Strangeness Electro- and Photo-Production at CEBAF

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Abstract. Strange-particle physics can extend our understanding of nuclear and nucleonic structure and reaction mechanisms. Numerous experiments at CEBAF will investigate strangeness in elementary production and nuclear reactions. The established program includes the study of hyperon electromagnetic decays, the elementary photo- and electro-production of hyperons on nucleons and light nuclei, and the electroproduction of light hypernuclear species. There are relevant experiments planned in all three experimental halls at CEBAF; advances made possible by these new facilities are discussed.

1 Introduction

The strangeness-related physics program at CEBAF has been evolving for several years. However, no experimental data have been obtained since I reviewed this subject last year [1]. This talk is thus an evolutionary update of that previous report, including several new proposals and letters of intent which have appeared since then.

A sketch of an idealized electromagnetic quark-pair creation is shown in Fig. 1. When the electron scatters, it produces a virtual photon with four-momentum $q = (\nu, \mathbf{q})$, leading to an interaction that results in an $s\bar{s}$ pair, which hadronizes into a kaon and a hyperon. While it would be wonderful if we could compute such processes directly from QCD, at CEBAF energies one cannot ignore the many baryonic resonances, or non-perturbative degrees of freedom, which play a role in arriving at the final state [2]. Thus the current state of the art is much more along the lines of Fig. 2, which shows some of the tree-level Feynman diagrams that describe the elementary production process. As we shall see, the mechanism of strangeness production is not yet well in hand even at this level of description, and this motivates new experiments

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at CEBAF. In passing we note that total cross sections for real strangeness photoproduction are on the order of a few microbarns, quite small fractions of the total photoproduction cross section.

Figure 1. Quark-line strangeness production picture, ignoring non-perturbative effects. Note that the photon need not couple directly to the strange quark pair.

The CEBAF accelerator is now complete; 4 GeV beam was achieved in May 1995. The approved experiments will be carried out in Halls A, B and C [4].

Figure 2. Resonance diagrams for the process $\gamma + p \rightarrow K^+ + \Lambda$. Born terms (left side) and resonant terms (right side) contribute. After ref. [3].

Table 1. Approved experiments at CEBAF involving strangeness, as of July 1995 [5].

Title of Experiment	Exp #	Hall	Contact person	Beam Days
Radiative Decays of the Low-Lying Hyperons	89-024	B	G. Mutchler Rice Univ.	65
Electromagnetic Production of Hyperons	89-004	B	R. Schumacher Carnegie Mellon	65
Measurement of the Structure Functions for Kaon Electroproduction	93-030	B	M. Mestayer CEBAF	50
L/T Cross Section Separation in $p(e,e' K^+) \Lambda(\Sigma^0)$ for $0.5 < Q^2 < 2.0$ (GeV/c) ² , $W > 1.7$ GeV, and $t_{\min} > 0.1$ (GeV/c) ² .	93-018	C	O.K. Baker Hampton Univ.	15
Measurements of the Electroproduction of the $\Lambda(\text{gnd})$, $\Lambda^*(1520)$, and $f_0(975)$ via the $K^+ K^- p$ and $K^+ \pi^- p$ Final States	89-043	B	L. Dennis Florida State	48
Study of Kaon Photo-production on Deuterium	89-045	B	B. Mecking CEBAF	23
Quasi-free Strangeness Production in Nuclei	91-014	B	C. Hyde-Wright Old Dominion	25
Electroproduction of Kaons and Light Hypernuclei	91-016	C	B. Zeidman Argonne	21
Investigation of the Spin Dependence of the ΛN Effective Interaction in the p Shell	89-009	C	E. Hungerford Houston	25
Measurement of the Polarization of the $\phi(1020)$ in Electroproduction	93-022	B	E. Smith CEBAF	15
G^0 : Measurement of the Flavor Singlet Form Factors of the Proton	91-017	C	D. Beck Univ. of Illinois	46+X
Measurement of Strange Quark Effects Using Parity-Violating Elastic Scattering from ^4He at $Q^2=0.6$ GeV ²	91-010	A	P. Souder Syracuse Univ.	42
Parity Violation on Elastic Scattering from the Proton & ^4He	91-004	A	E. Beise Univ. of Maryland	85

