CEBAF PROPOSAL COVER SHEET

This Proposal must be mailed to:

CEBAF
Scientific Director's Office
12000 Jefferson Avenue
Newport News, VA 23606

and received on or before OCTOBER 30, 1989

TITLE: Electric Form Factor of the Proton by Recoil Polarization

CONTACT PERSON: Charles F. Perdrisat

ADDRESS, PHONE AND BITNET:
Physics Department, College of William and Mary
Phone: 253-4471 (221-3522 after Nov. 1)
Bitnet: WP19CFP@WMMVS

THIS PROPOSAL IS BASED ON A PREVIOUSLY SUBMITTED LETTER OF INTENT

[X] **YES**
[ ] **NO**

IF YES, TITLE OF PREVIOUSLY SUBMITTED LETTER OF INTENT

Measurement of the Electric Form Factor of the Proton by Recoil Polarization

ATTACH A SEPARATE PAGE LISTING ALL COLLABORATION MEMBERS AND THEIR INSTITUTIONS

=======================================

(CEBAF USE ONLY)

etter Received 10-30-89

.og Number Assigned PR-89-014

3y KES

contact: Perdrisat

<u>THE HALL A COLLABORATION</u>

American University, Cal.State University LA,
Continuous Electron Beam Accelerator Facility,
Case Western Reserve & LANL, George Washington University,
University of Georgia, Indiana University Cyclotron Facility,
Kent State University, University of Maryland,
Massachusetts Institute of Technology, University of New Hampshire
National Institute of Science and Technology,
Norfolk State University, University of Regina,
University of Rochester, University of Saskatchewan,
Rutgers University, Stanford University,
University of Virginia, University of Washington,
College of William and Mary, NIKHEF-K, CEN Saclay,
University of Clermond-Ferrand, INF Sezione Sanita,
University of Lund.

Spokespersons: C. F. Perdrisat, Physics Department, College of William and Mary, 23185 Virginia (Bitnet WP19CFP @ WMMVS), and
Vina Punjabi, Physics Department, Norfolk State University, 2401 Corprew Ave. 23504 Virginia (Bitnet WP63VAP @ WMMVS)

Williamsburg, October 31, 1989

Introduction

The understanding of the structure of the nucleon is of fundamental importance; ultimately such an understanding is necessary to a first principle description of the nuclear force. The distribution of charge and currents inside the nucleon is best revealed by the electromagnetic probe, through the interaction of the virtual photon with the quark constituents of the nucleon.

Experiments to obtain information about the charge and current distribution of the nucleon have been carried out since the mid 1950's. The cross section for elastic scattering of unpolarized electrons on unpolarized nucleons is:

$$\frac{d\sigma}{d\Omega_e} = \frac{d\sigma}{d\Omega_{Mott}} \quad [G^2_{Ep}(Q^2) + \tau\ G^2_{Mp}(Q^2)\ \{1 + 2(1+\tau)\tan^2(\theta_e/2)\}] \quad (1$$

where τ is related to the four-momentum squared $Q^2 = -q_\mu{}^2$ by $\tau = Q^2/4m_N{}^2$ and $(d\sigma/d\Omega)_{Mott}$ is the Mott cross section for a structureless nucleon, given by:

$$\frac{d\sigma}{d\Omega_{Mott}} = (\alpha/2E_e)^2 \cos^2(\theta_e/2)/[1+(2E_e/M)\sin(^2\theta_e/2)]\sin^4(\theta_e/2), \quad (2)$$

where E_e is the incident electron energy and θ_e the electron scattering angle. The Sachs electric and magnetic form factors G_{Ep} and G_{Mp} are related to the Dirac and Pauli form factors F_1 and F_2 by:

$$G_E = F_1 - \tau F_2 \quad \text{and} \quad G_M = F_1 + F_2.$$

A complete description of the internal structure of the nucleon requires determination of F_1 and F_2, or equivalently G_E and G_M, for all values of four-momentum transfers Q^2. At the present time the form factors of the neutron are poorly defined at any Q^2; it may appear surprising that even for the proton the electric form factor is not well determined experimentally beyond Q^2=1 GeV^2.

Elastic ep differential cross sections have been measured by Arnold et al[1] up to four-momentum squared $Q^2 \approx 31$ (GeV/c)^2. However, the separate determination of G_{Ep} from a cross section measurement (see formula (1)) at large Q^2 is difficult because of the dominance of the magnetic term. An important step was achieved by Litt et al[2] when they isolated G_{Ep} up to the large Q^2-value of 3.75 GeV^2, although with relatively large error bars. More recently, Walker et al[3] (SLAC experiment E140) separated both G_{Ep} and G_{Mp} up to Q^2 = 3 GeV^2 with error bars for G_{Mp} smaller than 3%; these data can be seen in fig. 1 taken from ref. 3. In the same figure we observe that error bars for G_{Ep} reaches ±13.8% at 3 GeV^2, even though the statistical uncertainty is as low as 0.8%. This illustrates the difficulty in separating G_{Ep} from cross section data.

A new experiment at SLAC (NE-11) is expected to produce separated G_{Ep} and G_{Mp} form factors up to 6 GeV^2. The goals of this latest experiment, as stated in the proposal[4], are for error bars of ± 1.5 % for G_{Mp} at Q^2 between 2 and 6 GeV^2 and for G_{Ep} ± 4 % near 2 GeV^2, increasing to ±17% at 5 GeV^2.

The G_{Ep} results from ref. 3 are in disagreement with the older data of Bartel et al[5] which also went up to Q^2=3 GeV^2. The new data indicate a slow rise of the ratio of G_{Ep} to the dipole parametrization G_D with Q^2, and are in agreement with the data of Litt et al (ref. 2). It is thus important to verify the new data, and the present proposal shows that the measurement of G_{Ep} by the recoil polarization method will give total error bars (statistical plus systematical) ≈ 4.5 % at 4.5 GeV^2 and significantly smaller at smaller Q^2.

