



mRPC Development At Tsinghua & USTC

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Min Shao, USTC

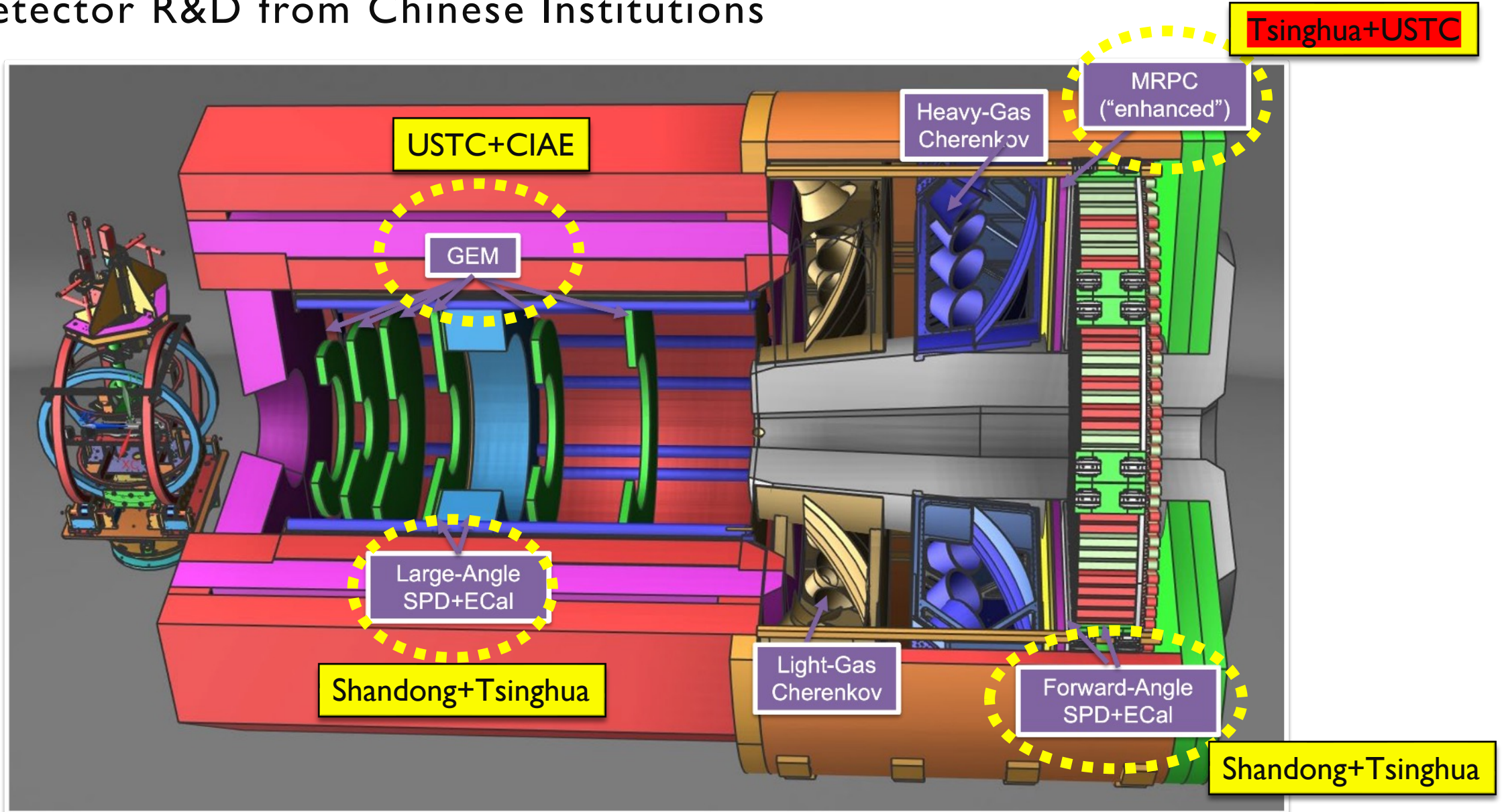
SoLID Collaboration Meeting, 06/22/2024



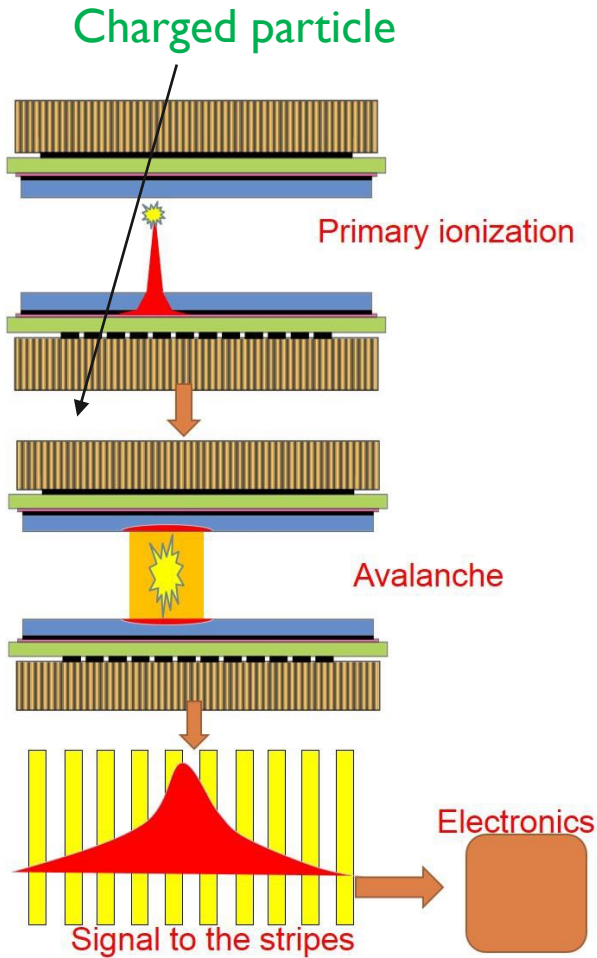
清华大学

Tsinghua University

