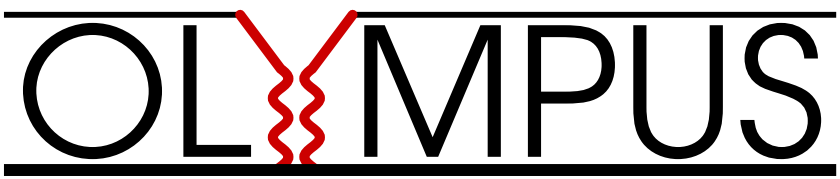
The OLYMPUS Experiment

73^{rd} DESY PRC

Alexander Winnebeck

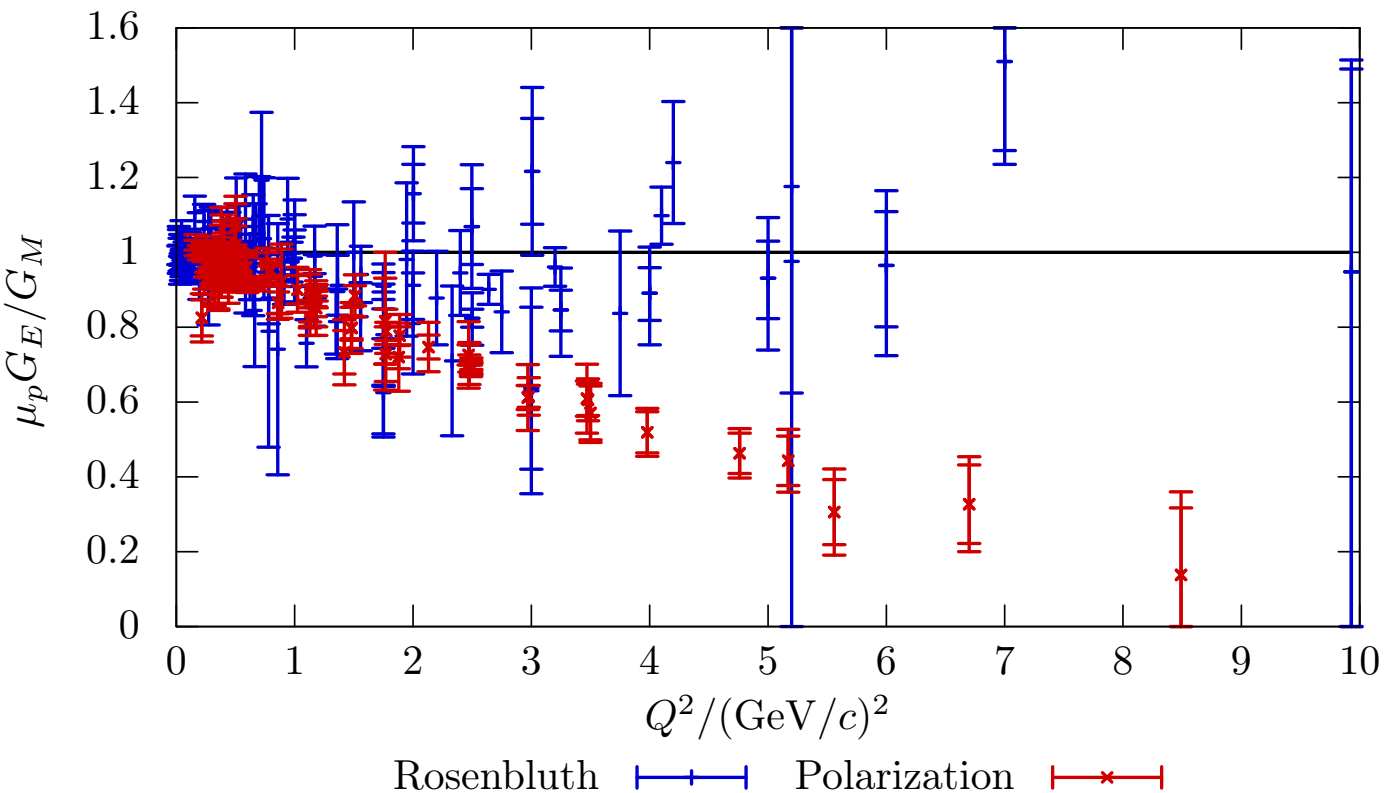
Massachusetts Institute of Technology, LNS

26th April, 2012



Form Factor Ratio Discrepancy

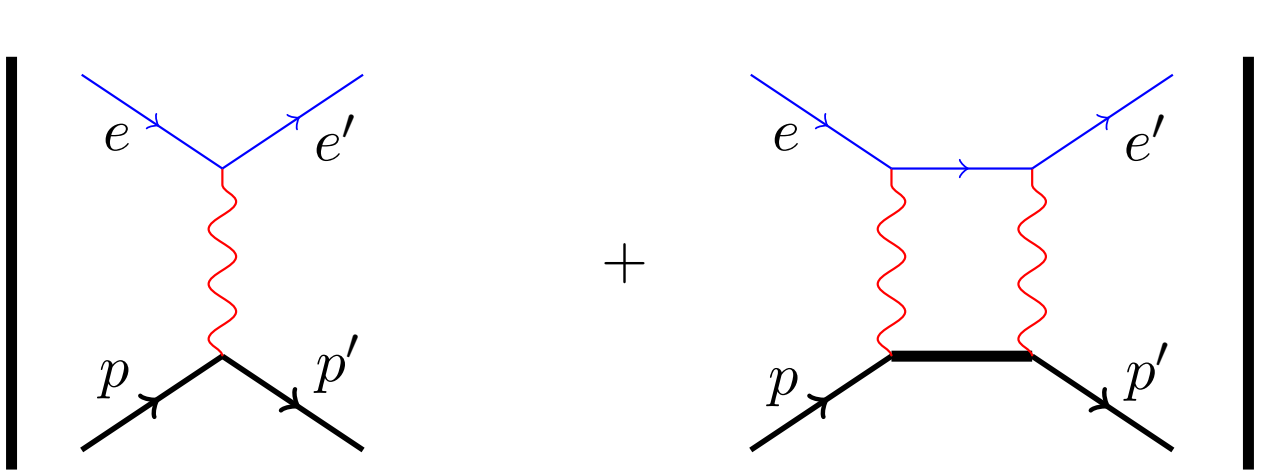
$$\frac{d\sigma}{d\Omega} = \frac{d\sigma}{d\Omega}\bigg|_{Mott} \frac{1}{1+\tau}\left(G_E^2 + \frac{\tau}{\epsilon}G_M^2\right)$$



Plot by Bernauer

$\Rightarrow$ 2 photon exchange

Principle of Measurement



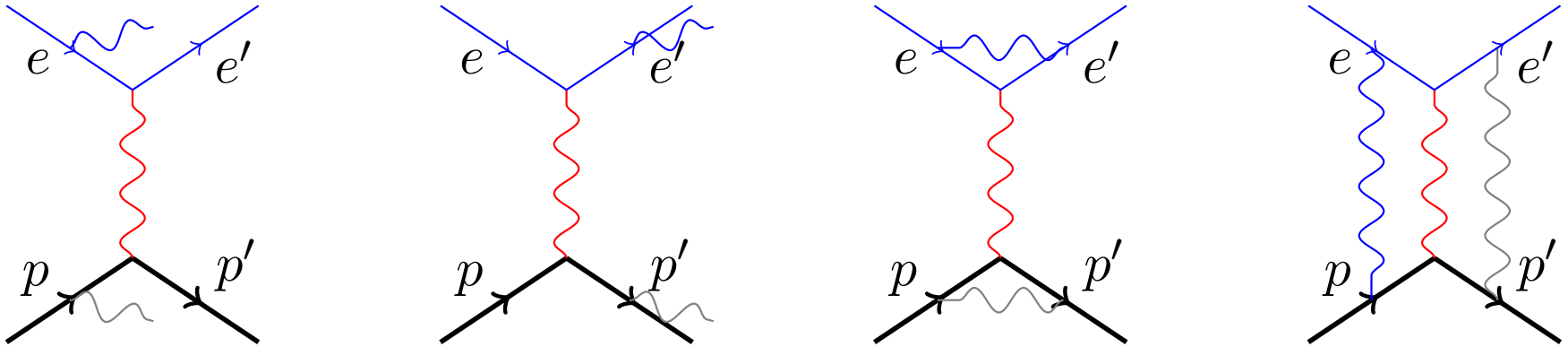
Difficult to calculate hard 2γ contribution

$\Rightarrow$ **Measure it!**

$$R = \frac{\sigma(e^+p)}{\sigma(e^-p)} \approx \frac{(1\gamma)^2\alpha^2 + 2\alpha^3(1\gamma)(2\gamma)}{(1\gamma)^2\alpha^2 - 2\alpha^3(1\gamma)(2\gamma)} \approx 1 + 4\alpha\frac{(2\gamma)}{(1\gamma)}$$

Olympus expects ≈5% effect

Radiative Corrections



- Processes generate radiative tail
- Elastic yield depends on acceptances, resolutions, and cuts

→ Need to correct for this (comparison between experiments)

- Weekly meeting at MIT
- Radiative Correction Workshops
  - July 2011 @ MIT
  - July 2012 @ St. Petersburg, Russia

