the beam power will be progressively increased as operational experience is accumulated, working toward 400 kW
- Accelerator improvement projects, capital equipment investments, and R&D projects are in progress to renovating legacy systems and maintain high availability during the beam power ramp-up
- Work is proceeding in preparation for future upgrades, including a doubling of the primary beam energy to 400 MeV/u to enhance the scientific reach of the facility

FRIB Facility for Rare Isotope Beams
U.S. Department of Energy Office of Science
Michigan State University

J. Wei, SRF2023 MOIAA01, Slide 29

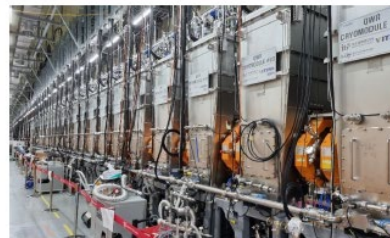
SRF Facility (2): RAON/IBS, Korea

Status of RAON Superconducting Linac at IBS

June. 26, 2023
SRF2023 Grand Rapids

Yeonsei Chung
on behalf of IRIS(Institute for Rare Isotope Science)

Superconducting Linac, SCL3 Tunnel and Gallery



QWR & HWR Cryomodule



Cryogenic Distribution to Cryomodule



Clean beam line assembly



CM/Cryogenic Control Rack and SSPA

Installation completion and ready for beam commissioning in 2021

Summary & Outlook

- **Injector beam commissioning was carried out, achieving machine setting and key measurements :**
 - measured beam parameters (energy, emittance, Twiss parameters, beam sizes etc)
 - capable of controlling LEPT and MEPT beam optics freely as needed
 - achieved beam transmission of 95% max (routinely > 90%)
 - machine verification including diagnostics devices
- **Linac(SCL3) beam commissioning**
 - 1st/2nd beam commissioning using 22 QWRs were successfully done
 - beam commissioning of HWR section was done in May 2023
 - delivered Ar(9+) beams to KoBRA target, then RI beams produced
- **Plan for SIB/RIB experiments**
 - RIBs from ISOL will be injected into SCL3/Injector in Q4 of 2023
 - SIB experiments(ECR→SCL3 → KoBRA/NDPS) is planned in 2024
- **Plan for SCL2 linac construction**
 - CM(SSR1, SSR2) R&D project : 2022.12~2025.12
 - SCL2 construction is expected to begin in 2026

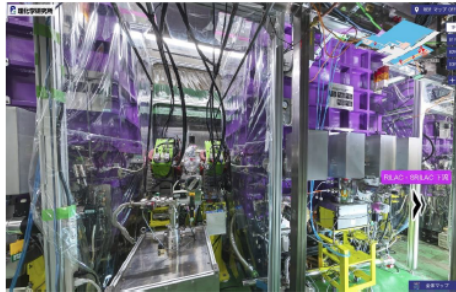
RAON

- Beam Energy = 17.6 MeV/u
- R & D of SC2 linac: 2022-2025 Dec.
- SCL2 construction 2026~

SRF Facility (3): SRILAC/RIKEN, Japan



Operational Experience for RIKEN Superconducting Linear Accelerator



Kazunari Yamada

SRILAC-RIKEN

- 345 MeV/u, 73.0 MHz, beta=0.078, 4.5 K,
- Differential vacuum pumping system
- 4 years operation, 90% availability
- Cryogenics: 600 W at 4.5 K
- X-ray: remarkably increase for 3 years
- Pulsed conditioning: 20 ms, 0.5 Hz, good effect
- 10 new couplers,
- 2 spare QWR cavities

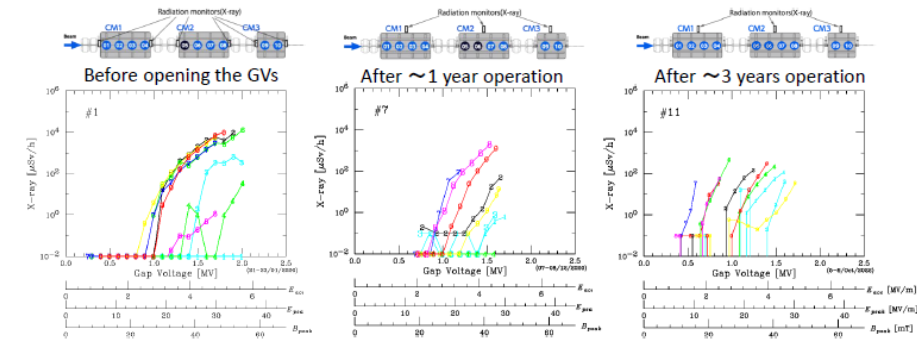
Summary

- SRILAC has been in actual operation for 4 years.
- Availability of the SRILAC part is over 99%.
- Beam tuning time is getting shorter.
- Pulse conditioning recovered the performance degradation caused by field emissions.
- The problem of helium pressure fluctuations still remains.
- New couplers and cavities are being prepared.

See you at the SRF2025 in Tokyo!

Degradation of SC-QWR performance

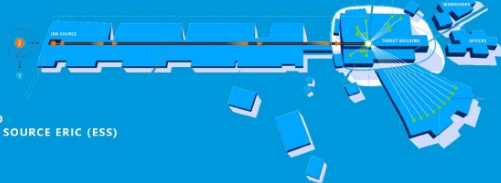
- After an impact of SC06 coupler-window-break emission levels of SC07, SC08 became higher than those of the measurement #1.
- The deterioration of SC05, 06, 07, and 08 (CM2) is significant.
- X-ray emissions were gradually increasing in the CM1 and CM3 after 3 years.
- Increase in the emissions occurs suddenly during beam delivery.
- No events such as increased beam loss or gate valve opening/closing at this time.



