PRELIMINARY DESIGN OF SUPERCONDUCTING MAGNETS FOR BEPC-II

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Abstract

There're two sets of superconducting magnets in the collision region in the BEPC-II. The magnets will use force-cooling liquid helium in 4.5K, non-iron yokes and for the stiff limitation in radial direction, the superconducting quadrupoles close to the IP shall be a challenge both in engineering design and fabrication.

1 INTRODUCTION

According to lattice design of BEPC-II Double Rings, there are two sets of superconducting magnet in the interaction region. Main parameters are shown in

Table 1.

Parameter	ASOL	SCB	SCQ
Distance to IP	0.6 m	0.6	1.15 m
Magnetic length		0.4 m	0.4 m
Integral Field strength	2.6Tm	0.32252Tm	
Main field strength		By=0.8063T	G=17.6T/m
Field quality		Bn/B1<1×10^{-4} at R=38mm	Bn/B2<1×10^{-4} at R=43mm
Steering dipole			Bx=200Gs
Vacuum tube aperture		∅106	∅120
Maximum diameter	< ∅280 mm at SCB, < ∅450 mm at SCQ		

Each set of superconducting magnet includes one quadrupole named SCQ, one bending magnet named SCB used for synchrotron radiation and one anti-solenoid named ASOL. In order to obtain good results for anti field, the ASOL is divided in to two parts, ASOL_1 and ASOL_2. The SCB and SCQ are inside the ASOL_1 and ASOL_2, respectively. The layout of the superconducting magnets of BEPB-II Double Rings is shown in Fig. 1.

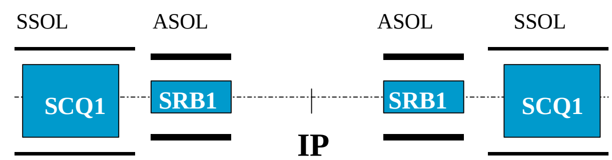

Fig. 1 Superconducting Magnets of BEPB-II Double Rings

2 THE COIL DESING

The superconducting magnets are located inside the BEPC Spectrometer (BES). There is about 1 T field inside the BES. Any iron yoke around the SC magnets will be magnetized. Consequently, there are not any iron yoke around the SC magnets.

The superconducting quadrupole magnet (SCB) is located inside the ASOL-2. The field gradient in the aperture is 17. 6 T /m and its magnetic length is 0.4 m. The requirement of field quality in the useful field region is B_n/B_2 (at R=43 mm)≤ 1×10^{-4}.

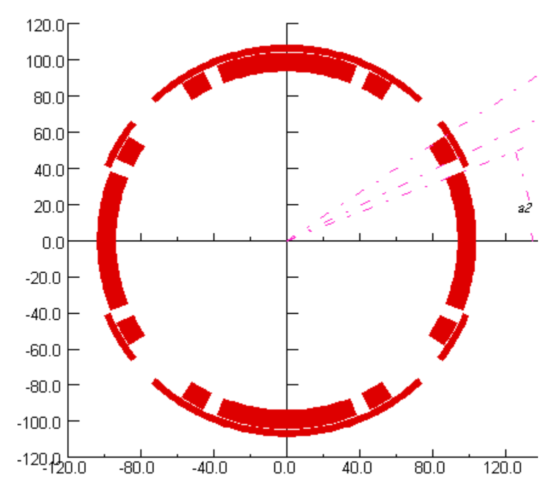

Fig. 2 Cross section of SCQ

The SCQ coils are composed of quadrupole coil and vertical steering dipole coil. The quadrupole coil is a inner coil. The steering dipole coil is beside the quadrupole coil. The SCQ coils (both quadrupole coil and steering dipole coil) are a set of cylindrical current shell with the angular wedges. The cross section of SCQ is shown in Fig. 2.

The quadrupole coils of SCQ have 3 double layers of conductor and its thickness is about 9.9 mm. The inner diameter of the SCQ1 quadrupole coil is ∅188 mm and the outer diameter is ∅207.8 mm. The steering dipole coils consist of one double layer with inner diameter of ∅210 mm and outer diameter of ∅216.6 mm. The results are shown in Ref[3].

