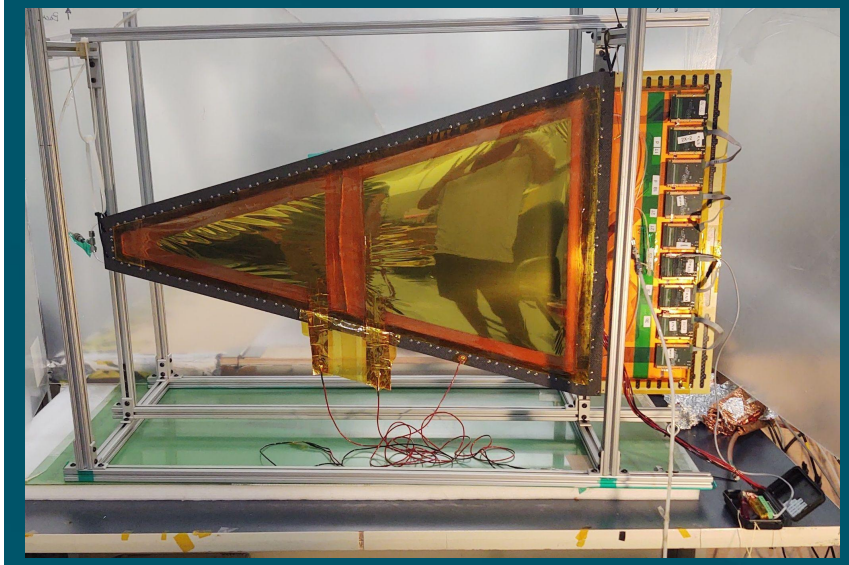

Modified GEM before testing at FermiLab

Construction and Performance of a Large Area GEM Detector with Low Mass and Zigzag-strip Readout

Merrick Lavinsky, Jared Hadley, and Marcus Hohlmann
Florida Institute of Technology

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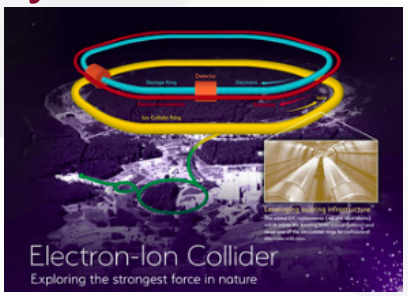
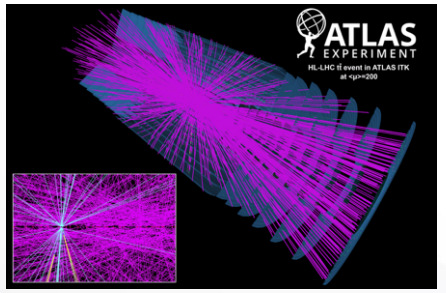
Motivation To Modify GEM Detectors

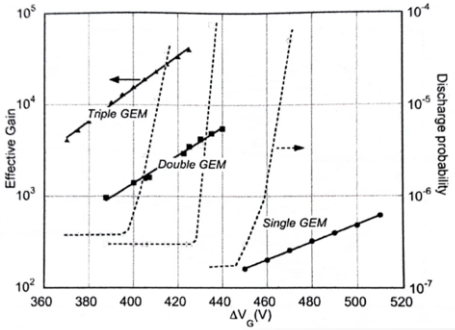
New Collider Designs
(ePIC, HL-LHC, etc..)



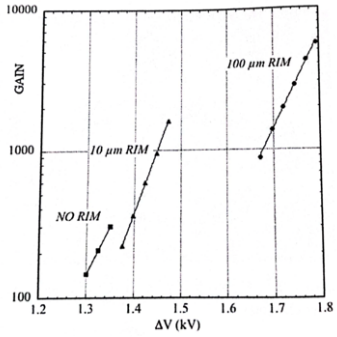
Poster for Future EIC Detector [7]



Simulated High-Luminosity Event in ATLAS [8]



Change in Gain with number of GEM foils



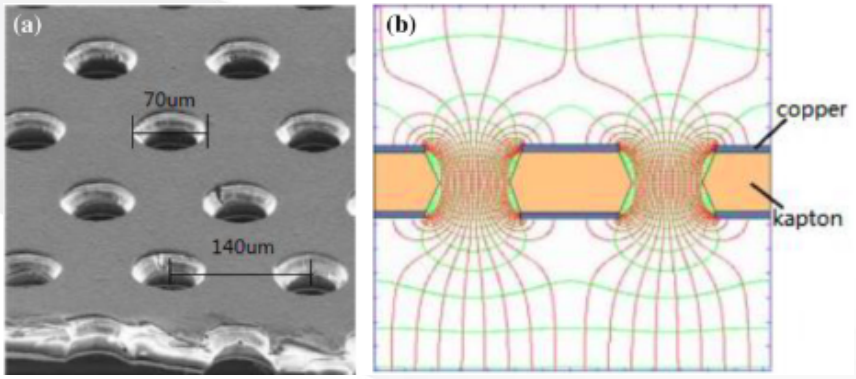
Change in Gain with Insulating rims added to holes [6]

More Effective Features

Less Expensive Manufacturing

How GEM Detectors Work

Gas Electron Multiplier foils amplify the signal within gaseous radiation detectors



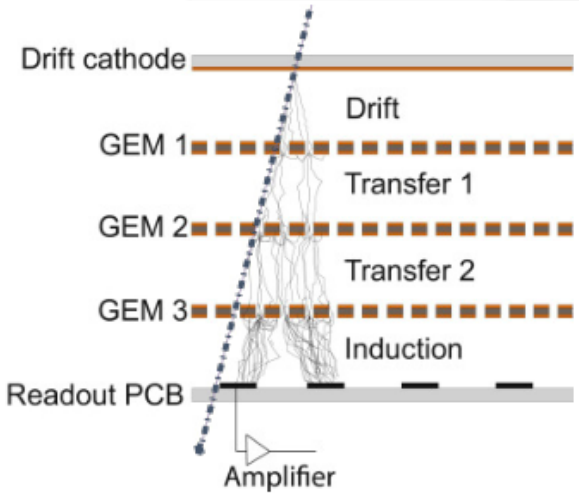
Left: Close up of GEM foil [5]. Right: Electric field pinching in GEM foil pores [5]

Radiation particle enters Detector

Ionizes gas, releasing electrons

Electrons forced towards Readout and through GEM foils via electric fields

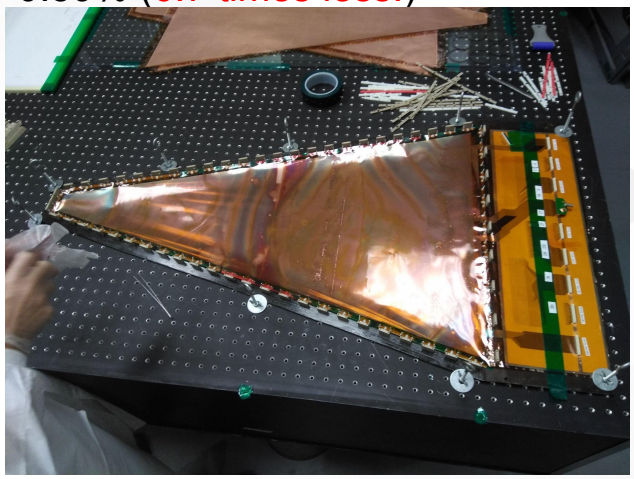
Readout signal induced on strips by electron showers



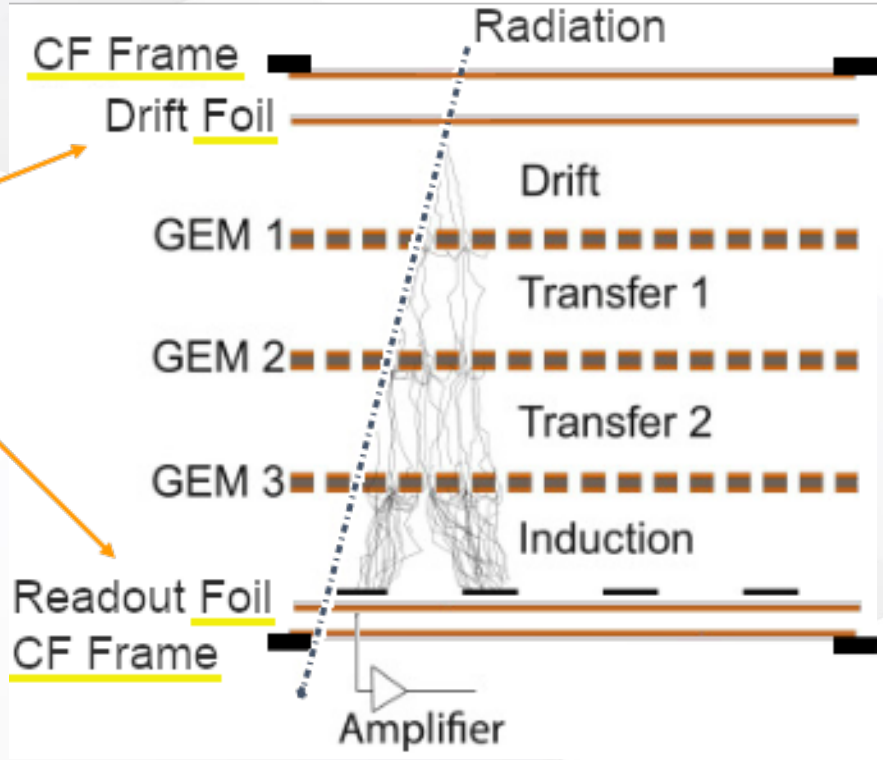
Left: Side view of radiation particle interacting with a GEM detector [4]

What Advantages Does Our Design Have?

- Ideal tracking detectors should be transparent to radiation
- Drift and Readout PCB's replaced with modified GEM foils
  - Radiation length reduced from 4% to 0.59% (6.7 times less!)



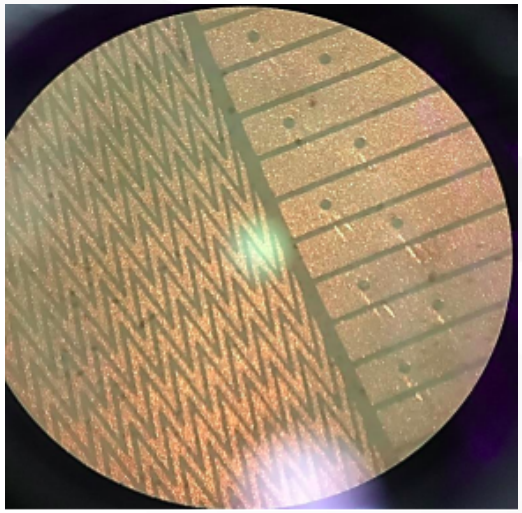
Modified GEM Readout Foil



GEM stack diagram with modified parts underlined in yellow

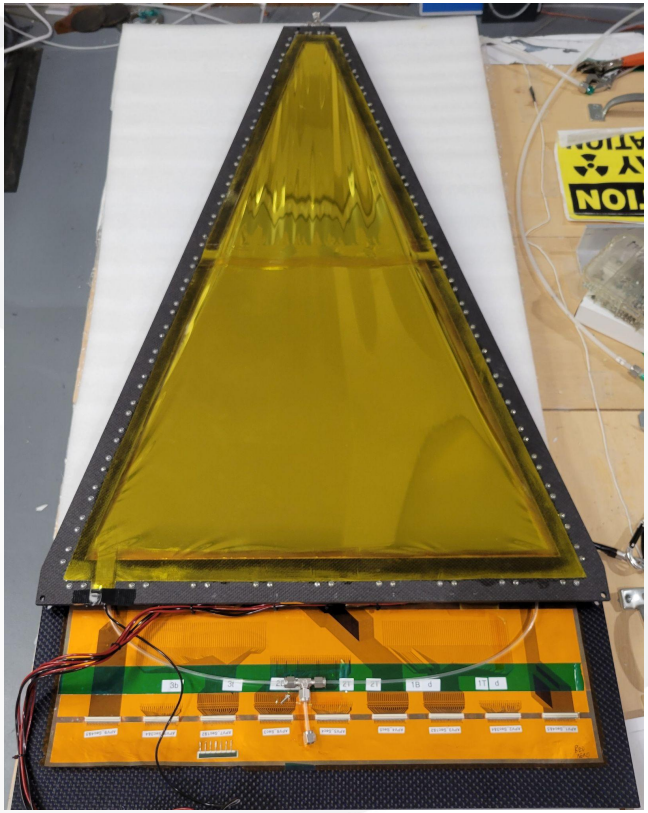
What Advantages Does Our Design Have?

- The spatial resolution of a tracker can be optimized with strip geometry
- This readout uses ZigZag readout strips
  - Equivalent spatial resolution to normal straight strips
  - 66% less channels for the readout!



Left: Microscopic view of the zigzag strips of sector 2 (left) next to the straight strips in sector 1 (right) [3]

Right: Modified GEM stack only needs 9 readout channels



More About External Windows

GEM foils need a working gas to operate
70%Ar:30%CO2

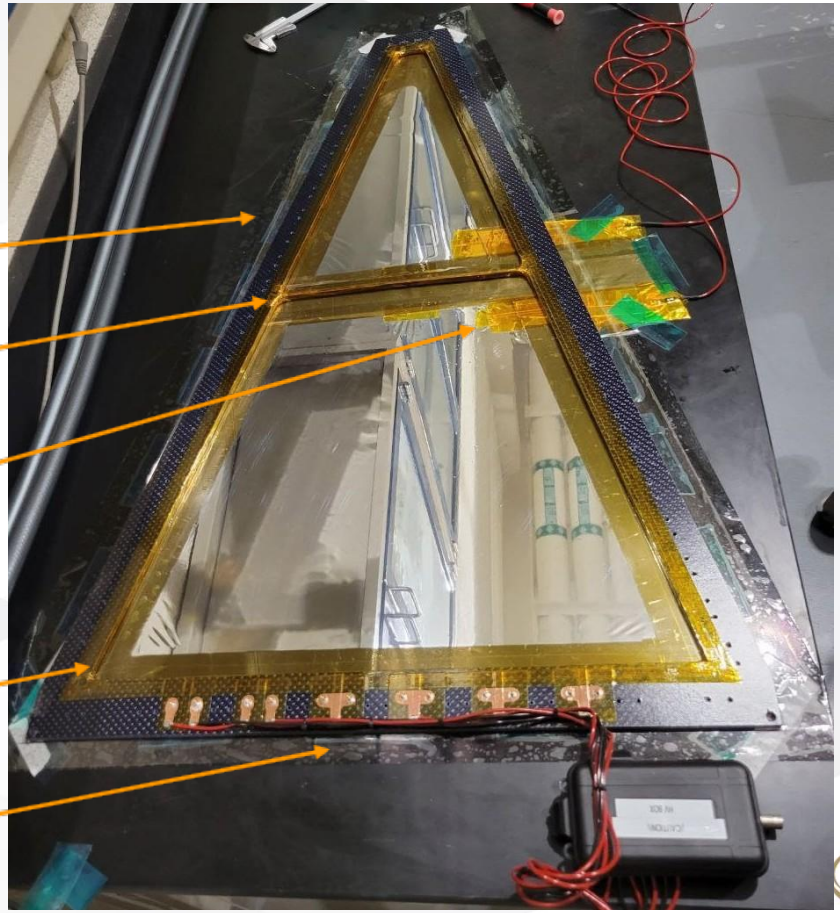
Carbon fiber (CF) frame with Al-Kapton windows

Narrow rib in frame to fortify window and frame

Voltage applied to Al side of Drift window to counteract Electrostatic force of Drift foil

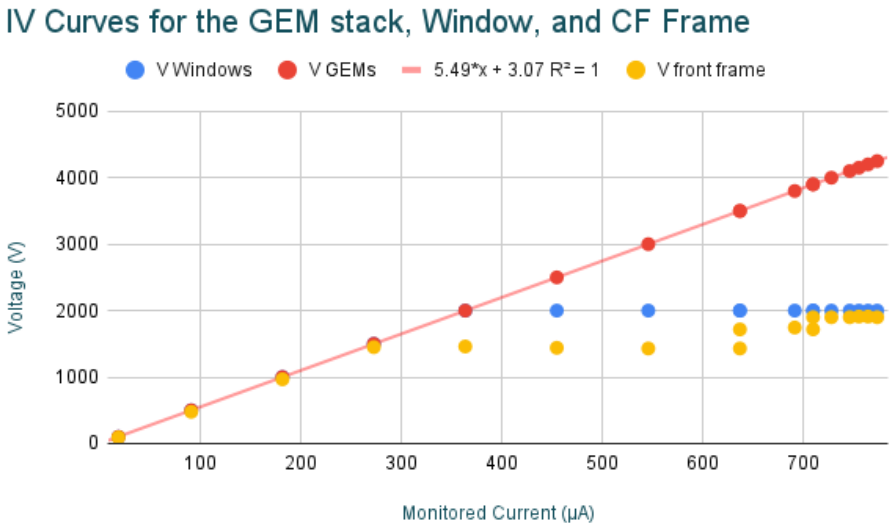
Top frame window edges were Vinegar wet-sanded to insulate from CF Frame

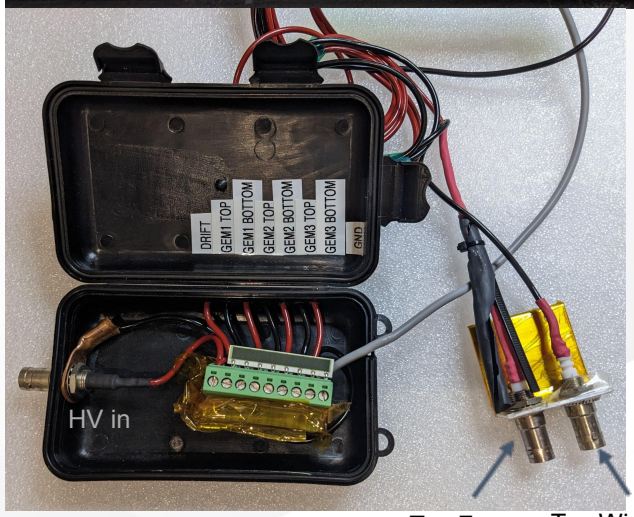
Electrical Connections to GEM foils



In Home Quality Control Testing

- Power is distributed to GEM foils via HV Divider
  - Ensure the HV divider is behaving in a linear, Ohmic manner
- Determine voltage limits of CF Frame
  - CF Frame becomes powered at 2700 V





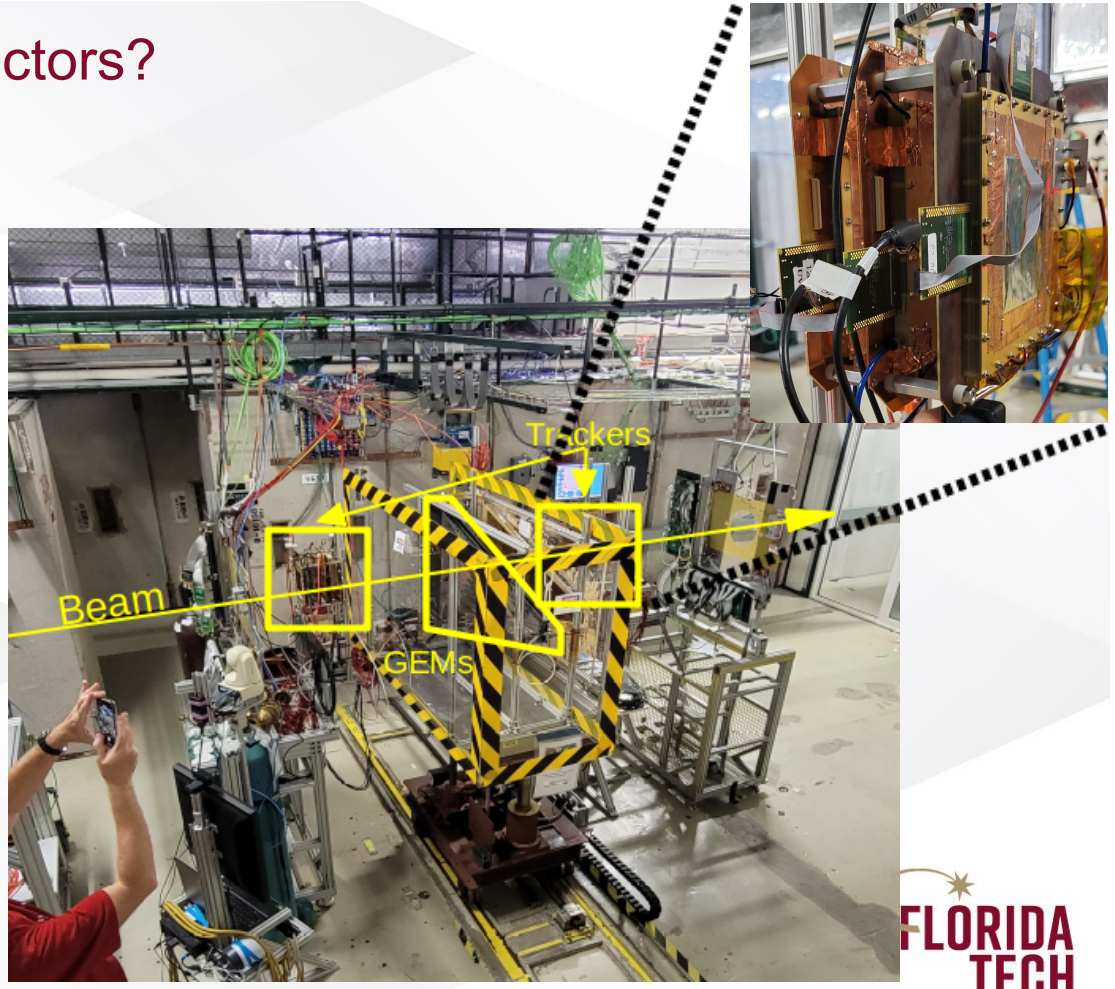
Top: HV Divider on M5 GEM Detector

Left: HV divider with power to top window and top frame for Modified GEM

How Do We Test Particle Detectors?

- FermiLab - America's premier particle accelerator
- Test Beam Facility (FTBF)
  - 120 GeV Protons (1s pulse / Minute)
- Install detector in beam, between 2 sets of calibrated GEM trackers

FermiLab National Laboratory



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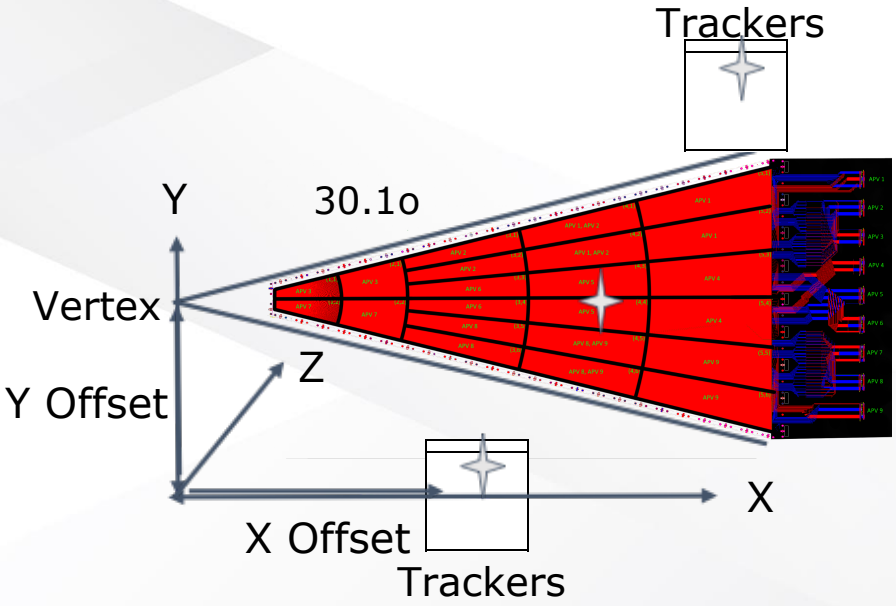
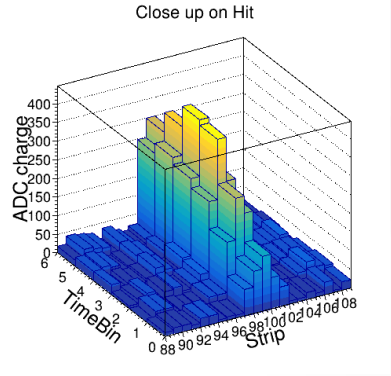
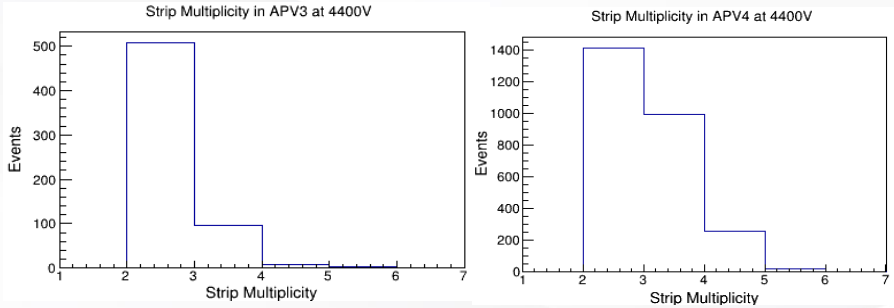
How We Analyze the Data

- Decode signal from strips in GEMs and Trackers
- Determine Strip Multiplicity and Gain
- Fit a line through coincidence Hits (Reconstruction)
  - Z positions were measured at FTBF
- Align Trackers and GEMs (X,Y and Rotational)
- Determine minimized residuals for GEM
  - Calculate Angular Resolution





Example Hit with Strip Multiplicity of 4

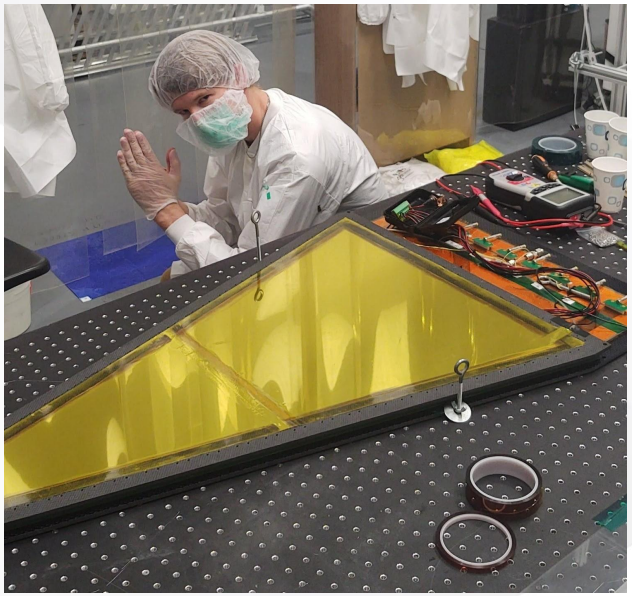


Comparison of Strip Multiplicities from Straight and ZigZag strips

Conclusions

Designed, Assembled, and Successfully received data from Modified GEM detector

Working to determine the Angular Resolution of detector design



Jared Kneeling beside Modified GEM after first successful complete assembly

Questions?

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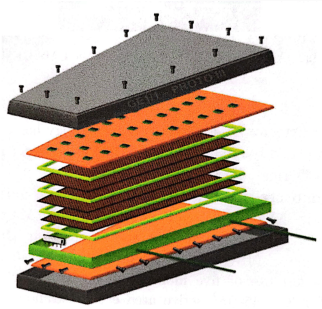
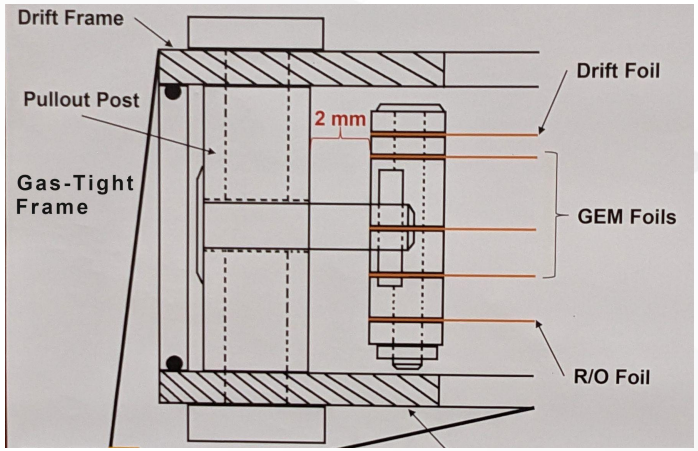
8. https://atlas.cern/updates/news/scientific-potential-high-luminosity-lhc

Backup Slides

How this GEM Detector was Assembled

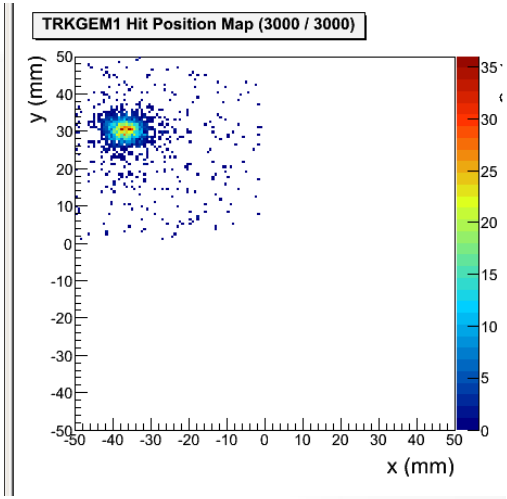




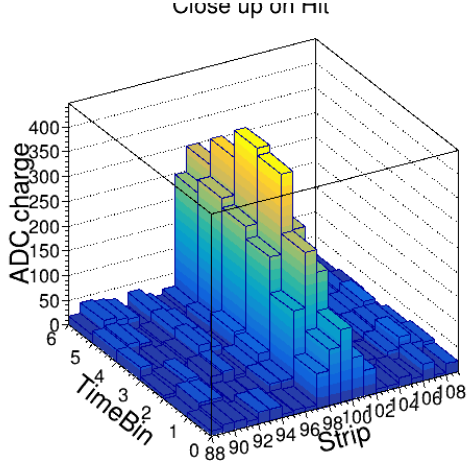
Exploded View [6] and Side Profile [] of assembled GEM stack

- Foils tested for Shorts
- GEM stack is assembled:
  - Foil placed on stack and stretched with tape
  - Spacer added
  - Foil tested for shorts
  - Repeat for all foils
- Tighten stack screws and cut tape
- GEM stack placed in bottom frame and connected to pullouts for last stretch
  - Planarity is Important for Uniform Gain
- Electrically test and add gas tight frame to seal top and bottom frames
- Screw on top frame and assembly is finished!

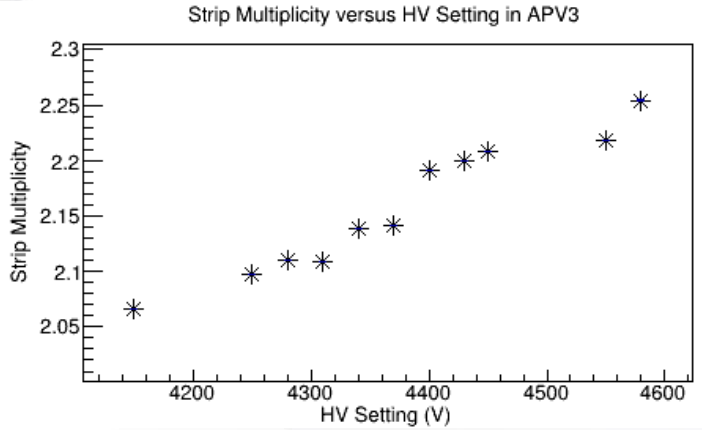
Data from FTBF!



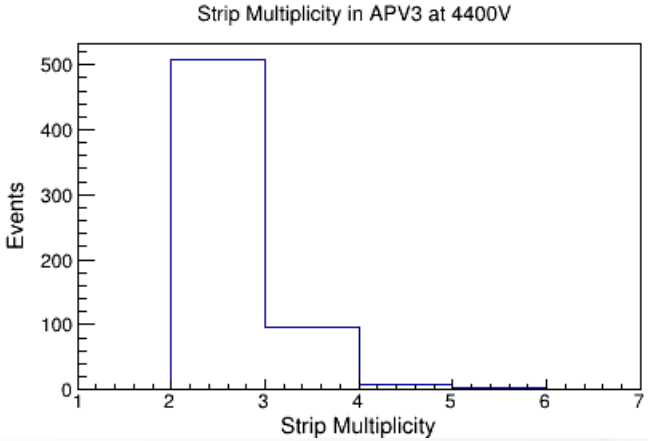
Hitmap of beam in Tracker 1

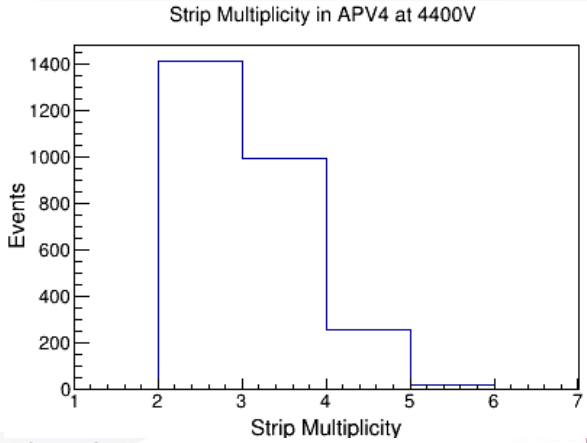


Example Hit with Strip Multiplicity of 4



Strip Multiplicity over a range of HV settings in APV3





Comparison of Strip Multiplicities from Straight and ZigZag strips