



PID Detectors R&D for EIC at Tsinghua University

Zhihong Ye

Department of Physics, Tsinghua University, Beijing, China

EIC Asia Meeting 2024/01/29-2024/01/31



清华大学

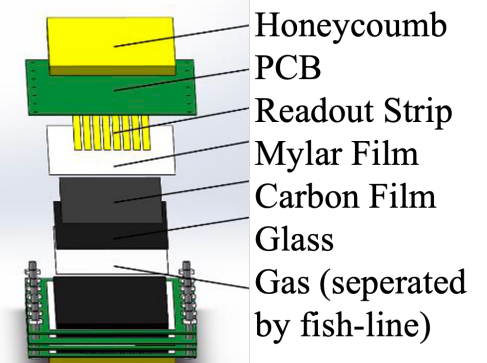
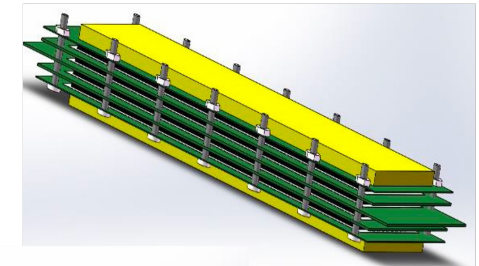
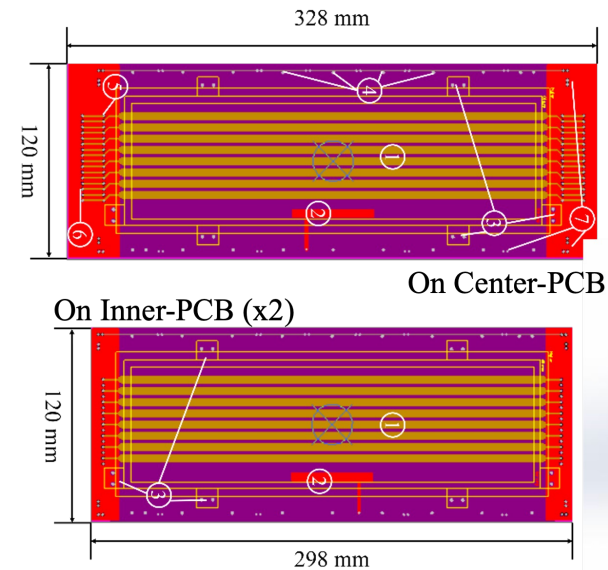
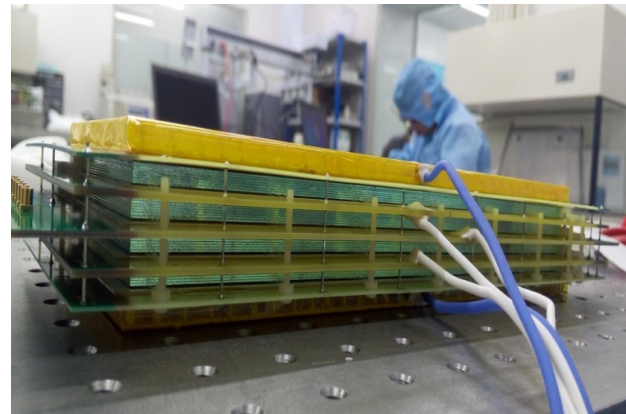
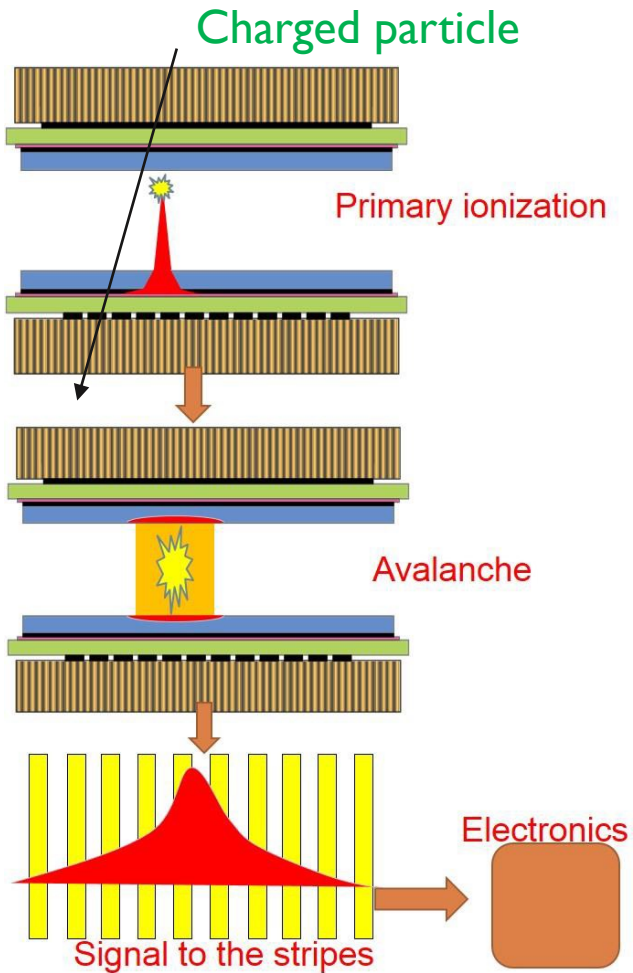
Tsinghua University

Almost “in person”!



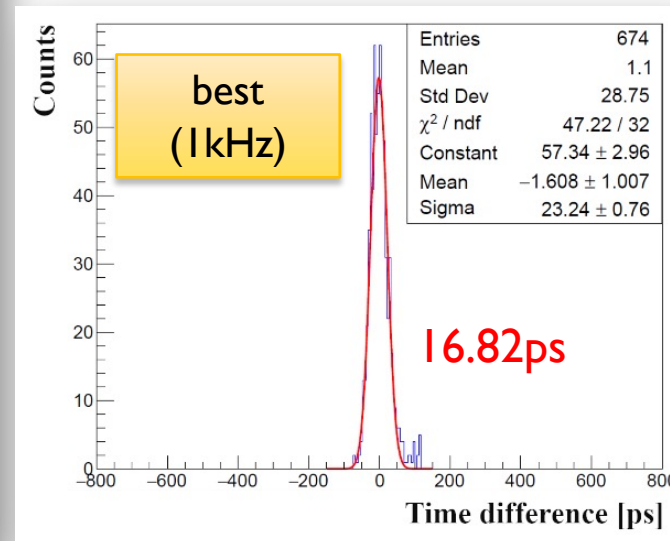
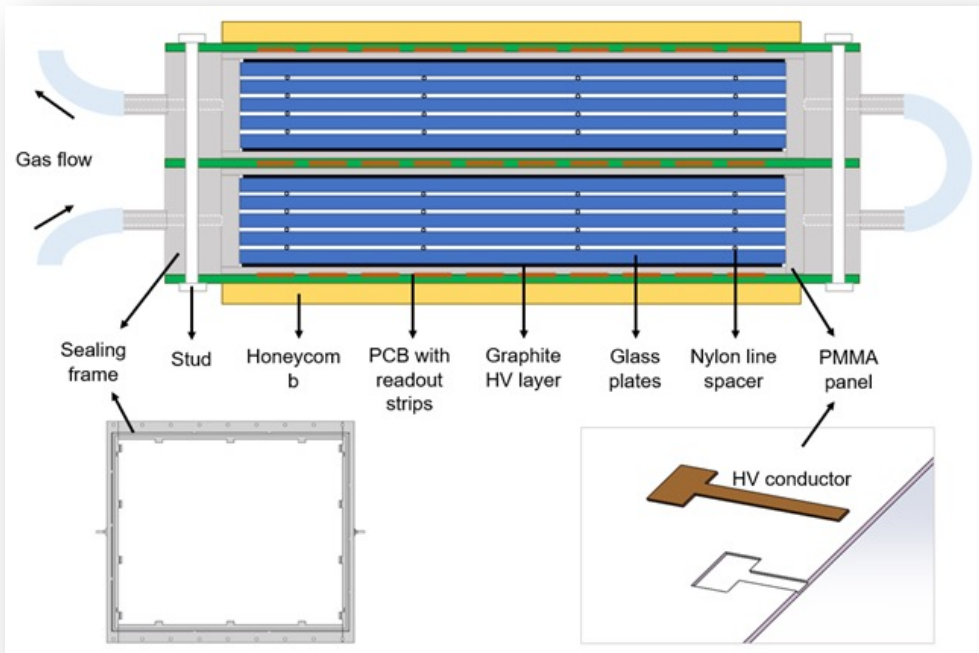
➤ Multi-gap Resistive Plate Chamber (mRPC)

