

A Improved Self-Stretching GEM Assembly Technique — Sliding Self-Stretching

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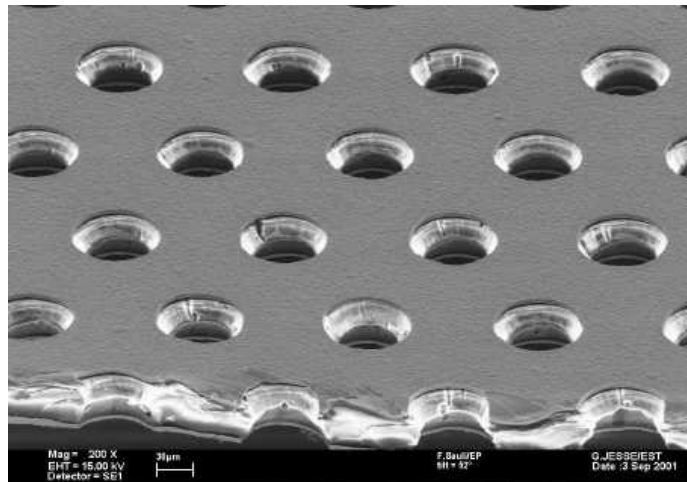
Outline

- Introduction
- Self-stretching technique
- Self-stretching R&D at USTC
- Sliding self-stretching
- Summary

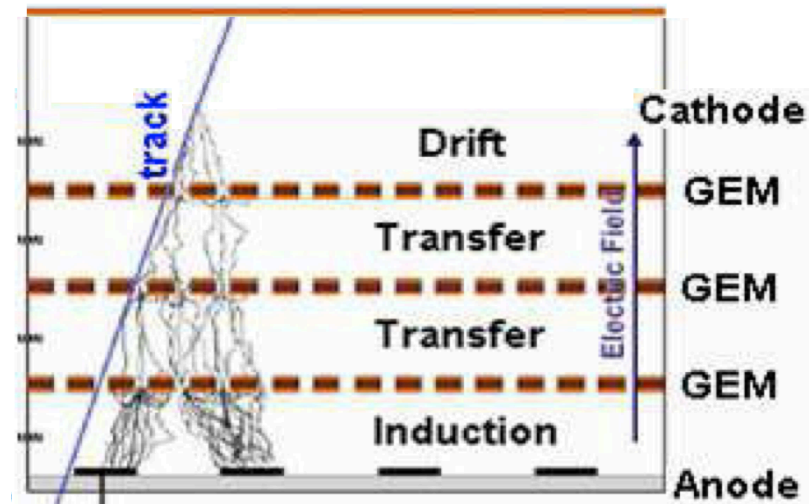
Introduction

- Gas Electron Multiplier (GEM) is one of the most popular micro-pattern gaseous detectors
- Advantages of GEM detectors
 - High rate capability (up to $1\text{MHz}/\text{cm}^2$)
 - Good position resolution ($\sim 100\mu\text{m}$)
 - Low mass and low cost

GEM foil

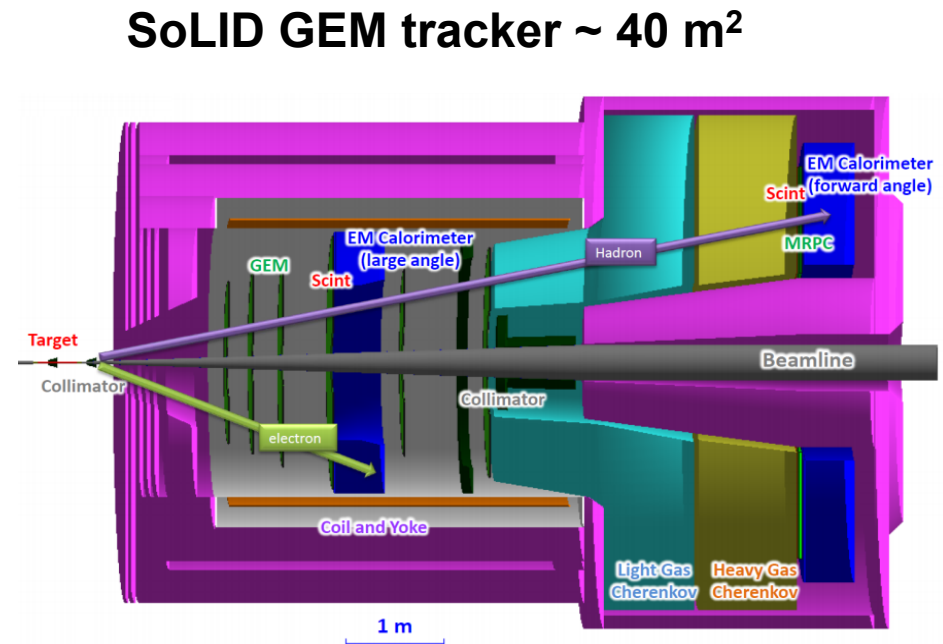
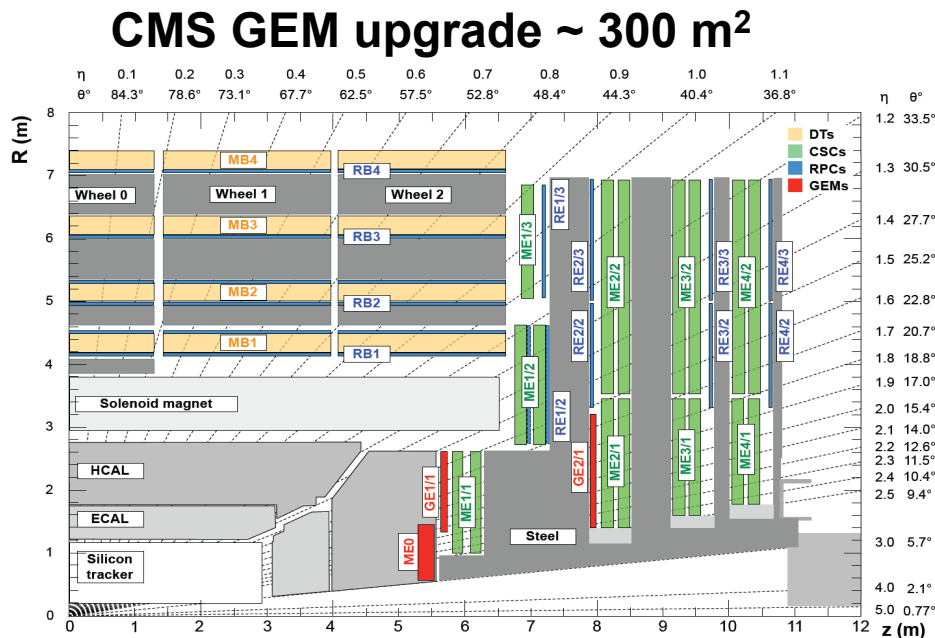


