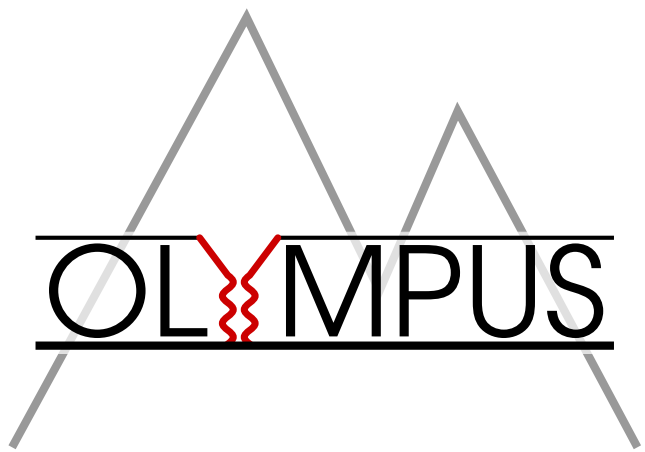
Status of the OLYMPUS Analysis

D.K. Hasell

M.I.T.

PRC Review



Outline

Optical Survey

Measurements taken by DESY survey group

- raw data $\rightarrow$ 2 angles and a distance relative to laser tracker
- targets on detectors, frames, walls, floor, the DORIS ring, ...
- offsets for target mount, target prism, angle relative to laser tracker

Different concepts or goals for the survey
Raw data analysed for OLYMPUS - Jan Bernauer (MIT)

- combined many sets of raw data, fixed inconsistencies
- performed global fit
- determined detector locations
- accuracy $< 100\ \mu$m for most points

GDML

Geometry Description Markup Language - Colton O'Connor (MIT)

- detailed description of detectors and infrastructure
  - target, scattering chamber, beamline, and shielding - fully implemented
  - toroid coils - to within 2 cm (placed according to field map fit)
  - wire chambers, TOF, GEM, SYMB - fully implemented
  - MWPC - active area fully implemented, electronics nearly finished
  - Lead Glass - active area fully implemented, need support structure
  - SiPMs - to within 1 cm along 12° line
- most elements based on optical survey results
- used for both analysis and Monte Carlo

Magnetic Field Mapping

March - April, 2013 measured magnetic field at 36,000 points

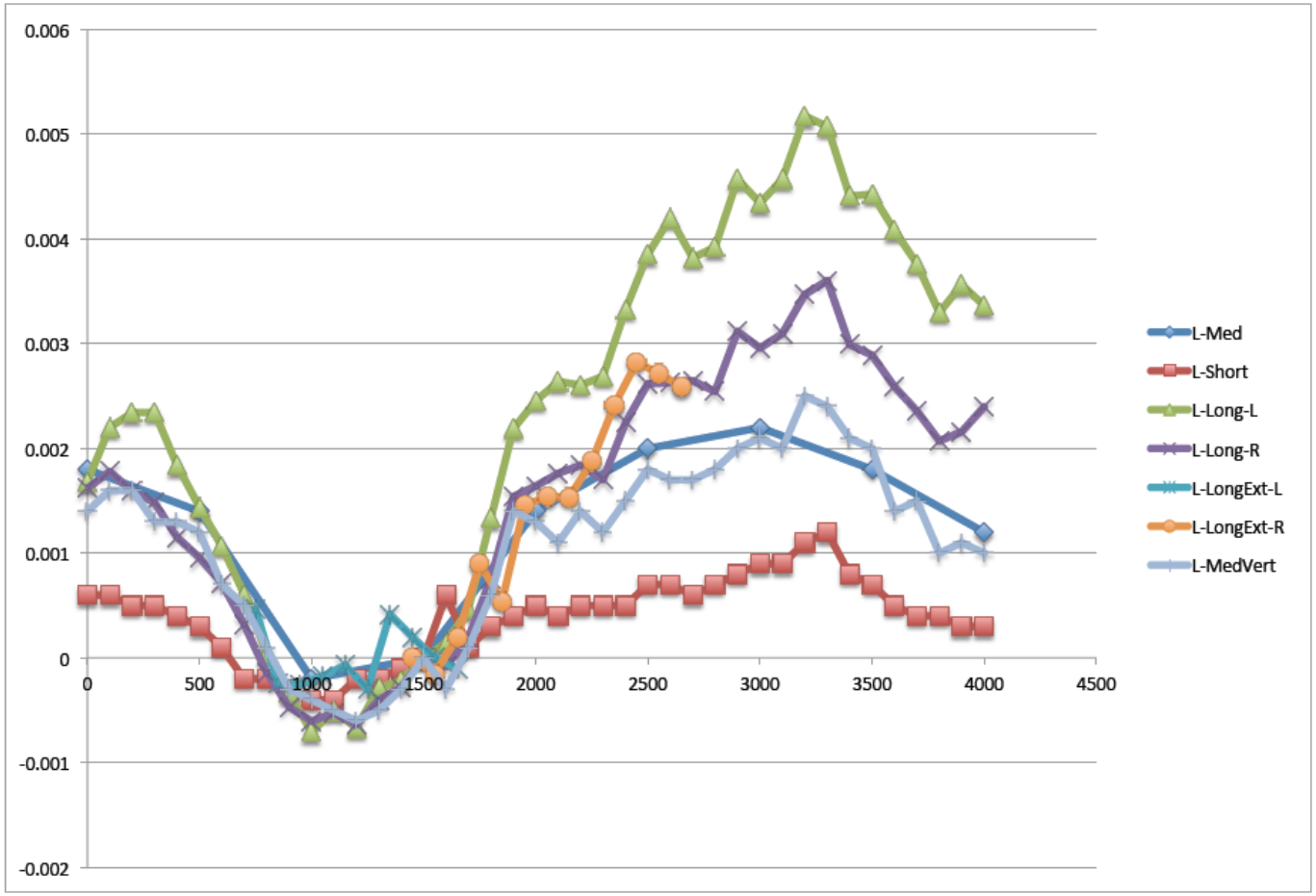
- group effort DESY, HU, MIT, PNPI, Yerevan
- two 6 hour shift per day, 3 persons per shift
- primary XYZ table ($\pm$100 mm X, $\pm$100 mm Y, $\pm 3,000$ mm Z)
- secondary XY table ($\pm$500 mm X, $\pm$500 mm Y)
- laser tracker only available for initial setup in left and right sectors
- several other setups required

Probe position oscillated $\pm$1–2 mm with Z

- measure oscillation for each setup with theodolite total station
- for each scan measure start and end points
- correct for oscillation assuming pattern fixed for each setup

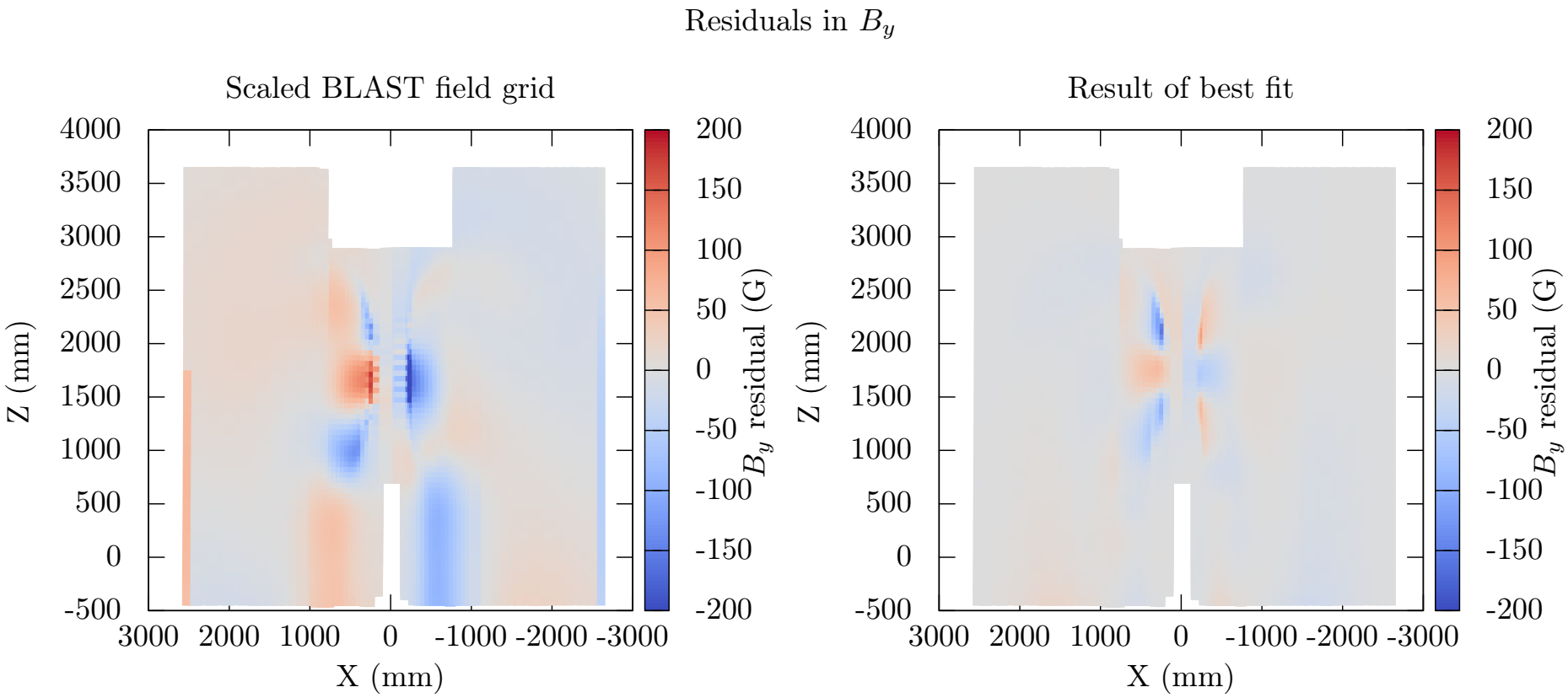
Analysis by Axel Schmidt, Brian Henderson, Colton O'Connor (MIT)