- ❑ Low-resistivity glasses, Standard gas (95% F134a + 5% iso-butane), HV(~12kV)
- ❑ Good performances: timing, efficiency, rate capacity, radiation-hard, magnet safe
- ❑ Low cost, easy manufacturing, large sensitive area (up to 1.0mx0.5m)
- ❑ Spatial resolution defined by strip pitch
- ❑ Used by ALICE, STAR, etc. To be used on CBM, CEE, **SoLID**



➤ Tsinghua's new Sealed MRPC (sMRPC)

- ❑ Gen3 MRPC with sealed gas (metal box not needed anymore)
- ❑ More compact, less radiation length
- ❑ Reduce greenhouse gas emission ($20\text{cc}/\text{cm}^2/\text{min}$)
- ❑ Mass production capability of at Tsinghua



- ❑ $\sim 17\text{ps}$ achieved with cosmic-ray & 10Gs/s oscilloscope

- ❑ To-do: $\sim 30\text{ps}$ with integrated FEE and in-beam

➤ sMRPC's Pros and Cons:

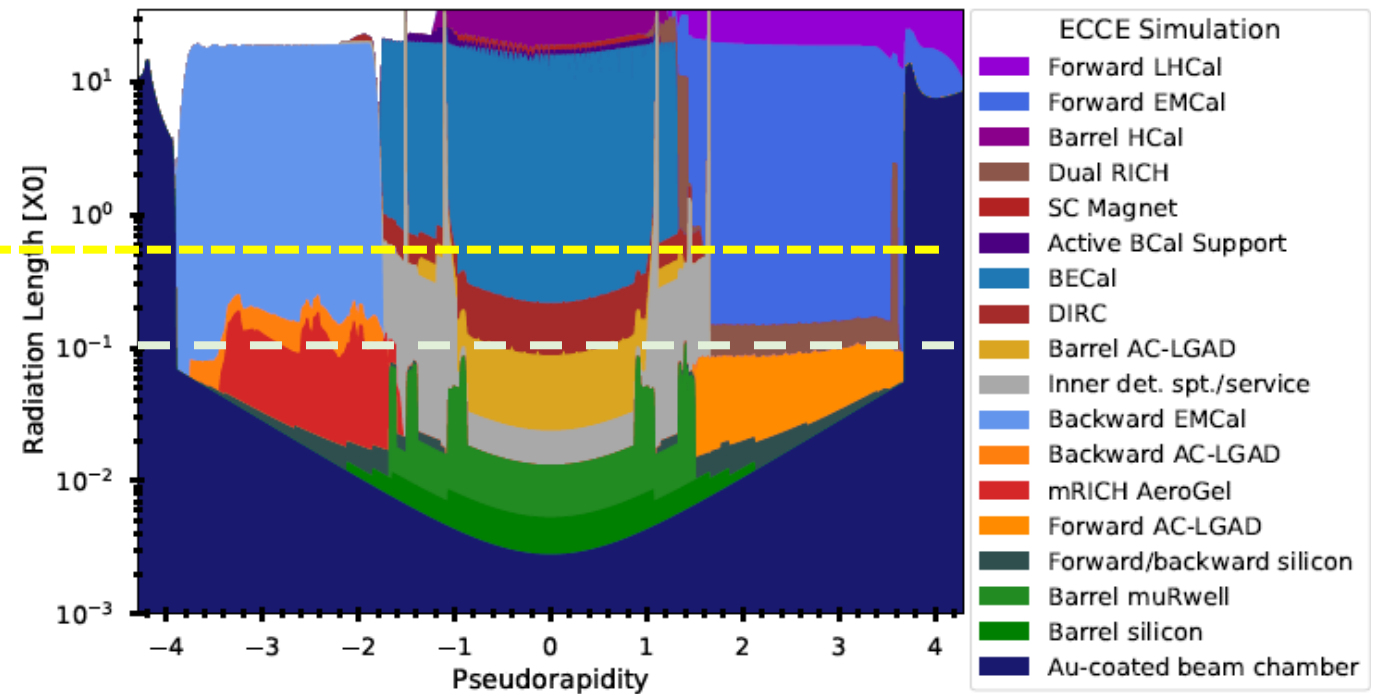
□ MRPC:

- 5% X_0 for 16 layers (30~40ps); 10% X_0 for a 32-layer one (20ps) → including all materials
- Position resolution depending on the strip pitch (hence # readout channels)

□ AC-LGAD: 1% X_0 for ePIC Barrel; 8% for Endcaps; Tracking capability



sMRPC at FermiLab (April 2022)



➤ sMRPC R&D for US-EIC

❑ Awarded \$80K by EIC R&D@2024 (PI: Zhihong Ye & Sanghwa Park)

❑ Goals:

- Performance w/ high-energy&-rate background
- Test out new high-time-resolution front-end electronics
- Investigate different eco-friendly gas mixtures
- Alternative to LGAD?
- TOF for Detector#2?

❑ To-do at JLab:

- 4 sMRPC have been moved from UIC to JLab
- Setting up test stand in EEL
- Ordering SAMPIC (restricted to China)
- Prepare beam test in Hall-A or C in 2024

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

Alexandre Camsonne¹, Sanghwa Park*¹, Yi Wang², Zhenyu Ye^{3,4}, Zhihong Ye^{†2}

¹Thomas Jefferson Lab, Newport News, Virginia, 23606, USA

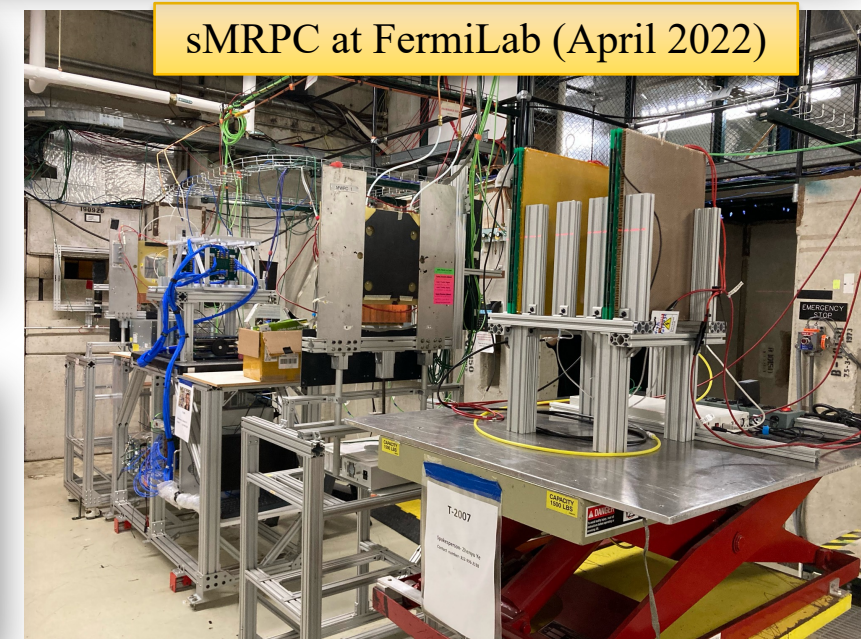
²Department of Physics, Tsinghua University, Beijing 100084, China

³Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

⁴University of Illinois at Chicago, Chicago, IL 60607, USA

[†]PI: Zhihong Ye, yez@tsinghua.edu.cn

*coPI: Sanghwa Park, sanghwa@jlab.org

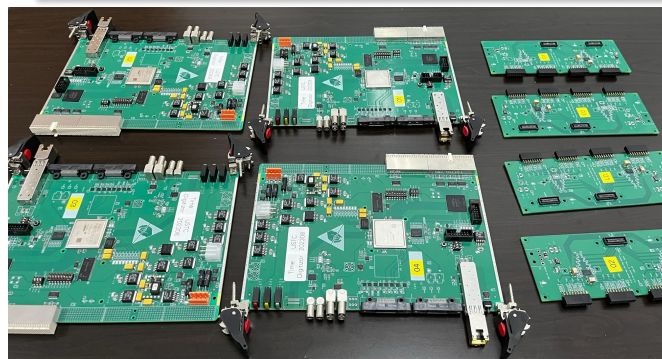


➤ sMRPC R&D for US-EIC

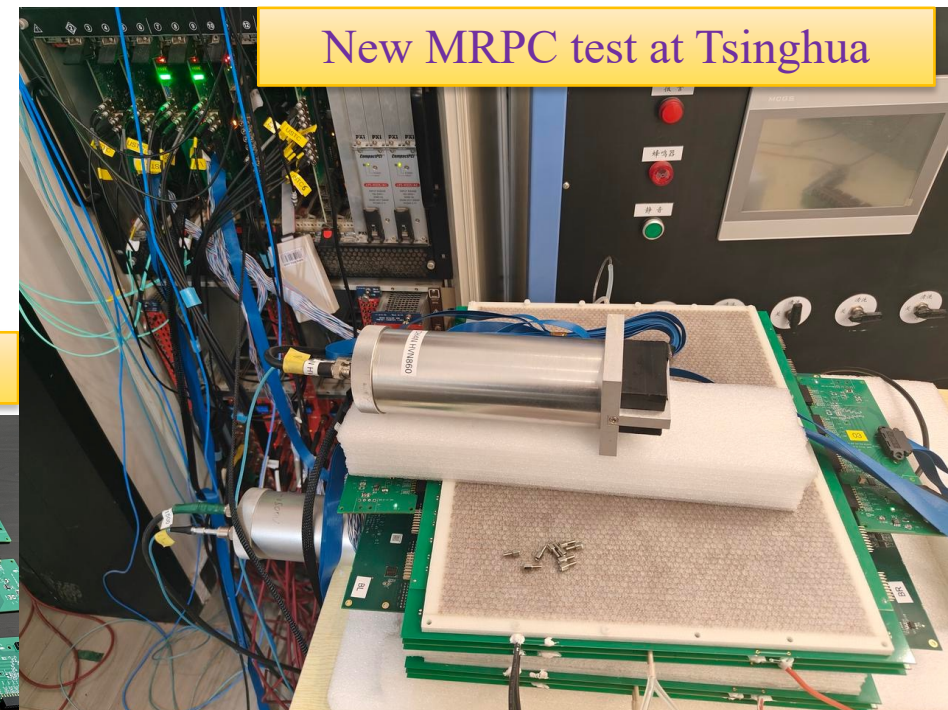
- ❑ 2 high-rate sMRPC built and test w/ cosmic-ray at Tsinghua
- ❑ Test out new ToT front-end electronics (FEE) options
- ❑ Send to JLab for beam-test with new FEE

- ✓ PreAmp + Discriminator
 - By USTC w/ NINO (discontinued)
 - pico2023 (CERN)
- ✓ TDC
 - USTC FPGA base
 - picoTDC (CERN)
 - VETROC (ordering w/ JLab)
- ✓ Waveform Sampler
 - DSR4
 - ~~SAMPIC (restricted to China)~~
 - NALU AARDVARC (?)

USTC FEE (NINO+FPGA-TDC)



