QCS quench protection plan

Contents

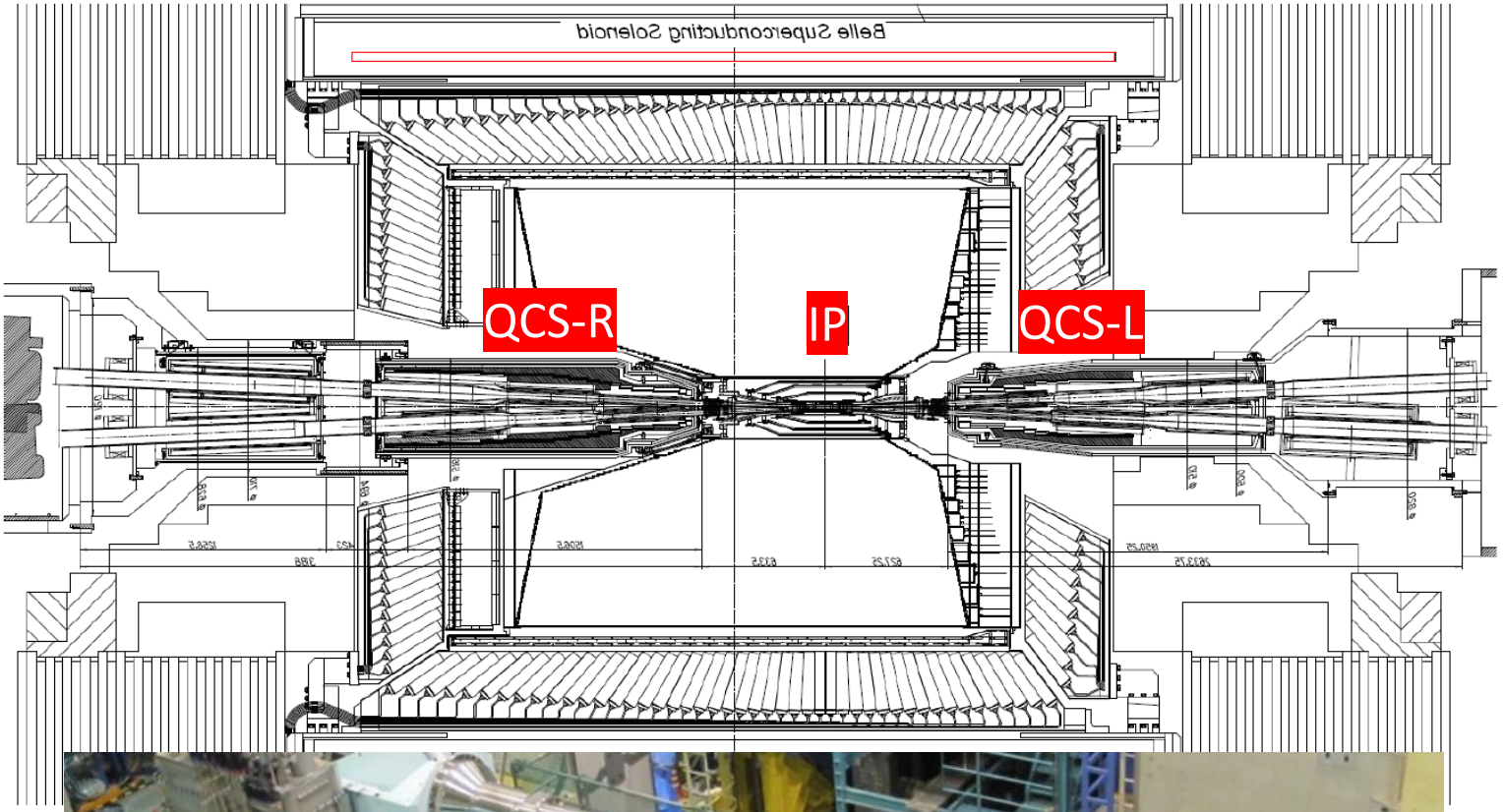
- ✓ QCS cryostats and magnets
- ✓ Quench result of phase-2
- ✓ Quench protection and monitoring systems
- ✓ Other protection plans
  - Collimator installation plan
  - Belle diamond abort system
  - Additional tungsten shield
- ✓ Summary

