



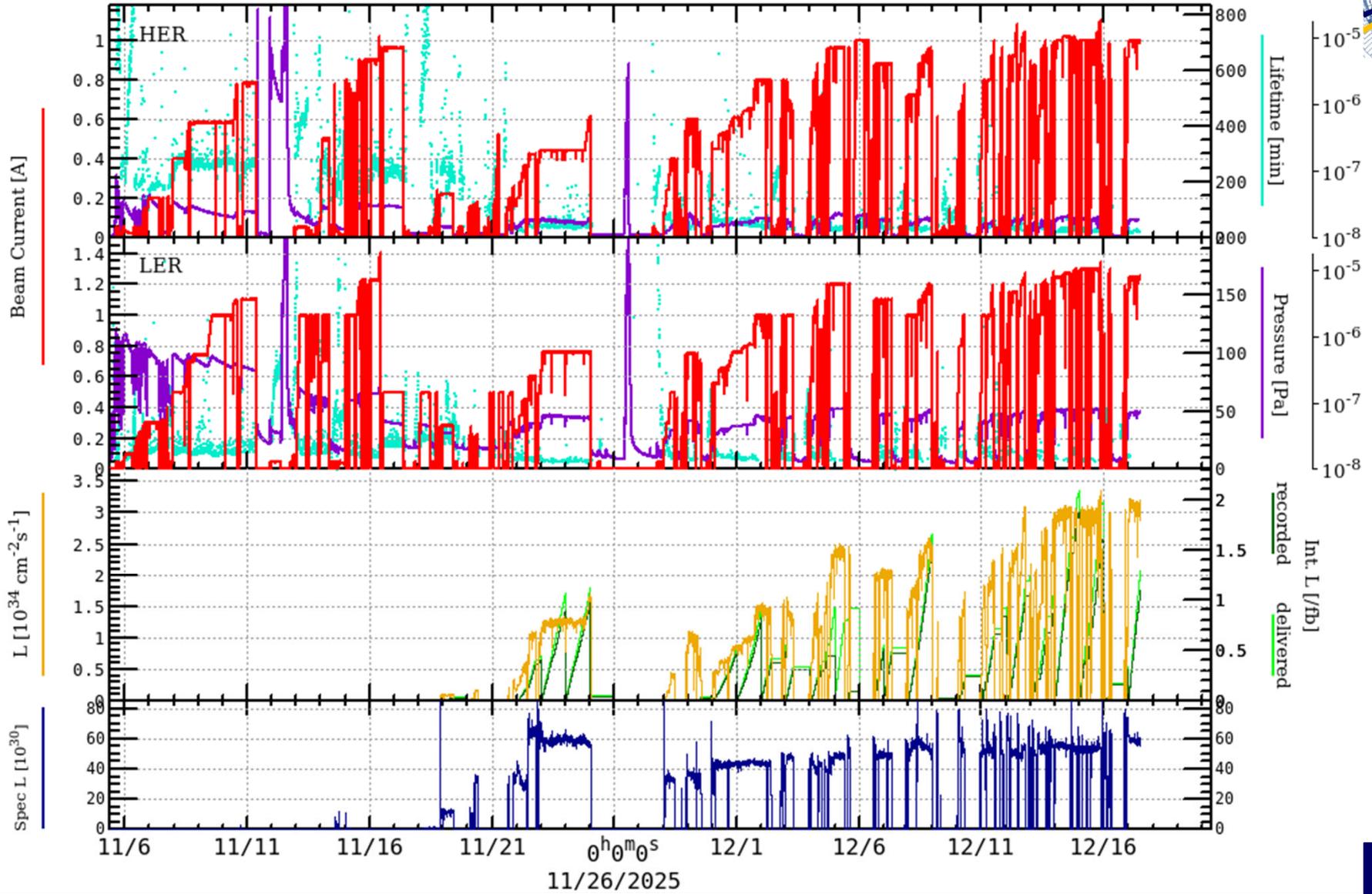
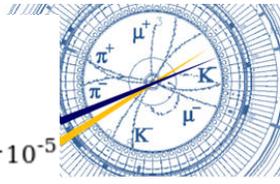
# SuperKEKB Accelerator Status



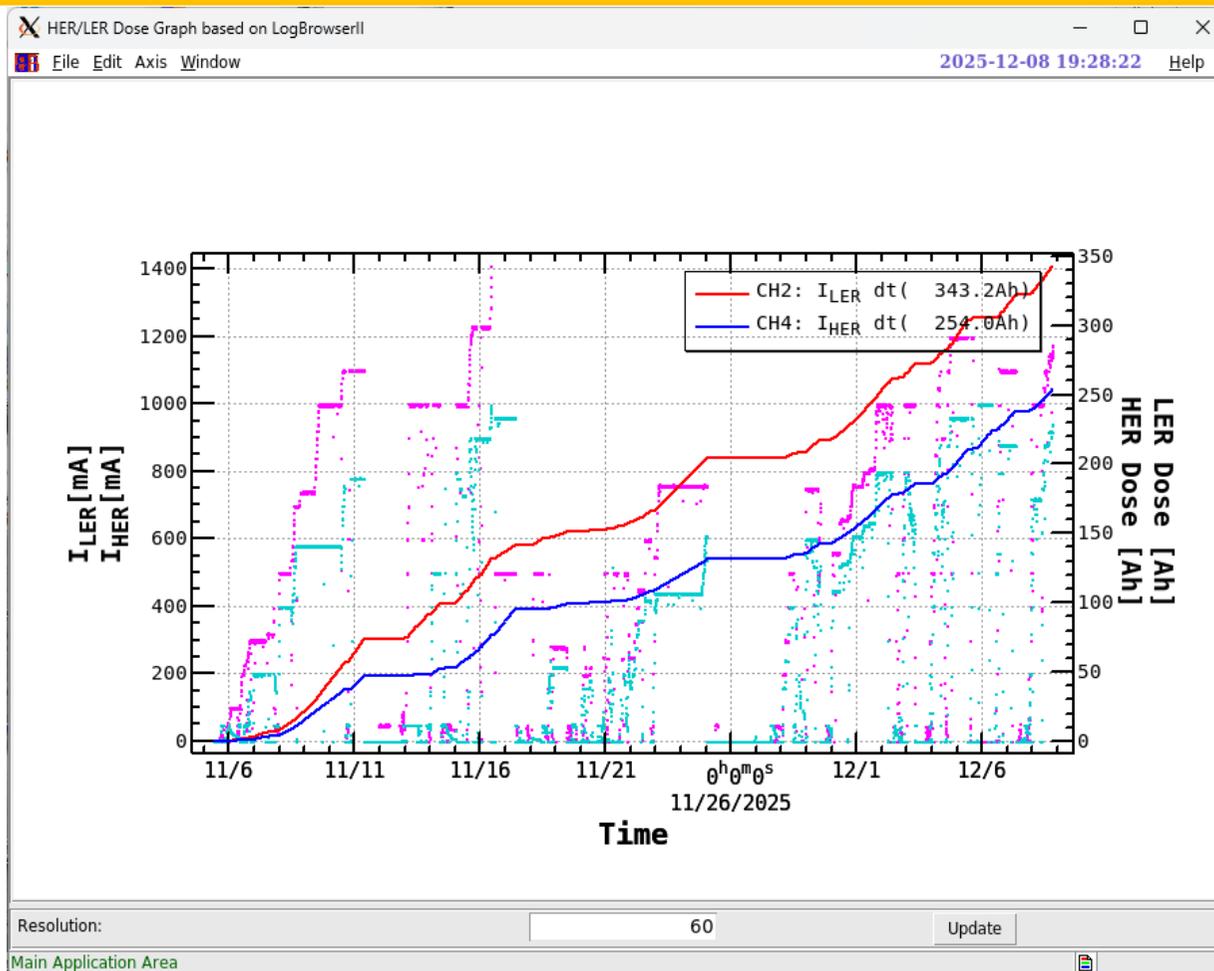
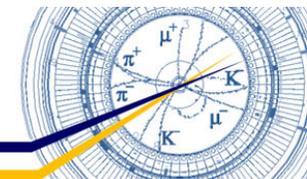
Makoto Tobiyama  
KEK Accelerator Laboratory  
(on behalf of SuperKEKB Accelerator Team)



Peak L 3.424 [ $10^{34}/\text{cm}^2/\text{s}$ ] @ 2025-12-15 20:37 HER  $I_{\text{peak}}$ : 1100.1 [mA]  $\beta_{x/y}^*$ : 60./ 1.00 [mm]  $n_b$ : 2346  
Int. L/day 1.088 / 1.290 [fb] LER  $I_{\text{peak}}$ : 1407.1 [mA]  $\beta_{x/y}^*$ : 60./ 1.00 [mm]  $n_b$ : 2346



# Vacuum scrubbing

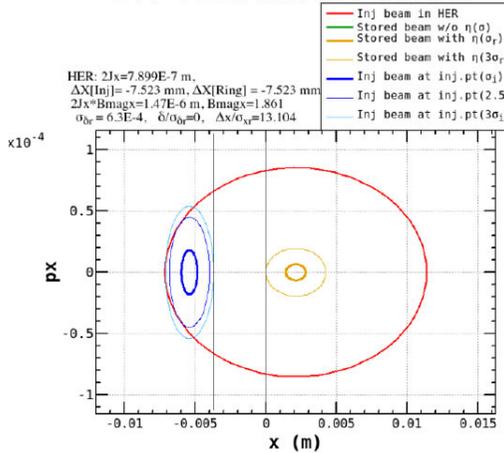


# HER: synchrotron injection

N. Iida,

BI w/o cancel coil

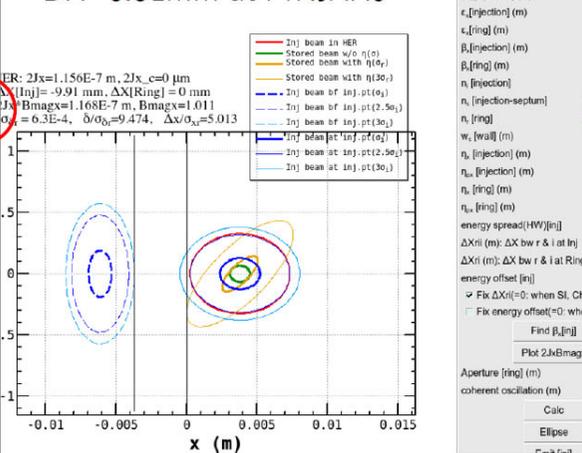
DX=7.523mm at PINJAX0



Parameter	Value
$\gamma_e$ [injection] (m)	1.40E-4
$\epsilon_x$ [injection] (m)	1.02E-8
$\epsilon_y$ [injection] (m)	4.60E-9
$\beta_x$ [injection] (m)	31.5950
$\beta_y$ [injection] (m)	108.366
$n_x$ [injection]	2.50
$n_y$ [injection-septum]	3.00
$n_x$ [ring]	3.00
$n_y$ [ring]	3.00
$w_x$ [wall] (m)	.0037
$n_x$ [injection] (m)	.0000
$n_y$ [injection] (m)	.0000
$n_x$ [ring] (m)	.0000
$n_y$ [ring] (m)	.0000
energy spread(HW)[inj]	.00175
$\Delta X_{in}$ (m): $\Delta X$ bw r & i [I]	-.00752
$\Delta X_{ri}$ (m): $\Delta X$ bw r & i at [R]	-.00752
energy offset [inj]	.00
Aperture [ring] (m)	7.90E-7
coherent oscillation (m)	5.22E-7

