A Practical Method to Estimate the Spatial Resolution of GEM Detector

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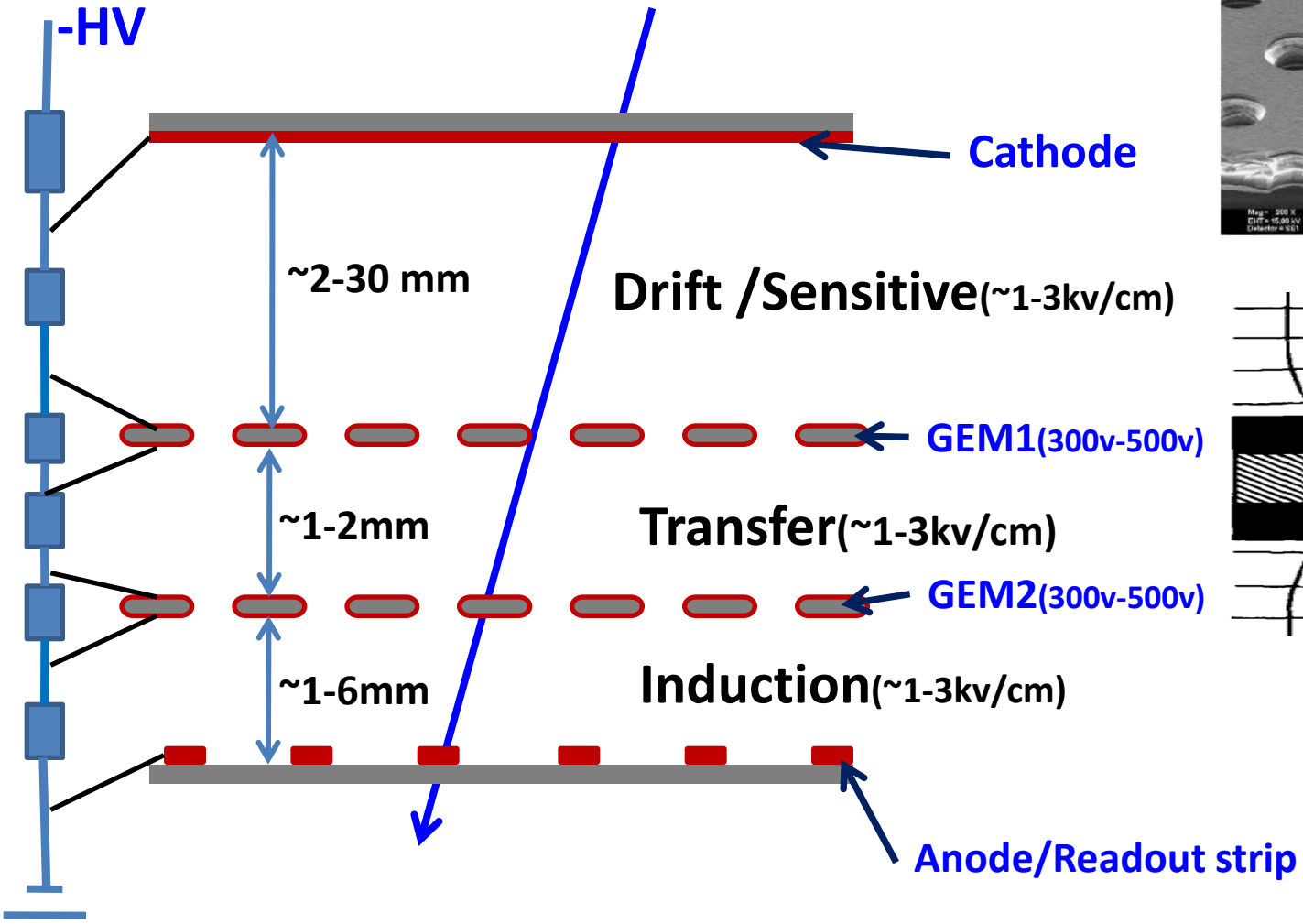
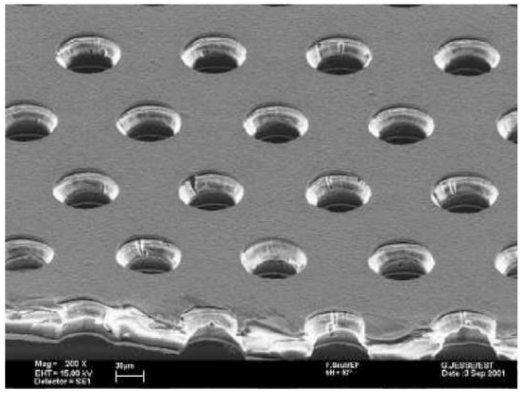
The Fourth Workshop on Hadron Physics in China and Opportunities with 12GeV JLab

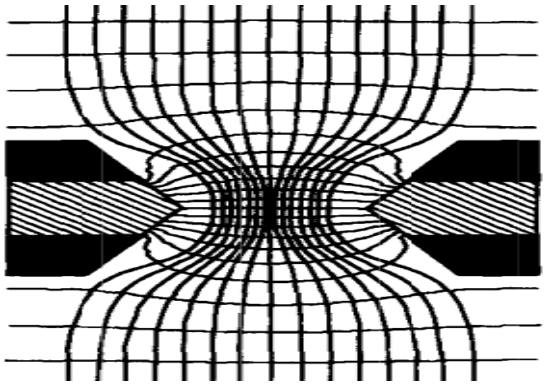
Outline:

- Introduction
- Method description
- Experimental results
- Near future plans
- Summary

