중이온가속기연구소
Institute for Rare Isotope Science

TTC 2026 meeting

Operational status of the RAON low energy linac

2025. 06. 10

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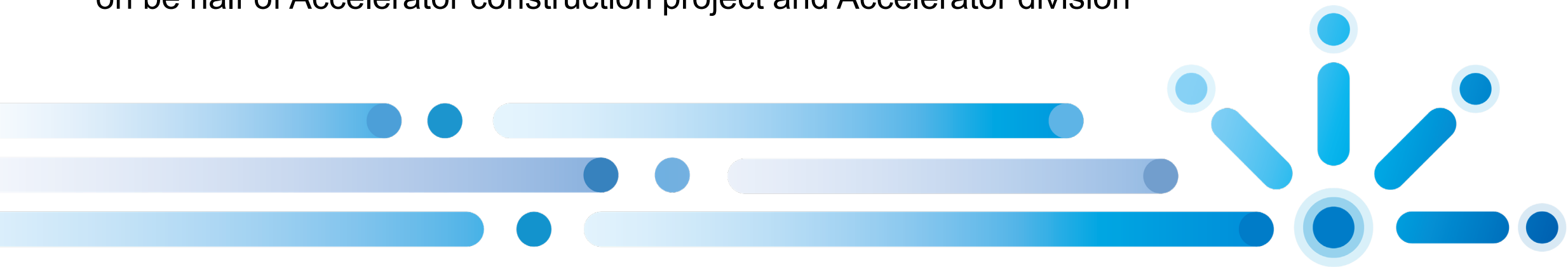
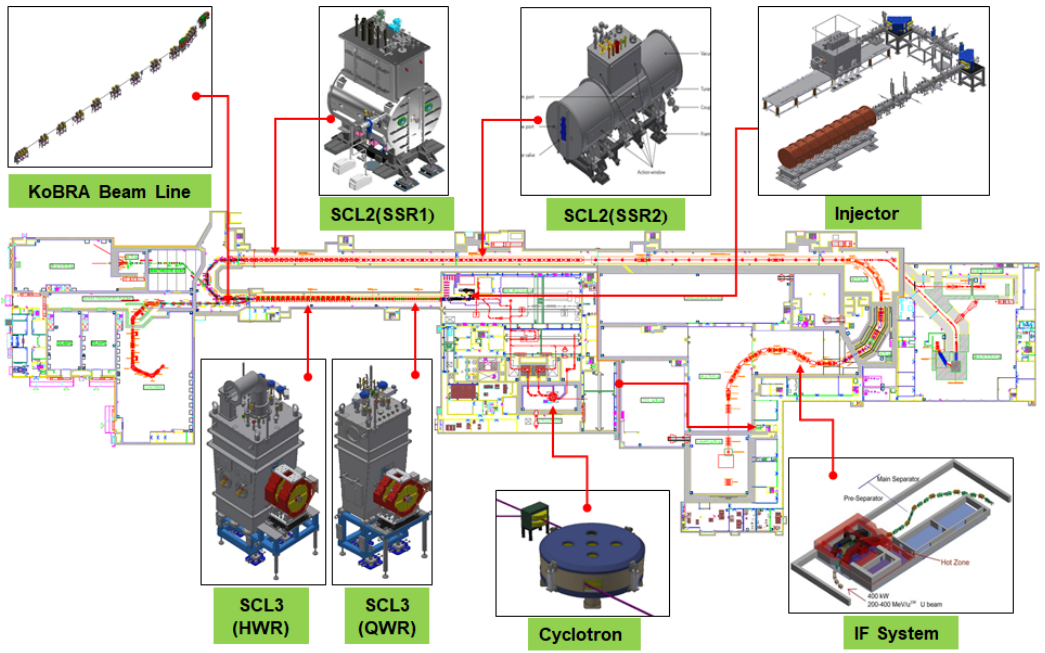
on be half of Accelerator construction project and Accelerator division