GEM operation principle

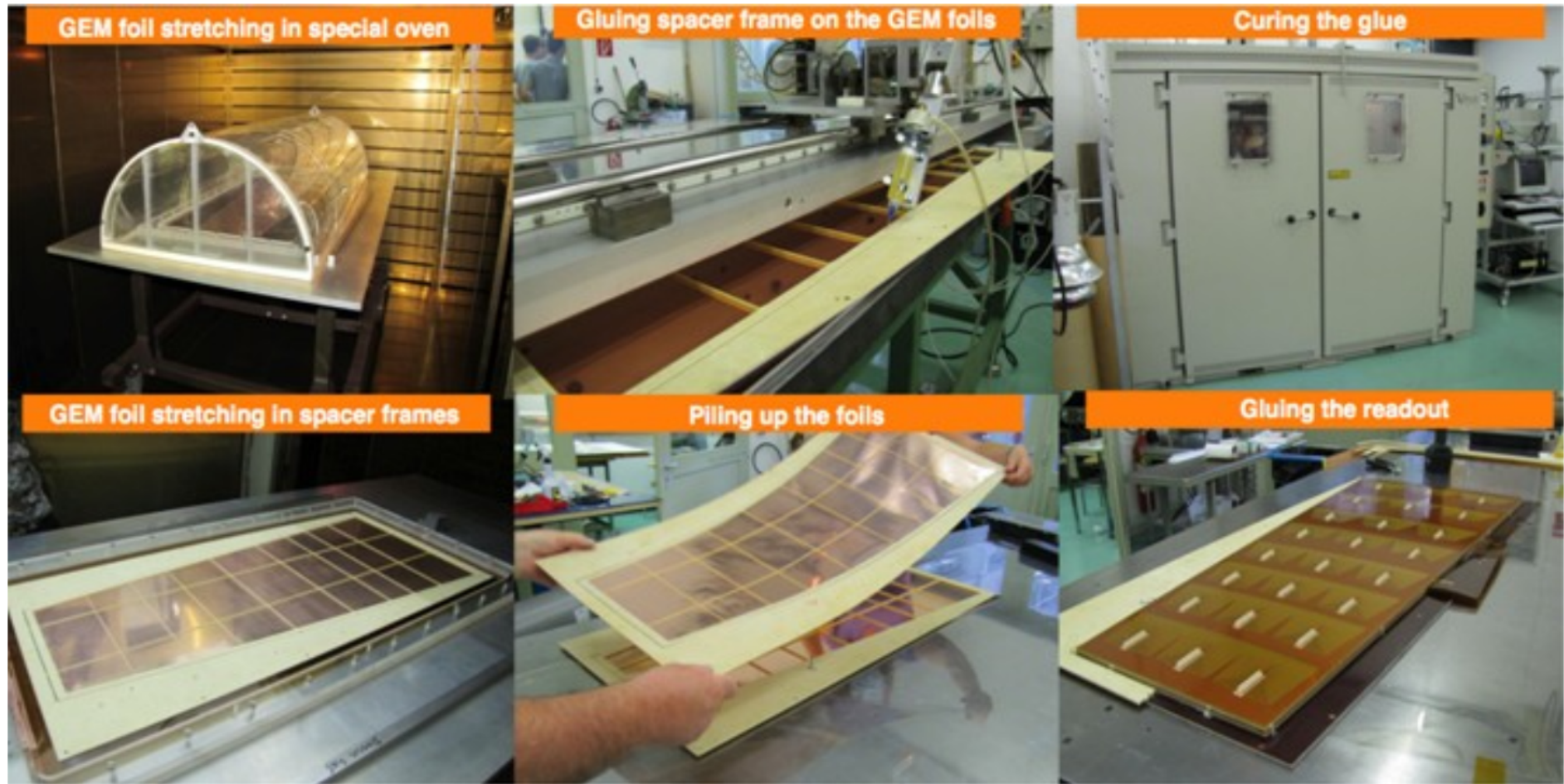


Large-size GEM

- A low-mass and cost-effective solution to high-precision and large-area tracking at high-rate and large-scale experiments such as CMS and SoLID.
 - **Key:** large-size ($\sim 1 \text{ m}^2$) GEM assembly



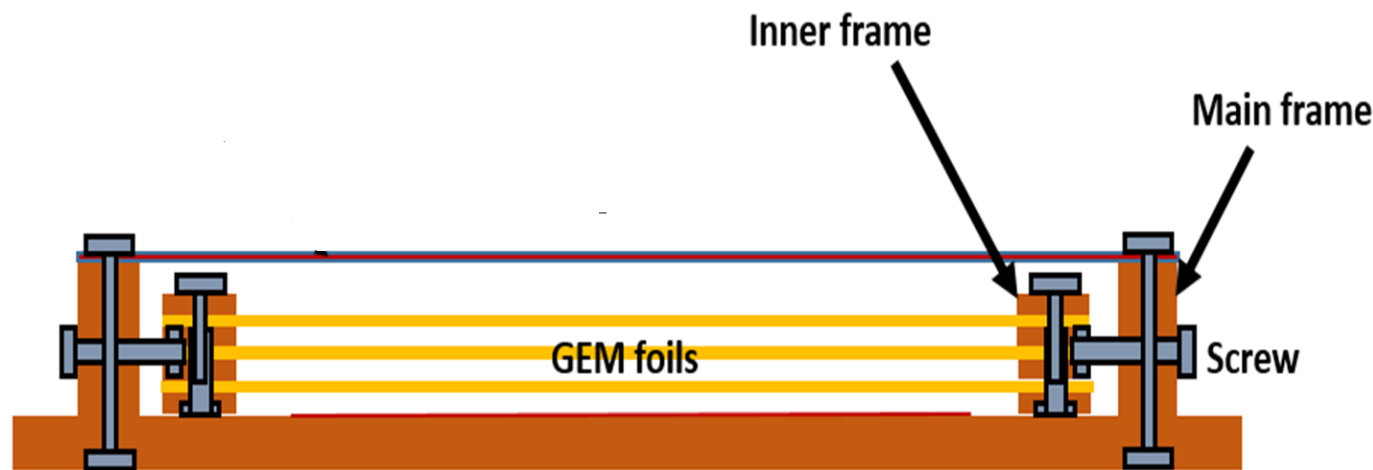
GEM Assembly by Gluing



Assembly time for one chamber ~ 1 week! And impossible to reopen for repairs. Have to find an alternative technique.

Self-Stretching Assembly

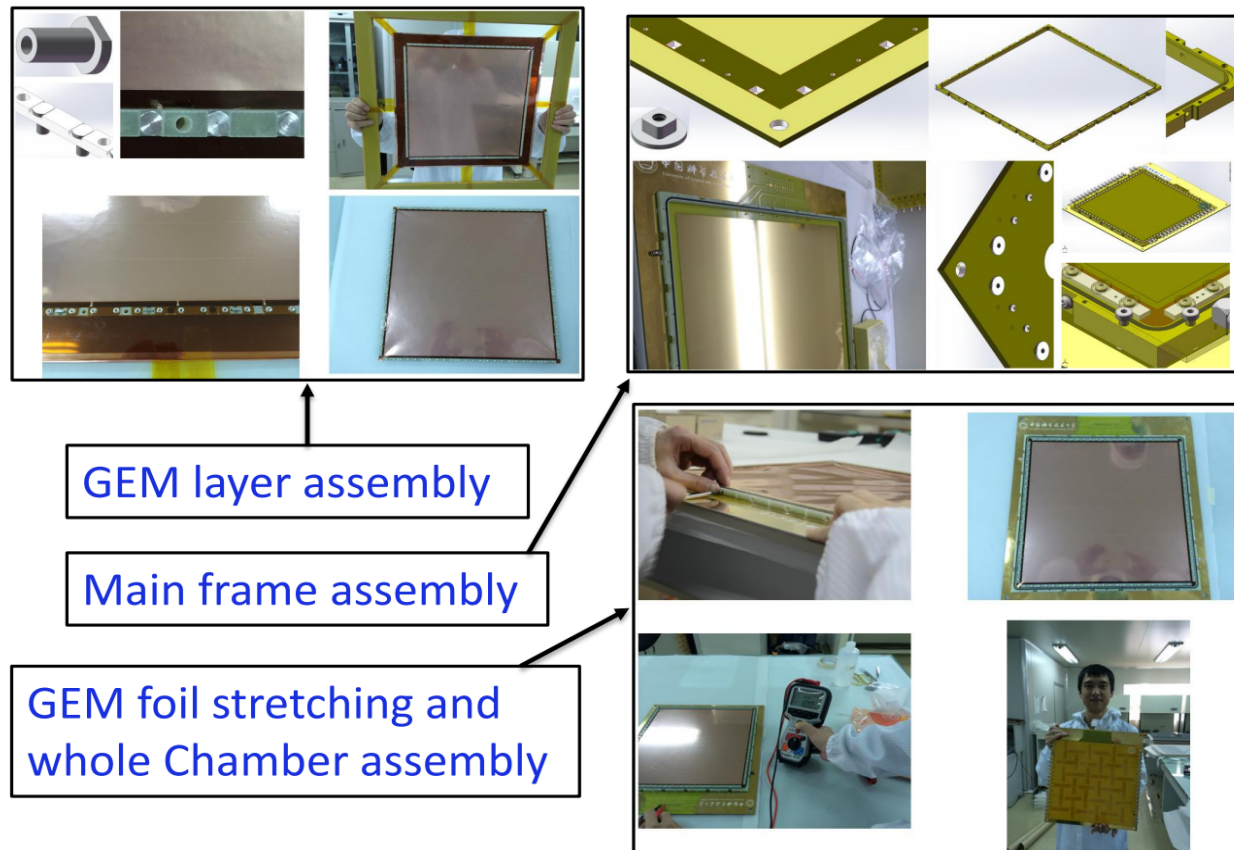
- A purely mechanical GEM assembly technique developed at CERN for the CMS GEM upgrade project.



