



核数据重点实验室

Progress on GEM and MicroMegas R&D in CIAE

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Outline

- **The progress of GEM foil in CIAE**
- **The Progress of MicroMegs in CIAE**

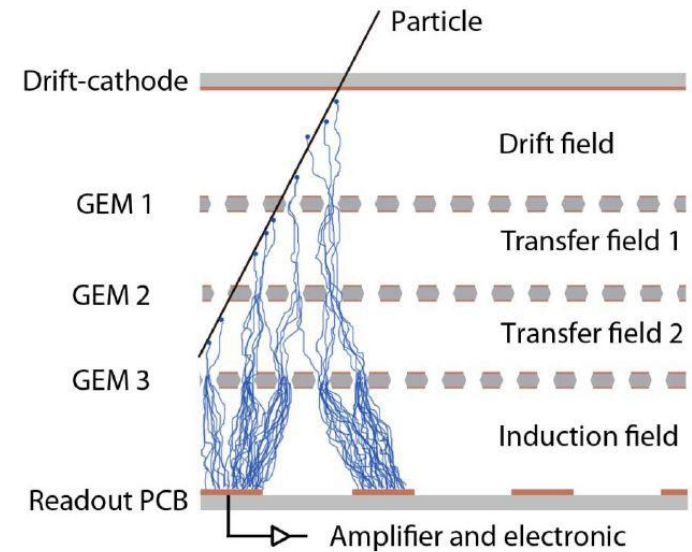
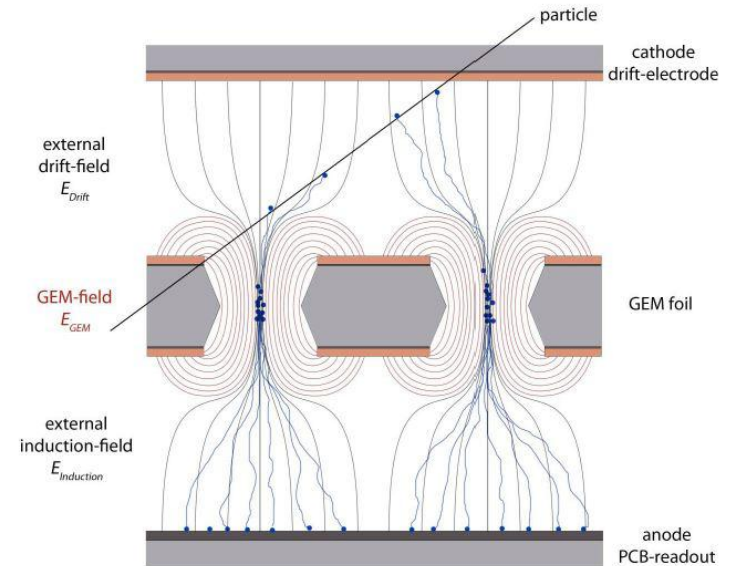


The Progress of GEM Foil in CIAE



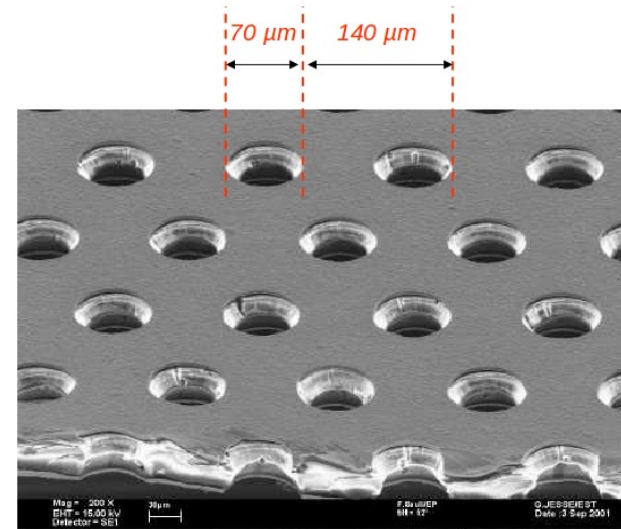
GEM Structure

- **GEM detector:**
 - Cathode, Drift field, GEM foil, Induction field and Readout board.
 - **GEM foil: the most important part of GEM detector . Normally 3 GEM foils in one GEM detector.**

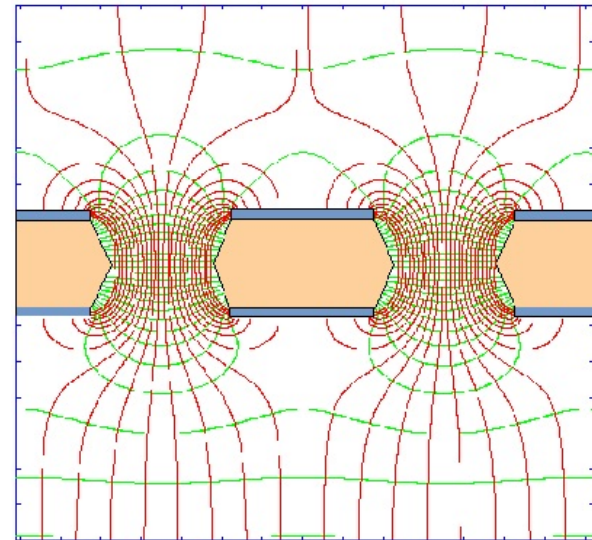


GEM Foil

1. Typical GEM Foil has 3 layers, two $5\mu\text{m}$ thick copper foils and one $50\mu\text{m}$ thick kapton foil in the middle.
2. Diameter of the hole is $70\mu\text{m}$, and the distance between them is $140\mu\text{m}$.
3. Apply electric voltages on the two copper layers.
4. Electric Field is very strong in the hole area, and weak outside the hole area.



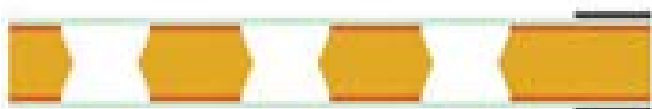
GEM Foil



GEM Field

The Procedure of GEM Foil

Double mask photolithography



50 μm kapton foil 5 μm
copper clad on both sides

Photoresist coating,
masking, exposure

Photoresist development,
copper etching

Kapton etching

Metal etching

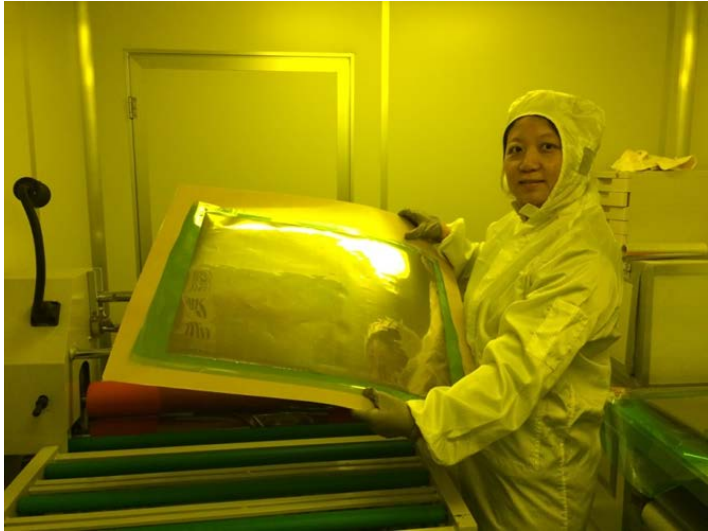
Second masking,
exposure

Development, etching,
final cleaning

Single mask photolithography

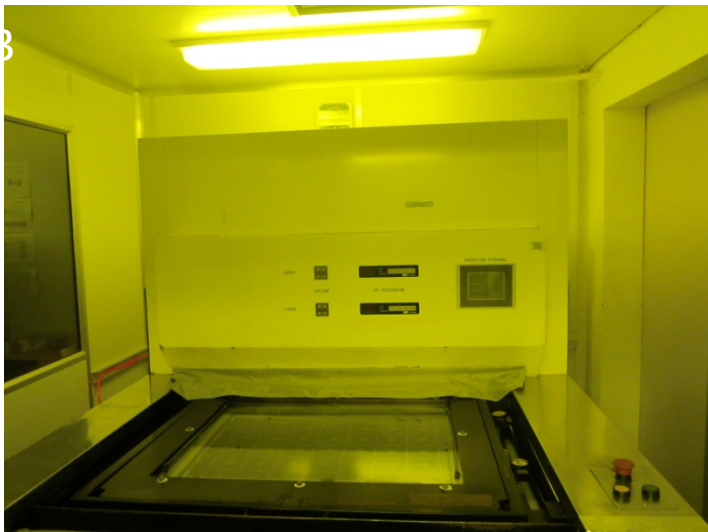


The Equipments for Lamination and Exposure of Dry Film Photoresist at CIAE



Lamination and exposure of dry film photoresist are the most important and difficult steps for GEM foil production.

