SuperKEKB status

BPAC Review in summer 2025

30th June 2025

Kyo Shibata

(on behalf of SuperKEKB)

Contents

- Major works during shutdown
  - Beam pipe cleaning
  - Collimator works
  - Radiation shielding at Oho
  - Electron RF gun
  - Others
- Vacuum works
- Major work schedule
- Summary

Major works during shutdown

1. Beam pipe cleaning (vacuum sealant (VACSEAL) removal)
   - Countermeasure against SBL
   - @IR (HER/LER), LER wiggler sections (D04, D10, D11)

   ⇨ Improvement of accelerator stability

2. Collimator works
   - Relocation (LER, D06V2 -> D03V4)
   - Damaged jaw replacement (LER D02V1, D05V1)
   - New water-cooled collimator (HER D09V3)

   ⇨ Protection of Belle II from SBL (D03V3), Beam impedance reduction (D02V1, D05V1), Suppression of abnormal pressure rise (D09V3)

3. Radiation shield reinforcement for full-scale use of NLC
   - Shielding radiation generated by NLC
   - Expansion of radiation control area around Oho experimental Hall

   ⇨ Background reduction, Beam impedance reduction

4. Electron RF gun replacement
   - New RF-Gun less prone to discharge

   ⇨ Stable two-bunch injection

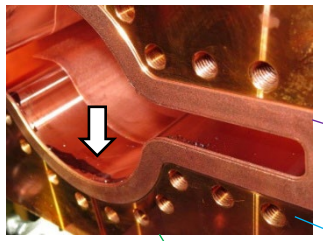
5. Installation of ECS into electron BT line
   - Reduction of energy spread of high charged bunch

   ⇨ Improvement of injected beam quality and injection efficiency

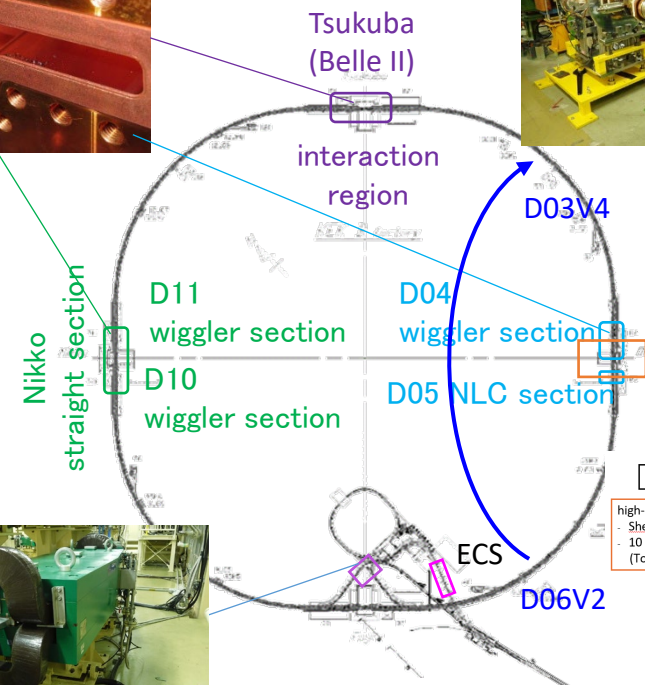
6. Magnet pole replacement of positron BT line
   - Emittance growth mitigation by improving the magnetic field.

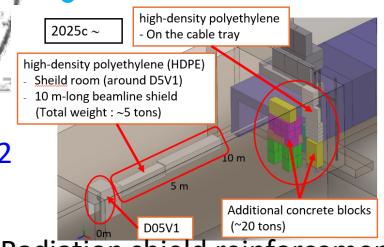
   ⇨ Improvement of injected beam quality and injection efficiency

Beam pipe cleaning



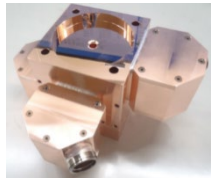
Collimator relocation
(LER D06V2 -> D03V4)

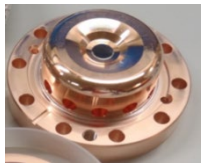


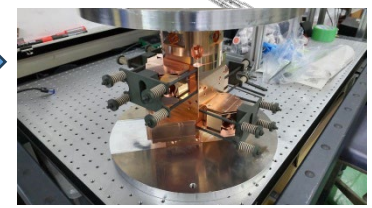


Radiation shield reinforcement

Magnet pole replacement (BTp)





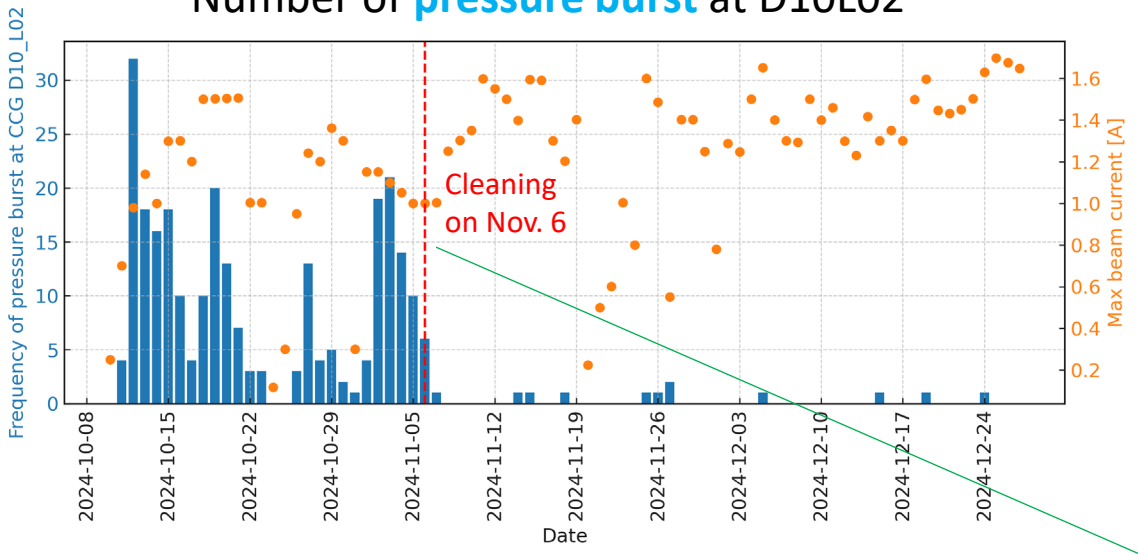


NEW RF-Gun cathode cell

Beam pipe cleaning 1

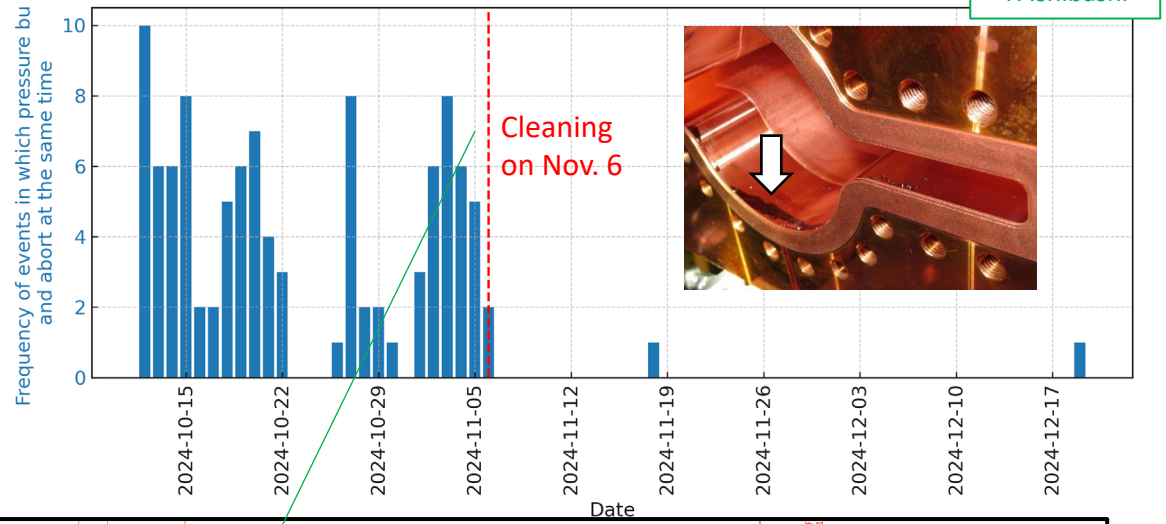
- Removal of black stains was found to be effective in reducing frequency of pressure burst and SBL event (2025c run)

