QCS

（Feb.25　15:10-15:30　N.Ohuchi）

Superconducting Magnets for the Interaction Region of Super-KEKB

2002-02-25 Ohuchi

CONTENTS

(1) Design conditions of S.C. magnets in the IR of Super-KEKB

(1) The crossing angle is 15mrad × 2.

(2) The superconducting magnets in one cryostat are a final focusing quadrupole (QCS), a compensation solenoid (ES) and three correctors.

(3) Spacial constraints of the QCS cryostats in the Belle detector are the same as KEK-B.

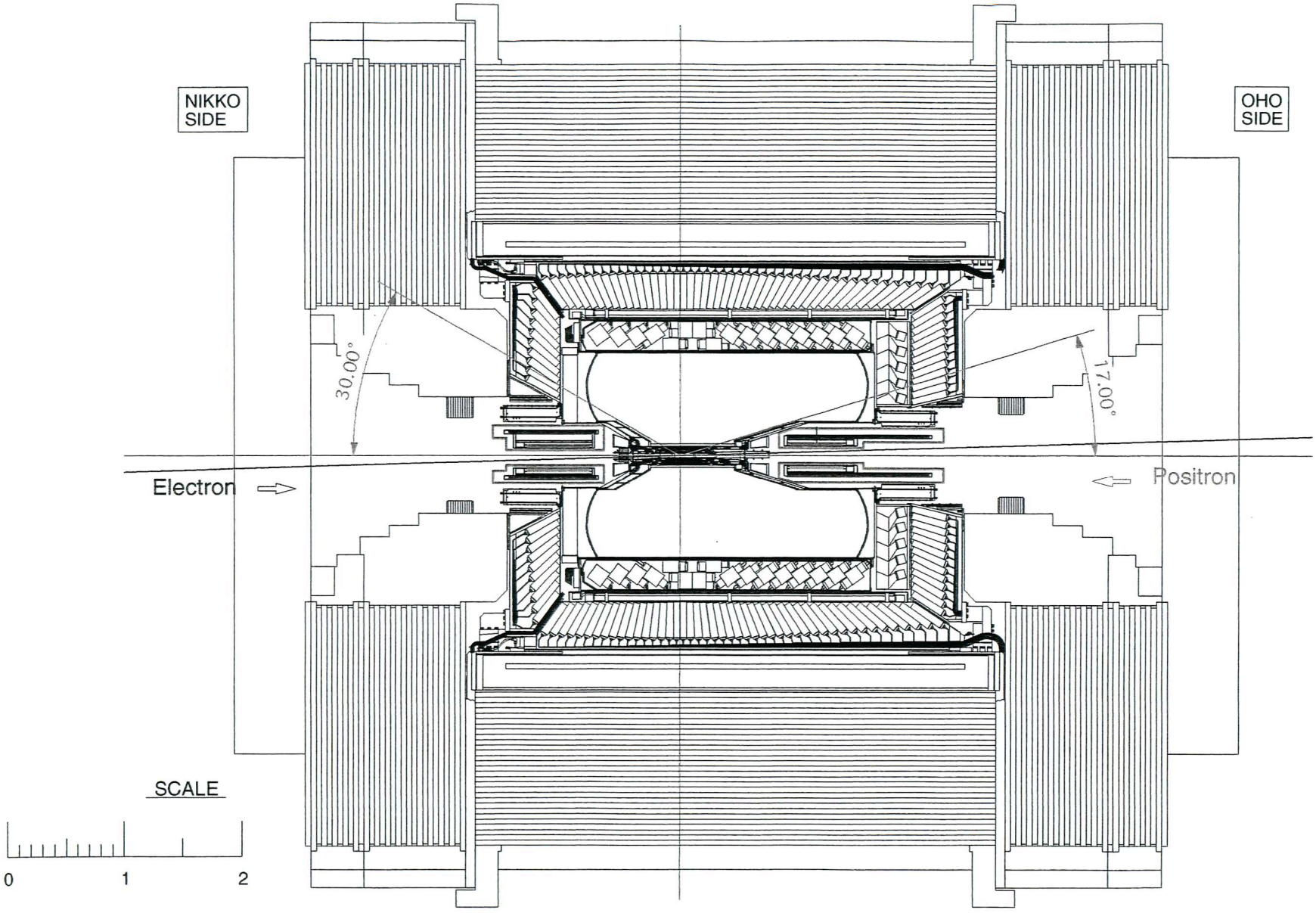
(4) The QCS locates at the position as close to IP as possible.

(5) The ES is placed on the outer side of the QCS.

