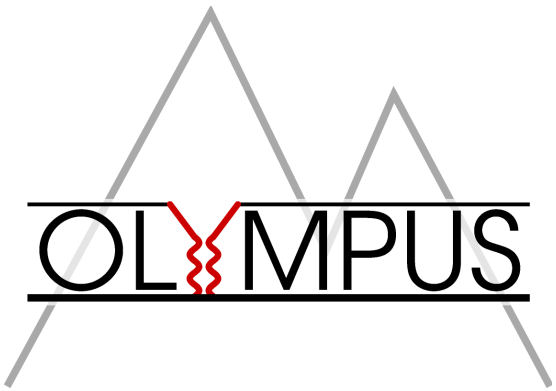
Hard Two-Photon Contribution to Elastic Lepton-Proton Scattering Determined by the OLYMPUS Experiment

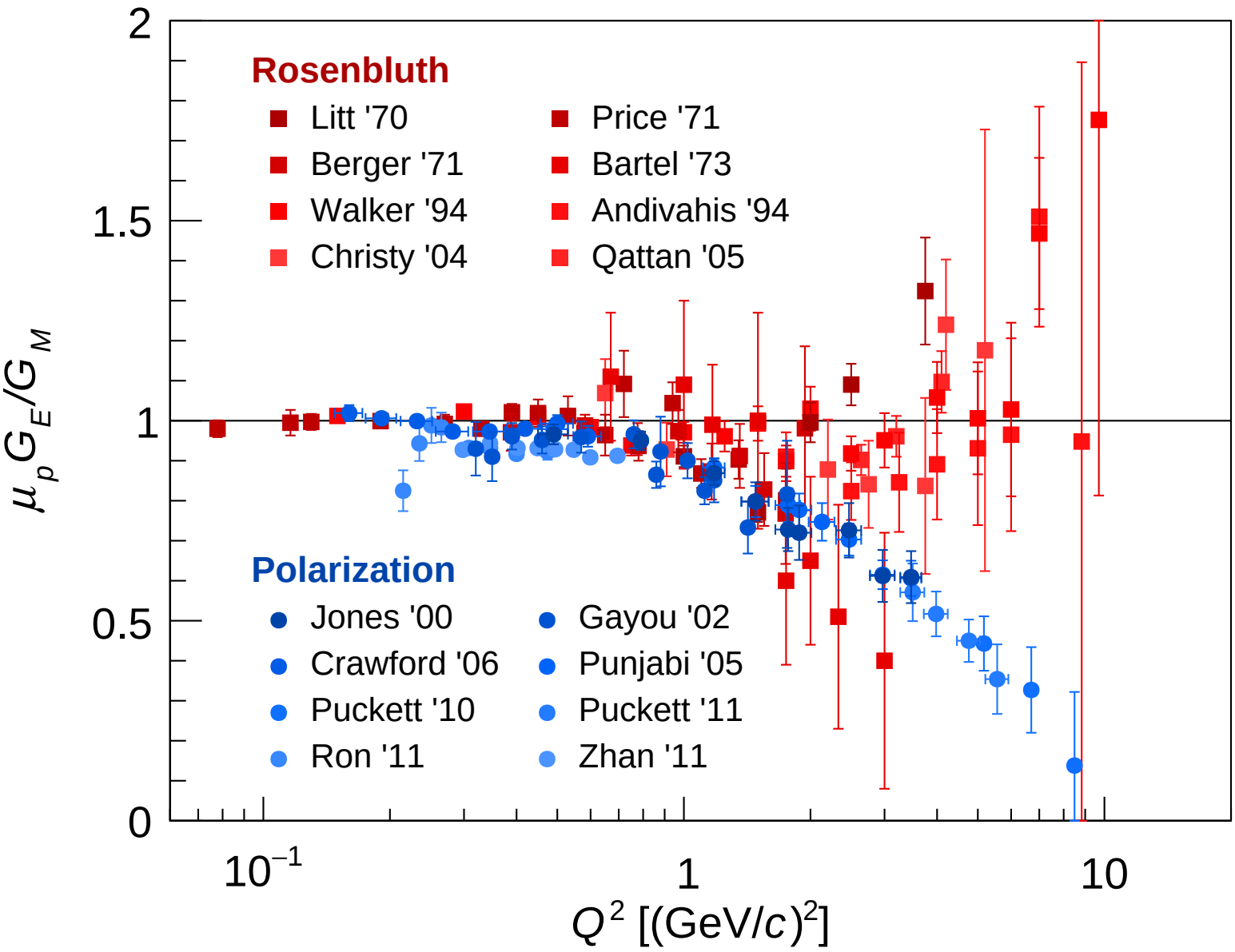
Dmitry Khaneft for the OLYMPUS collaboration

