Thermal-Bonding Method for Micromegas Fabrication and Its Applications

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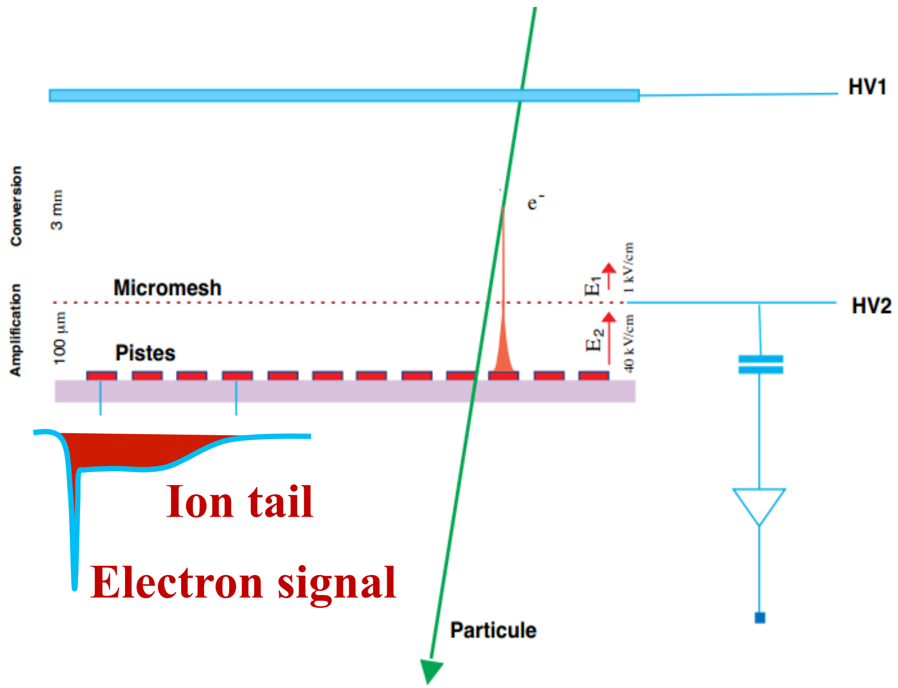
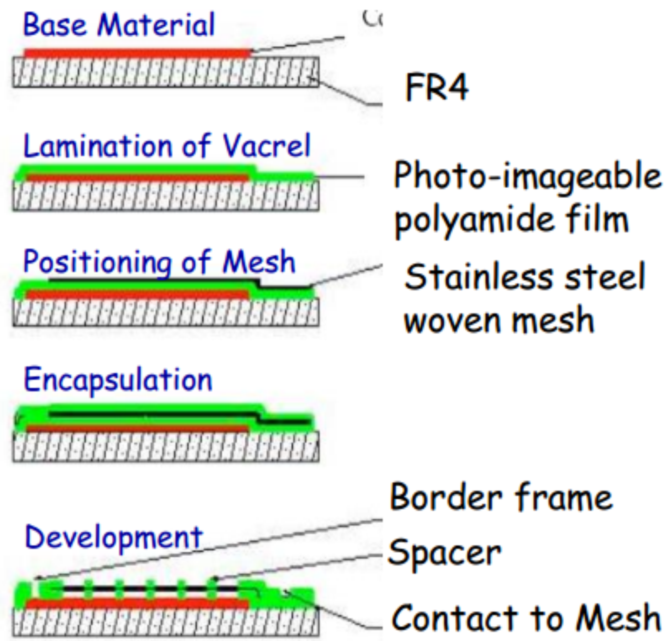
Micromegas

- A very popular and mature MPGD

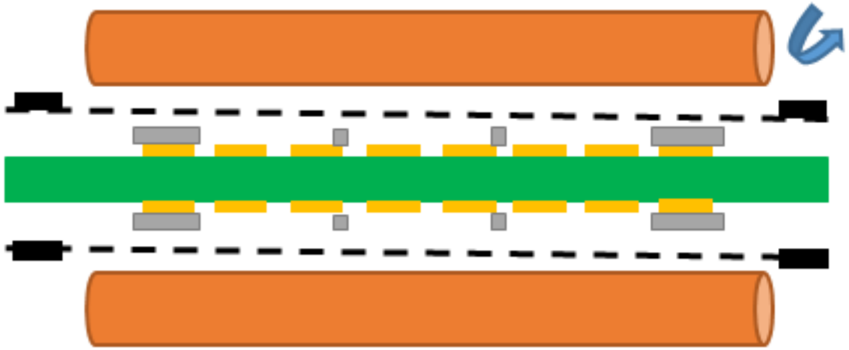


Micromegas in a Bulk



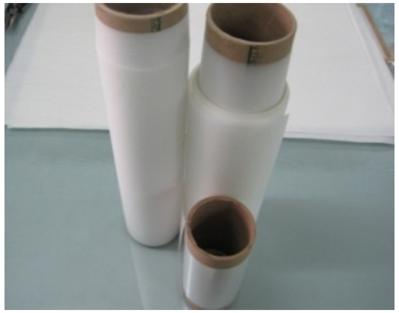
Very small avalanche gap without insulator: fast charge collection, fast signal, no charge-up, high rate, small diffusion, good spatial and time resolution …

