CH.00001

Status of the OLYMPUS Experiment *

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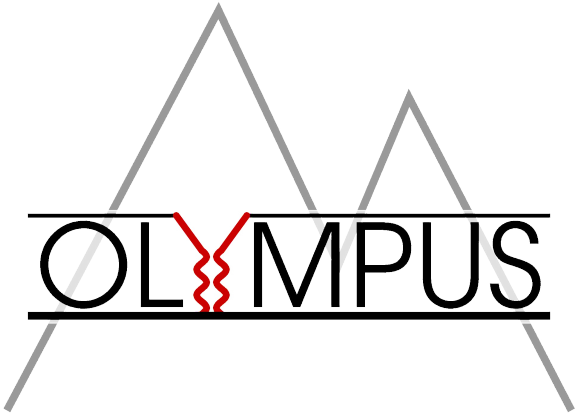
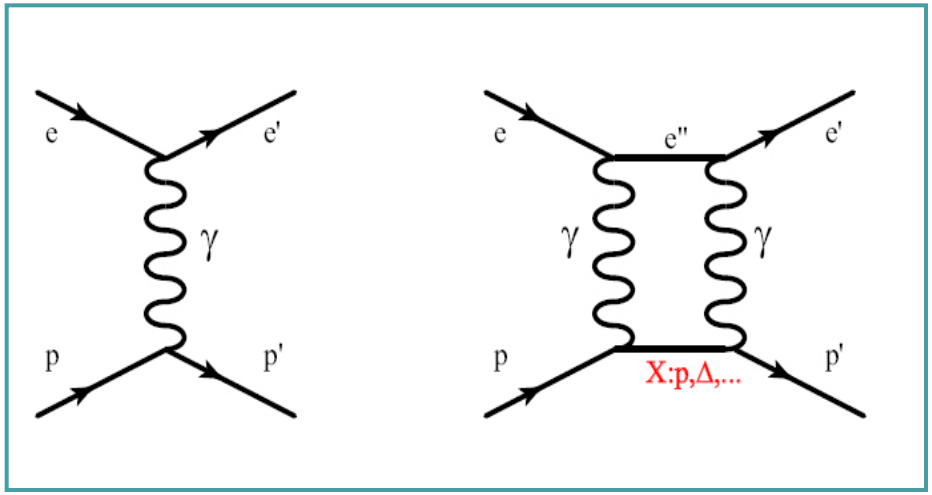
* Supported by DOE, NSF, BMBF, and DFG

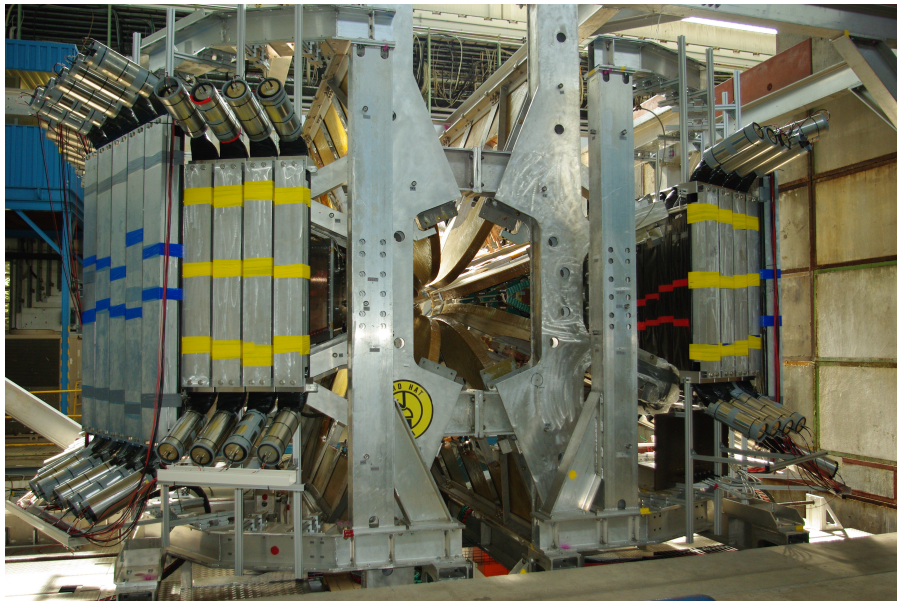
** Supported by NSF grants PHY-0855473, 0959521, and 1207672, and by DOE Early Career Award DE-SC0003884

The OLYMPUS experiment

- **The limit of one-photon exchange:**
  - **What is $G^p_E(Q^2)$ ⇔ proton charge distribution?**
  - **What is the nature of lepton scattering?**
- **Description of OLYMPUS**
- **OLYMPUS running**
- **Status and timeline**







OLYMPUS @ DESY

Presentations on OLYMPUS

Thursday

08:30-08:42 CH.00001 : Status of the OLYMPUS experiment
Michael Kohl (Hampton University)

08:42-08:54 CH.00002 : Status of the OLYMPUS Analysis
Brian Henderson (MIT)

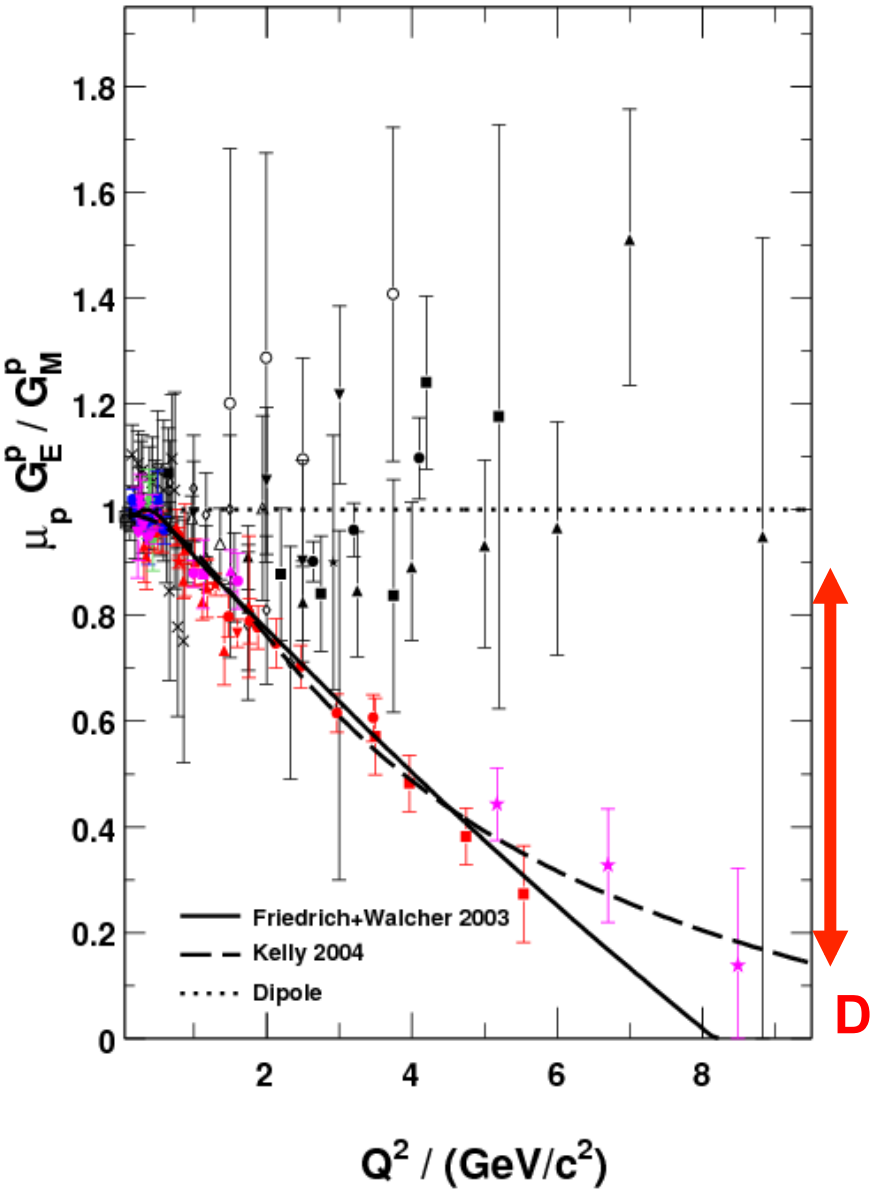
08:54-09:06 CH.00003 : Luminosity monitoring at OLYMPUS with forward-angle elastic scattering
Ozgur Ates (Hampton University)

09:06-09:18 CH.00004 : Radiative corrections for the OLYMPUS experiment
Rebecca Russell (MIT)

Friday

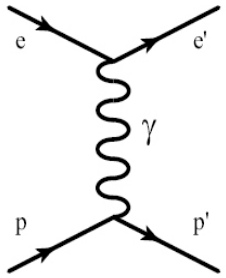
09:06-09:42 HA.00002 : Investigating the charge of the proton
Michael Kohl (Hampton University)

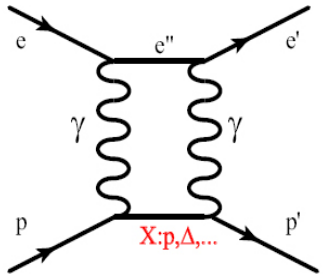
Proton form factor ratio



Jefferson Lab 2000–

- All Rosenbluth data from SLAC and Jlab in agreement
- Dramatic discrepancy between Rosenbluth and recoil polarization technique
- Multi-photon exchange considered best candidate

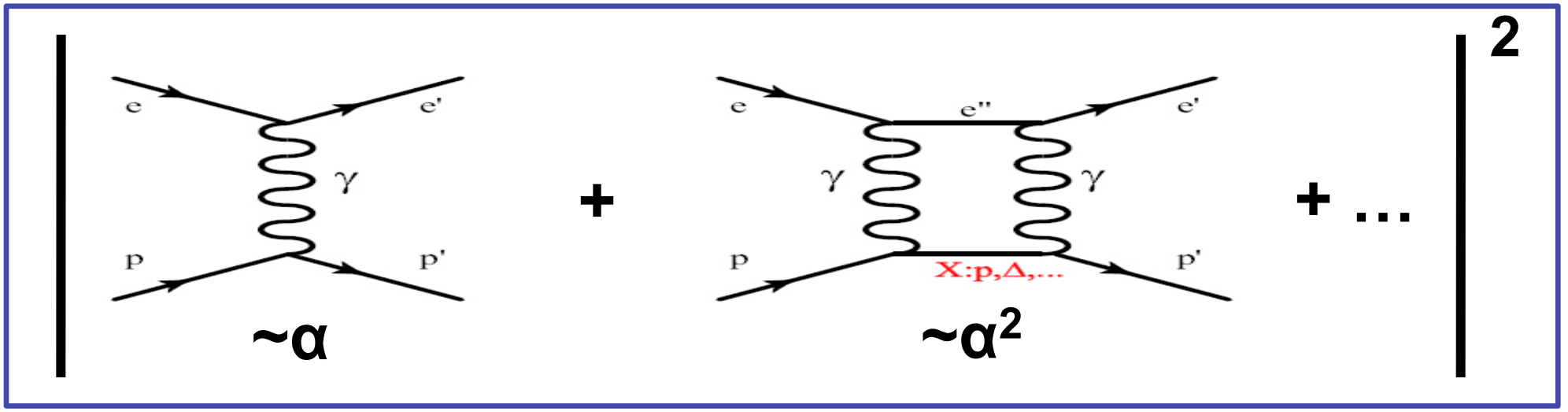




Dramatic discrepancy!

