PSI nEDM* Systematic : Leakage Currents

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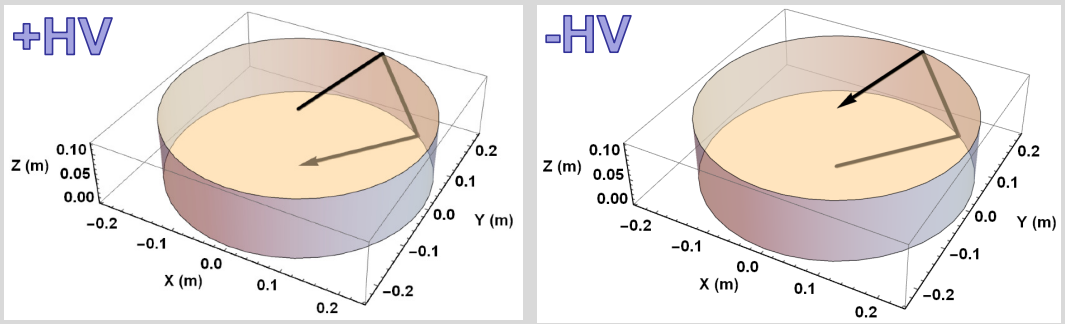
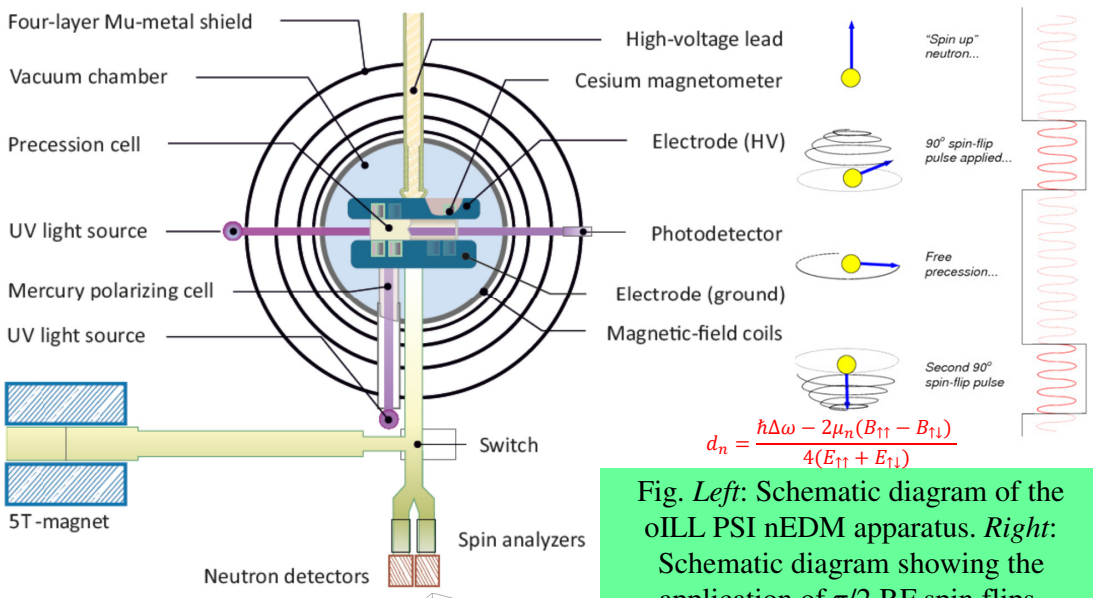
➢ 1. Introduction

HV correlated currents can cause E-field correlated B-field giving rise to false EDM.



$$d_n^{false} = \frac{h\gamma_n}{4E}\Delta B = \frac{h\gamma_n}{2E}B_{LC} \qquad d_{Hg}^{false} = \frac{h\gamma_{Hg}}{4E}\Delta B = \frac{h\gamma_{Hg}}{2E}B_{LC}$$

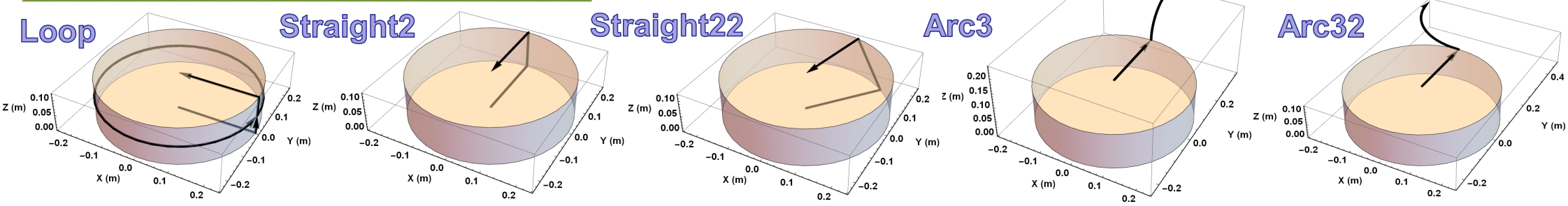
We assume $\Delta B \sim 2B_{LC}$ or the worst possible scenario.



