

E12-07-108: Precision Measurement of the Proton Elastic Cross-Section at High Q^2

Measurements of the cross section for the elastic scattering of electrons from protons provide some of the most fundamental information on the structure of the proton. Such measurements test our understanding of this structure in terms of the underlying theory of the strong interaction, Quantum Chromodynamics (QCD). This proton substructure results from the more fundamental quarks and their interactions, and is encoded in the elastic *form factors*, which are functions of the 4-momentum transfer, Q^2 , (or alternatively the wavelength) of the virtual photon exchanged during the electromagnetic interaction between the electron and the distributions of charge and magnetization.

This experiment aims to measure the elastic electron-proton cross section over a range of Q^2 from 7 to 17 $(\text{GeV}/c)^2$ with a high precision of better than 2%; several times better than previous measurements in this Q^2 region. With recent high- Q^2 measurements of the electric form factor, $G_E^p(Q^2)$, having clearly demonstrated that we have yet to reach high enough Q^2 for this form factor to exhibit the $1/Q^4$ scaling behavior expected from a perturbative expansion of QCD (pQCD), we need to move beyond existing measurements which are simply 'consistent with pQCD scaling within the uncertainties' to precision measurements of the Q^2 -dependence. High- Q^2 , high-precision data will provide strong constraints to models of nucleon structure, with lower Q^2 data on other form factors providing additional constraints on the separation of the u versus d quark contributions, and charge versus magnetization distributions.

Additionally, these measurements will provide critical input for a wide range of other topics which will be studied with the upgraded Jefferson Lab electron accelerator. For instance, the $G_M^p(Q^2)$ measurements will provide the highest Q^2 exclusive measurements for the Jefferson Lab program to study the relatively new paradigm of generalized parton distribution functions, which encode the full 3-dimensional image of quarks (or more generally *partons*) inside hadrons, and thus, incorporate the information contained in both the form factors and the ordinary parton distribution functions (PDFs) probed by inelastic scattering experiments. G_M^p is used as a baseline for all other form factor measurements with the uncertainty in the electron-proton cross section yielding a correlated uncertainty in the extraction of other form factors, such as the proton electric form factor G_E^p , and the neutron magnetic form factor G_M^n from many other experiments. As such, these measurements will reduce the uncertainties on the extraction of these other elastic form factors.