Superconducting Magnet System for IR

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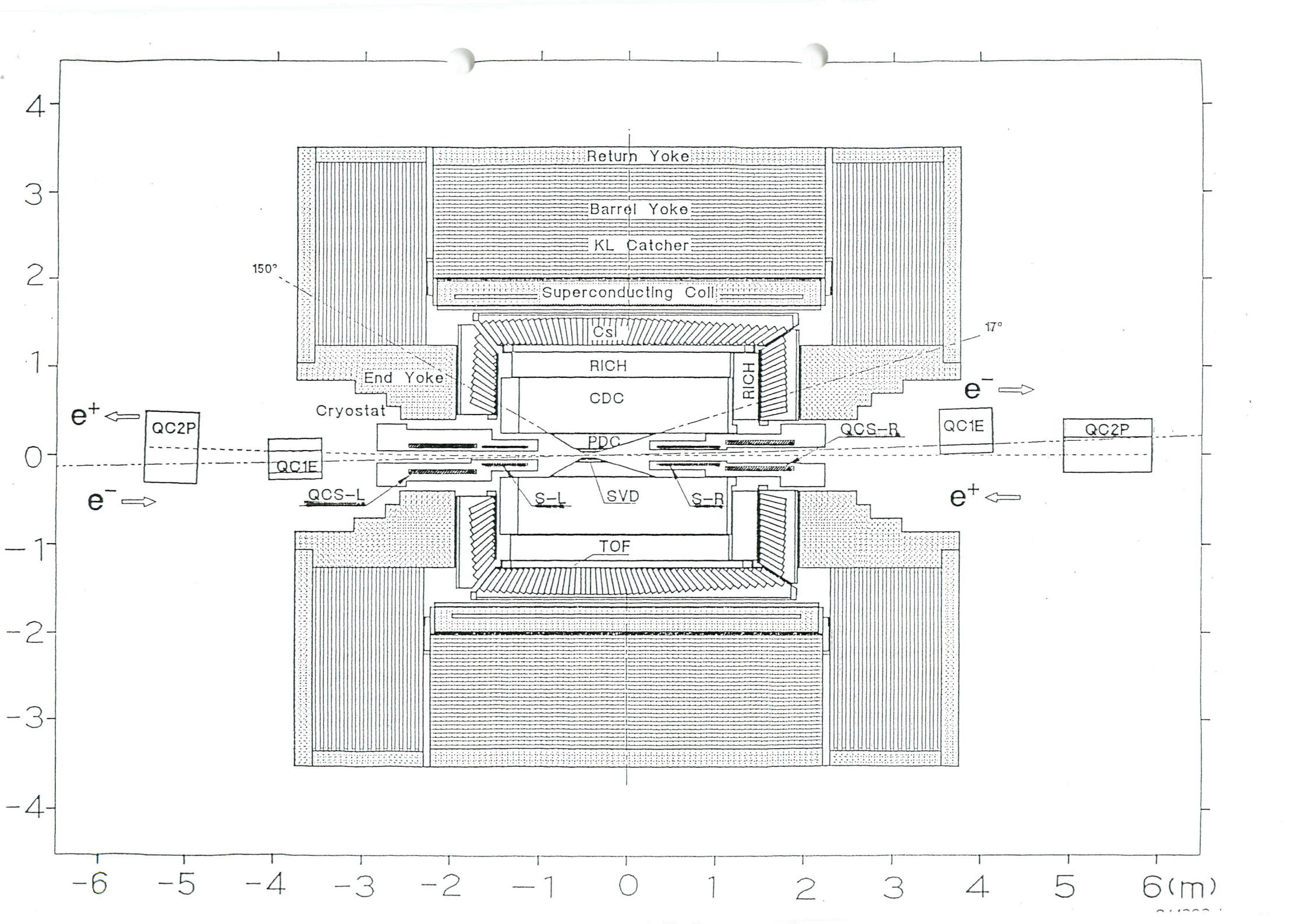
1) Compensation solenoids

2) Quadrupole magnets

3) Cooling system

4) Excitation system


Return Yoke
Barrel Yoke
KL Catcher
Superconducting Coil
CsI
RICH
RICH
CDC
PDC
SVD
S-L
S-R
TOF
End Yoke
Cryostat
150°
17°
e+
e−
e−
e+
QC2P
QC1E
QCS-L
QCS-R
QC1E
QC2P
4
3
2
1
0
−1
−2
−3
−4
−6
−5
−4
−3
−2
−1
0
1
2
3
4
5
6(m)

Compensation solenoids (S-R and S-L)

Design requirements and constraints:

1) $B_z \cdot L \approx \int_{IP}^{END} B_z \cdot dl$ of detector solenoid

2) The aperture of the magnet should be larger than 130 mm for S-R.
100 mm for S-L.

