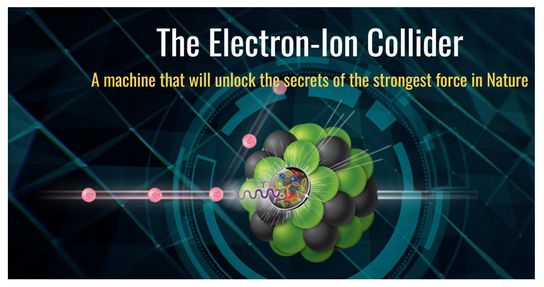
5PoM03-06

MT-28 International Conference on Magnet Technology
Aix-en-Provence, France, 10-15 September 2023

Brookhaven® National Laboratory



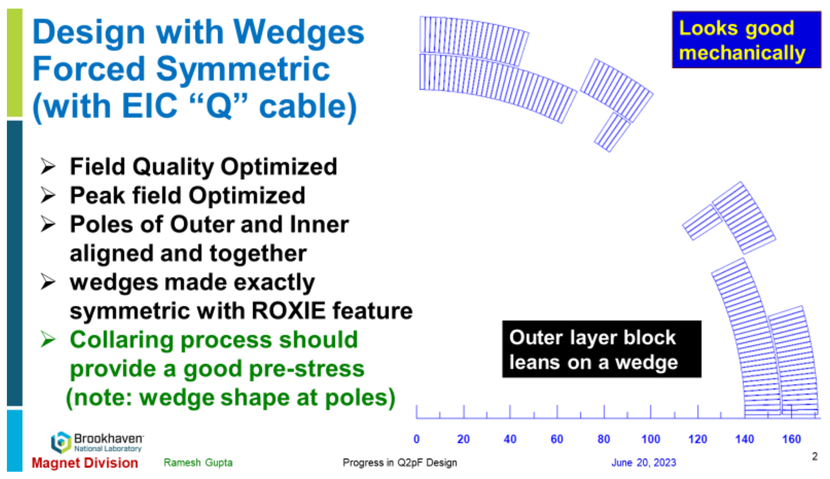
Magnetic design of the interaction region quadrupole Q2pF for EIC*

R. Gupta, K. Amm, M. Anerella, J. Cozzolino, C. Runyan, and H. Witte
Brookhaven National Laboratory, Upton, NY 11973 USA

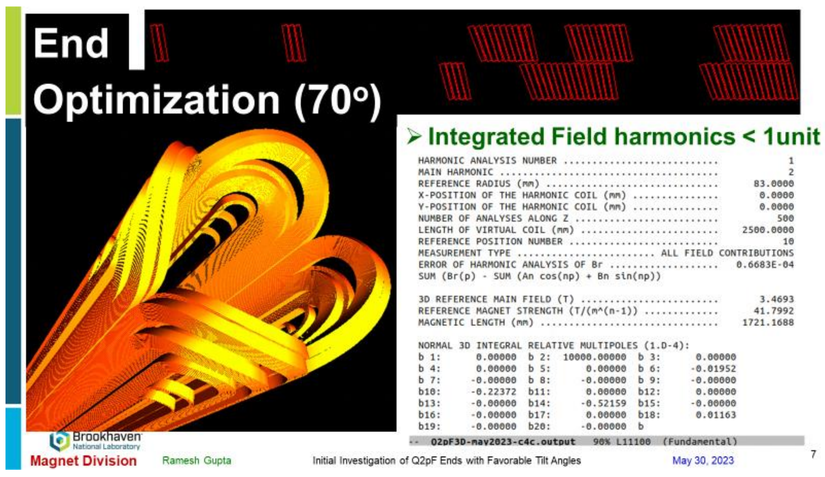
Abstract

The Electron-Ion Collider (EIC) is planned for construction at Brookhaven National Laboratory. The design of the Interaction Region (IR)quadrupole Q2pF of EIC is based on a 2-layer coil with an inner diameter of 280 mm. This is a challenging magnet with a computed peak field of 6.4 T at design in a relatively large coil aperture. With little time for R&D, the desired operating margin is >30% over the design. Another key requirement is the low field and low field errors in the electron beam which is traversing within the same iron yoke and is in a proximity to the main coils with separation between the two beams changing from one end to another end. The paper presents the status of the current design.