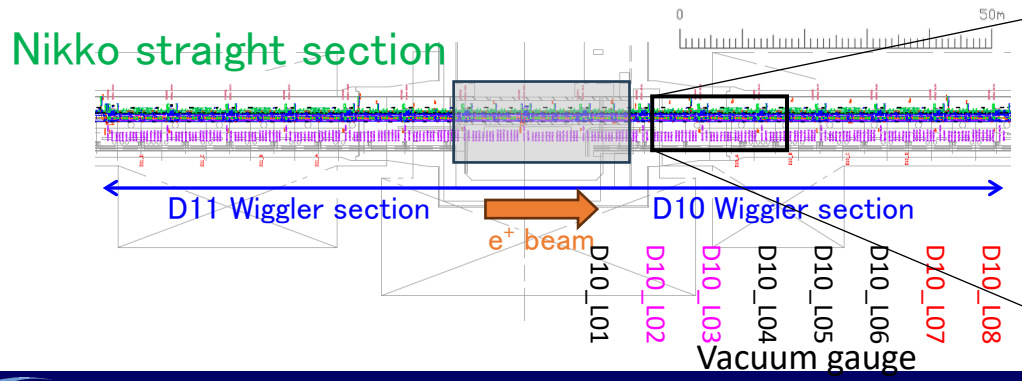
Number of **pressure burst** at D10L02

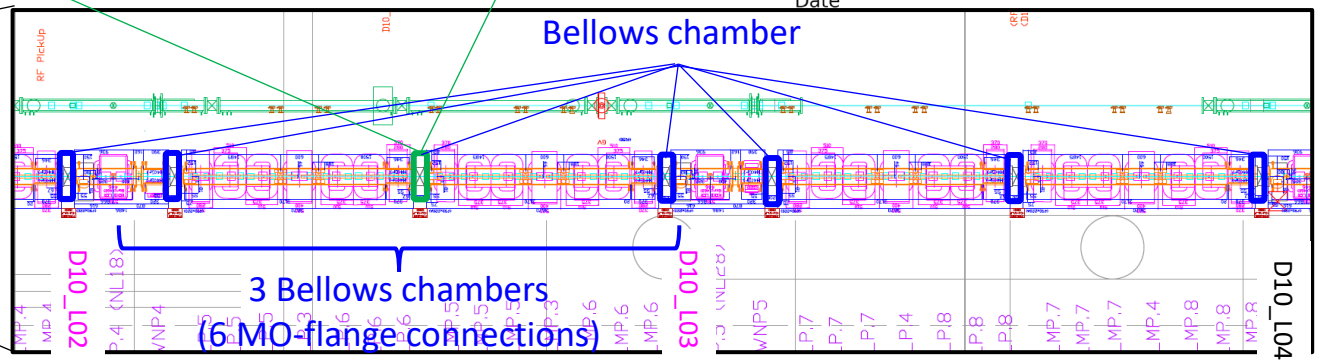


Number of **beam abort accompanied by pressure burst** at D10L02

T. Ishibashi





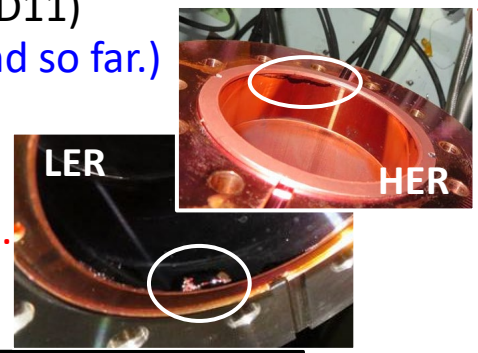


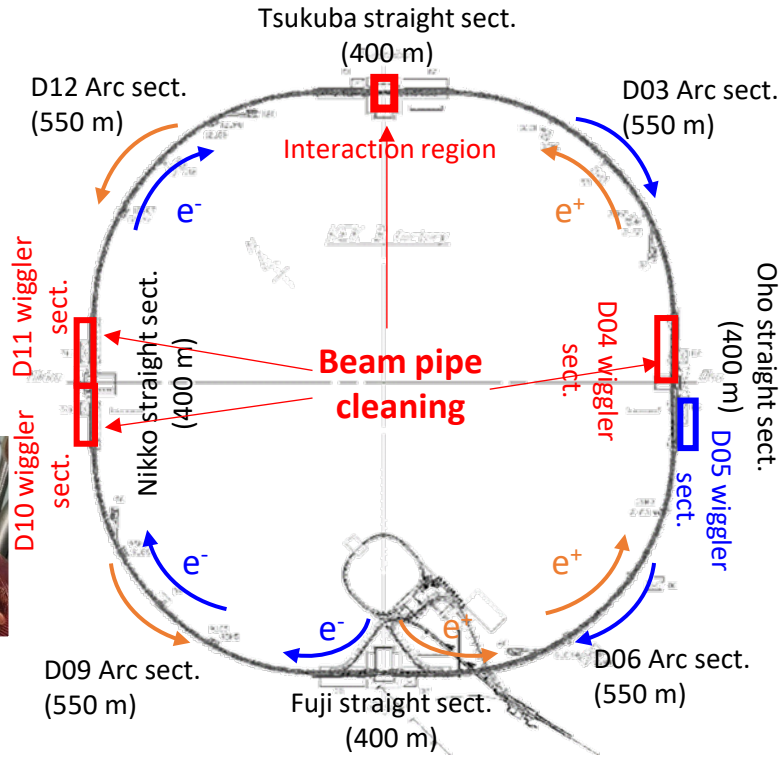
Beam pipe cleaning 2

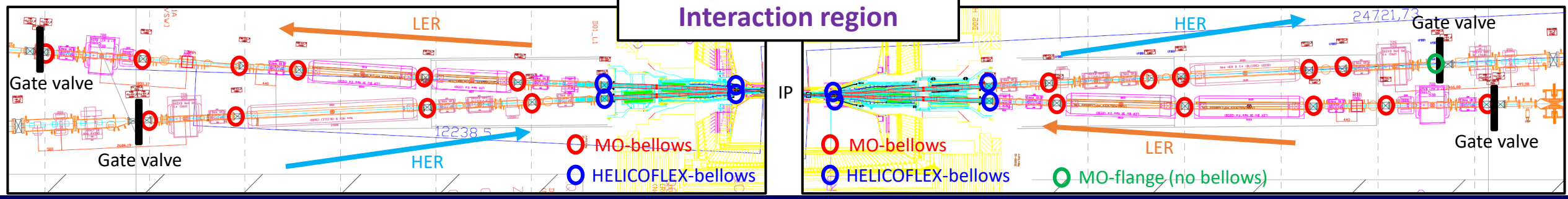
- Black stains are thought to be consist of liquid-type vacuum sealant (VACSEAL).
  - VACSEAL can enter the beam pipe via the MO-flange.
    - Strong SR irradiation turned VACSEAL into black stains?
  - Some black stains are flaky and easily turn to dusts.
- Black stain removal are being conducted.
  - At MO-flange connections most-likely with VACSEAL.
    - It is impossible to identify all MO-flanges with VACSEAL due to lack of records.
  - In sections where many pressure burst was observed with SBLs.

⇨ At interaction region (IR), LER wiggler sections (D04, D10, D11)
Not at HELICOFLEX-flange (No black stains have been found so far.)

- IR : All MO-flange connections were cleaned.
  - 41 MO-flange connections were opened.
  - Black stains were found in many MO-flanges and removed.
  - 16 HELICOFLEX flange connections left uncleaned.

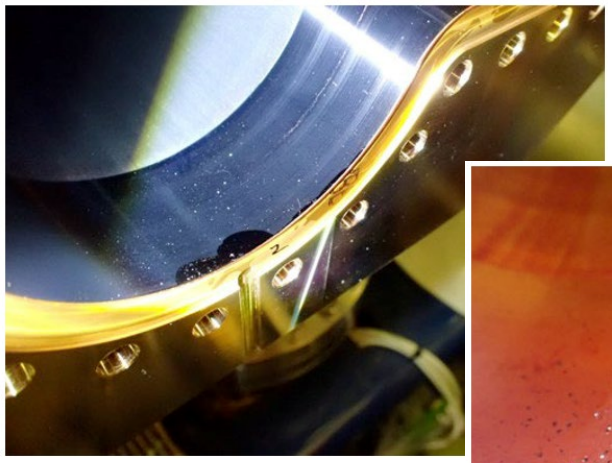


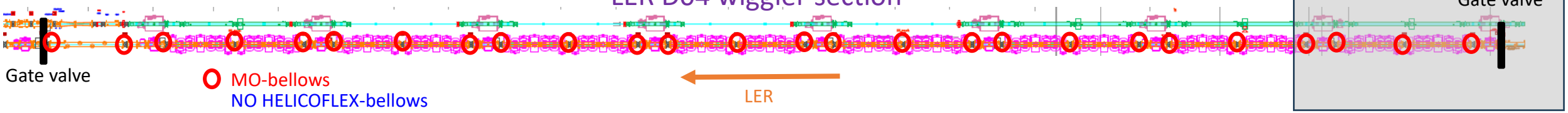




Beam pipe cleaning 3

- LER wiggler sections
  - Many pressure bursts accompanied with SBL events
  - Strong SR irradiation especially downstream wiggler section.
    - Vacuum leaks occurred more frequently than other sections
  - Many MO-flanges most-likely with VACSEAL
- LER D04&D10 : All MO-flange connections were cleaned.
  - D04 : 52 MO-flange connections (26 bellows chambers)
  - D10 : 54 MO-flange connections (27 bellows chambers)
  - Many black stains were found and removed.
- LER D11 : Ongoing (will be completed by mid-July)
  - 44 MO-flange connections (22 bellows chambers)
- And more
  - Some MO-flanges with VACSEAL applied to stop vacuum leaks