>800 citations

Lepton-proton elastic scattering



- **Interference term depends on lepton charge sign (C-odd)**

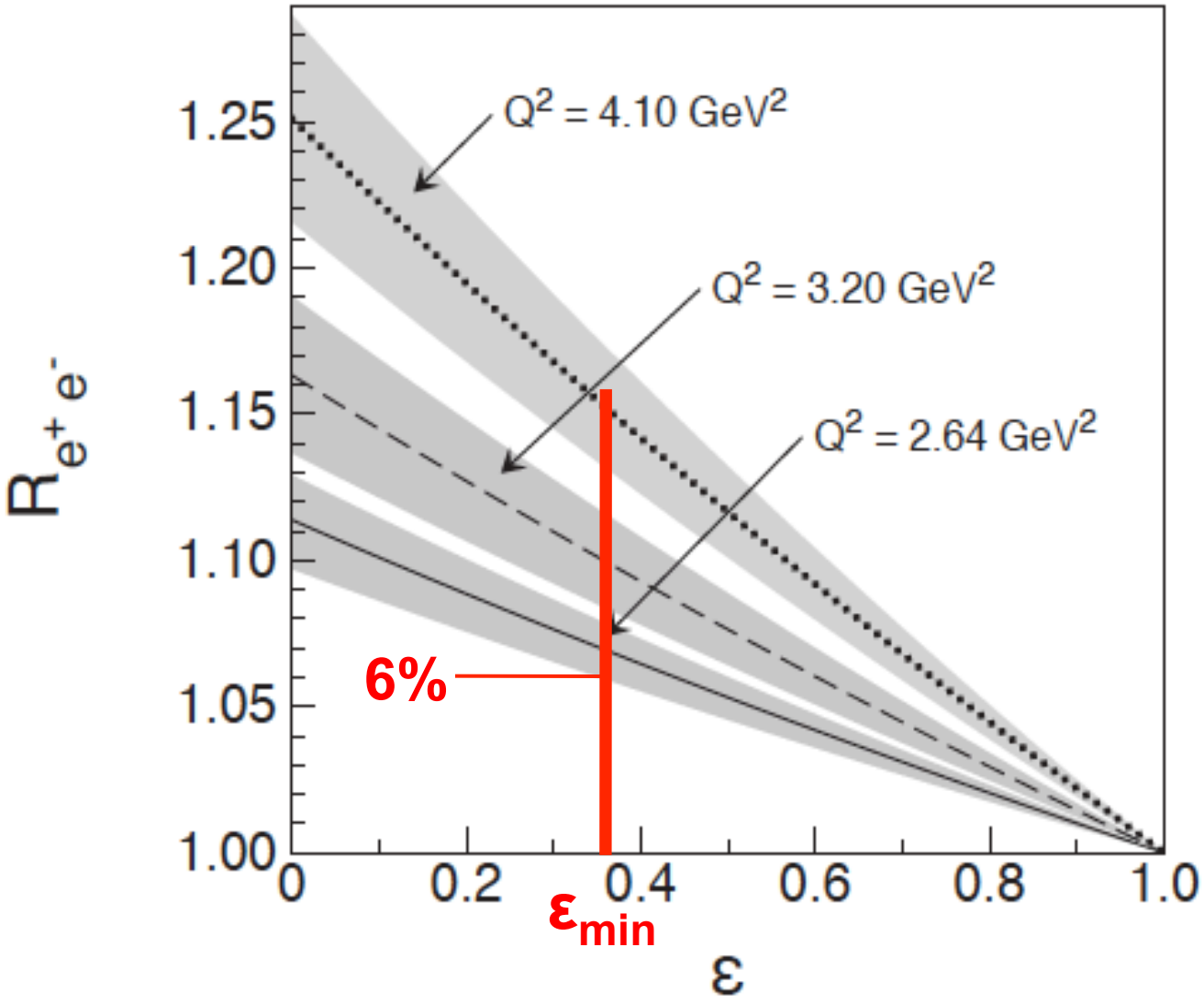
$$\sigma_{e^{\pm}p} = |\mathcal{M}_{1\gamma}|^2 \pm 2\Re\{\mathcal{M}_{1\gamma}^{\dagger}\mathcal{M}_{2\gamma}\} + \cdots$$

- **e^+/e^- ratio deviates from unity by two-photon contribution**

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

Empirical extraction of TPE amplitudes

J. Guttmann, N. Kivel, M. Meziane, and M. Vanderhaeghen, EPJA 47 (2011) 77

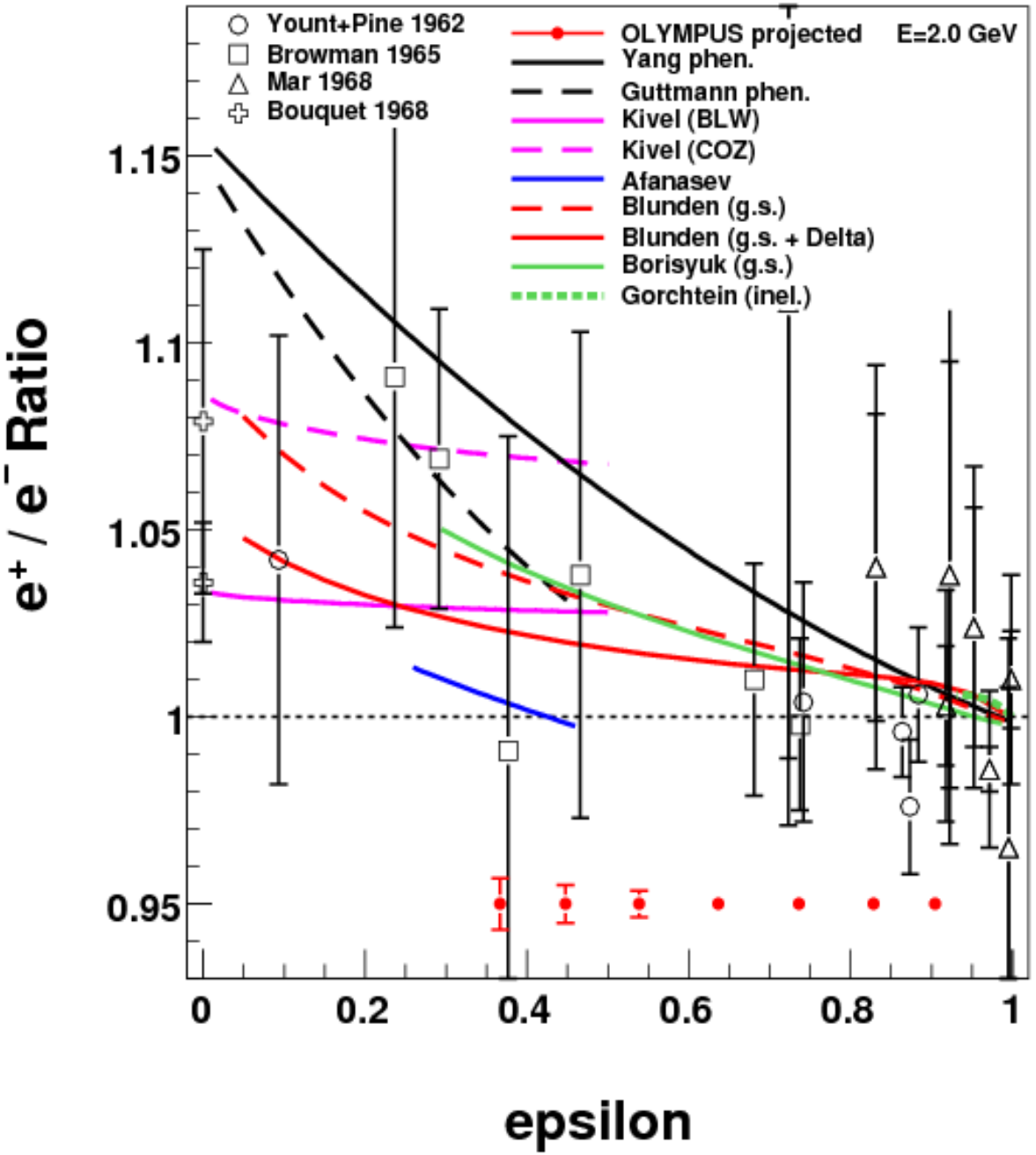


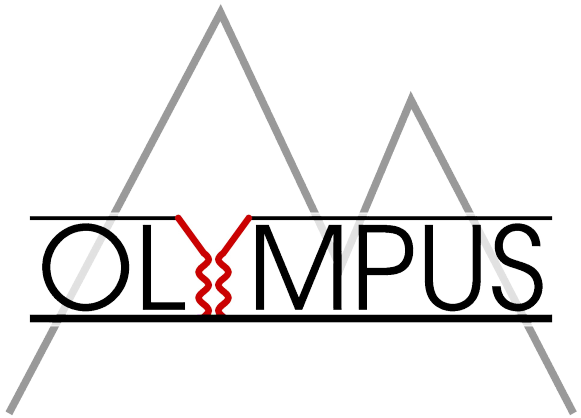
grows with Q^2!

