G_{Ep}/G_{Mp} with an 11 GeV Electron Beam in Hall C

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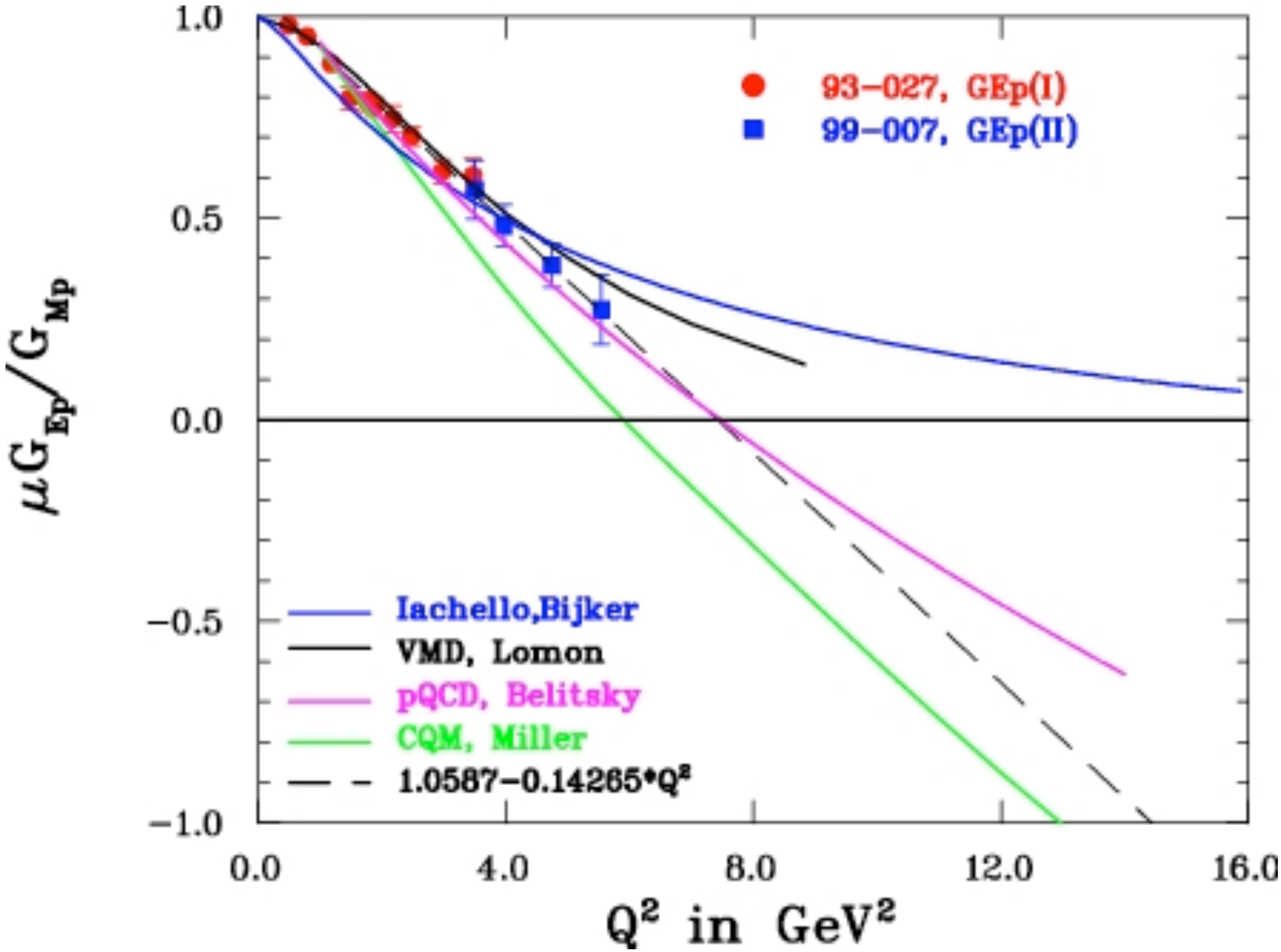
and the Gep-IV Collaboration

