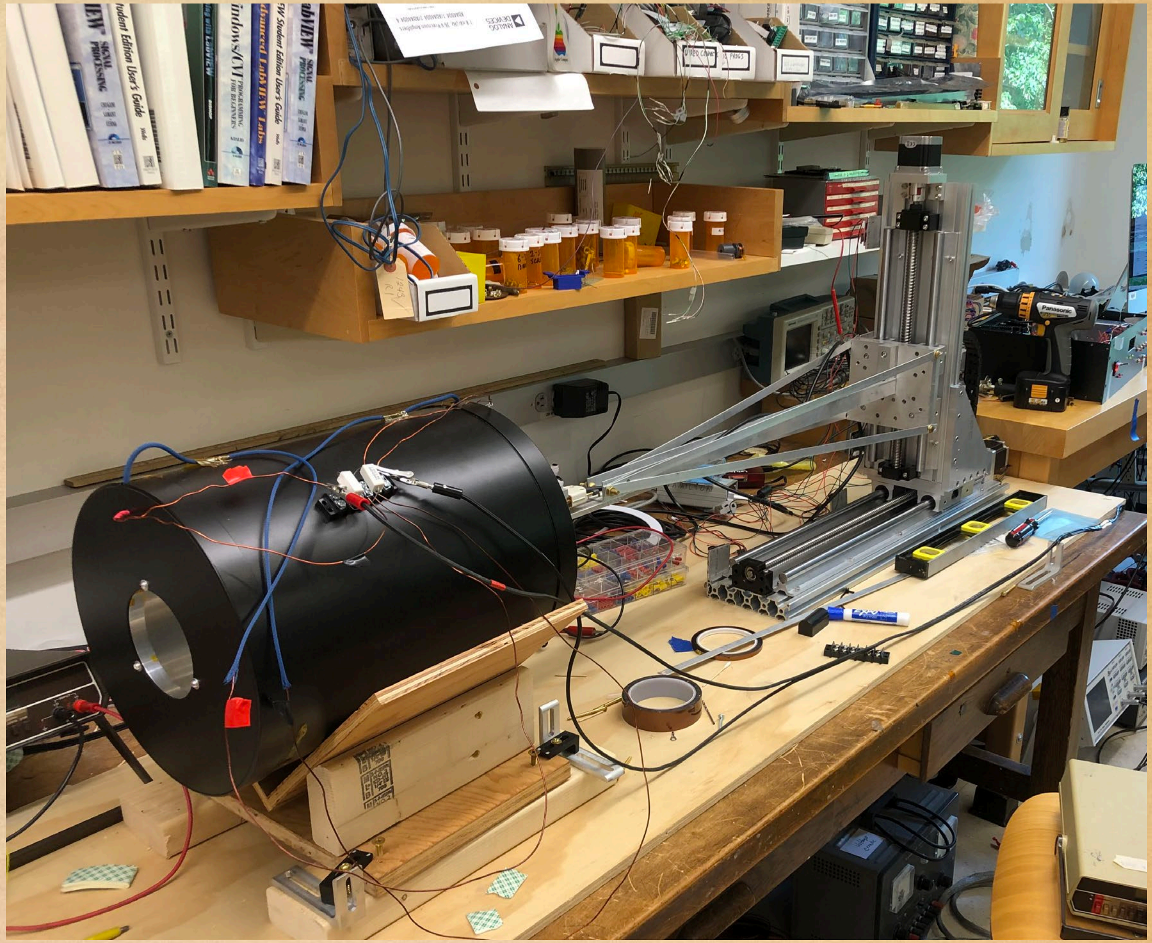
Optimizing a Magnetically Shielded Solenoid for Extended-Q SANS Polarization Analysis Capability

