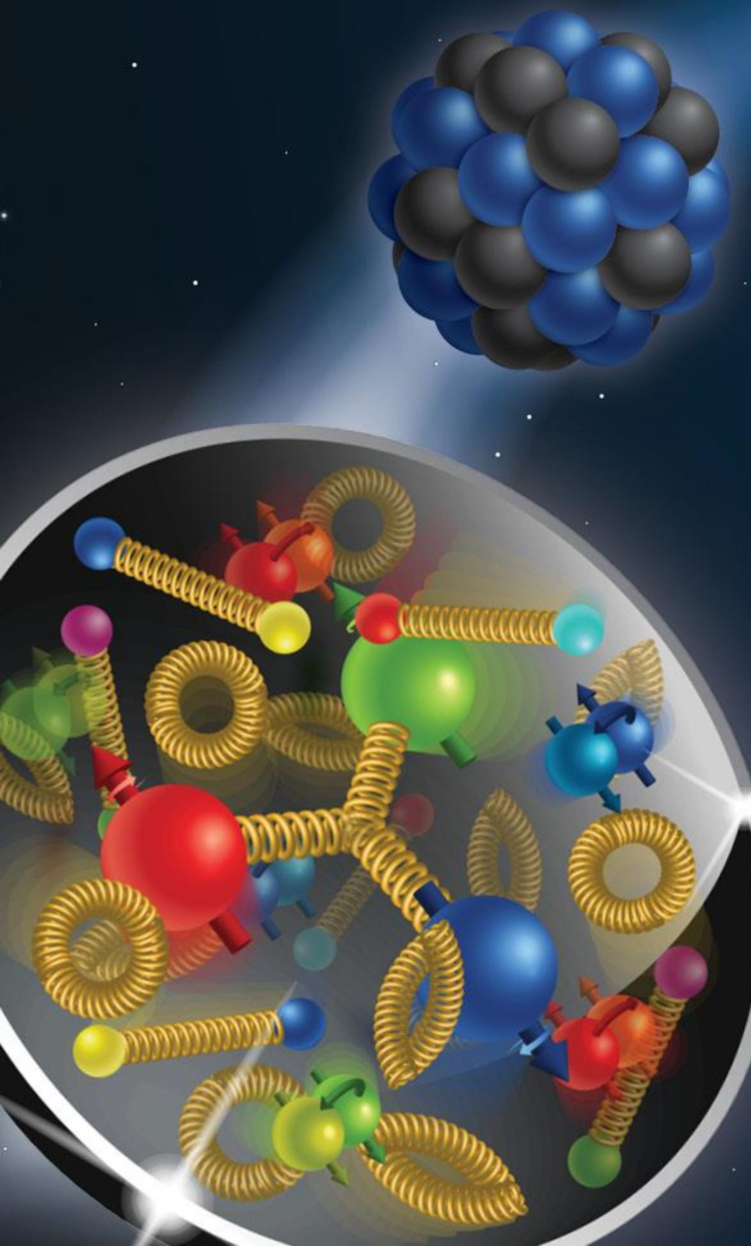

Design and Prototyping of Superconducting EIC – Interaction Region Magnets

Nuclear Physics Accelerator R&D PI Meeting

Peter Wanderer, BNL

November 13-14, 2018

Electron Ion Collider – eRHIC

BROOKHAVEN NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY | Office of Science

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- Brett Parker
- Mike Anerella
- Jesse Schmalzle
- DOE OHEP LARP R&D, ILC R&D

Design and Prototyping of Superconducting EIC – Interaction Region Magnets

Funding Source	PI	R&D Report Priority #	R&D Panel Priority Rating	Total $
FY17	P. Wanderer, M. Anerella	28	Hi-C	$210,000

- The panel identified the validation of magnet designs associated with high-acceptance interaction points by prototyping as a key area that is common for all EIC concepts (p. 41)

Outline

- Superconducting Quadrupole for EIC Insertion Region (IR)
- FY17 Task and Status
- Conclusions and Outlook

Superconducting Quad for EIC IR (1)

- EIC (Generic) Requirements for IR Magnets:
  - Hadron beam → superconducting (high energy)
  - Electron beam → low field (avoid synchrotron rad.)
  - Beams near the collision point are very close to one another → novel magnets