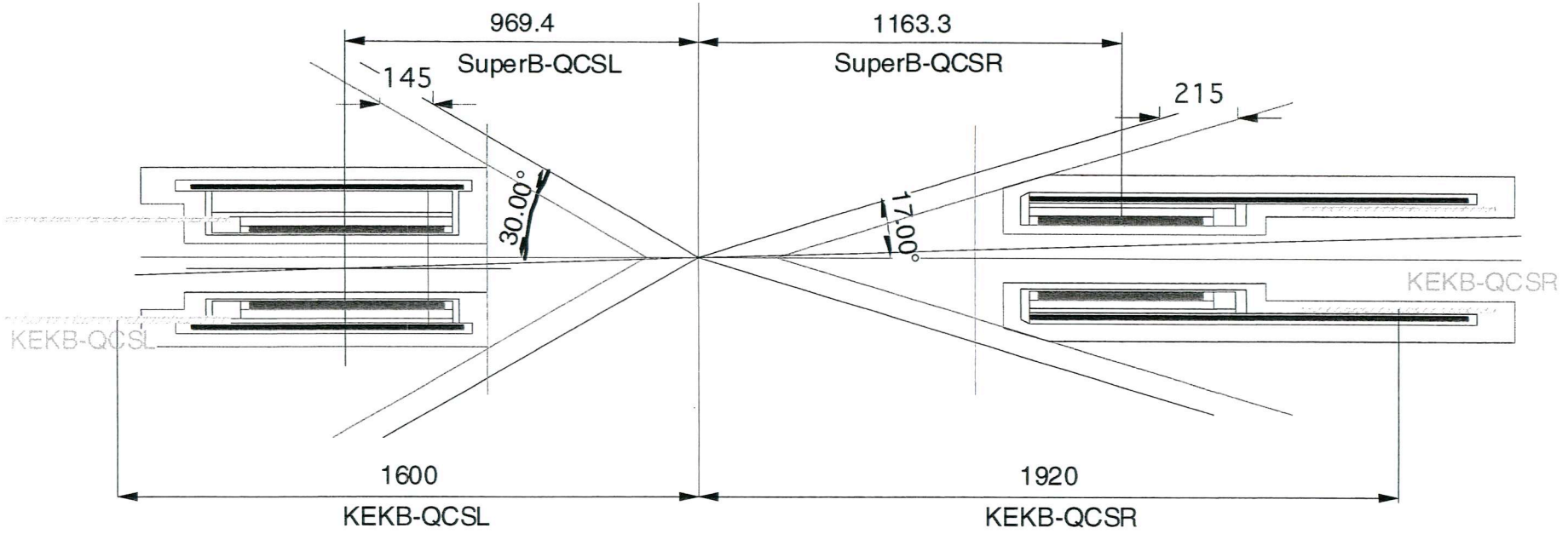
(6) The distance between the cold wall and warm wall in the cryostat is the same as that in the KEKB cryostat.

(7) The magnets are cooled by a sub-cooled liquid helium at 4.5 K and 0.16 MPa, of which saturated boiling temperature is 4.7 K.

(2) Overview of QCS inside the Belle detector for Super-KEKB



Super-KEKB QCS Position and Field Gradient



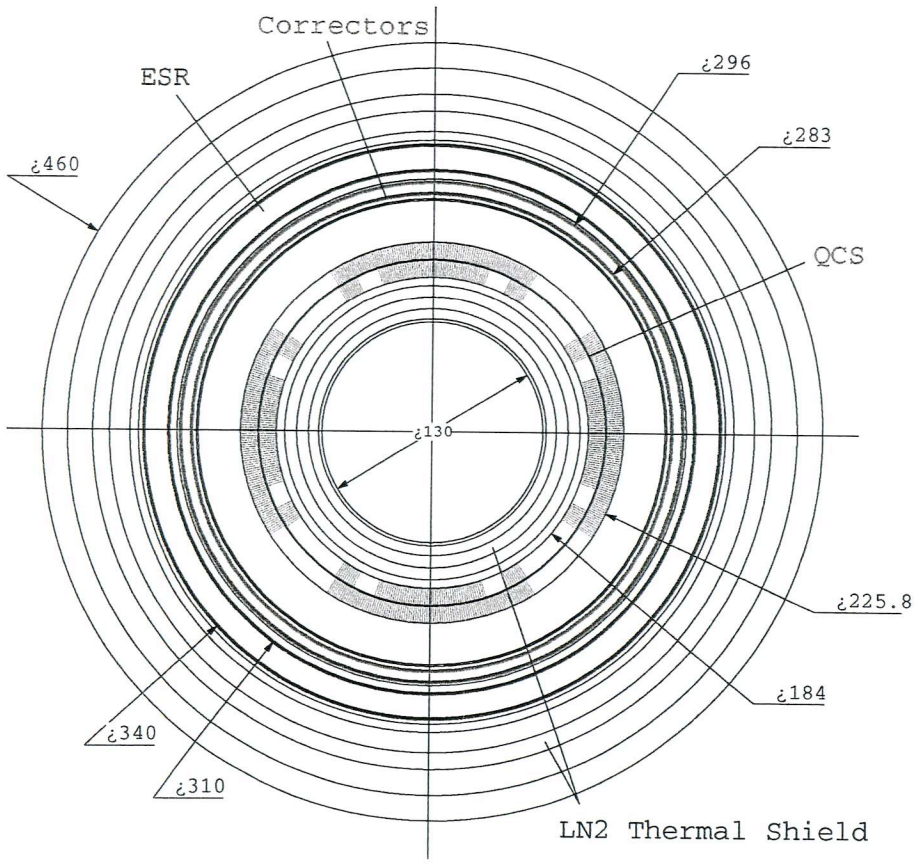
	KEKB			Super-B		
	Position from IP	G, T/m	GL, (T/m)m	Position from IP	G, T/m	GL, (T/m)m
QCSR	1920 mm	21.73	8.366	1163.3 mm	41.50	13.81
QCSL	1600 mm	21.66	10.462	969.4 mm	41.25	17.26

