Super-KEKB QCS R&D Magnet

KEK

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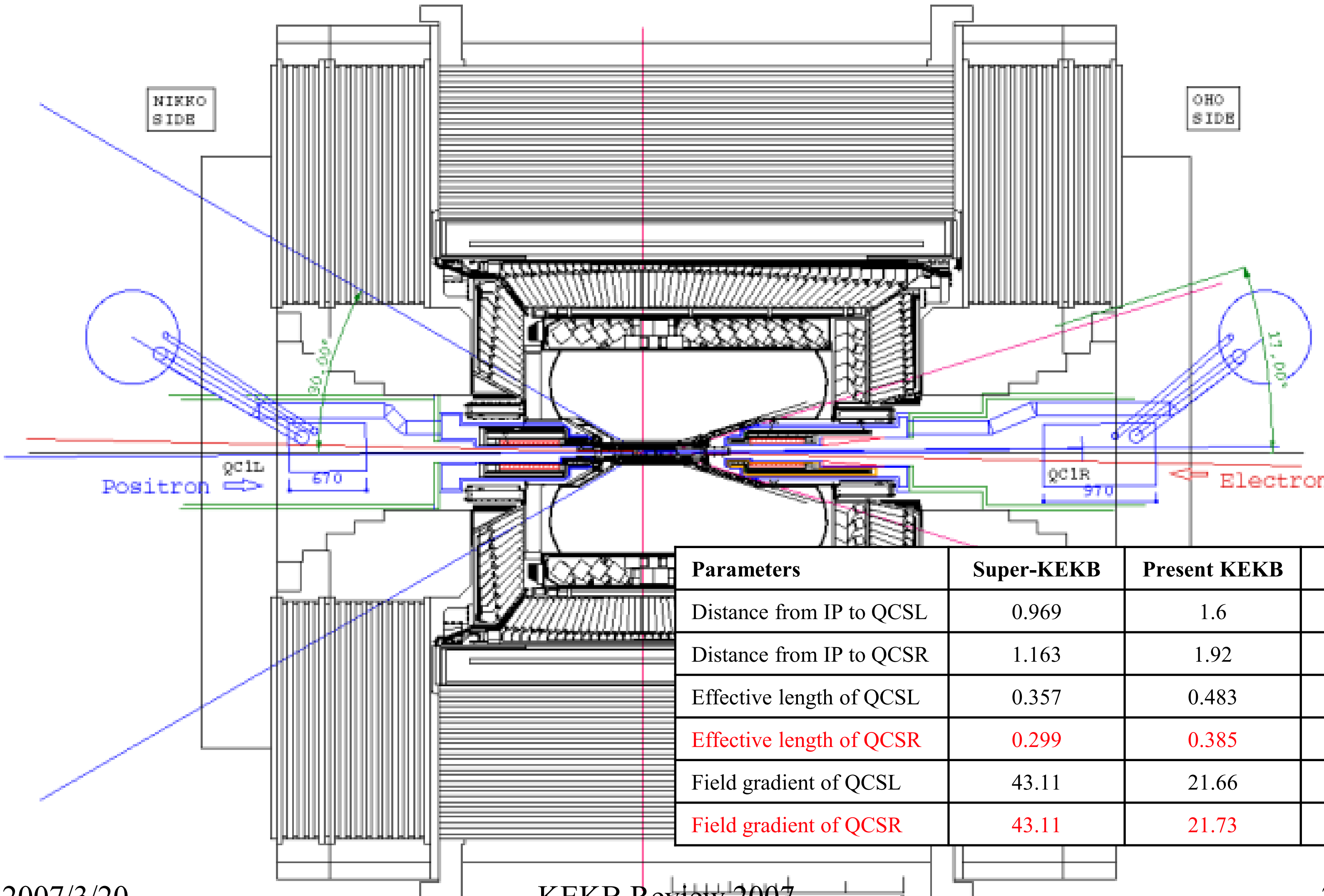
Super-KEKB QCS Magnets

