Large-area GEM chambers at USTC

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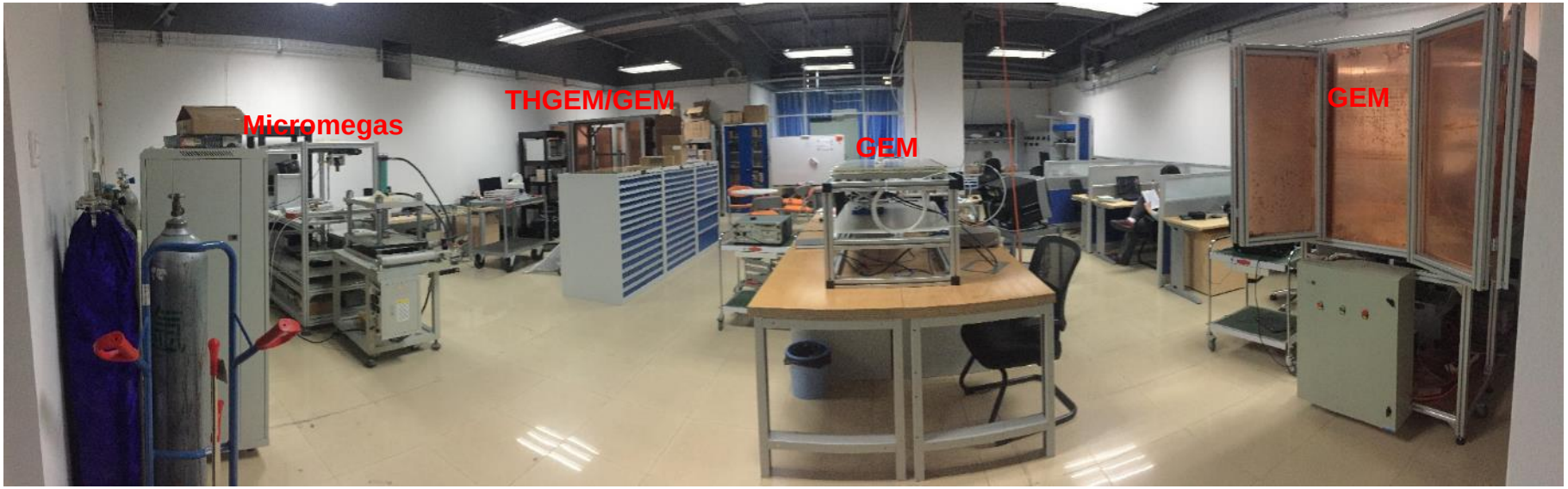
Outline

- **Introduction to our detector laboratories**
- **Work of the GEM detectors**
  1. 30cm×30cm GEMs with NS2 technique
  2. First prototype of 100cm×50cm GEM
  3. Stretching studies of the large-area GEM
  4. An improved 100cm×50cm GEM prototype
- **Work of Micromegas**
- **Summary**

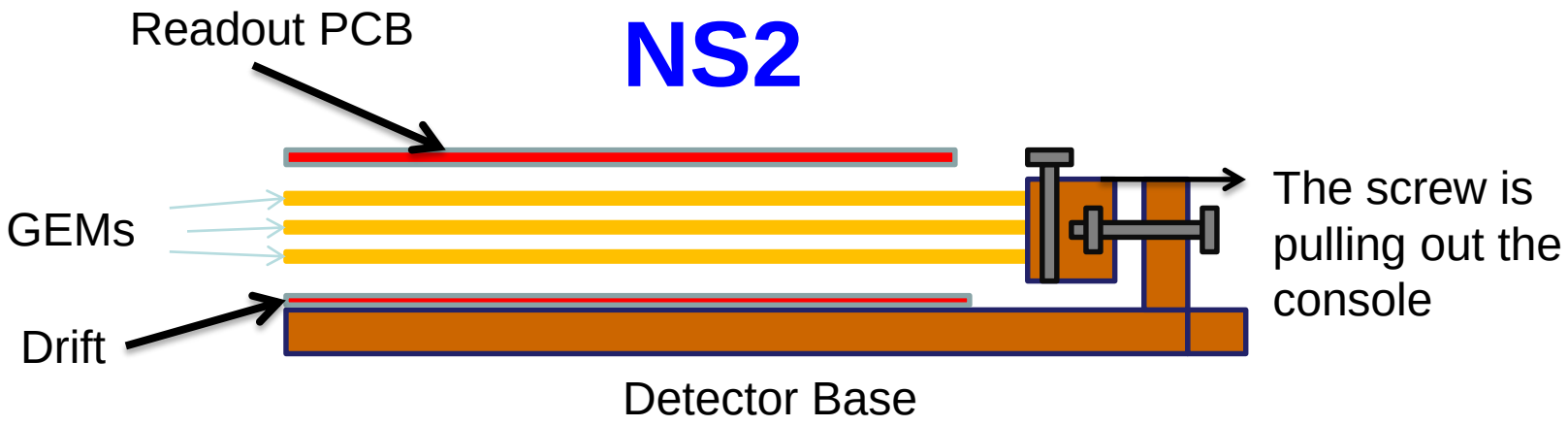
Detector Division
State Key Laboratory of Particle Detection and Electronics



MPRC Activities: STAR TOF Tray, STAR MTD, BESIII Endcap TOF, CBM Prototypes
PMT/Scintillator/SiPM Activities: LHAASO WCDA&MD, HIEPA, ADS
MPGD Activities: R&D of GEM and Micromegas, SoLID 12GeV upgrade(large-area GEM tracker)

NS2 Self-stretching technique

We learned the NS2 technique from RD51 lab and CMS GEM group at CERN in 2012

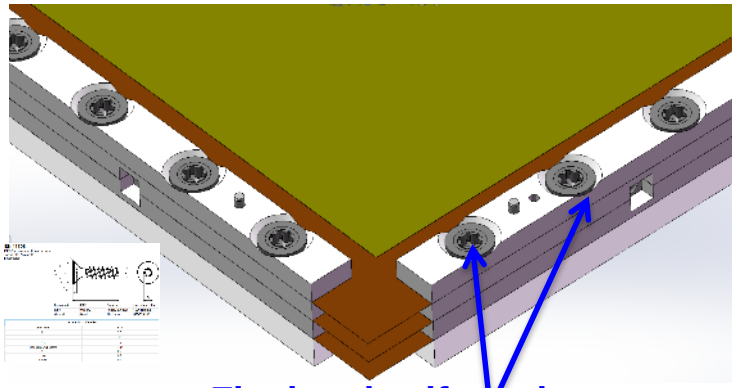


May ~ June, 2012, CERN

Design of 30cm×30cm self-stretching GEM

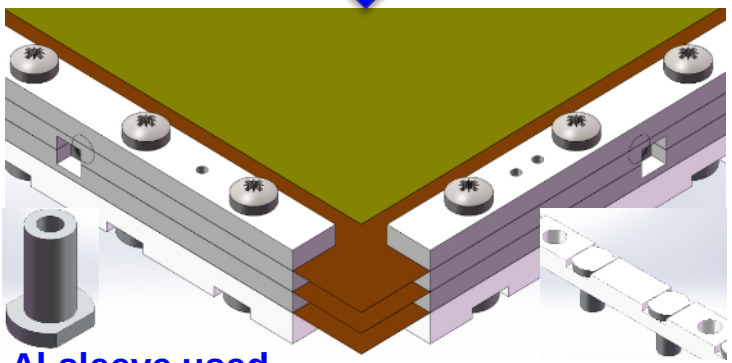
(V1→V2)

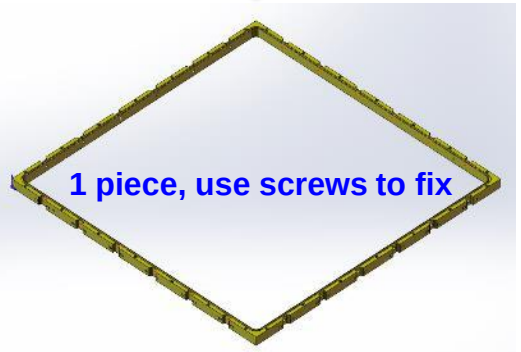
Framed GEM foils

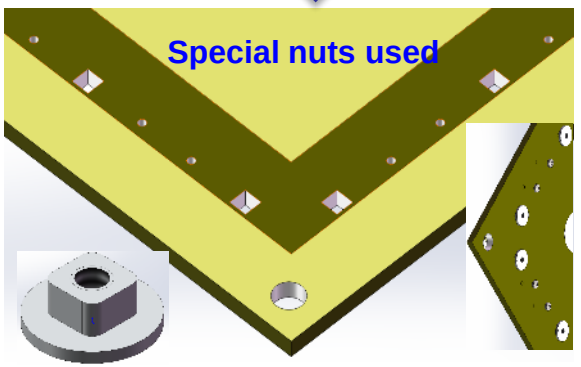


Outside frame

Nuts for readout PCB





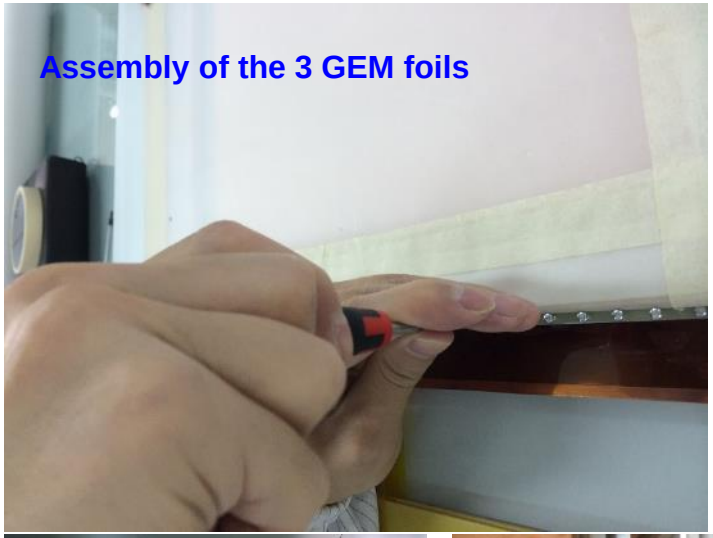


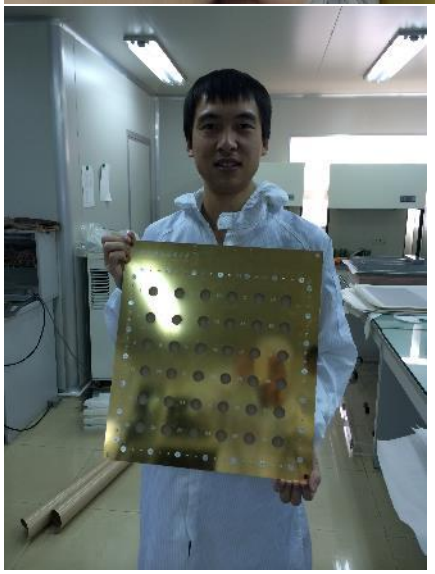
- Avoid the metal dusts dropping into GEM holes
- Avoid the self-tapping screws causing damage to the stretching frame