B2GM@KEK, 4 Feb. 2019

Xudong Wang

KEKB QCS Group

QCS cryostats (QCS-L and QCS-R)

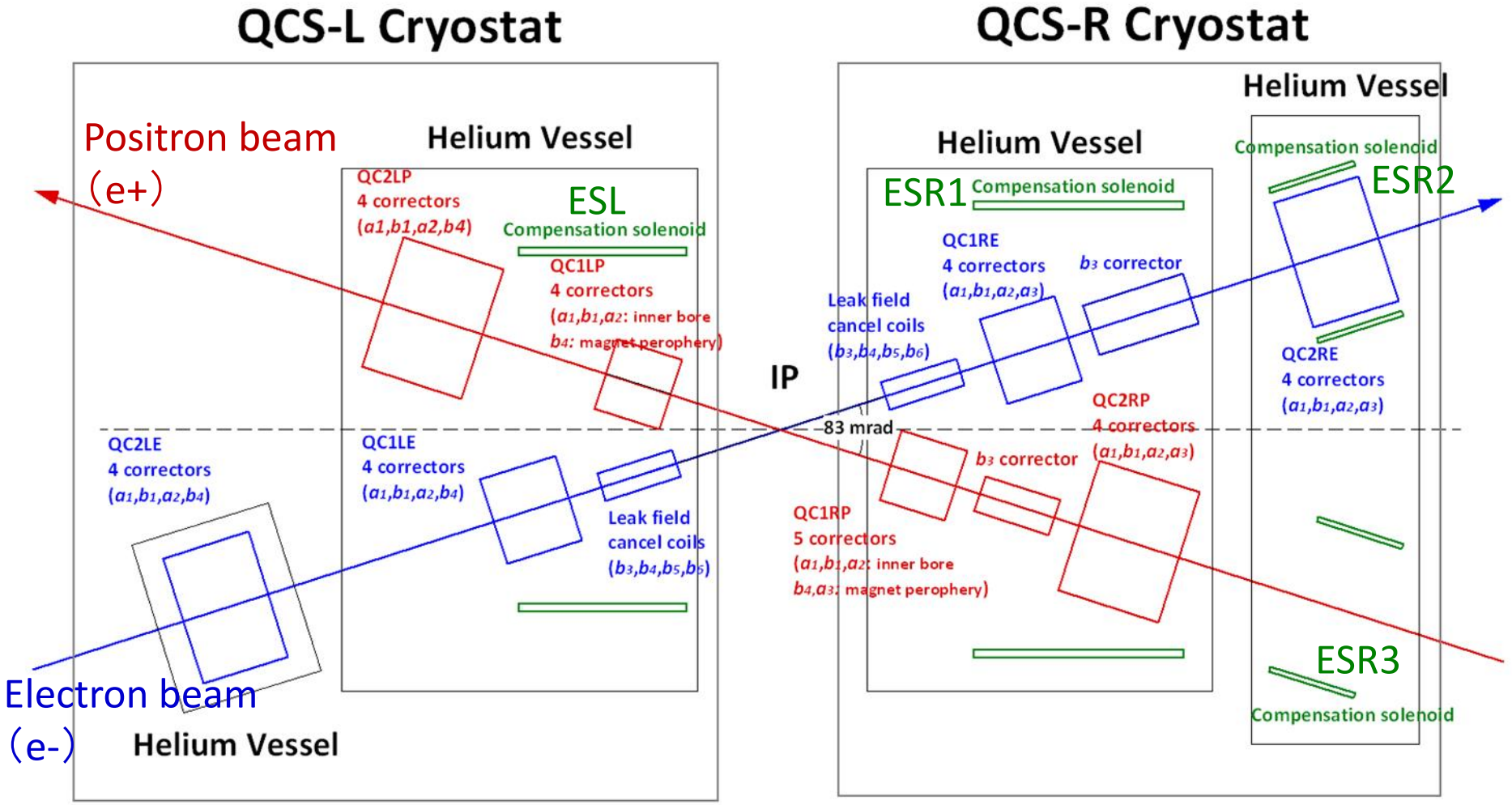


QCS magnets (54 magnets in total)