Expect ~6% effect for OLYMPUS@2.0GeV

OLYMPUS

Projected results for OLYMPUS





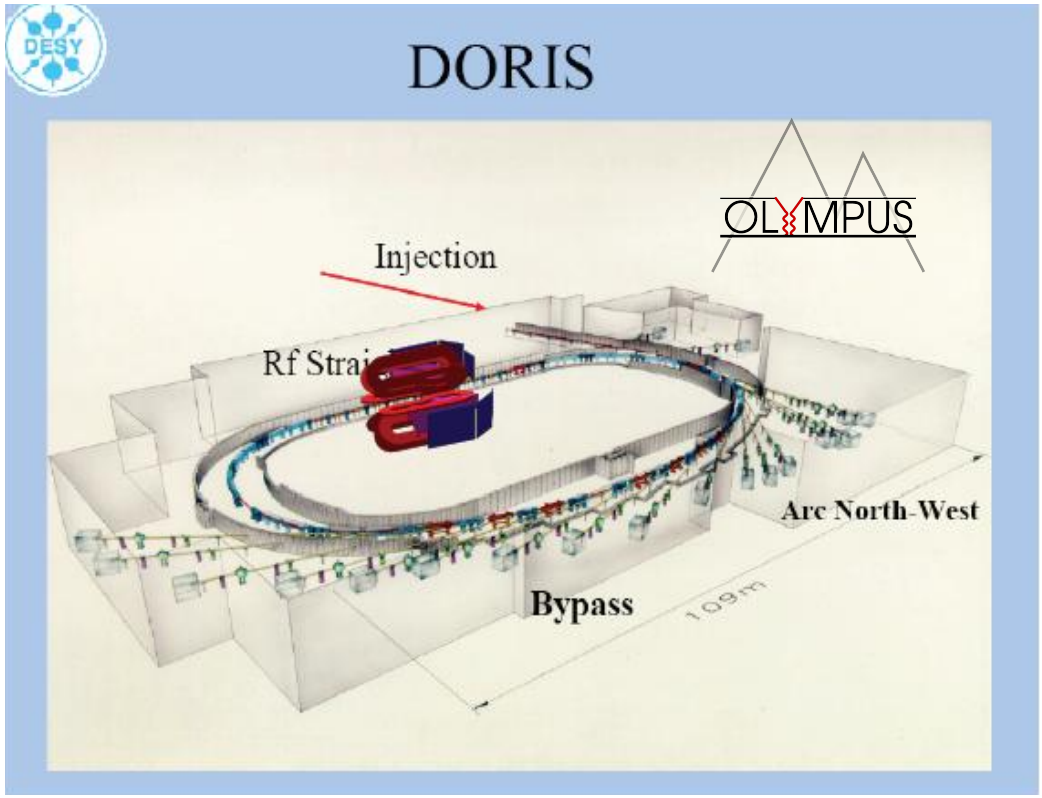
Data from 1960's

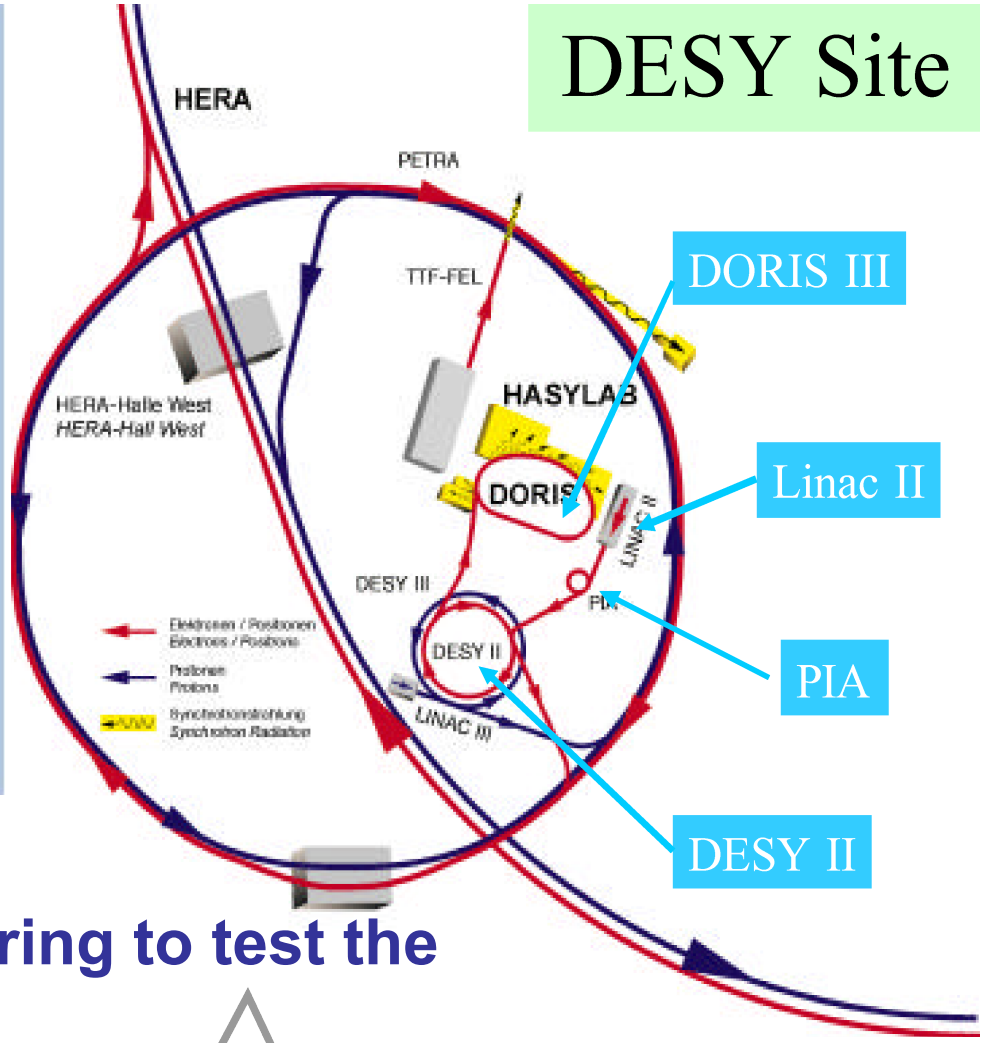
Many theoretical predictions with little constraint

OLYMPUS:

- **E= 2.0 GeV**
- **$0.6 < Q^2/(GeV/c)^2 < 2.2$**
- **Acquire 3.6 fb^{-1} for <1% projected uncertainties**

OLYMPUS @ DORIS/DESY





pOsitron-proton and
eLectron-proton elastic scattering to test the
hYpothesis of
Multi-
Photon exchange
Using
DoriS

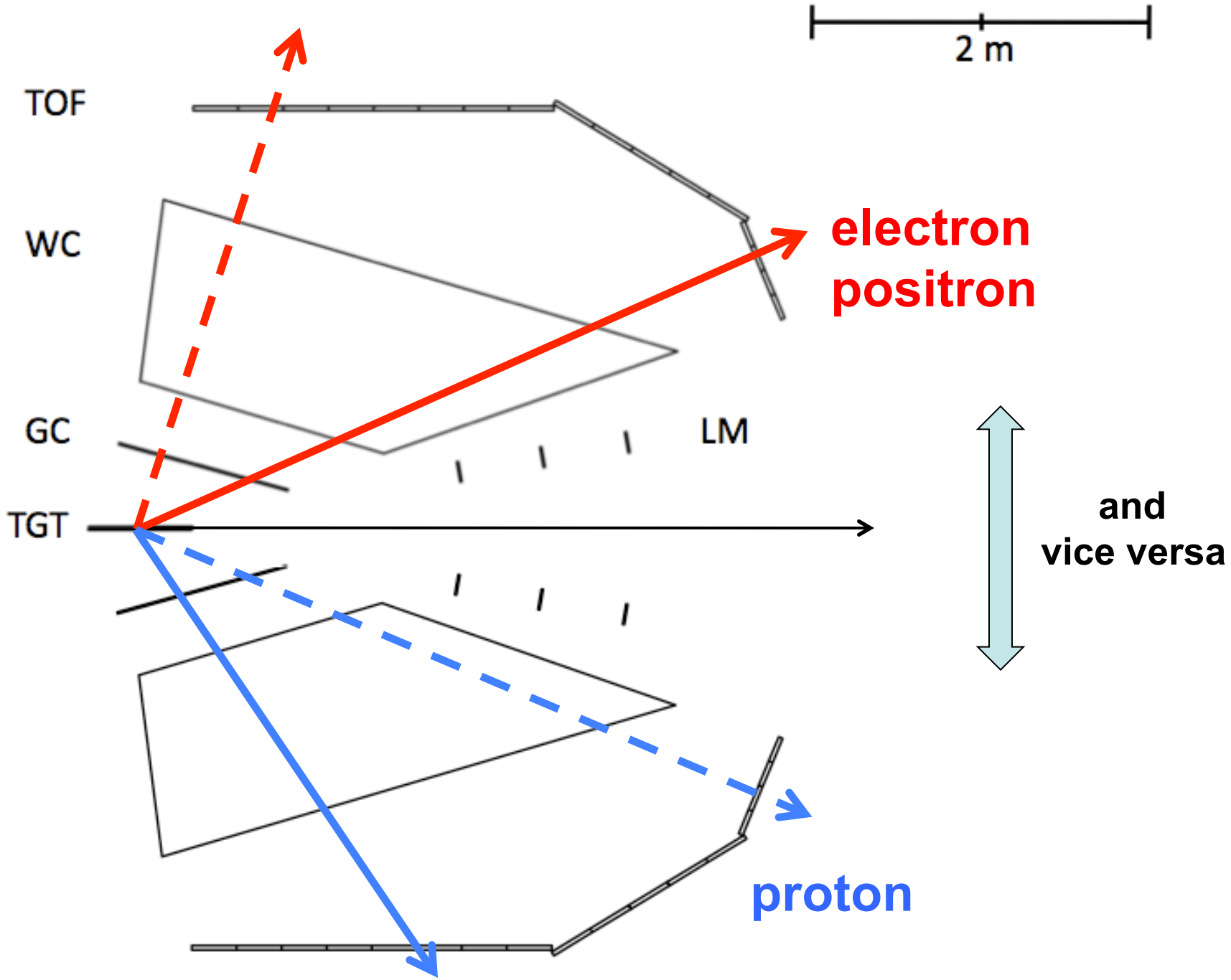
OLYMPUS

The OLYMPUS experiment

- Electrons/positrons (100mA) in 2.0–4.5 GeV storage ring
  DORIS at DESY, Hamburg, Germany
- Unpolarized internal hydrogen target (buffer system)
  3×10^{15} at/cm^2 @ 100 mA $\rightarrow$ L = 2×10^{33} / (cm^{2}s)
- Large acceptance detector for e-p in coincidence
  BLAST detector from MIT-Bates available
- Redundant monitoring of luminosity
  Pressure, temperature, flow, current measurements
  Small-angle elastic scattering at high epsilon / low Q^2
  Symmetric Moller/Bhabha scattering

