Construction and beam test analysis of GE1/1 prototype III gaseous electron multiplier (GEM) detector

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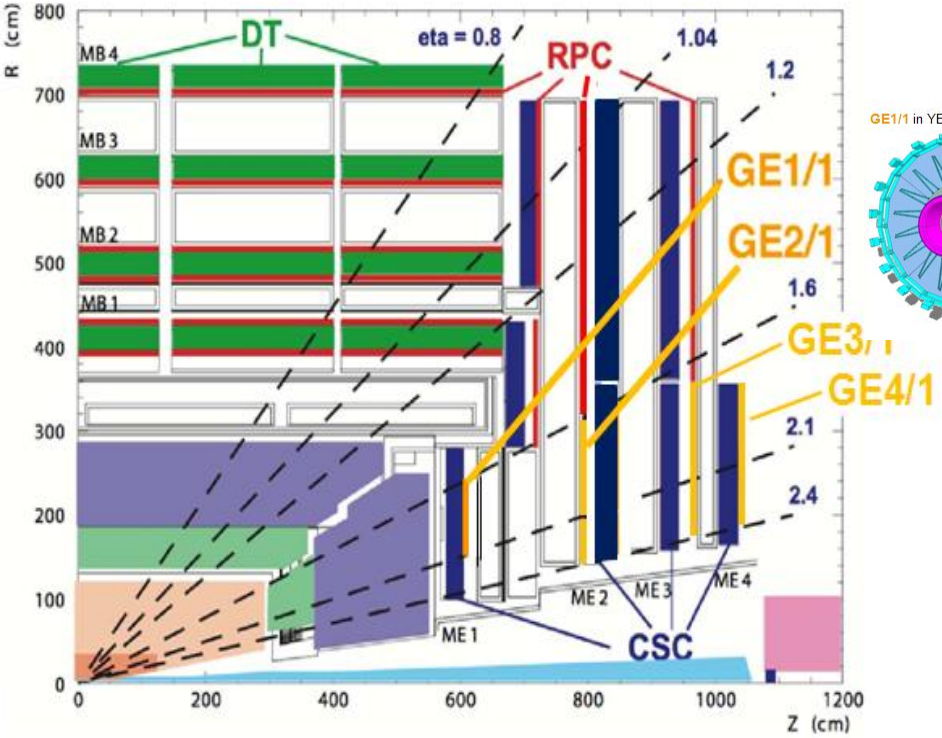
Outline

- Motivation
- Gas Electron Multiplier (GEM) detectors
- Construction of GE1/1 prototype III GEM detector
- Beam test setup at FNAL
- Different scenarios used for test
- Results:
  - Uniformity , efficiency and resolution
- Conclusion
- Future plans

Motivation

- Long shutdown Phase II of CMS experiment at CERN LHC involves forward muon endcap region upgrade

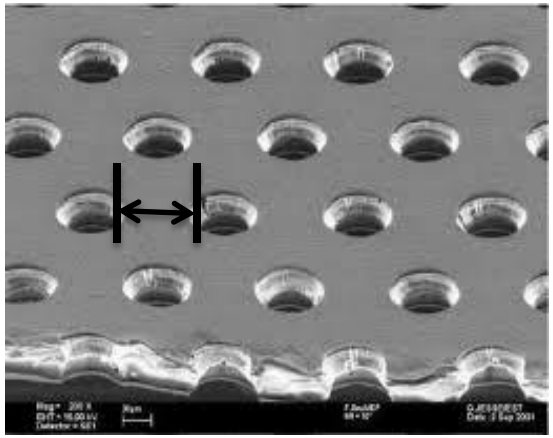


Source: Topic-of-the-Week Seminars, LHC Physics Center at Fermilab - Marcus Hohlmann

- Technology will be used is Gas Electron Multiplier (GEM)
  - In the form for 1m long GEM detectors
  - Provides fast triggering
  - Precise tracking
  - It will help to improve overall muon trigger
- Florida Tech is planning to make huge contribution in this upgrade project by producing 40 GEM detectors(app. 25% of the detectors)

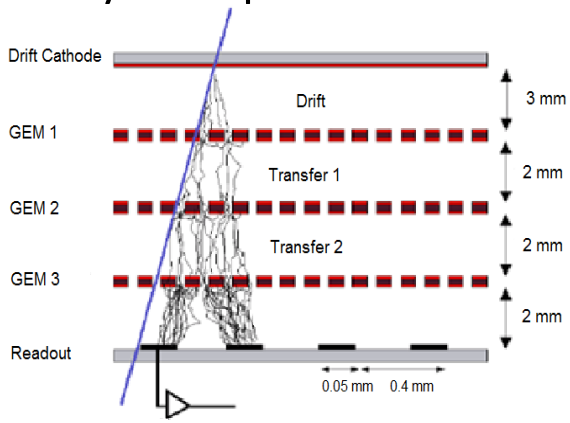
Gas Electron Multiplier (GEM) Detector

- It is micro pattern gas detector(MPGD)
- Consists of GEM foil that is made up of kapton foil coated with copper on both sides and has array of holes which are equidistant usually 140µm
- High voltage is applied across foils, which creates avalanche of electrons through holes
- Provides good efficiency and spatial resolution
- Provide a gain of 10^4 with gas mixture of Ar/CO_2



