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Two-photon exchange in unpolarized eP

E05-017 update

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UChicago Argonne LLC

Office of Science U.S. DEPARTMENT OF ENERGY

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Motivations

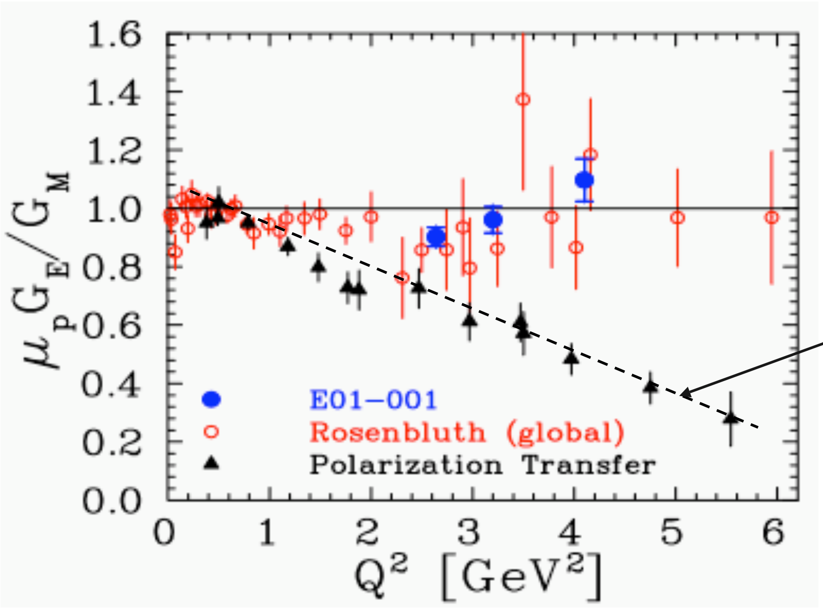
<u>In the Born approximation</u>, G_E/G_M can be extracted from:

Rosenbluth method

$$\frac{d\sigma}{d\Omega_e} = \frac{\sigma_{Mott}}{\varepsilon(1+\tau)}\left[\tau G_M^2(Q^2) + \varepsilon G_E^2(Q^2)\right]$$

Polarization transfer method

$$\frac{P_t}{P_l} = -\sqrt{\frac{2\varepsilon}{\tau(1+\varepsilon)}}\frac{G_E}{G_M}$$

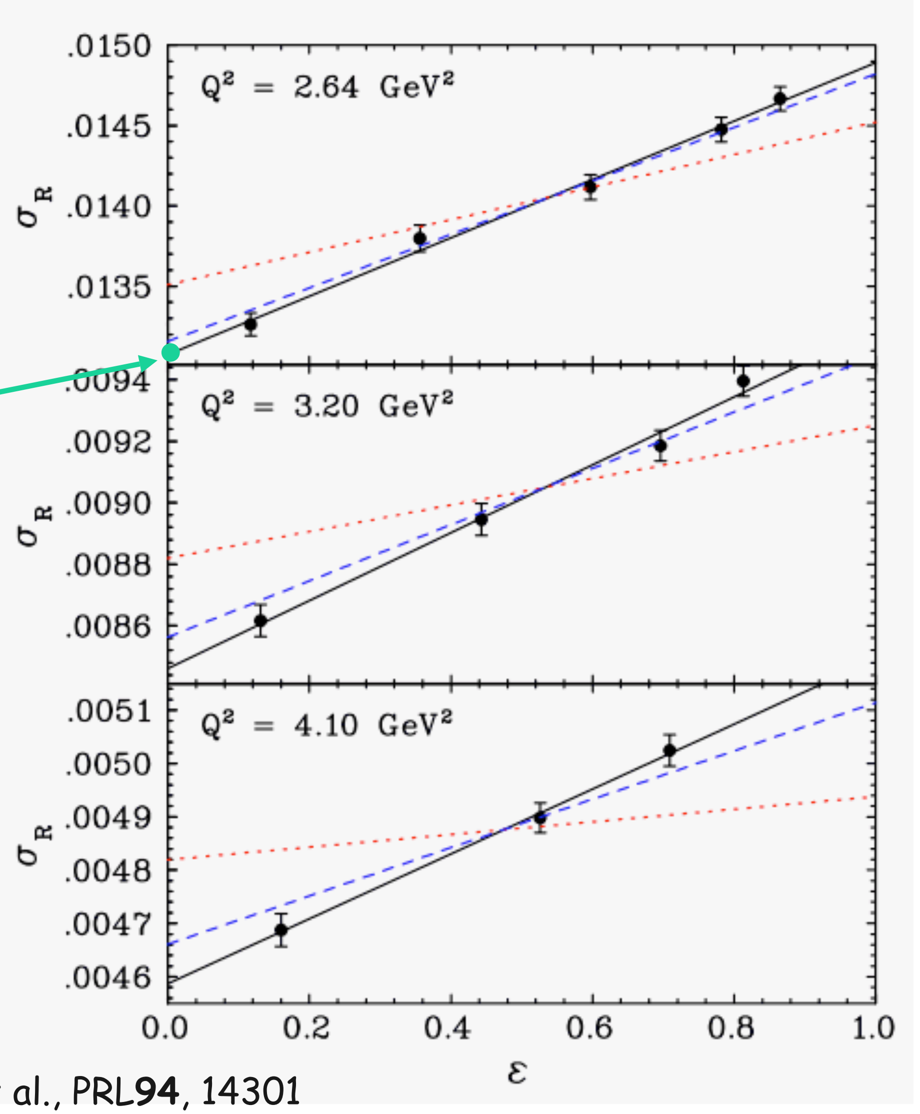


$$\frac{\mu_p G_E}{G_M} \approx 1 - 0.13(Q^2 - 0.04)$$

Rosenbluth separation

Extraction G_E and G_M for the proton:

$$\sigma_R = \frac{d\sigma}{d\Omega}\frac{\varepsilon(1+\tau)}{\sigma_{Mott}} = \tau G_M^2(Q^2) + \varepsilon G_E^2(Q^2)$$