SI  $\beta y^* = 0.9\text{mm}$ , CW60% w/o cancel coil

DX=9.91mm at PINJAX0



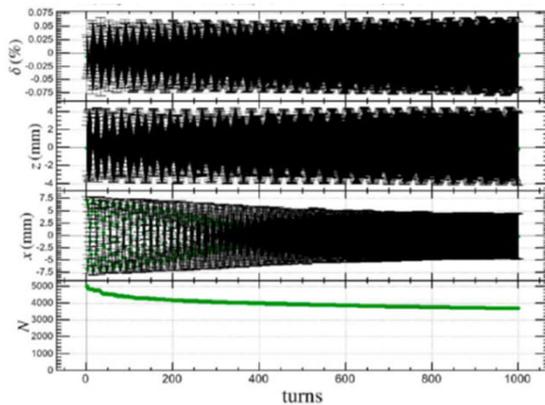
Parameter	Value
$\gamma_e$ [injection] (m)	1.40E-4
$\epsilon_x$ [injection] (m)	1.02E-8
$\epsilon_y$ [injection] (m)	4.60E-9
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$\beta_y$ [injection] (m)	108.366
$n_x$ [injection]	2.50
$n_y$ [injection-septum]	3.00
$n_x$ [ring]	3.00
$n_y$ [ring]	3.00
$w_x$ [wall] (m)	.0037
$n_x$ [injection] (m)	.0000
$n_y$ [injection] (m)	.0000
$n_x$ [ring] (m)	.0000
$n_y$ [ring] (m)	.0000
energy spread(HW)[inj]	.00175
$\Delta X_{in}$ (m): $\Delta X$ bw r & i [I]	-.00752
$\Delta X_{ri}$ (m): $\Delta X$ bw r & i at [R]	-.00752
energy offset [inj]	.00
Aperture [ring] (m)	7.90E-7
coherent oscillation (m)	5.22E-7

**Betatron injection (BI):**

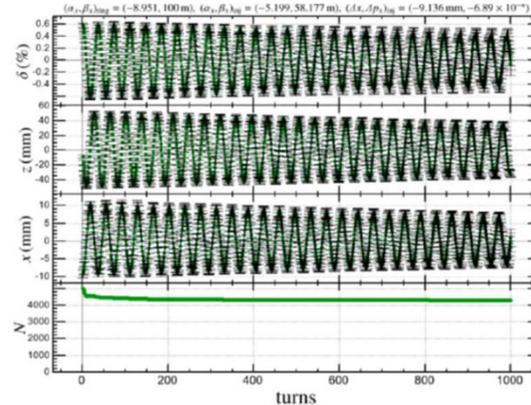
conventional method at SuperKEKB, horizontal distance at the injection region ( $\Delta X$ ) goes to betatron (horizontal) oscillation

**Synchrotron injection (SI):**

proposed method at SuperKEKB, horizontal distance at the injection region ( $\Delta X$ ) goes to synchrotron oscillation



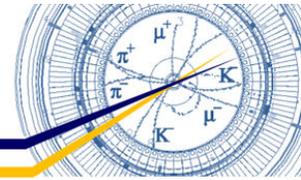
~75%



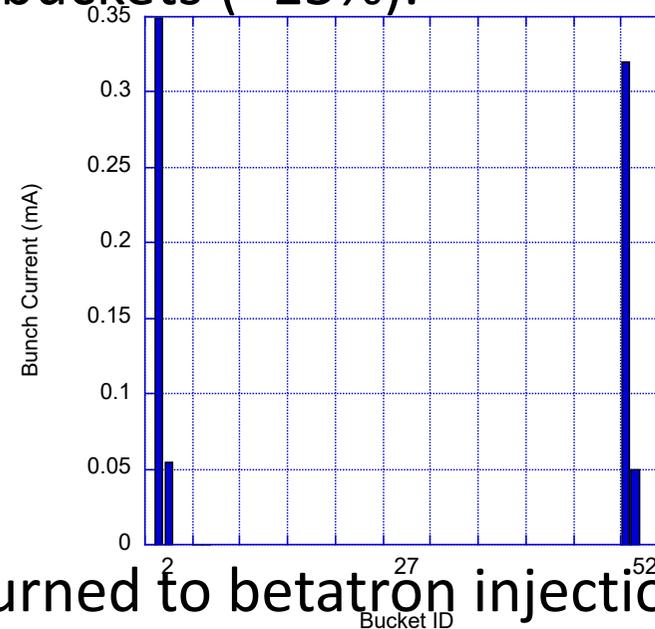
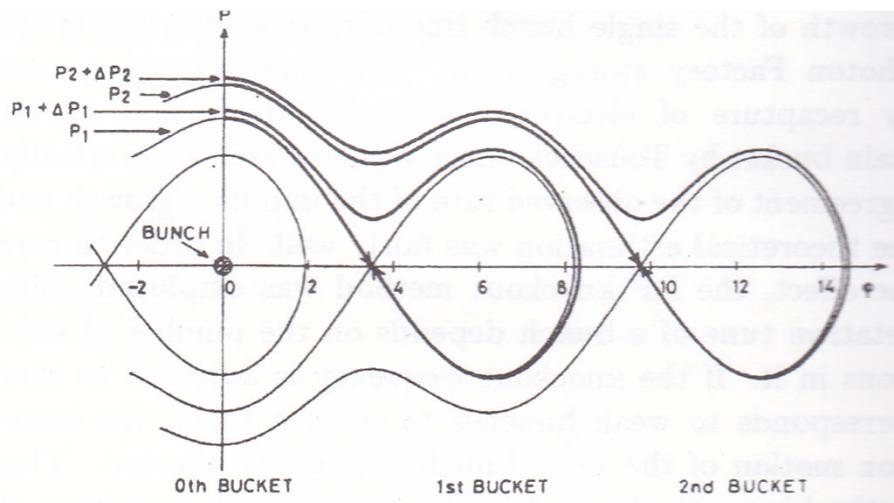
~85%

In synchrotron injection, beam-beam effects can be reduced, then the beam injection efficiency will come improved.

# Synchrotron Injection of HER

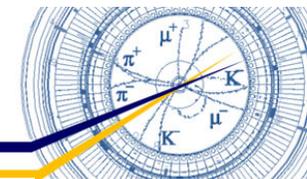


- For the collision optics with by\*~8 mm to 1 mm, we have struggled to get a good injection efficiency, but it did not work out for a higher repetition rate of larger than 12.5Hz.
- Significant charge leak to the following buckets (~15%).

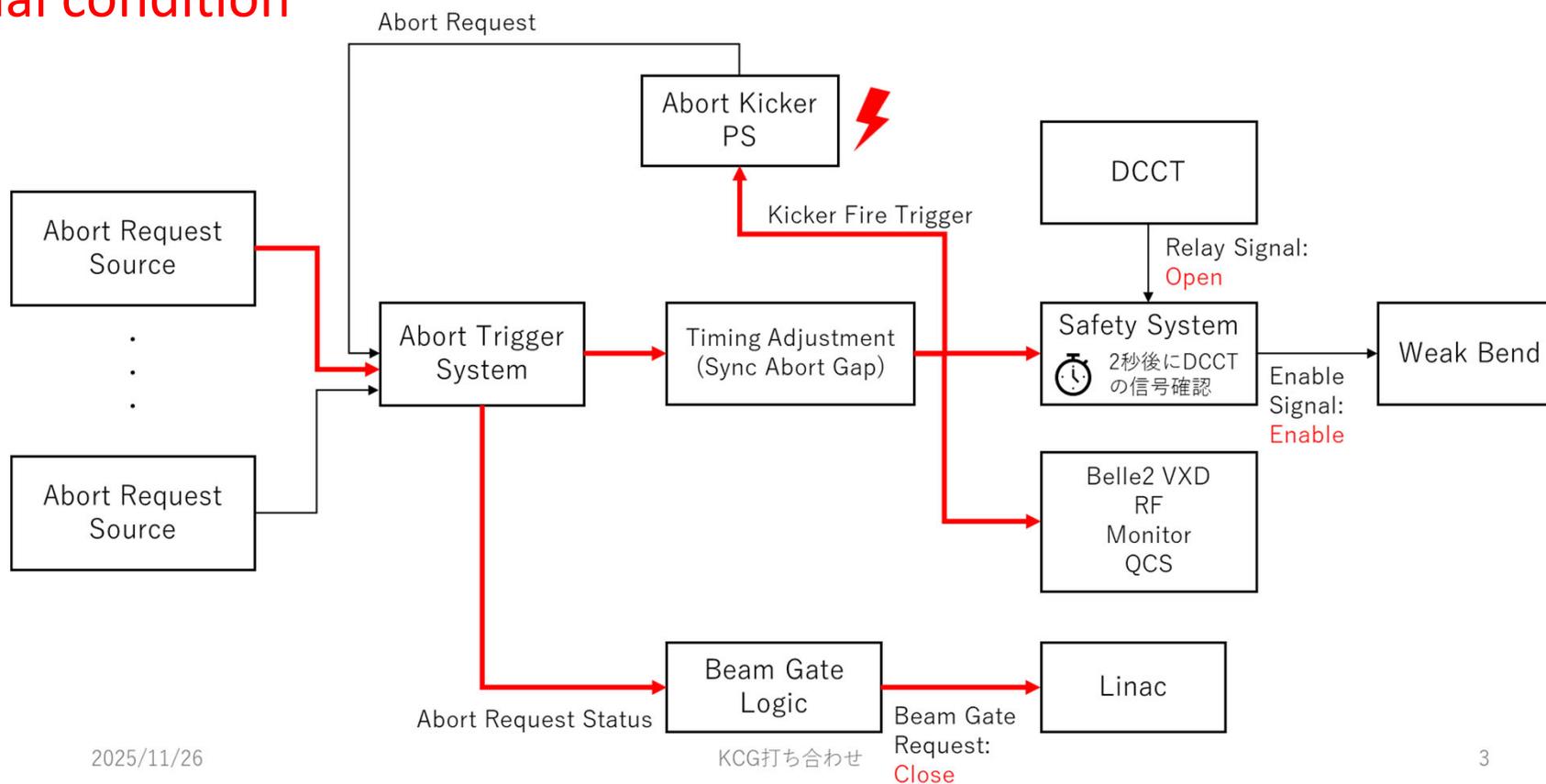


- Given up synchrotron injection and returned to betatron injection.