Cross-section Optimization

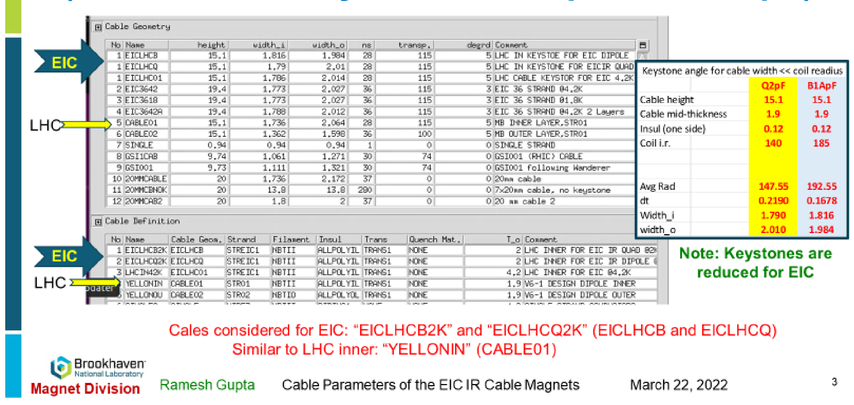


End Optimization



Cable Parameters

LHC Style Cable used in Quad & Dipole (based on full keystone for Q2pF and B1ApF)

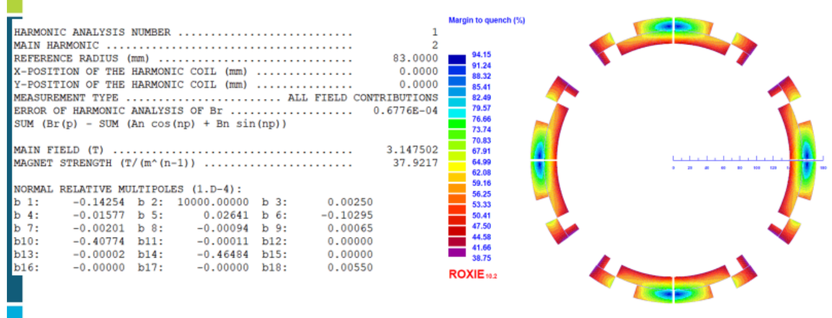


Magnet Design Parameters

Coil inner diameter	280	mm
Coil outer diameter	342.8	mm
Number of layers	Two	
Integrated gradient @design	133.55	T
Design gradient (@center of magnet)	38.22	T/m
Operating current @ design gradient	8500	A
Magnetic length	3.494	meter
Coil length (last turn to last turn)	3.64	meter
Yoke length	3.72	meter
Total number of turns per coil	70	per octant
Number of turns in inner layer	34	per octant
Number of turns in outer layer	36	per octant
Cable required (whole magnet)	2	km
Superconductor	NbTi	
Cu/Sc Ratio (nominal)	1.6	
strand diameter (mm)	1.065	
Number of strands in cable	28	
Cable width, bare (mm)	15.1	mm
Cable mid-thickness, bare (mm)	1.9	mm
Cable insulation radial	0.15	mm
Cable insulation azimuthal	0.12	mm
Cable width insulated	15.4	mm
Cable mid-thickness, insulated	2.14	mm
Operating temperature (nominal)	2	K
Stored energy @design gradient	2.7	MJ
Inductance	75	mH
Quech current	13700	A
Quench gradient	5.54	T/m
Peak field @design	6.4	T

* This work was supported by DOE Grant No. DE-SC0021578 and by Brookhaven Science Associates, LLC under contract No. DE-SC0012704, with the U.S. Department of Energy.