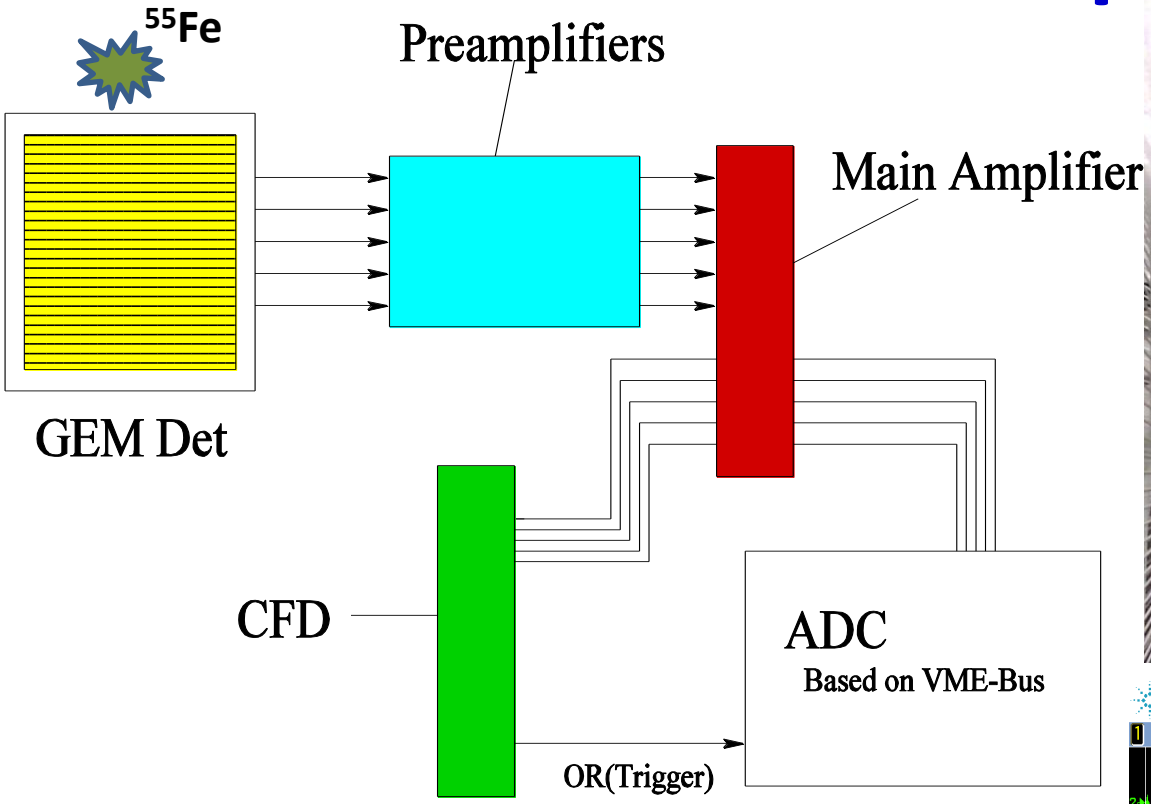
Brief introduction to GEM detector

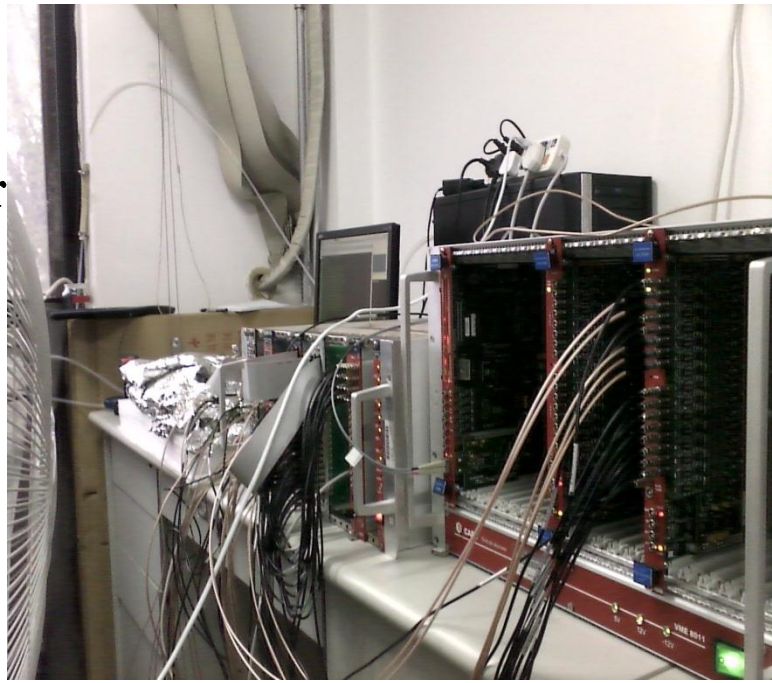


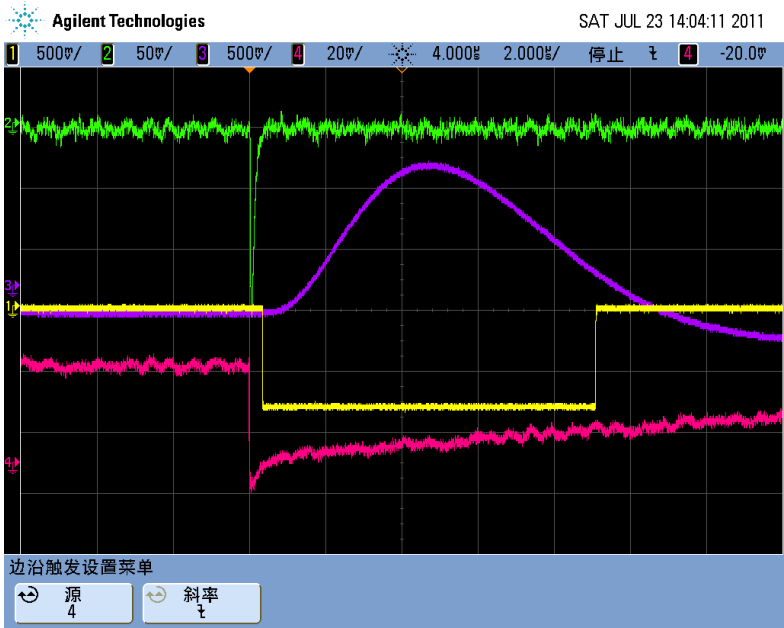




Introduction to the set up

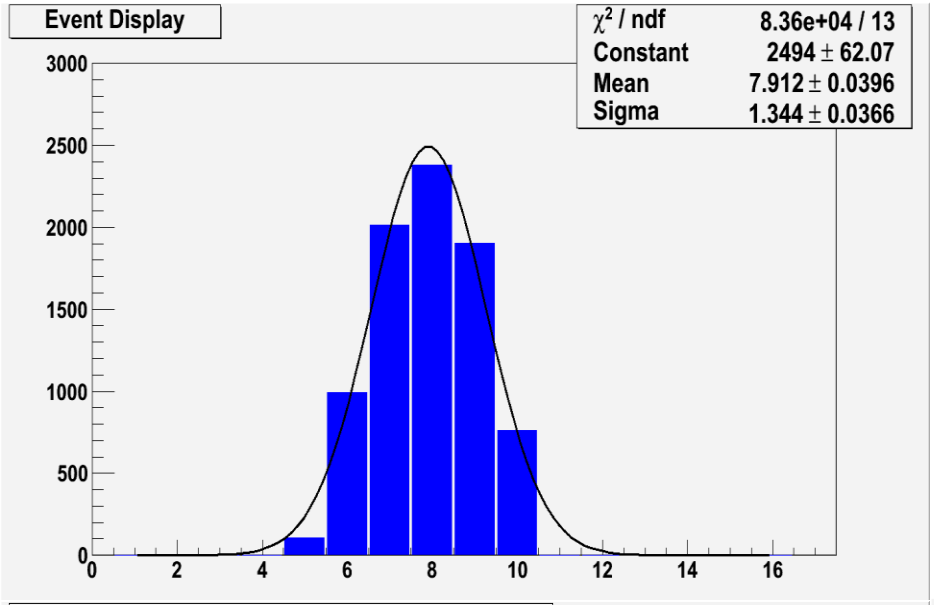


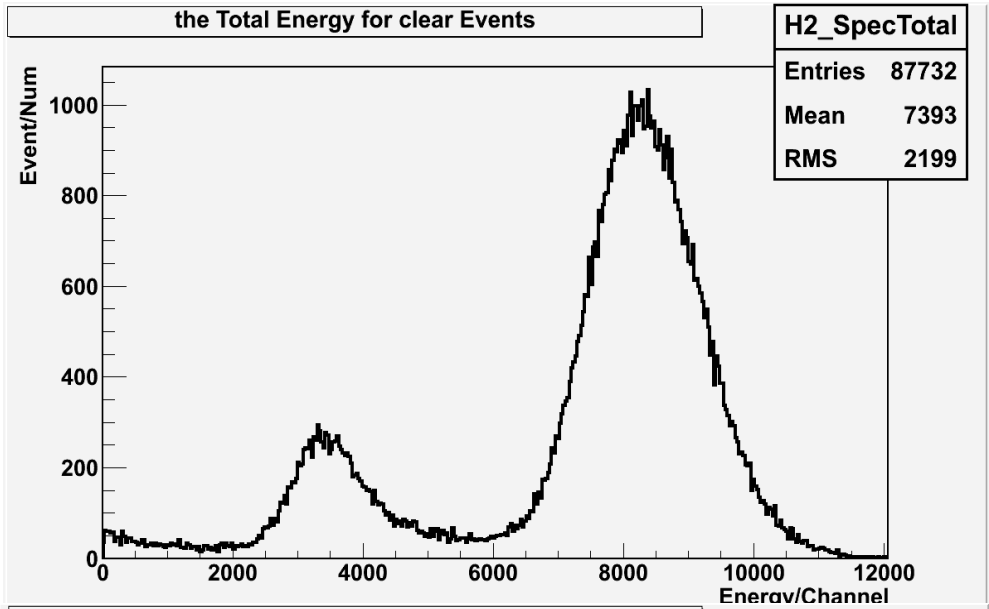


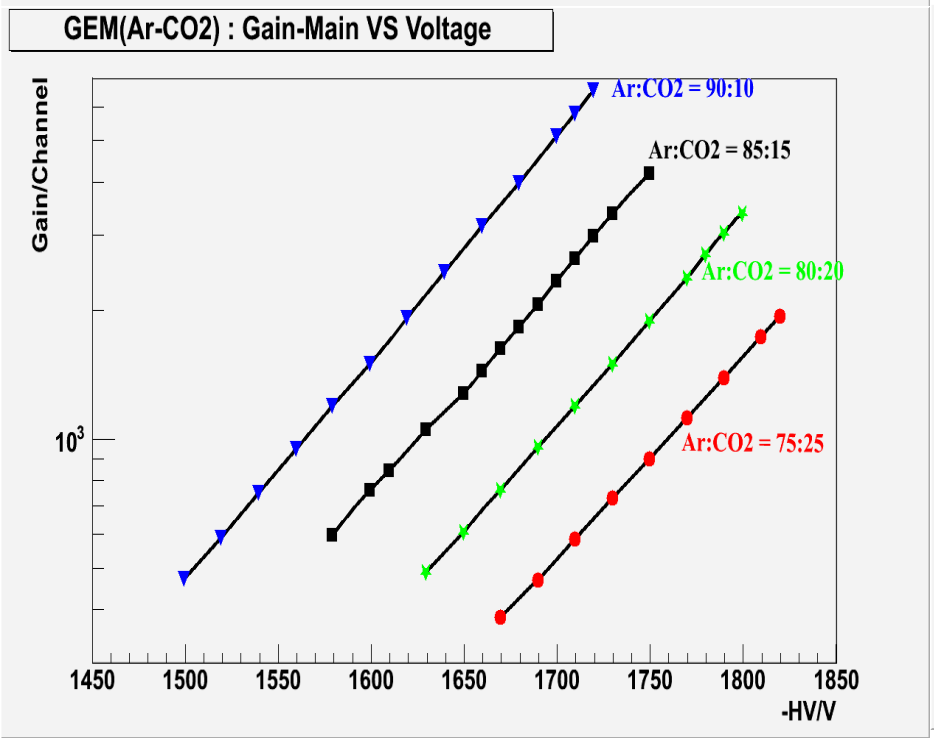


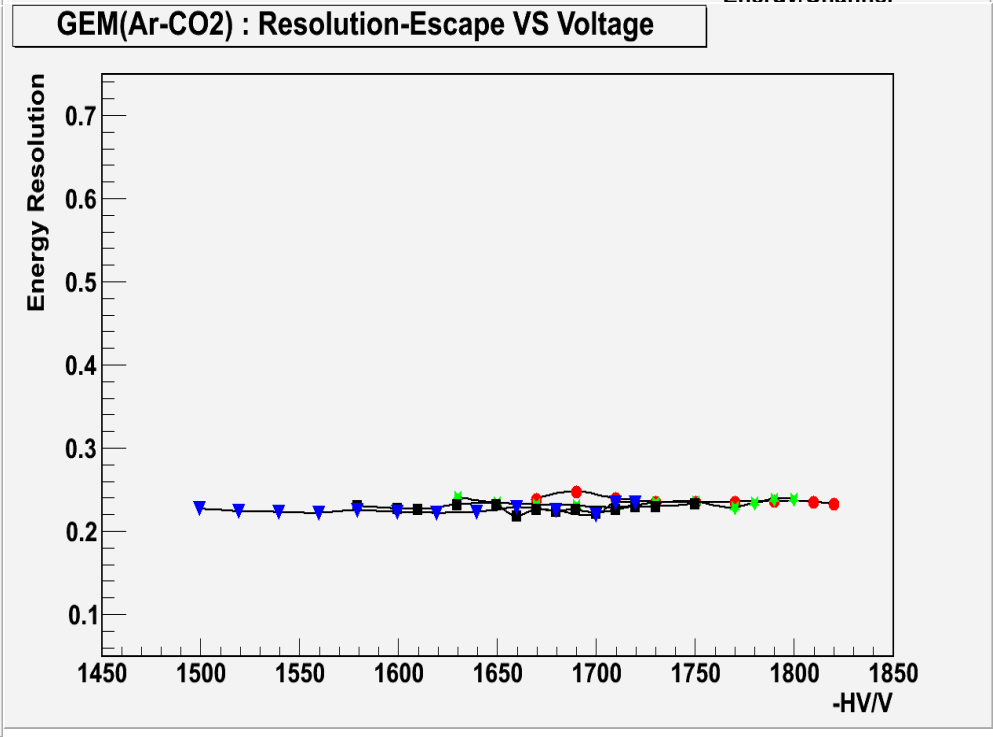
- Readout strip: 1-D, width=200um, 400um;
  2-D, width=400um
- Preamplifier: Charge-sensitive, 16 channels