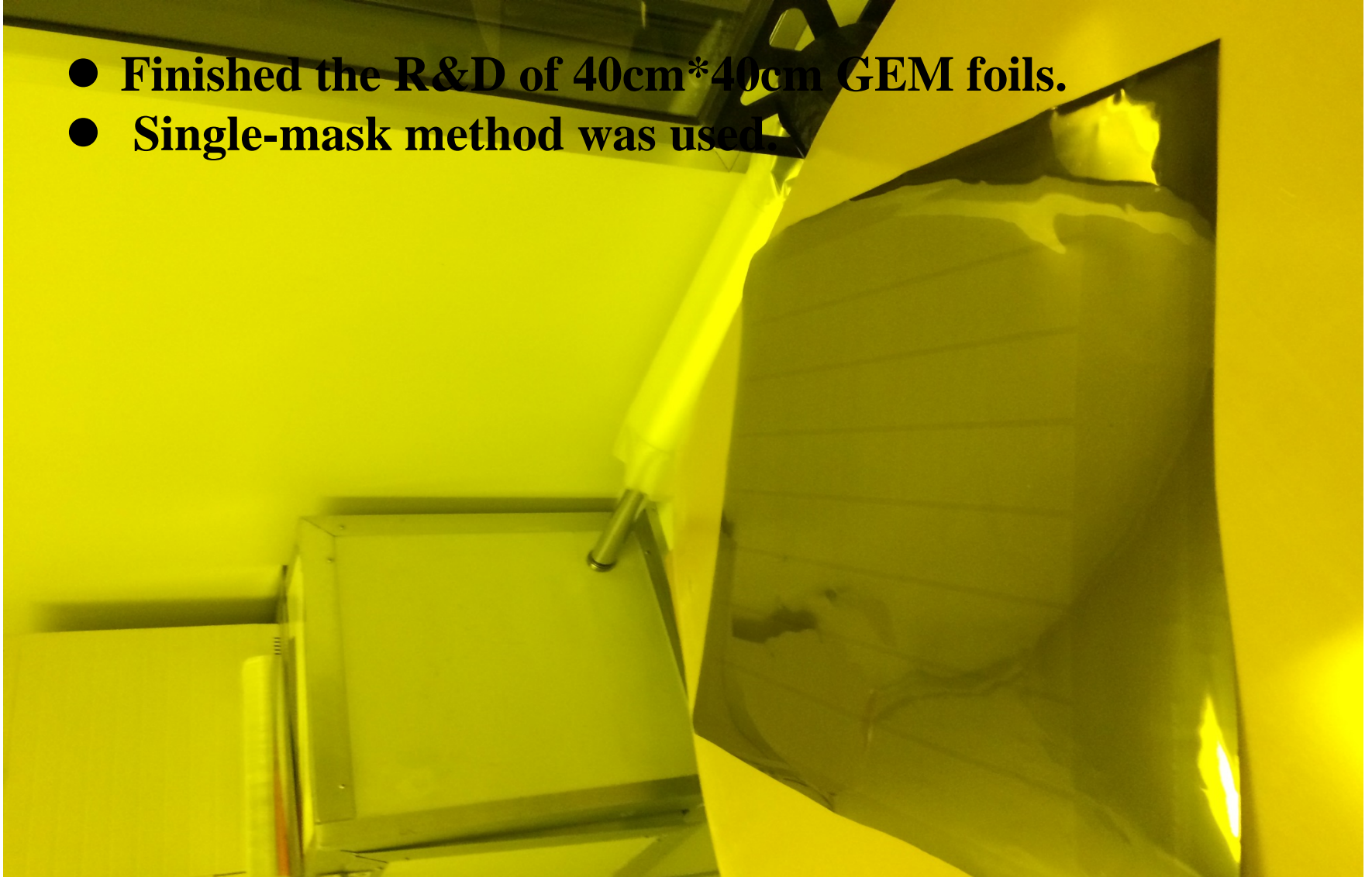
We have established a yellow light zone, and have introduced Hot Roll Lamination (HRL) machine and Exposure system.



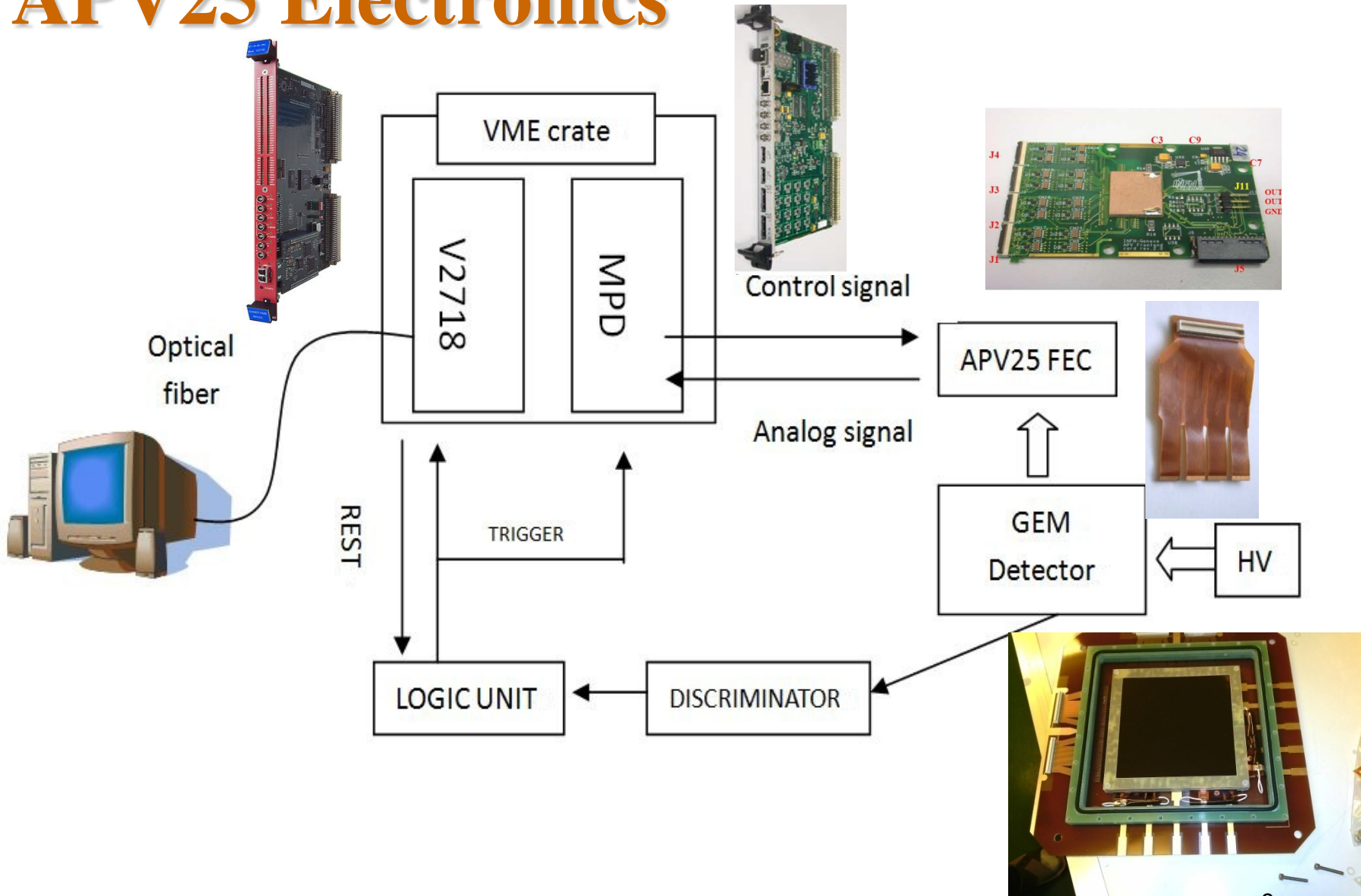
We invited the Senior engineer from a famous electronic factory to CIAE and taught the PCB technology.

