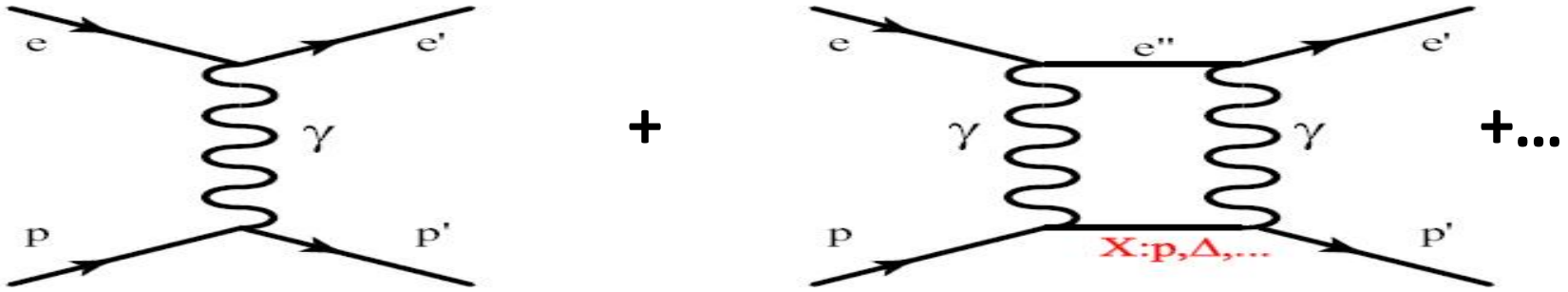
OLYMPUS : an update

- Physics case
- Funding
- Collaboration organization
- Personnel
- Progress on the experiment
- Schedule

Elastic electron scattering from proton



Dirac, Pauli FF

$$\langle N(P')|J^{\mu}_{\rm EM}(0)|N(P)\rangle =$$
$$\bar{u}(P')\left[\gamma^{\mu}F_1^N(Q^2) + i\sigma^{\mu\nu}\frac{q_\nu}{2M}F_2^N(Q^2)\right]u(P)$$

Sachs FF

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

Unpolarized elastic e-N scattering

$$\frac{d\sigma/d\Omega}{(d\sigma/d\Omega)_{Mott}} = \frac{\sigma}{\sigma_0} = A(Q^2) + B(Q^2)\tan^2\frac{\theta}{2}$$

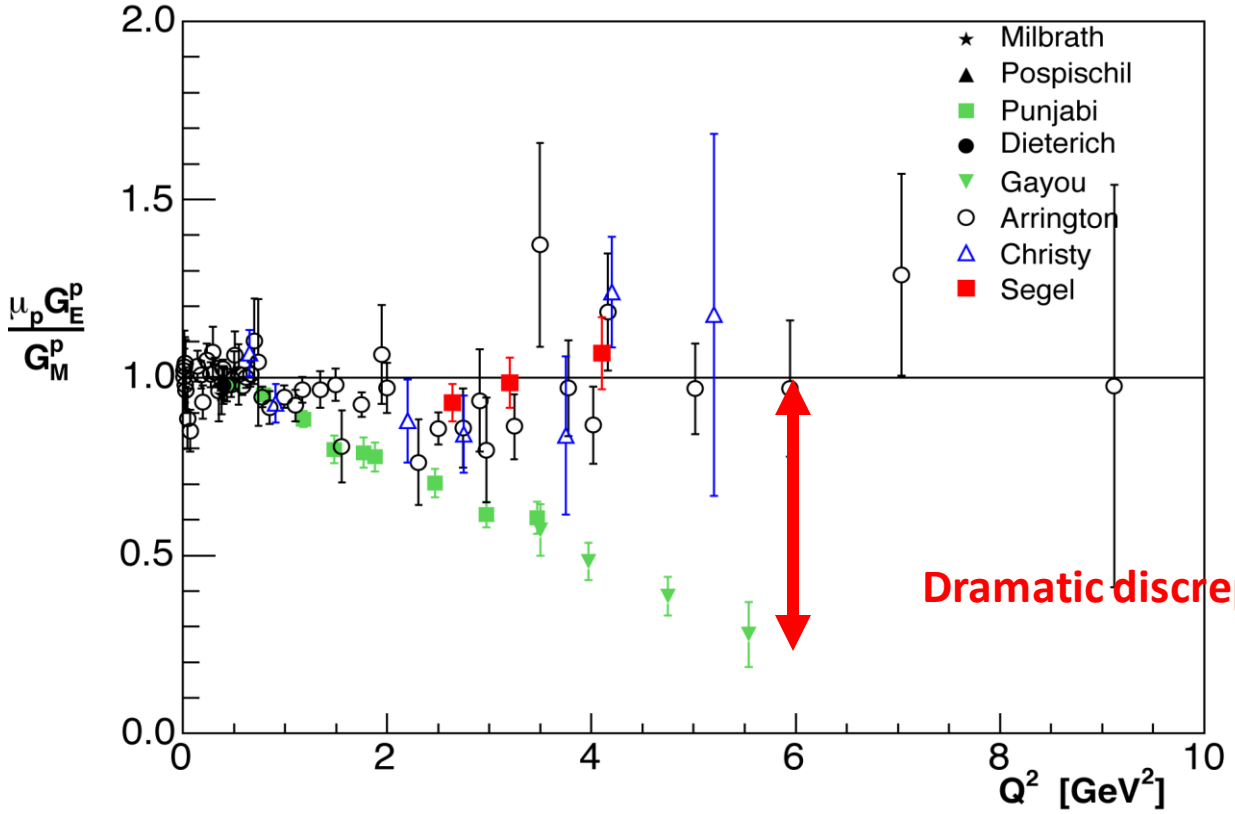
$$= \frac{G_E^2(Q^2) + \tau G_M^2(Q^2)}{1+\tau} + 2\tau G_M^2(Q^2)\tan^2\frac{\theta}{2}$$

For over 50 years, unpolarized cross section measurements have determined the elastic FF G^p_E and G^p_M using the Rosenbluth separation

$\sigma_{red} = d\sigma/d\Omega\ [\varepsilon(1+\tau)/\sigma_{Mott}] = \tau G_M^2 + \varepsilon G_E^2$

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

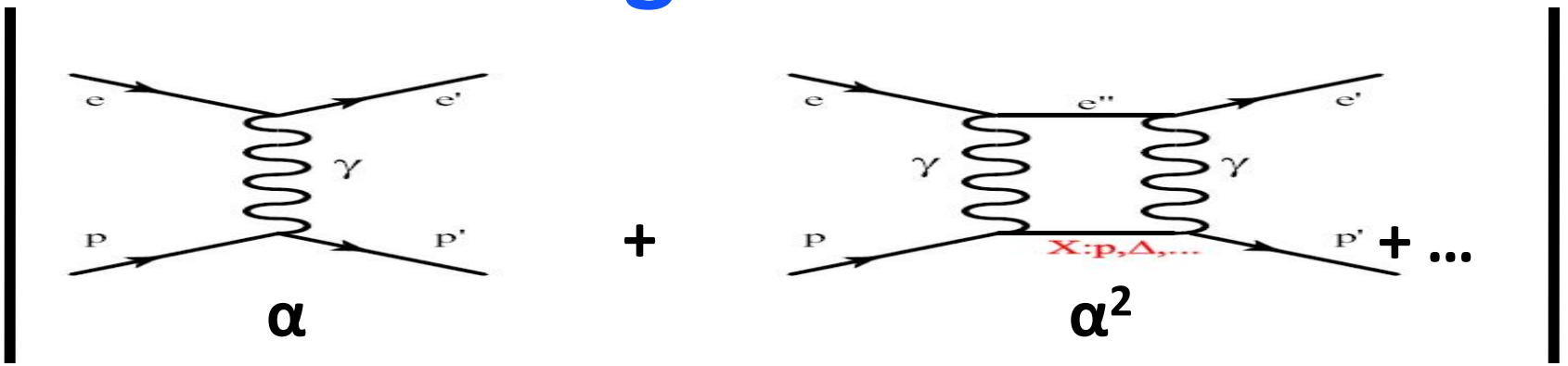
Proton form factor ratio



Jefferson Lab

- All Rosenbluth data from SLAC and Jlab in agreement.
- Dramatic discrepancy between Rosenbluth and recoil polarization technique
- Interpreted as evidence for two photon exchange

