

# EIC activities and Prospects from China-mainland Group

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Shandong University (山东大学)

Jan. 30, 2024  
4<sup>th</sup> EIC-Asia Workshop, Tainan

# Outline

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- EIC/ePIC participation status from China-mainland
- Forward EMCaI participation
- Interest with RICH/sMRPC
- Interest with LGAD

# EIC participation from China-mainland

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- **Oct 2020, 8 institutions in China-mainland submitted EOI to EIC, with main detector interests on calorimetry and tracking**
- **Participation in Yellow Report from Chinese institutions (2020~2021)**
  - ✓ Authors from 14 Chinese institutions involved in YR writing including both theorists and experimentalist, Bowen Xiao served as co-convener of semi-inclusive working group
- **Chinese groups actively participated in EIC detector proposals (2021)**
  - ✓ 8 institutions joined **ATHENA** proposal, Qinghua Xu served as co-convener of inclusive working group, with detector interest on EMCal etc.
  - ✓ 6 institutions joined **ECCE** proposal, Wangmei Zha served as co-convener of jets and heavy flavor working group, with detector interest on silicon tracker, MPGD etc.
- **After DPAP decision on EIC detector proposal ~March 2022, 6 Chinese universities are members of ePIC collaboration:**
  - ✓ **Central China Normal University (CCNU),**
  - ✓ **Fudan University,**
  - ✓ **Shandong University (SDU) ,**
  - ✓ **South China Normal University SCNU),**
  - ✓ **Tsinghua University THU),**
  - ✓ **University of Science and Technology of China (USTC)**

# EMCal interests with ePIC

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- **Institutions collectively involved:**

- Fudan University
  - Shandong University
  - Tsinghua University

- **Subsystems of interest:**

- **Forward Emcal (fEMCal) : W powder/SciFi**

- We are part of eRD106 proposal with W-ScFi technology, in close collaboration with UCLA group.

- These institutions have been actively working on different detectors at STAR, sPHENIX, ALICE experiments etc.

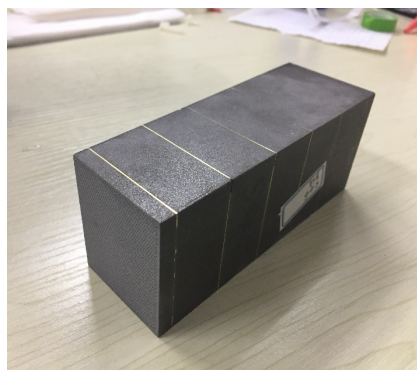
- talk by Weihui Ma on forward EMCal

# EMCal interests with ePIC

- **Previous experiences on fEMCal R&D and production:**
    - On Pb/Sc Shashlyk EMCal, both Tsinghua and Shandong University have lot of R&D experiences based on the Jlab-SOLID project, and several prototypes already.
    - On W powder/ScFi EMCal, Fudan/PKU/CIAE responsible for sPHENIX high-eta (0.8-1.1) EMCal Blocks .
  - **Collaboration with other institutes:**
    - In collaborating with UIUC, BNL, UCLA on W-powder EMCal for sPHENIX
    - In collaboration with Virginia University and Jlab on Pb/Sc Shashlyk EMCal for SOLID
- Blocks of W-powder/ScFi EMCal for sPHENIX produced at Fudan University.
- Pb/Sc Shashlyk prototypes made with SLOID at Shandong/Tsinghua University  
198 layers: 0.5mm Pb +1.5mm Sc.



