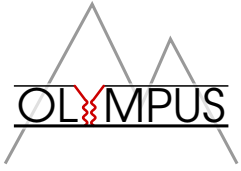
The Latest Results from the OLYMPUS Experiment

Axel Schmidt

MIT

September 12, 2016



The OLYMPUS Experiment

The OLYMPUS Experiment

Elastic scattering cross section ratio:

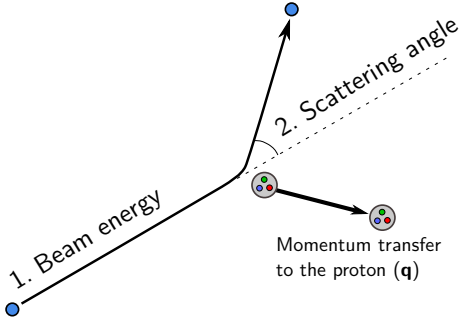
$$\frac{e^+ p \longrightarrow e^+ p}{e^- p \longrightarrow e^- p}$$

The important points:

1. Motivation:
   - Why the discrepancy calls for a measurement of $\sigma_{e^+p}/\sigma_{e^-p}$
2. Experiment:
   - How OLYMPUS worked
3. Results:
   - What other experiments have found
   - What impact OLYMPUS can have

Elastic scattering kinematics are fixed by two parameters.

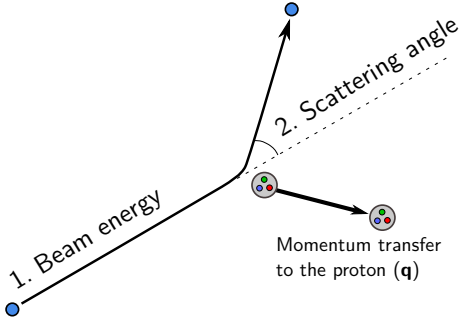
Experiment



Theory

Elastic scattering kinematics are fixed by two parameters.

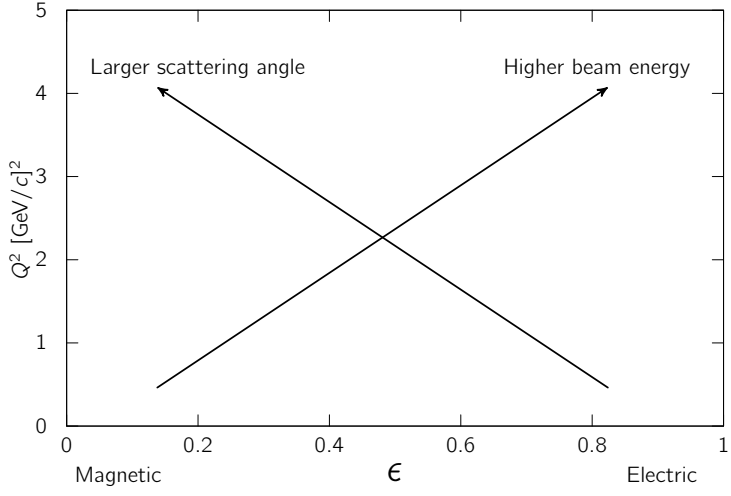
Experiment



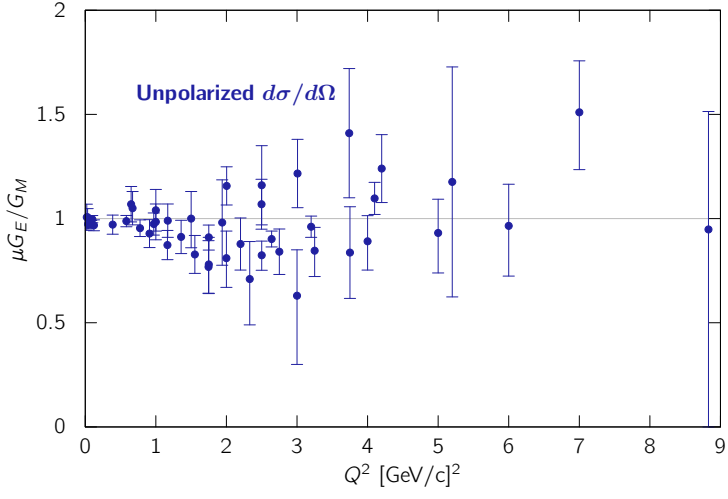
Theory

1. $Q^2 = -q_\mu q^\mu$
2. $\epsilon = \left[1 + 2\left(1 + \frac{Q^2}{4m_p^2}\right)\tan^2\frac{\theta}{2}\right]^{-1}$

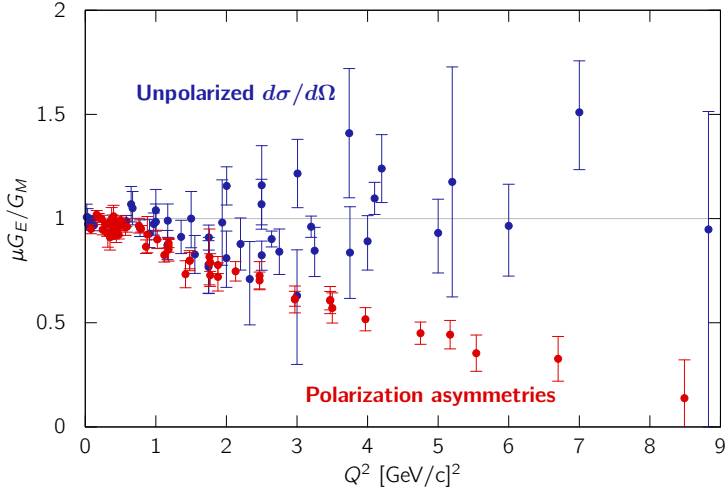
Elastic scattering kinematics are fixed by two parameters.



