Characterization of Noise Sources in the n3He Parity Violating Asymmetry Measurement

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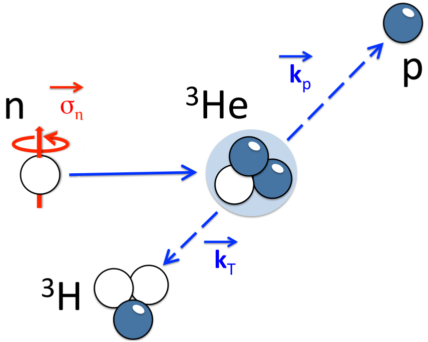
n3He Introduction

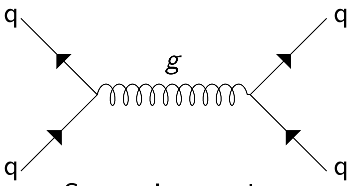
The n3He experimental goal is to make a high precision measurement of the parity violating directional asymmetry in the proton emission direction from the reaction

$$\vec{n} + {}^3He \rightarrow p + T + 765keV$$

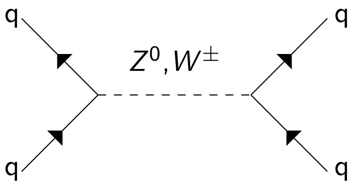


The asymmetry is expected to be small around 10^{-7} and our goal is to measure it to 2×10^{-8}.

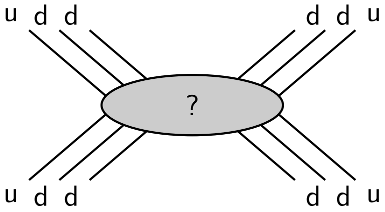
Theoretical Motivation



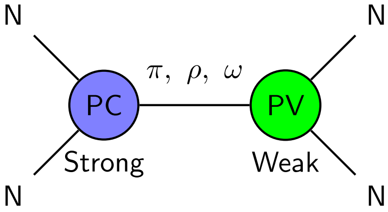
Strong Interaction



Weak Interaction



Uncertain HWI

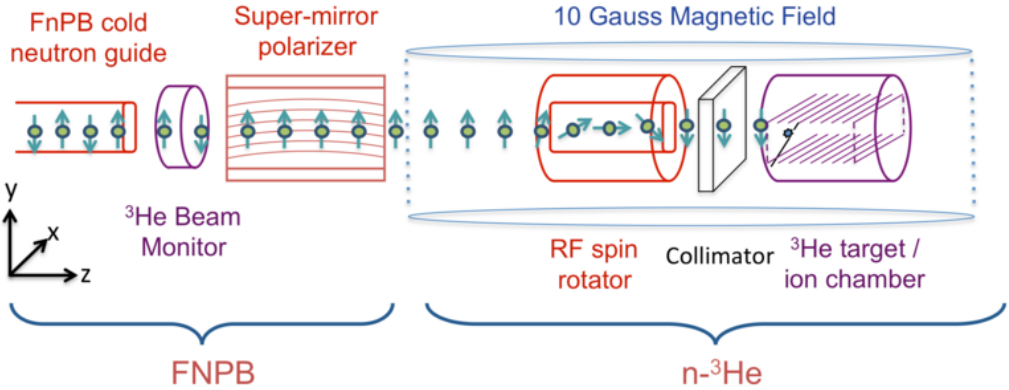


DDH Parameterization

DDH Meson Exchange Parameters:

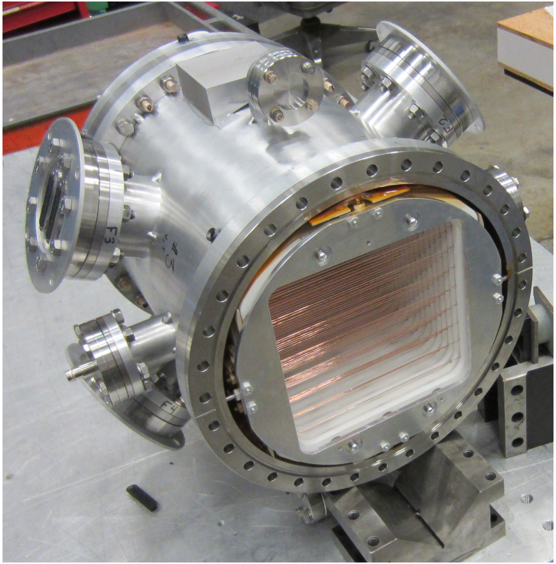
$$O_{pv} = a_\pi^1 h_\pi^1 + a_\rho^0 h_\rho^0 + a_\rho^1 h_\rho^1 + a_\rho^2 h_\rho^2 + a_\omega^0 h_\omega^0 + a_\omega^1 h_\omega^1 + a_\omega^{1'} h_\omega^{1'}$$