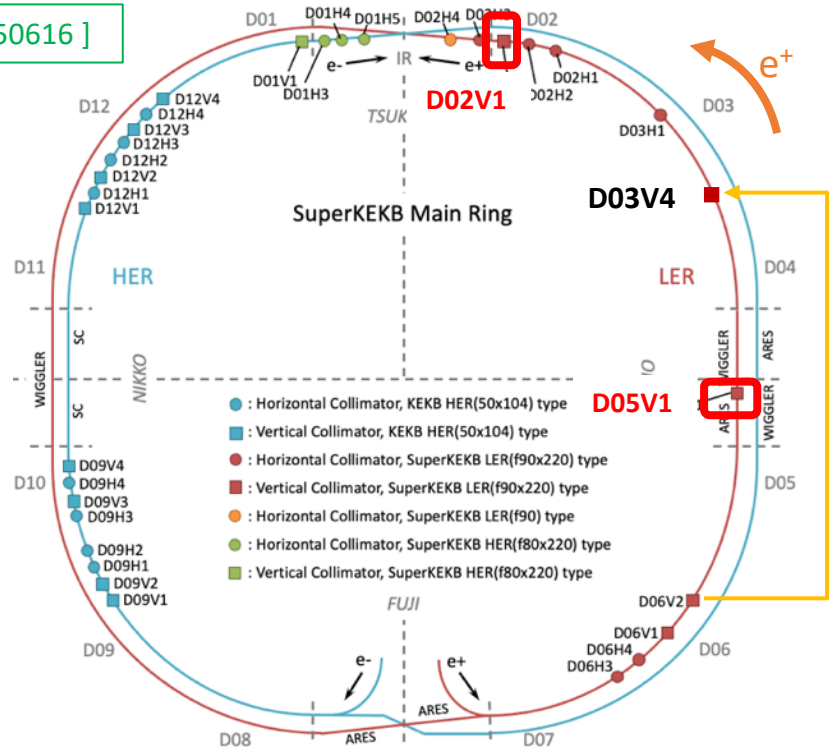


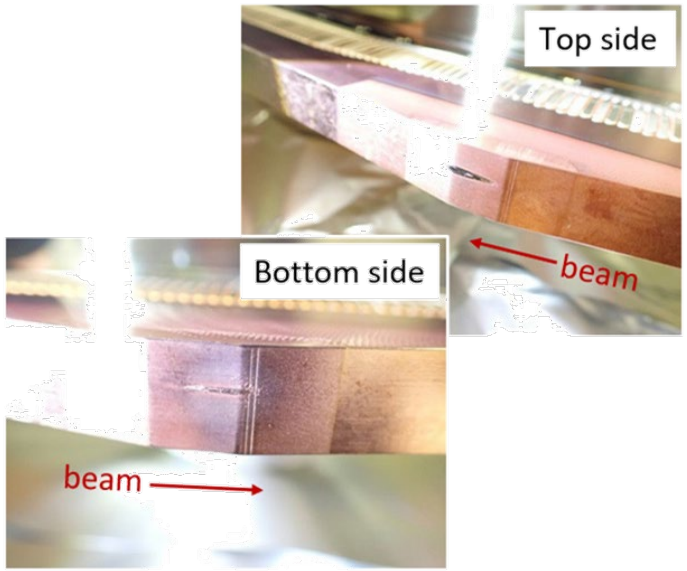


Collimator works 1

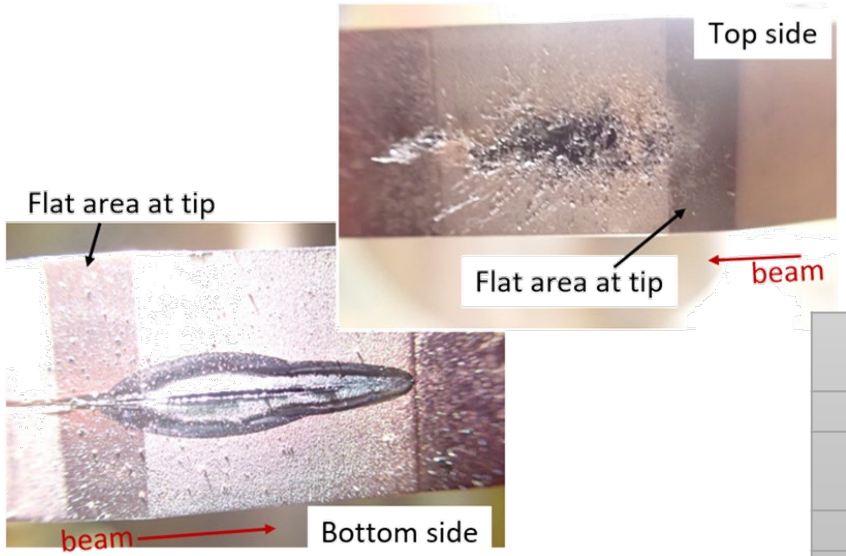
- Damaged jaw replacement (LER)
  - D02V1 and D05V1 were replaced with new ones.
  - D05V1 (NLC) top jaw material was changed to Ti.
    - Top side : Ta (4 mm) -> Ti (10 mm)
    - Bottom side : Ta (4 mm) -> Ta (10 mm)
    - Durability and background reduction performance of Ti jaw will be tested in coming beam operation.

T. Ishibashi [B2GM, 20250616]





Damaged jaws (D02V1, Ta, 10 mm)



Damaged jaws (D05V1. Ta, 4 mm)

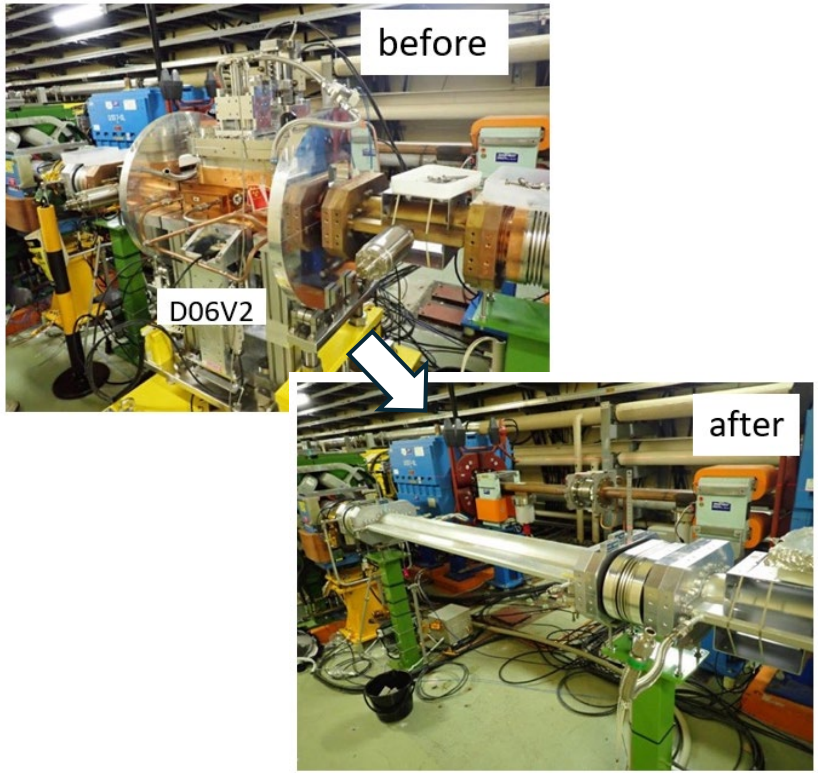
LER vertical collimators and jaws (at start of 2025c)

Name	Tip Material (): longitudinal length in mm	Tip Condition
D06V1	Ti (10)	Healthy
D05V1	Top: Ti (10) Bottom: Ta (10)	Healthy
D03V4	Hybrid: Ta (3) + C (7)	Healthy
D02V1	Ta (10)	Healthy