R&D of 40cm*40cm GEM Foil

- Finished the R&D of 40cm*40cm GEM foils.
- Single-mask method was used.



GEM Test system with APV25 Electronics



Spatial resolution

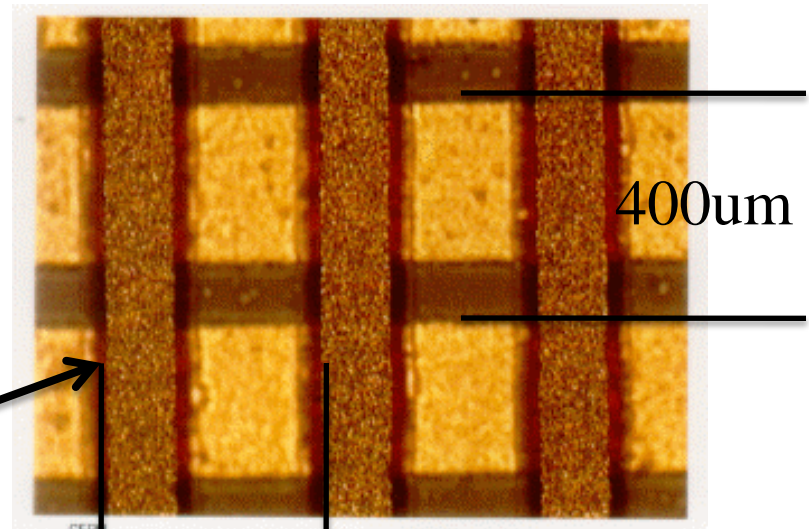
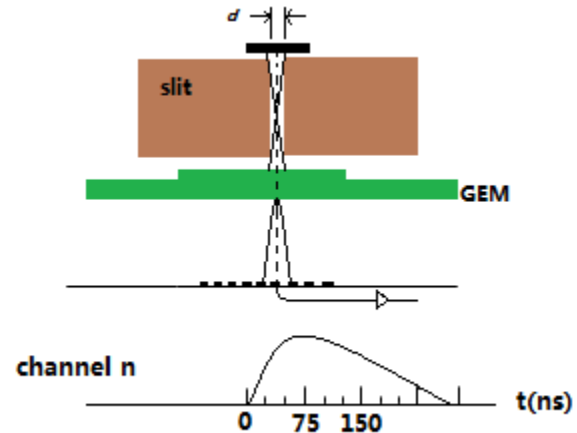
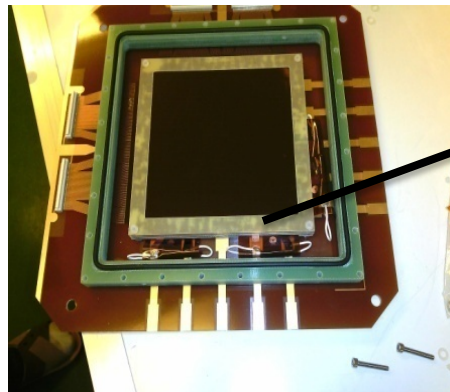
$$\sigma_{\text{tot}}^2 = \sigma_{\text{GEM}}^2 + c_1 \sigma_{\text{geometry}}^2$$

When: $\sigma_{\text{geometry}} \ll \sigma_{\text{GEM}}$

$$\sigma_{\text{tot}}^2 \cong \sigma_{\text{GEM}}^2$$

Spatial resolution $\approx 76\mu\text{m}$

- Slit(μm): 20;
- Ar: CO₂=70% : 30%;
- HV: 3600V;
- The distance between strips: 400 μm .

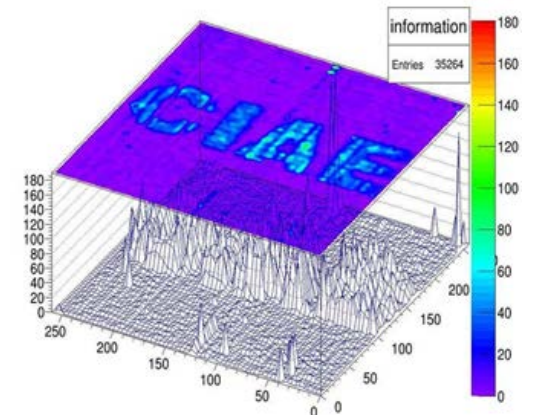
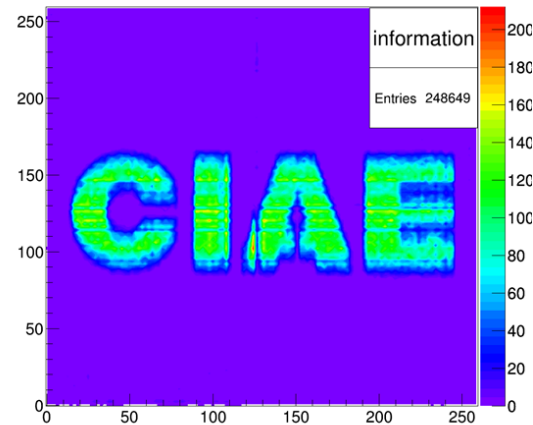


400 μm

X-ray imaging @ CIAE



- X ray Energy: 8.9KeV;
- about 1k sample rate
- 256 channels for each dimension(512 channel in total);
- 4 APV FECs were used (2 for each dimension)



