Electroproduction of strangeness on $^{3,4}_{\Lambda}$H bound states on Helium

F. Dohrmann[an], D. Abbott[b], A. Ahmidouch[dfe], P. Ambrozewicz[g], C. S. Armstrong[bh], J. Arrington[a], R. Asaturyan[j], K. Assamagan[f], S. Avery[f], K. Bailey[a], S. Beedoe[d], H. Bitao[f], H. Breuer[k], D. S. Brown[k], R. Carlini[b], J. Cha[f], N. Chant[k], E. Christy[f], A. Cochran[f], L. Cole[f], G. Collins[k], C. Cothran[l], J. Crowder[m], W. J. Cummings[a], S. Danagoulian[db], F. Duncan[k], J. Dunne[b], D. Dutta[o], T. Eden[f], M. Elaasar[p], R. Ent[b], L. Ewell[k], H. Fenker[b], H. T. Fortune[q], Y. Fujii[r], L. Gan[f§], H. Gao[a], K. Garrow[b], D. F. Geesaman[a], P. Gueye[f], K. Gustafsson[k], K. Hafidi[a], J. O. Hansen[a], W. Hinton[f], H. E. Jackson[a], H. Juengst[s], C. Keppel[f], A. Klein[t], D. Koltenuk[q], Y. Liang[u], J. H. Liu[s], A. Lung[b], D. Mack[b], R. Madey[fe], P. Markowitz[cb], C. J. Martoff[g], D. Meekins[b], J. Mitchell[b], T. Miyoshi[r], H. Mkrtchyan[j], R. Mohring[k], S. K. Mtingwa[d], B. Mueller[a], T. G. O'Neill[a], G. Niculescu[fv], I. Niculescu[fw], D. Potterveld[a], J. W. Price[x], B. A. Raue[cb], P. E. Reimer[a], J. Reinhold[cba], J. Roche[h], P. Roos[k], M. Sarsour[y], Y. Sato[r], G. Savage[f], R. Sawafta[d], R. E. Segel[o], A. Yu. Semenov[e], S. Stepanyan[j], V. Tadevosian[j], S. Tajima[z], L. Tang[f], B. Terburg[+], A. Uzzle[f], S. Wood[b], H. Yamaguchi[r], C. Yan$_1$[b], C. Yan$_2$[e], L. Yuan[f], M. Zeier[l], B. Zeidman[a], and B. Zihlmann[l]

[a]*Argonne National Laboratory*, [b]*Thomas Jefferson National Accelerator Laboratory*, [c]*Florida International University*, [d]*NC A&T State University*, [e]*Kent State University*, [f]*Hampton University*, [g]*Temple University*, [h]*College of William and Mary*, [j]*Yerevan Physics Institute*, [k]*University of Maryland*, [l]*University of Virginia*, [m]*Juniata College*, [n]*Forschungszentrum Rossendorf*, [o]*Northwestern University*, [p]*Southern University at New Orleans*, [q]*University of Pennsylvania*, [r]*Tohoku University*, [s]*University of Minnesota*, [t]*Old Dominion University*, [u]*American University*, [v]*Ohio University*, [w]*The George Washington University*, [x]*Rensselaer Polytechnic Institute*, [y]*University of Houston*, [z]*Duke University and Triangle Universities Nuclear Laboratory*, [§]*University of North Carolina at Wilmington*, [+]*University of Illinois*

Abstract. The $A(e,e'K^+)X$ reaction has been investigated at Jefferson Laboratory. Data were taken for $Q^2 \approx 0.35\,\mathrm{GeV}^2$ at a beam energy of 3.245 GeV for ^{1}H,^{3}He and ^{4}He targets. Evidence for Λ-hypernuclear bound states is seen for ^{3,4}He targets. This is the first time that the electroproduction of these hypernuclei has been observed.

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The high intensity CW electron beams at Thomas Jefferson National Accelerator Facility provide the ability to study the electroproduction of strangeness, a complementary approach to experiments with pion and kaon beams [1]. Jefferson Lab experiment E91016 measured the $A(e,e'K^+)X$ for Helium targets. Angular distributions of kaons were measured at forward angles with respect to the virtual photon, γ^*. Data for ^{1}H and ^{2}H targets have been are presented elsewhere [2].

