Improvement of Stability of Micromegas in High Gas Pressure Experiment

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中国科学技术大学
University of Science and Technology of China

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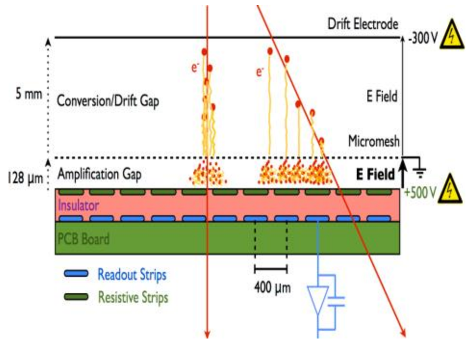
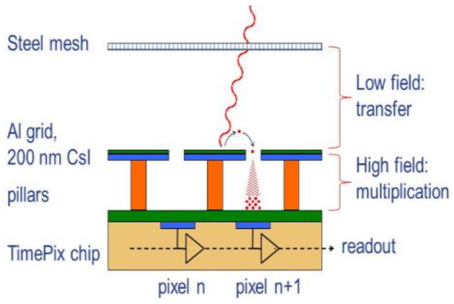
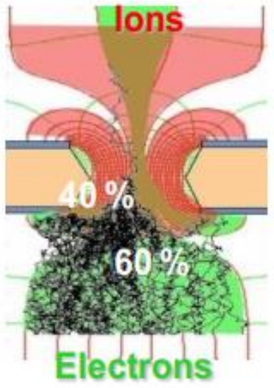
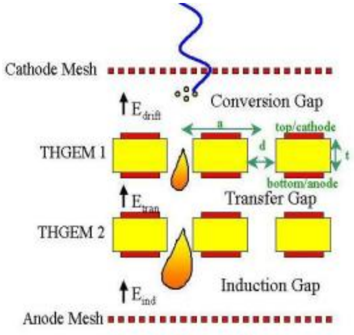
I MPGD and Gas Pressure ~1bar

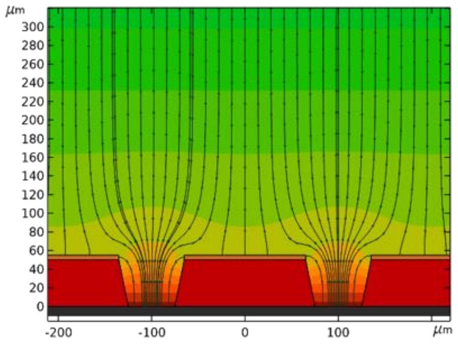
➢ MPGD usually operate in atmospheric pressure gas.

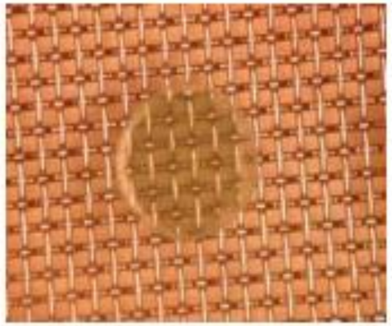


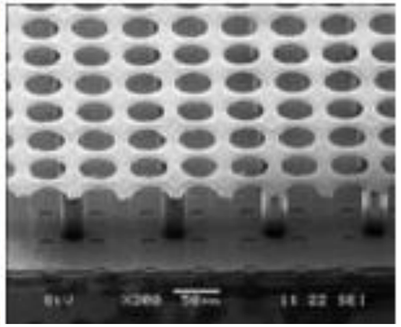


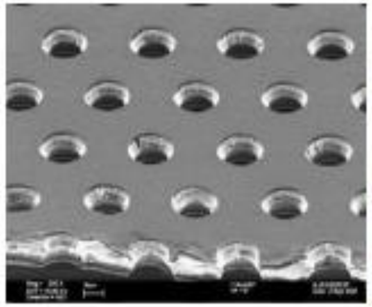


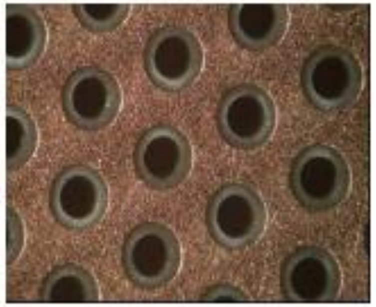


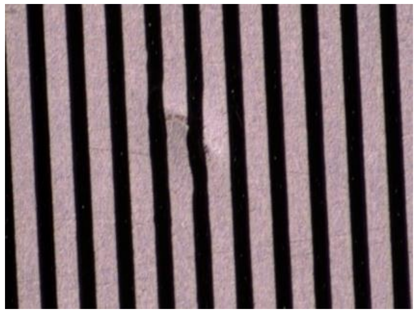












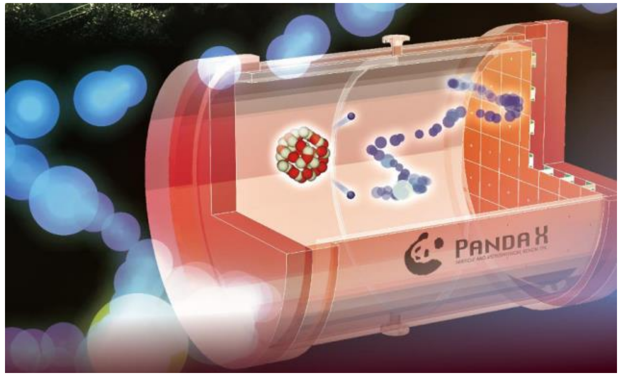
Micromegas Ingrid GEM THGEM μRGroove

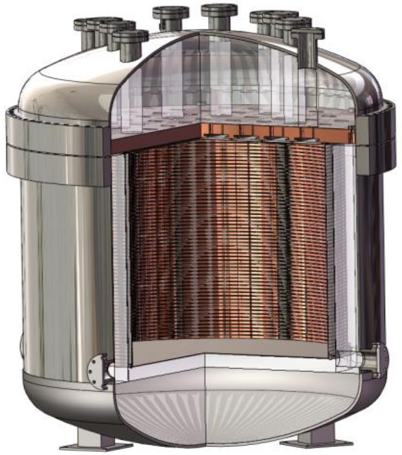
I MPGD and Gas Pressure 1-10 bar

➢ New requirements for MPGD in high pressure gas environment

The T-REX Project

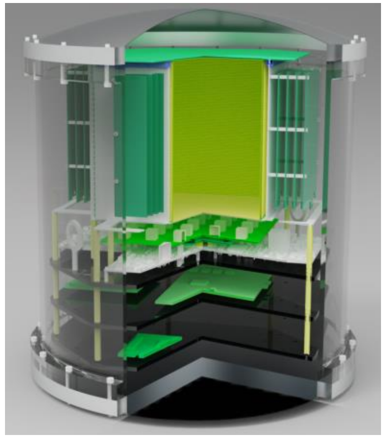
Gas： 10 bar Xe/TMA(99/1)





The Particle and Astrophysical Xenon Experiments-III (PandaX-III) experiment

Gas： 10 bar Xe/TMA(99/1)