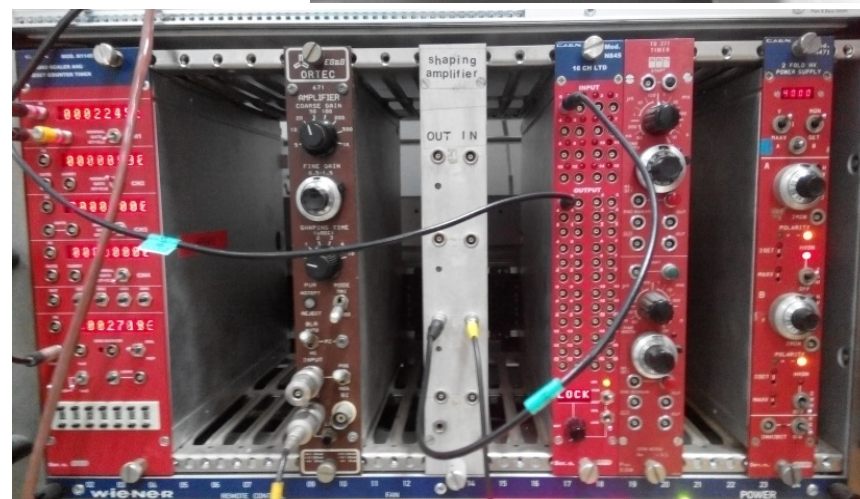
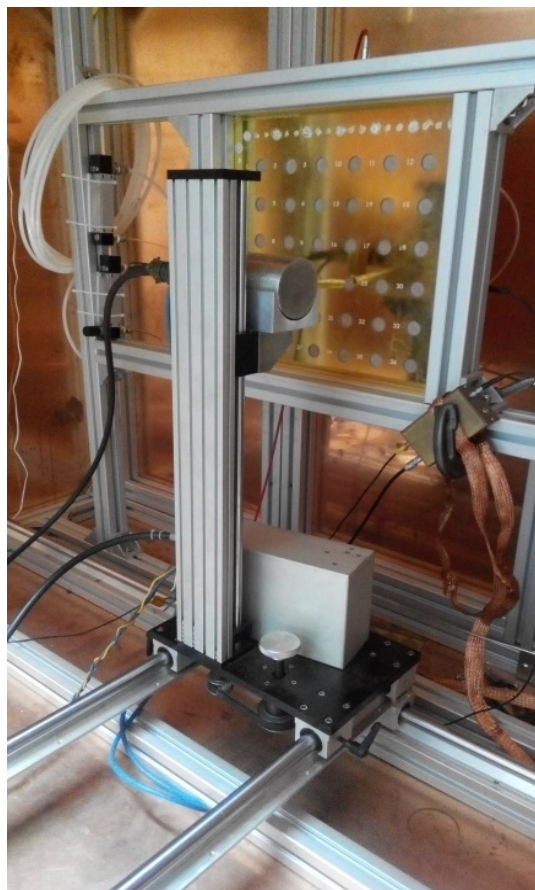
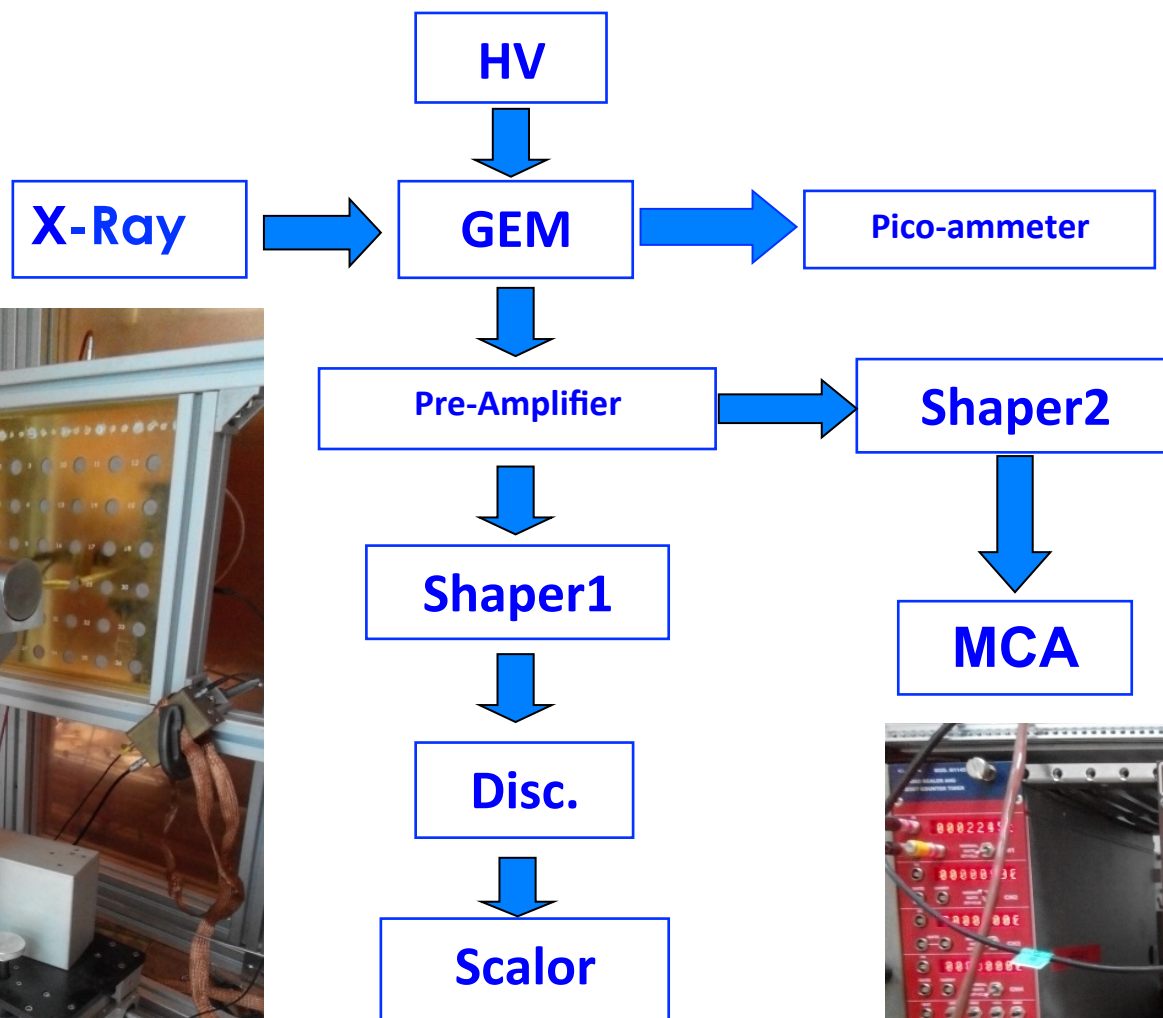
- No gluing, assembly easy and fast, highly efficient and labor saving
- No inner spacers, no dead areas, smooth gas flow
- Complete re-opening possible, full detector re-cleaning possible, highly replaceable and repairable, reduced cost

Self-Stretching R&D

- Intensive R&D on self-stretching technique by 30cm*30cm GEM prototyping.
- Modifications and improvements to original self-stretching.