(3) Sunperconducitng Magnets

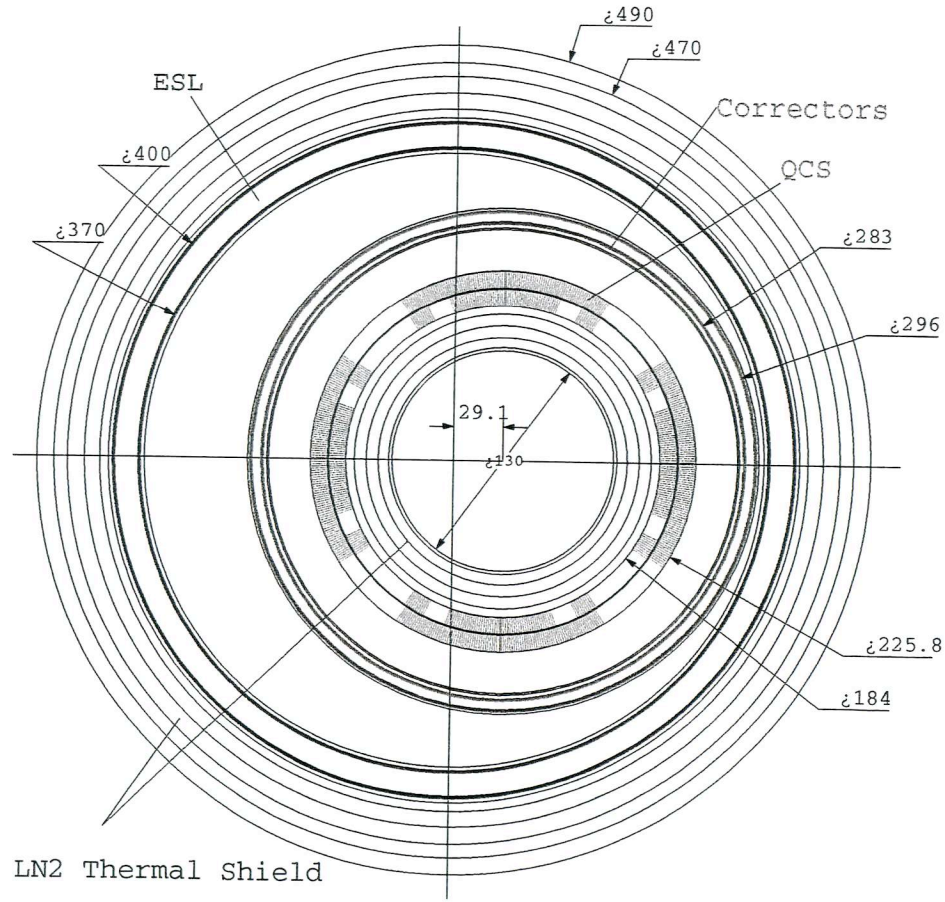
Final focusing quadrupole magnet, QCS

Cross Section of QCS Magnet Cryostat

QCSR

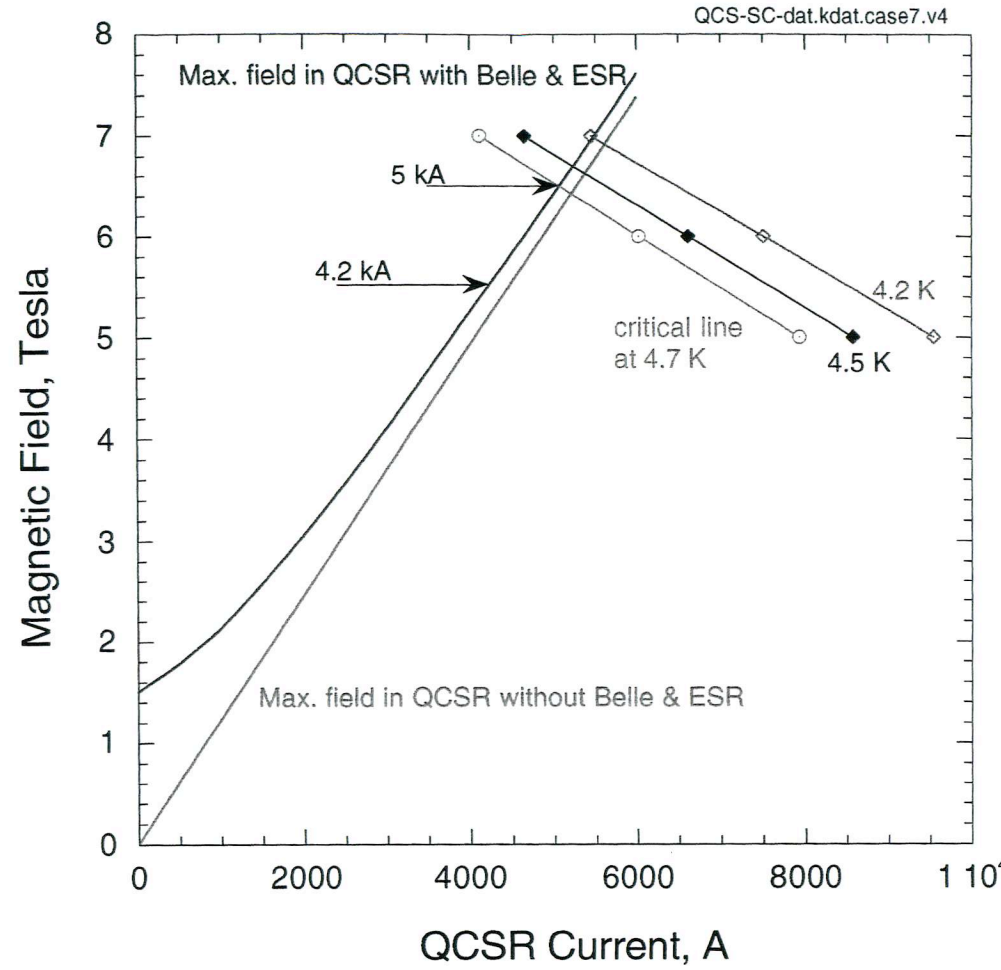


QCSL



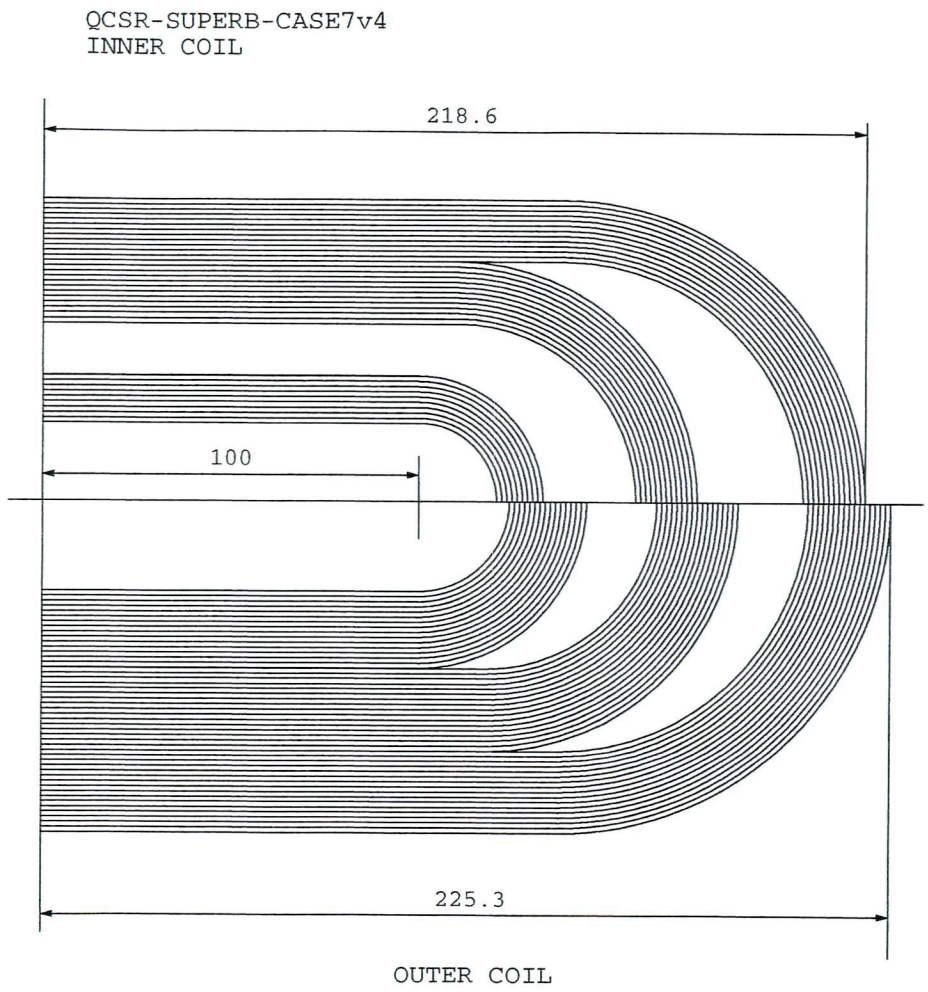
QCS Parameters

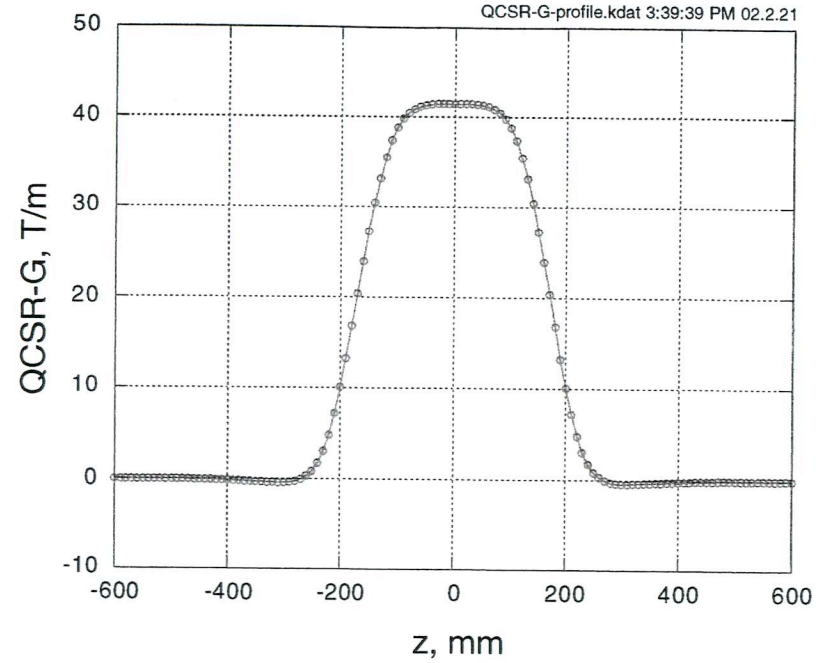
	Super-B	KEK-B
G, T/m		
QCSR	41.50	21.73
QCSL	41.25	21.66
I, A	4206	2963
Coil I.R., mm	92	130
Coil O.R., mm	112.9	144.9
Coil length, mm		
QCSR	450.6	521
QCSL	535.3	617
Conductor size, mm		
	1.1×10.0	1.09×7.0



The operating current of QCSR corresponds to 84 % of the critical current at 4.7 K. (QCSL=82%)

