

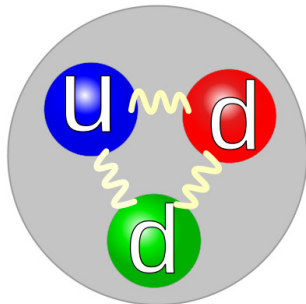
Effectiveness of a superconducting lead endcap in minimizing magnetic field gradients for the nEDM search

Aritra Biswas
Filippone Group, Kellogg Radiation Laboratory

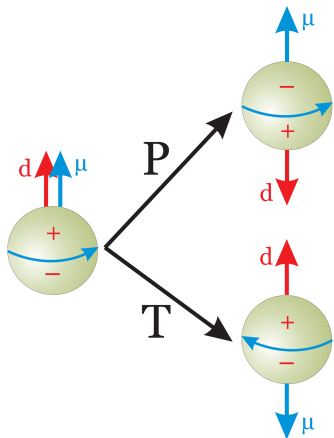
August 6, 2014

nEDM = neutron electric dipole moment

- ▶ up quark: $\frac{2}{3}e$
- ▶ each down quark: $-\frac{1}{3}e$
- ▶ electric dipole moment:
vector measuring separation
between + and - charges
and their orientation

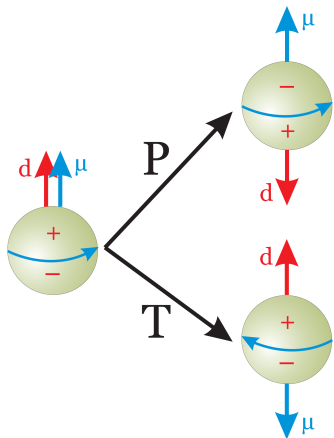


why does the nEDM matter?



► $C : q \mapsto -q$

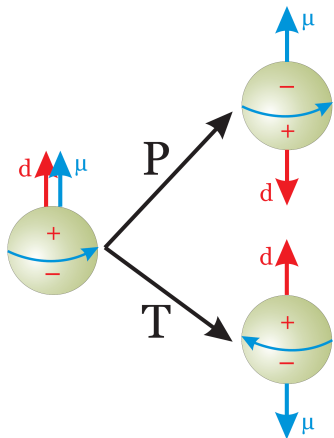
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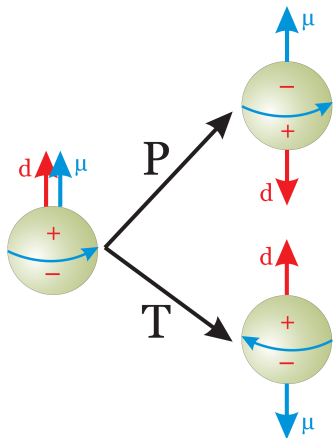
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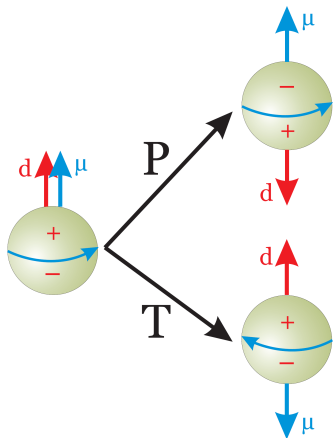
- ▶ $C : q \mapsto -q$
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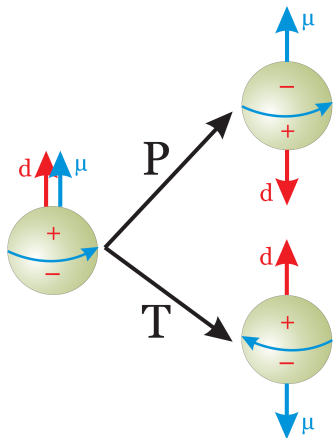
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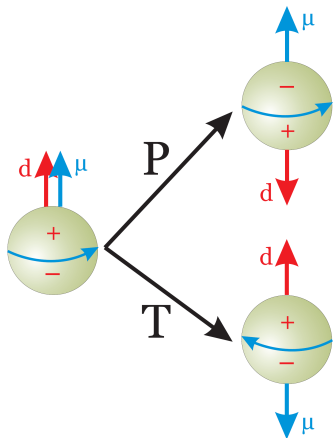
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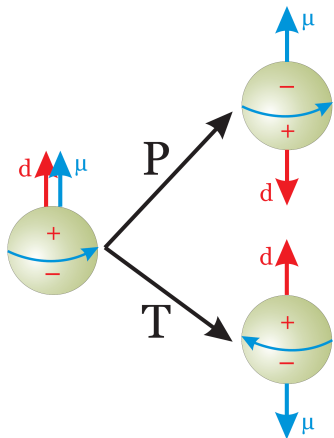
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- ▶ reformulations of Standard Model
- ▶ matter-antimatter asymmetry

