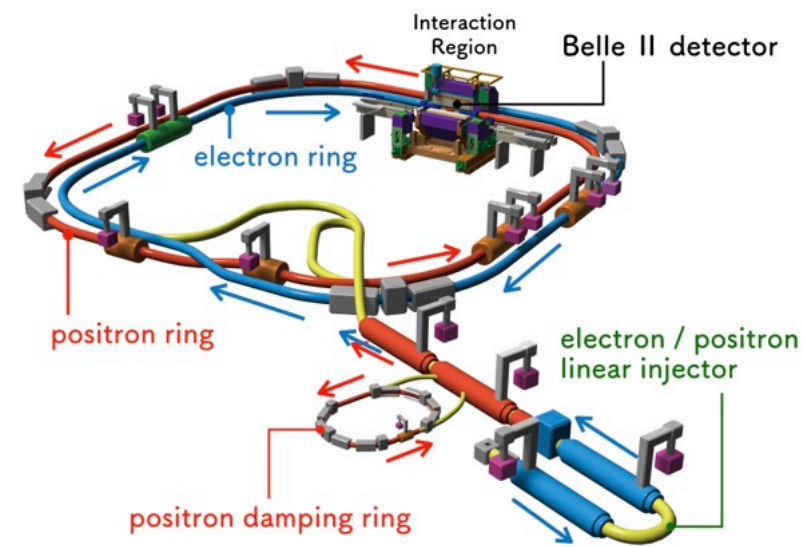




Overview of the current status and plans for the 2027ab run

Takaaki Yamaguchi
(on behalf of SuperKEKB accelerator team)

Contents

1. Summary of 2026ab run
2. Plans for the 2027ab run
3. Hardware works during this summer shutdown
 - i. RF
 - ii. Vacuum
 - iii. Injector

Brief summary of 2026ab run

- Achieved records:
 - ✓ Max. luminosity (Belle off) : $5.32 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
 - ✓ Max. luminosity (Belle on) : $5.28 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
 - ✓ Max. integrated luminosity/day:
 - 3.499 fb^{-1} (recorded)
 - 3.948 fb^{-1} (delivered)
 - ✓ Integrated luminosity/2026ab run:
 - 314.5 fb^{-1} (recorded)
 - 361.6 fb^{-1} (delivered)
 - ✓ Max. beam current:
 - LER: 1.73 A
 - HER: 1.37 A
- Successful 2-bunch injection to two rings
- Physics run with $\beta_y^* = 0.9 \text{ mm}$
- **Major hardware issues and related works during this summer shutdown:**
 - ✓ Abnormal vacuum-pressure rise of two RF cavities → Investigation
 - ✓ Several collimators damaged → Replacement of collimator jaws
 - ✓ Vacuum leak at beam pipes → Replacements and countermeasures

2026ab run

Plans for the 2027ab run

- Schedule from 2026c to 2027ab
- Actions for $L = 1 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$

Schedule (2026c–2027ab)

- 2026c operation (autumn)
 - Linac: Sep. 14–Dec. 24
 - DR, BT: Nov. 30–Dec. 24 → Beam tuning/study
 - MR: hardware works continue, beam operation is skipped.
- 2027a operation (former spring period)
 - Linac: Jan. 4–Mar. 31
 - DR, BT: Jan. 6–Mar. 31
 - 2–3 weeks for beam tuning/study before MR beam operation starts
 - MR: Jan. 25–Mar. 31
- 2027b operation (latter spring period)
 - The baseline plan is to continue the beam operation until the end of May.
 - Depending on the budgetary situation, the operation period may be extended.

However, the machine stability at increasing temperature must be considered.

2026c
November

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5

2026c
December

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2

2027a
January

Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	1	2	3	4	5	6

Machine parameters for $L = 1 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$

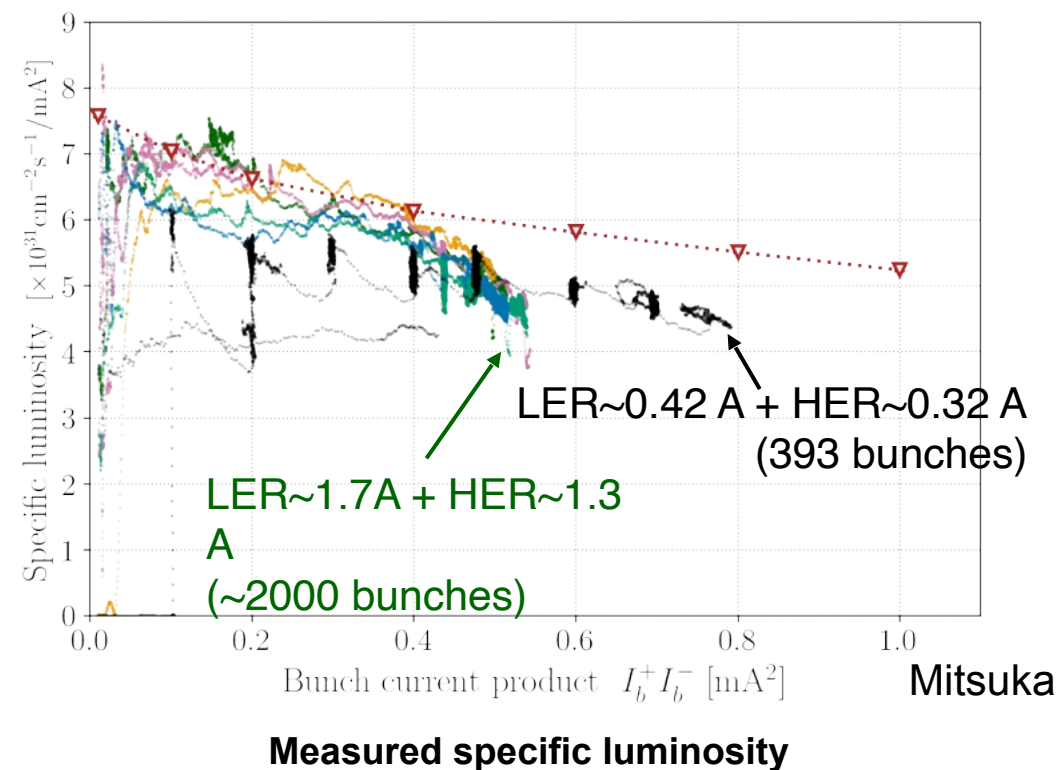
- To reach $L = 1 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$, we need to
 - ✓ Achieve **high beam currents** (LER: 2.6 A, HER 2.0A)
 - ✓ Keep **high beam qualities** (specific luminosity, beam lifetime, background, ...)
- Key issues:
 - ✓ High-quality injection (low injection background, high injection efficiency)
 - ✓ Suppress beam instabilities (sudden beam losses, ...)
 - ✓ Understand/suppress specific luminosity degradation (emittance blow-up, ...)

Main machine parameters

	5e34	6e34	7e34	8e34	9e34	10e34
Peak luminosity	5e34	6e34	7e34	8e34	9e34	10e34
Specific luminosity	5.5	5.3	5.1	4.8	4.5	4.4
HER beam (A) / bunch (mA) current	1.31/0.56	1.46/0.62	1.62/0.69	1.77/0.75	1.93/0.82	2.00/0.85
LER beam (A) / bunch (mA) current	1.64/0.70	1.83/0.78	2.02/0.86	2.21/0.94	2.41/1.03	2.60/1.11

2024/12 reached

Present target



Major actions to $L = 1 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$

1. High-quality injection

- RF gun replacement → lower emittance
- More precise beam control in Linac/BT under 2-bunch injection:
 - Auto-tuning/feedback systems for emittance and beam orbit,
 - Beam control using fast kickers,
 - Update of beam diagnostic system, ...
- Chamber replacement at the LER injection point

2. Suppress beam instabilities

- Suppression of sudden beam loss (SBL) events (SBL taskforce)
- Countermeasures against HER-unique vertical instabilities

3. Understand/suppress specific luminosity degradation

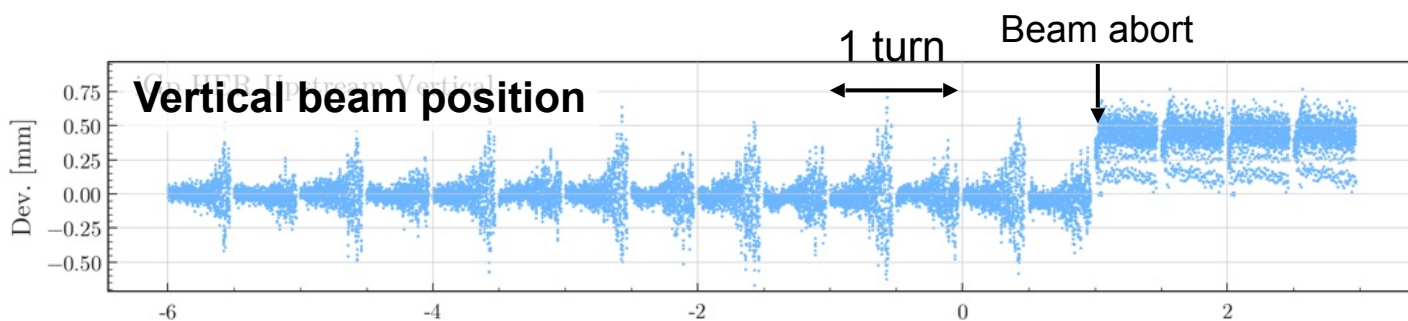
- Beam-beam taskforce
- Application of AI?