Overview



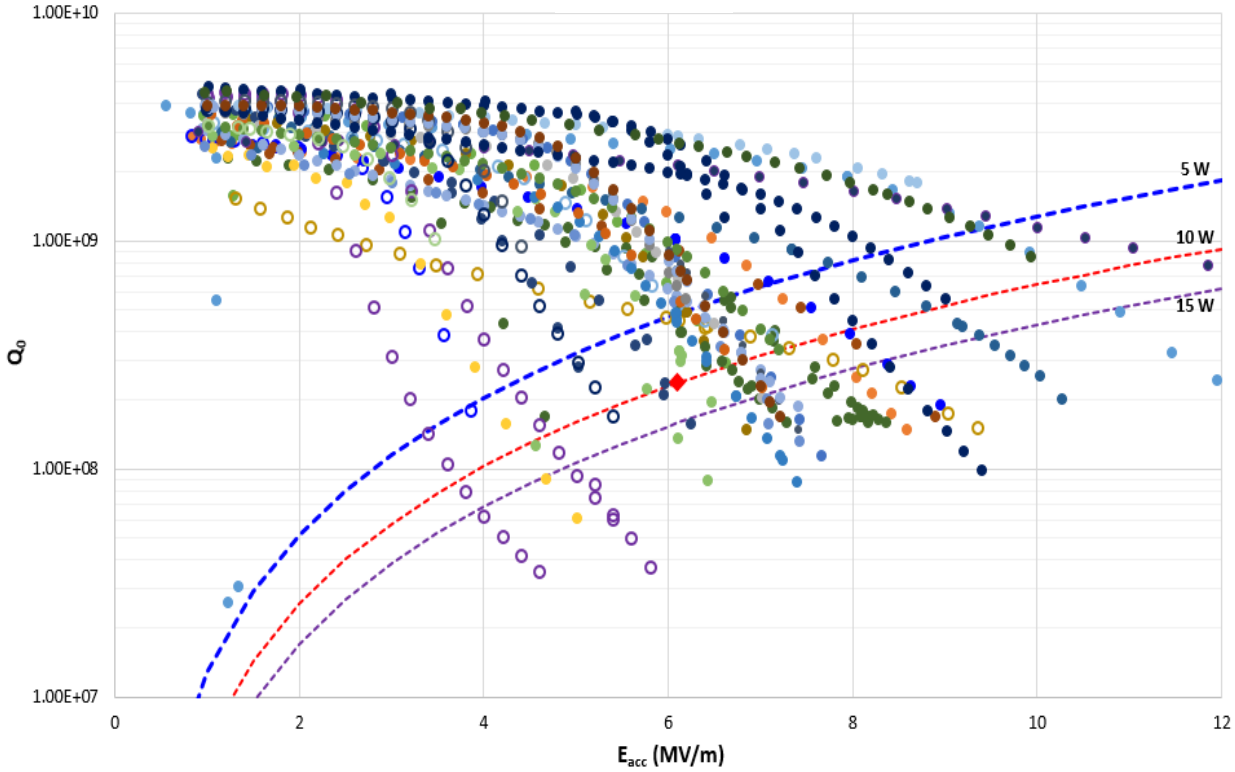
RF Parameters

	QWR	HWR
Optimum β	0.047	0.12
$f\ [MHz]$	81.25	162.5
$L_{eff}(=\beta_o\lambda)[mm]$	173.5	221.5
$R/Q\ [\Omega]$	469	295
$\boldsymbol{E_{acc}\ [MV/m]}$	**6.1**	**6.6**
$E_{peak}/Eacc$	5.7	5.2
$B_{peak}/E_{acc}\ [mT/(MV/m)]$	10.4	9.0
$V_{acc}\ [MV]$	1.06	1.46

	Cavity	# of cav. per CM	# of CM	Cav. Op. T (K)
SCL3	QWR	1	22	4.5
	HWR	2	13+2	2.05
		4	19	2.05
SCL2	SSR1	3	23	2.05
	SSR2	6	23+2	2.05

