Status report on RPC R&D for ATLAS phase-2 upgrade

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Outline

- Introduction
- Honeycomb readout panel production
- RPC gas gap production
- Validation of Double-end readout method with phase II RPC electronic prototype
- Summary

Introduction

➢Motivation:

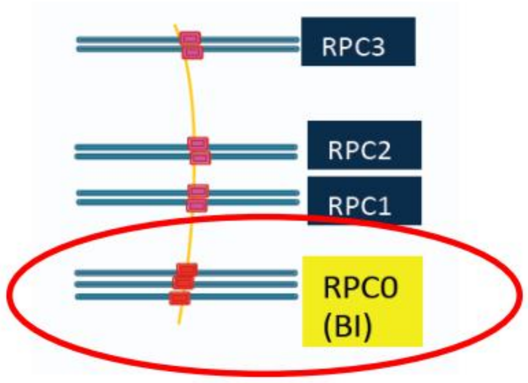
- The muon spectrometer must operate at high-luminosity environment of the HL-LHC without significant performance losses.
- The muon trigger need to be significantly upgraded to maintain low trigger momentum thresholds while keeping the trigger rates at a manageable level.

➢The main limitation of the RPC when operate @HL-LHC

- The redundancy of the present RPC system is insufficient
- The present geometrical acceptance of the trigger in the barrel is only approximately 80%
- The rate and latency of trigger and readout electronics are incompatible with the Phase II requirements
- Long-term operation at high rates is not affortable for current RPC
- The greenhouse impact of the RPC gas mixture

➢Solution

- The installation of triplets of new-generation RPCs in the BI-RPC ★
- The replacement of the trigger and readout electronics
- Retrofitting with new front-end electronics in the BO chamber



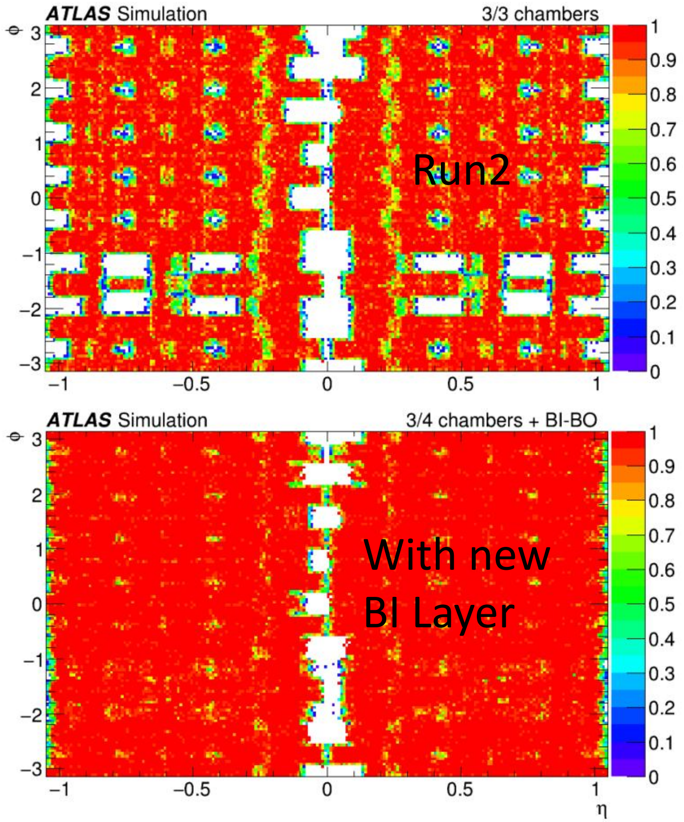
- 9 layers instead of 6

Introduction

- Installation of triplets of new-generation RPCs in the BI-RPC
  - Pros:
    - ✓ Recover most of the current geometrical acceptance holes
    - ✓ The redundancy of the system will be greatly enhanced
    - ✓ Full trigger efficiency can be maintained even if the old RPCs have to be operated at reduced efficiency (mix gas or reduced HV)
  - Components: 315 BIL + 359 BIS + 54 BIS78 chambers

- Tasks undertaken by ATLAS Chinese cluster (USTC-SDU-SJTU)
  - ~ 600 BIS read-out panels will be produced and qualified
  - Dozens of gas gap will be produced and qualified
  - All the singlets assemble carried out in China
  - Half electronics will be produced in China

① Honeycomb readout panel production ★
② RPC gas gap production ★
③ Validation of Double-end readout method ★
④ R&D on RPC signal integrity [(More details in Zirui's talk)]



BM and BO efficiency (%)	Trigger efficiency × acceptance (%) 3/3 chambers	3/4 chambers	3/4 chambers + BI-BO
100	78	91	96
90	73	90	95
80	62	87	93
Worst case	63	85	92

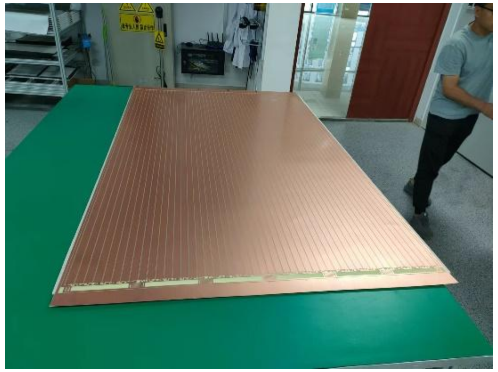
Worse case: A reduction of the high voltage of the BM and BO RPCs to ensure their longevity