Oscillation of 3D Hall Probe



Depended on left/right sector, long/medium/short rod, extension

Residuals in Magnetic Field



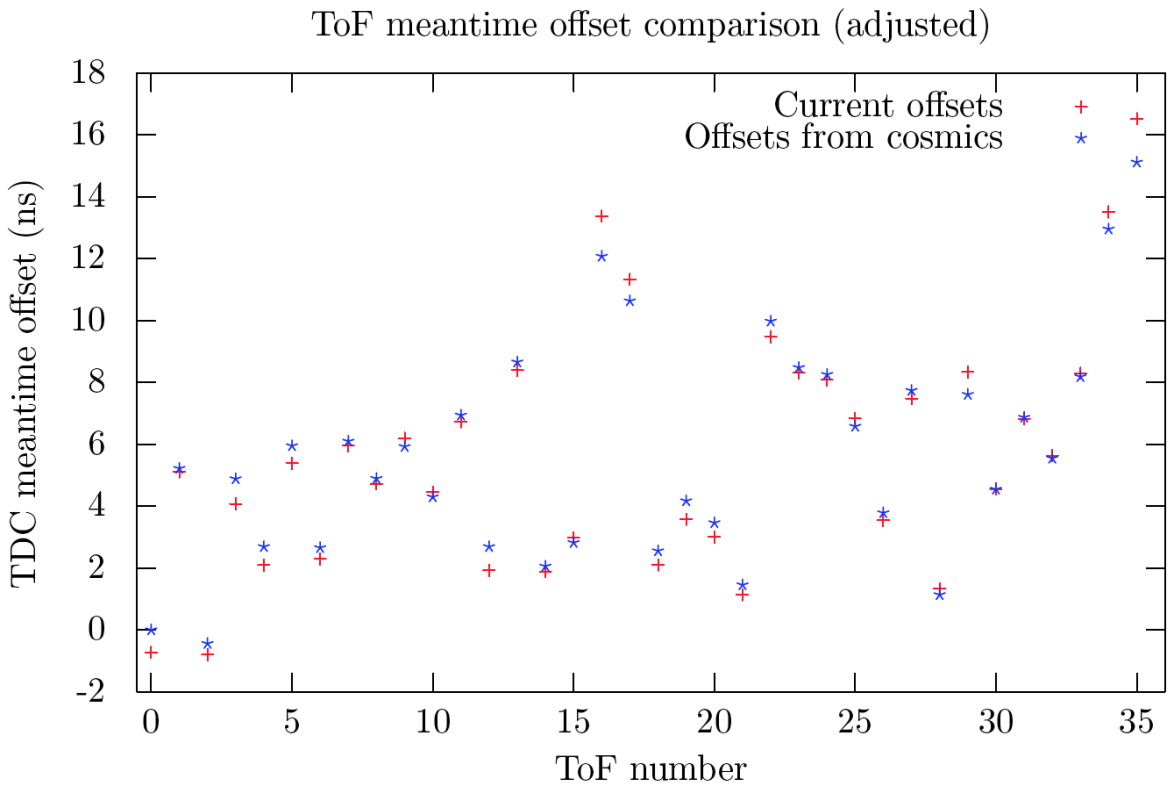
Global fit to magnetic field data using Biot-Savart calculation

- average residual at a point < 19 G
- generate regular grid, 420,000 points, for analysis and Monte Carlo

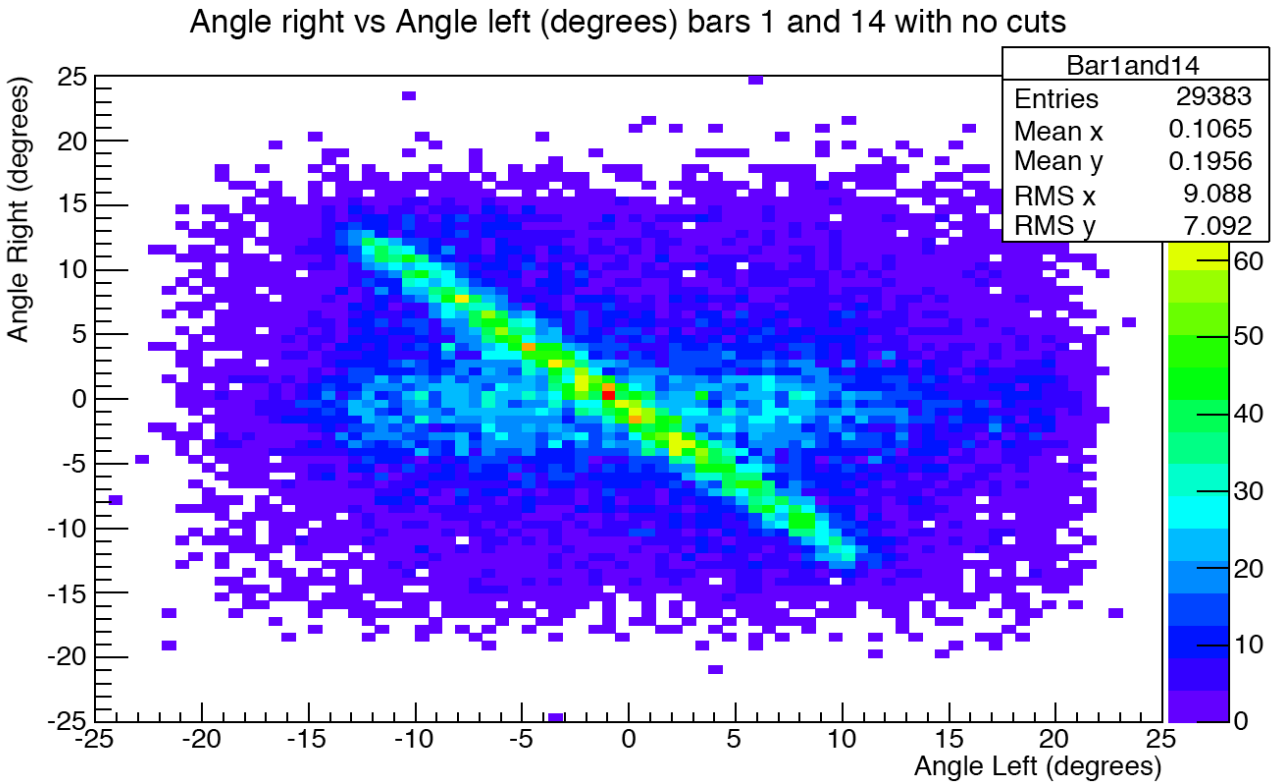
Time of Flight Detectors

Calibration and analysis by ASU, MIT, and Yerevan

- time offsets, ADC pedestals, gains, attenuation lengths



TOF Coplanarity - Lauren Ice (ASU)



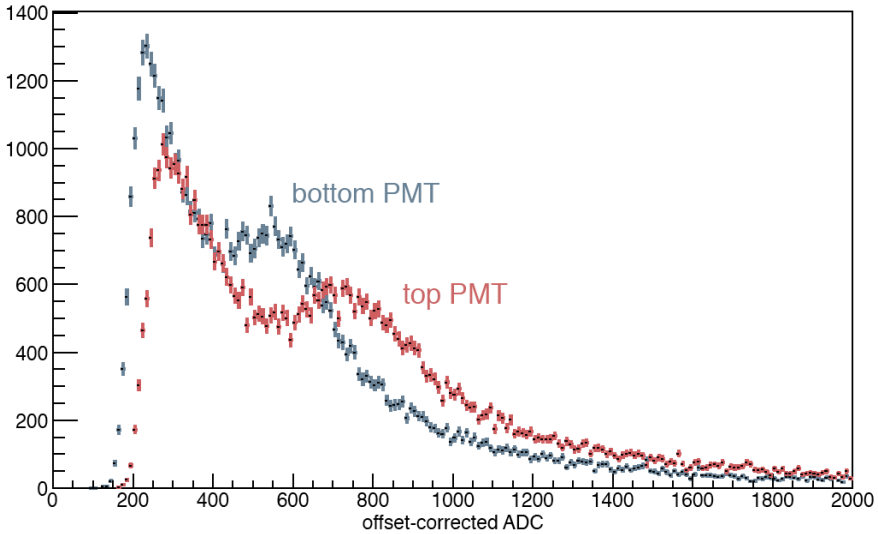
Azimuthal angle from top/bottom PMT time difference