W/ScFi EMCal blocks

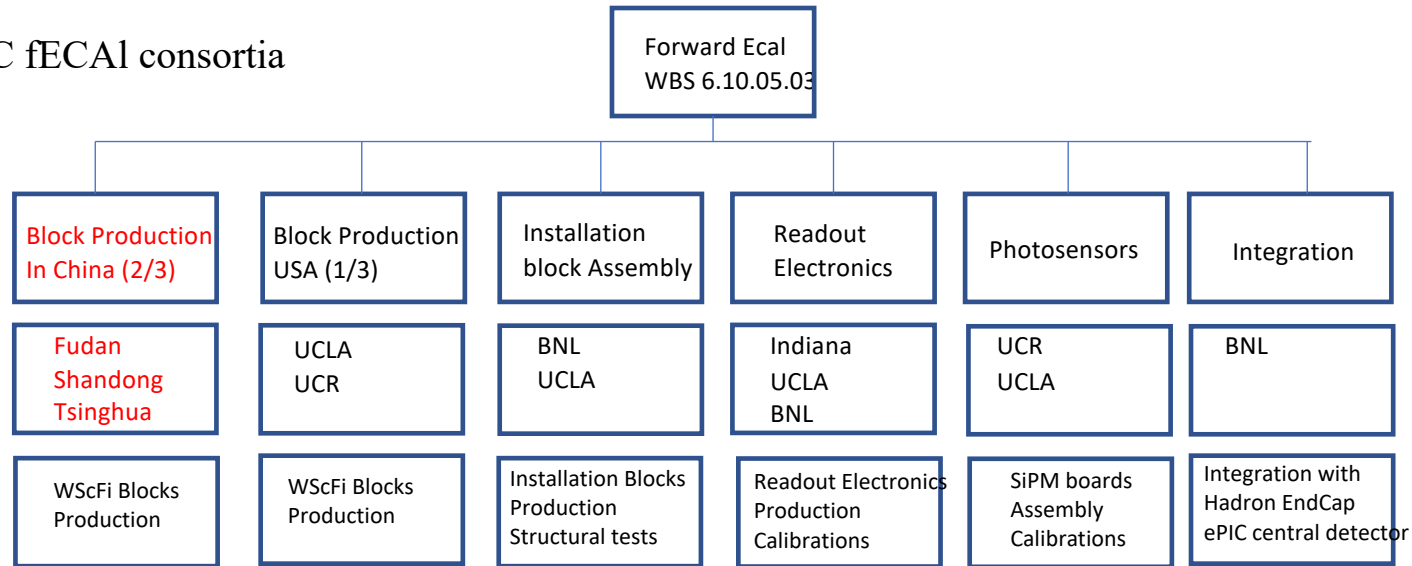


Pb/Sc Shashlyk module



Shashlyk module testing

## ePIC fECAL consortia



- Chinese fECal Consortium (Fudan University, Shandong University, Tsinghua University)
- University of California EIC Consortium (UCLA, UCR)
- Indian University
- BNL

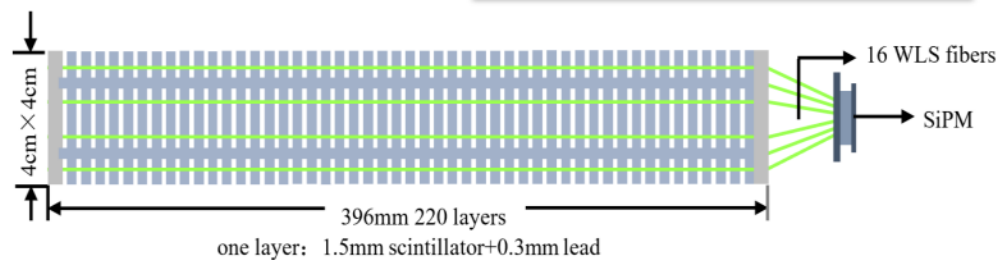
Groups have extensive expertise and capabilities in executing large scale projects in high energy and nuclear physics experiments around the world. (RHIC, JLab, CERN, Super KEKB).

Assumed, Production sites:

- China – 2/3 production blocks (backup plan is production of all blocks in the US)
- UC EIC (UCLA, UCR) – 1/3 production
- BNL – gluing 2/3 installation blocks and light guides.

