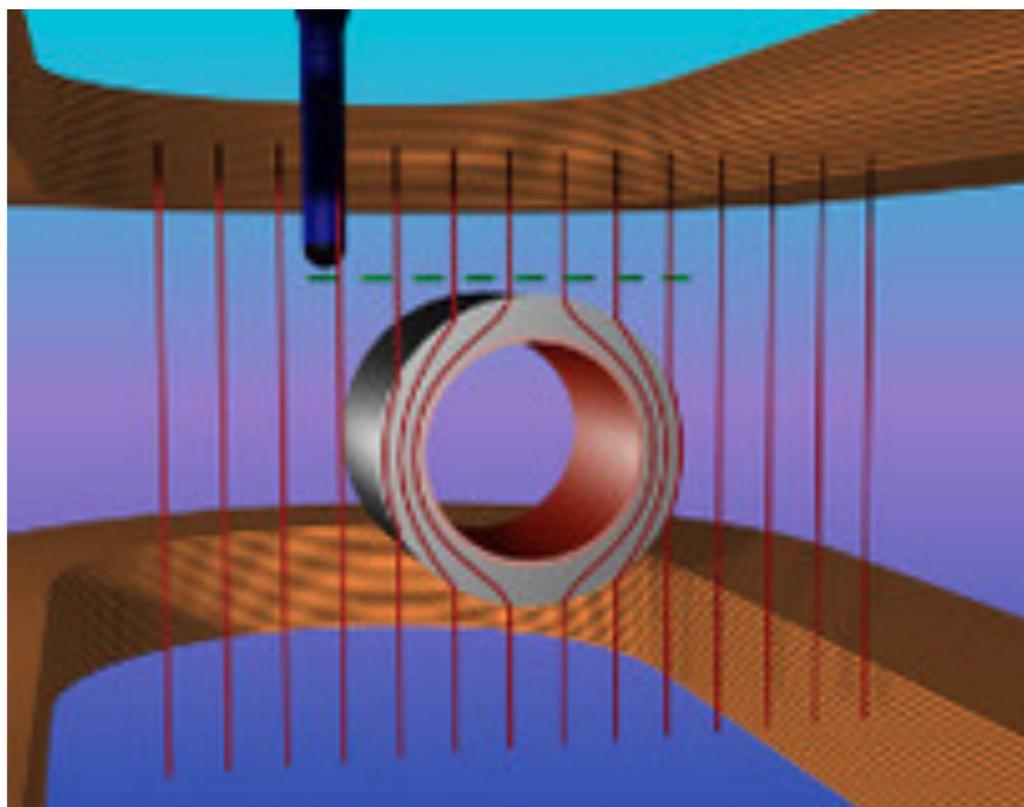




Stony Brook University



Magnetic Field Cloaking Device

RD2013-2 Progress Report

Abhay Deshpande, Nils Feege

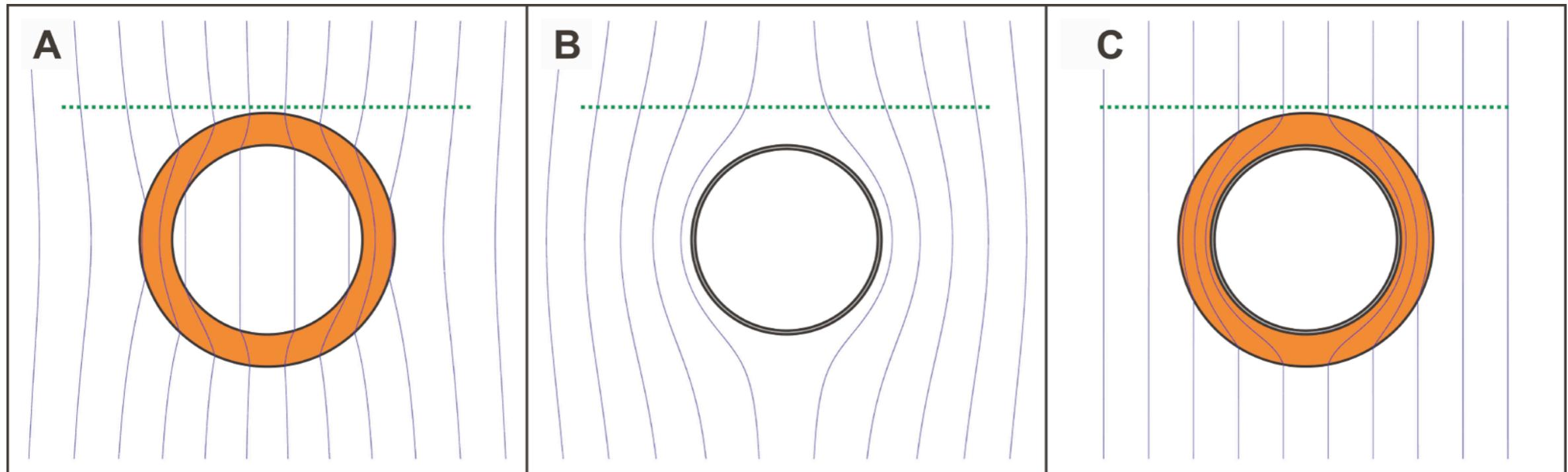
EIC Advisory Committee Meeting; BNL, July 22, 2014

A simple cylindrical magnetic cloak

ferromagnetic

superconducting

combined



R_1
 R_2

R_0
 R_1

Perfect cloak: magnetic permeability (ferromagnetic) $\mu_2 = \frac{R_2^2 + R_1^2}{R_2^2 - R_1^2}$

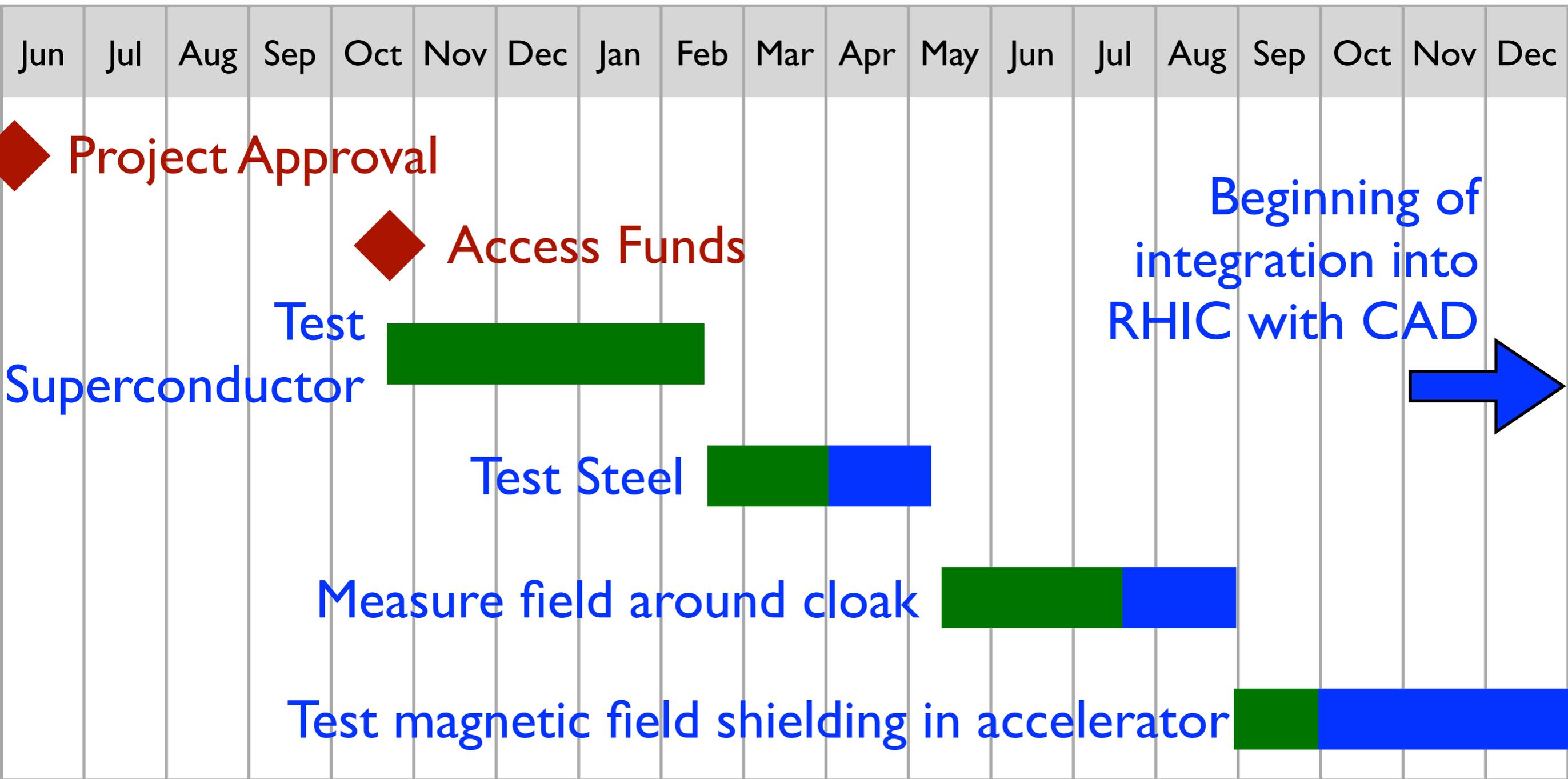
Fedor Gömory et al.

DOI: 10.1126/science.1218316

Project Timeline

2013

2014



Thanks to all our collaborators!

BNL Advisors

R. Gupta, B. Parker, V. Ptitsyn

RIKEN

Y. Goto, I. Nakagawa

RIKEN BNL Research Center

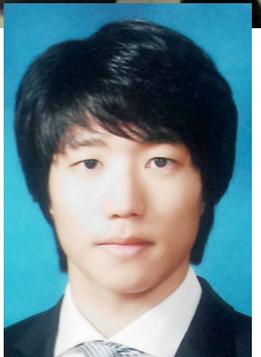
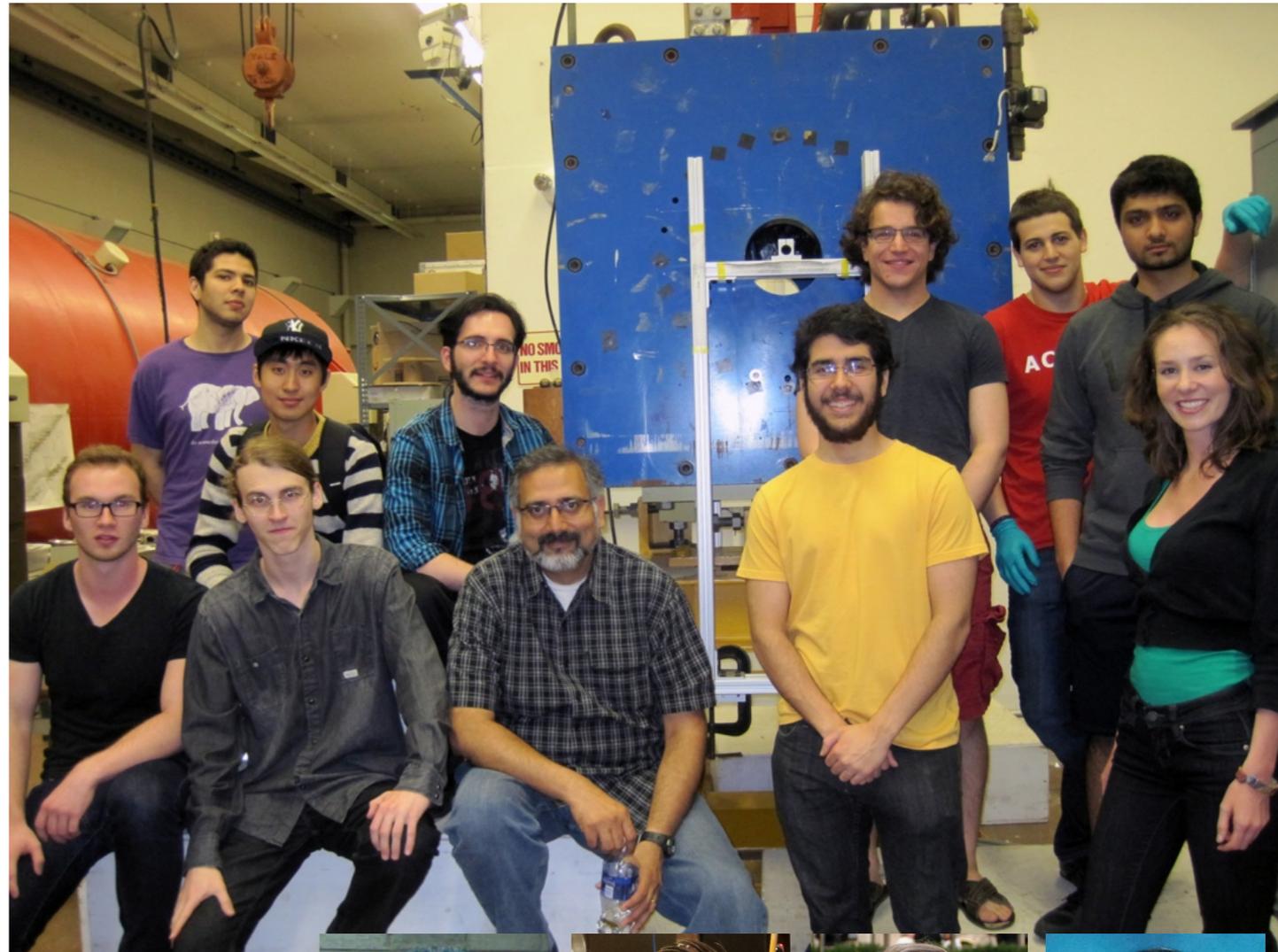
K. Boyle, J. Seele

Seoul National University

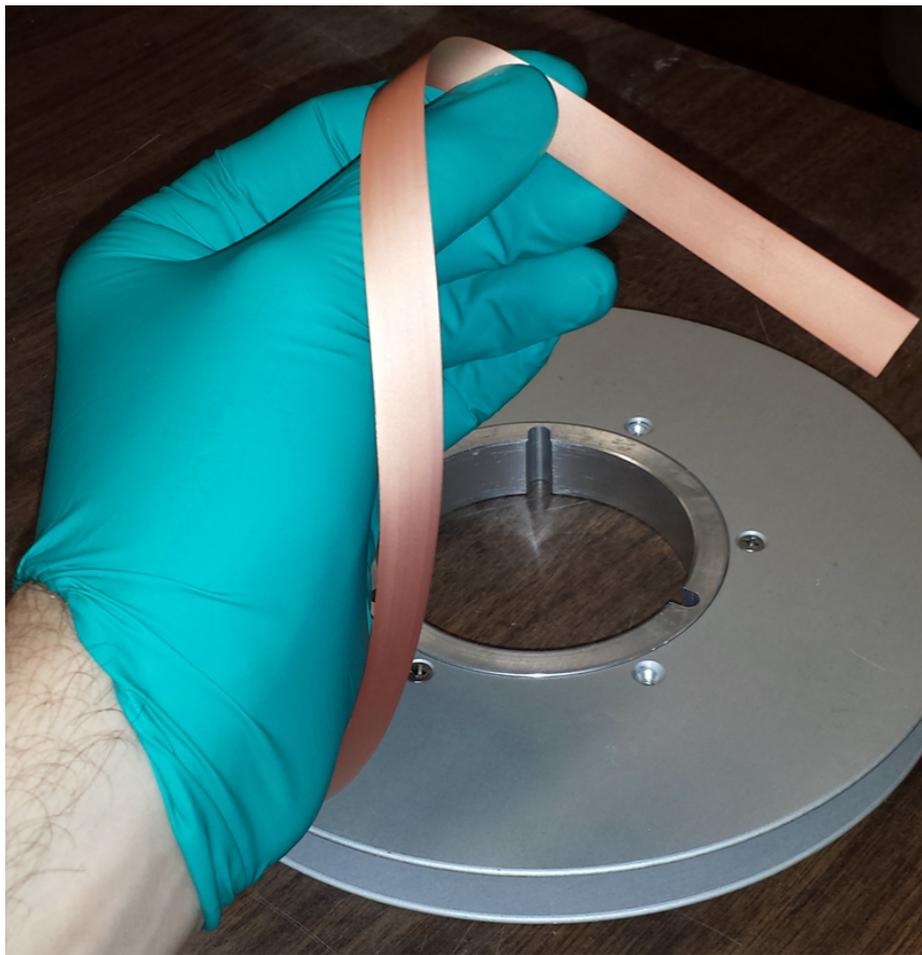
I. Yoon

Stony Brook University (SUNY)

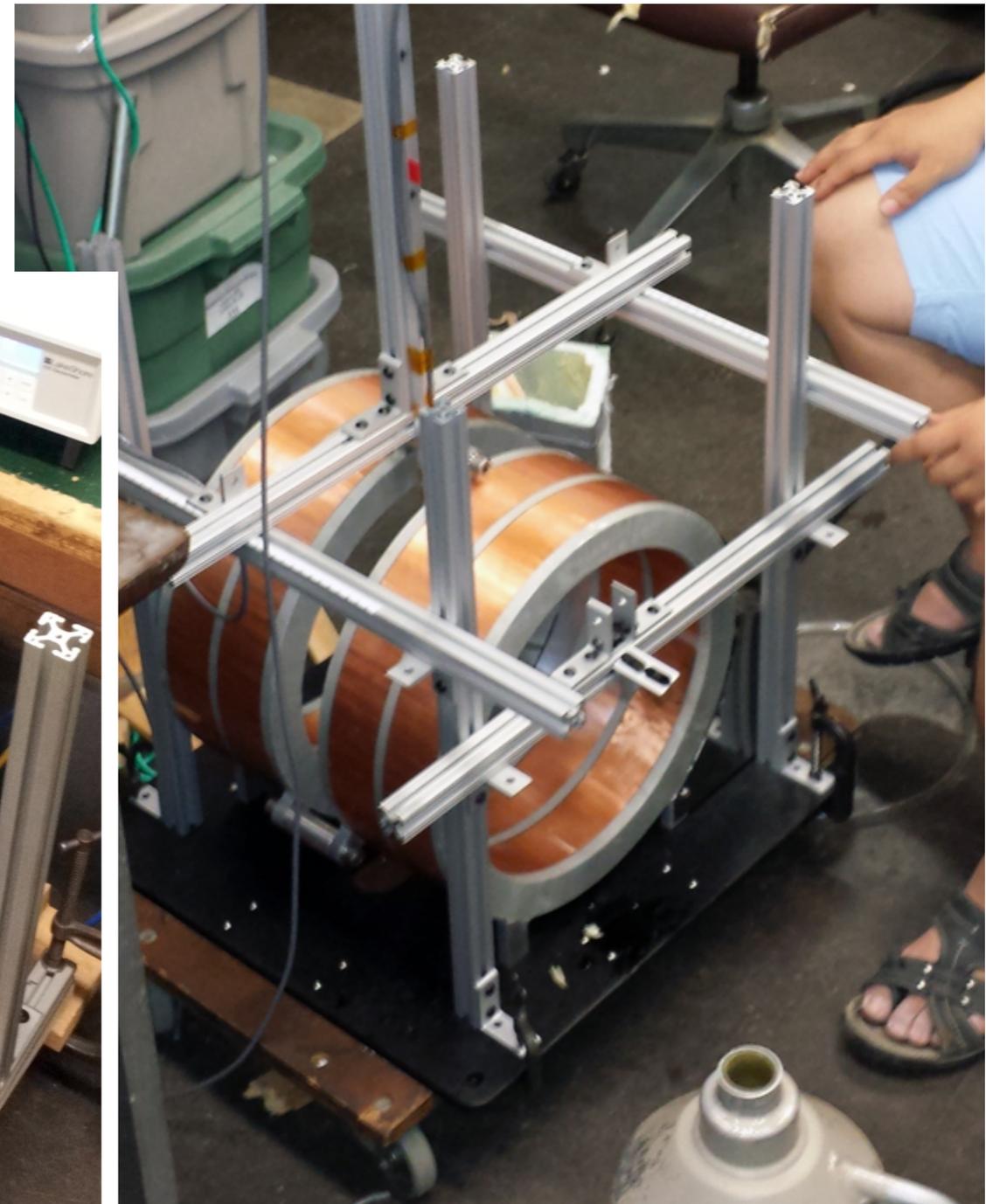
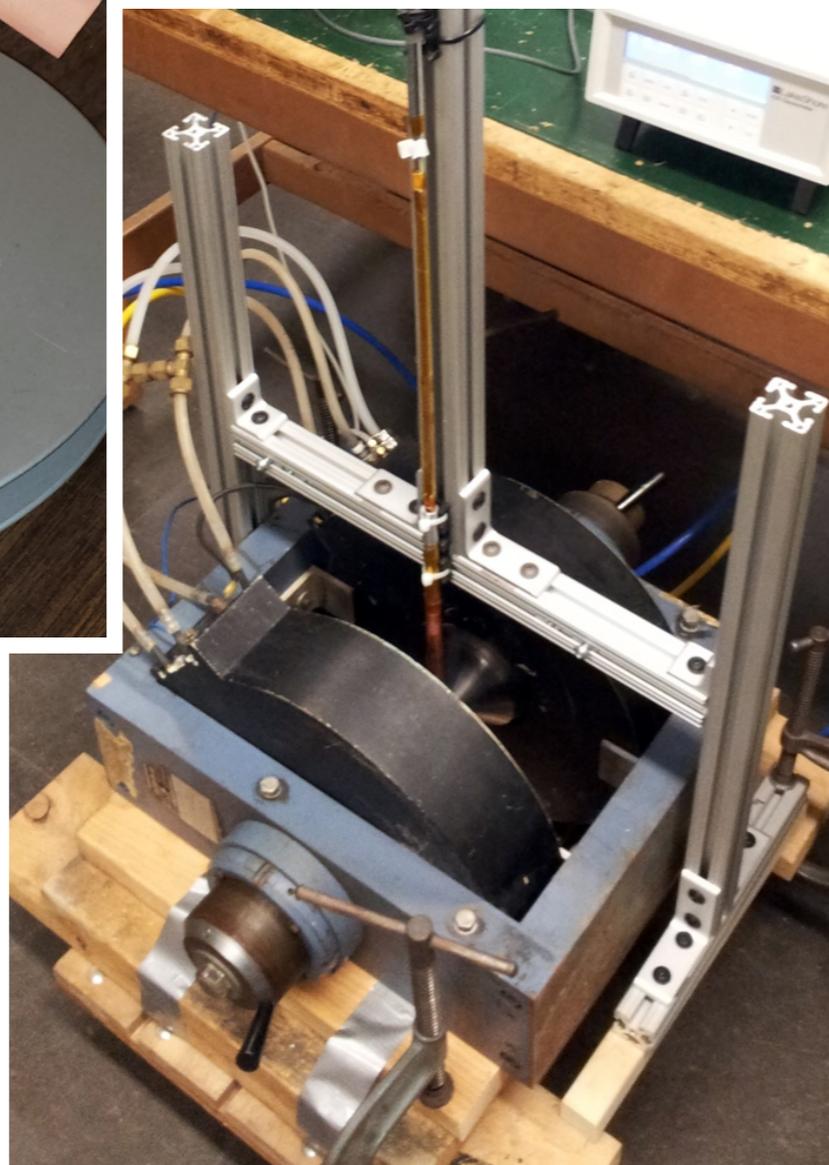
K. Capobianco-Hogan, R. Cervantes,
J. Chang, B. Coe, K. Dehmelt,
A. Deshpande, N. Feege, T. K. Hemmick,
P. Karpov, Y. Ko, T. LaByer, R. Lefferts, A. Lipski,
E. Michael, J. Nam, A. Quadri, K. Sharma



