NH_3 Contamination in the ND_3 Target for EG1b
EG1b Technical Note

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Abstract

The EG1-DVCS data were found to have hydrogen contamination in their ND_3 target, leading to this analysis for EG1b data that used a similar target. Using exclusive ep elastic and quasi-elastic events, the polar component of the proton's momentum was plotted for NH_3 and ND_3. By looking at fits of the peaks from the momentum distributions, there appears to be a 5-6% contamination of hydrogen in the ND_3 target. The double spin cross section difference was plotted to determine if the contamination was from NH_3 or from an unknown, unpolarized source.

1 Introduction

The ND_3 target for the EG1-DVCS experiment was found to have a 10-15% contamination by polarized hydrogen (H).[1] We decided to study whether the EG1b data might have the same type of contamination. The EG1b experiment used a similar target as EG1-DVCS, and therefore the target may have also been contaminated. Previous analyses assumed a typical contamination of about 1-5% polarized H in the ND_3; however, a larger contamination was found in EG1-DVCS. Unfortunately, the EG1b was run several years ago and there is no possibility of doing mass spectrometry analysis on the target. If target contamination is found, this could lead to a measurement of false asymmetries. This paper will discuss the methods and results of this contamination analysis.

2 Method

The method used in this analysis relies on a comparison of exclusive ep elastic events from the proton and quasi-elastic events on the deuteron. The events were selected by applying normal particle identification methods for the electron and proton and the additional cuts shown in table 1. In table 1, ϕ_e is the azimuthal angle of the scattered electron and ϕ_p is the azimuthal angle of the scattered proton.

The CLAS detector is much more efficient at determining angular resolutions than momentum resolutions for undetected particles. In terms of angular resolutions, the in-plane (polar) resolution is higher than the difference in azimuthal angles.[2] Using the polar component of the proton's momentum (p_θ), we are

Additional Cuts
$-3.0 < \phi_e - \phi_p - 180.0 < 3.0$
$E_{missing}$ <1.15 GeV
$0.0 <\mid p_{missing} \mid< 0.5$
0.9 GeV $< m_{missing} <$ 1.0 GeV

Table 1: Elastic and quasi-elastic event selection cuts.

able to separate quasi-elastic events and elastic events. The polar component of the proton's momentum is given by

$$p_\theta = |p_p|(sin(\theta_p) - sin(\theta_Q)). \tag{1}$$

where p_p is the momentum of the proton, θ_p is the polar angle of the proton, and θ_Q is the polar angle of the virtual photon. The polar angle of the virtual photon is given by

$$\tan\theta_Q = \frac{1}{\left(\frac{E_{beam}}{m_p} + 1.0\right) \tan\left(\frac{\theta_e}{2.0}\right)}, \tag{2}$$

where E_{beam} is the beam energy and m_p is the mass of the proton. For p_θ, we assume that the scattering is elastic to get the sharpest possible peak for p(e,e'p). For quasi-elastic scattering, a broad peak is expected; for elastic scattering, a narrow peak is expected. The width of the quasi-elastic peak reflects the Fermi momentum of the nucleons in the nucleus, while the elastic peak width comes only from the (very high) CLAS resolution.

We plotted p_θ for three targets: ^{12}C, ND_3, and NH_3 for the 4.2 GeV inbending beam energy runs. Inbending runs are characterized by a positive torus current. The distributions were categorized by target, target polarization, and beam helicity. The plots were then normalized by their respective Faraday Cup counts. Summing the four distributions of target polarization and beam helicity, we are able to obtain a full distribution of the three targets. Using the full ^{12}C data, we are able to find a background fit form (Fig. 1). This fit is a good representative of the N and He background in the ND_3 and NH_3 targets. Subtracting the background fit, we are able to find a pure peak for the full NH_3 data. Then, using the fits from ^{12}C and NH_3, we are able to decompose the ND_3 data into the wider, quasi-elastic (deuteron) peak, described by a Gaussian, and the narrow elastic (hydrogen) peak. The results can be seen in Figures 1, 2, and 3. We are able to determine the percentage of contamination by integrating the ND_3 and NH_3 peaks. The results of integrating shows a 5-6% contamination. This contamination may come from NH_3 impurities, frozen H_2O, or other sources.