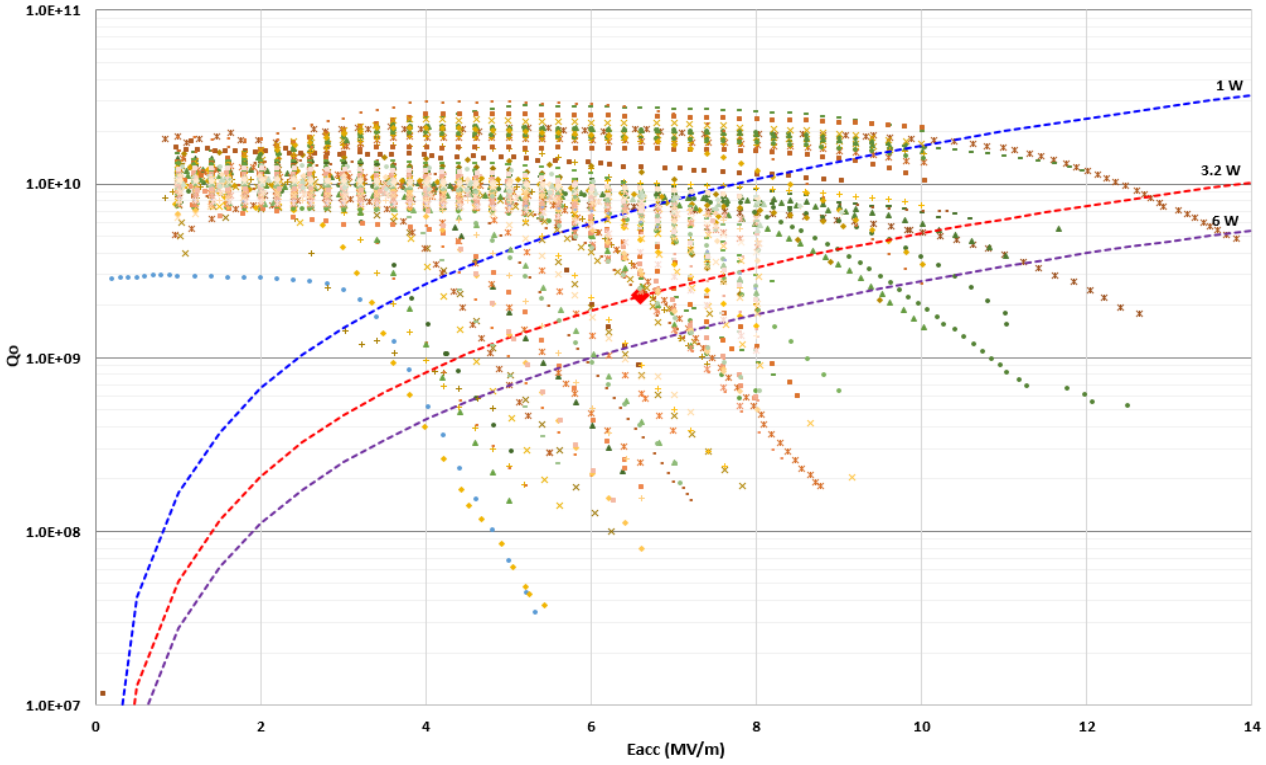
SCL3 cavities

QWR



Q_0=2.4e+8@4.2K, 6.1MV/m, 22 cavities

HWR



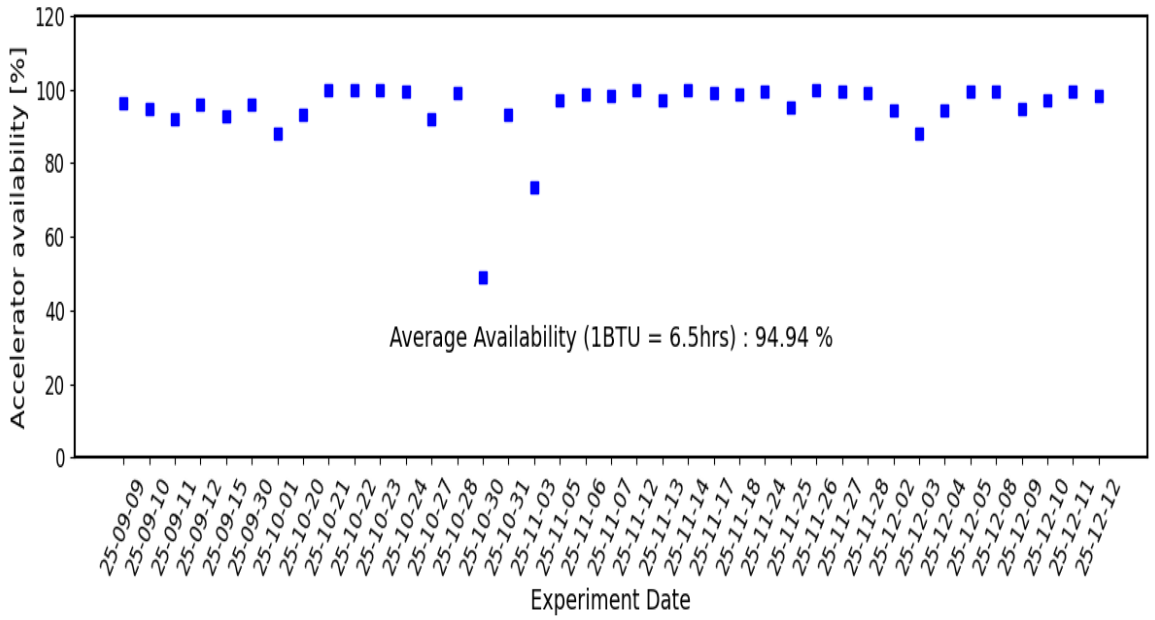
E_{acc}: 6.6 MV/m, Q_0=2.3e+9@2.05K, 6.6MV/m, 106 cavities