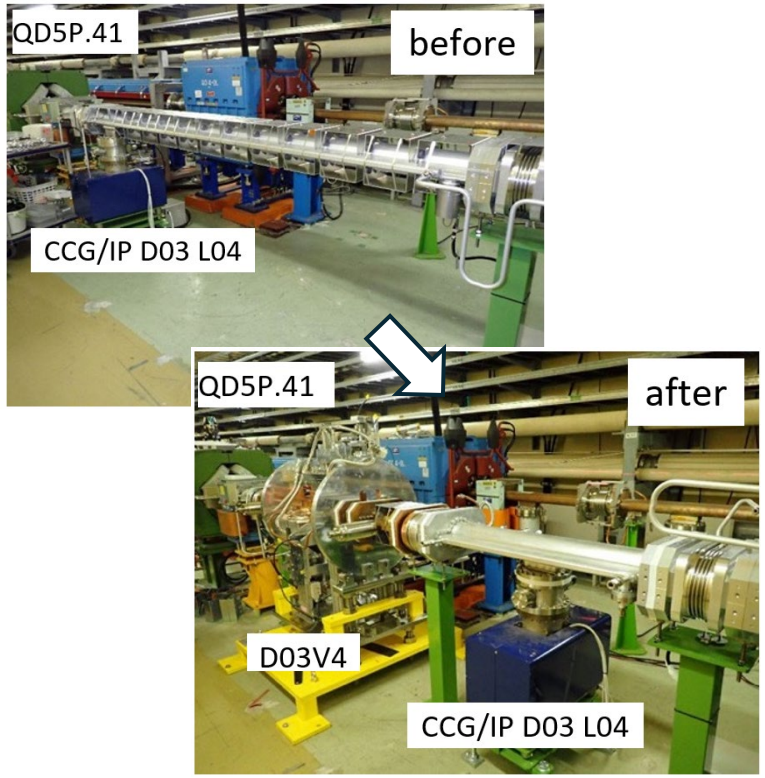
Collimator works 2

T. Ishibashi [B2GM, 20250616]

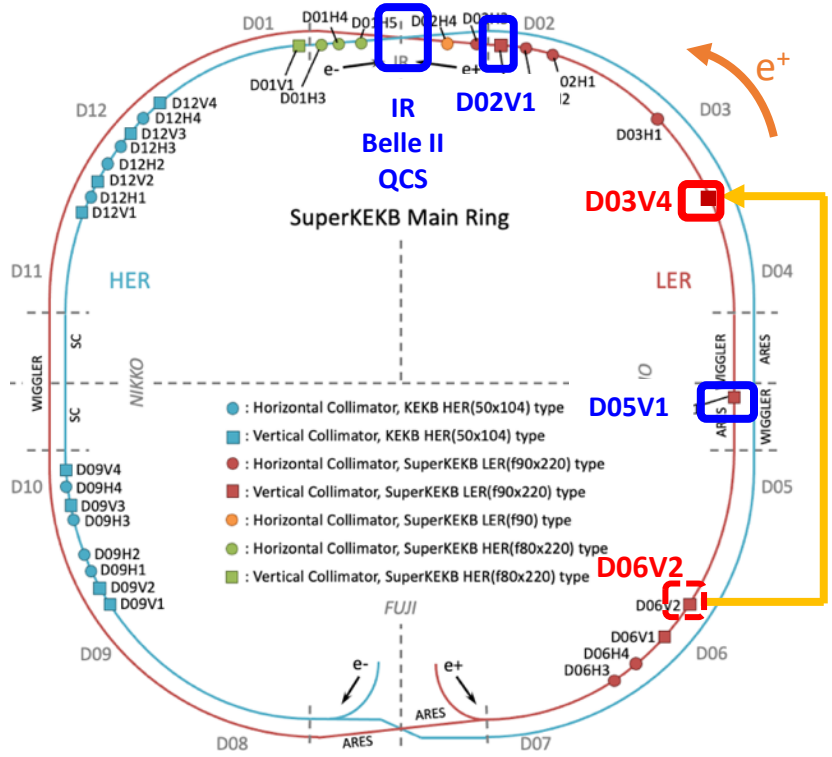
- Collimator relocation (LER)
  - D06V2 collimator was relocated to D03V3 as a countermeasure against SBLs
  - Protection for Belle II, QCS, and D02V1 from SBLs occurred downstream of D05V1 (e.g., D04 wiggler section).



Location of D06V2

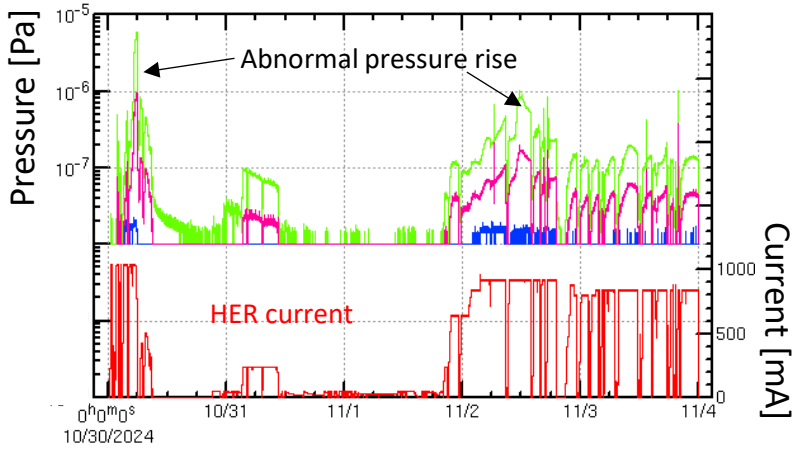


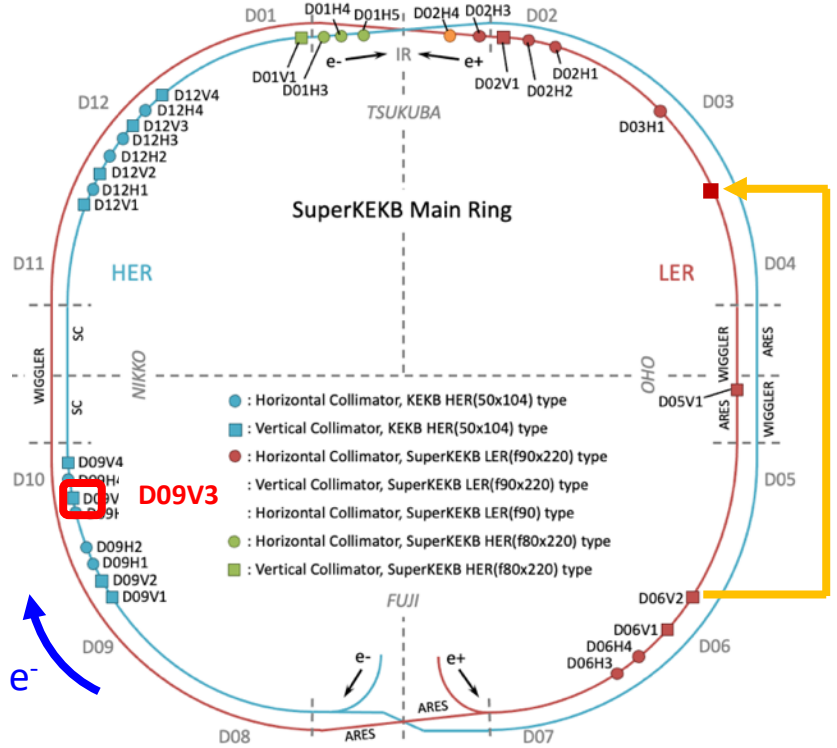
Location of D03V4



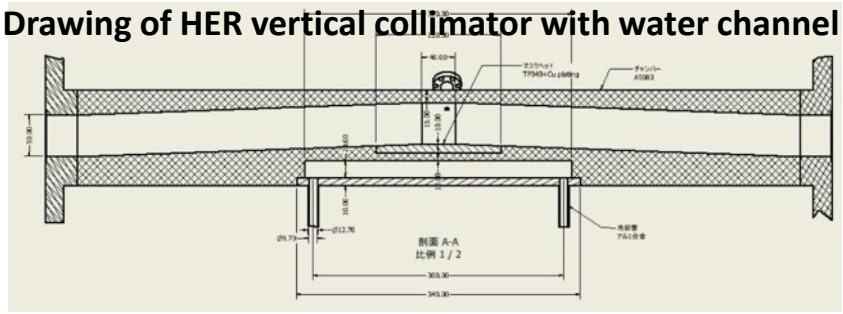
Collimator works 3

- New water-cooled collimator (HER)
  - Abnormal pressure rise was observed near D09V3 in 2024c run.
    - Pressure increased even if the beam current is constant.
    - Pressure depended on bunch current and collimator gap.
  - Collimator jaw may be heated by HOMs generated by itself.
    - Or discharge may occur around collimator jaw.
    - The cause of the abnormal pressure rise is still unclear.
  - D09V3 collimator will be replaced with water-cooled one.
    - New collimator is expected to be delivered by the end of October and installed in early November.



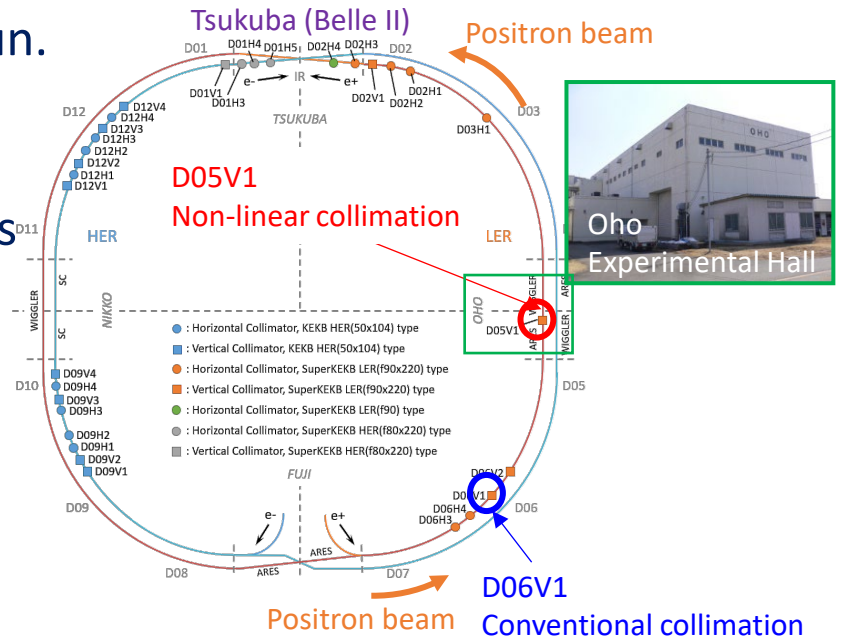


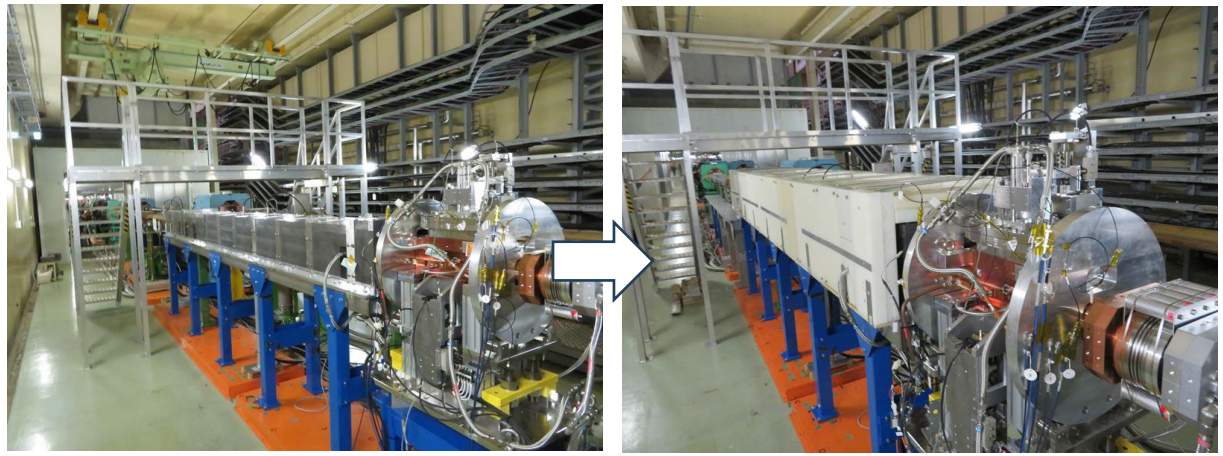
Drawing of HER vertical collimator with water channel



Radiation shielding at Oho 1

- LER current was limited by high radiation level at Oho Exp. Hall in 2024c run.
  - Radiation level in the Oho Experimental Hall increased as closing the D05V1 collimator gap.
- Radiation shielding was reinforced during 2024c run. (11/26-27), but it was not enough.
  - Polyethylene blocks were added on the existing lead shields in the tunnel.
  - Concrete shields were installed at Oho Experimental Hall to reduce the radiation levels outside.
- For full-scale use of the D05V1 collimator, it is required to reinforce radiation shielding and expand the radiation control area.