The MeV Gamma ray Telescope (MeGaT) experiment

Gas： 5 bar CF_4

More details can be seen in Wu Libo's report: New Mission Concept: a high precise MeV Gamma Telescope using TPC Technique read out with Micromegas on Wednesday

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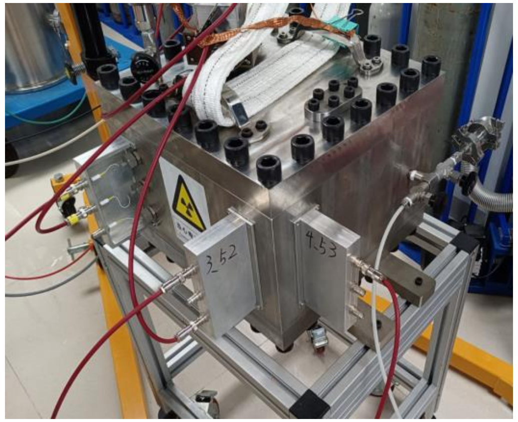
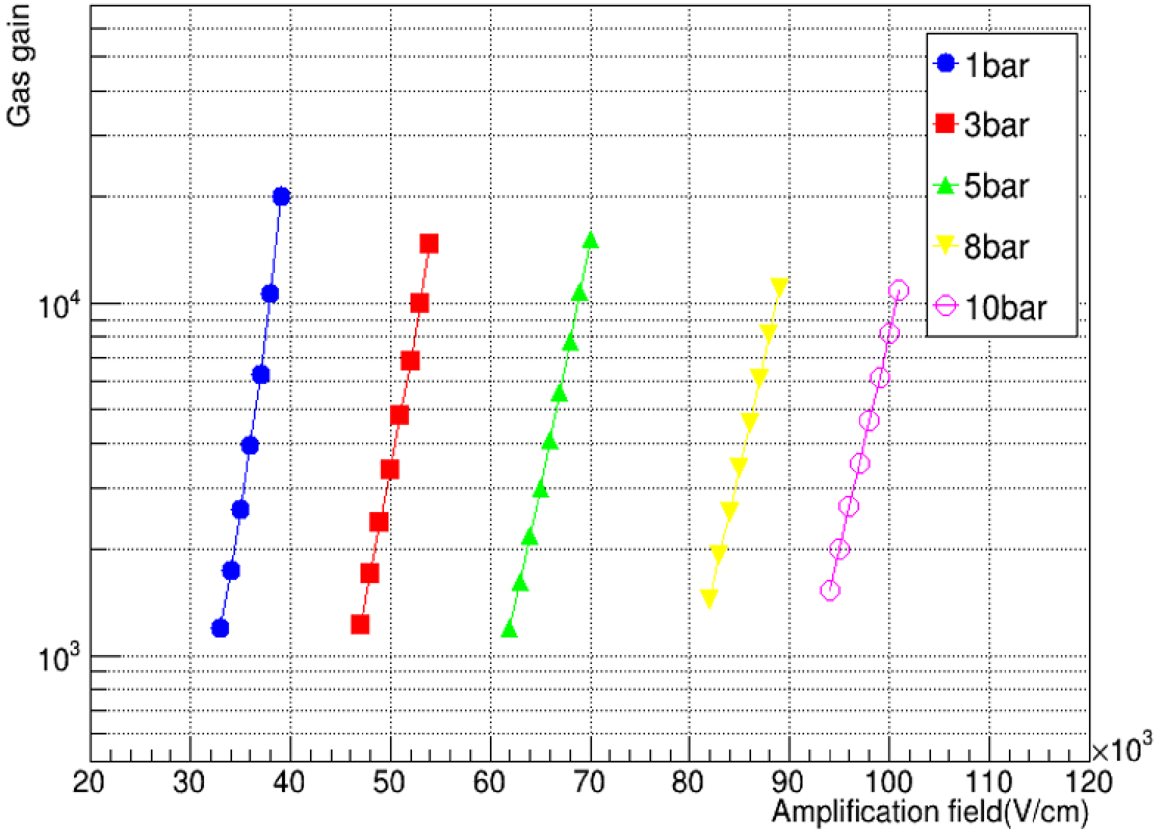
II Stability Problem

For Micromegas, as the gas pressure gradually increases in 1-10 bar

- The working voltage gradually increases
- The maximum gain gradually decreases
- The abnormal large noise frequency increases
- The stability gradually decreases