Lepton-proton elastic scattering cross-section



$$\sigma = (1\gamma)^2\alpha^2 + (1\gamma)(2\gamma)\alpha^3 + ...$$

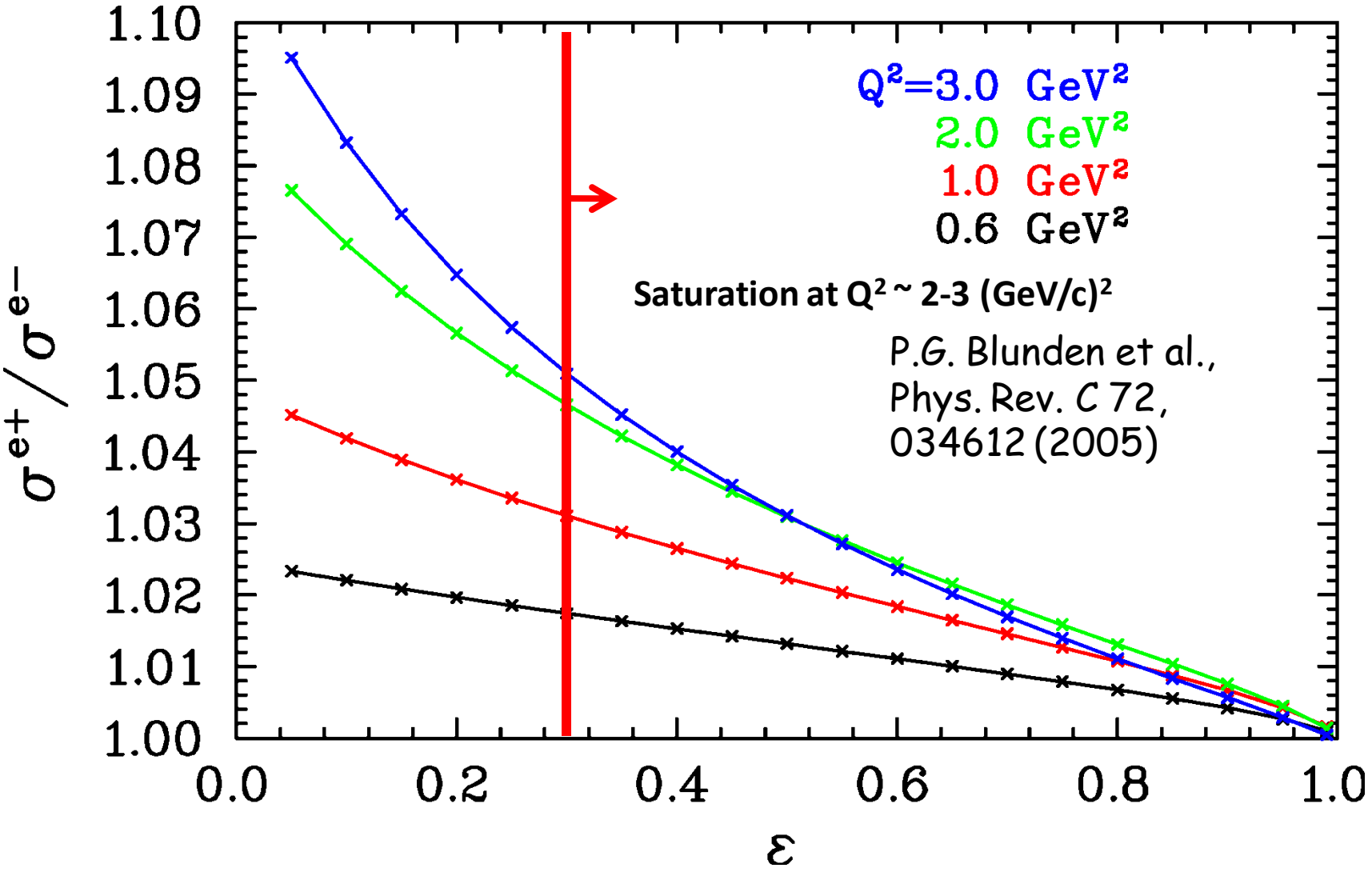
$$e^- \Longleftrightarrow e^+ \Rightarrow \alpha \Longleftrightarrow -\alpha$$

$$\sigma(\text{electron-proton}) = (1\gamma)^2\alpha^2 - (1\gamma)(2\gamma)\alpha^3 + ..$$

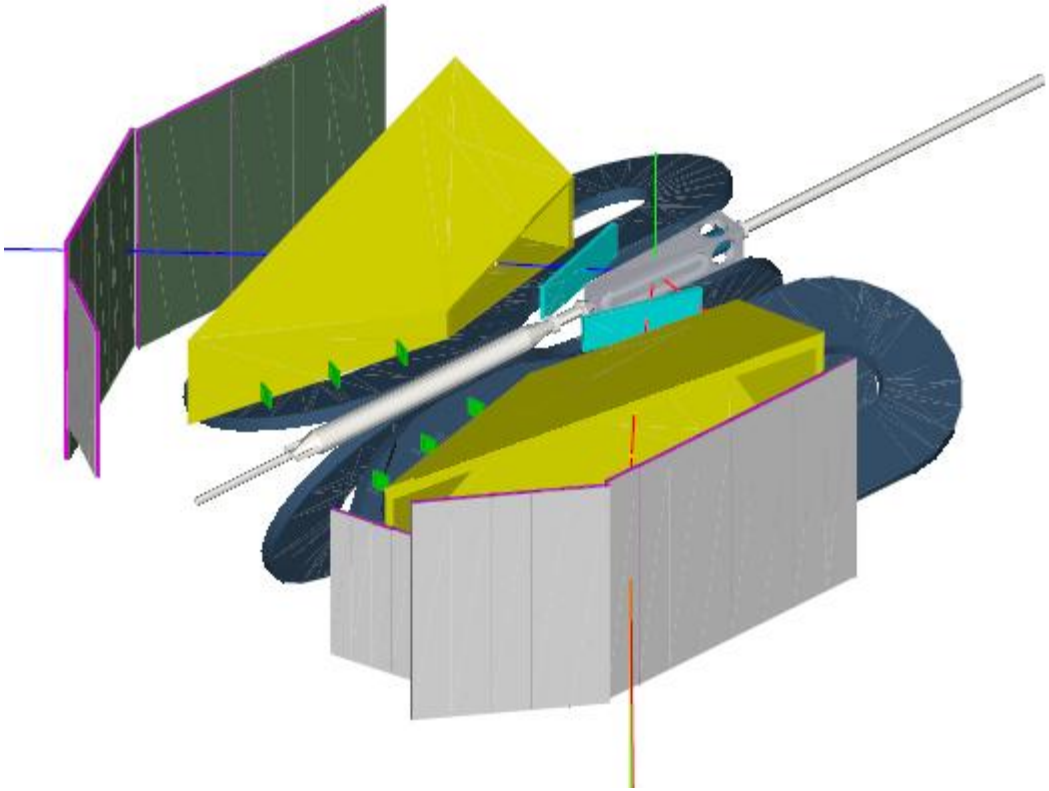
$$\sigma(\text{positron-proton}) = (1\gamma)^2\alpha^2 + (1\gamma)(2\gamma)\alpha^3 + ..$$