Based on LoI 12-06-103 to PAC30

Recoil Polarization Measurements

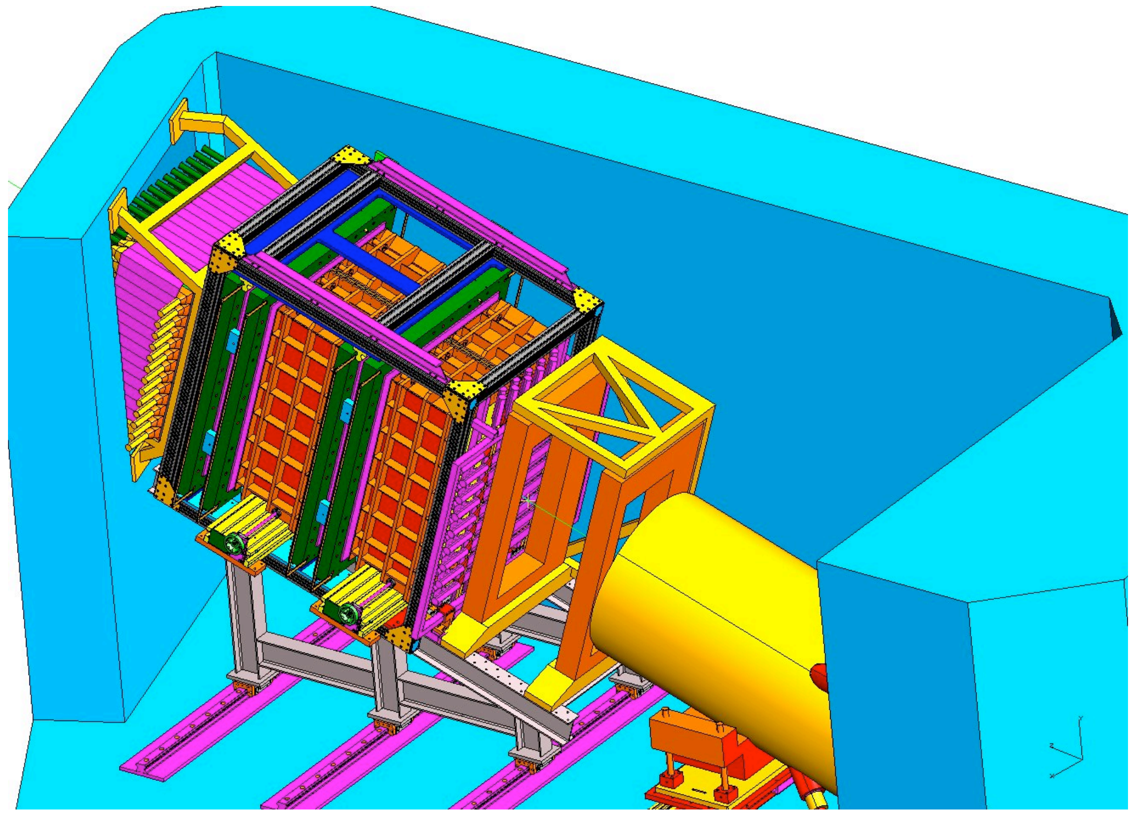


Gep-IV: Basic Plan

- Extend the measurement of G_{Ep}/G_{Mp} to the largest value of Q^2 possible using base equipment together with existing dectectors in Hall C

  - Hall C SHMS, equipped with the existing Hall C FPP, for proton detection

  - The existing BigCal detector for electron detector - perfect match to the SHMS



Gep-IV: Issues for Consideration

1. Spin Precession in the SHMS

2. Radiation Damage to BigCal

3. CH_2 Analyzing Power

Gep-IV: Spin Precession in the SHMS

- The proton spin components precess in the magnetic elements of the SHMS, so that:

$$\begin{pmatrix} \mathbf{P_n^{fp}} \\ \mathbf{P_t^{fp}} \\ P_l^{fp} \end{pmatrix} = \begin{pmatrix} S_{nn} & \mathbf{S_{nt}} & \mathbf{S_{nl}} \\ S_{tn} & \mathbf{S_{tt}} & \mathbf{S_{tl}} \\ S_{ln} & S_{lt} & S_{ll} \end{pmatrix} \begin{pmatrix} P_n^{tar} \\ \mathbf{P_t^{tar}} \\ \mathbf{P_l^{tar}} \end{pmatrix}$$