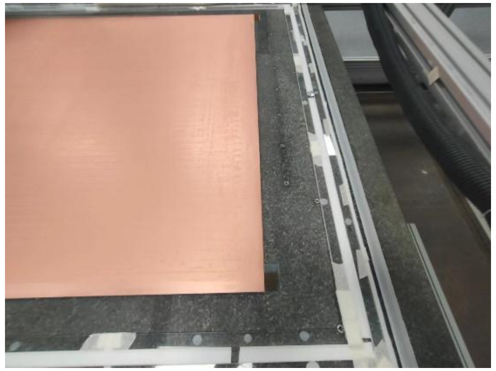
Honeycomb readout panel production

➢Components:

- PCBs: strip PCB + GND panel (0.4mm thick, size: 1706x1070 mm)
- Honeycomb core: 3mm thick
- Glue: Araldite 2011 (~180g /side)

Cell size: 5 mm (side to side)
Density: 32 kg/m^3





BIS-1 prototype

Araldite 2011

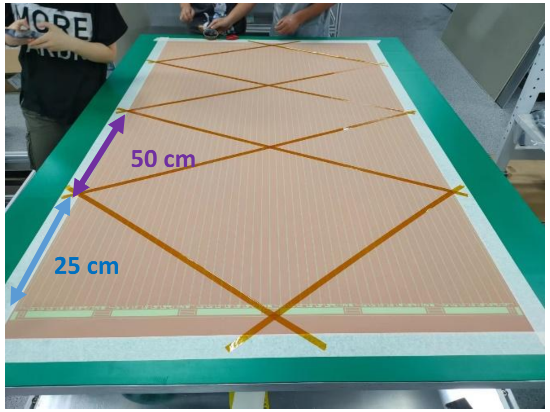
THINKY MIXER ARE-310

Assembly procedures

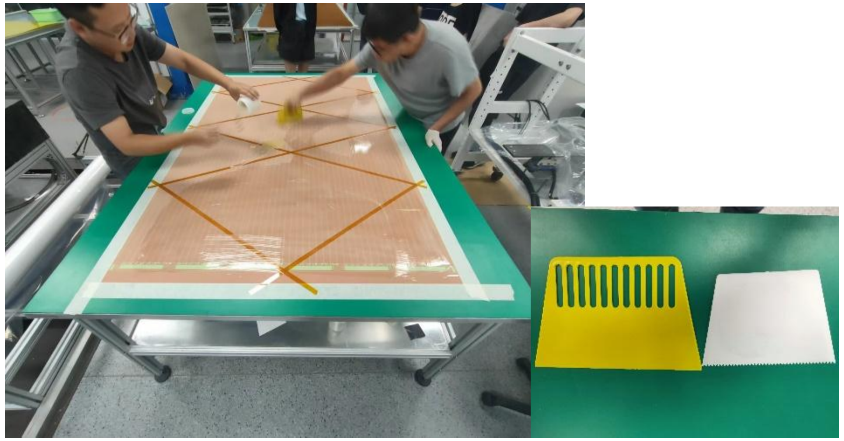
- Stick **X** shape tape on the PCB, and mix the epoxy glue
- Spread Araldite 2011 glue on the PCB
- Glue Aramid paper honeycomb on the PCB with the vacuum bag
- Align 2PCBs + honeycomb layers
- Glue 3 layers (2PCBs + honeycomb) with the vacuum bag
- Quality check

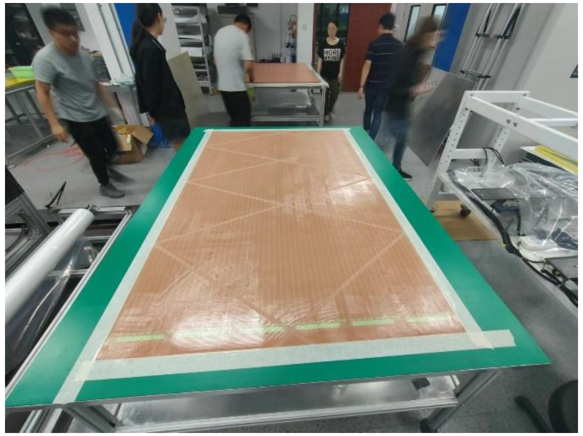
X shape tape sticking and glue spreading

- Stick X shape tape on the strip and GND panel
  - The distance between the two parallel tape is 50 cm
  - The edges of PCB are protected with mask (3mm)



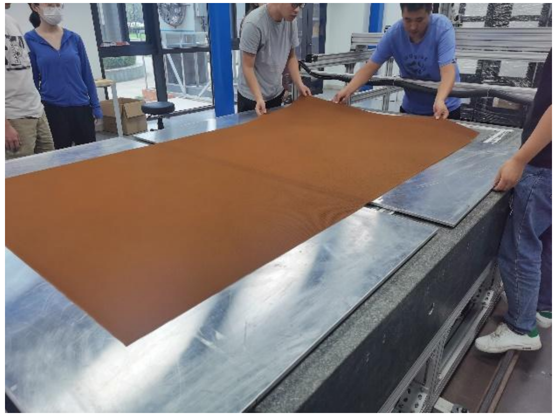
- Distribute the glue on the PCB (~ 10 minutes)
  - Pour the glue onto the panel (ARE-310 mixes the glue and gets rid of the bubbles)
  - Plastic spreader (Yellow) used to distribute the glue and then another spreader (white) with V-shaped notches used to spread the glue uniformly
- Remove the tapes

