A Large-area RWELL prototype for CEPC-DHCAL Application

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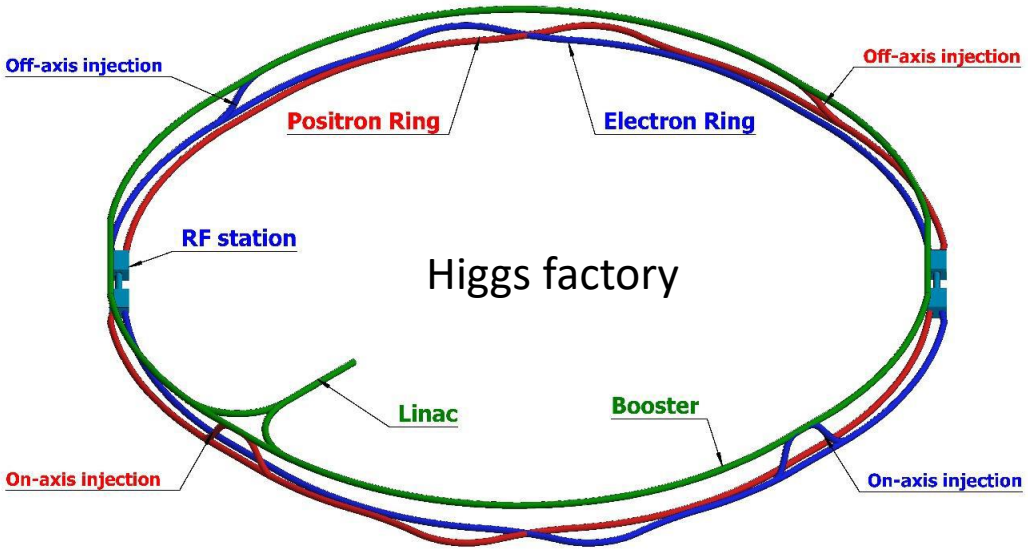
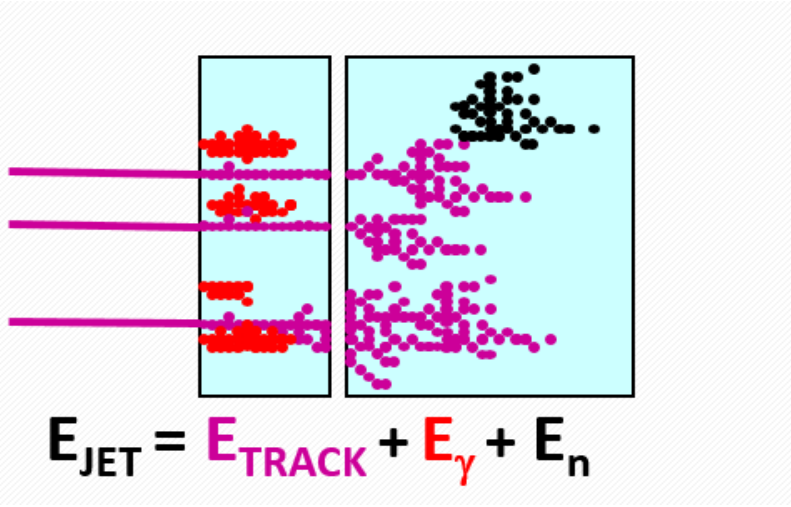
Introduction

- The Circular Electron Positron Collider (CEPC)



- The baseline detector concept-guided by Particle Flow Principle



Key component： high-granularity calorimeter

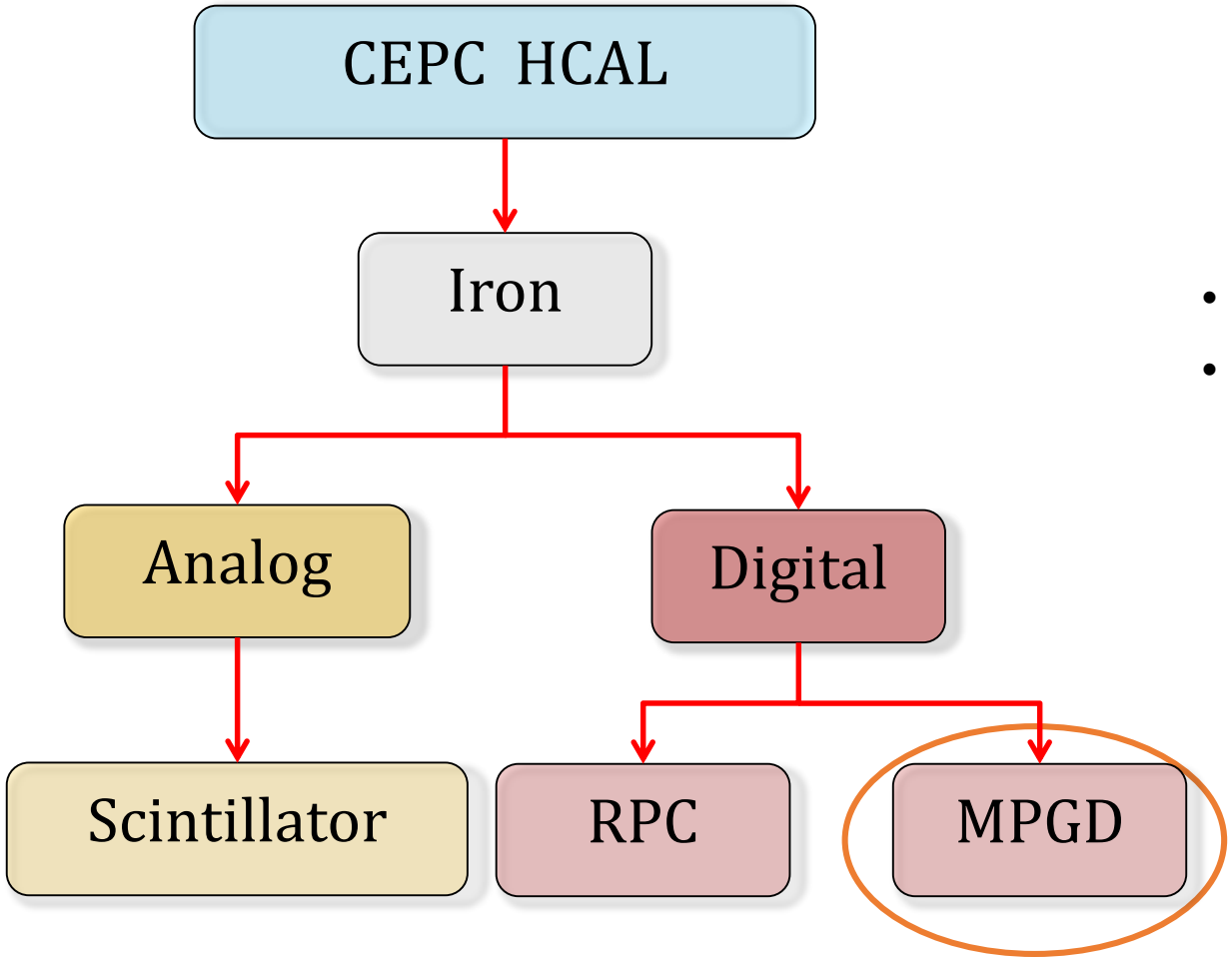
- Parameters:

