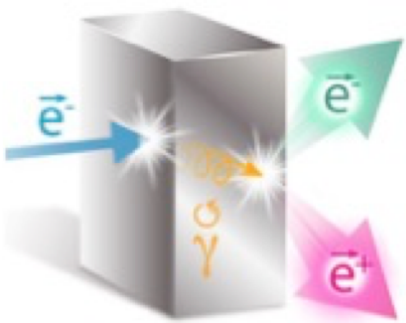
Extracting Two-Photon Exchange using Positrons at CLAS12

Axel Schmidt

Positron Working Group Meeting

December 7, 2022



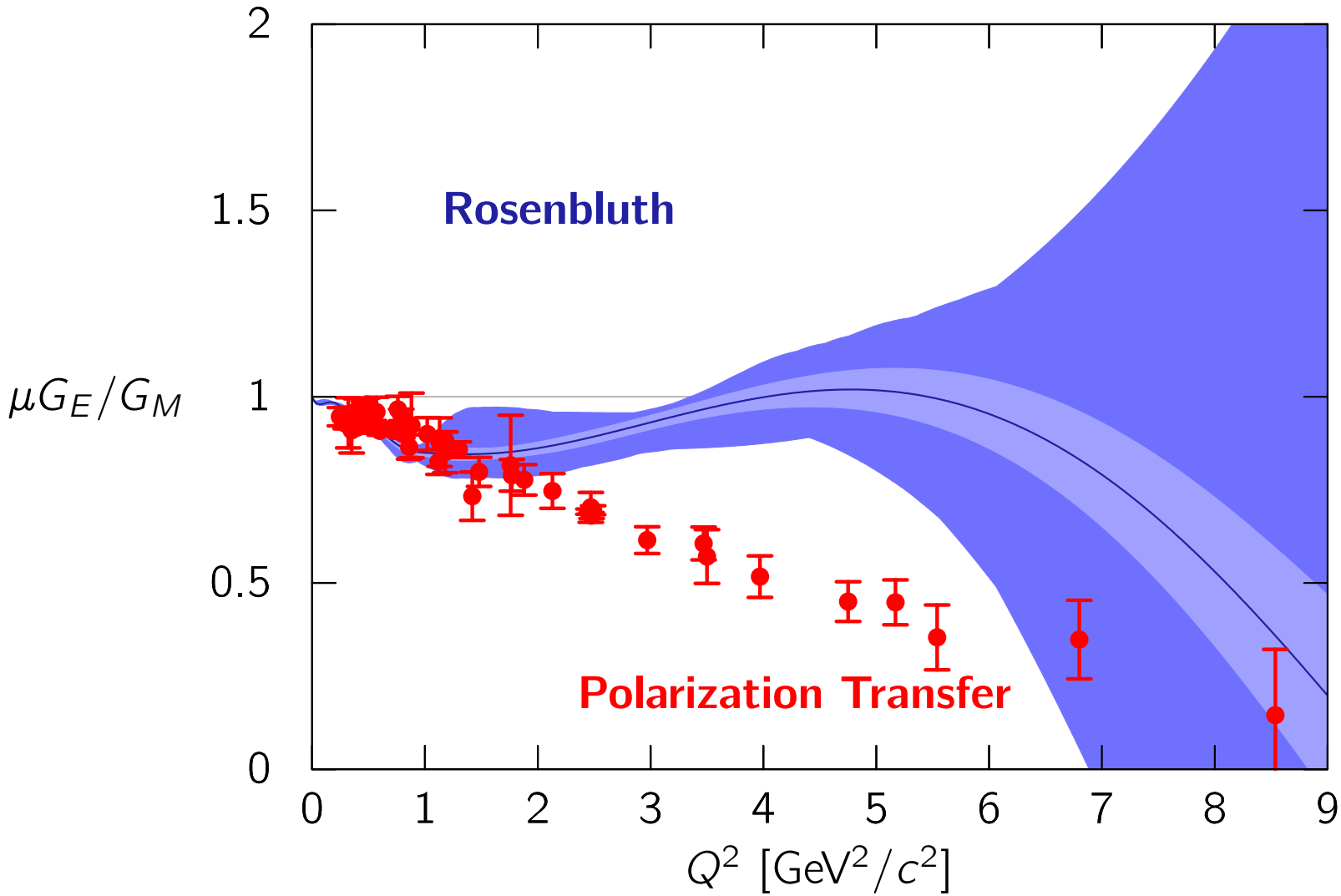
Goal of producing a PAC proposal to measure two-photon exchange at CLAS12 with positrons

- Spokespeople: J. C. Bernauer, V. D. Burkert, E. Cline, **A. Schmidt**, Y. Sharabian, T. Kutz
- Based on PWG White paper article:

  "Determination of two-photon exchange via e^+p/e^-p scattering with CLAS12"

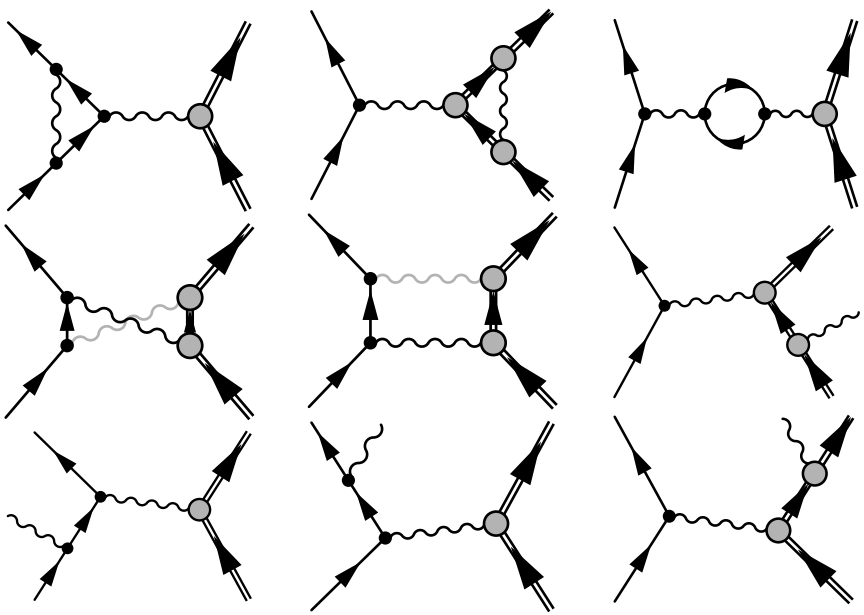
  J. C. Bernauer et al., EPJA 57:144 (2021)
- Experimental details:
  - e^+, e^- beams at 2.2., 3.3, 4.4, 6.6 GeV, unpolarized, ≈ 60 nA
  - Unpolarized H_2 target
  - ≈ 55 PAC days

