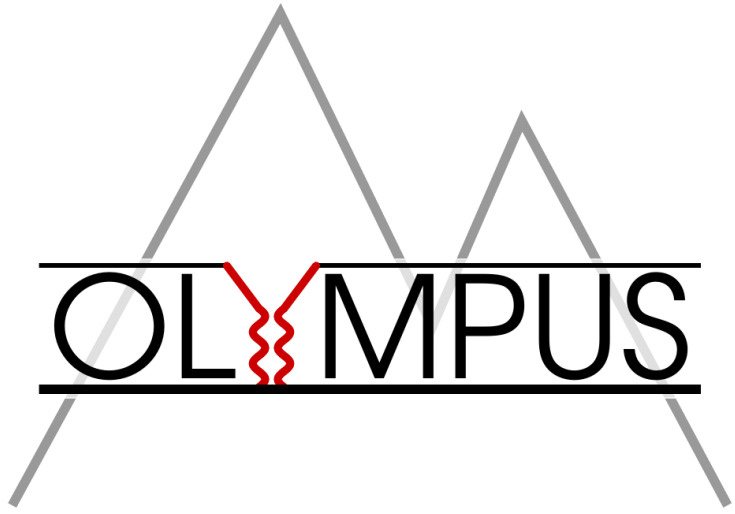
Overview and Status of



Rebecca Russell
Massachusetts Institute of Technology

April 3, APS April Meeting 2012

for the Olympus collaboration

Proton form factors

- Elastic *ep* scattering
- The Rosenbluth separation method at constant Q^2

Rosenbluth Formula

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{\text{Mott}} \frac{G_E^2 + \frac{\tau}{\varepsilon} G_M^2}{1+\tau}$$

where $\tau = Q^2/4M^2$ and $\varepsilon = [1 + 2(1+\tau)\tan^2(\theta/2)]^{-1}$

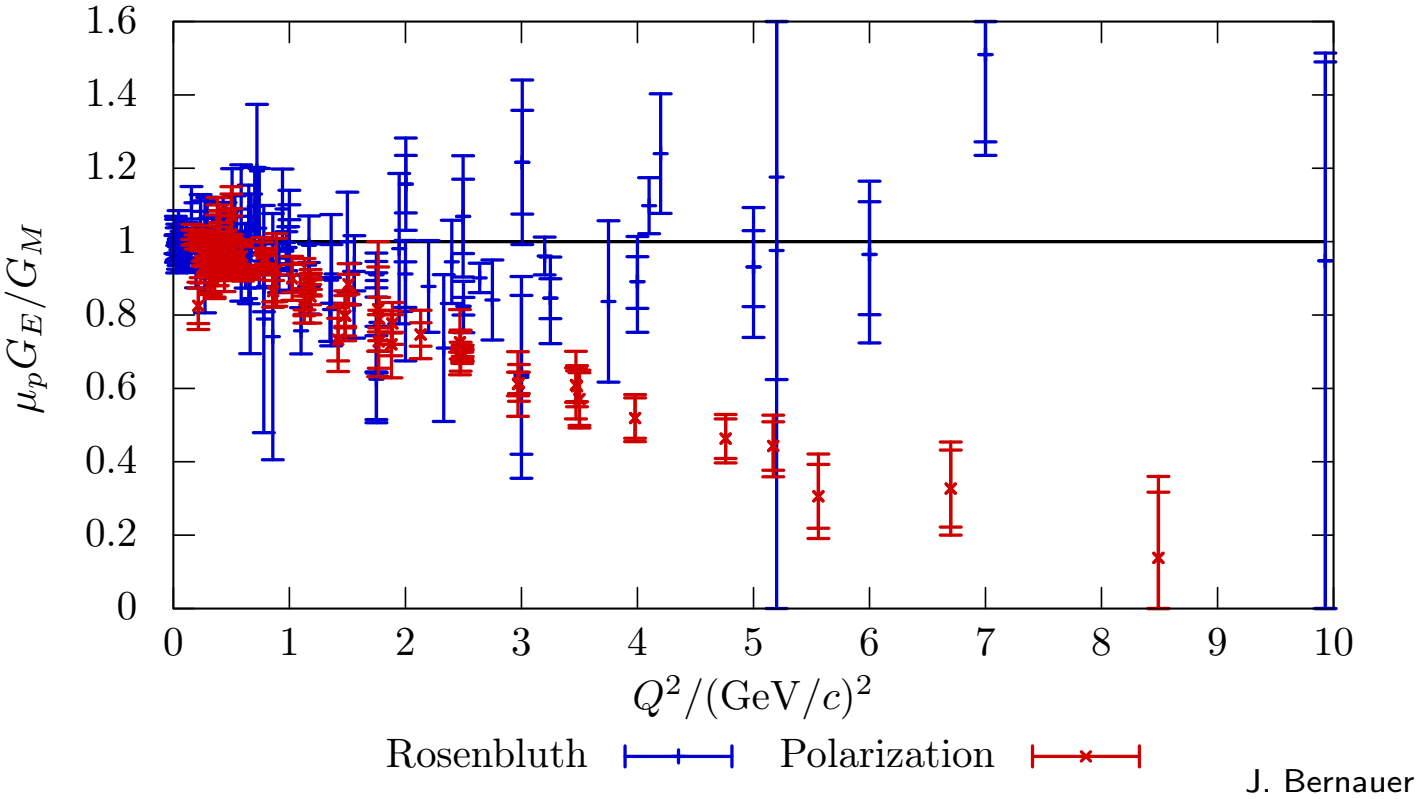
- New techniques with polarized beams and targets

Form factor ratio from polarization transfer

$$\frac{G_E}{G_M} = \frac{\mathcal{P}_t}{\mathcal{P}_\ell} \times (\text{kinematic factor})$$

