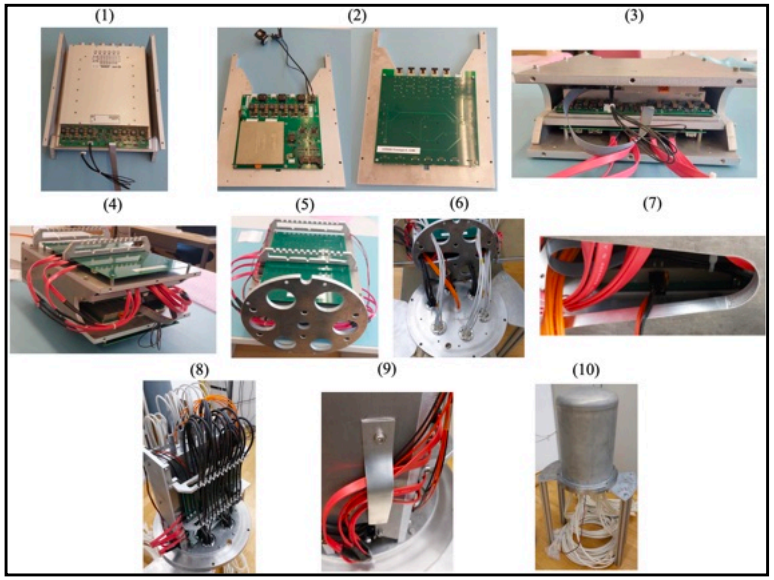
Status and future plan for CERN-JPARC cooperation on the proton accelerator

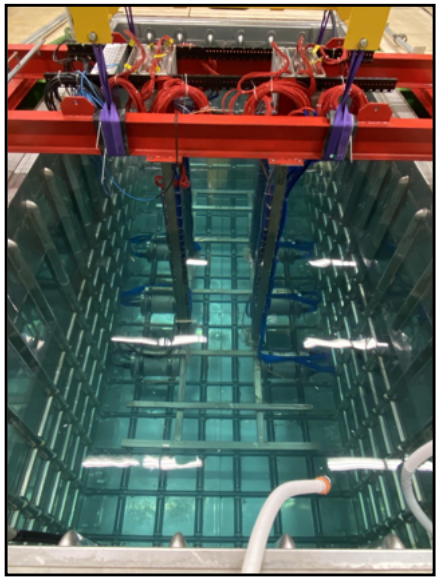
2024/11/26, CERN-KEK committee meeting

Ken Sakashita (KEK/J-PARC)

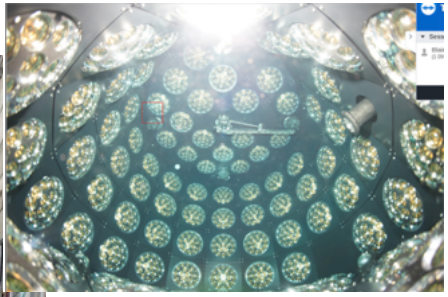
Before starting the main topics of this talk, I'd like to express our gratitude for CERN's cooperation on HyperKamiokande experiment

- There are various CERN's supports across a wide range of areas of HK project : Electronics assembly project (NP08), Test experiment for the Water Cherenkov detector (WCTE) and Hadron production experiment (NA61/SHINE)