Measurements of the proton's form factors are discrepant.

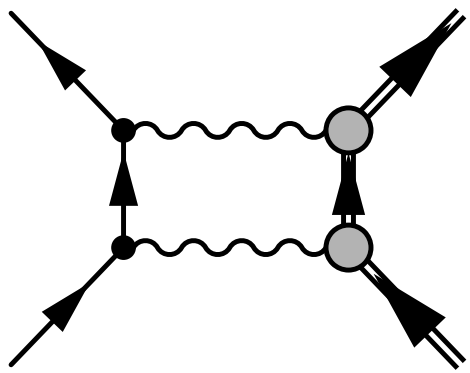


The one "missing" radiative correction is hard two-photon exchange.

The standard set



Hard two-photon exchange

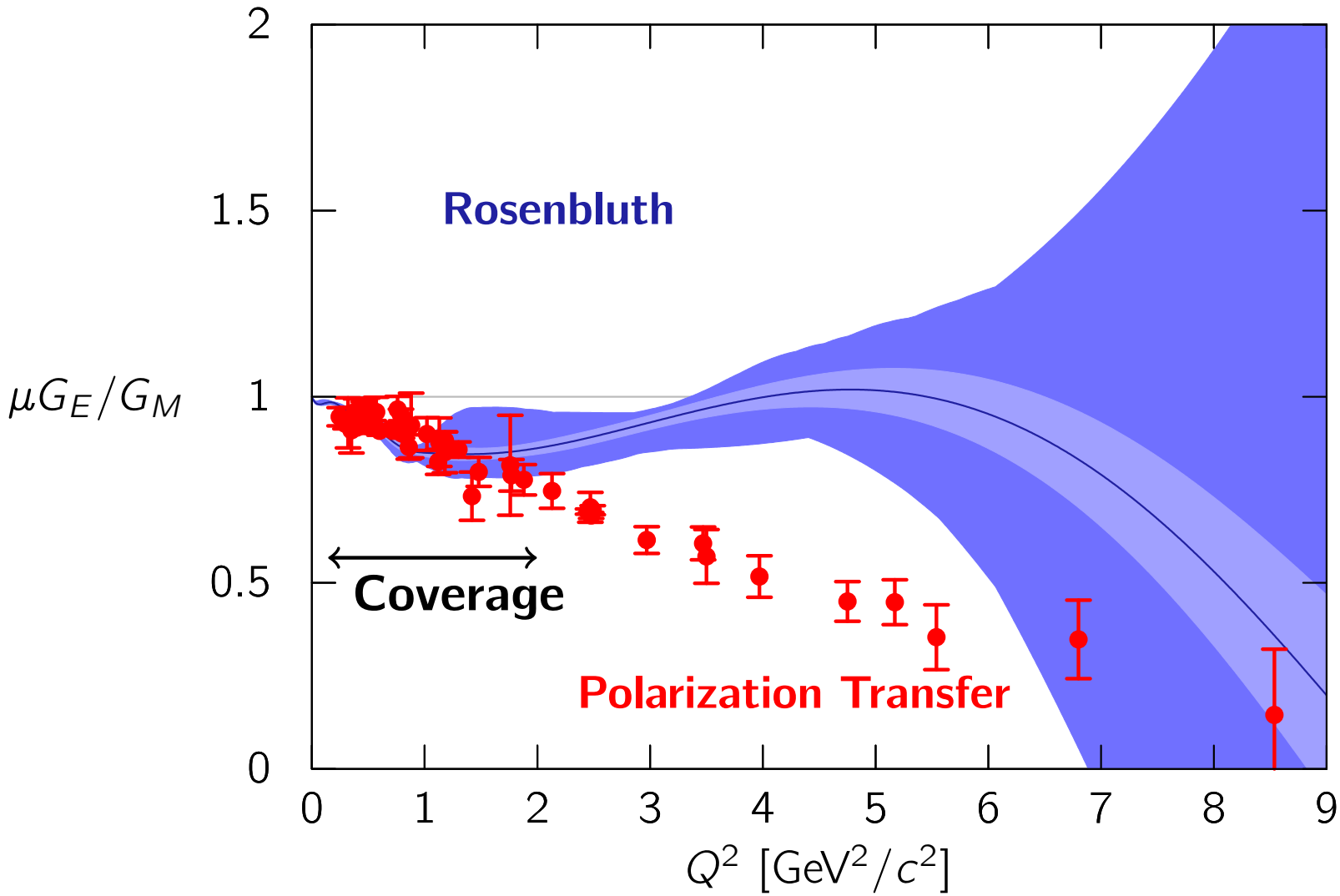


TPE produces an asymmetry between electron and positron scattering.

$$\mathcal{M} = \quad + \quad + \mathcal{O}(\alpha^3)$$

$$\sigma \approx |\mathcal{M}|^2 = \left| \right|^2 \pm 2\mathrm{Re}\left[\right] + \mathcal{O}(\alpha^4)$$

Recent measurements lacked the kinematic reach to be decisive.