Qattan et al., PRL**94**, 14301

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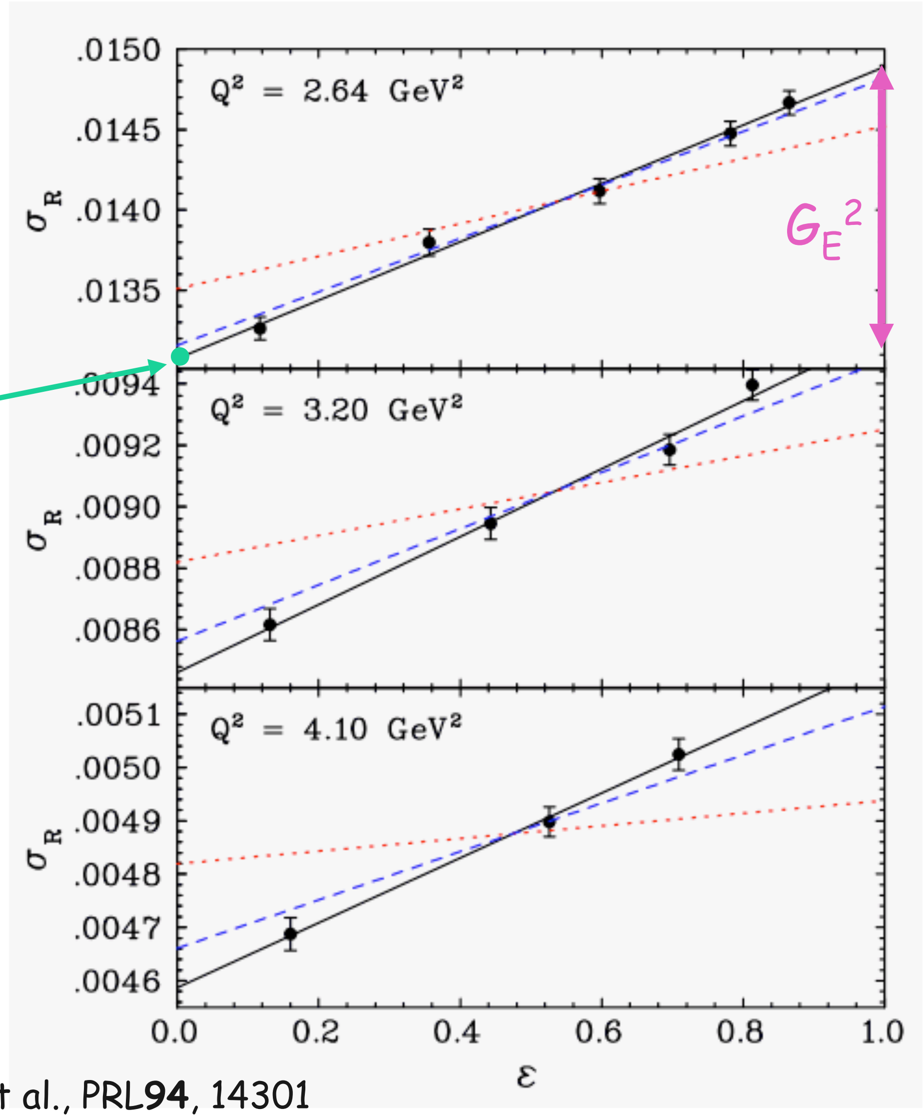

