核 数 据 重 点 实 验 室

原子能院GEM探测器研究现状及无中微子双Beta衰变调研

Xiaomei Li

Science and Technology

on Nuclear Data Laboratory

China Institute of Atomic Energy

2014.12 USTC

Outline

1. The progress of GEM foil at CIAE
2. APV25 Readout Electronics at CIAE
3. Next step

北京市275信箱46分箱 邮编102413 电话69357849 传真69357787

The Progress of GEM foil at CIAE

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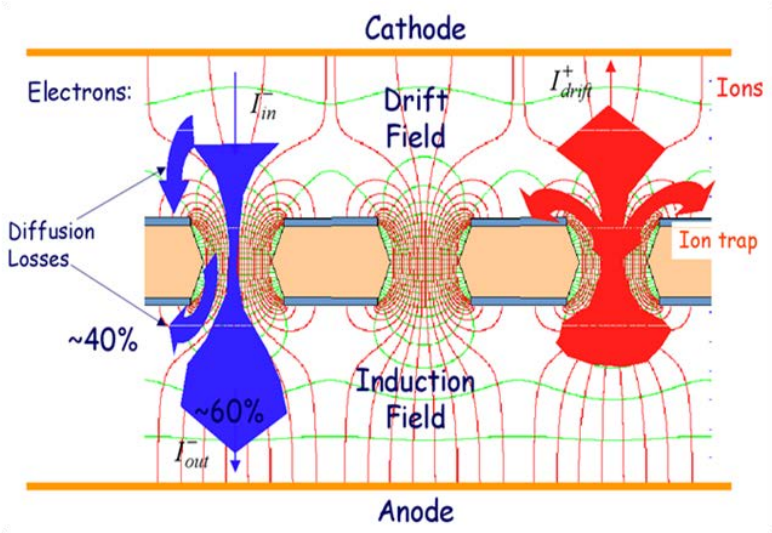
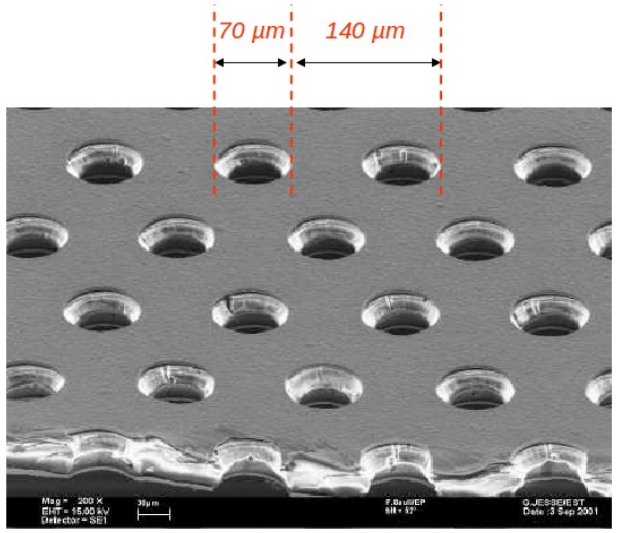
GEM Foil Structure

1. Typical GEM Foil has 3 layers, two 5µm thick copper foils and one 50µm thick kapton foil in the middle.
2. Diameter of the hole is 70 µm , and the distance between them is 140 µm .
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 Detector



GEM Foil

GEM License and Training

CIAE has signed officially the LICENSE AGREEMENT FOR MANUFACTURING AND COMMERCIALISATION OF GEM FOILS AND GEM-BASED PRODUCTS with CERN.

I took a training for GEM foil at CERN.

Clean Room

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

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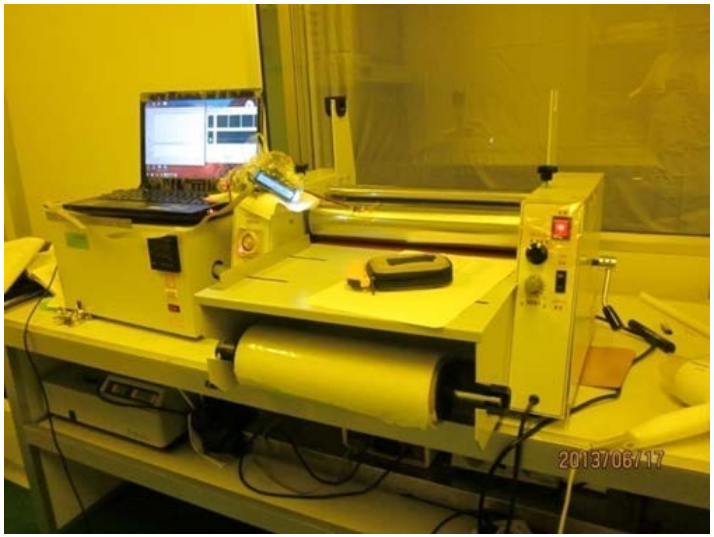
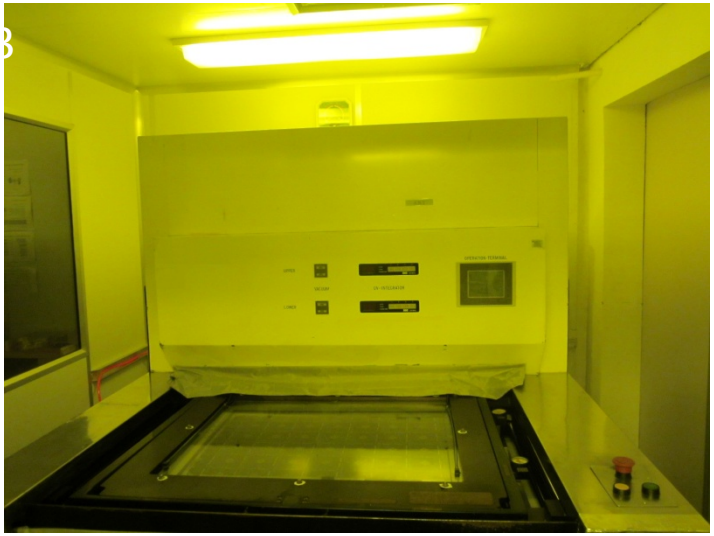
Photolithography Lab Construction At CIAE