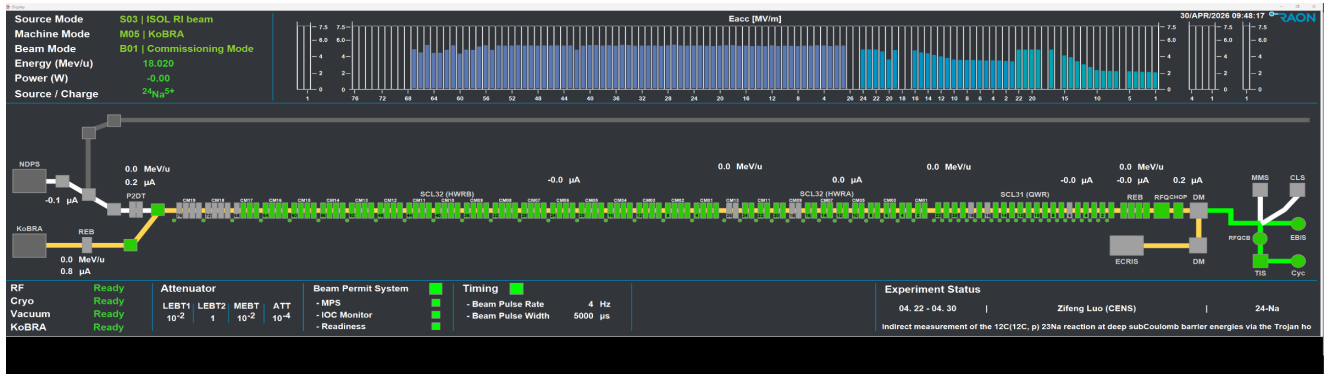
- Main cause of failure: field emission
- FE conditioning with pulsed RF power during HT
- Many cavities had field emission in operating E_{acc}.