Johannes Gutenberg University of Mainz
Helmholtz-Institute Mainz

Deep Inelastic Scattering
Birmingham, April 4, 2017

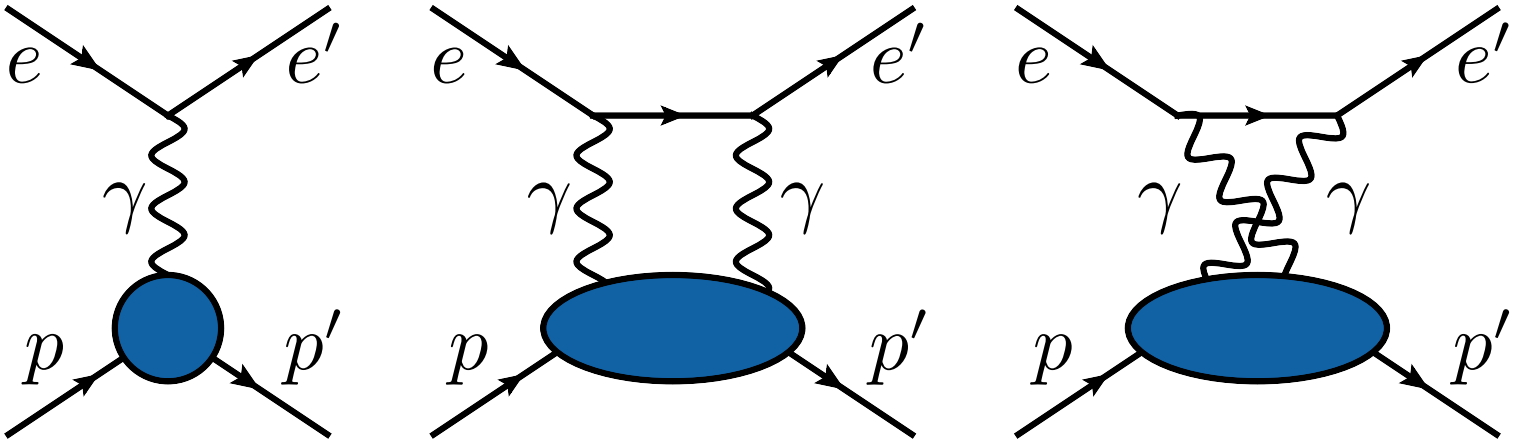


One Value - Two Methods - Two Results



The (Probable) Cause

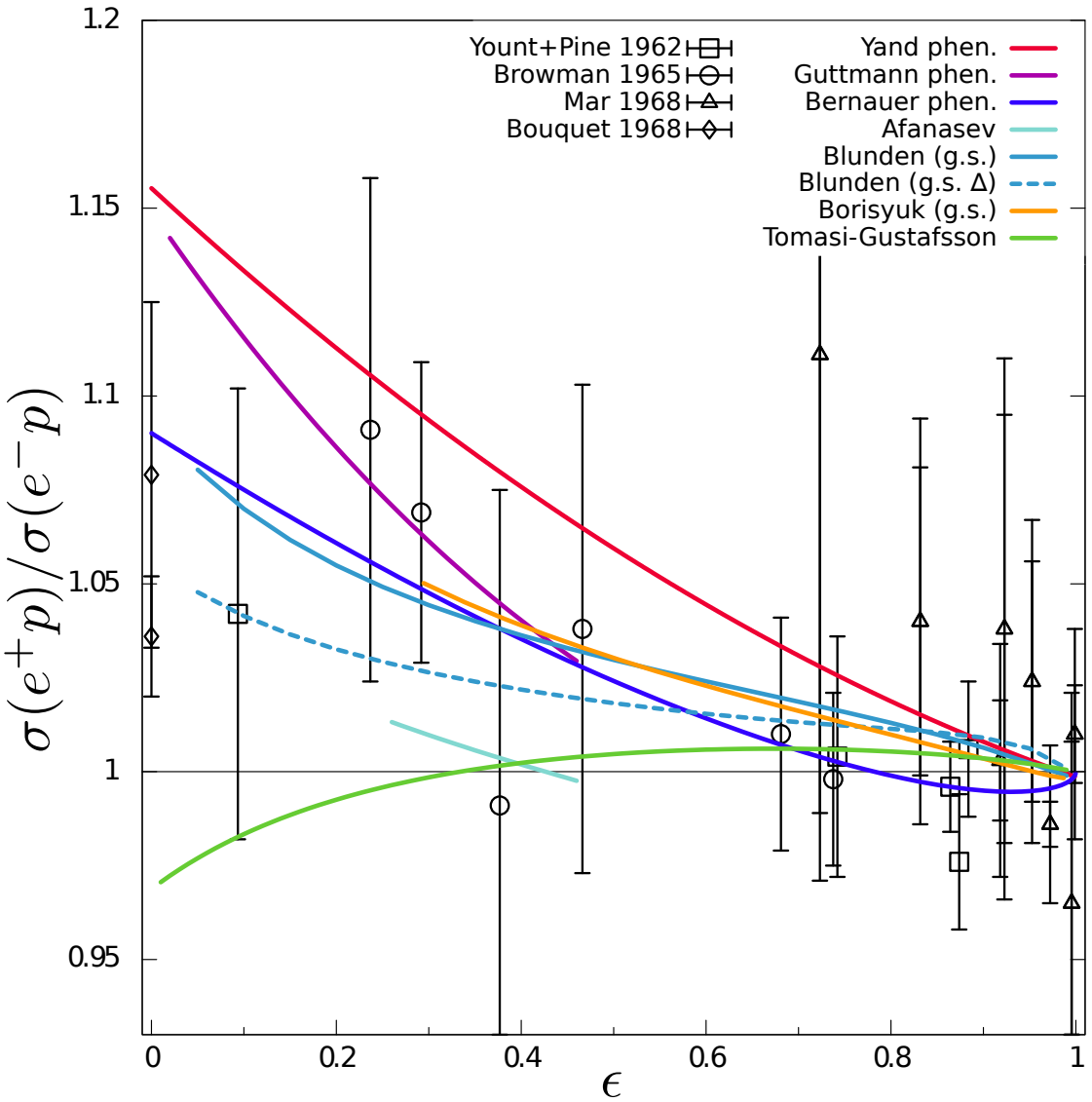
Unaccounted two-photon exchange



How to measure

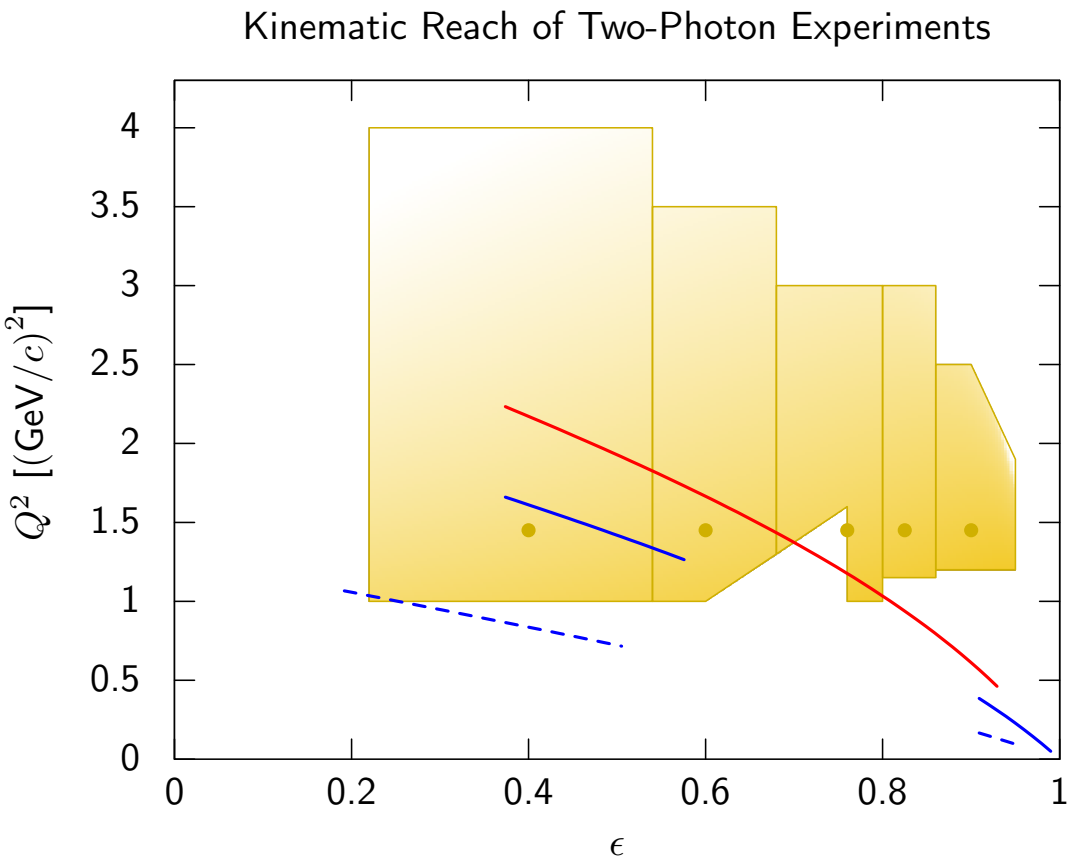
$$R_{2\gamma} = \frac{\sigma_{e^+p}}{\sigma_{e^-p}} = \frac{|\mathcal{M}^{e^+}_{1\gamma}|^2 + 2\mathcal{R}(\mathcal{M}^{e^+}_{1\gamma}\mathcal{M}^{e^+}_{2\gamma})}{|\mathcal{M}^{e^-}_{1\gamma}|^2 - 2\mathcal{R}(\mathcal{M}^{e^-}_{1\gamma}\mathcal{M}^{e^-}_{2\gamma})}$$

