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

Tsuneo Kageyai (*On behalf of CLAS collaboration*) *

Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA
kageya@jlab.org

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Psuedo-scalar meson photo production measurement has been carried out on longitudinally polarized neutron with the circularly and linearly polarized photon beams and the CLAS at Thomas Jefferson Accelerator Facility (Jlab). The experiments aim to obtain a complete set of spin observables on the neutron. Preliminary E asymmetries for an exclusive reaction, γ + n(p) $\rightarrow \pi^-$ + p(p), selecting quasi free neutron events will be discussed.

Keywords: spin; quark-model; HD.

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1. Introduction

We aim to study the missing resonances predicted from the quark models based on QCD but not observed experimentally. The resonances overlap each other due to their widths and some are not be coupled strongly to channels for which partial wave analyses have been performed in the past. Lattice calculations have recently supported the long-standing quark model predictions of many resonance states which are missing experimentally[1].

The I = 3/2 Δ resonances can be determined either from proton or neutron data alone. In order to study N* states with I = 1/2, both data from proton and neutron are required. The data for neutron are poorly known. The g14 experiments in the Hall-B were performed from December 2011 through May 2012 to observe a large number of spin observables for polarized neutron on deuteron using HD solid target with a circularly and linearly polarized photon beams. The data are expected to greatly improve the partial wave analyses.

*Tel.: +17572695460; fax: +17572695800

2. Data reductions and preliminary results for γ + n(p) $\rightarrow \pi^-$ + p(p)

Data were taken on circularly (64 days of 11x10^9 events) and linearly (30 days of 4x10^9 events) polarized photon beams whose energy ranged from 0.85 to 2.4 GeV and from 1.6 to 2.2 GeV, respectively.

The newly installed solid, frozen-spin Hydrogen Deuteride (HD) targets[2] were successfully used as neutron targets in the measurements in the Hall B. The In-Beam Cryostat inserted into CLAS has been designed and constructed by HDice group at Jlab. It is a dilution fridge which cools down to 50 mK at the mixing chamber and has a superconducting magnet whose holding field is 1 Tesla. The average D polarization in HD target was about 20% for the whole runs monitored by NMR and its spin relaxation time had been observed to be more than a year during the data taking.

For the exclusive reaction measurements, particle identification for charged particles has been carried out using β versus momentum distributions to select events in which one π^- and one proton were detected in the CLAS. In order to select quasi free neutron events, the following three distributions have been made and cuts are applied. In Figure 1 (a), an azimuthal angle difference between π^- and proton is shown to have a peak at around 180 degrees where the quasi free neutron events are located. Cuts are applied between 160 and 200 degrees as shown in shaded area. A missing mass squared distribution for γ + n(p) $\rightarrow \pi^-$ + p + X is shown in Figure 1 (b). The clear peak at around zero is observed; the peak at around 0.03 GeV^2 could be mainly from two pion events and the tail to the left from other background events. A cut has been applied to select the shaded area as shown in the figure. Missing momentum distribution for the reaction is shown in Figure 1 (c). A dashed curve shown in Figure 1 (c) based on P_N from Hamada-Johnson NN potential[3] reproduces the data shape which suggests that our cuts are appropriate. A cut has been applied to select the missing momentum to be lower than 0.2 GeV to exclude bound neutron reactions.

A background contribution from the target cell including pure thin aluminum wires to cool down HD is obtained by taking data with only the target cell to be used to extract a pure HD contribution. Figure 1 (d) shows the reconstructed vertex distributions; pure HD (solid curve) can be obtained by subtracting the target cell (dashed dotted curve) from the both of HD and target cell (dashed curve), where the distribution from the target cell has been normalized with the flux. The vertex cut as shown in the same figure as shaded area between two arrows has been applied for this purpose.

