

A PROPOSAL TO DEFINITELY DETERMINE THE CONTRIBUTION OF MULTIPLE PHOTON EXCHANGE IN ELASTIC LEPTON-NUCLEON SCATTERING

THE OLYMPUS COLLABORATION

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University of Colorado, USA

Universität Erlangen-Nürnberg, Germany

University of Glasgow, United Kingdom

University of Kentucky, USA

Universität Mainz, Germany

University of New Hampshire, USA

Elastic Electron Scattering from the Proton



Dirac, Pauli FF: $\langle N(P') | J_{EM}^\mu(0) | N(P) \rangle =$

$$\bar{u}(P') \left[\gamma^\mu F_1^N(Q^2) + i\sigma^{\mu\nu} \frac{q_\nu}{2M} F_2^N(Q^2) \right] u(P)$$

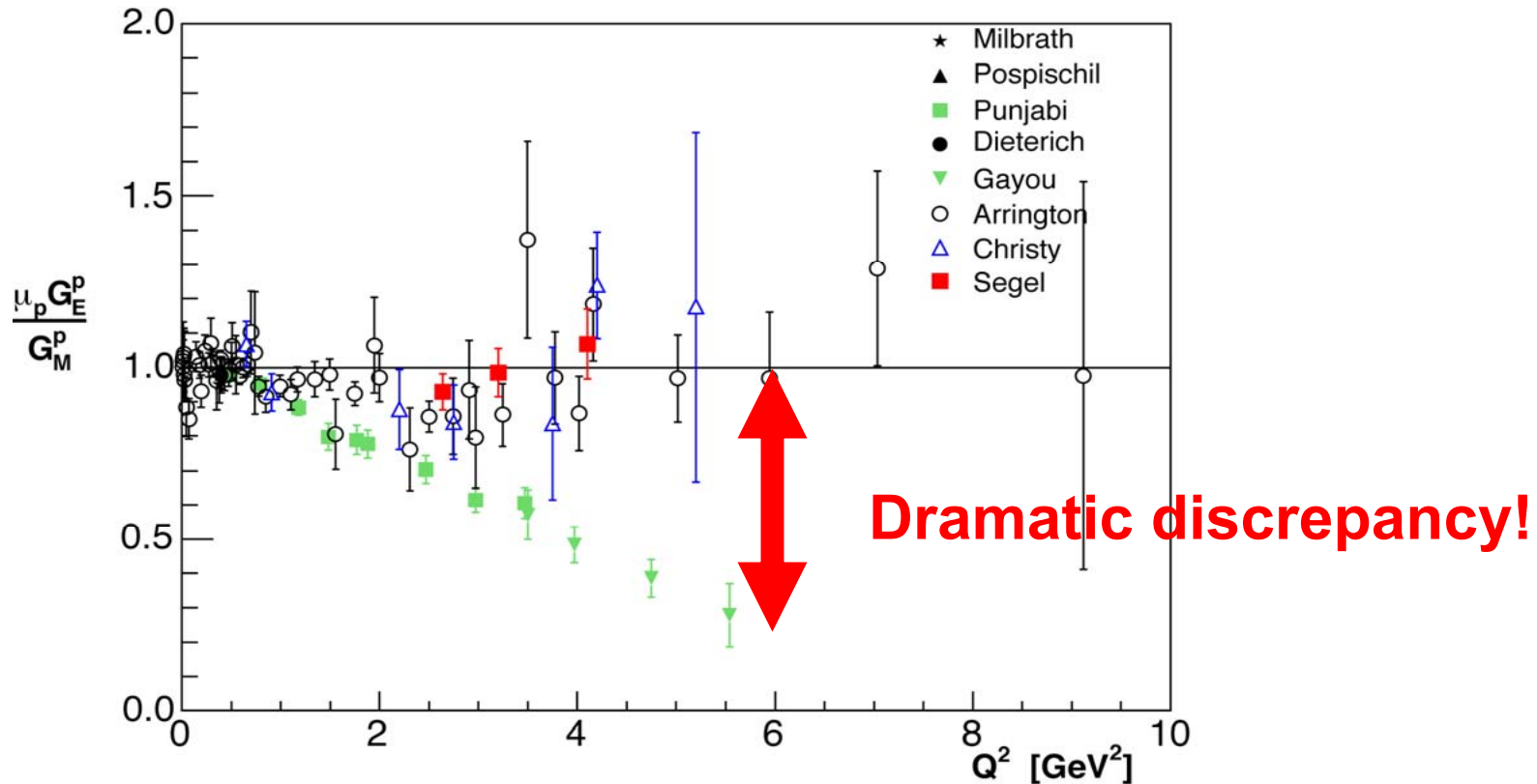
Sachs FF: $G_E = F_1 - \tau F_2; \quad G_M = F_1 + F_2, \quad \tau = \frac{Q^2}{4M^2}$