Hall B contains the Large Acceptance Spectrometer (CLAS), which is a toroidal magnet design optimized to track charged particles from 8 to 140 degrees for momenta from about 250 MeV/c to 4 GeV/c. An electromagnetic calorimeter and gas Cherenkov detector provide electron, photon, and π^0 detection for angles below 45°. For electroproduction, the luminosity limits expected to be about $10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$. Momentum resolution is expected to be about 1%. For strangeness production, K/p separation will be done by time-of-flight over a 4 meter flight path, and is expected to work up to about 2 GeV/c. For real photon experiments a photon tagging system operates from 20% to 95% of the

Table 2. Conditionally approved experiments and Letters-of-Intent involving strangeness, as of July 1995 [5].

Title of Experiment	ID #	Hall	Contact person	Beam Days
High Resolution 1p Shell Hypernuclear Spectroscopy	PR-94-107	A	F. Garibaldi Sanita/INFN	24
Electroproduction of Kaons up to $Q^2 = 3 \text{ (GeV/c)}^2$	PR-94-108	A	P. Markowitz Hampton Univ.	
Measurement of K^0 Electroproduction	LOI-94-106	B	R. Magahiz Carnegie Mellon	
Electroproduction of K^* Mesons	LOI-94-104	B	D.Doughty CEBAF	
High Resolution Electroproduction of Light Hypernuclei (Helium 4)	LOI-94-103	A	T. Saito	
Heavy Hypernuclei Lifetime, Direct Measurement at CEBAF	LOI-94-101	A	A.T.Margarian	

bremsstrahlung endpoint energy, with about 5 MeV energy resolution. Completion of CLAS is scheduled for late in 1996.

In Hall C there are two principal spectrometers. The Short Orbit Spectrometer (SOS) is suitable for detecting kaons up to 1.5 GeV/c with a momentum resolution of 0.1% FWHM and 7 msr acceptance. The High Momentum Spectrometer (HMS) will detect electrons up to 6 GeV/c, with similar momentum resolution and acceptance. These spectrometers are in their early data taking phases now. For high resolution hypernuclear physics, there are long-range plans for dedicated spectrometers for low momentum electrons and kaons, as well as a dipole to separate forward-scattered electrons and kaons from the beam (see Sect. 4).

In Hall A there are two identical high resolution spectrometers. Recently there have been proposals to use these spectrometers, both for studying elementary production, and when outfitted with septum magnets to reach small angles, for doing hypernuclear physics.

Table 1 is a list of all experiments at CEBAF which involve strangeness. In this talk I will outline these experiments, except those which probe the strange sea using the parity violation in electro-weak scattering of electrons. Table 2 lists recently proposed experiments which were conditionally approved (by PAC9), or are at the Letter of Intent stage.

2 Elementary Production

The field of photo- and electro-production of strange particles benefits from the substantial body of theory and experiment that exists for single pion production. Essentially all of the formalism for these studies is taken from the pion production area. The general formalism for pseudoscalar meson electro- and photo- production can be found in many places, for example refs. [3,6-9]. One

finds there are many minor variants among authors in defining notation, cross sections, coordinate systems, and amplitudes.

The relevant kinematic quantities for one-photon exchange are the 4-momentum of the virtual photon $q = (\nu, \mathbf{q})$ and the direction (θ_m, ϕ) of the meson relative to $\mathbf{q}$ in the electron scattering plane, as shown in Fig. 3. The photon's energy is $\nu = E - E'$, and its 3-momentum is $\mathbf{q}$. The electron vertex is perfectly well known, which means that the polarization of the virtual photon is determined purely from the electron kinematics. The polarization has three components, since the photon is off shell, two transverse and one longitudinal. The polarization parameter ϵ , defined as

$$\epsilon = \left(1 - 2 \frac{q^2}{q^2} \tan^2 \frac{\theta_e}{2}\right)^{-1} \quad (1)$$

ranges over ± 1 . It gives the degree of linear transverse polarization along x ($\epsilon = +1$) or y ($\epsilon = -1$), and is directly proportional to the longitudinal polarization along z . The reaction factorizes into a virtual photon cross section and a virtual photon flux. The virtual photon flux into a phase space element $dE' d\Omega_e$ is given by

$$\Gamma(E', \Omega_e) = \frac{\alpha}{4\pi^2} \frac{E'}{E} \frac{W^2 - m_n^2}{m_n} \frac{1}{-q^2} \frac{1}{1 - \epsilon} \quad (2)$$

where W is the invariant photon-nucleon energy and m_n is the nucleon mass.

