New Measurement of (G_E/G_M) for the Proton

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Introduction

The structure of the proton is clearly a matter of universal interest in nuclear and particle physics. Charge and current distributions are obtained through measurements of the electric and magnetic form factors, G_E and G_M, and as such it is extremely important to determine these quantities as accurately as possible. In elastic e-p scattering magnetic scattering dominates at all but the lowest four-momentum transfer, Q^2, and therefore e-p elastic scattering differential cross section measurements leave G_M quite well established. For the very same reason G_E is much harder to determine but a recent, and probably ongoing, experiment in Hall A uses a novel and elegant polarization transfer method to measure G_E/G_M. This group has reported results up to $Q^2 = 3.47$ GeV^2 with an accuracy of ranging from about ± 0.03

at $Q^2 = 1$ GeV^2 to about $\pm$ 0.06 at $Q^2 = 3$ GeV^2 [1]. However, these results are in disagreement with previous experiments[2] in which G_E and G_M were extracted by a conventional Rosenbluth, or L-T, separation. The situation is summarized in Figure 1.

We propose to measure G_E/G_M for the proton in a region where the two previous determinations differ well outside of experimental error by utilizing the L-T separation technique in a new way in which only ratios of cross sections are used. Because of this the results are independent of target thickness and beam intensity and, furthermore, are relatively insensitive to uncertainties in beam energy and scattering angle. Counting rates are high and a statistical accuracy of less than 1/2% can be achieved in less than a day of data taking at each point. We propose to take data at three different beam energies and in a total of less than 4 days of data taking determine (G_E/G_M) at $Q^2 = 1.4$ GeV^2 to $\pm$ 0.03 and at 3.2 GeV^2 to $\pm$ 0.06.

Method for Determining G_{E_p}/G_{M_p}

The differential cross section for e-p scattering can be written:

$$\sigma(E,\theta) = \sigma_0(E,\theta)(G_E^2 + \epsilon^{-1} G_M^2 Q^2 \kappa)$$

where E is the incident electron energy, θ the electron scattering angle, σ_0 the Mott scattering cross section and any accompanying kinematic factors, $\kappa = (\frac{\mu_p}{2M_p})^2 = 2.212$ and the magnetic form factor G_M is from now on in units of the proton magnetic moment μ_p. G_E and G_M are, of course, functions of Q^2 alone.

For a given E there is a one-to-one correspondence between θ and Q^2 and the cross