2003/ Feb./11-KEKB Review

Interaction Region Design for Super-KEKB

Norihito Ohuchi

(1) IR-design conditions
(2) QCS and ES
(3) Design of the special magnets for the IR (QC1 & QC2)
(4) Belle detector with QCSs and superconducting QC1s
(5) Further study for the IR

(1) IR-design conditions

(1) The crossing angle of two beams is 15mrad ×2.

(2) $\beta_x^* = 30$ cm, $\beta_y^* = 3$ mm

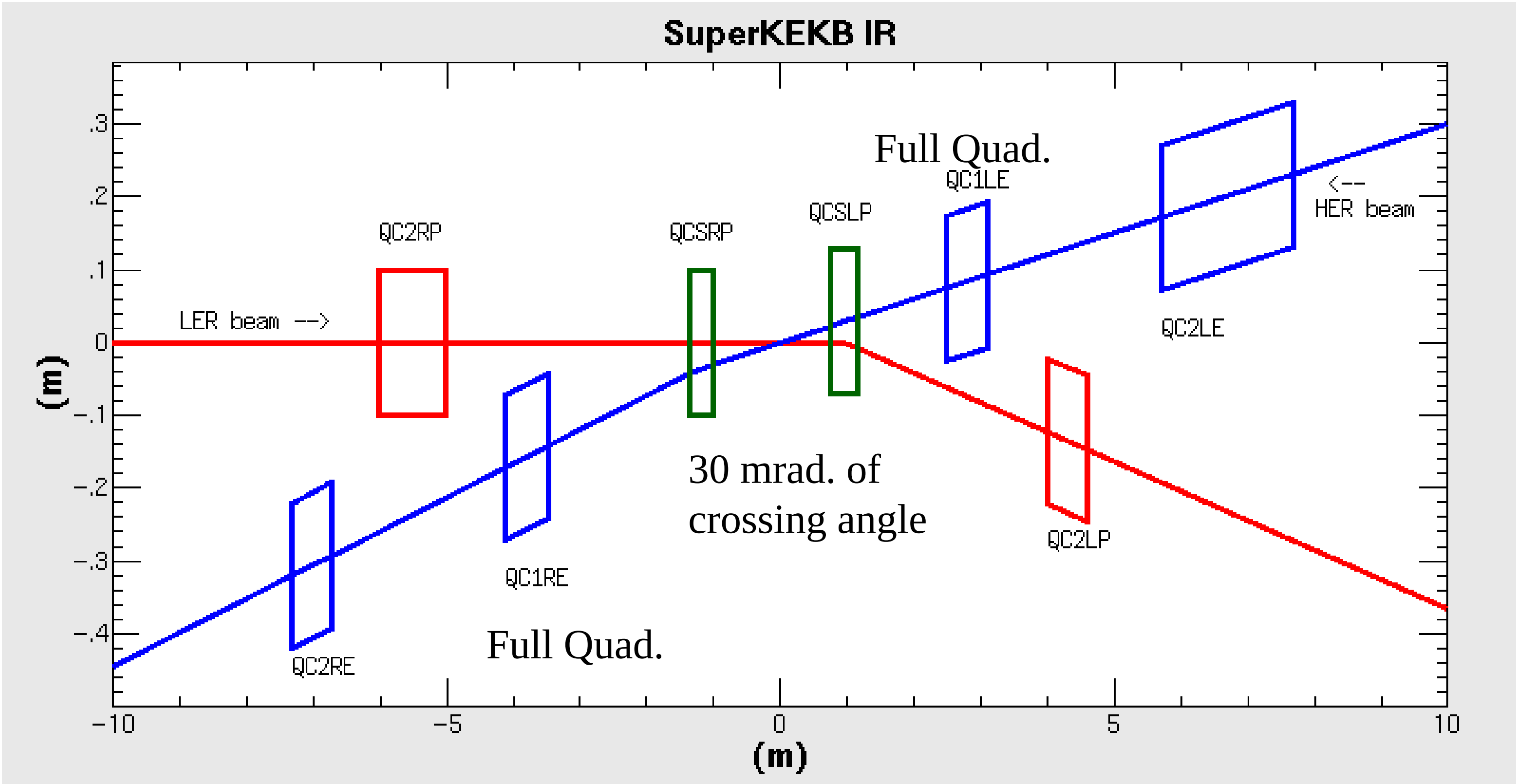
(3) Final focusing quadrupoles (QCS) locate at the position as close to the IP as possible. (In order to decide the QCS positions, spatial constraints against the Belle detector are assumed to be kept the same as KEK-B.)