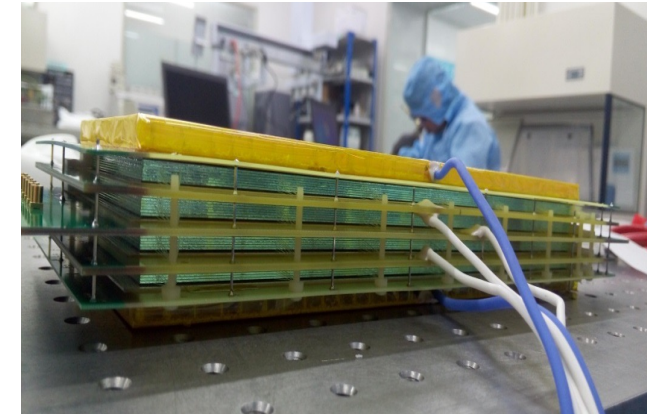
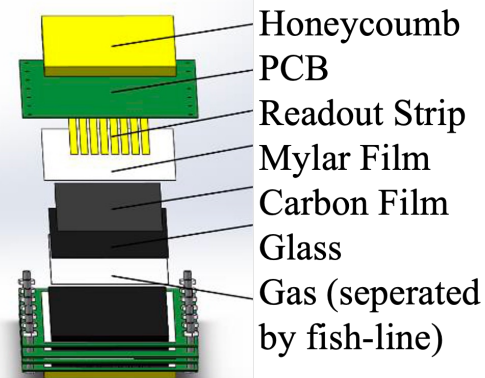
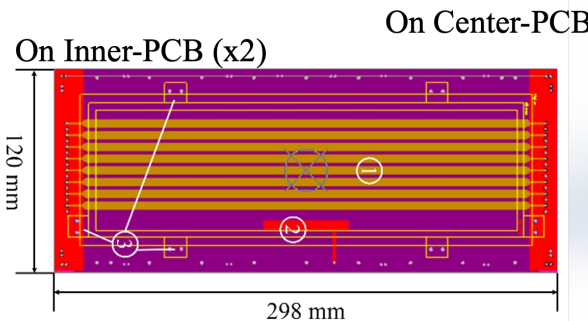
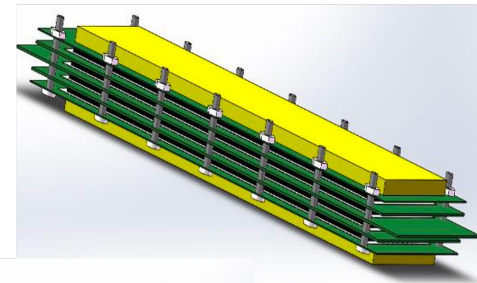
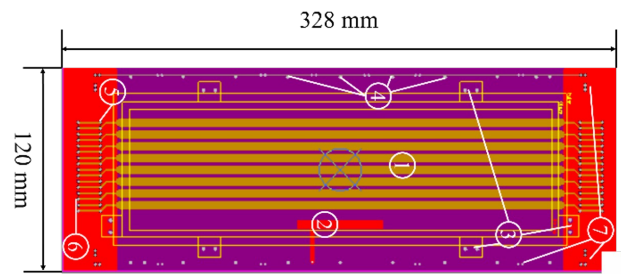
➤ Detector R&D from Chinese Institutions