Sudden beam loss (SBL)

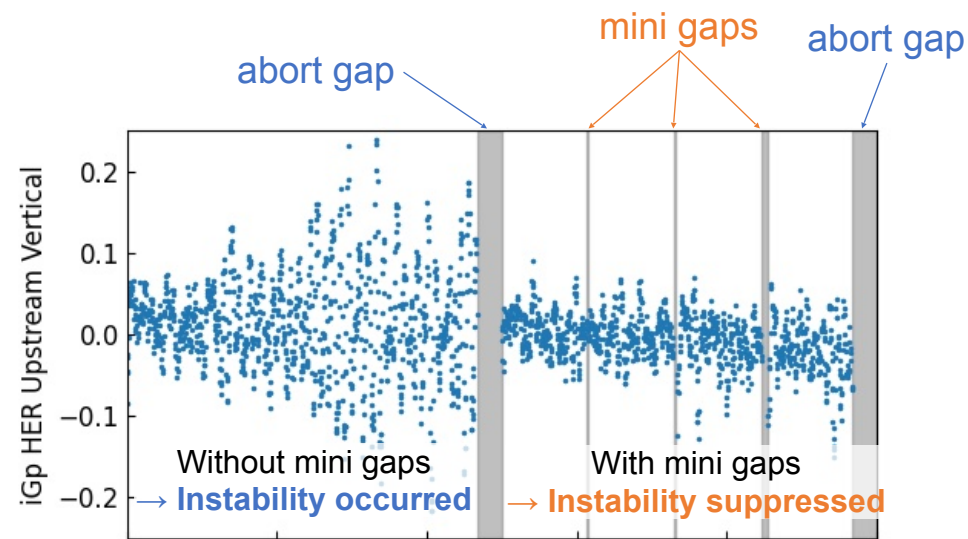
For the detail of SBL-related analyses,
see the MDI TF meeting talk by K. Uno (<https://kds.kek.jp/event/60798/>)

- Overview in 2026ab run:
 - LER:
 - ✓ Occurrence rate was significantly reduced by removing black stain generated by vacuum sealant (VACSEAL) inside beam chambers.
 - ✓ However, SBL still occurred at high current. → SBL sources still remain in LER?
 - HER:
 - ✓ HER-caused aborts were more than LER-caused ones.
 - ✓ ~30% of HER beam aborts were caused by a specific vertical beam instability (fast-ion instability?).
- Future plans and countermeasures are under discussion in SBL taskforce (K. Uno)
 - ✓ There are conditioning effects in SBL events of both rings (statistical analyses of SBL-related aborts by T. Abe, K. Uno).
 - ✓ Introduction of mini bunch gaps is effective to reduce the HER vertical instabilities (confirmed in 2026ab).
- Countermeasures & operation plan proposed by SBL TF:
 - ✓ Vacuum group will investigate the beam pipe insides suspected of SBL sources.
 - ✓ High current vacuum scrubbing (LER 2.0 A/HER 1.6 A, ~1 week)
 - ✓ Introduction of mini gaps in 2027ab run

**Black stain found
inside a chamber**



Vertical beam instability unique in HER ("triangle"-type abort)



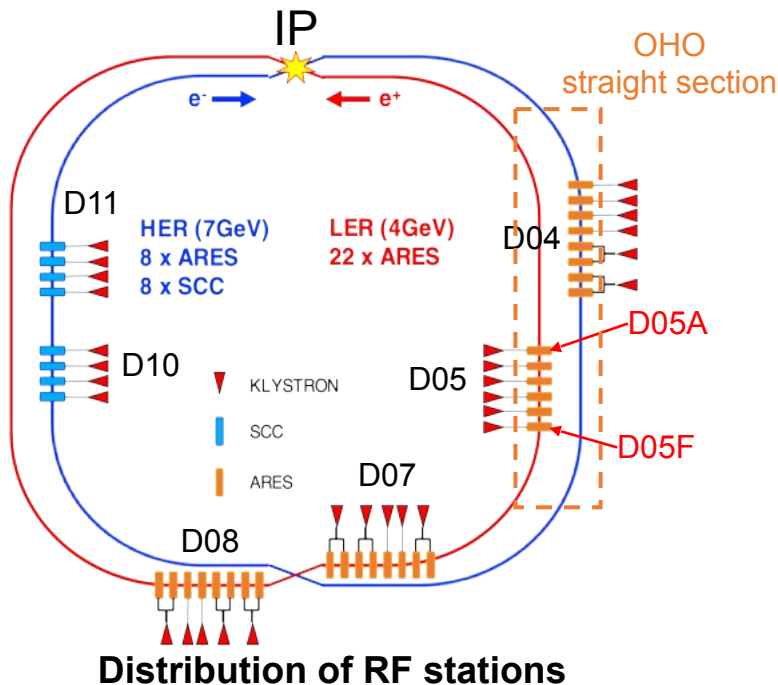
Mini-gap study in 2026ab run

Hardware works (RF)

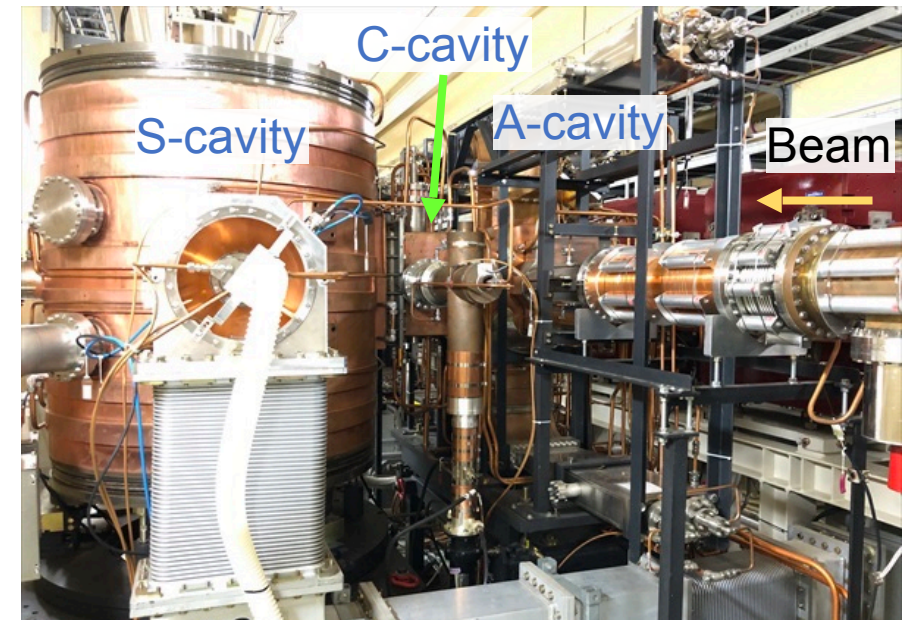
Investigations on vacuum-pressure rises in RF cavities

Vacuum-pressure rises in D05A and D05F cavities

- In 2025c–2026ab run, abnormal vacuum-pressure rises occurred at D05A and D05F cavities.
 - ✓ D05A: Dec. 5, 2025 (during beam operation)
 - ✓ D05F: Apr. 15, 2026 (during cavity aging on a regular maintenance day)
 - After the vacuum pressure rises, **these cavities were detuned (out-of-operation)**.
- Both cavities are the normal-conducting ARES cavities used for LER.
- In the 2026 summer shutdown, investigations were conducted by ARES cavity group.



ARES cavity

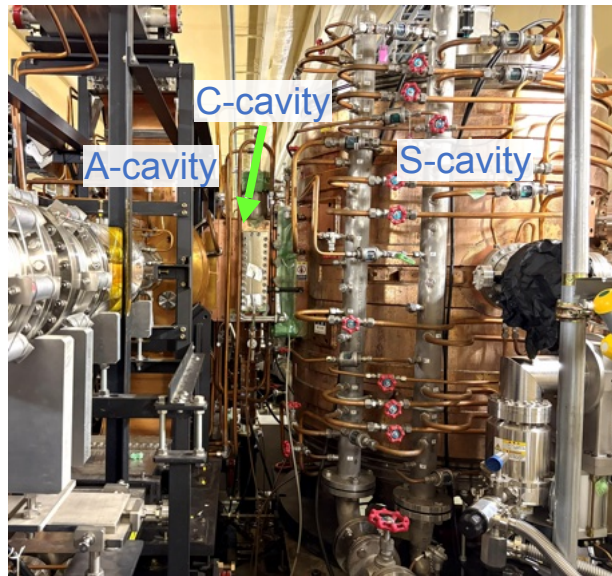


- ✓ **Three-coupled-cavity cavity system** to suppress coupled-bunch instability caused by accelerating mode¹⁰