Pos. from the IP	KEKB	Super-KEKB
QCS-R	1920 mm	1163.3 mm
QCS-L	1600 mm	969.4 mm

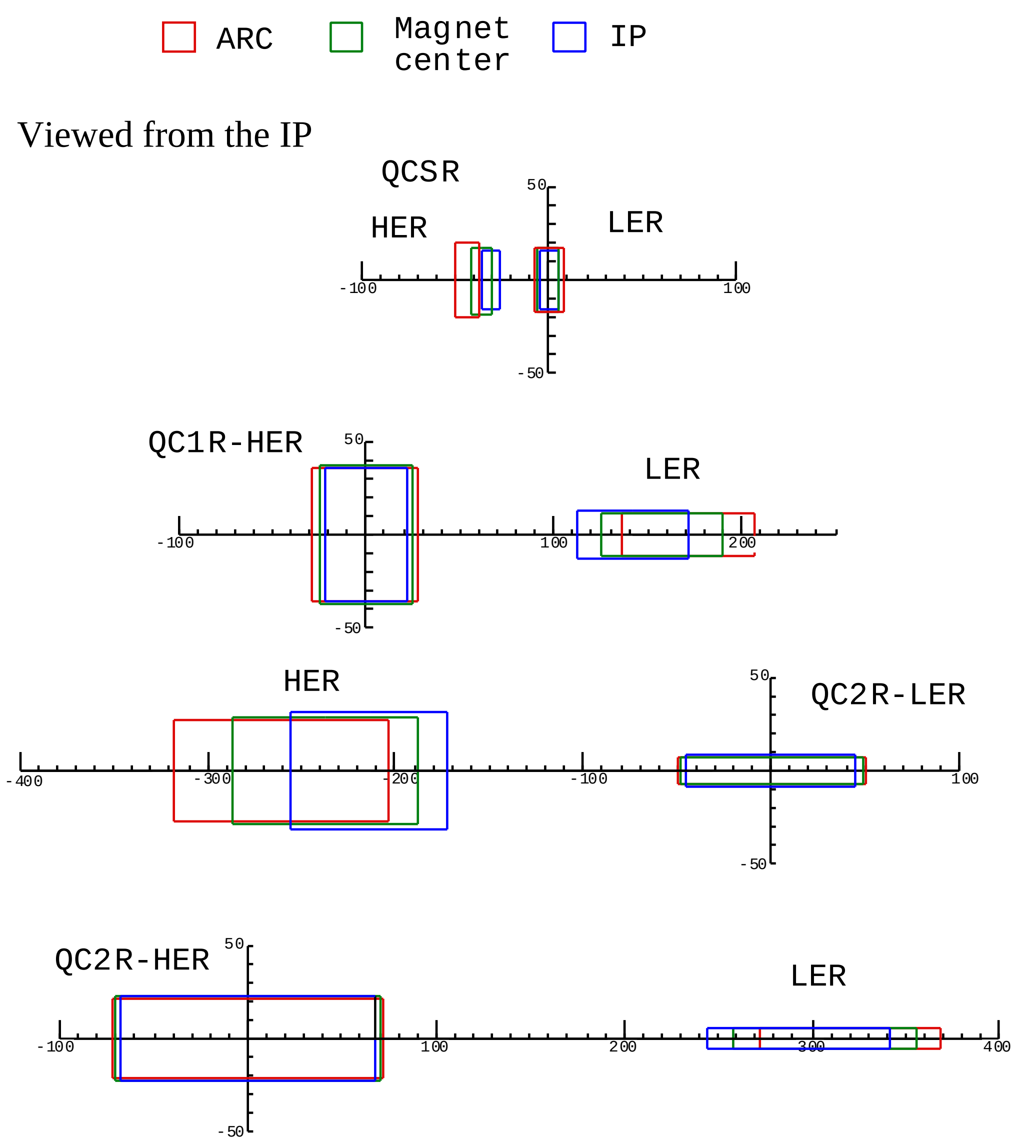
(4) The QCS magnets are overlaid with the compensation solenoids (ES). The axes of the QCSs and the ESs are parallel to the LER beam line, and the axes of the ESs are consistent with the Belle axis.

(5) The QC1 & QC2 locations are 500 mm closer to the IP than those for KEKB. (The first trial : iteration to optimize the design of optics and magnets is under way.)

Layout of the beam lines near the IP for Super-KEKB



IR-right-side-beam-envelope



QCSR : G=37.2 T/m L=0.3327 m

	Dist. from Belle axis (mm)		Dist. from IP (m)
	HER	LER	
Arc	-43.514	0.0	-1.3298
Mag. center	-36.358	0.0	-1.1633
IP	-30.540	0.0	-0.9968

QC1R-HER : G=14.10 T/m L=0.64 m

	Dist. two beams (mm)	Dist. from IP (m)
Arc	171.84	-4.12
Mag. center	156.95	-3.80
IP	142.06	-3.48

QC2R-LER : G=2.77 T/m L=1.0 m

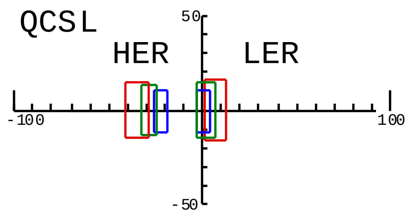
	Dist. two beams (mm)	Dist. from IP (m)
Arc	260.45	-6.015
Mag. center	237.23	-5.515
IP	214.00	-5.015

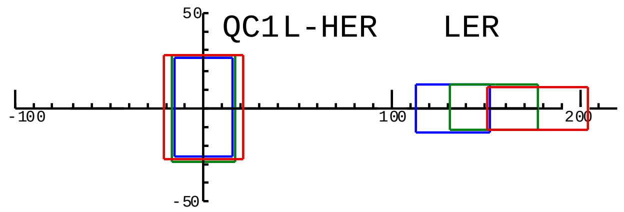
QC2R-HER : G=11.72 T/m L=0.6 m

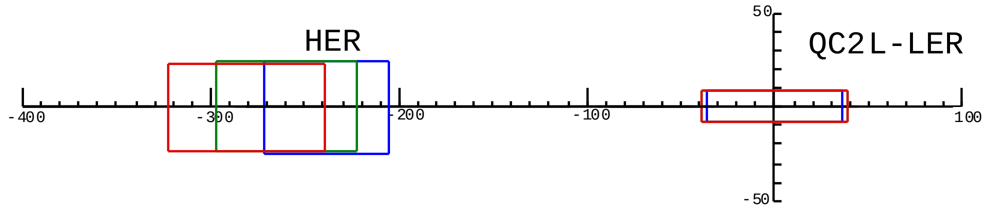
	Dist. two beams (mm)	Dist. from IP (m)
Arc	320.75	-7.311
Mag. center	306.81	-7.011
IP	292.88	-6.711

