Measurements of spin observables in pseudo-scalar meson photo-production using polarized neutrons in solid HD [a]

T. Kageya[†](*On behalf of CLAS collaboration*)

[†] *Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA*

Abstract

A measurement of psuedo-scalar meson photo production from longitudinally polarized solid HD has been carried out with the CLAS at Thomas Jefferson National Accelerator Facility with circular and linear polarized photon beams. Its aim is to measure a complete set of spin observables for the neutron simultaneously from the same experiment. As a polarized neutron, deutron in HD was used and its average polarization was about 20 %. The calibrations of the CLAS detectors are on going and preliminary asymmetries are shown for the π^- channel.

1. Introduction

Understanding the quark models based on QCD is an important issue for nuclear physics. Lattice calculations have recently confirmed the long-standing quark model predictions of many resonance states which are missing experimentally. The resonances overlap each other due to their widths. They might not be coupled to channels in which partial wave analyses have been done in the past data. This experiment aimes to explore this issue by observing a large number of spin observables simultaneously from the same experimental conditions, which will greatly improve the partial wave analyses.

The experiment was carried out from December 2011 through May 2012 in Hall-B at Thomas Jefferson National Accelerator Facility with circularly and linearly polarized tagged photon beams on longitudinally polarized solid HD target. The spin asymmetries can be decomposed into three amplitudes two with I = 1/2 and one with 3/2, resulting from coupling the I = 1/2 nucleon with iso-scalar and iso-vector components of the photon field

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to yield a total isospin of 1/2. The I = 3/2 amplitudes characterize the Δ states and ones with I = 1/2 the N* states. The I = 3/2 Δ resonances can be determined either from proton or neutron data alone, while I = 1/2 N* ones need both p and n data. The neutron data are very poorly known; the aim of this experiment is to take data for neutron using D in HD as a polarized neutron target.

2. Experimental setup

Circularly and linearly polarized photon beams have been obtained by bremsstrahlung via longitudinally polarized electron beams from CEBAF (Continuous Electron Beam Accelerator Facility), whose energy has been measured by tagging [1]. The energies of circularly and longitudinally polarized photon had ranges of 0.85 to 2.4 GeV and 1.6 to 2.2 GeV, respectively.

The CLAS (CEBAF Large Angle Spectrometer) consists of drift chambers with a Torus magnet, time-of-flight counters, gas Cherenkov counters and electromagnetic calorimeters [2]. For experiments using photon beams, a Start Counter [3] surrounding the polarized target was used for the first level trigger as well as TOF counters.

As a polarized neutron target, the newly installed frozen-spin HD solid target was used; this had has a small dilution factor and a long spin relaxation time. About 0.44 moles of HD was condensed into a Kel-F cylindrical cell of 1.5 cm diameter and 5 cm length. In the cell pure thin Aluminum wires were used to conduct the conversion heat from H_2 and D_2, which are present at the 10^{-3} level in HD. Ortho-H_2 and para-D_2 are used to polarize HD at 20 mK and 15 Tesla in an Oxford Dilution Fridge; in three months, the most of these spin states are converted into para-H_2 and ortho-D_2 which do not spin exchange with HD resulting in frozen spin states. The contributions of the Kel-F target cell and Aluminum wires to the spin-asymmetries can be subtracted to obtain the yield from pure HD, by measuring he yield from the target cell alone. Target polarizations were calibrated, measured and monitored by NMR using the cross coil method. An In-Beam cryostat (IBC) was designed and constructed at Jlab for the frozen spin HD target, which was inserted into the center of CLAS. The cryostat was a dilution refrigerator which cools to 50 mK in the mixing chamber and has a superconducting solenoid of 1 Tesla for a longitudinal holding field. The details of the polarized solid HD target are described in the contribution of this conference by Xiangdong Wei.

3. Experimental running conditions and preliminary results

1-prong or 2-prong triggers in which at least one or two charged particles were detected in CLAS were used during the first month; in the remainder

of the experiment, 2-prong with pre-scaled 1-prong triggers were applied. The 1-prong trigger was aimed to get reactions; γ + p $\rightarrow$ π^+ + X and γ + n(p) $\rightarrow$ π^- + X where (p) means the spectator proton, while the 2-prong one was for γ + n(p) $\rightarrow$ π^- + p + X(0, π^0, ...). Data were taken on circularly and longitudinally polarized photon beams for 64 days (11 B events) and 30 days (4 B events), respectively. The target H polarization was transferred to D using a saturated forbidden transition to get a higher D polarization. The average D polarization in HDice target was about 20 % during the data taking. D polarization was flipped by changing the polarity of the holding field, while ones for H were flipped and zeroed during different periods. The spin relaxation times for D and H were observed to be more than a year.

Particle identification for charged particles has been done using β versus momentum distributions to select $\pi^\pm$ and protons. The missing mass distributions have been made from the photon beam energies and reconstructed 4-momenta of $\pi^\pm$; clear peaks are observed at proton and neutron masses which give the missing mass cuts. Events whose vertices on the beam axis for are originated from the HD target have been selected.