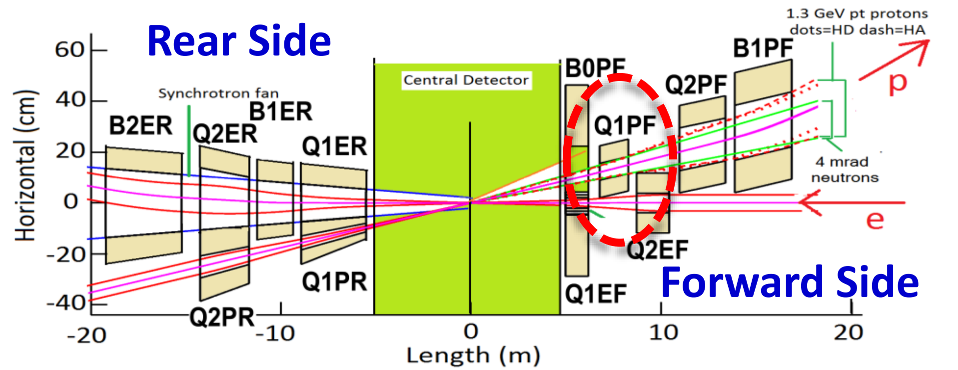
- Approach:
  - Proof of principal magnets useful to both labs. Most difficult magnet is Q1PF (first quad on proton forward side of IR), which needs Nb_3Sn coils. (NbTi inadequate)

Superconducting Quad for EIC IR (2)

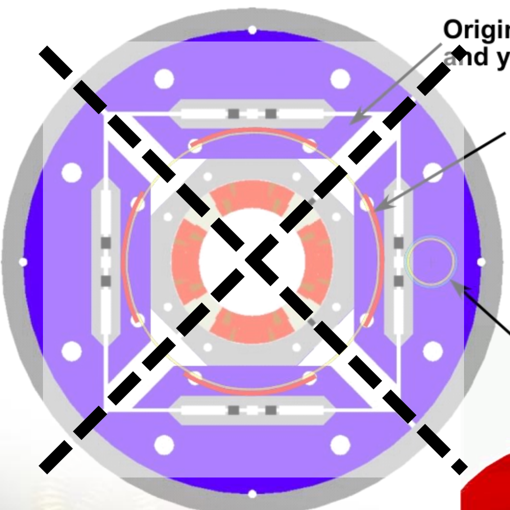
- Value Engineering:
  - Use existing hardware, specifically Nb_3Sn coils from the OHEP LARP program
  - Use novel concept: "Active Shielding," from OHEP ILC R&D program. Shield quad has opposite gradient and larger radius than main quad.

- Engineering Challenge:
  - much less radial space available for the structure that supports the quad coils against Lorentz forces.