e⁺ vs. e⁻:

$$\sigma(e^\pm) = \sigma_{Born} (1 \mp \delta_{2\gamma})$$

$$R = \frac{\sigma(e^+)}{\sigma(e^-)} \approx 1 - 2\delta_{2\gamma}$$

Proton Form Factor Ratio

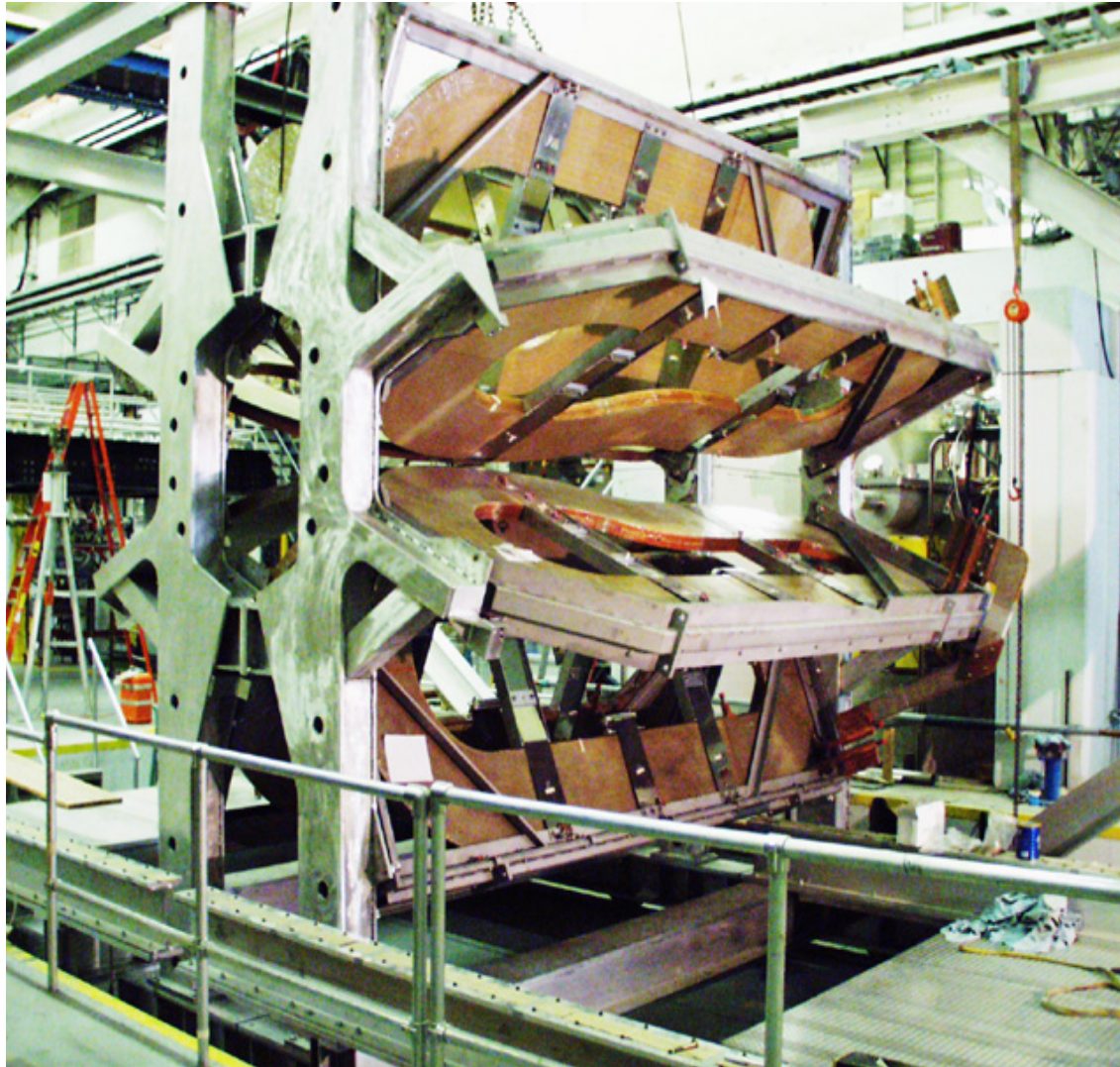


- All Rosenbluth data from SLAC and Jlab in agreement.
- Dramatic discrepancy between Rosenbluth and Jlab recoil polarization technique
- Discrepancy interpreted as evidence of multiple exchange contribution

Proposed OLYMPUS Experiment

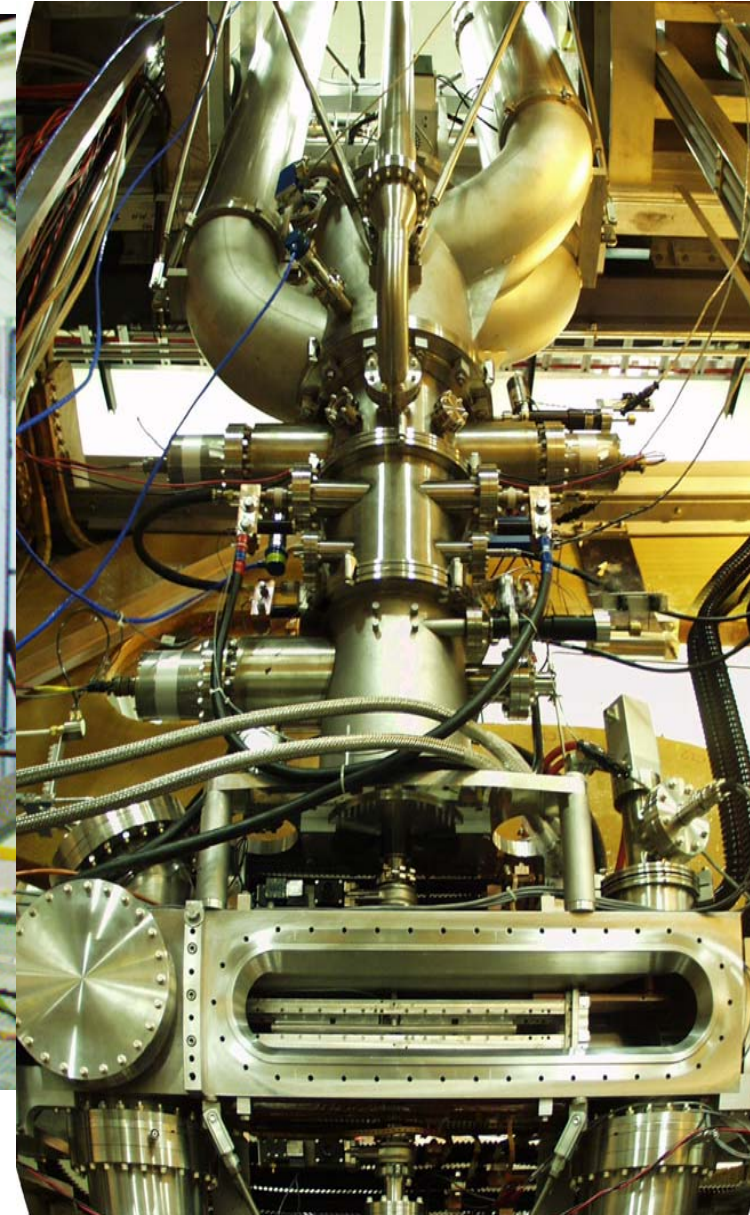
- Electrons/positrons (100mA) in multi-GeV storage ring DORIS at DESY, Hamburg, Germany
- Unpolarized internal hydrogen target (like HERMES) 3×10^{15} at/cm² @ 100 mA $\rightarrow L = 2 \times 10^{33}$ / (cm²s) at location of ARGUS experiment
- Measure elastic e⁺/e⁻ proton scattering to 1% precision at 2 GeV energy at $Q^2 \sim 0.6-2.4$ (GeV/c)² using the existing **B**ates **L**arge **A**cceptance **S**pectrometer **T**oroid
- Experiment requires switching from e⁺ beam to e⁻ beam on timescale of ≤ 1 day.
- Redundant monitoring of luminosity, pressure, temperature, flow, current measurements - at small scattering angle and low Q^2

