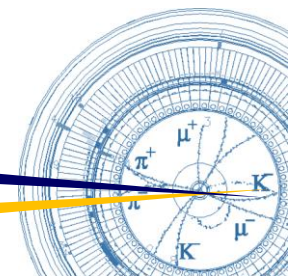


Vacuum

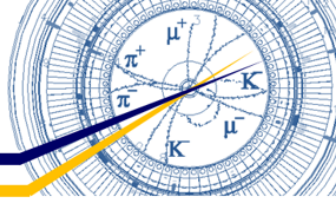


The 29th KEKB Accelerator Review Committee
26th October 2026

Mu-Lee Yao
On behalf of KEKB Vacuum Group



Outline

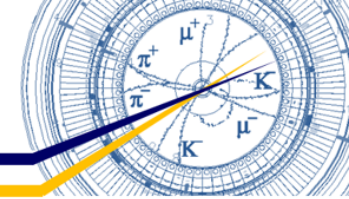


- Vacuum Status of 2025c and 2026ab
- Major Issues and Upgrades
 1. Pressure bursts and SBL-related investigations
 2. Vacuum limitations at higher beam currents
 3. Injection improvements
 4. Collimation improvements
 5. Operational reliability
 6. LS2 preparations
- Summary

	12
	1
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	3
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	6
	7
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	9
	10
2025c	11
	12
2026	1
2026ab	2
	3
	4
	5
	6
	7
	8
	9
	10
	11
	12



Beam dose & Maximum beam currents (MR)



- Integrated Beam Dose (2025c / 2026ab)

- HER : 449 / 3028 Ah

- LER : 601 / 3979 Ah

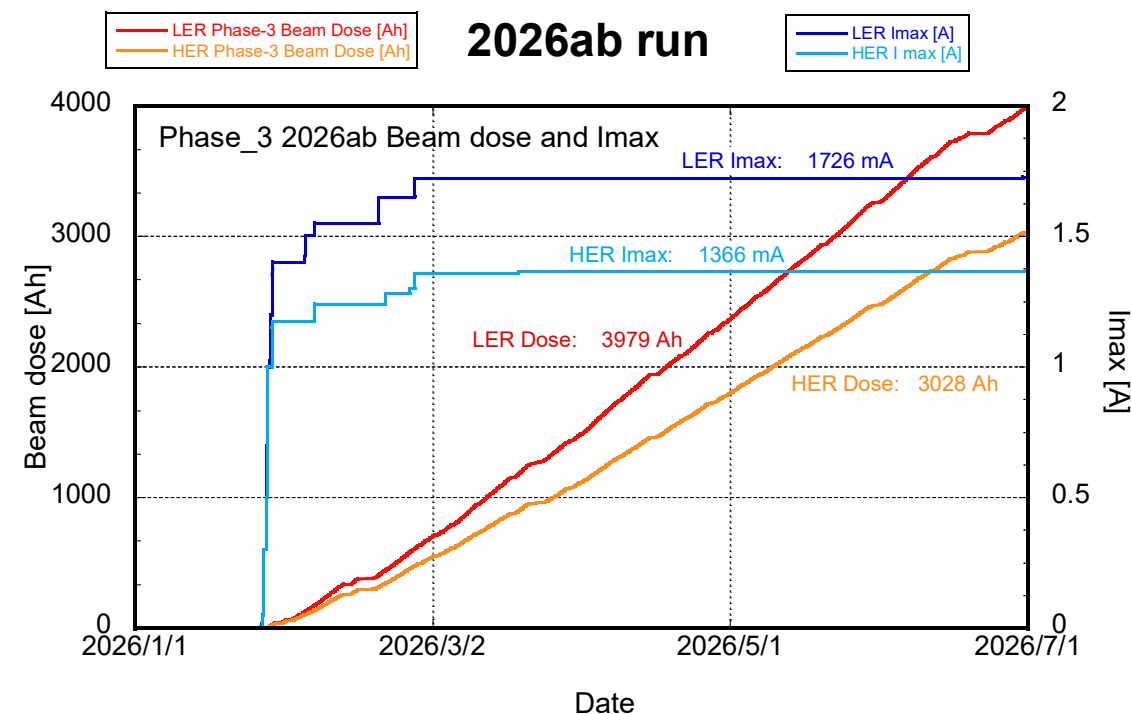
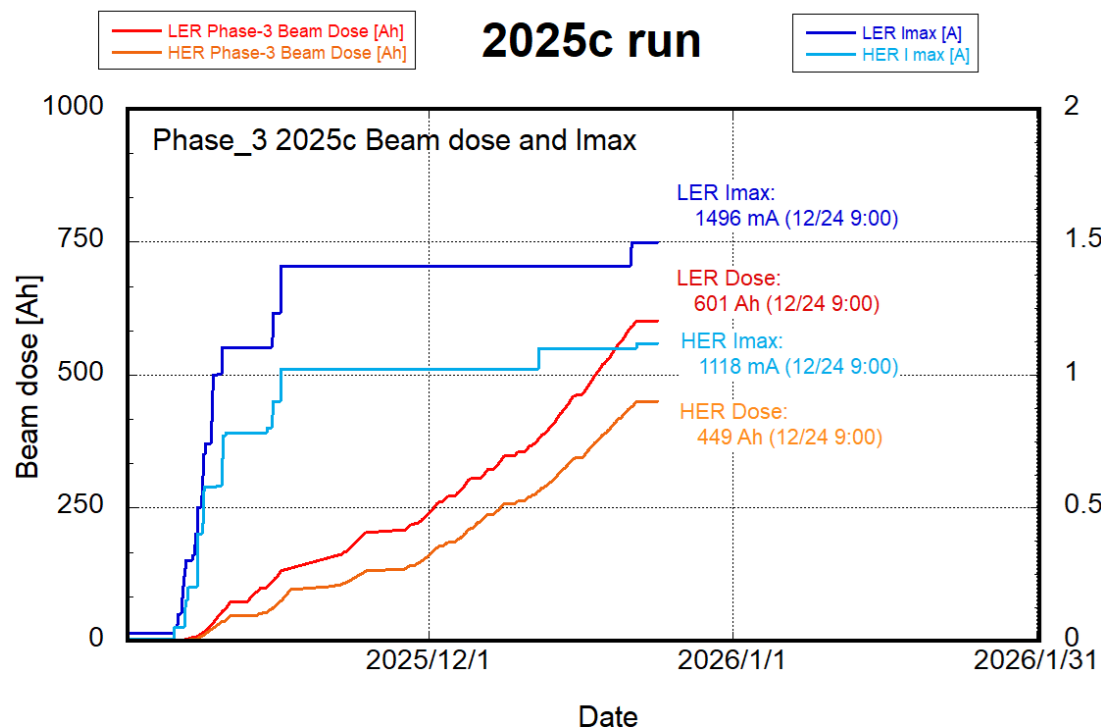
~1.5 months

~5 months

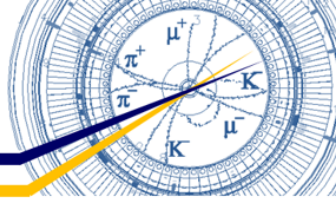
- Max. Beam Current (2025c / 2026ab)

- HER: 1118 / 1366 mA

- LER: 1496 / 1726 mA



Vacuum scrubbing status (MR)

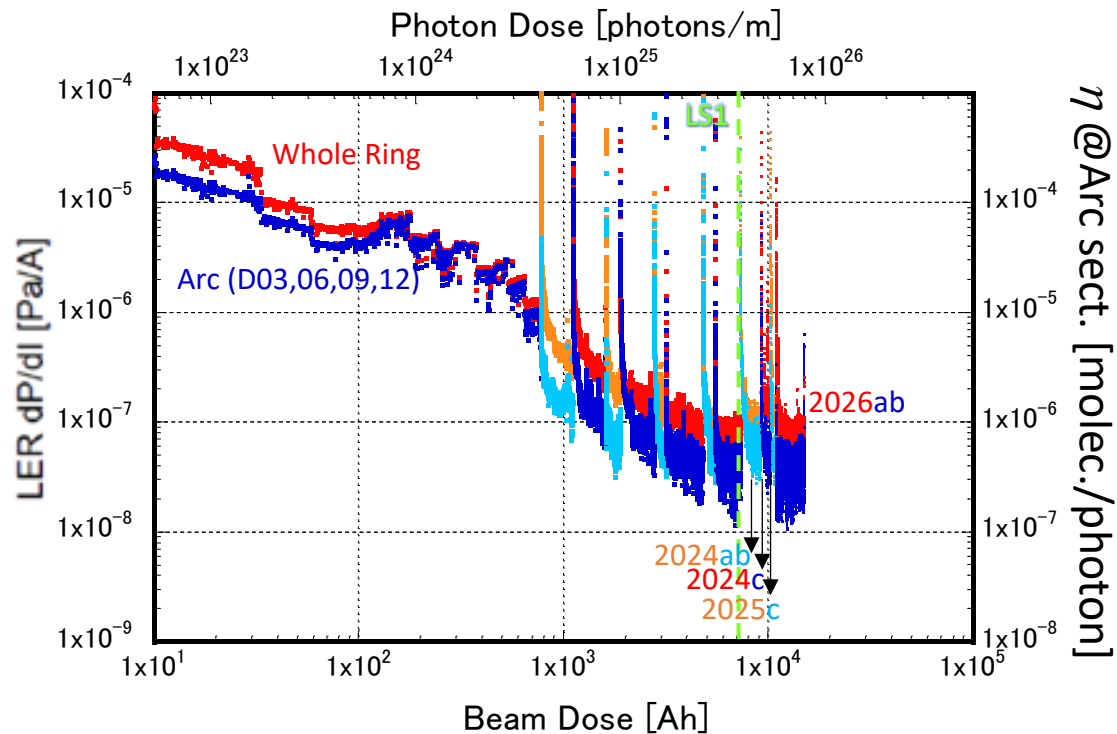


- Vacuum scrubbing status from Phase-I to Phase-III 2026ab run (~6/30)

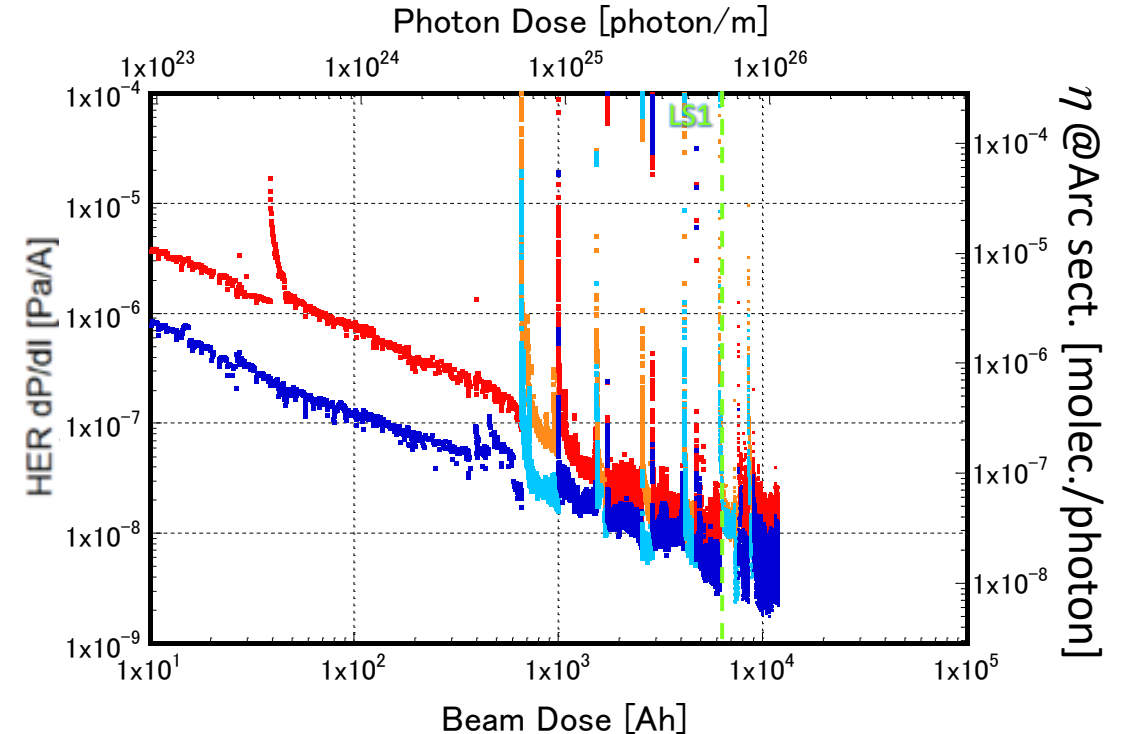
LER

HER

phase1-phase3_LER_scrubbing @09:00:00 06/30/2026

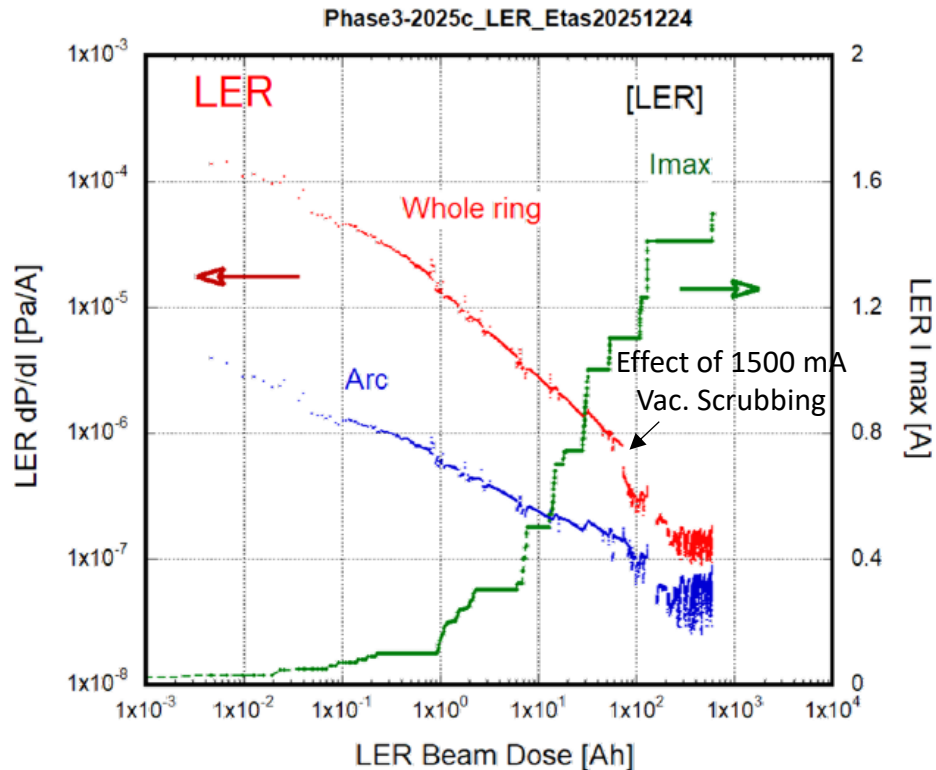


phase1-phase3_HER_scrubbing @09:00:00 06/30/2026

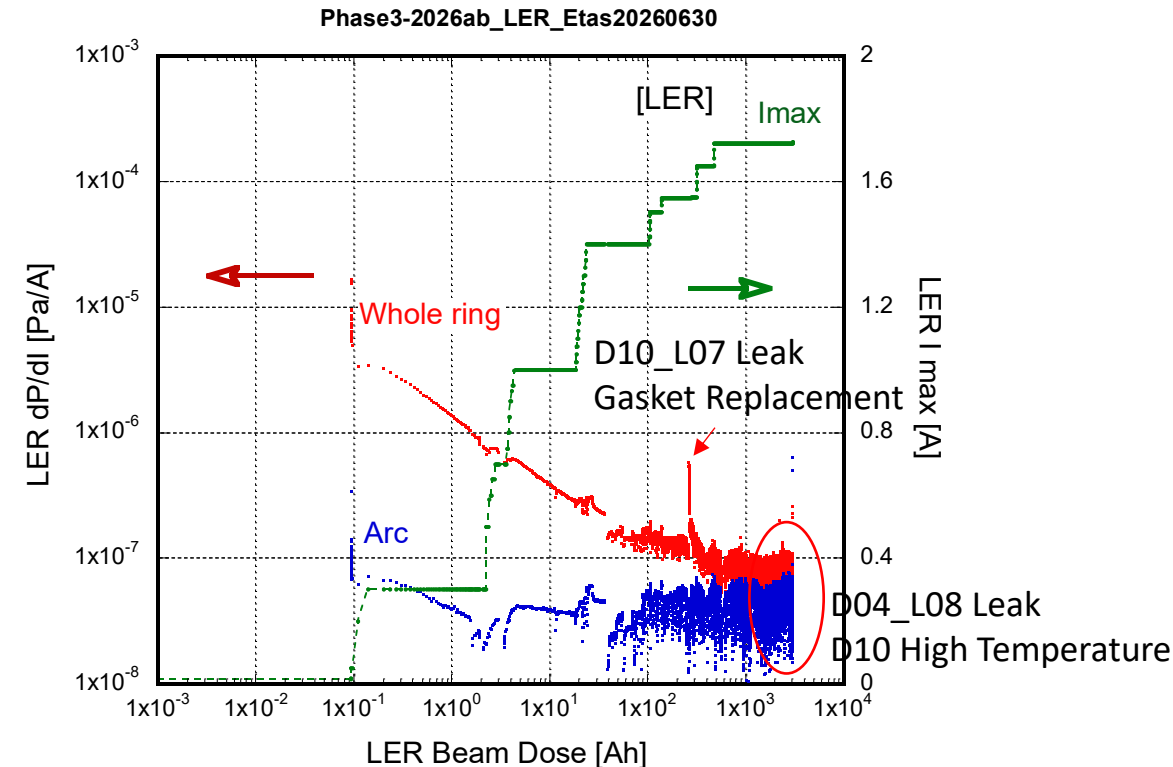


Vacuum scrubbing status (MR)

- Vacuum scrubbing status of **LER**: 2025c vs. 2026ab run
- **Estimated beam dose required for beam conditioning in 2027**
 - Replacement of water-cooled bellows chambers in the wiggler sections (D04 & D10)
 - QI6P chamber replacement
 - → Expected conditioning dose: **~100 Ah**, similar to the 2025c run.

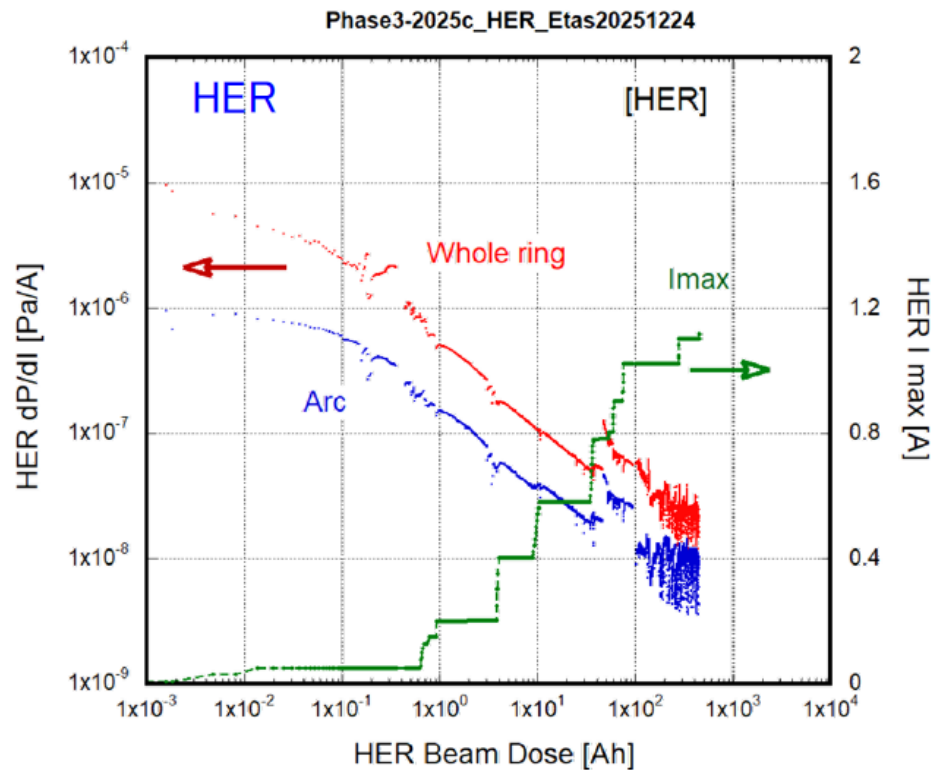


LER

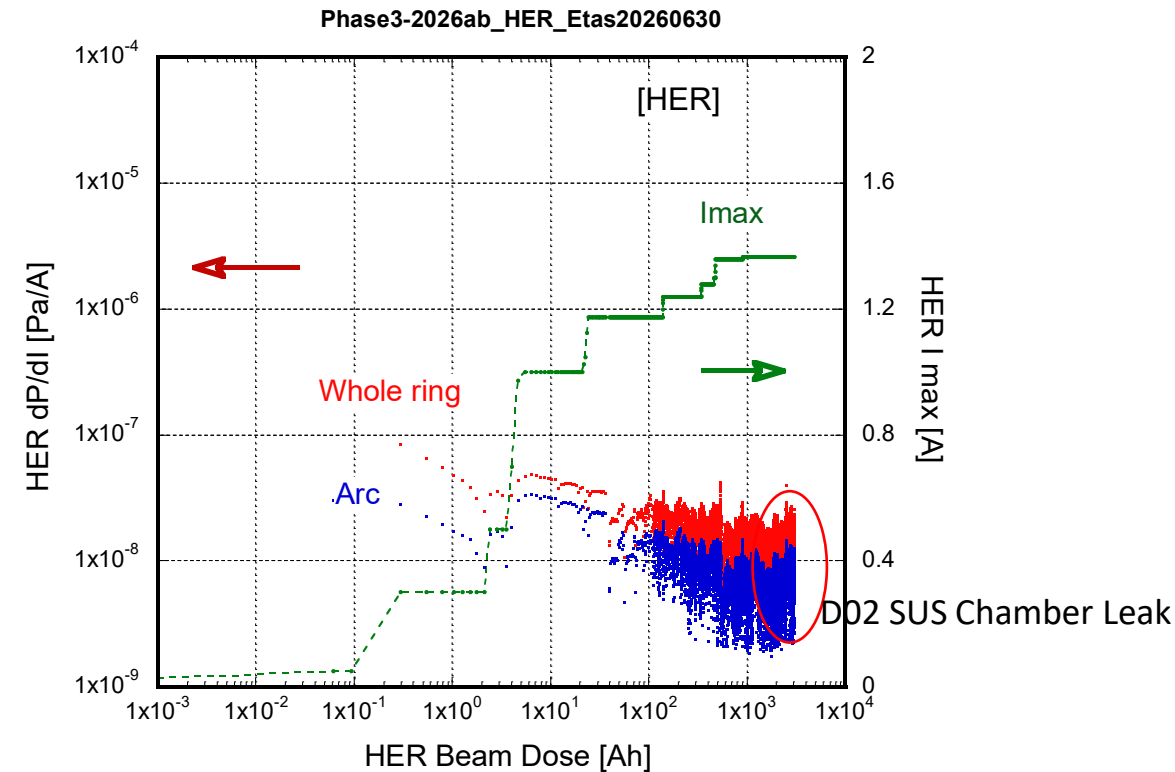


Vacuum scrubbing status (MR)

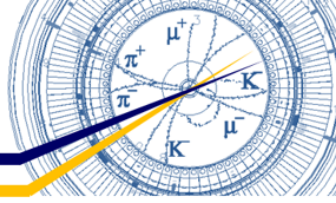
- Vacuum scrubbing status of HER: 2025c vs. 2026ab run
- **Estimated beam dose required for beam conditioning in 2027**
 - More than three collimator-related works
 - D02 SUS chamber replacement
 - → Expected conditioning dose: **~50 Ah**, also comparable to the 2025c run.