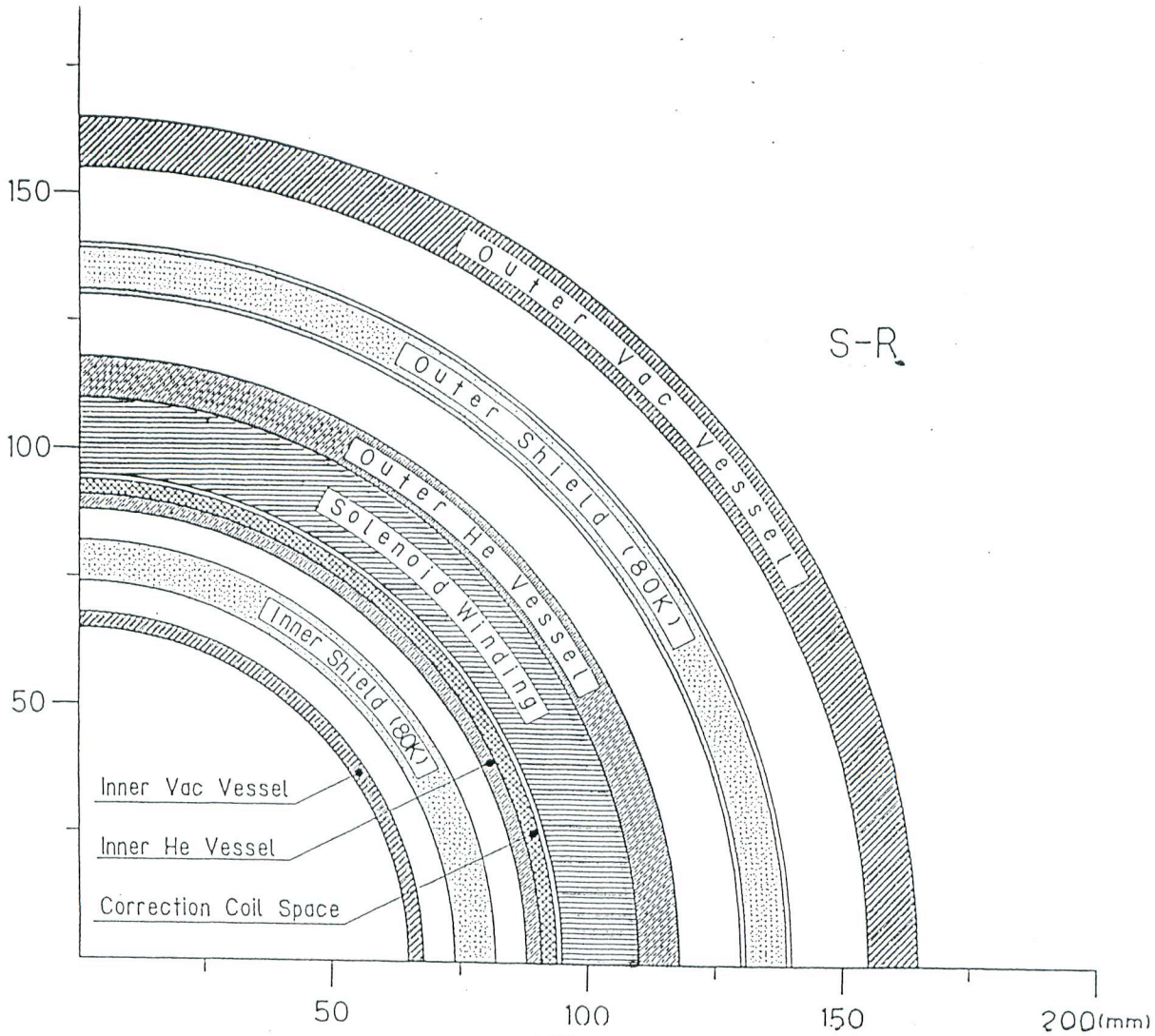
3) The central field of the solenoid < 5.5 Tesla.

4) The current density in the coil < 300 A/mm^2.