In order to determine if this contamination is polarized, we looked at the double spin cross-section (DSCS). The DSCS difference is given by

$$\text{DSCS} = (n^{\downarrow\uparrow} + n^{\uparrow\downarrow}) - (n^{\uparrow\uparrow} + n^{\downarrow\downarrow}), \tag{3}$$

where n is the number of normalized counts for p_θ with arrows indicating the relative beam and target polarizations. The DSCS difference was plotted for both polarized targets ND_3 and NH_3. Using the same fit parameters from the fitting of p_θ, we fitted the DSCS (Fig. 4). To determine the likelihood of a 5% contamination, a fixed contamination of 5% hydrogen was added to the fit for ND_3's DSCS. There was an increase in χ^2 of 1.22, as seen in figure 5. The increase in χ^2 suggests there is no polarized hydrogen contamination, with a 1-σ exculsion level of perhaps 2%. A 2% contamination of polarizable H would yield more than a 4% contribution to the DSCS. This contribution would appear strongly in the DSCS difference because H is more highly polarizable than D according to the equal spin temperature theory.

3 Conclusion

An analysis of p_θ shows a small contamination of 5-6% in the ND_3 data. There is no noticeable peak in the ND_3 data for the DSCS to suggest polarized H contamination. The contamination is unpolarized, as suggested by the χ^2 increase. Although the contamination appears to be unpolarized, and will not affect asymmetries, caution should be taken when analyzing the EG1b data as the contamination is another source of unpolarized background.

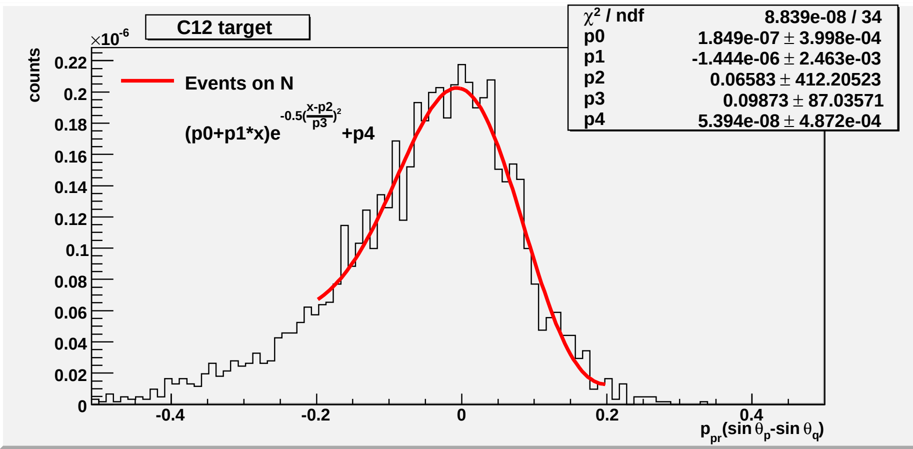

Figure 1: Results of p_θ distribution for ^{12}C(e,e'p)X

References

[1] Peter Bosted. Nh3 correction for nd3 target: Eg1-dvcs technical note 17. Technical report, November 2011.

[2] A. Klimenko and S. Kuhn. Momentum corrections for e6. Technical report, CLAS-NOTE-2003-005, 2003.

