Development of GEMs at Hampton University

Contents

- GEMs at HU.
- At Experiments.
- GEM performance analysis.
- Future Experiment.

Anusha Liyanage

Fall Meeting of the APS Division of Nuclear Physics
29th October, 2015

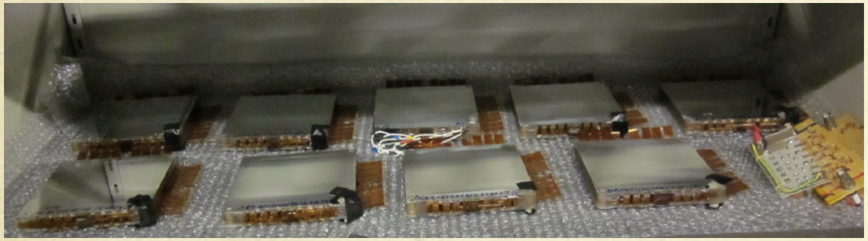
Two GEM telescopes,

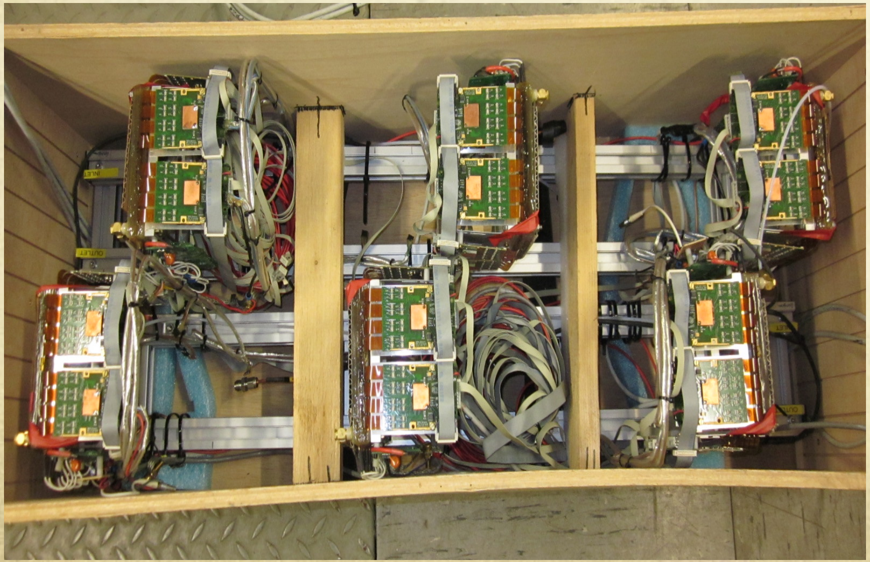
->Three 10x10 cm^2 triple-GEM chambers 30-40 cm apart. (70 cm long)

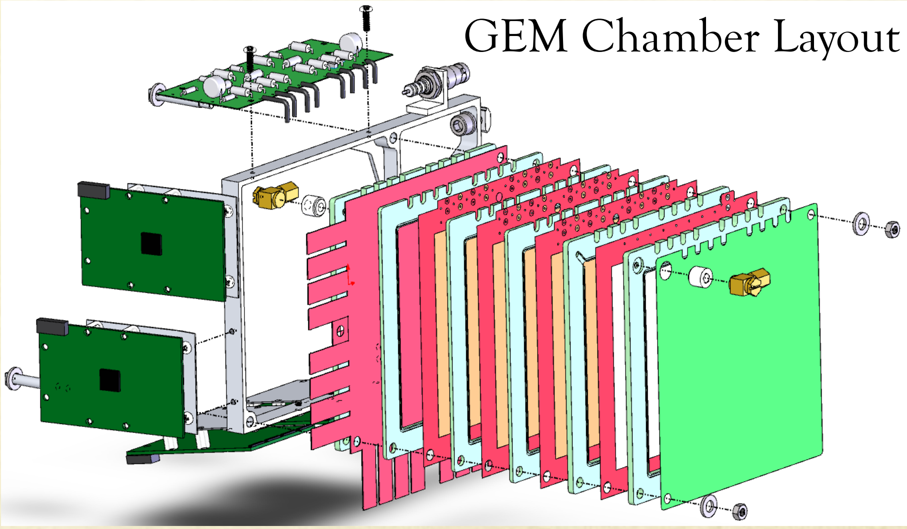
-> The charge is collected on a 2D readout plane, consisting of a copper strips at pitch of 400 μm.

-> 1500 channels per telescope (500 per element)

Were Built, Tested and Operated by the Hampton University.







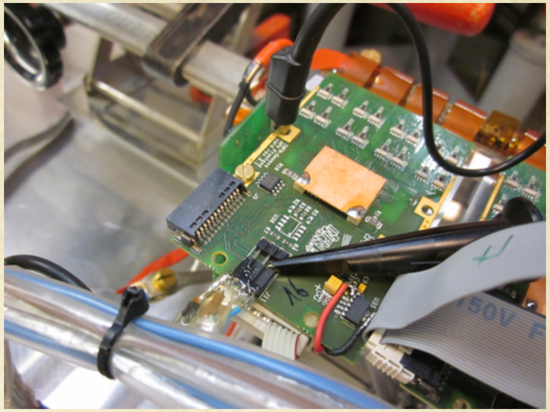
GAS SYSTEM:

- ✓ Flowing $ArC0_2$ (70:30) at 1liter/h for both sectors.
- ✓ Rota meters and bubblers read the gas flows.

GEM Data Acquisition System

- Use APV25 to read analogue signals coming from the GEM strips.
- The chip contains 128 channels of preamplifier and shaper driving a 192 column analogue memory into which samples are written at the 40MHz frequency.
- The latancy selects the sample to read out and the requested samples from the memory can then be processed with a filter, shaper and through an analogue multiplexer.