New MRPC test at Tsinghua



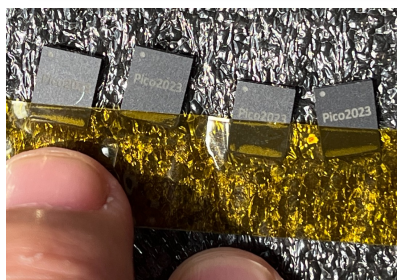
picoTDC



Pico2023

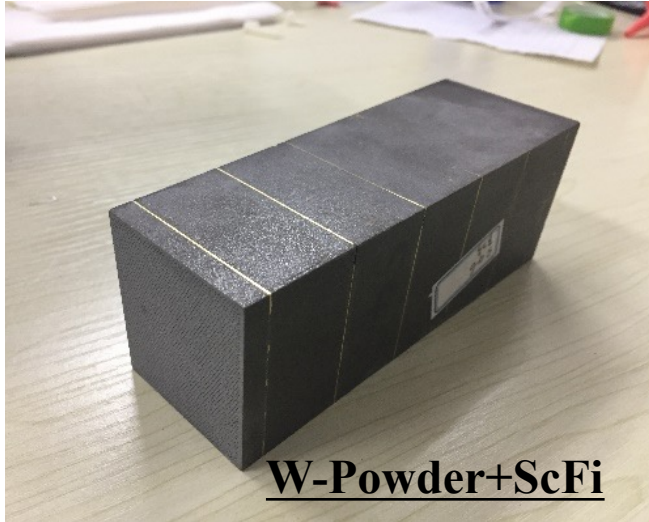


DT5742/v1742



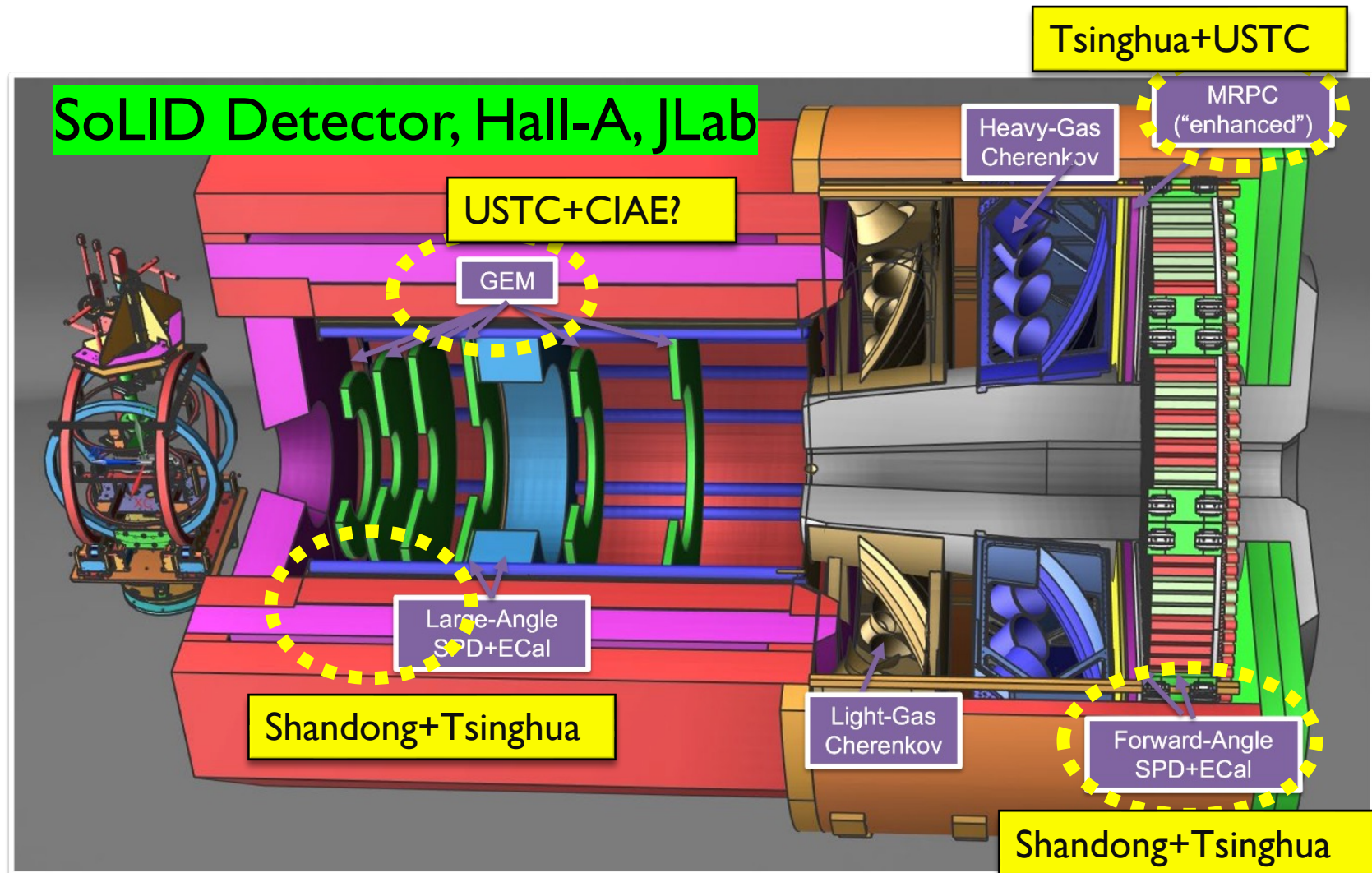
➤ Shashlyk ECal (by Shandong & Tsinghua):

- ❑ Tsinghua is working w/ Fudan&Shandong on the ePIC forward ECal (see WeiHu's talk)



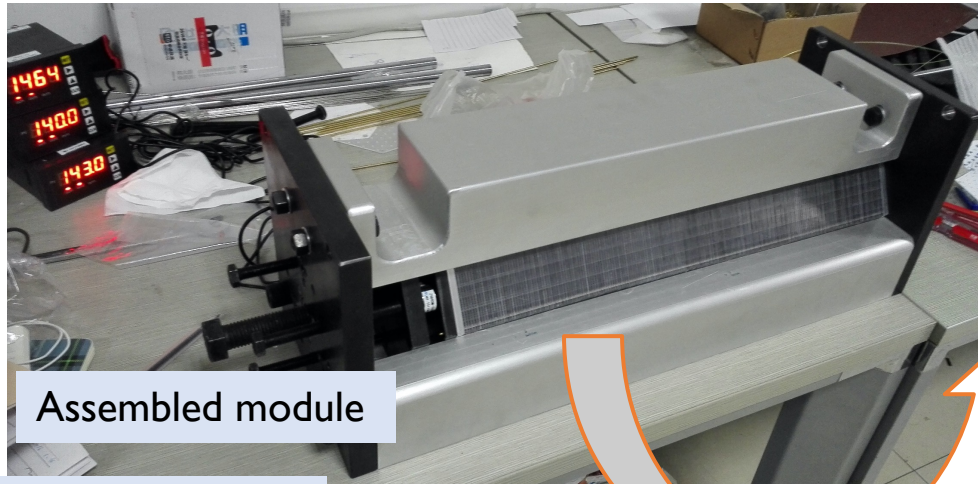
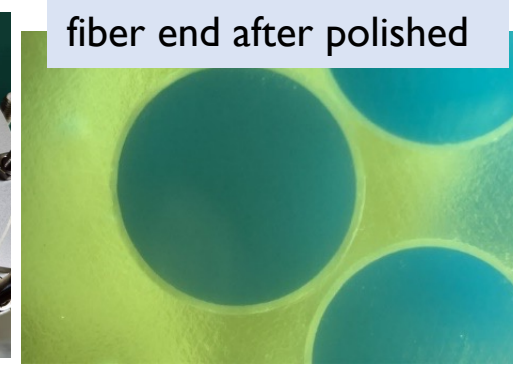
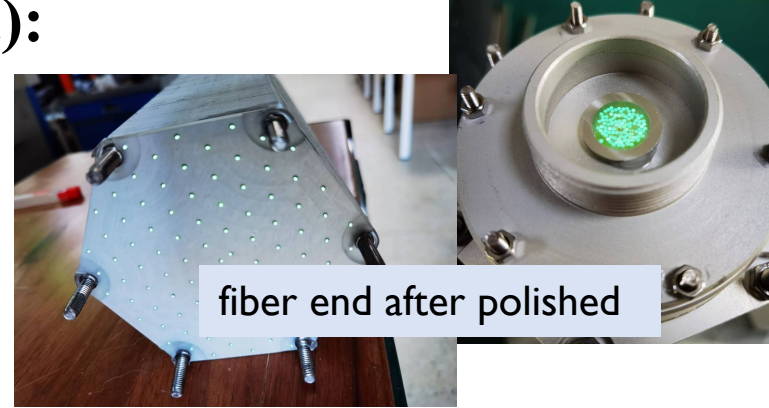
- ❑ Tsinghua & Shandong: 10+ years Shashlyk ECal R&D for SoLID

- ❑ Great candidate for EIC Detector#2

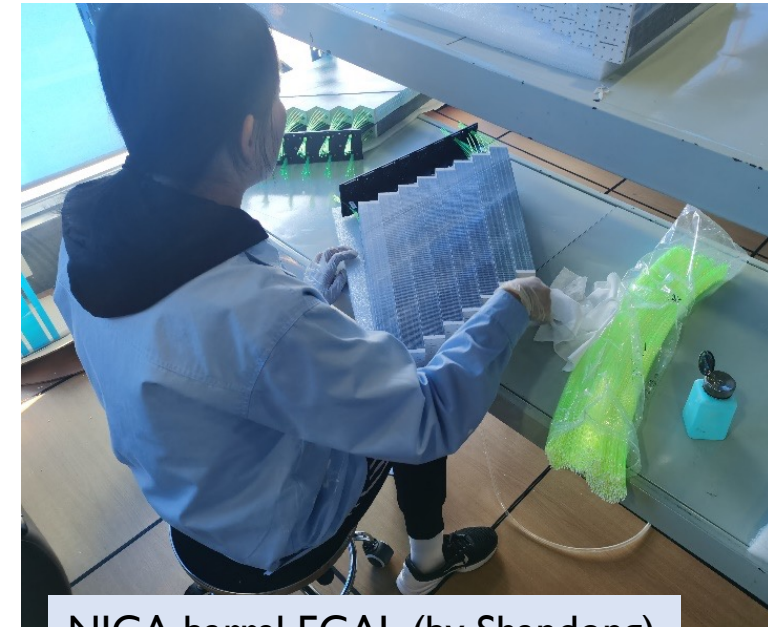
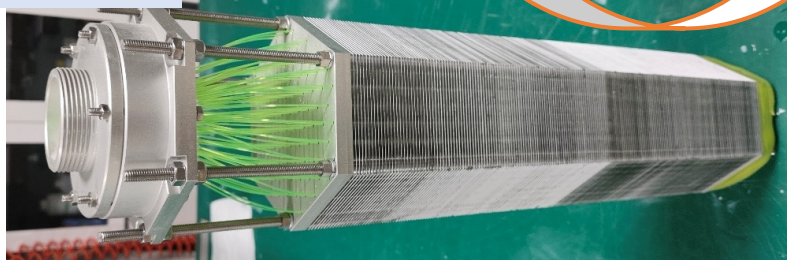


