E08-007 Part II Physics & Status

Guy Ron
Lawrence Berkeley National Lab
For the E08007 Collaboration

GENERAL

- Part II of a two part experiment to measure the proton form factor ratio at high precision downto Q^2 ~ 0.015 GeV^2.
- Part I completed during 2008 using recoil polarization (HRS) and electron tagging (BigBite).
- So why not just run the same way all the way down?

BIG(GEST) PROBLEM WITH RECOIL POLARIZATION

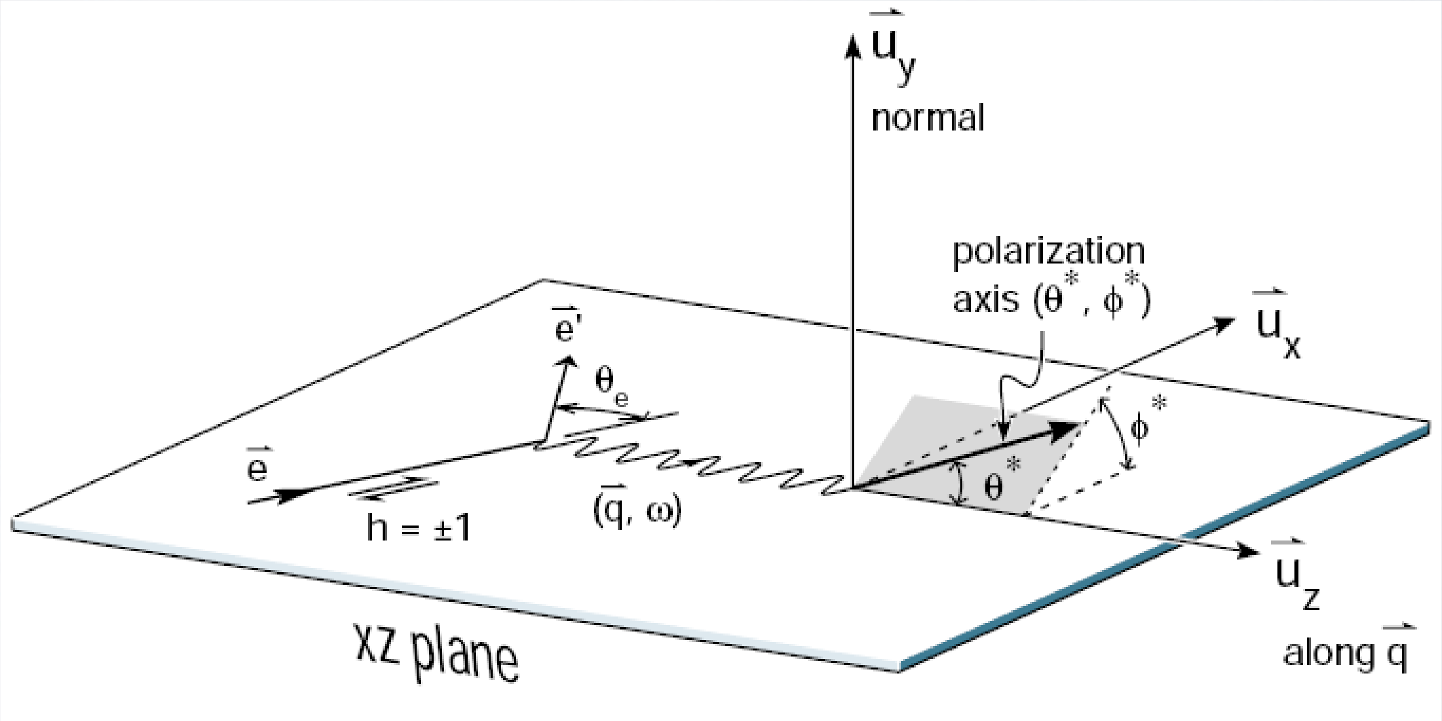
- Low Q^2 translates to low proton energy - will not survive secondary scattering in analyzer.

BUT ALSO

- Complement recoil polarization measurements using a different technique.

THE GENERAL IDEA

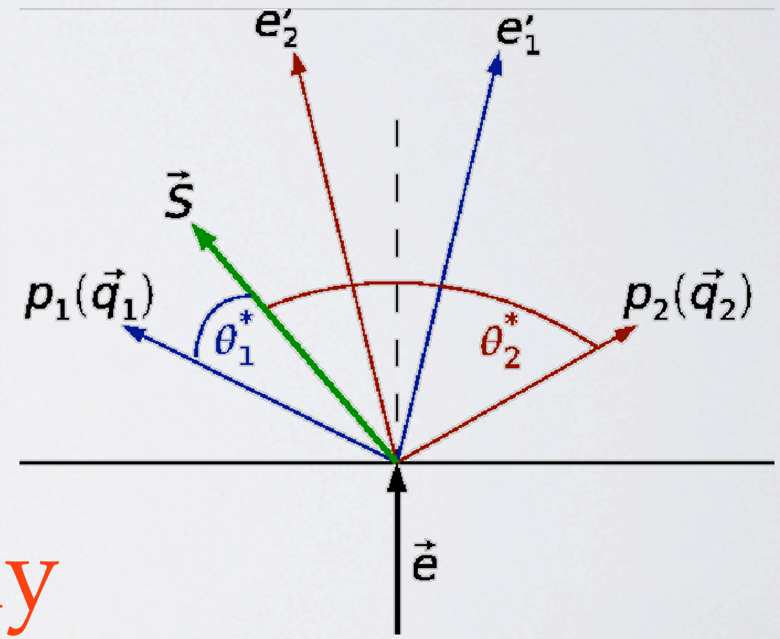
- Polarized electron - polarized target.