➤ General Principle

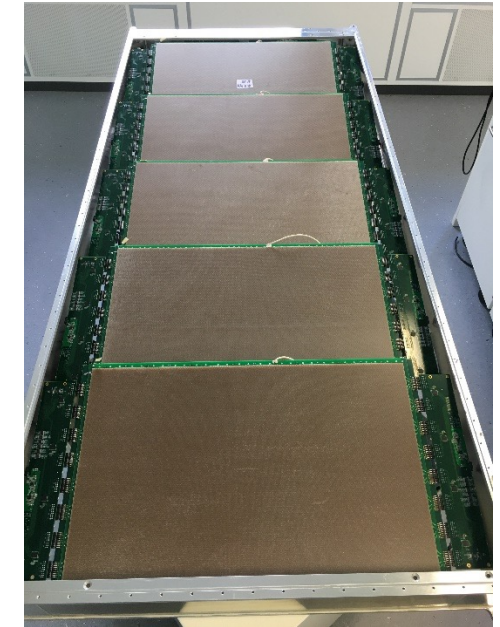
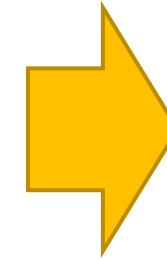
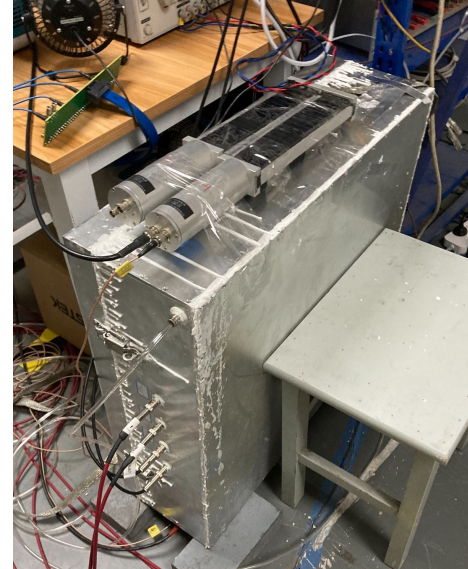
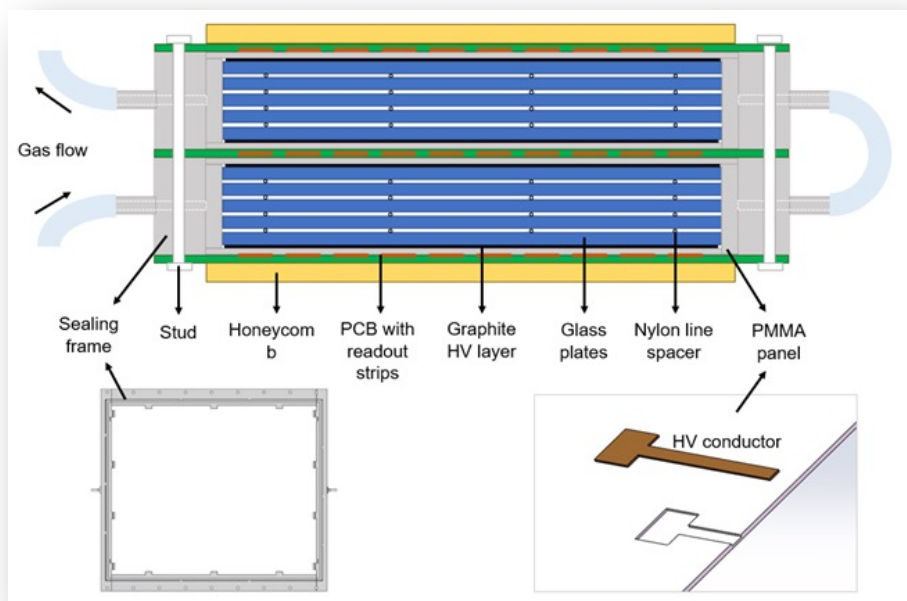


- ❑ Low-resistivity glass plates, Standard gas (95% F134a + 5% iso-butane), HV(~12kV)
- ❑ Good performances:
time resolution, efficiency, rate capacity ($>30\text{kHz}/\text{cm}^2$), radiation-hard, magnet safe
- ❑ Certain spatial resolution (by strip pitch, 0.5cm~1.0cm)
- ❑ Low cost, easy manufacturing, large sensitive area (up to 1.0m \times 0.5m)
- ❑ Used by ALICE, STAR, etc.



➤ Tsinghua's new Sealed MRPC (sMRPC)

- ❑ Gen3 MRPC with sealed gas → No more boxes!
- ❑ More compact, less radiation length
- ❑ Reduce greenhouse gas emission ($20\text{cc}/\text{cm}^2/\text{min}$)
- ❑ Regular glasses (max. rate limited)
- ❑ Can make into big sizes



- ❑ sMRPC for CEE & CBM experiments
 - ✓ $32 \times 27 \text{ cm}^2$
 - ✓ handle up to $25\text{KHz}/\text{cm}^2$
 - ✓ 8×2 layers at $140\mu\text{m} \rightarrow 60\text{ps!}$
 - ✓ Readout by NINO+TDC
 - ✓ Mass production at Tsinghua's Miyun workshop