Operation mode	$\sqrt{s}$ (GeV)	L per IP ($10^{34}\,\mathrm{cm^{-2}s^{-1}}$)	Years	Total $\int L$ ($\mathrm{ab^{-1}}$, 2 IPs)	Event yields
H	240	3	7	5.6	1×10^6

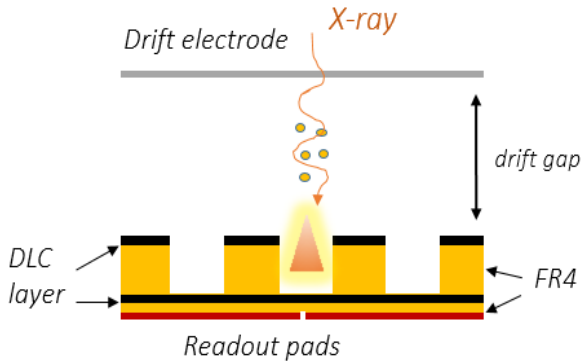
- Performance requirement:

$H \to q\bar{q}, WW^*, ZZ^*$	$\mathrm{BR}(H \to q\bar{q}, WW^*, ZZ^*)$	ECAL HCAL	$\sigma_E^{\mathrm{jet}}/E =$ $3 \sim 4\%$ at 100 GeV

MPGD&RWELL for CEPC HCAL

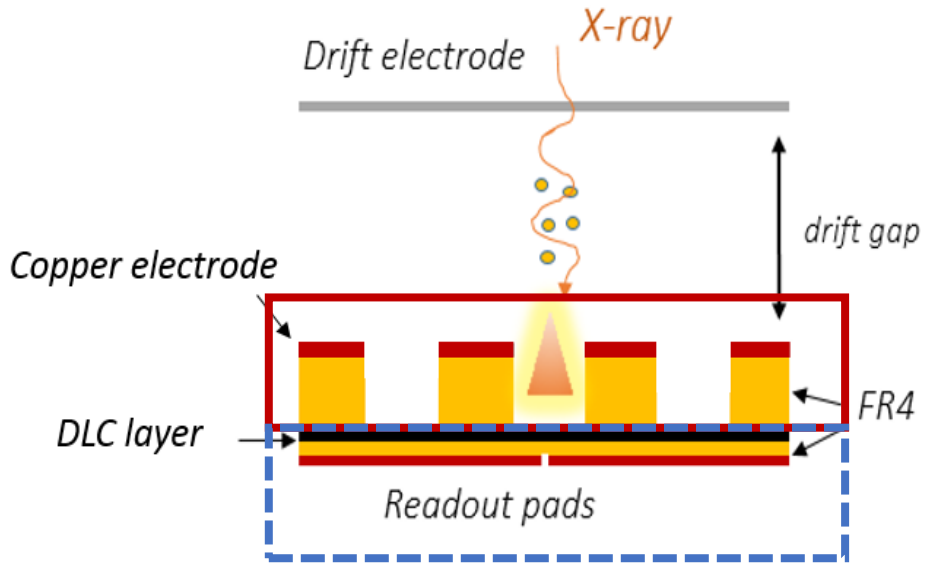


- Requirements of sensitive detector:
  1. Compact
  2. High detection efficiency
  3. Scalable to large size
  4. High granularity
- MPGD： one of the candidates
- Resistive WELL detector (RWELL):
  1. Single drift gap / stage amplification, very compact
  2. high gain
  3. Spark suppression by resistive layer - DLC



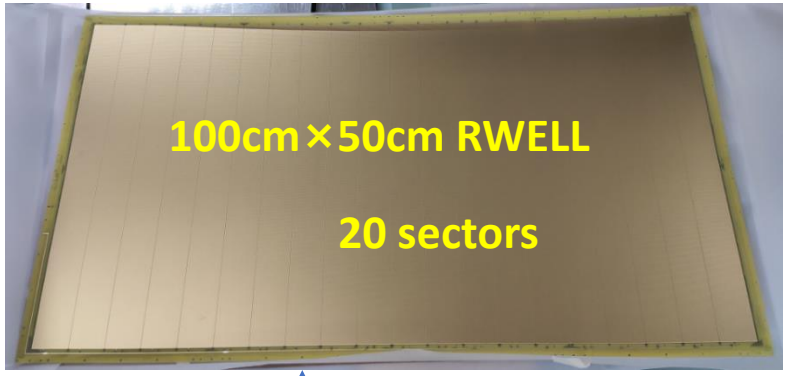
- **RWELL: A promising candidate for sensitive detector of DHCAL**

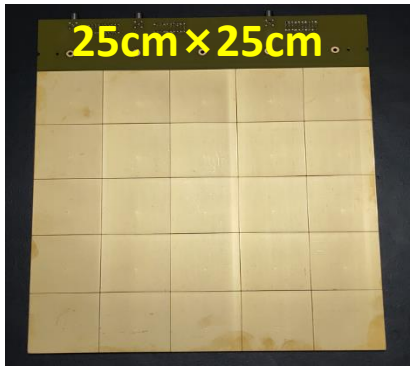
Design of 100cm×50cm RWELL detector

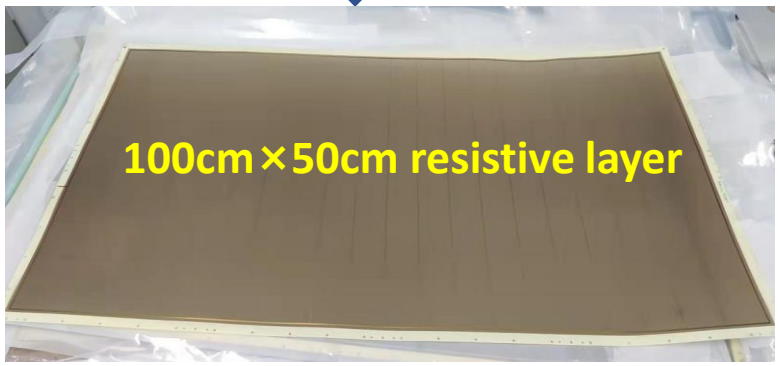


Design:

- Divide RWELL foil into 20 sectors
- Separate resistive layer from readout PCB
- Grounding circuit on the resistive layer
- 8 pieces of readout PCB -> large readout area







Gluing

Parameters of RWELL foil:

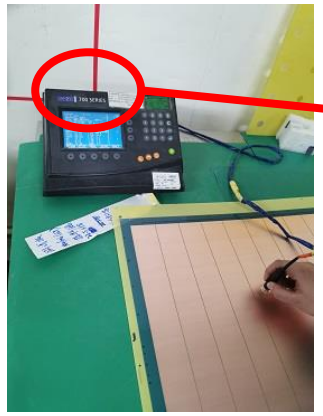
- Hole diameter: 0.5mm
- Pitch: 1mm
- Thickness: 0.5mm
- no rim

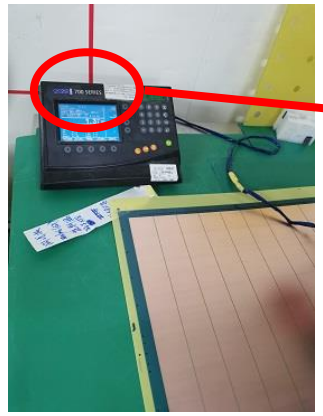
100cm×50cm readout PCB was divided into 8 pieces with 25cm×25cm each