SRF Facility (4): ESS/Lund, Sweden

Progresses in the ESS Superconducting Linac Installation

**SRF 2023
GRAND
RAPIDS**
HENRY PRZYBILSKI, CM INSTALLATION LEAD
ON BEHALF OF THE EUROPEAN SPALLATION SOURCE ERIC (ESS)
2023-06-26, SRF 2023, GRAND RAPIDS
MOIAAB3



ESS

- 2025 first commissioning
- 2027 first science
- 13 Spoke CM, 9 Medium beta CM, 27 High beta CM
- Installation 2 CM/months

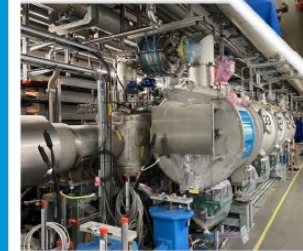
Installation in the ESS tunnel

Transport and positioning

ELL CM07 on its support



SPK CM04



ELL CM07 transport



Installation in the ESS tunnel

"Lessons learned"

The good installation procedure /
sequence / tooling

Elliptical cryomodule (TS2 experience)

- Jumper DN450 bellows
- Process pipe cups / 1 leak found
- Waveguide connections

Spoke cryomodule

- Process pipe cups
- Doorknob assembly
- Access / clashes

Preparing the series installation

Getting ready to install 2 CM/month



2023-06-26 PROGRESSES IN THE ESS SUPERCONDUCTING LINAC INSTALLATION

22

SRF Facility (5): LCLS-II/SLAC, USA

Commissioning and First Operation of the LCLS-II Linac

Dan Gonnella, SC-Linac-Physics Department Head
On behalf of the LCLS-II Collaboration

26 June 2023

SLAC NATIONAL
ACCELERATOR
LABORATORY

Cryomodule Installation

Last CM (spare) Delivered in May 2021



SLAC D. Gonnella, LCLS-II Commissioning

CM Installation Complete
February 2021



For more details see D. White MOPMB089

SC Linac Commissioning Accomplishments & Remaining Tasks

Linac Commissioning

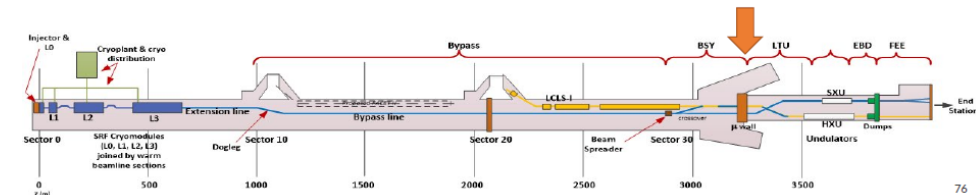
- ✓ Established the **first-time beam through the three main SC linac sections (L1B, L2B, and L3B)** in October 2022
- ✓ **3.5 GeV beam** transported to BSY dump in November 2022
- ✓ **Record injector performance** has been demonstrated
- ✓ Demonstration of **repetition rate of 93 kHz** in June 2023

Photon Commissioning

1. Beam transport to undulator halls
2. First photons

Estimate to complete August 2023

Current beam
commissioning progress



Summary

- Commissioning of the LCLS-II linac has progressed very well
- Cavity performance has been excellent with **NO DEGRADATION FROM INSTALLATION**
- Average Q_0 exceeds the LCLS-II specification and demonstrates **high- Q_0 in an installed linac for the first time**
- All linac commissioning milestones have been met, estimate to reach first light by the end of the summer
- This is only the beginning...

SLAC D. Gonnella, LCLS-II Commissioning

30

LCLS-II

- 2/6 Nitrogen Doping
- 35 CM, 280 9-cell cavities
- Degauss in tunnel for higher Q_0
- Microphonics less than 10 Hz
- 3.5 GeV beam energy, target 4.0 GeV
- 2023 August, Complete, first light

SRF Facility (6): LCLS-II HE/SLAC, USA

Status of Cavity and Cryomodule Production for LCLS-II-HE

Mattia Checchin on behalf of LCLS-II-HE project
Deputy Cryomodule Systems Manager
LCLS-II-HE project

26 June 2023

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Stanford
University
U.S. DEPARTMENT OF
ENERGY

HE vs LCLS-II CM test: field emission

LCLS-II-HE

- 15.0% of cavities with FE during CM test (6 cavities out of 40)
- Average onset: 16.03 ± 3.8 MV/m
- Admin limit 26 MV/m

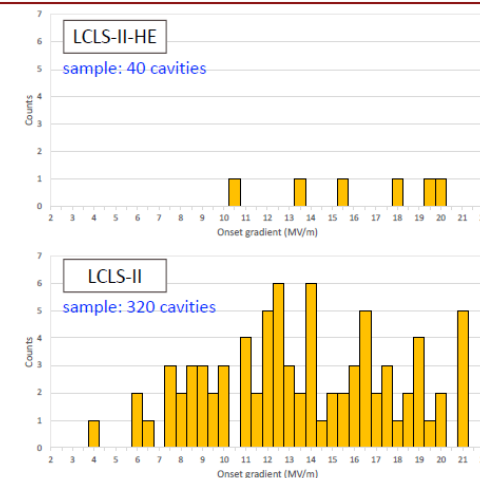
LCLS-II

- 25.3% of cavities with FE during test CM (81 cavities out of 320)
- Average onset: 13.4 ± 4.3 MV/m
- Admin limit 21 MV/m

FE-free qualification criteria outcome

- 10.3% less FE cavities in CM testing than LCLS-II

SLAC M. Checchin | SRF 2023, Grand Rapids, MI



Conclusions

Cavities qualification is proceeding without obstacles

- In average, cavities outperform VT qualification criteria
 - New surface processing is delivering the expected results
 - Material segregation by heat lot good practice to maintain high-Q in CM testing

CM assembly and test are underway

- In average, the CMs tested so far outperform LCLS-II-HE specifications
 - Average voltage: 202.6 MV
 - Average Q_0 : 3.0×10^{10} @ 173 MV
- 15% of cavities are field-emitting in CM testing
 - FE-free qualification criteria in VT is delivering the expected results

SLAC M. Checchin | SRF 2023, Grand Rapids, MI

30

LCLS-II HE

- 35 CM (280 cavities) + 23 CM (184 cavities) = 8 GeV
- CM installation 2025-2026
- 2/6 -> 2/0 doping
- Mixed 900/950 oC HT
- FE 26%, 65% after HPR

