Helicity asymmetry in ω meson photoproduction off the proton

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Abstract. The excitation spectrum of the proton is comprised of many broad overlapping resonances. One tool in helping to understand the nucleon resonance spectrum is ω meson photoproduction off the proton. The CLAS FROST running period using circularly polarized photons on a longitudinally polarized butanol target allowed for the extracton of the helicity asymmetry in ω meson photoproduction off the proton. In this presentation I will show preliminary helicity asymmetry results for this reaction.

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MOTIVATION

An important tool in the effort to understand the internal structure of the proton and neutron is the spectroscopy of their excited states. The challenges presented in understanding the nucleon structure are large, in part due to the complexity of this strongly interacting system and to the presence of many broad and overlapping resonances. Thus probes that help isolate individual states and ascertain the importance of specific contributions are quite useful. Since ω mesons have isospin zero, the reaction $\gamma\, p \to p\, \omega$ is ideal in this regard, because the reactions provide an "isospin filter" to the proton excited states, as the ωp final state can only originate (in one-step processes) from isospin I=1/2 systems.

Previous data for the reaction $\gamma\, p \to p\, \omega$ have focused on differential cross sections and spin density matrix elements, e.g. [1]. The polarization observables are sensitive to interference between amplitudes, and so will be helpful in constraining models of the nucleon resonance spectrum in ways that previous data alone could not. There is no published data for this asymmetry. This data was taken with a butonal frozen spin target in the CLAS detector.

HELICITY ASYMMETRY

This polarization observable requires a circularly polarized photon beam and a longitudinally polarized target. This allows to measure the asymmetry between helicity states. For pseudoscalar meson photoproduction, this has been named helicity asymmetry, and is given the symbol E. However, the ω meson is a vector meson, so the symbol for this asymmetry is $C_{zz}^{\gamma N}$. This describes what particles are polarized: the incoming photon, γ, and the initial proton, N, and along what axis: z axis for both particles. For the photon the z refers to circular polarization. The definition of the helicity asymmetry is,

$$C_{zz}^{\gamma N} = \frac{\sigma_- - \sigma_+}{\sigma_- + \sigma_+}, \tag{1}$$

where σ_+ and σ_- are the differential cross section when the helicity of the photon and the proton are aligned or anti-aligned, respectively. When analyzing the experimental results the polarization of the target and beam have to be taken into account in

$$C_{zz}^{\gamma N} = \frac{1}{P_z P_c} \frac{Y_- - Y_+}{Y_- + Y_+}, \tag{2}$$

where P_z is the polarization of the target, P_c is the polarization of the beam, and Y_+ and Y_- are the yields when the polarization of the beam and target are aligned or anti-aligned, respectively. The bound nucleons in butonal have no polarization.

EXPERIMENTAL FACILITIES

The data was taken from November 2007 to February 2008 with the, now defunct, CLAS detector [2]. The target for this experimental run was a butanol frozen spin target (FROST), which was maintained at a temperature near 35 mK and with a carbon target downstream of the butanol target. The carbon target was used to represent the bound nucleon contribution of butanol. The longitudinal polarization of the target averaged 80% during the run. The electron beam had energies of 1.645 GeV and 2.478 GeV, and an averaged 85% polarization.

ANALYSIS

Since the ω meson decays before it could be detected, and the ω is a neutral particle, it is not detected directly by the CLAS detector. The missing mass technique is used to find the ω, assuming the reaction $\gamma\, p \rightarrow p\, X$, where X is the missing particle. Unfortunately, the ρ peak overlaps with the ω peak in this missing mass spectrum. To separate the two signals the decay channel $\omega \rightarrow \pi^+\pi^-\pi^0$, which has a branching ratio of 89% [3], is used. The π^+ and π^- are detected in CLAS, and the π^0 is identified in the missing mass spectrum for the reaction $\gamma p \rightarrow p\pi^+\pi^- X$. Once events with a final state of $p\pi^+\pi^-\pi^0$ are identified a missing mass spectrum for the reaction $\gamma\, p \rightarrow p\, X$ is constructed from those events, and the ω peak can be fit with a Gaussian curve plus a polynomial curve to account for the background. From those fits, yields can be extracted and asymmetries formed following Eq 2. In Figure 1 preliminary helicity asymmetries for 50-MeV wide center-of-mass energy bins of W = 1775 MeV, 1825 MeV, 1875 MeV, and 1925 MeV are compared to predictions from M. Paris [4]. This model is an extension to the ωN channel of the Excited Baryon Analysis Center's dynamical coupled channel model [5]. These prediction curves follow similar trends as the data, but show definite differences,