# HER beam abort kicker malfunctioning



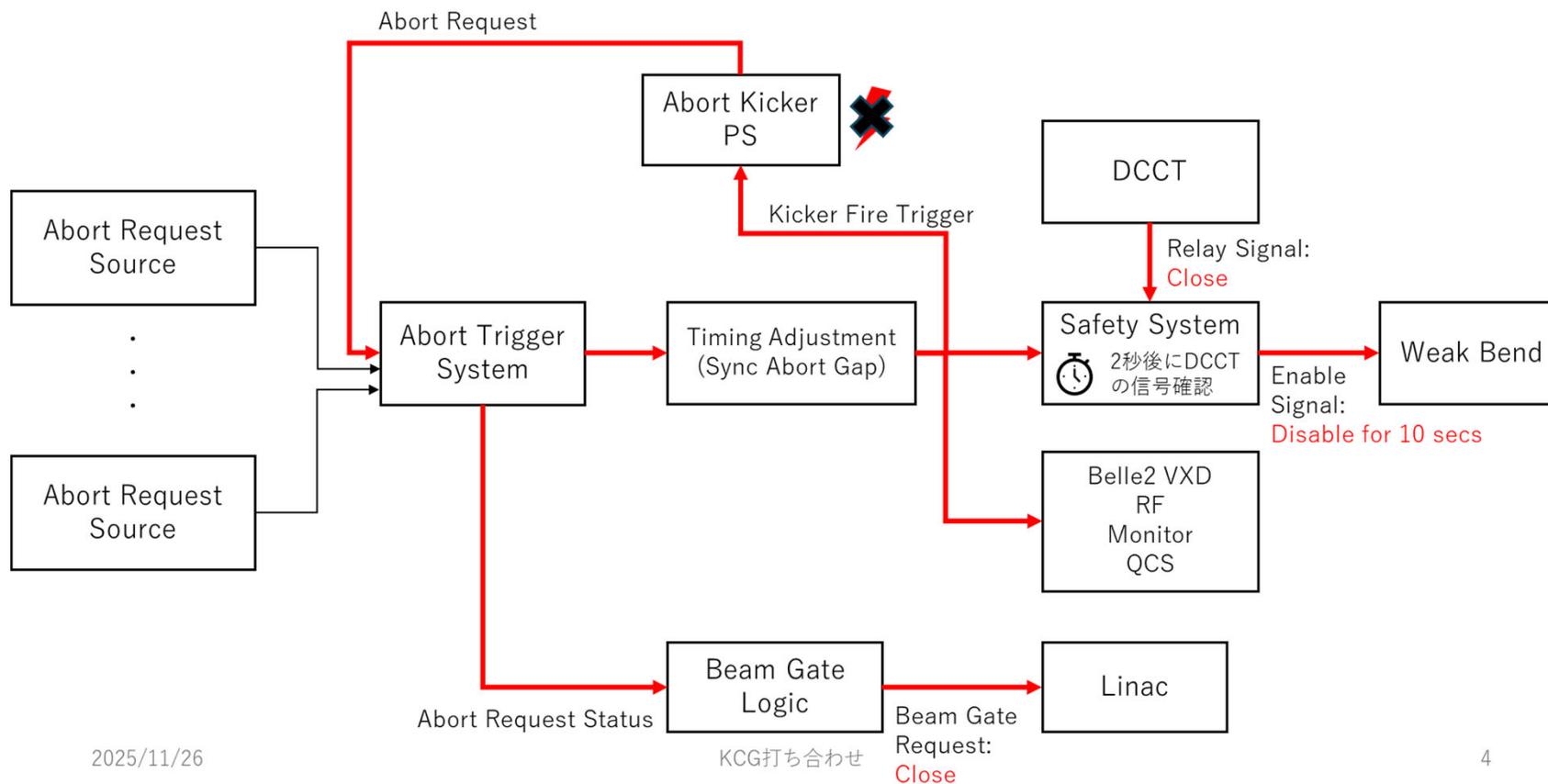
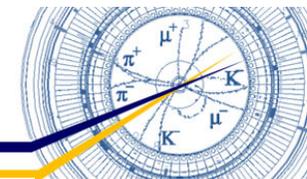
## Normal condition



2025/11/26

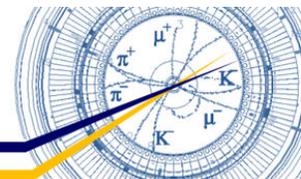
3

# Abort kicker malfunctioning

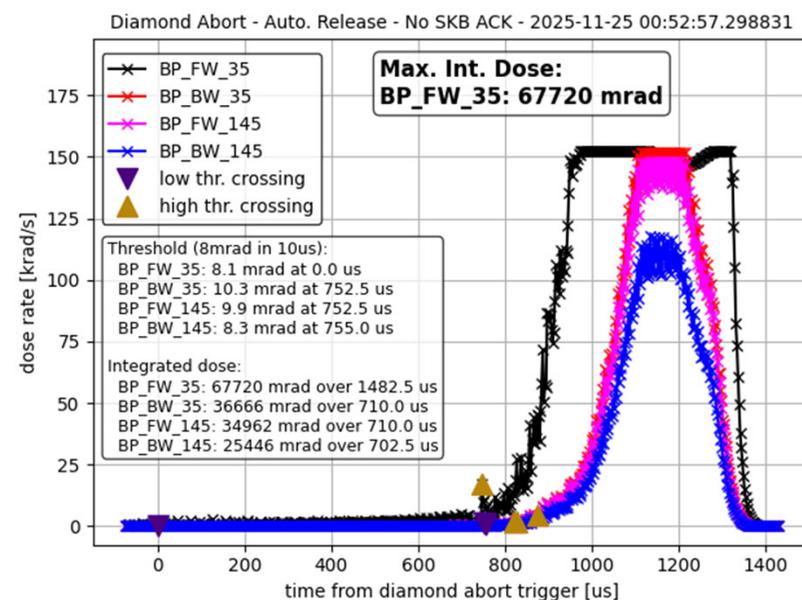


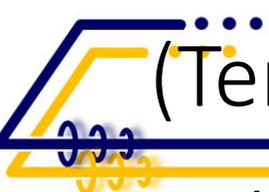
2025/11/26

4

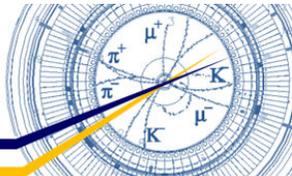


- Due to weak-bends cutoff, a large beam orbit primarily in the horizontal direction emerged with a time constant of 0.1 seconds, resulting in catastrophic beam loss.
- Simulation suggests more than 80% beam loss in the IR direction.
  - Large xy coupling.
  - Shrunk RF separatrix.
- The QCS on the L side caused a quench in all magnets, taking about 7 hours to restore the liquid level.

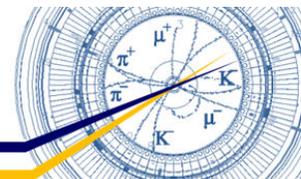




# (Temporally) countermeasure for both rings

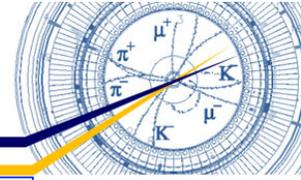


- When an abort kicker power supply malfunctions, do not issue an abort request.
  - In principle, it will not be strongly needed to abort the beam due to the malfunctioning of the abort kicker PS.
- Simultaneously with the power supply issue, we decided to send an HV shutdown request to Belle II, completed signal verification and operational confirmation at Belle II.
- During this period, we will attempt to restore the abort kicker power supply. If restored, use the abort kicker to abort the beam correctly. If restoration fails, wait until the current decays sufficiently, then drop the beam via RF off or weak-bends.
- Note: Even if the abort power supply is in an abnormal state, kicking is possible if charged. Therefore, changing the interlock logic is also under consideration.