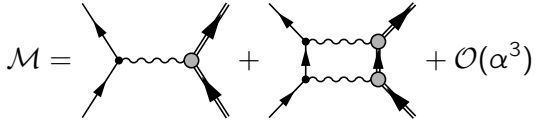
Polarized measurements disagree with unpolarized cross section measurements.



Polarized measurements disagree with unpolarized cross section measurements.



$\sigma_{e^+p}/\sigma_{e^-p}$ is sensitive to two-photon exchange.



$\sigma_{e^+p}/\sigma_{e^-p}$ is sensitive to two-photon exchange.

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

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

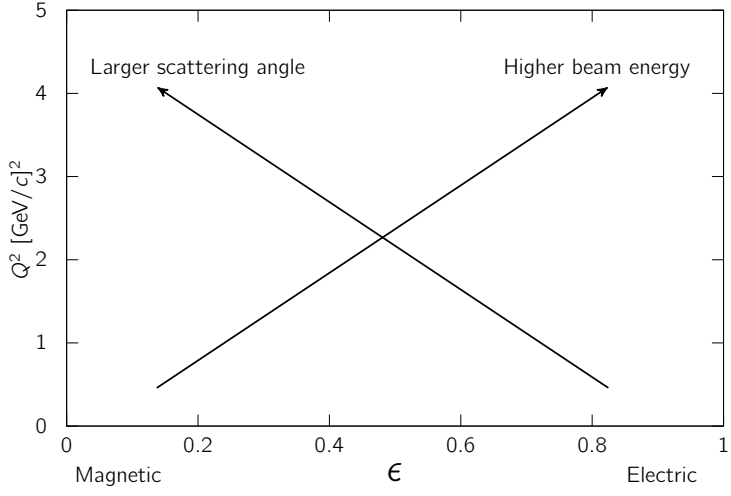
$\sigma_{e^+p}/\sigma_{e^-p}$ is sensitive to two-photon exchange.

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

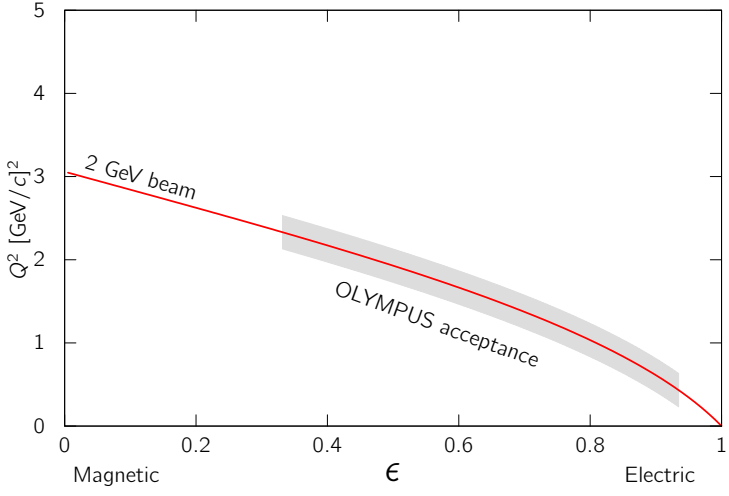
$$\sigma \approx |\mathcal{M}|^2 = \left| \quad \right|^2 \pm \mathrm{Re}\left[\quad \right] + \mathcal{O}(\alpha^4)$$

$$\frac{\sigma_{e^+p}}{\sigma_{e^-p}} \approx 1 + \frac{4\mathrm{Re}\{\mathcal{M}_{2\gamma}\mathcal{M}_{1\gamma}\}}{|\mathcal{M}_{1\gamma}|^2}$$

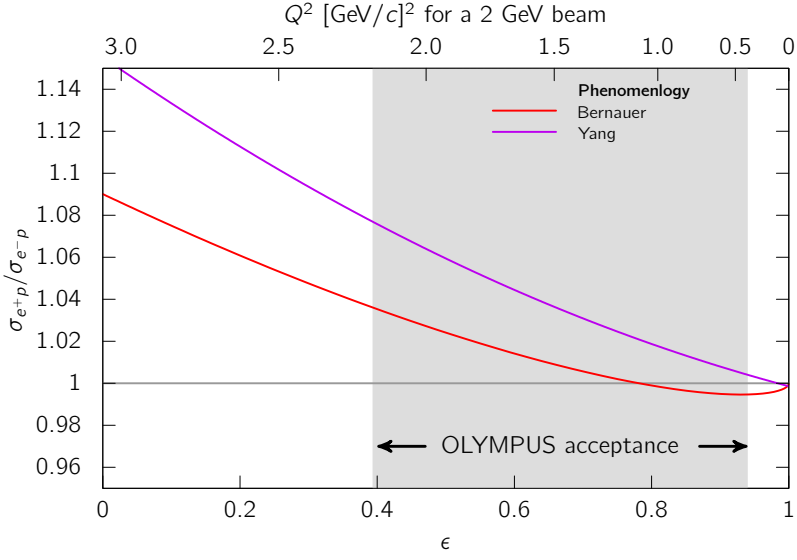
Elastic scattering kinematics are fixed by two parameters.