QCS Coil Geometry & Field Quality



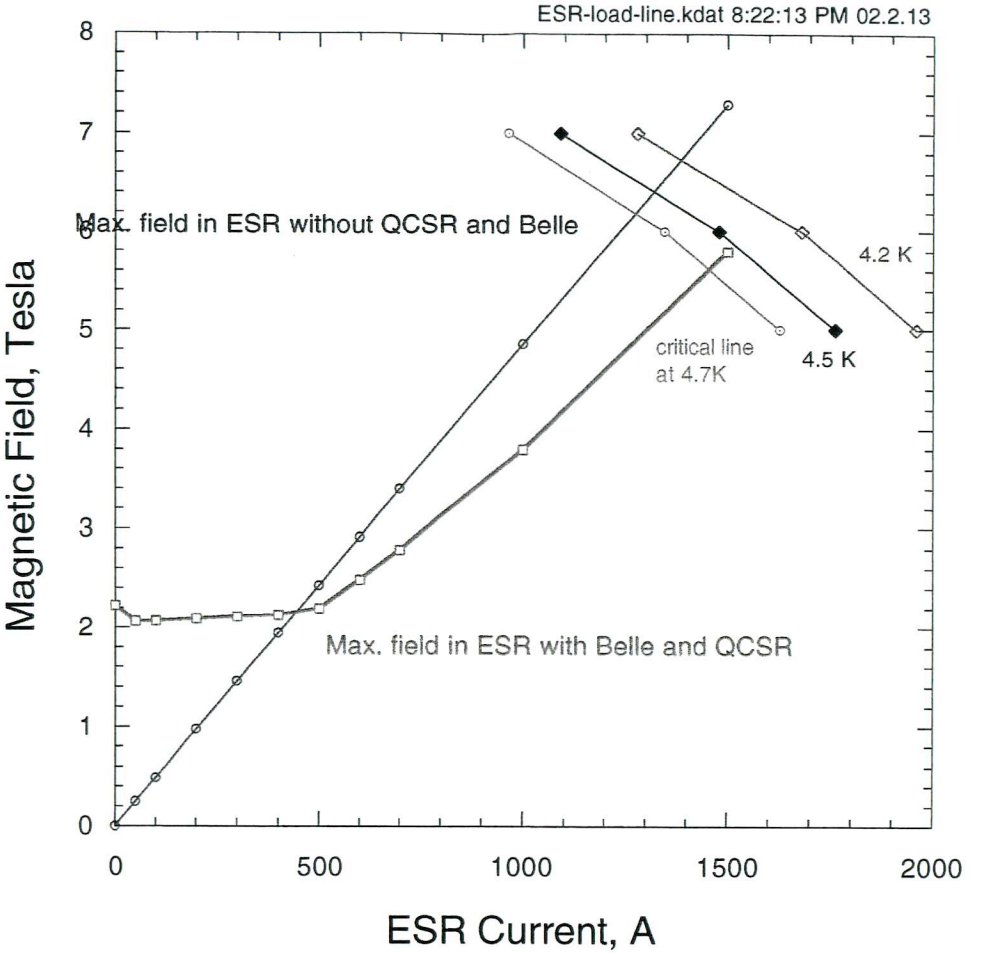


Integral Field Quality @ R=40 mm

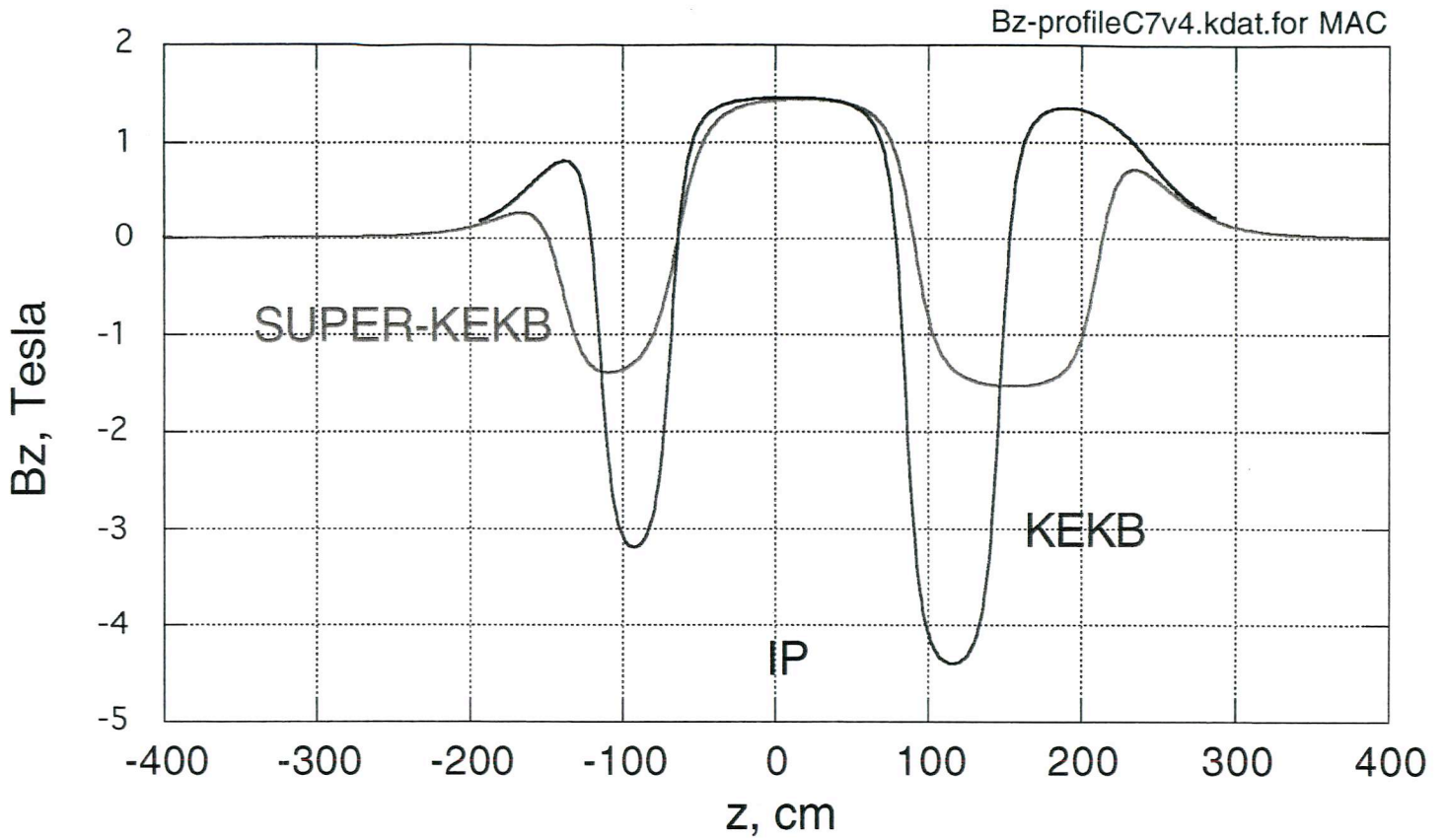
	b6	b10
QCSR	1.74×10^{-5}	8.34×10^{-6}
QCSL	1.51×10^{-5}	8.08×10^{-6}

