# Report on False Asymmetry Studies for E91011

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The FPP (focal plane polarimeter) is used to measure the polarization of the recoil proton at the focal plane. The proton goes through a secondary scattering in a carbon analyzer. The azimuthal asymmetry of this scattering gives a measurement of the polarization. Figure 1 shows the components of the FPP, including the straw chambers, the carbon analyzer, and the azimuthal angle of the scattering ($\phi$). "False" instrumental asymmetries may be caused by misalignments of the FPP chambers with respect to each other and the VDCs and variations in the efficiency of the chambers. This report documents efforts to evaluate these false asymmetries. The false asymmetry is parameterized by four coefficients describing the functional dependence. Using a non-polarized electron beam, in the absence of false asymmetries, the sum distribution of H should be flat:

$$\frac{\sigma^+}{2\sigma_o^+} + \frac{\sigma^-}{2\sigma_o^-} = 1 + a_o \cos\phi + b_o \sin\phi + c_o \cos 2\phi + d_o \sin 2\phi.$$

First, the false asymmetry was examined as a function of spectrometer "delta" ($\delta$) - a so-called "delta-scan". Three sets of data were examined and compared:

- Data set #1: Radiative tail of the elastic $\mathrm{H}\,(e,e'p)$ reaction which was accepted at the $\theta_{cm} = -90^o$ point of our production runs (central momentum setting of 1.066 GeV/c).
- Data set #2: Five different elastic $\mathrm{H}\,(e,e'p)$ runs taken at the beginning of the experiment with central momentum settings of 0.786, 0.803, 0.819, 0.836, and 0.852 GeV/c.
- Data set #3: Elastic $\mathrm{H}\,(e,e'p)$ runs taken at the end of the experiment with central momentum setting of 1.188 GeV/c.

The expectation is that the extracted false asymmetries should be the same for these three data sets. The $\delta$-scan was done by binning the momentum from $\delta = -5\%$ to $+5\%$ in bins of 1%.

The initial analysis was done using "standard" (loose) cuts on the polar scattering angle, $3° < \theta_{fpp} < 70°$, and the distance from the first VDC plane to the point of the second scattering, $340\,\mathrm{cm} < z_{fpp} < 390\,\mathrm{cm}$ ($z_{fpp}$ is the same

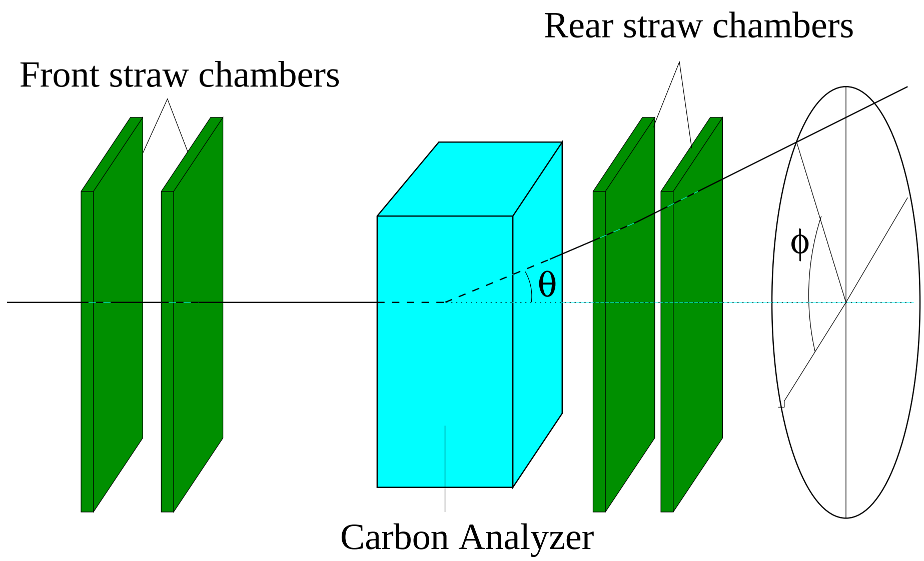



Figure 1: Components of the focal plane polarimeter (FPP).

as $zclose$). An alignment method developed by Mark Jones (MKJ method), that used software to translate and rotate the chambers for alignment and $f\,(track_{RAW}) \propto x,\, y,\, \theta,\, \phi$ was being implemented. Figure 2 is the resulting false asymmetry $\delta$-scans for the three data sets. As mentioned before, it is expected that all terms should be zero in the absence of false asymmetries.