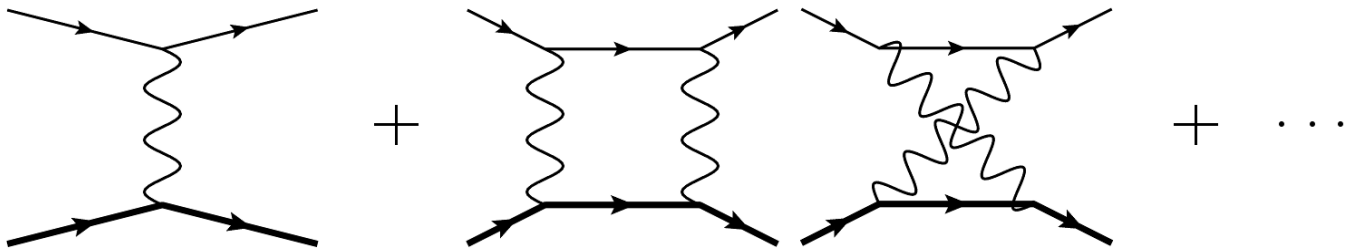
Form factor ratio discrepancy

The two methods do not agree!



Large two-photon exchange correction to Rosenbluth data?

Measuring the two-photon effect



- Odd α power in interference term

$$\sigma_{e^{\pm}p} = |\mathcal{M}_{1\gamma}|^2 \pm 2\Re\{\mathcal{M}_{1\gamma}^{\dagger}\mathcal{M}_{2\gamma}\} + \cdots$$

- e^+/e^- ratio sensitive to two-photon contribution

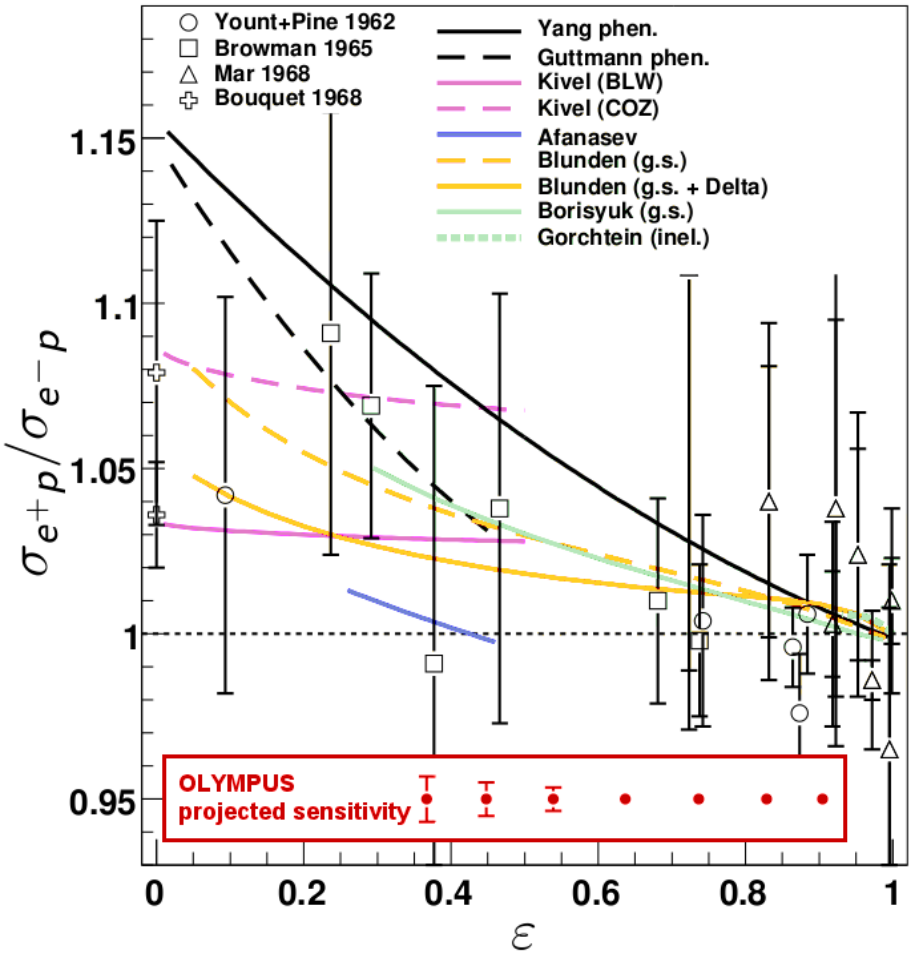
$$\frac{\sigma_{e^+p}}{\sigma_{e^-p}} \approx 1 + 4\frac{\Re\{\mathcal{M}_{1\gamma}^{\dagger}\mathcal{M}_{2\gamma}\}}{|\mathcal{M}_{1\gamma}|^2}$$

Status of measurements

- No precise measurements at low ε or high Q^2

The OLYMPUS experiment

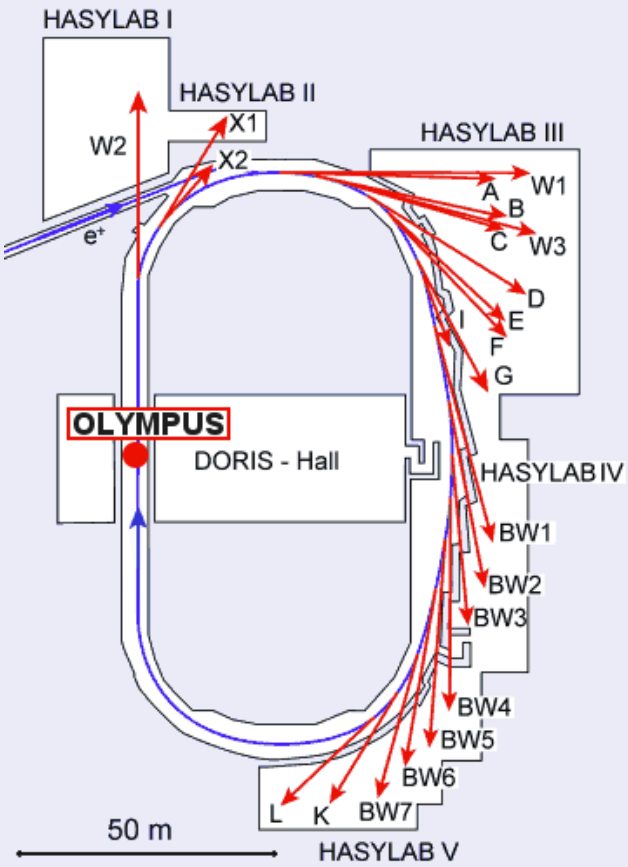
$$E = 2 \text{ GeV}$$
$$0.6 \text{ GeV}^2 \leq Q^2 \leq 2.2 \text{ GeV}^2$$
$$0.3 \leq \varepsilon \leq 0.9$$
Measure ratio to $< 1\%$