HER

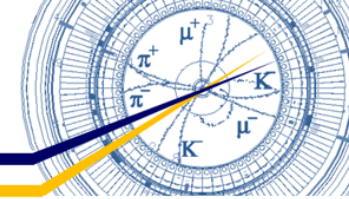


Major Issues and Upgrades



Objective	Main Countermeasures
1. Fewer Pressure Burst/ SBL	1. Vacuum Sealant Cleaning (2025 Shutdown): IR, LER D04, D10, D11 2. 4 Bellows Replacement: LER D04, D11
2. Higher Beam Current	1. More Permanent Magnets in LER D05 (2025 Shutdown) 2. LER Wiggler: 1. Clamshell, Clamp, 2. Enhanced water-cooled bellows, 3. RF Shield for NEG pump heating 3. HER enhanced water-cooled collimators (D09V3 and D09V1) 4. HER D02 SUS beam pipe ZVF4RE Leaks: Repair+ Replacement
3. Better Injection	LER Injection beam pipe QI6P alignment
4. Collimation Improvement	1. LER D03V4 Relocation 2. Replacement: LER D03V4, HER D01V1, LER D05V1 3. Status of Collimators 4. Revolver collimator development
5. Operational Reliability	1. HV connector of Ion Pump: Replacement and Dehumidification 2. More SLY independent supports in HER D01
6. LS2 Preparations	Design of IP bellows, Pressure Bump Study at IR

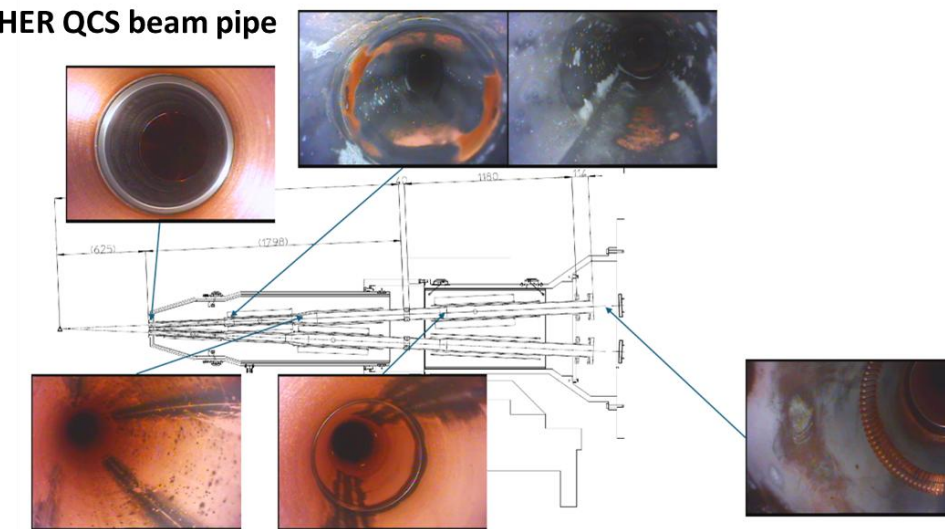
1. Pressure bursts and SBL-related investigations



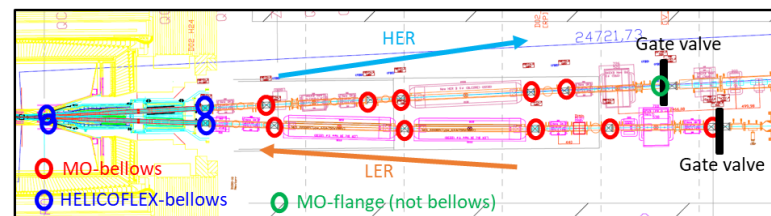
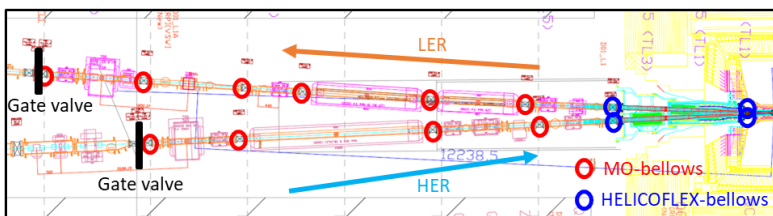
1. 2025 Shutdown inspection and cleaning

- IR Region:** Vacuum Sealant was used on all flanges in the IR during construction.
- We removed the Vacuum Sealant from all MO-flanges and reinstalled them without using it.
 - LER: 23 MO-flange connections (11 bellows chambers + 1 flange connection)
 - HER: 18 MO-flange connections (9 bellows chambers)
- The connections near the IP cannot be opened during this shutdown.
 - But HELICOFLEX-flange + Vacuum Sealant is safe

D02 HER QCS beam pipe



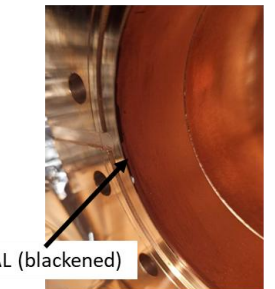
- An inspection of the inside of the QCS beam pipes using a fiber scope were performed. In particular, the surface on the HER D02 side showed discoloration—areas that were supposed to be copper-plated had turned black.



LER D01 Bellows Chamber



HER D01 Bellows Chamber



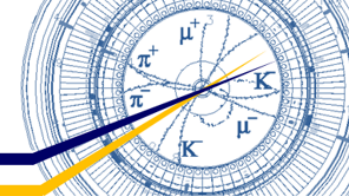
LER D02 beam pipe



HER D02 Bellows Chamber



1. Pressure bursts and SBL-related investigations

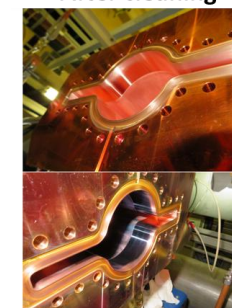
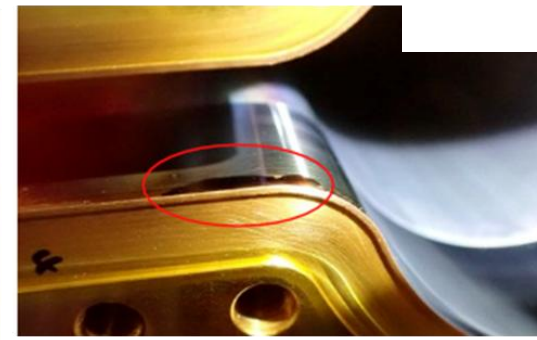
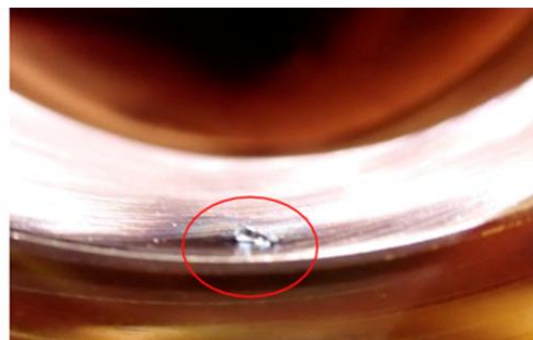
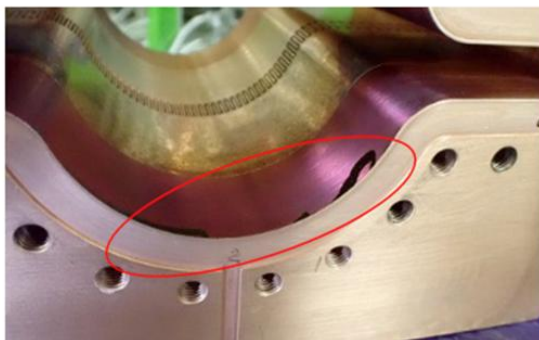


1. 2025 Shutdown inspection and cleaning

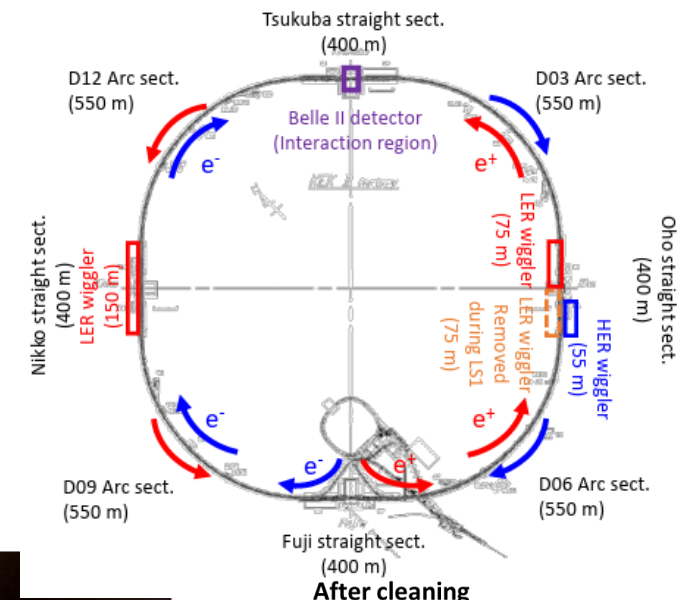
- **LER Wiggler section:** We removed and inspected all of the bellows chambers.
- We removed them and reinstalled the chambers without using Vacuum Sealant
 - Oho (D04): 52 MO-flange connections (26 bellows chambers)
 - Nikko (D10+D11): 98 MO-flange connections (49 bellows chambers)

Example D04

Inside of bellows chamber and beam pipe in the Oho Wiggler Section



Radiation shielding (concrete)



2025

12

1

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3

4

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7

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2025c

11

12

2026

1

2026ab

2

3

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5

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12

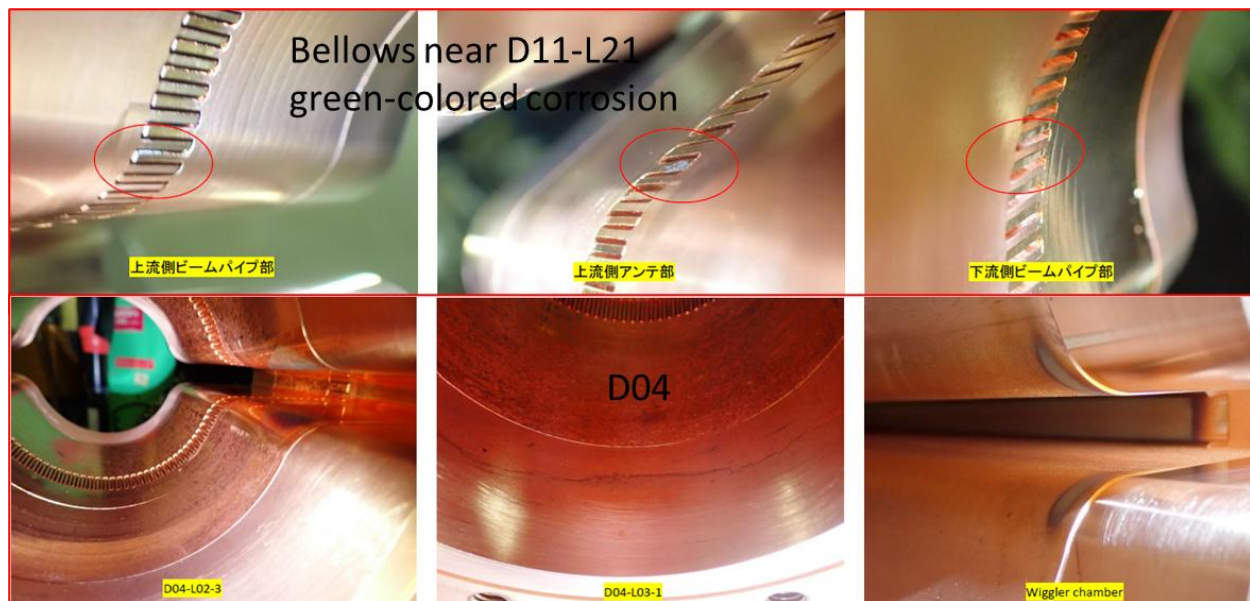
2027

12

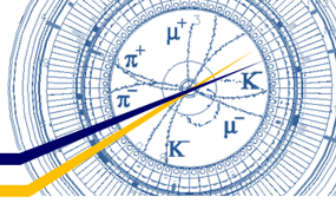
1. Pressure bursts and SBL-related investigations

2. LER Pressure bursts at D11 and D04 after 2025 shutdown

- Pressure bursts during SBL were still observed at D11 and D04
 - The interior of the bellows was checked, and both bellows were replaced — 4 units in total.
- Verification during 2026ab run: Pressure bursts frequency reduced (see following pages)
 - Bellows replacements?
 - Natural conditioning? Not sure
- The event frequency remains higher than before LS1, although the beam current is also higher.
- Beam losses accompanied by pressure bursts also occur in regions where Vacuum Sealant has not been used, suggesting that factors other than Vacuum Sealant also contribute to beam losses.

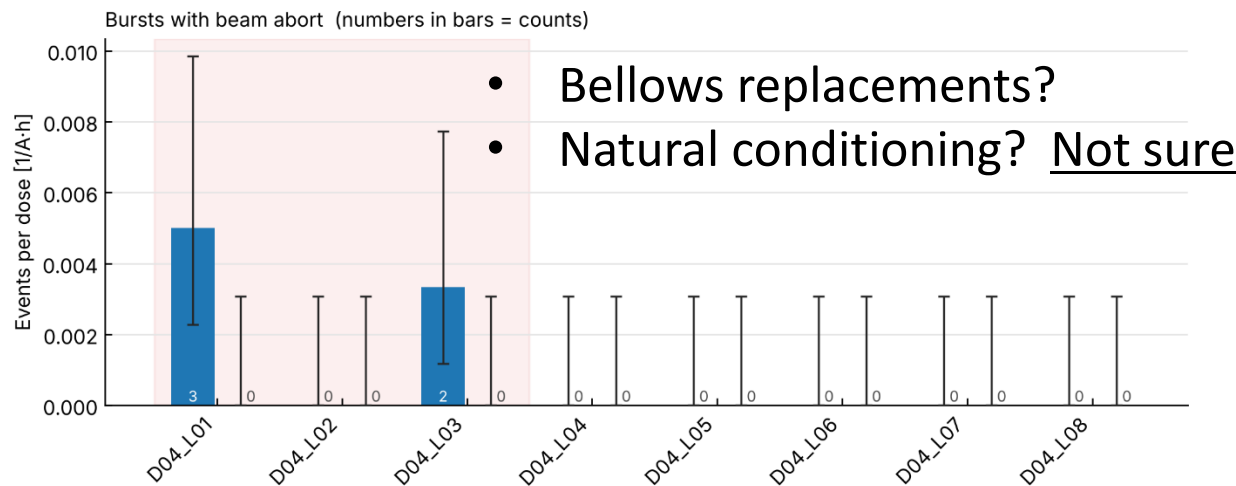
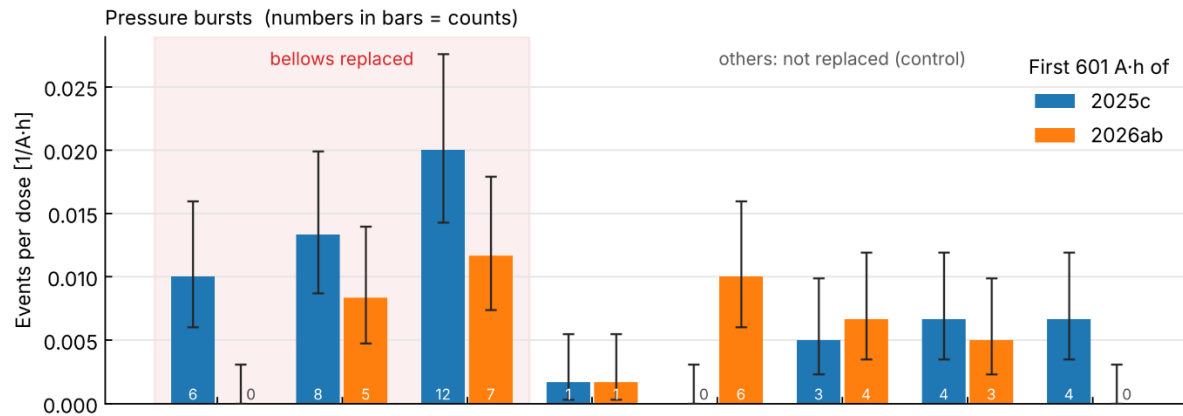


1. Pressure bursts and SBL-related investigations



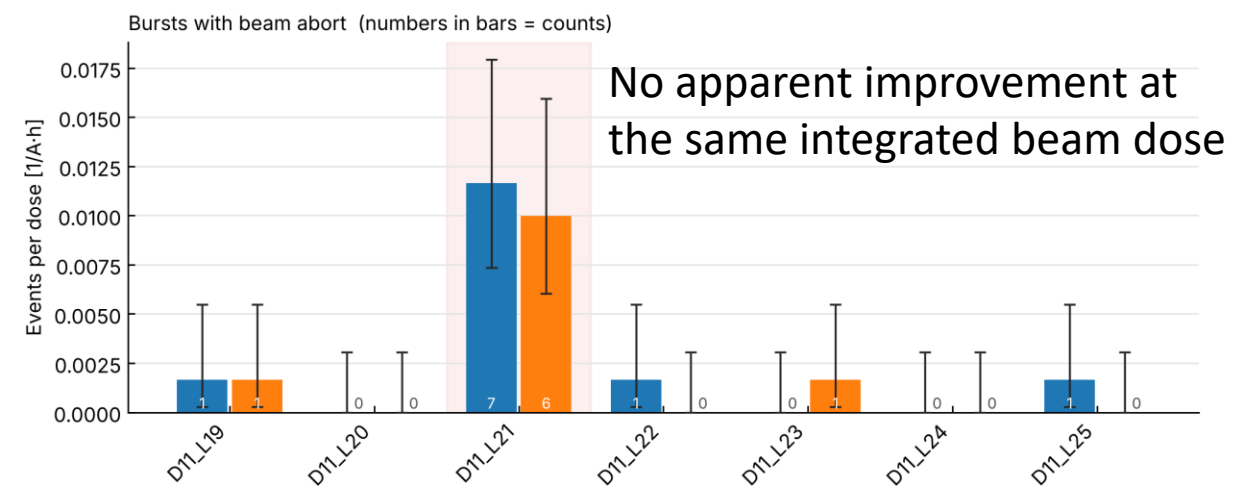
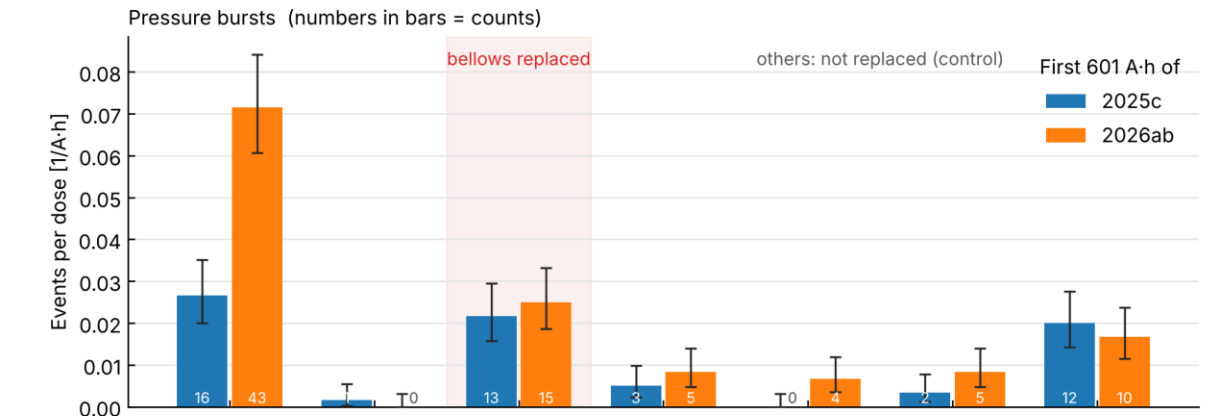
Effect of Bellows Replacement at LER D04 L01-L03