- Measure asymmetry in both HRSs at the same time (equal acceptance).

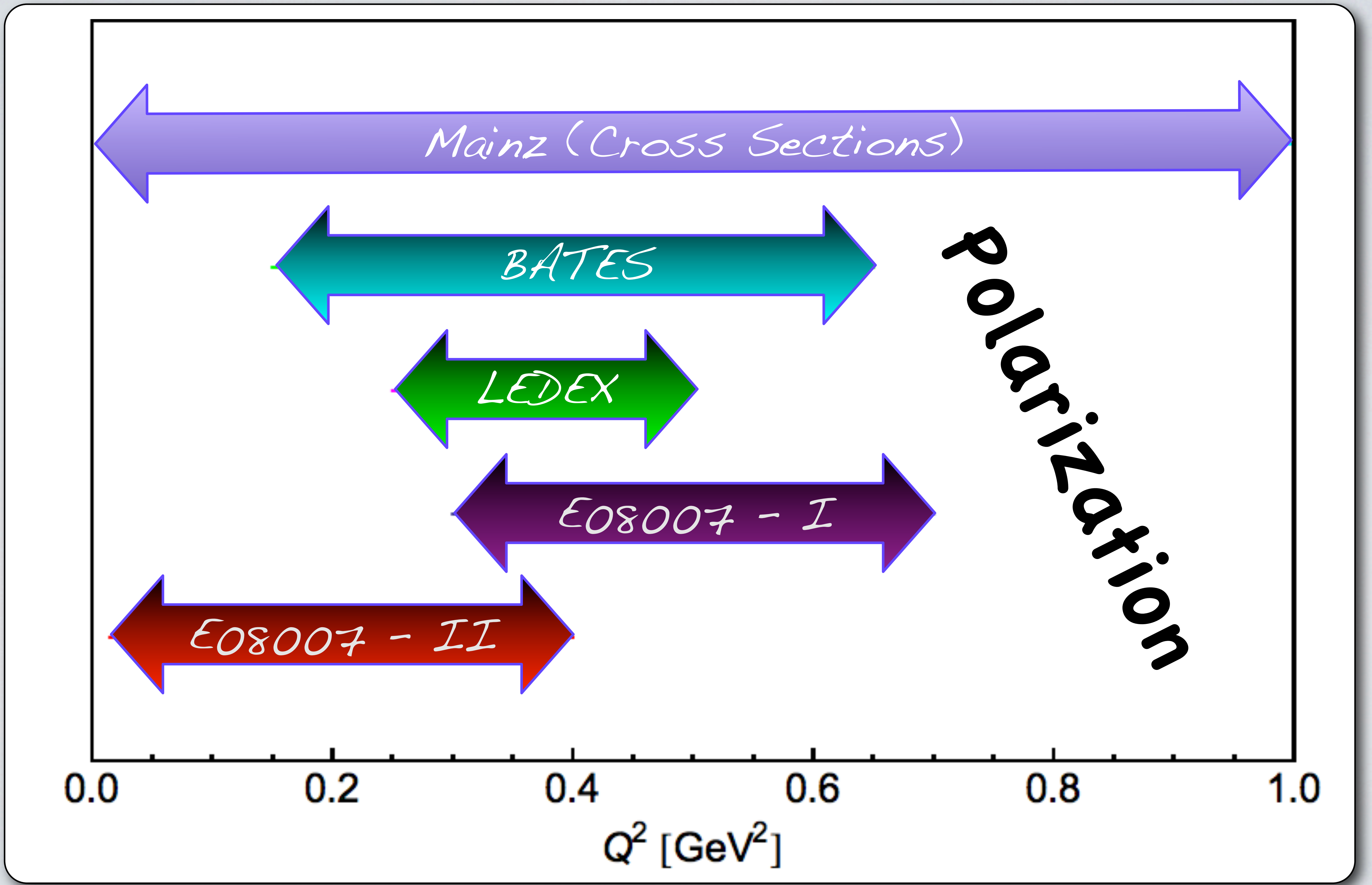
- Ratio of asymmetries gives:

$$\mu_p \frac{G_E}{G_M} = -\mu_p \frac{a(\tau,\theta)\cos\theta_1^* - \frac{f_2}{f_1}\frac{A_1}{A_2} a(\tau,\theta)\cos\theta_2^*}{\cos\phi_1^*\sin\theta_1^* - \frac{f_2}{f_1}\frac{A_1}{A_2}\cos\phi_2^*\sin\theta_2^*}$$