- Horizontal bender leads to mixing of long. and transverse components

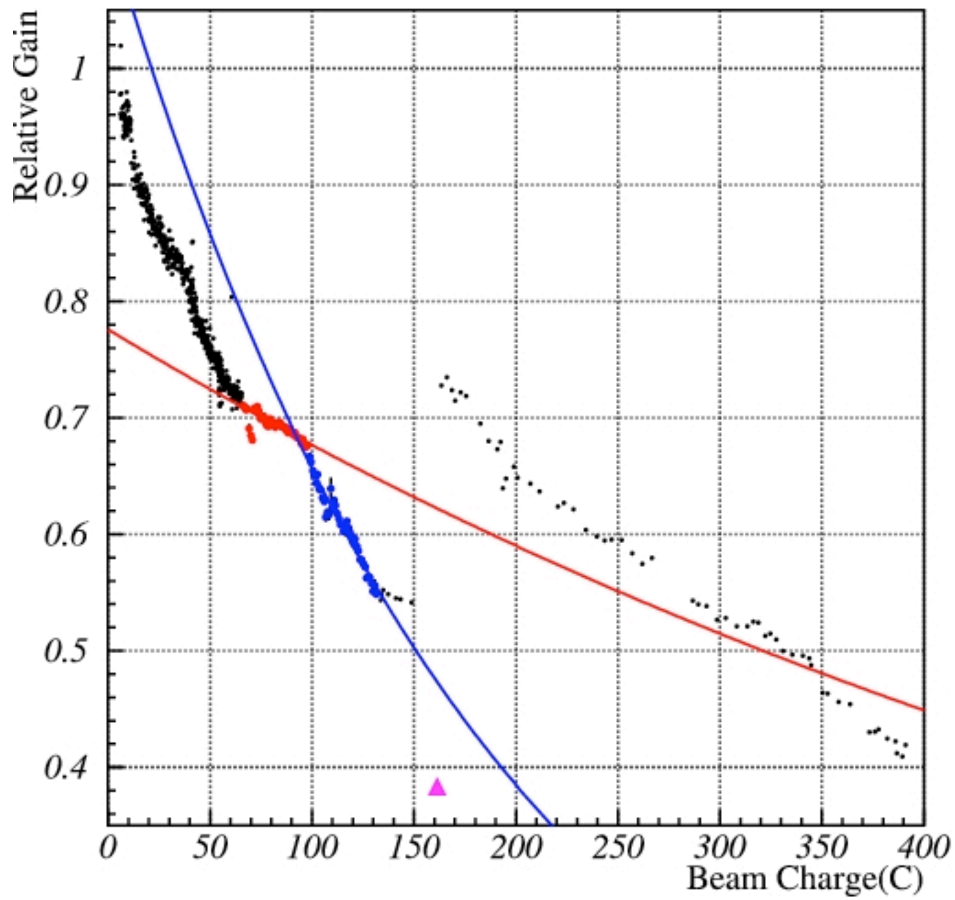
$$(\Delta P_t^{tar})^2 = \frac{2}{NA^2}(\cos^2\phi_{hb} + \frac{\sin^2\phi_{hb}}{\sin^2\phi_d})$$

$$(\Delta P_l^{tar})^2 = \frac{2}{NA^2}(\sin^2\phi_{hb} + \frac{\cos^2\phi_{hb}}{\sin^2\phi_d})$$