e- beam line : 4 quadrupole magnets, 17 corrector coils, and 8 cancel coils

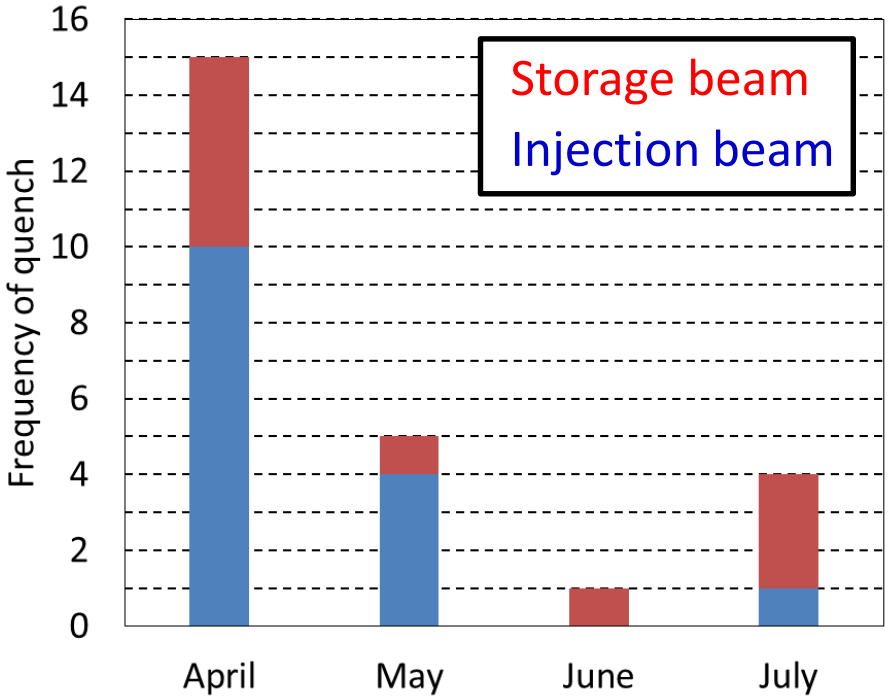
e+ beam line : 4 quadrupole magnets and 18 corrector coils

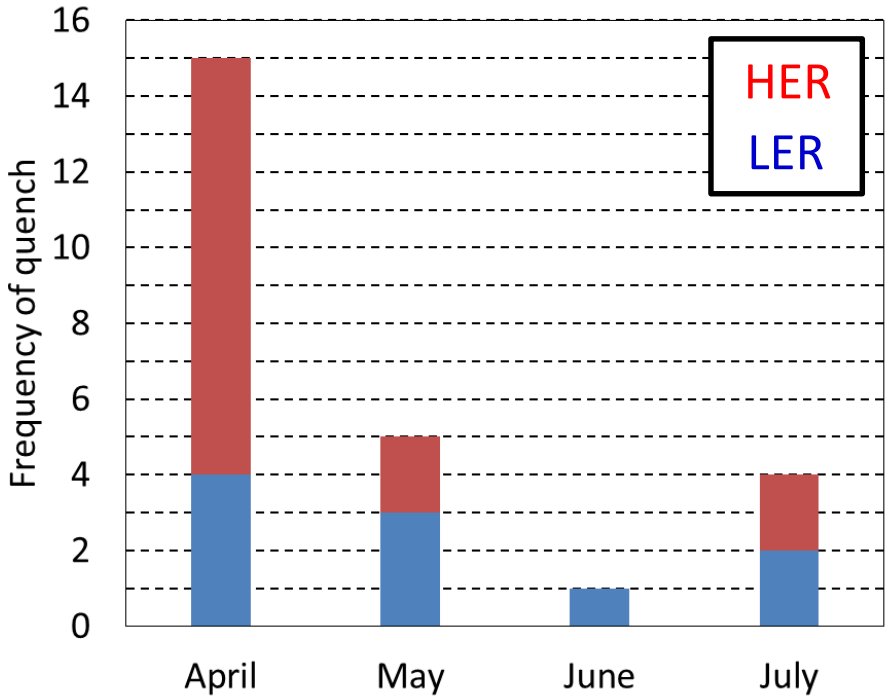
4 compensation solenoids are located on the outer surface of quadrupole magnets to cancel the influence of the Belle-II solenoid field on the collision beam.



