SRF Activities in Korea

2026. 10. 24.

Yeonsei Chung

Institute for Rare Isotope Science, IBS, KOREA

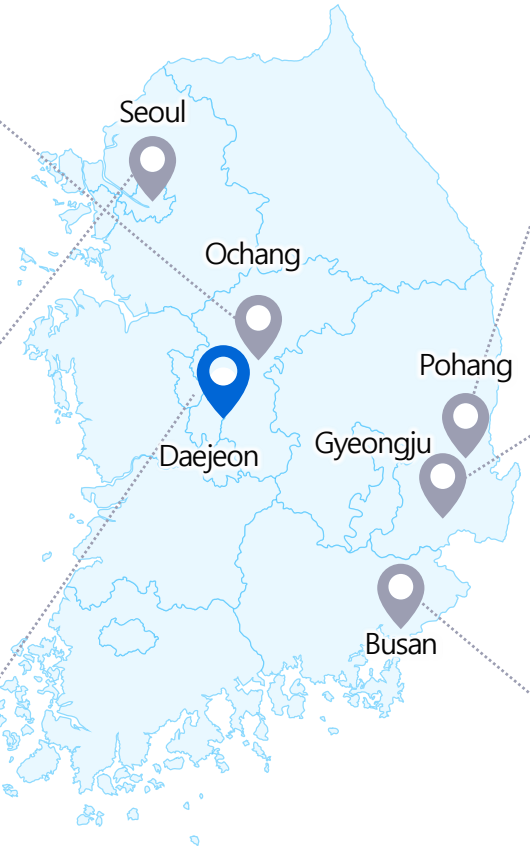
Major Accelerator Facilities in Korea


Korea Light Source (KLS)

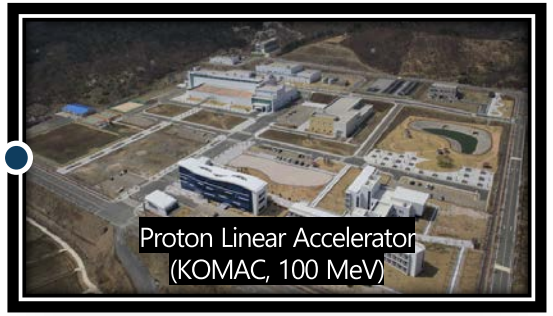


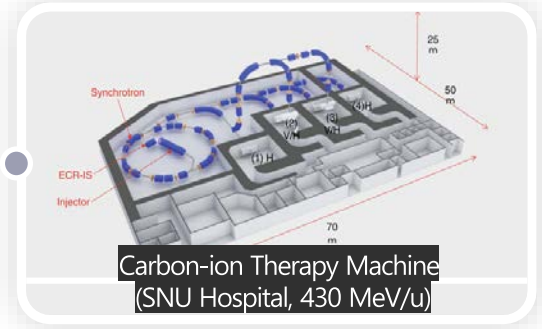
Carbon-ion Therapy Machine
(Yonsei Hospital, 430 MeV/u)


Heavy-Ion Accelerator (RAON)
(up to Uranium)




Pohang Light Source (PLS-II),
Pohang Accelerator **Laboratory** XFEL

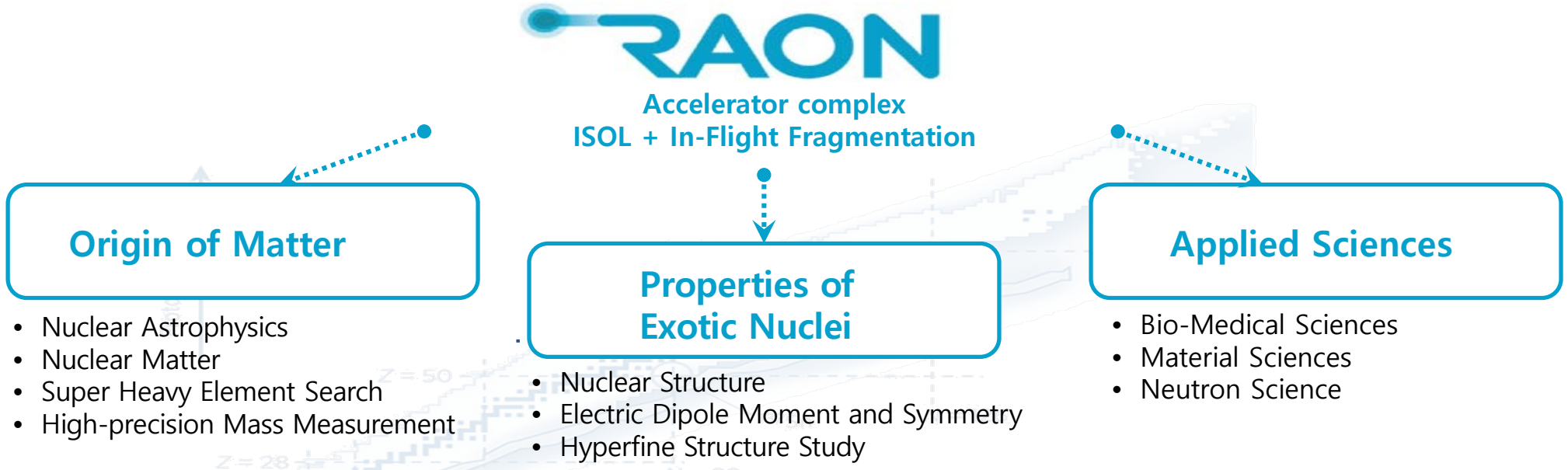

Proton Linear Accelerator
(KOMAC, 100 MeV)



Carbon-ion Therapy Machine
(SNU Hospital, 430 MeV/u)

RAON Rare isotope Accelerator complex for On-line experiments

IRIS 중이온가속기연구소 Institute for Rare Isotope Science



Goal To build **a heavy-ion accelerator complex RAON** for **rare isotope science** research in Korea

Status

Rare Isotope Science Project (RISP) : Dec. 2011 – Dec. 2022

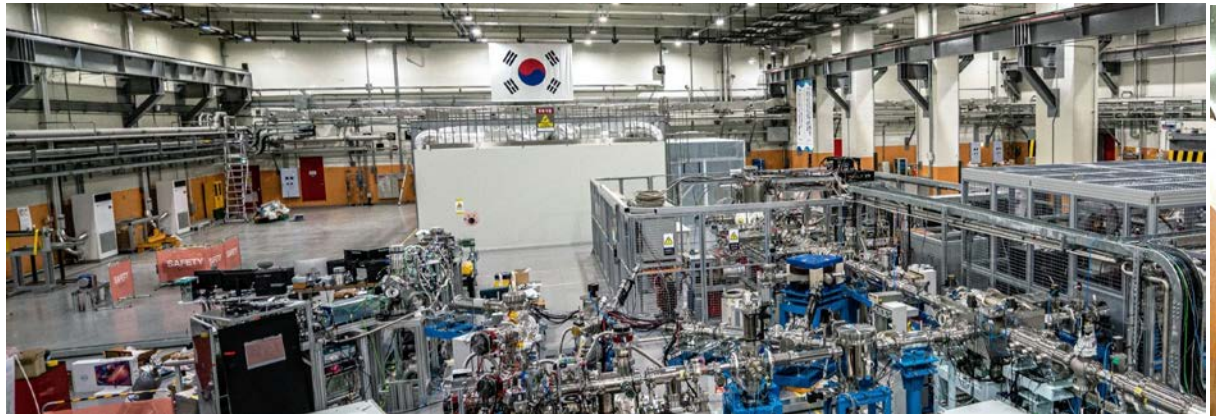
RISP is changed to "IRIS" as of July 1, 2022. (From project to operation)