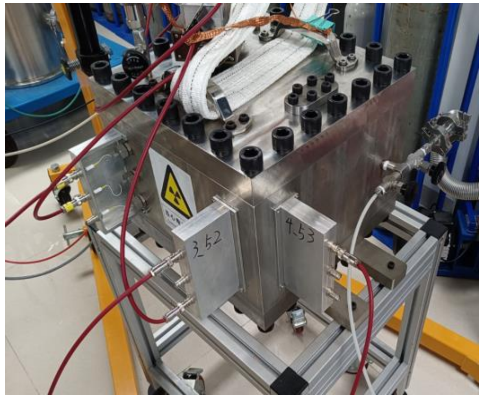




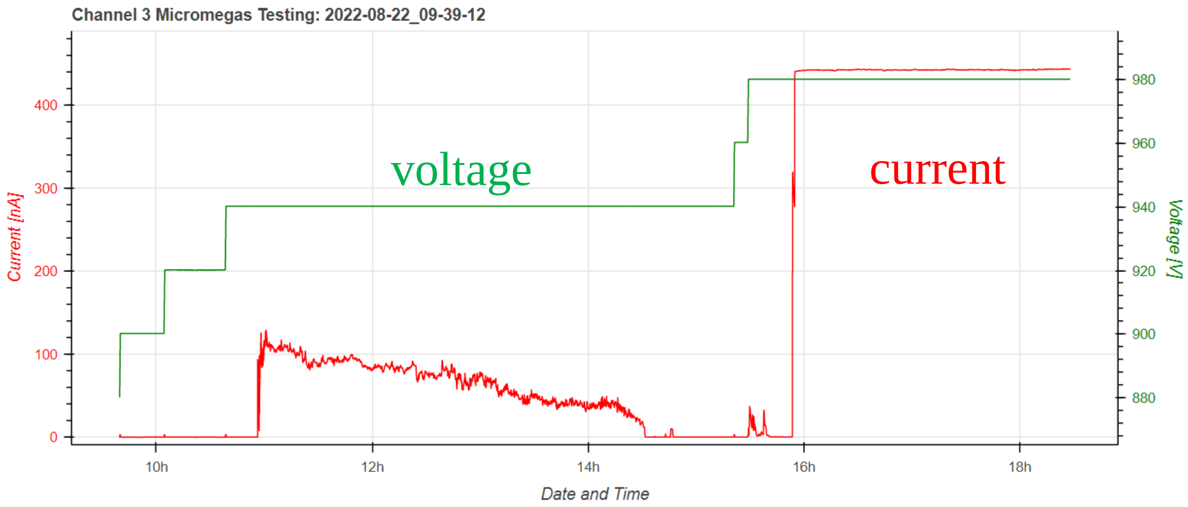
II Stability Problem

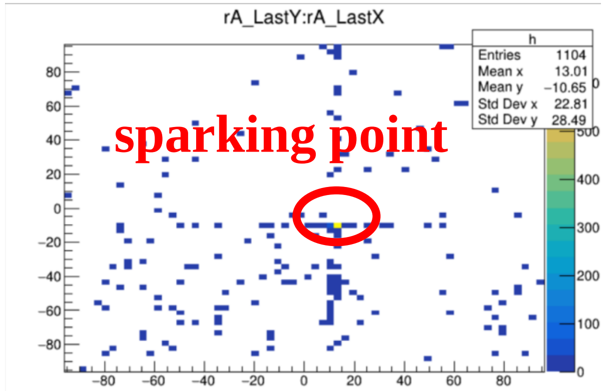
Gas：10 bar Ar+2.5%Iso

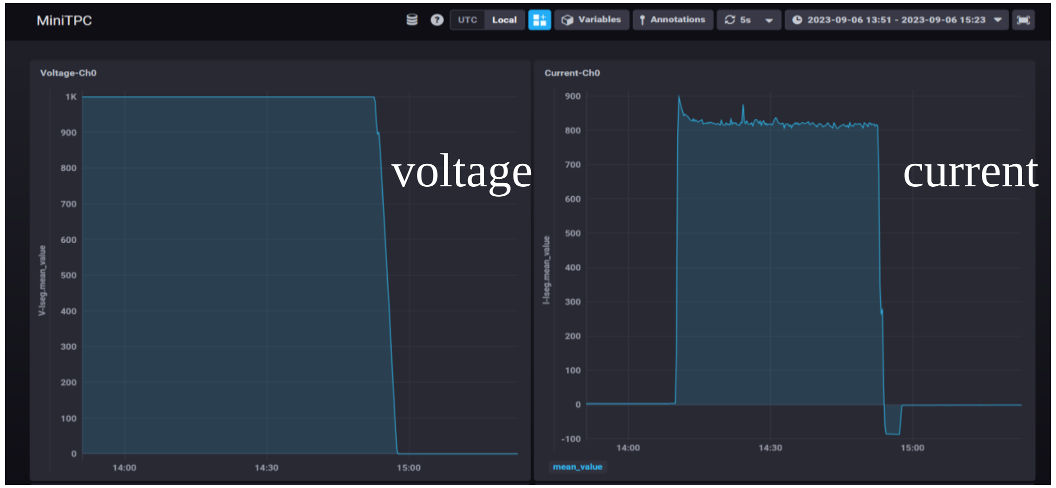
- Sudden large leakage current
- Unrecoverable
- Tests in both places with similar problems



Test in USTC

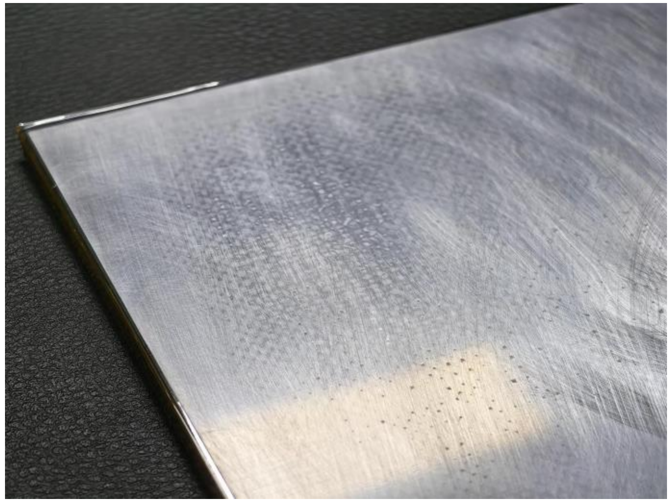


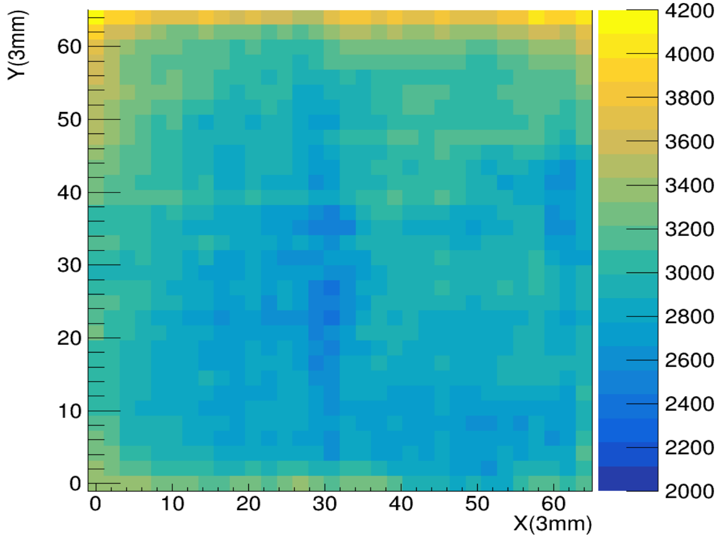




Test in SJTU

Stability Problem existing methods





Germanium (Ge) film-based resistive anode (thickness of Ge: 300nm) effectively improves the maximum gain and stability of Micromegas

Improving gain uniformity also helps to enhance the stability of Micromegas (avoiding high gain in edge)

Contents

III Thermal Bonding Method

Over the past decade, the thermal bonding method (TBM) has been developed for the efficient fabrication of Micromegas detectors at USTC. This method provides a concise and etching-free mass-productive process to fabricate Micromegas-like detector.

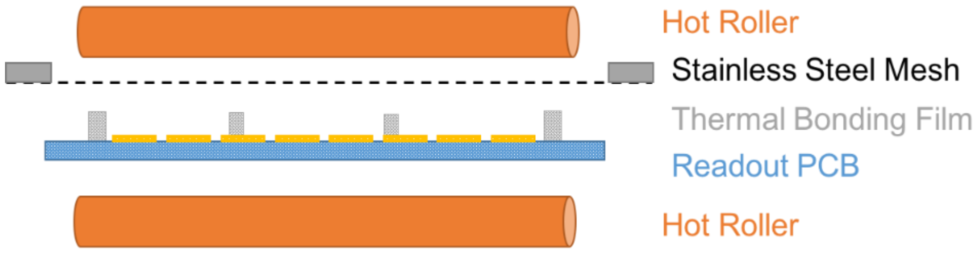
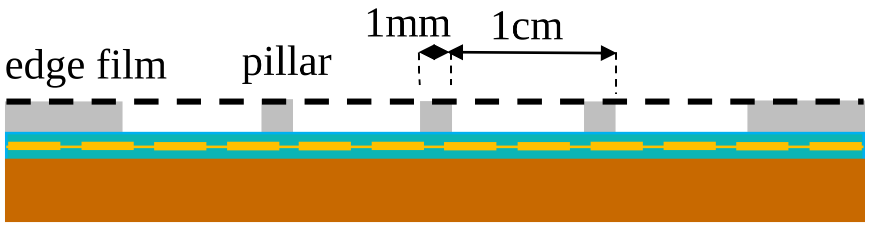
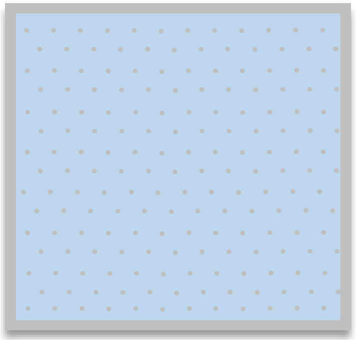