Schematic view of SuperKEKB-IR

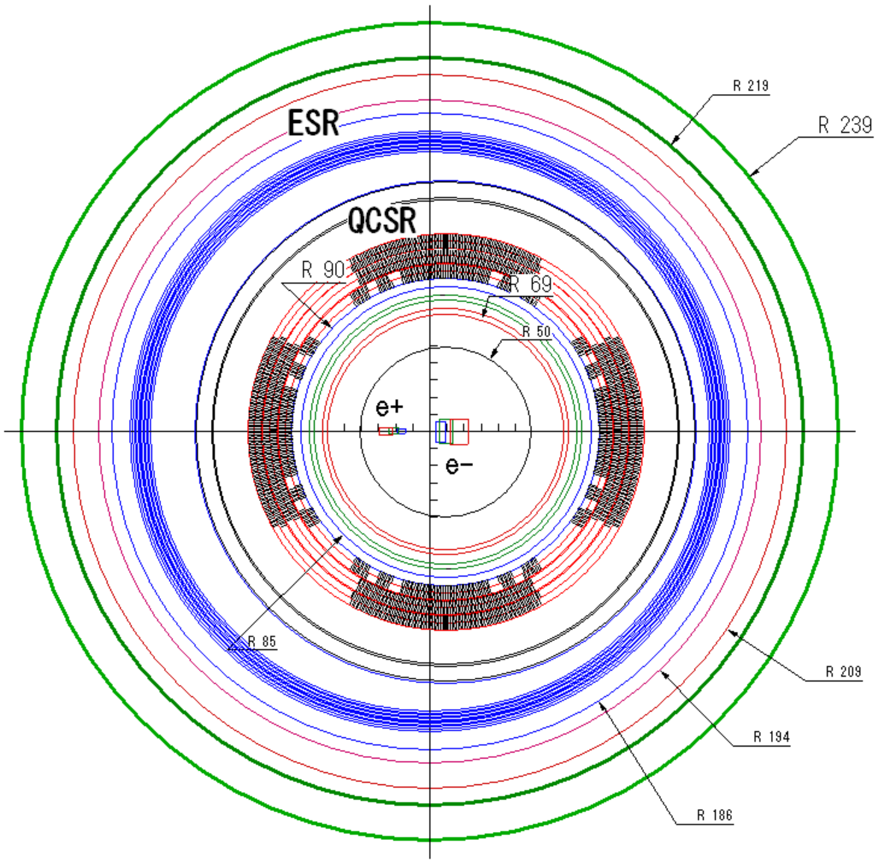
- QCS and ES magnets with Belle detector



Parameters	Super-KEKB	Present KEKB	Unit
Distance from IP to QCSL	0.969	1.6	m
Distance from IP to QCSR	1.163	1.92	m
Effective length of QCSL	0.357	0.483	m
Effective length of QCSR	0.299	0.385	m
Field gradient of QCSL	43.11	21.66	T/m
Field gradient of QCSR	43.11	21.73	T/m

Super-KEKB QCS Magnets

Cross Section of Magnet Cryostat and Parameters



Magnet cryostat cross section in the right side

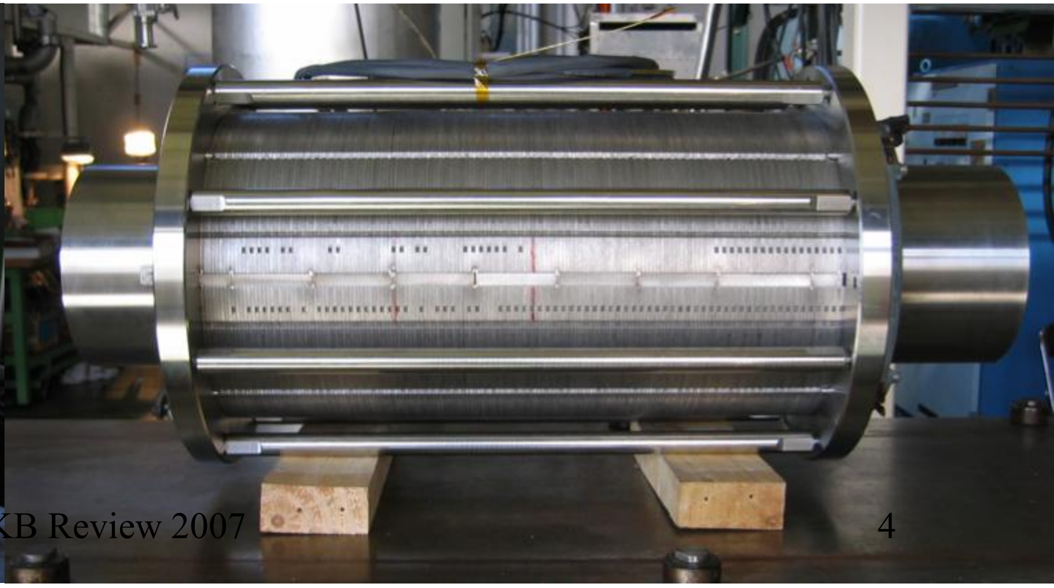
Design parameters of final focus quadrupole in the right side (QCS-R:R&D Magnet)

- 6 layer coils (3-double pane cake coils)
- Inner coil radius : 90.0 mm
- Outer coil radius : 116.8 mm
- Cable size : 1.1 mm × 4.1 mm
  - 1.1 mm × 7.0 mm (KEKB)
- Number of turns : 271 in one pole

