SoLID Detector R&D Tsinghua Side

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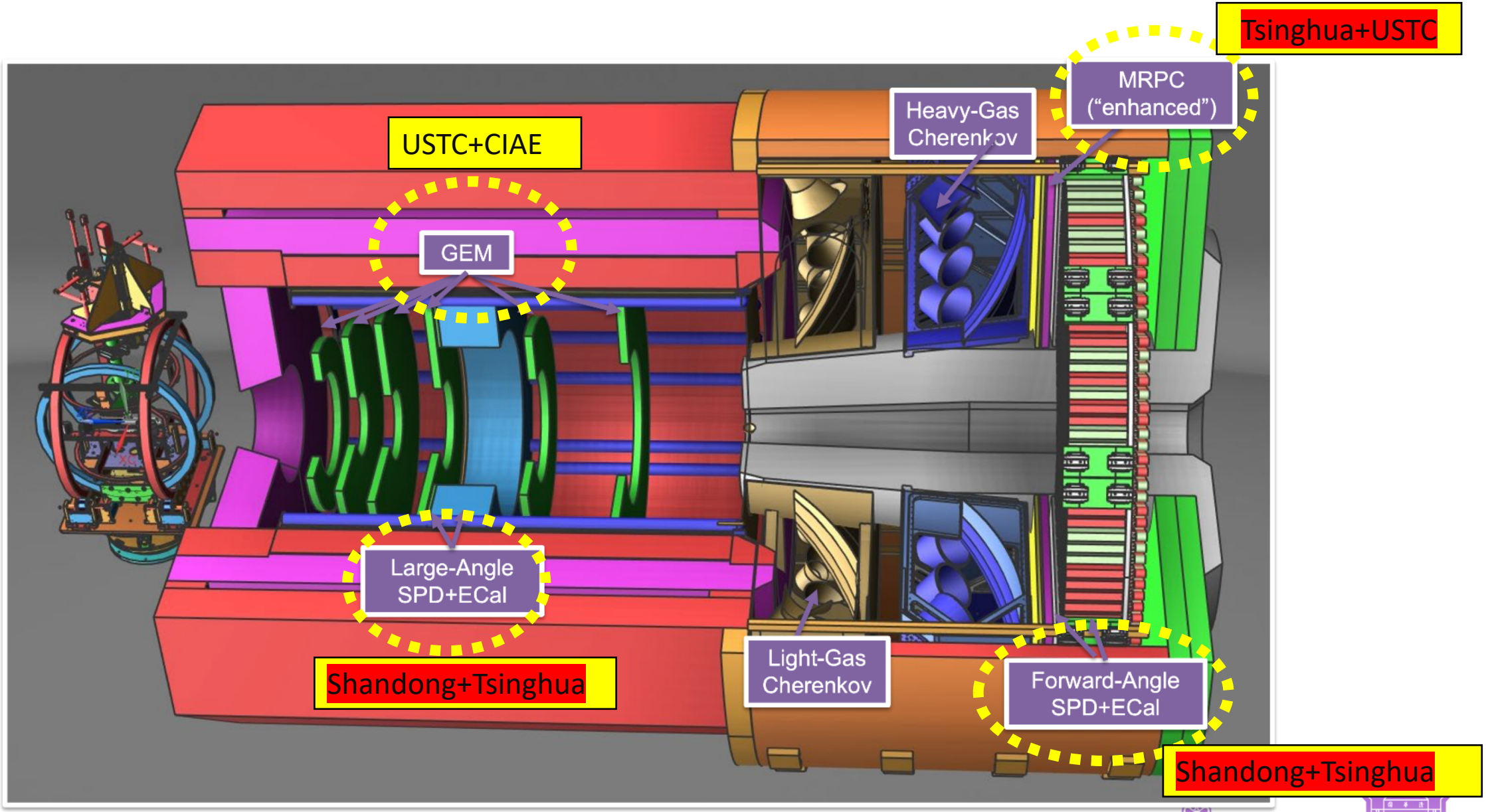
Department of Physics, Tsinghua University

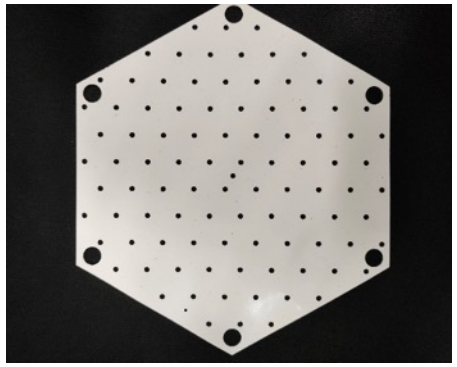
SoLID Collaboration Meeting, 01/09-10/2024

SoLID Detectors

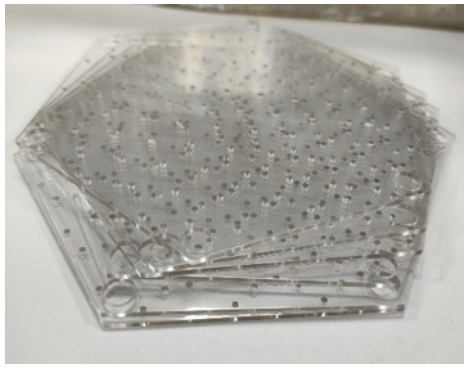


ECAL

➢ Shashlyk ECal Material Overview:

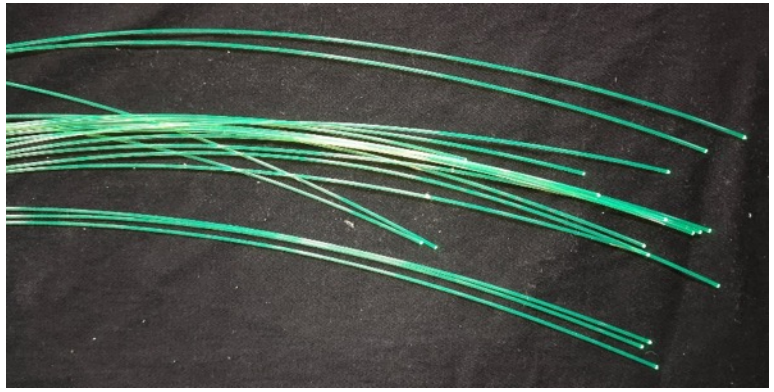


lead sheet with reflective coating



plastic scintillator

ESR with air coupling



Wavelength-Shifting Fiber

Part	Type/Material
scintillator	KEDI enhanced
WLS fiber	Y11 multi-cladding
outside surface	TiO2
fiber end reflector	ESR film
lead	paint TiO2*

*instead of reflective layer between lead

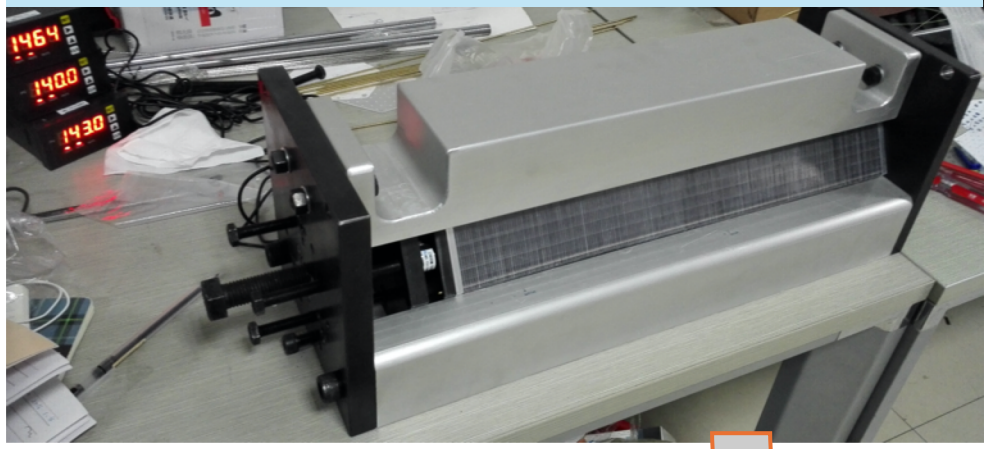
optical reflective glue

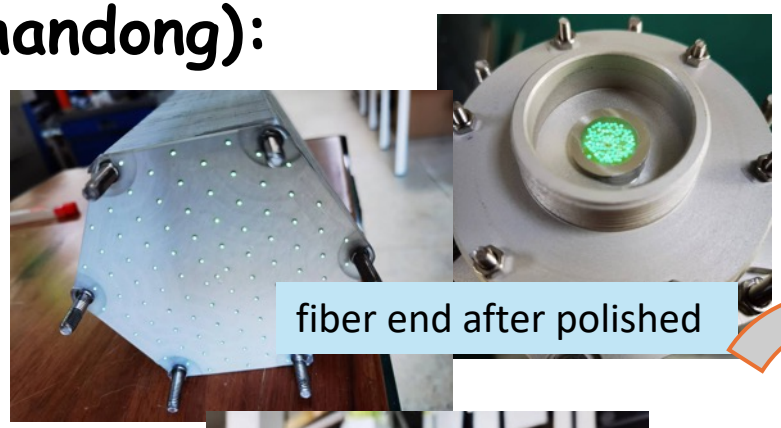
Tyvek

ECAL

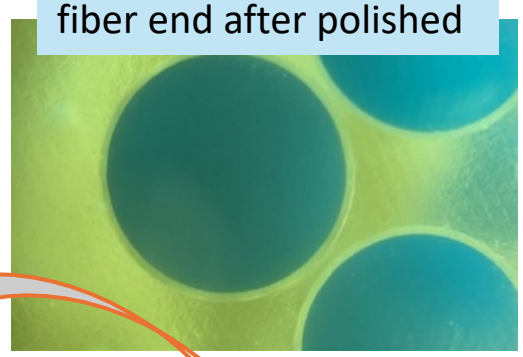
➢ Shashlyk ECal Assembly (by Shandong):

Scintillator tiles and leads are cross stacked in the mold, keeping pressure for one day.