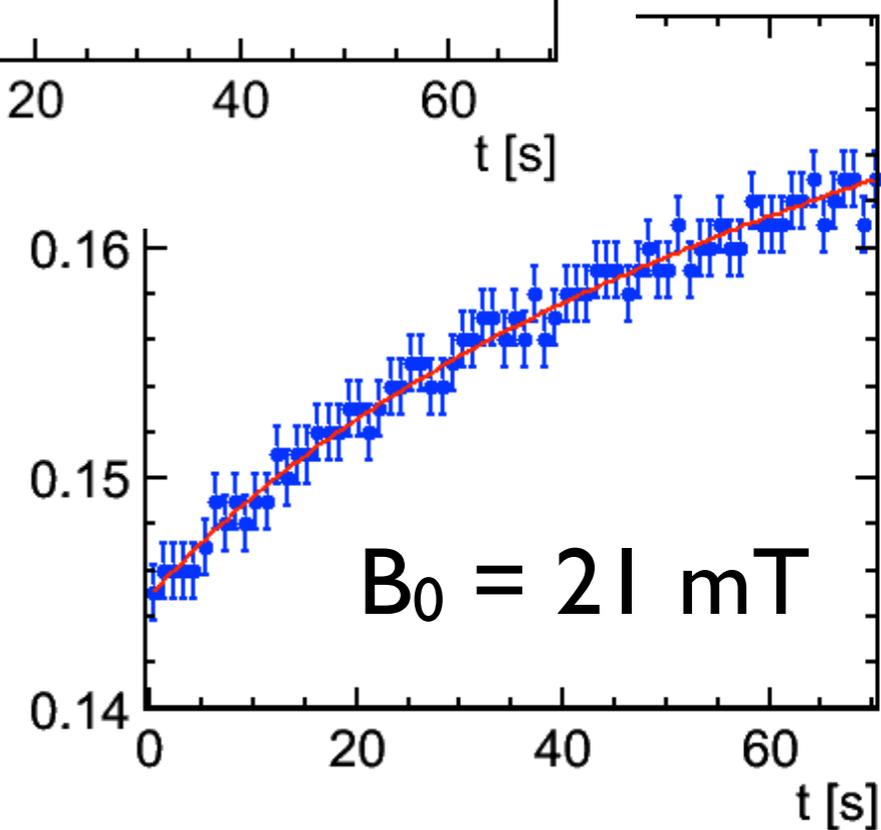
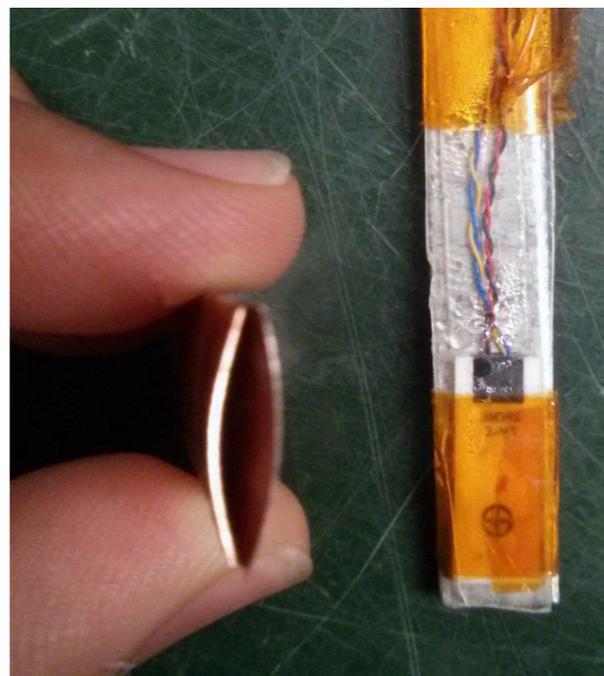
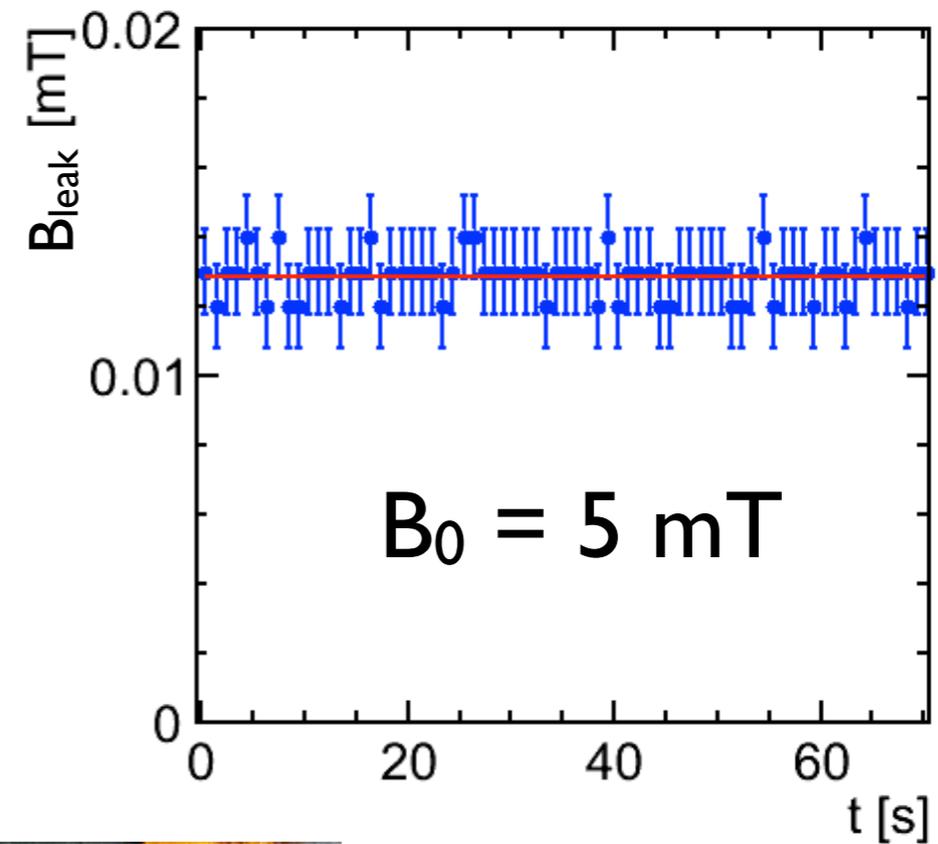
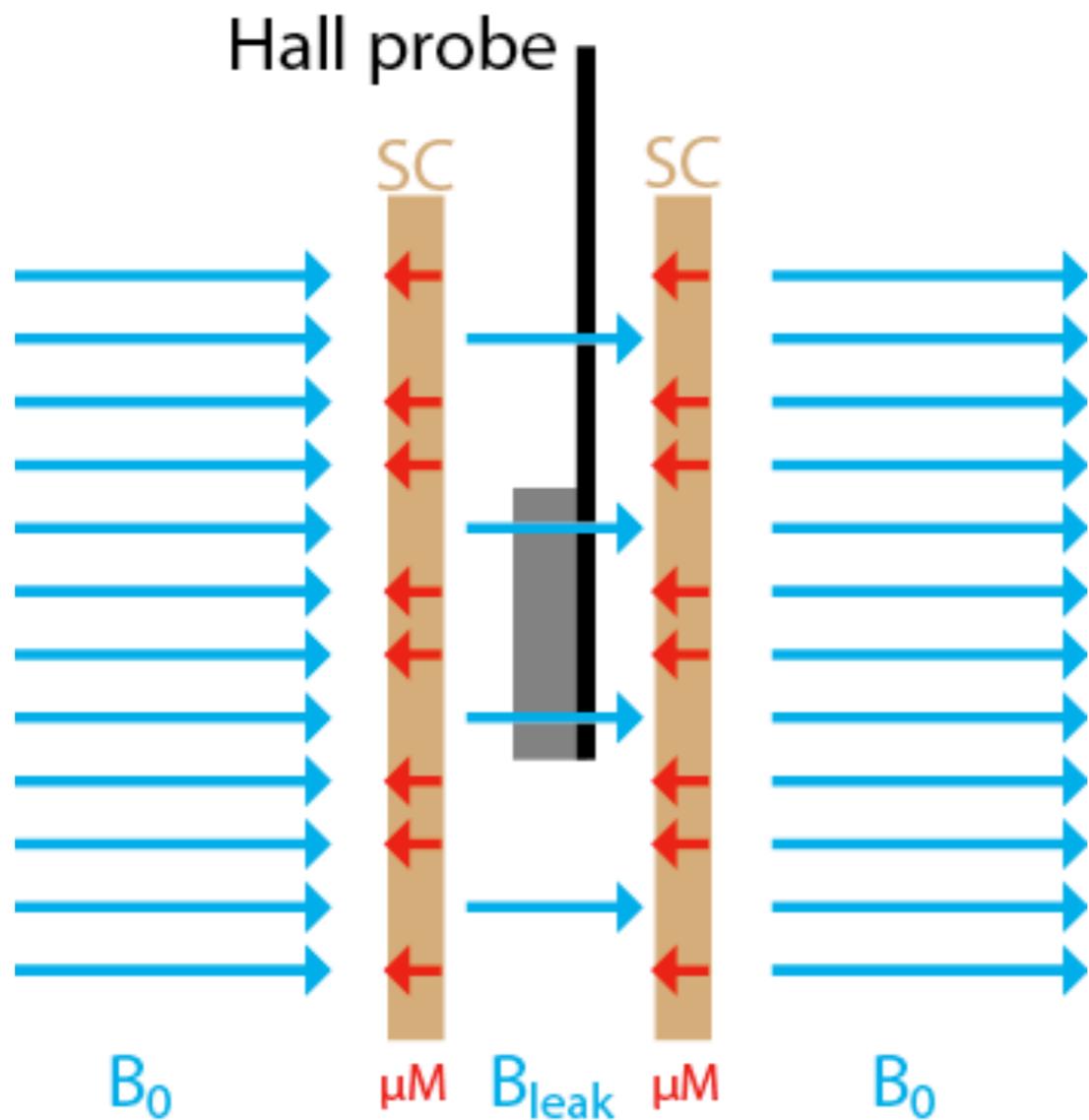
The superconducting layer



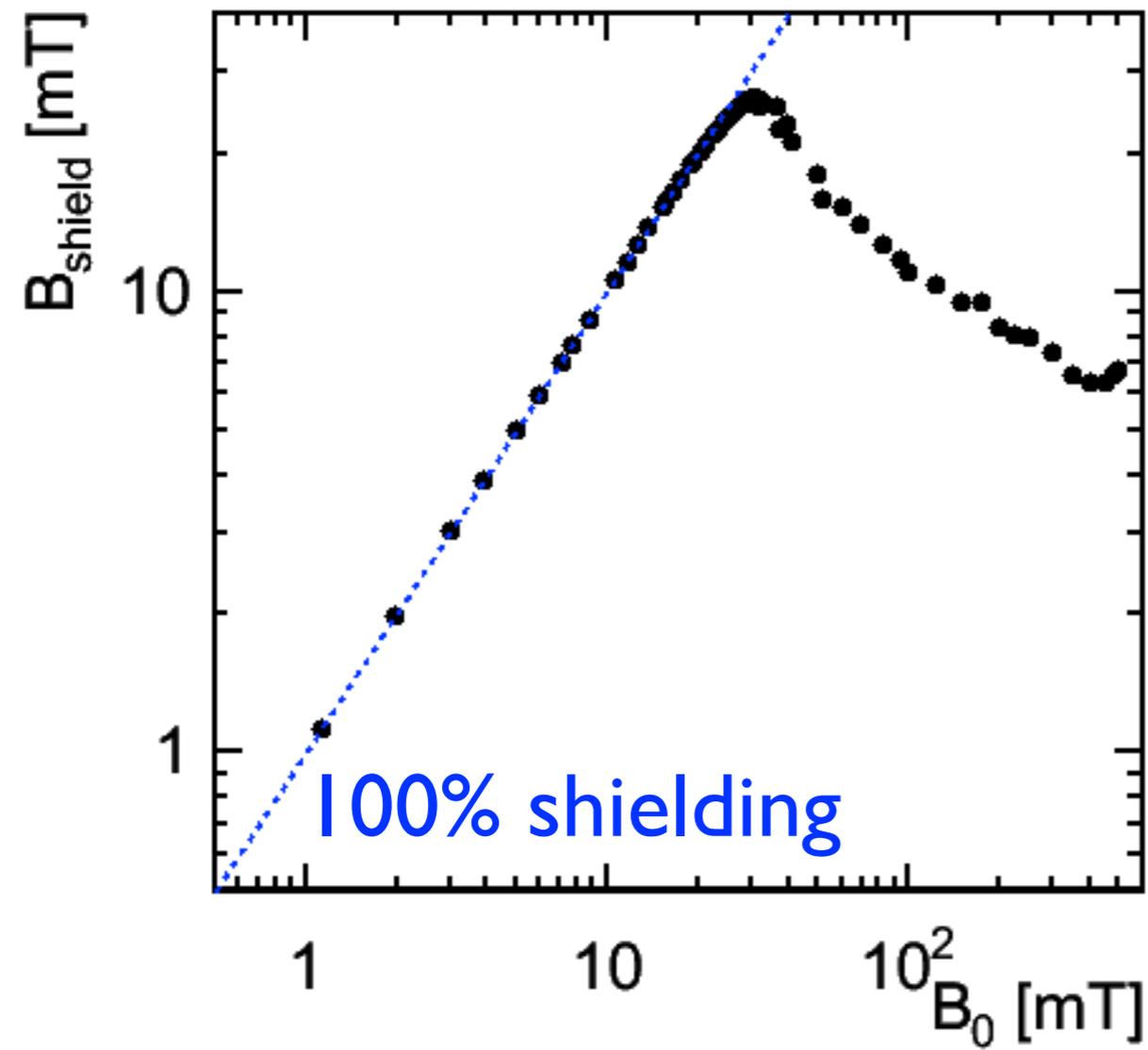
SC Tape
(SuperPower)
12 mm wide
 $I_c > 420$ A



