
Overview of High Granularity Timing Detector Activities in China

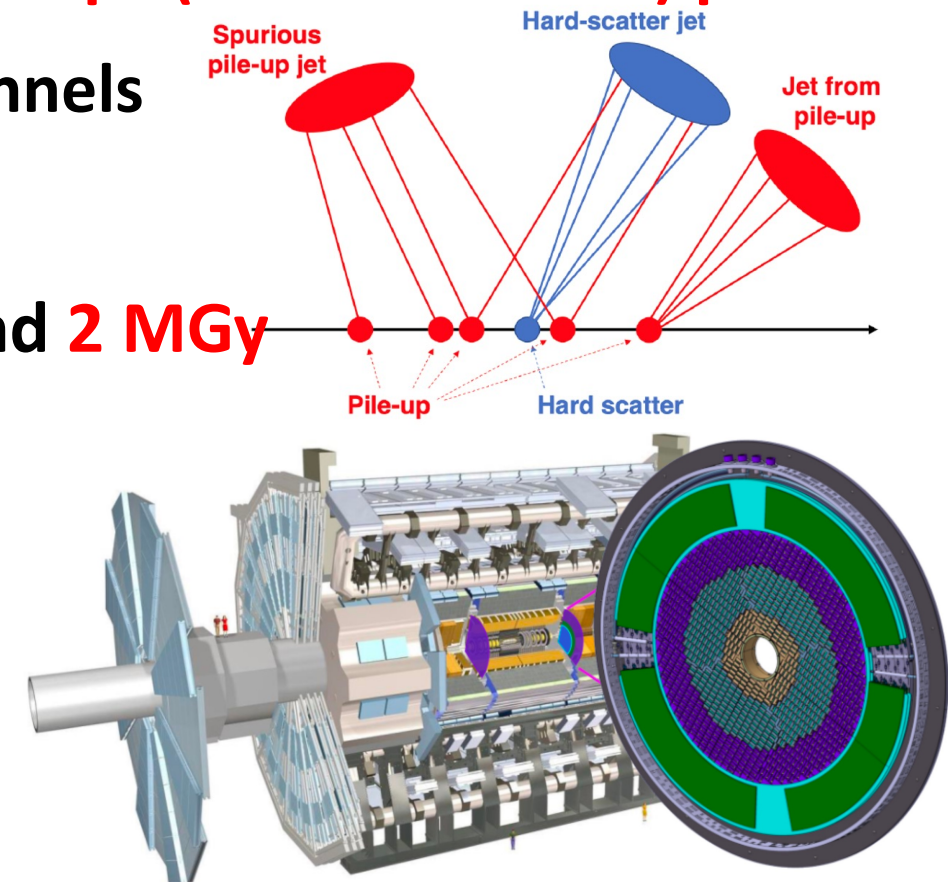
Zhijun Liang (梁志均)

IHEP, Beijing

On behalf of China HGTD team

ATLAS High Granularity Timing Detector (HGTD)

- HGTD aims to suppress pileup background contribution at HL-LHC
 - Timing resolution is better than **50 ps (start) - 70 ps (end of lifetime) per hit**
 - **6.4 m² area** silicon detector and **$\sim 3.6 \times 10^6$ channels**
 - High Granularity: Pixel size: **1.3 mm $\times$ 1.3 mm**
 - Radiation hardness : up to **$2.5 \times 10^{15} N_{eq}/cm^2$ and 2 MGy**
- Scientific value:
 - **Improve precision in the Higgs boson measurements**
 - **Improve the potential in new physics search**
- Innovation
 - **Pioneering Silicon-based timing detector @LHC**



China team in HGTD management

- ATLAS China team played an important role in HGTD management team
 - Mar. 2021- Feb 2025 , Joao was HGTD project leader
 - Mar 2025 - Feb 2027, Zhijun is serving as deputy project leader
 - 5 person as L2 conveners (Jie Zhang, Mei Zhao, Zhaoru Zhang, Zhijun Liang, Lailin Xu)
 - 3 person as Level-3 convener (Yunyun Fan, Lei Fan, Jie Zhang)
 - 1 person was speaker committee (Yanwen Liu)

Institute Board
Chair: Frank Flithaut

Project Leader: Stefan Guindon
Deputy Project Leader: Zhijun Liang

Resource Coordinator:
Laurent Serin

Schedule and Risk Manager:
Zhaoru Zhang

Latest HGTD management

L2 Coordinators

8.1: Sensors
Gregor Kramberger
Mei Zhao

8.2 Electronics
Jie Zhang
Nathalie Seguin-Moreau
Frank Flithaut

8.3: DAQ and Controls
Jonas Strandberg

8.4: Module
Assembly
Sebastian Grinstein
Zhijun Liang

8.4: Detector Unit
Loading and Testing
Lucia Masetti
Luca Cadamuro

8.5: Mechanics
Aboud Falou

8.5 + 8.6 + 8.7: Services,
Assembly, Installation
Sergei Malykov
Daniela Macina

8.8: Demonstrator
Daniela Macina
Stefano Manzoni

8.8.4: Testbeam
Djamel Boumdeiene
Xiao Yang
Stefano Manzoni

Simulation Performance
and Physics
Alexander Leopold
Louis d'Eramo

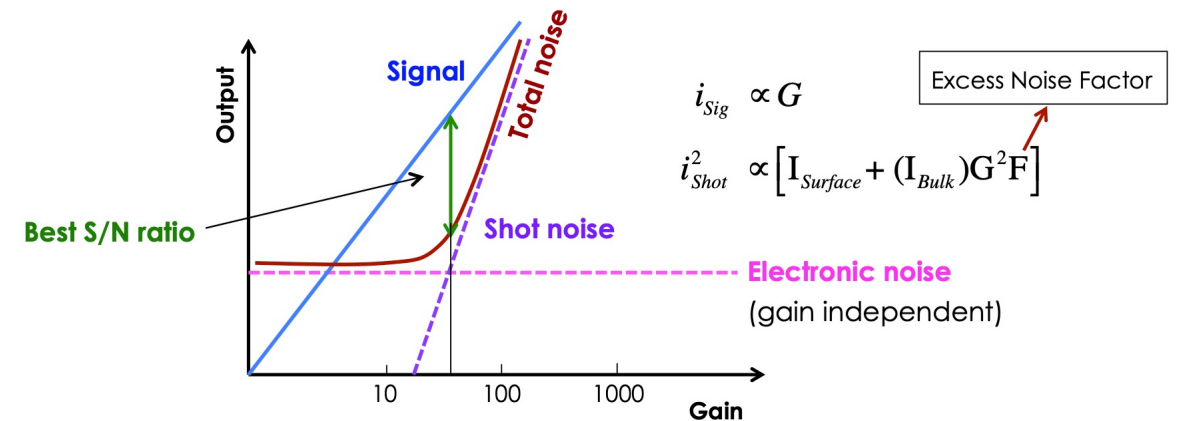


Low Gain Avalanche Diodes (LGAD)