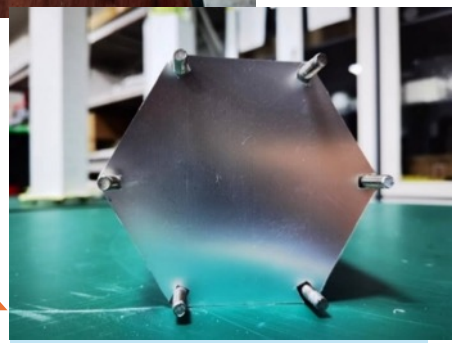




fiber end after polished

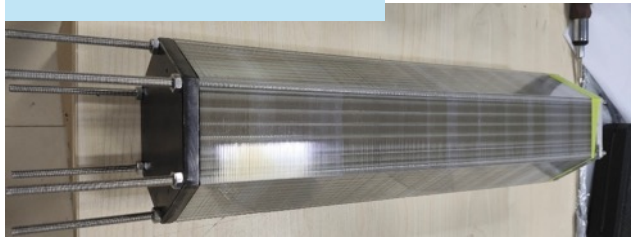


fiber end after polished

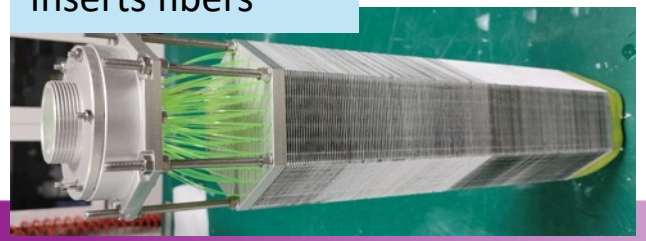


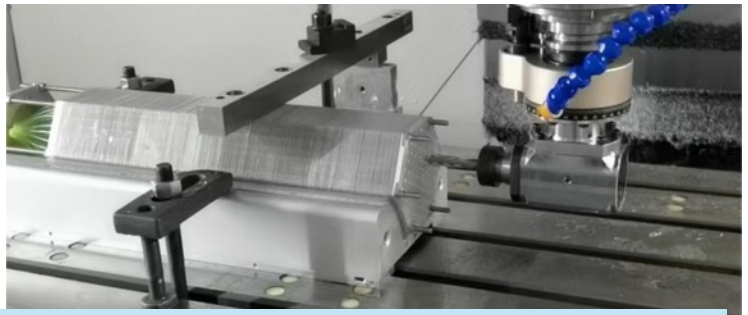
cover plate above ESR

Assembled module



Inserts fibers





fiber polished with CNC milling machine

TiO2 reflective layer

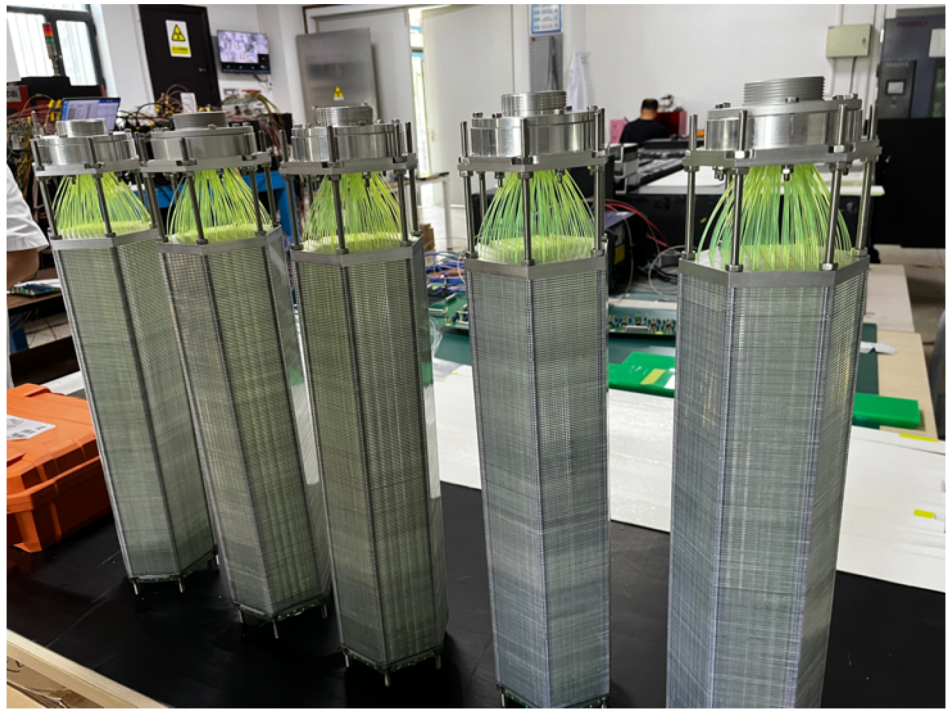
Tyvek

ECAL

➢ Shashlyk ECal Assembly (by Shandong):

- First bunch of 7 modules shipped to Tsinghua

- Second bunch of 7 modules made at Shandong already

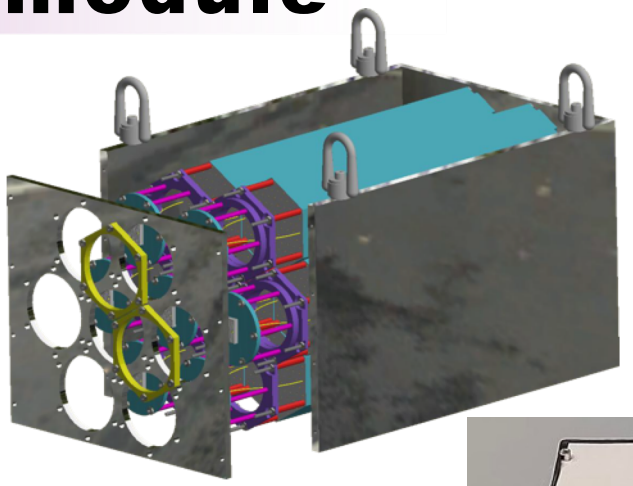


- Materials paid with my startup grant (gone) + SDU's own resources
- Stock up additional ~3000m WLS fibers

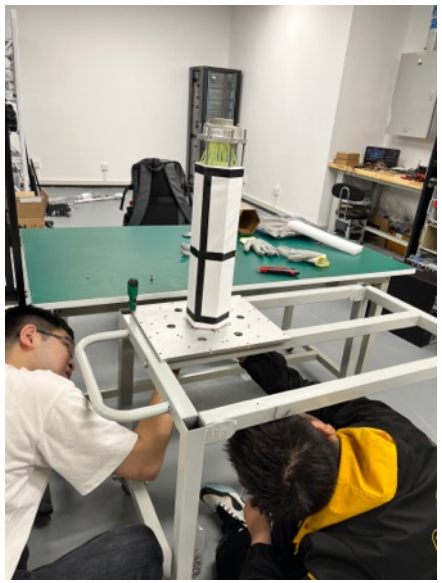
1st ECAL Super-module

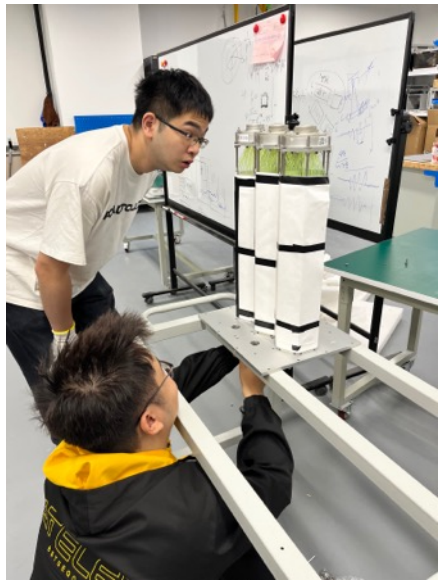
➢ Super-module Assembly (Tsinghua)

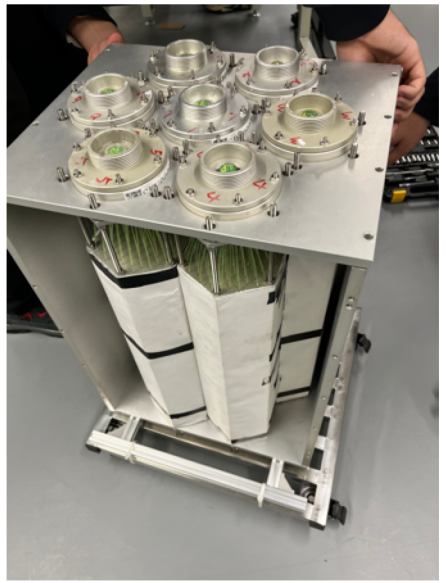
- Better to install all modules in the holes, install covers, then tighten them w/ screw caps → impossible to remove the central one after installation
- Very heavy! Each module weights 15kg → install them on the floor with a wheel-platform
- Light leak at the top and the bottom
- Still need to figure out how to install LED lights