Source: http://gdd.web.cern.ch/GDD/

Triple GEM configuration: Most popular and reliable



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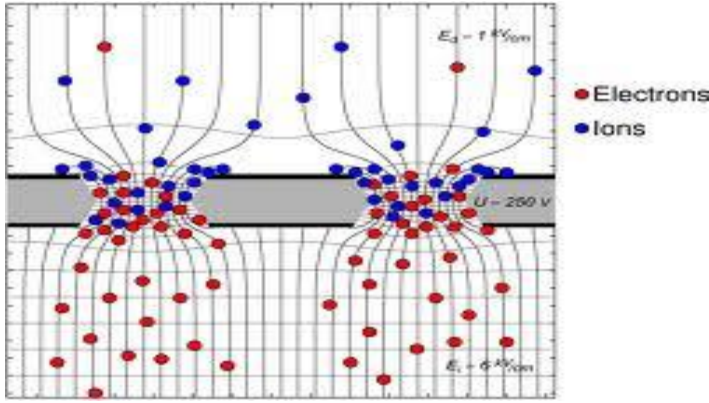
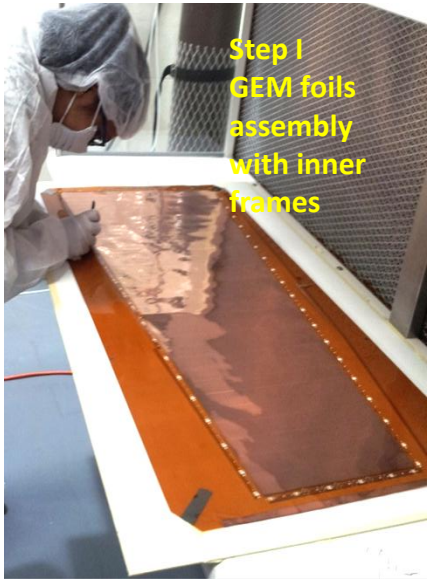
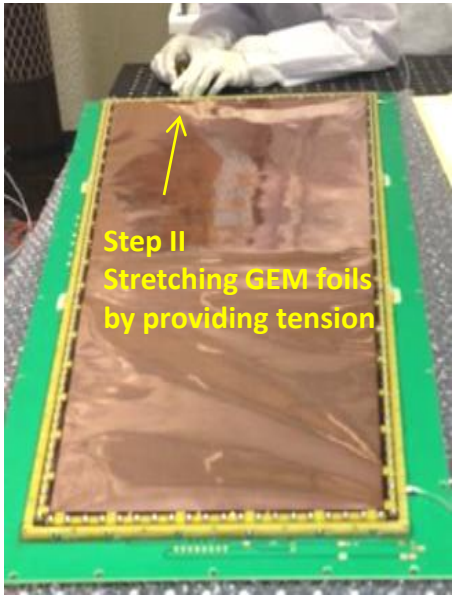


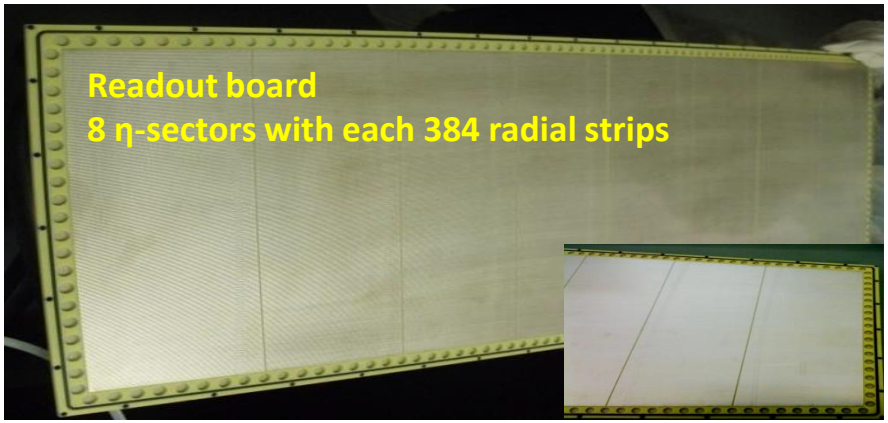
Source: http://www.flc.desy.de/tpc/basicsgem.php