- **Measure ratio of positron-proton to electron-proton unpolarized elastic scattering to 1% stat.+sys.**

OLYMPUS kinematics at 2.0 GeV

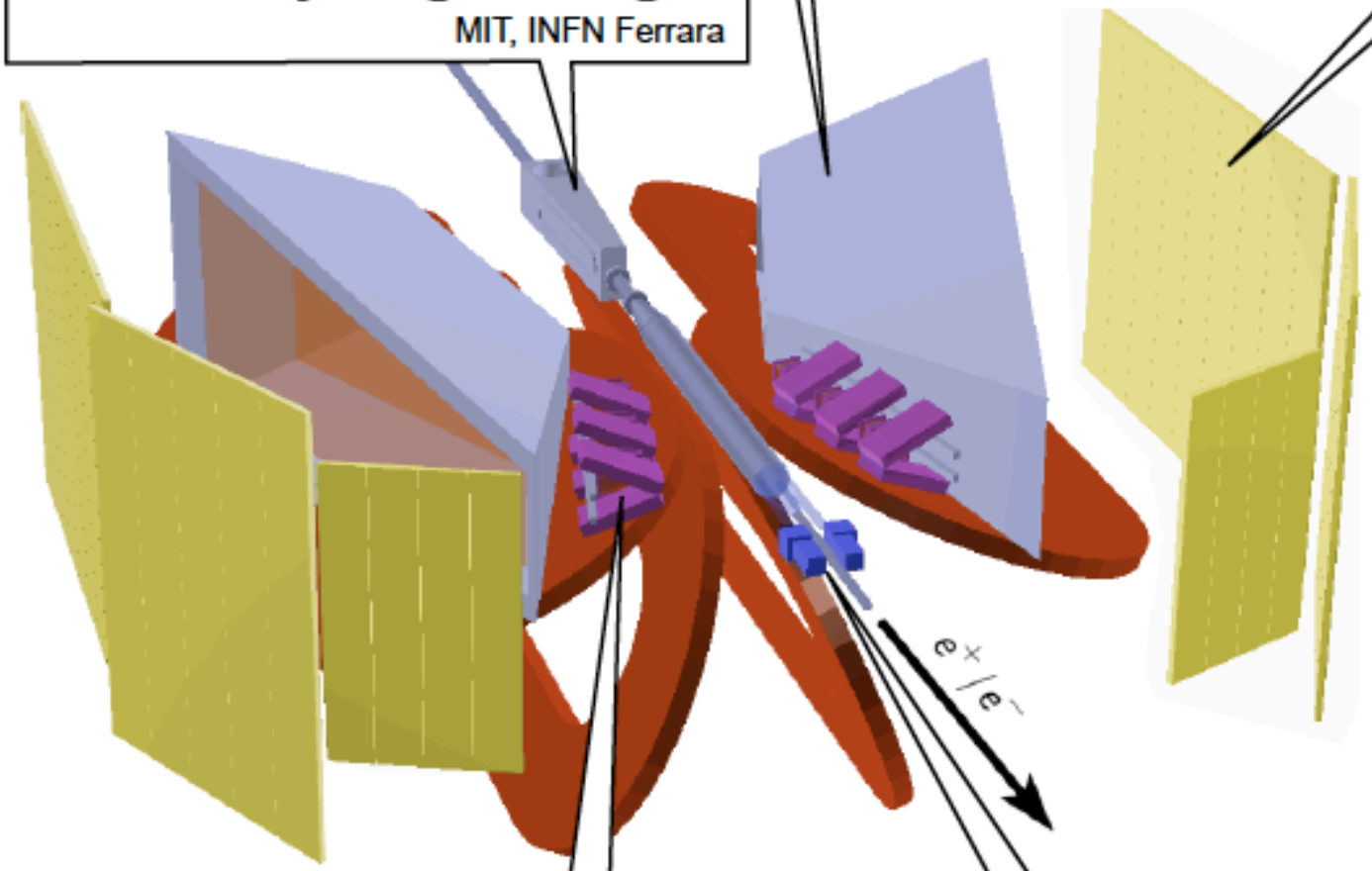


The designed OLYMPUS detector

Drift Chambers
MIT

Time-of-Flight Detectors
University of Glasgow,
YerPhI, Yerevan,
University of New Hampshire,
Arizona State University

Internal Hydrogen Target
MIT, INFN Ferrara



DORIS Upgrade, Toroid Support
DESY

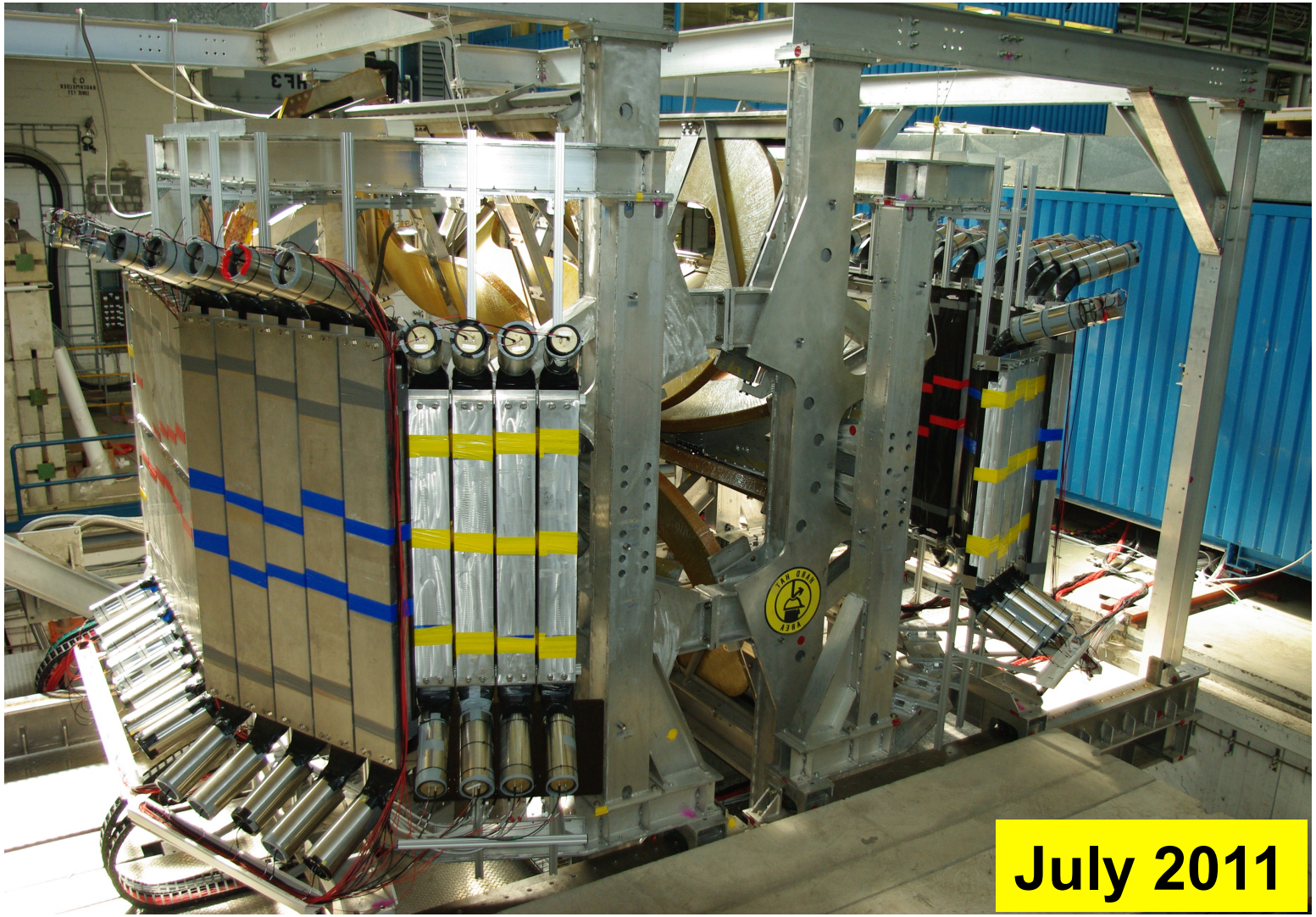
Trigger, DAQ, Online-Monitor
University of Bonn

