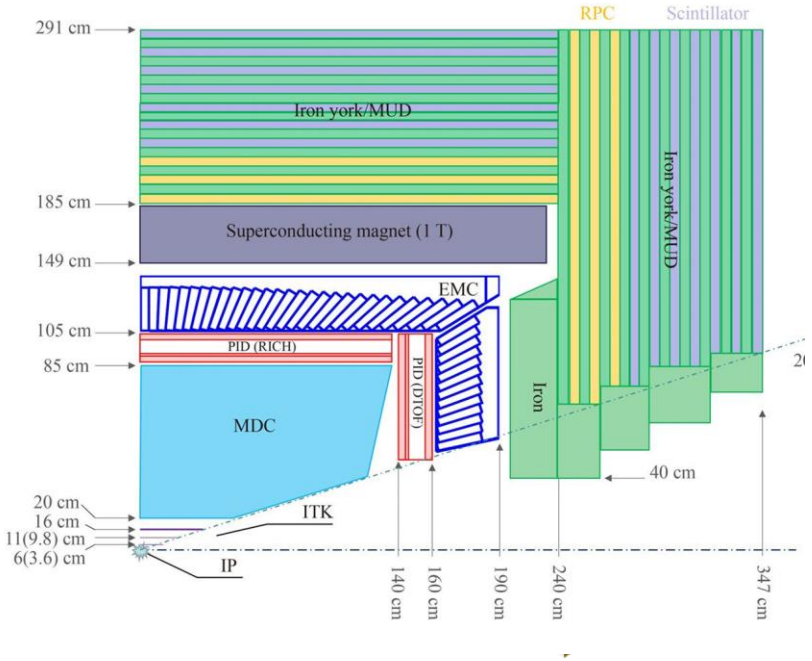
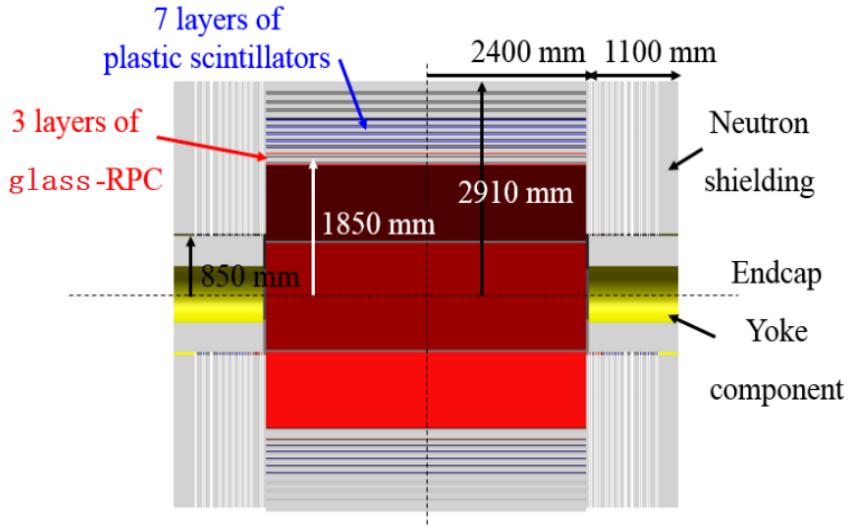
STCF MUON R&D PROGRESS

KUN HU
On Behalf of MUON GROUP
NOV 21st, 2024

Detector Overview-MUON

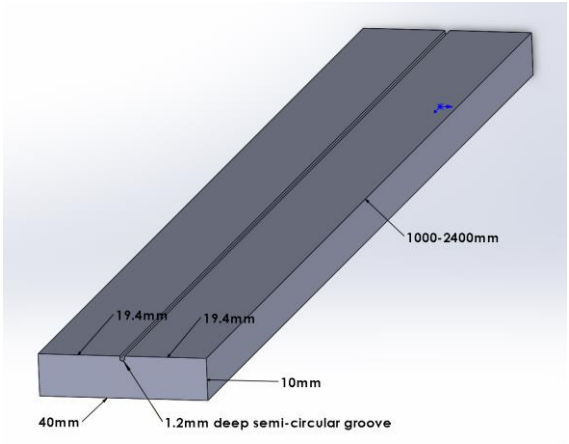


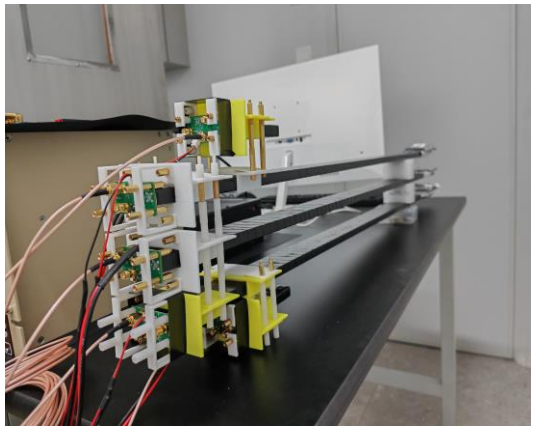


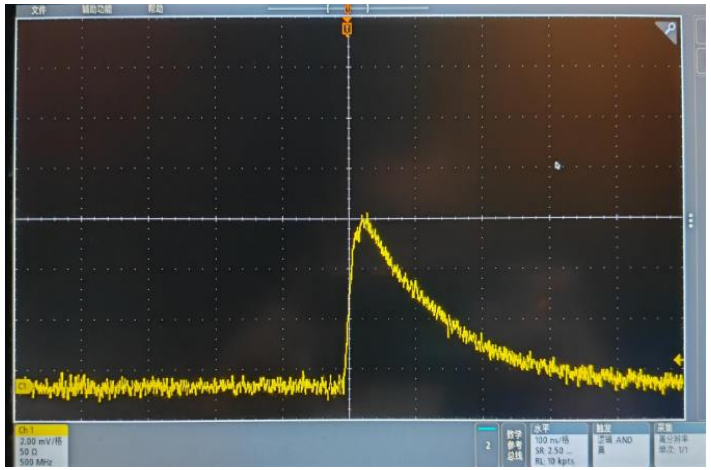
- Baseline design: *JINST* 16 (2021) 09, P09022
  - RPC + Plastic Scintillator(PS)
  - Inner 3 layers: RPC
  - Outer 7 layers: PS
- Requirements:
  - Muon detection efficiency > 95%, p > 0.7 GeV/c , with μ/π suppression power >30

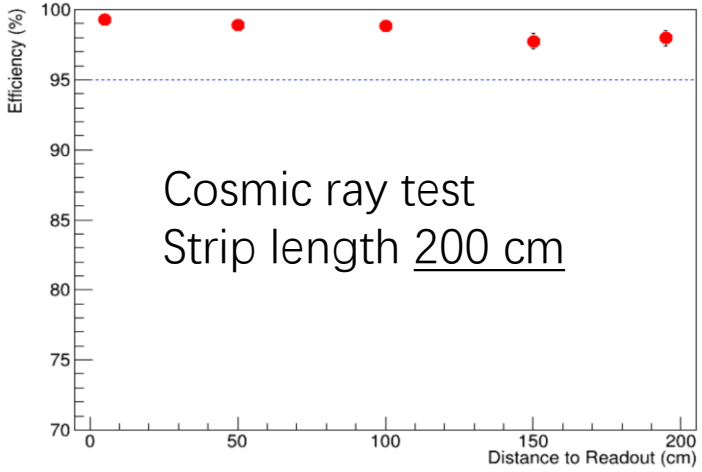
PS：strip

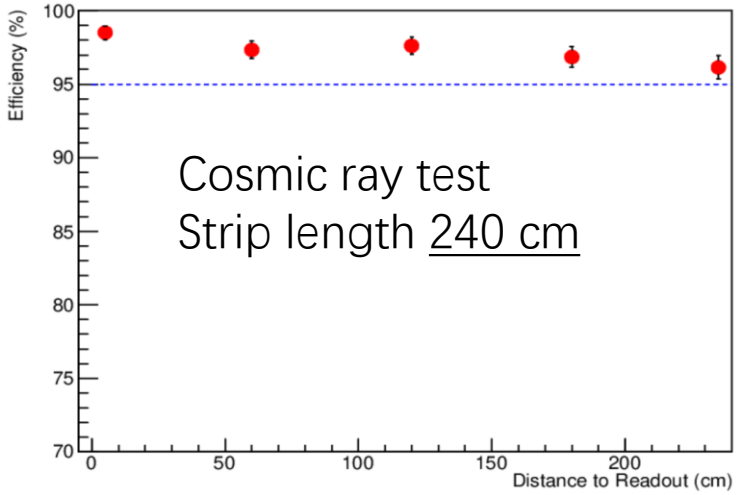
- 4cm * 1cm * (100~240cm)
- Printed TiO2 coating
- WLS(wave length shifting) Fiber
  - Kuraray, Y-11, $\phi = 1mm$
- SiPM: sensl,J-30035, 3*3mm
- Single-ended readout