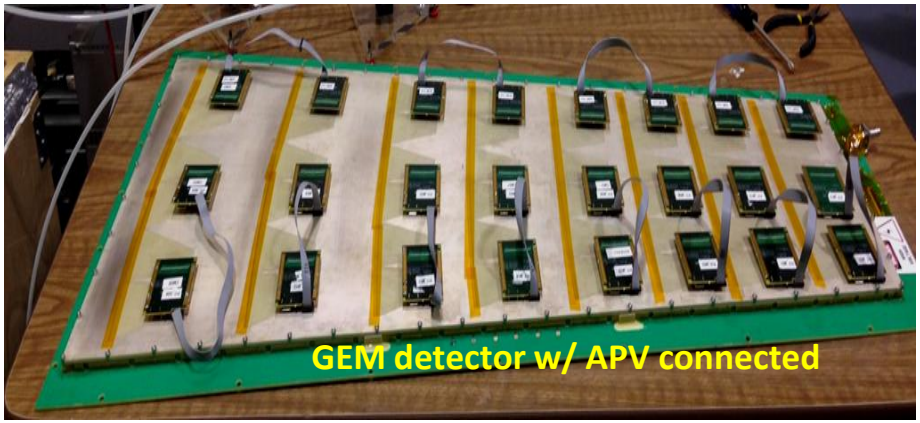
Construction of GE1/1 Prototype III

Total assembly time 3 Hrs 40 mins with 2 people

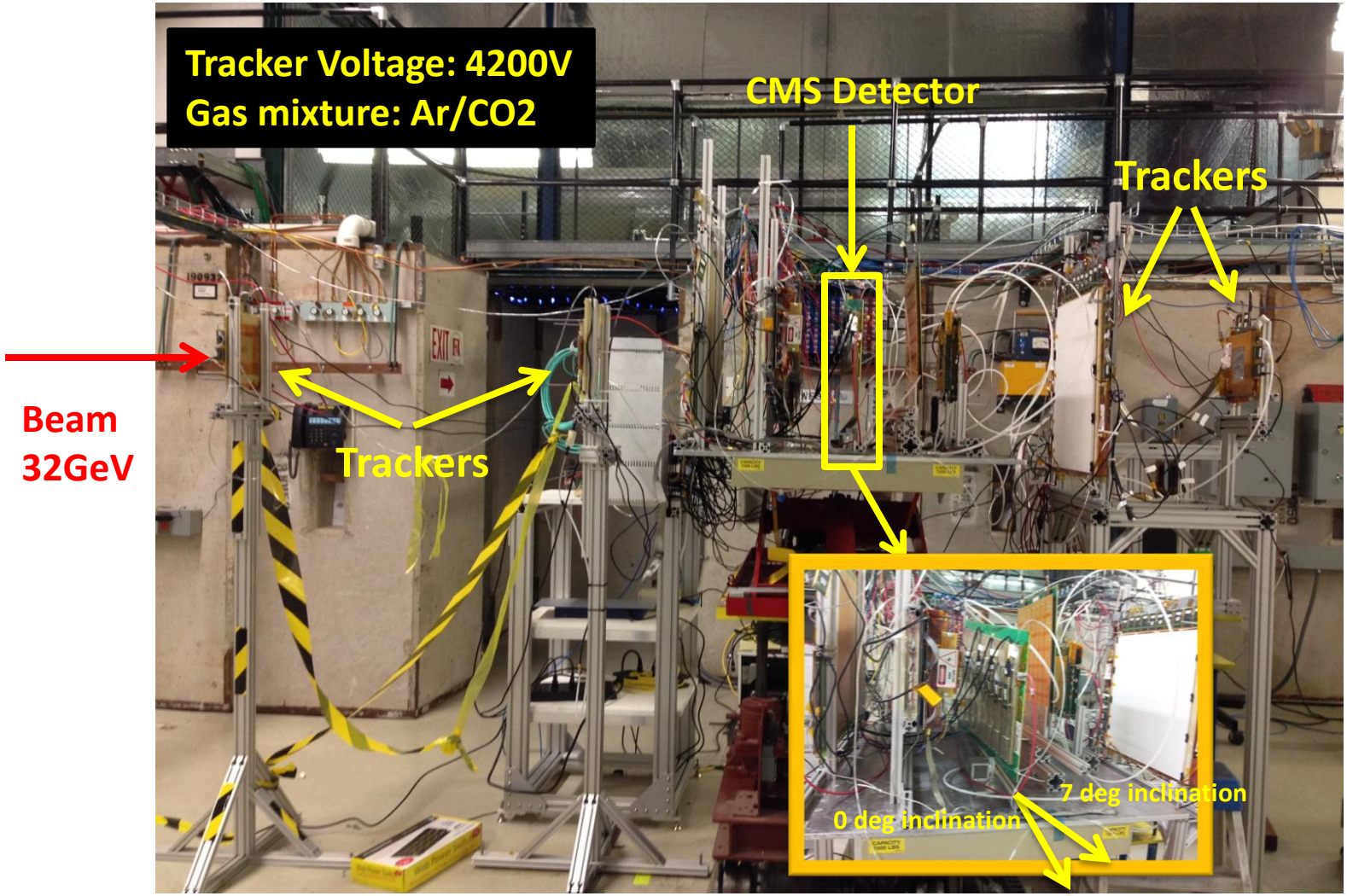








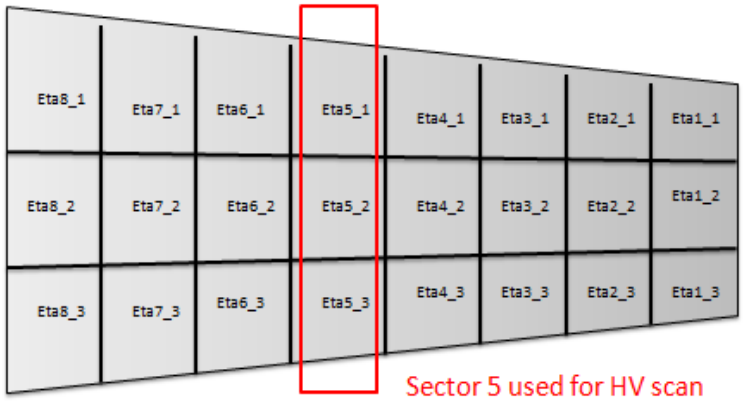
FNAL Test Beam Setup