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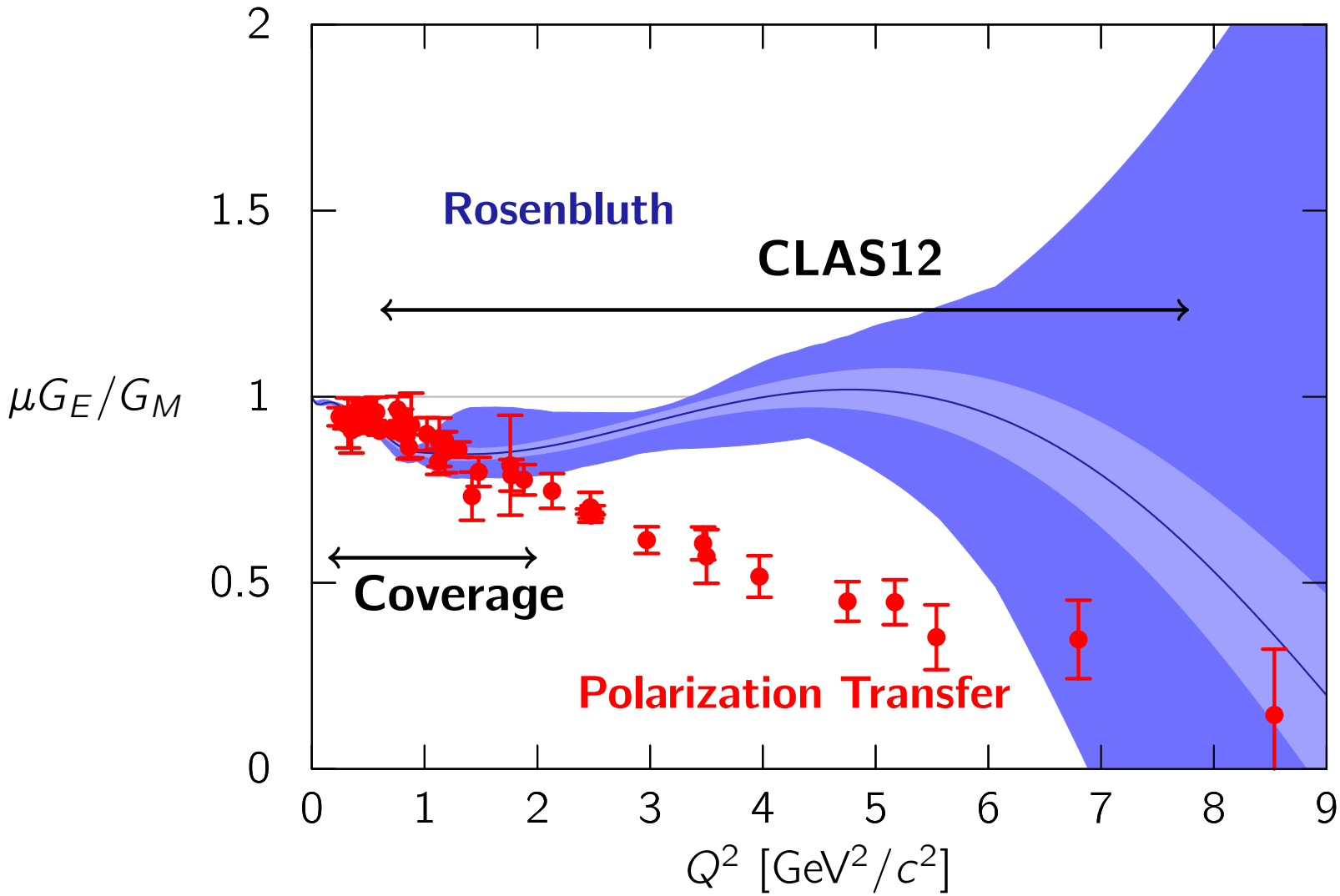