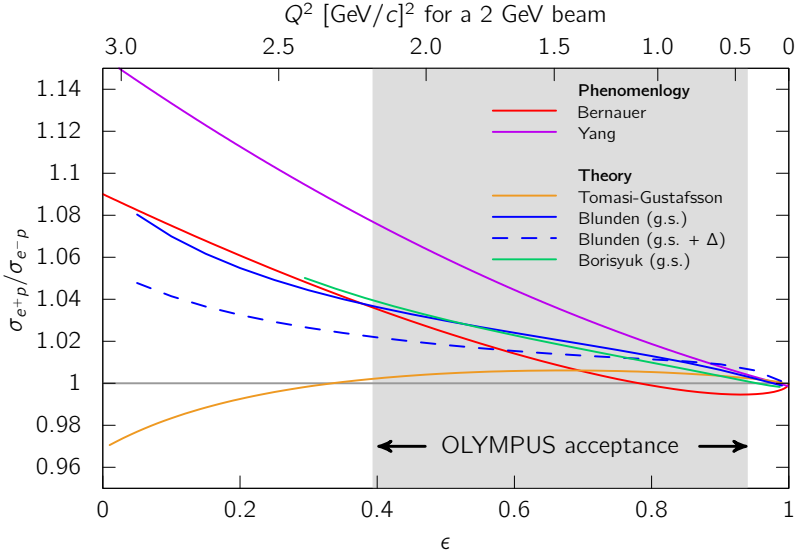
Elastic scattering kinematics are fixed by two parameters.



A few percent effect is large enough to resolve the discrepancy.



A few percent effect is large enough to resolve the discrepancy.

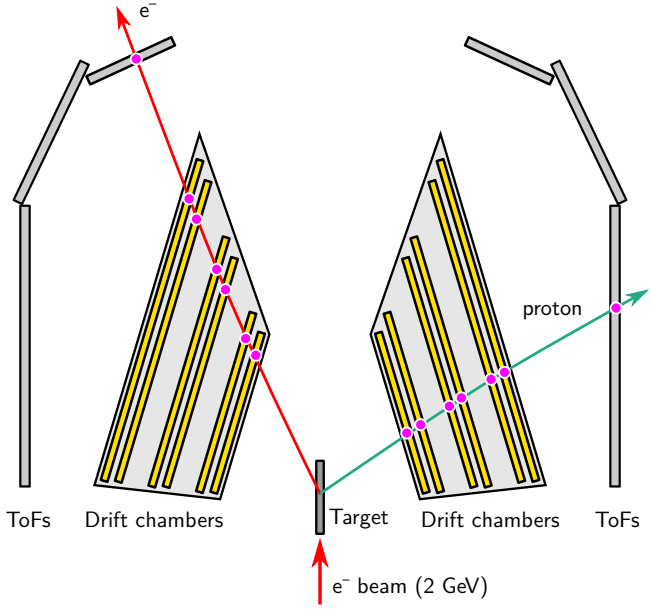


2. The Experiment

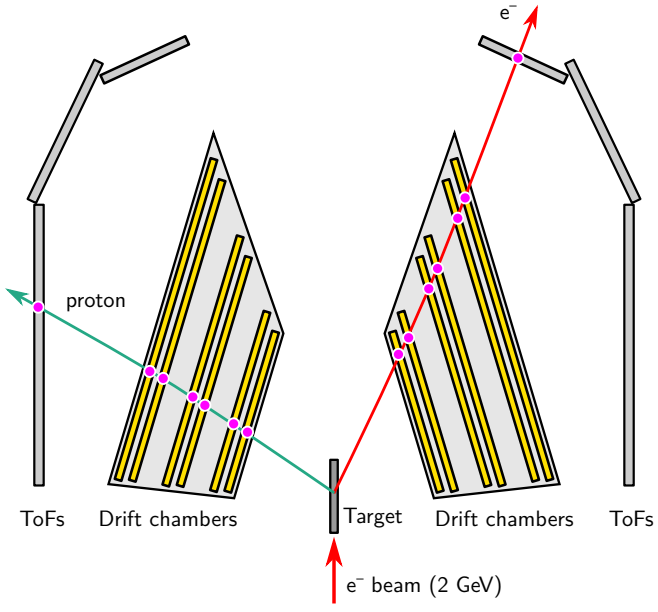
How OLYMPUS worked

- Alternating e^-, e^+ beams
- Hydrogen gas target
- Large acceptance spectrometer
- Finished data collection in early 2013

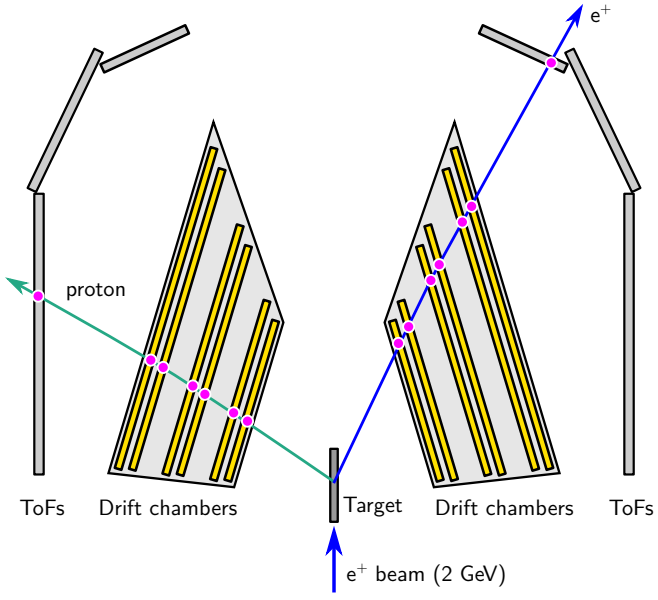
We detected the lepton and proton in coincidence.



