Beam Spin Asymmetry in Exclusive ω Photoproduction off the Bound Proton

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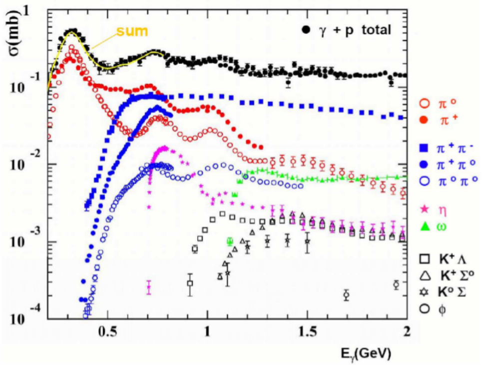
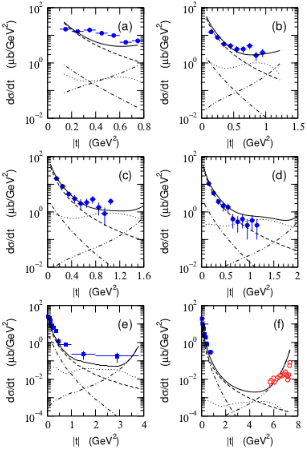
Motivation

- Baryon spectroscopy helps to understand the link between quark based models with QCD. Quark based models predict resonances that have not been experimentally observed.
- Studies of different channels should help finding "missing resonances"
- Resonances are broad and overlap. Spin observables are necessary to differentiate between resonant contributions.



ω channel

- s-channel dominant for high t.
- Previous data from GRAAL compared with Zhao model.(V. Vegna et al. PhysRevC.91.065207 (2015))



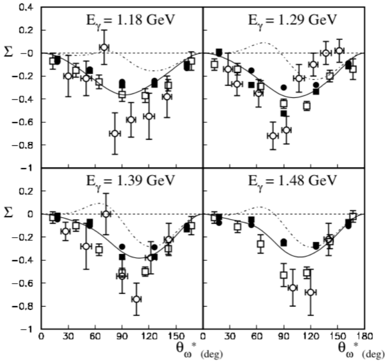
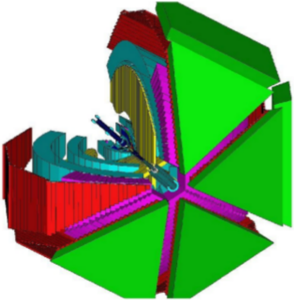
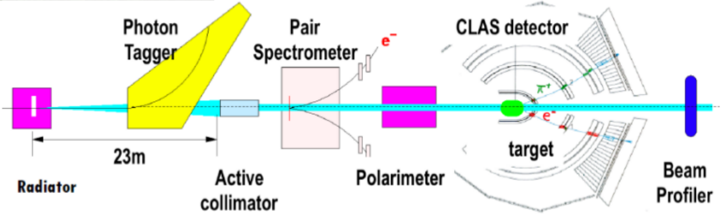


Figure: Oh, Y.; Titov, A. I.; Lee, T.-S. H., NSTAR 2001 proceedings

CEBAF: Continuous Electron Beam Accelerator Facility

CLAS: CEBAF Large Acceptance Spectrometer





$\vec{\gamma}p(n) \rightarrow \omega p(n)$ with $\omega \rightarrow \pi^+\pi^-\pi^0$ and $\pi^0 \rightarrow \gamma\gamma$

cut	description
PID charged particles	3σ for $\Delta\beta$ momentum dependent
PID photons	$\beta > 0.95$
tagged photon	$\Delta t_{\gamma\pi^-} < 2ns$
π^0 reconstruction	$3\sigma$for $IM^2(\gamma\gamma)$
charged particles time	$\Delta t_{\pi^-\pi^+}$ and $\Delta t_{\pi^-p} < 2ns$
other	fiducial, momentum and energy corrections, missing momentum