APV25 front-end card



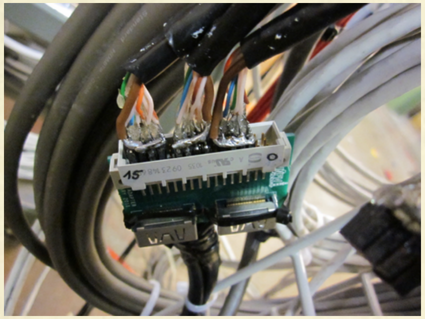
MPD Rev. 3.0

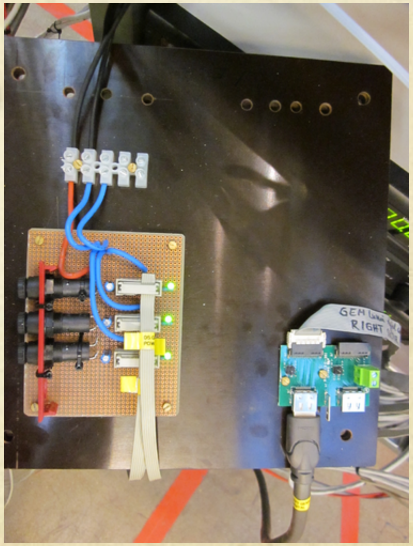
- The MPD (Multi Purpose Digitizer) Board has been designed to readout 16 APV25 front-end cards, reading out the analog data streams. And transmitting both the control and configuration signals.
- The FPGA mounted on it handle the VME interface, APV25 triggering, APV25 configuration etc...

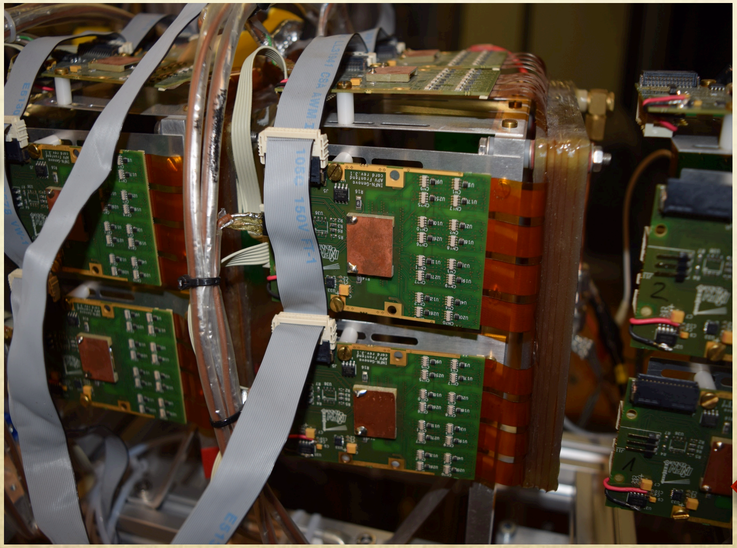
- Use V7768 VME controller with universe II tundra chip on it (From INFN, Rome).

GEM Cabling:

- ✓Patch Panels are used for digital and LV connections.
- ✓The digital information carries the APV configuration details via HDMI-A connector from the MPD.
- ✓It transfer it's details to the flat ribbon cable through the patch pannel.
- ✓ Analog signal cables are connected to a special connector which goes to HDMA-B in the MPD.
- ✓ 5 V required for APV operation is supplied through through the patch pannel.