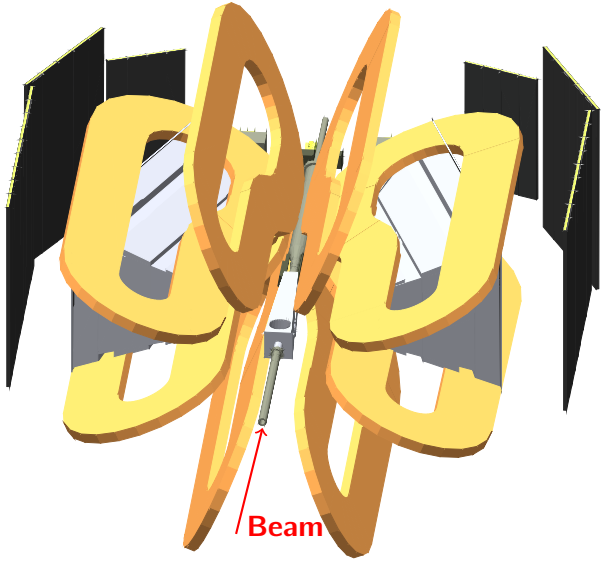
We detected the lepton and proton in coincidence.



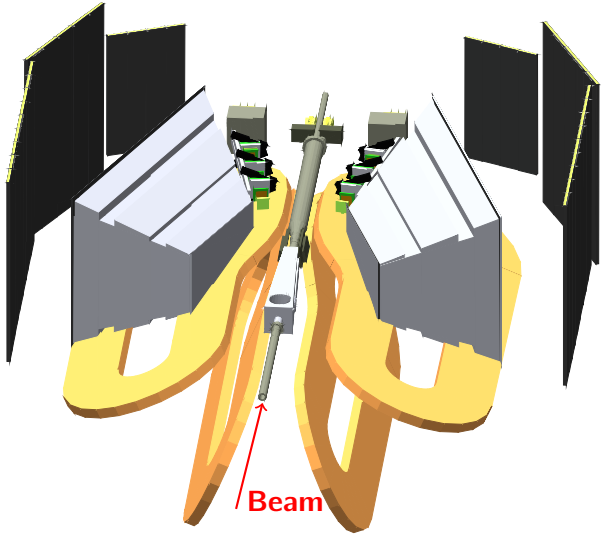
We detected the lepton and proton in coincidence.

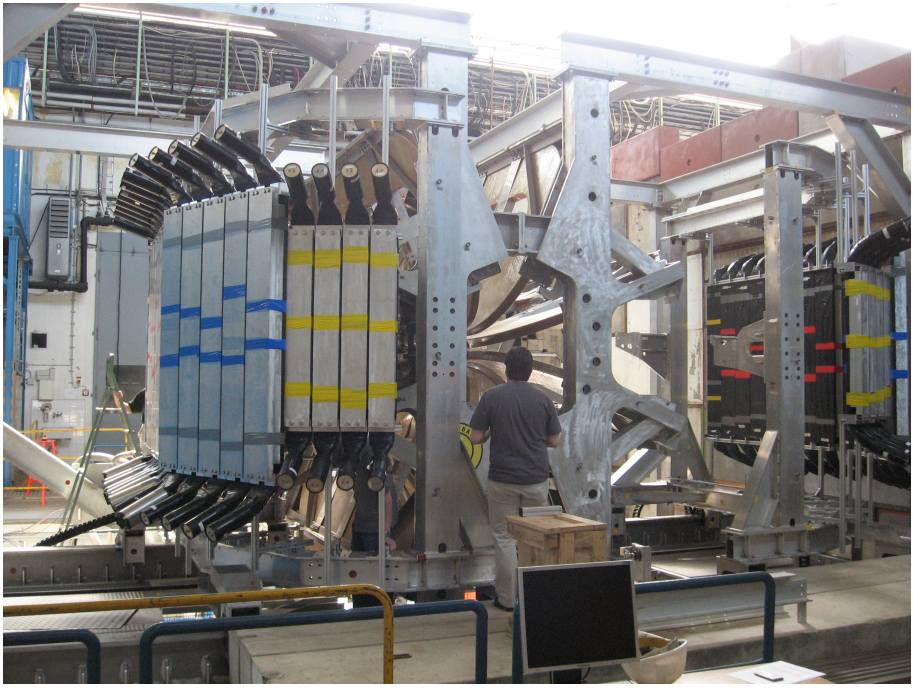


We used a toroidal spectrometer.

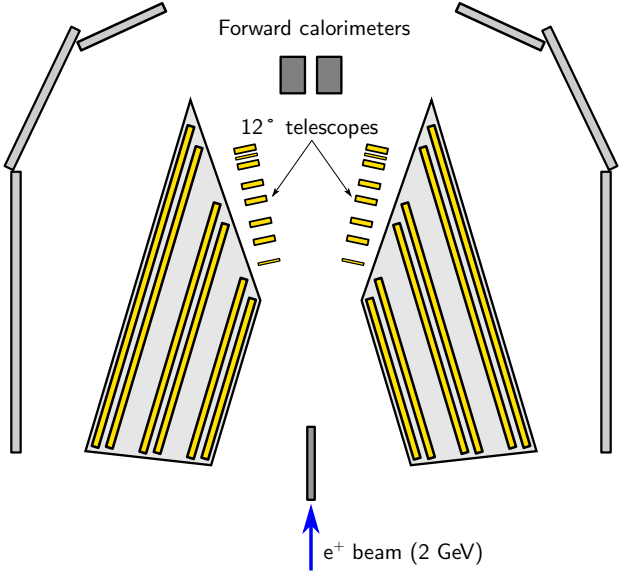


We used a toroidal spectrometer.