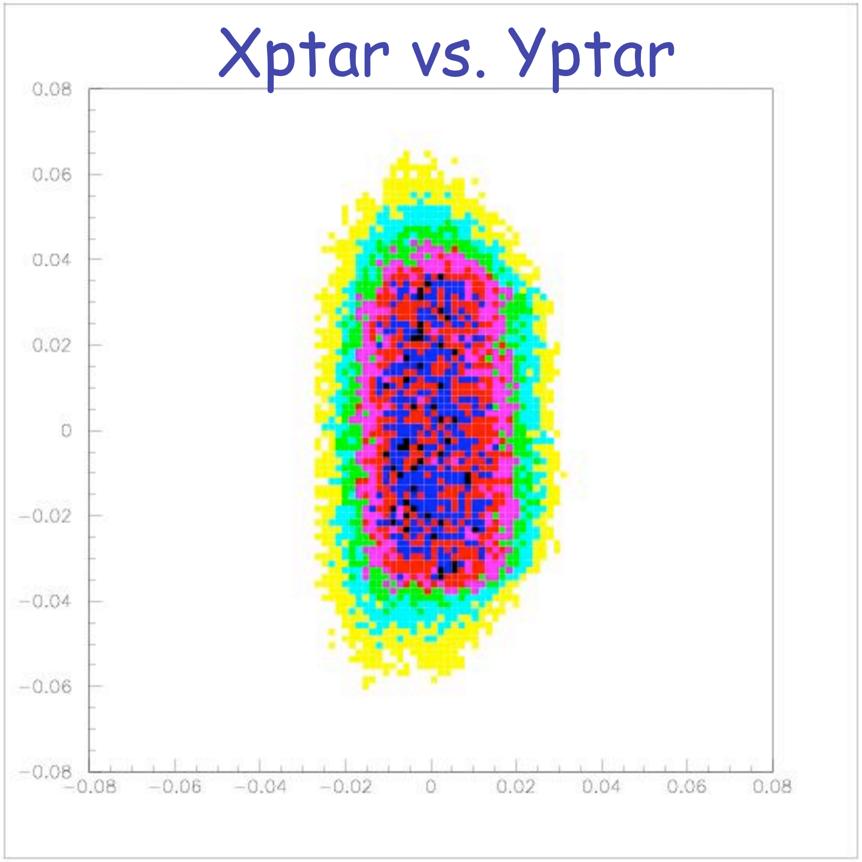
For $Q^2 = 13\ \mathrm{GeV}^2$, $\sin\phi_d \approx 1$, and thus $\cos^2\phi_{hb} + \frac{\sin^2\phi_{hb}}{\sin^2\phi_d} \approx 1$

Gep-IV:BigCal Radiation Damage

- Affects energy resolution
  - we are fairly insensitive to this.
- Main concern:
  - relatively high hardware threshold to keep the BigCal rates low
- Result of GEANT Simulation:
  - Curing about once per week in Gep-IV
- Use maintenance days -
  - need four hours of curing to recover one week of damage



SHMS Angular Acceptance



$$\Delta\theta_p = \pm 25 mr$$

$$\Delta\phi_p = \pm 50 mr$$

$$\Delta\Omega_p = 5 msr$$

Momentum resolution = 1%

Angular resolution = 0.5 mr

Electron Kinematics

Q^2 (GeV^2)	Jacobian	$\Delta\theta_e$ (mr)	$\Delta\phi_e$ (mr)
6.0	1.71	+/- 32.7	+/- 65.4
10.5	4.86	+/- 55.1	+/- 110
13.0	4.57	+/- 53.4	+/- 107

Electron Kinematics (Cont'd)