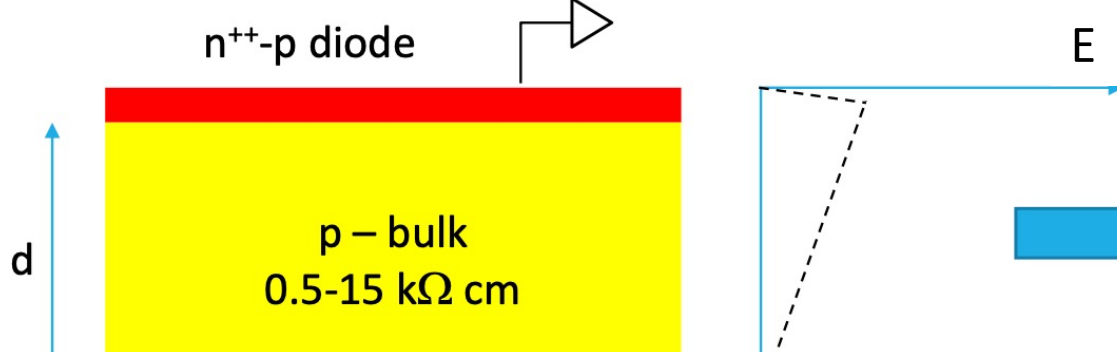
- Key technology developed in HGTD: LGAD sensor
- **Innovation: high-granularity Radiation-hard LGAD developed for Collider**
- LGAD has modest gain (~50), optimized to get the best S/N and fast timing

$$\sigma_{jitter}^2 = \left(\frac{t_{rise}}{S/N} \right)^2$$

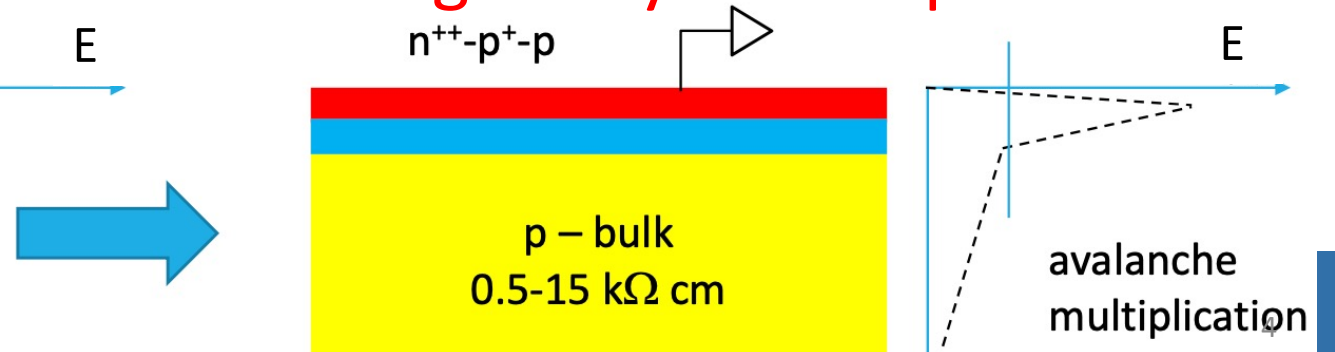
- Modest gain to increase S/N
- Thin detector to reduce t_{rise}



Conventional PiN diode



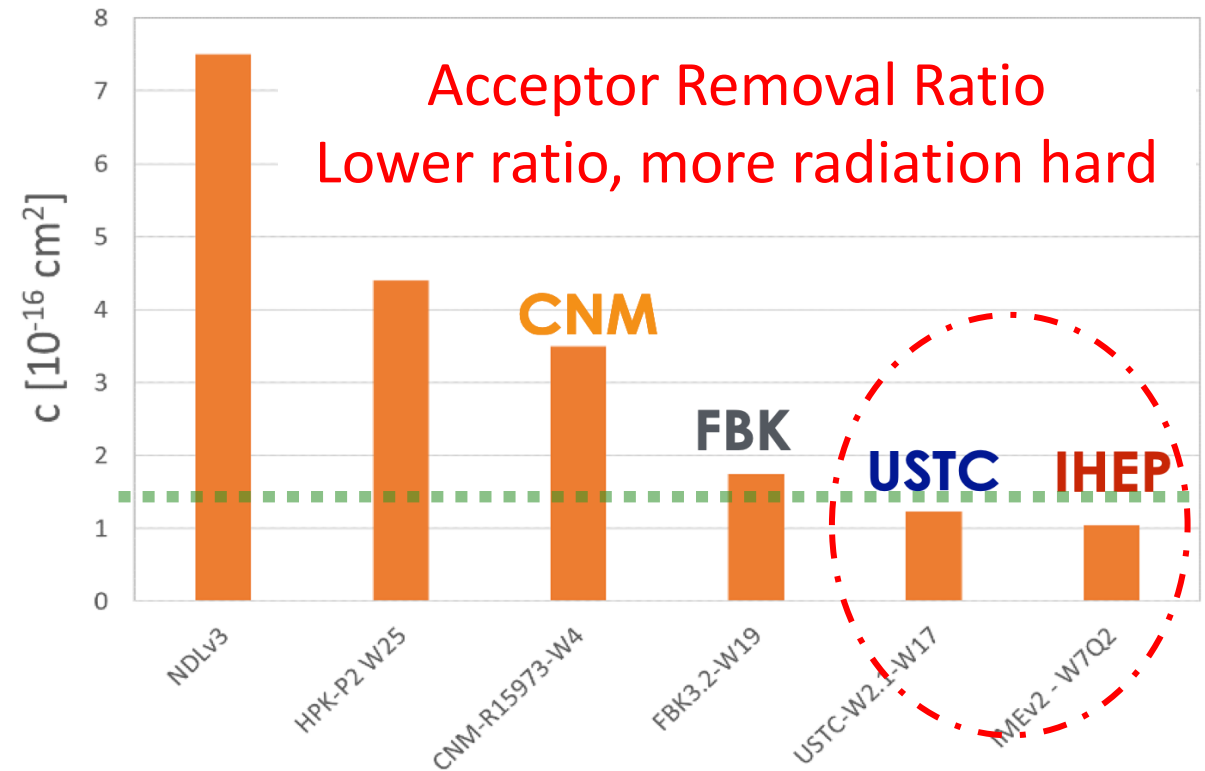
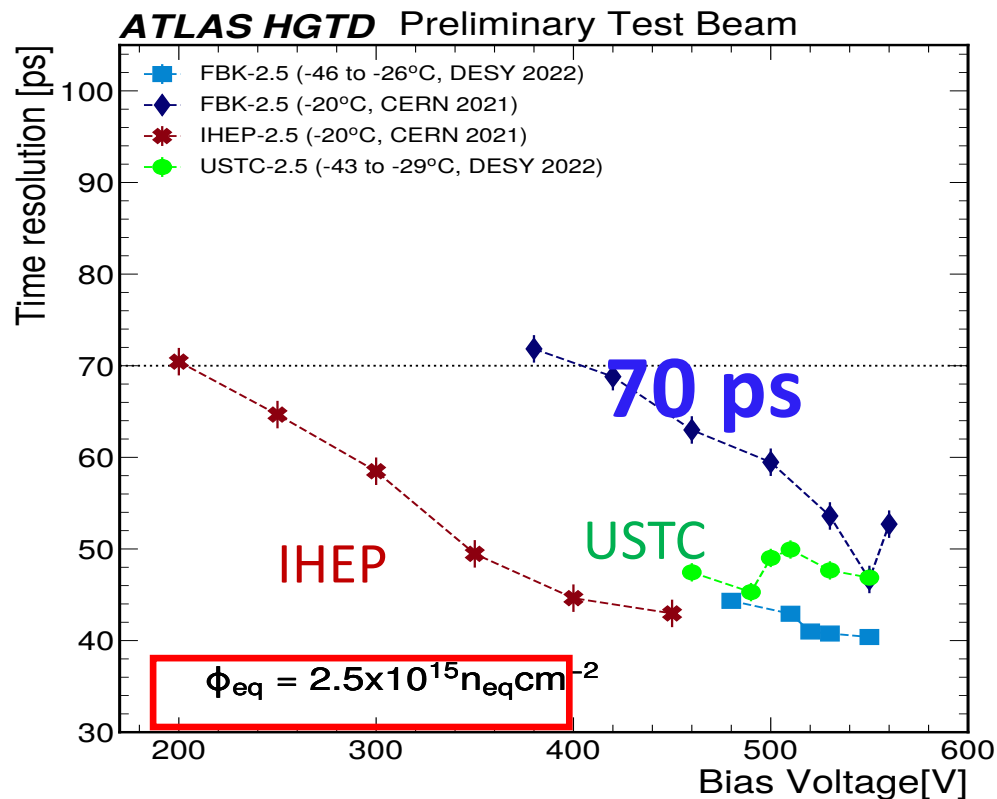
LGAD: P+ gain layer on top of PIN diode