PCB layer processing

- Thinned copper layer on the top part of THGEM

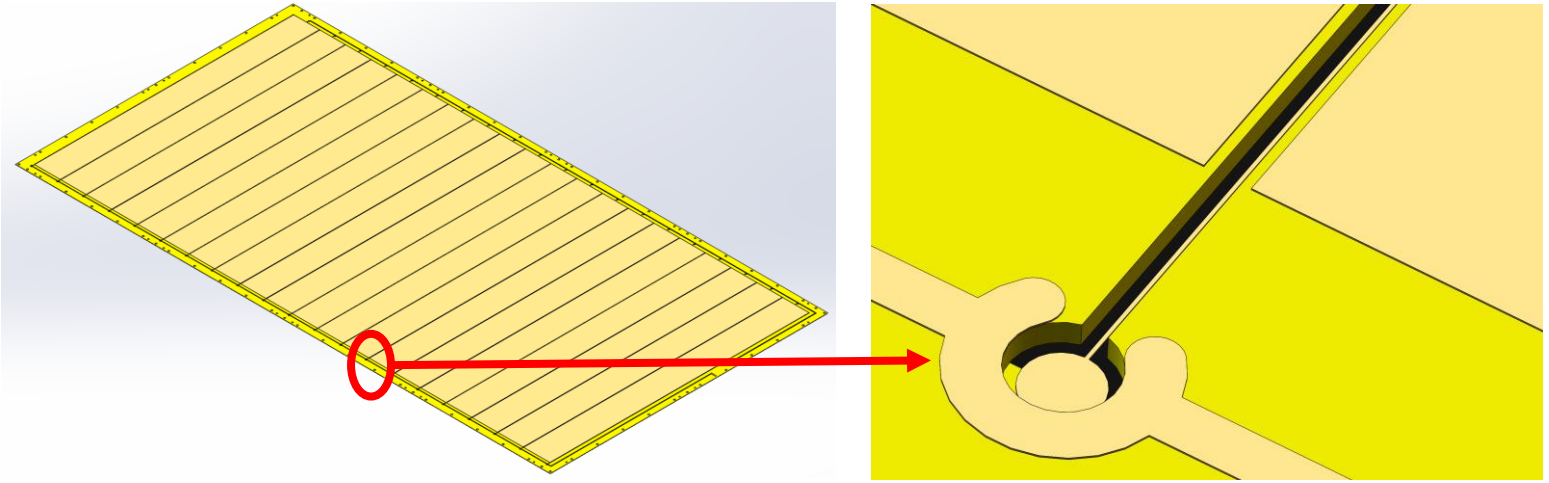







  - Reduce the copper thickness to less than 2μm by the standard copper reduction line

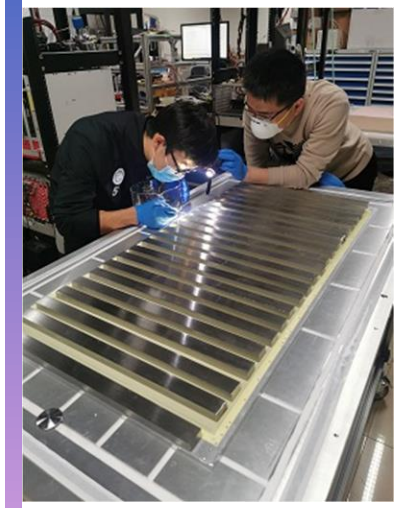
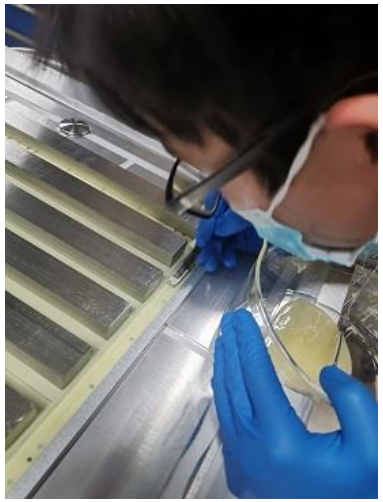
- Glue the THGEM PCB and the resistive layer together to get the RWELL PCB



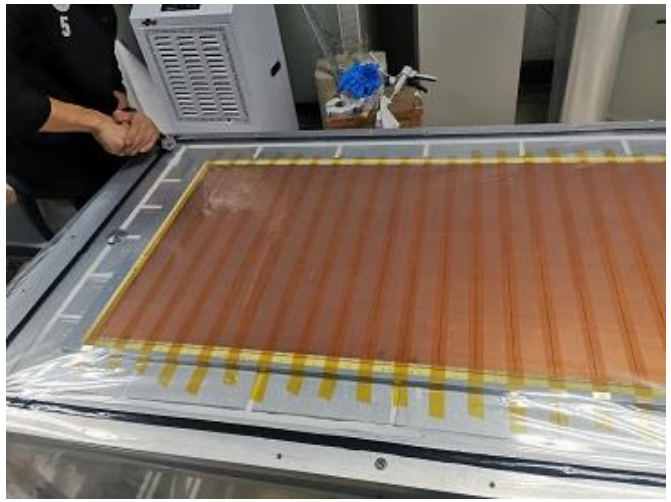
- With copper on the top of THGEM, we are able to divide the whole active area into 20 sectors by normal PCB technique
- GND lines lie on the resistive layer PCB, with DLC coating on the surface
- A slot between two adjacent sectors to hold the GND line, to ensure its flatness after gluing

Fabrication of 100cm×50cm RWELL detector

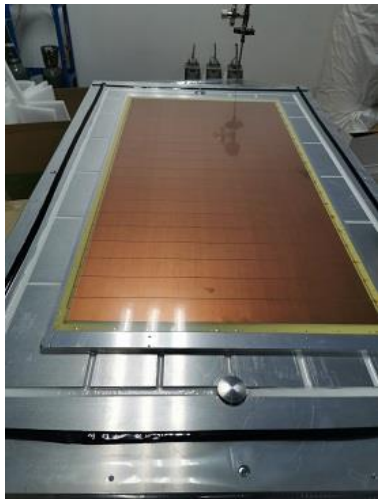
100cm×50cm RWELL detector:

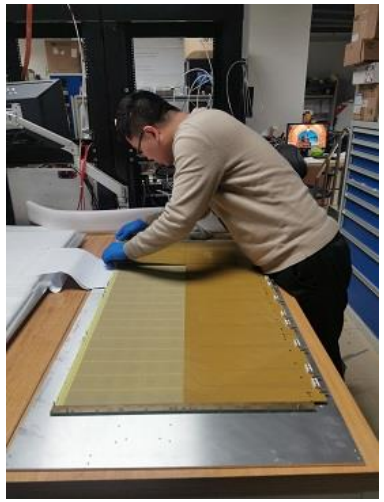
Glue painting



Seal the platform

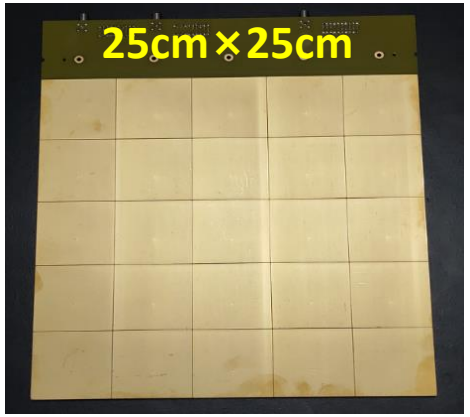


Pumping and drying



Assembling

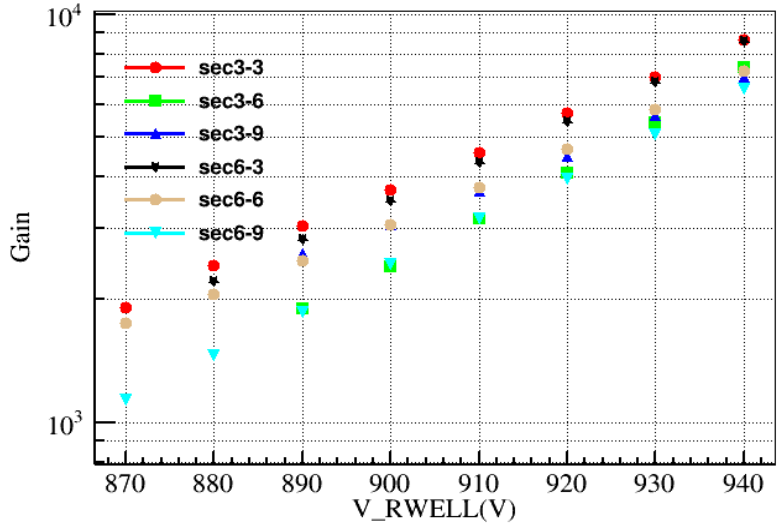
- Use a special PCB as the gluing mask
- Apply glue on both the resistive layer PCB and the THGEM PCB
- A vacuum platform for gluing
- 8 pieces of readout PCB, each containing 25 pad (Pad size 5cm×5cm), for large-area readout

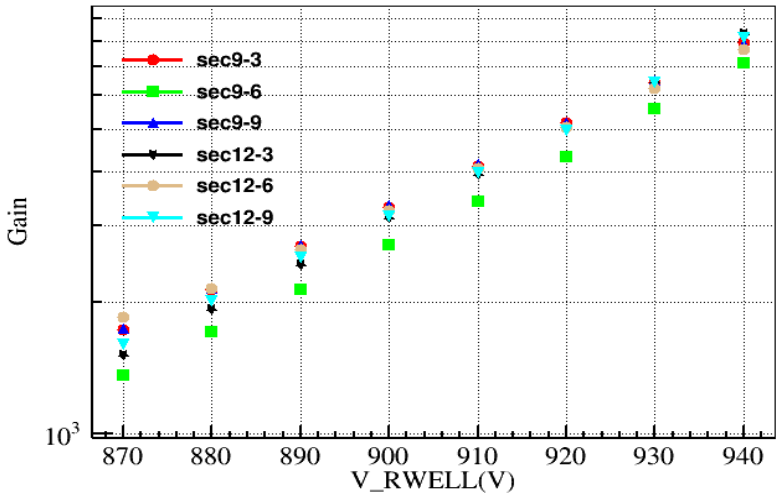


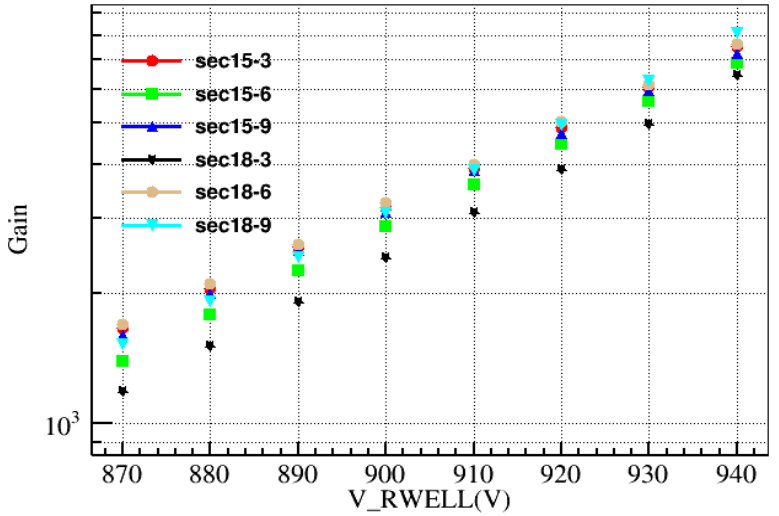
Performance of 1st version RWELL detector