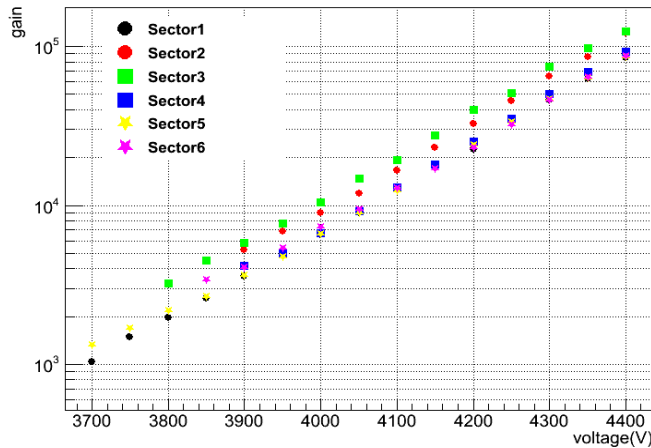


GEM X-ray Test

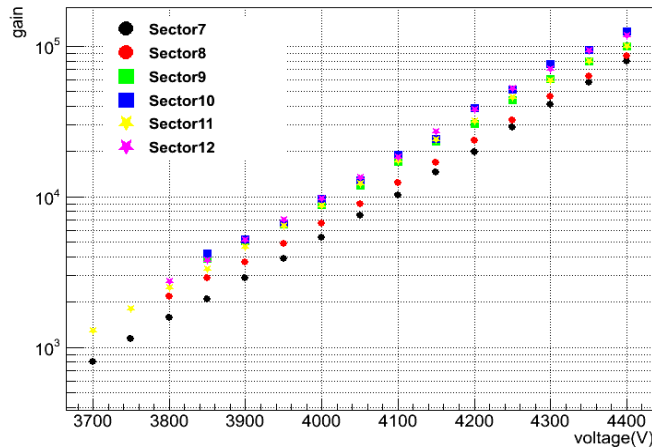


Gain vs. HV

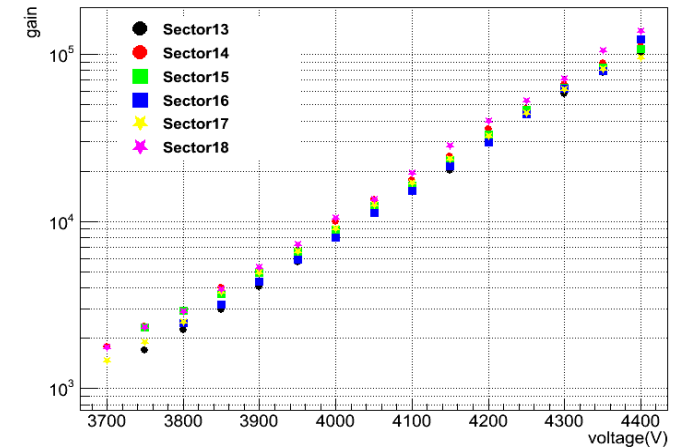
Sector1~6



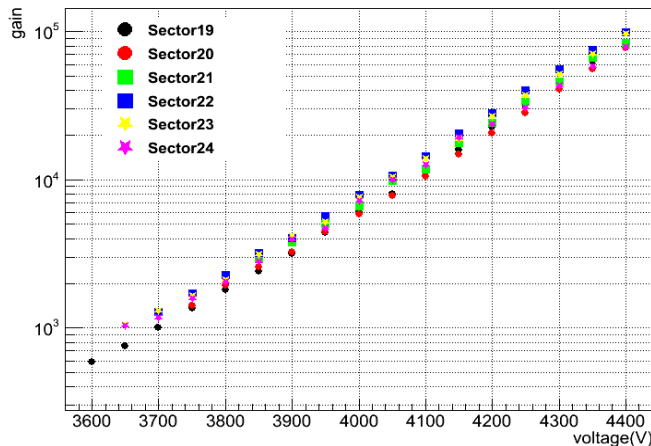
Sector7~12



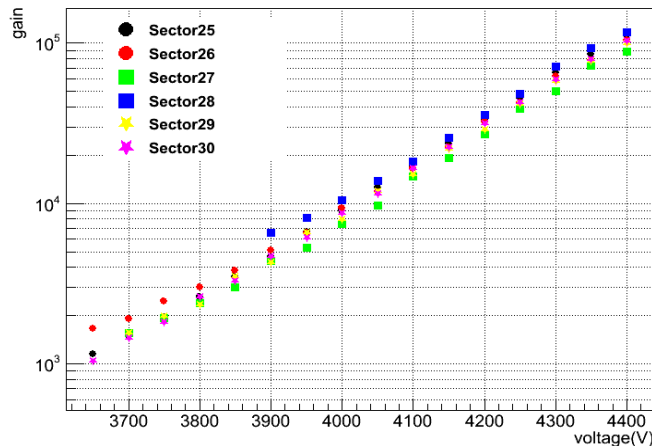
Sector13~18



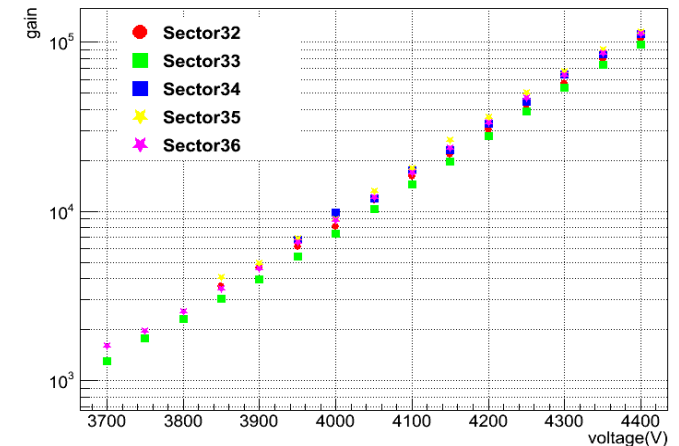
Sector19~24



Sector25~30



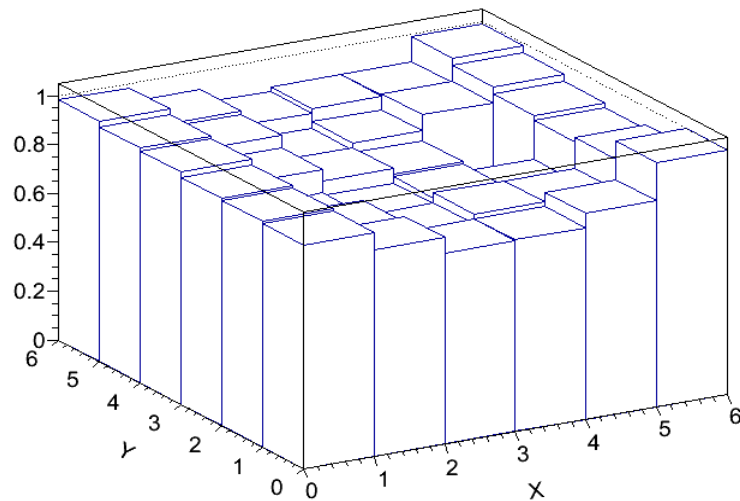
Sector32~36



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

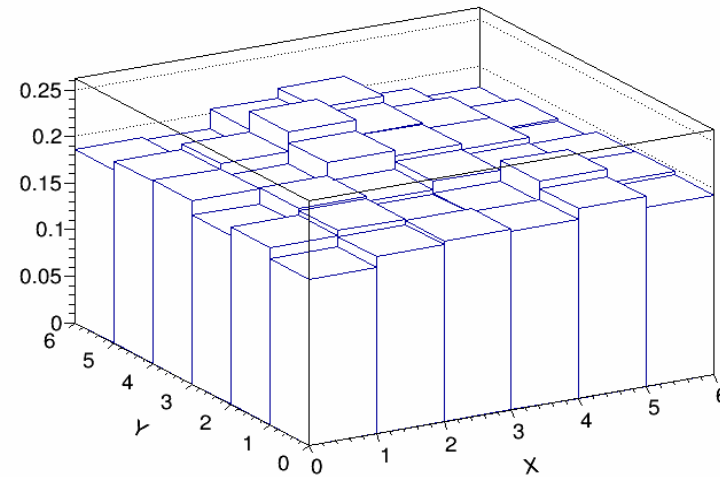
Response Uniformity

Gain in different sectors



Uniformity ~ 11%

Energy resolution in different sectors