➤ Shashlyk ECal (by Shandong & Tsinghua):

- ❑ Well developed manufacture lines at Tsinghua & Shandong (see Qinghua's talk)
- ❑ Mass production for NICA-SPD (barrel) and (to-be) for SoLID (endcaps)



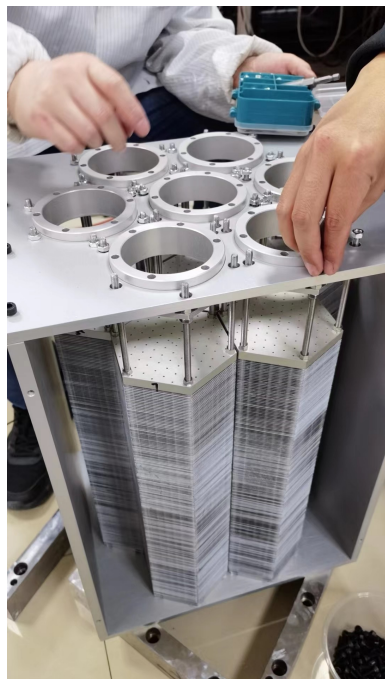
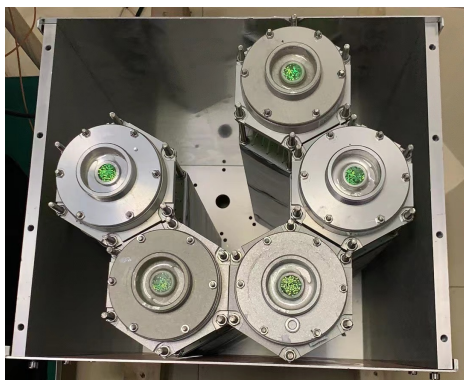
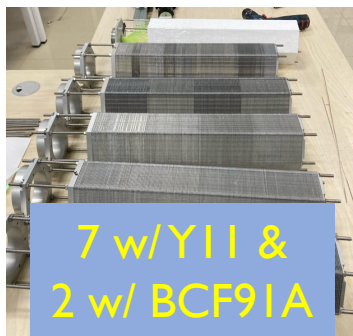
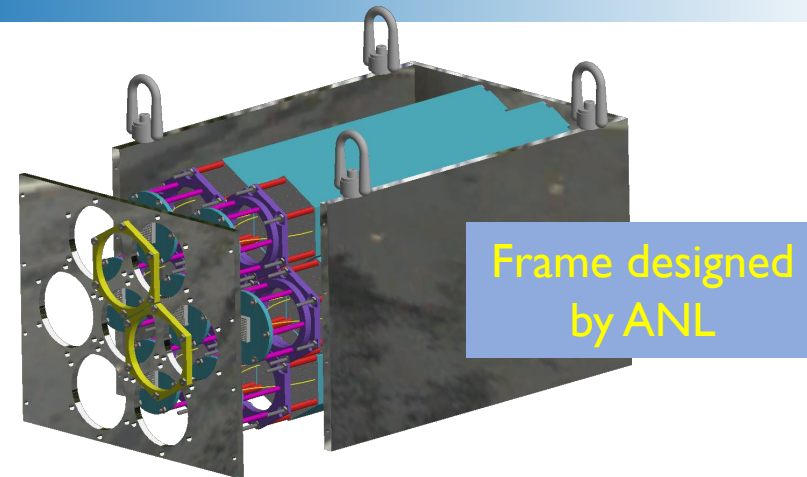
Inserts fibers



➤ Shashlyk ECal (by Shandong & Tsinghua):

❑ Super-module for SoLID:

- ✓ Performance of a full shower development w/ JLab e-beam
- ✓ Photo-sensor in 1.5T magnet (clear fiber+MaPMT, or MCP)
- ✓ Assembly & supporting structure optimization
- ✓ Slow control development (HV, LED, ...)



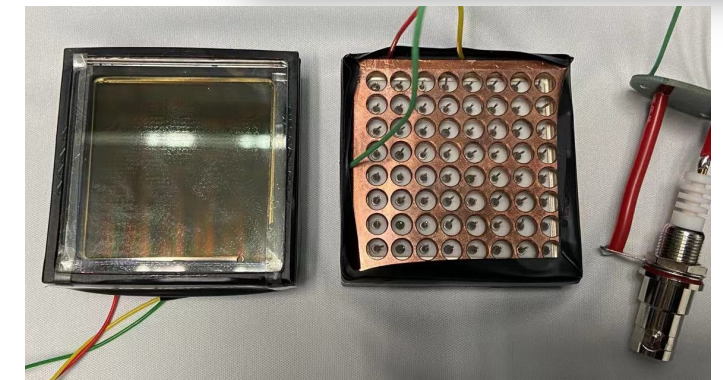
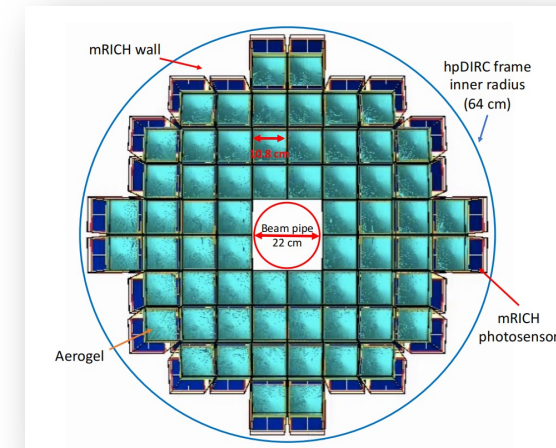
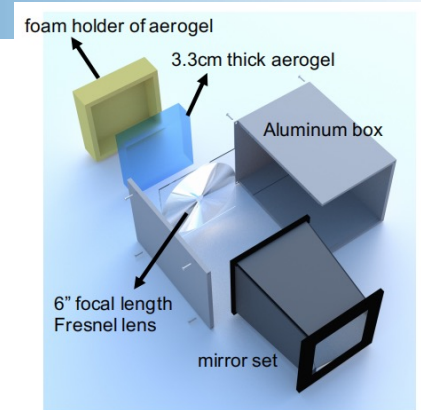
➤ RICH R&D:

- ❑ No much experience
- ❑ Worked on Geant4 Simulation on dRICH (not active anymore...)
- ❑ Involved in mRICH R&D

- ❑ mRICH was out-selected by ePIC, but Tsinghua is still continuously developing
 - Active support from GSU and other mRICH team members
 - Compact design for prototyping → studying aerogel tiles and photo-sensors
 - **EIC Detector#2?**