Sidney Molnar, Hamilton College '22

SURF Gaithersburg NCNR 2021

Mentor: Wangchun Chen



Overview

Background

SANS and vSANS Measurements

^{3}He Cell

Optimization

Turn Configurations

Sensitivity and Resistance

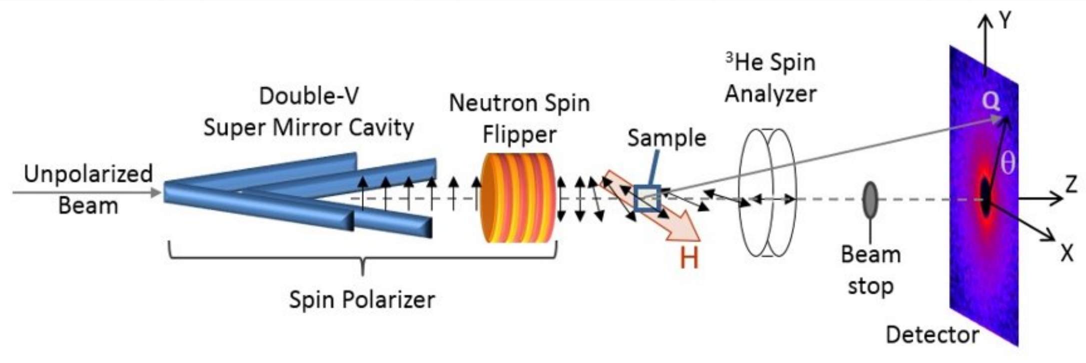
Results

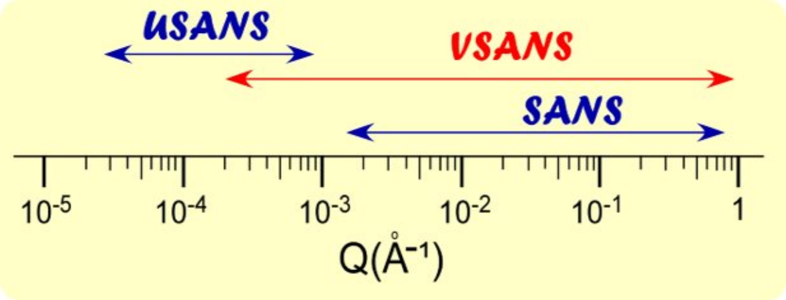
Figures of Merit

Background

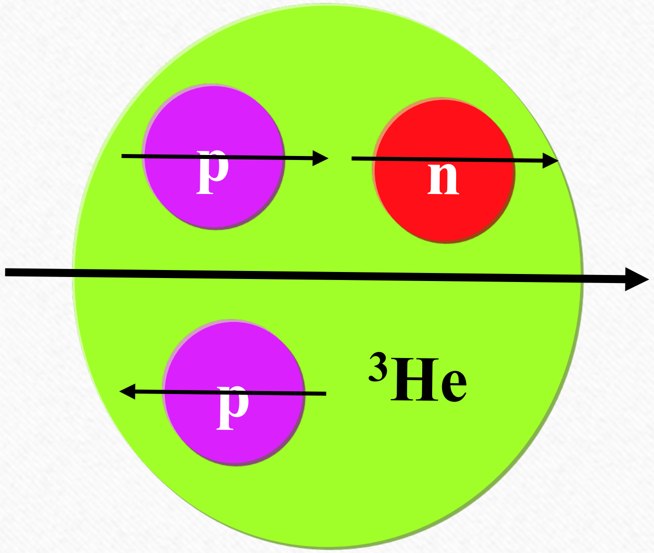
- SANS and vSANS
- The 3He Cell
- Our Solenoid