Commissioning of the 2nd JLAB C75 Cryomodule

& Performance Evaluation
of Installed C75 Cavities

M. McCaughan; G. Ciovati;
K. Davis; M. Drury; T. Powers;
A. Reilly

Monday, June 26, 2023

Jefferson Lab



Types of Cavities / Cryomodules:

		Types of Cavities / Cryomodules:			
		C20 String		C50 String	
Parameter	Unit	C20 (Orig. CEBAF/Cornell)	C50 (Refurbished)	C100 (Low Loss)	C75 (High Current)
Number of cells		5	5	7	5
L act	M	0.4999	0.4999	0.7	0.4916
Energy gain/CM (design)	MeV	20	50	100	75
Eacc/cavity (design)	MV/m	5	12.5	17.86	19.07
Q ₀ at 2.07 K		> 2.4e9	4.6e9	7.2e9	8.0e9
Q _{ext} /FPC spec		6.6e6 (± 20%)	8.0e6 (± 25%)	3.2e7 (± 20%)	2.0e7 (± 15%)
R/Q	[UeF ² /(ω*W)]	482.5		868.9	525.4
R/Q per cell	Ω	96.5		124.1	105.1

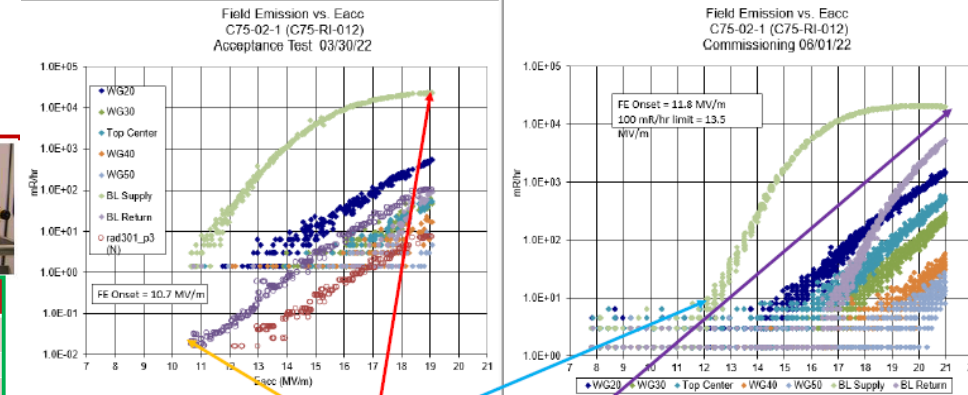
F. Marhauser et al., "C75 Cavity Specifications and Commissioning of the Prototype Cavity Pair", JLAB-TN-17-055, 12/6/17
SRF 2023

2

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Cavity Performance: Field Emission

GM Detectors @ FPCs and
fore and aft of the module.



Summary

- C75s cost-efficient & novel use of large grain boundary ingot Nb. Process industrialized with RI & CBMM.
- Enhanced gradient over legacy C50 program very helpful for the purposes of the CEBAF Performance Plan (CPP) and establishing / maintaining 12 GeV energy reach.
- Circulators limit primary barrier preventing installed C75 zones from operating at potential; remedying now – gradient limits & microphonics studies will be revisited.
- Steady state operational data and any possible performance degradation data (if it exists) will be extracted over next year+ and studied.
- C20 to C75 refurbishment schedule planned to continue at ~2 modules/year through at least C75-10.

A. Freyberger et al., The 12 GeV CEBAF Performance Plan; V. 1.1, JLAB-TN-17-022, 19 June 2017
SRF 2023

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JLAB upgrade

- Eacc = 19.07 MV/m, Q₀ = 8 x 10⁹
- T = 1 mm cryoperm, < 10 mG
- LG Nb, from CBMM ingot, fabrication by RI
- C100: Low loss – 7-cell, C75: High current- 5-cell
- X-rays > 14 MV/m

SRF Facility (8): PIP-II/FNAL, USA



PIP-II Overview and Status

Rich Stanek, Project Director
for the PIP-II Team
SRF 2023 MOXA02

PIP-II is a partnership of:

- US-DOE
- India-DAE
- Italy-INFN
- UK-STFC-UKRI
- France-CEA, CNRS/IN2P3
- Poland-WUST, WUT, TUL

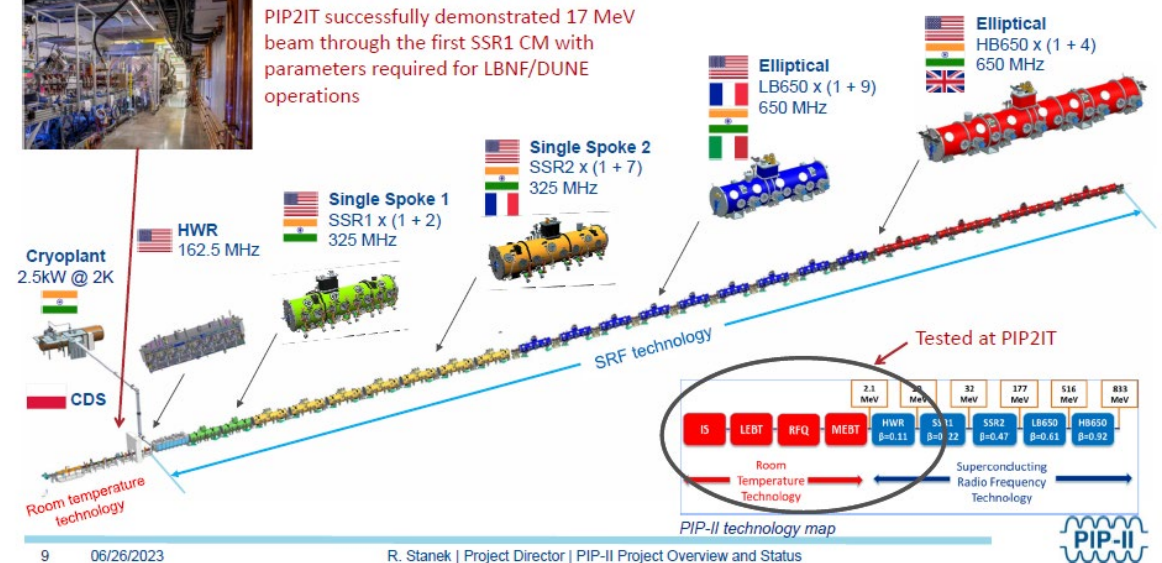
PIP-II

- 800 MeV, H- beam, 1.2 MW beam power
- 20 Hz, 1 mA
- HWR 162.5MHz, Spoke-1 325MHz, Spoke-2 325MHz, LB 650MHz, HB 650MHz
- LB650 CM by CEA-Saclay, HB650 CM by UKRI