Compensation Solenoid, ES

	ESR	ESL
Central Field, T		
Super-B	3.00	2.77
KEK-B	5.80	4.53
Magnet Current, A		
Super-B	619.2	615.3
KEK-B	603.1	487.9
Coil Length, mm		
Super-B	1200	752
KEK-B	616	461
Coil Inner Radius, mm		
Super-B	155	185
KEK-B	95	95
Conductor size, mm		
bare cable	1.1×1.9	
with insulation	(1.22×2.02)	



The operating current of ESR corresponds to 43 % of the critical current at 4.7 K.



Bz profile along the LER beam line

Maximum Bz	Super-KEKB	KEKB
Right side	-1.53 T	-4.40 T
Left side	-1.40 T	-3.20 T

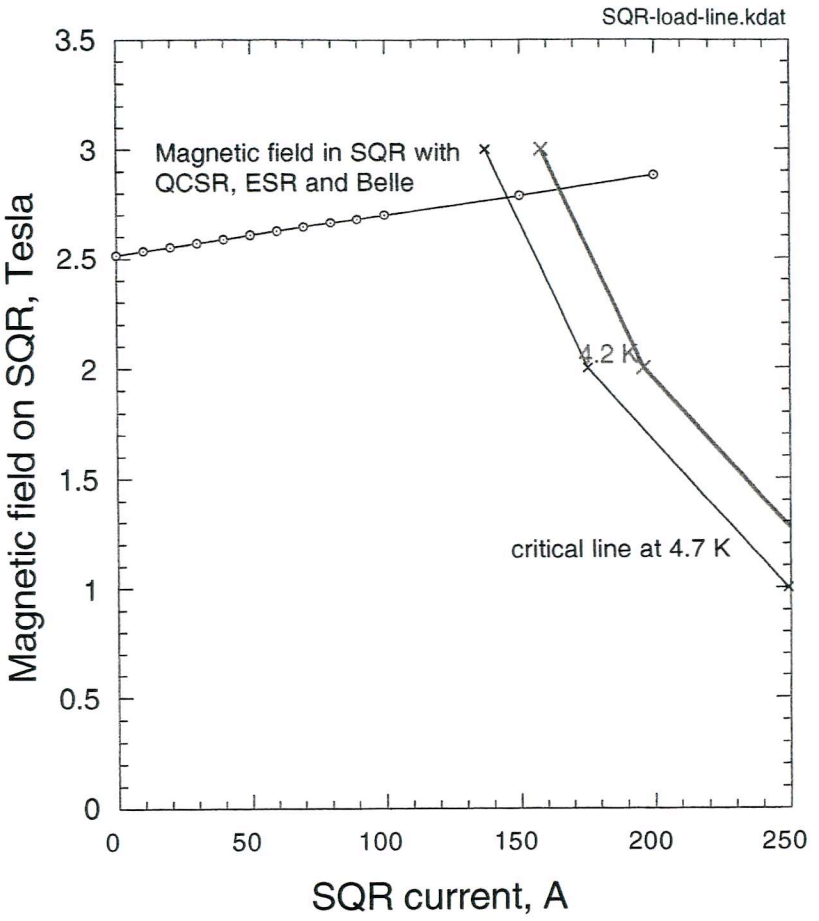
Corrector Coils

*The corrector system consists of a skew quadrupole, a normal dipole and a skew dipole.
*The magnetic center and mid-plane of coils are aligned with respect to those of QCS.
*The corrector coils place outside of stain-less collars of QCS.

coil radius:141.5 mm~146.5 mm
magnetic field from QCS and ES:
2.5 T (KEKB 3.5 T)