Detector and target exist at MIT-Bates

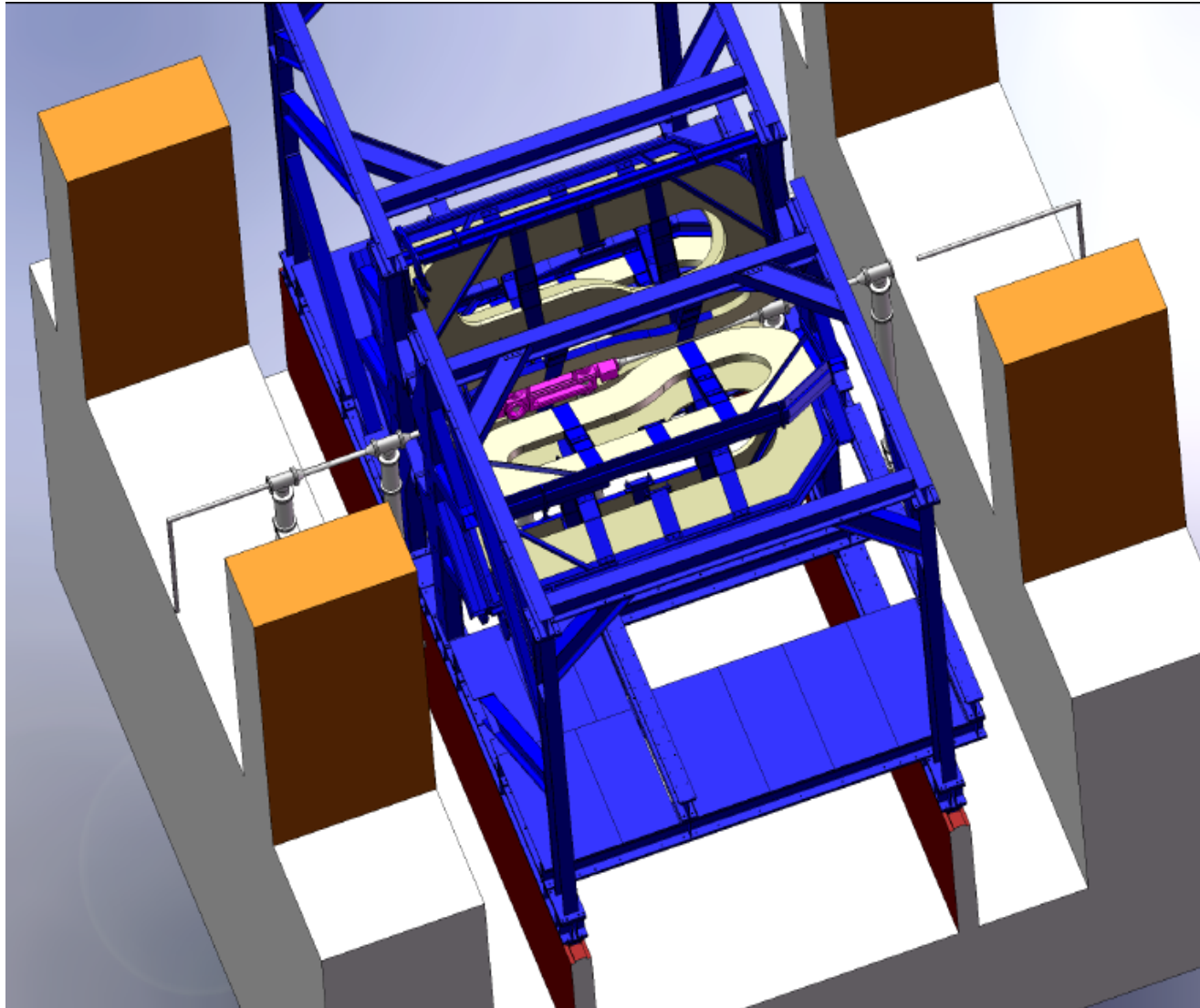