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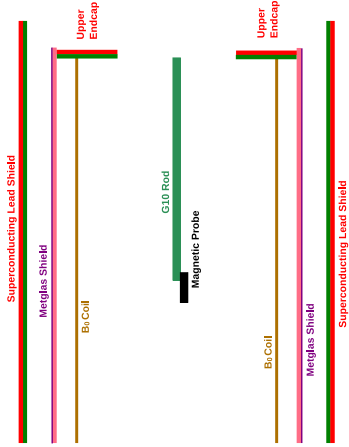
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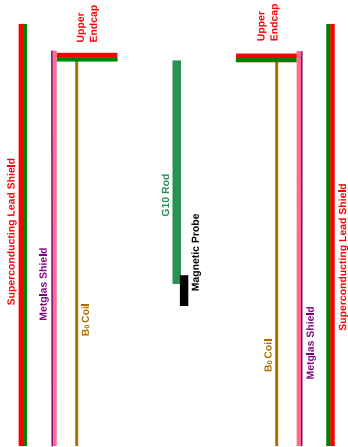
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- ▶ $\frac{\partial \mathbf{B}}{\partial(x,y,z)} \neq 0 \Rightarrow \frac{\partial \mathbf{B}}{\partial t} \neq 0 \Rightarrow$ effect of \mathbf{E} field $\Rightarrow \Delta\omega_{geo}$
- ▶ geometric phase \Rightarrow false measurement!

creating an uniform magnetic field

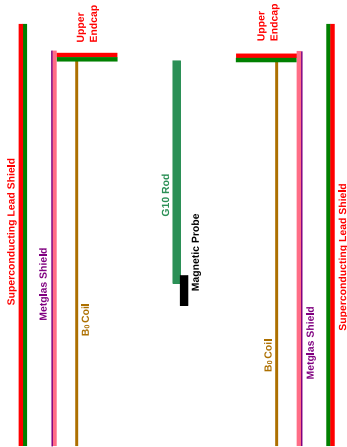


creating an uniform magnetic field



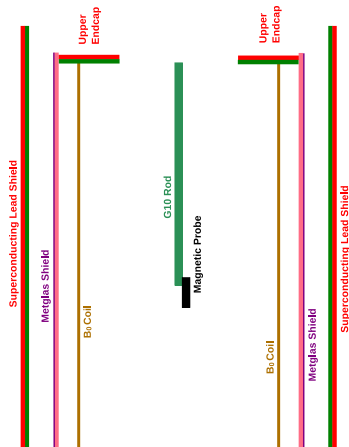
- B_0 coil: $\cos \theta$ coil geometry, emulates sheet current