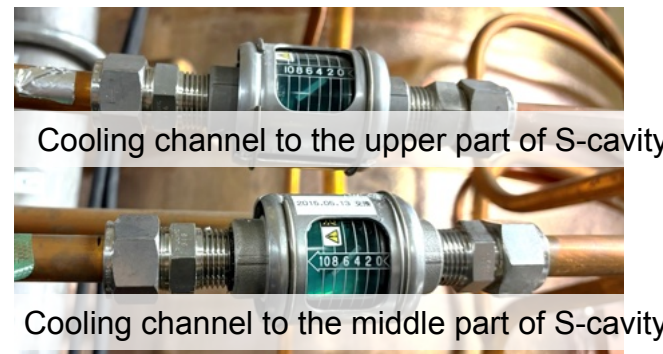
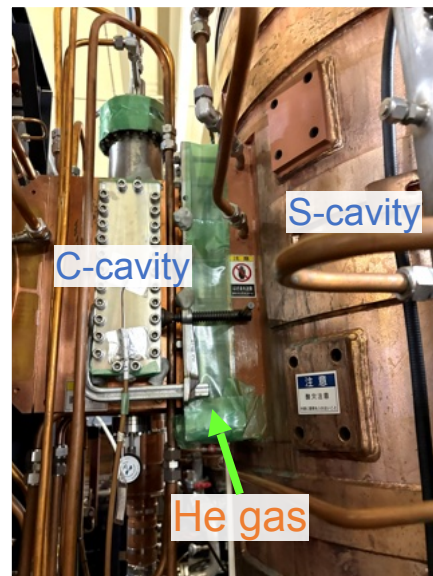
Investigation on cavity pressure rise

- D05A cavity:**
- The source of pressure rise was a vacuum leak at the joint between the C- and S-cavity.
 - By obscure failure of a flap flow meter, cooling water flow was insufficient at the middle part of the storage cavity.
→ Large thermal expansion led to vacuum leak at the joint.
- D05F cavity:**
- On a regular maintenance day, cooling water leak was found on the top of the storage cavity.
 - After partial removal work of cooling water, cavity aging was conducted as usual. → Abnormal vacuum-pressure rise occurred.
 - By leak tests and high-power tests in this summer shutdown, vacuum-pressure rise could not be reproduced.
 - A possible cause of the pressure rise is that the cooling water channel was not re-open after partial removal work of cooling water.

D05-A and -F cavities are normal and will return to operation without cavity replacement.
→ This will contribute to higher beam current!



Joint between the coupling cavity and storage cavity



Flap flow meters



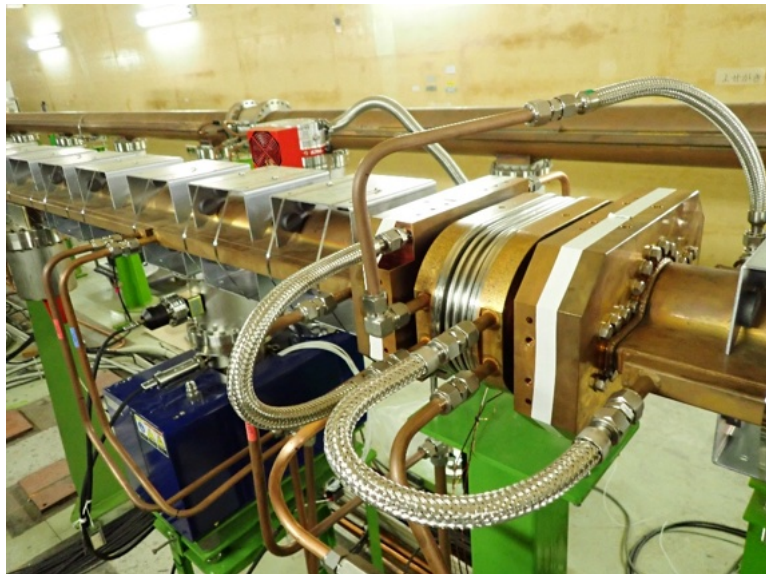
Cooling water leak at D05F cavity

Hardware works (Vacuum)

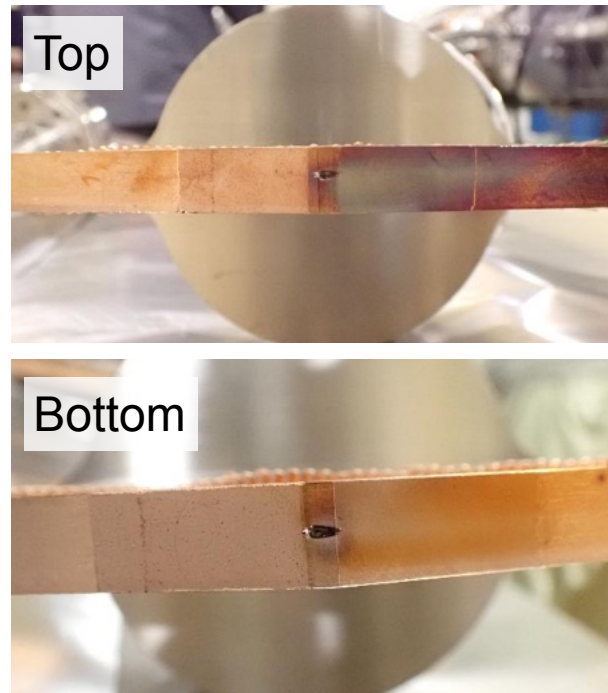
- Vacuum leak countermeasures
- Replacement of collimator jaws

Vacuum works (LER)

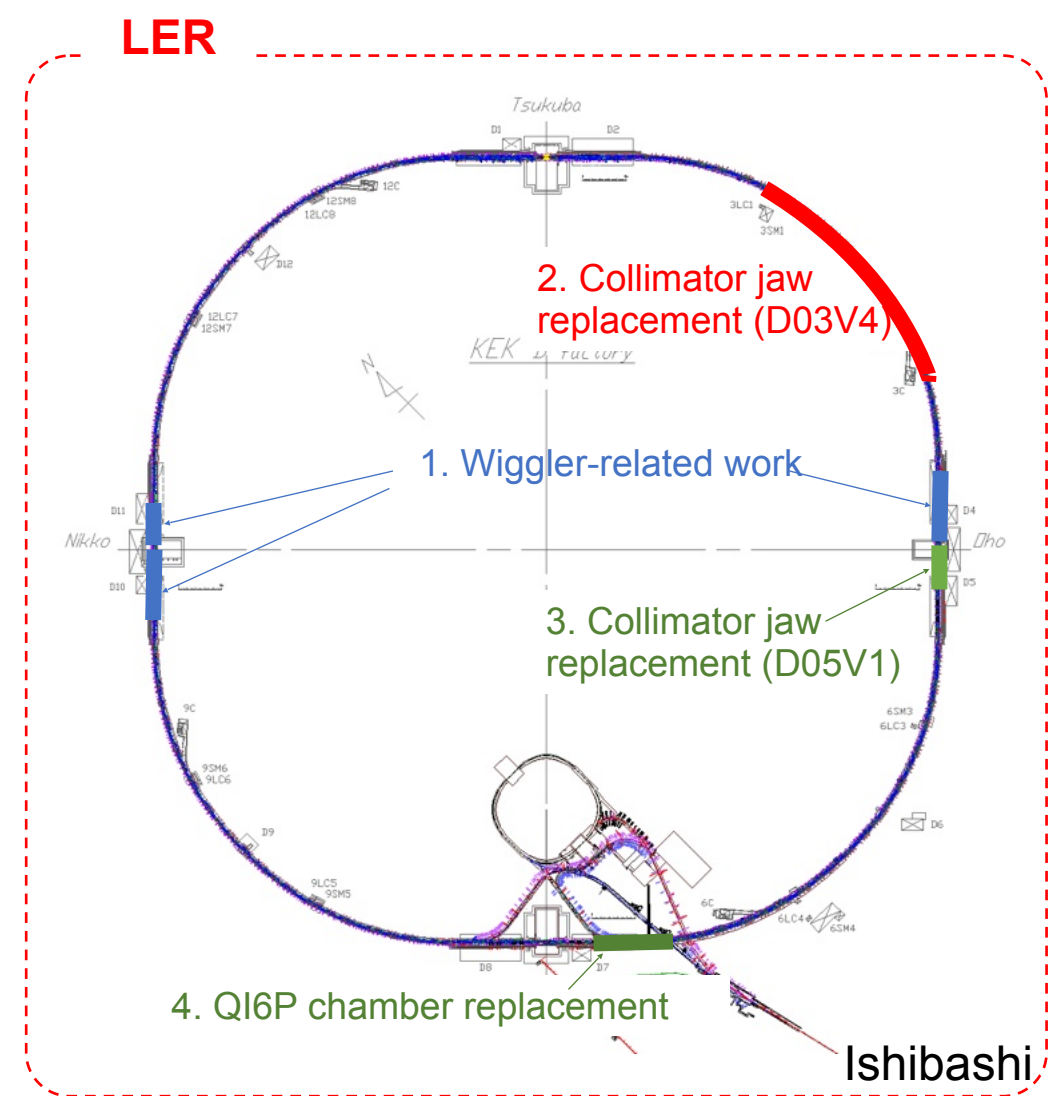
- Wiggler part
 - ✓ Countermeasures against vacuum leak
 - Bellows chambers with reinforced water cooling
 - Reduction of vacuum leak risk at high current
- Replacements of the collimator jaws
 - ✓ D03V4
 - ✓ D05V1
- Replacement of QI6P chamber (injection point)
 - ✓ Improvement of injection efficiency is expected.



