False Asymmetry Parameterization for E05-103: A report on J. Glister's Analysis

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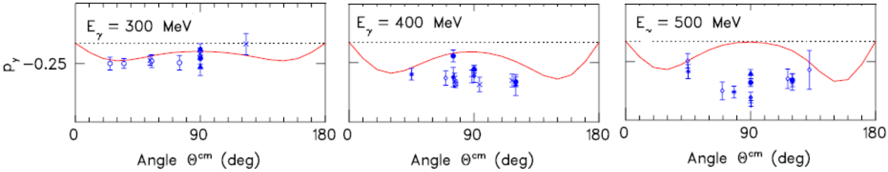
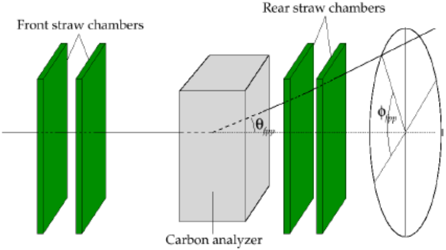
Motivation:Discrepancy in Proton Polarization Observables

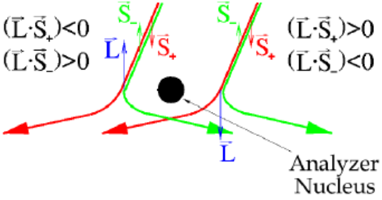
- As photon energy grows for deuteron photodisintegration, a disagreement between world data and the theoretical calculation (Schwamb and Arenhövel meson-baryon theory) for P_y emerges around $\theta_{cm} = 90^\circ$
- Motivation of experiment was to provide high-precision P_y and $P^c_{x,z}$ measurements to help resolve whether the problem lies with the world data or the calculation



Focal Plane Polarimeter

The spin-orbit interaction between the proton and carbon analyzer nucleus results in an asymmetry in the azimuthal scattering angle, ϕ_{fpp}. Left-right asymmetry gives the vertical component, P_x^{fpp}, while the up-down asymmetry gives the horizontal component, P_y^{fpp}.





Extracting Polarization Observables

The probability of scatter at a given polar angle θ_{fpp} and azimuthal angle ϕ_{fpp} is given by:

$$f^{\pm}(\theta_{fpp}, \phi_{fpp}) = \frac{1}{2\pi}\left[\xi \pm A_y(\theta_{fpp})(P_x^{fpp} sin(\phi_{fpp}) - P_y^{fpp} cos(\phi_{fpp}))\right] \quad (1)$$

where $\pm$ refers to positive and negative helicity states, A_y is the carbon analyzing power, and we only show the helicity-dependent polarizations. The term ξ is the instrumental or false asymmetry[1], which can be expanded as a fourier series:

$$\xi = 1 + a \times cos(\phi_{fpp}) + b \times sin(\phi_{fpp}) + c \times cos(2\phi_{fpp}) + d \times sin(2\phi_{fpp}) \quad (2)$$

The 2ϕ-terms are taken as indications of the size of the false asymmetry, but it is the ϕ terms that change the proton polarization one determines.

[1] This is also sometimes put in as a multiplicative, rather than an additive, term.

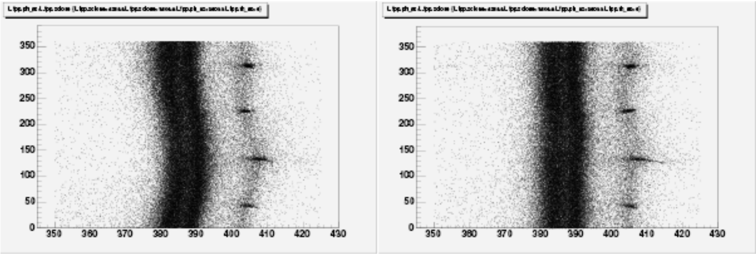
False Asymmetries

False asymmetries cancel for helicity-dependent transferred polarization, but not for helicity-independent, or induced, polarization. The asymmetry is caused by two factors:

- Misalignments: between the front and rear FPP chambers as well as between the FPP and the VDCs
- Inhomogeneities in efficiency across the FPP chambers

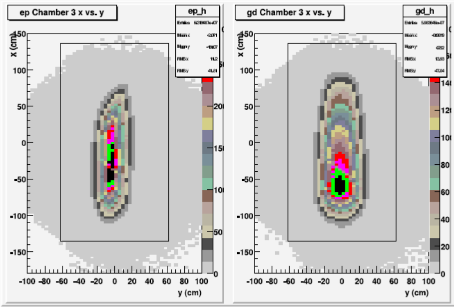
Alignment

- Data was taken without the carbon analyzer in order to align the front FPP chambers to the VDCs as well as the rear to the front
- Plots below show the azimuthal scattering angle ϕ_{fpp} on the y-axis and z of scatter on the x-axis, before and after alignment
- The blobs at $z \approx 405$ cm are mistrackings, often bad demux in chamber 4



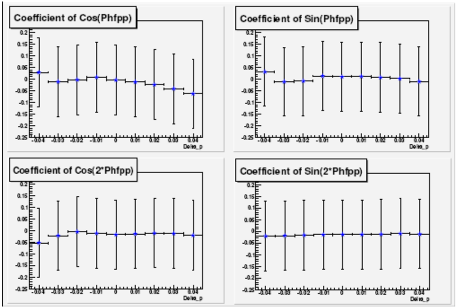
Elastic Data

- ep elastic scattering data taken: in the single photon approximation the induced polarization in elastic scattering should be zero, allowing for a direct measurement of instrumental asymmetries
- Obtained excellent coverage of the focal plane for elastic data (shown left) relative to the γd production data coverage (shown right)



