Highlights of TTC2022 meeting at Aomori

(11-14, October 2022')

Eiji Kako (KEK, Japan)
TTC Chair

October 25th , 2022

Mission of the TESLA Technology Collaboration

The mission of the TESLA Technology Collaboration is

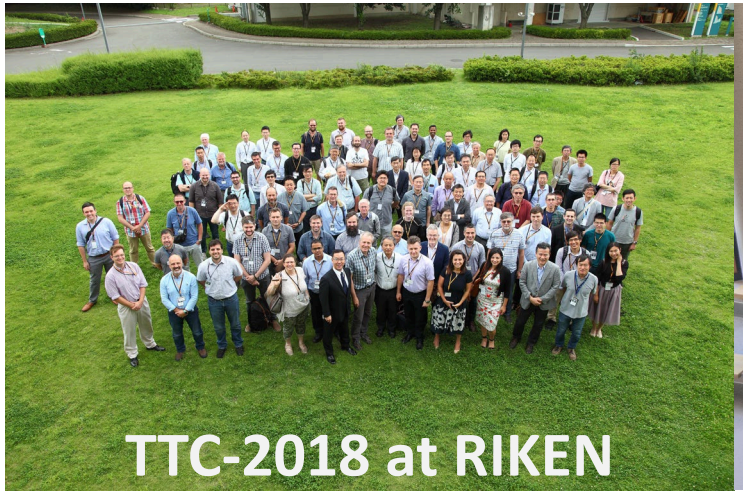
- to advance SCRF technology R&D and related accelerator studies across the broad diversity of scientific applications.
- to keep open and provide a bridge for communication and sharing of ideas, developments, and testing across associated projects.

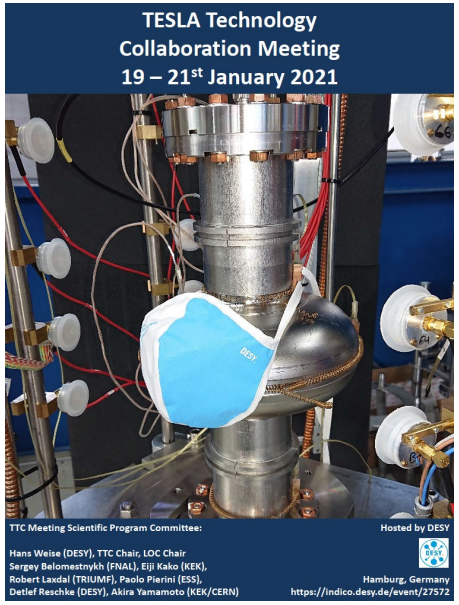
To this end,

- The TTC will support and encourage free and open exchange of scientific and technical knowledge, expertise, engineering designs, and equipment.

The TTC organizes regular collaboration meetings where new developments are reported, recent findings are discussed, and technical issues concluded.

Revival of in-person meeting



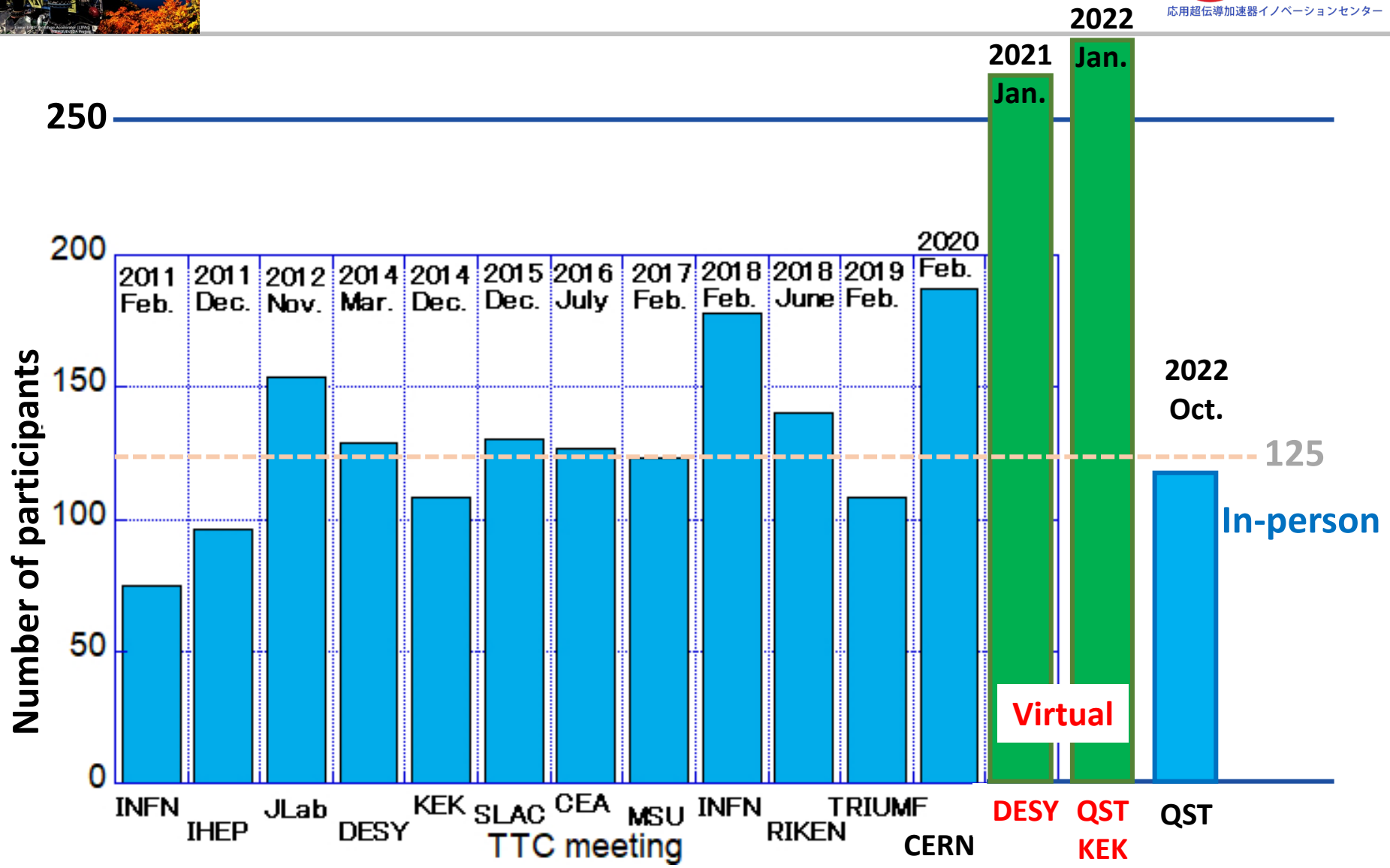


Now, TTC-2022 at Aomori
is an **in-person** meeting
with **face-to-face** discussions,
(in a small meeting room
without microphone.)

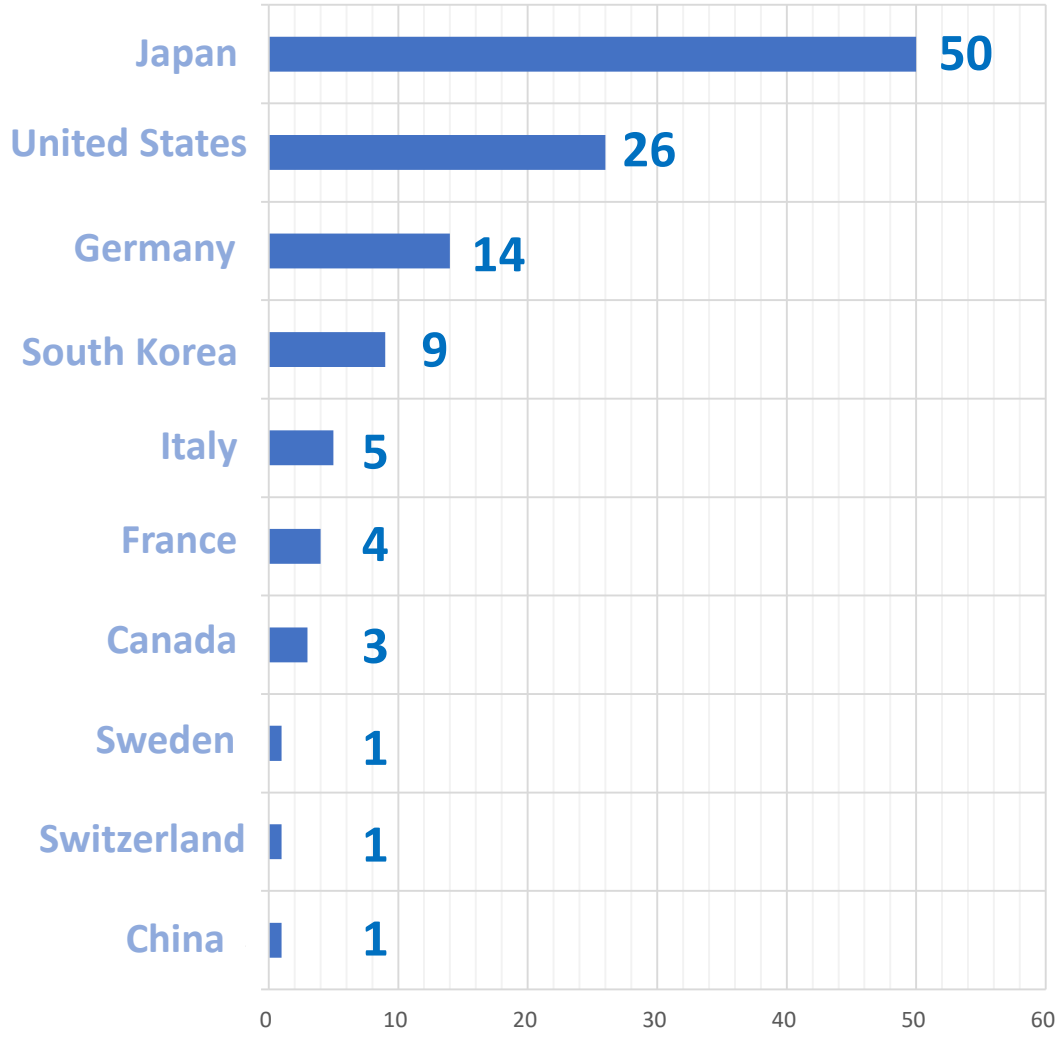
Thank you for your participation and fruitful discussions!