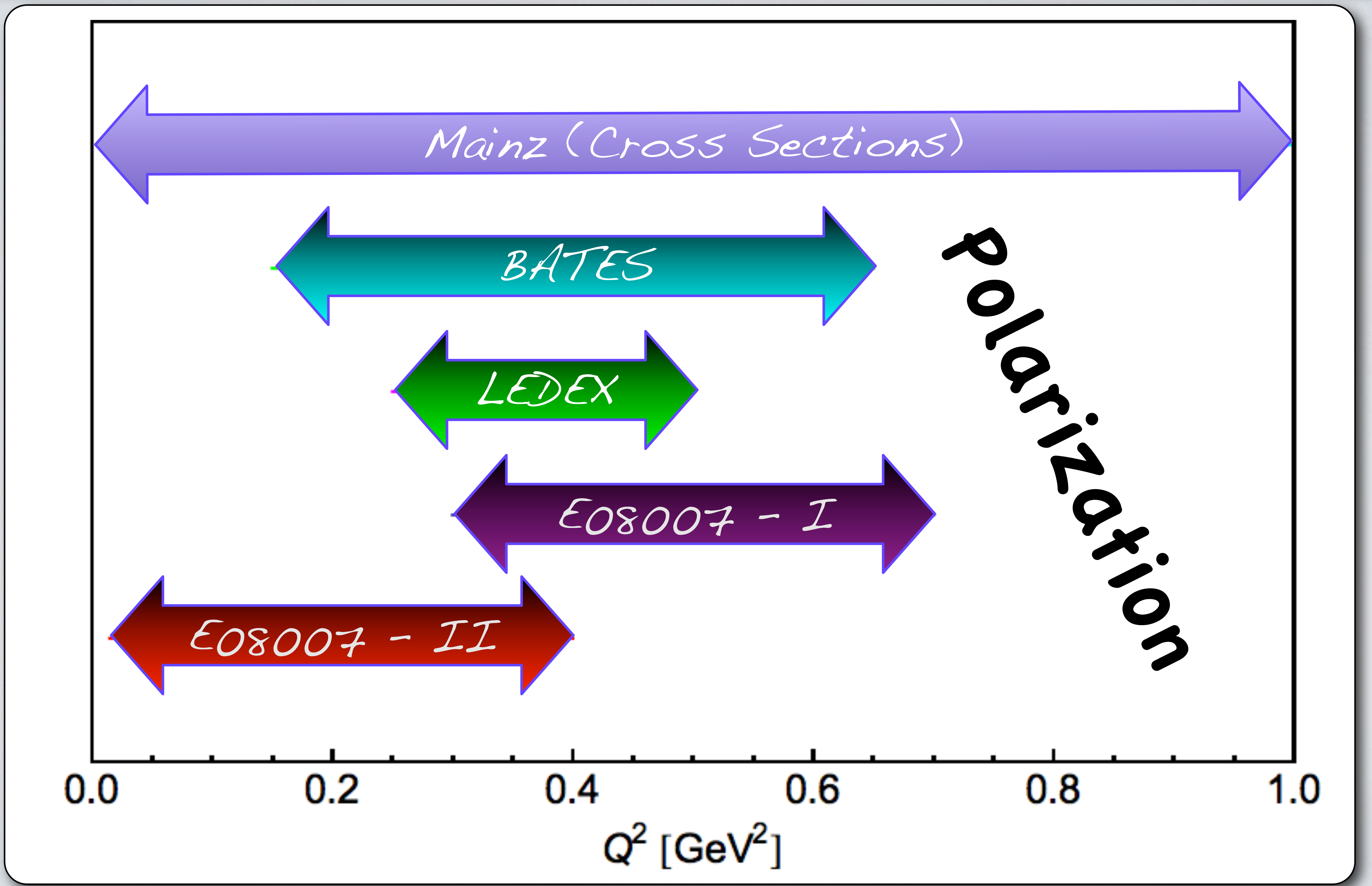
- Except asymmetries, everything is purely kinematical factors.