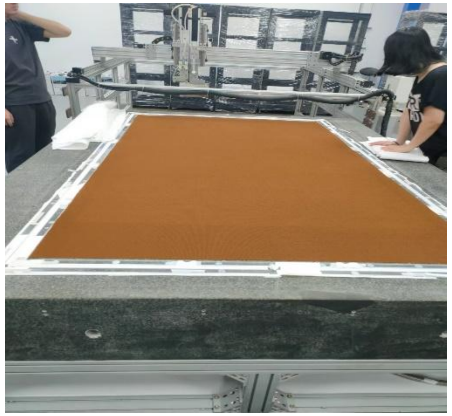




Put the honeycomb on PCB

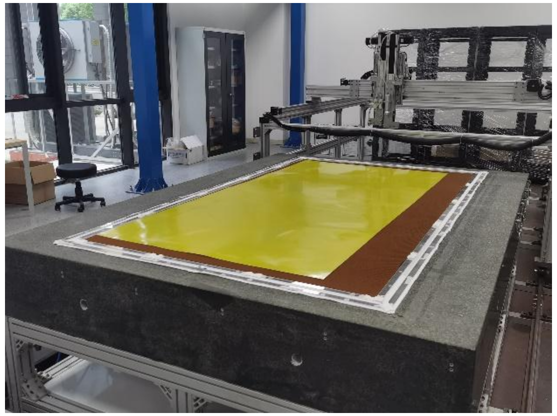
- Move the PCB from the working platform to the marble platform
- Hold the honeycomb layer on top of the PCB with a large board
- Slip the large board out slowly and align the honeycomb with the PCB (honeycomb layer is slightly larger than the PCB)

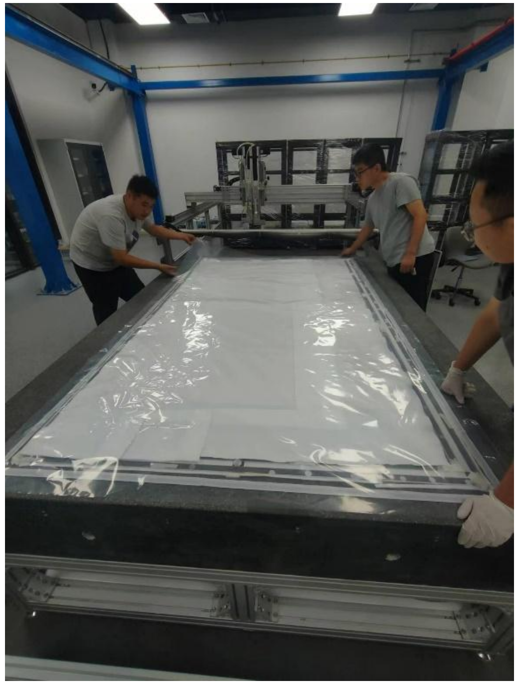




Curing with vacuum bag

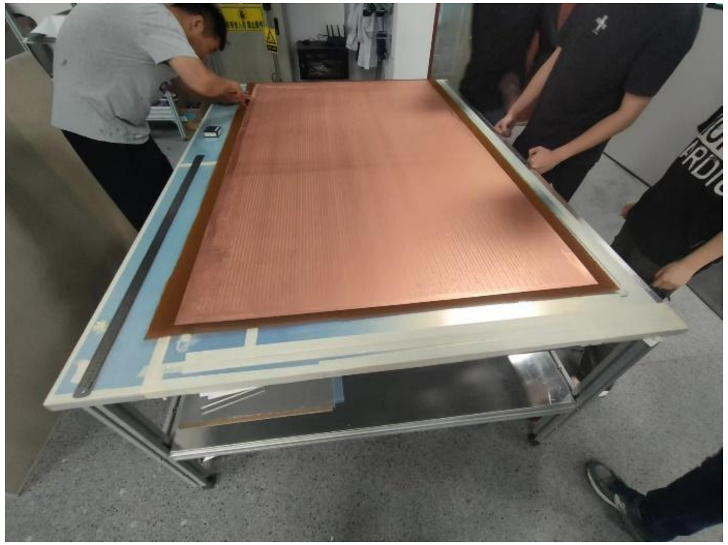
- Put a FR4 board and ventilated felt on the honeycomb board to ensure uniform pressure
- Put vacuum film on the top and start vacuuming
- The vacuum is kept for > 6 hours

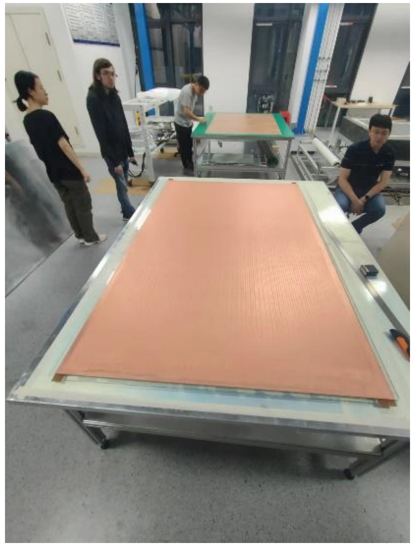





Align 2PCBs + honeycomb

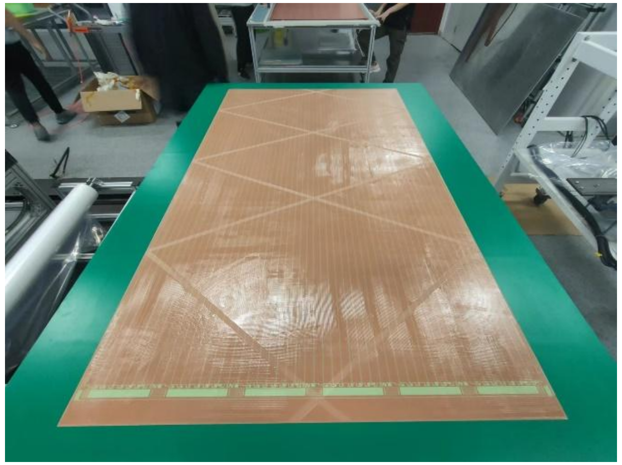
- A frame is designed to align 2PCBs + honeycomb. The size of the frame can be modified with respect to the panel size.
- Put the PCB + honeycomb on the frame
- Cut off any excess honeycomb layer along the PCB edge
- Honeycomb at four corners are kept for a better support against the pressure. (Protection structure at four corners will be applied in the mass production.)

