E02-013: G_E^n at High Q^2

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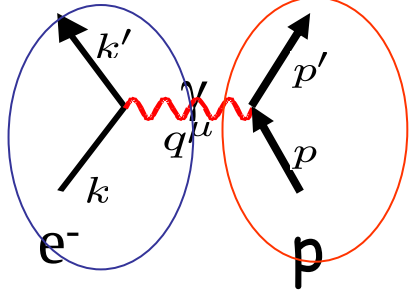
for the E02-013 collaboration

Standard Form Factor Stuff:



•Elastic cross section in written in terms of $F_1(Q^2)$ and $F_2(Q^2)$ or G_E and G_M:

$$\tau = Q^2/4M^2 \qquad \text{Kinematic factor}$$
$$G_E(Q^2) = F_1 - \kappa\tau F_2 \qquad \text{Electric Form Factor}$$
$$G_M(Q^2) = F_1 + \kappa F_2 \qquad \text{Magnetic Form Factor}$$

$$\frac{G_E(Q^2)}{G_M(Q^2)} = \frac{1-\kappa\frac{Q^2}{4M^2}F_2/F_1}{1+\kappa F_2/F_1}$$

High Q^2 pQCD prediction (Belitsky, Xiangdong and Yuan):

- F_2 (Dirac) operator requires nucleon spin flip
- For interaction with single quark:
  Helicity flip of quark suppressed ~ m/E
  •-> Need to change orbital angular momentum of quark
- Model result:

constant

$$F_2 / F_1 = C \frac{M^2}{Q^2} \ln\left[Q^2 / \Lambda^2\right]$$

$$\frac{G_E(Q^2)}{G_M(Q^2)} = \frac{1 - \kappa \frac{1}{4} C \ln\left[Q^2 / \Lambda^2\right]}{1 + \kappa C \frac{M^2}{Q^2} \ln\left[Q^2 / \Lambda^2\right]}$$

- Appears to work for proton even at Q^2 ~ 2 to 5 GeV^2
- E02-013 measures neutron G_E/G_M

E02-013 Collaboration

Spokespeople

- Bogdan Wojtsekhowski – JLab
- Gordon Cates – University of Virginia
- Nilanga Liyanage – University of Viginia

Analysis Coordinator

- Seamus Riordan – Carnegie Mellon University (graduate 2008), UVA

Ph.D. Students

- Serge Abrahamyan – Yerevan, Armenia
- Brandon Craver – University of Virginia
- Aidan Kelleher – College of William and Mary
- Ameya Kolarkar – University of Kentucky (graduated 2007), Boston U.
- Jonathan Miller – University of Maryland, College Park

Masters Student

- Tim Ngo – California State University, LA. (graduated 2007)

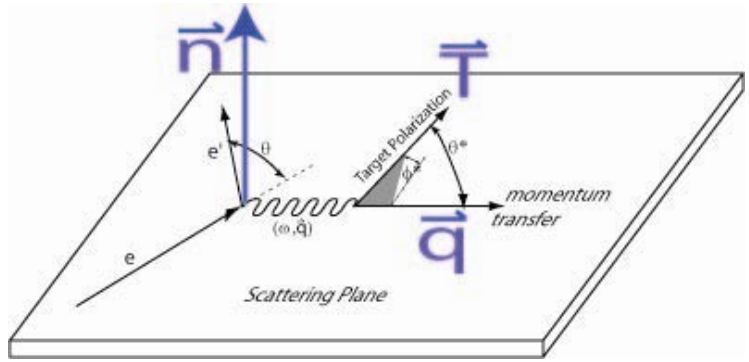
Postdoc

- Rob Feuerbach – JLab, College of William and Mary (thru 2007)

+ ~100 Collaborators

A_{phys} measures G_E/G_M

$$A_{phys} = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-}$$



$$A_{phys} = -\frac{[G_E/G_M]\,2\sqrt{\tau(\tau+1)}\tan(\theta/2)\,\hat{n}\cdot(\hat{q}\times\hat{T})}{[G_E/G_M]^2+\tau+2\tau(1+\tau)\tan^2(\theta/2)}$$