The Equipments for Lamination and Exposure of Dry Film Photoresist





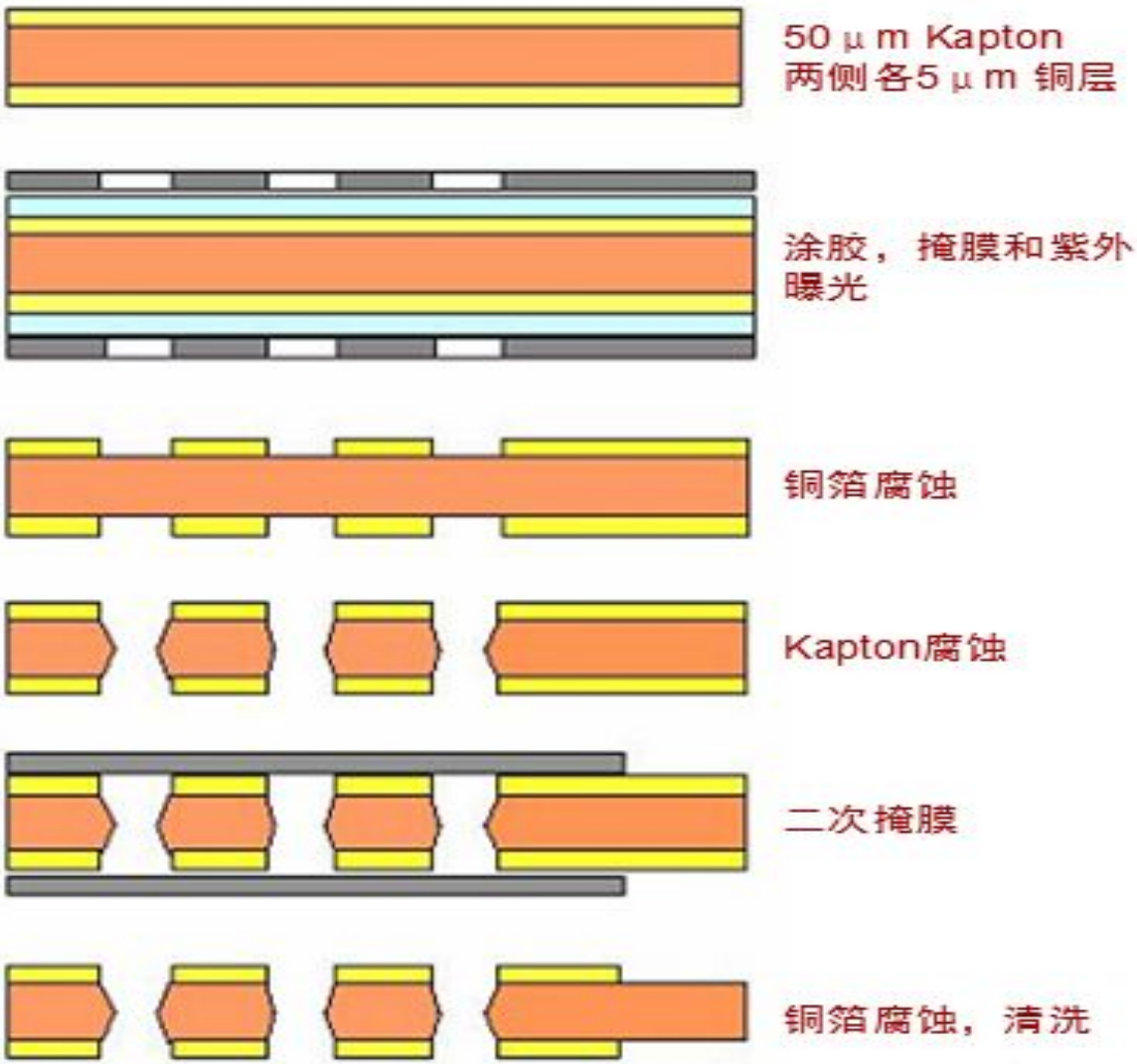
Lamination and exposure of dry film photoresist are the most important and difficult steps for GEM foil production.

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 teach the PCB technology.

