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View Abstract

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ABSTRACT TITLE: A Novel Combined Function Optimum Integral Design for EIC Spectrometer Magnet B0pF

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ABSTRACT: B0pF is a multi-purpose magnet system for the Electron Ion Collider (EIC), now under construction at Brookhaven National Laboratory. It provides bending for the hadron beam, focusing (with no bending) for the electron beam, and the spectrometer function for the experimentalists. This paper addresses a set of technical challenges associated with high field (~5.3 T on the conductor), large coil aperture (656 mm), and short coil length (1200 mm) of this magnet. A small length to aperture ratio (~1.8) makes the conventional cosine n-theta cable designs impractical for this magnet. Present design is based on direct wind technology which, for the cable chosen, allows a much smaller (12 mm) bending radius for the cable in the ends as compared to that in such large aperture cable magnets. The earlier baseline design was based on the serpentine geometry with eight layers of quadrupole coil in series with the two layers of dipole coil (total ten layers). Even though serpentine coils offered a solution, given the combination of high field, large aperture (stored energy ~0.73 MJ), B0pF is one of the most challenging magnets for mechanical structure and for quench protection. The combined function Optimum Integral Design (OID) offers a novel solution to significantly reduce the technical challenges and hence the risk. In the OID, the midplane turns extend essentially the full length. The integral field and the integral field harmonics in the body and ends are optimized together. This minimizes the loss in field integral due to the ends. Additional gains are achieved by making it a combined function magnet. This resulted in a set of major improvements, such as (a) the number of layers reduced from 10 to 6 or 8 (depending on the choice), (b) operating current reduced from 1143 A to 889 A (or 671 A), (c) load line fraction margin improved from 70% to 60% (or

50)% at 1.92 K operating temperature, (d) Lorentz force density gets reduced by about 30%, (e) voltage to ground reduced during the energy extraction reduced from 950 V to 535 V (or 466 V) and the quench heaters are no longer essential for reducing hot spot. The design, to be further optimized, is for (a) an integral field along the hadron beam path of 1.56 T.m, (b) a maximum integral field gradient of 9.75 T (actual value will depend on the beam energy and the gradient in the quadrupole Q0eF inside), (c) a zero integral field along the electron beam path with a variation below 0.02 T. We plan to start winding the first double layer in next few months and test by the end of the year, with a goal of demonstrating several key features of this new design. This paper will present the overall concept and magnetic design, while briefly reviewing the benefits of this approach in the mechanical design and in quench protection of this large aperture, high field combined function magnet.

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PRESENTATION PREFERENCE: Oral

Oral Presentation justification (if oral was selected): This is a novel design which is being applied to a major magnet in Electron Ion Collider (EIC) which significantly reduces risks to the program.

SUBMISSION CATEGORY: L-40: Accelerator, wiggler, undulator, special magnets

SUB-CATEGORY: 40c. Main accelerator magnets: NbTi

Appropriate for TES Workshop: Yes

STUDENT: No

LETTER OF INVITATION: No

MODERATOR AND/OR REVIEWER: Yes, both

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