SANS and vSANS Measurement Capabilities

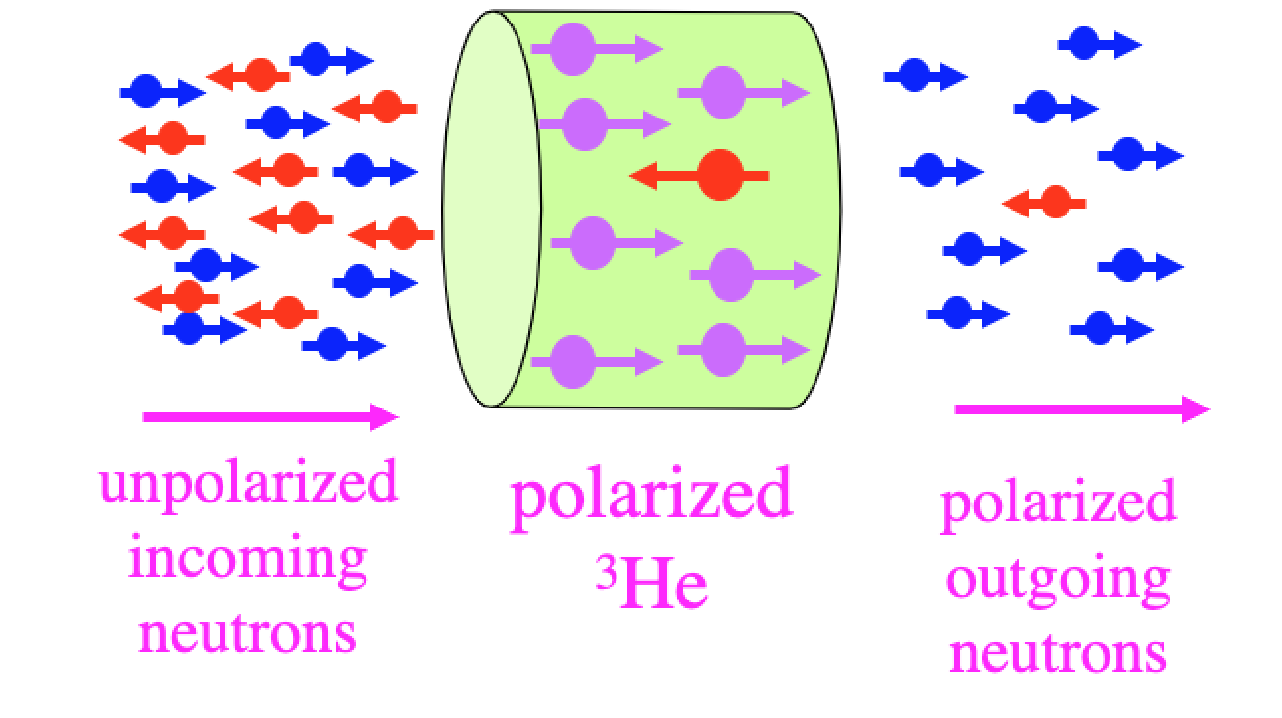




The ^{3}He Cell

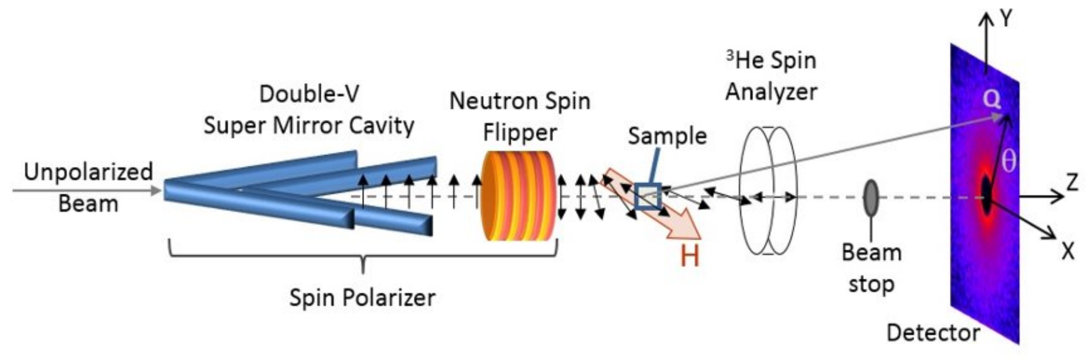


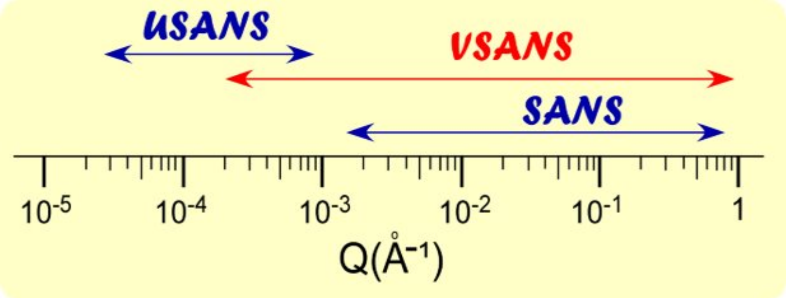
p
n
p
^{3}He

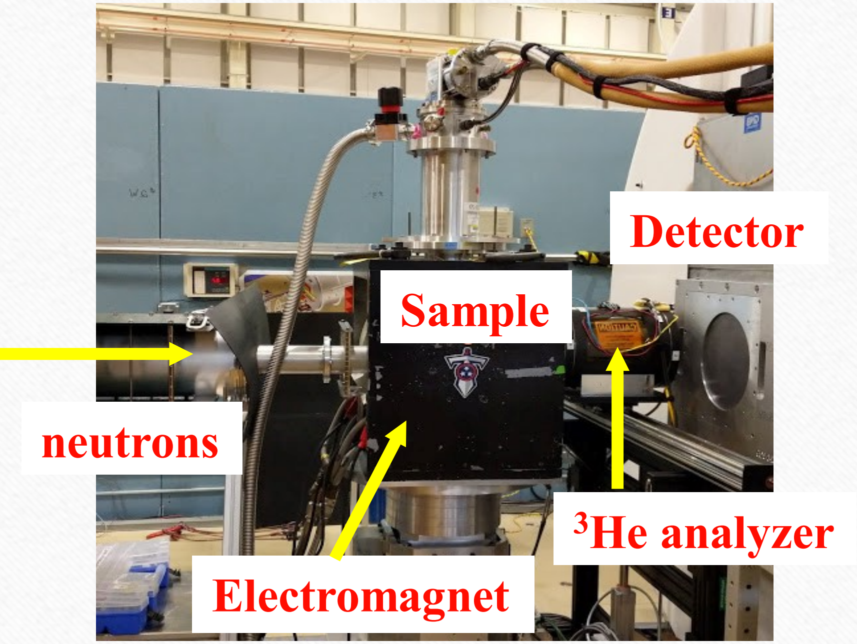


unpolarized incoming neutrons
polarized ^{3}He
polarized outgoing neutrons

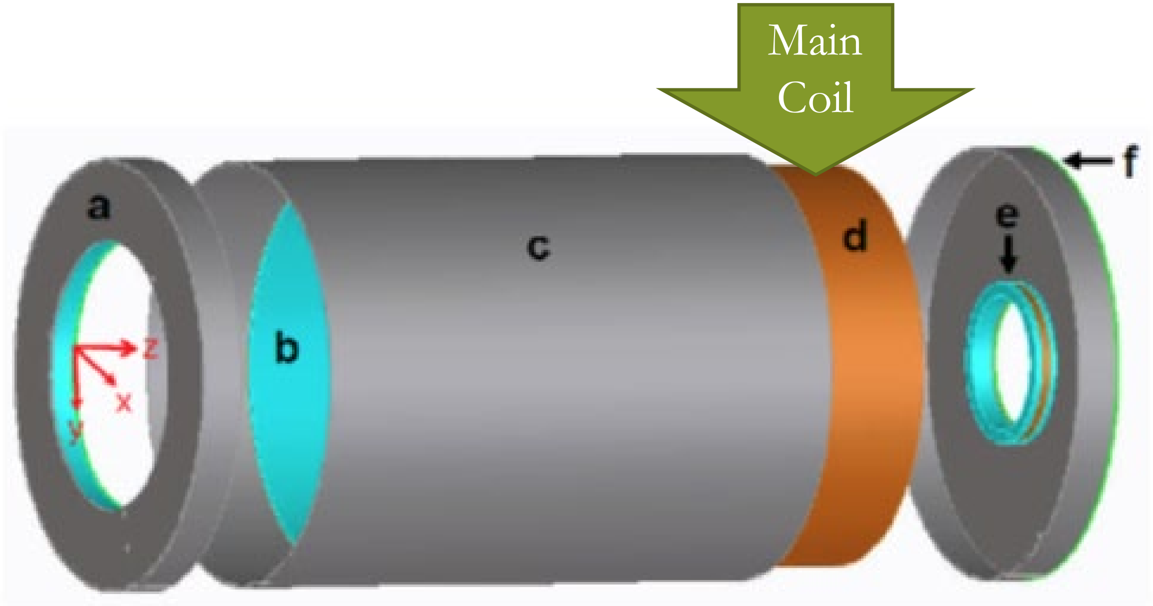
