Given by Liang Zhijun in Shanghai

The new silicon microstrips tracker for the Phase-II ATLAS detector

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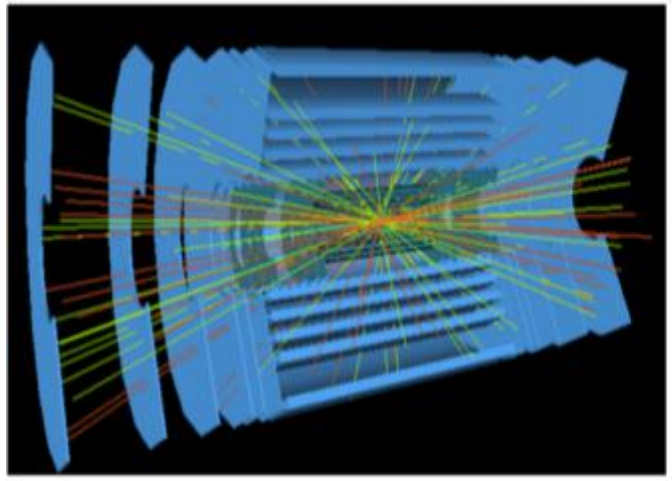
20180713

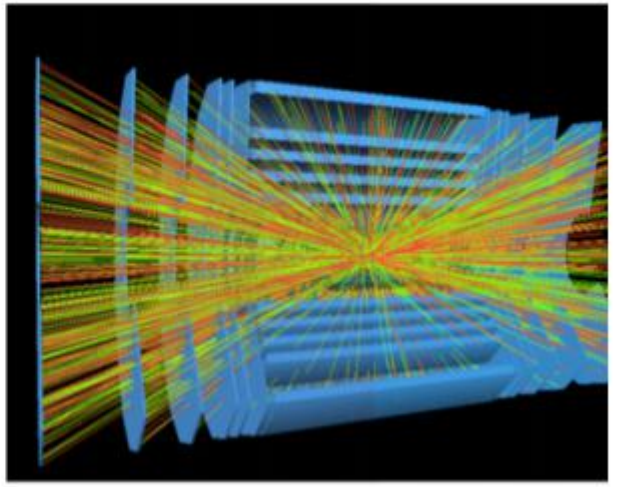
Introduction to LHC phase II upgrade

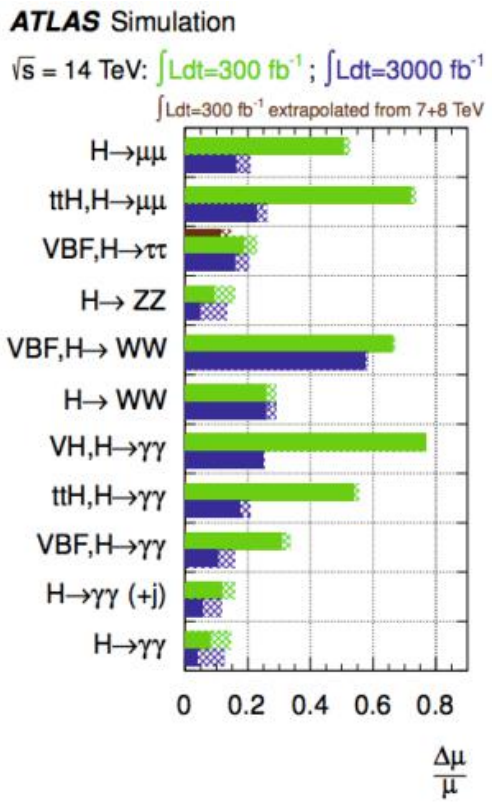
- High Luminosity-LHC(HL-LHC) is foreseen to be completed in 2026
  - will substantially improved Higgs measurement precision (eg: H->μμ)
  - aim to increase the iintegrated luminosity to about ten times the LHC design
  - instant luminosity ~5-7.5*$10^{34}cm^{-2}s^{-1}$, deliver 3000fb^{-1}
  - expect to have 200 collision per bunch crossing