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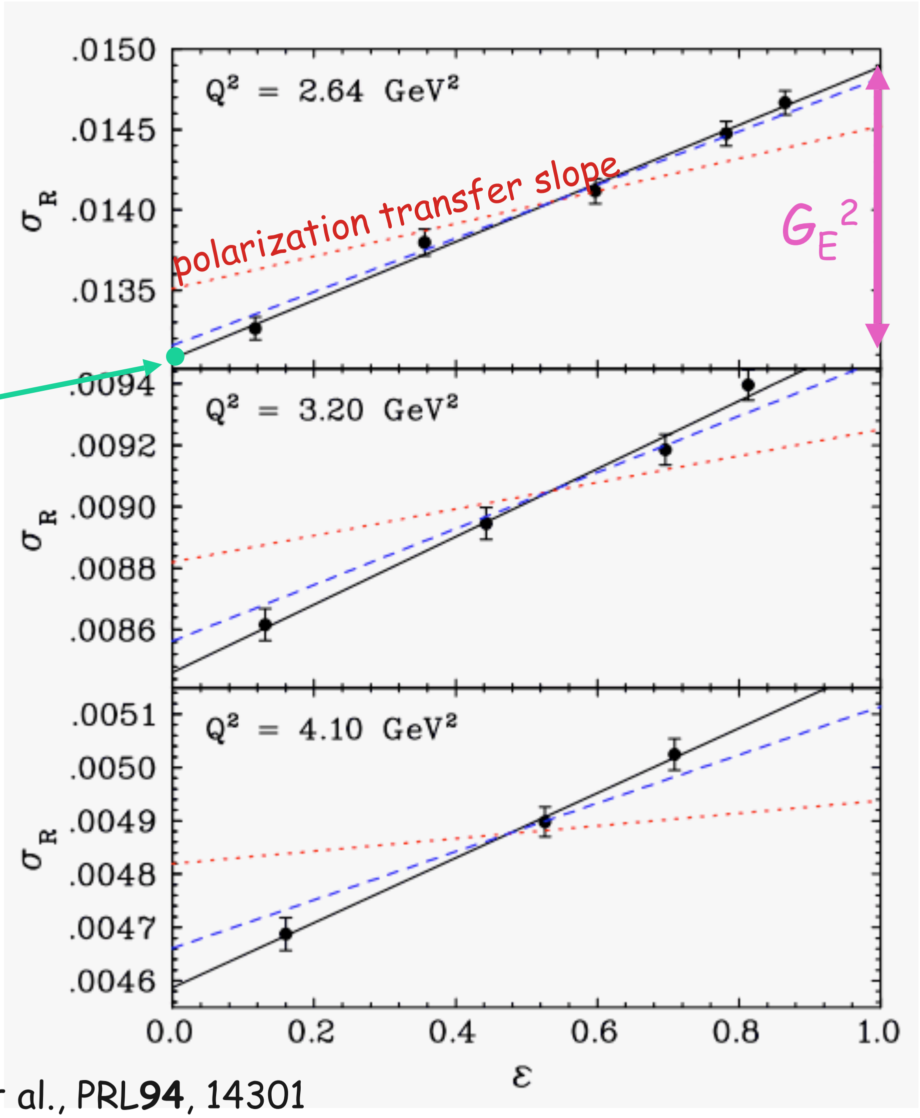

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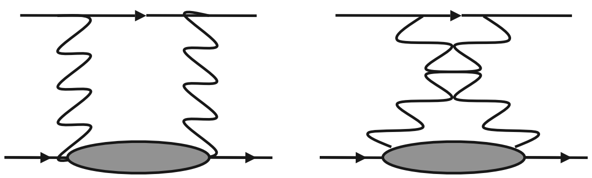
Discrepancy interpretations

Two-photon exchange (TPE)



- Neglected in standard radiative corrections (Mo & Tsai)
- Rosenbluth method is sensitive to TPE
- TPE has a negligible effect on Polarization transfer method in the Q^2-range covered by the existing data

Soft multi-photon exchange

- The discrepancy cannot be resolved by Coulomb distortion alone at high Q^2

Two-photon exchange extraction

J. Arrington, PRC71,015202 (2005)

$$\sigma_R = \boxed{G_M^2 + \frac{\varepsilon}{\tau} G_E^2} + 2G_M \mathcal{R}\left(\Delta\tilde{G}_M + \varepsilon \frac{\nu}{M^2}\tilde{F}_3\right) + 2\frac{\varepsilon}{\tau} G_E \mathcal{R}\left(\Delta\tilde{G}_E + \frac{\nu}{M^2}\tilde{F}_3\right) + O(e^4)$$

$\sigma_R^{1\gamma}$

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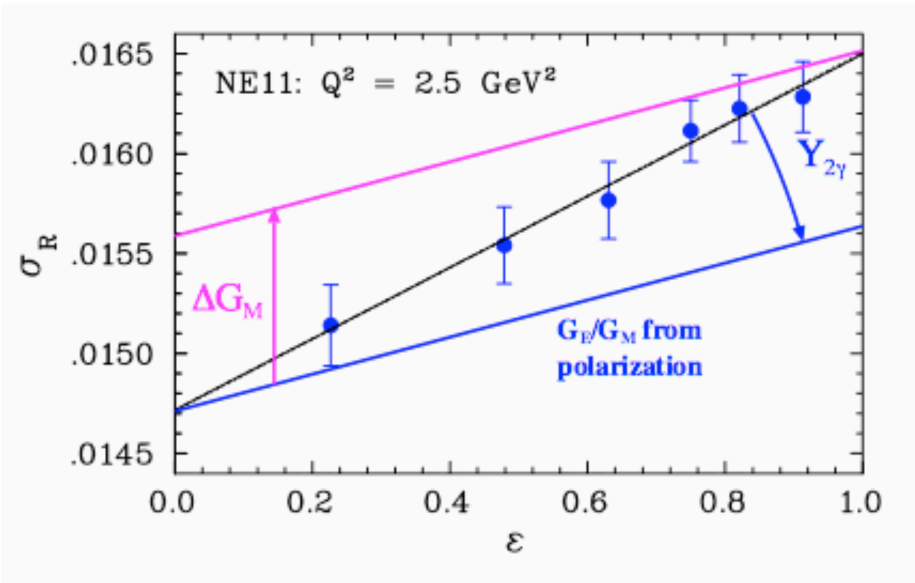

$$Y_{2\gamma}(\varepsilon, Q^2) = \mathcal{R}\left(\frac{\nu\tilde{F}_3(\varepsilon, Q^2)}{M^2|\tilde{G}_M|}\right)$$

