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Measurement of the $p(e,e'\pi^+)n$, $p(e,e'p)\pi^0$, and $d(e,e'\pi^-)pp$ in the 2nd and 3rd Resonance Region

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Electrons with energies of 2 and 4 GeV will be scattered from hydrogen and deuterium targets in the CLAS detector to study the single pion electroproduction reactions. Using the measured energies and angles of the scattered electron and the charged hadron (either a pion or a proton), we can select events with kinematics consistent with production of an intermediate state containing a nucleon resonance with mass between 1350 and 1800 MeV (sometimes referred to as the "second" and "third" resonance regions), in a range of electron momentum transfer, $0.1 < Q^2 < 3(\mathrm{GeV/c})^2$. These events will be dominated by pions resulting from decay of the intermediate resonance states. With only two charged particles in the final state, the expected low background will permit precision measurements of the properties of the excited nucleon states. The large kinematical phase space available in the final state makes the CLAS detector ideally suited for the experiment.

These measurements are important in understanding how quarks and gluons interact to form ordinary matter. There are a number of models, many of which differ considerably in concept, that yield predictions difficult to distinguish with existing data. These models include the low energy constituent quark model, which has many variants in detail, Skyrme-type soliton models, and quark-gluon models. An algebraic model, introduced recently by Iachello appears to encompass both the constituent quark model and string models. An interesting result obtained from the symmetries in the model is the prediction of parity doublets in the baryon resonance spectrum.

Inclusive electron scattering is dominated in the "second" resonance region by excitation of two resonances, the $S_{11}(1535)$ and the $D_{13}(1520)$ and in the "third" region by the $F_{15}(1690)$. Several other states in this mass region contribute, but so weakly that it has been difficult to extract much detail about their electromagnetic structure. Our measurements will greatly improve the accuracy of the electroproduction amplitudes for the dominant resonances, and are expected to yield significant measurements of weak amplitudes. For the range of Q^2 to be studied, there is some evidence indicating that resonance excitation is best described at the low end by low-energy models, while at the high end the simpler techniques of perturbative QCD may already have some applicability. For example, the production of some of these resonances is dominated by photon-quark helicity 3/2 at low Q^2 and by helicity 1/2 at high Q^2, consistent with the helicity invariance in a single quark transition expected as $Q^2 \to \infty$.

We hope to clarify the nature of the $P_{11}(1440)$ resonance, observed in photoproduction, but only very weakly in electroproduction. This behavior, along with its relatively low mass for a quark model N=2 state makes it important to understand this resonance in detail. There have been suggestions that the state might be a quark-gluon hybrid. Accurate measurements using both proton and neutron targets are required.

The third resonance region is particularly rich in N=2 states, providing additional candidates for quark-gluon states as well as a number of important tests of single quark transition models.