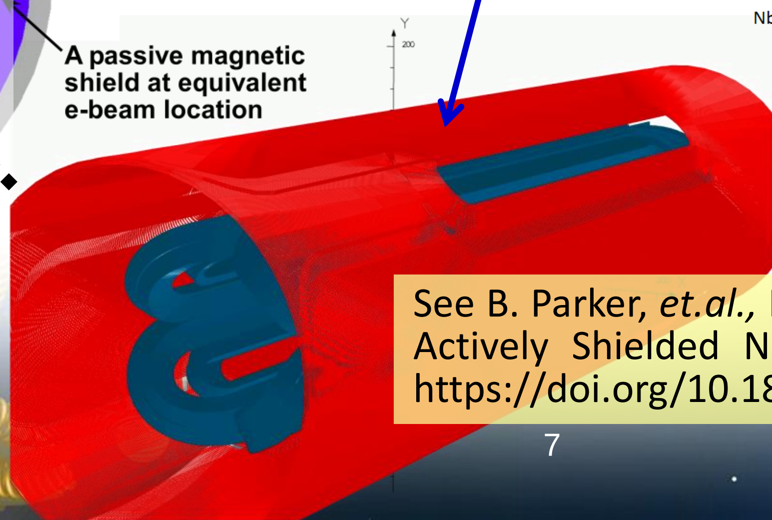
eRHIC and JLEIC: Fast Track R&D



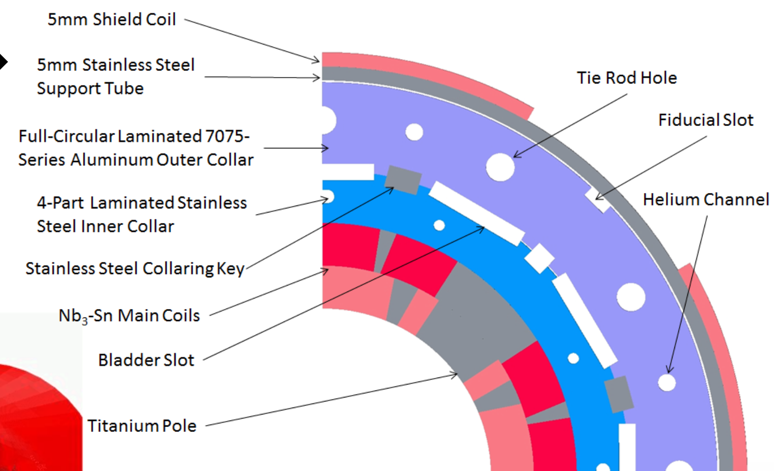
- Use existing Nb_3Sn coils (from LARP work) with a new active shield to prove out Q1PF concept.
- Main challenge is limited space for mechanical structure.



