CEBAF EXPERIMENT 94-103

The Photoproduction of Pions

The γN interaction is one of the most powerful ways of investigating hadron structure. In reactions with the nucleon, one may study the radiative-decay amplitudes of the N(I=1/2) and Δ(I=3/2) resonances without the complexities involved in heavier nuclei. These amplitudes are essential in testing theories of the strong interaction, especially those based on the quark model. In particular, pion photoproduction provides a means by which intermediate resonance states can be scrutinized in a straightforward manner, given the well-known nature of the electromagnetic interaction. The radiative decay of a resonance is sensitive to the dynamics of quarks within the hadron. However, the radiative amplitudes for many resonances are not well know; e.g., $S_{11}(1535)$, $P_{13}(1720)$, and $F_{17}(1990)$ to name a few; thus, current checks on the validity of some models are often difficult and inconclusive. The lack of good data, as well as other factors, such as the reliance on pion-nucleon elastic scattering analyses and their inherent complexity, often precludes extraction of accurate decay amplitudes.

We will measure single-pion photoproduction using CLAS and the Tagger Facility in Hall B at CEBAF with tagged photons having energies between 400 and 3040 MeV. Differential cross sections for the reactions $\gamma p \to \pi^0 p$ and $\gamma p \to \pi^+ n$, and for $\gamma n \to \pi^- p$ will be measured to an accuracy better than 4% in hydrogen and 6% in deuterium, for center of mass angular increments of 3^0 to 6^0 between 20^0 and 140^0, and for energy increments of 4.9 to 12.5 MeV. These measurements will provide unique and coherent results from tagged photons over a broad range of angle and energy; and with a few exceptions, represent the only pion photoproduction data above 1800 MeV. The differential cross sections extracted from this data will be analyzed to determine the partial wave amplitudes and the photocouplings for some 25 baryon resonances in the energy range of the experiment.

Many of the resonances which are predicted by the quark model between threshold and our energy cutoff are not observed in analyses of the current pion photoproduction data. Our new results, which in some cases will yield partial-wave amplitudes with uncertainties a factor of five smaller than current results, will determine current photocouplings more accurately, and can reveal currently unidentified weakly-produced resonance states. The photocouplings of baryon resonances are a crucial test of our understanding of nonperturbative quantum chromodynamics (QCD). The results will be compared with quick model predictions from multichannel analyses; e.g., $\gamma N \to \pi N, \gamma N \to \pi\pi N, \gamma N \to \eta N, \pi N \to \pi N, \pi N \to \pi\pi N$ and $\pi N \to \eta N$; and with other timely physics models. The establishment of the $Q^2=0$ electroproduction point in the more fundamental photoproduction processes will provide an important constraint on any results obtained in electroproduction experiments.