# Nuclear physics group at Fudan University

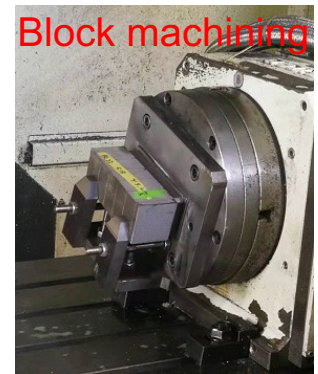
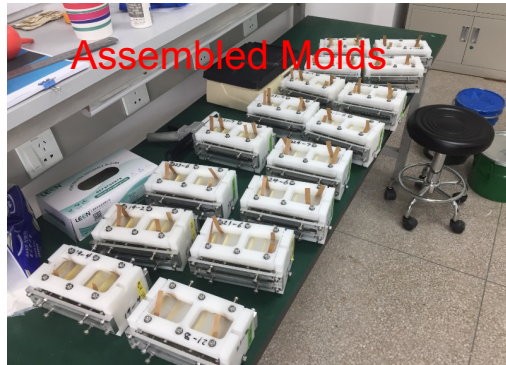
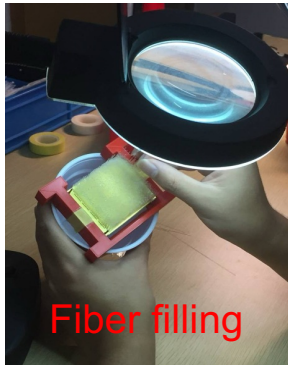
- Staff members: Jinhui Chen, Yugang Ma, Long Ma, Weihu Ma
- Fudan group has been actively working with STAR, sPHENIX, ALICE experiments, was responsible for sPHENIX high-eta (0.8-1.1) EMCal Blocks.
- At Fudan University, we established a laboratory with advanced standards and complete facilities to produce and test both Pb/Sc Shashlyk and W-powder/ScFi ECal EMCal modules.





# W/ScFi ECal production at Fudan University

- Fudan University has established the infrastructure for the construction of such W-powder/ScFi ECal blocks, including raw material procurement and testing, block production and processing, testing and QA, etc.
- China group has completed W/ScFi ECal production for sPHENIX successfully
- sPHENIX EMCAL blocks production flow at Fudan:



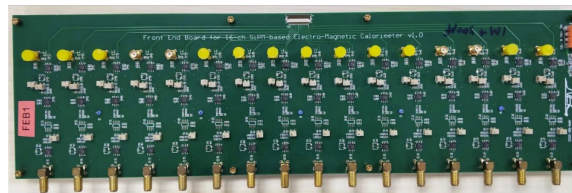


# Nuclear physics Group at Shandong University

- Staff members: Zhenyu Chen, Xiaqing Li, Xiaomei Li, Ting Lin, Weizhi Xiong, Qinghua Xu, Chi Yang, Li Yi, Jinlong Zhang
- Engineer: Kun Hu
- Technician: Jinxing Song, Pengfei Sun, Shengguo Zhang
- The SDU group is currently working with RHIC-STAR, CMS, Jlab experiments, and has been focusing on the nucleon spin structure and the heavy ion physics.
- Constructed the MWPC modules the inner TPC upgrade at STAR, also produced the small-strip Thin Gap Chamber(sTGC) for the forward tracking upgrade at STAR. Also a key part of EMCal R&D program for SOLID at Jlab.



