Magnetic Shielding for Neutrino Detector

Satuye Lacayo, Physics, slacayo@princeton.edu and Kasia Krzyzanska, Physics, kk19@princeton.edu

SUMMER RESEARCH COLLOQUIUM

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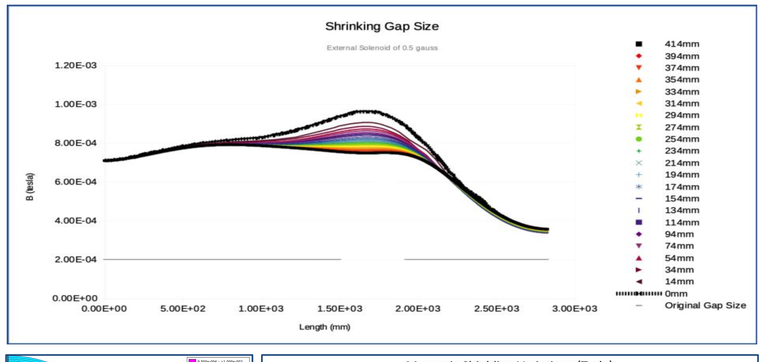
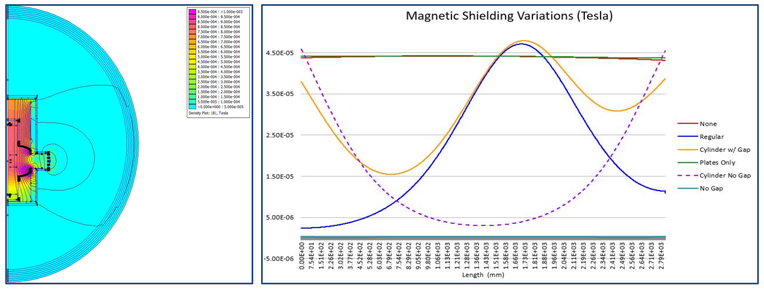
Background

- Three kinds of neutrinos known to exist, with a possible fourth, "sterile" neutrino
- HUNTER (Heavy Unseen Neutrinos from Total Energy-momentum Reconstruction) will search for sterile neutrinos using their mass
  - Cs-131 decays into neutrino, electron, ion, x-ray
  - Calculate mass of neutrino from momentum
- Need uniform magnetic field to detect electron
- Need magnetic shielding for a uniform field

Research Questions

How can magnetic shielding be effectively applied to the spectrometer to protect against external fields? How can solenoids within the apparatus be positioned and tuned to produce a uniform magnetic field?

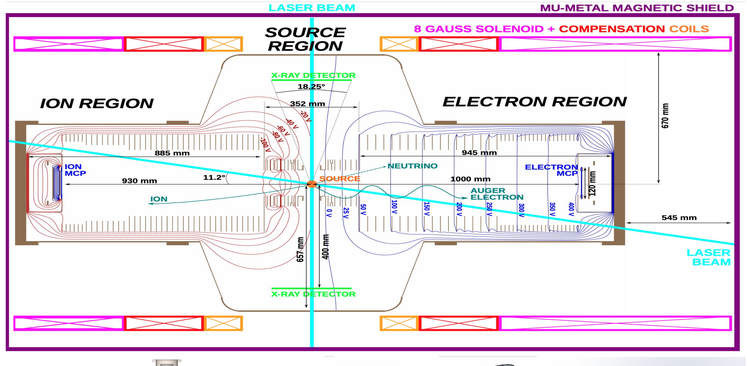


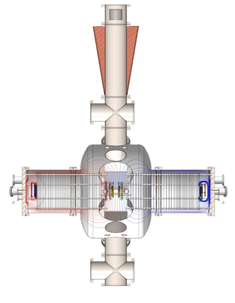


Top: Magnetic field strength along axis for shielding w/ a shrinking gap. Left: FEMM Model of cross section of spectrometer w/ a "mesh" made of magnetic materials built over the gap. Right: Magnetic field strength along axis for different variations of shielding tested against a uniform field.

Methods and Materials

- Gap in shielding for necessary equipment
- Use FEMM software to simulate effects of incomplete shielding
- Tested variations on shielding- change gap size, extend outwards, etc.
- Tested effects of individual component of shield
- FEMM is 2D, can only define shapes with unrealistic symmetries
- Radia software is 3D, more accurate depiction





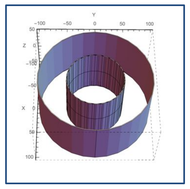
Top: Cutaway plan-view of HUNTER apparatus. Bottom: External views of HUNTER apparatus.

Results

- The current, preliminary shielding is inadequate
- Even small external fields like the Earth's magnetic field can cause significant changes to the internal field
- Ideally, the spectrometer should be completely covered for maximum shielding
- Changing the shielding will necessitate a change in the internal solenoids

Conclusion

- More needs to be done in order to best design shielding
- As a preliminary design, the shielding has been insufficiently studied
- Radia provides a more accurate model than FEMM



Radia model of cylindrical iron shielding inside a short coil.

Acknowledgments

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References

HUNTER: Precision Massive-Neutrino Search Based on Laser Trapped and Cooled Atomic Source

C. J. Martoff, Bernd Surrow, B. Lamichhane, Temple University; P. F Smith, E. R. Hudson, P. Hamilton, C. Schneider, UCLA; A. Renshaw, University of Houston; P. Meyers, Princeton University