SANS and vSANS Measurement Capabilities

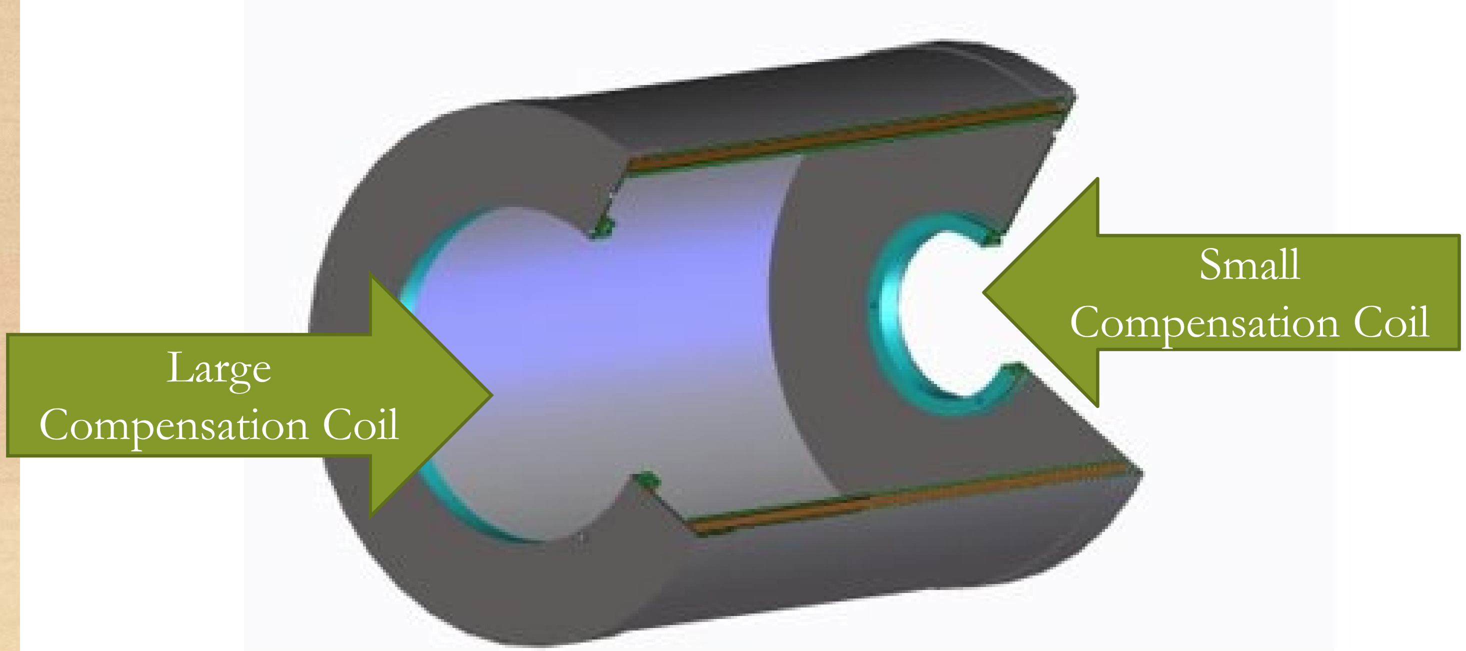






Essential Features of the Solenoid





Optimizing Uniformity of the Magnetic Field in a Shielded Solenoid

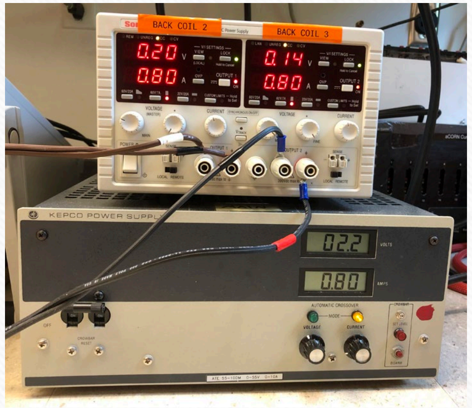
- Initial Calculations
- Final Turns
- Sensitivity
- Fractional Turns
- Off-Axis Scans