Thermal-Bonding Method

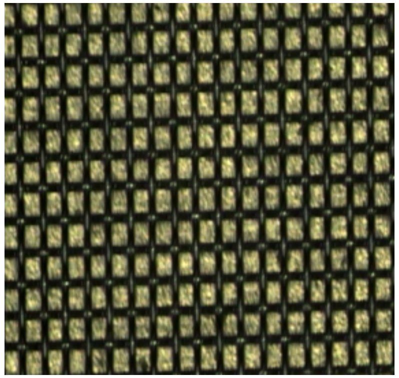


- Good energy resolution
- No etching, no pollution
- Easy to handle at lab
- Easy to make new structures
- Cheap
- But uniformity to be improved

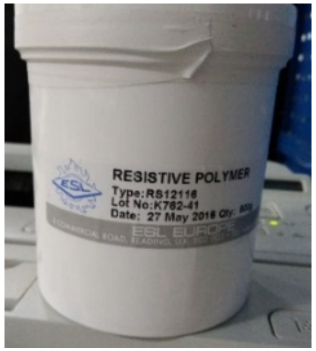
Materials and Specifics

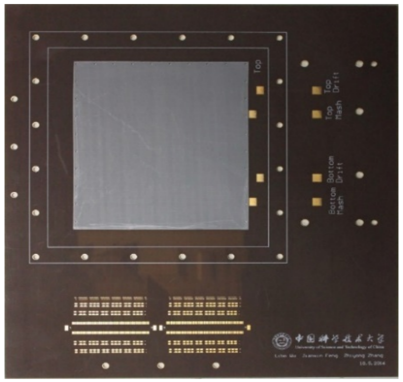


Thermo-bond films with a dry (hot-melt type) adhesive on both sides. A variety of specifications to choose.



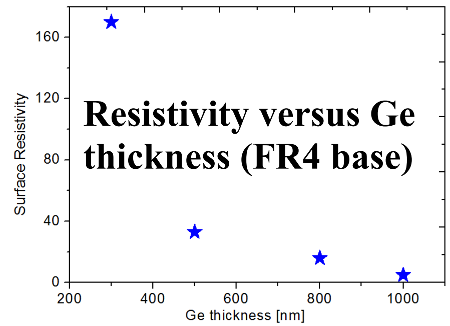
Wire Diameter: 16um, Thickness: 25um
LPI: 400, Opening rate: 55%
Tension: 30N/cm



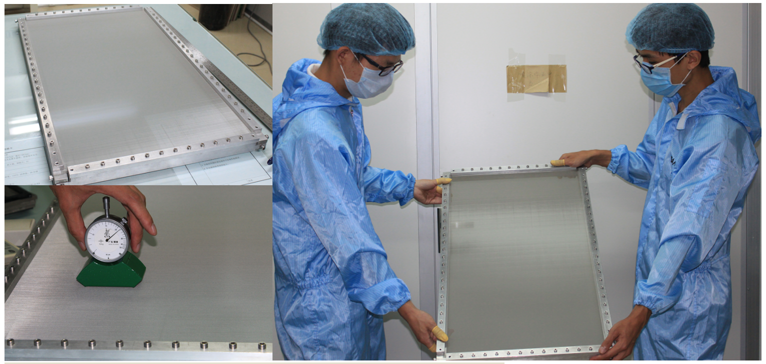


Resistive anode:

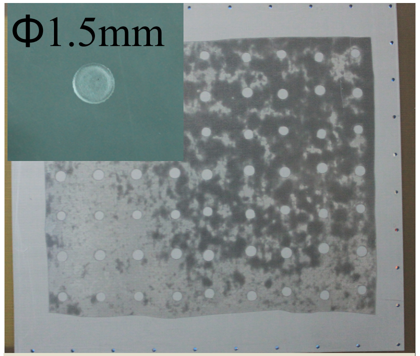
- Carbon paste printing: kΩ/☐ - 100MΩ/☐
- High purity Germanium coating: MΩ/☐ - 100MΩ/☐



