Measurement of G_E^n via $\vec{d}(\vec{e}, e'n)p$ at Jefferson Lab

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Outline

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- From $\vec{d}(\vec{e}, e'n)p$ to G_E^n
- Experimental Setup
- Results

Overview

Jlab Experiment E93-026 (*Gen01*):

- measured neutron charge form factor
  measure of charge distribution in neutron
- detected *quasi-elastically* scattered e^- and ejected neutron in coincidence
- used custom n detector and Hall C's *High Momentum Spectrometer*
- $Q^2 = 0.5\,GeV^2$ and $1.0\,GeV^2$
  $E_0 = 2.3\,GeV$ and $3.5\,GeV$
- ran August – December 2001 in Hall C of Jefferson Lab
  Newport News, Virginia
- 5×10^6 neutrons at $Q^2 = 0.5\,GeV^2$, 1×10^6 neutrons at $Q^2 = 1.0\,GeV^2$

Gen01 Collaboration

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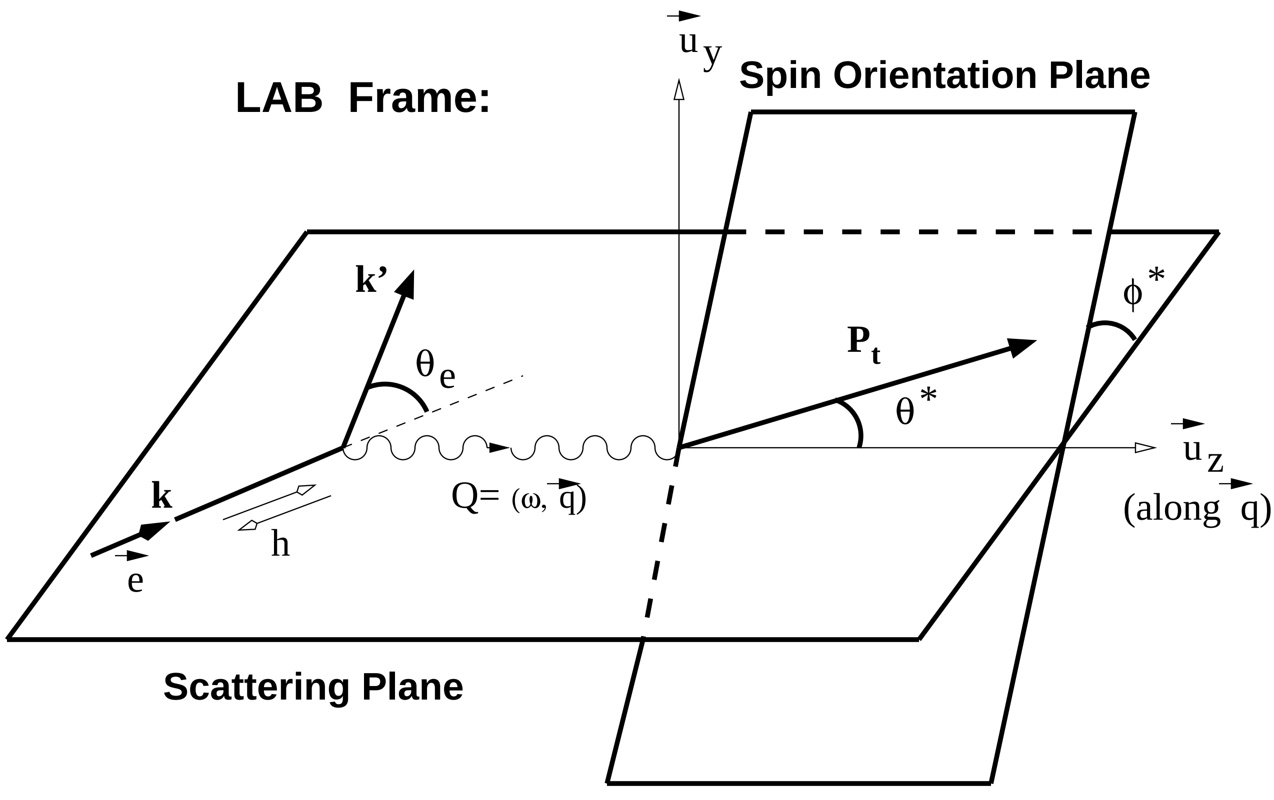
University of Maryland at College Park, University of Virginia,
Virginia Polytechnic Institute & State University,
Vrije Universiteit of Amsterdam, Yerevan Physics Institute