Figure 3. Kinematic variables for meson electroproduction.

When kaons are produced with unpolarized electron beams and only the electron and meson are detected, then there are four kinematically separable pieces to the cross section which can be written in the form

$$\frac{d\sigma}{dE'd\Omega_e d\Omega_m} = \Gamma(E', \Omega_e) \times \left(\frac{d\sigma_T}{d\Omega_m} + \epsilon \frac{d\sigma_L}{d\Omega_m} + \epsilon \cos(2\phi) \frac{d\sigma_{TT}}{d\Omega_m} + \sqrt{\epsilon(\epsilon+1)/2} \cos(\phi) \frac{d\sigma_{LT}}{d\Omega_m} \right) \quad (3)$$

The components of the cross section are each related to six complex gauge and Lorentz invariant amplitudes derived from the hadronic currents, $\mathbf{J}$. Various equivalent sets of amplitudes are used in the literature: helicity, transversity, and extended CGLN basis amplitudes are used, and all can be written as linear combinations of each other. In any representation, σ_T is the unpolarized transverse cross section, which in rectangular coordinates is proportional to $\int d\Omega_m [\langle J_x^* J_x + J_y^* J_y \rangle]$ (ref. [7]). The longitudinal cross section, σ_L , goes as $\int d\Omega_m \langle J_z^* J_z \rangle$. In inclusive experiments, where the meson is not detected, these two terms are extracted from data at fixed q^2 and W , but for differing ϵ , and doing the famous Rosenbluth separation. The transverse-transverse cross section σ_{TT} arises from the interference of the two components of transverse current, and is proportional to $\int d\Omega_m [\langle J_x^* J_x - J_y^* J_y \rangle]$. The photon vertex dictates that this term is proportional to $\cos\phi$, where $\phi = 0$ corresponds to the meson being detected on the “+x” side in the electron scattering plane. This term can also be accessed with linearly polarized real photons. The σ_{LT} term is due to the interference of the longitudinal and transverse parts of the current and is proportional to $\int d\Omega_m [\langle J_x^* J_z - J_z^* J_x \rangle]$.

Because the longitudinal photons transfer no angular momentum, σ_L is sensitive to the exchange of $0^\pm$ exchanges in the t -channel, and hence is sensitive to pions, diquarks, or other spin-zero objects in the nucleon. At low q^2 and near minimum t , the longitudinal cross section is dominant in pion production [7]. With suitable extrapolations it has been possible to extract the pion form factor from pion electroproduction data [10]. The analogous work for kaons has not been done, but will be the subject of several CEBAF experiments (see Sect. 2.2)

Computing the relevant amplitudes directly from QCD-inspired models has not been attempted until very recently for the strangeness-producing channels. More typically, models have been developed using hadronic and mesonic degrees of freedom. Figure 2 shows the diagrams that are needed. The lowest order Born terms involve proton, lambda, and kaon exchange in the s , u , and t -channels, respectively. Other important terms involve the exchange of the Σ , the spin-1 kaon resonances, the spin 1/2 and spin 3/2 nucleon resonances, and spin 1/2 hyperon resonances. The coupling constants can be extracted from the data and compared either with values predicted by SU(6), or with values obtained from other strangeness-producing reactions. The most elaborate theoretical treatment of kaon electroproduction, which includes crossing symmetry and s and t channel duality, is that of Cotanch and coworkers [11]. In photoproduction, where only four complex amplitudes are needed, recent work has been done by Adelseck and Saghai [12], Adelseck, Bennhold & Wright [3]; very recently a chiral quark model approach has been presented by Li [13].