https://www.ttc2022aomori.org/event/2/

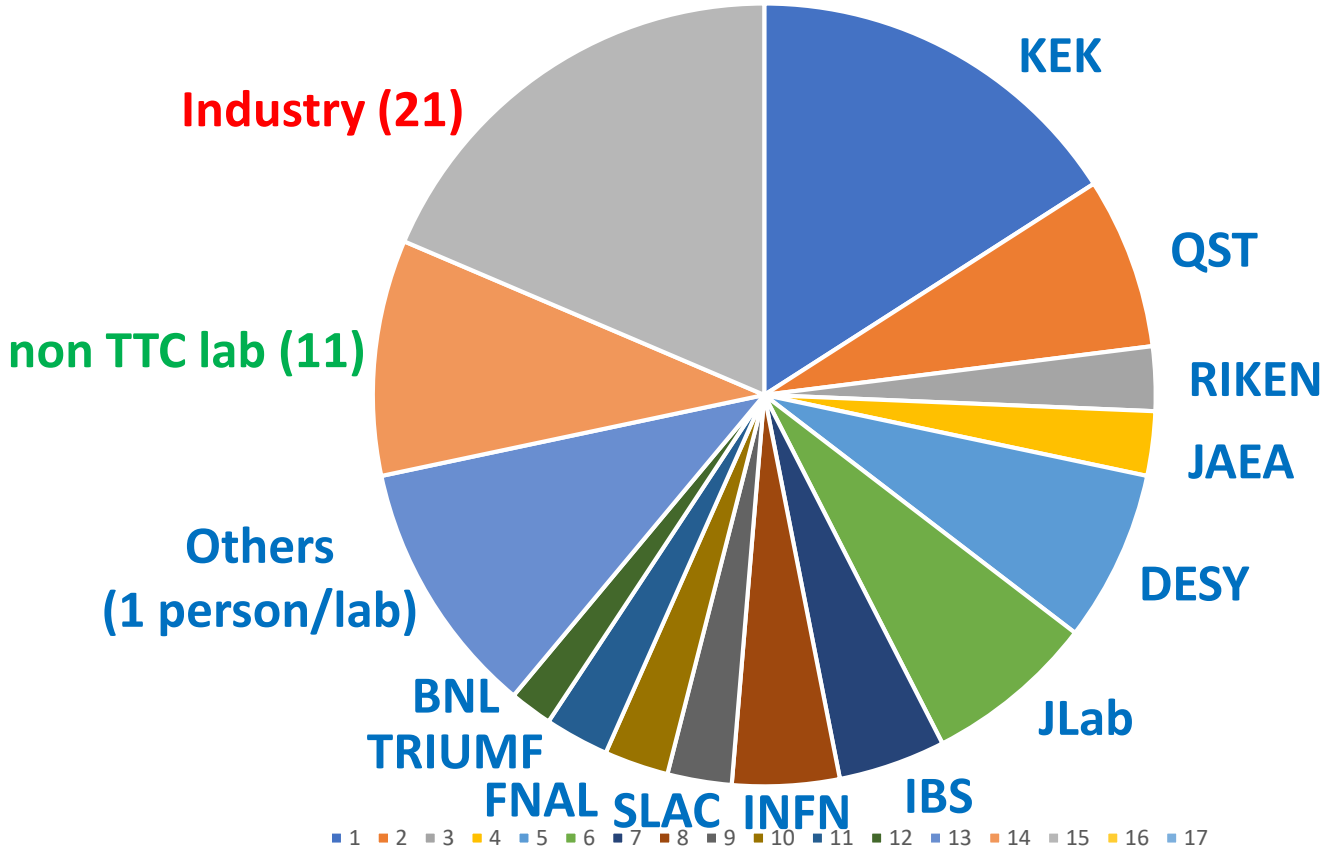
Number of participants in TTC



Participants in TTC-2022 Aomori



Participants : 114
Countries : 10



Scientific Program in TTC2022

Time	Date	October, 11 (Tue)	October, 12 (Wed)	October, 13 (Thu)	October, 14 (Fri)
8:45 - 9:00		Registration	Registration	Registration	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					Summary WG1/WG2
11:30 -12:00		WG1 / WG2	WG1 / WG2	WG3 / WG4	Summary WG3/WG4
12:00 - 12:30		(parallel)	(parallel)	(parallel)	TB/CB report, Closing
12:30 - 14:00	Lunch				
14:00 - 14:30					
14:30 - 15:00		WG1 / WG2	WG3 / WG4	WG3 / WG4	Technical Tour
15:00 - 15:30		(parallel)	(parallel)	(parallel)	
15:30 - 16:00	Coffee Break				
16:00 - 16:30					
16:30 - 17:00		WG1 / WG2	WG3 / WG4	Hot Topics	
17:00 - 17:30		(parallel)	(parallel)		
17:30 - 18:00	Break				
18:00 - 18:30		CB meeting	TB meeting		
18:30 - 19:00					
19:00 - 19:30					
19:30 - 20:00					

8 Plenary talks, 2 Special seminars, 1 Hot topic, and 4 WGs

Discussions in 4 Working Groups

WG-1: Progress of High Q and High Gradient activities

Conveners: Mathieu Omet (KEK), Christopher Bate (DESY), James Maniscalco (SLAC), (SPC: Detlef Reschke (DESY))

4 Sessions and 16 talks; 4 from Asia, 7 from N. America, 5 from Europe

WG-2: Low beta machine commissioning and operational experience

Conveners: Kai Masuda (QST), Zhongyuan Yao (TRIUMF), Jose Alberto Rodriguez (CERN), (SPC: Bob Laxdal (TRIUMF))

4 Sessions and 15 talks; 5 from Asia, 6 from N. America, 4 from Europe

WG-3: Applications and cooling schemes for Nb3Sn- cavities

Conveners: Kensei Umemori (KEK), Uttar Pudasaini (JLab), Oliver Kugeler (HZB), (SPC: Hiroshi Sakai (KEK))

4 Sessions and 17 talks; 5 from Asia, 9 from N. America, 3 from Europe

WG-4: Availability and operability of existing accelerators compared to their design goals

Conveners: Michiru Nishiwaki (KEK), Rong-Li Geng (ORNL), Francesco Grespan (LNL), (SPC: Camille Ginsburg (Jlab))

4 Sessions and 15 talks; 5 from Asia, 9 from N. America, 2 from Europe

Total 64 talks; 19 from Asia, 31 from N. America, 14 from Europe

Invited talks in plenary sessions

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FEATURE TESLA TECHNOLOGY COLLABORATION