12° Tracking Telescopes
Hampton University
INFN Rome, Genova
PNPI St. Petersburg

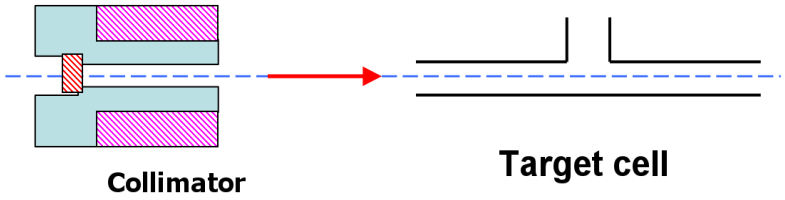
Symmetric Møller/ Bhabha Monitor
University of Mainz

based on a figure by R. Russell

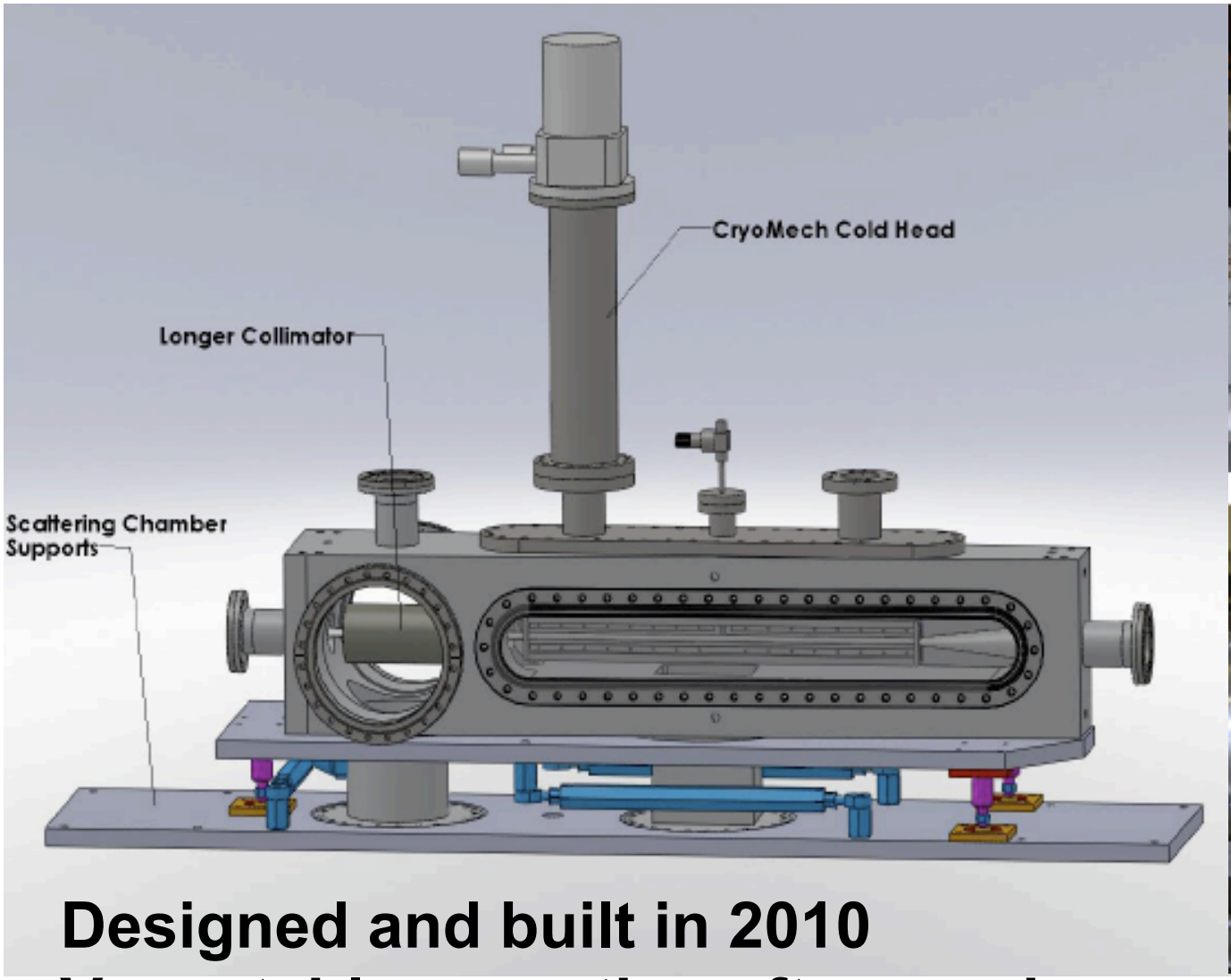
The realized OLYMPUS detector

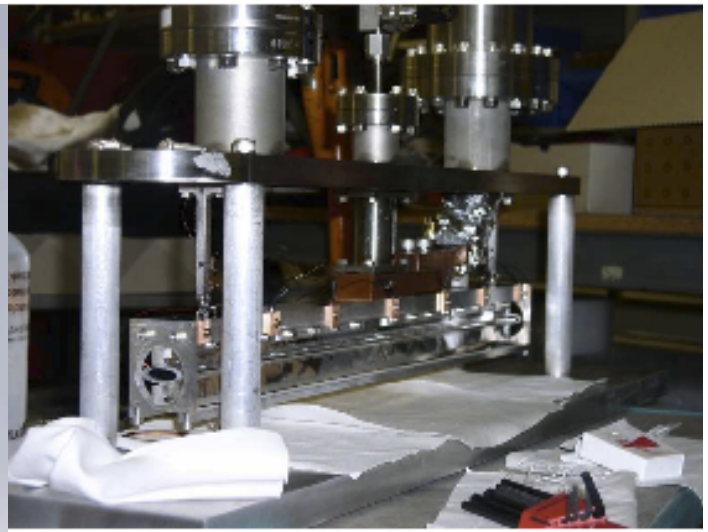


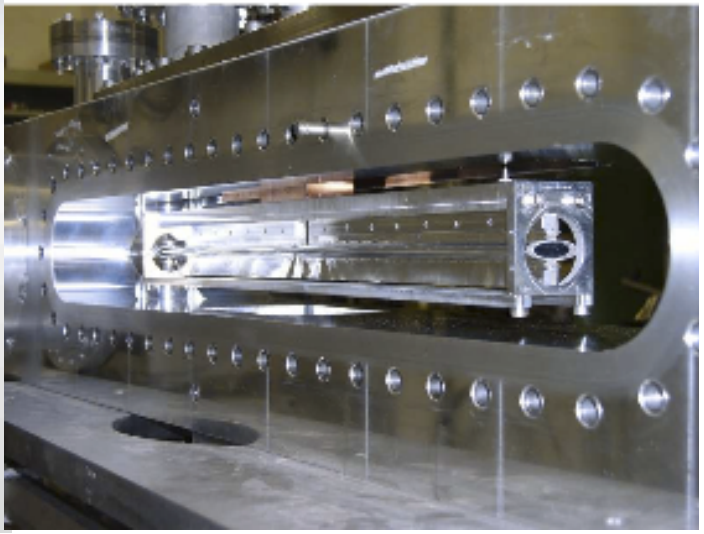
Target and vacuum system



MIT
INFN Ferrara



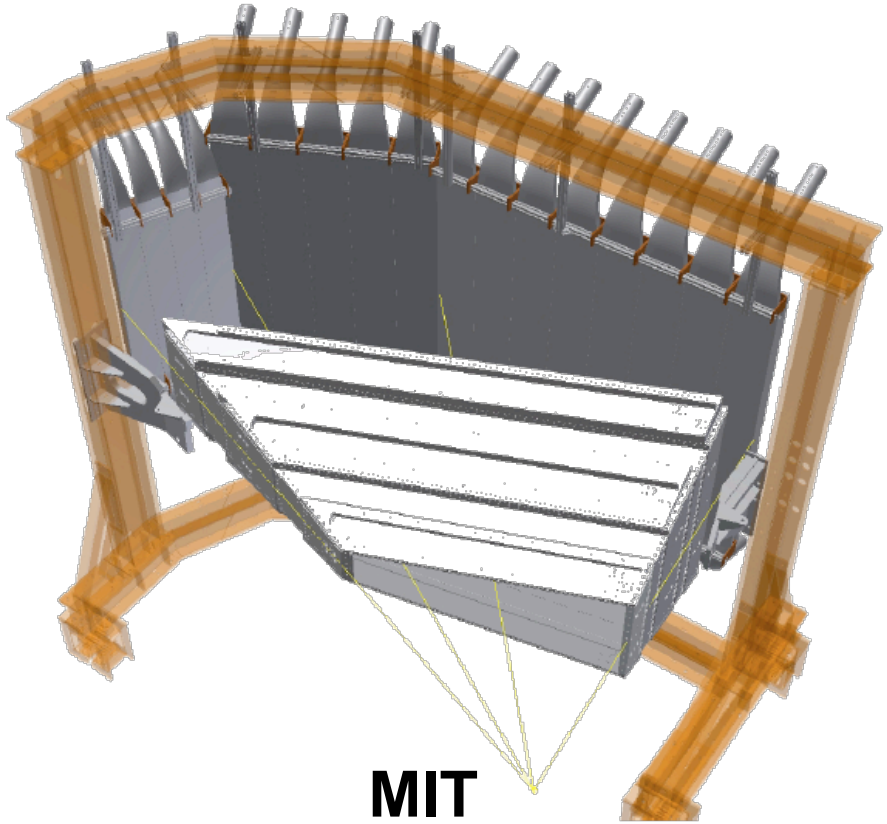




Designed and built in 2010
Very stable operation after repairs

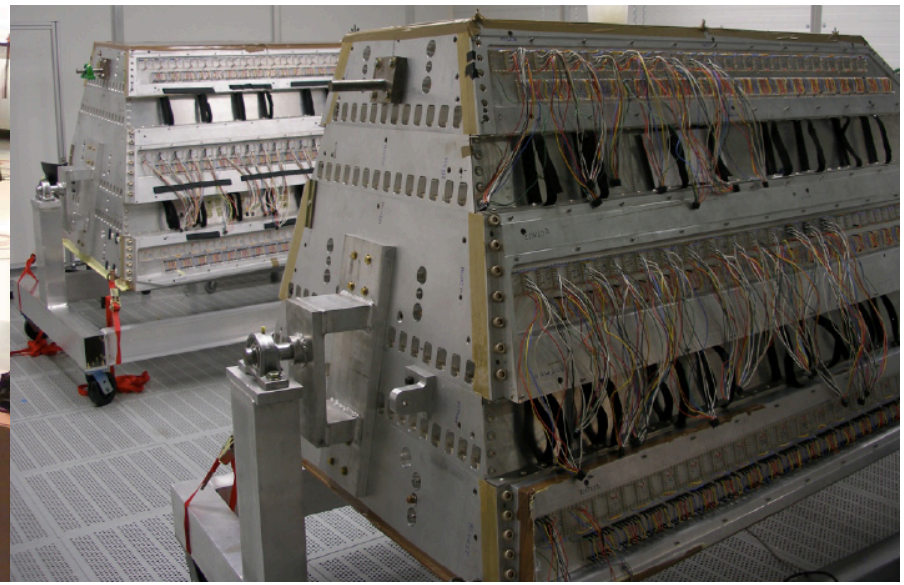
Wire chambers and TOF scintillators

- 2x18 TOFs for PID, timing and trigger
- 2 WCs for PID and tracking (z,θ,φ,p)
- WC and TOF refurbished from BLAST
  WC re-wired at DESY
  TOF rewrapped, efficiency tested
- Installed in OLYMPUS Apr-May 2011
- Stable operation



