CEBAF Program Advisory Committee Nine
Extension and Update Cover Sheet

This update must be received by close of business on Thursday, December 1, 1994 at:

CEBAF

User Liaison Office, Mail Stop 12 B

12000 Jefferson Avenue

Newport News, VA 23606

Experiment:　　**Check Applicable Boxes:**

E ^{89} - ^{004}　　☐ Extension　　☐ Update　　☒ Hall B Update

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Electromagnetic Production of Hyperons

R. A. Schumacher, Spokesperson

This experiment will obtain the world's most complete data set for real photon induced strangeness production, and use it to resolve problems in understanding this reaction process. Since the approval of this proposal in 1989 the intended scope of this experiment has evolved somewhat. Partly spurred by this proposal, there has been considerable theoretical work in this area. Unlike pion photoproduction, the elementary production of kaons is not dominated by a single strong resonance, while the quark pair which is produced is distinguishable, which leads to new and interesting problems in pseudoscalar meson production. The interest at CEBAF in elementary strangeness production is also underscored by the approval of two electro-production experiments, which will complement the results of this experiment.

There are three isospin channels on the proton which are of equal interest: $\gamma + p \rightarrow K^+ + \Lambda$; $\gamma + p \rightarrow K^+ + \Sigma^o$; and $\gamma + p \rightarrow K^o + \Sigma^+$. The contribution of CEBAF and CLAS to this field will be to provide data for all three elementary channels (the third one is essentially unmeasured), and to emphasize the hyperon polarization variables which show large sensitivity to typical model parameters. Experiment E89-004 will exploit CLAS to obtain these data, using the large detector acceptance to examine the self-analyzing weak decays of the hyperons. In the original written proposal the Λ and Σ^o reactions were emphasized, though already in the '89 PAC presentation the Σ^+ channel was shown to have appreciable acceptance in CLAS and hence would form part of the measurement program.

As a natural extension, circular polarization of the tagged photons in CLAS would enable significant beam-recoil double polarization measurements, one of the few instances where such highly selective measurements could be made relatively easily. Within the group involved in E89-004 there has been considerable discussion about this topic, and we expect that an appropriate extension will be requested of a future PAC. If circularly polarized beams are routinely available by the time this experiment runs, we will take our data in this mode.

Recent theoretical work includes a re-analysis of the existing data by Adelseck and Saghai [1], which revealed possible systematic inconsistencies in the old data. They tried to find reaction models with hadronic Born couplings consistent with the SU(3) values. Their pruning of the data set and other procedures were later criticized [2], but the analysis remains the best recent discussion of the existing data set. Photoproduction data were again analyzed by Williams,Ji,and Cotanch [3], in an approach that emphasized consistency with the crossed-channel radiative capture reaction $p(\gamma, K^+)\Lambda$. The same group then extended their model [4] to include all the strangeness electroproduction data as well. The result was the most comprehensive theoretical treatment to date within the framework of the hadrodynamic models, including constraints both from crossing symmetry and the notions of duality of s and t channel processes. Their need for more and better data is clear. In a study of all possible spin observables in near-threshold strangeness production, Fasano, Tabakin and Saghai [5] explored sensitivity of the "nodal structure" of the multipoles to resonances in the elementary amplitudes. This approach may prove useful when high quality data including polarization observables become available. The first calculation to attempt a direct quark-based approach to production has appeared [6]. partly inspired by the promise of new

data from CEBAF. An approach using the chiral quark model to compute the elementary amplitudes is presently under development [7]. Also, further work by Bennhold [8] on the incorporation of hadronic form factors to enforce unitarity is in progress.

On the experimental front, the Bonn group working with their Saphir detector has started measurements [9] of hyperon photoproduction. The intrinsically low intensity of that machine, the inability to do circularly polarized measurements, and the poor quality of the first data appearing in preprint form, indicates that CLAS will be competitive when we start our program. There are also plans at Grenoble/GRAAL, using a non-magnetic tracking and calorimetric device, to examine hyperon photoproduction. With a low top energy (1.5 GeV) and no charge identification it is clear that CLAS retains significant advantages for these studies.

Carnegie Mellon University is deeply involved in the construction of the CLAS detector with which these measurements will be made. The Region I tracking drift chamber, which sits inside the main toroid of the CLAS, is being designed and built jointly at CMU and the University of Pittsburgh. Carnegie Mellon is responsible for all the mechanical components of the drift chamber structure, including the 'endplates', the detector assembly components, the wire stringing structure, and the structure for installing the detector in the spectrometer. We developed the detailed design for the wire layout, as well as the strategy for integrating sectors of the chamber into one unit. Jointly with Pitt we will manage the stringing of the wires, and the final stages of assembly, testing, and commissioning. This detector is of importance to the experiment discussed here because reconstruction of the hyperons will ultimately always be limited the tracking capabilities of this detector. Applying vertex and distance-of-closest-approach cuts will place great demands on this drift chamber. Carnegie Mellon physicists are also active on several physics and technical working group committees within the CLAS collaboration.