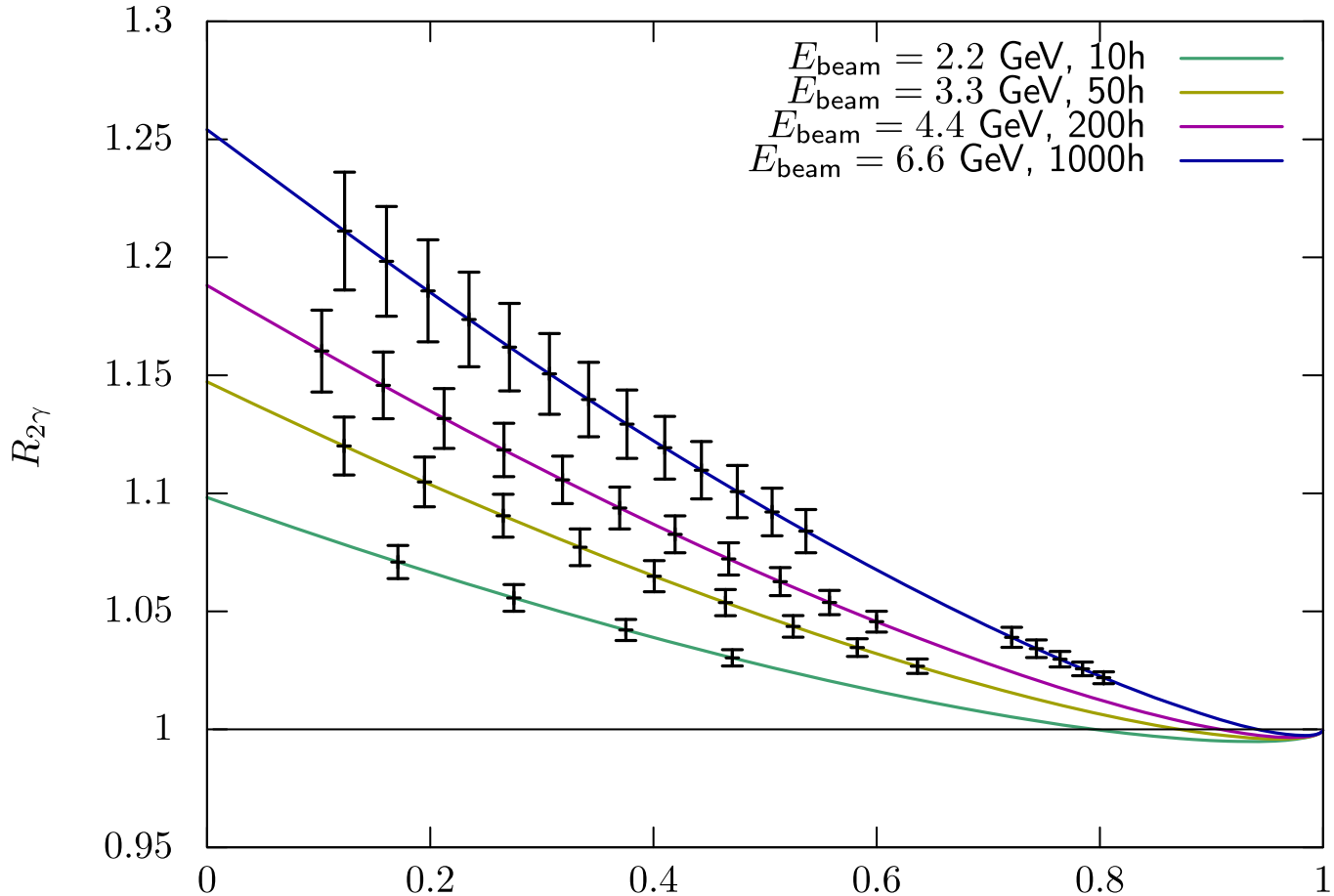
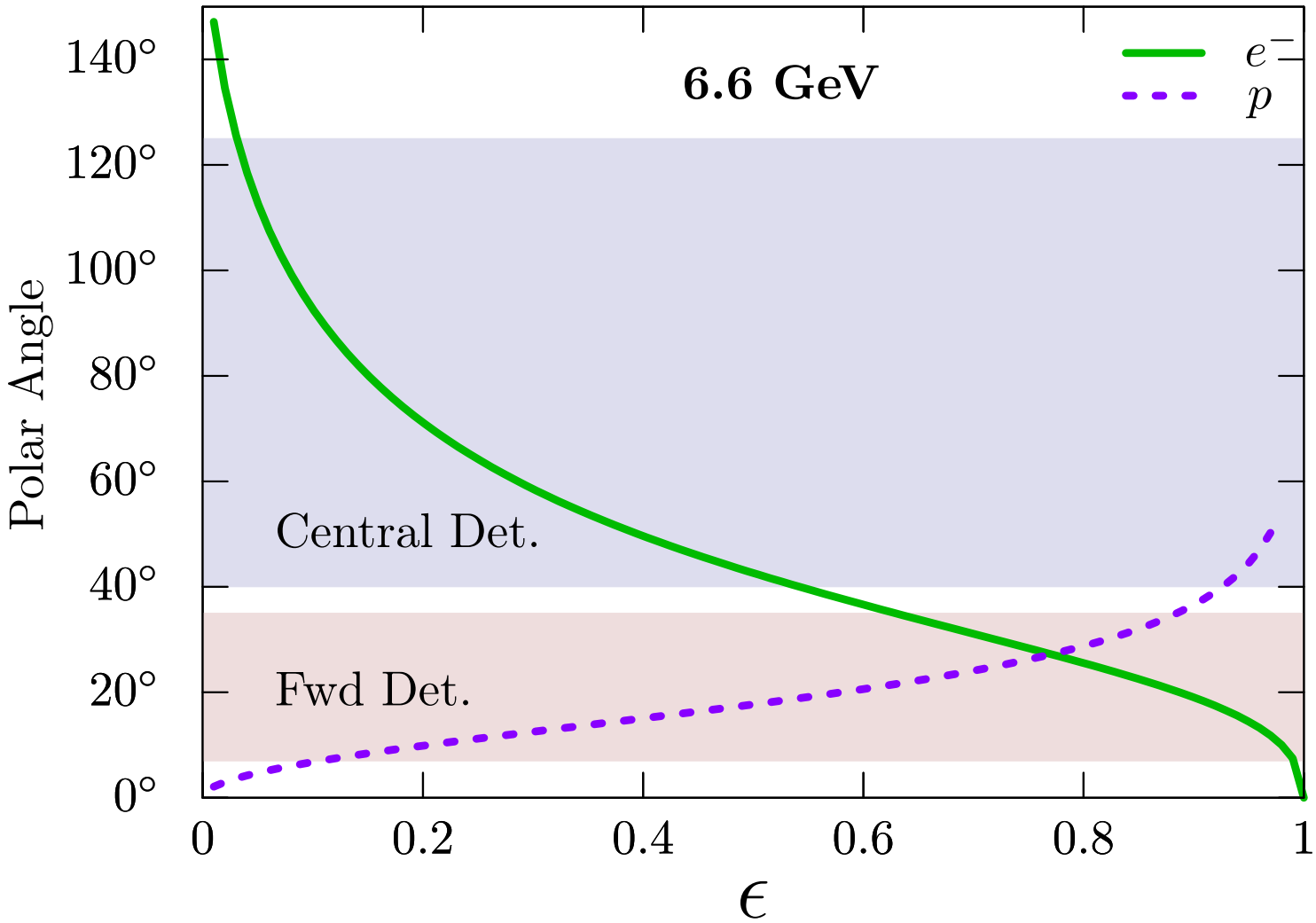


