GEM Activities at USTC

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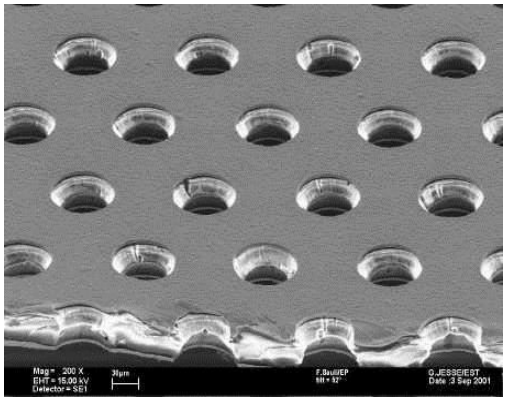
Outline

- Introduction: GEM detectors
- Self-stretching GEM assembly
  - NS2 technique
- 30cm*30cm GEM R&D
- Large-area GEM stretching studies
- 50cm*100cm GEM design and prototyping
  - Towards SoLID GEM
- GEM readout electronics
- Summary and plans

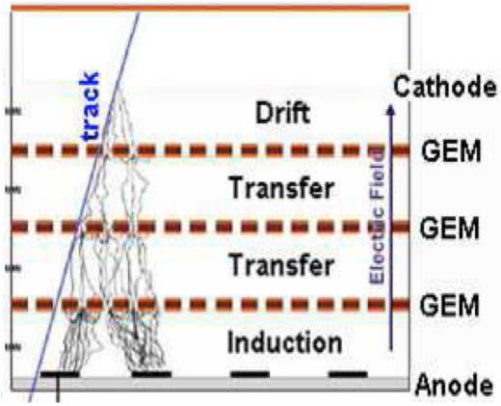
GEM Detectors

- Gas Electron Multiplier (GEM) detectors
  - electrons released in primary ionization are multiplied through small holes on GEM foils and finally collected on the anode plane.
- A low-mass and cost-effective solution to high-precision and large-area tracking at high-rate large-scale experiments such as SoLID.

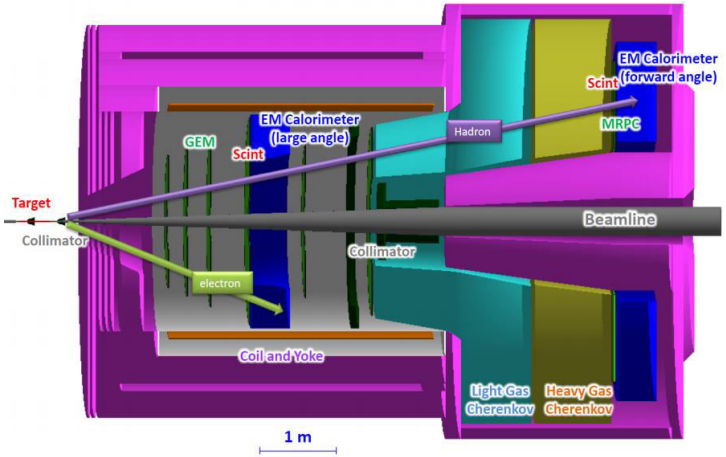
Holes on a GEM foil



GEM operation principle

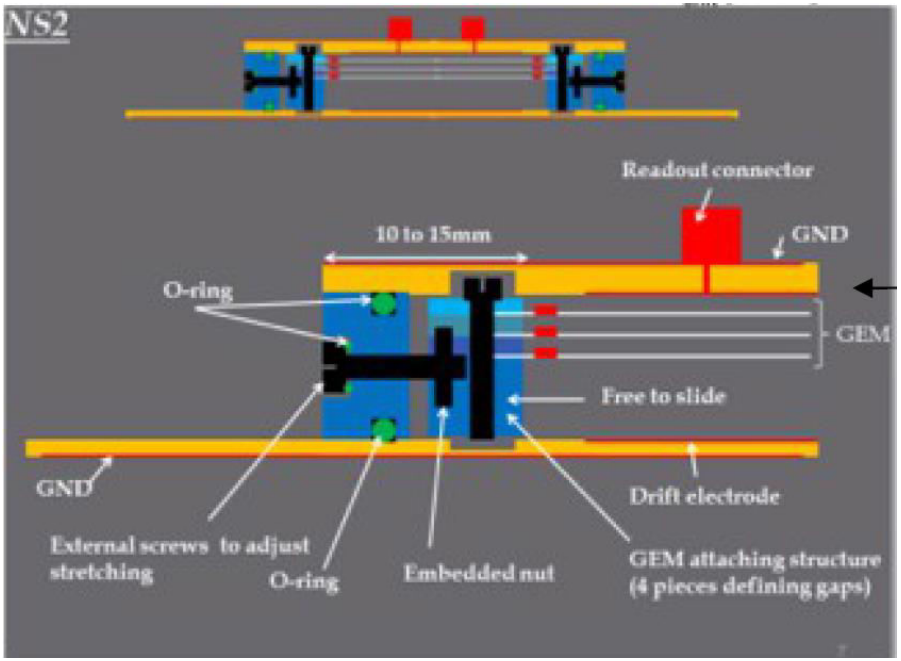


GEM tracker at SoLID



NS2 Technique

- A new GEM assembly method developed at CERN for the CMS GEM project.
- Main focus of large-size GEM detector R&D at USTC

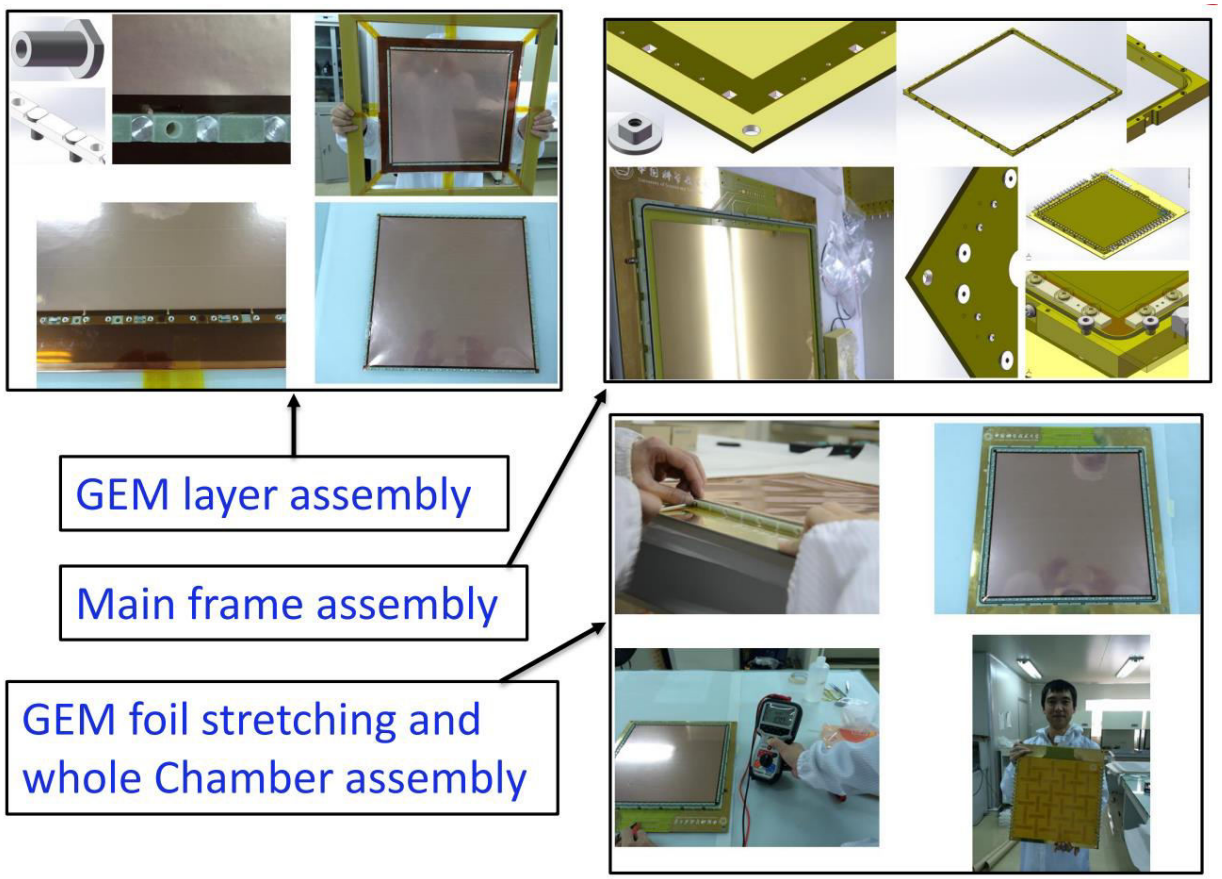


- **No gluing, assembly easy and fast, highly efficient and labor saving**
- **No inner spacers, no dead areas, smooth gas flow**
- **Complete re-opening possible, full detector re-cleaning possible, highly replaceable and repairable, reduced cost**

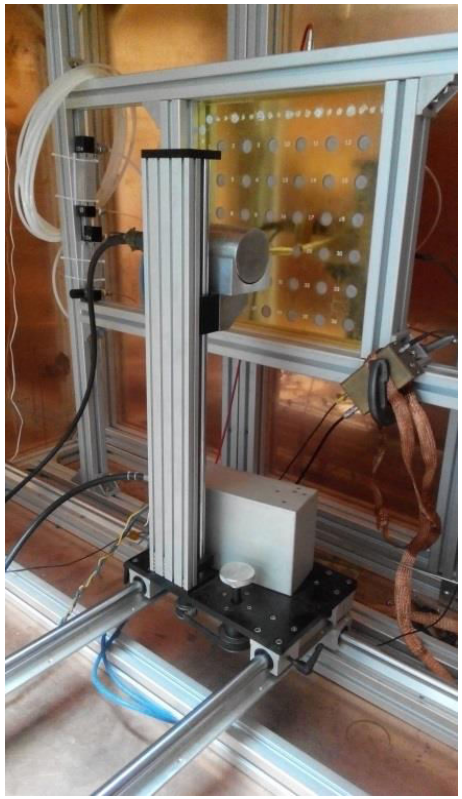
30cm *30cm GEM R&D

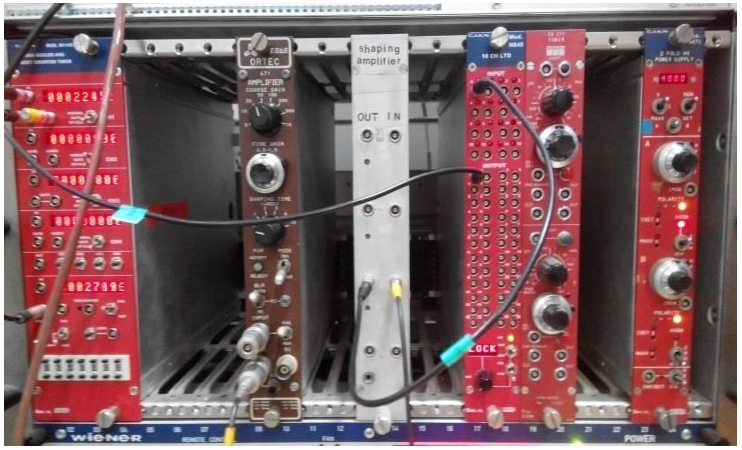
Assembly

- Intensive R&D on NS2 technique through 30cm*30cm GEM prototyping. Modifications and improvements to NS2.

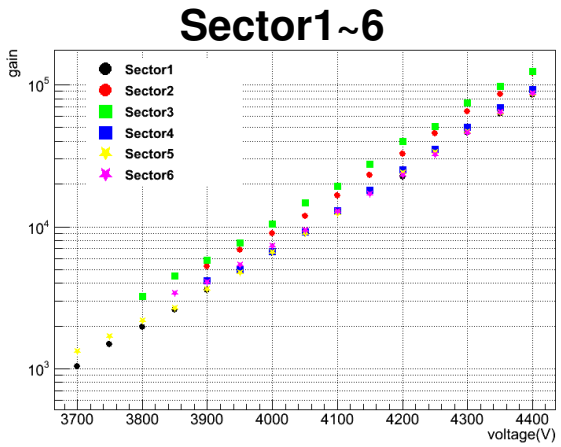


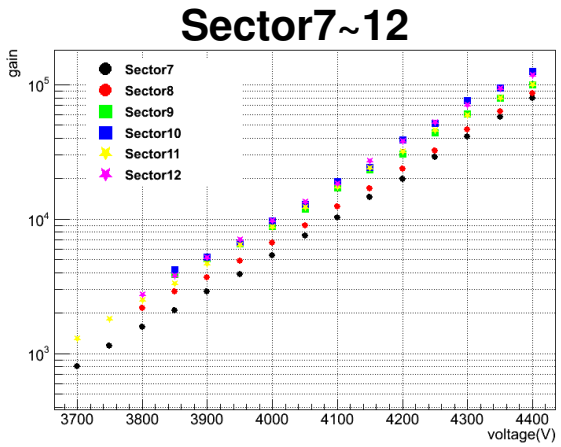
Testing

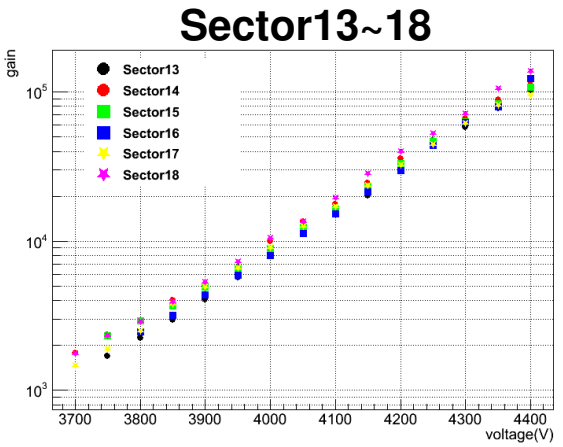


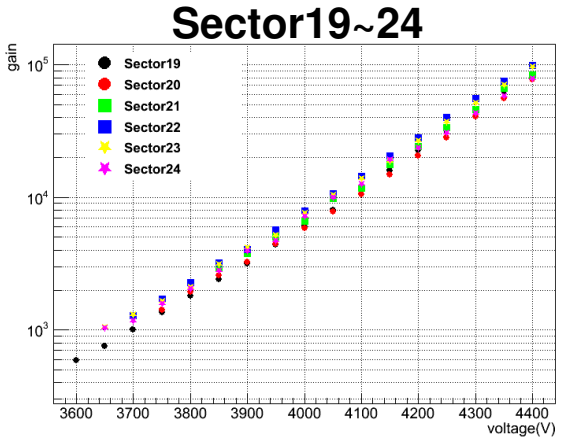


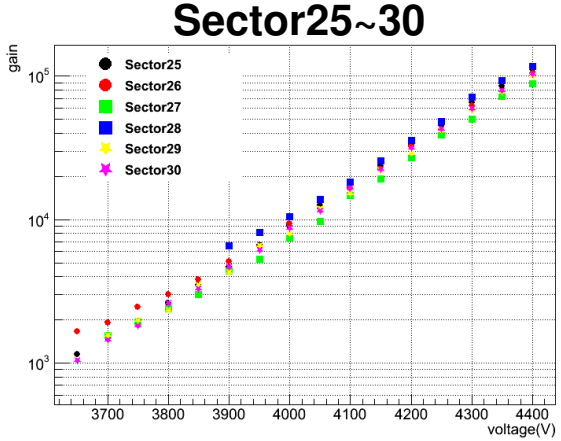
Gain vs. HV

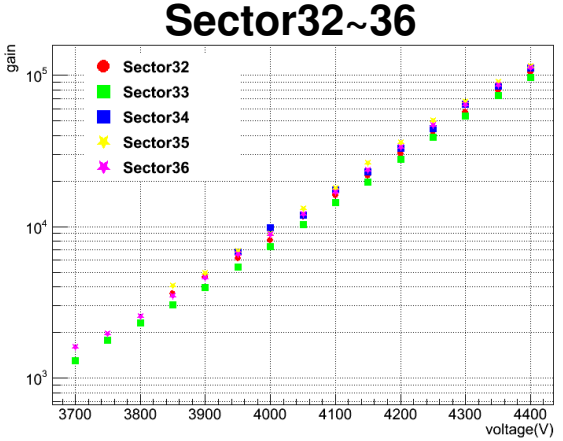








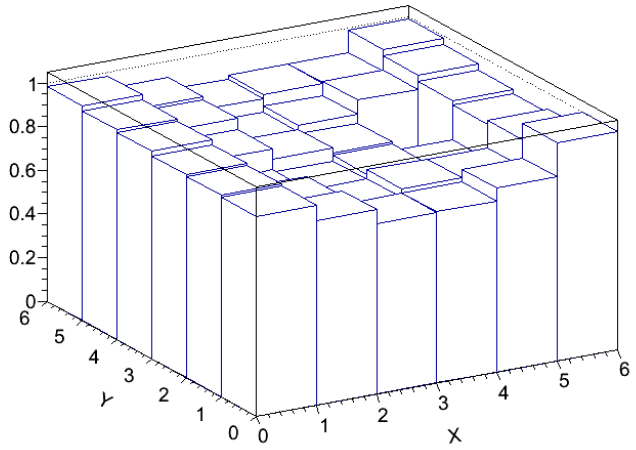




- Clear exponential dependence of gain on high voltage
- Can reach a gain of 10^4 at 4000V

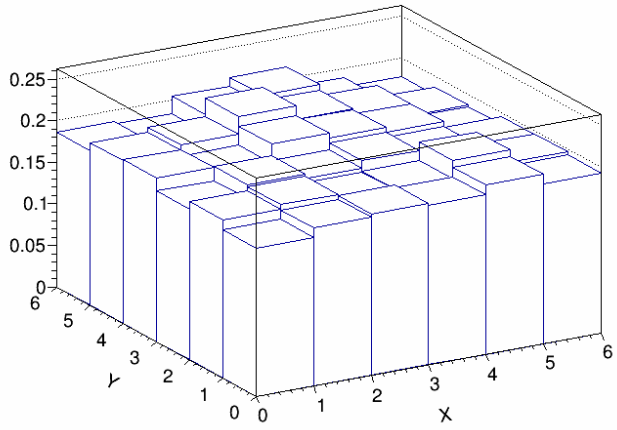
Response Uniformity

Gain at different sectors



Uniformity ~ 11%

Energy resolution at different sectors



Uniformity ~ 5.3%

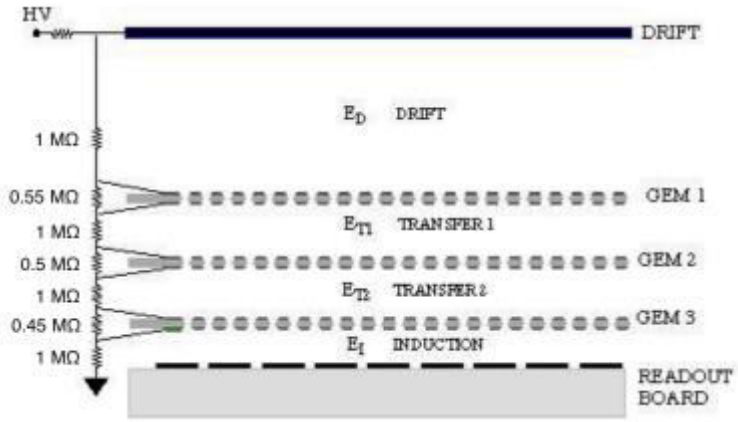
Good uniformity observed

Note: uniformity = RMS/Mean

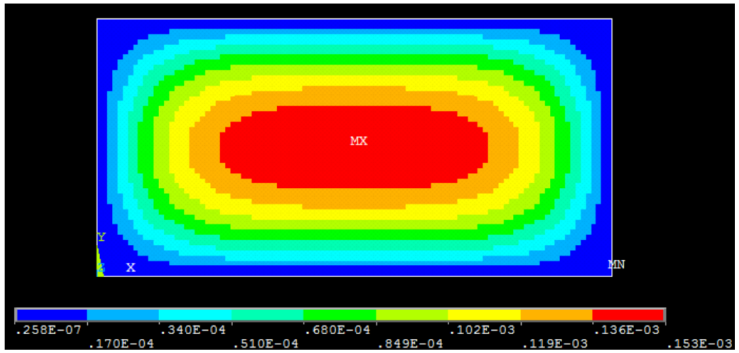
GEM Stretching Simulation

- Simulated displacement of stretched triple GEM foils (0.5m*1m) with HV applied.

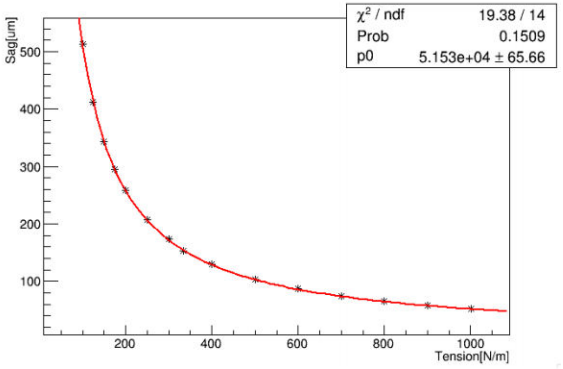
GEM model in simulation



GEM displacement due to sum of electric force and gravity



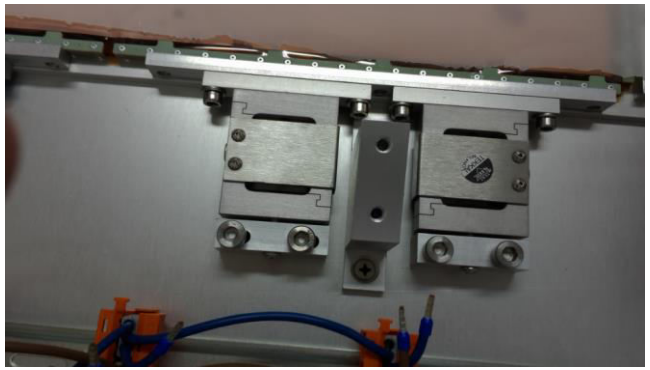
GEM displacement vs. tension applied



- Maximum GEM displacement ~ 150um when tensioned at ~0.3kg/cm per GEM
- Tensioning more doesn't help too much in further reducing displacement.

GEM Stretching Measurement

Stretching testing platform



GEM (0.5m*1m) deformation measurement

- Tensions applied to GEM: ~0.48kg/cm @ long side, ~0.39kg/cm @ short side
- GEM extension: ~1.3mm @ long side, ~0.7mm @ short side

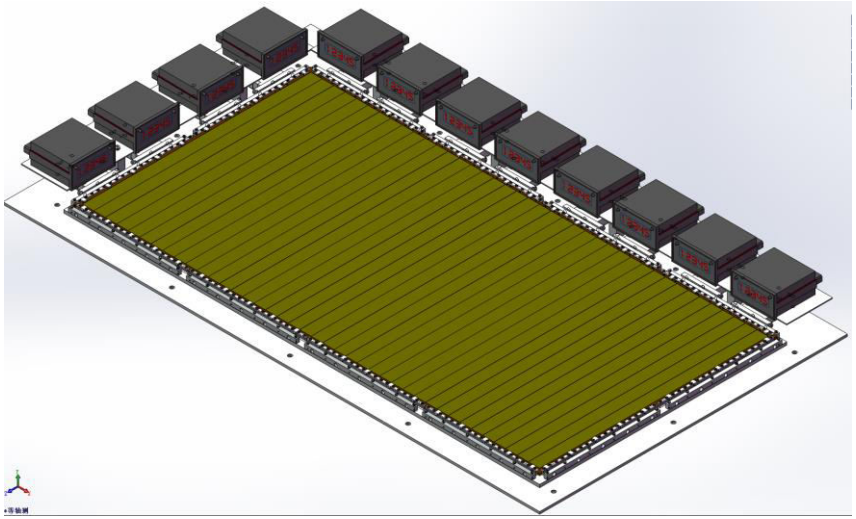
Valuable input for GEM tension determination and choice

Towards SoLID GEM:
50cm *100cm GEM

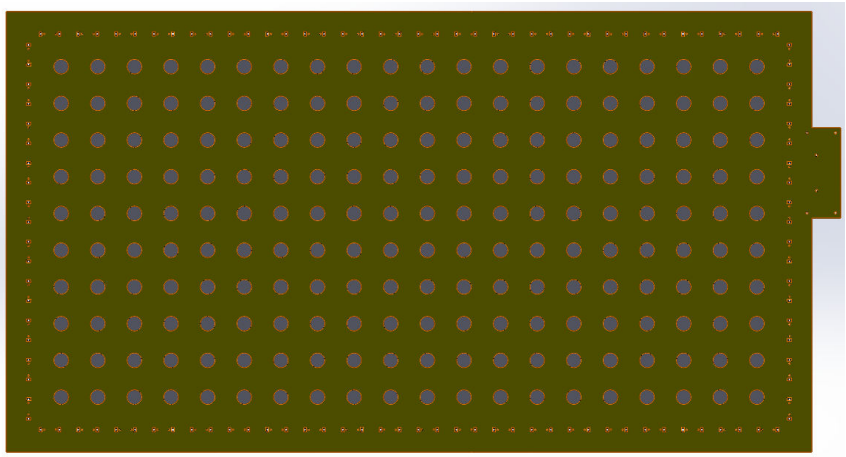
Design

- Main components in the design
  - GEM electrodes
  - GEM foil stretching components
  - Drift and readout electrodes
  - Main frame

Framed GEM foils

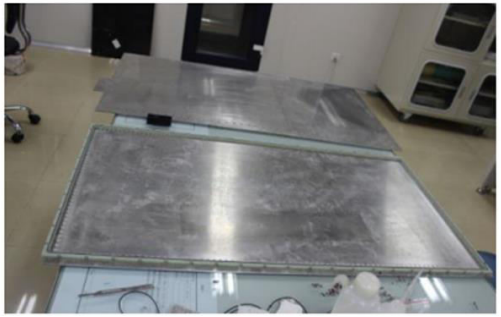


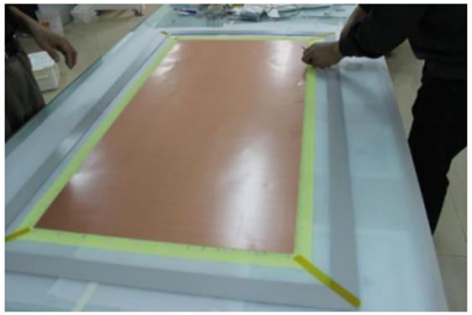
Drift electrode



Prototyping (I)

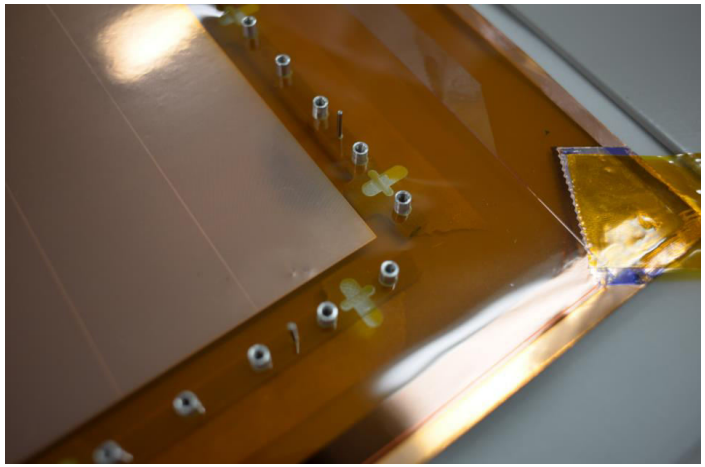
- A full-size mechanical mock-up of a 0.5m*1m GEM detector
  - to validate the mechanical design
  - to gain experience in large-size GEM stretching and detector assembly

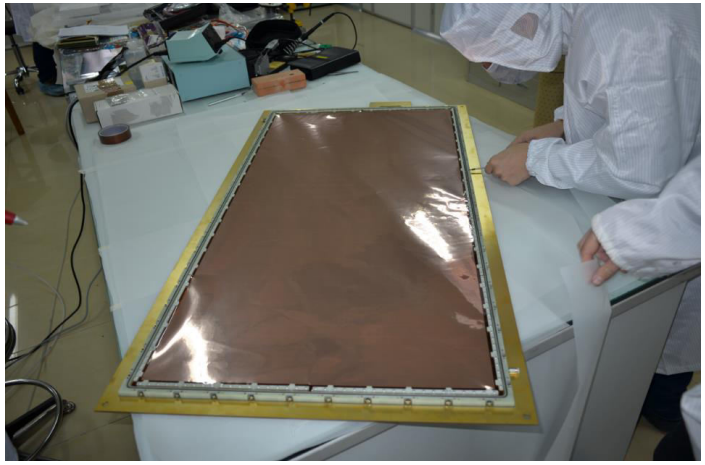


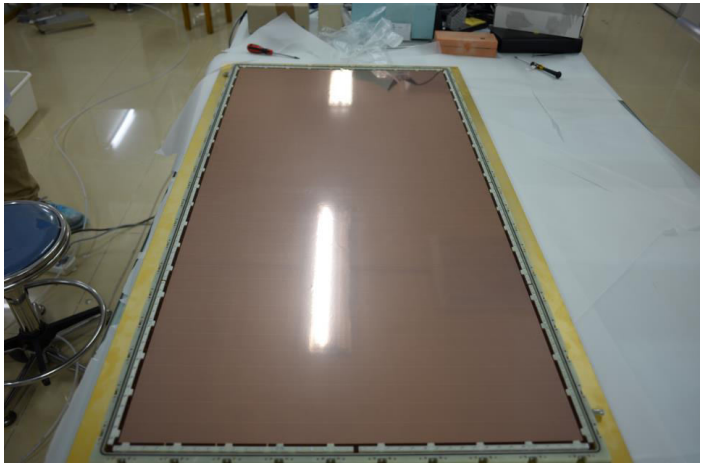


Prototyping (II)

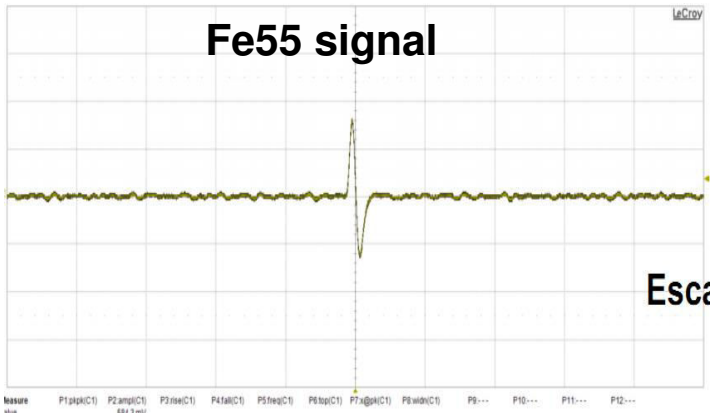
- Assembling an actual 0.5m*1m GEM prototype

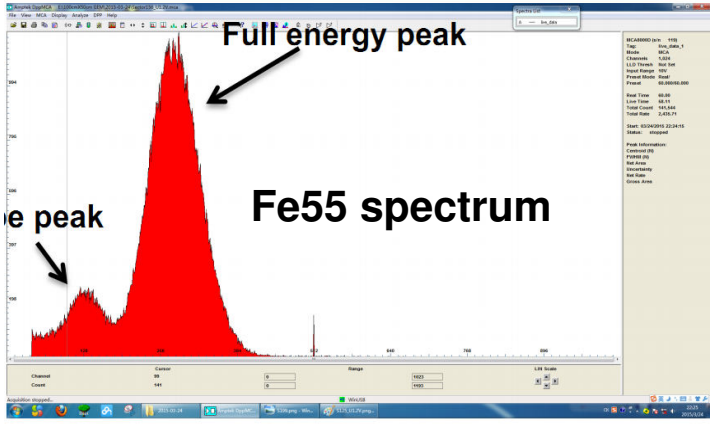






0.5m*1m GEM Under Test

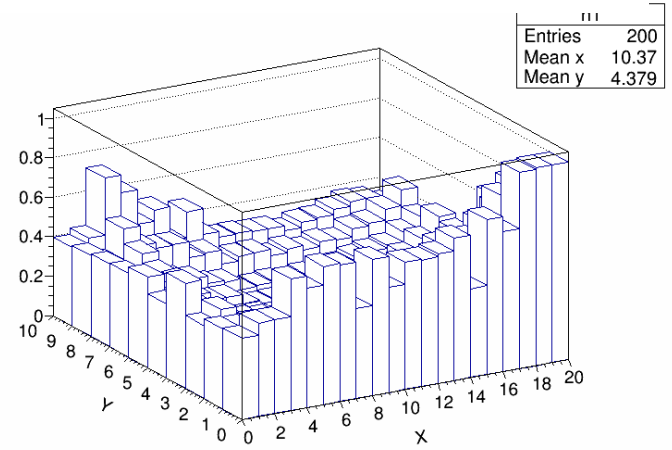




Response Uniformity

0.5m*1m GEM

Gain at different sectors

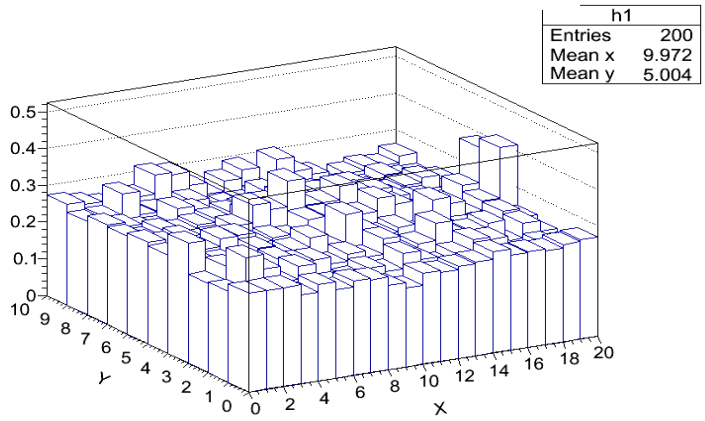


Uniformity ~ 51%

~ 11%

*Much worse than 30cm*30cm GEM*

Energy resolution at different sectors



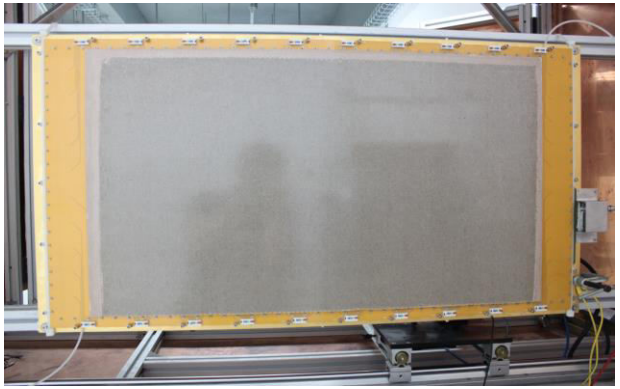
Uniformity ~ 11%

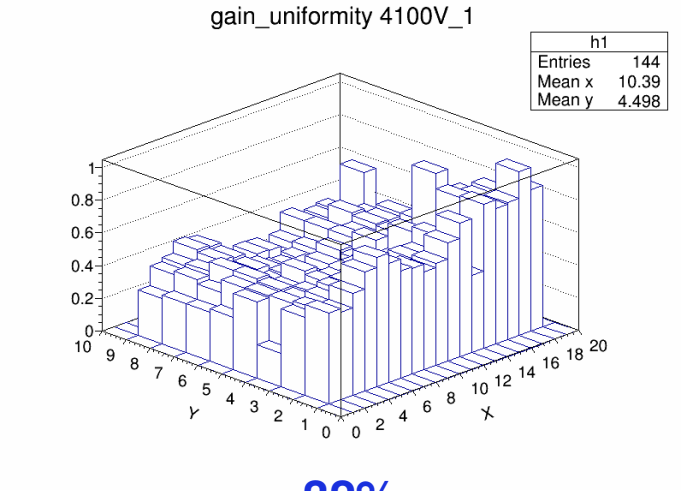
~ 5.3%

Note: uniformity = RMS/Mean

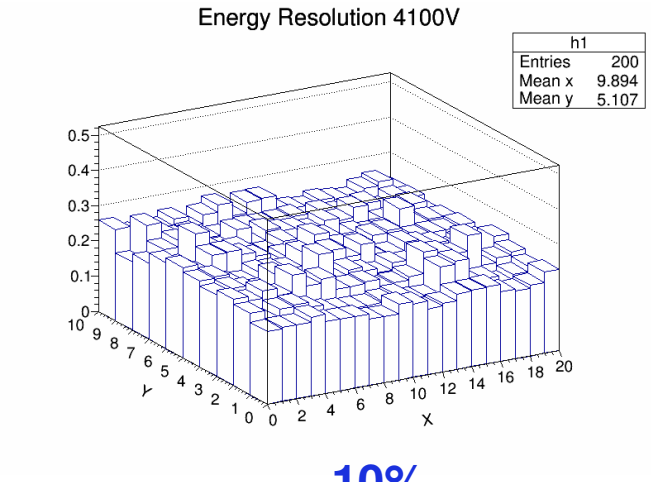
Improving Uniformity

- Large gain variations arose from chamber deformation under tension from GEM stretching and gas flowing.
- Gain uniformity improved by reinforcing the mechanic supporting frame and readout board.





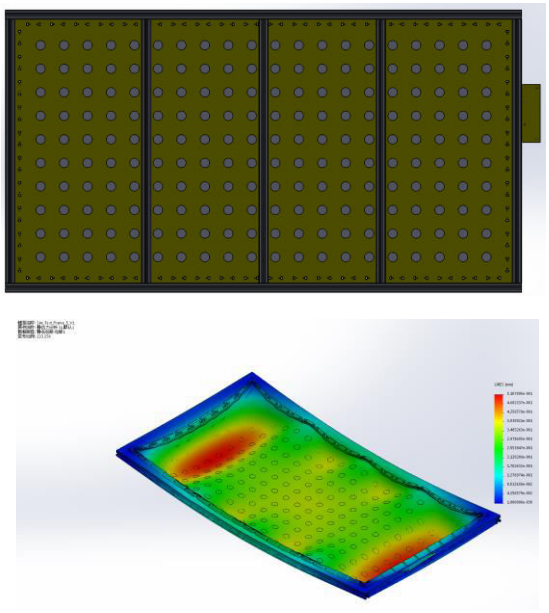
~ 32%

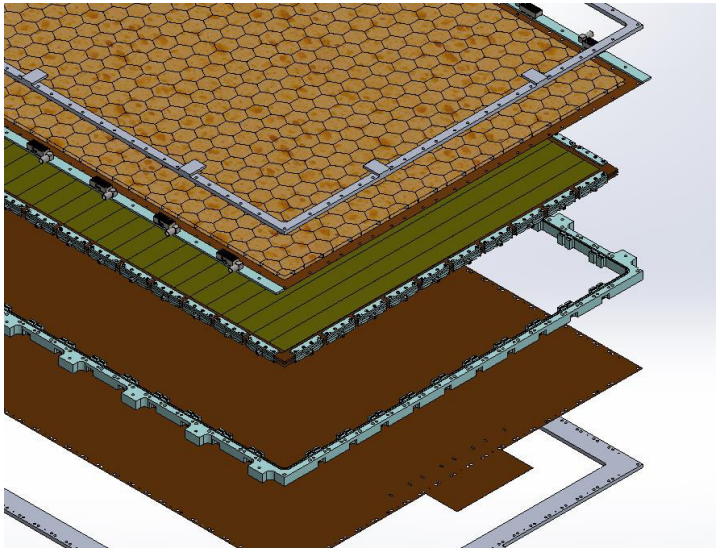


~ 10%

Design optimization

- Optimized 0.5m*1m GEM design based on results from prototyping and simulation.
  - Reinforced supporting frames
  - Segmented GEM clamping to better accommodate GEM extension when stretched
  - …

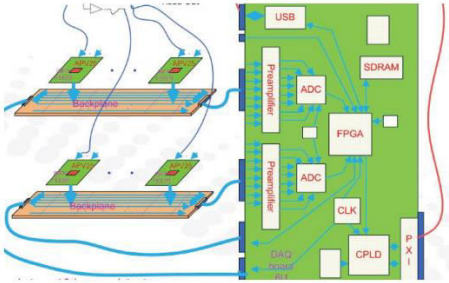




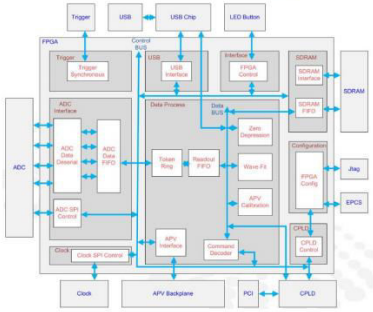
GEM Readout Development

- Developed a GEM readout system based on the INFN APV25 hybrid.
- Tested and characterized the readout system

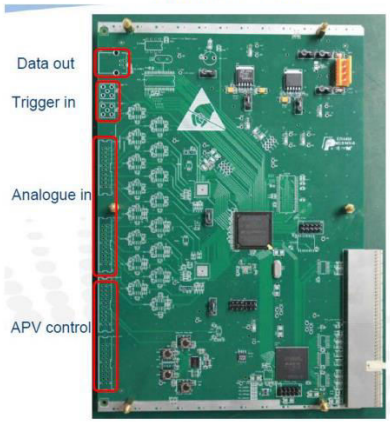
Design schematic diagram



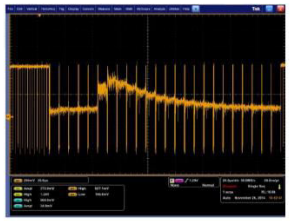
FPGA logic design



Main PCB



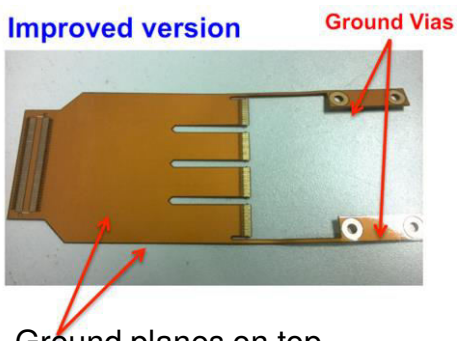
Testing and debugging



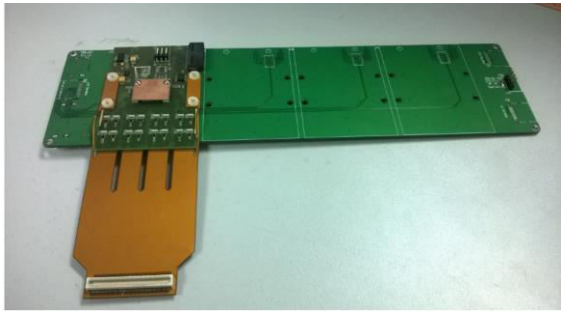
– The developer will graduate soon. Need to identify a successor to keep the work going.

APV25-MPD Readout

- Redesigned the FPC connector of APV25 hybrid to improve the grounding so as to reduce noise.

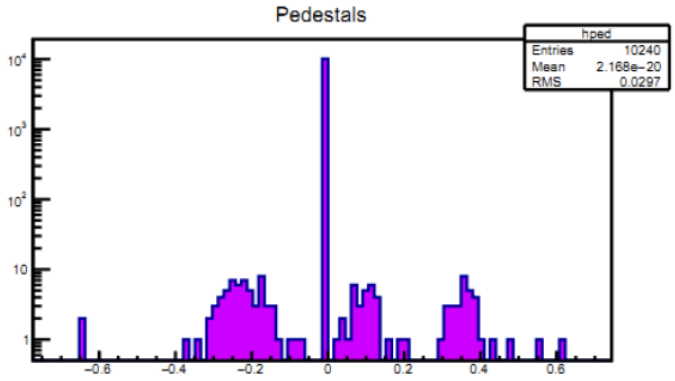


Ground planes on top and bottom layers



APV25 with the new FPC connector, mounted on a backplane

- Have gotten the APV25-MPD system working by upgrading the MPD firmware. Detailed tests underway.



Summary and Plans

- Active large-size-GEM R&D at USTC on both detectors and readout in the past year.
  - An important milestone achieved: successful first prototyping of **0.5m*1m GEM detectors** using an improved self-stretching technique.
- Near-term plans
  - Further optimize 0.5m*1m GEM detector design through more simulation and prototyping
  - Test GEM detector prototypes using APV25-MPD readout