At the present the form factors of the nucleon are calculated within the framework of either the vector meson dominance model (VMD), or QCD based quark models. The VMD calculations have given predictions which for G_{Ep} tend to decrease below G_D with increasing Q^2. Examples of such calculations are seen in fig. 1 taken from ref. 3. The dashed curve is from Hoehler et al[6] and incorporates the ρ, ϕ and ω mesons. The dotted line from Iachello et al[7] is also based on the VMD, and so is the low Q^2 part for the solid curve from Gari[8]. A prediction by Radyushkin[9] based on QCD sum rule and assuming quark-hadron duality is also shown in fig. 1 with a dot-dash line. In fig. 2, taken from a preprint by Warns et al[10], the solid line show a prediction for G_{Ep} and G_{Mp} based on a relativized quark model using the Isgur-Karl[11] baryonic wave function, and including a careful handling of the recoil corrections. The validity of the calculation is thought to extend to 2.6 GeV^2.

Although there is little doubt that nucleons and mesons are composed of quarks and gluons, it is less obvious that these ultimate components of the hadrons play a detectable role in the intermediate range of four-momentum transfers $1<Q^2<6$ GeV^2, which is parametrization G_D with Q^2, and are in agreement with the data of Litt et al (ref. 2). It is thus important to verify the new data, and the present proposal shows that the measurement of G_{Ep} by the recoil polarization method will give total error bars (statistical plus systematical) ≈ 4.5 % at 4.5 GeV^2 and significantly smaller at smaller Q^2.

At the present the form factors of the nucleon are calculated within the framework of either the vector meson dominance model (VMD), or QCD based quark models. The VMD calculations have given predictions which for G_{Ep} tend to decrease below G_D with increasing Q^2. Examples of such calculations are seen in fig. 1 taken from ref. 3. The dashed curve is from Hoehler et al[6] and incorporates the ρ, ϕ and ω mesons. The dotted line from Iachello et al[7] is also based on the VMD, and so is the low Q^2 part for the solid curve from Gari[8]. A prediction by Radyushkin[9] based on QCD sum rule and assuming quark-hadron duality is also shown in fig. 1 with a dot-dash line. In fig. 2, taken from a preprint by Warns et al[10], the solid line show a prediction for G_{Ep} and G_{Mp} based on a relativized quark model using the Isgur-Karl[11] baryonic wave function, and including a careful handling of the recoil corrections. The validity of the calculation is thought to extend to 2.6 GeV^2.

Although there is little doubt that nucleons and mesons are composed of quarks and gluons, it is less obvious that these ultimate components of the hadrons play a detectable role in the intermediate range of four-momentum transfers $1<Q^2<6$ GeV^2, which is deuterium at Q^2 between 0.26 and 0.53 GeV^2 [14] at Bates. A continuation of the Bates deuterium experiment at CEBAF is being proposed by the hall A collaboration[15].

With the 4 GeV polarized beam at CEBAF, G_{Ep} can be measured by the recoil polarization technique out to 4.5 GeV^2, with error bars 3-4 times smaller than the ones anticipated in the SLAC NE-11 experiment in approximately 60 days with a beam polarization h=0.4. With h=0.8, and for the same error bars, the required time would be 15 days. The characteristics of the pair of spectrometers in hall A are perfectly suited for this experiment which requires vertical angular resolution as good as ±1 mr in the Q^2-region where the precession angle of the longitudinal polarization P_l is near 180°. An extension to 6 GeV^2 will become possible with a future increase of the beam energy to 6 GeV, without restriction from the 4 GeV/c limit of the spectrometers in hall A.

The coincidence experiment proposed here requires that the hadron arm be equipped with a focal plane polarimeter with good performance up to 3.2 GeV/c (2.4 GeV); the second phase would require an extension of the performance range of the polarimeter to 4 GeV/c (3.2 GeV).

We propose a self-calibration technique which does not depend critically upon independent calibration of the polarimeter analyzing power at these high energies. The method uses the simultaneous measurement of the sideways and longitudinal components of the proton polarization, P_s and P_l, and values of G_{Mp} from the existing or forthcoming data pool, at the same Q^2 values as the polarization measurement.

No recoil polarization experiment for elastic ep has been done in recent time; however an experiment using a polarized proton target has determined the sign of G_E/G_M [16] some time ago. With a focal plane polarimeter installed in the hadron arm of hall A at CEBAF, there will be an unique opportunity to measure G_{Ep} by the recoil polarization technique. The experiment requires a high power liquid hydrogen target; this proposal assumes 100 μA on a 10 cm effective length. The kinematics we propose to measure are given in table 1, and the polarization components P_s and P_l, evaluated with dipole parametrization, are in table 2.

Recoil polarization measurement

With a focal plane polarimeter one measures the azimuthal angular distribution after a second scattering in a carbon block; this distribution has the form:

$$N_p(h;\theta,\phi) = f(\theta)\ N_p(h=0;\theta)(1 \pm h\ A_c(\theta)\ (P_s \sin\phi + P_l \sin\chi \cos\phi))\quad (3)$$

where h electron beam helicity

θ scattering angle after second scattering

ϕ azimuthal angle after second scattering

P_s sideways polarization at target

P_l longitudinal polarization at target

A_c analyzing power of second scatterer (graphite)

f usable fraction of events after second scattering

χ precession angle of the longitudinal component of the proton spin.

The measured quantities are the amplitudes:

$$a=h*A_c*P_s$$

$$\text{and}\quad b=h*A_c*P_l*\sin\chi, \qquad (4)$$

which are obtained by Fourier analysis of the ϕ-distribution behind the graphite block ; the analysis can be done for a number of scattering angle bins of width $\Delta\theta$ at θ; or a single analysis can also be done summing over all scattering angles θ within fixed limits. In either cases the absolute uncertainty in both a and b is:

$$\Delta a = \Delta b = (2/fN_p)^{1/2}, \qquad (5)$$

where fN_p is the number of events having been detected within the θ-limits chosen. Detailed analysis as a function of θ has the advantage of allowing the detection of possible systematic asymmetries.