creating an uniform magnetic field



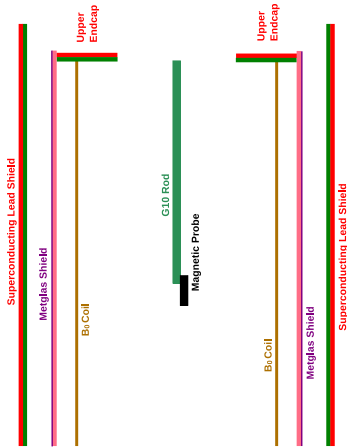
- ▶ B_0 coil: $\cos \theta$ coil geometry, emulates sheet current
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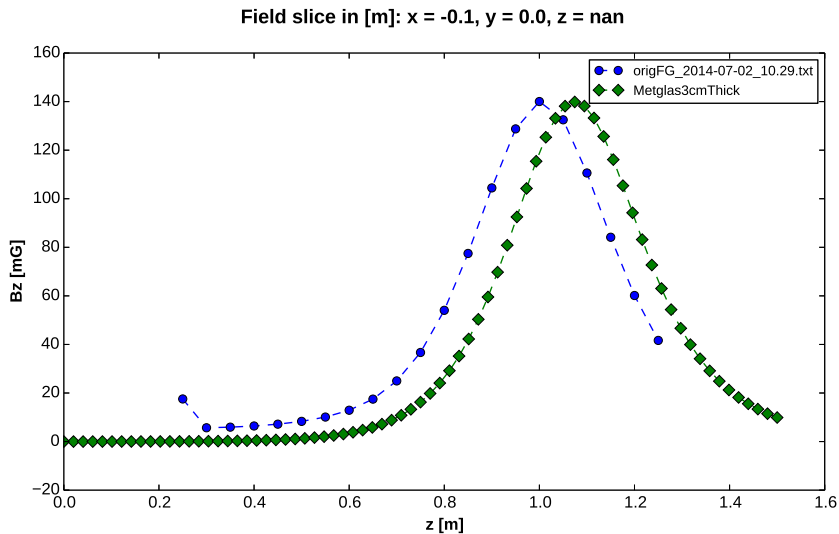
- ▶ B_0 coil: $\cos \theta$ coil geometry, emulates sheet current
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creating an uniform magnetic field



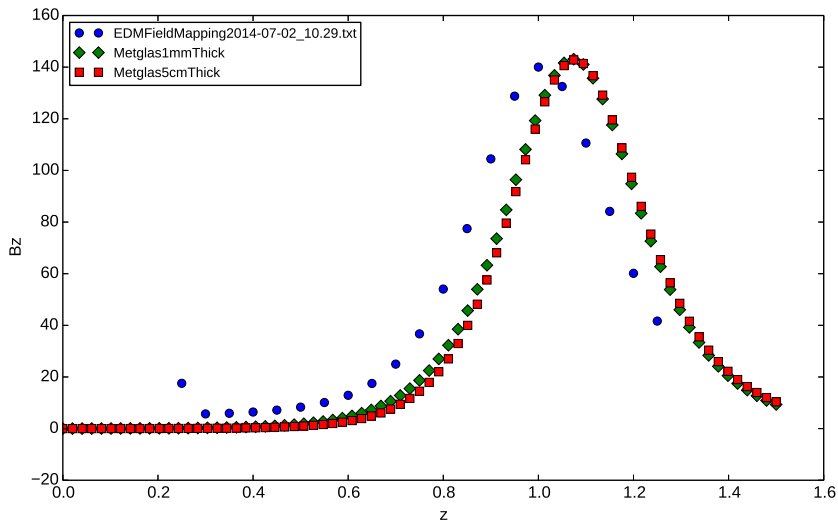
- ▶ B_0 coil: $\cos \theta$ coil geometry, emulates sheet current
- ▶ ferromagnetic Metglas shield
- ▶ superconducting axial shield
- ▶ superconducting upper endcap