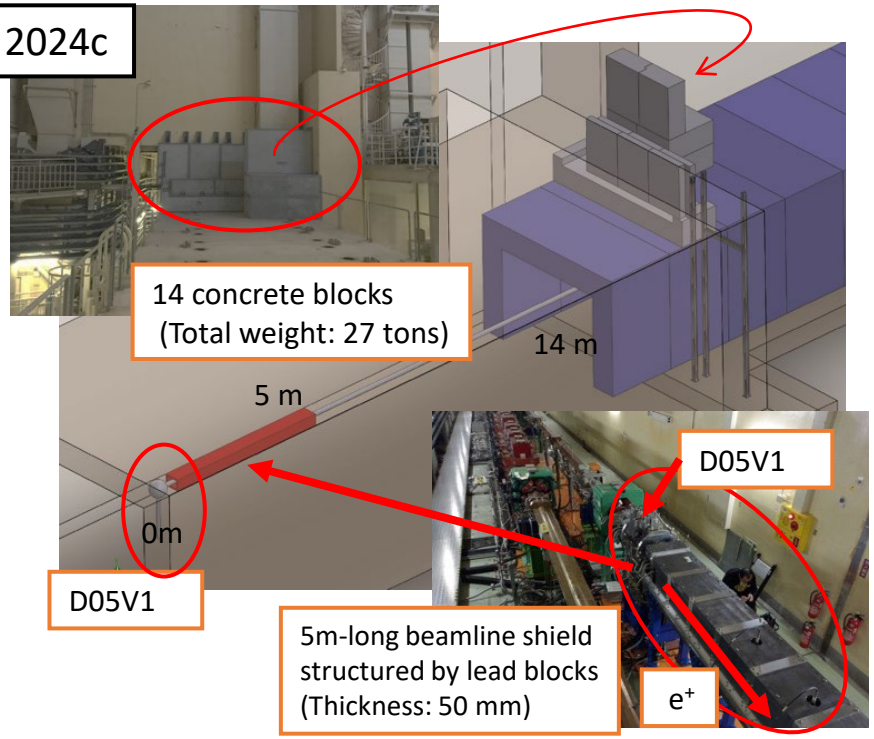
Countermeasures during 2024c run.

Radiation shielding at Oho 2

[K. Watanabe]

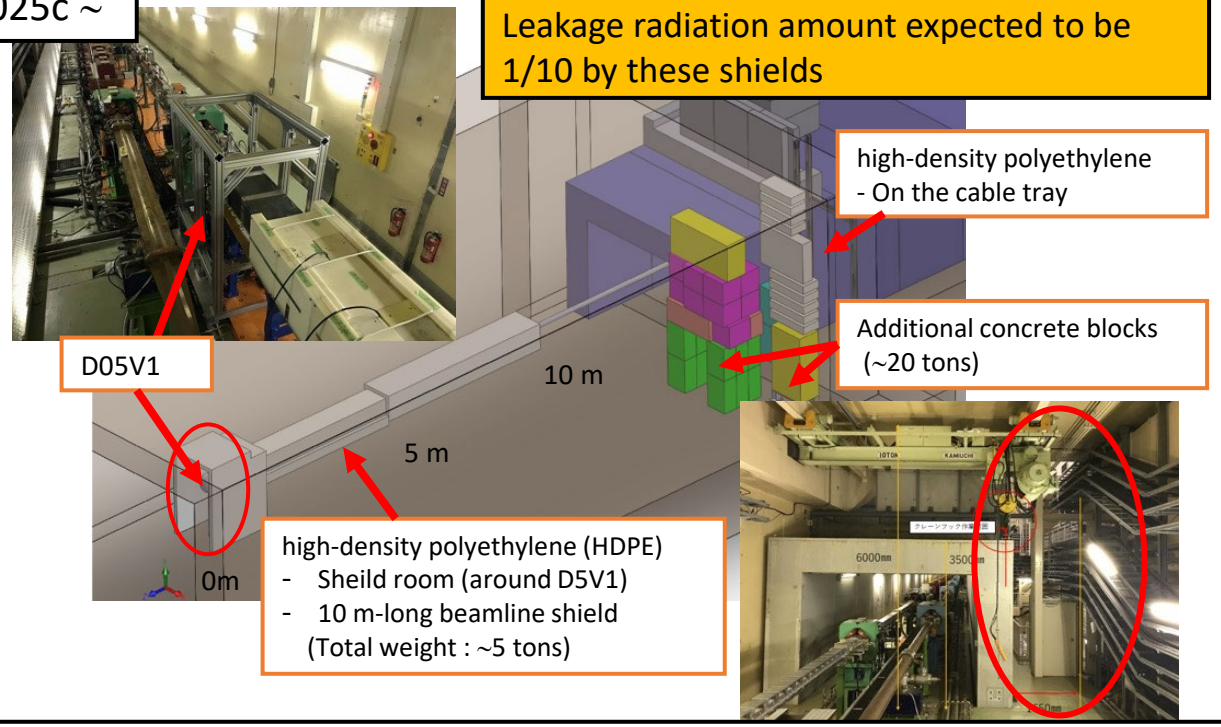
- Radiation shielding reinforcement around D05V1

Before 2024c



2025c ~

Leakage radiation amount expected to be 1/10 by these shields



- Radiation shields were installed at two locations.
  - A beamline shield covering ~5 m from D05V1
  - A concrete shield added onto the existing shield for the straight section
- The dose limit within the radiation control area was reached, making additional shielding necessary.

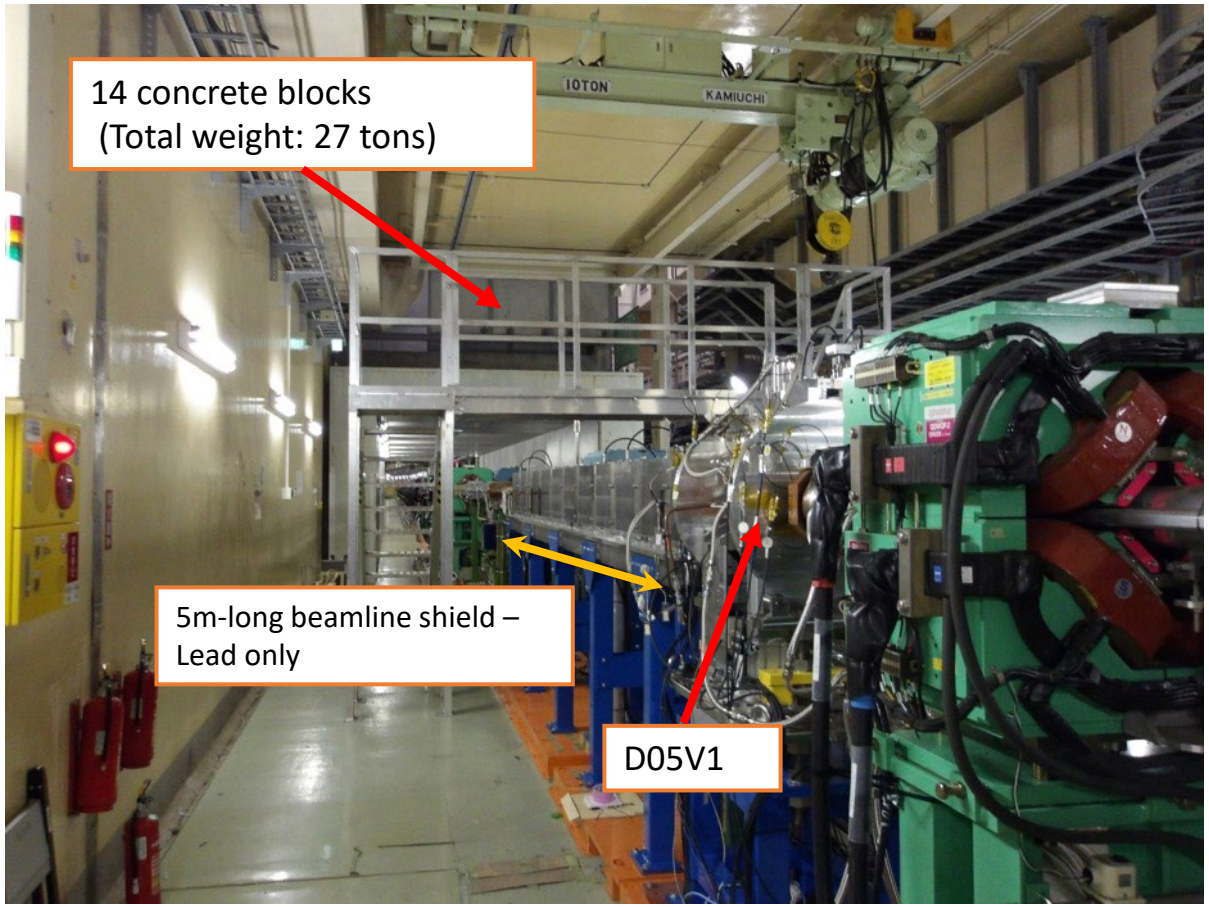
- Plan for installation of additional shields before the start of 2025c
  - For the beam line,
    - Shield room around D5V1 (HDPE, thickness: 100-200mm)
    - 10 m-long beamline shield (HDPE, thickness: 150-200mm)
    - Additional lead beamline shield (5-10m section, thickness: 50 mm)
  - For the inside of the accelerator tunnel,
    - Additional concrete shield (max. 4.5 m height, thickness: 0.6-1.2m)
    - Additional shield on the cable tray (HDPE)