LGAD sensor after Irradiation

More details in KHURAM's talk

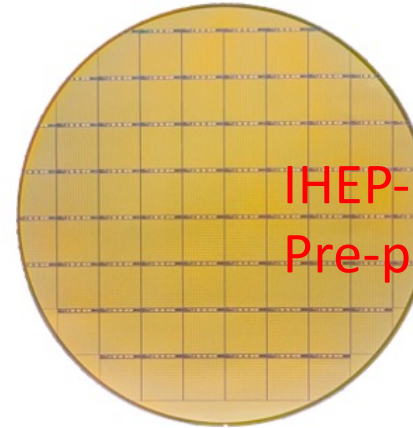
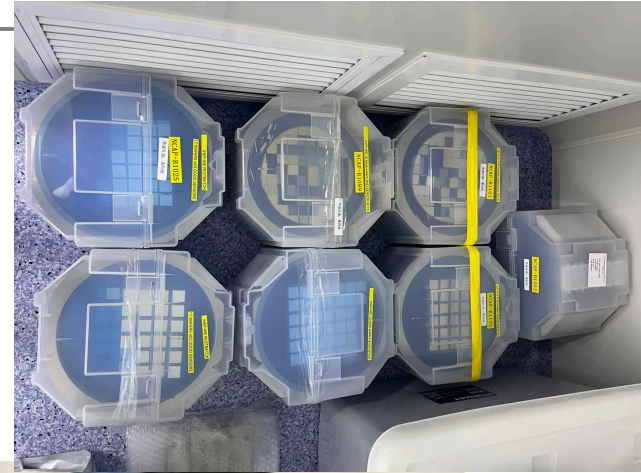
- IHEP and USTC team developed carbon enriched LGAD independently
 - Increased radiation hardness, met HGTD requirement, survive at fluence $2.5 \times 10^{15} \text{ n}_{\text{eq}}/\text{cm}^2$
 - Timing resolution better than 50ps after irradiation



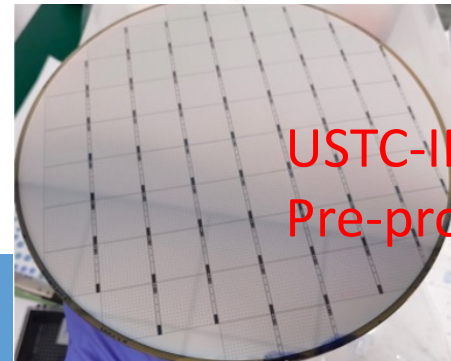
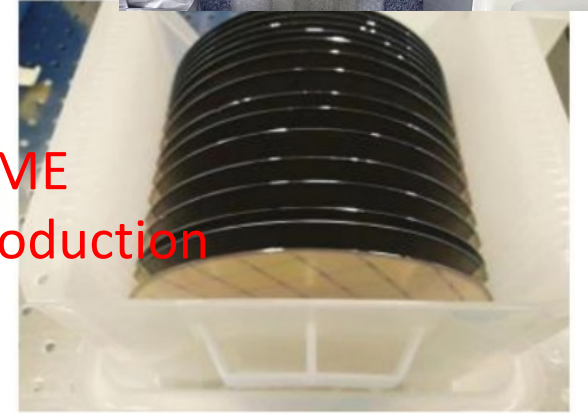
LGAD sensors pre-production and pre

- CERN chosen IHEP-IME sensor in tendering, **contract signed in Feb 2025**
 - IHEP-IME, FBK(Italy) and HPK(Japan) were completing
- The sensor production will be **100% done by China**
 - **First time domestic silicon sensor was used by CERN**
 - IHEP-IME: **90%** (**66% from CERN tendering+24% in-kind**): $\sim 8 \text{ m}^2$
 - USTC-IME: **10% in-kind contribution** ($\sim 0.8 \text{ m}^2$)
- **Production status**
 - IHEP
 - pre-production **1700** sensor fabricated in
 - Production: $\sim$ **3000** sensor fabricated ($\sim 15\%$)
 - Production still on-going
 - USTC
 - pre-production: $\sim$ **270** sensor fabricated

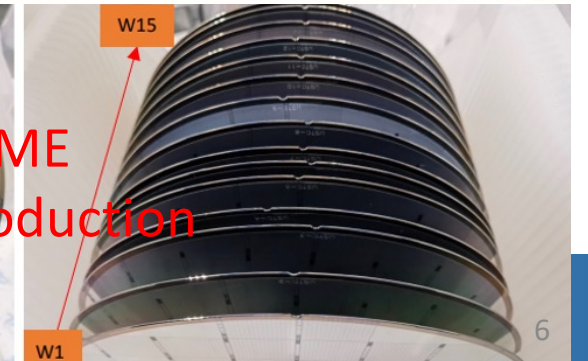
IHEP-IME production



IHEP-IME
Pre-production



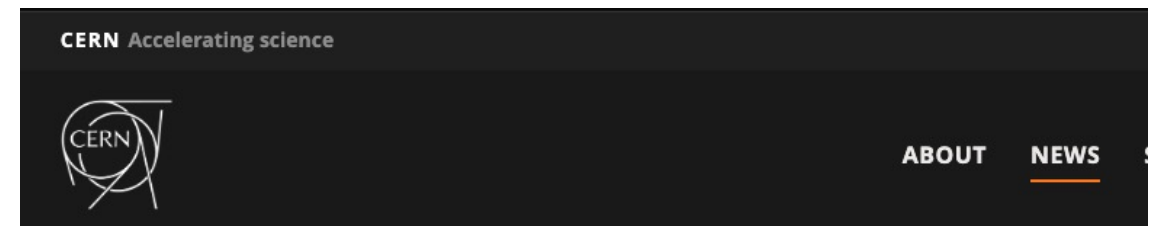
USTC-IME
Pre-production



More details in Tianyuan's talk

ATLAS Outstanding Achievement Award

- IHEP and USTC members won the 2025 Outstanding Achievement Award
 - for their development of the LGAD sensor in HGTD project
 - The list of ATLAS award for HGTD project: Bojan Hiti (Ljubljana), Alissa Howard (Ljubljana), Xuewei Jia (Munich MPI), Mengzhao Li (Beijing IHEP), Chihao Li (Michigan), Kuo Ma (Hefei), Theodoros Manoussos (CERN), Weiyi Sun (Beijing IHEP), Guilherme Tomio Saito (Sao Paulo), Iskra Velkovska (Ljubljana), Xiao Yang (CERN), Mei Zhao (Beijing IHEP)



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Celebrating the outstanding achievements of the ATLAS collaboration

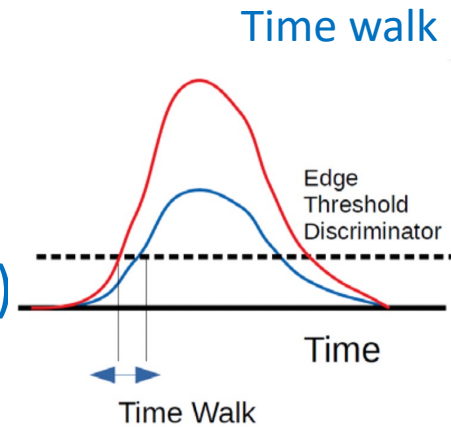
The ATLAS collaboration celebrated the dedication, ingenuity and collaborative spirit of its members at the 8th Outstanding Achievement Awards