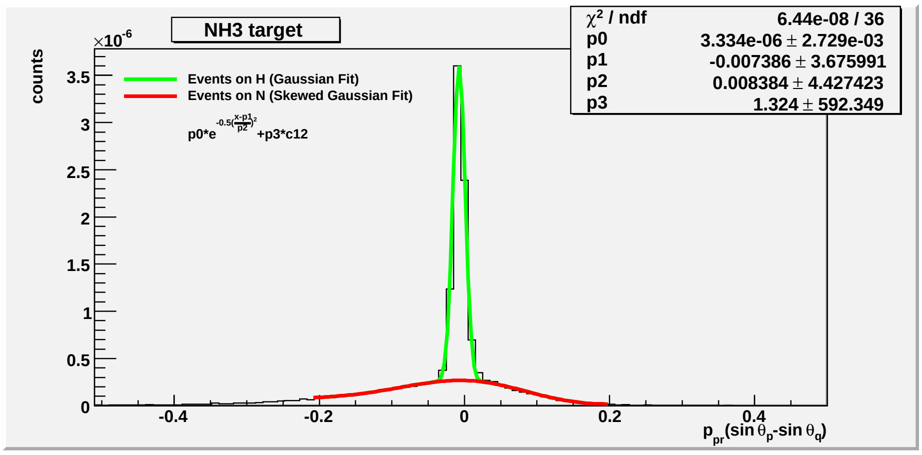

Figure 2: Results of p_θ for NH_3 targets.