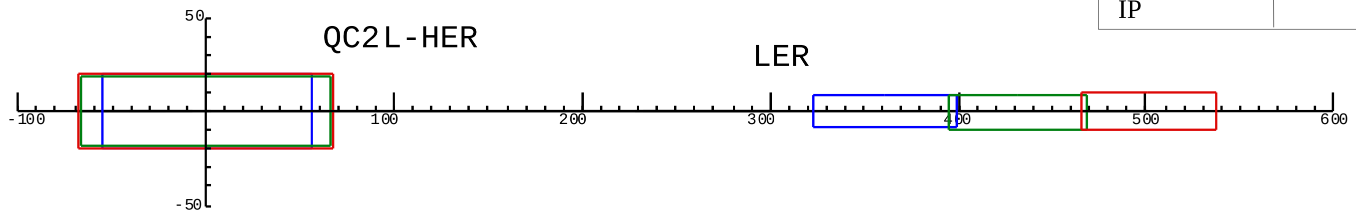
IR-left-side-beam-envelope

Viewed from the IP









QCSL : G=35.4 T/m L=0.4184 m

	Dist. from Belle axis (mm)		Dist. from IP (m)
	HER	LER	
Arc	-34.494	7.307	1.1788
Mag. center	-28.370	1.638	0.9694
IP	-22.204	0.003	0.760

QC1L-HER : G=15.54 T/m L=0.64 m

	Dist. two beams (mm)	Dist. from IP (m)
Arc	177.24	3.12
Mag. center	154.81	2.80
IP	132.38	2.48

QC2L-LER : G=5.87 T/m L=0.6 m

	Dist. two beams (mm)	Dist. from IP (m)
Arc	283.83	4.599
Mag. center	262.50	4.299
IP	241.16	3.999

QC2L-HER : G=3.37 T/m L=2.0 m

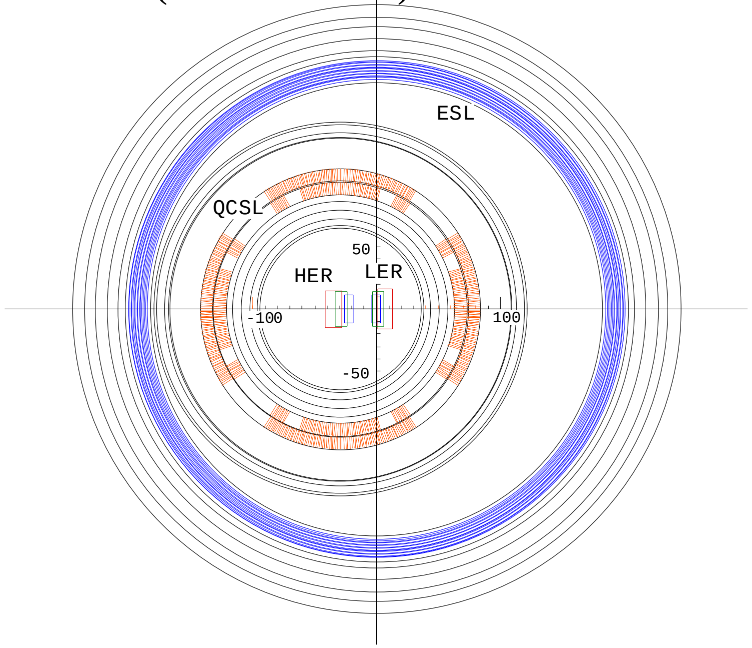
	Dist. two beams (mm)	Dist. from IP (m)
Arc	510.41	7.698
Mag. center	431.15	6.698
IP	360.90	5.698

(2) QCS and ES

QCS Parameters

	Design		Optics	
	QCSR	QCSL	QCSR	QCSL
G, T/m	41.5	41.25	37.2	35.4
L, m	0.3327	0.4184	0.3327	0.4184
S, m	-969.4	1163.3	-969.4	1163.3
o.p., %	84	82	75	70

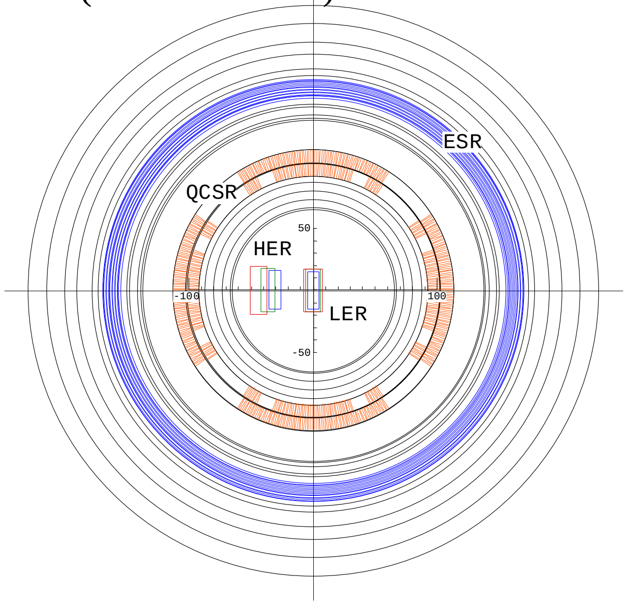
QCSL & ESL (viewed from IP)