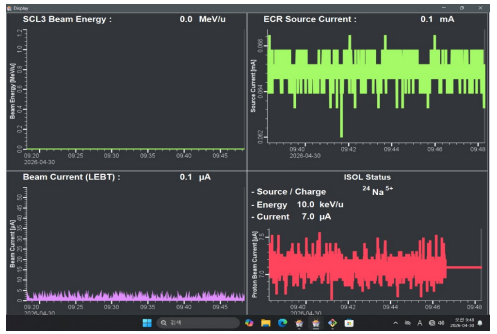
SCL3 beam operation (2024~2026)

	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)	5.0	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)	73 (24, 28, 61)	74 (2, 37)	72 (72~76)
SCL3 energy (MeV/u)	16.4	~19.2	~24.5 (22Ne6+)
Transmission(SCL3)	91~93%	~91%	~93%

- Installation of SCL3 was finished in 2022.
- SCL3 has been commissioned and operated from 2023.
- 8 cavities(2024), 10 cavities (2025) were not used
  - due to no spare SSPA's; spare parts under fabrication (2024~)
  - 2 HCMAs were dismounted from the SCL3 tunnel to test new couplers and improve tuners.
- HCMB#19 is not in operation due to the contamination resulting from a down stream vacuum accident.







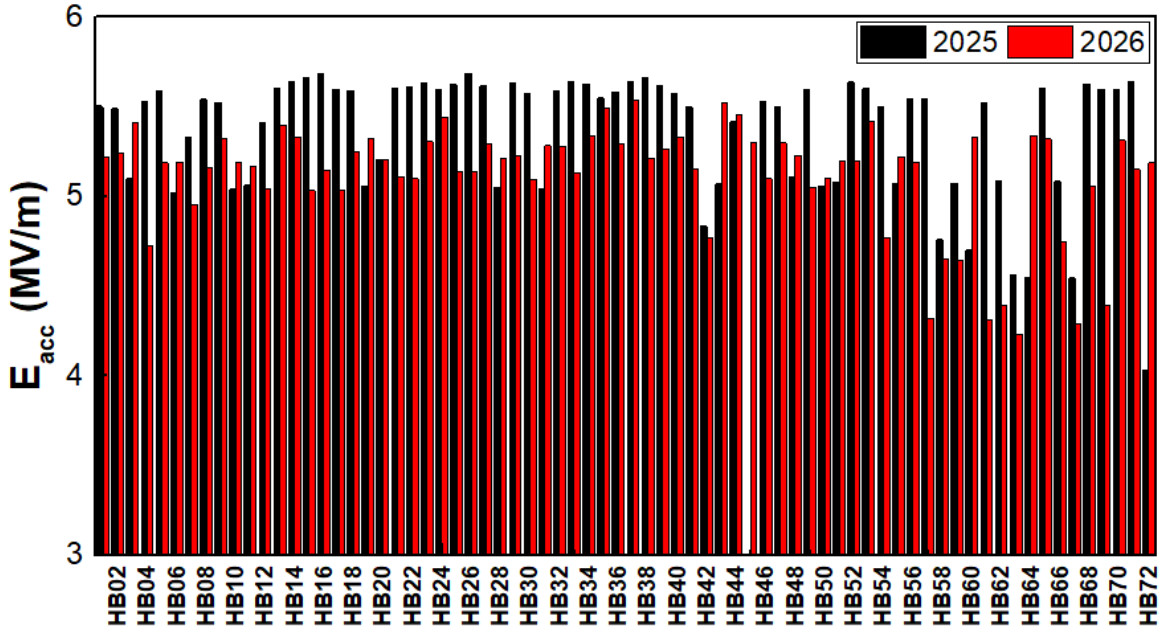
$^{24}Na^{5+}$beams (18.5 MeV/u) to KoBRA experimental hall

- In 2025,
  - Total beam delivery time = 430 hours
  - Accelerator availability ~ 95 %
    (Standby to deliver beam / 6.5 hours)