From $\vec{d}(\vec{e},e'n)p$ to G_E^n

- quasi-elastic scattering of e^- off d
- polarized, frozen $^{15}ND_3$ target
- polarized e^- beam
- e^- and n detected in coincidence
- extract G_E^n from asymmetry



Scattering Crossection & Form Factors

Unpolarized:

$$\left(\frac{d\sigma}{d\Omega}\right) = \left(\frac{d\sigma}{d\Omega}\right)_{\text{Mott}} \times \left[\frac{{G_E}^2 + \tau {G_M}^2}{1+\tau} + 2\tau {G_M}^2 \tan^2\frac{\theta_e}{2}\right]$$

$\tau = \frac{Q^2}{4M^2}$ $\quad$ $h =$ beam helicity

Polarized:

$$\left(\frac{d\sigma}{d\Omega}\right)^{pol} = \left(\frac{d\sigma}{d\Omega}\right)_{\text{Mott}} \times \left[\Sigma + h\,\mathcal{P}_{\text{target}}\,\Delta\right]$$

$$\frac{\Delta}{\Sigma} = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

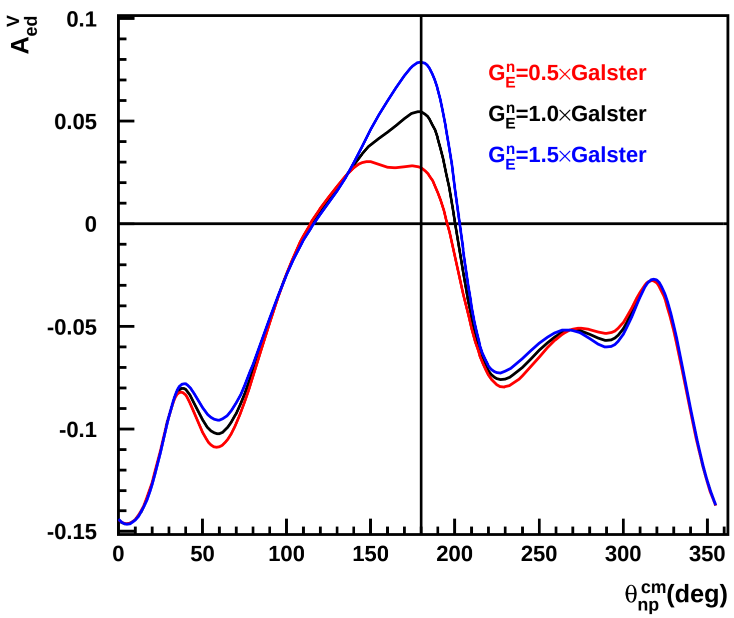
if $\mathcal{P}_{\text{target}} \perp \vec{q}$ and in scattering plane:

$$= \frac{-2\sqrt{\tau(1+\tau)}\,\tan\frac{\theta_e}{2}\,G_E\,G_M}{{G_E}^2 + \tau[1+2(1+\tau)\tan^2\frac{\theta_e}{2}]\,{G_M}^2}$$

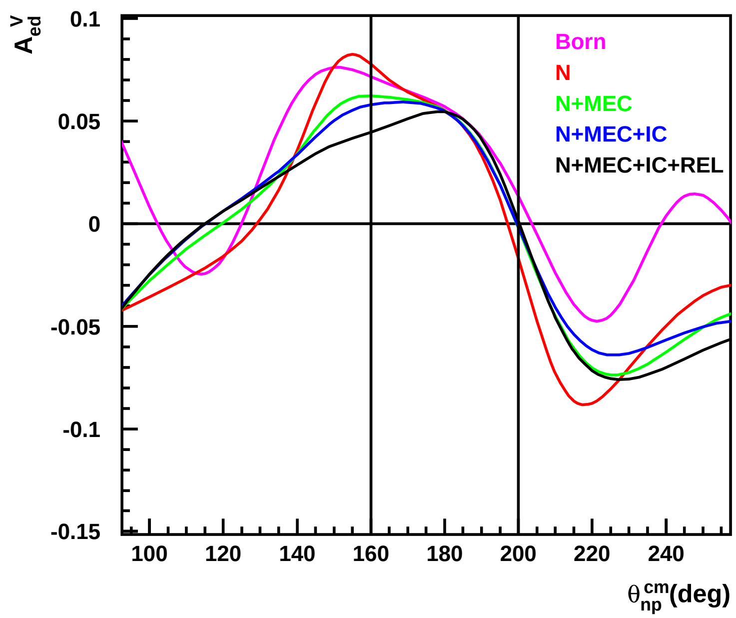
$$= \frac{\mathcal{E}_{ed}}{\mathcal{P}_{\text{beam}}\,\mathcal{P}_{\text{target}}} \times [\text{corrections}]$$

Why this way?