$$\frac{\sigma(e^+p)}{\sigma(e^-p)} = 1 + (2\alpha)\frac{2\gamma}{1\gamma}$$

e^+p/e^-p cross section ratio



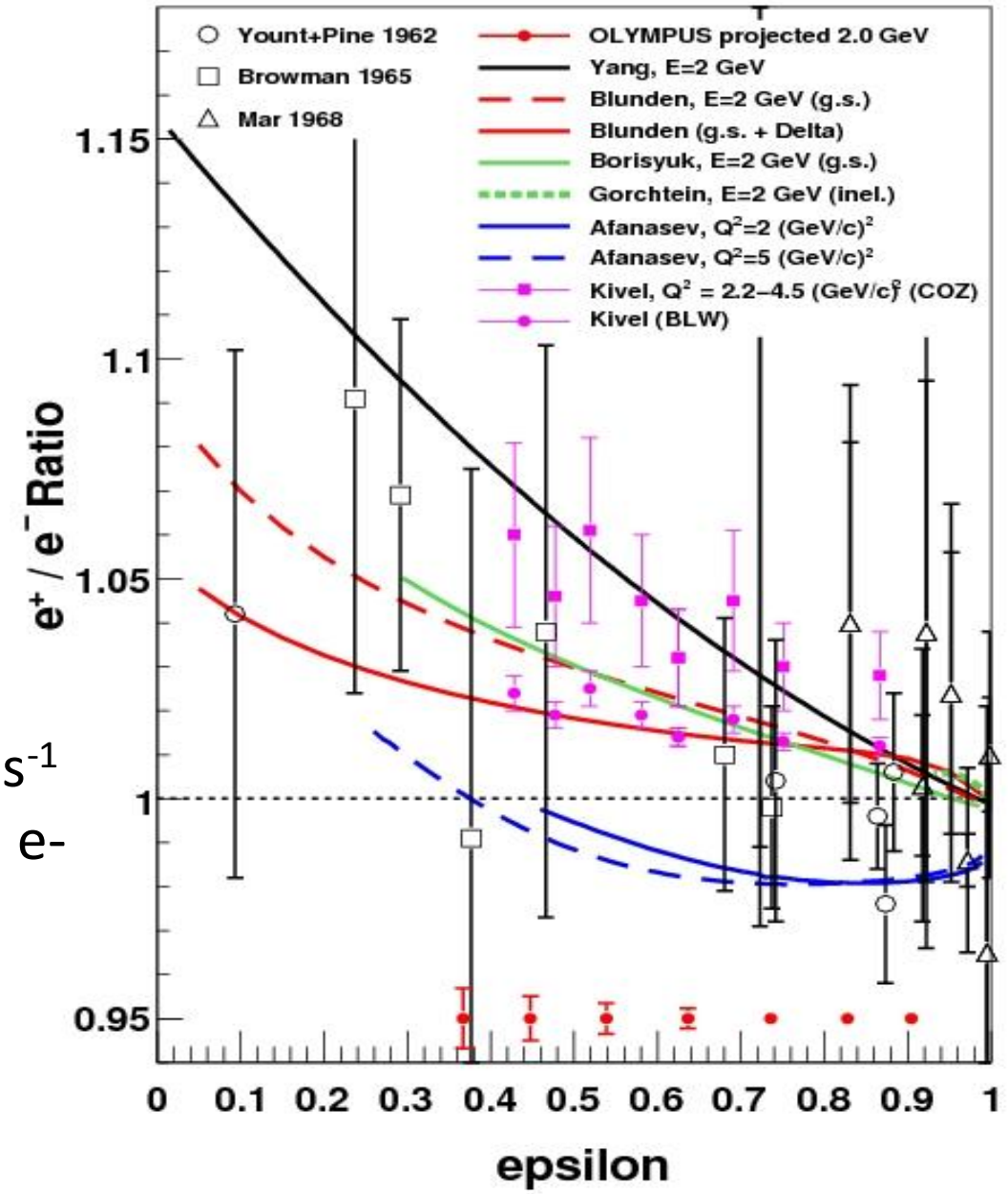
OLYMPUS experiment



- **Use the existing BLAST detector with 100 mA e-/e+ beams of DORIS incident on an internal hydrogen gas target to precisely measure the e^+p/e^-p cross section ratio**
- **Capitalizes on > $ 5 M previous investments**

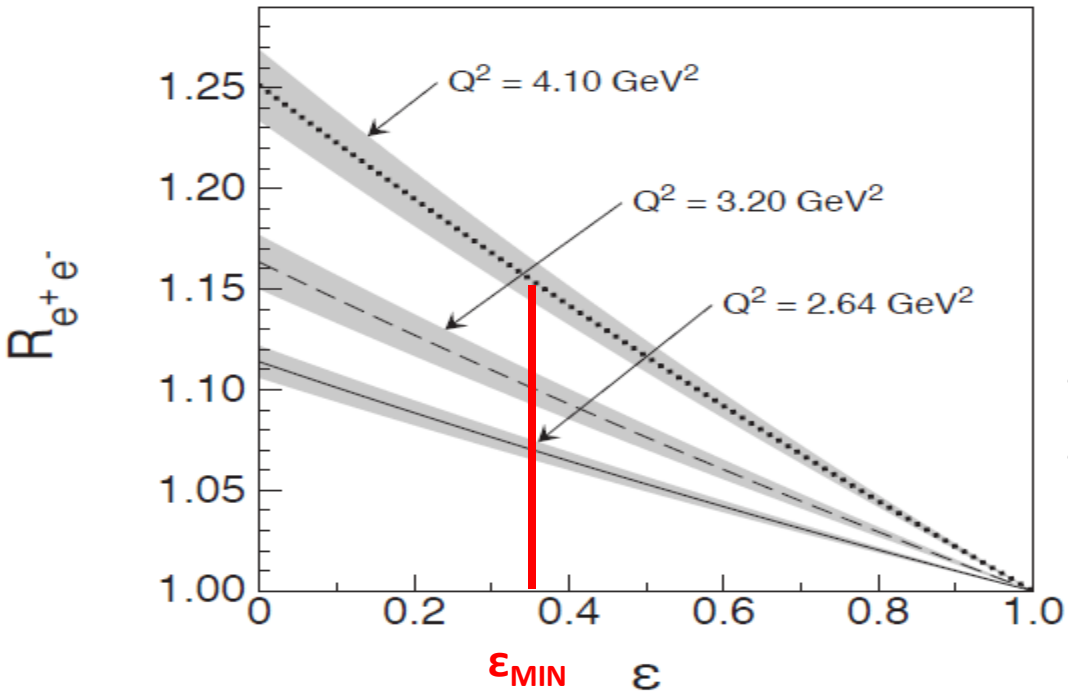
Projected OLYMPUS uncertainties

- Luminosity = 2 x 10^{33} cm^{-2} s^{-1}
- 500 hours each for e+ and e-
- 2 GeV energy