- DAQ: Based on VME-Bus, peak sensitive ADC

General performance





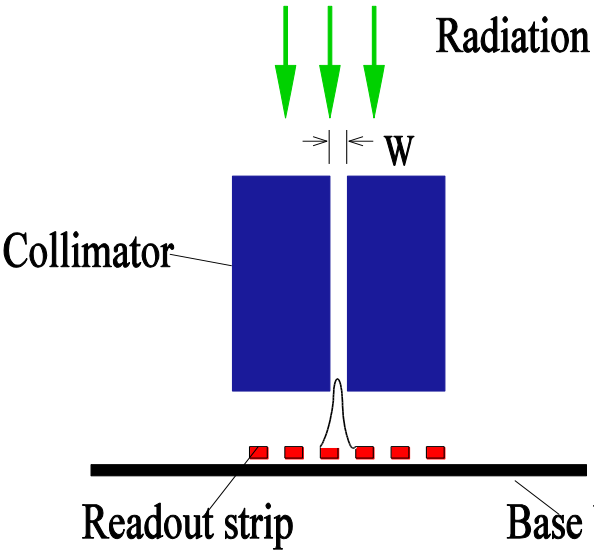




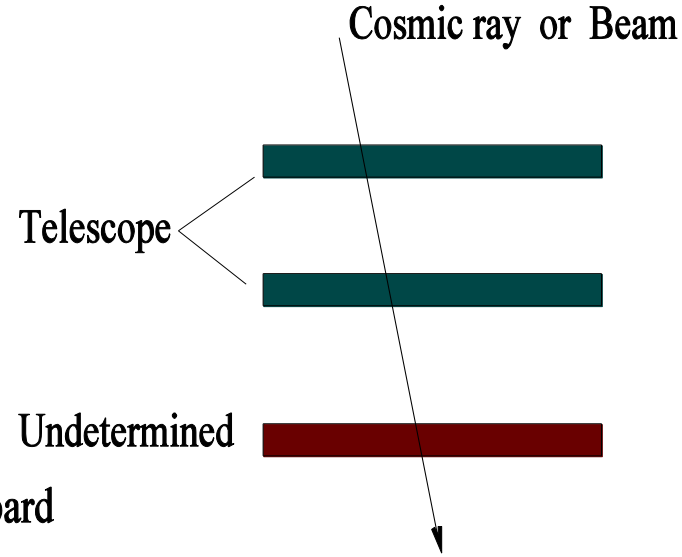
Method description

Conventional methods for spatial resolution

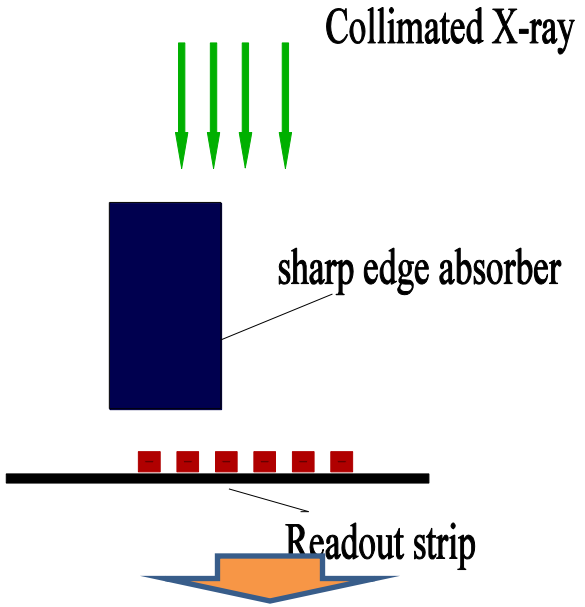
Method Ⅰ:

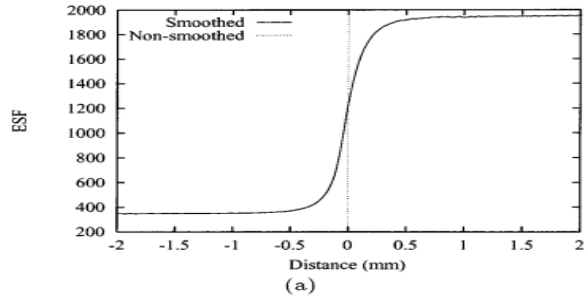


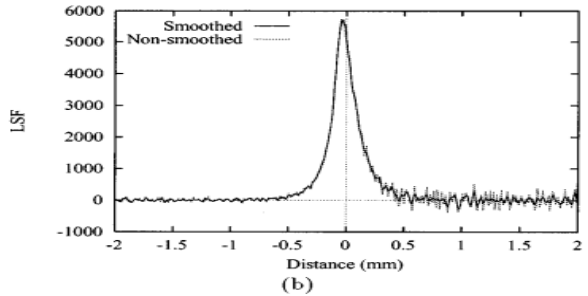
Method Ⅱ:



Method Ⅲ:







Ref:

1, RADIOLOGY 93: 257-272, August 1969.

