The OLYMPUS Experiment

73^{rd} DESY PRC

Alexander Winnebeck

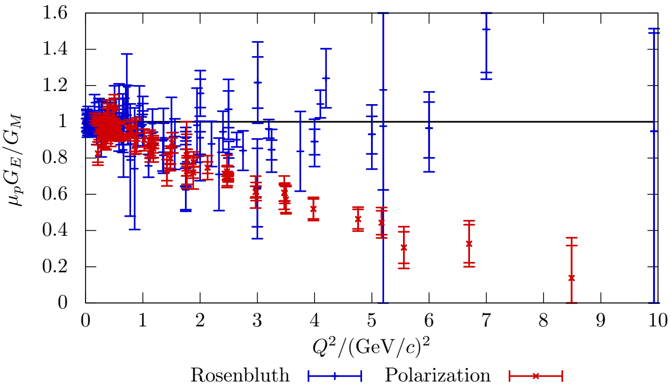
Massachusetts Institute of Technology, LNS

26th April, 2012

OLYMPUS

Form Factor Ratio Discrepancy

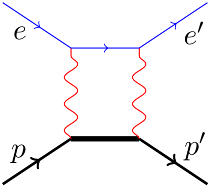
$$\frac{d\sigma}{d\Omega} = \frac{d\sigma}{d\Omega}\bigg|_{Mott} \frac{1}{1+\tau}\left(G_E^2 + \frac{\tau}{\epsilon}G_M^2\right)$$



Plot by Bernauer

⇒ 2 photon exchange

Principal of Measurement

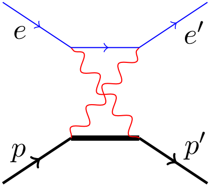


Not able to calculate hard 2γ contribution

$\Rightarrow$ **Measure it!**

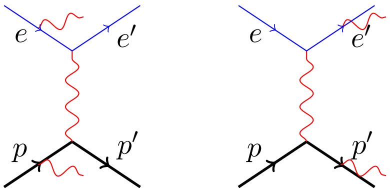
$$R = \frac{\sigma(e^+p)}{\sigma(e^-p)} \approx \frac{(1\gamma)^2\alpha^2 + 2\alpha^3(1\gamma)(2\gamma)}{(1\gamma)^2\alpha^2 - 2\alpha^3(1\gamma)(2\gamma)}$$

$$\approx 1 + 4\alpha\frac{(2\gamma)}{(1\gamma)}$$



Olympus expects ≈5% effect

Radiative Corrections



- Processes smear out kinematics
- Elastic yield depends on acceptances, resolutions, and cuts

$\rightarrow$ Need to correct for this (comparison between experiments)

Radiative Correction Workshop

- July 2011 @ MIT
- July 2012 @ St. Petersburg, Russia

Radiative Corrections II

Alternative: Look at the asymmetry instead of the cross section ratio:

$$A_{e^\pm} = \frac{\sigma_{e^-p} - \sigma_{e^+p}}{\sigma_{e^-p} + \sigma_{e^+p}} = \frac{1-R}{1+R} \rightarrow \frac{\alpha(odd)}{\alpha(even)}$$

- Measures deviation from zero
- Radiative corrections to numerator simpler and may cancel each other

→ Result less dependent on the correction

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 (Asymmetry)

Setup Overview

Drift Chambers
MIT

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

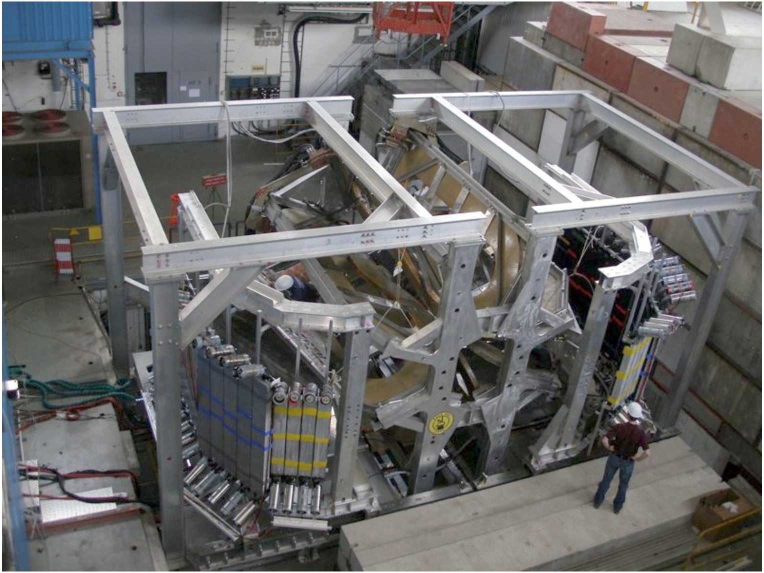
Internal HydrogenTarget
MIT, INFN Ferrara