Situation Until Recently

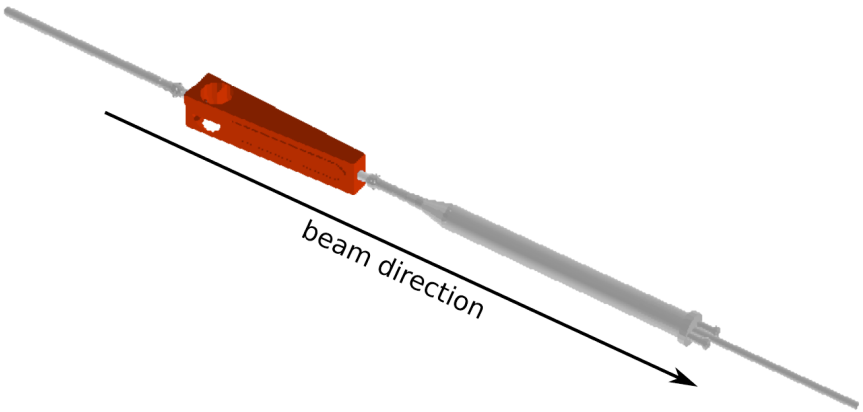


Modern TPE Experiments

- CLAS
  - 0.5-3.5 GeV $e^{\pm}$ beams
  - arXiv:1411.6908
- VEPP-3
  - 1/1.6 $e^{\pm}$ GeV beam
  - arXiv:1411.7372
- OLYMPUS
  - 2 GeV $e^{\pm}$ beams
  - arXiv:1611.04685