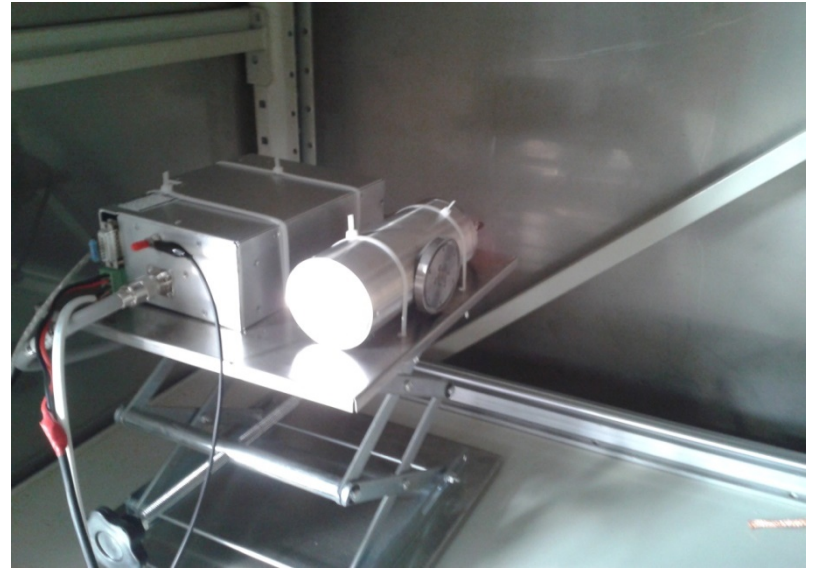
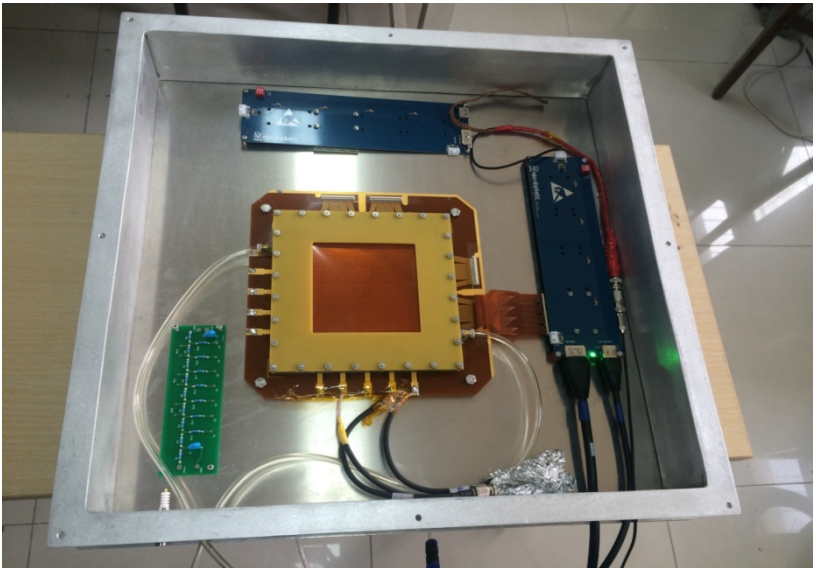
The upgrade of Clean Room



The cleanrooms at China Institute of Atomic Energy are ISO Class 6.

The upgrade of Lab

- Lead box
- X-ray generator
- 3D GEM test platform
- New test chamber

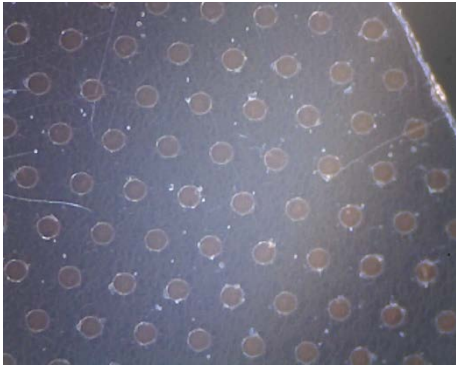


Collaborated with a Factory



Comparison of Foils (1)

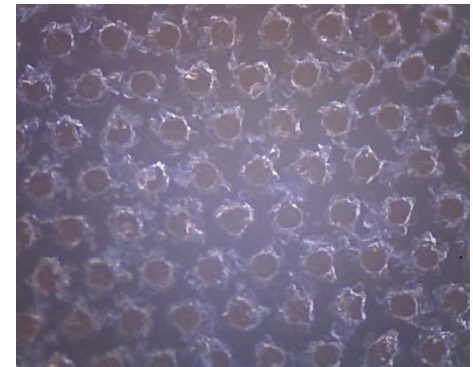
**Insufficient
development**



**Good
development**

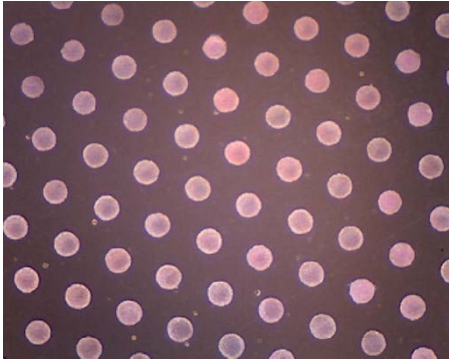


**Excessive
development**

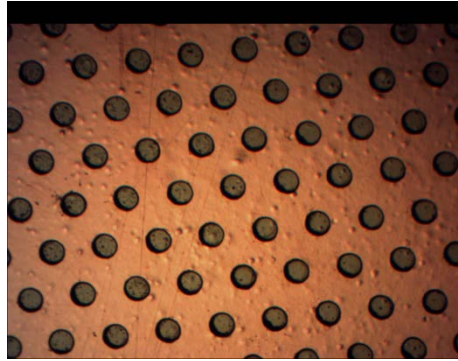


Comparison of Foils (2)

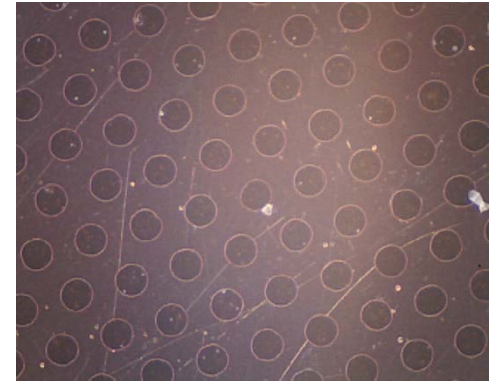
**Insufficient
copper etching**



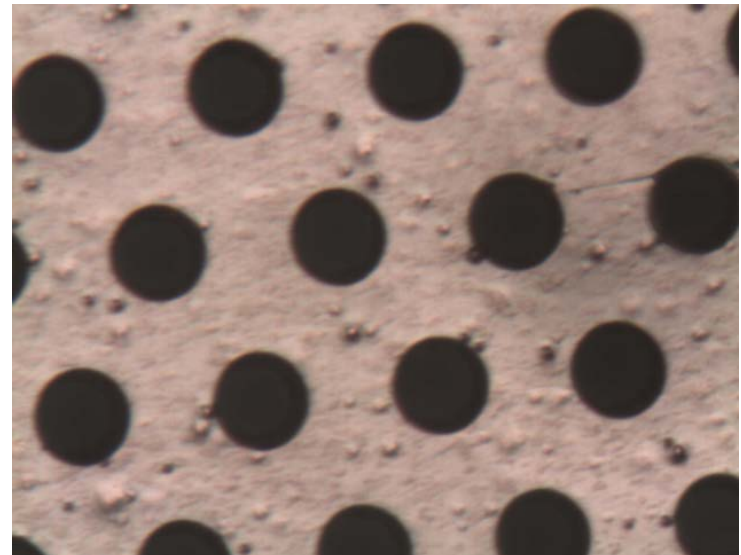
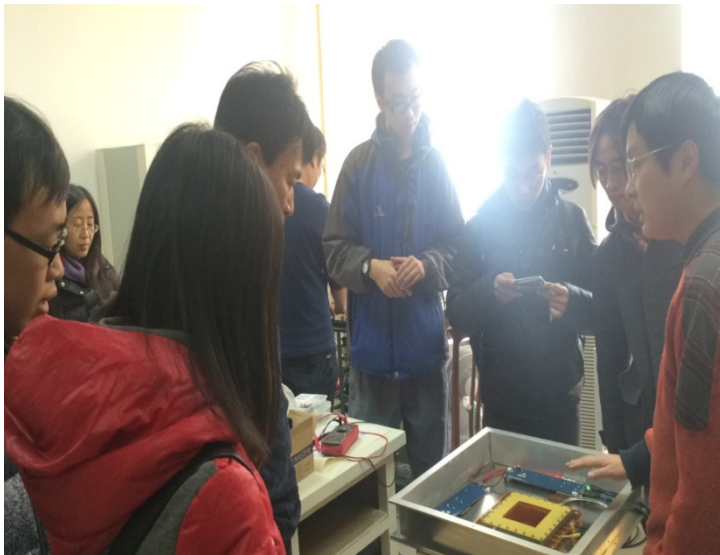
**Good
copper etching**