original comparison, warm



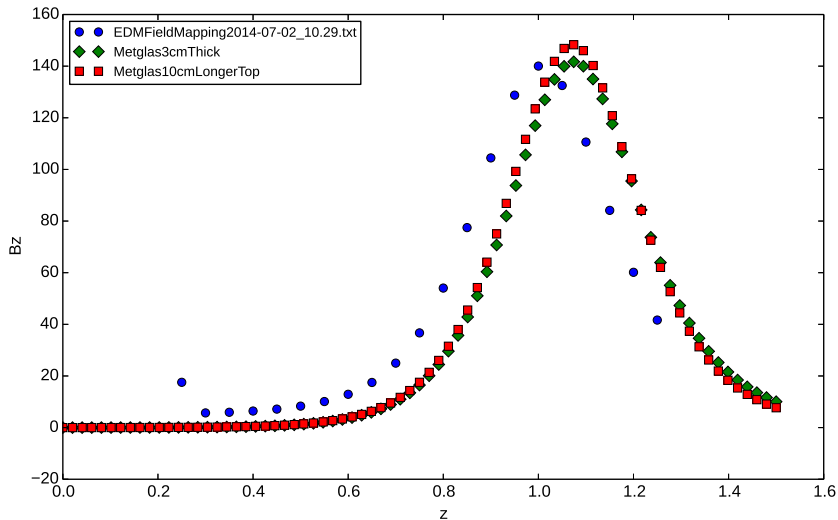
Metglas thickness

Field slice in [m]: x = -0.1, y = 0, z = None

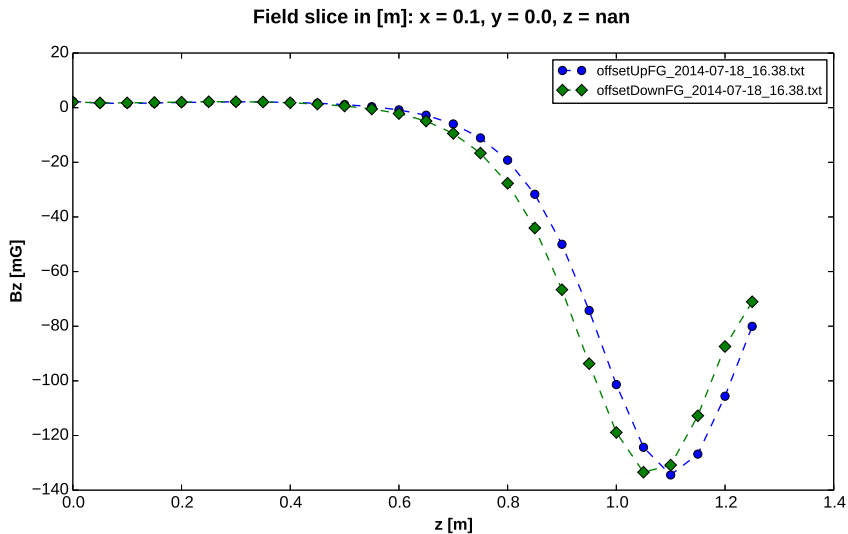


Metglas 10 cm longer on top

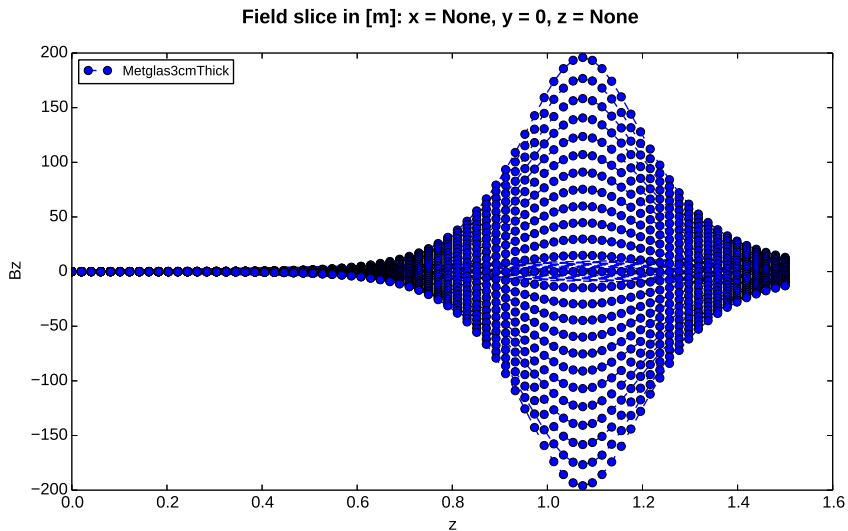
Field slice in [m]: x = -0.1, y = 0, z = None