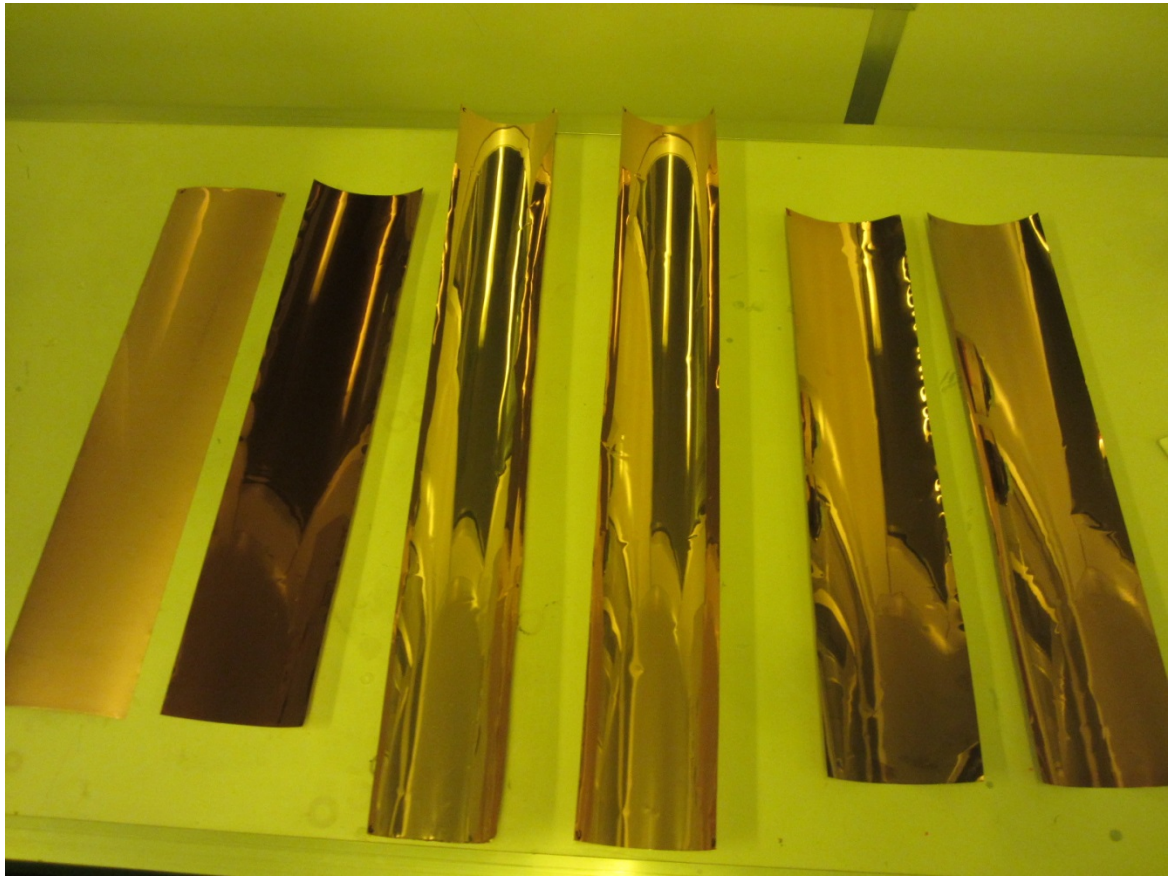
Etching Room Construction

The Procedure of GEM Foil



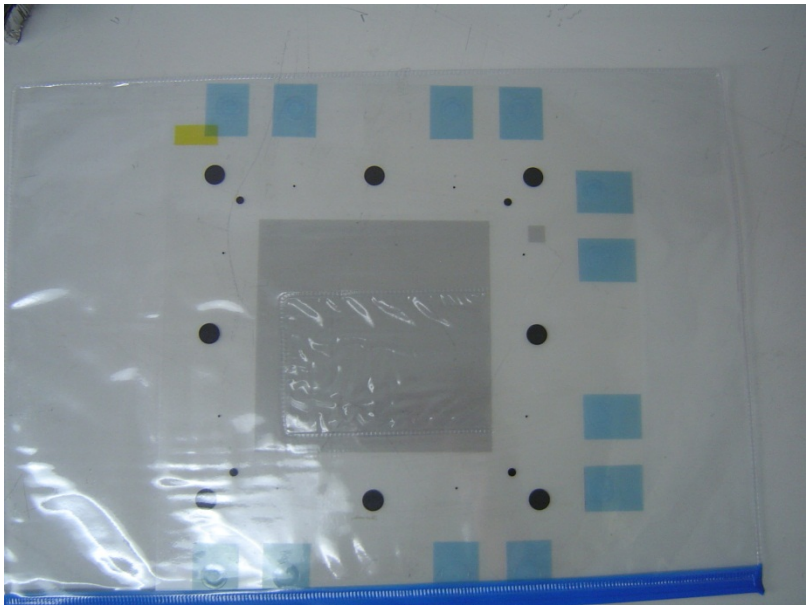
工艺流程

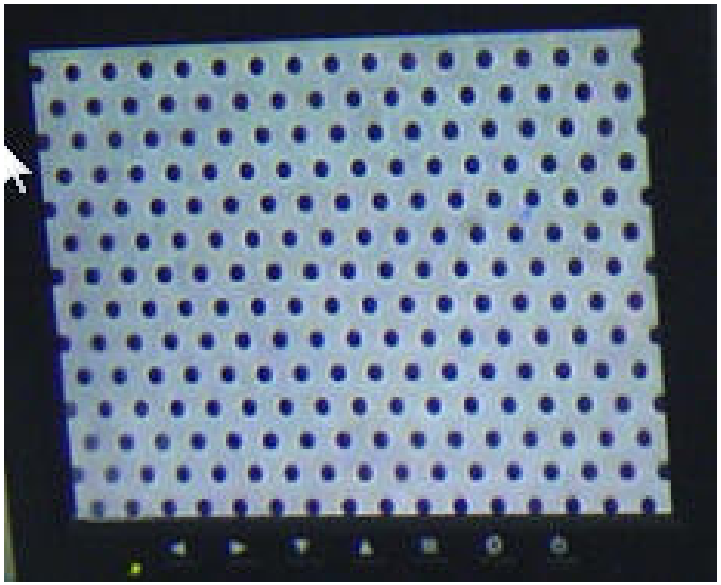
The Preparation of Raw Foils



Thanks a lot for the support of USTC, IHEP and Washington University .
The left two are from US, the others are from CERN (made by Korean).

GEM Photo Mask Plate

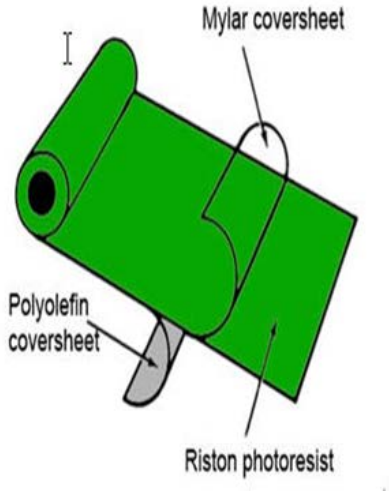


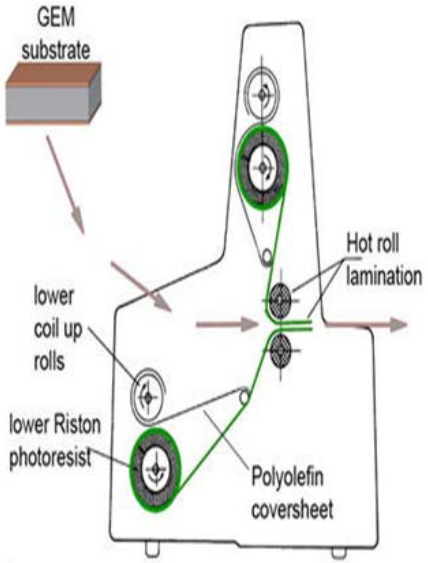


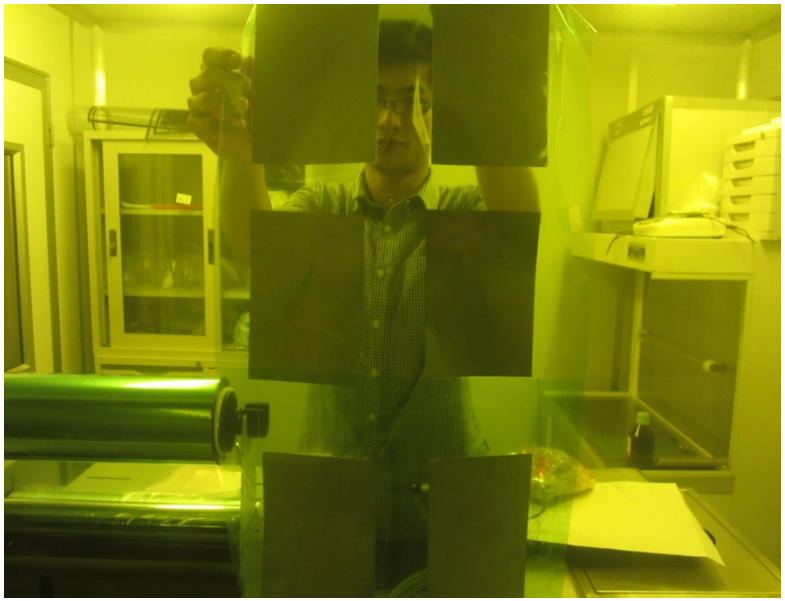
The copies of the photo-mask are done by photolithographic techniques and can be reproduced multiple times.

Lamination of Dry Film Photoresist

The photoresist is sandwiched between an inner polyolefin cover sheet and an outer Mylar protective layer.



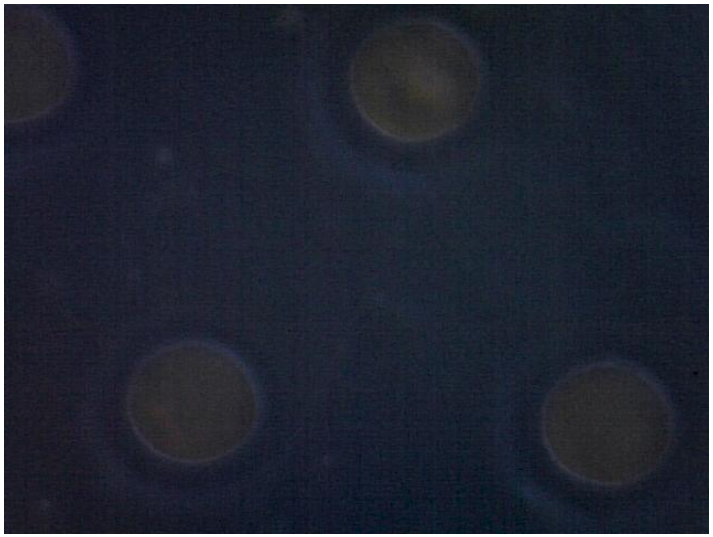




Exposure of Dry Film Photoresist

We use negative photoresist for GEM image transfer, unexposed areas are relatively unchanged and easily washed out by solvents during the development.

To obtain an identical copy of the photo-mask to the photoresist, vertical sidewalls in the resist are important.



