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Design and quench analysis for transparent superconducting solenoids for the Innovative Detector for Electron-positron Accelerators at the lepton Future Circular Collider

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As part of the European Strategy for Particle Physics there is an ongoing development towards a Future Circular Collider (FCC) where electron-positron collisions could produce Higgs particles in a low background environment due to the high center-of-mass energy and the leptonic nature of the collisions. Particle detectors are used to study these collisions and a strong magnetic field is required inside the detector volume to measure the particles' momenta.

In the Innovative Detector for Electron-positron Accelerators (IDEA) concept a 6 m long solenoid is placed in between a tracker detector and the calorimeters. Since the superconducting solenoid is placed inside the calorimeter it needs to be as transparent as possible to particles that are produced in the collisions. This transparency is usually expressed in the number of radiation lengths, the length a particle travels through a medium before losing a certain amount of energy. For the IDEA detector the transparency of the magnet should be below one radiation length. This poses challenges for the superconducting magnet design, because a reduction in the amount of material naturally leads to a more challenging quench protection and higher stresses in the coil mass.

This paper compares different design options for the IDEA detector magnet, towards a design that combines the requirement of maximum particle transparency with suitable quench protection and mechanics. The goal is to design a 2 T magnet with a bore radius of 2.2 m. The stored energy of the magnet system will be around 160 MJ. This includes the iron yoke on the outside of the detectors. In this paper the transparency of the coil, support structure, quench protection, winding layout, conductor, mechanics, and current supply are discussed.

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