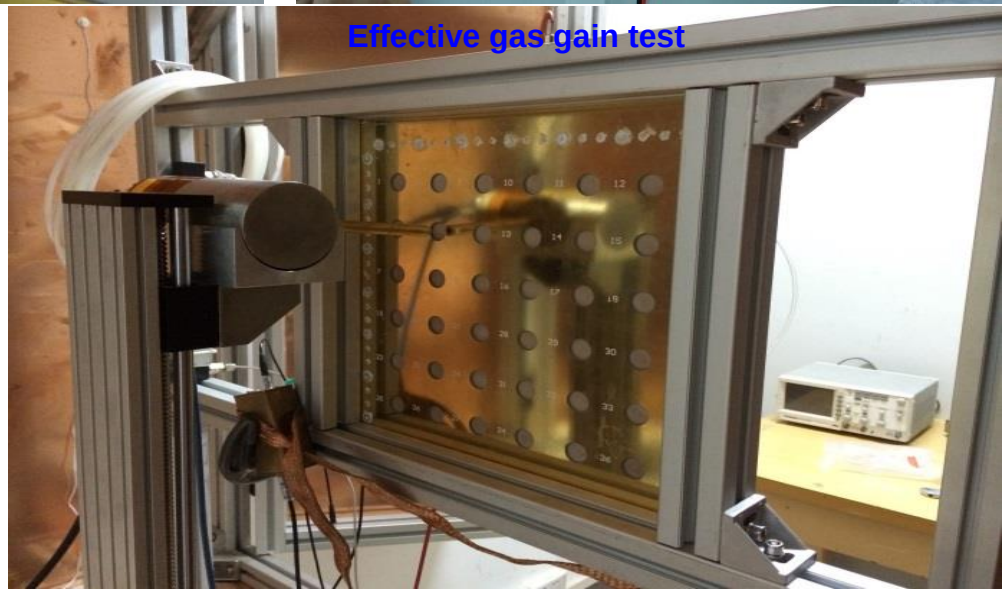
- Use screws to fix the outside frame, avoid the gluing procedure
- Decreased the assembly time

- Avoid the deformation of the drift PCB

Assembly of 30cm×30cm self-stretching GEM



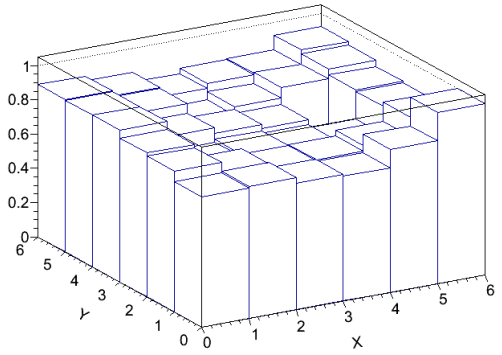




Gain uniformity test

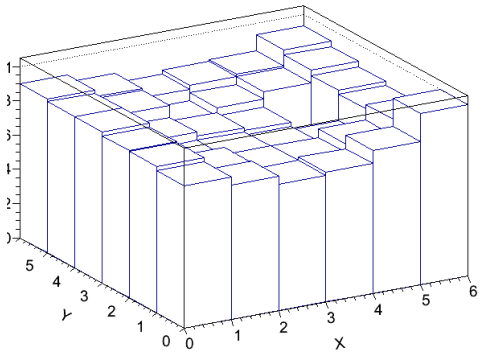
HV scans from 3900V to 4100V

Gain Uniformity 3900V



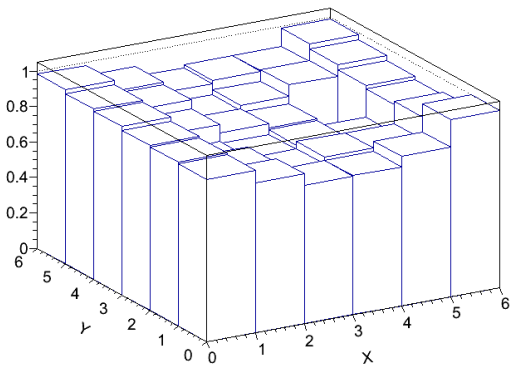
Max: 23.6%; Min: -13.8%; Variation = 8.8%

Gain Uniformity 3950V



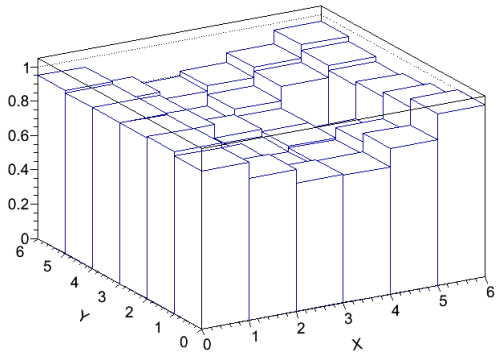
Max: 23.0%; Min: -14.5%; Variation = 8.6%

Gain Uniformity 4000V



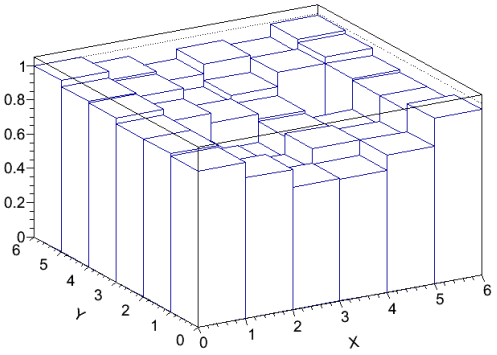
Max: 15.5%; Min: -13.5%; Variation = 8.6%

Gain Uniformity 4050V

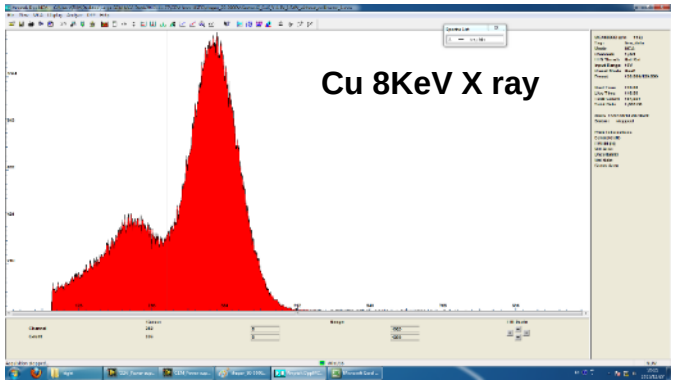


Max: 20.0%; Min: -15.5%; Variation = 10.8%

Gain Uniformity 4100V

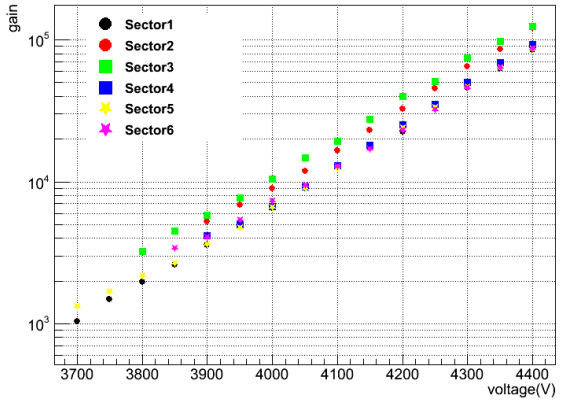


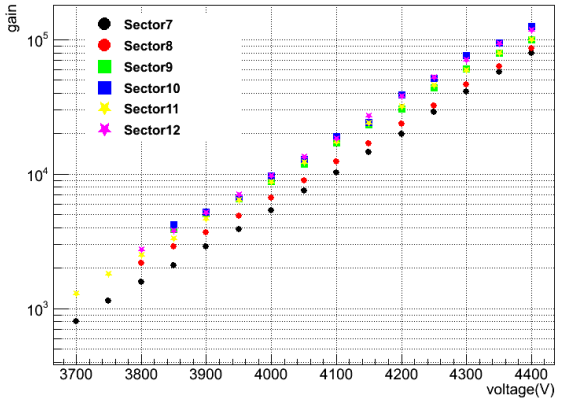
Max: 16.1%; Min: -23.11%; Variation = 11.0%

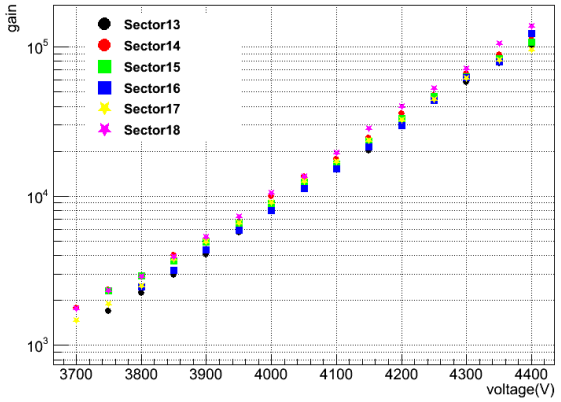


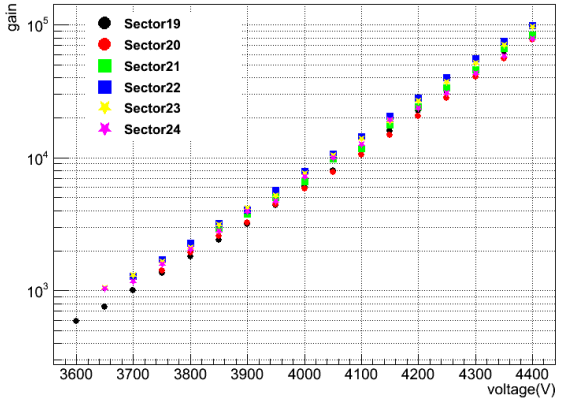
$$\text{Variation} = \frac{\text{Std. Deviation}}{\text{Average}} \times 100\%$$

