Effects of a superconducting lead endcap on the magnetic field profile for the nEDM search

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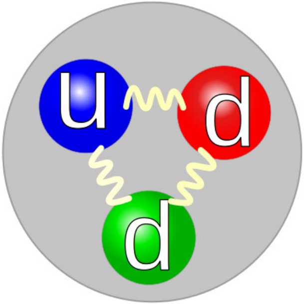
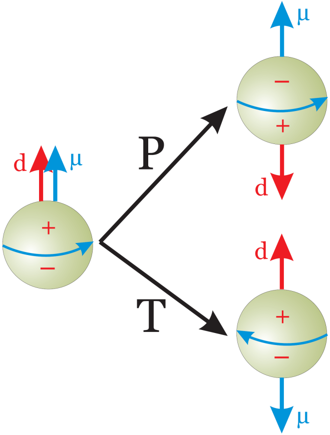
nEDM = neutron electric dipole moment

- distributed + and - charges inside neutron
- electric dipole moment (EDM) measures separation between centers of + and - charge



Horvath A. Quark structure neutron. Wikimedia.

why does the nEDM matter?



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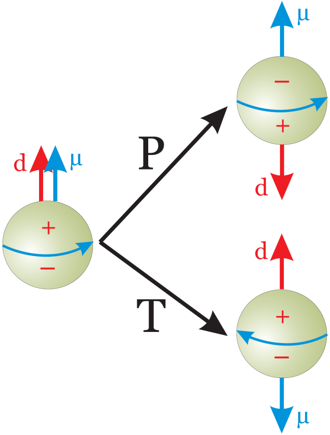

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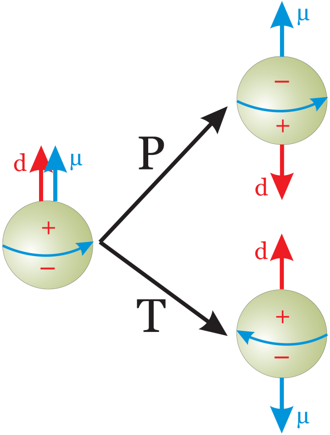

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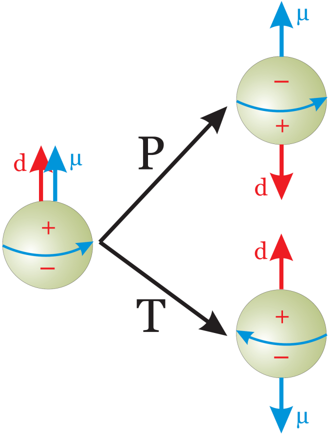

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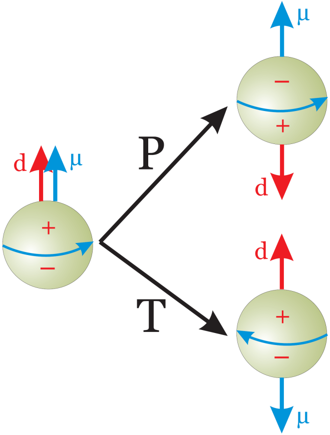

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- CPT symmetry

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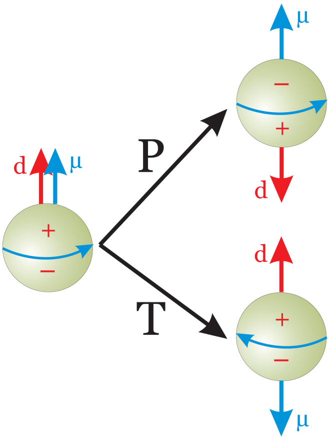

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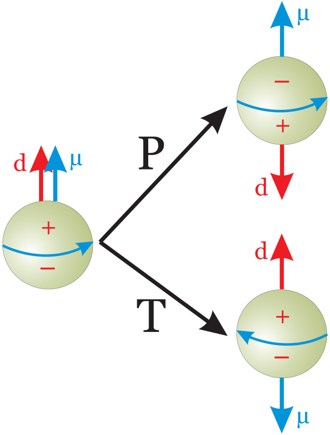