Empirical extraction of two-photon amplitudes

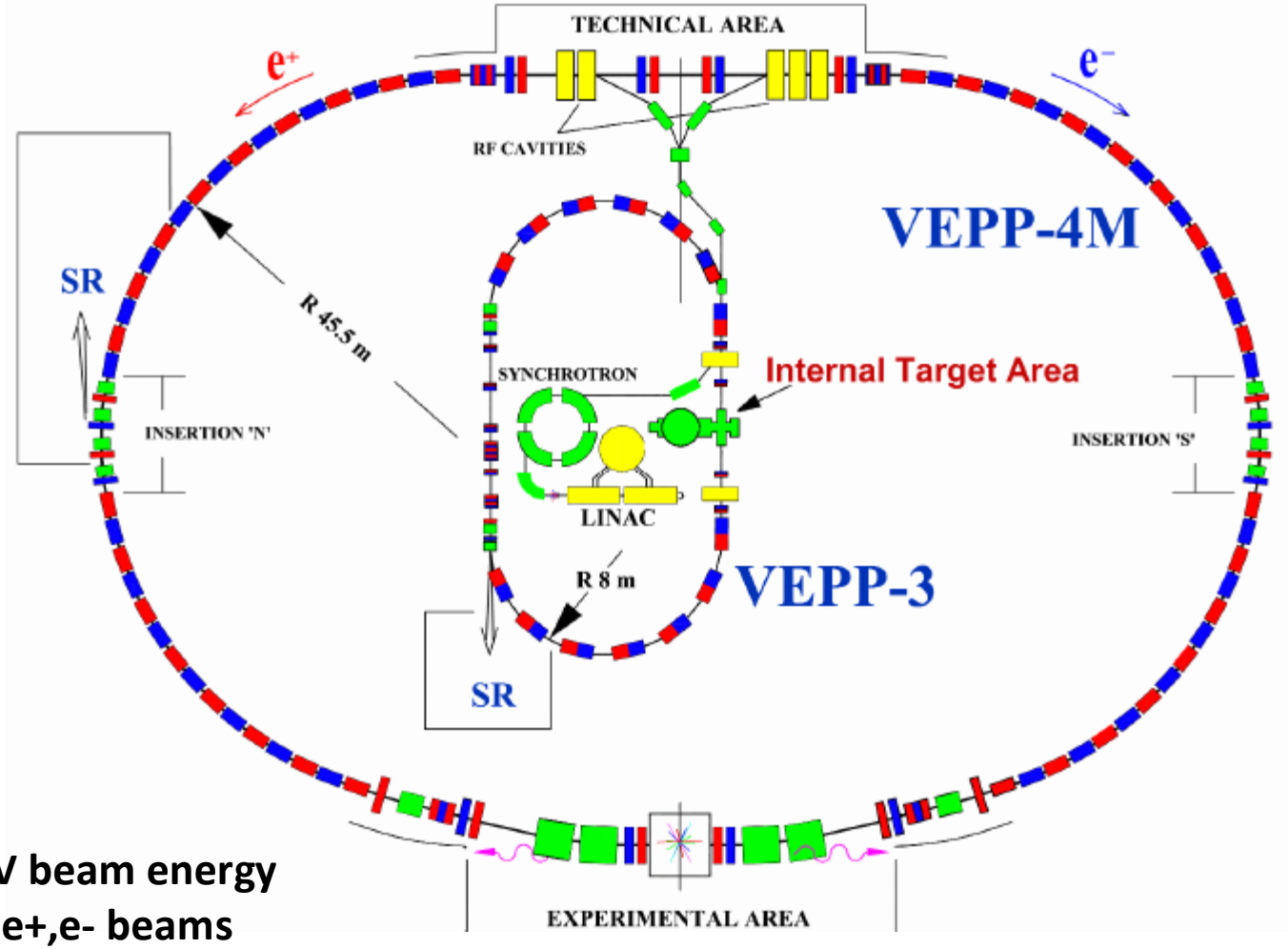
- Vanderhaeghen *et al.*



- **6% effect for OLYMPUS**
- **Grows with Q^2!**

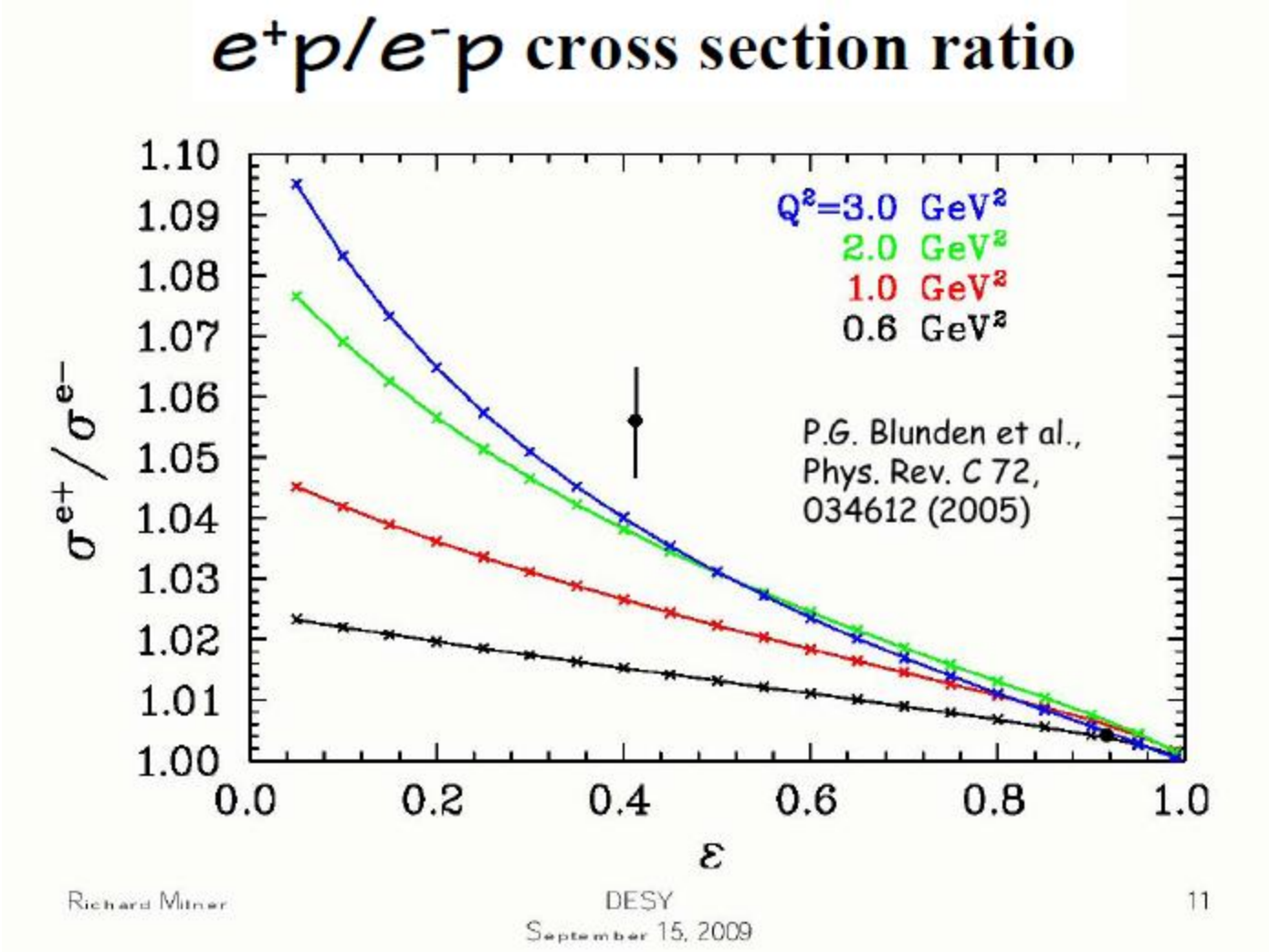
FIG. 5: Predictions for the e^+p/e^-p elastic cross section ratio $R_{e^+e^-}$ as a function of ε, together with their 1σ error bands. The results are based on the fits of the JLab/Hall A cross section data [6], together with the P_t/P_l, and P_l/P_l^{Born} data from Ref. [12] at $Q^2 = 2.5$ GeV^2.

Novosibirsk experiment

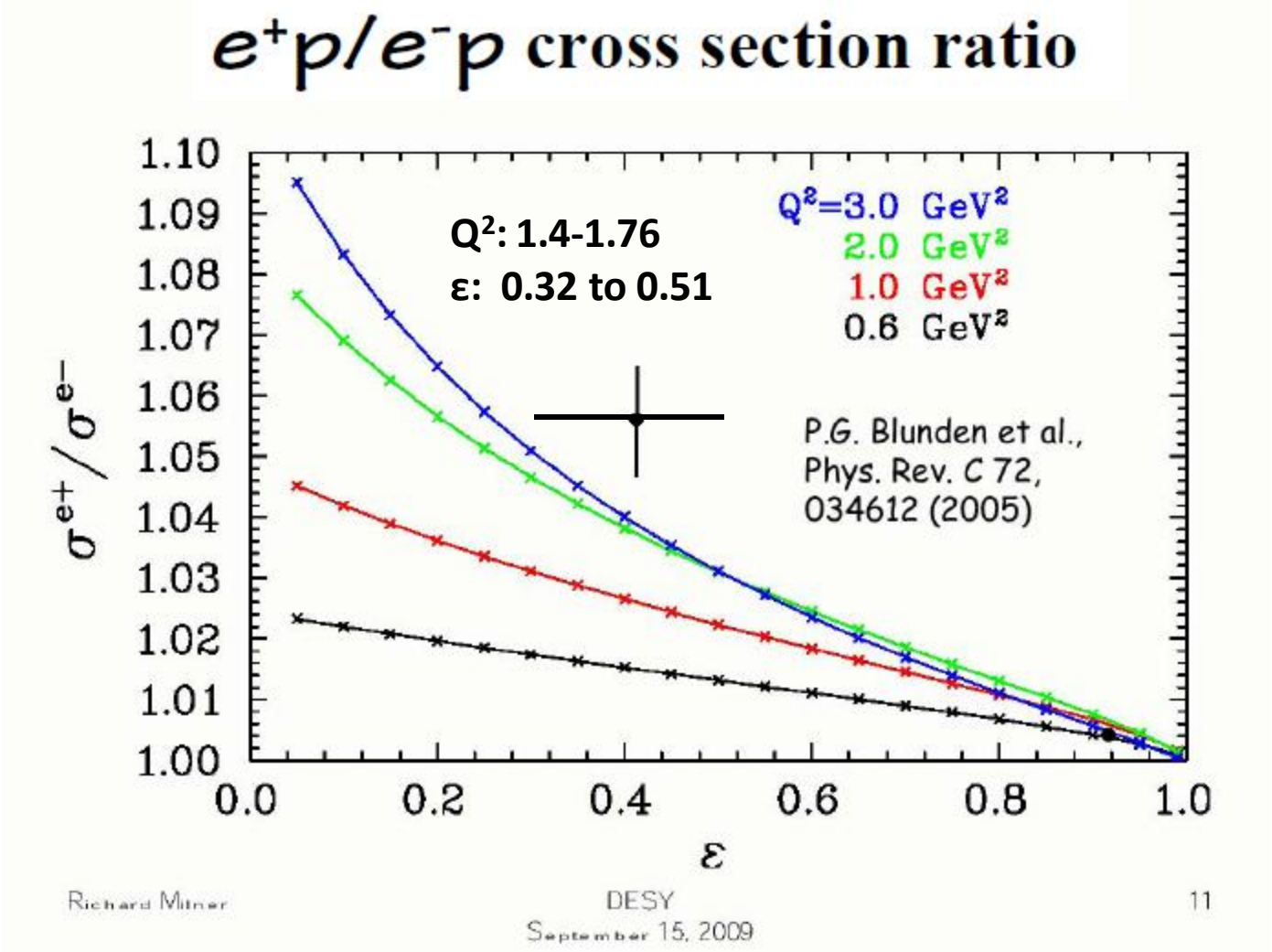


1.6 GeV beam energy
50 mA e+,e- beams
54 kC run

Unofficial Novosibirsk information



Unofficial Novosibirsk information



OLYMPUS Funding

- U.S. equipment funding approved:
  $ 1.2 M to MIT (DOE) and
  $ 620 k to Hampton U. (NSF)
- U. Bonn and U. Mainz awaiting decision by DFG but proceeding to fulfill commitments
- PNPI funding approved: $ 20 k
- Italian and Armenian group activities funded under existing agreements
- U. Glasgow awaiting U.K. funding decision: `shortlisted'