HK electronics assembly at Bldg. 182



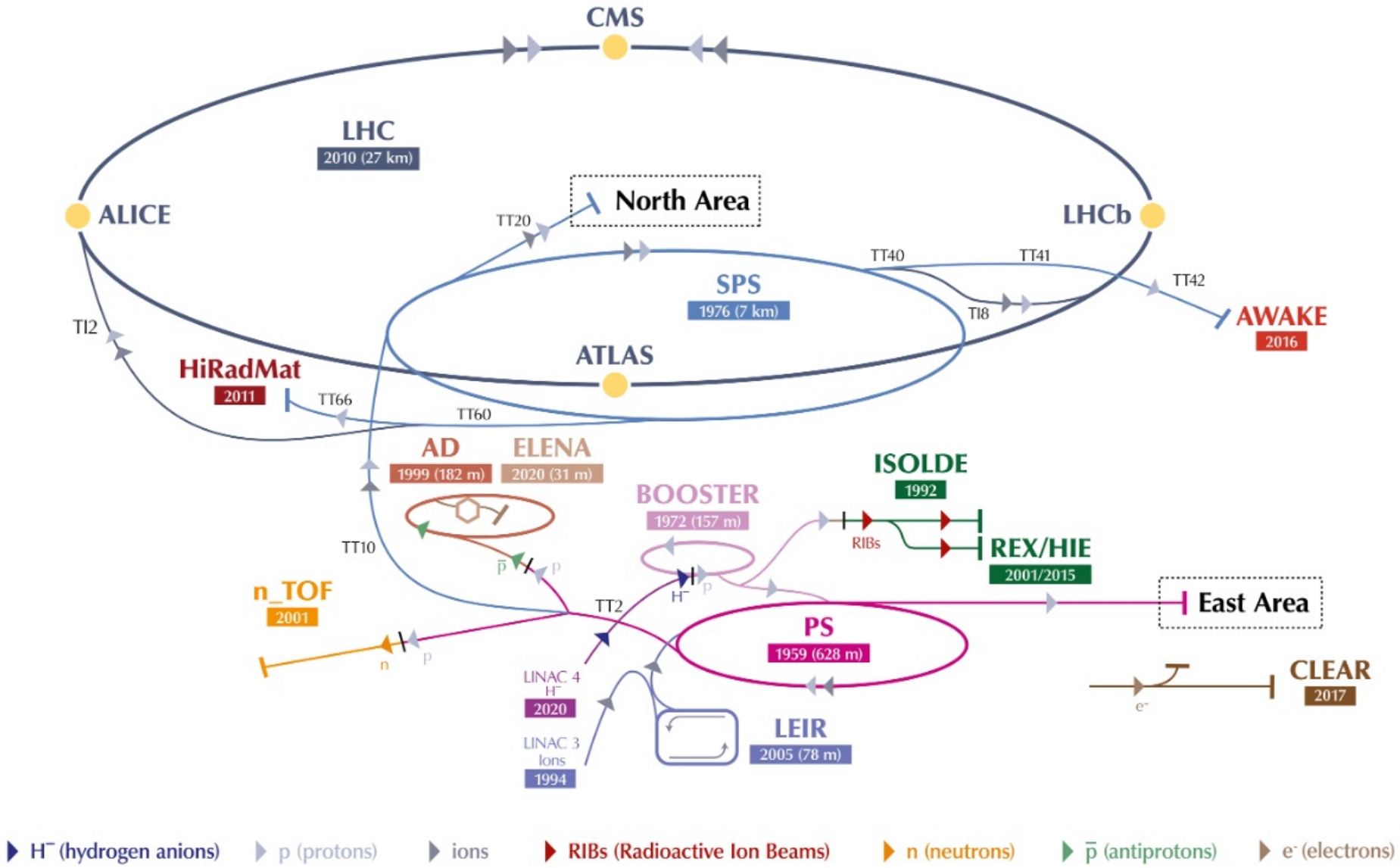
WCTE detector & beamline @ East Area

We deeply appreciate CERN's support for HK

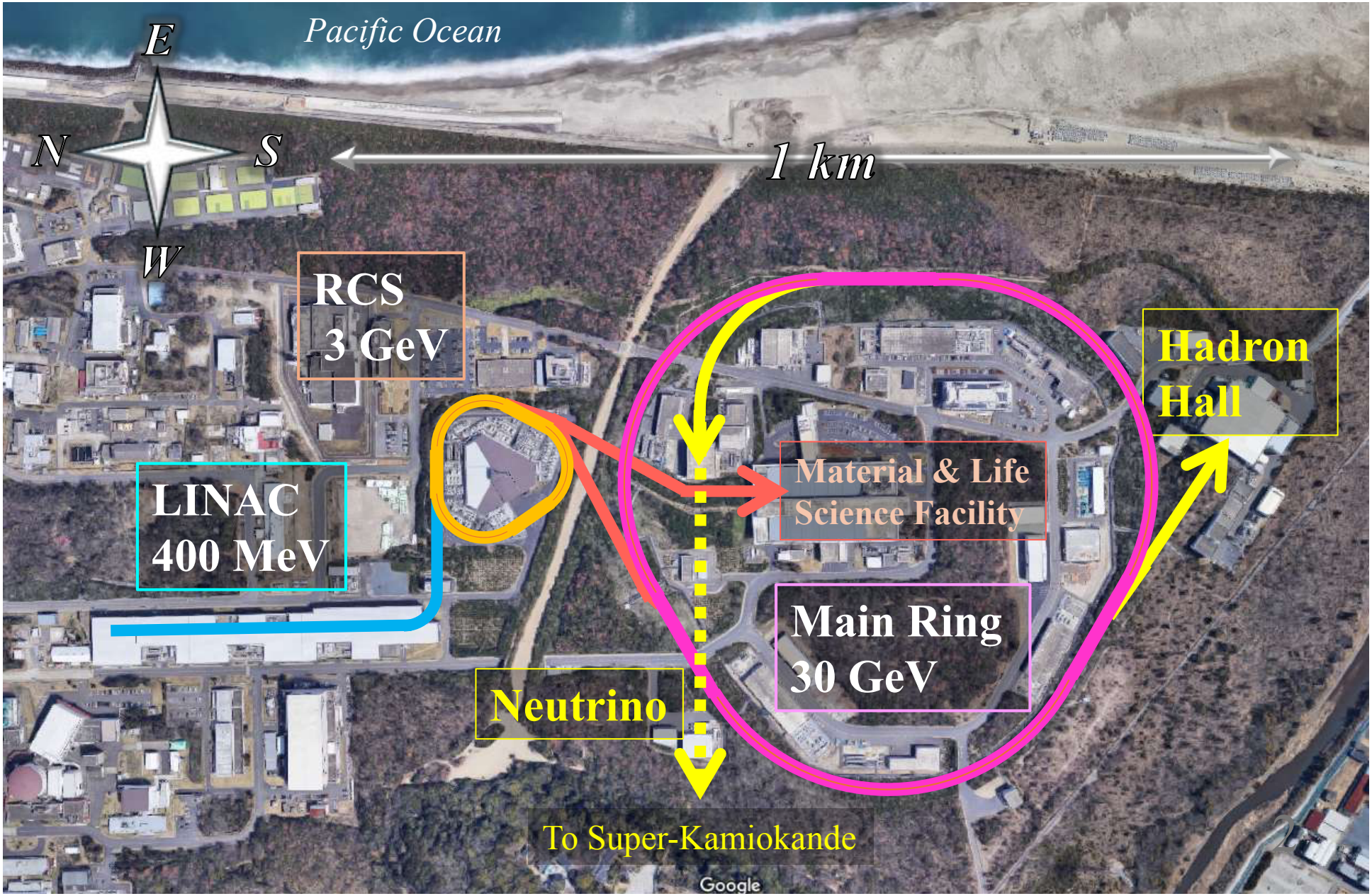
Contents

- Introduction of CERN & J-PARC cooperation on the proton accelerator
- CERN J-PARC workshop 2024 and introduction of some cooperation works
- Future prospects
- Summary

CERN accelerator complex



J-PARC accelerator complex



CERN & J-PARC cooperation on the proton accelerator

- Originally started around 2009 on proton LINAC reinforcement
- Agreement document for cooperation among KEK/JAEA/CERN for proton LINAC on 2011 (“arrangement”)
- Amendment No. 1 on 2016 to include beam dynamics studies/RF/LLRF/beam commissioning
- Amendment No. 2 on 2019 to include beam intercepting devices (targets/beam window/collimators/dump), high intensity target facility related items

CERN-JPARC high power beam workshop

- From October 10 to 12, the CERN-JPARC High Power Beam Workshop was held in Tokai, Japan. Approximately 50 researchers from CERN, J-PARC and KEK
- This is the 2nd workshop since it was last held at CERN in 2019

Workshop photo

Photos of discussion & facility tour

CERN-JPARC high power beam workshop

https://conference-indico.kek.jp/event/274/timetable/?view=standard