- Two other ongoing experiments: at JLab and Novosibirsk

Conception of the experiment

OLYMPUS in DORIS



- Large acceptance spectrometer

  BLAST at MIT-Bates

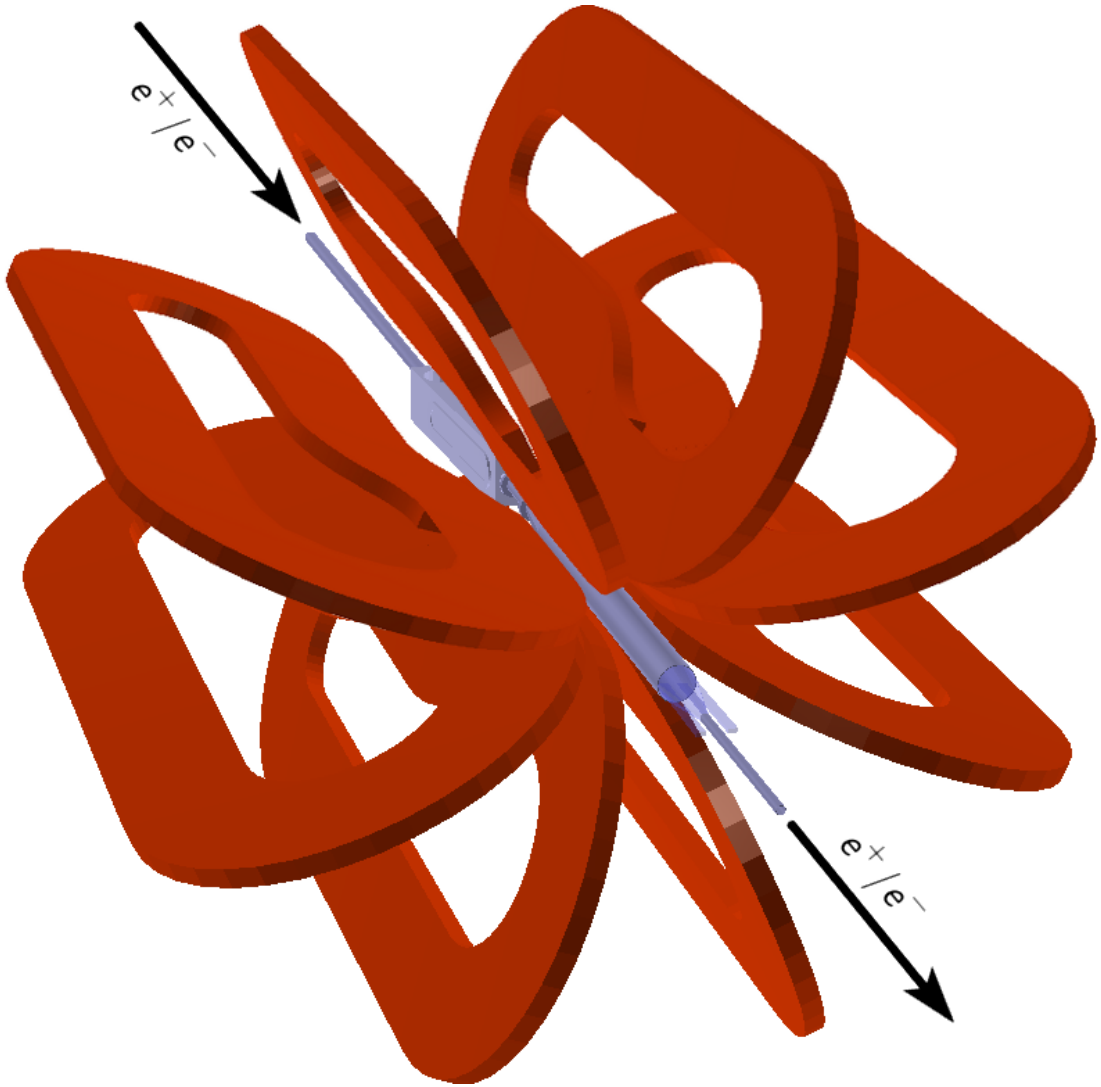