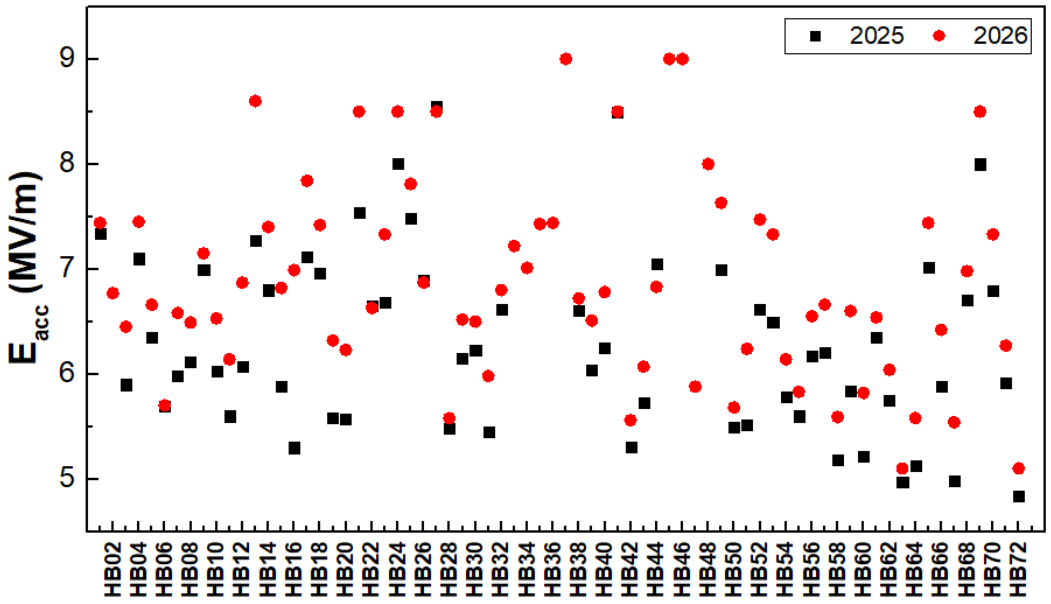
- Beam operation in 2026
  - Accelerate various A/q beams: 22Ne5+, Ar(8+,9+,11+), RIs from ISOL/EBIS (3.5<A/q<5.5)
  - Maximum beam duty: 10%(5 msec, 20 Hz)
  - Successfully accelerated and delivered 24Na5+(A/q=4.8) based on the Ar and Ne beam commissioning
  - Total beam time planned in 2026: ~ 1,000 hours

Operational FE limit

- Field emission limit was defined to ensure stable operation in 2026: < 100 uSv/hr
  - The operating gradient of each cavity was determined with consideration of the FE limit.
- Field emission was mitigated through HPP processing, which resulted in an increase in the achievable accelerating gradient at the FE limit of the cavity.
- In 2026, since the user's energy requirement was relatively modest, an accelerating gradient of around 5 MV/m was adequate.