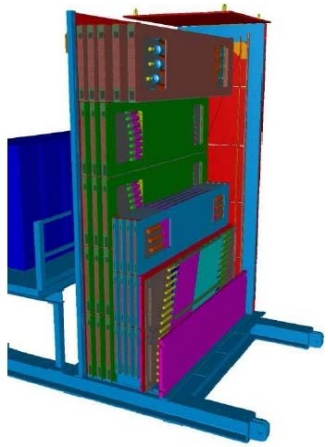
$$-\frac{2\tau\sqrt{1+\tau+(\tau+1)^2\tan^2(\theta/2)}\tan(\theta/2)\,(\hat{q}\cdot\hat{T})}{[G_E/G_M]^2+\tau+2\tau(1+\tau)\tan^2(\theta/2)}$$

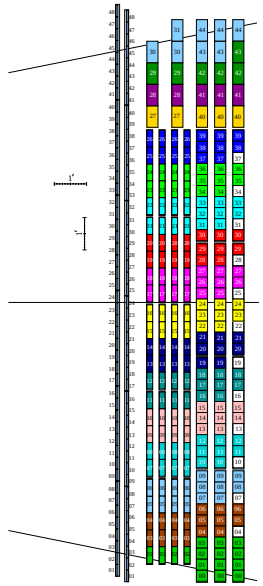
E02-013: Target polarization $\hat{T}$ in scat. plane and perpendicular to $\hat{q}$

Maximizes 1st term, minimizes 2nd term

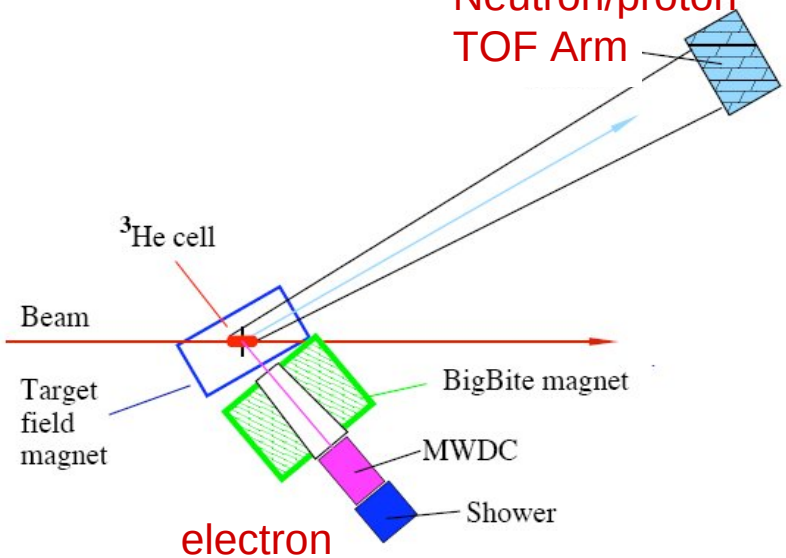
E02-013 Setup

Polarized Target: $^3\vec{\mathrm{He}}(e,e'\mathrm{N})x$

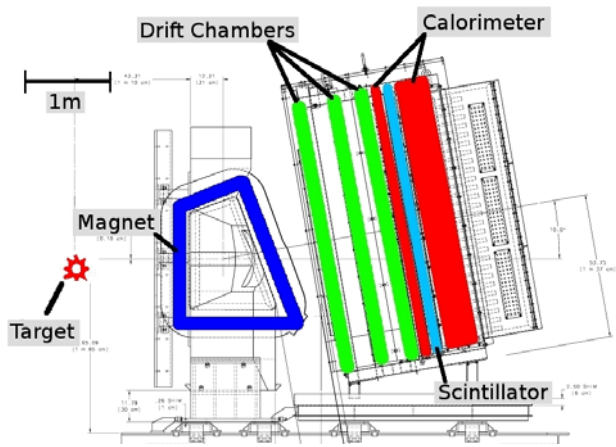




Neutron/proton TOF Arm



electron arm



The Gen data run (Spring 2006)