Bellows chambers with reinforced water cooling

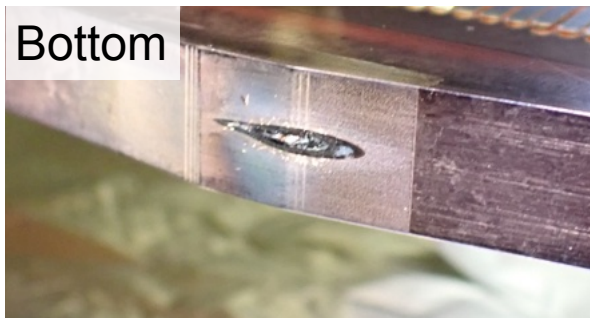
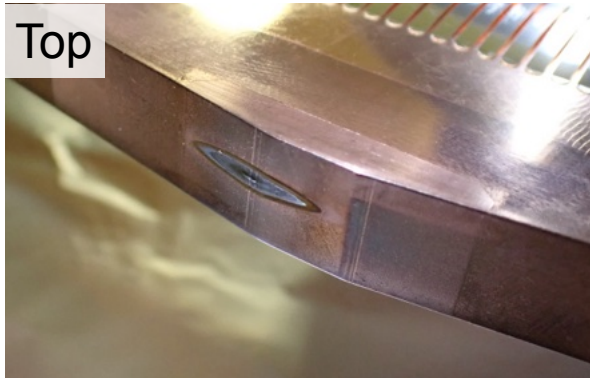


Damaged collimator jaws (D03V4)

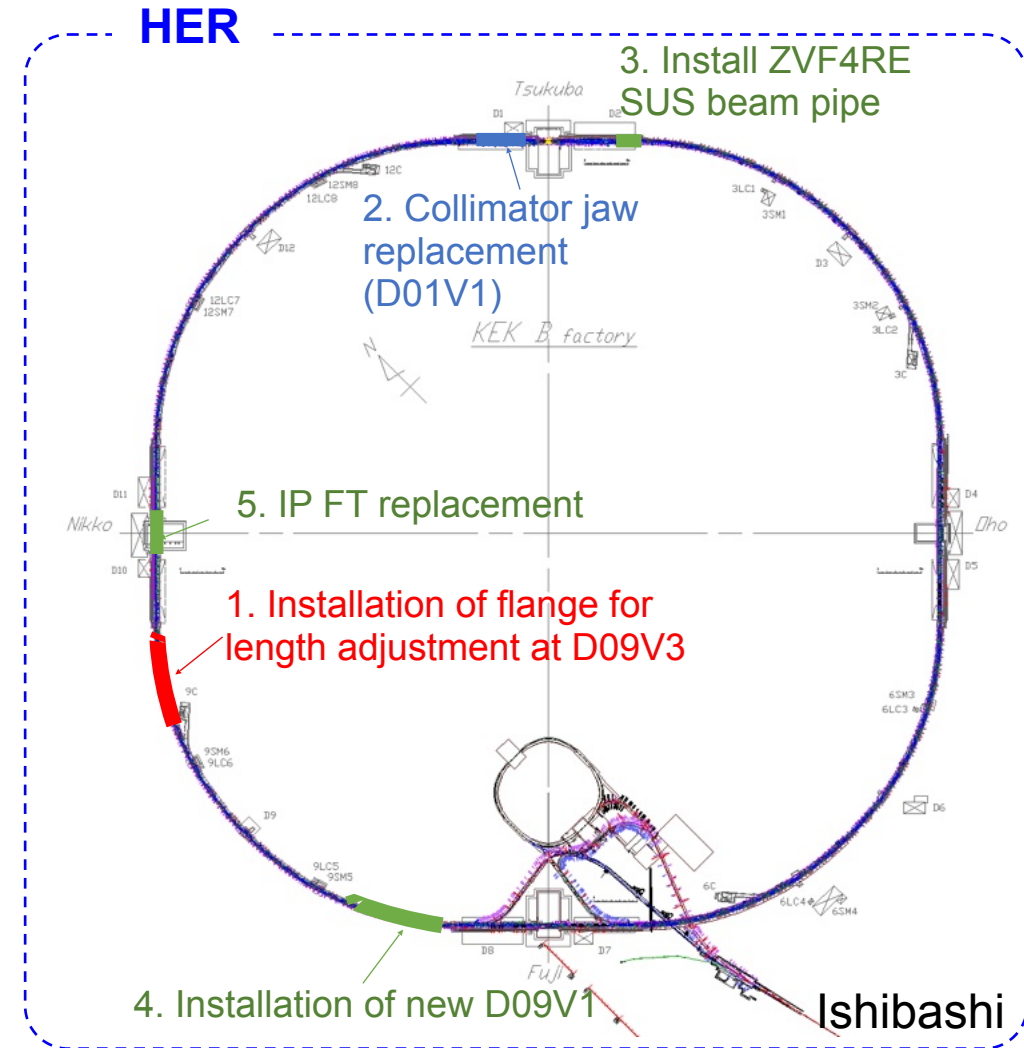


Vacuum works (HER)

- Replacement of the collimator jaws
 - ✓ D01V1
- Installation of the new D09V1 collimator with water cooling channel
- Repair of ZVF4RE stainless-steel beam pipes
 - ✓ Large vacuum leak occurred in 2026ab run.
 - ✓ Fabrication of a new chamber underway



Damaged collimator jaws (D01V1)

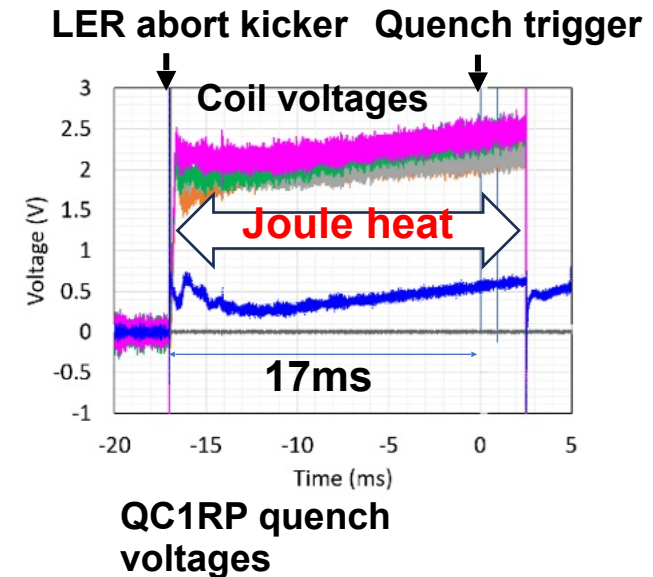
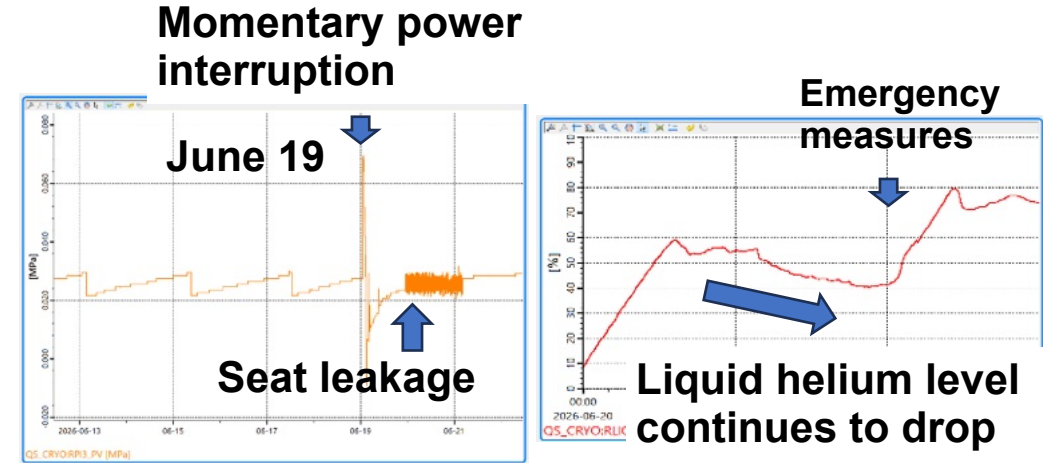


Hardware works (QCS)

- Adjustment of a cryogenic valve (CV414) experiencing seat leakage
- Adjustment of the QC1RP quench detection voltage to prevent ESR1 from quench

QCS works

- Adjustment of a cryogenic valve (CV414) experiencing seat leakage
 - Following a momentary power interruption on June 19, seat leakage occurred at CV414, making it impossible to maintain the liquid helium level used to cool the QCS superconducting magnet. Emergency measures were taken to stop the seat leakage, and accelerator operation continued while maintaining the liquid level.
 - The opening of CV414 relative to the commanded value was inspected, and no abnormalities were found. A visual inspection and adjustment of the valve element are scheduled for November.
- Adjustment of the QC1RP quench detection voltage to prevent ESR1 from quench
 - When massive beam loss occurred at intensities exceeding 0.8 mA/bunch, the quench detection for QC1RP took approximately 17 ms; consequently, heat generation in QC1RP caused ESR1 to quench twice during the 2026ab run.
 - To accelerate quench detection and reduce heat generation in the QC1RP, we will attempt to lower the quench detection voltage threshold from the current 1 V to 0.2 V.



Hardware works (Injector)

Installation of a new RF electron gun

Installation of a new RF gun

- The current RF gun was installed in the summer shutdown in 2025.
 - ✓ Cavity trips were successfully reduced.
 - ✓ Several troubles occurred in the fabrication process.
- To achieve higher RF power, a new RF gun cavity is installed in this summer shutdown.
 - ✓ Long cavity aging was done without any problems.
 - ✓ Lower emittance in 2-bunch injection expected.