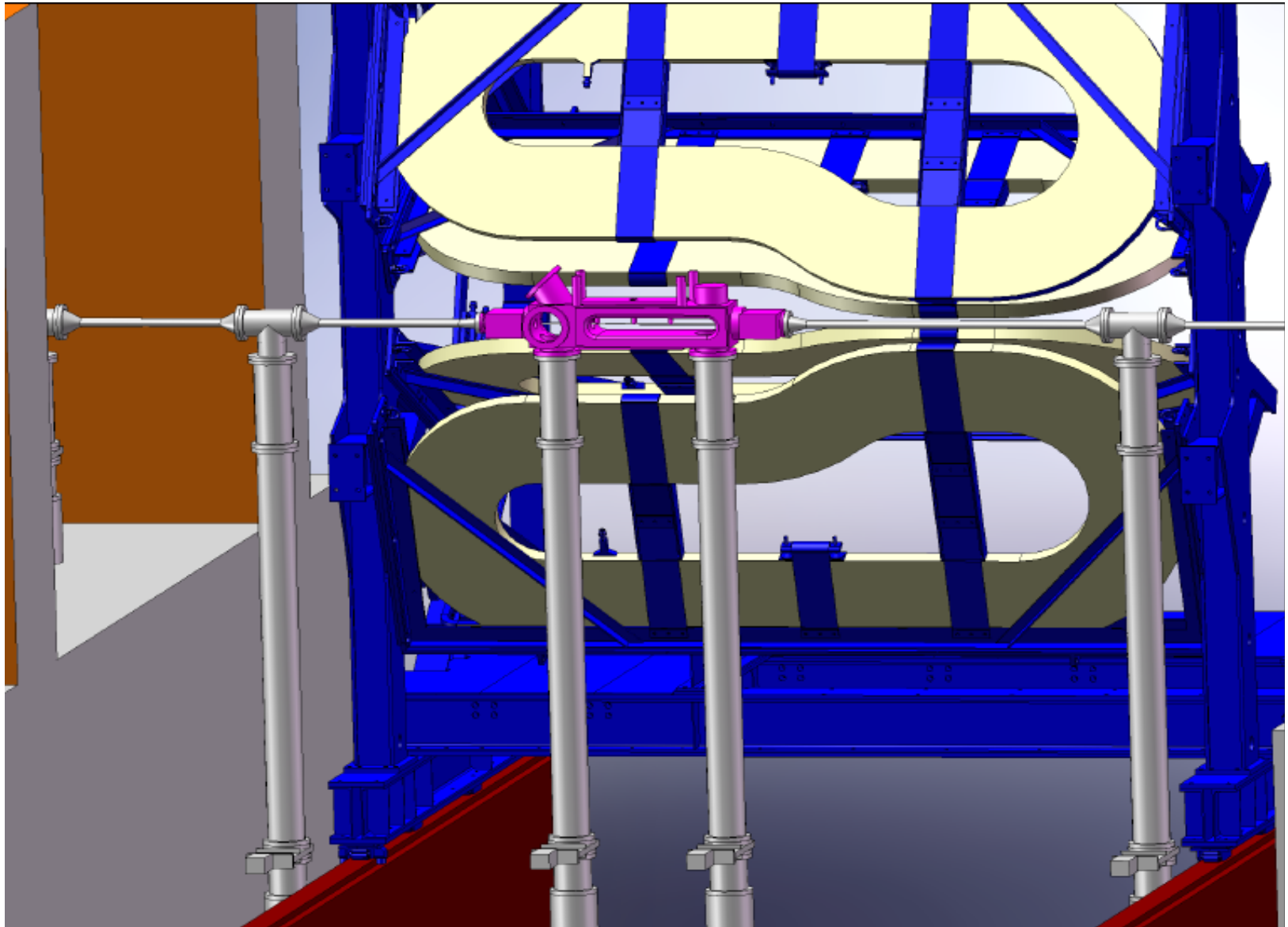
Richard Milner

PRC66 Zeuthen
October 1-2, 2008