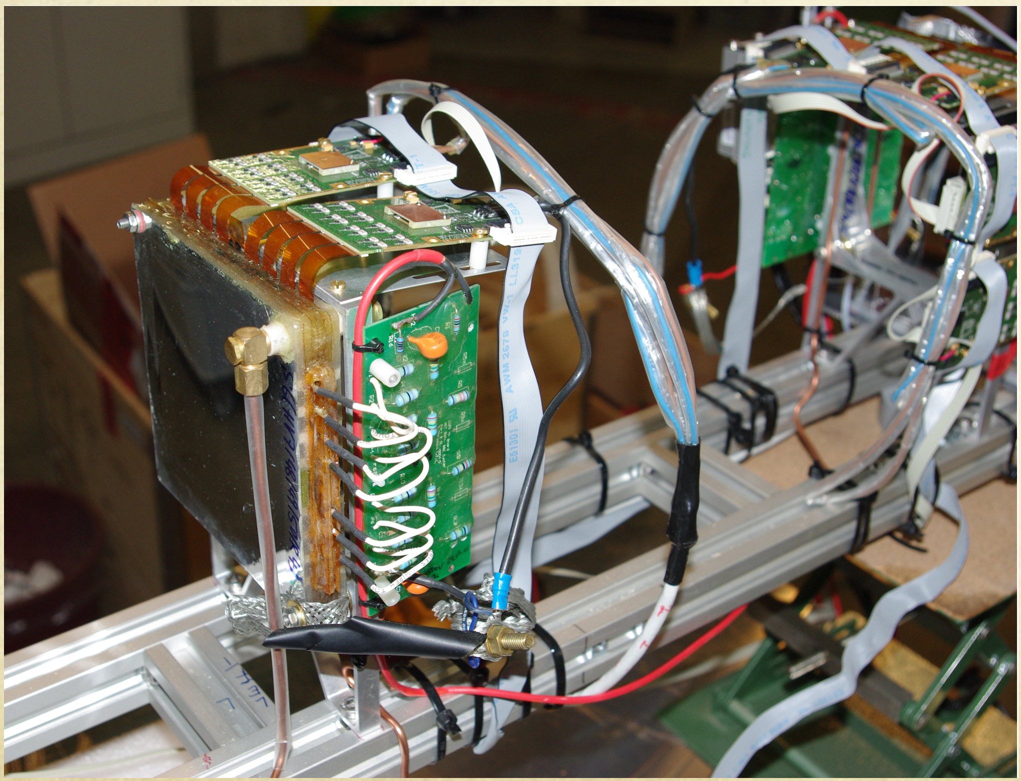


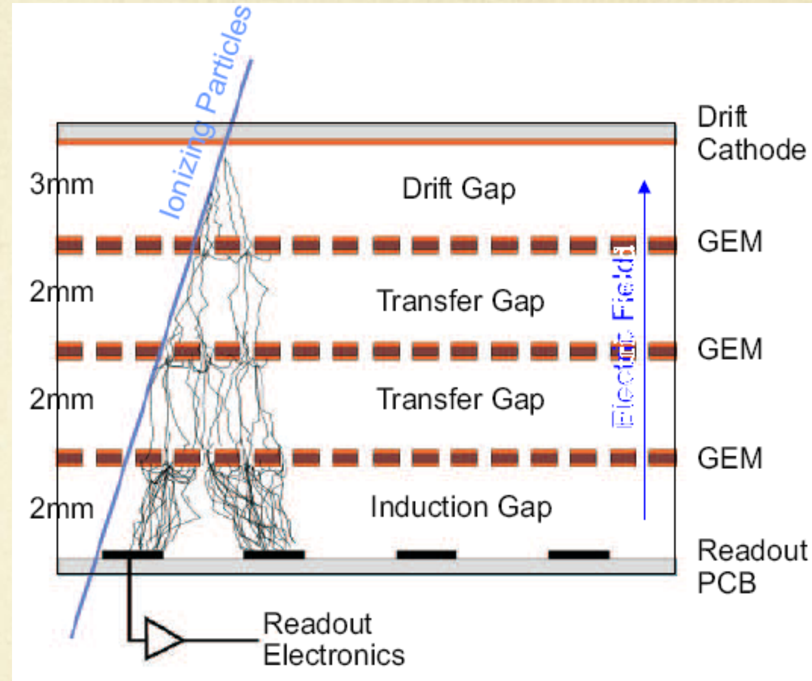




High Voltage:

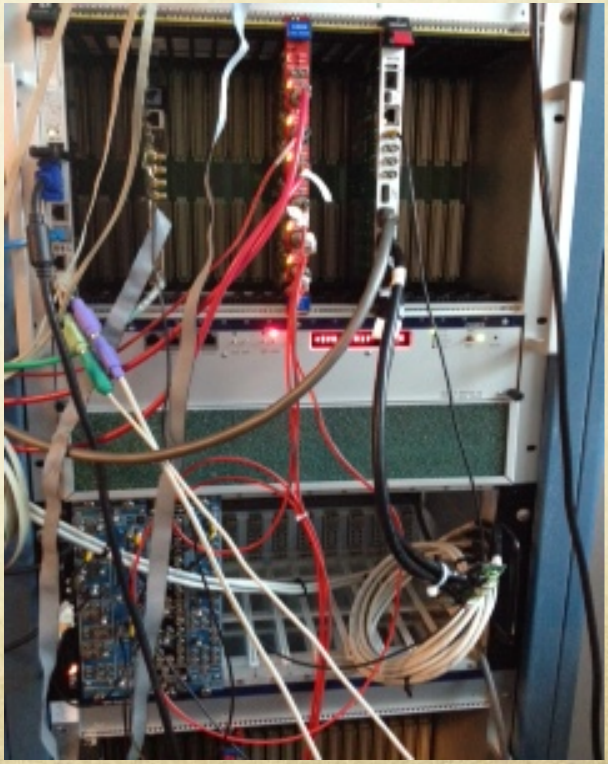
- ✓ 3 VDs/telescope.
- ✓ Each VD covered with epoxy and heat cured.
- ✓ Each VD tested at max design voltage as 4500V.
- ✓ Runs at -3800 V.





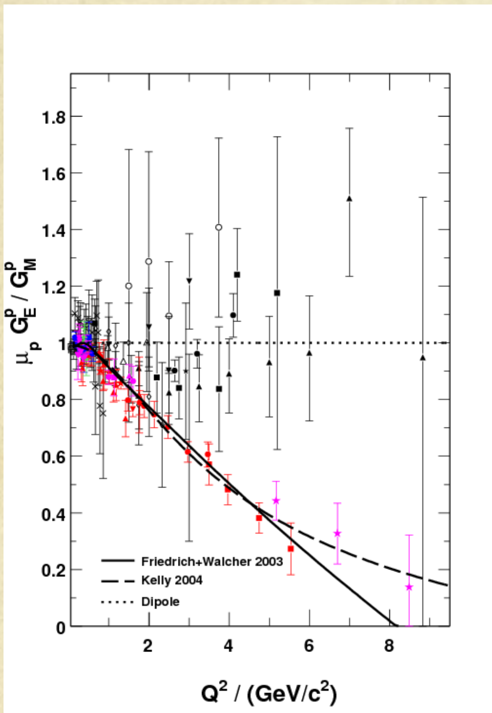
Our setup at HU

- GEM DAQ: NIM modules, HV modules, MPD
- Ar/CO_2 70:30 gas flow
- 10 cm x 10 cm single GEM and 3-GEM telescope.
- Trigger scintillators.



OLYMPUS at DESY

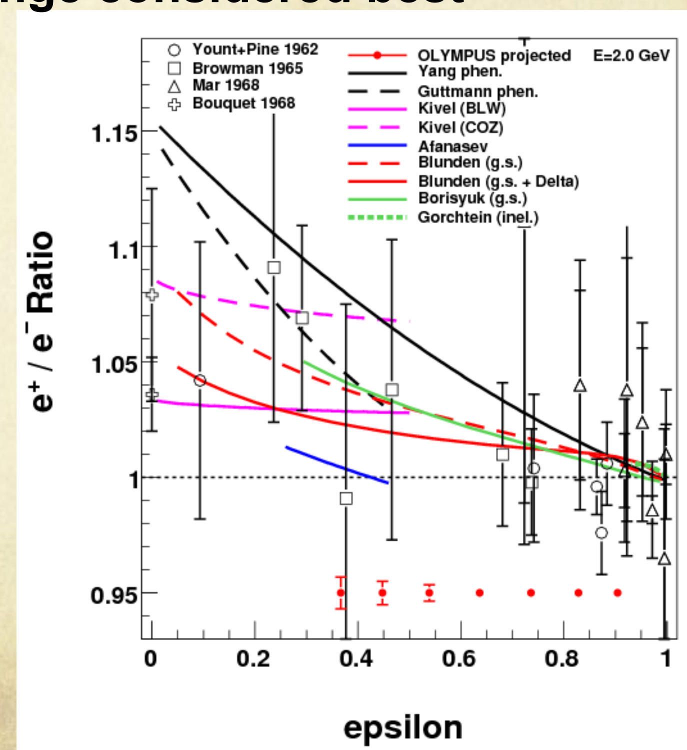
Electrons/positrons (100 mA) in multi-GeV storage ring.
DORIS at DESY, Hamburg, Germany
Comparison of e+p and e-p elastic scattering to study the effect of "Two Photon Exchange"