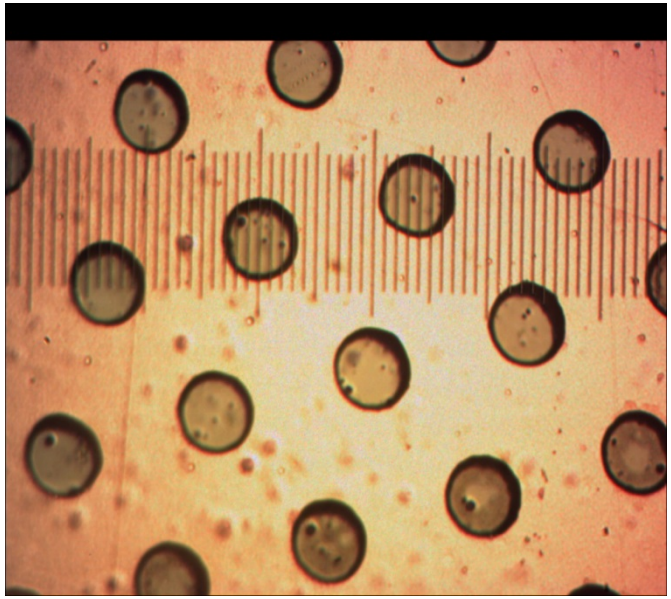
We can observe the image transfer with good accuracy.

Copper Etching

- The solution used to copper etching consists of water, ferric chloride and hydrochloric acid.

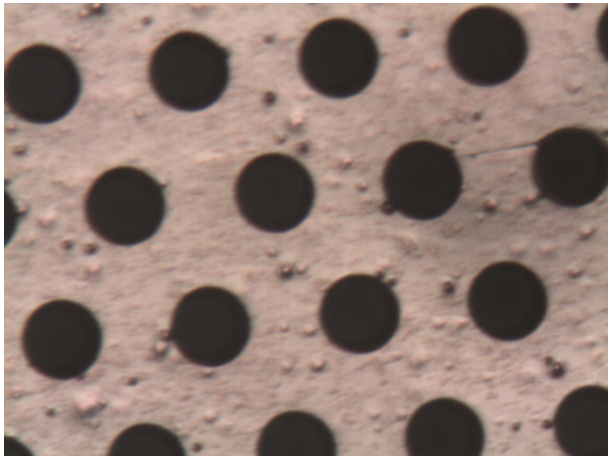
- Generally the holes in the resist of standard GEMs are 50 μm of diameter. The favored diameter of holes at copper layer is 70 μm with a pitch of 140 μm.

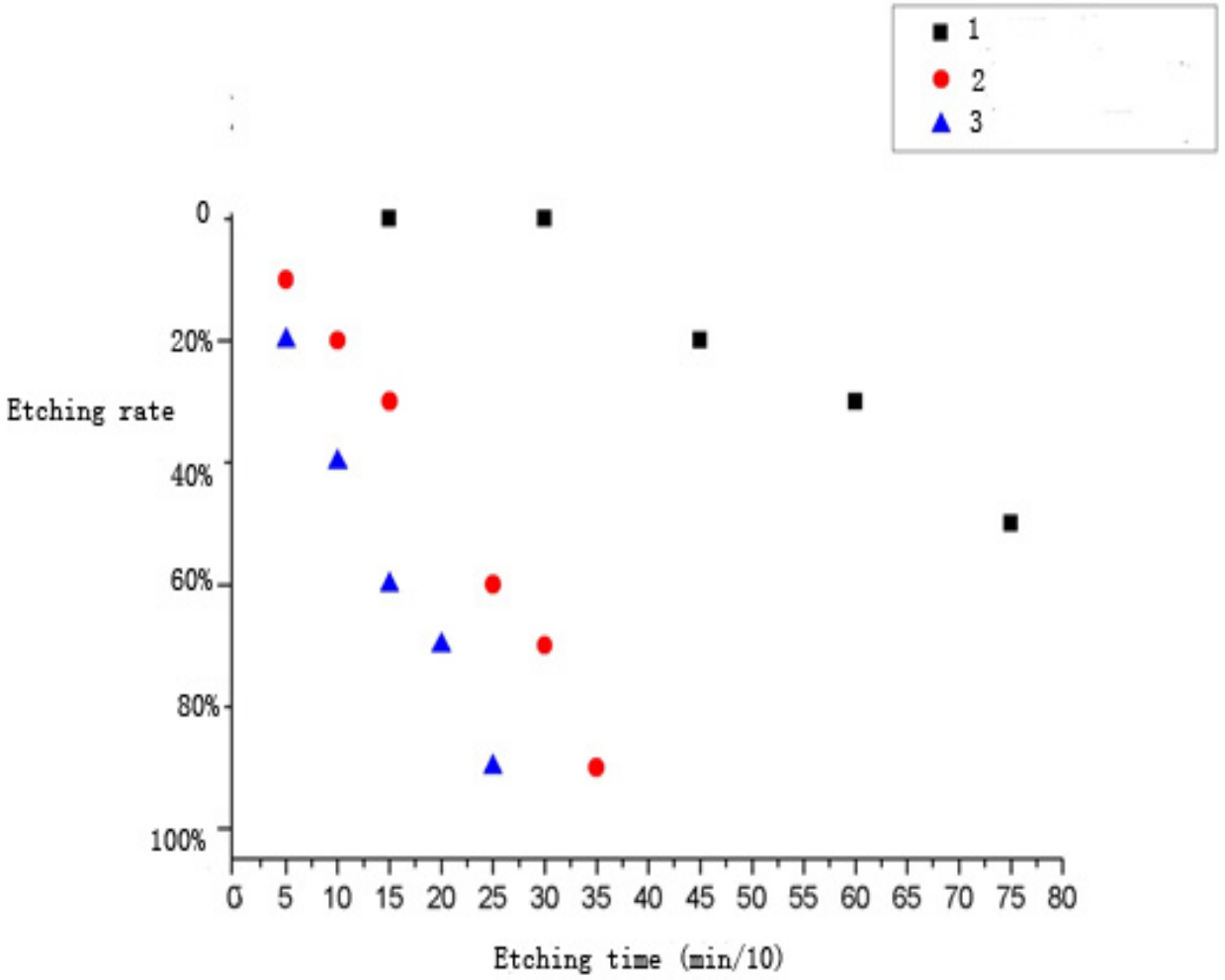
- Remove photoresist after copper etching



We did more than hundred times experiments before reaching this result.

Kapton Etching

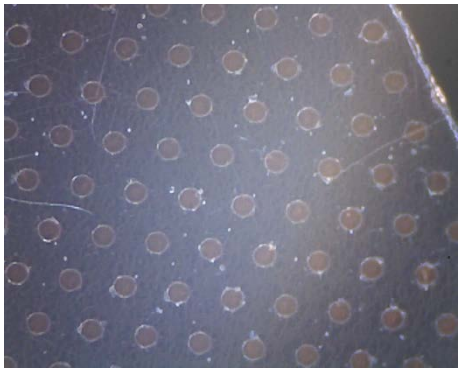




Comparison of Foils Making by Different Conditions

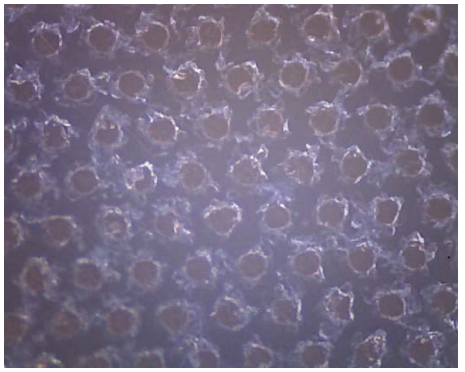
- More than 2000 samples have been tested