Frame designed by ANL





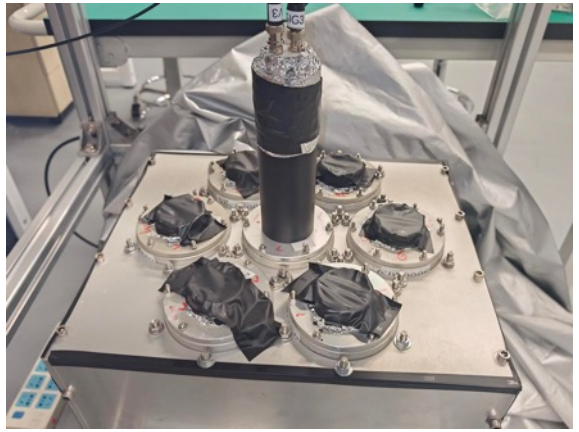


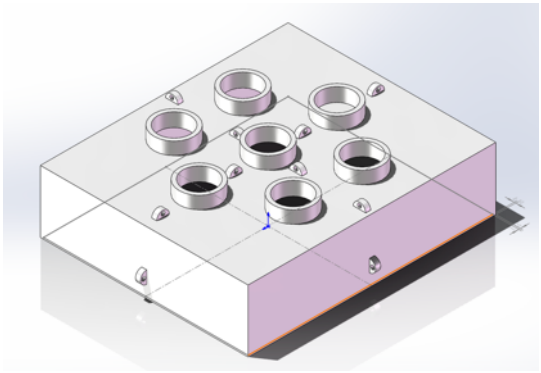
Light-Leak at the top&bottom

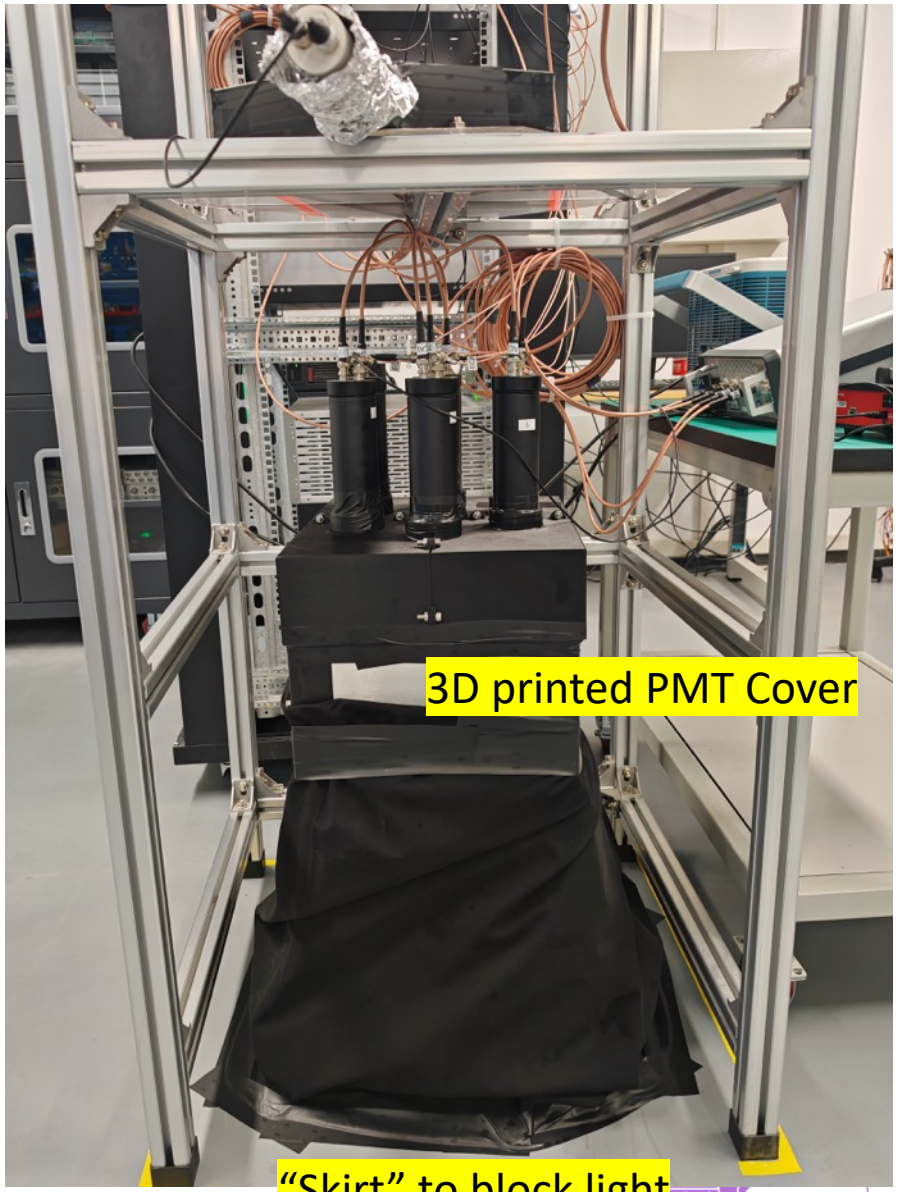
1st ECAL Super-module

➢ Super-module Assembly (Tsinghua)

- ☐ Install 7 Hamamatsu PMTs
- ☐ Design and order 7 metal cover tubes
- ☐ 3D printed a plastic cover to fix PMTs and block out lights on top