8 JULY, 2025 | By [ATLAS collaboration](#)

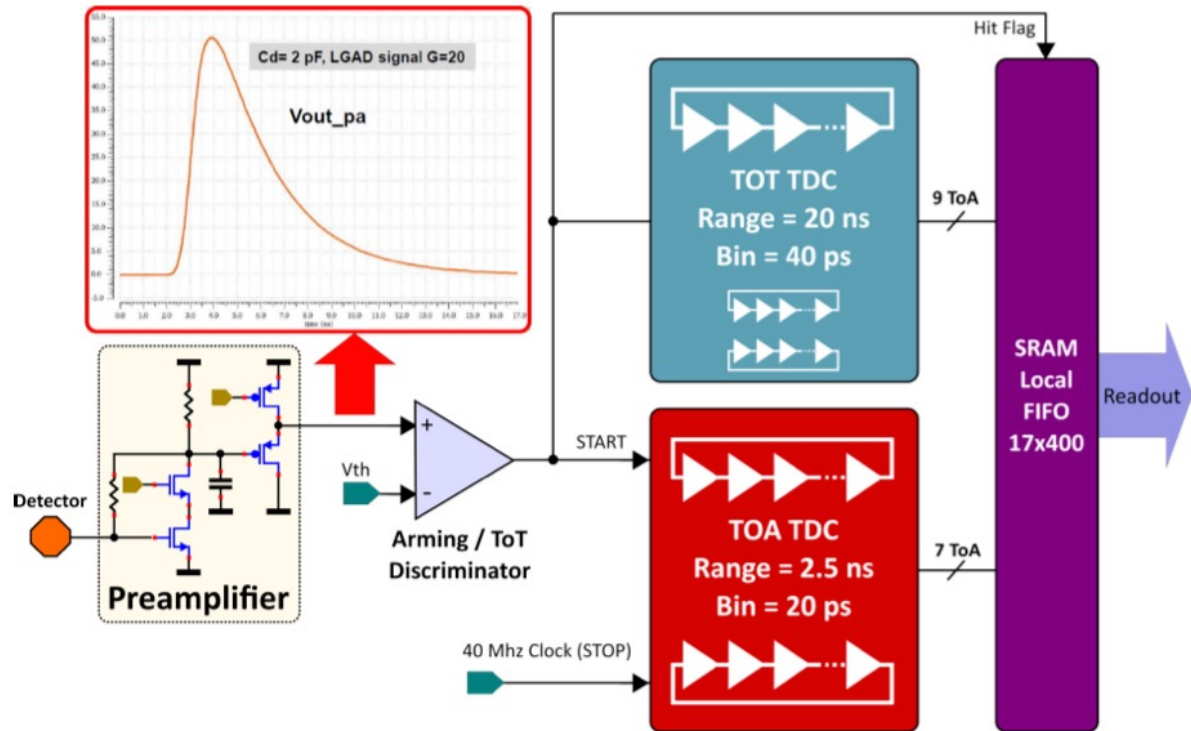
ALTIROC : Fast Timing ASIC



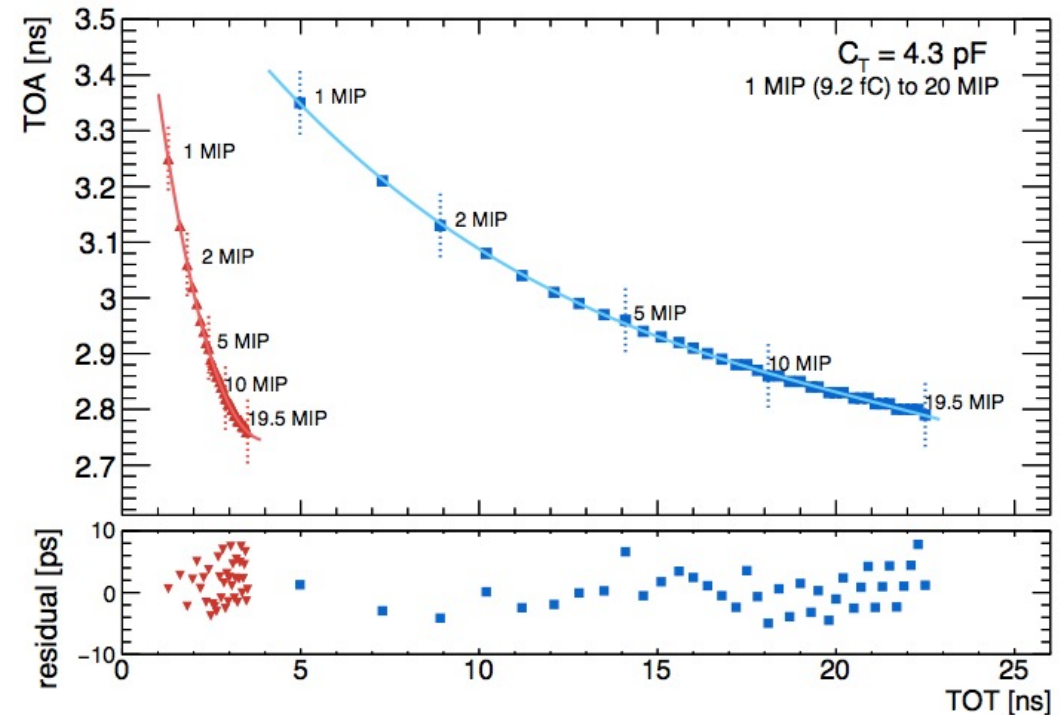
- **225 front-end channels** in ALTIROC, each channel has
 - Two TDC (Time to Digital Converter) to provide digital **Hit data**
 - Time of Arrival (TOA) : Range of **2.5 ns** and a bin of **20 ps** (7 bits)
 - Time Over Threshold (TOT) : range of **20 ns** and a bin of **40 ps** (9 bits)



ALTIROC timing ASIC in nutshell



Time walk correction with TOT

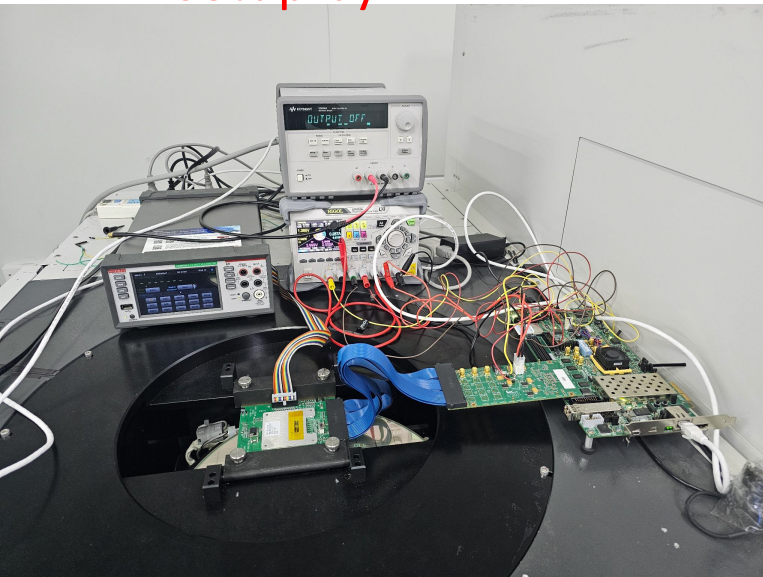


ALTIROC ASIC wafer testing

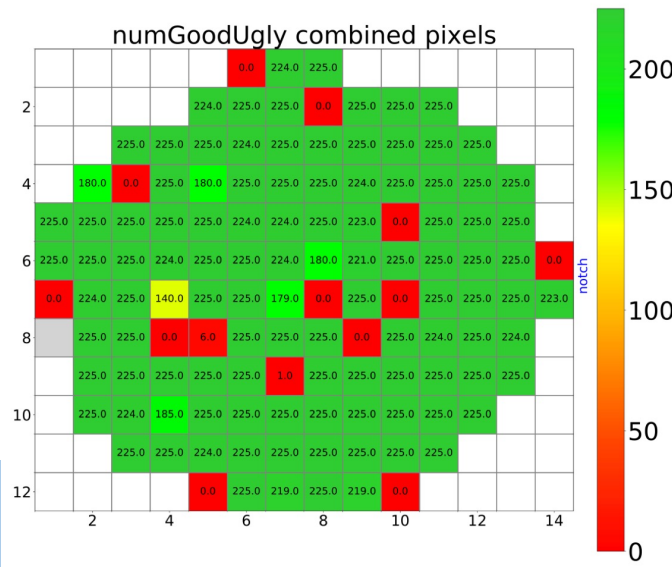
More details in Hancen's poster

- China and IJClab (France) share **50%** of wafer probe test (225 ASIC wafers in total)
- China team (IHEP, SJTU/TDLI, SDU) will complete the full ASIC testing from 2025 to 2026
 - China team setup a ASIC wafer test system based on fully automatic probe station
 - Important to test all ASICs and select the good ones, **typical yield is 70% ~ 80%**
 - Tested 7 ASIC wafers (~1000 ASIC), is more advanced compared to our collaborators
 - **Passed CERN Production Readiness Review**