Target-Detector Distance = 4.5m
Target Length = 30 cm

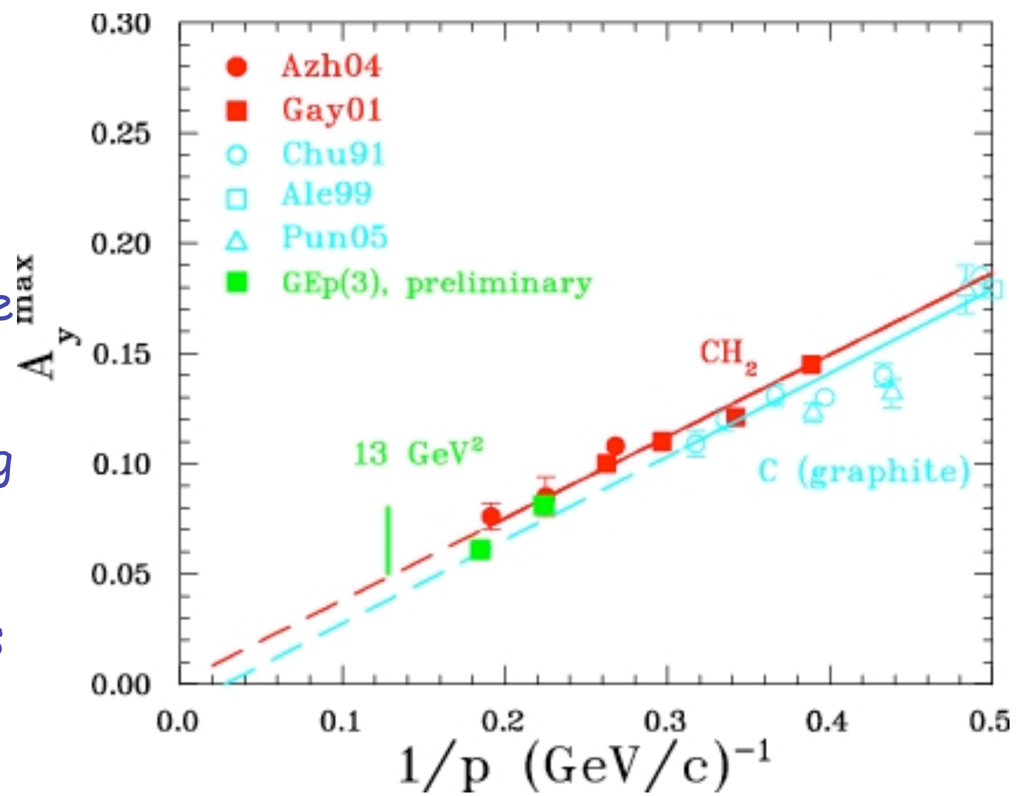
Q^2 (GeV^2)	$\Delta y_e (cm)$	$\Delta x_e (cm)$
6.0	44.9	58.9
10.5	68.0	99.6
13.0	64.5	96.6

Gep-IV: CH_2 Analyzing Power

- As a by-product of the polarization transfer experiments, we can extract the (average/maximum) CH_2 analyzing power in the FPP

- Empirically, the maximum analyzing power scales as 1/p, the shape of the distribution scales in a similar manner; this allows us to make accurate predictions of the analyzing power at various momenta

- In addition, full GEANT3 simulations have been performed to estimate the scattering efficiency (describes Gep-III data well)