Basic tests of superconductor tape



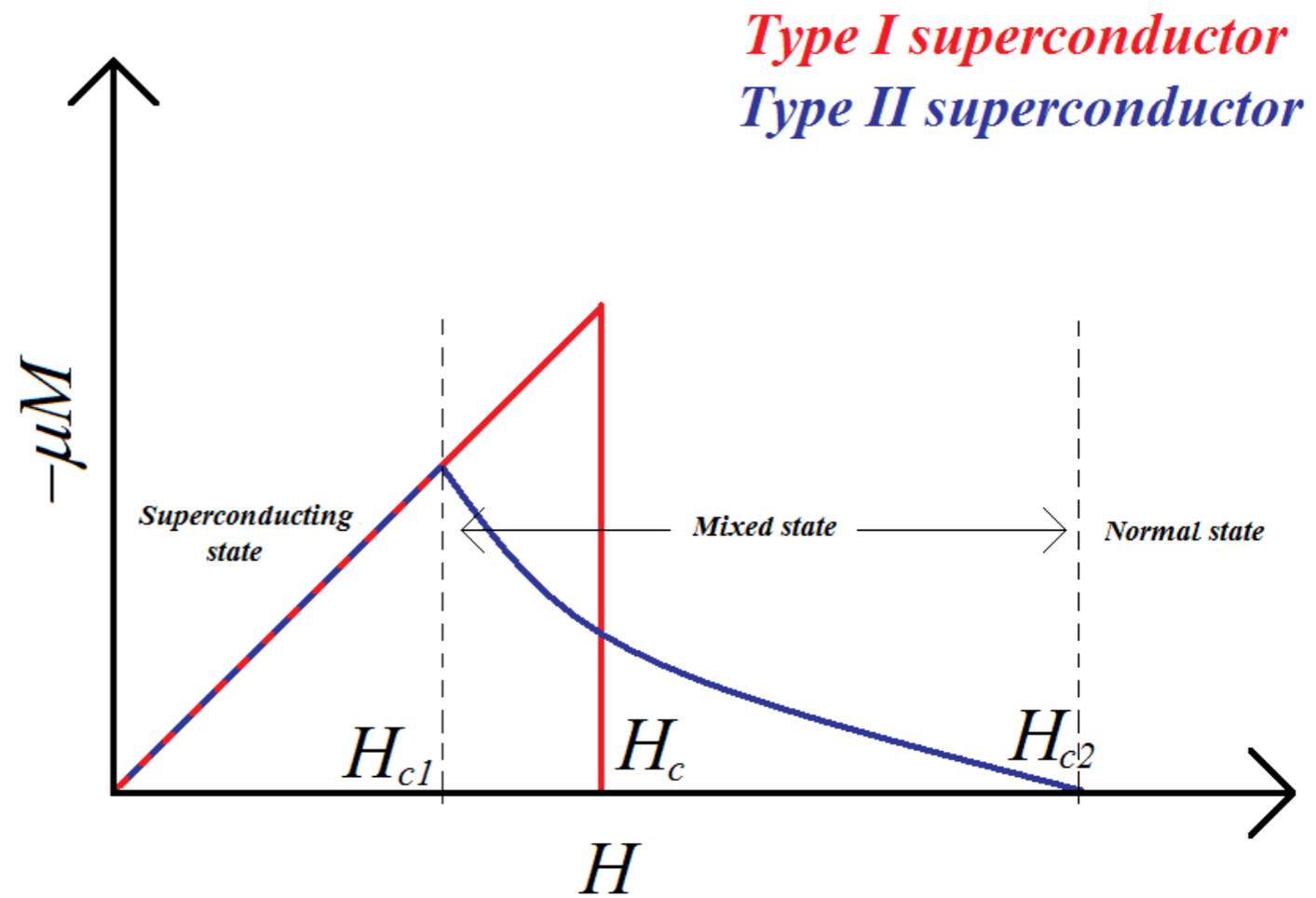
SC tape performance at high fields



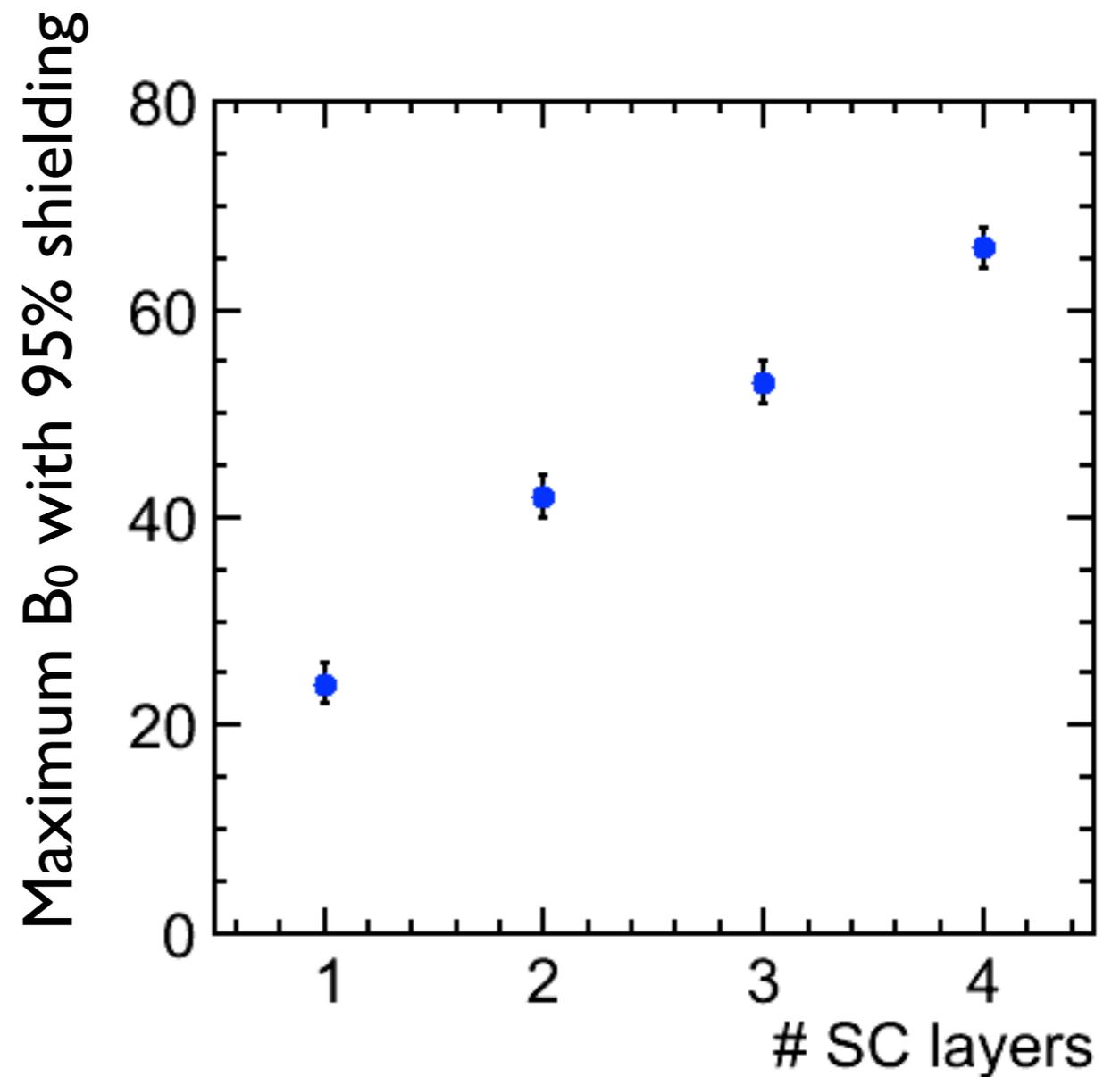
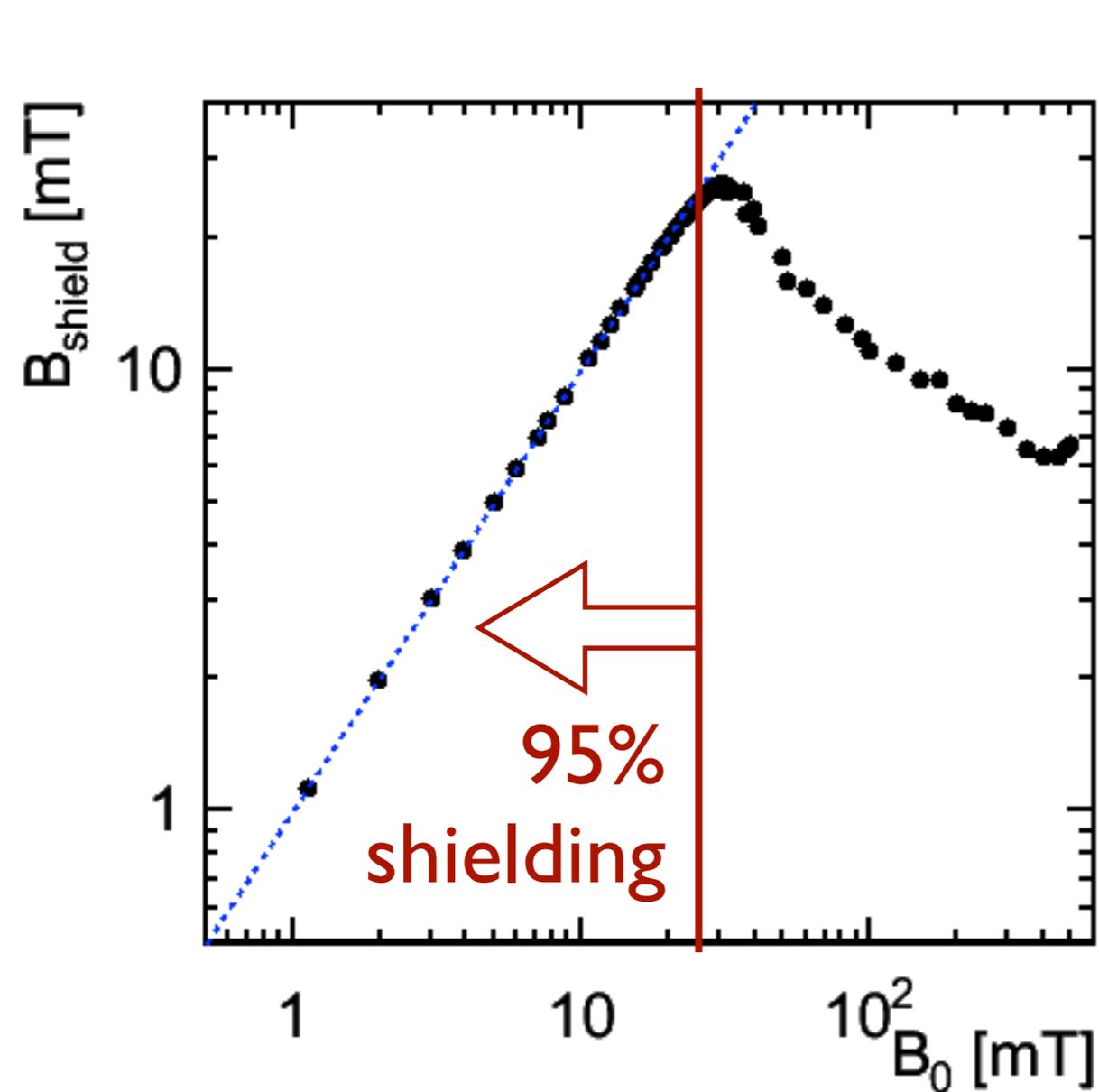
100% shielding

$B_{C1} \sim 20$ mT

$B_{C2} > 500$ mT



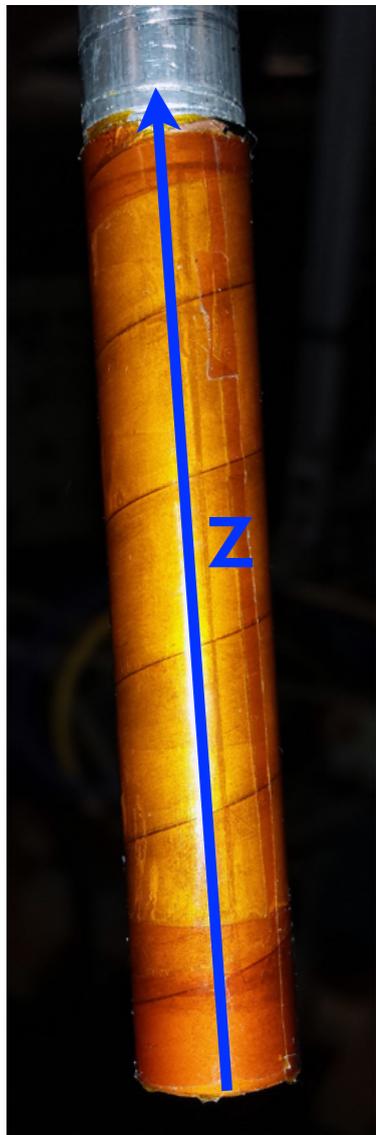
Multiple SC layers improve shielding



Linear extrapolation:

95% shielding (500 mT) with 36 layers (8 mm SC + 2 mm Kapton)

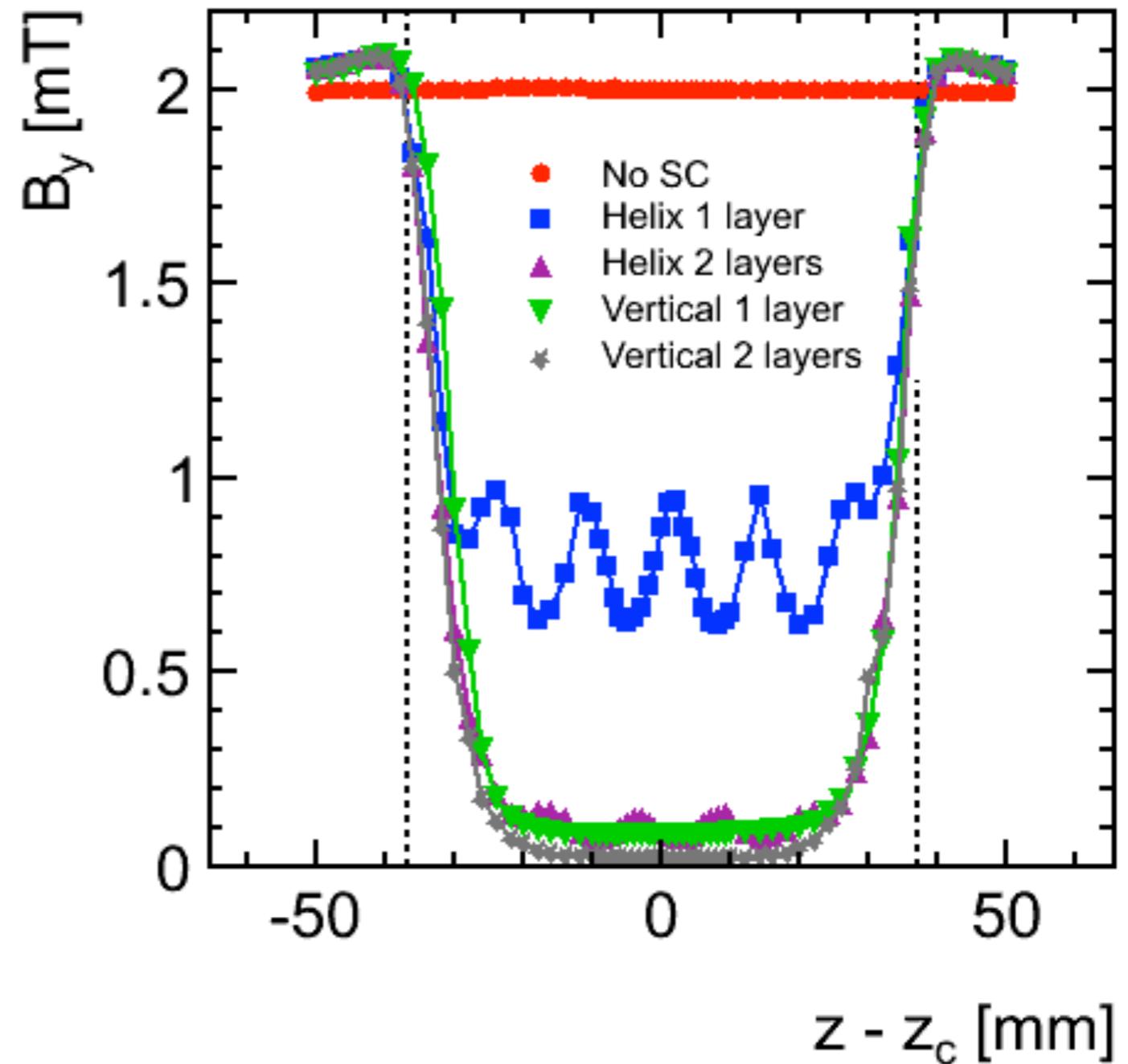
Superconductor wrapping options



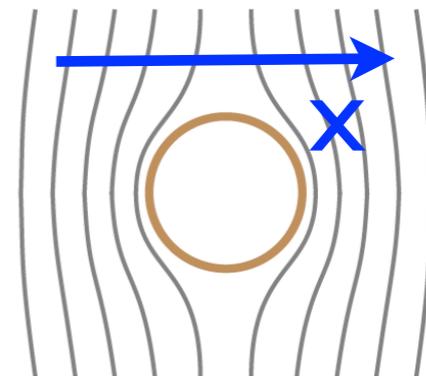
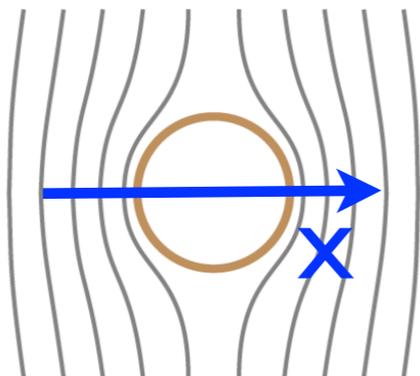
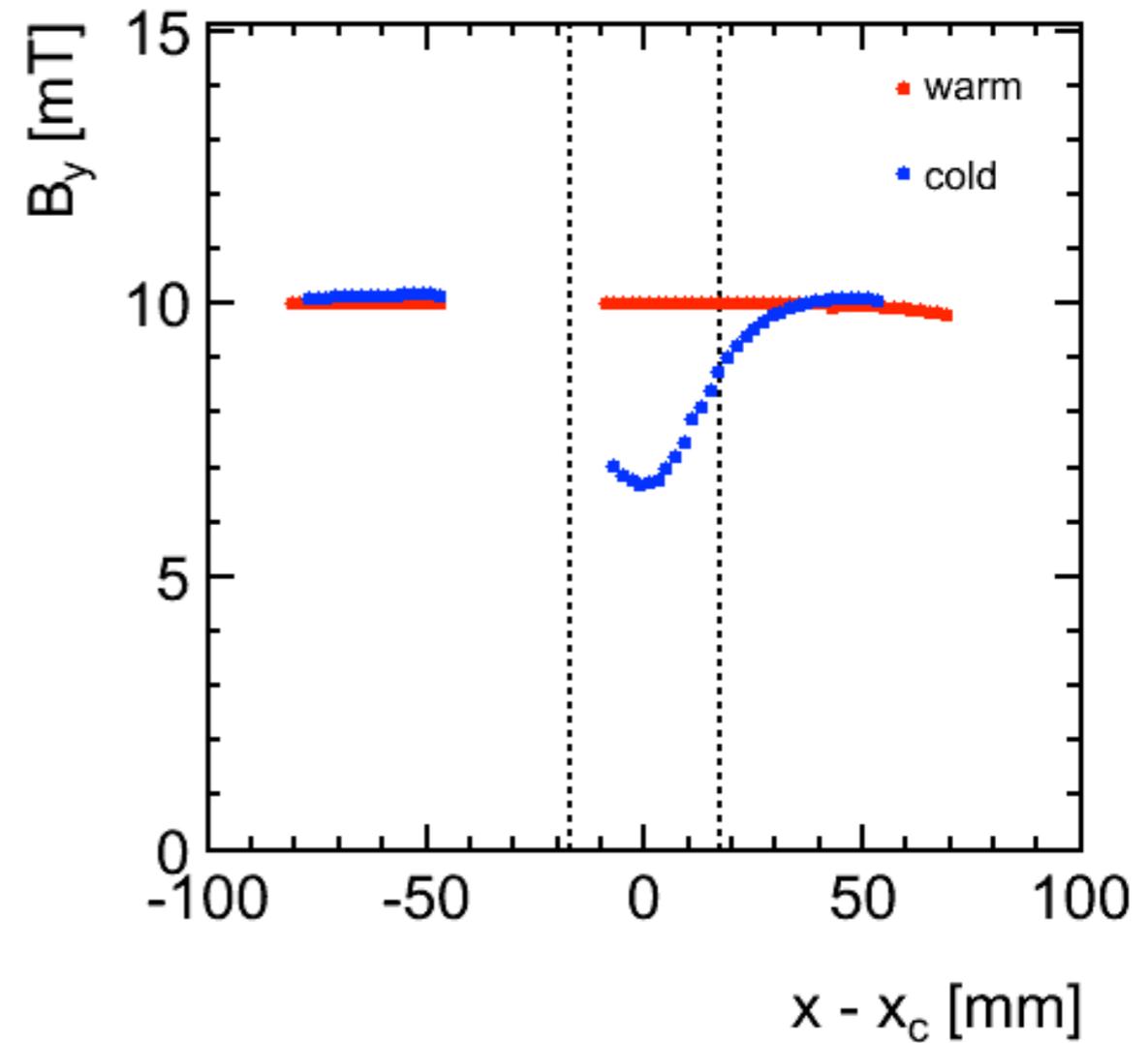
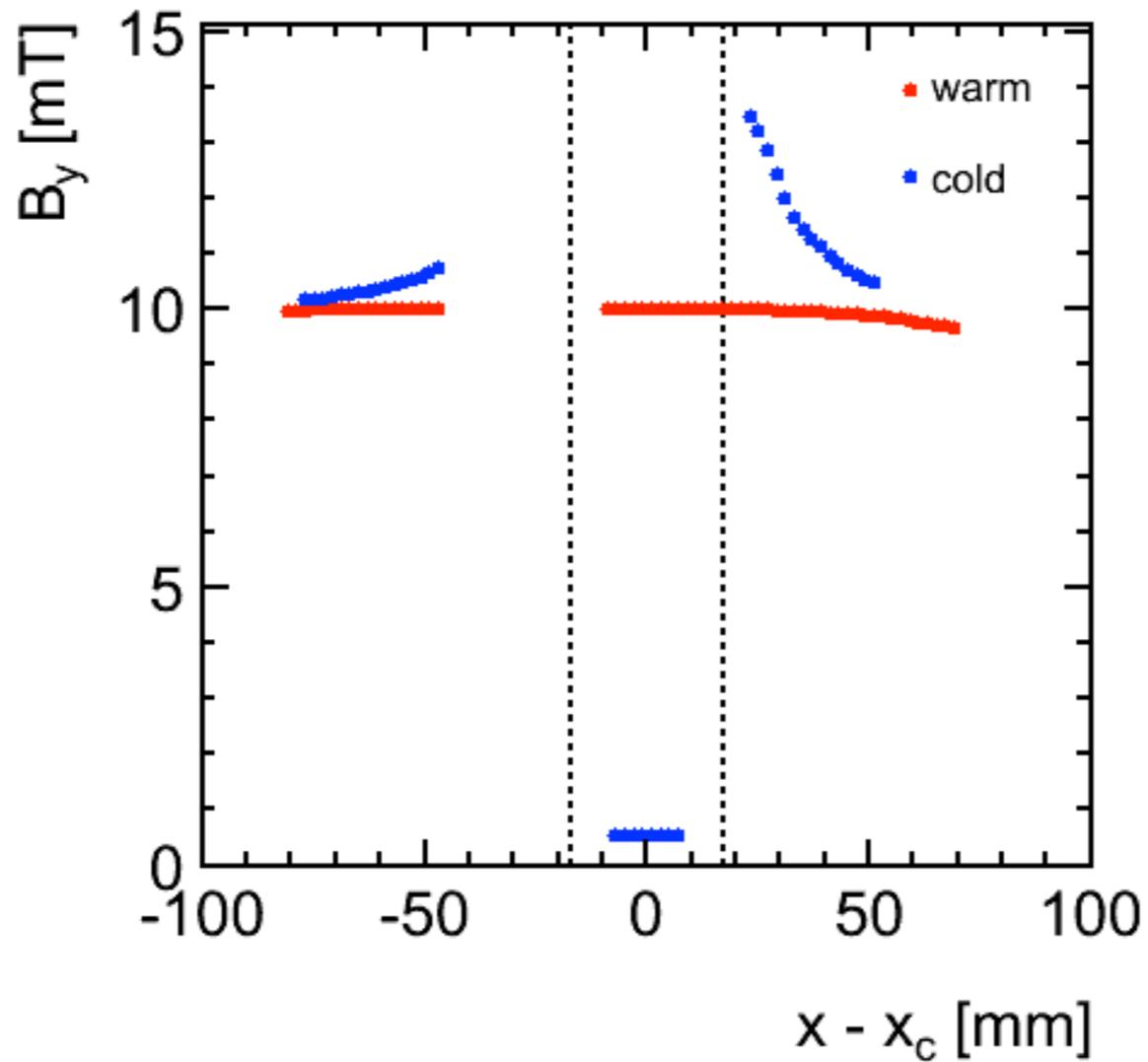
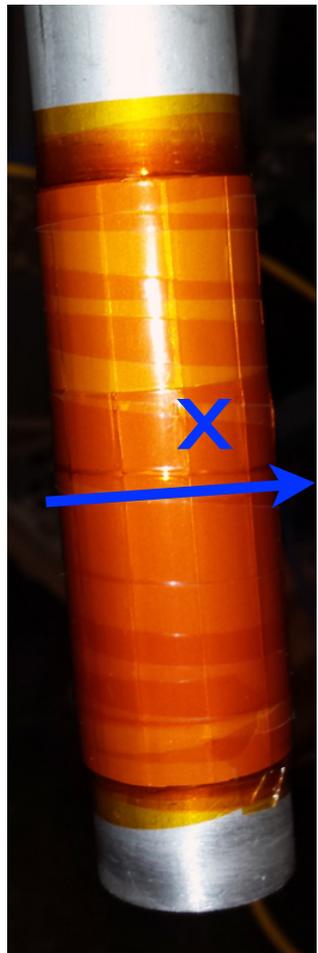
'helix'