2.1 On the proton - photoproduction

The elementary photoproduction reactions on the proton are $\gamma + p \rightarrow K^+ + \Lambda$, $\gamma + p \rightarrow K^+ + \Sigma^0$, and $\gamma + p \rightarrow K^0 + \Sigma^+$. Total cross sections exist for all cases, differential cross section data exist for the Λ and Σ^0 , and very sparse hyperon and target polarization data exist for the Λ . While being restricted to $q^2 = 0$, real photon experiments using tagged or untagged bremsstrahlung beams have been more numerous than electroproduction experiments because of their relative simplicity. Figure 4 gives an example of the existing Λ differential cross section data and polarization data [14, 3]. About a dozen theoretical models of these reactions have been published over the past thirty years, all based on the diagrammatic techniques mentioned earlier. The relatively poor quality of the data has led to a wide range of "best" fits, such that even the principal Born couplings g_{KAN} and g_{KEN} (see Fig. 2) vary over a wide range, differing even in sign in some cases [15]. Unlike pion photoproduction where one strong resonance, the $\Delta(1232)$, dominates the reaction, for hyperons the resonance structure is just not well known.

The contribution of CEBAF to this field will be to provide data for all three elementary channels, and to emphasize the polarization variables which show large sensitivity to the model parameters. Experiment E89-004 will use CLAS to obtain such data, using the detector to examine the self-analyzing weak decays of the hyperons to an extent impossible in earlier measurements. Figure 4, for example, shows an old analysis of Renard [14] which illustrates the sensitivity of that model to Λ polarization data: the hatched region shows the range of predictions due to reasonable variations of the couplings g_{KAN} and g_{KEN} . The polarization shown is that of the hyperon perpendicular to the (γ, K) plane (albeit with the sign opposite to most modern authors' usage). The Σ^0 polarization information will be accessible in CLAS because this hyperon decays 100% to $\Lambda\gamma$. The polarization of the Λ , turns out to be $-1/3$ of the Σ^0 polarization, thus preserving in diluted form the polarization produced in the reaction. In another category of polarization measurements, CLAS will be able to operate with circularly polarized photon beams produced by bremsstrahlung from polarized electrons. Discussions are underway to extend E89-004 to include such measurements.

Real photoproduction of the Σ^+ and Σ^0 and Λ are of equal importance, since all three reactions ought to be described within the same theoretical framework. An interesting feature of Σ^+ production is the absence of simple t -channel exchange because the photon does not couple to the K^0 . This results in a backward peak in the predicted differential cross section, which would be easy to find experimentally [16]. By detecting $K^0 \rightarrow \pi^+\pi^-$ this reaction will be accessible in CLAS.

For the Σ^+ there exist only a few total cross section data points. But Mart et al. [17] have recently shown how existing models can fail badly when applied to the sparse data in this channel, typically overpredicting the cross section by an order of magnitude, thus underscoring the need for significant data in this area. Z. Li[13] has recently presented a chiral quark model of strangeness

Figure 4. (a) Differential cross sections for $\gamma + p \rightarrow K^+ + \Lambda$ as a function of kaon c.m. angle, from ref. [14]. The shaded region corresponds to $g_{KAN}/\sqrt{4\pi}$ varying from 1.1 to 2.8. (b) Λ polarization data for $p(\gamma, K^+)\Lambda$ for kaon c.m. angles of $90^\circ \pm 5^\circ$.

photoproduction which overcomes the guesswork and data-fitting of traditional hadronic models. In his model the mesons are treated as Goldstone bosons, but couplings to known resonances are computed exactly, and the low energy theorem is fulfilled. The Λ data are reproduced well, and problems in other models with unitarity at higher energies and blow-up of the Σ^+ cross section are gone.

2.2 On the proton - electroproduction

Several CEBAF experiments will study the $(e, e'K)$ reaction on the proton. Each of them plans to separate the four components of the cross section in Eq. (3). Experiment 93-030 will use CLAS to obtain charged kaon production data over a wide kinematic range to maximize the ability to do the L/T separations. While systematic uncertainties inherent in a large acceptance detector are a possible limitation, the acceptance also makes extraction of the interference structure functions potentially easier than in a conventional spectrometer. A recent Letter of Intent, 94-106, would extend these studies in CLAS to include the neutral kaon channels. K^0 's have essentially never been measured in electroproduction, and CLAS is ideally suited to their detection.