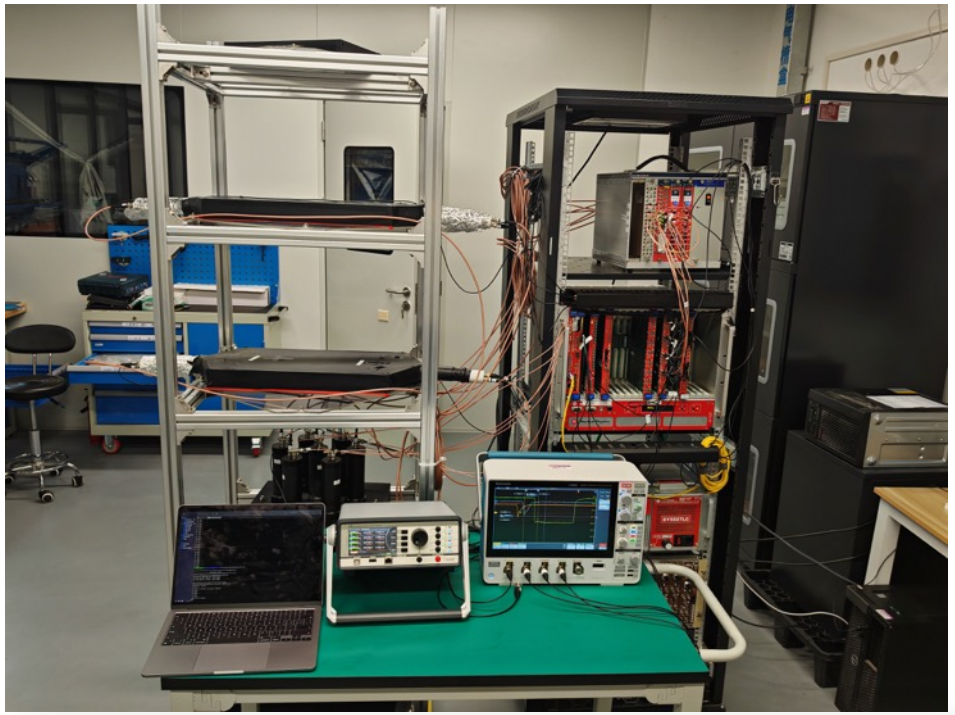


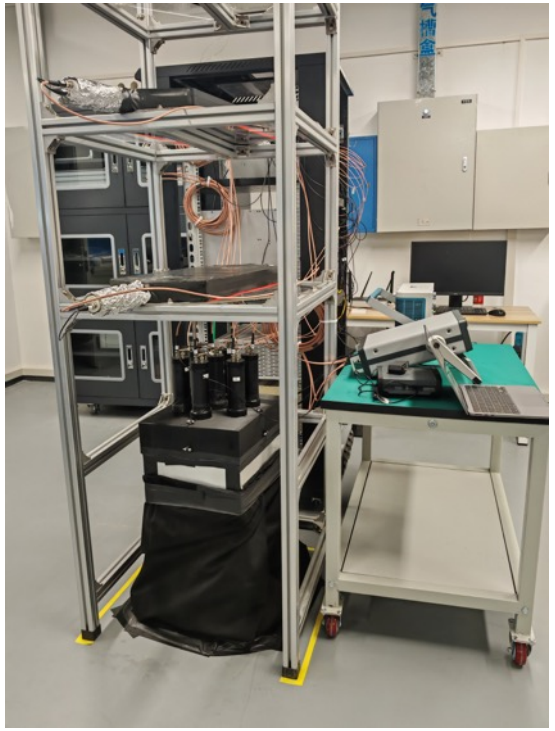


1st ECAL Super-module

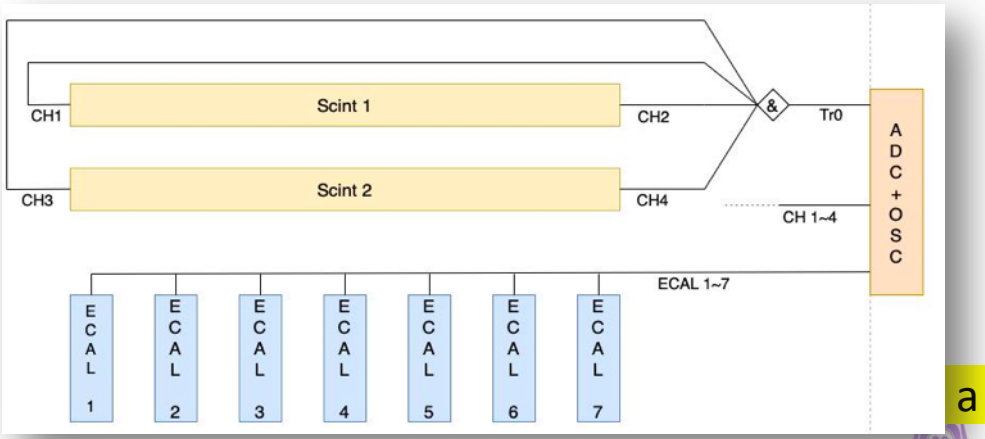
➢ Cosmic-ray Test at Tsinghua

- DAQ Setup:
  - ✓ Two scintillator pads (4 chs)
  - ✓ NIM crate for HV + triggers, VME crate for QDC, v1742
  - ✓ Setting up CODA→ need CPU
  - ✓ To add two layers of Micromegas trackers next week → need APV25 or similar readout electronics.



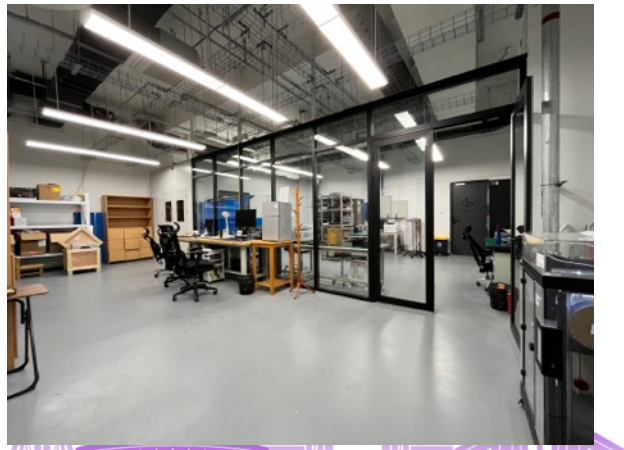


- Two photon sensor options:
  - Three single anode MCP-PMTs
    May not need clear fibers
  - Hamamatsu MaPMT in hand:
    2x H12700A, 2x H12700A-03,
    2x H12445-100

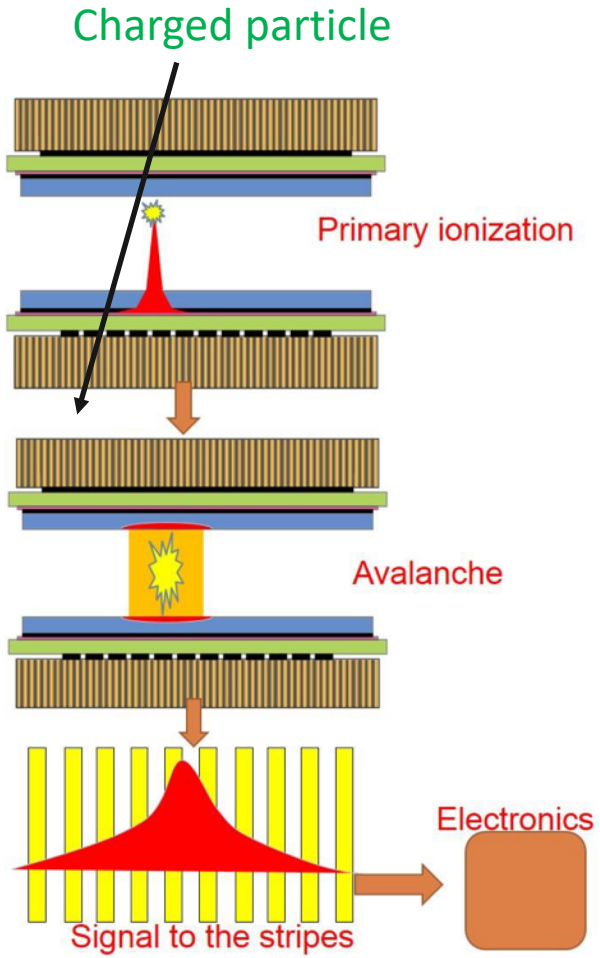


New Lab at Tsinghua

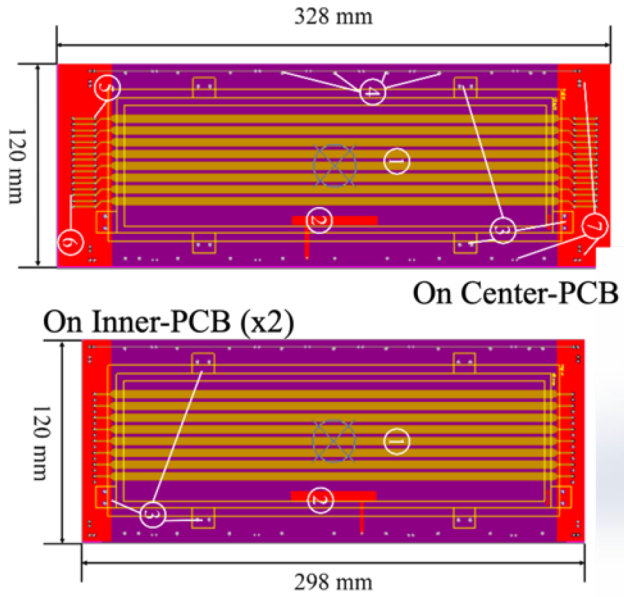
- Full Operation in December 2024
  - Underground 2nd floor, 100m^2,
  - Two test rooms, one dark/clean room

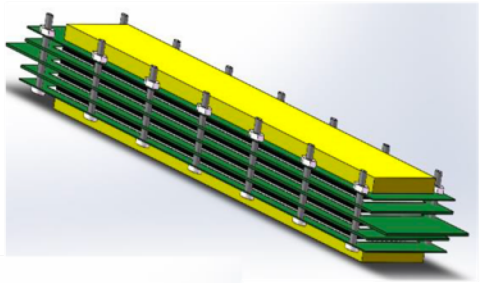


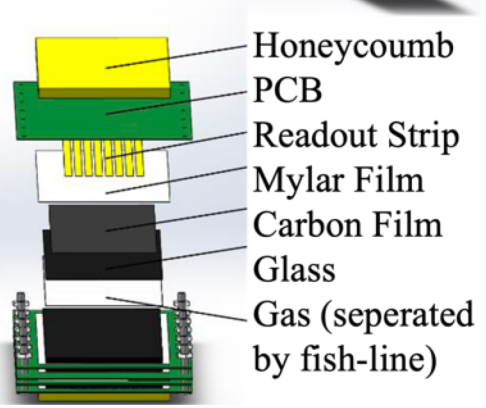
Multi-gap Resistive Plate Chamber (MRPC)

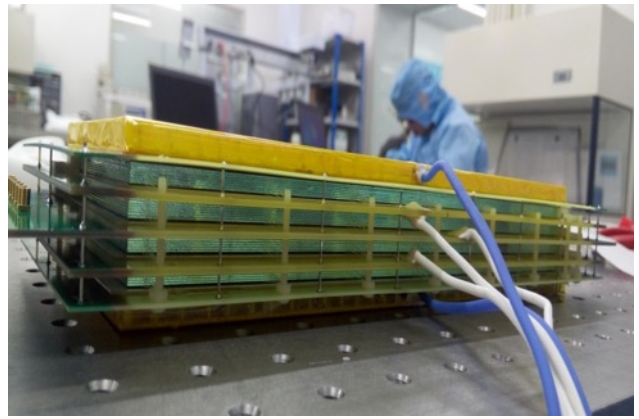


- Low-resistivity glass plates, Standard gas (95% F134a + 5% iso-butane), HV(~12kV)
- Good performances:
  time resolution, efficiency, rate capacity (>30kHz/cm^2), radiation-hard, magnet safe
- Certain spatial resolution (by strip pitch, 0.5cm~1.0cm)
- Low cost, easy manufacturing, large sensitive area (up to 1.0mx0.5m)
- Used by ALICE, STAR, etc.