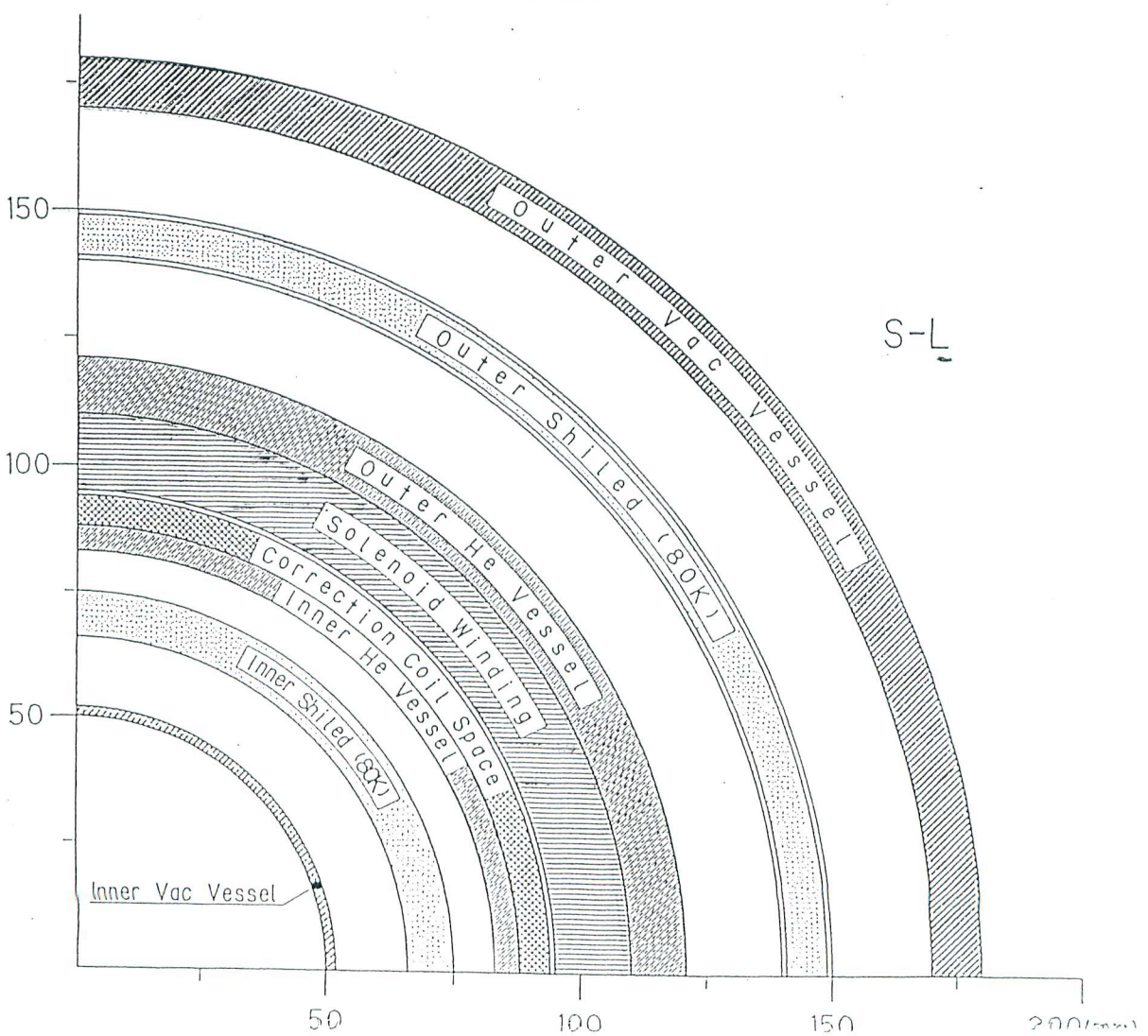
} $\Rightarrow I_{op}/I_c \lesssim 60\sim65\%$

5) The outer diameter of the cryostat should be as small as possible.

6) Both solenoids should have same coil ID and OD.



acc-941205-S-R



acc-941205-S-L

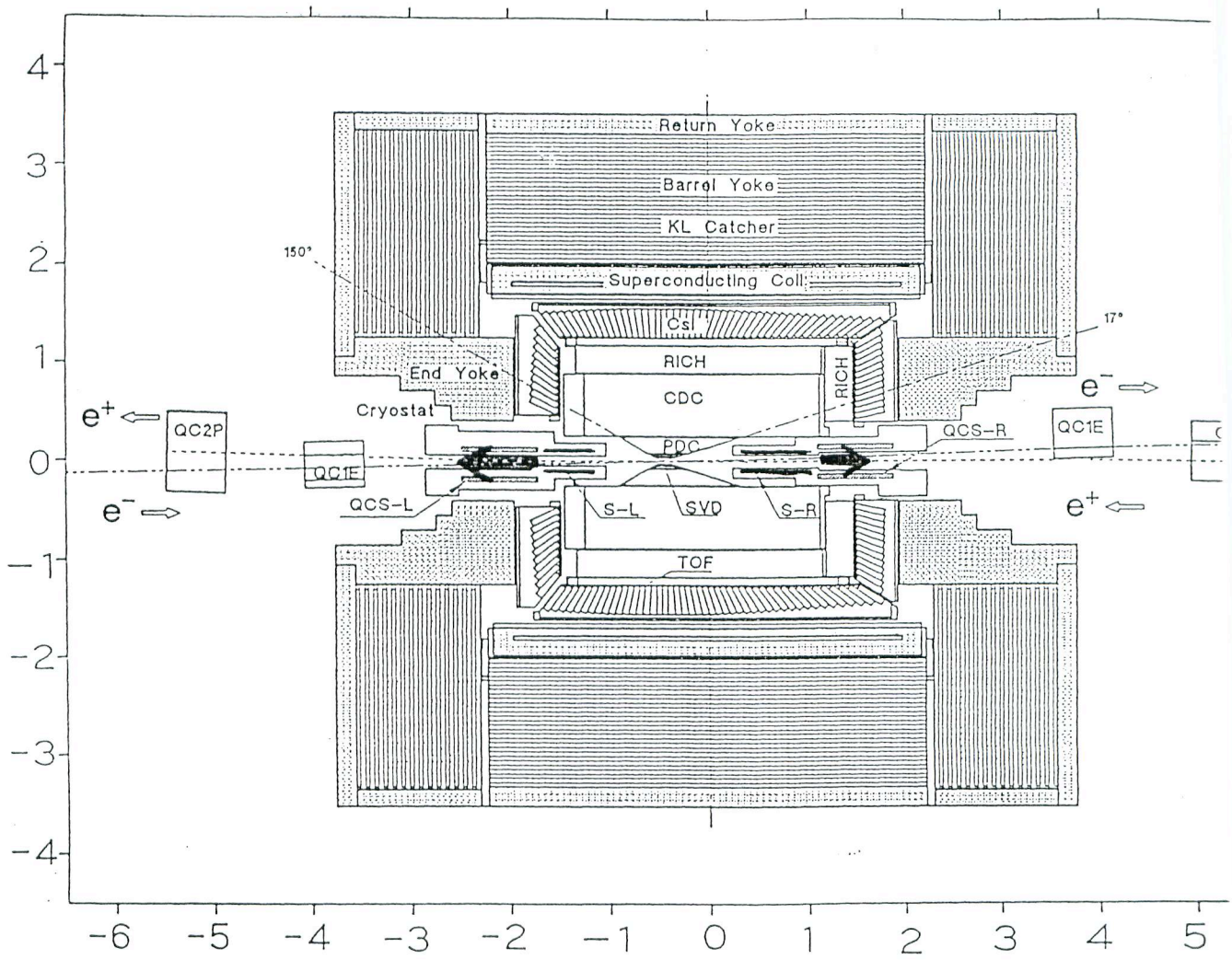
Table 6.5. Main parameters of the solenoids

