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Electroproduction of Kaons and Light Hypernuclei

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ELECTROPRODUCTION OF KAONS AND LIGHT HYPERNUCLEI

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ABSTRACT

Since both the electron and K^+ are particles that interact weakly, electroproduction of light hypernuclei provides a relatively low distortion means of investigating the fundamental interactions between nucleons, lambdas, and sigmas in few-body systems. The $(e,e'K^+)$ reaction will be studied on deuterium and He targets with coincident detection of the emergent e and K^+ in the HMS and SOS magnetic spectrometers in Hall C. In addition to providing new information on the phases and momentum dependence of hyperon-nucleon interactions and measurements of hypernuclear formation, the study will investigate bumps in the cross sections that are anticipated near values of the missing mass that correspond to threshold production of the sigma.

INTRODUCTION

The study of the structure of nuclei containing strange baryons is one of the tantalizing frontier areas of nuclear research. While there has recently been a marked increase in the amount of data available for (K^-,π^-) and (π^+,K^+) reactions, there has been relatively little progress in providing unambiguous answers to questions relating to modifications of interactions within the nuclear medium, e.g. the existence and widths of bound sigma-hypernuclear states; the relationships between 2-body and 3-body interactions in complex hypernuclei. The study of two-body and few-body systems limits the complexity of possible interactions and provides information in systems that are amenable to detailed theoretical calculations and that can elucidate the detailed features of hyperon-nucleon interactions in the nuclear medium. Because of the strong interaction between the lambda and sigma hyperons whose masses differ by less than 80 MeV, analyses of the structure of complex lambda hypernuclei imply the need for a three-body effective interaction,[1] if only lambdas are considered explicitly. Since there is no bound hypernucleus of mass two, the hyper-triton, being the lightest bound hypernucleus, plays the role of the deuteron in hypernuclear physics.[2] The present proposal, therefore, focuses upon examination of hypernuclear interactions in the very lightest nuclei leaving weakly- or nearly-bound states.

MOTIVATION

In recent years, there have been a number of theoretical discussions of the D(e,e'K) reaction, particularly in the proceedings of CEBAF summer workshops.[3] Cotanch, Donnelly et al. have shown that a careful study of electroproduction of kaons on deuterium will provide important information about the K-nucleon-Y coupling constants, where Y is either lambda or sigma, and a unique method for studying the Y-neutron interaction which is poorly understood. It has been repeatedly stressed[2,10,12] that realistic descriptions of hypernuclei need improved data for YN interactions, particularly the relatively low energy lambda-neutron scattering that may be obtained from the D(e,e'K) reaction. Of particular interest are a theoretically predicted[4] cusp in the inclusive kaon cross section for an invariant missing mass of roughly 2.13 GeV, that is illustrated in Fig. 1, and strong mass dependent changes in the kaon angular distributions,[3,4] displayed in Fig. 2, very near the threshold for sigma production. Both the shape and magnitude of the cusp are dependent upon the unknown relative phase between the lambda and sigma elementary production amplitudes that can be measured only in the D(e,e'K) reaction.[4] Such a cusp was originally observed in the D(K^-,π^-) reaction[5] and has also been seen in the D(π^+,K^+) reaction[6] and high energy pp → K+X studies.[7] The peak has been interpreted as an enhancement in the $^3S_1$ channel, resulting from coupling[8] between the lambda-N and the sigma-N amplitudes; this description being incorporated into the prediction of a constructive interference cusp in the inclusive kaon electroproduction spectrum,[4] shown in Fig. 1.

Rather interesting, although speculative, possibilities are strangeness -1 dibaryons predicted[9] to have masses just above and below the sigma threshold. In all of the experiments involving hadronic production of kaons,[5,6,7] bumps are seen in the spectra at masses that are roughly 15 MeV greater than the threshold for sigma production. While the primary peak may be treated as resulting from lambda-sigma interference,[8,10] it has not been possible to account for the excess yield in the vicinity of 2.14 GeV without invoking some sort of a resonance. There have been attempts to identify the the bumps as being L = 1, strange di-baryons.[10,11] If such identifications are valid, then a spin singlet, di-baryonic state should occur at a mass slightly below the sigma threshold,[9] but, because of spin, isospin, and parity, could not have been seen in the hadronic reactions.[11,12] There is no such restriction in the D(e,e'K) reaction and it may be possible to observe such a state if it is present.

Bound hypernuclear states are produced by (e,e'K^+) reactions on ^{3}He and ^{4}He where the beginnings of interactions in the nuclear medium may be investigated. There are two bound states in the $^4_\Lambda$H hypernucleus: a 0^+ ground state, lambda binding energy of 2.04 MeV, that should be very weakly excited in (e,e'K) reactions and sensitive to variations in the elementary amplitudes; and a 1+ state at an excitation energy of 1.04 MeV that is expected to have a relatively large cross section.[4] While a weak coupling description of the corresponding mass 3 hypernucleus suggests three states, a $3/2^+$ state and two

$1/2^+$ states, the only bound state is a $1/2^+$ state, bound by only 0.13 MeV, that corresponds to coupling the lambda to the deuteron.[13] Investigation of the bound state angular distributions in the previously unstudied He(e,e'K$^+$) reactions will provide tests of the wave functions used to describe these states. Since the location of the unbound $3/2^+$ state is important in evaluating model calculations,[14] the missing mass spectrum for the hyper-triton will be examined carefully to see if there is evidence for low-lying unbound states.

Although, in (K^-,π^-) and (π^+,K^+) reactions on complex nuclei, numerous peaks have been observed at the missing masses expected for sigma hypernuclear states, these peaks are much narrower than expected on the basis of the lambda-sigma mixing.[15] As a result, identification of of the peaks as being narrow sigma-hypernuclear states remains controversial.[15] Recently, there was a report of the observation of a sigma hypernuclear bound state[16] in ^{4}He(K^-,π^-) reaction together with a theoretical model[17] based on realistic NN and ΣN interactions that predicts both the apparent binding energy of the sigma, 3.2 Mev (about 1 MeV more than the lambda binding), and the width of the state, ~4.6 MeV. Moreover, there is independent experimental evidence that supports this result.[18] Confirmation of such a peak in the ^{4}He(e,e'K) reaction would be quite interesting, even if it were not truly bound, i.e. if it were analogous to the threshold peak in the deuteron.

