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: E 91 - 008

Check Applicable Boxes:

- [ ] Extension
- [ ] Update
- [x] Hall B Update

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Receipt Date: 12/14/94

By:

PR 94-127

Update for Approved Experiment 91-008

Photoproduction of η and η' Mesons

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CEBAF Large Acceptance Spectrometer Collaboration

ABSTRACT

Differential cross sections for the photoproduction on the proton of $\eta(549)$ and $\eta'(958)$ mesons will be measured using the CEBAF Hall B bremsstrahlung photon tagger and the CEBAF Large Acceptance Spectrometer in Hall B. Tagged photons of energies from 0.65 to 2.25 GeV will be incident on a liquid hydrogen target. Identification of the η and η' will be made by detection of the recoil proton in the CLAS. The measurements will provide important information on properties of the mesons themselves and on the $S_{11}(1535)$ and $P_{11}(1710)$ nucleon resonances and form a firm basis for future experiments studying η and η' interactions with nuclei.

Collaboration Activities

As noted in the proposal, the collaboration responsible for this experiment has been active in the development of the Hall B Photon Tagger through participation in the Photon Tagger Working group. Several members of the collaboration have also worked on design and construction activities on other components of Hall B instrumentation and support. The spokesman, working within the Photon Tagger Working Group, is responsible for the focal plane electronics for the tagger. His group has led efforts in determining the electronics logic for the tagger, and has designed and prototyped modularized electronics for the focal plane. Presently, the group has a contract with CEBAF to assemble the full complement of modularized electronics specific to the tagger. Other members of this collaboration are playing critical roles in the design and construction of Hall B instrumentation crucial to this and all approved experiments using the CLAS and photon tagger.

Current Physics Issues

As noted in the original proposal, the measurements to be undertaken for this experiment are of significant interest, with the following being only a partial list of the motivations:

1. Existing data are too sparse in kinematical coverage or are too limited in precision to provide accurate determination of the amplitudes involved in the elementary process $\gamma p \rightarrow \eta p$.

2. Data on the photoproduction of η' mesons from the nucleon are practically non-existent.

3. η photoproduction cross sections on the nucleon provide an isospin selectivity which will be extremely valuable in unraveling the spectrum of baryon resonances.

4. Significant questions about the structure of the mesons themselves, particularly the η', exist.

5. It may be possible that the strange content of the mesons can be exploited to help probe the strange quark content, if any, of the nucleon.

6. Investigations of η and η' interactions with the neutron and with nuclei require a detailed understanding of η and η' interactions with the proton.

The physics underpinnings of these motivations have not changed significantly since the approval of the proposal in 1991. In particular, it is still true that practically nothing is known concerning η' photoproduction on the nucleon, and that situation is unlikely to change until CEBAF and GRAAL are operating with sufficiently energetic photon beams.

The database with respect to η photoproduction on the proton will soon be expanded. Recently, the spokesman and collaborators at Bonn have extended η photoproduction measurements on the proton and the deuteron to 1.2 GeV. However, these measurements, while extremely important, still lie in a region where previous measurements have provided some insight already. The opportunity to more fully investigate the baryon resonance spectrum via η photoproduction must await the capabilities of Hall B.

In the original proposal, the relationship of this experiment to other CEBAF experiments was discussed. Since this proposal was approved, additional η and η' photoproduction experiments on the deuteron (94-008) and in heavy nuclei (93-008) have been approved. While each of those experiments will focus on somewhat different important physics issues, each will rely heavily on the results to be obtained in this experiment on the proton in order to obtain reasonable interpretations of the phenomena observed.

Thus, the motivations and interests in the photoproduction of these mesons remain. These measurements will be critical to resolving important questions related to our understanding of the structure of the nucleons, the structure of the mesons themselves, and the interactions of nucleons and these mesons with each other. They also provide a foundation for understanding the results of other approved experiments.

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.

CEBAF Proposal No.: 89-004, 89-024, 91-008, 93-033, 94-015 (For CEBAF User Liaison Office use only.) Date: 12-94

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 800, 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 (For CEBAF User Liaison Office use only.)

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: ____