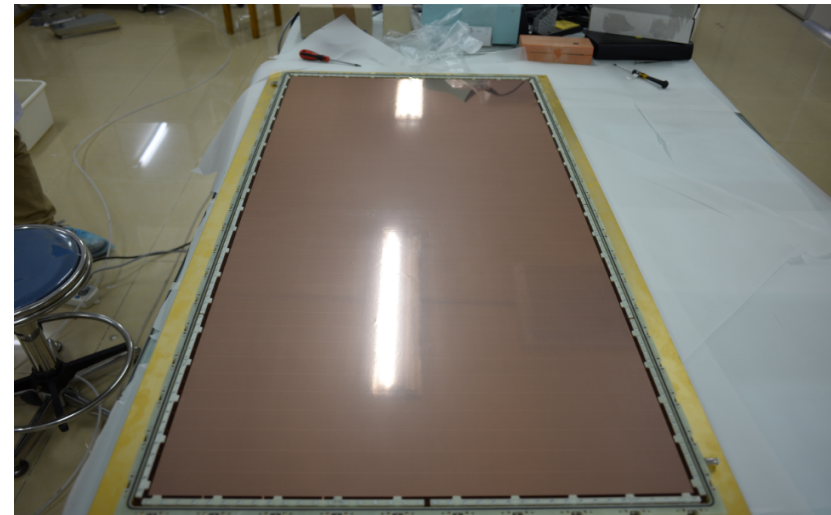
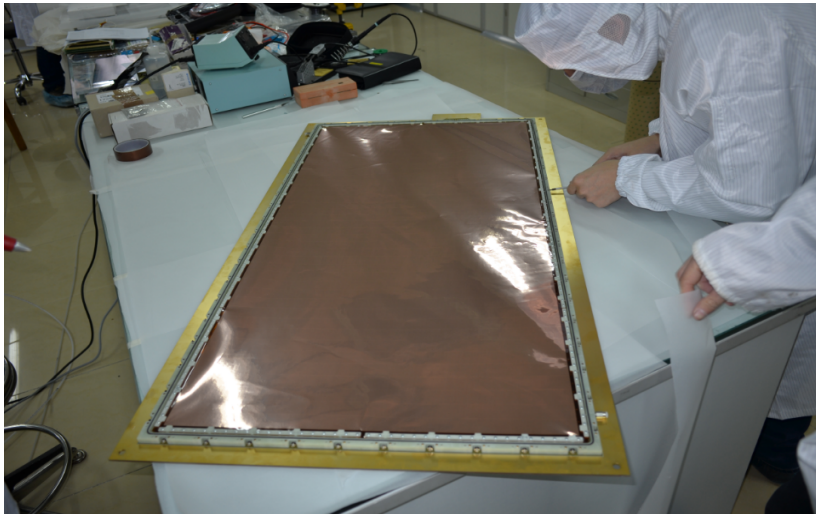
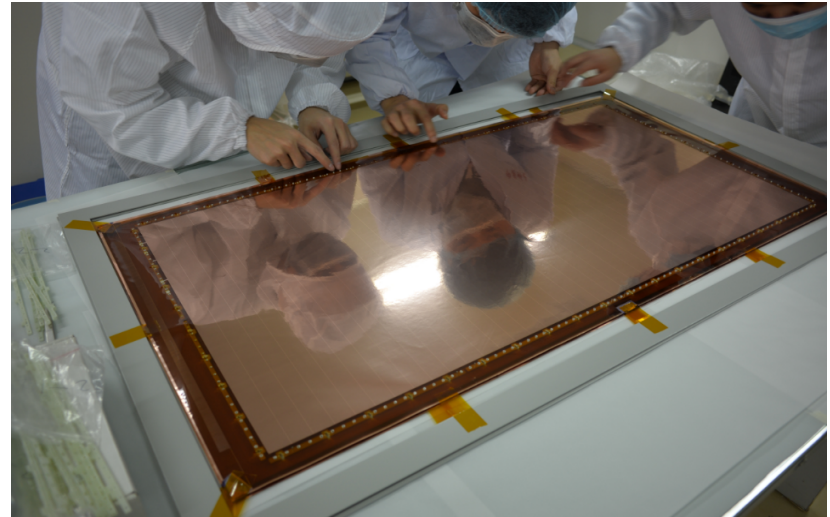
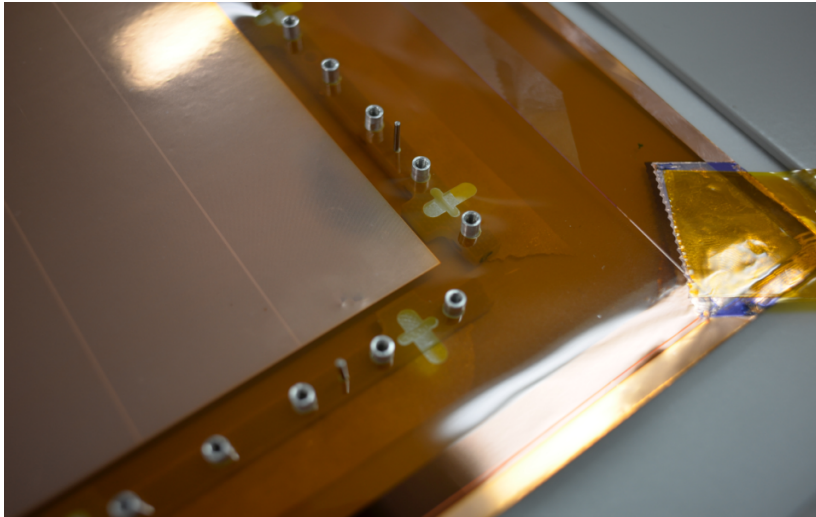
**Resolution <20% @ 8 keV,
Uniformity ~ 5.3%**

Good uniformity observed

Note: uniformity = RMS/Mean

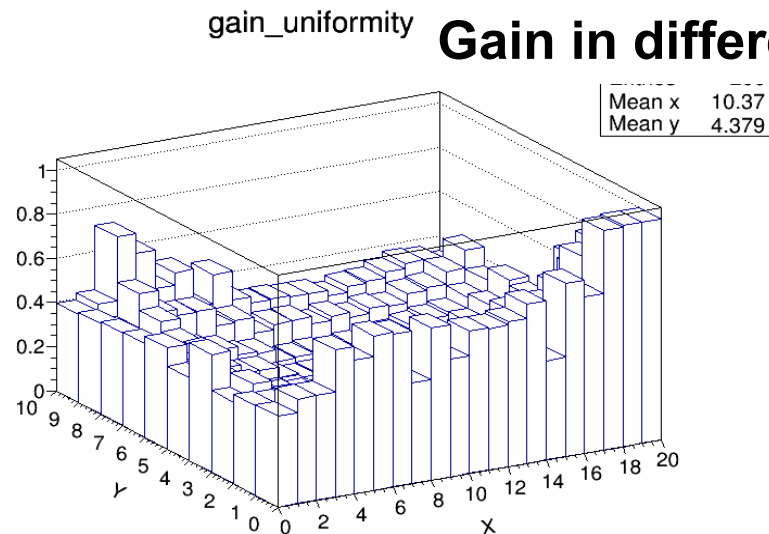
Going for Larger Size

- Assembling an 0.5m*1m GEM with self-stretching technique.

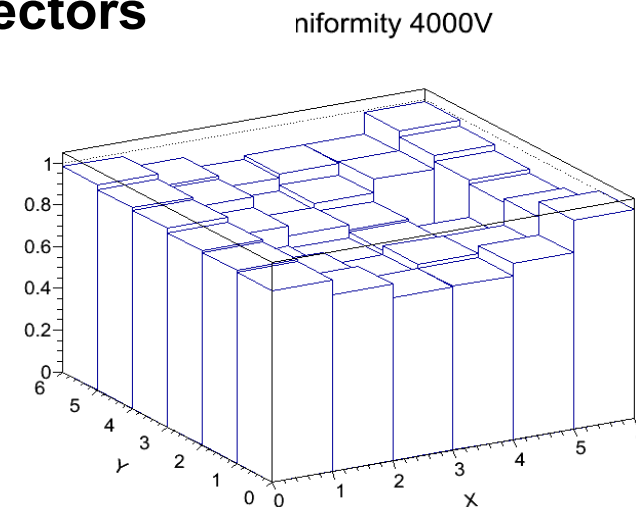


Uniformity in Large Area

0.5m*1m: **51%** v.s. 30cm*30cm: **11%**



Uniformity ~ 51%



Uniformity ~ 11%

- The uniformity of the 0.5m*1m GEM is much worse than that of the 30cm*30cm GEMs.