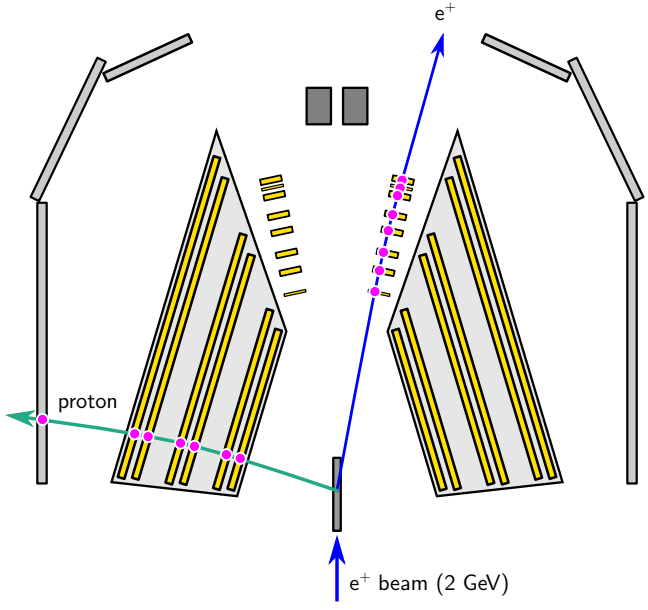




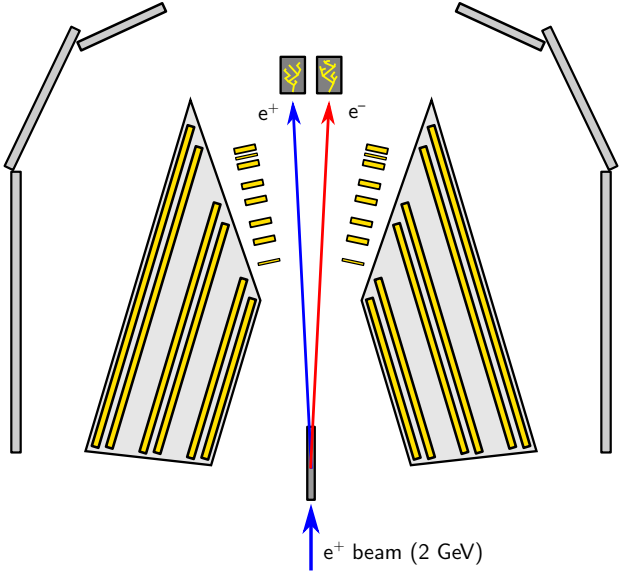
We had redundant luminosity monitors.



We had redundant luminosity monitors.



We had redundant luminosity monitors.



3. The Results

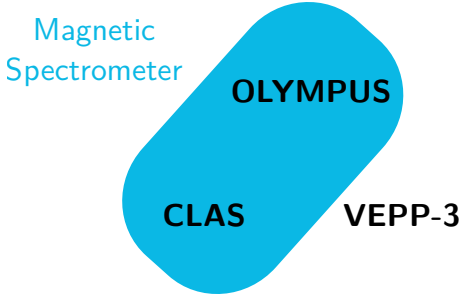
What other experiments have found, what impact OLYMPUS can have

OLYMPUS

CLAS **VEPP-3**

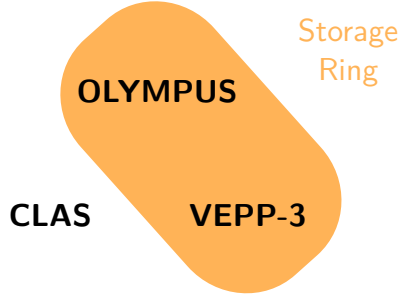
3. The Results

What other experiments have found, what impact OLYMPUS can have

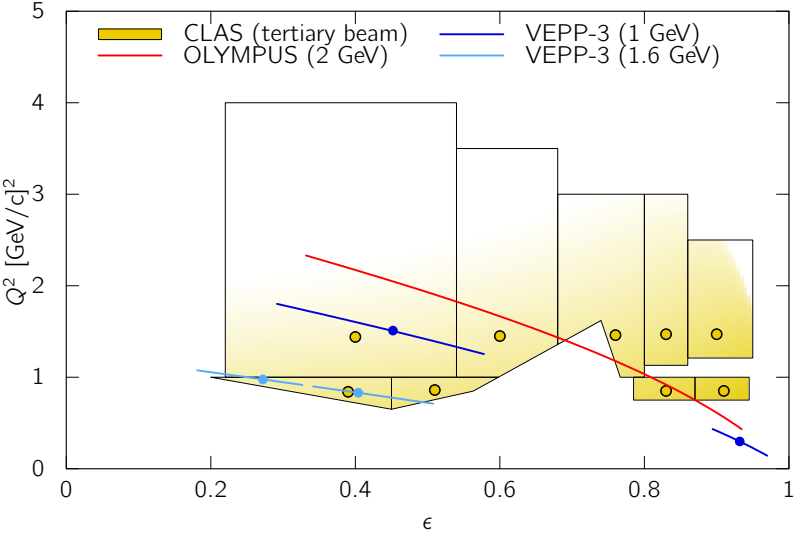


3. The Results

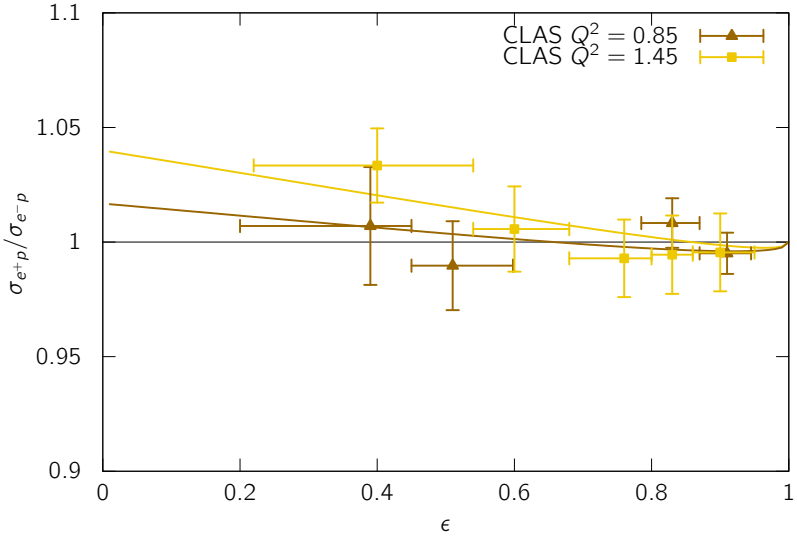
What other experiments have found, what impact OLYMPUS can have