Linac Scope



PIP2IT successfully demonstrated 17 MeV beam through the first SSR1 CM with parameters required for LBNF/DUNE operations

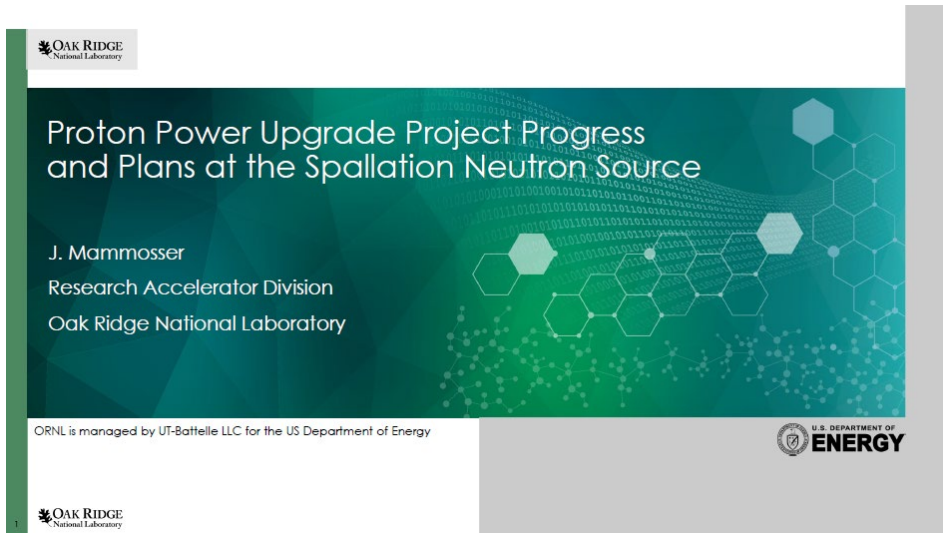


Summary

- PIP-II Team is working very well together
 - Partners are engaged and committed to delivering their components
- PIP-II experienced unprecedented turnover in the management team but we have rebuilt and now have a strong, experienced team in place
- Technical progress at both Fermilab and Partners has been good
 - Contracts for key components are being executed and parts delivered
 - Moving closer to cryomodule production

Project execution is underway, our technical teams are talented and motivated to deliver the PIP-II Project

SRF Facility (9): PPU/ORNL, USA



PPU-ORNL

- Beam power: 1.4 MW to 2.8 MW
- Beam energy: 1.0 GeV to 1.3 GeV,
- +7 CM (32 cavities by RI)
- 60 Hz, 27 mA
- 2022' 2 CM, 2023' 2 CM, 2024' 3 CM
- No HOM coupler
- 2.1 K, 16 MV/m, $Q_0 > 1 \times 10^{10}$
- Multipacting: 11~15 MV/m

Cryomodule receiving testing and installation:



Conclusion

- PPU Project is now 80% complete going extremely well with only one remaining down for installation of equipment and remaining civil construction
- The PPU cryomodules, ring magnets and target system upgrades are underway with good progress
 - **Installed equipment is functioning at design specifications**
- Thanks to our Partner Labs and Industrial Vendors, PPU is on track due to the excellent collaborations

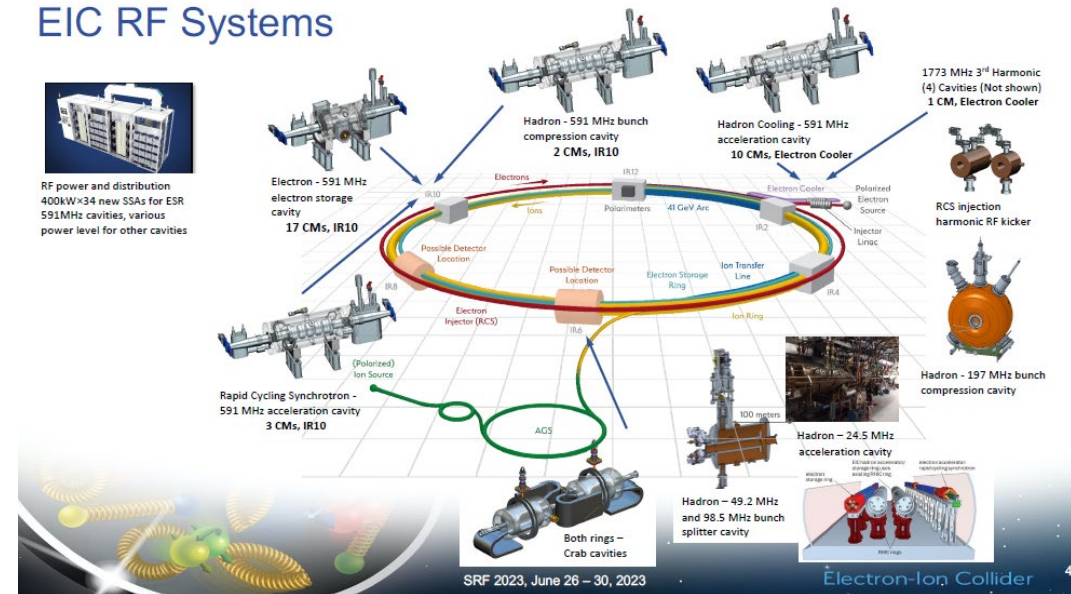
SRF Facility (10): EIC/BNL, USA



EIC project

- 197 MHz QWR SRF-Gun
- ESR 591 MHz 1-cell cavity with 2 FPC: 3.7 MV, 800 kW per cavity
- 591 MHz, 400 kW SSA
- 61 kW HOM power, RT water cooling, SiC cylinder
- FPC: 1 MW TW, 500 kW full reflection, window brazing test
- 197 MHz Crabbing cavity, 394 MHz RFD Carb cavity
- Crab cavity cryomodule design: press forming R&D
- Prototyping of 591 MHz single-cell cavity and 197 MHz crab cavity
- 60 cavity, 47 cryomodules: last unit installed by 2031

EIC RF Systems



Summary

- FPCs are one of most challenging items in EIC RF/SRF system
- Recent developments on the broadband, high power FPC window for EIC was reported.
- EIC prototype testing in Sept. 2024!