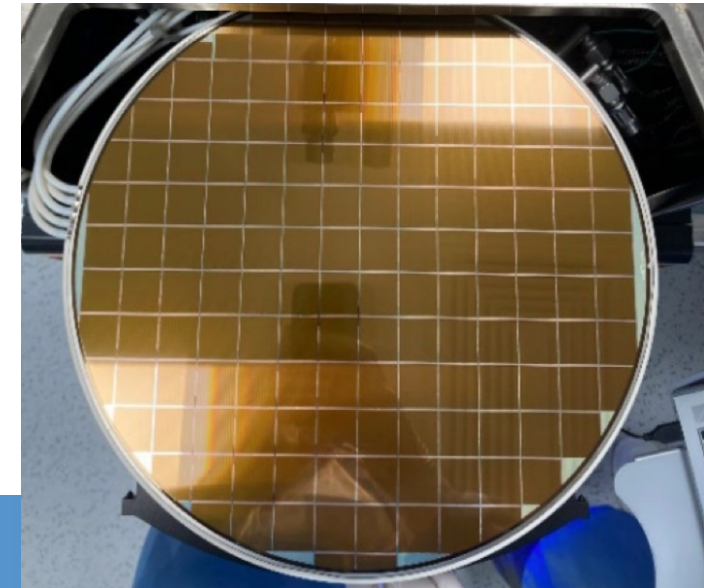
ASIC wafer test system
setup by IHEP



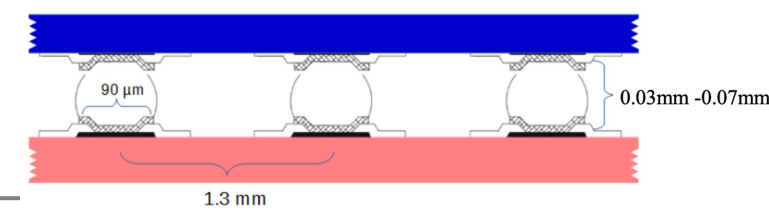
ASIC wafer test result



ALTIROC-A wafer

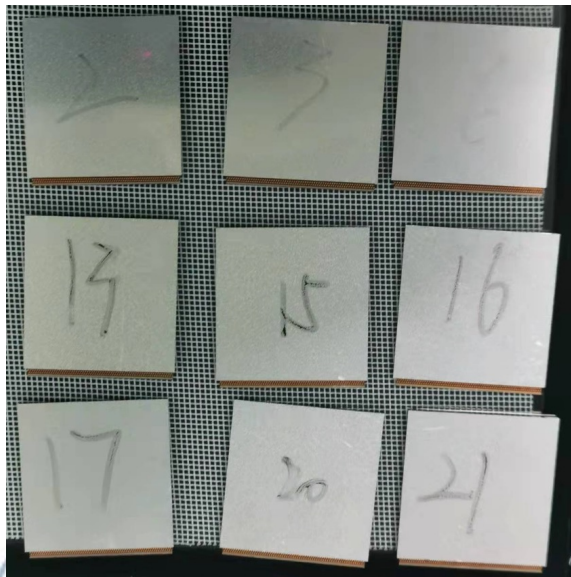


Sensor+ASIC Hybrid

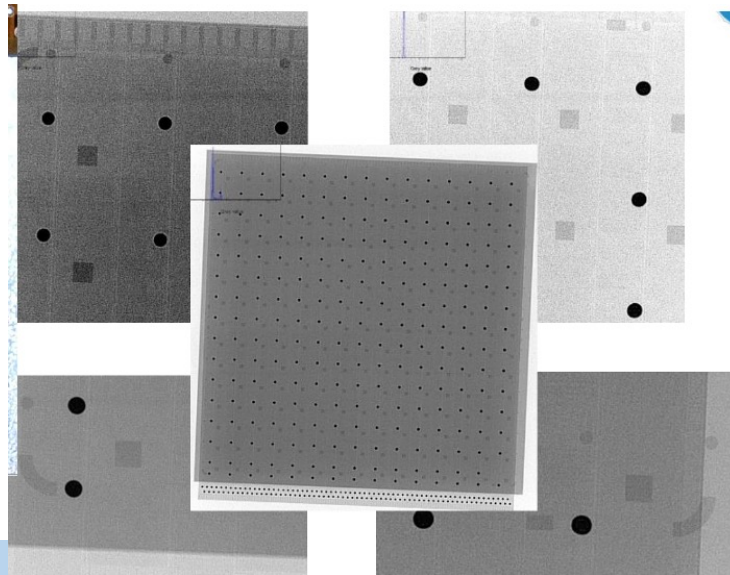


- China (IHEP) and Europe (Spain, France) share 50% of hybrids production
 - **Challenge:** ATLAS ITK pixel had hybrid bump delamination issue
- Updated :
 - IHEP led the hybrid R&D, solved the bump delamination issue in old HGTD hybrids
 - Produce ~150 ALTIROC-A hybrids @ pre-production, no bump issue by far.

