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Electroproduction of $K^+\Lambda$ at JLab Hall-C

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Abstract A Λ hypernuclear spectroscopic experiment, JLab E05-115 was performed at JLab Hall-C in 2009 by the (e, e′K^+) reaction. Data of Λ hypernuclei with mass numbers from A = 7 to A = 52 were successfully taken, and the analyses are in progress. A polyethylene (CH_2) target was used as a proton target to calibrate energy scales, and to study elementary process of the p(e, e′K^+)Λ, Σ^0 reaction. A preliminary differential cross section of $K^+\Lambda$ electro-production at low Q^2 [$\sim$0.01 (GeV/c)^2] and at small kaon angles ($\cos\theta_K^{CM} \sim 0.97$) is reported in the present article.

1 Introduction

The p(e, e′K^+)Λ data is important to understand the electro-production of Λ hypernuclei. Though there are data of $K^+\Lambda$ photo-production by CLAS [1], SAPHIR [2] and older experiment [3], they show lack of consistencies of the differential cross sections at forward kaon angles. Furthermore, some theoretical predictions also show different behaviors particularly at forward kaon angles [4]. Therefore, high statistical data particularly at forward kaon angles have been awaited ($\cos\theta_K^{CM} > 0.8$). A preliminary results of differential cross section of $K^+\Lambda$ electro-production at very forward kaon angle ($\cos\theta_K^{CM} \sim 0.97$) is reported in the present article.

The definition of the kinematic parameters of the (e, e′K^+) reaction are given in the Fig. 1 (left), and the setup of JLab E05-115 is shown in the Fig. 1 (right). An incident electron reacts a proton mediated by a virtual

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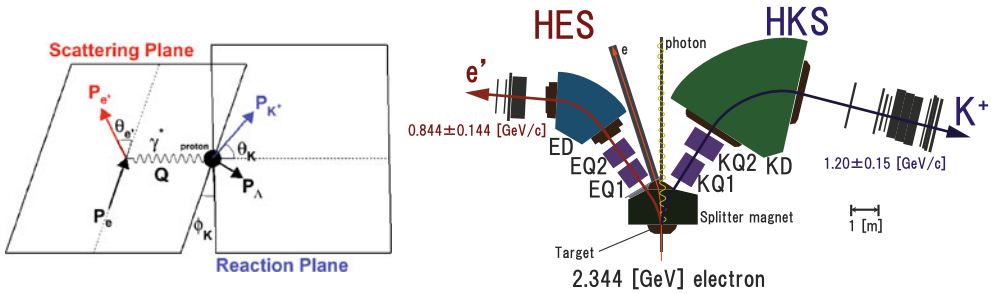

Fig. 1 A schematic drawing of the (e, e′K$^+$) reaction and the experimental setup of JLab E05-115

photon, then the proton is converted into a Λ and a kaon is generated. The differential cross section of the p(e, e′K$^+$)Λ, Σ^0 can be described as the following equation [5];

$$\frac{d\sigma}{dE'_e d\Omega'_e d\Omega_k} = \Gamma\left(\frac{d\sigma_T}{d\Omega_k} + \varepsilon\frac{d\sigma_L}{d\Omega_k} + \varepsilon\frac{d\sigma_P}{d\Omega_k}\cos 2\phi_k + \sqrt{2\varepsilon(1+\varepsilon)}\frac{d\sigma_I}{d\Omega_k}\cos\phi_k\right) \quad (1)$$

$$\varepsilon = \left(1 + \frac{2\mid q\mid^2}{Q^2}\tan\frac{\theta_e}{2}\right)^{-1},\ Q^2 = 2E_eE'_e\sin^2\frac{\theta_e}{2} \quad (2)$$

where, Γ is virtual photon flux factor, and the terms denoted by T, L, P and I are transverse, longitudinal, polarization and interference cross sections, respectively. ε is polarization factor, and Q is 4-momentum of the virtual photon. For a real photon, only the transverse term is not vanished as $Q^2 \to 0$. Since the Q^2 is very small [$Q^2 \sim 0.01$ (GeV/c)^2] in our experimental setup, the virtual photon can be treated as almost real photon.

2 Experimental Setup

As shown in the Fig. 1, an electron beam of 2.344 GeV is impinged on the target, then a scattered electron and a generated kaon of ∼1 GeV/c associated with Λ, Σ^0 production are measured in each spectrometer, High Resolution Electron Spectrometer (HES) and High Resolution Kaon Spectrometer (HKS), respectively. The HES and HKS consist of Q-Q-D magnets. The momentum resolutions of these spectromenters are $\Delta p/p \sim 2\times10^{-4}$ at $p \sim 1$ GeV/c particles.