  1st layer = 38, 2nd layer = 39
  3rd layer = 46, 4th layer = 47
  5th layer = 50, 6th layer = 51
- Field gradient : 40.124 T/m
- Magnet current : 1186.7 A
- Magnetic length : 0.299 m
- Inductance : 69.98 mH
- Stored energy : 49.3 kJ

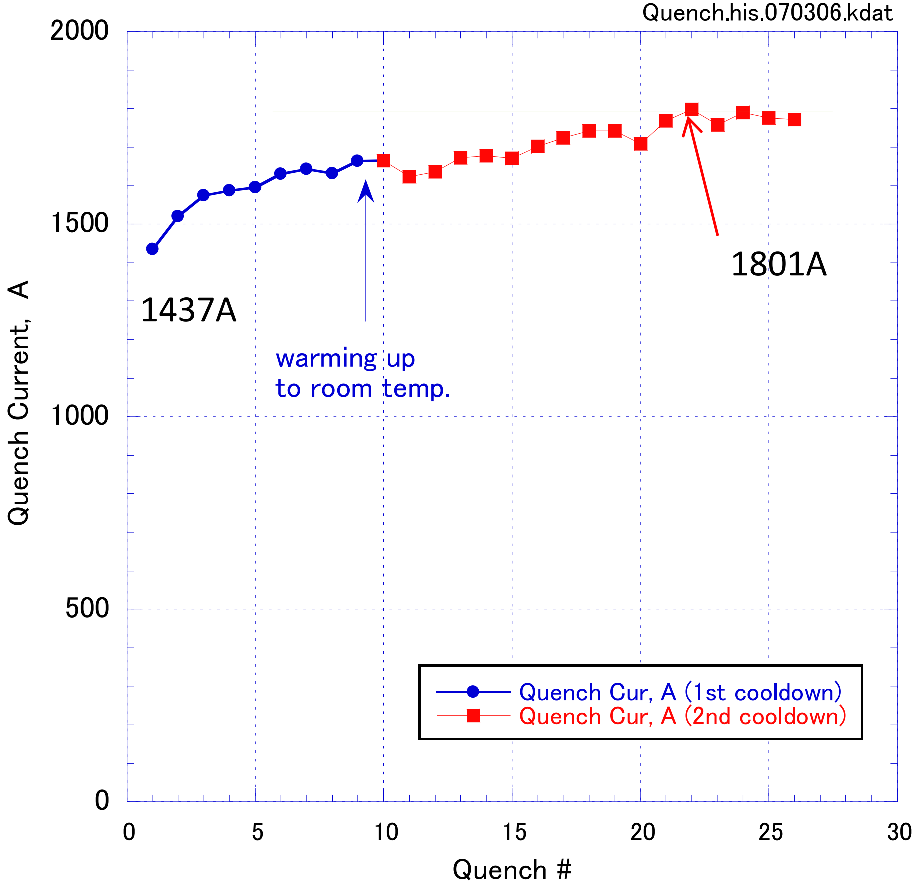
Super-KEKB QCS Magnets

12 Cured Coils and Completed Collared Magnet



Cold Tests of QCS R&D Magnet

Excitation Test at 4.2 K

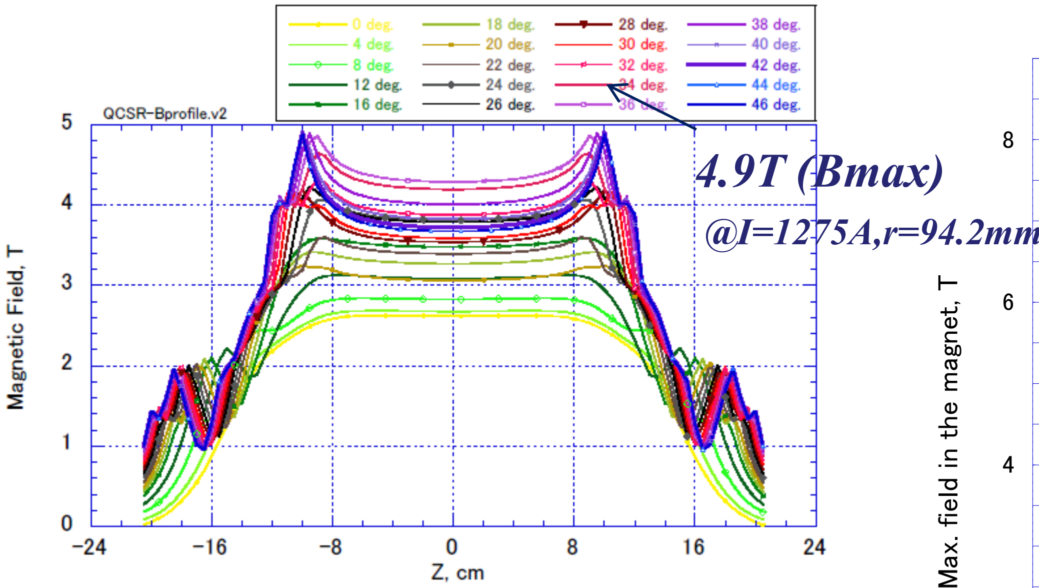


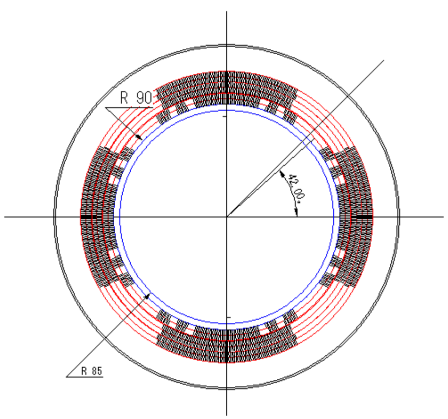
History of the quench training

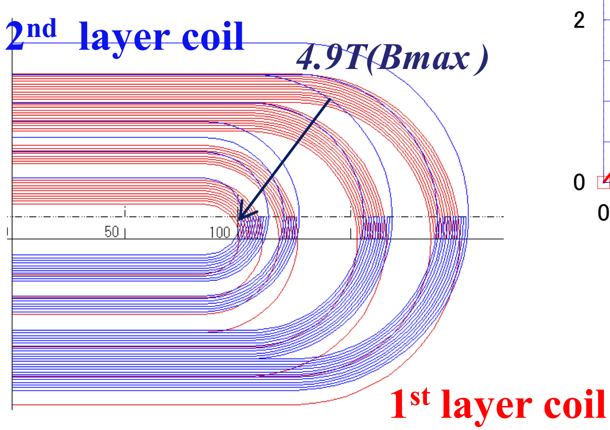
The 1st quench training started at 1437 A.