'vertical'



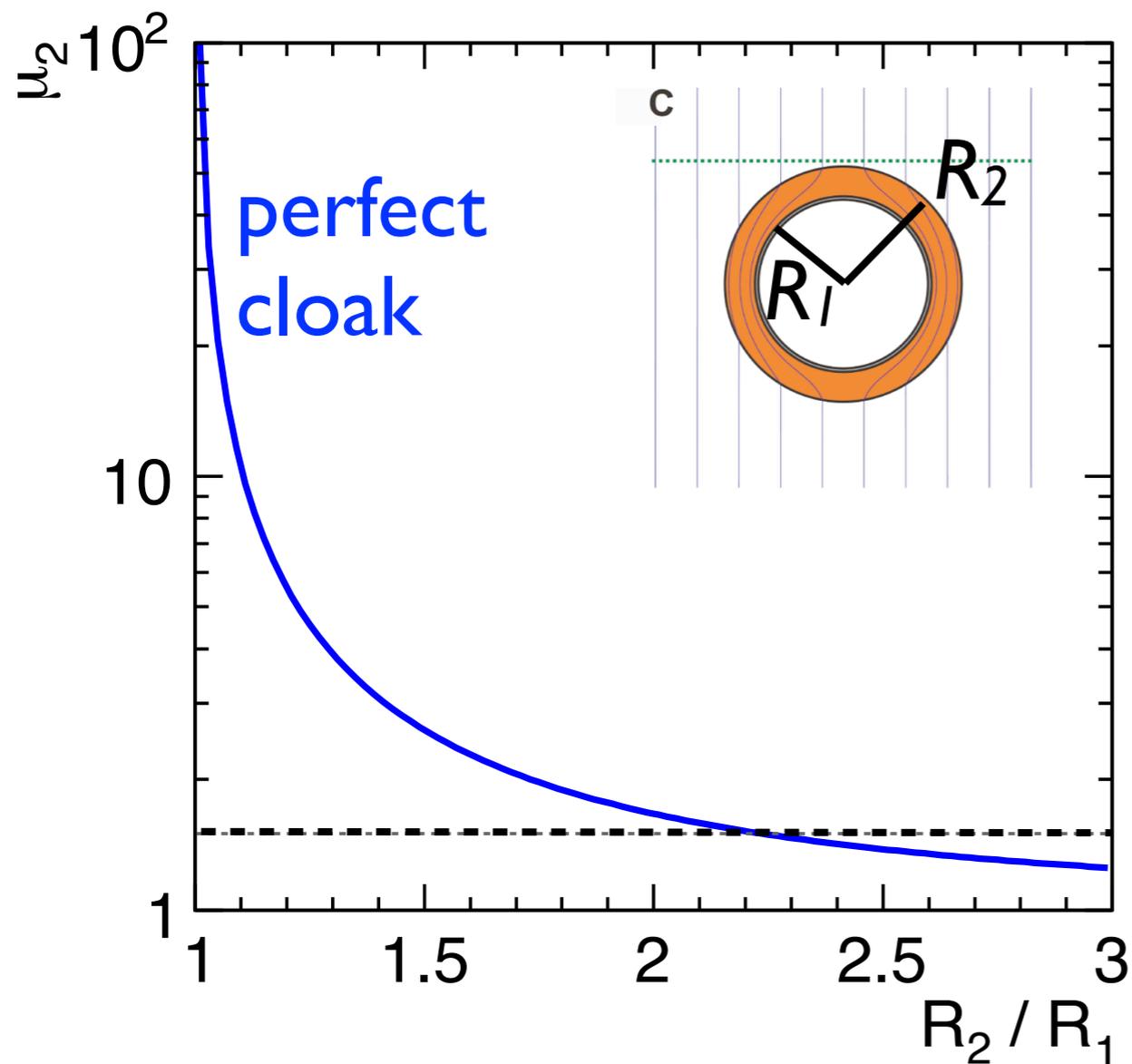
Field disturbance around SC cylinder



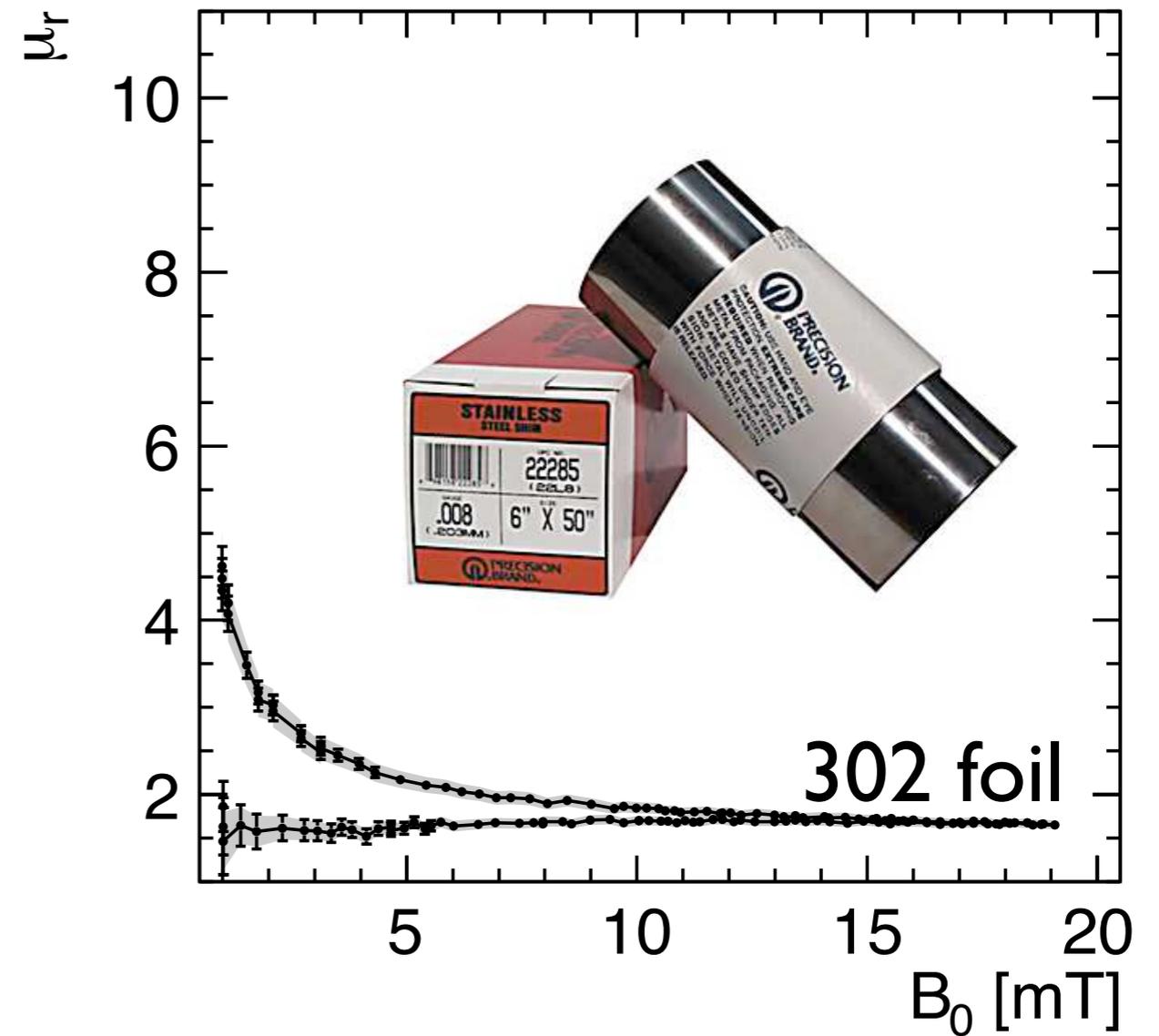
4 layer
'vertical'

Permeability of 302 stainless steel foil

Cold working 302 stainless steel foil is not practical for us



$R_1 = 17.5$ mm

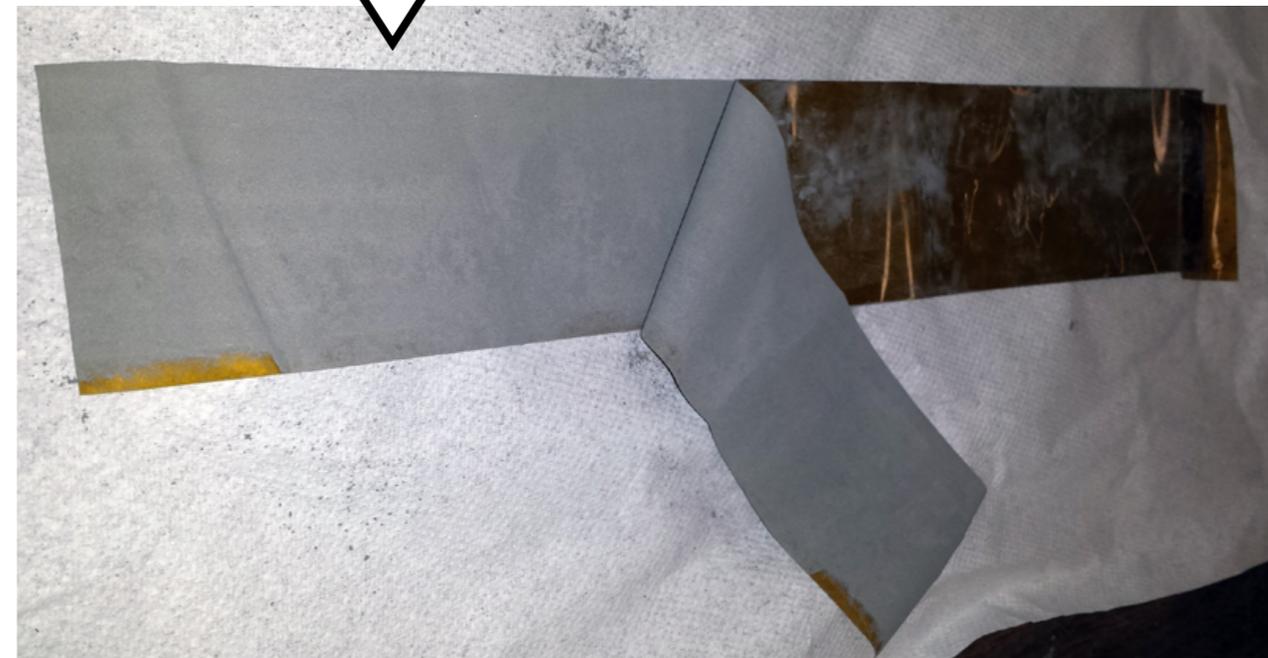
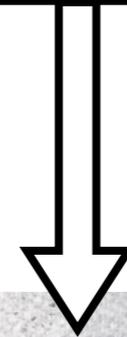
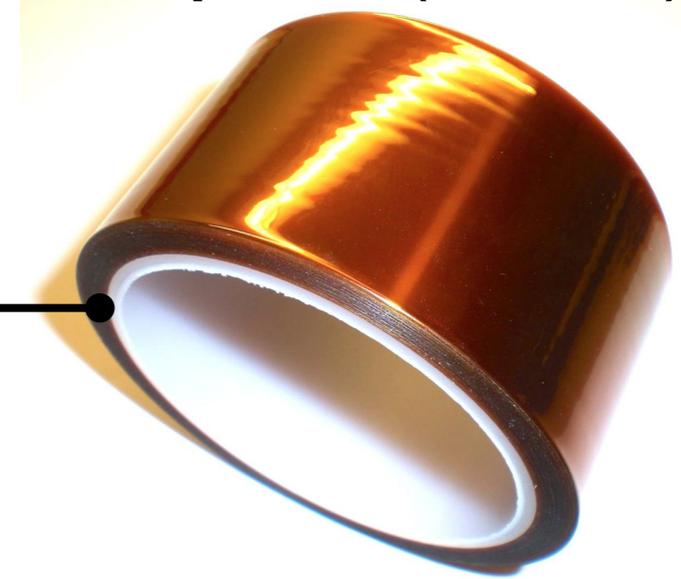
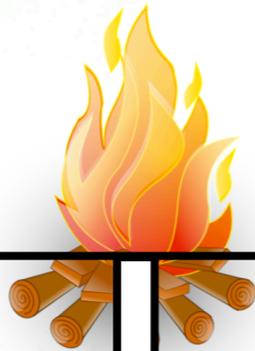


An alternative ferromagnetic layer

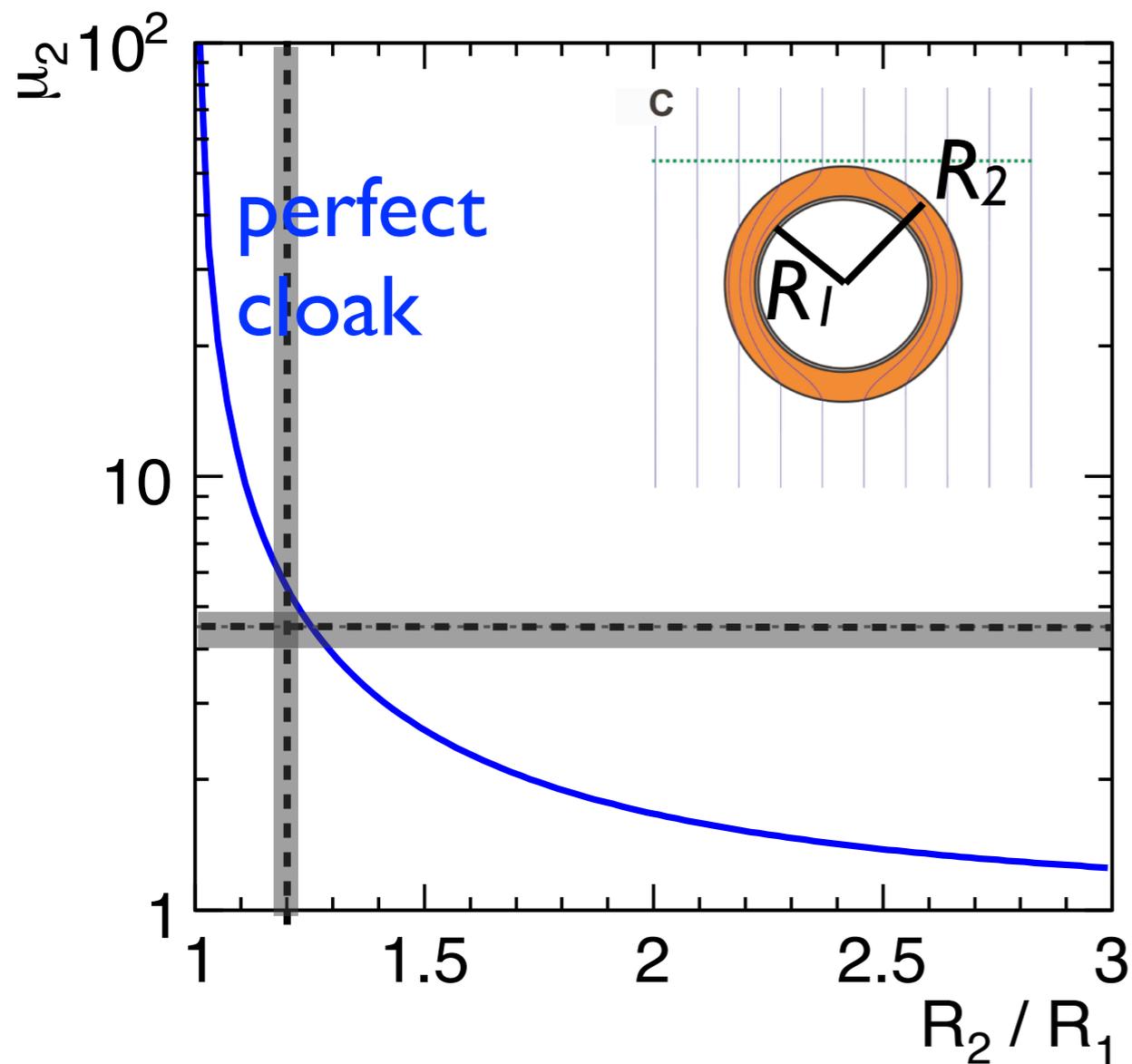
430 Stainless Steel ($\mu_r \sim 800$)

Aluminum ($\mu_r = 1$)

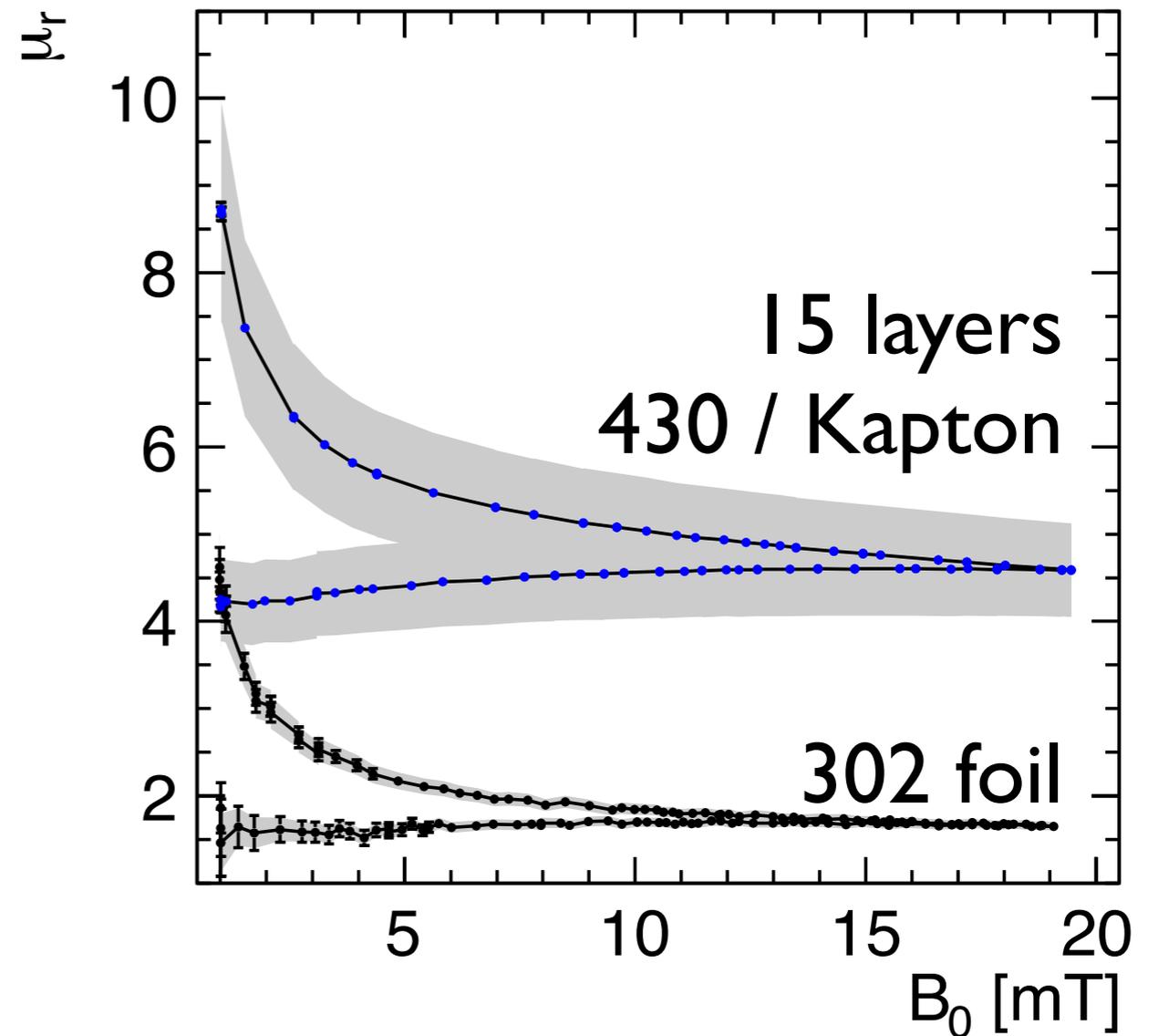
Kapton ($\mu_r = 1$)