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

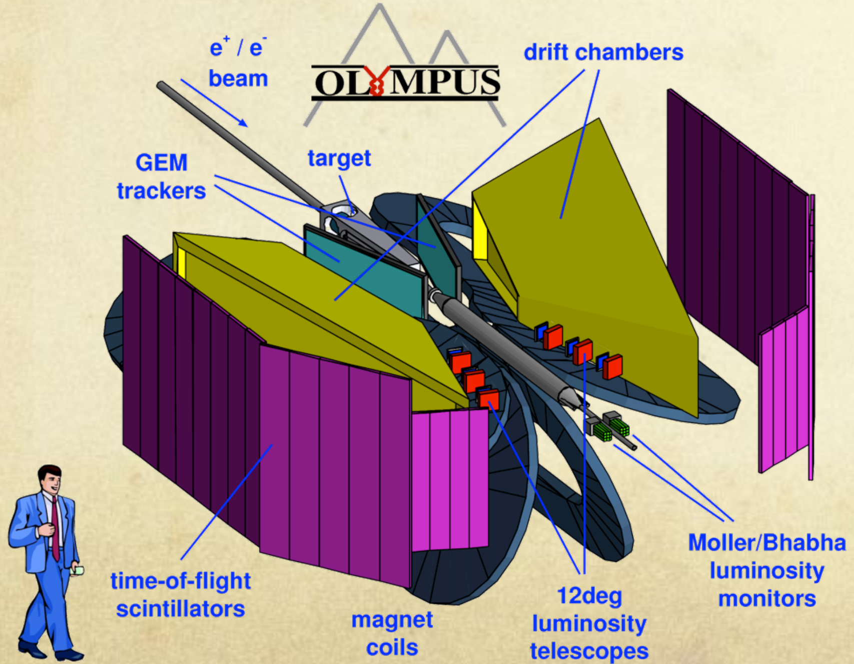
OLYMPUS:

E = 2 GeV, ε = 0.37-0.9
Q^2 = 0.6-2.2 $(GeV/c)^2$
<1% projected uncertainties
500h @ $2x10^{33}$ / cm^2s e+,e-

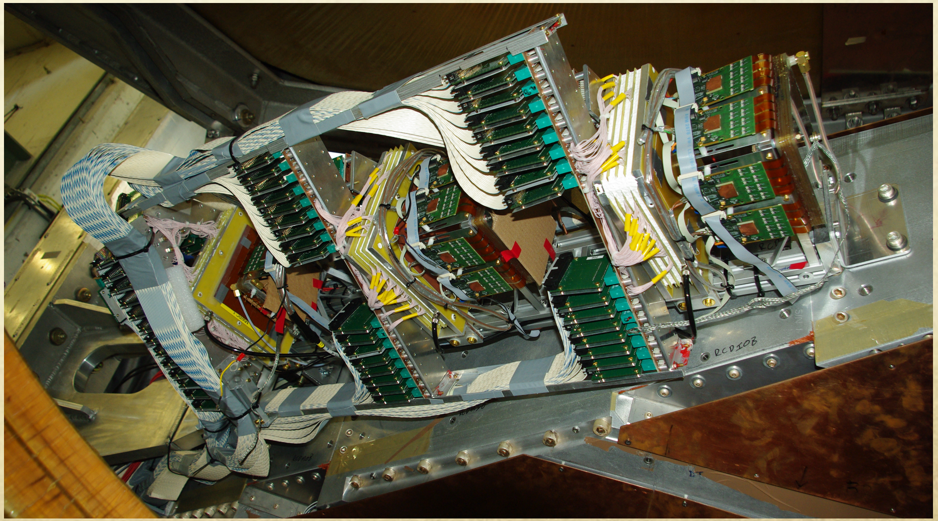


GEMs for OLYMPUS

- Telescopes of three GEMs and MWPCs interleaved Mounted on wire chamber forward end plate.
- Detect leptons in coincidence with Recoil proton detected in the opposite sector and vice versa.
- Operated until Jan. 2013