R&D for high-energy linac (SCL2) : Dec. 2022 – Dec. 2027

RAON Rare Isotope Accelerator Complex



Brief History of RAON : RISP to IRIS



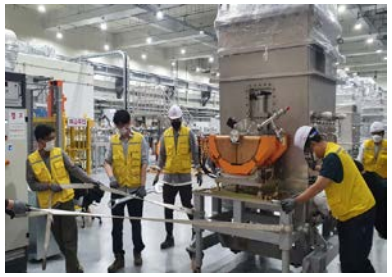


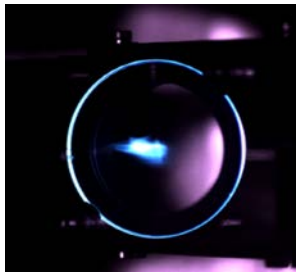












2011

- ‘10.02 Preliminary Design Study
- ‘11.02 Conceptual Design Study
- ‘11.11 IBS Established
- ‘11.12 Rare Isotope Science Project (RISP)
- ‘14.02 Purchasing the Land (RAON Site)
- ‘17.02 Civil Construction started

2015

2019

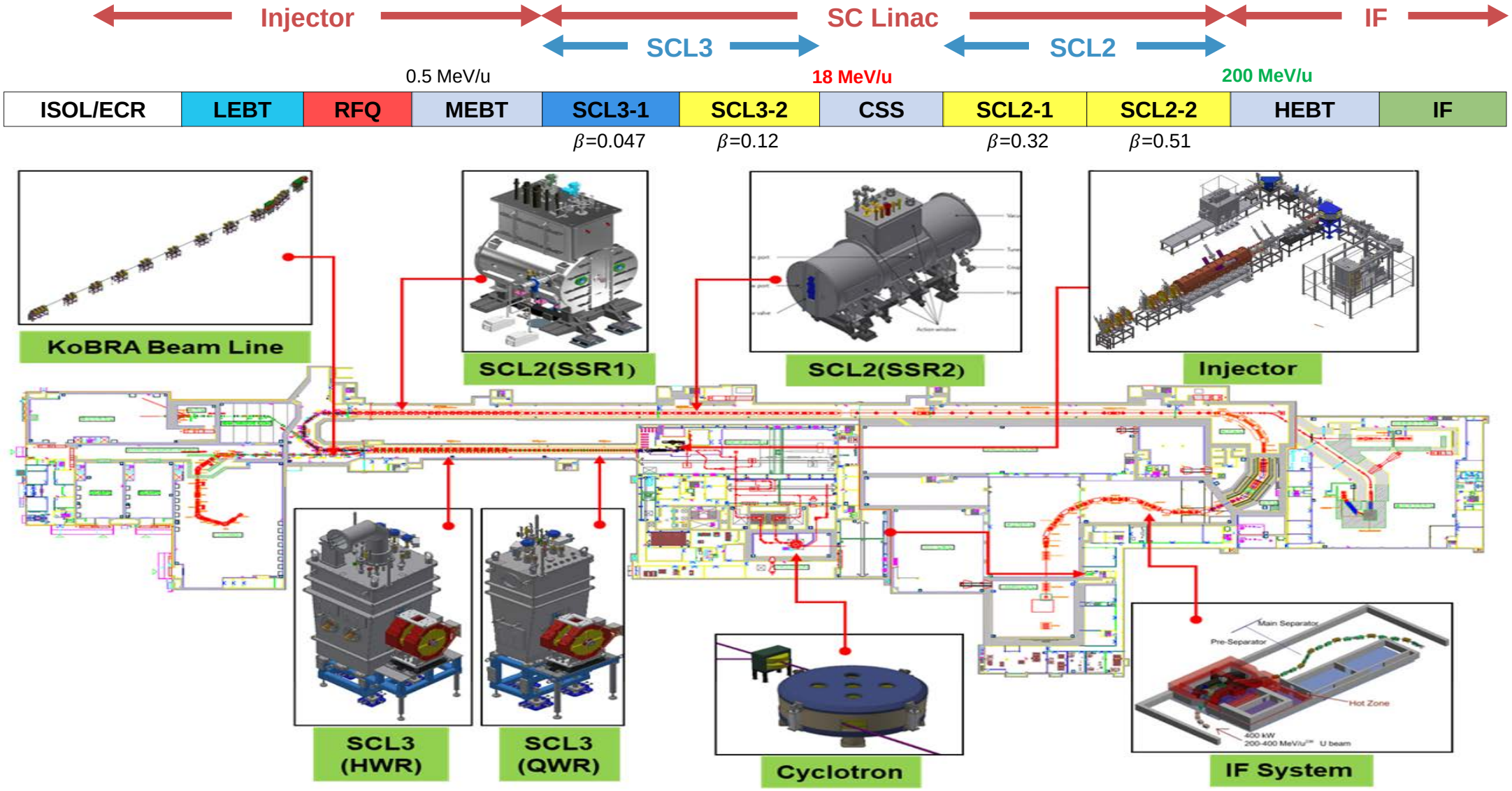
- ’19.04 RISP moved on RAON site
- ‘19.09 Installation Started
- ’20.09 QWR CM Installation
- ’21.12 HWR CM Installation
- ’22.07 Institute for Rare Isotope Science
- ’22.08 SCL3 Cryoplant commissioning
- ’22.12 1st Phase Completed

2023

- ’23.03 1st ISOL RIB Production
- ’23.05 SCL3 Beam commissioning
- ‘23.12 1st Call for Proposals
- ‘24.03 1st PAC meeting
- ‘24.07 User Beam Experiments started
- ‘25.01 2nd Call for Proposals
- ‘25.05 2nd PAC meeting
- ‘25.09 3rd Call for Proposals
- ‘26.01 3rd PAC meeting