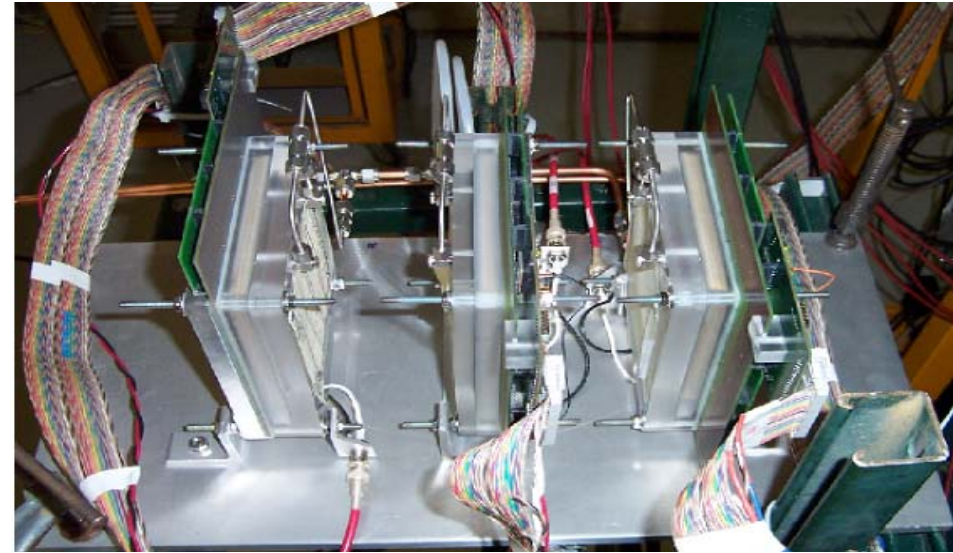
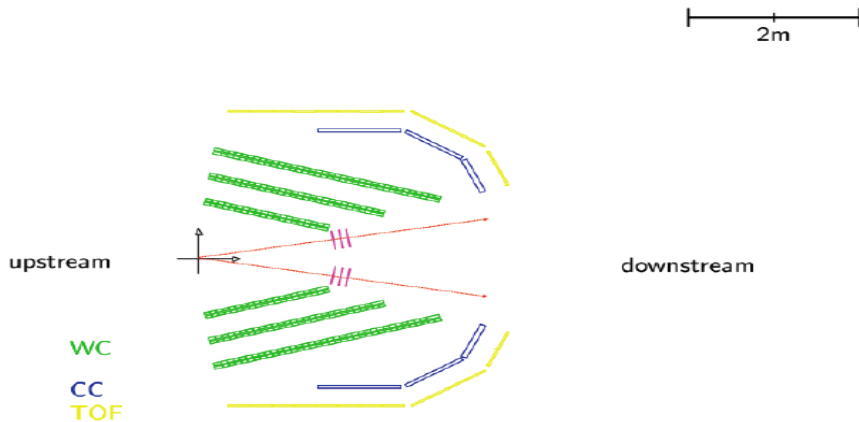


