to within a factor of 2 or less. We would like to thank Professor U. Fano for bringing these results to our attention.

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ELECTRON-PROTON SCATTERING AT HIGH MOMENTUM TRANSFERS*

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This Letter reports some recent results on the elastic electron-proton scattering cross-section measurements carried out at the 6-BeV Cambridge Electron Accelerator. Data have been obtained for electron-scattering angles at 35° and 70° in the laboratory. Incident electron energies are varied to attain q^2 (4-momentum transfer squared in F^{-2}) = 45, 75, 100, and 125 F^{-2} for 35°, and q^2 = 75 and 100 F^{-2} for 70°, respectively. This work represents the first attempt to measure the electromagnetic form factors of the proton beyond $q^2 = 45$ F^{-2}.[1] Our data are consistent with a suggestion that G_E and G_M are equal and fall off as $1/q^2$ at large momentum transfers.

The internal electron beam of the Cambridge Electron Accelerator is allowed to strike a liquid hydrogen target. The bremsstrahlung from the electrons traversing the target is monitored in the forward direction by a total integral ionization chamber, the quantameter, as well as a thin-walled helium-filled ionization chamber. The target container is made out of 0.0005-inch Mylar. The target illumination is governed by horizontal and vertical clippers located at an integral number of betatron wavelengths upstream from the target. During each run the distribution of bremsstrahlung production in the full target as a function of horizontal position in the median plane of synchrotron is measured.

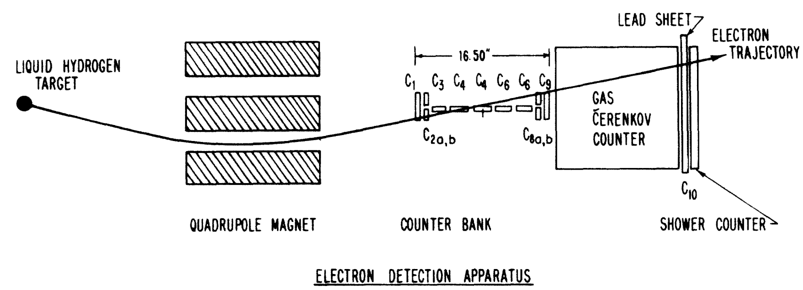
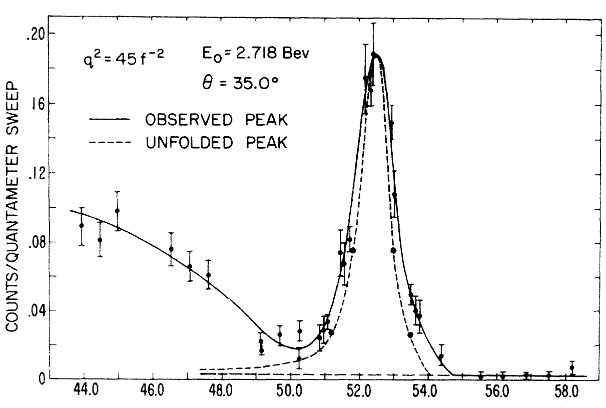


FIG. 1. Counter arrangement for electron detection. A quadruple (Q) coincidence between $C_1C_{2a}C_{8b}C_9$ or $C_1C_{2b}C_{8a}C_9$ signifies a charged particle crossing the focal plane between C_2 and C_8.

The knowledge of the distribution determines the ratio of bremsstrahlung from hydrogen to the total bremsstrahlung as monitored by the quantameter. The elastically scattered electrons are magnetically analyzed by a single quadrupole magnet used in a previous experiment.[2] The electrons are focused vertically onto the detection system shown in Fig. 1. Counters C_2 and C_8 are split vertically to define the electron trajectories. Genuine 4-fold coincidences $C_1C_2C_8C_9$ were 10 to 50 times as numerous as electron-scattering events. The origin of this background is not clear but may include π mesons scattering through the spectrometer and low-energy knock-on electrons. In order to eliminate this background, a butane-filled threshold Cherenkov counter is used which is sensitive only to electrons. High-energy pions and muons can be detected only by their δ rays. A shower counter, C_{10}, follows the Cherenkov counter to help reject low-energy electrons resulting from a knock-on process and pion charge-exchange reactions. During each run the magnet current is adjusted so that the elastic peak is clearly exhibited on the five thin (1/16-in.) slat scintillation counters, C_3, C_4, C_5, C_6, and C_7. Figure 2 shows typical elastic peaks for $q^2 = 45$ and 125 F^{-2}. At $\theta = 35°$ and $q^2 = 100$ and 125 F^{-2}, pions were counted in the Cherenkov counter. Since pions are not expected to produce large cascade showers, pion events were rejected by demanding a large pulse in the shower counter. The loss in the shower counter efficiency for electrons is estimated to be 7.6% ± 4.0%.[3] At $\theta = 70°$ it becomes increasingly difficult to maintain a high efficiency in the shower counter due to the large reduction in scattered electron energy. In order to insure proper discrimination against random background caused by the presence of abundant low-energy electrons and by the low counting rates, a high bias is set