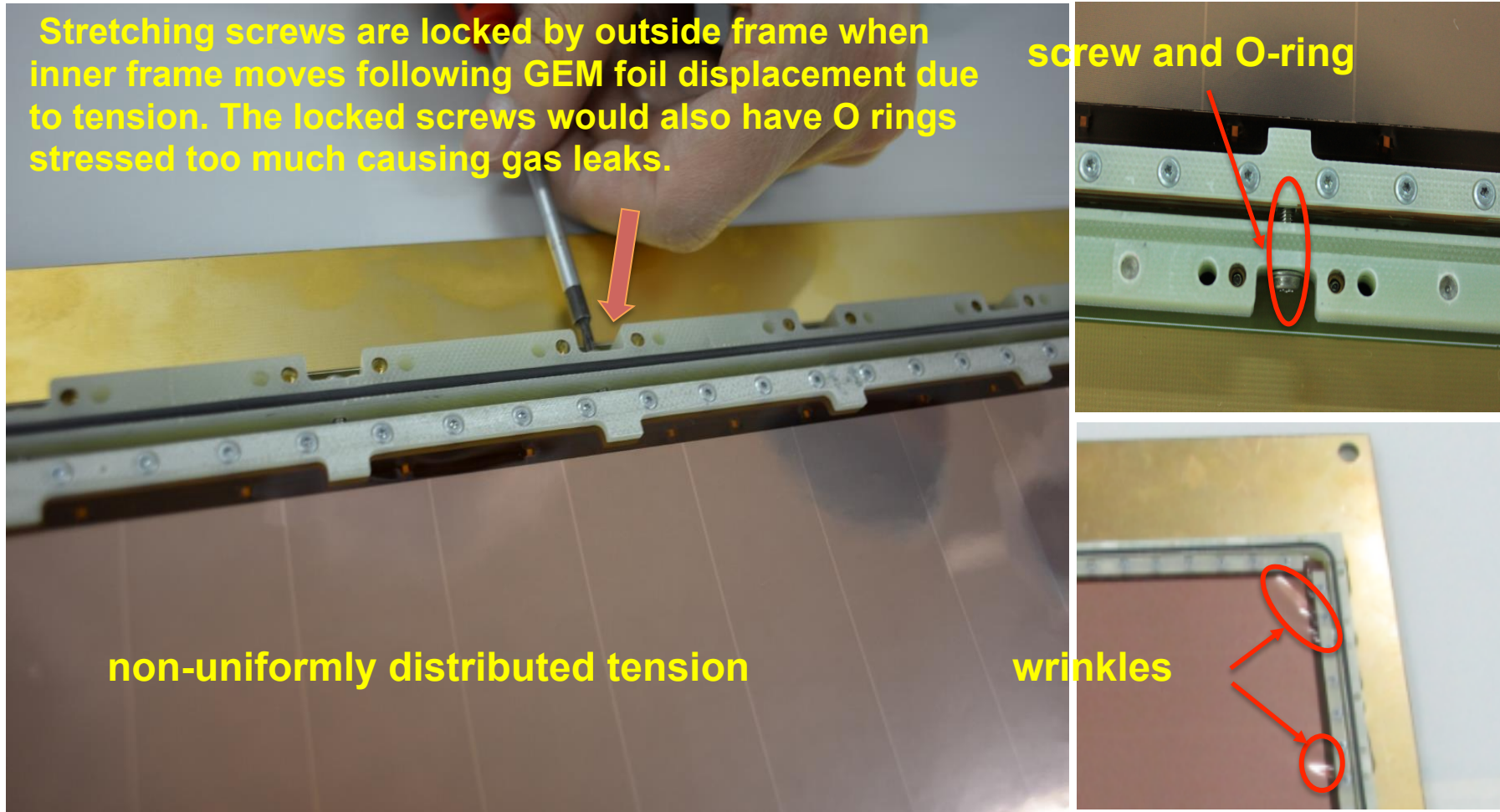
Issues with Self-Stretching

Stretching screws are locked by outside frame when inner frame moves following GEM foil displacement due to tension. The locked screws would also have O rings stressed too much causing gas leaks.

screw and O-ring

non-uniformly distributed tension

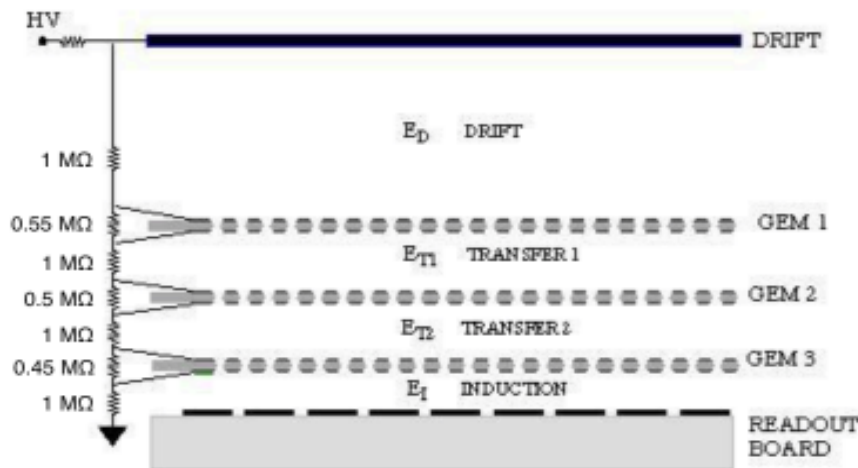
wrinkles



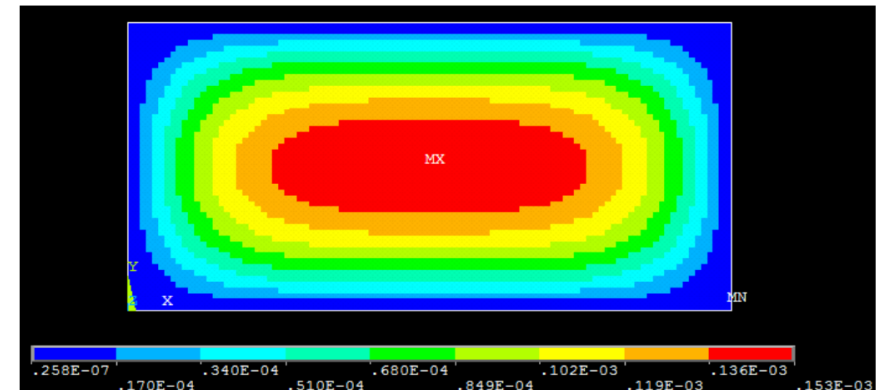
GEM Stretching Simulation

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

GEM model in simulation

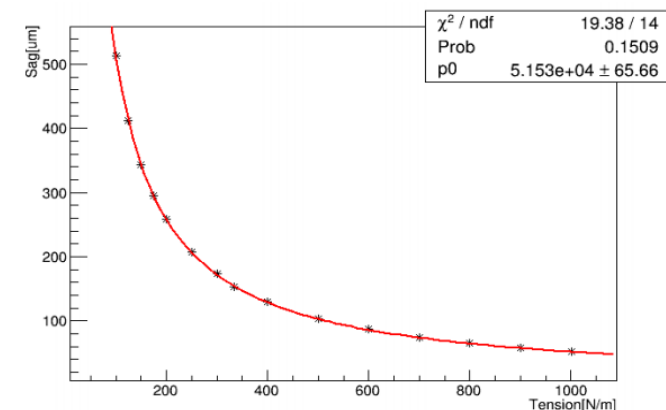


GEM displacement due to sum of electric force and gravity



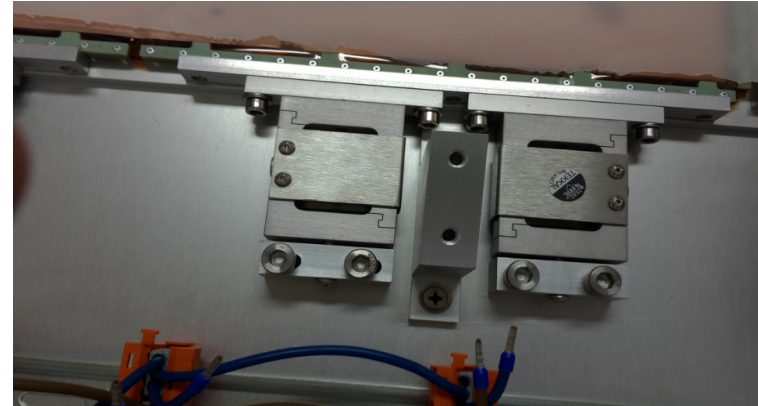
- Maximum GEM displacement $\sim 150\mu\text{m}$ when tensioned at $\sim 0.3\text{kg/cm}$ per GEM
- Tensioning more doesn't help too much in further reducing displacement.