Diagram of the thermal-bonding method



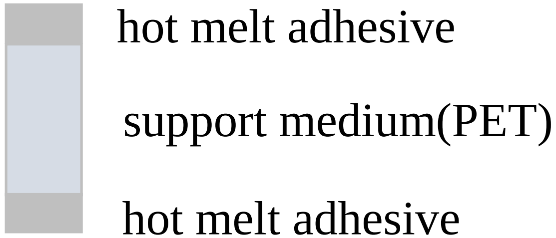
Lateral View of Detector



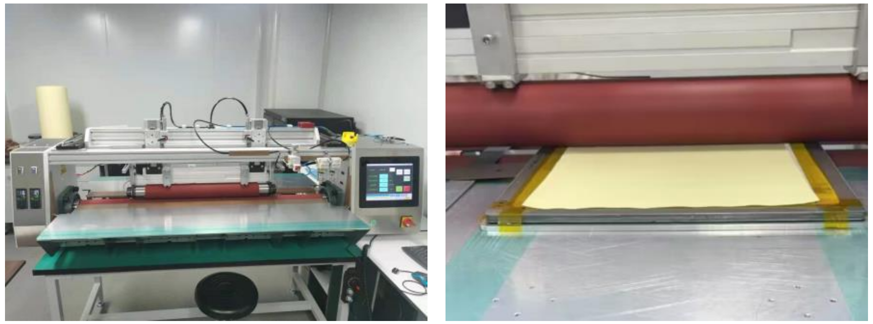
Vertical View of Detector

Advantages of TBM:

- No etching, no pollution
- Easy to handle at lab
- Easy to make new structures
- Low cost
- Φ0.5mm- Φ1mm spacers, ~1cm pitch
  - ➔easy to clean, especially for large area
  - ➔less than 1% spacer area

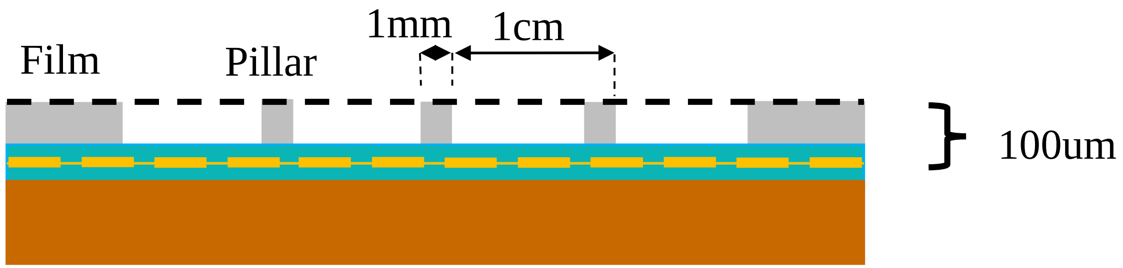


Schematic diagram of the hot melt adhesive film

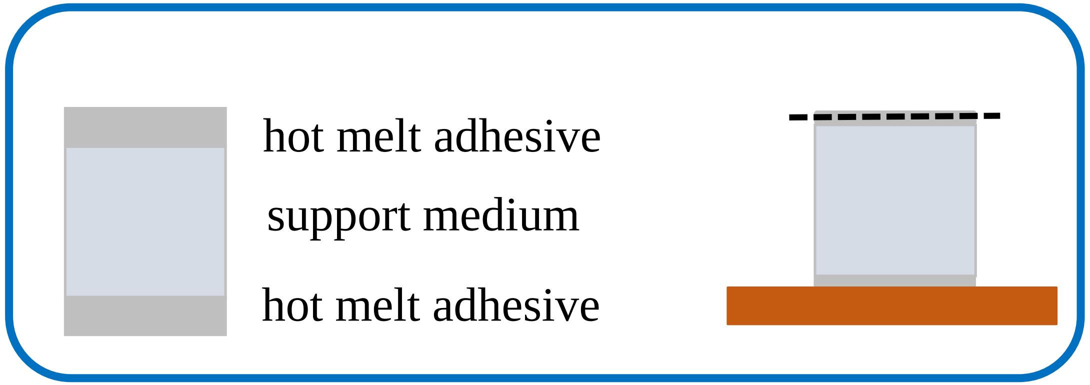


Photos of thermal-bonding machine

Improved thermal-bonding method

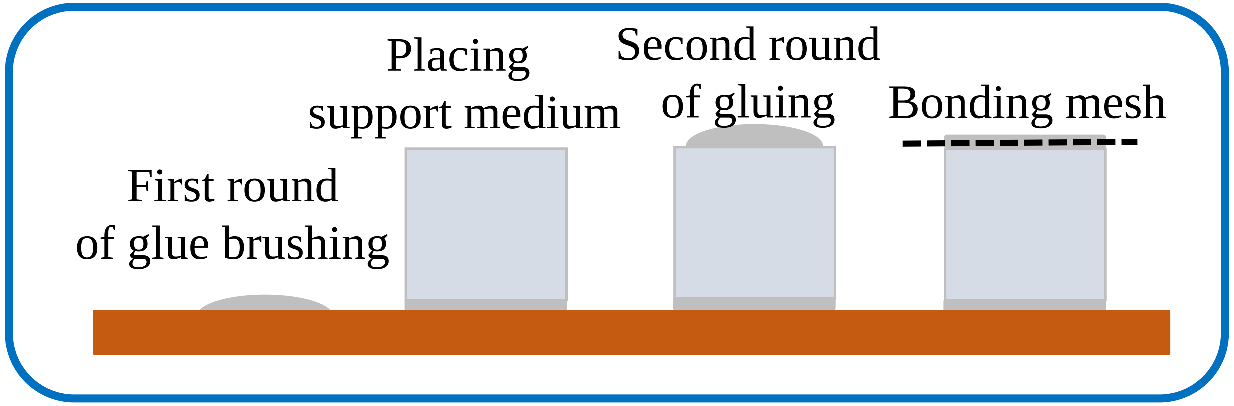


Lateral View of thermal-boding Micromegas



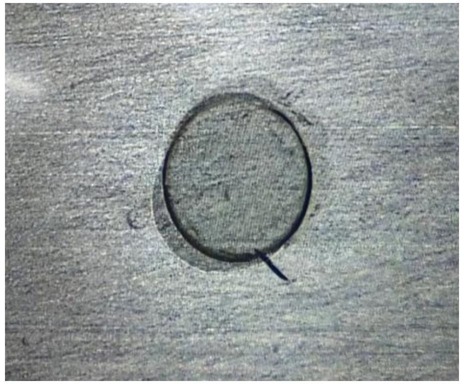
Schematic diagram of the traditional thermal-bonding method