	S-R	S-L	
Central field	5.4	4.4	Tesla
Coil current density	300	258	A/mm^2
Coil			
Inner diameter	190	190	mm
Outer diameter	220	220	mm
Length	650	470	mm
Max. field on the conductor	5.4	4.5	Tesla
Stored energy	225	115	kJ
Magnetic pressure in radial direction	9.2	6.4	MN/m^2

0.94 kg/m²

Table 6.6. Pressure and force on the solenoids placed in a 1.5 Tesla detector magnet

	S-R	S-L	
Magnetic pressure in radial direction	3.1	1.4	MN/m^2
Body force in axial direction	2.8	22	kN



Quadrupole magnets (QCS-R and QCS-L)

Design requirements and constraints:

1) The warm bore diameter should be 178 mm (140 mm).

2) The operating field gradient is 18.8 T/m and the effective length is 420 mm (490 mm).

3) The operating current should be smaller than 2500 A.

4) The maximum allowable outer size of the magnet, including cryostat is 480 mm (580 mm).

5) The both magnets should have an identical coil structure.

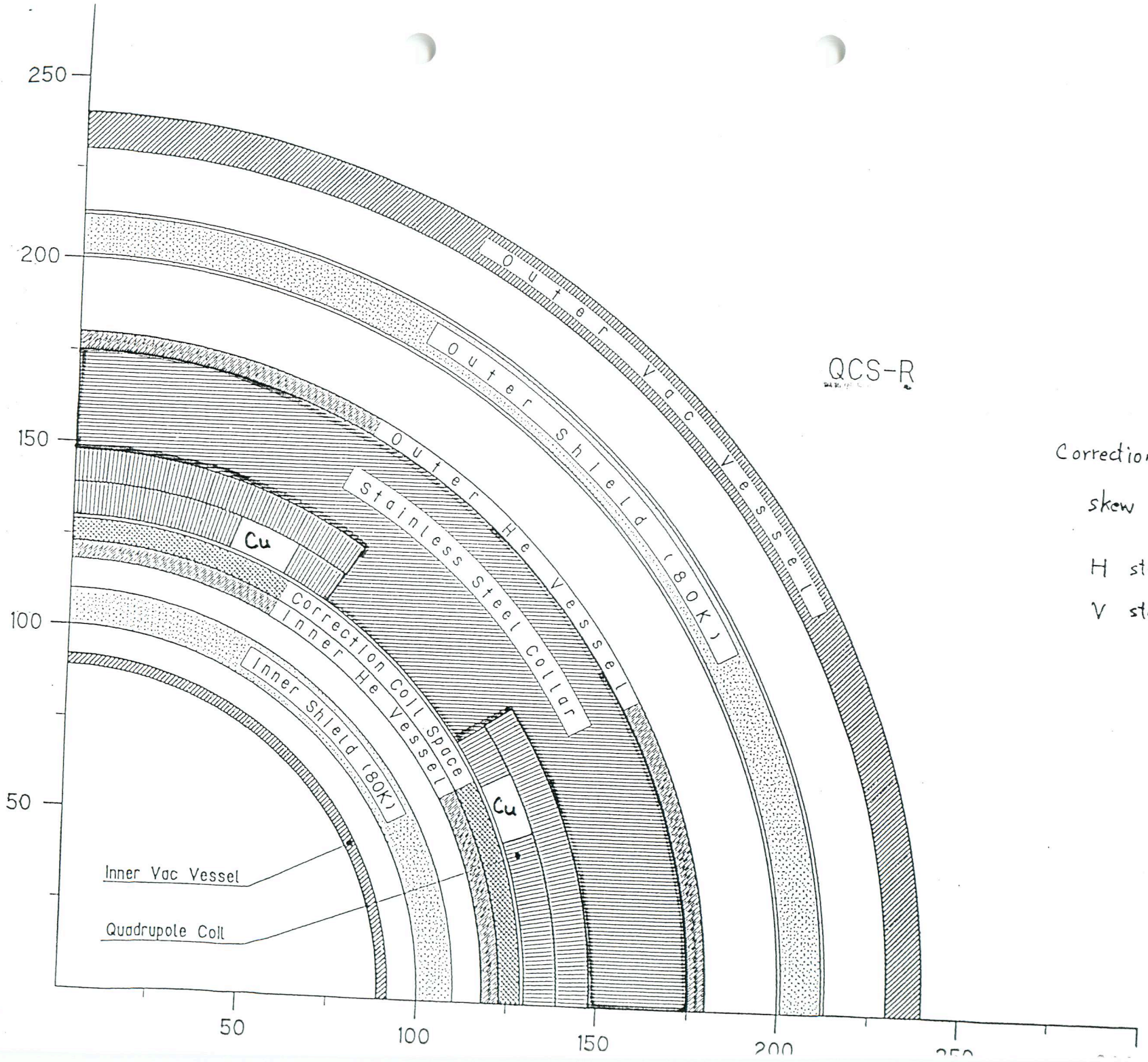

250
200
150
100
50
50
100
150
200
Outer Vac Vessel
Outer Shield (80K)
Outer He Vessel
Stainless Steel Collar
Cu
Correction Coil space
Inner He Vessel
Inner Shield (80K)
Cu
Inner Vac Vessel
Quadrupole Coil
QCS-R
Correction Coil
skew Quad 0.4T/m
H steering 0.6 kG
V steering 0.6 kG
-941205-QCS-R

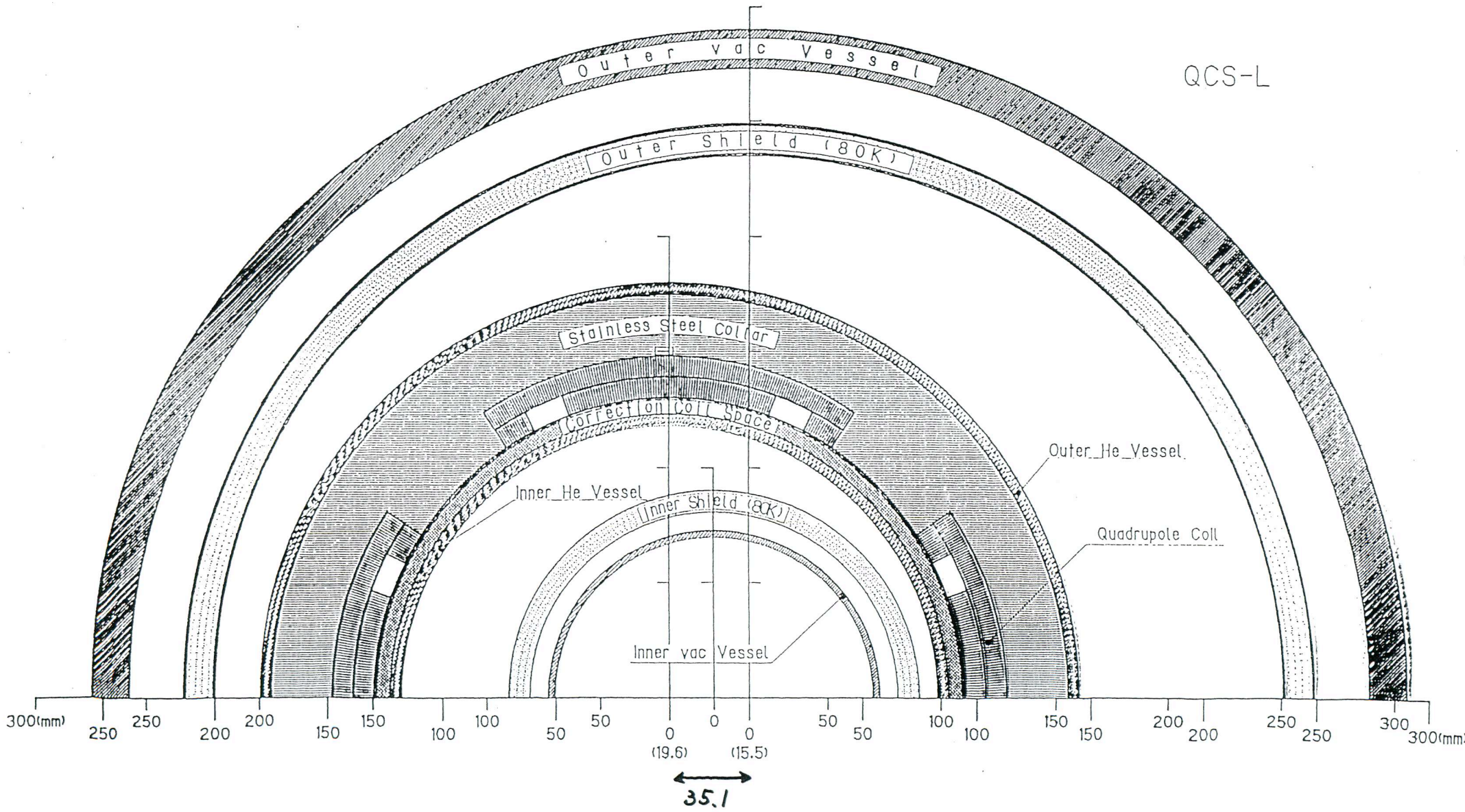
Table 6.7. Parameters of the superconducting quadrupole magnet