Studies were done by Sonja Dieterich on the alignment methods used in the false asymmetry analysis. She compared the MKJ method to a method implemented by Ed Brash (EB method) which used the front track coordinates to determine rear track alignment also with $f\,(track_{RAW}) \propto x, y, \theta, \phi$. Figure 3 shows the comparison of these two methods. It seems from this plot that neither method is perfect in alignment. The straight line plotted over the data should fit the data in every region of the carbon, which is not the case. Sonja, along with Steffen Strauch developed a new alignment method (SSSD method). This method uses front track coordinated to align the front chambers, rear track coordinates to align the rear chambers, and $f\,(track_{RAW}) \propto x,\, y$ because of large angle-position correlations. Figure 4 shows a comparison of $\phi_{fpp}$ versus $z_{close}$ for EB, MKJ, and SSSD alignment methods. This type of plot should show the carbon analyzer region very clearly. The carbon should be straight, with sharply defined edges. Events not reconstructed inside the carbon analyzer should be rejected because they are unphysical. The EB method shows a non-straight carbon region while the MKJ method shows a straight carbon region, but edges which are not clearly defined. The SSSD method shows a sharply straight carbon region, allowing for a clear cut on the edges of the carbon. The SSSD alignment method should then be used in the false asymmetry analysis.

Next, the false asymmetry was examined as a function of $\theta_{fpp}$, using the

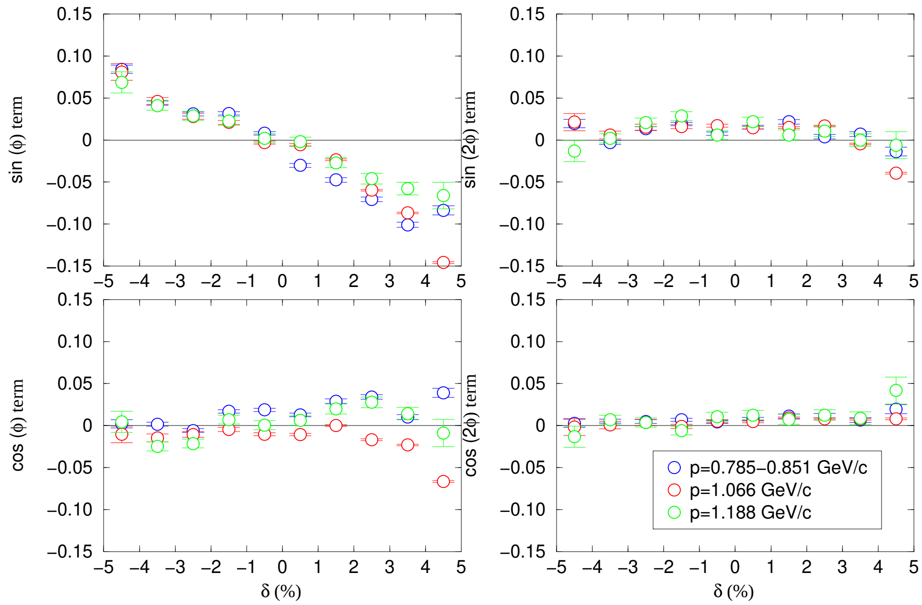
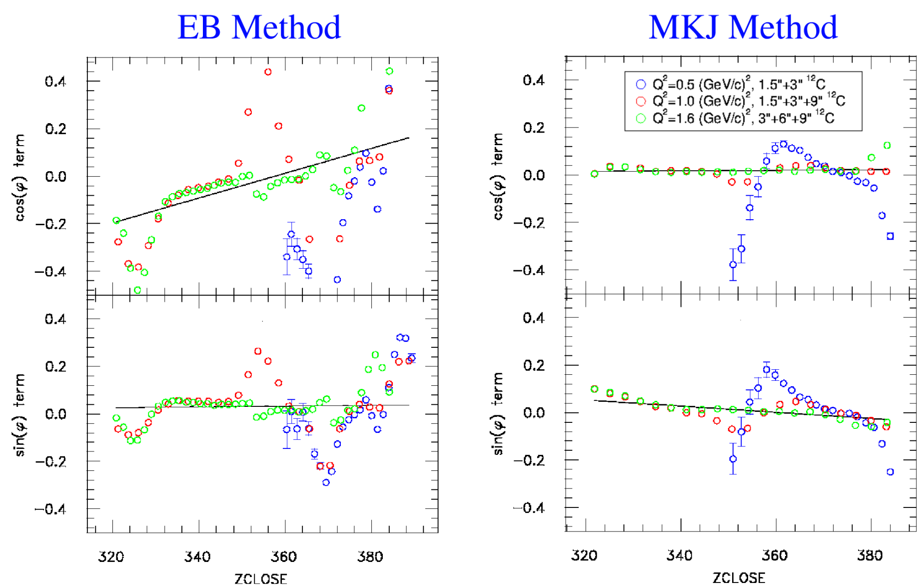