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

Symmetric Moeller/ Bhabha Monitor
University of Mainz

based on a figure by R. Russell

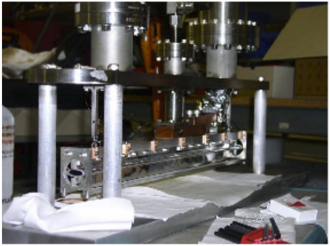
Experiment in Reality

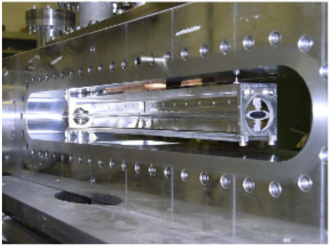


Target System

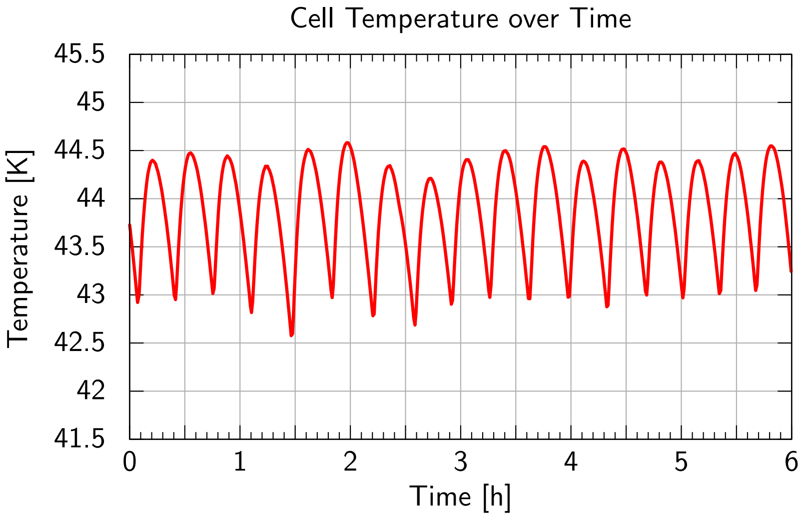
- Windowless internal gas target
- 60 cm long storage cell
- Elliptical cross section (27 mm x 9 mm)
- 100 μm thick aluminum wall
- Cryo cooled (43.5$\pm$1 K)
- $\rho = \mathcal{O}10^{15}$ atoms/cm^2
- Hydrogen generator (electrolysis)