Field gradient	18.8	T/m
Current	2224	A
Coil		
Inner diameter	260	mm
Outer diameter	295.4	mm
Overall length of the coils	780	mm (for QCS-L)
	710	mm (for QCS-R)
Collars		
Materials	SUS316LN	
Radial thickness	27	mm
Integrated field uniformity (at r= 40 mm)		
B_6L/B_2L	$< 1 \times 10^{-4}$	
$B_{10}L/B_2L$	< 1 x 10-4	
Effective magnetic length	490	mm (for QCS-L)
	420	mm (for QCS-R)
Max. field on the conductor	3.1	T
Stored energy	157	kJ/m
Resultant of magnetic forces per meter length in the coil octant		
Fx (horizontal)	125	kN/m
Fy (vertical)	-290	kN/m

* Overall length of the coils doesn't include coil end spacer and magnet end plates.

Table 2. Conductor parameters (Rutherford Type Cable)

Cable dimensions	
width	8.35 ±0.05 mm
thickness	0.925 ±0.02 mm
Number of SC strands	16
Number of Cu strands	16
Cu/SC ratio of SC strand	2.0
Strand diameter	0.510±0.005 mm
Filament diameter	less than 6 μm
RRR of stabilizing copper	180 ±20
Cable twist pitch	70 ± 5 mm
Critical current in cable (at 4.2K)	
	more than 2900 A at 5T
	more than 4200 A at 3T



acc-941206-QCS-L

Cooling system

Cooling system will be the same as that of TRISTAN mini-beta quadrupole, which has been used without serious problems since 1991.

One of the cooling systems for TRISTAN mini-beta insertion quadrupole will be reused for KEKB.

The features of the system are:

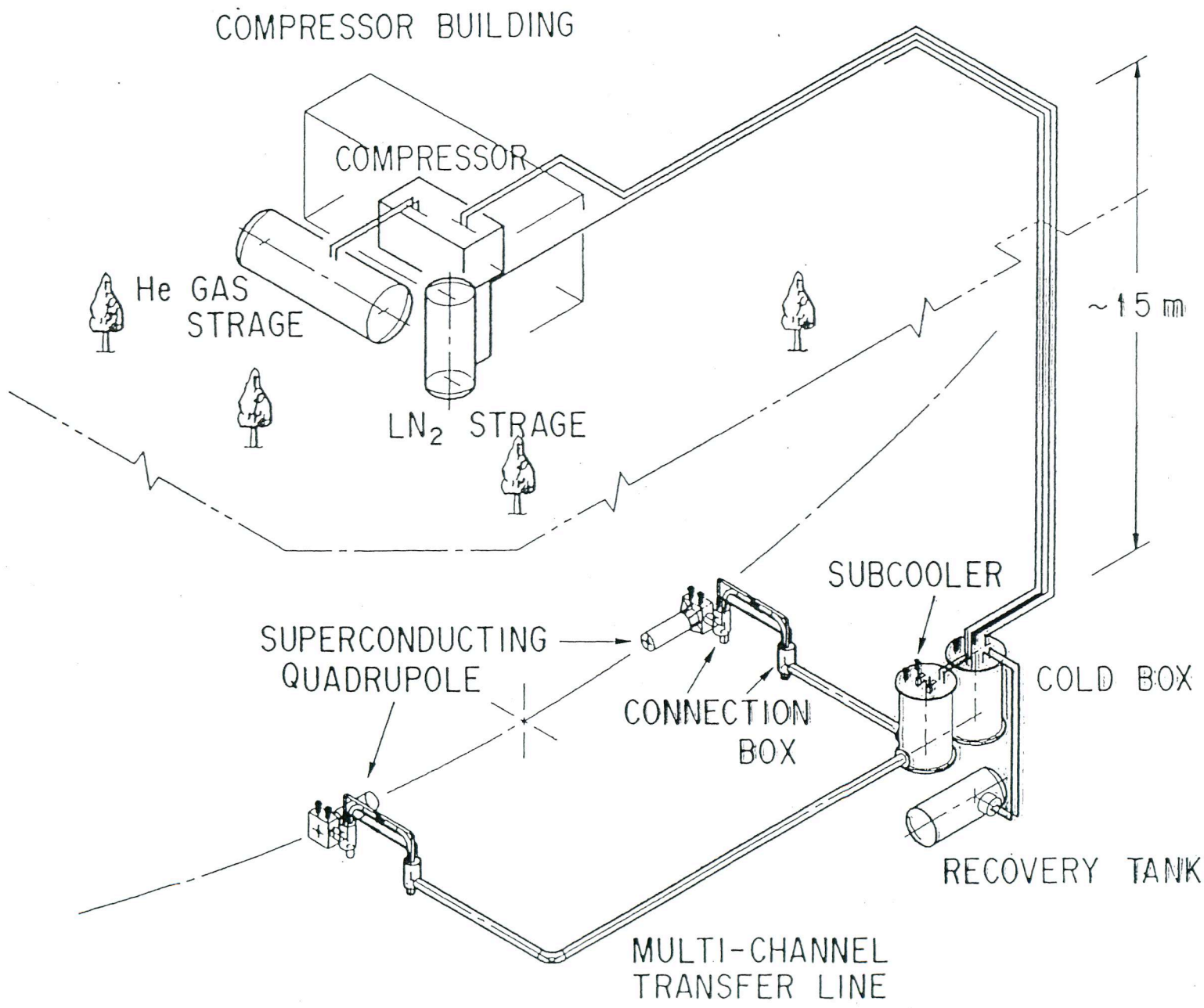
- two cryostats are cooled by single-phase LHe (~4.4 K and 0.162 MPa).