Arizona State University, USA
DESY,Hamburg, Germany
Hampton University, USA
INFN, Bari, Italy
INFN, Ferrara, Italy
INFN, Rome, Italy
Massachusetts Institute of Technology, USA
Petersburg Nuclear Physics Institute, Russia
Universität Bonn, Germany
University of Colorado, USA
University of Glasgow, United Kingdom
University of Kentucky, USA
Universität Mainz, Germany
University of New Hampshire, USA
Yerevan Physics Institute, Armenia

Collaboration organization

There have been three full OLYMPUS collaboration meetings at DESY since the last PRC meeting: 30 Nov-Dec 1 2009, 23-24 Feb 2010, and 26-27 April 2010.

At the December 2009 meeting, the collaboration elected the following people to management positions

- Spokesman: R. Milner (MIT)
- Deputy Spokesman R. Beck (U. Bonn)
- Technical Coordinator: D. Hasell (MIT)
- Project Manager: U. Schneekloth (DESY)

Phone call every two weeks

Subsequently, the collaboration has appointed the following Coordinators

- Tracking – D. Hasell (MIT)
- Scintillators – I. Lehmann (U. Glasgow)
- Luminosity monitor – M. Kohl (Hampton U.)
- Symmetric Moller monitor – F. Maas (U. Mainz)
- Target – R. Milner (MIT)
- Data acquisition – C. Funke (U. Bonn)
- Slow controls – A. Izotov (PNPI)

8.2 Institutional responsibilities

The responsibilities of each institution are listed as follows:

Arizona State University: TOF support, particle identification, magnetic shielding
DESY: Modifications to DORIS accelerator and beamline, toroid support, infrastructure, installation
Hampton University: Luminosity monitor, simulations
INFN, Bari: GEM electronics
INFN, Ferrara: Target
INFN, Rome: GEM electronics
MIT: BLAST spectrometer, wire chambers, tracking upgrade, target, transportation to DESY, simulations
Petersburg Nuclear Physics Institute: Slow controls, simulations
Universität Bonn: Trigger and data acquisition
University of Colorado: Wire chambers
University of Glasgow: Particle identification
University of Kentucky: Simulations
Universität Mainz: Trigger, data acquisition, symmetric Moller luminosity monitor
University of New Hampshire: TOF scintillators
Yerevan: Removal of ARGUS, TOF system

Institute Faculty	Physicist FTE	Ph.D. Student	Engineer FTE	Fraction Requested
ASU:				
Alarcon	0.3	1		
DESY:				
Brinker, Holler, Schneekloth	2		3	
Hampton:				
Kohl	1.5	1		
Italian Groups:				
Cisbani, DeLeo, Ferretti Dalpiaz, Frullani, Garibaldi, Lenisa, Nappi, Steffens	2.1	2	3	2 Ph.D. stud.
MIT:				
Matthews, Milner, Redwine	3	2	1.5	1.5 Engineers ✓
Petersburg:				
Belostotski, Miklukho, Naryshkin	1	1	3	3 Engineers ✓
U. Bonn:				
Beck, Klein, Schmieden	2	1	0.5	1 p.d. ✓
U. Colorado:				
Kinney	0.2			
U. Glasgow:				✓
Kaiser,Rosner	1.3	1	0.5	1 p.d., 1 Ph.D. stud.
U. Kentucky:				
Crawford		1		
U. Mainz:				✓
Denig, Maas, Von Harrach	1.9	1	0.5	1 p.d., 1 Ph.D. stud.
U. New Hampshire				
Calarco	0.5	1		
Yerevan				
Akopov, Avetisyan, Elbakian, Marukyan	0.8	2		
Total	✓ 16.6	14	✓ 12	

Table 8.1: Personnel committed to the OLYMPUS experiment by institution.

Personnel

With the availability of funding, all Ph.D. physicists and engineers requested have been put in place

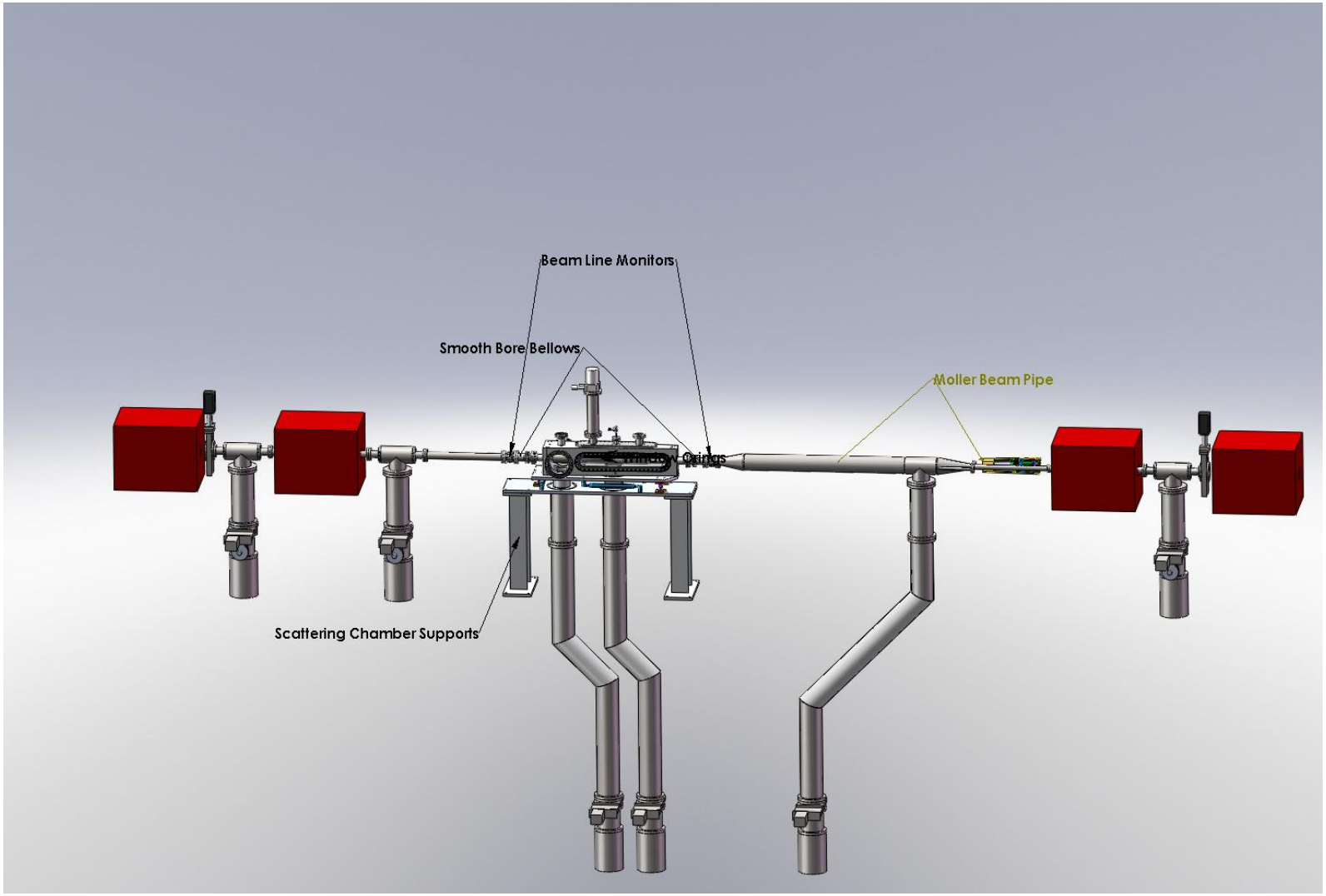
- MIT has hired 2 post-docs, 2 graduate students and Bates engineers are fully engaged
  - a team of six students is coming to DESY to work on restringing the drift chambers in summer 2010
- U. Bonn has several post-docs working on DAQ and GEM readout
- U. Mainz has a post-doc working on the Moller/Bhabha lumi monitor
- Hampton U. is hiring a post-doc and has a graduate student working on the GEMs
- Armenia personnel have helped with the disassembly of ARGUS
- Glasgow has scientific and technical personal working on the TOFs
- Ferrara is constructing target cells

Collaboration pleased to occupy assigned office suite in building 66.

