中国科学技术大学

University of Science and Technology of China

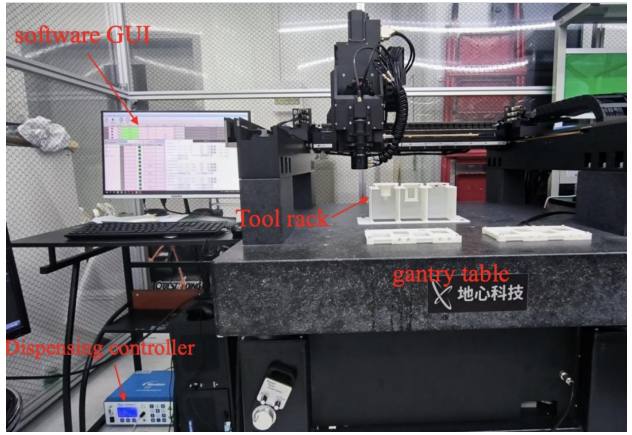
LGAD activities at USTC

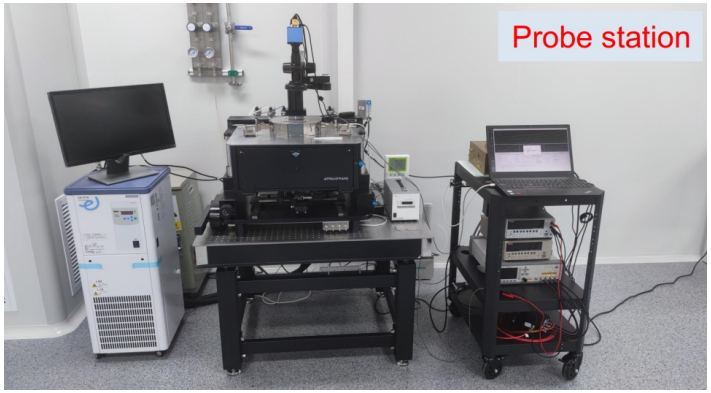
Yifei Zhang for the USTC LGAD group

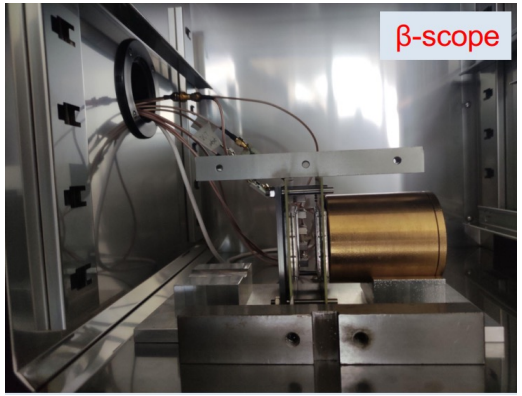
University of Science and Technology of China

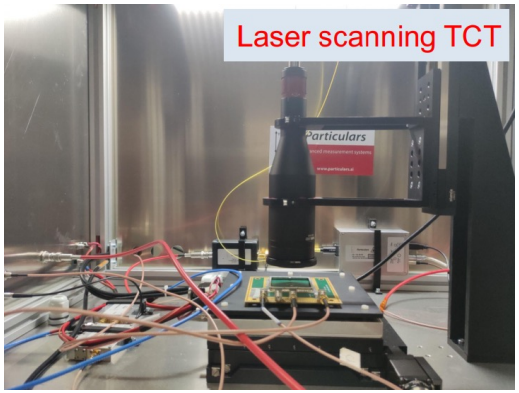
USTC lab resources for sensor tests

- Probe station equipped with a cooling system
- Sr-90 beta-scope (inside an environment chamber)
- Infrared-laser TCT
- (a dedicated clean room of 270 m^2 for HGTD assembly)









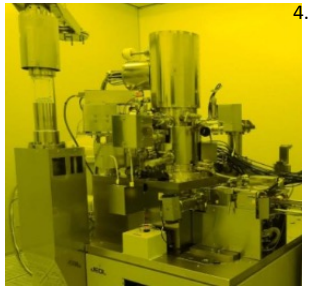
USTC Center for Micro-and Nanoscale Research and Fabrication

- Our work is strongly supported by the USTC NRFC that is equipped with devices for semi-conductor processing and testing housed in 3 clean rooms (surface:1200 m^2 in total)
  - e.g Lithography, etching, coating, dicing, wedge-bonding

1.