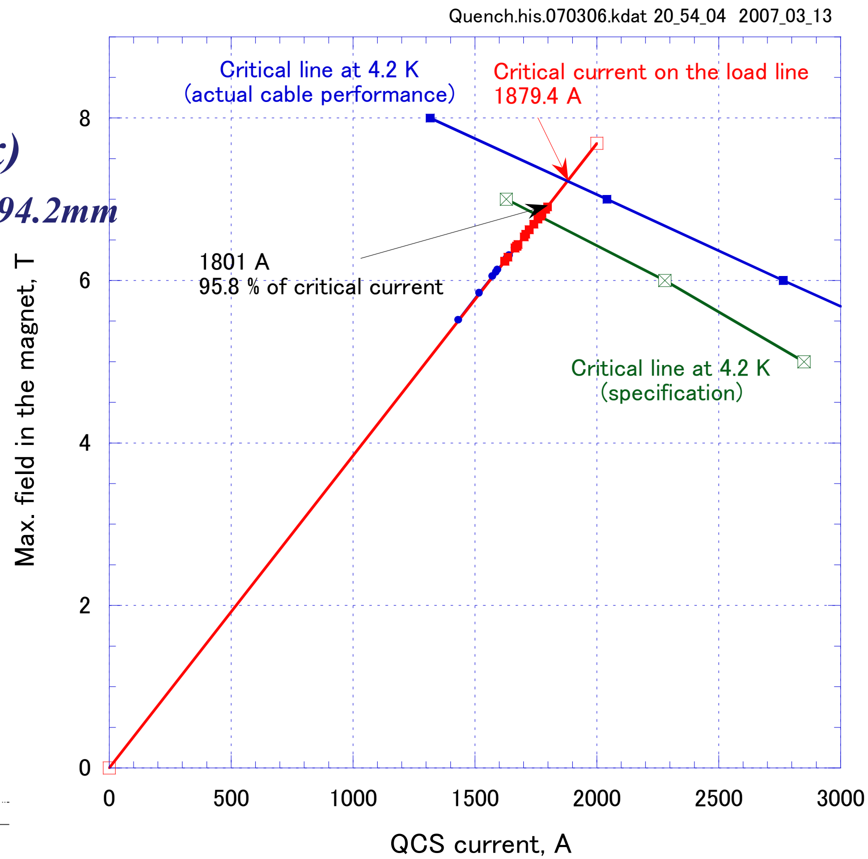
Cold Tests of QCS R&D Magnet

Load line of QCS R&D magnet





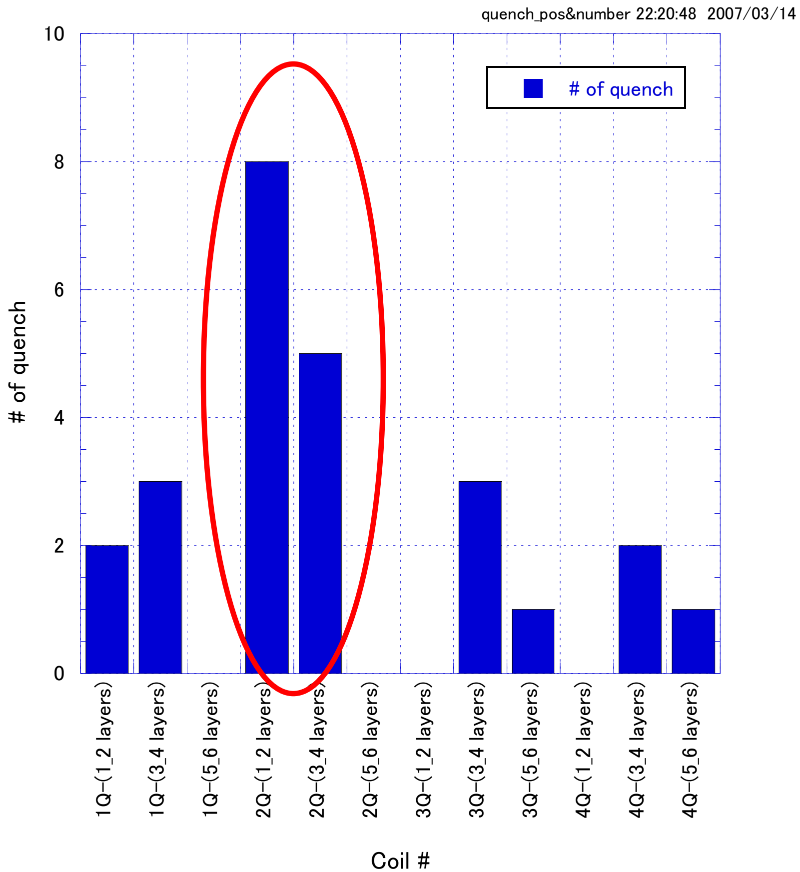




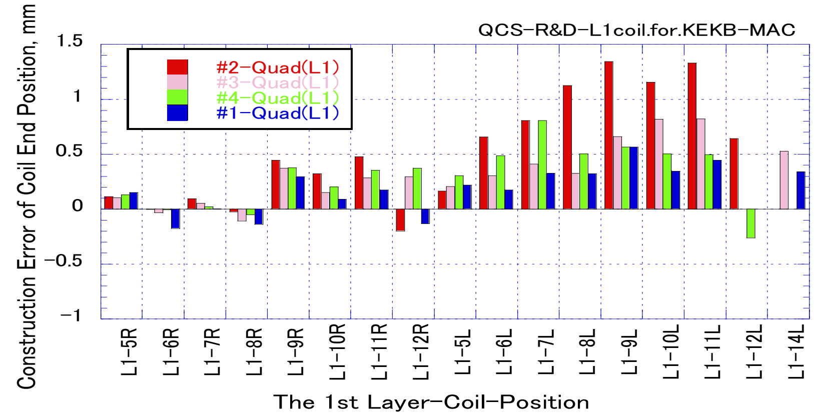
QCS load line vs. S.C. cable performance