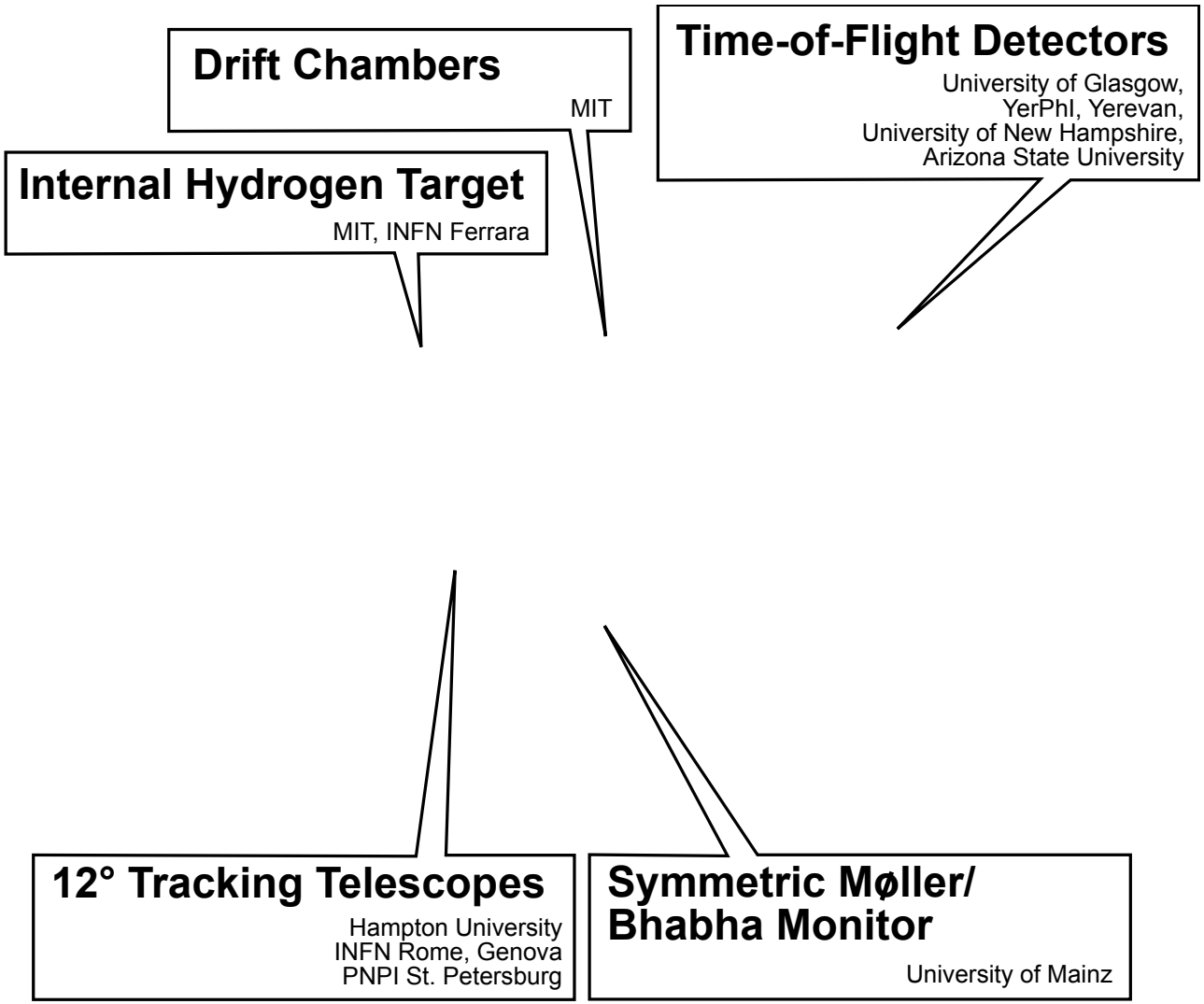
Strategy to Obtain Results

0. Have detector working and get data
1. Hit and track reconstruction
2. Elastic event selection
3. Applying radiative corrections with Monte Carlo methods
4. Extract Ratio

Schedule of Olympus

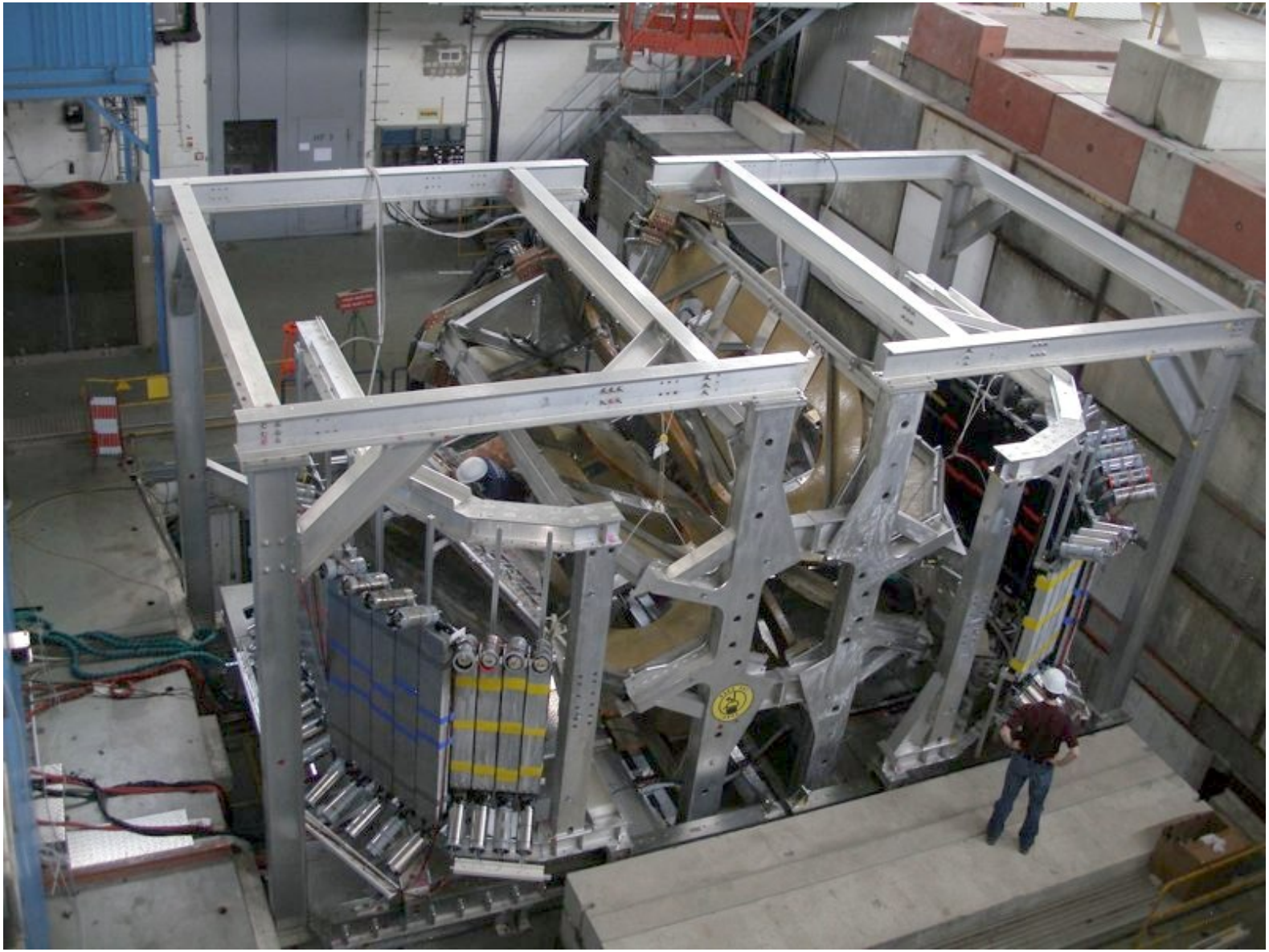
- Proposal (9/2008)
- DOE funding (1/2010)
- Shipping of Blast (spring 2010)
- Test experiment at DORIS (2/2011)
- Detector installation (until 7/2011)
- Detector Roll-in (7/16/2011)
- Olympus test beam at DORIS (8/2011)
- First data taking (1-2/2012)
- Second data taking (10-12/2012)