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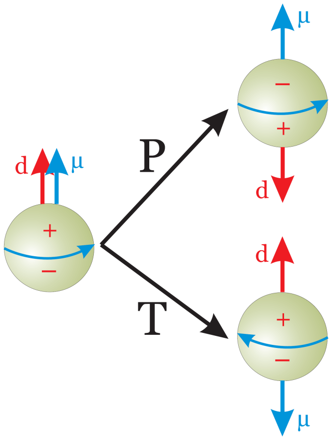

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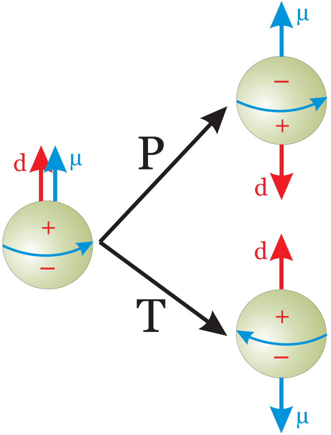

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- reformulations of Standard Model
- matter-antimatter asymmetry

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how do we measure the nEDM?

- put ultra-cold neutrons (UCN) in **E** and **B** fields

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- engineering challenge: creating an uniform magnetic field

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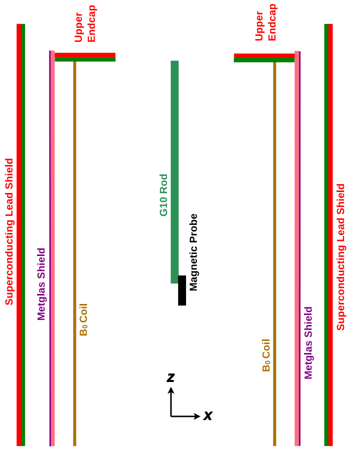
the half-scale model



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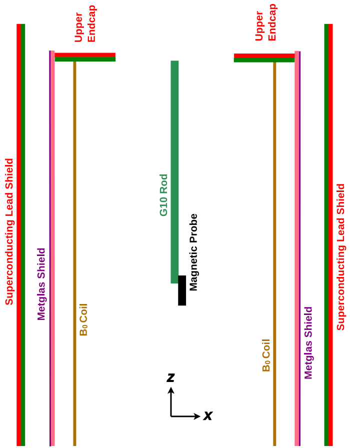

- B_0 coil: $\cos\theta$ coil geometry

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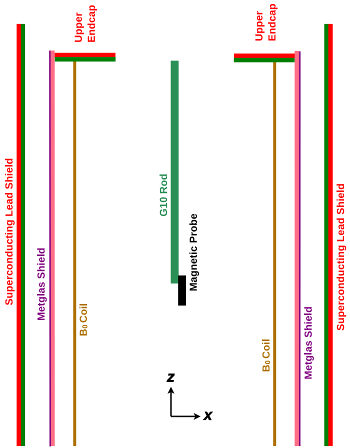

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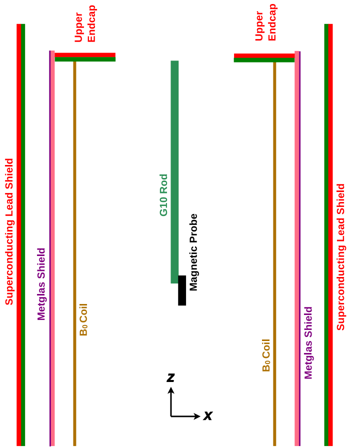