- ❑ At Tsinghua:
 - A mRICH frame designed by A. Eslinger to be manufactured soon
 - MaPMT: 2*H12700A, 2*H12700A-03, 2*H12445-100
 - 2 * MCP-PMT (8*8, same form-factor as H12700, made in China)
 - Lenses
 - Laser & LED source (down to single-photon)
 - China and BINP aerogels

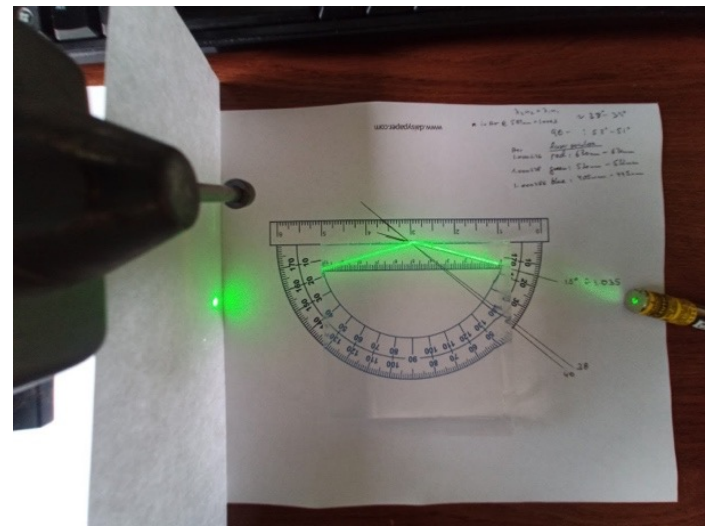
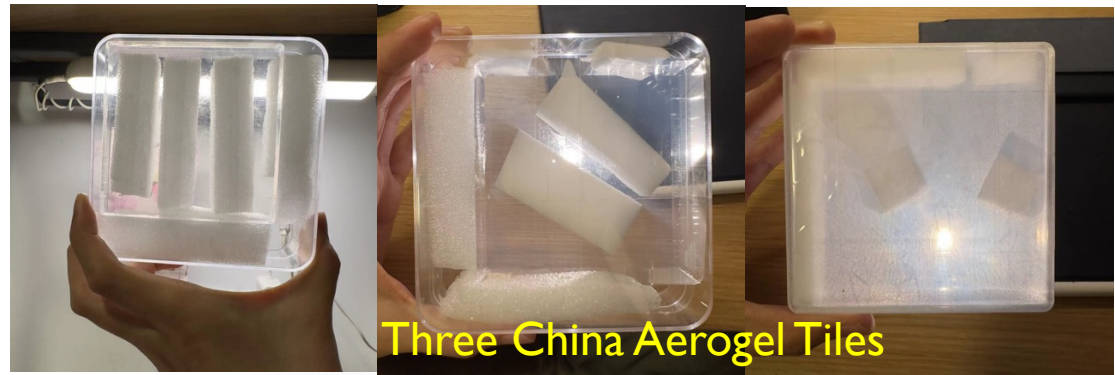
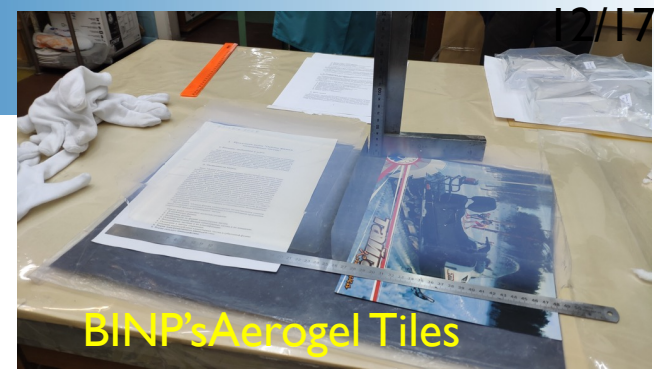
❑ **To-Do: Build a mRICH prototype in 2024 summer**



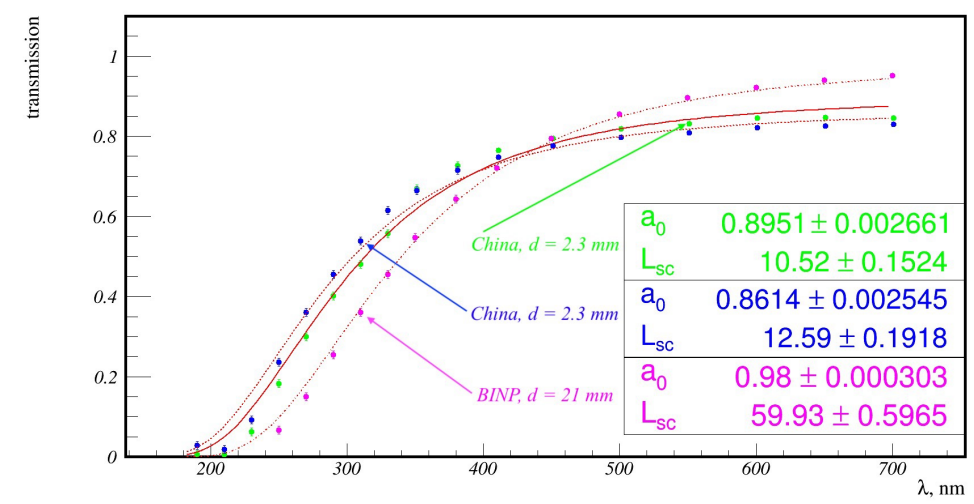
RICH & Aerogel

➤ Aerogel R&D:

- ❑ CLAS12 and ePIC previously used BINP's aerogels (not anymore!)
- ❑ Japan-Chiba's aerogel available but risk of mass production capability
- ❑ Collaborated with SINANO on producing hydrophobic aerogels (reudcing the risk)
 - ✓ Three samples sent to JLab (10cm*10cm*2cm)
 - ✓ $n \sim 1.03$ (measured by Dave Mark)



- ✓ Good transparency (slightly worse than BINP-Aerogel)
- ✓ Uniformity and flatness needed to be improved



➤ Aerogel R&D:

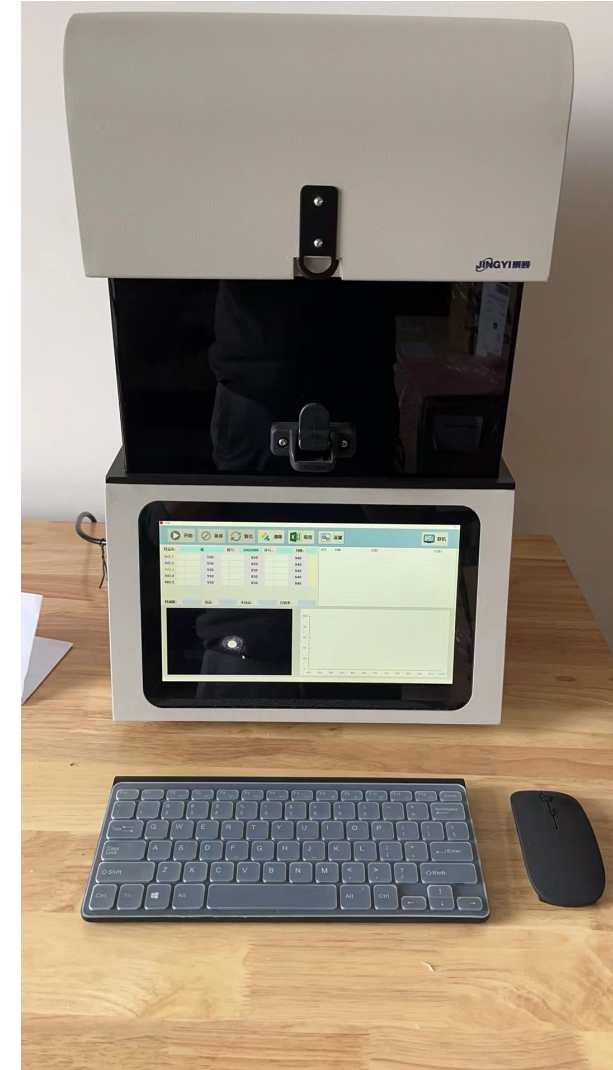
❑ Setting up a new production line at Tsinghua (collaborator left SINANO)