The relations between the amplitudes a and b extracted from the measurement and the form factors are as follows

$$P_s = -[2\{\tau(1+\tau)\}^{1/2}\, G_{Mp}\, G_{Ep}\, \tan(\theta_e/2)]/I_o \;= a/hA_c$$

$$P_l = ((E+E')/M)\;[\tau(1+\tau)]^{1/2}\, G^2_{Mp}\, \tan^2(\theta_e/2)/I_o = b/hA_c\sin\chi \qquad (6)$$

where $I_o = G^2_{Ep} + \tau\, G^2_{Mp}[1 + 2(1+\tau)\, \tan^2(\theta_e/2)]$,

It follows that G_{Ep} can be obtained directly from the measured quantities a and b, together with G_{Mp} taken from the existing data base with the relation:

$$G_{Ep} = -(a/2b)\, G_{Mp}\, ((E+E')/M)\, \sin\chi\, \tan(\theta_e/2) \qquad (7)$$

which has the remarkable property of being independent of both A_c and h, the polarization of the beam. This does not, of course, mean that no beam polarization is required. The relative uncertainty on G_{Ep} does directly depend on h, f and A_c, but these need to be known only to the precision one requires on the uncertainty ΔG_{Ep}, rather than G_{Ep} itself; the total (statistical plus systematical) relative uncertainty is given by:

$$\Delta G_{Ep}/G_{Ep} = \{(\Delta a/a)^2 + (\Delta b/b)^2 + (\Delta\sin\chi/\sin\chi) + (\Delta G_{Mp}/G_{Mp})^2\}^{1/2} =$$

$$= \{(2/fN)[1/(hA_cP_s)^2 + 1/(hA_cP_l\sin\chi)^2] +$$

$$+ (\Delta\chi/tg\chi)^2 + (\Delta G_{Mp}/G_{Mp})^2\}^{1/2}. \qquad (8)$$

The errors in table 3 are calculated with formula (8). Other sources of errors, come from uncertainties in the measurement of θ_e and E', which determine Q^2, and put constrains on the spectrometer characteristics. Error estimates in table 3 assume that θ_e is known to 3.5 mr, $E_{e'}$ to 2.5 10^{-3}, and $\Delta(\sin\chi)/\sin\chi \approx 0.5\text{x}10^{-2}$. The requirement from the precession angle χ demands a precision on the vertical angle of the proton trajectory of ±1 mr at the target when close to 180°, i.e. in kinematics 4 and 5 (see table 1). Multiple scattering of the incoming electron and of the outgoing proton in the target contributes about ±0.7 mr to the angular resolution for the precession angle in the hadron arm. Radiation corrections will be necessary to obtain the correct value of Q^2. Asymmetries in the polarimeter, may come from edge effects and anisotropies in the detection efficiency. Switching of the beam polarization sign, and analysis of N(h>0)-N(h<0), rather than N(h), eliminates most of the detector asymmetries. Possible residual asymmetries will be evaluated by analysis of the data; they should be small.

Polarimeter characteristics

Even though the simultaneous measurement of the sideways and longitudinal components of the proton polarization determines G_{Ep} independently of the analyzing power A_c and usable fraction f in the polarimeter, the uncertainty on G_{Ep} depends directly upon optimalization of these two numbers. In fact it is $A^2_c f$ which should be as large as possible. The only one parameter available, if graphite is chosen as the scatterer in the polarimeter, is the thickness of the scatterer, d. Recent work at Saturne (Bonin et al.[17]) has shown that at 1.2 GeV proton kinetic energy, the best thickness is close to d=30 cm (the density of the graphite used in ref. 17 was 1.7 gcm^{-2}). As the energy increases the nuclear scattering angular distribution becomes increasingly forward peaked; however, a region around 0° must be excluded by fast hardware veto to avoid accumulating events for which the protons had no nuclear interaction but were only Coulomb scattered, and therefore carry no polarization information. From ref. 17 one learns that at 1.2 GeV, the average analyzing power A_c remains constant when the thickness is increased from 20 to 30 cm, but f increases from 0.17 to 0.20. We are able to reproduce these data with a Monte Carlo simulation of the polarimeter, using as input scaled down pp analyzing power data which are available in parametrized form up to 12 GeV/c (Spinka et al[18]). As the energy increases, the analyzing power becomes increasingly dominated by the quasi-elastic (p,pN) reaction, justifying this approximation. For the cross section a high energy approximation for the inclusive $^{12}C(p,p')X$ reaction as suggested by the data of Bellettttini et al[19] was used for the high energy end of the study. At lower energy (1.2 GeV) we used a modified parametrization which reproduces the experimental angular dependence of f in ref. 17 well. The results of this calculation have been used in the estimates for this proposal, and they are shown in fig. 4 in the form of $A^2_c f$ versus T_p for two different graphite thickness schedules. The Monte Carlo results also indicate that to achieve efficient elimination of Coulomb scattered events will require an on-line angular resolution of 0.3-0.4°. We are currently working on a scheme to achieve this angular resolution with scintillation fiber planes. Proposed experiments at Saturne will help determine polarimeter characteristics up to at least 1.86 GeV in the near future.

Rates and time request

We propose to measure G_{Ep} for 9 kinematics with Q^2 -values between 0.5 and 4.5 GeV^2, in steps of 0.5 GeV^2. The choice of the beam energies and electron angles is shown in table 1 (we use reaction variables θ for the scattering angle, ϕ for the azimuthal angle, rather than TRANSPORT angles); the selection is guided by the need to maximize the value of $P_s^2 d\sigma/d\Omega_{ep}$, to minimize the statistical error for a given data taking time. However, the maximum of this function, evaluated by assuming that both the electric- and the magnetic form factors have the dipole form, is fairly wide, thus allowing selection of beam energies other than tabulated without significant loss of performance. As we measure both P_s and P_l, the only other contributions to the total uncertainty on G_{Ep} besides statistics are the uncertainties on the G_{Mp} values which are to be taken from existing measurements, and of χ, the precession angle for the longitudinal component of the polarization. The polarization and event rates in the focal plane are shown in table 2; also shown are the polarimeter performance numbers f and $A^2_c f$ (the latter is the "coefficient of merit") which have been discussed in the preceding section. The rates are arbitrarily limited to about 2500 s^{-1}, by decreasing the beam intensity when needed; they are calculated assuming the following parameters for the spectrometers and target of hall A:

2 identical 4 GeV/c spectrometers with solid angle 8 msr, momentum acceptance $\delta/p=\pm5\%$, horizontal acceptance ±30 mr, vertical

acceptance ±65 mr.

A liquid hydrogen target with a useful length of 10 cm (0.7 gcm^{-2}).

The intensity for most of the points is 100 μA.