Figure 2: $\delta$-scan comparison of the p=0.785-0.851 GeV/c, p=1.066 GeV/c, and p=1.188 GeV/c elastic data sets. Using MKJ alignment, $3^\circ < \theta_{fpp} < 70^\circ$, and 340 cm $<z_{fpp}<$390 cm.

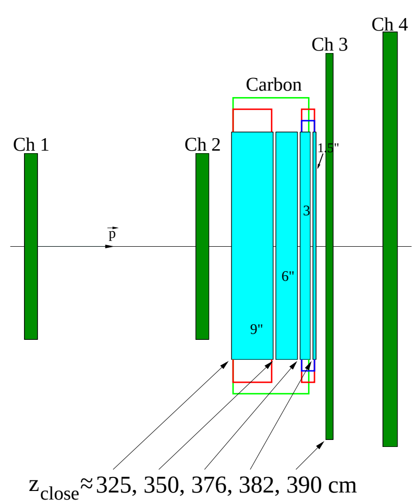
full $\delta$-range ($-5\% < \delta < +5\%$), the SSSD method, and cuts on the edges of the carbon block determined by making cuts on $z_{close}$ at the edges of the carbon. The result of this "$\theta_{fpp}$-scan" is shown in figure 5 where it is clear the false asymmetry changes rapidly for $\theta_{fpp} < 5^\circ$ and $\theta_{fpp} > 20^\circ$. For this reason, only events in the region of $5^\circ < \theta_{fpp} < 20^\circ$ will be included in further false asymmetry analysis.

Finally, using the above defined criteria: the SSSD alignment method, tight cuts on the carbon thickness in $z_{close}$, and $5^\circ < \theta_{fpp} < 20^\circ$, another $\delta$-scan was performed, for the range of -4.5%$<\delta<$+4.5% due to questions about the spectrometer acceptance reconstruction outside of this range. The results of this scan are shown in figure 6. Figure 8shows a comparison of the x versus y coverage at the position of straw chamber 3 of the elastic data used in the false asymmetry analysis to the x versus y coverage at chamber 3 of the production data for the N $\rightarrow \Delta$ experiment. The false asymmetry analysis was performed using a substantial region of the focal plane. Therefore, it is believed that the false asymmetries are understood very well.

Now, how do we deal with this false asymmetry in the final analysis? Should the values for the false asymmetry be averaged over the entire range of $\delta$, or should each $\delta$ bin be considered separately? Figure 7 shows the average $\delta$-scan of the three sets of elastic data over each term while table 1 shows the average of these terms over the full focal plane.




(a) Comparison of EB and MKJ methods.




(b) The colored lines at the carbon show the thickness, and therefore the zclose values of carbon used for the corresponding colored points in figure (a).

Figure 3: False asymmetry $\sin\phi$ and $\cos\phi$ term comparison of EB and MKJ alignment methods, performed by Sonja Dieterich.