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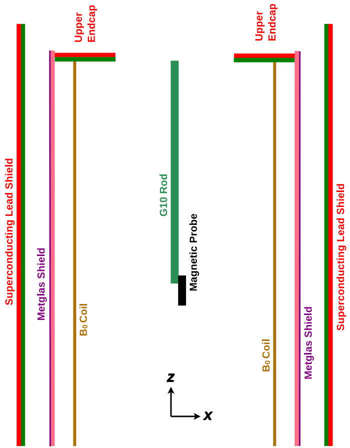

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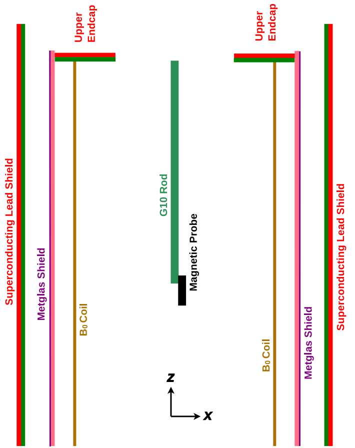

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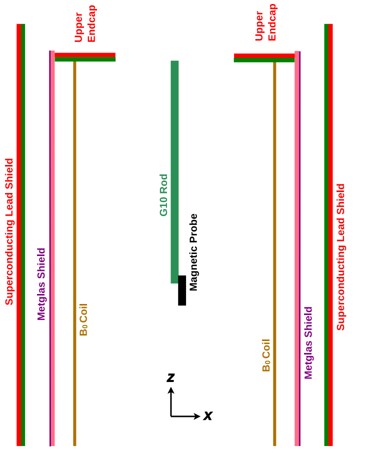

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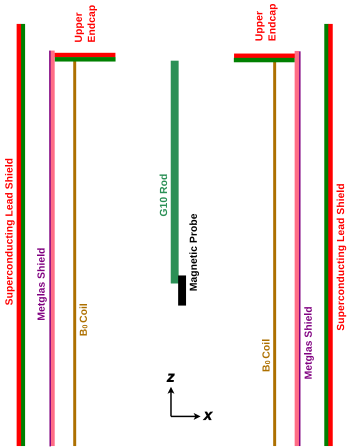

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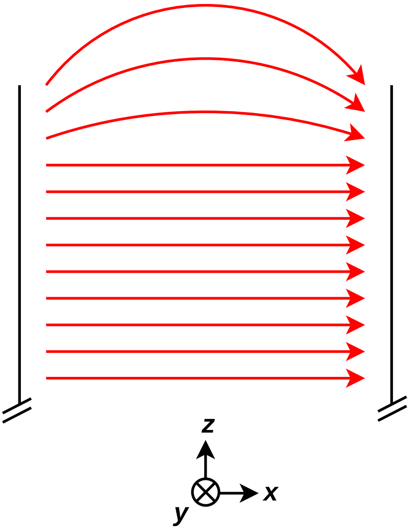
- superconducting upper endcap