Shashlyk prototyping



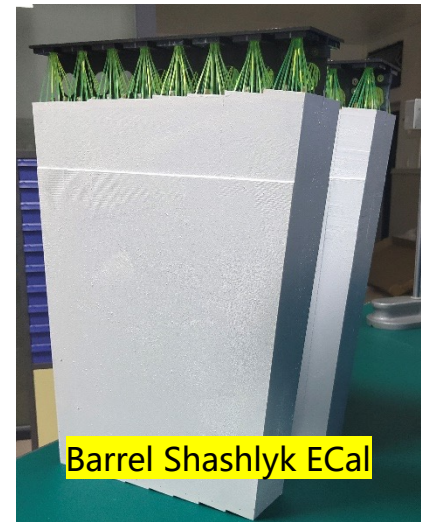
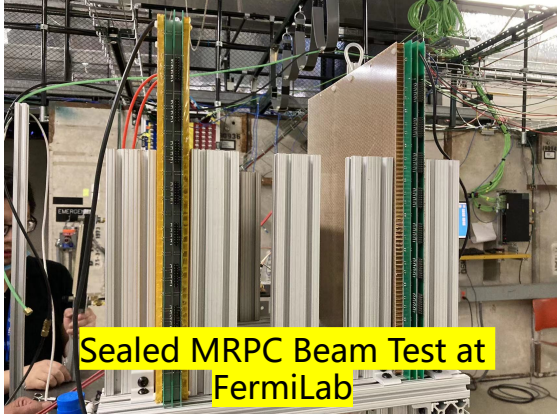
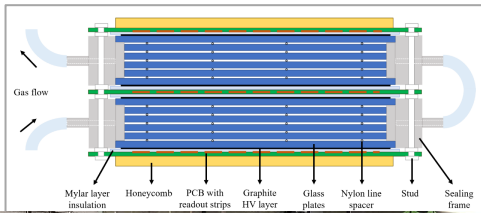
Front End Board for  
SiPM-based Ecal



CNC center

# Nuclear physics Group at Tsinghua University

- Staff members: Dong Han, Yi Wang, Zhigang Xiao, **Zhihong Ye**
- Technician: 3 full-time
- The Tsinghua group is working on multiple experimental projects at Jefferson Lab (Hall-A, B, C, SoLID) and RHIC-STAR experiment. Our physics interests are on hadronic structure of nucleons, e.g., spin, PDF, TMD, GPD, as well as nuclear structure of nuclei, e.g. SRC & EMC effect, asymmetric energy, equation of states, critical points etc.
- Tsinghua has extensive experience in developing the Shashlyk Ecal and the high-resolution sealed MRPC. We constructed MRPCs for RHIC-STAR, GSI-CBM and CSR-CEE. We are leading or heavily involving in the R&D efforts for SoLID and US-EIC.



# sMRPC R&D effort at Tsinghua University

- talk by Zhihong Ye

## ➤ sMRPC R&D for US-EIC

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

### ❑ Goals:

- Real performance with high-energy/high-rate background
- Test out high-time-resolution front-end electronics
- Investigate different eco-friendly gas mixtures

### ❑ To-do at JLab:

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

## ➤ R&D Task#2: Readout Electronics

- ❑ 2 high-rate sMRPC built and test w/ cosmic-ray at Tsinghua
- ❑ Goals: Test out new front-end electronics options

### 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 Camsonne<sup>1</sup>, Sanghwa Park<sup>\*1</sup>, Yi Wang<sup>2</sup>, Zhenyu Ye<sup>3,4</sup>, Zhihong Ye<sup>†2</sup>

<sup>1</sup>Thomas Jefferson Lab, Newport News, Virginia, 23606, USA

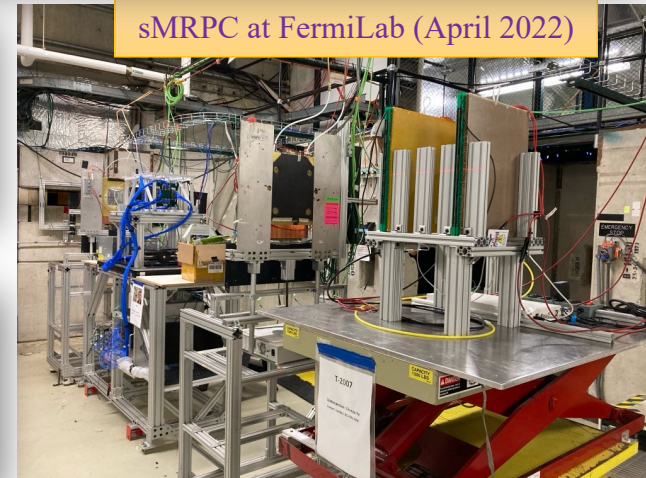
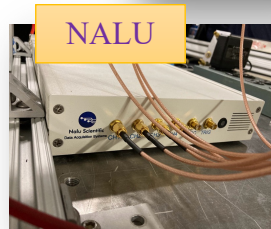
<sup>2</sup>Department of Physics, Tsinghua University, Beijing 100084, China

