EIC activities in China-mainland

Qinghua Xu, Shandong University

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Outline:

- EIC participation status from China-mainland
- EMCal interests with ePIC
- Interests with Silicon and RICH
- Interest with LGAD

EIC participation from China-mainland

- **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 remain with EIC detector 1, i.e., ePIC experiment.** Wangmei Zha serves as co-convener of jets and heavy flavor working group.
  - ✓ 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

- **Institutions collectively involved/contact person:**

  Xu, Qinghua, Shandong University, xuqh@email.sdu.edu.cn
  Chen, Jinhui, Fudan University, chenjinhui@fudan.edu.cn
  Ye, Zhihong, Tsinghua University, yez@tsinghua.edu.cn
  Li, Hengne, South China Normal University,
  Hengne.Li@m.scnu.edu.cn

- **Subsystems of interest:**

  - **Forward EMcal :** W powder/ScFi

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

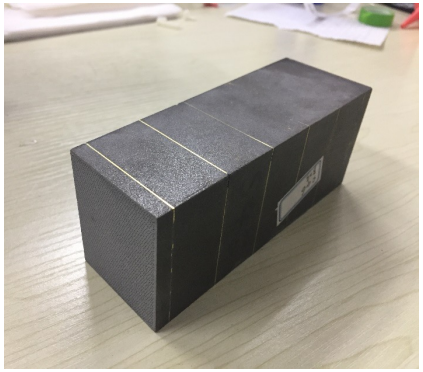
- These institutions have been actively working on different detectors at STAR, sPHNIX, ALICE, LHCb experiments.

EMCal interests with ePIC

- **Previous experiences on EMCal 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

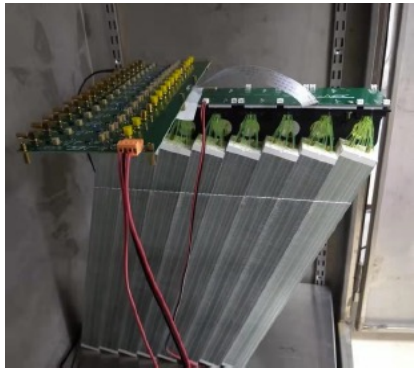
➢ Blocks of W-powder/ScFi EMCal for sPHENIX produced at Fudan University.

➢ Pb/Sc Shashlyk prototypes made with SLOID at Shandong/Tsinghua University 198 layers: 0.5mm Pb +1.5mm Sc.



W/ScFi EMCal blocks

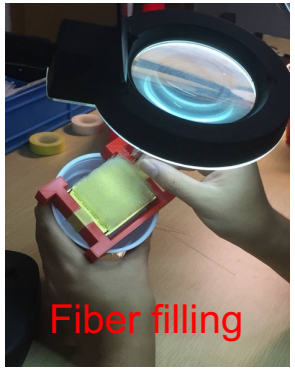
Pb/Sc Shashlyk module

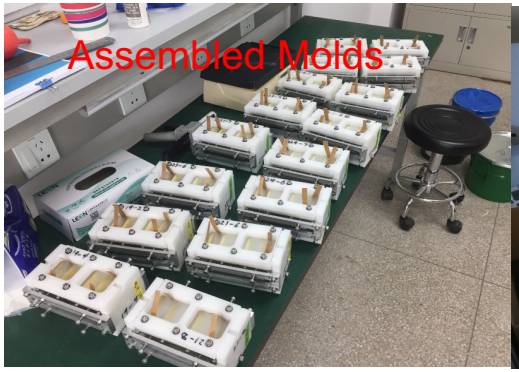


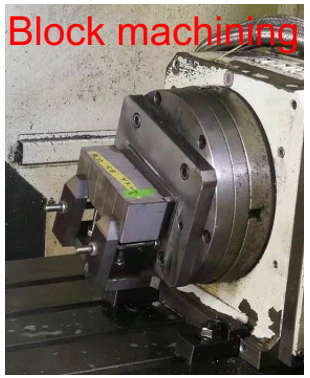
Shashlyk module testing

W-powder/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 ECall production for sPHENIX successfully
- sPHENIX EMCal blocks production flow at Fudan:

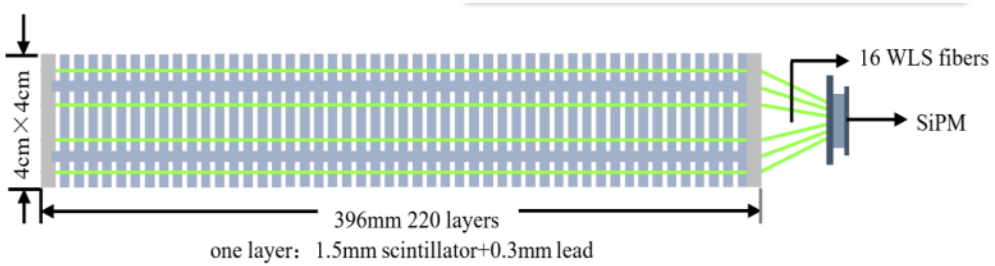






Nuclear physics group at Fudan University

- 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.

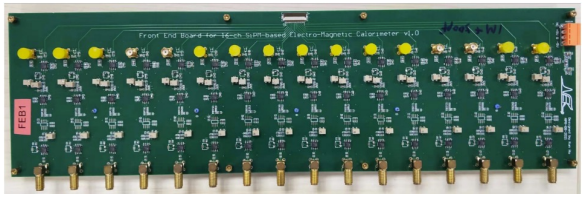


Nuclear physics Group at Shandong University

- Staff members: Zhenyu Chen, 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 experiment, 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

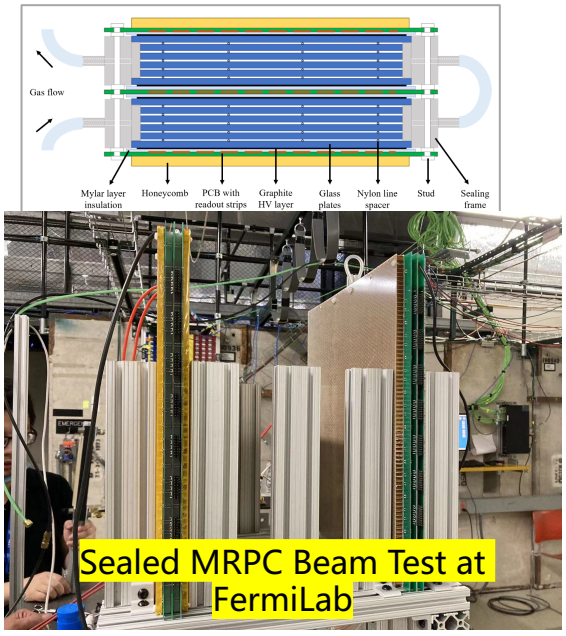


Front End Board for SiPM-based Ecal

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 currently working on multiple experimental projects at Jefferson Lab (Hall-A, B, C, SoLID) and RHIC-STAR experiment. Our major physics interests are on the hadronic structure of nucleons, e.g., spin, PDF, TMD, GPD, as well as the 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 RICH-STAR, GSI-CBM and CSR-CEE. We are leading or heavily involving in the R&D efforts for SoLID and US-EIC.



Sealed MRPC Beam Test at FermiLab

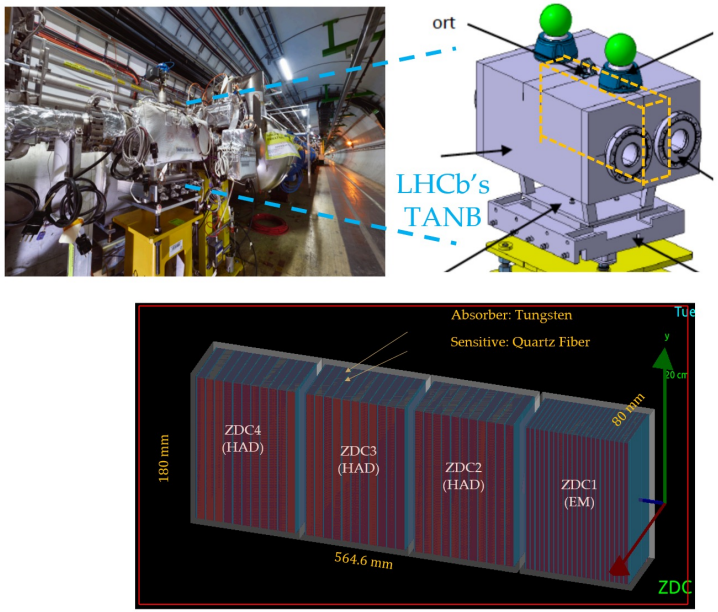

SoLID Shashlyk Ecal Beam Test at JLab


Barrel Shashlyk ECal

Nuclear physics Group at South China Normal University

- Staff members: Hengne Li, Guoming Liu, Shuai Yang
- The SCNU group is currently working with LHCb, RHIC-STAR experiment, and has been working on heavy ion, soft QCD and electroweak physics.
- We have constructed the China Southern Nuclear Computing Center (SNSC). We are also developing a Tungsten-Quartz sampling calorimeter prototype based on Cerenkov radiation.

SCSC



LHCb ZDC design

Interests with Silicon and RICH at EIC

- **Silicon tracker: R&D and mass production**
  - ✓ CCNU is part of the silicon consortium for the EIC, in close collaboration with LANL and LBNL.
  - ✓ Previous experiences on silicon tracker R&D and production:
    - MAPS chip development at CCNU (TopMetal series, MIC series); Co-design of the ALPIDE pixel chip, and mass production of the ALICE ITS2 outer barrel HIC modules (production yield 85%) at CCNU, part of ALICE ITS3 project.
    - FELIX based readout and DAQ system for pixel R&D

- **RICH: R&D and mass production**
  - ✓ THU is part of the eRD101 proposal for mRHIC, leading the exploration of Aerogel production R&D in China as part of the risk factor mitigation, in close collaboration with GSU. THU is also participating in the R&D design and simulation of the dRICH.

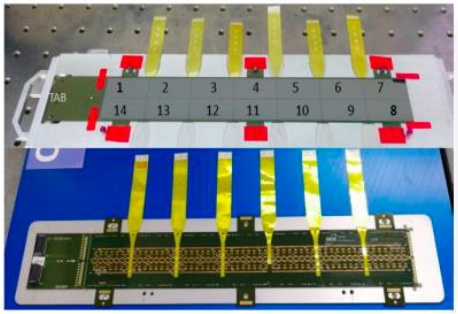
CCNU interests and experiences

➢ Interests to the EIC:

- pixel sensor design
- Pixel detector assembly & test (including thinning & stitching)
- Readout electronics & DAQ
- Tracking simulation, physics simulation

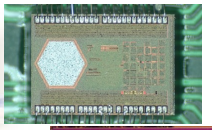
➢ Prior experiences and infra-structure:

- Participated in the ALPIDE chip design
- Participated in the ALICE ITS2 outer barrel HIC mass production
- Developing MAPS chips in China (Top-metal series chips, MIC series chips, etc.)
- Contributing to sPHENIX MVTX (MAPS) related readout, trigger and DAQ.

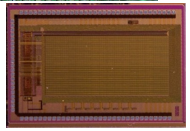


ALICE ITS2 OB HIC

ISO6 clean room (100 m²)



Topmetal-S



MIC4/5

PCIe-based DAQ

Member list (faculty) with CCNU

	Name	Affiliation	Contact	Interests
1	Prof. Kai Chen	CCNU	chenkai@ccnu.edu.cn	Readout electronics and DAQ
2	Prof. Xiangming Sun	CCNU	sphy2007@126.com	Pixel sensor design
3	Prof. Yaping Wang (IB representative)	CCNU	wangyaping@mail.ccnu.edu.cn	Pixel detector assembly and test
4	Prof. Zhongbao Yin	CCNU	zbyin@mail.ccnu.edu.cn	Physics simulation
5	Prof. Yuxiang Zhao	CCNU	yxzhao88@gmail.com	Detector assembly, testing and support of operation; tracking simulation

Interest with LGAD and USTC experiences

- 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), will be installed at $2.4<|\eta|<4.0$, time resolution per hit 35 ~ 70 ps up to NIEL of 2.5E15 cm^{-2} Si 1 MeV n_{eq})
- USTC responsibilities in sensor and assembly RD: design and fabricate 10% of the sensors and assemble 10% of the detector modules

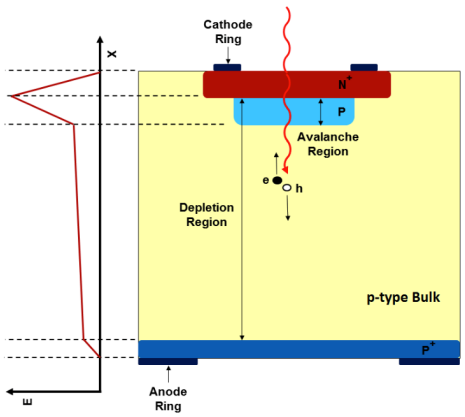
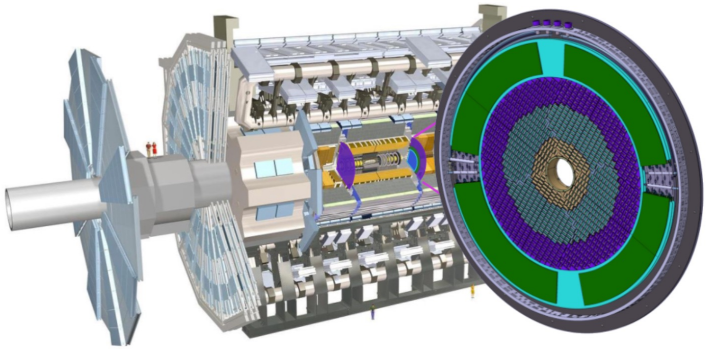