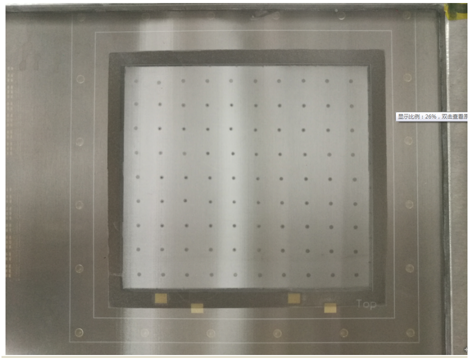
Thermal-Bonding Process



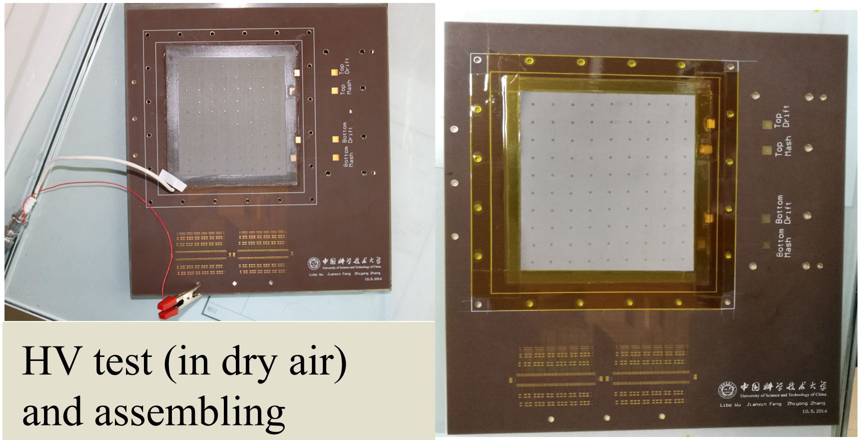
Mesh stretching ~24N/cm



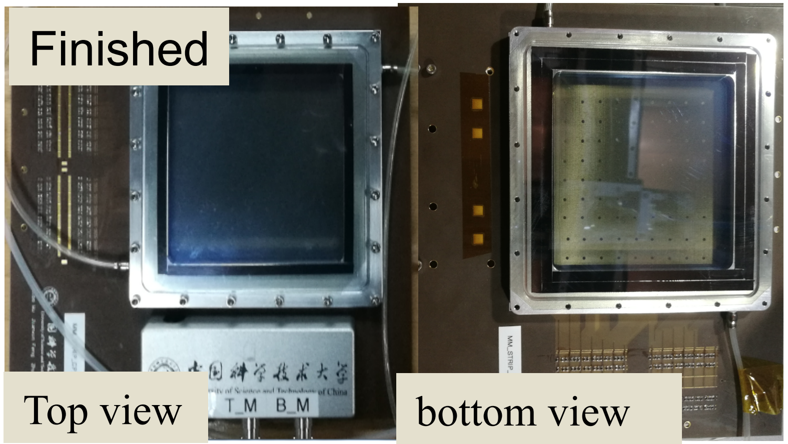
Spacer setting



Thermal bonding



HV test (in dry air)
and assembling



Finished

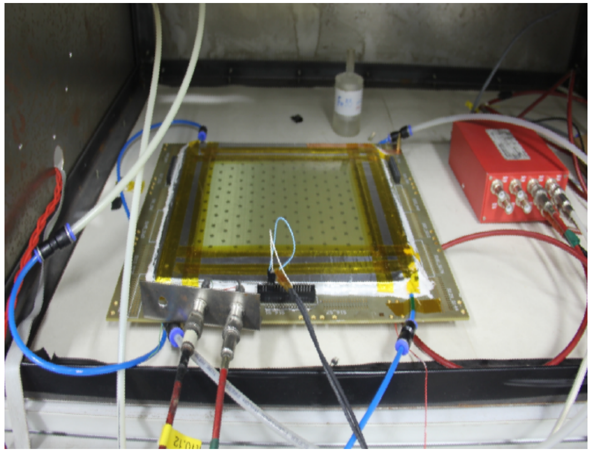
Top view

bottom view

Spacer setting could be very labor consuming. We have developed a technique using water-soluble film to do the job more efficiently: pattern water-soluble film → attach the film to PCB → set spacers in the pattern → thermal bonding → water bath to remove the water-soluble film.

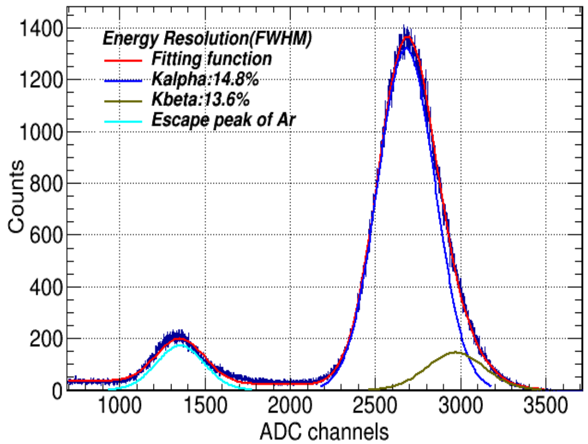
Performance

A 20×20 cm^2 Micromegas

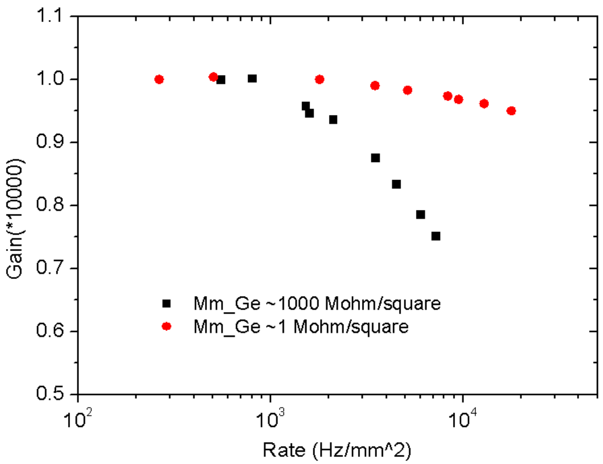


- ➔ Energy resolution for 5.9keV x-rays: 14.8% (FWHM)
- ➔ Active area: 20×20 cm^2 , but could easily go up to 20×60 cm^2
- ➔ High gain above 10^4
- ➔ High rate capability: up to 10^6 Hz/cm^2