Comparison to other Experiments Coverage

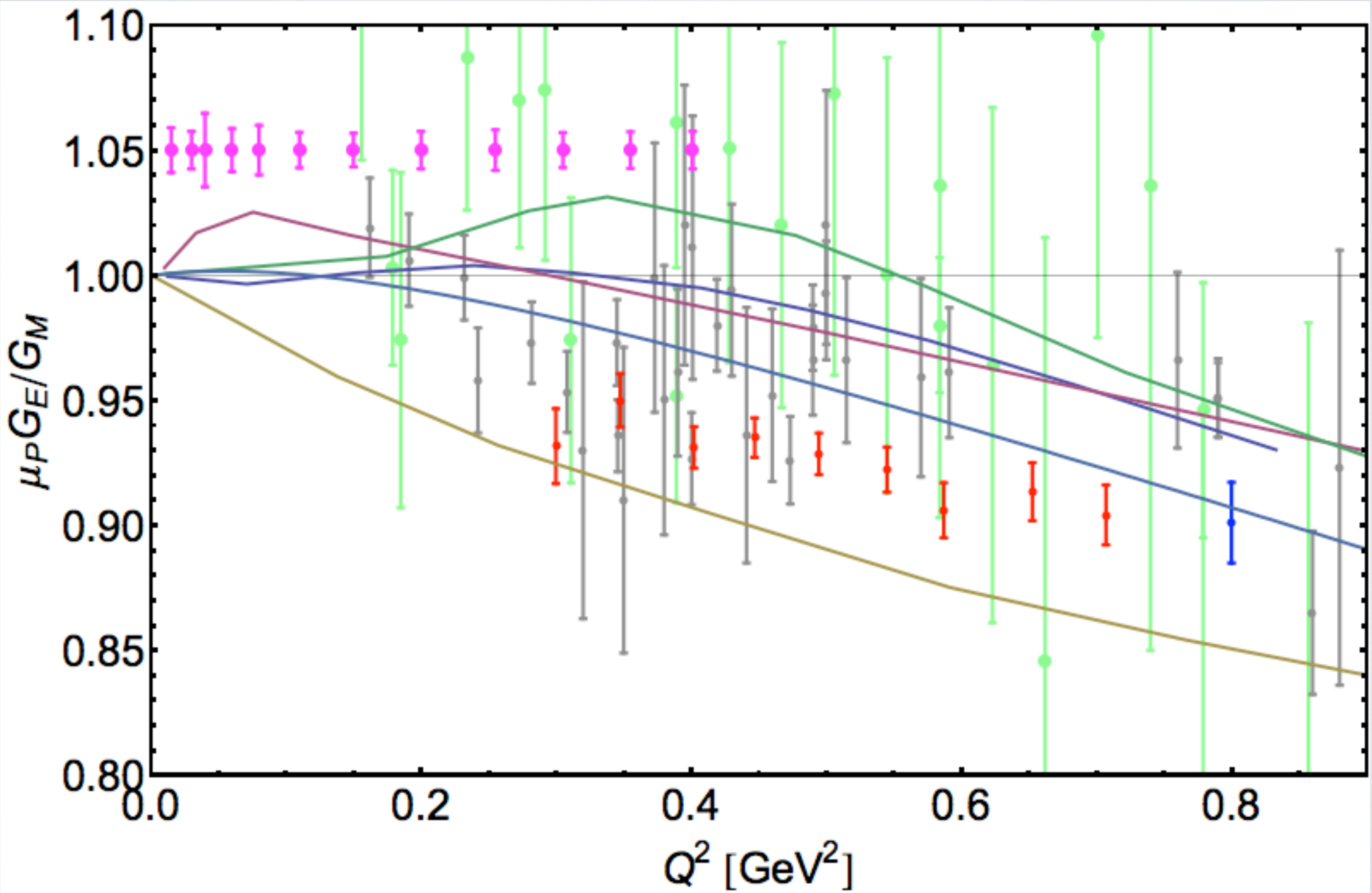


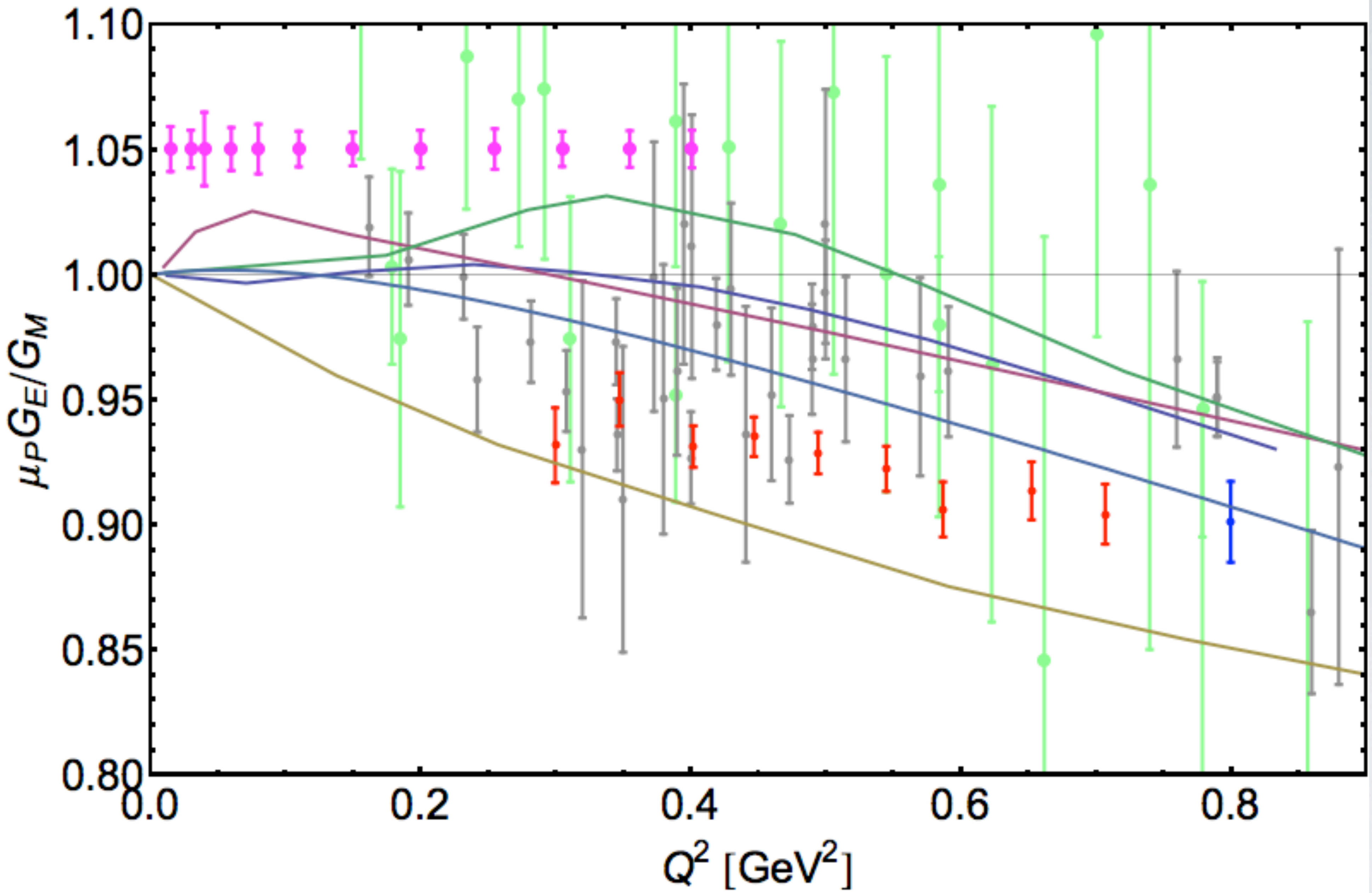
Complements MAINZ

Overlaps LEDEX, E08007-I - Different technique (systematics)