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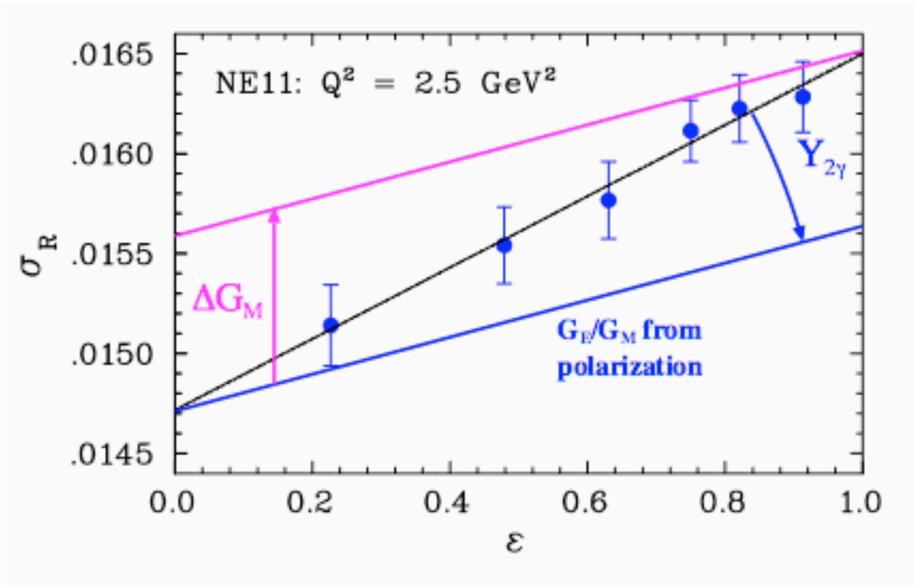

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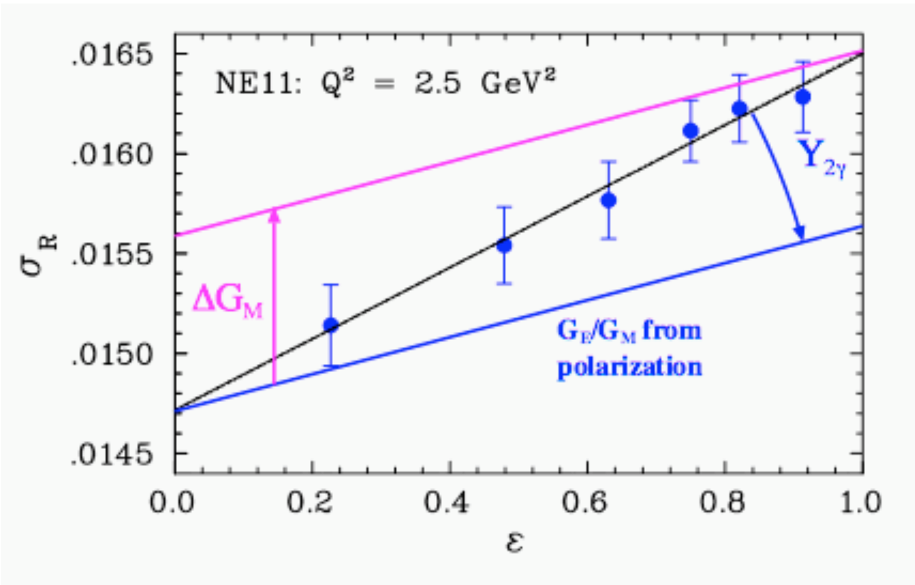

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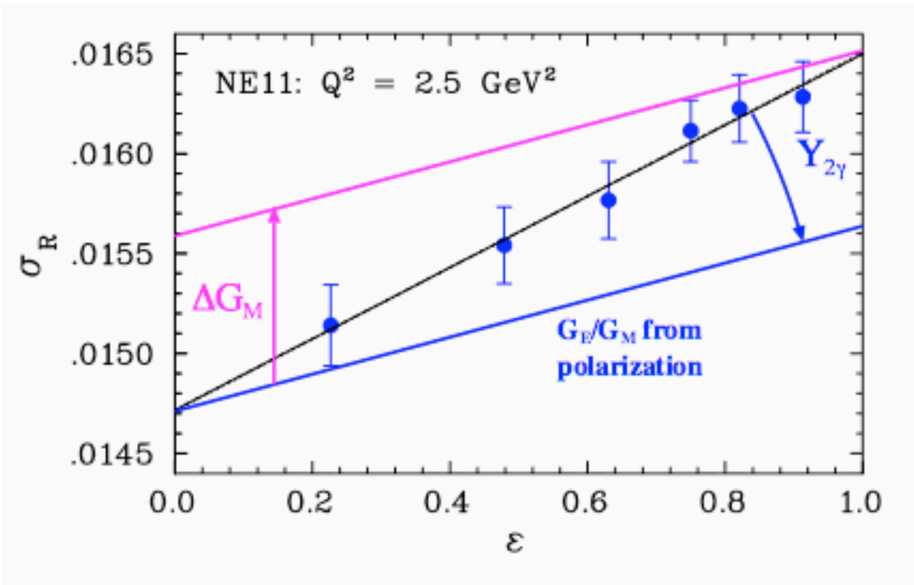

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→ mapping of the Q^2-dependence of TPE