**Excessive
copper etching**



Cooperation and exchange

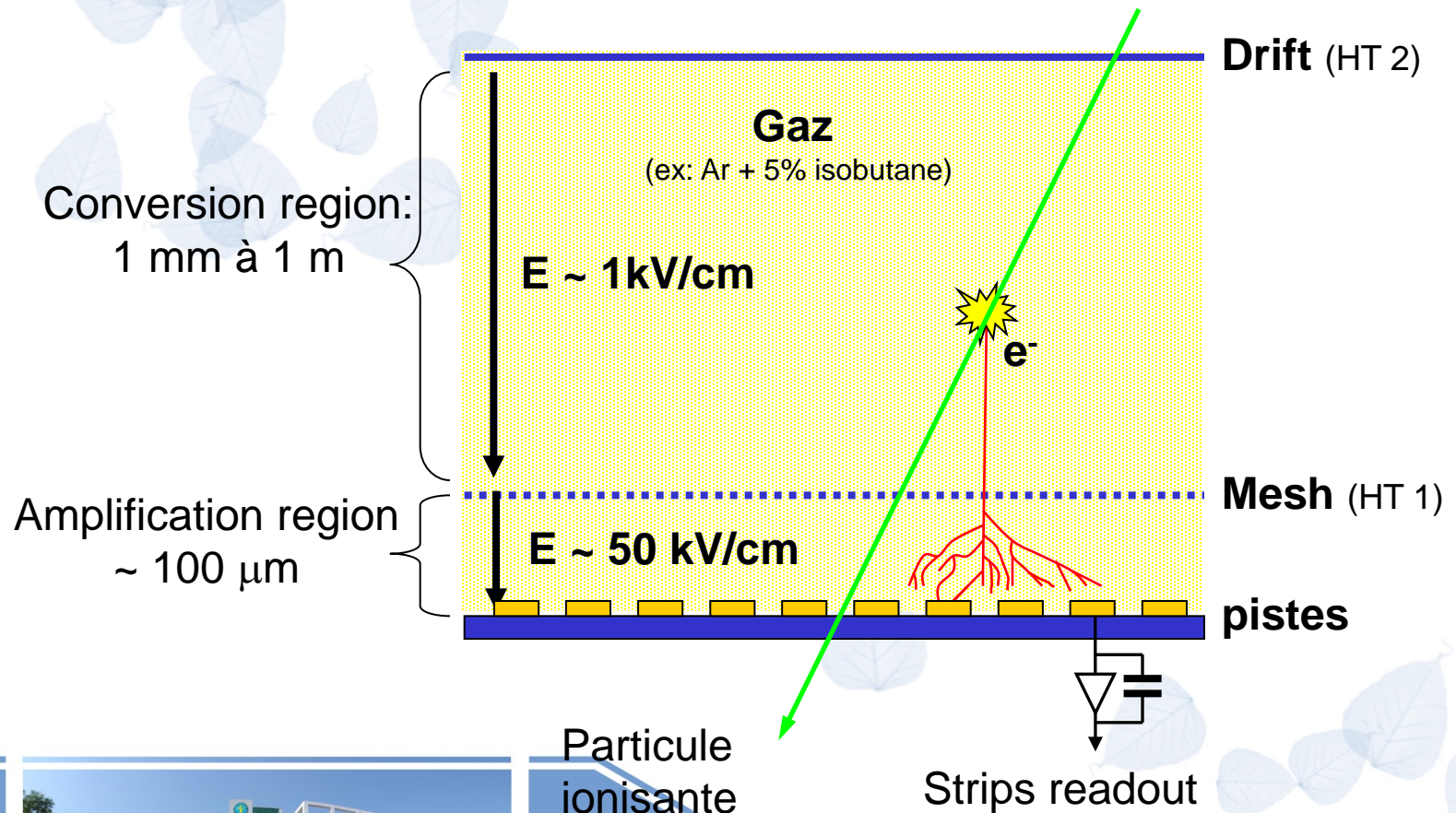


The Progress of MicroMegs in CIAE



MicroMegas Structure

- The core of the detector is the amplification region



11/08/2016

Three types of Micromegas

– Classic Micromegas

- Mesh on a frame (USTC, Lanzhou...)

– Bulk Micromegas

- photolithography process is used to attach the mesh on the PCB.

– Microbulk Micromegas

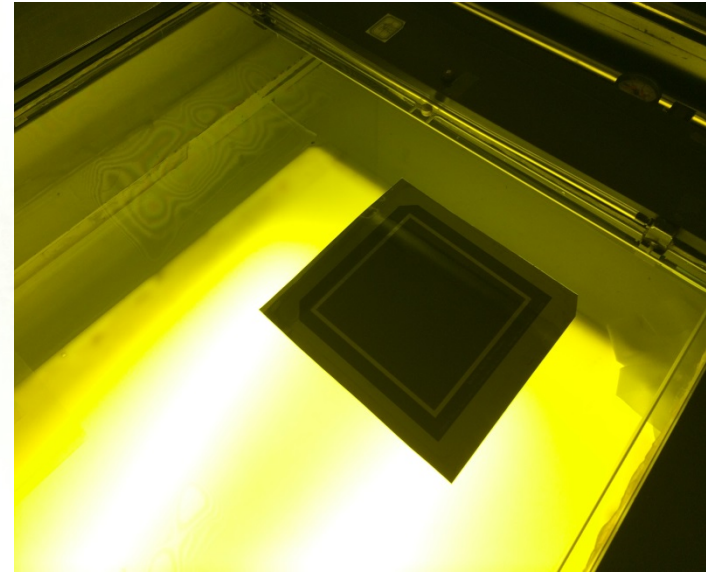
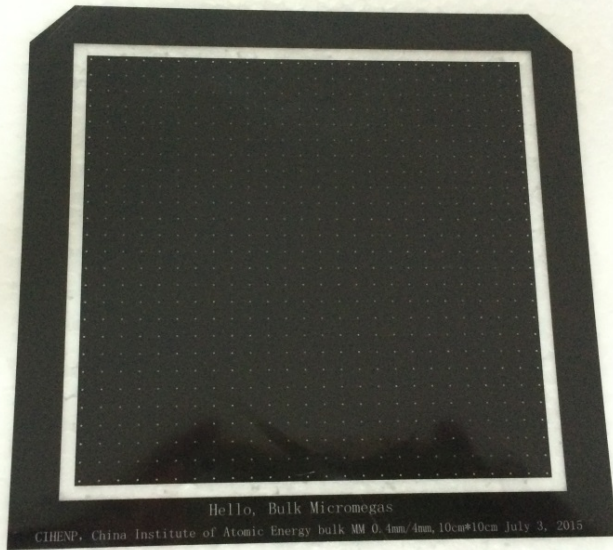
- Mesh and PCB made on a unique kapton foil, the mesh layer is thinner.