Current LHC



High luminosity LHC

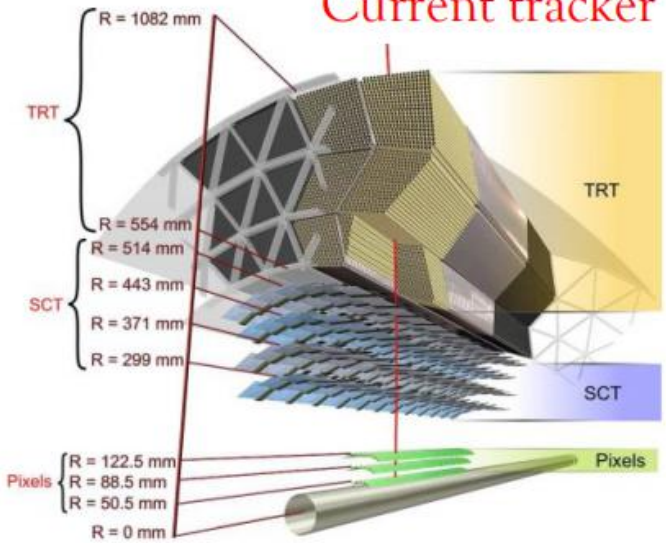




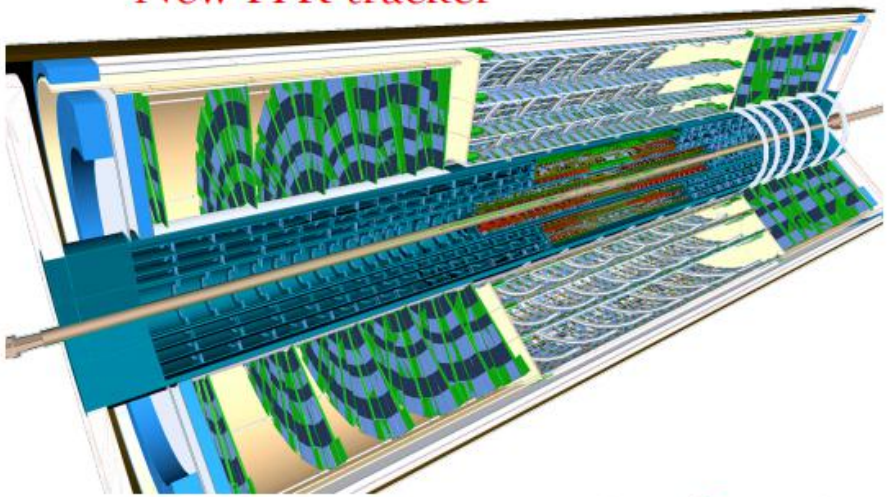
ATLAS Inner TracKer(ITK) upgrade

- Require a new full-silicon tracker for upgrade(more area/channels)