The beam polarization is taken to be h=0.40.

The uncertainty on h affects only the <u>uncertainty</u> on G_{Ep}, not the value of G_{Ep}. Only when the precession angle is near 180° does the uncertainty on χ enter critically; a precision of 0.5 % for $\Delta\sin\chi/\sin\chi$ can be achieved with a precision of ±1 mr on the vertical angle of the proton at the target. Table 3 shows separately the two first contributions to the uncertainty on G_{Ep} in formula (8) that are of statistical origin (5^{th} and 6^{th} columns). The total uncertainty $\Delta G_{Ep}/G_{Ep}$ in table 3 (7^{th} column) includes a contribution from G_{Mp} (±1.5%) and one from the precession angle χ as indicated above. The corresponding actual data taking times in the last column of table 3 include the radiation correction.

As this experiment requires two fully operational spectrometers (albeit with a resolution no better than 10^{-4}), and in addition a polarimeter with known properties, it is presently difficult to evaluate the setup time. Part of this setup time would have to include preliminary tests of the polarimeter, studies of its intrinsic asymmetries and limiting data rate, and so on. The experiment does in fact calibrate the polarimeter with a precision of 2-4%. Nevertheless it might be desirable to measure A_c and f independently in a polarized proton beam of well known polarization, as other polarization transfer experiments will not