Preliminary exclusive E asymmetries after the above cuts using circularly polarized photon beams on longitudinally polarized nucleon target ($\sim$ 10% of the data) are shown in Figure 2 for the reaction, γ + n(p) $\rightarrow \pi^-$ + p(p). Significant asymmetries are observed. Only statistical errors are shown and their sizes will be decreased as CLAS calibrations proceed and more data are combined. In the same figure, pre-

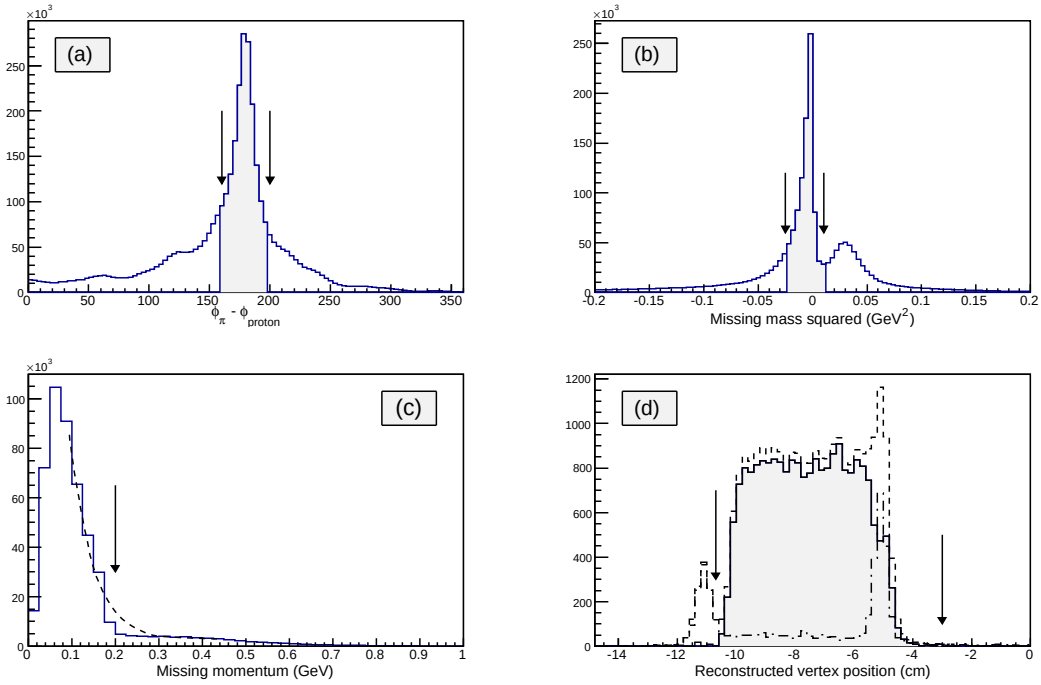

Fig. 1. Data reductions to extract quasi-free neutron reactions; (a) co-planarity cut from the azimuthal angle difference between π^- and proton, (b) missing mass squared distribution and cut and (c) missing momentum and cut. The data distributions are from data for the range of 1.48 $\leq$ W $\leq$ 1.82 GeV. The selected areas are shown as shaded ones between two arrows ((a) and (b)) and a cut to be less than 0.2 GeV is applied to (c). A curve based on P_N from Hamada-Johnson NN potential normalized to the data for its shape comparison is also shown in the dashed curve in (c). (d) shows the vertex distributions reconstructed by CLAS whose data were taken for 0.4 $\leq$ cosθ_{π^-} $\leq$ 0.5 on 1.72 $\leq$ W $\leq$ 1.82 GeV; the pure HD contributions (shaded) are obtained by subtracting the target cell (dashed dotted) from data taken with HD (dashed). A vertex cut between two arrows has been applied.

dictions from SAID (SN11)[4] and MAID[5] are shown with solid and dashed curves, respectively.

