Superconducting Magnet with the Reduced Barrel Yoke for the Hadron Future Circular Collider

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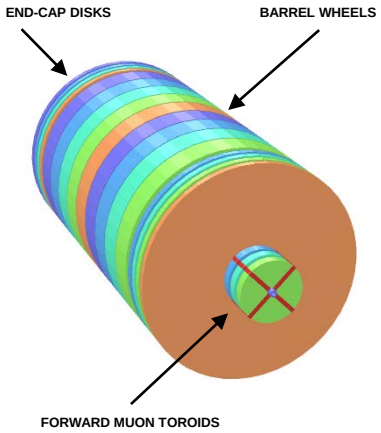
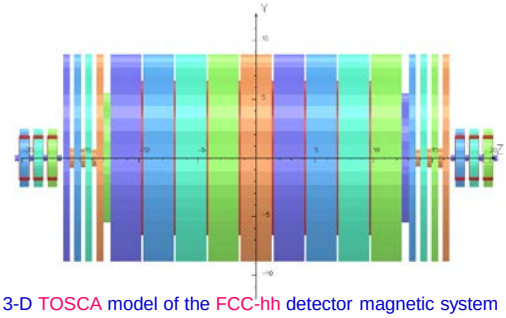
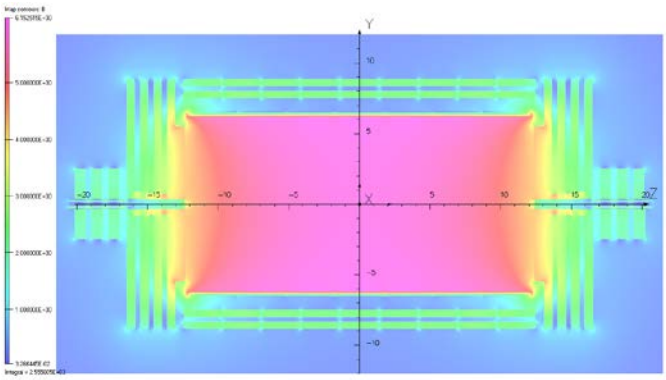


The hadron Future Circular Collider (FCC-hh) with a center-of-mass energy of the order of 100 TeV assumed to be constructed in a new tunnel of 80-100 km circumference, requires to use in the experimental detectors the superconducting solenoid coils with a free bore of 12 m in diameter and with the central magnetic flux density of 6 T. The physics requirements assume the location of the major sub-detectors inside the coil.

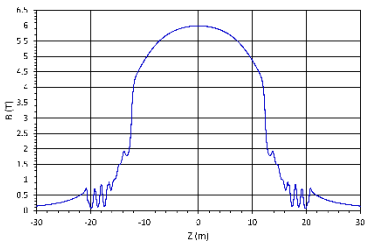


3-D TOSCA model of the FCC-hh detector magnetic system

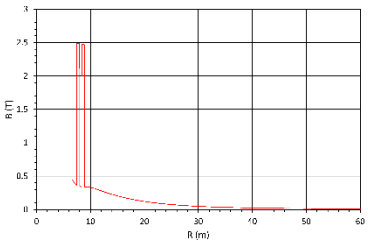


Magnetic flux density distribution in the vertical plane. The color magnetic field map plotted with the cell size of 0.05 m has the width of 43 m and the height of 24 m. The color scale unit is 1 T. The minimum and maximum magnetic flux density values are 0.0327 and 6.1525 T

- ***The coil with 6 layers of the Cu-stabilized NbTi conductor and 127.25 MA-turns has the inner diameter of 6.19 m at the room temperature and the length of 24.518 m.***
- ***The steel yoke of 20.74 kt with total length of 41.2 m has the outer diameter of 17.7 m and includes 9 barrel wheels of 2.65 m width, 2 nose disks of 0.7 m thick, 8 end-cap disks of 0.6 m thick, and 6 forward muon toroids of 0.8 m thick and 5 m outer diameter with 24 conventional copper coils with the current of 907.6 A.***



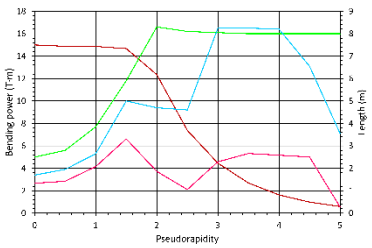
Magnetic flux density variation along the coil axis



Magnetic flux density out of the coil in the coil middle plane vs. radius

The coil consists of seven modules of 3.5 m long with 3 mm thick insulation between the modules. The coil radial thickness without the quench back cylinder is 0.418 m, the 22×68 mm² conductor mass is not less than 3418 t. The total number of turns is 6342, and the current corresponding to the central magnetic flux density of 5.9906 T is 20065 A.

The stored energy of 43.3 GJ in the coil gives the ratio of the stored energy to the coil mass of 12.66 kJ/kg that is about the CMS value of this ratio. The axial pressure in the coil middle plane is 68.47 MPa; the average radial pressure is 14.35±0.79 MPa. The axial force to each end-cap is 480 MN including the axial force to each forward muon spectrometer of 7.2 MN, and the maximum axial force to the barrel wheel is 46.8 MN. The stray magnetic flux density drops to 14.1 mT at the radius of 50 m off the coil axis and to 5.4 mT at the radius of 100 m.



Magnetic flux density bending component integrals (left scale) and the length of the charged particle trajectory (right scale) in the inner tracker (dark red and green curves), and in the muon system (pink and the light blue curves) vs. the pseudorapidity

Summary

- **The parameters of the superconducting solenoid coil and the magnet steel yoke seem to be reasonable.**
- **The magnet provides the required free bore of 12 m diameter and the central magnetic flux density of 6 T.**
- **The charged particle momenta can be measured in the pseudorapidity interval of ±3.5.**
- **The muon momenta identification can be done within the pseudorapidity interval of ±4.6.**