Quench result of phase-2

25 quenches occurred around the QC1 magnets (near to the IP).





- ✓ Beam injection was not stable and the collimator was not closed in April.
- ✓ Frequency of quench dropped by closing the collimator at the end of April.
- ✓ No quench occurred from May 25 to June 25!
- ✓ Two collimators, D2V1 (LER) and D1V1 (HER), were damaged in June 25 and July 9.
- ✓ After the collimator was damaged, beam operation began to become unstable and the quench began to occur again.

Quench protection system

54 QCS magnets

Main detector

Quench detector 1

Subsidiary detector

Quench detector 2

Magnet temperature

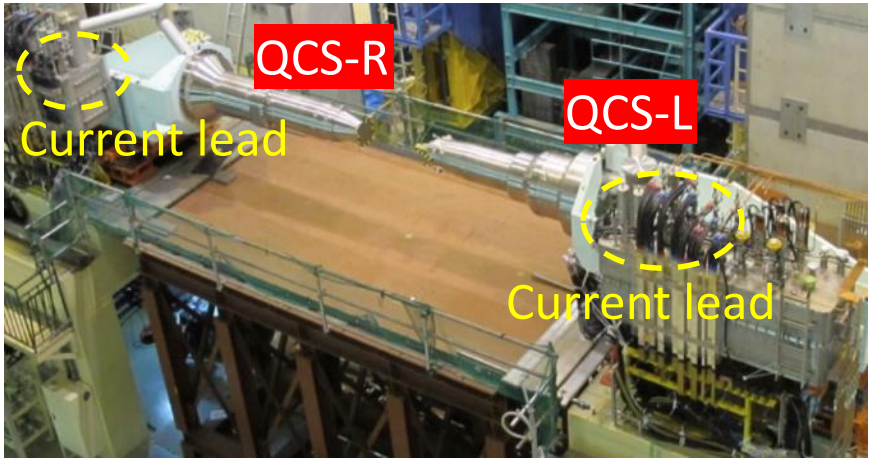
Current lead temperature

Pressure of LHe cooling line

Flow rate of current lead

Quench trigger

Power supplies in D2 building



Quench protection system

Quench detector 1 and 2

Quench detector 1

Using the **balance voltage**

= V1 - V2

- ✓ Sensitive to the resistive voltage
  Independent from the inductive voltage
- × Not detectable when V1 = V2