3. Summary

Double spin polarization experiments for a neutron have been carried out in Hall B at Jlab using polarized photon beams, CLAS and frozen spin HD solid targets. Calibrations of CLAS detectors have been ongoing and determinations of target polarizations have been performed. Preliminary exclusive E asymmetries are shown in this contribution and more analyses are ongoing for different channels to obtain other spin observables.

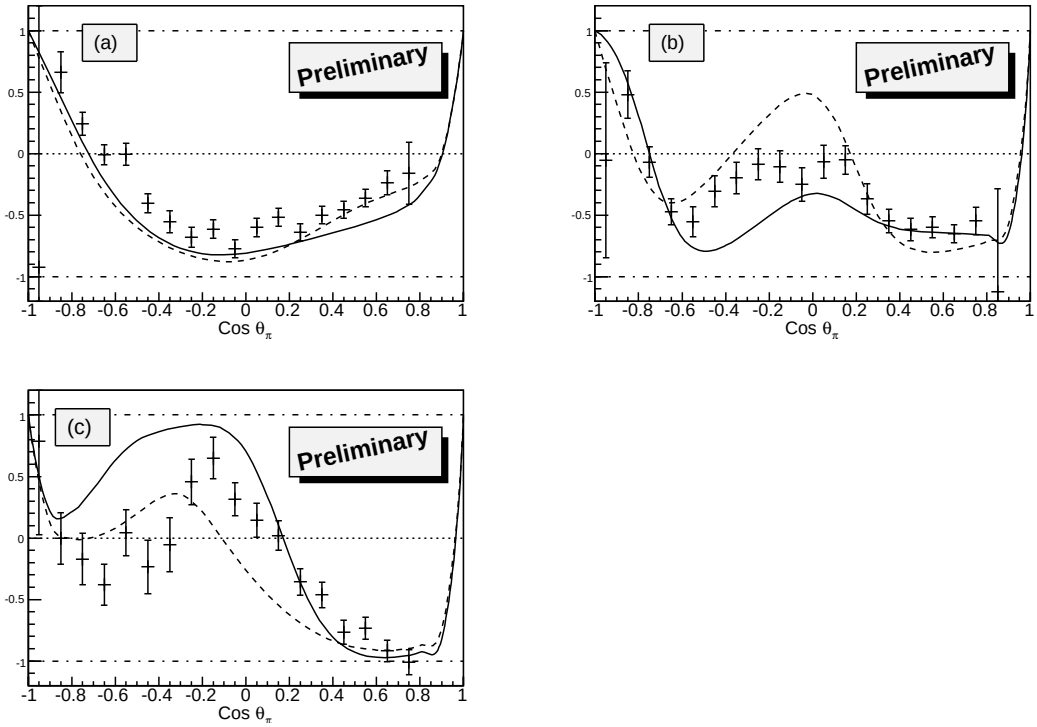

Fig. 2. Preliminary exclusive E asymmetries (π^-'s polar angle dependences at CM) for γ + n(p) $\rightarrow \pi^-$ + p(p). (a) 1.48 $\leq$ W $\leq$ 1.60 GeV, (b) 1.6 $\leq$ W $\leq$ 1.72 GeV and (c) 1.72 $\leq$ W $\leq$ 1.82 GeV, where about 10 % of well calibrated data are used and P_D is estimated to be 26.5%. Only statistical errors are shown. Solid and dashed curves are predictions from SAID (SN11) and MAID, respectively.

References

1. R.G. Edwards *et al.*, Phys. Rev. D **84**, 074508 (2011).
2. X. Wei *et al.*, J. Phys.: Conf. Ser. **400**, 052042 (2012).
3. T. Hamada, I.D. Johnston *et al.*, Nucl. Phys. **34**, 382 (1962), T. Hamada, K. Nakamura, R. Tamgaki, Prog. Theor, Phys. **33**, 769 (1965)
4. SAID partial wave analysis facility, URL http://gwdac.phys.gwu.edu/.
5. wwwkph.kph.uni-mainz.de/MAID//