The Structure of the Free Neutron Via Spectator Tagging

(Experiment E03-012)

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A CLAS collaboration proposal

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E03-012 Experimental Summary

The structure of the proton has been studied in great detail through inelastic lepton scattering for several decades. Much less is known about the structure of the neutron, however, due to the absence of free neutron targets, and the substantial theoretical uncertainties associated with extracting information from neutrons bound in nuclei. Knowledge of neutron structure is vital if one is to reconstruct, for instance, the distributions of valence quarks in the nucleon.

To overcome this problem, this experiment will measure the inclusive electron scattering cross section on an almost free neutron using the CEBAF Large Acceptance Spectrometer (CLAS) and a novel recoil detector with low momentum threshold for protons and high rate capability. This detector will allow tagging of slow backward-moving spectator protons with momentum as low as 70 MeV/c in coincidence with the scattered electron in the reaction $D(e, e'p_s)X$. This will ensure that the electron scattering took place on an almost free neutron, with its initial four-momentum inferred from the observed spectator proton spectrum.

The spectator tagging technique will be used to extract the structure function F_2^n over a large range of Q^2 (up to $\sim$ 5 GeV^2) and W (from the elastic peak to W = 3 GeV), using beam energies of 4 and 6 GeV over a 25 day run period. The kinematic coverage, including the elastic and resonance regions, as well as part of the deep inelastic continuum (from $x = 0.2$ to $x = 0.6$), will allow us to extract neutron elastic form factors, resonance excitation strengths, and the ratio of the neutron to proton structure functions F_2^n/F_2^p at high x. These data will also allow quantitative tests of quark-hadron duality in the neutron for the first time, and will open up a wide range of opportunities for studying the structure of the free neutron in future.