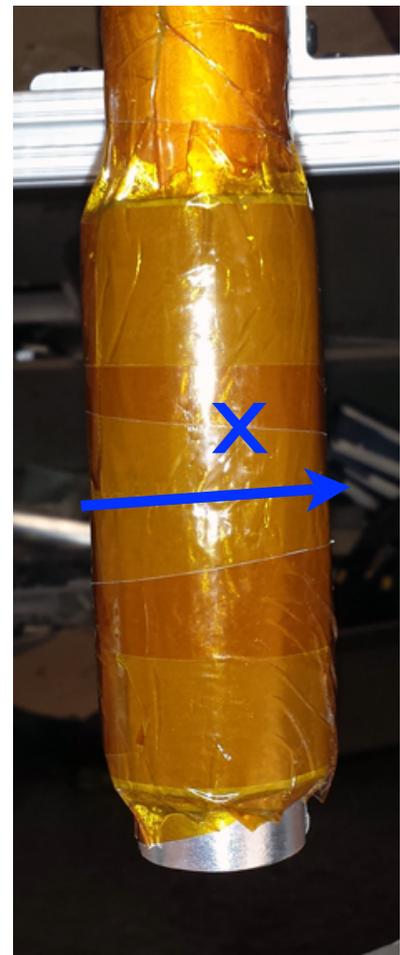
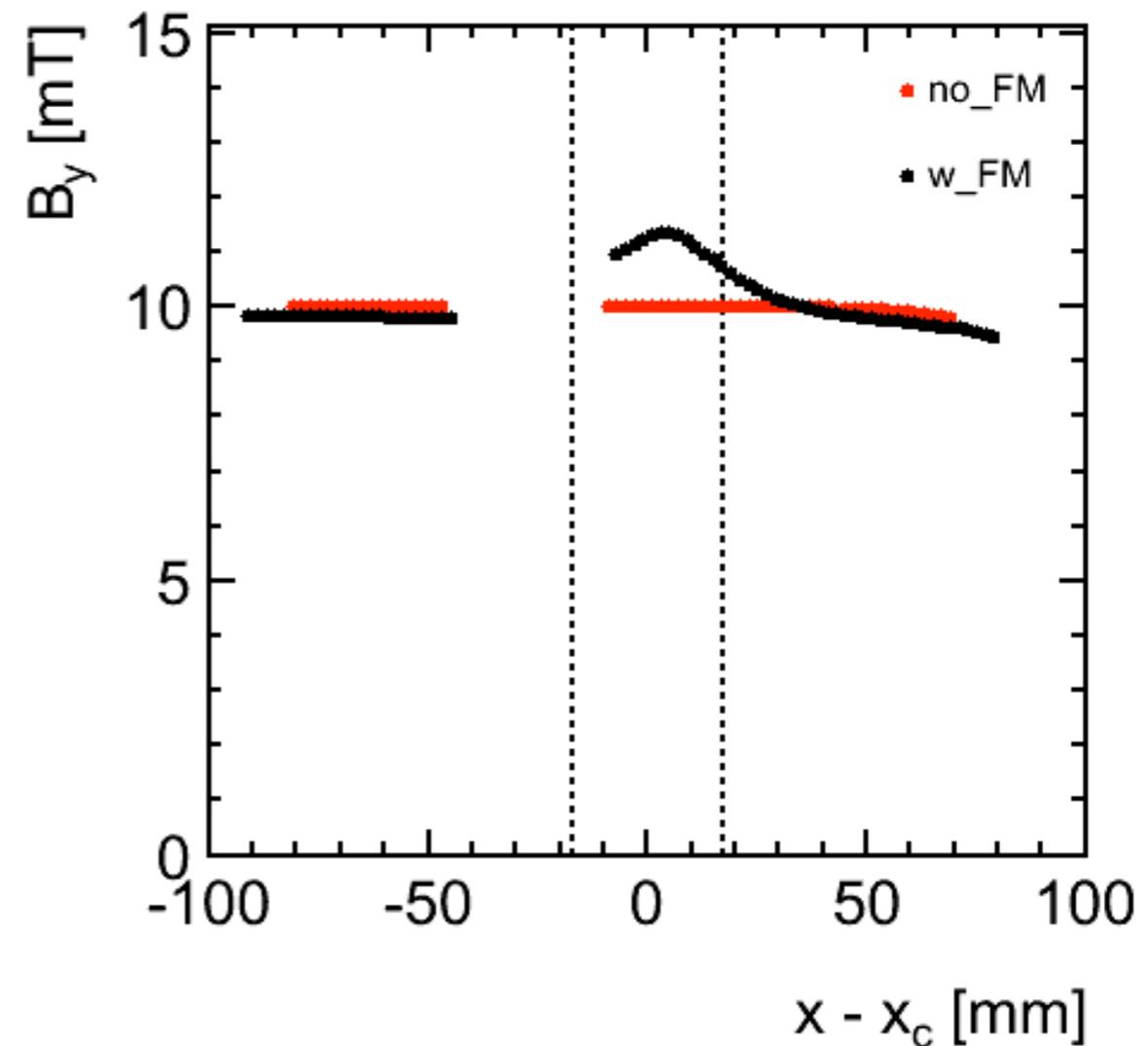
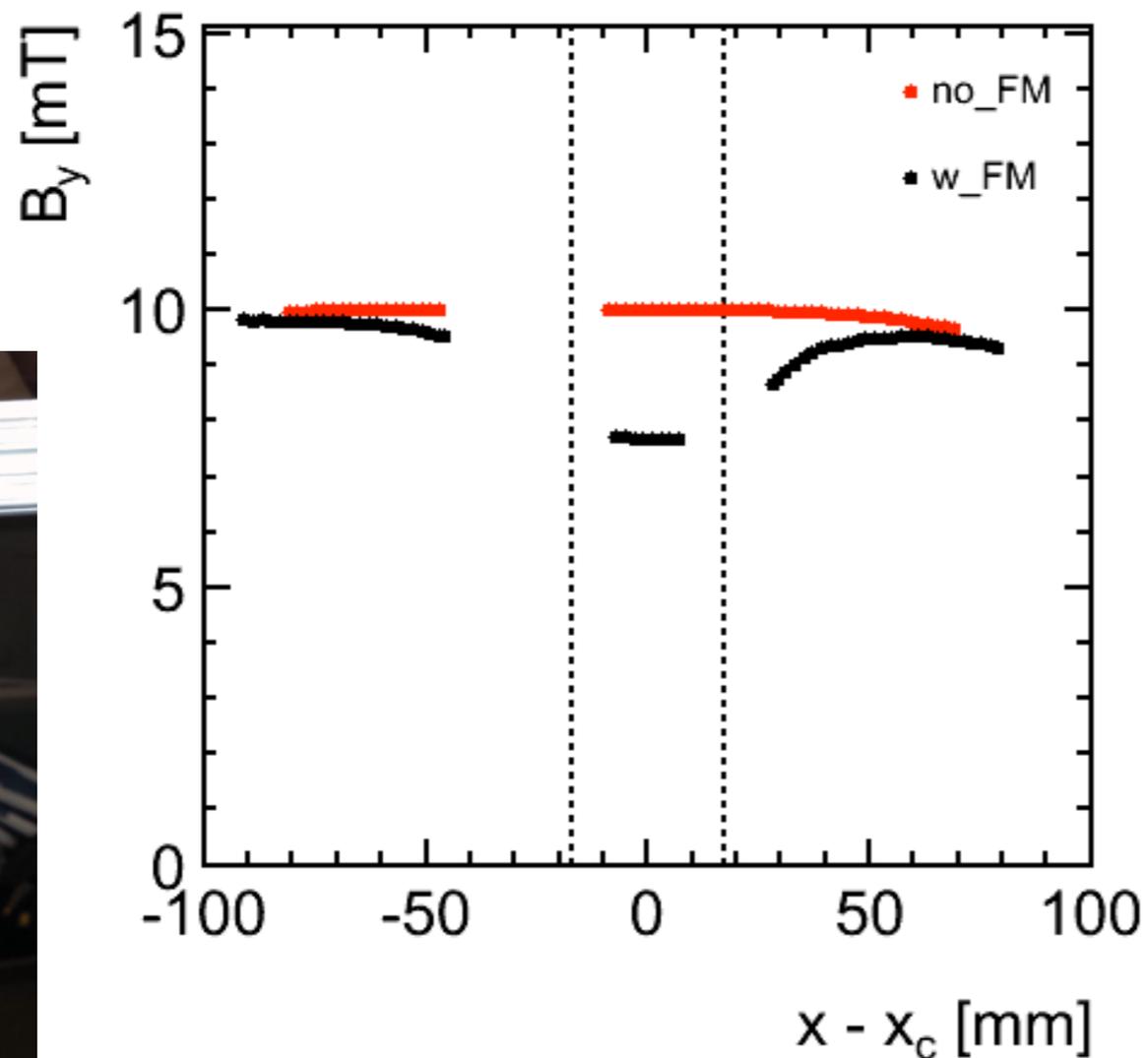
Permeability of 15 layers of 430 stainless steel powder / Kapton



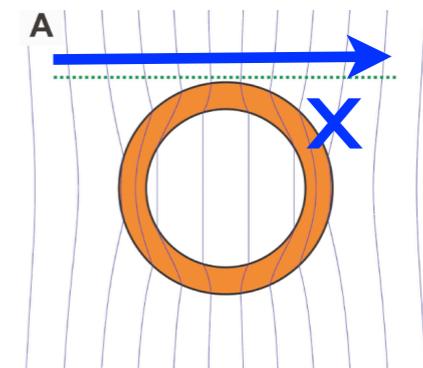
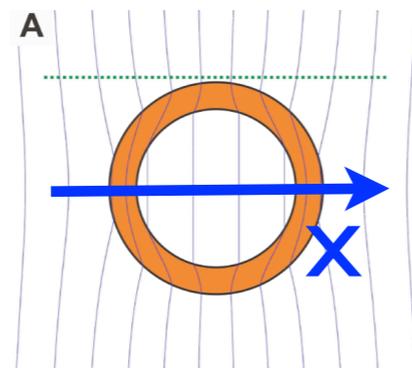
$$R_1 = 17.5 \text{ mm} \quad R_2 = 21 \text{ mm}$$



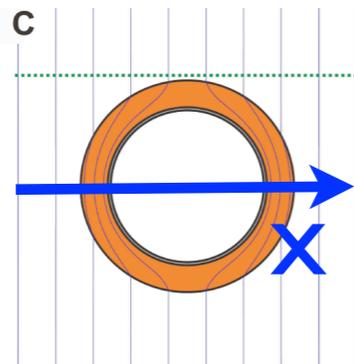
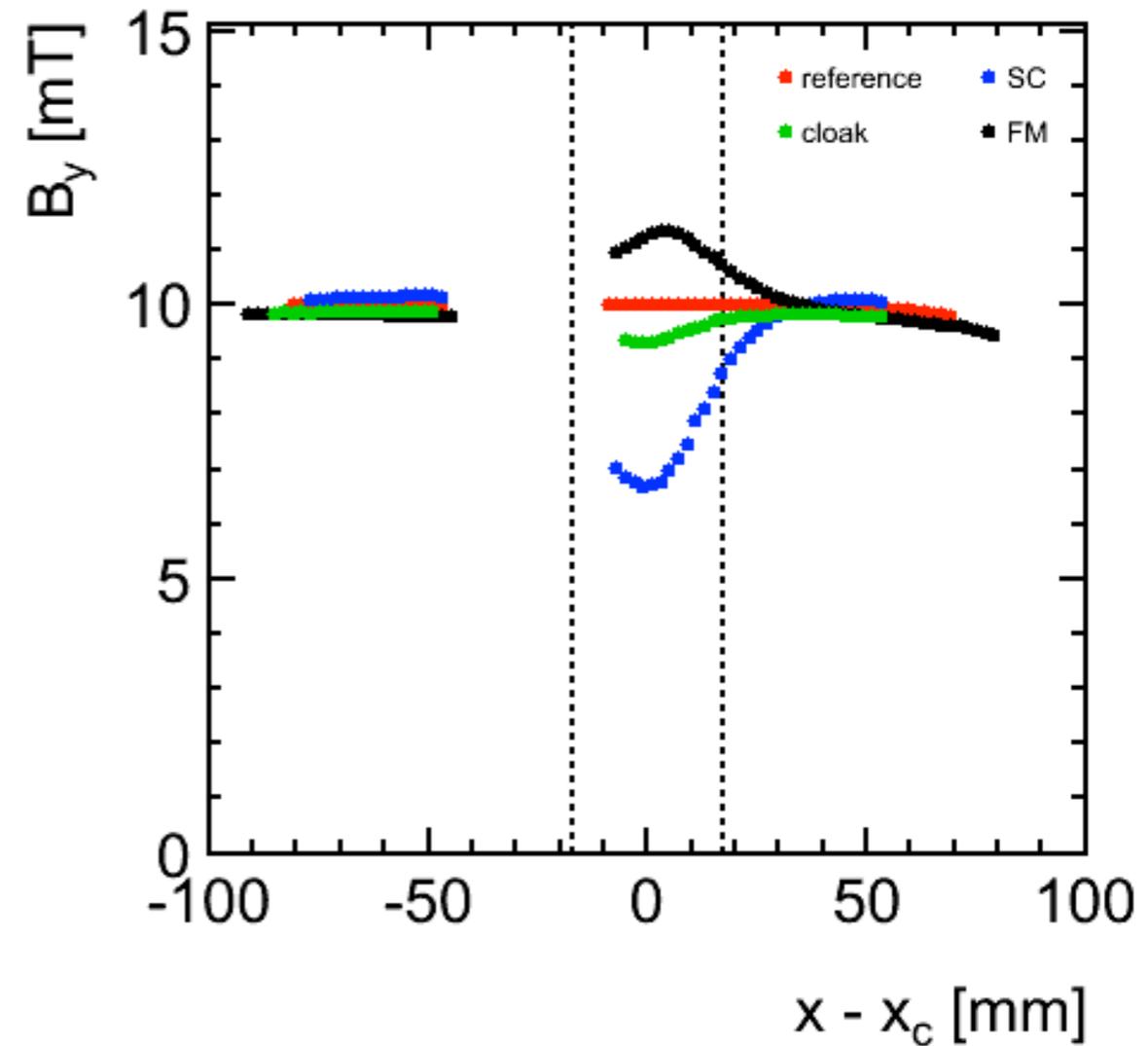
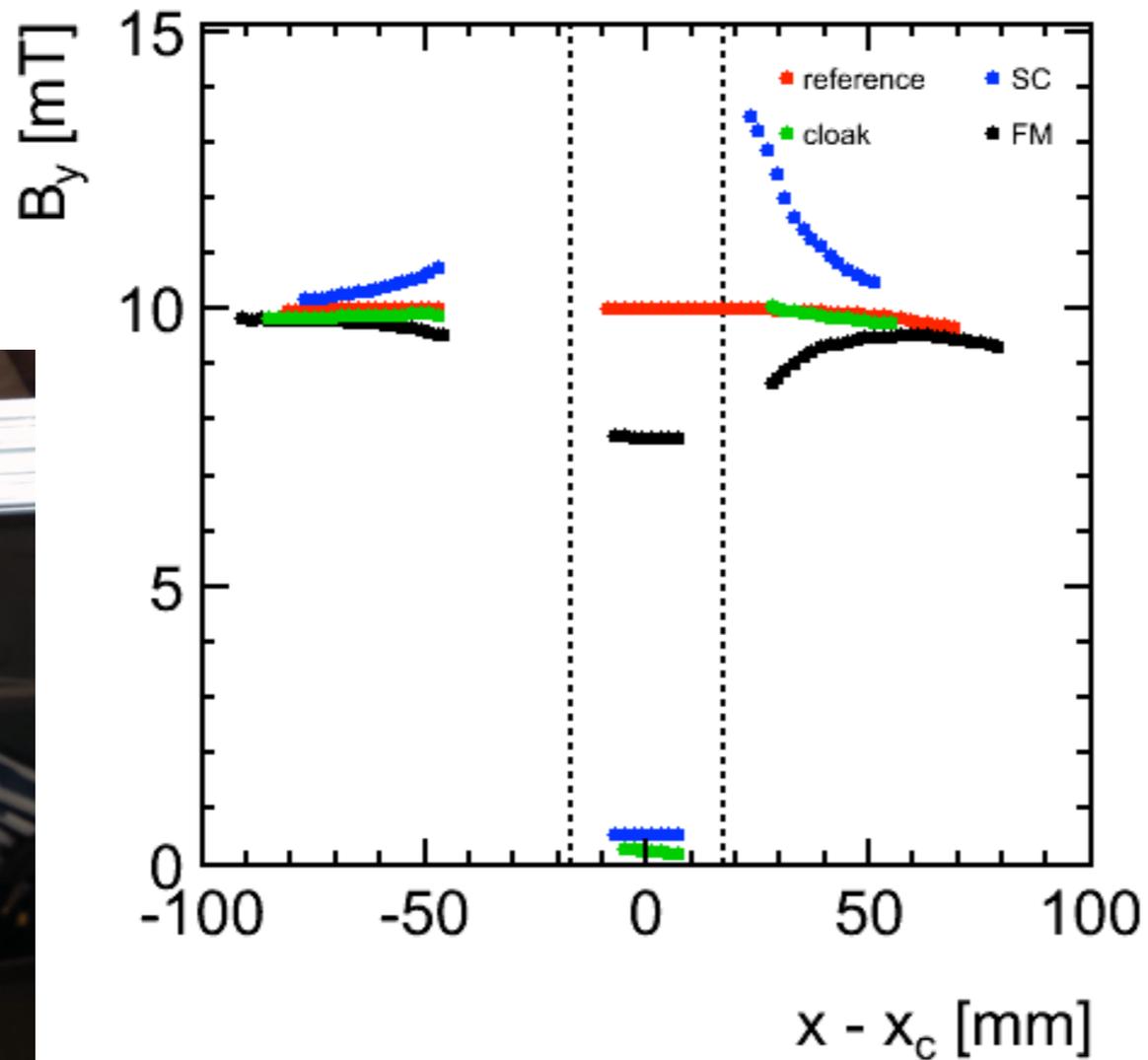
Field disturbance around FM cylinder