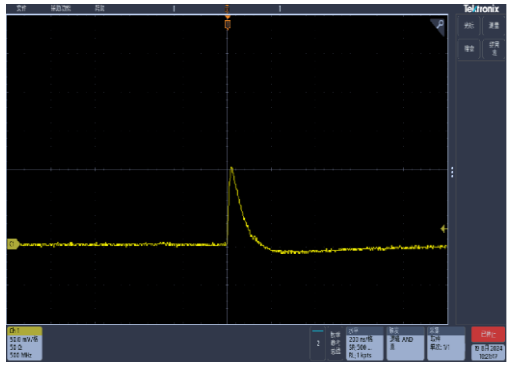


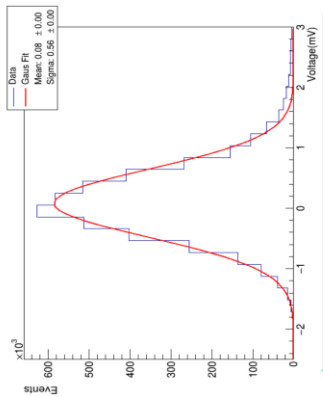


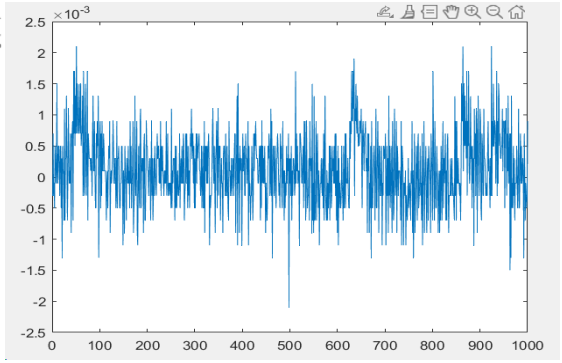


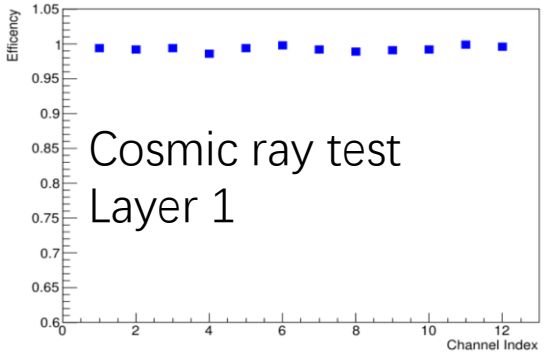
PS：small scale scintillator system

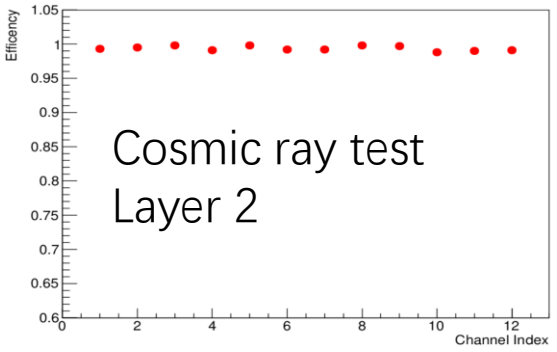
- scintillator strips unit size： 50*4*1cm
- System scale： 53*51cm
- 2 layers
- Single-ended readout











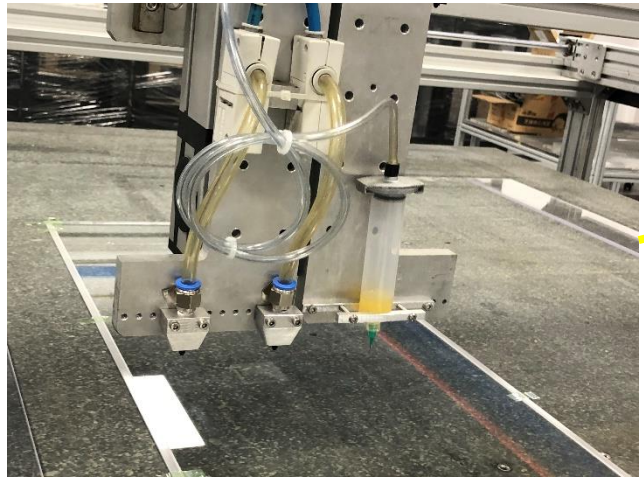
The platform of gas gap production

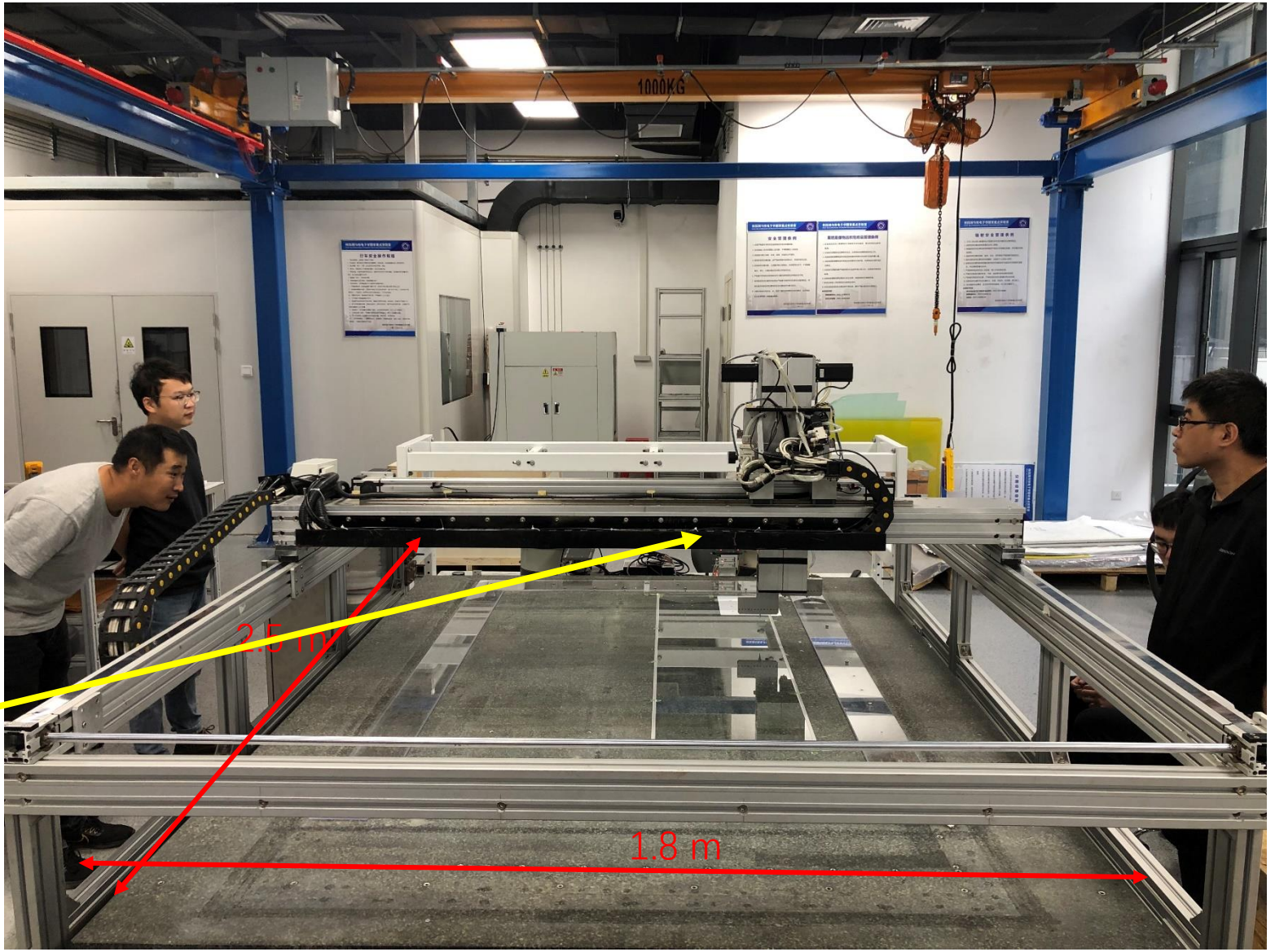
- A marble table as base:

  2.5m×1.8m

- A head stock supported by a gantry moving in 2-D.

- Automatic gluing and spacer placement.

