G_E^n measurement at Q^2 of 3.4 GeV^2

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The Neutron Detector

At hall A in Jefferson Laboratory

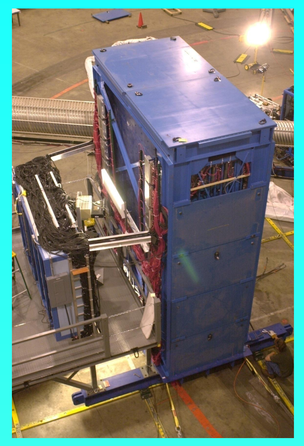
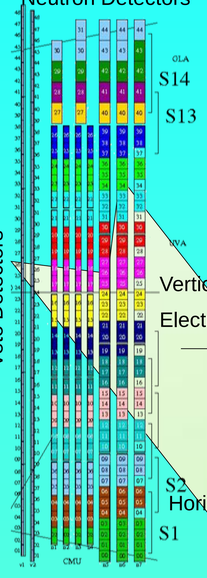


Photo of the neutron detector.

Neutron Detector Schematic

Neutron Detectors



The colors show detectors in separate trigger channels. The start of the trigger for the experiment was formed by an OR of all the trigger channels (with left and right being separate).

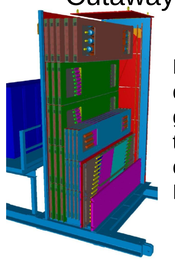
Neutron Detector Calibration

The final calibration of the neutron arm is done using 3 separate components. First, the time of flight for protons between the Big Bite scintillators and the Neutron arm is used to calibrate the detector vertically. Next, events of coincidence between marker bars and plane 1 detectors is used to calibrate the hoizontal position. Finally, the depth into the detector is calibrated by using deep tracks (relative to the first plane).

Veto Detector Efficiency

Deep tracks were also used to determine the efficiency of the veto detectors. This was found to be 99.5%. However, because of (p,n) conversion in the shielding, the actual efficiency at detecting charged particles was 96%.

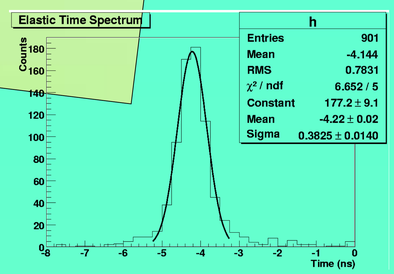
Cutaway Diagram



Brown are the veto detectors, while blue, light green, and dark green are the various neutron detectors respectively. Dark blue is the shielding.

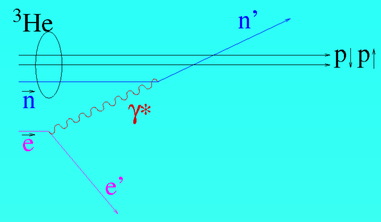
Elastic Time Resolution

For the 3.4 GeV^2 data point, a resolution in the neutron detector of 380 ps has been achieved for elastic protons.



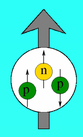
The Measurement

$\overrightarrow{^3He}(\vec{e}, e'n)$ Reaction

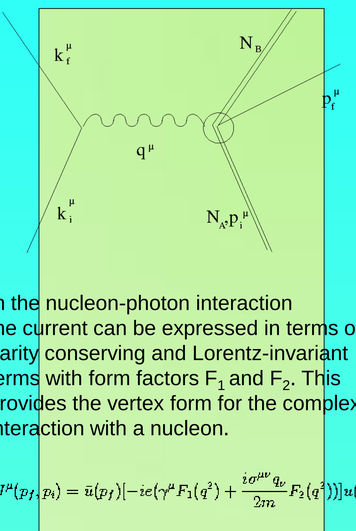


In this measurement, a polarized beam of electrons interacts with a polarized Helium 3 nucleus via a virtual photon. In the quasi-elastic approximation, only a single nucleon interacts in nucleon knockout.

Scattering from a Nucleon



In the Helium 3 nucleus, the polarization of the neutron is given by the polarization of the nucleus.`



In the nucleon-photon interaction the current can be expressed in terms of parity conserving and Lorentz-invariant terms with form factors F_1 and F_2. This provides the vertex form for the complex interaction with a nucleon.

$$J^\mu(p_f, p_i) = \bar{u}(p_f)[-ie(\gamma^\mu F_1(q^2) + \frac{i\sigma^{\mu\nu}q_\nu}{2m}F_2(q^2))]u(p_i)$$

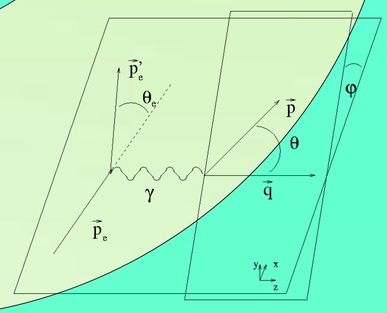
The F_1 and F_2 form factors can be expressed in terms of the Sachs form factors.

$$G_E = F_1 - \kappa\tau F_2, G_M = F_1 + \kappa F_2$$

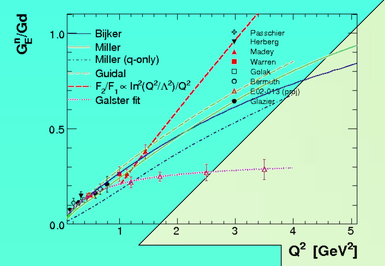
Rosenbluth Cross Section

$$\frac{d\sigma}{d\Omega} = f_{rec}\sigma_{Mott}[\frac{G_E^2 + \tau G_M^2}{1+\tau} + 2\tau G_M^2 \tan^2\frac{\theta_e}{2}].$$

Polarization exchange in the one-photon exchange approximation.



Expected Results



Previous double polarization experiments provide data at half this measurement's 3.4 GeV^2 kinematic value. This measurement's proposed points are plotted along the Galster parameterization. Included are representative models.

Double Polarization Asymmetry Measurement

The asymmetry, given in terms of the polarization angles θ and ϕ, allows the measurement of the ratio of the form factors, when the electric form factor is small.

$$A = \frac{2\sqrt{\tau(1-\tau)}\tan\frac{\theta_e}{2}\sin\theta\cos\phi G_E^n G_M^n + 2\sqrt{\tau(1+\tau)}\sqrt{\tau[1+(1+\tau)\tan^2\frac{\theta_e}{2}]}\cos\theta(G_M^n)^2}{(G_E^n)^2 + \tau[1+2(1+\tau)\tan^2\frac{\theta_e}{2}](G_M^n)^2}$$

The experimental asymmetry is related to the perpindicular asymmetry ($\theta = 0$) by the polarization of the beam and neutron, and by dilution factors.

$$A_{exp} = P_e \cdot P_t \cdot D \cdot V \cdot A_{perp}$$