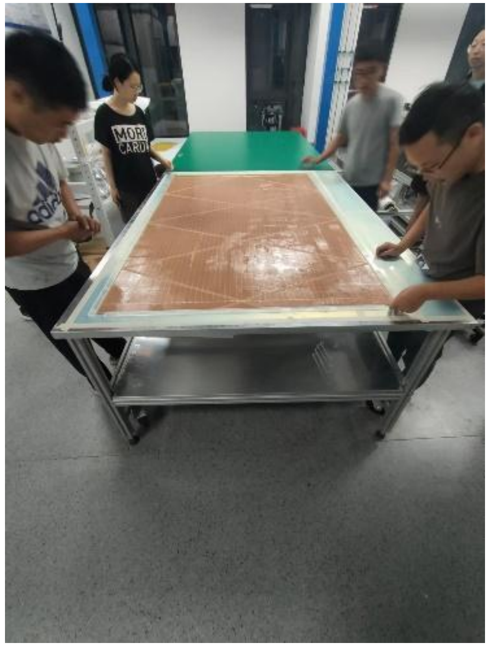




Align 2PCBs + honeycomb

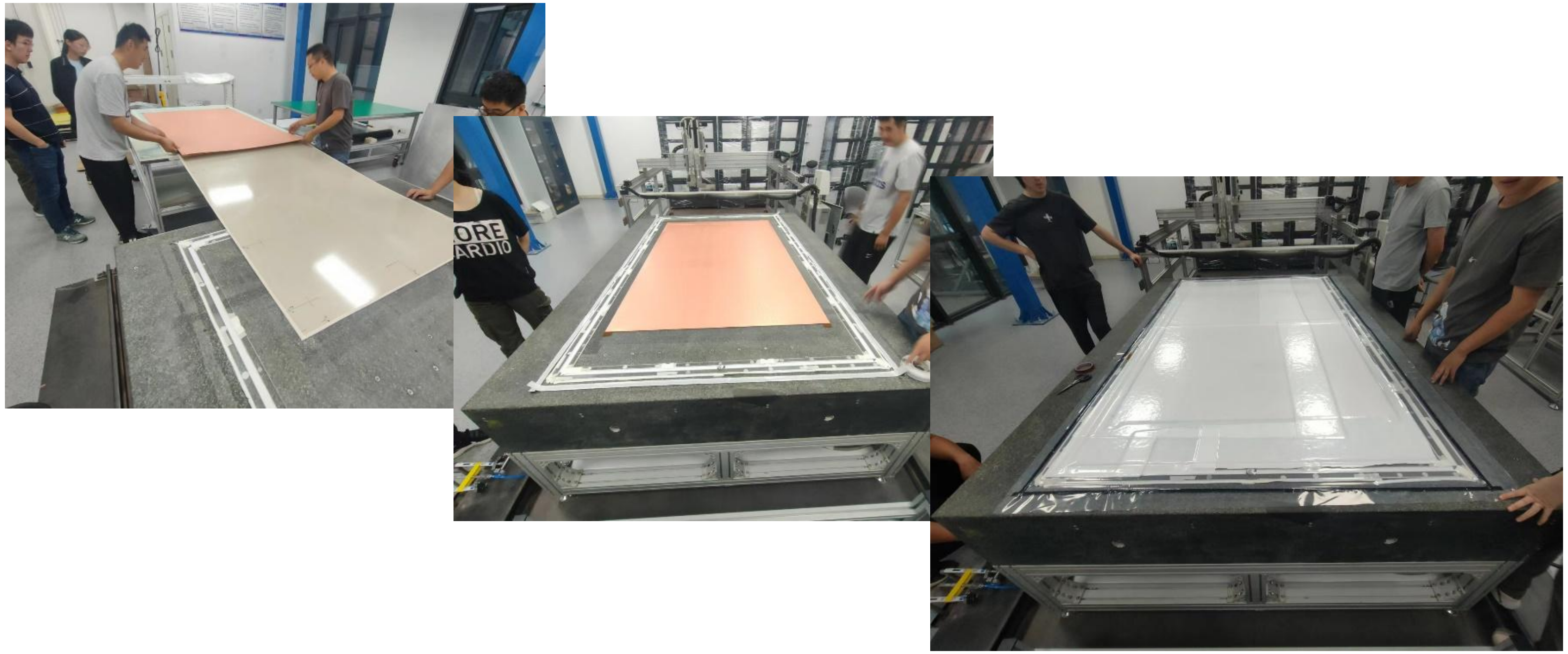
- ➢Put the strip PCB (after glue distribution) in the frame
- ➢Slip the PCB + honeycomb on the strip PCB carefully
- ➢Align three layers (2PCB+ honeycomb) within the frame

