CEBAF Program Advisory Committee Nine
Extension and Update Cover Sheet

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Experiment: **Check Applicable Boxes:**

E 91 - 014 ☐ Extension ☐ Update ☒ Hall B Update

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Summary of the $\gamma 3$ Running Period for the CLAS Collaboration

M. F. Vineyard, University of Richmond
for the
$\gamma 3$ Experiment Group

[December 15, 1994]

The CLAS Collaboration has developed a run plan to maximize the scientific output of Hall B by exploiting the capability of the CLAS to simultaneously obtain data for experiments with similar running conditions. A number of experiment combinations have been identified which can run simultaneously with minor compromises. One of these combinations, which has been identified as the "$\gamma 3$" running period, includes the following approved experiments:

- E-91-014: Quasi-Free Strangeness Production in Nuclei, C. E. Hyde-Wright, Spokesperson
- E-93-008: Inclusive η Photoproduction in Nuclei, M. F. Vineyard, Spokesperson
- E-93-044: Photoreactions on ^3He, B. L. Berman, P. Corvisiero, and G. Audit, Spokespersons

While these experiments have multiple physics goals, there is one motivation that is common to all three: the study of the formation and propagation of nucleon resonances in nuclear matter. One experiment (E-91-014) will study this phenomenon through the photoproduction of kaons. Another (E-93-008) will use η meson photoproduction to investigate the S_{11} and P_{11} resonances. The third experiment (E-93-044) will study the D_{13} and F_{15} resonances through the exclusive $N\pi$ and $N\pi\pi$ channels.

The other scientific motivations of the three experiments are diverse and address a number of important physics issues. The strangeness production experiment (E-91-014) will investigate kaon-nucleus and hyperon-nucleus interactions and photon coupling to correlated nucleon-nucleon pairs in the nucleus. Experiment E-93-008 will provide information on the η-nucleon interaction. The study of photoreactions on ^3He (E-93-044) will investigate the three-body effects in the NNN breakup channel and the ΔNN component of the ^3He wave function.

It is important to point out that these experiments are integral components of the Hall B physics program. There are significant connections between these studies and photoproduction experiments on other targets and electroproduction measurements that address topics that are related to those outlined above.

The basic running conditions of the three experiments are the same, and all the spokespersons agree that the details of the running period can be worked out with only minor compromises. The spokespersons also agree that it is important that the running period be broken up into several periods, as proposed for the early stages of Hall B operation, and that the first running period of these experiments be as early as possible. This will allow us to gain a better understanding of the Hall B equipment and to optimize the running conditions for the later periods, which will result in higher quality measurements.

The collaborations of the $\gamma 3$ experiment group are responsible for many significant and critical elements of the Hall B instrumentation, as detailed in the individual updates. These include two substantial contributions from outside the United States: the cryogenic target system from Saclay and the large-angle calorimeters from our Italian collaborators. Other components include the region-2 drift chambers, the pair spectrometer, the photon collimation system, the drift-chamber gas system, the focal-plane detector array for the tagger, and software.

Update of Experiment 91-014 in Hall B

Quasi-Free Strangeness Production in Nuclei

C.E. Hyde-Wright (spokesperson)
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for the real photon group

Strangeness production is a few percent of the total photo-absorption cross section. However, because of the relatively large mean free path of Kaons and Lambdas in nuclei (due to the absense of a one-pion-exchange potential), strangeness production is an attractive way to study photo-absorption in nuclei. In addition to information on the kaon-nucleus and hyperon-nucleus optical potentials, this experiment will shed new light on two inter-related questions: How do nucleon resonance states propagate in nuclei, and how does a photon couple to a correlated nucleon-nucleon (NN) pair in the nucleus?

All six amplitudes: $p(\gamma, K^+)\Lambda$, $p(\gamma, K^+)\Sigma^0$ $p(\gamma, K^0)\Sigma^+$ $n(\gamma, K^0)\Lambda$, $n(\gamma, K^0)\Sigma^0$, and $n(\gamma, K^+)\Sigma^+$, contribute to the total cross sections for photo-production of strangeness in nuclei. However, most of the existing photo-kaon data are for the $p(\gamma, K^+)$ channels. We have published a semiphenomenological analysis of Σ photo-production, including independent constraints on K^0 production and strangeness production on neutrons.[1]

There are also new theoretical results for photokaon production in the quark model, using the $^3P_0$ $q\bar{q}$ production model.[2] This approach provides a semi-microscopic basis for separating the total amplitude into Born and resonance terms. This separation is important because it is likely that the Born and resonance terms will be affected differently by the nuclear medium. There is some new evidence that nucleon resonances are strongly damped in nuclei. For example, the total photo-absorption cross section per nucleon in Be and C shows a 30% suppression in the region of the S_{11} and D_{13} resonances.[3] This is not a purely fermi-motion effect, as illustrated by the fact that the photo-absorption in the Δ-region scales with A. We note further that since the total (γ, K) amplitude is the result of partial cancelation of several diagrams, damping the resonance terms may actually increase the total cross section in nuclei.

Semi-exclusive events, of the type $^AZ(\gamma, KY)$ at large missing momentum offer the prospect of new information on NN correlations. We have a reasonably quantitative understanding of NN correlations in $A \leq 4$ nuclei and nuclear matter. On the theoretical side, we have exact or near exact calculations of the ground states of these systems. On the experimental side, we have precision measurements, including elastic and quasi-elastic electron scattering data on light systems that confirm the role of correlations. However, the electromagnetic coupling to a correlated pair remains a major challenge for our field. The longitudinal/transverse anomaly observed in both quasi-free (e, e') and $(e, e'p)$ reactions is indicative that a high momentum NN pair is not necessarily made of two static nucleons. We expect that strangeness production at large missing momentum will be dominated by strangeness production on a correlated pair. In contrast to $(e, e'p)$ data, which have focussed on the elastic $(\gamma + NN \rightarrow NN)$ structure of NN pairs, our data will explore the inelastic structure (*e.g.* $\gamma + NN \rightarrow NN^*$) of the NN pairs in nuclei.

Although our experiment was proposed with unpolarized beams, we are prepared to run with either unpolarized or longitudinally polarized beams. The weak decays of the hyperons are self analysing (e,g. $\Lambda \rightarrow p + \pi^-$). With polarized beams we will be able to measure polarization observables such as the spin transfer coefficient from the photon to the Λ. Since the Λ-nucleus spin-orbit interaction is known to be small, spin-dependent effects in the Λ-nucleus final state interaction should also be small. Thus modifications of spin observables should be dominated by effects of the initial production vertex.

On the equipment side, members of this collaboration are responsible for significant elements of the CLAS and associated equipment. One of us (C.E. H.-W.) has recently joined the Old Dominion University group building the region-2 drift chambers, and has taken responsibility for the electronics. C.E. H.-W., in collaboration with members of the U.VA. group is also designing the Pair-Spectrometer to monitor the tagged photon flux. C.E. H.-W. and D.S. at U.W. are designing the collimation system for the tagged photon beam.

References

[1] "Constraints on Coupling Constants through Charged Σ Photoproduction", T. Mart, C. Bennhold, and C.E. Hyde-Wright, submitted for publication, Aug. 1994.

[2] "Photoproduction of Kaons in a Semirelativistic Quark Model" A. Kumar and D.S. Onley, BAPS **39** (1994) 1421.

[3] "Behavior of the Be and C total photonuclear cross section in the nucleon resonance region", M. Anghinolfi, *et al.*, Phys Rev **C47** (1993) R922.