Setup Overview



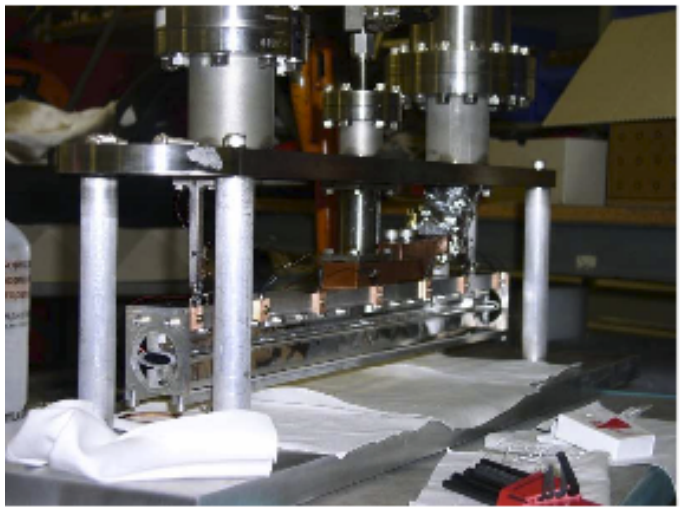
based on a figure by R. Russell

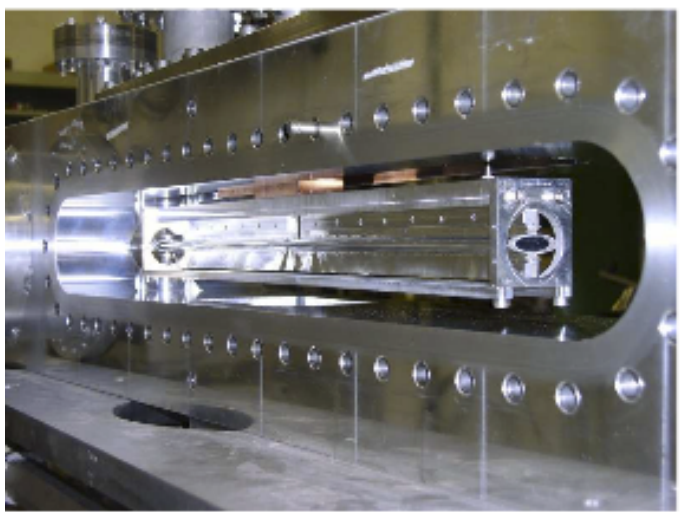
Experiment in Reality



Target System

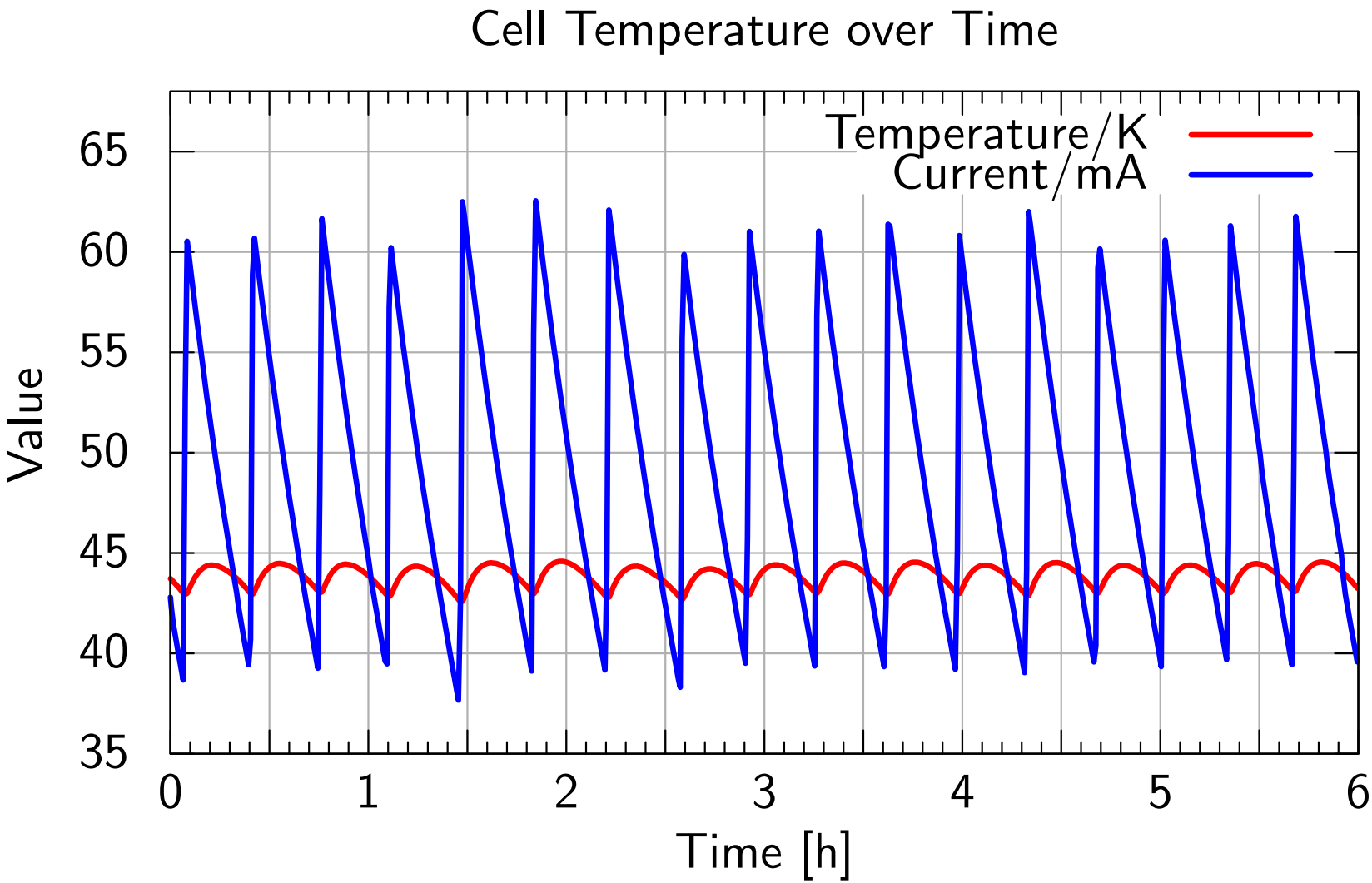
- Windowless internal gas target
- 60 cm long storage cell
- Elliptical cross section (27 mm x 9 mm)
- 100 μm thick aluminum wall
- Cryo cooled (43.5$\pm$1 K)
- $\mathcal{O}(10^{15})$ atoms/cm^2
- Hydrogen generator (electrolysis)



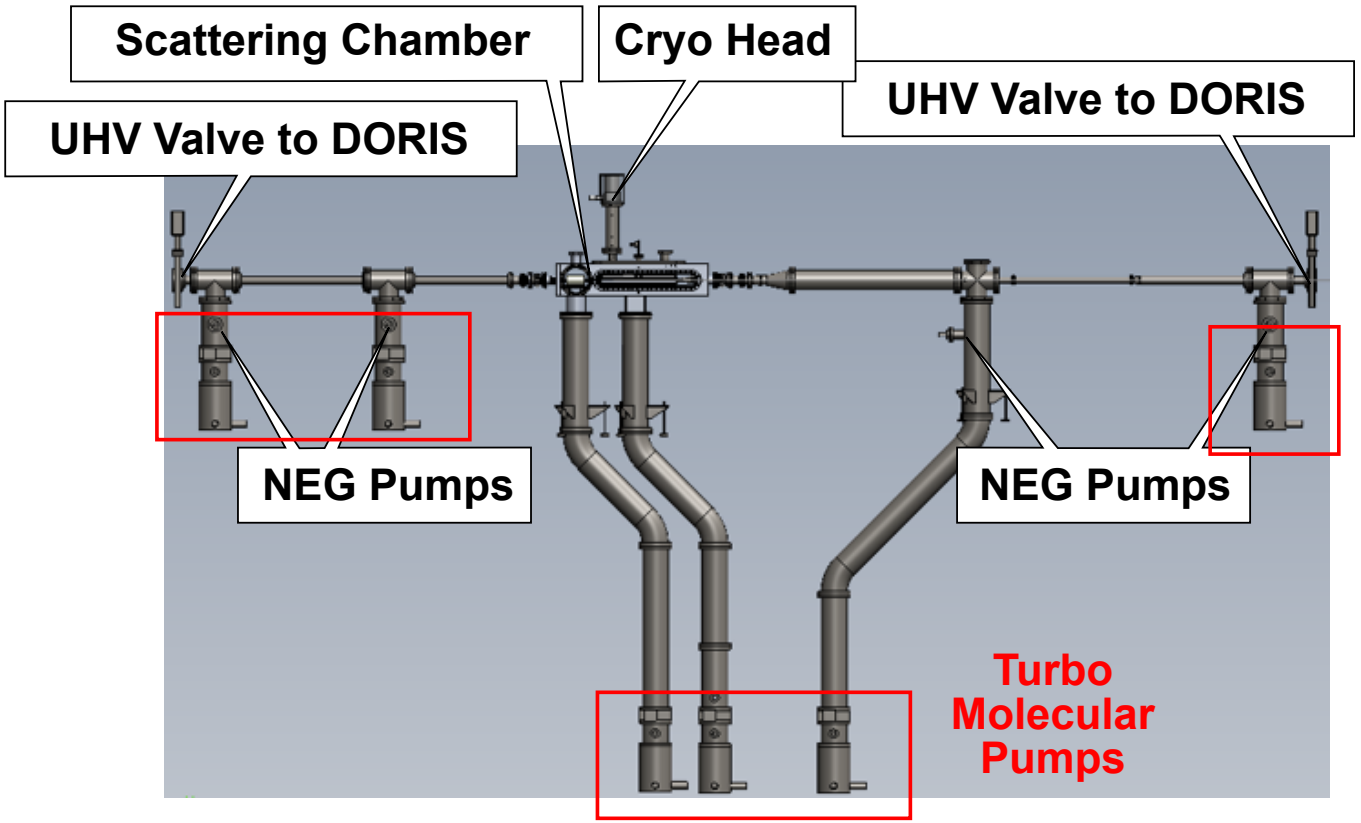


INFN Ferrara, MIT

Target Cell Temperature during Run

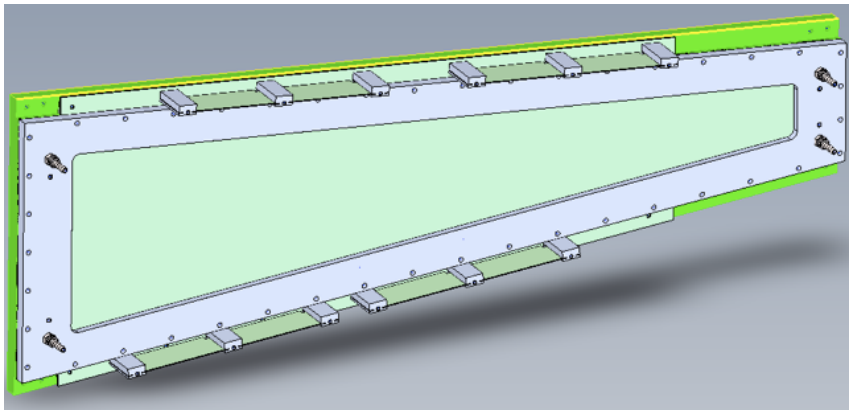


Vacuum System



- Pressure outside experiment: $2{\cdot}10^{-10}$ mbar ($7{\cdot}10^{-8}$ mbar)
- Beam life time: $\approx$6 h (0.7 h)
- Build-up time 0 $\leftrightarrow$ 0.8 sccm: 90 s

GEM Tracker (Upgrade for 2^{nd} run)



- Active area: 840 mm x 250/110 mm
- Patched triple GEM stack
- 2D readout board with 18.4° stereo angle
- 12 APVs per detector

MIT, DESY, Hampton, Bonn

Status

- Aluminum parts manufactured
- Readout boards delivered
- 14/24 GEM foils delivered
- APV cards ready and tested
- Voltage divider in assembly
- Supply boards in assembly
- Readout electronics tested
- DAQ and offline ready
- Assembly: May/June (MIT)
- Testing: July (DESY)