BLAST at ARGUS location



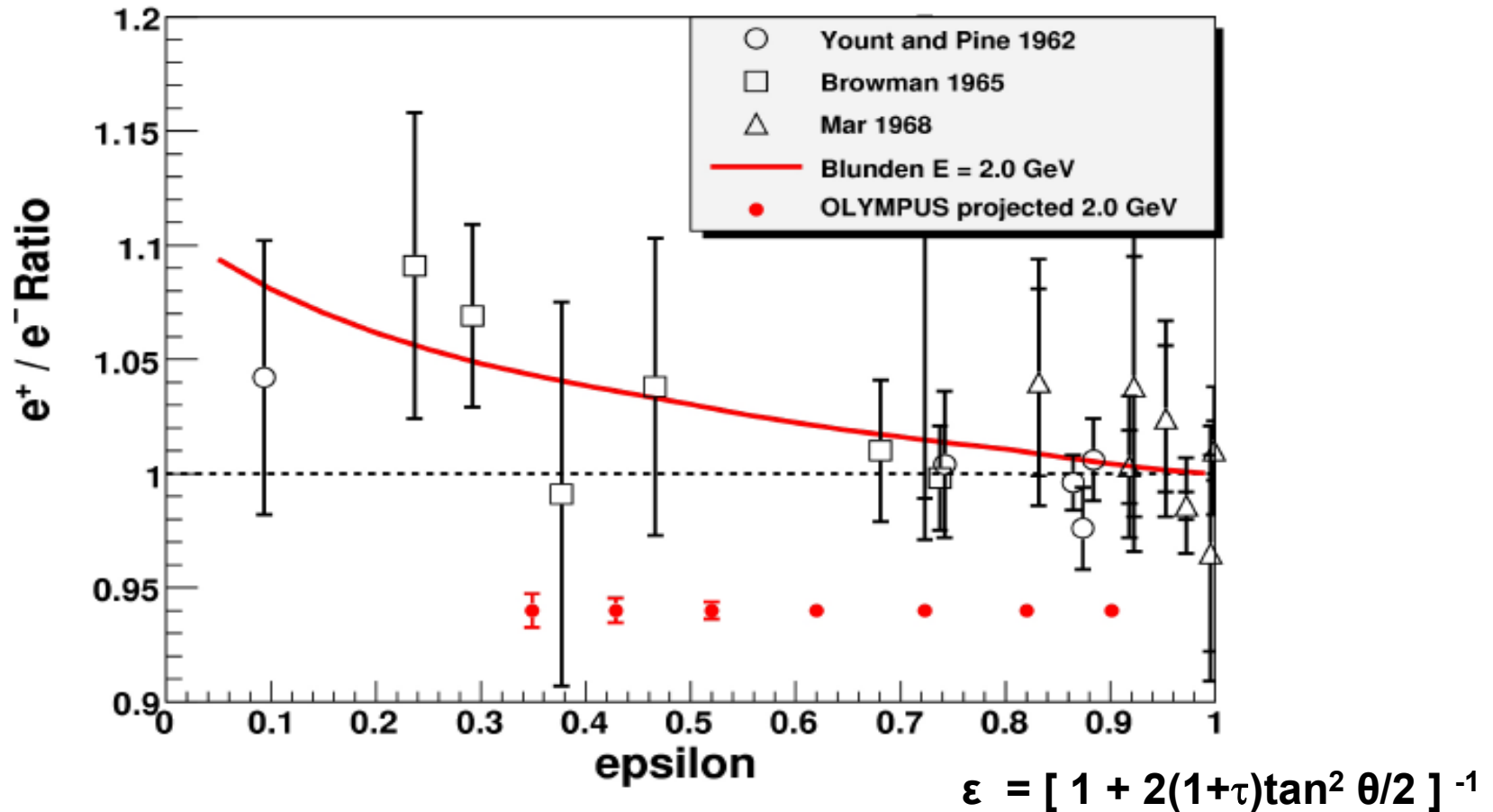


Luminosity monitor



- **Luminosity will be monitored by detecting forward e^+/e^- in a position sensitive detector in coincidence with the recoil proton detected in BLAST**
- **Package of three planar triple-GEM detectors**
- **Such detectors have been constructed at MIT and successfully tested at Fermilab**