Other hardware works

- Linac
 - ✓ Repair of fast kicker power supply
 - ✓ Replacement of 12 old accelerating structures
- BT
 - ✓ Water quality improvement of magnets
 - Prevention of pipe clogging → downtime reduction
 - ✓ Installation of more magnet thermometers
 - Monitor temperature rise caused by water flow reduction
 - ✓ Update of BPM readout system
 - Enables more precise beam control under 2-bunch injection scheme
- Injection point
 - ✓ Replacing the thyatron in the LER injection-kicker power supply with a different type.
 - Prevention of accidental kicker fires → downtime reduction
- MR
 - ✓ Installation of more beam loss monitors
 - ✓ Maintenance of the cooling water system for the ring magnets
 - Interlock threshold check, pipe cleaning → downtime reduction
 - ✓ Measurement of all quadrupole magnet tilts
 - ✓ Addition of radiation shielding for the magnets downstream of the collimator

Summary

- In 2026ab run, we achieved the stable high current beam operation and updated the luminosity world record.
- The hardware works and operation planning are ongoing since the summer shutdown:
 - ✓ High-quality injection
 - ✓ Stable/reliable operation
 - ✓ Suppression of SBL events

Back-up

2027ab Startup Schedule (Proposal)

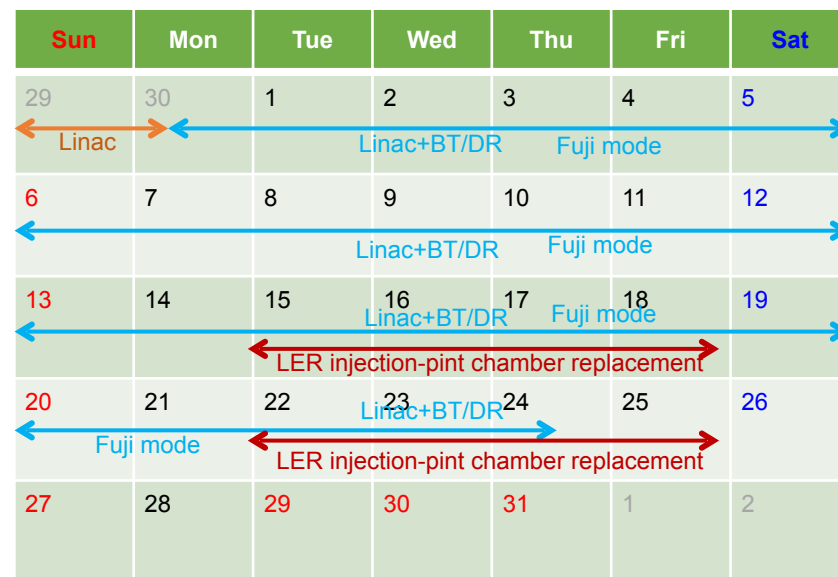
2026.10.6

Kyo Shibata

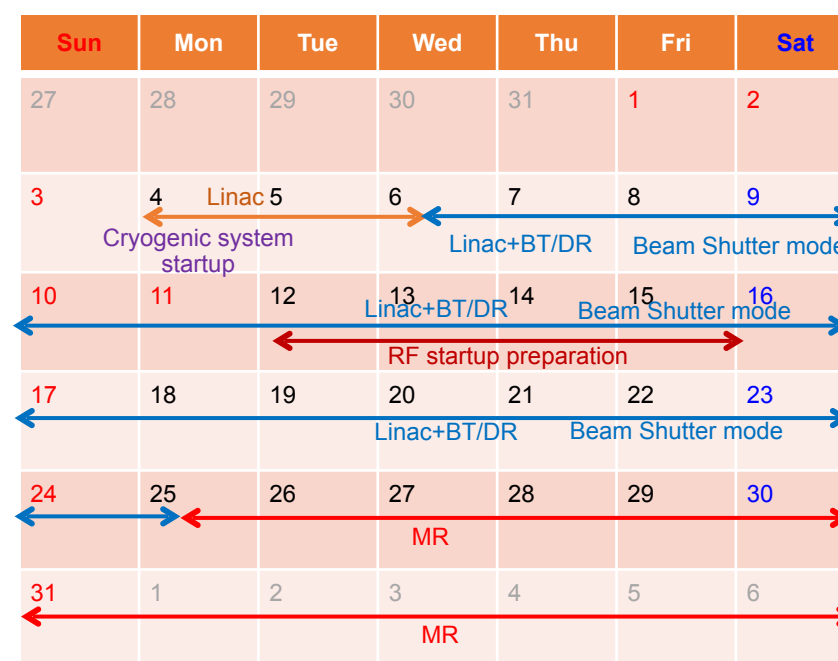
Startup schedule for the 2027ab run

- Before the New Year
 - Linac operation: 9/14 - 12/24
 - BT/DR operation: 11/30 - 12/24
 - ~ 3 weeks are required for BT/DR tuning in Fuji mode.
 - Fuji mode:
 - Beam operation only up to the beam dump in the downstream section of the BT.
 - Precise beam tuning for MR injection is not possible.
 - Half of the MR ring remains accessible.
 - Replacement of the LER injection-point chamber is also scheduled.
 - BT operation is not possible during the daytime shift.
 - BT operation cannot start before Nov. 30 due to maintenance of the BT magnet power supplies.

2026c
December



2027a
January



Startup schedule for the 2027ab run

- After the New Year
 - Linac operation: 1/4 -
 - BT/DR operation: 1/6 -
 - ~ 3 weeks are required for BT/DR tuning in Beam Shutter mode.
 - Beam Shutter mode:
 - Beam operation up to the beam shutter at the downstream end of the BT.
 - Precise beam tuning for MR injection is possible.
 - MR ring is not accessible.
 - RF startup preparation is also scheduled.
 - Beam Shutter mode operation must be interrupted.
 - MR operation: 1/25 –
 - The cryogenic system will be started on Jan. 4.
 - No cryogenic operation is required during the winter shutdown (12/29-1/3).
 - The earliest possible date for MR startup is Jan. 25.
 - Starting the cryogenic system before Jan. 4 would not allow an earlier MR startup.
- **Proposal: Start MR operation on Jan. 25**
 - The 2027ab run will continue through the end of May.

2026c
December

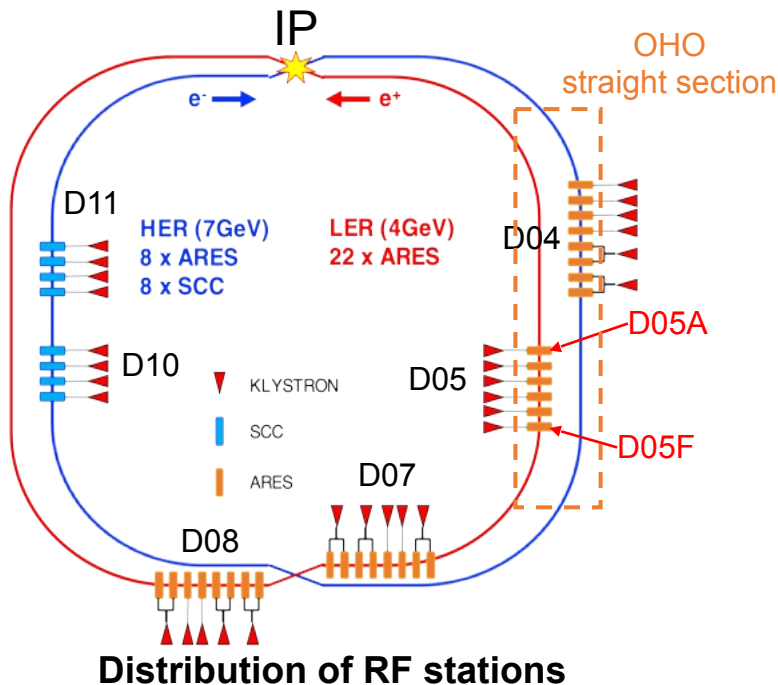
Sun	Mon	Tue	Wed	Thu	Fri	Sat
29 ← Linac	30 ←	1	2	3	4	5
6 ←	7	8	9	10	11	12
13 ←	14	15	16	17	18	19
20 ←	21	22	23	24	25	26
27	28	29	30	31	1	2

2027a
January

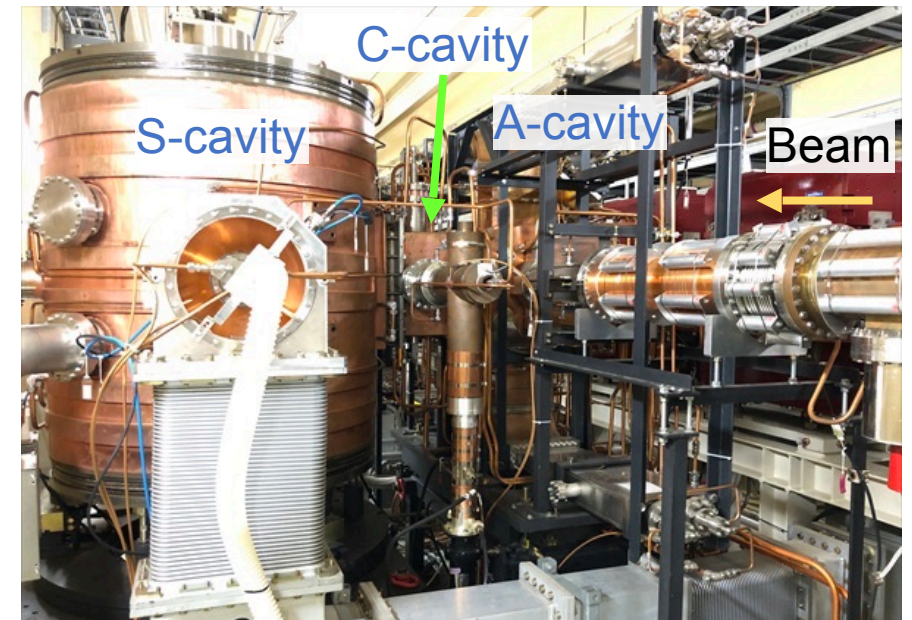
Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	1	2	3	4	5	6