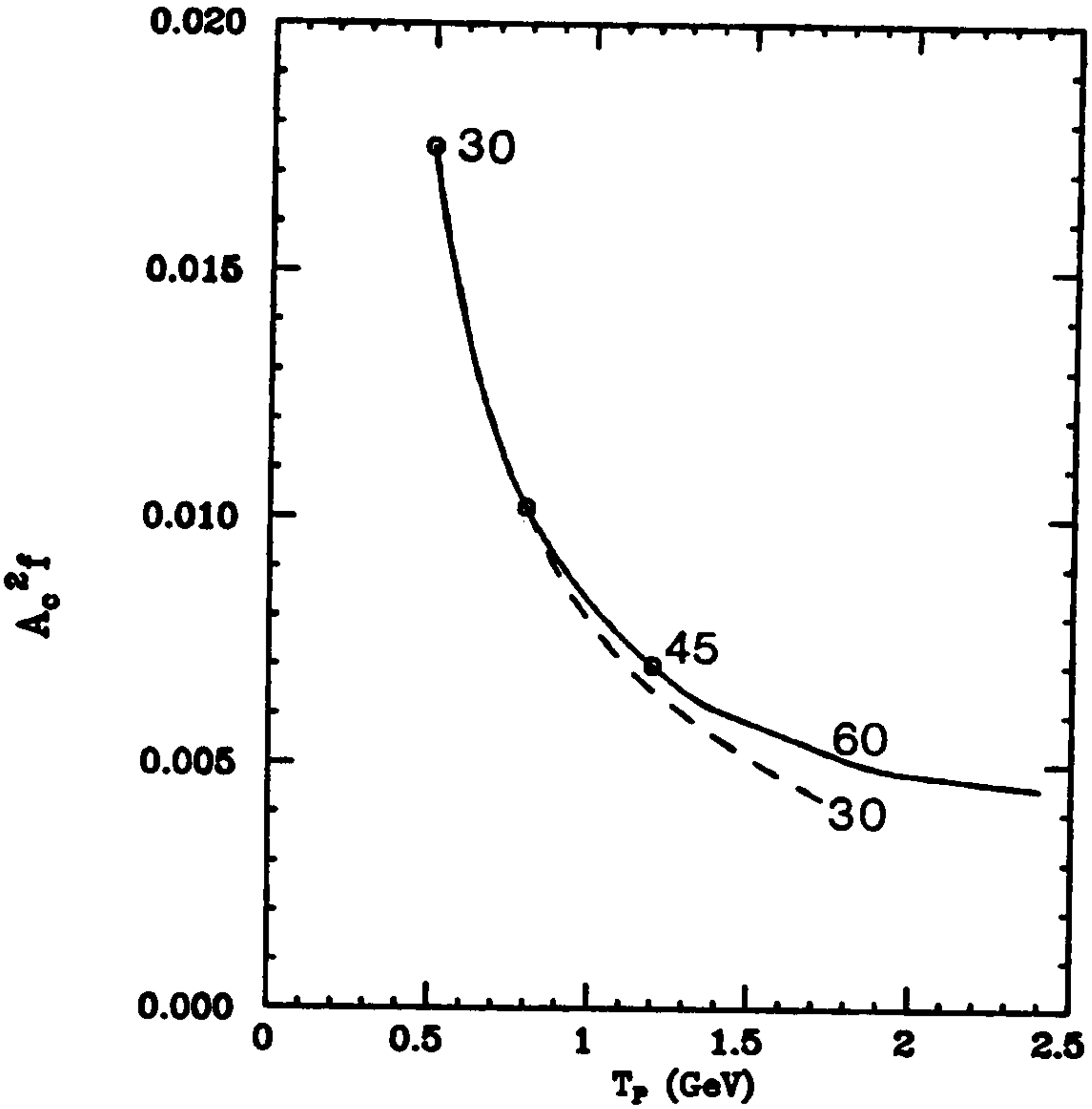


Fig 4

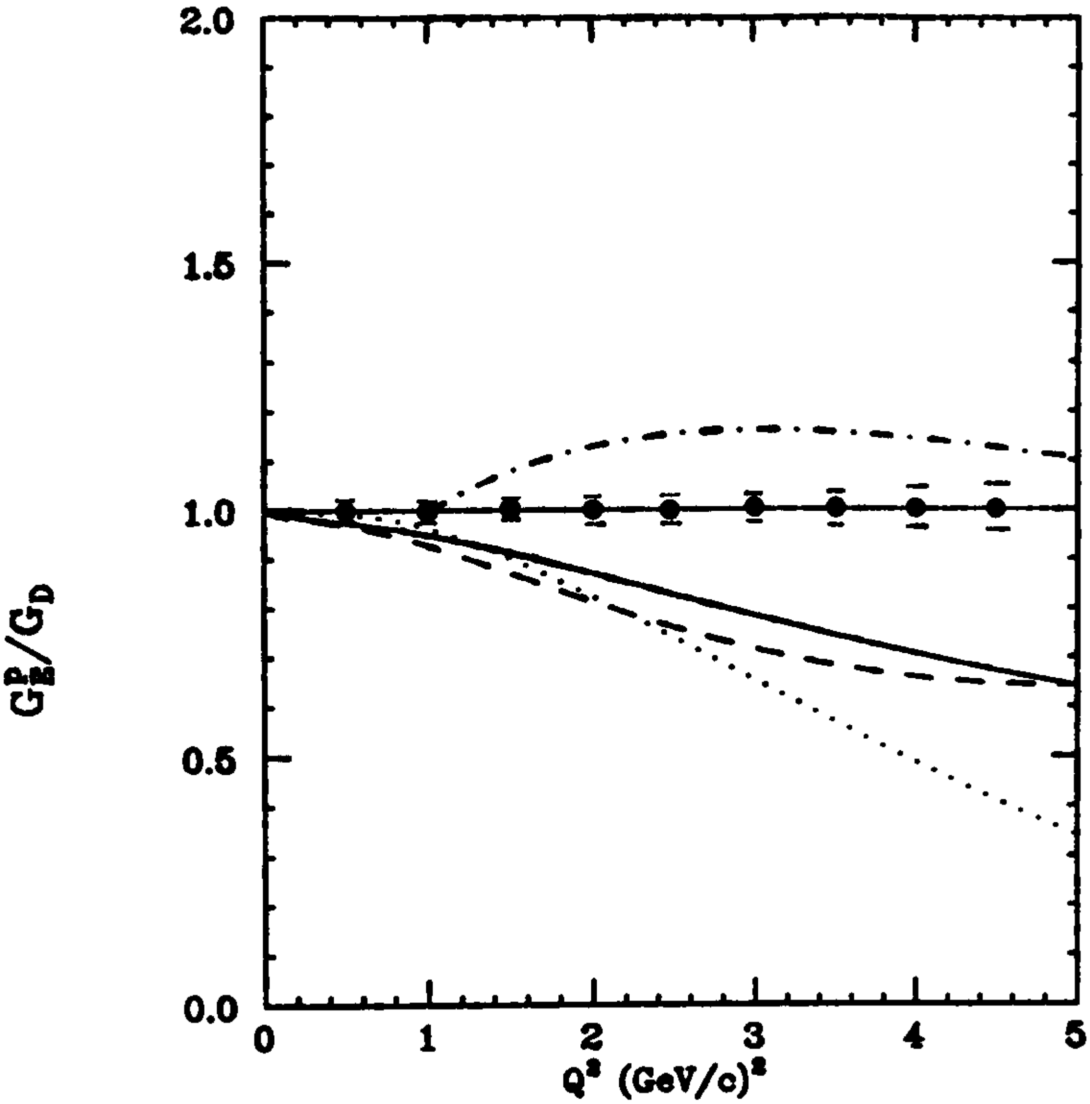


Fig 3

lend themselves to the self calibration method we propose here. Saturne in Saclay can provide such beams up to the maximum energy required in the present experiment, 2.7 GeV.

Table 4 show partial derivatives of kinematic quantities of interest; these show that the two spectrometer acceptances are well matched for the kinematics of this experiment. For all kinematics but the first one, the electron arm defines the solid angle; for the first kinematics one will have to limit the electron arm solid angle with a collimator. Table 5 shows singles rates obtained with the codes of Lightbody and O'Connell[20]. Coincidence events with a pion in the final state never enter into the experimental acceptance of the detectors. The contribution of pions to the singles proton rates remains always small. Accidental events are never a problem.

The total time requested according to the information in table 3 is 1344 hours including radiation corrections. If one includes setup and calibrations the total time becomes 60 days for this experiment.

Conclusion

We are proposing to measure the elastic electric form factor of the proton, G_{Ep}, at four-momentum transfers squared Q^2 between 0.5 and 4.5 GeV^2 in steps of 0.5 GeV^2. The total error bars are predicted to be between 2% at the lowest Q^2 and 4.5% at the highest. G_{Ep} will be obtained directly from the measurement of the polarization of the recoil proton from:

$$G_{Ep} = -(a/2b)\ G_{Mp}\ ((E+E')/M)\ \sin\chi\ \tan(\theta_e/2)$$

where a and b are the Fourier components of the ϕ-distribution. The main advantage of this method over the separation method, is that, for a given Q^2, it requires measurement at a single beam energy and angle θ_e, whereas the separation technique typically requires 3 to 5 energies and angles; the experimental advantages are obvious. At Q^2=4.5 GeV^2 the error bars anticipated (systematics included) are 3-4 times smaller than expected from the latest SLAC separation data. By using values of G_{Mp} which will be known to ±1.5%, we will obtain G_{Ep} without independent calibration of the "coefficient of merit", $A^2_c f$, of the polarimeter. Independent calibration of the polarimeter at a few proton energies may still be desirable to check the internal consistency of the method.

The total time required for this proposal, including setup and in-house calibration (but excluding calibration of the polarimeter in a direct proton beam) is 60 days.

References

1 R. Arnold et al, Phys. Rev. Lett. 57, 174 (86); R. Arnold, Town Meeting Report, (MIT) April 1989

2 Litt et al., Phys. Lett. 31B, 40 (1970)

3 R.C. Walker et al., preprint (1989)

4 "A proposal to separate the charge and magnetic form factors of the neutron and proton at large momentum transfer", R. Arnold et al. (SLAC proposal NE11)