ES Parameters

	ESR	ESL
Bz (central field), T	3.00	2.77
L (coil length), m	1.20	0.752
o.p., %	43	43

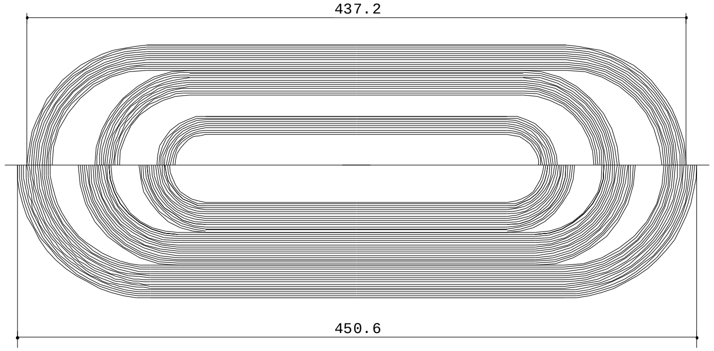
QCSR & ESR (viewed from IP)

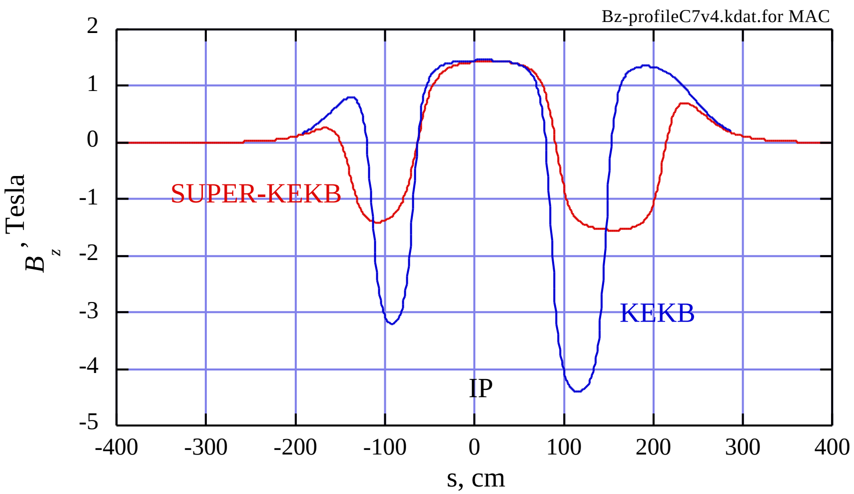


QCSR

Field Profile by ESR, ESL and Belle

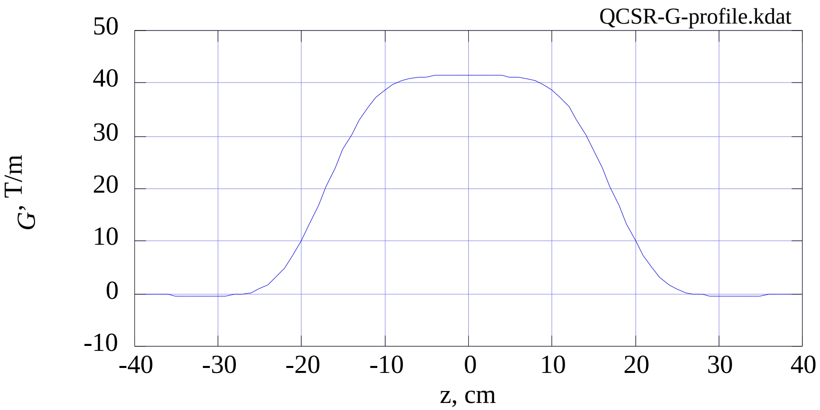
Coil-geometry





G profile along the magnet

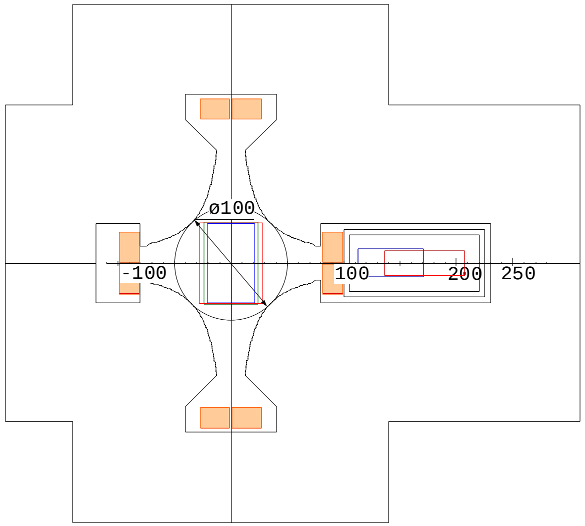
B_z profile along the LER beam line



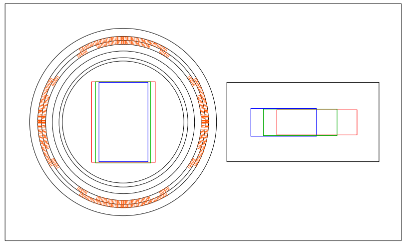
Max. B_z	Super-KEKB	KEKB
Right side	-1.53 T	-4.40 T
Left side	-1.40 T	-3.20 T

(3) Design of the special magnets for the IR (QC1 & QC2)