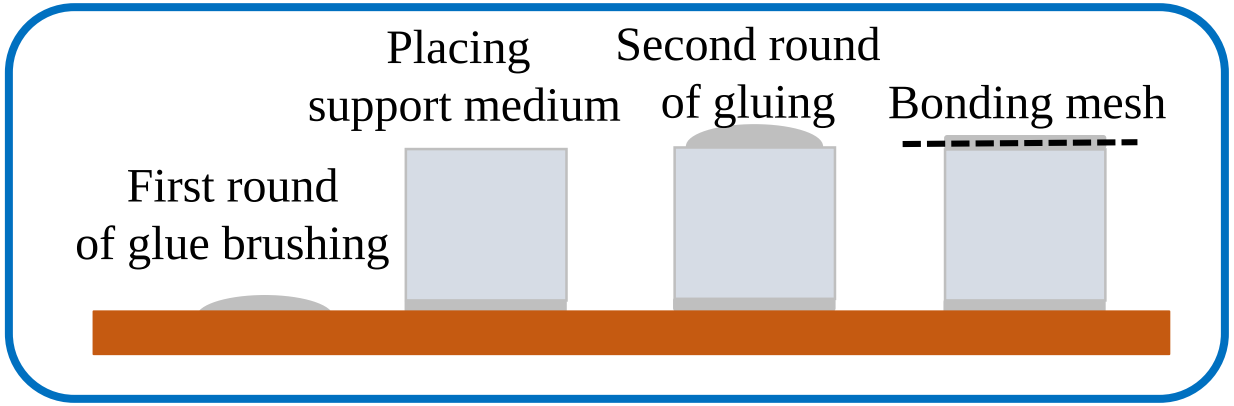
- ➢Both methods are to glue the mesh, support medium and PCB together
- ➢The hot melt adhesive film (composed of the hot melt adhesive and the support medium in the middle) is integrated, and can be placed directly during thermal-bonding
- ➢The glue and support medium required for the improved method are placed separately



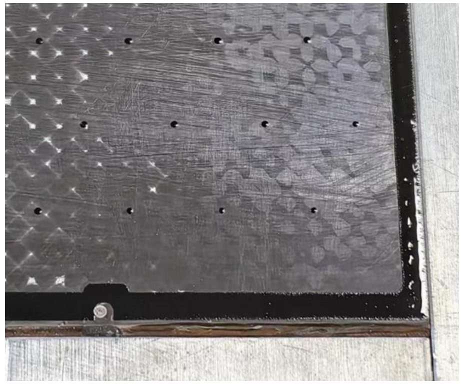
Schematic diagram of the improved thermal-bonding method

Improved thermal-bonding method





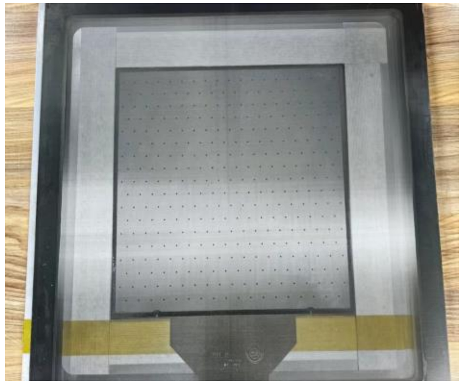
Schematic diagram of the improved thermal-bonding method



First round
of glue brushing

Placing
support medium

Second round
of glue brushing



Bonding mesh

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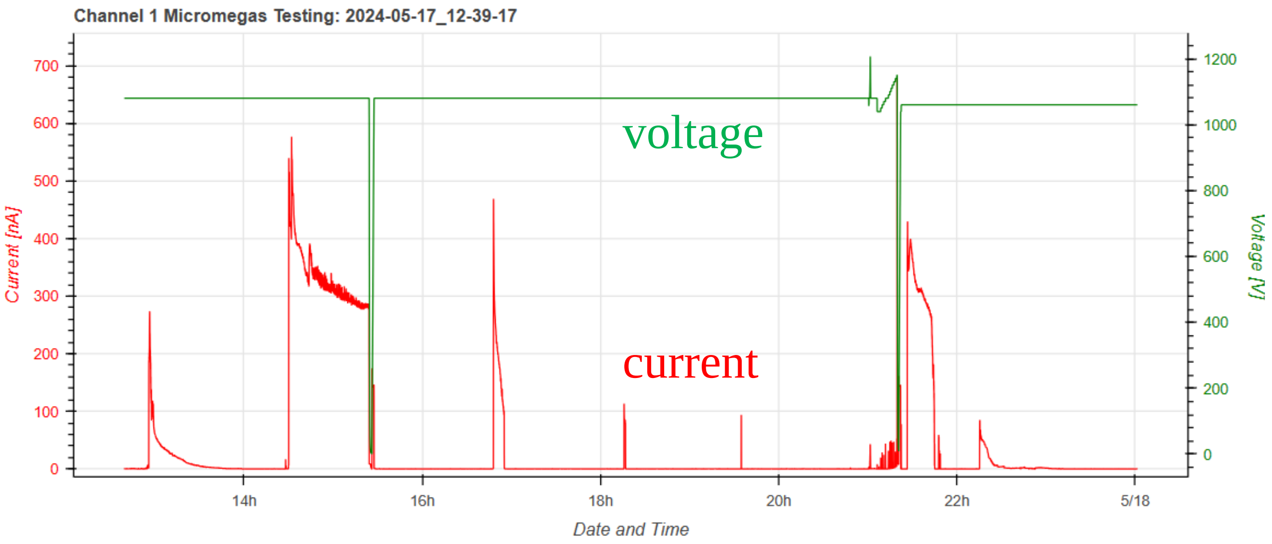
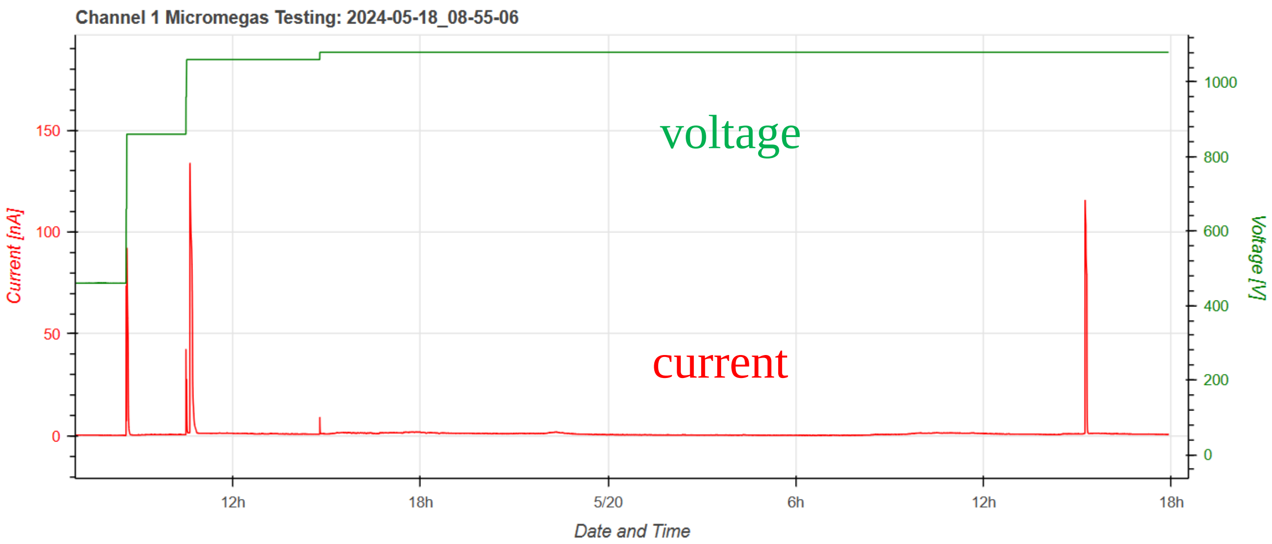
IV The improvement of stability