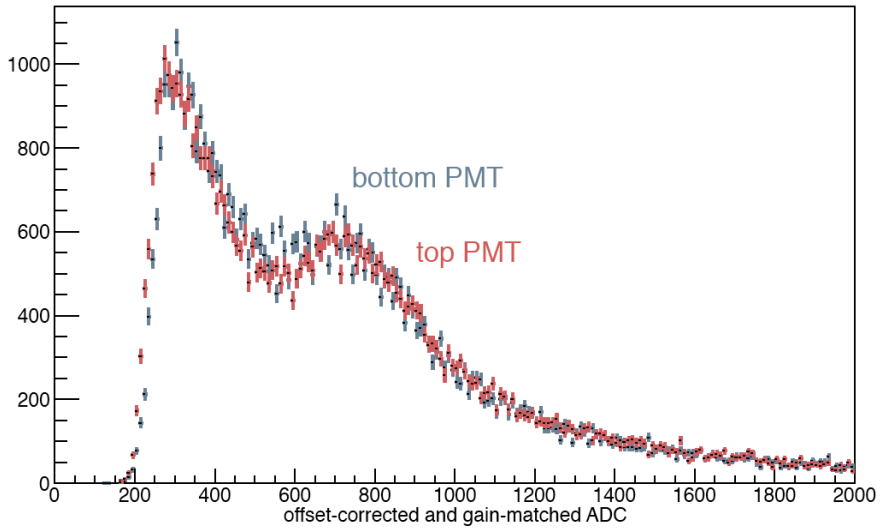
- clear correlation above background and random coincidences

ADC Gain Analysis - Rebecca Russell (MIT)

$$ADC_{i,t} = G_i\ f\ E_{dep}\ e^{\frac{(y-0.5L_i)}{l_i}} + C_{i,t}$$

$$ADC_{i,b} = \alpha_i\ G_i\ (1-f)\ E_{dep}\ e^{\frac{-(y+0.5L_i)}{l_i}} + C_{i,b}$$



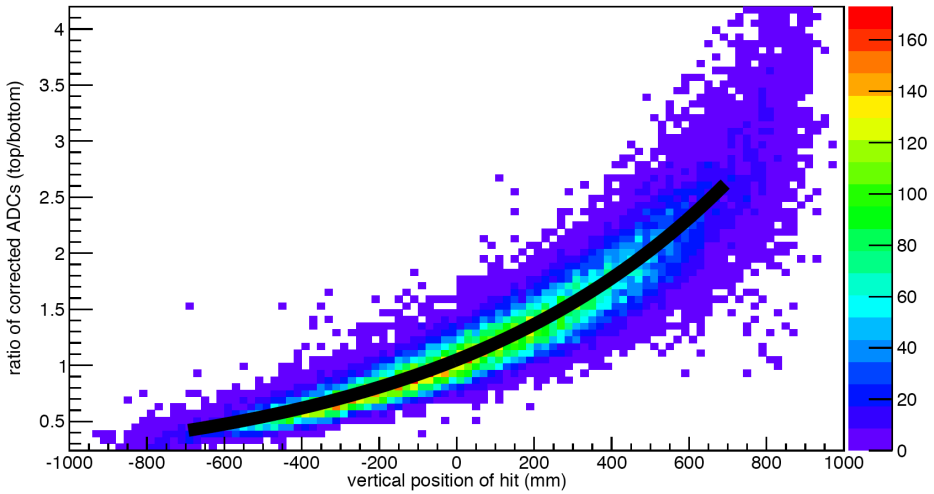


- α_i relative gain matching of top / bottom PMTs on each TOF bar
- $f \sim 0.5$ mostly independent of track angle and vertical position

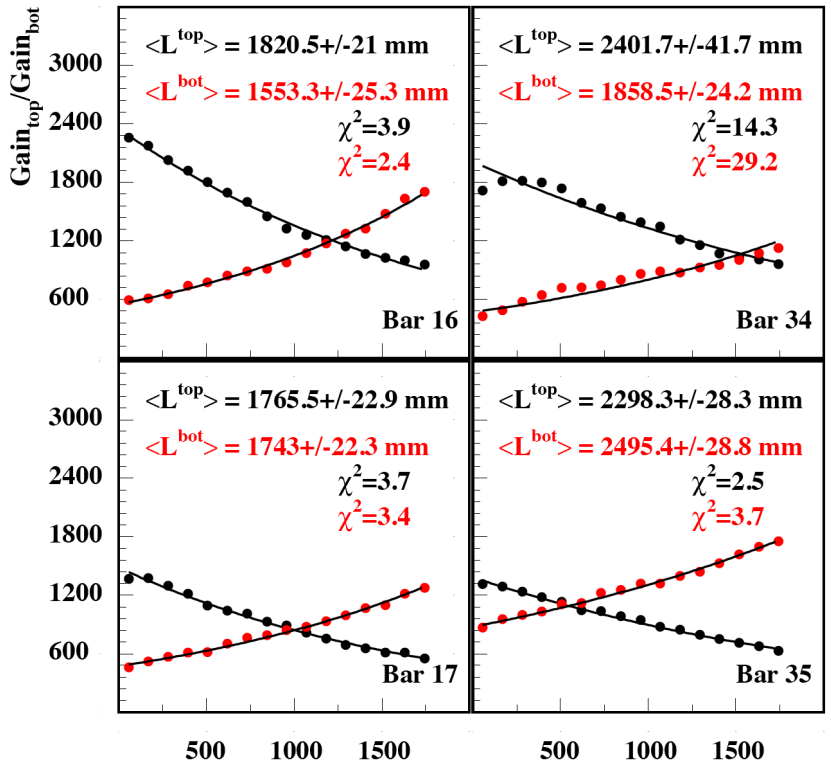
TOF Attenuation Lengths

Two approaches Rebecca Russell (MIT) and Norik Akopov (Yerevan)

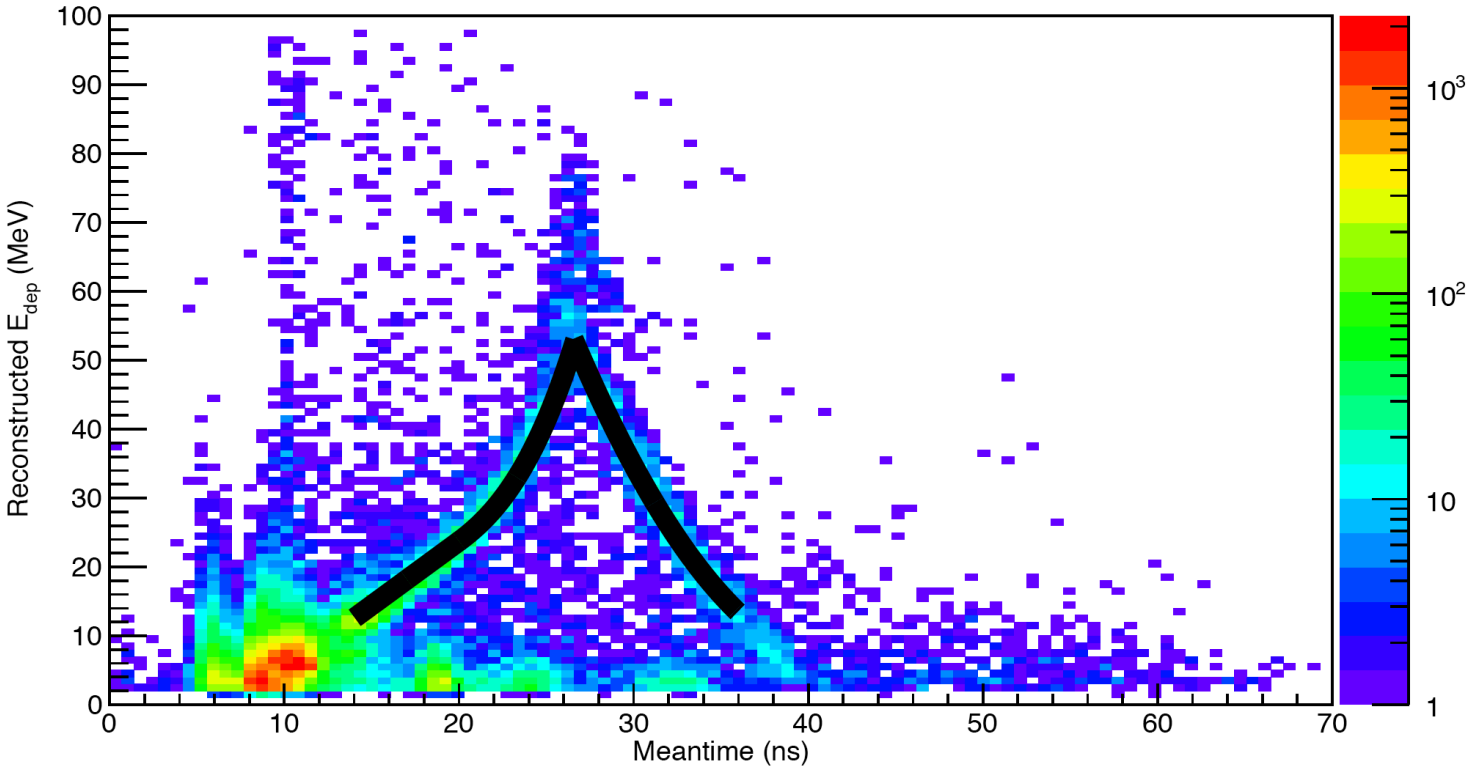
- comparable results



$$\frac{\alpha_i \left(ADC_{i,t} - C_{i,t}\right)}{ADC_{i,b} - C_{i,b}} = \left(\frac{f}{1-f}\right) e^{2y/l_i}$$