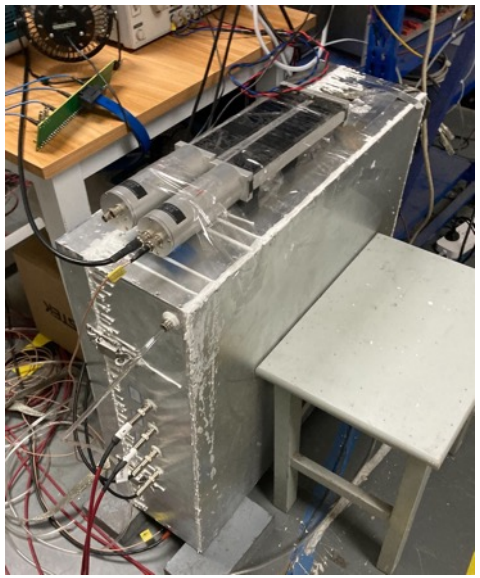


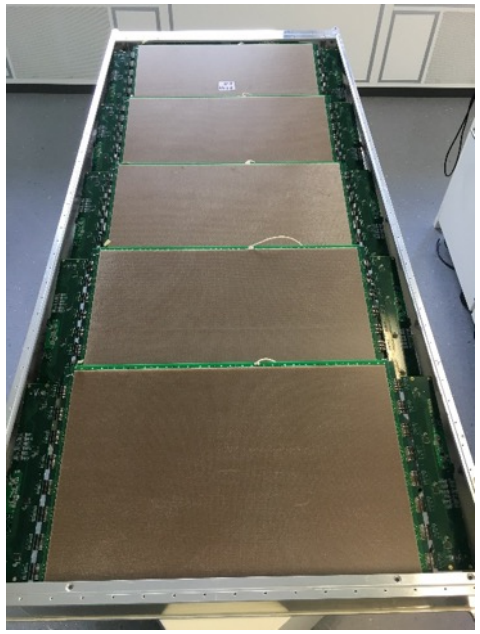


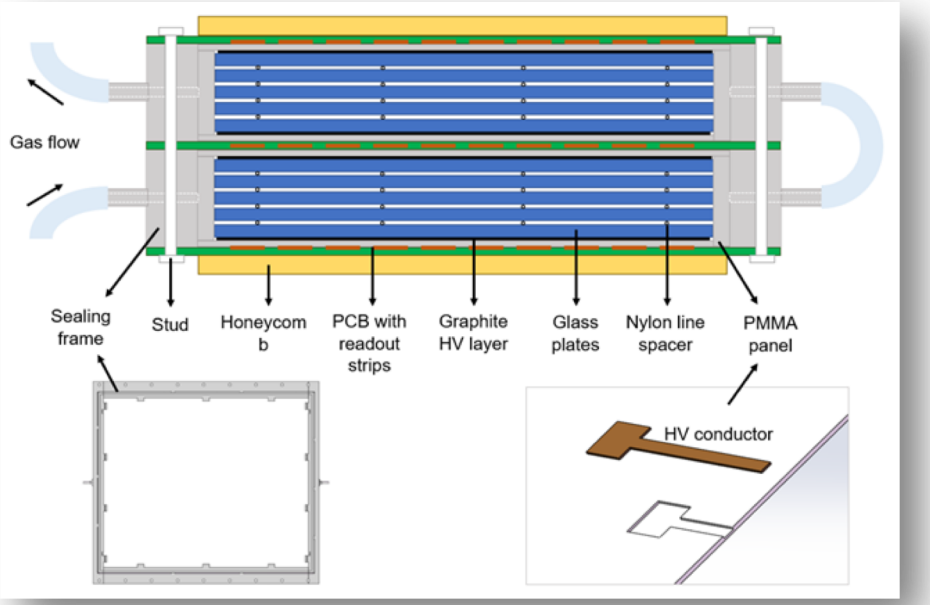
MRPC at Tsinghua

➢ Tsinghua's new Sealed MRPC (sMRPC)

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

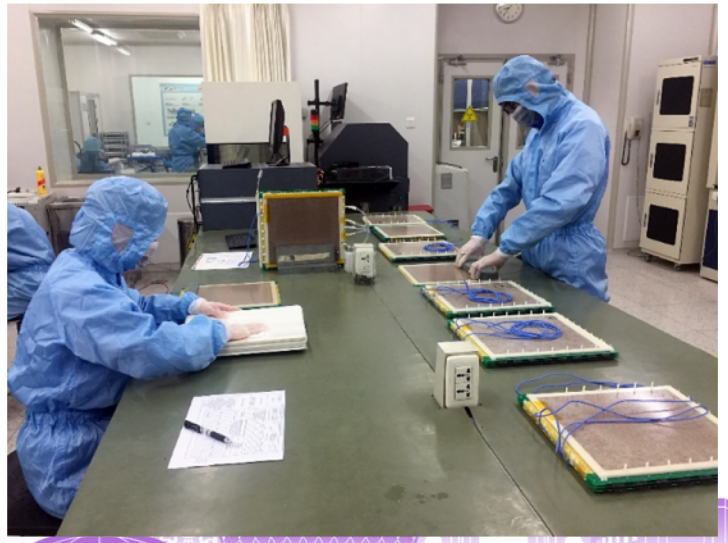






- ❑ sMRPC for CEE & CBM experiments
  - ✓ 32 x 27 cm^2
  - ✓ handle up to 25KHz/cm^2
  - ✓ 8x2 layers at 140um → 60ps!
  - ✓ Readout by NINO+TDC
  - ✓ Mass production at Tsinghua's Miyun workshop

Y. Wang et al 2019 JINST 14 C06015
D. Hu et al 2019 JINST 14 C09014

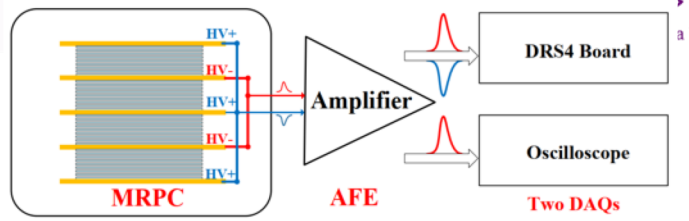


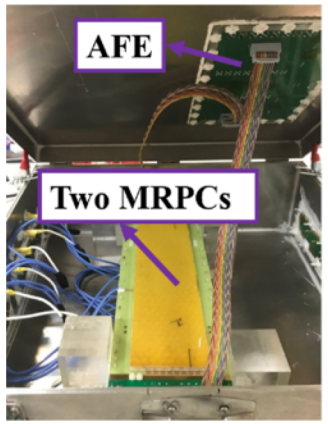
MRPC at Tsinghua

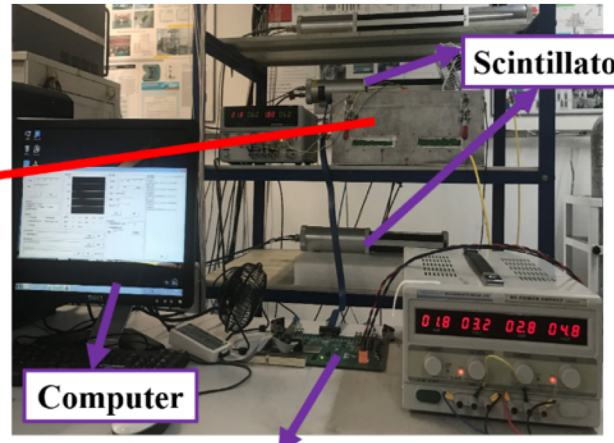
➢ Tsinghua's High-Time Reoslution MRPC

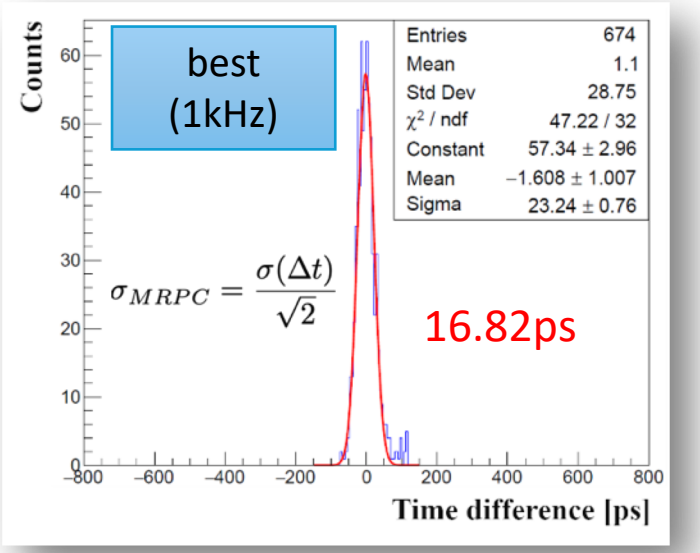
❑ For SoLID's high-rate & high-background environment

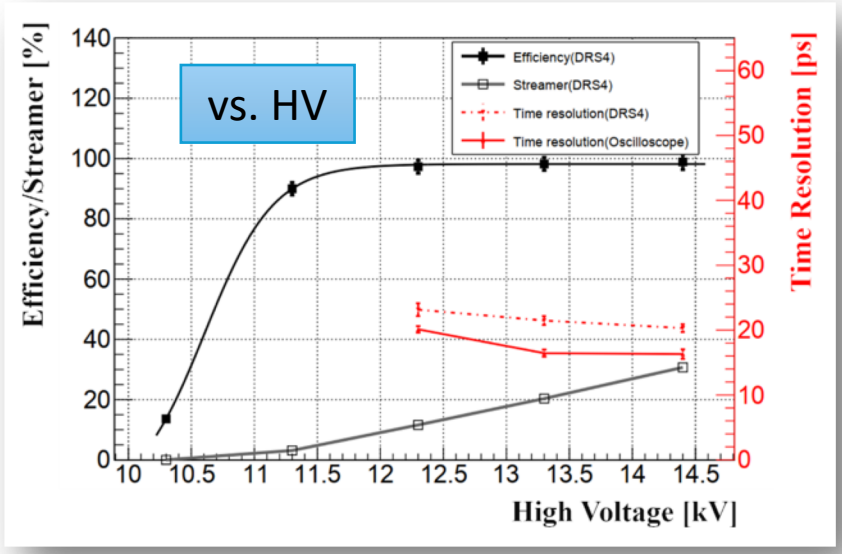
- ✓ Low resistance glass ($10^{10}\Omega \cdot cm$, best quality)
- ✓ 32-gaps (4 stacks), 400um thin glasses
- ✓ 104um gas-gap + waveform-sampling
  - → 20ps & 95% efficiency at 15kHz
- ✓ 128um gas-gap + ToT method → 20ps at 15kHz
- ✓ Small sizes & not sealed yet

