HELICITY-DEPENDENT ANGULAR DISTRIBUTIONS FOR DOUBLE-CHARGED-PION PHOTOPRODUCTION*

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Two-pion photoproduction in the reaction $\vec{\gamma}p \to p\pi^+\pi^-$ has been studied at Jefferson Lab Hall B using a circularly-polarized tagged photon beam in the energy range between 0.6 GeV and 2.3 GeV. Beam-helicity-dependent angular distributions of the final-state particles were measured. The large cross-section asymmetries that have been found exhibit strong sensitivity to the kinematics of the reaction, and are compared with preliminary model calculations by Mokeev and Roberts.

1. Introduction

Many nucleon resonances in the mass region above 1.6 GeV decay predominantly through $\Delta\pi$ or $N\rho$ intermediate states into $N\pi\pi$ final states (see the Particle-Data Group review[1]). This makes electromagnetic exclusive double-pion production an important tool in the investigation of N^* structure and reaction dynamics, as well as in the search for "missing" baryon states. Unpolarized cross-section measurements of double-pion electroproduction have been reported recently by the CLAS collaboration.[2] Further constraints are to be found in polarization observables.

Here, for the first time in the resonance region, a measurement of the $\vec{\gamma}p \to p\pi^+\pi^-$ reaction is reported, where the photon beam is circularly polarized and no nuclear polarizations (target or recoil) are specified. The

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cross-section asymmetry is defined by:

$$A = \frac{1}{P_\gamma} \cdot \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-} , \quad (1)$$

where P_γ is the degree of circular polarization of the photon and $\sigma^\pm$ is the cross section for the two photon-helicity states $\lambda_\gamma = \pm 1$. For this kind of study, a final state of at least three particles is necessary, since reactions with two-body final states are always coplanar and have identical cross sections for unpolarized or circularly polarized photons, so that $A = 0$.

2. Experiment

The $\vec{\gamma} p \to p \pi^+ \pi^-$ reaction was studied with the CEBAF Large Acceptance Spectrometer (CLAS)[3] at Jefferson Lab. A schematic view of the reaction is shown in Fig. 1.[a] Longitudinally polarized electrons with an energy of

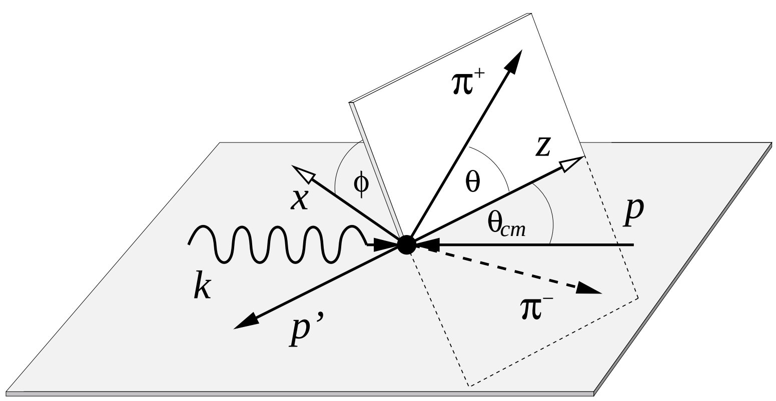

Figure 1. Angle definitions for the circular polarized real-photon reaction $\vec{\gamma} p \to p \pi^+ \pi^-$ in the helicity frame; θ_{cm} is defined in the overall center-of-mass frame, θ and ϕ are defined as the π^+ polar and azimuthal angles in the rest frame of the $\pi^+ \pi^-$ system.

2.4 GeV were incident on the thin radiator of the Hall-B Photon Tagger[6] and produced circularly-polarized tagged photons in the energy range between 0.6 GeV and 2.3 GeV. The collimated photon beam irradiated a liquid-hydrogen target. The circular polarization of the photon beam was determined from the electron-beam polarization and the ratio of photon

[a]The definition of ϕ is following the convention of Schilling, Seyboth and Wolf[4], and differs by a phase of π from Φ^* in Ref. [5].

and incident electron energy.[7] The reaction channel was identified by the missing-mass technique, which requires the detection of at least two out of three final-state particles (p, π^+, and π^-). Owing to the large angular acceptance of the CLAS, complete azimuthal angular distributions of the cross-section asymmetries were observed.

