G_{Ep}/G_{Mp} with an 11 GeV electron beam

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The first precise measurement, in Hall A in 1998[1], of the G_{Ep}/G_{Mp} ratio to a Q^2 of 3.5 GeV^2 showed markedly different Q^2 dependence for G_{Ep} and G_{Mp}. The second experiment in Hall A[2], in 2000, further demonstrated that G_{Ep}/G_{Mp} continues to decrease linearly with Q^2, starting at 1 GeV^2 up to 5.6 GeV^2 as illustrated in figure 1 which shows all the JLab data points. Approved experiment 01-109 will continue these measurements in Hall C up to Q^2=9 GeV^2. All 3 JLab experiments are recoil polarization measurements. The contribution from the electric form factor to the elastic cross section becomes too small for a Rosenbluth separation above about 3 to 4 GeV^2. The decrease

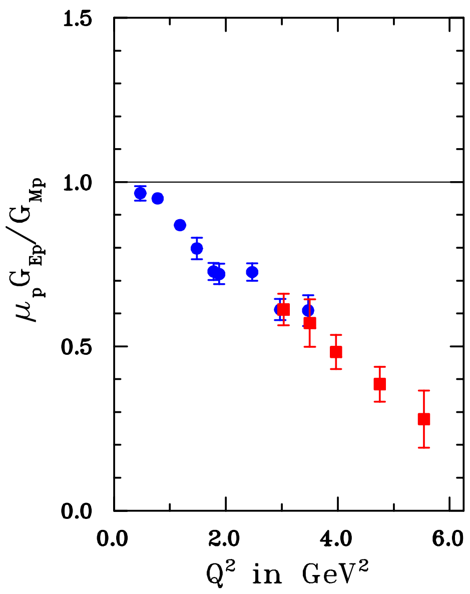

Figure 1: The JLab data for $\mu_p G_{Ep}/G_{Mp}$: blue dots expt. 93-027, red squares expt. 99-007.

of G_{Ep}/G_{Mp} with Q^2 discovered at JLab had not been predicted, but in retrospective it was not a surprise either: specific features of quark based, as well as meson based models have since been shown to account for it, provided relativistic effects are included in the approach. The data available sofar clearly suggest that the G_{Ep}/G_{Mp} ratio might be heading for a zero in the range $7 < Q^2 < 9$ GeV^2. However, the possibility that the ratio stops falling at large Q^2, as suggested by pQCD, is one of the tantalizing prospects of future measurements beyond 9 GeV^2. But there are perhaps even more compelling reasons to strive to measure the nucleon elastic form factors to the largest possible Q^2 values; one such reasons is the fact that the characterization of the structure of the nucleon is the defining problem of hadronic physics, as the hydrogen atom is to atomic physics. Another is that elastic nucleon form factors are key ingredients of this characterization. Ideally all 4 nucleon form factors should be measured to the highest possible Q^2. Currently only G_{Mp} is known up to about 15 GeV^2[3] with an accuracy better than 5%, and 30 GeV^2 with larger error bars. New measurements of G_{Mn} in Hall B[4] will bring the knowledge of this form factor to comparable levels of accuracy up to Q^2=7.5 GeV^2. For the neutron electric form factor, recent experiments in Hall C [5] have been carried out to ∼1.5 GeV^2; a new experiments in Hall A [6] will reach Q^2=3.4 GeV^2 with an accuracy comparable to the 3 other form factors.

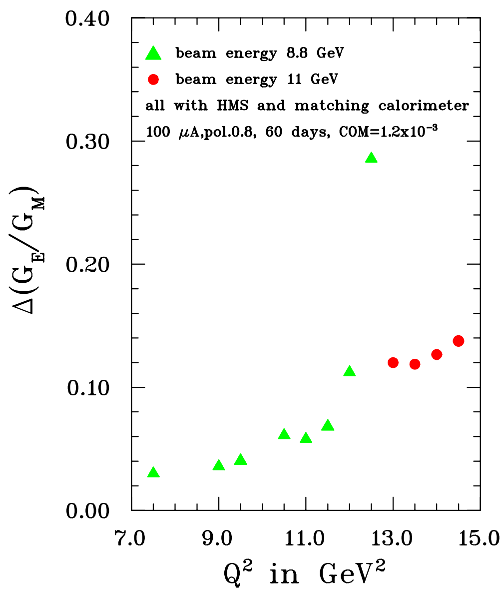

Figure 2: Statistical uncertainty versus Q^2, for the beam energies 8.8 GeV and 11 GeV, with matching of the electron and HMS's solid angles.