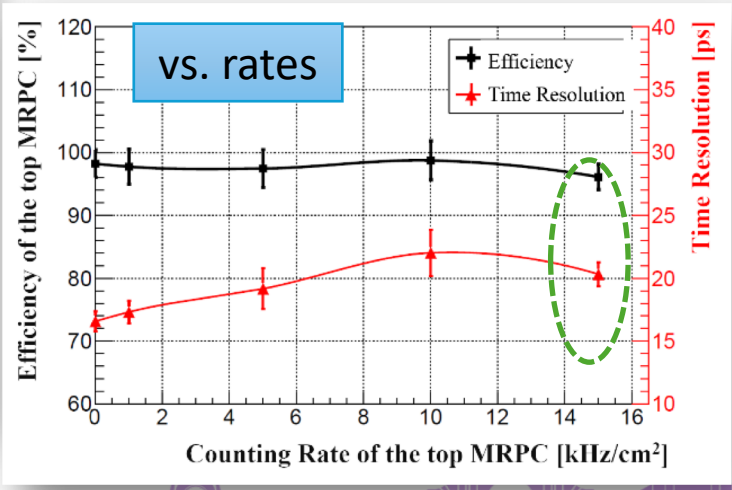












❑ Not proven in real beam!

Y. Yu et al 2022 JINST 17 P02005

Y. Yu et al 2020 JINST 15 C01049

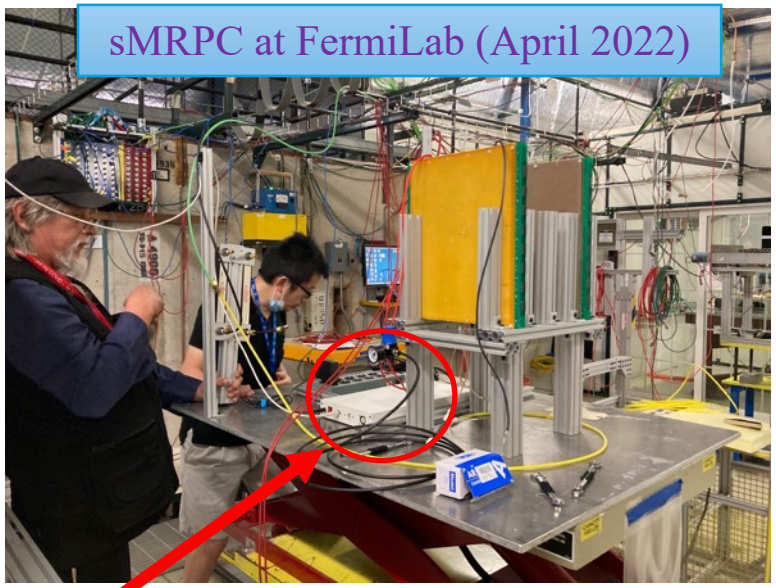
FEE for MRPC

➢ Readout Electronics

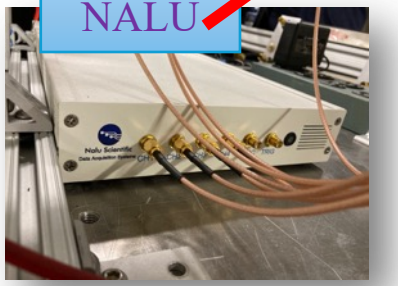
❑ Goals: Test out time-resolution w/ front-end electronics options

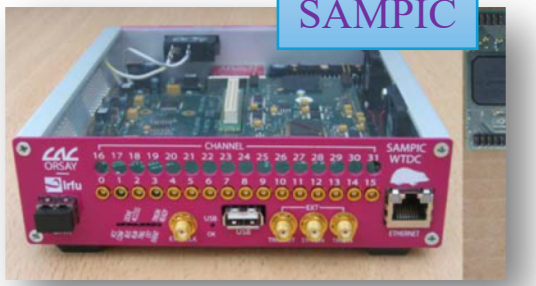
❑ Supports from Crispan Williams, Jorgen Christiansen, David Porret (CERN), Lei Zhao (USTC), & Zhen Hu (Shenzhen Advanced Research

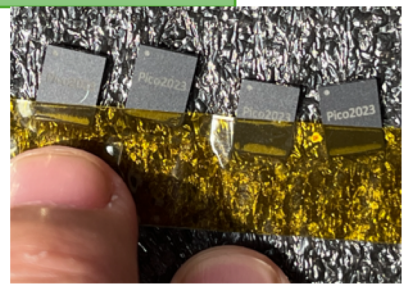
- ❑ PreAmp + DIS
  - NINO (discontinued)
  - pico2023 (*NEW*)
- ❑ TDC
  - FPGA base (not rad. dard)
  - picoTDC (*NEW*)
- ❑ Waveform Sampler
  - DSR4 (slow)
  - SAMPIC （at Jlab now)
  - NALU AARDVARC



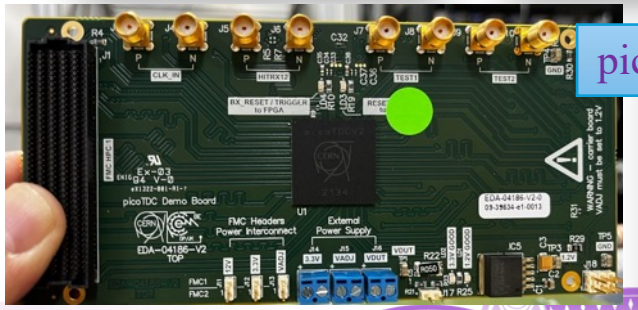

USTC FEE (NINO+FPGA-TDC)


NALU


SAMPIC




Pico2023 (replacing NINO)


picoTDC

MRPC Test Plan

➢Recent updates:

- JLab local test with cosmic-ray + xray background (Sanghwa & Alex & Barcu)
  - ✓ 4 planes of 16-layer sMRPC + SAMPIC & NALU → ordering gas now

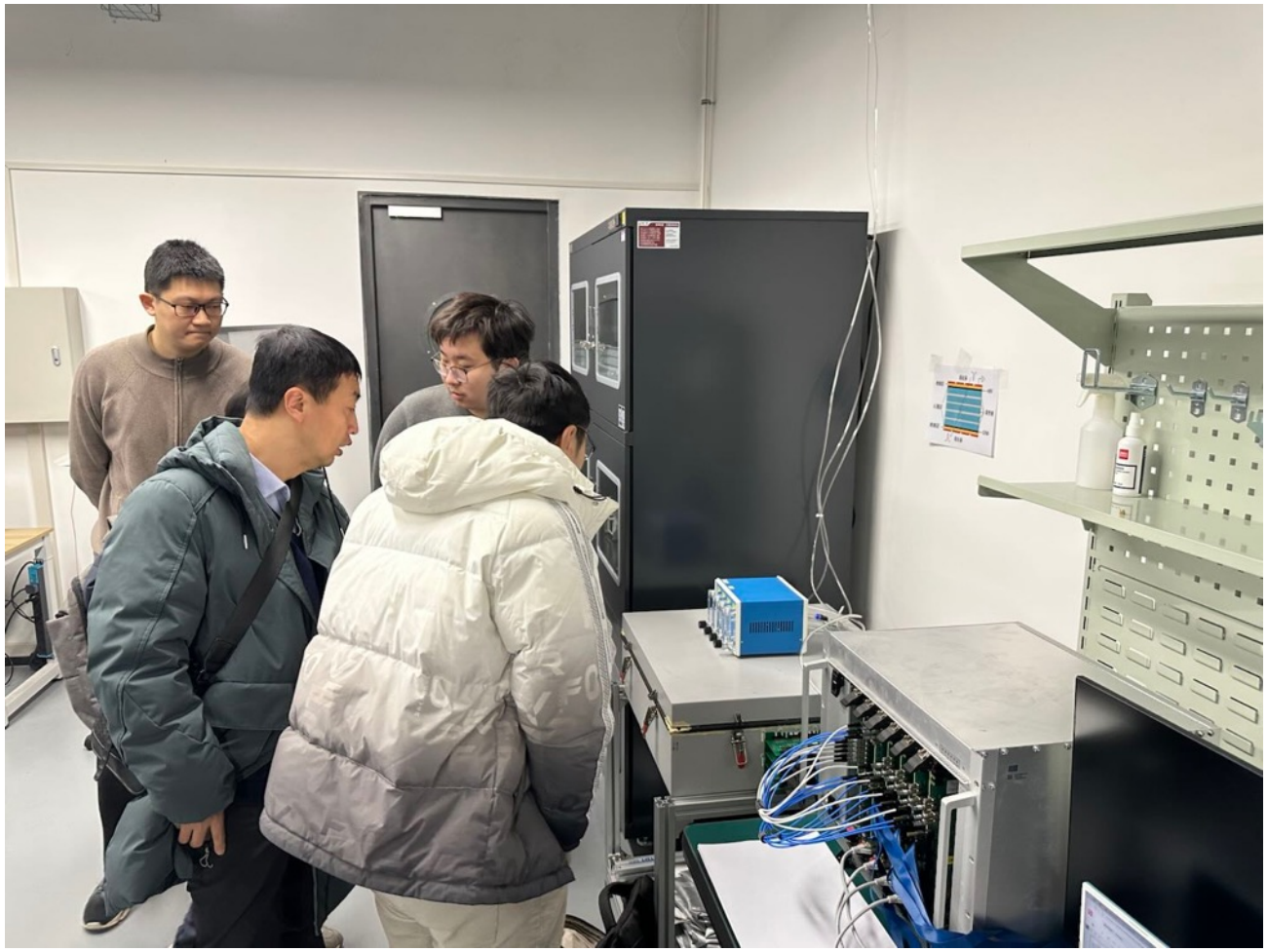
- Tsinghua's local test with cosmic-ray + x-ray background
  - ✓ 1 plane of 32-layer high-rate MRPC (not sealed) + 1 plane of 16-layer sealed mRPC (regular rate)
  - ✓ FEE to test: USTC FEE 64 chs in hand + 128 channels in production , pico2023 + DT5202 (picoTDC)
  - ✓ Order of 200 picoTDC chips on hold due to Euro-Union regulation
  - ✓ Restrict to by SAMPIC