The calculation[17] that predicts binding of the sigma in mass 4 does not, however, predict binding in mass 3. Q. Usmani has performed a similar, although somewhat more sophisticated, calculation for the sigma hyper-triton and confirms that the Σ^o is unbound.[19] He also finds that within the theoretical uncertainties, binding can be achieved by increasing the depth of the potentials by ~20% and the width of the peak is less than 1 MeV. Preliminary data[18] suggest the presence of enhanced yield near and below the Σ^- threshold in the ^{3}He(K^-,π^+) reaction. This implies possible binding of a Σ^- and adds credence to both Usmani's calculation and the possibilities for a bound or nearly bound sigma in mass 3 discussed earlier.[15] In the ^{3}He(e,e'K) reaction, the observation of either a bound sigma or a threshold interference effect in the hyper-triton would therefore have significant consequences.

In any event, it should be emphasized that because of the 3-body final states in (e,e'K) reactions, a broad range of both kaon and electron energies must be detected in both spectrometers. The ~75 MeV difference between the lambda and sigma masses is much smaller than the dynamic range of the momentum bite in each of the spectrometers so that data for the region of sigma production will be acquired routinely.

EXPERIMENT

The experiment involves coincident detection of inelastically scattered electrons and kaons, i.e. $(e,e'K^+)$ reactions, with the use of the HMS and SOS spectrometer systems in Hall C. The targets will consist of either liquid H, D, ^3He, and ^4He. As has been discussed previously,[3,4] the flux of virtual photons is maximized by scattering at a far forward angle and the coincidence count rates are maximized when the kaons are detected at angles in the general direction of the virtual photon. Since the reaction involves three-body final states, each detector arm covers a broad range of energies for a given final state or fixed missing mass.

While detectors at far forward angles are preferred, the physical dimensions of the spectrometers being constructed for Hall C will restrict the study to angles greater than 12°. For the present experiment, detection of electrons at 12.5° results in virtual photon angles that range from 6.1° for the highest energy photons, to ~15° at the lowest energies. With the kaon spectrometer at 12.5°, it is therefore possible to detect kaons in the photon direction for a wide range of energies for both D and He. Data will also be obtained at 18.5°, for all targets, and at 21.5° for D. With electron detection at 12.5°, the photon flux, and hence the yield, is reduced by ~35% relative to the geometry indicated in Fig. 2, ($\theta_e = 10°$, $\theta_\gamma = 4.9°$), but kaon detection along the photon direction partially compensates for the larger electron scattering angle. Although angular distributions for the kaons will be measured by changing the SOS angle, because of the three-body kinematics, each spectrometer setting will provide data that cover a range of kaon-photon angles for a given missing mass.

TECHNICAL ISSUES

The emergent particles will be detected in the HMS and SOS spectrometers in Hall C; the electron arm being the HMS spectrometer operated in its standard electron detection mode, the kaon arm being the SOS spectrometer with modifications of the detector package to be described below. Both the HMS and SOS have been described in the Conceptual Design Report, CDR, for Hall C. The HMS spectrometer will have a solid angle of ~6 msr with a momentum bite >10% of the central momentum, while the SOS will have a solid angle of 9 msr with a 40% momentum acceptance. The momentum resolution in the SOS will be 10^{-3} p_0 and that of the HMS 6×10^{-4} p_0 so that, with target effects, an overall missing mass resolution of ~3 MeV is anticipated for coincident detection of particles with momenta of ~1.3 GeV/c in both spectrometers. The proposed detector package for the HMS will suffice for the detection of electrons in the present experiment. Anticipated electron and π^- count rates of $<3\times10^4$/s and $<5\times10^4$/s, respectively, should be well within the projected capabilities of the the detectors and particle identification (pion rejection $>10^2$) is straightforward. On the other hand, kaon detection in the SOS will require some modification of the detector in order to extract kaons from the much higher flux of pions and protons; the proposed system will be similar to that planned for kaon detection in (approved) experiment 89-09.

The standard SOS detector package proposed for the detection of electrons and pions is shown in Fig. 3A, while the modifications for kaon (and proton) detection are illustrated in the lower section, Fig. 3B. For kaon detection: there is no alteration of configuration for the first two wire chambers, WC1 and WC2, and the first set of scintillator hodoscopes, S1XY, thereby maintaining the momentum and timing calibrations from the standard configuration; the gas Cerenkov and shower counters are removed; an Aerogel Cerenkov counter and an additional set of scintillator hodoscopes, S3XY, are added; WC3 and S2XY are repositioned. These changes are motivated by need to not only select kaons in the presence of a much higher flux of pions and protons, but also a desire to maximize the real to random ratio for electron-kaon coincidences.

Over the momentum range to be covered in the SOS, Table 1 shows that the ratio of pion to kaon singles rates will range from 100 to 1000.

Inasmuch as "clean" kaon spectra are needed, a pion rejection ratio of $>>10^3$ is desired and two separate approaches will be used, namely an Aerogel threshold Cerenkov counter and measurement of velocities by time-of-flight. Table 2 lists both velocities and differences in flight times (from target to S3X,S3Y) for pions, protons, and kaons over the full range of momenta to be studied. From the table, there is a clear demarcation in velocity between pions and both protons and kaons, namely $\beta_\pi > 0.974$ and $\beta_K < 0.964$, for all momenta.

An Aerogel threshold Cerenkov counter with n = 1.03 will provide a high efficiency, >99%, technique for pion rejection.[20] Despite this efficiency, however, it is doubtful that 10^3 pion rejection could be achieved. It is therefore desirable to utilize time-of-flight (TOF) techniques that provide a second, independent, means of rejecting pions and an extremely effective method for proton identification.