Current tracker



New ITK tracker

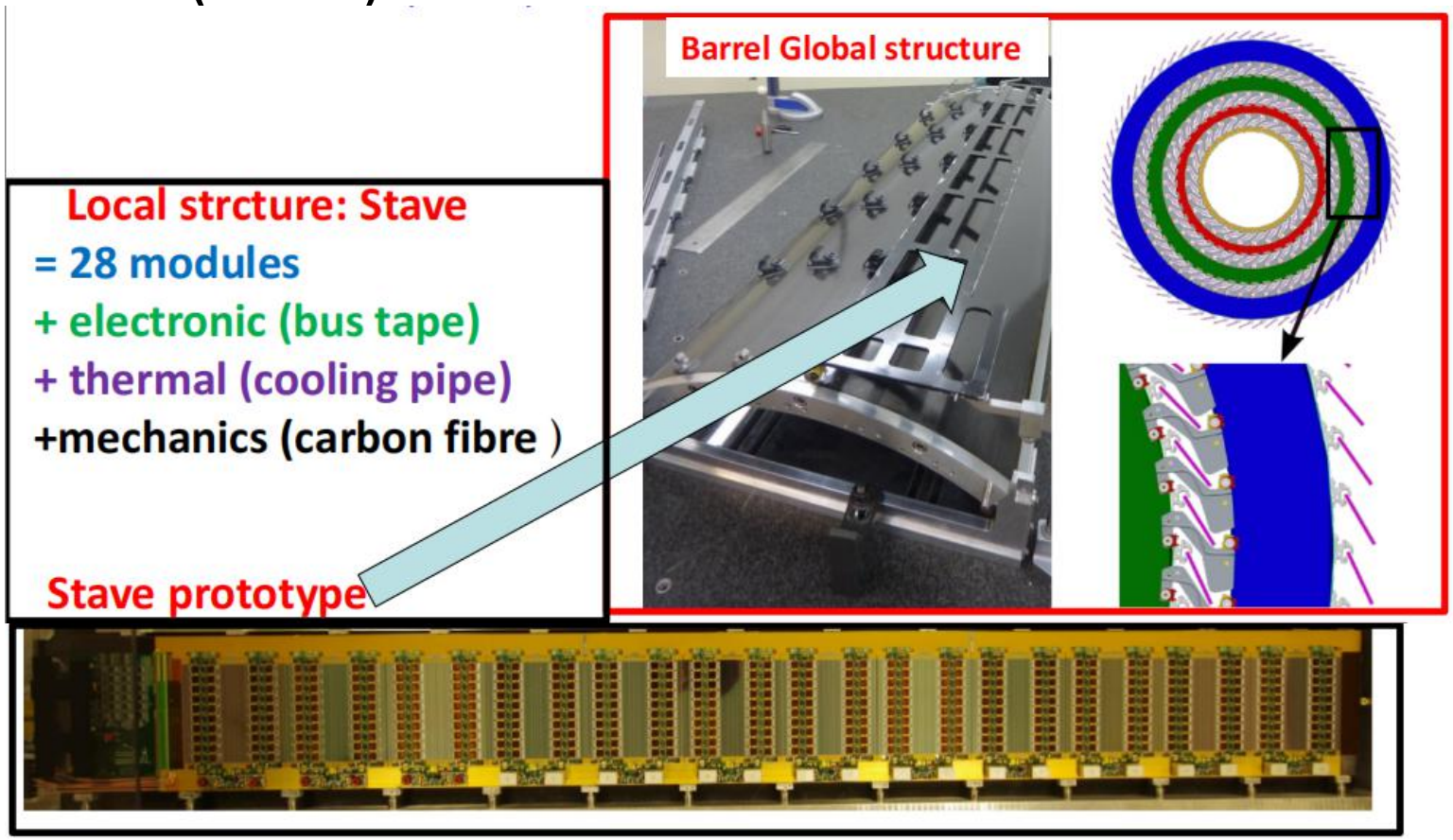


IHEP will contribute 1000 modules (10 m^2 silicon)
In the ITK strip tracker upgrade

Strip detector comparisons	Current Inner strip tracker (SCT)	Future ITK strip tracker
Radial distance	300-560mm	400-1000mm
Channels	~8 millions	~100 millions
Modules	4 thousands	~20 thousands (165m^2 silicon)