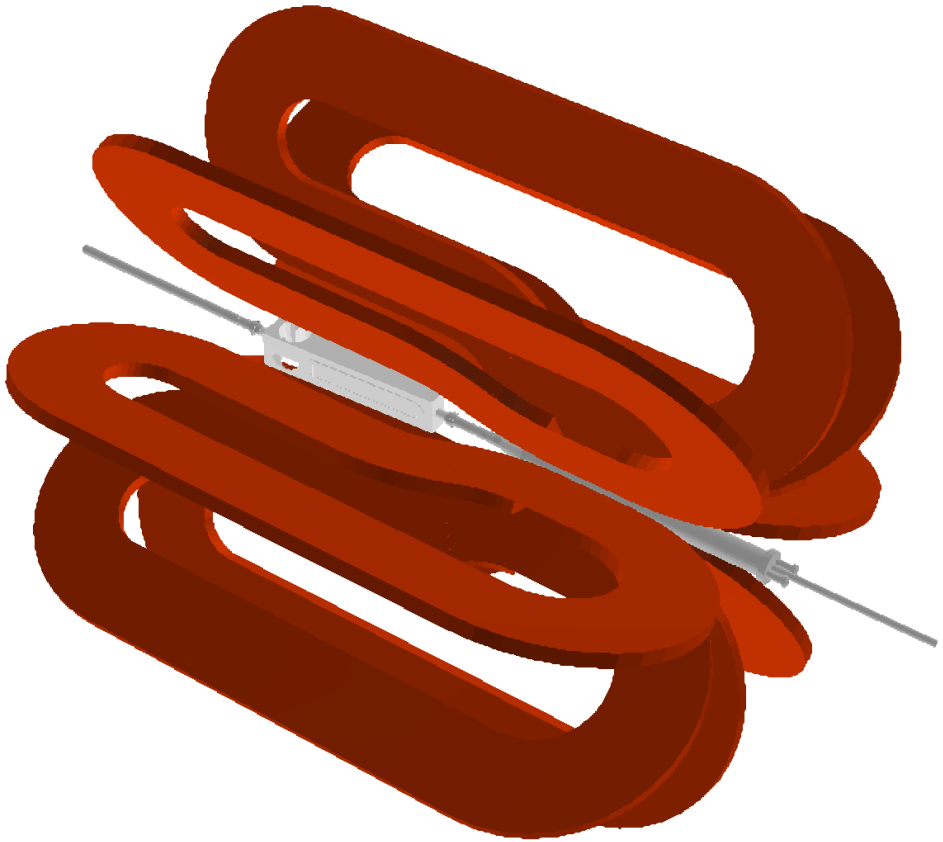
OLYMPUS detector



Target chamber

- Hydrogen gas target
- Cooled to >70 K

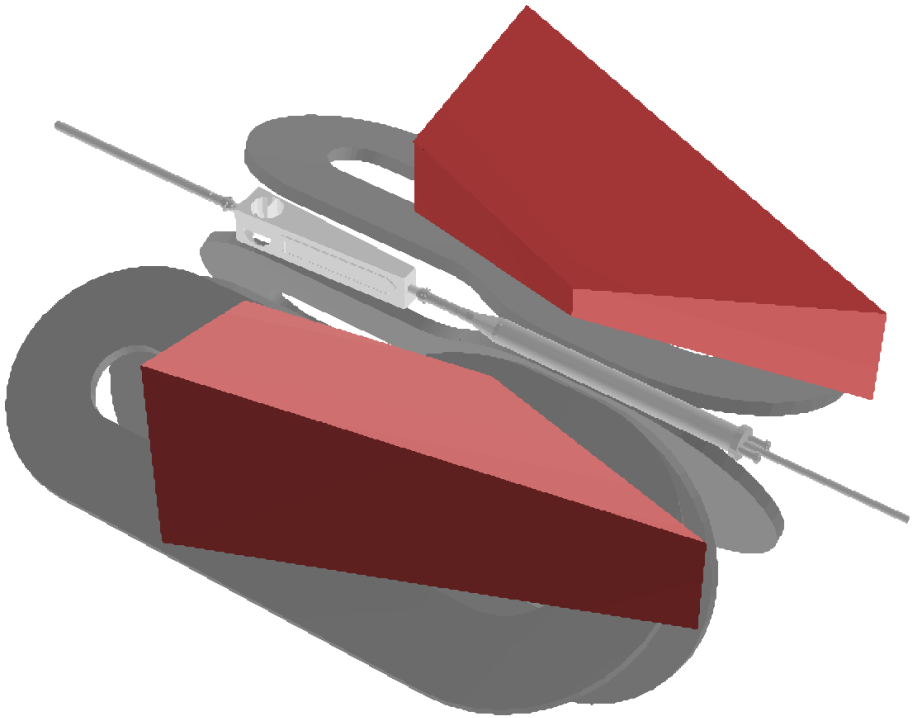
OLYMPUS detector



Toroid magnet

- Current 5000 A
- Field 0.28 T

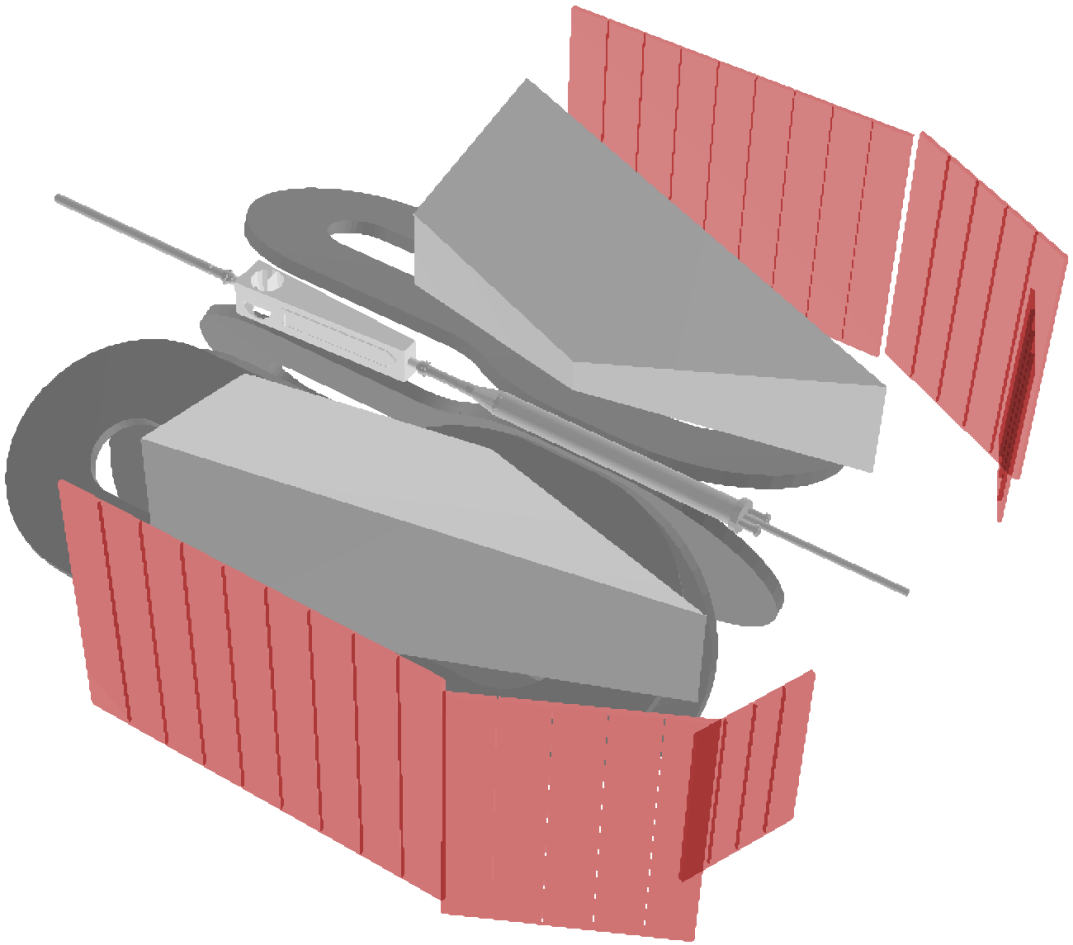
OLYMPUS detector



Drift chambers

- $20^\circ < \theta < 80^\circ$
- -15° $< \phi <$ 15°

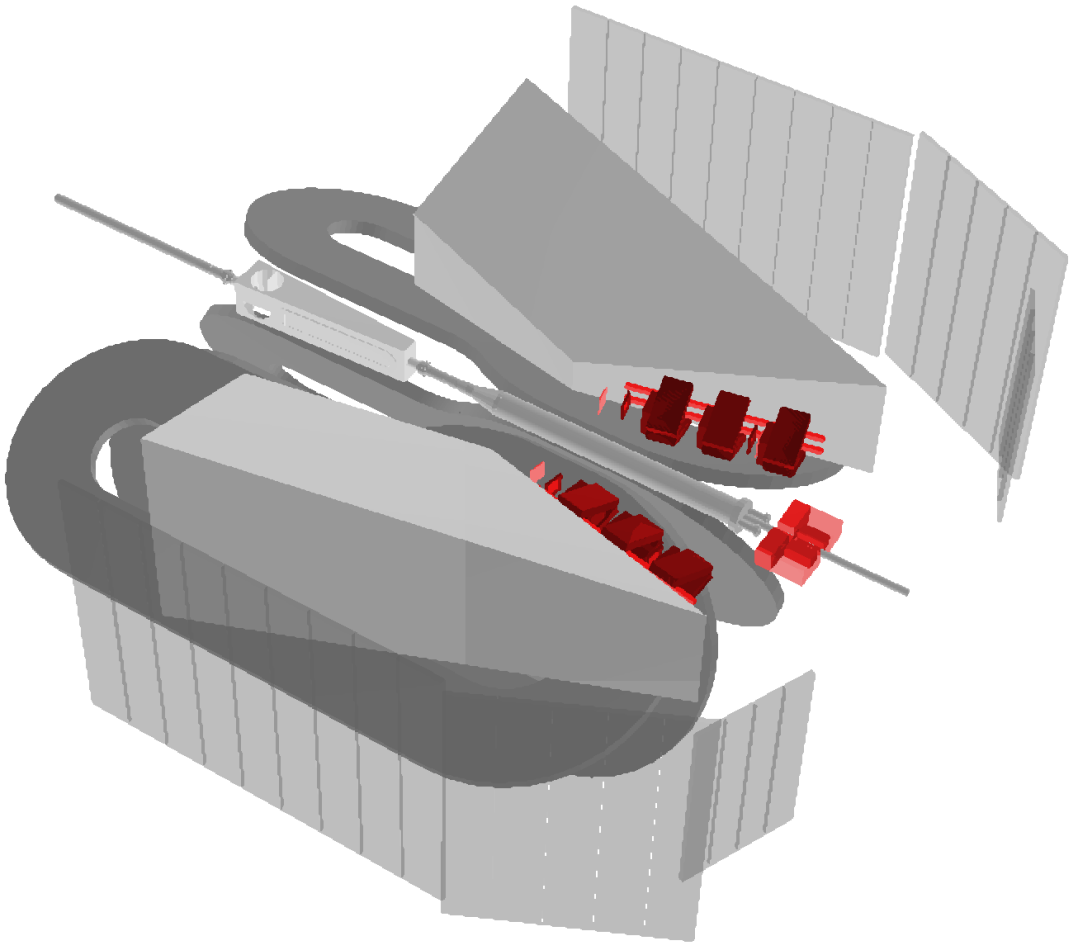
OLYMPUS detector



Time of flight

- Main trigger
- Particle ID

OLYMPUS detector



Luminosity monitors

- Slow control
- 12° detector
- Symmetric Møller/Bhabha monitor

Luminosity Measurements

Slow Control:

- On-line luminosity measurement using running conditions
- Absolute uncertainty 5 %, relative 2 %

12° MWPC monitor:

- Elastic lepton-proton scattering