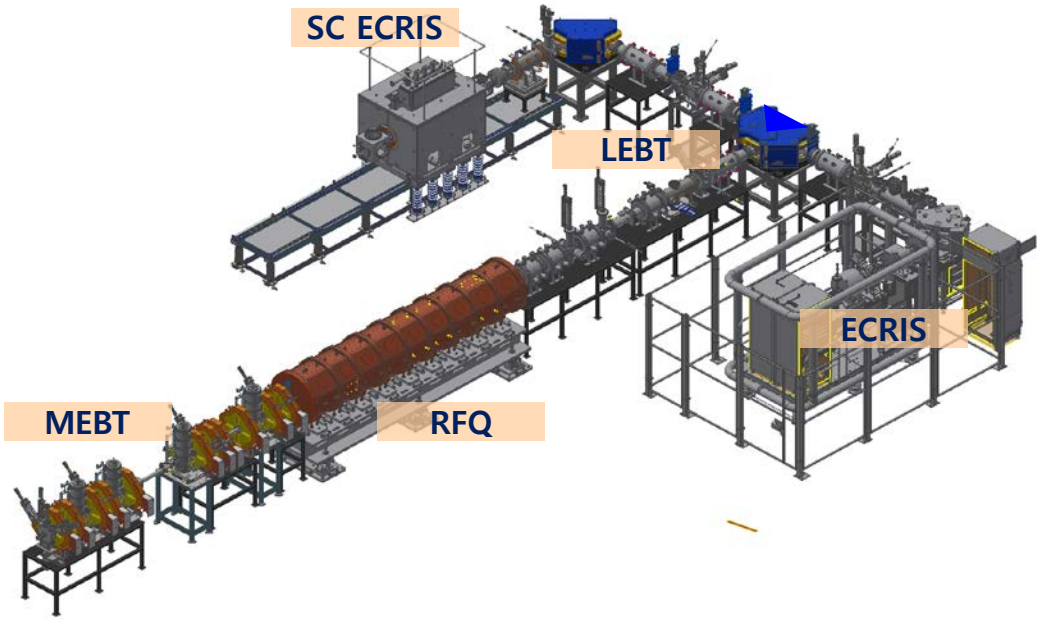
2026

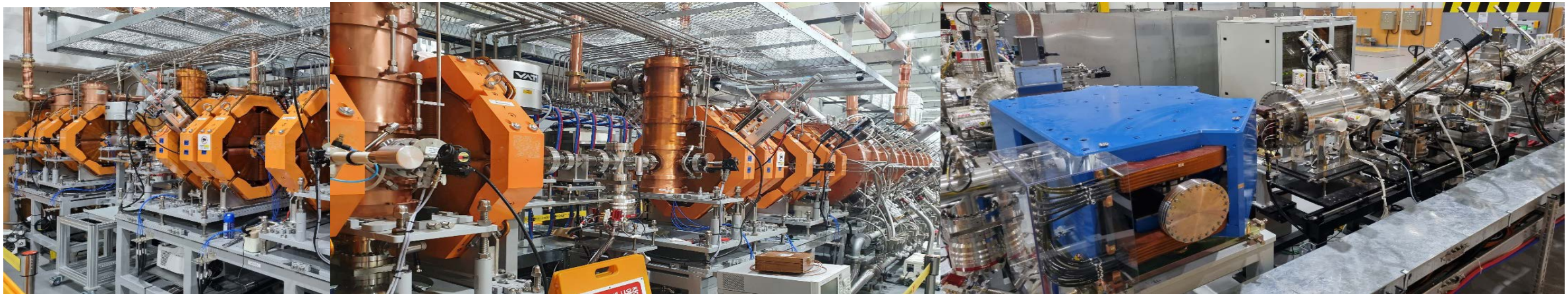
RAON Accelerators



Injector System

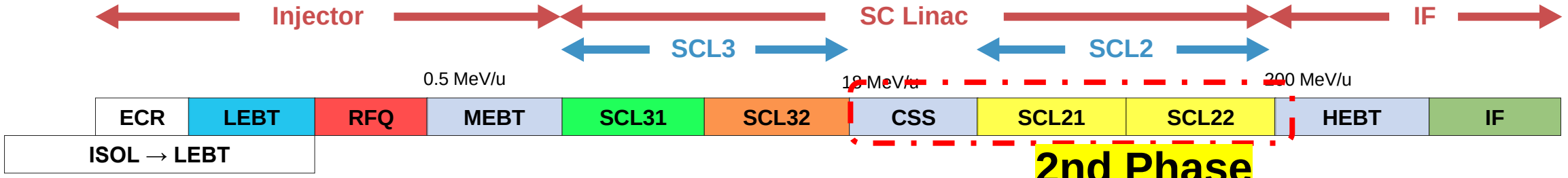
- **Two ECR-IS on high voltage platforms**
  - 14.5 GHz ECR ion source
  - 28 GHz superconducting ECR ion source
- **LEBT (E = 10 keV/u)**
  - 10 keV/u, Dual bending magnet
  - Chopper & Electrostatic quads, Beam instrumentation
- **RFQ (E = 500 keV/u)**
  - 81.25 MHz, Transmission Eff. ~98%
  - CW RF Power 94 kW (SSPA: 150 kW)
- **MEBT (E = 500 keV/u)**
  - Four RF bunchers (SSPA: 20, 15, 2×4 kW)
  - Eleven quadrupole magnets, Beam instrumentation





- Installation completed and beam commissioning from October, 2020

Superconducting Linear Accelerator



2nd Phase

Superconducting Linac 3(Low-energy section)



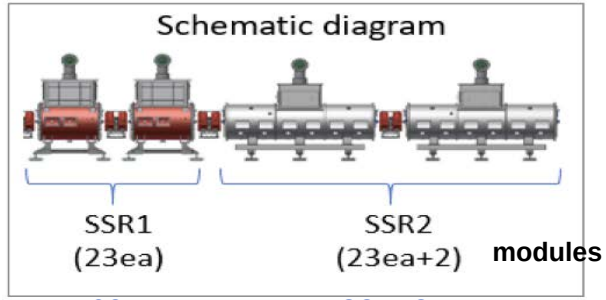
Superconducting Cavity (QWR/HWR)

Total (124 cavities)

Superconducting Linac 2(High-energy section)

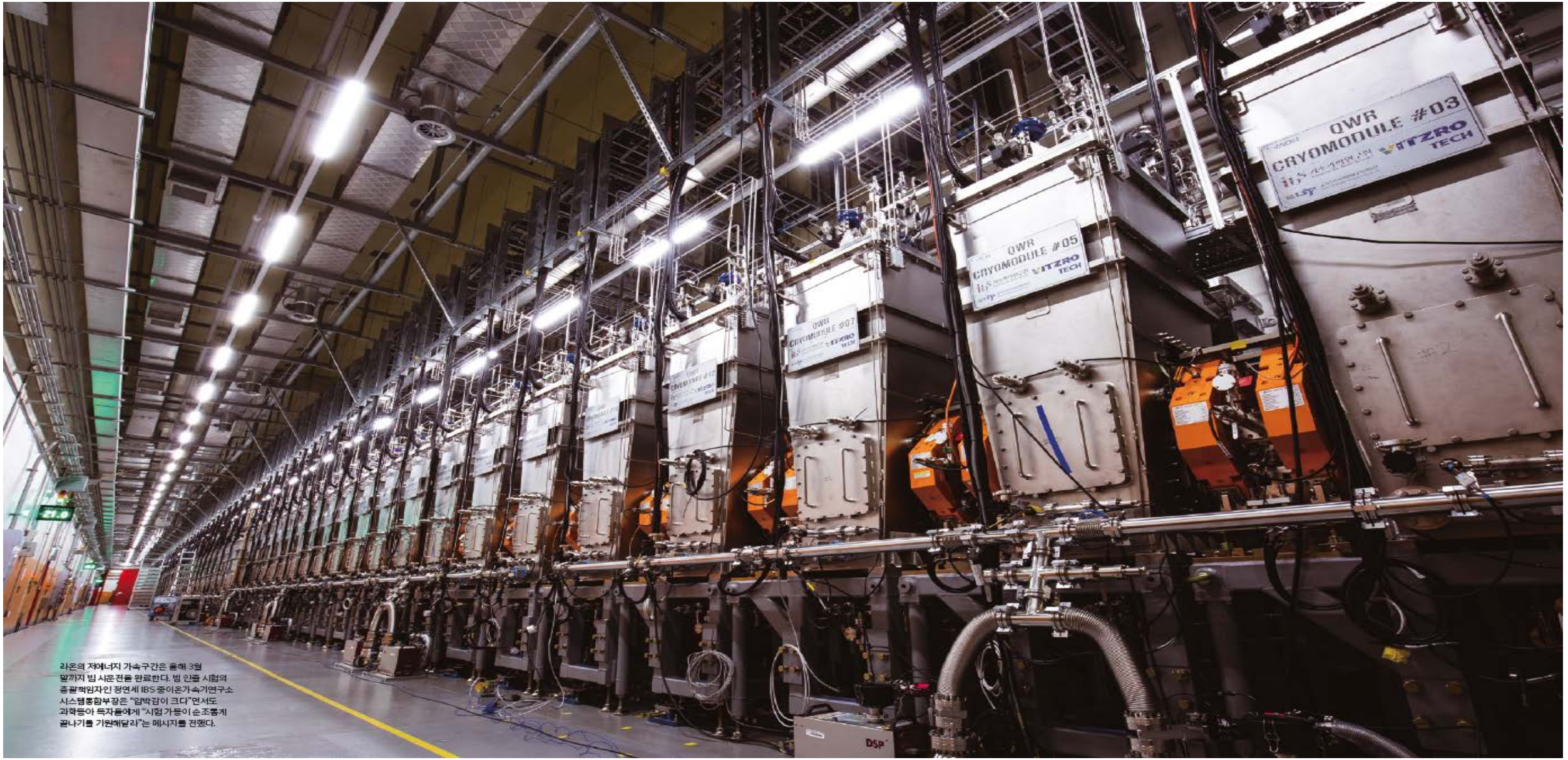


Superconducting Cavity (SSR1, SSR2)