D04 WIG: burst frequency at equal integrated dose (0-601 A-h from run start)
error bars: Poisson 68% (Garwood)

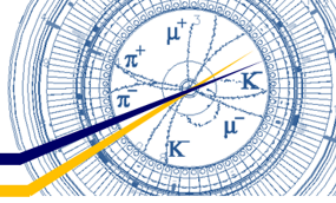


Effect of Bellows Replacement at LER D11 L21

D11 WIG: burst frequency at equal integrated dose (0-601 A-h from run start)
error bars: Poisson 68% (Garwood)

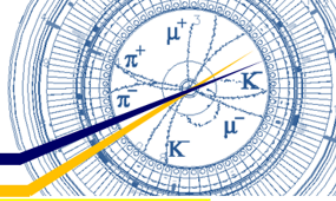


Major Issues and Upgrades



Objective	Main Countermeasures
1. Fewer Pressure Burst/ SBL	1. Vacuum Sealant Cleaning (2025 Shutdown): IR, LER D04, D10, D11 2. 4 Bellows Replacement: LER D04, D11
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3. Better Injection	LER Injection beam pipe QI6P alignment
4. Collimation Improvement	1. LER D03V4 Relocation 2. Replacement: LER D03V4, HER D01V1, LER D05V1 3. Status of Collimators 4. Revolver collimator development
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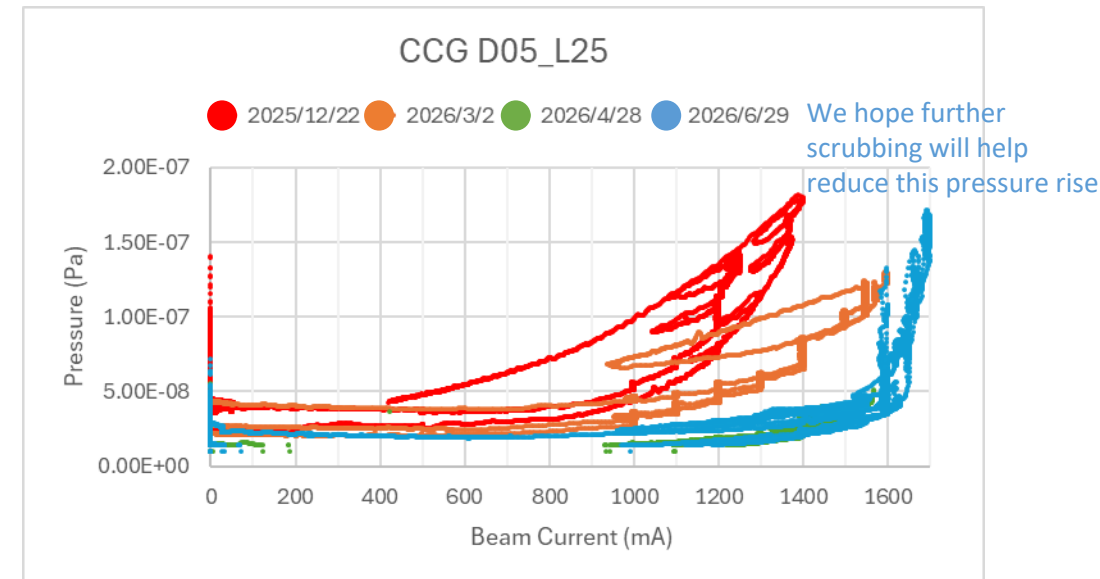
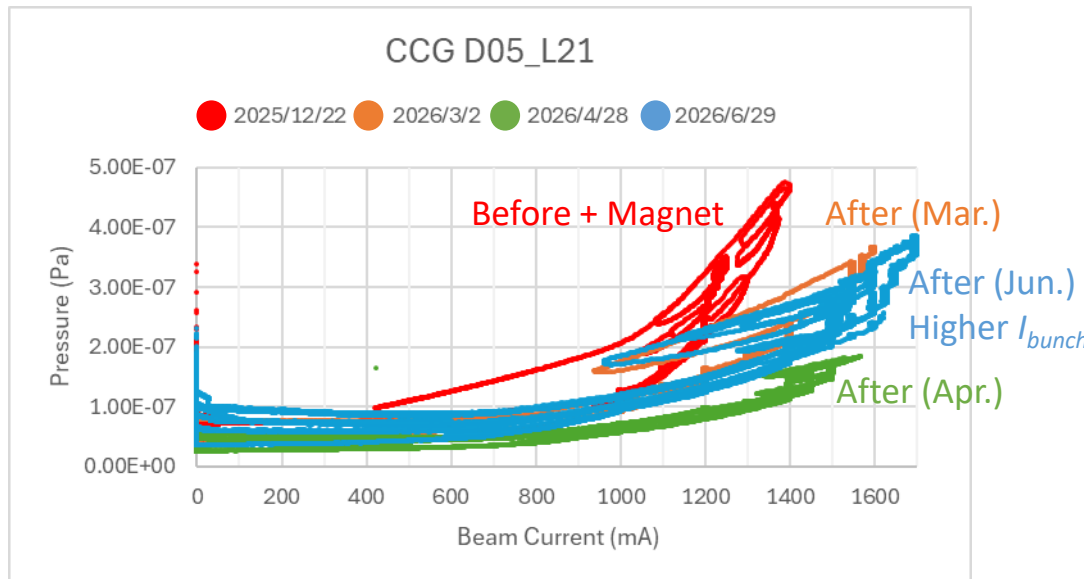
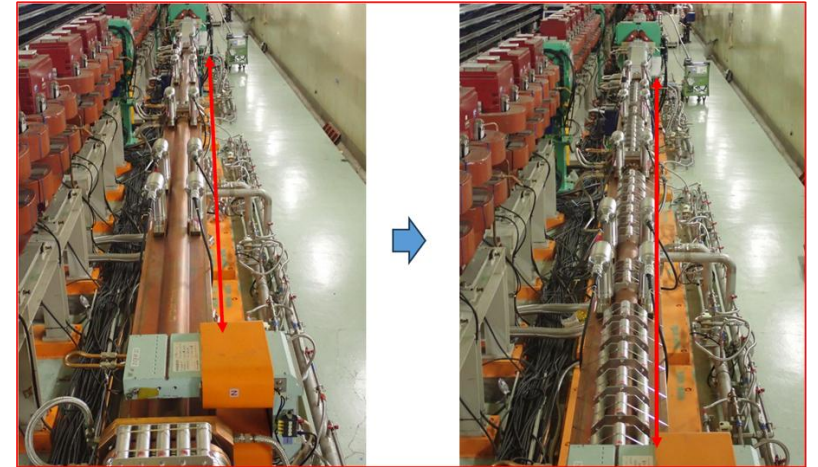
2. Vacuum limitations at higher beam currents



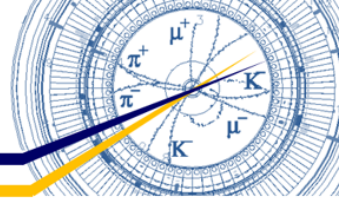
1. Nonlinear pressure rise around non-linear collimator (NLC) in the D05 section

- Permanent magnets were added to sections where no permanent magnets had previously been installed
- 02/16 and 03/18 NEG activation
- 2025c → 2026a An improvement was observed
- 03/18 The permanent magnets at D05_L25 and D05_L26 were replaced with stronger ones: ● → ●
- Effective: stronger magnets? or beam conditioning?
- The pressure rise at D05_L25 becomes pronounced above 1650 mA
- → ● Bunch number decreased (2346 → 2026), bunch current increased

+ More permanent magnet sets



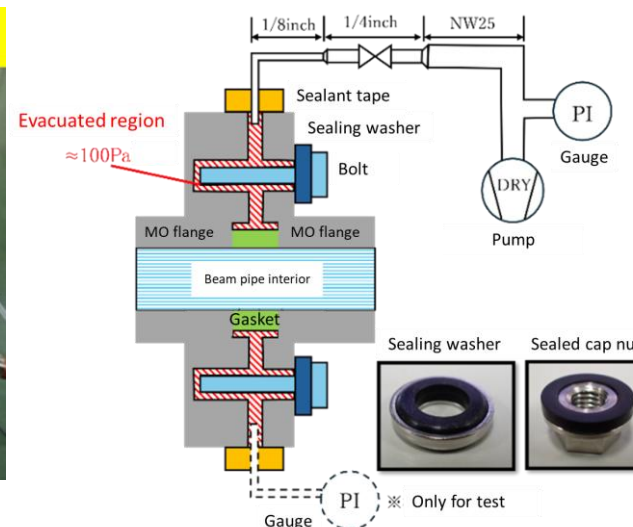
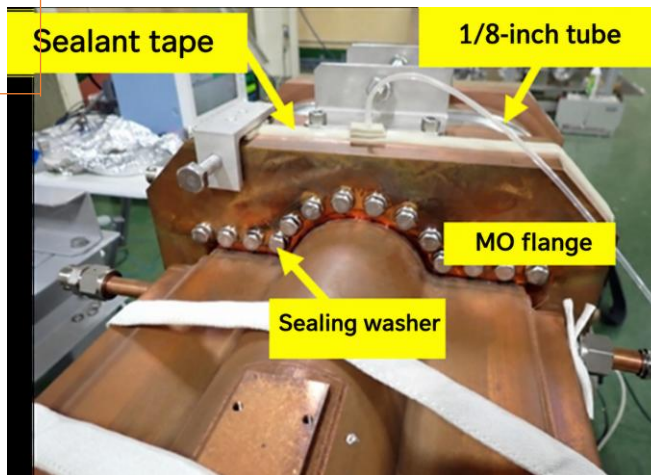
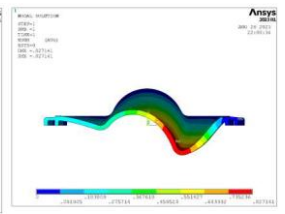
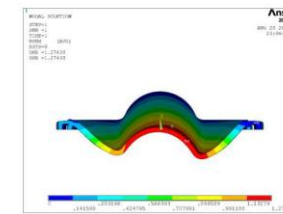
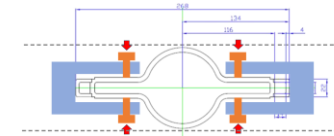
2. Vacuum limitations at higher beam currents



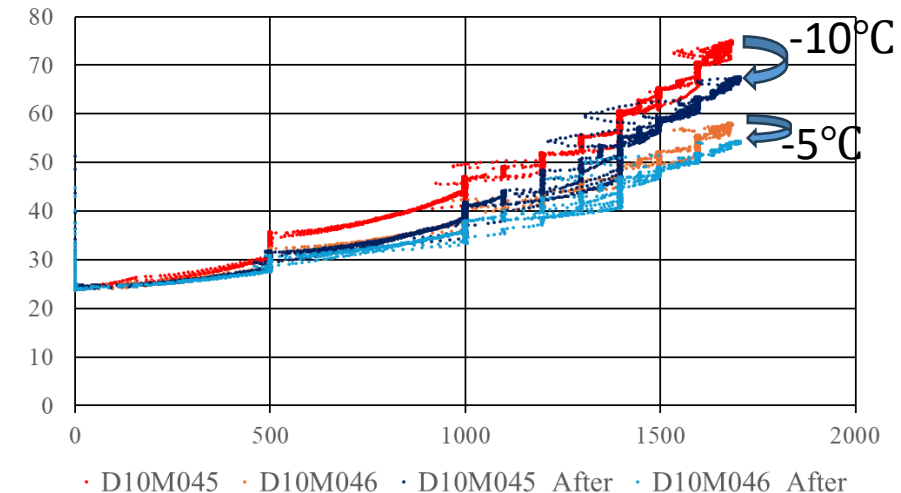
2. LER wiggler: Leaks, Clamshell, and Clamp

1. Nikko CCG D10_L07

- 2025/11 (2025c): Installed a **clamshell** upstream of D10_L07
- 2026/02: Repeated leaks at CCG D10_L07 (Feb. 4, 9, and 12) were resolved by retightening and gasket replacement
- 2026/02: Installed another clamshell upstream of D10_L08, **clamped** the antechambers at four locations (two on the inner side and two on the outer side), and aligned the bellows
- Results: Improved temperature and pressure behavior in the surrounding area

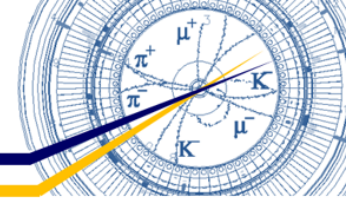


CCGD10L09 downstream temperature before/after 4 clamps installation on 2026/03/18



Akita's Report: PASJ2026 THP068

2. Vacuum limitations at higher beam currents

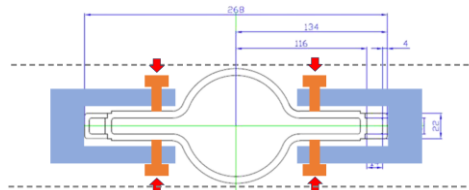


2. LER wiggler: Leaks, Clamshell, and Clamp

1. Nikko CCG D10_L07

• Detail of Clamp

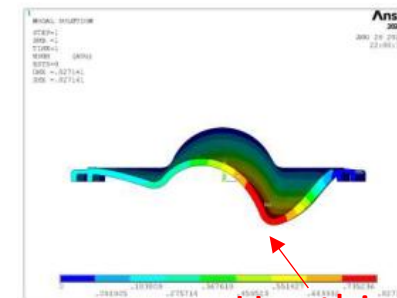
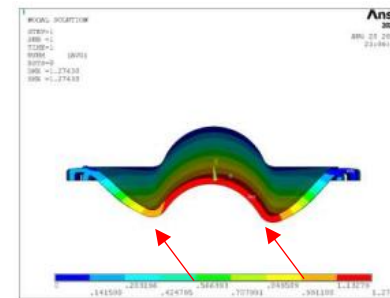
GV_D10_L2



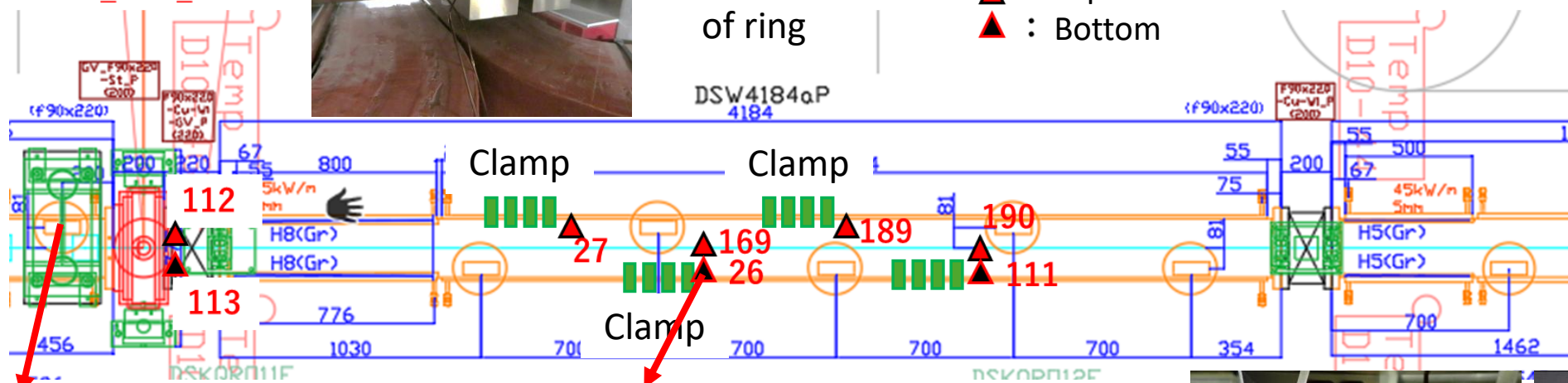
Outer side
of ring

DSW4184aP
4184

▲ : Top
▲ : Bottom

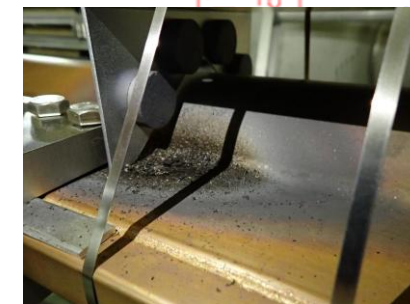


Use this part
as SR Mask



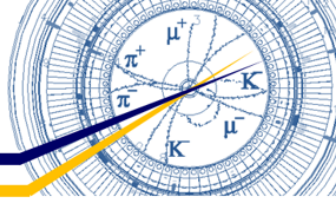
IP/CCG
D10_L09

- Pressure rise at CCG D10_L09 - associated with upstream beam pipe heating
 - Black copper oxide was observed (#169: 280°C/ #27:180 °C @1600 mA)
 - Before 2027ab: 1. Replace the upstream bellows with an SR-mask-equipped unit, 2. reverse the chamber orientation, and 3. fabricate a spare
 - Clamping is effective, but the amount of deformation must be controlled



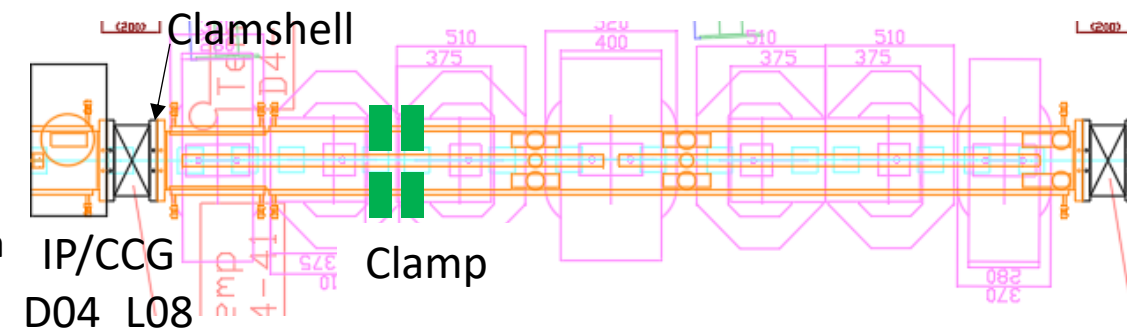
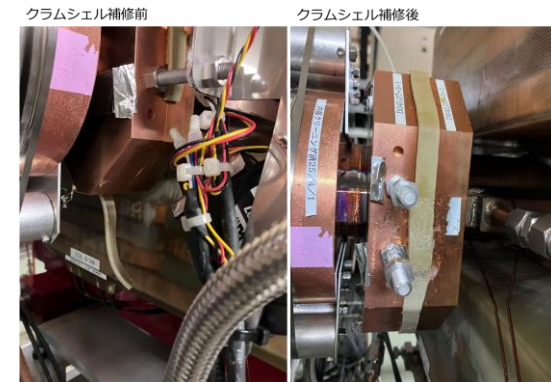
Interior

2. Vacuum limitations at higher beam currents

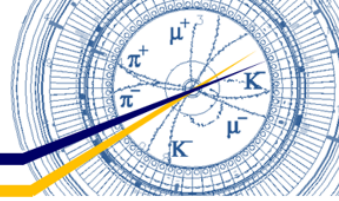


2. LER wiggler: Leaks, Clamshell, and Clamp 2. Oho CCG D04_L08

- 2026/02/15 A leak developed at the upstream flange of CCG D04_L08 after a beam abort
 - Retightening
 - 2/16 Installed a clamshell at the D04_L08 bellows connection and antechamber clamps on the upstream chamber (two each on the inner and outer sides).
- 05/06 The same flange leaked again after a beam abort
 - Some sealant had detached from the clamshell side. Retightened the flange and repaired the clamshell
- 06/06 Another leak occurred after a beam abort
 - Retightening 3 times
 - Following orbit adjustment in the wiggler section CCG pressure reduced $1.1 \times 10^{-7} \text{ Pa} \rightarrow 0.8 \times 10^{-7} \text{ Pa}$



2. Vacuum limitations at higher beam currents



2. LER wiggler:

2. Enhanced water-cooled bellows

- Temperature differences between the top and bottom of the flange have been confirmed to cause vacuum leaks
- Structural simulations indicate no significant reduction in flange stiffness
- Thermal simulations:
63°C without water cooling
45°C at 1.5 L/min / 35°C at 3.5 L/min
- Heating-tape tests also confirmed effective temperature reduction (2026/06)

