In order to study the fifth structure function, we use an asymmetry $A'_{LT}$. To extract $A'_{LT}$ from our data, we start with the differential cross section for the quasielastic reaction $^2\text{H}(e,e'p)n$ with polarized beams.

$$
\frac{d^2\sigma}{dQ^2 dp_m d\phi_{pq}} = \sigma_+ + \sigma_- + \sigma_T \cos \phi_{pq} + \sigma_{TT} \cos 2\phi_{pq} + h\sigma_{LT} \sin \phi_{pq}
$$

(1)

The symbol $\pm$ refers to the beam helicity, $\Phi_{pq}$ is shown in Figure 3, $p_m$ is the missing momentum defined as $p_m = q - p$, where $q$ is the 3-momentum transfer and $p$ is the ejected proton 3-momentum. The $\sigma_i$'s are the partial cross sections for each component. The helicity asymmetry is

$$
A_i(Q^2, p_m, \Phi_{pq}) = \frac{\sigma_i - \sigma_o}{\sigma_+ + \sigma_- + \sigma_T \cos \phi_{pq} + \sigma_{TT} \cos 2\phi_{pq} + h\sigma_{LT} \sin \phi_{pq}}
$$

(2)

where $Q^2$ is the square of the 4-momentum transfer.

The magnitude of $p_m$ grows with increasing $\theta_{pq}$, where $\theta_{pq}$ is the angle between the 3-momentum transfer $q$ and the proton 3-momentum $p$. By substituting Equation 1 into Equation 2, we get the following.

$$
A_i(Q^2, p_m, \Phi_{pq}) = \frac{\sigma_i - \sigma_o}{\sigma_T + \sigma_{TT} \cos \phi_{pq} + \sigma_{LT} \cos 2\phi_{pq} + h\sigma_{LT} \sin \phi_{pq}}
$$

(3)

The numerator in the equation is proportional to $\sin \theta_{pq}$, and the denominator is approximately constant ($\sigma_T$ and $\sigma_{TT}$ are small and can be ignored). One obtains,

$$
A_i(Q^2, p_m, \Phi_{pq}) \approx \frac{\sigma_i - \sigma_o}{\sigma_T + \sigma_{TT} \cos \phi_{pq} + \sigma_{LT} \cos 2\phi_{pq} + h\sigma_{LT} \sin \phi_{pq}} = A'_{LT} \sin \phi_{pq}
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Therefore, the amplitude of a fit of $A_i$ would be $A'_{LT}$.

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We analyzed the data using a C++ code based on the ROOT package from CERN. We generated ROOT 2D histograms for both beam helicities as a function of the missing momentum $p_m$ and the out-of-plane angle $\Phi_{pq}$. We calculated the ratio of the difference of the opposite beam helicity histograms divided by their sum (see Equation 2) to create a new set of 2D histograms in $p_m$ and $\Phi_{pq}$ bins. Data for a given $p_m$ bin were projected out and the $\Phi_{pq}$ dependence was fitted to a sinusoidal curve (see Figure 4 and Figure 5 for examples) over the range $p_m = 0.7$ GeV/c in nine bins. We completed these steps for both the normal and reversed magnetic polarities of the CLAS toroidal magnetic field.

Conclusions

We have developed a method to extract the asymmetry $A'_{LT}$ from fits to the helicity asymmetry. We measured $A'_{LT}$ for both torus polarities using this method and compared our results to the $\sin \Phi_{pq}$ weighted method. The differences are consistent with zero within uncertainties for both torus polarities. Both methods of extracting $A'_{LT}$ are equivalent.

References