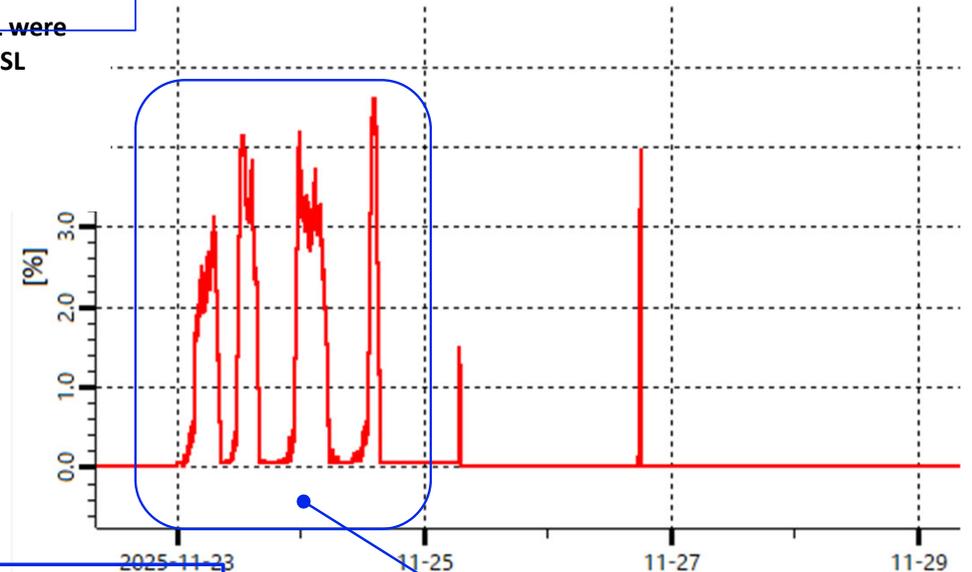
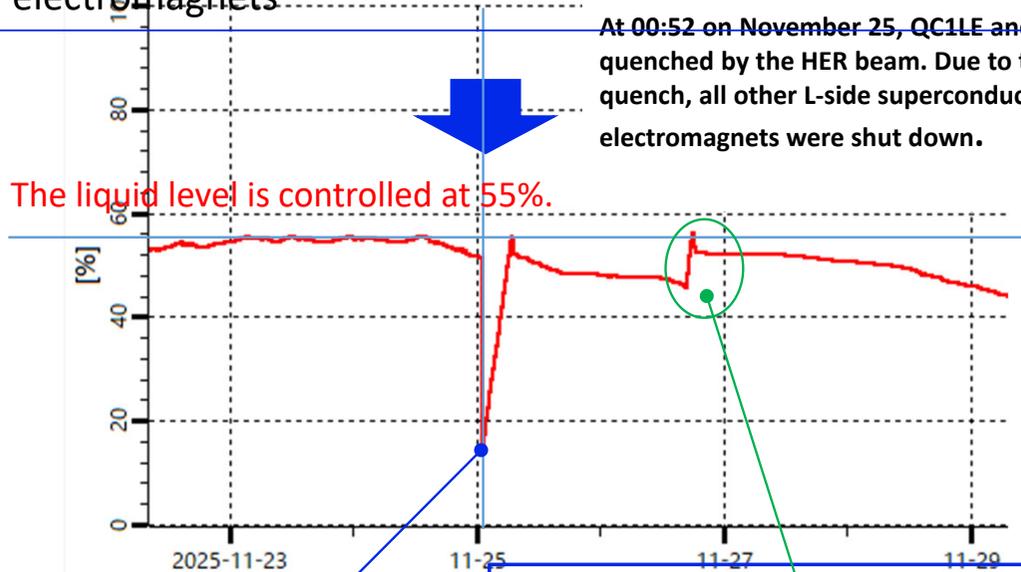
- Weak bend and RF OFF are extremely dangerous beam abort methods, so we are considering other approaches
  - (A) Control weak bend (and horizontal steering magnets) to direct the beam to a radiator that can be damaged
    - Simulation shows the beam will be crossing strong resonance lines such as 3<sup>rd</sup> slowly after  $B_y < 90\%$ .
    - Considering preparing a horizontal bump at horizontal emergency radiators.
  - (B) With RF OFF, direct the beam to a radiator located in a safe area
- In either case, we are currently studying the beam trajectory with simulation. After confirming the orbit, we will check the orbit with the real beam (with a tiny beam current).

# L-Side QCS Li-He reserver level



Liquid helium surface level near atmospheric pressure for producing supercooled liquid helium to cool QCSL superconducting electromagnets

Heater operation status to maintain liquid helium level at 55%



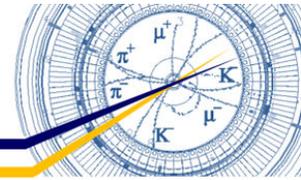
QS\_CRYO:LLIC611\_PV [%]

QCSL electromagnet quench reduced to 15%.

After system recovery from quench, the liquid level dropped to 46%. **Set all QCSL electromagnets to 0A and reduce the helium gas flow for current lead cooling to raise the liquid level.** (Reduce the heat load on the cryostat)

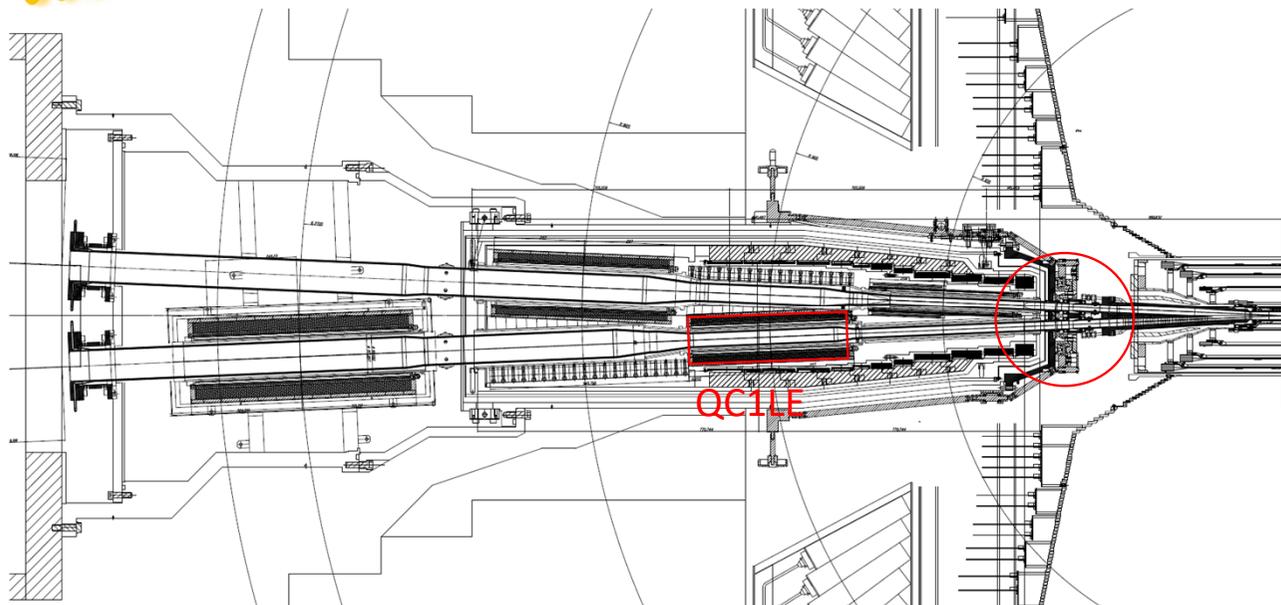
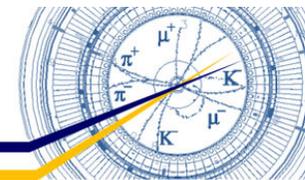
During normal operation, when the liquid helium level reaches 55% or higher, the heater inside the liquid helium container activates to maintain the level at 55%.

# Why can't we keep the Li-He level?

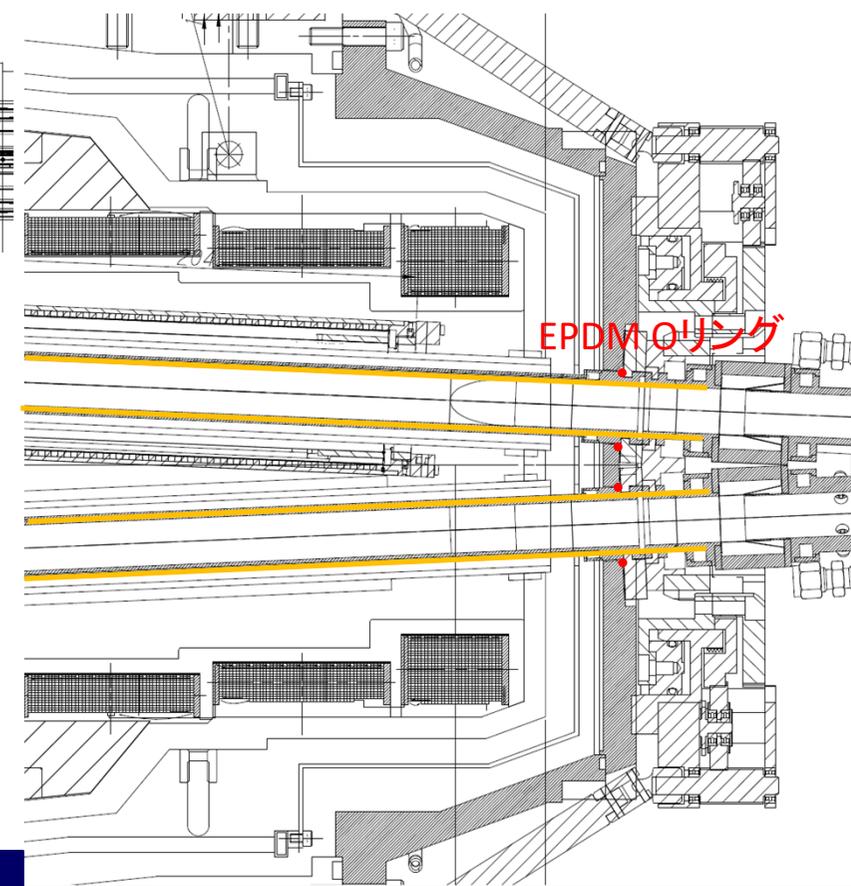


- The heat load of the QCS cryostat has increased.
  - Air leak in the thermal vacuum chamber.
  - Air leakage may have occurred due to deterioration of the O-ring at the cryostat tip, potentially causing air to condense on the surface of the liquid helium container.