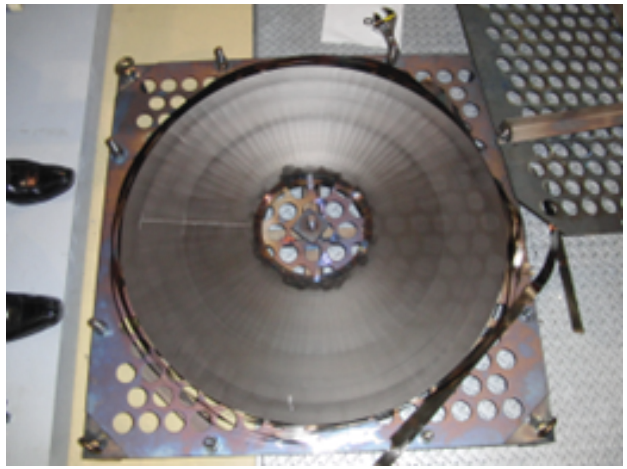
- Discussed various research collaborations (and potential future collaborations) on proton accelerators and high-intensity proton beam facilities

  - some example of topics : RF, beam monitor, beam dynamics, slow extraction, target, dump, horn, radiation effect on materials (RaDIATE) and/or electronics, H2 low-E beamline etc.

- In today's my talk, I will introduce some actual collaborative works as well as future prospects

RF cavity

- Over 20 years effort on RF Magnetic-Alloy (MA) cavities
- Collaboration for the LHC Injectors Upgrade project of the PSB



FINEMET(FT3L) core

Table 1: Magnetic Alloy Cavities

Facilities	Rings	Number of Cavities	Cell per Cavity	Total Voltage	Q-value	Cooling	Core	O.D. of core	Purposes
CERN	LEIR	2	1	8 kV	<1	Direct	FT3M	67 cm	Acc., 2nd
	PSB	3 × 4	2 ×6	24 kV	<1	Indirect	FT3L	33 cm	Acc.,2nd, 3 blow-up
	PS	1	5	5 kV	<1	Indirect	FT3L	33 cm	damper, barrier RF
	ELENA	1	1	500 V	<1	Indirect	FT3L	33 cm	Decel.
	AD	1	5	4 kV	<1	Indirect	FT3L	33 cm	Decel.
J-PARC	RCS*	~~11~~ 6	3	396 kV	~2.3	Direct	FT3M	85 cm	Acc.,2nd
		~~1~~ 6	4	36 kV	~2.5	Direct	FT3L	85 cm	Acc.,2nd
	MR*	~~8~~ 9	4	448 kV	~20	Direct	FT3L	80 cm	Acc.
		~~1~~ 0	4	55 kV	~10	Direct	FT3L	80 cm	2nd
		~~1~~ 2	4	55 kV	~10	Direct	FT3M	80 cm	2nd