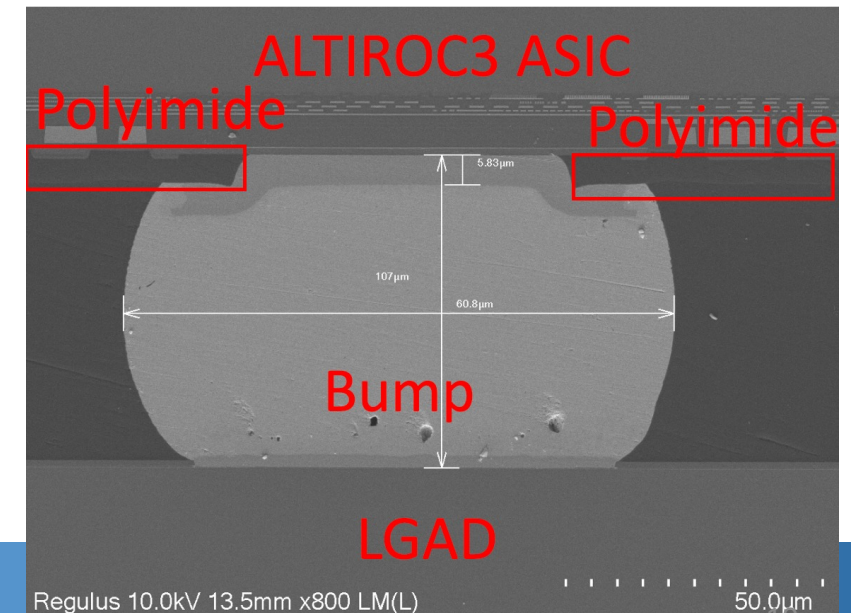
Sensor + ASIC hybrid



Hybrid X-ray photo



SEM photo of hybrid cross section

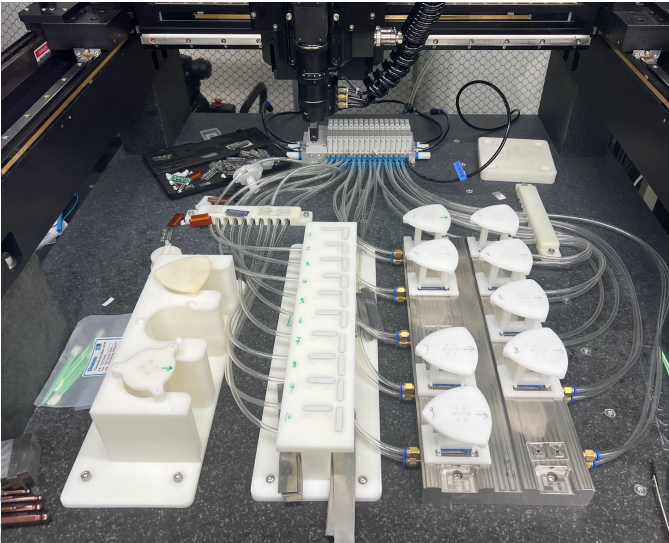


Module and detector units

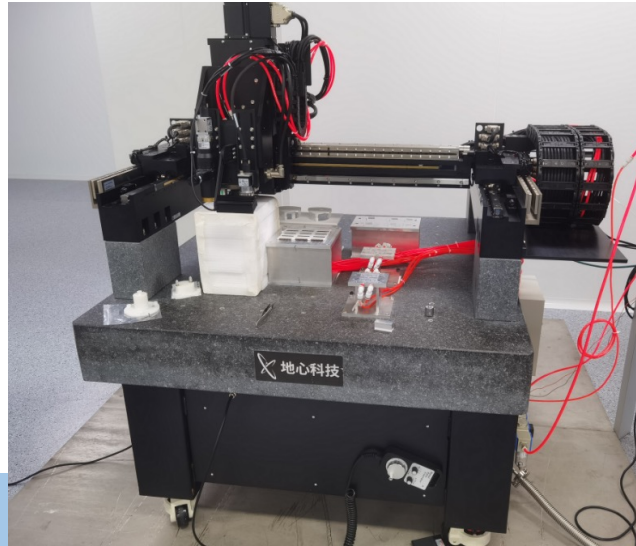
More details in Xinhui's poster

- 5 production site at HGTD (China, Mainz (Germany), France, IFAE(Spain), Morocco)
 - China is largest site, will assemble 44% of the module (~4000 modules)
 - China module team included IHEP/USTC/SDU/SJTU/Naikai, assembly lab is in IHEP
- Latest update
 - IHEP finished module flex pre-production (400 module flexes)
 - IHEP and USTC developed gantry robot for automatic assembly
 - IHEP team prototyped more than 100 modules, including ~10 ALTIROC-A modules

Gantry robot @IHEP



Gantry robot @USTC



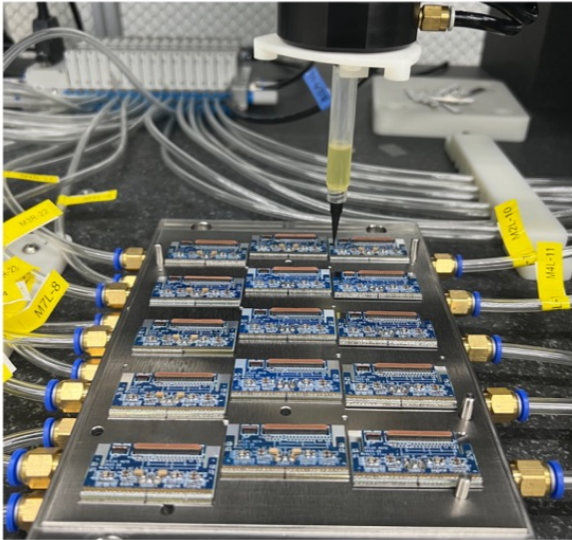
Module flex pre-production @ IHEP



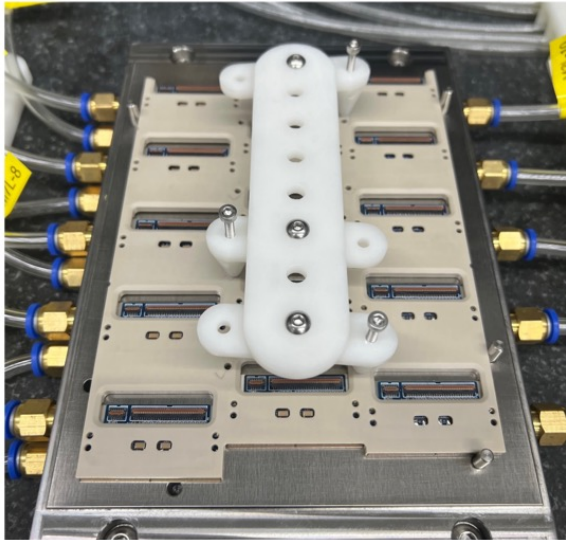
HGTD module loading

- IHEP loaded the two ALTIROC3 detector units for demonstrator
 - Use Gantry system to position all 15 modules and glue dispensing
 - Delivered to CERN, and integrated in 54-modules demonstrator
- USTC/IHEP are developing program with gantry robot in IHEP hall 3
 - Using a larger gantry, Finalizing the setup for production

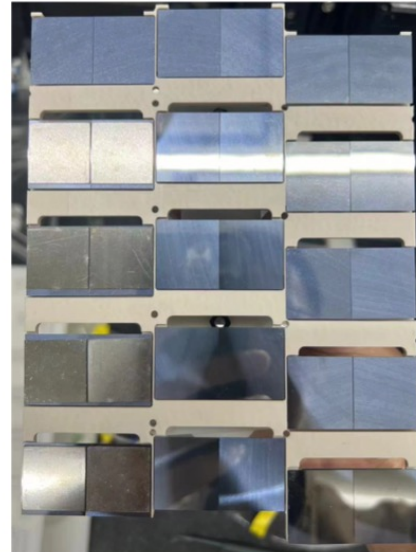
Dispensing with GluingTool



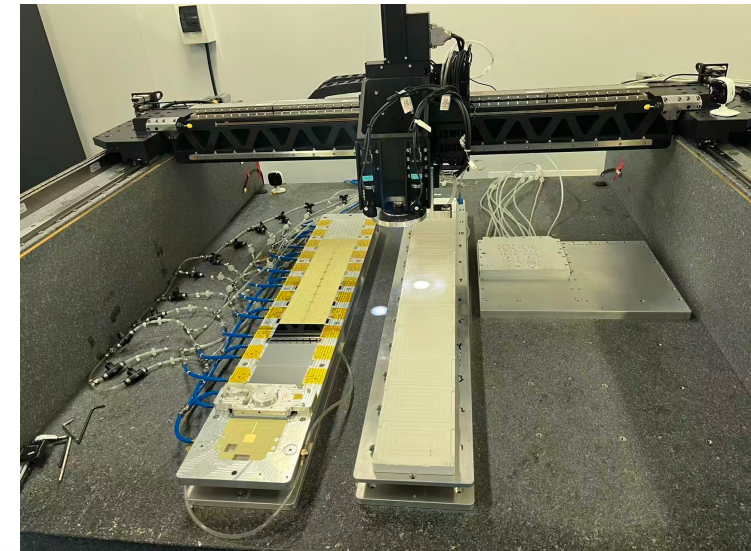
Put the support unit



Backside view after removal

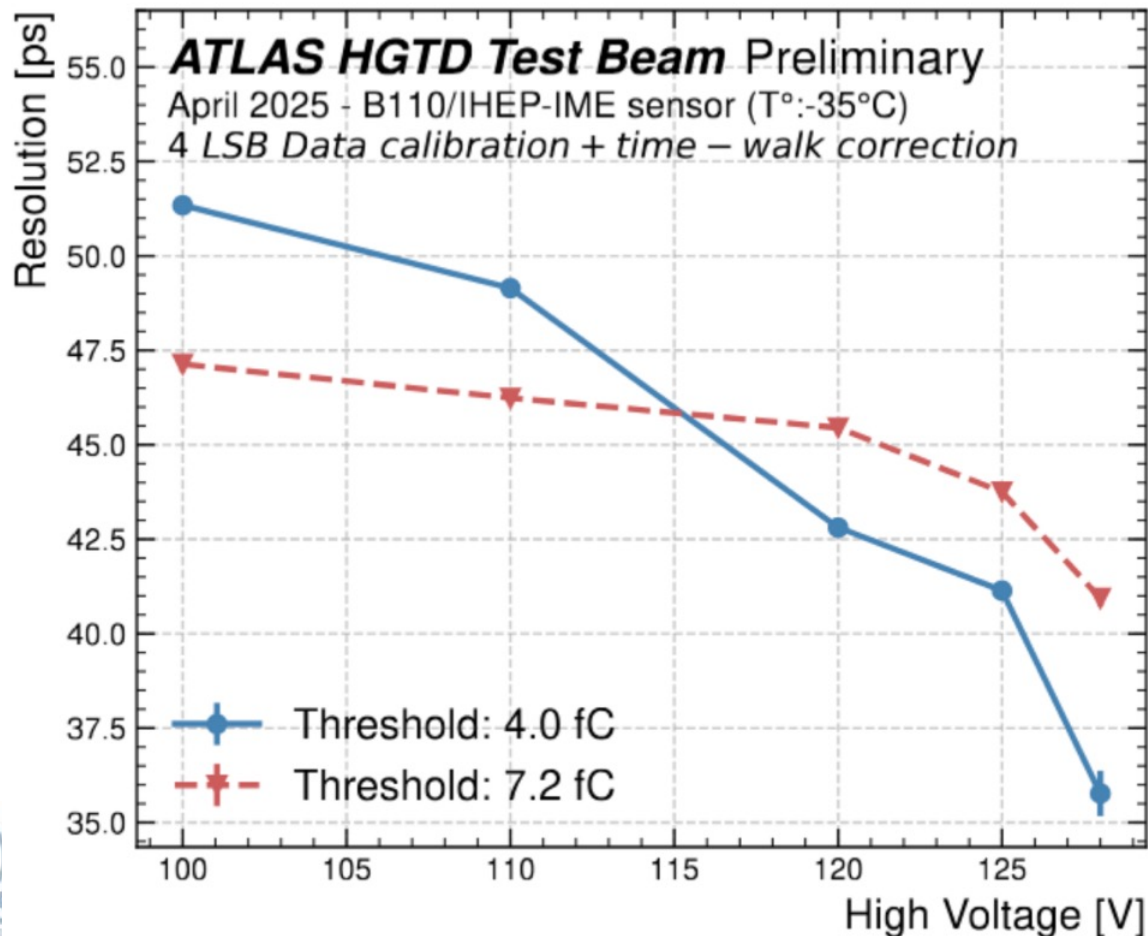


Gantry robot in IHEP hall 3



HGTD Module beam tests

- Module level Test beam showed that
 - Individual channels is better than 50ps timing resolution
 - In next few years, HGTD will have more than 3M channels @ ~50ps resolution

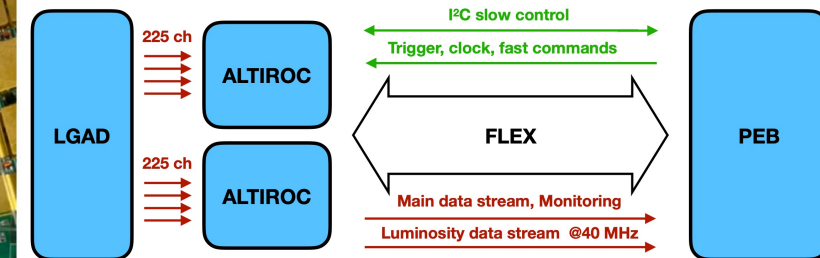
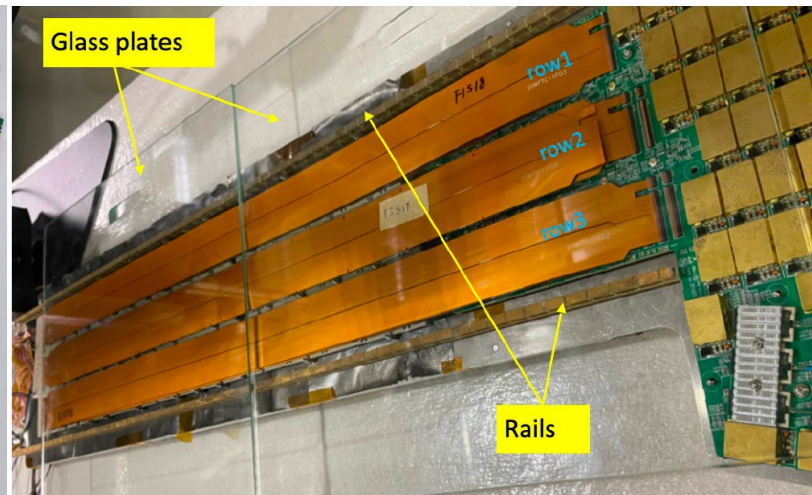
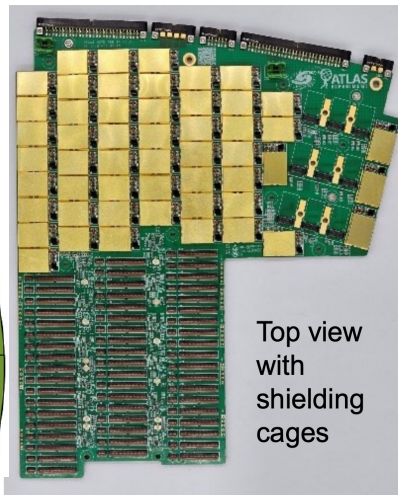
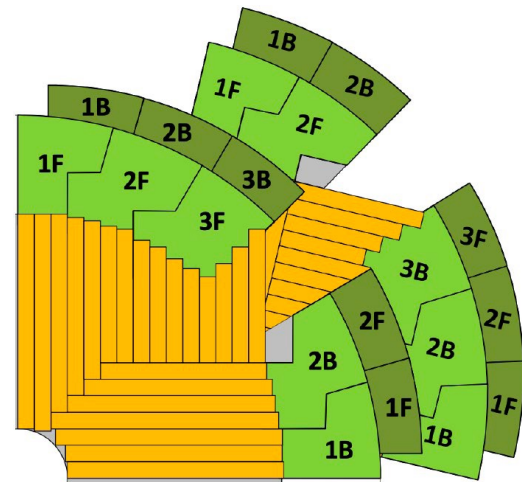


Peripheral Electronics Board (PEB)

- China (IHEP/NJU) will design and produce 100% PEB (PCB fabrication)
- Challenge: fast communication with 55 modules, 24 metal layers in PCB
- IHEP and NJU developed 1st Peripheral Electronics Boards
 - Designed by IHEP, fabricated by NJU in domestic company

6 types of PEB

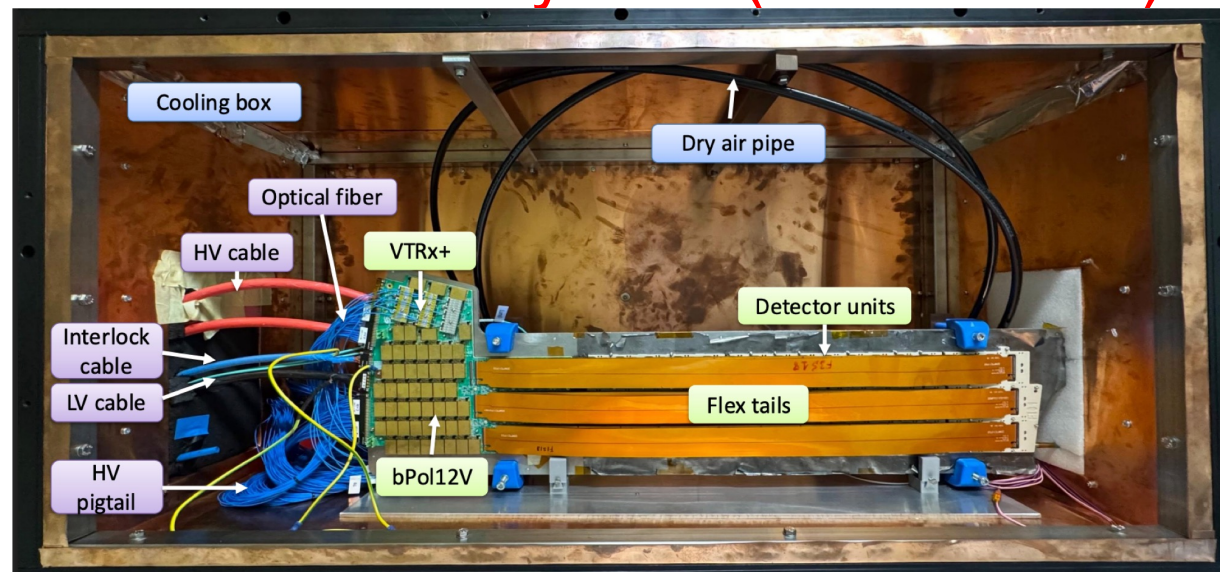
PEB1F prototype



Demonstrator

More details in Yimin's talk

- Demonstrator setup at CERN with full chain from module to DAQ server
- IHEP/NJU/USTC/SDU played important role demonstrator system at CERN
 - 1st time to demonstrate large scale detector system (55 modules)



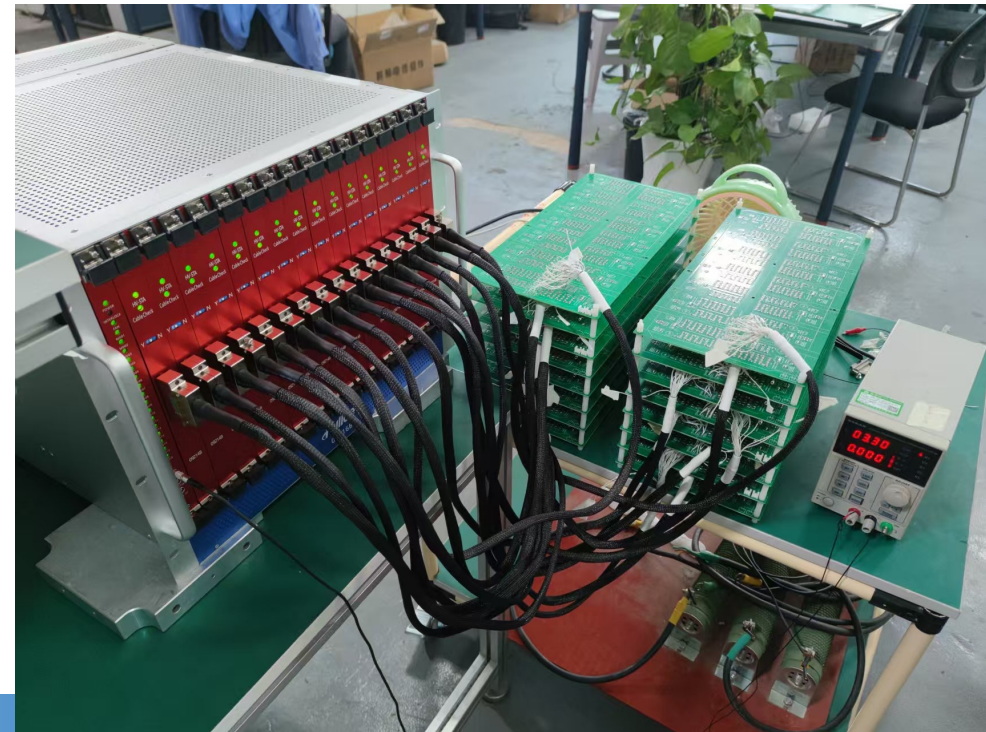
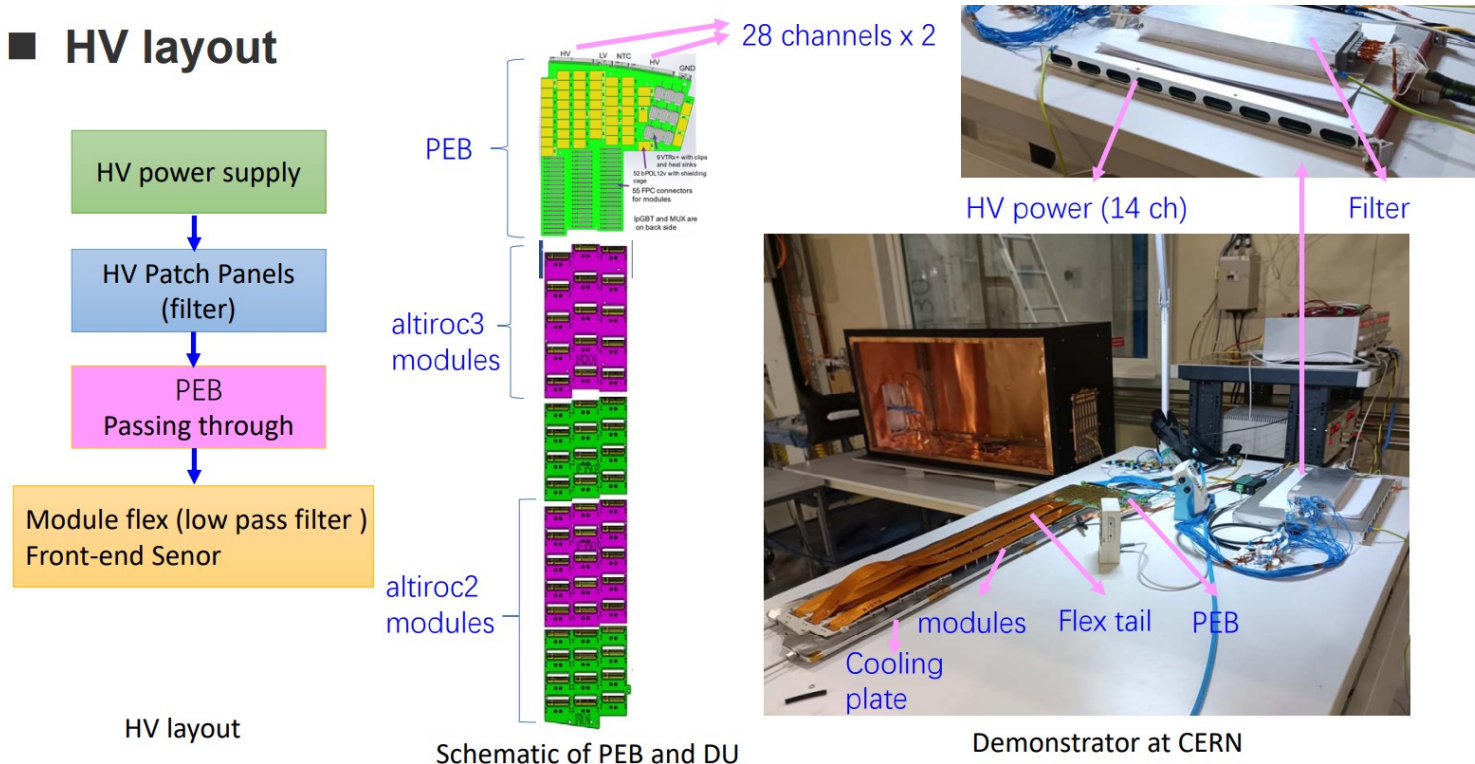
High voltage power supply

- IHEP/SDU team is developing HV power supply prototype for HGTD
 - high resolution current measurement, Dedicated Interlock for ATLAS
- Finished HV power supply in pre-production in Sep 2025

HV supply testing setup at HGTD demonstrator

pre-production HV power supply

■ HV layout



HGTD summary

- **China is making key contributions to HGTD**
 - **100%** (90% IHEP, 10%USTC) LGAD sensor, **produced ~3000 sensor @production**
 - **50%** hybridization (IHEP), **produced 150 hybrids @ pre-production**
 - **50%** ASIC testing (IHEP, SJTU/TDLI,SDU), **finished pre-production (~1000 ASIC tested)**
 - **44%** module assembly (IHEP, USTC,SDU,Naikai,SJTU), **loaded two ALTIROC3 detector units**
 - **100%** front-end electronics board (IHEP, NJU), **prototyped 1st full-size PEB**
 - **>16%** high-voltage systems(IHEP,SDU), **finished 2 crate HV supply @ pre-production**
 - **33%** flexible PCB tails (SDU), **1st prototyped tested**
 - Contributed also to TDAQ, software and physics