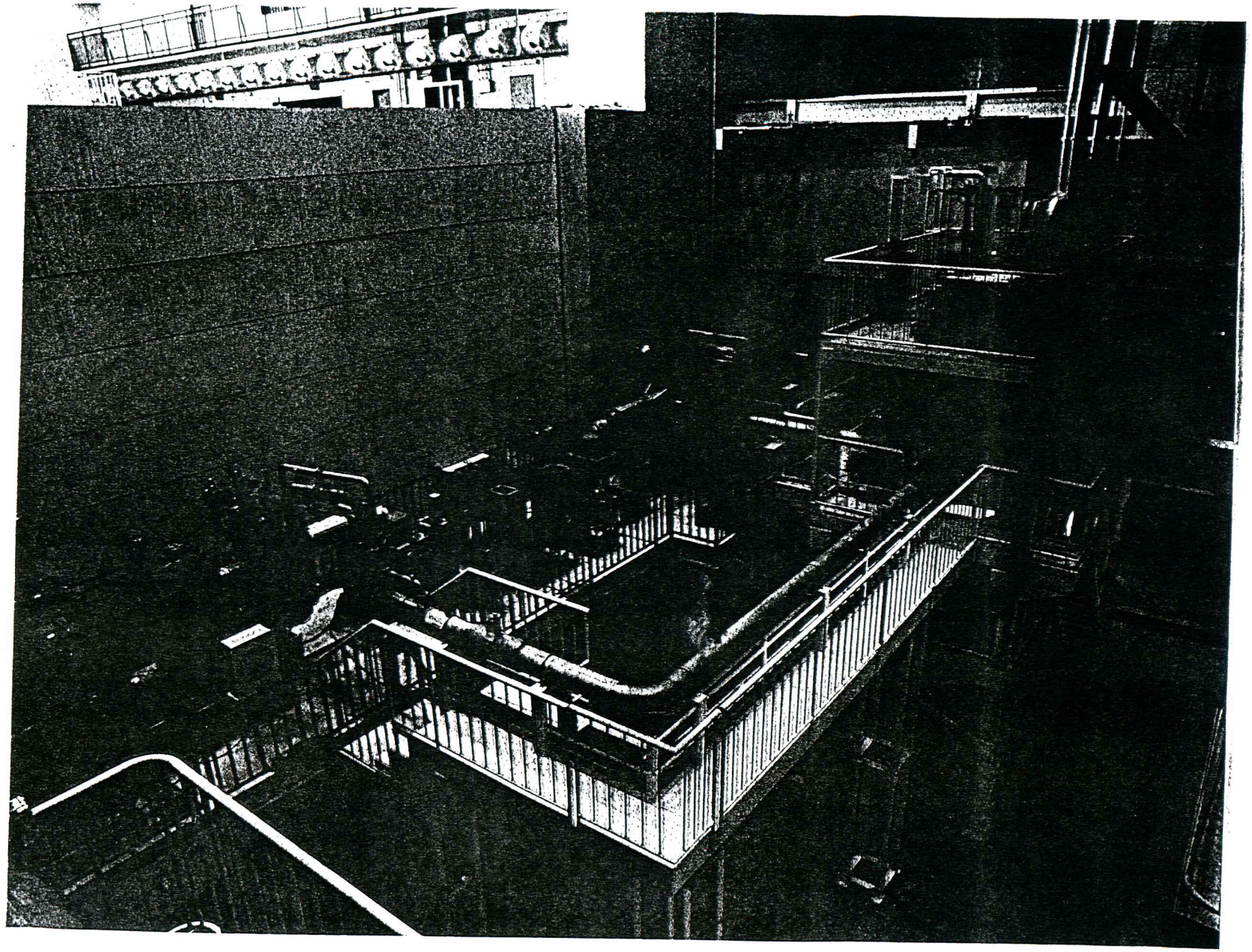
- multi-channel transfer lines containing SC bus for serial connection of two quadrupole.