Wire Chambers

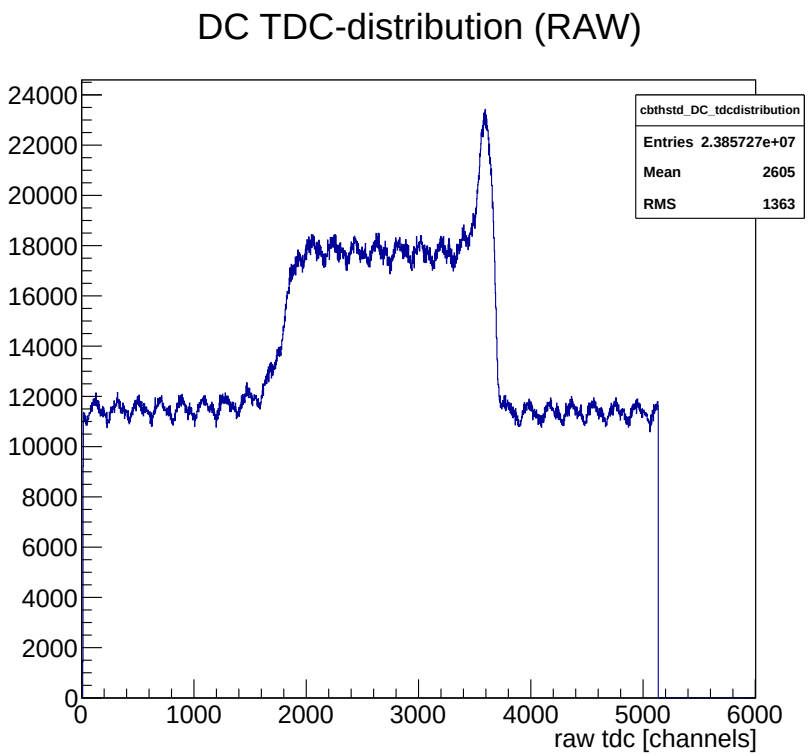
Specifications

- 3 in 1 chambers
- $ArCO_2$ (90:10) drift gas
- $V_{sense} = 3800\,V$

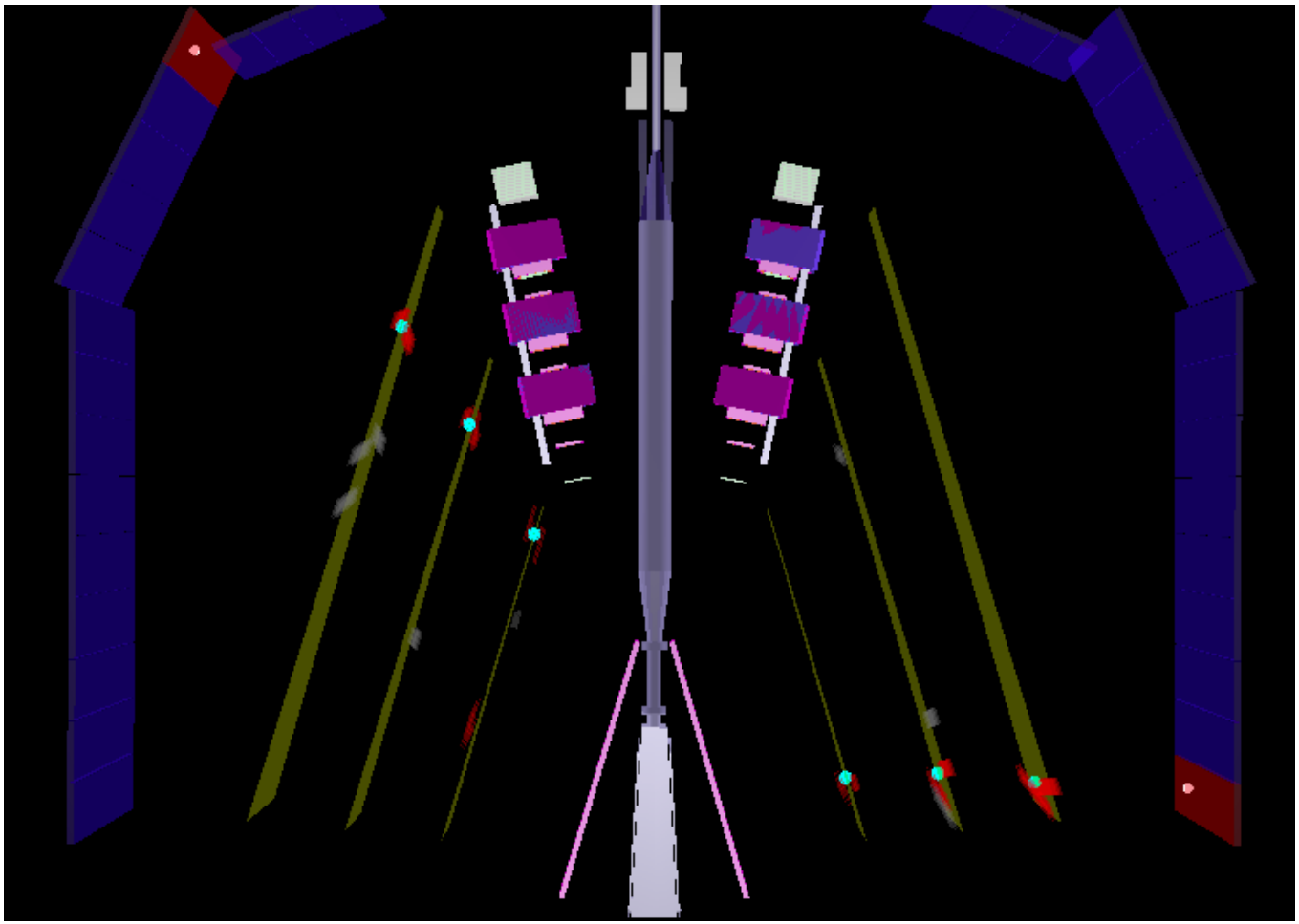
Status

- No hot wires anymore
- 97.5% of cells working fine

$\rightarrow$ Repair rest in June



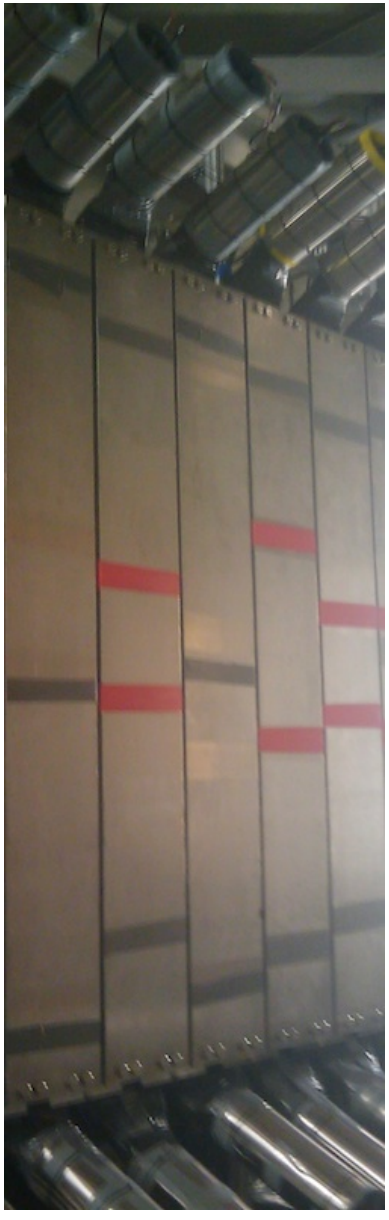
Event Display



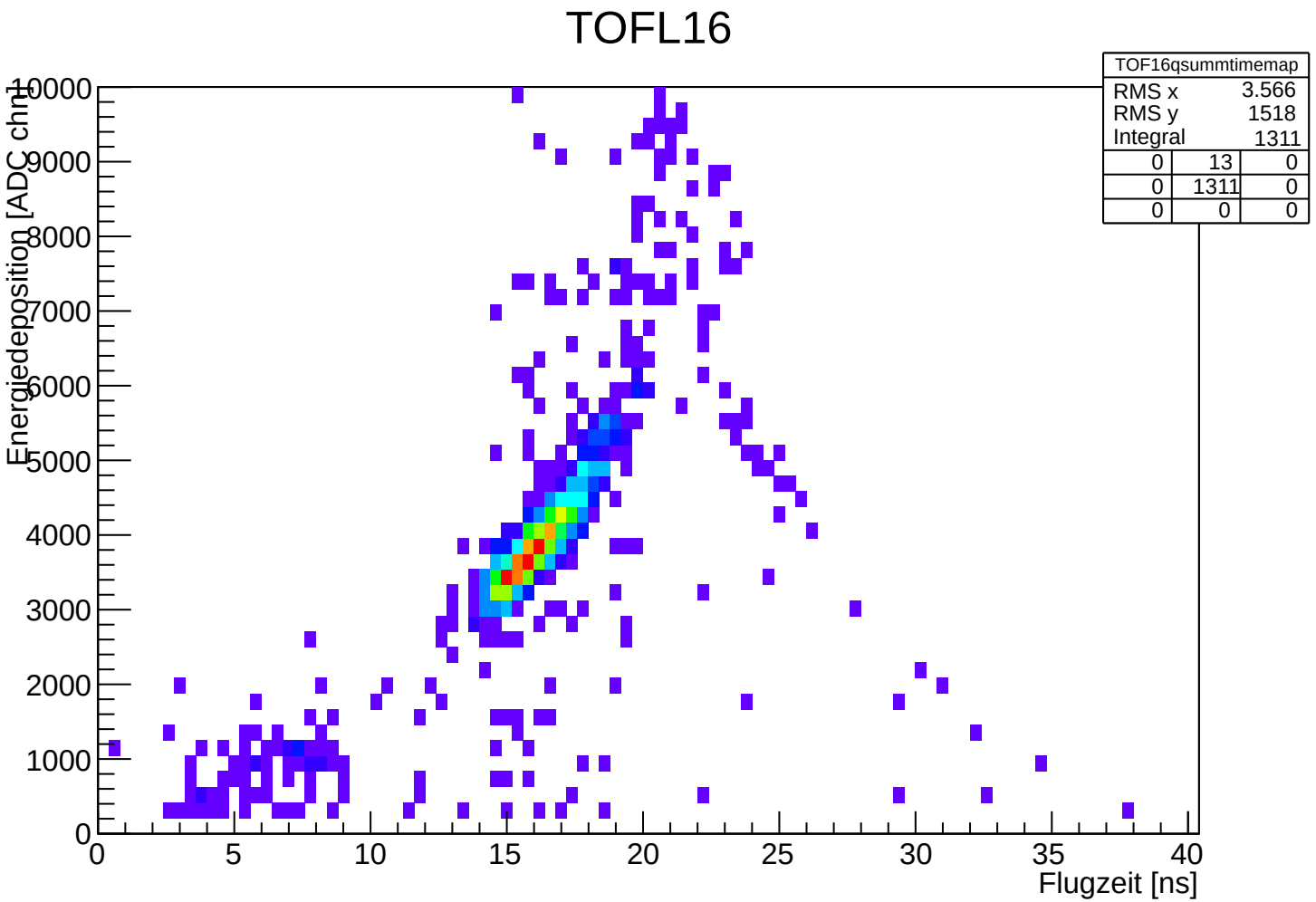
Time of Flight Detectors

- 18 detectors per sector
- Double sided PMT readout
  - → Noise suppression
  - → Hit location: $(t_1 - t_2)/2$
  - → Mean time: $(t_1 + t_2)/2$
- Measure ToF, E_{dep}
- Derive trigger signals
  - ORs, top bottom coincidence
  - Subsection OR
  - Kinematic trigger