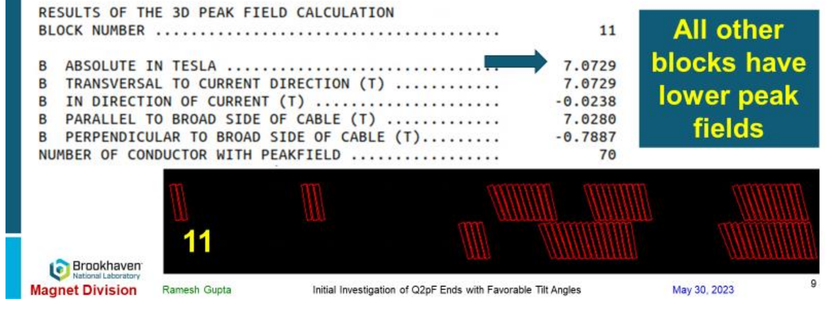
2-d Field Quality and Quench Margin



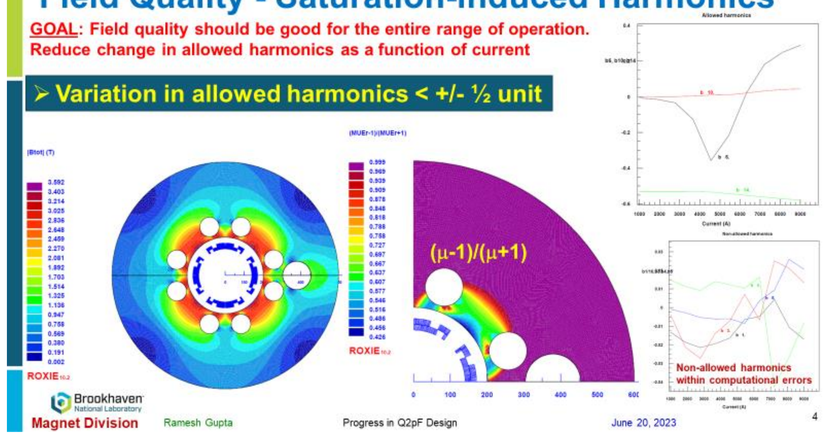
Peak Field in the Ends (Linear Iron)

- Peak field in the body (including self field) : 7.05 T
- **Peak field in the ends (including self field): 7.07 T**

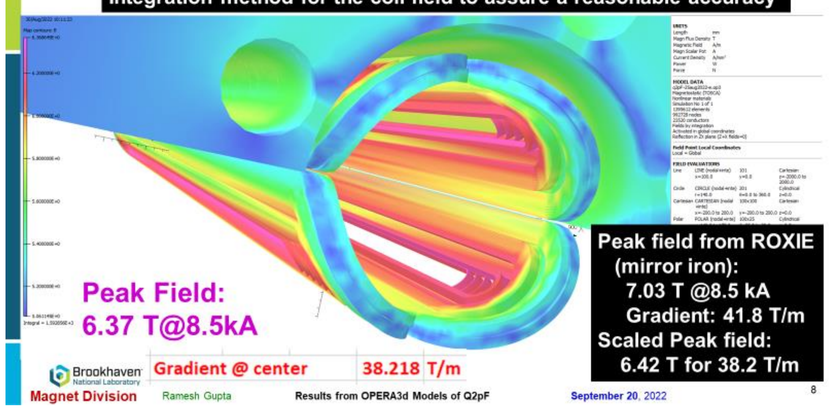
✓**Peak field in the Ends is close to the field in cross-section**