GEM displacement vs. tension applied

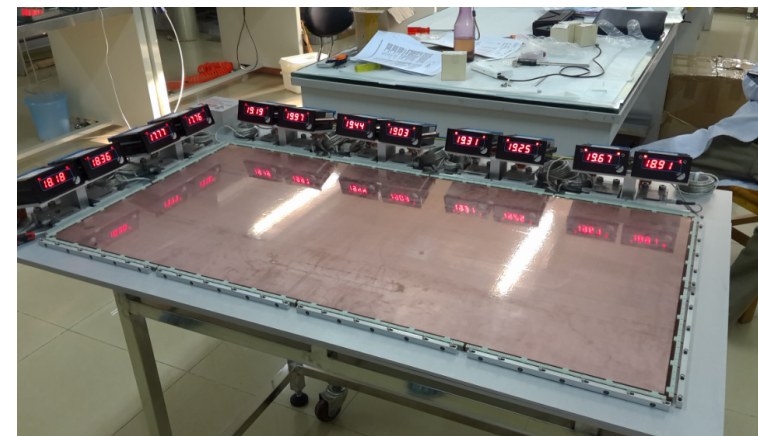


GEM Stretching Measurement

Stretching testing stand



GEM (0.5m*1m) deformation measurement

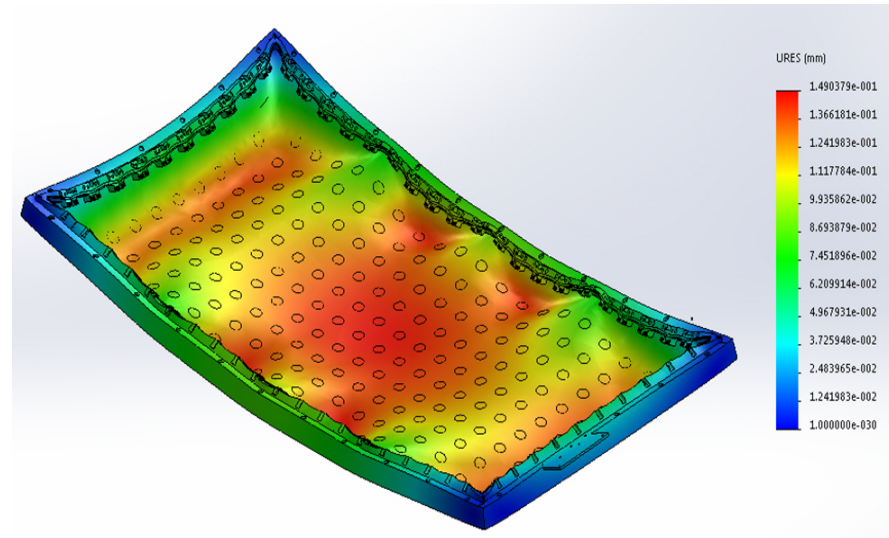
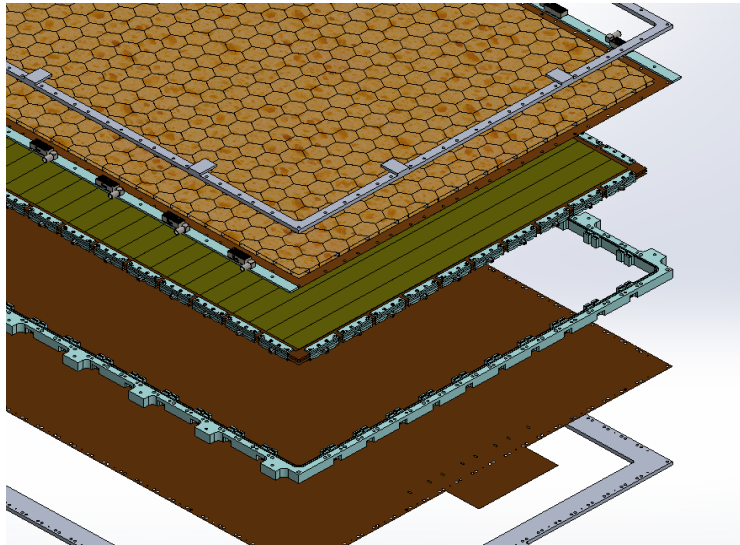


- Tensions applied to GEM: $\sim 0.48 \text{ kg/cm}$ @ long side, $\sim 0.39 \text{ kg/cm}$ @ short side
- GEM extension: $\sim 2.5 \text{ mm}$ @ long side, $\sim 1.0 \text{ mm}$ @ short side

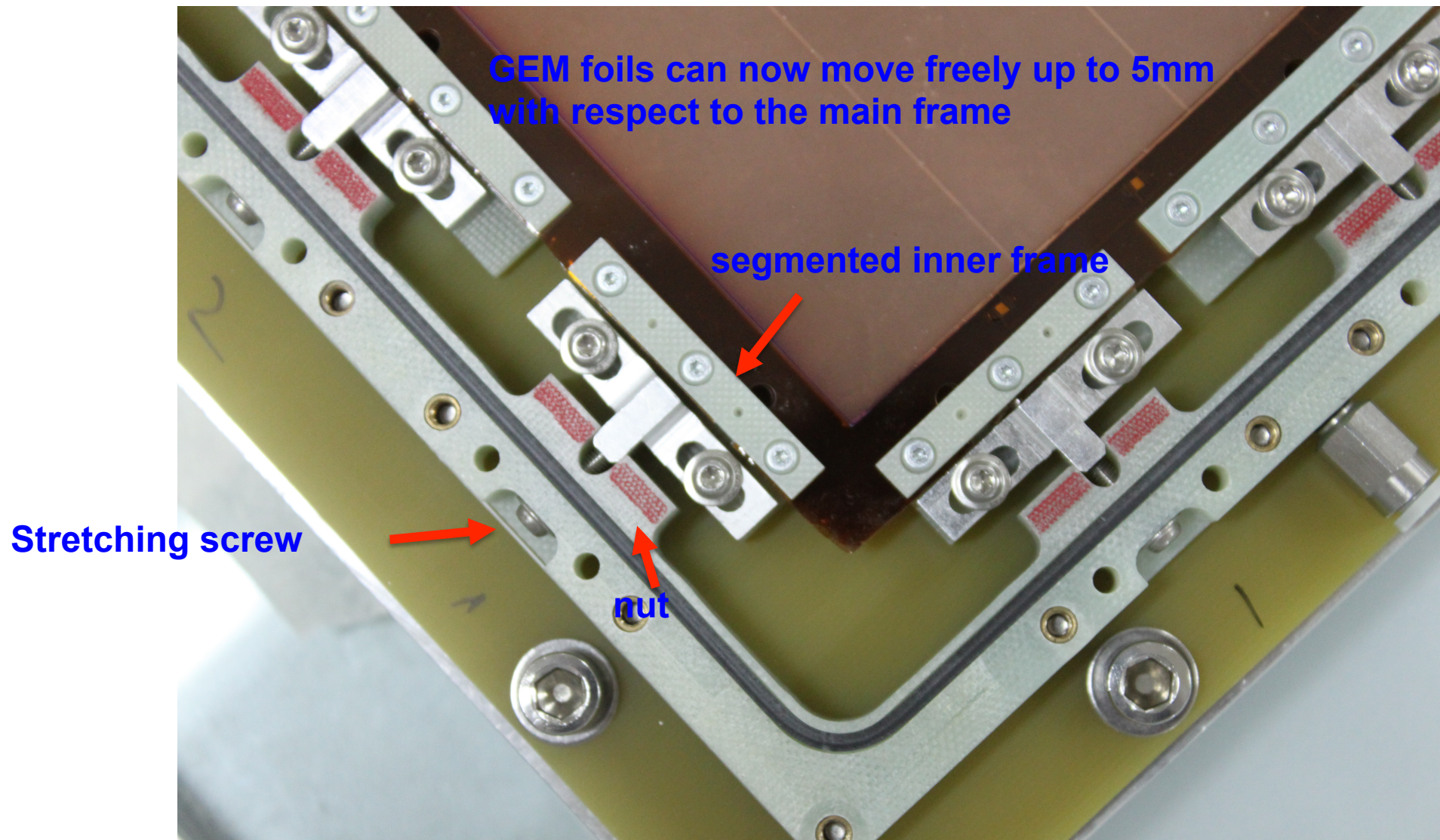
Valuable input in GEM tension determination