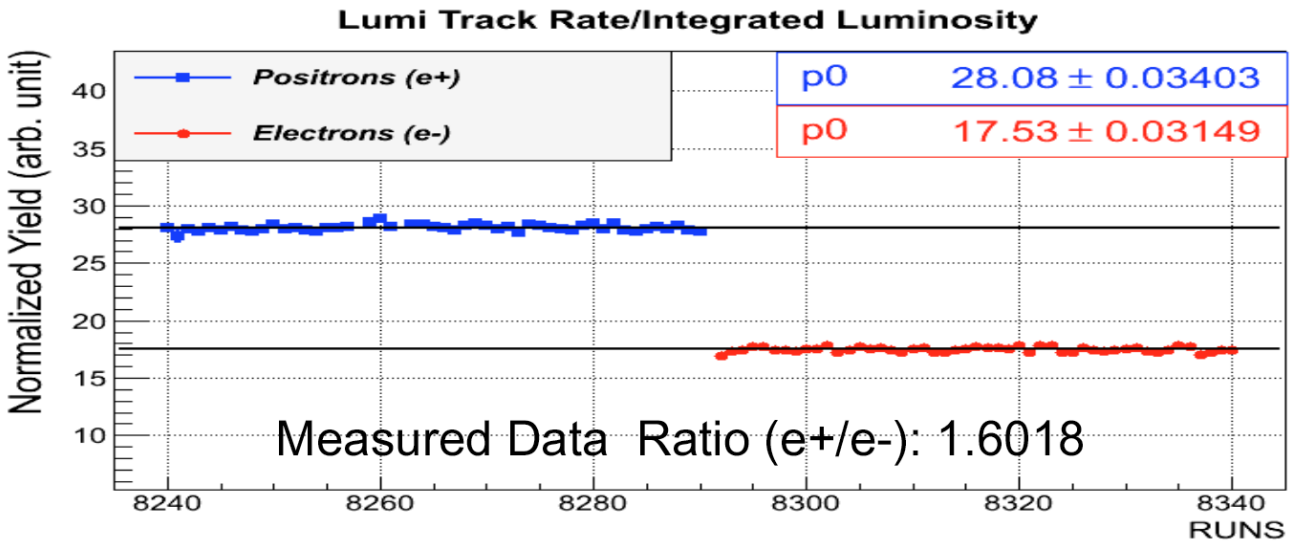


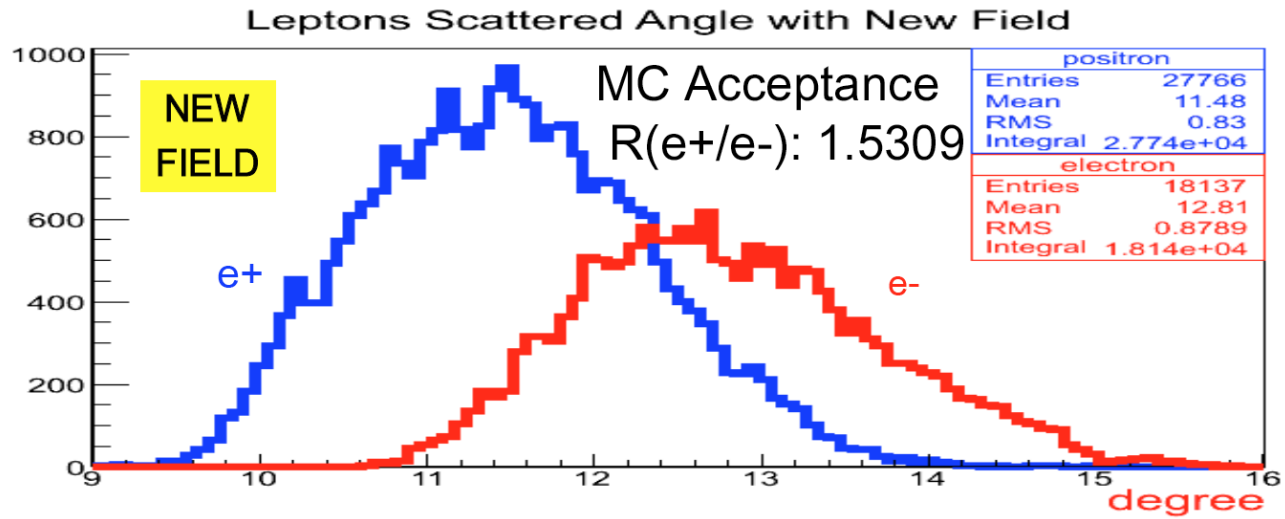
Absolute TOF Gain from Protons - Rebecca Russell (MIT)



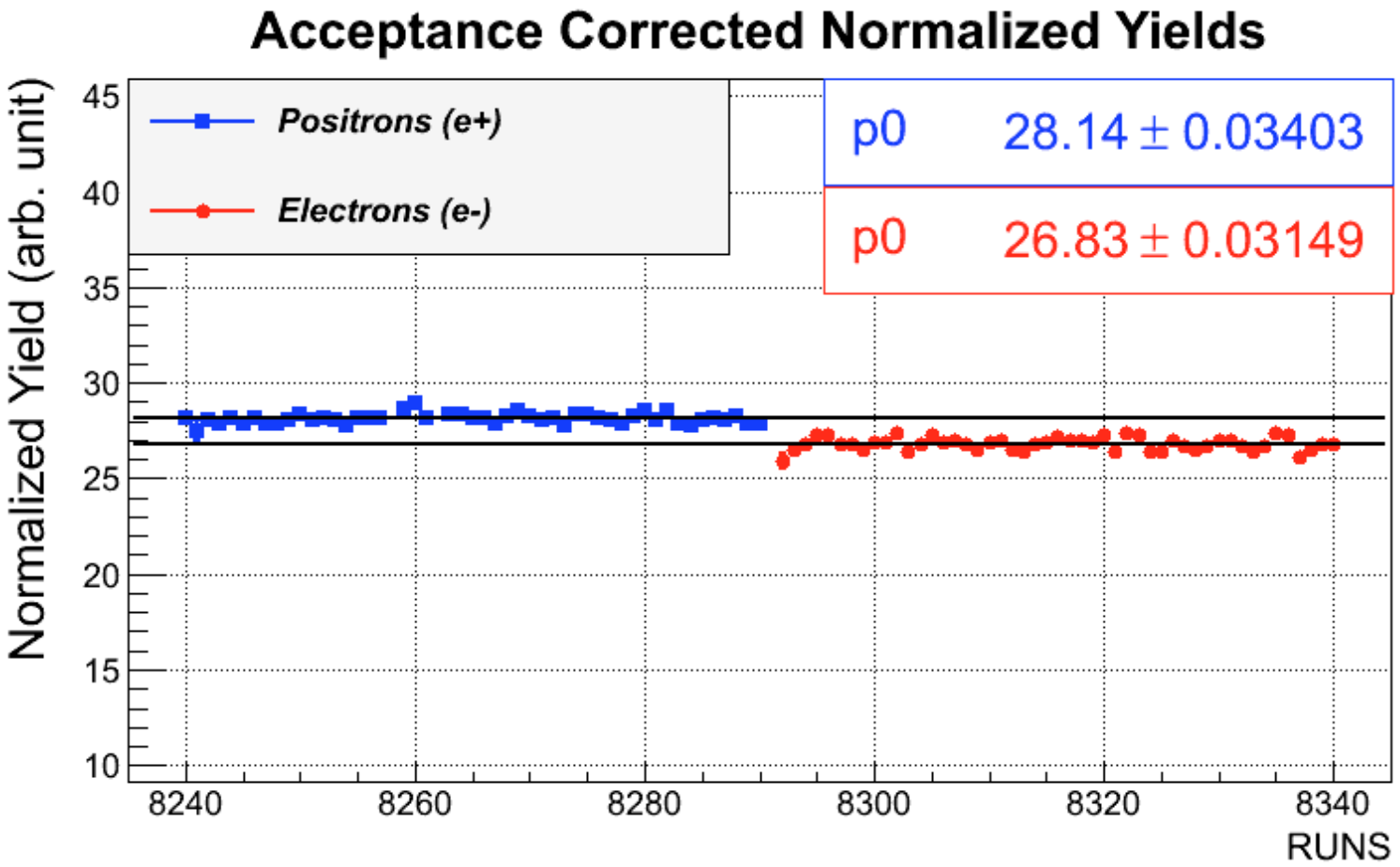
- correction for ADC overflow
- poor statistics for forward bars
- comparable results using muons from cosmic runs

GEM Detector Rates - Özgür Ates (HU)