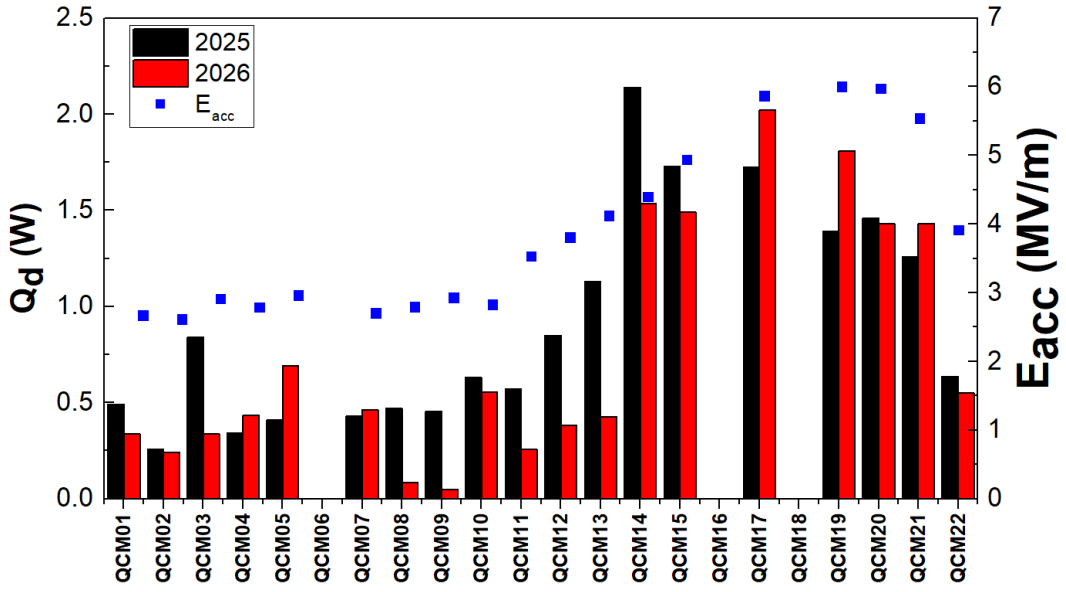


Operation E_{acc} of HWRs in 2025 and 2026

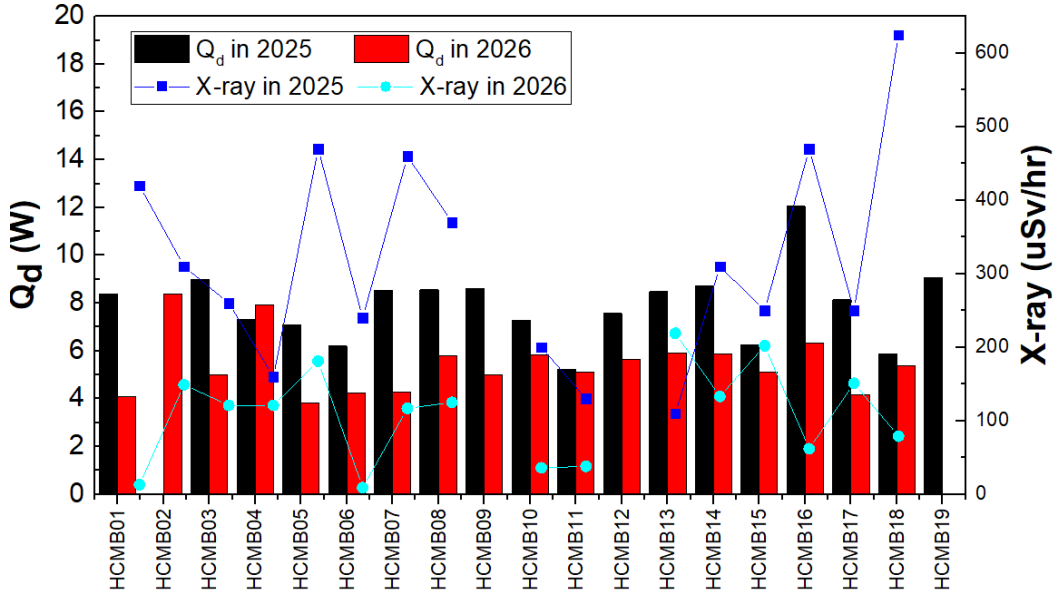


E_{acc} of HWRs at FE limit(100 uSv/hr)

- In the QWR section, a slight performance degradation was observed in the cavity immediately downstream of an unused cavity. However, this is not a major issue because sufficient margin remains with respect to the heat load.
- In the HWR section, stable operation is currently maintained at a lower X-ray level than in 2025, taking the X-ray limit into consideration. Also, sufficient margin remains from the standpoint of cryogenic heat load.



