CEBAF EXPERIMENT 94-014

The $\Delta(1232)$ Form Factor at High Momentum Transfer

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This experiment will disentangle the "$\Delta(1232)$ Form Factor" at the highest possible momentum transfer Q^2 possible at CEBAF. This is a unique opportunity to uncover the nature of the strong interaction where it is now most poorly understood.

Physicists generally believe that Quantum Chromodynamics (QCD), a quantum field theory of colored quarks and gluons, is the correct description of the strong interactions. Most experimental support for QCD, however, comes from high energy, i.e. "perturbative", inclusive reactions where only the simplest Feynman diagrams contribute. At lower energies, the Quark Model describes the structure of hadrons (i.e. strongly interacting particles). This model has essentially the same degrees of freedom as QCD, but their interactions are very much different.

A prime goal of Nuclear Physics is to identify reactions where the perturbative and non-perturbative descriptions clash. These reactions are exactly what we need to test more "complete" solutions of QCD if, for example, their outcomes are not only distinctly different, but also are calculated with certainty, in both perturbative QCD (pQCD) and in the Quark Model. Such examples are rare, and this experiment will determine the outcome of one of them.

Our experiment measures the structure of the $\Delta(1232)$ using the reaction $ep \to e'\Delta$ followed by $\Delta \to p\pi^0$. This reaction excites the Δ electromagnetically by absorbing a "virtual" photon, with invariant mass Q^2, on a proton. The Δ decay is sensitive to different contributions to the excitation. In particular, we determine the angular distribution of the $p\pi^0$ decay system in the Δ rest frame, which tells us the ratio of "electric quadrupole" to "magnetic dipole" amplitudes, written E_1^+/M_1^+, in Δ excitation. The Quark Model predicts a very small value for $E_1^+/M_1^+ \approx 0$, and this is in fact verified[1] for real photon (i.e. $Q^2 = 0$) excitation where the Quark Model is on its most firm ground. However, for electro-excitation at very high Q^2, pQCD predicts $E_1^+/M_1^+ = 1$. We will measure this reaction at the highest possible Q^2 at CEBAF, namely $Q^2 = 4$ GeV/c^2, where a pQCD description might become apparent.[2]

The experiment uses a 4 GeV electron beam and the High Momentum Spectrometer (HMS) and Short Orbit Spectrometer (SOS) in Hall C. The SOS detects the scattered electron from $ep \to e'\Delta$, and the decay proton from $\Delta \to p\pi^0$ is measured in the HMS. The momentum and angular resolutions of the spectrometers is more than sufficient to convincingly establish the missing π^0, and to measure the decay angular distribution. We expect to be sensitive to $E_1^+/M_1^+ \approx 0.1$ or higher.

[1]See, for example, R.M. Davidson, N.C. Mukhopadhyay, and R. Whittman, Phys. Rev. **D43**(1991) 71
[2]P. Stoler, Phys. Rev. **D44** (1991) 73