INFN Ferrara, MIT

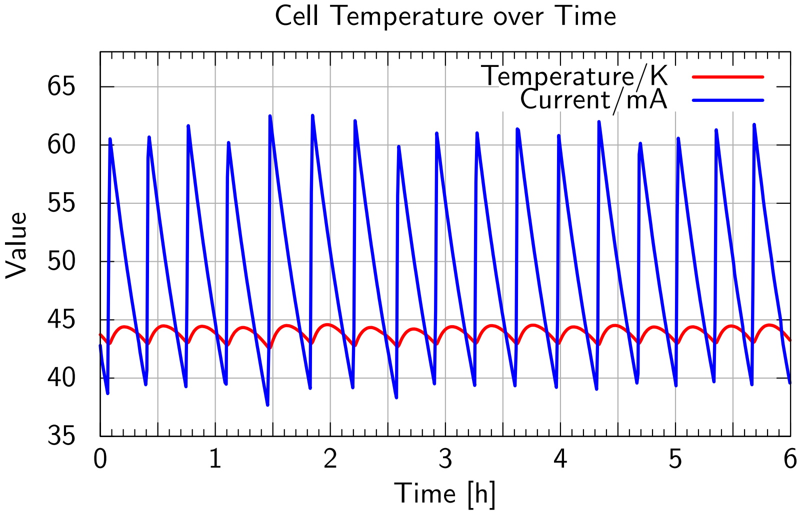




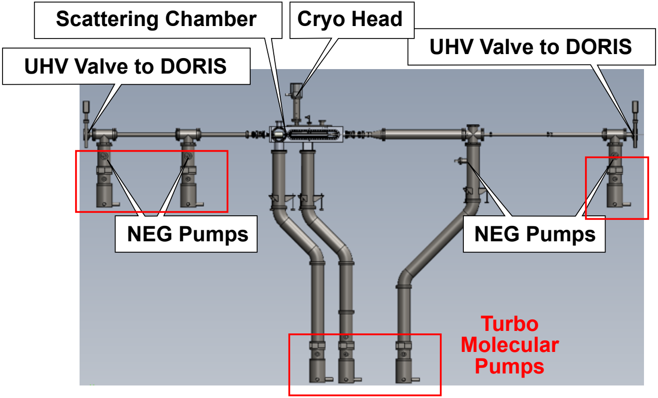
Target Cell Temperature during Run



Target Cell Temperature during Run

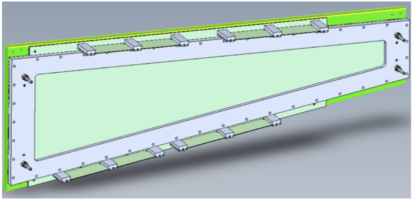


Vacuum System



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

GEM Tracker



- 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

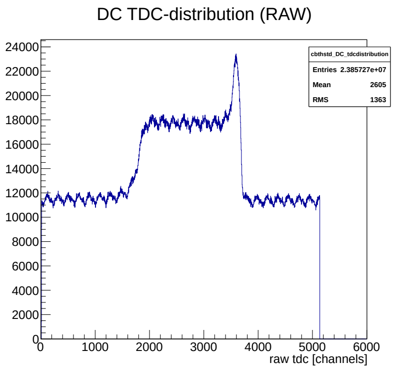
- 3 in 1 chambers
- $ArCO_2$ (90:10) drift gas
- $V_{sense} = 3800\,V$

Status

- No hot wires anymore
- 8 out of 318 cells disconnected

→ Repair in June

- High occupancy in inner chamber

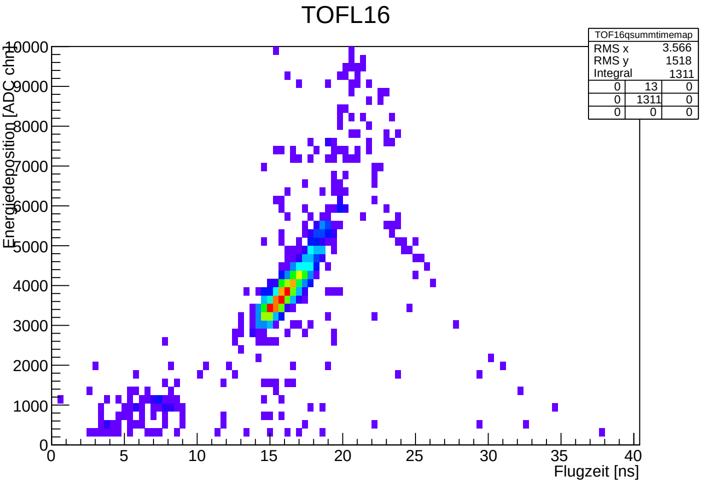


Time of Flight Detectors

- 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

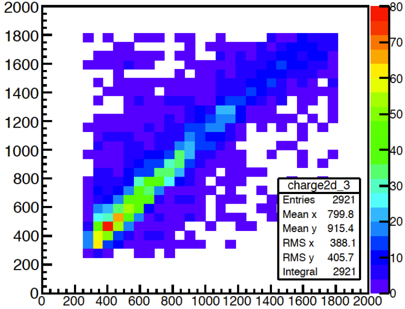
Luminosity Monitoring

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
- Symmetric Møller Bhabha Detector
  - Count symmetric events

Lumi GEMs

Cluster amplitude correlation



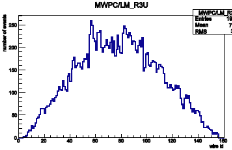
Plot by J. Diefenbach

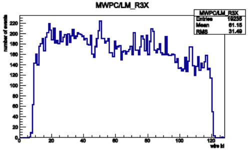
Specs and Status

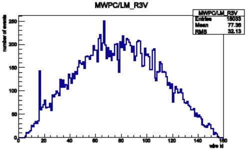
- 3 detectors per arm
- Triple GEM stack with 2D readout
- 23 out of 24 APVs working fine
- $\delta_{res} \approx 200\,\mu$m