SRF Facility (11): SHINE/SARI, China

Status of SRF activities for SHINE

Jinfang Chen

Shanghai Advanced Research Institute(SARI), Chinese Academy of Sciences

26 June, 2023

25-30 June 2023
AMWAY GRAND PLAZA HOTEL
Grand Rapids, Michigan, USA

SHINE

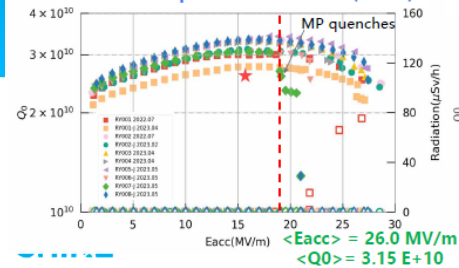
SHINE

- 75 CM, 130 MV/CM
- Two standard CM prototype
- CM2: 6 mid-T baked, 1 N-dope, 1 LG = 136 MV, $Q_0 = 2.44 \times 10^{10}$
- Microphonics < 10 Hz
- Cavity fabrication by HERT+IHEP, OSTEC+PKU, HIT+SARI, RI+DESY
- FPC: 14 KW TW, 7 kW SW in CW
- Dual layer magnetic shield < 5 mG
- Demagnetization of Cryostat
- SHINE tunnel completed

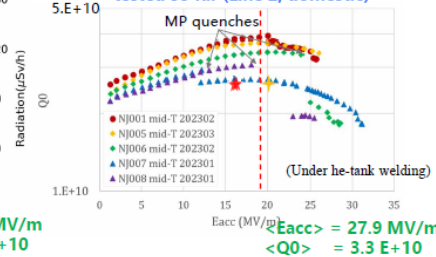
Status of small-batch high-Q cavities

- International cavities (RI and ZANON): N-doping, 3/60 recipe applied
- Domestic cavities (~half half): N-doping and mid-T baking
- So far, **two production lines have been qualified** by small batch cavities: One international and one domestic.
- Cavities of the other two lines are underway (surface treatment and waiting for VT)

All the 8 N-doped dressed cavities (Line 1)



All the mid-T baked bare cavities tested so far (Line 2, domestic)



SUSPB039,
Yue Zong et al.

14/28

Fundamental Power Coupler and HOM absorber

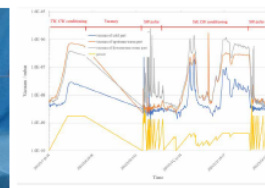
- 30 1.3 GHz FPC prototypes have been manufactured and power conditioned with 14-kW traveling wave (TW) and 7-kW standing wave (SW) in CW mode.

- The first two 3.9 GHz FPCs have been fabricated, surface treated, vacuum baked and power conditioned with 2.2-kW TW and 2-kW SW in CW mode.
- The first two beam line HOM absorber prototypes with silicon carbide material have been designed, fabricated, and preliminary tested.

Poster WEPWB102,
Zhenyu Ma



SHINE 1.3GHz FPC prototype



1.3GHz FPCs RF conditioning historical curves



3.9GHz FPC prototype sub-assemblies

Summary

- Two standard CM prototypes, have been assembled and tested, reaching their basic goals. Accelerating voltage >128 MV, and high-Q are preserved in horizontal test. Further optimization and iteration are in plan.
- SRF key components and technology of cryomodule have been developed through prototypes, including high-Q cavity, FPC, magnetic shielding, tuner, SCQ, cBPM, SSA etc. Many new suppliers are qualified.
- Both N-doping and mid-T baking technologies have been realized with SHINE facilities and applied on small batch production, bringing good performance. Recipe for the domestic medium-batch cavities will be chosen soon.
- SRF infrastructures for cavity surface-treatment, CM assembly and test have been built and put into operation. Further construction to improve production capacity is expected to complete within 2023.
- Up to now, around 1/3 of the SHINE CM components have been contracted and under fabrication.
- CMs for injector are under assembly, aiming to install in the beginning of 2024.
- Many progresses, but also many challenges

SHINE

SRF Facility (12): S3FEL/IASF, China

Shenzhen Superconducting Soft-X-Ray Free Electron Laser (S³FEL)

Weiming Yue (on behalf of Weiqing Zhang)

S³FEL team

深圳综合粒子设施研究院
Institute of Advanced Science Facilities, Shenzhen

SRF cavity overview for S³FEL



26 × 1.3 GHz CM



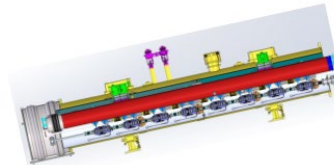
208 × 1.3 GHz Cavity



208 × 1.3 GHz Coupler



208 × 1.3 GHz tuner



2 × 3.9 GHz CM



16 × 3.9 GHz Cavity



16 × 1.3 GHz Coupler



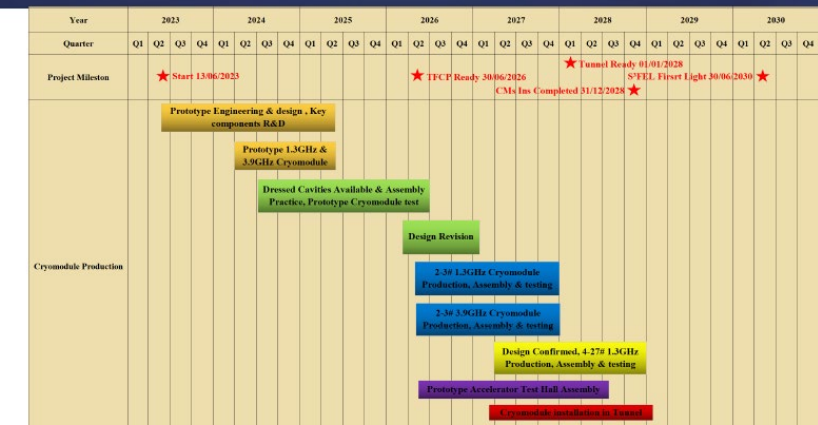
16 × 1.3 GHz tuner

June.27, 2023, SRF2023

S3FEL

- 6 years construction period
- 2.5 GeV, approved
- 26 CM, 208 9-cell cavities, Input couplers, tuners
- SRF module Test Facility (SMTF)
- Cooperation with SHINE and IHEP
- 2023 start, 2028 complete