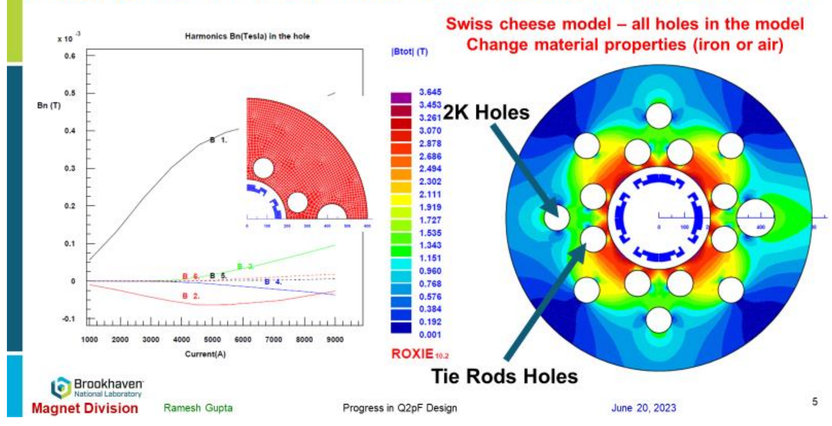
Field Quality - Saturation-induced Harmonics



Calculation of Peak Field with OPERA3d (non-linear iron)

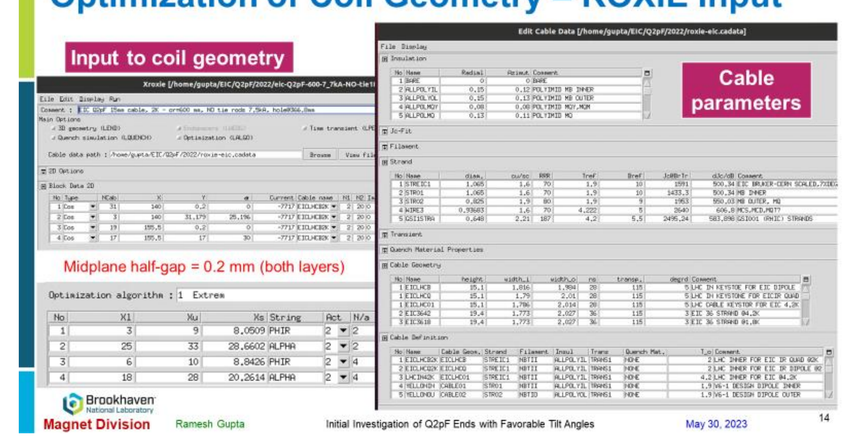


Placement of Tie Rods Holes to Reduce field in electron Hole

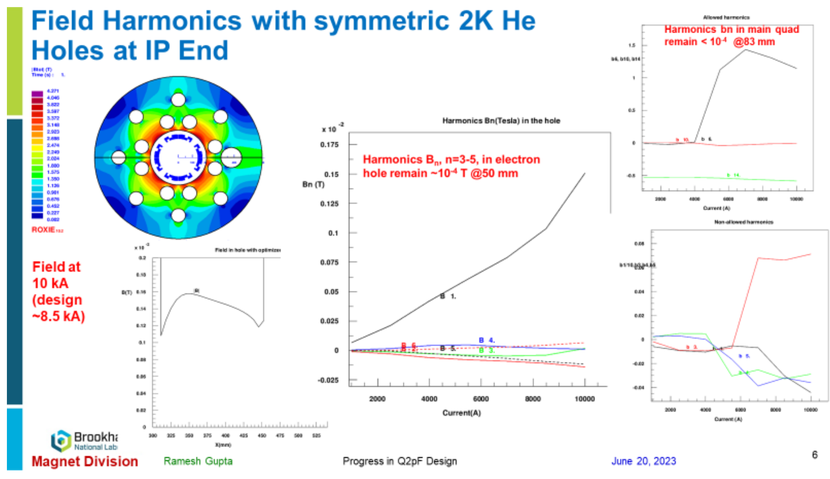


Field Quality Tuning After Construction

Optimization of Coil Geometry – ROXIE Input



Field Harmonics with symmetric 2K He Holes at IP End



Slot for tuning shims starting at 27°

(10 mm deep, 5° wide, 8-fold symmetry)