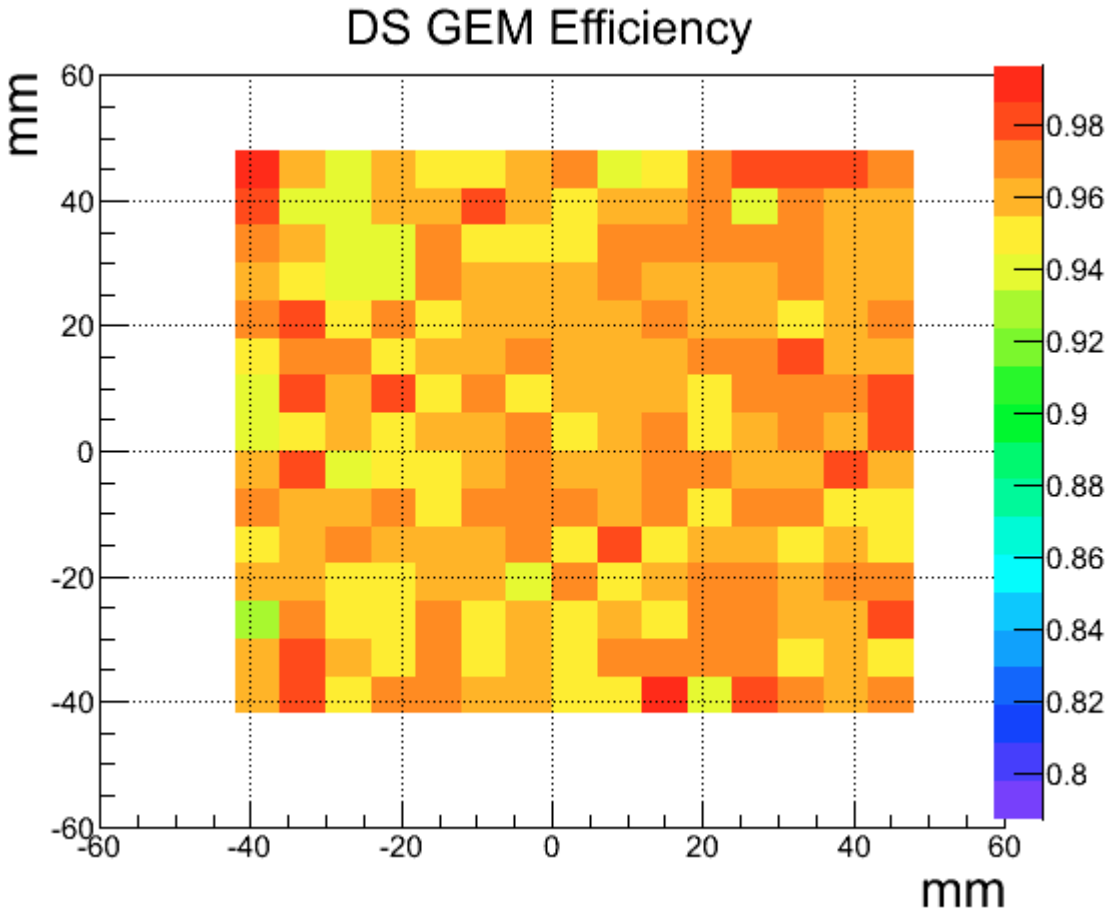


GEM Acceptance Corrected Detector Rates



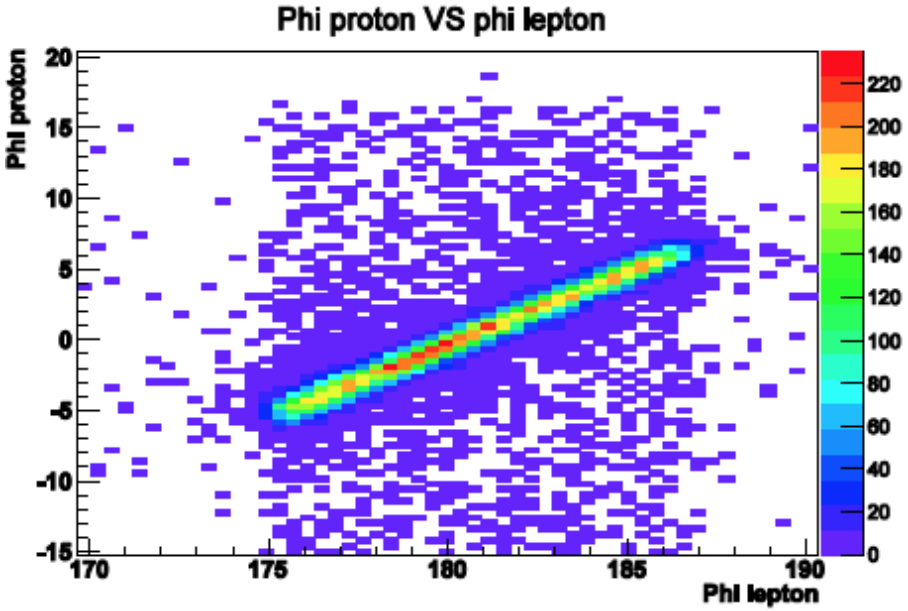
Ratio 1.049 ± 0.005

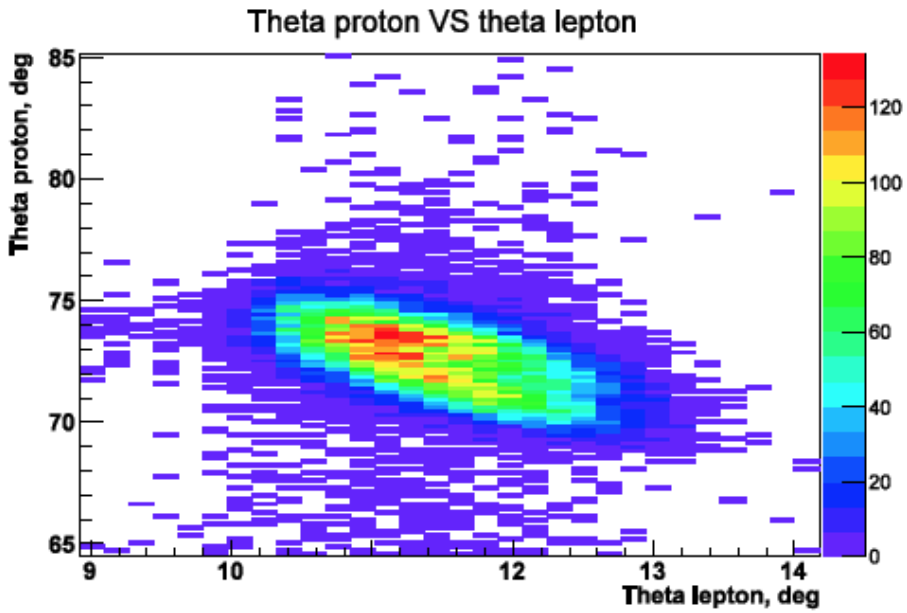
GEM Detector Efficiency - Özgür Ates (HU)



- efficiency $\sim$ 95 % in all detectors
- good agreement between MC simulation and measured rates

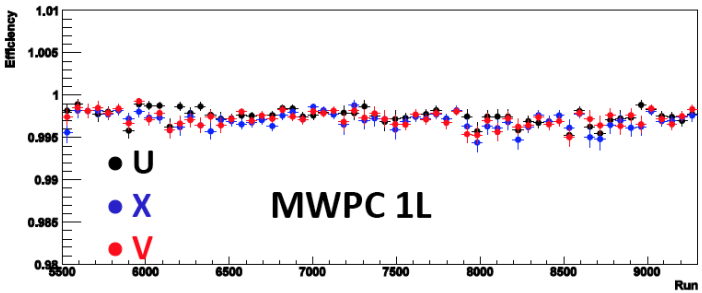
MWPC - Denis Veretennikov (PNPI)

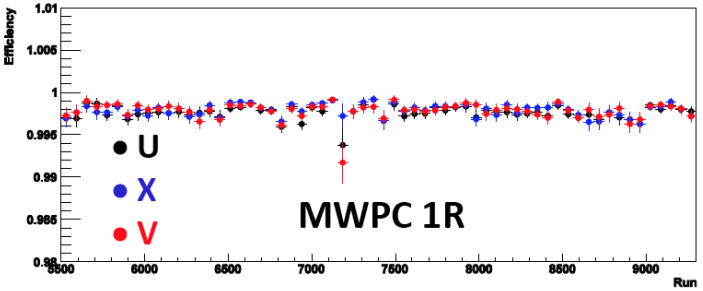


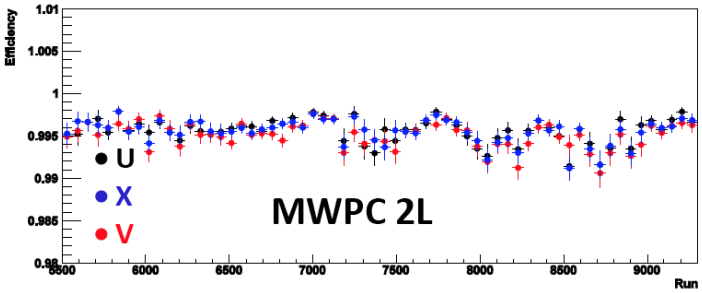


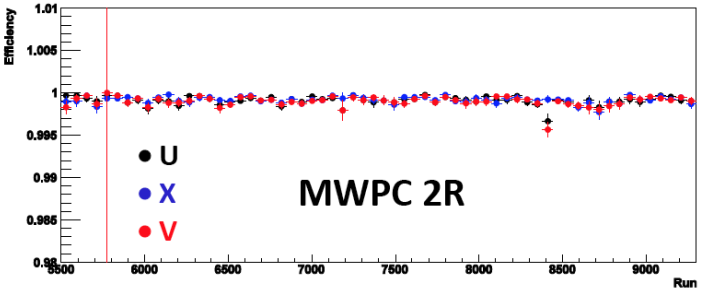
- reasonable ep elastic resolution
- ratio of e^+p/e^-p rates agree with MC to ~ 5 %