n3He Schematic Diagram



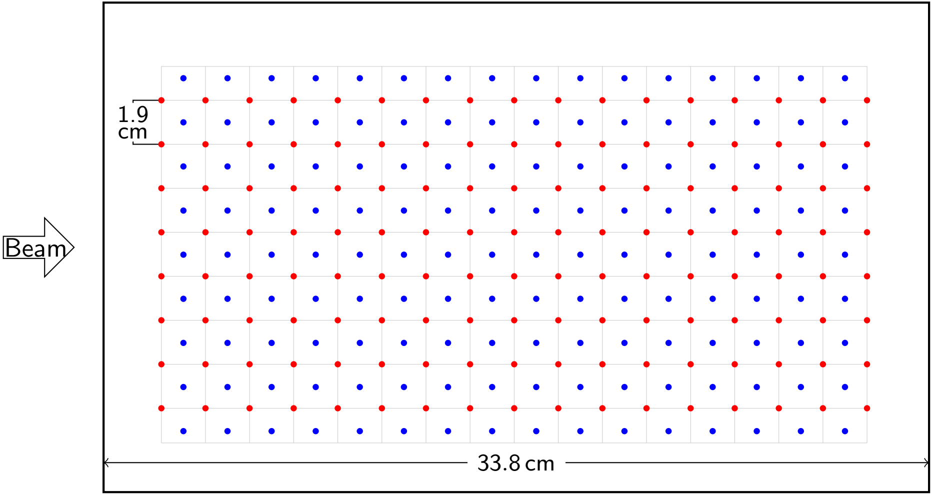
- located at the Oak Ridge National Laboratory (ORNL) in Tennessee
- 60 hertz pulsed spallation source
- n3He took data during 2015 on the Fundamental Neutron Physics Beamline
- 20 K liquid hydrogen moderator for cold neutron beam lines

Target Chamber



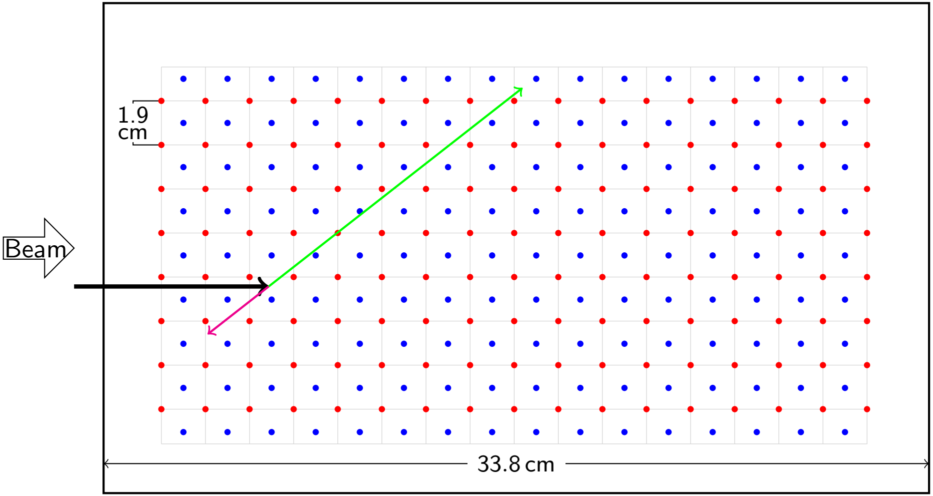
- Multi-wire proportional chamber
- 0.47 atm pure He-3 fill gas
- operated near unity gain
-