- 2 GeV electrons and positrons

  DORIS at DESY

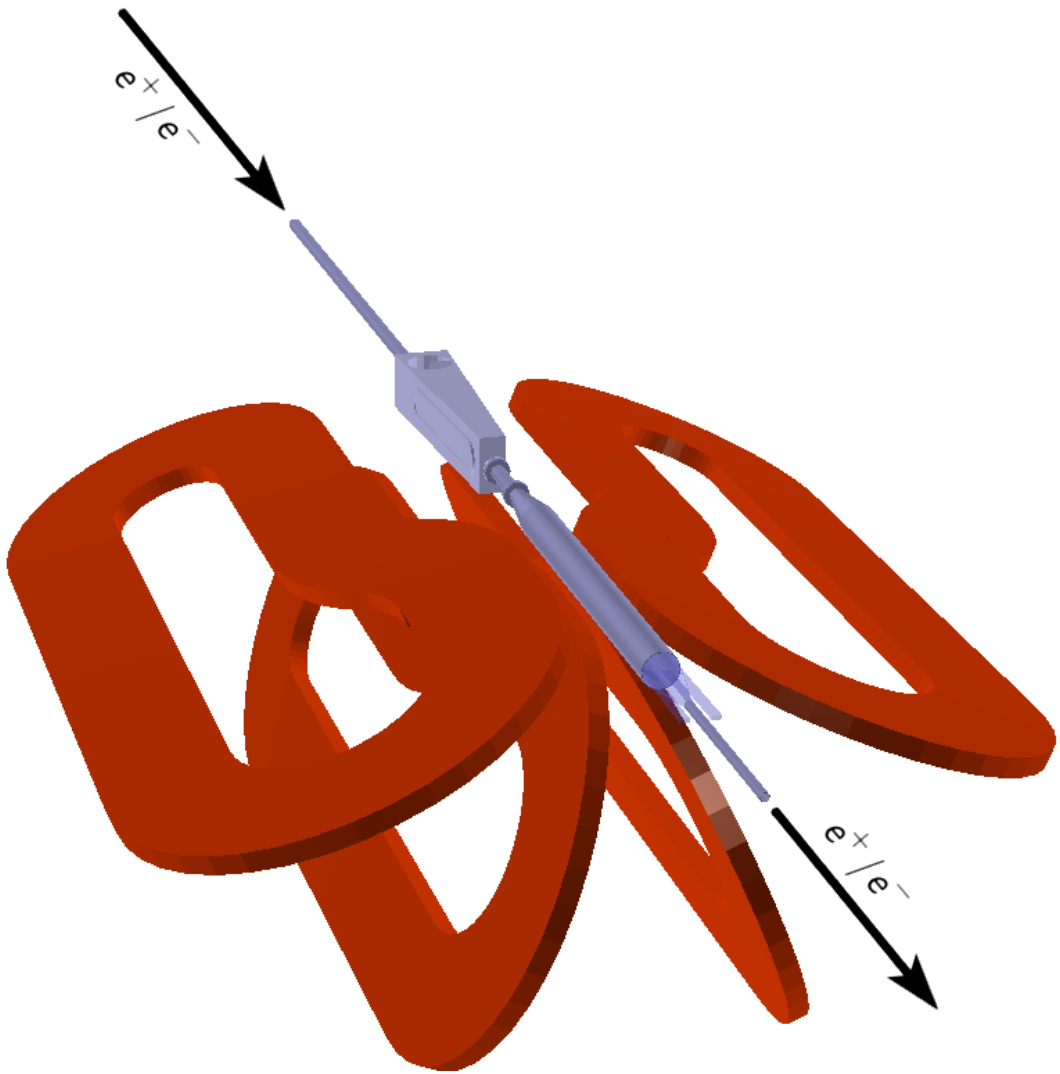
- BLAST moved to Hamburg, Germany

- Upgrades and new sub-detectors

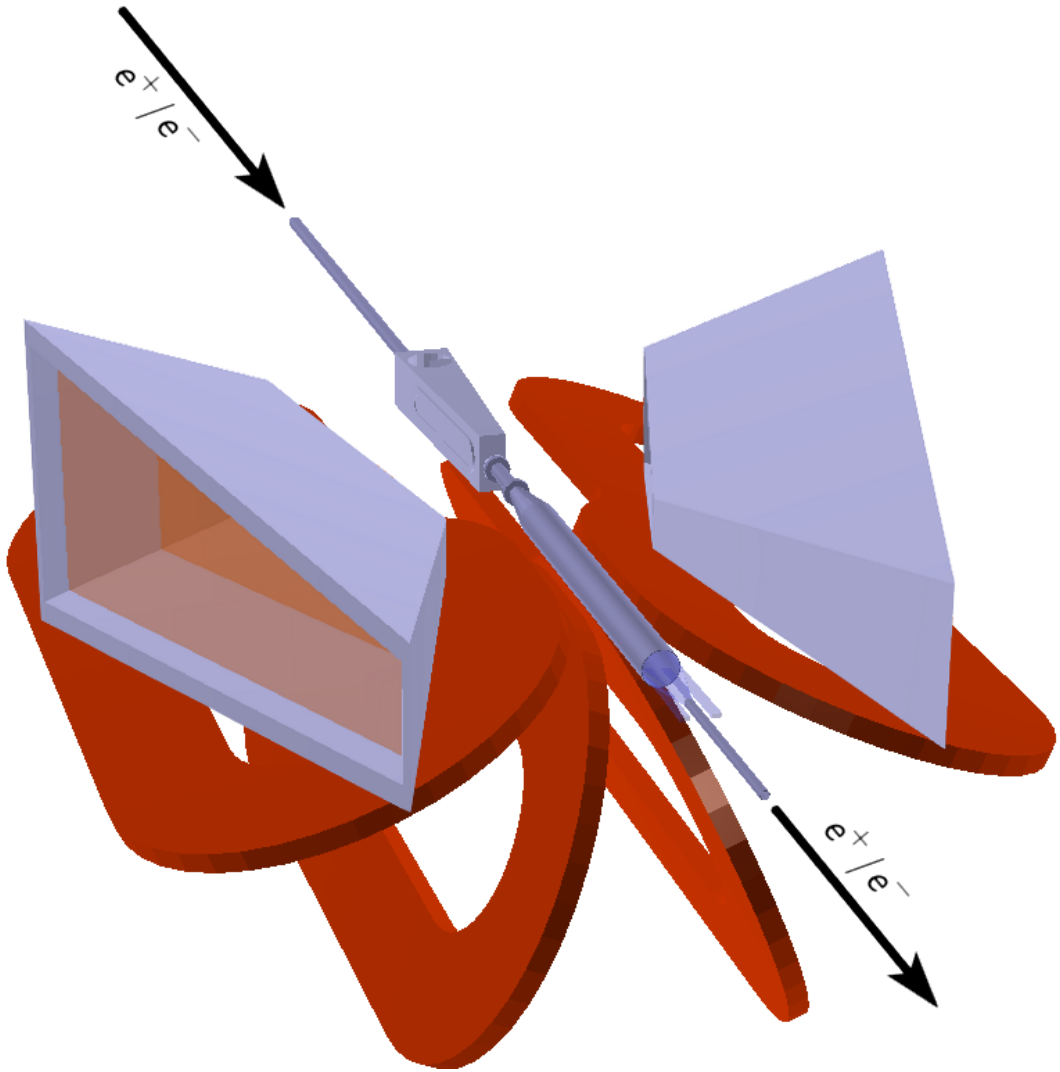