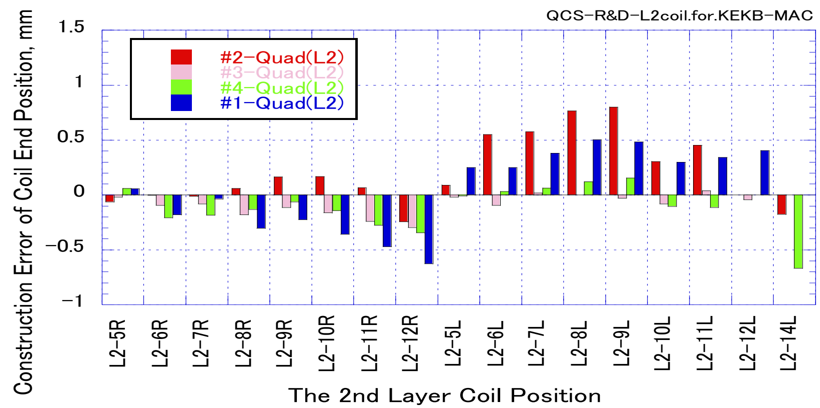
Cold Tests of QCS R&D Magnet

Quench Location



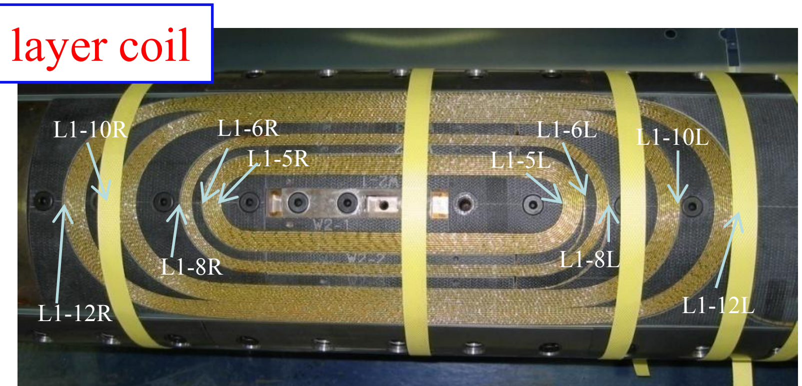
The location of the transition from the superconducting to the normal condition is mainly in the 2nd quadrant.