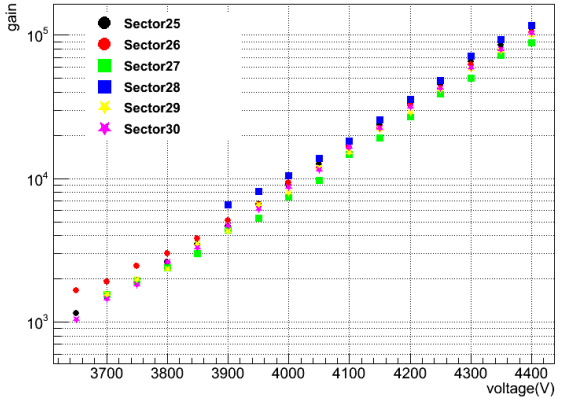
Effective gas gain .VS. HV

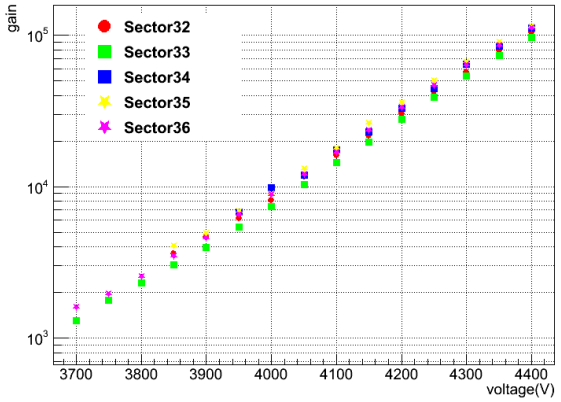








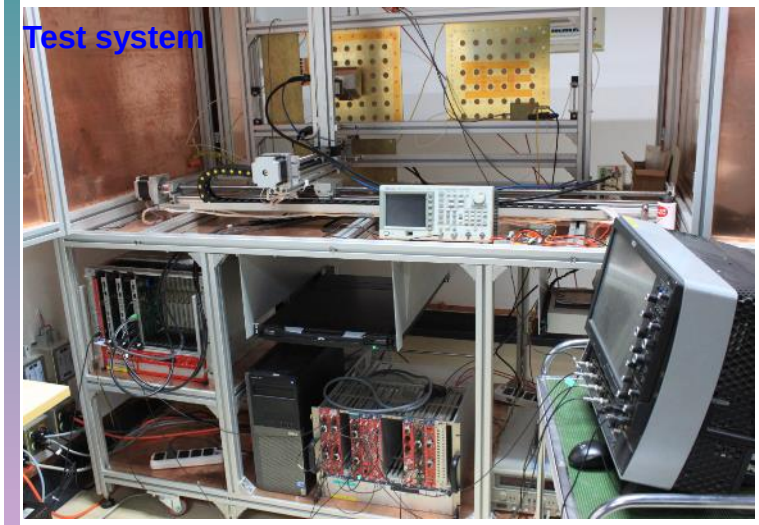


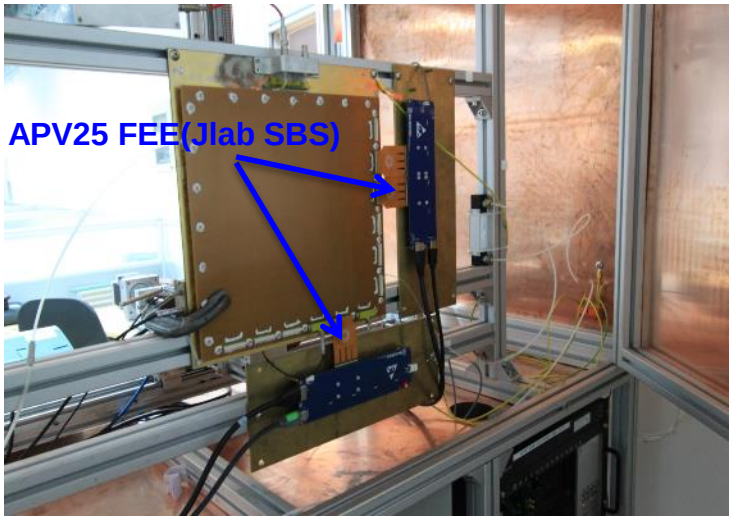


HV scans from 3700V to 4400V, the gain exponentially increases with the HV

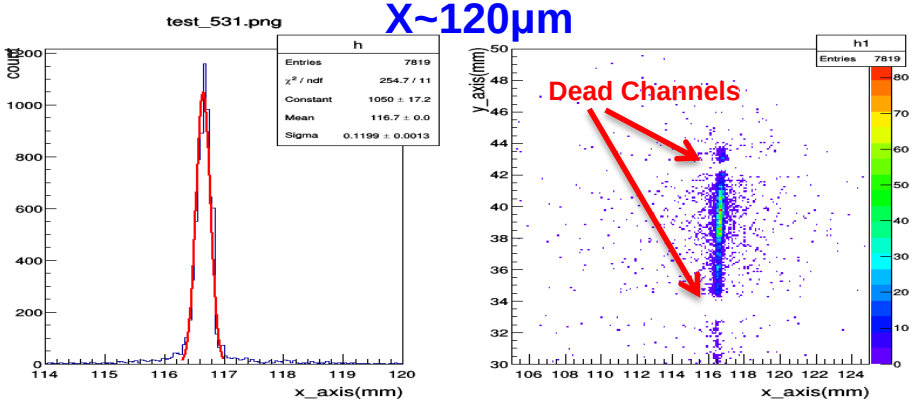
First test for position resolution

image of a 50μm slot

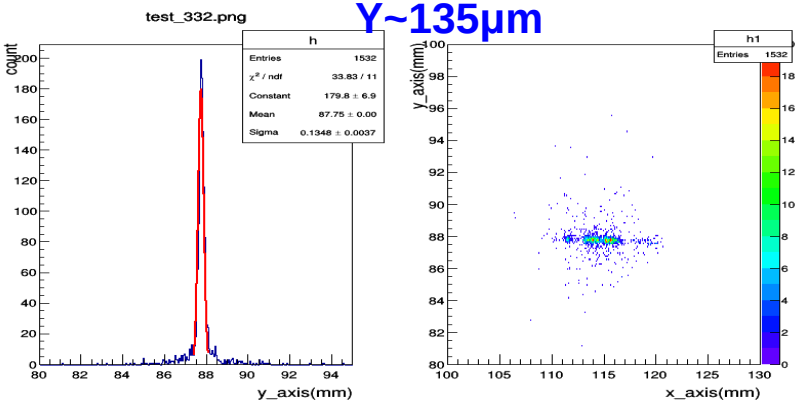




X~120μm



Y~135μm

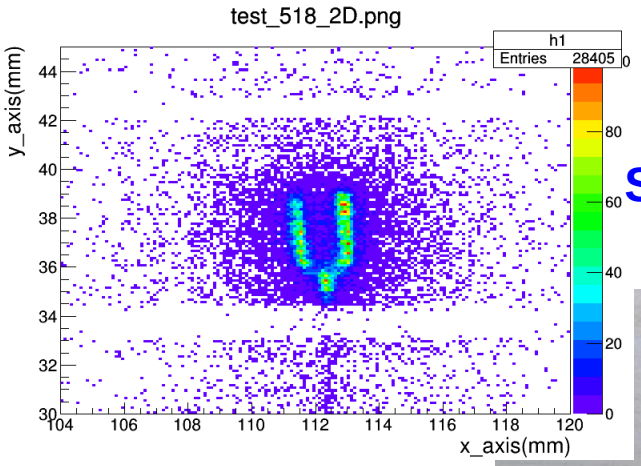


Next step:

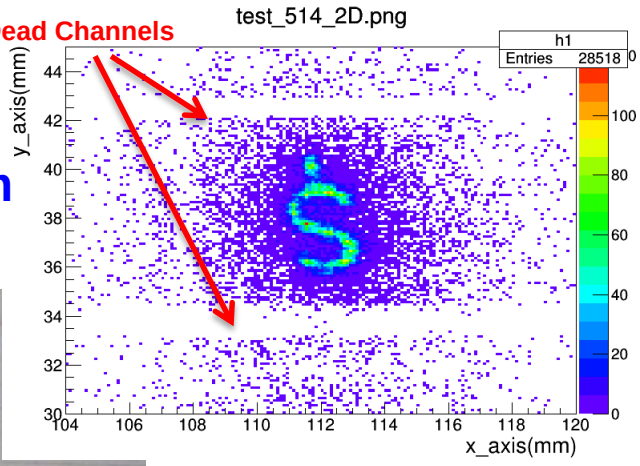
- **Use a foil window instead of the PCB**
- **Use a pre-amplifier which has fast rise time for the trigger signal**

X-ray imaging test

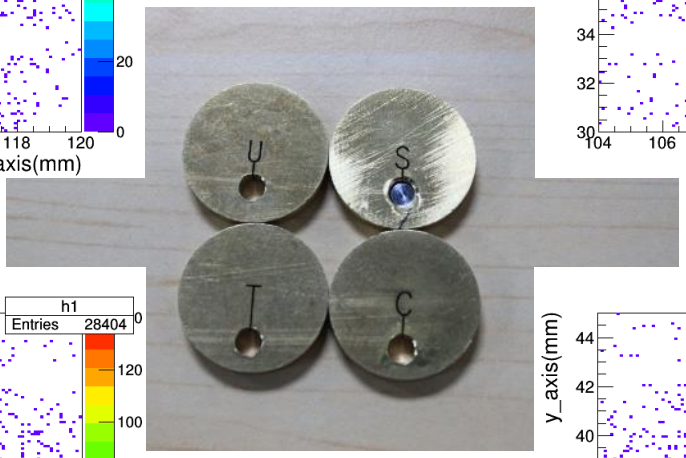
2D Image of “USTC”