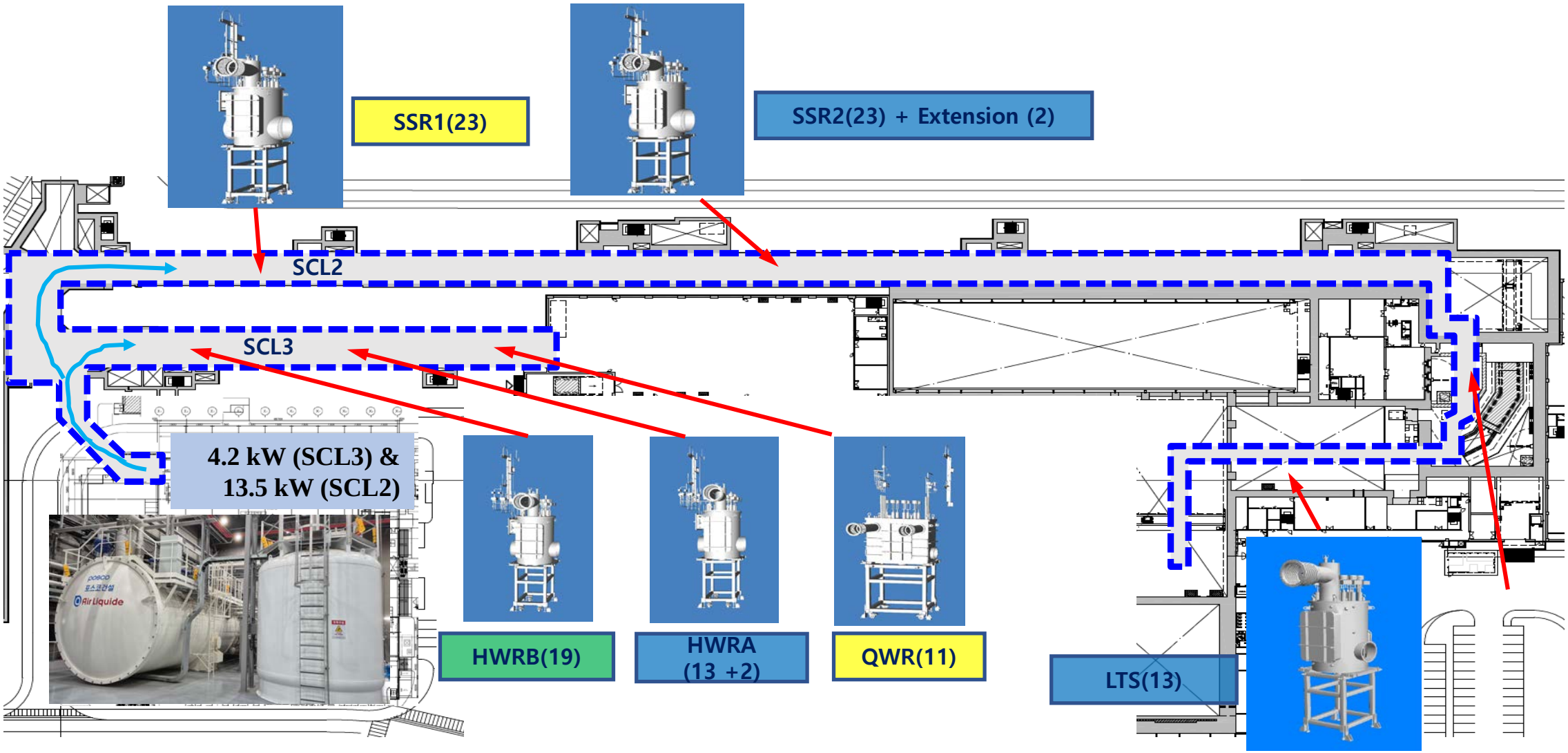
Total (219 cavities)

Superconducting linear accelerator (SCL3) in the tunnel



라온의 저에너지 가속구간은 올해 3월 말까지 빔 시운전을 완료한다. 빔 인출 시험의 총괄책임자인 정연세 IBS 중이온가속기연구소 시스템통합부장은 "압박감이 크다"면서도 과학동아 독자들에게 "시험 가동이 순조롭게 끝나기를 기원해달라"는 메시지를 전했다.

Layout of Cryogenic Distribution Systems

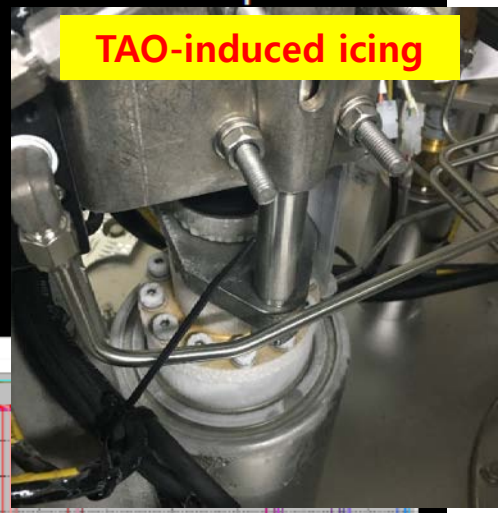


1st Cool-down of SCL3 in 2022.9-2023

2022 → 2023

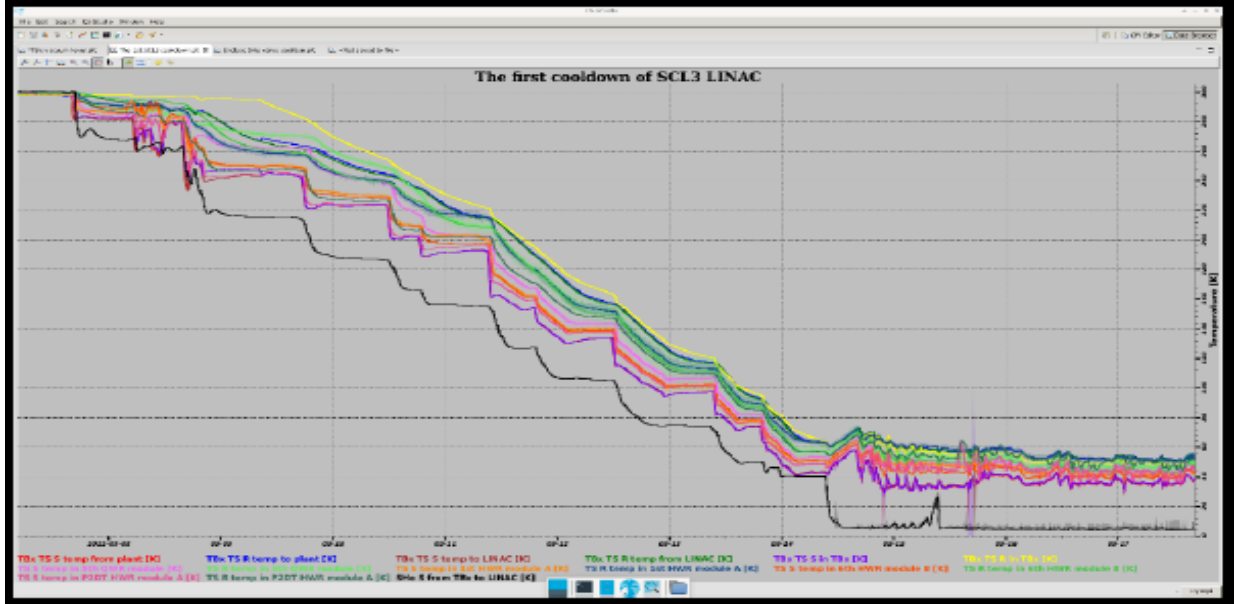
- Sep. 7th – Oct. 26th
  Cooldown under 4.5 K
- Nov. 24th – Jan. 11th
  1st cooldown under 2 K
- Feb. 21st – 24th
  2nd Cooldown under 2 K
- Apr. 21st
  3rd Cooldown under 2 K
- Jun. 8th – 31st
  Warmup

- Sep. 21th – Oct. 7th
  Beam commissioning (6 QWR)
- Nov. 4th – Dec. 16th
  Beam commissioning (22 QWR)
- Feb. 27th – Jun. 7th
  Beam commissioning (SCL3)



◈ Cooling strategies

- **Step 1 : Step Cool-down(20K~50K) controlled by Turbine 1 → "SCL3 CBx + HDS(TBX / CTL / EBx)+THS(HDS/CM)"**
- **Step 2 : QWR/HWR fast cool-down(150K ~ 50K / one by one)**