- Absolute uncertainty 2.4 %, relative 0.46 %

Symmetric Møller/Bhabha monitor:

- Multi-interaction lepton-lepton and lepton-proton events (MIE)
- 0.1 % statistical, 0.27 % systematic

Luminosity Measurements

MIE methods was chosen as the most accurate

TPE at 1.29° is negligible

- $\langle Q^2 \rangle = 0.002 GeV^2$
- $\langle \epsilon \rangle = 0.99975$

TPE was also measured at 12° using MPWC

- $\langle Q^2 \rangle = 0.165 GeV^2$
- $\langle \epsilon \rangle = 0.98$

Timeline

2007
- Letter of Intent

2008
- OLYMPUS Proposal approved

2010
- BLAST detector shipped from MIT to DESY

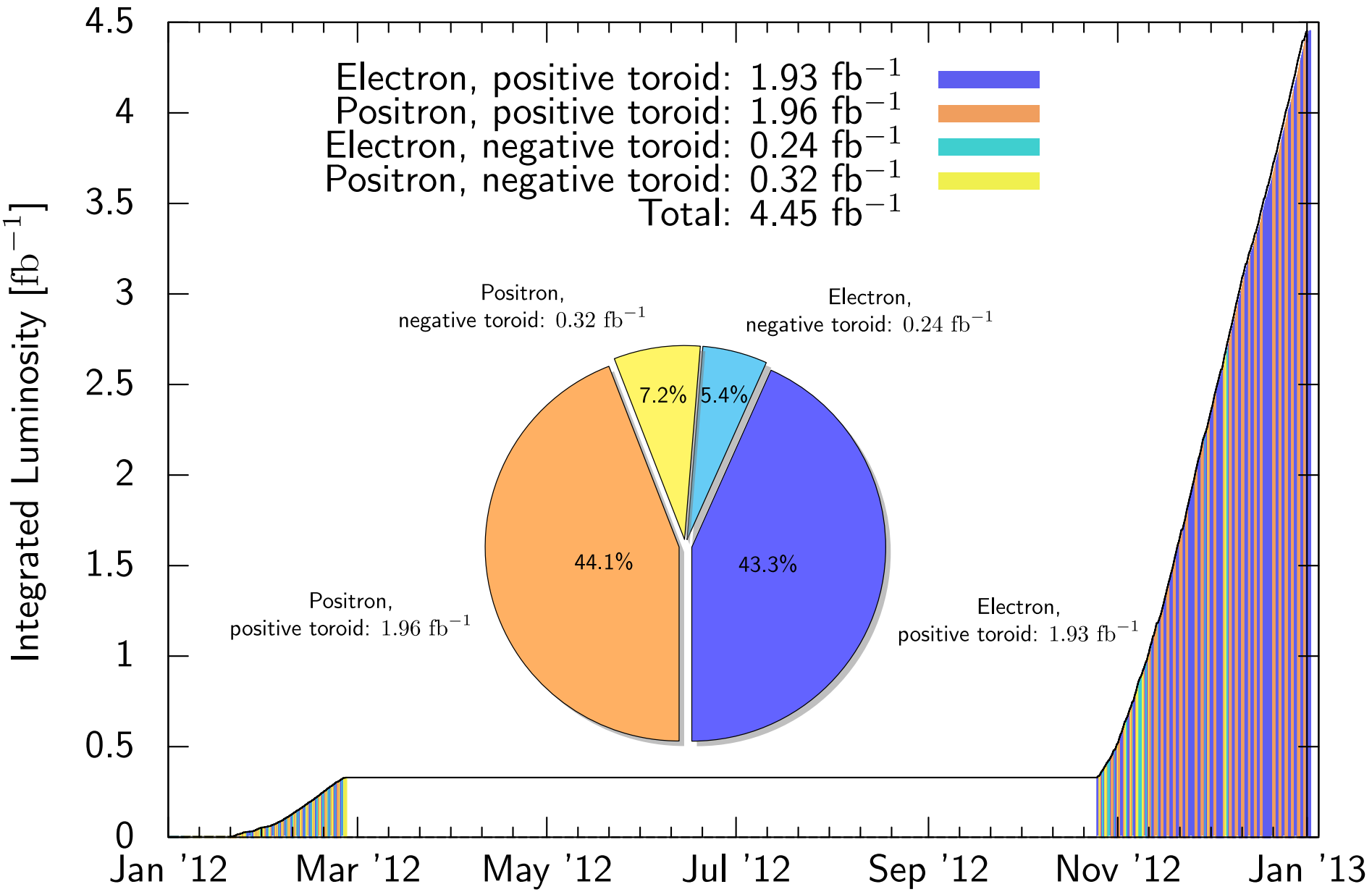
2011
- Commissioning

2012-2013
- Run I, improvements, Run II

2013
- Cosmic runs
- Detector and magnetic field surveys
- Beam position monitor calibration