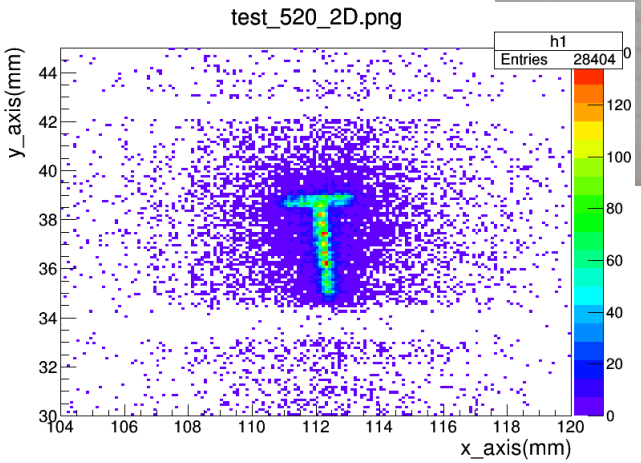


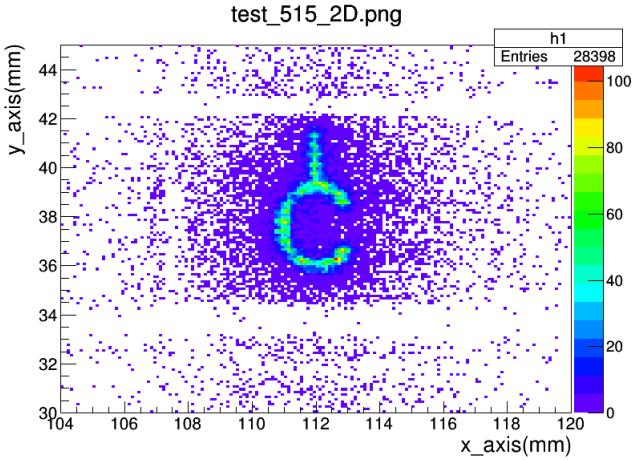
Dead Channels



Slot width: 0.2mm

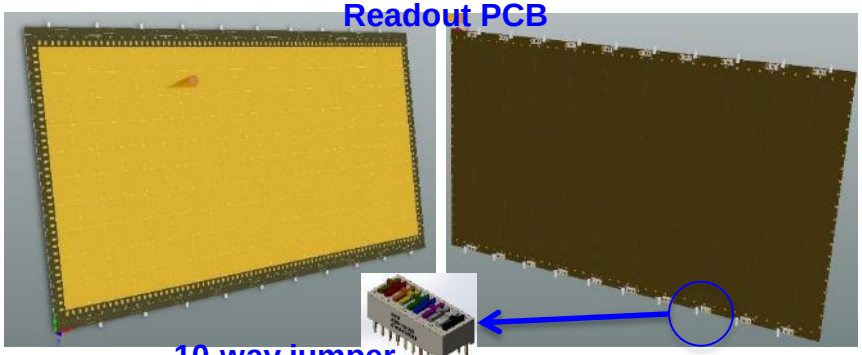


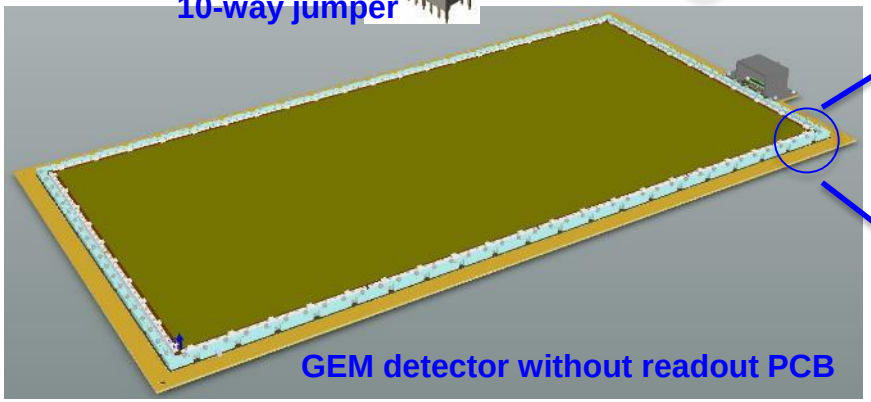


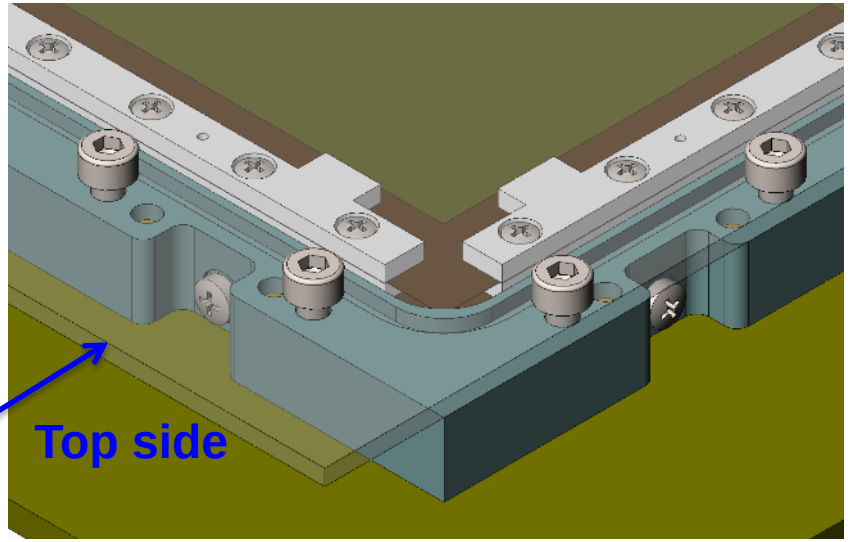


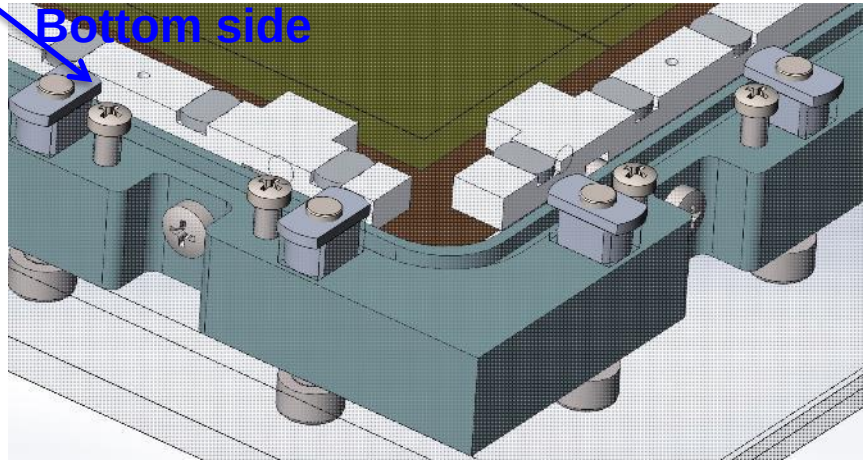
The dead channels may be caused by soldering problems, we are going to check soon

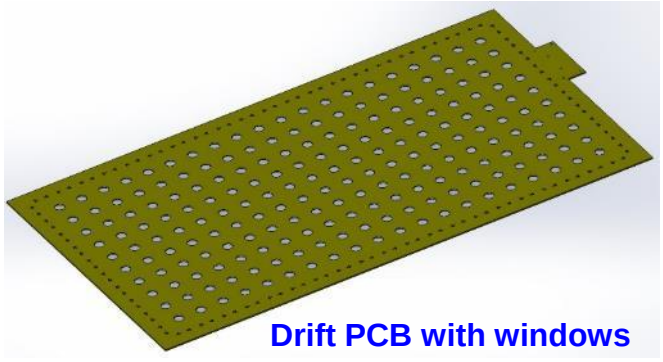
Design of 100cm×50cm GEM (V1)





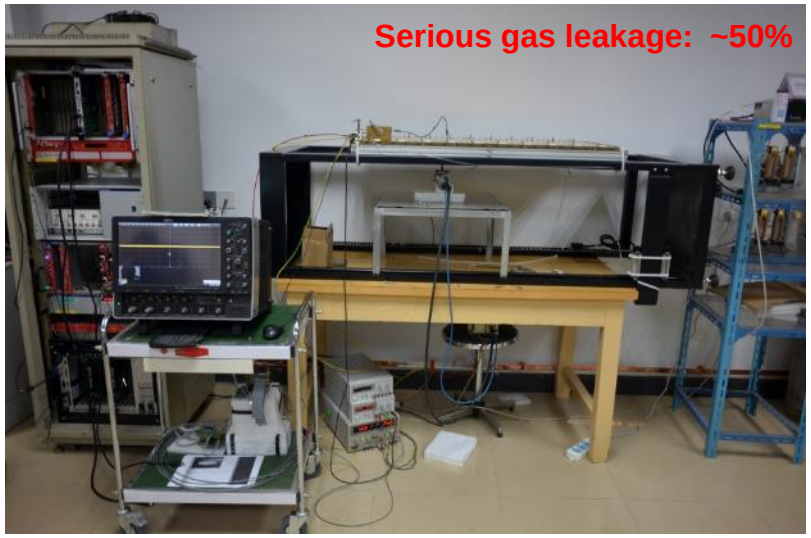


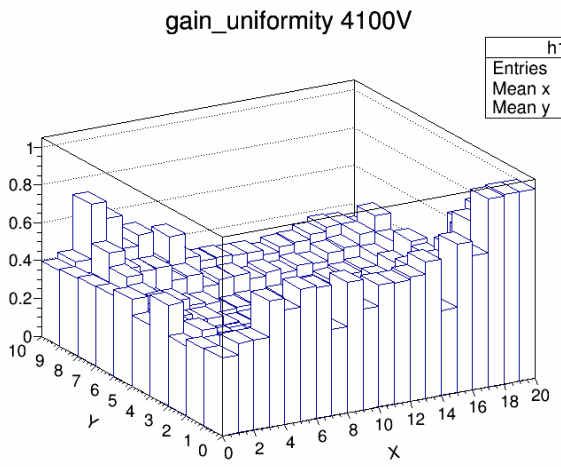




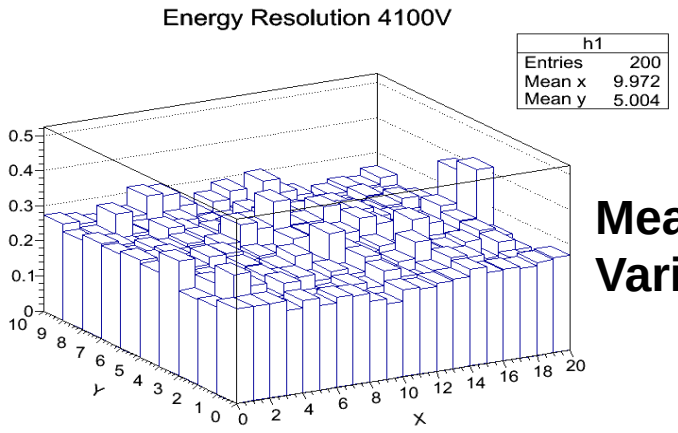
Gain Uniformity test (V1)