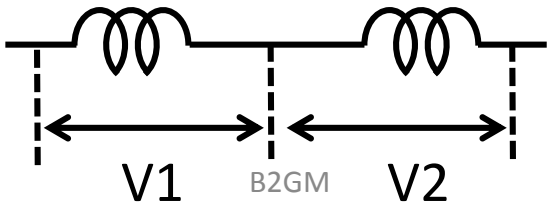
Quench detector 2

Using the **end-to-end coil voltage**

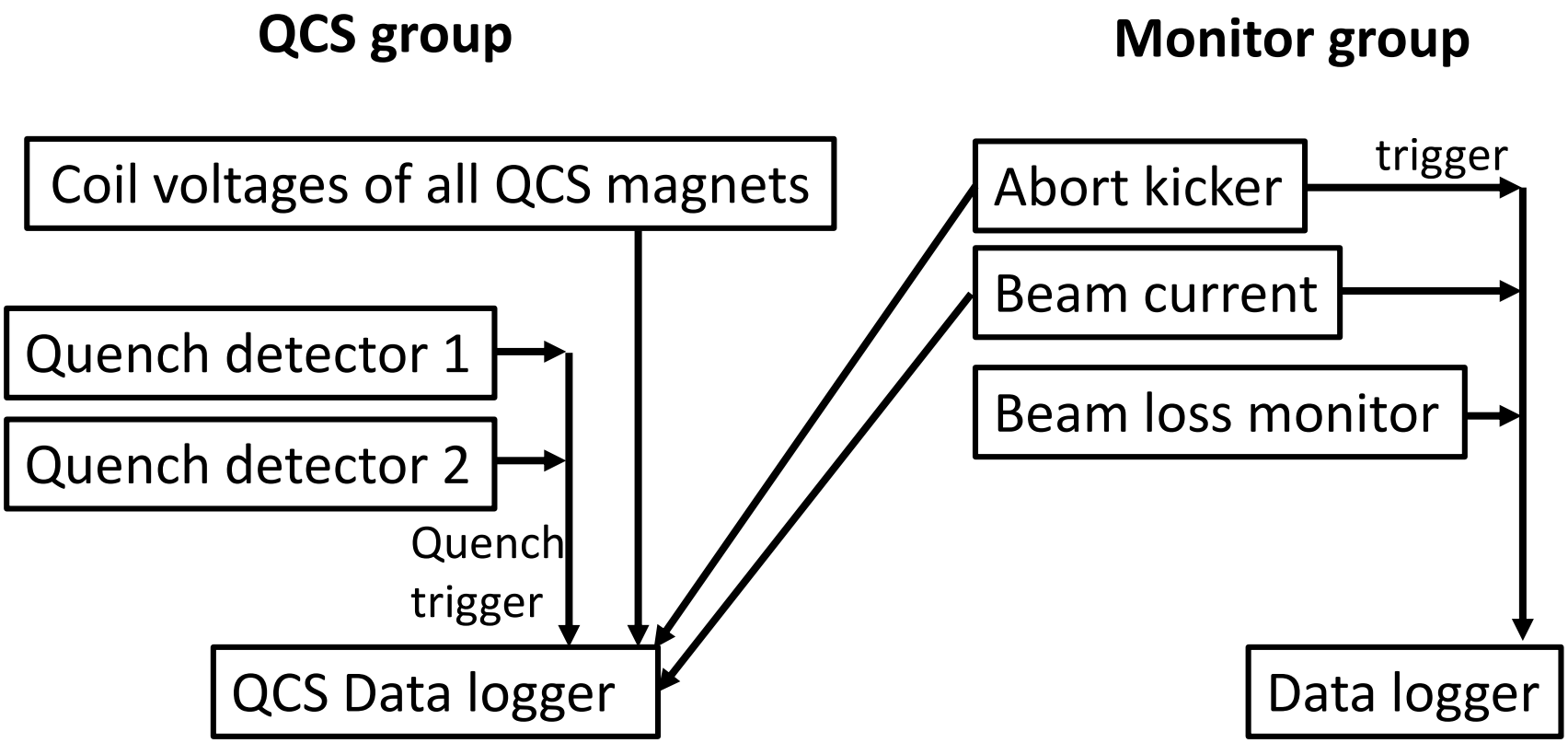
= V1 + V2

- ✓ Detectable even when V1 = V2
- × Not sensitive to the resistive voltage
  V1+V2 includes the inductive voltage