n3He Target Chamber Schematic



- HV 17 HV Frames with 8 wires each
- Signal 16 signal Frames with 9 wires each

n3He Target Chamber Schematic



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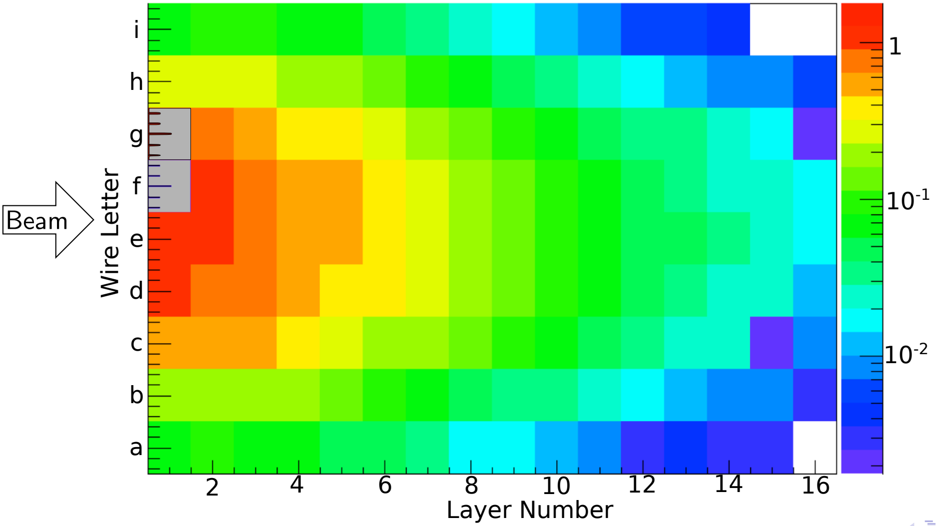
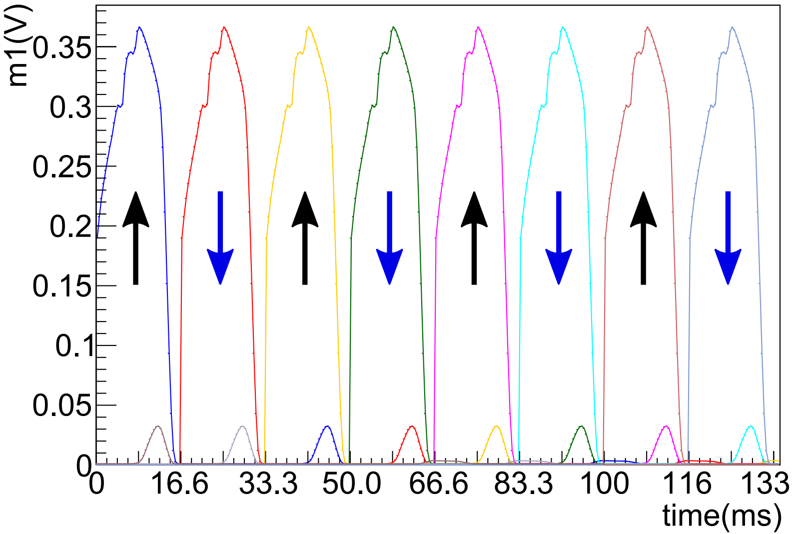
Measured Charge Distribution in the Chamber



60 Hz Neutron Pulse Spin Sequence



- ↑ indicates is a neutron pulse with the spin flipper off and the neutron polarization orientated parallel to gravity
- ↓ indicates a pulse with the spin flipper on the neutron polarization anti-parallel

Physics Asymmetry Calculations

For the signal wire i the mean wire yield for a pulse k is:

$$\bar{Y}_i = \frac{1}{40}\sum_{t=5}^{44} Y_{i,t} = S_i + b_i \tag{1}$$

where S_i is the neutron contribution to the signal and b_i is the electronic pedestals. The single wire physics asymmetry is calculated for a pairs of consecutive neutron pulses with the spin sequence $\uparrow\downarrow$:

$$A_i^{phys} = \frac{\bar{Y}_i^{\uparrow} - \bar{Y}_i^{\downarrow}}{\bar{Y}_i^{\uparrow} - \bar{Y}_i^{\downarrow}} \approx \frac{1}{G_i}\frac{S_i^{\uparrow} - S_i^{\downarrow}}{S_i^{\uparrow} + S_i^{\downarrow}} + \frac{1}{G_i}\frac{b_i^{\uparrow} - b_i^{\downarrow}}{S_i^{\uparrow} + S_i^{\downarrow}} \tag{2}$$

where $\bar{Y}_i^{\uparrow}$, and $\bar{Y}_i^{\downarrow}$.

Instrumental Asymmetry Calculations

To measure the effect on the uncertainty of the physics asymmetry by the pedestals beam off data was taken at 1 week intervals during data taking with an instrumental asymmetry calculated for pairs of consecutive neutron pulses with the spin sequence $\uparrow\downarrow$:

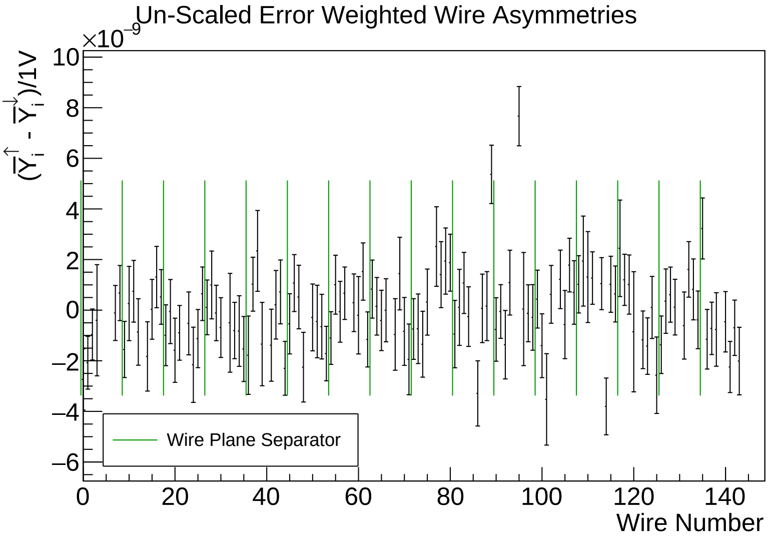
$$A_i^{inst} = \frac{1}{G_i}\frac{\bar{Y}_i^{\uparrow} - \bar{Y}_i^{\downarrow}}{2\bar{S}_i} \tag{3}$$