Noise improved after installation of transformer



TOF Spectrum



Large angle TOF bar with trigger on 12 degree particle

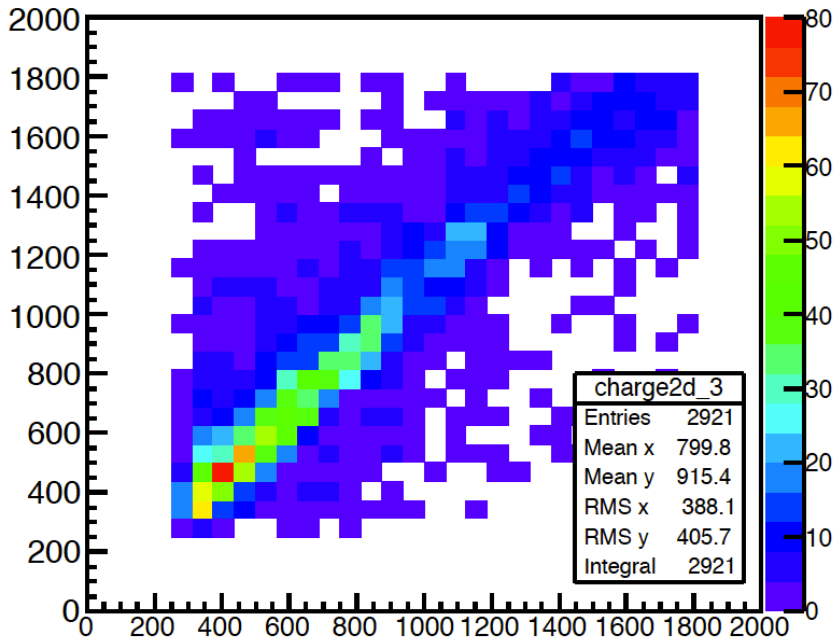
Luminosity Monitoring

Need precise relative luminosity measurements to compare relative cross sections

- 12° tracking telescopes
  - Elastic ep at $\epsilon > 0.97$ (TPE $\lesssim 1\%$)
  - Count tracks with protons in coincidence in TOFs
  - 2 telescopes, each has 3 GEMs and 3 MWPCs
- Symmetric Møller/Bhabha Detector
  - Count symmetric events

Lumi GEMs

Cluster amplitude correlation



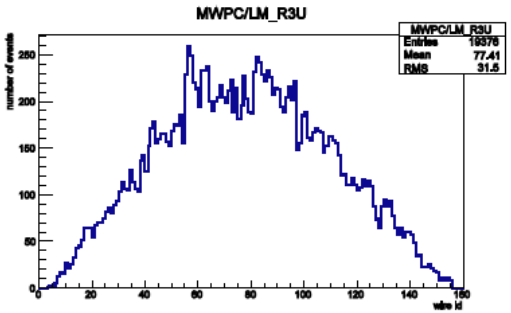
Plot by J. Diefenbach

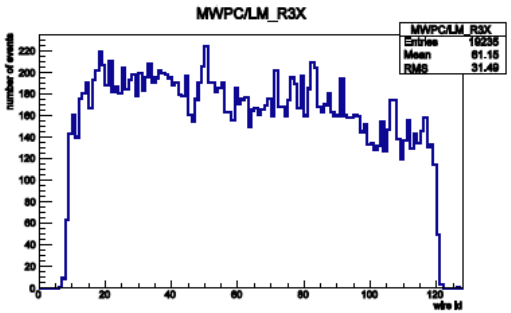
Specs and Status

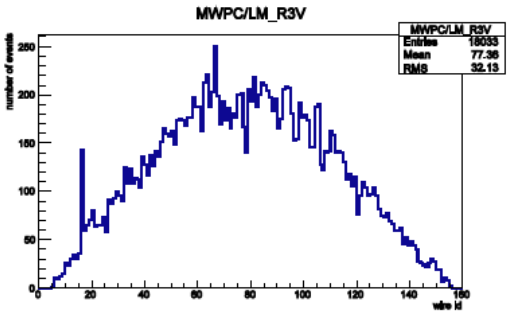
- 3 detectors per telescope
- Triple GEM stack with 2D readout
- APV readout working fine
- $\delta_{res} \approx 200\,\mu$m

Hampton, INFN, MIT

Multi Wire Proportional Chambers

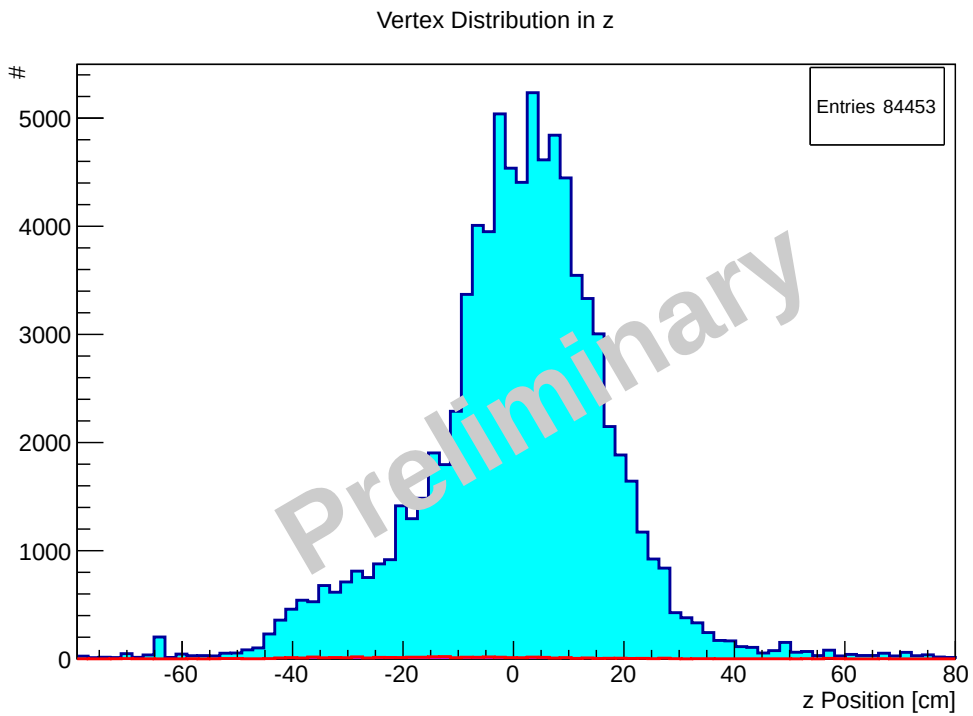






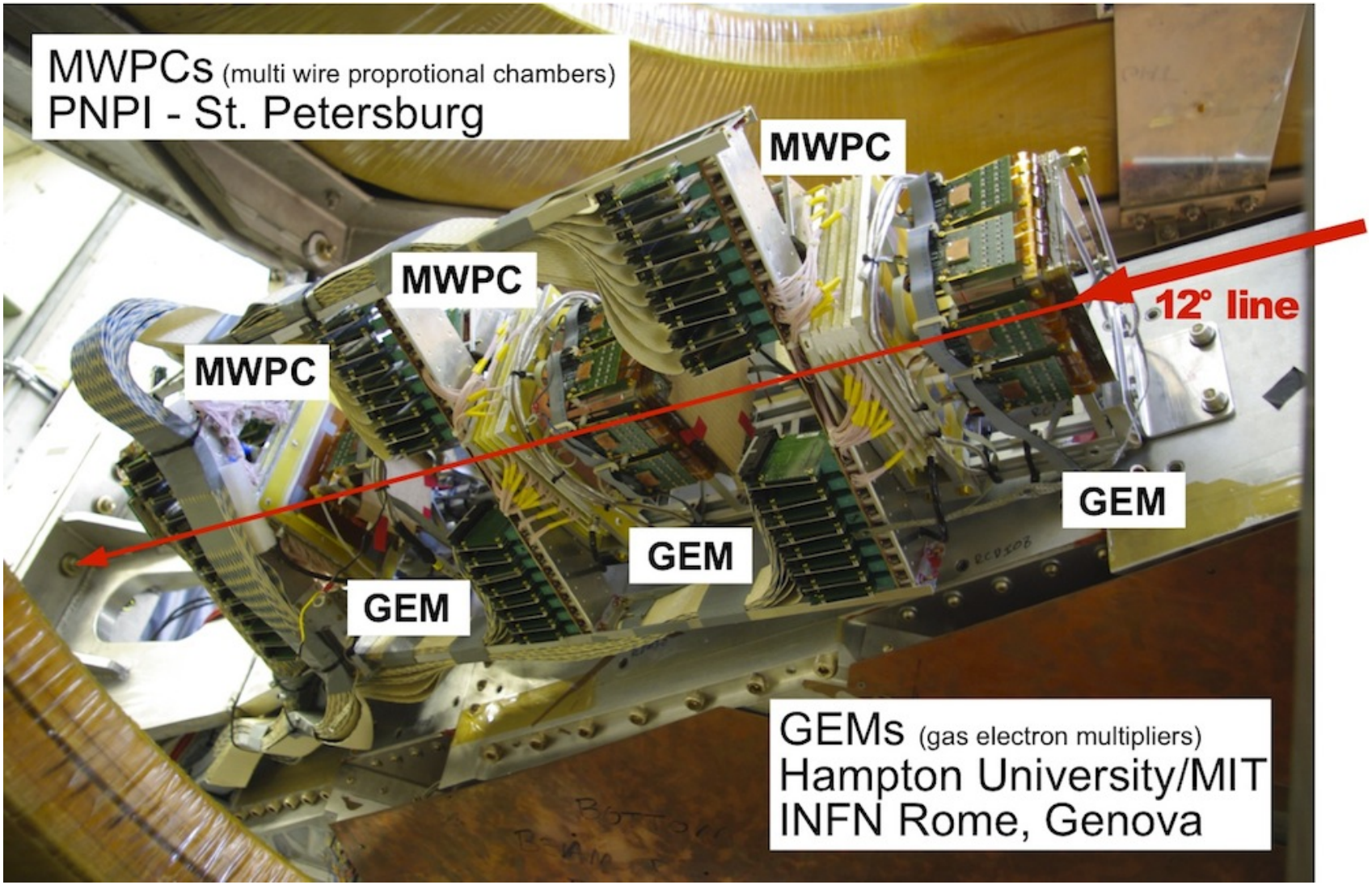
Specifications

- 3 chambers per telescope
- 3 planes per detector
- 99.9% of wires working fine
- $\eta_c = 0.98\text{-}0.99$