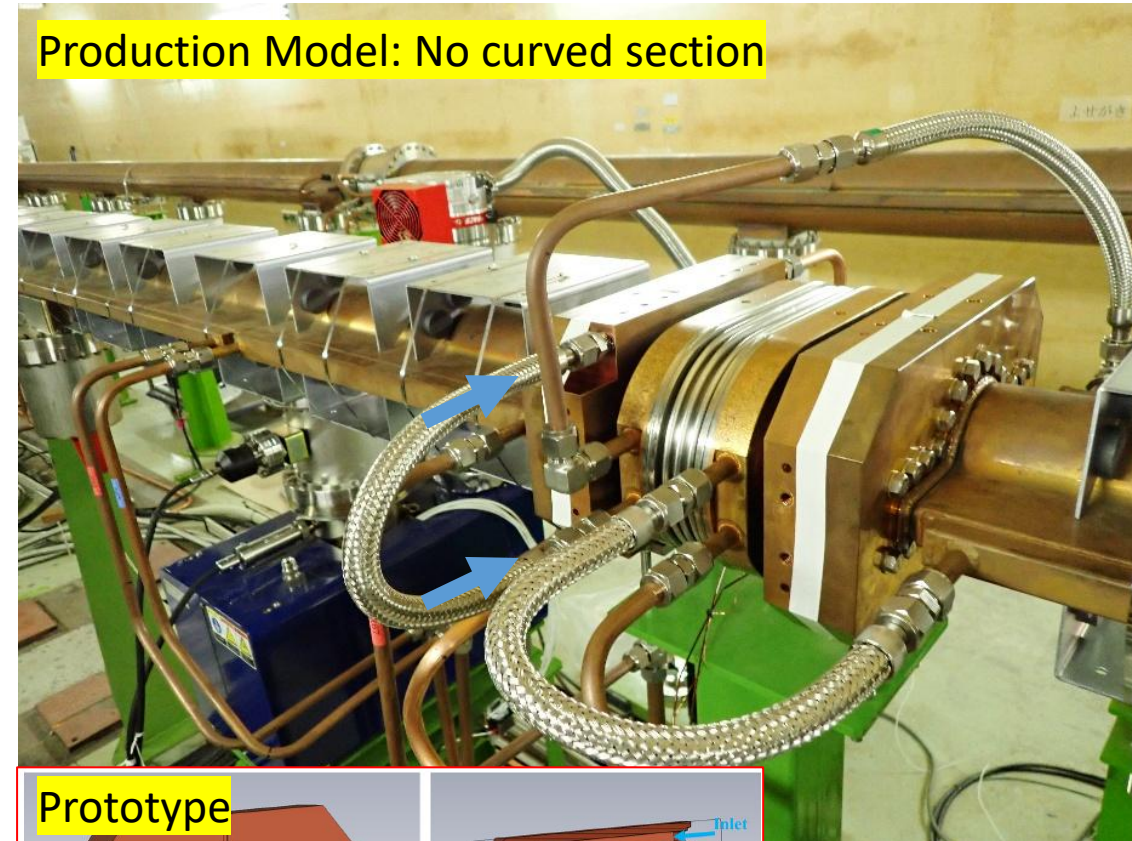
- Prioritize locations with high leak risk (clamshell sites)
 - D04: 3 units/ D10: 13 units/ D11: 10 units (All Completed)



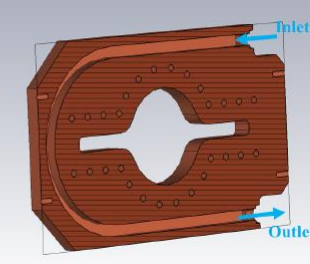
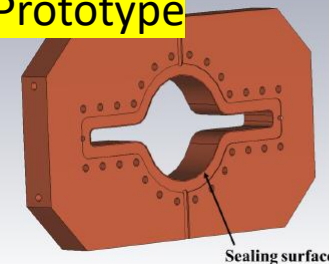
Heating-Tape Tests

- Without water cooling: chamber temperature reached 100°C
- Cooling water: 20°C, 3 L/min
- Flange temperature: below 35°C

Production Model: No curved section

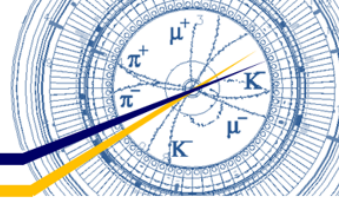


Prototype



Terui's Report:
PASJ2026 FRP081

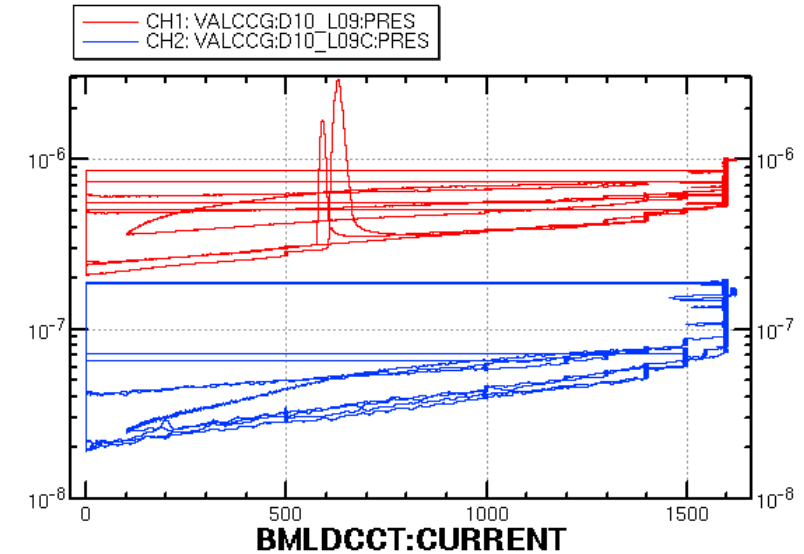
2. Vacuum limitations at higher beam currents



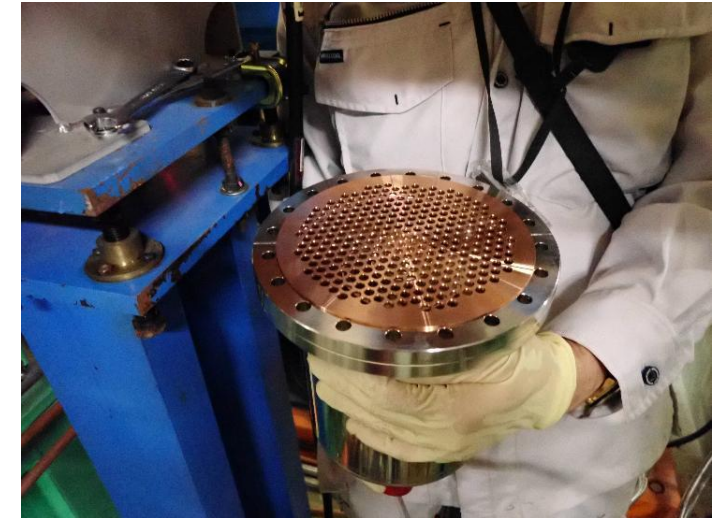
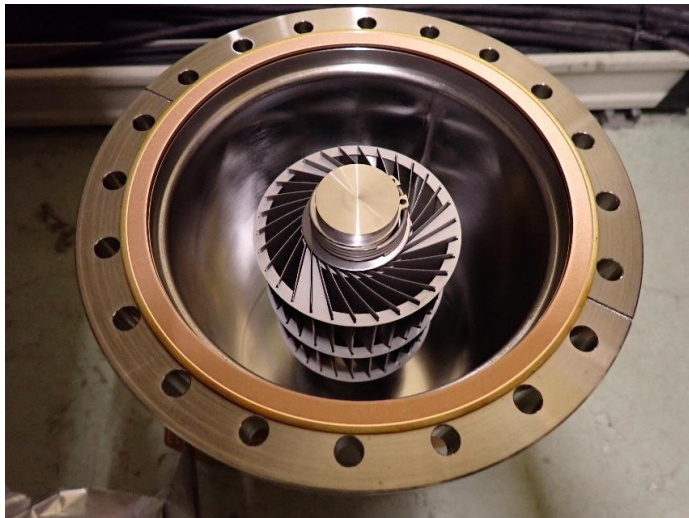
2. LER wiggler:

2. NEG pump heating

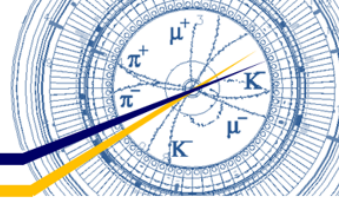
- Pressure rise was observed at CCG D10_L09C in LER wiggler section
- Chamber opened for inspection on 7/3; only slight gasket discoloration was observed
- RF-screen gaskets were installed at the NEG pumps near CCG D10_L09C and also CCG D04_L09C



NEG Pump near CCG D10_L09C

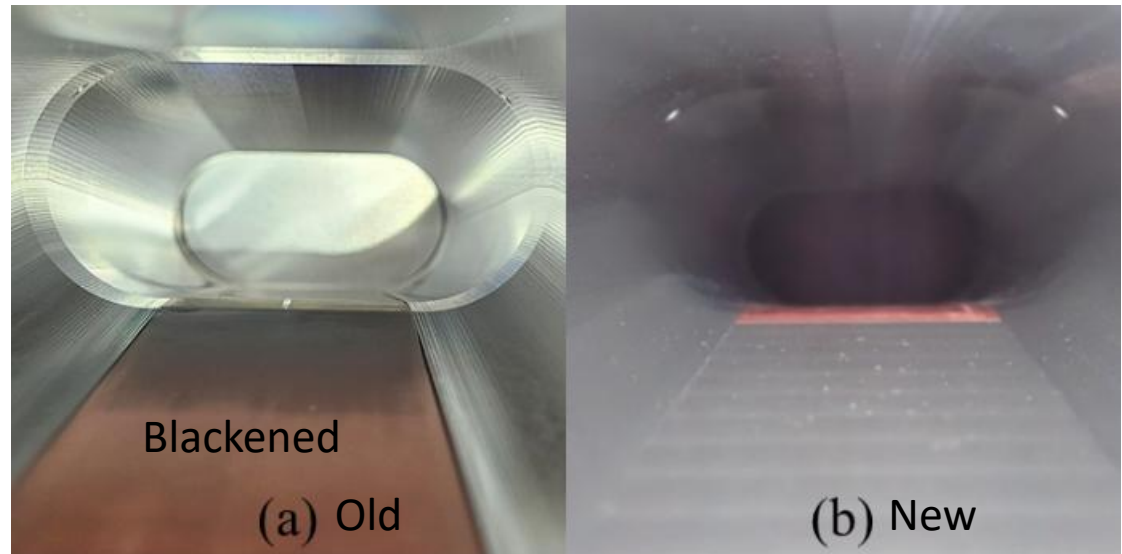
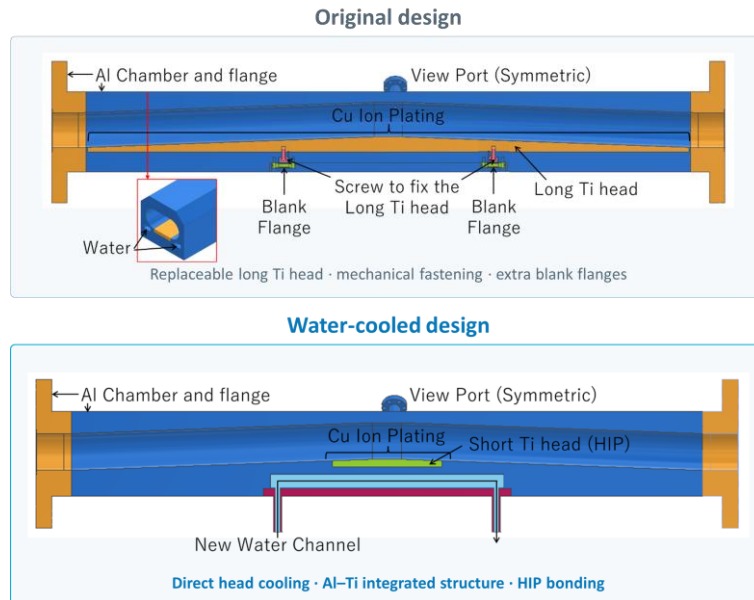


2. Vacuum limitations at higher beam currents

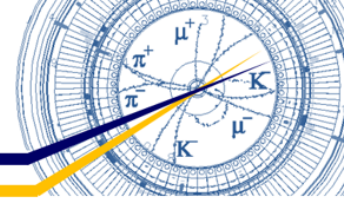


3. HER enhanced water-cooled collimators

- Nonlinear pressure rises were observed at several HER collimators
- Suspected mechanism: SR heating causes head deformation, reducing thermal contact with the chamber and cooling efficiency, leading to sharp temperature and pressure rises
- A water-cooled KEKB-type collimator was installed at D09V3 before the 2025c run to suppress nonlinear pressure rise
- The removed head showed pronounced blackening, suggesting possible overheating to 200–300°C, although discoloration alone cannot establish the temperature

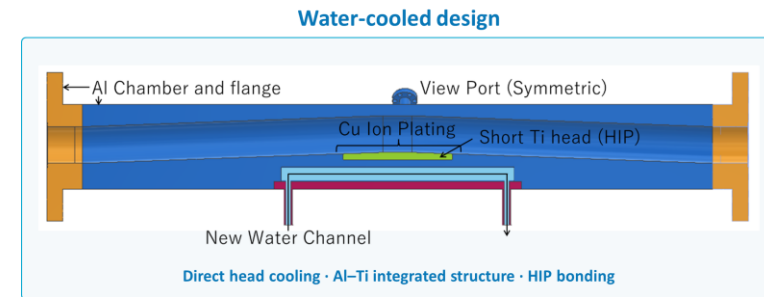


2. Vacuum limitations at higher beam currents

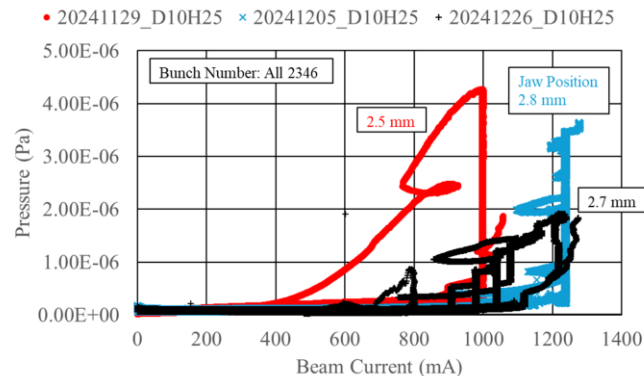


3. HER enhanced water-cooled collimators

- No nonlinear pressure rise was observed in 2025–2026, despite narrower gaps than in 2024
- In 2026, fewer bunches (2026 bunches vs. 2346 bunches) may have increased wakefield heating at the same total current, but still no nonlinear pressure rise was observed
- Similar nonlinear pressure rise was observed at D09V1; replacement with a water-cooled unit is scheduled for Oct. 2026, before the next run (Yao's Report: PASJ2026 FRP084)

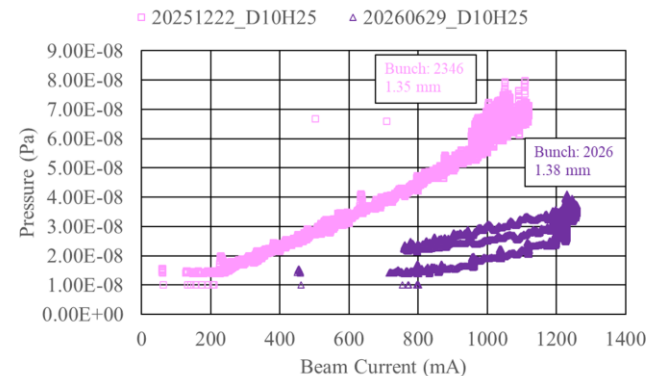


Before: original collimator (2024)

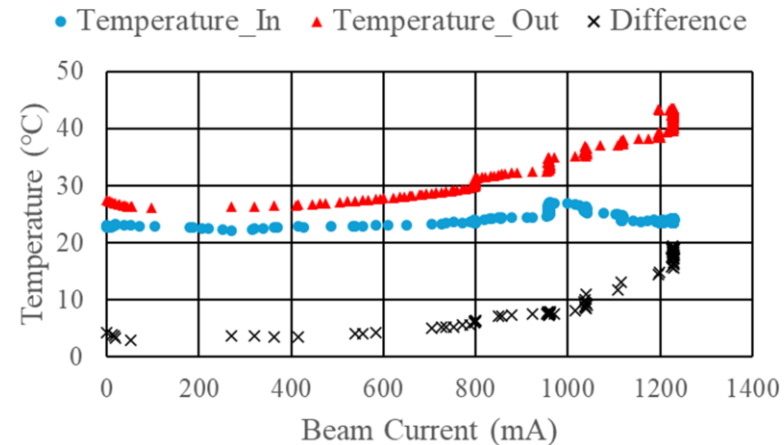


Clear nonlinear rise above ~1000 mA
(jaw position 2.5 mm)

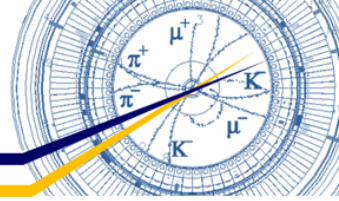
After: water-cooled collimator (2025–2026)



Stable up to ~1300 mA
(jaw positions 1.35–1.38 mm)

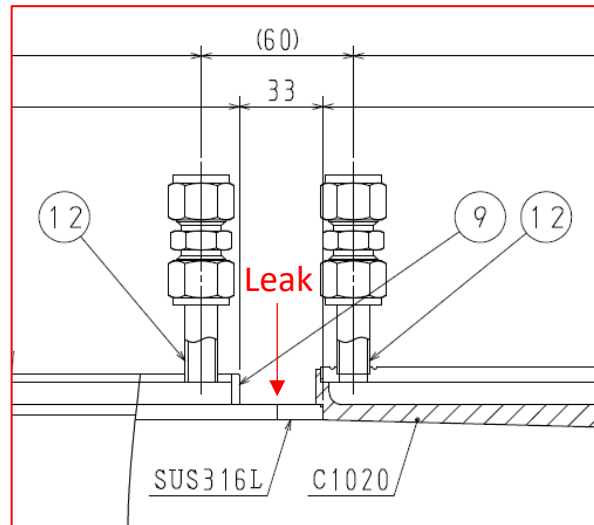
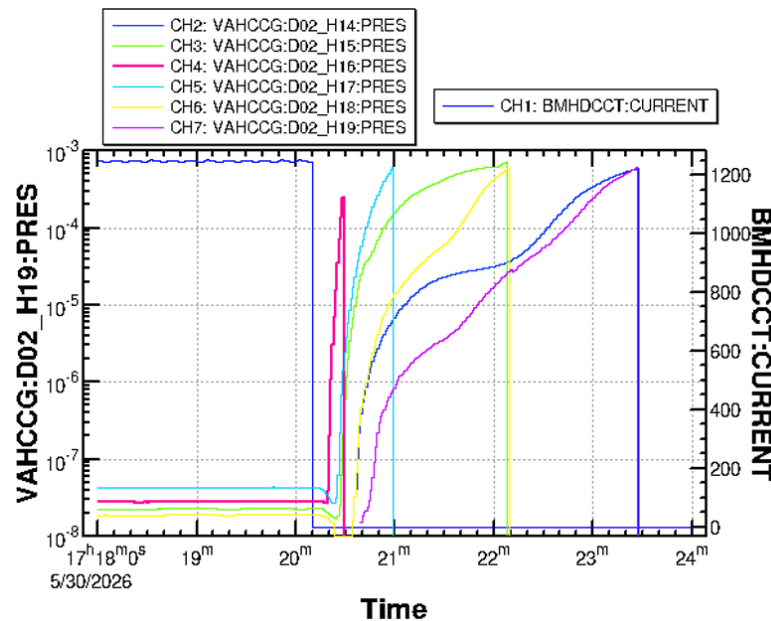
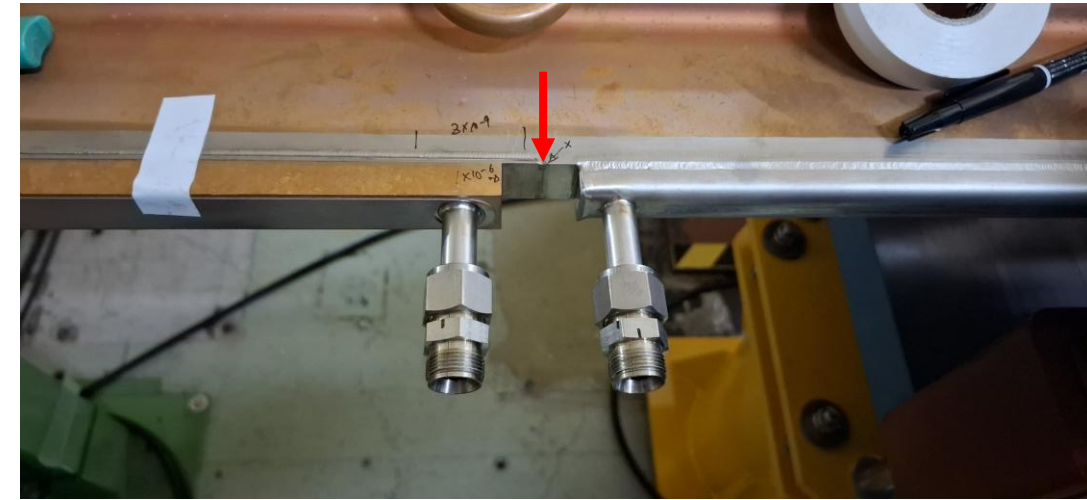


2. Vacuum limitations at higher beam currents

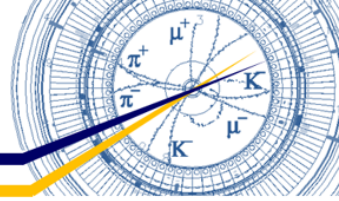


4. HER SUS beam pipe ZVF4RE Leaks

- 2026/05/30 A leak developed at a weld in the stainless-steel beam pipe for ZVF4RE (iBump steering), near CCG D02_H16.
- Temporarily sealed with General Sealants and Vacuum Sealant during operation
- Suspected cause: Thermal fatigue cracking due to SR from BLA2RE striking the weld



2. Vacuum limitations at higher beam currents

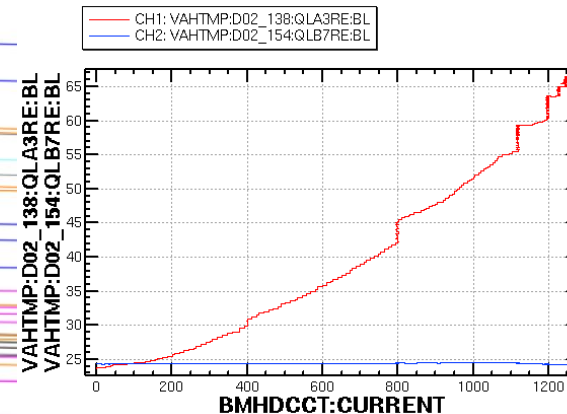
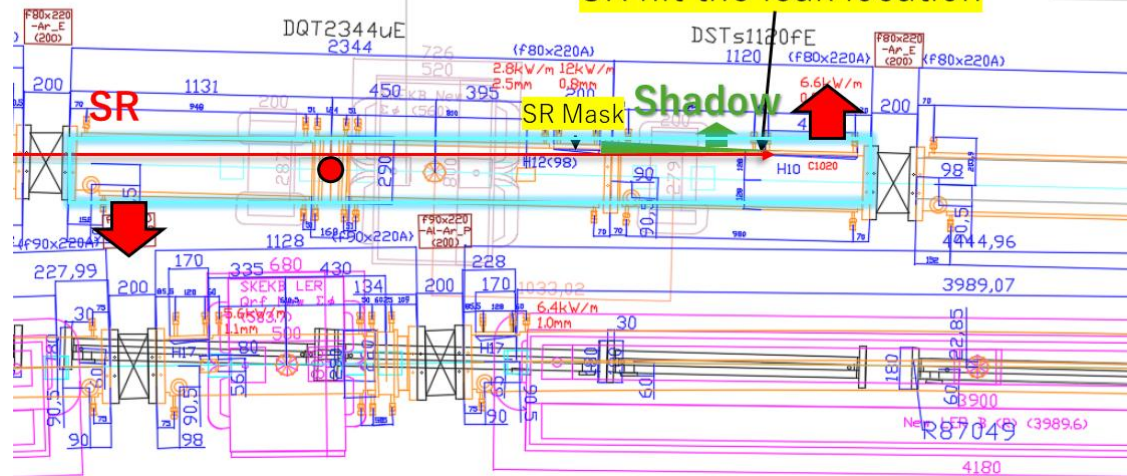


4. HER SUS beam pipe ZVF4RE Leaks

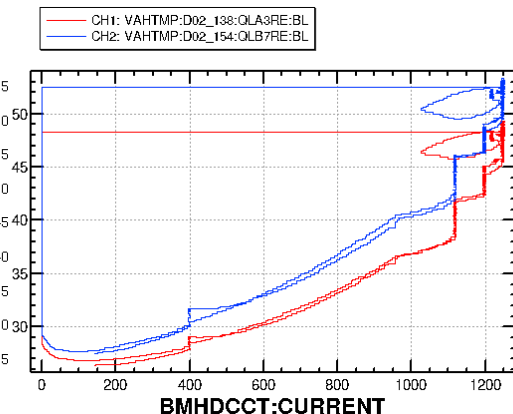
- 6/11 As an emergency measure, rotated the upstream QLA3RE beam pipe 0.5° counterclockwise about the BPM
 - The rotation reduced the temperature by approximately 15 °C at 1200 mA
- Occasional pressure spikes and fluctuations persisted at CCG D02_H16, but remained within the acceptable range.