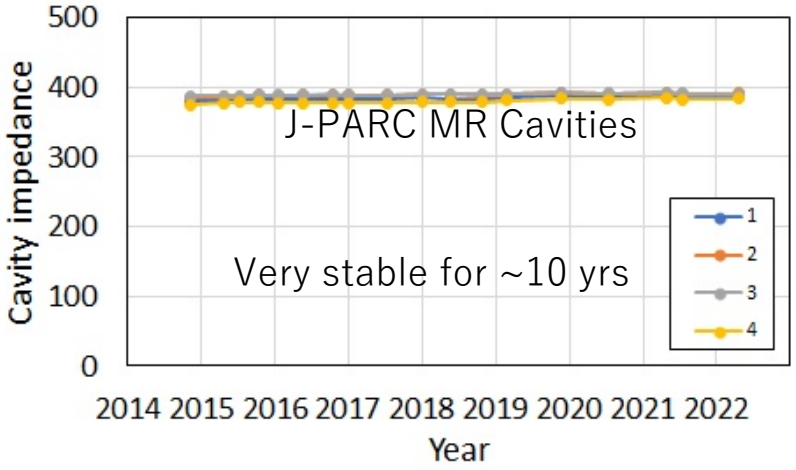
FT3M and FT3L are the name of cores which were annealed without and with magnetic field.

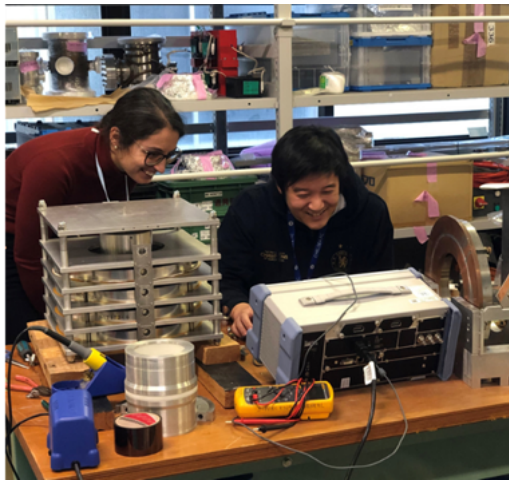
* Sep. 2023,- RF system upgrades are ongoing at J-PARC.

for 1.3 MW beam operation!

Recent and future cooperation on RF

- Sharing knowledge about the long term stability of MA cavities
- Low level RF system for multi-harmonic beam loading compensation which is a common issue between CERN PSB and J-PARC (RCS, MR)
- Amplifier (High dose, high power) R&D : e.g. GaN, solid-state Amp.
- Other topics of common interest

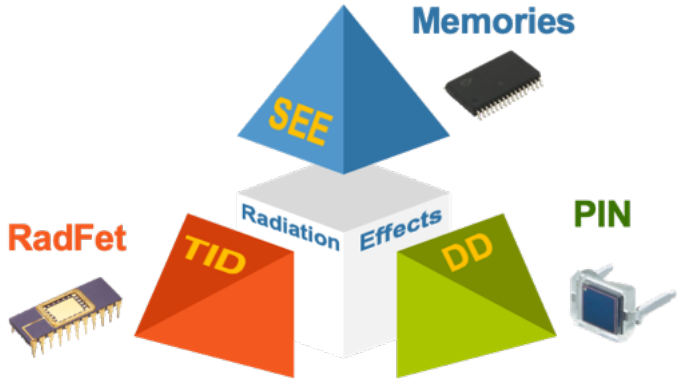


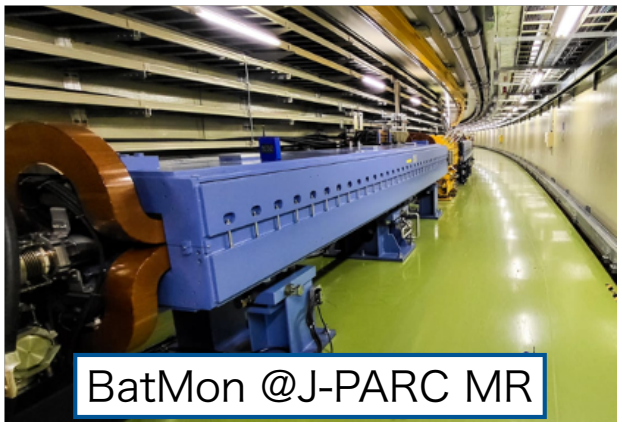


Stay tuned !

RADMON system

- RADMON, developed at CERN, is also being used at J-PARC for radiation tolerance testing of RF amplifiers
- Also utilized at other J-PARC facilities, e.g. 3NBT and Neutrino experimental facility for SEE evaluation
- Recently, test of the Wireless IoT BatMon was conducted



