R&D For A Magnetic Field Cloaking Device

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The research team at Stony Brook
Goal: Measure particle momenta with dipole + tracker close to beam pipe

Magnetic Cloak:
- Shield fields up to 0.5 T
- No outside field disturbances
- Thin, > 1 m long
A simple cylindrical magnetic cloak

ferromagnetic  superconducting  combined

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

Fedor Gömöry et al.
DOI: 10.1126/science.1218316
COMSOL model of the cloak in a dipole field
The superconducting layer

SC Tape (SuperPower)
12 mm wide, $I_c > 420$ A
Basic tests of superconductor tape

$B_0 = 5 \text{ mT}$

$B_0 = 21 \text{ mT}$
SC tape performance at high fields

Type I superconductor
Type II superconductor

- $B_{C1} \sim 20 \text{ mT}$
- $B_{C2} > 500 \text{ mT}$
Superconductor wrapping options

'helix'

'vertical'

![Graph showing B_y vs z - z_c with different winding configurations: No SC, Helix 1 layer, Helix 2 layers, Vertical 1 layer, Vertical 2 layers.](image)
Field disturbance around SC cylinder

4 layer ‘vertical’
Creating our ferromagnetic layer

Aluminum ($\mu_r = 0$)

430 Stainless Steel ($\mu_r \sim 800$)

Goal: $\mu_r \sim 10 - 20$
Soon: Measure field disturbance in ‘big solenoid’

Homogeneous field up to 0.5 T

L 1092 mm
Ø 718 mm
Soon: Test magnetic field shielding in accelerator

Switcher magnet

Van de Graaff

10 MeV p

1.3 m

B_{\gamma}[mT] vs. z [cm]
Summary

Successful tests of cylinders made from high-temperature superconductor tape at ~10 mT.

Evaluation of shielding at higher fields and addition of ferromagnetic layer ongoing.

Magnetic cloak is an elegant device with enormous potential for accelerator applications and beyond.
ADDITIONAL SLIDES
Potential Cloak Use In Polarized $^3$He Ion Source at BNL?

Preliminary ideas based on discussions with C. Epstein and R. Milner from MIT

![Diagram of EBIS setup with Pumping Cell, Transfer Line, and EBIS Solenoid]

Depolarization due to transverse magnetic field gradients

→ Need correction coil OR magnetic cloak
Testing the simple magnetic cloak

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ferromagnetic (FM)
superconducting (SC)

Calculation

Measurement
Required permeability for cloak

Relative Permeability Stability

$\mu_r$ vs $R_2/R_1$
Type II superconductors

$B \perp T$

$B_{c1}$

$B_{c2}$

$T_c$

$T$
Measuring field around superconductor

4 layer ‘vertical’