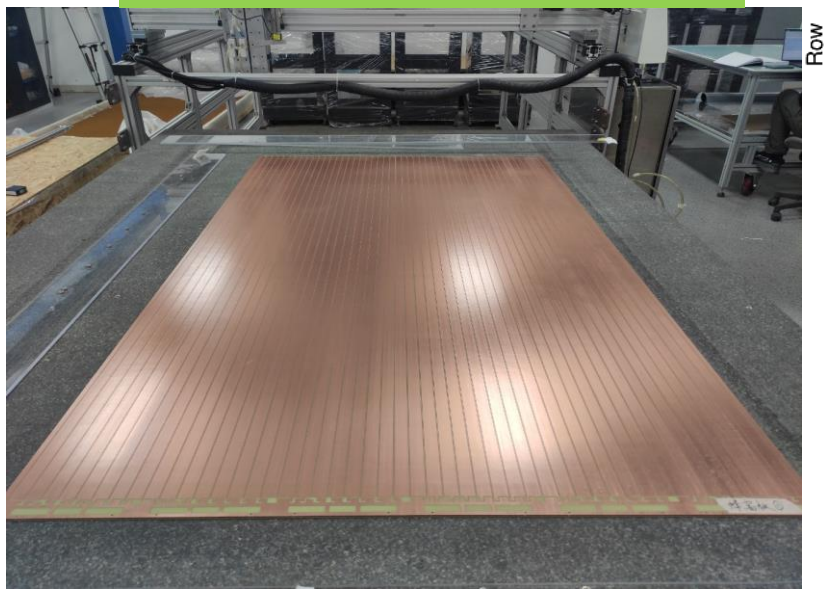




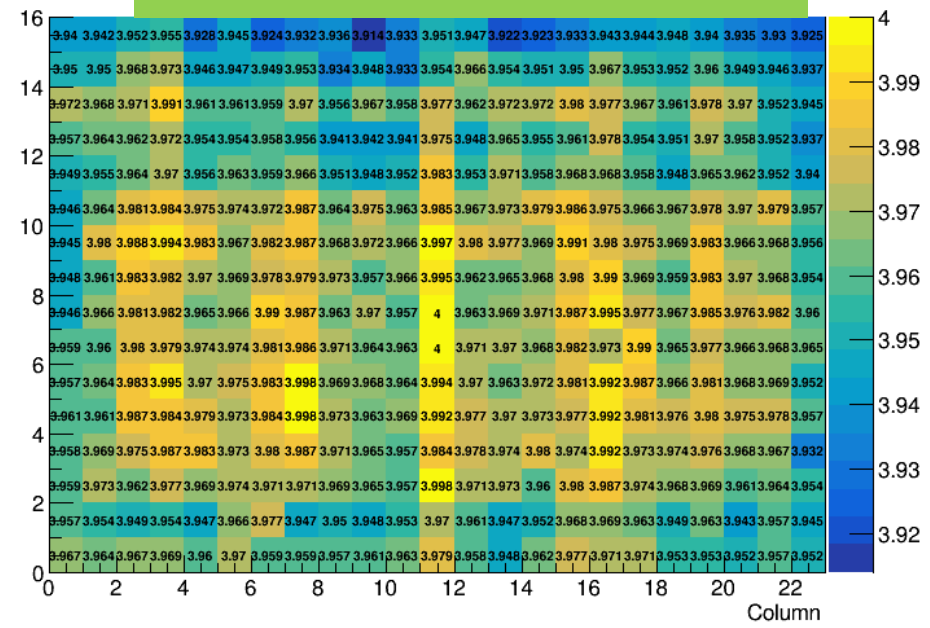
Large-scale RPC production

- Honeycomb readout board： ~ 1.1×1.7m
- Board Flatness： 100μm

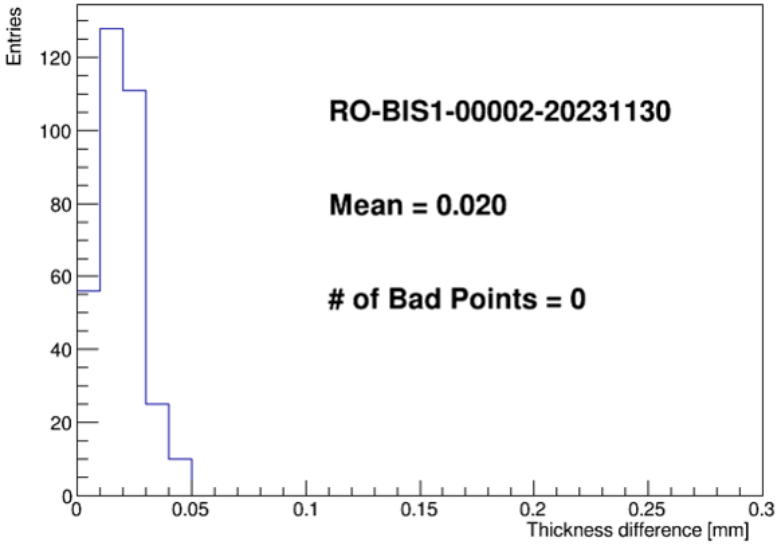
HoneyComb Readout Board



Board Thickness Measurement

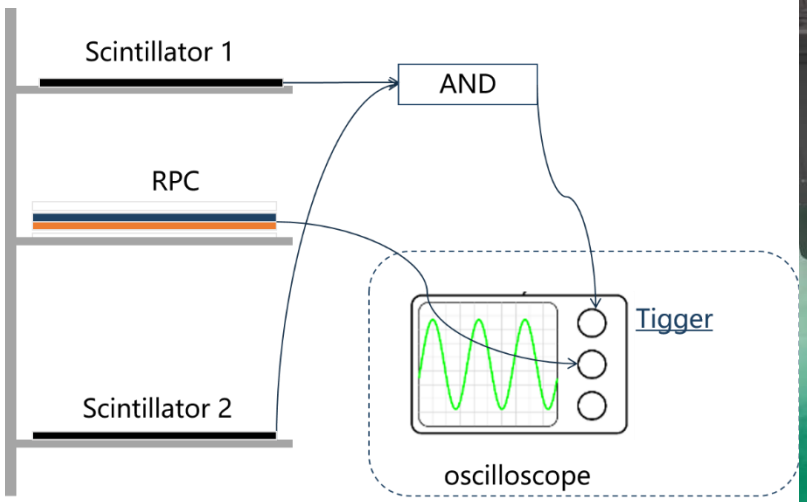


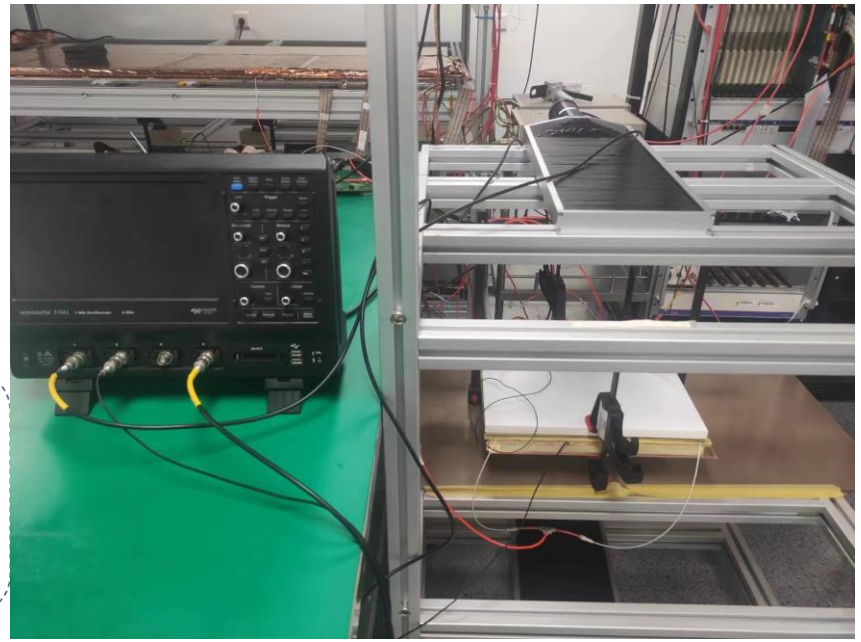
Thickness Distribution

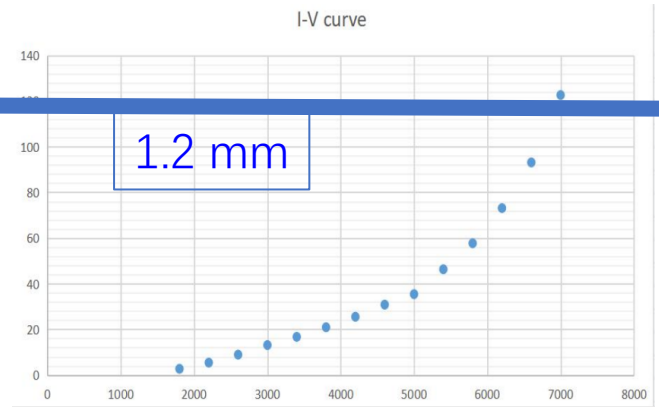


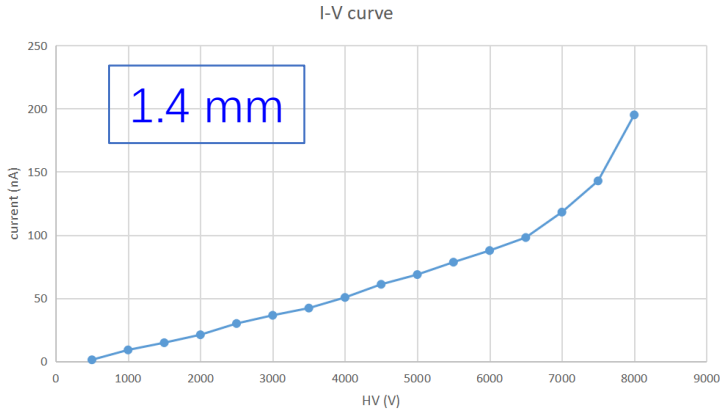
RPC: glass RPC test

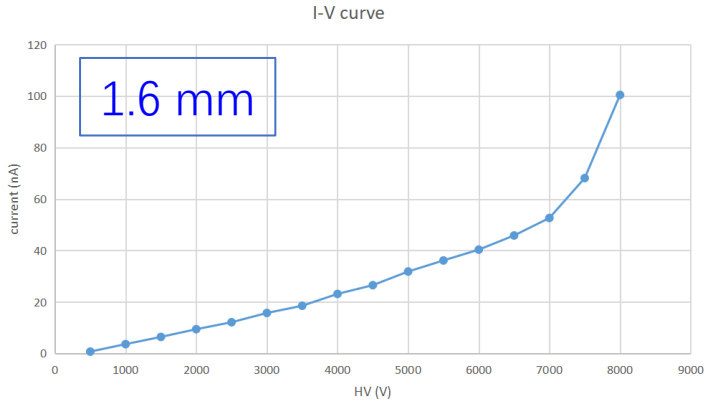
- gas：R134 94.7%、C4H10 5%、SF6 0.3%
- I-V curve measured under High voltage
- Cosmic ray signals captured through oscilloscope