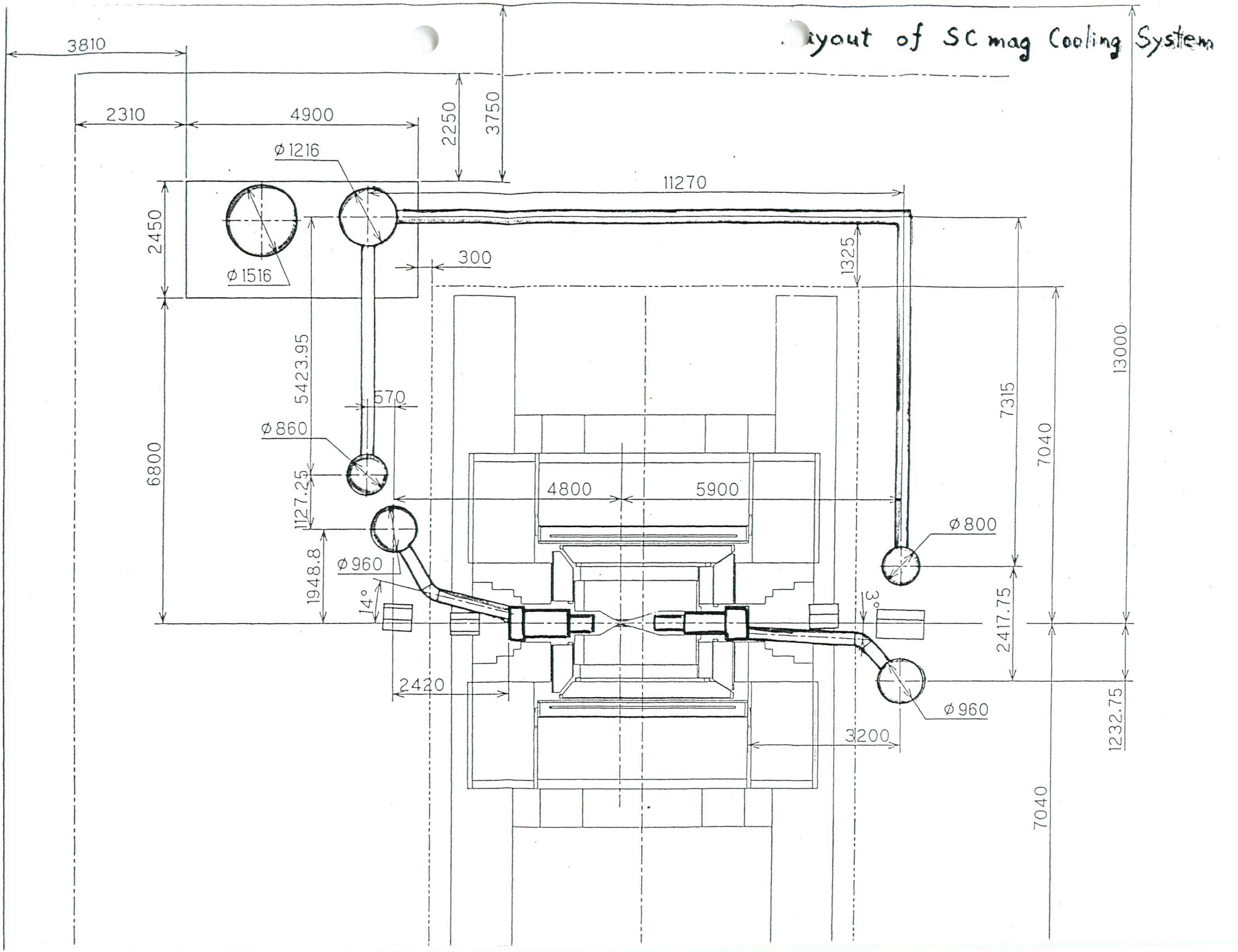
- connection box scheme is adopted in order to make the cryostats easily detachable from the transfer lines.

- automatic operation system automatic cooldown, warm up, and automatic reaction to magnet quench or turbine trouble.

Schematic layout of
TRISTAN QCS cooling system






Layout of SC mag Cooling System
3810
2310
4900
2250
3750
ø1216
ø1516
11270
2450
300
1325
5423.95
570
ø860
6800
1127.25
4800
5900
7315
7040
13000
ø800
1948.8
ø960
14°
3°
2417.75
2420
ø960
3200
1232.75
7040

Heat load budget for KEKB system

		KEKB	TRISTAN QCS
Cryostat (including connection box)	x 2	35 W at 4.4 K	44~21 W
Current leads			
for QCS-R and QCS-L	2500 A x 2 + 100 A	11 L/h	13 L/h
for S-R and S-L	1000 A x 4	7 L/h	
for six kinds of correction coils	100 A x 12	9.5 L/h	
Subcooler		6.6 W	6.6 W
Transfer line (including 2 connection boxes)	~35 m (1.6 W/m)	56 W	62~48 W (3.1~1.4 W/m)
Total		97.6 W+27.5 L/h	106~75 W + 13L/h
Cold box capacity of QCS system (measured)		203 W + 27.5 L/h (safety margin 2.1)	230~205 W + 13 L/h (margin 3.1~2.0)

Excitation circuit

QCS-R and QCS-L will be excited in series with one power supply.
One of the TRISTAN QCS power supplies will be reused.

S-R, S-L and other correction coils will be excited separately.

new power supplies	2	for S-R and S-L
	at least 6	for correction coils

June. 5 '95

KEKB IR Superconducting Magnets Schedule