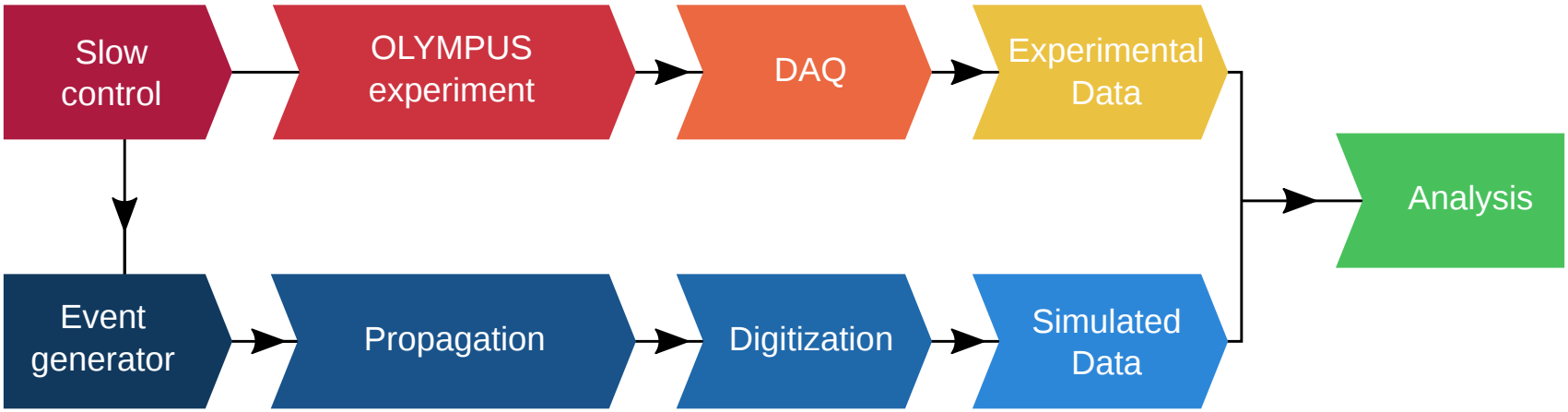
2013-2016
- Data analysis

Collected Luminosity

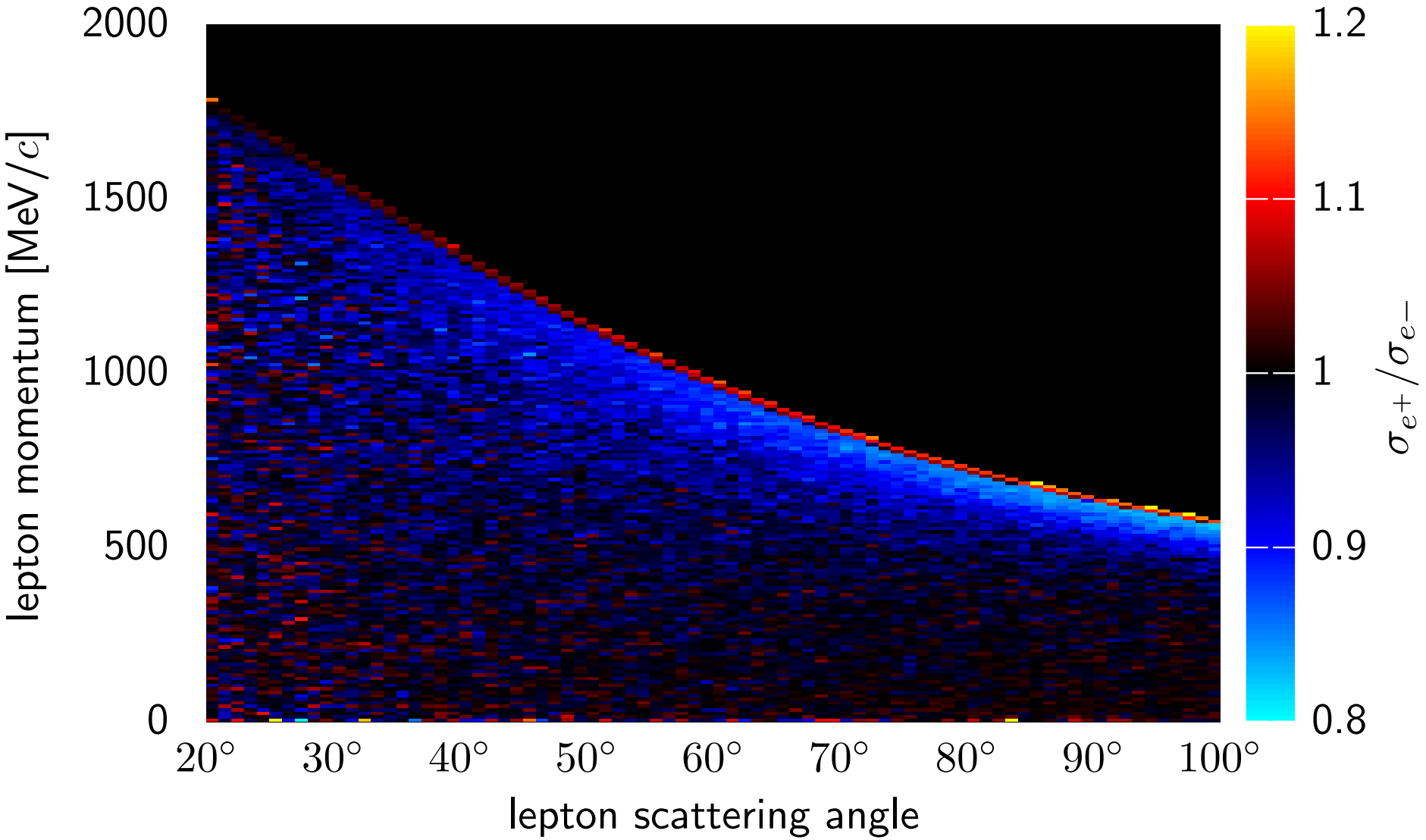


Analysis Chain

- Experimental and simulated data have the same format
- Experimental and simulated data are analyzed with the same code