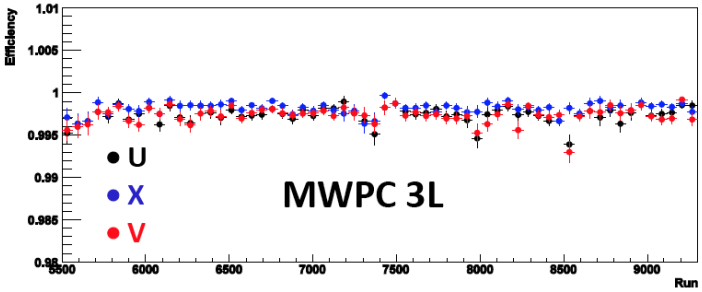
MWPC Efficiency - Denis Veretennikov (PNPI)

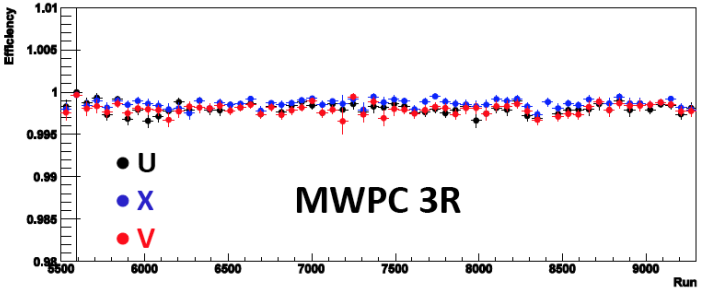












- efficiency $\sim$ 99 %

Symmetric Møller / Bhabha Detector

Analysis and Monte Carlo - Roberto Pérez Benito (Mainz)

- using optical survey data to account for geometric effects
- correcting for beam position and slope
- Monte Carlo simulation at tree level working
  - higher order effects being discussed with theory group at Mainz
- dynamic non-linearities in ADC being studied

Good results shown in April seem to have changed

- naive approach gave good agreement
- corrections, particularly geometric effects, cause discrepancy
- needs to be investigated further

Symmetric Møller / Bhabha Detector

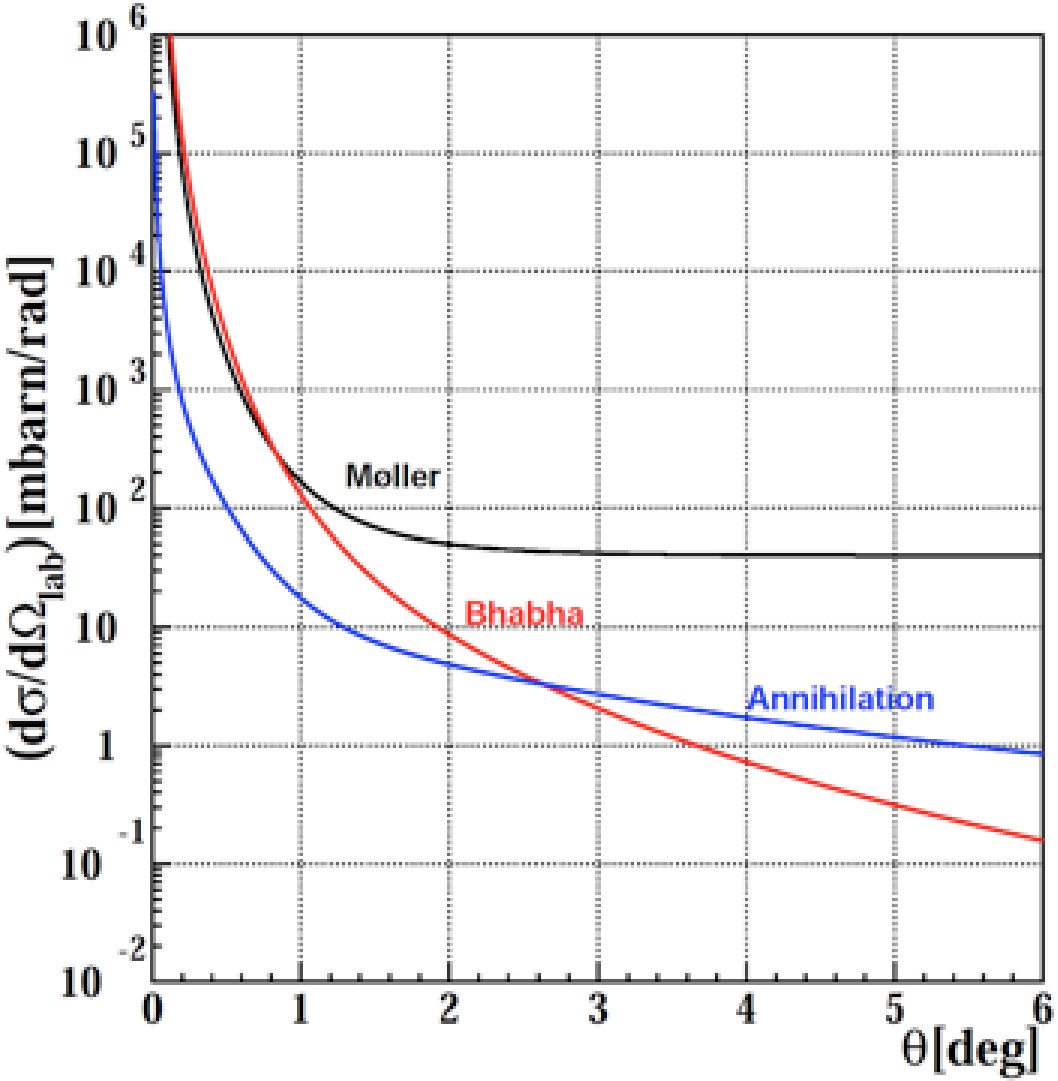
	Geometrical Cross section [mbarn]	Loss cross section %	Coincidence cross section [mbarn]
Møller (MC run 9505)	0.00538	23.2	0.00414
Bhabha+Annihilation (MC run 9429)	0.00322	29.3	0.00227
ratio	1.67		1.82

	Measured cross section [mbarn]
Møller (run 9505)	0.00471
Bhabha + Annihilation (run 9429)	0.00294
ratio	1.60

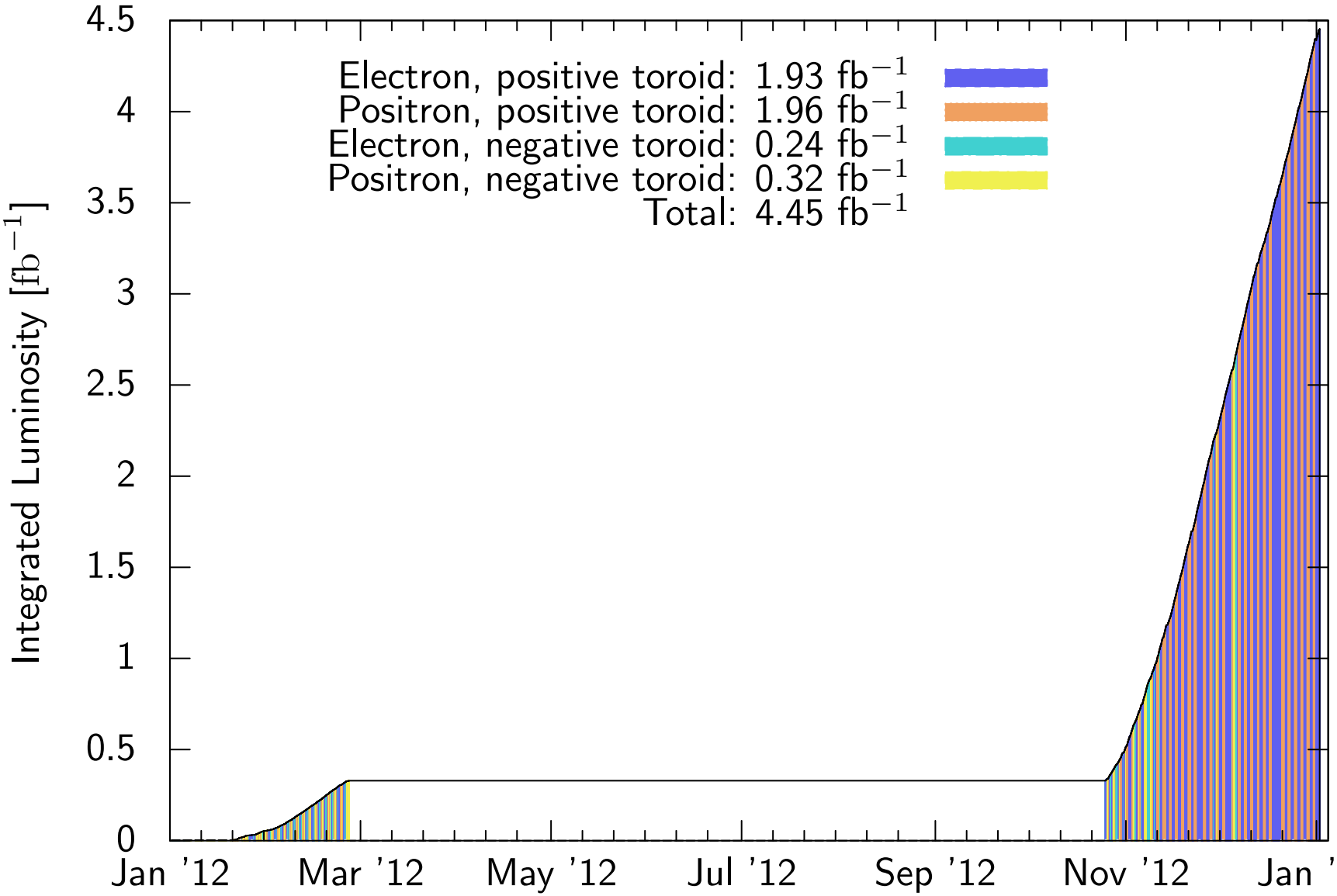
Run 9505 Møller
dtc luminosity : 7.0667e+35 cm^{-2}
møller events 3326573
measured cross section 0.00471 mbarn