Vacuum-pressure rises in D05A and D05F cavities

- In 2025c–2026ab run, abnormal vacuum-pressure rises occurred at D05A and D05F cavities.
 - ✓ D05A: Dec. 5, 2025 (during beam operation)
 - ✓ D05F: Apr. 15, 2026 (during cavity aging on a regular maintenance day)
 - On the same day, cooling water leak was found.
 - After the vacuum pressure rises, these cavities were detuned (out-of-operation).
- Both cavities are the normal-conducting ARES cavities used the OHO straight section.
- In the 2026 summer shutdown, investigations were conducted by ARES cavity group.



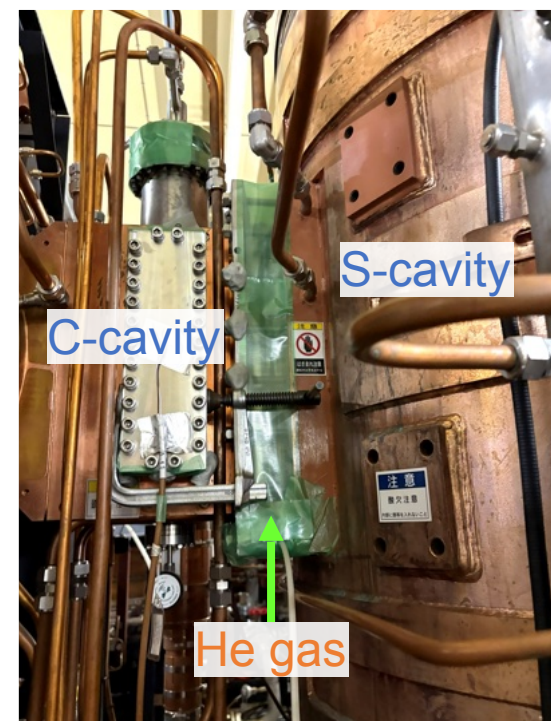
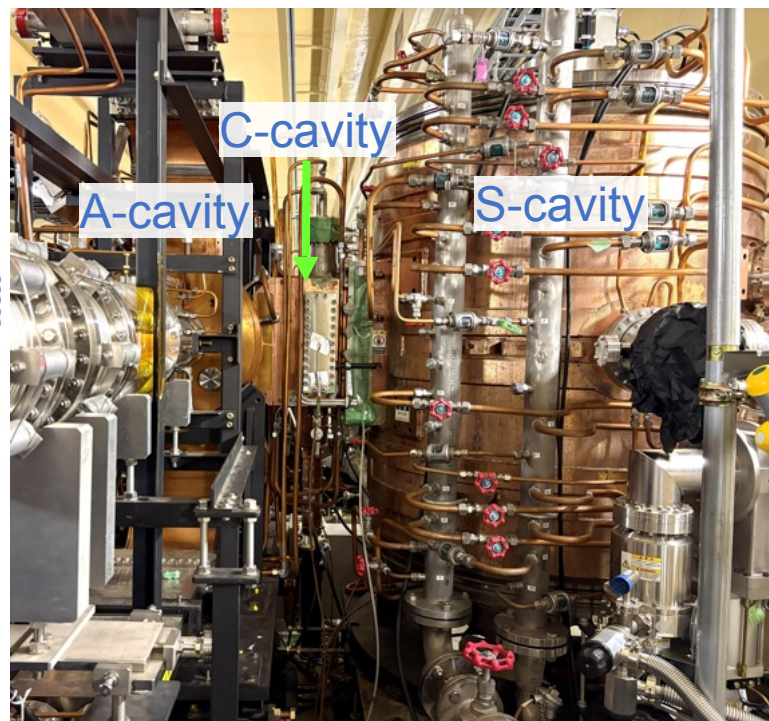
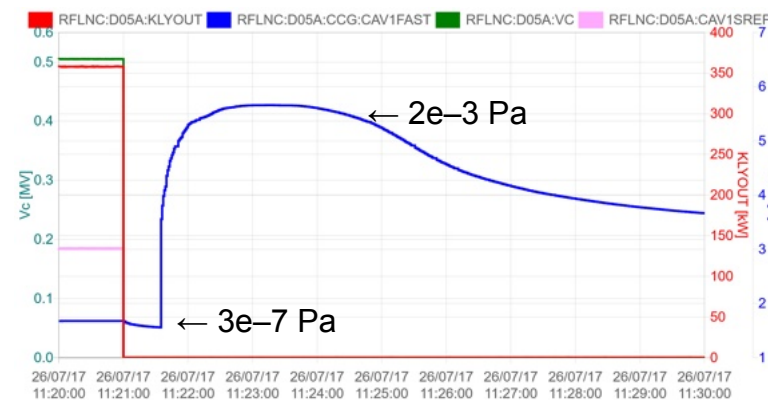
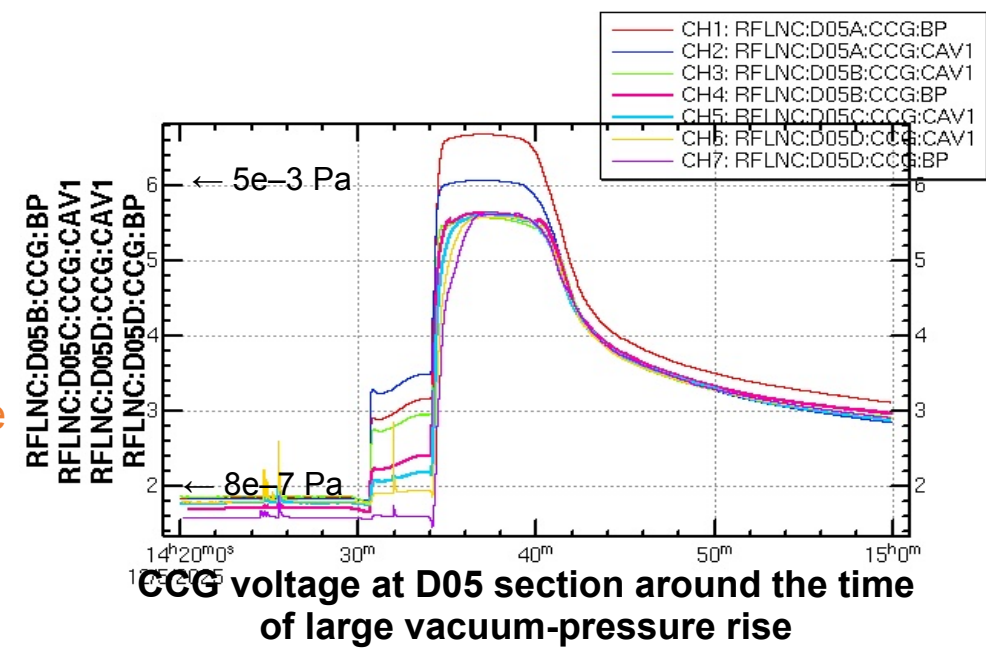
ARES cavity



- ✓ Three-coupled-cavity system to suppress coupled-bunch instability caused by accelerating mode²⁵