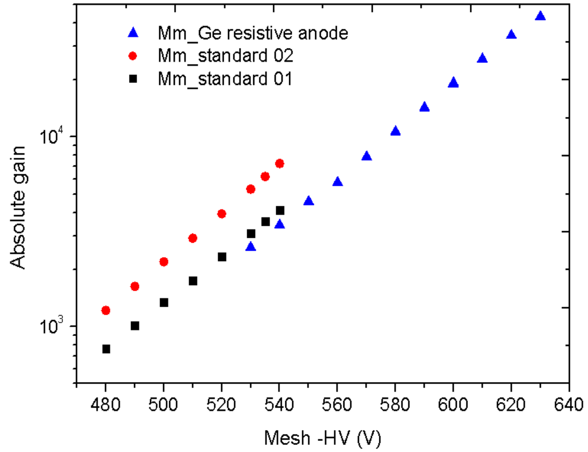
^{55}Fe x-ray spectrum



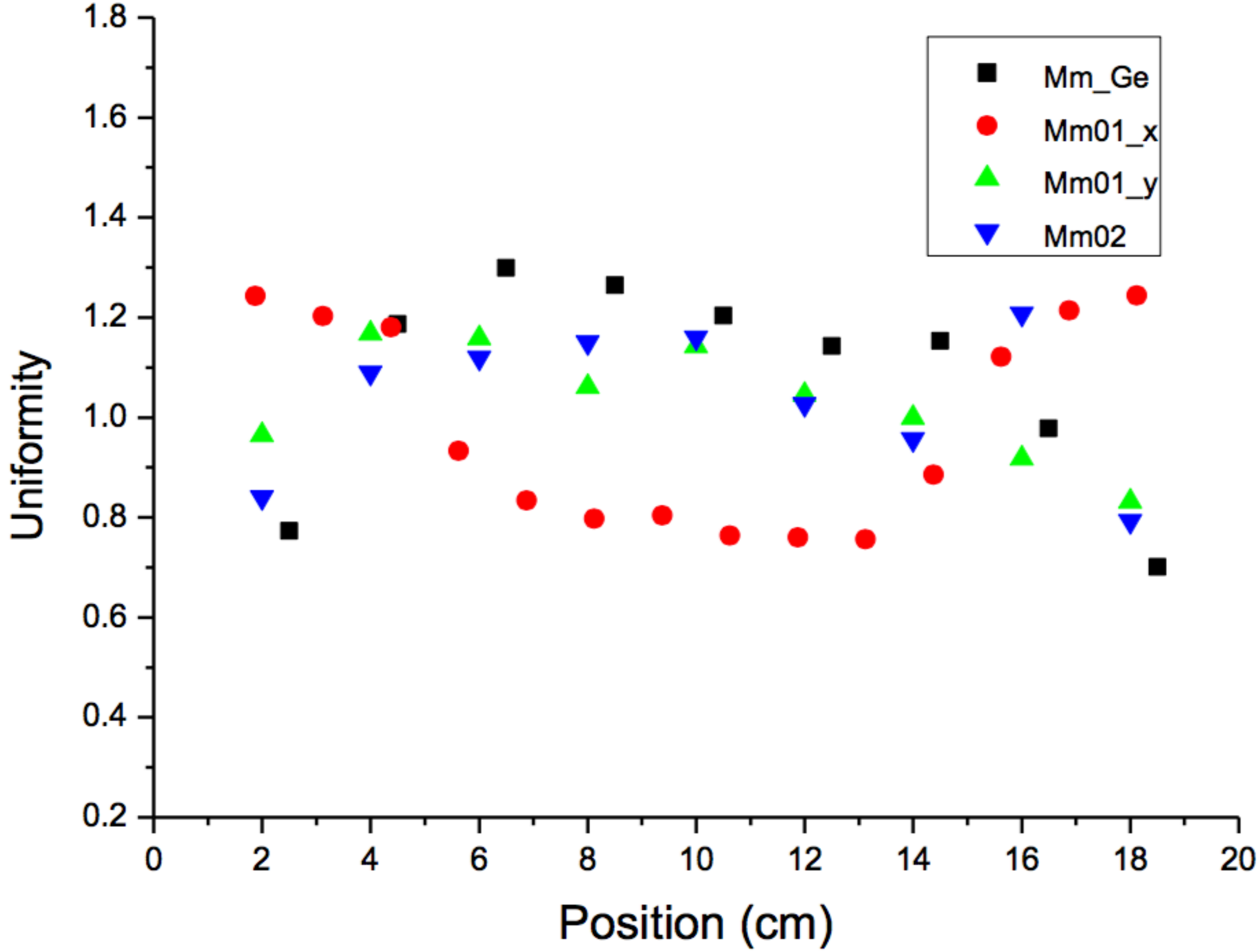
Gain v.s. rate



Gain v.s. mesh voltage



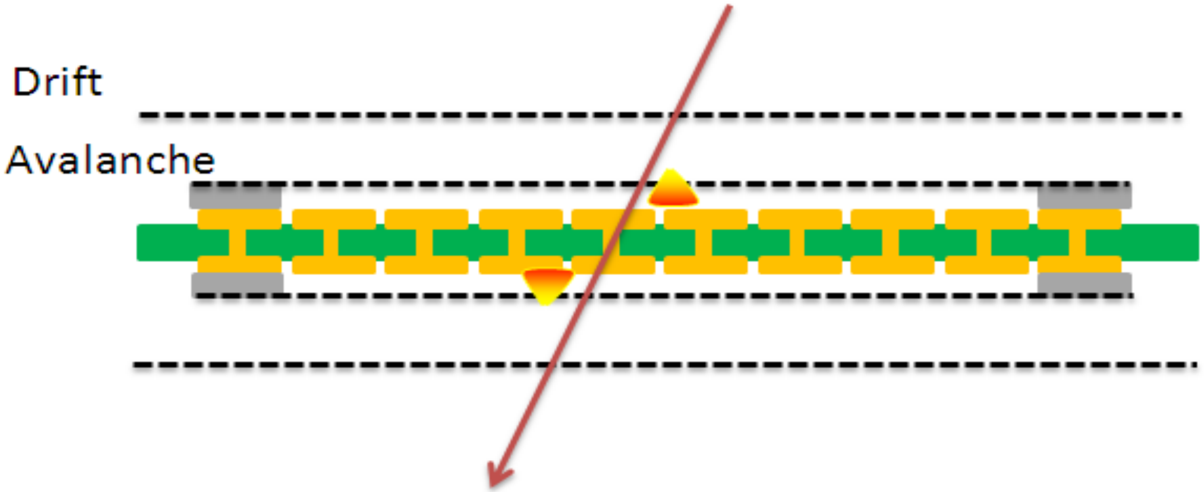
Uniformity



1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Uniformity
0
2
4
6
8
10
12
14
16
18
20
Position (cm)
Mm_Ge
Mm01_x
Mm01_y