# O-ring at the tip of cryostat



QCS-L side cryostat

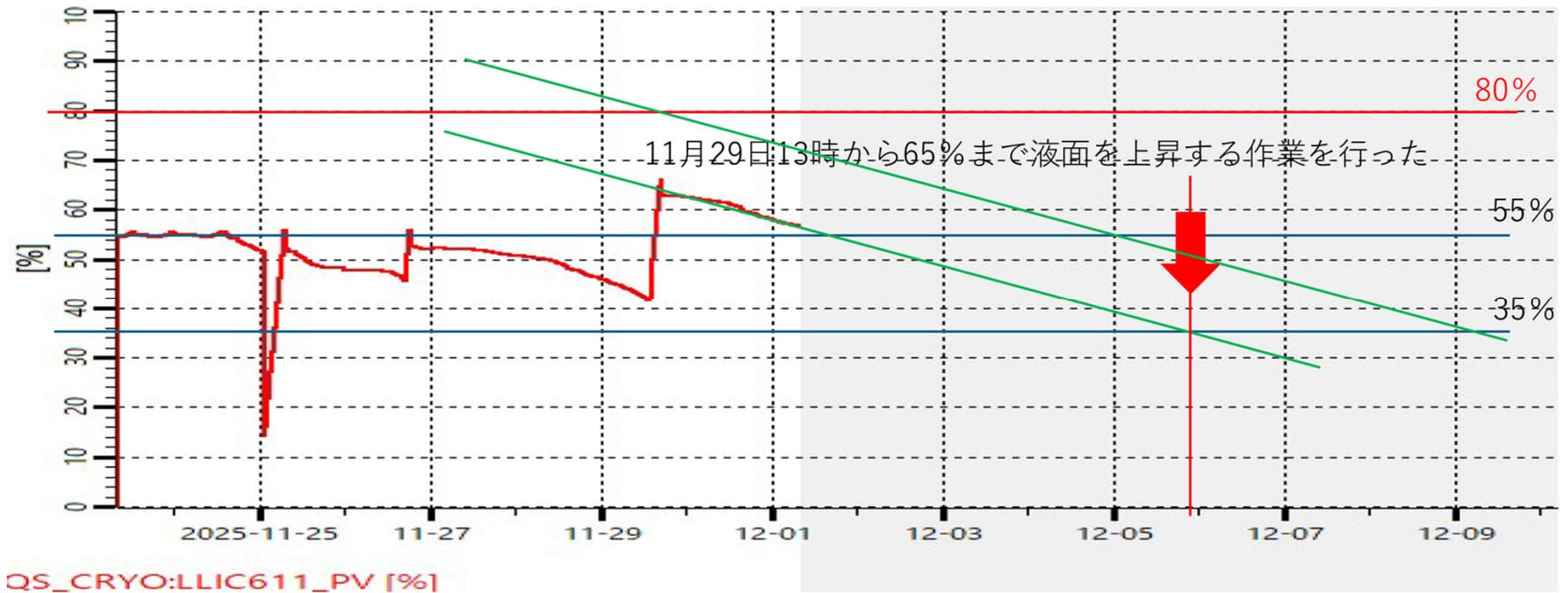
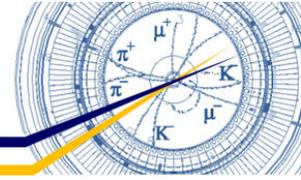


## EPDM O-ring

The vacuum vessel (vacuum layer) of the QCS cryostat is sealed from the atmosphere using the end face of the vacuum vessel and the outer circumference of the beam pipe.

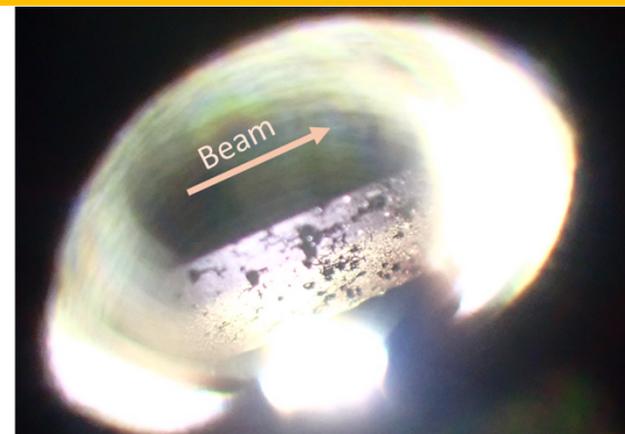
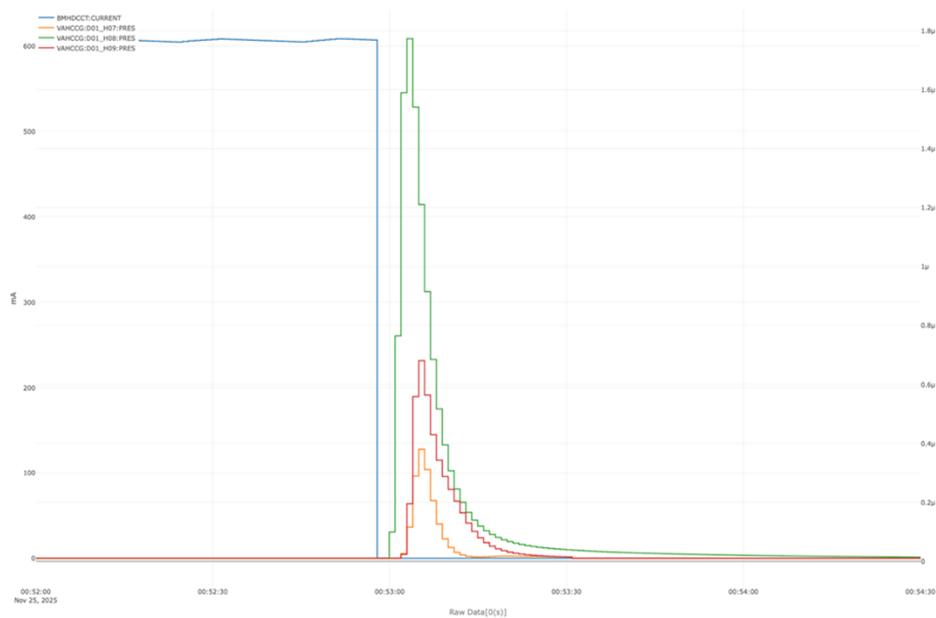
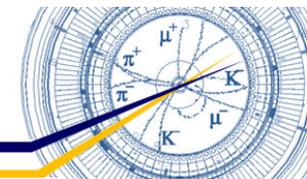


# Power off the QCS magnets and raise the liquid He level

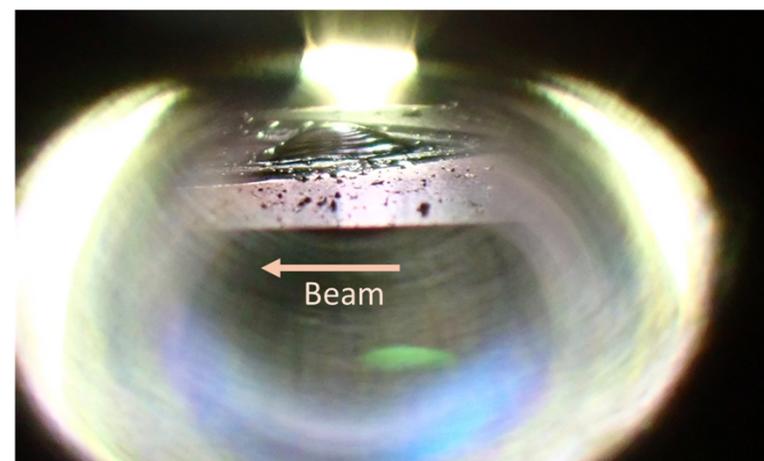


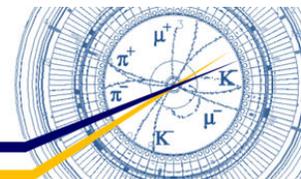
Needs roughly 8 hours to increase the Li-He level. After the process, we need to re-do the optics correction (8h)

# D1V1 collimator head has been damaged



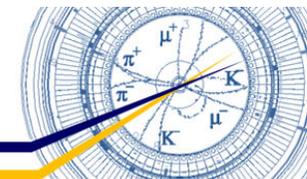
D01V1 BOTTOM



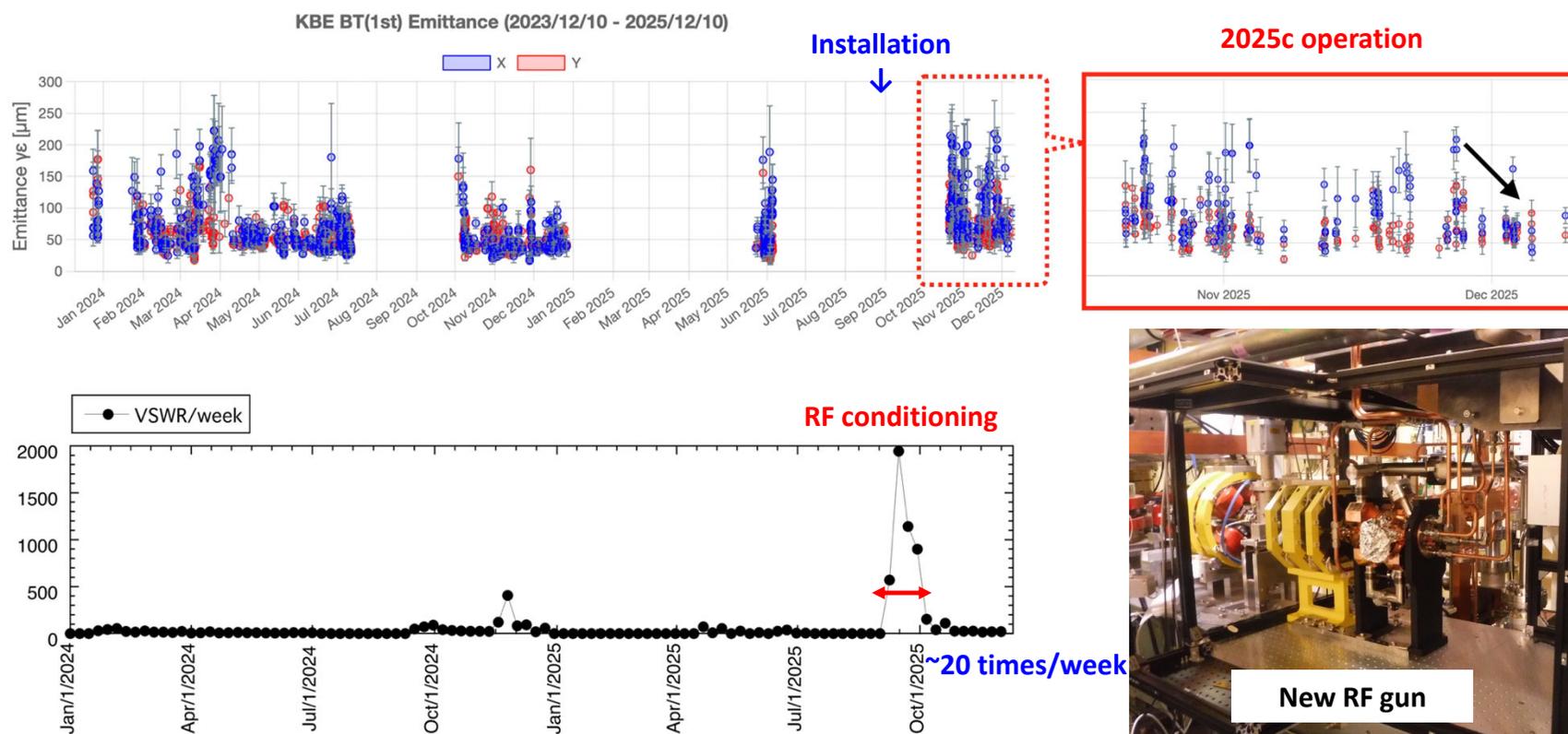


- By moving the damaged vertical collimator 1.5 mm horizontally and adjusting the other vertical collimators, we are currently able to continue operation while keeping the background to the Belle II detector within acceptable limits.
- However, this situation results in the vertical collimator being significantly narrowed, considerably reducing the HER's injection efficiency.