2, Med. Phys. 25(1), January 1998

3, Med. Phys. 11(6), 1984

Comparison of different methods

#Method	σ_0 /μm
Method 1 (slit width=200μm) No deconvolution	1314.9
Method 1 (slit width=200μm) With deconvolution	65.0
Method 1 (slit width ~10μm)	59.9
Method 3	71.3
Method 3 (with improved data processing)	63.3

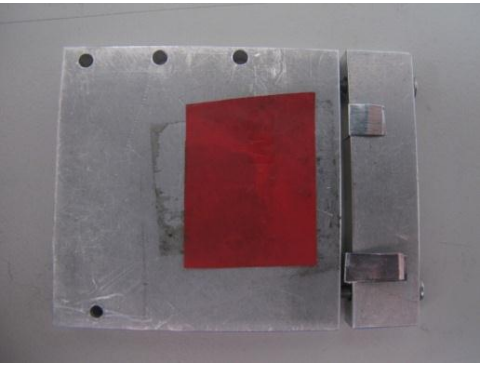
Ref: Chinese Physics C, Vol. 36, No. 3, Page 228-234

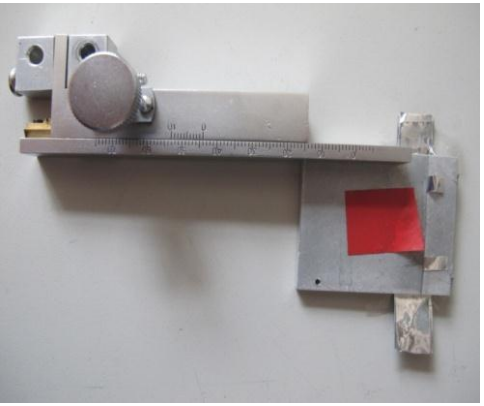
Difficulties:

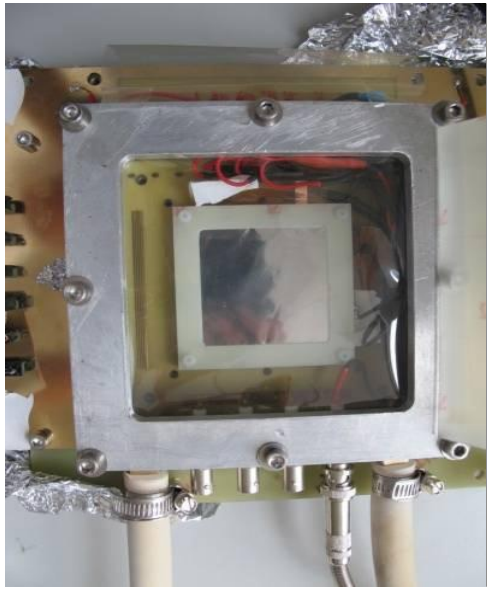
- ◆Method 1: Precise slit fabrication and alignment in the radiation; or intense radioactive source;
- ◆Method 2: Complex auxiliary equipment;
- ◆Method 3: Precise edge fabrication and collimated X-ray source needed;

But, what we have:

1， A slit with adjustable width, but the width can NOT be measured precisely.

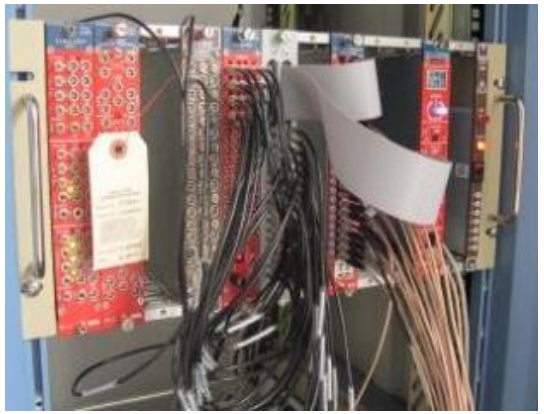






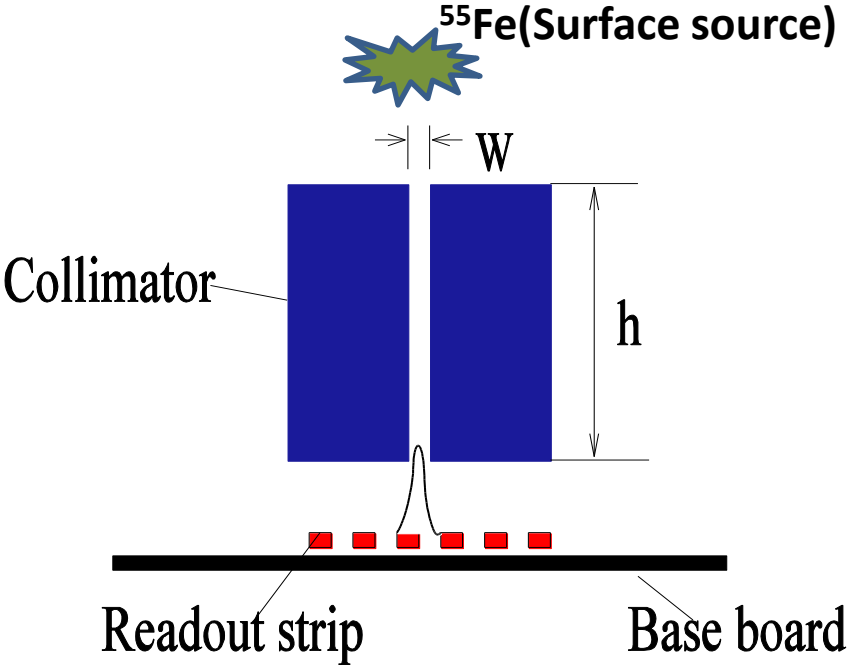
2, a ^{55}Fe with low Activity (5 × 10^4 Bq), Surface source, s～ 0.78cm^2

3, Very limited in electronics (16 channels);