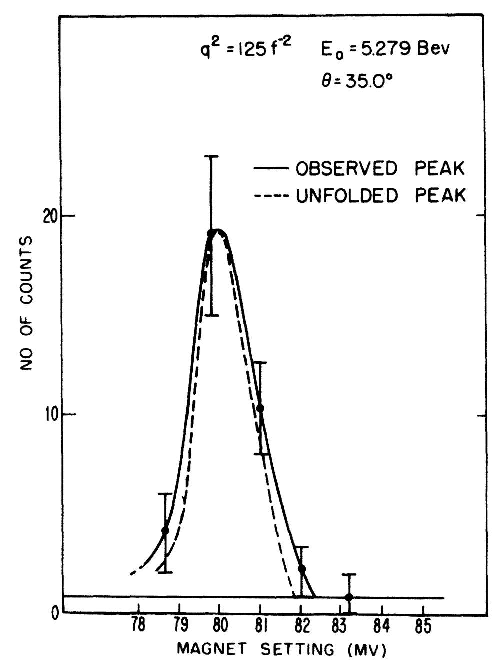


FIG. 2. (a, b) Typical experimental elastic peaks as observed in the five 1.17% slat momentum counters at $q^2 = 45$ and 125 F^{-2}. The unfolded elastic peak has an estimated 2.0% full width at half-maximum as compared to 2.8% as shown.

Table I. Typical correction factors and uncertainties.

	$\theta = 35°$ $q^2 = 45$ F^{-2}	$q^2 = 125$ F^{-2}
Counter efficiency	1.010 ± 0.030	1.086 ± 0.040
Inelastic contamination	1.000 ± 0.010	1.000 ± 0.025
1% change in machine energy	1.000 ± 0.054	1.000 ± 0.055
Solid angle	1.000 ± 0.020	1.000 ± 0.020
Slit scattering	0.990 ± 0.010	0.990 ± 0.010
Angle measurement	1.000 ± 0.005	1.000 ± 0.005
Monitoring		
(a) Quantameter calibration	1.000 ± 0.030	1.000 ± 0.030
(b) Hydrogen radiation length	1.000 ± 0.020	1.000 ± 0.020
(c) Target wall corrections	1.000 ± 0.035	1.000 ± 0.030
Radiation corrections		
(a) Real bremsstrahlung	1.000 ± 0.000	1.000 ± 0.000
(b) Schwinger[a]	1.157 ± 0.020	1.169 ± 0.020
Loss outside momentum acceptance	1.000 ± 0.020	1.110 ± 0.020
Counting statistics	1.000 ± 0.040	1.000 ± 0.160
Overall	8.7%	18.8%

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for the detection of electrons. Under this circumstance, random events were found to be negligible. The shower counter efficiency is estimated to be 88% ± 6%.

The treatment of the hydrogen data is outlined in Table I. The cross sections so obtained are given in Table II. All cross sections are absolute. The errors include an estimated 7.2% systematic uncertainty which is common to all measurements. The counting statistics for $q^2 = 45$ F^{-2} is 4% and ranges from 9 to 16% for other points.

We have attempted to separate the electromagnetic form factors for the proton assuming the validity of first Born approximation. The values for G_{Ep}^2 and G_{Mp}^2 so obtained are also listed in Table II. The errors on G_{Ep} and G_{Mp} are almost completely correlated. For $q^2 = 45$ F^{-2}, we have used the backward angle measurements of Berkelman et al.[4] Our value for G_{Ep} at $q^2 = 45$ F^{-2} is more precise than that of Berkelman et al. due to the enhanced sensitivity to charge scattering at forward angles. The separation of G_{Ep} at $q^2 = 75$ and 100 F^{-2} is less precise than that at $q^2 = 45$ F^{-2} as is shown in Fig. 3.