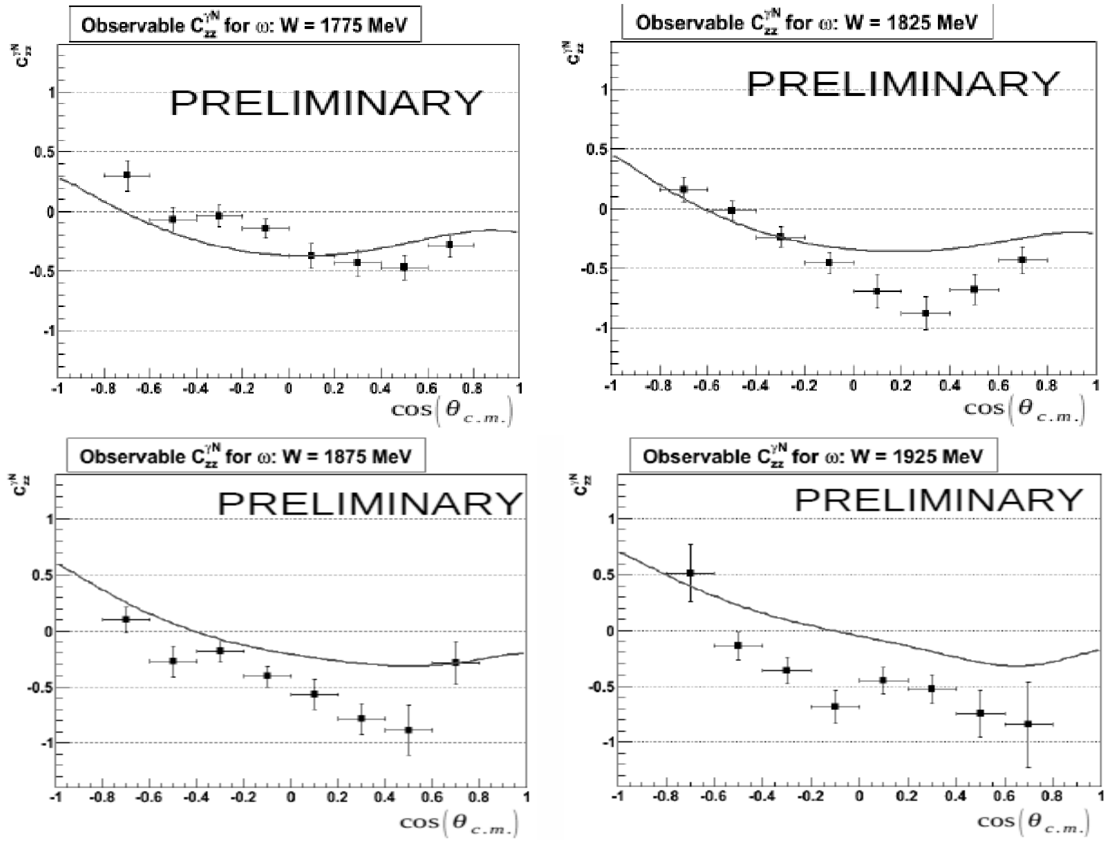

FIGURE 1. Helicity asymmetries for $\gamma\, p \rightarrow p\, \omega$, where $\theta_{c.m.}$ is the polar angle of the ω in the center-of-mass system. The curves are predictions from M. Paris [4].

an example of how this data will be useful in improving models of the nucleon resonance spectrum.

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