In Hall C, Experiment 93-018 uses the SOS and HMS spectrometers to do the strange-particle analog of the single pion electroproduction done in the past. σ_{LT} will be obtained over a small range by moving the SOS spectrometer left and right in the lepton scattering plane. The goals are the same as for the Hall B experiments. Using the Hall A spectrometers has also been proposed (PR94-108) for extending the electroproduction measurements from 2 to 3 $(\text{GeV}/c)^2$, but this will require 6 GeV beam and successful running of the Hall C experiments.

The resonance structure of $(e, e'K)$ is unknown, as mentioned above, and the reaction is not dominated by a single strong resonance. As one example of the physics to be addressed, Fig. 5 shows the Q^2 dependence ($Q^2 = -q^2$) of the electroproduction of Λ and Σ^0 for a fixed value of the total c.m. energy W . For Λ production the cross section first rises from the real photon point at $Q^2 = 0$, while for Σ^0 production the drop is monotonic with Q^2 . This is interpreted as an indication that longitudinal photon contributions are important for Λ production but not Σ production. A rough longitudinal-transverse separation was obtained [18] by measuring at different ϵ for the same W and Q^2 , supporting the conclusion that a large longitudinal component contributes to Λ production only. A suggested explanation [19] is that longitudinal photons contribute strongly to kaon exchange in the t -channel, but this process is expected to be larger for Λ production than for Σ production since $g_{KAN} > g_{K\bar{S}N}$, and hence the difference in Q dependence.

Figure 5. Q^2 dependence for $\gamma(v) + p \rightarrow K^+ + \{\Lambda, \Sigma^0\}$. The trends away from the real photon point at $Q^2 = 0$ differ strongly. Data are from ref.[23] and others cited therein. $d\sigma/d\Omega^*$ is the sum of longitudinal and unpolarized transverse cross sections in the c.m. of the photon and proton.

The Q^2 dependence of Σ^0 production is much steeper than that for Λ production. In quark-parton models [20-22] this feature was interpreted as consistent with the decrease of the ratio $F_1^{\gamma n}/F_1^{\gamma p}$, the deep inelastic electron-nucleon structure functions of the neutron and proton, as Bjorken $x = Q^2/2M\nu$ goes to 1. In this limit the production of forward-going kaons off u -quarks tends to leave behind an isospin 0 pair $u-d$ quarks, from which the production of $I=1$ baryons (Σ) is suppressed in favor of $I=0$ baryons (Λ).

The t dependence of the longitudinal cross section can also be interpreted

in terms of the kaon form factor, similar to work done on the pion form factor. Experiment 93-018 will emphasize this aspect of their analysis.

2.3 On the deuteron - photoproduction

After the elementary production mechanism on the proton is established, it only makes sense to extend our knowledge using a deuteron target to get the three reactions on the neutron: $\gamma + n \rightarrow K^+ + \Sigma^-$; $\gamma + n \rightarrow K^0 + \Lambda$; $\gamma + n \rightarrow K^0 + \Sigma^0$. A set of data including all isospin channels will naturally provide the most rigorous test of our understanding. This will be done by CEBAF experiment 89-045. No data of this kind exist to date. Besides extracting the elementary cross sections [24], it may be possible to explore YN interaction effects; since the photon and the K^+ both interact "weakly," the deviations from quasi-free behavior in the (γ, K) reaction will be due to the interaction of the final state hyperon-nucleon system [25]. This experiment will also scan the cross section as a function of missing mass in the region between the Λ and the Σ^0 . Here the amplitudes for production of the two hyperons will interfere, producing a cusp that has been predicted to be visible [26]. This channel-coupling cusp has been seen in $D(\pi^+, K^+)$ and $D(K^-, \pi^-)$ reactions [27] but electromagnetic studies of the shape of the cusp will reveal the relative phase of the production amplitudes. Experiment 91-016 will also hunt for this cusp in electroproduction in Hall C.