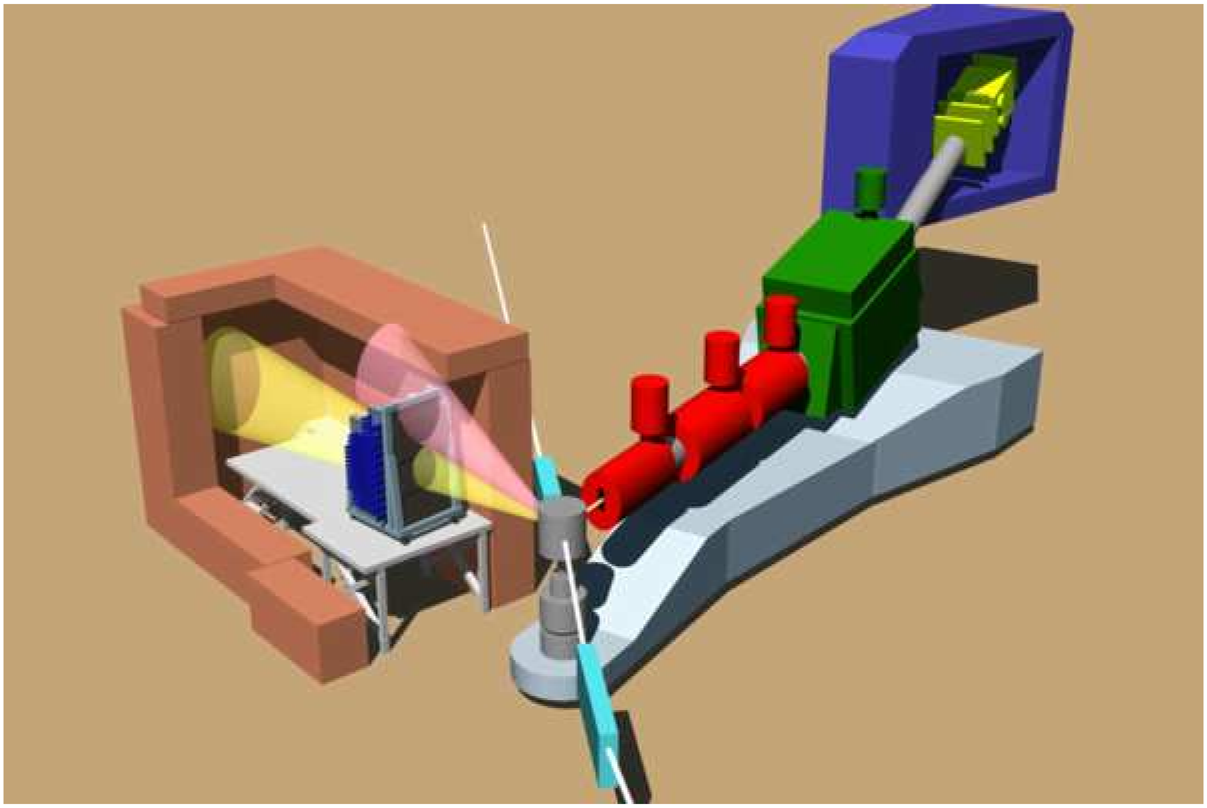
Maximize Sensitivity to G_E^n



Minimize Model Dependence



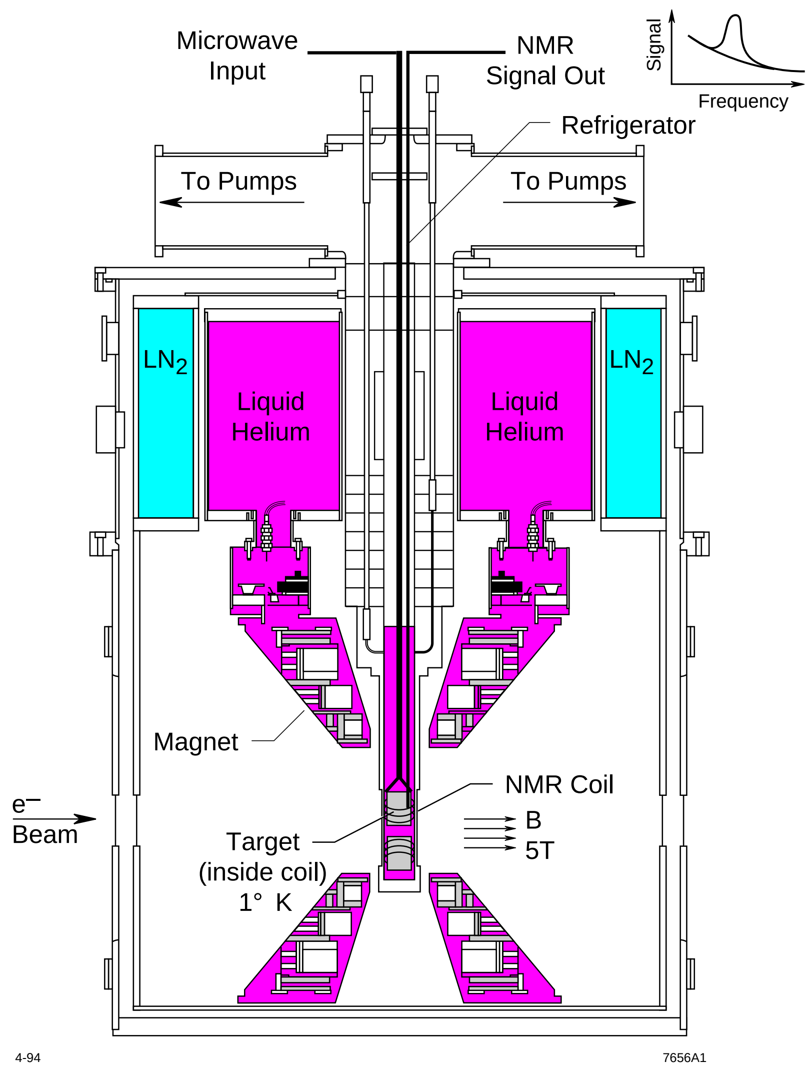
Experimental Setup



* polarized target
* High Momentum Spectrometer
* custom neutron detector

Target

- ∗ frozen ND_3
- ∗ ^{4}He evaporation refrigerator
- ∗ $5T$ polarizing field
- ∗ dynamic nuclear polarization driven by microwaves
- ∗ remotely movable insert