Move the leak location into the shadow of the SR mask.

SUS welding line:
SR hit the leak location

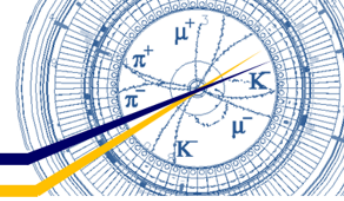


6/11 Before rotation: The D02_154 thermometer had detached



6/11 After rotation: The D02_154 thermometer was resecured

2. Vacuum limitations at higher beam currents



4. HER SUS beam pipe ZVF4RE Leaks

- Repair: On-site welding was successful (2026/10)
- A new chamber will be fabricated and installed (2027/02)
- Rotation of another similar chamber on the upstream side of D02 is also planned



On-site welding: Before



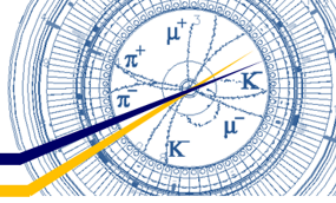
After recess machining



After welding

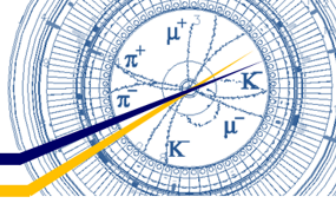
2025	12
	1
	2
	3
	4
	5
	6
	7
	8
	9
	10
2025c	11
	12
2026	1
2026ab	2
	3
	4
	5
	6
	7
	8
	9
	10
	11
2027	12

Major Issues and Upgrades



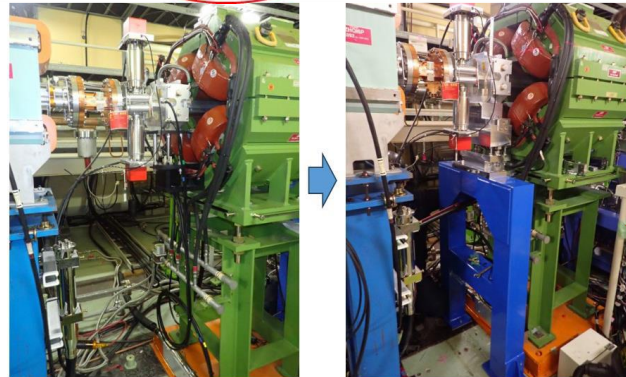
Objective	Main Countermeasures
1. Fewer Pressure Burst/ SBL	1. Vacuum Sealant Cleaning (2025 Shutdown): IR, LER D04, D10, D11 2. 4 Bellows Replacement: LER D04, D11
2. Higher Beam Current	1. More Permanent Magnets in LER D05 (2025 Shutdown) 2. LER Wiggler: 1. Clamshell, Clamp, 2. Enhanced water-cooled bellows, 3. RF Shield for NEG pump heating 3. HER enhanced water-cooled collimators (D09V3 and D09V1) 4. HER D02 SUS beam pipe ZVF4RE Leaks: Repair+ Replacement
3. Better Injection	LER Injection beam pipe QI6P alignment
4. Collimation Improvement	1. LER D03V4 Relocation 2. Replacement: LER D03V4, HER D01V1, LER D05V1 3. Status of Collimators 4. Revolver collimator development
5. Operational Reliability	1. HV connector of Ion Pump: Replacement and Dehumidification 2. More SLY independent supports in HER D01
6. LS2 Preparations	Design of IP bellows, Pressure Bump Study at IR

3. Injection improvements

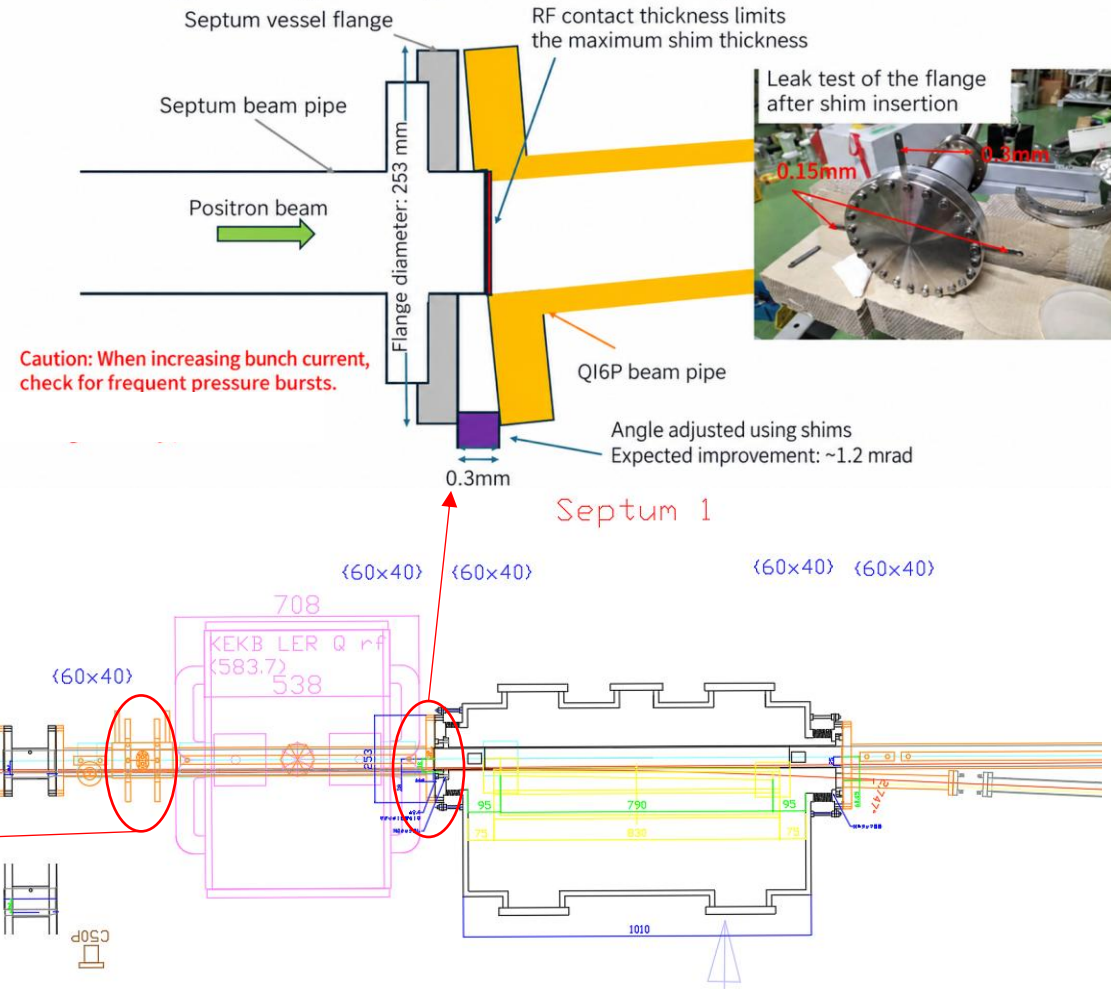


LER Injection beam pipe QI6P alignment

- An offset of approximately 3–3.6 mm was observed at the LER injection-point BPM
- 2024 single-beam studies confirmed improved injection efficiency by reducing 2Jx
- During the 2025 shutdown, alignment adjustments using an independent BPM support and shims reduced the offset to approximately 2.8 mm (July 2025)



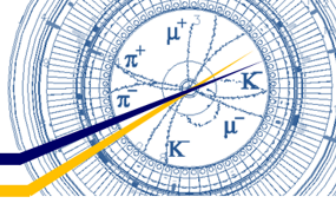
Work During the 2025 Shutdown Flange Angle Adjustment Using Shims



Septum 1

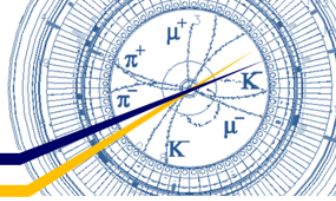
-
- Technical drawing of the injection region of the SuperKEKB accelerator. The drawing includes a longitudinal cross-section at the top, a detailed cross-sectional view of the septum wall in the middle, and a cross-section of the yoke at the bottom. Key components and labels include:
- New Chamber**: A chamber with dimensions $\langle 60 \times 40 \rangle$ and $\langle 60 \times 40 \rangle$.
 - Septum chamber**: A chamber with dimensions $\langle 60 \times 40 \rangle$ and $\langle 60 \times 40 \rangle$.
 - Recess here**: A recessed area in the septum wall.
 - Magnetic shield**: A shield with dimensions $\langle 60 \times 40 \rangle$ and $\langle 60 \times 40 \rangle$.
 - Septum wall**: The wall separating the storage and bump orbits.
 - Yoke**: The main structure of the magnet.
 - Stored beam**: The beam path in the storage orbit.
 - Storage orbit**: The orbit for the stored beam.
 - Bump orbit**: The orbit for the bump beam.
 - Injected beam**: The beam path in the injected beam orbit.

Major Issues and Upgrades



Objective	Main Countermeasures
1. Fewer Pressure Burst/ SBL	1. Vacuum Sealant Cleaning (2025 Shutdown): IR, LER D04, D10, D11 2. 4 Bellows Replacement: LER D04, D11
2. Higher Beam Current	1. More Permanent Magnets in LER D05 (2025 Shutdown) 2. LER Wiggler: 1. Clamshell, Clamp, 2. Enhanced water-cooled bellows, 3. RF Shield for NEG pump heating 3. HER enhanced water-cooled collimators (D09V3 and D09V1) 4. HER D02 SUS beam pipe ZVF4RE Leaks: Repair+ Replacement
3. Better Injection	LER Injection beam pipe QI6P alignment
4. Collimation Improvement	1. LER D03V4 Relocation 2. Replacement: LER D03V4, HER D01V1, LER D05V1 3. Status of Collimators 4. Revolver collimator development
5. Operational Reliability	1. HV connector of Ion Pump: Replacement and Dehumidification 2. More SLY independent supports in HER D01
6. LS2 Preparations	Design of IP bellows, Pressure Bump Study at IR

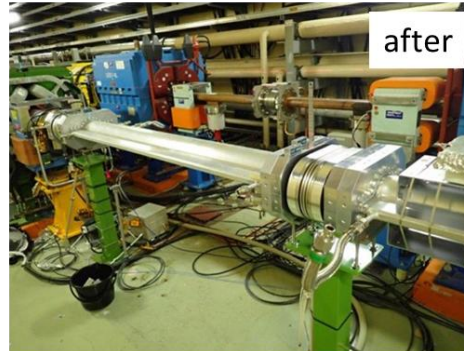
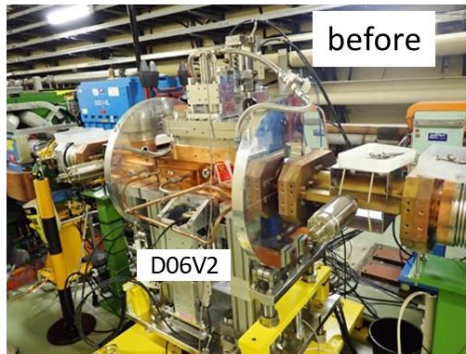
4. Collimation improvements



1. LER D03V4 Relocation during 2025 shutdown

- The D06V2 collimator was relocated to D03V4 as a countermeasure against SBLs to reduce losses at the IR and D02V1 regions.

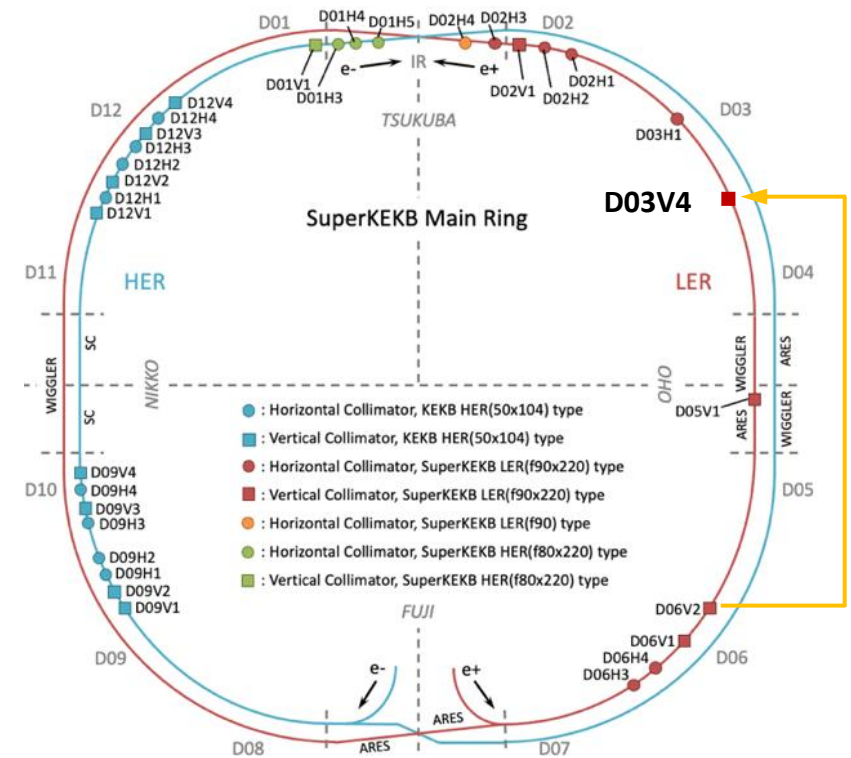
Location of D06V2



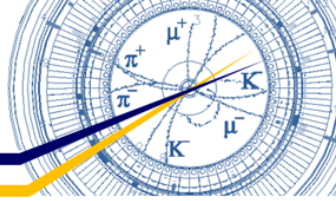
Location of D03V4



Location of collimators



4. Collimation improvements



2. Replacement:

1. LER D03V4 (7/16~) Hybrid (CFC+Ta)
2. HER D01V1 (8/17~) Ta
3. LER D05V1 (10/6~16)
Bottom Ta
Top Ti → Ta

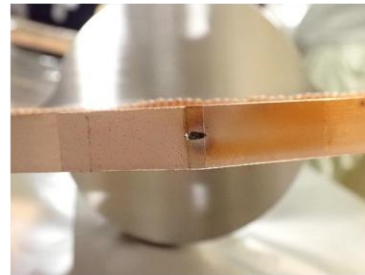
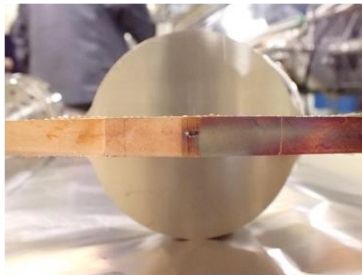
D03V4 コリメータヘッド交換(7/16~) 継続
駆動部取外し

上側ヘッド

Top

下側ヘッド

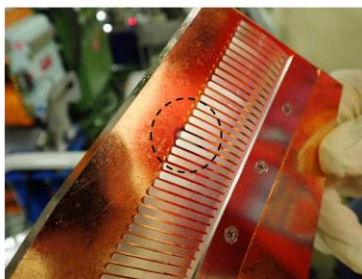
Bottom



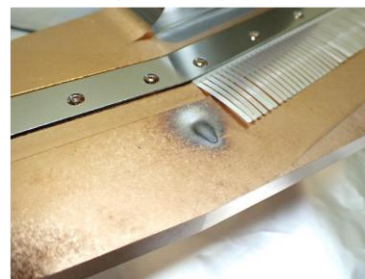
取外したヘッド



上側ヘッドの放電痕

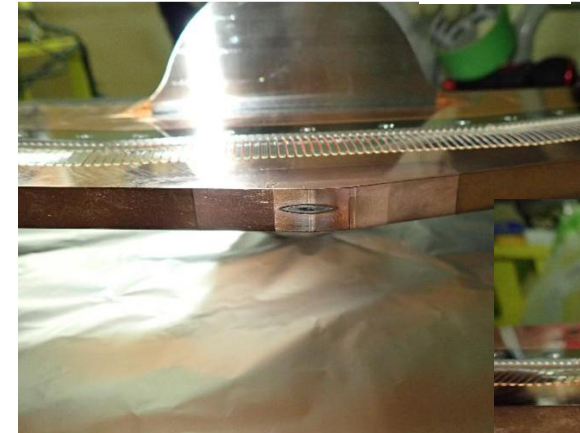


下側ヘッドの放電痕



上側ヘッド

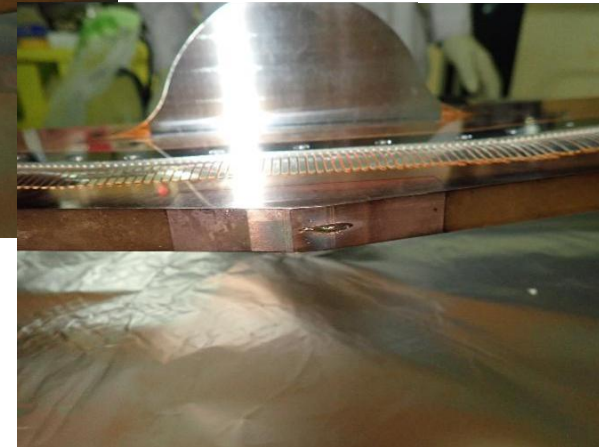
Top



D01V1

下側ヘッド

Bottom



D05V1

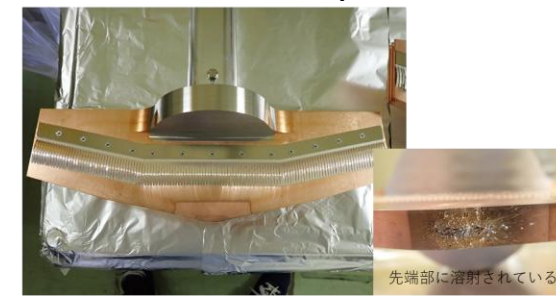
Bottom

下側ヘッド (RFコンタクトに放電痕を多数確認)