# Injector / injection efficiency

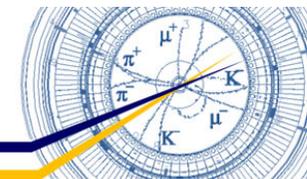


- New RF gun operation status  
Emittance and frequency of VSWR at the same level as before



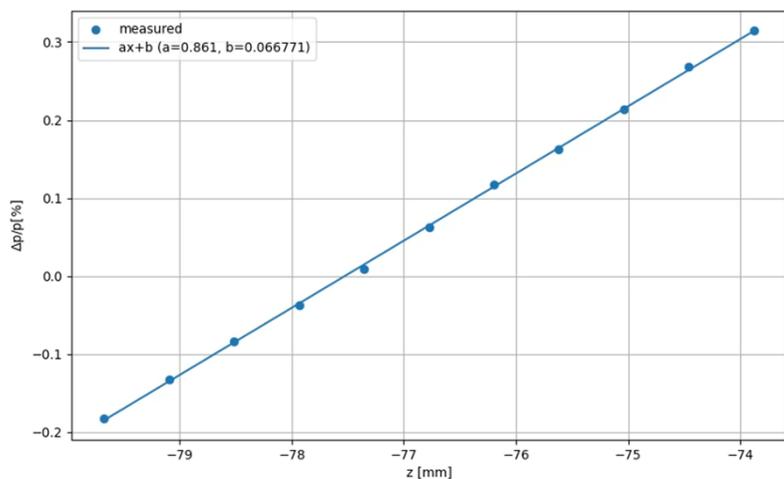
By M. Yoshida et al.

# Injector / injection efficiency



- Electron ECS operation status  
 Design  $V_c = 100$  MV and  $R_{56} = -0.7$ m attained  
 Energy compression confirmed

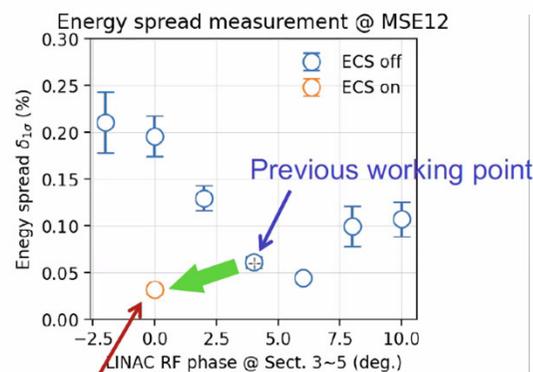
Measured voltage : 100.08 MV



By T. Natsui

## BTe-ECS Verification @ MSE12

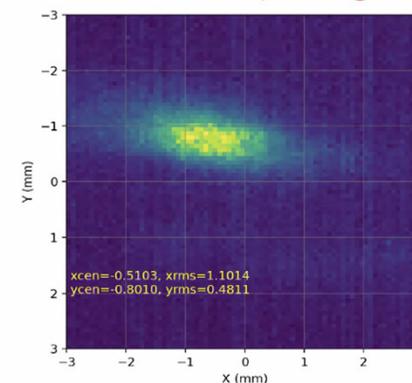
Measurement date: 20251125



Present working point

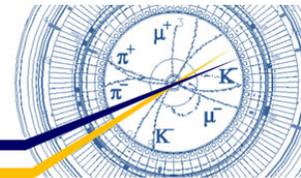
Present energy spread is  $\sim 0.032\% < \sim 0.061\%$  (2024 working point).

## Nominal beam profile @ MSE12



By T. Yoshimoto

# Injector / injection efficiency

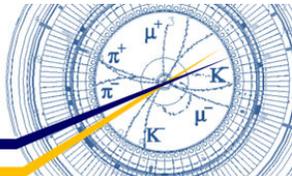


## The other studies on BT and DR for injection improvement

- BT
  - Resolution improvement of BPMs for BTe-ECS by using VME system :  $72 \rightarrow 7.5 \mu\text{m}$
  - SY3 new precise beam diagnostics line for HER  $e^-$  beam commissioned
    - Tests of new ML beam-optimization and auto-phase tuning in progress
  - Test of transverse beam-size minimization by Bayesian and Down-hill optimization with BT beam profiles (Two SR monitors required)
  - BTe new energy- and orbit-feedback
  - Disappearance of XY-coupling by revised bending magnets in BTp
  - BTe and BTp dispersion correction
  - Auto phase scanning program for both eECS and pECS
- DR
  - Successful horizontal orbit correction for only 2<sup>nd</sup>  $e^+$  bunch by using new horizontal strip-line kicker in RTL

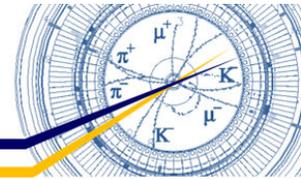


# Obstacles to High beam current storage



- Vertical emittance of injection beam.
- Beam jitter of the injection beam.
- Beam-beam related injection efficiency.
  - Increase  $B_x$  at injection point, Decrease  $B_x$  at collision point
- Vacuum burst at ARES cavities
  - A cavity that periodically deteriorates the vacuum, such as argon instability(D8).
  - ARES cavity experiencing sudden vacuum deterioration, as if due to an internal leak (D5A).

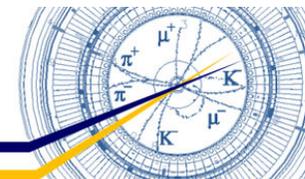
# Improvement of injection efficiency



- Optical matching between the beam transport line and the ring has significantly improved the HER's injection efficiency.
  - The results do not agree well with optical calculations, and a correction method has not yet been established.
- Two-bunch injection of LER worked well to double the injection rate.
  - The equalization of injection efficiency between Bunch 1 and Bunch 2 resulted from adjusting RTL Strip Line Kicker No. 2 and matching the energy levels of both bunches.

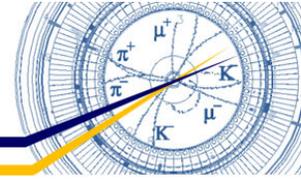


# Vertical beam size



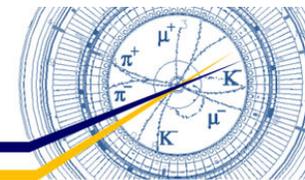
- In HER, the vertical emittance during single-beam operation has only been achieved at levels equivalent to the previous period (2024c).
  - However, there are cases where the effects of synchro-beta resonance lines can be mitigated (this depends heavily on the results of optical correction).
- In LER, a smaller vertical emittance than the previous term has been achieved.
- For the collision performance, initial concerns were raised about low specific luminosity and significant geometric deviation. However, through continued tuning, the deviation has decreased, and a specific luminosity comparable to that in the previous period has been achieved.

# Summary

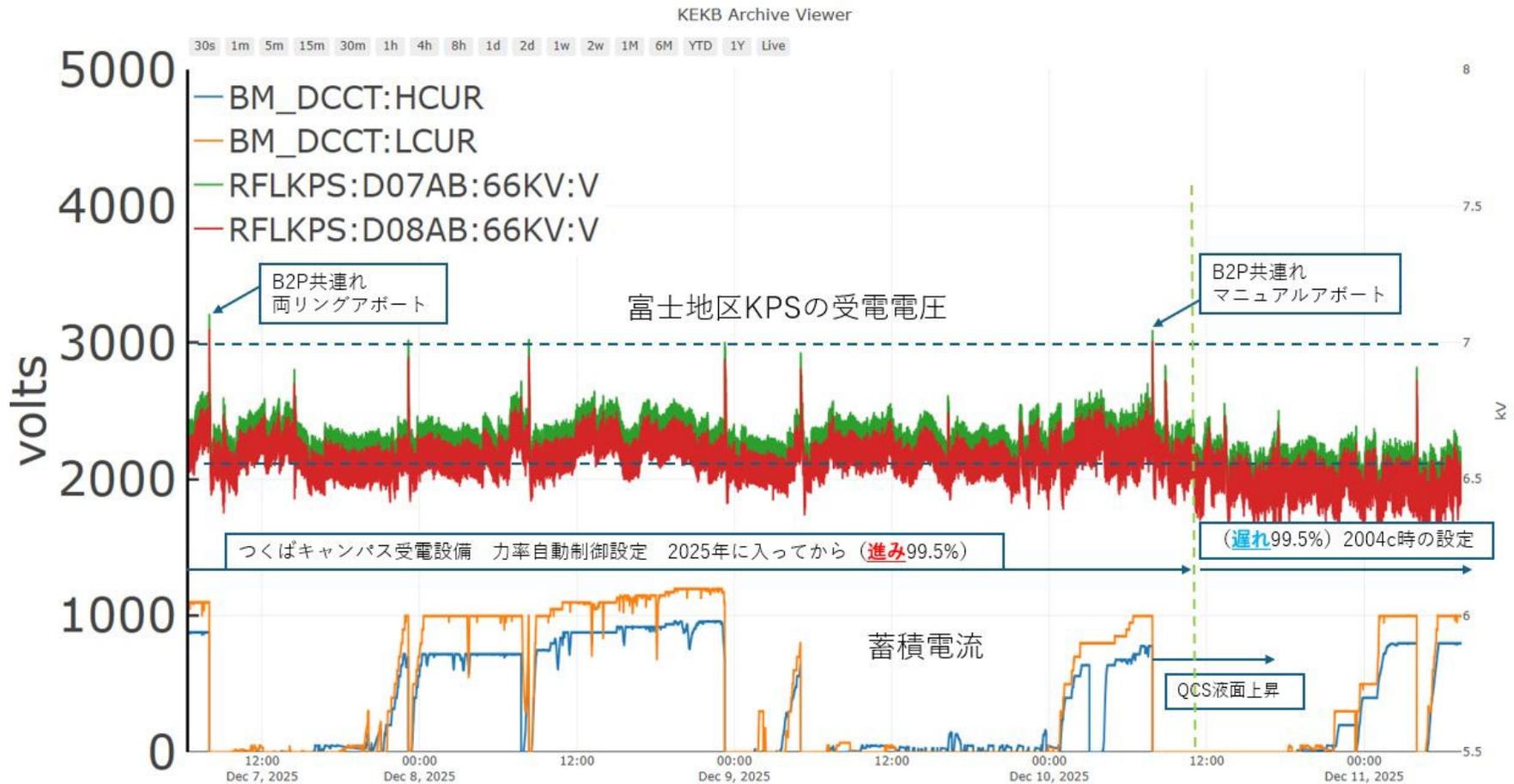
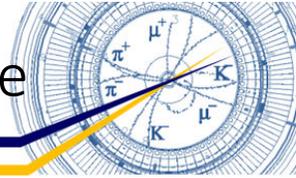


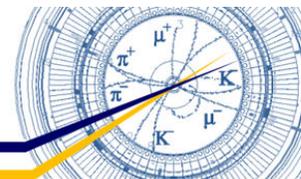
- The SuperKEKB Accelerator resumed operation as scheduled.
- We attempted synchrotron injection at HER, but due to difficulties with beam injection during collisions, we reverted to the previous betatron injection method.
- Unexpected problems have been occurring frequently, and we have not yet achieved the target performance.
  - Synchrotron injection-related troubles
  - Numerous failures associated with weak bending magnet off during HER Abort system malfunctions.
  - Large vacuum burst (internal leak?) of LER D05A ARES cavity.
  - Disruptions caused by the earthquake off the eastern coast of Aomori Prefecture
  - Difficulties to keep Liq-He level.