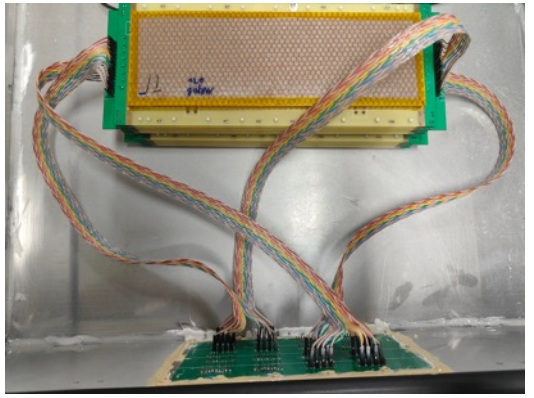
- Prepare Jlab beam test soon
- Use mRPC in the upcoming Hypernuclear experiment? → Electronics channels needed and how to get them?

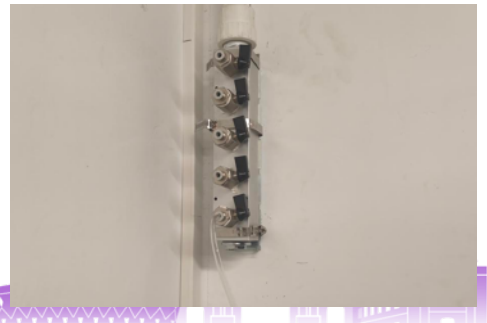
MRPC Test Plan

➢ Cosmic-ray Test at Tsinghua

- ❑ Complete new test setup in the new lab (high-rate MRPC + USTC FEE + picoTDC)
- ❑ To be integrated with the ECAL test



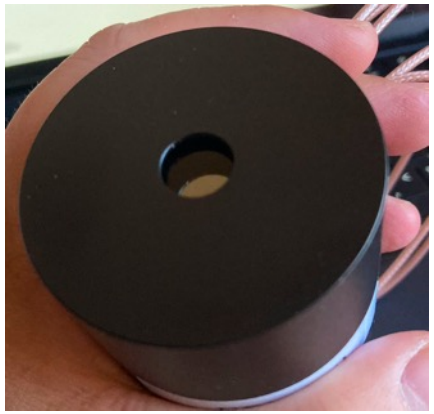




Beam Test Plan

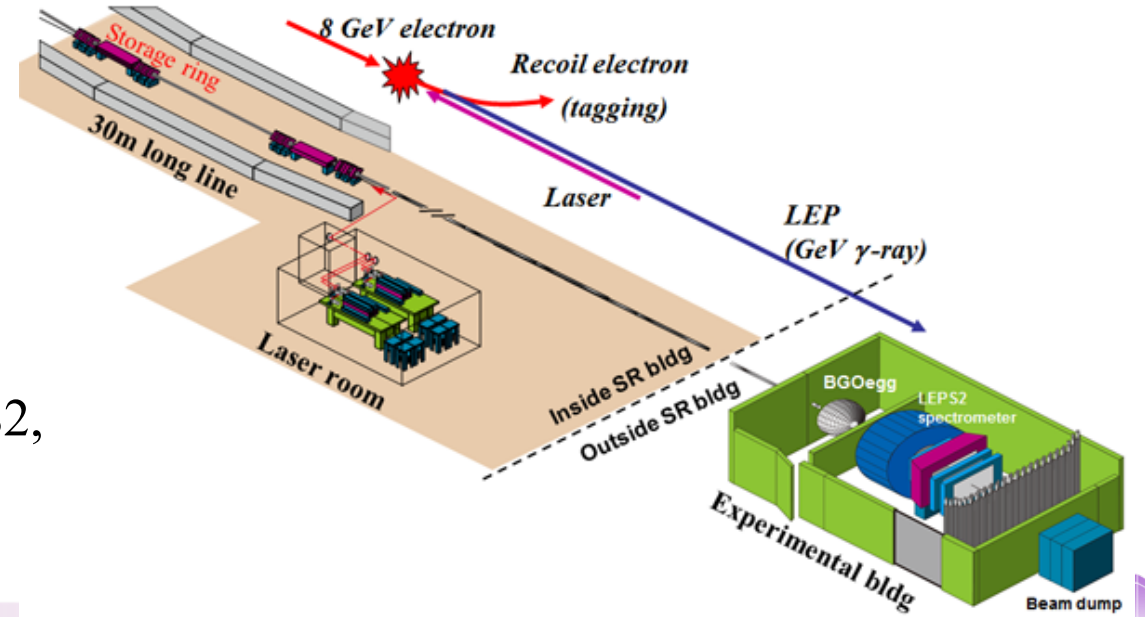
- Test of photon-sensors for ECAL:
  - 3x MCP-PMTs from night-vison to do radiation tolerance test at IMP or CSNS in 2025
  - Magnet field test at Jlab (one MCP at Jlab now)

Single-Anod MCP



- MRPC test at IMP w/ proton beam

- Explore electron beam test facilities, e.g. Spring-8 LEPS2, DESY, or Hall-D? → need to discuss



Summary

- Tsinghua's cosmic ray test lab is ready for ECAL and mRPC Tests
- First ECAL Super-module assembled and ready to do cosmic ray tests
  - ✓ Second super-modules to be assembled
  - ✓ Start SPD & Pre-Show R&D?
- mRPC tests are in underway at Tsinghua and preparing at Jlab
- Explore Beam test facilities for ECAL + mRPC
- Need CODA to do integrated tests with ECAL, mRPC, micro-megas

➢ Better to think earlier for strategies to move forward with uncertain future!

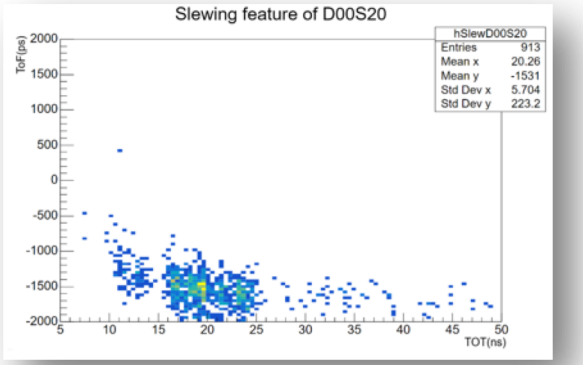
THANKS!