edge effects and the superconducting endcap



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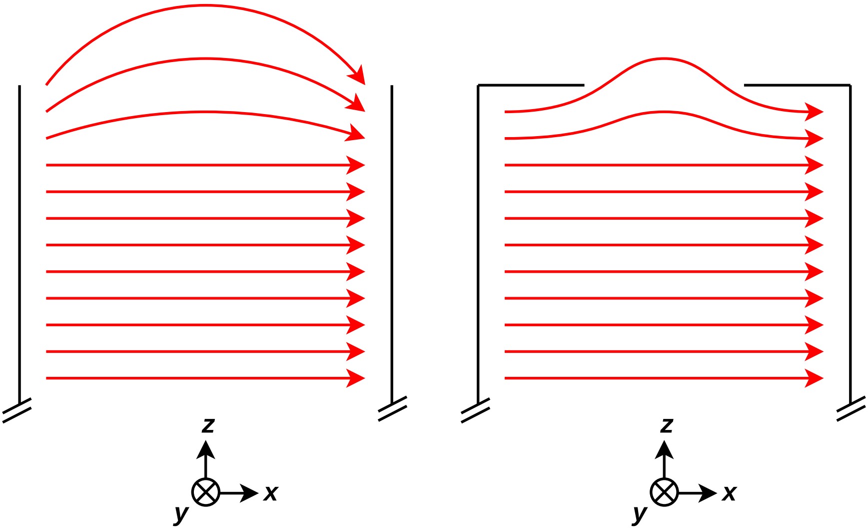
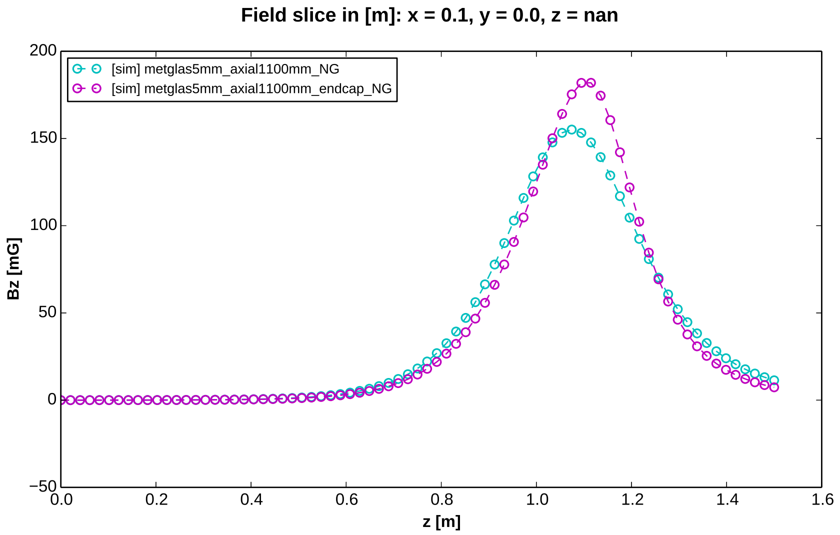
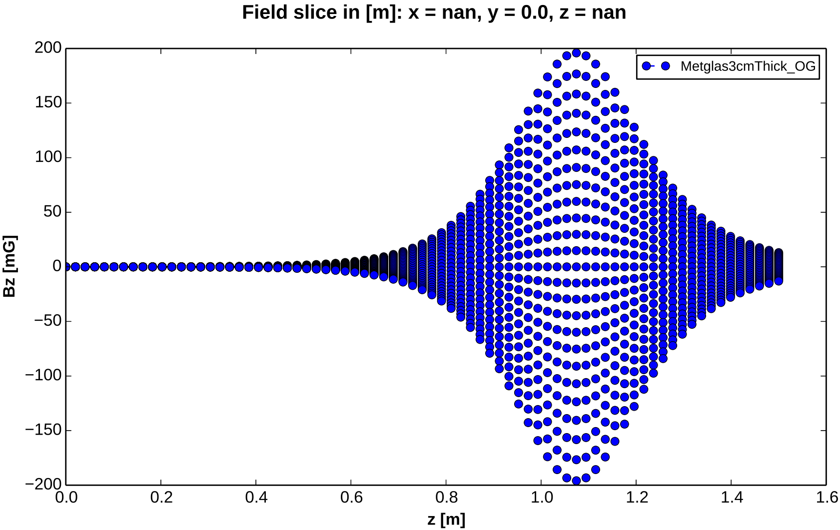