Mm02

Application (1)

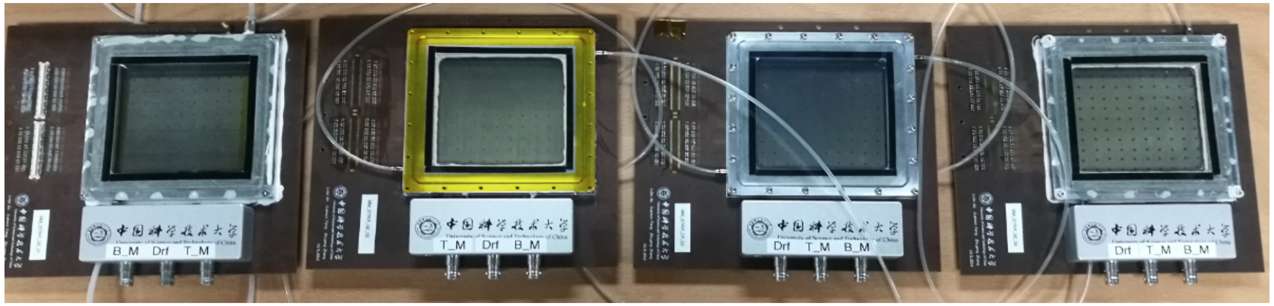
- Double-avalanche structure



- Double meshes cancel out tension on PCB by mesh
- Good for time resolution and efficiency
- A good two-dimension tracker

Double-avalanche MicroMegas

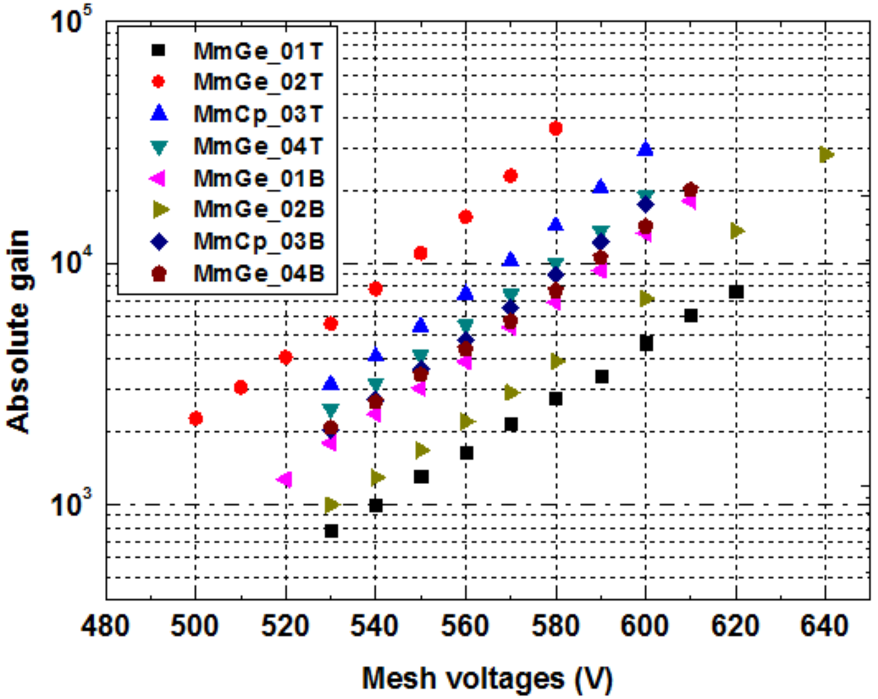
Active area：
10cm*10cm
Strip pitch：
412um