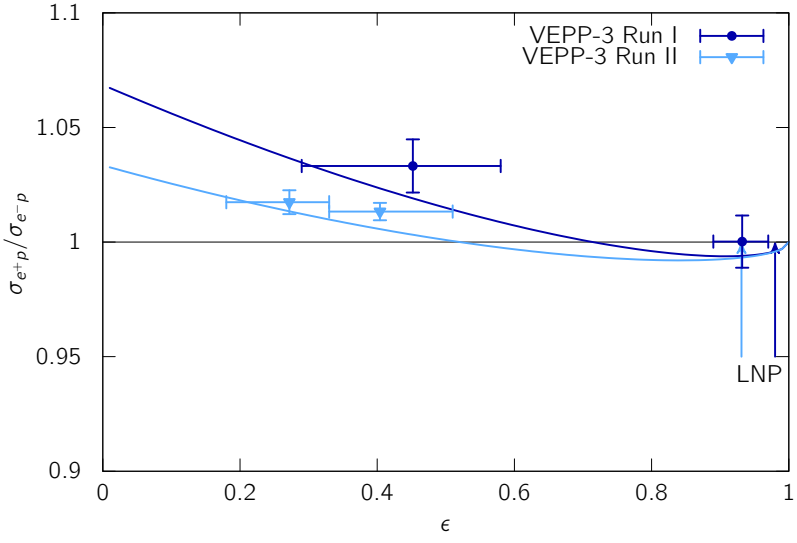
All three probe the relevant, low ϵ, high Q^2 phase space.



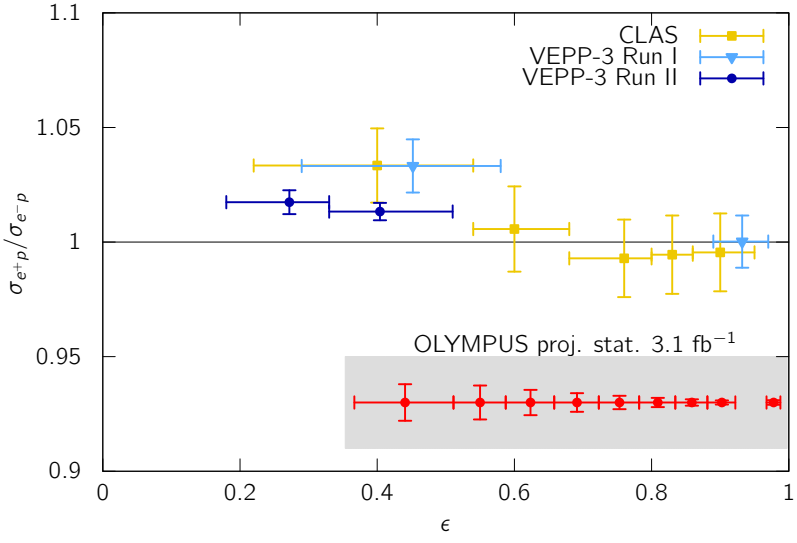
CLAS results



VEPP-3 results

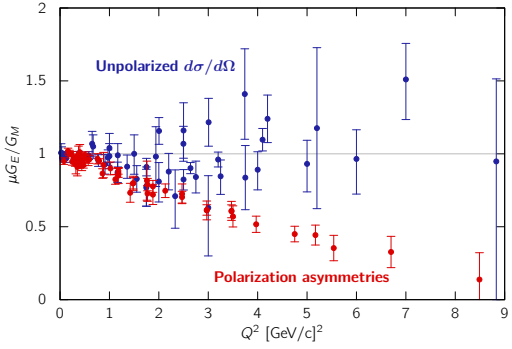


Projected OLYMPUS precision



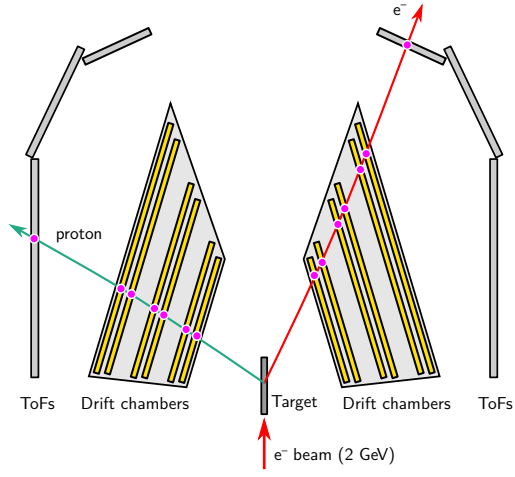
The important points

- $\sigma_{e^+p}/\sigma_{e^-p}$ will say if two-photon exchange causes the form factor discrepancy.