Improving Self-Stretching

- Lots of effort put in optimizing the design of the 1m*0.5m self-stretched GEM:
 - Reinforced supporting frames
 - Segmented GEM clamping → sliding self-stretching

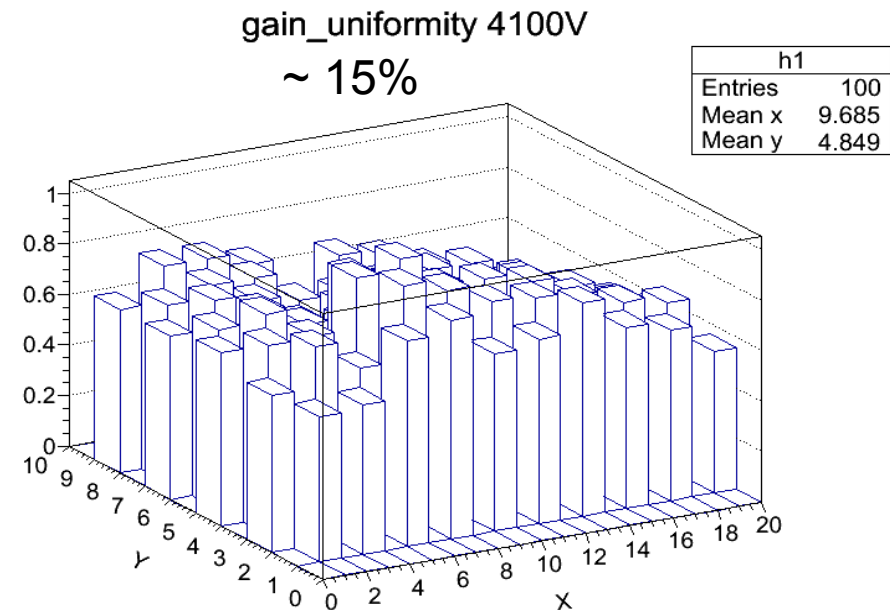
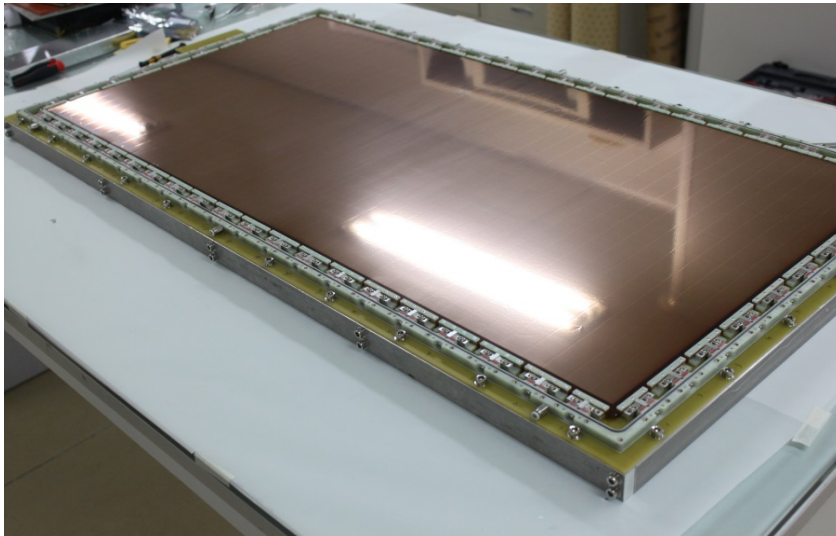


A Close-up of Sliding Self-Stretching

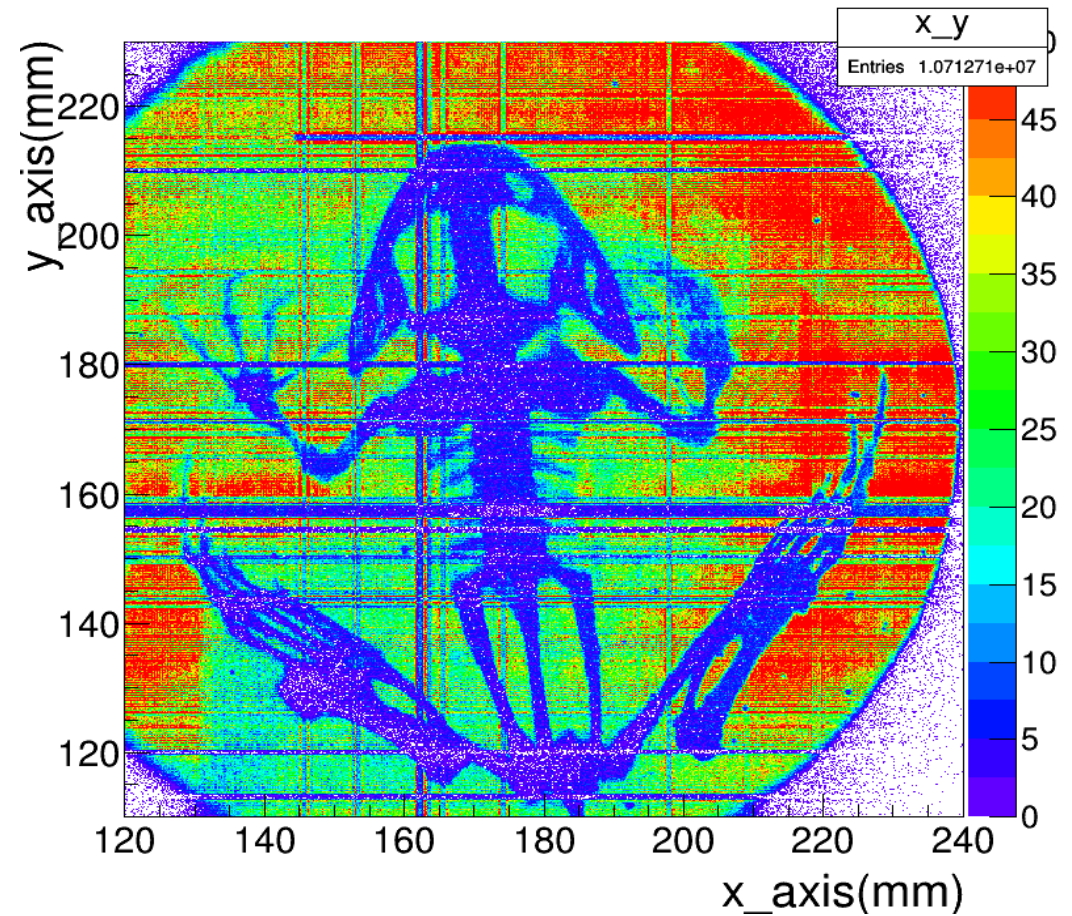


Sliding Self-Stretched GEM

- High quality GEM stretching with no visual wrinkles.
- Very good gain uniformity $\sim 15\%$, comparable to 30 cm * 30 cm !



2D X-ray Imaging



Summary

- Active R&D on self-stretching GEM assembly at USTC in the past few years.
- Improved the original self-stretching technique by segmenting GEM foil clamping to allow room for GEM displacement
 - sliding self-stretching
- Built a 0.5m*1m GEM prototype with sliding self-stretching technique
 - Very good uniformity over large area

MPGD lab @ USTC

- Central gas supply
- A class-10000 clean room
- A general-purpose work station and a large-area regular work bench
- Three detector testing areas