D05A cavity

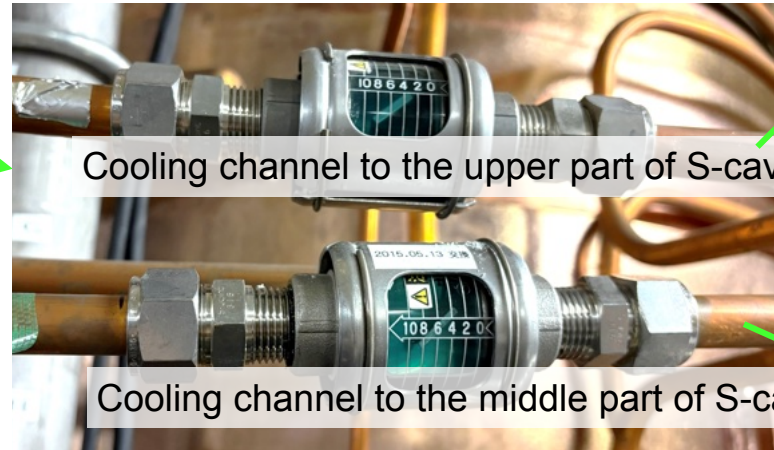
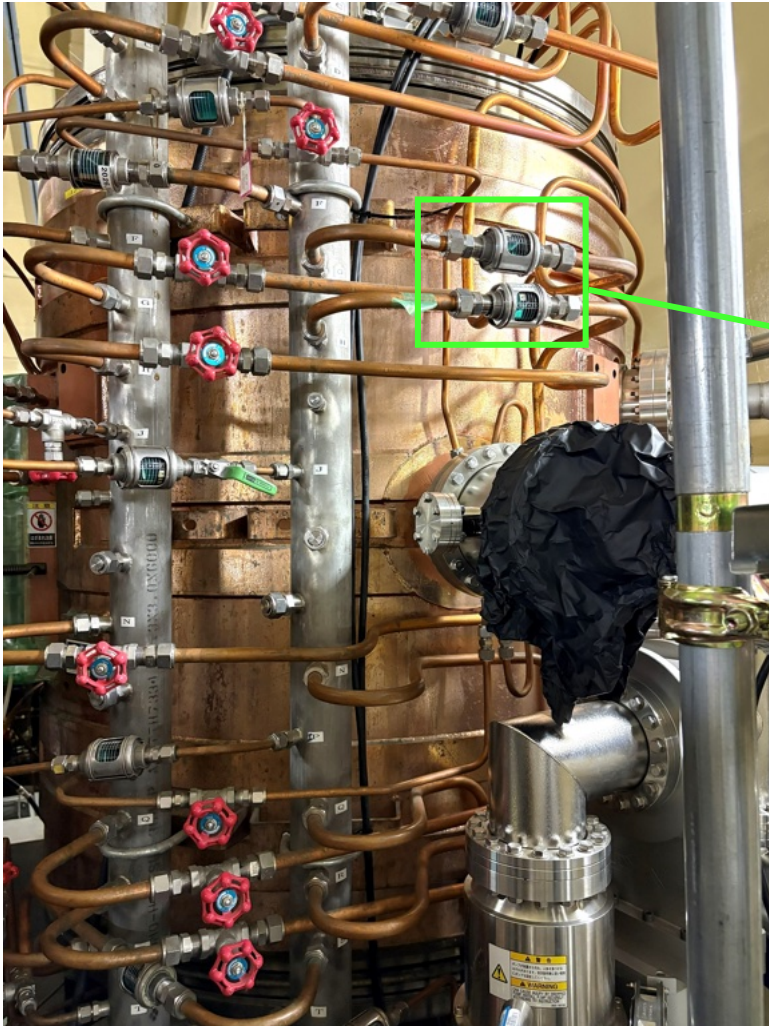
- Large vacuum-pressure rise occurred on Dec. 5, 2025 (during beam operation).
- During the 2026 summer shutdown, ARES cavity group investigated the source of pressure rise.
 - Similar vacuum pressure rise was reproduced due to a vacuum leak at the joint between the C- and S-cavity (confirmed by He leak test)
 - The joint is vacuum-sealed by a metal O-ring.



Vacuum sealing

Cause of D05A cavity vacuum leak

- By **obscure failure of a flap flow meter**, cooling water flow was insufficient at the middle part of the storage cavity.
 - Thermal expansion led to vacuum leak at the joint.



Flap flow meters

- ✓ With the normal cooling water flow, we have confirmed no vacuum leak at the joint during high-power operation with maintaining $V_c = 0.5$ MV/cavity.



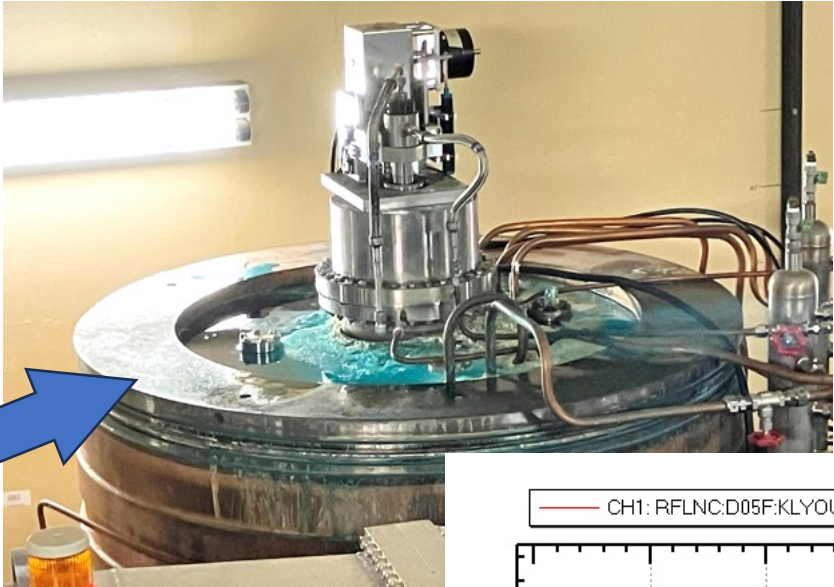
**Temperature measured
17 min. after RF turned off** 27

D05F cavity

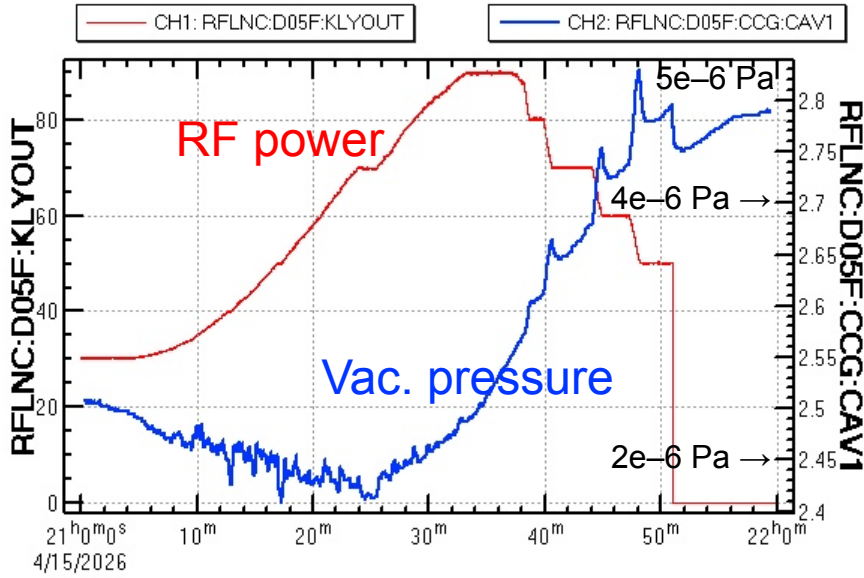
- On a regular maintenance day (Apr. 15, 2026), cooling water leak was found on the top of the storage cavity.
- After partial removal work of cooling water, cavity aging was conducted as usual. → **Abnormal vacuum-pressure rise** occurred.



Partial removal
of cooling water



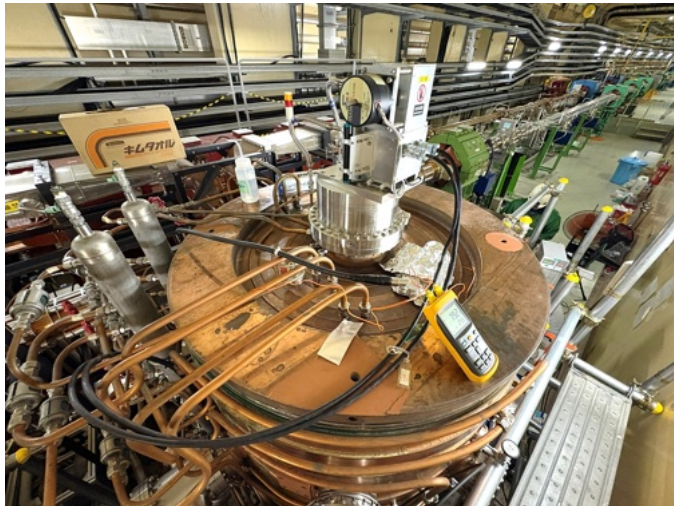
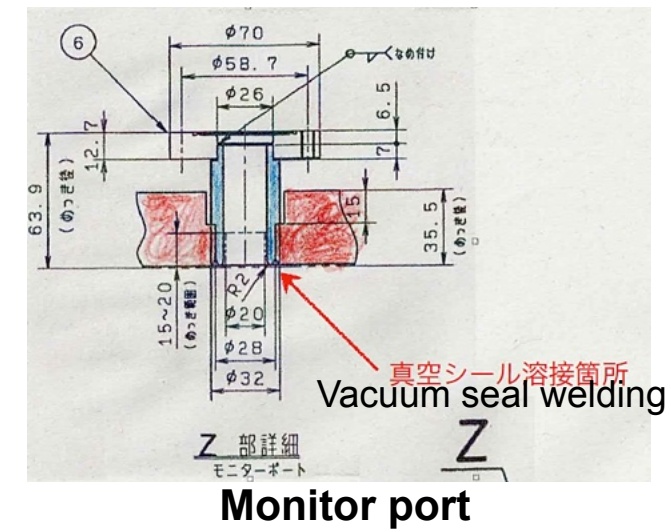
Cooling water including rust inhibitor
(the storage cavity is made from iron)