Y. Wang et al 2019 JINST 14 C06015

D. Hu et al 2019 JINST 14 C09014

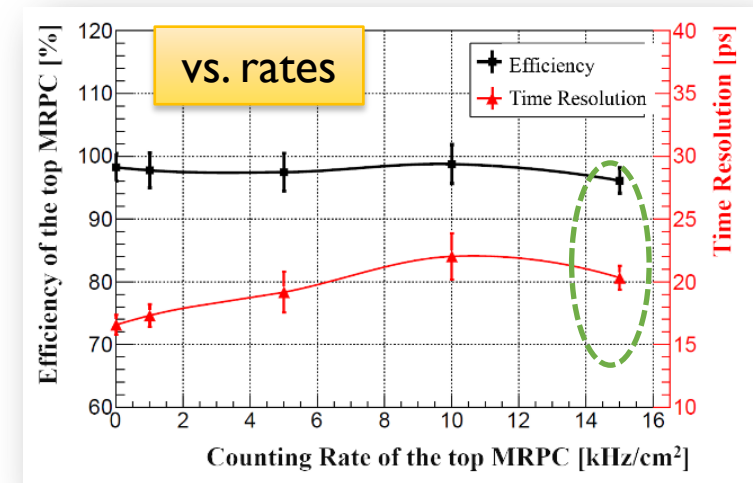
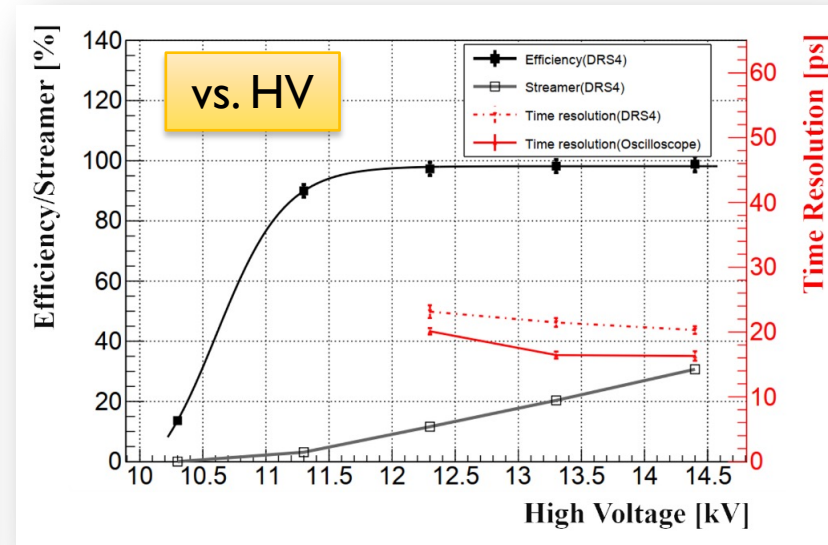
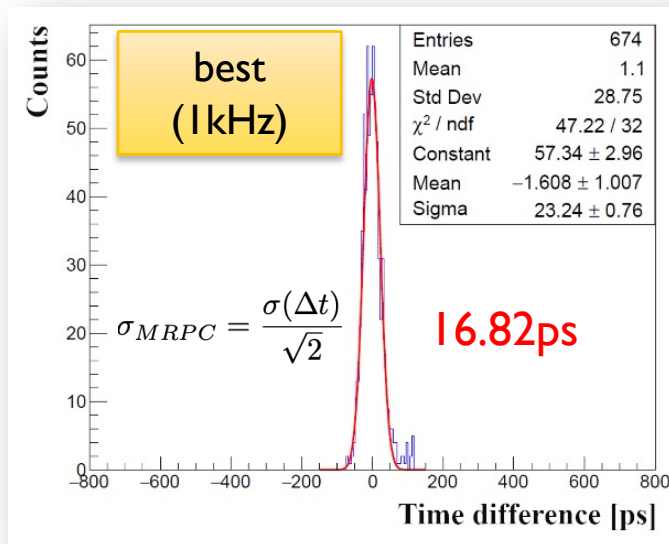
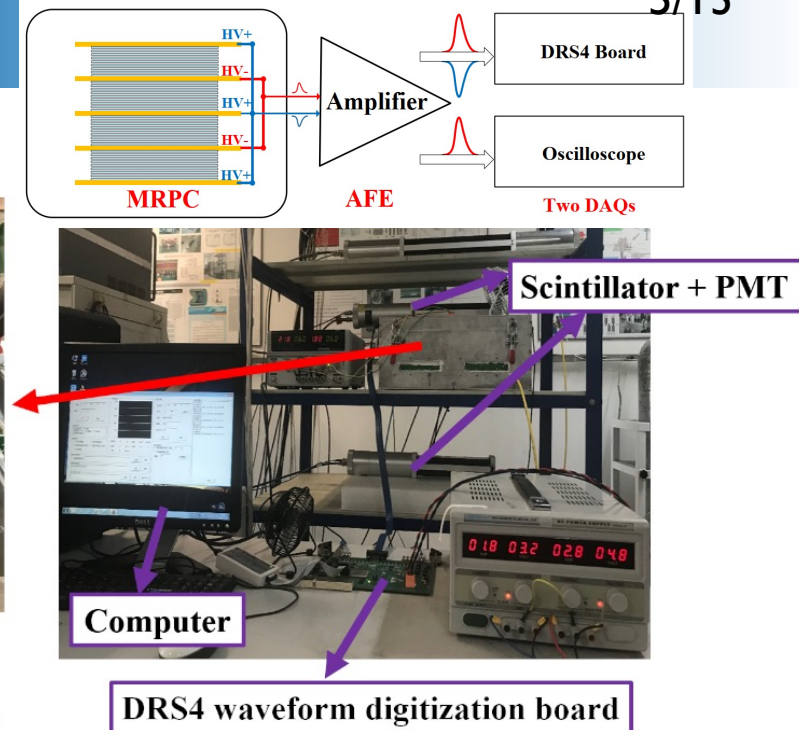


➤ Tsinghua's High-Time Resolution MRPC

❑ For SoLID's high-rate & high-background environment

- ✓ Low resistance glass ($10^{10} \Omega \cdot cm$, best quality)
- ✓ 32-gaps (4 stacks), 400um thin glasses
- ✓ 104um gas-gap + waveform-sampling
→ 20ps & 95% efficiency at 15kHz
- ✓ 128um gas-gap + ToT method → 20ps at 15kHz
- ✓ Small sizes & not sealed yet

❑ Not proven in real beam!