Two coil blocks of a QCS magnet

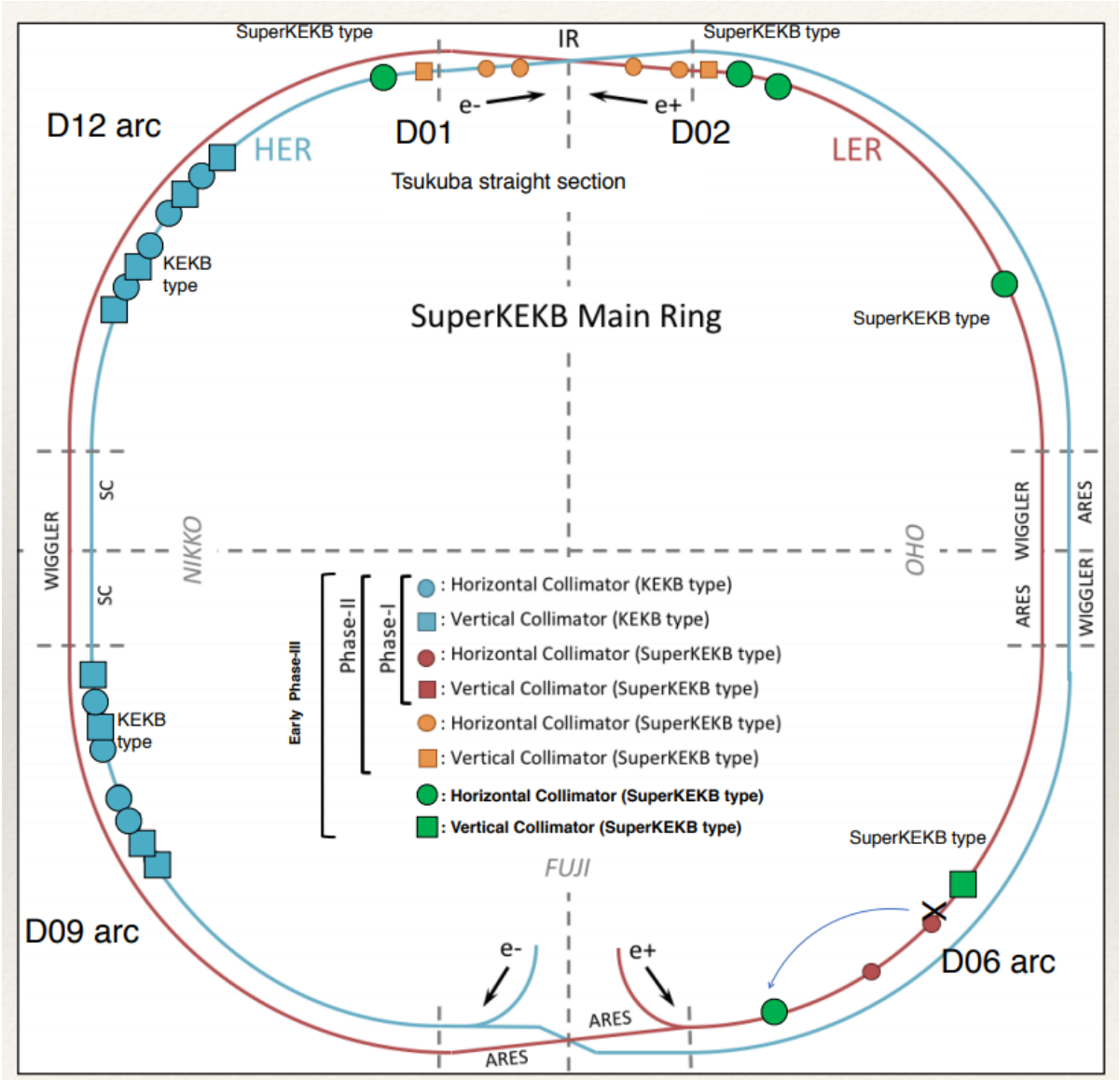


Quench monitoring system



- ✓ Coil voltages of all QCS magnets are monitored by the QCS data logger.
- ✓ We can compare the magnet voltage of QCS group with the beam loss of monitor group by using the same signals of abort kicker and beam current.