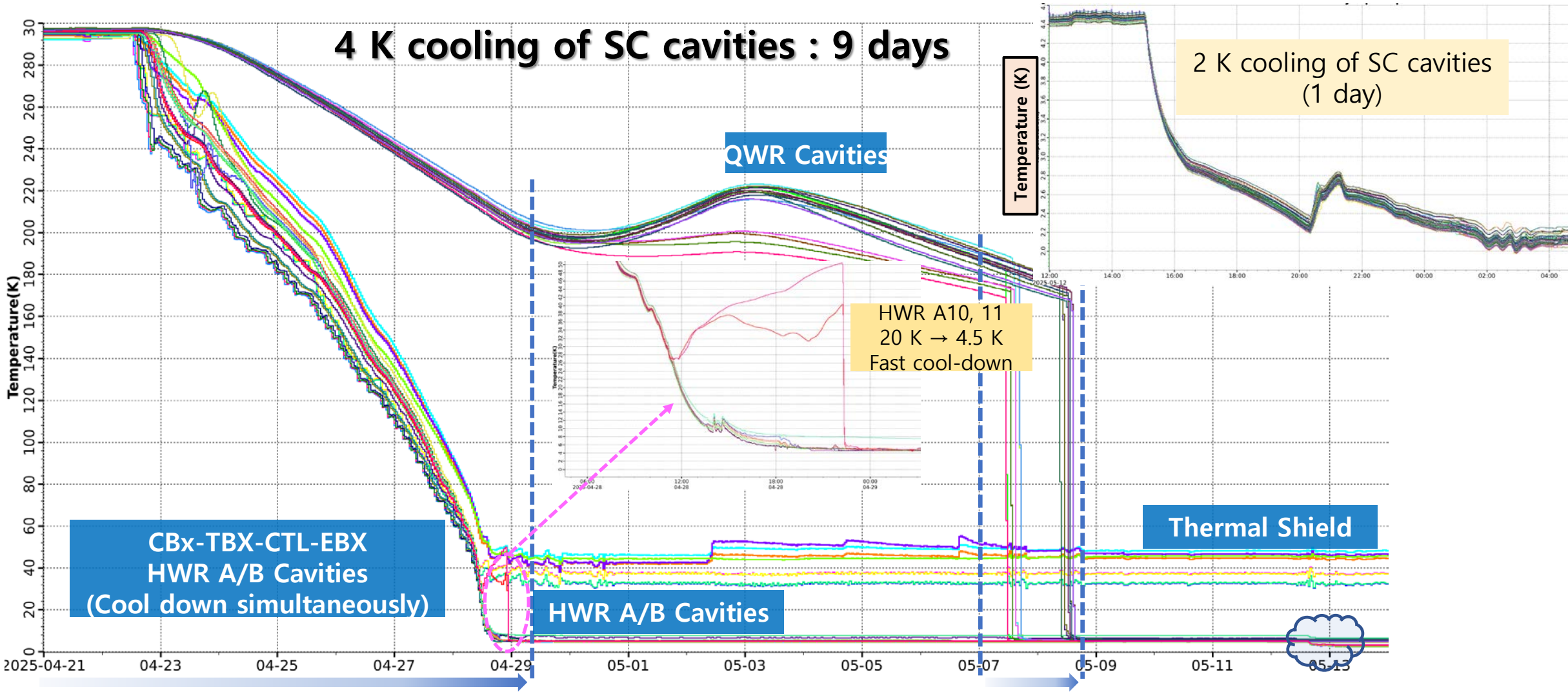


Cooldown from 300 K to 4.5 K



Cooldown from 4.5 K to 2.05 K

Cool-down (3rd) of SCL3 in 2025

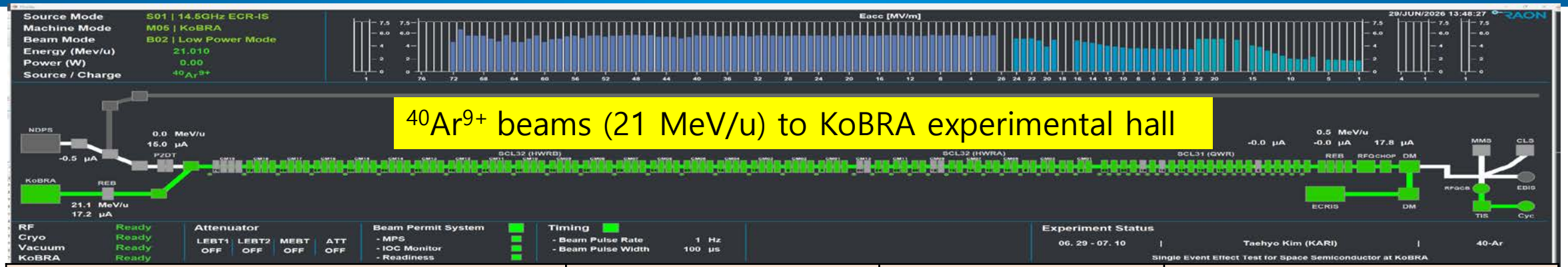


CBx-TBx-CTL-EBx and HWR A/B 4.5K Cool-down
Thermal Shield 40 K Cool-down(7 days)

QWR 4.5K
Cool-down(2 days)

HWR A/B 2K
Cool-down(1 day)

SCL3 SI Beam Commissioning (2024~2026)



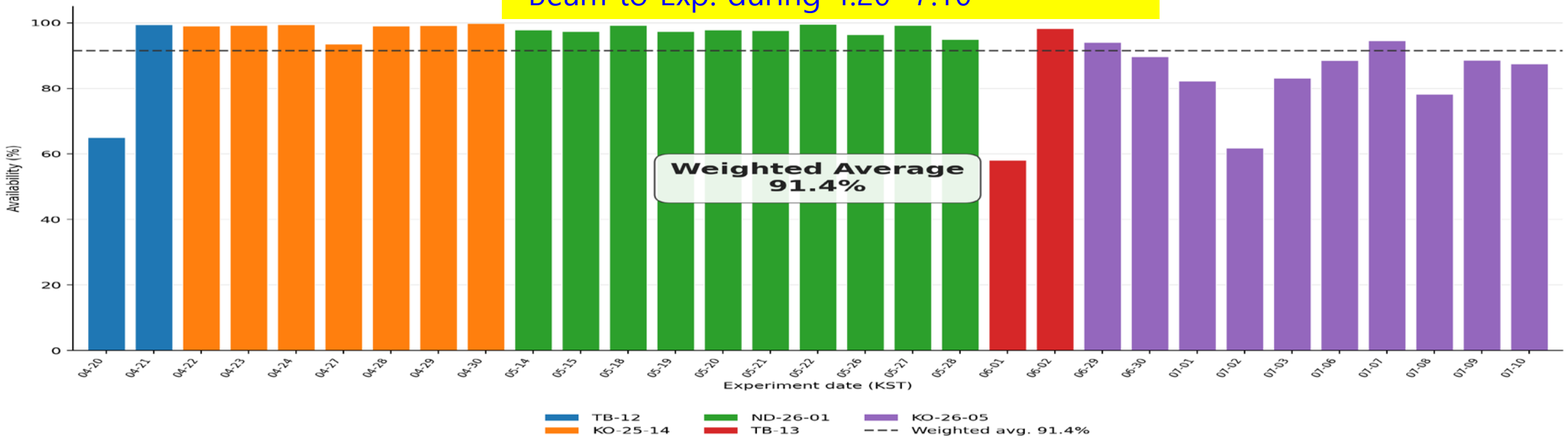
	2024	2025	2026
Particle	$^{40}Ar^{8+}$	$^{40}Ar^{8+}$	$^{22}Ne^{6+}$, $^{40}Ar^{8+ \& 9+}$
Current (MEBT, μA)	42.4	46	3, 46, 20
QWR Field(MV/m)	5.0	5.0	5.0
HWR-A Field (MV/m)	5.0	5.0	5.0
HWR-B Field (MV/m)	(<±1%, <±1°)	5.5	5.5
QWR (Unused cavities)	19 (3, 12, 21)	19 (6, 16, 18)	19 (6, 16, 18)*
HWRA (Unused cavities)	24 (6, 8)	21 (6, 17&18, 25&26)	22 (17&18, 25&26)**
HWRB (Unused cavities)	71 (24, 28, 61)	72 (2, 37)	68
SCL3 energy (MeV/u)	16.4	~19.2	~24.5 MeV/u(22Ne6+, A/q=3.7), ~21 MeV/u(40Ar9+, A/q=4.4)
Transmission(SCL3)	91~93%	~91%	~93%