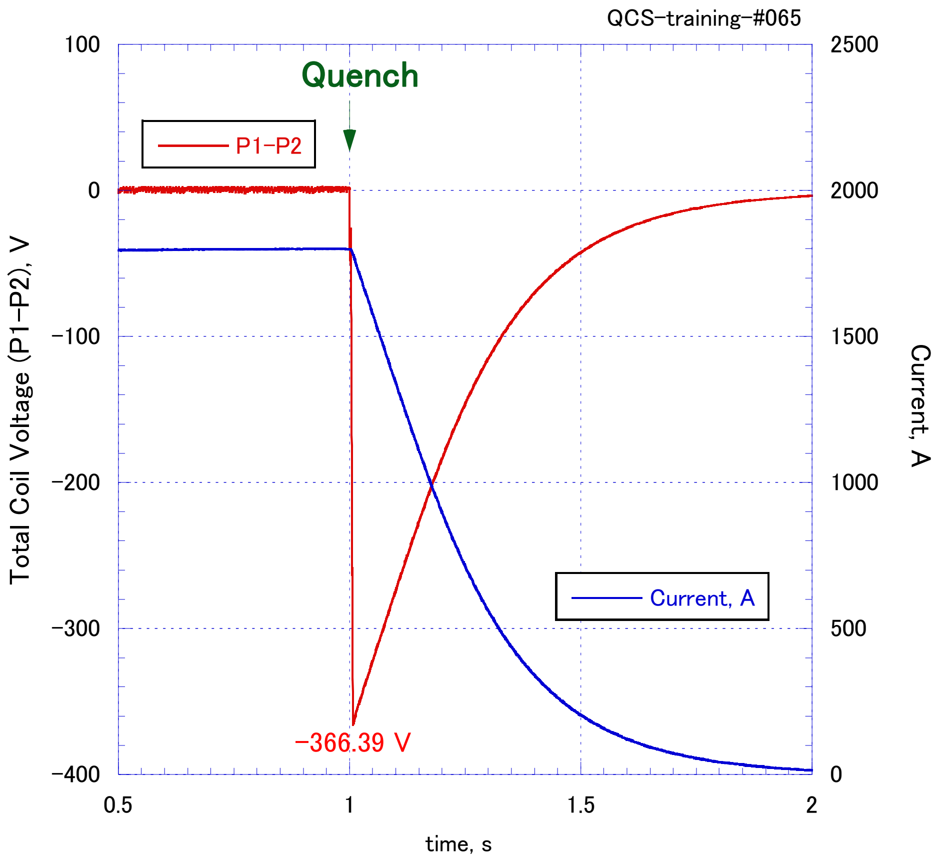
Construction error of 1st and 2nd layer coils

1st layer coil



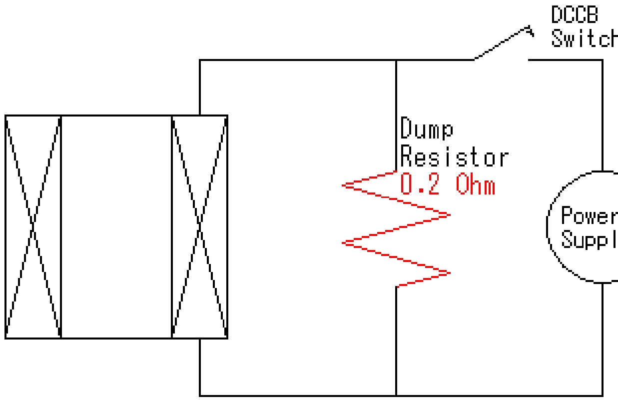
Cold Tests of QCS R&D Magnet

Quench Energy (Protection Circuit System)