Another goal of E89-045 in Hall B is to look for narrow structures near the ΣN threshold which might be interpreted as $S = -1$ dibaryons [28]. The spin-one $D1$ should be 20-40 MeV above the cusp while the spin-zero $D0$ should be 20 - 40 MeV below the cusp. The $D1$ can be reached from the deuteron using reactions with small spin-flip probability: (π, K) , (K, π) , and (γ, K) . But the (γ, K) reaction is special because only it can also populate the spin-flipped $D0$ state. This state should be narrower than the $D1$, and therefore might be worth a look despite failure to detect the $D1$ in the mesonic reactions [29].

2.4 On heavier nuclei - inclusive kaon photoproduction

Once the elementary amplitudes for kaon photoproduction are known, it is interesting to know if the inclusive nuclear response can be described in a simple quasi-free picture, i.e. incoherent production on individual nucleons. From inclusive $A(e, e')$ and $(e, e'p)$ studies it is known that medium modifications such as two-nucleon currents can substantially alter quasi-free behavior. There may be analogous effects in strangeness production, though no earnest theoretical estimates have been made.

Experiment 91-014 will study the relative importance of the one-nucleon (γ, K) versus either two-nucleon (γ, K) currents or KY final state interactions (FSI). The targets will be ^3He , ^4He , and ^{12}C . Due to strangeness conservation, the total $A(\gamma, K)$ cross sections will be insensitive to FSI, since either a K^+ or a K^0 must emerge once either has been created. The A dependence of kaon production for $\text{D}:\text{He}:\text{C}$ thus will be sensitive to the presence of medium

modifications of the elementary amplitudes. The ratio of K^+/K^0 yields for isoscalar nuclei will be measured and compared to deuterium. This ratio would probe either two-nucleon currents or charge-exchange final state interactions. Finally, the differential ^3He data will be a detailed test of the quasi-free model, because good wavefunctions exist and calculations should be most reliable.

3 Radiative Hyperon Decays

Radiative decays are in general useful for testing quark models of baryons. Their widths are sensitive to the detailed quark wave functions used in the models, with predictions presently varying by a factor of sixty. In an elementary quark model certain radiative transitions are forbidden: *e.g.* the $I = 0$ $\Lambda(1405)$ cannot decay to the two lower-lying $I = 1$ Σ states because a single photon, described by one-body operators, cannot connect states that involve changing two quarks. There is some belief that the $\Lambda(1405)$ consists at least partly of a KN molecular state, owing to the proximity of the KN threshold at 1437 MeV. Because the $\Lambda(1405)$ and the $\Sigma(1385)$ are below this threshold they cannot be studied using stopped K^- on liquid hydrogen.

The CLAS spectrometer is suited to making these states using the reaction $\gamma p \rightarrow K^+ Y^*$. In Experiment 89-024, the incident real photons are tagged, the kaons are detected and together used to construct the Y^* missing mass; in the cases of the $\Lambda(1405)$ and the $\Sigma(1385)$ there is an overlap because the states are 50 and 36 MeV wide, while the $\Lambda(1520)$ is well separated. The radiative decays to the ground state Λ will be detected by following the decay chain $Y^* \rightarrow \gamma \Lambda$ followed by $\Lambda \rightarrow \pi^- p$. Detection in the EGN calorimeter of the photon, in addition to the charged particles, greatly suppresses the background due to π^0 decays. Detection of decays with the $\Sigma(1193)$ as an intermediate state will be more difficult because both decay photons must be detected.

4 Hypernuclear Production

No data exist on electromagnetic production of hypernuclear states. The reasons are clear: the large momentum transfers (comparable to the (π, K) reaction) and small predicted cross sections (on the order of 10 nb/sr for even the lowest momentum transfers) make such reactions challenging to measure. The 5 MeV photon energy resolution of the CLAS photon tagging system make hypernuclear photoproduction experiments in Hall B unlikely. In Halls A and C, however, the $A(e, e' K)_{\Lambda} A$ reaction will be studied. Detecting the electrons close to zero degrees minimizes the momentum transfer, and the count rate for populating specific states will be on the order of several counts per day, similar to (π, K) studies. There are two main benefits in doing $(e, e' K)$ hypernuclear spectroscopy. The first is that up to an order of magnitude improvement in resolution may be possible over present hadronic data. The second is that while the (π, K) reaction populates high-spin natural-parity states, the $(e, e' K)$ reaction also populates the unnatural parity states, starting from 0^+ nuclei, via

the spin-flip interaction. CEBAF can therefore provide data complimentary to the hadronic production reactions.