First Method: Fitting Helicity Sum

- One way of determining the asymmetry is to take a helicity sum of elastic data, therefore canceling any helicity-dependent polarization: $f^{+}(\theta_{fpp}, \phi_{fpp}) + f^{-}(\theta_{fpp}, \phi_{fpp}) = \xi/\pi$
- Fitting a fourier series to the helicity sum distributions as a function of ϕ_{fpp} in bins of δ_p using ROOT led to very large and unreliable errors. The plot below indicates that all of the coefficients are zero within error bars



Second Method: Estimators for Coefficients

- In order to avoid histogramming the data and fitting a complicated function, a method based on the maximum likelihood method was used to extract the fourier series coefficients (NIM 166, 515 (1979))
- The coefficients and their errors are calculated by taking a sum over all elastic events, where x = coefficient of trig(ϕ), y = coefficient of trig(2ϕ) and trig= [cos,sin]:

$$x = \frac{\sum_i trig(\phi_i)}{\sum_i trig^2(\phi_i)} \tag{3}$$

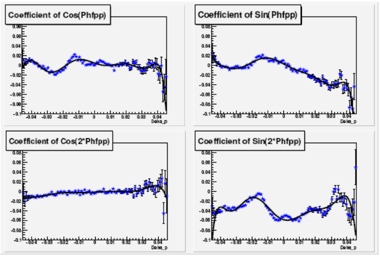
$$y = \frac{\sum_i trig(2\phi_i)}{\sum_i trig^2(2\phi_i)} \tag{4}$$

$$\sigma_x = \sqrt{\frac{1}{\sum_i trig^2(\phi_i)}} \tag{5}$$

$$\sigma_y = \sqrt{\frac{1}{\sum_i trig^2(2\phi_i))}} \tag{6}$$

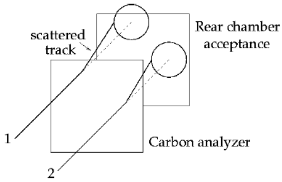
Fitting δ_p Dependence of Coefficients

- The coefficients agree for both methods, whereas the second method has much smaller errors, allowing for finer binning in δ_p and the ability to resolve finer structures in the inhomogeneities as one moves along the focal plane
- A polynomial fit as a function of δ_p was made for each coefficient (black curve)
- Note scale on plot below is 2.5$\times$ smaller than previous plot



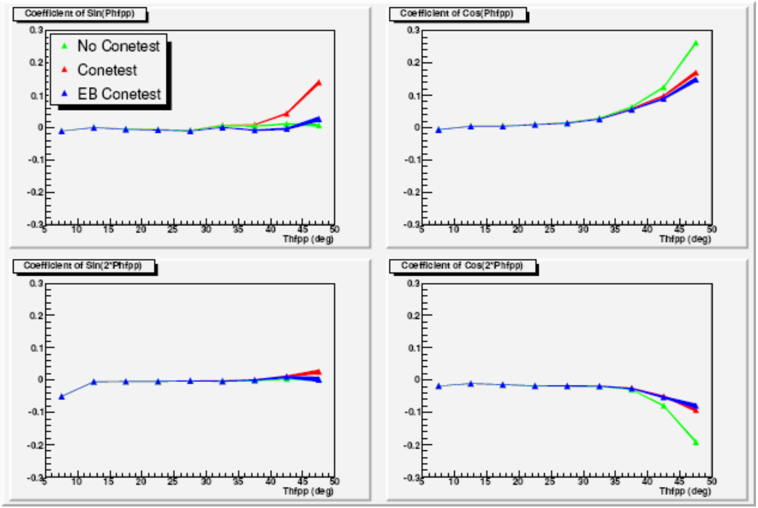
Conetest and False Asymmetries

- Two conetest options are available to help reduce false asymmetries
- For the original conetest, the hit location on the rear chamber $\pm$ a radius defined by the opening scattering angle, θ_{fpp}, in both x and y directions must lie within physical chamber area, otherwise the event is cut
- New conetest from Ed Brash replaces physical chamber area with polygon defined by responsive chamber area and calculates 8 points on circumference around hit which all must lie inside this polygon



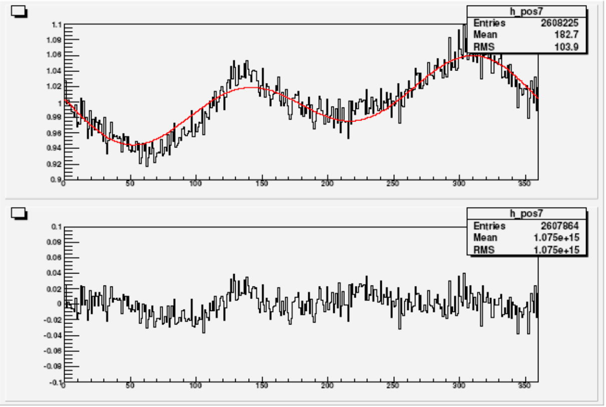
Dependence on Scattering Angle Theta

Small reduction in false asymmetries at higher angles when either conetest is implemented. Very few events at higher angles, so it is just as effective to make a cut of $\theta_{fpp} < 30^o$.



Result of Parameterization

Results of parameterization shown below as a function of ϕ_{fpp}. Top plot is helicity sum of elastic data for $0.015 < \delta_p < 0.025$, along with the instrumental asymmetry parameterization plotted for dp = 0.02. Bottom plot shows helicity sum subtracted by polynomial fit, resulting a flat distribution centered at zero.



E05-103 Induced Polarization Results

Shown below are the false asymmetry subtracted induced polarization results for the LEDEX experiment (black points). As the excitation energy grows, both the LEDEX and world data begins to diverge from the theoretical model of Schwamb and Arenhövel, indicating something is missing in the calculation.