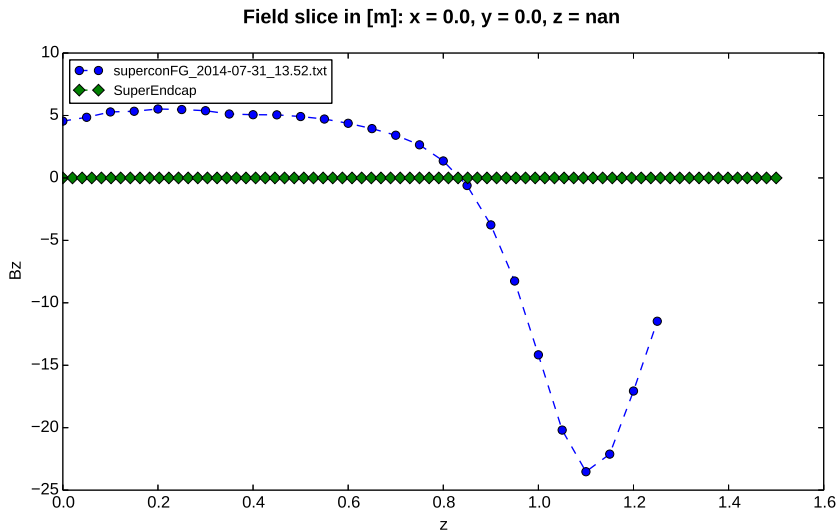
correction 1: probe measurement time



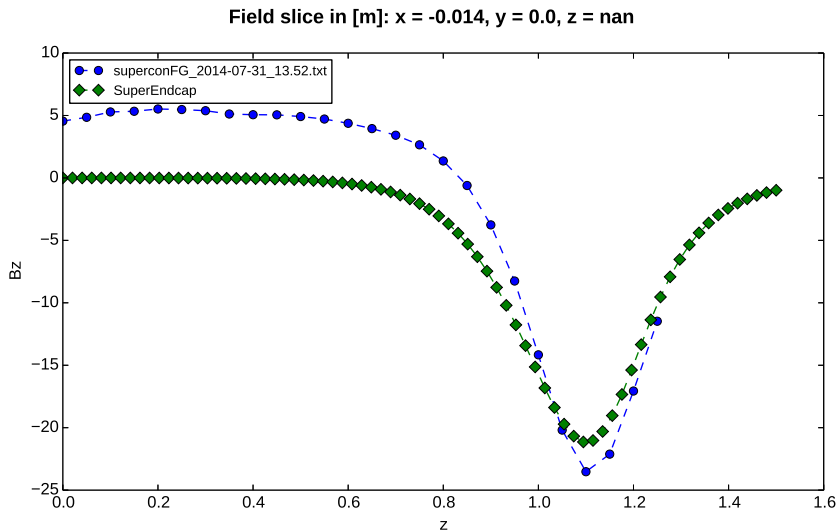
correction 2: x centering



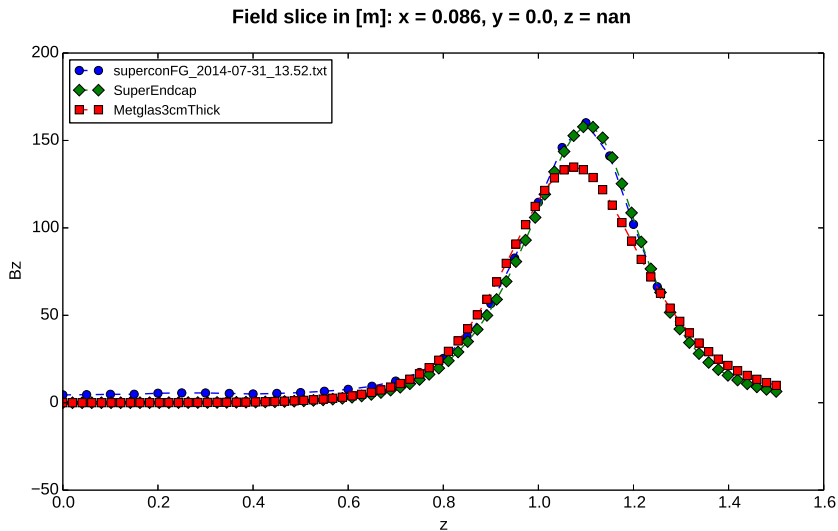
correction 2: x centering, superconducting