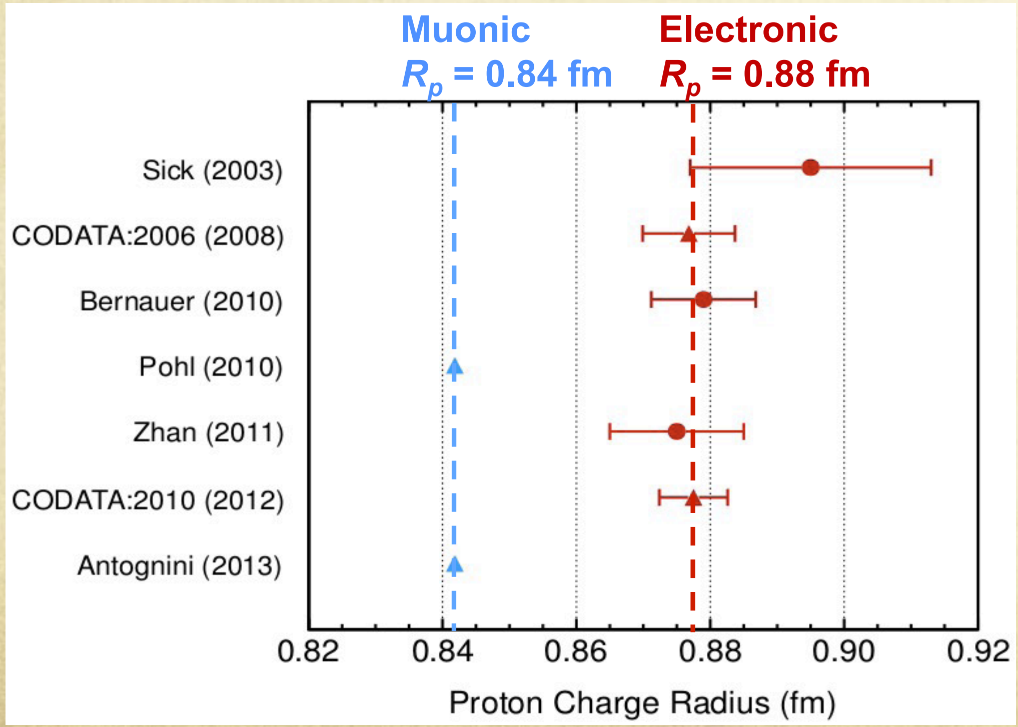
12 deg, 1.2 msr
Very stable operation.
High efficiency ~95%
High spacial resoluton ~70 mum



MUSE at PSI

Use the world's the most powerful low-energy separated e/pi/mu beam for a direct test if ep and mup scattering are different to study the "Proton Radius Puzzle".
Paul Sherrer Institute, Switzerland.

Simultaneous, separated beam of (e+/π+/μ+) or (e-/π-/μ-) on liquid H2 target
→ Separation by time of flight
→ Measure absolute cross sections for ep and μp
Directly disentangle effects from two-photon exchange (TPE) in e+/e-, μ+/μ-
Multiple beam momenta 115-210 MeV/c to separate GE and GM (Rosenbluth)



▲ Spectroscopy
● Scattering

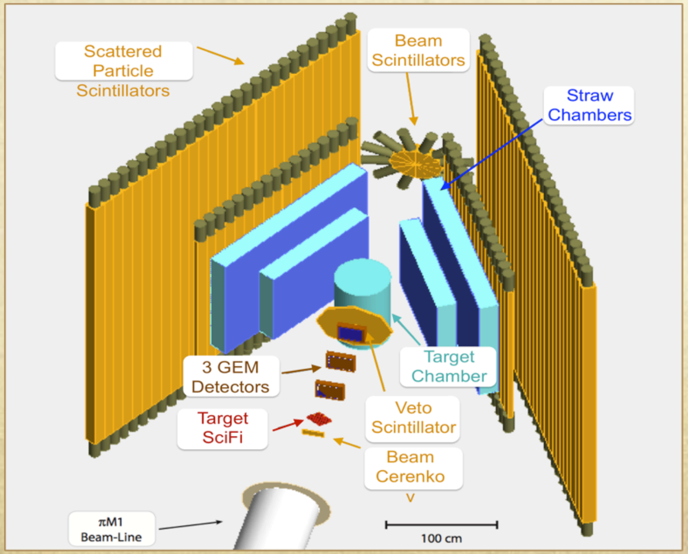
R_p = 0.84184(67) fm
R_p = 0.875(10) fm
R_p = 0.8775(51) fm
R_p = 0.84087(39) fm

- >7sigma (4%) descrepency between muonic and electronic measurements.
- Puzzle unresolved.

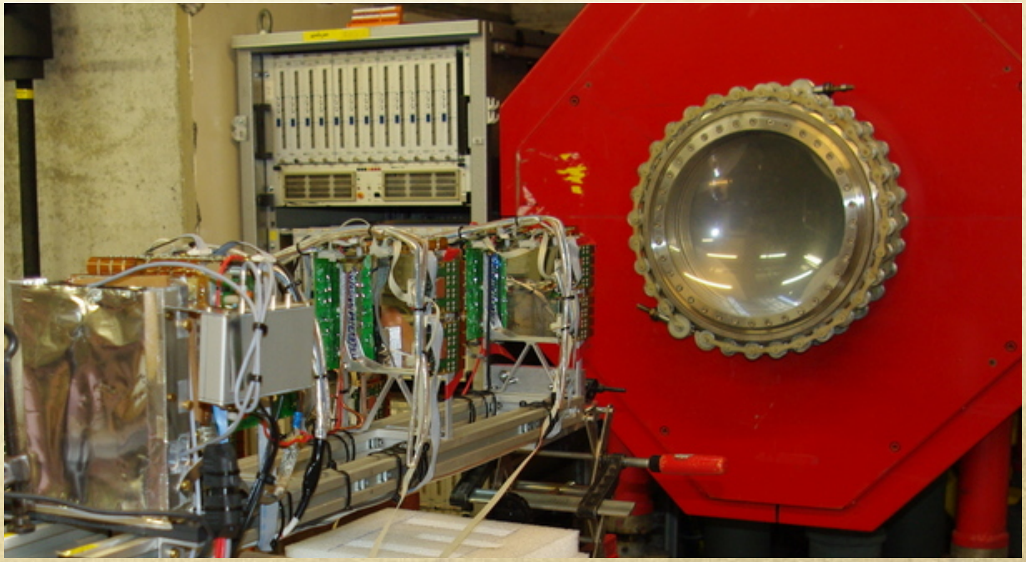
GEMs for MUSE

- PSI πM1 beam line provides a beam with ~2 cm radius at the scattering target.
- Operate at 5MHz beam flux.
- Use GEM detectors as beam line elements to determine the precise particle scattering angles.
- Expect ~100 μm spatial resolution.
- Operated in beamtimes May-June 2013, Dec. 2013, June+Dec. 2014, June+July 2015.
- Telescope Transferred from OLYMPUS in May 2013.