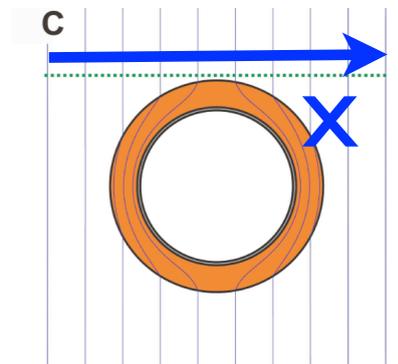
15 layers steel powder / Kapton



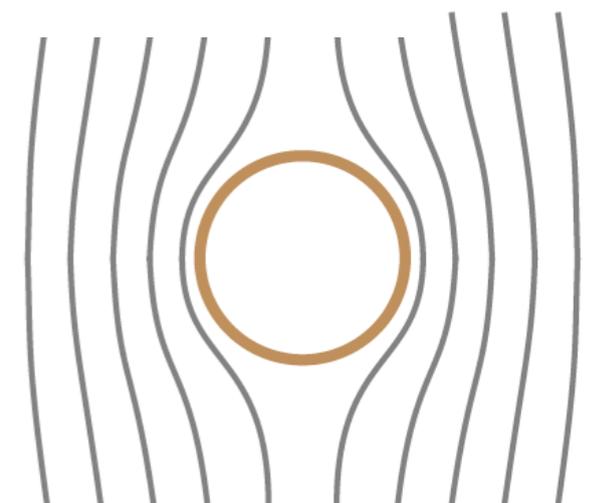
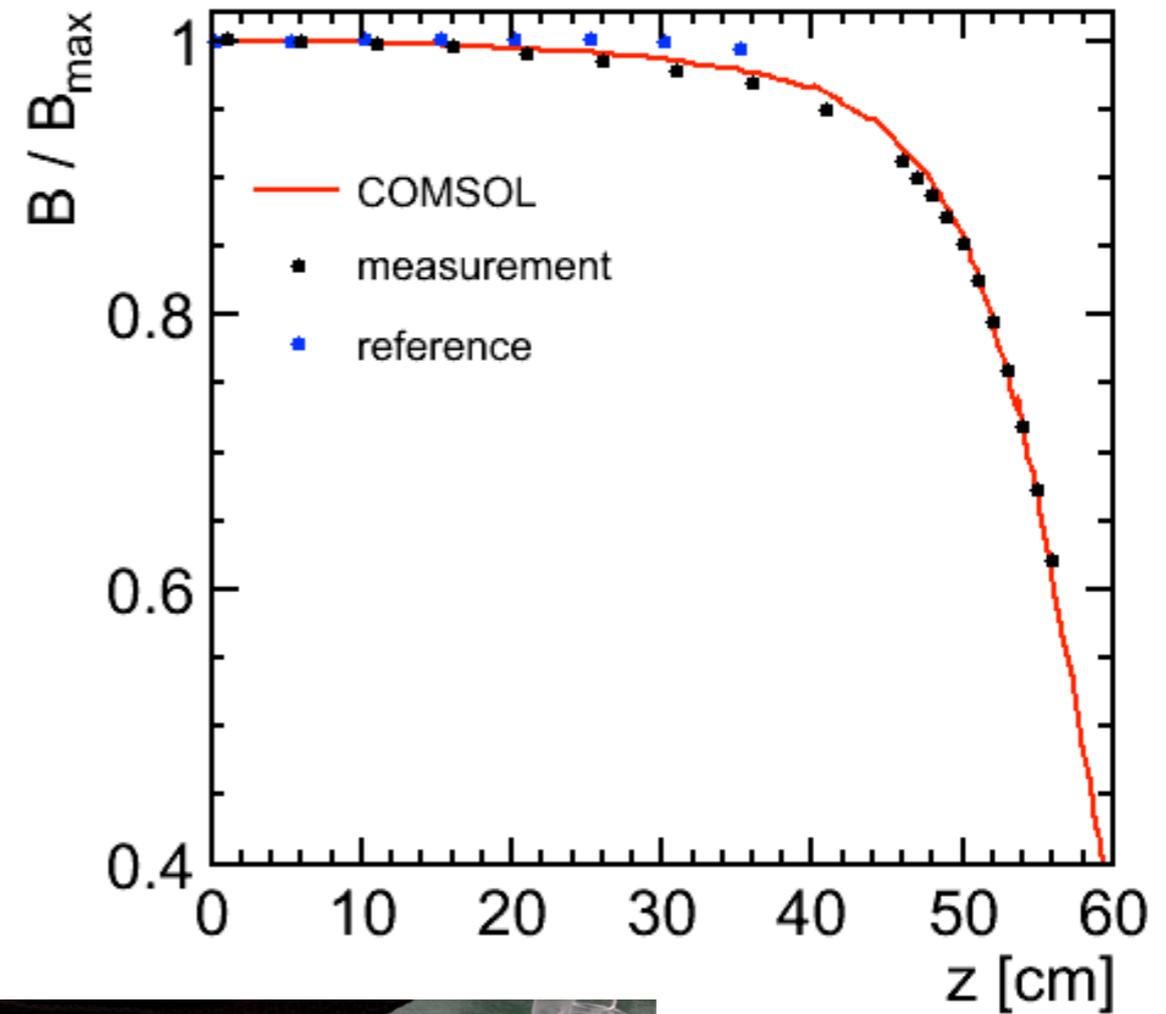
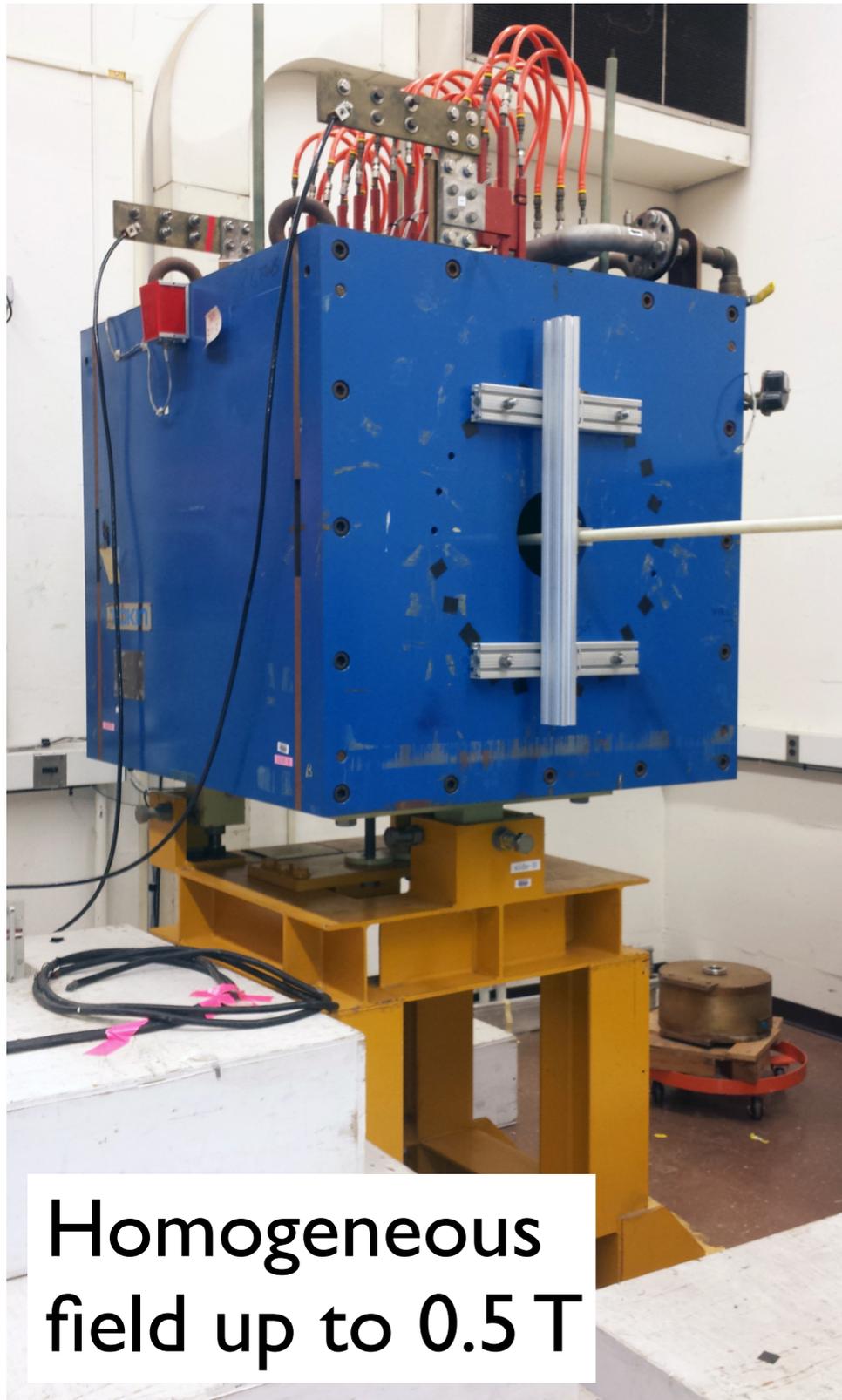
Near-total Cloaking Achieved!



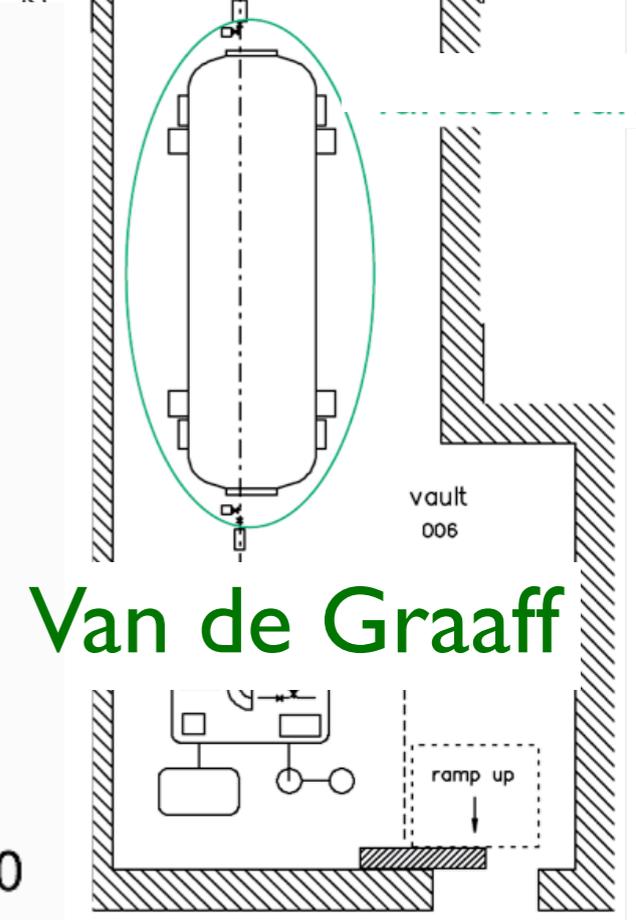
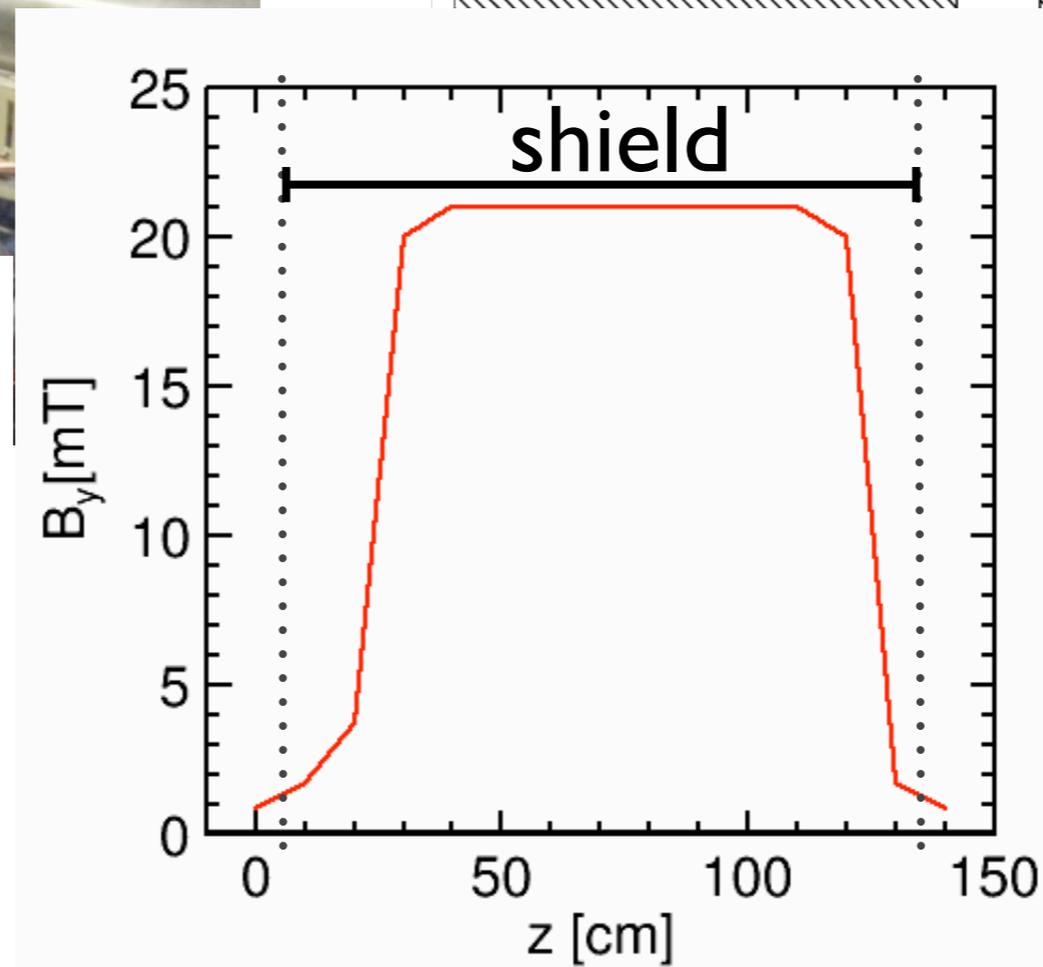
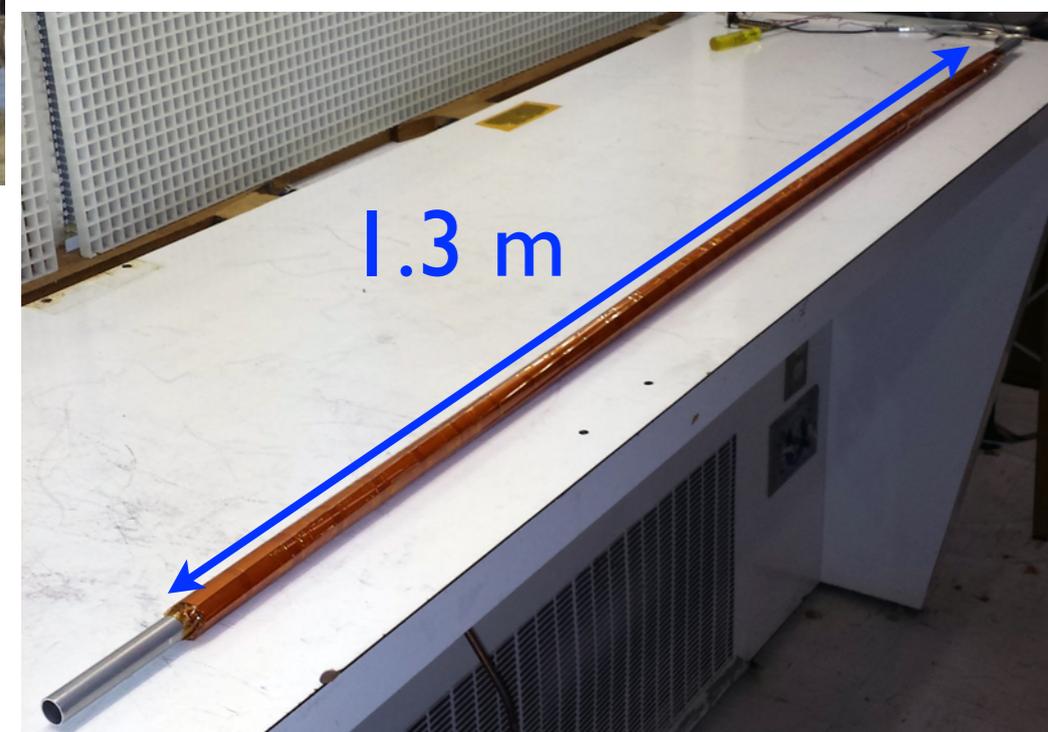
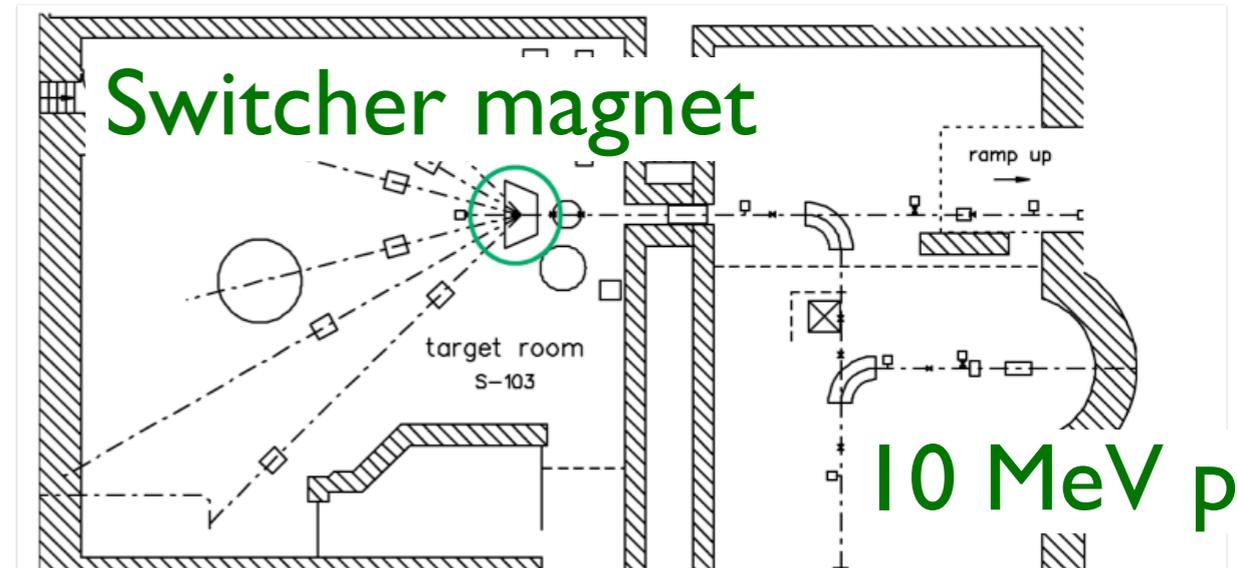
> 80% of SC field disturbance cloaked!



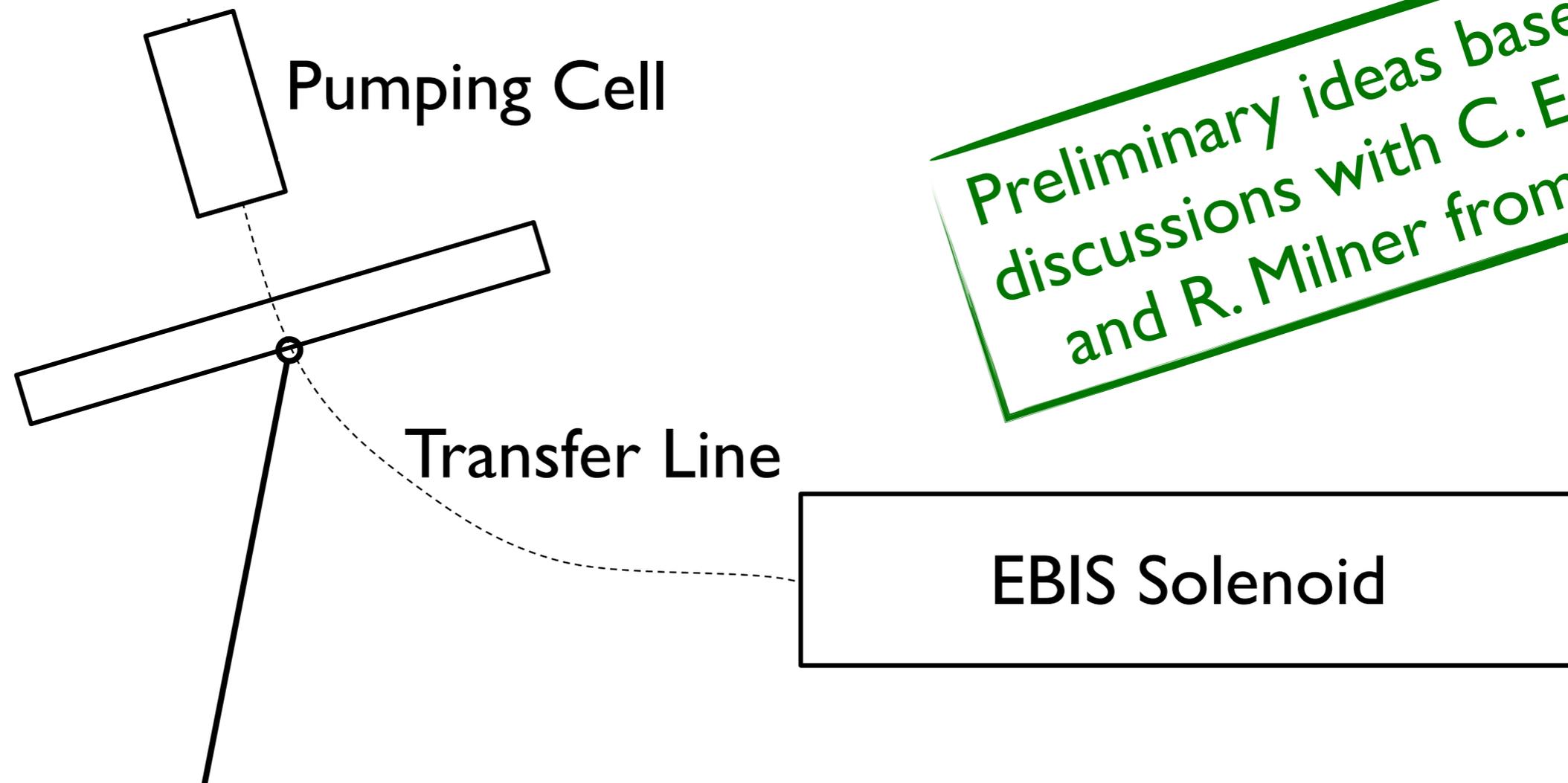
Soon: Measure cloak effect in 'big solenoid'



Soon: Test magnetic field shielding in accelerator



Potential Cloak Use In Polarized ^3He Ion Source at BNL?