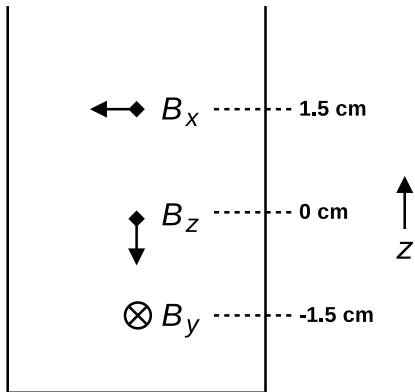
correction 2: x centering, superconducting, 1.4 cm offset



comparison, superconducting

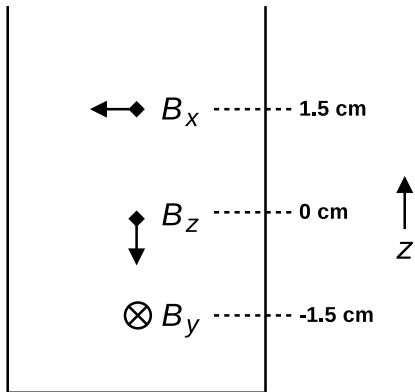


correction 3: probe axis offset



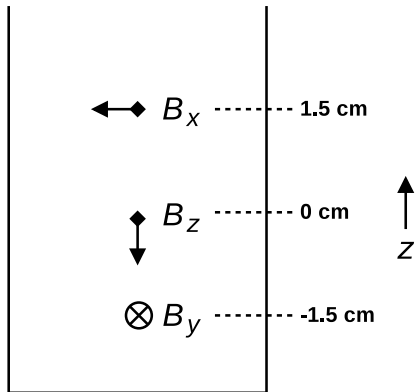
- ▶ 3 separate 1-axis probes

correction 3: probe axis offset



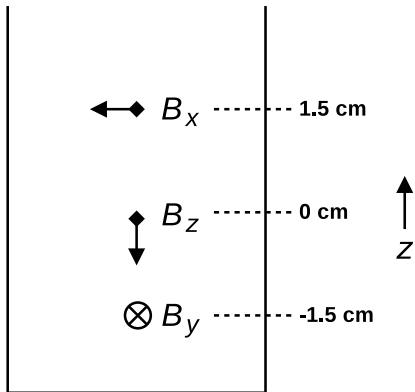
- ▶ 3 separate 1-axis probes
- ▶ incomplete vector map

correction 3: probe axis offset



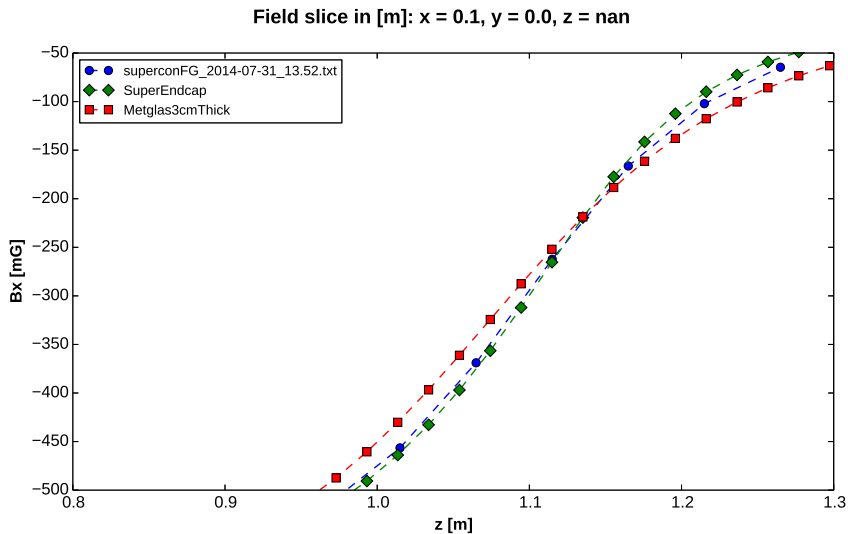
- ▶ 3 separate 1-axis probes
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- ▶ need to store z-axis offset vector along with z array