As is seen in Fig. 4, at S3 the TOF difference between π and K is >1 ns and there is more than a 3 ns difference between protons and kaons over the full momentum range; Table 2 lists time differences for all momenta at S3. Indeed, given the anticipated overall time resolution of <600 ps fwhm, TOF provides an unambiguous means, ~12σ p-K centroid separation, of identifying protons at any acceptable energy. Figure 5 shows the effectiveness of the combination of Aerogel and TOF in rejecting pion contamination in the kaon spectrum. Solid lines indicate the singles rates for pions and kaons (from Table 1). The dotted line represents the rate for pions assuming only Aerogel rejection of 10^2, while the dashed line shows the pion rate that falls within a TOF window that accepts 99% of the kaons. It is seen that TOF pion rejection alone is adequate for momenta below ~1.4 GeV/c, but at higher energies does not suffice. The lowest solid line indicates the rate for pions that fall within the kaon time window and also are not rejected by the Aerogel. The combination, therefore, will achieve the desired goal of $>>10^3$ pion rejection at all energies. It should be noted that the detector packages in both the HMS and SOS each utilize multiple hodoscopes so that time resolutions can be much smaller than are achievable with a single scintillator. The major difficulty in utilizing TOF is providing an accurate measure of the "effective" start time, i.e. determining the differences in flight times for the various particles.

Complementary methods will be utilized: coincidence timing between the HMS and the SOS detectors; and using the HMS detector to correlate with the RF structure in the primary beam. Since electrons detected in the HMS have $\beta = 1$, the flight times between target and the HMS detector will be the same for all central momenta. Any variations will depend upon flight path differences associated with the range of trajectories, relative to the central trajectory, that fall within the spectrometer acceptance and are limited to <1 ns, correctable by tracking. Measurement of the SOS time, also corrected for trajectory, allows an effective determination of the relative timing between the two spectrometers and hence the flight time differences for various particles. In this method, the uncertainty in flight time is a convolution of the time resolutions in both detectors. [A time resolution of <600 ps, fwhm, has been demonstrated for coincidences between similar systems in the 1.6 and 8 GeV spectrometers at SLAC in experiment NE18.]

The beam on target will have short bursts, <<20 ps, spaced every ~660 ps in the early running and every 2 ns when all three halls are operating. As noted above, flight times in the HMS are constant, independent of central momentum, and the electrons will be detected at a fixed time after scattering in the target. Detection of an electron in HMS will then specify the RF burst of origin and the start time will have negligible error. The TOF uncertainty in this mode is therefore determined by the SOS alone.

In coincidence with the HMS, the combination of TOF and the Aerogel threshold counter will result in $>>10^3$ pion rejection and suffice for both pion and proton rejection.

COUNT RATES

Count rate estimates are based upon the specifications of the HMS and SOS spectrometers, outlined in the Hall C CDR, together with 4 cm long liquid deuterium and liquid He targets. The resultant target thicknesses of $\sim 10^{23}$ atom/cm^2 coupled with average electron beam currents of ~15 μamp implies power dissipation in the targets of 30 W, a value that is achievable with present technology. While higher beam current will be available, the proposed luminosity provides adequate count rates and signal to background ratios, as seen in Table 3. If it is necessary to utilize pressurized, cooled gas targets with lower densities, the luminosity can be recovered with increased beam currents and longer targets.

Inasmuch as all hodoscope planes in the SOS are highly segmented, the anticipated singles count rates for pions, $<5.5\times10^5$/s, and protons, $<3\times10^5$/s, with particle rejection, do not constitute a significant source of background. This is illustrated in Fig. 6 in which crude estimates of the relative count rates as a function of momentum are shown for both a narrow bite (~10 MeV) and the full bite for electron detection in HMS. Also shown is the relative rate for pion contamination with the full bite. The primary background results from random e-K coincidences, i.e. coincidences between uncorrelated scattered electrons and kaons from quasifree production. The use of TOF together with the microstructure in the beam allows an off-line analysis to provide a highly accurate measurement of the random contribution within the short resolving time of the TOF window.

A listing of representative count rates, angles, and random rates is presented in Table 3 where it is seen that the real to random ratio varies from ~20 for deuterium to $\lesssim$1 for ^{3,4}He in the region of interest. The true coincidence rates are based upon theoretical cross sections,[3,4] the spectrometers, and luminosities discussed above while background rates are estimated with the use of the Lightbody and O'Connell programs[20] for a resolving time of 1 ns, roughly twice the anticipated TOF resolution. The run times have been estimated on the basis of the predicted increase (decrease) in yields in the vicinity of the Σ threshold, shown in Fig. 1, and theoretical cross sections.[3,4] The count rates in other regions of the missing mass spectra will be higher. Since the predicted change seen in Fig. 1 is roughly 15%, a ~20% measurement of the change will require about 2 days. The large dynamic range of both the HMS and SOS spectrometers allows data to be accumulated over the entire mass spectrum in a single setting, but it is desirable to utilize a second momentum choice at most angles; the missing mass spectrum being the sum of two runs.

TIME REQUEST

The primary objectives of this experiment are to investigate the missing mass spectra in the deuteron, ^{3}He, and ^{4}He to study the momentum dependence of the hyperon-nucleon interaction, angular dependences, and to investigate threshold effects related to the possibility of bound sigma hypernuclei. With the count rates listed in Table 3, spectra can be obtained in 1 day per setting for all targets. Data are desired at two momentum settings per angle and at three angles for deuterium, 12.5°, 18.5°, 21.5°, to measure angular distributions. For the He targets, it is planned to take data only at 12.5° and 18.5° initially. No time is required to take measurements of count rate related backgrounds since the TOF technique will allow these to be measured concurrently. Backgrounds that result from windows and target cells must be measured and we estimate that 12 hours per angle will be required. The total time per angle for each target will therefore be approximately 3 days, allowing time for calibrations with a proton target and minor problems, so that a total of 21 days is requested.

RESPONSE TO PAC IV COMMENTS: PR-89-013

In deferring the proposal, the PAC indicated two main areas of concern: 1) a detailed design for the detector package in the SOS; 2) a joining of efforts with the proponents of high resolution hypernuclear studies. Both of these concerns have been addressed in the present proposal, and in addition, the motivation for the experiment has been updated.

1. In particular, Fig. 3 shows the proposed design of the detector package for kaon and proton detection and indicates the modifications of the basic e-π system that are required. This design is currently being implemented for use in approved experiment 89-09. The text discusses the package and, together with Figs. 4 and 5, includes a more detailed description of the time-of-flight system, and the rationale involved in the design. In addition, there is a more complete discussion of rates, background rejection, and particle selection (also see Appendix).