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

Depolarization due to transverse magnetic field gradients
→ Need correction coil OR magnetic cloak

Budget Request FY 15

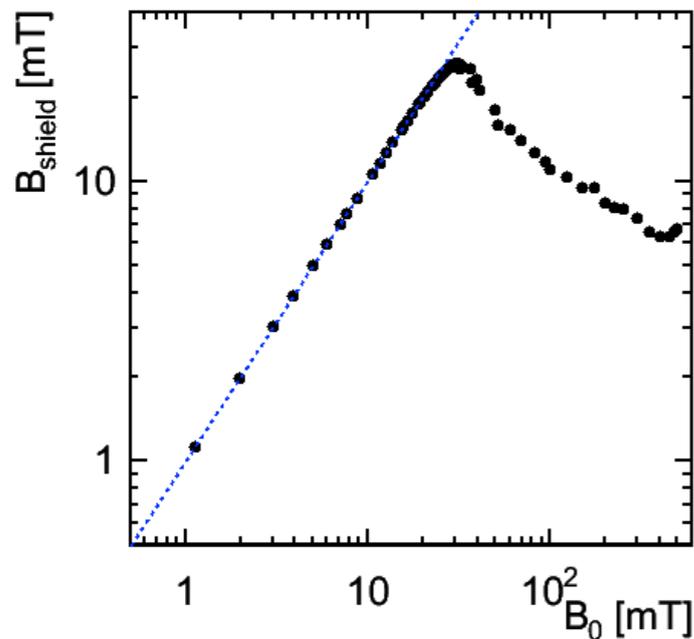
Item	Cost Estimate [\$]
High-temperature superconductor tape	24,000
Liquid Nitrogen supplies	1,000
Total	25,000
Overhead (indirect)	14,500
Total Request FY 15	39,500

Preliminary Budget Request FY16

Item	Cost Estimate [\$]
Post-doc salary (3 months) + fringe benefits	12,500 + 5,500
Graduate student salary (1 year) + fringe benefits	25,000 + 8,000
Low-temperature Superconductor	10,000
Liquid Helium supplies	5,000
Total	66,000
Overhead (indirect)	30,000
Preliminary Request FY16	96,000

Summary

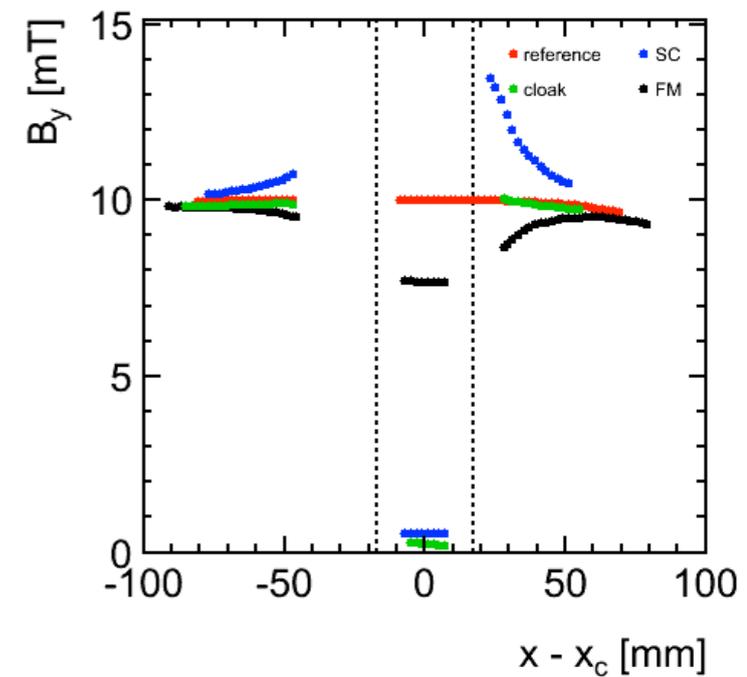
Successful construction and test of our first **complete** magnetic cloak prototype.



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

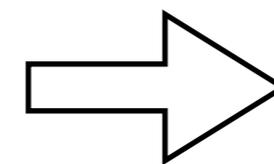
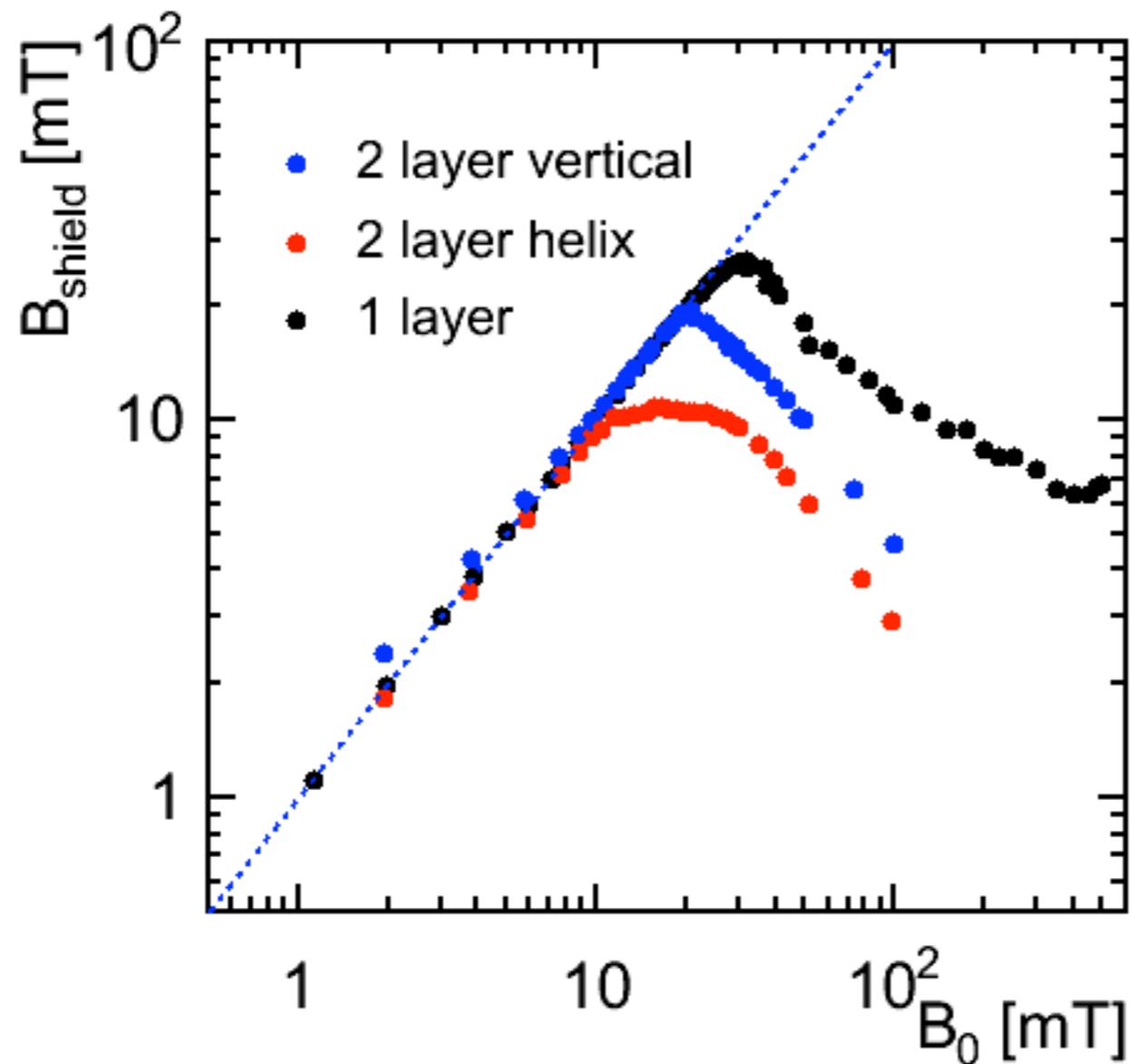
Excellent opportunity for students to collect laboratory experience.

To be continued...



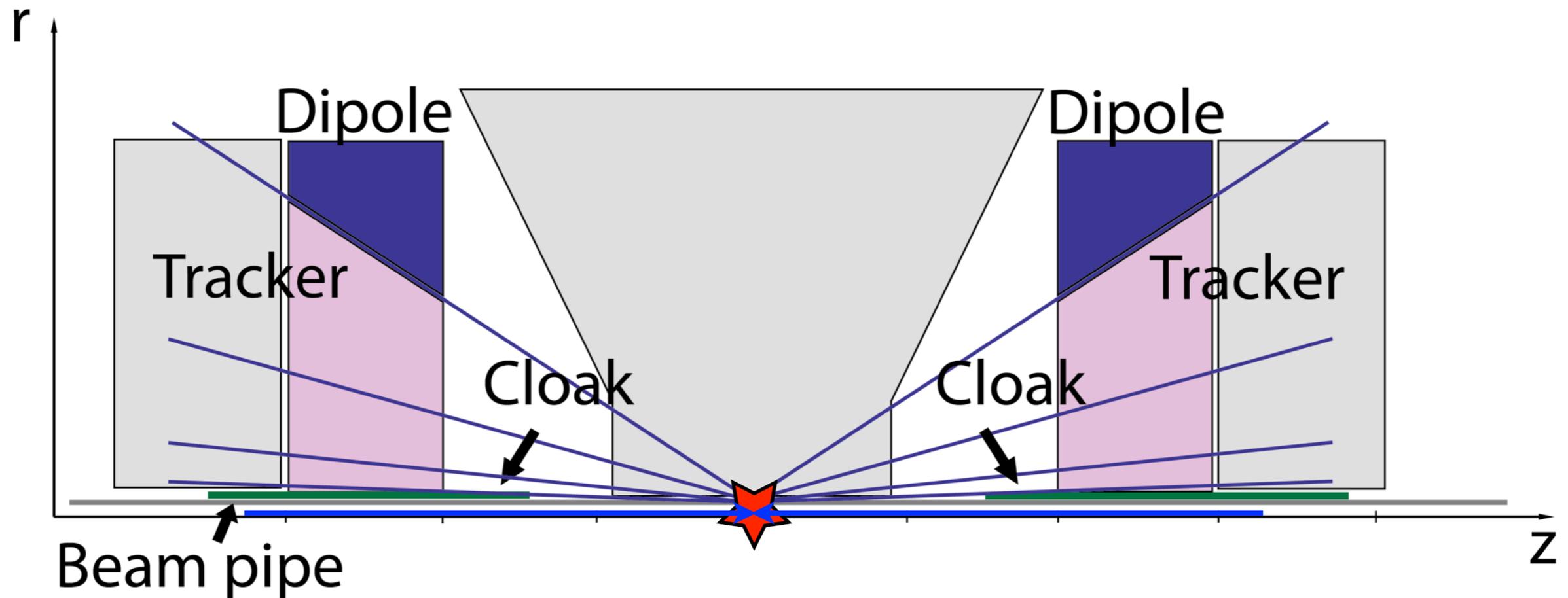
ADDITIONAL SLIDES

SC cylinders show worse magnetic field shielding performance than the tape itself



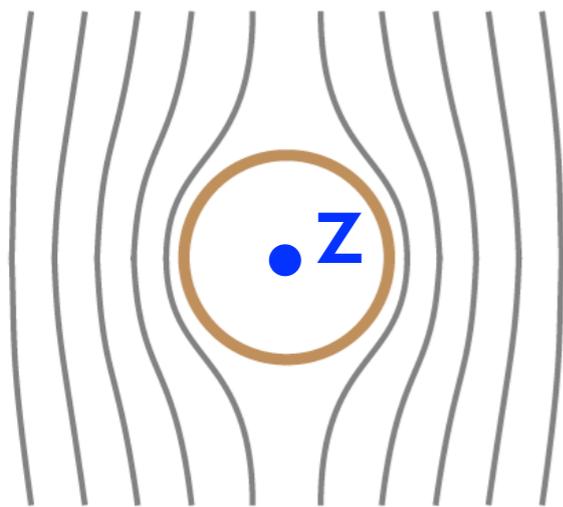
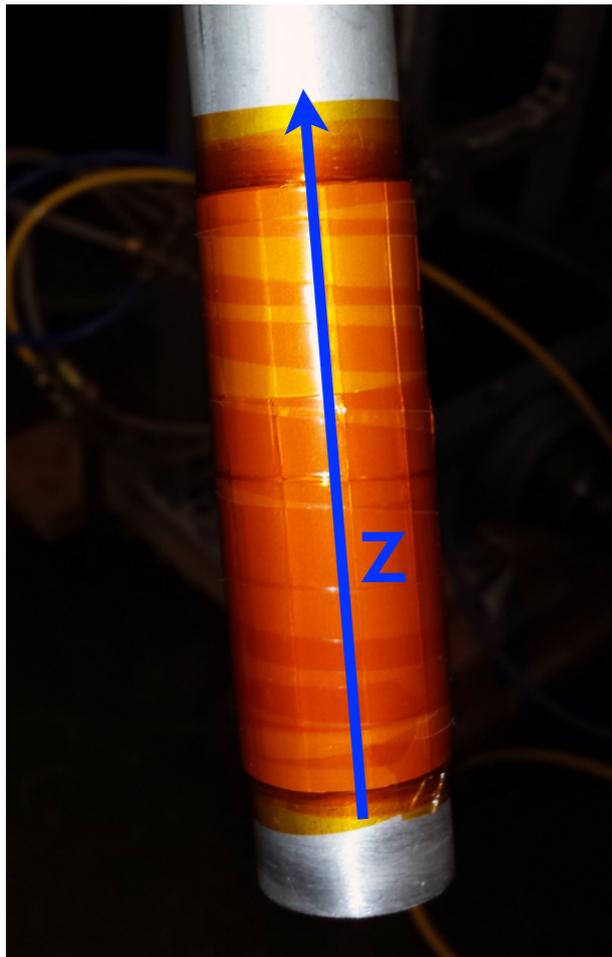
More detailed investigation ongoing

Goal: Measure particle momenta with dipole + tracker close to beam pipe

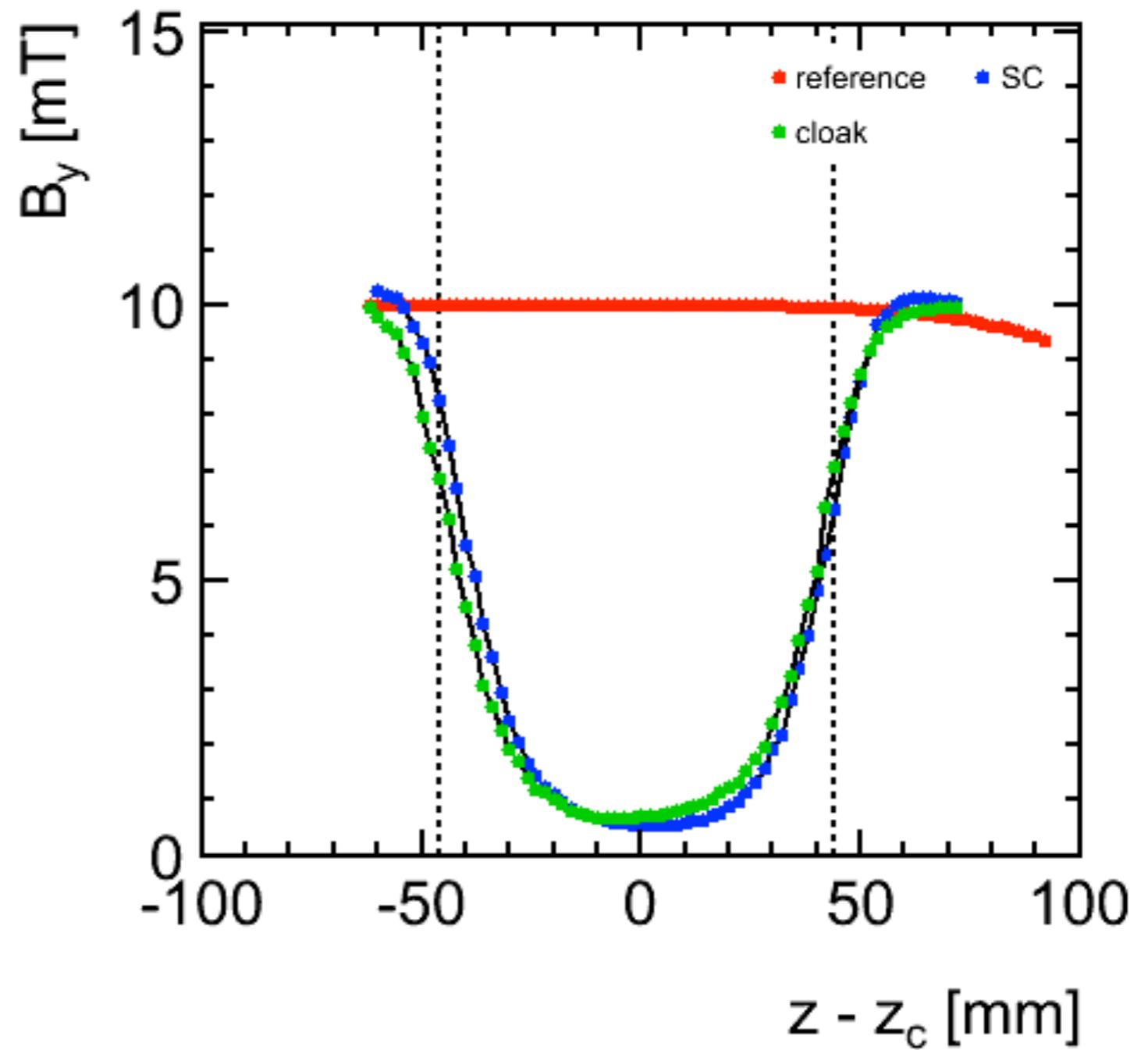


- Magnetic Cloak:**
- Shield fields up to 0.5 T
 - No outside field disturbances
 - Thin, > 1 m long