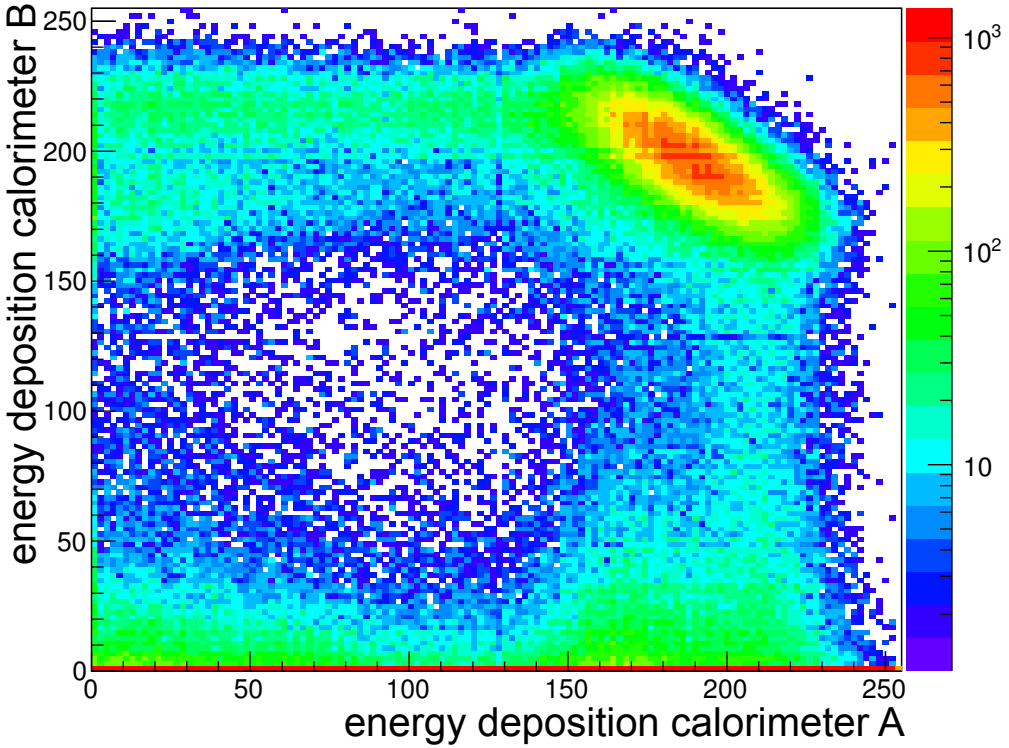


PNPI

12° Tracking Telescopes



Symmetric Møller/Bhabha Detector

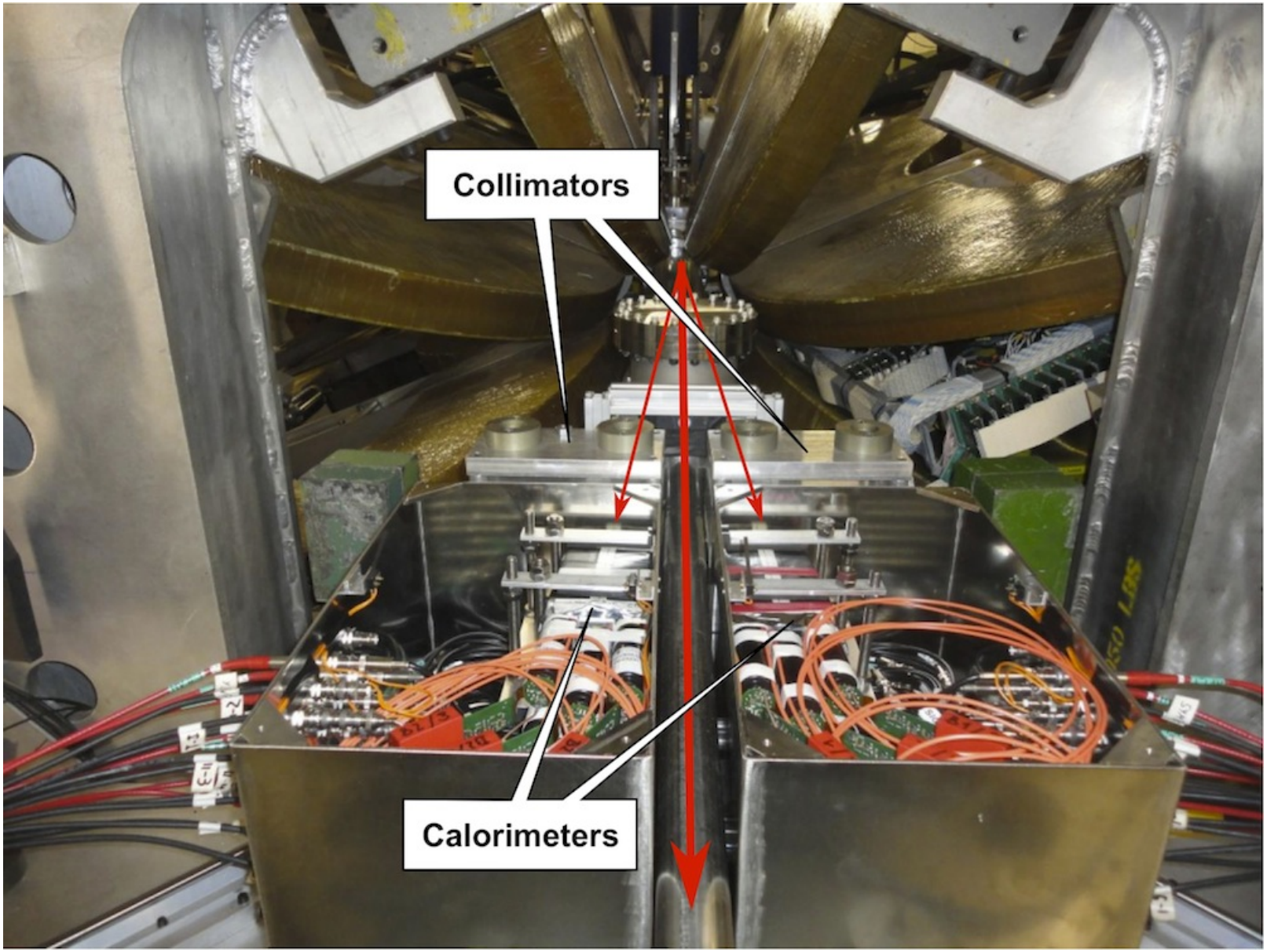


Plot by J. Diefenbach

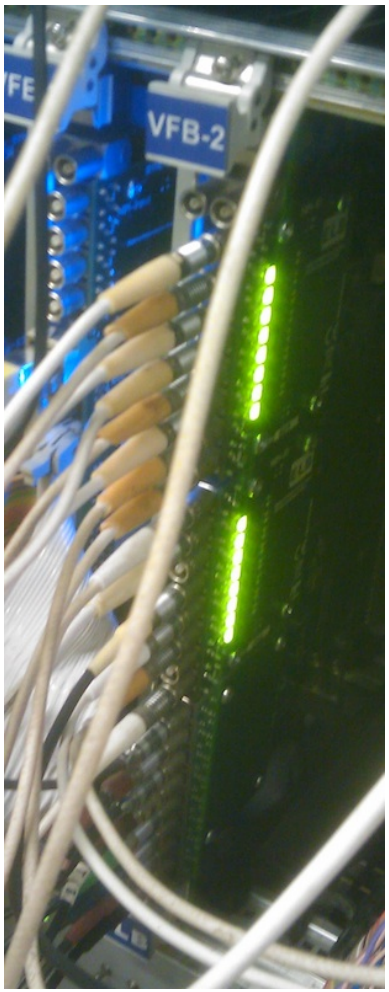
- Pure QED processes
- Independent measurement
- Quasi dead time free ($t_d = 20\,\text{ns}$)
- Left/right coincidence with 1 GeV each
- Possible to see also elastic ep

Univ. of Mainz/HIM

Symmetric Møller/Bhabha Detector



Main Trigger System



MIT

- Single level scheme
- VME based FPGA board
- Dynamic configurable at runtime
- 16 parallel trigger conditions (incl. veto + pre-scaler)
  - Main trigger (≈75%)
  - 2 Luminosity trigger
  - 8 Calibration trigger
- Counters for inputs and trigger conditions

Plan to install 2^{nd} level trigger with information from wire chambers to improve deadtime (≈ x10).