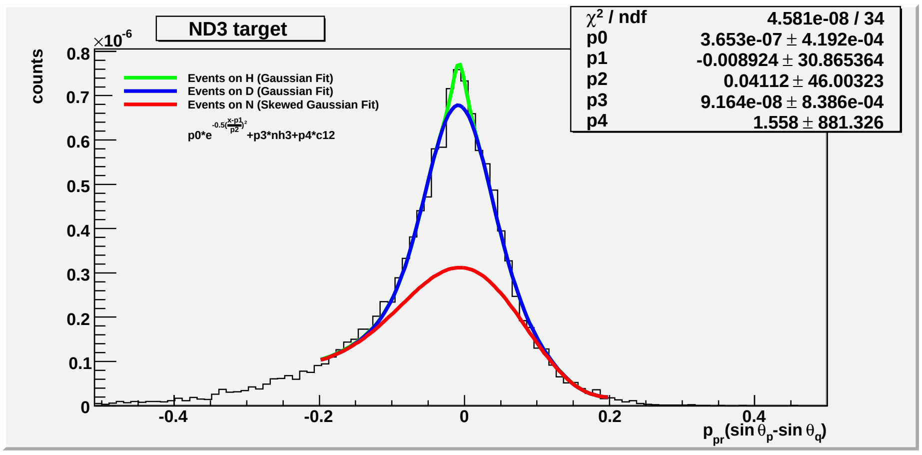

Figure 3: Results of p_θ for ND_3

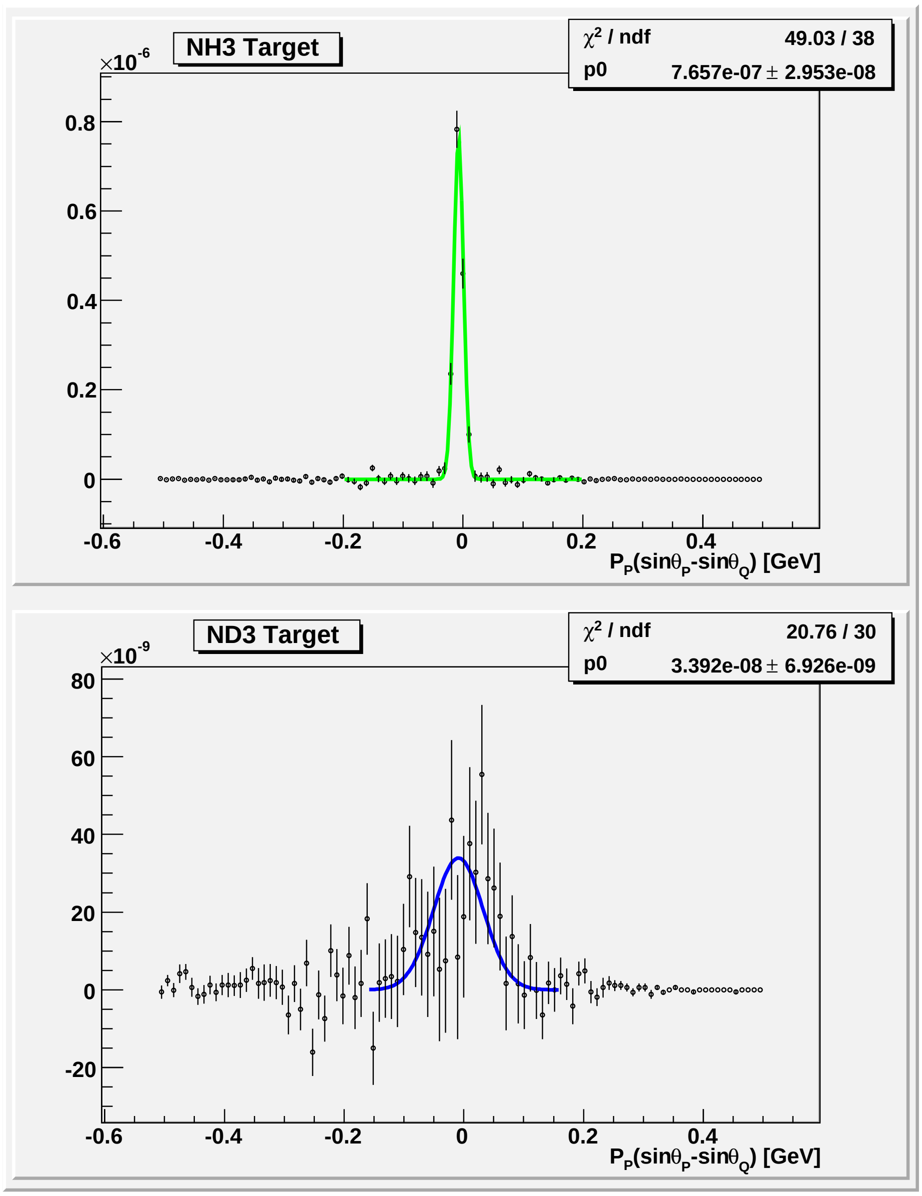

Figure 4: Double Spin Cross-Section Difference

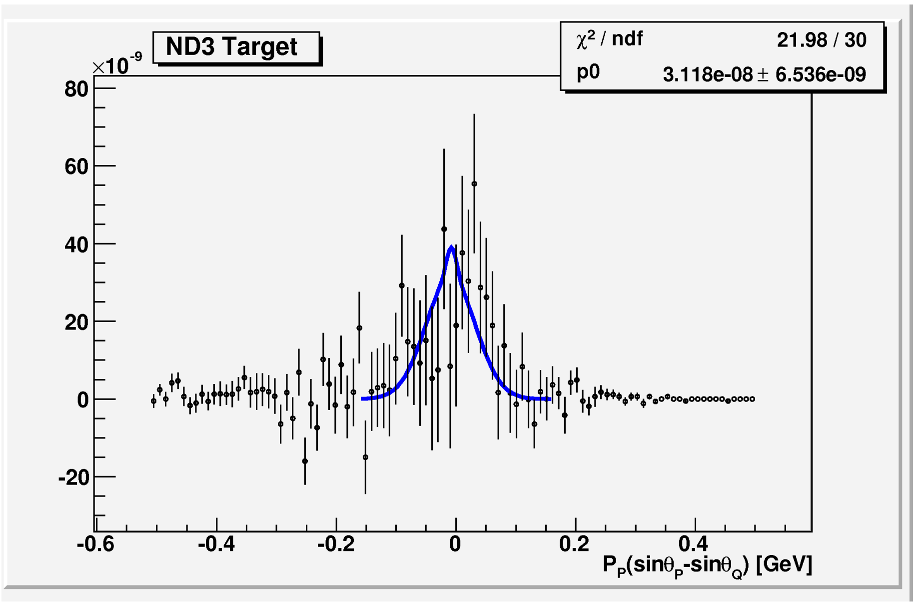

Figure 5: Double Spin Cross-Section Difference for ND_3 with a forced 5% H contamination fit