Different Scenarios used for test

HV scan

- Operating plateau voltage
- Efficiency at different voltages

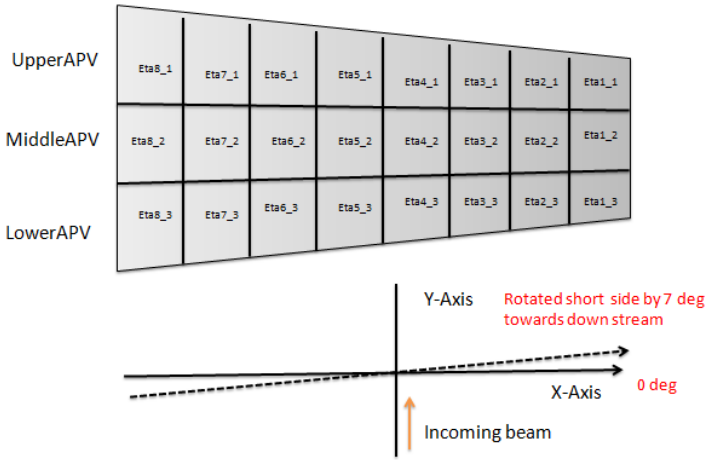


- Range of voltages: 2900V-3300V

Position scan

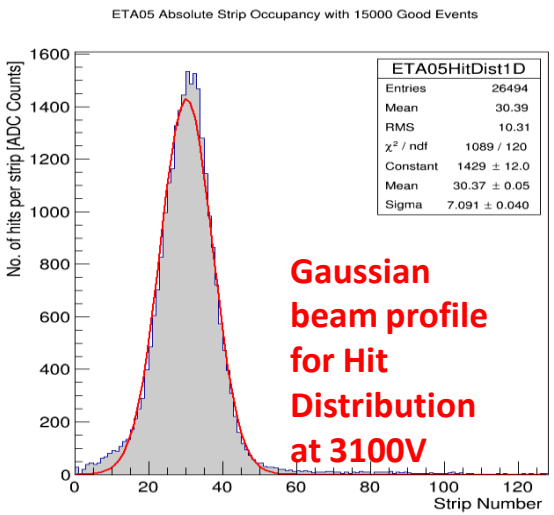
- Overall performance of the detector