- 4 Kinematic Points, Q^2 = 1.2, 1.7, 2.5, and 3.5 GeV^2
- ^3He target polarization 45 to 50% !
- Commissioning of proton/neutron TOF detector
- Commissioning of BigBite tracking chambers
- ^3He, H_2, and N_2 target

Gen analysis issues

- BigBite tracking and optics software
- Calibration of neutron/proton detector time-of-flight
- Determination of neutron/proton efficiency and PID
- Development of Monte Carlo simulation

Selection of quasi-elastic events using $\vec{p}_{miss}$

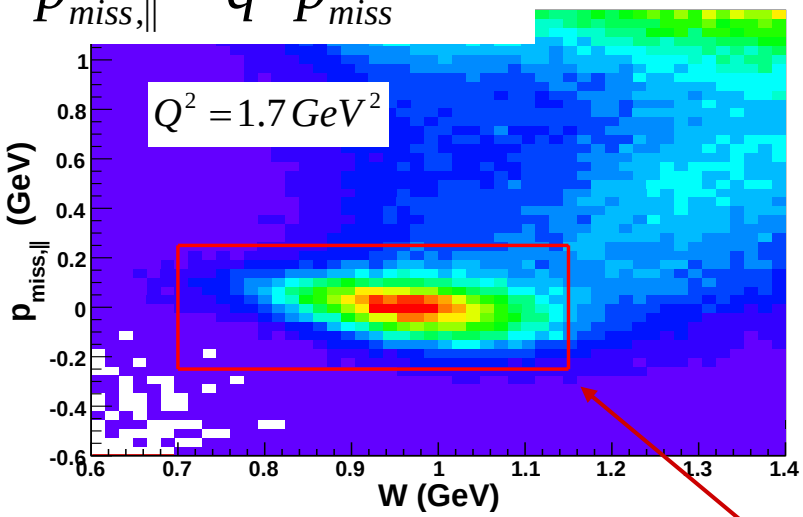
Missing momentum : $\vec{p}_{miss} = \vec{q} - \vec{p}_{NA}$

Recoil hadron momentum determined by Neutron Array

Momentum transfer determined by BigBite

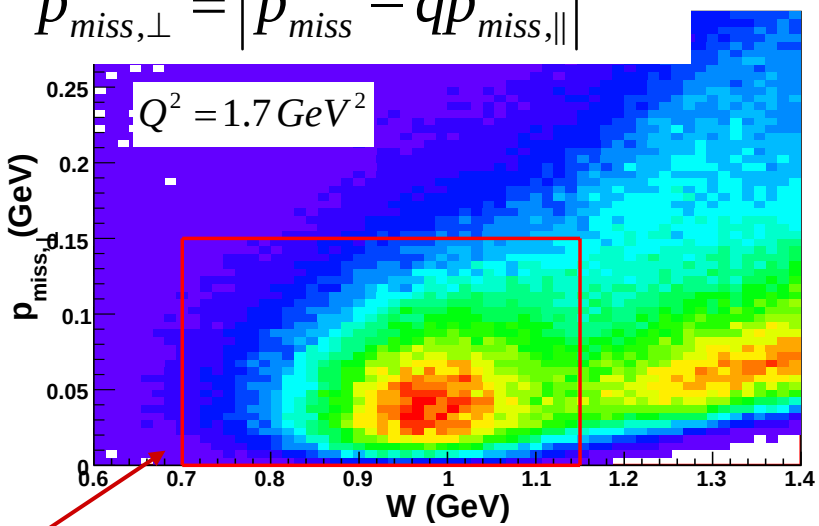
Parallel component :

$p_{miss,\parallel} = \hat{q} \cdot \vec{p}_{miss}$



Perpendicular component :