# Bäckup



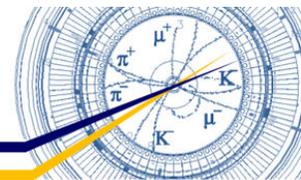
# B2P power supply down due to overvoltage of the primary 6.6kV line



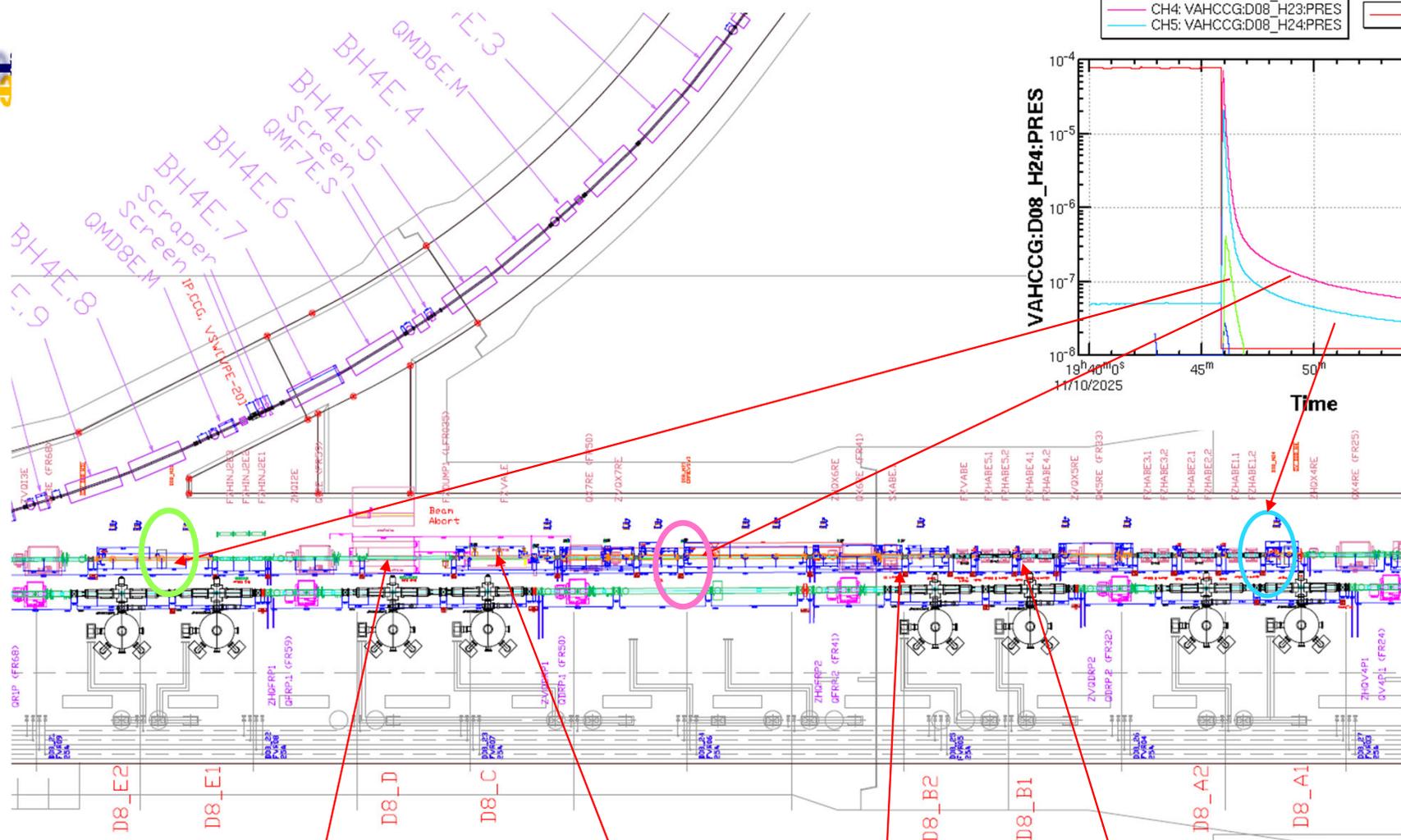


- The LER bending magnets power supply (B2P) tripped due to a primary voltage (6.6kV) overlimit interlock (occurred twice) caused by the trip of all RF sources of Fuji area due to beam abort.
- After investigating the cause with KEK's Facilities Department, it was determined that the settings for the power factor correction capacitors at KEK's power receiving section—intended to improve power efficiency—differed from those used in fiscal year 2024 (having been adjusted toward greater energy savings). These settings were reverted to their original configuration.
  - Efforts were also made on the RF side to reduce power consumption in the Fuji area.
  - After this, the B2P power supply is not interlocked.

# Synchrotron Injection for HER



- Successfully with the detuned optics, but
  - Damage the vacuum chamber wall (and flange) around the beam dump due to the aborted beam, which resulted in a large vacuum leak after one day of operation.
  - The issue was temporarily resolved by re-examining the trajectory of the abort beam and modifying it to maintain sufficient distance from the chamber wall.

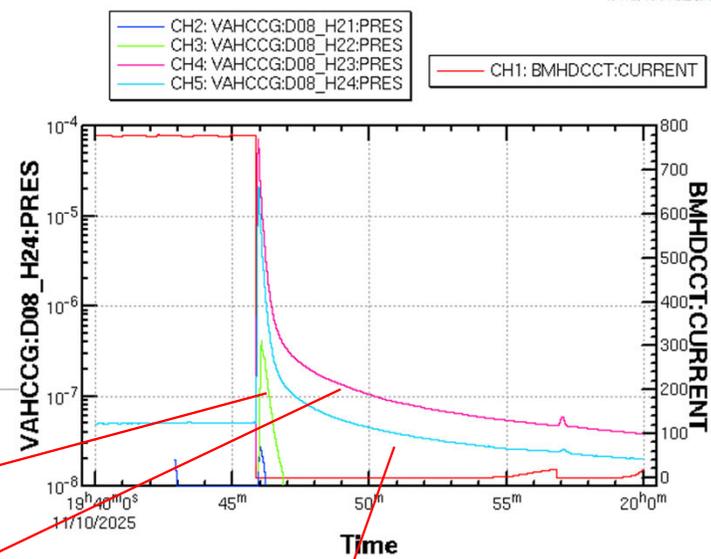


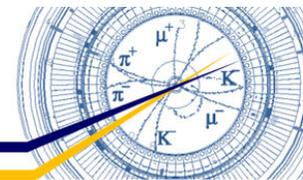
ビームダンプ

ランバートゾン

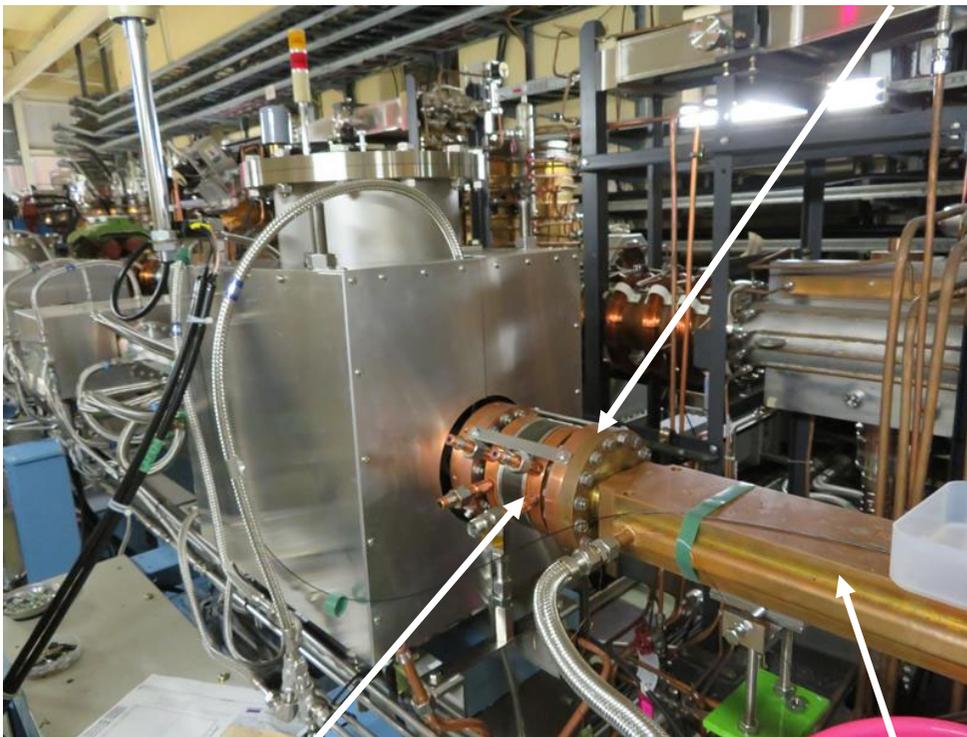
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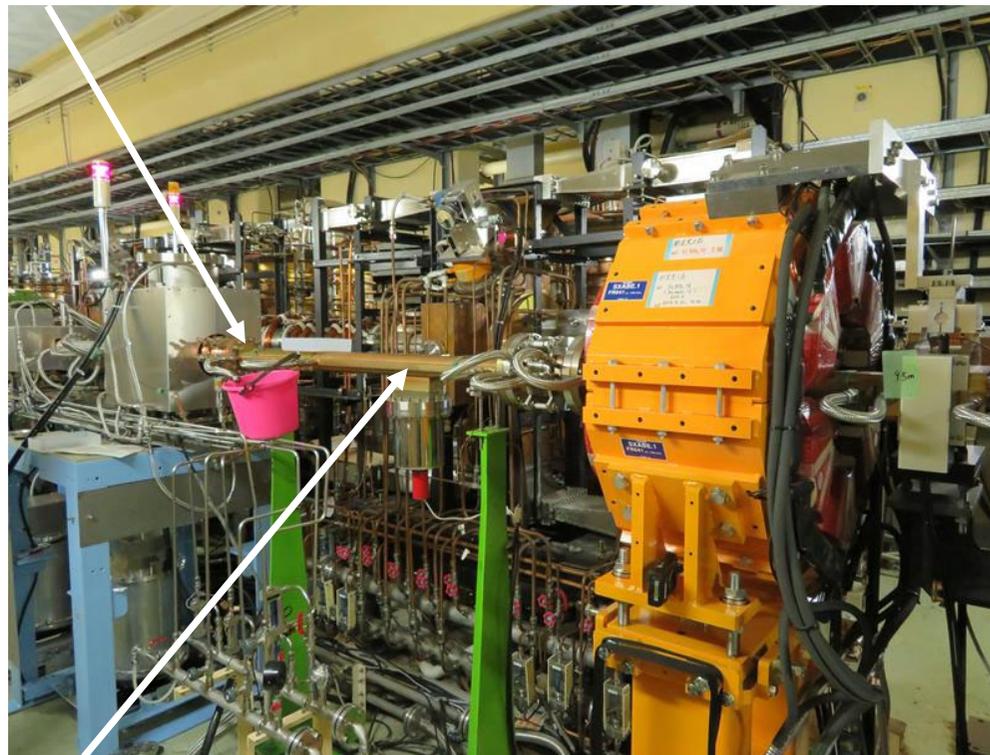