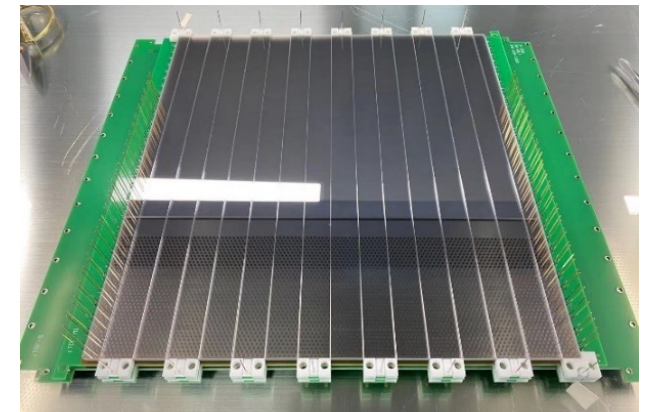
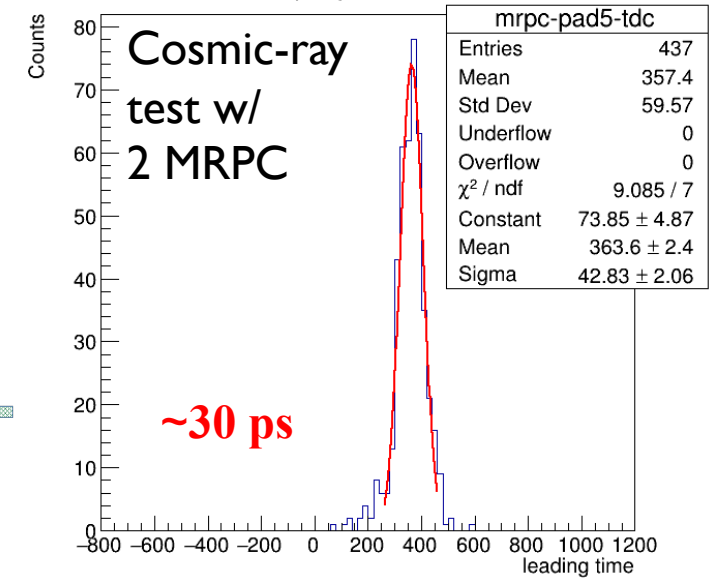
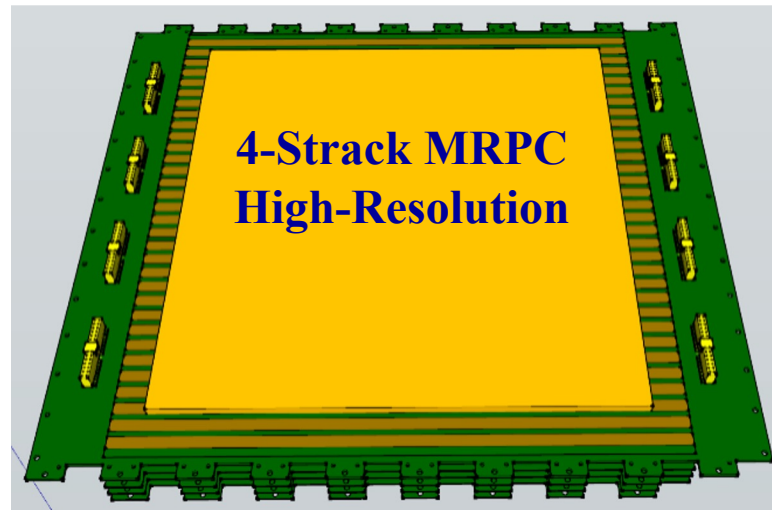
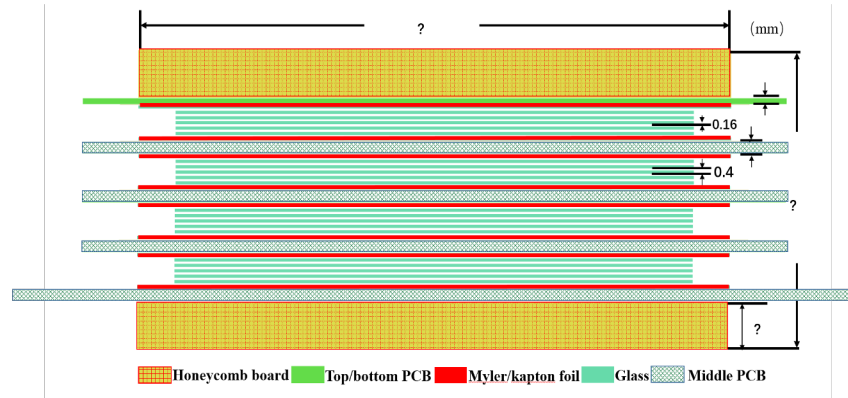
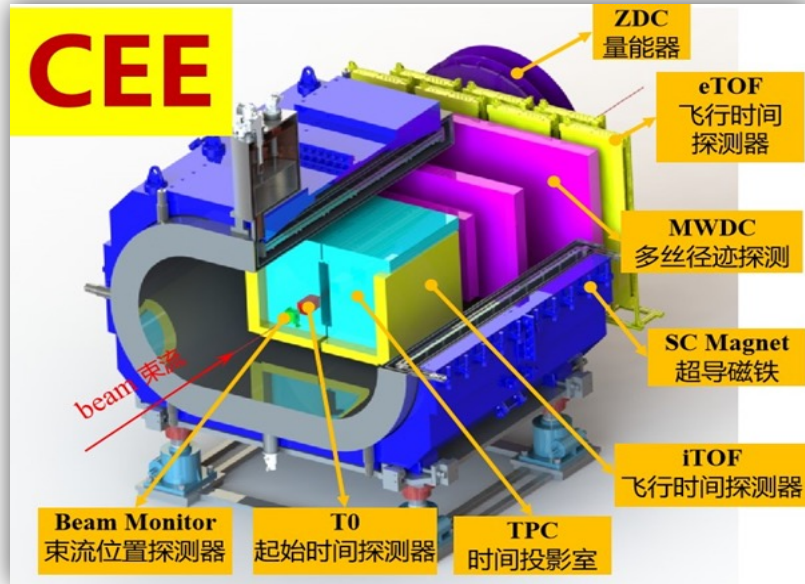