Run 9429 Bhabha+Annihilation
dtc luminosity : 1.3511e+35 cm^{-2}
bhabha+annihilation events 396772
measured cross section 0.00294 mbarn

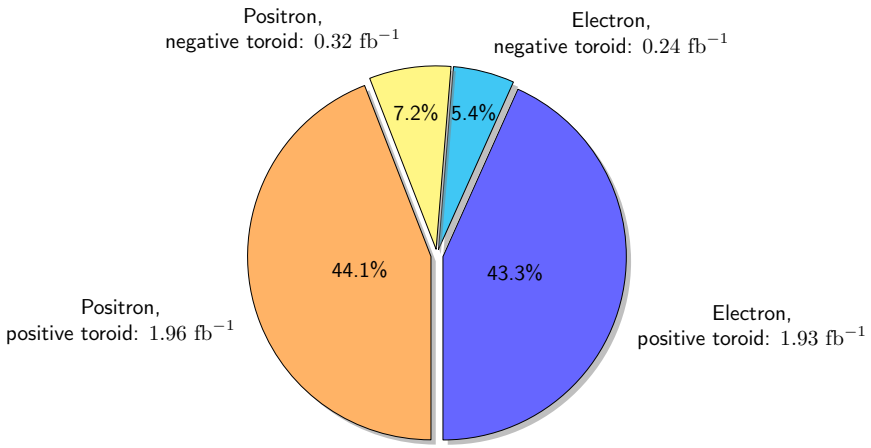
Symmetric Møller / Bhabha Detector



Luminosity from Slow Control - Jan Bernauer (MIT)



Luminosity



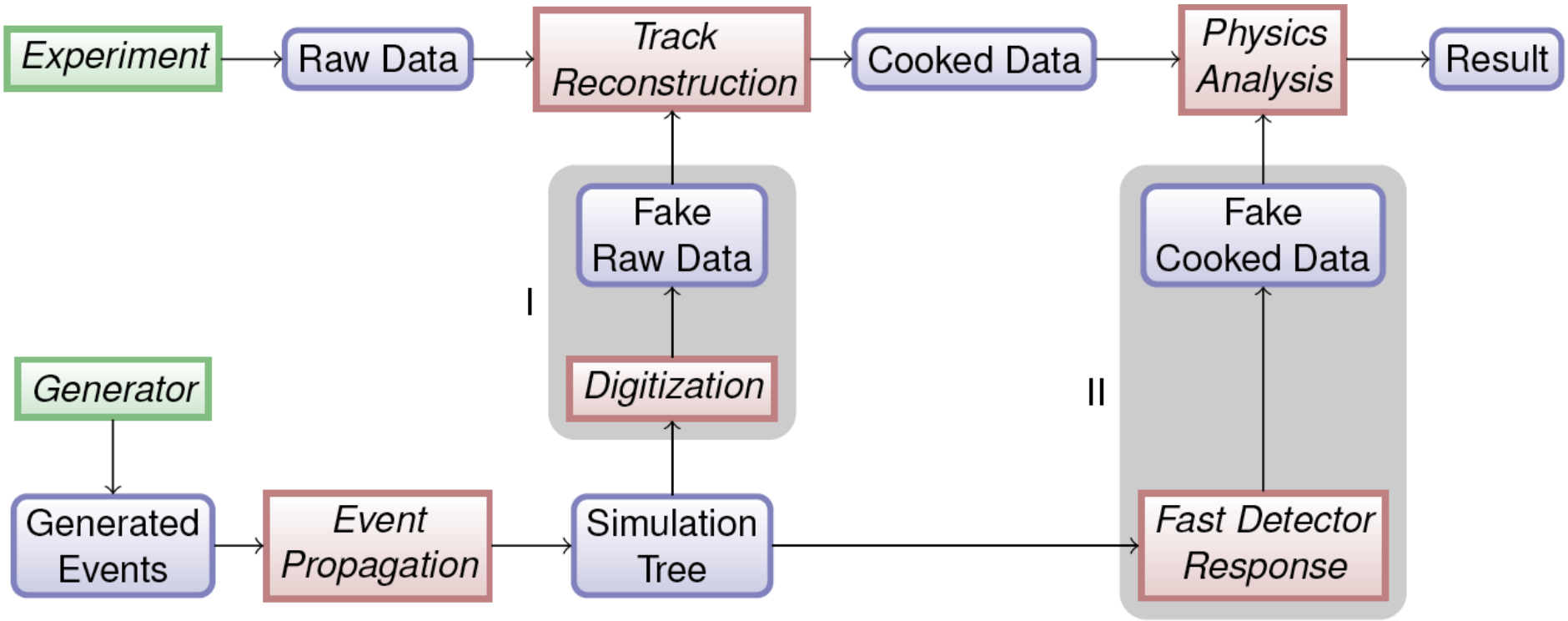
Most data with positive magnetic field

- negative polarity bends electrons into the wire chambers
- wire chambers unable to handle noise rate

Luminosity work in progress - Jürgen Diefenbach (Mainz)

- comparing 12° luminosity detector and Møller/Bhabha results
- started using new MC for 12° for acceptance studies

Monte Carlo



- new framework for Monte Carlo integrated in Cooker framework
- all groups expected to contribute to analysis and MC repository
  - primarily MIT, ASU
  - some from HU, Mainz, PNPI

Monte Carlo Generators and Digitization

Generators - MIT, ASU, DESY

- basic generators and pion generator - 100 %
- implementing radiative effects in generators
  - internal bremsstrahlung generator - 90 %
  - port of Novosibirsk generator almost - 90 %
  - common effort with JLAB and Novosibirsk
  - DESY version of Maximon and Tjon done but not in repository

Digitization

- digitization of all components underway
  - TOF 90 %
  - WC 50 %
  - GEM 70%
  - MWPC 10 %
  - SYMB
  - trigger 100 %

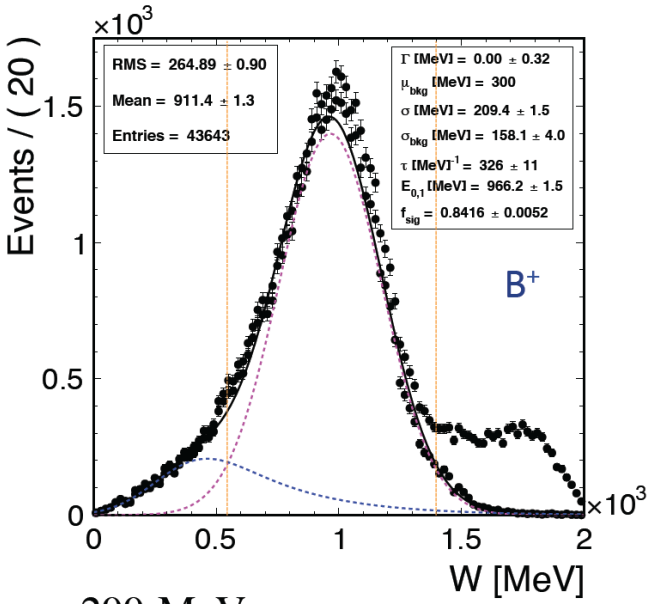
Track Reconstruction - Jan Bernauer (MIT)