✓ Supercritical-dryer oven



✓ Multi-point transmission scanner

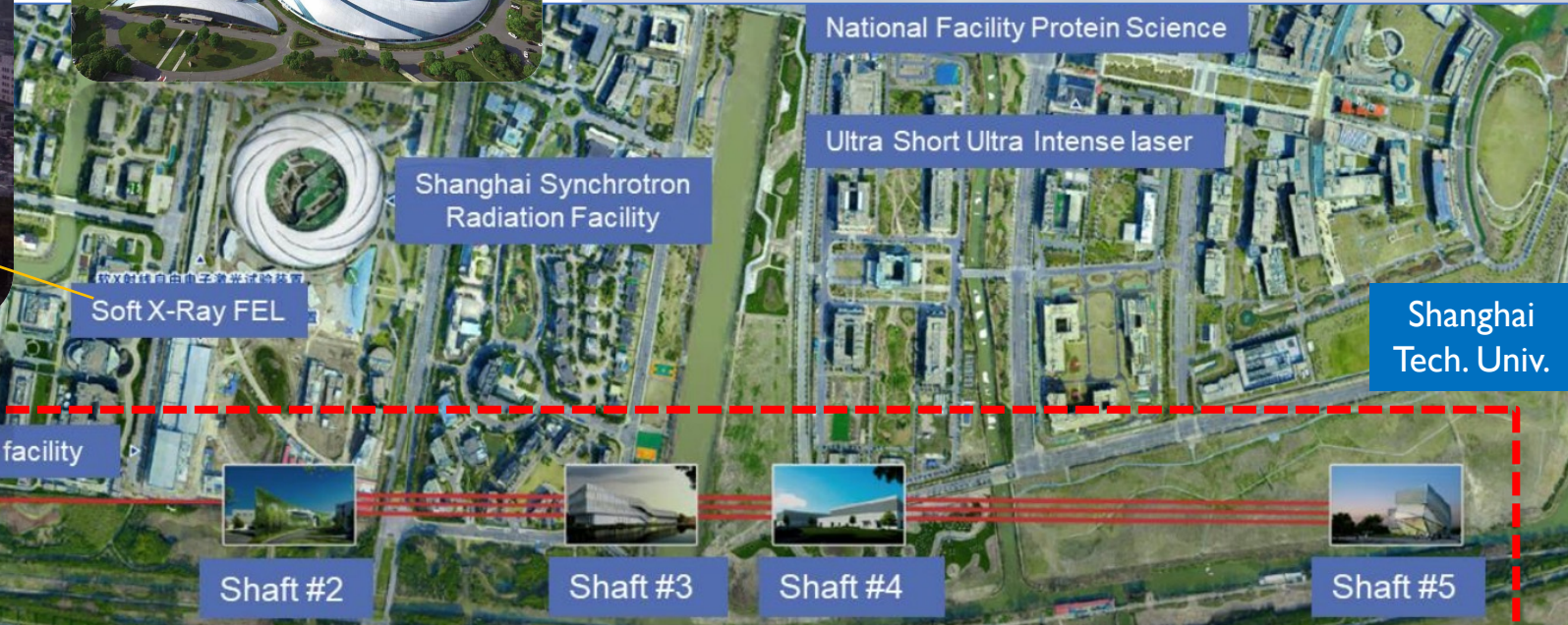
✓ Other accessories



❑ **HOWEVER**, due to recent lethal incident, setting up and running high-pressure devices at Tsinghua is difficult!

→ Look for off-campus labs or new chemistry collaborators?

➤ Shanghai Advanced Research Institute (SARI):

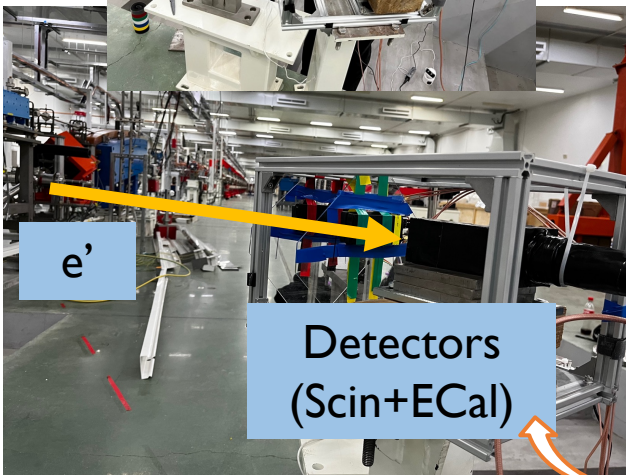
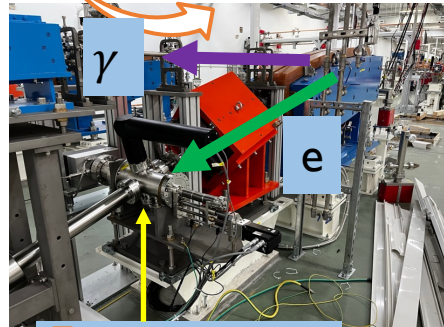
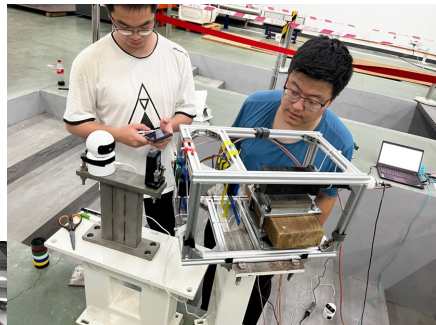
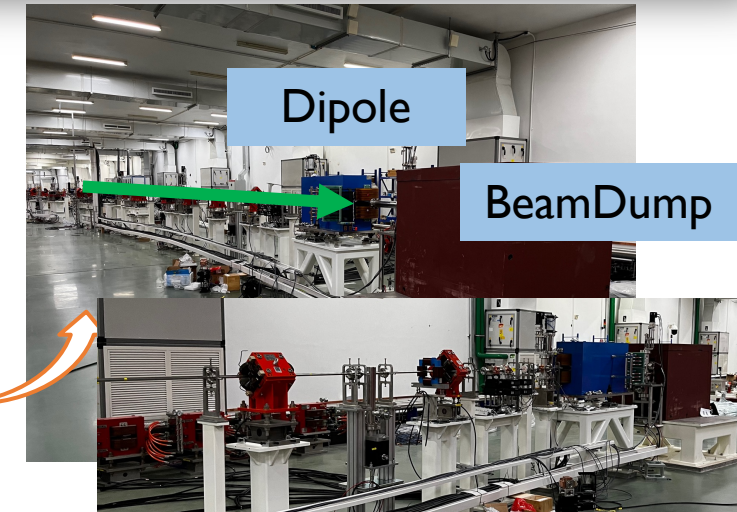
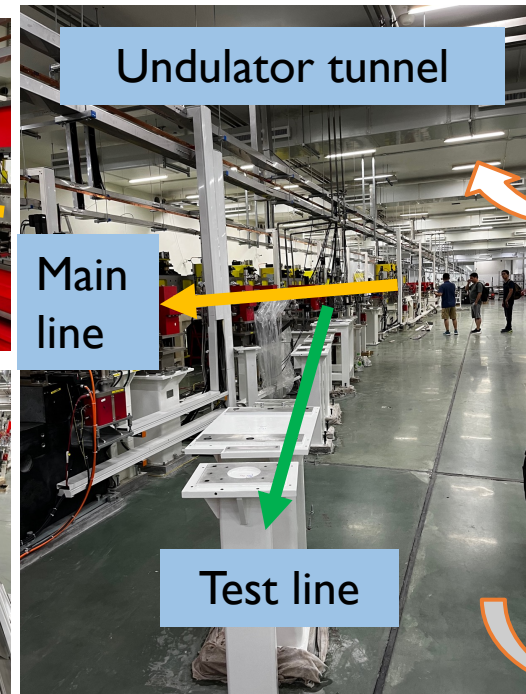
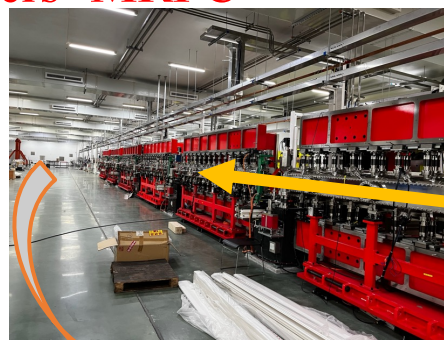