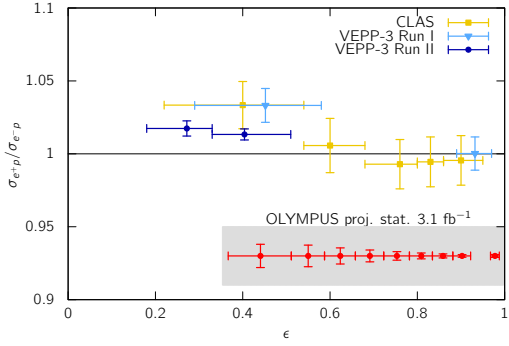
The important points

- $\sigma_{e^+p}/\sigma_{e^-p}$ will say if two-photon exchange causes the form factor discrepancy.
- OLYMPUS experiment
  - Alternating e^+, e^- beams
  - Toroidal spectrometer
  - Redundant lumi monitors



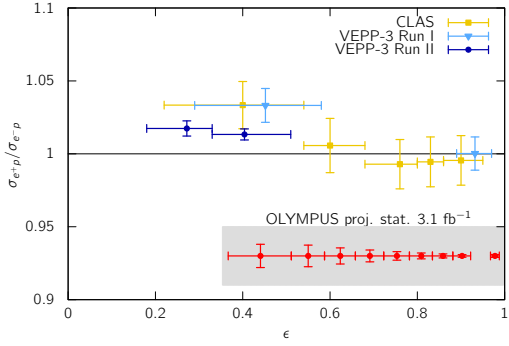
The important points

- $\sigma_{e^+p}/\sigma_{e^-p}$ will say if two-photon exchange causes the form factor discrepancy.
- OLYMPUS experiment
  - Alternating e^+, e^- beams
  - Toroidal spectrometer
  - Redundant lumi monitors
- OLYMPUS results will strongly constrain two-photon exchange.



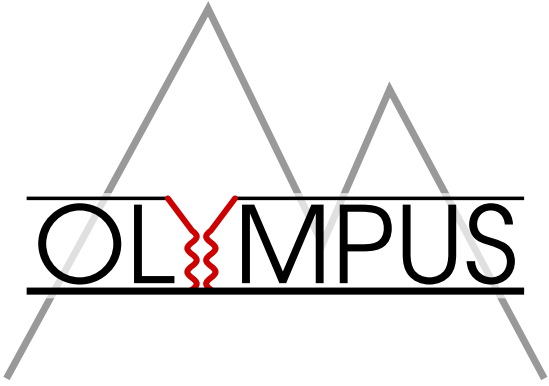
The important points

- $\sigma_{e^+p}/\sigma_{e^-p}$ will say if two-photon exchange causes the form factor discrepancy.
- OLYMPUS experiment
  - Alternating e^+, e^- beams
  - Toroidal spectrometer
  - Redundant lumi monitors
- OLYMPUS results will strongly constrain two-photon exchange.

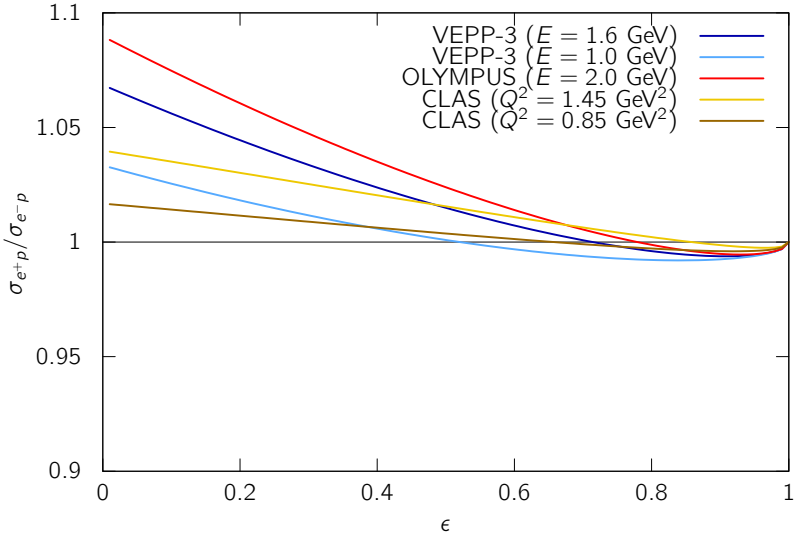


Expect results very soon!

Back-up slides



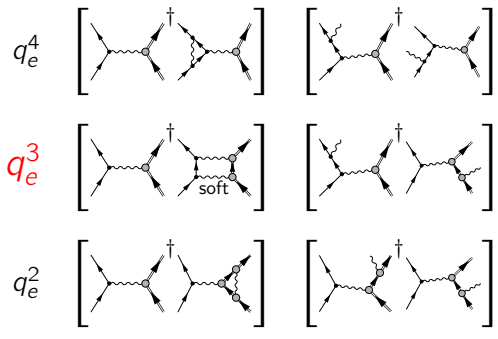
Bernauer prediction for all three experiments

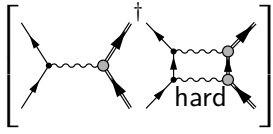


Standard radiative corrections neglect hard two-photon exchange.