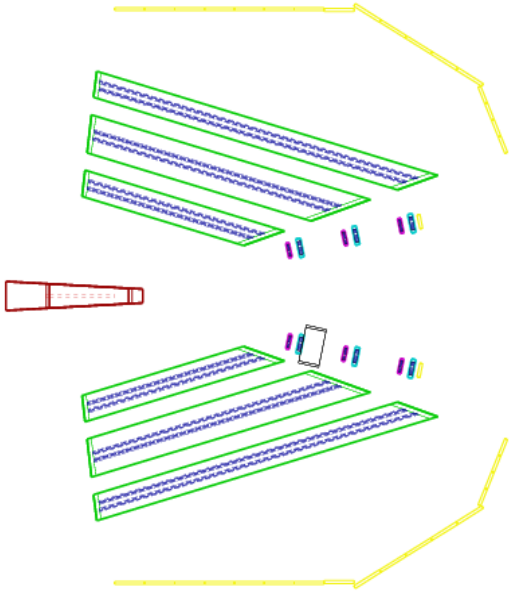
Glasgow, Yerevan, UNH, ASU

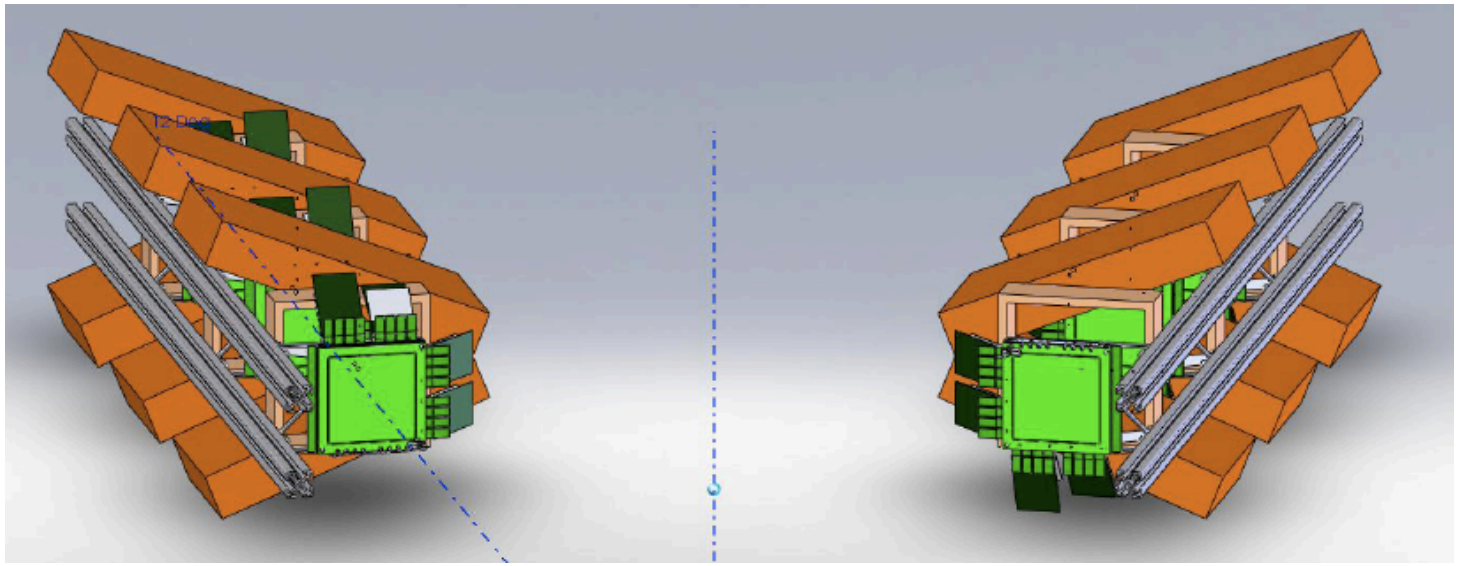
MIT



Luminosity monitors: GEM + MWPC

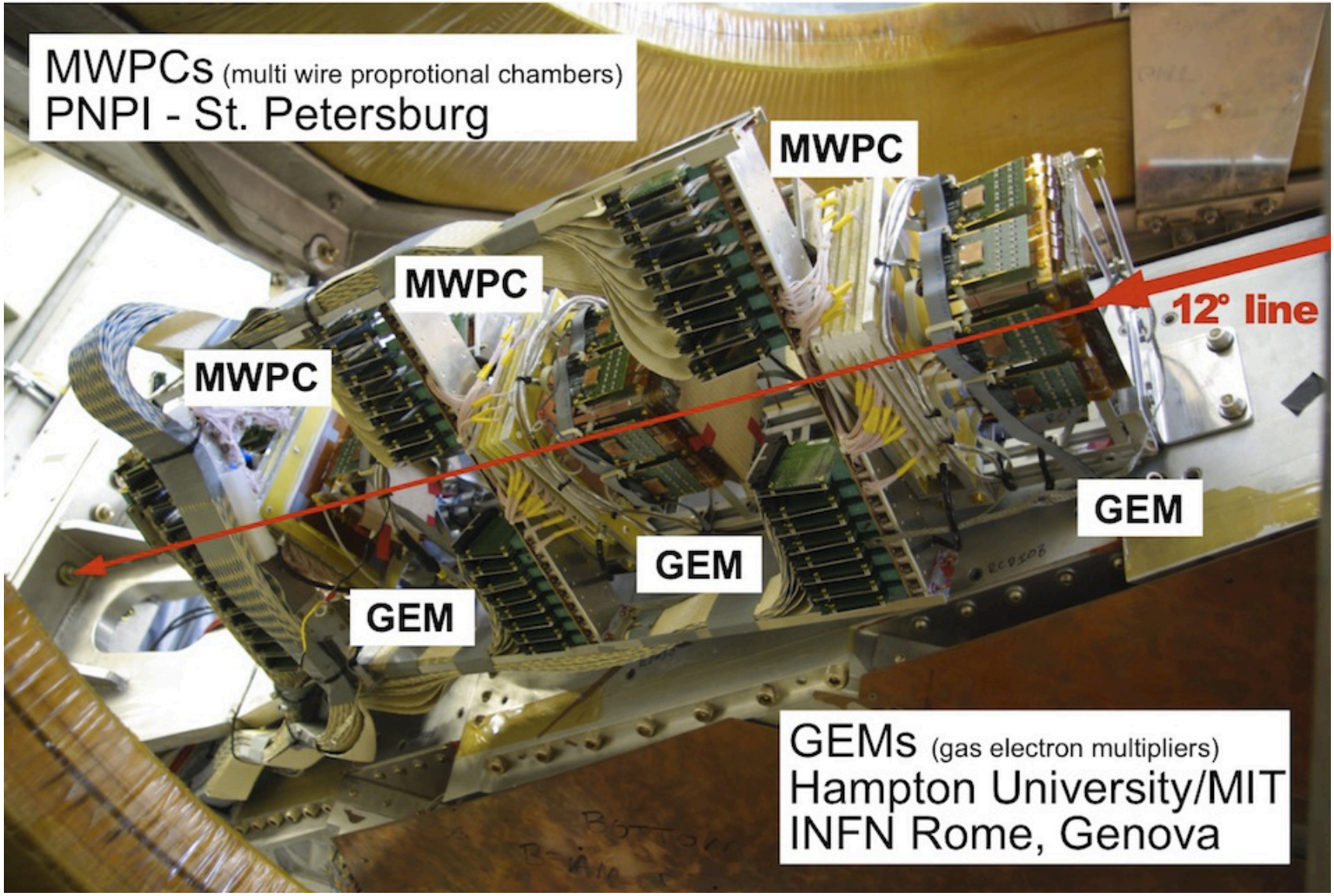
- Forward elastic scattering of lepton at 12° in coincidence with proton in main detector
- Two GEM + MWPC telescopes with interleaved elements operated independently
- SiPM scintillators for triggering and timing
- Sub-percent (relative) luminosity measurement per hour at 2.0 GeV
- High redundancy – alignment, efficiency
  Two independent groups (Hampton/INFN, PNPI)





Designed to fit into forward cone

Luminosity monitors: GEM + MWPC

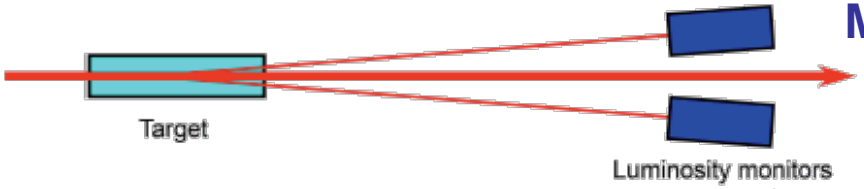


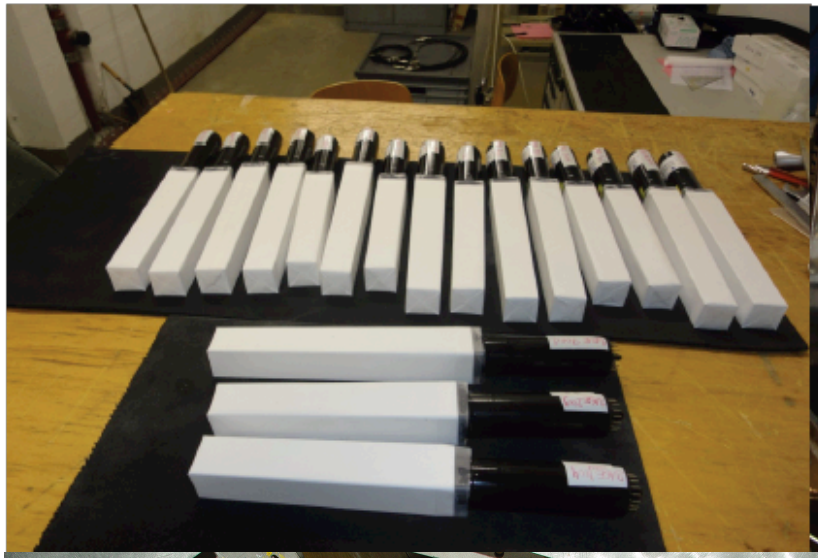
Telescopes of three GEMs and MWPCs interleaved
Mounted on wire chamber forward end plate
Extensively tested at DESY test beam facility