显影不足

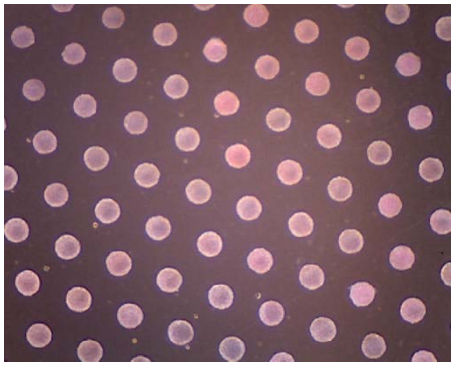


显影适合

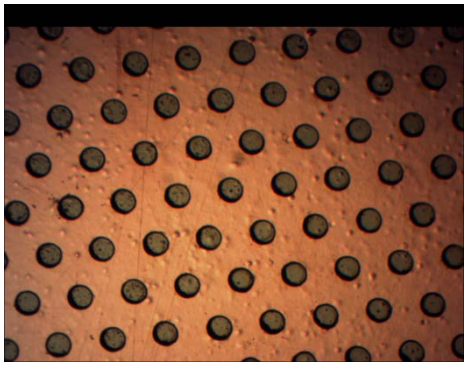
显影过度



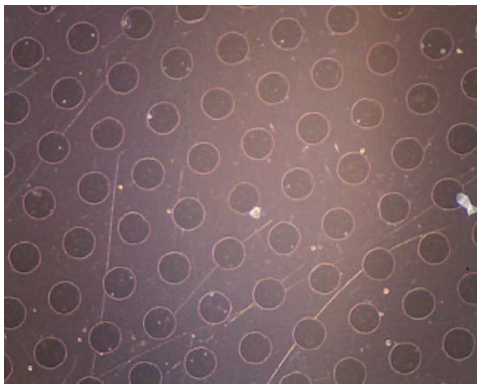
酸刻不足



酸刻适合

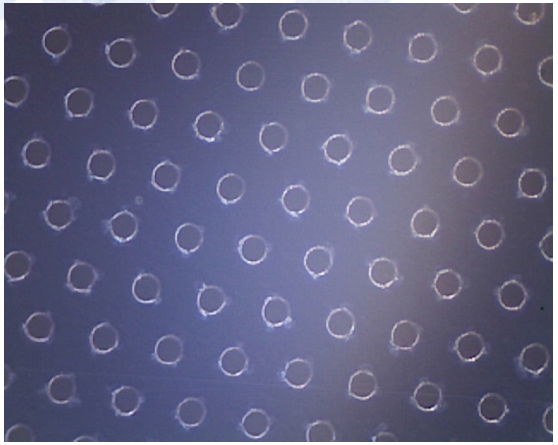
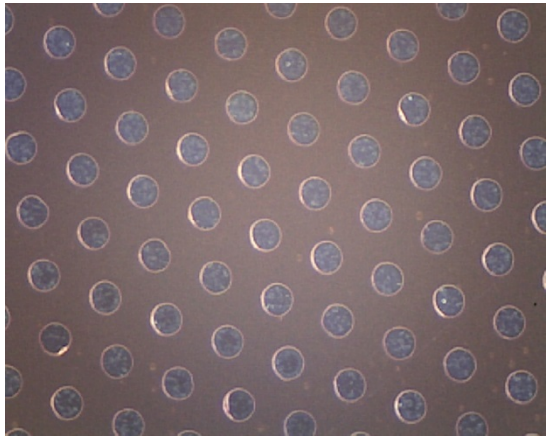
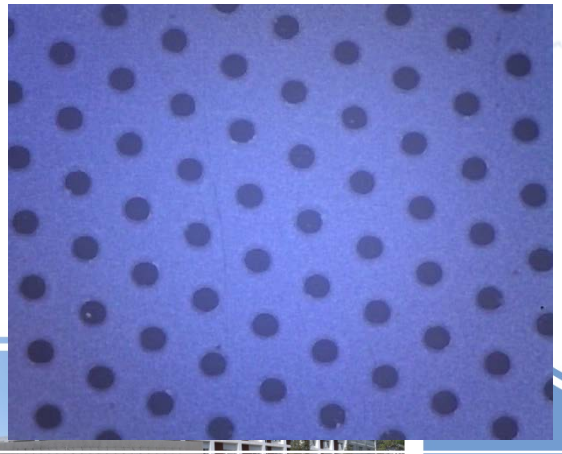


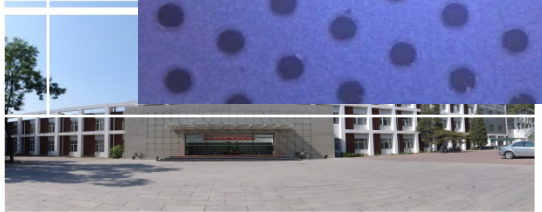
酸刻过度



Comparison of Different foils

The results are very nice

	After Copper foil etching	After photoresist removed
Raw foil from CERN		
Raw foil from USA		



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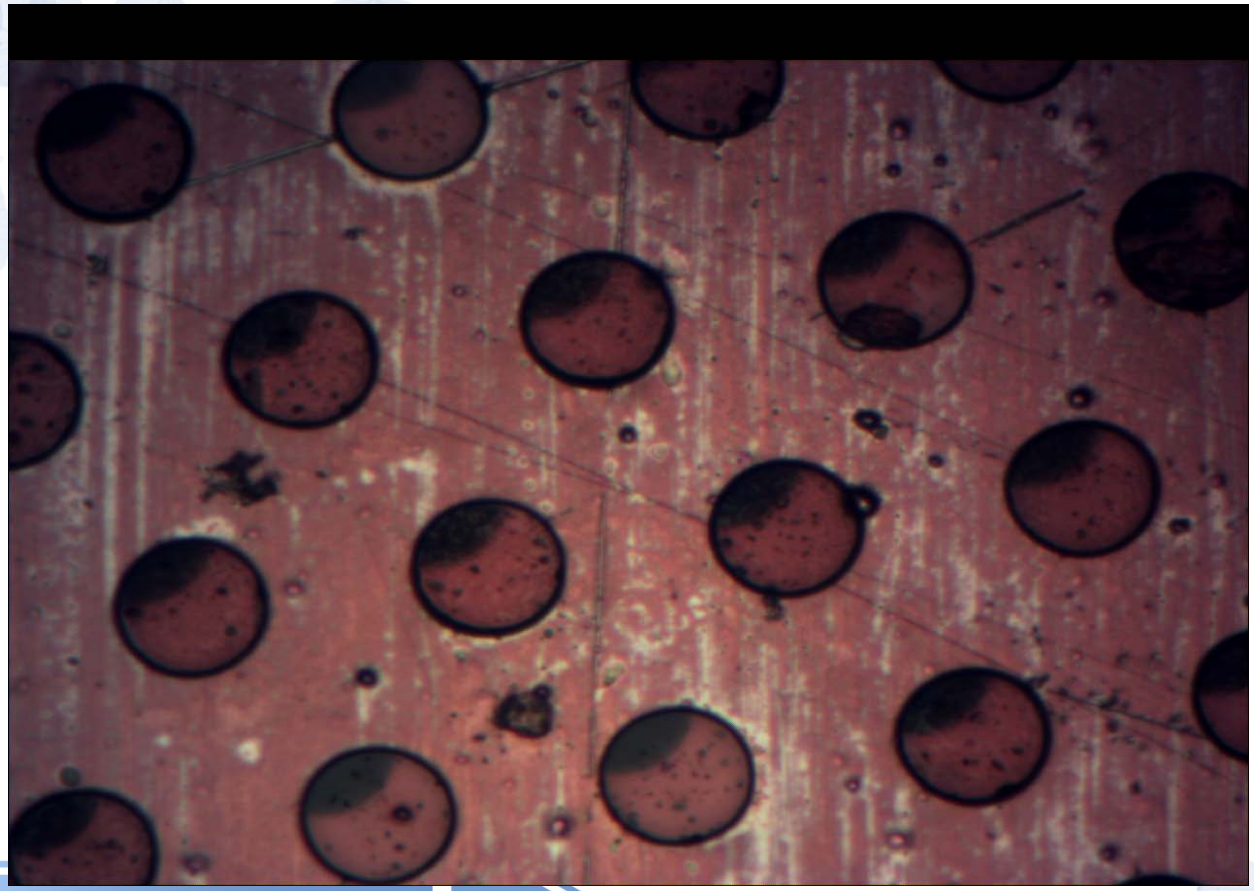
Key Problem



