A Modular Quadrupole Design

- A magnet design with simple flat racetrack coils
- Achieves similarly high gradients as those achieved in cosine theta quadrupole designs
- Modular design uses coil modules (cassettes) which allows rapid turn around and low cost R&D

Two Styles of Modular Design

Simple

Symmetric

A Unique Feature of the Modular Design Different Apertures with the Same Coils

In a modular quadrupole design, R&D models of several high gradient EIC quadrupoles having different apertures can be demonstrated with the same racetrack coils by re-assembling them with different spacing providing a significant cost and schedule savings. This is not possible with the cosine designs.

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EIC High Gradient Quad Designs

Project Considerations for the Cost of Magnet Development

- Two major project costs for high field magnets:
  - Cost of material, plus cost of labor per magnet
  - Cost of tooling, cost of engineering, and cost of R&D
- If the project needs only one or a few high performance magnets then (a) the cost of material is less important and (b) the cost of design, R&D and cost of tooling, etc. is more
- If there are a number of “one of a type” magnets, then a common tooling and a common R&D would reduce cost

Approach for Developing High Gradient Modular Quad for EIC

Primary goal:

Develop a modular quadrupole design for all high gradient Nb₃Sn quadrupoles in EIC that is simpler and flexible but as good as a typical cosine design

Key design considerations:

For a few key IR magnets, the design should be efficient in creating field gradient; it need not be so efficient in minimizing the conductor usage

Racetrack coil magnets:

It has been generally observed that the high field Nb₃Sn magnets made with the simple racetrack coils tend to perform better in the first model itself

<table>
<thead>
<tr>
<th>Design</th>
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<th>Field Gradient (T/m)</th>
<th>Magnetic Length (m)</th>
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<tbody>
<tr>
<td>A</td>
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<td>140</td>
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</tr>
<tr>
<td>B</td>
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TABLE III

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SUMMARY

- Demonstrated a good field quality in both “symmetric” and “simpler” modular quadrupole designs.
- Demonstrated that the same racetrack coils can be used in the R&D models of Q1PF of eRHIC at BNL, and as several JLEIC quadrupoles (QFFB1_US, QFFB2_US and QFFB3_US) of JLab.
- Mechanical design and assembly work still to be performed during the Phase 1 SBIR.
- Proof-of-principle quadrupole for EIC based on the modular design will be built and tested during the Phase II SBIR, if funded.