Gas: Ar+5%iC_4H_{10}

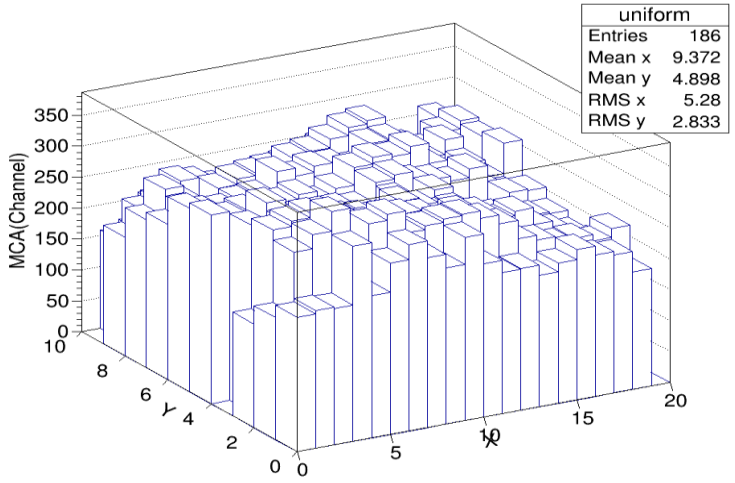
- **Gain vs HV:**

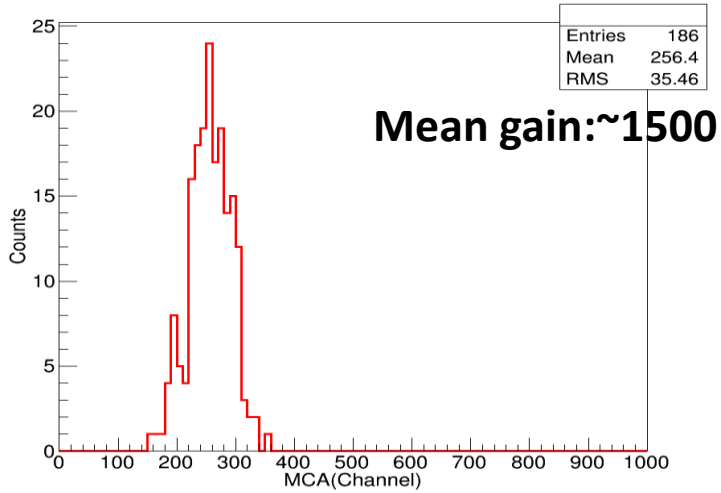






- **Gain uniformity : RMS/Mean=35.46/256.4 ~ 13.8%**

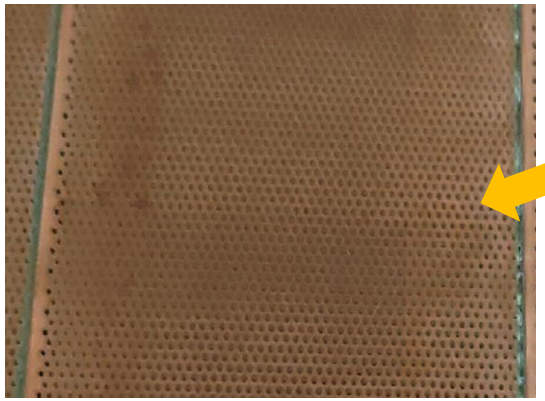




Mean gain:~1500

Problem and improvement

- Cu electrode oxidized after several times of cleaning



Copper electrode

- Cleaning && drying

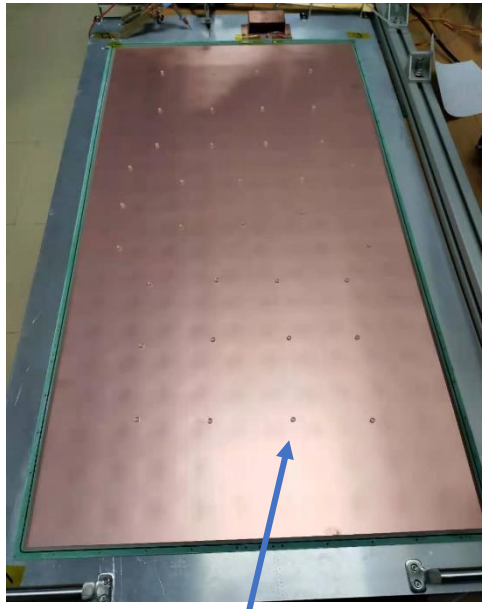
- Cu reduction && micro-etching

- Gold deposition: avoid oxidation

Assembly

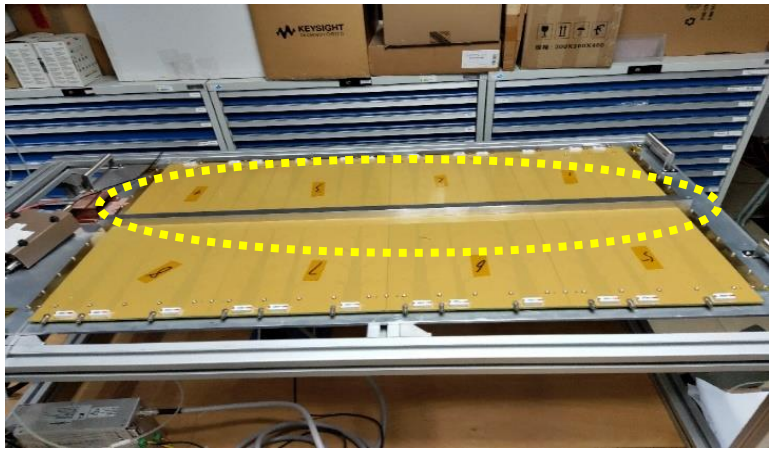
2nd version RWELL detector

- ~ 40 spacers in the detector



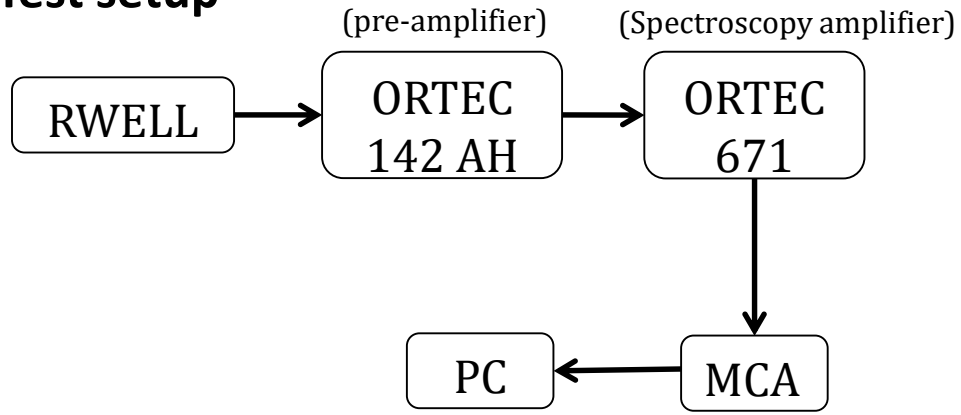
Acrylic cylinder spacer

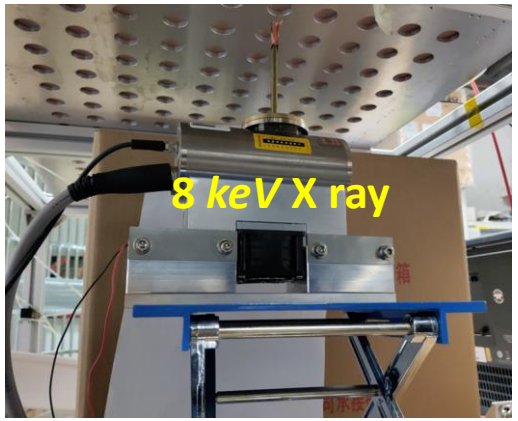
■ The long metal bar on the readout PCB of 1st version RWELL detector was replaced by five short metal bars