CLAS12 is ideal for mapping TPE over a wide phase space.



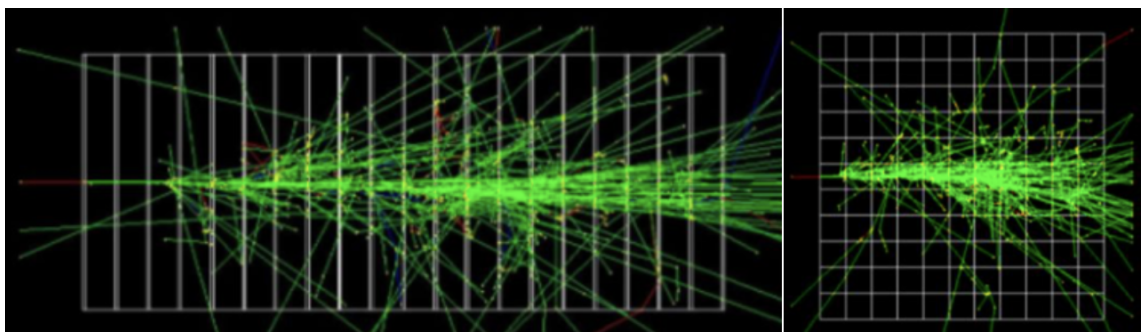
J. C. Bernauer et al., Eur.Phys.J.A 57, p. 144 (2021)

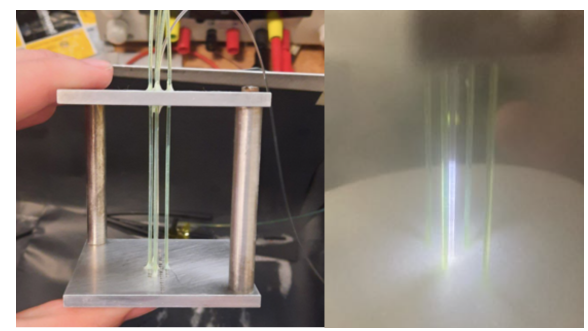
Current CLAS12 equipment lack the means to trigger on a central $e^{\pm}$.



Proposed solution: replace CLAS CND with new "Central Electron Calorimeter"

- Design based on previous CLAS12 CEC concept
  - Some proof-of-concept work done by group in Paris-Saclay
- Tungsten powder calorimeter
- Light collected by fiber, sent to SiPMs





Summary

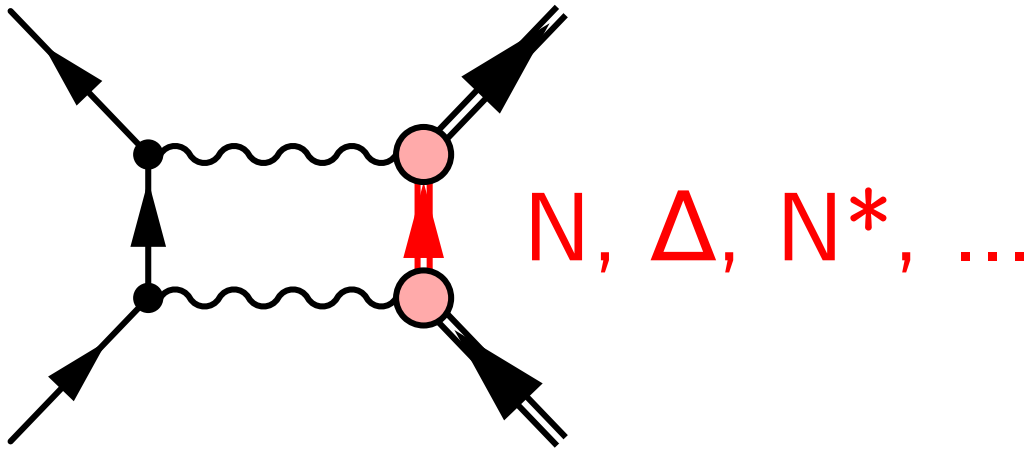
- TPE calls for measurements e^+p/e^-p over wide kinematic range.
- CLAS12's large acceptance makes it advantageous
- Problem to overcome: triggering central $e^{\pm}$
- Plan to submit a PAC proposal this spring

Back Up

Calculations of two-photon exchange come with model dependency.

Hadronic Approaches

- Treat off-shell propagator as collection of hadronic states.
- e.g. Ahmed, Blunden, Melnitchouk, PRC 102, 045205 (2020)



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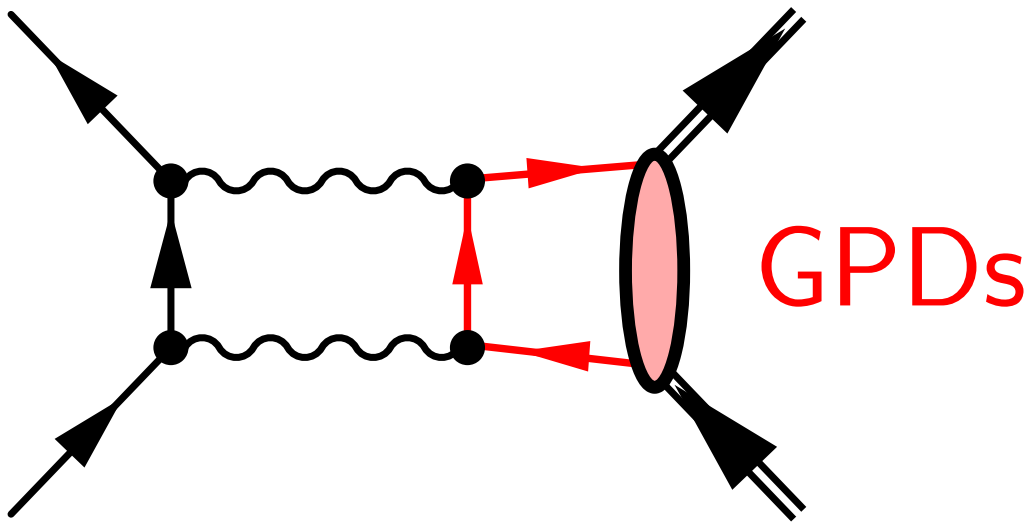
Partonic Approaches