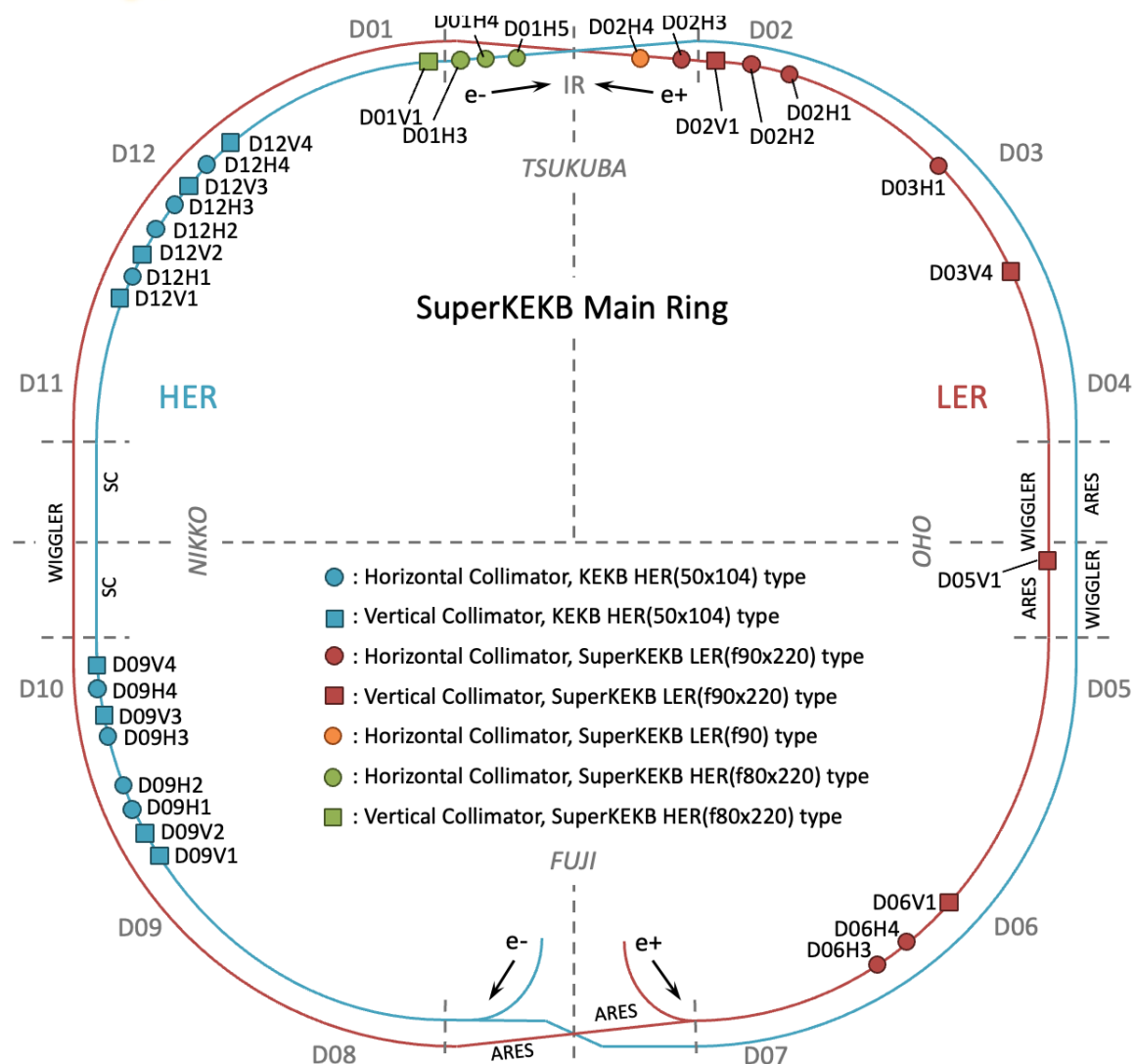
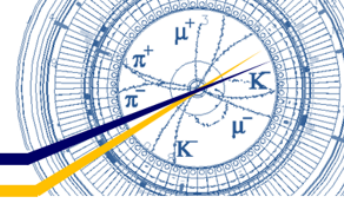
上側ヘッド

Top



先端部に溶射されている

4-3-1. Status of LER collimator before 2027ab



Vertical collimator

× = damaged/ ○ = healthy

Name	Type	Tip Material	Cu coating	Tip condition
D02V1	SuperKEKB	Ta (10 mm)	○	○
D03V4	SuperKEKB	Hybrid (3 mm)	○	○
D05V1 TOP	SuperKEKB	Ti (10 mm) → Ta	○	○
D05V1 BTM	SuperKEKB	Ta (10 mm)	○	○
D06V1	SuperKEKB	Ti (10 mm)	○	○

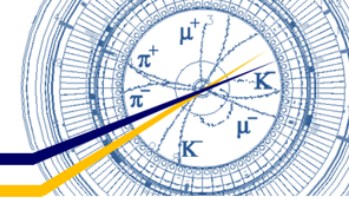
Horizontal collimator

Name	Type	Tip Material	Cu coating	Tip condition
D02H1-H4	SuperKEKB	W (10 mm)	×	○ D02H1 × ?
D03H1	SuperKEKB	W (10 mm)	×	○
D06H3	SuperKEKB	C (160 mm)	○	○
D06H4	SuperKEKB	Ta (10 mm)	×	○

Remarks

- D02H1 may be damaged due to the injection kicker accidental firings.

4-3-2. Status of HER collimator before 2027ab



• Vertical collimator

× = damaged/ ○ = healthy

Name	Type	Tip Material	Cu coating	Tip condition
D01V1	SuperKEKB	Ta (10 mm)	○	○
D12V1	KEKB	Ti (40 mm)	○	× (shifted)
D12V2	KEKB	Ti (40 mm)	○	×
D12V3	KEKB	Ti (40 mm)	○	○
D12V4	KEKB	Ti (40 mm)	○	×
D09V1-V4	KEKB	Ti (40 mm)	○	○

• Horizontal collimator

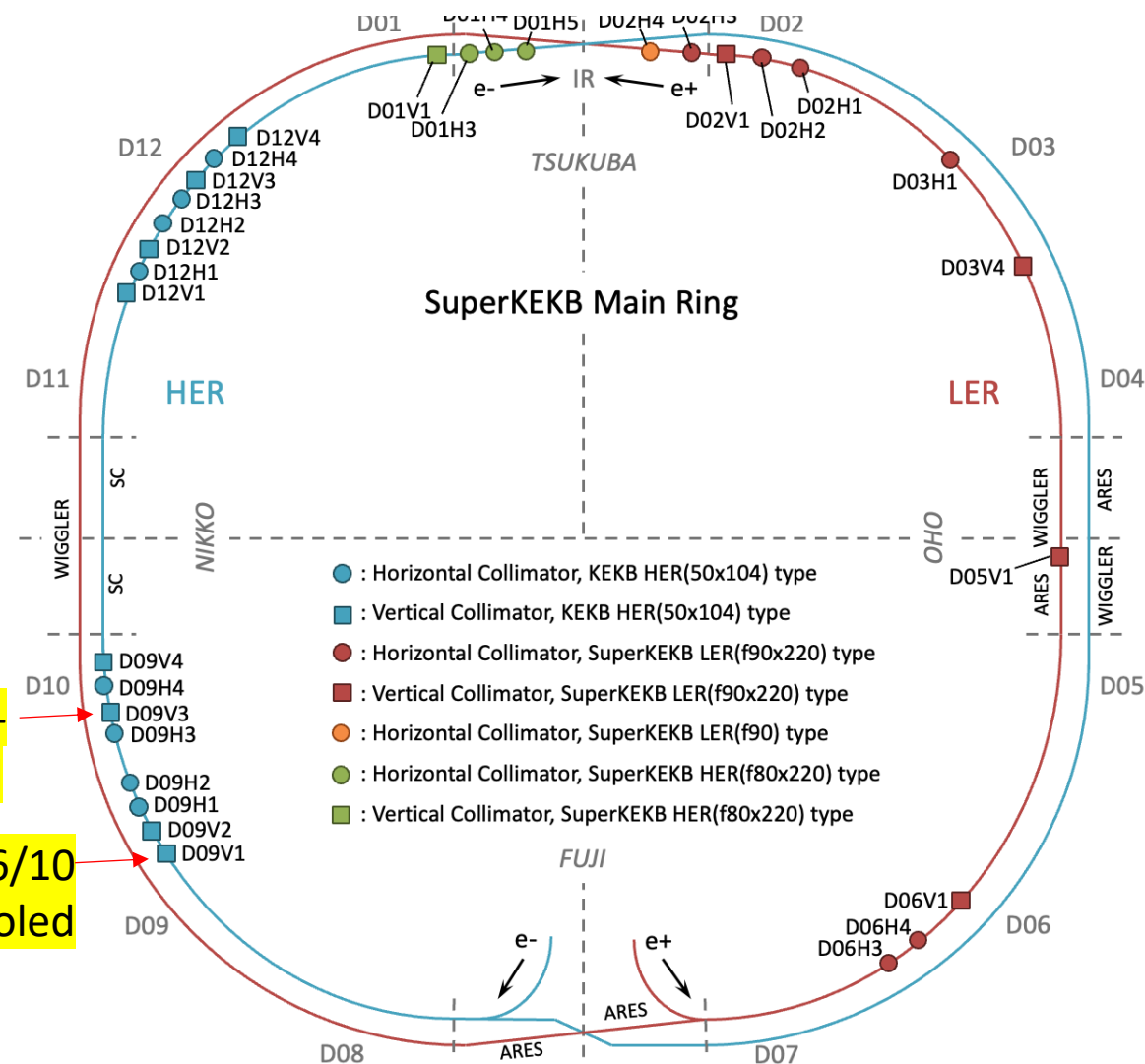
Name	Type	Tip Material	Cu coating	Tip condition
D01H3-H5	SuperKEKB	W (10 mm)	×	○
D12H1, H3	KEKB	Ti (40 mm)	○	○
D12H2, H4	KEKB	Ti (40 mm)	○	×
D09H1-H4	KEKB	Ti (40 mm)	○	×

• Remarks

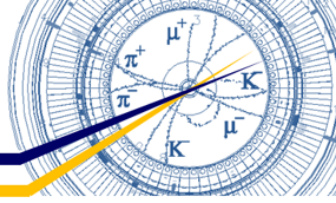
- D01V1 and D12V4 were damaged during 2026ab.

Water-cooled

2026/10
Water-cooled



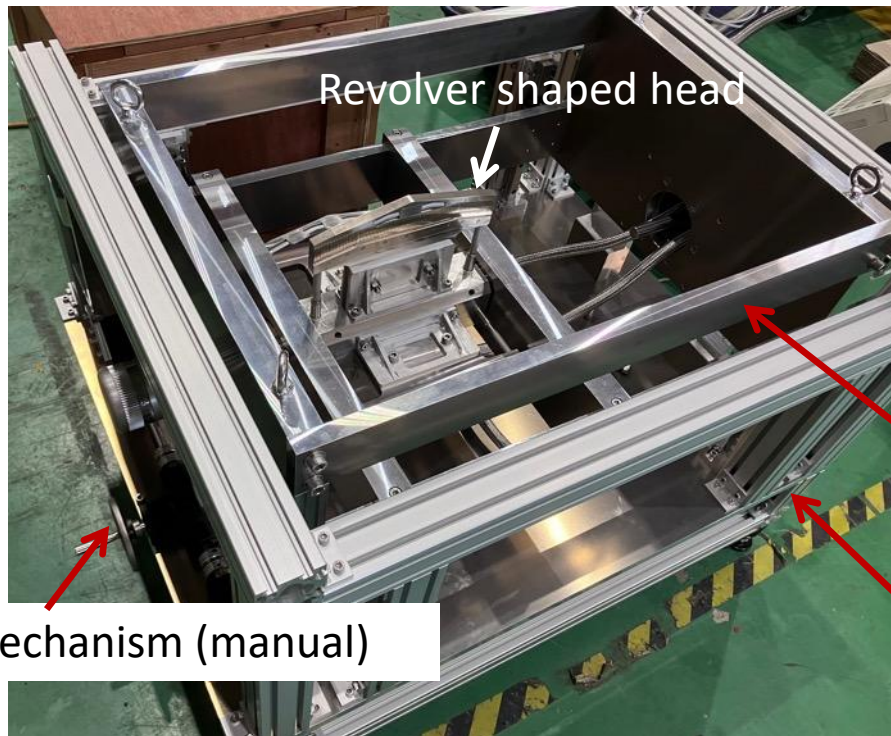
4. Collimation improvements



4. Revolver collimator development

- Up to four jaw replacements without breaking vacuum
- Reduced radiation exposure and replacement time
- No additional vacuum scrubbing after replacement
- Atmospheric and vacuum prototypes developed; ring-unit design started
- Ready for fabrication

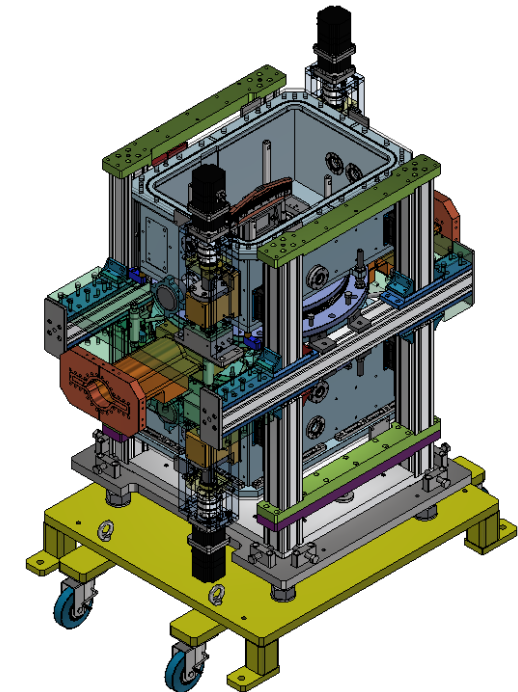
Prototype of the revolver type collimator (atmospheric specifications)



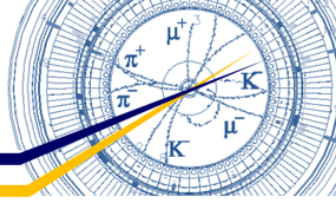
Frame assumed for vacuum chamber

Supporting frame

Drawing of the revolver type collimator

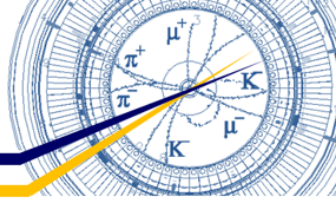


Major Issues and Upgrades



Objective	Main Countermeasures
1. Fewer Pressure Burst/ SBL	1. Vacuum Sealant Cleaning (2025 Shutdown): IR, LER D04, D10, D11 2. 4 Bellows Replacement: LER D04, D11
2. Higher Beam Current	1. More Permanent Magnets in LER D05 (2025 Shutdown) 2. LER Wiggler: 1. Clamshell, Clamp, 2. Enhanced water-cooled bellows, 3. RF Shield for NEG pump heating 3. HER enhanced water-cooled collimators (D09V3 and D09V1) 4. HER D02 SUS beam pipe ZVF4RE Leaks: Repair+ Replacement
3. Better Injection	LER Injection beam pipe QI6P alignment
4. Collimation Improvement	1. LER D03V4 Relocation 2. Replacement: LER D03V4, HER D01V1, LER D05V1 3. Status of Collimators 4. Revolver collimator development
5. Operational Reliability	1. HV connector of Ion Pump: Replacement and Dehumidification 2. More SLV independent supports in HER D01
6. LS2 Preparations	Design of IP bellows, Pressure Bump Study at IR

5. Operational reliability



1. HV connector of Ion Pump: Replacement with new type or Dehumidification

- Suetsugu's Report: PASJ2024 WEP078

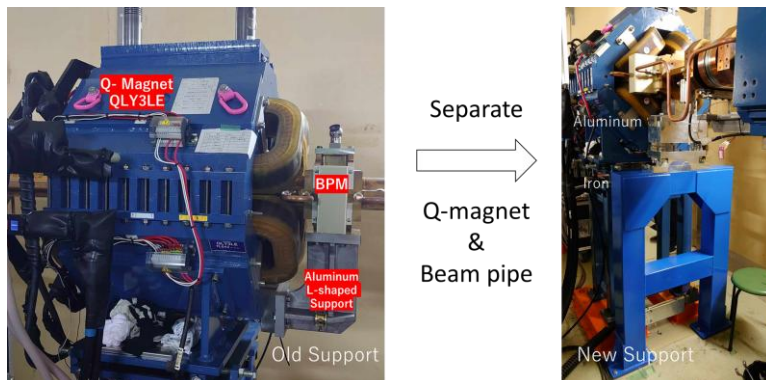
Existing design: Add desiccant to prevent discharge

New design (Suetsugu type): Larger internal space reduces discharge risk

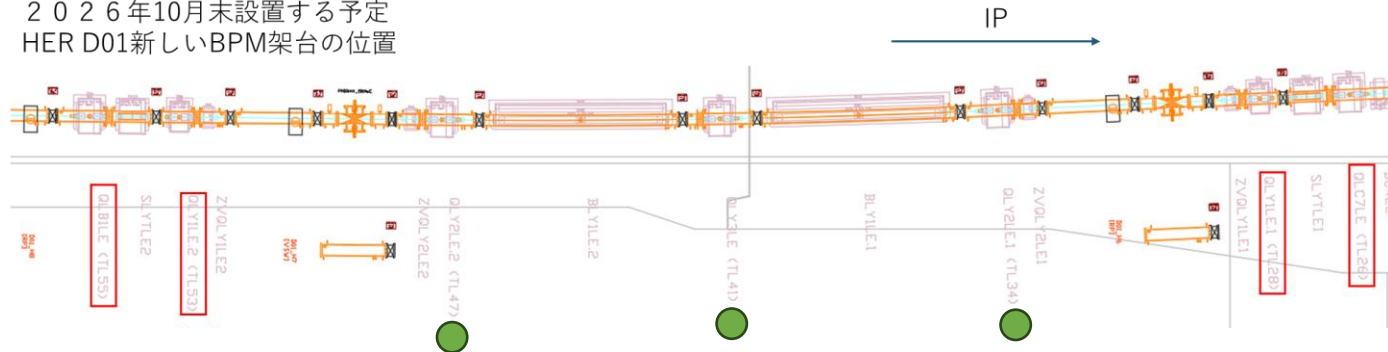


2. More SLY independent supports in HER D01 (2026/11)

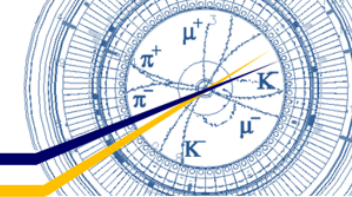
- Yao's Report: PASJ2024 FRP083
- Add 4 more independent BPM supports



2026年10月末設置する予定
HER D01新しいBPM架台の位置



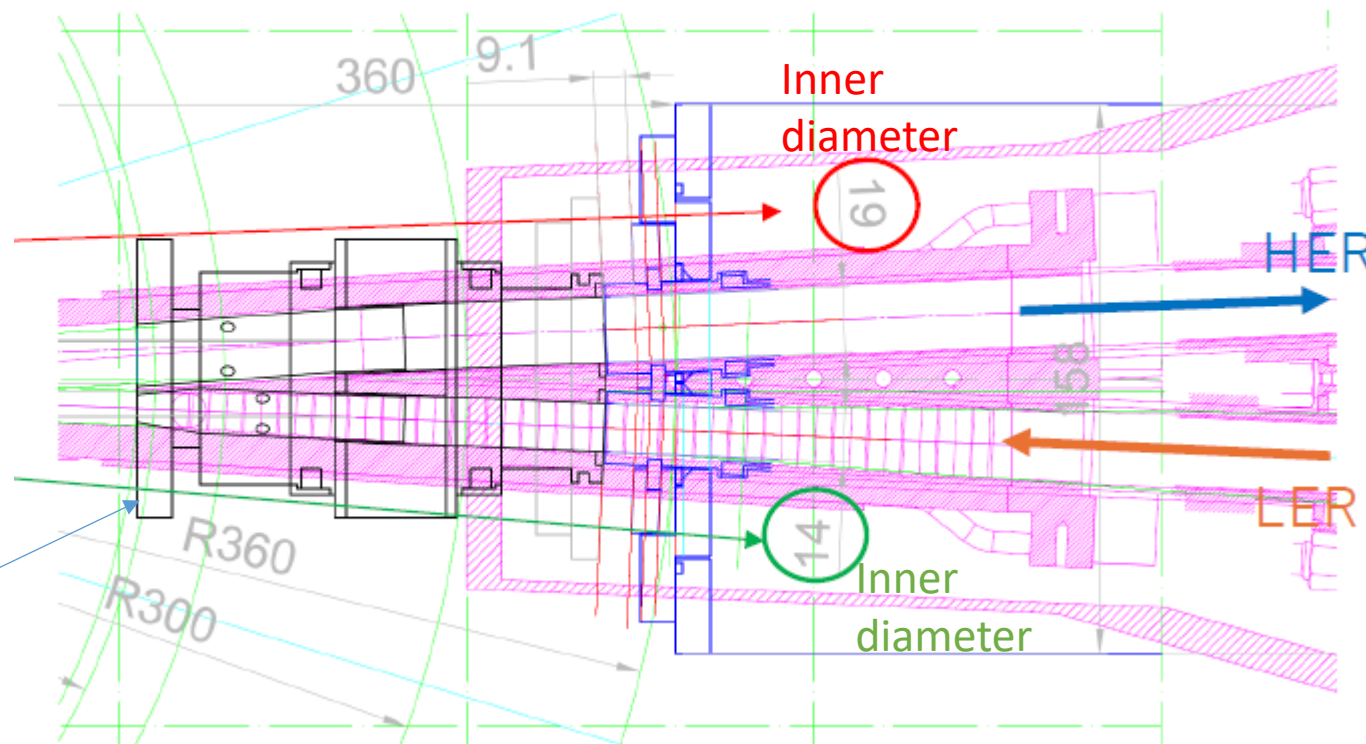
6. LS2 preparations



1. IR Beam Pipe Modifications

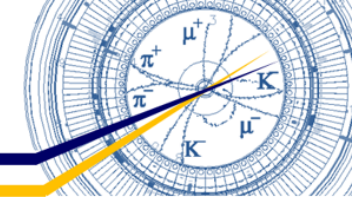
- Moving QCS toward the IP requires relocating the beam pipe branching point
- Adding compensation coils reduces available space and may require a smaller beam pipe inner diameter

Resin Model



2025	12
	1
	2
	3
	4
	5
	6
	7
	8
	9
	10
2025c	11
	12
2026	1
2026ab	2
	3
	4
	5
	6
	7
	8
	9
	10
	11
	12
2027	

6. LS2 preparations



2. Pressure Bump Study at IR (Terui's Report: PASJ2026 THP002)

- Motivation: Short LER lifetime limits beam current and luminosity
- Q1. Touschek or Coulomb scattering?
- Experiment
 - 1. Vary bunch number at fixed bunch current and emittances: Touschek unchanged/ Coulomb change
 - 2. Vary vertical emittance (or acceptance) at fixed beam current: Touschek change/ Coulomb unchanged
- Result (Rough estimate): > 1600 mA, Coulomb scattering accounts for > 60% of total losses; ~ half originates from the IR (>30% of total losses)

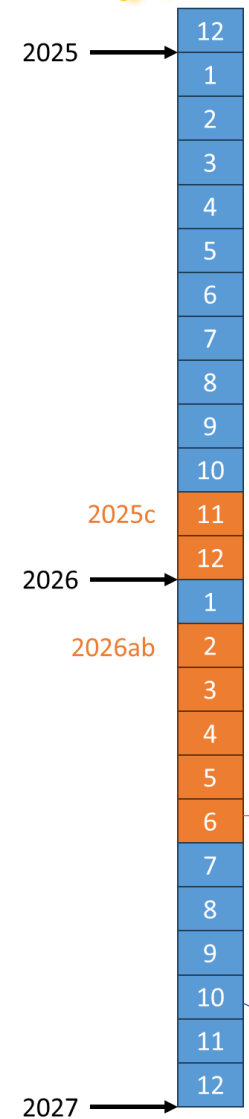
Q2: Is the IR pressure contribution so significant?