Radiation shielding at Oho 3

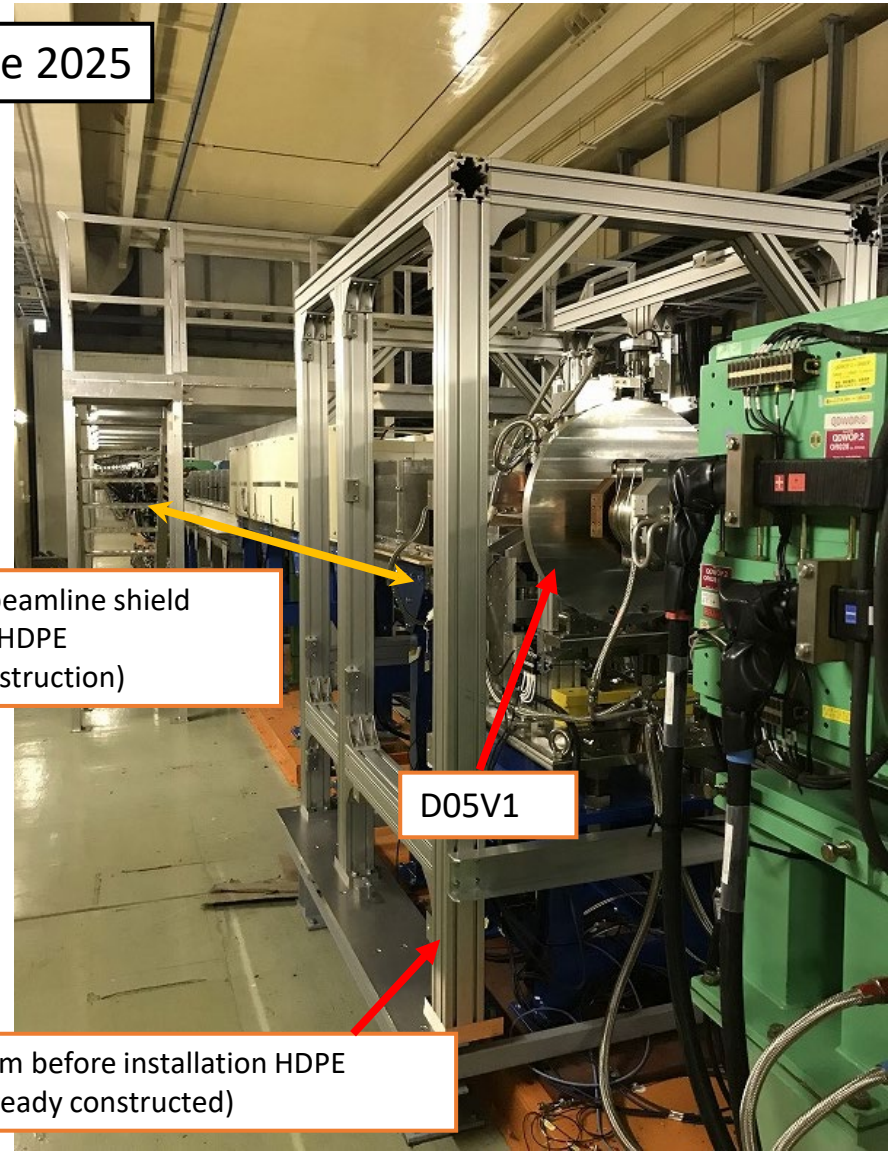
- Shield installation progress

[K. Watanabe]

Oct. 2024



June 2025

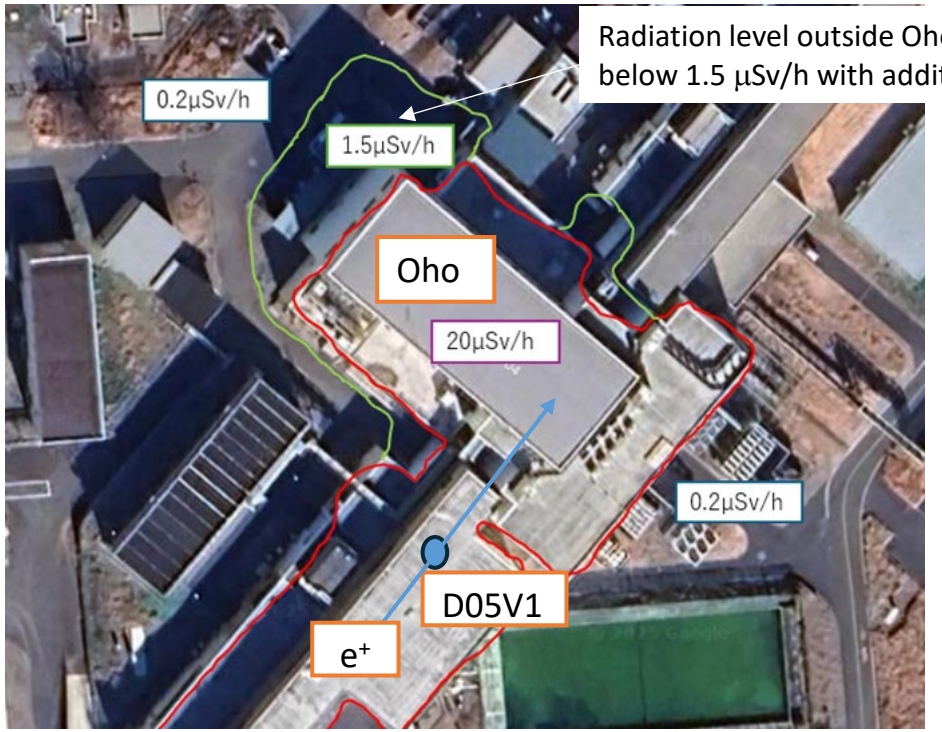


Radiation shielding at Oho 4

- Expansion of Radiation Control Area around Oho Experimental Hall

[K. Watanabe]

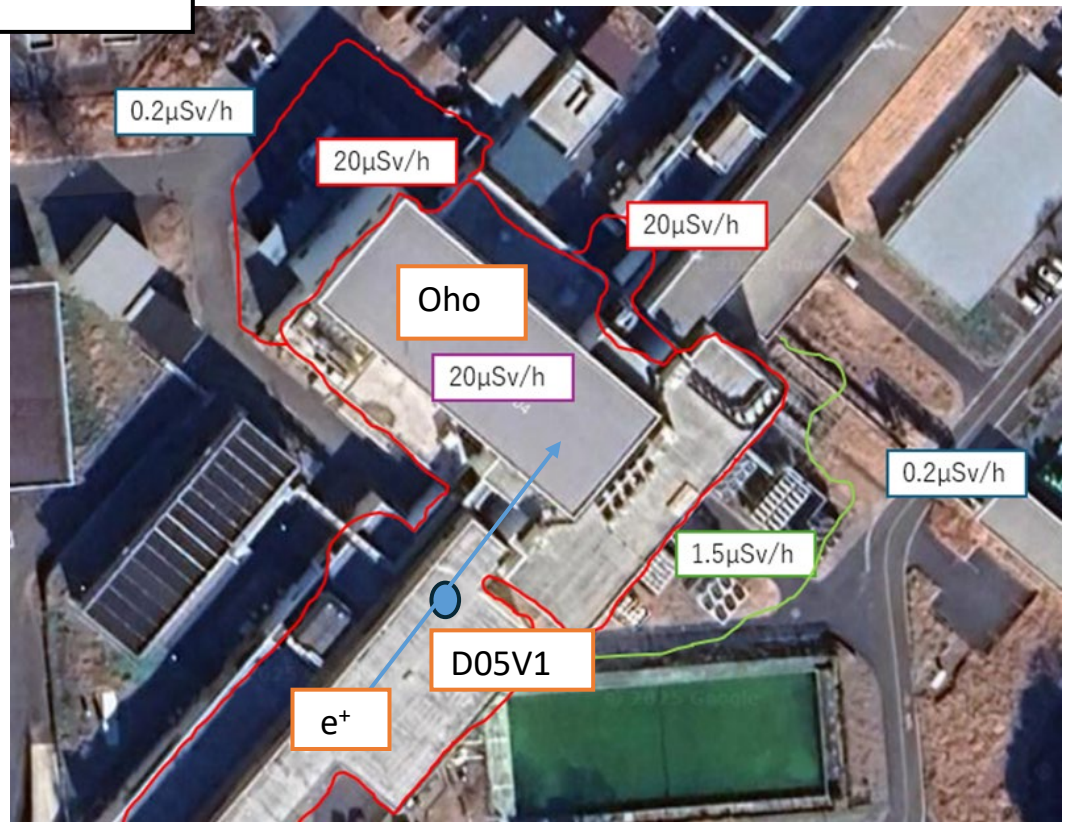
Oct 2024



Radiation level outside Oho Exp. Hall was maintained below 1.5 μSv/h with additional concrete shields.

Radiation control area (< 20μSv/h)

June 2025



A fence is being constructed to establish the boundary of the radiation control area until September 2025.