* Unable to tune cavity to resonance frequency(81.25 MHz) due to tuner failure

** 2 HWR CMs with the upgraded couplers and tuners are under evaluation at the SRF test facility.

SCL3 Beam Operation in 2026

Total beam delivery time = 226 hours
*Beam to Exp. during 4.20~7.10



- ❖ Total available beam time in 2026: ~ 1,000 hours planned
- ❖ Accelerator Beam Availability: ~98 % during regular experiments (KO-. ND-)
- ➢ No major downtime in key accelerator components (Injector, SCL3)
- ➢ Lower Beam Availability due to users requested beam stops
- ❖ Cryogenic system recovery took ~3 days after a brief power glitch (0.2s, June 8)
- ❖ Demonstrated 24Na5+, 22Na6+ (RI) beam acceleration/delivery based on the Ar, Ne (SI) beam commissioning

SCL2 R&D project (2022.12~2027.12)

- **Purpose:** Develop and validate key technologies for SCL2 prior to mass production.
- **Scope:**

1) Fabrication of prototype CM for both SSR1 and SSR2 of SCL2 (one unit each)
2) Demonstration of Phase-1 prototype CM's performance
3) SRF technology development and operation
4) Project management and coordination



Cavity Type	Manufacturer	Vertical Test(VT)	Horizontal Test(HT)
β=0.32 SSR1	VitzroNextech	**Completed**	**by 2027**
β=0.51 SSR2	IHEP(China)	**Old) Completed(3), Preparation(3)** **New) fabrication (HERT/IHEP)**	**Old) by 2026** **New) by 2027**



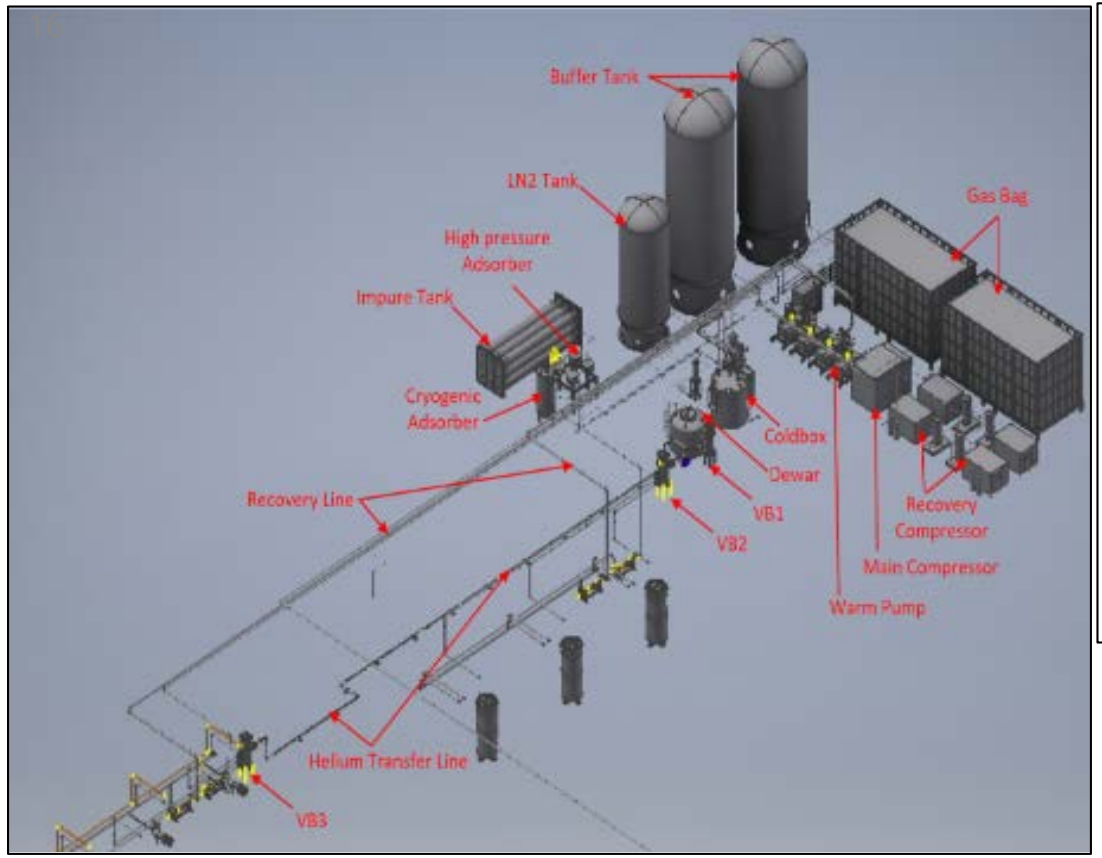
◆ **(SSR1 Balloon-type)** Design and engineering are led by IRIS, while the manufacturing process development is carried out by a domestic company ('24.1, VITZRO Tech)

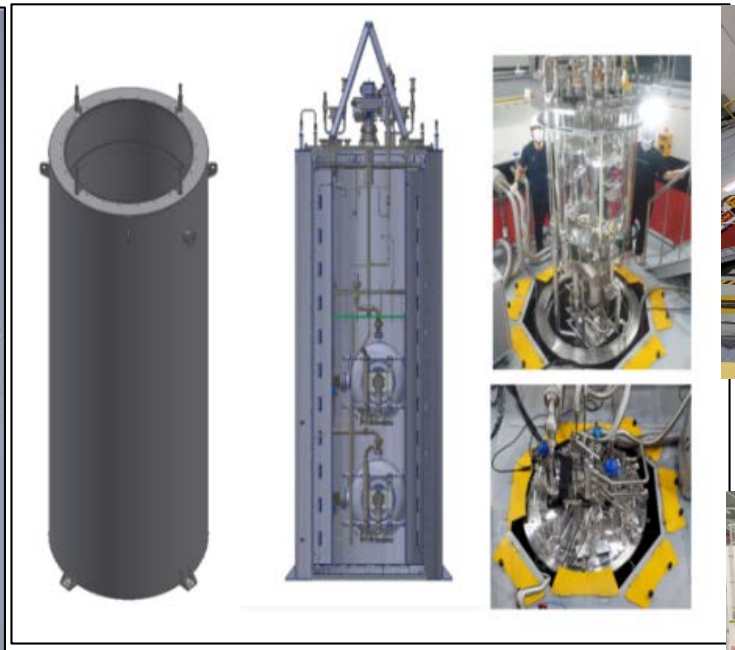
- Jacket material of SSR1 cavity has been changed from STS (prototype #1) to Titanium (prototype #2)

➢ **β = 0.29 HWR considered as an alternative due to SSR1 fabrication complexity.**

◆ **(SSR2 Cylinder-type)** Considering the high technical complexity, we maximally utilize the use of external resources (KAT & IHEP) from engineering design to manufacturing

SRF Test Facility











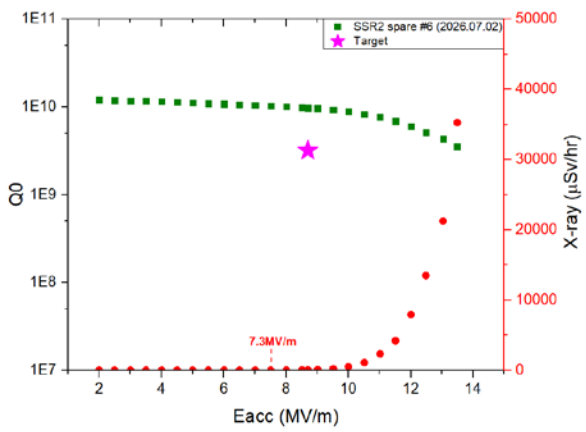


- 3 pits for Vertical Test, 3 bunkers for Horizontal Test
- Clean Room (10, 100, 10000 class)
- USC, BCP, HPR, High T. Furnace, etc.
- 900W (250 L/h) Helium Liquefier

