ASYMMETRIES ANALYSIS FROM THE FORWARD ANGLE PART OF THE G0 EXPERIMENT.

J. ROCHE FOR THE G0 COLLABORATION

Jefferson Lab,
12000 Jefferson Avenue,
Newport-News, VA 23606, USA
E-mail: jroche@jlab.org

The G0 project is a parity violation experiment using elastic electron scattering. It is dedicated to the measurement of the contribution of strange quarks to the charge and magnetization distributions in the nucleon. After introducing the physics case this paper describes the analysis progress of the first part of the experiment.

1. Proton strange quark form factors measured by G0

Parity violation in elastic electron scattering arises through the interference of Z^0 and γ exchange. If one supposes the neutron and proton electromagnetic form factors to be known, the relative asymmetry[1,2] of the cross-sections for the two helicity states of the beam (R or L), can be expressed as:

$$A = \frac{\sigma^R - \sigma^L}{\sigma^R + \sigma^L} = \eta + \xi G_E^s + \chi G_M^s + \phi G_A^e \qquad (1)$$

where ξ, χ and ϕ are kinematic factors, G_E^s, G_M^s are the strange quark proton form factors and G_A^e is the axial form-factor of the nucleon. η is a known asymmetry which, for G0, ranges between -1 and -35 $\times 10^{-6}$. The G0 program[3] will completely separate G_E^s, G_M^s and G_A^e without any experimental assumptions. Asymmetries are measured with a hydrogen target at forward (7^o) electron angle and hydrogen and deuterium targets at backward (110^o) electron angles. Moreover, the evolution of those observables at momentum transfers below Q^2= 1 (GeV/c)^2 will be measured. Figure 1 shows the expected total errors of the G0 measurements for G_E^s and G_M^s compared to other experimental data already available or planned. The projected errors presented here include the statistical ($\frac{\Delta A}{A}$=5%) and systematic errors. Also, in the backward angle configuration, the inelastic asymmetries will be measured simultaneously to the elastic ones measuring the parity violation effect in the N to Δ transition[7].

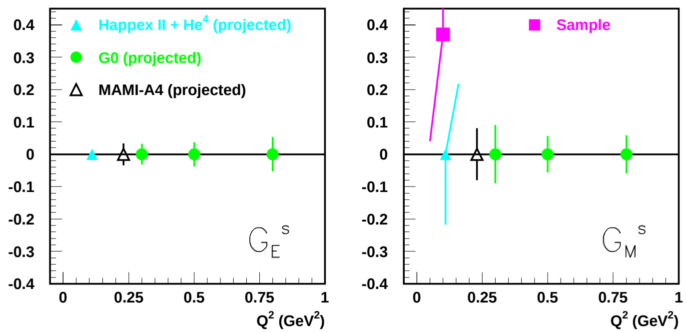

Figure 1. Expected G0 results (full circles) as a function of Q^2 compared with world data (JLab-HAPPEX[4] generation two, MAMI-A4[5] and BATES-SAMPLE[6]). Expected results on G_A^e can be found in reference[3].

2. The forward angle G0 data taking

The first part of the G0 program (forward angle) was carried out during the winter of 2004 in Hall C/JLab. It used a dedicated apparatus[3] of large solid angle (0.7 sr), operating at large luminosity (2×10^{38} cm^{-2} s^{-1}) and able to handle large counting rates (2 MHz per detector). An azimuthally symmetric magnet bent the elastic recoil protons toward a specific focal plane detector (FPD) accordingly to the Q^2 of the reaction. In this configuration, the Q^2 range of G0 ranges from 0.1 to 1.0 (GeV/c)^2 and is measured in 16 FPDs. The measured signals are histograms of the Time of Flight (ToF) of the particles from the target to the detectors which provide a particle identification for the elastically scattered protons. In order to measure the ToF, the beam was pulsed at 31 MHz, although usually the beam delivered at JLab operates at 499 MHz. Figure 2 show the signal registered for each FPD and for each beam helicity window (R or L). The statistical goal of the experiment was achieved and most subsystems of the apparatus worked at or above their design goals. Especially, delivering beam with this time structure at 40 μA and tight helicity-correlated constraints required extensive development work on the part of the JLab accelerator group.