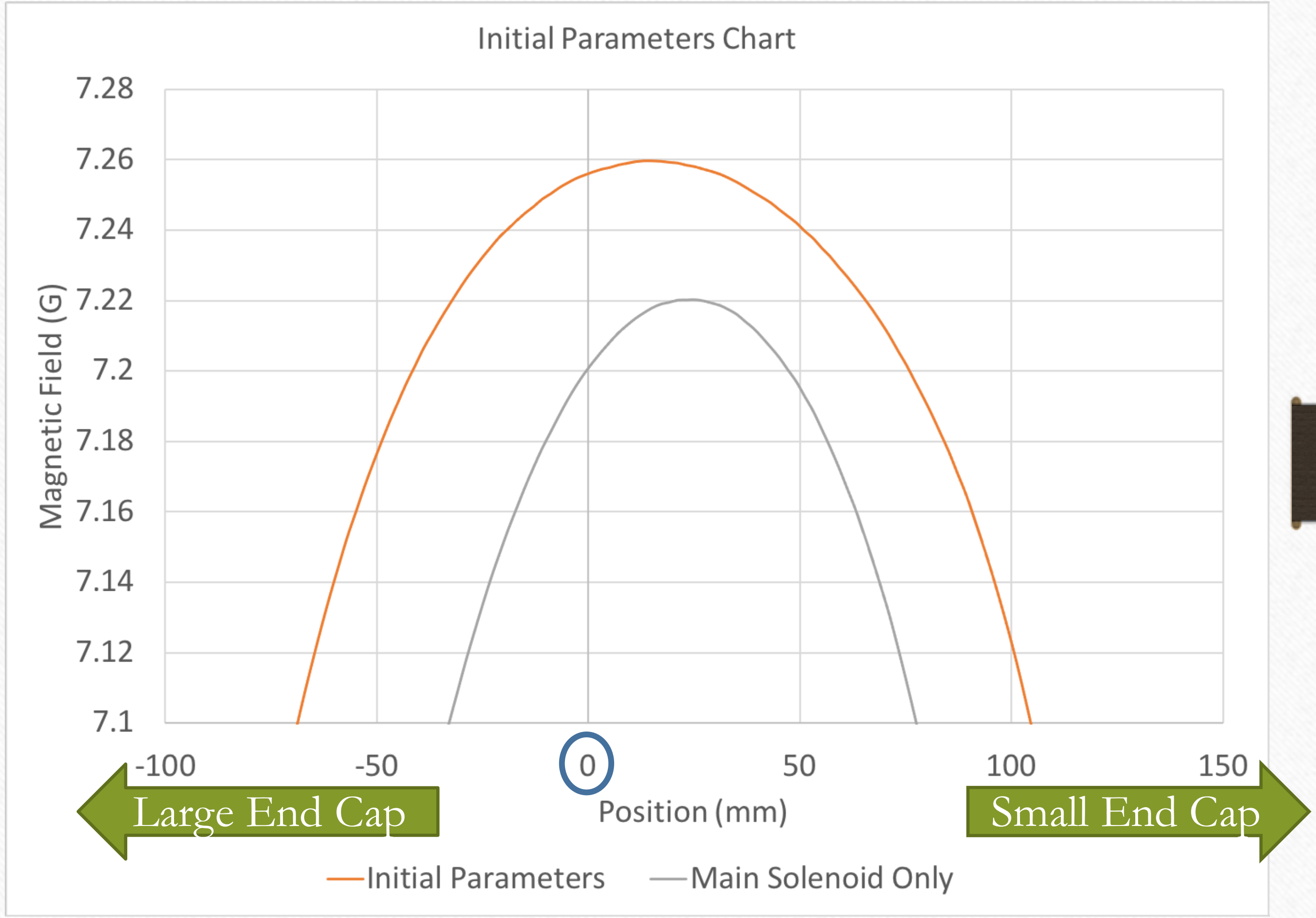
Initial Parameters for Optimization

8 small compensation coil turns

15 large compensation coil turns

0.8 amps of current through each coil