Data Acquisition System

- Easy to use DAQ GUI
- Online data display
- Data backup
  - Raid + mirror server
  - DESY computing center
  - External hard drive
- Automated data mapping and pre-processing
- Run database + Elog

Run I (1st-27th February)

- 1 billion triggers collected
- 1710 runs
- Raw data on disc: 3.4 TB
- DAQ active: 19d 11h 14m (74%)
- Average dead time: 25%

Univ. of Bonn/HISKP

Control and Monitoring

MIT, Univ. of Bonn/HISKP

Slowcontrol

- Single system
- Web front end
- TINE interface

Monitoring

- Monitor online data stream
- Simple histograms + first analysis
- Checks DAQ and trigger

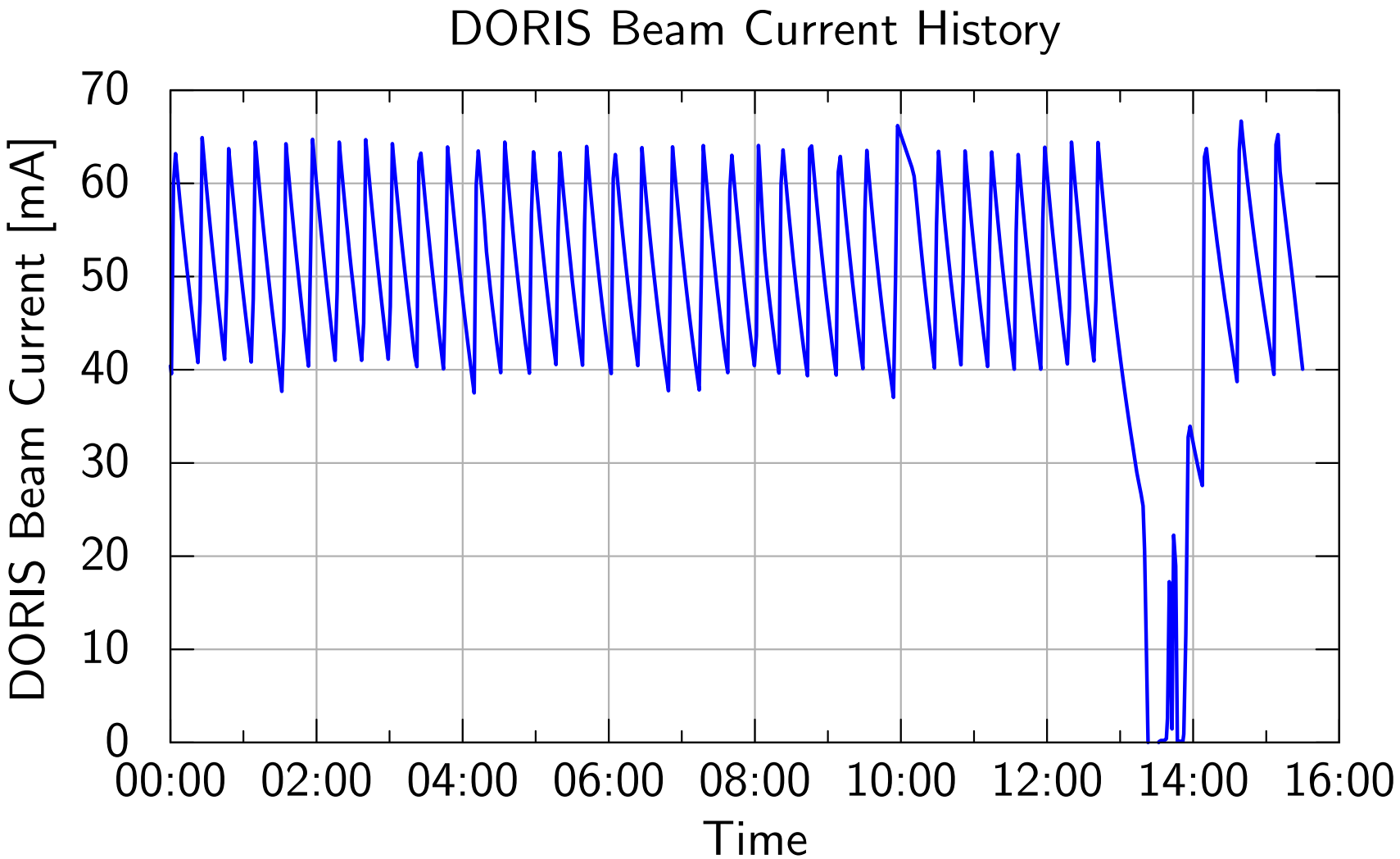
Operation schedule

1^{st} run (1^{st}-27^{th} February 2012)

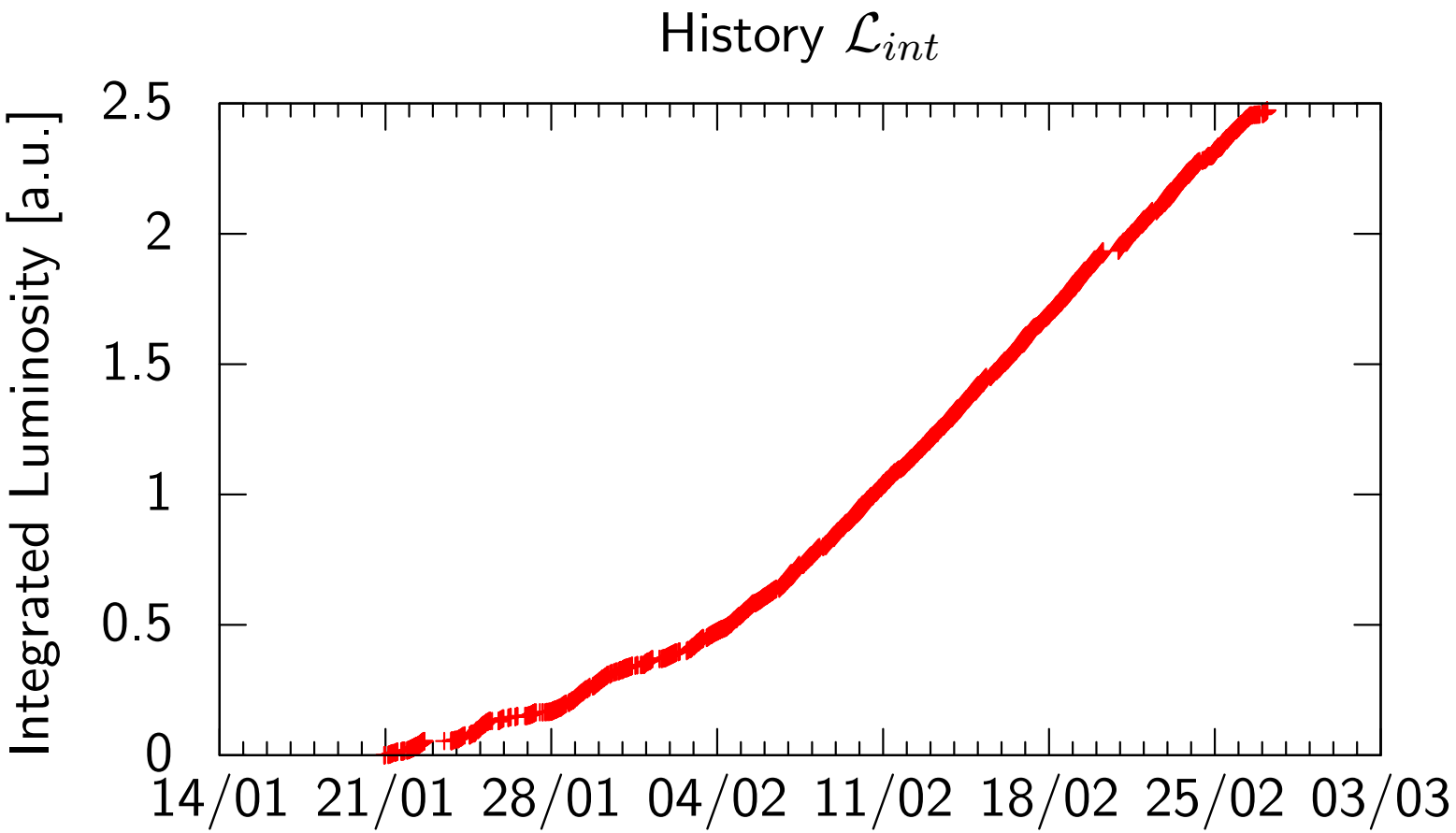
- Switch beam species every day ($\lesssim$ 30 min)
- Switch magnet polarity 2.5 times a day (+ - - +, - + + -)
- Target flow 0.8 sccm (2 empty target runs per day)
- Beam current 60..40 mA
- Beam refill every 20 min (takes 1-2 min)

