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Development of conductors for thin solenoids for ultra radiation-transparent detector magnets

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In the frame of the ongoing design study of the Future Circular Collider (FCC), new options for detector magnets are being developed. In the current concept, the first phase of the FCC may be the FCC-ee, an electron-positron collider operating at energies up to 350 GeV in a 100 km long tunnel. As second phase it may be replaced by a 100 TeV hadron-hadron collider (FCC-hh). The particle detectors and their superconducting magnets are required to provide sufficient resolution. For FCC-hh, for example, this requires 4 T over 20 m in a 10 m diameter free bore. In current general-purpose detector systems, the magnetic field not only encloses the inner tracker where the magnetic field is actually needed, but also the electromagnetic and hadronic calorimeter. Essentially because current high field detector magnets are insufficiently radiation transparent. This implies a waste of magnetic field, stored energy and financial resources. A proposed solution is to build an ultra-thin,particle transparent solenoid, which only covers the inner tracker, similarly to the ATLAS Central Solenoid. The idea is to build a thin coil (<1 radiation length), which is able to provide thermodynamic stability and quench protection. This requires a conductor with a RRR of > 500. In addition, the conductor has to act as mechanical reinforcement to handle the magnetic pressure leading to hoop stress of about 300 MPa. Advanced doped Aluminium alloys are most promising given their density to strength ratio. The development of such a conductor is approached from different sides. One is to look for a multi-material reinforced sandwich like alloy with high RRR and sufficient tensile strength at 4.2 K. Second is to create a hybrid conductor from micro-alloyed Aluminium providing electro-thermal stability to the superconductor, reinforced by welding to an ultra-high yield strength Al-alloy of the 7000 series, or a mixed option.

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