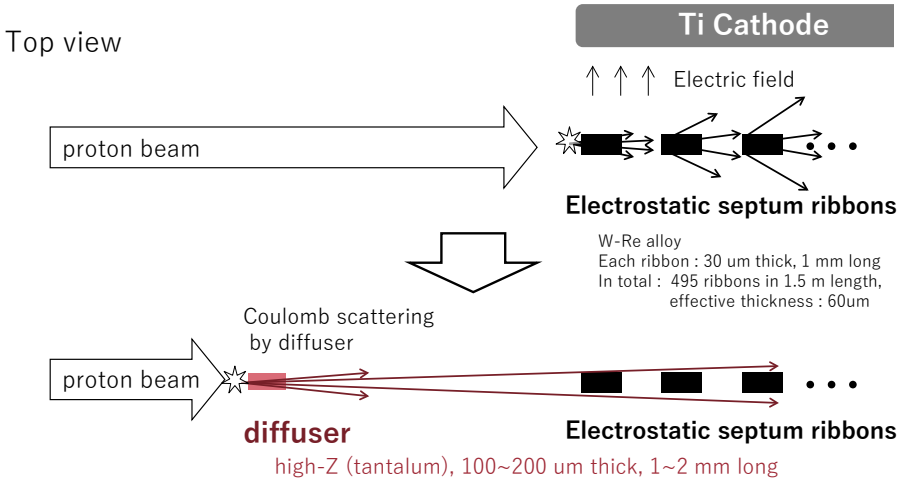

BatMon @J-PARC MR

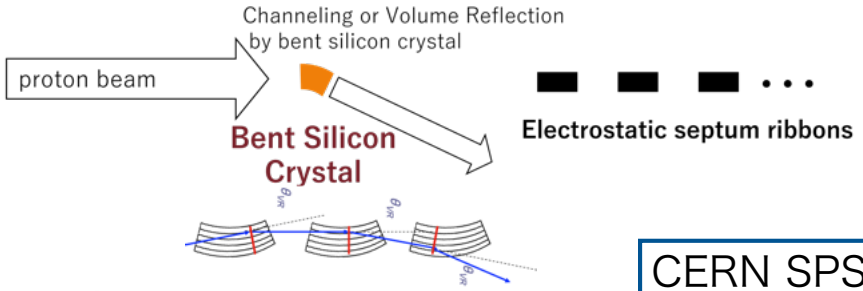

RADMON@
J-PARC Neutrino taget station

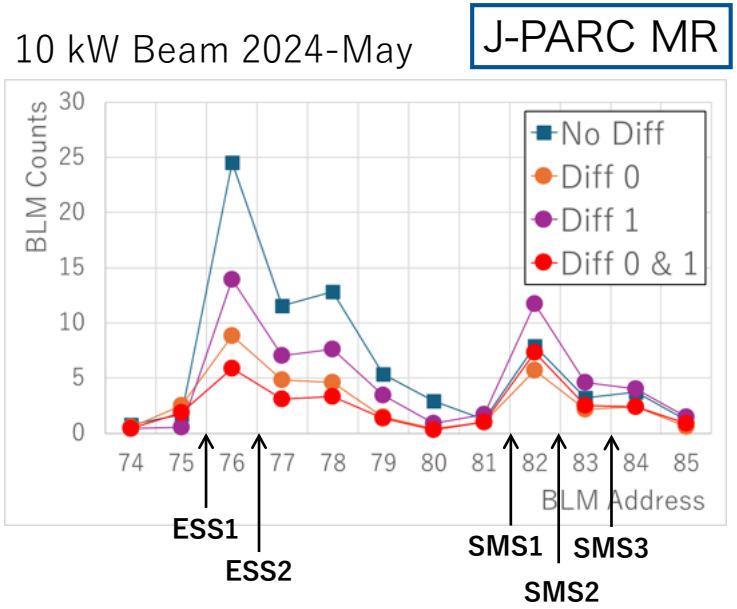
Future applications are anticipated

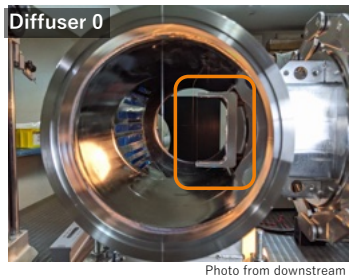
Slow extraction

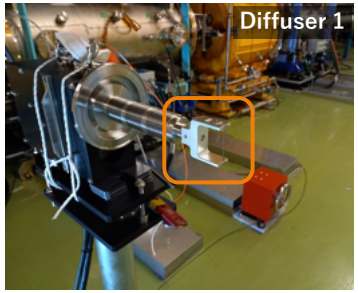
- CERN SPS and J-PARC MR have many common challenges in slow extraction (e.g. beam loss reduction)
- Cooperation on various slow extraction challenges
  - Diffuser, Bent silicon crystal

