

# Study of the Hyperon-Nucleon (YN) Interaction in Exclusive $\Lambda$ Photoproduction off the Deuteron

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**Abstract.** This study aims to extract the polarization observables  $C_x$ ,  $C_z$ ,  $\Sigma$ ,  $O_x$ , and  $O_z$  for final-state interactions (FSI) in  $\vec{\gamma}d \rightarrow K^+\vec{\Lambda}n$ . The data were taken with the CE-BAF Large Acceptance Spectrometer (CLAS) at Thomas Jefferson National Accelerator Facility during the E06-103 experiment. These are the very first results for FSI observables in hyperon photoproduction and are expected to constrain the free parameters of YN potentials. This work is funded in part by the U.S. NSF under grant PHY-125782.

## 1 Introduction

The YN interaction plays a key role in the understanding of hypernuclei and strange nuclear matter, and is an important part of the baryon-baryon interaction. While considerable progress has been made in the understanding of the nucleon-nucleon (NN) interaction, we are still far from a complete understanding of the YN interaction. Typically, good NN potential is first constructed from meson-nucleon models, and then SU(3) symmetry is used to extend the NN potential to YN potential. Due to the broken SU(3), there are free parameters in the YN potential, which must be obtained from fits to experimental data. Since experiments with hyperon beams or targets are difficult, high-statistics data on exclusive  $\Lambda$  photoproduction off the deuteron initiated with highly-polarized photons offer unique opportunity to extract a large sample of polarization observables for FSI events. Theoretical studies have shown that these polarization observables can be used to constrain hyperon-nucleon potentials ([1] and references therein).

Exclusive hyperon photoproduction observables can be specifically used to extract a spin-averaged  $\Lambda n$  scattering length from the  $\Lambda n$  invariant-mass distribution by using the theoretical method described in Ref. [2]. The method has been applied to inclusive  $K^+$  hadro-production. Photoproduction data are expected to yield results with comparable systematic uncertainty.

While quasi-free (QF)  $\Lambda$  photoproduction is the main contributor to the cross section of the reaction  $\vec{\gamma}d \rightarrow K^+\vec{\Lambda}n$ , exclusivity allows to reduce this contribution significantly by applying kinematic constraints, both in the data and in the theoretical models. This is expected to reduce the theoretical uncertainty in the interpretation of data.

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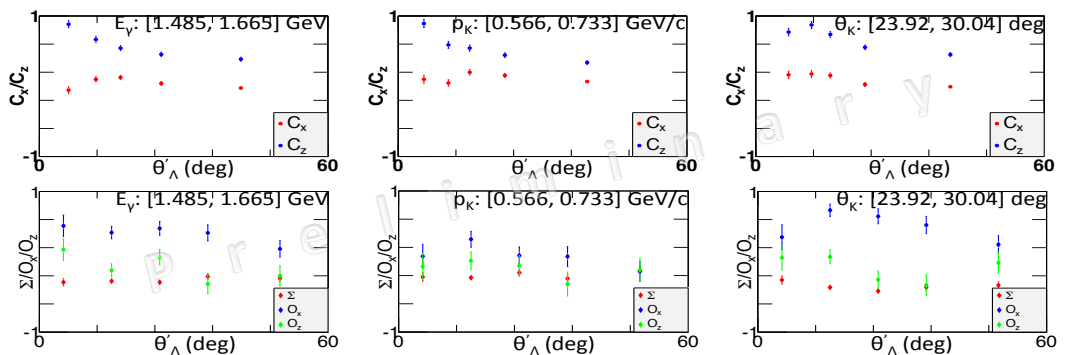
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## 2 Experiment

The data for this study were collected with the CLAS [3] at Jefferson Lab in Newport News, VA. Both circularly- and linearly-polarized photon beams were generated during the E06-103 experiment [4]. A 40-cm-long unpolarized liquid deuterium target was used in this experiment. Circularly-polarized photon beam, with polarization of 30% – 80%, gave access to  $C_x$  and  $C_z$ , while linearly-polarized photon beam, with polarization of 75%, gave access to  $\Sigma$ ,  $O_x$ , and  $O_z$ .

## 3 Results and Discussion

After the reaction reconstruction, data were binned in different combinations of kinematic variables. The variables are the photon energy ( $E_\gamma$ ), the momentum of  $K^+$  ( $p_K$ ), the polar angle of  $K^+$  ( $\theta_K$ ), the polar angle of  $\Lambda$  with respect to the momentum transferred to the  $\Lambda n$  system ( $\theta'_\Lambda$ ), and the invariant mass of  $\Lambda n$  ( $IM_{\Lambda n}$ ). Preliminary one-fold and multi-fold differential estimates for FSI observables of the reaction  $\vec{\gamma}d \rightarrow K^+\vec{\Lambda}n$  were determined. The one-fold differential estimates suggest that the polarization observables are not sensitive to  $E_\gamma$ , but are sensitive to  $p_K$ ,  $\theta_K$ , and  $\theta'_\Lambda$ .  $\theta'_\Lambda$  dependent two-fold differential estimates for one bin in  $E_\gamma$ ,  $p_K$ , and  $\theta_K$ , respectively, are shown in the Fig. 1, and clearly indicate that the available statistics is sufficient to produce meaningful results. Three- and four-fold estimates have also been extracted. These results will be fitted to theoretical models in order to constrain YN potentials. The distribution of each observable over  $IM_{\Lambda n}$  can be used to extract the spin-average  $\Lambda n$  scattering length by the method in Ref. [2]. These studies are in progress in collaboration with theorists.



**Figure 1.** Preliminary two-fold differential estimates for FSI in the reaction  $\vec{\gamma}d \rightarrow K^+\vec{\Lambda}n$ . The figure shows observables as a function of  $\theta'_\Lambda$  for fixed  $E_\gamma$  (left column),  $p_K$  (middle column), and  $\theta_K$  (right column). The top row shows observables  $C_x$  and  $C_z$ . The bottom row shows observables  $\Sigma$ ,  $O_x$ , and  $O_z$ .

## References

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