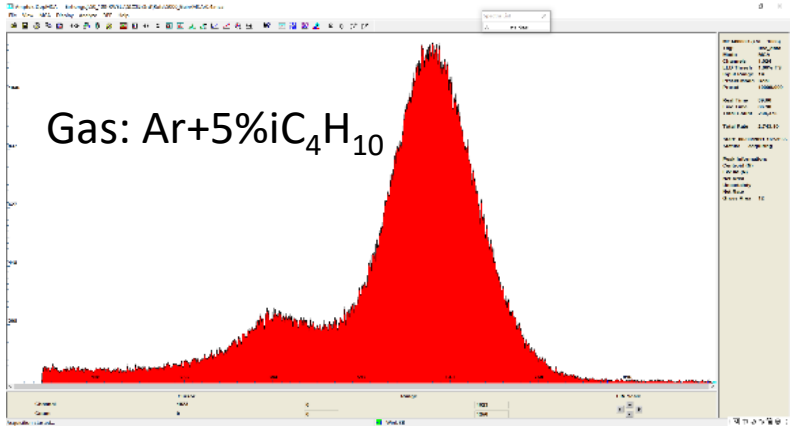


Performance of 2nd version RWELL detector

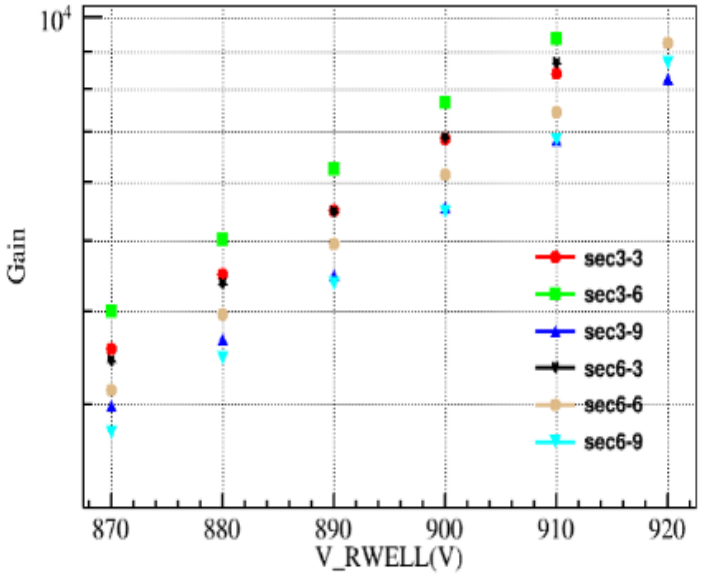
- **Test setup**

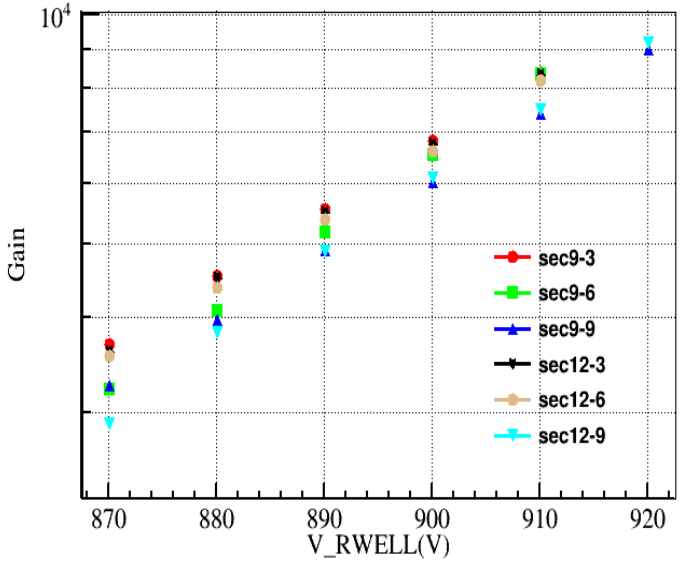


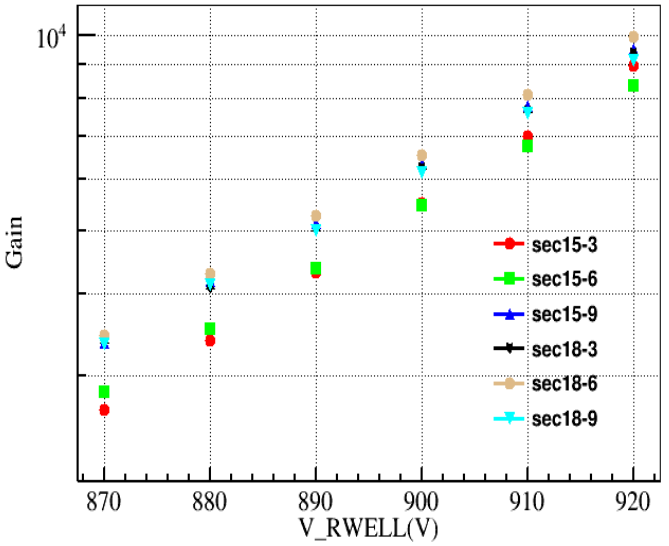




- **Gain vs HV:**



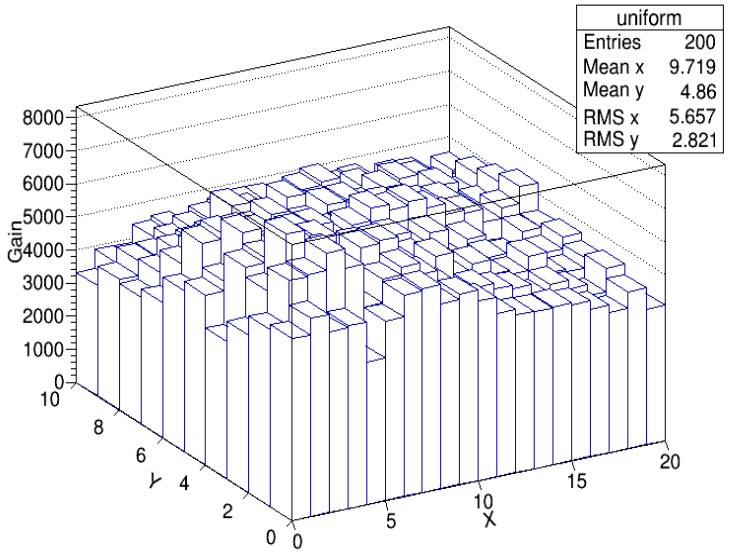


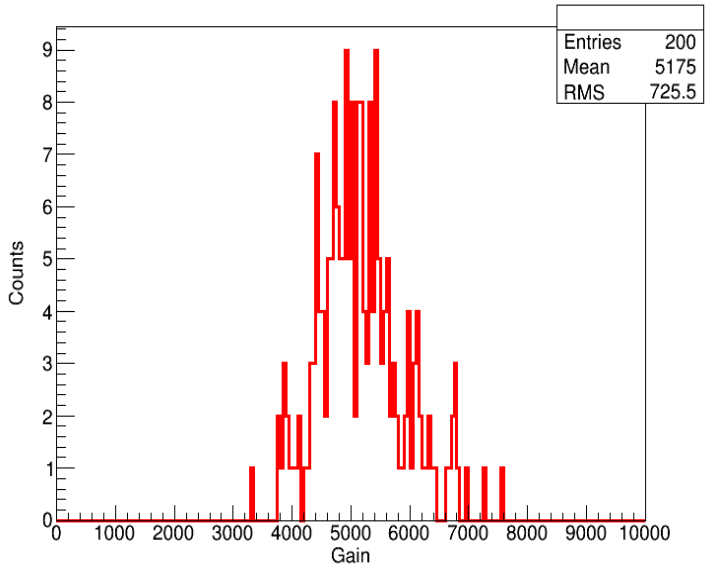


Gain uniformity & Rate capability

2nd version RWELL detector

- Gain uniformity

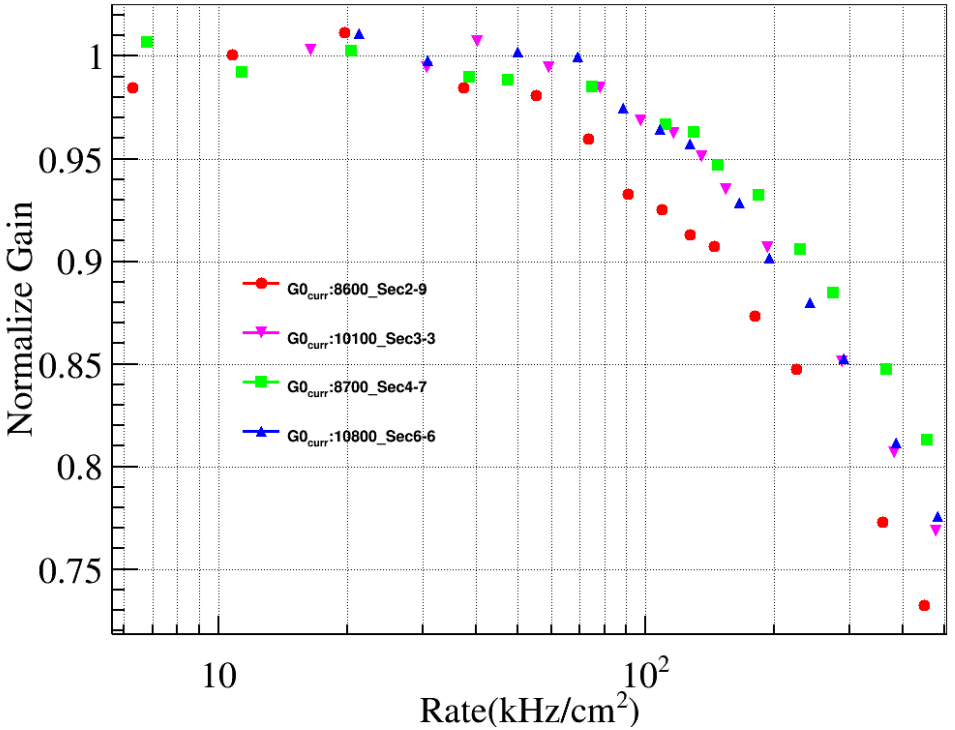




RMS/Mean: ~ 14.0%@~5175 Gain

- Collimator dia: 5.5mm, 8keV X-ray

($G0_{curr}/G0_{eff}$~2.15)