QCS V-I curves after quench

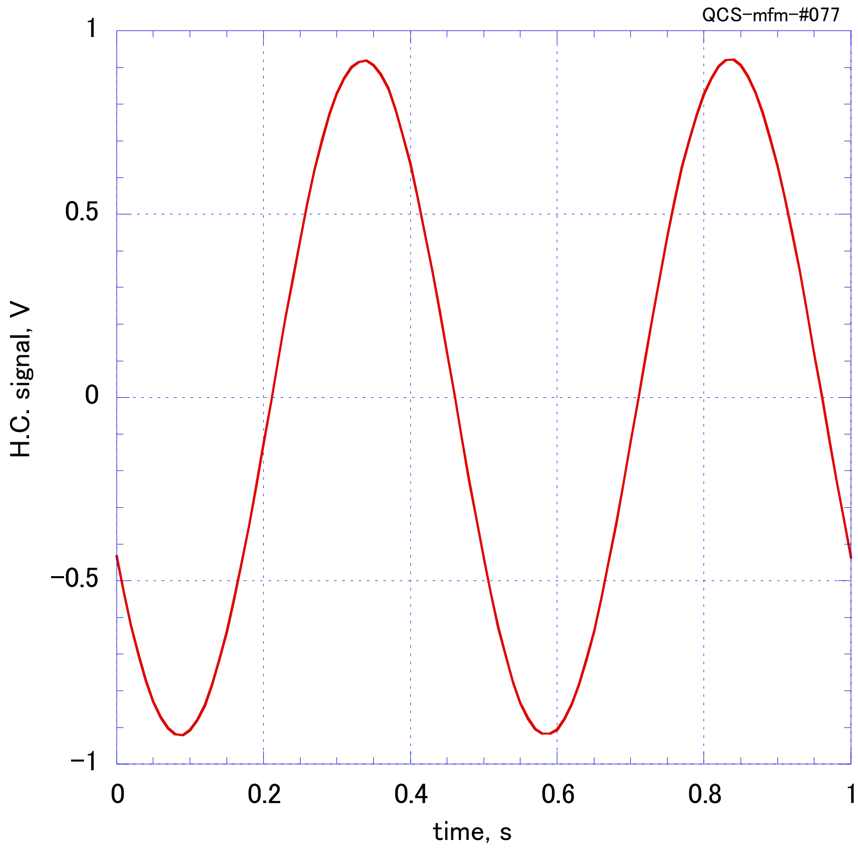
$V_{trigger}$=0.5 V
t=27 msec



- L_{QCSR}=69.98 mH (calculation)
  Q_{QCSR}=113.5 kJ at 1801A
- Q_{dump}=91.0 kJ (from V-I curves)
  Q_{coil}=22.5 kJ
- From the liquid helium consumption:
  Evaporated LHe=13.96 L (measured)
  Q_{LHe}=36.4 kJ
- In the previous analysis, the temperature rise of the magnet was less than 60 K for the stored energy of 49 kJ at 1186.7 A.

Cold Tests of QCS R&D Magnet

Field Measurement by harmonic coil (rough measurement)



@ magnet current = 1578A

The generated field gradient = 53.2 T/m

The magnetic length = 0.299 m (design)

@ design current (operation current) = 1186.7 A

The estimated field gradient = 40.03 T/m

The calculated field gradient = 40.12 T/m

The error of the quadrupole component = 0.23%

The value of 0.23% corresponds to the geometry error of 0.7mm in coil length, or 0.2 mm in coil radius.

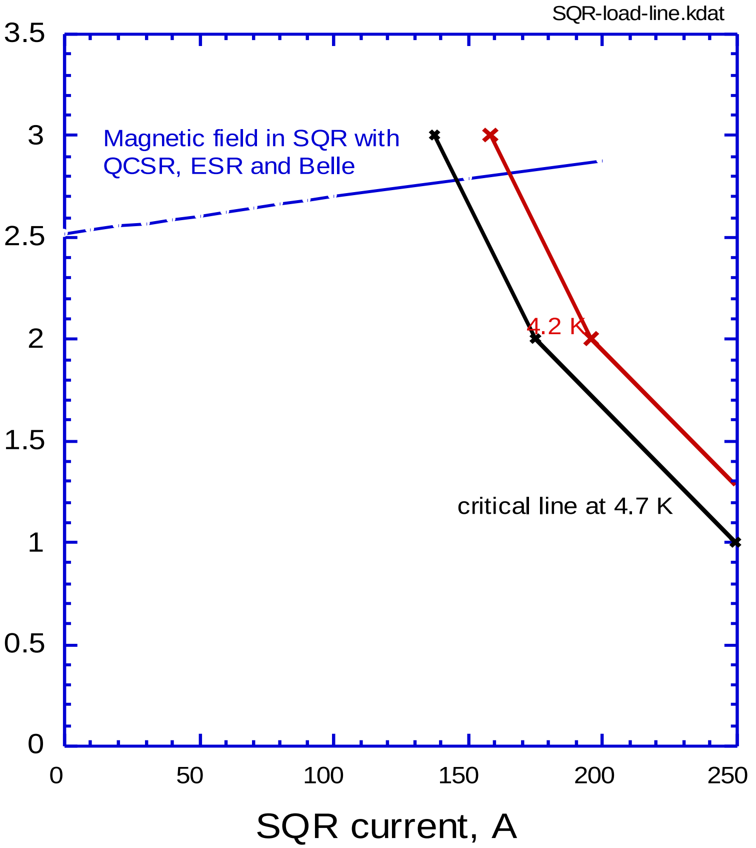
Voltage signal of the harmonic coil (one rotation) .
The harmonic coil is a quadrupole tangential winding.
The coil radius is 48 mm, and the length is 800 mm.