MUSE Detector Setup



GEM telescope at PSI



Optimization of GEM Performance

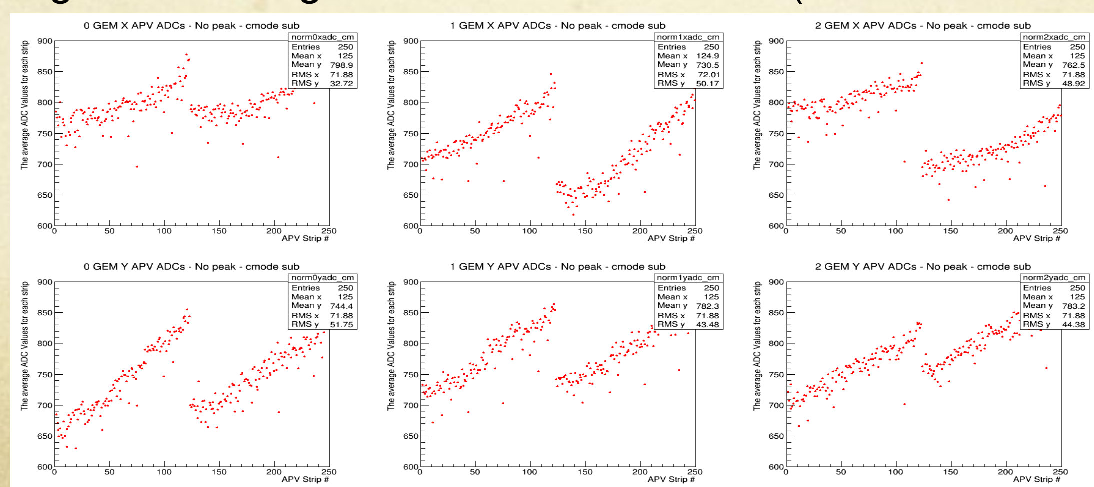
(1) Common-mode noise subtraction.

The various noise types, the so-called common-mode noise can be determined per event, a correlated up and down per event for all channels together.

(2) Bin-to-bin pedestal subtraction.

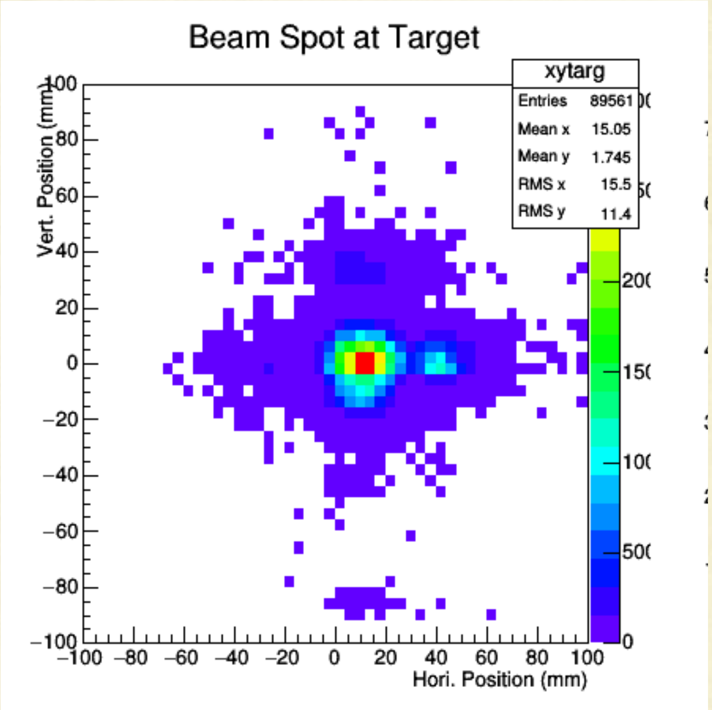
The raw ADC has a pedestal and is prone to noise. The individual pedestal can be determined by averaging each channel over many events.

The average ADC histogrammed for all channels (After common mode subtraction).



The hit finder

(Originated from Brian Handerson, OLYMPUS)



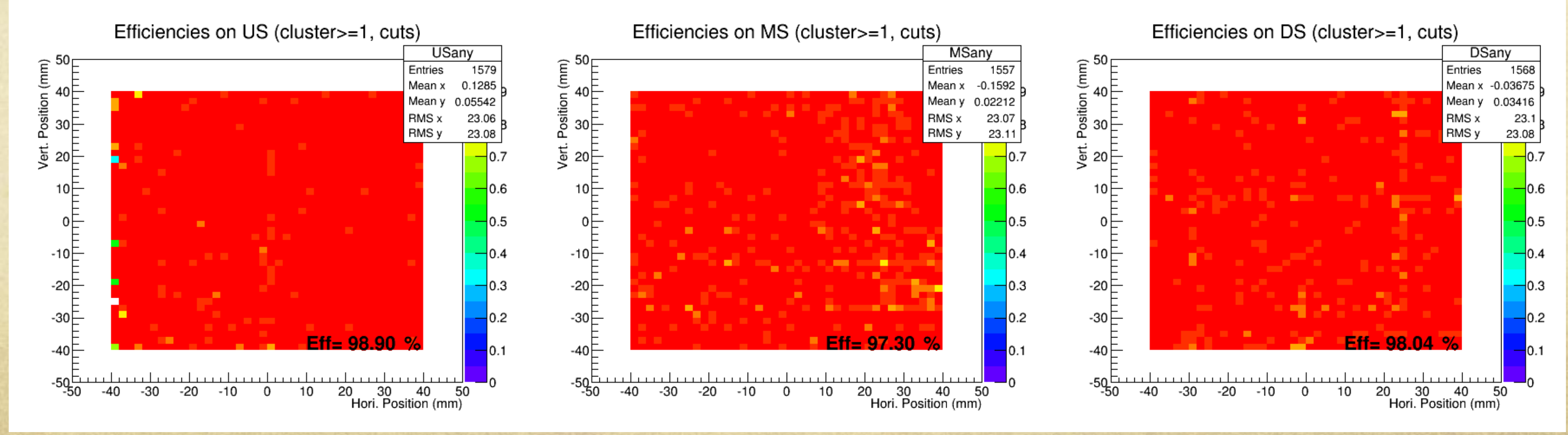
- Local Maxima in both X and Y are determine after both common mode and pedestal subtraction.
- Hit candidates are determined by pairing these X and Y local maxima and charge sharing

-→This removes ID hit candidates which come from hot channels/noise, accepted as “valid clusters” in the older hit finder.