Neutron Detector

* segmented scintillator

  high rate: $\sim 100kHz$

* 2 proton VETO layers,

  6 conversion layers

  142 elements total

* vertically extended for

  symmetric p^+ acceptance

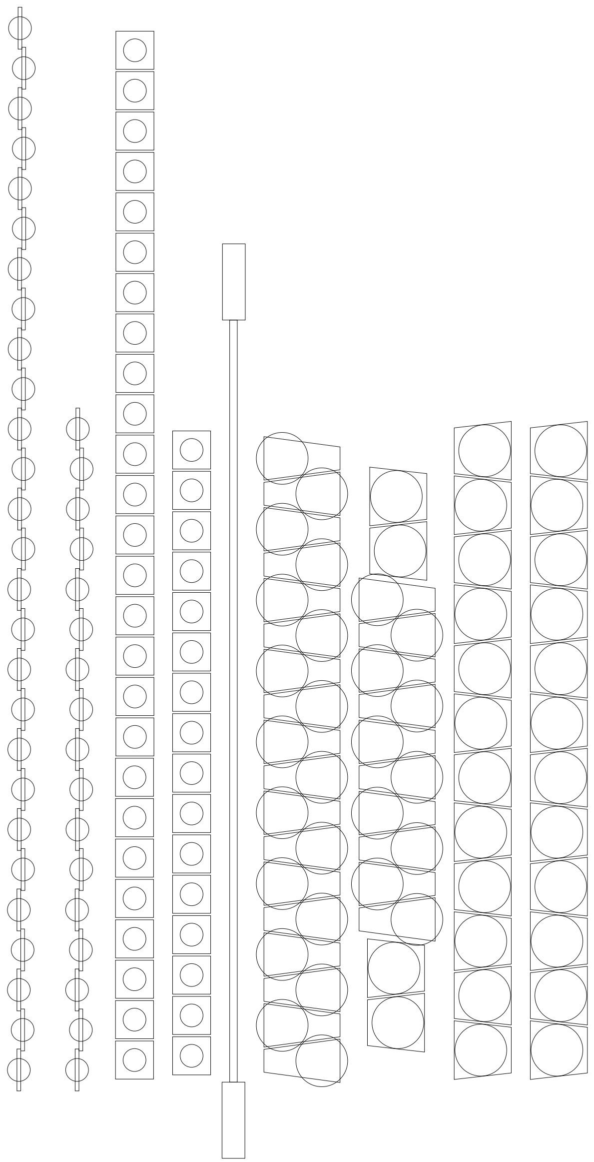
* phototubes at both ends