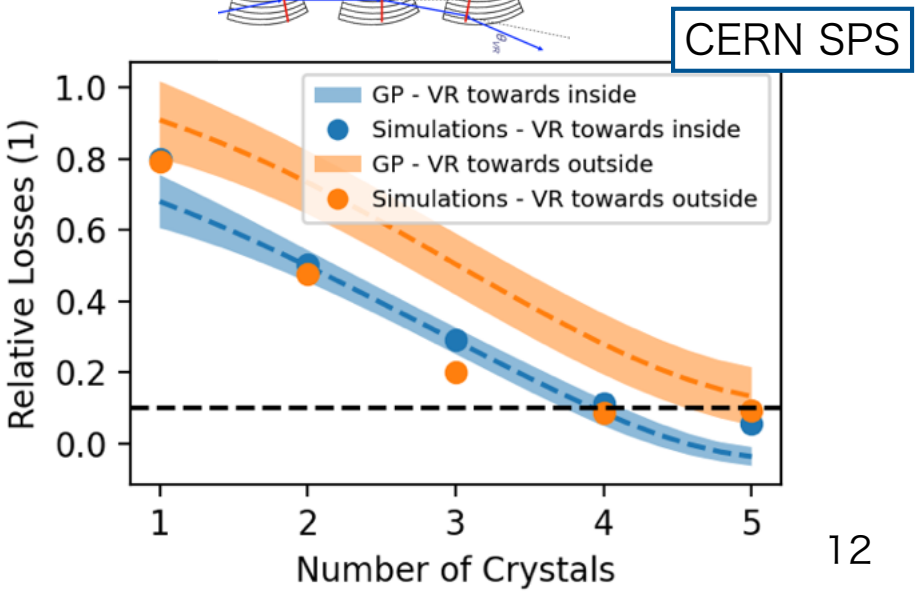












Antiproton Decelerator (AD) target at CERN

The process of signing a Memorandum of Understanding in underway

- The TFGR-W (Toughened Fine Grained Recrystallized tungsten alloy) developed by the J-PARC will also be utilized in the CERN AD target
- Study the irradiated target (including PIE) to understand the rad-hardness of the TFGR-W
- New cooperation between CERN and J-PARC

APPENDIX N°2 KN6225/SY
TO THE ARRANGEMENT KN1839/BE

COLLABORATION FOR UPGRADE OF ANTIPROTON DECELERATOR TARGET AT CERN WITH KEK DEVELOPED TFGR TUNGSTEN ALLOYS

BETWEEN

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH ("CERN"), an Intergovernmental Organization having its seat at Geneva, Switzerland,

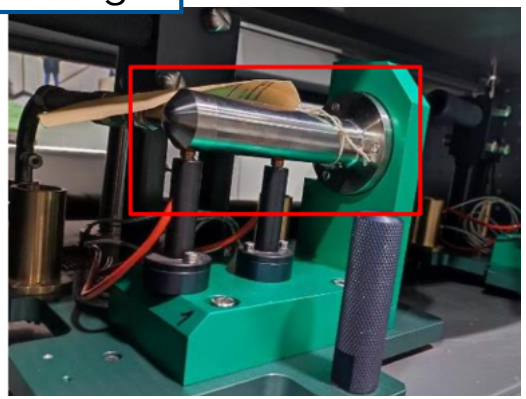
AND

THE HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION ("KEK"), established at 1-1 Oho, Tsukuba-shi, Ibaraki-ken 305-0801, Japan,

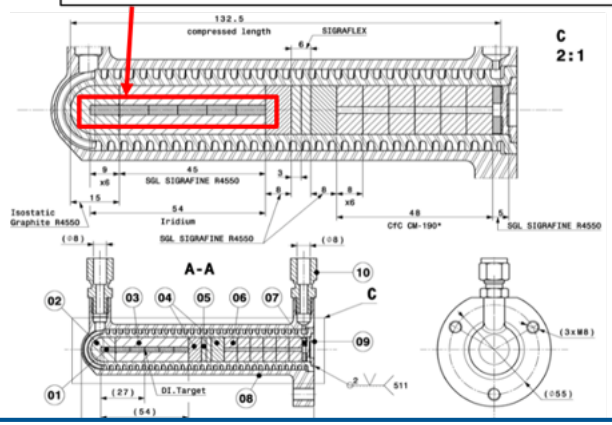
AND

THE JAPAN ATOMIC ENERGY AGENCY ("JAEA"), established at 765-1 Funaishikawa, Tokai-mura, Naka-gun, Ibaraki-ken 319-1184, Japan

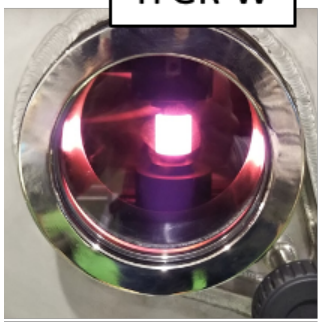
AD target



One rod in six Iridium rods is replaced with TFGR-W



TFGR-W



The TFGR-W has overcome the challenge of its embrittlement

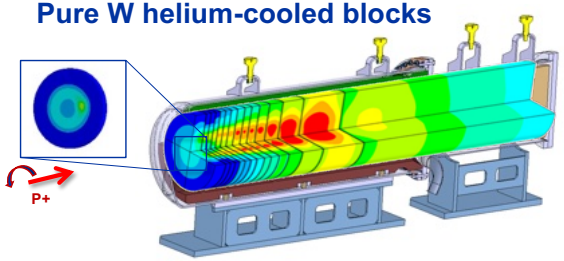
Also benefits to other J-PARC experiments (e.g .COMET target, HD target)