$$d_n = \frac{\hbar\Delta\omega - 2\mu_n(B_{\uparrow\uparrow} - B_{\uparrow\downarrow})}{4(E_{\uparrow\uparrow} + E_{\uparrow\downarrow})}$$

Fig. *Left*: Schematic diagram of the oILL PSI nEDM apparatus. *Right*: Schematic diagram showing the application of π/2 RF spin flips.

➢ 2. How Do We Obtain B_{LC}?: FEM



Here are the fundamental leakage current pathways used to calculate B_{LC}. Finite element method (Biot-Savart Law) gives us the discretised field @ ~2M points uniformly. Uses finite current carrying element of length 1μm stitched together to make the pathways of leakage current.

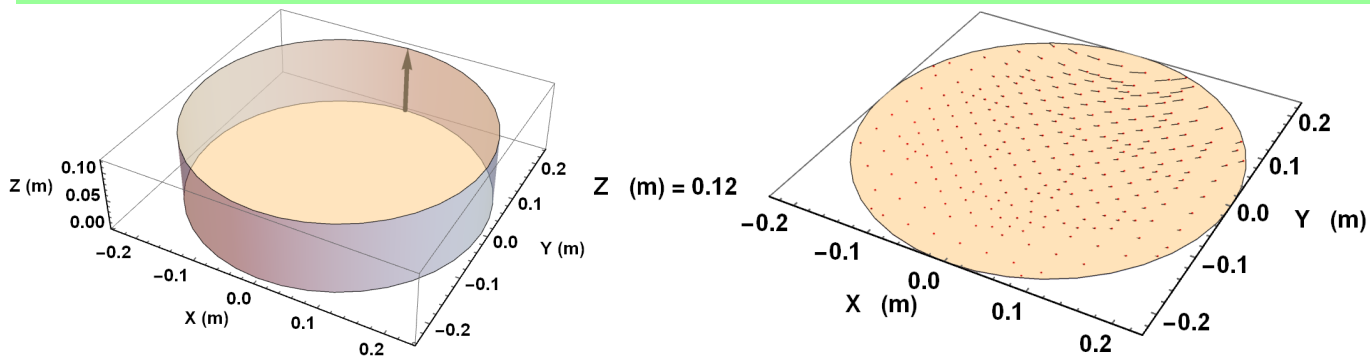


Fig: Visualization of the magnetic field obtained using FEM method in the test case.

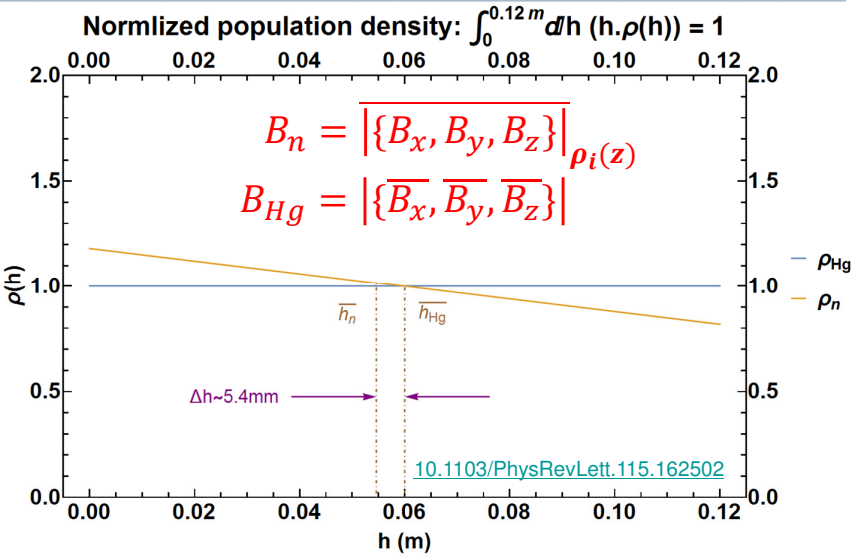
➢ 3a. Field Seen by Hg: Non-Adiabatic Field Sampling