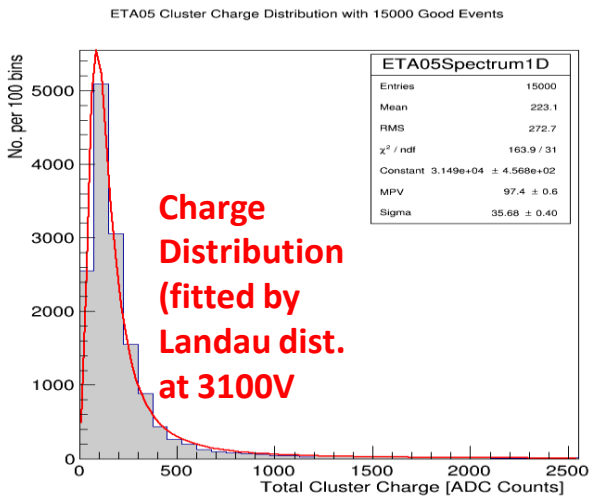
  Uniformity, Cluster Size, Efficiency

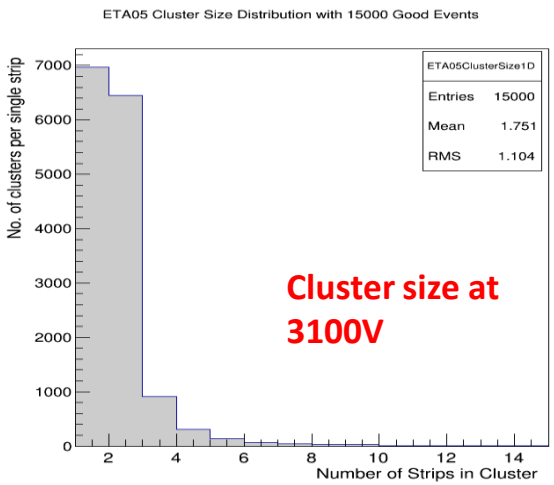


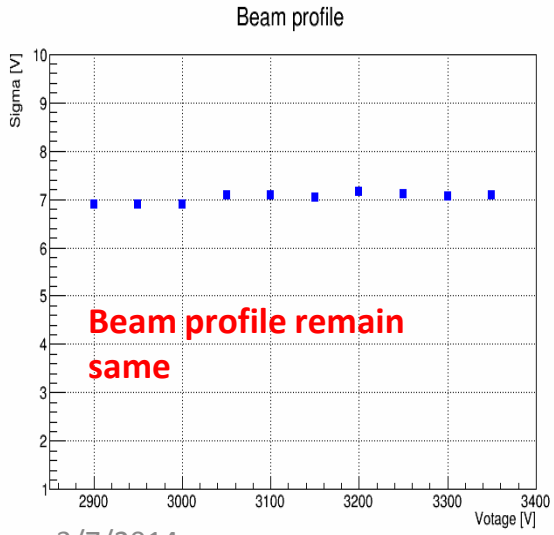
- Voltages: 3250V

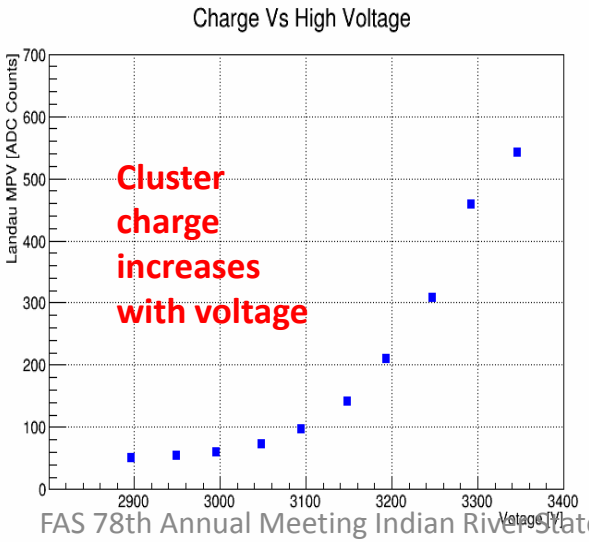
Results: HV scan