<sup>3</sup>Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

<sup>4</sup>University of Illinois at Chicago, Chicago, IL 60607, USA

<sup>†</sup>PI: Zhihong Ye, yez@tsinghua.edu.cn

<sup>\*</sup>coPI: Sanghwa Park, sanghwa@jlab.org





# RICH & Aerogel R&D for EIC at Tsinghua

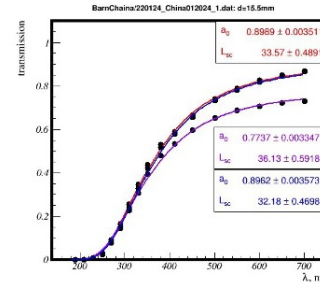
## ➤ Aerogel R&D:

### ❑ R&D of hydrophobic aerogels

✓ Three samples sent to JLab (10cm\*10cm\*2cm)



- ✓  $n \sim 1.03$
- ✓ Good transparency
- ✓ Need improving uniformity and flatness



- talk by Zhihong Ye

### ❑ Setting up a new production line at Tsinghua

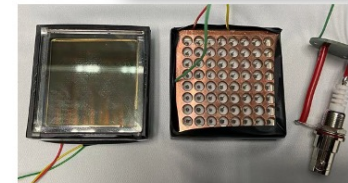
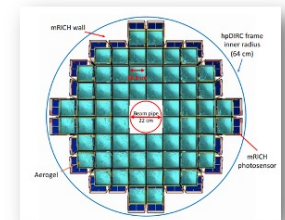
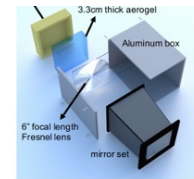
❑ **HOWEVER**, a recent incident at Tsinghua makes it difficult to set it up  
 → Look for off-campus lab or new chemistry collaborators?



## ➤ RICH R&D:

- ❑ Worked on Geant4 Simulation on dRICH (not active anymore...)
- ❑ Actively involved in mRICH R&D
- ❑ mRICH was out-selected by ePIC, but Tsinghua is still continuously developing
  - Active support from X. He and other mRICH team members
  - Compact design for prototyping → studying aerogel tiles and photo-sensors
  - For EIC Detector#2 and Chinese-EIC
- ❑ What availables at Tsinghua:
  - Building a mRICH frame designed by A. Eslinger
  - MaPMT ordered: 2\*H12700A, 2\*H12700A-03, 2\*H12445-100
  - 2 \* MCP-PMT (8\*8, same form-factor as H12700)
  - Lenses & Laser system
  - LED source (down to single-photon)
  - XYZ-step-motor (for pixel-scan)
  - China and BINP aerogels

❑ To-Do: Build a mRICH prototype in 2024 summer (w/ THU aerogels)



# CCNU interests and experiences



➤ Staff members: Kai Chen, Xiangming Sun, Yaping Wang, Zhongbao Yin, Yuxiang Zhao

## ➤ Interests to the EIC:

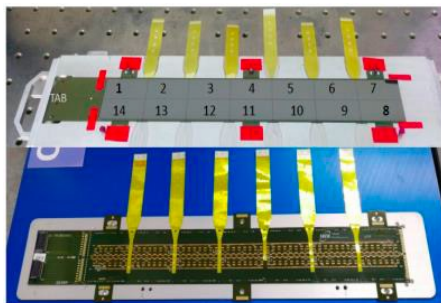
- Pixel sensor design
- Pixel detector assembly, test & production
- Readout electronics & DAQ
- Tracking simulation, physics simulation

## ➤ Prior experiences and infra-structure:

- Co-developed the ALPIDE chip
- Contributed to ALICE ITS2 module mass production (constructed the ALICE ITS2 HIC and stave production lines at CCNU)
- Contributed to sPHENIX MVTX (MAPS) related readout, trigger and DAQ
- Developing MAPS chips in China (Top-metal series chips, MIC series chips, etc.)