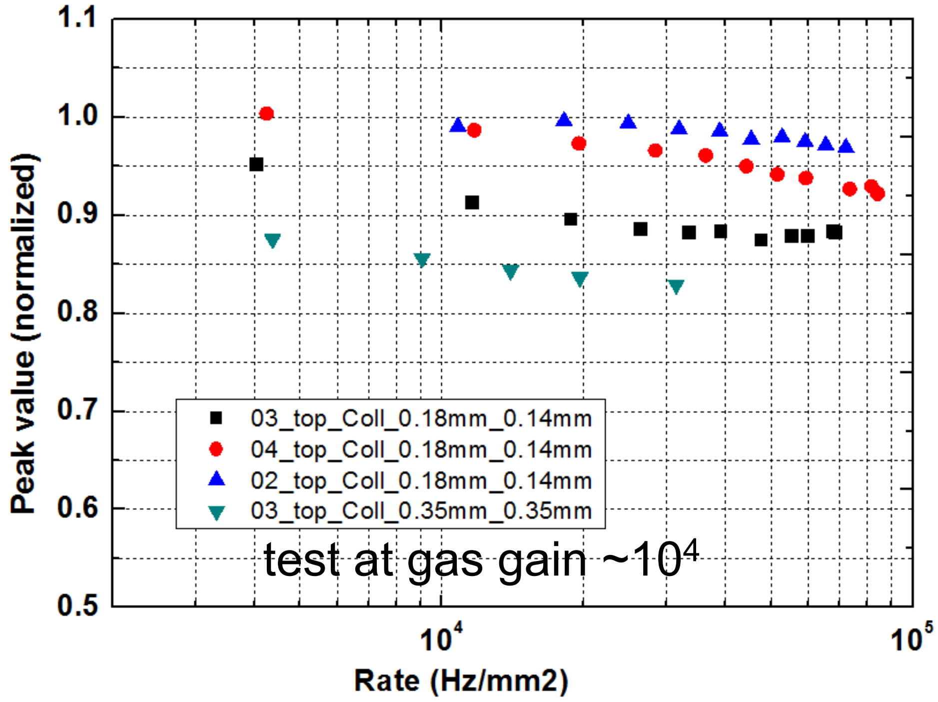


No.	Mm_Ge_01	Mm_Ge_02	Mm_Cp_03	Mm_Ge_04
Resistive anode	Ge 100nm/ 200nm	Ge 800/1000nm	Carbon paste ~20um	Ge 300/500 nm
Surface resistivity	-- --	10MΩ/□ , 5MΩ/□	0.9MΩ/□ , 0.8MΩ/□	165MΩ/□ , 35MΩ/□
Mesh（Stainless steel）	350IPL, dia23 um 48um	400IPL, dia19 um 29um	400IPL, dia19 um 29um	325IPL, dia23 um 31um
Tension	20-23 N/cm	22-24 N/cm	22-24 N/cm	22-24 N/cm

Spacer：Φ 1.5mm with 10mm pitch
(for the bulk technique, Φ 0.2-0.4mm with 2mm pitch)