Project Schedule



June.27, 2023, SRF2023

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深圳综合粒子设施研究院
Institute of Advanced Science Facilities, Shenzhen

SRF Facility (13): Super-KEKB/KEK, Japan



Operating Experience of SRF System at High Beam Current in SuperKEKB

Michiru Nishiwaki on behalf of RF group of SuperKEKB

SRF2023 Grand Rapids

June 26, 2023

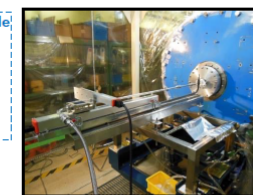
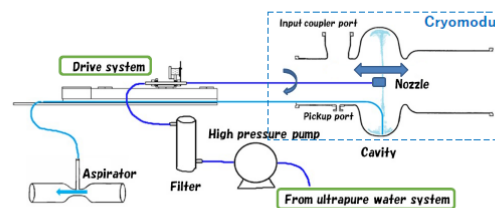
MOIXA05

Super-KEKB

- 8 CM, 508 MHz, beam current = 2.6 A, HOM 37 kW
- FPC: 5×10^4 , CW 400 kW
- Additional SiC HOM absorber:
- In-situ HHPR: 3 CM, recover cavity performance
- MP in cavity, piezo break-down, chiller failure for HOM absorber, trip rate= 0.04-0.07/day

Horizontal High-Pressure Rinse (HHPR) system

- New High-Pressure Rinse (HPR) with ultrapure water system was developed.
- We can apply HPR to the cavity in the cryomodule.
- The system is equipped with automatic nozzle driving system in horizontal and rotational.
- Input coupler and both end groups, including ferrite HOM damper, taper chamber, bellows chamber, ion pump, vacuum gauges and GV, are removed before HHPR in a clean booth.
- Water in the cell is pumped up by aspiration system during rinsing.
- Only cell and iris area are rinsed.



HHPR Parameters	
Water Pressure	7 MPa
Nozzle	$\phi 0.54 \text{ mm} \times 6$
Driving speed	1 mm/sec.
Rotation speed	6 deg./sec.
Rinsing time	15 min.

Stainless Steel Nozzle

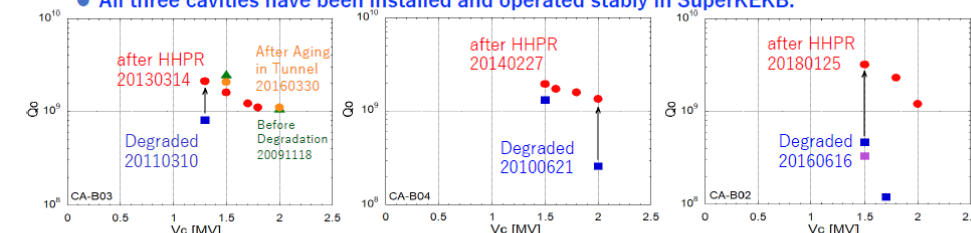


June 26, 2023 (MOIXA05) SRF2023, M.Nishiwaki (KEK), Operating Experience of SRF System at High Beam Current in SuperKEKB

11

Performance Recovery by HHPR

- We have already applied HHPR to three cryomodules degraded by strong FE.
- HHPRed modules were tested with high power at 4K.
- Before cooling, baking were not performed.
- Cavity performances were successfully recovered.
- All three cavities have been installed and operated stably in SuperKEKB.



We are planning to perform the HHPR in the accelerator tunnel. There are many difficulties such as maintaining cleanliness, working in narrow spaces, and supplying ultrapure water. However, it has the great advantage that no extensive work is required to move the cavity out of the tunnel. We will continue R&D.

June 26, 2023 (MOIXA05) SRF2023, M.Nishiwaki (KEK), Operating Experience of SRF System at High Beam Current in SuperKEKB

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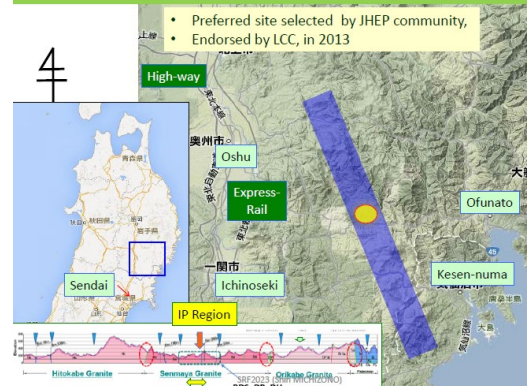
SRF Facility (14): ILC/KEK, Japan

Current Status and Future Technological Collaboration for the ILC

KEK / IDT-WG2
Shin MICHIZONO (KEK)

- Why linear collider?
- Higgs Factory
- Global Collaboration
- ILC Accelerator
 - ILC design
 - Recent Progress
 - Candidate site
- Pre-lab proposal
- Global Project
- ILC Technology Network
- KEK's effort
- Future Upgrade
- Beam dump (industrial application)
- Sustainability
- Summary