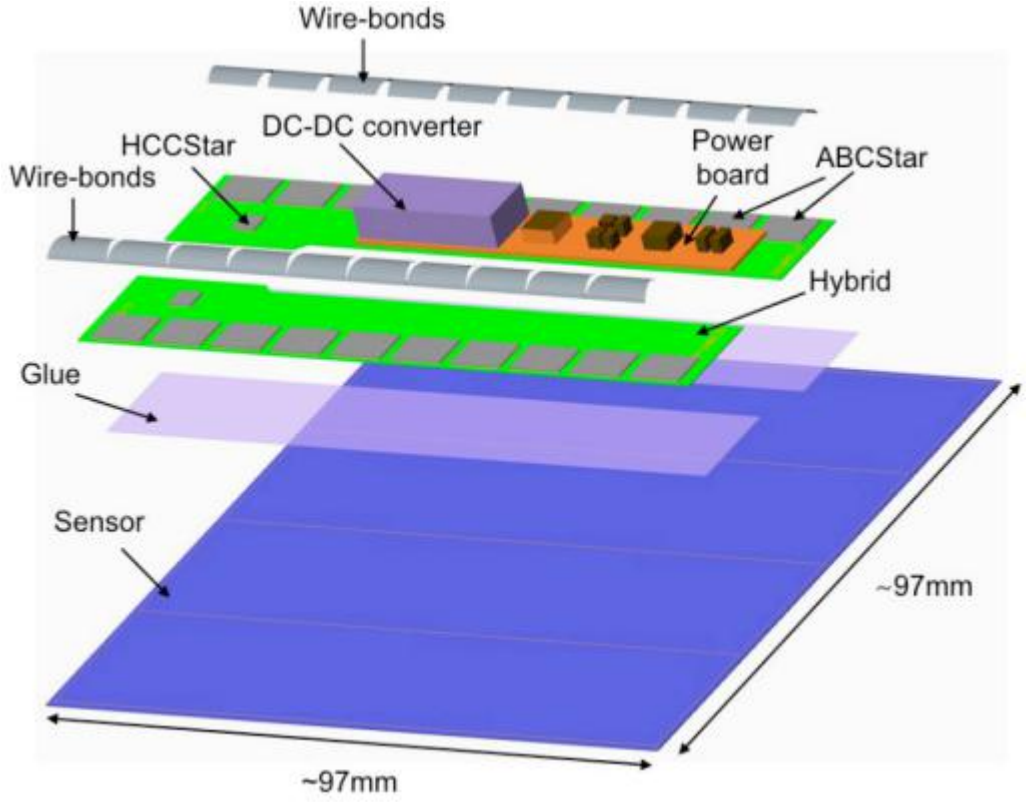
Structure of the silicon strip tracker

- Global structure: 4 layers of silicon strip tracker in Barrel
- Local structure(Stave): 28 barrel modules on each stave

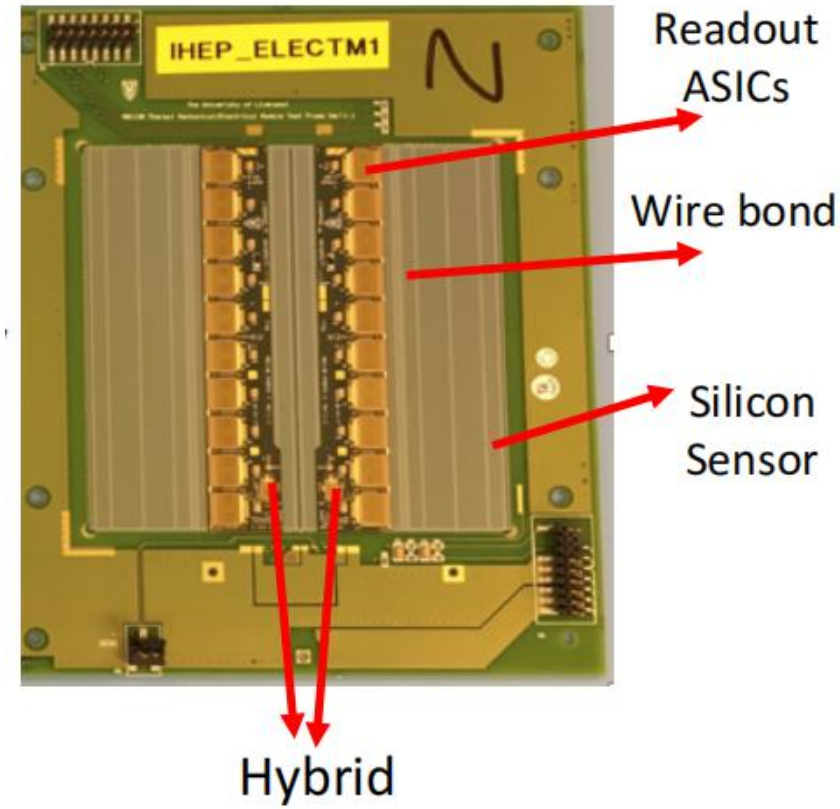


Module: the basic detector unit

- 10 readout ASIC(ABC130) wire-bonded on one hybrid
- 2 hybrid are glued on short strip sensor, and wire bonded to sensor to readout 2560 channels each