$p_{miss,\perp} = \left| \vec{p}_{miss} - \hat{q}\vec{p}_{miss,\parallel} \right|$



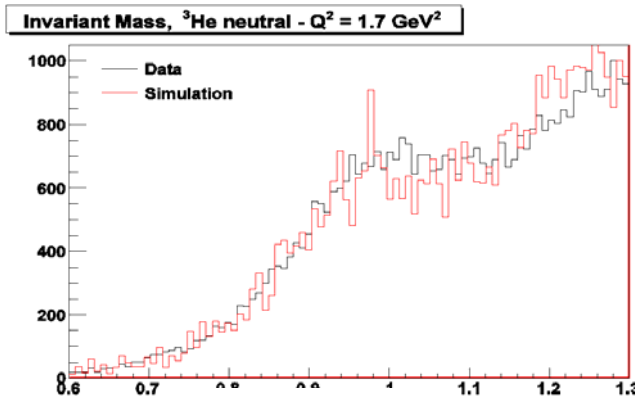
Kinematic Cuts

Monte Carlo based corrections

Quasi-elastic model

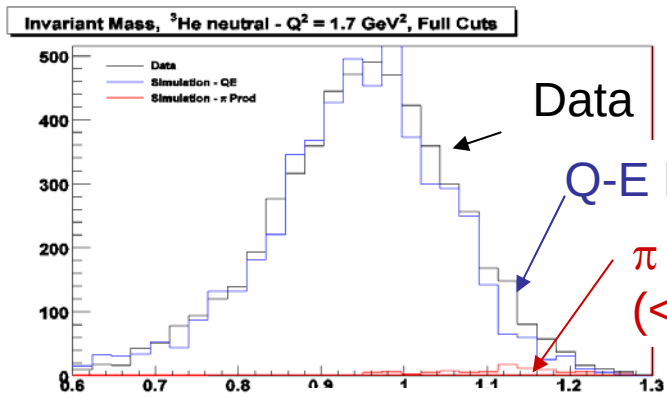
+ MAID parameterization for π production

counts



W (GeV)

"No" cuts



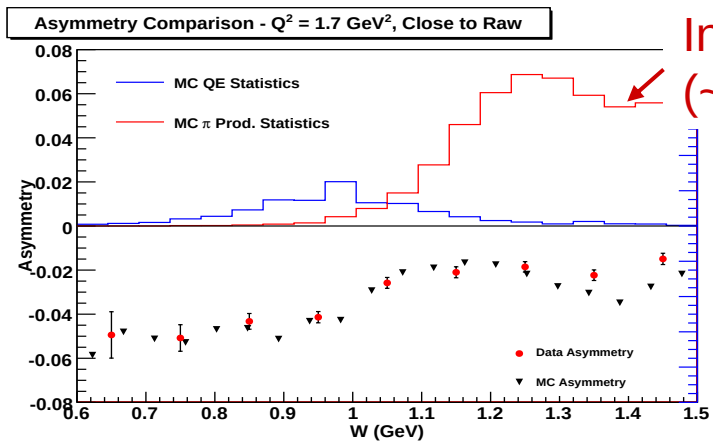
Data

Q-E Model

π production (<1%)

W (GeV)

After cuts



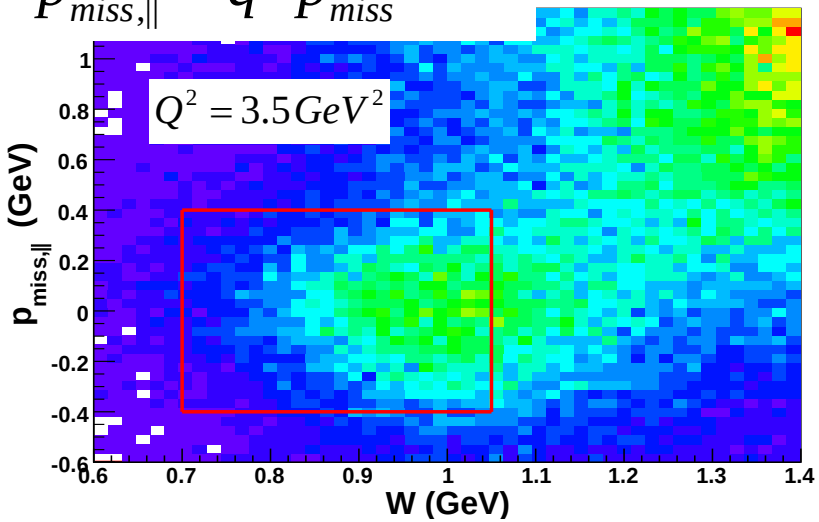
Inelastics before cuts (~1% after cuts)