Hampton, INFN, MIT

Multi Wire Proportional Chambers



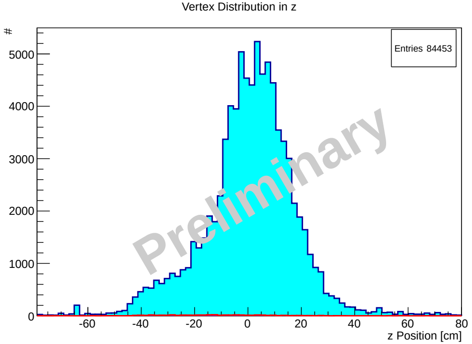




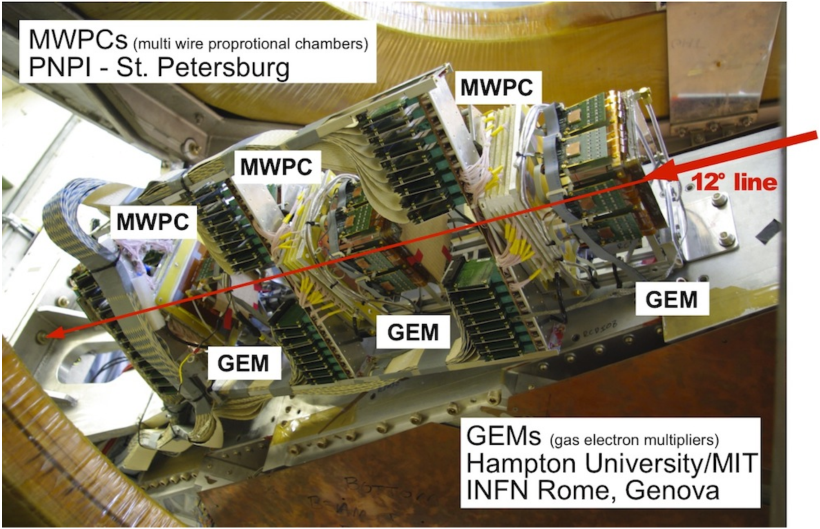
Specifications

- 3 chambers per arm
- 3 planes per detector
- 1 hot + 2 warm wires out of 2700
- $\eta_c = 0.98\text{-}0.99$

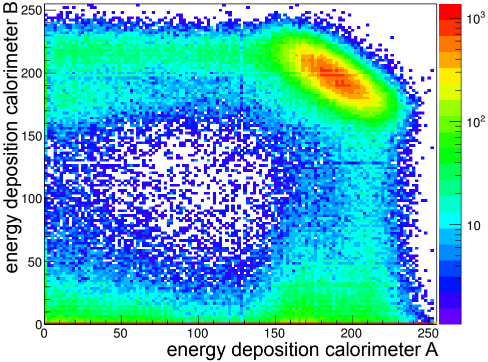
PNPI



12° Tracking Telescopes



Symmectric Møller/Bhabha Detector

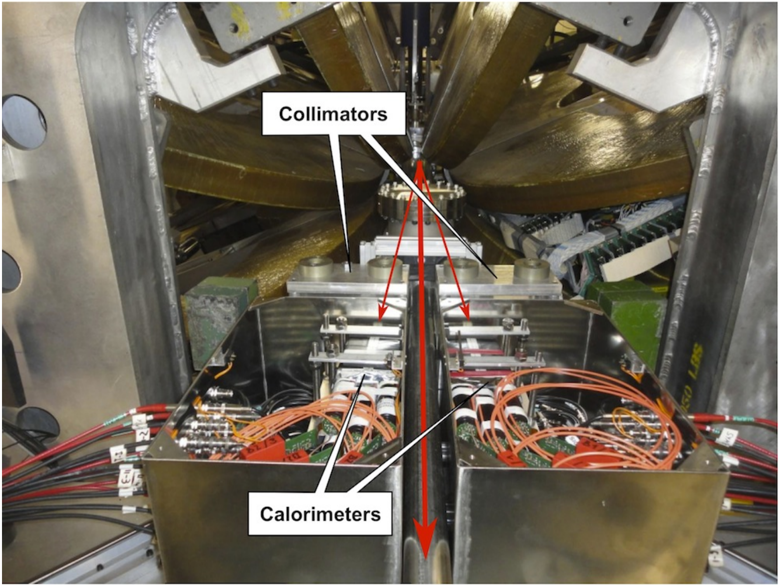


Plot by J. Diefenbach

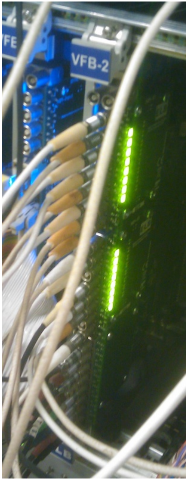
- Pure QED processes
- Independent measurement
- Quasi dead time free ($t_d = 20\,\text{ns}$)
- Left/right coincidence with 1 GeV each
- Possible to see also elastic ep