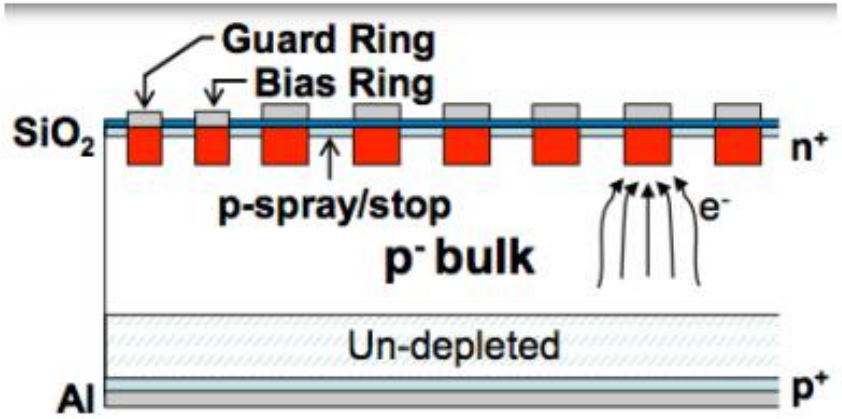


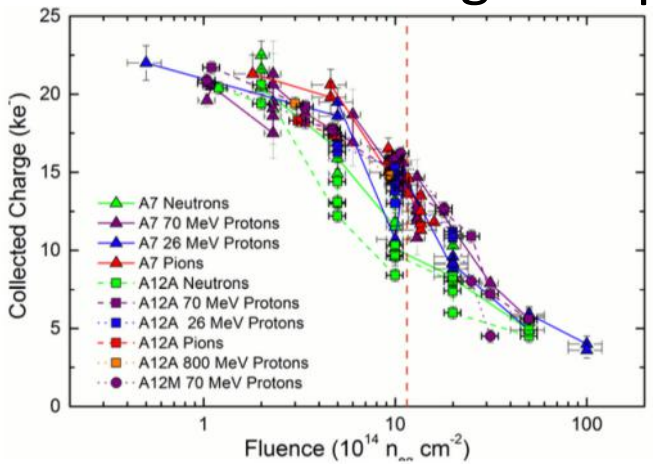
One Module prototype by IHEP



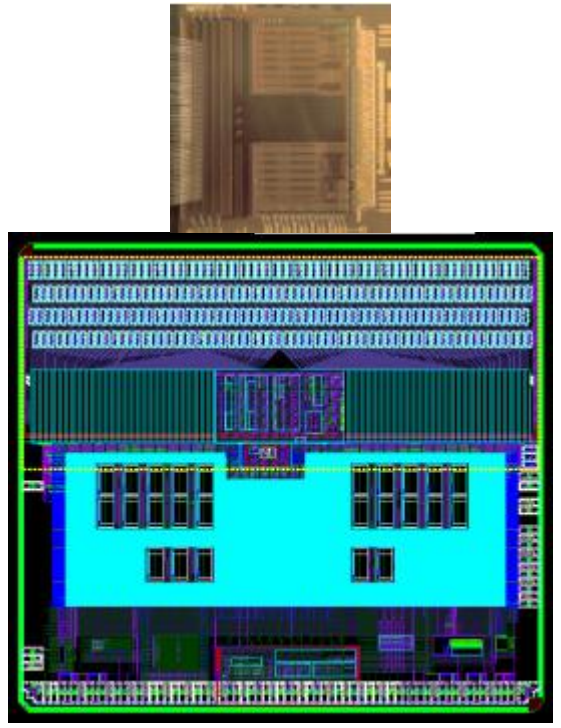
Radiation hard strip sensor

- n+-on-p strip sensor(9.7cm² * 9.7cm²)
  - collect electrons(fast carrires, reduce charge trapping)
  - > 22k(10k) electrons for MIP before(after) irradiation
- Market survey for 2 company(Infineon and hamamatsu)
  - Infineon gave up the project recently
  - final sensor is likely to order from hamamatsu
  - final round of prototyping this year, IHEP contribute to testing and qualify sensors