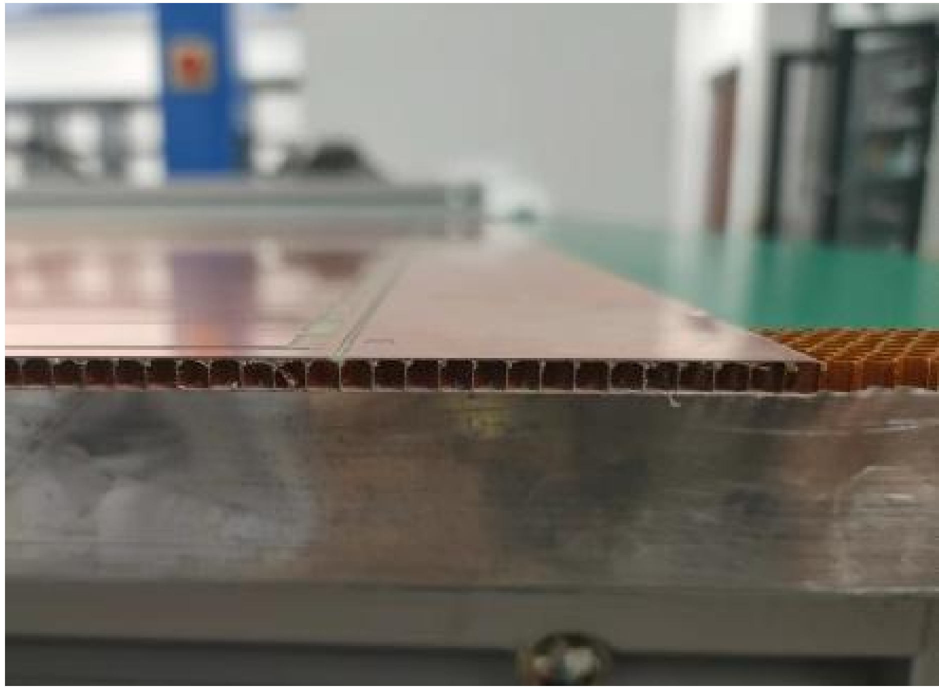




Gluing 3 layers together

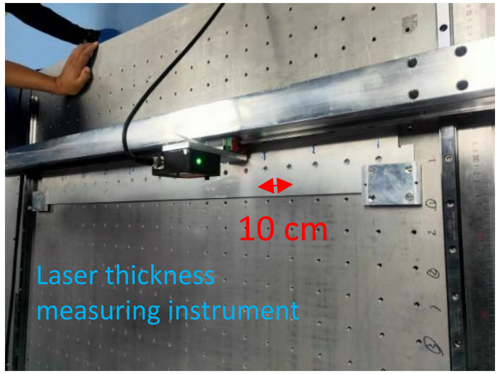
- Slip the aligned 2PCBs + honeycomb onto the marble platform
- Apply the same vacuum procedures again
- Apply copper tapes along the edges.