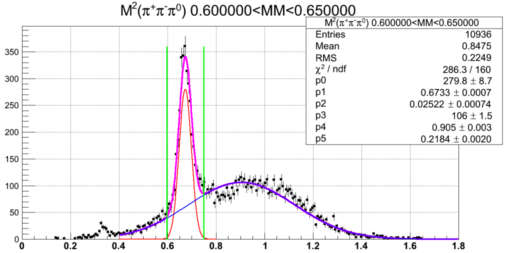


Figure: Invariant mass squared of the three pions for missing mass squared $0.6 < M^2(\vec{\gamma}d \rightarrow p\pi^+\pi^-\pi^0X) < 0.65 GeV/c^2$

$$\frac{(\frac{dN}{d\phi})^{\parallel} - (\frac{dN}{d\phi})^{\perp}}{(\frac{dN}{d\phi})^{\parallel} + (\frac{dN}{d\phi})^{\perp}} = \frac{F_R - 1 + \frac{F_R P_R + 1}{P_R + 1} 2\bar{P}\Sigma \frac{\sin\Delta\phi}{\Delta\phi} \cos\left(2(\phi - \phi_0)\right)}{F_R + 1 + \frac{F_R P_R - 1}{P_R + 1} 2\bar{P}\Sigma \frac{\sin\Delta\phi}{\Delta\phi} \cos\left(2(\phi - \phi_0)\right)} \quad (1)$$

with the flux ratio $F_R = \frac{F^{\parallel}}{F^{\perp}}$, polarization ratio $P_R = \frac{P^{\parallel}}{P^{\perp}}$, average of the polarization $\bar{P} = \frac{P^{\parallel} + P^{\perp}}{2}$, $\frac{\sin\Delta\phi}{\Delta\phi}$ correction for the bin width $\Delta\phi$ and ϕ_0 is the offset of the photon polarization vector [1]. We fix all but one variable in the fit.

- P_R and $\bar{P}$ are found using the polarization tables.

[1] Ref. N. Zachariou PhysRevC.91.055202 (2015)

$$\frac{(\frac{dN}{d\phi})^{\parallel} - (\frac{dN}{d\phi})^{\perp}}{(\frac{dN}{d\phi})^{\parallel} + (\frac{dN}{d\phi})^{\perp}} = \frac{F_R - 1 + \frac{F_R P_R + 1}{P_R + 1} 2\bar{P}\Sigma \frac{\sin\Delta\phi}{\Delta\phi} \cos(2(\phi - \phi_0))}{F_R + 1 + \frac{F_R P_R - 1}{P_R + 1} 2\bar{P}\Sigma \frac{\sin\Delta\phi}{\Delta\phi} \cos(2(\phi - \phi_0))} \quad (1)$$

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- P_R and $\bar{P}$ are found using the polarization tables.
- Calculate F_R based on a fit over the (1) integrated over all the $\cos\theta$ bins.

$E_\gamma(GeV)$	P_R	$\bar{P}$
1.1-1.3	0.88	0.754
1.3-1.5	1.01	0.782
1.5-1.7	0.96	0.750
1.7-1.9	0.94	0.676
1.9-2.1	0.99	0.730
2.1-2.3	1.02	0.695

[1] Ref. N. Zachariou PhysRevC.91.055202 (2015)

$$\frac{(\frac{dN}{d\phi})^{\parallel}-(\frac{dN}{d\phi})^{\perp}}{(\frac{dN}{d\phi})^{\parallel}+(\frac{dN}{d\phi})^{\perp}}=\frac{F_R-1+\frac{F_R P_R+1}{P_R+1}2\bar{P}\Sigma\frac{\sin\Delta\phi}{\Delta\phi}\cos\left(2(\phi-\phi_0)\right)}{F_R+1+\frac{F_R P_R-1}{P_R+1}2\bar{P}\Sigma\frac{\sin\Delta\phi}{\Delta\phi}\cos\left(2(\phi-\phi_0)\right)} \quad (1)$$

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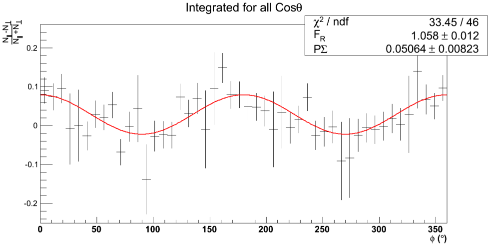