ILC Site Candidate Location in Japan: Kitakami



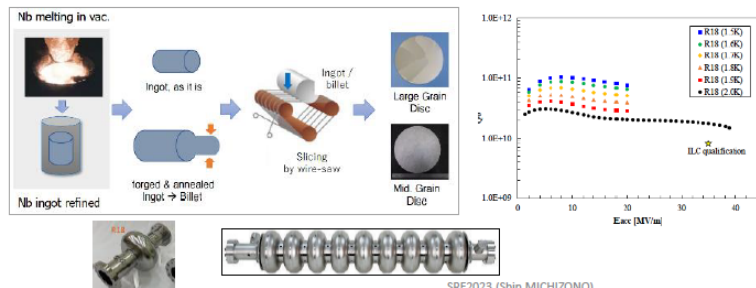
Summary

- ILC is the e-/e+ linear collider for **the Higgs factory**.
- Current global organization is **ILC International Development Teams (IDT)**
- The ILC key technologies of **"SRF"**, and **"Nano-beam"**
 - Matured** to be ready for an e+e- Higgs Factory based on the **Linear Collider** technology.
- ILC is the **global project** like ITER and SKA.
- IDT-WG2 identified important and time-consuming WPs.
- These WPs will be carried out by international collaboration as **"ILC Technology Network"**.
- KEK obtained a budget** for these R&Ds and started the activity from this April.
- New SRF technology (such as **Nb3Sn**, **TW**) can be applied to ILC future upgrade.
- Beam dumps of the ILC are also useful for the industrial application like **"Soft error"** analysis.
- Sustainability** is the also important topics for the large accelerators.

WP-prime 1: SRF Cavity (Scoping the Industrial-Production Readiness)

Referring European XFEL and LCLS-II experiences

- Research with single-cell cavities to establish the **best production process** including:
 - Advanced Nb sheet production method
 - Advanced surface treatment recipe
- Globally common design with **compatible High Pressure Gas Safety (HPGS) regulation**
- 24 nine-cell cavities are to be developed for industrial-production readiness
 - 8 cavities (4 / batch) in each region
 - Production process encouraged to be optimized in each region
 - Cavity performance expected: $E_{acc} = <35 \text{ MV/m}$ (+/- 20%), $Q_0 = 1.0 \times 10^{10}$, Yield = $\geq 90\%$
- RF performance/success yield to be examined (including 2nd pass and further)
 - 3rd pass to be examined if effective

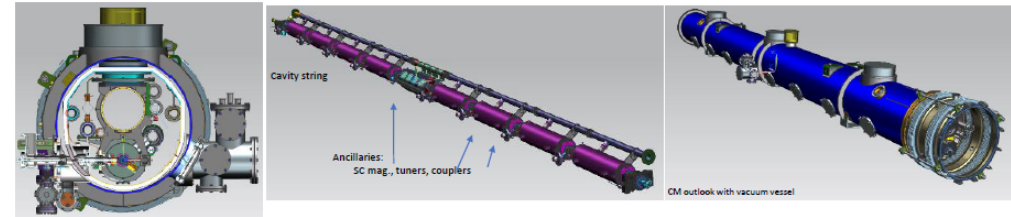


SRF2023 (Shin MICHIZONO)

WP-prime 2: Cryomodule (CM) Design (Scoping the CM Global Transfer and Performance Assurance)

Referring European XFEL and LCLS-II experiences

- Unify cryomodule (CM) design with ancillaries, based on **globally common engineering design**, drawings & data-base
- Establish globally compatible safety design base to be approved/authorized by HPGS regulations individually in each region, most likely referring ASME guidelines to be compatible with Japanese regulations.



Region Regulation	Americas ASME	Europe Eu-EN, TUV	Japan/Asia JP-HPGS Act
CM tech. design base	LCLS-II	Euro-XFEL	KEK-STF, AST-IFMIF
ILC CM design	Common CM design globally compatible to HPGS regulation in all regions, and most likely ASME guidelines to be compatible with Japanese regulations.		

SRF2023 (Shin MICHIZONO)

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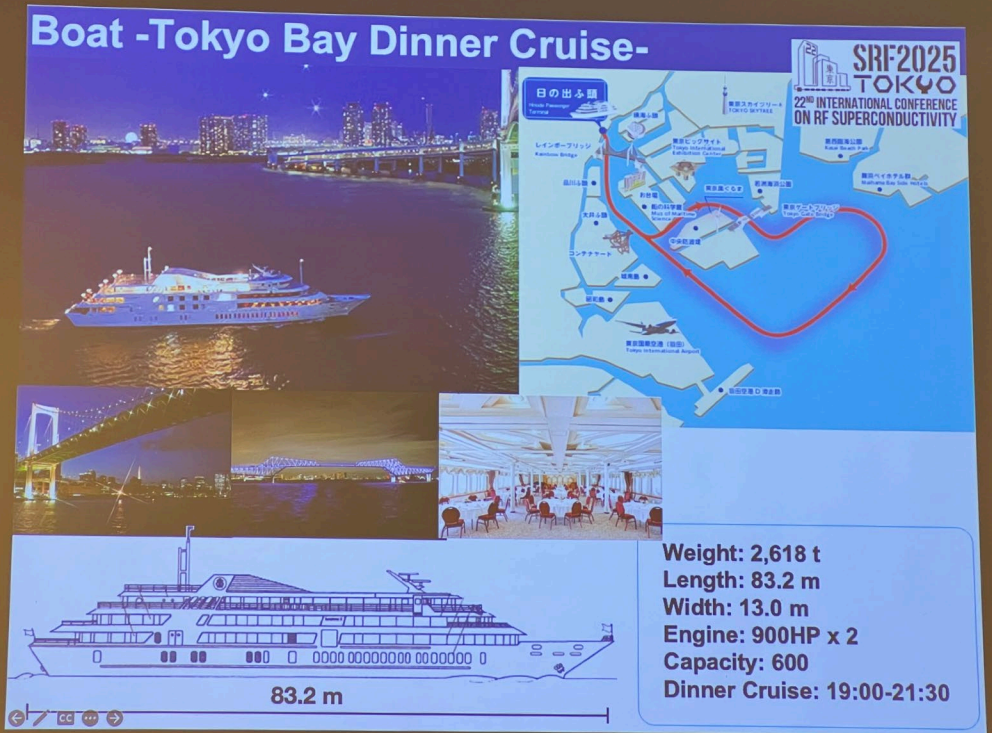
54