References

[1] R. A. Adelseck and B. Saghai, Phys. Rev. **C42** (1990) 108.

[2] Ron L. Workman Phys. Rev. **C44** (1991) 552.

[3] R. A. Williams, C-R Ji, and S. R. Cotanch, Phys. Rev. **C43** (1991) 452; ibid. Phys. Rev. **D41** (1990) 1449.

[4] R. A. Williams, C-R Ji, and S. R. Cotanch, Phys. Rev.**C46** (1992) 1617.

[5] C.G.Fasano, Frank Tabakin, and Bijan Saghai, Phys. Rev. **C46** (1992) 2430.

[6] A. Kumar and D.S. Onley, Ohio University preprint.

[7] Zhenping Li, CMU, priv. comm.; see Zhenping Li, Phys. Rev.**D50** (1994) 5639.

[8] C. Bennhold, priv. comm.; previous work in H. Tanabe, M. Kohno, and C. Bennhold, Phys. Rev. **C39**, (1989) 741, and C. Bennhold Nucl. Phys. **A547** (1992) 79c.

[9] M. Bockhorst *et al*, University of Bonn preprint (1994), to be published in Z. Phys.

The $\gamma 1$ Running Period at CLAS

December, 1994

The CLAS running period entitled $\gamma 1$ (Gamma 1) presently consists of those experiments which use a liquid hydrogen target and the real photon tagger. The running requirements of the experiments are overlapping and will be outlined here. The experiments are:

- 89-004 Electromagnetic Production of Hyperons (Schumacher *et al*)

- 89-024 Radiative Decays of the Low-Lying Hyperons (Mutchler *et al*)

- 91-008 Photoproduction of η and η' Mesons (Ritchie *et al*)

- 93-033 Search for Missing Baryons Formed in $\gamma p \rightarrow p\pi^+\pi^-$ Using the CLAS at CEBAF (Napolitano *et al*)

- 94-015 Study of the Axial Anomaly Using the $\gamma\pi^+ \rightarrow \pi^+\pi^o$ Reaction Near Threshold (Miskimen, Wang, Yegneswaran *et al*)

As can be seen from the titles, the range of physics addressed by these experiments is broad. Two involve the production and decay of strange particles, one seeks to determine the presently unknown eta photoproduction cross sections, while the others exploit the relative simplicity of photoproduction to probe poorly known sectors of hadronic physics. E89-004 will explore the photoproduction of the ground state hyperons Λ, Σ^o and Σ^+, adding abundant polarization data available for the first time. This will make it possible to extract several hadronic couplings and definitively describe the resonance structure of these reactions. E89-034 will use CLAS as a copious source of excited hyperons, such as the $\Lambda(1405)$, and extract the small radiative decay branching ratios by reconstruction of the hadronic decay products. These provide particularly sensitive tests of quark model structure of the hyperons. E91-008 plans to measure the differential cross sections for η and η' photoproduction using detection of the recoil protons in CLAS. These measurements are viewed as providing a foundation for later eta production measurements in nuclei, and for studying baryon resonances which couple to etas. E93-033 will search for firmly predicted yet undiscovered baryon states which decay to, for example, $\Delta\pi$ instead of the better-studied Nπ. This experiment will undertake the analysis of $p\pi^+\pi^-$ final states and do the necessary partial wave analysis to extract new intermediate states. E94-015 seeks to measure an amplitude strictly forbidden by the full QCD Lagrangian, but which is present as an "anomaly" in the simplest effective Lagrangian which is solvable. The experiment will actually use the reaction $\gamma p \rightarrow \pi^+\pi^o n$, and hinges on extraction of the t-channel pole term corresponding to the anomalous reaction.

It should be noted that each of the groups involved in these experiments is playing a substantial role in developing the hardware for the CLAS spectrometer or photon tagger.

For several years there has been an understanding within the collaboration that several of the real photon experiments would gather data in parallel. At the present time the

plan is for all of these experiments to accumulate data within the same 65 day running period. This concept was endorsed by PAC6. Compromises in running conditions mean that no experiment collects data at an optimal rate, but all participants have so far expressed agreement with the proposed running scenario. This scenario pre-supposes that the trigger for the CLAS will work as advertised, that is, up to a full 1,500/sec single-particle event rate will be recorded with acceptably small deadtime. In other words, the trigger can be "minimum bias," with no on-line selection of rare types of events necessary. Because the tagged photon spectrum goes roughly as 1/E, data taking will be prescaled at the trigger level to suitably even out the recorded rate as a function of energy. The present running scenario is as follows:

Beam endpoint energy: $E_o = 2.4$ GeV 5 days setup, 52 days running

- Liquid hydrogen target, 1.0 gm/cm^2

- Tagging range: 20% to 95% of E_o for 0.48 to 2.28 GeV

- Total tagging rate of 1×10^7 photons/second

- Prescale factors:

    16 - from 0.48 to 0.85 GeV (10% of all tagged photons)

    4 - from 0.85 to 1.40 GeV (26%)

    1 - from 1.40 to 2.28 GeV (64%)

- Trigger: the estimated single-charged particle rate under these running conditions is 360/sec, without correcting for acceptances. The estimated deadtime is then 24%. The total hadronic rate in the spectrometer will be about 3000 /sec.