- Cluster positions are determined by ADC count weighted average in each dimension for the selected hits.

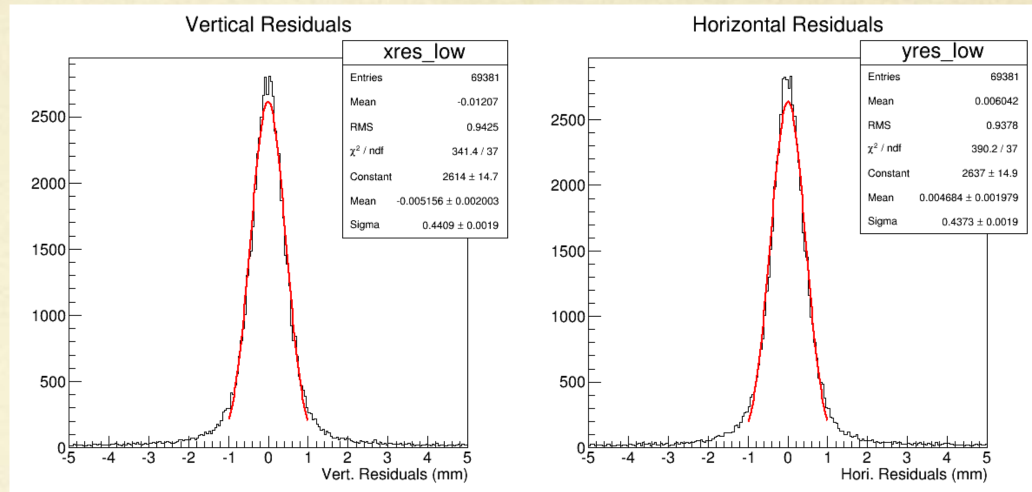
GEM Efficiency

- The GEM detector has moved to far back to fully eliminate the 10 x 10 cm^2 GEMs.
- SiPM is a 4 mm thick 12x12 cm^2 scintillator array with two Si PMTs at the top and bottom ends.
- It is attached to the third GEM and use for triggers.
- SiPM is operate at 73 V+- 10 mV.

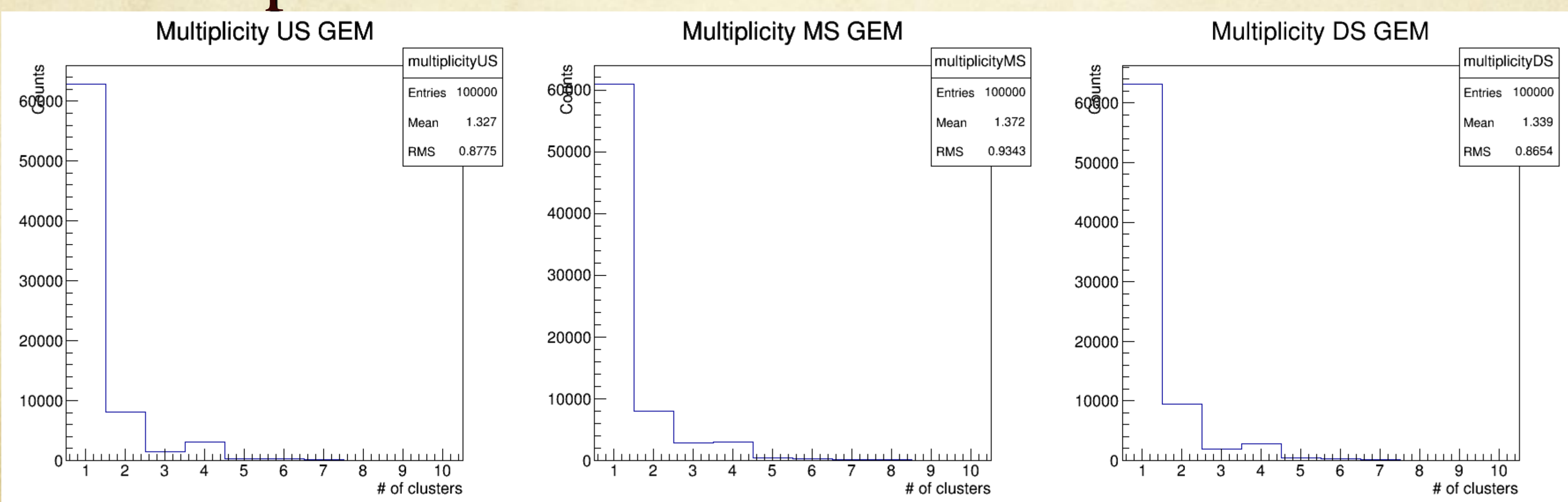


Horizontal/ Vertical Residua on MS GEM

- Determined a valid clusters on the US and DS GEMs and make a track.
- The residuals are calculated on MS GEM using the projected X/Y position of the above track on the MS GEM and the detected cluster positions (for the same event) on the MS GEM.