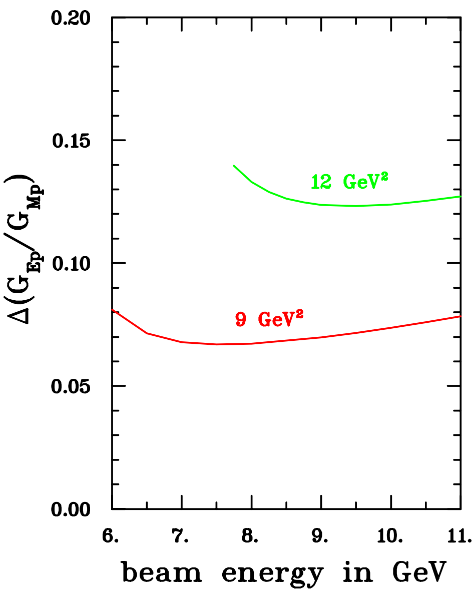

Figure 3: Statistical uncertainty versus beam energy, for the Q^2-values 9 and 11 GeV^2, with matching of the electron and HMS's solid angles.

The recoil polarization technique itself is limited by the largest proton energy for which the polarimeter analyzing power, A_y, is sufficiently large; the absolute limit might be Q^2=17 GeV ^{2}, an energy at which the small angle pp analyzing power vanishes. In figure 2 we demonstrate that the statistical uncertainty for a given data taking time, increases monotonically with Q^2, except for a spike at Q^2=12.5 GeV^2; this is the proton momentum for which the spin precession angle is 360° in the HMS. The point at Q^2= 12 GeV^2 can be obtained in 60 days without any modification to the Hall C instrumentation which will be available following experiment 01-109. This measurement could therefore be accomplished immediately after the 11 GeV polarized beam becomes available. We also show in figure 3 that as long as the electron detector solid angle is

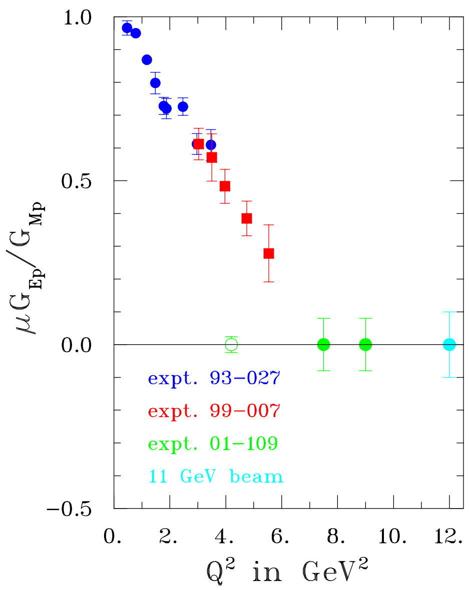

Figure 4: The results of experiments 93-027 and 99-007, the projected errors for 01-109, and for the 12 GeV^2 data point proposed here.

matching the hadron detector solid angle, the choice of the beam energy is not critical. The advantage of choosing the largest possible energy for the proposed Q^2= 12 GeV^2 data point is that the HMS angle becomes a comfortable 17.4°, instead of 13.8 at 8.8 GeV (where the error bar has only a very shallow minimum). Absolute values of the uncertainties can not be evaluated at this time; the analyzing powers, A_y, is not known beyond 5.3 GeV/c proton momentum. Both in figure 2 and 3 we have assumed a constant value of the analyzing power, the best guess we can make at this time, based on the results of our recent cali-

Q^2	E_e	θ_e	$E_{e'}$	θ_p	p_p	$d\sigma/d\Omega_e$	ϵA_y^2	χ	$\Delta\Omega_e$	rate
GeV^2	GeV	deg	GeV	deg	GeV/c	cm^2/sr		deg	msr	Hz
12	8.8	45	2.4	13	7.27	1.0×10^{-37}	1.2x10−3	350	60	2
12	11.0	28	4.6	17	7.27	4.4×10^{-37}	1.2x10−3	350	16	2

Table 1: Kinematics proposed

bration at the Synchrophasotron in Dubna. One may well consider attempting a measurement of the analyzing power of CH_2 near 7 GeV/c before starting data taking at Q^2=12 GeV^2.

In figure 4 the data point we propose to measure in Hall C with an 11 GeV beam is placed in the perspective of the data points to be obtained in experiment 01-109 which should occur in 2005. We place all future data points on the G_{Ep}/G_{Mp}=0 line, as there is no unique prediction of its further evolution with Q^2 past 6 GeV^2.

Q^2	E_e	absolute $\Delta(G_{Ep}/G_{Mp}$	time
GeV^2	GeV		hours
12.0	8.8	0.12	1440
12.0	11.0	0.12	1440

Table 2: Absolute uncertainties, including systematics, and times required. The assumed beam intensity and polarization are 75 μA and 0.8, respectively.

The analyzing power of the CH_2 does not need to be known to obtain the G_{Ep} and G_{Mp} ratio; however A_y determines the size of the error bar. As in the 2 Hall A experiment, and in the future 01-109 experiment, the polarimeter will be calibrated from this experiment.

The kinematics for the new data point proposed here, are shown in Table 1. The proposed error bar and the required time are in Table 2.

To conclude, the measurement of a data point at Q^2=12 GeV^2 in Hall C could occur immediately after polarized 11 GeV electrons enter the Hall; no modifications of the Hall C equipment available at that time will be required.

References

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