Vacuum leak during cavity aging

Investigation on D05F cavity

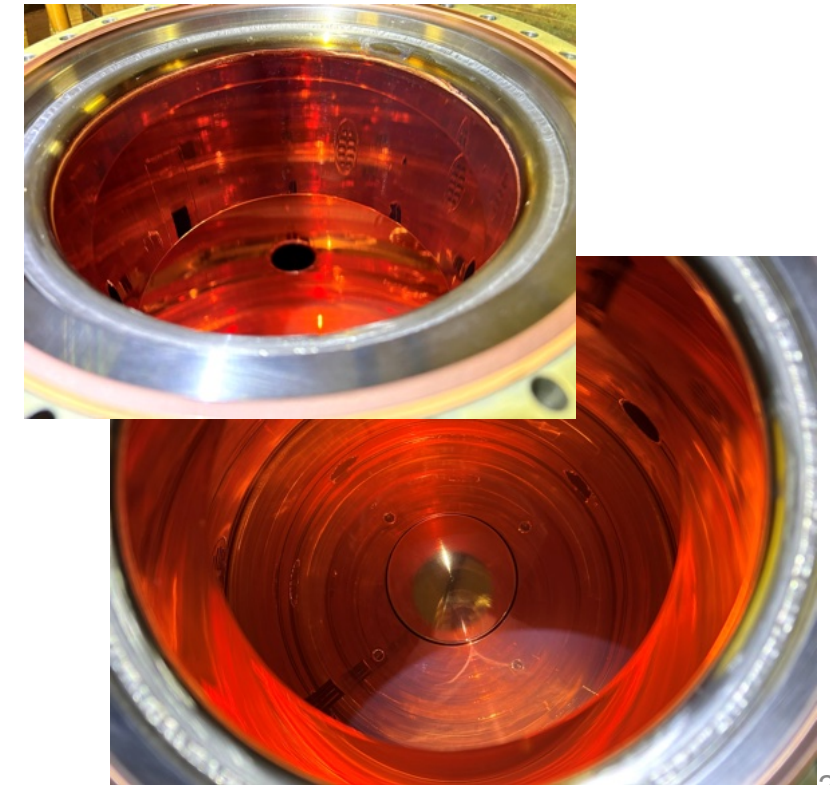
- During this summer shutdown, investigation on D05F was conducted parallel with that on D05A.
- ARES cavity group first suspected **galvanic corrosion** between the monitor port (stainless steel) and cavity main part (carbon steel).
- They conducted the following tests:
 1. Cleaning work (Jul. 3, 2026) → Baking of the monitor ports at 80°C
 2. Leak test without RF input → no leak found
 3. Leak test with RF input → no leak found
 4. Injected acetone and ethanol → leak test → no leak found
 5. High-power test at the RF voltage of 0.5 MV → no leak
 - In the investigation of D05F, **the pressure rise could not be reproduced!**
 6. Observed the cavity inside → nothing wrong



D05F Cavity after cleaning



Solvent injected to the root of the monitor port



Cavity inside investigation

Summary of investigation on abnormal vacuum-pressure rises

- **D05A (clear)**

- ✓ By obscure failure of a flap flow meter, cooling water was insufficient.
- ✓ Thermal expansion induced vacuum leak at the joint between the coupling cavity and storage cavity.
 - Adjustment of cooling-water flow should not rely on the flap flow meter but on opening valve of each valve (flap flow meters used as reference only).

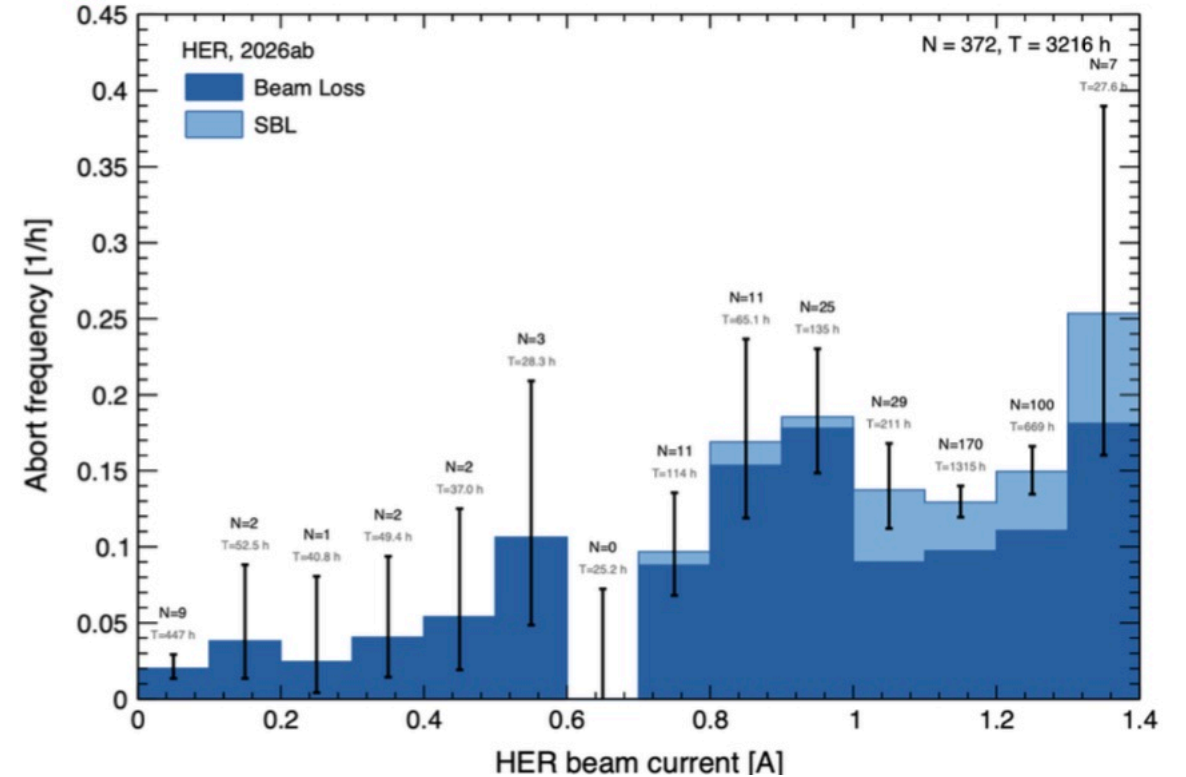
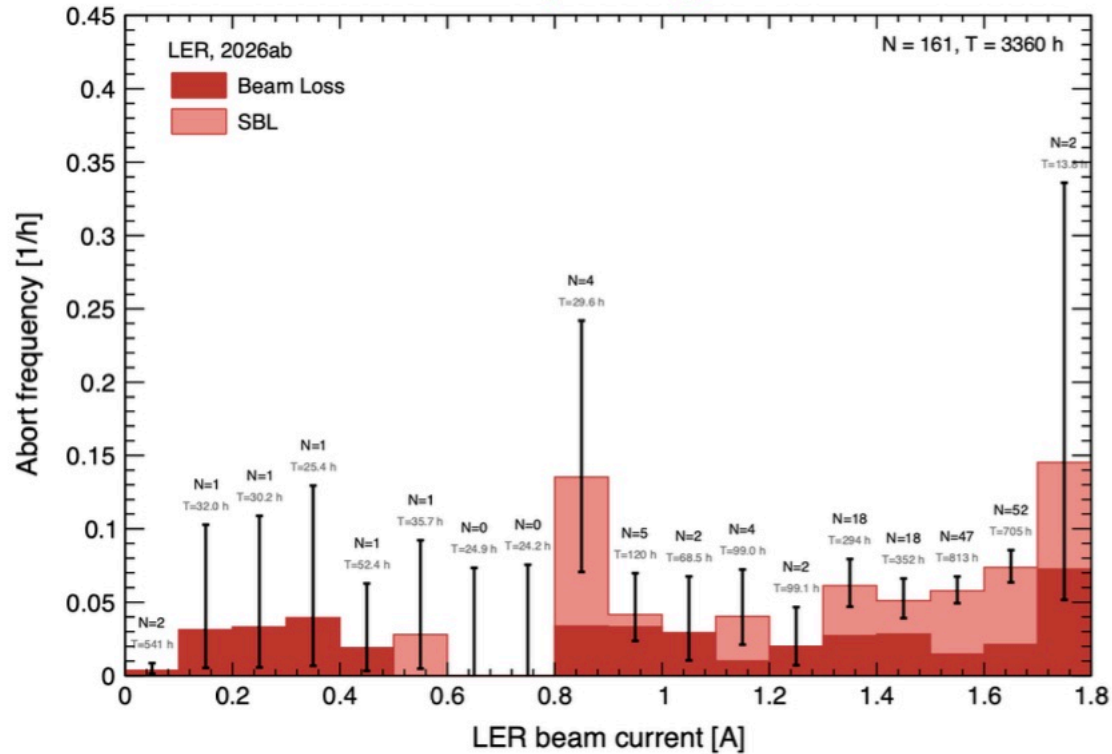
- **D05F (unclear)**

- In the investigation, the vacuum-pressure rise could not be reproduced.
- D05F cavity passed all the tests conducted in this summer shutdown.
- Suggested scenario of pressure rise:
 1. On the maintenance day when the water leak was found, the cooling channel concerned was tentatively closed to fix the water leak.
 2. After the work, they forgot to re-open the cooling channel? ← No confirmation
 - ✓ The cooling channel is for the movable frequency tuner of the storage cavity.
 - ✓ The tuning plunger would be very hot during high-power operation, leading to vacuum-pressure rise.

D05-A and -F cavities are normal and will return to operation without cavity replacement.
→ This will contribute to higher beam current!

Frequency of beam aborts caused by SBL/Beam losses

Reminder: frequency of beam aborts categorized as SBL+Beam Loss in 2026ab



K. Uno