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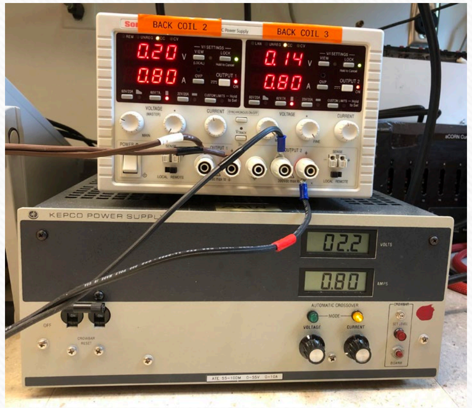
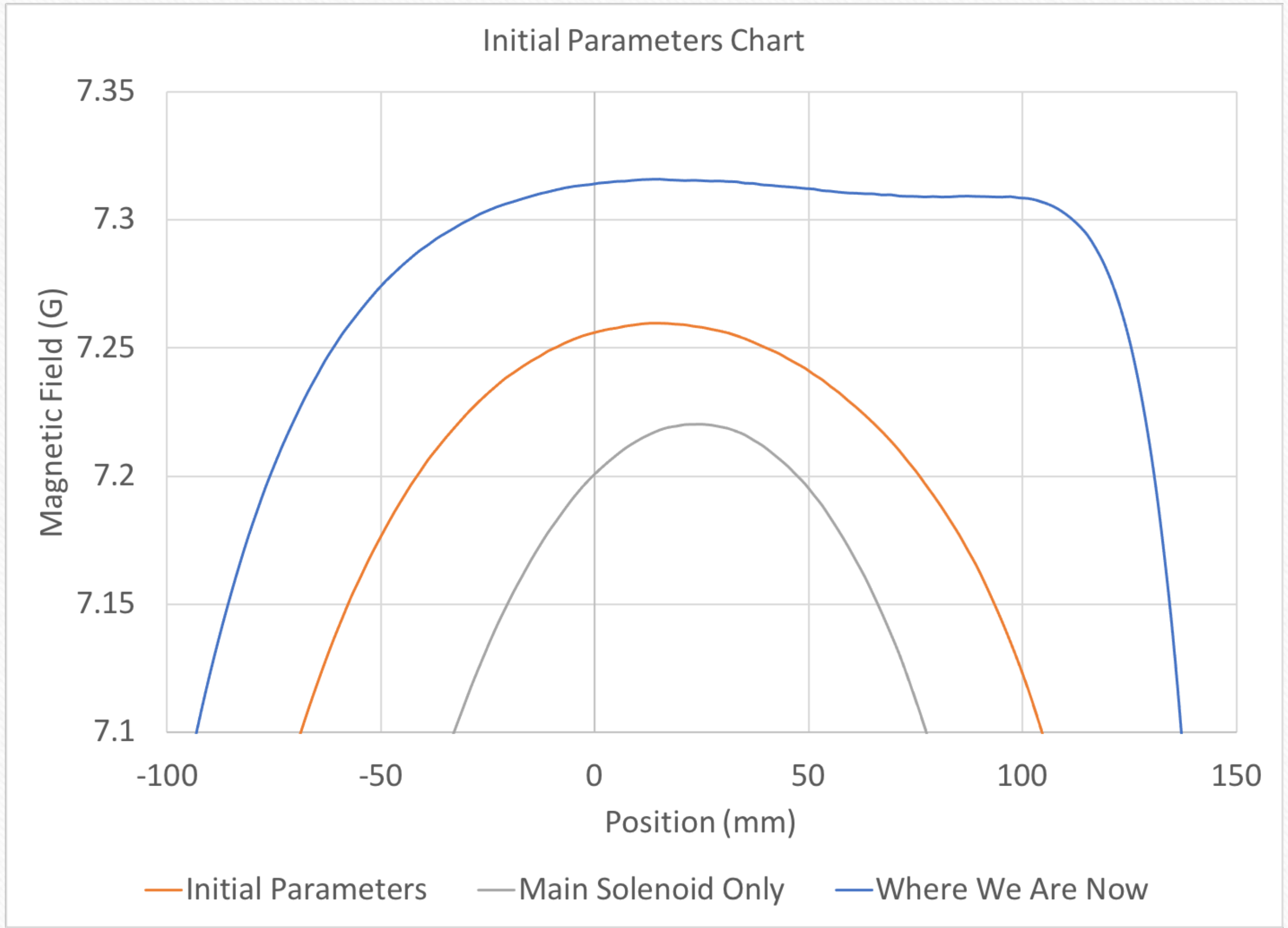
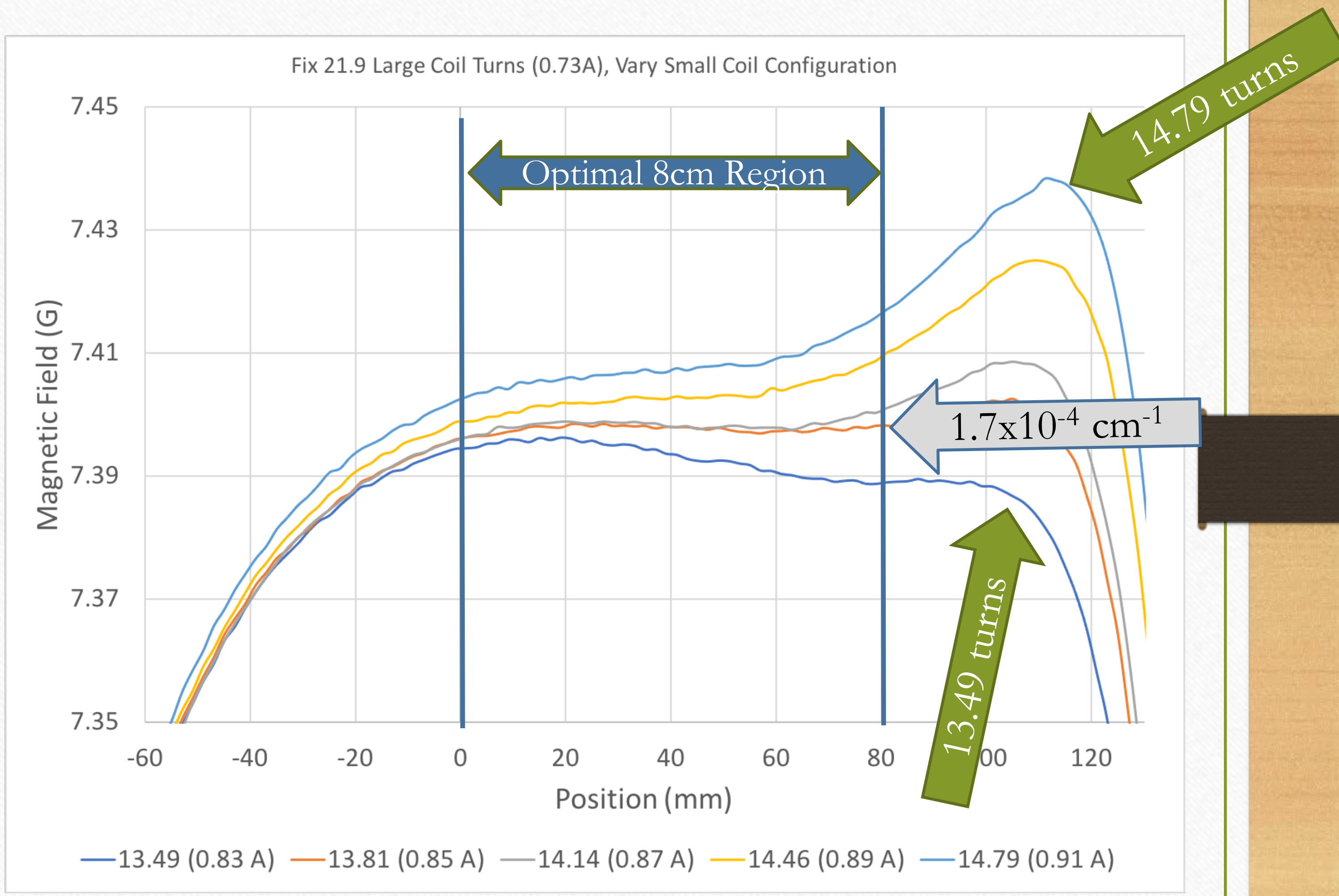