Preliminary inclusive double-spin E asymmetries (polar angle dependence at CM) using circularly polarized photon beams (about 10 % of the data) for the reaction, γ + n(p) $\rightarrow$ π^- + X are shown in Figure 1 (four photon beam energies). Significant asymmetries are observed. Calibrations for the tagger, start counters, time of flight counters, drift chamber, and electromagnetic calorimeter as well as the determinations of the target polarizations are on going. A further analysis for an exclusive reaction, γ + n(p) $\rightarrow$ π^- + p in which both of π^- and p were detected in CLAS, will be done with an coplanarity cut and the empty target subtractions.

The detailed results for H in the g9 (FROST) experiments have been presented by B. Briscoe in the contribution of this conference.

4. Summary

The double spin polarization experiments have been carried out in Hall B at Jlab using polarized photon beams, CLAS and polarized HD solid targets. Preliminary E asymmetries are shown in this contribution and more analyses are on going for different channels to obtain other spin observables.

References

1. *Stepanyan S. et al* Nucle. Instr. and Meth. A 2007. V.572. P.654.
2. *Mecking B.A. et al* Nucle. Instr. and Meth. A 2003. V.503. P.513.
3. *Sharabian Y.G. et al* Nucle. Instr. and Meth. A 2006. V.556. P.246.

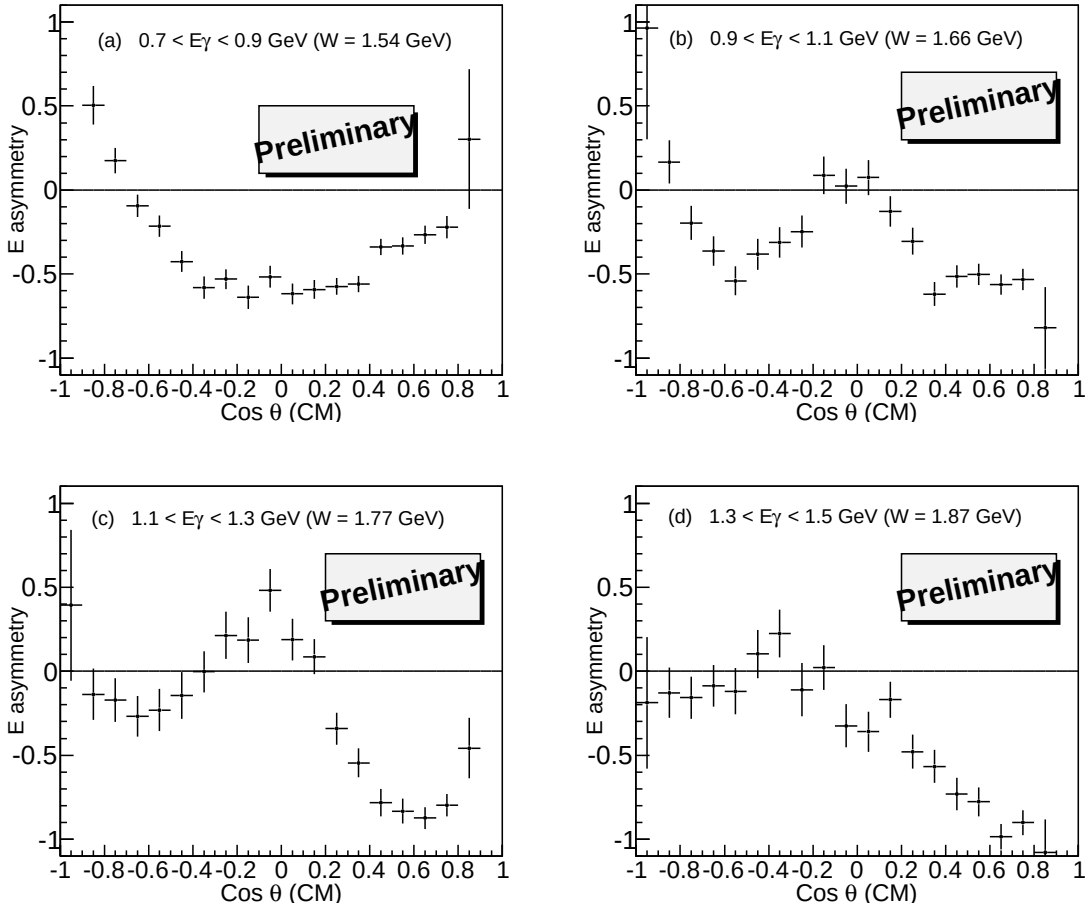

Figure 1. Preliminary double spin E asymmetries (polar angle dependences at CM) for γ + n(p) $\rightarrow$ π^- + X(p) after the particle identification of π^- and missing mass cuts (about 10% of data used). (a) $0.7 \leq E_\gamma \leq 0.9$ GeV (W = 1.54 GeV), (b) $0.9 \leq E_\gamma \leq 1.1$ GeV (W = 1.66 GeV), (c) $1.1 \leq E_\gamma \leq 1.3$ GeV (W = 1.77 GeV) and (d) $1.3 \leq E_\gamma \leq 1.5$ GeV (W = 1.87 GeV) where P_D is assumed to be 26.5 %. Only statistical errors are shown.