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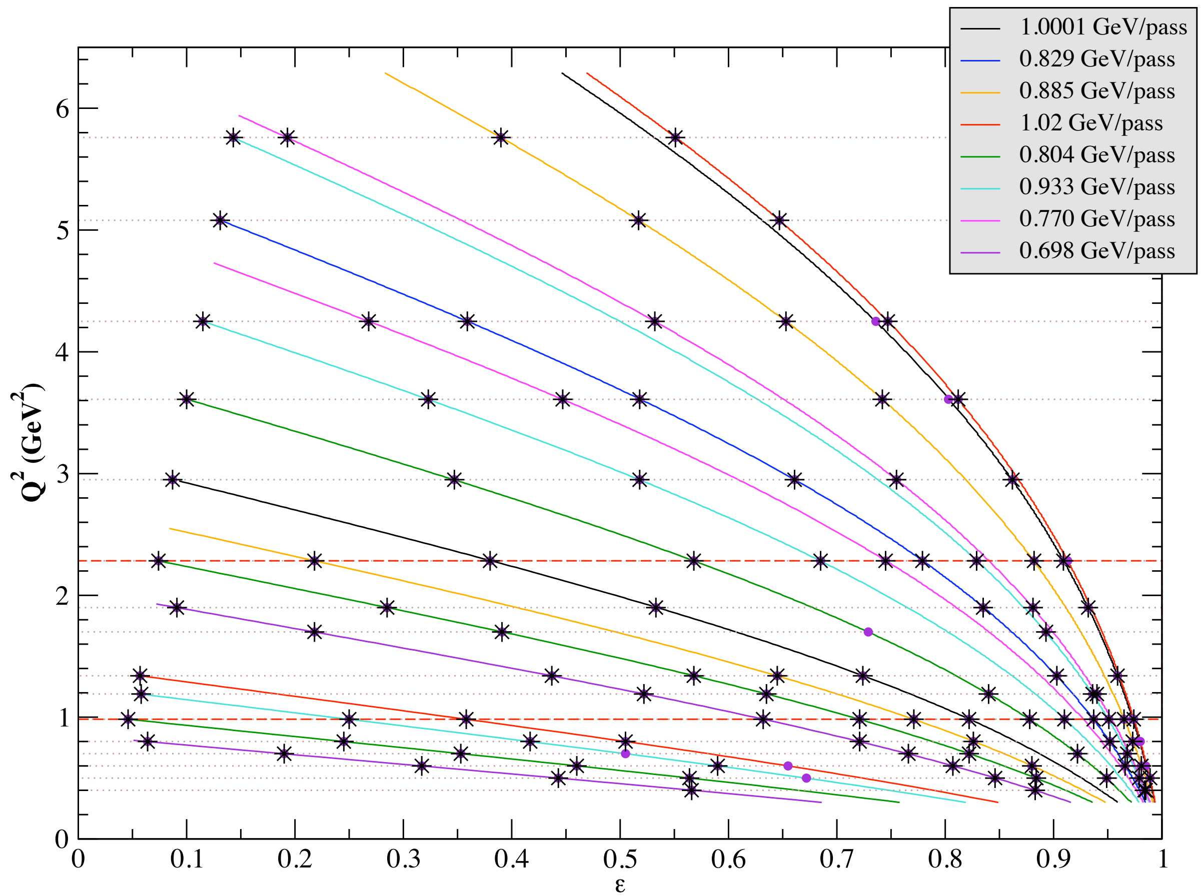
E05-017 coverage

- 8 linac settings for 17 total incident energies
- Detect struck proton --> improvement in stat. & syst.