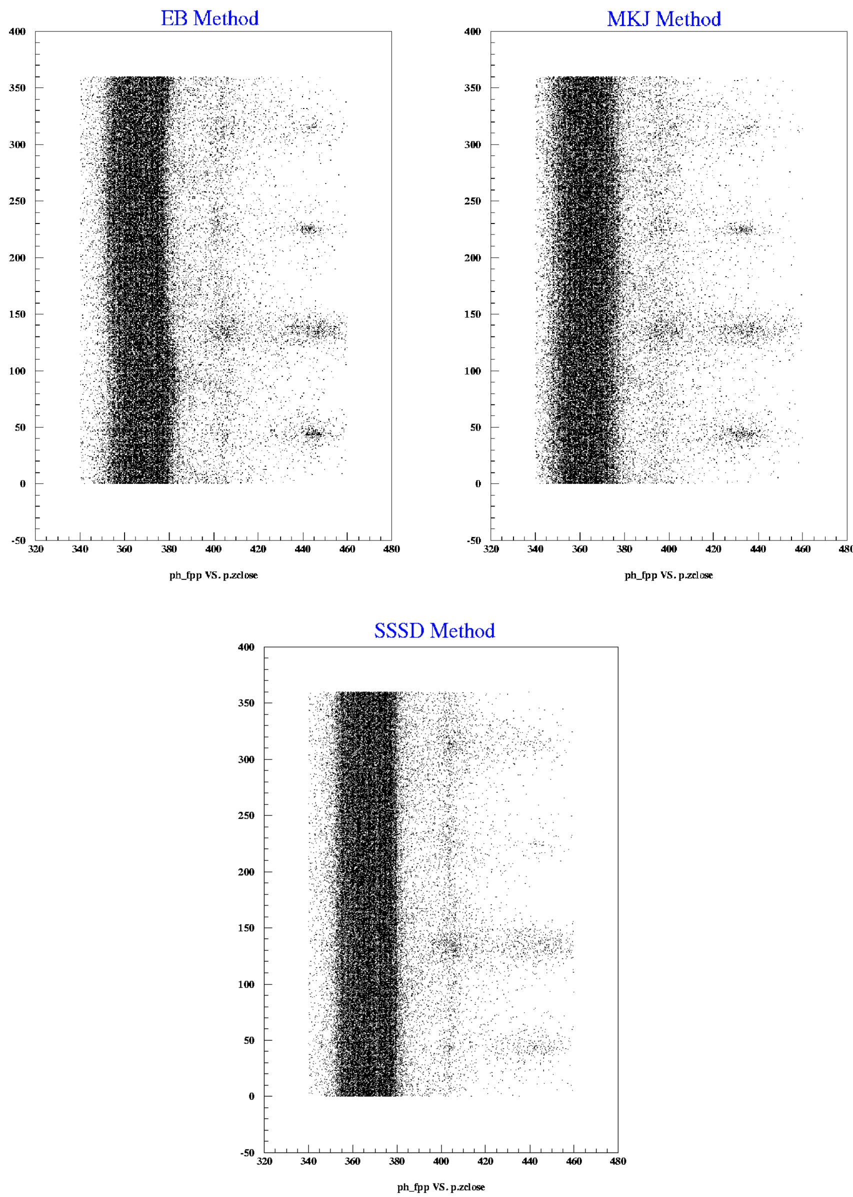



Figure 4: Comparison of $\phi_{fpp}$ versus $z_{close}$ for EB, MKJ, and SSSD alignment methods.

