Comment on G_E^p measurement in Exp. 93-026

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The measurement of the proton charge form factor in expt. 93-026 is done in two ways: inclusive $e{-}p$ elastic asymmetry measurement on ammonia $^{15}NH_3$ and exclusive quasielastic $d(e,e'p)$ measurement on deuterated ammonia $^{15}N^2H_3$.

- Inclusive measurement: this measurement involves only detecting elastically scattered electrons in the Hall C HMS spectrometer. It is a systematics dominated measurement, that takes only about 5% of the time approved for the G_E^n experiment, to measure A_{ep} to 2% statistics. The main sources of systematic error are the target polarization (2.5% relative), beam polarization (2%) and dilution factor (1%). The correction for the ^{15}N contribution is negligible. Combining the statistical and systematic errors in quadrature, the expected error in A_{ep} is 3.9%. This small error propagates very favorably at high four-momentum transfer.

The choice of kinematics is determined by the neutron measurement. An independent measurement would imply optimizing the figures of merit $A_{ep}^2\sigma_{e-p}$ or $\sigma_{e-p}/(\partial(G_E^p/G_M^p)/\partial A_{ep})^2$, where σ_{e-p} is the elastic cross-section. The first figure of merit favors small angles at all values of four-momentum transfer. Although at the lowest $Q^2 = 0.5$ GeV^2 the second figure of merit has a 6-to-1 advantage, this advantage becomes a 14% LOSS at 1 GeV ^{2}, and it gets worse at the higher kinematic settings, even if one considers only the reduced maximum optimal angles allowed by the coil (which would not be relevant for a single arm experiment). At the actual optimum angles suggested by the denominator of the second figure of merit the situation is even less favorable.

- Exclusive measurement: this is a simultaneous measurement with the G_E^n determination. Therefore, its kinematic setting are determined by the optimum settings for measuring the neutron form factor. The error propagation from the measured asymmetry to the form factor value is the same as for the neutron, with the appropriate substitutions (proposal eq. (19)). Given the large size of G_E^p at low Q^2, the asymmetry is rather insensitive to G_E^p at $Q^2 = 0.5$, but the situation improves rapidly with Q^2, and at $Q^2 \geq 1.0GeV^2$ the technique provides competitive precision. At $Q^2 = 0.5GeV^2$ the expected statistical error is smaller than that for the neutron by the product of 3.8 (cross section) times 3 (detector efficiency) times 0.5 (detector acceptance) to the 1/2 power, or about 2.4 times smaller than the neutron 4.8% proposed error. At $Q^2 = 1.75$ it is 1.9 times smaller, or about 10%. This implies that the error on the ratio G_E^p/G_M^p would be 17%, combined statistical and systematic errors.

To obtain the optimum kinematics setting for an independent proton measurement the effect of the target magnetic field on the detector acceptance must be taken into account. Moreover, not all optimum angles are accessible because of limitations in the target magnet openings. In particular, for $Q^2 \geq 1.6GeV^2$, all beam energies below about 4.3 GeV are ruled out, as well as the corresponding angles above $\simeq 19°$.

The proton measurement in expt.93-026 provides a valuable measurement in a region where other techniques have significant limitations. Moreover, the combination of inclusive and exclusive measurements contributes significantly to clarifying the neutron measurement in the high Q^2 region, where additional information is most useful.

Q^2	Eo optimum	θε	theta_q	θB	E actual	θε actual	Gain in (dg/dAeD)	Loss in <σ>	Net gain
0.5	1.00	48.8	46.7	43.3	2.724	15.72	5.8		
1.0	2.06	32.8	46.7	43.3	4.232	14.5	4.0	4	1
1.5	3.70	21.6	46.6	43.3	4.996	15.4	1.8		
1.8	4.95	17.07	46.6	43.3	4.996	16.9	1.0		
2.0	not accesible								

FIG. 1. Table shows limiting angles determined by coil openings