Variation= σ/Mean

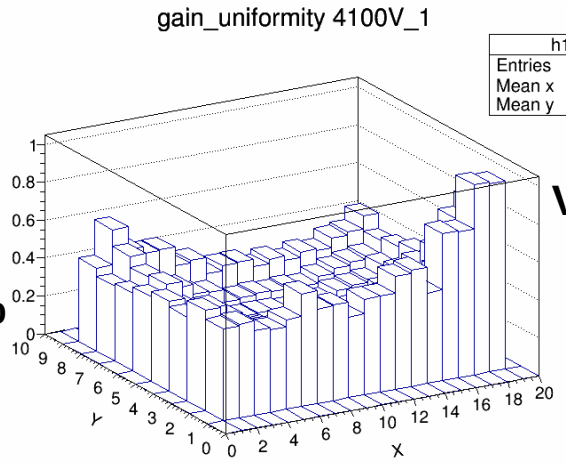




Variation=51%

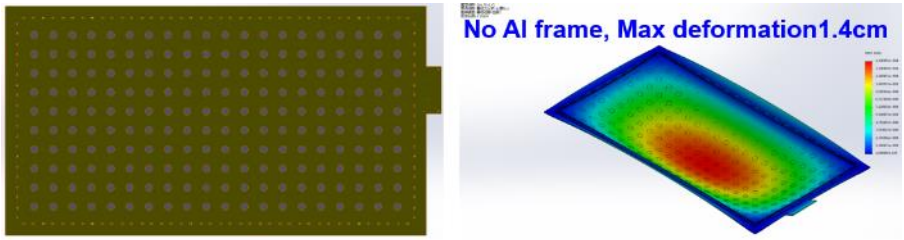


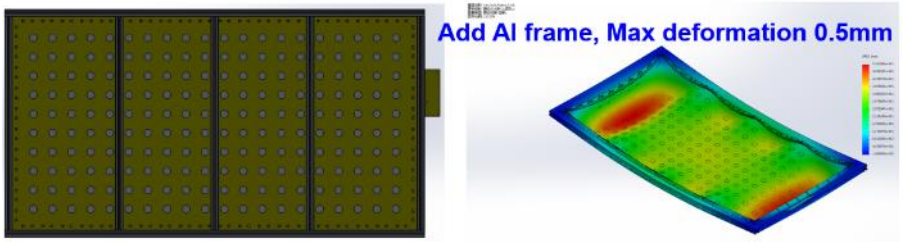
Mean=26.7%
Variation=11%

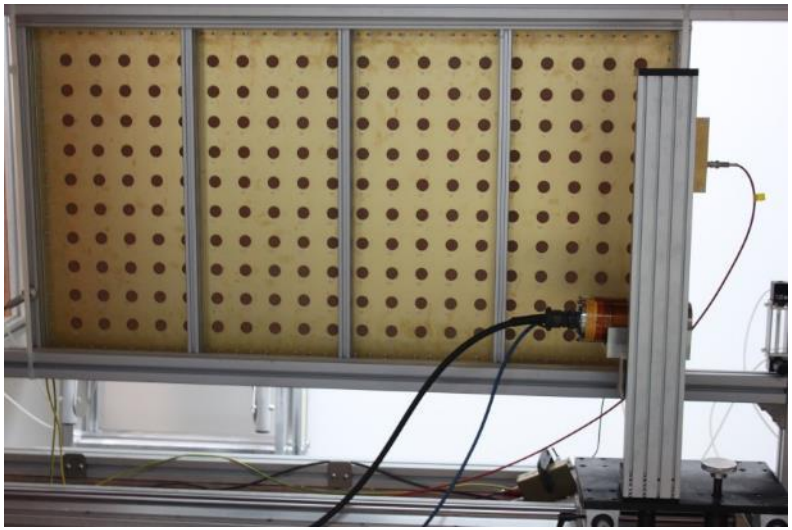


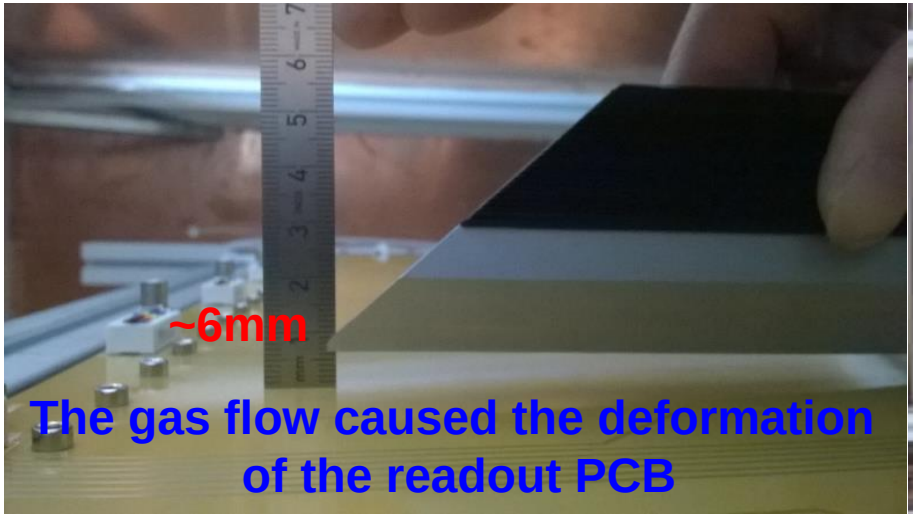
Variation=44%

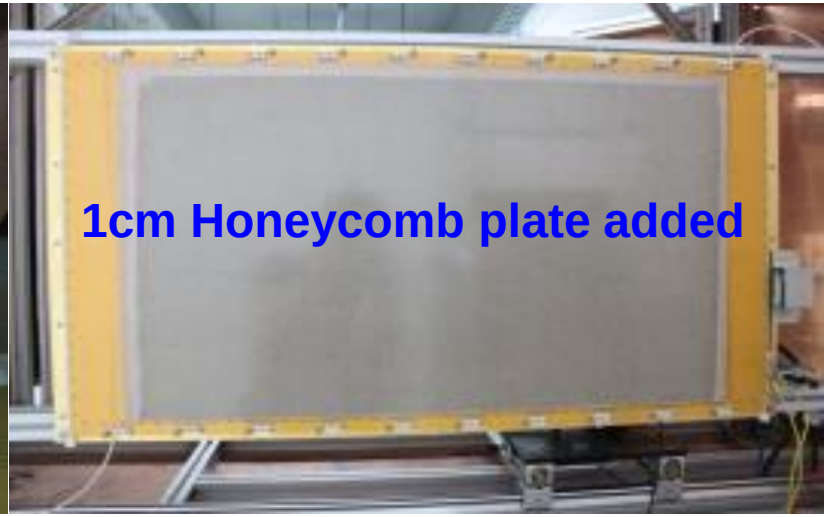
Deformation and Solution





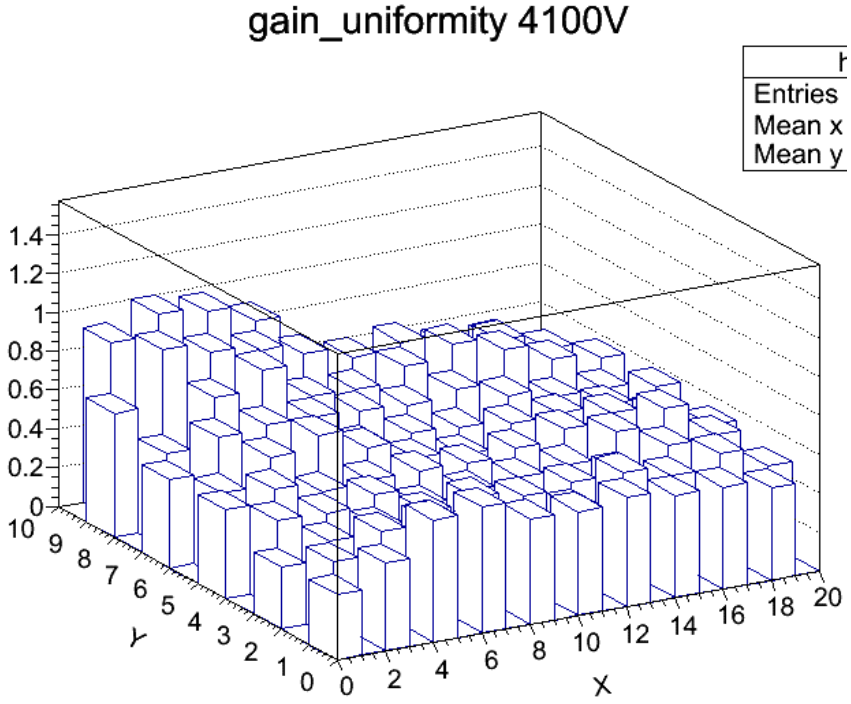




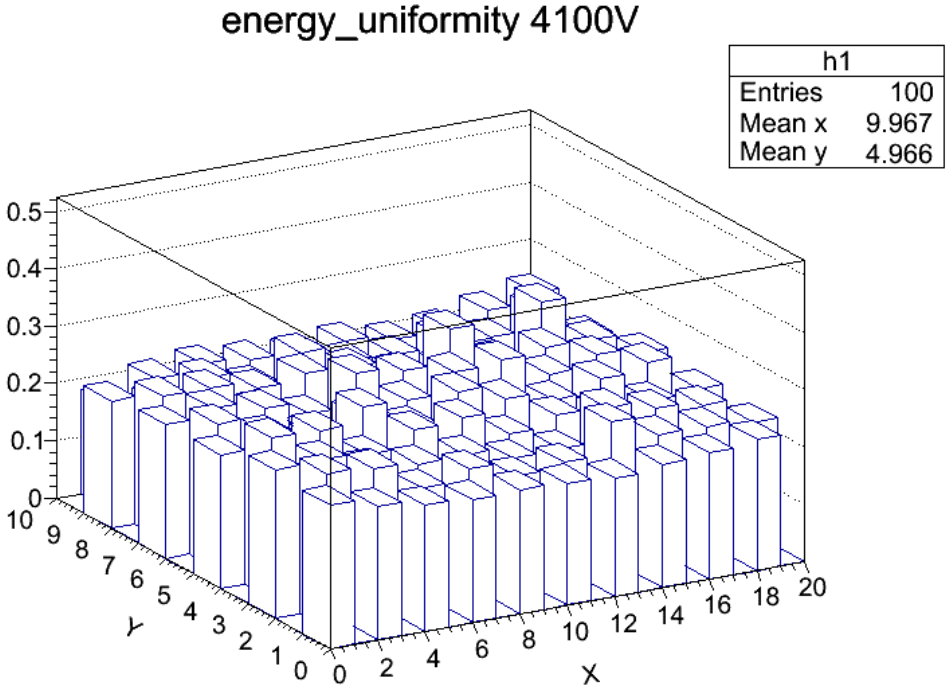


Gain Uniformity (deformation solved)

Variation= σ/Mean



Variation=23.3%



Mean=23.4% ;
Variation=9.6%

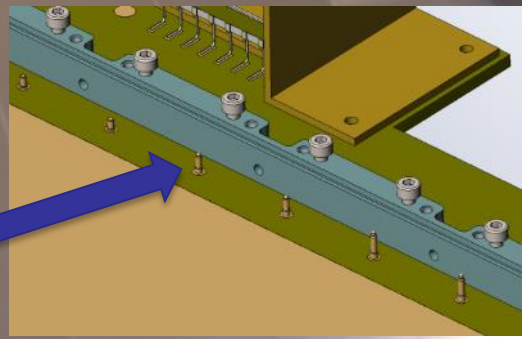
We find that the test of 100 (50%) segments gives almost the same result as the test of 200 (100%) segments.