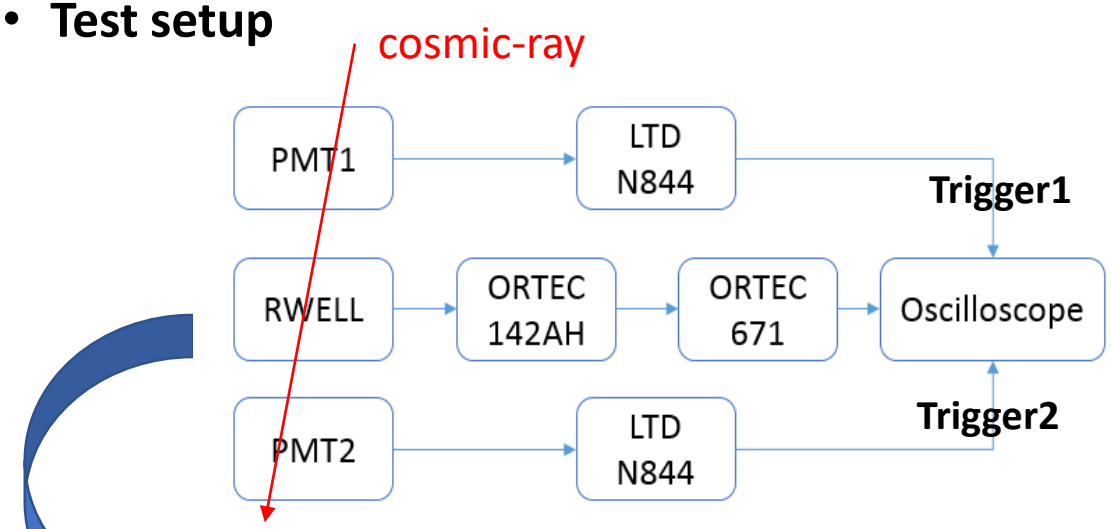


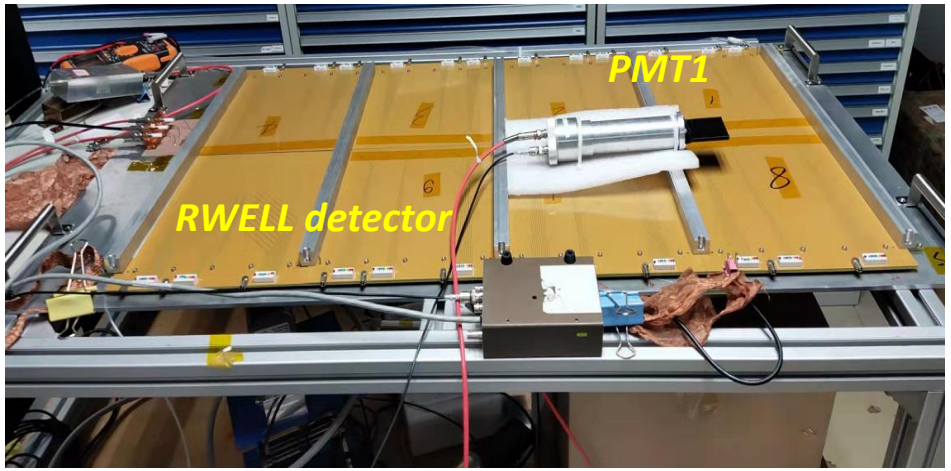
Rate capability: >100 kHz/cm2

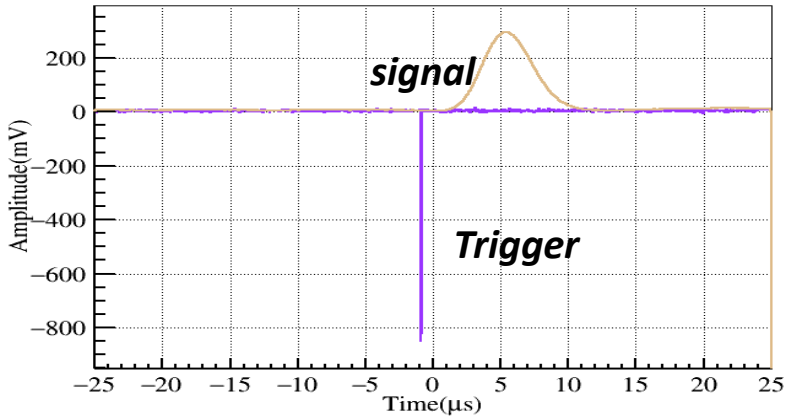
Detection efficiency for MIPs

Gas: Ar+5%iC_4H_{10}

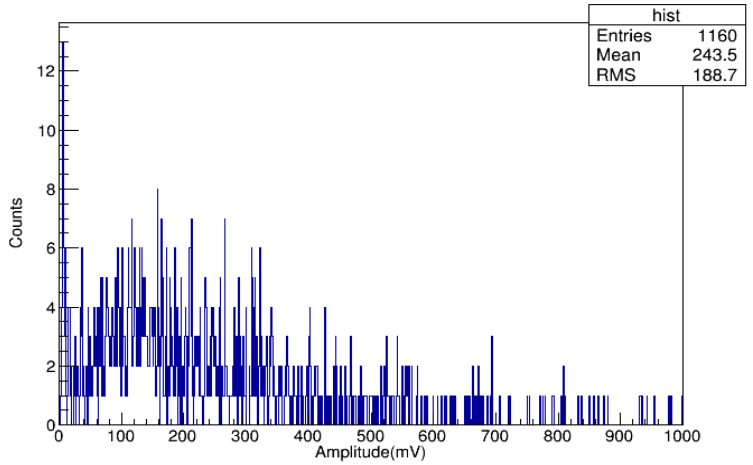
- **Test setup**





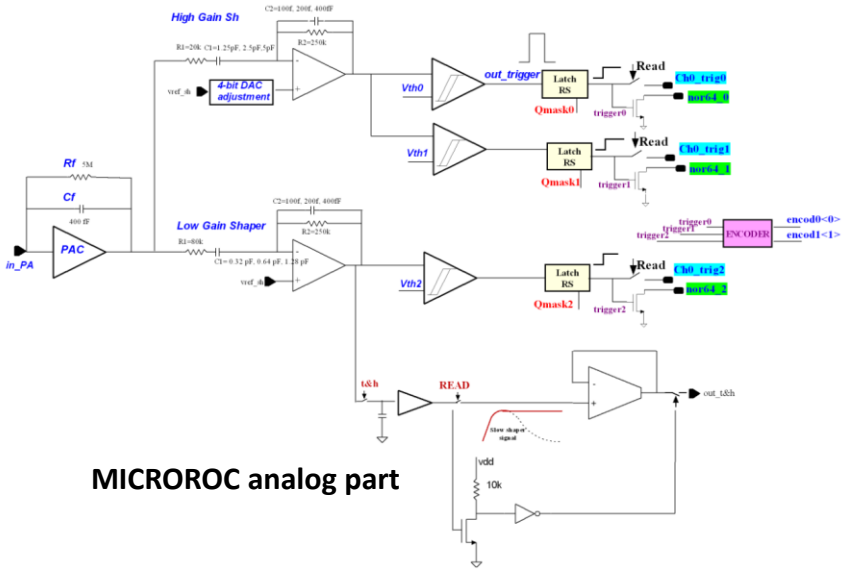


- **Detection efficiency:** ~95.9%



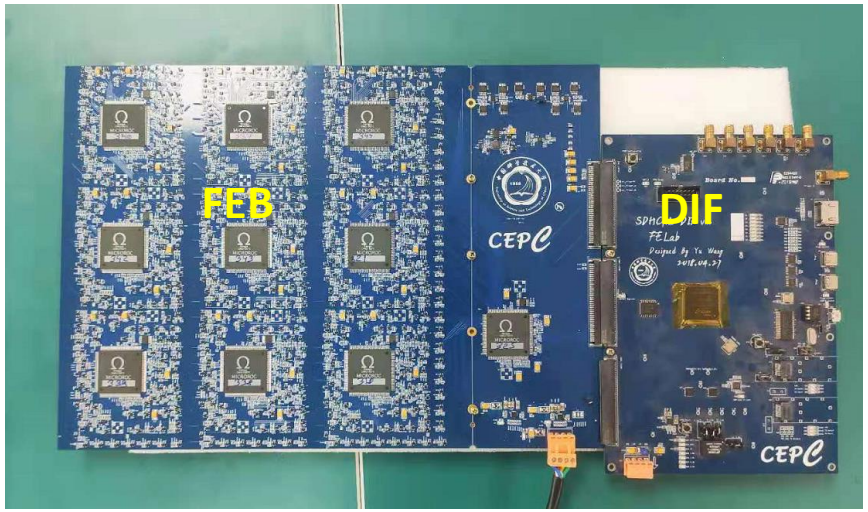
MICROROC based electronic system

- **MICROROC Parameters**
  - 64 Channels
  - 3 threshold per channel
  - Dynamic range:1~500 fC



MICROROC analog part

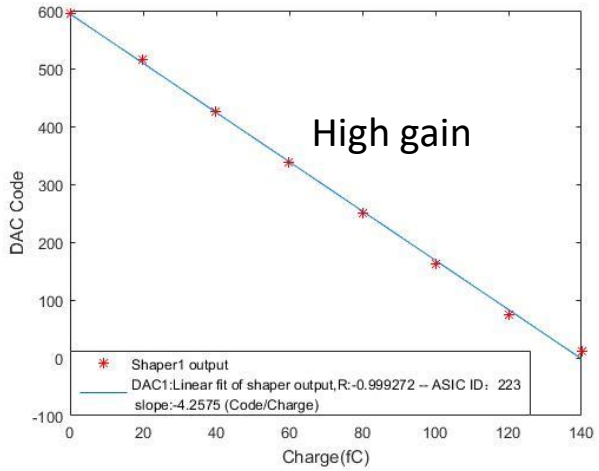
- **Readout board: integrated with MICROROC**
  - 625 channels
  - Readout pads: 1cm×1 cm

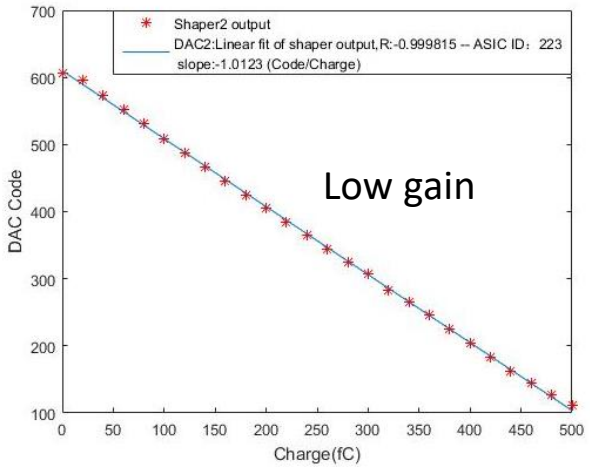


Preliminary result

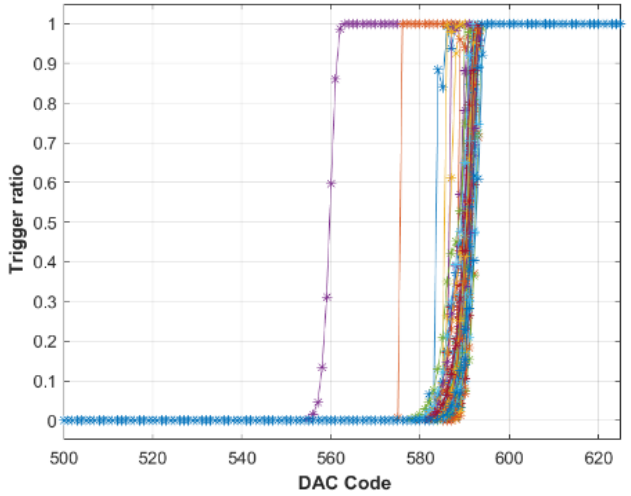
