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Funnel-shaped end-cap solenoids: A possible alternative for the solenoid & dipoles combination

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As part of the conceptual design phase of the Future Circular Collider for hadron-hadron collisions, new detector magnet designs with stored energies on the order of 50 GJ are being developed that provide sufficient bending power to track particle products resulting from 100 TeV collisions. The main designs currently under consideration feature both solenoids and dipoles, where bending power for low-eta (i.e. low pseudorapidity) particles is provided by the former and bending power for high-eta particles is provided by the latter. The combination of solenoids and dipoles in close vicinity results in very large forces and torques, which is a challenge and an important design consideration.

As an alternative to combining solenoids and dipoles, an investigation is performed in which the twin solenoid is combined with end-cap solenoids to augment the bending power for high-eta particles and thus reduce the need for dipoles. Two variants are proposed: The first variant involves an funnel-shaped end-cap solenoid with an inner free bore that is much smaller than that of the twin solenoid. The advantage of this variant is a significant enhancement in field homogeneity, but this variant comes with the disadvantage of a large (over 100 MN) net force towards the twin solenoid. The second variant involves two concentric funnel-shaped coils in which the outer cancels the stray field generated by the inner. Like the first variant, this variant has enhanced field homogeneity, but also net force neutrality, superior stray field reduction and a more suitable field orientation and amplitude for muon tracking, at the cost of greater complexity.

The two variants are compared to the previously published twin solenoid & dipoles option and discussed in terms of complexity, volume, mass, and field integrals, to determine whether these options may be suitable alternatives to the solenoid & dipoles combination.

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