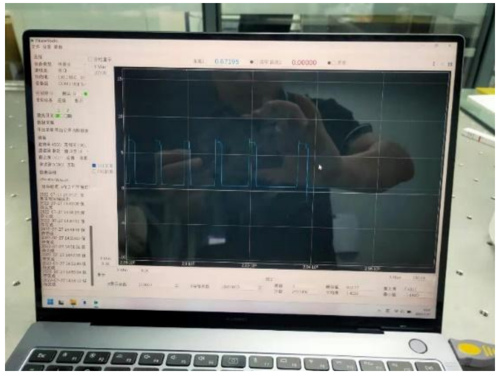


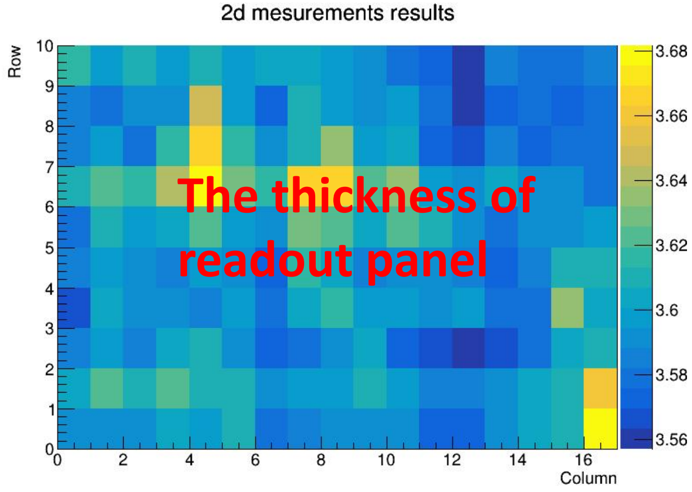


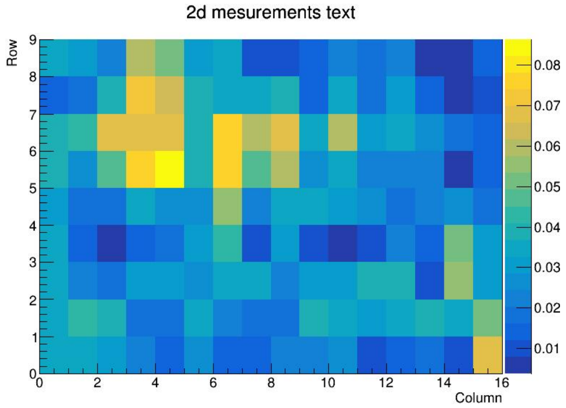
Flatness check

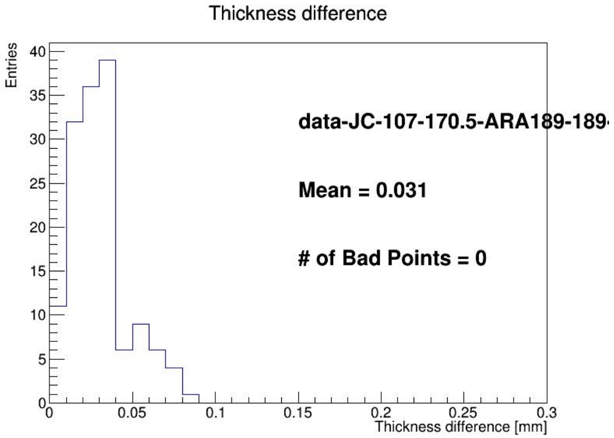
- ➢The thickness is measured in a 10 x 10 cm matrix with a laser sensor.
- ➢Flatness: The maximum variation of 4 points in a 10 x 10 cm range.
- ➢The requirement of flatness < 100 μm can be achieved.







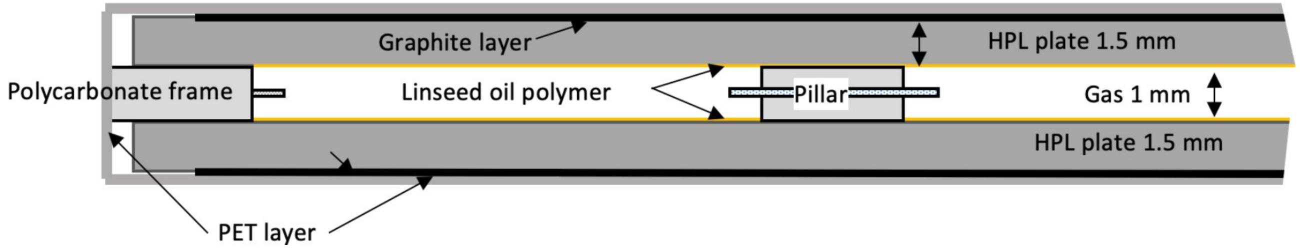




RPC gas gap

➢General description

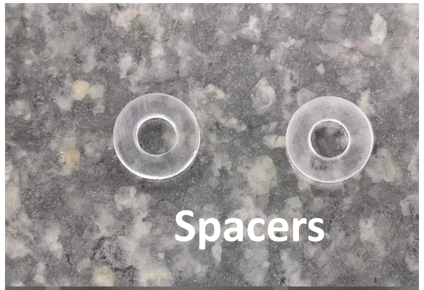
- It has large area parallel plate structure
- it works on the avalanche mode

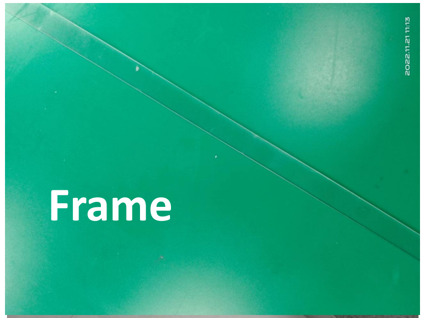


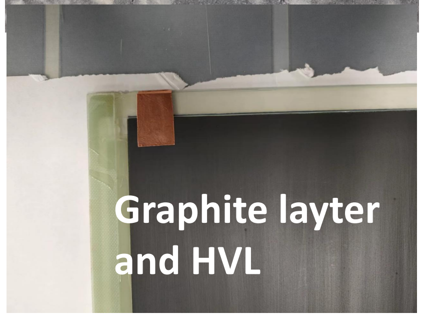
Sketch of a Gas Volume

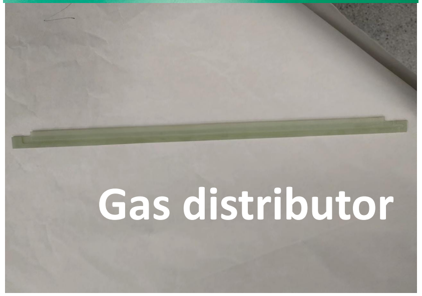
➢ Components:

- Electrode plate: High-Pressure Laminate (HPL), 1.5mm thickness
- Spacer: 1.00 +/- 0.01 mm
- Polycarbonate frame
- Graphite layer
- Graphite connected high voltage link
- PET layer
- Gas distributor