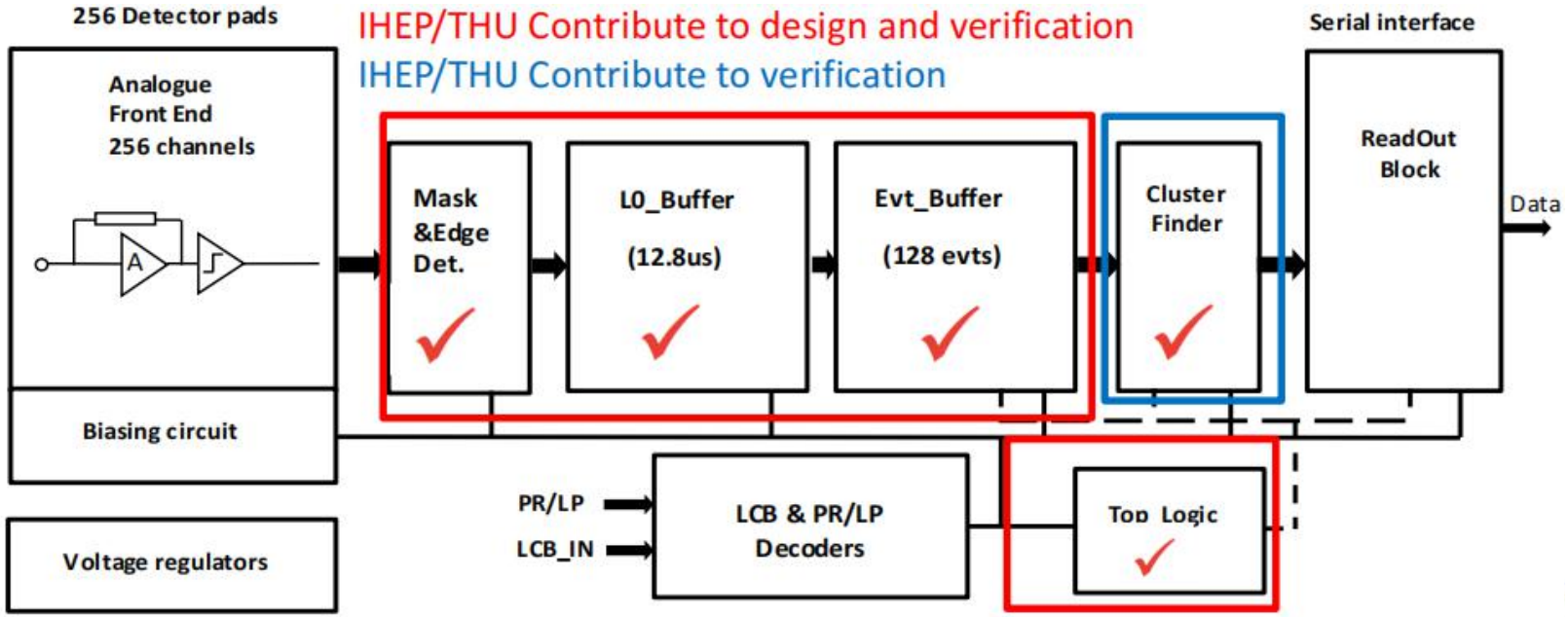




Frontend ASIC: ABCStar chip

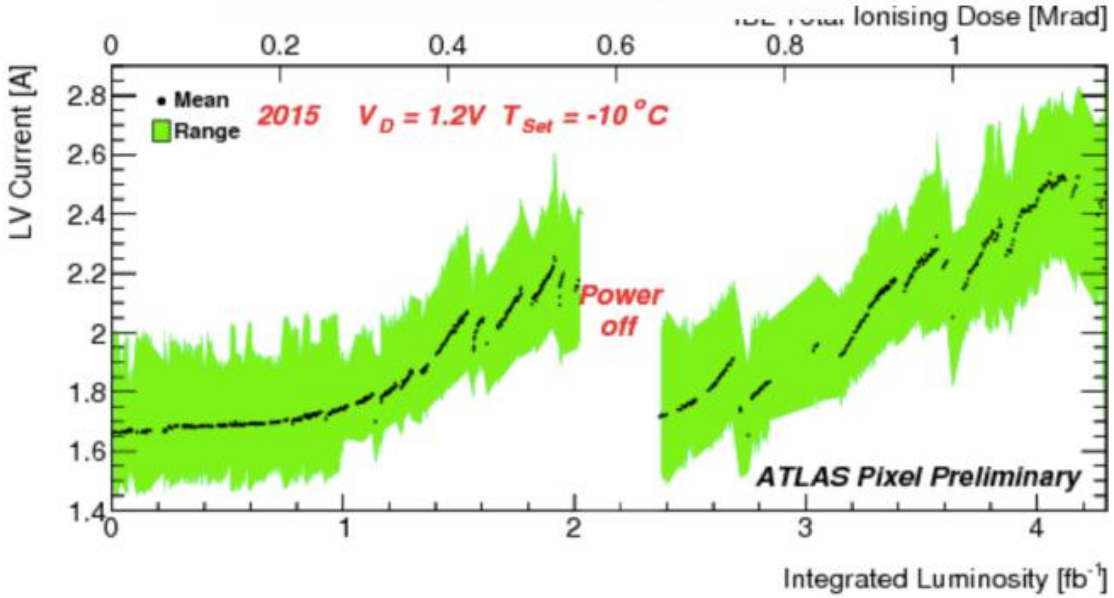


- IHEP/THU contributed to ASIC digital design
- ABCStar readout chip
  - Standard binary readout architecture
  - Radiation hard design
  - IBM/GF 130nm technology



Progress: ASIC radiation hardness

- Lesson from ATLAS Insertable B layer pixel(IBL) operation
  - Digital current in FEI4 ASIC(IBM/GF 130nm CMOS) increase significantly



ITK project irradiation

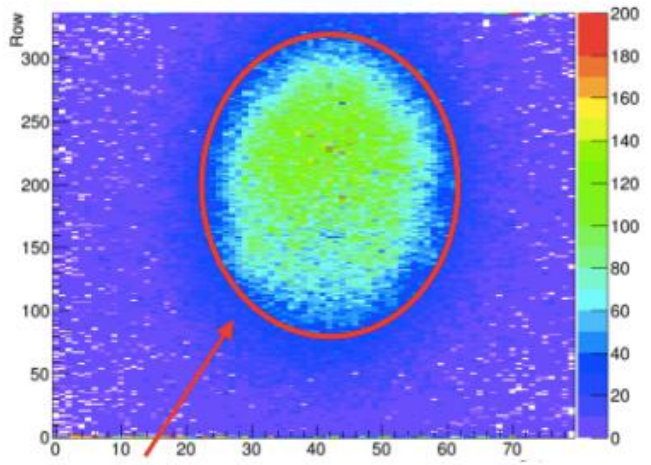
- IHEP/THU group coordinated the ITK irradiation at SPS(CERN)