Comparison of Data to Monte Carlo for Q^2=1.7 GeV^2

Tighter kinematic cuts used at Q^2=3.5 GeV^2

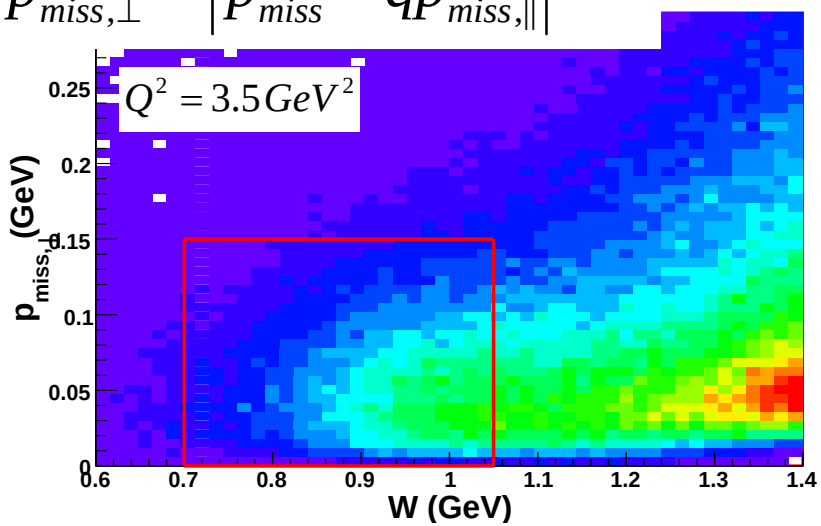
Parallel component :

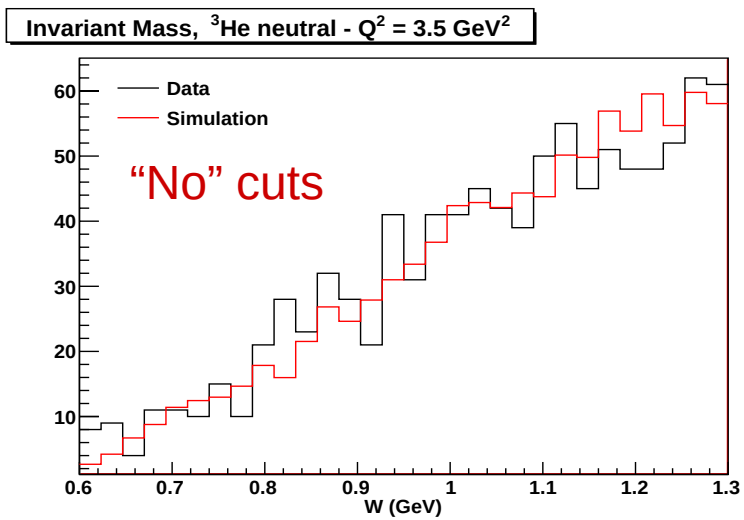
$$p_{miss,\parallel} = \hat{q} \cdot \vec{p}_{miss}$$