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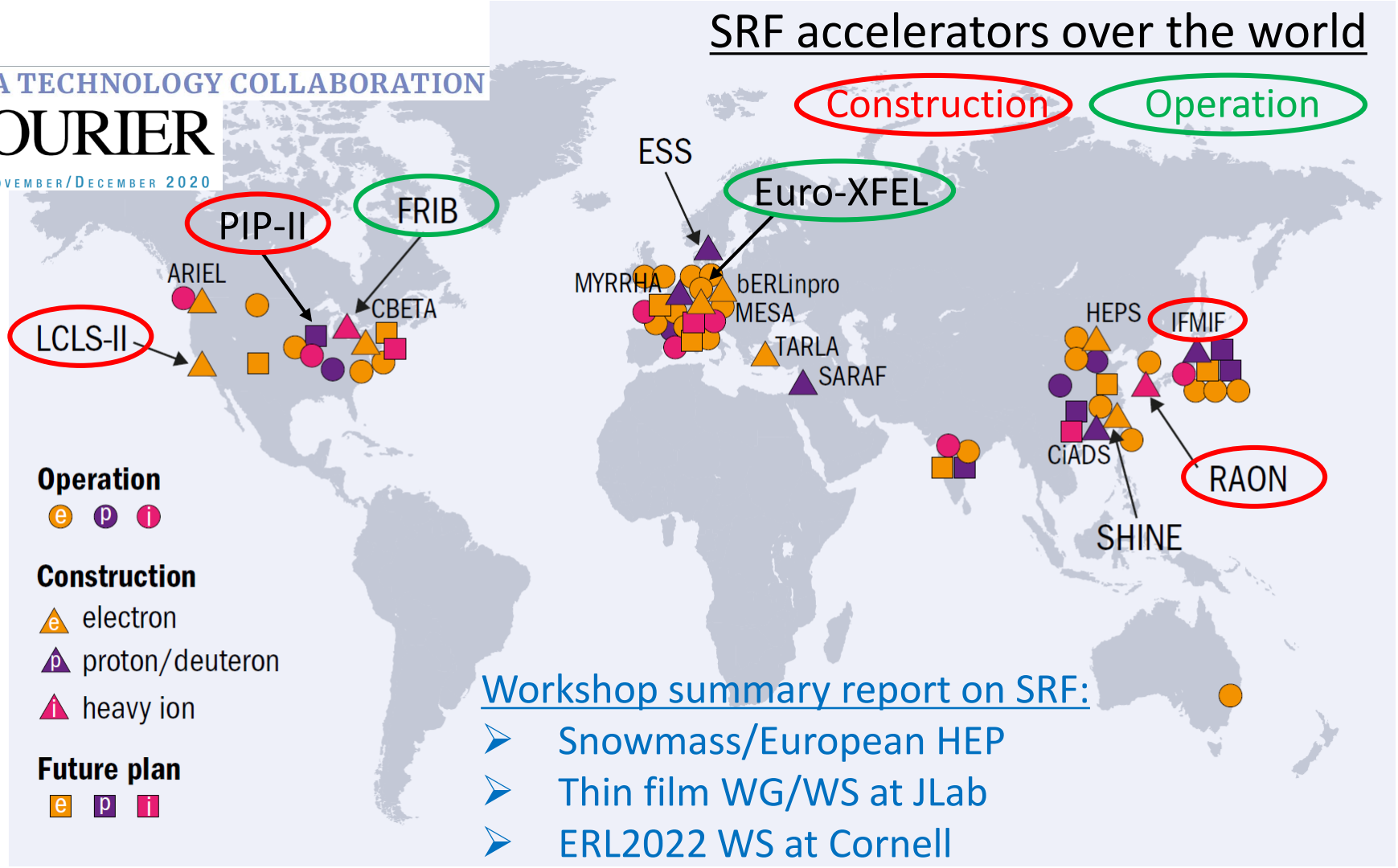
VOLUME 60 NUMBER 6 NOVEMBER/DECEMBER 2020

SRF accelerators over the world



Workshop summary report on SRF:

- Snowmass/European HEP
- Thin film WG/WS at JLab
- ERL2022 WS at Cornell

Special Seminars:

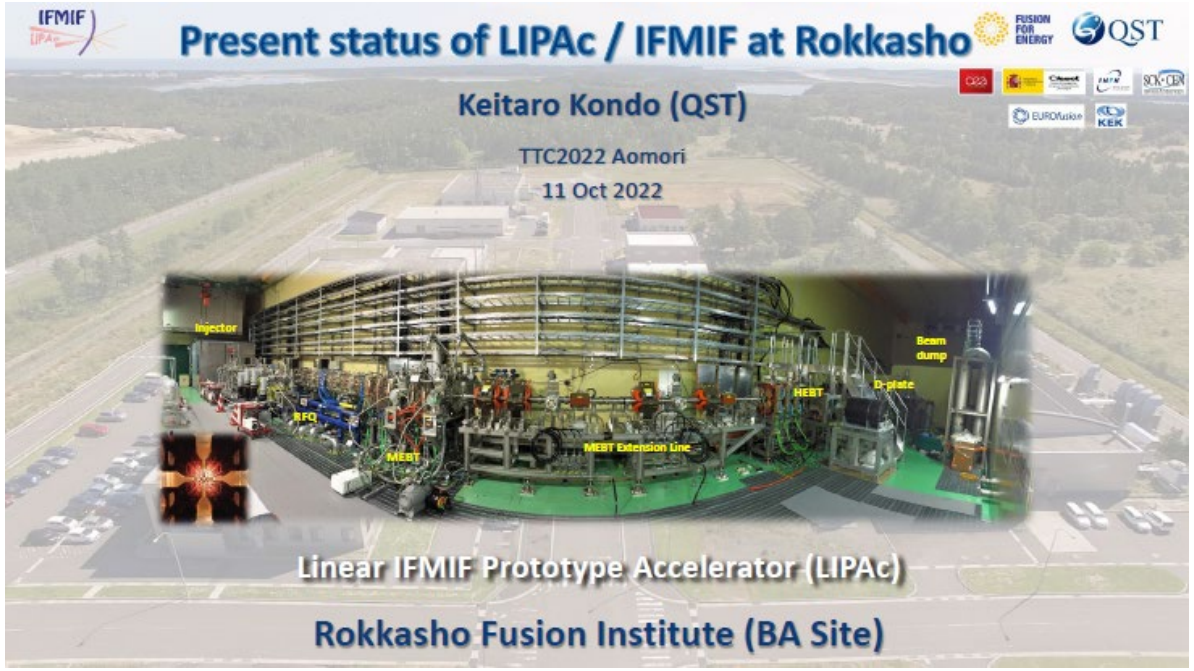
- Availability of Nb
- Japanese ADS

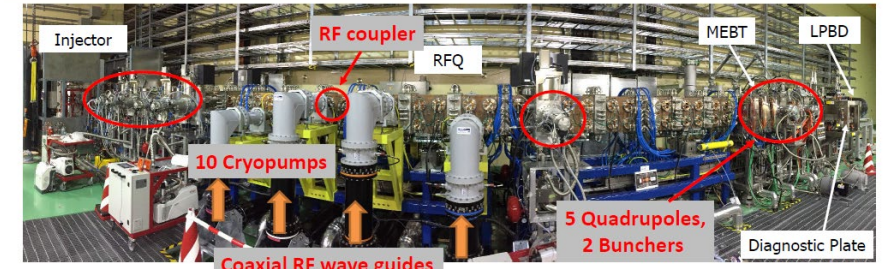
Hot topic discussion:

- Global He resource

IFMIF at QST/Rokkasho

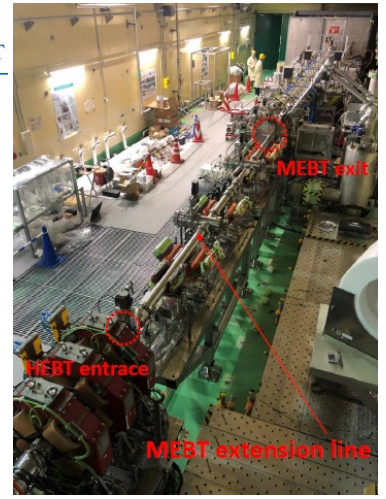
"Present status of LIPAc/IFMIF at Rokkasho" by K. Kondo (QST)





- LIPAc RFQ is the world longest (9.8 m) and delivering the highest power in the world (5 MeV x 125 mA = 0.625 MW). 125 mA deuteron beam (1 ms, 1 Hz) acceleration was successfully achieved on July 24, 2019 first time in the world.
- RF is injected from eight different RF couplers.
- MEBT has two bunchers that perform matching to SRF.

11/10/22



- Beam commissioning of RFQ
- Cavity string assembly in clean room
- Assembly of IFMIF cryomodule

RAON at RISP/IBS, Korea

"Status of RAON Heavy Ion Accelerator Facility" by M. Kwon (RISP/IBS)

RAON Rare isotope Accelerator complex for ON-line experiments

Status of RAON heavy ion accelerator facility

M. KWON on behalf of RISP
IBS, Daejeon, Korea

October 12, 2022
Aomori, JAPAN

ibs 기초과학연구원 Institute for Basic Science

RISP 중이온가속기건설구축사업단 Rare Isotope Science Project

RAON SRF Linac Assembled and Installed

SCL3 and Cryo-plant Installation completed 2021 & Beam commissioning just started

-Cryomodule(CM) & Warm section is clean assembled in the clean booth@tunnel
-Total Particle counts(size=0.5um above/10 mins) were less than 30 counts

RAON Cryo-plants are ready

- Plant configuration
  - SCL3 cryoplant (4.2 kW @4.5K) for SCL3
  - SCL2 cryoplant (13.5 kW @ 4.5 K) for SCL2
  - To combine two plants through the distribution box. If one plant down, the other can maintain cold SCL 2&3 together or only one.

Cold box

Warm compressors

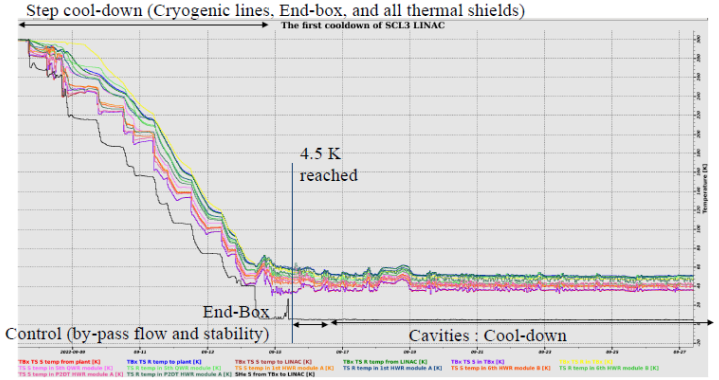
LHe distribution box

- Plant status
  - Mechanical installation and commissioning was done in July, 2022
  - Cold box was connected to the Main distribution box.
  - First cool down begins September 7, 2022.

RAON First Cool-down on September 15, 2022

Cooling down cryogenic distribution system, thermal shields of all cryomodules with SCL3 cryoplant, simultaneously.