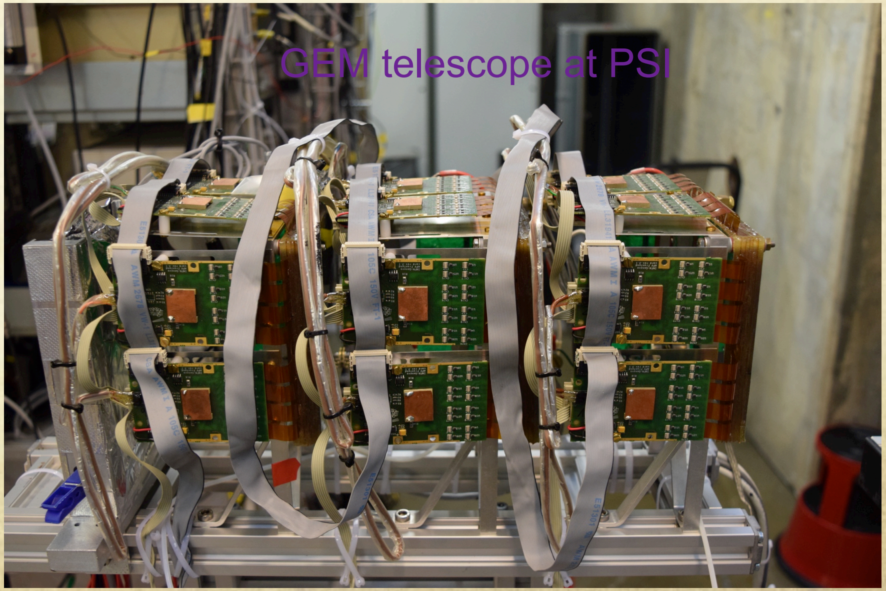
Multiplicities



In progress ……

- Software
  - Gain matching : Calibrate channel-2-channel gain variations to obtain uniform ADC on each channel.
  - Optimize the cluster findings.

- Hardware
  - Reduce gaps to 12.5 cm between chambers.
  - Require re-orientation APVs in order to reach the gaps 9-10 cm in final setup.
  - Reduce analog+digital transfer cables from 25 m (in Plympus) to 10 m



- GEM DAQ read out speed
  - Presently < 1 kHz @ 100% dead time (1 ms/eve.). Data rate ~5MB/s. VMEbus limit ~100 MB/s
  - Goal=2 kHz @ 20 % dead time (100 mus/eve.)->Require factor 10, or more..
  - Current system SHOULD actually operate 4X faster (!20 MB/s) than it does. Most likely due to VME controller GEv7768 and universe-II chip set. ->Under Investigation
  - Optimize frontend code for 32-Bit block transfer BLT32 (2X, <40MB/s) by packaging data before sending via VME bus
  - Present VME master V7768 (Universe-II/Tundra chip) only supports BLT32. MPD supports BLT64, require controller with tsi148 chip (2X, <80 MB/s)
  - Use the new controller, XVR15 with JVME drive from Jlab.->Require Re-write of DAQ frontend software for XVR-15.

Future Experiments for our group

DarkLight at JLAB

Dark photons (universal coupling) well motivated by dark matter observations (astronomical, direct, positrons) in combination with gμ-2 anomaly .

To be run at the Low Energy Recirculator Facility (LERF) at Jefferson Lab

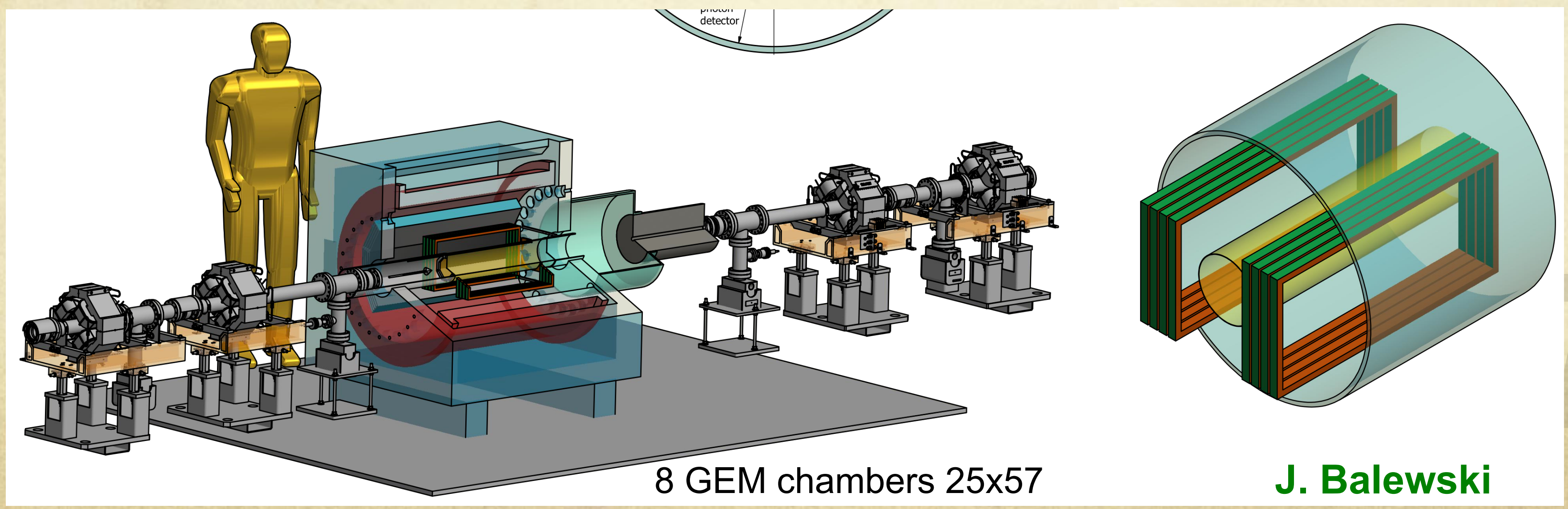
-> Search for visible decays modes of A' → e+e- in ep→epA' →epee

-> Search for invisible decays A' → X in ep→epX

-> DarkLight phase I:

Funded (NSF-MRI) in 2014, HU responsible for lepton tracker

Prepare to run phase 1a/b in 2016 and phase 1c in 2017



Thank You