5 W. Bartel et al, Nucl. Phys. 39B, 407 (1972)

6 G. Hoehler et al. Nucl. Phys. B114, 505 (1976).

7 F. Iachello et al, Phys. Lett. 43B, 191 (1973)

8 M. Gari and W. Krumpelman, Z. fur Phys. A322, 689 (1985)

9 A.V. Radyushkin, Acta Phys. Polnica B15, 403 (1984)

10 M. Warns, H. Schroder, W. Pfeil and H. Rollnik, preprint Universitaet Bonn, (1989), to be published

11 N. Isgur and G. Karl, Phys. Rev. D18, 4187 (1978)

12 R. Arnold, C. Carlson and F. Gross, Phys. Rev. c23, 363 (81).

13 R. Madey et al, approved experiment at Bates.

14 J. Finn et al, approved experiment 88-21 at Bates.

15 P. Ulmer and J.M. Finn, proposal to CEBAF, October 1989.

16 M.J. Alguard et al, Phys. Rev. Lett. 37, 1258 (1976)

17 B. Bonin et al. submitted for publication in Nuclear Instruments and Methods, July (1989)

18 H. Spinka et al, Nucl. Inst. and Meth. 211, 239 (1983).

19 G. Bellettini et al, Nucl. Phys. 79, 609 (1966).

20 J.W. Lightbody and J.S. O'Connell, Computers in Physics, May-June (1988), p. 57

Table 1

Kin #	E_e GeV	Q^2 GeV^2	E_e' GeV	$\theta_{e'}$ °	T_p GeV	p GeV/c	θ_p °	$d\sigma/d\Omega_e$ cm^2/sr
1	1.00	0.50	0.73	49	0.27	0.76	46.7	2.9 10-32
2	1.30	1.02	0.77	60	0.53	1.16	36.0	2.6 10-33
3	1.95	1.50	1.17	48	0.80	1.46	36.5	1.3 10-33
4	2.45	1.99	1.39	45	1.06	1.76	33.8	4.6 10-34
5	3.20	2.45	1.90	37	1.30	2.04	34.1	3.4 10-34
6	4.00	3.06	2.37	33	1.63	2.39	32.7	1.8 10-34
7	4.00	3.50	2.15	37	1.85	2.63	29.6	7.9 10-35
8	4.00	4.00	1.87	43	2.14	2.93	25.7	2.7 10-35
9	4.00	4.53	1.59	50	2.41	3.22	22.1	1.1 10-35

---

with a beam energy of 6 GeV

	5.25	5.0	2.61	35	2.60	3.45	26.0	1.8*10-35
	6.0	6.0	2.78	35	3.20	4.05	23.0	0.7*10-35

Table 2

E_e	Q^2	P_s	P_1	$A_c^2 f$ (10-3)	f	rate sec^{-1}	χ
1.00	0.50	-.39	.46	25.0	.10	2472*	103.9°
1.30	1.02	-.38	.68	17.5	.16	2770&	126.3°
1.95	1.50	-.32	.64	10.0	.18	1385&	149.5°
2.45	1.99	-.28	.67	7.8	.20	980$	171.8°#
3.20	2.45	-.25	.64	6.6	.25	724	168.9°##
4.00	3.06	-.21	.59	5.6	.33	384	198.7°##
4.00	3.47	-.22	.66	5.2	.41	168	240.6°
4.00	4.00	-.22	.75	4.7	.44	58	264.7°
4.00	4.53	-.21	.82	4.5	.47	23	287.9°

with a beam energy of 6 GeV:

5.25	5.00	-.19	.69	4.0	.47	38	307.4°
6.0	6.00	-.18	.73	3.5	.47	15	335.4°

* beam intensity reduced to 4 μA

& intensity reduced to 50 μA

$ intensity 100 μA on 10 cm LH_2 target (0.7 gcm^{-2}), luminosity $L=2.66*10^{38}$, $\Delta\Omega$ = 8 msr

\# hadron spectrometer tuned to δ=-2%

\## tuned to δ=+2%

Table 3

E_e	Q^2	N	2/fN	$(hA_cP_s)^{-2}$	$(hA_cP_1 \sin\chi)^{-2}$	$\Delta G_{Ep}/G_{Ep}$	hours
1.00	0.50	3.8(7)	5.3(-7)	1.64(2)	1.25(2)	0.020	5
1.30	1.02	6.0(7)	2.3(-7)	3.74(2)	1.80(2)	0.019	8
1.95	1.50	1.1(8)	8.9(-8)	1.26(3)	1.22(3)	0.021	31
2.45	1.99	1.3(8)	7.4(-8)	2.00(3)	9.37(3)	0.033	53
3.20	2.45	1.1(8)	7.9(-8)	3.79(3)	5.63(3)	0.031	80
4.00	3.06	7.3(7)	8.3(-8)	7.59(3)	1.96(3)	0.032	77
4.00	3.45	5.4(7)	9.0(-8)	1.02(4)	1.44(3)	0.037	134
4.00	4.00	4.1(7)	1.1(-7)	1.21(4)	1.05(3)	0.042	296
4.00	4.50	3.6(7)	1.2(-7)	1.48(4)	1.07(3)	0.046	660
				total running time			1344
				with a beam energy of 6 GeV			
5.25	5.00	5.5(7)	7.7(-8)	2.03(4)	1.05(3)	0.042	400
6.00	6.00	4.3(7)	9.8(-8)	2.59(4)	9.08(2)	0.053	800

Table 4

E_e GeV	Q^2 GeV^2	$\Delta E_{e}'/E_{e'}$ ($\pm$30 mr in $\theta_{e'}$)	$\Delta p/p$ ($\pm$30 mr in $\theta_{e'}$)	$d\theta_p/d\theta_e$	$d\phi_p/d\phi_e$	$\frac{d\sigma_{ep}/\sigma_{ep}}{d\theta_e}$ %/deg
1.00	0.50	±1.76%	±2.76	-0.66	0.96	11.6
1.30	1.02	±2.33%	±2.54%	-0.64	0.83	13.5
1.95	1.50	±2.75%	±2.60%	-0.64	0.79	15.0
2.45	1.99	±3.16%	±2.82%	-0.66	0.78	16.0
3.20	2.45	±3.59%	±3.30%	-0.71	0.84	19.0
4.00	3.06	±4.13%	±3.46%	-0.69	0.79	21.0
4.00	3.50	±4.16%	±3.65%	-0.71	0.71	19.8
4.00	4.00	±4.06%	±2.73%	-0.57	0.64	17.0
4.00	4.53	±3.99%	±1.99%	-0.46	0.49	13.7

Table 5

Singles rates and accidentals

(for a few kinematics only)

E_e	Q^2	$d\sigma/d\Omega(e,e')$	$d\sigma/d\Omega(e,p)$	e-rate	p-rate	π^+/p	$\frac{\text{real}}{\text{random}}$
GeV	GeV^2	cm^2/sr	cm^2/sr	s^{-1}	s^{-1}	%	
1.95	1.5	1.1 (-33)	4.6 (-32)	1155	4.9 (4)	0	2070$
3.2	2.5	3.4 (-34)	5.9 (-32)	714	1.2 (5)	0	800
4.0	3.5	8.1 (-35)	6.2 (-32)	172	1.3 (5)	4	750
4.0	4.5	2.1 (-35)	7.8 (-32)	44	1.6 (5)	10	288

$ this point with 50 μA, all others with 100 μA.