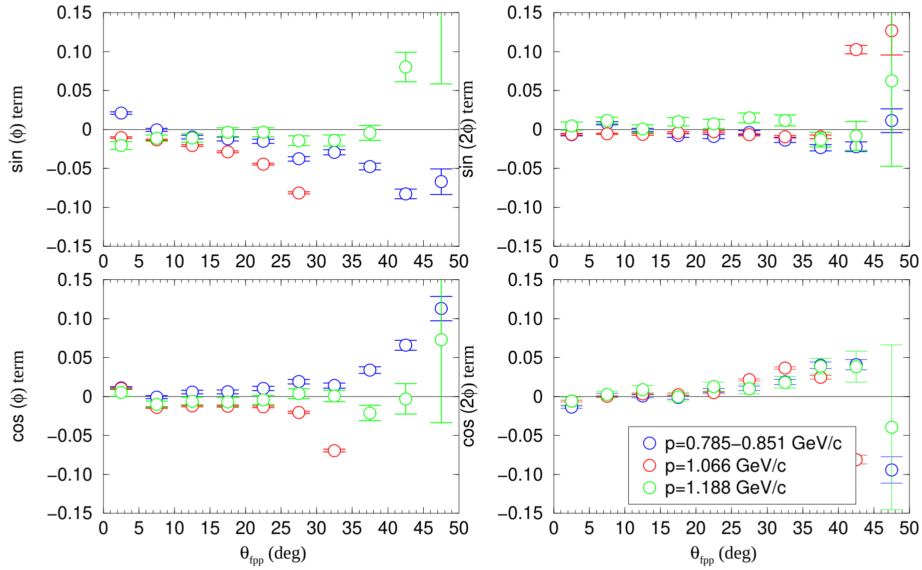



Figure 5: $\theta_{fpp}$-scan comparison of the p=0.785-0.851 GeV/c, p=1.066 GeV/c, and p=1.188 GeV/c elastic data sets. Using SSSD alignment, -5%<$\delta$<+5%, p=0.785-0.851 GeV/c: 369.5 cm<$z_{fpp}$<387.0 cm (1.5+3" $^{12}$C), and p=1.066 and p=1.188 GeV/c: 351.0 cm <$z_{fpp}$<381.0 cm (3+6" $^{12}$C).

| false asymmetry term | average over focal plane |
|---|---|
| $\cos\phi$ | -0.0068±0.0015 |
| $\sin\phi$ | -0.0070±0.0015 |
| $\cos 2\phi$ | 0.0032±0.0015 |
| $\sin 2\phi$ | 0.0003±0.0015 |

Table 1: Values obtained for the false asymmetries for the whole focal plane.

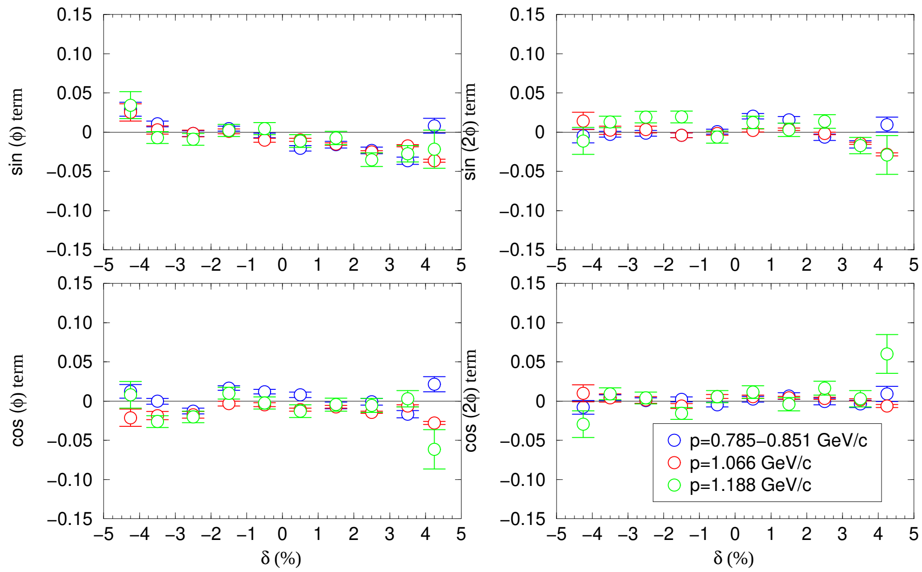



Figure 6: $\delta$-scan comparison of the p=0.785-0.851 GeV/c, p=1.066 GeV/c, and p=1.188 GeV/c elastic data sets. Using SSSD alignment, $5^\circ < \theta_{fpp} < 20^\circ$, p=0.785-0.851 GeV/c: 369.5 cm$<z_{fpp}<$387.0 cm (1.5+3" $^{12}$C), and p=1.066 and p=1.188 GeV/c: 351.0 cm $<z_{fpp}<$381.0 cm (3+6" $^{12}$C).