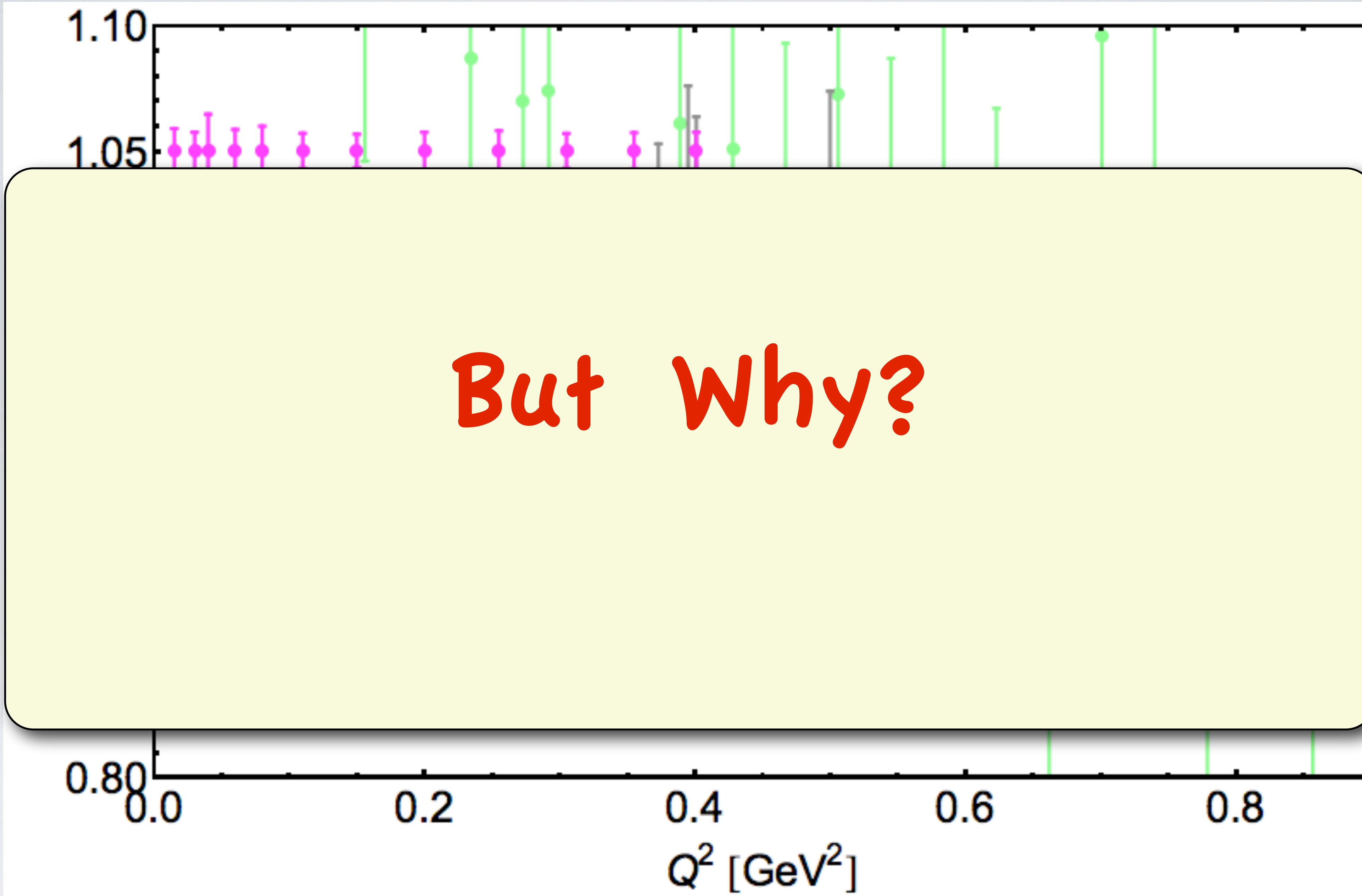


E08007 - Part II
Projected uncertainties





Q^2 (GeV^2)	0.015	0.03	0.04	0.06	0.08	0.1	0.15	0.2	0.25	0.25	0.3	0.35	0.4
$(\Delta R\ /\ R)_{tot}$ (%)	0.8	0.65	1.42	0.63	0.83	0.51	0.47	0.52	0.51	0.51	0.52	0.52	0.53



But Why?

