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

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Experiment: **Check Applicable Boxes:**

E ^{89} - ^{024} ☐ Extension   ☐ Update   ☒ Hall B Update

Contact Person

Name: Gordon S. Mutchler

Institution: Rice University

Address: Bonner Lab   MS-315

Address: P. O. Box 1892

City, State ZIP/Country: Houston, TX   77251

Phone: 713-285-5315   **FAX:** 713-285-5215

E-Mail → Internet: mutchler@physics.rice.edu

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Receipt Date: _12/14/54_   PR 94-124

By: _____ 𝓎𝓅 _____

Radiative Decays of Low-Lying Hyperons

Rice University, College of William and Mary and the CLAS Collaboration
G.S. Mutchler, Spokesperson

The goal of this experiment is to make a model-independent measurement of the electromagnetic branching ratios of the $\Lambda(1520)$, $\Lambda(1405)$ and $\Sigma(1385)$ hyperons, free of any hadronic initial state interactions. Such data will provide a stringent test of the various quark models of the hyperons. This document updates some of the now obsolete information in the original proposal. Specifically, only the measurement of the reaction $\gamma p \rightarrow K^+ Y^*$, $K^+ Y^* \rightarrow \gamma \Lambda$ has been approved, due to the limited shower counter coverage. Also since the decision has been made to group several experiments for simultaneous running, much of the discussion on various possible running configurations and triggering options is no longer valid.

In the proposal, Table I listed the radiative widths, Γ_γ(keV), calculated from various models, and Table II listed the existing data. New calculations of Γ_γ(keV) and further analysis of the existing data have since been published. Updated values of theory and data are given in Table I. All of the existing data were derived from $K^- p \rightarrow \Lambda \gamma, \Sigma^0 \gamma$ data, so that the Γ_γ experimental values quoted are model dependent. For example, the $\Lambda(1405)$ lies below the $K^- p$ threshold and hence can be excited only via the high energy tail of the resonance. In the table, NRQM refers to the nonrelativistic quark model of Isgur and Karl, RELQM refers to a relativised constituent quark model calculation due to Warns et al and the bag models are calculations using the static-cavity approximation to the MIT bag model of Jaffe and DeGrand.

Table I Radiative Decays Widths (keV)

Transition $Y^* \rightarrow \Lambda\gamma$	NRQM (3,4)	MIT BAG(3)	Chiral BAG(1)	RELQM (2)	Experiment K - P
$\Lambda(1520)$	156	46	32	215	150±30 (5) 30±11 (6)
$\Lambda(1405)$	200	17	75	118	27±8 (7,8)
$\Sigma(1385)$	273	152		267	
$Y^* \rightarrow \Sigma\gamma$					
$\Lambda(1520)$	55	17	51	293	47±17 (6)
$\Lambda(1405)$	72	2.7	1.9	46	10±4 (7,8) 23±7 (7,8)
$\Sigma(1385)$	22	15		23	

Table II shows the updated count rates for the approved measurement, $Y^* \rightarrow \Lambda\gamma$, using the proposed 52 days of running at $E_0 = 2.4$ GeV, and 7 days at $E_0 = 3.2$ GeV, as outlined in the covering pages. The assumed running conditions are $10^7 \gamma/sec$ tagged and prescaled, a 1.0 gm/cm² LH_2 target and the forward shower counter. At 3.2 GeV, 160 hours of running was assumed for $B = 0.5 B_{max}$, with negatives bending out, and 1200 hours at 2.4 GeV, for $B = 0.2 B_{max}$. The count rates were estimated using the FASTMC program distributed by CEBAF, agumented to give a better measure of multiple scattering in the target flask and vacuum vessel. A range of values of the radiative widths, as suggested by the data in Table I

