eRD2 Progress Report
Magnetic Field Cloak

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for the Magnetic Cloak Team and collaborators

EIC Generic Detector R&D Advisory Committee Meeting
Brookhaven National Laboratory, January 26, 2017
The people behind the plots

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Graduate Students

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A Magnetic Field Cloak
We have completed…

- **beam shielding** tests with the BNL Van de Graaff accelerator,

- **high-field shielding** tests with the MRI magnet at Argonne National Lab,

- **high-field cloaking** tests with the MRI magnet at Argonne National Lab.
• **beam shielding** tests with the BNL Van de Graaff accelerator,

• **high-field shielding** tests with the MRI magnet at Argonne National Lab,

• **high-field cloaking** tests with the MRI magnet at Argonne National Lab.
Thanks to the staff at the BNL Van de Graaff for their support
Initial tests with Hall sensors

Field map in y-direction taken at BNL with

- no shield
- with shield

Magnet Current [A]

B (mT)

no shield

with shield

position (mm)
Beam Test with lithium-7 at BNL Van de Graaff

Published in Proc. 2nd North American Particle Accelerator Conf. (NA-PAC’16)
• **beam shielding** tests with the BNL Van de Graaff accelerator,

• **high-field shielding** tests with the MRI magnet at Argonne National Lab,

• **high-field cloaking** tests with the MRI magnet at Argonne National Lab.
The 45 Superconductor Layer Cloak Prototype
Thanks to the staff at Argonne National Lab for their support.
Test setup with MRI magnet at Argonne National Lab
Shielding MRI Magnet Field

45-layer MRI shielding

$B_{in}$ (T)

- $B = 555$ mT
- $B = 515$ mT
- $B = 435$ mT

$B_0$

Hall probe

$\mu M$

$B_{leak}$

$\mu M$
We shield 99% of 0.45 tesla!

~95% shielding at 0.50 T
• **beam shielding** tests with the BNL Van de Graaff accelerator,

• **high-field shielding** tests with the MRI magnet at Argonne National Lab,

• **high-field cloaking** tests with the MRI magnet at Argonne National Lab.
Permeabilities of different ferromagnets up to 0.5 T

- Good cloaking at 40 mT
- Good cloaking at 450 mT

'ideal' cloak (theory)
Cloak reduces front field distortions by 90% at 0.45 T.
Cloak reduces front field distortions by 79% at 0.50 T

\[ \sum \frac{|B_{sc+fm} - B_{nom}|}{|B_{sc} - B_{nom}|} \approx 21\% \]
Magnetic field cloaking ‘across cloak’

Cloaking at 0.45 T (field measured across prototype)

Cloaking at 0.50 T (field measured across prototype)
Long-range Cloaking Effect

superconductor only

cloak
Getting ready for publication
A magnetic field cloak seems to be a viable option for EIC. We think we understand its design parameters, fabrication, and limitations.
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ADDITIONAL SLIDES
Shielding MRI Magnet Field

45-layer MRI shielding

- **no time dependence**
- **time dependence**

\[ B_{in} (T) \]

\[ B_{out} (T) \]

Hall probe

- \( B_0 \)
- \( \mu M \)
- \( B_{\text{leak}} \)
- \( \mu M \)
- \( B_0 \)
Cloaking at different fields

![Graph showing cloaking at different fields with x-axis representing x-position (mm) and y-axis representing $B_r$ (mT), with different colors representing different fields and fM = 0.618.](image)
Beam Test with oxygen-16 at BNL Van de Graaff