Measurement of the Double Polarization Observables $C_x$ and $C_z$
for the Final-State Interactions in $\sqrt{s}d \to K^+Λn$

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This work is supported by the U.S. National Science Foundation: NSF PHY-125782

Motivation and Goal

Motivation:
1. Building a comprehensive picture of the strong interaction is the goal of the modern nuclear physics. While considerable progress has been made in the past decades for the nucleon-nucleon interaction, we are still far from a comprehensive picture of the hyperon-nucleon (YN) interaction, which plays a key role in hypernuclear matter and neutron stars.
2. One can access the dynamics of the YN interaction by studying nuclear reactions in which hyperons are produced. While performing YN scattering experiments is a daunting task due to the short lifetime of the hyperons, hyperon photoproduction on the deuteron is an alternative nuclear reaction for testing the available YN potential models.

Goal:
1. This work aims to extract the polarization observables $C_x$ and $C_z$ for final-state interactions in the reaction $\sqrt{s}d \to K^+Λn$.
2. The final results will be used to constrain the free parameters of theoretical models for the hyperon-nucleon potential.

Theoretical Predictions

Three different YN potentials make different predictions for observables:


Invarient Yn lab momentum and angle are fixed.

Method of Study

The main mechanisms of the reaction are quasi free scattering, $K^0$ rescattering, $Λ$ $\pi$ rescattering and pion mediated rescattering.

Mechanism A

Quasi free

Mechanism B

Pion mediated

Mechanism C

$Λ$ $\pi$ rescattering

Mechanism D

$K^0$ rescatterring

Our objective is to gain information about the dynamics of the $Λ$ $\pi$ re-scattering by eliminating the quasi-free mechanism from data and determining observables only for final-state interactions.

Polarization Observables $C_x$ and $C_z$

General polarized differential cross section for hyperon photoproduction off the nucleon:

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma}{d\Omega(inc)} \cdot [1 - P_{\pi} \cos(2\varphi - \cos\theta_e \cdot P_{\pi} \sin(2\varphi - \cos\theta_e)]$$

$$\cos\theta_e = \frac{1}{2} \frac{x \cdot p}{s \cdot \bar{s}}$$

$C_x$ and $C_z$ characterize the transfer of the polarization from incident photon to the produced hyperons.

Preliminary Results

Helicity asymmetry: The analysis strategy for extracting $C_x$ and $C_z$ relies on the beam helicity asymmetry distribution which is derived using differential cross section.

$$\sigma(\cos\theta_e, \cos\theta_e) = \frac{d\sigma}{d\Omega}(inc) \cdot [1 + \alpha P_{\pi} \cos(\theta_e)]$$

$A(\cos\theta_e, \cos\theta_e)$: Helicity-dependent reaction yields in a given kinematic bin.

$\alpha$: The self-analyzing power of $A$; $0.62 \pm 0.015$.

$P_{\pi}$: polarization of circularly polarized photon beam.

C: Constants.

$P_{\pi}$: The helicity-dependent incident photon flux, and their value are the same.

$A_{\text{acc}}$: The acceptance of the detector system.

Our analysis consists of determining the beam helicity asymmetry, $A$, for each kinematic bin, plotting it against $\cos\theta_e$ and $\cos\theta_e$, fitting it by 2-dimension function, and then corresponding parameters dividing out $\alpha$ and $P_{\pi}$. Preliminary, bins in $E_{\gamma}$ and $\theta_e$ have been considered.

Summary and Outlook

- The available statistics is sufficient to produce meaningful results.
- Realistic simulations are in progress
  - Comprehensive event generator developed
  - Background subtraction
  - Acceptance effects
- Results for other kinematic variables will be extracted.
- Systematic uncertainties will be analyzed.
- Comparison to theoretical models will be used to interpret our results.