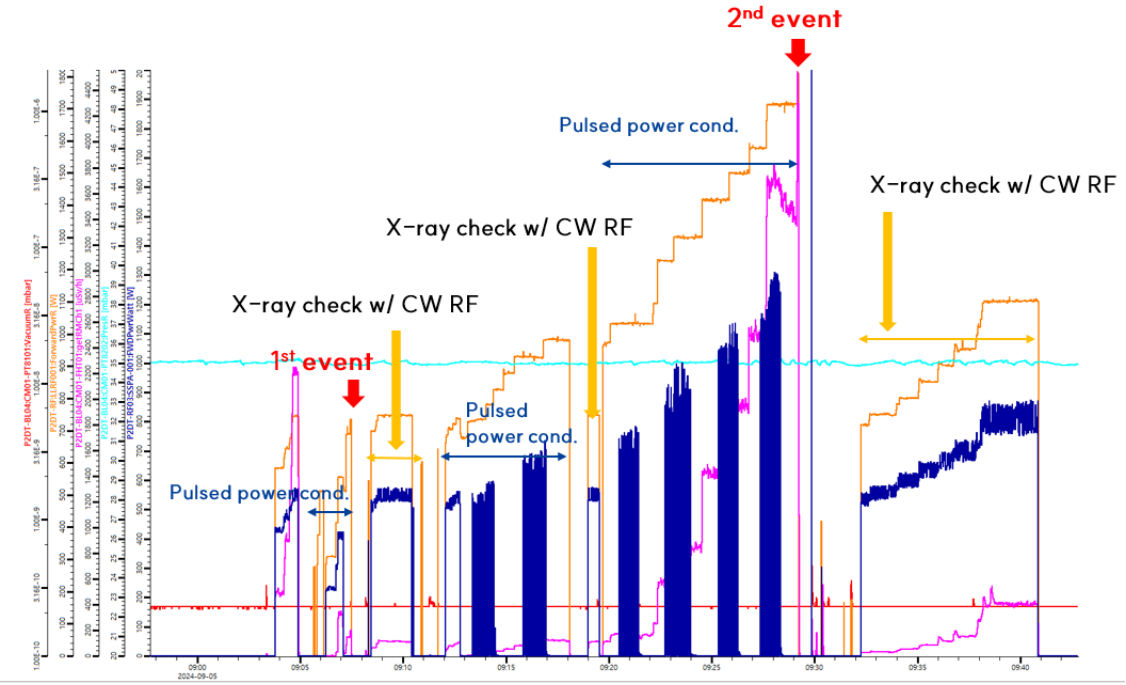
Dynamic heat load of QCMs
(available dynamic heat load per CM is 15 W at 4.5 K)



Dynamic heat load and X-ray level of HCMBs
(available dynamic heat load per CM is 19 W at 2.05 K)

FE mitigation with HPP processing

- Pulsed RF power: f = 1~5 Hz, width = 20~25 ms.
- Conditioning was continued until the reduction of X-ray level was not observed after the event or no more event was occurred.
- FE was mitigated acceptable level (heat load) by pulsed power conditioning.



Measurement of cavity performance after pulsed power conditioning for P2DT CM

	E_{acc} (MV/m)	X-ray (uSv/hr)		Q_d (W)
Cavity #01	6.0	230	513	3.3
Cavity #02	6.0	277		

- Static thermal load: 4.2 W
- Radiation level increased upto 1 mSv/hr at 6.6 MV/m of E_{acc} for both cavity.

Summary

- The RAON low-energy linac (SCL3) has been successfully operated since the completion of beam commissioning in 2023.

- No significant irreversible cavity degradation has been observed during operation, and cavity performance can be recovered through HPP processing when necessary. So far, HPP processing has been effective in recovering cavity performance.

- Since 2026, the FE limit has been defined as 100 μSv/hr, and HPP processing has progressively increased the achievable E_{acc} at this limit.

- Research on plasma processing is currently underway to achieve more reliable and stable improvement of cavity performance.

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THANK YOU