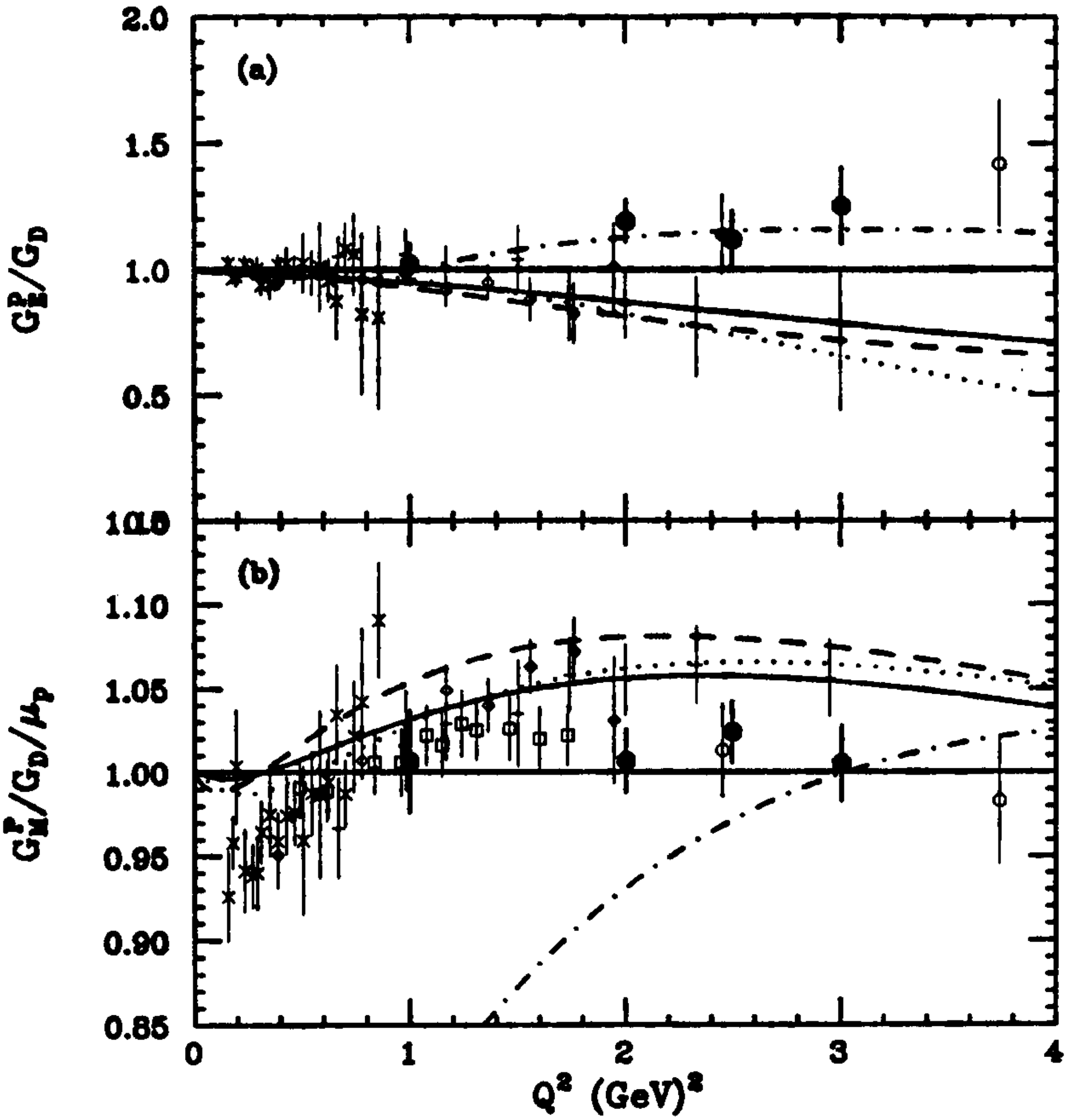
Figure caption

Figure 1 The separated data of SLAC experiment E140 (ref. 3) compared to previous data and various theoretical predictions which are briefly highlighted in the text. The new data point (full circle) have substantially smaller error bars than older data and for G_{Ep} are larger than most older results had suggested.

Figure 2 Predictions for G_{Ep} and G_{Mp} based on a relativized quark model with Isgur-Karl type wave function; the data of ref. 3 are not included.

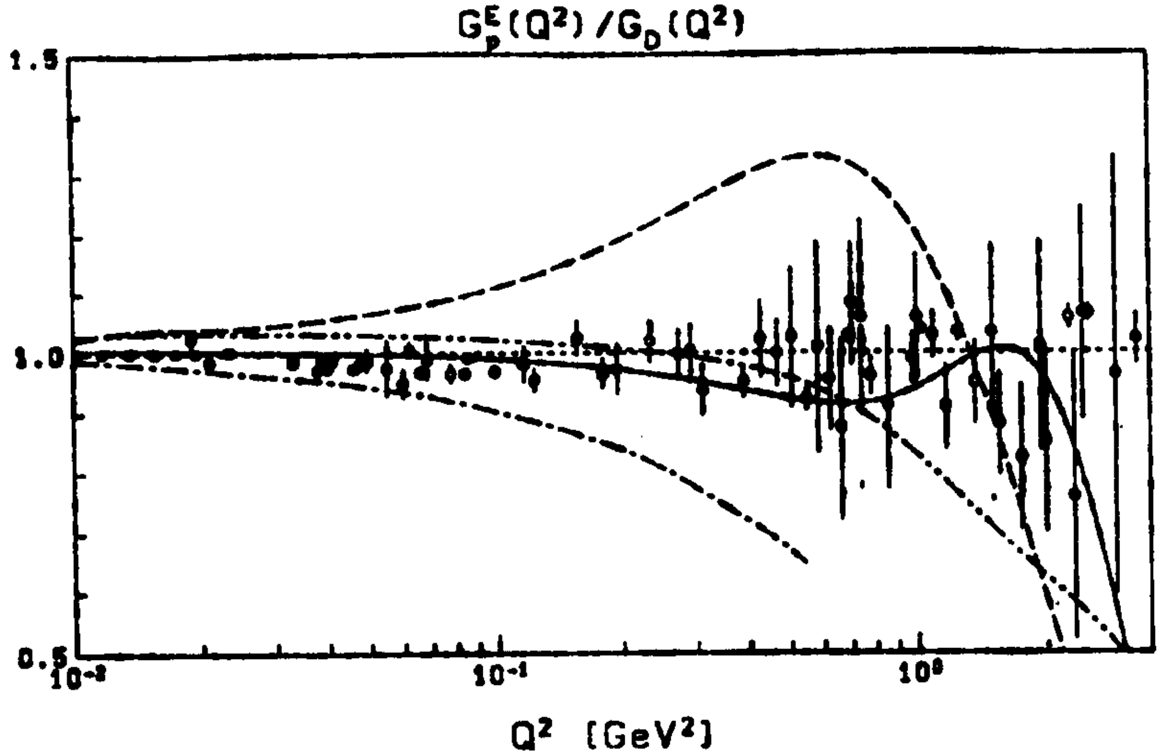
Figure 3 A comparison between the error bars anticipated in the proposal of ref. 4(NE-11) and the present proposal.