Problems during the stretching procedure

The stretching screws will be blocked by the outside frame when it moves with the inner frame, and the tilted screws cause the gas leakage.

There is a deformation on the outside frame caused by the pulling of the foils

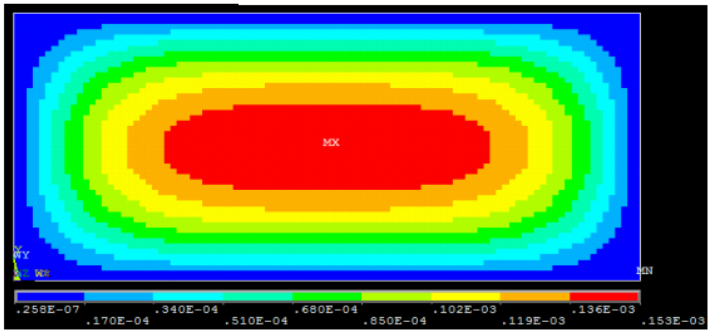
The frames moved a long distance, touched and pushed the spring contactor



Tension simulation and measurement

Ansys simulation:

Detector structure: 3-2-2-2 ; HV: 4000V

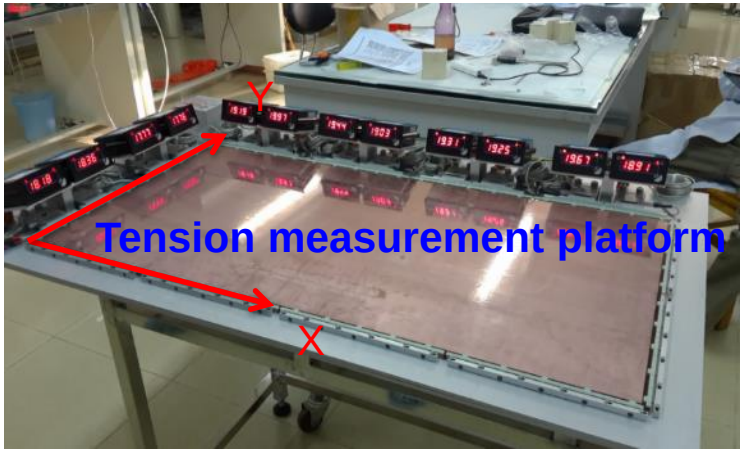


Gap：3mm-2mm-2mm-2mm HV: 4kV

Max deformation .VS. Tension

Tension (N/m)	Max Deformation(μm)	Tension (N/m)	Max Deformation(μm)	Tension (N/m)	Max Deformation(μm)
100	513	250	207	600	86.9
125	412	300	173	700	74.6
150	344	333	156	800	65.3
175	295	400	130	900	58.1
200	259	500	104	1000	52.3

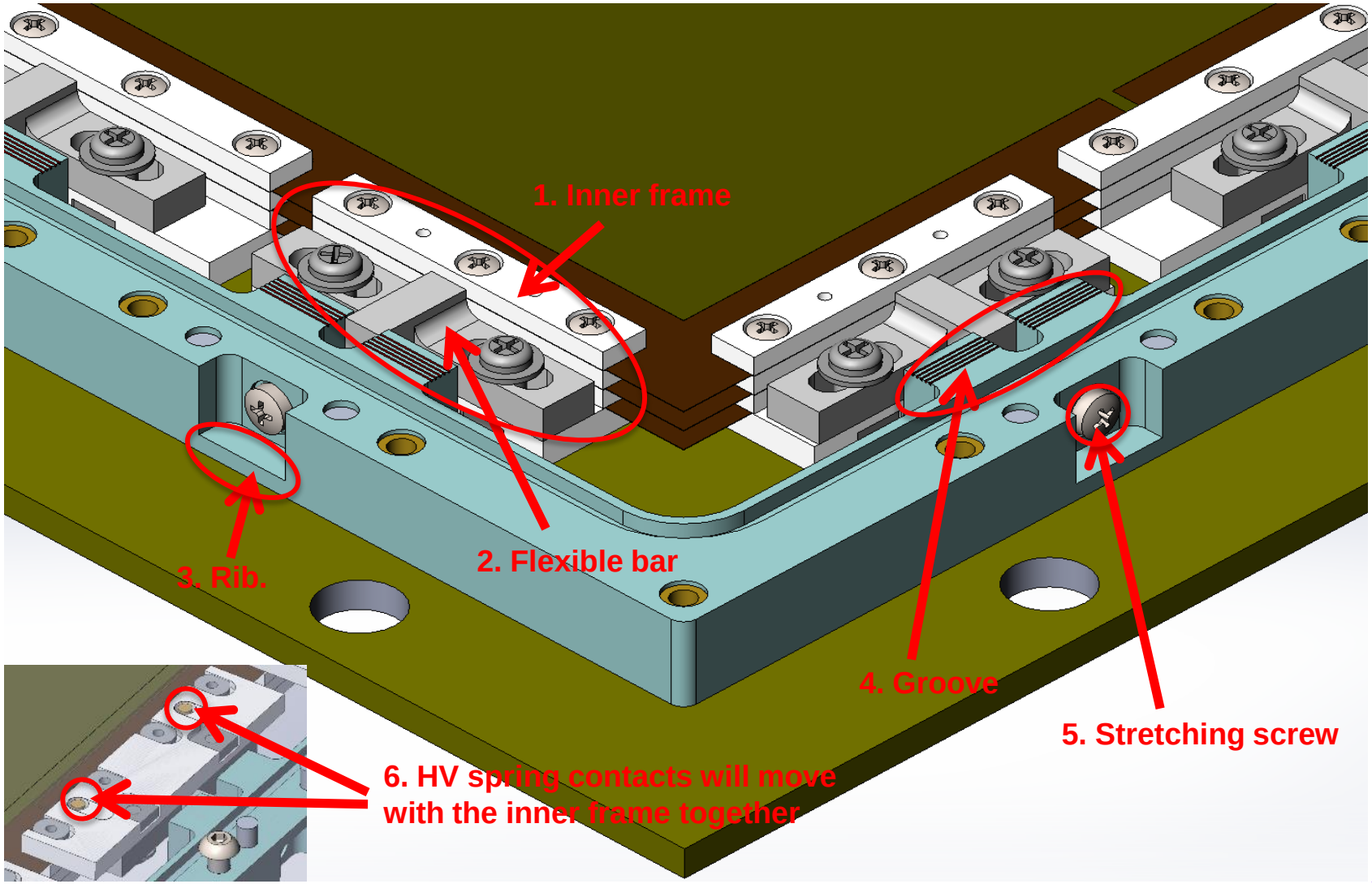
Tension: 0.33kg/cm (3.3N/cm) per foil, Max deformation: ~153um



The actual tension：
X: 0.48kg/cm(4.8N/cm)
Y: 0.39kg/cm(3.9N/cm)；

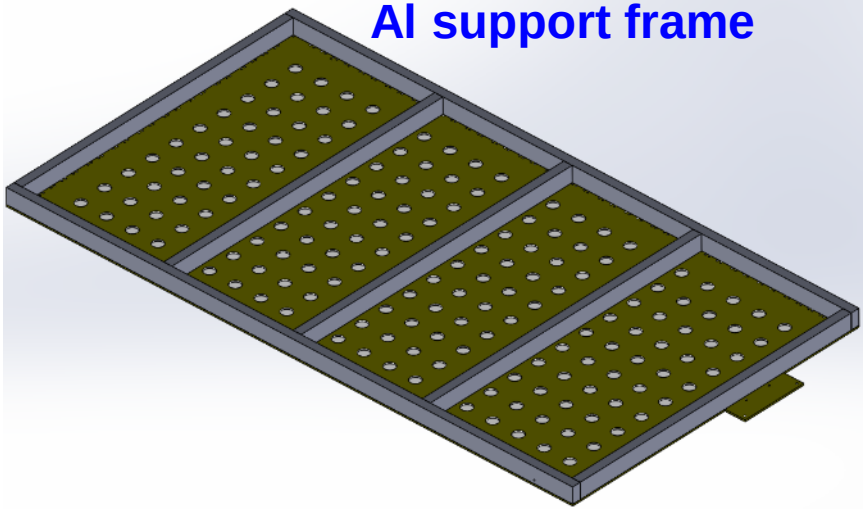
Stretching amount：
X 2.6mm(1.3mm on each side)
Y 1.4mm(0.7mm on each side)