2. The collaboration has been expanded with the addition of a number of groups, including the proponents of high-resolution hypernuclear studies and major participants in experiment 89-09, namely the Houston and BNL groups. Indeed, their recent efforts have focused upon the few-body systems that are the subject of this proposal. Other groups are currently active at SLAC in experiments NE17 and NE18, which involves two magnetic spectrometers operated in coincidence.

COMMITMENTS

The participants in this proposal constitute most of the Hall C collaboration and have provided MOUs that commit them to construction of various components of the Hall C system. The ANL group is responsible for construction of the SOS, CEBAF for the HMS, the other members of collaboration have responsibilities for detectors and software. Other approved proposals require cryogenic targets similar to those needed in the present experiment and we will cooperate in construction and testing.

APPENDIX - DETECTOR PACKAGE

The detector packages shown in Fig. 3 follow the general design principles outlined in the Hall C CDR and are currently being implemented by the members of the collaboration. Responsibility for various components of the detector have been assumed by a number of laboratories: 1) Scintillator Hodoscopes, ODU; 2) Gas Cerenkov Detector, Colorado, ANL; 3) Shower Counters, CEBAF; 4) Drift Chambers, BNL; 5) Aerogel Cerenkov, Houston.

The layout shown in Fig. 3 is being used as the basis for detailed design studies and construction of components.

1. The scintillation hodoscopes, S1XY, S2XY will consist of ~5 mm thick plastic, each paddle 5 cm wide with phototubes at both ends. To cover the full extent of the beam, S1X will consist of 12 segments, S1Y of 8 segments, S2X of 16 segments, S2Y of 10 segments. S3X and S3Y will be 10 cm wide, also double ended, and will consist of 8 segments in X and 6 in Y. Old Dominion University has prime responsibility for the hodoscopes and is investigating plastics, light pipes, phototubes to minimize cost while providing the best time resolution possible. It is expected that the final performance will exceed the requirements specified in the proposal.

2. Further design studies have been performed. A more detailed description is seen in the update for PR-89-11.

3. Shower counter development is proceeding at CEBAF.

4. Drift chamber designs and preliminary engineering studies are under way at BNL. To meet the requirements of the experiments proposed for SOS, two different sizes will be used. WC1 and WC2 will be 60 cm (X) x 40 cm (Y); WC3 will be 80 cm (X) x 55 cm (Y). Each chamber will contain 3 coordinates, X, U, V oriented at 0°, 60°, and 120° w.r.t. the momentum direction of the SOS. Each coordinate will consist of 2 planes, offset by 5 mm, cell size 1 cm, to resolve left-right ambiguities. Expected spatial resolution is 100μ RMS with a resolving time of ~ 25 ns. Count rates $>10^5$/s/cm of wire will be handled.

5. Studies are in progress to determine whether a contact or diffusion coupling to the phototubes is best. The Aerogel will be 50×80 cm, ~10 cm thick, and enclosed in an air-tight container. Approximately 10 phototubes will be utilized with ≥6 photoelectrons per pion expected; the efficiency should exceed 99.5%.

TABLE 1. SINGLES RATES/100 MeV/c IN SOS

p GeV/c	Singles Rates/s P	π^+	K^+	π^+/K^+
0.8	4.5×10^4	1.66×10^5	219	758
1.0	3.2×10^4	1.03×10^5	187	551
1.2	2.2×10^4	6.18×10^4	164	377
1.4	1.45×10^4	3.63×10^4	146	249
1.6	9.0×10^3	2.06×10^4	131	157
1.8	5.7×10^3	1.13×10^4	119	95

D Target, E_e = 3 GeV, SOS at 12.5°.

TABLE 2. TIME DIFFERENCES (ns) FOR KAON DETECTION IN SOS AT S3 (10m)

p_K	β_K	β_π	β_p	$\Delta t(k-\pi)$	$\Delta t(k-p)$	$\Delta t(k-e)$
0.6	.772	.974	.54	8.96	18.7	9.84
0.9	.877	.988	.69	4.23	10.10	4.68
1.2	.925	.993	.79	2.45	6.28	2.70
1.5	.950	.996	.85	1.59	4.23	1.75
1.6	.955	.996	.86	1.45	3.73	1.58
1.8	.964	.997	.89	1.14	3.01	1.24

TABLE 3. COUNT RATE ESTIMATES/5 MeV

Target	E_e	$E_{e'}$	θ_e	θ_K	θ_γ	Q^2	p_K	Rate/hr	Random/hr
D	3.0	1.0	12.5	12.5	6.1	0.15	1.6	20	1.5
D	3.0	1.5	12.5	12.5	11.9	0.19	1.08	24	1.2
D	3.0	1.5	12.5	18.5	11.9	0.19	1.07	20	0.8
^3He	3.0	1.5	12.5	12.5	11.9	0.19	1.09	6	2.5
^4He	3.0	1.5	12.5	12.5	11.9	0.20	1.09	6	3.4

Energies and momenta in units of GeV, GeV/c; angles in degrees relative to beam direction.

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FIGURE CAPTIONS

Fig. 1 Inclusive laboratory cross section for d(e,e'K)(Λn + Σ^0n)[4]. The arrow indicates the cusp discussed in the text.

Fig. 2 Sensitivity of the missing mass spectrum to the Λn final state interaction as a function of the angle between the kaon and virtual photon.[3,4]

Fig. 3 Schematic detector packages: A) standard detector for electrons and pions; B) modified for detection of kaons and protons.

Fig. 4 Differences in flight times between the target and S3 (10 m), relative to $\beta = 1$, as a function of momentum for pions, kaons and protons.

Fig. 5 Count rates in SOS. Solid lines denote the estimated singles count rates for π^+ and K^+ as a function of momentum in the SOS. The dotted line indicates the effect of pion rejection solely from the Aerogel Cerenkov detector. The dashed line is the rate for pions that fall within a TOF window that includes 99% of the kaons. The bottom solid line is the rate for pions that fall within the TOF window and are not rejected by the Aerogel.