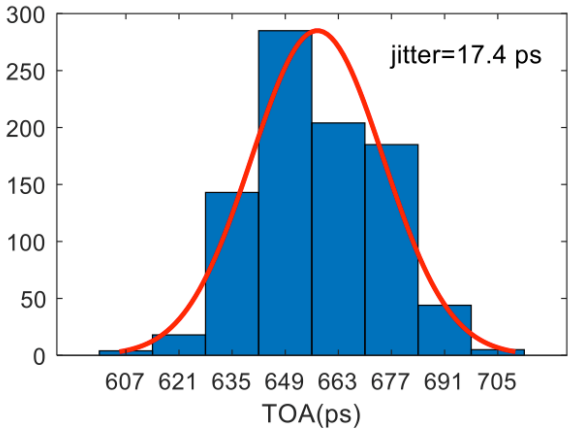
Illustration the LGAD technology



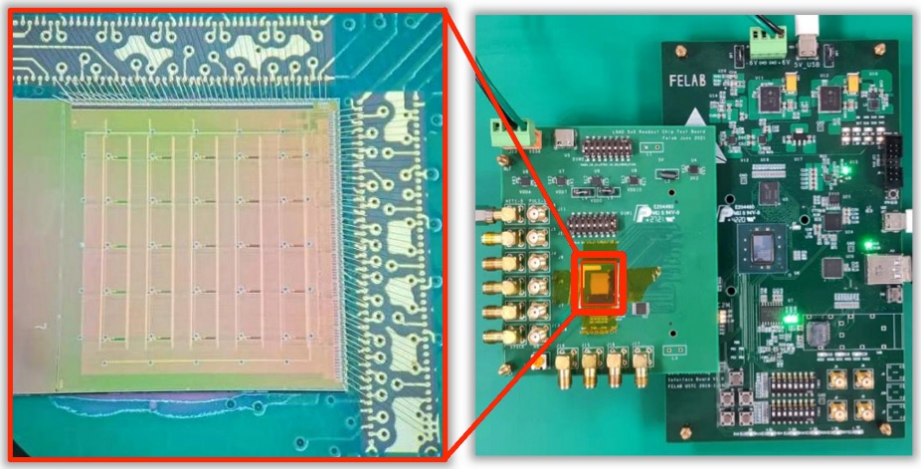
Planned installation location of HGTD in ATLAS

Readout ASIC for LGAD at USTC

- Working on the readout ASIC for LGAD, which will be bump bonded to sensors directly.
- The 1st version prototype ASIC has been tested:
  - 25 channels: 5 x 5 pixel matrix
  - Preamplifier, discriminator +TDC inside in the ASIC
  - Input charge: 5~40 fC
  - Time resolution: jitter < 25 ps @ 10 fC



Time resolution @ 10 fC input charge



channels with a common source preamp integrated

18.56	15.04	11.3	9.66	10.19
13.55	11.58	14.56	10.86	9.59
16.45	15.96	16.49	15.87	17.4
15.54	14.77	13.78	10.76	9.35
14.4	12.14	12.29	11.03	10.03

18 16 14 12 10 (ps)

channels with a common gate common source preamps integrated

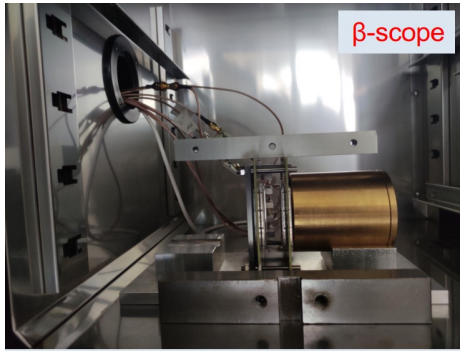
USTC LGAD team and the plan

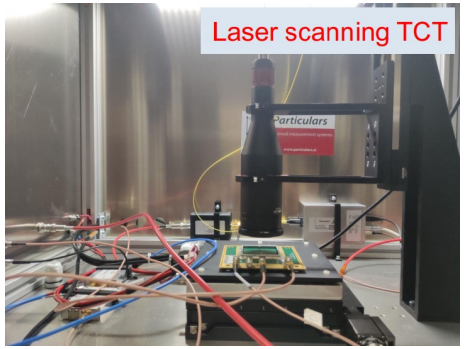
- Faculty: Lei Zhao, Hao Liang, Yanwen Liu, Yongjie Sun, Yusheng Wu, Lailin Xu, Yifei Zhang, Zhengguo Zhao
- Postdocs: Quanyin Li, Jiajin Ge*, Jiajun Qin
- Students: Yongkang Cai, Han Chen*, Chihao Li, Han Li, Kuo Ma, Tao Wang, Aonan Wang, Xiao Yang, De Zhang, Xiangxuan Zheng

Blue = detector

Red = electronics

* Members that have left





The USTC plan with EIC:

- Thinking how to involve in EIC LGAD project:
  Sensor R&D and fabrications, ASIC, simulations …
- Manpower and funding