- Treat interaction of $\gamma\gamma$ with quarks, distributed by GPDs.
- e.g. A. Afanasev et al., PRD 72, 013008 (2005)



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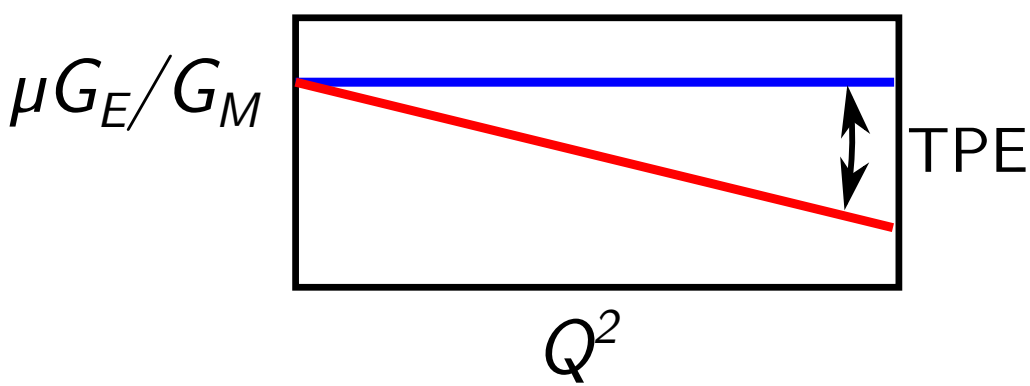
- Assume the discrepancy is caused by TPE, estimate the effect.
- e.g. A. Schmidt, JPG 47, 055109 (2020)



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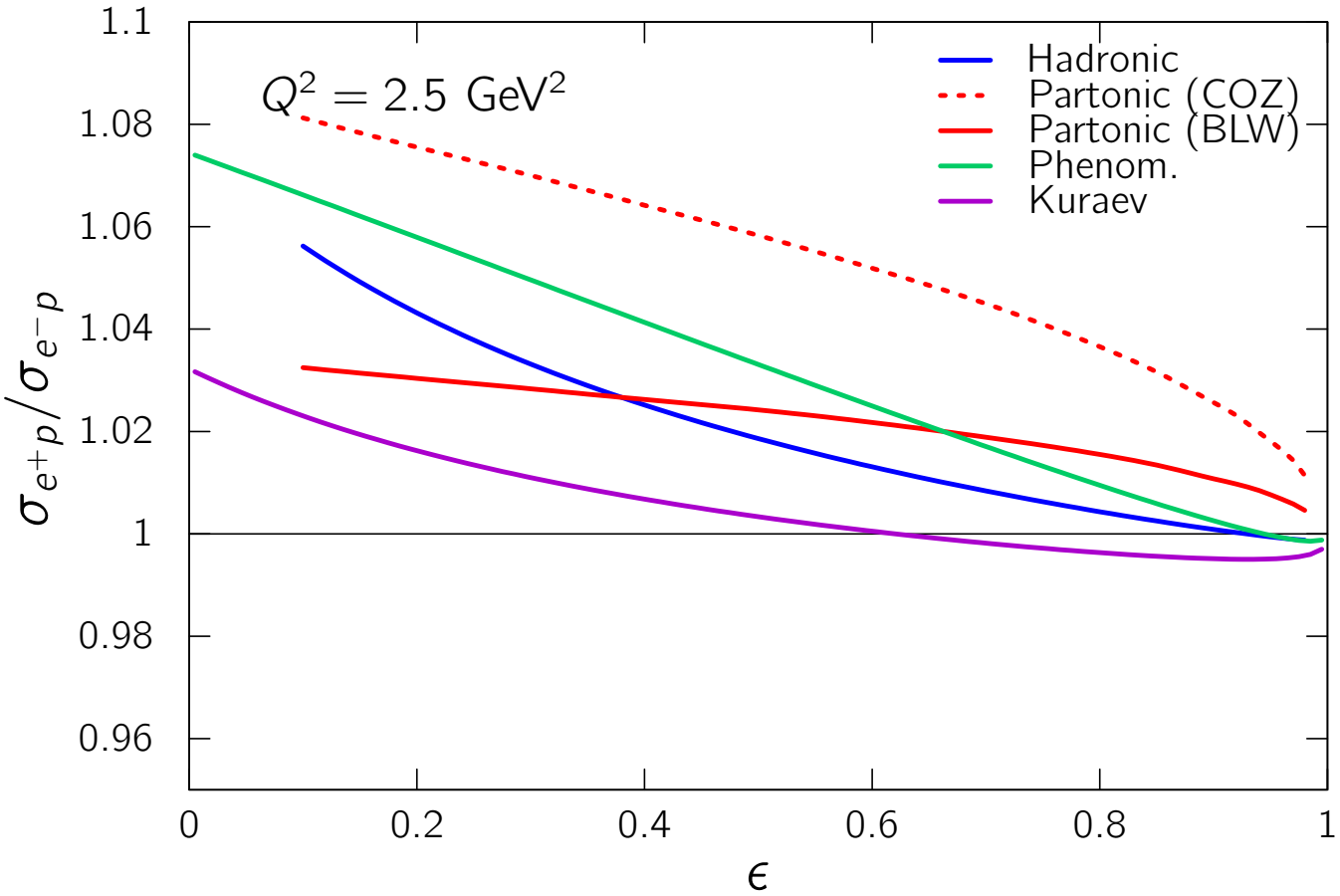
Alternate Approaches

- e.g., E. A. Kuraev et al., Phys. Rev. C 78, 015205 (2008)

Theory predictions for $\sigma_{e^+p}/\sigma_{e^-p}$ are not in agreement.