Univ. of Mainz/HIM

Symmectric 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

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
- PostgreSQL DB back end

Monitoring

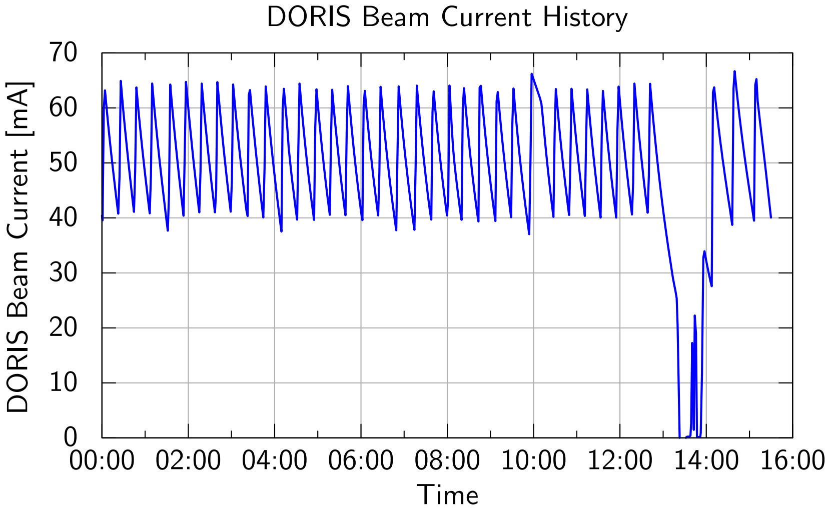
- Monitor online data stream
- Simple histograms + first analysis
- Checks DAQ and trigger

Operation schedule

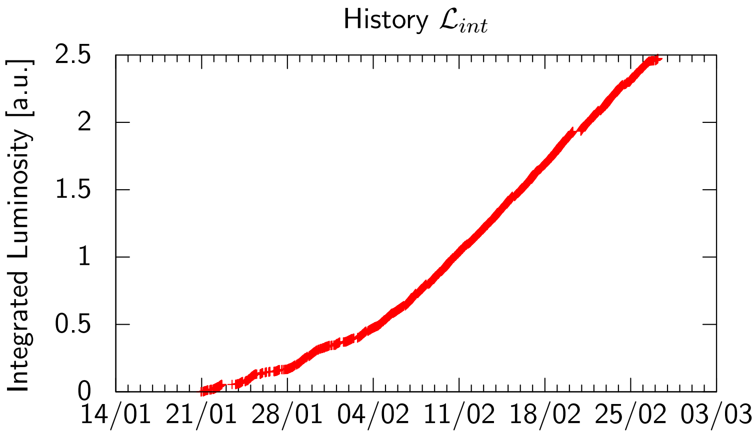
- Switch beam species every day ($\lesssim 30$ min)
- Switch magnet polarity 4 times a day (+ - - +, - + + -)
- Target flow 0.8 sccm (2 empty target runs per day)
- Beam current 60..40 mA
- Beam refill every 20 min (takes 1-2 min)