Figure: Example for $2.1 < E_{\gamma} < 2.3 GeV$

[1] Ref. N. Zachariou PhysRevC.91.055202 (2015)

$$\frac{(\frac{dN}{d\phi})^{\parallel} - (\frac{dN}{d\phi})^{\perp}}{(\frac{dN}{d\phi})^{\parallel} + (\frac{dN}{d\phi})^{\perp}} = \frac{F_R - 1 + \frac{F_R P_R + 1}{P_R + 1} 2\bar{P}\Sigma \frac{\sin\Delta\phi}{\Delta\phi}\cos(2(\phi - \phi_0))}{F_R + 1 + \frac{F_R P_R - 1}{P_R + 1} 2\bar{P}\Sigma \frac{\sin\Delta\phi}{\Delta\phi}\cos(2(\phi - \phi_0))} \quad (1)$$

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- P_R and $\bar{P}$ are found using the polarization tables.
- Calculate F_R based on a fit over the (1) integrated over all the $\cos\theta$ bins.
- $\phi_0 = 0$ as suggested by large statistics channel study

$E_\gamma(GeV)$	F_R	χ^2/NDF
1.1-1.3	0.485 ± 0.015	1.098
1.3-1.5	1.024 ± 0.015	1.325
1.5-1.7	1.198 ± 0.014	1.358
1.7-1.9	0.914 ± 0.009	0.875
1.9-2.1	1.056 ± 0.011	0.677
2.1-2.3	1.058 ± 0.012	0.727

[1] Ref. N. Zachariou PhysRevC.91.055202 (2015)

$$\frac{(\frac{dN}{d\phi})^{\parallel} - (\frac{dN}{d\phi})^{\perp}}{(\frac{dN}{d\phi})^{\parallel} + (\frac{dN}{d\phi})^{\perp}} = \frac{F_R - 1 + \frac{F_R P_R + 1}{P_R + 1} 2\bar{P}\Sigma \frac{\sin\Delta\phi}{\Delta\phi} \cos(2(\phi - \phi_0))}{F_R + 1 + \frac{F_R P_R - 1}{P_R + 1} 2\bar{P}\Sigma \frac{\sin\Delta\phi}{\Delta\phi} \cos(2(\phi - \phi_0))} \quad (1)$$

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Preliminary Results. Only statistical errors are shown

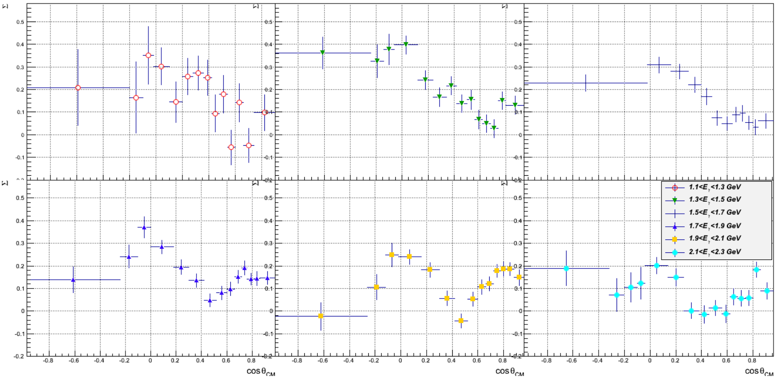

Figure: Beam Spin Asymmetry for $1.1 < E_\gamma < 2.3 GeV$ in energy bins of $\Delta E_\gamma = 200 MeV$

Conclusion and future work

* The method described before can be used to analyse quasi-free omega photoproduction data.
* We have enough statistics to calculate the Beam Spin asymmetry for energies between $1.1 < E_\gamma < 2.3 GeV$
* Background studies have to be done in order to compare our results with the GRAAL data (study already started, suggests that the background is not polarized).
* Systematic errors have to be calculated
* The Beam asymmetry for the ω can give us a hint about different missing resonances contributions for this channel

THANK YOU!