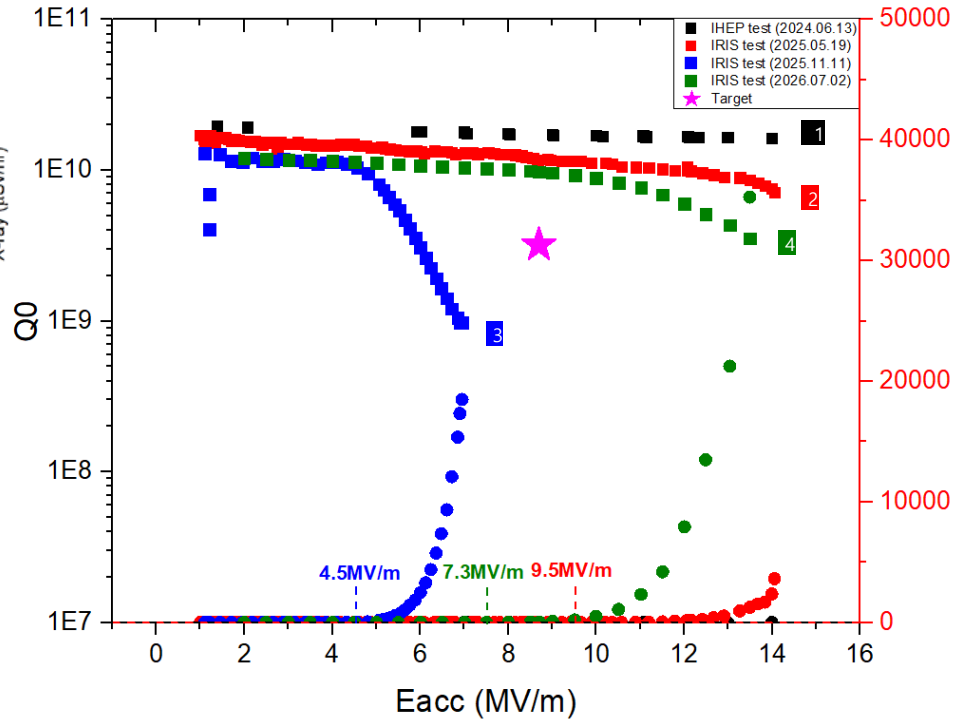
SSR2 Prototype (IHEP/IRIS) Performance

- (Performance Verification) Reconfirmation of Q0 requirement at the target operating gradient
- (Process Qualification) UPW and HPR systems & Class 10 process validation (HPR/Clean Assembly)

SSR2 old cavity #6



Parameter	Value
Initial Q_0 @2MV/m	1.21E10
Q_0 @8.7MV/m	9.76E9
Onset field (1μSv/h)	7.3 MV/m
X-ray dose @8.7MV/m	43.4 uSv/h



Condition	1st (2024)	2nd (2025)	3rd(2025)	4th (2026)
Surface Treatment /VT	IHEP	IHEP/ VT:IRIS	IRIS	IRIS
UPW Control	X	-	X TOC :X Resistivity :12MΩ	O TOC :16ppb Resistivity :18.1MΩ
자켓 외부 클리닝	External Cleaning	-	X	O (USC)
Flange Assembly Direction	Bottom up	-	Multi-direction Assembly	Bottom-up Assembly
LTB Condition	120℃, 48h	-	120℃, 48h	120℃, h
Remarks	VT@IHEP	VT@IRIS	UPW Control Issue	UPW, HPR, Assembly Control

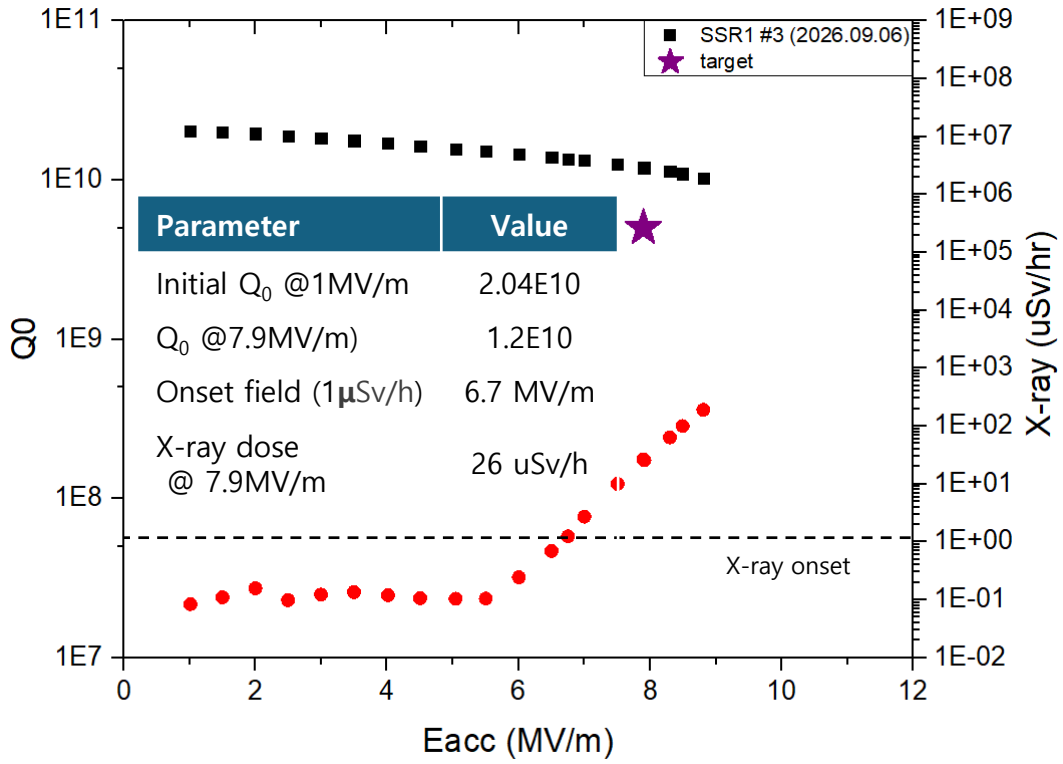
➢ **Performance improved through UPW quality and process optimization**

* (SSR2 Performance Requirement) Eacc 8.7 MV/m @3.2E9

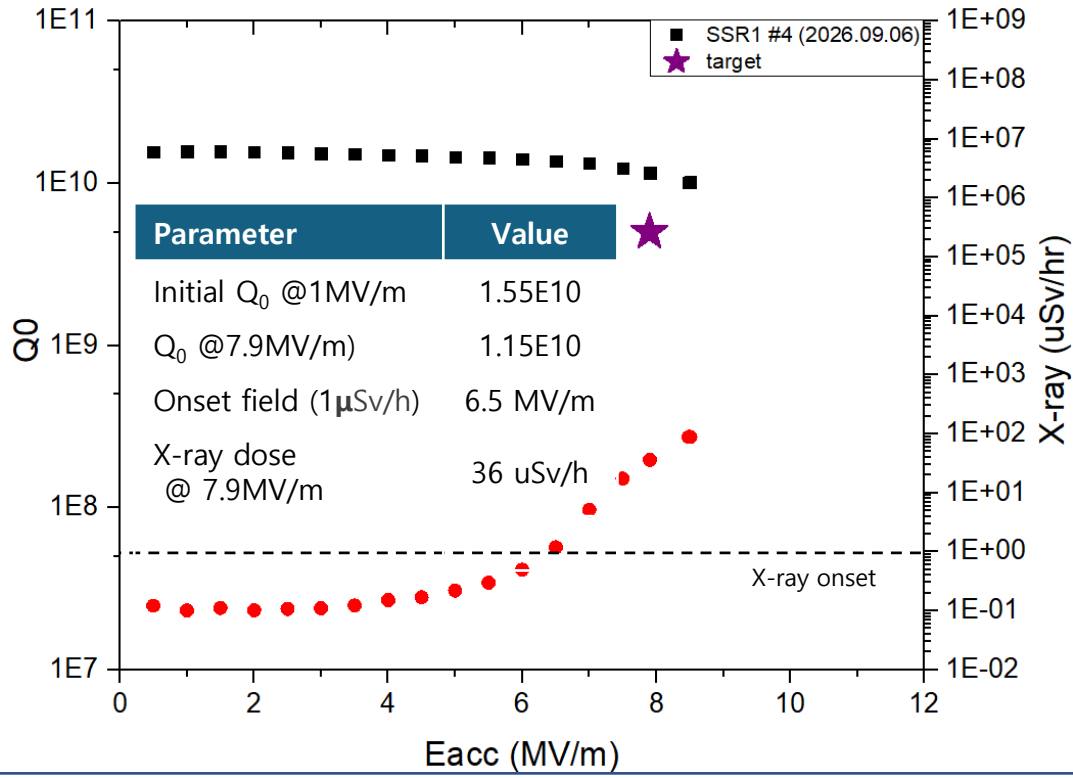
SSR1 Prototype (Vitzro/IRIS) Performance