Smooth machine operation and very good collaboration with machine group

Machine Stability

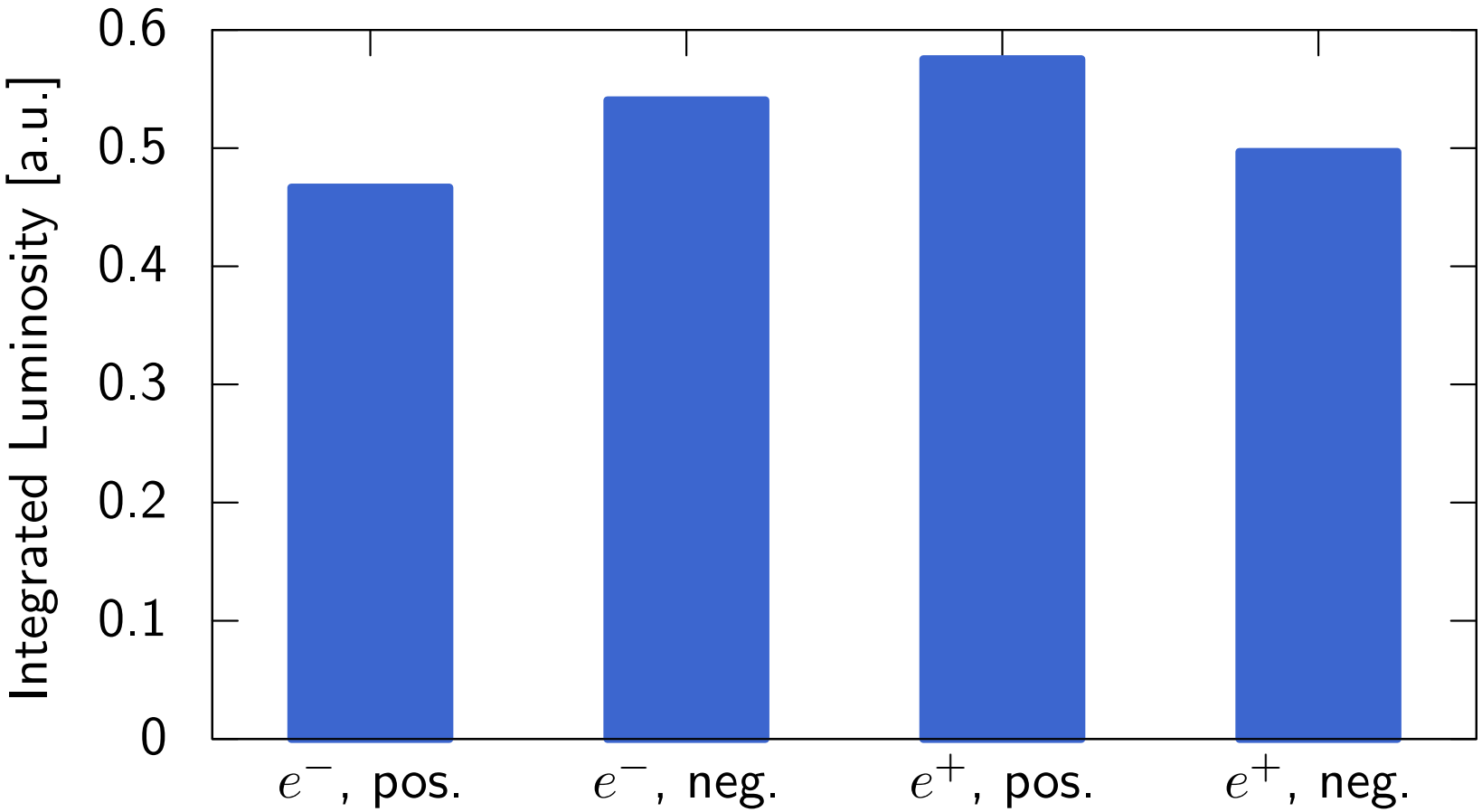


Integrated Luminosity over Time

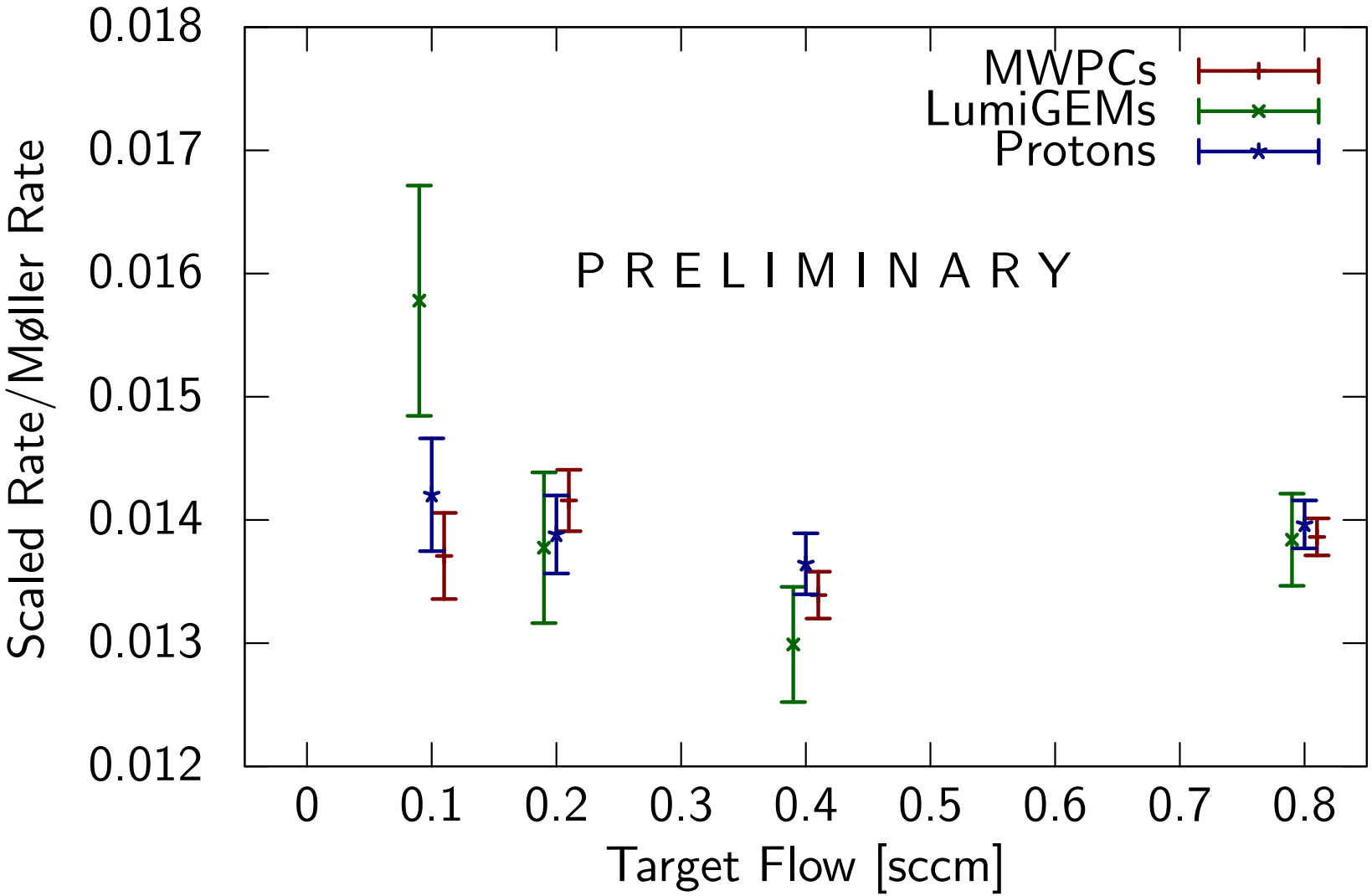


$\Rightarrow$ 4 million elastic events

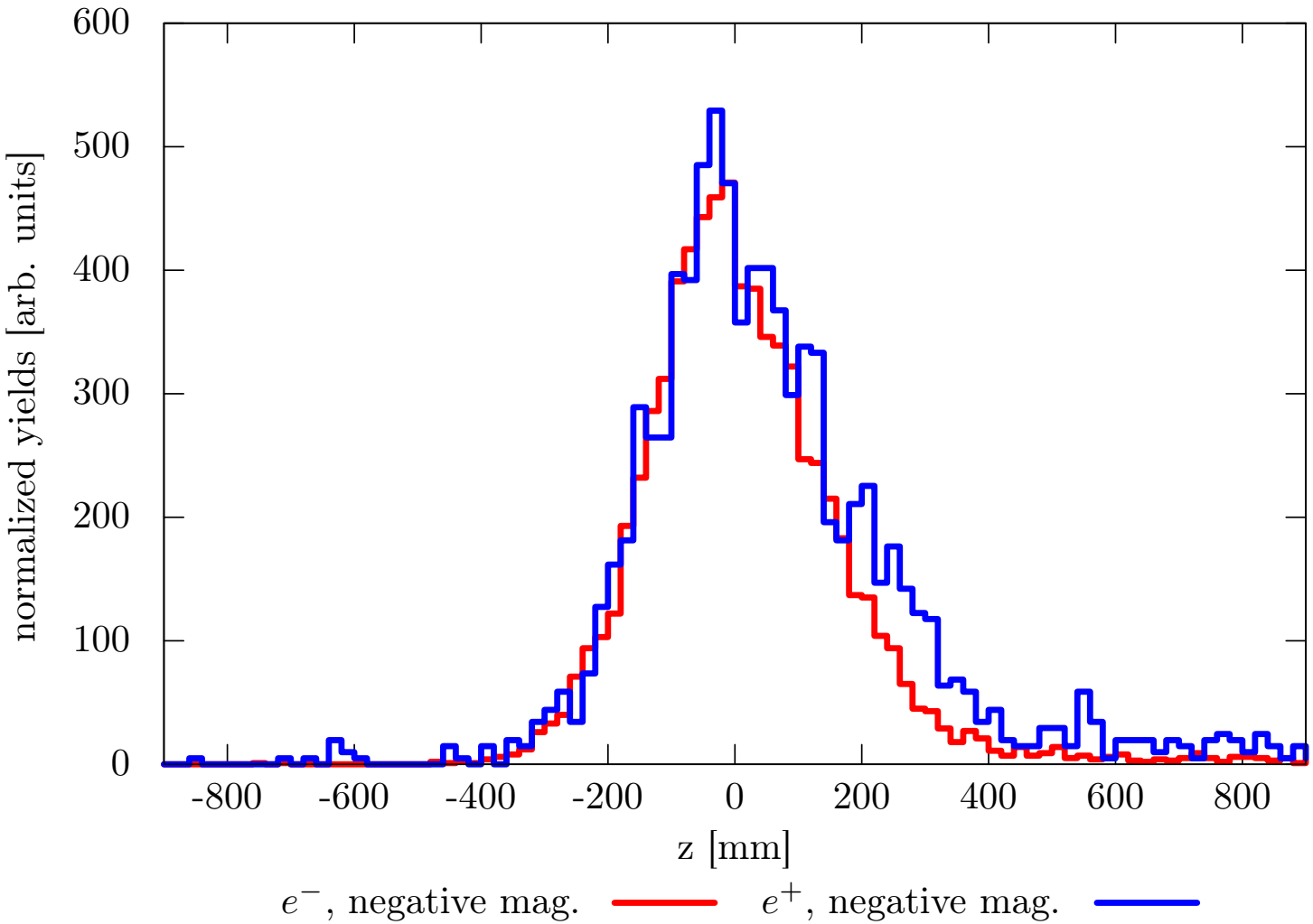
Integrated Luminosity per Configuration



Luminosity Monitors vs. Target Flow



Vertex Distribution (preliminary)



J. C. Bernauer

Summary

- Smooth and stable machine operation
- Detectors worked stable
- DAQ, online monitoring, and slowcontrol easy to use and reliable
- Collected a good data sample (4M elastic events)
- Most of the reconstruction implemented
- Detailed treatment of radiative effects and corrections

Outlook

- Upgrades
  - GEM tracker
  - Improved 12° trigger scintillators
  - 2^{nd} level trigger
- Complete reconstruction
- Analysis including radiative corrections

Looking forward to run II (Oct 22^{nd} - Dec 21^{st}) to collect full statistics we need.

OLYMPUS Collaboration

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

OLYMPUS