High precision Rosenbluth separations for 16 Q^2-settings

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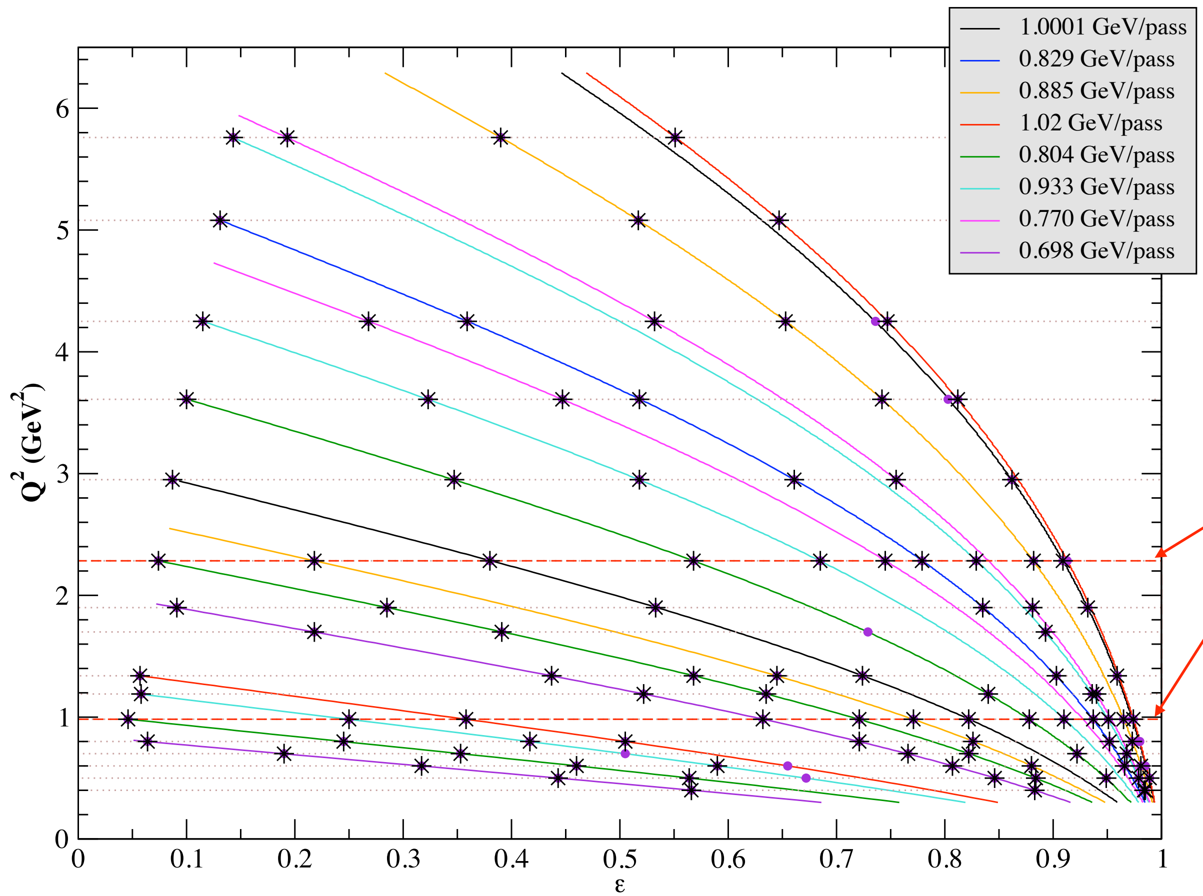
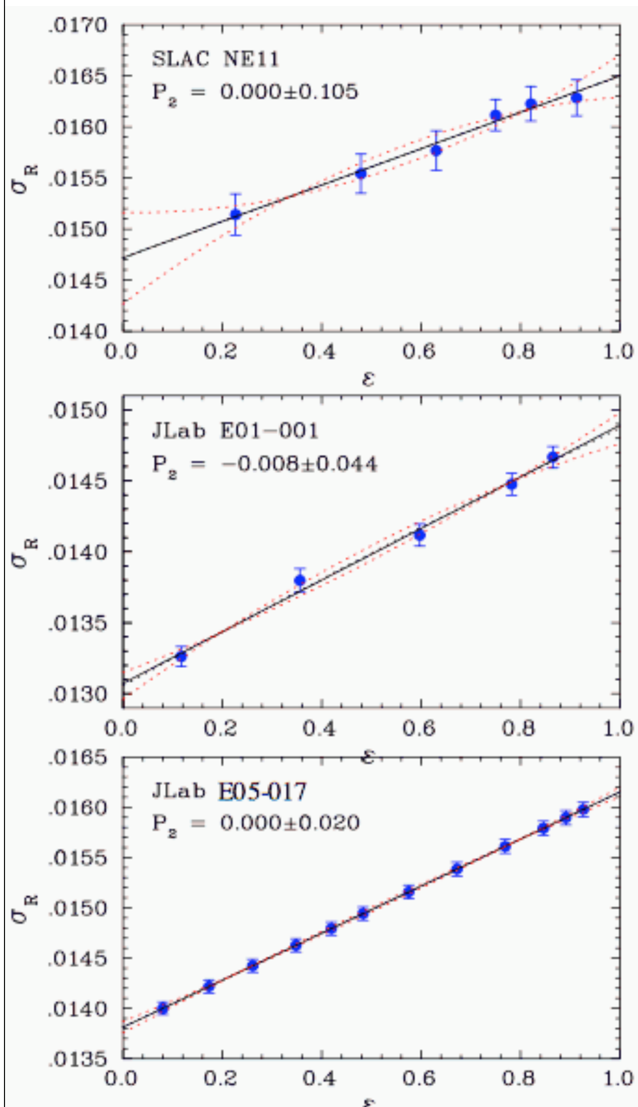


Linearity test of the ε-dependence

13 data points at $Q^2 = 0.98$ GeV^2
and
10 data points at $Q^2 = 2.28$ GeV^2

Linearity test

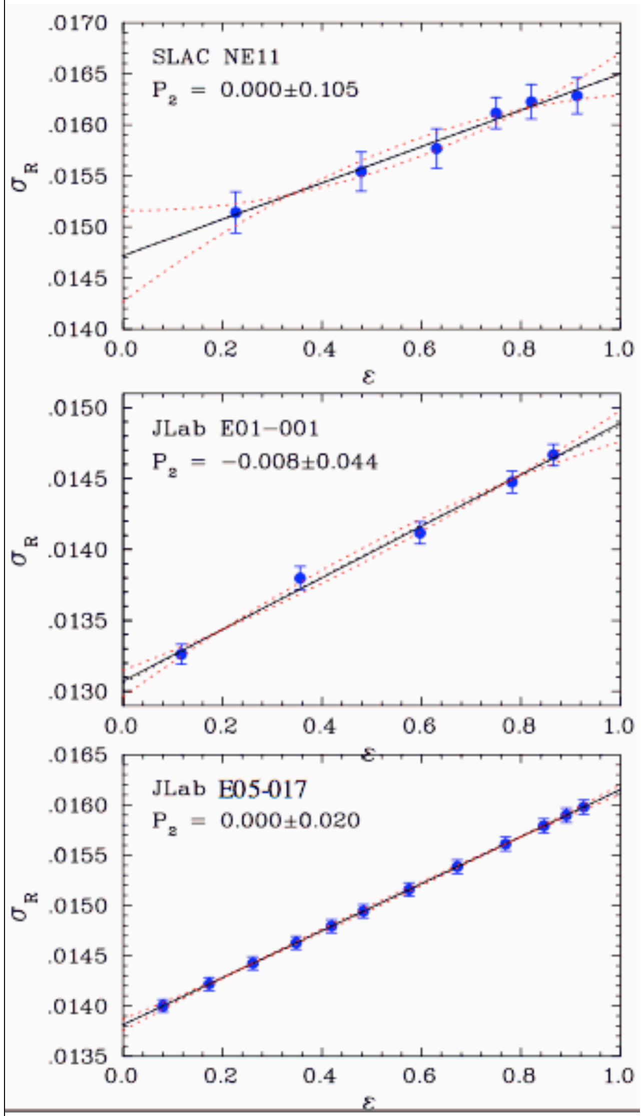


$$\sigma_R = P_0\left[1 + P_1\varepsilon + P_2\varepsilon^2\right]$$

Relative size of nonlinear terms

E05-017: Test of sensitivity to nonlinearities at both small and large ε for Q^2=0.98 & 2.28 GeV^2