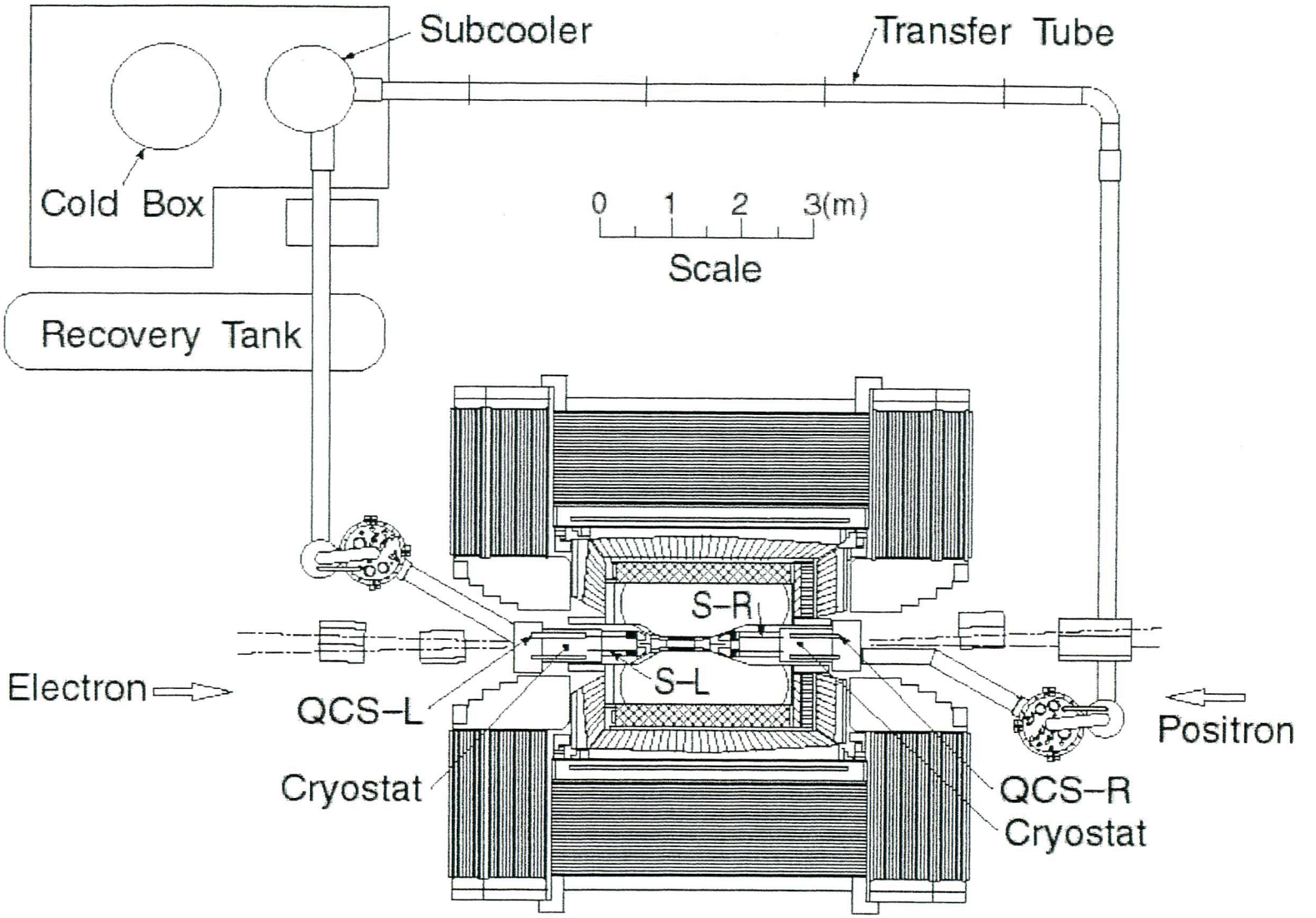
Parameters of the skew quadrupole, SQR, for QCSR

corrective angle for QCSR	±10 mrad (0.83 T/m)
coil radius	142.5 mm
turns in one pole	122
S.C. diameter	0.3 mm
operation current for ±10 mrad	102 A



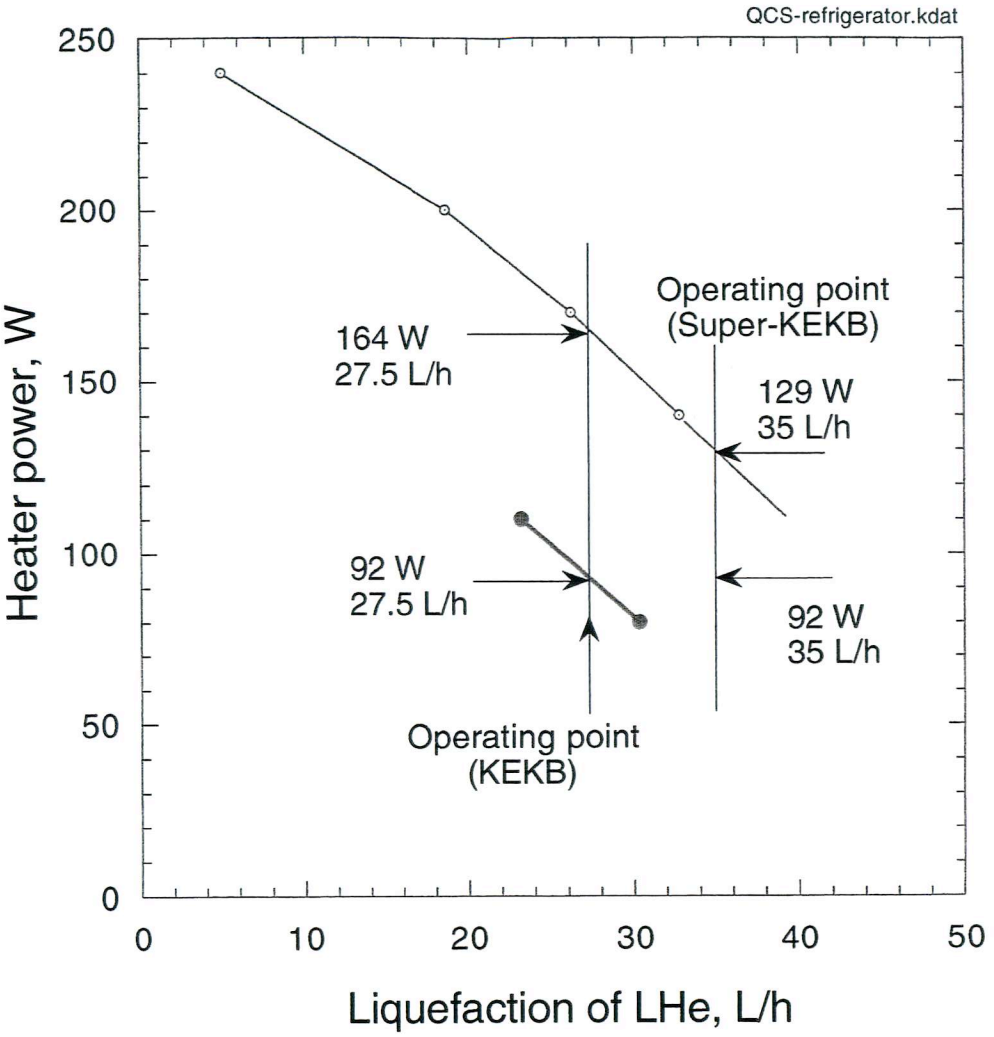
The SQR current of 102 A corresponds to 70% of the critical current at 4.7 K.