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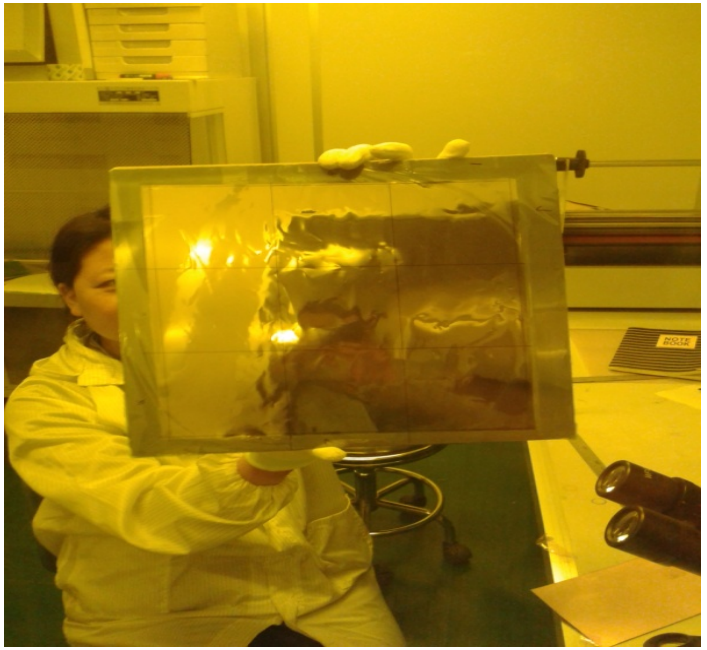
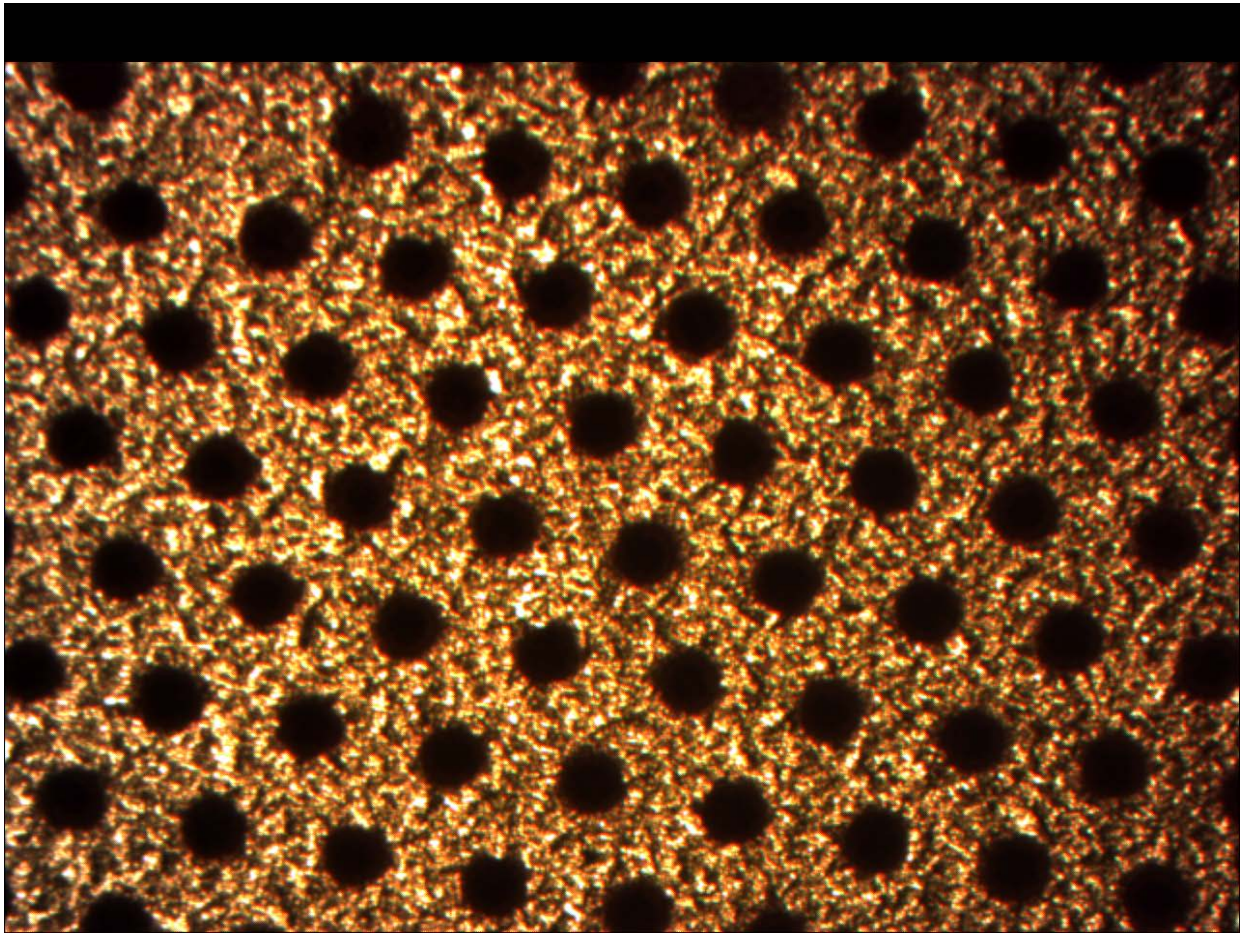
30cm*30cm GEM foil