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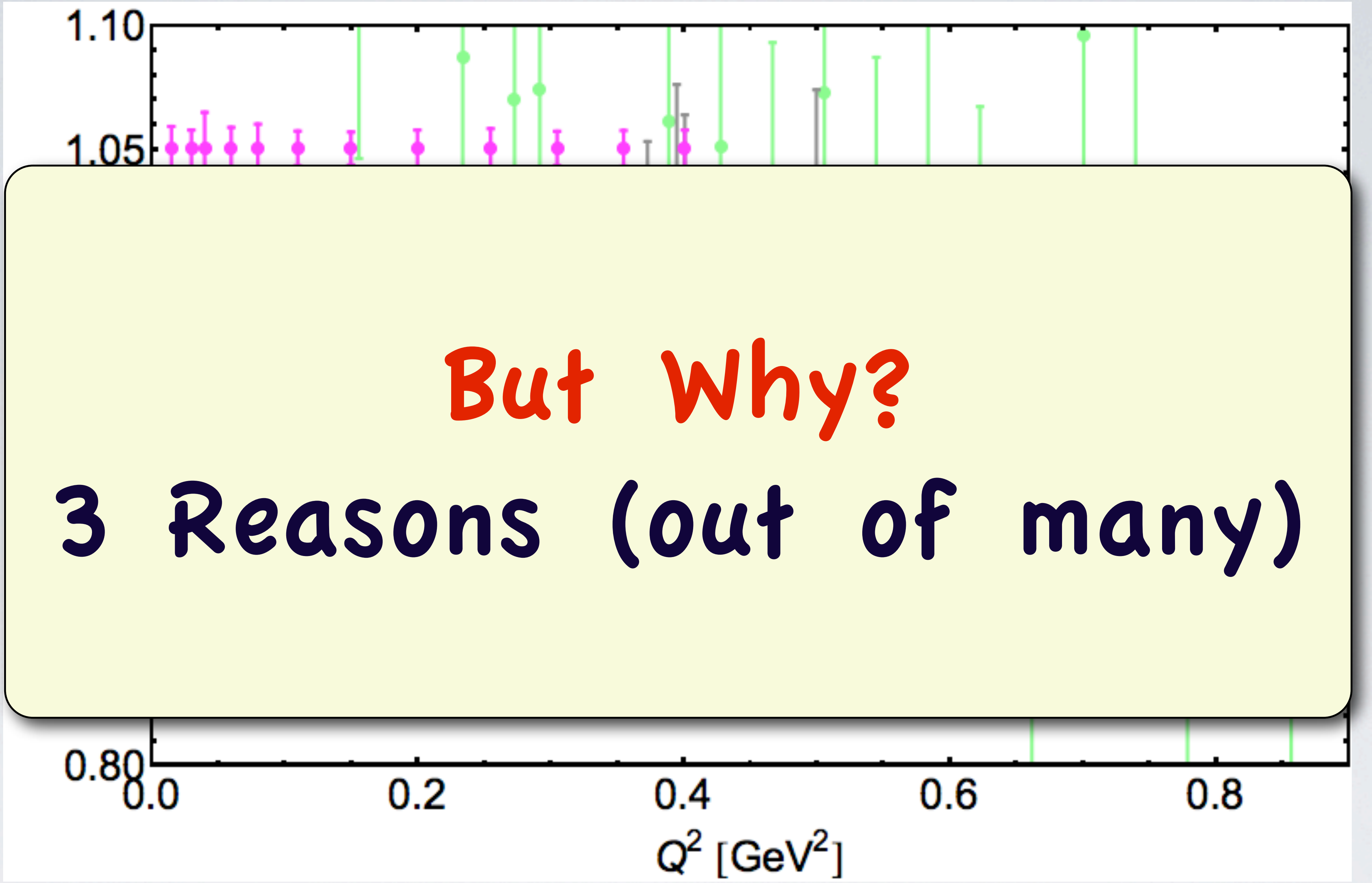

But Why?

3 Reasons (out of many)

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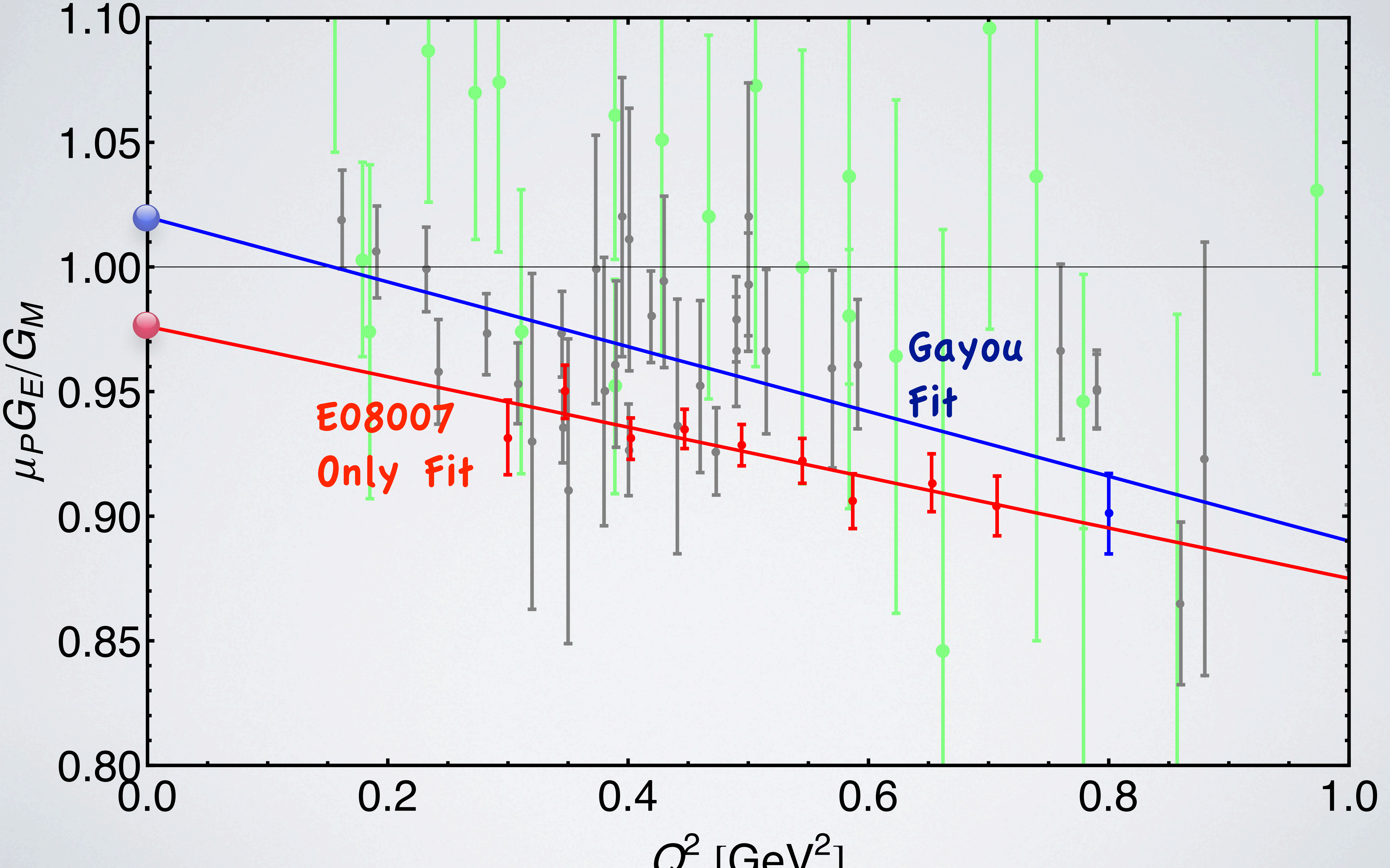
(Compelling) Reason 1 - Low Q^2 Data inconsistent