Electron RF Gun status

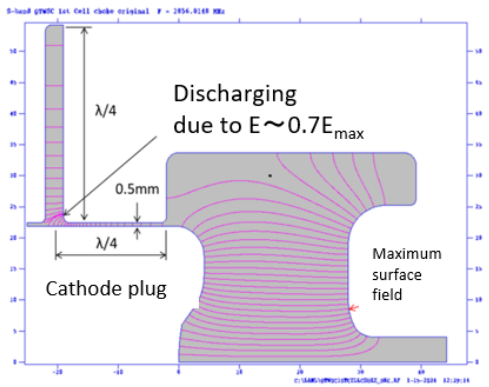
T. Ishibashi [B2GM, 20250616]

Status of RF Gun (Linac) – Updated QTWSC RF Gun

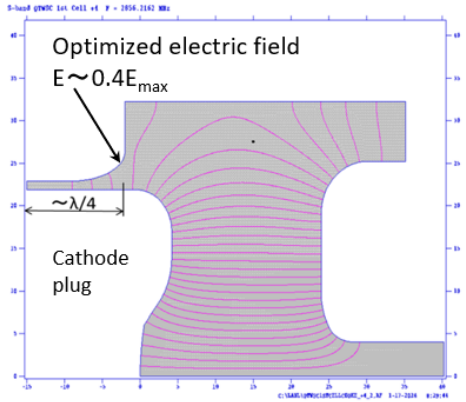
[M. Yoshida *et al.*]

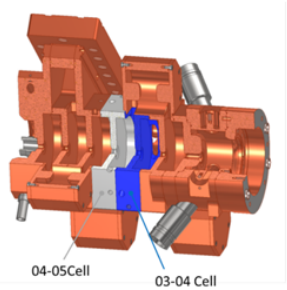
- The current RF gun cathode cell includes a choke structure for thermal cleaning of the cathode.
- The updated cathode cell is designed with:
  - Optimized surface field
  - Additional vacuum pumping
  - A new triplet downstream of the gun
- During brazing, the wrong cavity cell was assembled, resulting in a 10 MHz frequency offset (No tuning required for cathode side cavity chain).
- Tuning of the RF cavity is scheduled this week. RF conditioning will be performed until July.

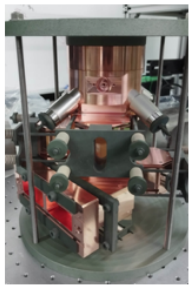
Current



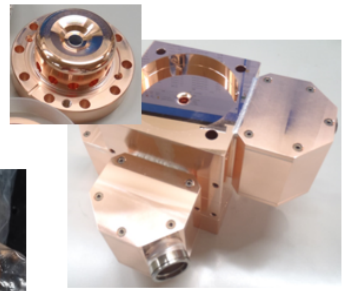
Updated

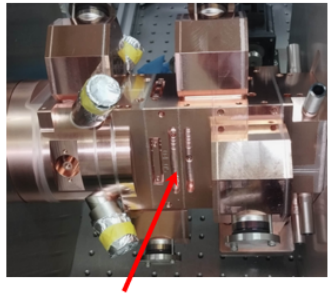






Brazing assembly





- If tuning cannot sufficiently correct the frequency offset and the schedule is delayed, a new IrCe cathode plug will be installed in the current RF gun.

New IrCe Cathode Plug

Additional machining for tuning

- Tuning will take about two weeks.
- It is still unclear that the tuning can correct the frequency offset.

- Until the end of 2026b run, it will be possible to conduct HER 2-bunch injection with a new cathode.

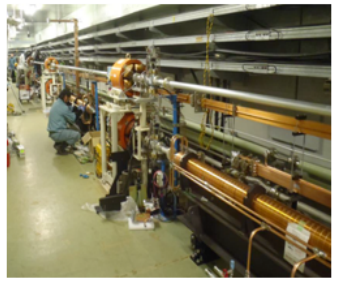
Other works

Other Upgrade Tasks

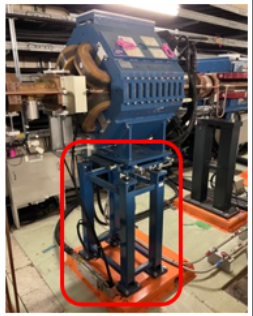
- Energy Compression System (ECS) installation at BTe [M. Yoshida *et al.*]
  → Suppress the energy spread of high-charge bunches.
  - This system will be available for the 2025c run.
- Reinforcement of a Q-magnet mount in SLY [R. Ueki *et al.*]
  → Suppress Q-magnet displacement at high beam current to stabilize the orbit.
  - The specific Q-magnet to be worked on is still under consideration.
- Installation of gap sensors for vertical collimators [T. Ishibashi]
  → Measure jaw displacement with higher precision and cross-check with the existing displacement sensors.
- Replacement of bending magnet poles (BH3P) at BTp [M. Tawada *et al.*]
  → Mitigate emittance growth in BTp.
  - To improve magnetic field quality, poles for 11 bending magnets will be replaced by Oct.
- Investigation and realignment of the LER injection point beam pipes [VA, BT Gr. *et al.*]
  → Ensure that the injection point configuration is consistent with the model.
  - Correcting this misalignment may improve the injection efficiency.

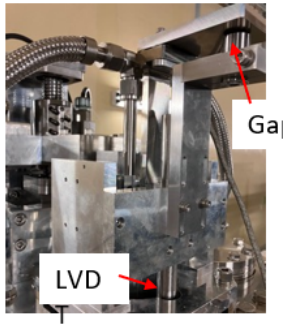
etc.

ECS at BT1

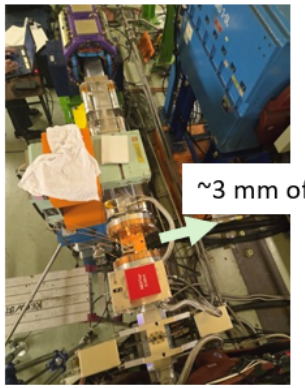


Q-magnet in HER SLY





Drive mechanism of D02V1



Beam pipes around the injection point (downstream of QI6P).

T. Ishibashi [B2GM, 20250616]

16

Vacuum works (LER)

1. Internal inspection and cleaning of beam pipes in IR → Completed
2. Cleaning of beam pipes in the Oho wiggler section → Completed
3. Cleaning of beam pipes in the Nikko wiggler section

   → Ongoing (May - July)
4. Replacement of damaged jaws in the D02V1 collimator

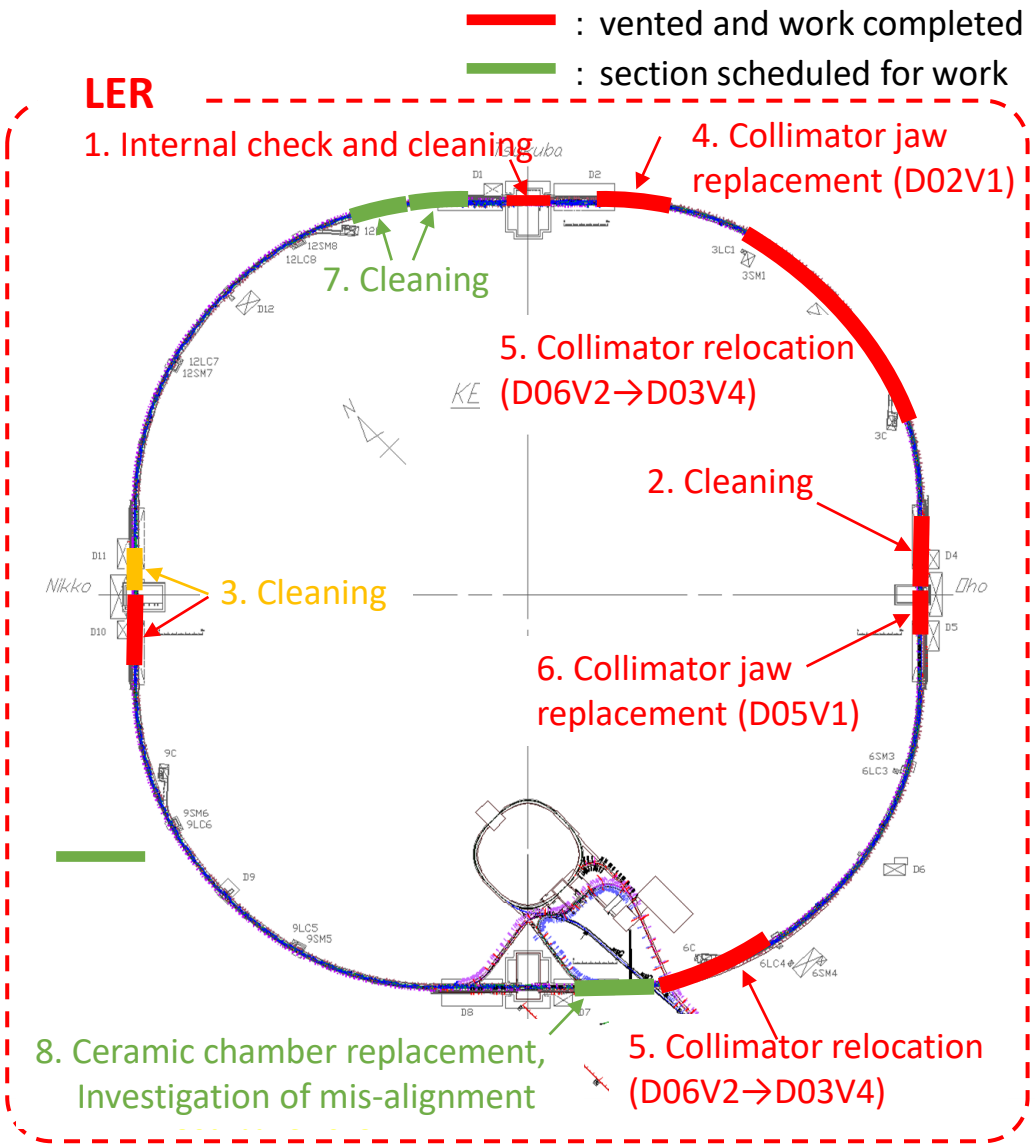
   → Completed
5. Relocation of the D06V2 collimator to D03V4 → Completed
6. Replacement of damaged jaws in the D05V1 collimator