New cooperation on beam intercepting devices

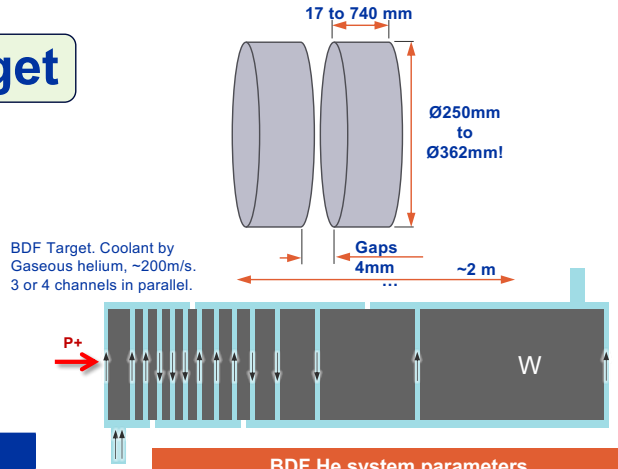
- A new cooperation will begin on beam intercepting devices such as high-power targets, dumps, and collimators, as well as on facilities

BDF W Helium cooled Target

Pure W helium-cooled blocks

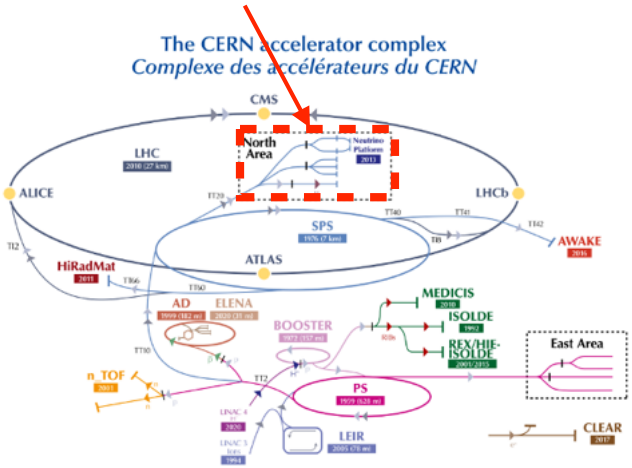


BDF operational conditions	
Beam parameters	400GeV/c, 4x10^{13} ppp. 4x10^{19} POT 1/7.2 s spill/cycle length 8-16mm 1σ, 50mm radi sweep
Target design lifetime	~5 years
Max dpa	1.6 to 1.2
Max He implantation	220 to 143 appm
Max stresses	150 Mpa
Max bulk temperature	400 °C
Max W-to-He surface Temperature	350 °C



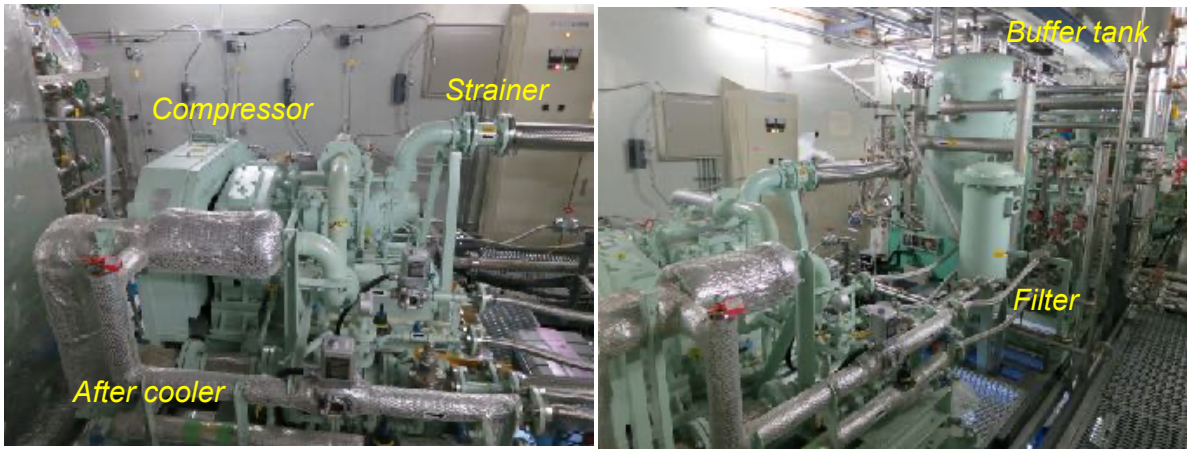
BDF He system parameters	
Thermal Power	305 kW (350kW beam power)
Inlet Pressure	16 bara
Pressure Drop	<2 bar (high estimate)
Mass flow	345 – 400 g/s
Volume flow	0.13 -0.15 m^3/s
Inlet temperature	30 °C
Outlet temperature	200-170 °C
Heat transfer coefficient	1000-2000 W/m2/K

One of main items is the W target with helium cooling at new Beam Dump Facility @CERN North Area

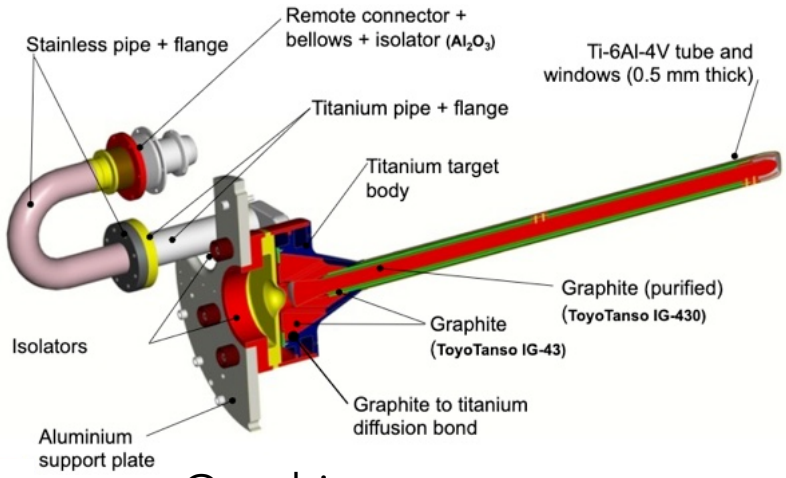


Helium cooling systems and W target are common technological topics between CERN and J-PARC