Toroidal magnet



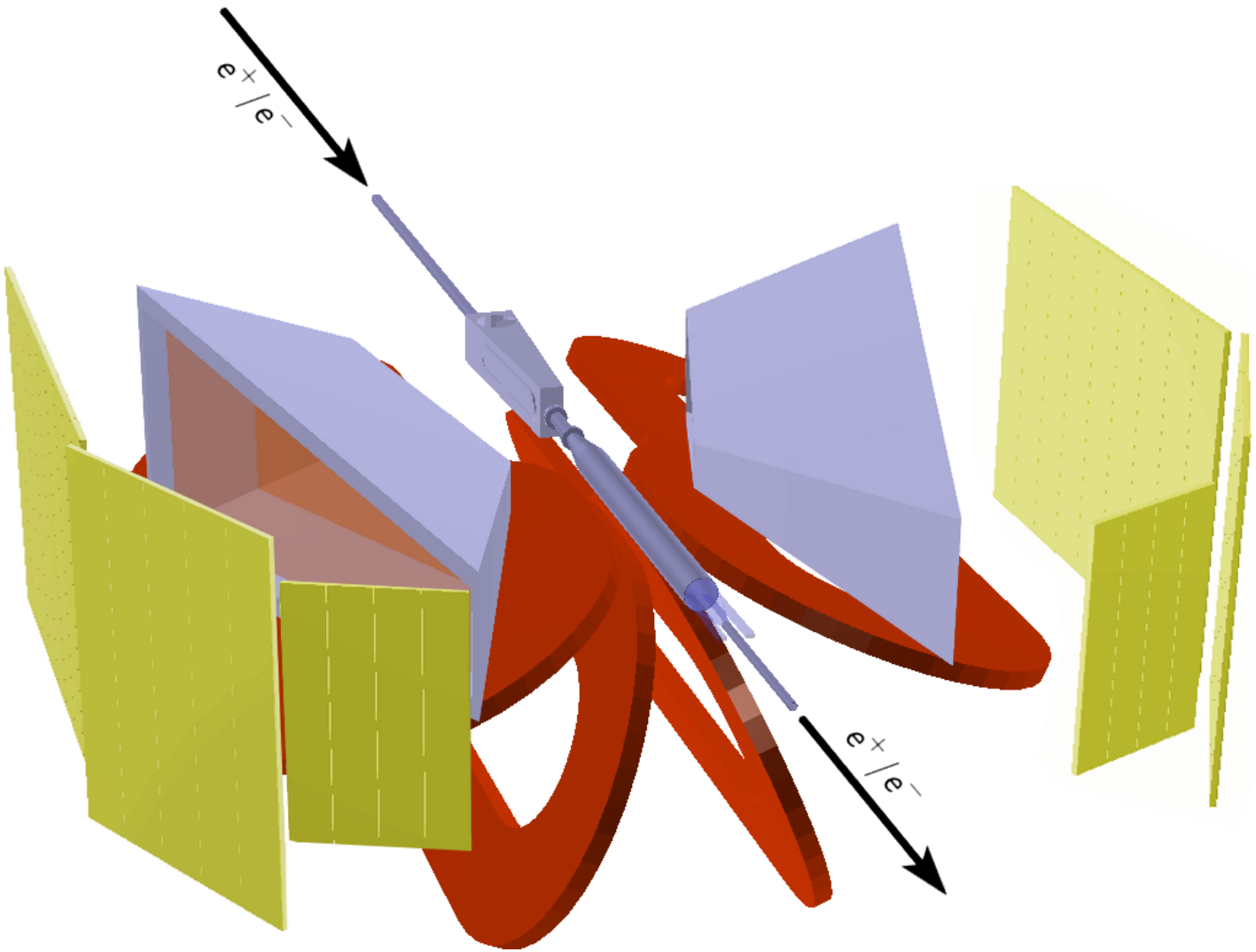
Internal hydrogen target



Drift chambers



Time of flight detectors



Measuring the cross section ratio

Small asymmetries in detector setup?