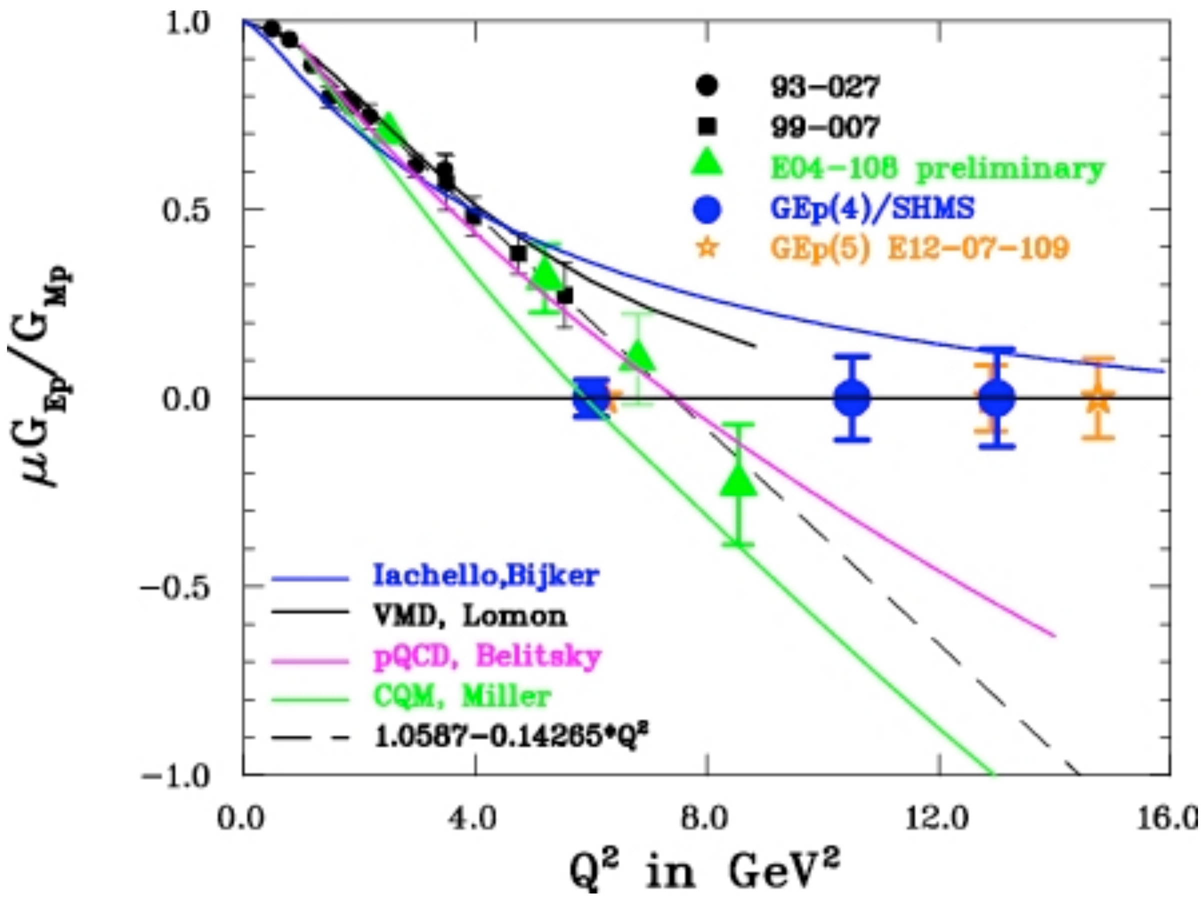
Gep-IV: Kinematics

Q^2	E_e	θ_e	$E_{e'}$	θ_p	p_p	$d\sigma/d\Omega_e$	ϵ	χ	$\Delta\Omega_e$
GeV^2	GeV	deg	GeV	deg	GeV/c	cm^2/sr		deg	msr
6	6.6	30	3.4	25	4.03	1.1×10^{-35}	0.72	145.4	8.6
10.5	8.8	35.5	3.20	16.7	6.47	3.5×10^{-37}	0.55	229.7	24
13	11.0	31.3	4.07	15.7	7.81	1.6×10^{-37}	0.58	276.5	23

Table 2: *The proposed kinematics. Assumed SHMS spectrometer solid angle: 5 msr. Assumed beam characteristics: 75 μA, 85% polarization. Assumed target: 30 cm LH_2.*

Q^2	E_e	COM	absolute $\Delta(G_{Ep}/G_{Mp})^*$	time
GeV^2	GeV			days
6.0	**6.6**	3.9×10^{-3}	**0.04**	**4**
10.5	**8.8**	1.5×10^{-3}	**0.11**	**30**
13.0	**11.0**	1.1×10^{-3}	**0.13**	**60**