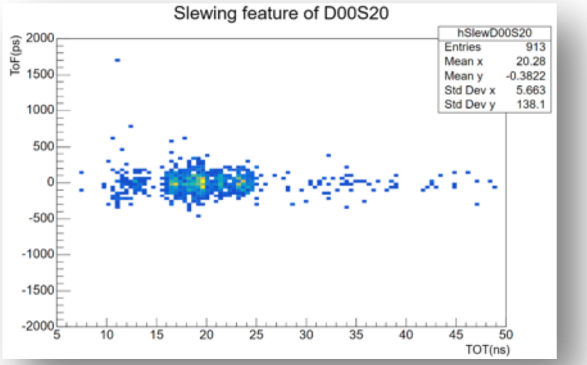
清華大學
Tsinghua University

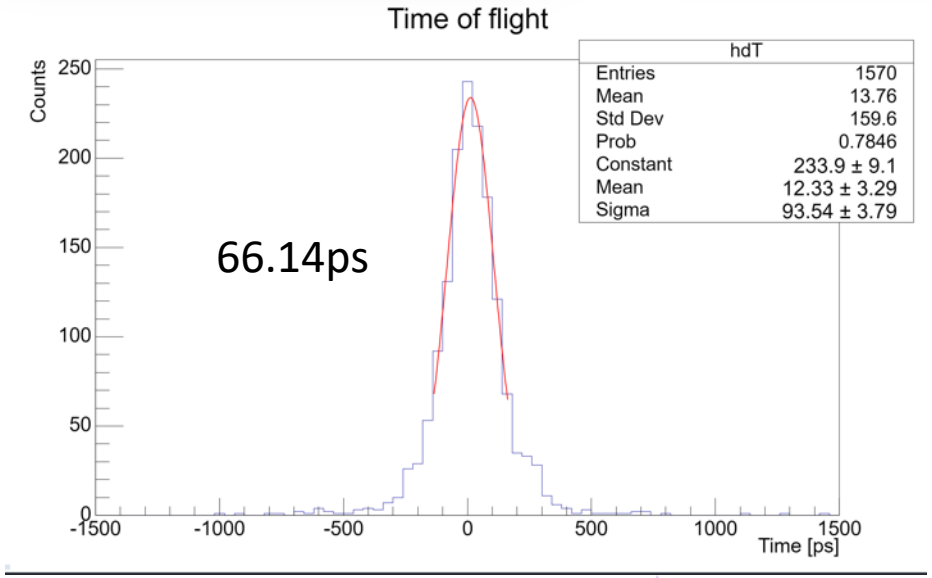
MRPC Test Plan

➢ Cosmic-ray Test at Tsinghua

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





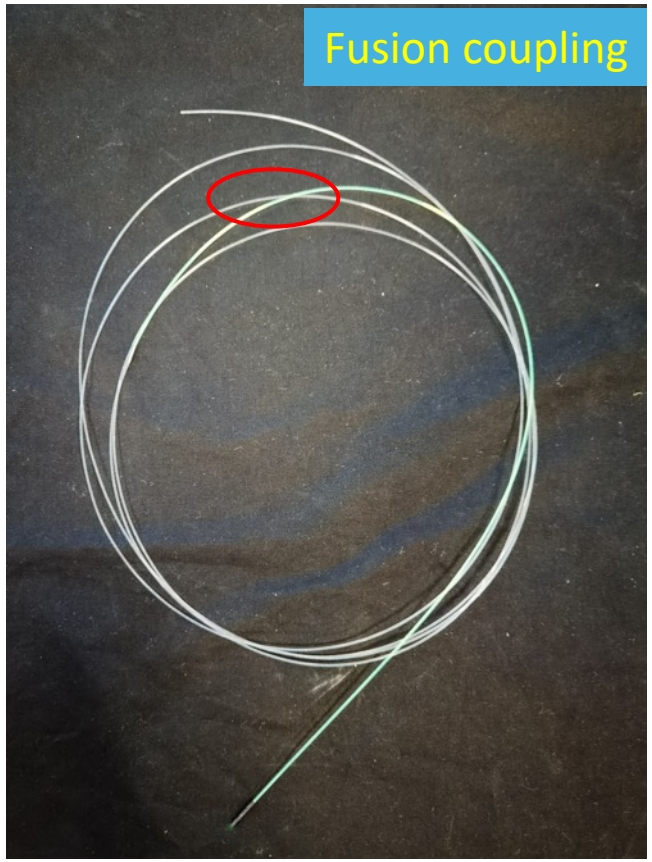


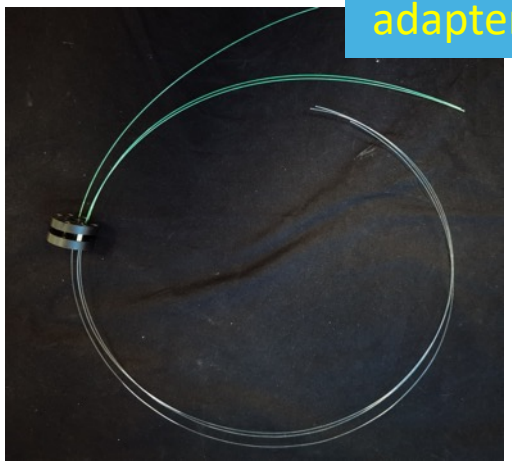
By Kai Sun, Zhaolin Chen

ECAL

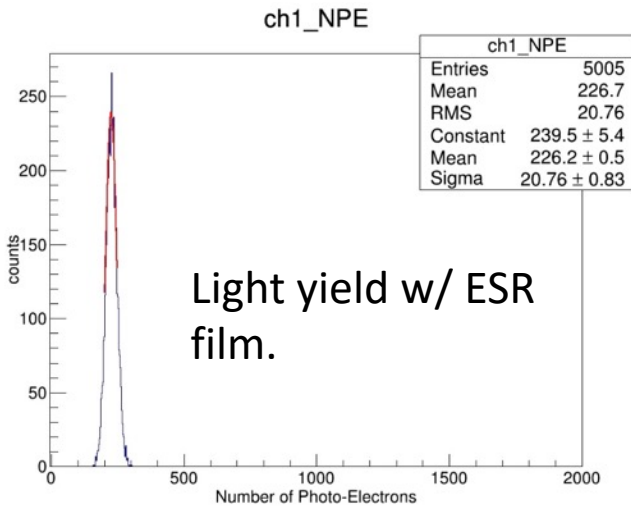
- **Shashlyk ECal Assembly (by Shandong):**

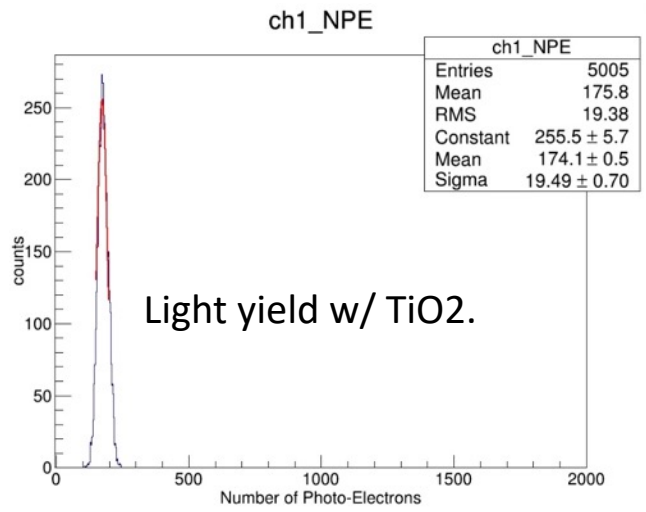
  - The fiber coupling test is ongoing. The new adapter design is easy for assembling, still under study to improve the quality.





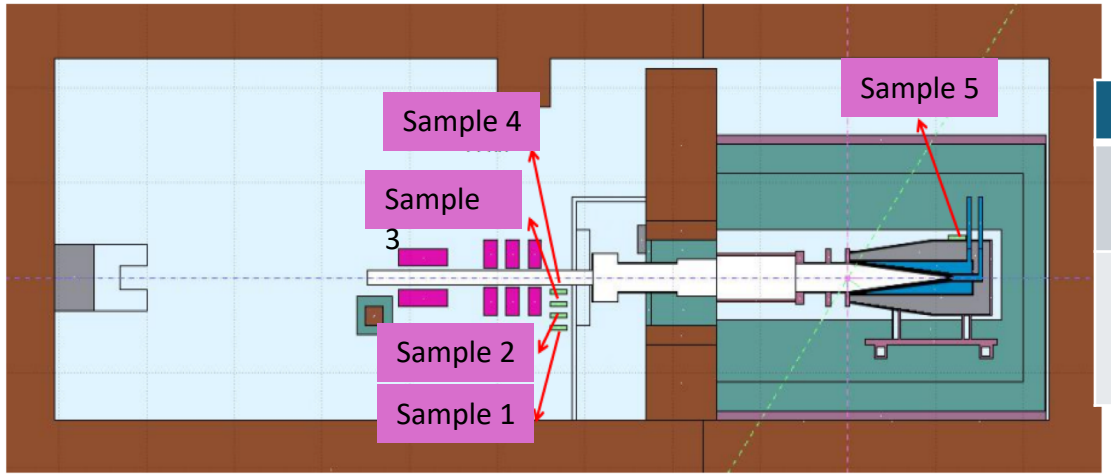
  - The reflectivity of ESR film is better than TiO2 painting





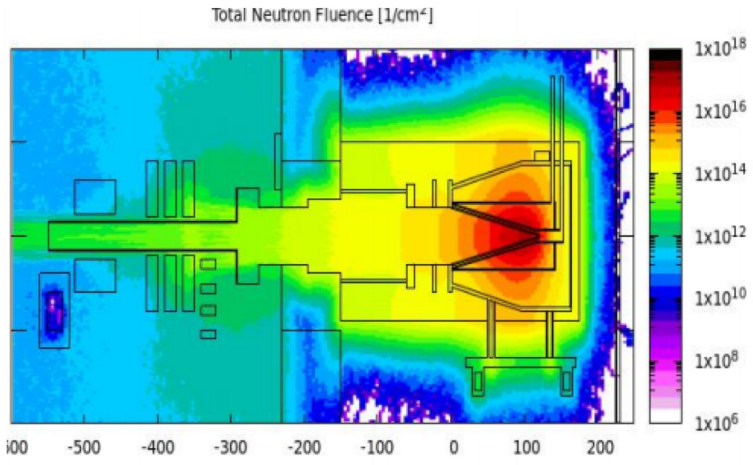
ECAL

- **Shashlyk ECal Assembly (by Shandong): :**



❑ Irradiation resistance test at IMP

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Total Irradiation(MeV/cm^2) by simulation (uncertainty 10%)	8.6E+11	1.4E+12	2.8E+12	3.7E+13	1.1E+14 **(Not tested)**
Test material	clear fiber	clear fiber BCF91A-MC scintillator	clear fiber BCF91A-MC scintillator	clear fiber BCF91A-MC scintillator	BCF91A-MC scintillator



❑ Satisfy radiation resistance requirement