Measure the superratio

$$\frac{\sigma_{e^+}}{\sigma_{e^-}} = \sqrt{\frac{n_{(e^+,\uparrow)} n_{(e^+,\downarrow)}}{n_{(e^-,\uparrow)} n_{(e^-,\downarrow)}} \cdot \frac{n^{\text{lumi}}_{(e^-,\uparrow)} n^{\text{lumi}}_{(e^-,\downarrow)}}{n^{\text{lumi}}_{(e^+,\uparrow)} n^{\text{lumi}}_{(e^+,\downarrow)}}}$$

- Switch beam species regularly
- Switch magnet polarity regularly

Measuring the cross section ratio

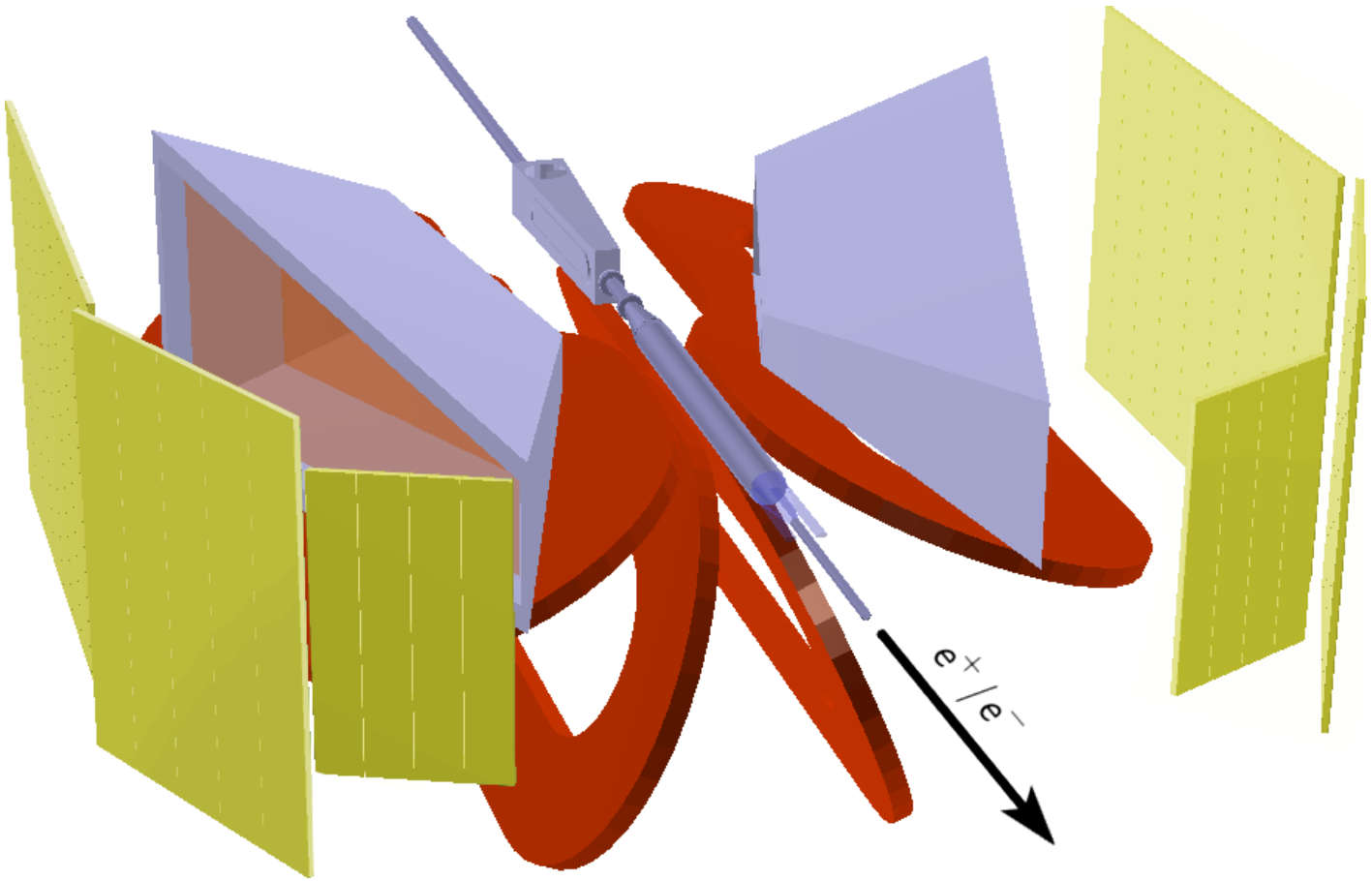
Variance in beam current and target density?