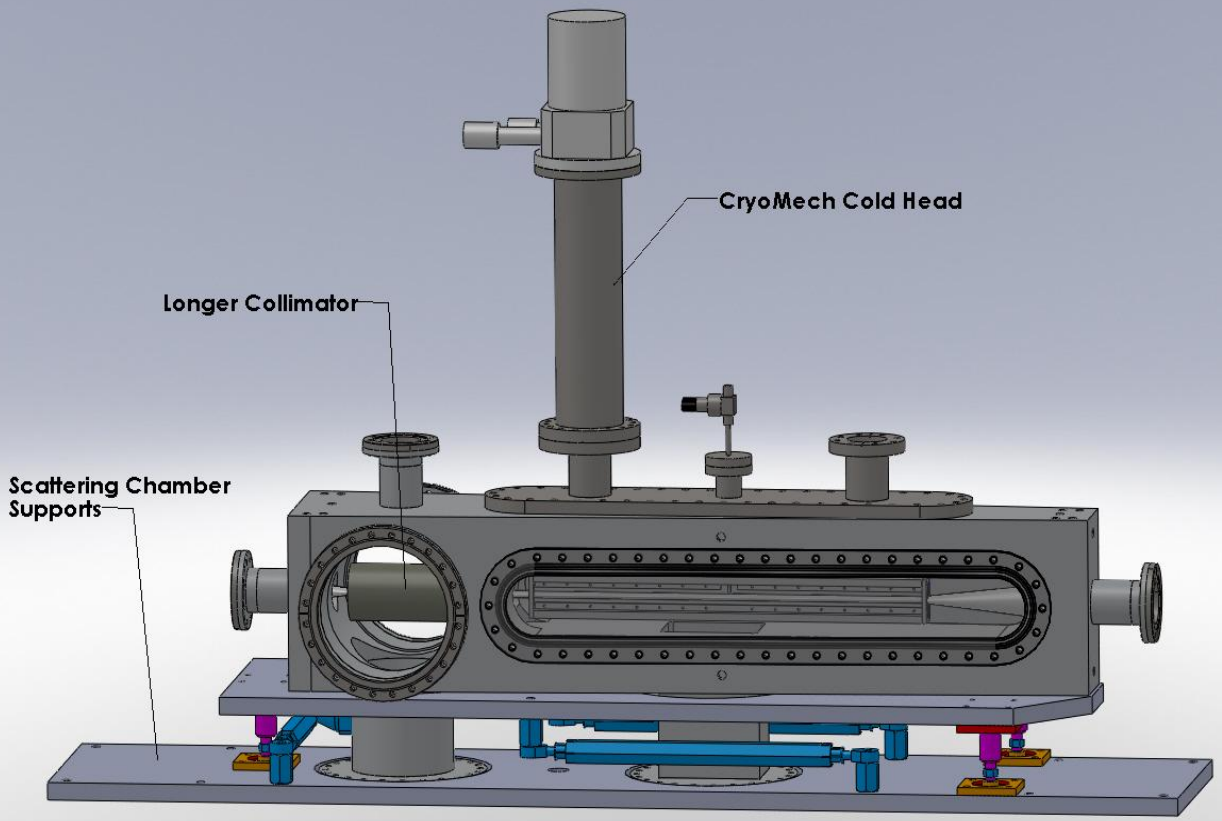
Preparation of the experiment

- ARGUS detector removal completed
- Target and vacuum system
  - full design completed, target chamber ordered
  - heat loads determined and accounted for in design
  - target cells under construction at Ferrara
  - Moller/Bhabha lumi monitor fully integrated
  - control system development to start May 2010
- Drift chambers
  - decision taken to rewire drift chambers at DESY in summer 2010
  - will take place at Tasso hall
  - materials and personnel in place – need housing!
- TOFs
  - TOFs tested and calibrated at Bates in January 2010
  - U. Glasgow coordinating
  - supports currently being redesigned
- Luminosity monitoring
  - both 12 deg. elastic (Hampton U.) and 1.2 deg Moller/Bhabha (U. Mainz) monitors being developed
- GEMs
  - H.U. group at MIT in summer 2010
  - Readout system for STAR/FGT GEMs developed for tracking GEMs
  - H.U. pursuing readout system from Rome/JLab for lumi GEMS
- DAQ
  - U. Bonn coordinating
  - System will be brought into operation in summer 2010 at DESY
- Slow controls
  - -PNPI coordinating

OLYMPUS vacuum system

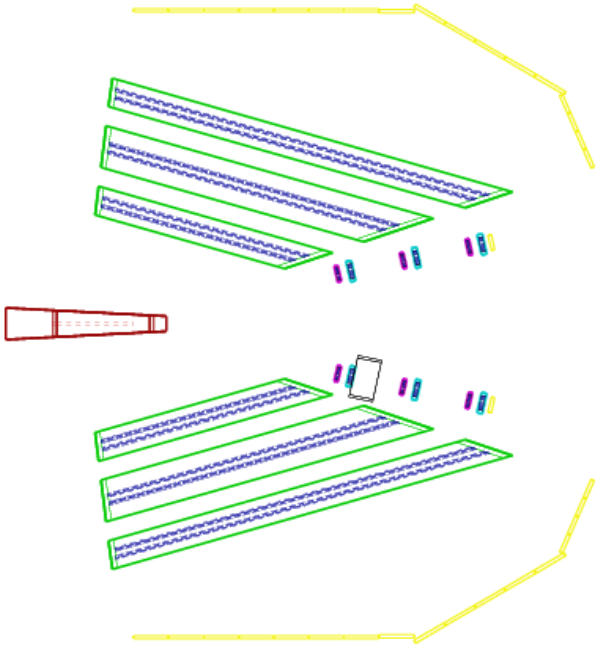


Target chamber



Under construction

12 deg. elastic luminosity monitor



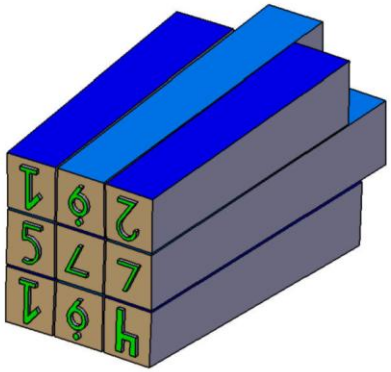
- Two MWPC telescopes with 3 x/u/v elements after each GEM element to be constructed by PNPI
- Scintillator for triggering and timing
- High redundancy
  No interference
  Two independent groups
- Well suited for efficiency and alignment calibration
- Both GEM and MWPC telescopes can operate independently

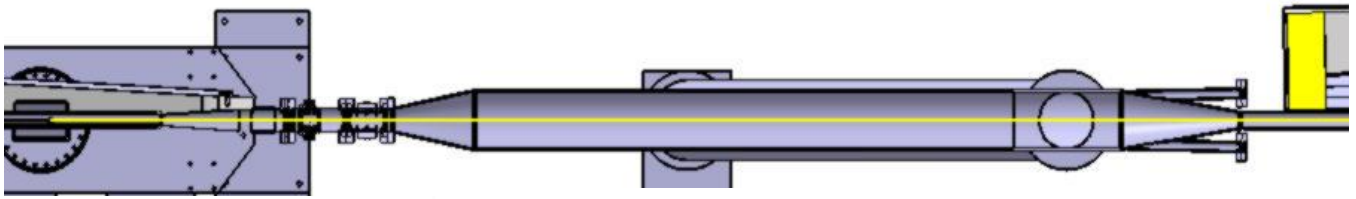
	δz [cm]	$\delta\theta$	$\delta\phi$	$\delta p/p$ [%]
GEMs alone	1.67	0.137°	0.301°	4.57
GEMs alone + MWPC material	1.74	0.142°	0.309°	4.86
MWPCs alone + GEM material	3.94	0.294°	0.407°	9.58
GEMs + MWPCs	1.60	0.132°	0.308°	4.43