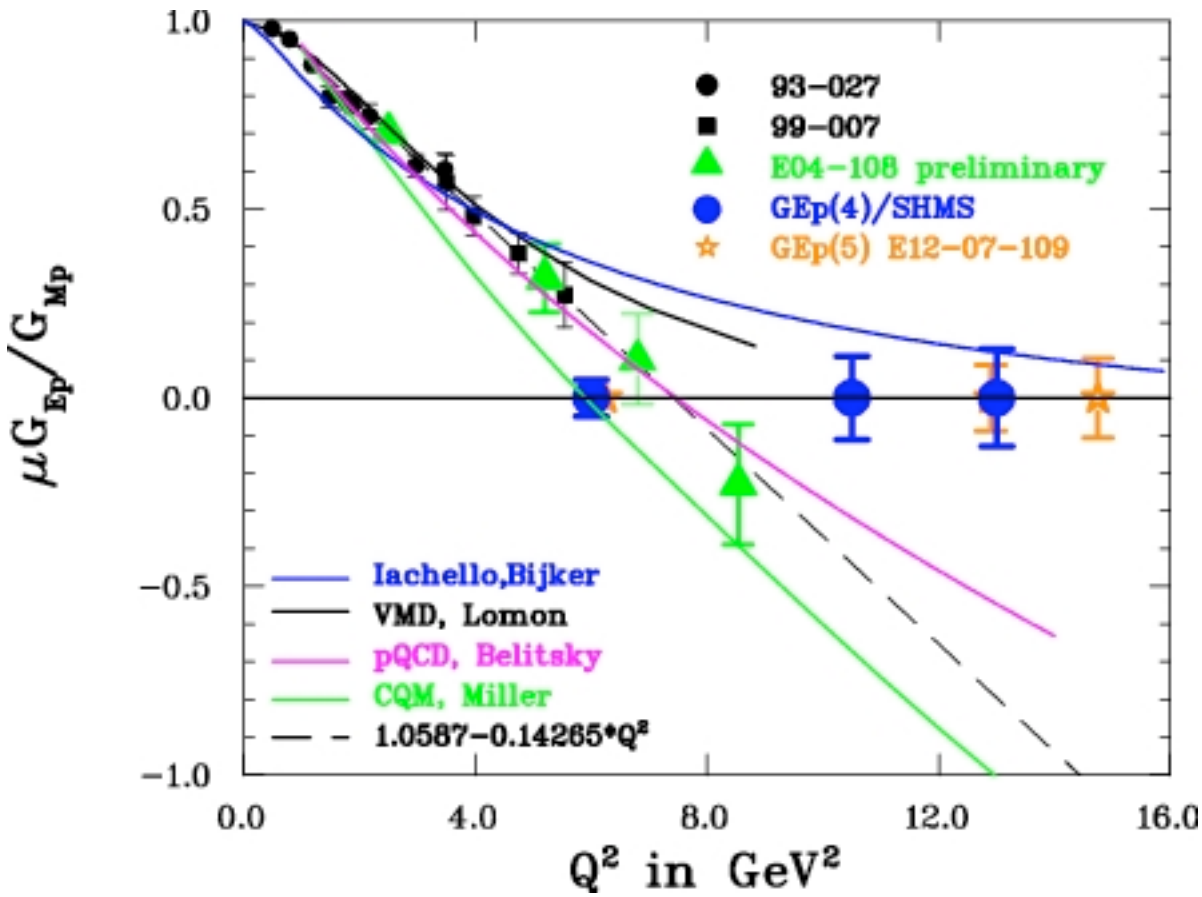
Gep-IV: Predictions



Conclusions

- Many competing/complementary theoretical models, with different approaches
- While most modern calculations describe the data well in the lower Q^2 regime, they begin to diverge significantly beyond the currently available data
- New data at higher Q^2 (for both proton and neutron) will place stringent constraints on available models, and will continue to motivate more advanced calculations
- Gep-IV will provide high quality data on the form factor ratio up to $Q^2 = 13$ GeV^2, using existing/base equipment. The experiment can be carried out as soon as the 11 GeV electron beam is available in Hall C - could even be used as a commissioning experiment for the SHMS
- No major technical issues face this experiment - hardware and software are "ready to go"

Gep-IV: Predictions



Gep-IV vs. Gep-V

- Clean identification of elastic events is of crucial importance
  - SHMS has better momentum resolution
  - SBS has better angular resolution and y_target resolution
- As a result, elastic identification will be accomplished in very different ways in the two experiments, resulting in different systematics
- SHMS will have much lower level of random/accidental background
- Gep-IV uses existing/base Hall C equipment - this has technical as well as financial/funding advantages
- Gep-IV can be run very early post-upgrade
- Software algorithms are refined and well-tested

Q^2	E_e	COM	Horiz. Bender	$\Delta(G_{Ep}/G_{Mp})^*$	time
GeV^2	GeV		Factor		days
6.0	**6.6**	$\mathbf{3.9 \times 10^{-3}}$	**1.15**	**0.04**	**4**
9.0	8.8	2.0×10^{-3}	1.70	0.11	30
10.5	**8.8**	$\mathbf{1.5 \times 10^{-3}}$	**1.30**	**0.11**	**30**
12.0	8.8	1.2×10^{-3}	1.01	0.12	60
12.0	11.0	1.2×10^{-3}	1.01	0.12	60
13.0	**11.0**	$\mathbf{1.1 \times 10^{-3}}$	**1.00**	**0.13**	**60**
14.0	8.8	0.9×10^{-3}	1.06	0.20	120
14.0	11.0	0.9×10^{-3}	1.06	0.16	120

Table 6: *Absolute uncertainties (not including systematics), and times required. The assumed beam intensity and electron beam polarization are 75 μA and 0.85, respectively. The target length is 30 cm, and the SHMS solid angle is 5.0 msr.*
* *Note that the increase in the error bar due to precession in the horizontal bender has been included.*