Smooth machine operation and very good collaboration with machine group

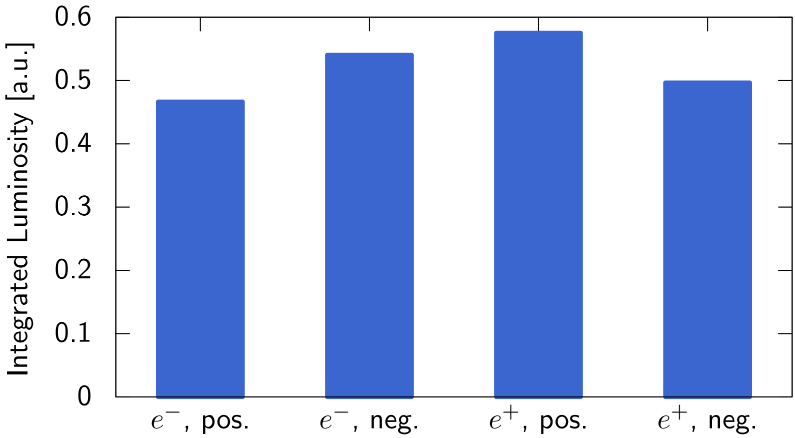
Machine Stability



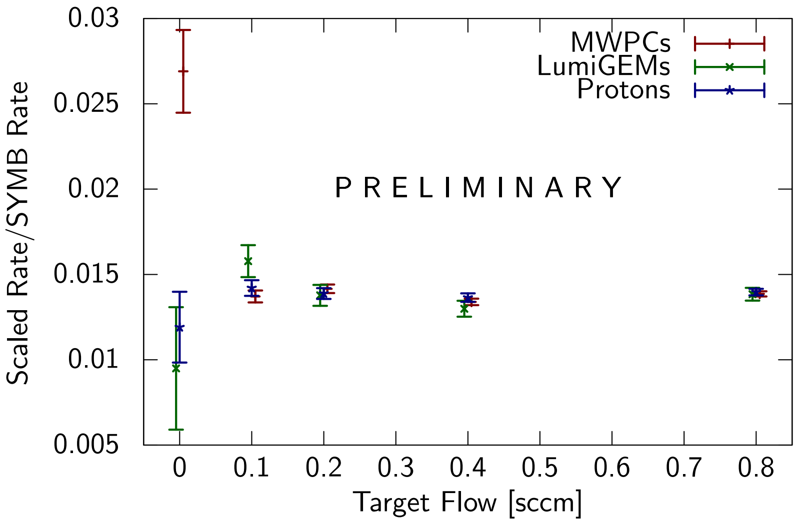
Integrated Luminosity over Time



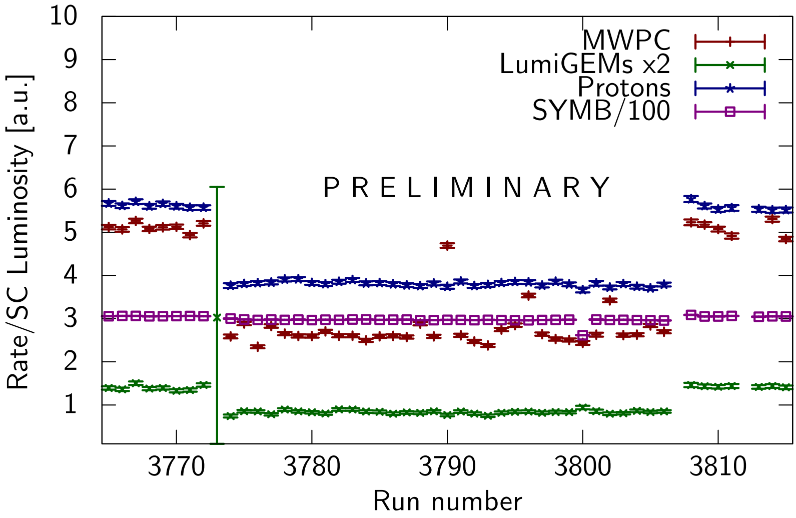
Integrated Luminosity per Configuration



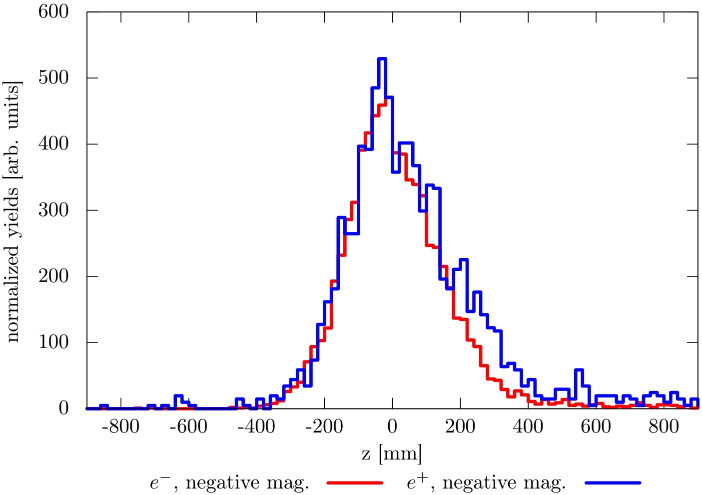
Luminosity Monitors vs. Target Flow



Luminosity Monitors Stability



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 run II (Oct 22nd - Dec 21st) 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