Excursion : Boat Tour



Banquet : Dinner





SRF2027 at Padua, Italy



Fermilab
**TESLA Technology
Collaboration Meeting**

December 5 - 8, 2023

TTC2023 meeting at FNAL



December 5 - 8, 2023' [TTC2023 Home-page
https://indico.fnal.gov/event/60446/](https://indico.fnal.gov/event/60446/)

Time	Date	December, 5 (Tue)	December, 6 (Wed)	December, 7 (Thu)	December, 8 (Fri)
8:30 - 9:00		Registration			
9:00 - 9:30		Welcome/Introduction	Plenary talk 3	Plenary talk 6	Special Seminar 1
9:30 - 10:00		Plenary talk 1	Plenary talk 4	Plenary talk 7	
10:00 - 10:30		Plenary talk 2	Plenary talk 5	Plenary talk 8	Special Seminar 2
10:30 - 11:00	Coffee Break				
11:00 - 11:30		WG1 / WG2 (parallel)	WG1 / WG2 (parallel)	WG3 / WG4 (parallel)	Summary WG1/WG2
11:30 - 12:00					Summary WG3/WG4
12:00 - 12:30					TB/CB report Closing
12:30 - 14:00	Lunch				
14:00 - 14:30		WG1 / WG2 (parallel)	WG3 / WG4 (parallel)	WG3 / WG4 (parallel)	Lab. Tour
14:30 - 15:00					
15:00 - 15:30					
15:30 - 16:00	Coffee Break				
16:00 - 16:30		WG1 / WG2 (parallel)	WG3 / WG4 (parallel)	Hot Topics	
16:30 - 17:00					
17:00 - 17:30					
17:30 - 18:00					
18:00 - 18:30		CB meeting	TB meeting	Dinner	
18:30 - 19:00					
19:00 - 19:30					
19:30 - 20:00					

TTC Scientific Program Committee

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Hiroshi Sakai (KEK), SPC Co-Chair
Eiji Kako (KEK), TTC Chair
Bob Laxdal (TRIUMF), Deputy TTC Chair
Sergey Belomestnykh (FNAL)
Grigory Ereemeev (FNAL), LOC Chair
Jie Gao (IHEP)
Catherine Madec (CEA)
Anne-Marie Valente-Feliciano (JLAB)
Hans Weise (DESY)
Akira Yamamoto (CERN/KEK)

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Grigory Ereemeev (FNAL), LOC Chair
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Sergey Belomestnykh (FNAL)
Bianca Giaccone (FNAL)
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Christina O'Neal (FNAL)
Lezlee Ongena (FNAL)



<https://indico.fnal.gov/event/60446/>

5th Asian School on Superconductivity and Cryogenics for Accelerators (ASSCA 2023)

Hands-on Training and Lectures on Superconducting Cavities, Superconducting Magnets and Cryogenics

Date

Jan. 28 - Feb. 5, 2024

Venue

High Energy Accelerator Research Organization (KEK), Tsukuba, Japan

Objectives

- To educate next generation who has possibility to contribute to future accelerators
- To provide not only knowledge on superconductivity and cryogenics for accelerators but also experience on them through hands-on training

Application Submission Deadline

Oct. 31, 2023 (no registration fee)

Contact Information

E-mail: assca2023@ml.post.kek.jp
URL: <https://conference-indico.kek.jp/event/216/>



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Supported by

International and Inter-institution Network for Accelerator Science to Next Generation (IINAS-NX),
High Energy Accelerator Research Organization (KEK)



ASSCA2023 at KEK



Jan. 29 – Feb. 4, 2024' [ASSCA2023 Home-page](https://conference-indico.kek.jp/event/216/)
<https://conference-indico.kek.jp/event/216/>

School Time Table (as of September 22, 2023)

Time	Jan. 28, 2024 Sunday	Jan. 29, 2024 Monday	Jan. 30, 2024 Tuesday	Jan. 31, 2024 Wednesday	Feb. 1, 2024 Thursday	Feb. 2, 2024 Friday	Feb. 3, 2024 Saturday	Feb. 4, 2024 Sunday	Feb. 5, 2024 Monday		
- 8:30	Arrival Day	Breakfast							Excursion	Departure Day	
8:30 - 8:40 (10 min.)		Welcome	Information / Announcement								
8:40 - 10:10 (90 min.)		Introduction 1 (SC & Cryo) Tripti Sekhar DATTA IIT Kharagpur, India	SC Magnet (1) Michinaka SUGANO KEK, Japan	SC Magnet (4) Yasuhiro MAKIDA KEK, Japan	SC Cavity (2) Takeshi DOHMAE KEK, Japan	Special Talk 2 (SC Cavity) Michael PEKELER RI, Germany	Cryogenics (3) Hirotaka NAKAI KEK, Japan				
10:10 - 10:30 (20 min.)		Group Photo	Coffee Break								
10:30 - 12:00 (90 min.)		Introduction 2 (SC Magnet) Toru OGITSU KEK, Japan	SC Magnet (2) Yasushi ARIMOTO KEK, Japan	Special Talk 1 (SC Magnet) Masami IIO, KEK, Japan	SC Cavity (3) Jun TAMURA JAEA, Japan	Cryogenics (1) Tripti Sekhar DATTA IIT Kharagpur, India	Cryogenics (4) Xilong WANG IASF, China				
12:00 - 13:10 (70 min.)		Lunch									
13:10 - 14:40 (90 min.)		Introduction 3 (SC Cavity) Eiji KAKO KEK, Japan	SC Magnet (3) Kento SUZUKI KEK, Japan	SC Cavity (1) Hiroaki UMEZAWA Tokyo Denkal, Japan	SC Cavity (4) Naruhiko SAKAMOTO RIKEN, Japan	Cryogenics (2) Rui GE IHEP, China	Special Talk 3 (Cryogenics) Taekyung KI IBS, Korea				
14:40 - 15:00 (20 min.)		Coffee Break						Closing			
15:00 - 16:00 (60 min.)		Training A Introduction	Training A	Training B Introduction	Training B	Training C Introduction	Training C				
16:00 - 18:30 (150 min.)		Training A		Training B		Training C					
18:30 -		Welcome Party	Dinner					Banquet			

Thanks for your attention.



