Q1ApF Coil and Q1BpF Iron plus Q1BpF Coil Redesign for 4K Operation

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Overview

➢ Design studies of Q1ApF coil for a possible 4.2 K operation.
➢ Q1BpF yoke optimization to reduce field in electron beam region.
➢ Q1BpF coil redesign to increase margin for 4.2 K operation
➢ Several cases examined; only one each of above will be presented.
➢ In all cases, peak field (margin), field quality and field in the electron beam region are being optimized together.
➢ The design consider several fronts - geometric, mechanical, magnetic design. Anis will continue on further optimization.
➢ Strand/wire used: dia =1.065 mm, Cu/Sc =1.3 and 1.6.
➢ Use this cable (and RHIC dipole type cable) for all EIC magnets.
➢ Some thoughts on system optimization
Q1ApF Coil 2 Layers, Four wedges
41 turns/pole (18 inner, 23 outer)

- Poles of inner and outer layers aligned
- Coil poles have proper angles for collaring
- Two wedges in each layer to deal with keystone

Coil radius: 71 mm (Q1B had 93 and Q2B had 140)
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Q1ApF Coil, Q1BpF Iron, Q1BpF Coil Redesign for 4K Operation

Field Harmonics in Q1BpF

A reasonably good field quality is obtained with a good mechanical design (coil radius 71 mm) (all harmonics <1 unit)

Gradient

72.6 T/m

at ~9.3 kA
Iron Yoke - Initial Design

Yoke: \( r_i = \sim 131 \text{ mm}; \text{ or } = 550 \text{ mm (or 500 mm)} \)
Hole@ \( x = 230.5 \text{ mm to 259 mm} \)
Radius of hole = 44.6 & 58.4 mm (+20 mm for electron beam)
Collar width = \( \sim 20 \text{ mm} \)
Very Good Margin
Field Margin at 4.2 K
Temperature Margin at 4.2 K Over Different Blocks
Field Margin
at 4.6 K, Cu/Sc = 1.6
Iron Optimization to Reduce Field in the electron Beam Region
Field in the electron beam region

Yoke OR = 550 mm, Hole@288.3 mm

Shown a couple week ago (6/30/2020)
Field in electron Beam Region 0.02 T
Several techniques from the first principle examined.

Only a couple of cases shown
Technique: Guide flux away from electron beam region

Provide circular shielding for electron and ion beam
Over an order of magnitude reduction in field

This field can be shield with mu-metal, etc.
Further Reduction

- Q1ApF Coil, Q1BpF Iron, Q1BpF Coil Redesign for 4K Operation
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Tiny current on the two side of circular yoke over e-beam (still shielding for electron and ion beam)
Two order of magnitude reduction

Tiny current on the two side of circular yoke over e-beam gives a solution (still shielding for electron and ion beam)
Redesign of Q1B to increase margin
- Poles of inner and outer layers aligned
- Coil poles have proper angles for collaring
- Two wedges in each layer to deal with keystone

Coil radius: 93 mm  (Q1A has 7a and Q2B has 140 mm)
Coil 2 Layers, Three wedges (2+1)
54 turns/pole (24 inner, 30 outer)

- Poles of inner and outer layers aligned
- Coil poles have proper angles for collaring
- Two wedges in the inner to deal with keystone

Coil radius: 93 mm (Q2B had 140 mm)
A reasonably good field quality is obtained with a good mechanical design (coil radius 93 mm) (all harmonics <1 unit)

Gradient 66.2 T/m at ~9.8 kA
Field Margin at 4.2 K
Cu/Sc = 1.3

MAXIMUM LOADLINE IN BLOCK  23 (%) .................  78.4529
MINIMUM TEMPERATURE MARGIN IN BLOCK  23 (T) ......  1.2764
Field Margin at 4.2 K

EIC IR Meeting

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Temperature Margin at 4.2 K Over Different Blocks

Temperature margin (at Jop,Bop,Top)(K)

ROXIE

Q1ApF Coil, Q1BpF Iron, Q1BpF Coil Redesign for 4K Operation

EIC IR Meeting

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Discussion

➢ Good results for 4.2 K option
➢ Q1A and Q1B have the same polarity
➢ Q1A has much bigger margin than Q1B (though new Q1B is in acceptable range)
➢ Re-optimize optics for either increasing length of Q1B (reduce length of Q1A) or increasing design gradient of Q1A and reducing that of Q1B

➢ Next task – Q1A iron