3. Results

The $\vec{\gamma}p \to p\pi^+\pi^-$ reaction has been analyzed for center-of-mass energies W up to 2.3 GeV. Figure 2 shows preliminary ϕ angular distributions of the cross-section helicity asymmetry for various selected 25-MeV wide c.m. energy bins between $W = 1.40$ GeV and 1.65 GeV. The data are integrated over the full CLAS acceptance. The preliminary analysis shows large asymmetries, with the symmetry $A(\phi) = -A(2\pi - \phi)$. This is expected from parity conservation.[4] A more detailed analysis has revealed a rich structure of these data with rapid changes of the angular distributions with photon energy or with any other kinematical variable.[5]

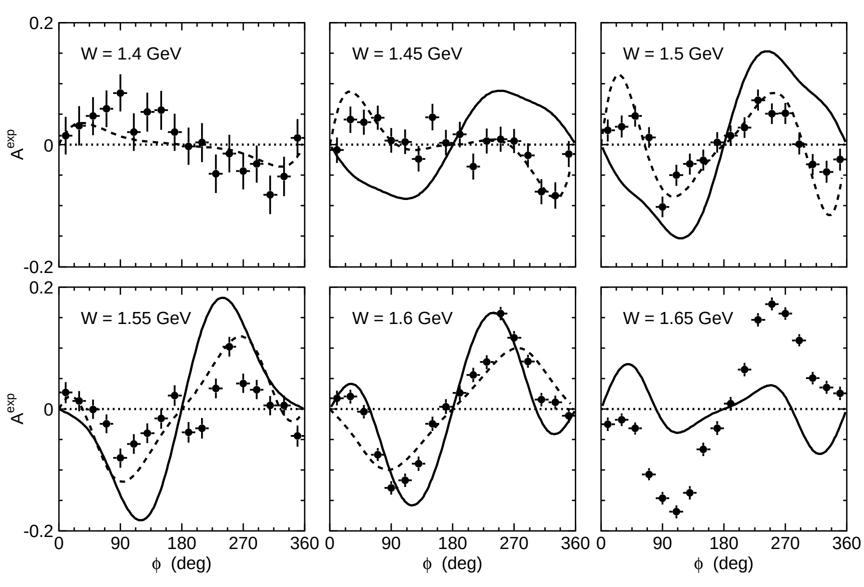

Figure 2. Preliminary angular distributions for six different center-of-mass energy bins ($\Delta W = 25$ MeV) of the cross-section asymmetry for the $\vec{\gamma}p \to p\pi^+\pi^-$ reaction. The dashed curves are calculations by Roberts[8] (4π integrated, $W \leq 1.60$ GeV). The solid curves are calculations by Mokeev *et al.*[9] (acceptance corrected, $W \geq 1.45$ GeV).

K. Schilling, P. Seyboth and G. Wolf discussed the case of photoproduction of vector mesons by polarized photons on an unpolarized nucleon and their subsequent decay distribution.[4] Preliminary calculations of cross-section asymmetries in the general case of $\vec{\gamma}p \rightarrow p\pi^+\pi^-$ were done by Oed and Roberts using a phenomenological Lagrangian approach.[8] It is important to note that the calculations performed to date have been integrated over 4π, whereas the experimental data have been measured only over the coverage of the CLAS. The results of these calculations are shown in Fig. 2 as the dashed curves. Calculations including the CLAS acceptance will be available soon. In general, a very good description of the data has been achieved. Results have also been obtained by Mokeev *et al.* in a phenomenological calculation using available information on the N and Δ states.[9] Parameters of this phenomenological code have been fitted to CLAS cross-section data for real- and virtual-photon double-charged-pion production. The results are shown in Fig. 2 as the solid lines. The CLAS acceptance was taken into account in this calculation. Neither model has yet been adjusted to the polarization data, and therefore these results are preliminary. There clearly is room for improvement in the model parameters. In fact, current studies have indicated a strong sensitivity of the helicity asymmetries to the relative contributions of various isobaric channels and interference among them.[5,9] These data will therefore prove to be an important tool in baryon spectroscopy.

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