LARP mechanical structure comparison



NbTi active shield coil around an Nb_3Sn inner coil

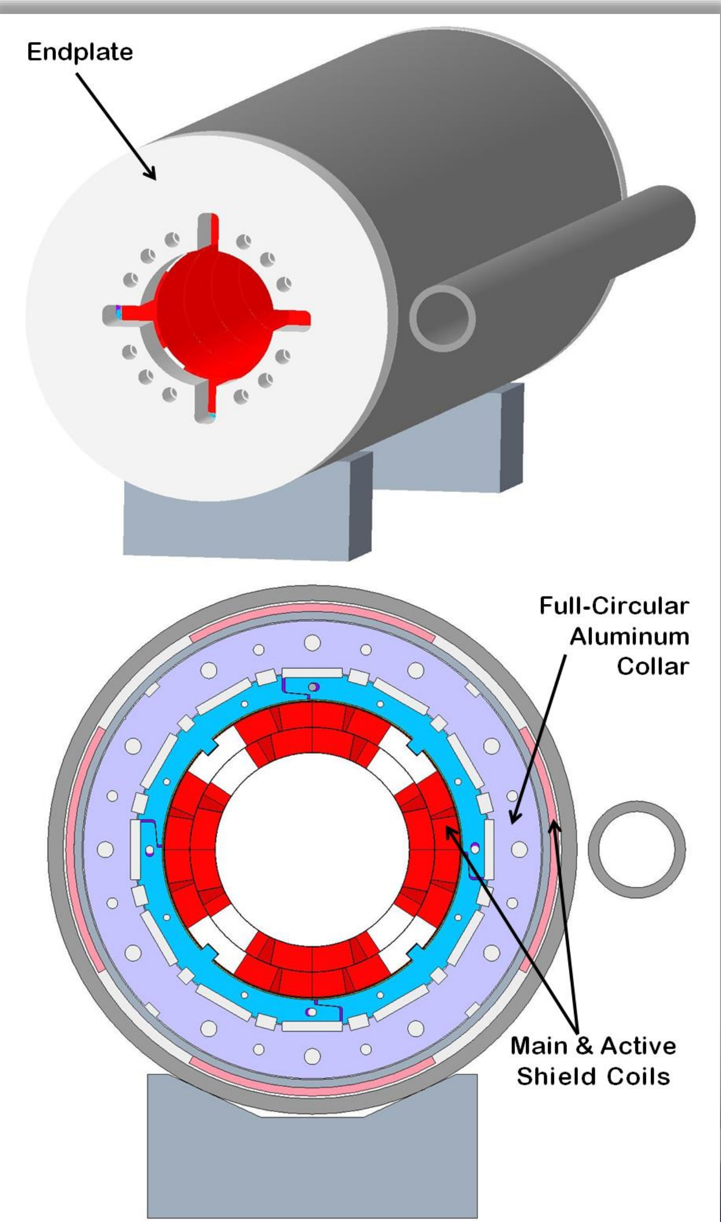


New proposed compact mechanical structure

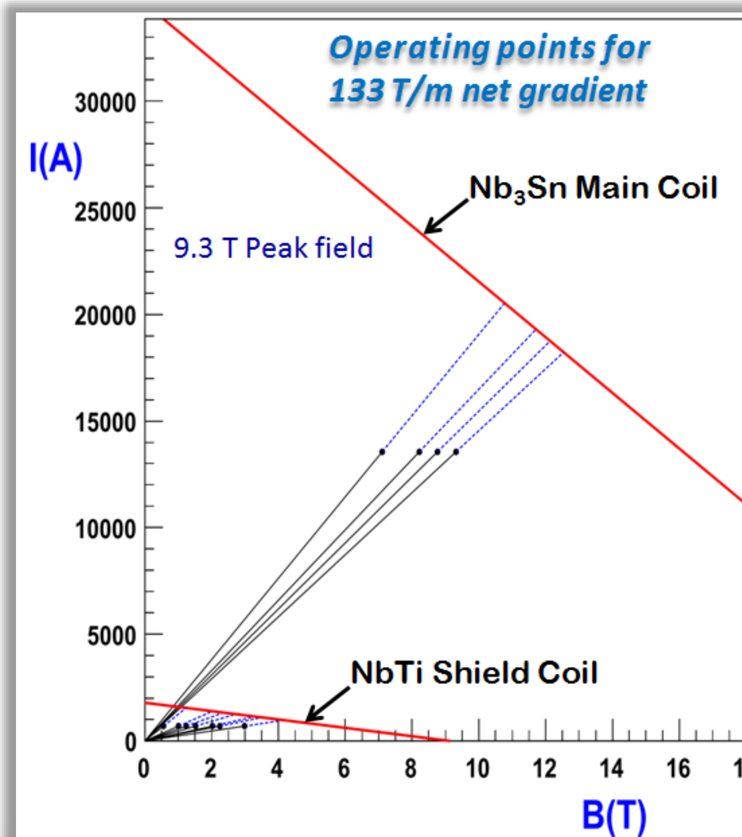
See B. Parker, *et.al.*, IPAC18 paper, WEPMF014, “Fast Track Actively Shielded Nb3Sn IR Quadrupole R&D,” at URL: https://doi.org/10.18429/JACoW-IPAC2018-WEPMF014

Fast Track R&D Magnet: Design Summary

- Longitudinal pre-stress is applied from endplates.
- Linear transfer function (i.e. no yoke to saturate).
- Coordinated operation using two power supplies.



Fast Track Magnet 3D Mechanical Assembly.



Operating Gradient:

G_{main} = 143 T/m

G_{shield} = -10 T/m

G_{net} = 133 T/m

Operating: I_{main} = 13.6 kA

I_{shield} = 705 A

Stored Energy = 466 kJ

(Total Combined Energy)

Inductance: L_{main} = 5.6 mH

L_{shield} = 192 mH

Mutual Inductance:

L_{12} = 5.2 mH

Inductance Coupling Coefficient: K = 16 %

$(K = L_{12}/\sqrt{L_1 \times L_2})$

Fast Track Magnet Operating Parameters.

Task Using FY17 Funding

- Response to Engineering Challenge:
  - Assemble 15 cm-long LARP coil sections, available from a previous engineering test.
  - Instrument with strain gauges.
  - Assemble at high preload by pressurizing “bladders” made from stainless steel.
  - Cool to 77K (liquid nitrogen).
  - Measure preload.

Status: Nearly Complete

Costs and Schedule

	FY10+FY11	FY12+FY13	FY14+FY15	FY16+FY17	Totals
a) Funds allocated				210,000	210,000
b) Actual costs to date				202,566	202,566

Activity	Start Date	End Date
Design and purchase of an initial set of components		September 2017 ✓
Complete Assembly and Test		September 2018

- Assembly and test – anticipate completion November 2018

Conclusion and Outlook

- Test will be completed by 11/30/18.
- Test will yield engineering data needed for final design of High Gradient Actively Shielded Quadrupole project (funded via FY18 FOA)
  - Schedule: fabrication complete 8/19; test complete 12/19.