It is natural to use method 1. But…

A practical method



$$\sigma^2_{tot} = \sigma^2_{GEM} + c_1\sigma^2_{Geometry}$$

when $w \sim \sigma_{GEM}$

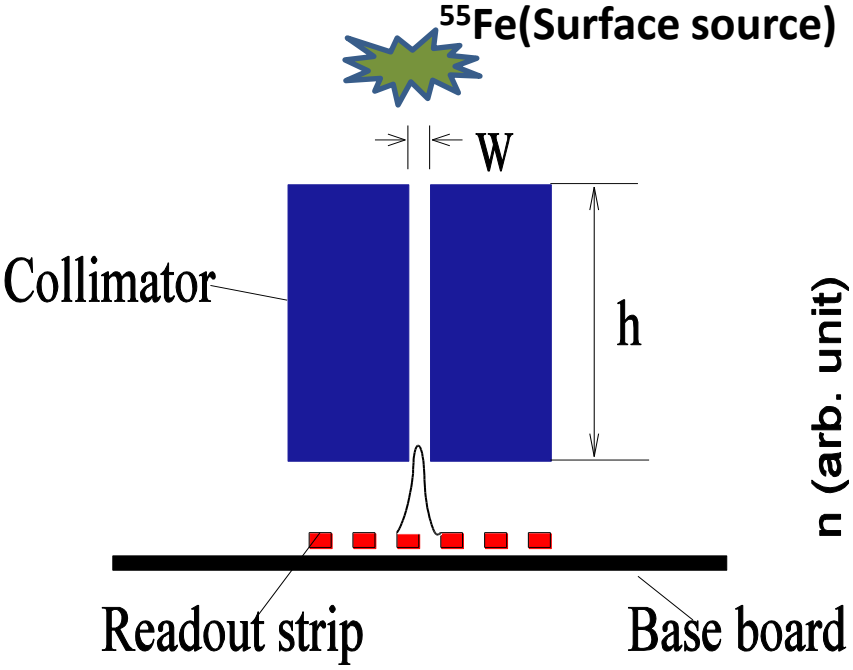
$$\sigma_{Geometry} = c_2 w$$

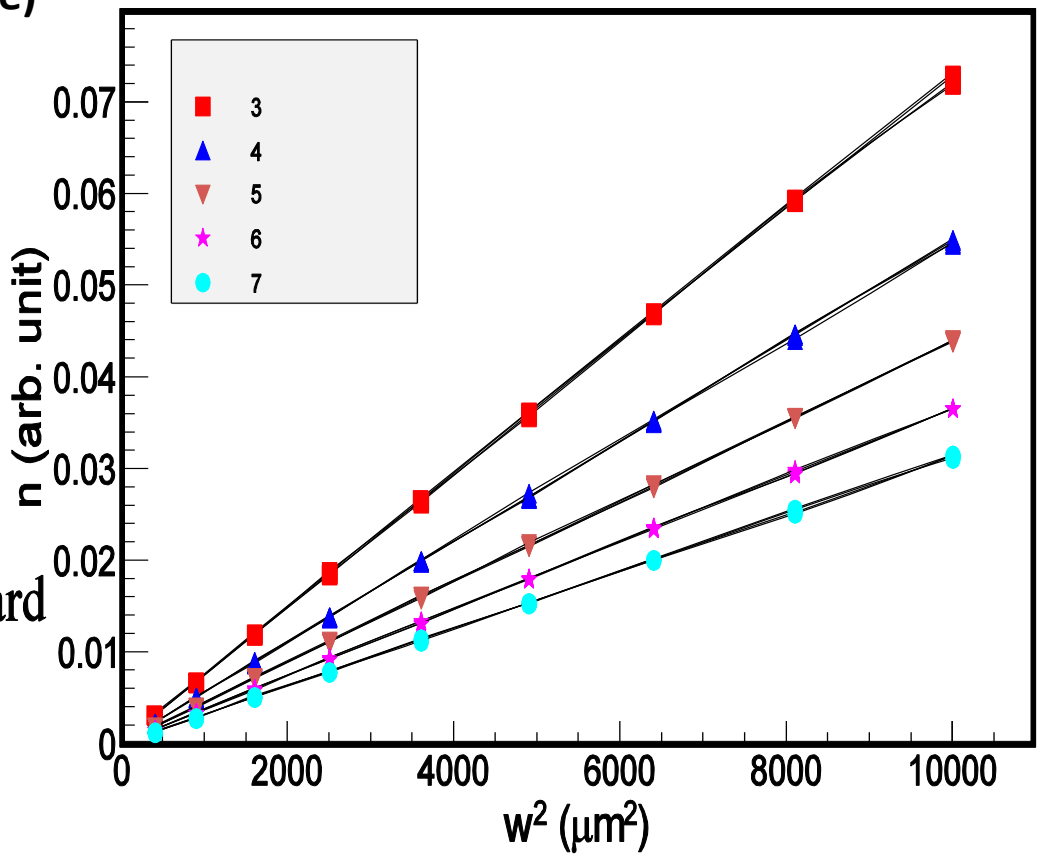
$$\sigma^2_{tot} = \sigma^2_{GEM} + c_0 w^2$$

But, the slit width can NOT be measured precisely.

Luckily:

A practical method (Continue)





$$n = c_2 w^2$$

therein, n means the counting rate

$$\sigma^2_{tot} = \sigma^2_{GEM} + c_0 n$$

Simulation Results(1-D)

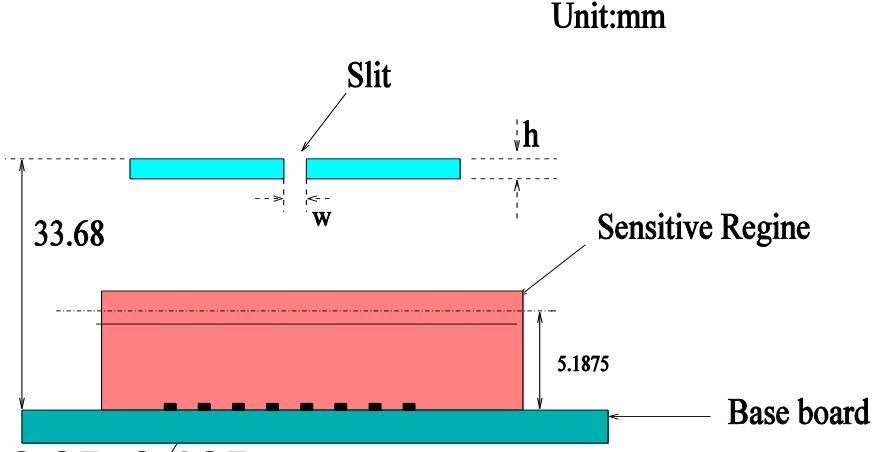
Simulation conditions:

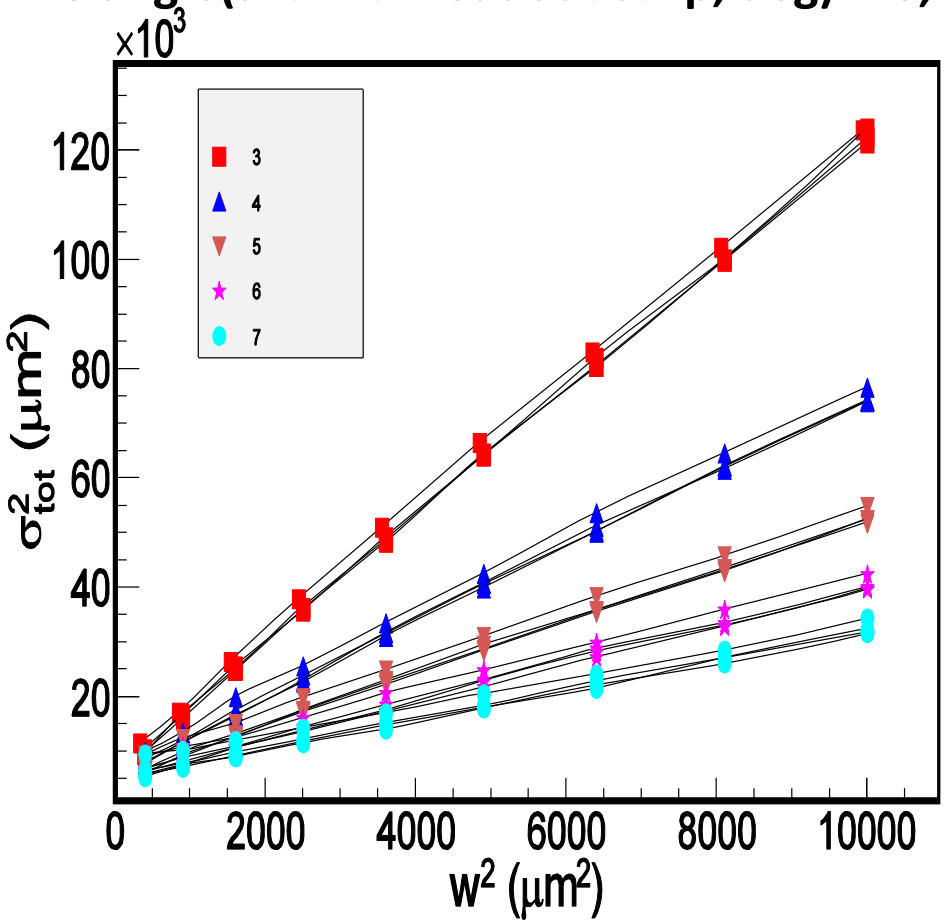
GEM spatial resolution: 70μm;