Projected OLYMPUS results



500 hours of data taking for each of e^+ and e^- at 2 GeV

Control of systematics

$$N_{ij} = L_{ij} \sigma_i \kappa_{ij}^p \kappa_{ij}^l \quad \begin{array}{l} i = e^+ \text{ or } e^- \\ j = \text{pos/neg polarity of BLAST} \\ \text{field} \end{array}$$

Geometric proton efficiency: $\kappa_{e^+j}^p = \kappa_{e^-j}^p$

$$\frac{N_{e^+j}/L_{e^+j}}{N_{e^-j}/L_{e^-j}} = \frac{\sigma_{e^+}}{\sigma_{e^-}} \cdot \frac{\kappa_{e^+j}^l}{\kappa_{e^-j}^l} \quad \text{Ratio in single polarity } j$$

Geometric lepton efficiency: $\kappa_{e^++}^l = \kappa_{e--}^l$ and $\kappa_{e^+-}^l = \kappa_{e^-+}^l$

Control of systematics (contd.)

Super ratio:

$$\left[\frac{N_{e^{++}}/L_{e^{++}}}{N_{e^{-+}}/L_{e^{-+}}} \cdot \frac{N_{e^{+-}}/L_{e^{+-}}}{N_{e^{--}}/L_{e^{--}}} \right]^{\frac{1}{2}} = \frac{\sigma_{e^{+}}}{\sigma_{e^{-}}}$$

Cycle of four states ij
Repeat cycle many times

- **Change between electrons and positrons regularly**
- **Change BLAST polarity every day**
- **Left-right symmetry provides additional redundancy – two identical experiments simultaneously taking data**

The OLYMPUS Collaboration

- Collaboration of more than 50 physicists from 15 institutions in Germany, Italy, Russia, U.K. and U.S.
- Substantial technical expertise in successfully carrying out internal target experiments at storage rings
- Significant fraction of the OLYMPUS collaboration has been working at DESY on the HERMES experiment
- Collaboration sees a window in the period 2009 to 2012 to carry out the definitive experiment.

Budget

EQUIPMENT	COST k\$
target	450
BLAST toroid shipping	500
luminosity monitor	120
trigger electronics	80
wire chamber upgrade	75
on-line system	70

- **Equipment: > \$ 5 million existing + \$ 1.3 million**
- **DORIS modifications: Euro 728 k**
- **DORIS power costs: Euro 450 k**
- **OLYMPUS operating costs: Euro 160k/month**

Possible timescale

- From approval of funding, it will take ~ 1 year to design, construct and transfer to DESY the necessary equipment.
- If requested funding is approved in ~ Spring 2009, then the OLYMPUS experiment could be installed in summer 2010.
- Pending green light from DESY, requests to the funding agencies will be submitted in Fall 2008
- Commissioning would be carried out in parallel with light source operation.
- Data taking could be carried out in 2011-2012.
- Analysis is straightforward - final results will be obtained essentially online.

Summary

- The elastic form-factors of the proton are in question - the contribution of multiple photon exchange processes is essential to resolving the discrepancy.
- A definitive, precision comparison ($\sim 1\%$) of elastic electron-proton and positron-proton elastic scattering at 2 GeV can be carried out at DORIS using the available MIT-BLAST detector and an unpolarized hydrogen gas target.
- The OLYMPUS collaboration requests approval from DESY to proceed with the experiment in a timely manner.