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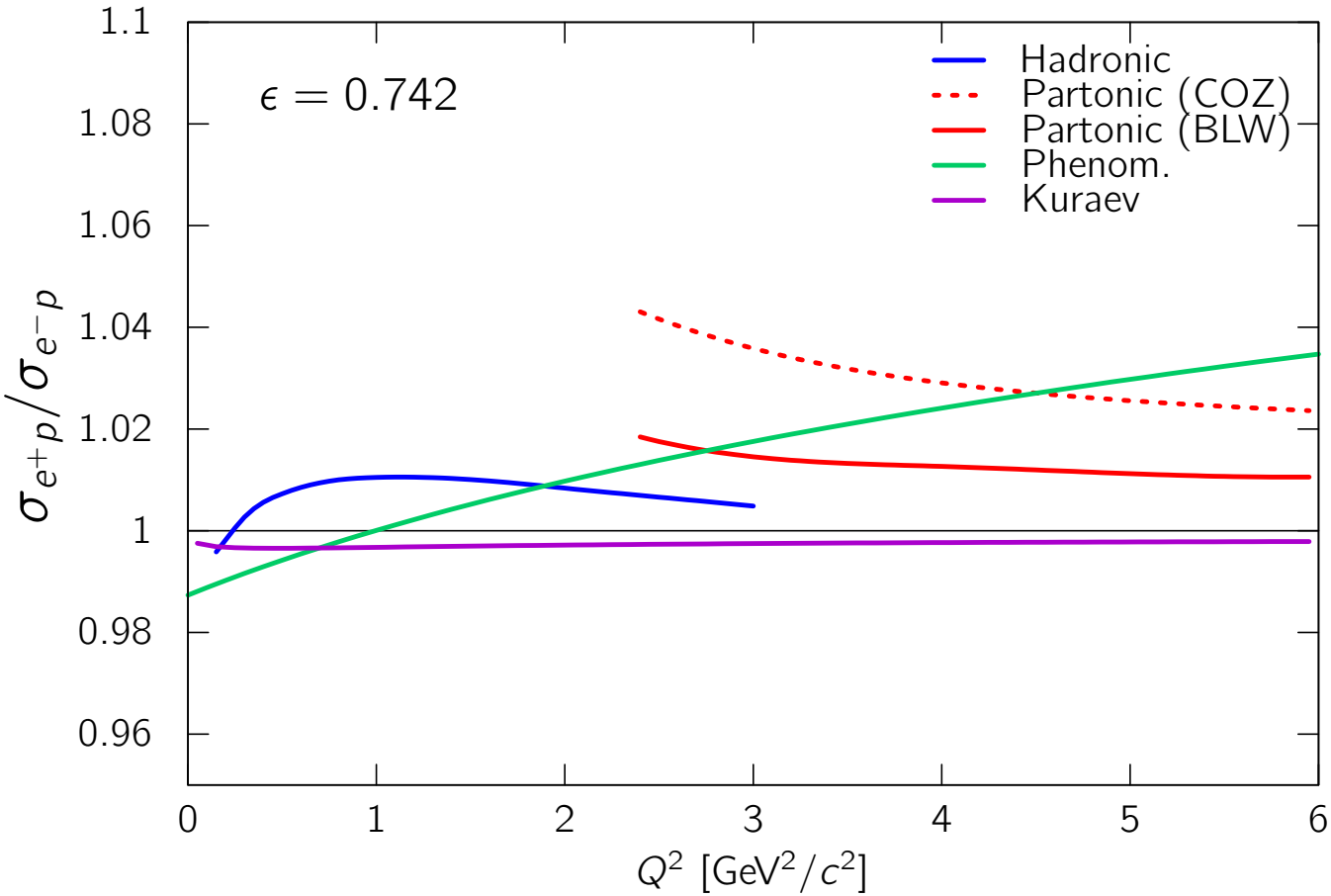
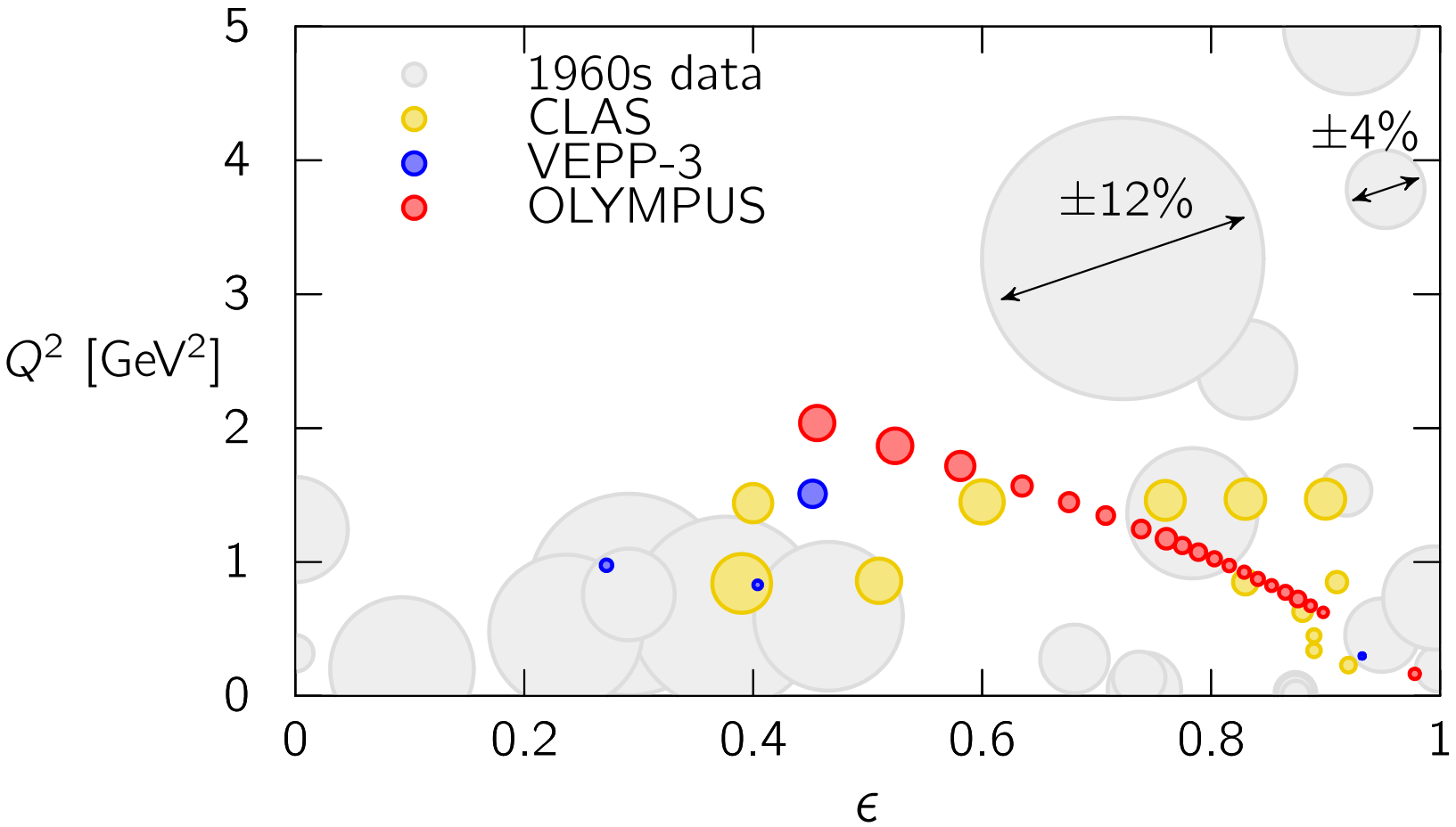