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R&D of Bulk MicroMegas

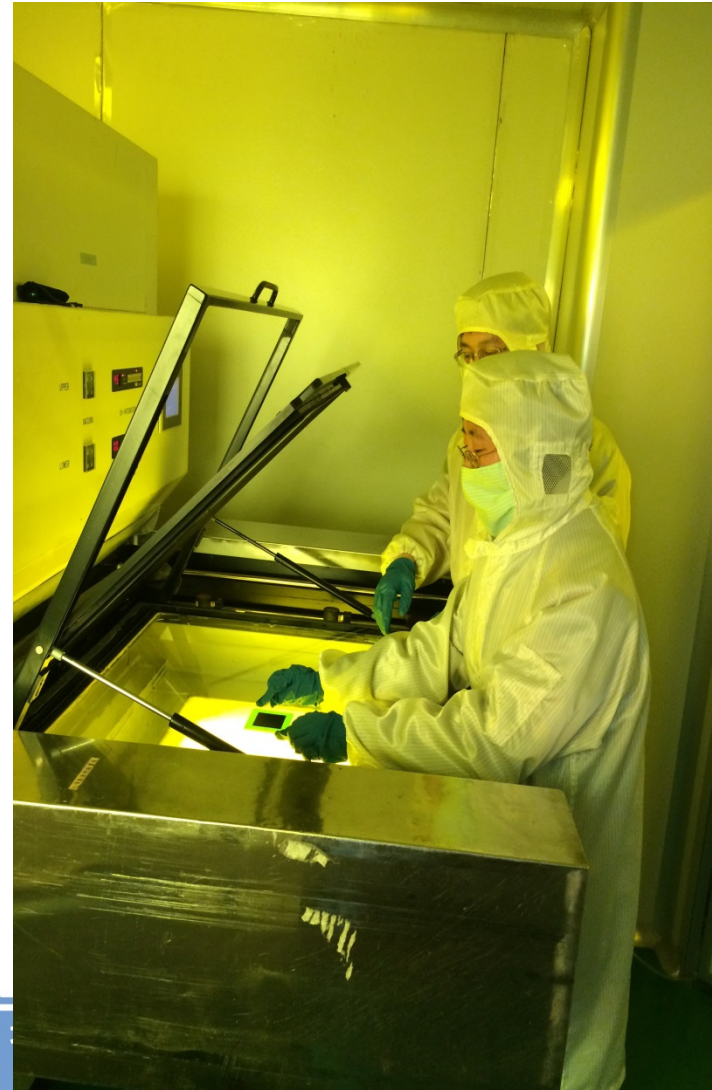
Based on the Collaboration with CEPC TPC (IHEP)



R&D of Bulk MicroMegs at CIAE

Detector

- Active Area: 3cm*3cm and 10cm*10cm
- Photolithography technology used
- Resistance: 15-100G Ω



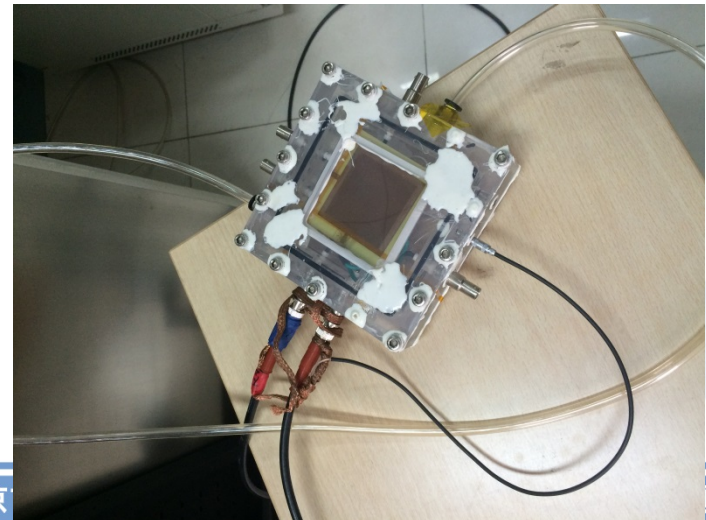
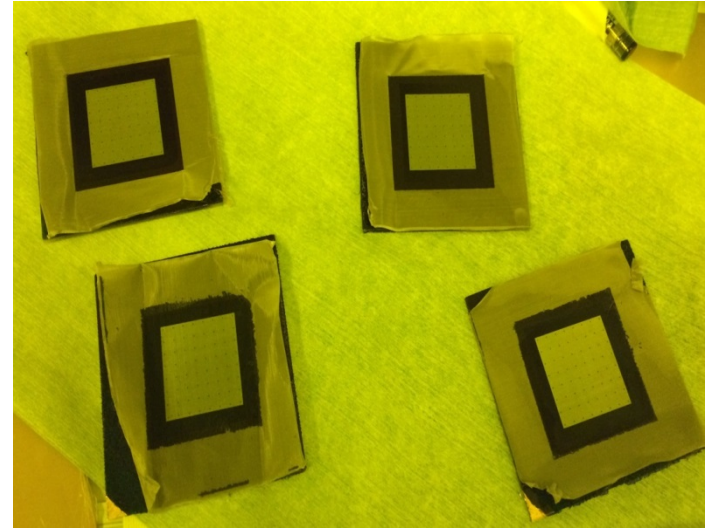
R&D of MicroMegas at CIAE



R&D of MicroMegas at CIAE

Test:

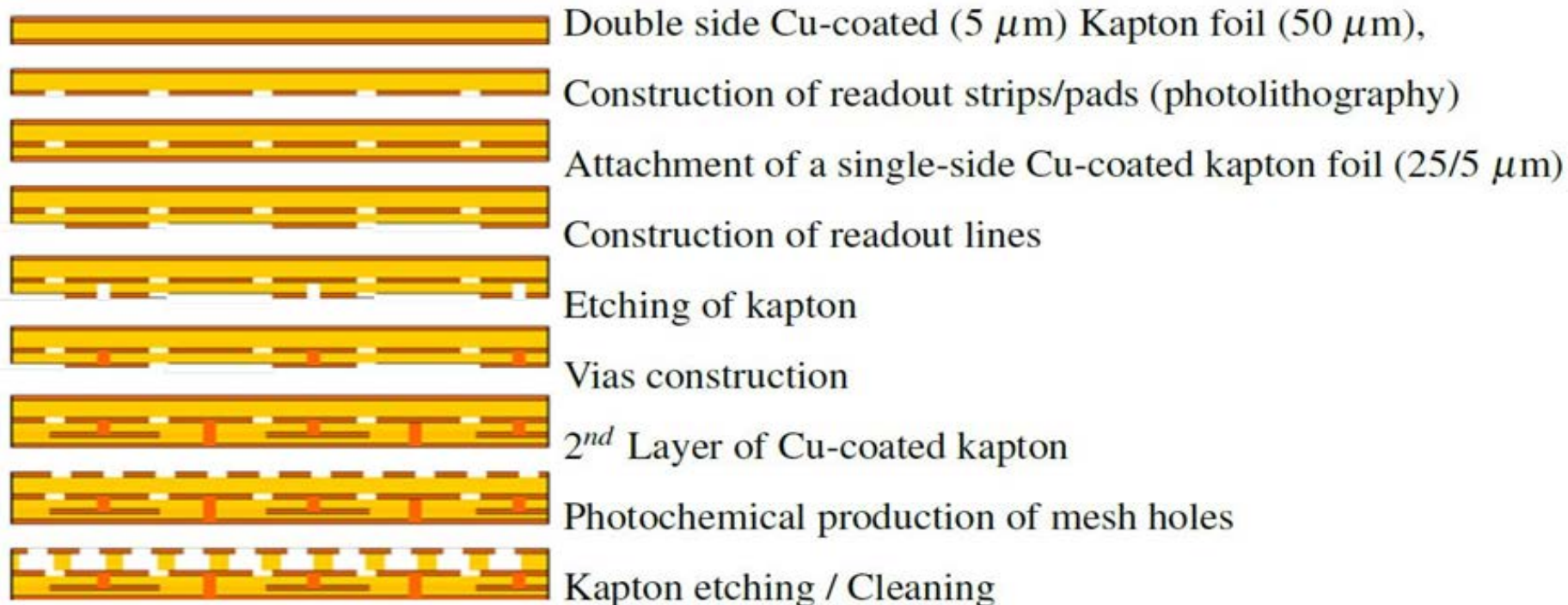
- Ar: CO₂=70% : 30%;
- Start to see spark signal at HV: 380V;



R&D of MicroBulk MicroMegas

Microbulk Micromegas Fabrication Process

This technology is inspired by
the GEM detector fabrication process invented at CERN .



For the energy resolution the best results are obtain
when the amplification gap distance is constant: i.e.
when the mesh is thinner.