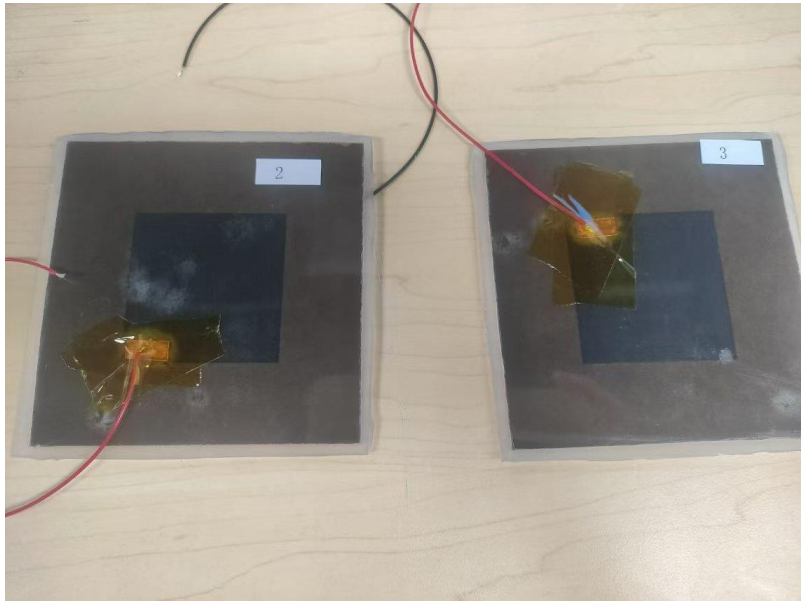






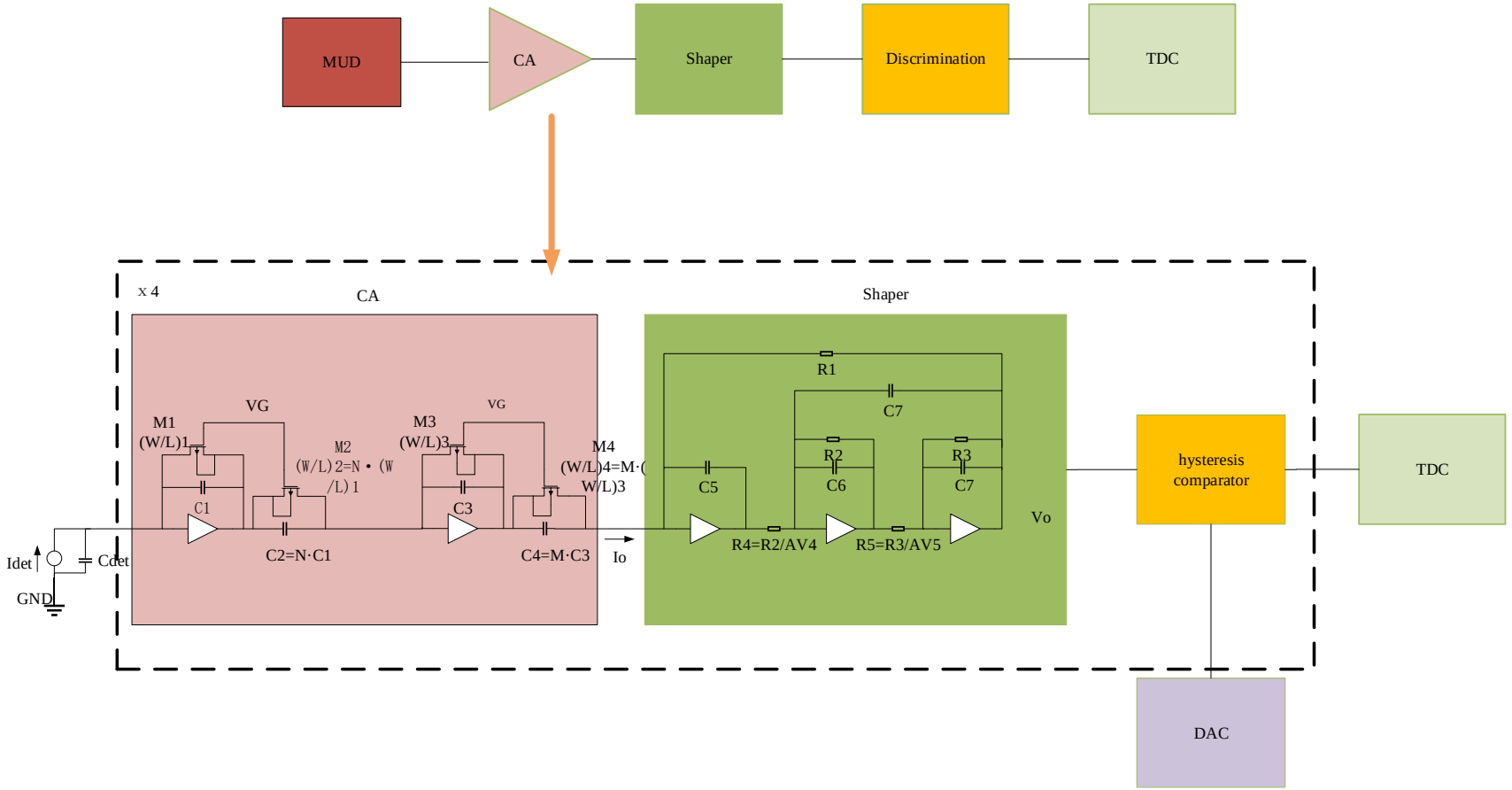
RPC: resistivity offset

- The use of low resistivity glass is to achieving high event rate
- ρ: 10^9- 10^{11} Ω·cm body resistivity
- Glasses were packaged and HV applied to the electrodes to see the resistivity offset



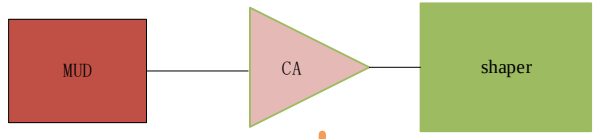
Electronics： ASIC Design

- Front end Amplifier-Shaper-Discriminator ASIC
- TDC ASIC

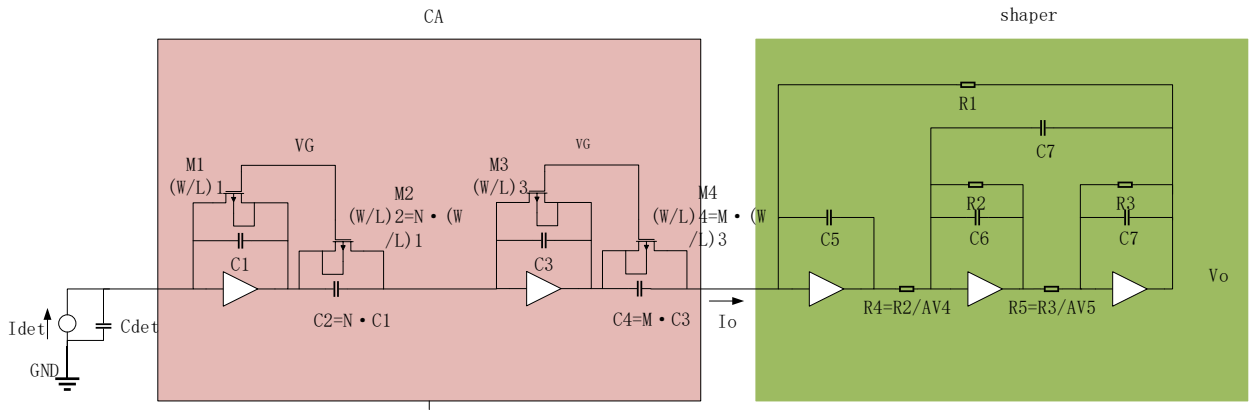


Electronics： Front-end ASIC

- Two-stages charge amplifier
- Three-stages shaper
- Multi-gain: 0.4mV/fC, 4mV/fC, 24mV/fC

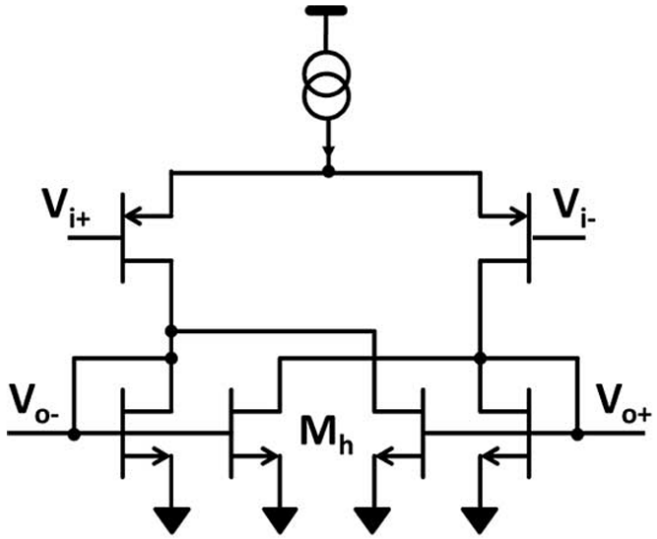


- $Io = (N \times M) \times I_{det}$
- $Vo = \frac{R1}{s^3\frac{\tau1\tau2\tau3}{A_{v4}A_{v5}} + s^2\frac{\tau1[\tau2(1-\alpha_x)+\tau3]}{A_{v4}A_{v5}} + s\frac{\tau1}{A_{v4}A_{v5}} + 1} Io$
- $\tau1 = R1C5, \tau2 = R2C6, \tau3 = R3C7,$
- $\alpha_x = \frac{A_{v5}R2C7}{\tau2}$