Y. Yu et al 2022 JINST 17 P02005

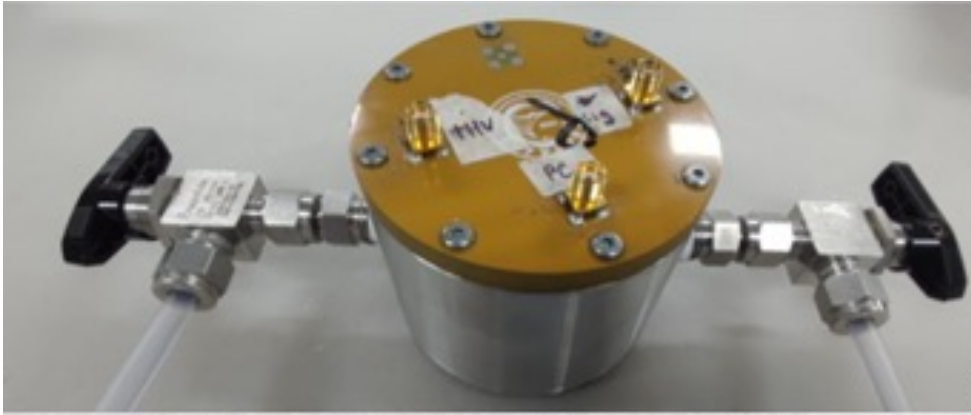
Y. Yu et al 2020 JINST 15 C01049

➤ For CEE project at HIRFL, IMP, Lanzhou

☐ MRPC as the iTOF System → 30ps needed



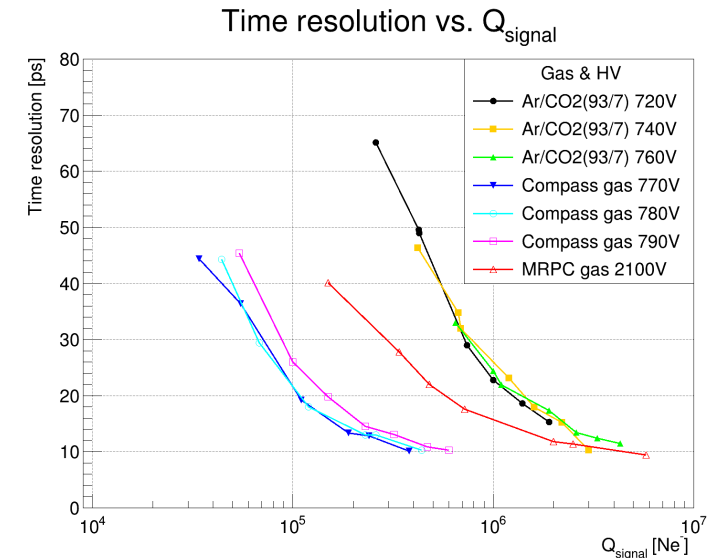
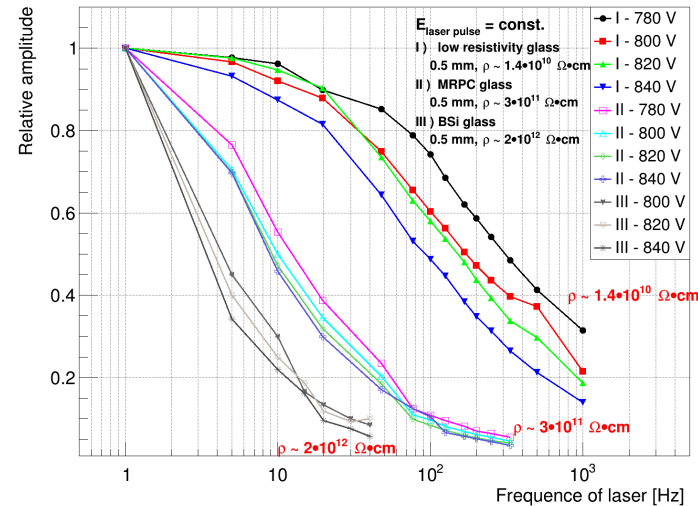
mRPC glasses coating w/ F2Mg



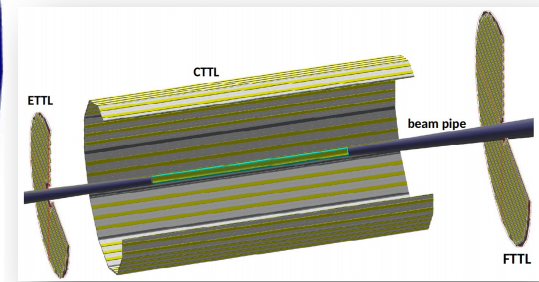
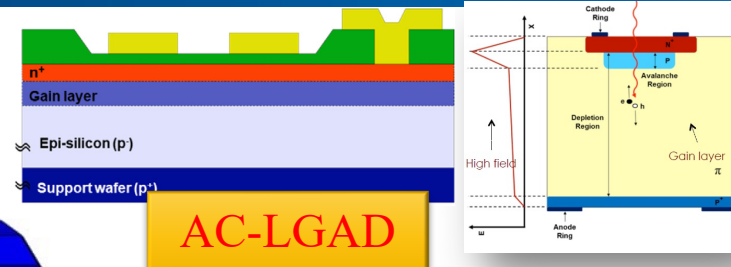
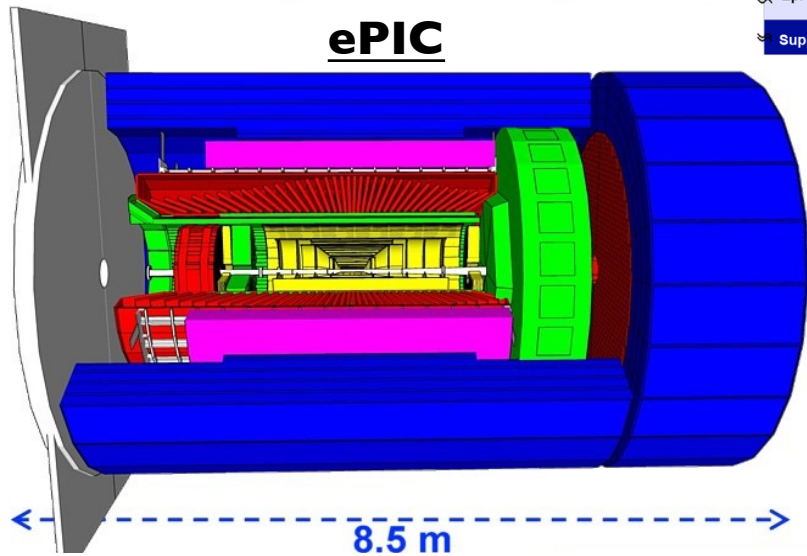
1. Photoelectric gas detector with RPC structure
2. Rate capability: $\sim \times 100$ better with low-resistivity float glass
3. Tested different gas (composition & ratio)
4. $\sigma_{t_{NPE=1}} \sim 25ps$, $\sigma_{t_{NPE \sim 10}} < 10ps$