- Experiment
 - Heat the NEG pump closest to the IP to generate a local pressure bump
 - Affected region: Only ~30 m (~1% of the ring), but with large beta functions
- Preliminary results broadly agree with the model:
IR pressure significantly affects lifetime and increases beam background

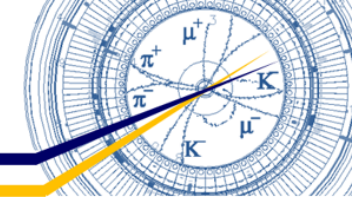
Table 1: Calculated Coulomb loss rate and lifetime for different IR vacuum models at 1400 mA. IR pressure is assumed to be 67% of the 722 Ah simulation to match the 1400 Ah measurement condition in June 2024.

Parameters	Case 1 (No IR)	Case 2 (IR: CO)	Case 3 (IR: CO ₂)
IR Pressure Assumption	0	Calc. × 0.67	Calc. × 0.67
Calculated τ_C [min]	31.8	17.2	13.6
Calculated Loss Rate [mA/s]	0.84	1.55	1.96
IR Contribution [%]	0	45.9	57.2

- Pumping improvements under consideration: Additional NEG pumps, NEG coatings, or cryogenic pumping...
- Direct NEG coating of the chamber wall was ruled out: 1. Insufficient pumping capacity, 2. with thicker coatings posing delamination and beam impedance concerns
- Synrad+Molflow Simulation: + 2 commercial NEG pumps through conductance-limited ports → limited improvement
- Pumping over a larger area may be required

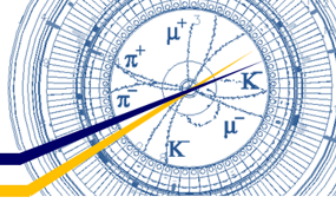


Comments from last (28th) KEKB Review



- **R12.1:** Determine whether pressure bursts precede or follow beam losses, and classify loss types. Automate daily vacuum monitoring, and document all tunnel interventions.
- Answer:
 1. Investigation ongoing (see Uno's talk tomorrow)
 2. SBL events are logged on a dedicated website
 3. Machine-Learning-Based Pressure Anomaly Detection (Suetsugu's Report: <https://doi.org/10.1103/PhysRevAccelBeams.27.063201>) Extended to monitor ion pump discharge currents, temperatures, and cooling-water flow rates (under testing)
 4. Tunnel interventions are documented in the Vacuum Wiki (Confluence)
- **R12.2:** Identify flanges exposed to uneven SR heating and monitor temperatures for leak risks.
- Answer: Temperature sensors are installed above and below every bellows chamber in the wiggler sections. Additional sensors will cover a wider area of the chamber surfaces following clamp installation
- **R12.3:** Avoid Vacuum Sealant. Define acceptable leak rates for short-term operation until shutdown repairs. Consider clamshells to maintain rough vacuum around leaks.
- Answer:
 1. Vacuum sealant is used only on the atmospheric side in emergencies, as for the leaking SUS chamber, which is scheduled for replacement.
 2. Acceptability depends on beam-vacuum pressure, lifetime, background, and thermal-cycle stability. As a numerical guideline, a local beam-vacuum pressure below 1×10^{-7} Pa after clamshell installation is acceptable for temporary operation
- **R12.4 :** Remove Vacuum Sealant where possible and clean chambers. Minimize dust introduction during vacuum work.
- Answer: All accessible Vacuum Sealant has been removed from the IR and LER D04, D10, and D11 sections.

Summary

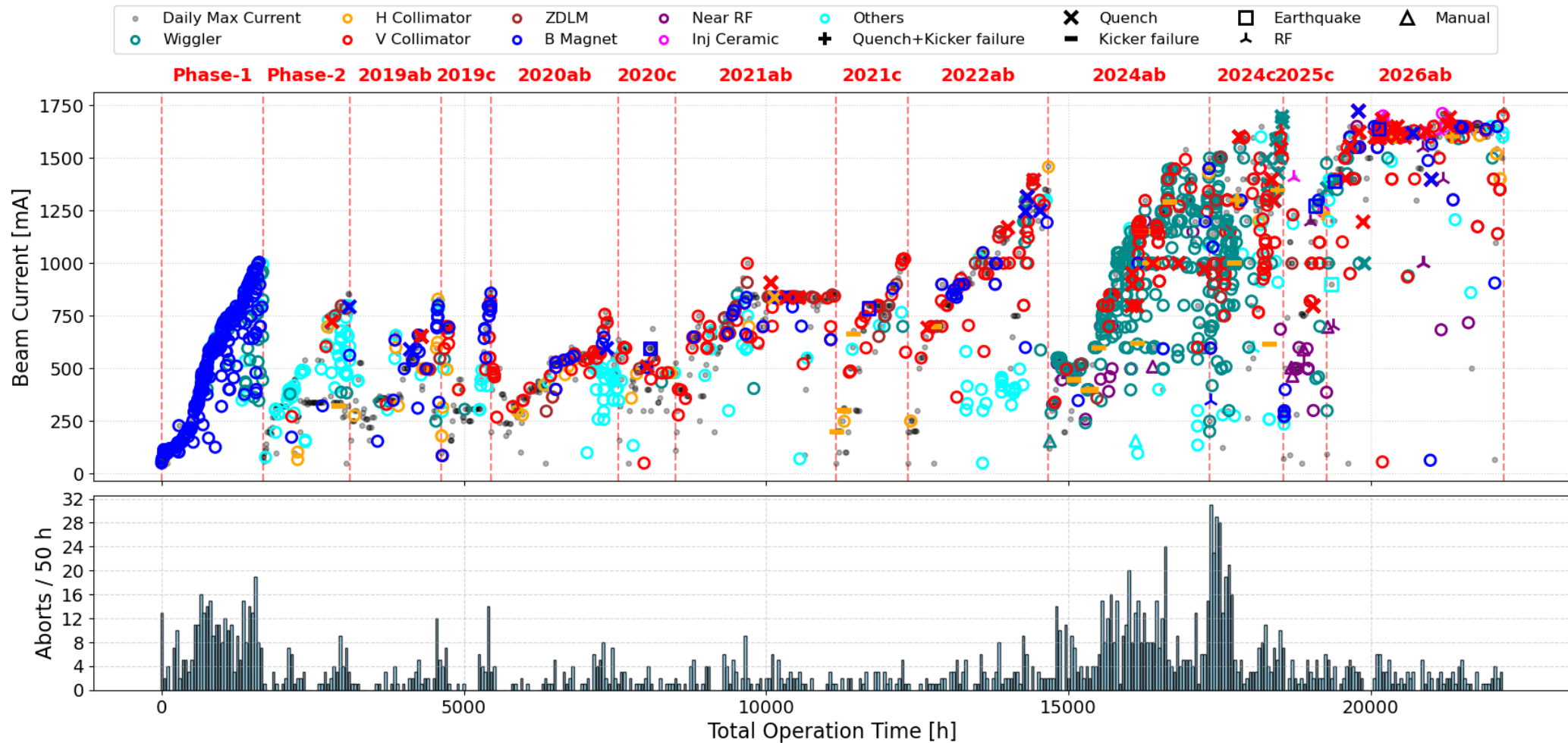


Objective	Main Countermeasures
1. Fewer Pressure Burst/ SBL	- Vacuum Sealant Cleaning (2025 Shutdown): IR, LER D04, D10, D11 4 Bellows Replacement: LER D04, D11
2. Higher Beam Current	- More Permanent Magnets in LER D05 (2025 Shutdown) - LER Wiggler: 1. Clamshell, Clamp, 2. Enhanced water-cooled bellows, 3. RF Shield for NEG pump heating - HER enhanced water-cooled collimators (D09V3 and D09V1) - HER D02 SUS beam pipe ZVF4RE Leaks: Repair+ Replacement
3. Better Injection	LER Injection beam pipe QI6P alignment
4. Collimation Improvement	- LER D03V4 Relocation - Replacement: LER D03V4, HER D01V1, LER D05V1 - Status of Collimators - Revolver collimator development
5. Operational Reliability	- HV connector of Ion Pump: Replacement and Dehumidification - More SLV independent supports in HER D01
6. LS2 Preparations	Design of IP bellows, Pressure Bump Study at IR

Yellow: To be verified during the 2027ab run
Green: Long-term plans

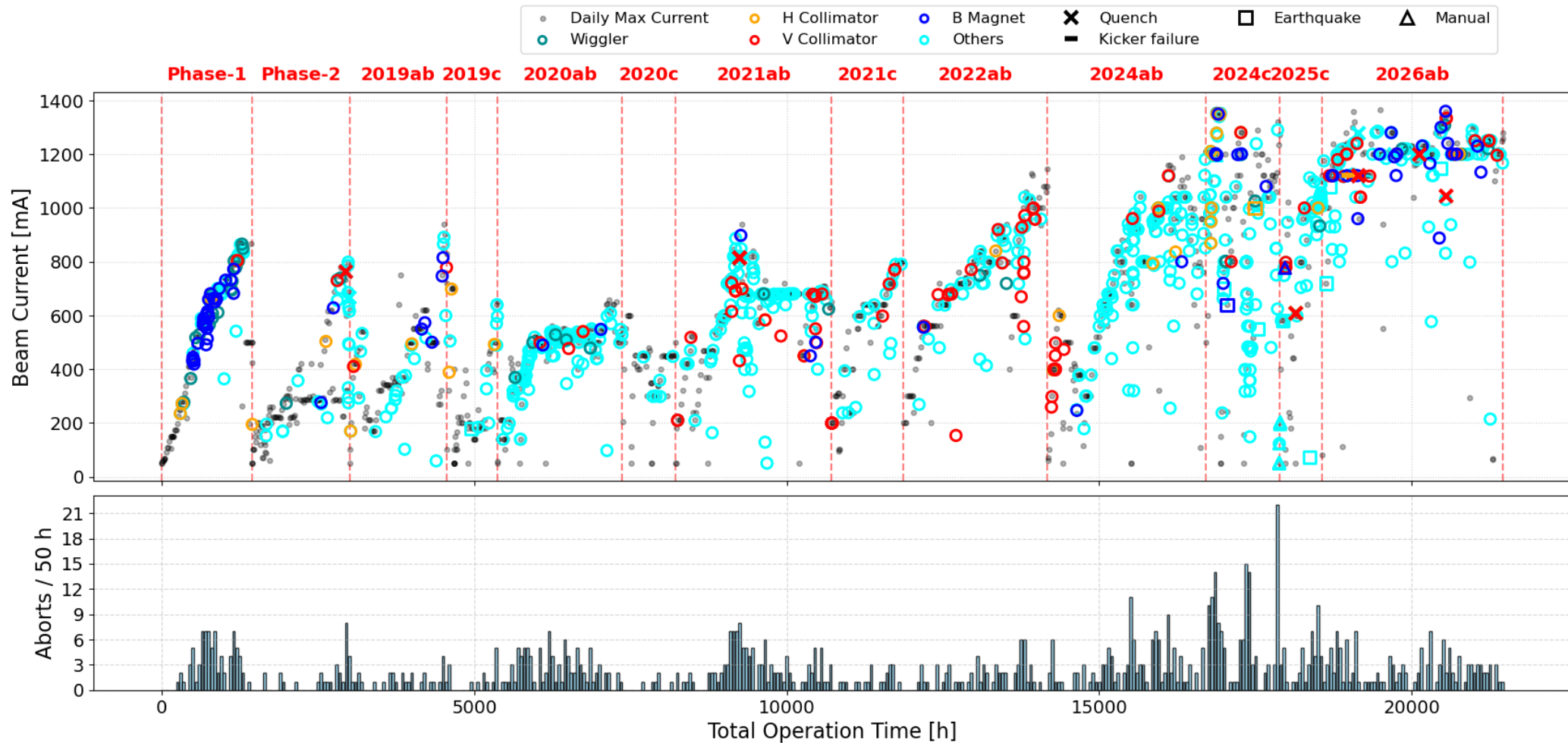
Summary

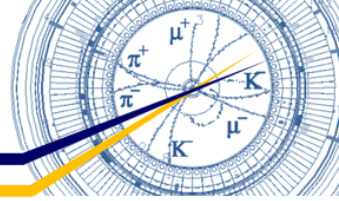
LER Bursts History → The measures implemented in the wiggler sections effectively reduced pressure bursts in those regions and the total number of beam aborts.



Summary

HER Bursts History → The measures implemented in the wiggler sections effectively reduced pressure bursts in those regions and the total number of beam aborts.

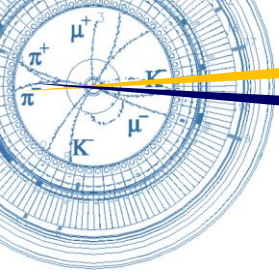




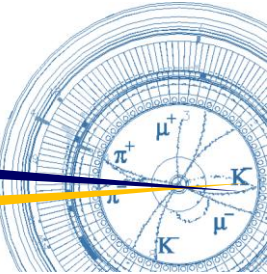
Potential Limitations to Further Current Increases

- IR pressure: Long-term countermeasures are needed
- Possible deformation of the LER injection chamber:
Replacement of the chamber inside the septum?
- Regions with nonlinear pressure rise:
Monitor conditioning in LER D05 and the cooling capacity of the water-cooled KEKB-type collimators
- Recurring vacuum leaks in the wiggler sections: Continued attention is required

“We’ve addressed several local vacuum limitations, but thermal stability and IR pressure remain key concerns as we move to higher currents.”



Fin.



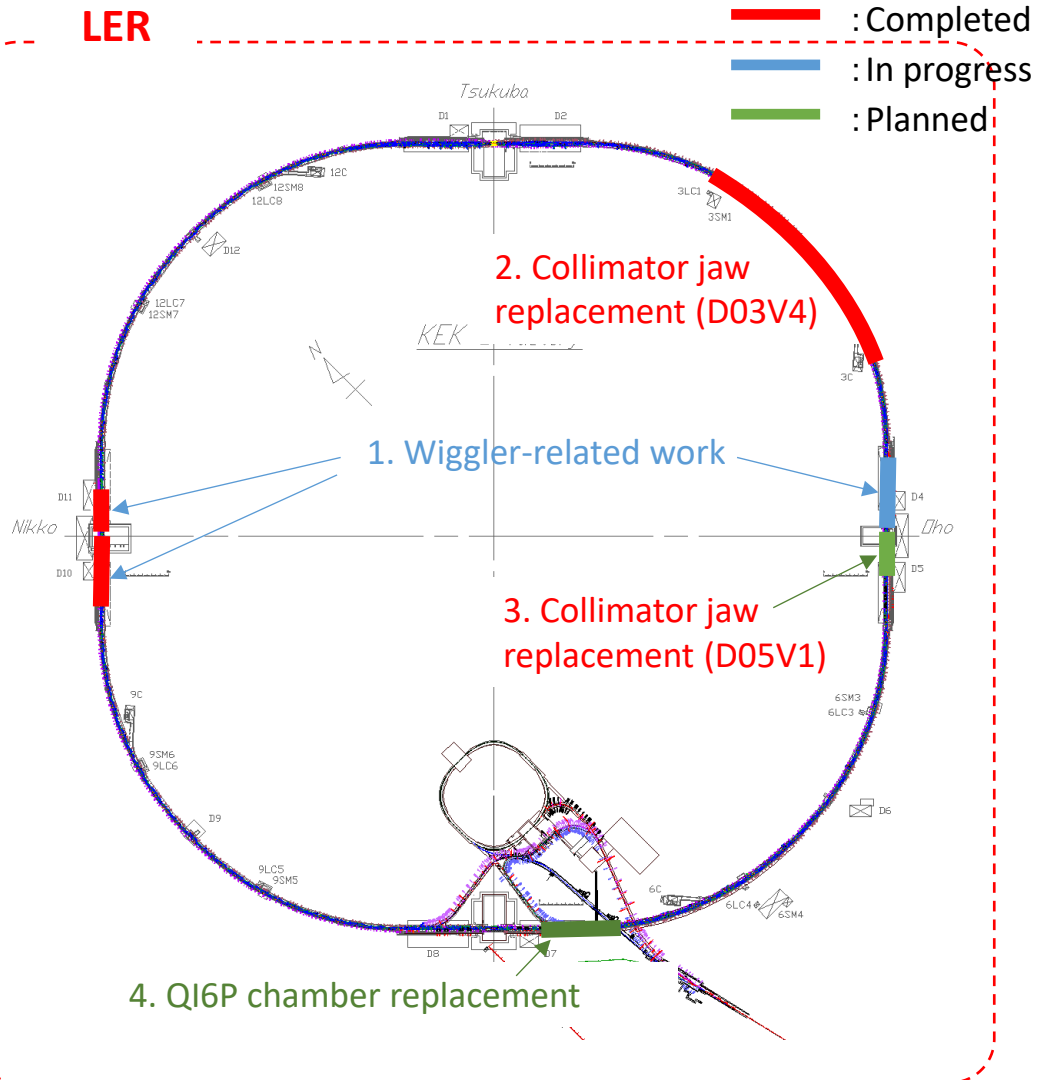
Thank you for your attention.