Collimator installation plan



No. of collimators

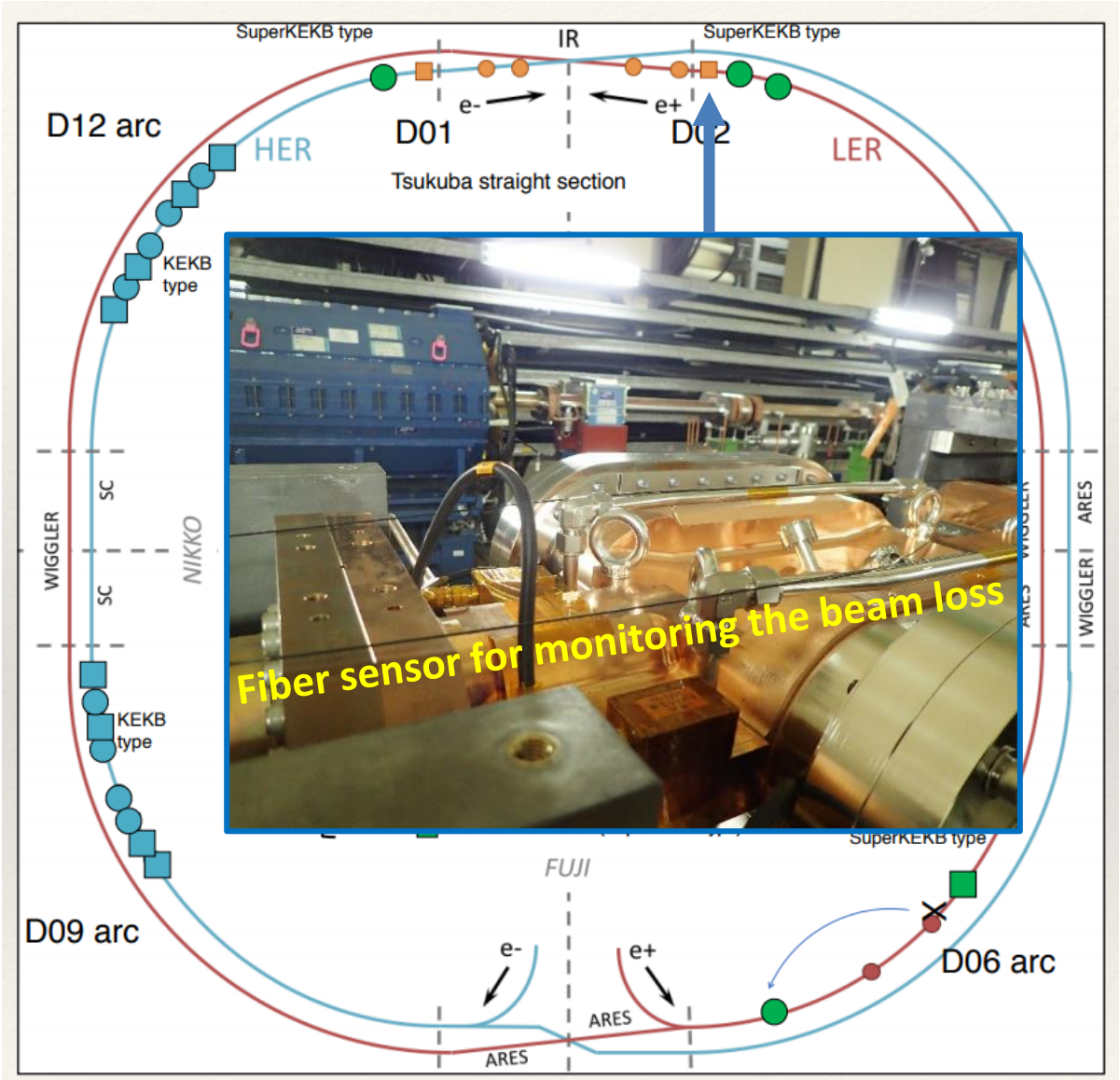
Phase-2	LER	HER
Horizontal	4	10
Vertical	1	9

The number of collimators was not enough for LER in phase-2.
The damaged collimators of D2V1 (LER) and D1V1 (HER) were replaced.

Phase-3	LER	HER
Horizontal	7	11
Vertical	2	9

LER beam loss is expected to be suppressed by the added collimators.

Loss monitor around the collimator



No. of collimators

Phase-2	LER	HER
Horizontal	4	10
Vertical	1	9

The number of collimators was not enough for LER in phase-2.
The damaged collimators of D2V1 (LER) and D1V1 (HER) were replaced.

Phase-3	LER	HER
Horizontal	7	11
Vertical	2	9

LER beam loss is expected to be suppressed by the added collimators.

Belle diamond abort system

Diamond system may prevent QCS quenches by aborting the beams.