J-PARC Neutrino Experimental Facility (NEF)



He gas circulation system

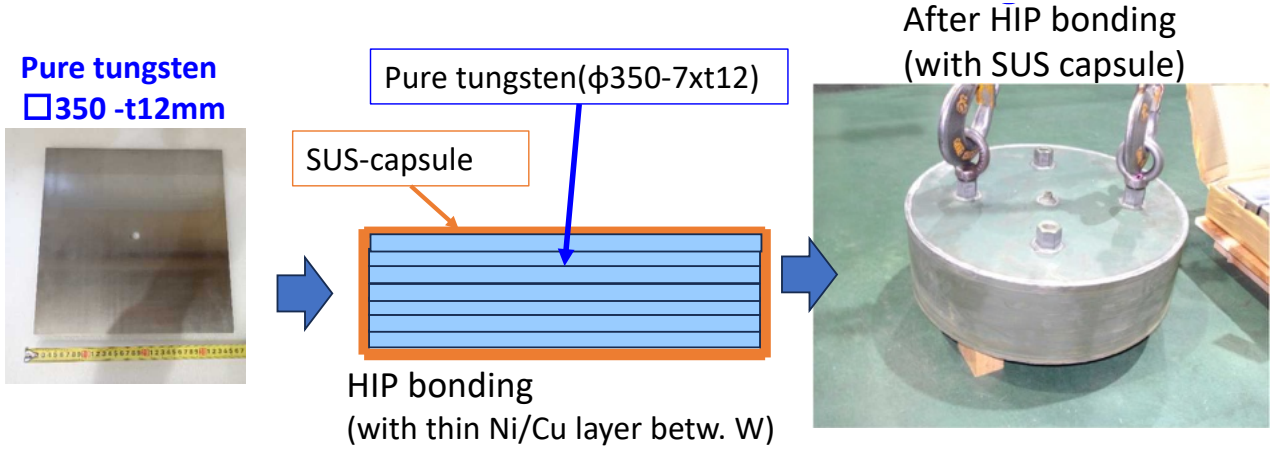


Graphite target

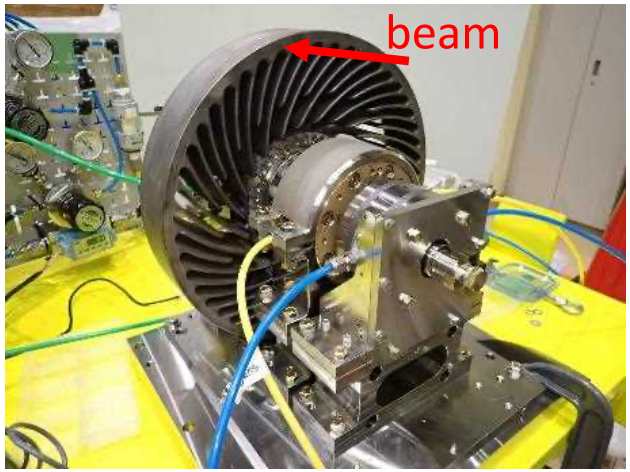
- At the neutrino experimental facility, the neutrino production target are cooled using helium gas. Also, the pion decay volume vessel (~1500 m^3) are filled helium gas. These are under operation with 800kW beam power.

Helium cooling systems and W target are common technological topics between CERN and J-PARC

J-PARC Hadron Experimental Facility (HEF)



A part of pure-W disk bonding procedures



Rotating W target

- At the Hadron Experimental Facility, a rotating W target is being developed as a new target for future high-intensity beams. Helium gas will also be used for target cooling

- There are several specific common development items between CERN BDF and J-PARC HEF&NEF
  - W-W joining technologies
  - Beam test experiments (at CERN) to validate the performances & strength of W-W bonding
  - He-cooling systems (filtering, contamination measurement)
  - He-gas conversation system
  - Other items

We will initiate research collaboration on these topics (including a couple of weeks exchange of personnel)

Future prospects

- In the workshop, various other potential future collaborations were also discussed
- We will continue workshops in the future. Plan to have the next one at CERN in 2026 (every two years)
- We would like to extend the “arrangement” (which will be expired on 2026 April) in order to advance future research collaboration

Summary

- There are various collaborative research projects between CERN and J-PARC on the proton accelerators
- From October 10 to 12, the CERN J-PARC High Power Beam Workshop was held in Tokai, Japan
- Specific new collaborative work, such as beam intercepting devices, are about to start

We aim to further develop collaboration between CERN and J-PARC on the proton accelerators