A polyethylene (CH_2) target of ∼450 mg/cm^2 was used as a proton target to calibrate the energy scale and to study elementary process of the p(e, e′K$^+$)Λ, Σ^0 reaction. The beam of ∼2 μA on the polyethylene target was rastered with an area of 1^xmm × 3^ymm to prevent making a hole on the target. However, there were still enough amount of heat to cause alteration of the target. Hydrogens in the polyethylene target escaped during the experiment due to the heat on the target. Time dependence of hyperion production was carefully studied and the extrapolation to time zero was applied to estimate the cross section.

3 Result

A missing mass spectrum of the plyethylene target is shown in the Fig. 2. Peaks of Λ and Σ^0 with energy resolutions of ∼1.8 MeV/c^2 (FWHM) are clearly seen. The background events in the missing mass spectrum consist of two components. One is quasi-free Λ from carbon in the polyethylene target. This distribution was measured by using a ^{12}C target. Another component of the background events is accidental coincidence event. The number of Λ can be counted after subtracting those background events from the original missing mass spectrum.

A preliminary result of the differential cross section of the p(γ^*, K$^+$)Λ is shown in the Fig. 3 superimposing on the data [1,2] for real photon and a few theoretical predictions [6,7]. We provided high statistical data at very forward kaon angles ($\cos\theta_K^{CM} \sim 0.97$) in the CMS energy (W) range of 1.922 < W < 1.947 GeV. The dash box represents systematic error to be reduced by further analysis. The consistency check with data of another proton target, H_2O is now in progress.

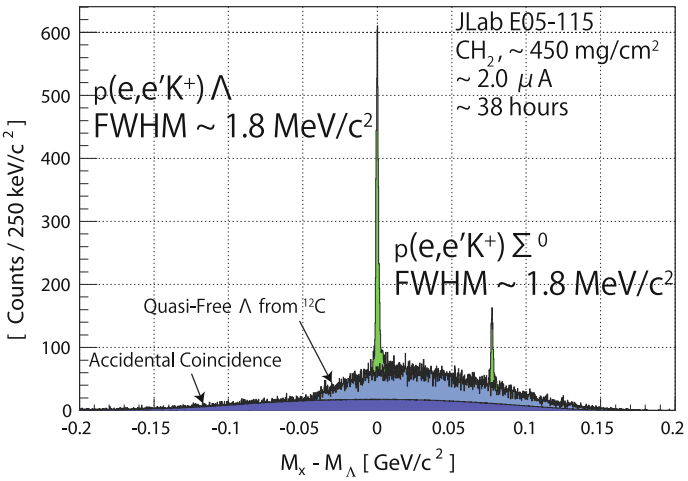

Fig. 2 The missing mass spectrum of the polyethylene (CH_2) target.

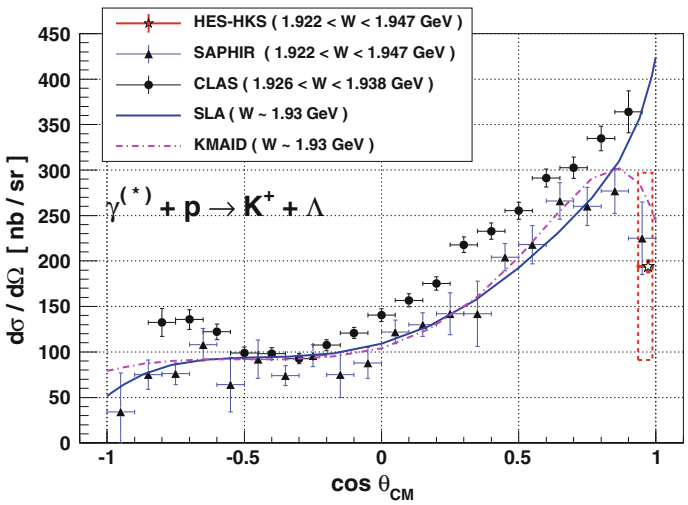

Fig. 3 A preliminary result of the differential cross section of the $p(\gamma^*, K^+)\Lambda$ is shown superimposing on the data [1,2] and a few theoretical predictions [6,7] of photo-production of $K^+\Lambda$. The *dash box* represents systematic error

4 Summary

The Λ hypernuclear spectroscopic experiment, E05-115 at JLab Hall-C provided high statistical data of $K^+\Lambda$ electro-production at very forward kaon angles ($\cos\theta_K^{CM} \sim 0.97$) in the energy range of $1.922 < W < 1.947$ GeV from the polyethylene target. The analysis is in progress to reduce the systematic error, and also to check the consistency with data of another proton target, H_2O.

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