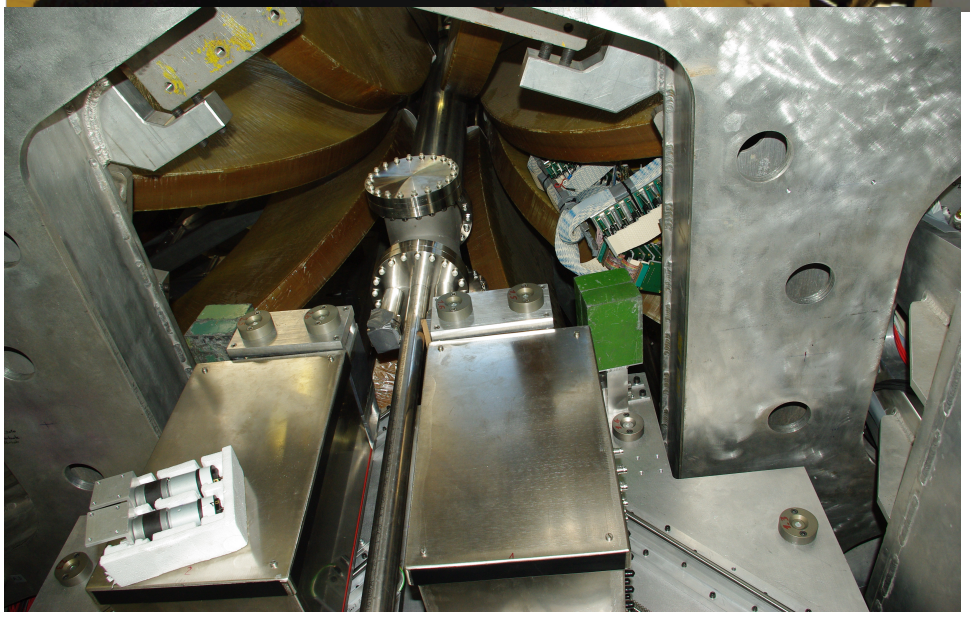
Symmetric Møller/Bhabha monitor

OLYMPUS

Mainz University



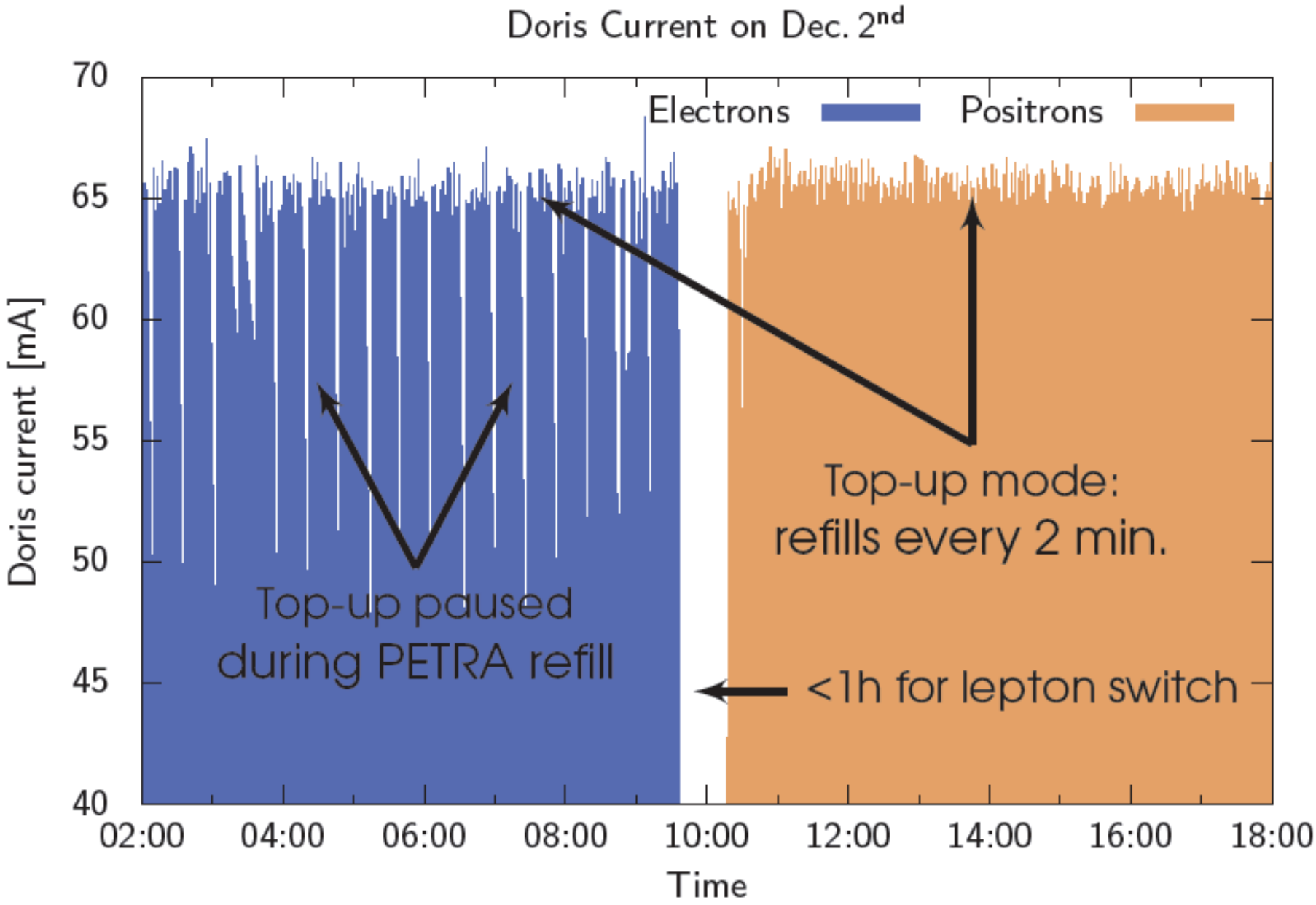




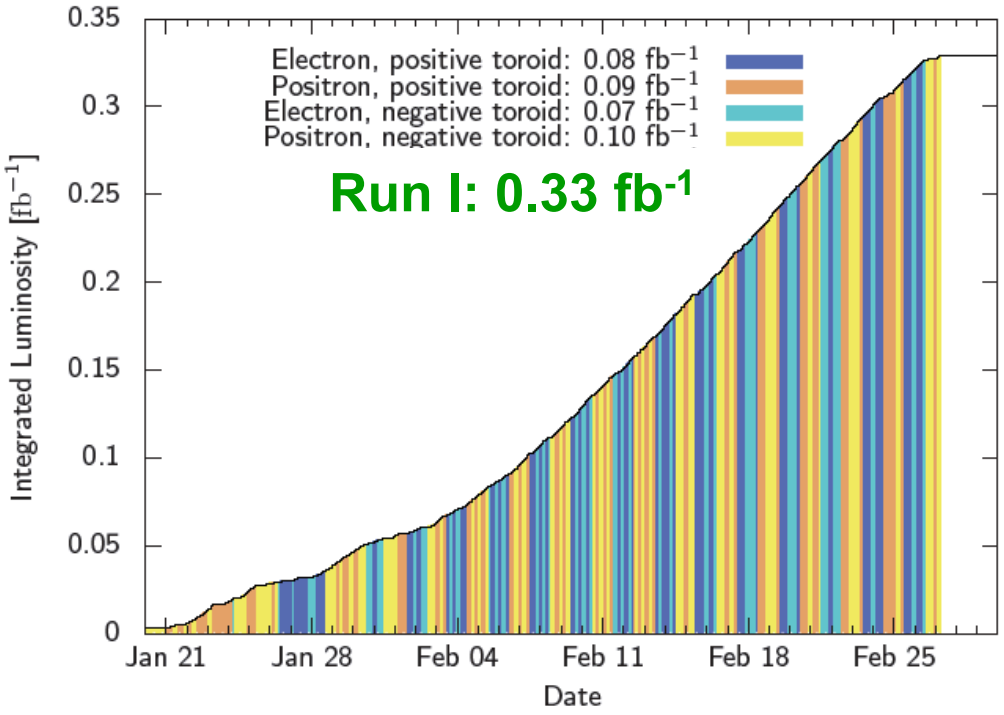
- Symm. angle 1.3° @ 2.0 GeV
- Matrix of 3x3 PbF_2 crystals
- Tested at DESY and MAMI