Step cool-down (Cryogenic lines, End-box, and all thermal shields)



- Installation of QWR and HWR cryomodules
- First cool-down of superconducting LINAC
- Beam commissioning of QWR cryomodules

LCLS-II at SLAC

"LCLS-II SRF Commissioning" by S. Aderhold (SLAC)

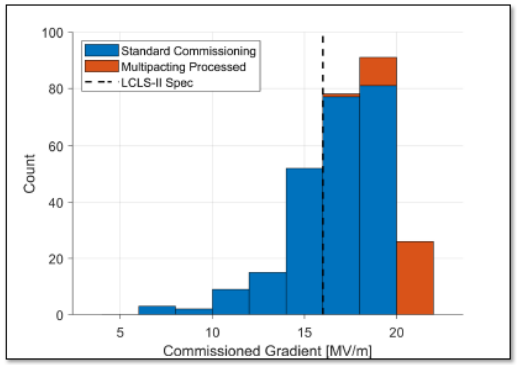
- CM installation Completed
- Cool-down and pump-down
- Beam commissioning started

Cryomodule Installation

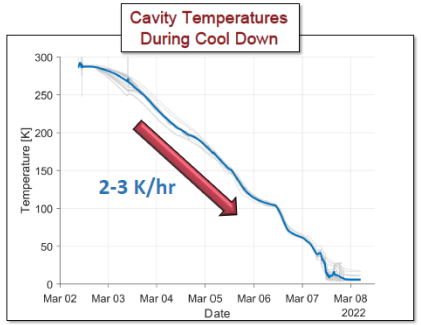
Last CM (spare) Delivered in May 2021

CM Installation Complete February 2021

Gradient Performance

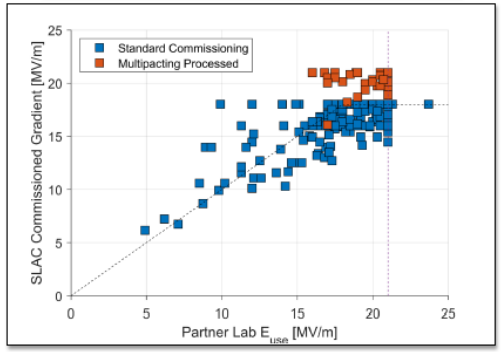


Cool Down & Pump Down to 2 K



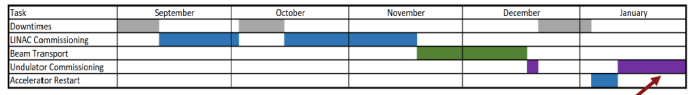
- Cool down of the entire linac was completed in ~5 days!
- A rate of 2-3 K/hour was maintained over that duration
- Cool down was near-fully automated by the cryogenic controls system
- After multiple attempts, stable operation at 2 K was achieved only 11 days later

Comparison with Acceptance Test



Admin limits:
- 18 MV/m in commissioning
- 21 MV/m in acceptance test

Schedule Out



1st Light Milestone is anticipated in January of 2023

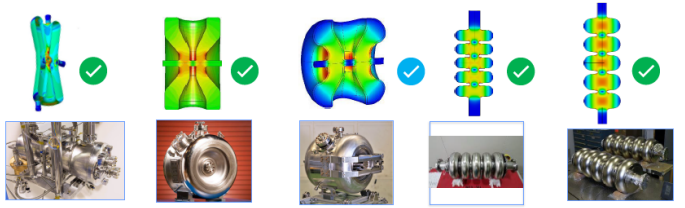
PIP-II at FNAL

"Operational experience with accelerating H- through prototype low-beta cryomodules for PIP-II" by D. Passarelli (Fermilab)

Operations experience with accelerating H- through prototype low-beta cryomodules for PIP-II

Donato Passarelli
TTC meeting
Plenary talk 4
October 11-14, 2022

PIP-II SRF Cavities



Name (Qty.)	HWR (8)	SSR1 (16)	SSR2 (35)	LB650 (36)	HB650 (24)
Type	Half-Wave	Single Spoke	Single Spoke	Elliptical	Elliptical
β	0.11	0.22	0.47	0.61	0.92
Frequency	162.5 MHz	325 MHz	325 MHz	650 MHz	650 MHz
Q_0	$8.5 \cdot 10^9$	$8.2 \cdot 10^9$	$8.2 \cdot 10^9$	$2.4 \cdot 10^{10}$	$3.3 \cdot 10^{10}$
Gradient	9.7 MV/m	10 MV/m	11.5 MV/m	16.8 MV/m	18.7 MV/m
Doping	No	No	No	Yes	Yes

Prototype built Prototype validated

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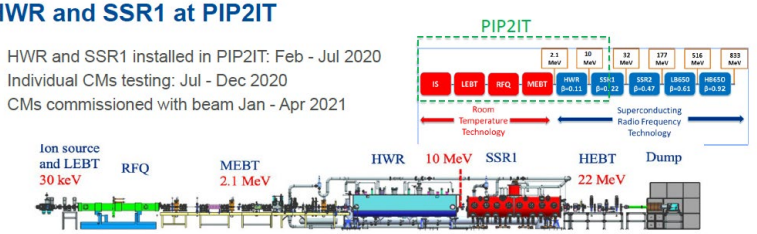
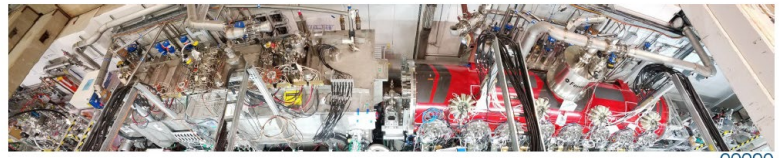
HWR and SSR1 at PIP2IT

- HWR and SSR1 installed in PIP2IT: Feb - Jul 2020
- Individual CMs testing: Jul - Dec 2020
- CMs commissioned with beam Jan - Apr 2021





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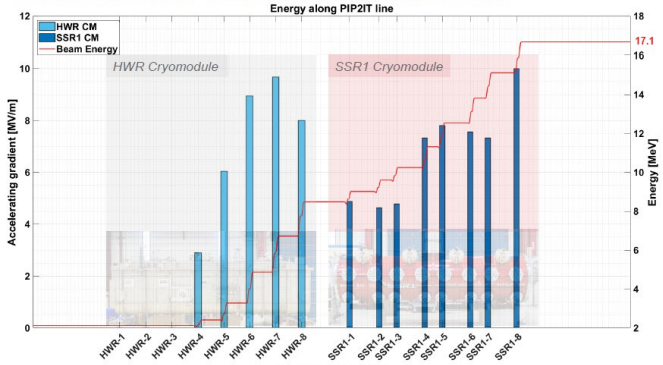
HWR and SSR1 Commissioned with Beam



Beam accelerated to 17.1 MeV ✓

HWR and SSR1 Prototype cryomodules performance validated with beam ✓

HWR cavities 1,2&3 not used for acceleration, otherwise final beam energy would have been 22 MeV

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- PIP-II Injector Test (PIP2IT)
- Installation of HWR and SSR1 cryomodules
- HWR and SSR1 Beam commissioning

FRIB at MSU

“FRIB Commissioning and First Operation” by S.-H. Kim (MSU)

TESLA TECHNOLOGY TTC COLLABORATION

FRIB

FRIB Commissioning and First Operation

October 12, 2022

TTC2022 at Aomori, Japan

Sang-hoon Kim on behalf of FRIB

MICHIGAN STATE UNIVERSITY

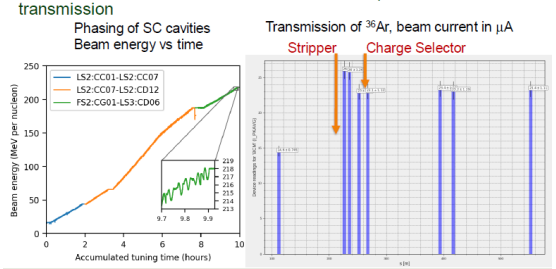
U.S. DEPARTMENT OF ENERGY | Office of Science

This material is based upon work supported by the U.S. Department of Energy Office of Science under Cooperative Agreement DE-SC0000661, the State of Michigan and Michigan State University. 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 Physics.