- Voltage： 1080V
- Gas: 10 bar Ar+2.5%Iso
- Gain： ~2500
- Radiation Source： ^{55}Fe
- In the test at USTC, 6 of 8 Micromegas detectors operated with good stability in 10 bar



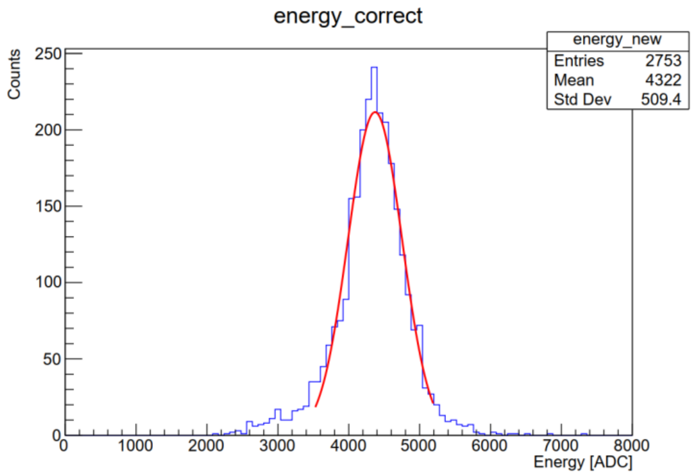


Long-term voltage and current monitoring

IV The improvement of stability

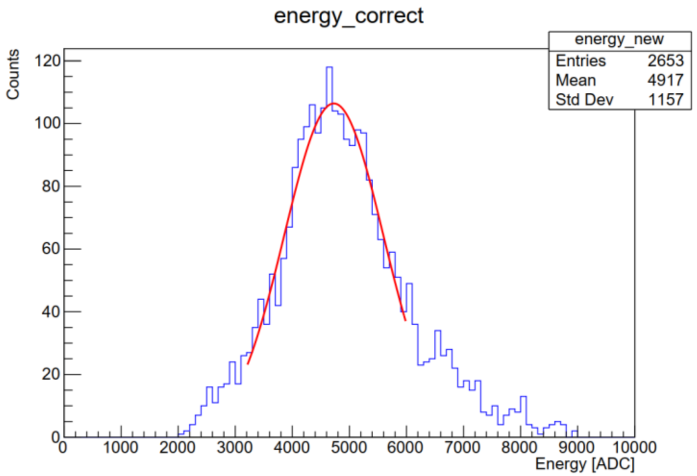
- ➢Setup： miniTPC
- ➢Radiation Source： ^{109}Cd

- ➢Gas： 10 bar Ar+2.5%Iso
- ➢Micromegas had been operated stably in the test of 3 days in SJTU
- ➢Gain:7800
- ➢Energy resolution: 20%（FWHM)



- ➢ Gas:10 bar Xe+1%TMA
- ➢ Micromegas operated stably in 10 bar xenon gas in the test of **one month** (the best result is two days before).
- ➢ The stability problem has been solved initially
- ➢ Too many impurities in the gas made energy resolution bad.

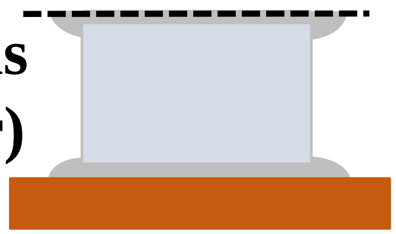
- ➢ Voltage：1050V
- ➢ ADC：4930
- ➢ Gain：2150
- ➢ Energy resolution：43%（FWHM）

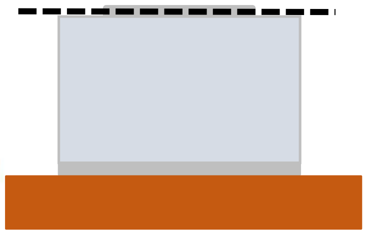


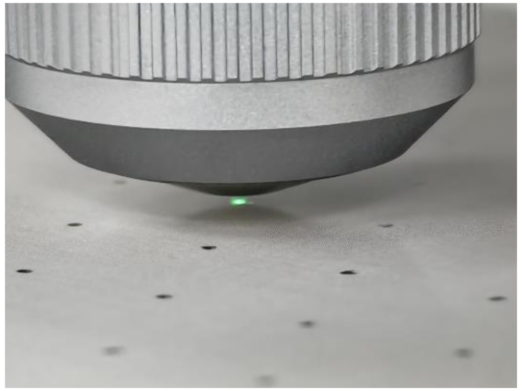
IV The improvement of stability

3D image of pillar

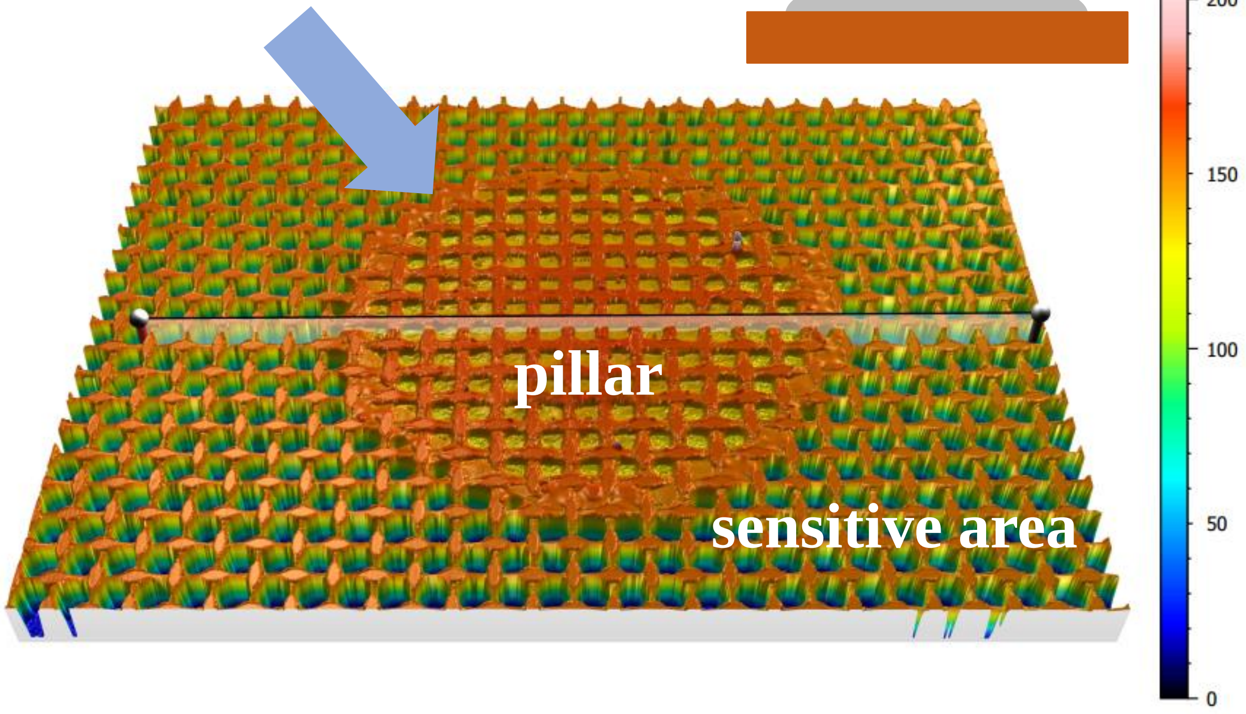
- Measurements were made using a Leica Digital Confocal Microscope
- the two 3D images were processed through the software MountainsMap



