Design of a 56 GJ Twin Solenoid & Dipoles Detector Magnet System for the Future Circular Collider

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Abstract — An aggressive low mass and high stress design of a very large detector magnet assembly for the Future Circular Collider (FCC-hh), comprising a "Twin Solenoid" and two dipoles, is presented. The twin solenoid features two concentric solenoids. The inner solenoid provides 6 T over a free bore of 12 m and a length of 20 m, enclosing the inner particle trackers as well as electron and hadron calorimeters. The outer solenoid reduces the stray field of the inner solenoid and provides additional bending power for high-quality muon tracking. Dipoles are included providing 10 Tm of bending power in a 6 m mean free bore covering the forward directions for $\eta \geq 2.5$ particles. The overall length of this magnet assembly is 43 m.

The presence of several separate magnets in the system presents a challenge in terms of forces and torques acting between them. A rigid support structure, part of the cold mass, holds the inner and outer solenoids of the twin solenoid in place. The dipoles are equipped with lateral coils so that the net force and torque are reduced to zero.

The second challenge is the substantial conductor and support structure mass used for containing the magnetic pressure. A doped aluminum stabilized and reinforced conductor is proposed allowing minimal overall mass of the system.

The result is a system comprising a 53 GJ twin solenoid, and two 1.5 GJ dipoles. The cold mass and vacuum vessel mass of the twin solenoid are 3.2 and 2.4 kt, respectively, and the dipole cold mass weighs 375 tons. Various properties of the magnet system are discussed such as magnetic, mechanical and thermal properties, quench behavior, and assembly.

Keywords (Index Terms) — FCC, detector magnet, twin solenoid, dipole.