- FRIB beam commissioning
- SRF operational experience
- R&D for future energy upgrade

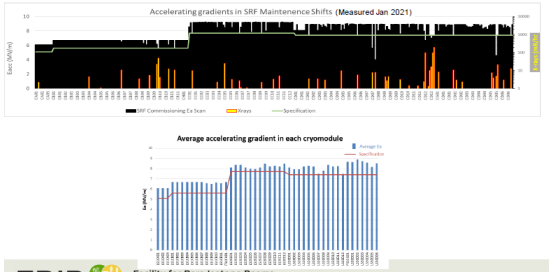
^{36}Ar, ^{86}Kr and ^{129}Xe Accelerated above 200 MeV/u

- Three-charge-state $^{124}Xe^{49+,50+,51+}$ and two-charge state $^{86}Kr^{33+,34+}$ were also accelerated and delivered to the beam dump with 100% transmission



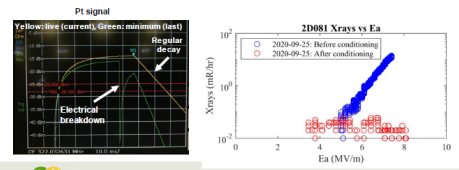
Accelerating Gradient in Linac Cryomodules

- Total accelerating voltage exceeds the FRIB specifications, which provides operational margins



Impacts of Field Emission on Operation

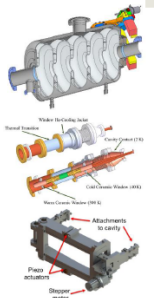
- Issue with field emission
  - Observed conditioning effects such as fast breakdown in a few cavities with relatively high field-emission (FE) X-rays
- Pulsed RF conditioning recovered FE performance in some cavities, particularly if fast (electrical) breakdown happened
  - However, in the other cavities, this technique did not work due to thermal breakdown
- Started plasma processing development as a long-term solution

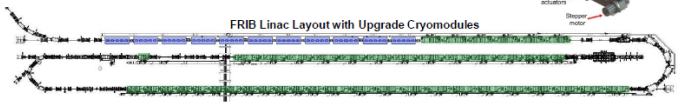


FRIB400: Linac Energy Upgrade to 400 MeV/u

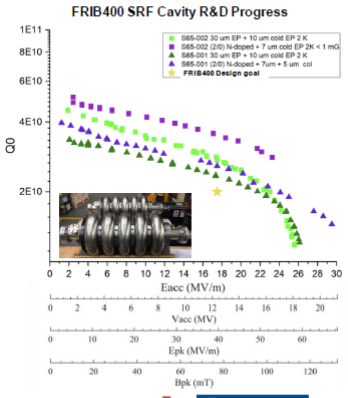
FRIB400 White Paper (2018)

- Low-energy nuclear physics community made science cases
  - Luminosity gain over 50 for rarest isotopes
  - Energy well-matched to exploring physics of neutron-star merger
- Technical approaches
  - Add 11 cryomodules to the space reserved for energy upgrade
  - β=0.65 644 MHz elliptical cavity, design goal: Q0 = 2e10 @ Eacc of 17.5 MV/m
  - Lever frequency tuner combined with stepper motor and piezos
  - Double window FPC





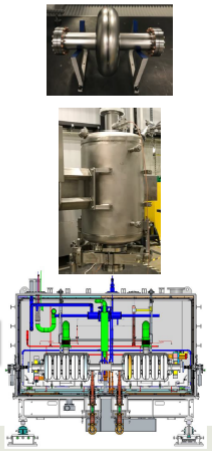
FRIB400 SRF R&D Achievements and Plan



High Q R&D with 1-cell cavity

Development of Jacketed cavity, tuner, FPC

High-β spare buncher with upgrade cavities



Argonne NATIONAL LABORATORY | Fermilab

Euro-XFEL at DESY

"European XFEL: Experience with 5 Years of Operation" by H. Weise (DESY)

European XFEL
Experience with 5 Years of Operation

TESLA Technology Meeting, Aomori, Japan

Julien Branlard and **Nick Walker** and Hans Weise (as presenter…)
for the linac operations team
and all contributors to the XFEL construction

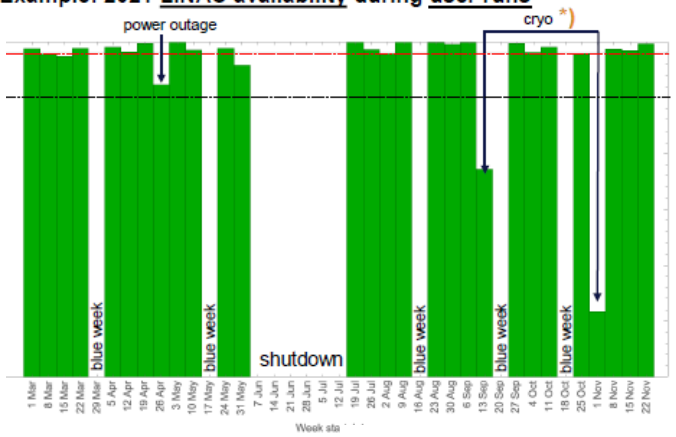
Aomori, 13.10.2022

European XFEL

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

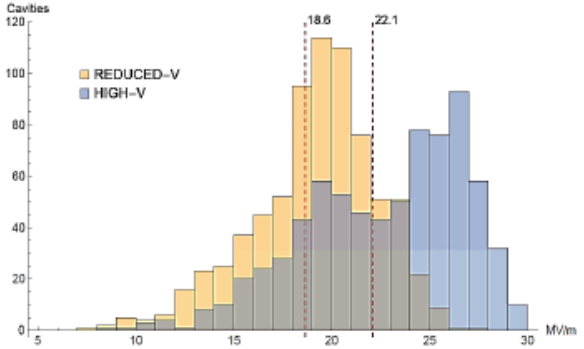
European XFEL

Example: 2021 LINAC availability during user runs



Operation Config.	REDUCED V ≤14.5 GeV	MAX V >16 GeV
2021	79%	21%
2022	68%	32%

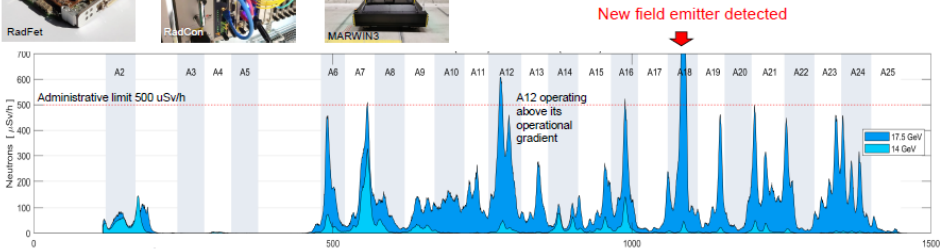
RF CONFIG	Time Frame	Average Dynamic Load (W)	Effective average Q_0
LOW-VS	01.09—15.10.2020	400	1.04×10^{10}
HIGH-VS	20.10—15.11.2020	600	0.98×10^{10}



European XFEL - experience with 5 years of operation

Dark Current Radiation in the Tunnel

Detector	Type	Radiation	Sensitivity	Typical use
RadFet	integral	gamma	~0.01-0.1 Gy	Outside rack shielding. Continuous monitoring during operations
RadCon	rate	gamma	~0.1 µGy/h	Inside rack shielding. Continuous monitoring during operations
MARWIN robot (mobile Pandora)	rate	gamma, neutron	~ 1 µSv/h	Tunnel operation as needed (scheduled studies)



- SRF LINAC availability > 95%
- Dark current radiation in the tunnel
- Cavity degradation observed on ~1%

Snowmass/European HEP

“SRF activities discusses within Snowmass and European HEP strategy process” by S. Belomestnykh (FNAL) and H. Weise (DESY)

SRF activities discussed within Snowmass and European HEP strategy process

TESLA Technology Meeting, Aomori, Japan

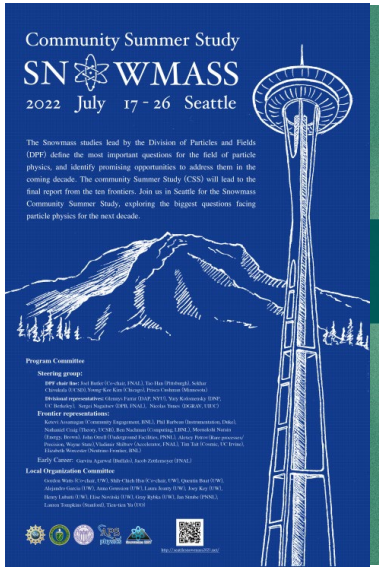
Sergey Belomestnykh and **Hans Weise**
for the SNOWMASS and for the LDG Team

http://seattlesnowmass2021.net/

https://doi.org/10.23731/CYRM-2022-001.61

Aomori, Oct 11th, 2022

Fermilab DESY.



Key Directions for SRF R&D (1)

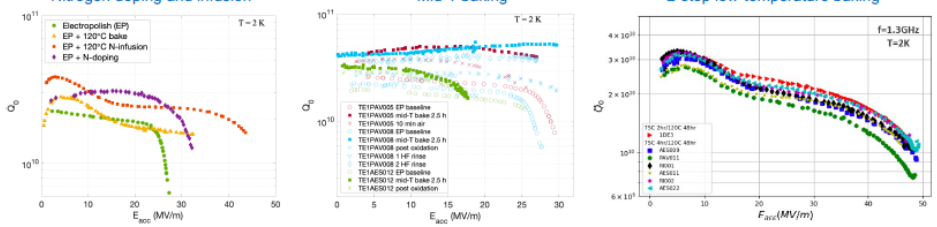
From AF7-rf Topical Group Report, White Papers, and Presenttaions

The **key directions for SRF technology R&D** are outlined in the AF7-rf Topical Group Report to be pursued during the next decade. In the next slides we list these directions and show some examples.