- Magnetic field setting: 20% of nominal field with negative particles bending out. This configuration maximizes acceptance for low momentum particles, especially negative pions from hyperon decays.

Beam Endpoint energy: 3.2 GeV 1 day setup, 7 days running

- Tagging range: 71% to 95% of E_o for 2.28 to 3.04 GeV

- Total tagging rate of 1×10^7 photons/second

- Prescale factors: unity

- Trigger: One charged particle

- Magnetic field setting: 50% of nominal field with negative particles bending out.

Discussions now underway suggest that this running period may be split over three calendar years. It must be expected that some addition setup time will be needed in each year to reestablish and continue the run from previous years.

BEAM REQUIREMENTS LIST

CEBAF Proposal No.: 89-004, 89-024, 91-008, 93-033, 94-015

Date: 12-94

(For CEBAF User Liaison Office use only.)

List all combinations of anticipated targets and beam conditions required to execute the experiment. (This list will form the primary basis for the Radiation Safety Assesment Document (RSAD) calculations that must be performed for each experiment.)

Condition #	Beam Energy (MeV)	Beam Current (μA)	Polarization and Other Special Requirements (e.g., time structure)	Target Material (use multiple rows for complex targets — e.g., w/windows)	Target Material Thickness (mg/cm²)
1	2400	0.1	Circular Polarization	LH2	1 gm/cm^2
			(if available)		
2	3200	0.1	Circular Polarization	LH2	1 gm/cm^2
			(if available)		

The beam energies, E_{Beam}, available are: $E_{Beam} = N \times E_{Linac}$ where N = 1, 2, 3, 4, or 5. For 1995, E_{Linac} = 800 MeV, i.e., available E_{Beam} are 1600, 2400, 3200, and 4000 MeV. Starting in 1996, in an evolutionary way (and not necessarily in the order given) the following additional values of E_{Linac} will become available: E_{Linac} = 400, 500, 600, 700, 900, 1000, 1100, and 1200 MeV. The sequence and timing of the available resultant energies, E_{Beam}, will be determined by physics priorities and technical capabilities.

HAZARD IDENTIFICATION CHECKLIST

CEBAF Proposal No.: 89-004, 89-024, 91-008, 93-033, 94-015

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Date: 12-94

Check all items for which there is an anticipated need.

Cryogenics
- __X__ beamline magnets
- __X__ analysis magnets
- __X__ target
- type: __LH2__
- flow rate: _____
- capacity: _____

Electrical Equipment
- __X__ cryo/electrical devices
- _____ capacitor banks
- __X__ high voltage
- _____ exposed equipment

Radioactive/Hazardous Materials
List any radioactive or hazadorous/toxic materials planned for use:
NONE

Pressure Vessels
- _____ inside diameter
- _____ operating pressure
- _____ window material
- _____ window thickness

Flammable Gas or Liquids
- type: __LH2__
- flow rate: _____
- capacity: _____

Drift Chambers
- type: __CLAS__
- flow rate: _____
- capacity: _____

Other Target Materials
- ___ Beryllium (Be)
- ___ Lithium (Li)
- ___ Mercury (Hg)
- ___ Lead (Pb)
- ___ Tungsten (W)
- ___ Uranium (U)
- ___ Other (list below)

Vacuum Vessels
- _____ inside diameter
- _____ operating pressure
- _____ window material
- _____ window thickness

Radioactive Sources
- _____ permanent installation
- _____ temporary use
- type: _____
- strength: _____

Large Mech. Structure/System
- _____ lifting devices
- _____ motion controllers
- _____ scaffolding or
- _____ elevated platforms

Lasers
- type: _____
- wattage: _____
- class: _____

Installation:
- _____ permanent
- _____ temporary

Use:
- _____ calibration
- _____ alignment

Hazardous Materials
- ___ cyanide plating materials
- ___ scintillation oil (from)
- ___ PCBs
- ___ methane
- ___ TMAE
- ___ TEA
- ___ photographic developers
- ___ other (list below)

General:

Experiment Class:
- __X__ Base Equipment
- _____ Temp. Mod. to Base Equip.
- _____ Permanent Mod. to Base Equipment
- _____ Major New Apparatus

Other: _____