Construction of corrector and solenoid R&D magnets

Design of the corrector R&D coils

The corrector system was reported at H.L. B-Factory 2002.

1. The system consists of a skew quadruple and two dipole coils as same as the KEKB-QCS.
2. The corrector coils are placed outside of the stainless steel collars of QCS.
   - Coil radius=141.5~146.5mm
   - Magnetic field from QCS and ES=2.5T
   - Parameters of the skew quadrupole (SQR)
     - Corrective angle ±10mrad (0.83T/m)
     - Coil radius=142.5mm
     - Turns in one pole=122
     - S.C. wire diameter=0.3mm
     - Operation current=102A



The SQR current of 102 A corresponds to 70 % of the critical current at 4.7 K.

Construction of corrector and solenoid R&D magnets

Construction of the corrector R&D coils

The corrector coils will be set on the outer surface of the QCS helium vessel in the improved design inside the cryostat.

1. The corrector coils are cooled by thermal conduction via the helium vessel at 4.5 K.
2. The R&D coils are directly wound on the helium vessel.
   - The outer diameter of the helium vessel =216.3 mm (smaller than the original corrector design).
   - S.C. cable dia.=0.78mm
   - Turns of one pole=114
   - Dipole field=0.069 T @100A
     Available correction of misalignment = ±1.7mm
3. The HTS current leads will be used for transporting the current to the coils.
   - The refrigerator will have the additional cooling power of 15 W at 4.5K.

Automatic winding of the skew and the normal dipole correctors by Toshiba.

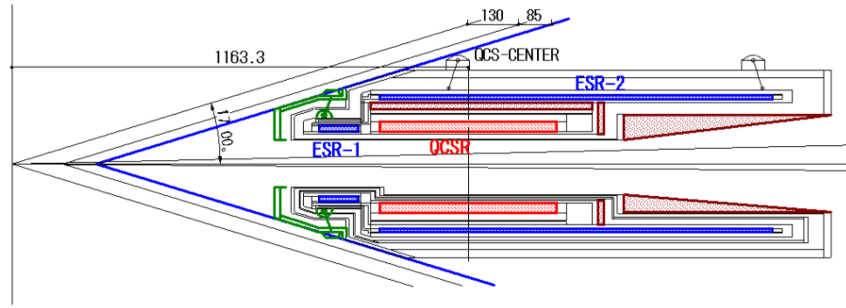
Construction of corrector and solenoid R&D magnets

Construction of the solenoid R&D magnet

The compensation solenoids are designed to locate in front of the QCS and on the periphery of the QCS.

1. The solenoid R&D magnet are being built by Toshiba in order to be combined with the QCS R&D magnet.
2. Parameters of R&D solenoid (ESR-2).
   - Coil length = 1000 mm.
   - Coil inner diameter = 330 mm
   - Turns of solenoid = 4000
     500 turns × 8 layers
   - Operation current = 619A
   - Designed central field = 2.98 T
3. Parameters of ESR-1
   - Coil length = 150 mm
   - Coil inner diameter = 154 mm
   - Designed central field = 2.11 T

The solenoid R&D magnet is being constructed by Toshiba, and it will be completed in March.



Solenoid winding @ Toshiba

Summary and Schedule

- The QCS-R R&D was built and successfully tested at 4.2 K.
  - The magnet quench started from the magnet current of 1437 A, which is higher than the design operating current.
  - After 21 times of quenches, the magnet current reached 95% of the S.C. cable limitation.
  - The quench location concentrated on the first built coils (2^{nd} quadrant). It is considered that the cause came from the immature control of the coil size.
  - The integral field gradient of the quadrupole was roughly measured, and the measured value is 0.23 % different from the design.
  - The precise field measurement will be performed with the harmonic coil system and the signal integrators until this summer.
- The corrector and the compensation solenoid R&D magnets are being built now, and they will be completed in March.
  - The corrector R&D coils will be cooled by thermal conduction from the helium vessel, and for transporting the current, the HTS current leads will be used in the system in order to reduce heat load. The system will be tested until this summer.
  - The solenoid R&D magnet will be tested separately at first. After this test, the QCS R&D magnet will be assembled in the solenoid bore, and the excitation test of both magnets will be performed in this year.

Corrector magnet test cryostat and solenoid R&D magnet combined with QCS R&D magnet