- Studies to **push performance of niobium** and improve our understanding of SRF losses and ultimate quench fields via experimental and theoretical investigations
- Developing **methods for nano-engineering the niobium surface layer** and tailoring SRF cavity performance to a specific application, e.g., a linear collider, a circular collider, or a high-intensity proton linac

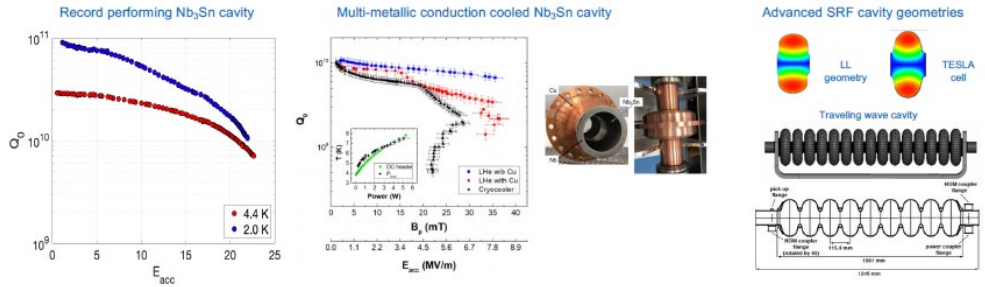
Examples of new cavity treatment methods:

Nitrogen doping and infusion | Mid-T baking | 2-step low-temperature baking



Fermilab SRF activities discussed within Snowmass and European HEP strategy process - TTC Aomori, Oct 2022

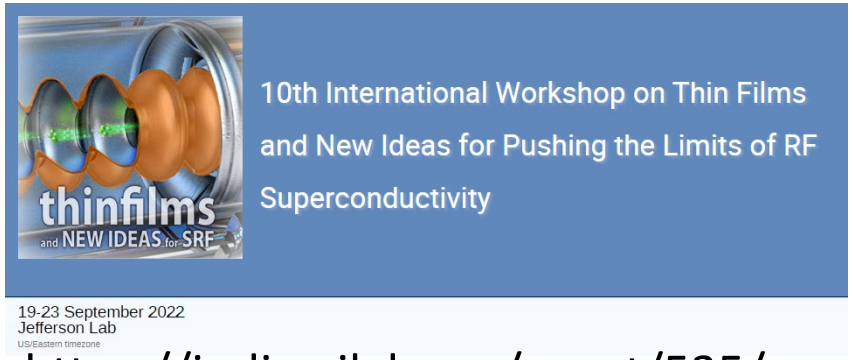
Record performing Nb_3Sn cavity | Multi-metallic conduction cooled Nb_3Sn cavity | Advanced SRF cavity geometries



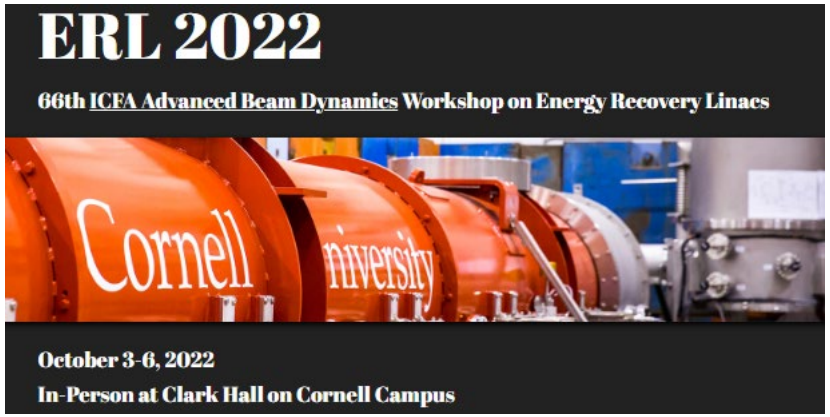
Thin Film WS / ERL2022 WS

“Summary report of TTC Thin Film WG and Thin Film WS” by A.M. Valente (JLab)

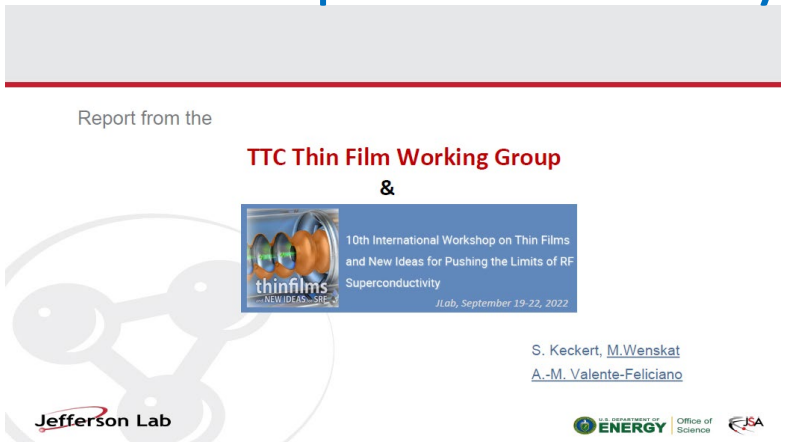
“Summary report of ERL2022 Workshop at Cornell” by H. Sakai (KEK)

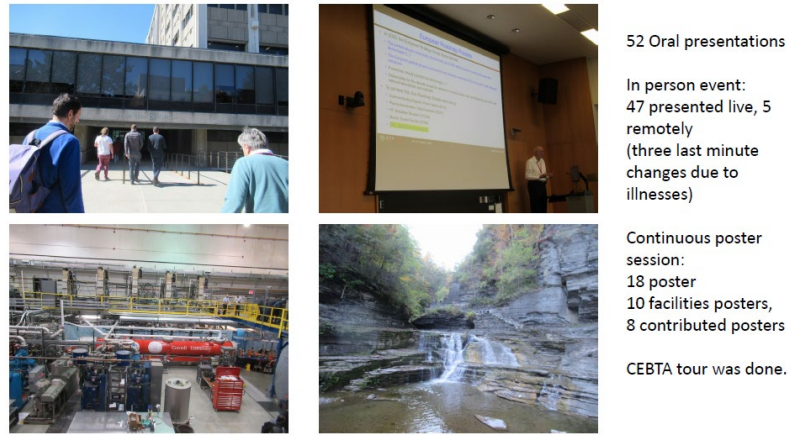


https://indico.jlab.org/event/535/



https://www.classe.cornell.edu/NewsAndEvents/ERL2022/





Hot topic: Global He Resources

"Global helium resource status and future prospect in Japan" by R. Sagiyama (U. of Tokyo)
"Helium management at CERN, global resource status and prospect" by D. Delikaris (CERN)

Global helium resource status and future prospect in Japan

ヘリウム資源の国際情勢と日本の展望

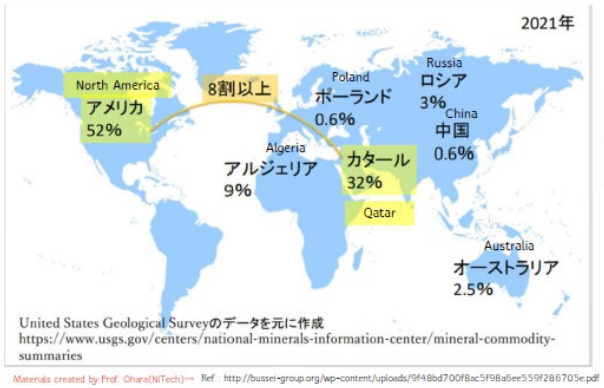
東京大学 物性研究所

TECHNICAL SPECIALIST

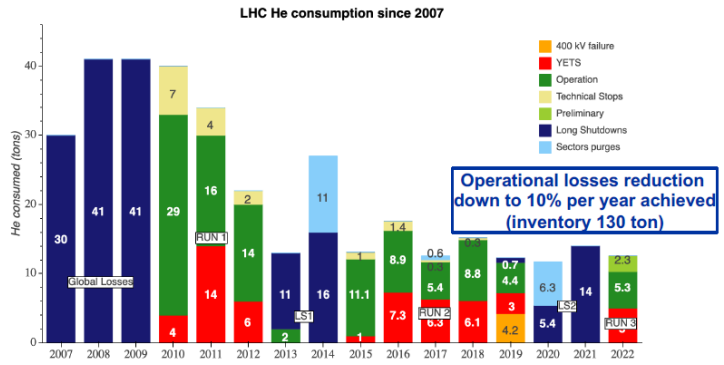
REIKO SAGIYAMA

技術専門職員 / 鷲山 玲子

Current producing country and their percentage of helium production



Helium management in LHC accelerator



CERN

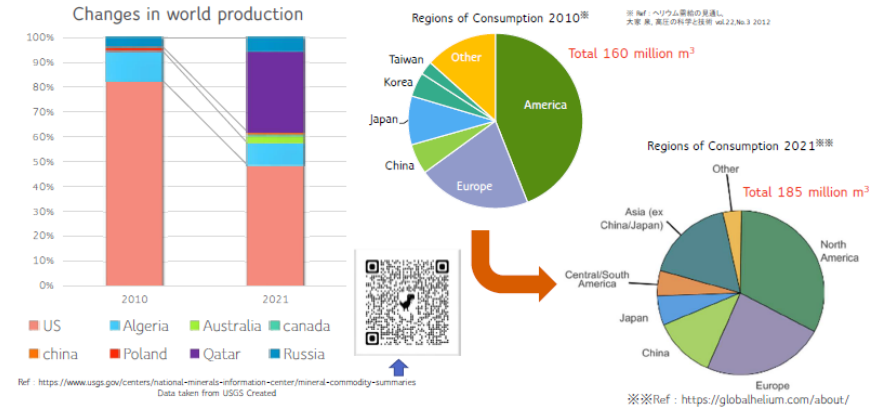
Helium management at CERN, global resource status and prospect