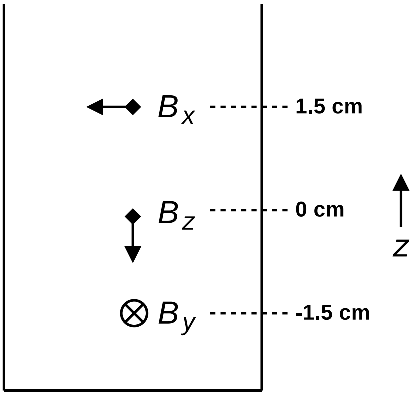
simulations of endcap effect



correction: probe x centering



correction: probe axis offset



- 3 separate 1-axis probes

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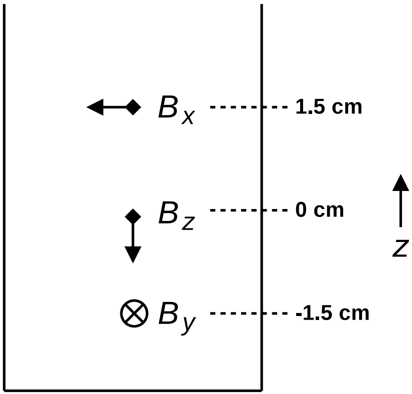

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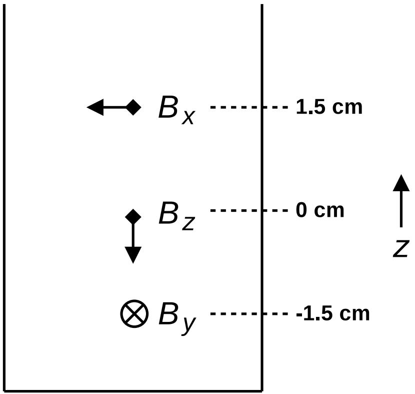

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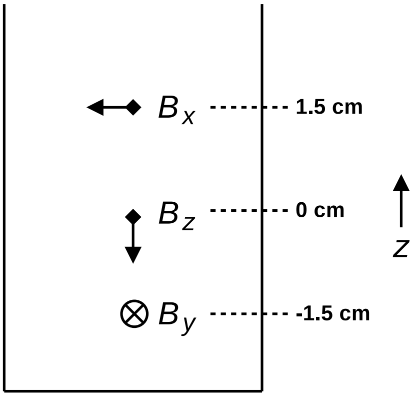

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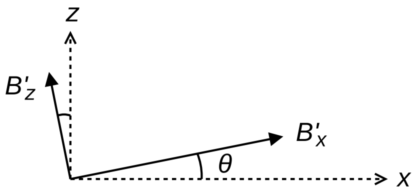

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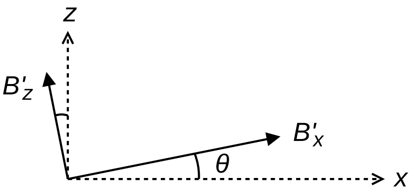

$$B_x = B'_x \cos\theta - B'_z \sin\theta, \quad B_z = B'_z \cos\theta + B'_x \sin\theta \qquad (3)$$

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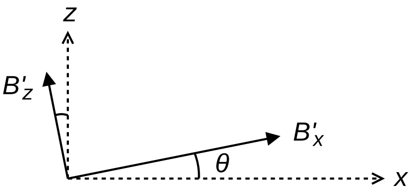

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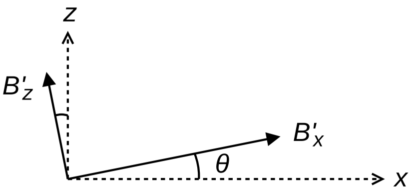

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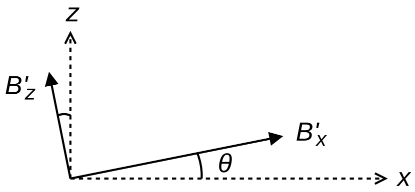

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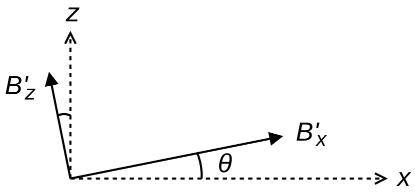