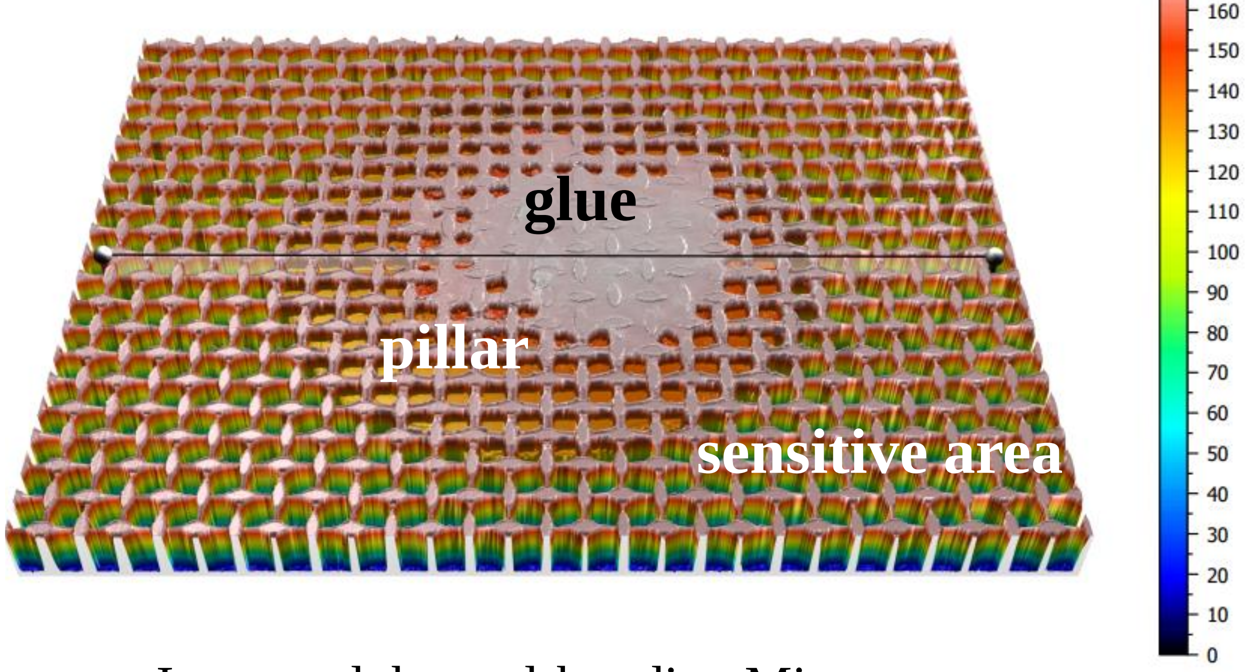




hot melt adhesive which was extruded (around the pillar)