where $\bar{S}_i$ is the mean wire signal over all beam on running
An additional check called the Null Asymmetry was calculated using four pulse sequences, $\uparrow\downarrow\uparrow\downarrow$ to calculate the asymmetry:

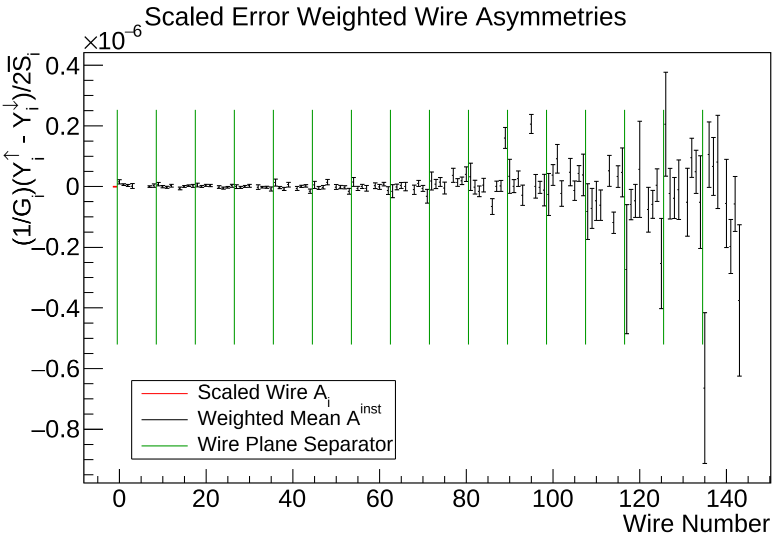
$$A_i^{null} = \frac{1}{G_i}\frac{\bar{Y}_i^{\uparrow} - \bar{Y}_i'^{\uparrow}}{2\bar{S}_i} \qquad A_i'^{null} = \frac{1}{G_i}\frac{\bar{Y}_i^{\downarrow} - \bar{Y}_i'^{\downarrow}}{2\bar{S}_i} \tag{4}$$

which should average to zero if the spin flipper

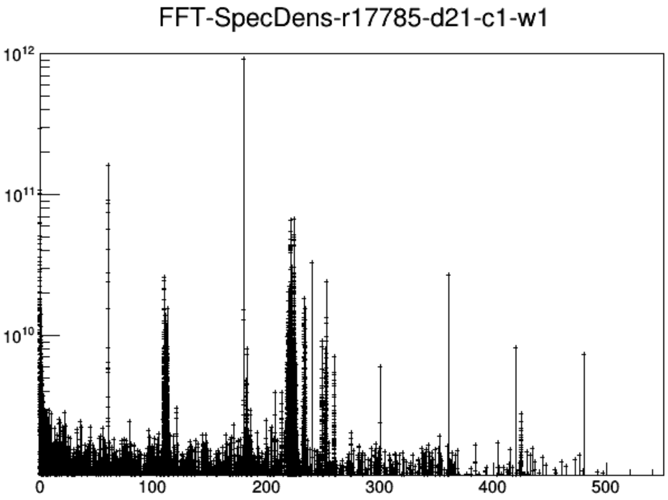
Un-Scaled Wire Instrumental Asymmetry Comparison



Scaled Wire Instrumental Asymmetry Comparison



FFT Analysis Results



Features of Note:

- large 180 Hertz peak on most wires
- variable cluster of peaks near 210 Hz wire resonance
- other peak variable
- No dominant peak in wire values

Conclusion

Asymmetry	
Preliminary Physics	$(10 \pm 10) \times 10^{-9}$
Instrumental	$(-0.2 \pm 1.18) \times 10^{-9}$
Null	$(\pm) \times 10^{-9}$

- The instrumental asymmetry is small compared to the physics asymmetry, and consistent with zero.
- The null asymmetry is consistent with zero indicating no spin flipper leakage into the signal readout.
- The systematic uncertainty in the experimental result should is small compared to the statistical uncertainty.

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