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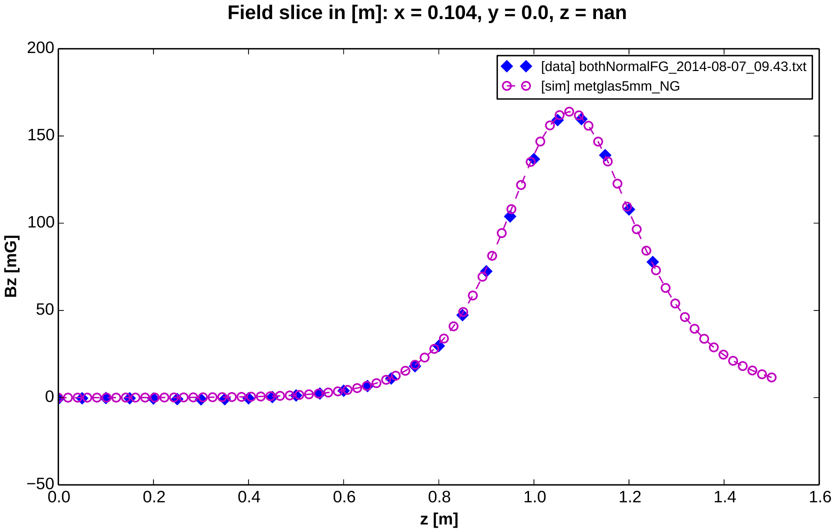
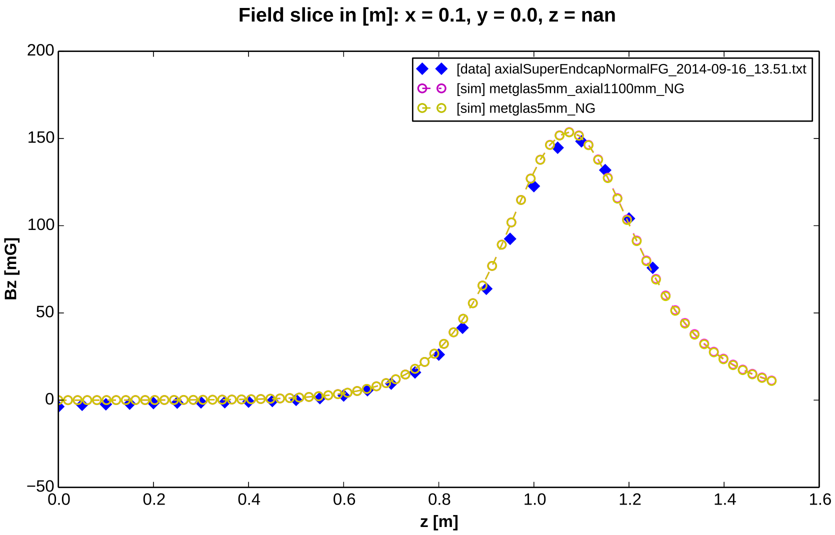
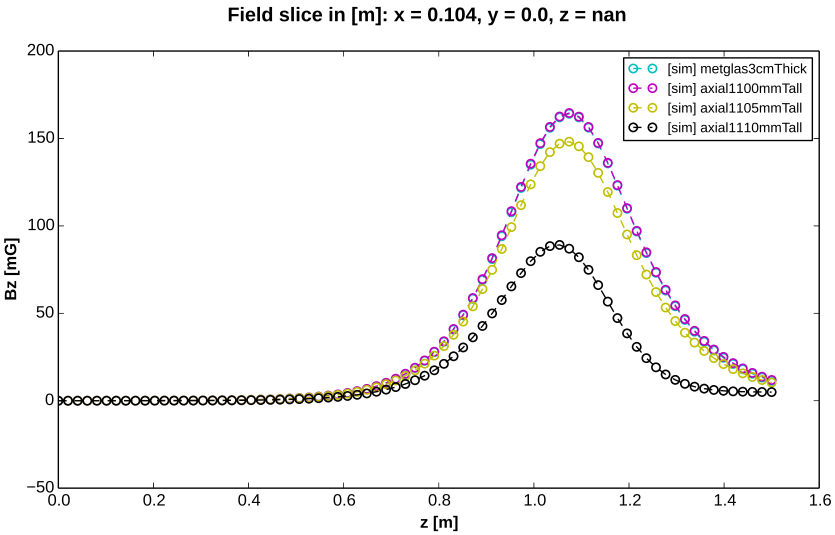
comparison: axial shield normal, endcap normal