Figure 4 Values of the "coefficient of merit" $A^2_c f$ for the polarimeter used in the present proposal. The full circles correspond to the calibration points from Saclay (ref. 16). The full line follows a graphite schedule considered for CEBAF; the thickness is increased from 30 cm at 500 MeV up to a maximum of 60 cm above 1.8 GeV. The dashed line is for constant graphite thickness d=30 cm (density 1.7 gcm^{-2}).



(a)
(b)
2.0
1.5
1.0
0.5
1.10
1.05
1.00
0.95
0.90
0.85
0
1
2
3
4
G_E^p/G_D
$G_M^p/G_D/\mu_p$
Q^2 (GeV)^2

Fig 1


$G_p^E(Q^2)/G_D(Q^2)$
1.5
1.0
0.5
10^{-2}
10^{-1}
10^0
Q^2 [GeV^2]

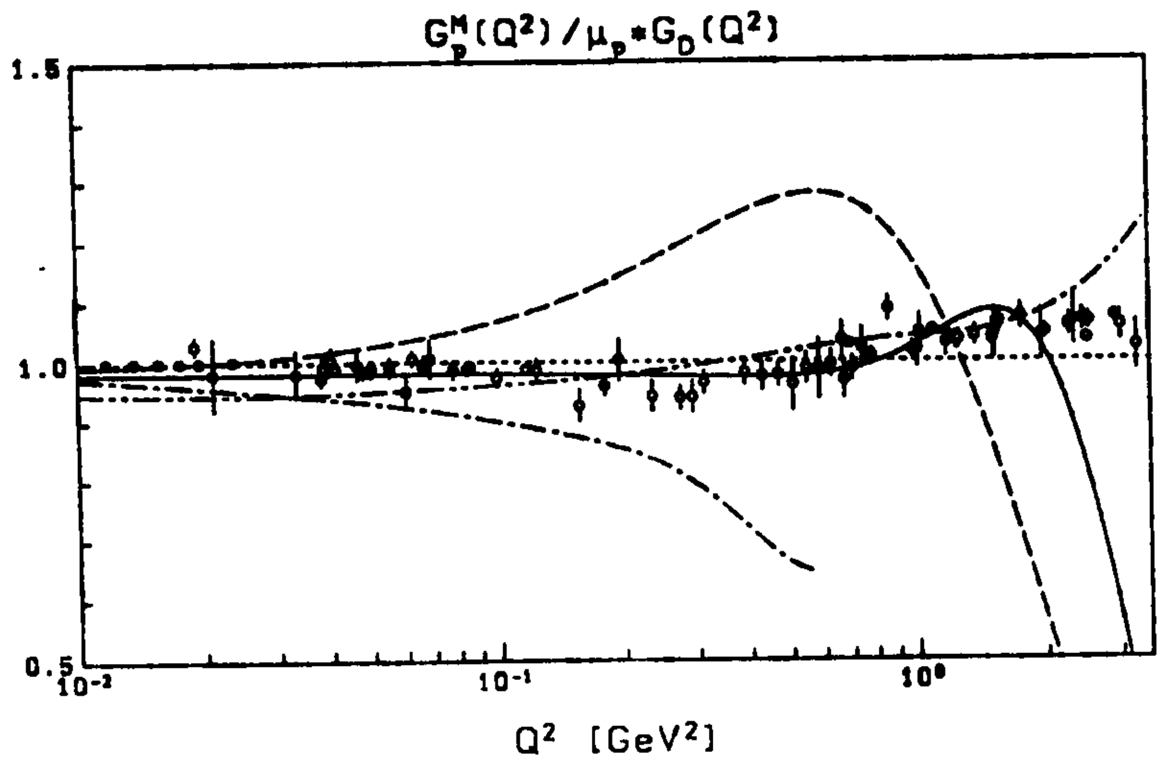

$G_p^M(Q^2)/\mu_p * G_D(Q^2)$
1.5
1.0
0.5
10^{-2}
10^{-1}
10^0
Q^2 [GeV^2]

Fig 2

Transmit Confirmation Report

No.	:	009
Receiver	:	90113910313358
Transmitter	:	CEBAF DIRECTORS OFFICE
Date	:	Jun 07'93 14:15
Time	:	16'21
Mode	:	Norm
Pages	:	30
Result	:	OK

FAX TRANSMITTAL SHEET

CEBAF

12000 Jefferson Avenue
Newport News, Virginia 23606

Director's Office Telefax Number: 1-804-249-7398

TO: PROF. RICCO

INSTITUTION/COMPANY: INFN

FAX NUMBER: 39-10-313358

FAX Transmittal Sheet is Page #1 of 30 pages.

To acknowledge transmission, or if you did not receive all pages of this transmission, please call Gladys (804) 249-7586

Sender: ROY WHITNEY

Date: 6/7/93

Time: 1:40 p.m.

Comments: