GEM Status from SoLID Chinese Cluster

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SoLID Collaboration Meeting

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JLab

Chinese Cluster in SoLID

China Institute of Atomic Energy (CIAE)

中國原子能科學研究院
China Institute of Atomic Energy

Lanzhou University

蘭州大學

Tsinghua University

清華大學
Tsinghua University

University of Science and Technology of China (USTC)

中国科学技术大学
University of Science and Technology of China

Outline

- GEM detector R&D
  - General R&D
  - Large-area GEMs
- R&D on GEM foil production
  - Double mask technique
- GEM readout
  - APV25-based
  - Others

General GEM R&D

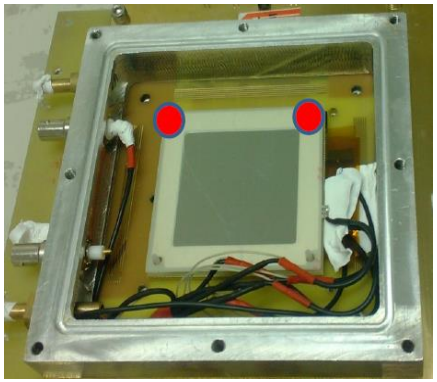
- Studies of a 5cm*5cm double-GEM prototype at Tsinghua University
- Studies of a 10cm*10cm triple-GEM prototype at Lanzhou University

A 5cm*5cm double-GEM prototype

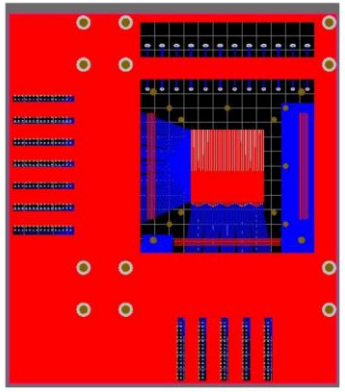
Tsinghua

- 2d readout, strip pitch: 0.45mm (X) and 0.625mm (Y)

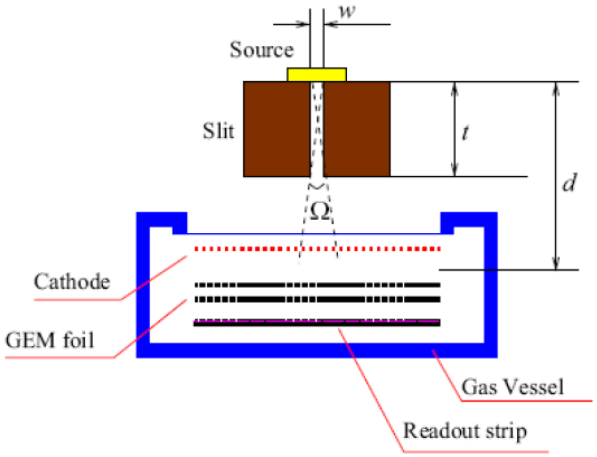
GEM chamber



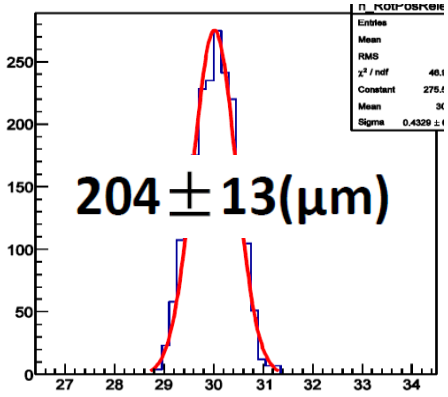
Readout board



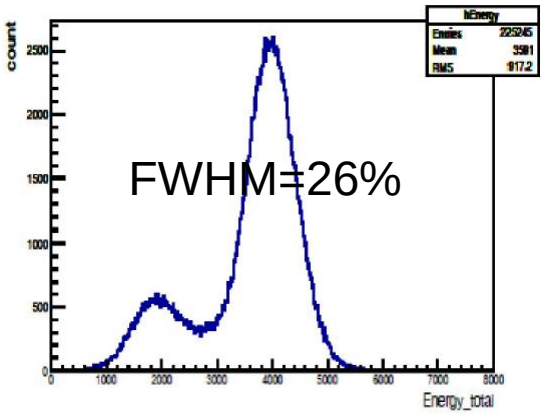
Test setup



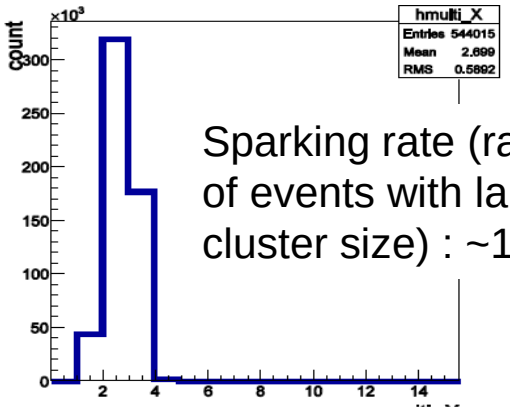
position resolution



Energy resolution



Cluster size
(hit strip multiplicity)

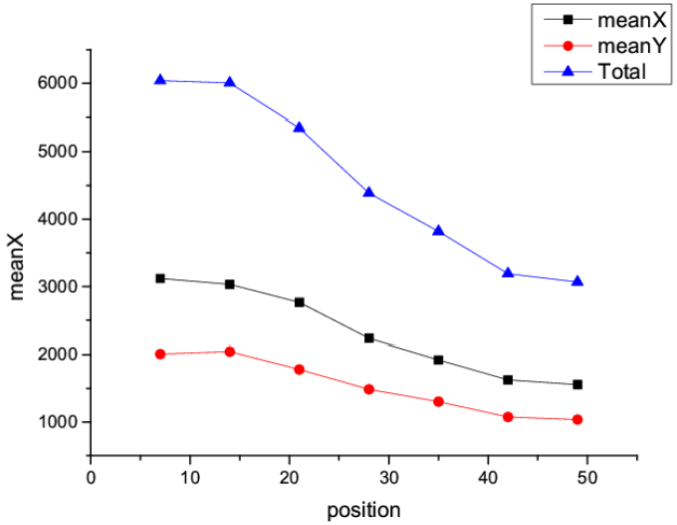


Sparking rate (rate of events with large cluster size) : ~10^{-6}

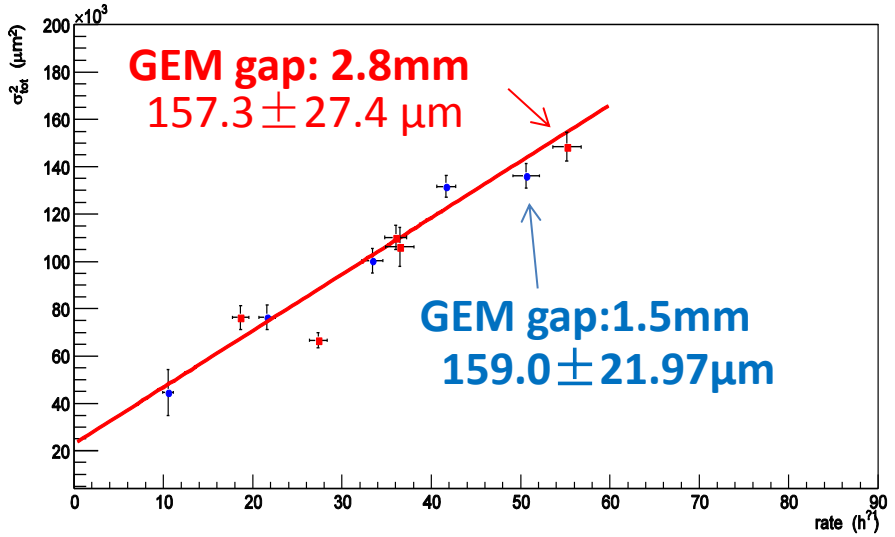
Detector response vs. GEM spacing

Tsinghua

- Studied the sensitivity of detector response to distance between GEMs by artificially pushing up a GEM plane on one side.



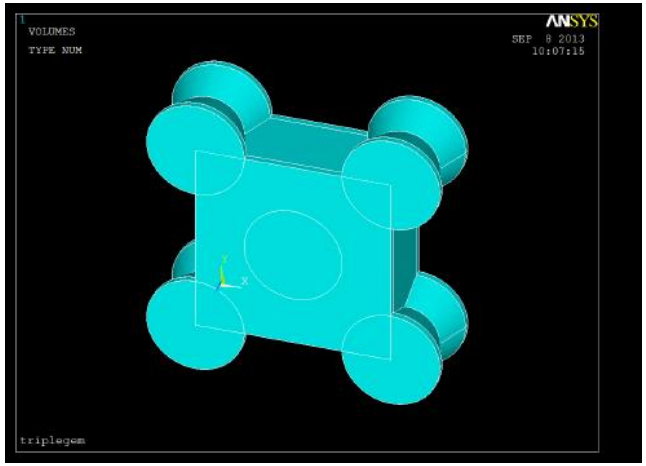
Energy peak vs. readout position

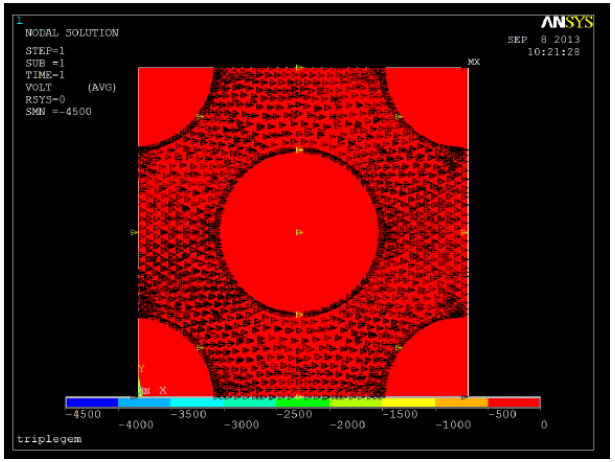


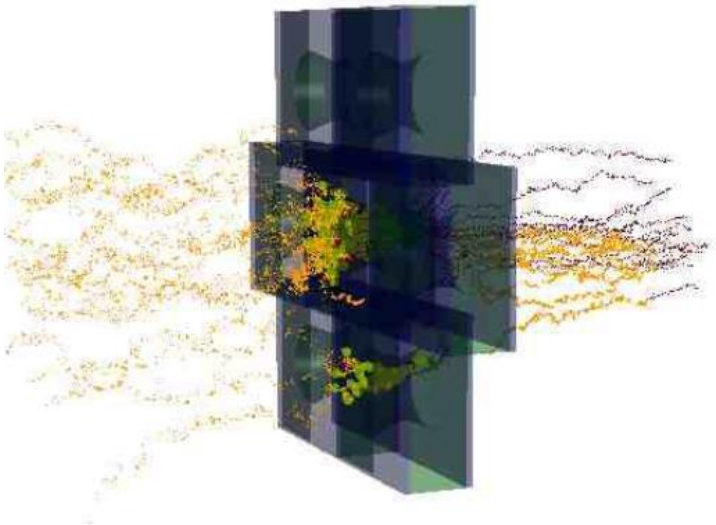
Impact on spatial resolution

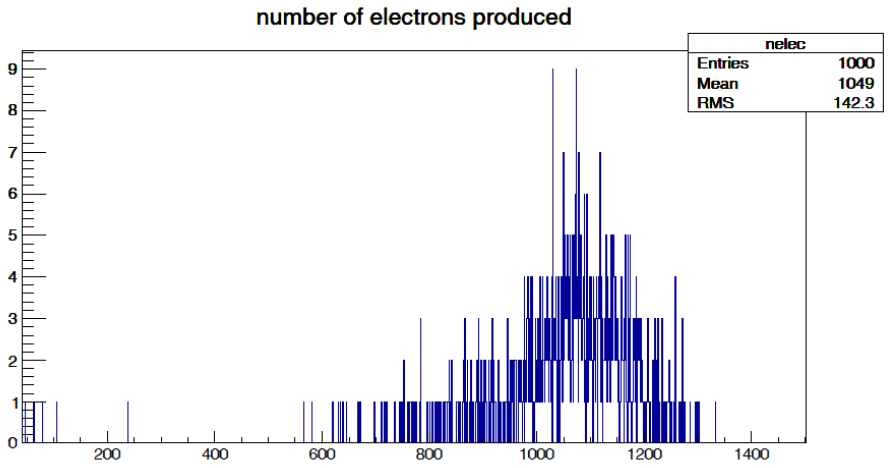
GEM Simulation

Tsinghua





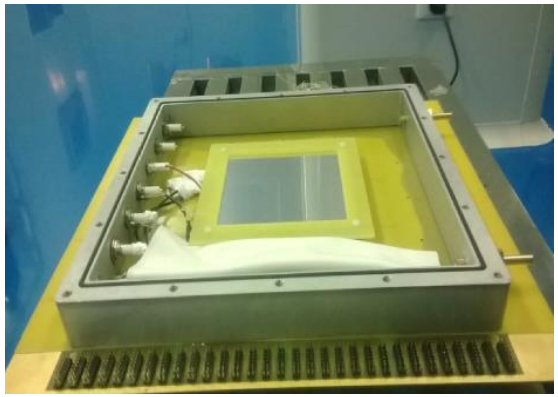




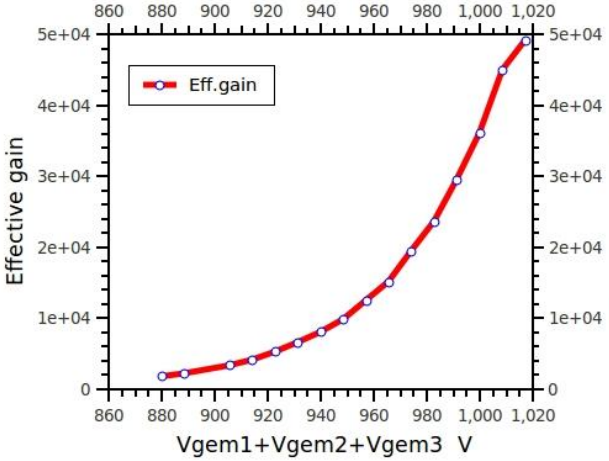
A 10cm*10cm triple-GEM prototype

Lanzhou University

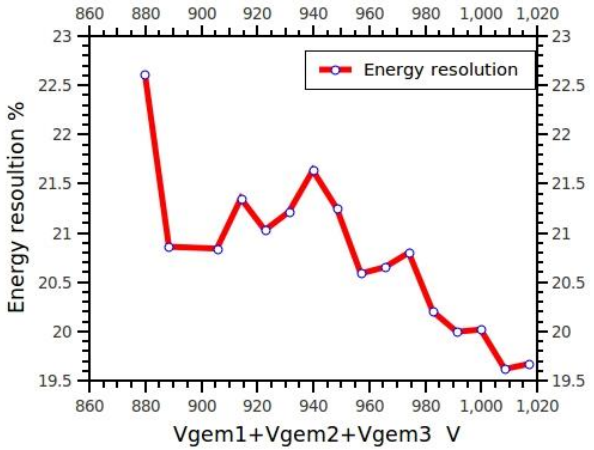
GEM chamber



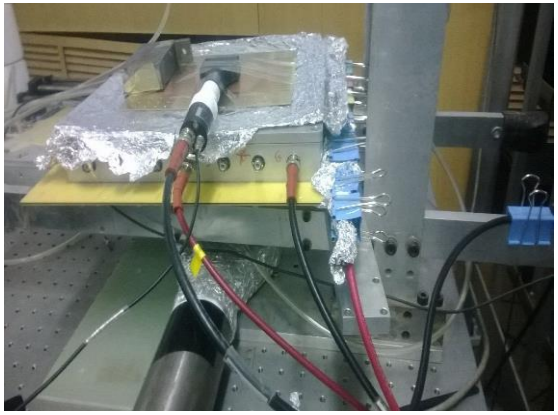
Effective gain vs. high voltage



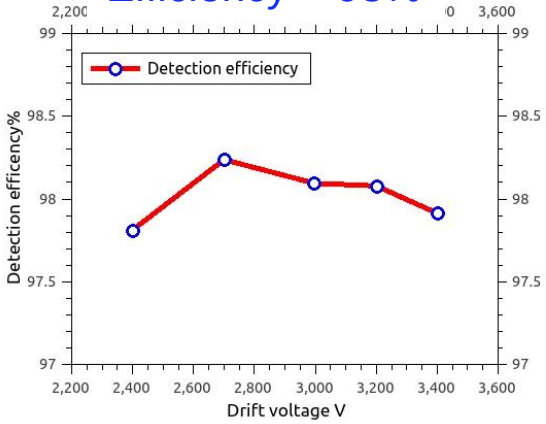
Energy resolution vs. high voltage



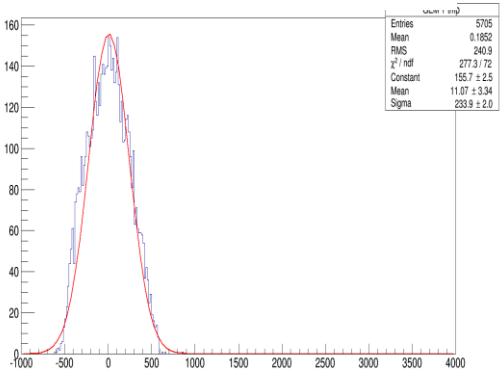
Test setup



Efficiency > 98%

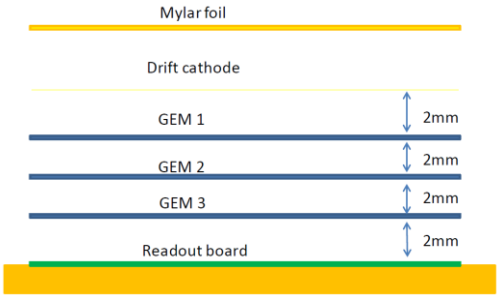


Time resolution ~23ns

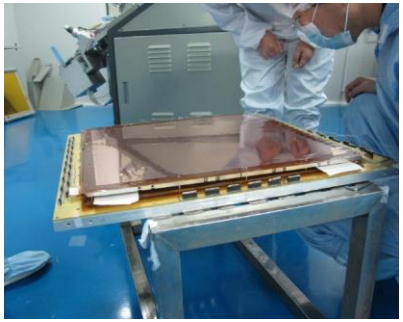


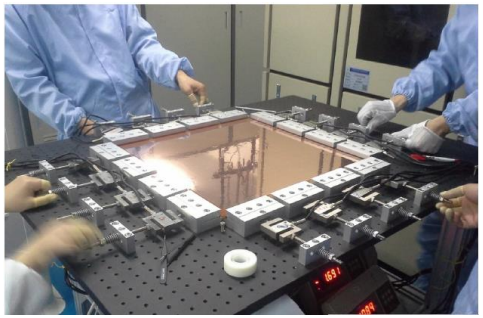
Large-area GEM R&D at Tsinghua

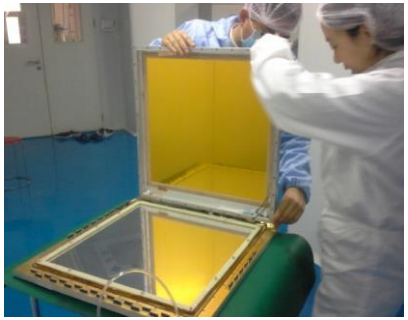
- Built a 45cm*45cm GEM chamber



Assembling process

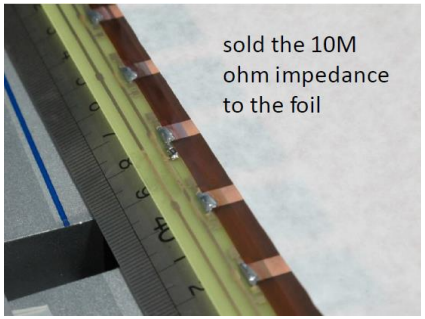


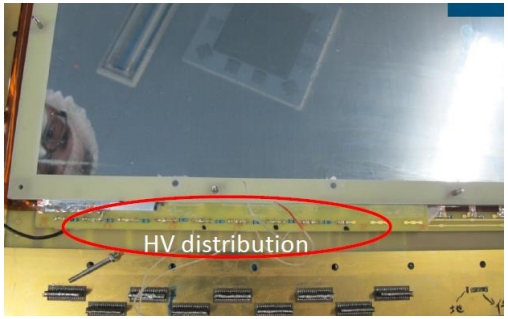




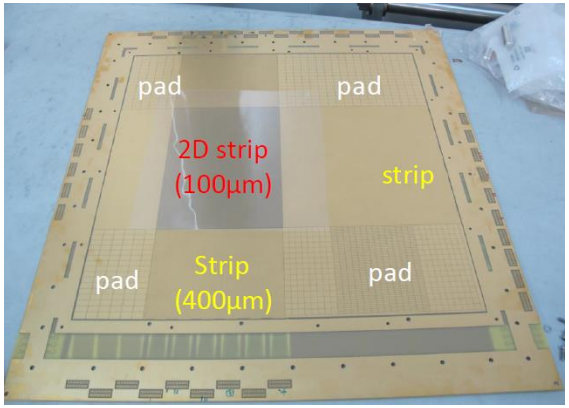
Tsinghua

High voltage distribution





Hybrid readout board

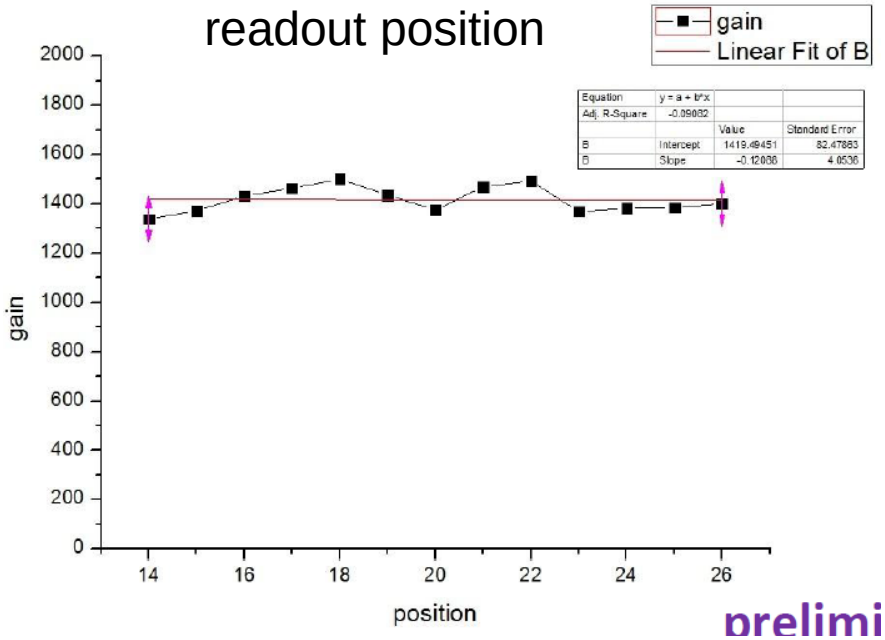


Performance

Tsinghua

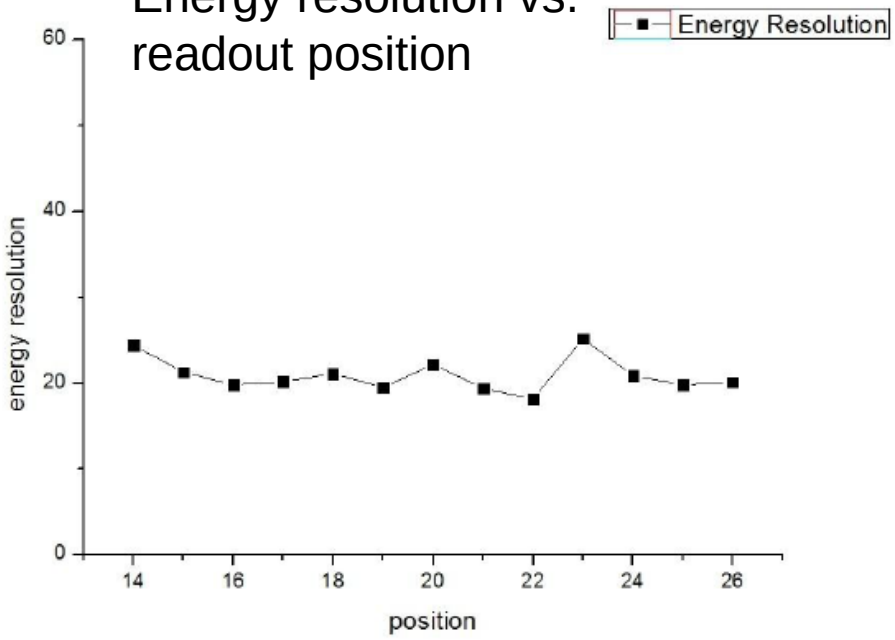
- Tested the GEM chamber with only two GEM layers assembled

Effective gain vs. readout position



prelimi

Energy resolution vs. readout position

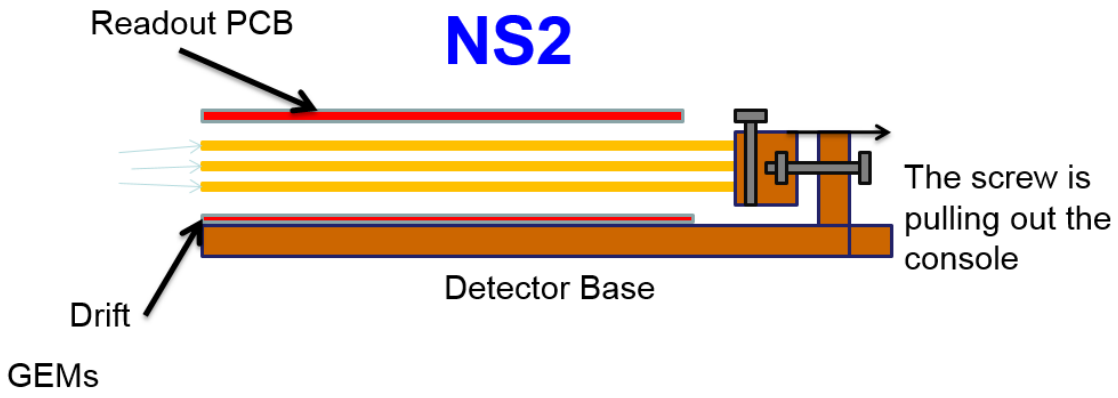


Problem being worked on: One sector of the second GEM foil shorted. May need to change the GEM foil.

Large-area GEM R&D at USTC

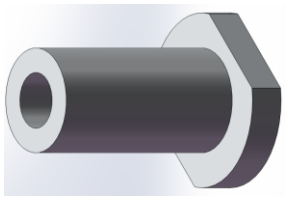
USTC

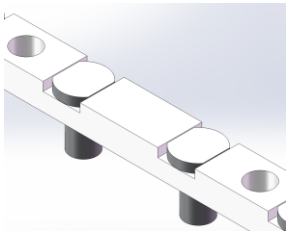
- Built a new 30cm*30cm GEM using NS2 technique developed at CERN.
- Lots of improvements in design compared to a previous chamber of the same size.
  - Screws
  - Main frame
  - GEM foil frame
  - ….

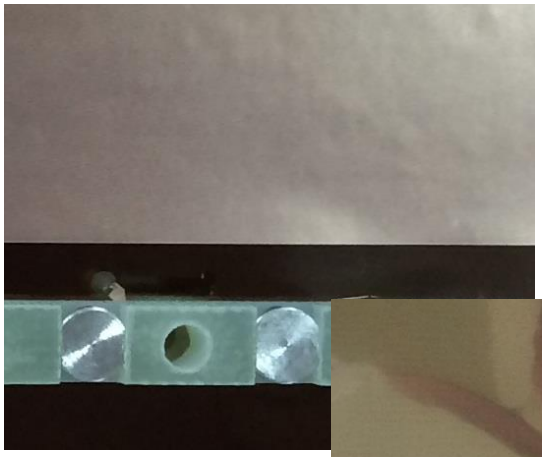


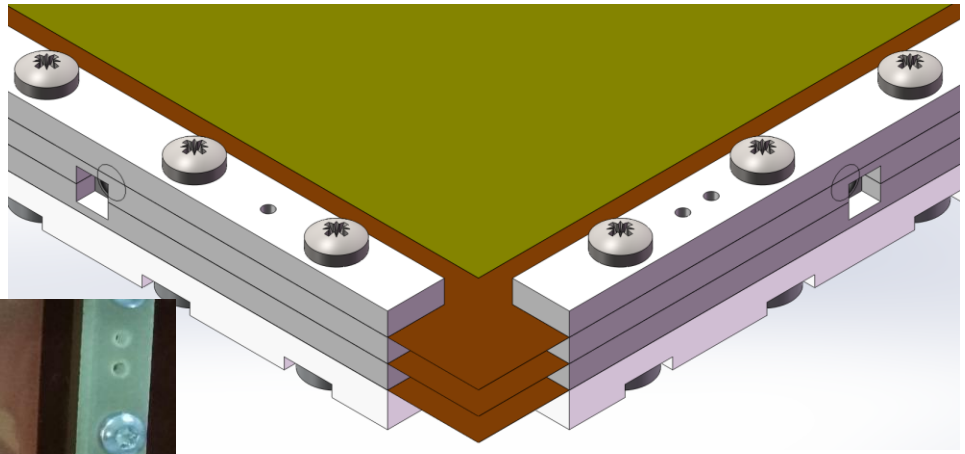
Fabrication of GEM layers

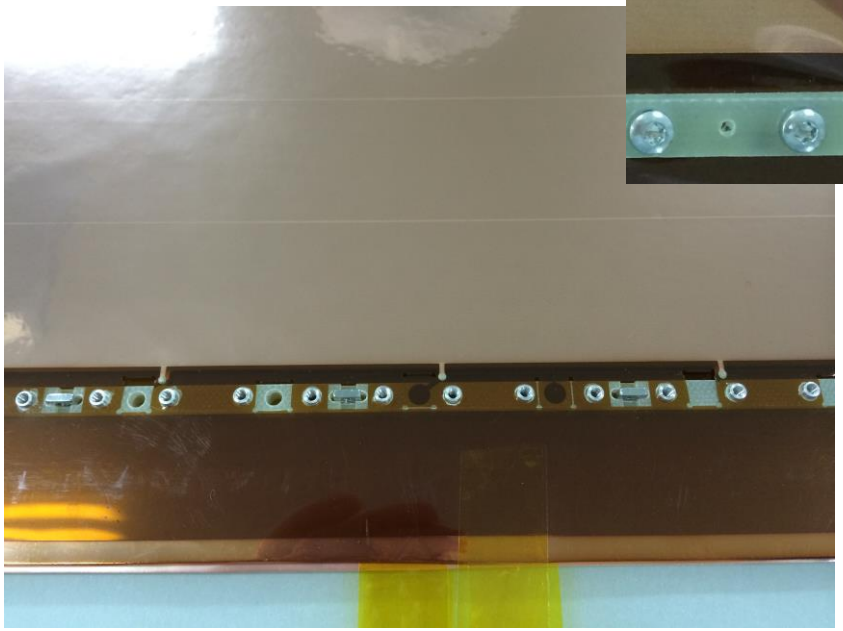
USTC

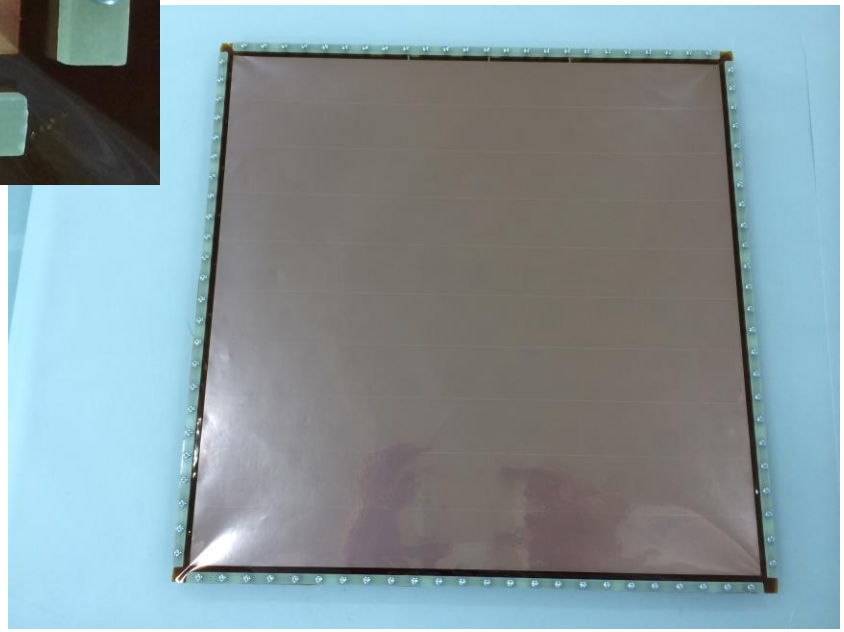






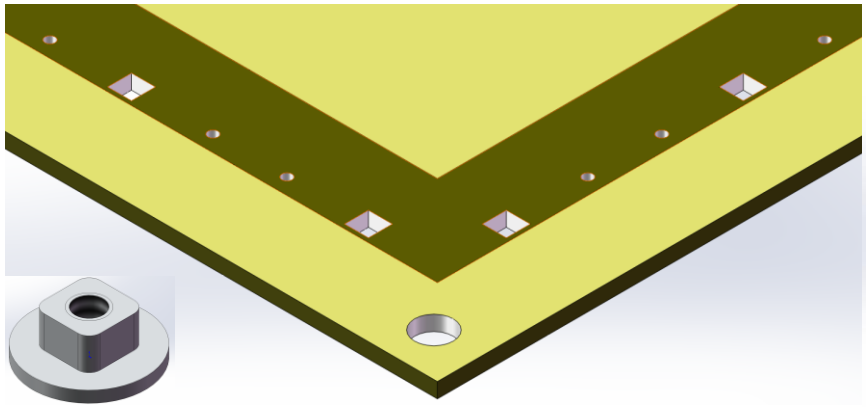


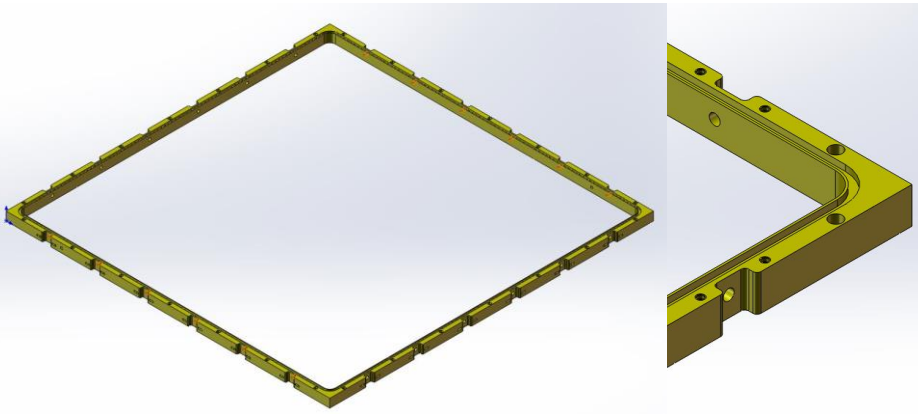


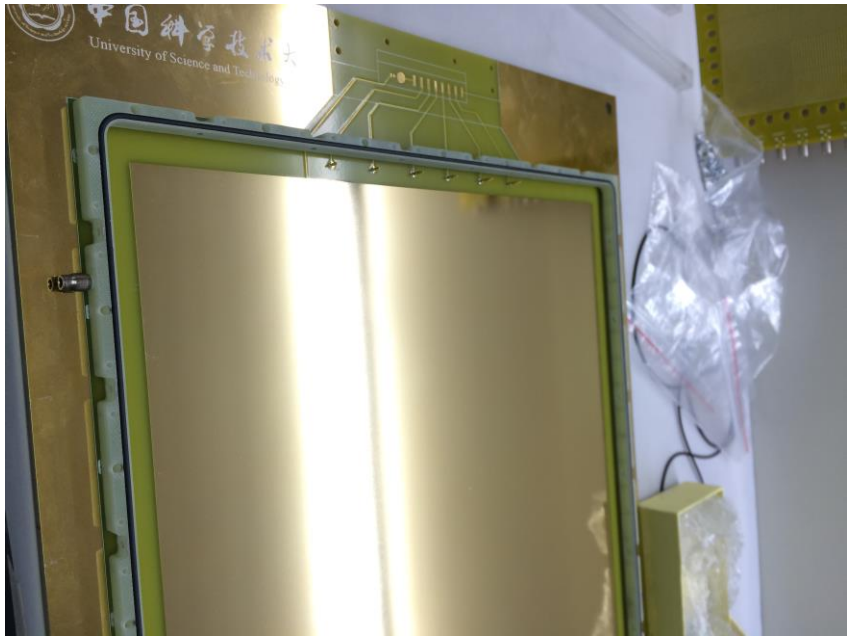


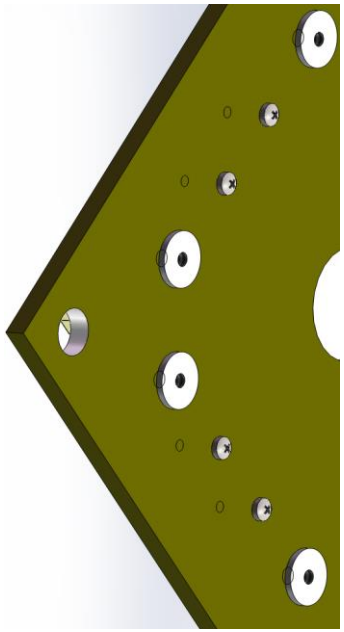
Main frame

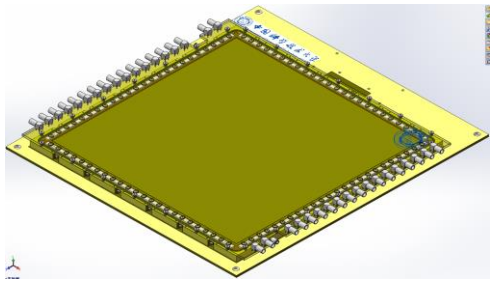
USTC

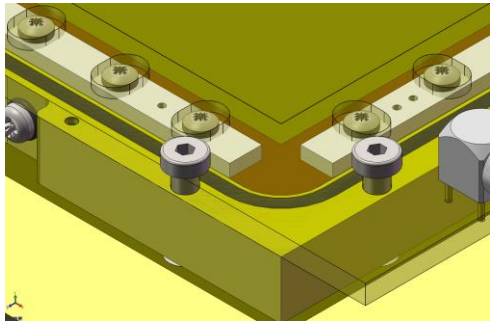




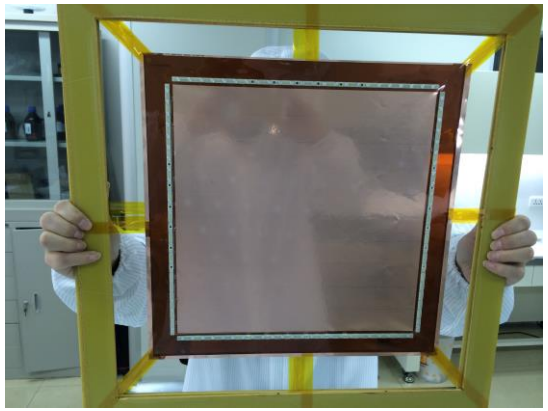


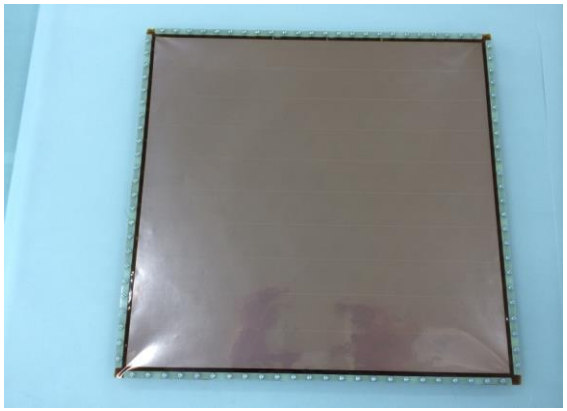


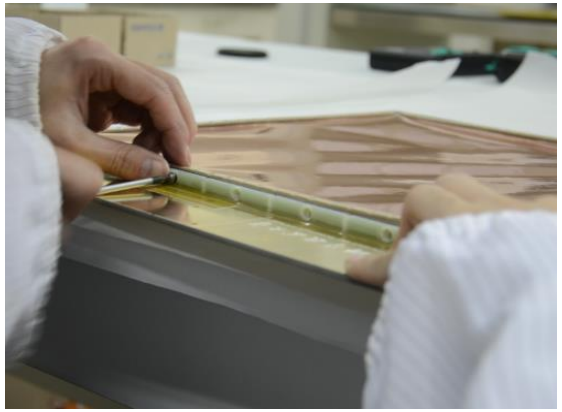


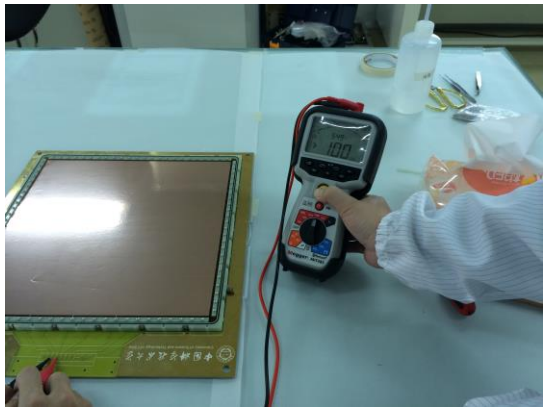


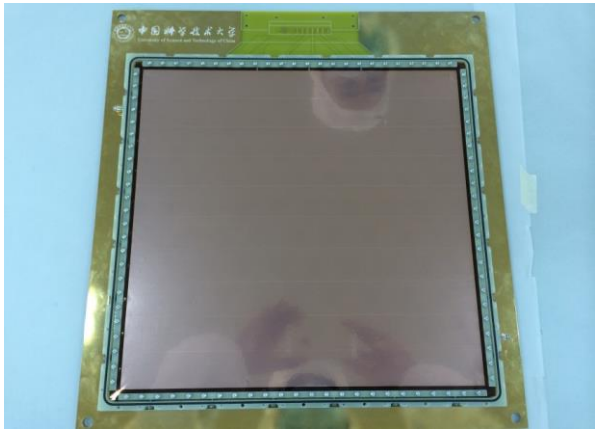
Chamber Assembly

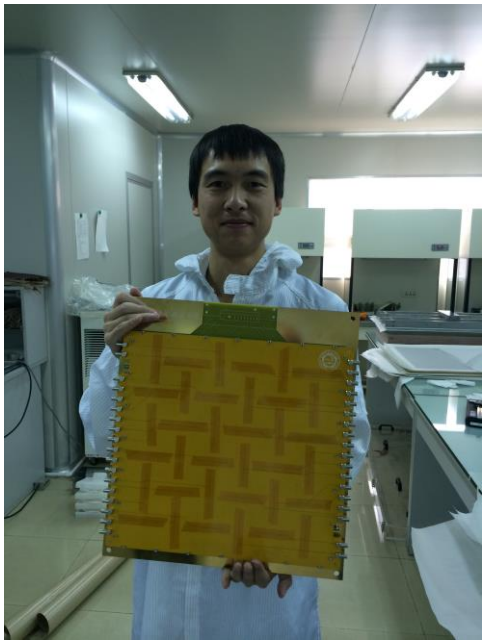












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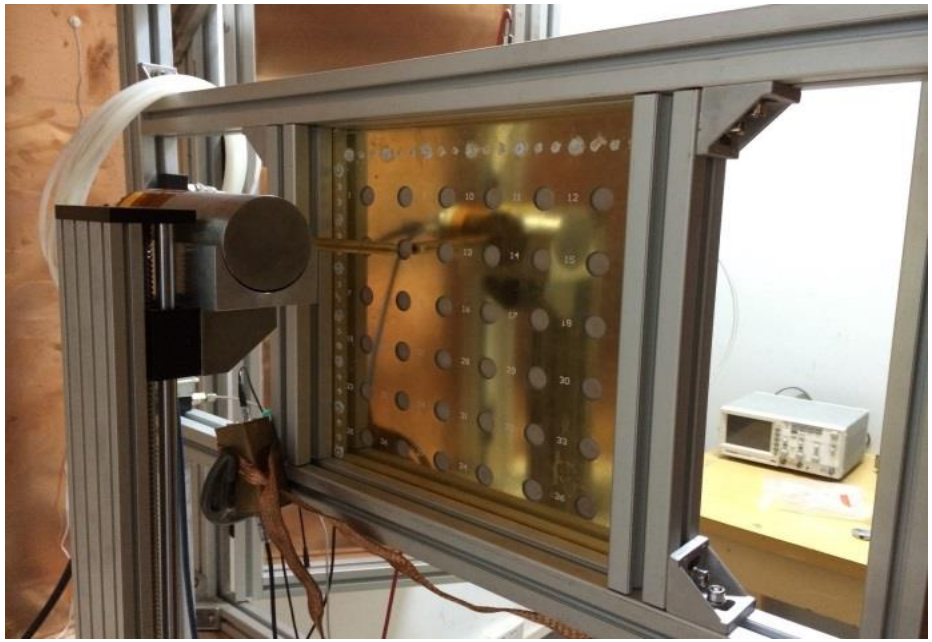
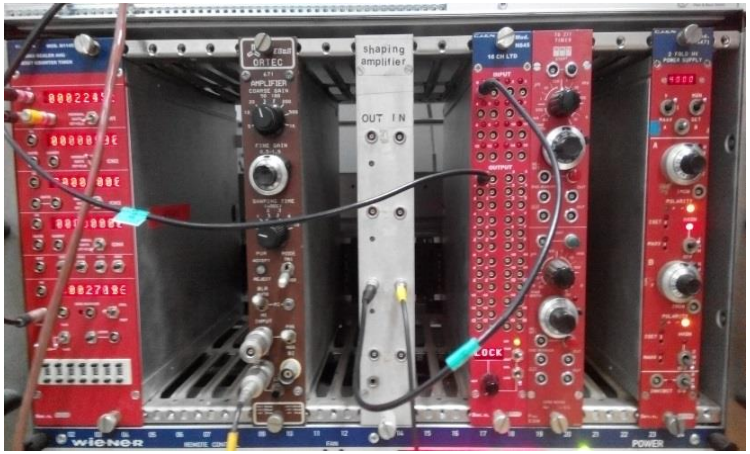
GEM Test





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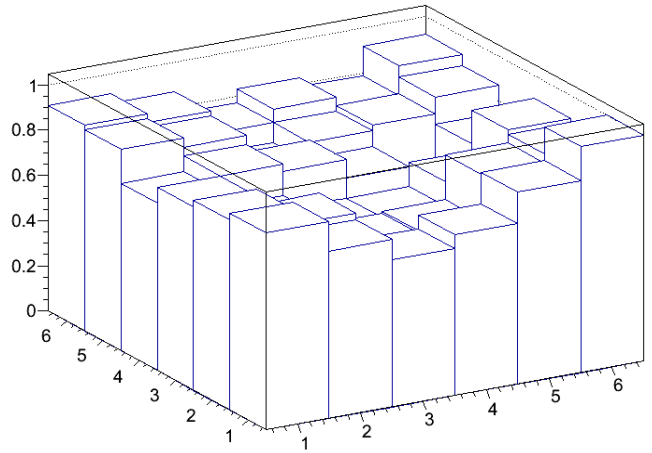
Performance

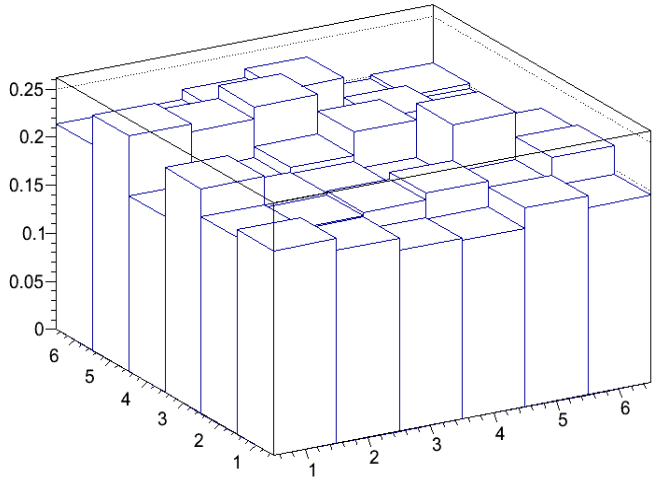
USTC

Effective gain in different readout sectors

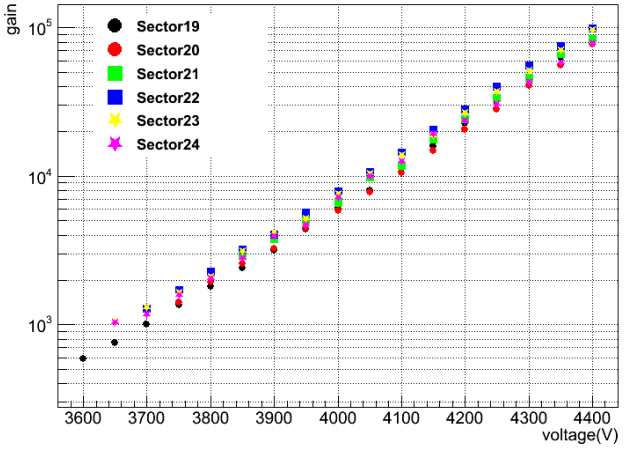


Gain uniformity : 31%
(in contrast to 75% of the previous chamber)

Energy resolution: ~20%



Effective gain vs. High voltage

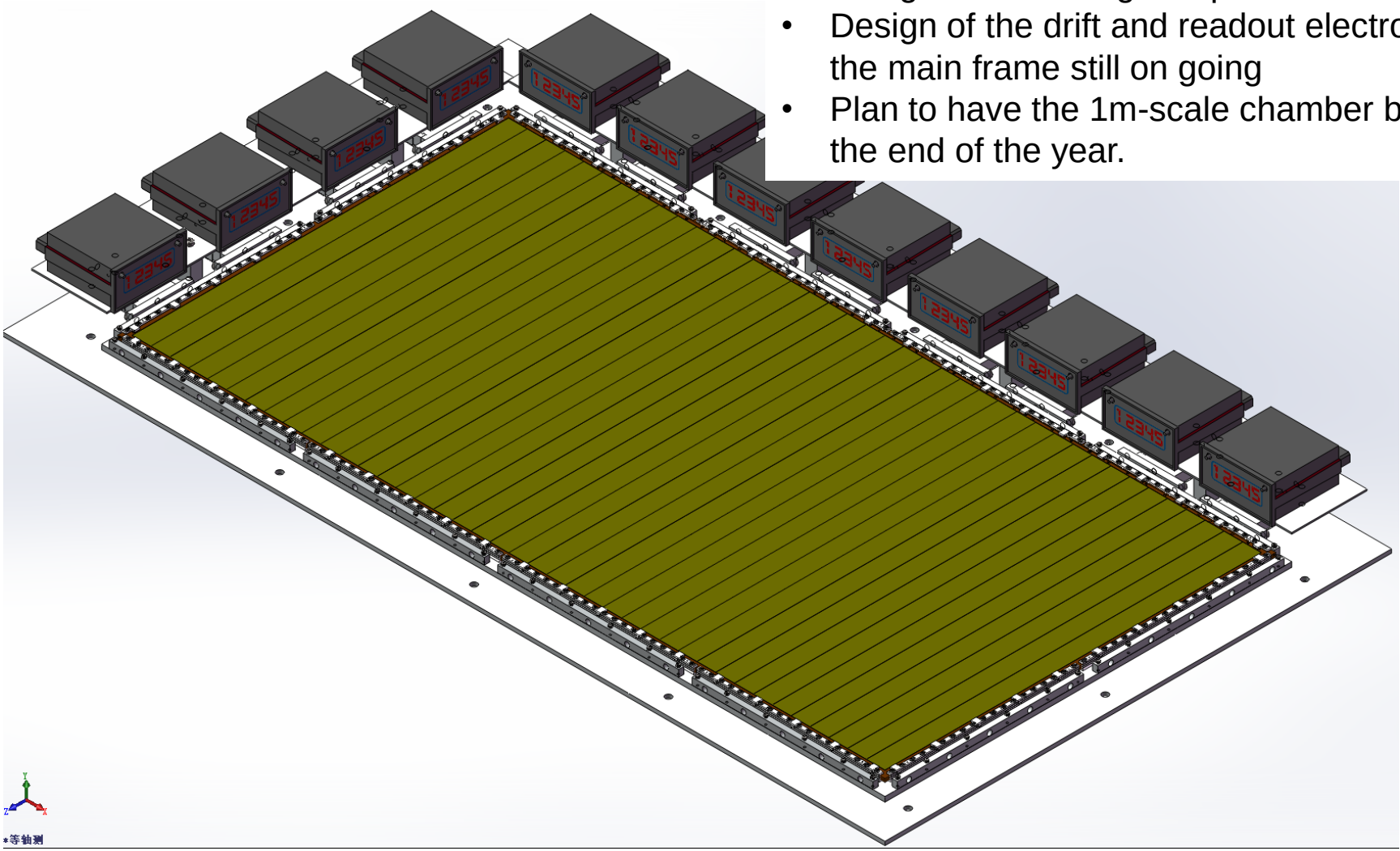


~10^4 @4000V

Towards 1m*0.5m

USTC

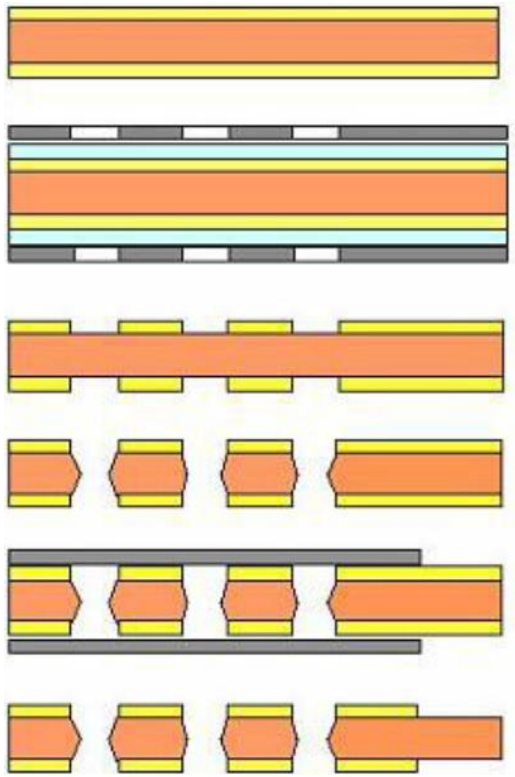
- Design of the tension monitoring system done
- Design of GEM electrodes done
- Design of stretching components done
- Design of the drift and readout electrodes and the main frame still on going
- Plan to have the 1m-scale chamber built by the end of the year.



R&D on GEM foil production

CIAE

- A big effort by China Institute of Atomic Energy
- A facility for GEM foil production established on site
- GEM foil production size reached up to 30cm*30cm using double-mask technique

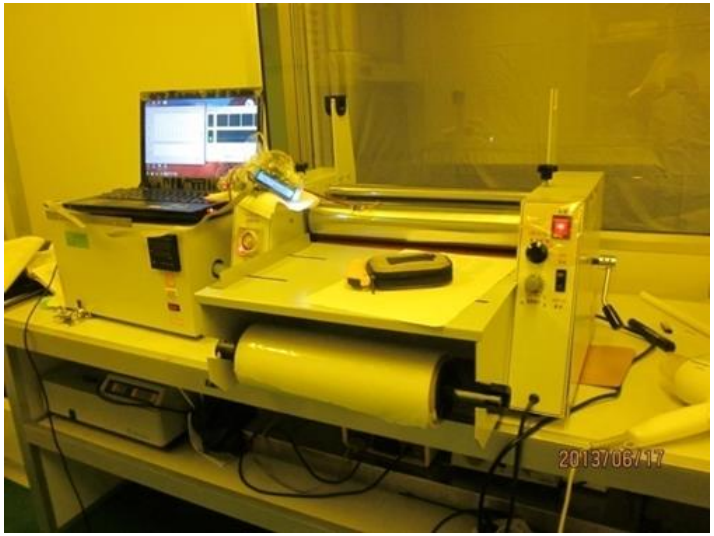


Process flow of GEM foil production with double-mask technique

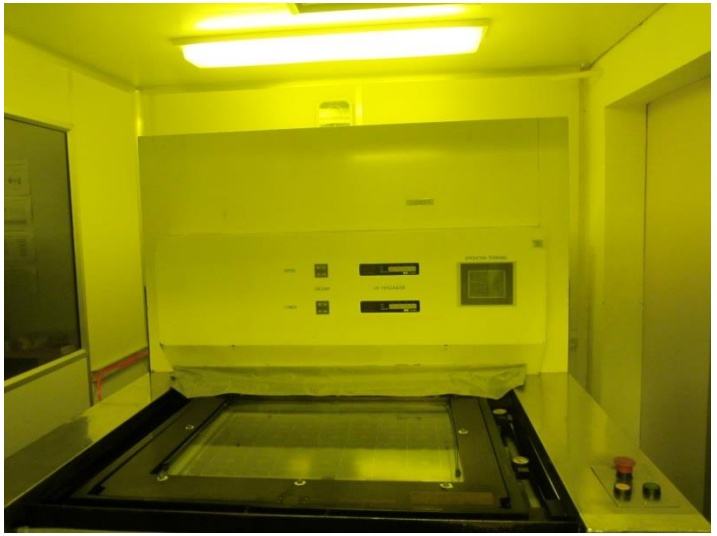
GEM foil production facility

CIAE

Hot Roll Lamination machine



Exposure machine



- The two most important and difficult steps in GEM foil production: Lamination and exposure of dry film photoresist.
- A yellow-light area has been set up, as required for the operation of the two machines.
- Invited a senior PCB engineer to get training

GEM foil production facility

CIAE

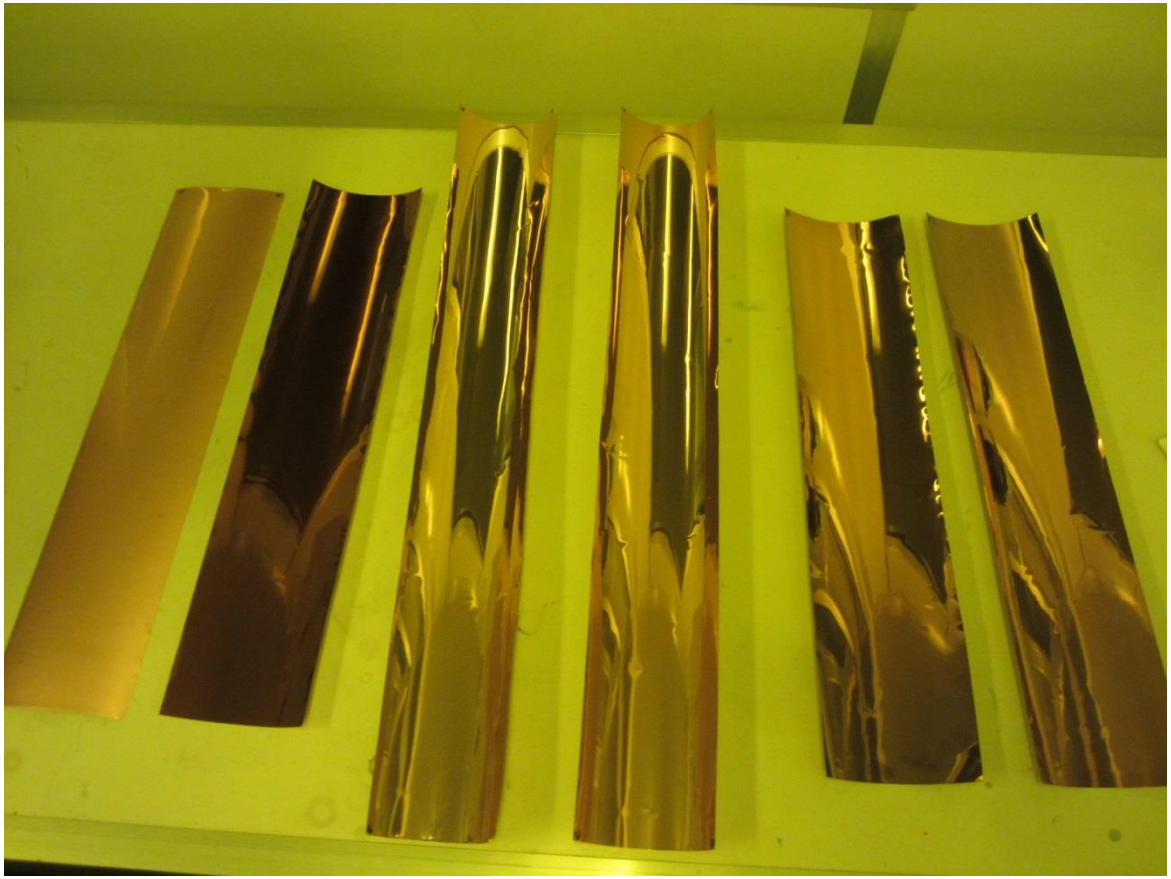
Etching rooms

kapton etching

copper etching

Raw Foils

CIAE



Tried raw foils from different producers (left two from US, the rest from CERN but made in South Korean)

GEM foil Production Process

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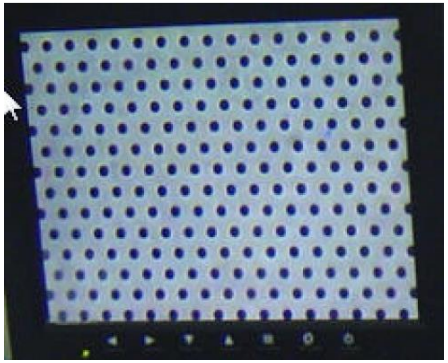
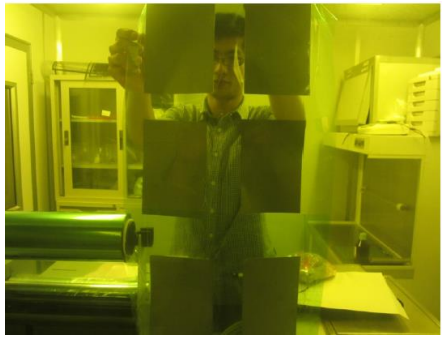
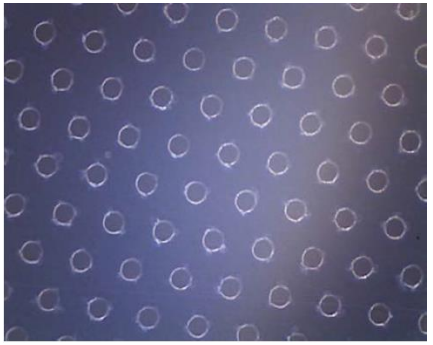
Mask plate



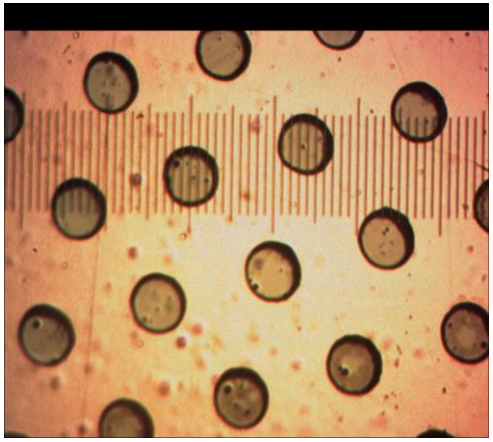
Lamination of photoresist



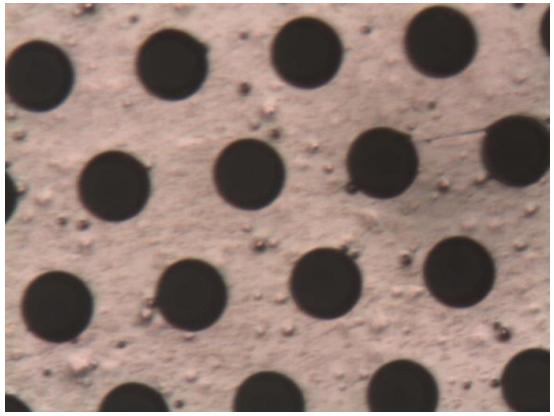
Exposure of photoresist



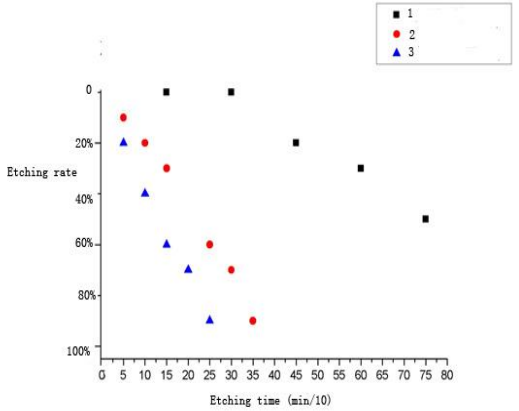
Copper etching



Kapton etching



Kapton etching under different conditions



Comparison of different raw foils

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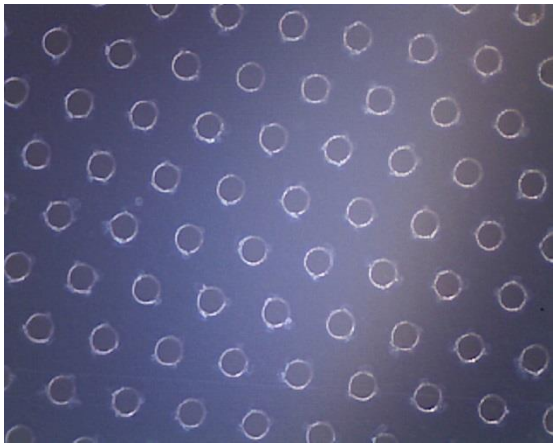
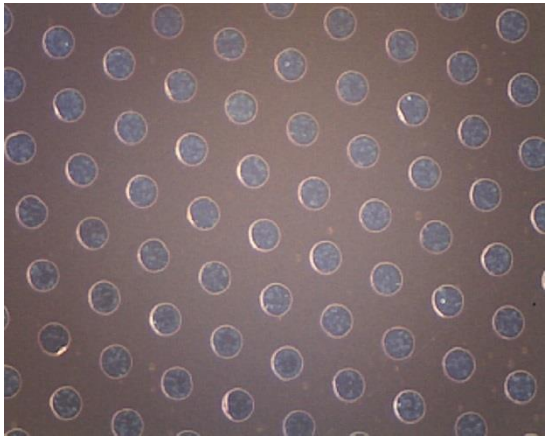
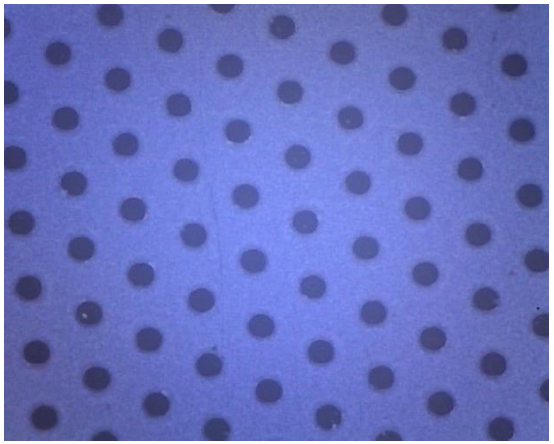
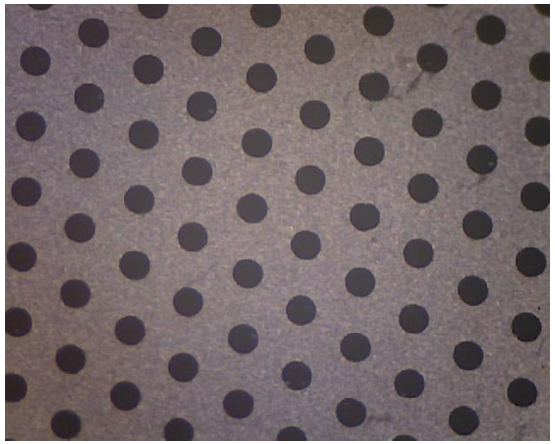
	After etching copper	After removing photoresist
Raw foils from CERN		
Raw foils from the US		

Etching result looks good with both types of raw foils

30cm*30cm GEM foils

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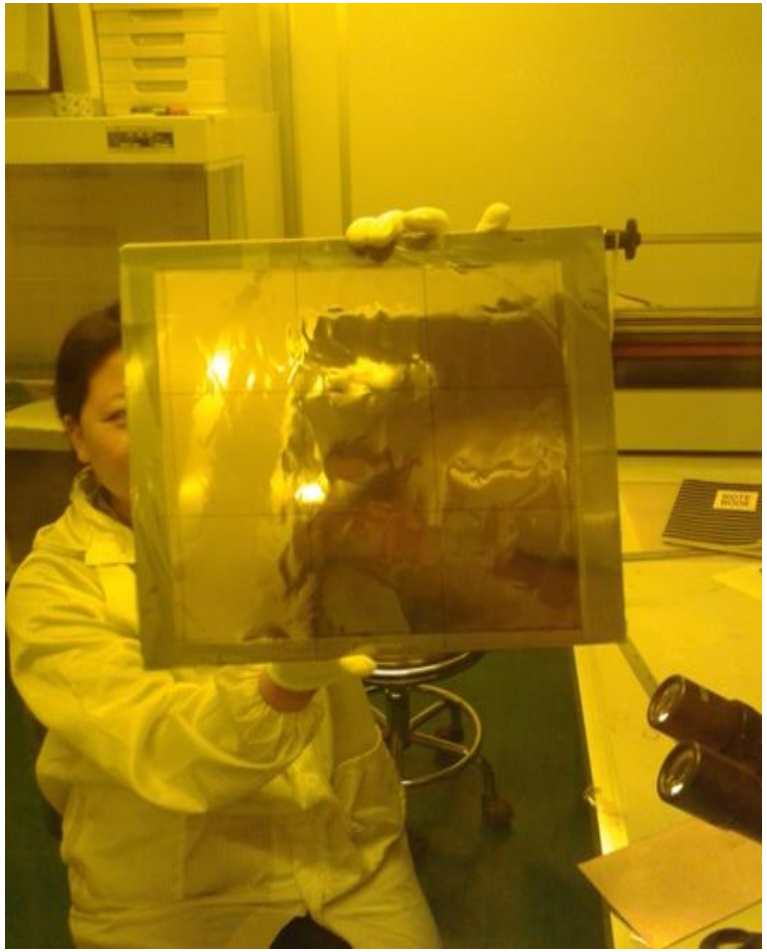
A 30cm*30cm GEM foil



- Successfully produced 30cm*30cm GEM foils using the double-mask technique after ~2000 experiments.
- Top and bottom masks misaligned sometimes. Being worked out.

A GEM foil produced with top and bottom mask misaligned

GEM Readout

- APV25-based
  - Setting up and test of the “INFN” readout system
  - Design effort
- CASAGEM-based
- SFE16-based

“INFN” readout system

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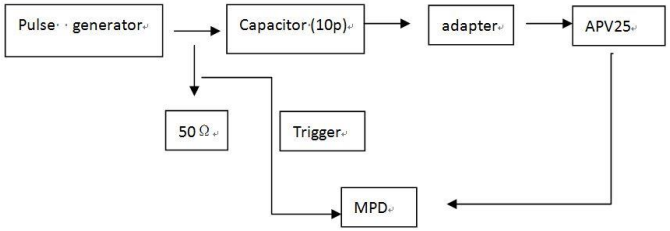
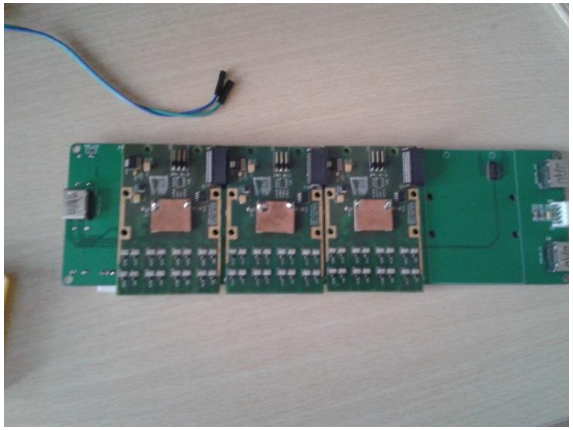
System debugging

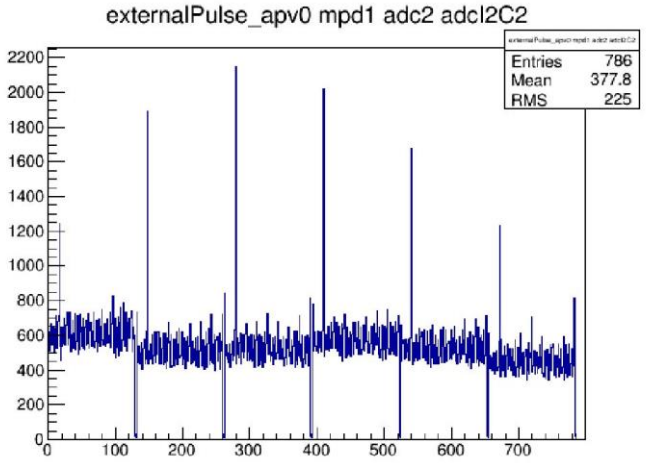
Calibration system



New backplane made at CIAE



Data frame with calibration pulses



Imaging with “INFN” readout

- A GEM chamber equipped with the “INFN” readout for X-ray imaging test
- The whole system worked fine.
- Working on further improving the “combined” performance of GEM with “INFN” readout.

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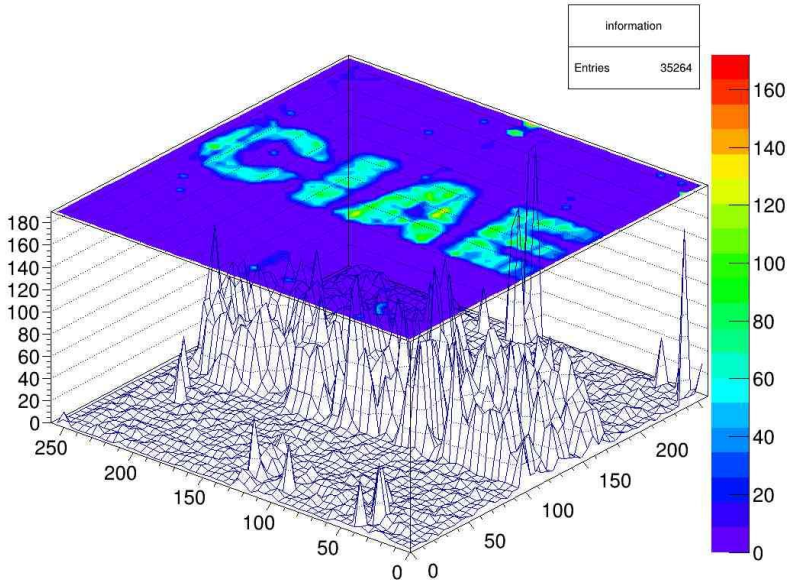
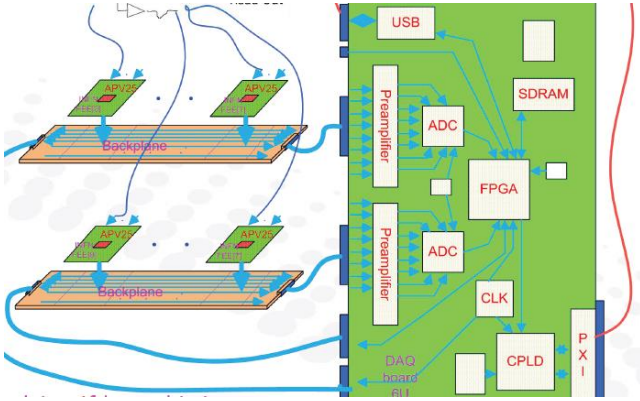
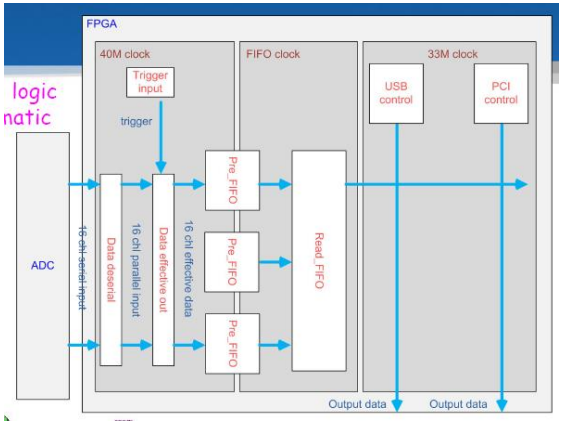


Design Effort at USTC

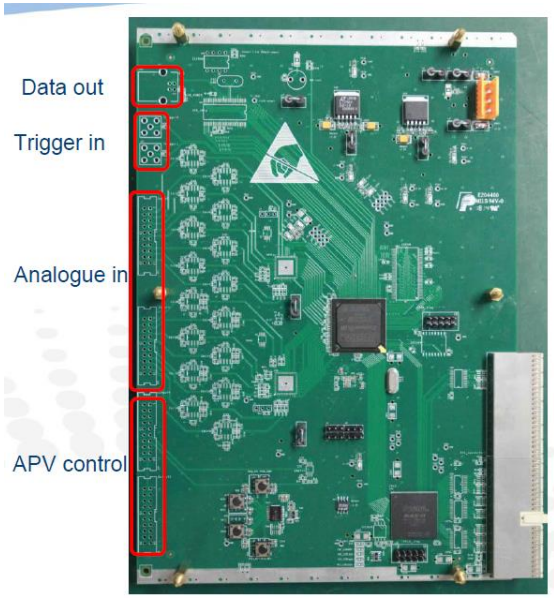
Design schematics



FPGA logic design



Main PCB under test



Specifications of main components

MODULE	DEVICE
Preamplifier	AD8138
ADC	AD9257
Clock	AD9577
FPGA	EP3C80F484
CPLD	EPM2210F324
SDRAM	MT48LC4M32
USB	CY7C68013A
Interface	USB && PXI

- Developing a readout system based on APV25
- Expected to be ready for test with GEM in a few months.

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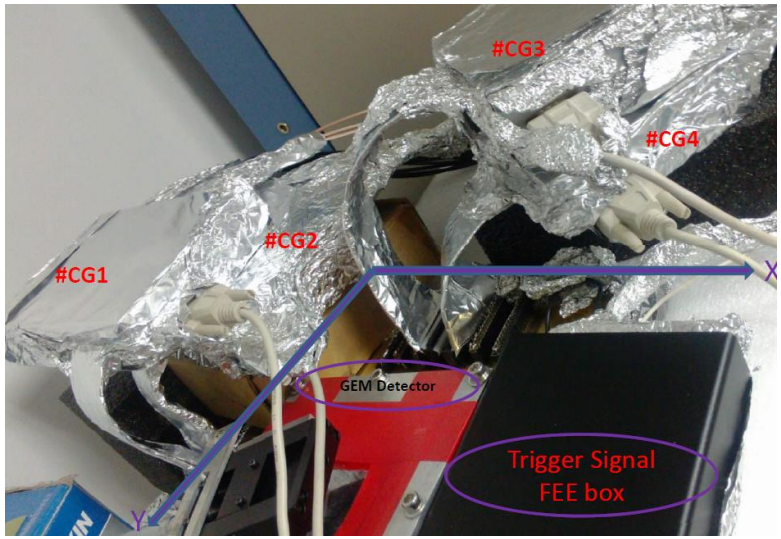
CASAGEM-based readout

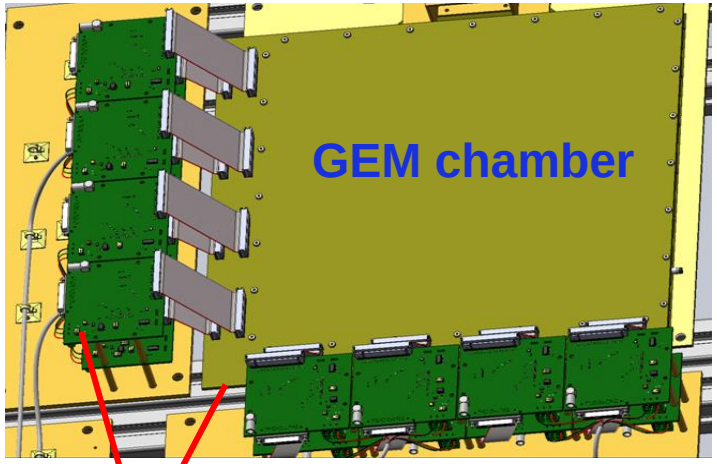
- Developed by Tsinghua University and has been used for GEM R&D at Tsinghua.



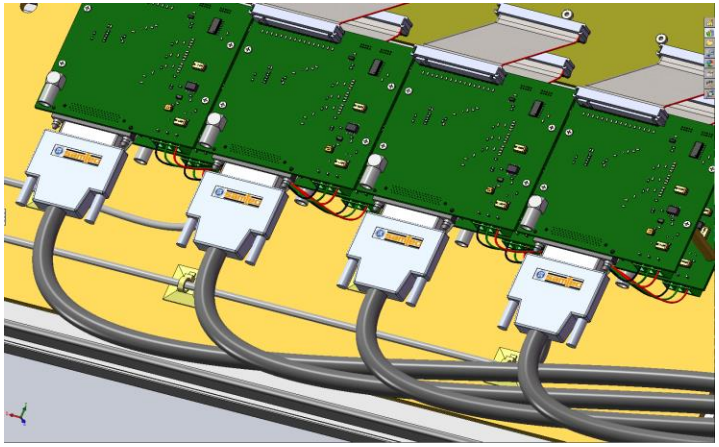
Tsinghua

SFE16-based readout

Being tested at USTC and will be used for performance studies of the 30cm*30cm GEM chamber.

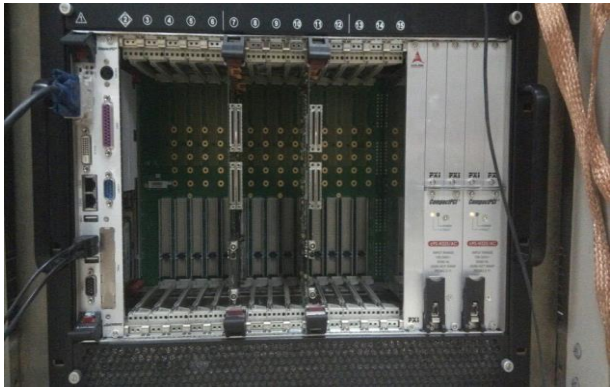


16 SFE16 chips



Cables connecting SFE16 and HPTDC

HPTDC



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Summary

- Active GEM R&D in the Chinese cluster
  - General GEM performance studies using GEM prototypes.
    - Spatial and energy resolutions, effective gain, response uniformity and sensitivity …
  - Design and fabrication of large-area GEM chambers
    - Reached ~0.4*0.4 m^2 , going towards 0.5*1.0 m^2
  - GEM foil production
    - Successfully produced a 30*30 cm^2 foil. Working on improving production process for a higher rate of quality foils.
  - GEM readout systems
    - APV25-based “INFN” readout system works now in principle. The whole cluster will benefit from it.
    - Other readout systems developed/established/being designed