

## 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:

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**Experiment:**      **Check Applicable Boxes:**

**E** 93 - 008

Extension

Update

Hall B Update

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Update for Experiment 93-008

## Inclusive $\eta$ Photoproduction in Nuclei

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Through the study of the excitation, propagation, and decay of nucleon resonances in the nuclear environment one ultimately expects to understand how the strong interaction is affected by baryon structure. Over the last twenty years, a wealth of information on the  $\Delta(1232)$  and its dynamics within the nuclear medium has been obtained through pion studies. However, very little is known about medium properties of the higher energy excited states of the nucleon. This is primarily due to the fact that the dominance of the  $\Delta$  and the overlapping of higher resonances prevents studying one specific state by  $\pi$ -production experiments. The  $\eta$  meson, on the other hand, couples only with isospin-1/2  $N^*$  resonances since it is an isoscalar particle, and therefore provides an excellent way to isolate these resonances. In this experiment, inclusive measurements of the photoproduction of  $\eta$  mesons in nuclei will be performed to investigate medium modifications of the  $S_{11}(1535)$  and  $P_{11}(1710)$  resonances which are the only nucleon resonances of mass less than 2 GeV with significant  $\eta$  decay branches.

These measurements will also provide information on the  $\eta$ -nucleon interaction. Due to the lack of  $\eta$  beams, very little is known about the interaction of  $\eta$  mesons with nucleons. In this experiment, final-state interactions of the  $\eta$  meson propagating through the nucleus will be used to investigate the  $\eta N$  interaction. The study of  $\eta$  interactions with nucleons and nuclei can provide significant tests our understanding of meson interactions which has been developed through pion studies. Also a comparative study of the response of  $\eta$  and  $\eta'$  mesons in the nuclear medium may provide insight into the mixing in these two mesons and the structure of the  $\eta'$ .

Recently, Carrasco [1] calculated inclusive  $\eta$  photoproduction cross sections through the excitation of the  $S_{11}(1535)$  resonance with a model that includes nuclear-medium modifications of the decay width, Fermi motion, Pauli blocking, and final-state interactions. The results indicate that the inclusive cross sections are sensitive to both nuclear-medium modifications and final-state interactions at energies around the  $S_{11}(1535)$ .

Since the experiment was approved by PAC6 in the summer of 1993, we have performed simulations to investigate the CLAS acceptance for the recoil nucleons in coincidence with the  $\eta$  mesons assuming quasi-free photoproduction. The angle-summed acceptance at an incident photon energy of 0.8 GeV is 2% for either (proton +  $2\gamma$ ) or (neutron +  $2\gamma$ ) coincidences, and increases to 7% and 4% at 1.5 GeV for (proton +  $2\gamma$ ) and (neutron +  $2\gamma$ ) detection, respectively. Detection of the recoil nucleons will allow the reconstruction of the invariant

mass squared  $s = (p_\eta + p_N)^2$  of the system which should provide an independent measure of the in-medium mass and width of the resonances. It will also enable the use of the missing mass from the recoil baryon kinematics, in addition to the invariant mass from the  $2\gamma$  decay, to improve the  $\eta$  identification.

Two  $\eta$  photoproduction experiments have been performed recently at other laboratories. Measurements were made at MAMI on  $^1H$ ,  $^2H$ ,  $^{12}C$ ,  $^{40}Ca$ ,  $^{93}Zr$ , and  $^{nat}Pb$  targets over the photon energy range from 600 to 790 MeV [2]. The preliminary results of these measurements indicate that the data is of high quality, however, the energy range covered is only from threshold to just below the peak of the  $S_{11}(1535)$  resonance. The other experiment was performed at Bonn on  $^1H$ ,  $^2H$ , and  $^{14}N$  targets from threshold to 1.15 GeV. The preliminary results for the energy dependence of the inclusive cross sections measured in this experiment show a depletion and broadening of the  $S_{11}(1535)$  resonance in the nuclear medium [3]. A comparison of their  $^{14}N$  results with Carrasco's calculation for  $^{16}O$  shows good agreement up to 900 MeV which is the high energy limit of the calculation. The CEBAF experiment discussed here will complement these measurements and extend them to higher energies and more targets. The extended energy range will allow the investigation of the contributions to the cross section from the  $S_{11}(1535)$  and  $P_{11}(1710)$  resonances, and non-resonant production. The measurements will be made on  $^2H$ ,  $^3He$ ,  $^4He$ , and  $^{12}C$  targets enabling the study of the evolution of medium effects with target mass.

The members of this experiment collaboration are making various important contributions to the experimental equipment in Hall B. The University of Richmond group is responsible for the construction of the drift-chamber gas system and the associated control system. The group is also working on the development of drift-chamber and data-acquisition software.

- [1] R. C. Carrasco, Phys. Rev. C48, 2333 (1993).
- [2] H. Stroehler, private communication.
- [3] M. Breuer *et al.*, Bonn preprint.