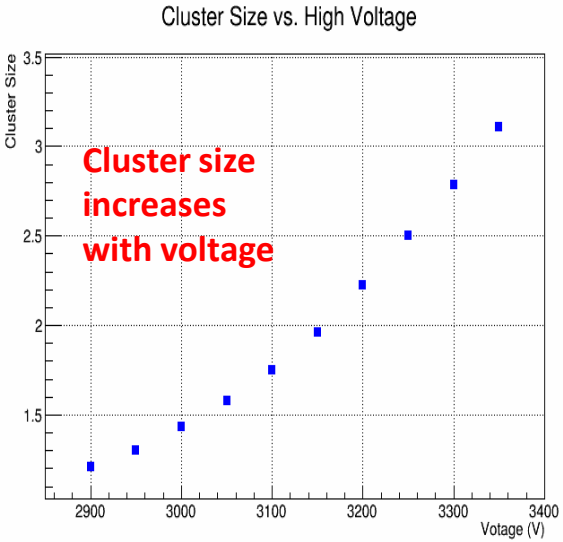












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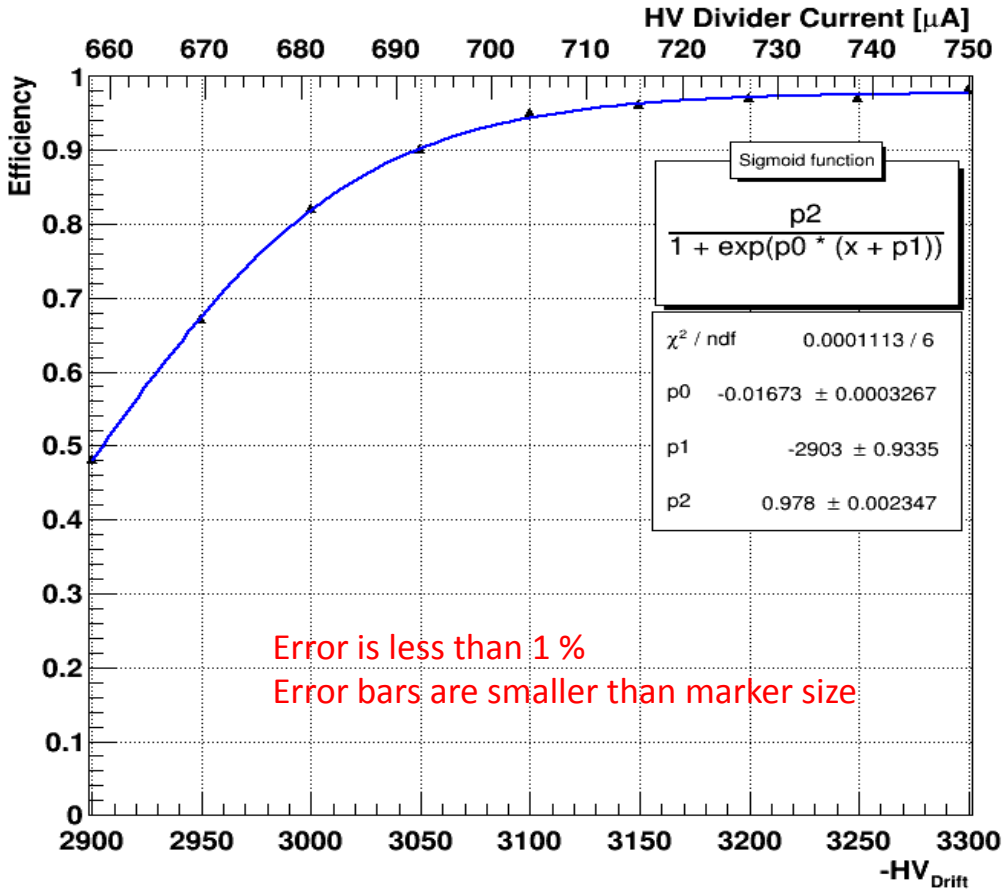
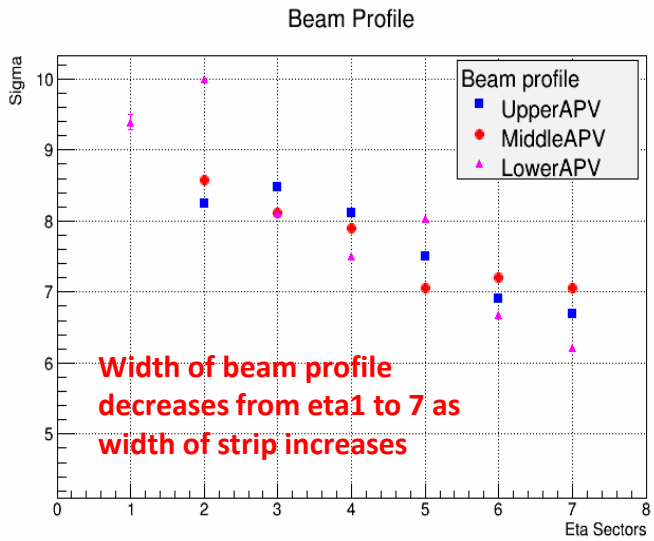
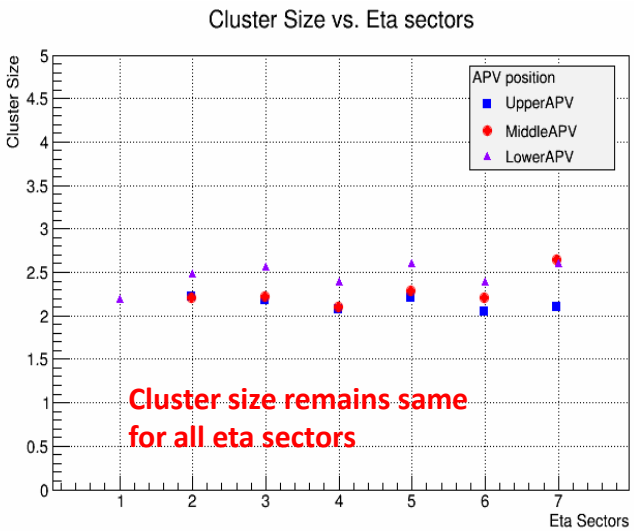
Results: HV Scan

- Operating efficiency obtained using sigmoid fit is 97.8%

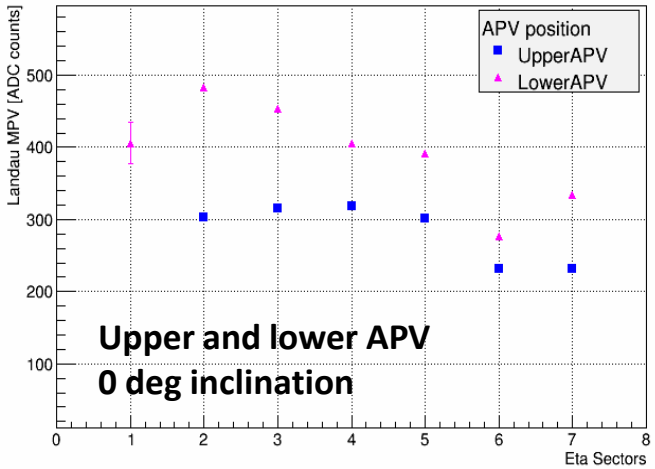


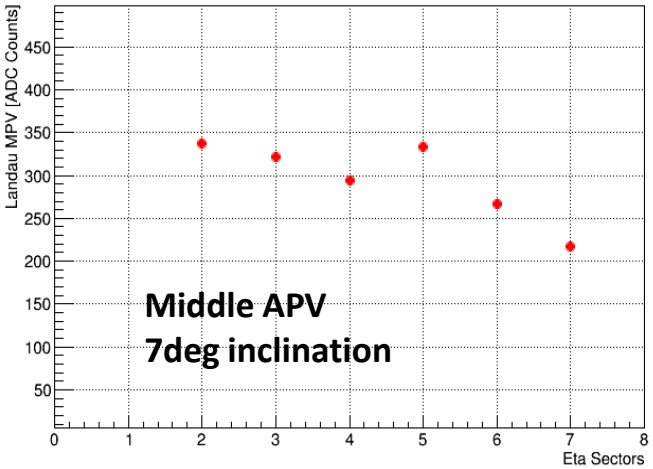
Results: Position Scan





Charge uniformity looks consistent for all three APV positions





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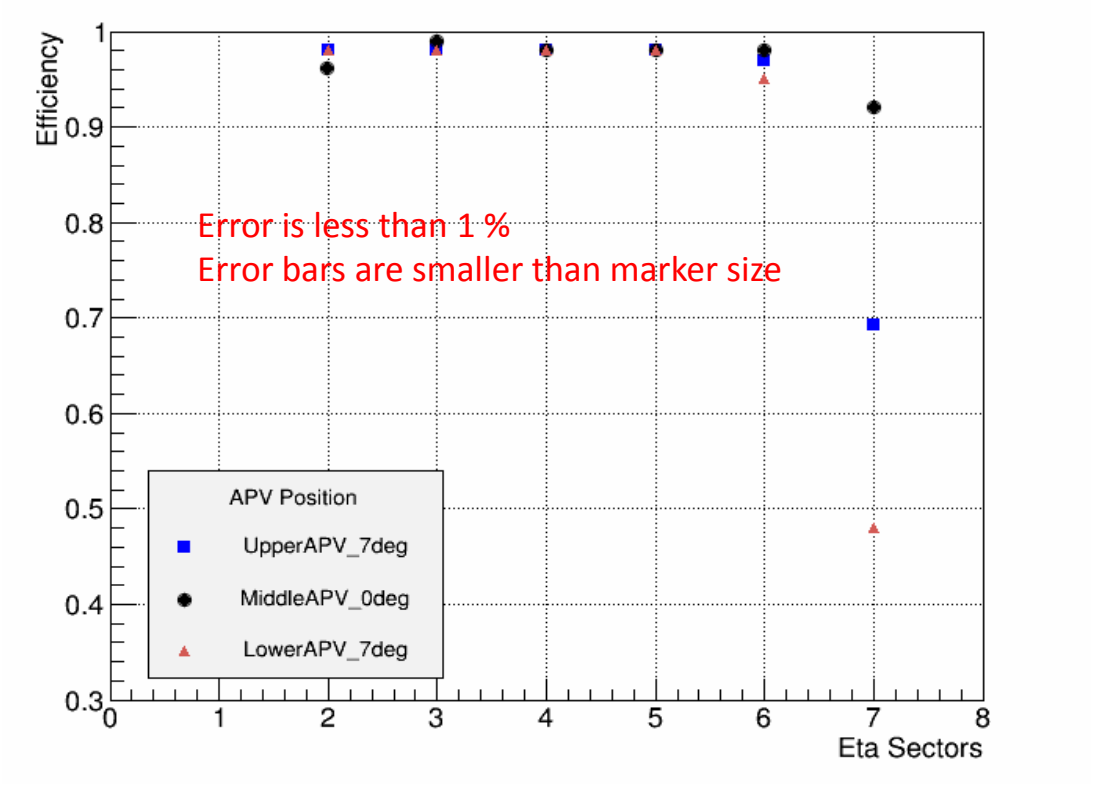
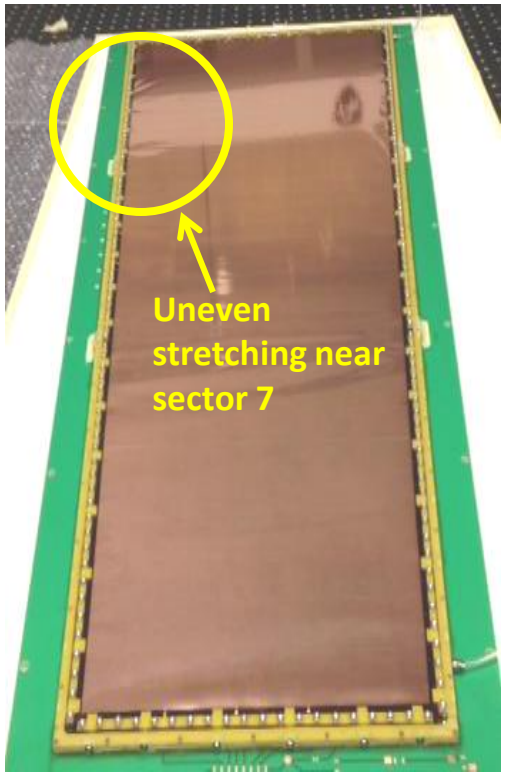
Results: Position Scan

- Overall efficiency of the detector for all sectors is consistent with operating efficiency we found out in HV scan which approximately 98%





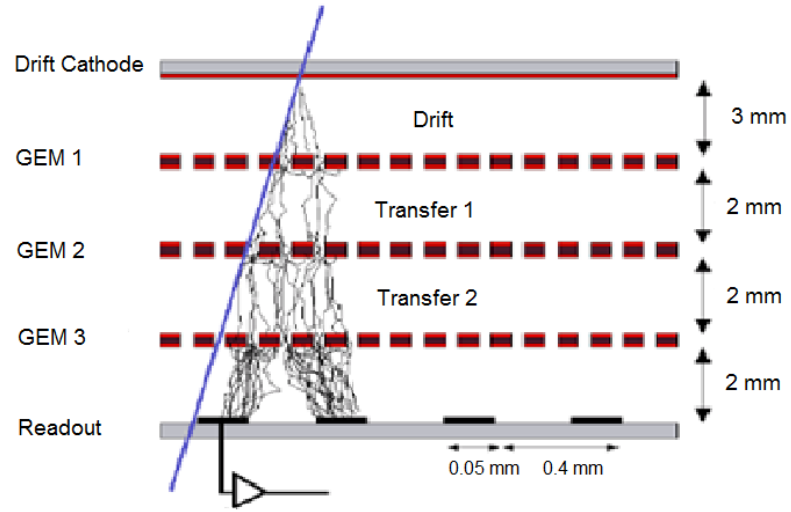
Conclusion

- Detection efficiency for GE1/1 prototype detector III form HV scan is 97.8% which is consistent with overall efficiency
- Charge uniformity is consistent for all three APV position as well as for different angle inclination.
- Future Work
- Find the spatial resolution of the detector and study the tracking information

Thank you!

Triple GEM detector

- Most popular and reliable configuration is Triple GEM configuration
- Consists of stack of 3 GEM foils between the drift and readout
- Several experiments use Ar/CO_2 gas mixture in 70:30
- Advantages of using this gas
  - Non flammable
  - Chemically stable
  - Fast electron drift velocity
  - Provides high gain



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Backup

- Studied the hit distribution, charge distribution and cluster size for HV scan and Position scan
- Evaluates the efficiency from cluster multiplicity(CM)

$$efficiency = \frac{N1}{(N - N2)}$$

Where, N1: No. of events with CM≥1 for given sector

N: Total no. of events

N2: sum of the no. of events with CM≥1 for other sectors