Fig. 6 Relative coincidence rates as a function of kaon momentum. Relative count rates are shown for $E_e = 3$ GeV, $E_{e'} = 1$ GeV, $\theta_{e'} = 12.5°$, $\theta_K = 12.5°$. The solid curve roughly corresponds to a narrow band of electron energies (~10 MeV/c) in the HMS, adapted from the missing mass spectrum in Fig. 1, and approximates the kinematics of the first line in Table 3. The upper dashed curve is the response expected under the same conditions with the full bite, ~100 MeV, of electron energies, i.e. for electron energies between 1 and 1.1 GeV. The bottom dashed line is the relative count rate for misidentified pions with the full acceptance. The range of momentum acceptance for SOS with p_o = 1.5 GeV/c is indicated by the dotted line.

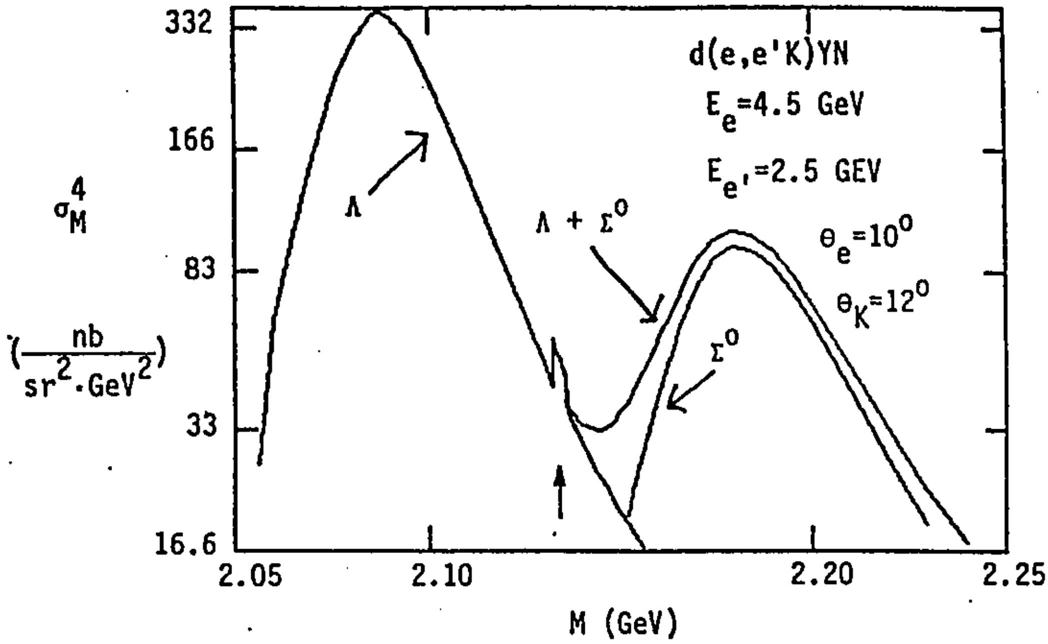


FIGURE 1

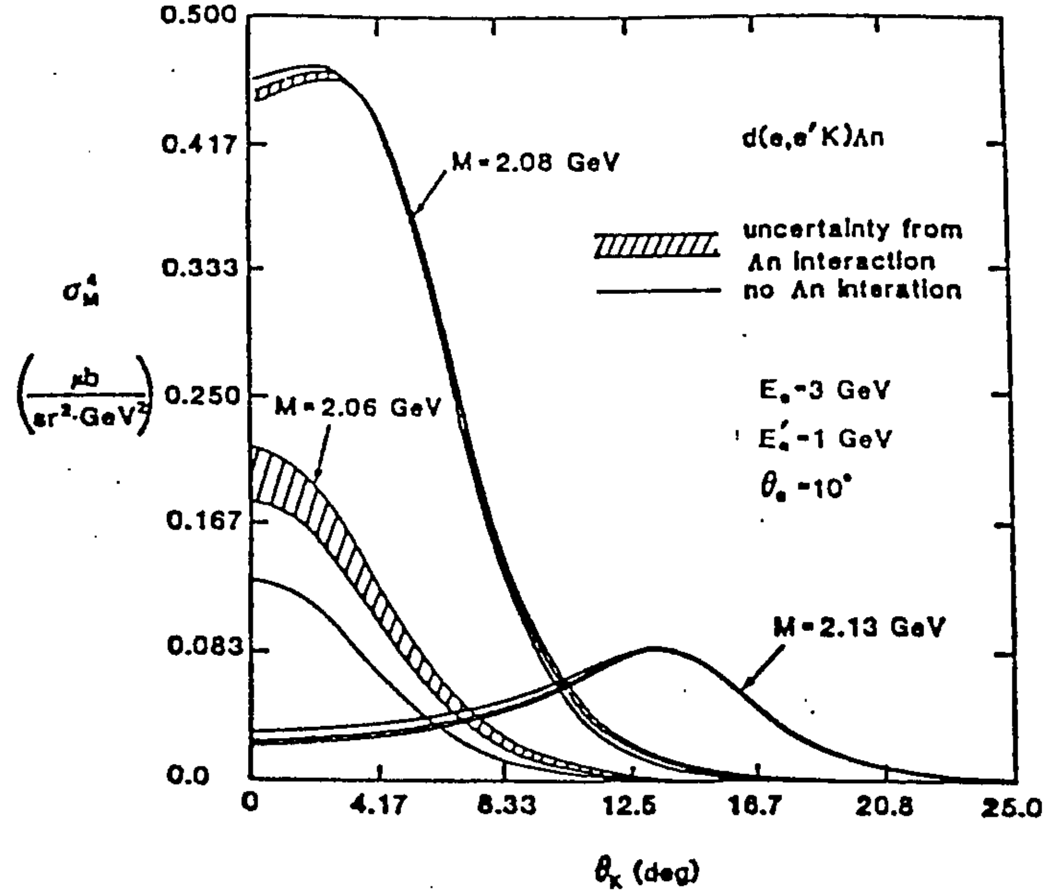


FIGURE 2

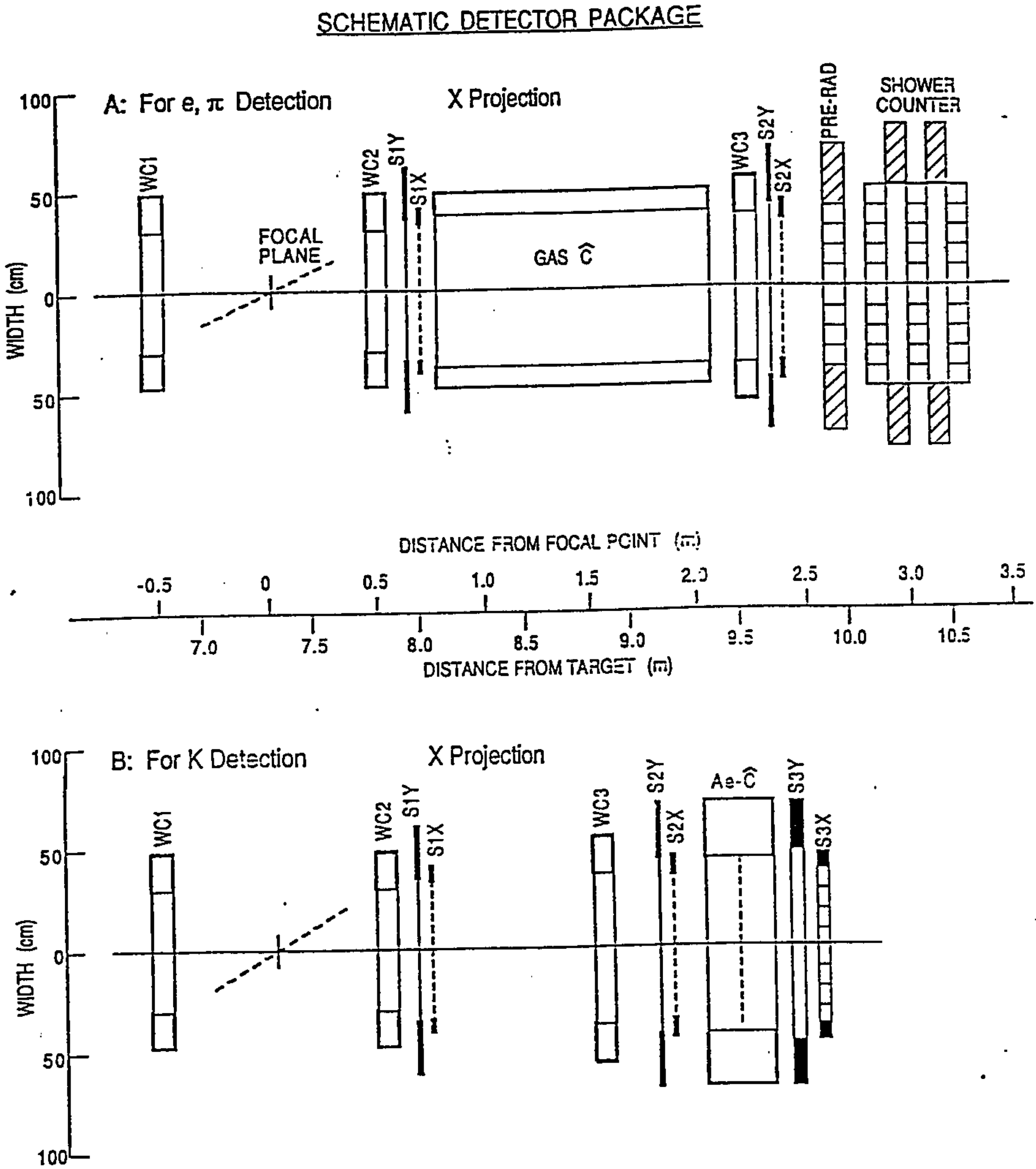

SCHEMATIC DETECTOR PACKAGE
A: For e, π Detection
X Projection
WIDTH (cm)
100
50
0
50
100
WC1
FOCAL PLANE
WC2
S1Y
S1X
GAS Ĉ
WC3
S2Y
S2X
PRE-RAD
SHOWER COUNTER
DISTANCE FROM FOCAL POINT (m)
-0.5
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
DISTANCE FROM TARGET (m)
B: For K Detection
X Projection
WIDTH (cm)
100
50
0
50
100
WC1
WC2
S1Y
S1X
WC3
S2Y
S2X
Ae-Ĉ
S3Y
S3X