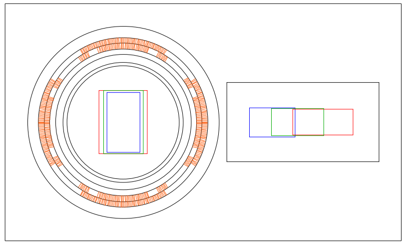
Conventional QC1R-HER



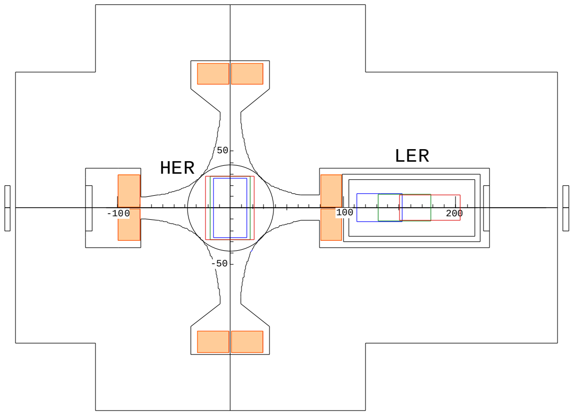
Superconducting QC1R-HER



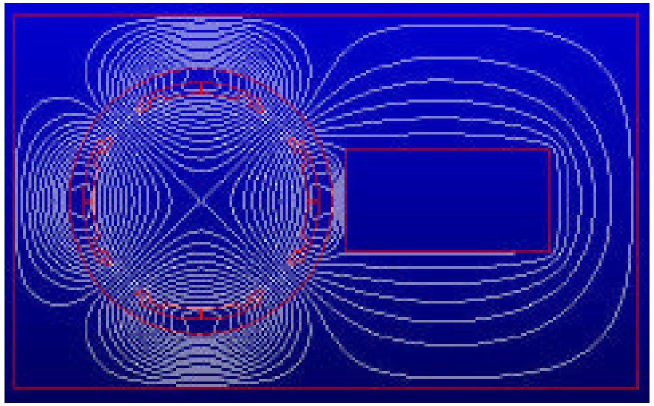
Superconducting QC1L-HER



Conventional QC1L-HER



Magnetic flux lines for super. QC1



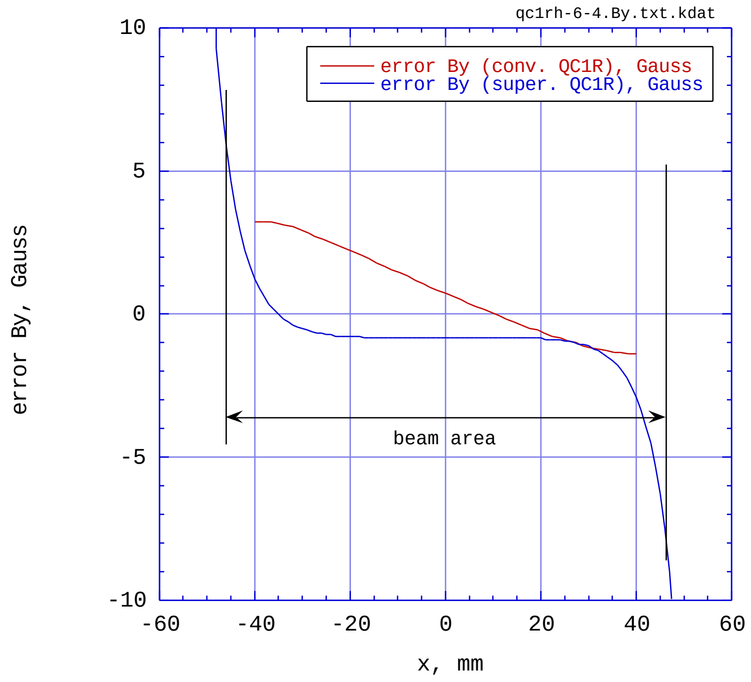
Error field in magnet bore

for superconducting and conventional QC1R-HER

	G, T/m	*L*, m