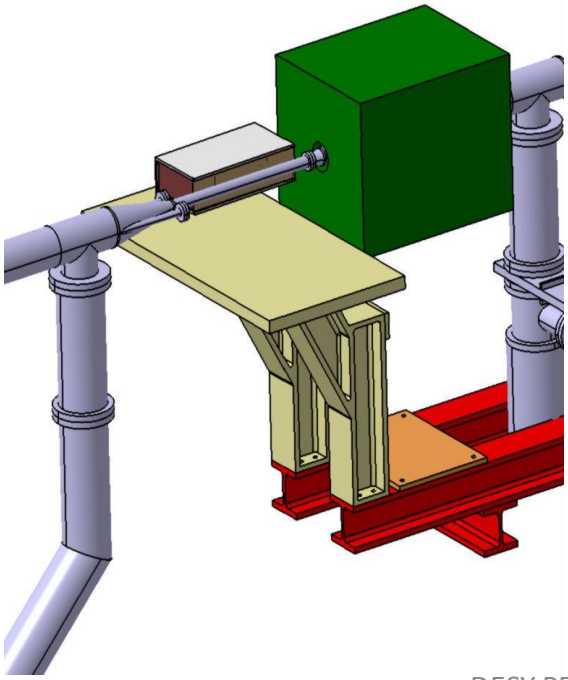
Number of planes	3 (XUV): 0, +/-30 degrees
Clear acceptance	112x112mm^2
Anode wire spacing	1mm
Number of channels	400
Material budget	0.25% rad.length
Readout system	LeCroy PCOS4 (Rome group)
Gas mixture	Ar/CO_2/CF_4 (65/30/5%)

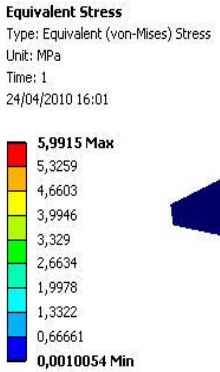
1.2 deg. Moller/Bhabha luminosity monitor

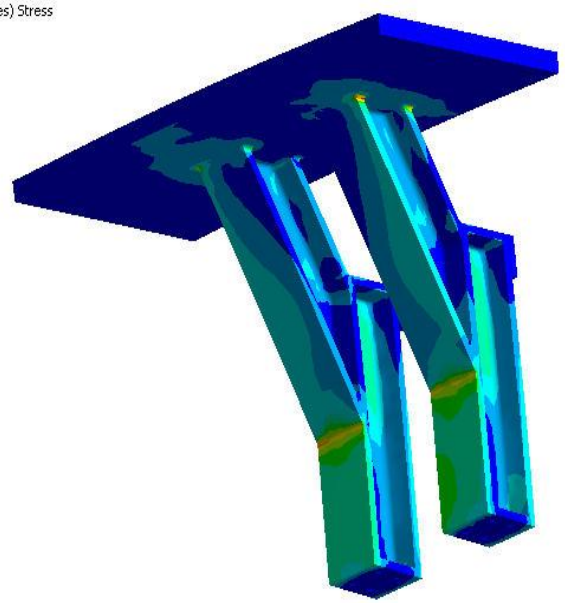
- Existing radiation hard PbF_2 crystals at U. Mainz
- 560 kHz rate expected at 2 GeV
- 26 X 26 X 160 mm^3
- Needs to operate from 2 to 4.5 GeV