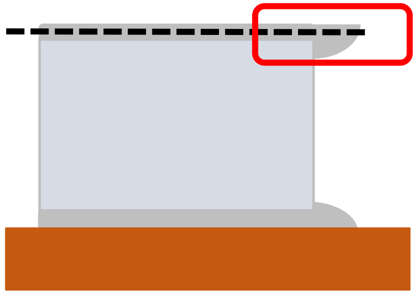
Traditional thermal-bonding Micromegas

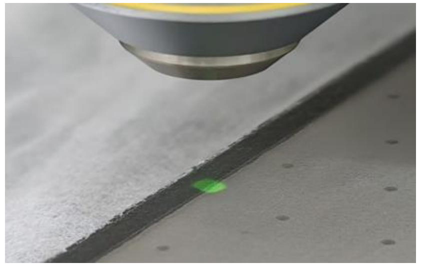


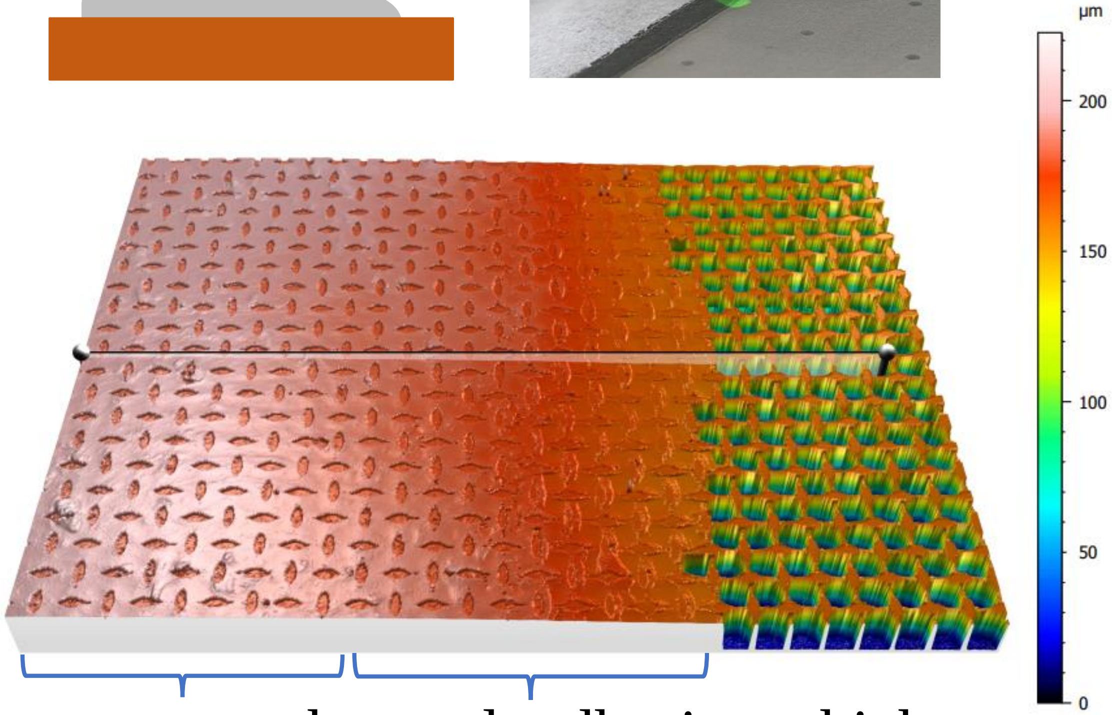
Improved thermal-bonding Micromegas

IV The improvement of stability

3D image of edge film



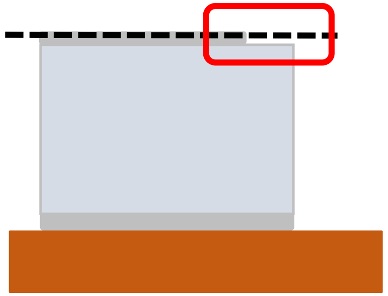


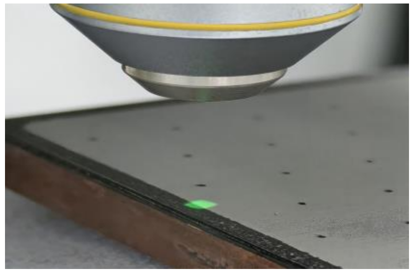


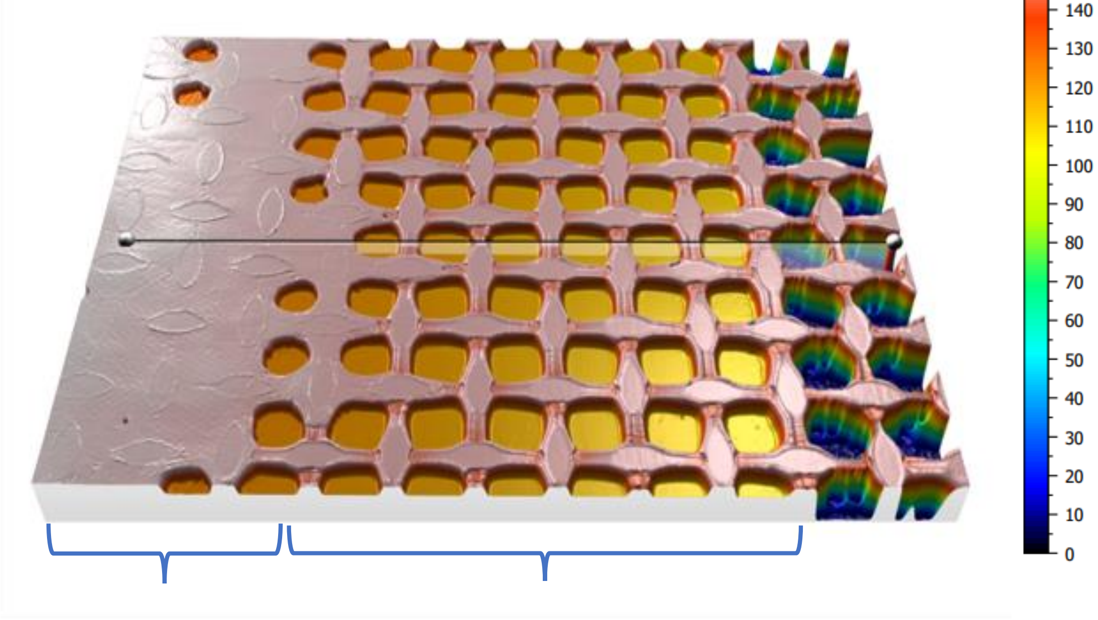
edge film

hot melt adhesive which was extruded

Traditional thermal-bonding Micromegas







glue

PET

Improved thermal-bonding Micromegas

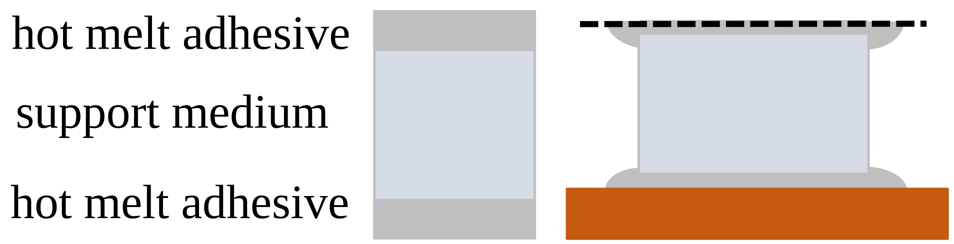
IV The improvement of stability

➢Conjecture: Due to the influence of the polarization charge on the surface of the hot melt adhesive, the electric field intensity of the gas part increases, which reduces the overall stability of the detector

in Gas | in adhesive

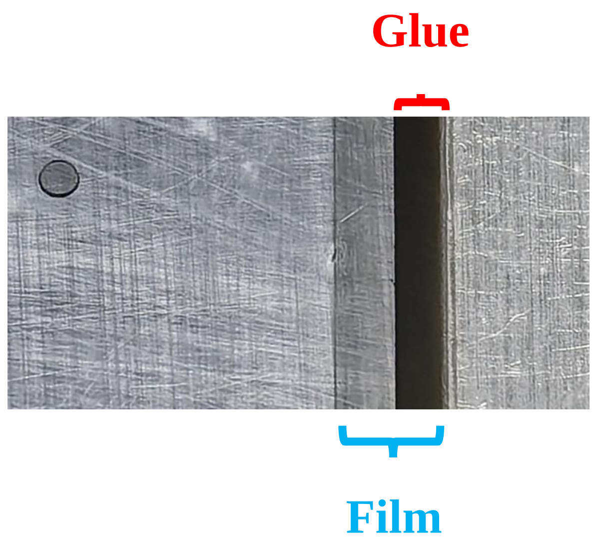
$$\int_0^{l_1} \mathrm{E}\cdot \mathrm{d}l + \int_{l_1}^{l_2} (\mathrm{E}_0 + E')\cdot \mathrm{d}l = V$$

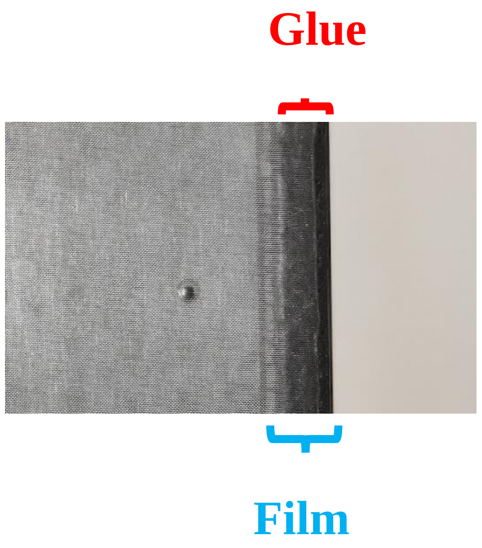
Depolarization field



Edge state of hot melt adhesive film

➢Using less glue instead of hot melt adhesive to avoid overflow to optimize the gas gap near the films and pillars and improve the stability of Micromegas under high gas pressure





The edge state of film of improved thermal-bonding method

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Summary

- ➢Long-term operation stability is the basic requirement for MPGD under high gas pressure
- ➢The traditional methods can't solve the stability problem
- ➢The improved thermal-bonding Micromegas has great performance in operation stability
- ➢The stability problem of Micromegas in high gas pressure had been solved initially.

Thanks for listening

Welcome to visit our laboratory in **C1404** room of the Physical Science and Research Building on Wednesday