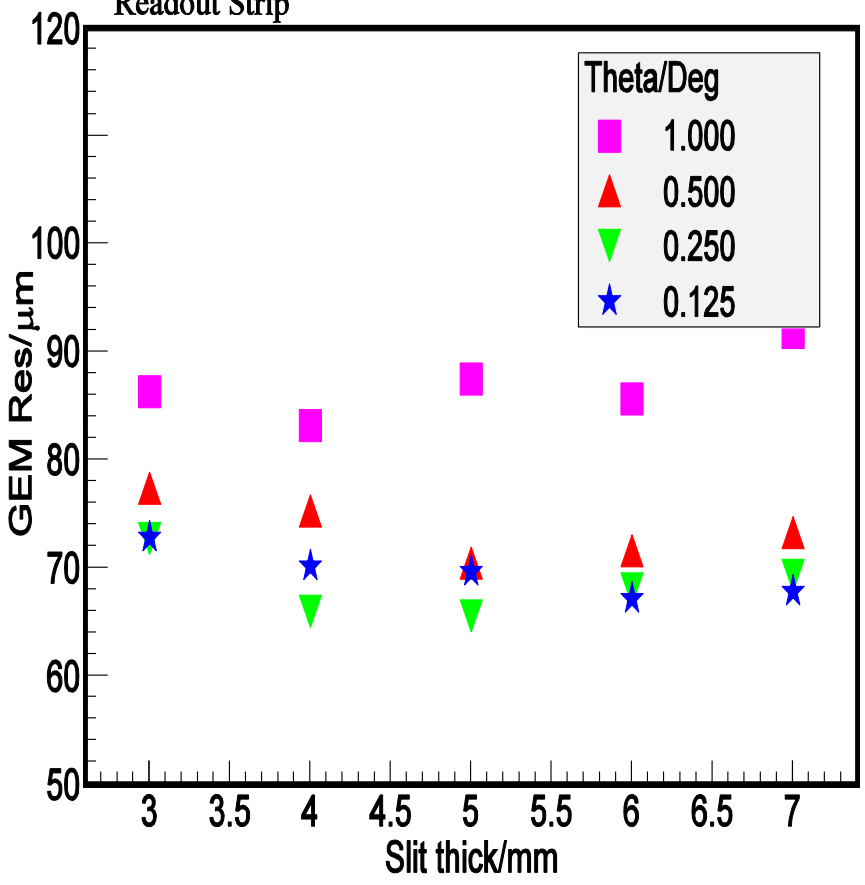
Slit thickness(mm): 3, 4, 5, 6, 7;

Slit width(μm):20,30… 100;

The angle(slit with readout strip, deg):1.0, 0.5, 0.25, 0.125;

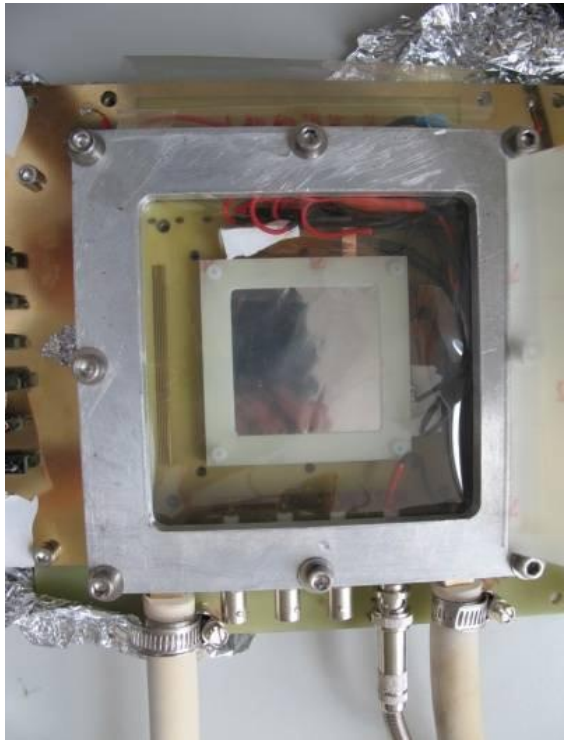


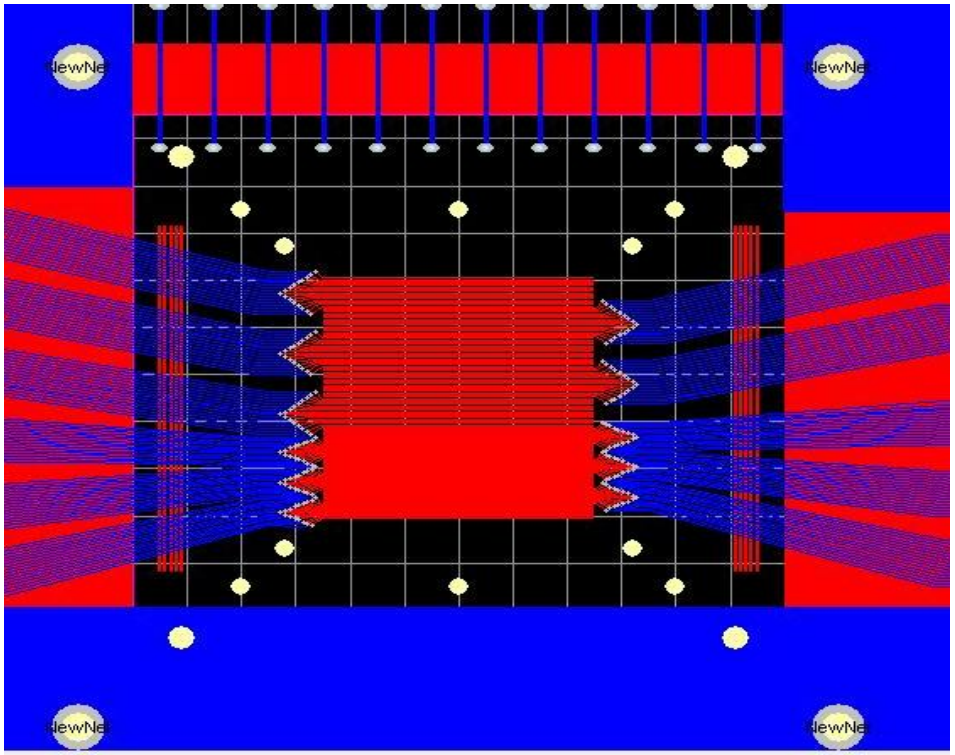




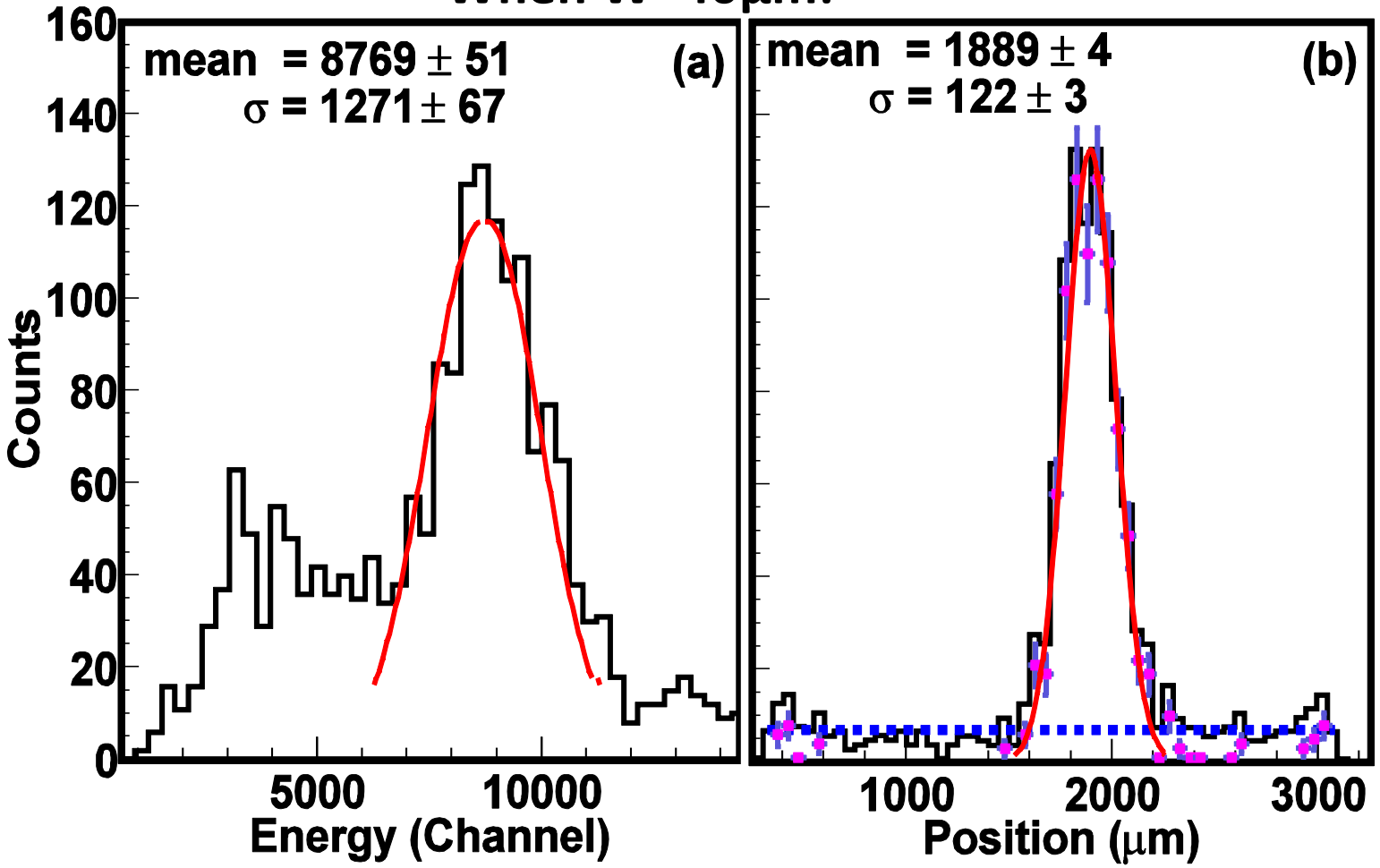
Experimental result

- **1-Dimension Readout**
- **Readout strip: D=200um 400um;**





When W≈40μm:

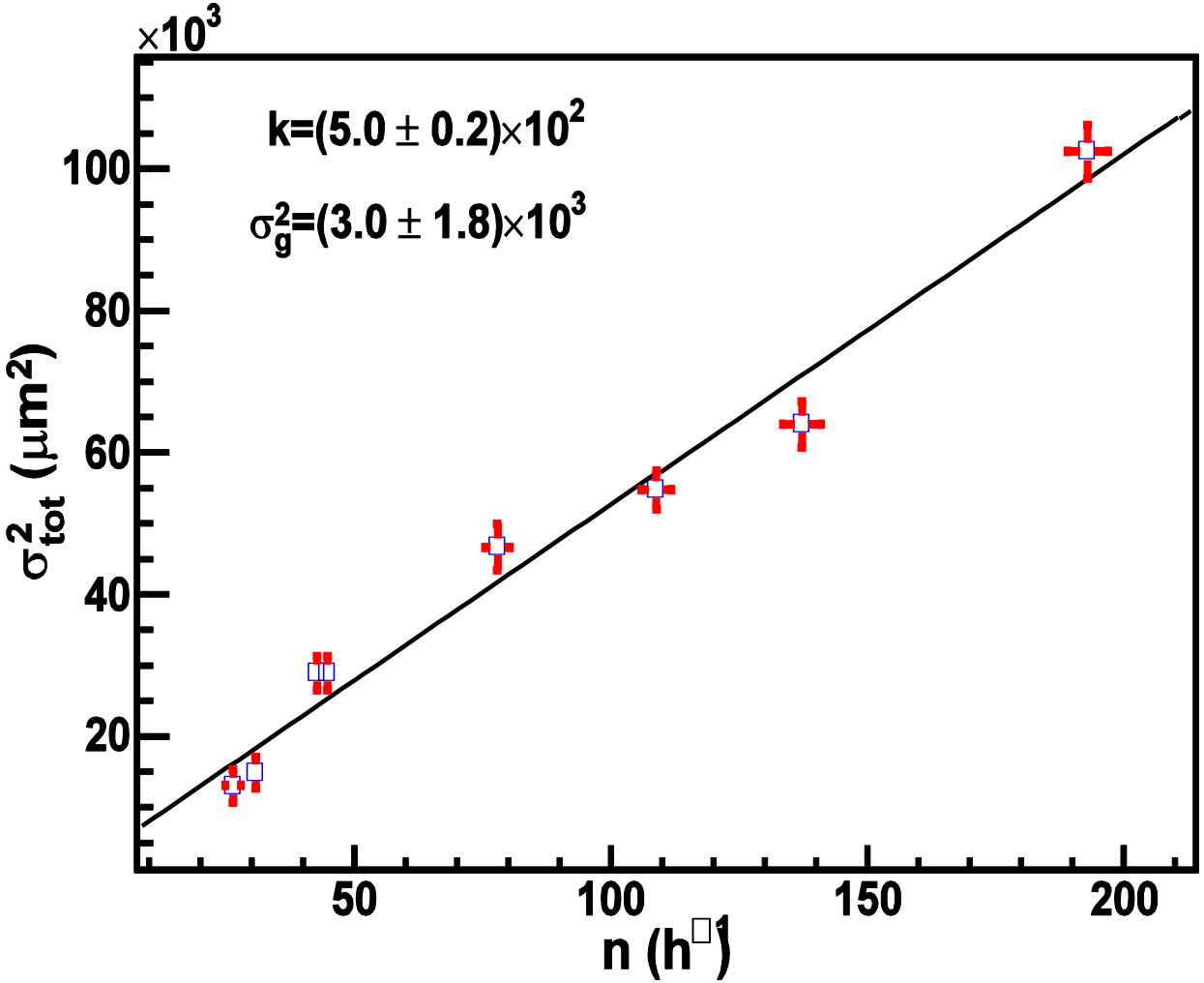


1, (a): get the events from main peak(mean $\pm 2\sigma$), covered with the red line;

2, (b): calculate the position by the centre-of-gravity method; subtract the background(under the blue dotted line), then fit it with gaus-func;

3, $\text{ratio} = \frac{S}{T}$, Therein: S-the area of main peak; T-the testing time

The Test result(1-D, 200μm readout strip)



$$\Delta n = \sqrt{\frac{n}{T}};$$

$$\Delta(\sigma_{\text{tot}}^2) = \Delta(\sigma_{fit}^2)$$

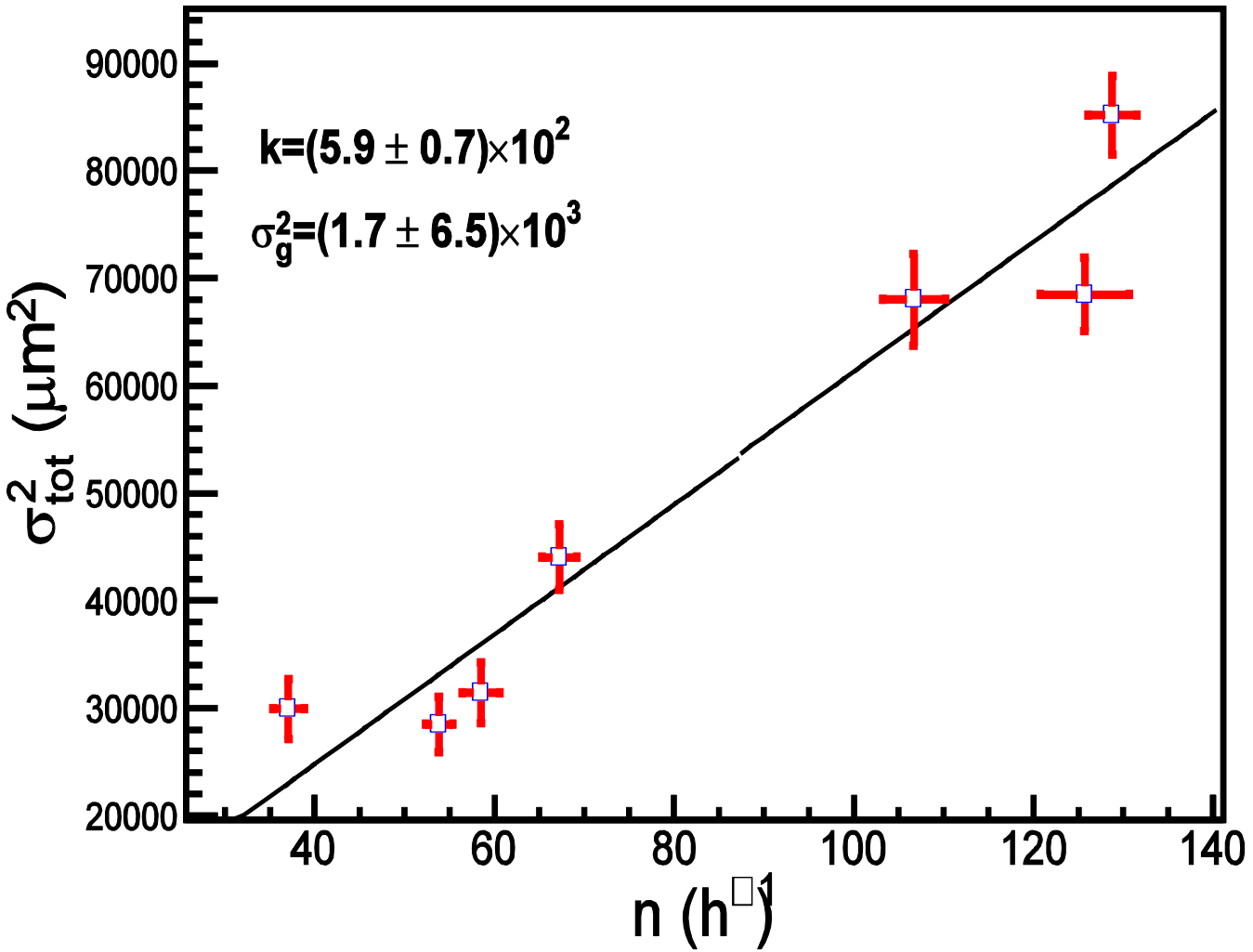
$$+\Delta(\sigma_{non-\text{parallel}}^2)$$