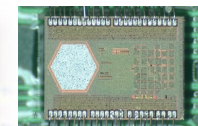
ISO7 clean room (60 m<sup>2</sup>)



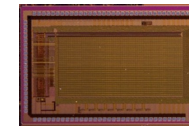
ALICE ITS2 OB HIC module



ISO6 clean room (100 m<sup>2</sup>)



Topmetal-S



MIC series



PCIe-based DAQ



# USTC experiences and interest with LGAD

- Staff members : Lei Zhao, Hao Liang, Yanwen Liu, Yongjie Sun, Yusheng Wu, Lailin Xu, Yifei Zhang, Zhengguo Zhao
- High Granularity Timing Detector (HGTD) is an upgrade project for HL-LHC to mitigate the high pile-up running condition by adding timing info
- Sensor technology: Low-Gain Avalanche Detector (LGAD), time resolution per hit 35 ~ 70 ps up to NIEL of  $2.5E15 \text{ cm}^{-2} \text{ Si } 1 \text{ MeV } n_{eq}$
- USTC responsibilities in sensor and assembly RD: design and fabricate 10% of the sensors and assemble 10% of the detector modules
- Possible interest with LGAD project: Sensor R&D and fabrications, ASIC, simulations

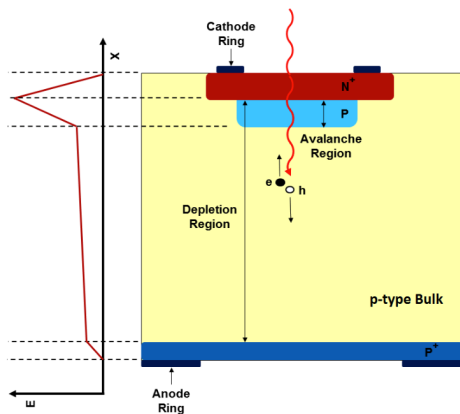
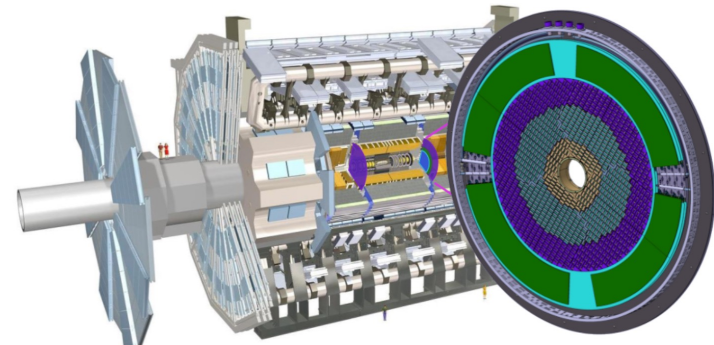


Illustration the LGAD technology



Planned installation location of HGTD in ATLAS

# Nuclear physics Group at South China Normal University

- Staff members: Faculties: Jifeng Hu, Hengne Li, Guoming Liu, Shuai Yang
  - Guoming Liu and Shuai Yang participate the EIC project
- The SCNU group is currently working with LHC-CMS, LHC-LHCb, RHIC-STAR and BEPCII-BESIII experiments
  - Heavy-ion physics, electroweak physics
- Setting up a test platform for LGAD R&D
  - Clean room available detector R&D
  - SCNU already has 10 HPK LGAD sensors for CMS end-cap MIP Timing Detector



# Test platform for LGAD R&D at SCNU

## ➤ Probe station for I-V, C-V measurements of semiconductor sensors

- High/low temperature:  $-100 \sim 300^{\circ}\text{C}$
- Micropositioner resolution :  $1 \mu\text{m}$