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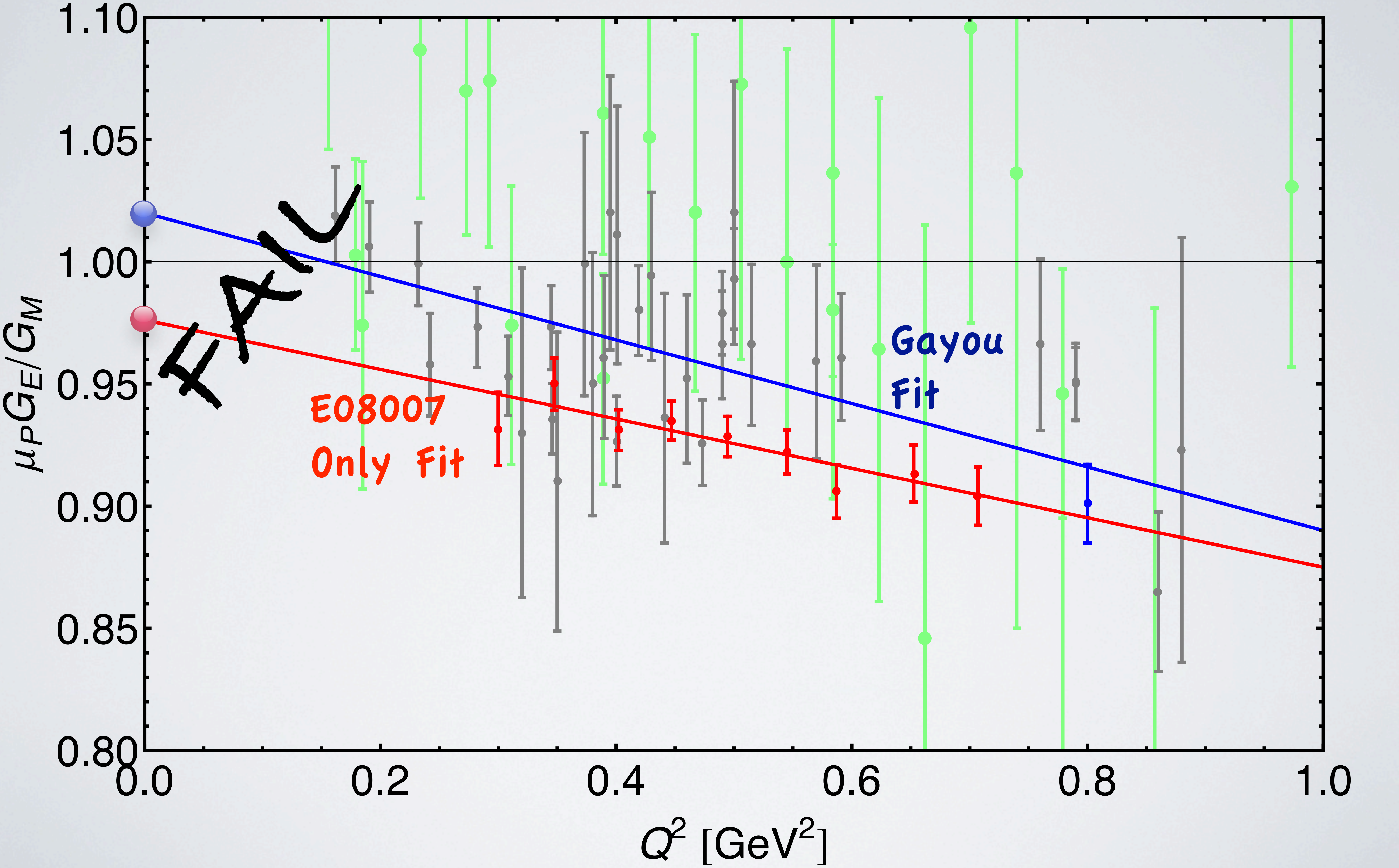


(Compelling) Reason II - Transverse Radii Difference

It can be shown that...

(Miller et al., PRL 101, 082202 (2008))

$$F_1(Q^2) \sim 1 - \frac{Q^2}{4} \langle b^2 \rangle_{Ch}$$

$$\mathcal{R} \sim 1 - \frac{Q^2}{6} \left(R_M^{*2} - R_E^{*2} \right)$$

$$F_2(Q^2) \sim \kappa \left(1 - \frac{Q^2}{4} \langle b^2 \rangle_{Ch} \right)$$

$$\langle b^2 \rangle_M - \langle b^2 \rangle_{Ch} \sim \frac{\mu}{\kappa} \frac{2}{3} \left(R_M^{*2} - R_E^{*2} \right) + \frac{\mu}{M^2}$$

World Data (including E08007-I) gives:

$$\langle b^2 \rangle_M - \langle b^2 \rangle_{Ch} = 0.0909 \pm 0.0035\,\mathrm{fm}^2$$

but limited Q^2 - how valid is this fit?

