## CONSTRUCTION AND TEST OF A MAGNETIC FIELD CLOAK

EIC GENERIC DETECTOR R&D PROJECT ERD2

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#### NILS FEEGE

Electron Ion Collider User Group Meeting 2017 Trieste, Italy, July 18 - 22, 2017



#### A MAGNETIC FIELD CLOAK MAKES A VOLUME INVISIBLE TO MAGNETIC FIELDS







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#### 'Invisibility Cloak'







'Magnetic Field Cloak'

#### Superconductor

#### Ferromagnet

#### Magnetic Field Cloak



$$\mu_2 = \frac{R_2^2 + R_1^2}{R_2^2 - R_1^2}$$

Fedor Gömöry et al. DOI: 10.1126/science.1218316



## SUPERCONDUCTING CYLINDERS <sup>5</sup> DEFLECT MAGNETIC FIELDS









## BEAM TEST AT BNL VAN DE GRAAFF ACCELERATOR



# SUCCESSFULLY SHIELDING CHARGED ION BEAMS





2-layer superconductor shield



# OUR 45-LAYER PROTOTYPE SHIELDS 99% OF 0.45 TESLA



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#### TUNING MAGNETIC PERMEABILITY<sup>11</sup> OF FERROMAGNET CYLINDERS



 $\mu_2$ 

## MRI TEST SETUP AT ARGONNE<sup>12</sup> NATIONAL LABORATORY



### CLOAK REDUCES FRONT FIELD<sup>13</sup> DISTORTIONS BY 90% AT 0.45 T



### CLOAKING EFFECT AT LARGER DISTANCE FROM THE PROTOTYPE







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cloak

#### THANKS TO ALL OUR COLLABORATORS-<sup>15</sup> MOSTLY UNDERGRADUATE STUDENTS!















We have demonstrated magnetic field cloaking at magnetic fields up to 0.45 T with

- 99% field shielding inside the cloak, and
- 90% reduced field distortions near the cloak.







A magnetic field cloak is a viable option for EIC.

#### arXiv:1707.02361

## **ADDITIONAL SLIDES**

# **AT HIGH FIELDS, FIELD INSIDE**<sup>19</sup> **SHIELD INCREASES WITH TIME**







#### MAGNETIC PERMEABILITY DECREASES <sup>20</sup> WITH INCREASING APPLIED FIELD





# MEASUREMENT SETUP USING HELMHOLTZ COILS





# FIELD DISTORTIONS ALONG LONGITUDINAL CLOAK AXIS





# FIELD DISTORTIONS ALONG TRANSVERSE CLOAK AXIS



#### **CLOAKING DEPENDENCE ON ALIGNMENT OF SUPERCONDUCTOR GAP**





## CLOAKING WITH DIFFERENT SUPERCONDUCTOR CYLINDERS



## SHIELDING WITH DIFFERENT SUPERCONDUCTOR CYLINDERS