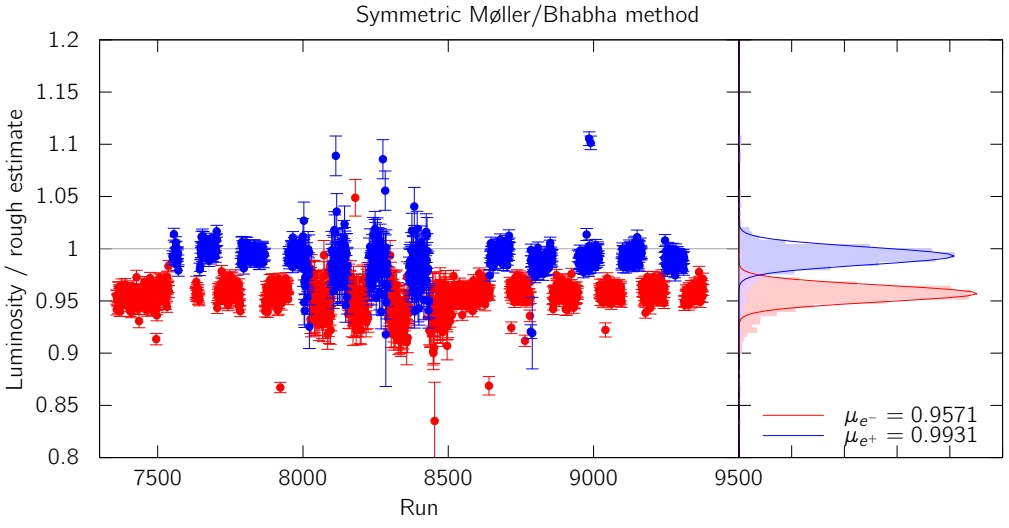
Standard corrections

Not included

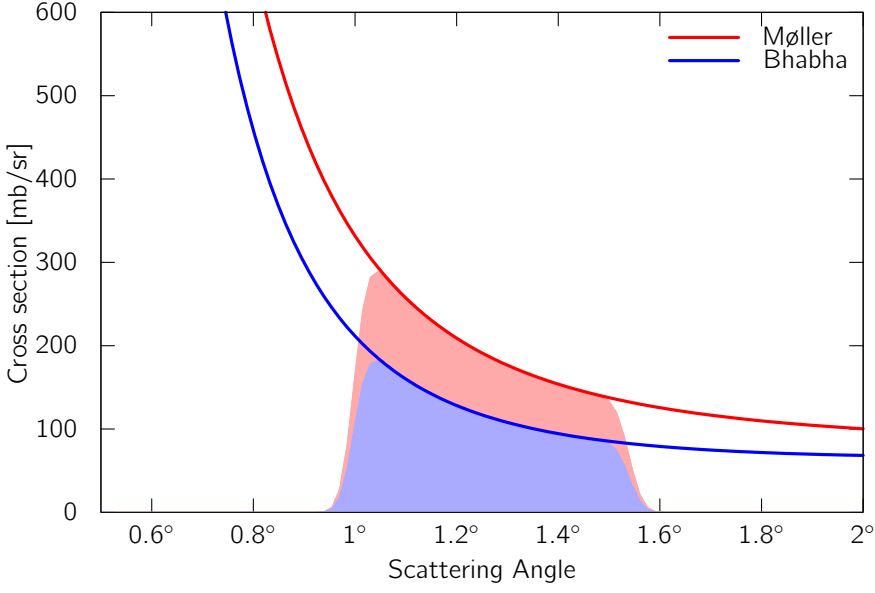




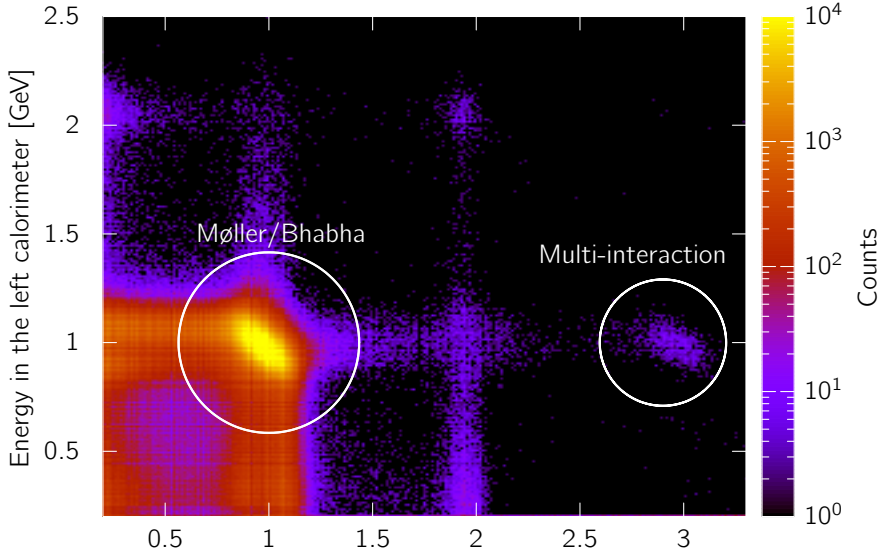
The Møller/Bhabha analysis was not successful.



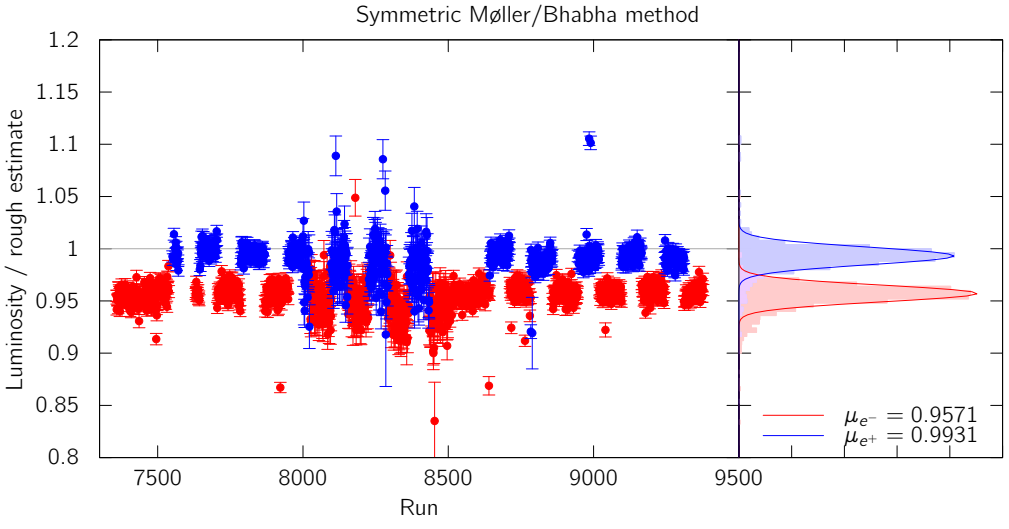
The Møller and Bhabha cross sections are quite different.



We designed a better method using multi-interaction events.



The multi-interaction method is accurate to within 0.3%.



The multi-interaction method is accurate to within 0.3%.