- **(SSR1 Performance) Required Q_0 achieved at the target gradient for three cavities**
- **(FE onset) Average field-emission onset: 6.6 MV/m**

SSR1 #3



SSR1 #4

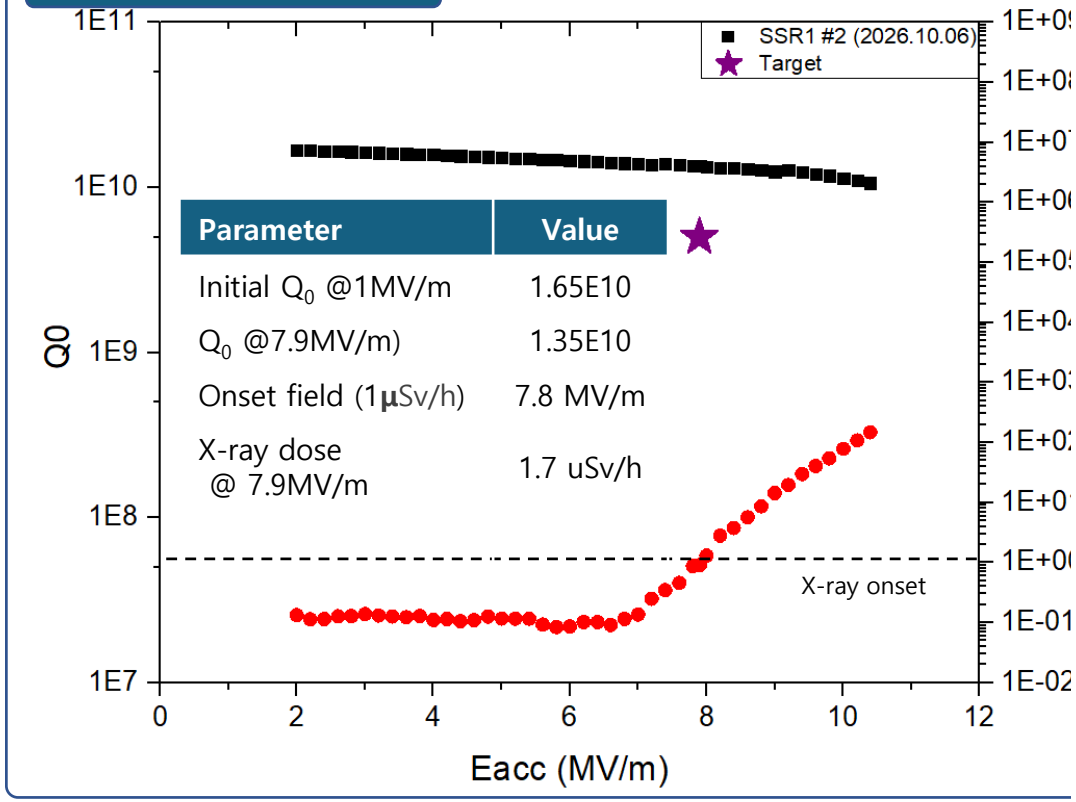


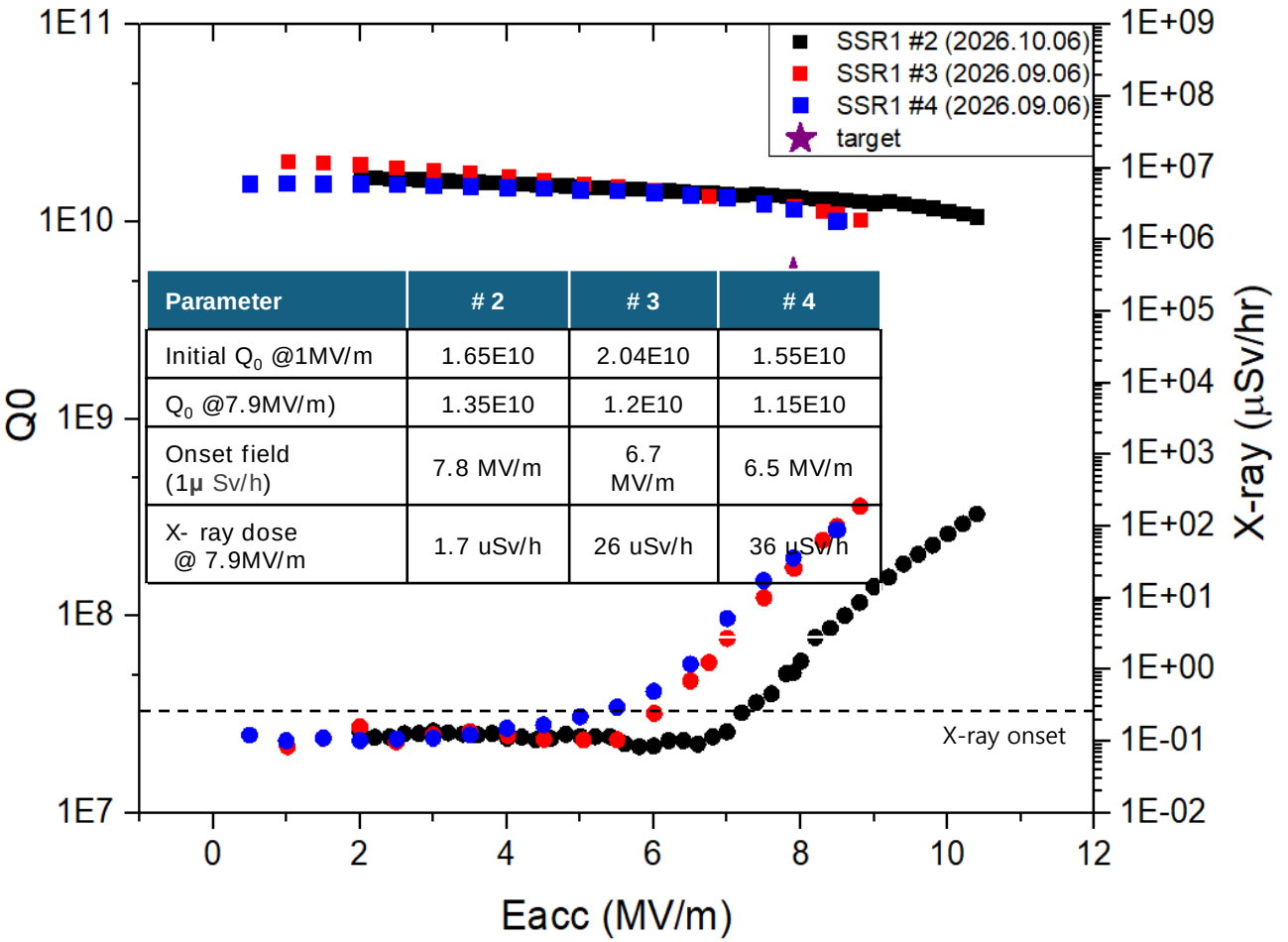
* (SSR1 Performance Requirement) Eacc 7.9 MV/m @5.0E9

SSR1 Prototype (Vitzro/IRIS) Performance

- (SSR1 Performance) Required Q_0 achieved at the target gradient for three cavities
- (FE onset) Average field-emission onset: 6.6 MV/m

SSR1 #2





* (SSR1 Performance Requirement) Eacc 7.9 MV/m @5.0E9

Summary and Outlook

- **SCL3 is in stable user operation**, achieving **~98% beam availability and ~93% transmission** in 2026.
- **SRF performance has significantly improved** through optimization of UPW/HPR and clean assembly processes.
- **SSR1(balloon-type) cavities achieved $Q_0 > 1.1\times10^{10}$ at 7.9 MV/m**, exceeding the design requirement.
- **In-house SRF capabilities have been strengthened**, from surface processing and clean assembly to cavity performance verification.
- **SCL2 R&D is progressing toward reliable cavity and cryomodule production.**

Thank You for Your Attention

感谢您的聆听！