An improved GEM stretching method

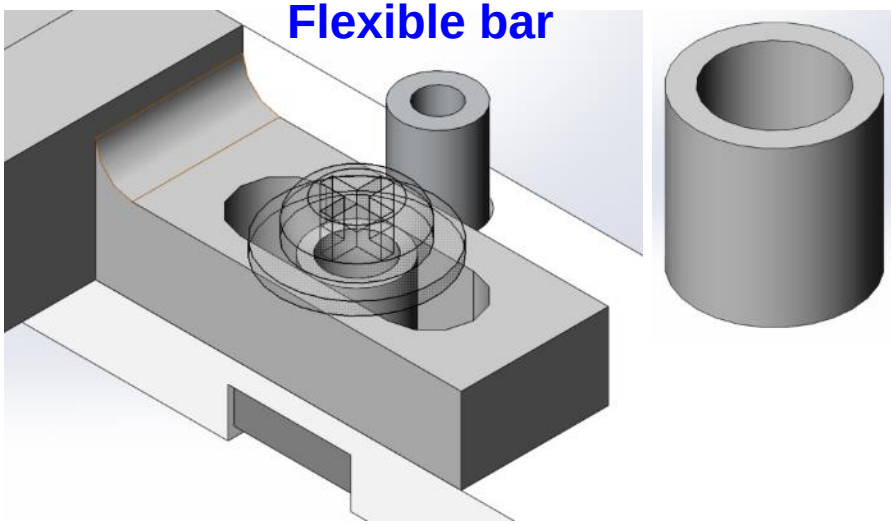


Deformation simulation

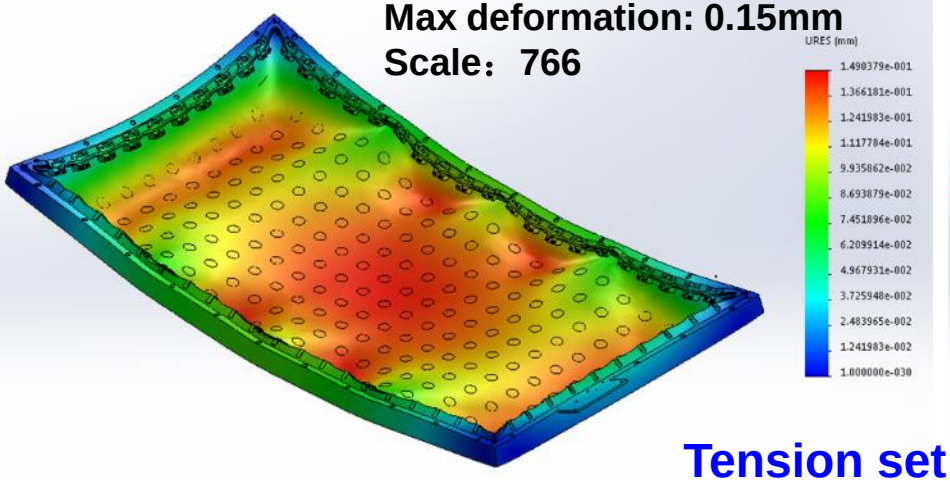
Al support frame



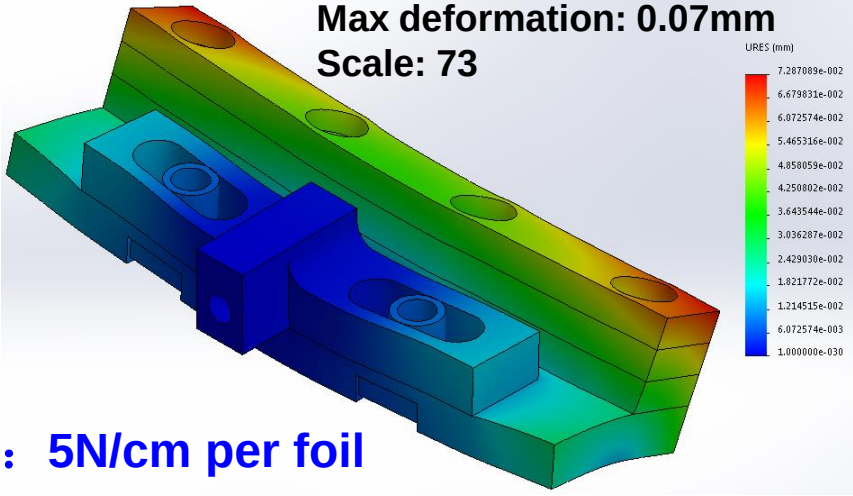
Flexible bar



Max deformation: 0.15mm
Scale：766



Max deformation: 0.07mm
Scale: 73

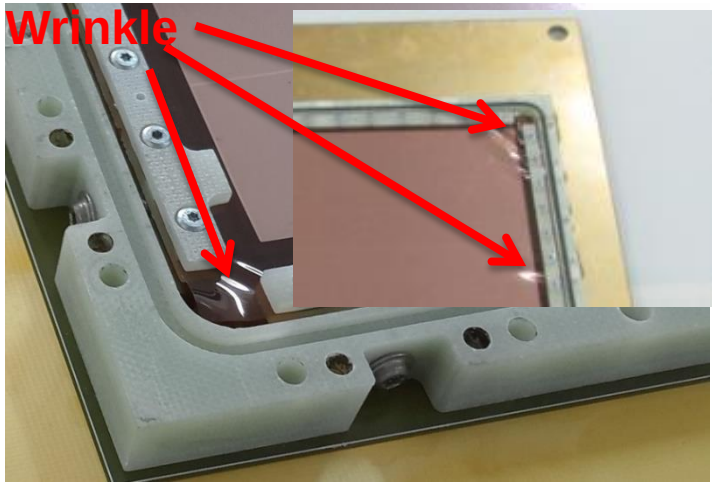


Tension set：5N/cm per foil

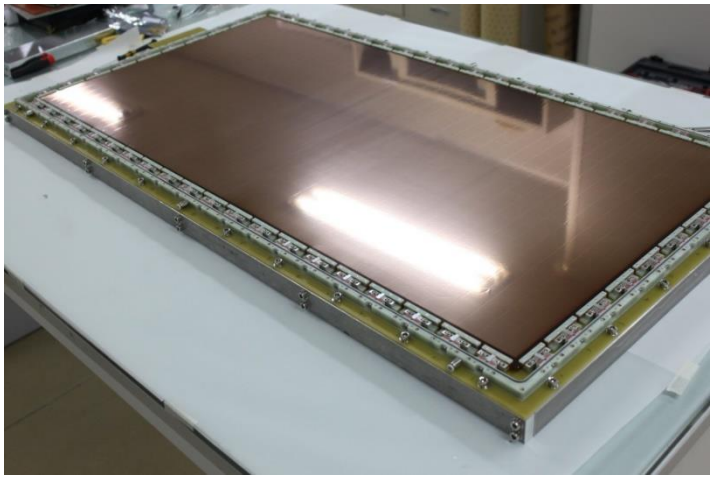
Improvement in foil stretching quality

There is no any wrinkle on the 2nd 100cm×50cm detector (1 week observation)

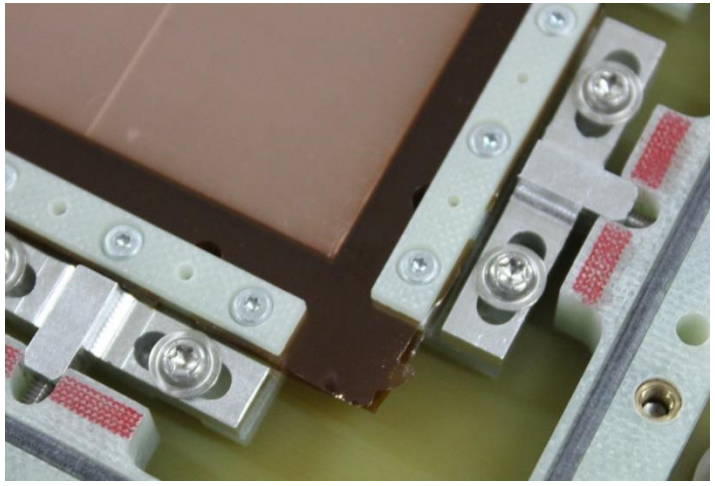
30cm×30cm and 1st 100cm×50cm detector



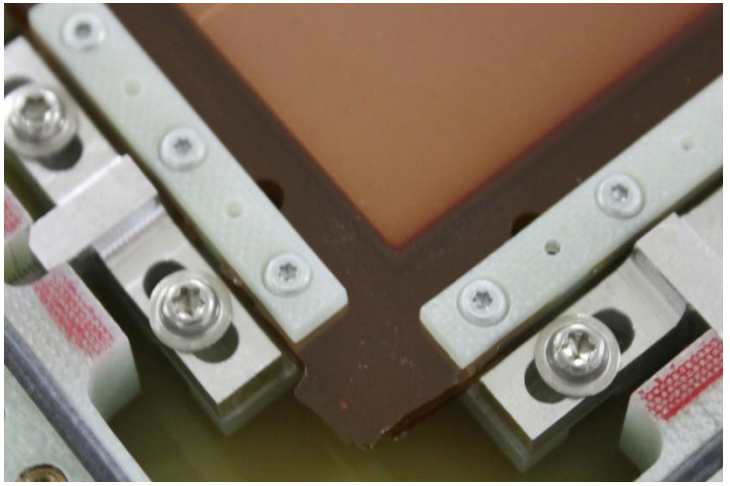
2nd 100cm×50cm detector



2nd 100cm×50cm detector (one corner)

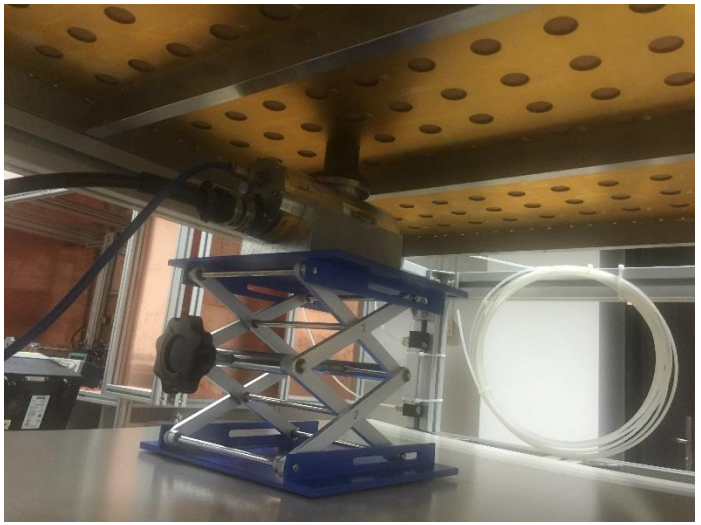


2nd 100cm×50cm detector (another corner)



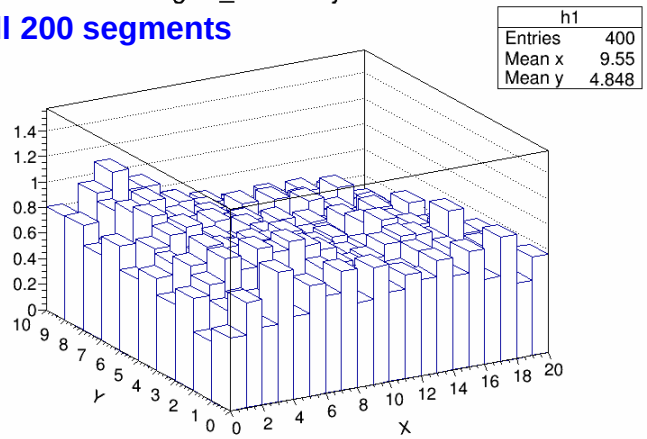
Gain Uniformity test(GEM V2)