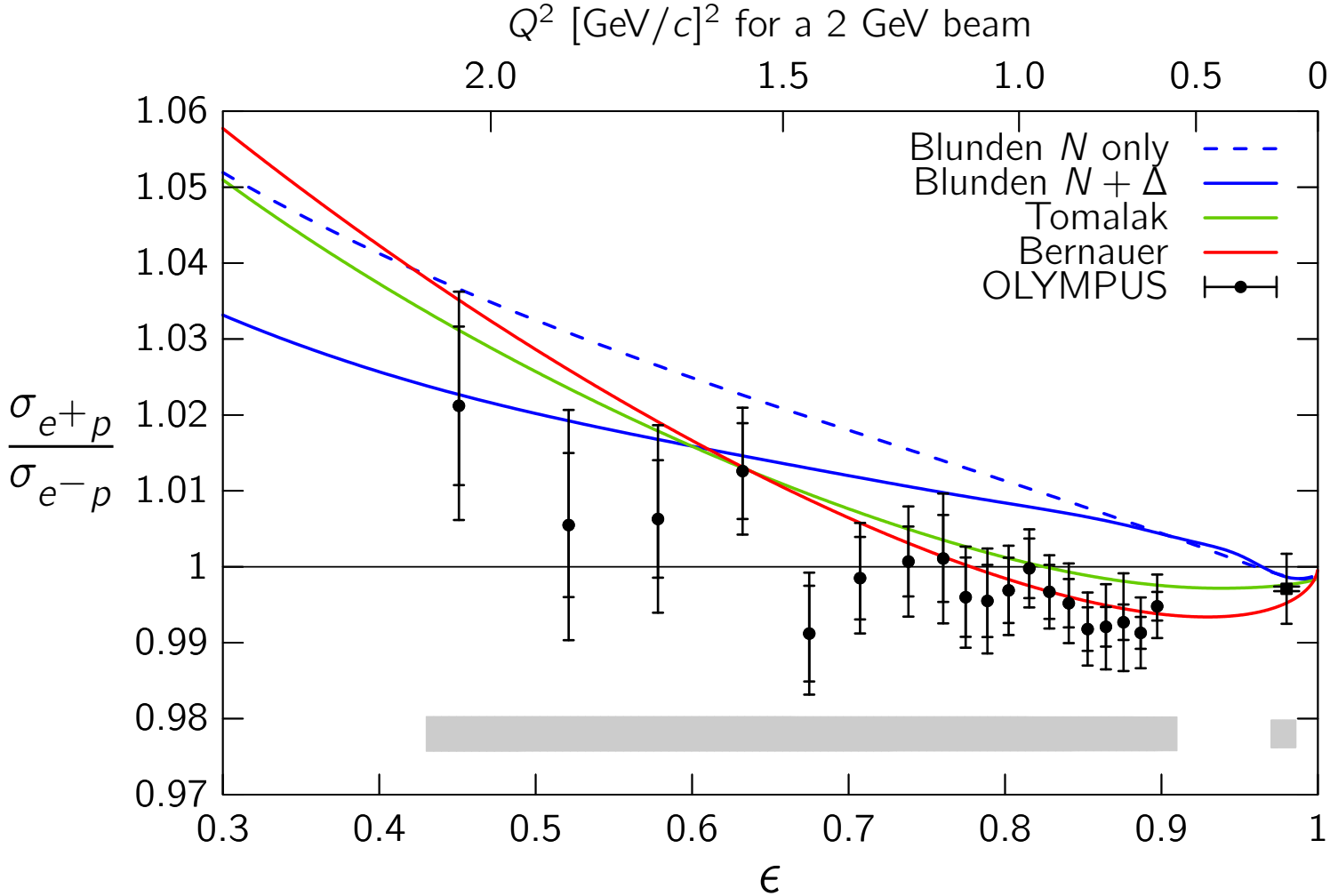


Three recent experiments measured hard TPE.



OLYMPUS observed a small TPE effect.



Henderson et al., PRL 118, 092501 (2017)