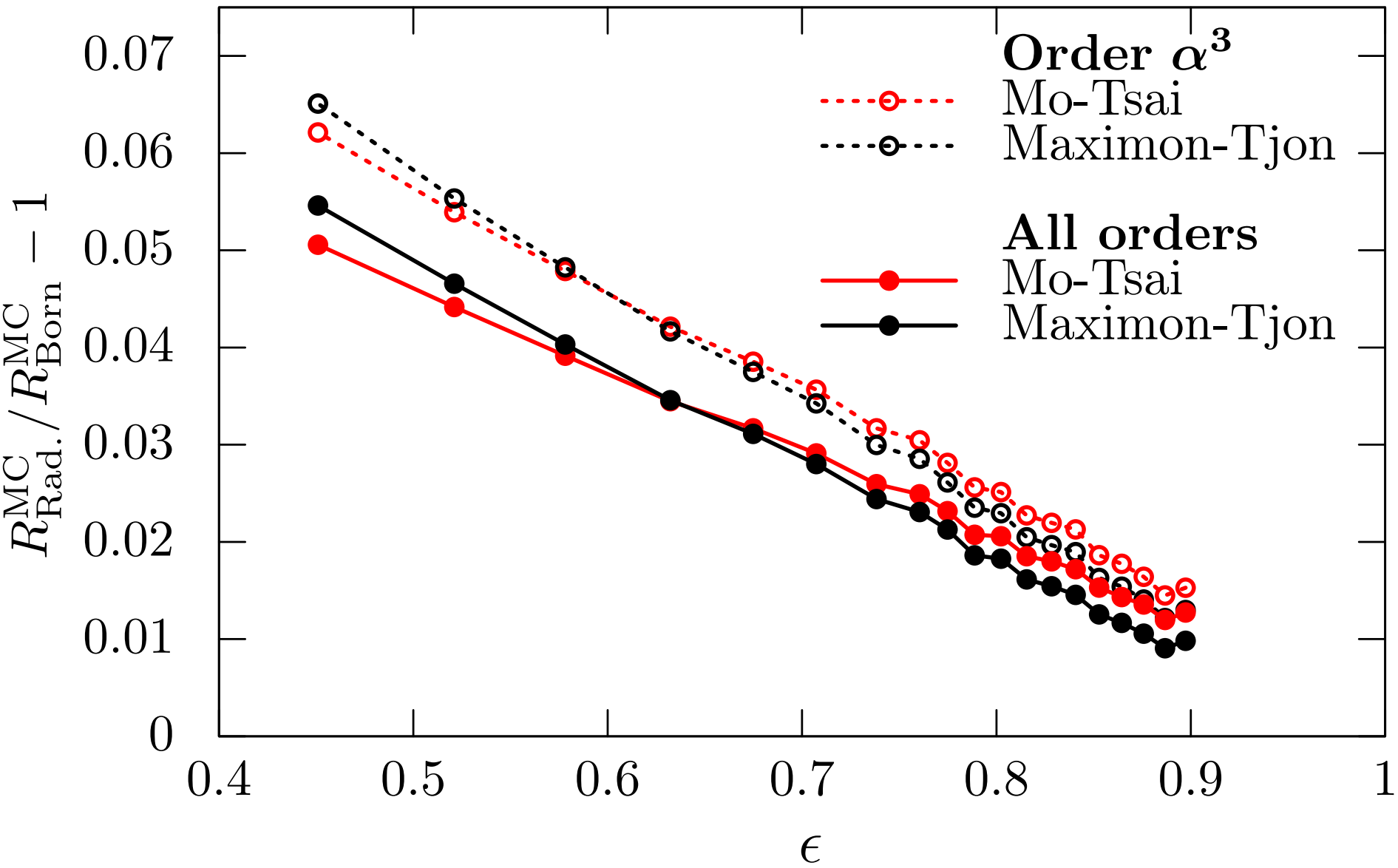


Radiative Corrections



Jan Bernauer, Rebecca Russell, and Axel Schmidt, MIT

Radiative Corrections



Analysis Procedure

Four* analyses with the same:

- experimental data samples
- simulated data samples
- Q^2 and ϵ binning
- yield normalization the SYMB-MIE luminosity

and different:

- particle identification
- cuts' size

Results are a combination of the four analyses

*Axel Schmidt, Brian Henderson, Colton O'Connor, Rebecca Russel

First OLYMPUS Results

PRL 118, 092501 (2017) PHYSICAL REVIEW LETTERS week ending 3 MARCH 2017

Hard Two-Photon Contribution to Elastic Lepton-Proton Scattering Determined by the OLYMPUS Experiment