Linearity test



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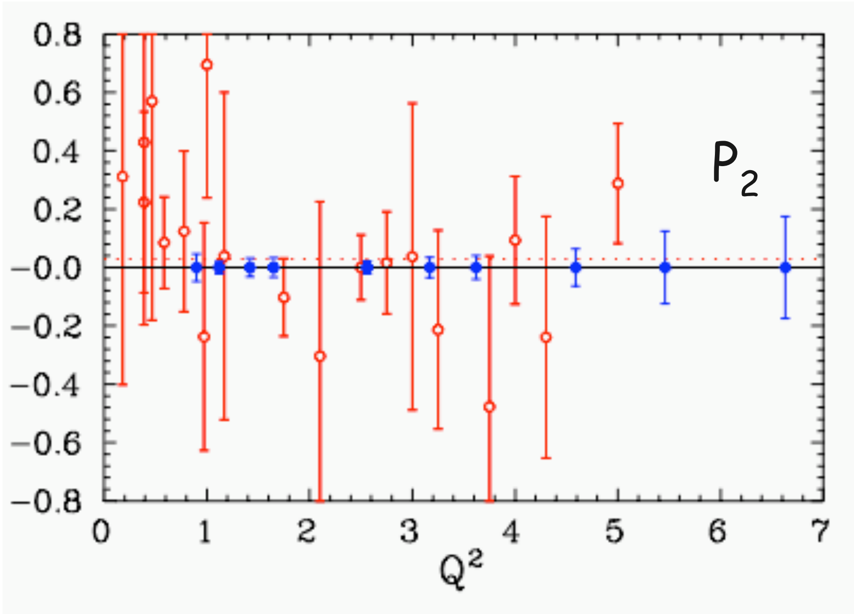
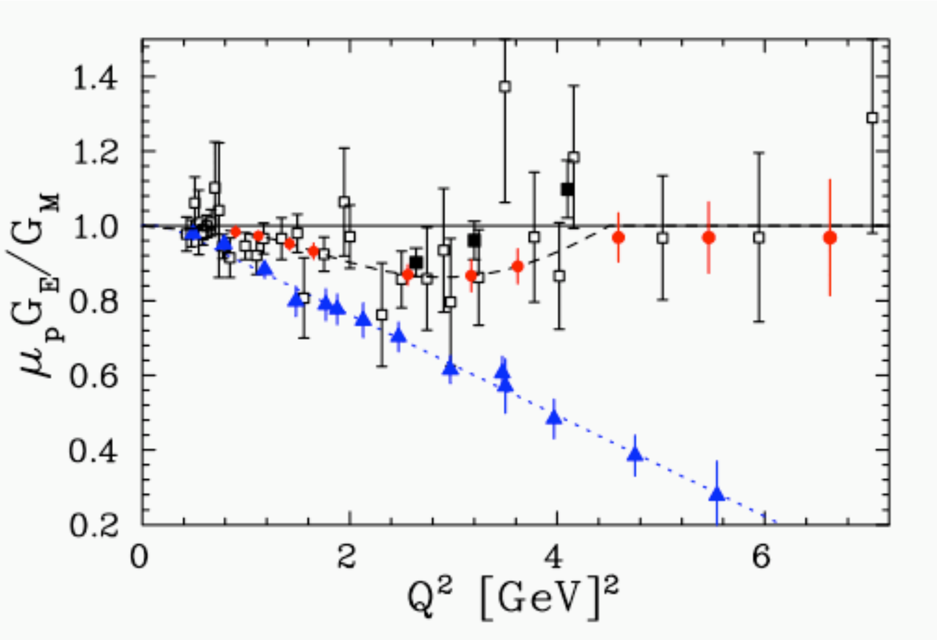


E05-017: Test of sensitivity to nonlinearities at both small and large ε for Q^2=0.98 & 2.28 GeV^2

Expected results



High precision G_E/G_M from Rosenbluth method

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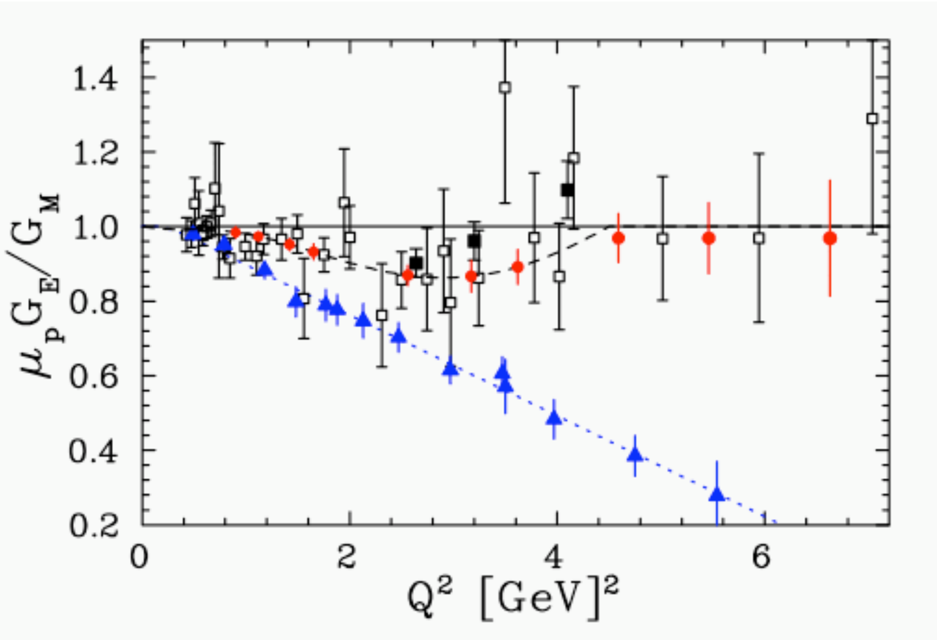