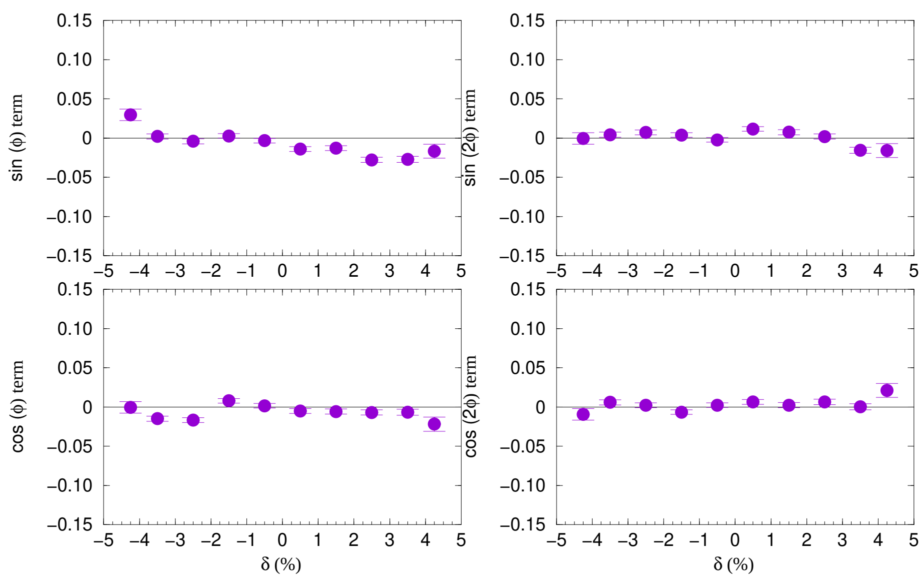



Figure 7: $\delta$-scan average of the p=0.785-0.851 GeV/c, p=1.066 GeV/c, and p=1.188 GeV/c elastic data sets. Using SSSD alignment, $5^\circ < \theta_{fpp} < 20^\circ$, and cuts in $z_{close}$ on the edges of the carbon blocks.

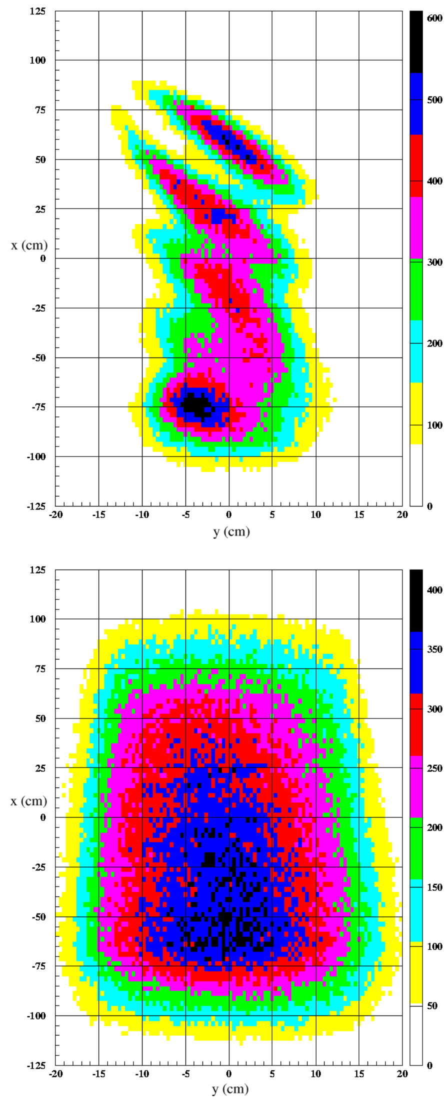



Figure 8: Comparison of elastic data used for false asymmetry analysis to actual coverage over entire experiment.