conventional	13.0	0.7
superconducting	14.99	0.6019

O.P. for S.C. QC1R < 20 %

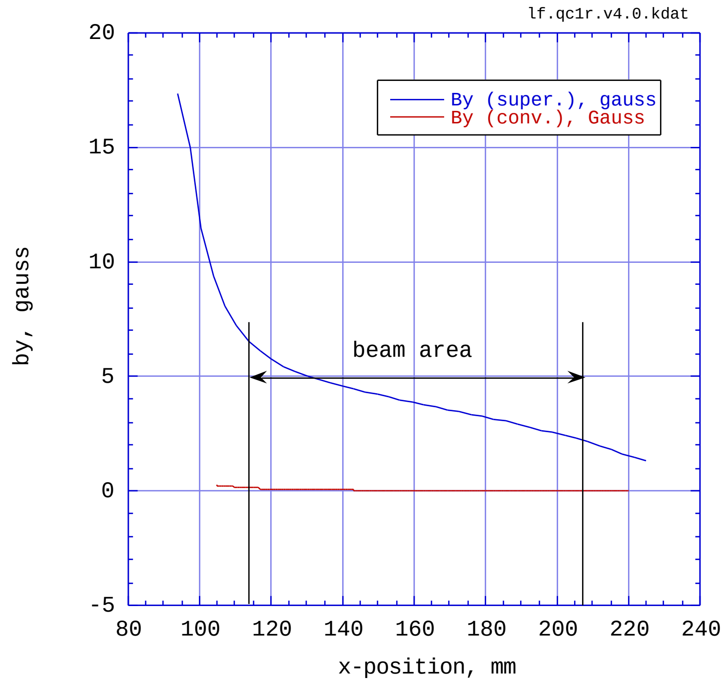
Max. field in the S.C. coil =1.23 T



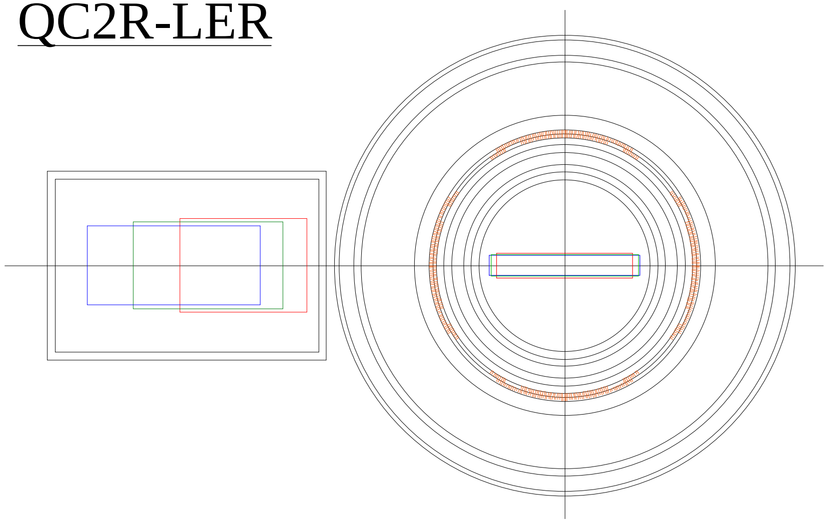
Leak field on the LER beam

In the calculation model:

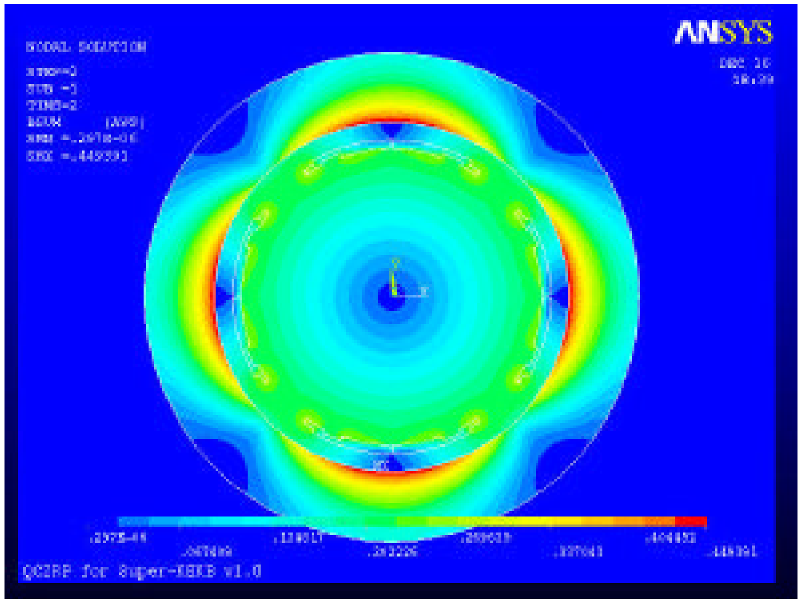
- the conventional QC1R with magnetic shield
- the superconducitng QC1R without magnetic shield