2.

3.



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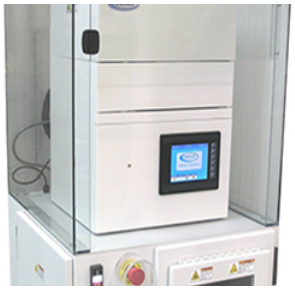
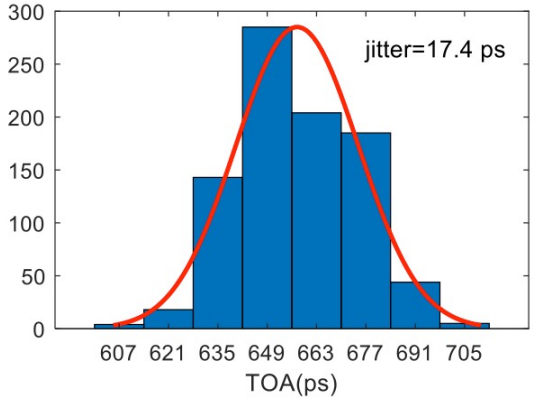
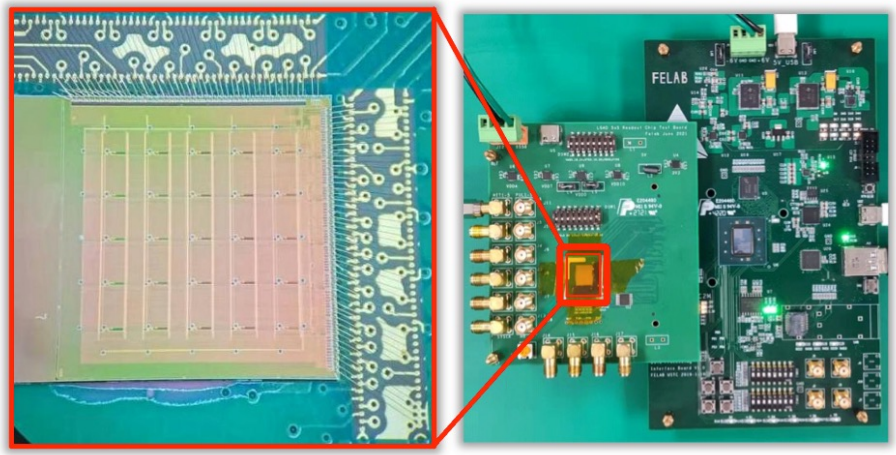


Readout ASIC for LGAD

- 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

Team and Projects involved

- 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 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
- Possible interest with LGAD project: Sensor R&D and fabrications, ASIC, simulations

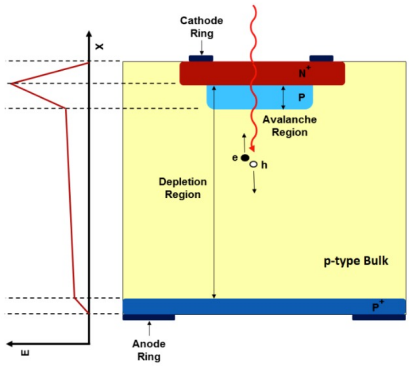
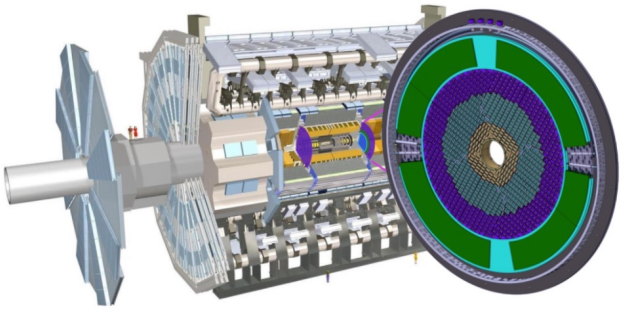