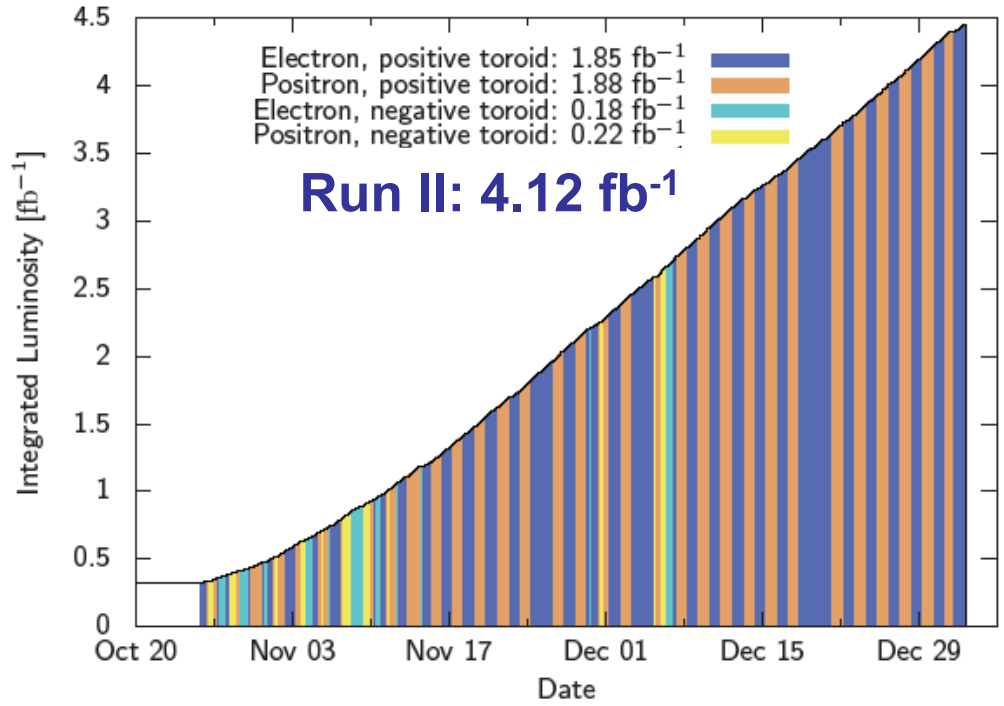
Performance of DORIS

- DORIS top-up mode established
- Typically 65mA / 0.5 sccm
- Refills every ~2 minutes by few mA
- PETRA refills every 30 minutes



Timeline of OLYMPUS





- 2007 Letter of Intent
- 2008 Proposal
- 2009 Technical review
- 2010 Approval and funding
- Summer 2010 BLAST transfer
- Spring 2011 Target test run
- Summer 2011 Detector installed
- Fall 2011 Commissioning

First run Jan 30 – Feb 27, 2012
… acquired < 0.3 fb-1

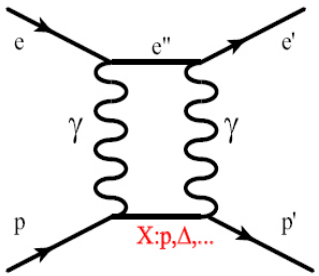
- Summer 2012 Repairs and upgrades

Second run Oct 24, 2012 – Jan 2, 2013
… acquired > 4.0 fb-1

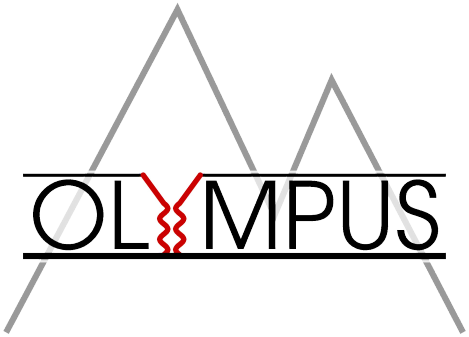
- Spring 2013 Survey & field mapping
- Smooth performance of machine, target, detector
- **Analysis underway – see next 3 talks**

Summary

- The limits of OPE have been reached with available today's precision
  - ➔ Nucleon elastic form factors, particularly G_E^p under doubt
- The TPE hypothesis is suited to remove form factor discrepancy, however calculations of TPE are model-dependent



- Need both positron and electron beams for a definitive test of TPE – OLYMPUS, CLAS, VEPP-3
- OLYMPUS prepared and commissioned at DESY/DORIS in 2010-2011
  - First running block in February 2012
  - Second running block October 24, 2012 – January 2, 2013
  - Aiming to probe TPE to <1% up to $Q^2 \sim 2.2$ (GeV/c)^2 and $\varepsilon < 0.4$



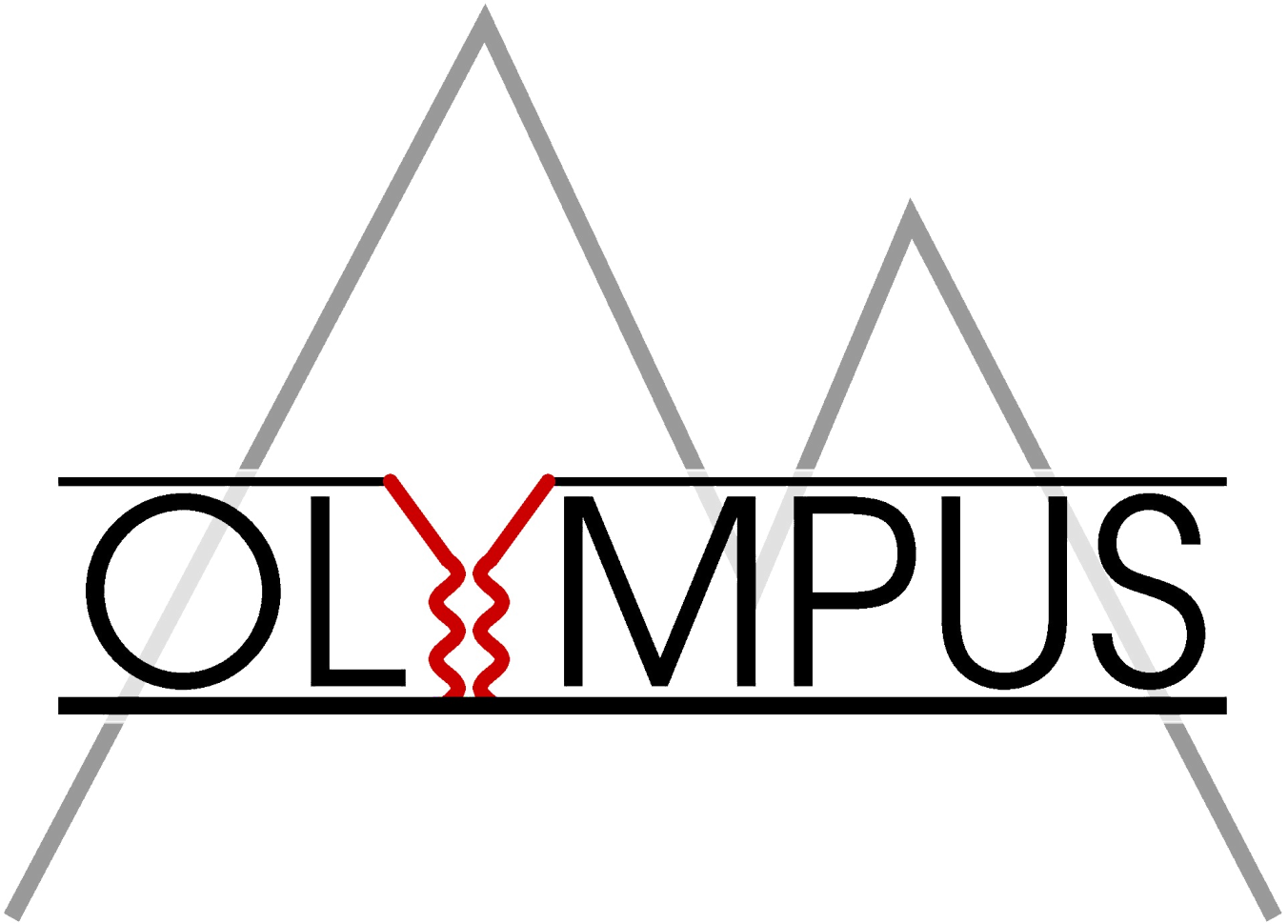
OLYMPUS collaboration

~50 physicists from 13 institutions in 6 countries

Elected spokesmen / deputy:	**R. Milner / R. Beck**	**(2009–2011)**
	M.K. / A. Winnebeck	**(2011–2013)**
	D. Hasell / U. Schneekloth	**(2013–)**

- **Arizona State University:** TOF support, particle identification, magnetic shielding
- **DESY:** Modifications to DORIS accelerator and beamline, toroid support, infrastructure, installation
- **Hampton University:** GEM luminosity monitor
- **INFN Bari:** GEM electronics
- **INFN Ferrara:** Target
- **INFN Rome:** GEM electronics
- **MIT:** BLAST spectrometer, wire chambers, tracking upgrade, target and vacuum system, transportation to DESY, simulations, slow control, analysis framework
- **Petersburg Nuclear Physics Institute:** MWPC luminosity monitor
- **University of Bonn:** Trigger, data acquisition, and online monitor
- **University of Mainz:** Trigger, DAQ, Symmetric Moller monitor
- **University of Glasgow**: TOF scintillators
- **University of New Hampshire:** TOF scintillators
- **A. Alikhanyan National Laboratory (AANL), Yerevan:** TOF scintillators

Backup



Comparison of e^+/e^- experiments

	VEPP–3 Novosibirsk	OLYMPUS DESY	EG5 CLAS JLab
beam energy	3 fixed	1 fixed	wide spectrum
equality of $e^\pm$ beam energy	measured	measured	reconstructed
e^+/e^- swapping frequency	half-hour	8 hours	simultaneously
e^+/e^- lumi monitor	elastic low-Q^2	elastic low-Q^2, Möller/Bhabha	from simulation
energy of scattered $e^\pm$	EM-calorimeter	mag. analysis	mag. analysis
proton PID	$\Delta E/E$, TOF	mag. analysis, TOF	mag. analysis, TOF
e^+/e^- detector acceptance	identical	big difference	big difference
luminosity	1.0×10^{32}	2.0×10^{33}	2.5×10^{32}
beam type	storage ring	storage ring	secondary beam
target type	internal H target	internal H target	liquid H target
data taken	2009, 2011-12	2012	2011

Comparison of e^+/e^- experiments

- Novosibirsk experiment ($E_{\text{beam}} = 1.6$, 1 and 0.6 GeV)
- CLAS @ JLab experiment ($E_{\text{beam}} = 0.5 \div 4$ GeV)
- OLYMPUS @ DESY experiment ($E_{\text{beam}} = 2$ GeV)