D. Delikaris, Head of Cryogenics group, CERN

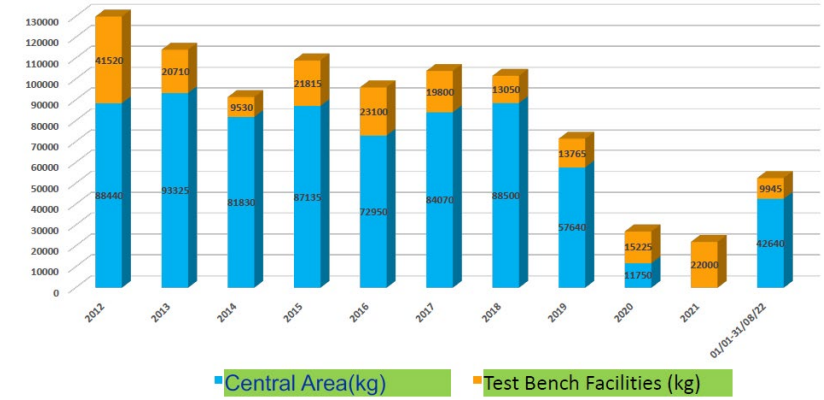
A. Yamamoto, KEK/CERN, Presenting on behalf of D. Delikaris

Thursday, October 13th, 2022, TCC2022, Aomori, Japan

1.2. Changes in Helium Resources



Helium recycling & purification (kg/year)



Special seminar (1): Availability of Nb

“High purity Tantalum and Niobium of JX-NMM” by S. Irumata (JX)

- Mother company of Tokyo Denkai
- Ta and Nb for sputtering target
- Stable supply of Nb sheets for SRF

Future of Nb sheets for SRF Cavities

TANIOBIS

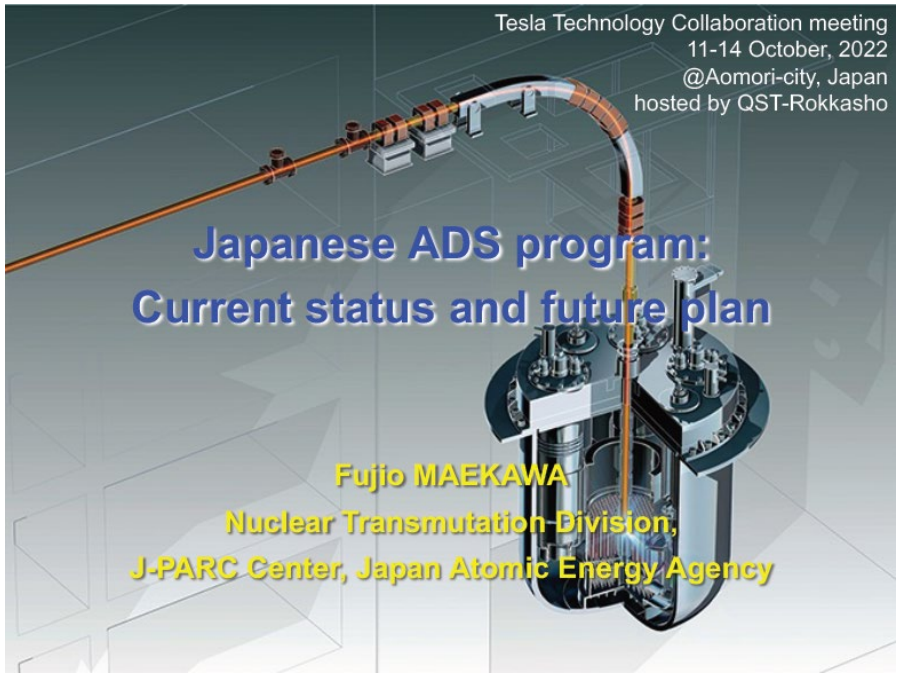
JX NMM / Taniobis supply various Niobium products (metal/alloy/compounds) now and are looking for “new” application of Niobium products.

JX NMM understands that the application for SRF cavity is very promising.

JX NMM / Tokyo Denkai / Taniobis will fulfill our supply responsibilities as a supplier of Niobium sheet for SRF Cavities.

Special seminar (2): Japanese ADS project

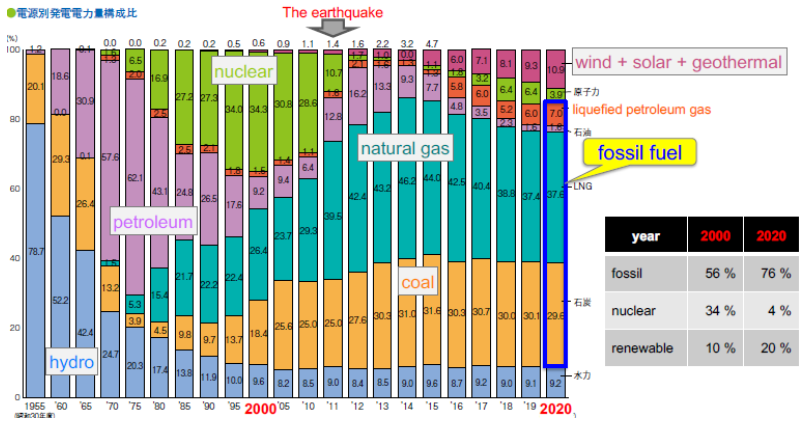
"Japanese ADS program: Current status and future plan"
by F. Maekawa (JAEA)



- Experimental Facility in J-Parc
- R&D of proton SC LINAC

Electric power generation in Japan

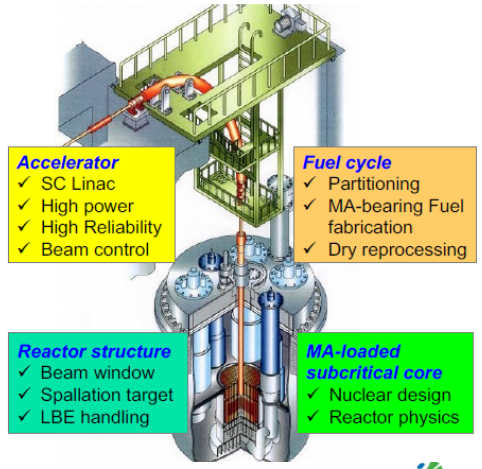
- I believe Japan needs nuclear power.
- To promote it, we need to solve the nuclear waste problem!



year	2000	2020
fossil	56 %	76 %
nuclear	34 %	4 %
renewable	10 %	20 %

ADS proposed by JAEA - LBE Target/Cooled Concept -

- Proton beam: 1.5 GeV, 20 mA, 30 MW
- Spallation target: Pb-Bi eutectic (LBE)
- Coolant: LBE
- Subcriticality: k_{eff} = 0.97
- Thermal output: 800 MWt
- Core height: 1000 mm
- MA initial inventory: 2.5 t
- Fuel composition: (60%MA + 40%Pu) Mono-nitride
- Transmutation rate: 10%MA / Year (=250 kg: MA from 10 units of LWR)
- Burn-up reactivity swing: 1.8%Δk/k

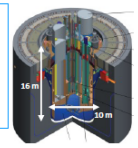


MYRRHA project in Belgium

MYRRHA (Multi-purpose hYbrid Research Reactor for High-tech Applications)

- The world's first large scale Accelerator Driven System project at power levels scalable to industrial systems, developed by Belgian Nuclear Research Centre

- Accelerator: SC-Linac, 600 MeV, 4 mA (2.4 MW)
- Target: LBE, 7,800 tons
- Sub-critical reactor: 100 MW_{th}, MOX fuel, k_{eff} = 0.95, LBE cooling
- Purposes: R&D for nuclear waste treatment, Production of nuclear medicine, Nuclear science, Fusion reactor physics



- In 2018 the Belgian Federal Government decided to have the MYRRHA project built on the SCK CEN site in Mol. Based on a total budget of 1.6B€, the government committed 558M€ towards the project's phased approach.
- The Belgian government announced the establishment of an international non-profit organisation that will be ideally suited to welcome investment from additional participating countries.

2019 — 2026 2027 — 2038

Phase-1 (accelerator up to 100 MeV) (287M€) | operation (156 M€)

- To confirm the linac's operational reliability
- Proton Target Facility for the production of medical radioisotopes and for fundamental and applied research in physics as well as for material research
- Fusion Target Station, where materials for fusion reactors will be tested

CiADS project in China

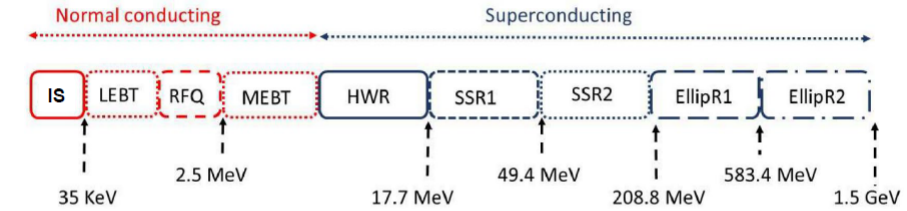
- As one of the national major science and technology infrastructures, **the China initiative Accelerator Driven System (CiADS)** will be the world's first prototype of ADS facility at megawatt level to explore the safe and proper technology of nuclear waste disposal.
- Lead by Institute of Modern Physics (IMP), CAS, with four partners, China National Nuclear Corporation (CNNC), Institute of High Energy Physics (IHEP), GNC and Hefei Institutes of Physical Science (HIPS)

- Phase I (2011-2016) R&D on Superconducting Linac
- Phase II (2018-2024) Construction of **CiADS**
  - ✓ Accelerator: proton Linac, 500 MeV, 5 mA (2.5 MW)
  - ✓ Sub-critical reactor: 7.5 MW_{th}, LBE cooling
  - ✓ Site: Huizhou City, Guangdong Province, next to HIAF
- Phase III (~2032) ADS demo reactor
  - ✓ 1 GeV, 10~15 mA (10~15 MW), 600 MW