Illustration the LGAD technology



Planned installation location of HGTD in ATLAS

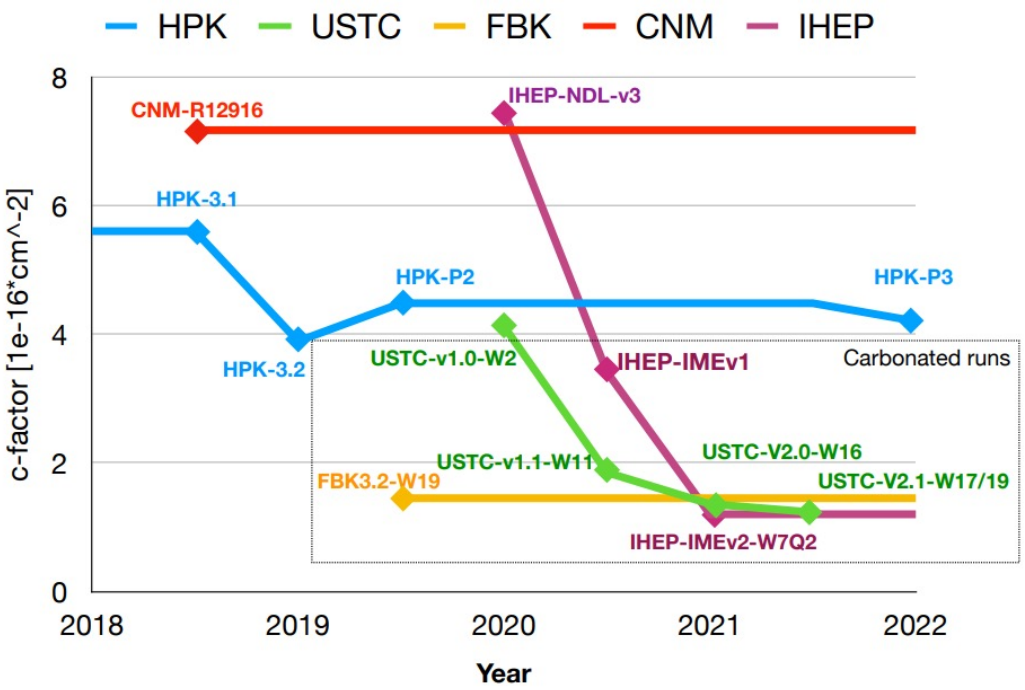
See Qinghua ‘s talk

Projects involved

ATLAS Phase 2 Upgrade

High Granularity Timing Detector (HGTD)

Under mass production in 2024. Fully installed in 2027.1.



Review of IME in kind production of IHEP and USTC sensor designs.

Reviewer committee: Dominik Dannheim (CERN), Gregor Kramberger (IJS), Joern Schwandt (Hamburg University), Michael Moll (CERN)

USTC-IME design: the design ready and the LGAD structure has been shown to comply with requirements and specifications. The only non-compliant property are alignment marker that **are outside the specifications** and is therefore **not ready for pre-production sign-off yet**. Further comments need to be considered:

- The sensor design is very aggressive in pad-edge distance which gives smaller sensor size. This is within the specifications, but there is a risk of larger leakage/earlier breakdown without any gain in total coverage. Would a slightly larger sensor allow for a different GR design with full alignment marker and without a loss of 52 sensors/wafer?
- Although USTC will delivery sensors on wafers and UBM/dicing will be done elsewhere the design should be made as easy as possible assuring enough QC-TS. Some extra cuts will be needed to preserve QC-TSs together with partially cut sensors.

Pass the qualification review and match the requirements and specifications of the HGTD project

Projects involved

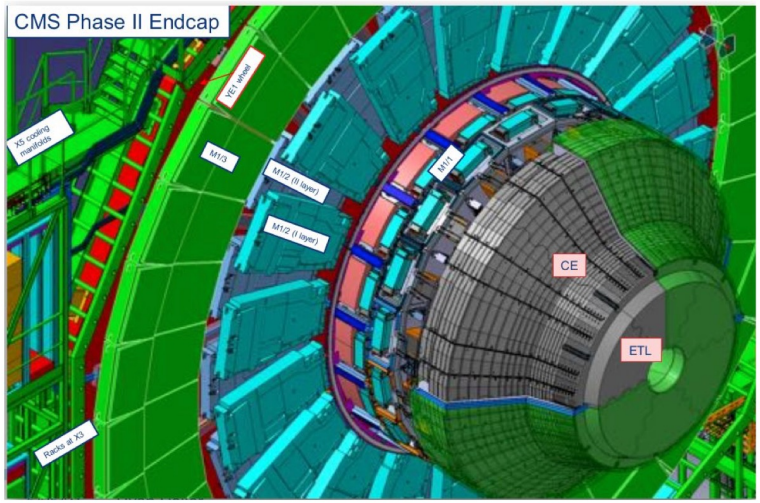
CMS Phase 2 Upgrade

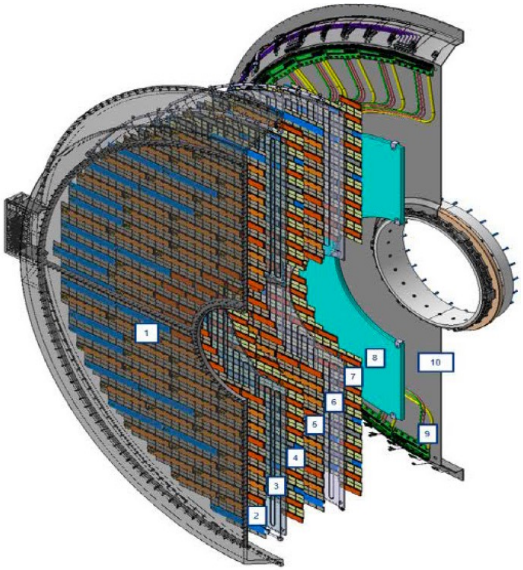
Endcap Timing Layer (ETL)

Based on the similar technology as ATLAS HGTD.

Plan to produce part of the LGAD sensors and testing.

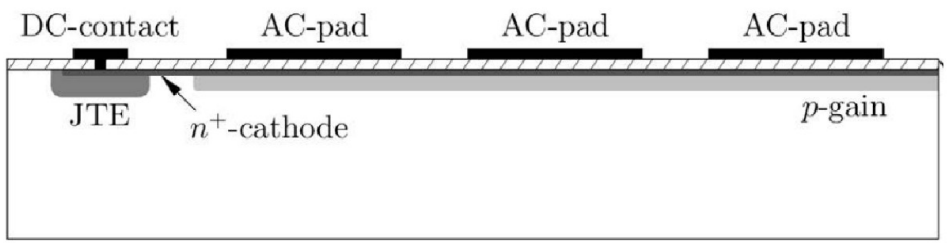
Fully installed in 2028.



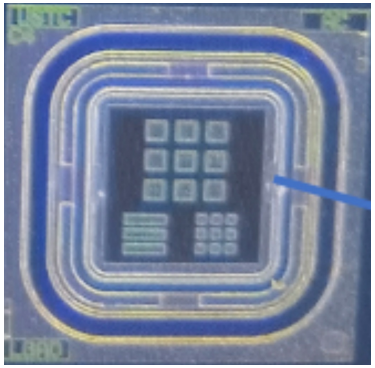


Development on AC-LGAD

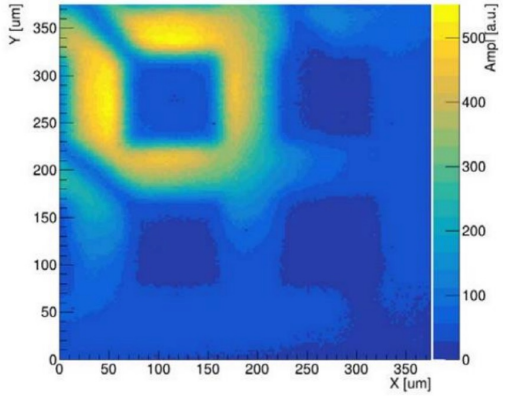
- Made a few prototype AC-LGAD samples for proof of principles.
- Optimized the layout of the readout pads with simulation.
- Plan to start fabricating the next version in February.
- Timing resolution ~30ps, spatial resolution ~5μm, no dead area.



schematic of AC-LGAD



prototype



Signals from laser testing