Variation= σ/Mean



gain_uniformity 4000V

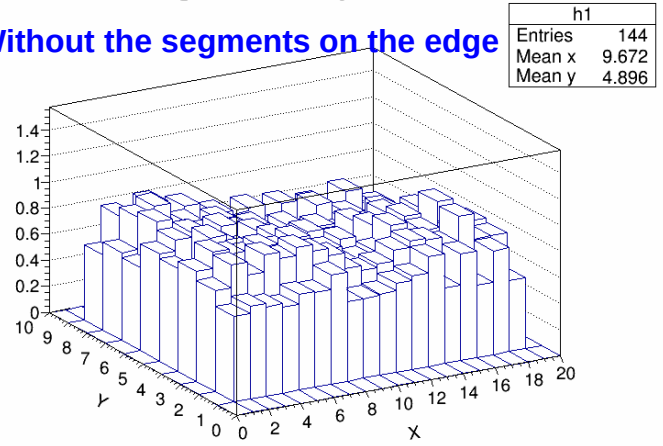
Full 200 segments



Variation=20.6%

gain_uniformity 4000V

Without the segments on the edge

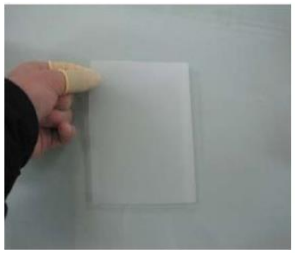
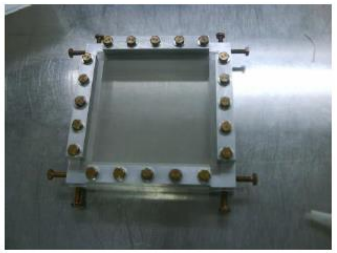
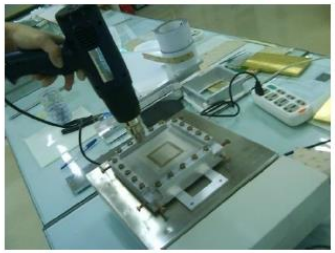
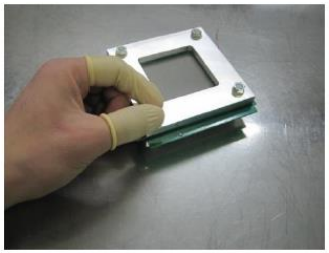
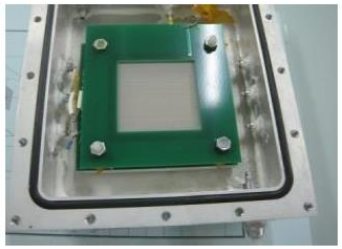


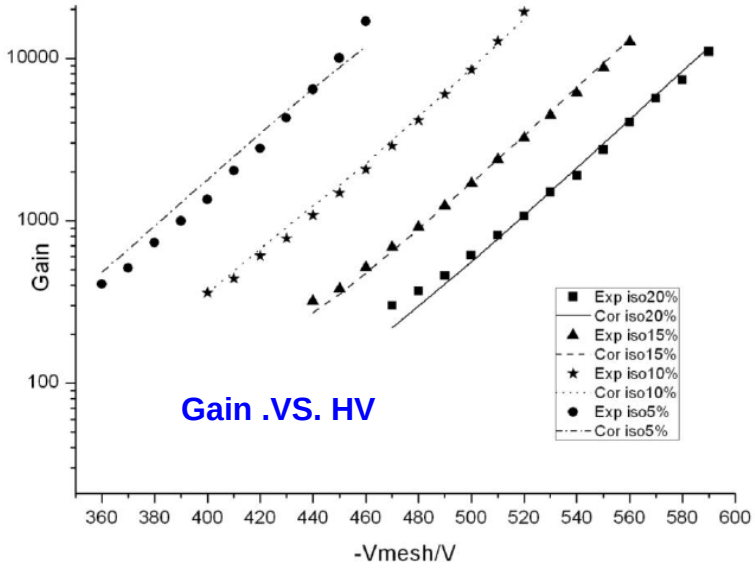
Variation=17.2%

Micromegas assembly method

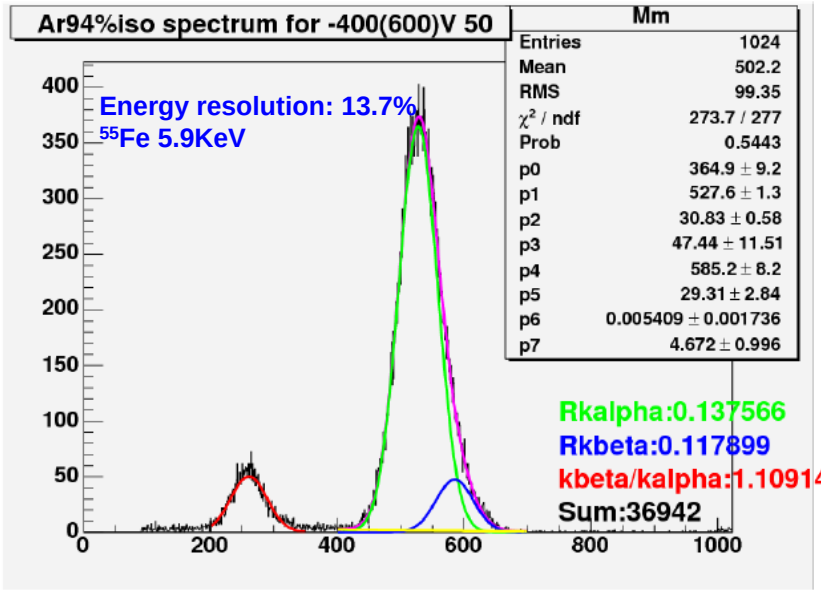
Thermo-bonding method

Thermo-bond film → Mesh stretching → Use hot platen Thermo-attaching → Assembling

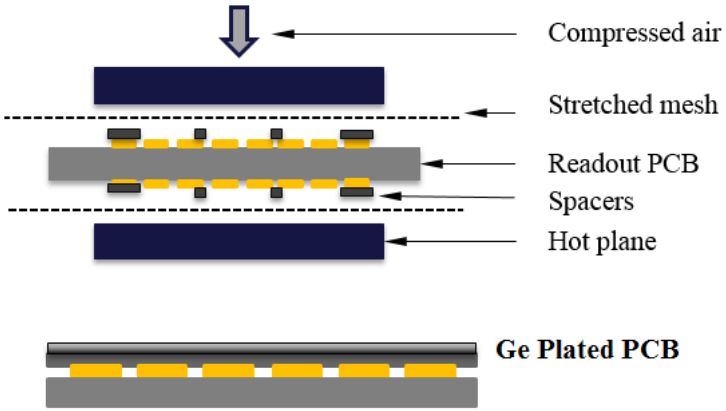






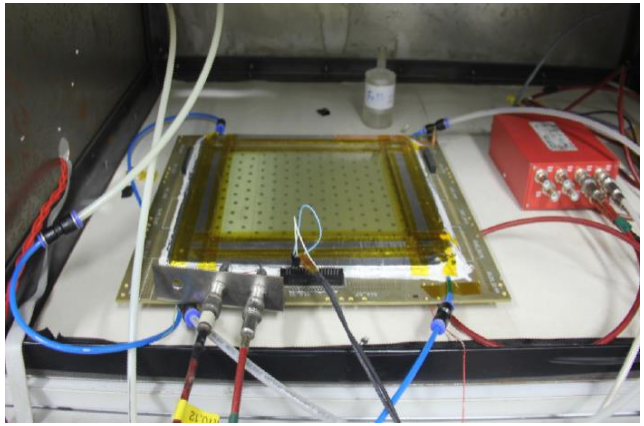


Gain .VS. HV

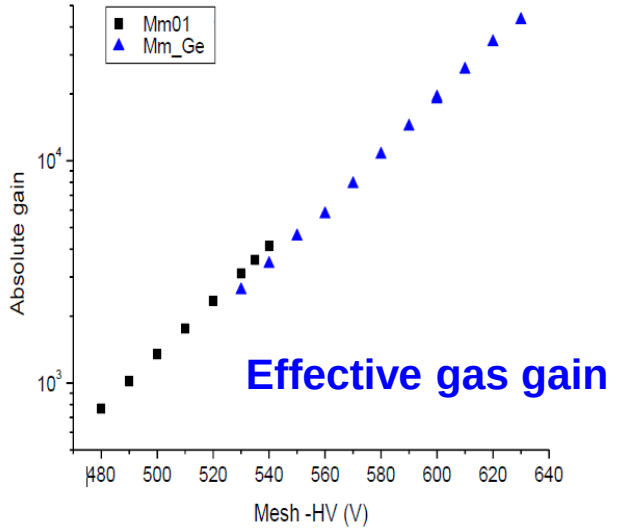


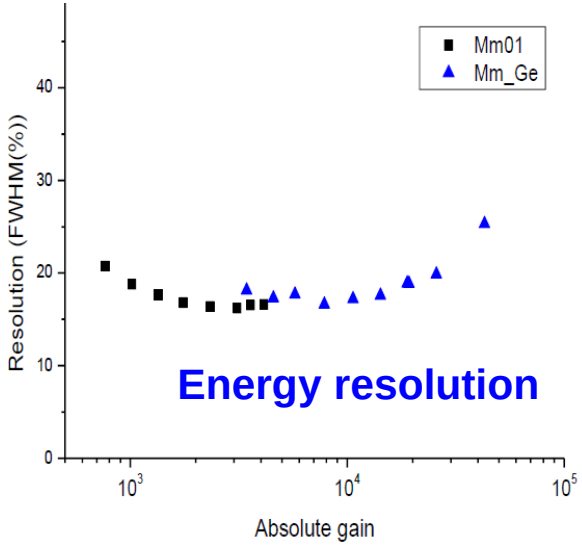
Micromegas with Ge plated anode





20cm×20cm
Ge_Micromegas





Ge_Micromegas: ~5×10⁴
Normal Micromegas: ~5×10³

Best Energy resolution (both): 16%

Summary & near future work

- Very active MPGD R&D at USTC
- We have assembled two 30cm×30cm GEMs, the effective gain and position resolution are tested, they are good but can be improved.
- We have assembled two 100cm×50cm GEMs and developed a improved stretching method. The new method shows many advantages, more detailed tests are undergoing.
- For the X-ray test in our lab, we are going to change the drift PCB to a kapton window, then stretching the drift foil with 3 GEM foils together.
- More activities of the other MPGDs will be started soon.