Thick GEM Foil



APV25 Readout Electronics at CIAE

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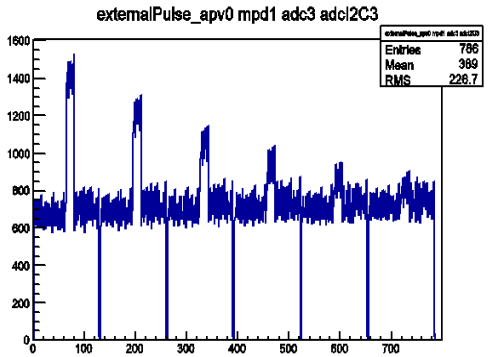
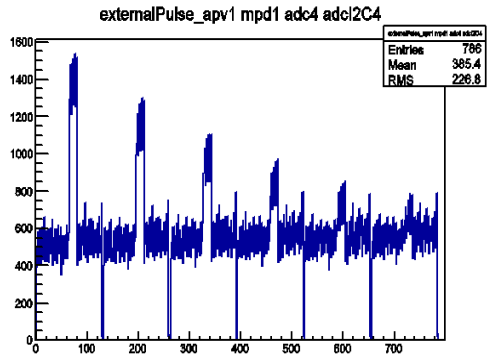
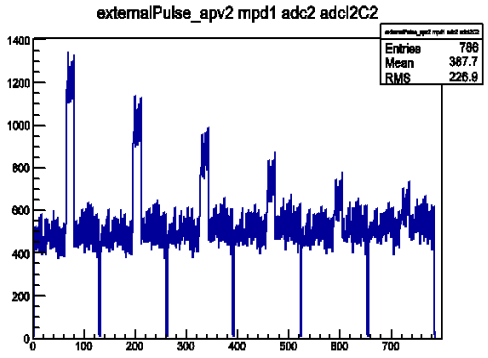
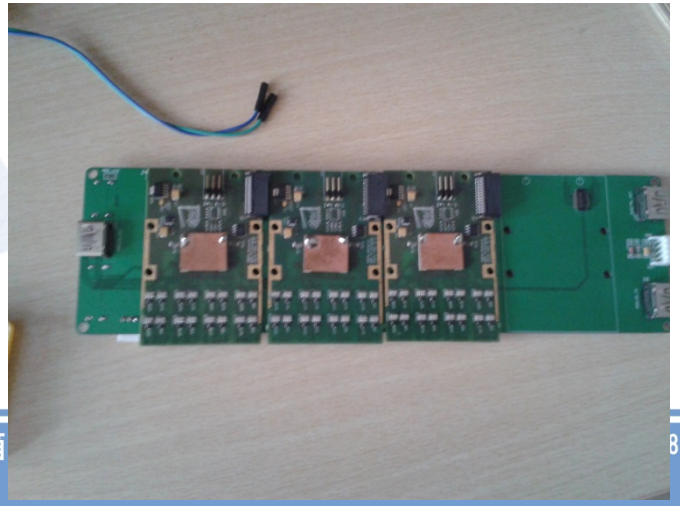
APV25 Readout Electronics

- Tested APV25 readout electronics successfully.
- Made backplanes by collaborating with a factory at CIAE.
- debugging the system to get better performance.





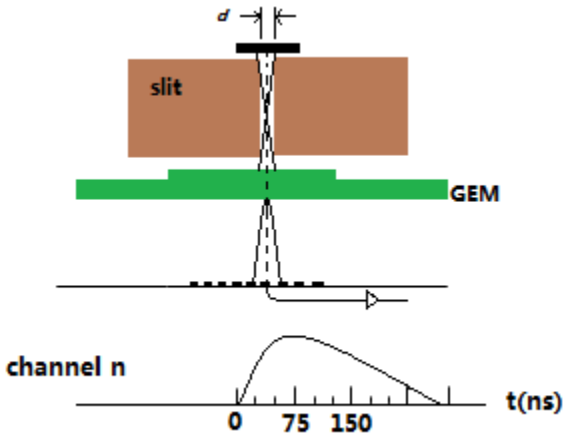




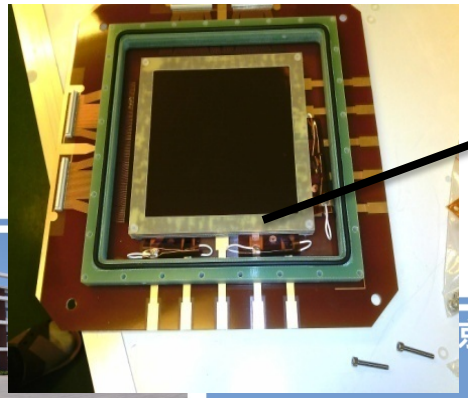
$$\sigma_{tot}^2 = \sigma_{GEM}^2 + c_1\sigma_{geometry}^2$$

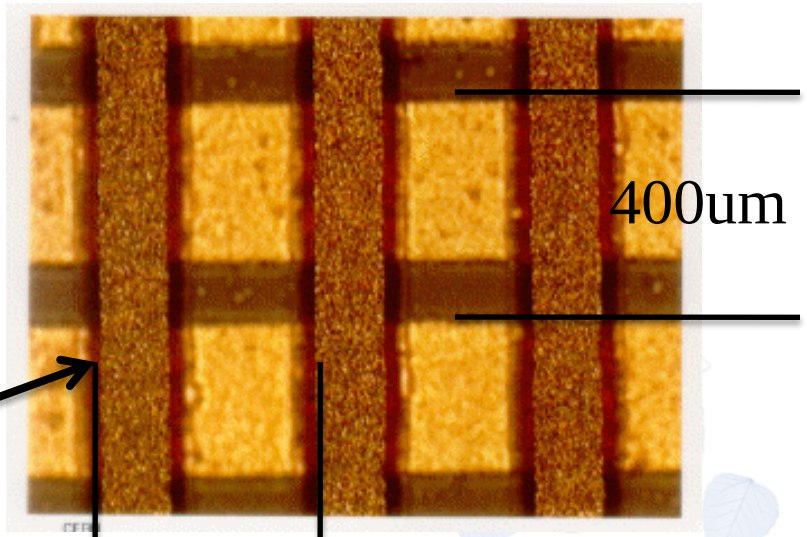
When: $\sigma_{geometry} \ll \sigma_{GEM}$

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



- **Slit(um): 20;**
- **Ar: CO_2=70% : 30%;**
- **HV: 3600V;**
- **The distance between strips: 400um;**