$$B_{Hg} = \left|\{\overline{B_x}, \overline{B_y}, \overline{B_z}\}\right|$$

➢ 3b. Field Seen by n⁰: Adiabatic Field Sampling

$$B_n = \overline{\left|\{B_x, B_y, B_z\}\right|}$$

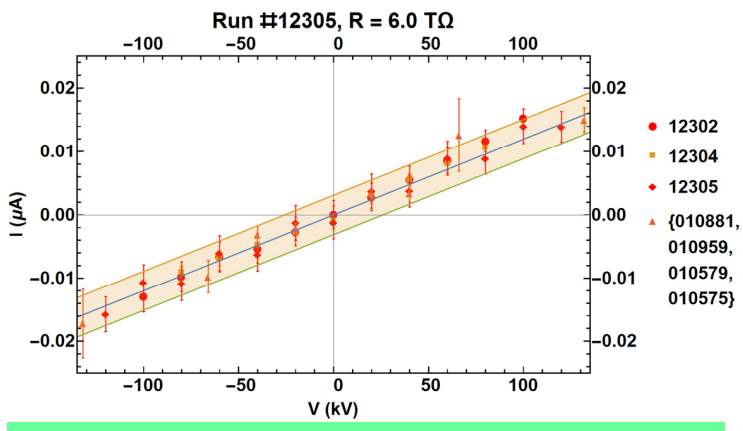
➢ 3c. N⁰ & Hg Population Densities



The field averages are weighted with the population densities.

➢ 4. Estimation of I_{LC} & I_{ARC}

I_{LC} is estimated using the leakage current device and is typically observed to be under 1nA.



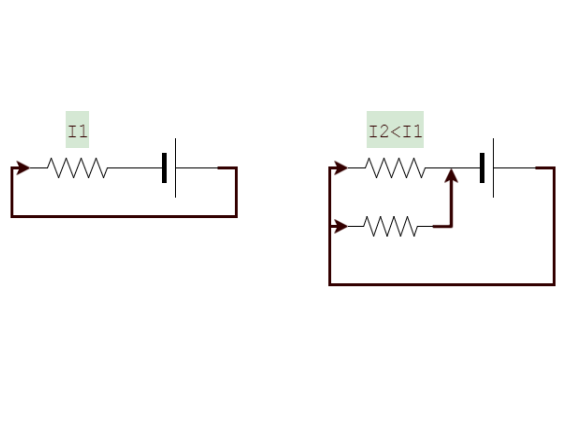


Fig. We can observe the V-I curve of the power supply and determine if at higher currents the V-I curve for steady state deviates from the expectation. Especially if it deviates towards negative, meaning the charges are finding their way out to ground via another pathway : I_{Arc} < 2nA.

➢ 6. Summary

$$_{cor.}d_n^{false} < 1.19 \times 10^{-27} e.cm$$

➢ 5. Field Averages & Corrected False EDM

The neutron frequency obtained from Ramsey method is corrected with mercury frequency provided by a co-magnetometer.

$$_{cor.}d_n^{false} = \frac{h\gamma_n}{2E}\left|(B_n - B_{Hg})\right|$$

Model	$\overline{B_x}$ (10^{-11}μT)	$\overline{B_y}$ (10^{-11}μT)	$\overline{B_z}$ (10^{-9}μT)	B_n (10^{-9}μT)	B_{Hg} (10^{-9}μT)
Loop	6.4 (1)	6.5 (1)	2.1 (1)	3.3 (1)	2.2 (1)
Straight2	6.8 (1)	1.4 (1)	0.1 (1)	0.5 (1)	0.1 (1)
Straight22	8.5 (1)	2.0 (1)	1.0 (1)	0.6 (1)	1.1 (1)
Arc3	2.6 (1)	0.2 (1)	0.1 (1)	0.3 (1)	0.2 (1)
Arc32	2.6 (1)	0.0 (1)	1.2 (1)	0.6 (1)	1.2 (1)

Model	d_n^{false} (10^{-28}e.cm)	d_{Hg}^{false} (10^{-28}e.cm)	$_{corrected}d_n^{false}$ (10^{-28}e.cm)	
Loop	51.6	28.8	11.9	$I_{LC} \leq 1nA$
Straight2	29.5	5.98	3.42	
Straight22	29.4	4.37	4.38	
Arc3	56.6	4.34	4.41	$I_{Arc} \leq 2nA$
Arc32	91.2	9.74	9.92	

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