Finding the Final Configuration

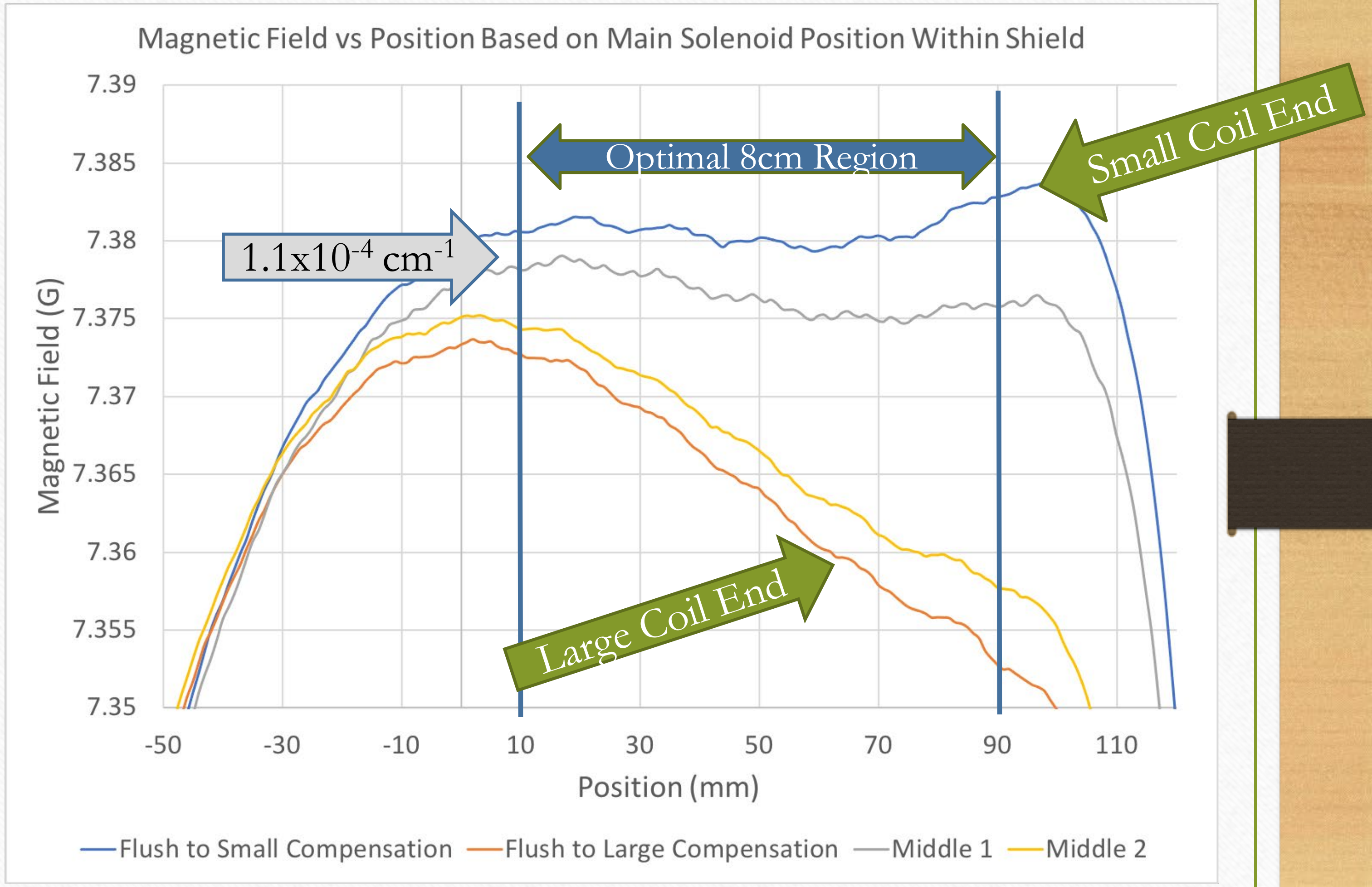
- 14 small coil turns
- 22 large coil turns

Figure of Merit:
Line Average = $(dB_z/dz)/|B_z|$



Sensitivity Analysis

How does the position of the solenoid within the mu-metal shield affect our field?

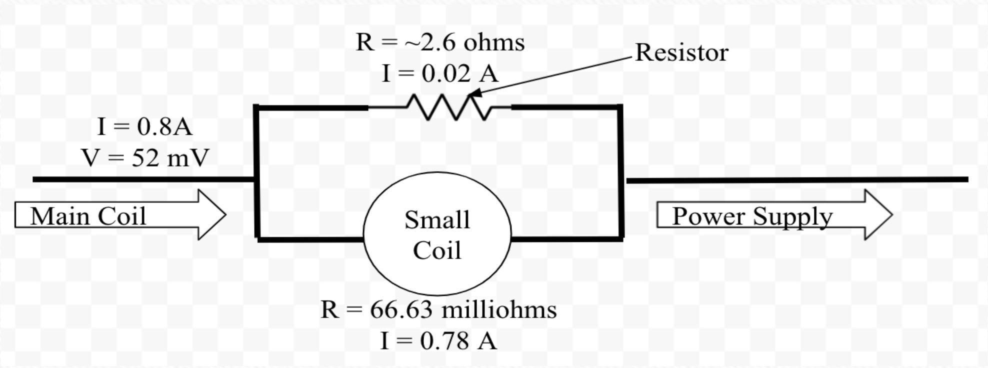


Adjustments for Fractional Turn Configurations

- Parallel Resistance =

$$\frac{(\text{Coil Current} * \text{Coil Resistance})}{\text{Parallel Current}}$$