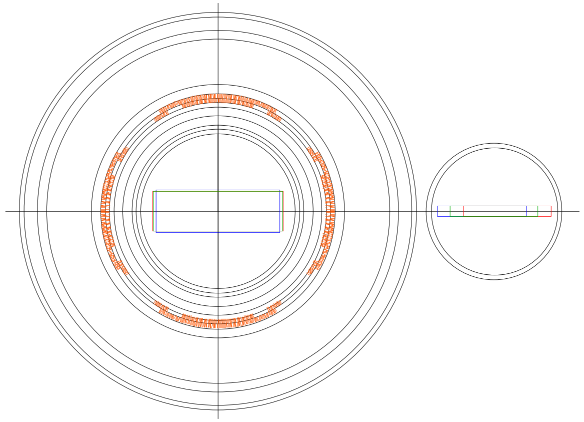
QC2R-LER



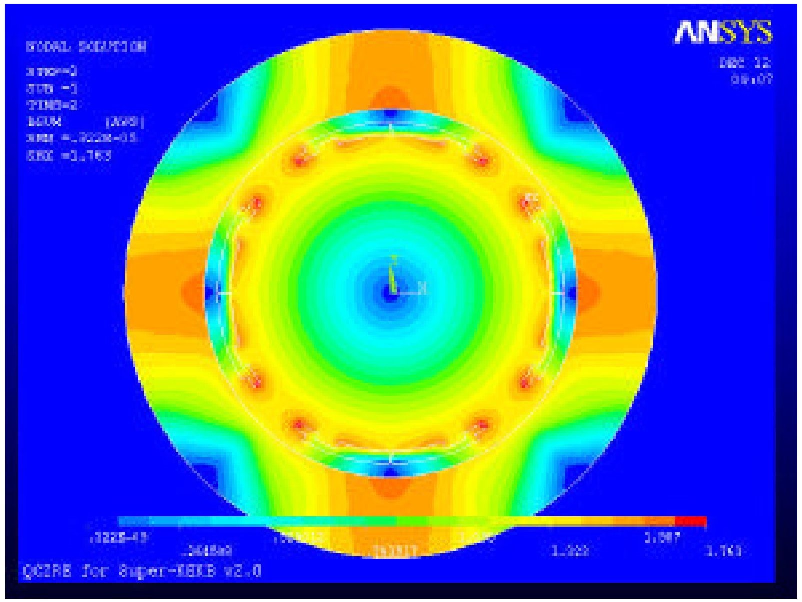
G =2.7 T/m
B_{max} < 0.3 T



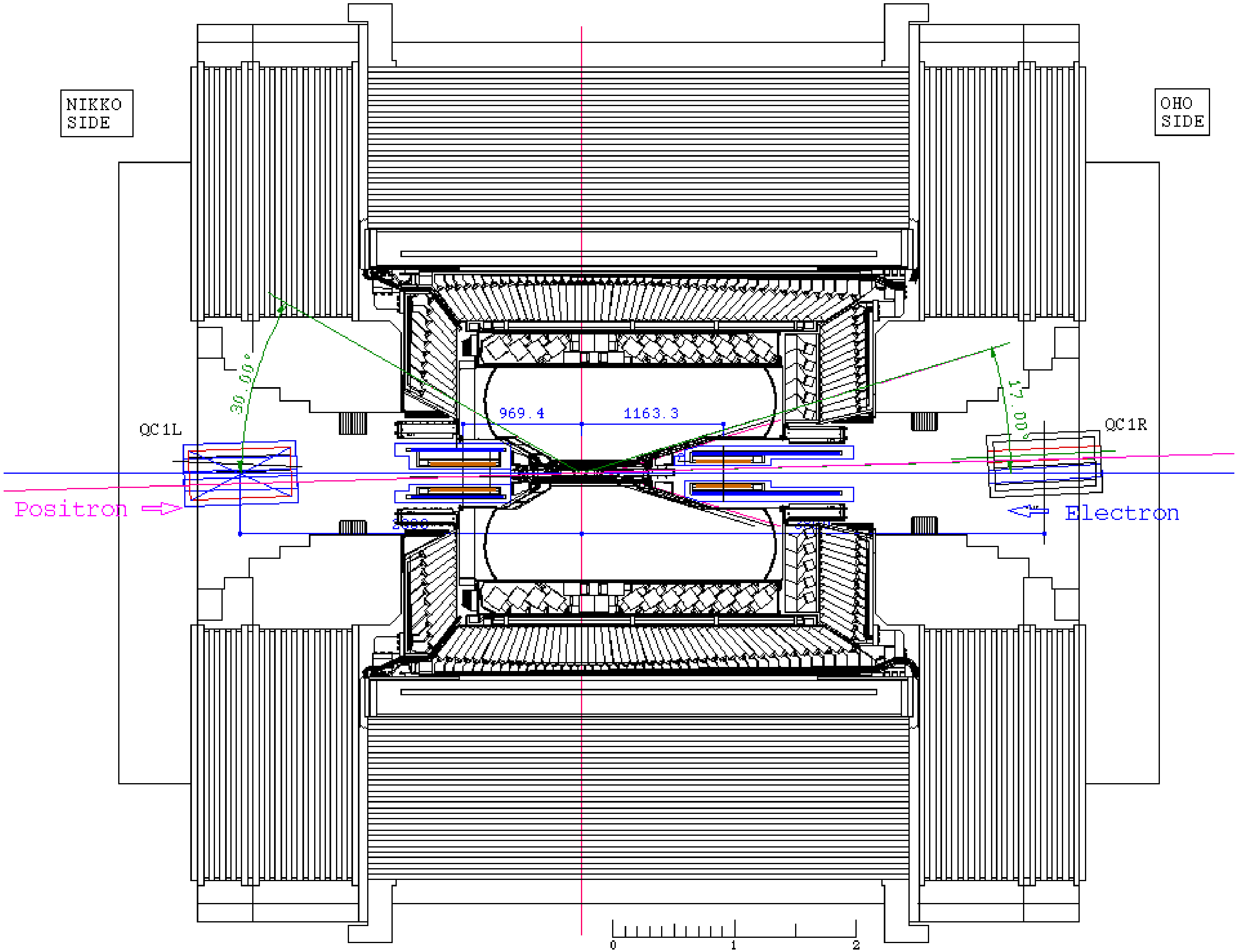
QC2R-HER



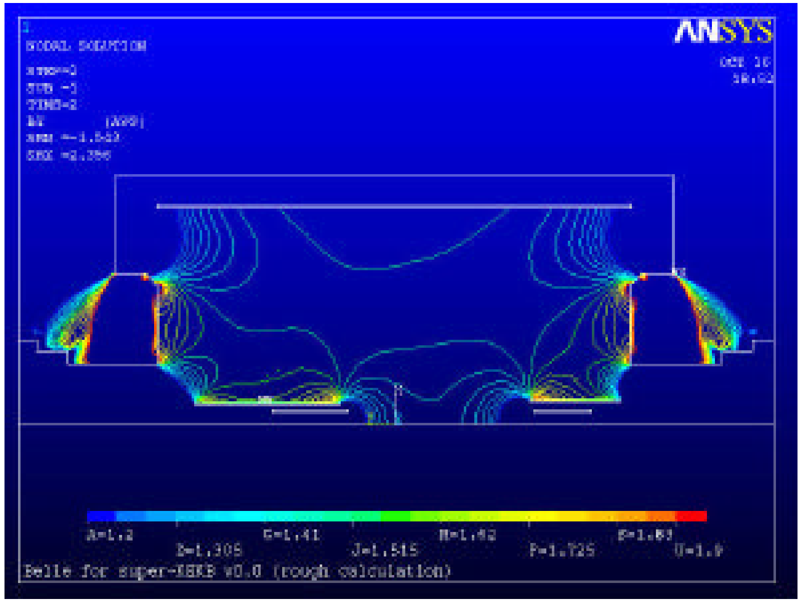
G =12.5 T/m
B_{max} = 1.76 T



(4) Belle detector with QCSs and superconducting QC1s

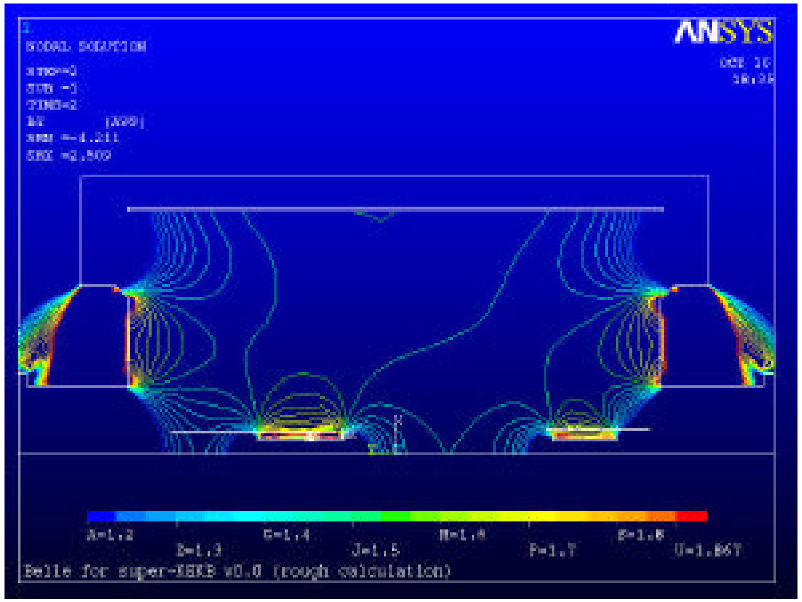


Field distortion in the Belle detector for Super-KEKB



Super-KEKB
(present design)

	ESR	ESL
Bz (central field), T	3.00	2.77
L (coil length), m	1.20	0.752



KEKB

	ESR	ESL
Bz (central field), T	5.80	4.53
L (coil length), m	0.616	0.461

Electro-magnetic force acting on ESR and ESL from the Belle (force in z-direction)

KEKB