Float low resistance glass: $\rho \sim 1.4 \cdot 10^{10} \Omega \cdot cm$
 (typical: $\sim 10^{12} \Omega \cdot cm, < kHz/cm^2$)
 rate capability improved $\sim 10^2$ times



Best time resolution $\sim 9.5ps$



Statement of Work
Project EIC GENERIC R&D (2023 #14)
Date: 01/03/2024

Development of High Precision and Eco-friendly MRPC TOF Detector for EIC

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Moved to LBL

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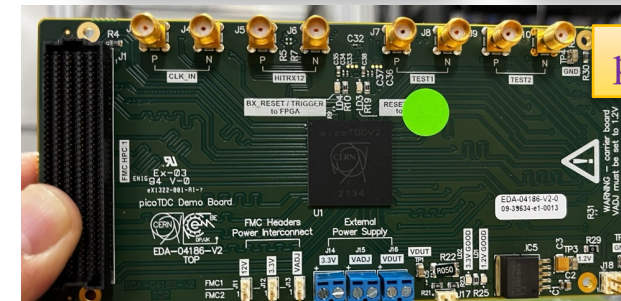
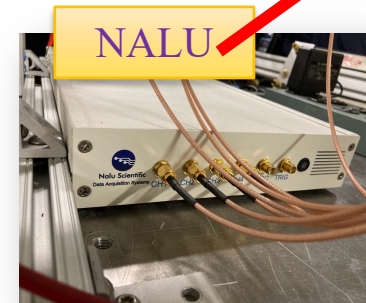
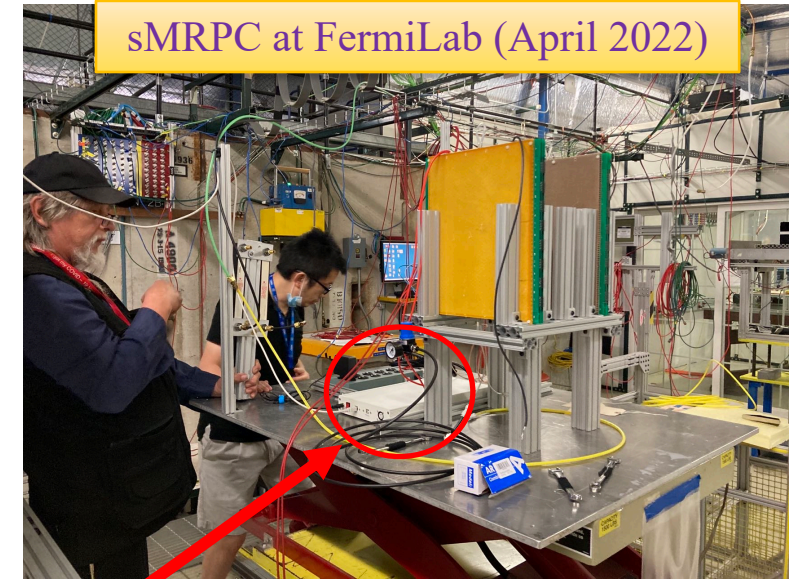
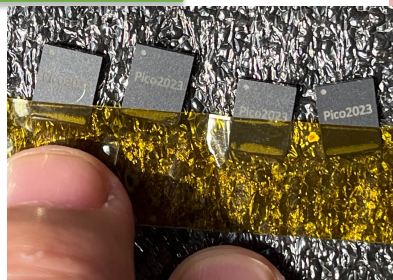
- ❑ ePIC chose AC-LGAD as the TOF
 - Goals: Time resolution ~25ps, Tracking resolution ~100 um
 - MRPC vs. AC-LGAD:
 - thick (10% X₀), less position precision
 - Cost effective, radiation hard, no risk

- ❑ Generic R&D for EIC (#14, awarded \$80K for 2024):
 - Possible for part of Detector#1 TOF, & Detector#2
 - Optimize thickness and position precision
 - Eco-friendly gas
 - In-beam performance
 - Readout electronics (synergic to AC-LGAD)

➤ Readout Electronics

- ❑ Goals: Test out time-resolution w/ front-end electronics options
- ❑ Supports from Crispian Williams, Jorgen Christiansen, David Porret (CERN), Lei Zhao (USTC), & Zhen Hu (Shenzhen Advanced Research Inst.)...