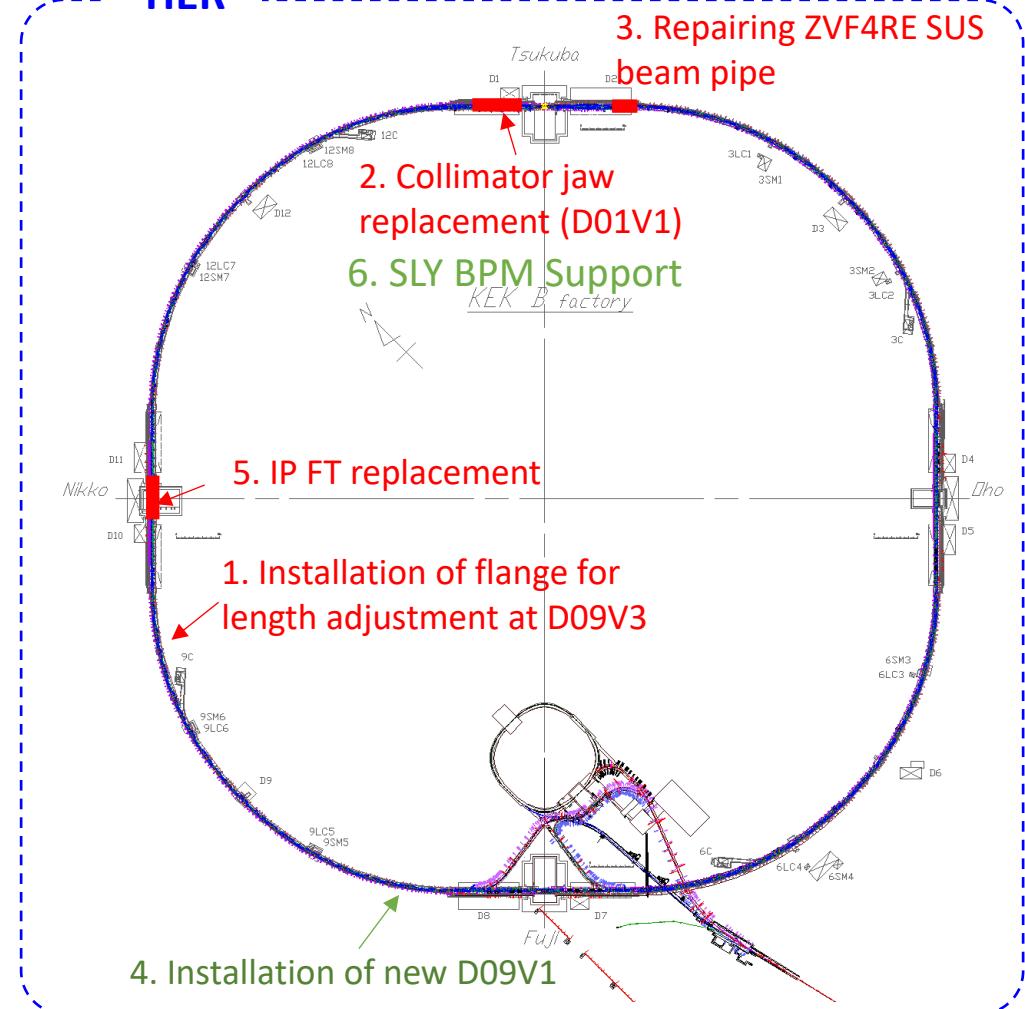
Backup

Major Issues and Upgrades

LER



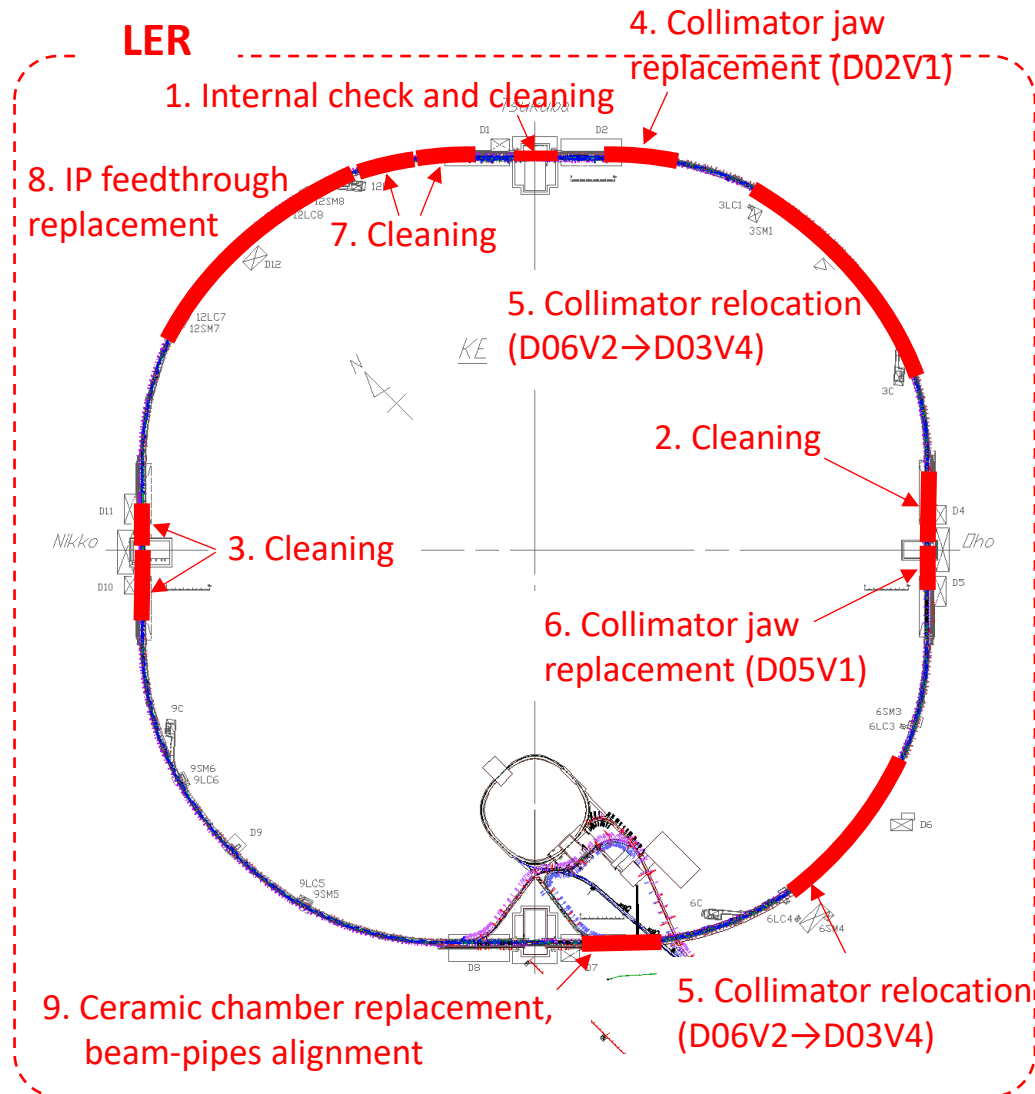
HER



2025年シャットダウン中の主な作業 - LER

石橋さんの資料2025-10-22
Commissioning Meeting

One word: Cleaning



1. IR区間ビームパイプ内部確認・クリーニング
 2. 大穂ウィグラー区間ビームパイプ内部クリーニング
 3. 日光ウィグラー区間ビームパイプ内部クリーニング
 4. D02V1ヘッド交換 (Ta-10 mm)
 5. コリメータ移設 (D06V2→D03V4)
 6. D05V1ヘッド交換 (Top: Ti-10 mm、Bottom: Ta-10 mm)
 7. VACSEALを使用したMOフランジの内部クリーニング
 - CCG D01_L10, D01_L15周辺
 8. イオンポンプ部HVフィードスルー交換
 - 異常放電によりリークが発生したため (D12_L19)
 9. キッカー用セラミックチェンバーの交換 (BTグループ)
- セプタムおよびQI6Pビームパイプのミスアライメント調査とアライメント
([2025-09-19 コミッショニングミーティング参照](#))

2026/10/26 焼き出しに必要なビームドーズ(目安): 100 An

The 29th KEKB Accelerator Review Committee (2026)

2025年シャットダウン中の主な作業 - HER

石橋さんの資料2025-10-22

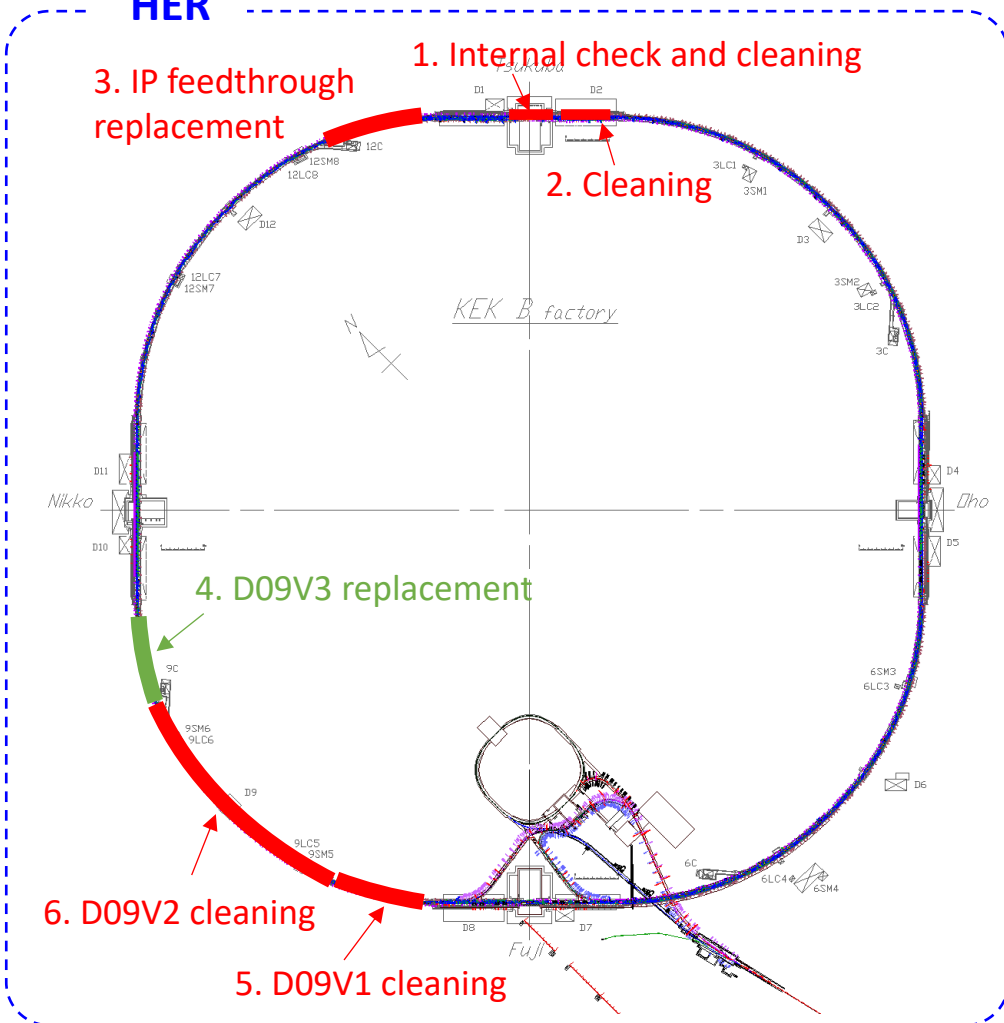
Commissioning Meeting

— : 大気開放した作業区間

— : 作業予定

One word: Cleaning

HER



1. IR区間ビームパイプ内部確認・クリーニング

- CCG D02_H24を増設
- IPからのCCG設置位置 D02_H24: ~7 m、D02_H23: ~11 m

2. VACSEALを使用したMOフランジの内部クリーニング

- CCG D02_H22周辺のSUSフランジ

3. イオンポンプ部HVフィードスルー交換 (D01_H19)

4. D09V3コリメータ交換

- 2024c運転中にD09V3のヘッドが損傷。
- 運転中に異常な圧力上昇も見られていたことから、水冷機構付きのコリメータを開発。
 - 10/27 納品、ベーキング開始
 - 10/29 設置
 - 10/30 リークテスト
 - 10/31 粗排気撤収
- D09V3を取り外したところ、ヘリコフレックスにおけるビームチャネルへのVACSEAL染み出しが確認された。クリーニングを実施。

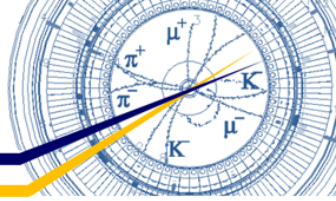
5. D09V1コリメータ周辺の内部クリーニング

6. D09V2コリメータ周辺の内部クリーニング

2026/10/26 焼き出しに必要なビームドーズ(目安): 50 Ah

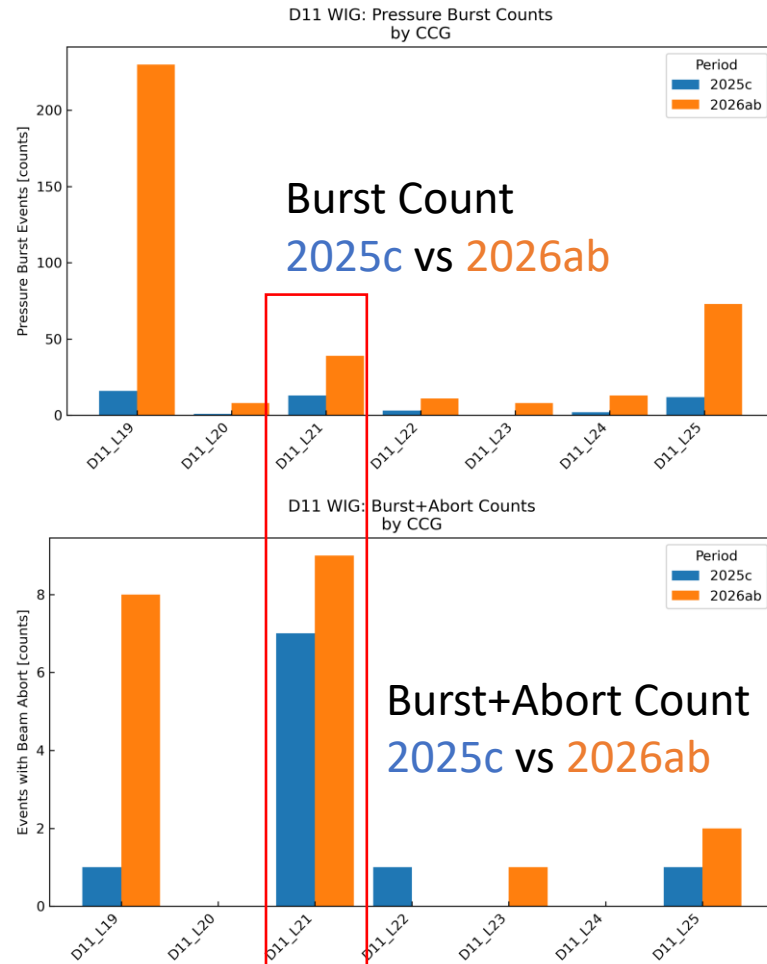
The 29th KEKB Accelerator Review Committee (2026)

1. Pressure bursts and SBL-related investigations

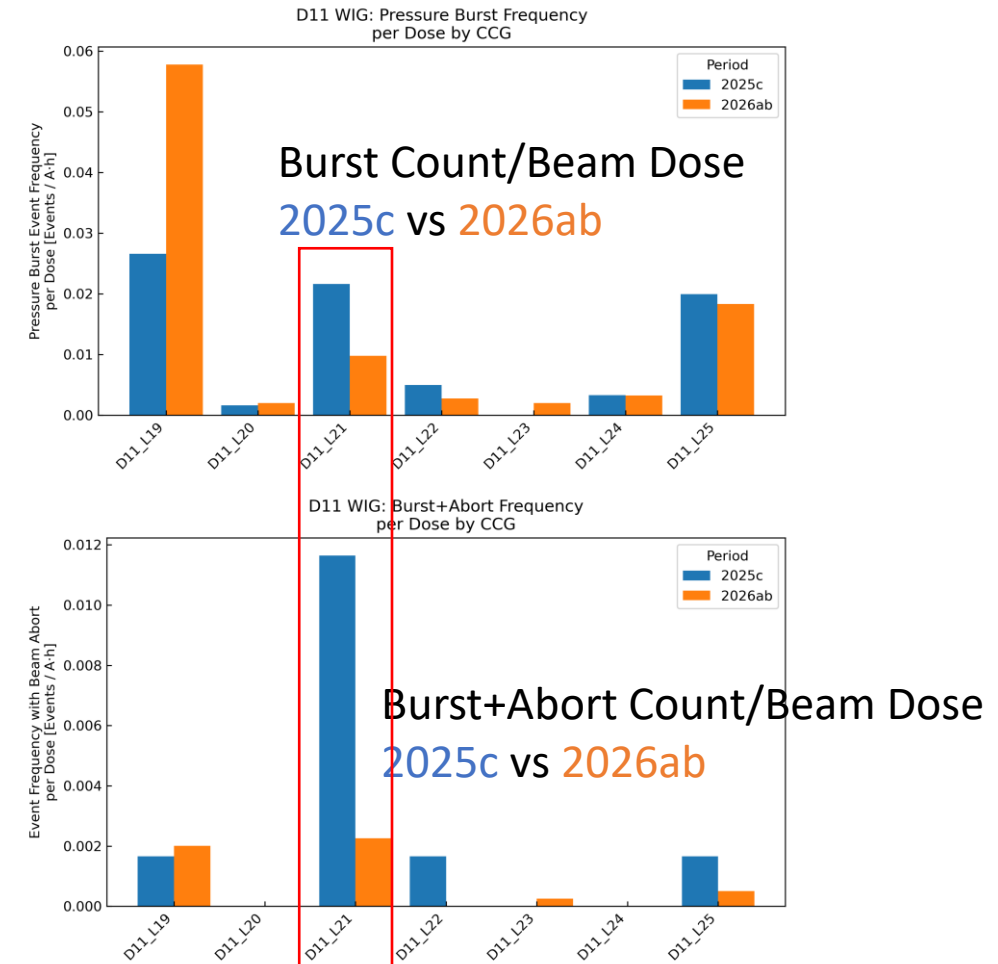


Effect of Bellows Replacement at LER D11 L21

- Bellows replacements?
- Natural conditioning? Not sure



Divided by
Beam Dose
(Time)



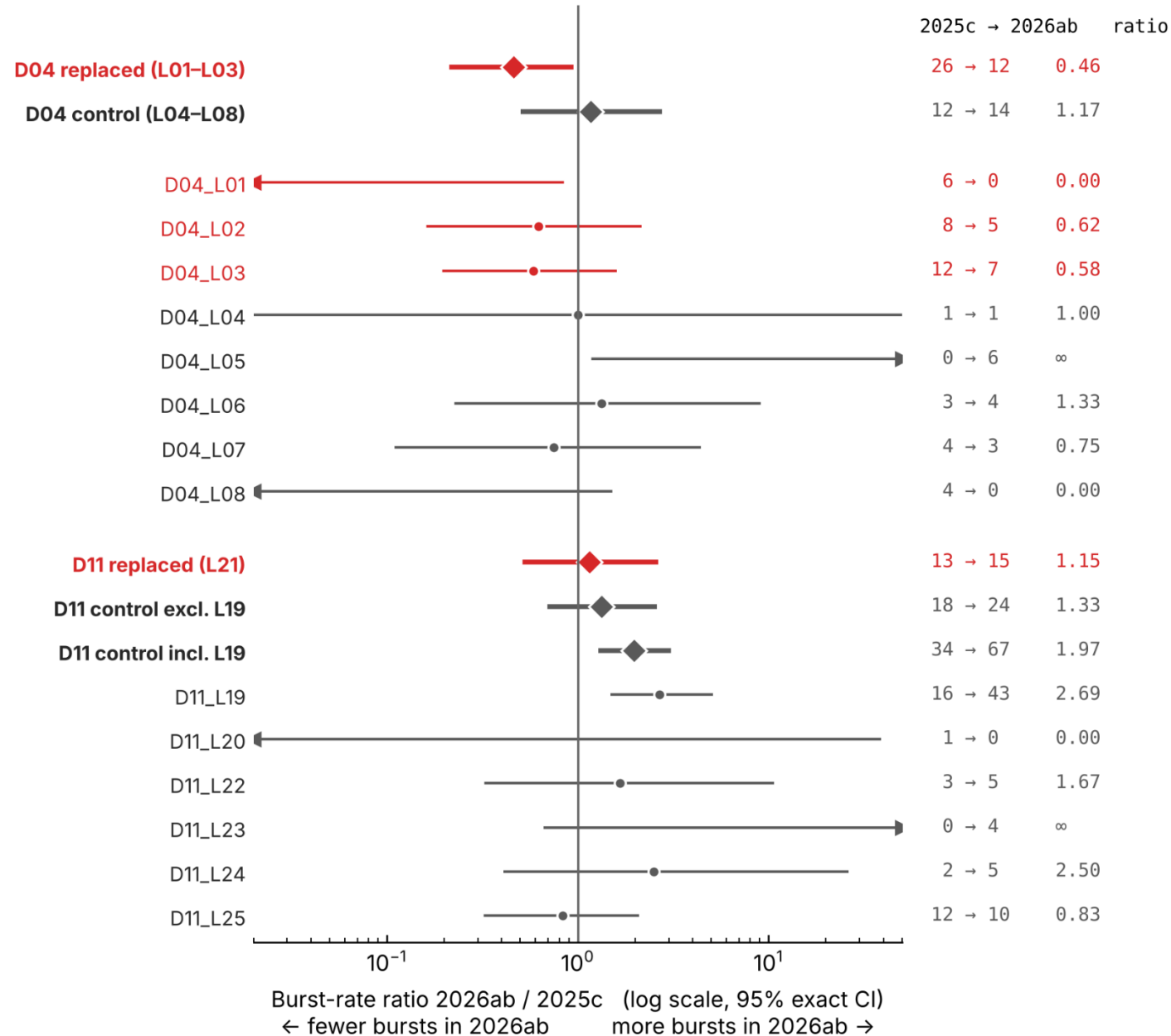
Effect at equal dose (first 601 A·h of each run)

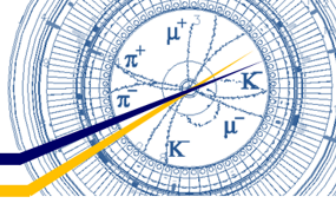
Ratio of rate ratios, 95% CI:

D04: replaced/control = 0.40 [0.12, 1.25], Fisher p = 0.119

D11 (excl. L19): replaced/control = 0.87 [0.30, 2.53], Fisher p = 0.810

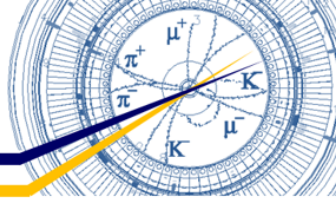
D11 (incl. L19): replaced/control = 0.59 [0.23, 1.51], Fisher p = 0.268





- Plan to replace
 - LER D03V4
 - It is also highly likely that this has a significant impact on LER's tune shift.
- Considering the replacement
 - HER D01V1
 - LER D05V1 Top or Bottom
 - We haven't used the top jaw (Ti) because of the high radiation level around Oho experimental hall, so another option would be to replace the top one with Ta.
 - If only the top jaw is being replaced, there is no need to rotate the chamber, and the radiation shield does not need to be dismantled to any great extent, so the amount of work required is relatively minimal.
 - HER D12V4
 - With the jaw width of 40 mm, we can avoid the damaged region by shifting the collimator horizontally.
 - For example, the D12V1 is used in a position shifted 2.5 mm outward from the ring.

4-3-3. Spare Jaws



Tip Material (): longitudinal length in mm	Collimator to be installed (assumed)	Remarks
~~HER vertical: Cu coated Ta (10)~~	~~D01V1~~	Delivery in mid-February
~~HER vertical: Cu coated Ta (10)~~	~~D01V1~~	Delivery in mid-February
HER vertical: Cu coated W (10)	D01V1	
HER vertical: Cu coated Ti (40)	D09V1-V4, D12V1-V4	KEKB type
HER vertical: Cu coated Ti (40)	D09V1-V4, D12V1-V4	KEKB type
~~LER vertical: Cu coated Ta (10)~~	D02V1, D03V4, ~~D05V1~~ , D06V1	Delivery in mid-February
~~LER vertical: Cu coated Ta (10)~~	D02V1, D03V4, ~~D05V1~~ , D06V1	Delivery in mid-February
LER vertical: Cu coated Ta (10)	D02V1, D03V4, D05V1, D06V1	
LER vertical: Cu coated Ti (10)	D03V4, D05V1, D06V1	
~~LER vertical: hybrid (3)~~	~~D03V4~~ , D05V1, D06V1	
~~LER vertical: hybrid (3)~~	~~D03V4~~ , D05V1, D06V1	
LER horizontal: Ta (10)	D06H3, D06H4	