Gas Gain and Rate Capability



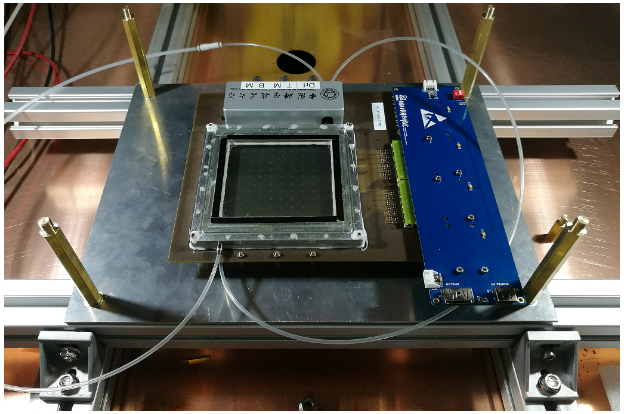


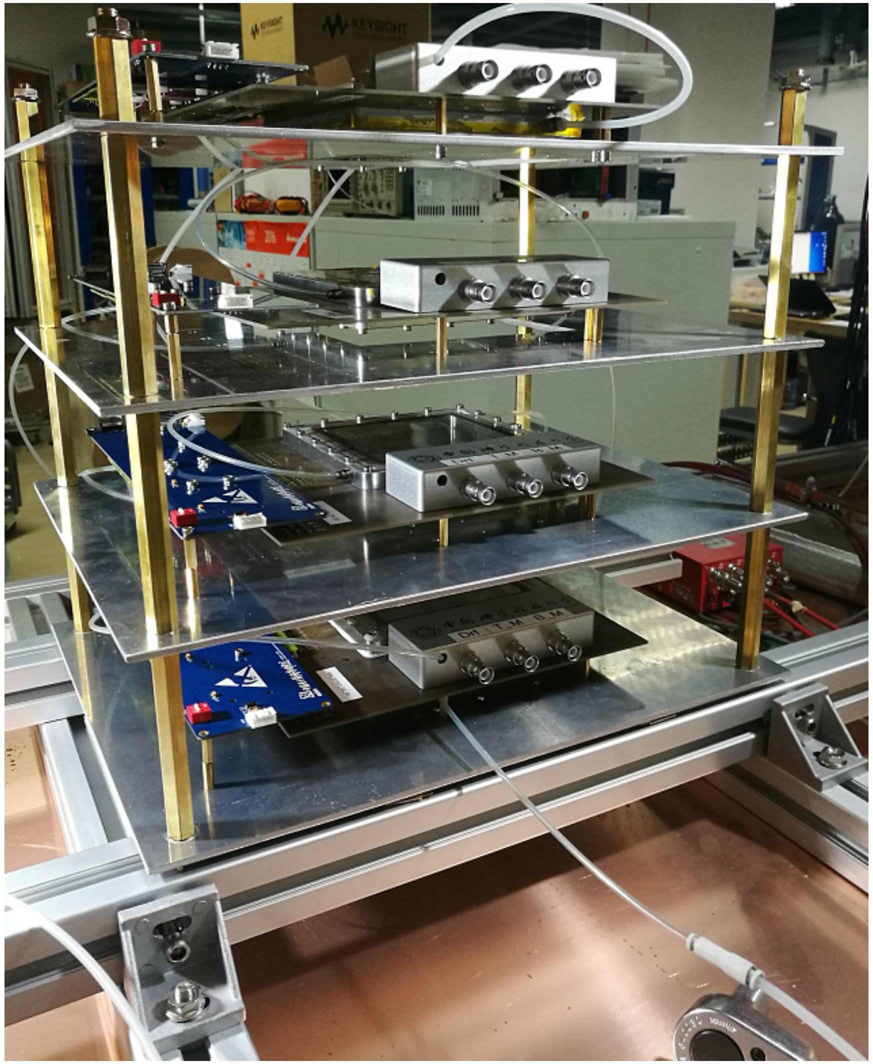
Gas gain of the 8 avalanche structure of the four double-avalanche detectors

Rate capability tested with collimated X-rays

Cosmic-ray Telescope

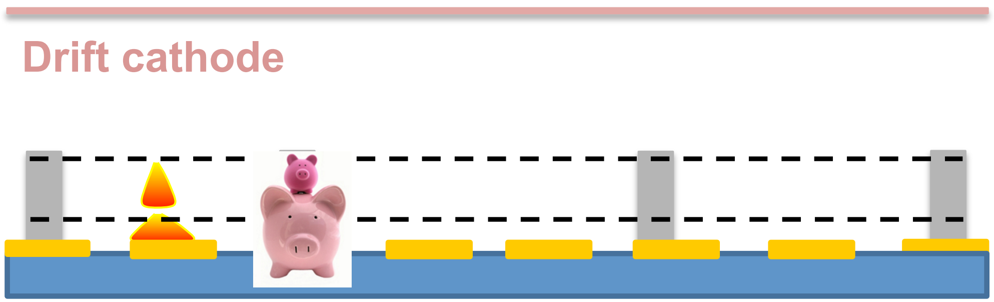
A cosmic-ray telescope was set up by the four double-avalanche Micromegas detectors





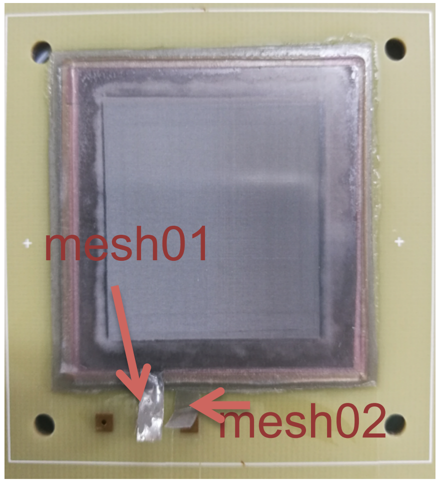
Application (2)

- A piggyback structure

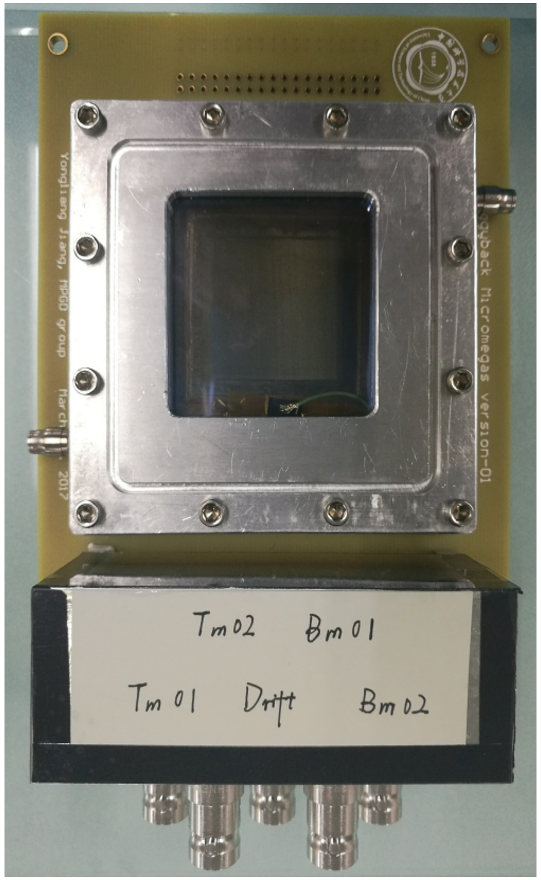


- Stacked two meshes
- Gap between the stacked meshes: 200-300um, serving as pre-amplification
- Gap between the bottom mesh and anode: 50-100um for main amplification
- This structure allows to achieve very high gain, and yet significantly reduce ion back-flow.

