Jefferson Lab
Proposal Cover Sheet (Generic)

Experimental Hall: _____
Days Requested for Approval: _____

Submission Date: 5/94
Other: PAC 8

☐ **New Proposal Title:**
☒ **Update Experiment Number:** 93-027
☐ **Letter-of-Intent Title:**
(Choose one)

Proposal Physics Goals
Indicate any experiments that have physics goals similar to those in your proposal.

Approved, Conditionally Approved, and/or Deferred Experiment(s) or proposals:

Contact Person

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Receipt Date: 5/94 PR 94-036
By: _____

G_{Ep} by Recoil Polarization
PAC 6: 93-27; 16 days

Spokespersons: C.F. Perdrisat (contact person, College of Willim and Mary),
V. Punjabi (Norfolk State university)
and M. Jones (College of William and Mary, **to be added**).

This experiment will measure the electric to magnetic form factor ratio, and obtain G_{Ep} with the help of the world data base for G_{Mp}.

The scientific interest of the information to be obtained is of a fundamental nature; it will decrease the uncertainty on the elastic electric form factor of the proton by a factor of at least 3 compared with present data, in the Q^2 range from 0.5 to 4.5 GeV^2, corresponding to a distance scale of 0.4 down to 0.1 fm. Obtaining a much more precise data base for G_{Ep}, than has been available so far, is a *sine qua non* condition for using this characteristic of the proton to investigate the effect of the nuclear medium on the structure of a proton embedded in the nucleus. The technical interest of this experiment is that it will transform the hadron arm into a beam polarimeter very early after polarized electrons enter hall A. And then, when a Moeller polarimeter performs in the range 1-2% uncertainty, it will calibrate the FPP polarimeter with uncertainties in the range 0.015 to 0.045 (relative) for proton energies between 0.25 and 2.4 GeV. Thus this experiment will open the way for all other FPP experiments in the hall.

The principles of the recoil polarization technique are quickly reviewed first. The azimuthal angular distribution after the graphite analyzer in the FPP has the form:

$$N(\theta,\phi) = N(h=0,\theta)\{1+h\, A_c(\theta)[P_t \sin\phi + P_l \sin\chi \cos\phi]\}$$

which can be Fourier analyzed to give the 2 amplitudes

$$a = h\, A_c\, P_t\,, \quad b = h\, A_c\, P_l \sin\chi$$

These then give the transverse and longitudinal polarizations:

$$P_t \propto G_{Ep}\,, \quad P_l \propto G_{Mp}^2$$

The result of the experiment is the ratio

$$\frac{G_{Ep}}{G_{Mp}} = -\frac{a}{2b}\,\frac{(E_e+E_e')}{M}\,\sin\chi\,\tan\left(\frac{\theta_e}{2}\right)$$

which contains neither the beam polarization nor the polarimeter analyzing power, but requires the precession angle of the longitudinal component of the polarization, χ. If the beam polarization is measured independently (with Moeller or Compton polarimeter), then the polarimeter is calibrated simultaneously with the measurement of G_{Ep}/G_{Mp}, from:

$$A_c = \frac{b[\![(\frac{a}{2b})^2\ (\frac{E_e+E_e'}{M})^2\ \sin^2\chi\ +\ \tau[\cot^2\theta_e+2(1+\tau)]]\!]}{h\ (\frac{E_e+E_e'}{M})\ \sqrt{\tau(1+\tau)}\ \sin\chi}$$

We propose to measure the three lower Q^2 points: 0.5 and 1 and 1.5 GeV^2 in the proposal, very soon after a polarized electron beam enters hall A.
With beam energy known to 10^{-3}, recoil proton momentum measured to the same level of accuracy, and spin precession angle measured with uncertainty 10 mr, either one of the two lowest points can be used to make the hadron arm a BEAM POLARIMETER in the 3-4% range of accuracy. This can be achieved by extracting a and b defined above, and then using the last formula to get the helicity h, using the world analyzing powers known to 2-3% below 0.8 GeV proton energy. The current and energy on target for the lowest Q^2 -point is 8 μA at 0.5 GeV; with 500 events acquired per sec., the data taking time necessary for the Q^2-point is 1 day.

At the next level of sophistication the transverse to longitudinal ratio can be obtained for the 3 lowest Q^2-points of the proposal, and G_{Ep} measured in the 2-3% uncertainty range WITHOUT BEAM POLARIZATION MEASUREMENT. This is already half the error bar of the world data and therefore publishable. Data taking times at the limited data rate of 500 acquired/sec would be 1 day, 2 days and 3 days for these 3 Q^2-points.

A remeasurement of these points at a later time, with data rates in the 2500 events/ sec range and a beam polarimeter operational in the 1-2% accuracy range, would then calibrate the polarimeter in the energy range o.25 to 0.8 GeV in 2 days total.

Of course it is the calibration above 800 MeV proton which is most important for the rest of the program in hall A, and this will require overall performances closer to the design characteristics of machine and HRS's.

None of the above will happen unless their is a cryotarget in hall A; the recommissioning of the cryotarget is therefore our greatest concern.

The FPP is being constructed in parts at Rutgers U. and in parts at William and Mary. At this point in time the expectation is that the detector planes will be ready for installation at the same time as the Focal Plane Detectors; no remote control of the FPP analyzer block configuration is necessary for this experiment which uses only 3 graphite thicknesses: 30, 45 and 60 cm.