were assumed and are listed in column 2 of the table. (The radiative widths for the $Y^* \to \Sigma\gamma$ background were also given a range; specifically 40 and 20 keV for the $\Lambda(1405)$ and 22 and 15 keV for the $\Sigma(1385)$. It was set to 45 keV for the $\Lambda(1520)$ in both cases). Column 3 of the table lists the count rate for $K^+ p\pi^-$ detected and column 5 for $K^+ p\pi^- \gamma$. Columns 4 and 6 list the corresponding backgrounds due to the reaction $Y^* \to \Sigma\gamma$. Detecting the gamma ray greatly reduces this background at the cost of a factor of 3 in the count rate. Both types of data will be available. As can be seen from the table, the proposed joint running will yield an adequate measurement of the electromagnetic branching ratios.

Table II Count Rate Estimates

$E_0 = 3.2$ GeV		$K^+ p\pi^-$ Detected		$K^+ p\pi^- \gamma$ Detected	
Transition	Γ_γ keV	Counts/ 160 hrs	Bkgd $(\gamma\Sigma)$	Counts/ 160 hrs	Bkgd $(\gamma\Sigma)$
$\Lambda(1520) \to \Lambda\gamma$	150	530	10	165	2
	30	106	2	33	0
$E_0 = 2.4$ GeV		$K^+ p\pi^-$ Detected		$K^+ p\pi^- \gamma$ Detected	
Transition	Γ_γ keV	Counts/ 1200 hrs	Bkgd $(\gamma\Sigma)$	Counts/ 1200 hrs	Bkgd $(\gamma\Sigma)$
$\Lambda(1520) \to \Lambda\gamma$	150	3020	33	1060	5
	30	604	7	210	1
$\Lambda(1405) \to \Lambda\gamma$	200	1340	30	413	15
	30	200	5	62	2
$\Sigma(1385) \to \Lambda\gamma$	270	2250	15	602	0
	50	417	3	112	0

The main background will be from the reaction $\gamma p \to \pi^+ p\pi^-$ with the π^+ miss-identified as a K^+. This will be most likely to occur due to accidental events from an adjacent beam bucket, see figures 13 and 14 in the proposal. Not only will the kaon be miss-identified, but an incorrect photon energy will be assigned to the event. To solve this problem, the Rice group is designing a "start counter". This consists of six thin, 3mm thick, scintillation counters that surround the LH_2 target and covers $7^0 < \Theta < 150^0$. The design goal is a time resolution of $\sigma = 300ps$. This coupled with the $\sigma = 300ps$ time resolution of the Tagger scintillators will greatly reduce accidentals due to the 2 ns time structure of the beam. The William and Mary group is fabricating parts of the TOF scintillators and constructing the TOF laser calibration system. During the last year their shop has constructed over 70 light guides for the forward angle TOF counters and several prototypes for the large angle TOF counters. They are also involved in software development for the CLAS data acquisition system.

References.
1. Y. Umino and F. Myher, Nucl. Phys. A554 (1993) 593.
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3. E. Kaxiras, et al., Phys. Rev. D32 (1985) 695
4. J.W. Darewych, et al., Phys. Rev. D28 (1983) 1125.
5. T.S. Mast et al., Phys. Rev. Lett. 21 (1968) 1715.
6. R. Bertini et al., Contribution No. M18 to the Particles and Nuclei 10th Int. Conf. (1984) Heidelberg (unpub); R. Bertini, Nucl. Phys. B279 (1987) 49.
7. D.A. Whitehouse et al., Phys. Lett. 63 (1989) 1352.
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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 $\gamma p \to p\pi^+\pi^-$ Using the CLAS at CEBAF (Napolitano *et al*)

- 94-015 Study of the Axial Anomaly Using the $\gamma\pi^+ \to \pi^+\pi^o$ 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 $N\pi$. 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 $\gamma p \to \pi^+\pi^o n$, 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

(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/cm²
			(if available)		
2	3200	0.1	Circular Polarization	LH2	1 gm/cm²
			(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

(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: _____