Shanghai High Repetition Rate X-ray FEL and Extreme Light Facility (SHINE)
(8 GeV, 10 exp. Stations, operation in 2024)

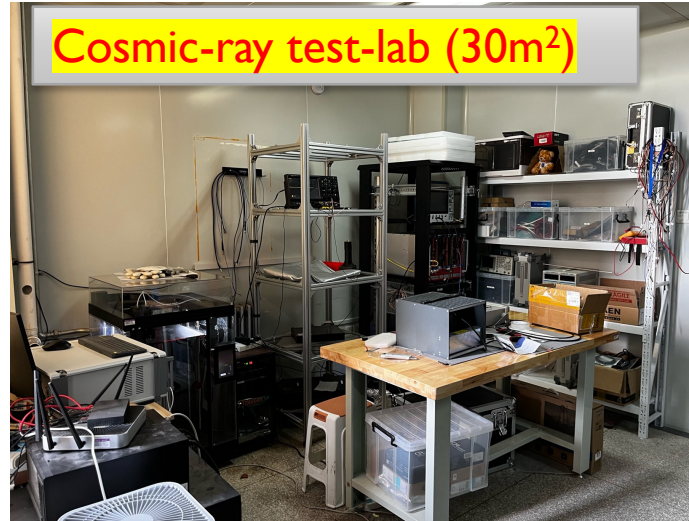
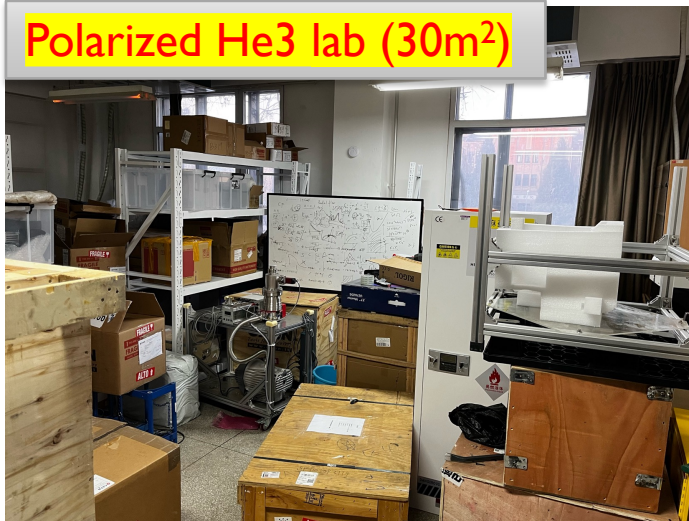
➤ Soft X-Ray FEL (SXFEL):

- ❑ 1.5 GeV electron (10Hz, 500pC/p, 2ps-width)
- ❑ “Demo”-Test in Summer 2023:
 - ✓ 4 scintillators as triggers, measure electron signals in ECal (W-power)
 - ✓ Detectors in the tunnel (not easily accesible)

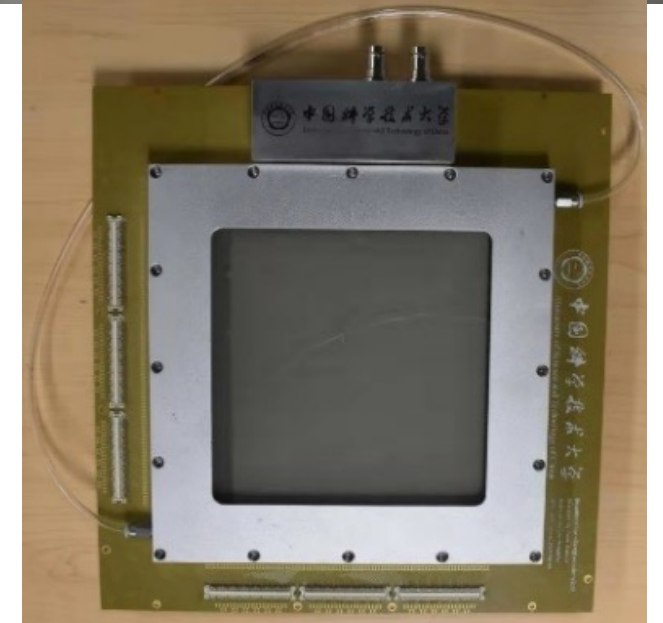
❑ 2024: SoLID ECal+Trackers+MRPC



- ❑ We are moving into a new physics building → a 100m² new lab to be operational in Spring 2024 (cause work-delay)



- ❑ Two CAEN VME crates + two Weiner VXS VME crates
 - Setting up JLab-CODA DAQ (some parts restricted to China)
- ❑ A “almost” full set of VME modules & Power-supplies for regular testing
- ❑ Handful scintillating counters as triggers
- ❑ Two 40cm² micromegas trackers from USTC (For MRPC & RICH testing)
- ❑ Prof. Wang Yi’s mRPC & ECal Detector-Labs



- ❑ Tsinghua has great capability of producing high-time-resolution mRPC and Shashlyk Ecal
 - EIC R&D fund (2024) to support mRPC beam test with multiple new FEE
 - R&D experiences in Shashlyk Ecal for SoLID and NICA-SPD → for Detector#2?

- ❑ Working with collaborators in producing Chinese aerogels for RICH
 - Building a mRICH prototype in summer 2024

- ❑ Exploring 1.5GeV electron beam in China for testing MRPC, mRICH and ECAL

- ❑ New and well-equipped labs for continuous detector R&D for EIC

- ❑ Need more open-scientific environment and ePIC's support
 - Funding mRPC R&D for EIC is a good start → appreciate support from JLab and the R&D committee
 - Work-around of some restrictions to Tsinghua and more to other Chinese institutes
 - Invite and encourage more Chinese institutes to contribute to EIC