PandaX-III experiment



Workshop on Ovdbd with Xe136

氙136无中微子双贝塔衰变研讨会

Shanghai Jiao Tong University, Mar 23-25, 2015

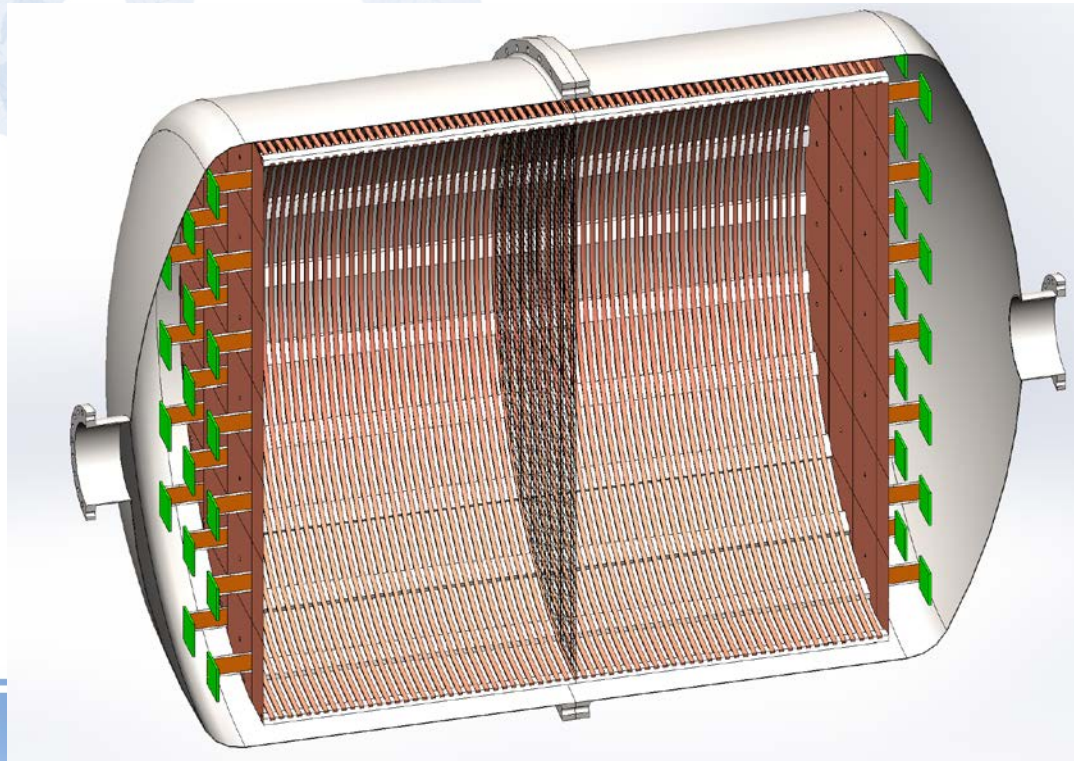


8/11/2016

北京市215信箱40万相 邮编102415 电话01051649 传真69357787

200kg HP Gas TPC

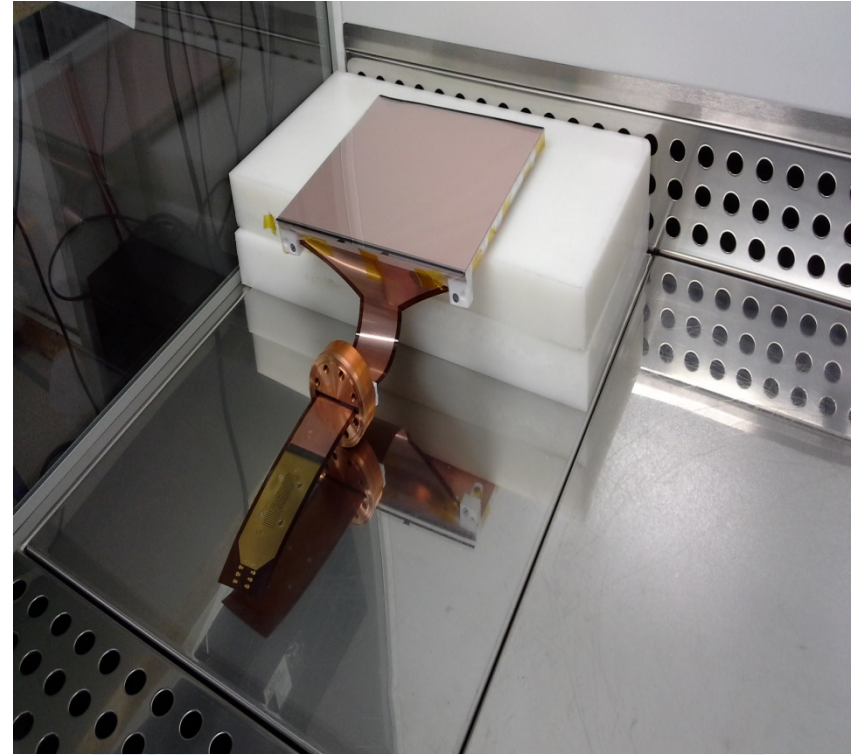
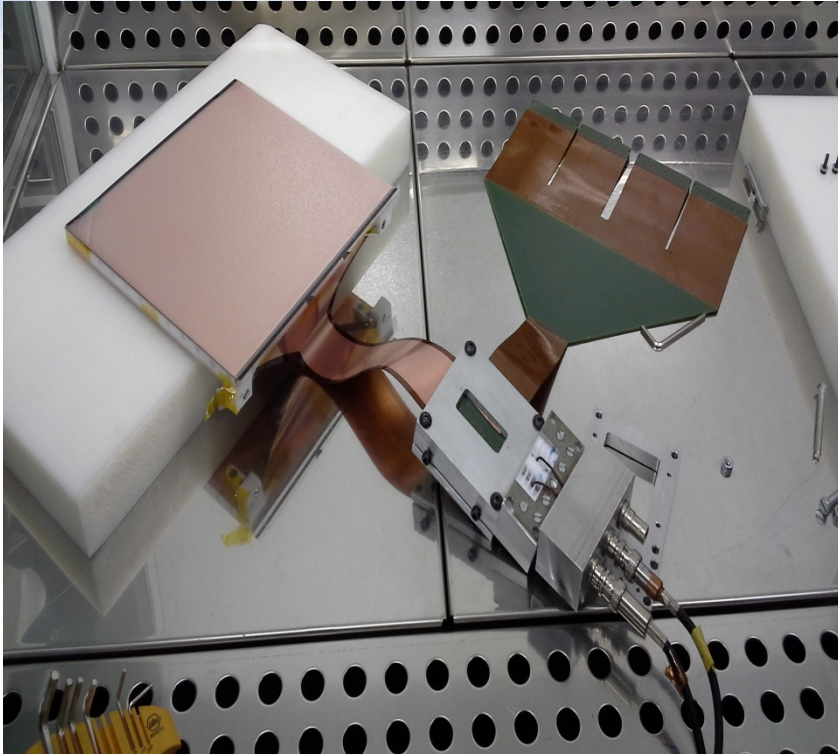
- Size: 1.5m in diameter, 2m long cylinder