The goal of all the proposed hypernuclear experiments is measuring the Λ -nucleus spin-orbit splitting, which is related to the ΛN spin-orbit interaction. The strength of this interaction is known to be small [30], with splittings of under 0.5 MeV, in contrast to the nucleon spin-orbit interaction which is of order several MeV. Thus, while gamma-ray studies have seen transitions between widely spaced levels, the fine structure has not been seen. Experiment 89-009 will study the spectroscopy of the p-shell in Hall C; the plan is to use a 1.8 GeV electron beam, a dedicated Enge split-pole magnet to detect scattered electrons at zero degrees, and the SOS spectrometer with about 1.2 MeV resolution for the kaons. A "splitting magnet" must be added at the target to peel off the electrons and kaons to large enough angles to enter the spectrometers. A survey of p-shell nuclei is planned to map the overall response and to evaluate rates and backgrounds. As a future development this program hopes to develop a dedicated kaon spectrometer with resolution in the range of 120 keV.

The conditionally approved proposal 94-107 plans a similar program of p-shell studies in Hall A, with a goal of 300 to 400 keV resolution [31]. There, too, the target must be moved upstream, septum magnet placed in front of each spectrometer; full approval awaits a review of technical feasibility.

Experiment 91-016 will examine electroproduction of kaons, again in Hall C, on the proton, deuterium, ^3He and ^4He , but without special efforts to obtain high resolution. The physics goals are examination of the $\Lambda - \Sigma$ cusp in deuterium (see Sect. 2.3) and examination of bound state angular distributions in the helium isotopes. Other goals include dibaryon hunting near the $\Sigma - N$ cusp, and searching for narrow Σ states. The measurements are essentially exploratory to obtain cross sections and count rates. This experiment will use the "standard" Hall C configuration, combining the SOS for kaons (same as experiment 89-009) with the HMS for the electrons. Both spectrometers will be at angles greater than 12 degrees, and the missing mass-resolution is expected to be about 3 MeV.

5 Hidden Strangeness

Hidden strangeness means that the strangeness quantum number is zero in the initial and final states, but strange quarks manifest their presence in some particular property of a system. We will not discuss the parity violation experiments here, but mention instead plans to measure $\phi(1020)$ electroproduction as a method of measuring the strange quark content of the nucleon. In a hard scattering process, an $s\bar{s}$ component of the proton may be knocked out to create a final state ϕ . In a model due to Henley and coworkers [32], such contributions may be of the same order as the diffractive processes described using vector meson dominance if the strange quark sea of the nucleon in the range of 10% to 20%.

Experiment 93-022 plans to look for such ϕ knock-out via electroproduction

with the CLAS spectrometer. The key to separating the diffractive from the knockout interactions is to examine the self-analyzing decay of the ϕ 's. Henley et al. predict that the knockout mechanism of interest goes via pseudo-scalar (0^-) exchange, different from production that involves scalar (0^+) exchange. In the rest frame of the decaying ϕ 's the kaons are produced with an angular distribution, W , as

$$W(\phi) = \frac{3}{8\pi} \sin^2 \theta (1 \pm \epsilon \cos 2\psi) \quad (4)$$

where θ is the kaon polar angle and ψ is the azimuthal angle with respect to the lepton plane. Pseudo-scalar and scalar exchange are characterized by the $+$ and the $-$ sign, respectively. By measuring this decay distribution, the experiment plans to achieve a sensitivity of a 5% admixture of pseudo-scalar exchange, at which level the OZI-suppressed π and η exchange diagrams are also expected to contribute. Any larger measured amount of 0^- exchange would be a possible signature of strange quark components in the nucleon.

6 Conclusion

This broad overview has only skimmed the contents of strangeness-related proposals at CEBAF. I hope, however, that it has convinced you that an important and exciting aspect of CEBAF's overall program is in the area of strangeness physics. In another year or two I hope there will actually be some new results to report.

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