Measure the luminosity

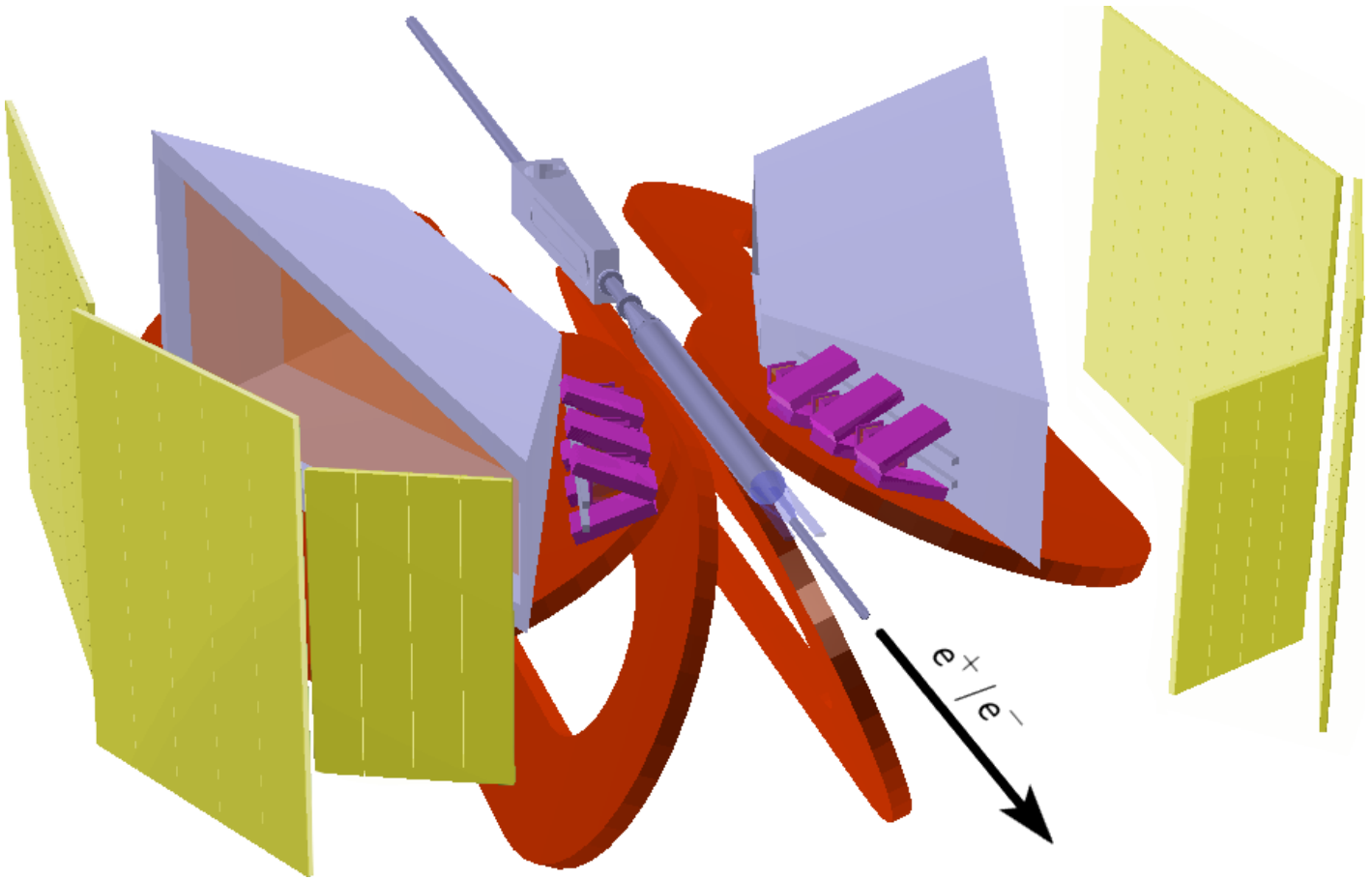
$$\frac{\sigma_{e^+}}{\sigma_{e^-}} = \sqrt{\frac{n_{(e^+,\uparrow)} n_{(e^+,\downarrow)}}{n_{(e^-,\uparrow)} n_{(e^-,\downarrow)}} \cdot \frac{n^{\text{lumi}}_{(e^-,\uparrow)} n^{\text{lumi}}_{(e^-,\downarrow)}}{n^{\text{lumi}}_{(e^+,\uparrow)} n^{\text{lumi}}_{(e^+,\downarrow)}}}$$