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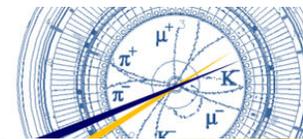


ベローズ

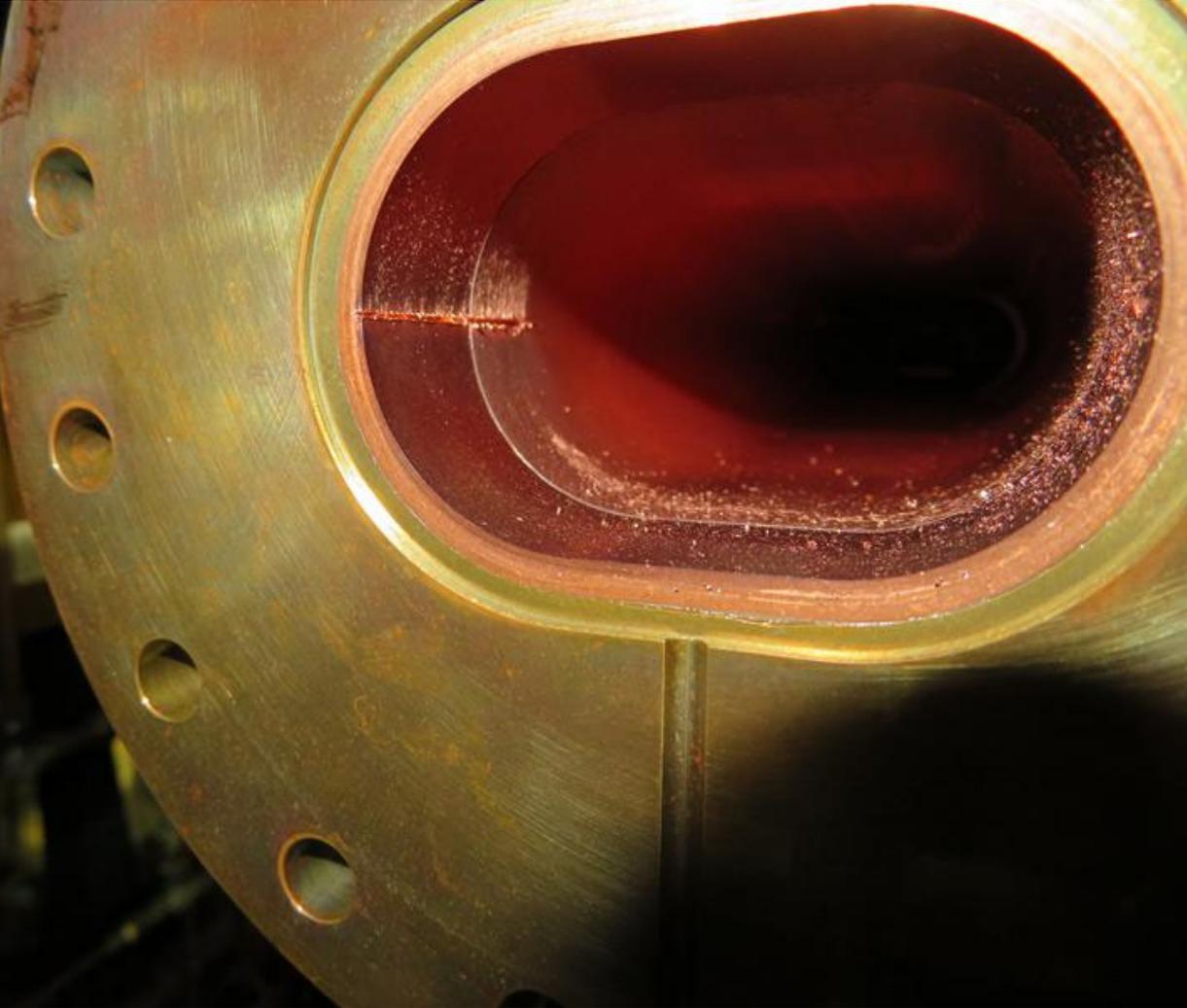


テーパークェンバー

このチェンバーでH60 x V40からH104 x V50に変換



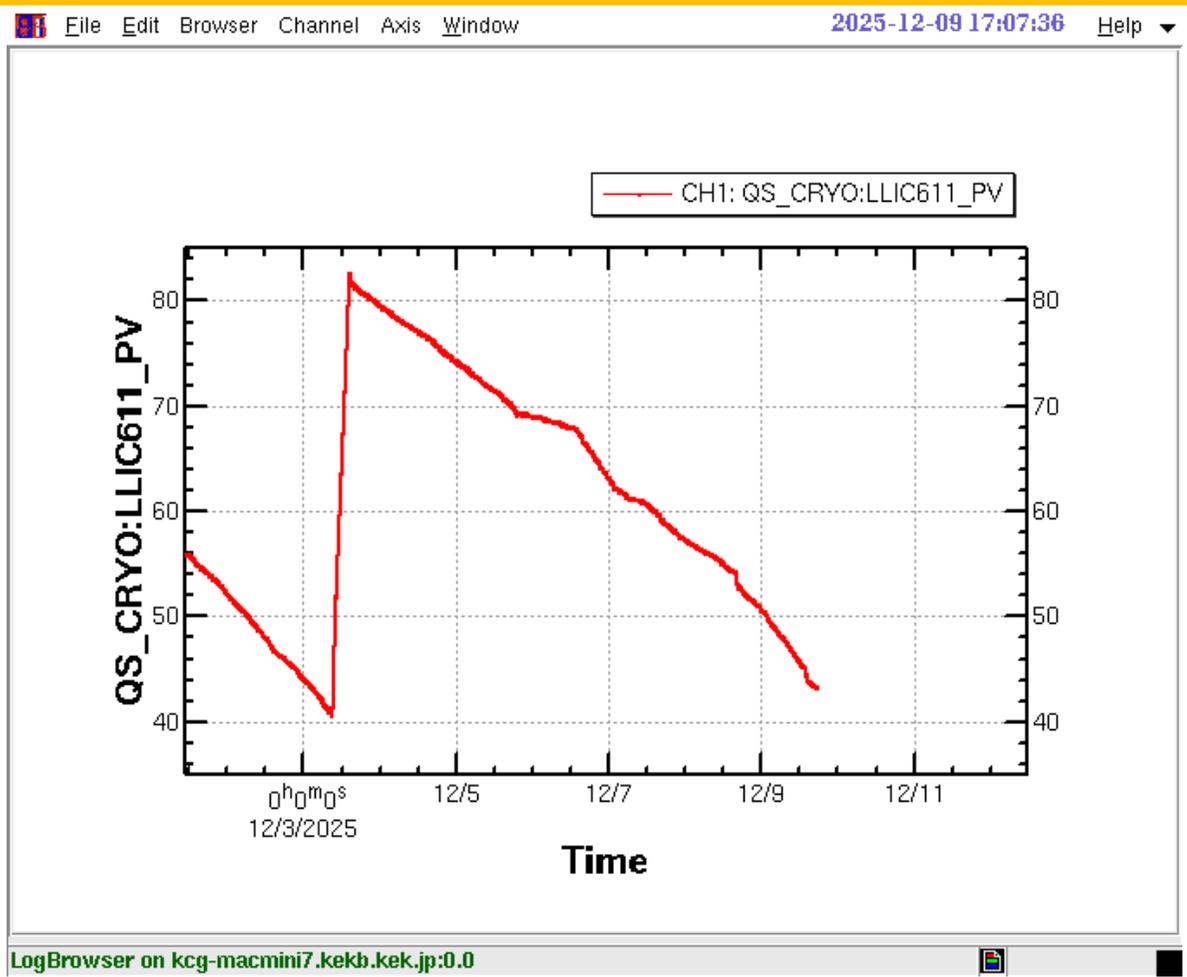
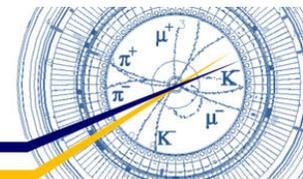
リング外側  
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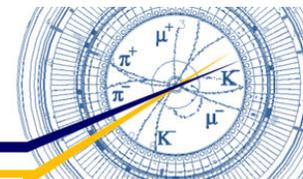


リークしたフランジの  
ヘリコフレックスガスケット

リークしたフランジ側から見たテーパ chambers







Browser Update Time : 2025/12/09 17:08:05