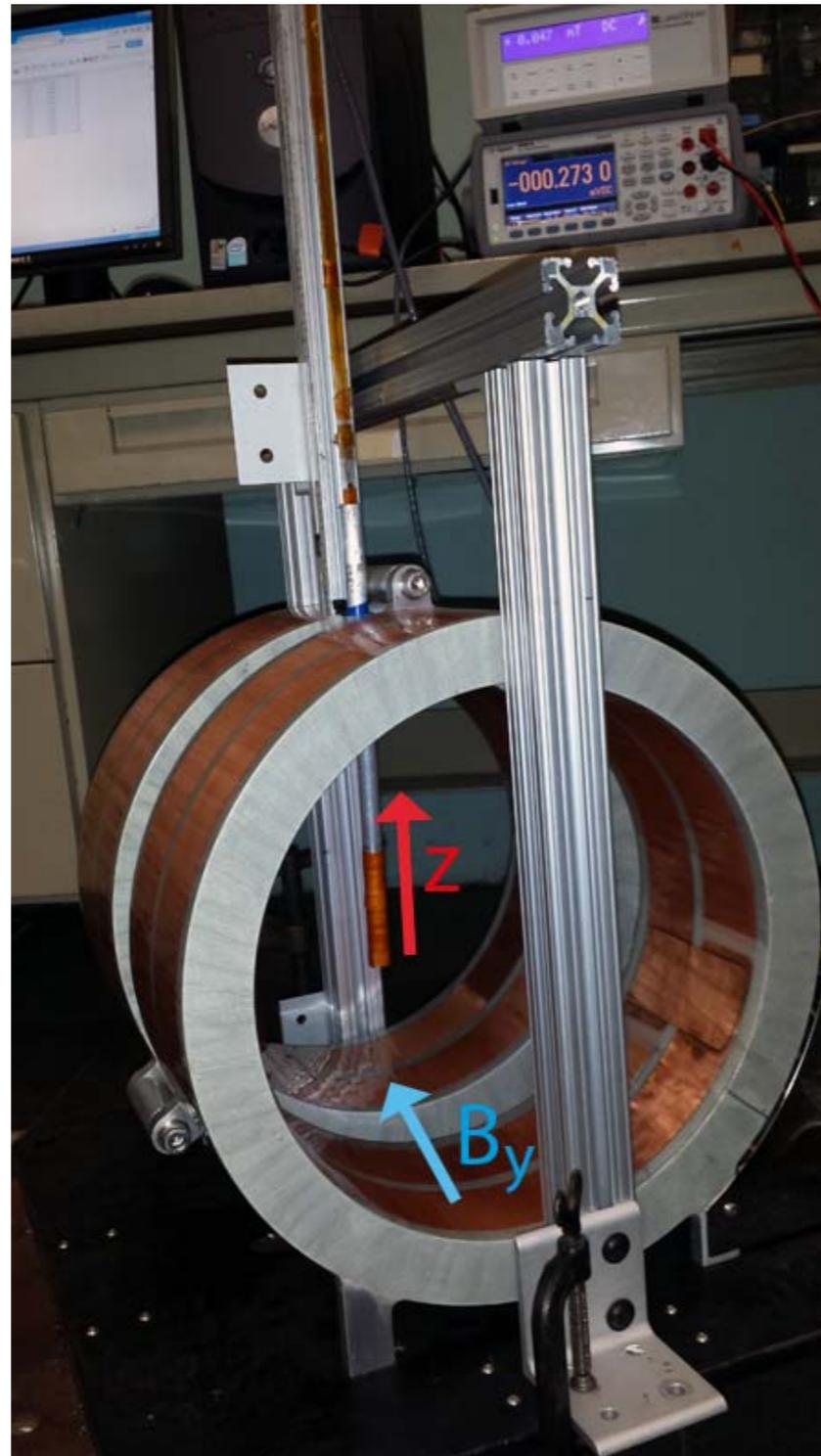
Measuring field around superconductor



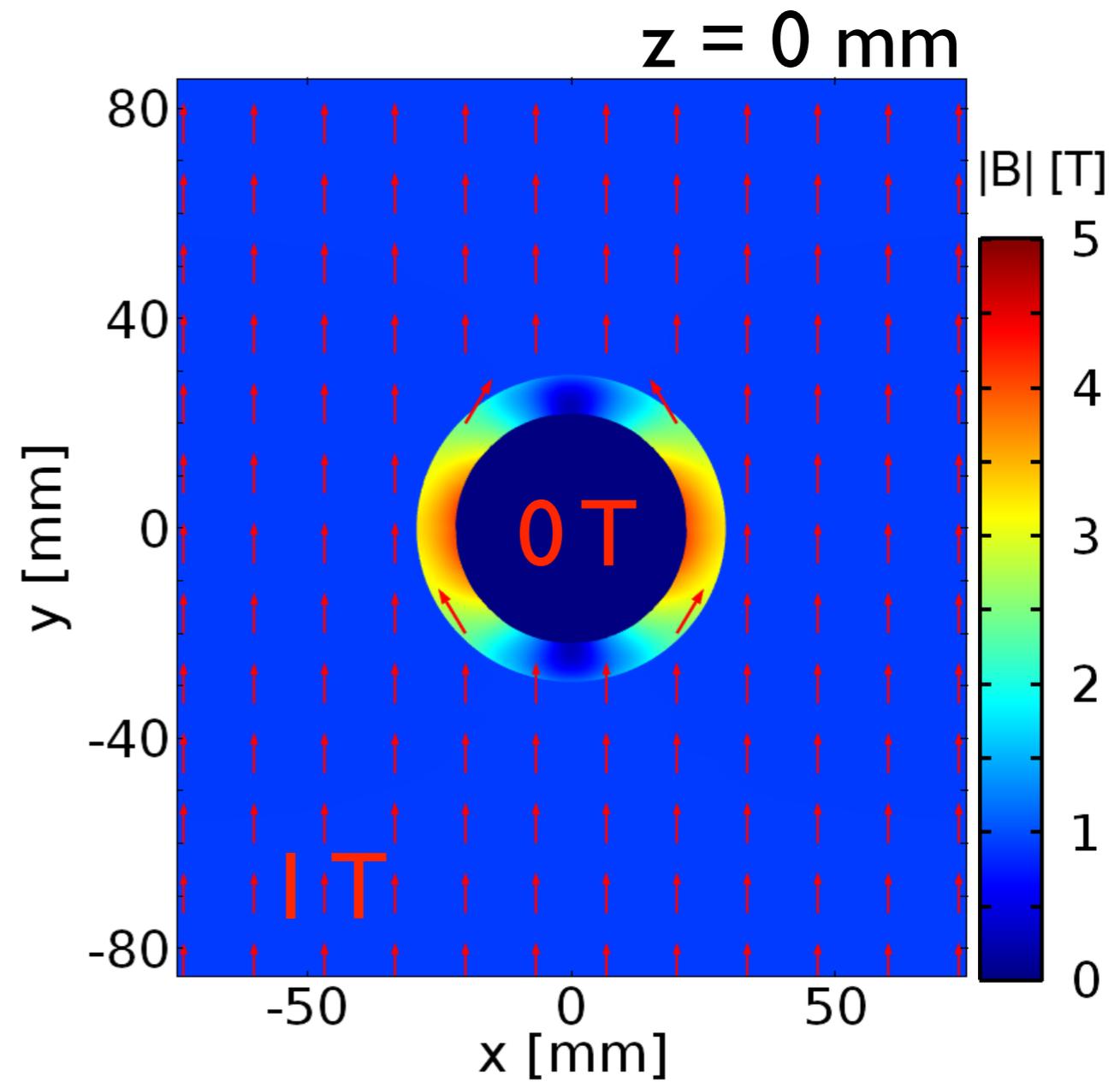
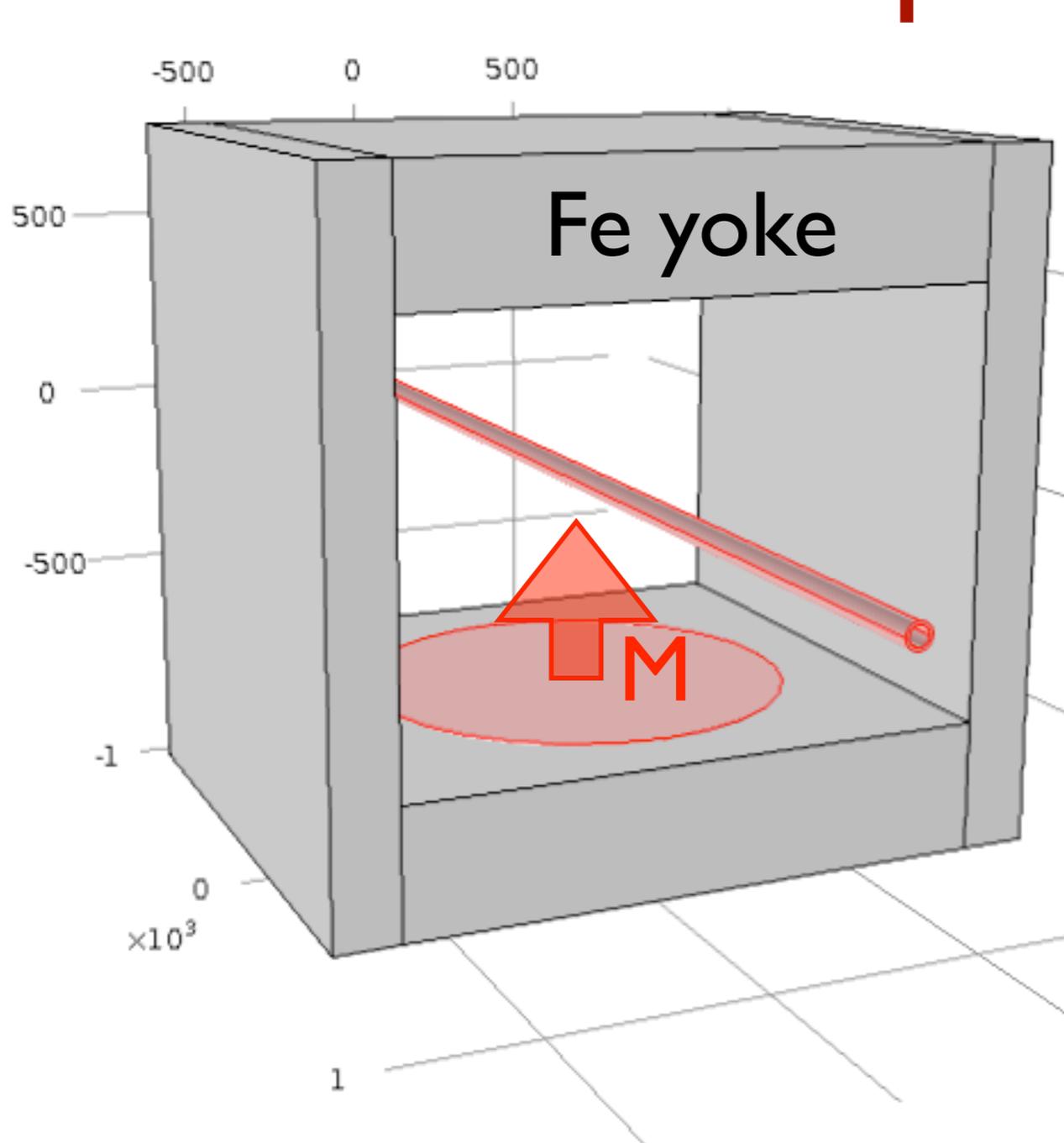
4 layer 'vertical'



Field disturbance measurement setup



COMSOL model of the cloak in a dipole field



Testing the simple magnetic cloak

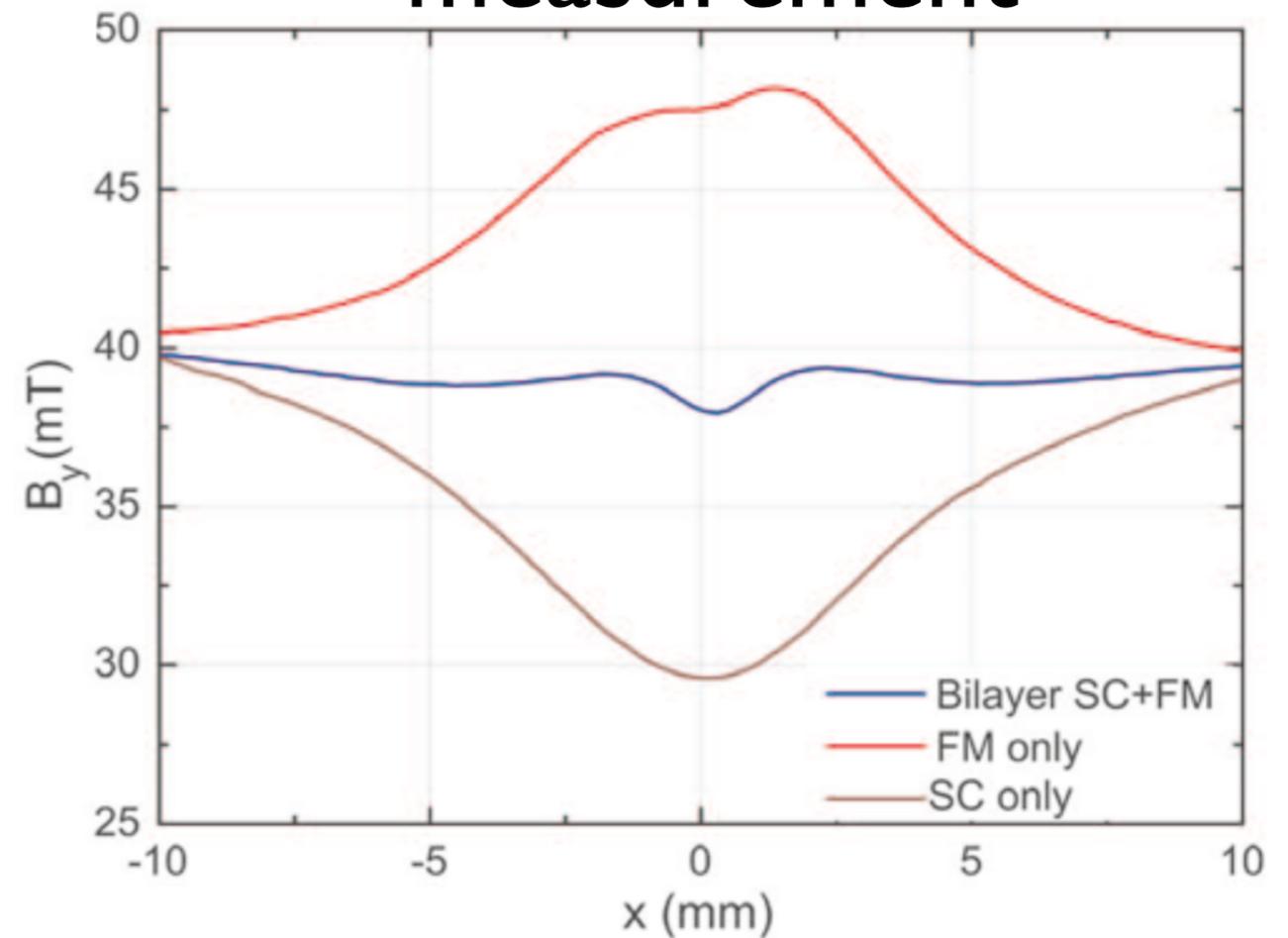
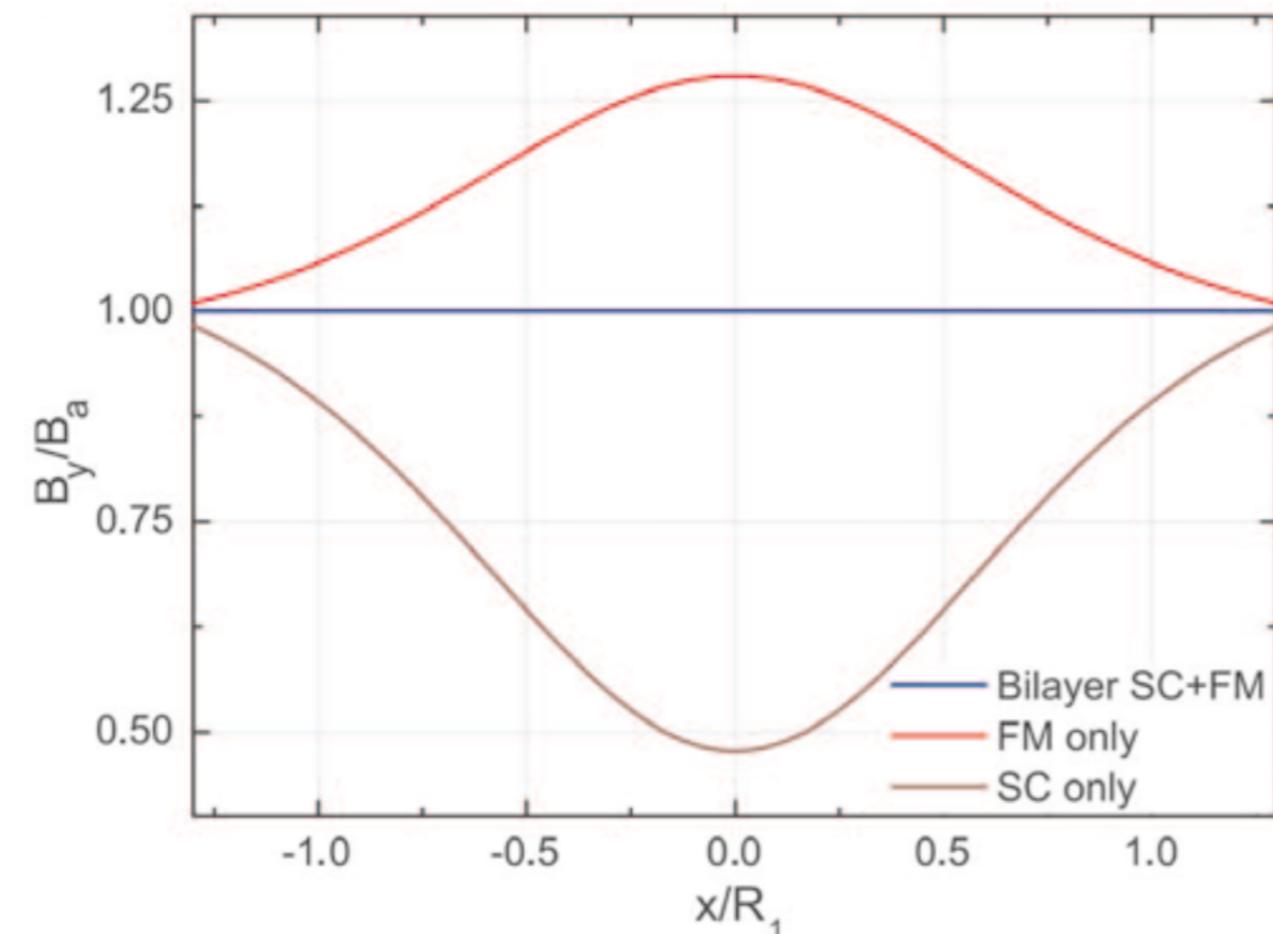
Fedor Gömöry et al.

DOI: 10.1126/science.1218316

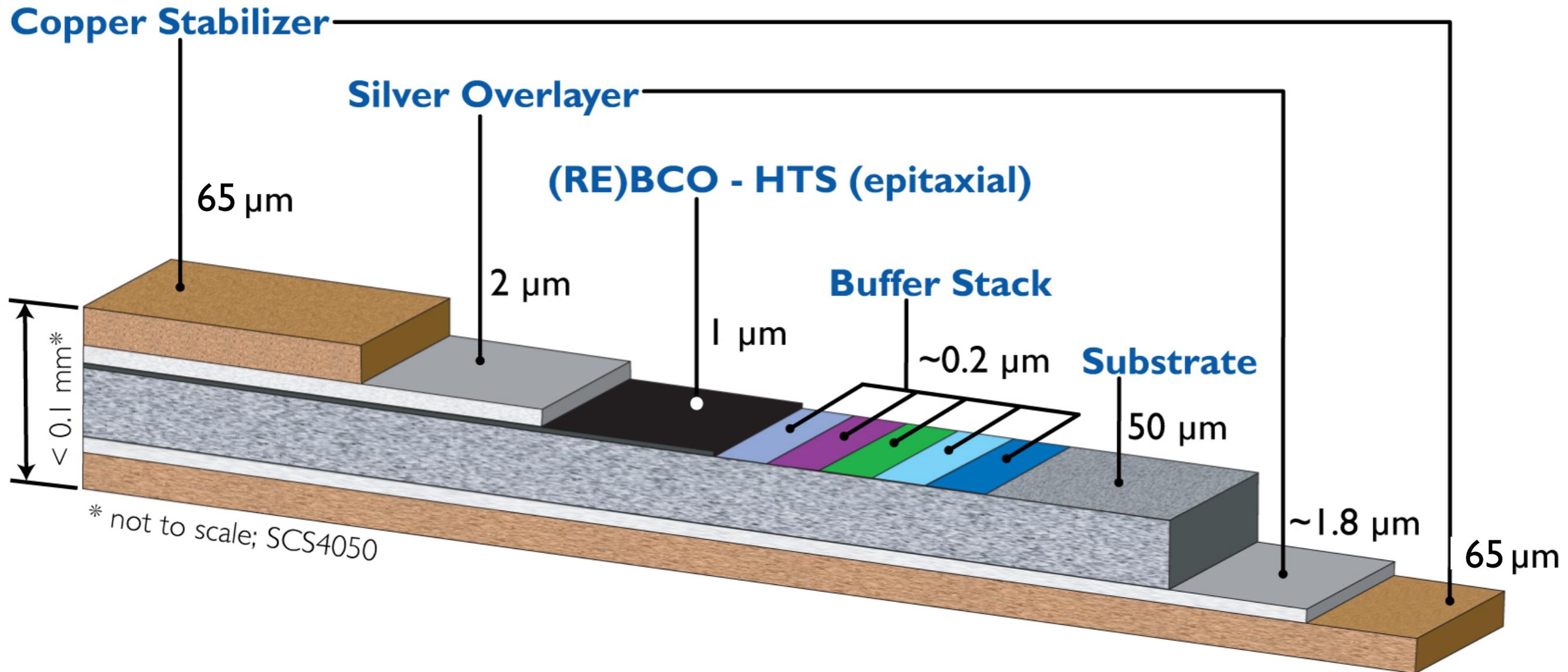


calculation

measurement



Our HT Superconductor Tape



Type II superconductors