- Beam and target measurements
- Luminosity monitors

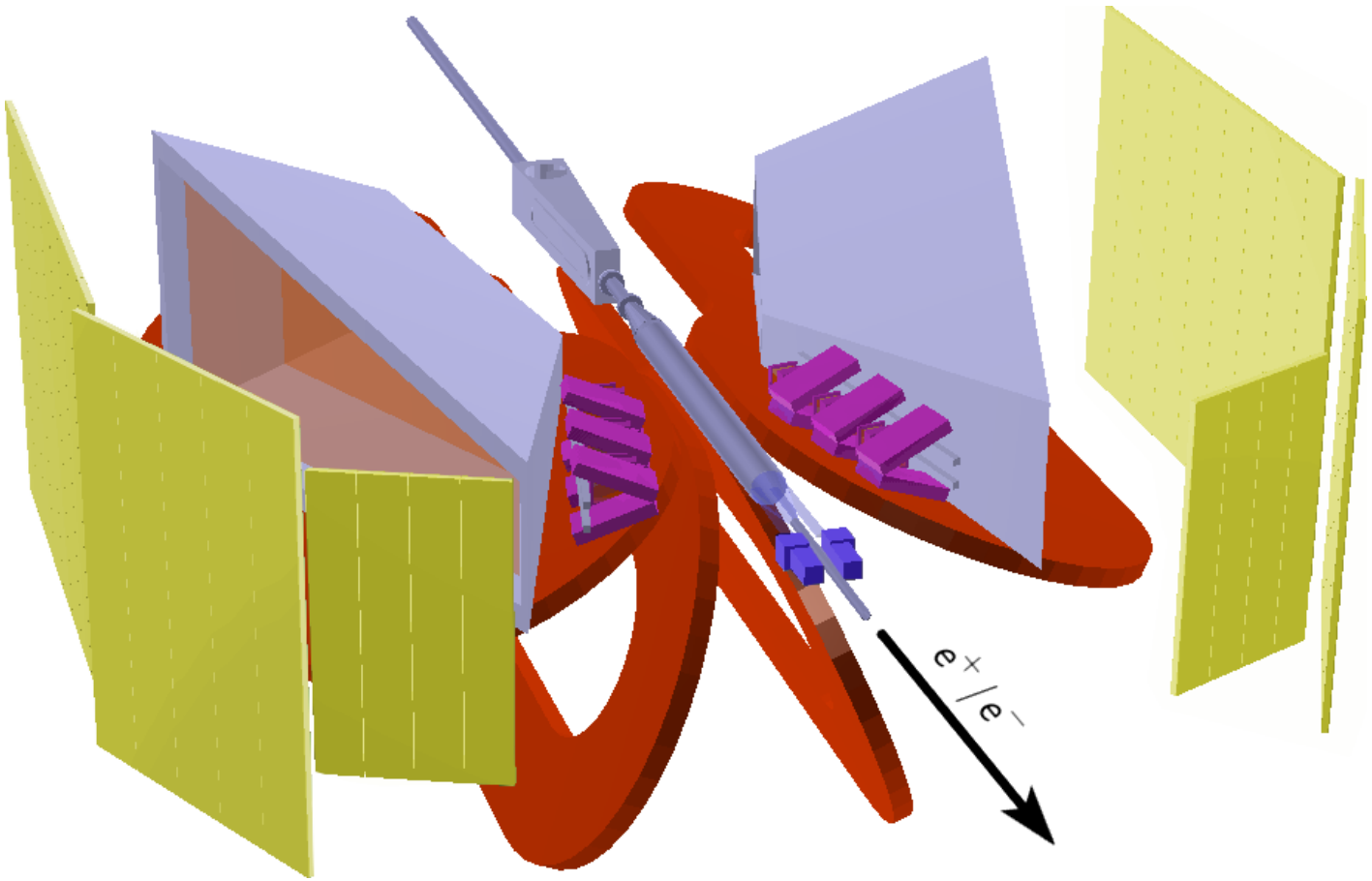
12° luminosity monitors



12° luminosity monitors

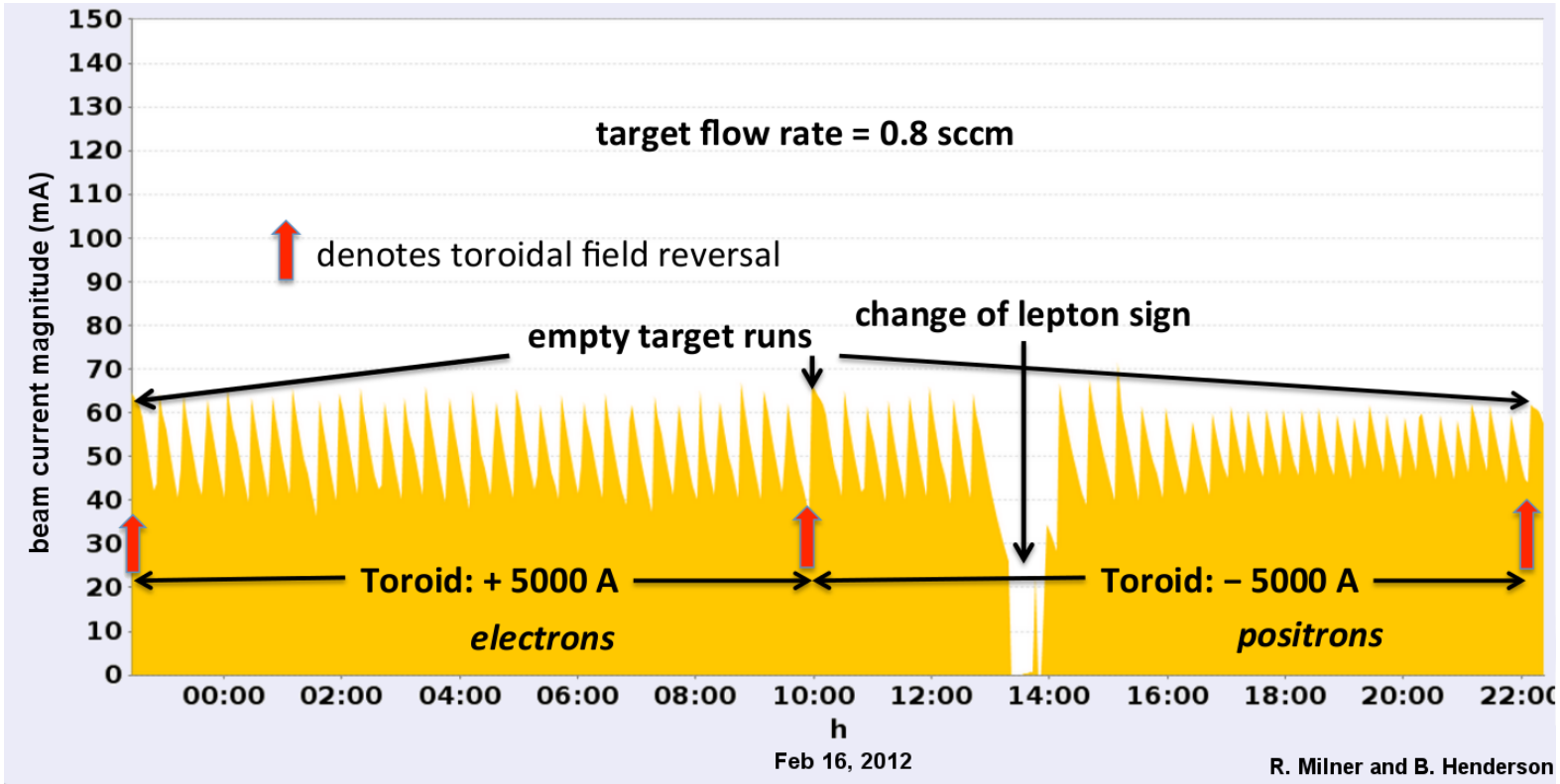


Symmetric Møller/Bhabha detectors



OLYMPUS first run

- Month-long run in February 2012
- Successful start of data collection



- Analysis underway

OLYMPUS timeline

- OLYMPUS full proposal — **September 2008**
- Experiment funded by DOE — **January 2010**
- BLAST moved to Germany — **Spring 2010**
- Target test experiment — **February 2011**
- Drift chambers installed — **Spring 2011**
- 12° luminosity monitors installed — **Summer 2011**
- OLYMPUS rolled in to DORIS beam line — **July 2011**
- First full OLYMPUS test experiment — **August 2011**
- Symmetric Møller/Bhabha installed — **Fall 2011**
- **First data run** — **January 2012**
- Tracking detector upgrade — **Summer 2012**
- **Second data run** — **October-December 2012**
- DORIS retires — **2013**

The OLYMPUS Collaboration

Members from...

- Arizona State University, USA
- DESY, Hamburg, Germany
- Hampton University, USA
- INFN Bari, Ferrara, and Rome, Italy
- MIT and MIT-Bates, USA
- Petersburg Nuclear Physics Institute, Russia
- University of Bonn, Germany
- University of Glasgow, United Kingdom
- University of Mainz, Germany
- University of New Hampshire, USA
- Yerevan Physics Institute, Armenia