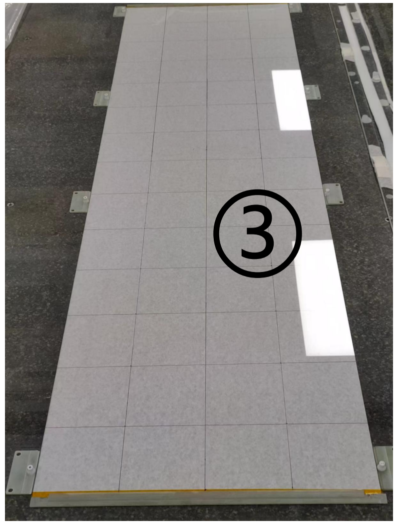




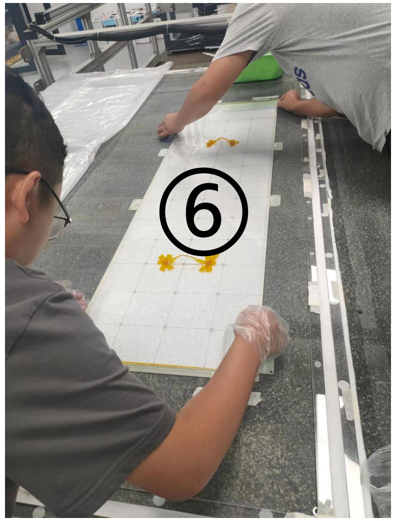
Profile Display

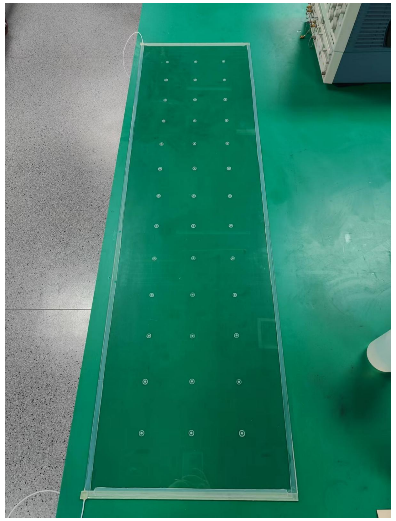
RPC gas gap production

- Assembly procedures:
  ① Glass and platform cleaning
  ② Glue the distributer to the glass
  ③ Put the glass on the platform
  ④ Glue the spacers on the glass with distance of 10 cm
  ⑤ Glue the frame on the glass
  ⑥ Put another glass on the spacers/frames



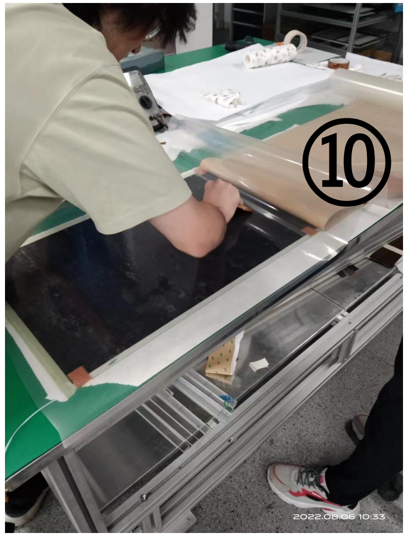
The distance between any spacers is 10 cm

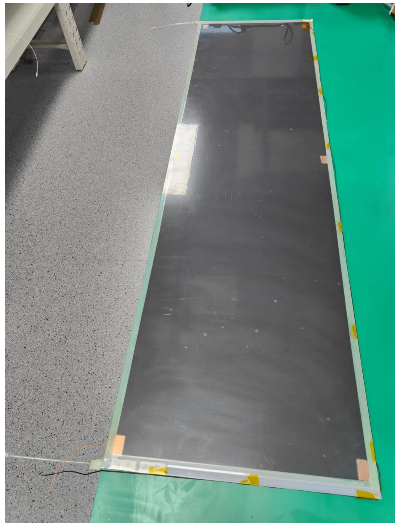




RPC gas gap production

- **Assembly procedures:**
  ① Glass and platform cleaning
  ② Glue the distributer to the glass
  ③ Put the glass on the platform
  ④ Glue the spacers on the glass with distance of 10 cm
  ⑤ Glue the frame on the glass
  ⑥ Put another glass on the spacers/frames
  ⑦ Press the gas-gap for at least 6 hours
  ⑧ Graphite coating
  ⑨ Attach the HV contact on the graphite
  ⑩ bond the PET film to the Graphite layer with 3M double-side tape





Double-end readout method with phase II RPC electronic prototype

Motivation

- To check if FEE works properly in double-end scheme
- To check the space resolution performance

Experimental setup

- FEE board: chip-based, which will be used in RPC Phase II upgrade
- 32 BIS7s RPC gives reference position
- TDC: V1190 (100 ps resolution)

Reconstruction

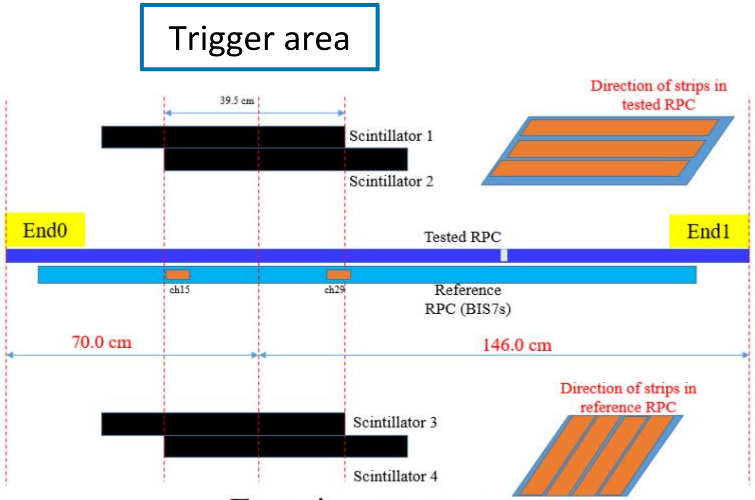
- Reconstructed hit position: x’ = (T2-T1)*v/2
- Reference position x is the center of the reference strip

Results:

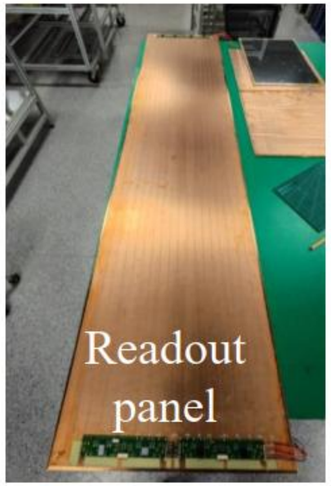
- Resolution: position difference, x-x’

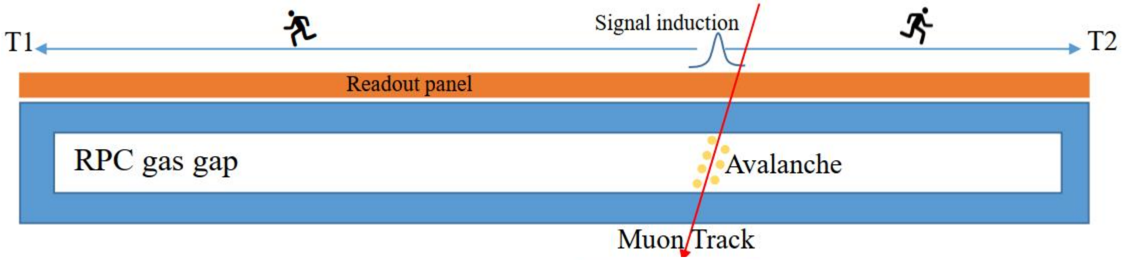
$$\sigma(x-x') = \sqrt{\sigma(x)^2 + \sigma(x')^2}$$

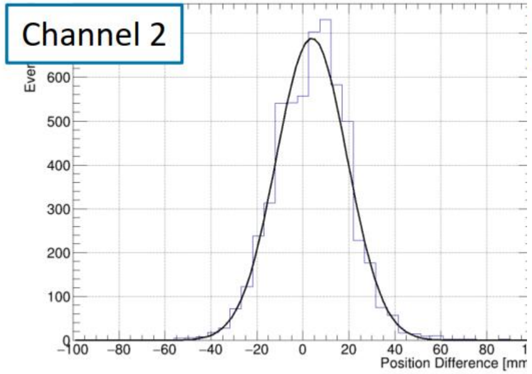
- The $\sigma(x')$for the four center strips:
  - ✓ 1.24, 1.32, 1.26, 1.39 cm
- The results meet the requirement of RPC Phase II upgrade(<2cm).

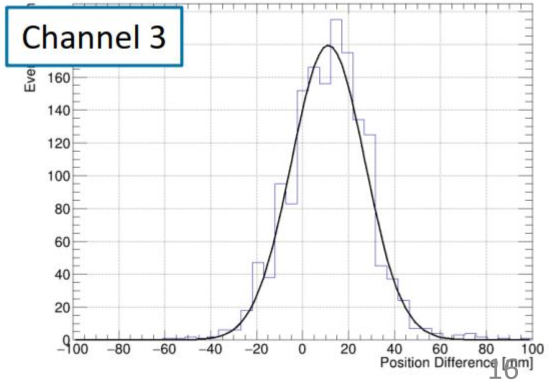


Experiment setup









Summary

- The vacuum-bag-based honeycomb readout panel production method has been established and optimized at USTC.

- The full BIS size (1706x1070 mm) panels can be built, the flatness of the Readout panel < 100um, satisfy the design requirement.

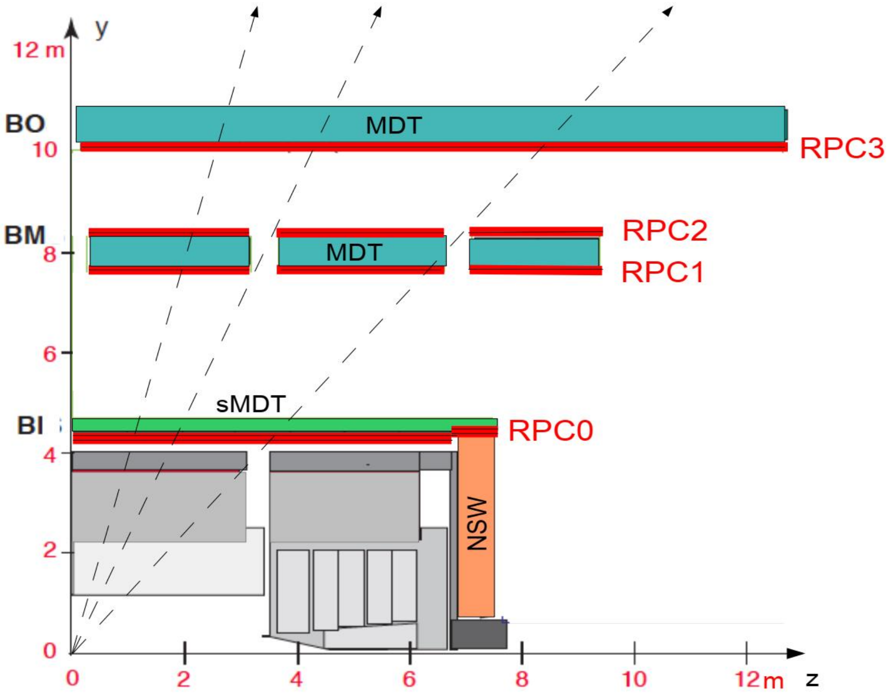
- The production procedures of gas gap are still working in progress.

- Double-end readout method - Validated with phase II RPC electronic prototype, the space resolution meet the design requirement.

Thank you for your attention

Back up

Geometrical acceptance and trigger eff.



Trigger	Requirement
3/3 chambers	3[RPC1+RPC2] AND 1[RPC3]
3/4 chambers	(3[RPC1+RPC2] AND 1[RPC3]) OR (2[RPC0] AND 3[RPC1+RPC2+RPC3])
3/4 ch. + BI-BO	(3[RPC1+RPC2] AND 1[RPC3]) OR (2[RPC0] AND 3[RPC1+RPC2+RPC3]) OR (2[RPC0] AND 1[RPC3])