(4) Cryogenic System



Heat load for the cryogenic system

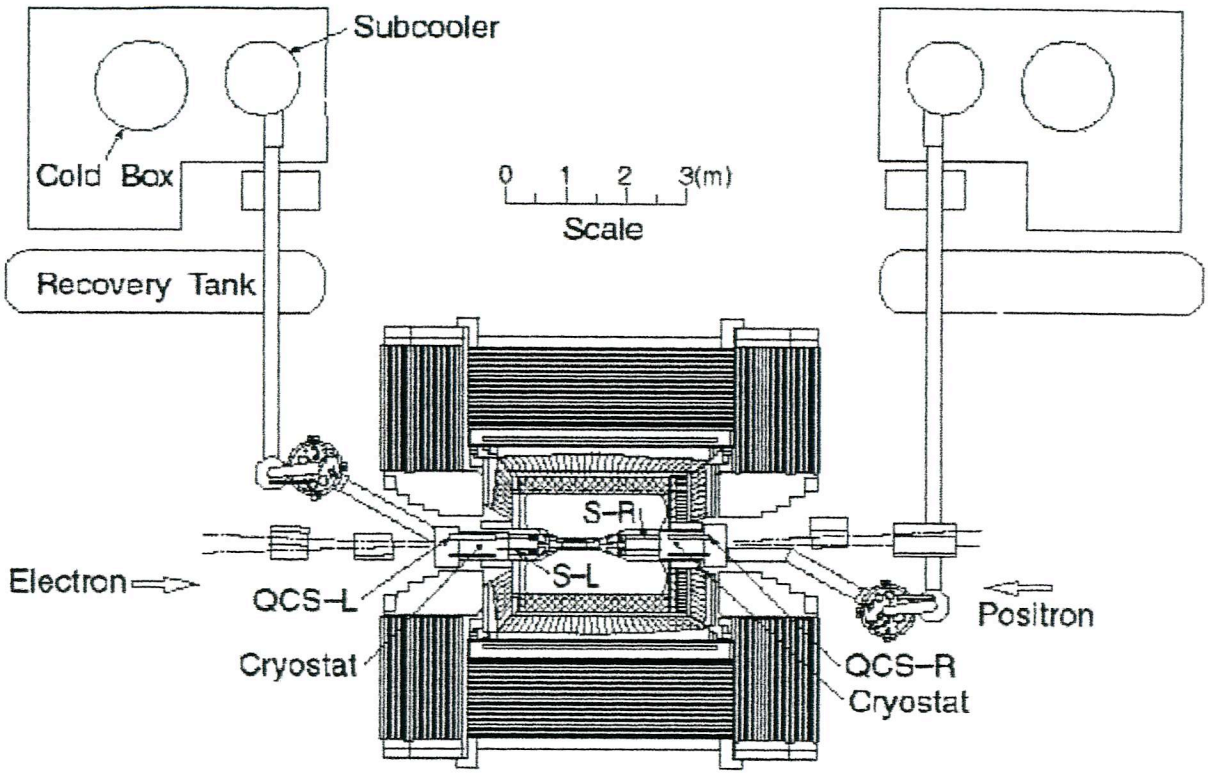
	KEKB	Super-KEKB
Current leads		
QCS	15 L/h	22 L/h
ES	8.5 L/h	9 L/h
Correctors	4 L/h	4 L/h
Cryostat	22 W	22 W
Transfer line	70 W	70 W
Total	27.5 L/h +92 W	35 L/h +92 W
Refrigerator	27.5 L/h +164 W	35 L/h +129 W
Margin	72 W	37 W



In case of one refrigerator for one cryostat
(two refrigerator in total)

Heat load for one refrigerator

	two ref.	one ref.
Current leads		
QCS	22 L/h	22 L/h
ES	4.5 L/h	9 L/h
Correctors	2 L/h	4 L/h
Cryostat	11 W	22 W
Transfer line	35 W	70 W
Total	28.5 L/h +46 W	35 L/h +92 W
Refrigerator	28.5 L/h +160 W	35 L/h +129 W
Margin	114 W	37 W



Summary

(1) From the calculation of magnetic field, the QCSs can be upgraded as shown in the follwing table, and the operating point of the magnets is less than 85% of the critical point, including the compensation solenoids and corrector coils.

	KEKB		Super-B	
	Position from IP	GL, (T/m)m	Position from IP	GL, (T/m)m
QCSR	1920 mm	8.366	1163.3 mm	13.81
QCSL	1600 mm	10.462	969.4 mm	17.26

(2) In order to get a stable condition for operating these magnets, two refrigerators are necessary.

(3) Calculation of electro-magnetic force between the ES, the QCS, the corrector coils and the Belle detector will be performed for mechanical design.