MICROROC based electronic system

- **Calibration**

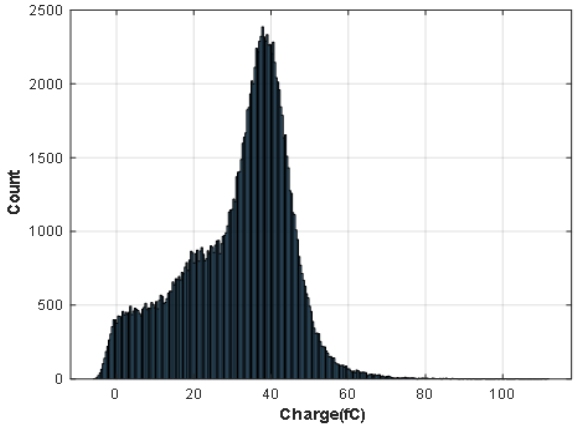




- **S curve**



- **Spectrum measured with external ADC**



- **Cosmic ray test is ongoing**

Summary

- **Two versions of 100 *cm*×50 *cm* RWELL detector was produced. Gain uniformity of ~ 14%@~5200 gain, and rate capability >100 kHz/cm^2, are achieved. Detection efficiency for MIPs is ~95.9%.**
- **Readout PCB with MICROROC was developed. Test with RWELL detector has started.**
- **Cosmic ray test is ongoing.**

Outlook

- **Advanced test of the MICROROC based FEE with RWELL**
- **Further optimization of RWELL detector**

Special thanks to:

Lanzhou Institute of Chemical Physics and China Fastprint

兴森科技 FASTPRINT

For their great help on the detector production