ESR: 7050.5 N (0.7 tons)

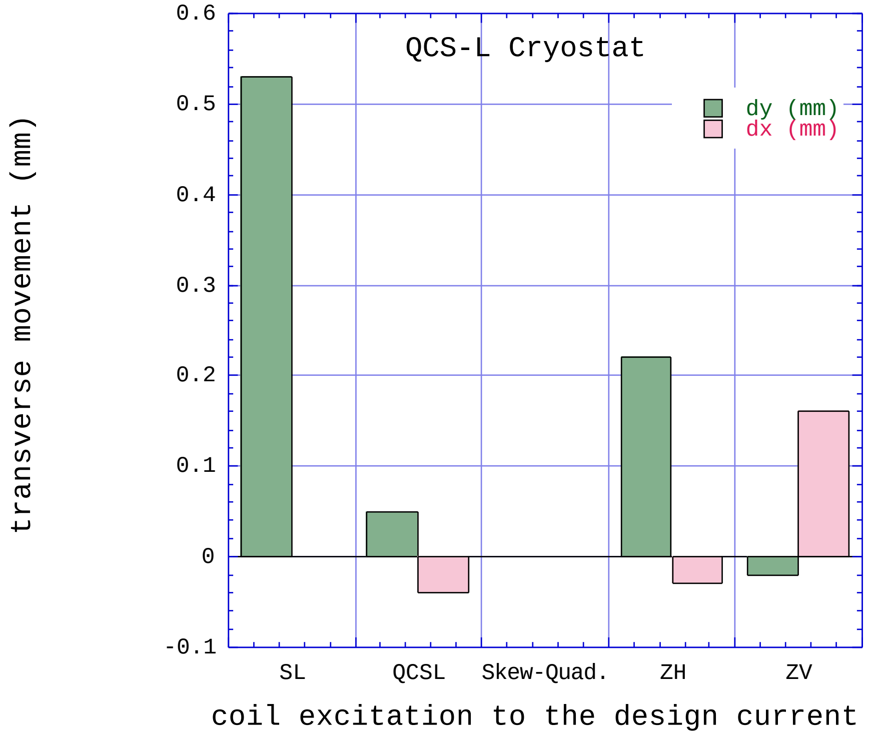
ESL: -23505 N (2.4 tons)

Super-KEKB

ESR: 42288 N (4.3 tons)

ESL: -134820 N (13.8 tons)

KEKB-QCSL-Cryostat movement



(5) Further study for the IR

(1) Vacuum chamber design:

Interference with QCSs, QC1s and QC2s

Estimation of SR heat load from QCSs

(2) Optimization of ESR and ESL to reduce the electro-magnetic force from Belle

Mechanical design of the supporting system

Re-design QCSs including the magnetic field induced by ESR, ESL and Belle

(3) Detailed design of QC1 and QC2 (superconducting or conventional magnet)

Magnetic profile calculation with 3-D model

(4) Detector back ground noise issue