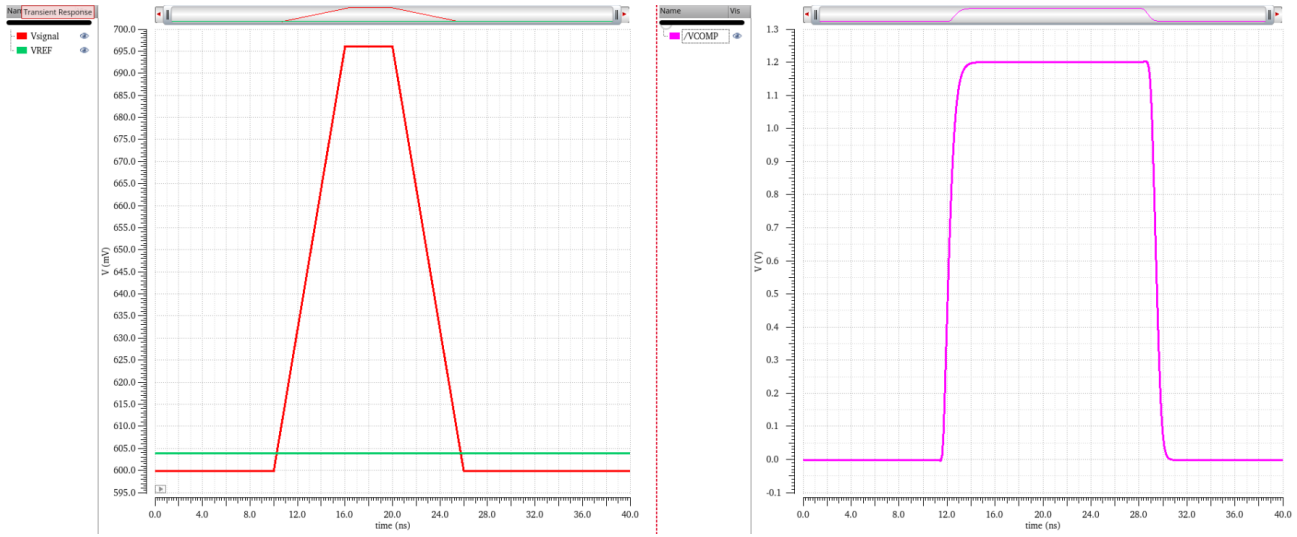


Electronics：Front-end ASIC

- Discriminator: delayed comparator

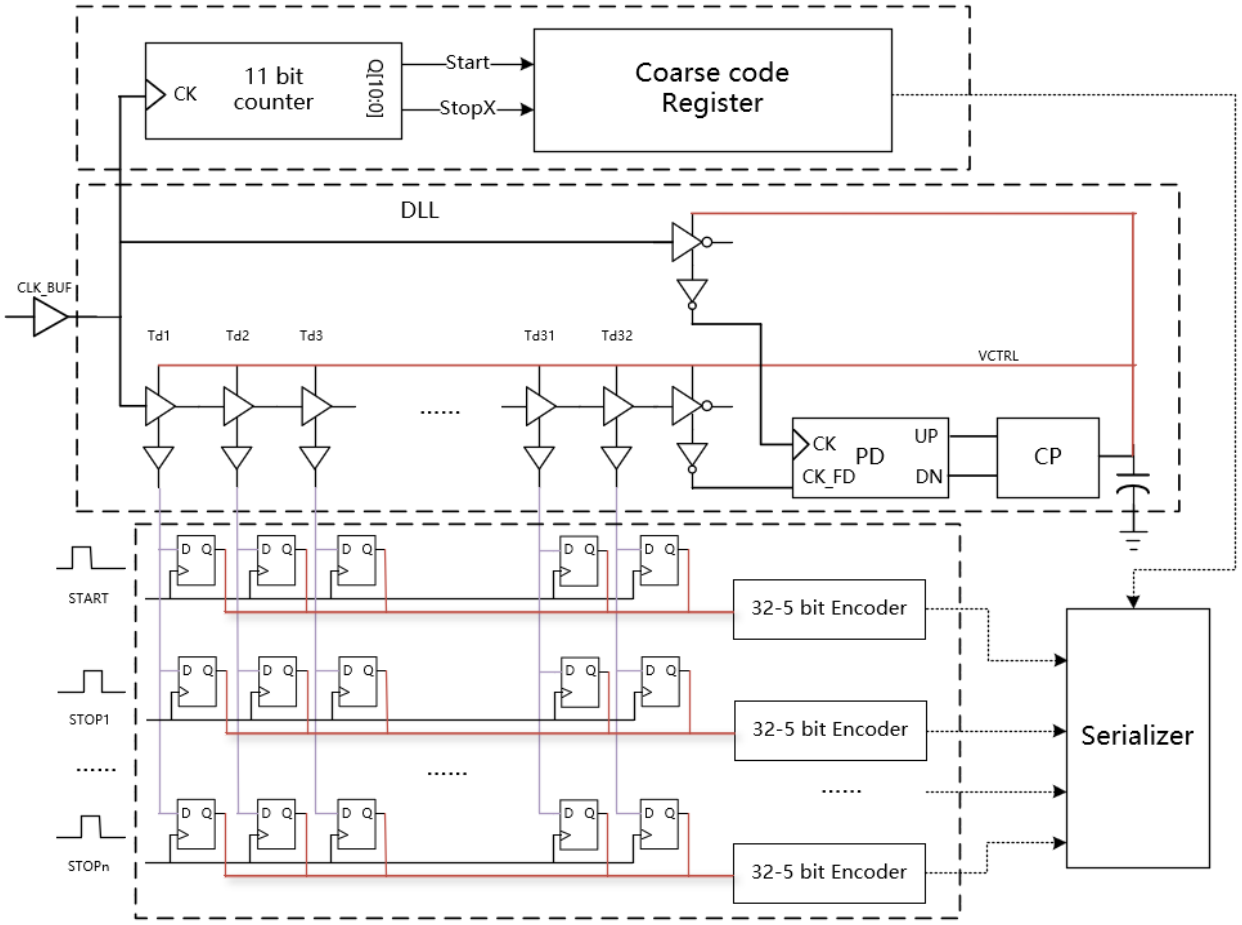


Input stage



Simulation results

Electronics：TDC prototype design

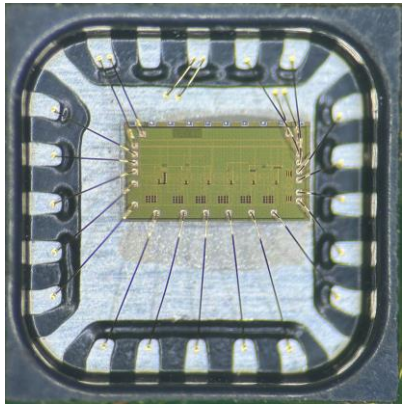


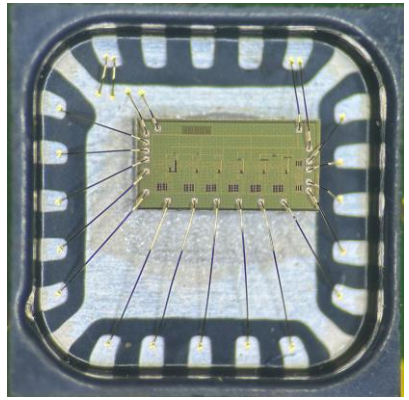
TDC ASIC diagram

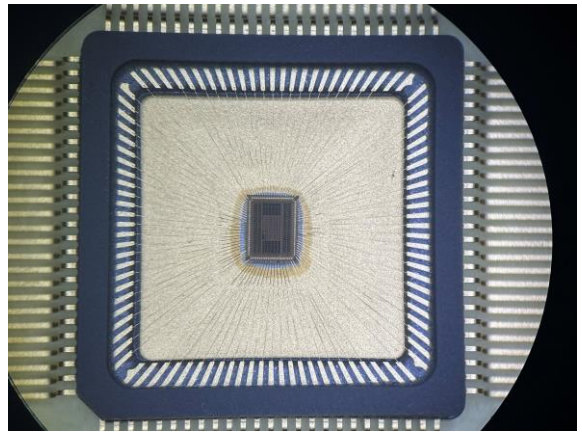
Channel	1 start; 4stop
LSB	156.25ps
Time resolution	<60ps
Power consumption	<10mW/Channel
Event rate	>200kHz
Full Range	10us
Nonlinearity	<1LSB

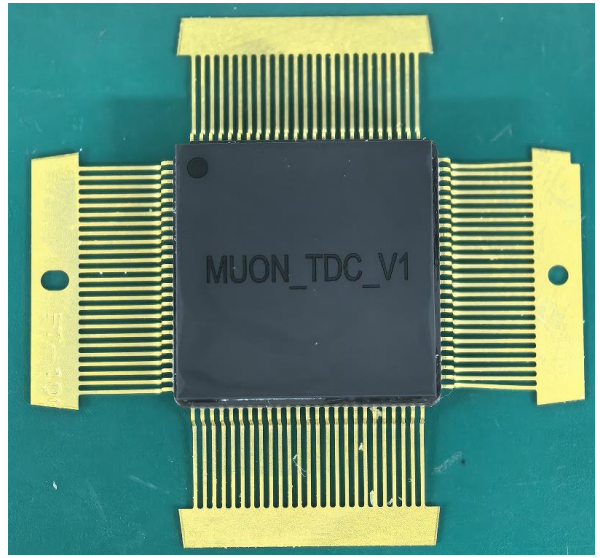
Electronics: ASIC tests

- SMIC 130nm mixed-signal process
- Sent out for fabrication July 23rd
- Die delivered late October
- Just get the packaged ASICs
- ASIC test ongoing