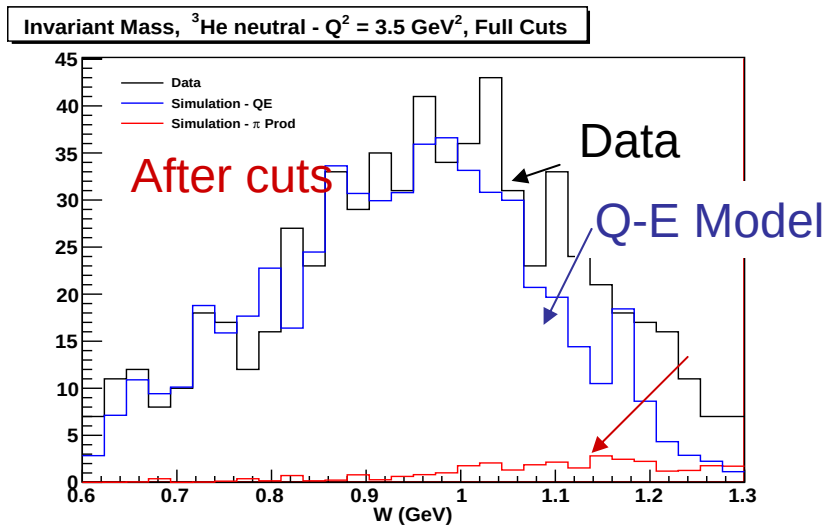


Perpendicular component :

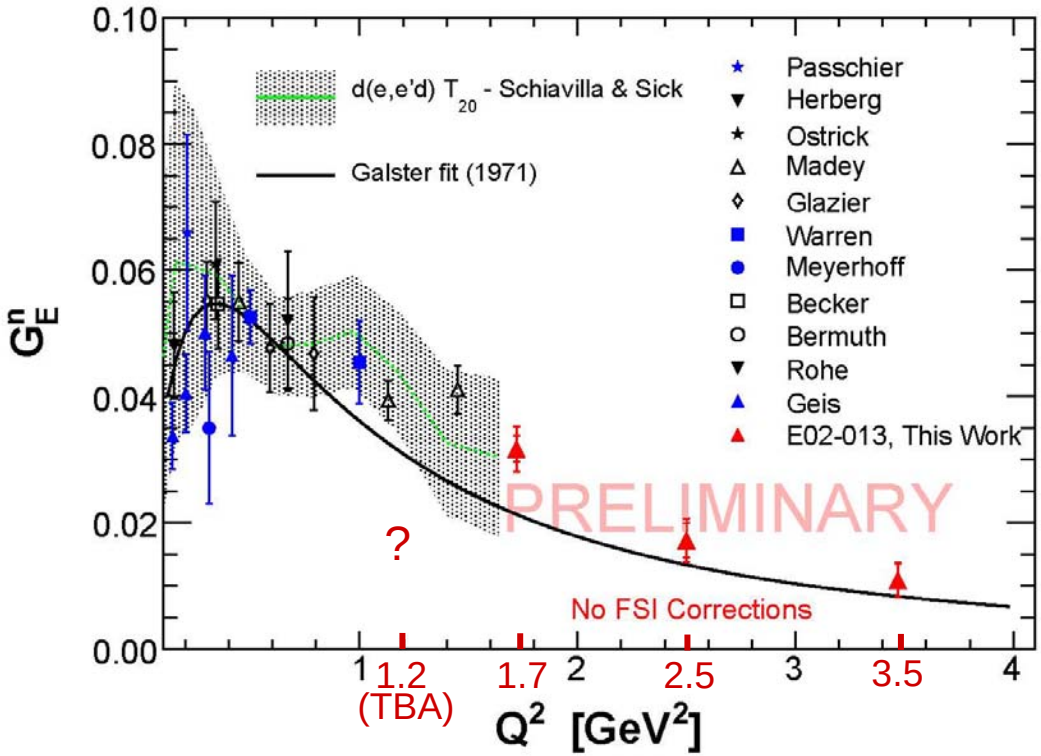
$$p_{miss,\perp} = \left| \vec{p}_{miss} - \hat{q}\vec{p}_{miss,\parallel} \right|$$