FIGURE 3

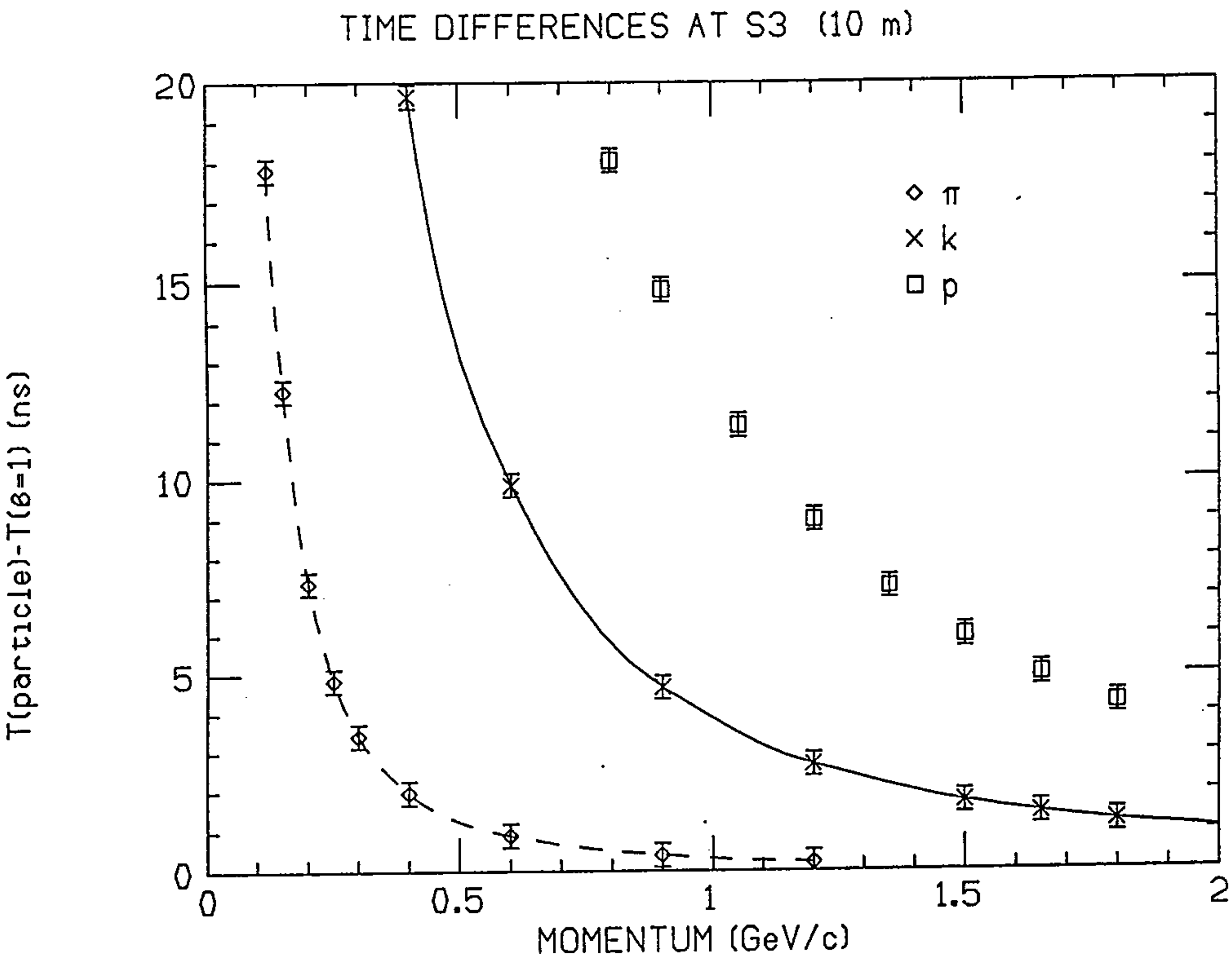

TIME DIFFERENCES AT S3 (10 m)
π
k
p
20
15
10
5
0
0
0.5
1
1.5
2
MOMENTUM (GeV/c)
T(particle)-T(β=1) (ns)