Probe Station



+



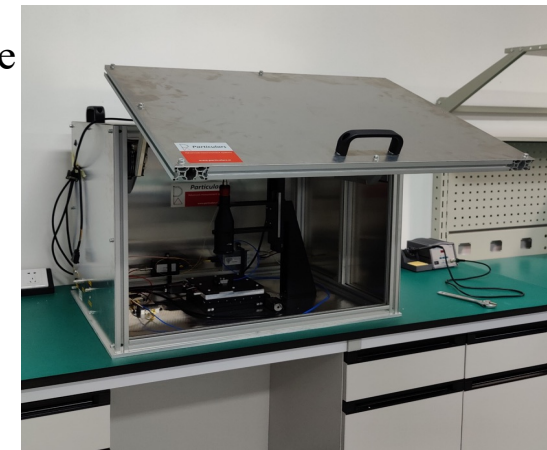
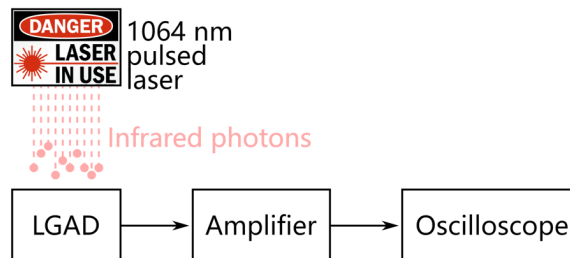
LCR meter



Source Meter  
SMU

## ➤ Scanning TCT system

- Test LGAD efficiency & time resolution with laser or beta-source
- Pico- second IR laser with spot diameter around  $10 \mu\text{m}$
- Moving position resolution:  $1 \mu\text{m}$



# Summary

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- 6 universities from China-mainland are participating ePIC experiments since 2022. 12 institutions in EIC user group.
- Hardware prospects:
  - Forward EMCAL R&D, construction for ePIC
  - R&D of RICH/sMRPC for ePIC
  - Interest with LGAD
- Collaborate and contribute to EIC as much as possible. Organize next EIC-Asia meeting in Shanghai in July 2024.

# Next EIC-Asia workshop in Shanghai

- We are planning for 4<sup>th</sup> EIC-Asia meeting in Shanghai, July 1-5, 2024.  
<https://indico.cern.ch/event/1361239/overview>

## The 4th EIC-Asia Workshop


Jul 1 – 5, 2024  
Asia/Shanghai timezone


- Overview
- Timetable
- Venu
- Visa to China
- Hotels
- Previous EIC-Asia workshops

The aim of this workshop is to discuss in depth the opportunities as well as experimental and theoretical activities relevant to the upcoming EIC, in particular on the contribution/collaboration of/among Asian physicists to the EIC relevant physics.

### International Advisory Committee

- Elke-Caroline Aschenauer (BNL)
- Jian-Ping Chen (Jefferson Lab)
- Abhay Deshpande (Stony Brook U.)
- Rolf Ent (Jefferson Lab)
- Yuji Goto (RIKEN)
- Yongsun Kim (Sejong U.)
- John Lajoie (Iowa State U.)
- Zuo-Tang Liang (Shandong U.)
- Yu-Gang Ma (Fudan U.)
- Bedanga Mohanty (NISER)
- Swagato Mukherjee (BNL)
- Carlos Munoz-Camacho (IJCLab, Orsay)
- Paul Newman (Uni. of Birmingham)
- Marco Radici (INFN, Pavia)
- Yi Yang (NCKU)
- Ben-Wei Zhang (CCNU)
- Binsong Zou (Tsinghua U.)

 **Starts** Jul 1, 2024, 8:00 AM  
**Ends** Jul 5, 2024, 6:00 PM  
Asia/Shanghai

 [Jinhui Chen](#)  
[Heng-Tong Ding](#)  
[Qinghua Xu](#)