Calculations for the PANDA-Magnet System*

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Abstract

Several finite element models of the PANDA solenoid and the PANDA-dipole [1] were created and analyzed in order to optimize the design of the magnets and the configuration of the detectors. The extensive design work done at JINR Dubna is published elsewhere [2].

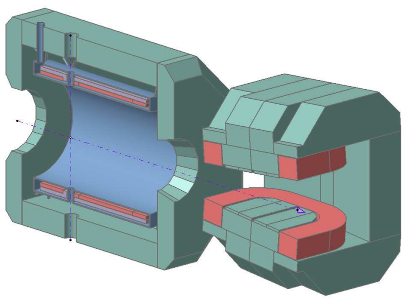

Figure 1: Cut through the PANDA solenoid and dipole models.

Solenoid

For the spectroscopy of low momentum particles at larger angles PANDA will use a superconducting solenoid surrounding the target region. Operation of acluster jet or pellet target requires piping close to the interaction point. Therefore openings for incoming and outgoing pipes through the solenoid are needed causing field distortions.

The nominal field in the tracking area is 2 Tesla. The main question in the solenoid design was concerning the inhomogeneity in the tracking area. In order to get a value of less than ±2.5 % the axial length of the coil was increased from 50 to 80 cm upstream of the target axis. For the inhomogeneity, the ratio of the current density in the end sections of the coil and the density in the middle section has an important influence. A ratio of 1.6 results in an inhomogeneity of ±4 %, a ratio of 2.0 gives a value of ±2 %.

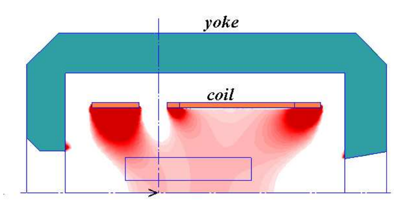

Figure 2: B-field contours in the solenoid. The vertical dahesd line indicates the target axis.

A higher ratio would improve the homogeneity but it would also enhance the maximum field at the windings, and this would require more stabilization of the superconductor.

Since the iron yoke of the solenoid can not be made mirror-symmetric, the axial force on the coil is not proportional to the excitation current. Depending on the design of the yoke the direction of the axial force might even change during the ramp-up. If the opening angle of the downstream end-cap is 22° the axial force is in the order of 100 t. In the latest design proposal with an angle of 10°, the axial force can be limited to less than 40 t, furthermore the homogeneity in the tracking area can be improved and the stray field between the solenoid and the dipole can be reduced.

Dipole

The main requirements for the Dipole magnet are a bending power of 2 Tm, and horizontal and vertical opening angles of ±10° and ±5°, respectively. Other requirements are low power consumption, a low stray field, and a small length in beam direction.

Different coil shapes were analyzed. Complex shapes like the classical bedstead-type give a more uniform field distribution than the simple racetrack-type and require less iron in the return yoke. The disadvantages of the complex types are higher manufacturing costs and higher power consumption.

Using copper or aluminium conductors with low current density the power consumption is in the order of 400 kW. Superconducting coils would require less electric power for the refrigeration, but manufacturing and maintenance cost are higher and the complex support structure required for the magnetic forces is disadvantageous. Like for other dipoles, for instance the one at LHCb [3], normal conductivity is more favourable.

For the choice of the length of the dipole different aspects have to be considered. A small length results in smaller dimensions of the forward spectrometer because it can be positioned nearer to the target. On the other hand, a longer dipole gives less stray field, less power consumption and less field saturation in the iron poles where an average value of 2 T should not be exceeded. Taking this value, a minimum length of 2.5 m is required for a 400 kW racetrack-type dipole made of low-carbon steel.

References

[1] Technical Progress Report for PANDA, Darmstadt 2005.

[2] E. K. Koshurnikov et al., *Conceptual Design of the PANDA Magnet System*, Proceedings of the MT-19, Genoa 2005, to be published in IEEE TAS, 2006.

[3] LHCb Magnet TDR, CERN/LHCC/2000-007.

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