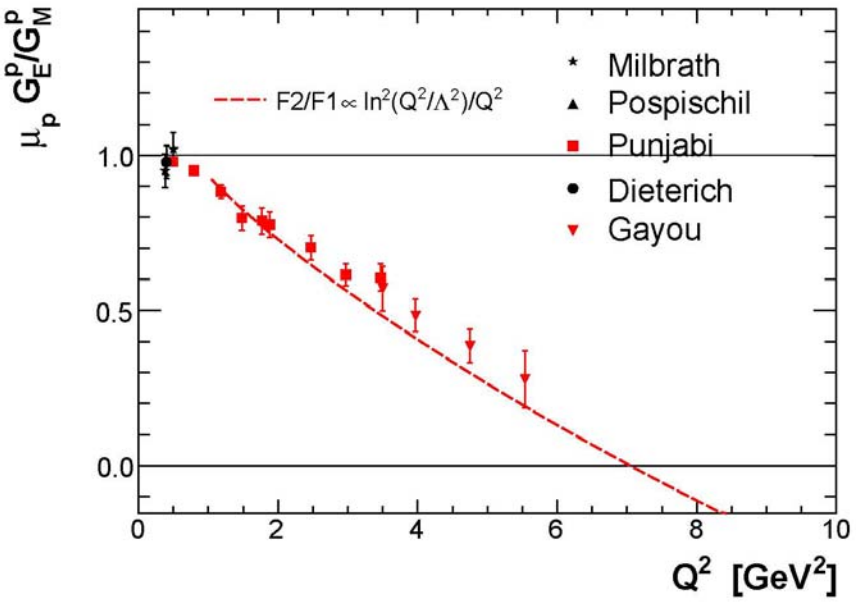




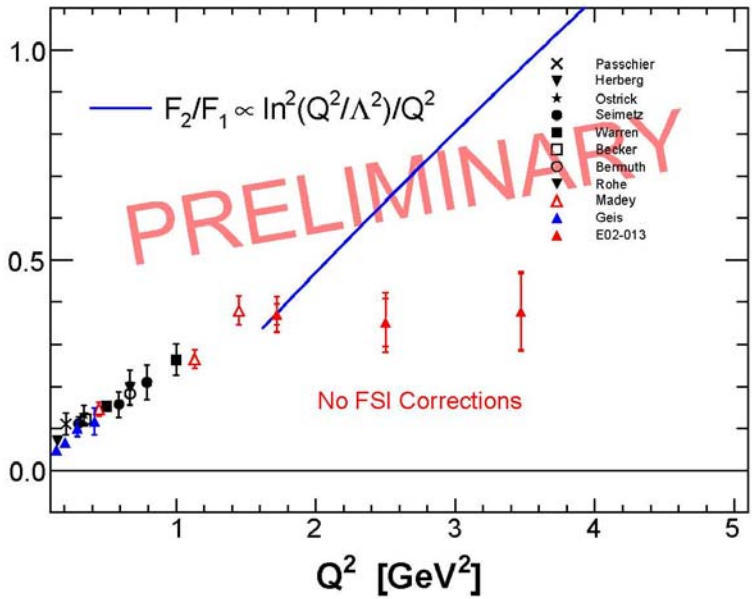
E02-013 Results



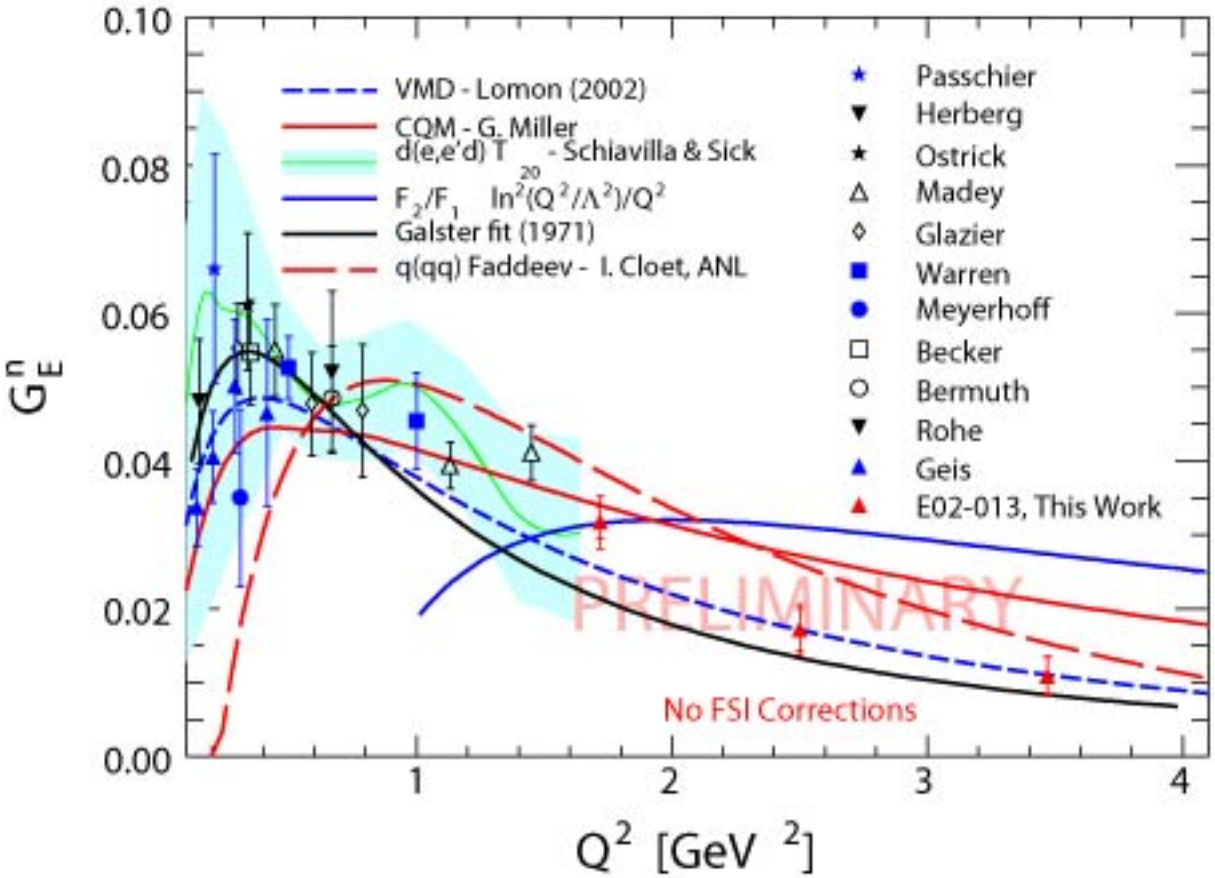
Neutron data does not exhibit high Q^2 scaling prediction



Existing Proton Data



New Gen Neutron Data


0.10
0.08
0.06
0.04
0.02
0.00
G_E^n
1
2
3
4
Q^2 [GeV ^{2}]
VMD - Lomon (2002)
CQM - G. Miller
d(e,e'd) T$_{20}$ - Schiavilla & Sick
F_2/F_1 $\ln^2(Q^2/\Lambda^2)/Q^2$
Galster fit (1971)
q(qq) Faddeev - I. Cloet, ANL
Passchier
Herberg
Ostrick
Madey
Glazier
Warren
Meyerhoff
Becker
Bermuth
Rohe
Geis
E02-013, This Work
PRELIMINARY
No FSI Corrections

The Wrap Up

- New analysis run planned to improve statistics
  - Improved calibration of neutron detector
  - Improved BigBite tracking and optics
  - Looser cuts
- Corrections for Final State Interactions
  - Initial estimates ~5% correction
  - Calculations by Laget in progress
- Final results to be approved at April Gen meeting
- Publication ready for submission in June
- (Lowest Q^2 analysis delayed till after 1st publication)