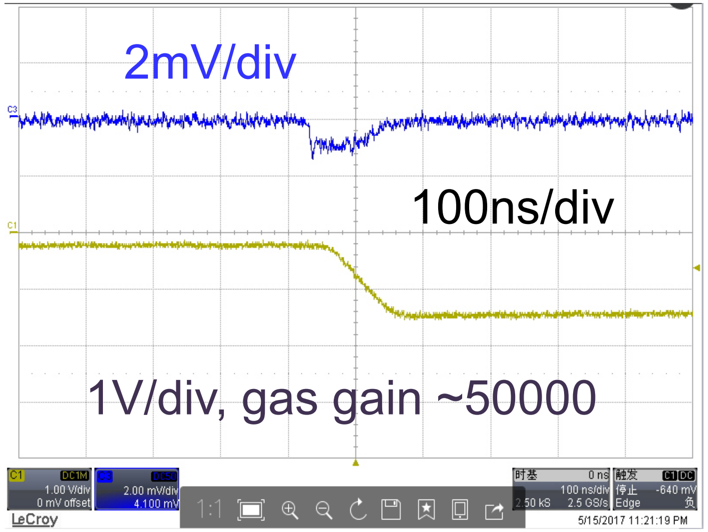
Piggyback Micromegas



- 2.5x2.5 cm^2 active area;
- Gap between two meshes: ~240um
- Mesh to anode: ~120um
- Ge-coated anode



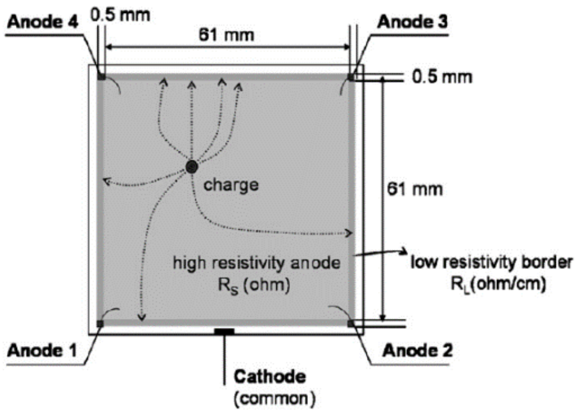
Anode signal without amplifier, 50Ω impedance



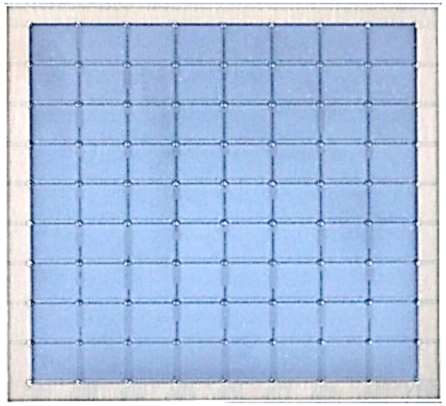
Mesh02 signal after a charge sensitive pre-amplifier

Application (3)

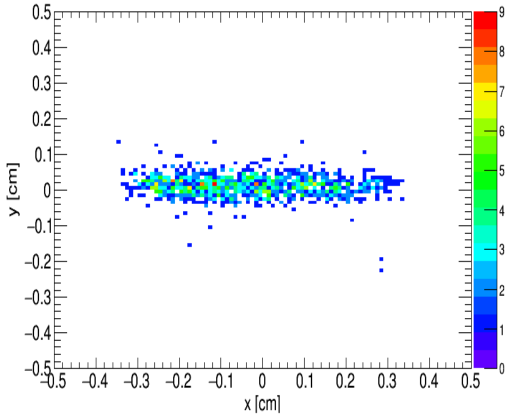
- Micromegas with four-corner readout to reduce number of readout channels while maintaining reasonable spatial resolution.

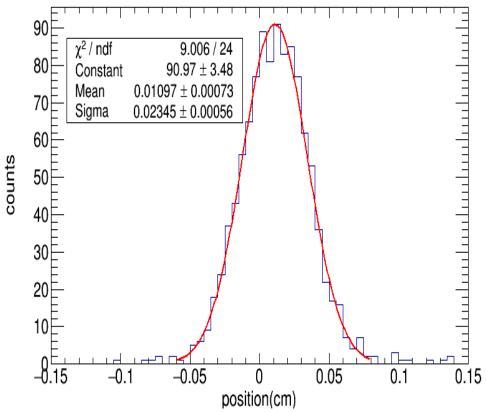


4-corner readout concept



4-corner readout PCB (by screen printing) for Micromegas
cell-size: 1cm*1cm





Spatial resolution measured with X-rays: 235um

Summary

- Presented a new method for fabricating Micromegas detectors – thermal bonding method
  - No etching, simple and flexible, lab-friendly, cheap
  - No fundamental issue with going to large size – spacer setting is the key
  - Uniformity needs to be improved
- Potential for various applications

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