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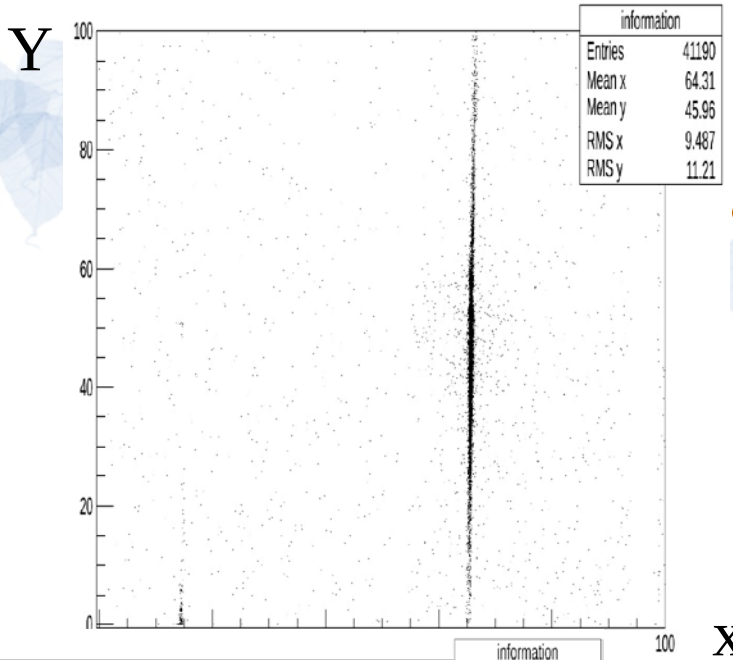
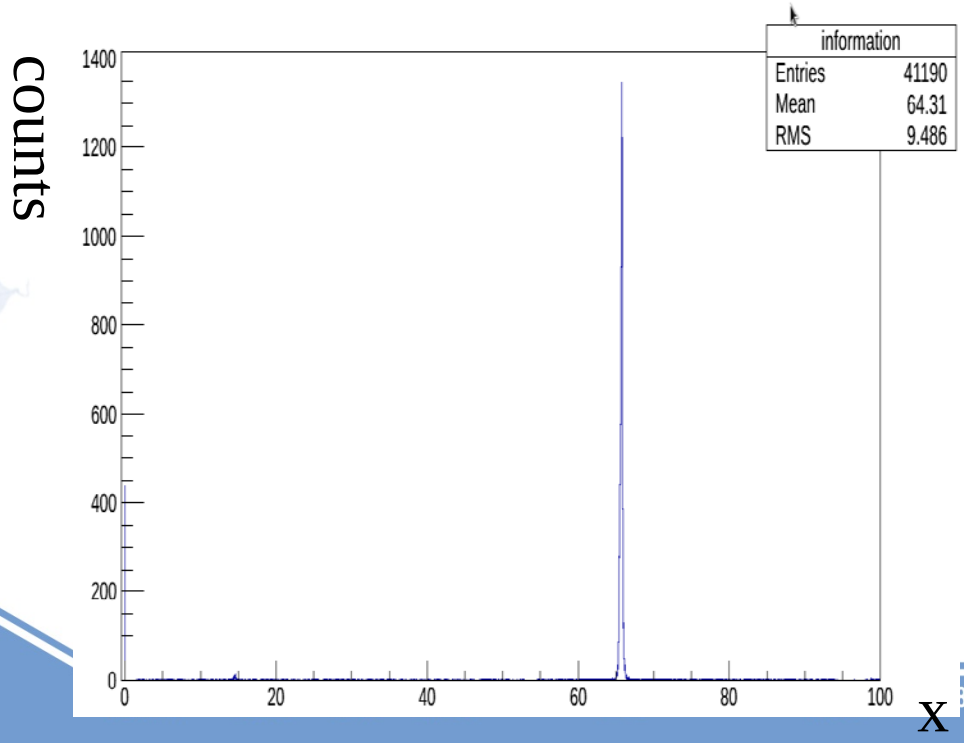
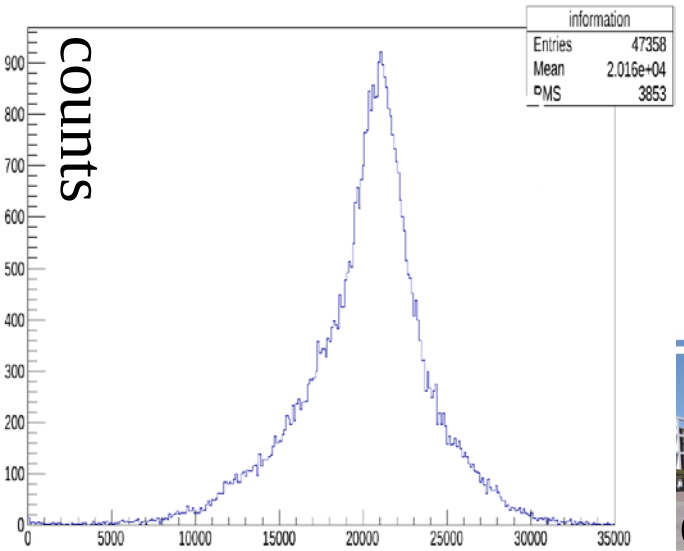
Spatial resolution

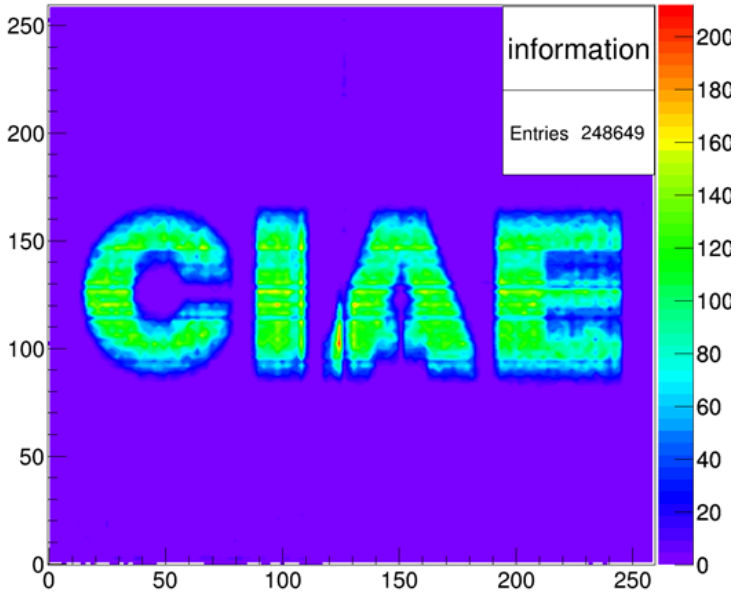


- Spatial resolution≈76um(sigma)





X-ray imaging @ CIAE



- X ray Energy: 10KeV;
- about 1k sample rate
- 256 channels for each dimension(512 channel in total);
- 4 APV FECs were used (2 for each dimension)

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总结与展望

•我们已经掌握GEM膜研制的所有技术，完成GEM膜研制实验室建设，采用双面掩膜技术成功研制30cm*30cm GEM 膜。双面掩膜的情况下GEM膜的上下孔对正是一个很大的问题，通过改进曝光机对正系统已基本解决。正采用单面掩膜技术进行40cm×40cm面积的GEM膜研制。

•完成GEM探测器APV25电子学测试、改进和成像研究

•完成更大面积GEM探测器研制和更多路数APV25电子学测试和成像研究

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无中微子双Beta衰变调研

孙汉城

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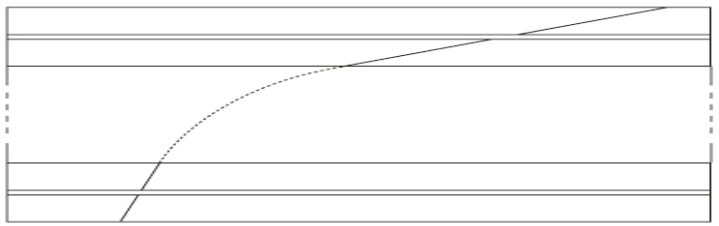
方案1) 将^{130}Te,（或^{100}Mo）与^{48}Ca这些有双β衰变的核做成50-100纳米大小的微粒混在乳胶中，放在地下实验室中积累事件，2-3年后显影。先观察挑出从纳米颗粒中向180^0相反方向发出两个电子的事件。再测这两个电子的能量。为了提高能量分辨率，用磁场将电子径迹偏转来测其动量。乳胶叠是多层薄片，两片之间隔5cm空气，电子从上一片乳胶中穿出后，在空气中穿过时受磁场作用而弯曲（磁场强度1000高斯，由永磁体产生）进入下一片乳胶，由此定出动量。此方案比世界上其他方案的特点是：它既有最好的空间分辨(1μm)，又有良好的能量分辨（约1%）。如图。



方案2）用室温半导体碲锌镉（CZT）代替目前世界上最好的方案用的低温量热器氧化碲。CZT的最大优点是不用低温，就在室温工作，可以省下大量低温费用，减少低温装置带来的放射性本底。唯一差一点的是能量分辨率，低温热器是0.3%,CZT是0.5%。这一点是没有多大影响的。

还有点不同的是氧化碲测的是碲，CZT测的是镉，镉的Q值2.8大于碲的2.53。更好测。

还有一个现实的优点是现在世界上做CZT最好的美国INNEL公司的掌门人李陇遐是美籍华人，已将公司迁回国内，可以更好合作。

Thank You !

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