- "slow" = **200 mRad/s** (average dose rate) in **1 second** => integral = **200 mRad**

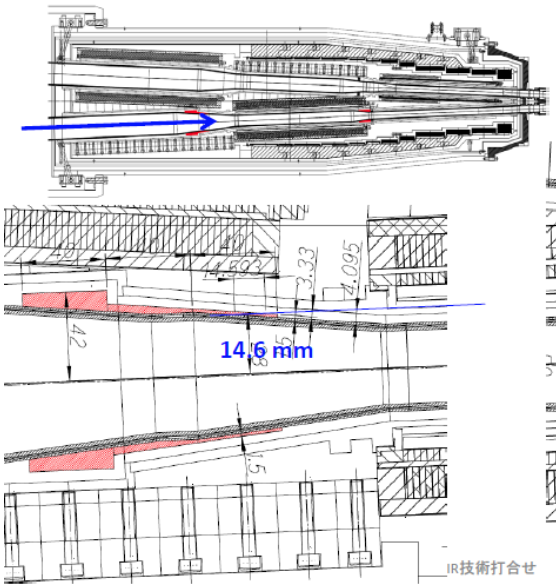
With these settings 15 out of 19 QCS quenches would have been avoided.

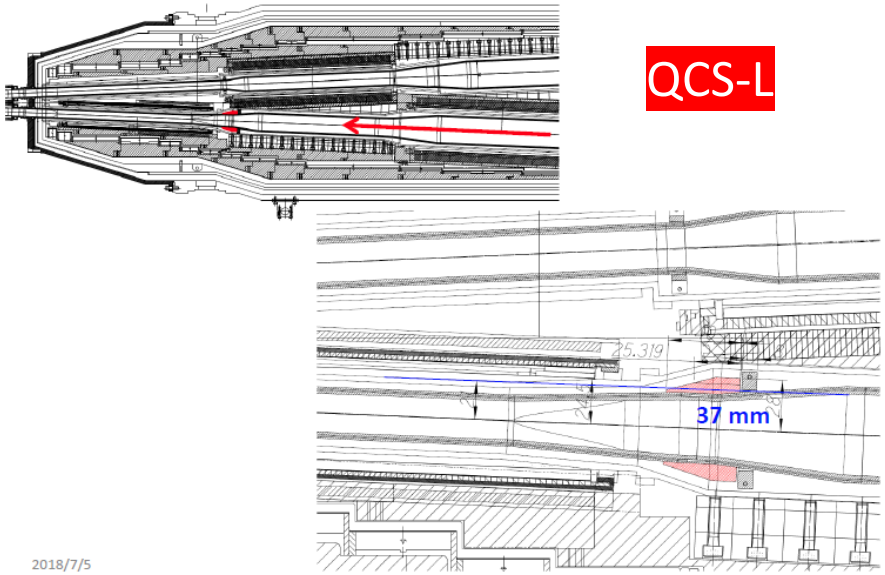
These new settings will help in preventing QCS quenches, hopefully, without interfering with accelerator tuning. Iterations and adjustments might be needed to tune the system in a better way.

QCS quench meeting 2018/05/23 by Giovanni Bassi

Additional tungsten shield

- ✓ Several additional tungsten shields were proposed to suppress the beam loss to the QCS magnet.
- ✓ The tungsten shields are supposed to be placed between the QCS inner pipe and beam pipe.
- ✓ Some simulation results, which were reported by Y. Funakoshi, show the tungsten shields may effective to suppress the beam loss.
- ✓ To determine the detail shape of the tungsten shields, we need more information of the beam loss simulation from Y. Funakoshi and H. Nakayama.





Summary

- ✓ In phase-2, most quench was caused by the unstable beam injection and the incomplete collimator setting. After the tuning of injection and collimator setting, no quench occurred from May 25th to June 25th.
- ✓ Quench protection and monitoring systems of QCS group are all ready for the phase-3 commissioning.
- ✓ LER beam loss is expected to be suppressed by the added collimators.
- ✓ We also expect the Belle diamond abort system work well in phase-3.
- ✓ For the additional tungsten shields, we need to continue to discuss the detail.