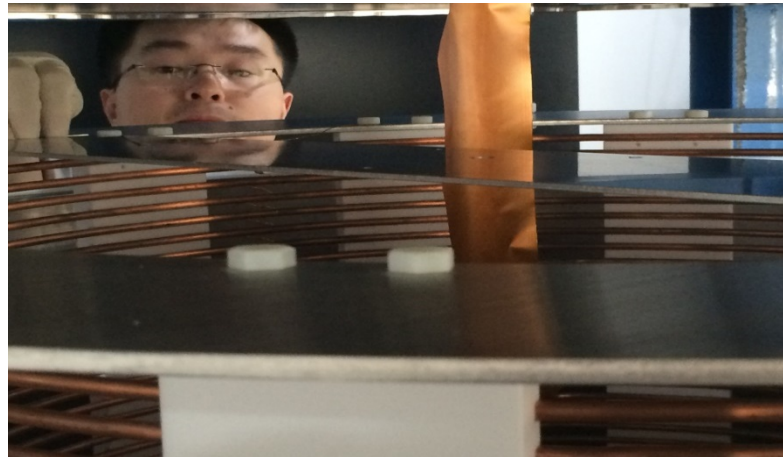
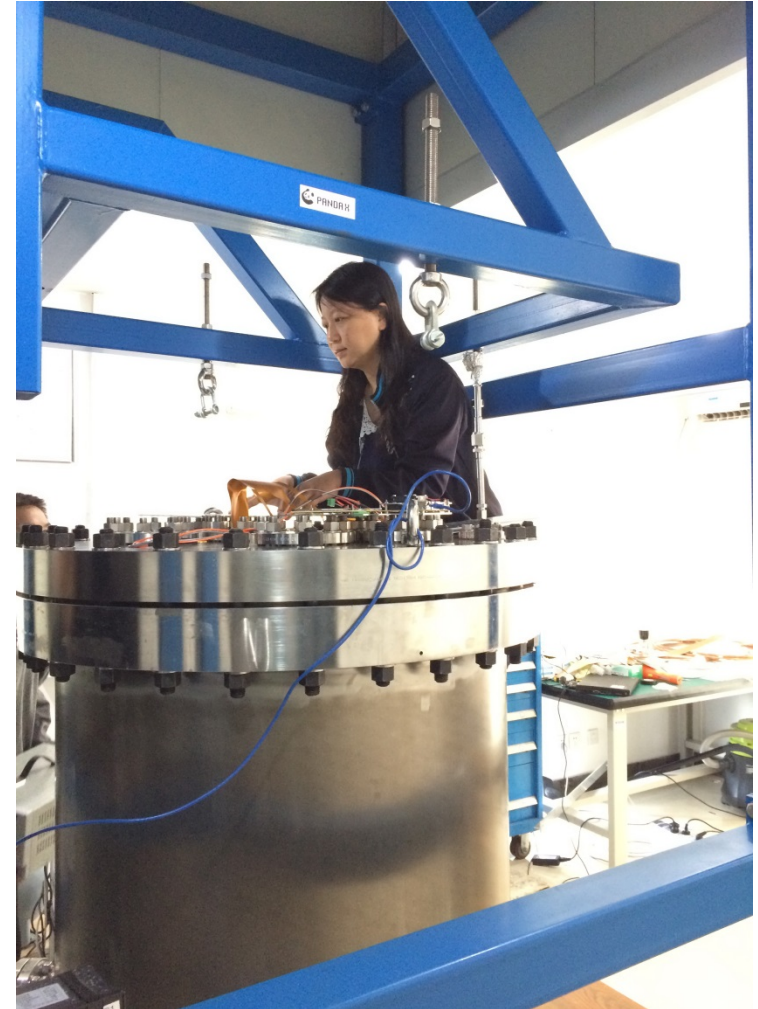
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Microbulk MicroMegas for PandaXIII



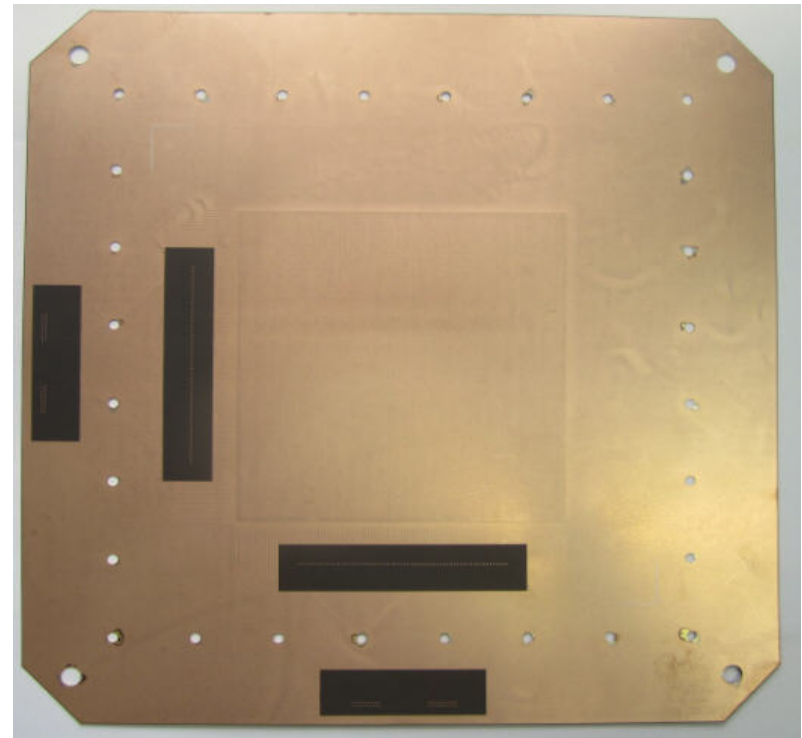
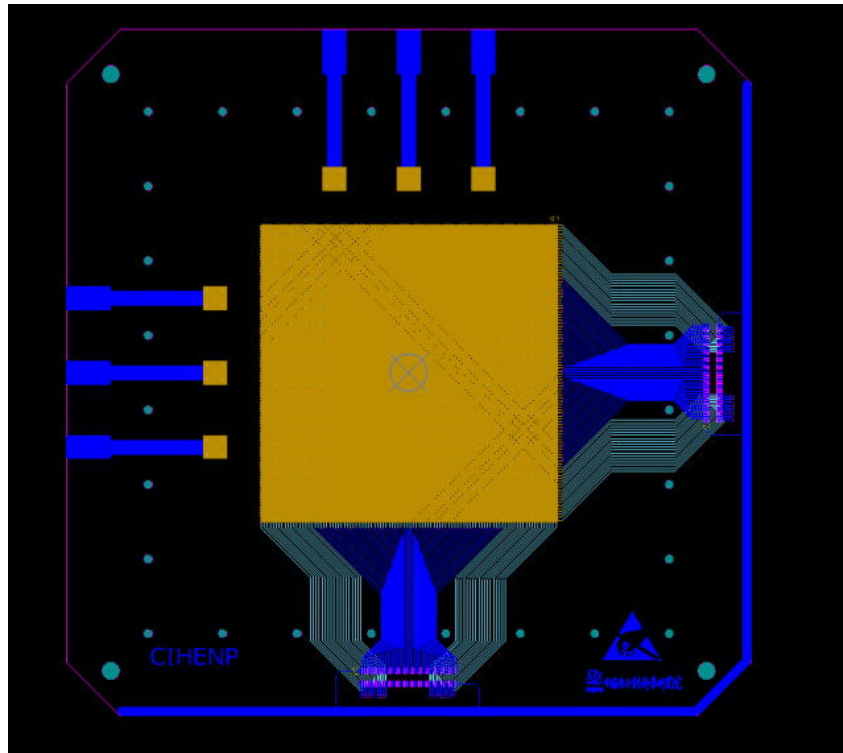
PandaXIII prototype at STJU



The detector works very stable and we have reached good noise levels.

MicroBulk MicroMegas in CIAE

Based on the Collaboration with PANDAXIII(SJTU)
New design of 10cm*10cm MicroBulk MicroMegas
Prototype: XY readout, 200 channels electronics



Next Step

- **Support collaborated company to build some facilities which will be used only for GEM foil production. From prototype to real production step by step.**
- **More R&D on Bulk MicroMegas and Microbulk MicroMegas**
- **New R&D on Hybrid detector (GEM+MicroMegas) collaborated with IHEP.**



Thank You !