3. Data analysis of the forward angle data

The analysis of the forward angle data is currently underway. The data reduction from measured ToF and beam characteristics (charge, positions,

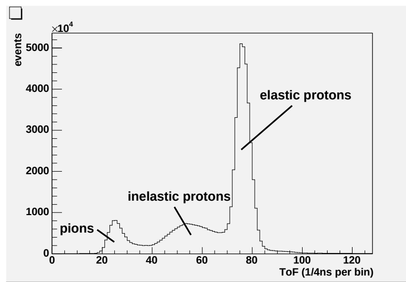

Figure 2. Typical ToF spectra measurement of the G0 experiment

angles and energy) is completed. Thanks to the active feedback systems, the helicity-correlated beam properties delivered during the run were such that the false asymmetries arising from them are estimated to be of the order of 0.01 ppm[a]. The largest systematic associated with the beam helicity properties arose from a leakage of the beam produced by the Hall A and B lasers[b]. Only a thousandth of the beam current measured in Hall C was produced by the leaking lasers, but this beam component had a large charge asymmetry (∼350 ppm) and a different time structure than the main G0 beam. It could not be measured by the beam current monitors. Dedicated measurements allowed us to quantitatively relate the charge asymmetry of the leakage current to the asymmetries measured by the FPDs in a range where no events produced by the main G0 beam are detected. For those measurements, the three lasers (A, B and C) were successively turned off. The correction to the asymmetry is of the order of 0.4 ppm, known with a precision of 0.1 ppm. This correction will dominate the systematic errors a small Q^2. The current focus of the analysis is the extraction of the elastic asymmetry (A) from the measured one as background processes have their own asymmetries :

$$A_{measured} = f_{el}\, A \,+\, f_{bg}\, A_{bg} \tag{2}$$

where f_{el} (f_{bg}) is the fraction of events which are purely elastic (background) out of all events. Within a cut of 4 ns wide centered around the elastic peak, the values of f_{bg} vary between 8 and 18% (depending on the FPD) coming roughly half from the entrance and exit windows and half from the hydrogen itself. This background measured on either side of the

[a] 1 ppm= one Part Per Million = 10^{-6}
[b] At JLab, three experimental halls A, B and C receive beam simultaneously.

elastic peak (see figure 2) has a significant asymmetry. For low and medium Q^2 the background asymmetry varies slowly across the elastic peak, while for the larger Q^2 it shows a large variation across the peak. In this later case, the correction is likely to dominate the systematic error on the final elastic asymmetry. Figure 3 shows the preliminary results for the first 12 FPDs (low Q^2) including preliminary background corrections. These results are blinded by an overall multiplicative factor and should not be interpreted as anything other than an indication of the overall quality of the data and the present status of the analysis.

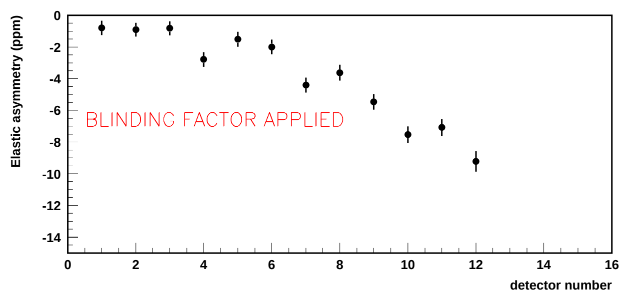

Figure 3. Preliminary G0 forward angle data. The data are blinded by an overall multiplicative factor comprised between 0.75 and 1.25. The error bars are statistical only.

4. Summary

The forward part of the G0 program was completed in May 2004. The analysis of the data is underway. The turnaround and upgrade of the apparatus in preparation of the backward angle part has begun. The forward and backward measurements will provide a full separation of the electric and magnetic strange form-factors of the proton for a Q^2 ranging from 0.3 to 0.8 (GeV/c)^2.

References

1. D.H. Beck and R.D. McKeown, Ann. Rev. Nucl. **51** (2001), 189.
2. K. de Jager, these proceedings.
3. JLab proposal E00-006 and E01-116, D.H. Beck spokesperson, http://www.npl.uiuc.edu/exp/G0/g0Main.html
4. D. Lhuillier, these proceedings.
5. F. Maas *et al.*, Phys. Rev. Lett. **93**, 022002 (2004).
6. T. Ito *et al.*, Phys. Rev. Lett. **92**, 102003 (2004).
7. JLab proposal E01-115, S.P. Wells and N. Simicevic spokespersons.