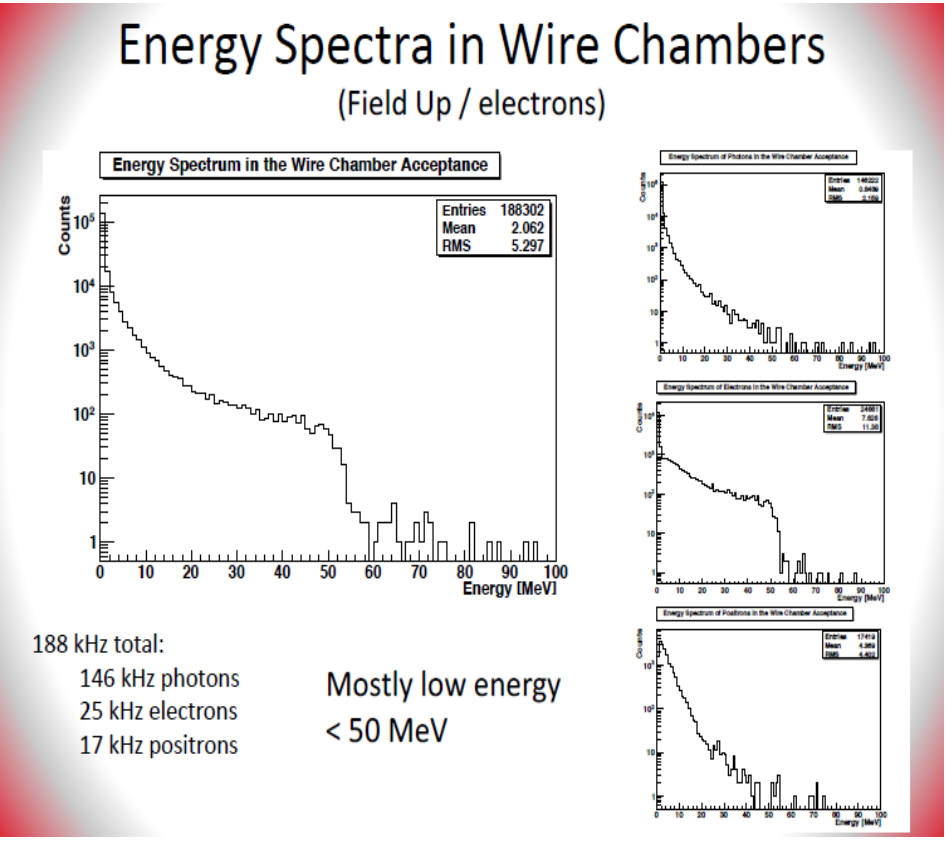


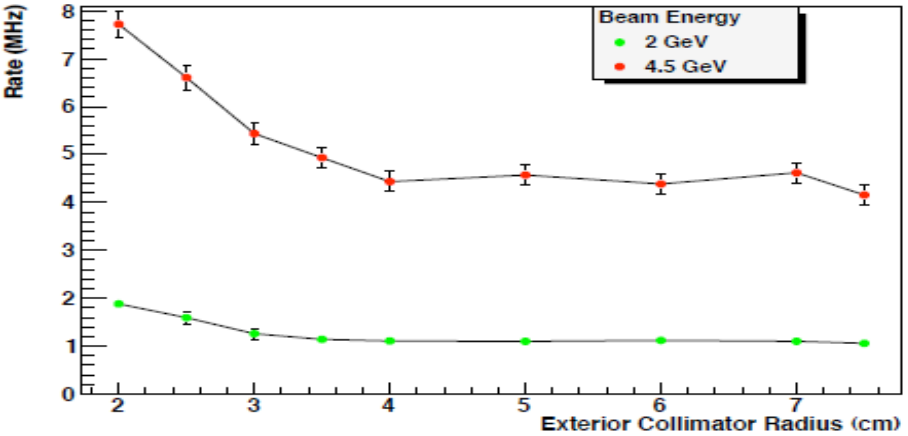


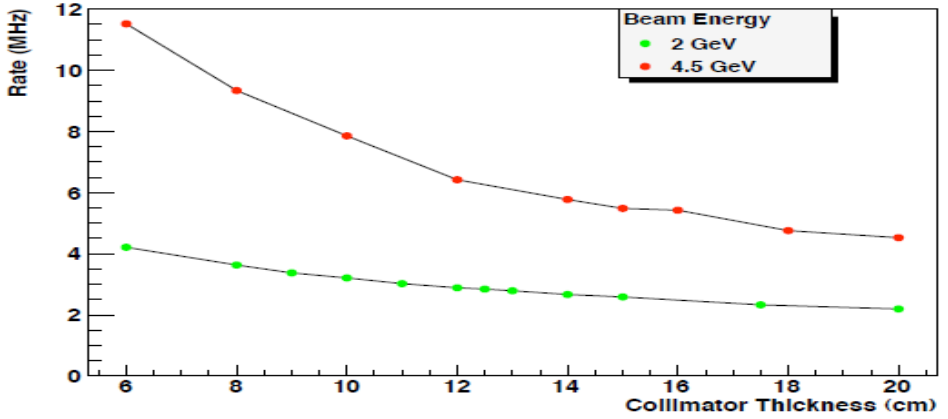


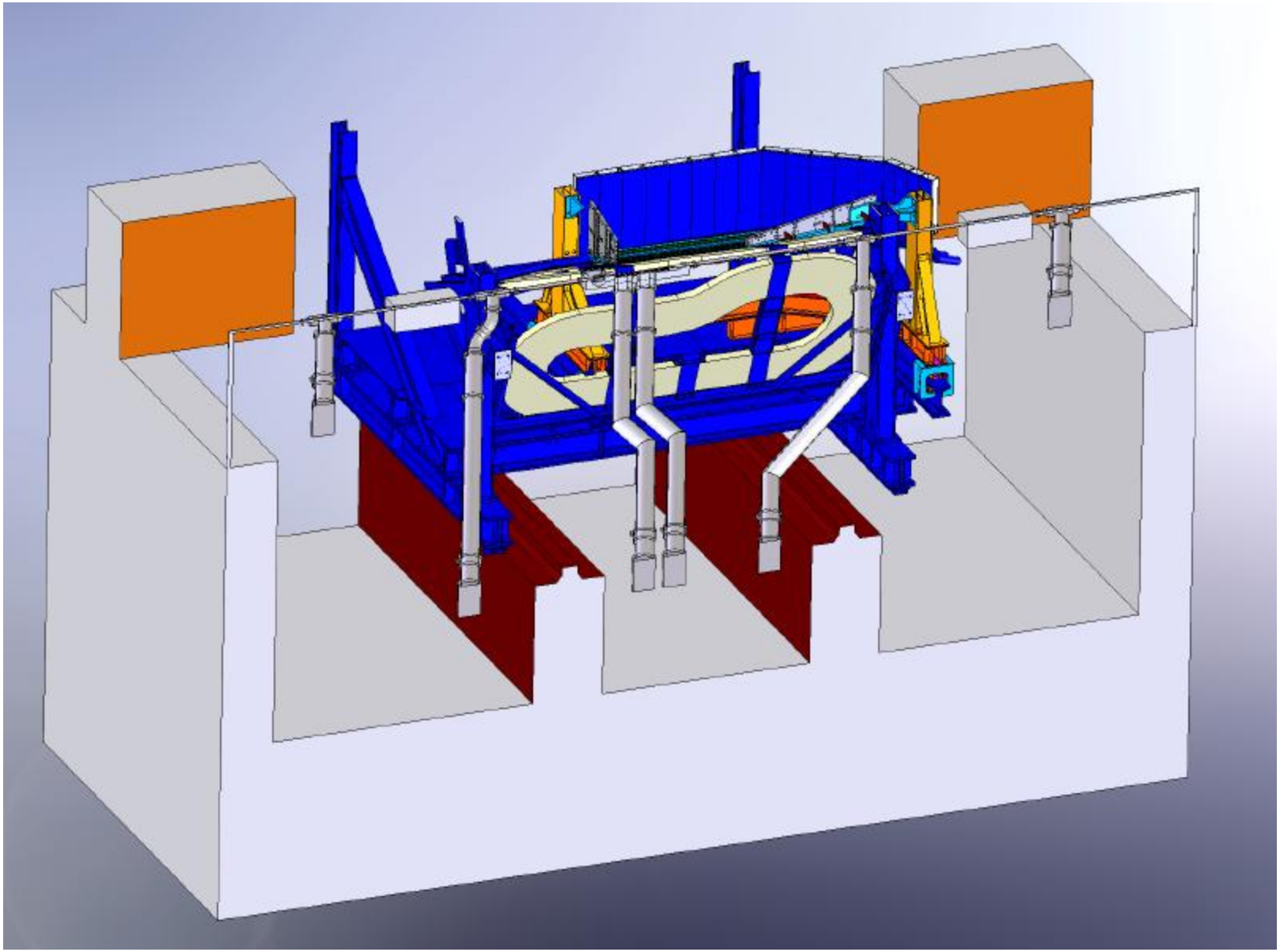
Monte Carlo simulation

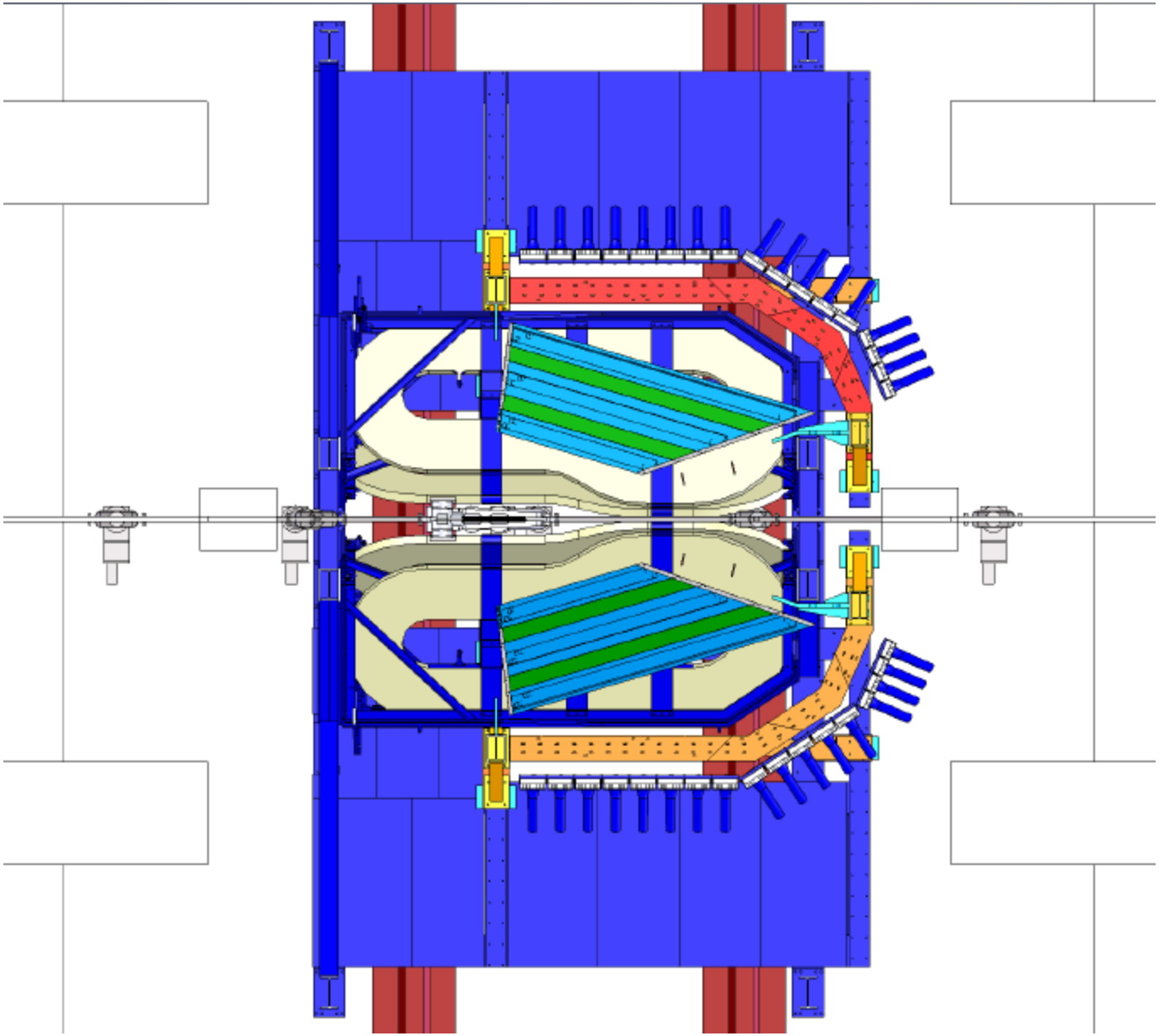
- GEANT4 simulation developed and used extensively
- Design of the dimensions of the fixed collimator using model for beam halo











Schedule

Transfer of detector from MIT-Bates to DESY

- detector completely disassembled at MIT-Bates
- drift chambers, TOFs, detector subframes to be shipped in two weeks
- will arrive at DESY at the end of May
- two additional shipments approx. every two weeks
- all detector elements at DESY by beginning of July
- intensive work at DESY begins in June: restringing wire chambers, TOF preparation, toroid assembly, DAQ

Assembly and testing of target at MIT-Bates

- target chamber ordered, scheduled to be delivered in July
- commissioning of gas system underway
- development of target control system to begin in May
- target cells from Ferrara to arrive in June
- complete system to be tested at Bates in August-September 2010
- ship to DESY in October 2010
- install in December-February shutdown

Install test experiment in December 2010-February 2011

Install complete experiment in August 2011

Commission in fall 2011

Take data in two running blocks in 2012

Detailed schedule with critical milestones available

Summary

- Physics case growing – new perspective on Q^2 dependence being evaluated
- Collaboration organized and funding largely in place
- Intensive activities since fall 2009
- Transfer of detector to occur in summer 2010 with significant continuous presence at DESY by OLYMPUS beginning in June
- Target will be assembled at MIT-Bates in summer 2010 and shipped in fall
- Test experiment will be installed in winter 2010/11 shutdown
- Schedule is tight but milestone of winter installation can be met