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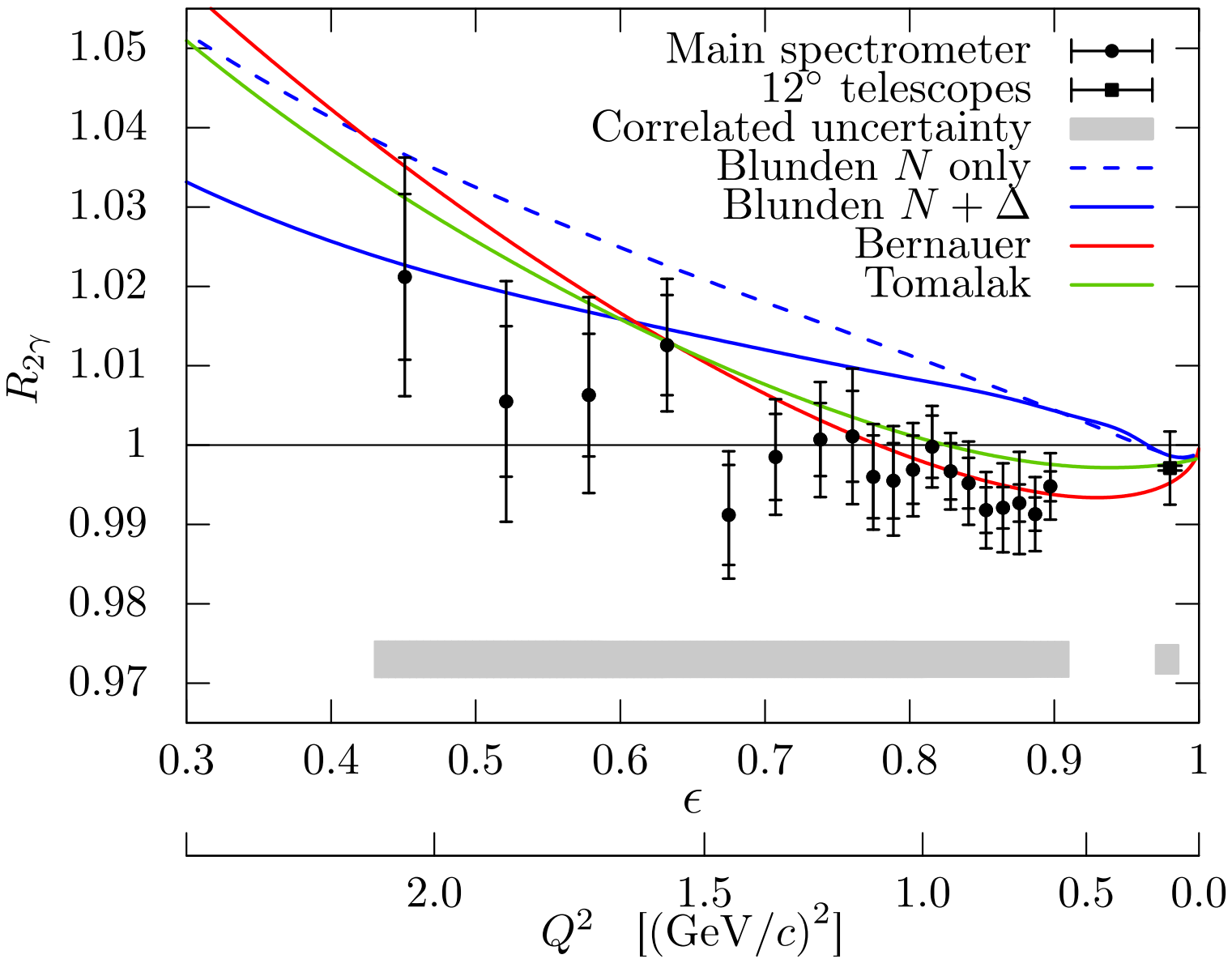
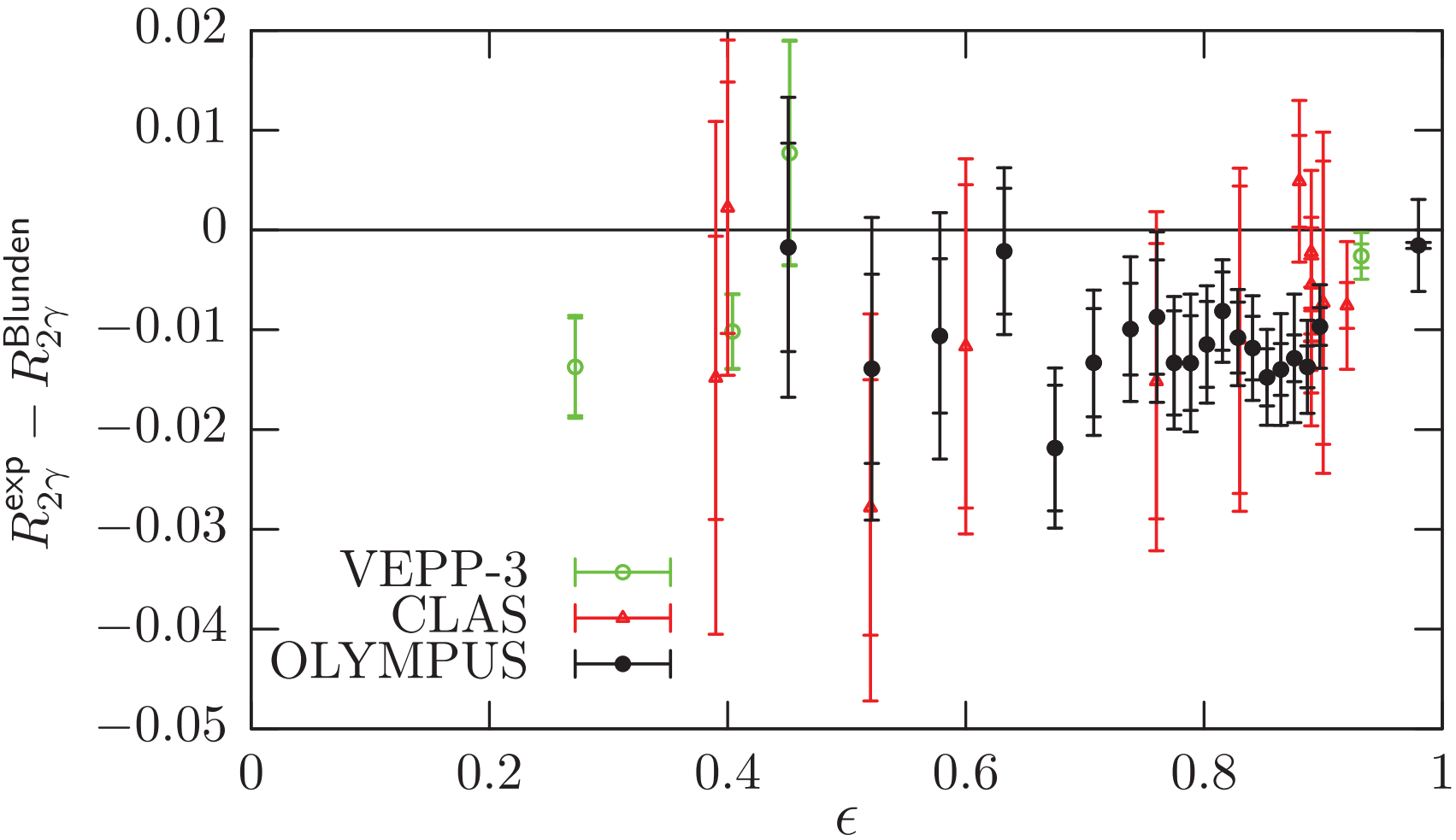
(OLYMPUS Collaboration)

First OLYMPUS Results



OLYMPUS - CLAS - VEPP-3 Comparison



Conclusion

- All three modern experiments show similar results
- Data indicates that TPE is small at lower Q^2
- More experimental data are needed at higher energies