   → Completed
7. Cleaning of MO-flanges known to have used VACSEAL

   (location: around CCG D01_L10, D01_L15)
8. A) Replacement of ceramic chambers in the kicker magnets (to reduce residual kicks)

   B) Alignment check and correction of beam pipes around the injection point

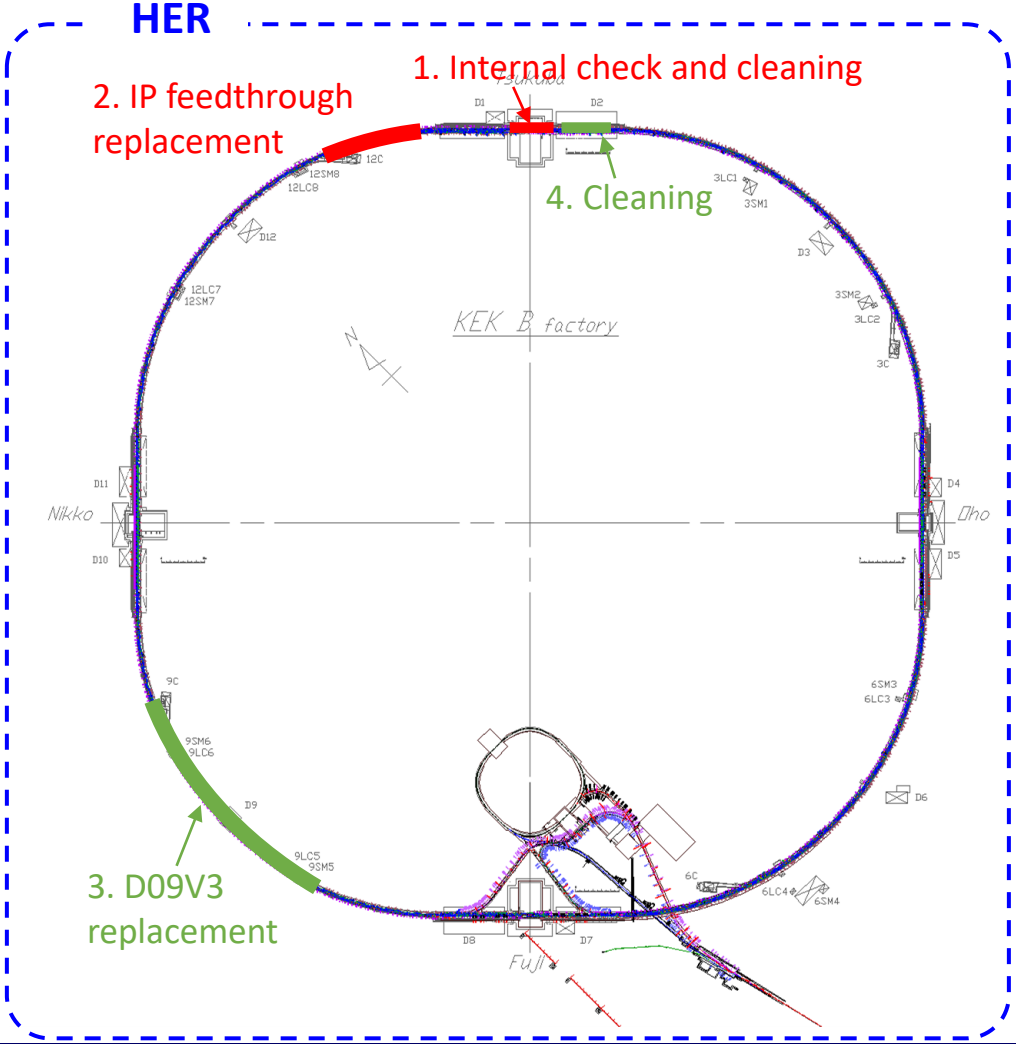
T. Ishibashi [B2GM, 20250616]



Vacuum works (HER)

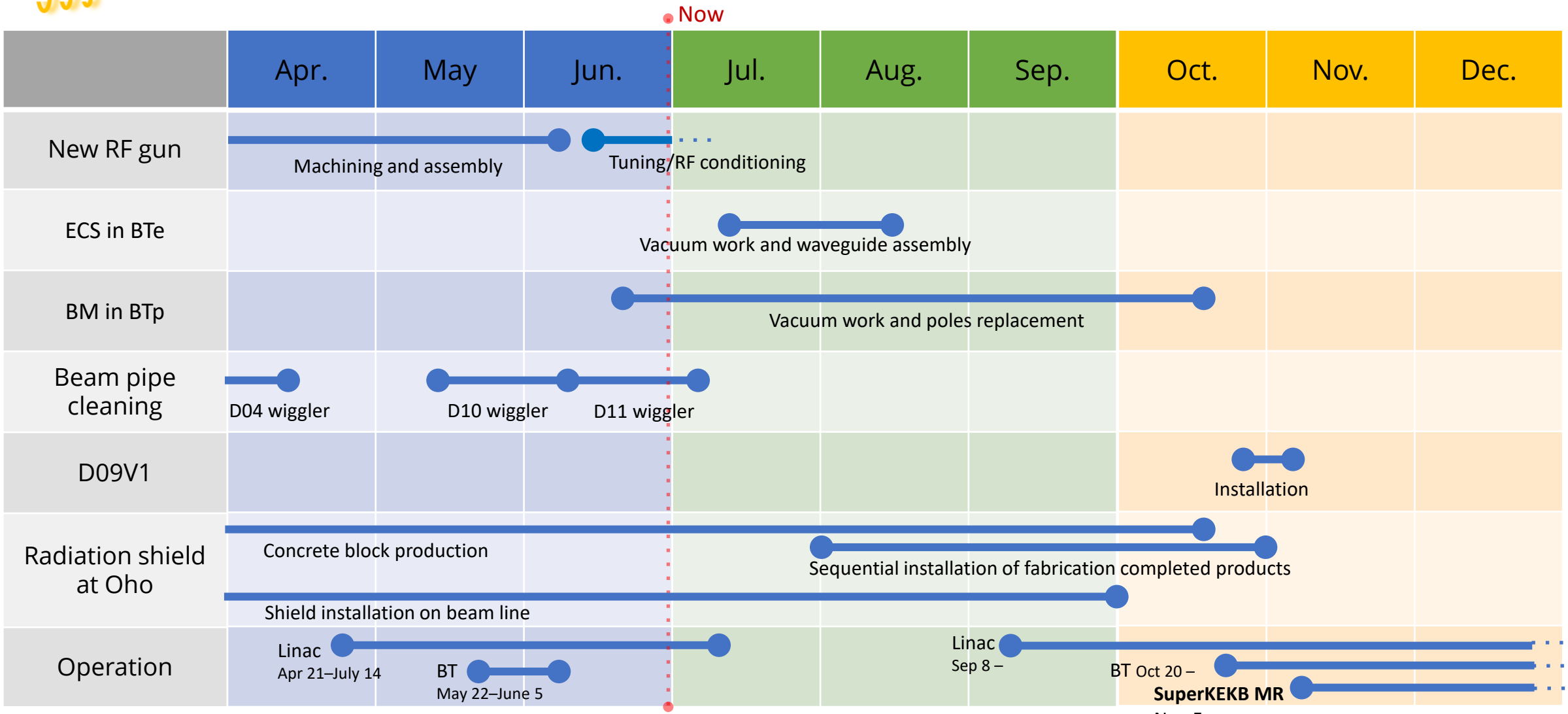
1. Internal inspection and cleaning of beam pipes in the IR → Completed
2. Replacement of an ion pump feedthrough → Completed
   - Vacuum leak was caused by abnormal discharge in the HV connector.
3. Replacement of the damaged jaw in the D09V3 collimator
   - A new collimator with a cooling water channel is being manufactured. Installation is scheduled for the beginning of Nov.
4. Cleaning of MO-flanges known to have used VACSEAL.
   (location: SUS flanges around CCG D02_H22)

: vented and work completed
: section scheduled for work



T. Ishibashi [B2GM, 20250616]

Major work schedule leading up to 2025c



Summary

- Beam pipe cleaning
  - IR, LER wiggler sections (D04, D10, D11)
  - Many black stains were found and removed.
  - will be completed by July
- Collimator works
  - Damaged jaws were replaced with new ones (LER D02V1, D05V1)
  - LER D06V2 was relocated to D03V4 to protect Belle II, QCS, and D02V1 from SBLs.
  - HER D09V3 will be replaced with new water-cooled one to mitigate abnormal pressure rise.
- Radiation shielding reinforcement
  - Radiation shielding at D05V1 is being reinforced.
  - Radiation control area will be expanded before 2025c run.
  - Full-scale usage of D05V1 will be possible from 2025c run.
- Electron RF gun
  - New RF gun trouble is being addressed now.
  - HER 2-bunch injection will be possible in coming operation.
- others
  - ECS installation, BTp dipole magnet pole replacement, etc.
  - Work is progressing as scheduled in preparation for the start of MR operation on Nov. 5th

Fin.

Thank you for your attention.

Back up