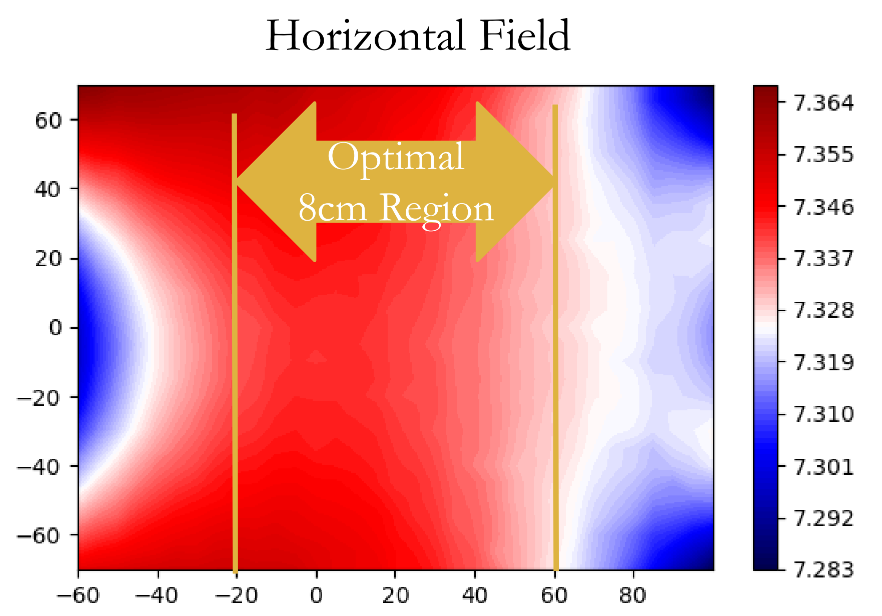
- Parallel Resistance: ~2.6 ohms



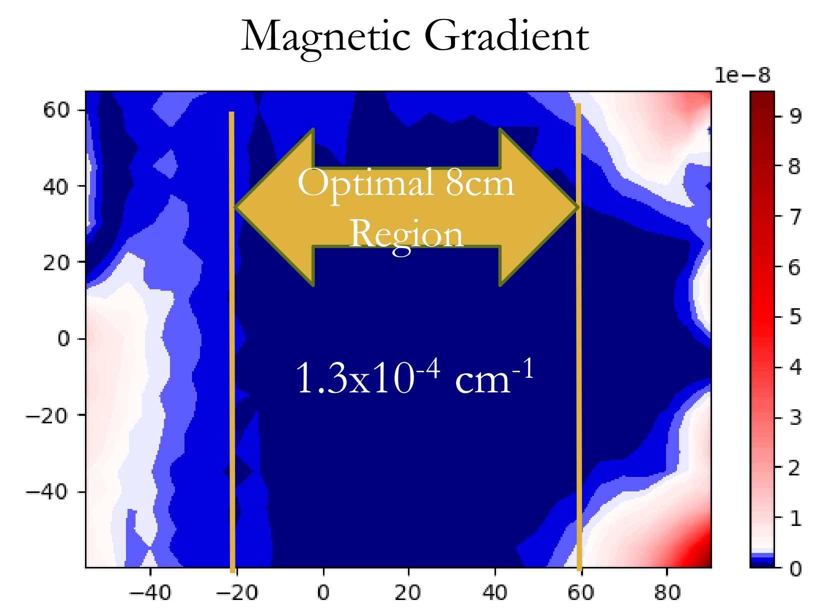
Off-Axial Scans

Volume Avg Parameter:
$(B\_Grad/B)^2$

Scanning the Field for Two Dimensions



Calculating a Volume Average



Summary of Our Results

- Extended Q-Range for small-scale nanomagnetic research
- Optimal uniformity for longer relaxation time of ^{3}He cell
- Final Figures of Merit reduced significantly from our original calculations

Acknowledgements

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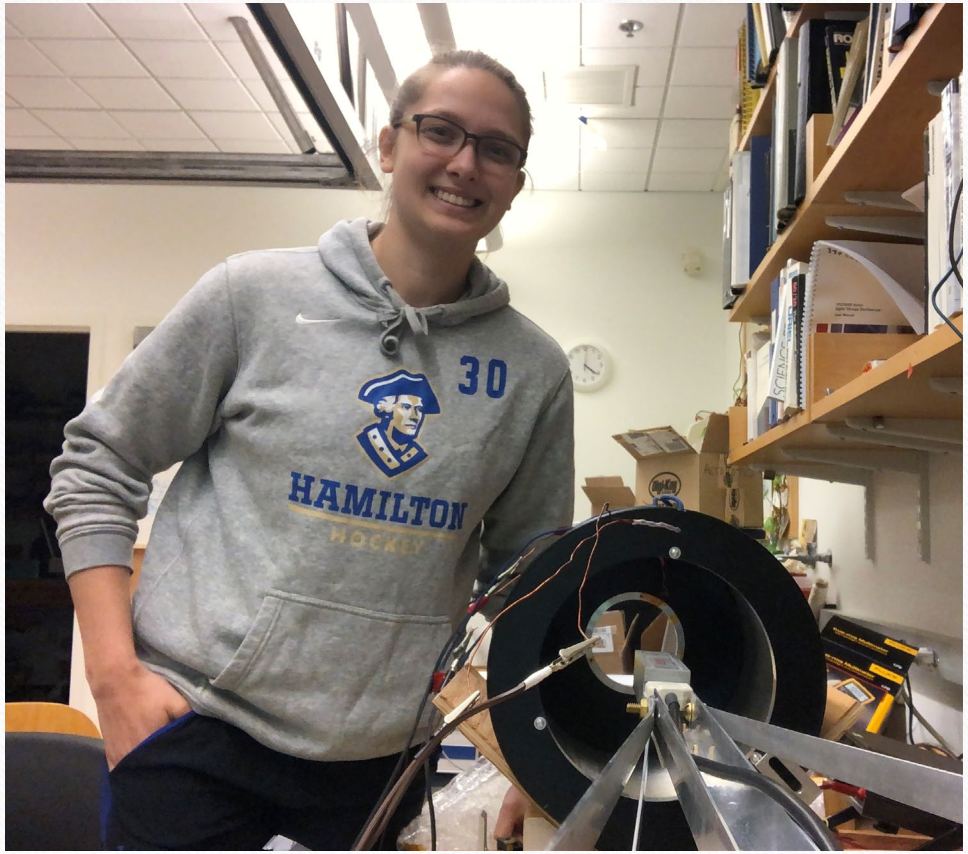
CHRNS → for making this summer's research possible.



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