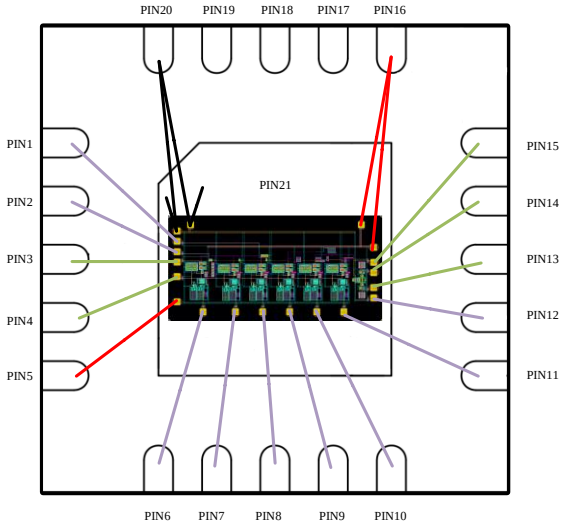




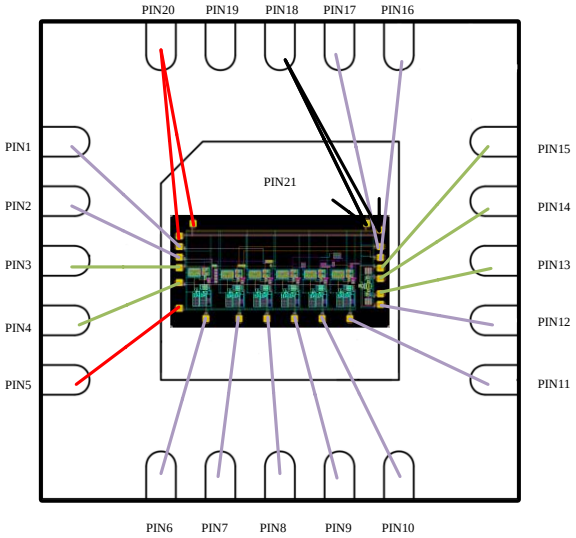
TDC

Front end ASICs

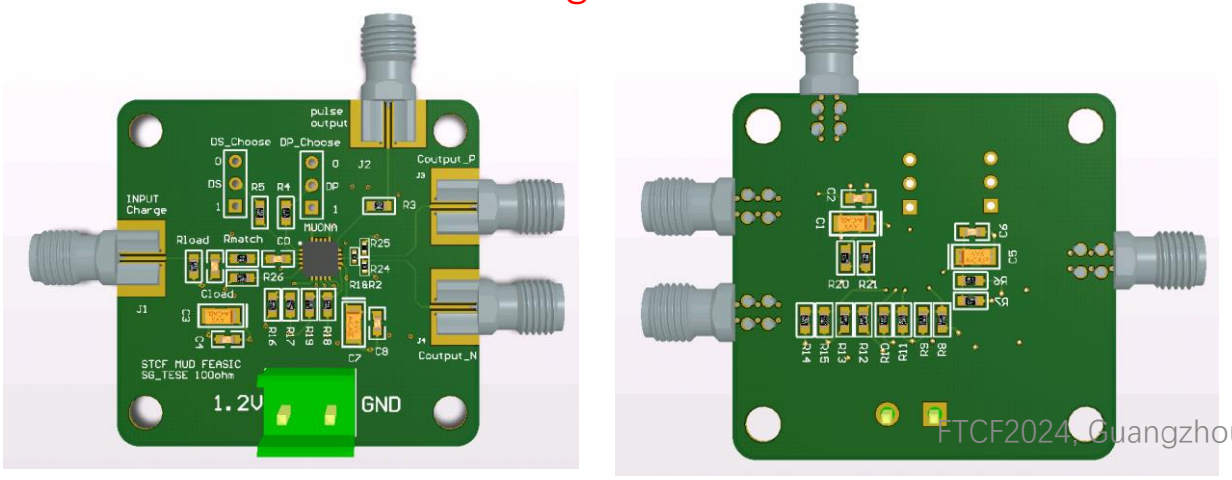
Electronics: Front ASD ASIC test



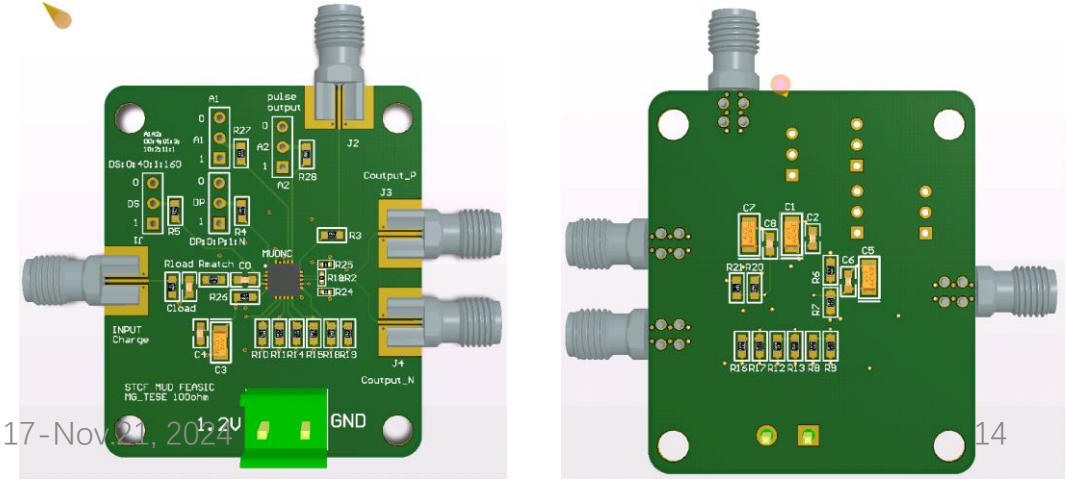
Bonding and QFN20 package



Fixed gain ASIC Test Board

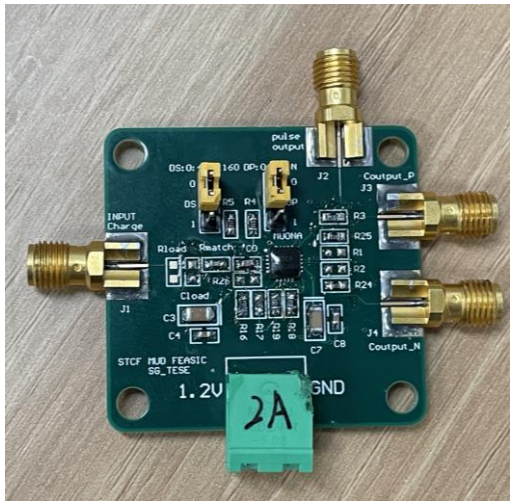


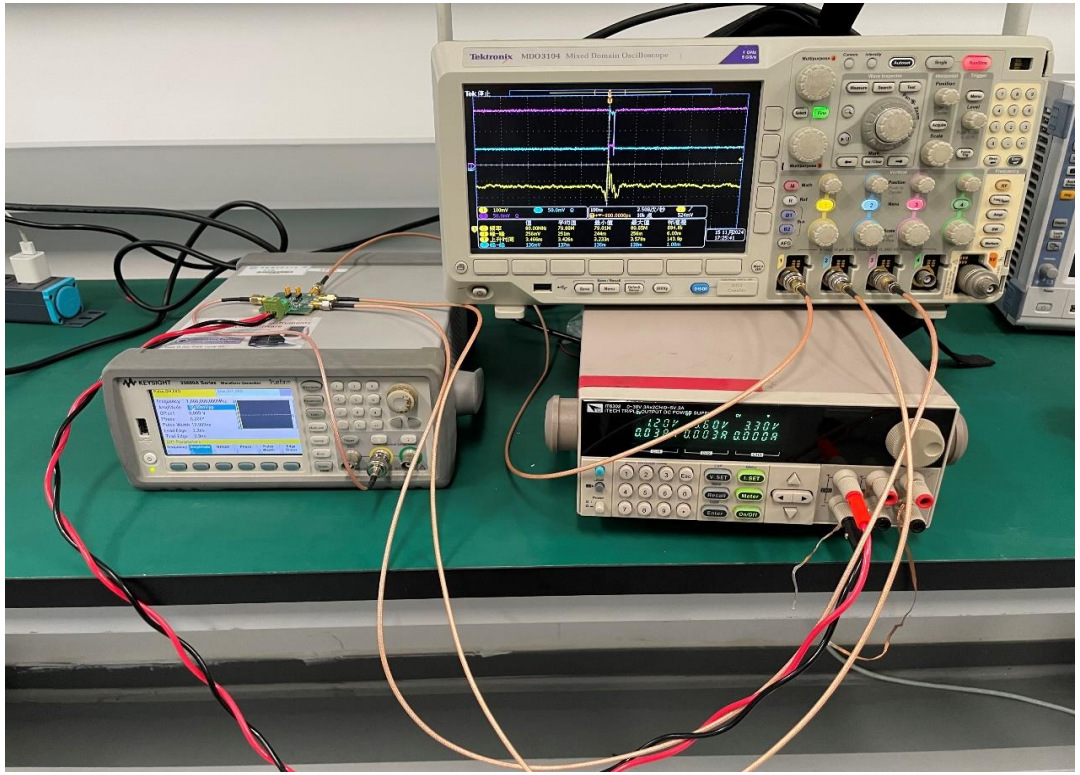
Multi gain ASIC Test Board



Electronics: Front end ASIC test

- DUT: ASIC with fixed gain at 4mV/fC
- Waveform Generator: Keysight 33600A
- Power: Keithley 2231A
- Oscilloscope: Tek MDO3032