correction 3: probe axis offset



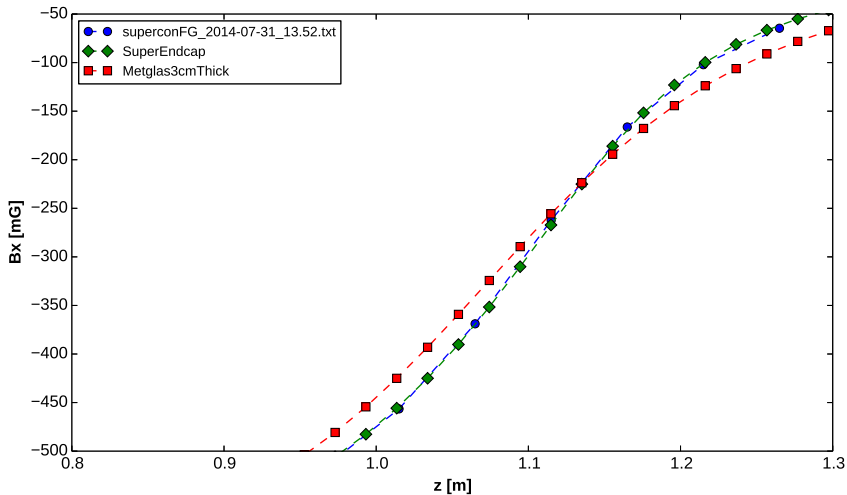
- ▶ 3 separate 1-axis probes
- ▶ incomplete vector map
- ▶ need to store z-axis offset vector along with z array
- ▶ `OffsetAxis` class to return proper spatial axis array based on desired vector component

comparison, superconducting, no probe axis offset

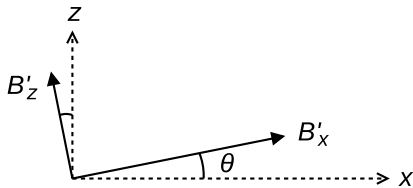


comparison, superconducting, probe axis offset

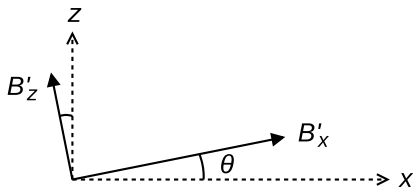
Field slice in [m]: $x = 0.086$, $y = 0.0$, $z = \text{nan}$



correction 4: probe tilt

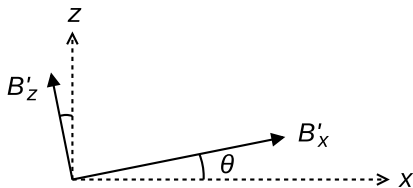


correction 4: probe tilt



$$B_x = B'_x \cos \theta - B'_z \sin \theta, \quad B_z = B'_z \cos \theta + B'_x \sin \theta \quad (3)$$

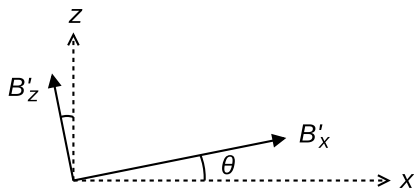
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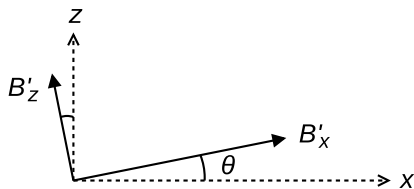


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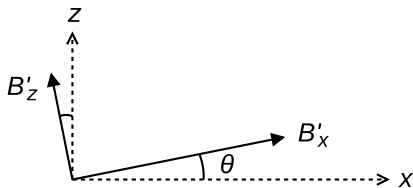
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$$\theta = -\frac{B'_z}{B'_x}$$

comparison, superconducting