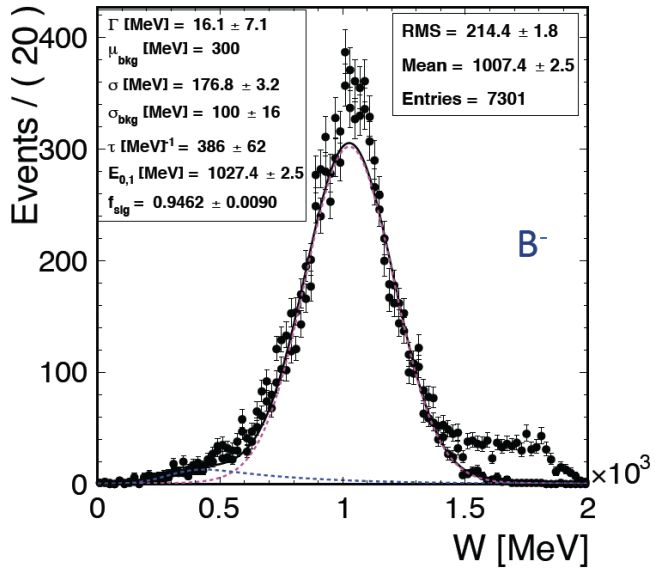
- will use Elastic-Arms-Algorithm
  - global fit version of Kalman filter
  - also have Kalman filter
  - early tests encouraging
  - decided to wait until optical survey, magnetic field map, and data reprocessing completed and implemented
  - need to find time-to-distance for each wire from data
  - must also tune algorithm (cut-offs, etc.)
  - replaced path swimming with spline lookup to improve speed
- ready to begin

Analysis of February Data - Nicola D'Ascenzo (DESY)

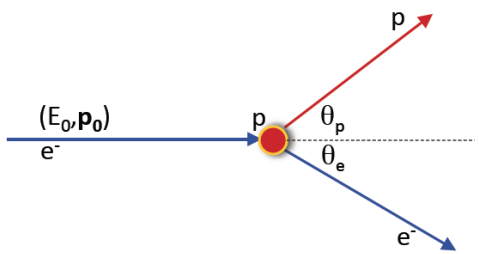
Using a small subset of February runs with tracking results

Reconstruction from angles and energy





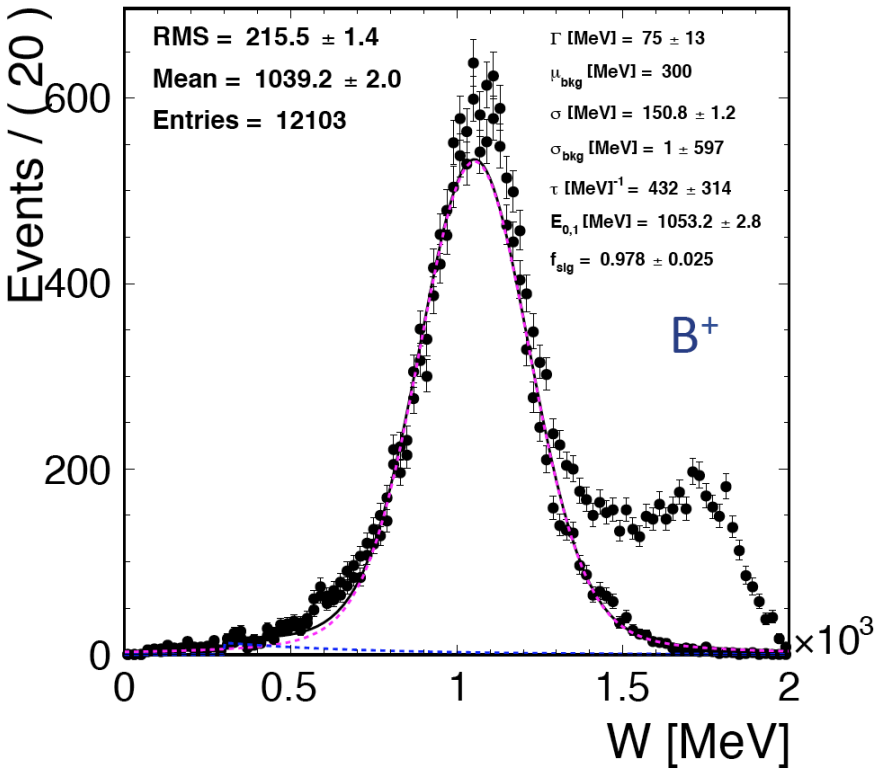
$\sigma \approx 200$ MeV

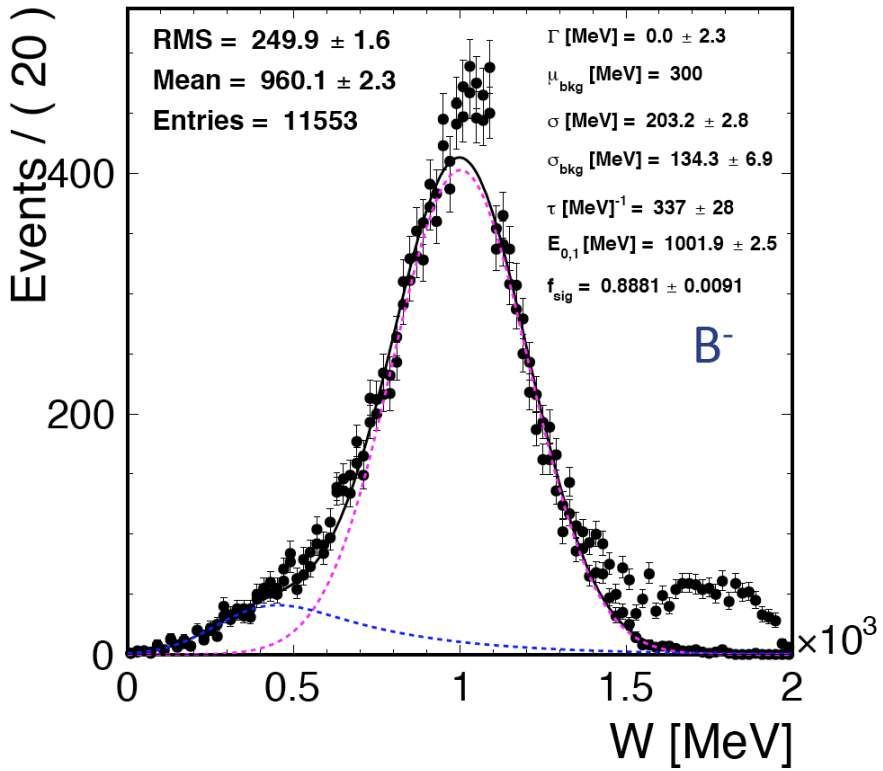


$$W = \sqrt{m_p^2 + 2m_p\left(E_0 - E_e\right) - 4E_0E_e\sin^2\frac{\theta_e}{2}}$$

For elastic events W= m_p

Analysis of February Data - Nicola D'Ascenzo (DESY)





- *ep* elastic scattering events clearly seen
- based on old, first attempt at track reconstruction
- missing tracks from B^- runs

Outline

Disassembly and Shipping

- after magnetic field mapping and optical survey complete
- started disassembly of OLYMPUS experiment
- useful items (electrons, power supplies, vacuum equipment, computers, etc.) recovered by various institutes
- mechanical structure of the experiment and the magnet coils scrapped

Moving Computers and Reprocessing - Bonn

- after cosmic data run computers moved to Bonn
- temporarily without access to nominal run database, wiki, data, etc.
- converting raw ZEBRA data to ROOT files used for analysis
  - some channels mis-mapped
  - first reprocessing had some problems
  - solved now and most data converted
- data will be available at MIT and DESY

Collaboration Meeting at MIT July 8–11, 2013

- very successful and productive meeting
- 2 mornings of normal meeting - updates and status reports
- rest of meeting in workshops
  - concentrated on specific areas
  - tutorial on using the Cooker framework
  - tutorial on using the new Monte Carlo
  - special sessions on MC, Tracking, TOF, GEM, MWPC, etc.
  - reviewed analysis, discussed work to do, simulation, digitization, ...

Next Collaboration Meeting at DESY, October 17-18, 2013

- ahead of PRC meeting October 24-25, 2013
- working on radiative correction workshop at Orsay, October 7-8, 2013

NIM Paper on OLYMPUS Experiment

- description of experimental configuration and operation
  - DORIS accelerator
  - internal, gas target and vacuum system
  - detector system
  - trigger, data acquisition, slow control, data quality control
  - operation of experiment
- before experts disappear or forget
- available for citation
- paper fully written
- comments, suggestions, details until September
- final version ready for approval by October

Summary

- a lot of work has been done
- field mapping, optical survey, GDML, and data reprocessing all done
- analysis well advanced on TOF, GEM, and MWPC ahead of tracking
- track reconstruction is set to begin
- Monte Carlo incorporated into Cooker framework
- several components digitized
- first radiative corrections added to generators, planning workshop
- luminosity determinations have to be improved/understood
- main effort is at MIT (ASU student was at MIT)
- other efforts isolated and/or need to be integrated better
- NIM paper ready for submission in October

Timeline

- first passes on track reconstruction in September
- initial tracking results in October
- detailed analysis by April, 2014
- final results by end 2014