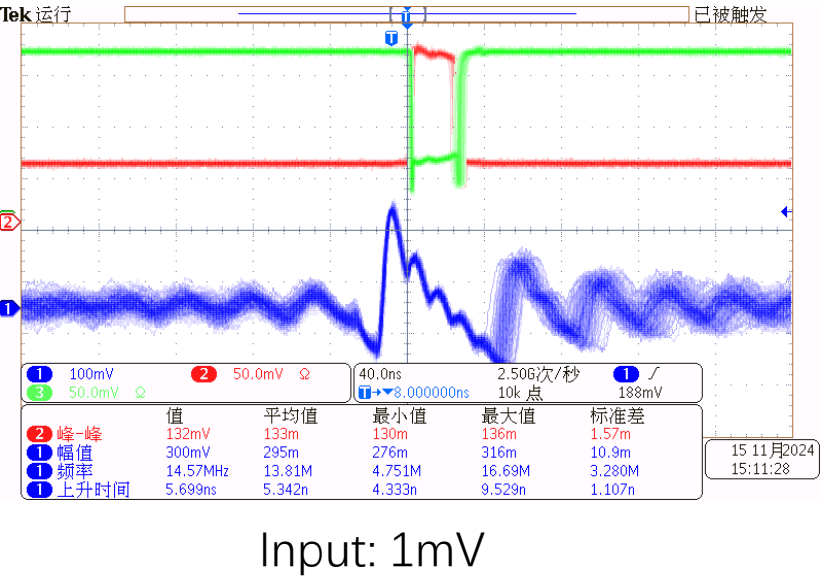




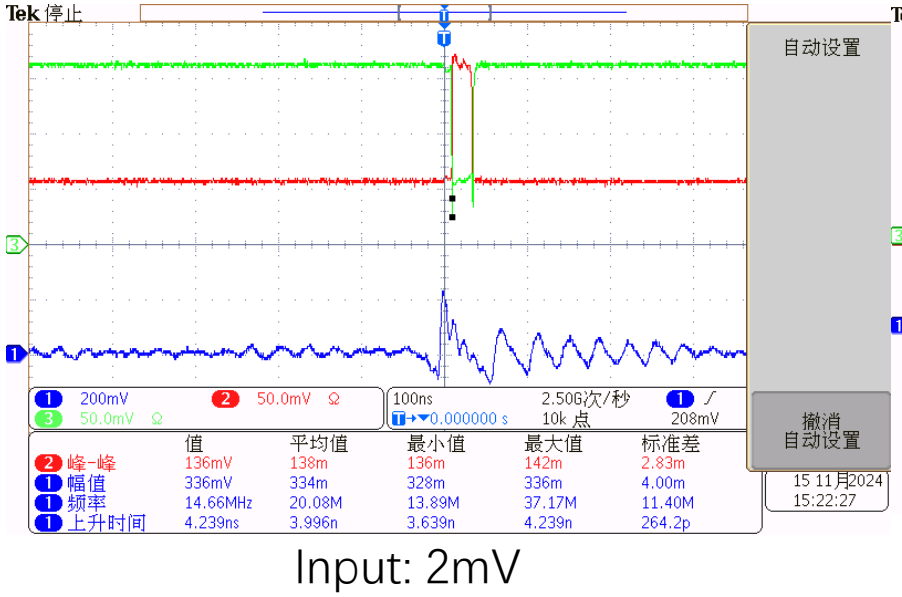
Electronics: Preliminary result

Input:
tr = tf = 2.9ns
Pulse width: 10ns
Pulse Freq: 1MHz

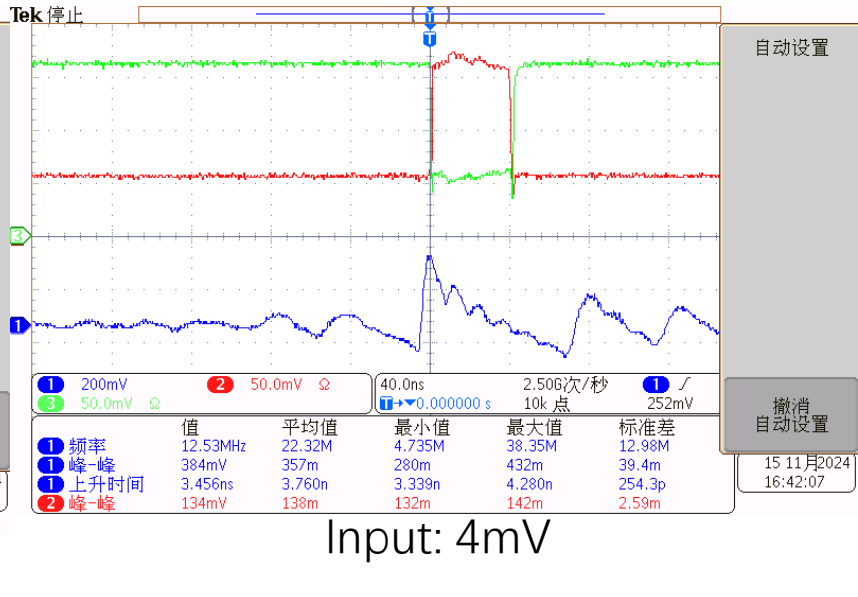
Outputs:
CH1: Amplification output
CH2/3: Differential comparator outputs



Input: 1mV



Input: 2mV

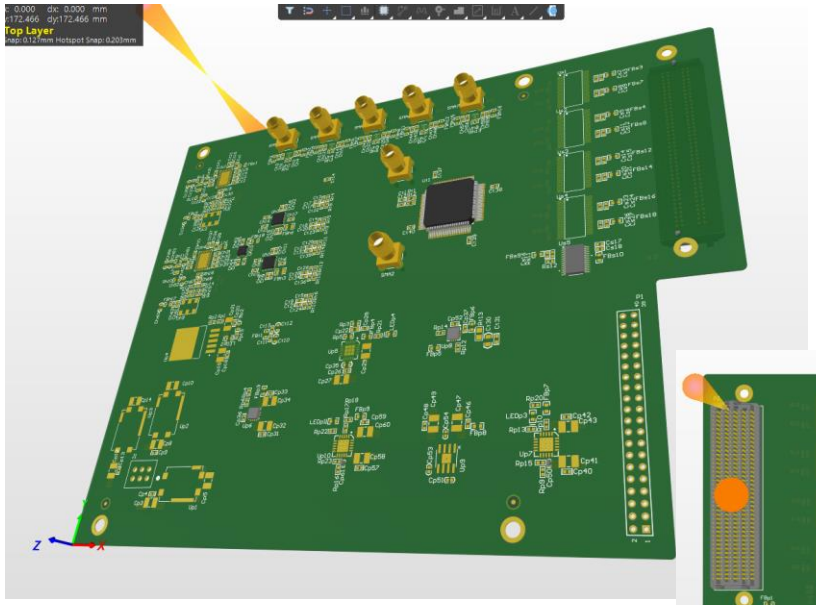


Input: 4mV

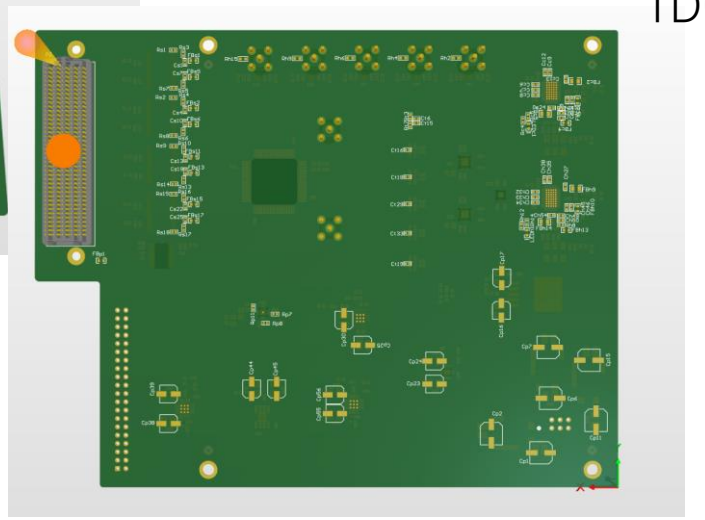
Test is ongoing and the typical application circuit will be given for the integration with SiPM and RPC detectors