New TTC-CB membership (1)

SRF activities in JAEA (Japan):

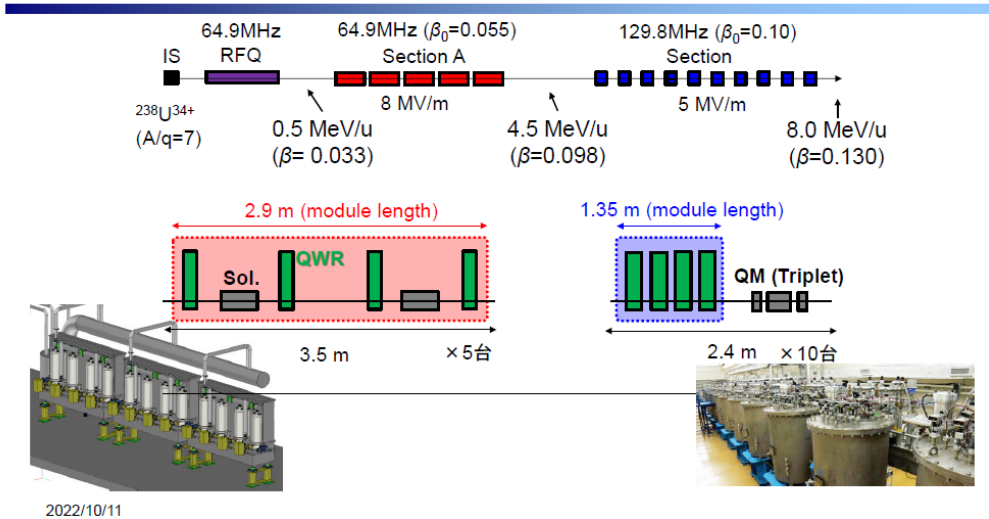
Overview of the JAEA-ADS linac



Parameters for JAEA ADS linac	
Energy (GeV)	1.5
Current (mA)	20
Duty (%)	100 (CW)
Power (MW)	30

	HWR	SSR1	SSR2	EllipR1	EllipR2
Frequency (MHz)	162	324		648	
β_g	0.08	0.16	0.43	0.68	0.89
Eacc (MV/m)	7	7	8	14	14

Detail plan of the Tandem successor



2022/10/11

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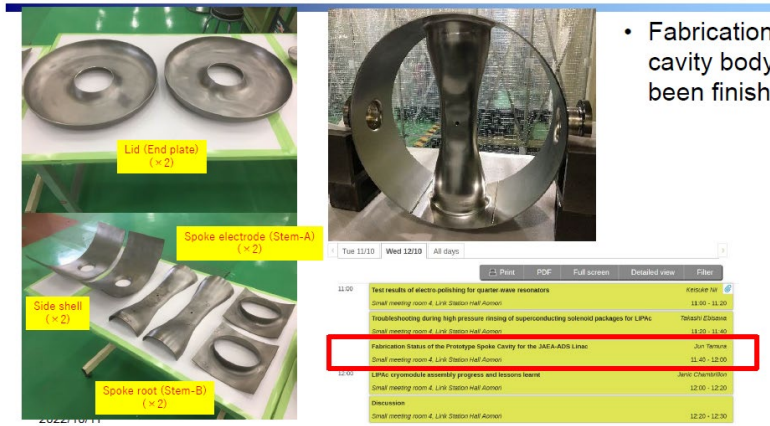
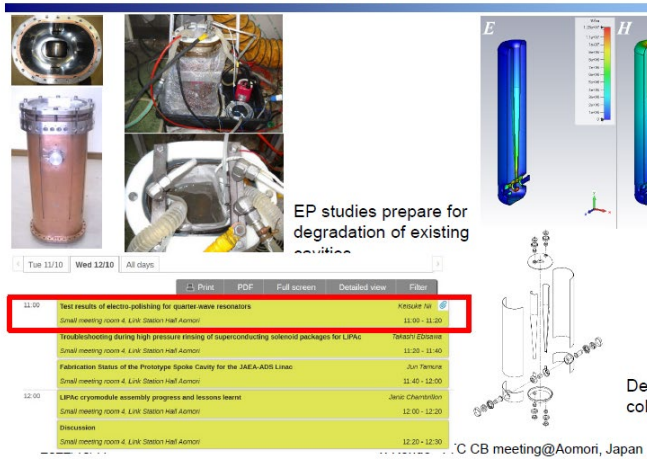
Current status



- Fabrication of cavity body has been finished.

6

Current activities



EP studies prepare for degradation of existing

Design work of new 65-MHz QWR collaboration with RIKEN and KEK

C CB meeting@Aomori, Japan

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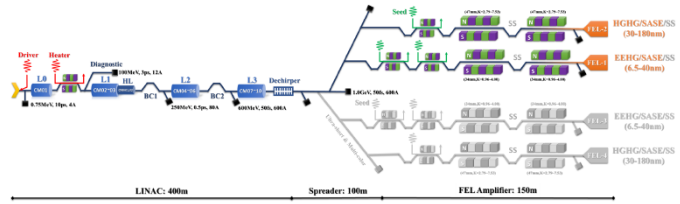
New TTC-CB membership (2)

SRF activities in IASF (China):

Dalian advanced light source (DALS)

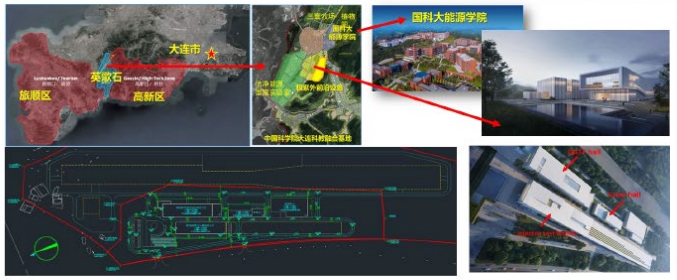


Parameter	design
beam energy/ GeV	1
charge/ pC	100
emittance/ mm-mrad	0.5
rep. rate/ MHz	1

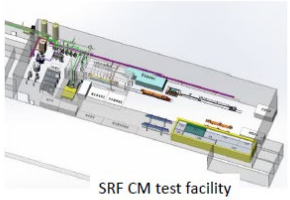
CM type	Frequency [GHz]	Number of Cavities	Number of CM
9-cell cavity CM	1.3	80	10
9-cell cavity CM	3.9	16	2

Dalian advanced light source (DALS)

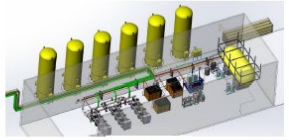
深圳综合粒子设施研究院 Institute of Advanced Science Facilities, Shenzhen



Start from 2021/9/22



SRF CM test facility



Cryo hall

- DALS R&D project launch on 2021/9/22
- 1 × injector test facility
- 1 × SRF CM test facility
- Cryoplant with 370 W@2 K

http://cryo.dicp.ac.cn/

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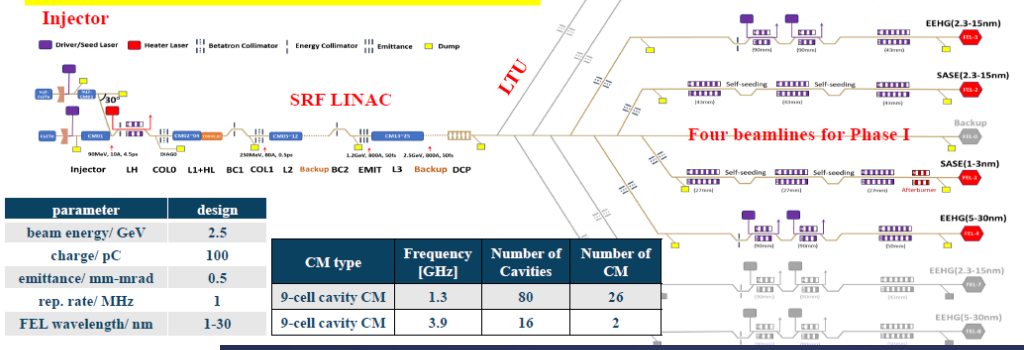
深圳综合粒子设施研究院 Institute of Advanced Science Facilities, Shenzhen

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

We are the same team!
All resources and personal from DALS will be duplicated/transferred for S³FEL project



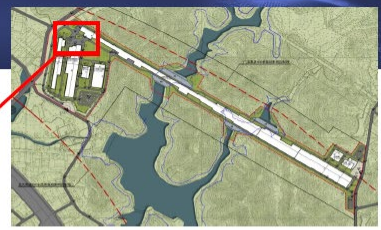
parameter	design
beam energy/ GeV	2.5
charge/ pC	100
emittance/ mm-mrad	0.5
rep. rate/ MHz	1
FEL wavelength/ nm	1-30

CM type	Frequency [GHz]	Number of Cavities	Number of CM
9-cell cavity CM	1.3	80	26
9-cell cavity CM	3.9	16	2

There is no soft X-ray F

Current situation

Construction of the first building (office) for S³FEL is done in 09/2022.
Civil engineering construction for Linac will be started soon.



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See you in the next TTC in-person meeting at FNAL in Chicago, early December 2023’

Thank you for your attention!