  horizontal position

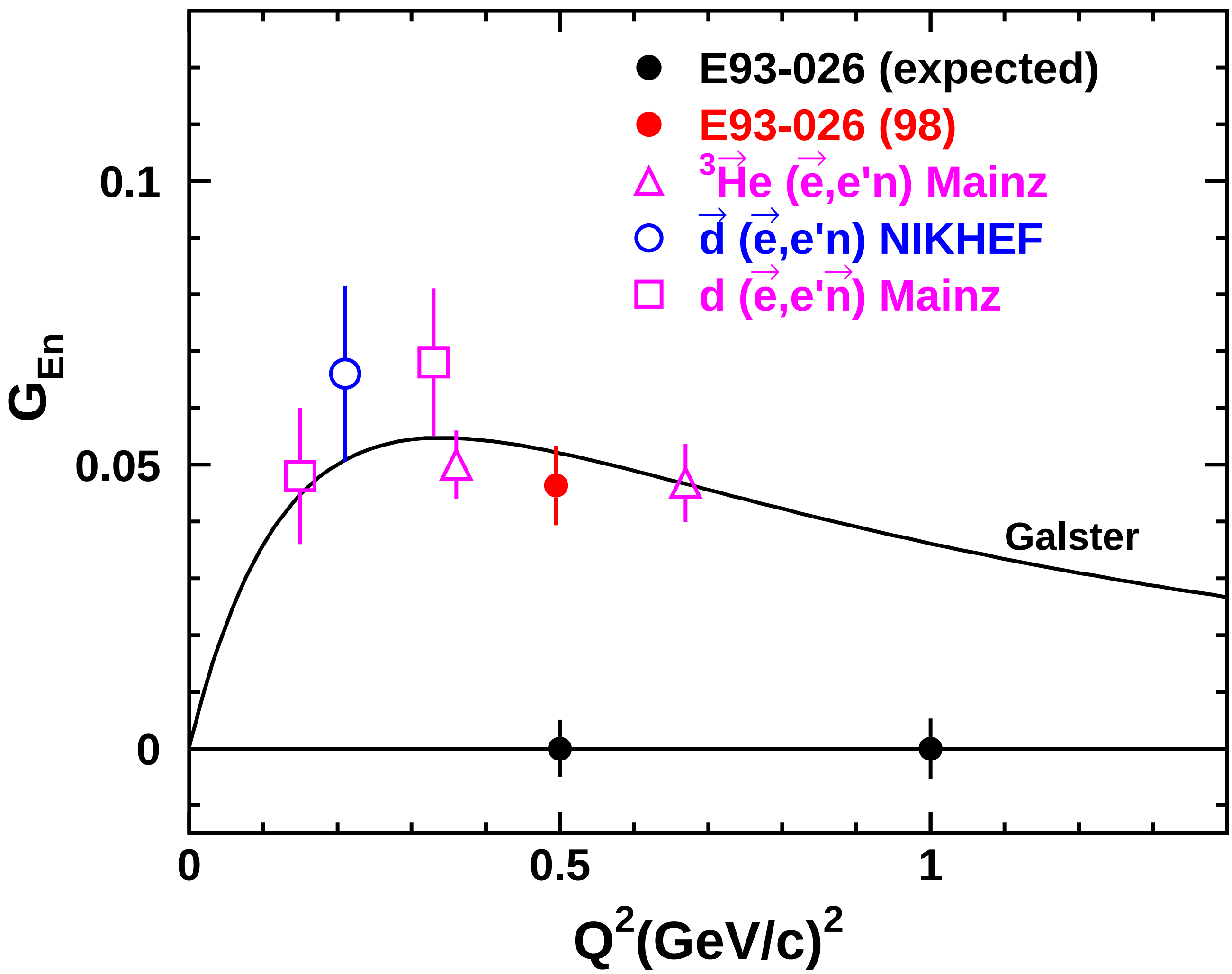
  2 vertical elements for calibration

* provides 3 space coords,

  time and energy



Results



E93-026 (expected)
E93-026 (98)
3He (e,e'n) Mainz
d (e,e'n) NIKHEF
d (e,e'n) Mainz
Galster
G_En
0.1
0.05
0
0.5
1
Q2(GeV/c)2