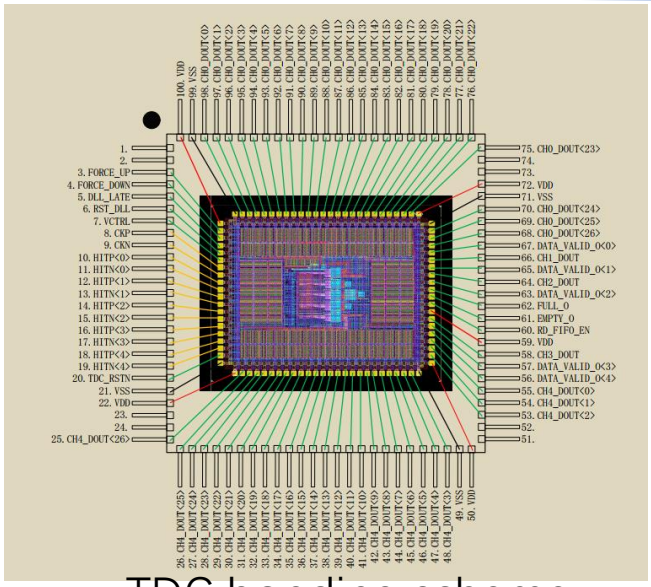
Electronics: TDC test board

- TDC： CQFP100 packaging
- TDC test board is under soldering

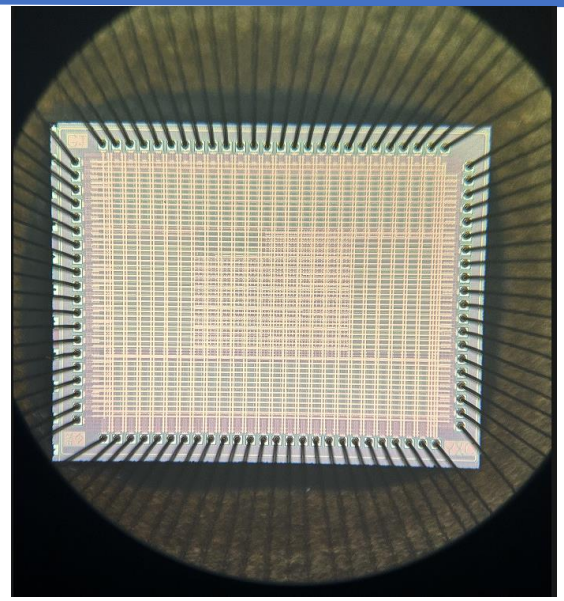


TDC test board

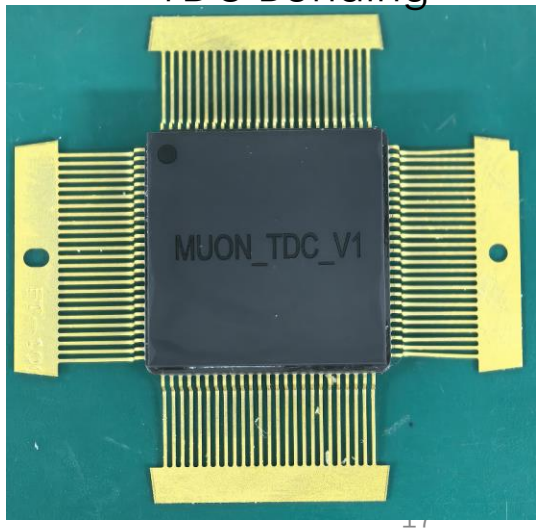




TDC bonding scheme

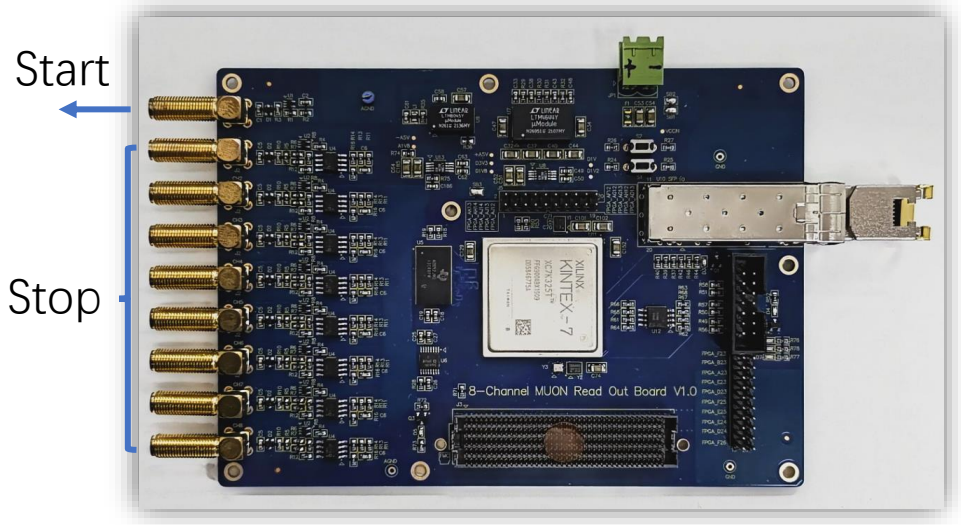


TDC Bonding

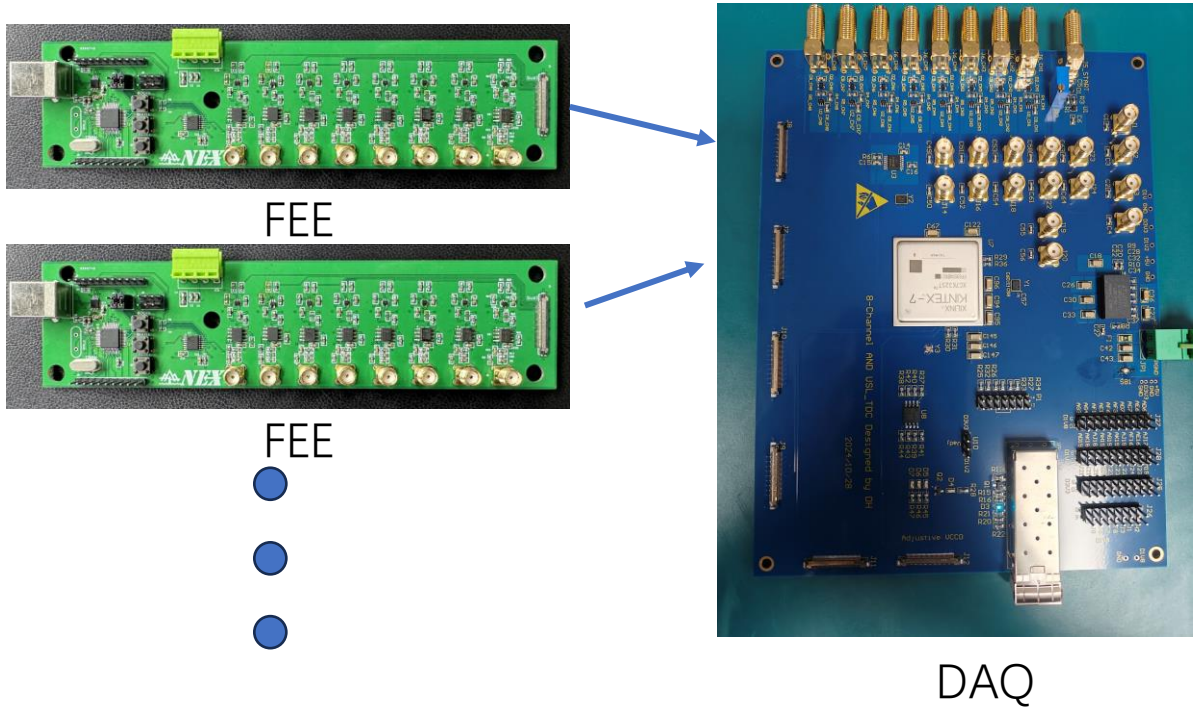


TDC CQFP100

Board level Electronics upgrade

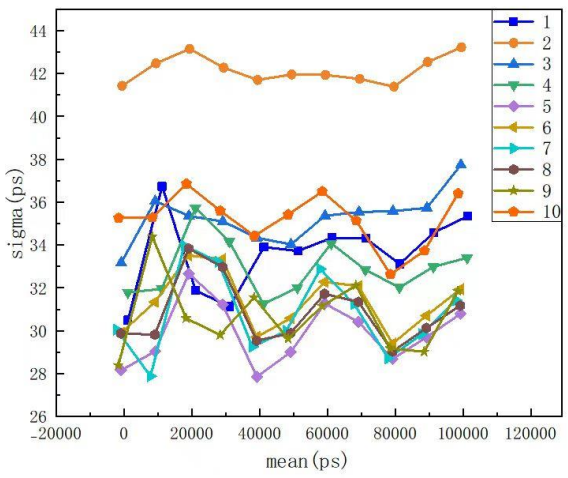


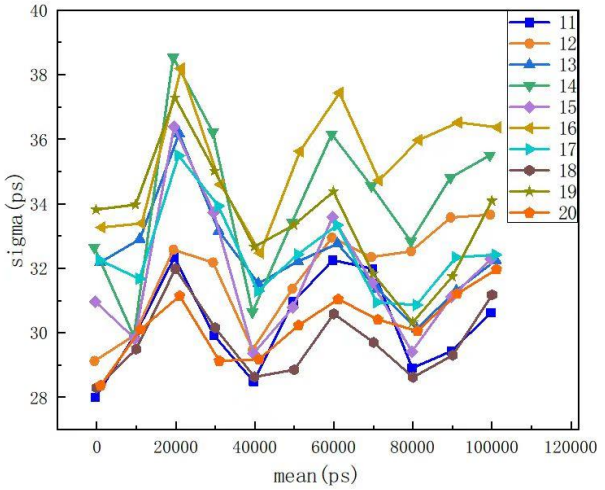
8-ch time measurement system

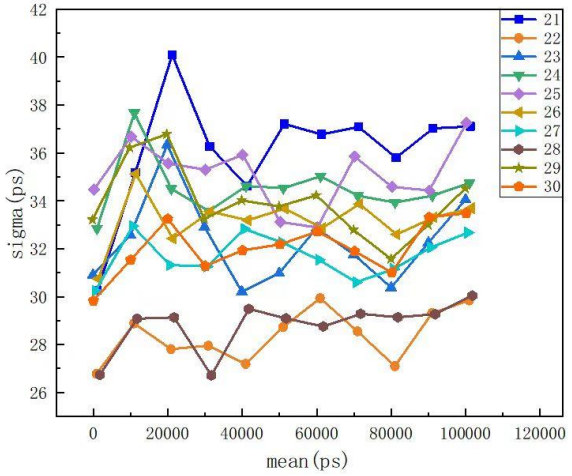


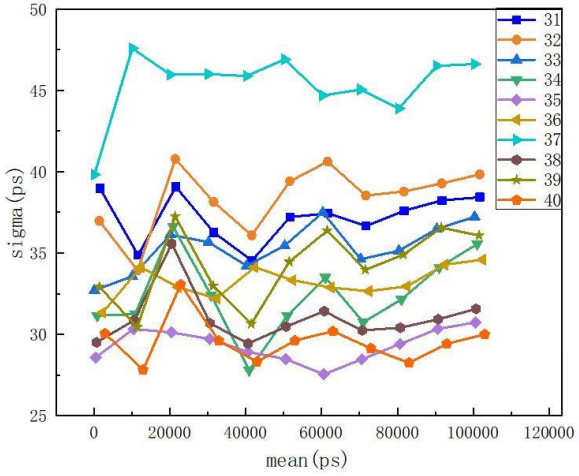
FEE + DAQ:
FEE: 8-ch amplifier & comparator, ASD chip;
DAQ: multi-ch TDC; TDC chip.

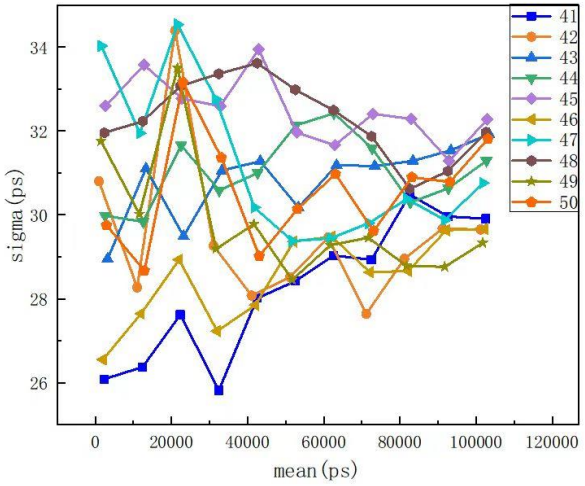
Board level Electronics upgrade











100-ch TDC test results: subtract any adjacent 2 channels of TDCs , all of time resolution is < 50 ps.

Summary

- Both plastic scintillator and RPC make a good progress;
- ASICs are just received, the following works are focused on testing and integration with detector;
- Improved board-level electronics will be sent out to detector production site for testing.