(1), When w ≈40, 50,60,70,80μm,
with the ratio as the x axis, with the σ^2_{tot} as the y axis.
(2), Fit the graph with line-func, we can get

$$\sigma_{\text{tot}}^2 = 3.0\times10^3 + 5.0\times10^2 n$$

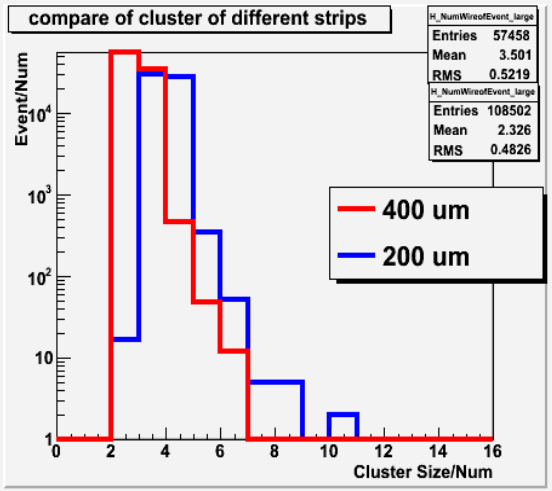
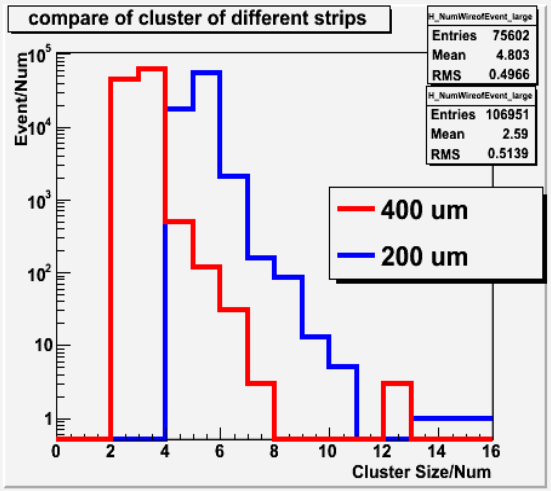
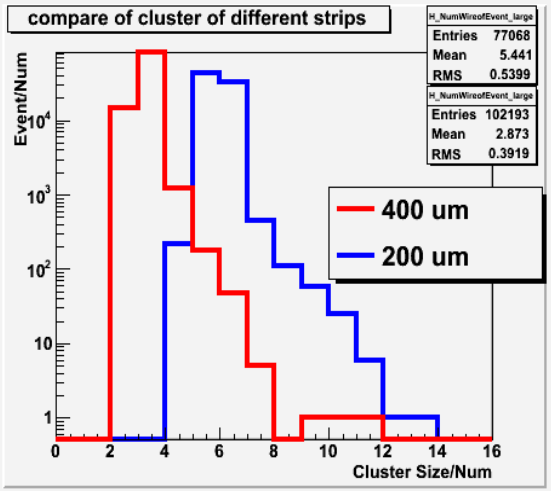
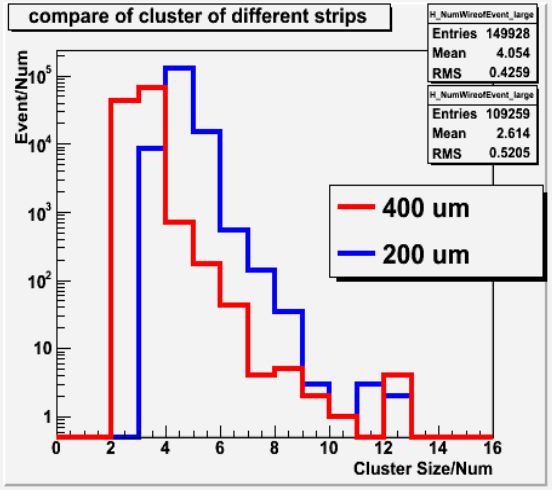
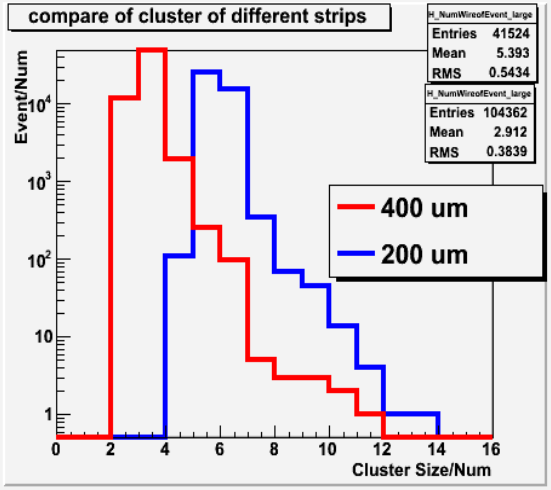
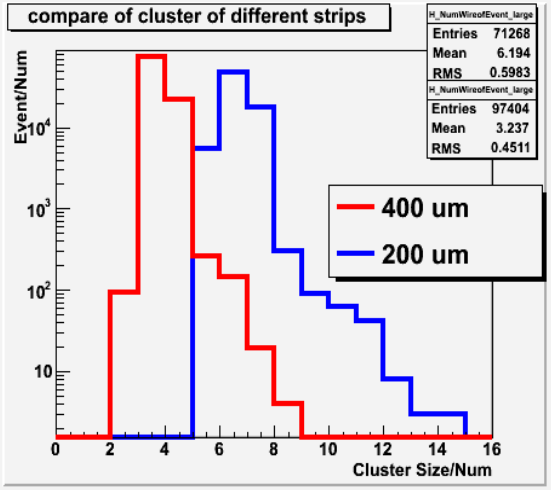
⇨ σ_{GEM}=56 ±15μm

The Test result(1-D, 400μm readout strip)



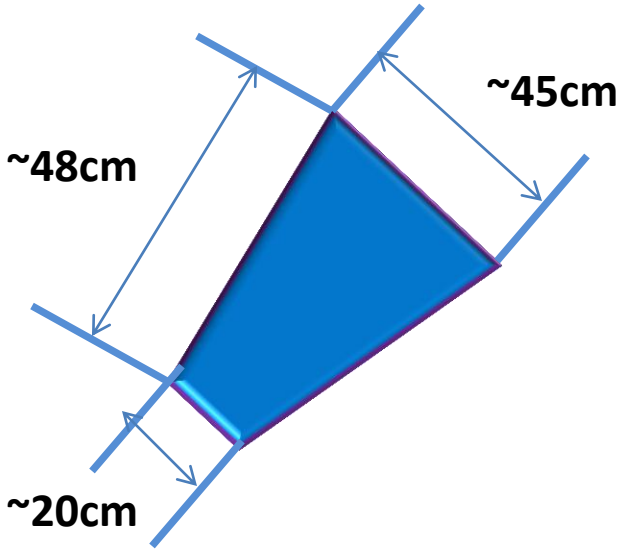
$\sigma_{GEM}=41\pm79\mu m$

Cluster size of signal of main peak

-HV	Ar 75	80	85
1710			
1750			

Near Future Plans

- **Further test:**
  - Position resolution for 2-D detector;
  - Simulation with Garfield;
  - Time resolution;
- **A prototype for SoLID**
- **APV electronics (1024)**
  Asic-based electronics
- **Develop the new DAQ**



Summary

- ◆GEM-Detector prototype test is ongoing in our lab;
- ◆ A new method to evaluate the GEM spatial resolution:
  1) For 1-D and $W_{readout}$=200μm, σ_{gem}=56±15μm(1σ);
  2) Global performance tested for the prototype ;
     Consistent with literature report
- ◆Next step is to build a prototype for SoLID with new electronics and DAQ;

Looking forward to the arrival of the GEM foil and the APV electronics

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Thanks!