We note that the data are consistent with the attractive assumption[5] that $G_{Ep} = G_{Mp}$ at large momentum transfers. If we make this assumption the errors are smaller than those shown in Table II, and at $q^2 = 125$ F^{-2} we find $G_{Mp} = G_{Ep} = 0.050 \pm 0.005$. If we put $G_{Mp}^2 = 0$, $G_{Ep} = 0.09 \pm 0.01$. If $G_{Ep}^2 = 0$, $G_{Mp} = 0.06 \pm 0.006$. In all cases the form factor falls as the momentum transfer increases, so that these numbers are upper limits on a possible core. Our data are not consistent with an early indication[2,4,6] of a

Table II. Experimental differential *ep* cross sections and proton electromagnetic form factors.

θ	E_0 (BeV)	q^2 (F^{-2})	q^2 (BeV/c)^2	$\Delta P/P$[a]	$(d\sigma/d\Omega)\times 10^{32}$ (cm^2/sr)	G_{Ep}^2	dG_{Ep}^2	G_{Mp}^2	dG_{Mp}^2	G_{Ep}	dG_{Ep}	G_{Mp}	dG_{Mp}
35°	2.720	45	1.75	3.5%	0.202 ± 0.019	0.0230	0.005	0.0550	0.005	0.152	0.020	0.234	0.013
35°	3.725	75	2.91	6.0%	0.0262 ± 0.0037	0.0037	0.0067	0.0141	0.005	0.061	0.061	0.119	0.020
70°	2.460	75	2.91	3.5%	0.00395 ± 0.0006								
35°	4.480	100	3.88	6.0%	0.0103 ± 0.0019	0.0059	0.0050	0.0053	0.0022	0.077	0.060	0.073	0.017
70°	3.047	100	3.88	3.5%	0.00134 ± 0.00025								
35°	5.180	125	4.85	3.5%	0.00329 ± 0.00060								

[a]$\Delta P/P$ is the momentum acceptance.

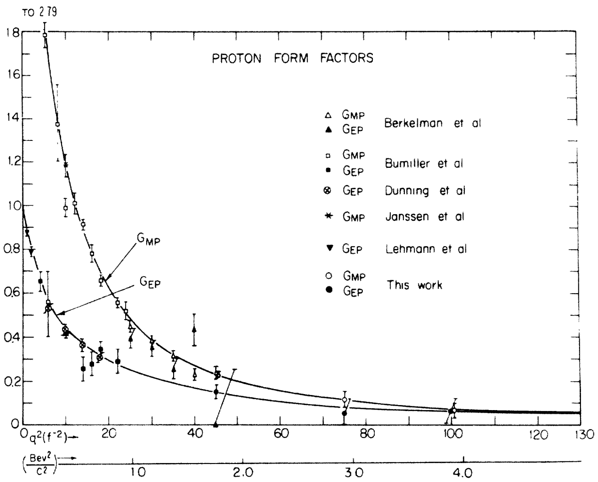

FIG. 3. The solid line gives the best fit for the electromagnetic form factors of the proton, G_{Ep} and G_{Mp}, as obtained in Table II. G_{Ep} and G_{Mp} are equal within statistics. The error limits do not include the 4 % scale uncertainty which is common to all points. No separation is made at $q^2=125$ F^{-2} since the cross section is measured at one angle only.

core in the electric form factor of 0.2.

If the form factors are due to a multipion resonance, we expect terms of the form $(1/q^2+m^2)$, where m is the mass of the resonant state. For $q^2 \gg m^2$ we therefore expect $G \sim 1/q^2$. The form factors in this region fall off consistently with this behavior. Our data are therefore consistent with no core in either the electric or magnetic form factor.

We intend to repeat and extend these measurements on hydrogen and deuterium in the near future.

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FINAL-STATE INTERACTIONS IN THE DECAY $\eta \to 3\pi$†

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In this Letter we present the results of an analysis of the Dalitz-Fabri plot of 97 eta decays, $\eta \to \pi^+ + \pi^- + \pi^0$. The etas were produced in the reaction $\pi^+ + p \to \pi^+ + p + \eta$, by using π^+ of 1170 MeV/c (76 events) and 1050 MeV/c (21 events) incident on the Alvarez 72-in. hydrogen chamber. Our sample differs from previously published samples in two important respects.[1] First, our background is negligible.[2] Second, the contaminating decay mode $\eta \to \pi^+ + \pi^- + \gamma$,