Lower Q^2 = Better Fit

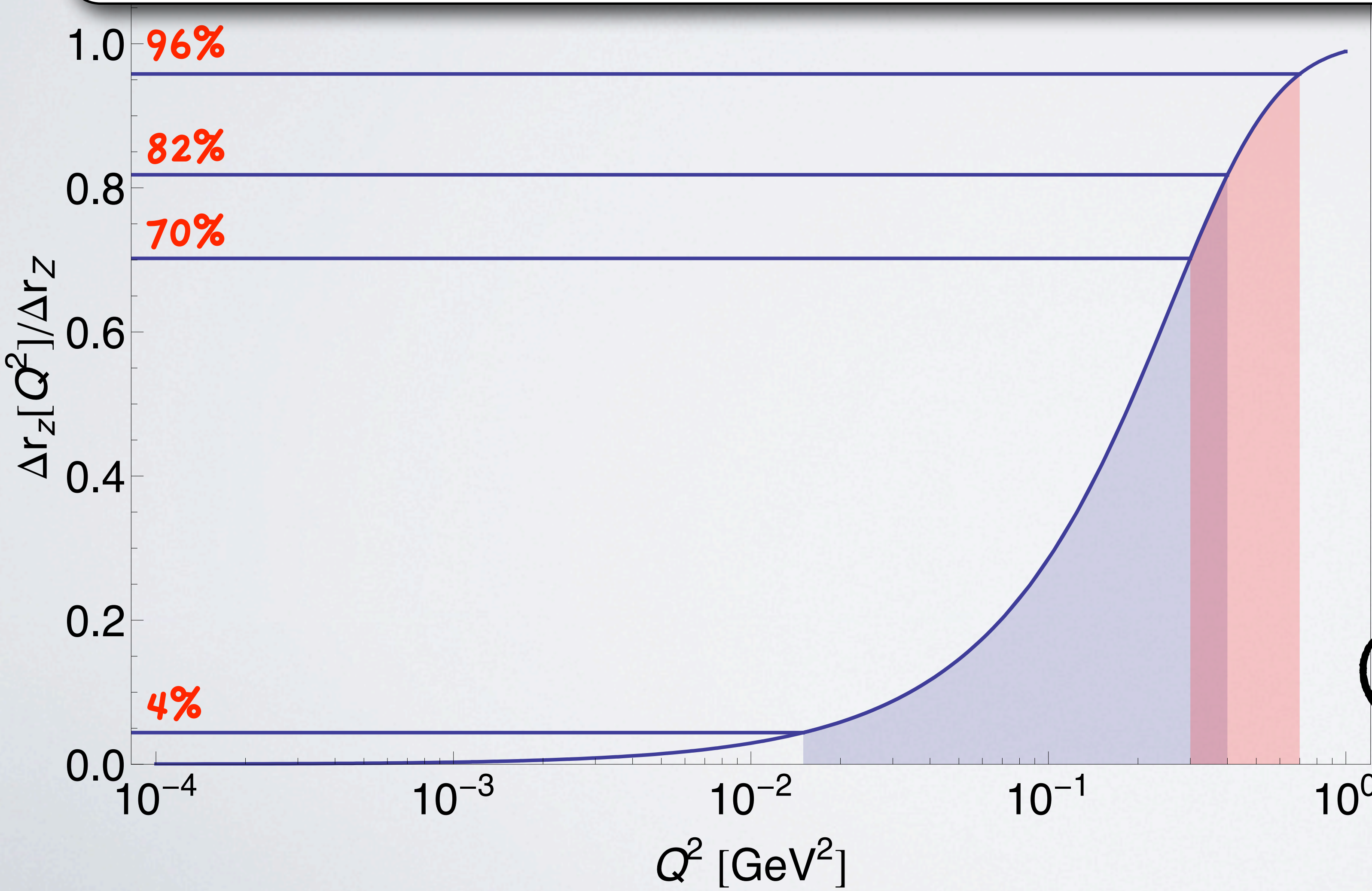
(Compelling) Reason III - Zemach Radius

$$E_{hfs} = (1 + \Delta_{QED} + \Delta^p_{hvp} + \Delta^p_{\mu vp} + \Delta^p_{weak} + \Delta_S)E^p_F$$

$$\Delta_S = \underline{\Delta_Z} + \Delta^p_R + \Delta_{pol}, \quad \Delta_Z = -2\alpha Z \frac{m_e m_p}{m_e + m_p} r_Z$$

$$r_Z = -\frac{4}{\pi}\int_0^\infty \frac{dQ}{\underline{Q^2}}[G_E(Q^2)G_M(Q^2)/(1+\kappa_p) - 1]$$

Quantity	value (ppm)	uncertainty (ppm)
$(E_{\mathrm{hfs}}(e^- p)/E^p_F) - 1$	1 103.48	0.01
Δ_{QED}	1 136.19	0.00
$\Delta^p_{\mu\mathrm{vp}} + \Delta^p_{\mathrm{hvp}} + \Delta^p_{\mathrm{weak}}$	0.14	
Δ_Z (using [31])	−41.43	0.44
Δ^p_R (using [31])	5.85	0.07
Δ_{pol} (this work, using [31])	1.88	0.64
Total	1102.63	0.78
Deficit	0.85	0.78



Plot shows fractional uncertainty in r_Z vs. Q^2

(Kelly Parametrization)

E08007 - Part II
Status and Requirements

- Polarized target.
- Septum Magnets.
- Beam Line Modifications.
- Insensitive to exact beam and polarization.
- Short target (reduce dilution factor mismatch).
- Target being repaired (UNH/UVa).
- Collaboration meeting tomorrow.
- Tentatively scheduled for 2012 (with E08027).