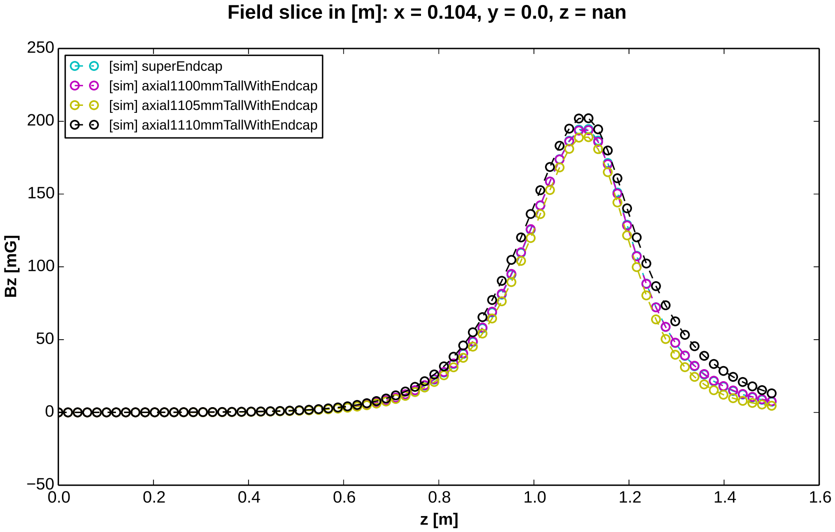
comparison: axial shield SC, endcap normal



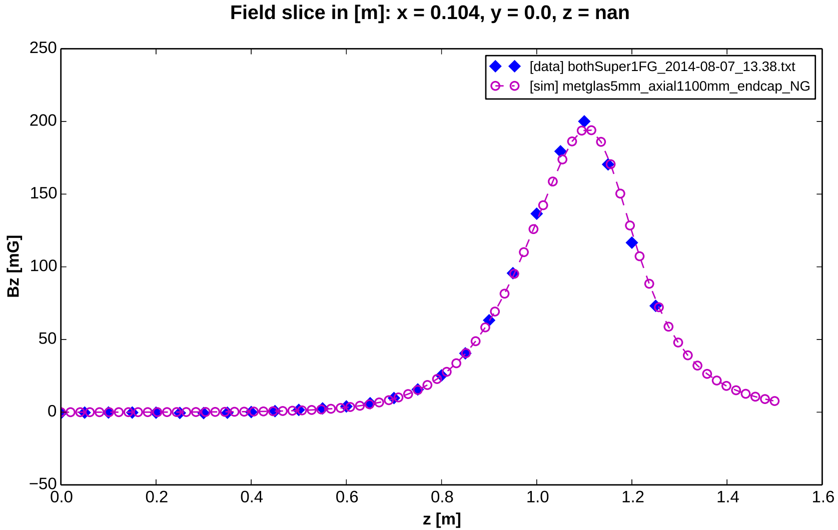
simulation: varying axial shield height



simulation: varying axial shield height, with endcap



comparison: axial shield SC, endcap SC



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- our endcap seems to shift the B_z peak away from magnet center
- axial shield effect is stronger when more of it is “uncovered” by the Metglas
- SC endcap hides axial shield influence, even over small variation in height

acknowledgments

- Mentor: Brad Filippone
- Co-mentor: Simon Slutsky
- Chris Swank, Chub Osthelder, Bob Carr
- Arthur R. Adams SFP Fellowship
- Caltech SURF Program