The scattered electrons, e', were detected in the High Momentum Spectrometer (HMS) in coincidence with the electroproduced K^+, detected in the Short Orbit Spectrometer (SOS) in Hall C of Jefferson Lab, see [3]. During the experiment the spectrometer angle for detecting the e' was kept fixed; the K^+ arm was varied. Three angle settings between the virtual photon γ^* and the ejected kaon were studied, $\theta^{lab}_{\gamma^* K} \simeq 1.7^o$, $\simeq 6^o$ and $\simeq 12^o$. Special high density cryogenic targets were used, the background, consisting of random coincidences as well as contributions from the aluminum walls of the targets cells were subtracted to obtain charge normalized yields.

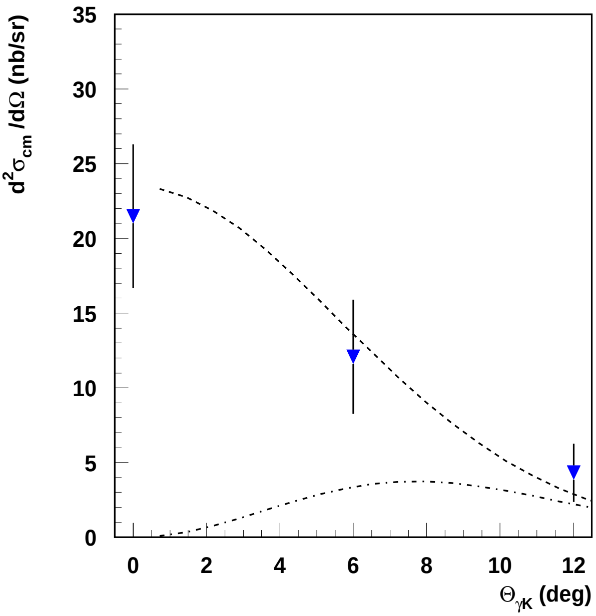

FIGURE 1. Differential cross section in the center of mass for electroproduction of $^4_\Lambda$H as a function of the angle between the virtual photon and the emitted kaon in the laboratory. The curves show theoretical calculations for the excited state (dashed) and ground state (dashed-dotted), resp. which have been renormalized to fit the data [4, 5].

For $^1\mathrm{H}(e,e'K^+)Y$ the two spectrometer coincidence acceptance as well as radiative processes are computed by Monte Carlo simulations [2, 3]. A parametrization of the $\gamma^* N$ cross section has been derived by fitting the kinematic dependences of the $^1\mathrm{H}(e,e'K^+)Y$ cross section over the acceptance; the same parametrization has been used for our data on ^{3,4}He. Using the impulse approximation, we obtain momentum and in-medium energy of the struck nucleon in the nucleus from full spectral functions [6] for the Helium targets. Excess yields close to the Λn threshold are attributed to final state interaction

(FSI) [2]. For ^{3,4}He we model the FSI by an effective range approximation [7]. The analysis of the quasifree electroproduction of kaons on Helium is described in detail in [8]. In the regions of the quasifree Λ-thresholds for $A = 3$ and 4, we find narrow enhancements that we attribute to $^{3}_{\Lambda}$H and $^{4}_{\Lambda}$H bound states. For both Helium targets, these structures are evident at all angles and are centered, within the resolution of the experiment, at the correct binding energy [9]. Fig. 1 shows the angular distribution for the reaction $^{4}\mathrm{He}(e,e'K^{+})^{4}_{\Lambda}\mathrm{H}$. Furthermore, Fig. 1 shows theoretical calculations for the ground as well as the excited state of $^{4}\mathrm{He}(e,e'K^{+})^{4}_{\Lambda}\mathrm{H}$ taken from [4, 5]. The resolution of the experiment does not allow for a separation of the ground and first excited states of $^{4}_{\Lambda}$H, although data taken at forward angles should strongly favor the excited state, as supported by the theoretical curves. The analysis yields a cross section for the $^{3}_{\Lambda}$H state of less than 5nb/sr and 25 nb/sr for the $^{4}_{\Lambda}$H state, both at the smallest angle. These measurements of the angular distributions for $^{3,4}\mathrm{He}(e,e'K^{+})^{3,4}_{\Lambda}\mathrm{H}$ are very important for precise studies on the hypernuclear wave functions [4].

For the first time the electroproduction of the bound hypernuclei $^{3}_{\Lambda}$H and $^{4}_{\Lambda}$H has been achieved. For ^{3,4}He targets spectral functions are used to describe the struck nucleon in the nucleus. A model derived from our $^{1}\mathrm{H}(e,e'K^{+})Y$ data is used in impulse approximation to describe the quasifree production on Helium.

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