FIGURE 4

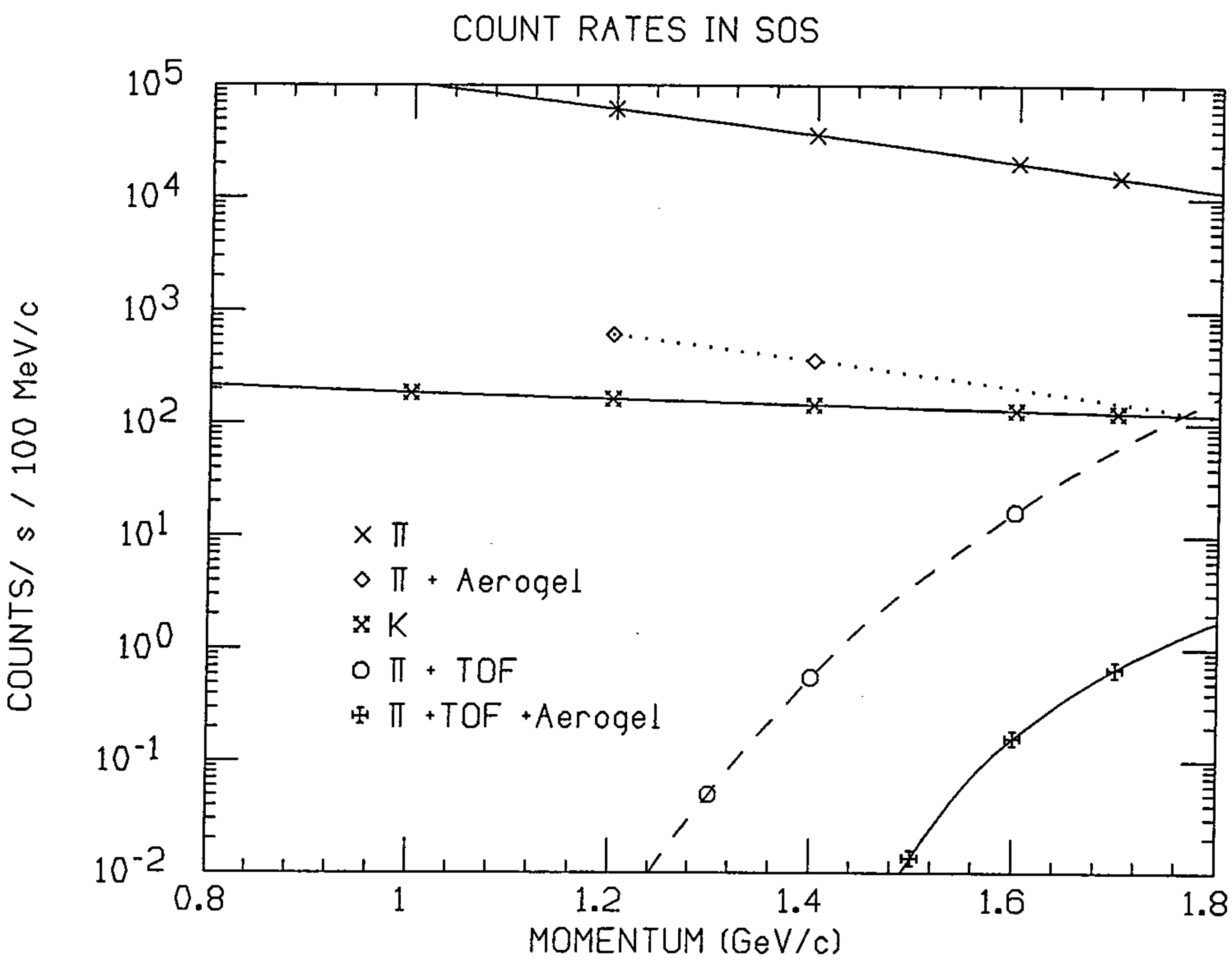
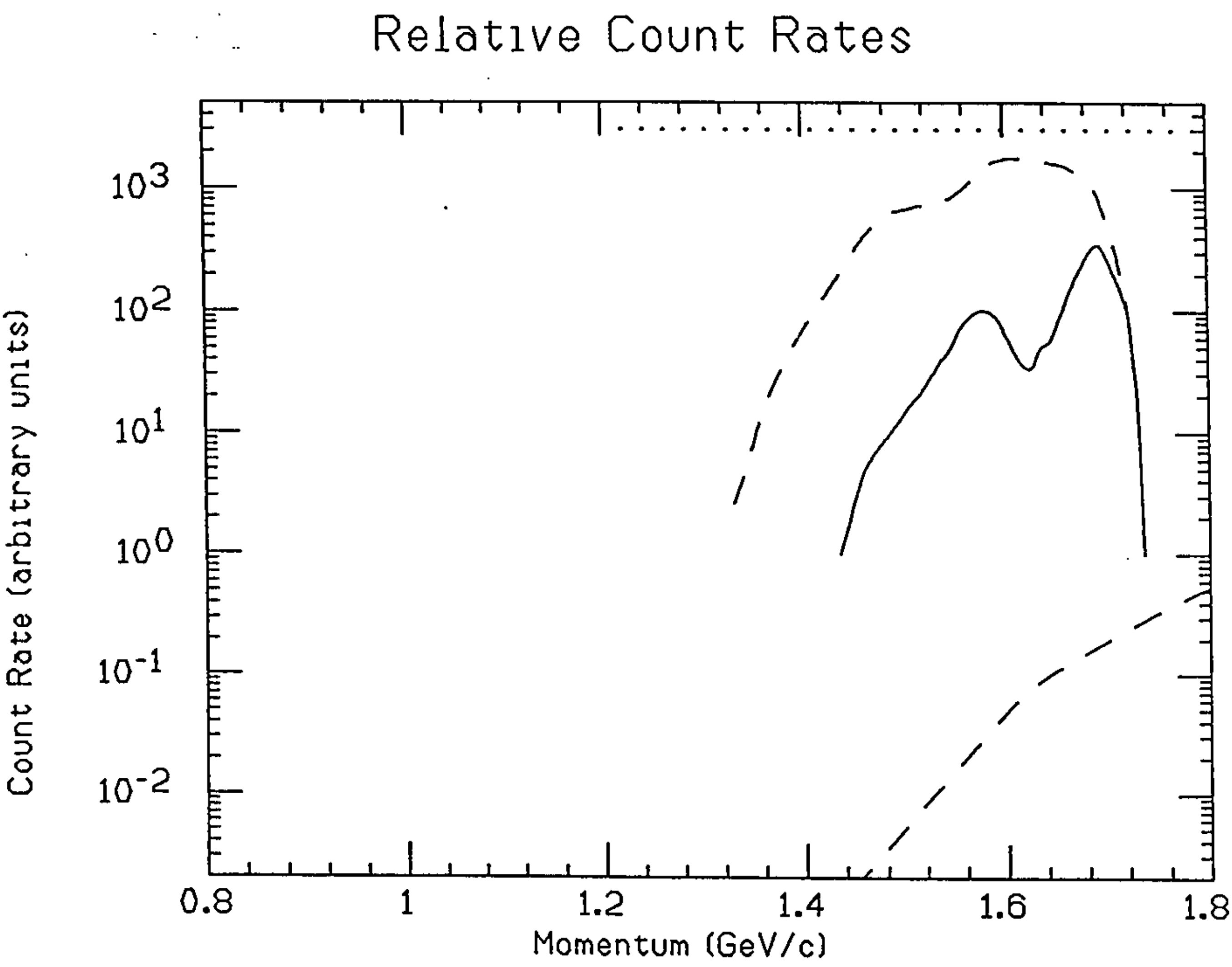

COUNT RATES IN SOS
COUNTS/ s / 100 MeV/c
MOMENTUM (GeV/c)
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
0.8
1
1.2
1.4
1.6
1.8
π
π + Aerogel
K
π + TOF
π +TOF +Aerogel

FIGURE 5



Relative Count Rates
Count Rate (arbitrary units)
10^3
10^2
10^1
10^0
10^-1
10^-2
0.8
1
1.2
1.4
1.6
1.8
Momentum (GeV/c)

FIGURE 6

CEBAF Experiment Requirements

Date Submitted 9 / 30 /91

Title & Spokesperson Electroproduction of Kaons and Light Hypernuclei

B. Zeidman

Estimated total beam time (hours)	500
Electron beam energy(s) required	3.0
Beam current(s) (μA)	15
Total μA-hours required	8000
Solid target(s) material	–
Solid target(s) thickness	–
Cryogenic target -type and length (cm)	Liquid 4 cm, Gas 10 cm
Power deposition in cryogenic target (Watts)	Approx. 30 watts
Polarized beam (y/n)	n
Polarized target (y/n)	n
Power deposition in polarized target	–
Effective beam spot diameter (≥100 microns)	1 mm
Scanned beam at target (y/n)	n
Dispersed beam (y/n)	n

Spectrometer Requirements	*e' Arm*	*Hadron Arm*
Solid angle acceptance (msr)	6	9
Momentum acceptance (FWHM %)	10	40
Momentum resolution (FWHM %)	0.1	0.1
Scattering angle (degrees)		
Minimum	12.5	12.5
Maximum	20	30
Scattering angle, uncertainty (mr)	0.5	2.0
Central orbit momenta (MeV/c)		
Minimum	500	900
Maximum	2000	1800
Spectrometer settings, reproducibility,		
Central angle (mr)	0.5	1
Central momentum (MeV/c)	1	1
Particle identification requirements		
Rejection type (e.g. π^-/e^-)	π^-/e^-	$p,\pi^+/K^+$
Required ratio (e.g. 10^{-3})	10^2 reject π^-	$>>10^3/1$ reject π,p
Traceback capability required (y/n)	y	

Position accuracy along beam (mm)	10
Luminosity range ($cm^{-2}\ sec^{-1}$)	9×10^{36}

Remarks: