0.1 E93-008

Inclusive η Photoproduction in Nuclei

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0.1.1 Introduction

Jefferson Lab Experiment 93-008 uses the CEBAF Large Acceptance Spectrometer (CLAS) and the photon tagging system in Hall B to measure inclusive η photoproduction in nuclei. The primary motivation of this experiment is to investigate nuclear medium modifications of nucleon resonances and the η-nucleus interaction. This experiment is part of both the g2 and g3 run groups of the CLAS Collaboration.

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. 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 Δ and the overlapping of higher resonances prevents the study of only a single specific state by π-production experiments. The η meson, on the other hand, couples only with isospin-$\frac{1}{2}$ N^* resonances since it is an isoscalar particle, and therefore provides a way to isolate these resonances. In this experiment, inclusive measurements of the photoproduction of η mesons in nuclei are performed to investigate medium modifications of the $S_{11}(1535)$ and possibly other isospin-$\frac{1}{2}$ resonances.

These measurements will also provide information on the η-nucleus interaction. Due to the lack of η beams, very little is known about the interaction of η mesons with nuclei. In this experiment, final-state interactions of the η meson propagating through the nucleus will be used to investigate the η-nucleus interaction. The study of η interactions with nucleons and nuclei can provide significant tests of our understanding of meson interactions which has been developed through pion studies.

Data were obtained several years ago at MAMI for the inclusive reaction on ^{12}C, ^{40}Ca, ^{93}Nb, and ^{nat}Pb nuclei for photon energies up to 790 MeV [Ro96]. However, though these data are of high quality, the energy range covered is from threshold to just below the peak of the $S_{11}(1535)$ resonance. From the analysis of these data, it was concluded that the total cross section scales as $A^{2/3}$ and a Glauber model analysis indicated an η-N cross section of about 30 mb. No evidence of a shift in mass or a depletion of strength of the $S_{11}(1535)$ was observed from a comparison with an effective Lagrangian model [Ca93]. However, it should be stressed that this conclusion was drawn from a comparison of the slopes of the data and calculations on the low-energy side of the $S_{11}(1535)$ rather than over the entire line shape of the resonance.

Recently, the $^{12}C(\gamma,\eta)$ reaction was investigated at photon energies between 0.68 and 1.0 GeV at the 1.3-GeV electron synchrotron at KEK-Tanashi [Yo00]. The cross section as a function of incident photon energy was observed to increase with photon energy up to 0.9 GeV and then begin to decrease. This was interpreted as the first observation of the $S_{11}(1535)$ resonance in the carbon nucleus. It was shown that some of the differences between the shapes of the cross sections measured on carbon and hydrogen can be accounted for by medium effects such as Fermi motion, Pauli blocking, and η-N and N-N* collisions in quantum molecular dynamics calculations.

There have been a number of theoretical results on η photoproduction from nuclei in the last decade. In the effective Lagrangian approach of Carrasco *et al.* [Ca93], the η-N final state interactions are taken into account by a Monte Carlo code using calculated reaction probabilities. In the work of Lee *et al.* [Le96], the quasifree production is calculated in the distorted-wave impulse approximation and the final state interactions are treated with an η-A optical potential. Effenberger *et al.* [Ef97] use the production cross sections on the free nucleon as input and take into account the final state interactions with a coupled-channel Boltzmann-Uehling-Uhlenbeck model. Recently, Hedayati-Poor and Sherif [He98] introduced a relativistic model in which an effective Lagrangian approach is used to describe the elementary production process and the dynamics of the nucleon motion is based on a relativistic mean field theory. Several of these models provide reasonable descriptions of the MAMI total cross sections. However, detailed agreement with the differential cross sections is not obtained with any of the models.

The Jefferson Lab experiment discussed here will extend the MAMI and KEK-Tanashi measurements to higher energies and more targets. The extended energy range will completely cover the region of the $S_{11}(1535)$ resonance and allow for a more thorough investigation of possible nuclear medium modifications. It will also allow for the measurement of contributions to the cross section from other resonances and non-resonant production. The measurements are being made on a variety of targets enabling the study of the evolution of medium effects with target mass and the investigation of the η-nucleus interaction.

0.1.2 Experiment Status

Data are currently being analyzed for η photoproduction on ^{1}H, ^{2}H, ^{3}He, and ^{4}He targets. Future measurements on ^{12}C and Pb targets are planned.

Shown in Figure 1 are preliminary invariant mass spectra for $\gamma\gamma$ events from hydrogen, deuterium, and ^{3}He targets. The spectra are fitted with a function consisting of a quadratic piece to describe the background in the mass region 0-0.23 GeV, an exponential part to fit the background at higher mass, and two gaussians to fit the π^0 (mass = 0.135 GeV) and η (mass = 0.547 GeV) peaks. These spectra represent a small fraction ($\leq$ 5%) of the total data set on each target.

References

[Ro96] M. Roebig-Landau, *et al.*, Phys. Lett. **B373**, 45 (1996).

[Ca93] R.C. Carrasco, Phys. Rev. **C48**, 2333 (1993).

[Yo00] T. Yorita *et al.*, Phys. Lett. **B476**, 226 (2000).

[Le96] F.X. Lee, L.E. Wright, C. Bennhold, and L. Tiator, Nucl. Phys. **A603**, 345 (1996).

[Ef97] M. Effenberger *et al.*, Nucl. Phys. **A614**, 501 (1997).

[He98] M. Hedayati-Poor and H.S. Sherif, Phys. Rev. **C58**, 326 (1998).

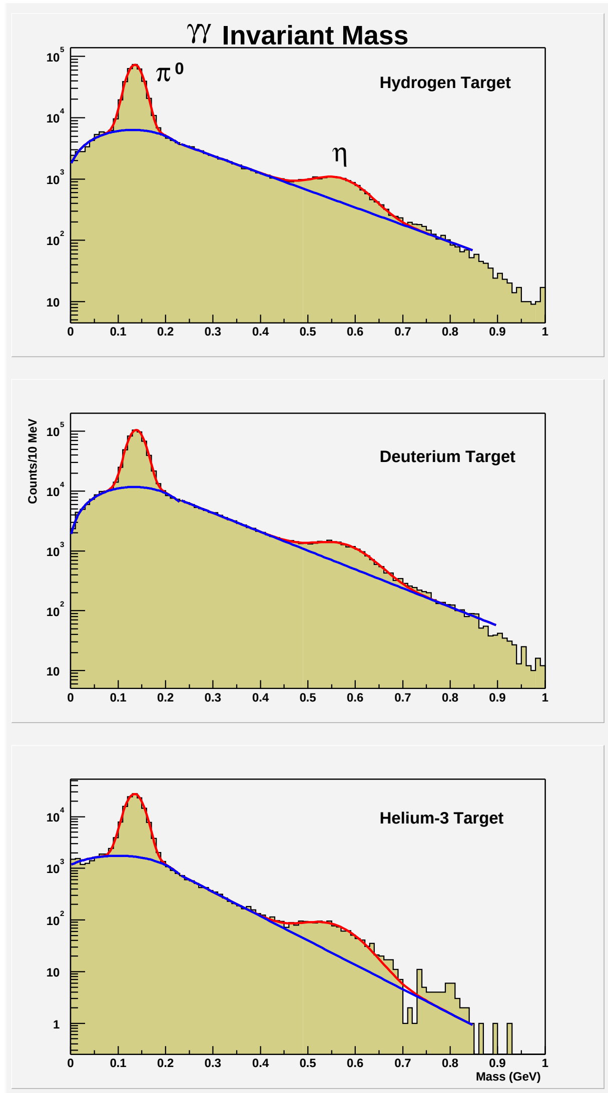

Figure 1: Preliminary invariant mass spectra for $\gamma\gamma$ events from hydrogen, deuterium, and ^{3}He targets. The spectra are fitted with a background function and two gaussian functions. The background function has a quadratic form over the range 0-0.23 GeV and an exponential form at higher mass. The π^0 (mass = 0.135 GeV) and η (mass = 0.547 GeV) peaks are fitted above the background with the gaussian functions. These spectra represent a small fraction ($\leq 5\%$) of the total data set on each target.