3 STRUCTURE DESIGN

The whole structure of the superconducting magnet is shown in Fig. 3. The SCQ, SCB and ASOL coil are installed in one cryostat. Separate the magnet from beam vacuum tube to facilitating for installing the beam tube from two side of interaction point. ASOL, SCB and SCQ are installed in same cryostat to easy for supporting and for installing the magnets into BES detector.

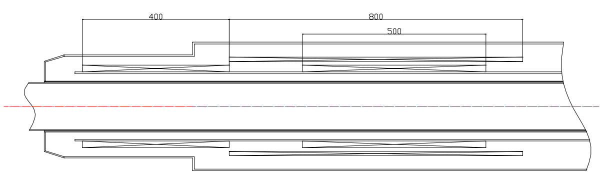

Fig. 3 Structure of the superconducting magnet

The Cross section of the magnet at SCQ is shown in Fig. 4. The beam tube shape in the magnet is round with inner diameter of ∅126 mm and outer diameter of ∅130 mm. The coil support tube is round with outer radius of ∅188 mm and with a thickness of 5 mm. The SCQ quadrupole coil and steering dipole coil are winded round the support tube. The shield solenoid coil (ASOL-2) is winded round SCQ coils. The maximum diameter of the magnet at SCQ is ∅350 mm.

The Cross section of the magnet at SRB and ASOL-1 is shown in Fig. 5. The beam tube shape in the magnet is round with inner diameter of ∅126 mm and outer diameter of ∅130 mm, too. The coil support tube is round with outer radius of ∅188 mm and with thickness of 6 mm. The SRB coil and ASOL coil are winded round the support tube. The maximum diameter of the magnet here is ∅280 mm.

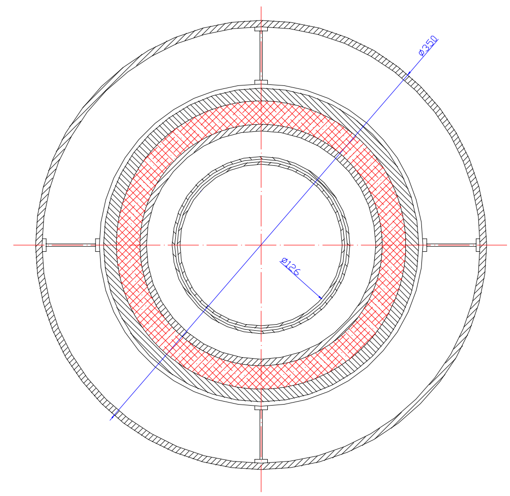

Fig. 4 The cross section of the magnet at SCQ

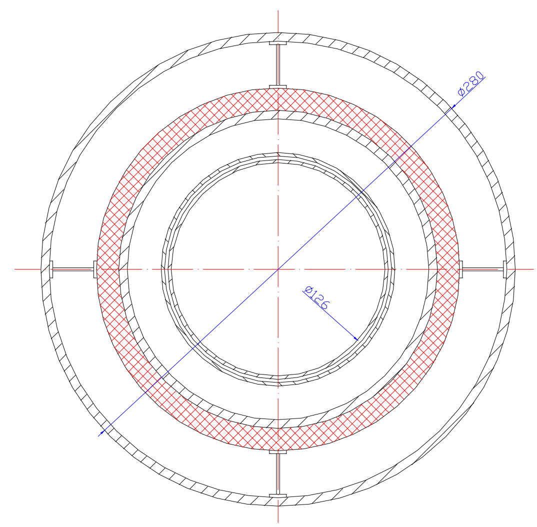

Fig. 5 The cross section of the magnet at SCB

4 CRYOGENIC DESIGN

The designed operation temperature for SCQ, SCB and ASOL is at 4.5 K with a temperature margin of about 0.6K.

The cooling circulation are shown in Fig. 6.

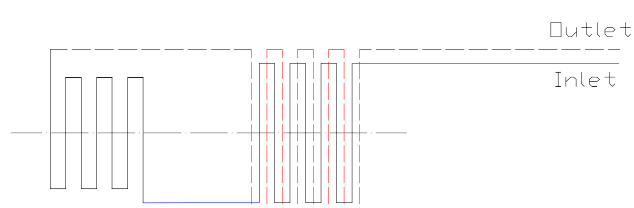

Fig. 6 circulation of cooling liquid helium in the magnet

Quench Protection:

The magnet ring is divided into several sectors made up of series connected magnets. The sectors are powered independently and are electrically independent. Once a quench is detected in a magnet, the power supply of the sector to which the magnet belongs is turned off and sector is discharged over a dump resistor, bypass element R_b. See Fig. 7.