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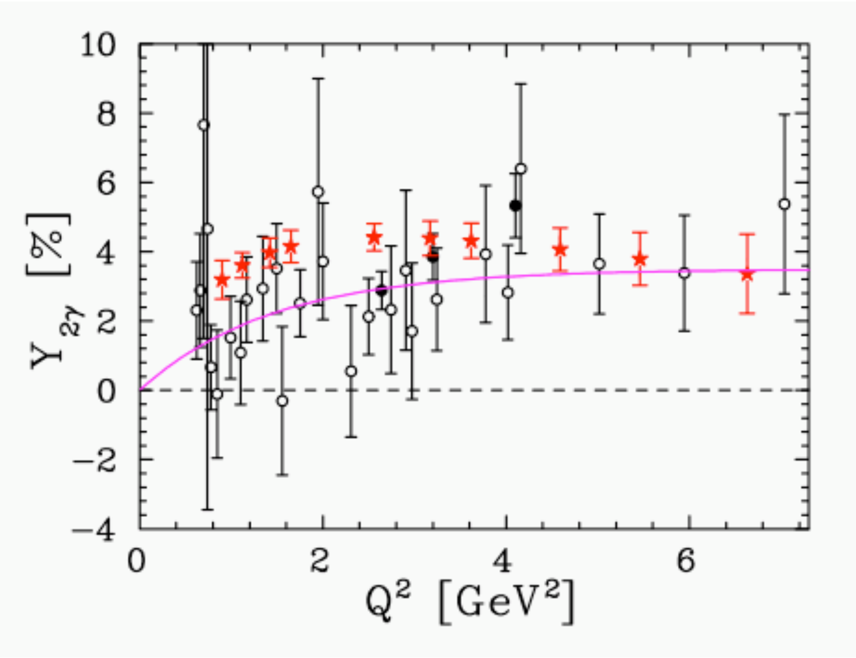


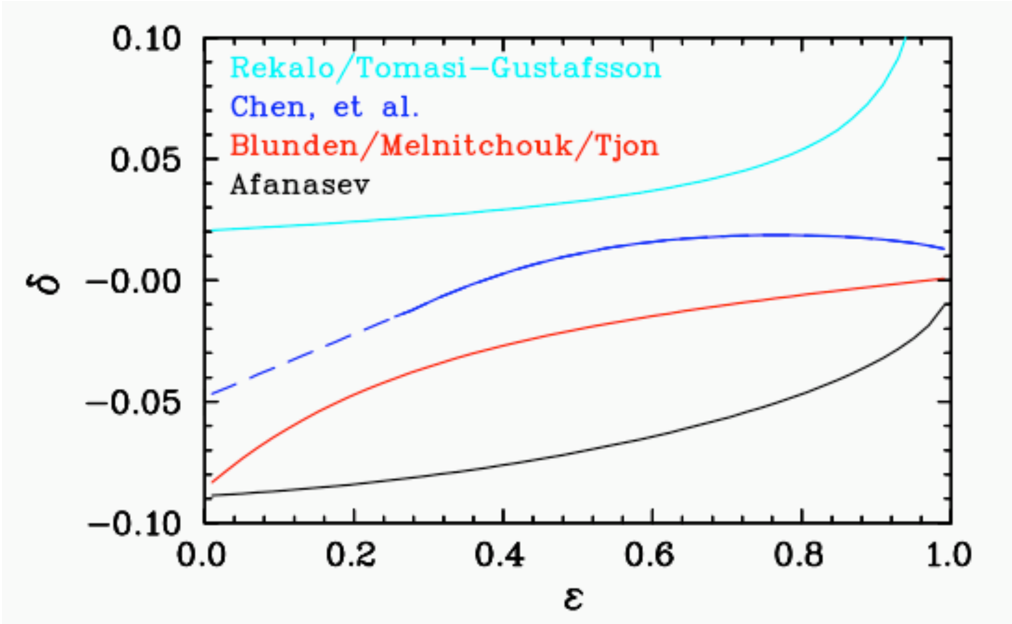
Precison extraction of the Q^2-dependence of TPE

Summary

- E05-017 will:
  - precisely map the ε-dependence of σ_R
  - provide high precision Rosenbluth data for G_E and G_M at Q^2 between 0.40 and 5.76 GeV^2
  - extract TPE amplitudes to correct G_E/G_M and G_M
  - constrain TPE models

Analysis status

ε-dependence of two-photon exchange



TPE contribution to elastic
e-p cross section:

$$\delta = \frac{(\sigma_{2\gamma} - \sigma_{1\gamma})}{\sigma_{1\gamma}}$$

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