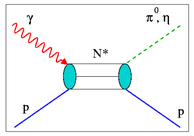
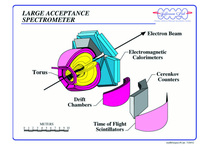


Extraction of Yields for Neutral Meson Photoproduction from the Proton and ^{3}He with the CLAS Detector at Jefferson Lab



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Abstract

The photoproduction of π^0 and η mesons from hydrogen and ^{3}He targets over an incident photon energy range of 0.5 - 1.5 GeV is being studied using data from the CEBAF Large Acceptance Spectrometer (CLAS) at Jefferson Lab. This is part of a systematic study of meson photoproduction from the proton and light nuclear targets to investigate possible nuclear medium modifications of nucleon resonances and meson-nucleon interactions. The neutral mesons are reconstructed from their two-photon decay. Two-photon invariant mass spectra binned in incident photon energy and production angle are fitted to extract yields for π^0 and η meson photoproduction. Monte Carlo simulations are also being performed to determine the acceptance of the CLAS detector for these reactions. The analysis is described and the procedures used to extract the yields and determine the acceptance are discussed.

Experiments

This analysis is being performed using data collected during the g1c and g3 runs of the CLAS Collaboration. In these experiments electron beams from the CEBAF accelerator with energies of 1.6 (g3) and 2.4 GeV (g1c) were converted into photon beams with the photon tagging system in Hall B. The overlapping energy range of the two photon beams was 0.5 – 1.5 GeV. The photon beams bombarded liquid hydrogen and ^{3}He targets at the center of CLAS and the reaction products were detected using the various components of the spectrometer shown in Figure 1 [1]. The CLAS is a multi-gap spectrometer with six superconducting coils producing a toroidal magnetic field around the beam axis. The detector packages in the spaces between the coils consist of three regions of drift chambers to track charged particles, Cerenkov counters to identify electrons, scintillator counters for time-of-flight measurements, and electromagnetic calorimeters to detect electrons, photons, and neutrons.

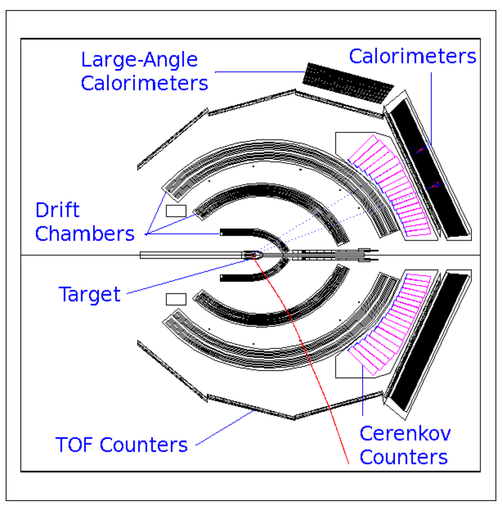

Figure 1: A schematic view of the CLAS detector sliced along the beam axis. Shown in the figure is a simulated π^0 photoproduction event.

Identifying Neutral Mesons

The neutral mesons were reconstructed from their two-photon decay. Photons were identified as neutral hits depositing at least 100 MeV of energy in the calorimeters and with $\beta > 0.95$. A β spectrum for neutral particles is shown in Figure 2. We selected two-photon events and reconstructed the neutral mesons by adding the four-vectors of the two photons, and squaring the resultant four-vector to get the invariant mass. Shown in Figure 3 is a histogram of invariant mass for two-photon events from a hydrogen target. The spectrum is fitted with a background function and two gaussian functions. The background function has a quadratic form over the range 0-0.23 GeV/c^2 and an exponential form at higher mass. The π^0 (mass = 0.135 GeV/c^2) and η (mass = 0.547 GeV/c^2) peaks are fitted above the background with the gaussian functions.

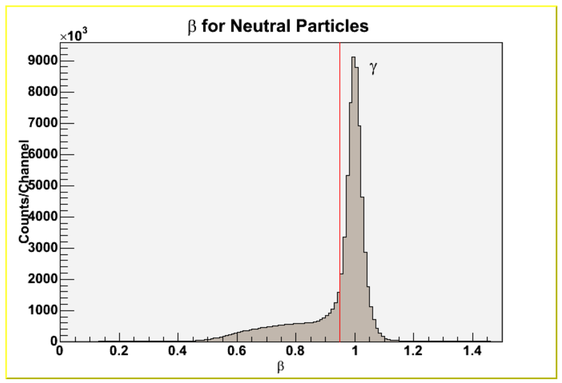

Figure 2: A beta spectrum for neutral particles detected in the electromagnetic calorimeters. The red line indicates the cut used to identify photons.

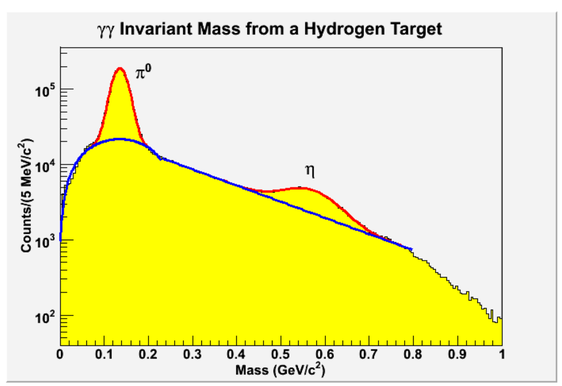

Figure 3: A two-photon invariant mass spectrum for photoproduction from a hydrogen target. The spectrum is fitted with two gaussians (red) and polynomial and exponential background functions (blue).

Extraction of Yields

In order to determine the differential cross sections for the photoproduction of the neutral mesons from the free proton and the quasi-free production from a proton in the ^{3}He nucleus, we selected events in which two photons and a proton were detected and divided the data into bins in production angle and incident photon energy. Then for each bin, we created a histogram of invariant mass and fitted the spectrum with a gaussian plus a background function to extract the yield. An example of a fit to extract the yield for η mesons produced at 20 - 30 degrees with photons in the energy range of 1.3 – 1.4 GeV is shown in Figure 4. The data are fitted with a gaussian and an exponential background function.

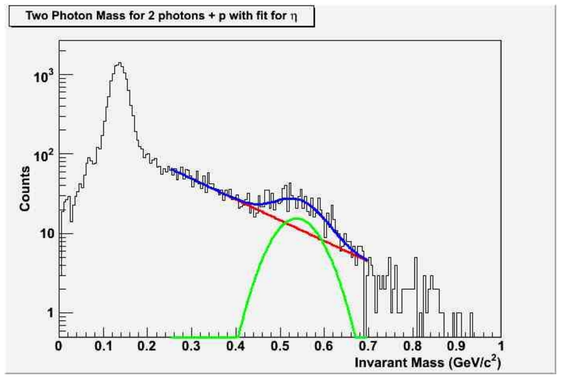

Figure 4: A two-photon invariant mass spectrum for photoproduction from a ^{3}He target with meson production angles between 20 and 30 degrees and incident photon energy of 1.3 to 1.4 GeV. The data are fitted with a gaussian (red) and an exponential background function (blue) to extract the yield for the η meson.

Simulations

Monte Carlo simulations are being performed with the CLAS GEANT simulation code GSIM [2] to determine the acceptance of CLAS for these reactions. The π^0 and η photoproduction events have been generated with the phase-space code psg and the code genbos [3]. The generated events were run through GSIM to simulate the CLAS response. Then the events were run through the code gpp to account for dead channels in the spectrometer. Next the simulated data were processed with the CLAS data analysis code in the same way as the data. A simulated two-photon invariant mass spectrum for photoproduction from hydrogen is compared to the data in Figure 5.

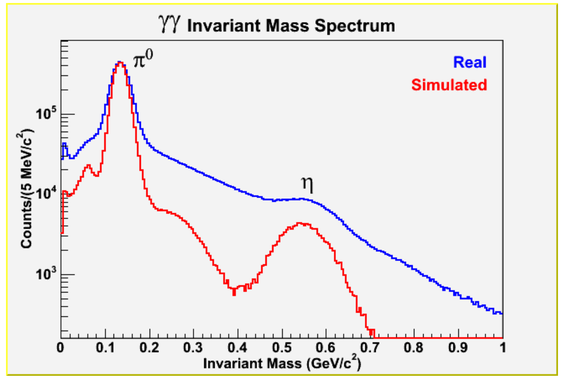

Figure 5: A comparison of a simulated two-photon invariant mass spectrum (red) with data (blue) for photoproduction from a hydrogen target.

Status

Yields have been extracted for the photoproduction of π^0 and η mesons from a hydrogen target, and for the π^0 meson from a ^{3}He target. In addition, Monte Carlo simulations are being performed to determine the acceptance of CLAS for these reactions.

Future Work

We need to finish extracting yields for η mesons from a ^{3}He target, and to calculate the acceptance functions from the Monte Carlo simulations. Once this is done, we will be able to calculate cross sections and compare to theory, as well as compare results from the hydrogen and ^{3}He targets to look for nuclear medium modifications and investigate the meson-nucleon interaction.

References

[1] B. Meckling *et al.* (The CLAS Collaboration), Nuclear Instruments and Methods **503/3**, 513 (2003).

[2] CLAS GEANT Simulation Code, http://www.physics.unh.edu/~maurik/gsim_info.shtml

[3] A.S. Iljinov *et al.*, Nuclear Physics **A616**, 575 (1997).

Acknowledgements

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