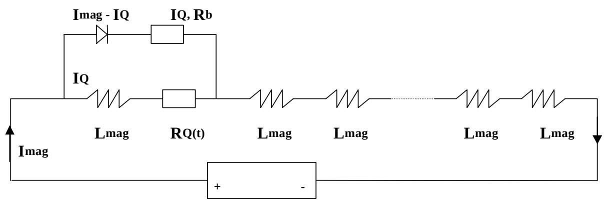

Fig. 7 Electric circuit of a quenching magnet in a magnet ring

5 CONFIGURATION

The magnets that will be symmetrically placed in Beijing Spectrometer (BES).

Cryostat support

The cryostat is supported from a movable stage (support-1). The movable stage is support in the oriented orbit, it can move along the beam line by approximately 3 meter. The superconducting magnet can be pulled out and pushed in with this motion. The alignment position and angle of the superconducting magnet can be accurately adjusted by a mechanism installed on the support-1 base. The support-1 base can be moved horizontally (X direction) and vertically (Y direction) in the plane perpendicular to the beam axis, and can be rotated around the X and the Y-axes. By adjusting the support-1 base, the position of the superconducting magnet will achieve the requirement in physics; the closed orbit distortion was minimized. The oriented orbit is fixed an adjustable stage (support-2); its length is 3.5 meters. The support-2 base serves as a common support base for other accelerator magnets (Q3 and Q4) located in the IR hall.

Magnet alignment

To align the left and right superconducting magnets, hair cross targets are installed on the surface of each superconducting magnet cryostat. The targets are grouped in two pairs, each of which determines the horizontal and vertical position. On each endplate of the main drift chamber in BES, two quartz windows with a radius of ~7 mm will be installed. They will allow the surveyors to look through the left and the right pair of targets. This way, the pair of superconducting magnets can be aligned within 0.1 mm. Then, the position of the superconducting magnet can be used as a reference to connect lines on both sides of the detector.

Endcan and lead tower

The cryogenic transfer tubes will deliver the superconducting power cables and liquid coolant from the outside connection boxes to cryostat. Its routing in the neighborhood of the crowded beam line near the IP will be studied. Details concerning installation procedures for the entire beam line near the IR, including the cryostat, vacuum components and transfer tubes, are being worked out. It is a challenging to connect commendably beam pipe between two superconducting.

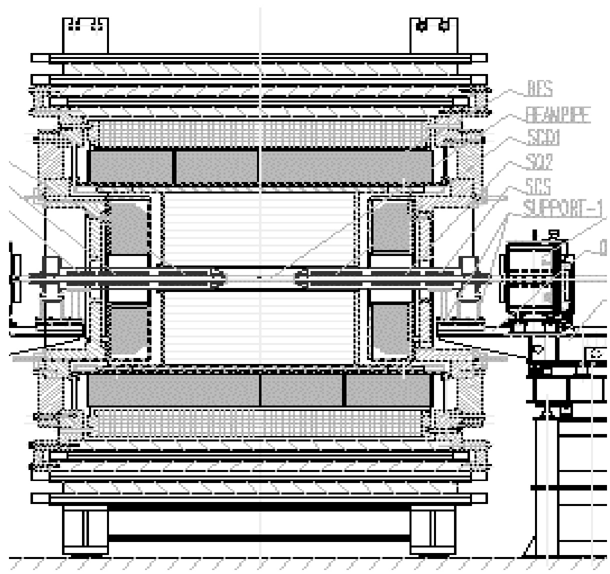

Fig. 8 Installation of BEPC-II IR Magnets

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REFERENCES

[1] Mini-workshop, lecture by Dr. Brett Parker, BNL, IHEP, Beijing, Oct. 2000

[2] Arnaud Devred, 1999 Review of superconducting dipole and quadrupole magnets for Particle Accelerators.

[3] 'Superconducting magnet Design for BEPC-II Interaction Region', will also be presented in APAC'01.