- ❑ PreAmp + DIS
 - NINO (discontinued)
 - pico2023 (*NEW*)
- ❑ TDC
 - FPGA base (not rad. dard)
 - picoTDC (*NEW*)
- ❑ Waveform Sampler
 - DSR4 (slow)
 - SAMPIC (JLab ordered)
 - NALU AARDVARC



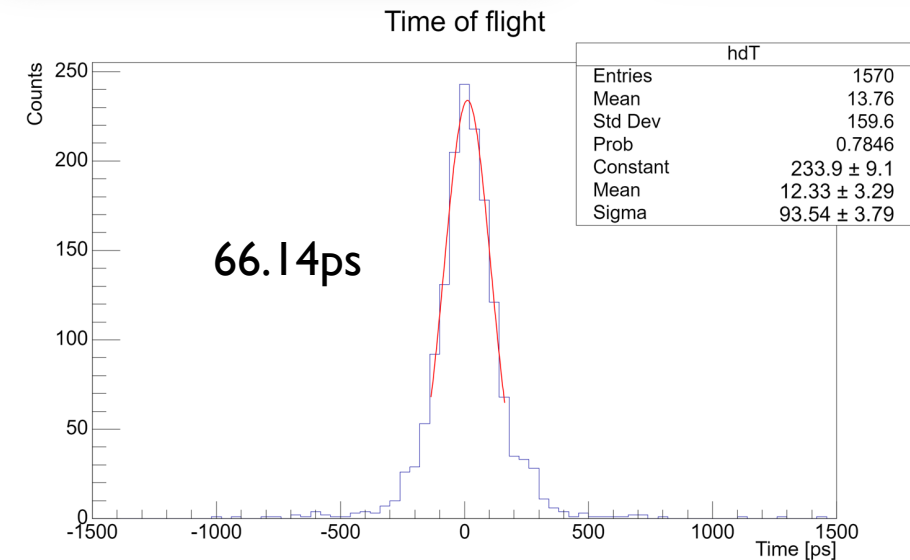
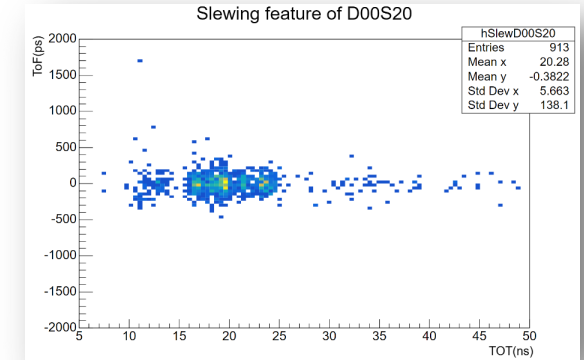
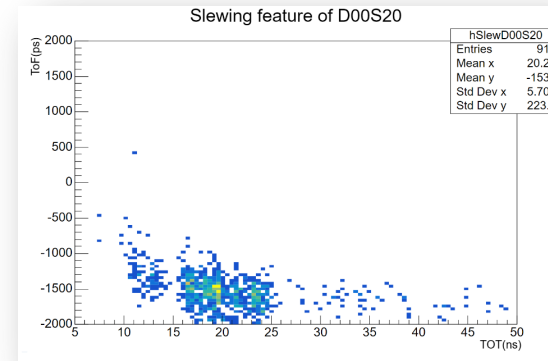
☐ To-dos:

- JLab local test with cosmic-ray + xray background (Sanghwa & Alex & Barcu)
 - ✓ 4 planes of 16-layer sMRPC + SAMPIC & NALU
- Tsinghua's local test with cosmic-ray + x-ray background
 - ✓ 2 planes of 32-layer high-rate MRPC
 - ✓ FEE to test: USTC FEE, DT5742 (DSR4), pico2023 + DT5202 (picoTDC)
 - ✓ Send some of these FEEs to JLab
- Jlab beam test
 - ✓ 4x planes of sMRPC & 2x high-rate mRPC with diff. FEE options;
 - ✓ Two Tsinghua students plan to participate the beam test (while participate upcoming experiments)
 - ✓ also test USTC's mRPC?
- Very difficult for USTC to get involved now, but promise to remain interests

MRPC Test Plan

➤ Cosmic-ray Test at Tsinghua

☐ Wang's lab (sMRPC + USTC FEE, diff. gas mixtures)



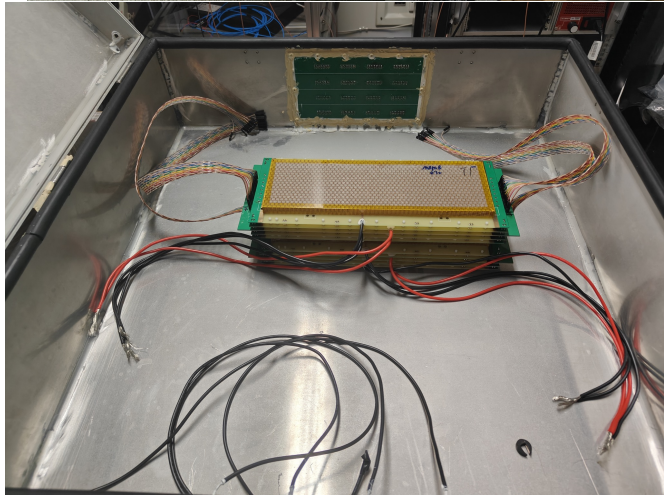
By Kai Sun, Zhaolin Chen

MRPC Test Plan

➤ Cosmic-ray Test at Tsinghua

❑ Ye's lab (high-rate MRPC + USTC FEE + picoTDC)

- Slow progress due to delays of ordering some parts
- Test system setup completed in the old lab
- Taking cosmic-ray data now
- Will test USTC's MRPC
- Moving into the new lab in summer 2024



By Zhaolin Chen & Zeyu Zhang



- **MRPC** by Tsinghua & USTC aims for improving TOF at high-rate & high-background
 - Sealed mRPC w/ regular glasses; 60ps with 16 layers; 4 modules now at Jlab; preparing beam test
 - High-rate modules at Tsinghua & USTC → down to 20ps; need beam test; not sealed yet
 - Exploring FEE options (US institutes to lead?)
 - Support from EIC R&D funding
 - synergy with other JLab projects (especially for FEE)?

- Opportunities of using mRPC on Hypernuclear experiment in Hall-C