  - C. Bertella presented this study in HSTD2017 conference

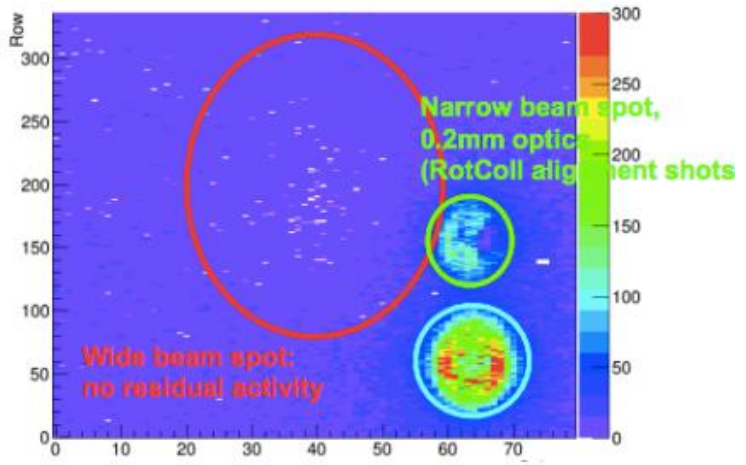
Global irradiation: 2 mm beam

- Completed few hours
  - RotColl out of the beam (no interference)
  - 1, 4, 12, 24, 36, 72, 144, 288 bunches (0.5 x 10^{11}p), 288 bunches (10^{11}p)
- Beam spot due to material activation (after glow).
- The intensity of the spot was increasing after each shot.
- The intensity of the spot was decreasing with time
- After each shot, module configuration was lost

Local Irradiation: 0.4mm beam

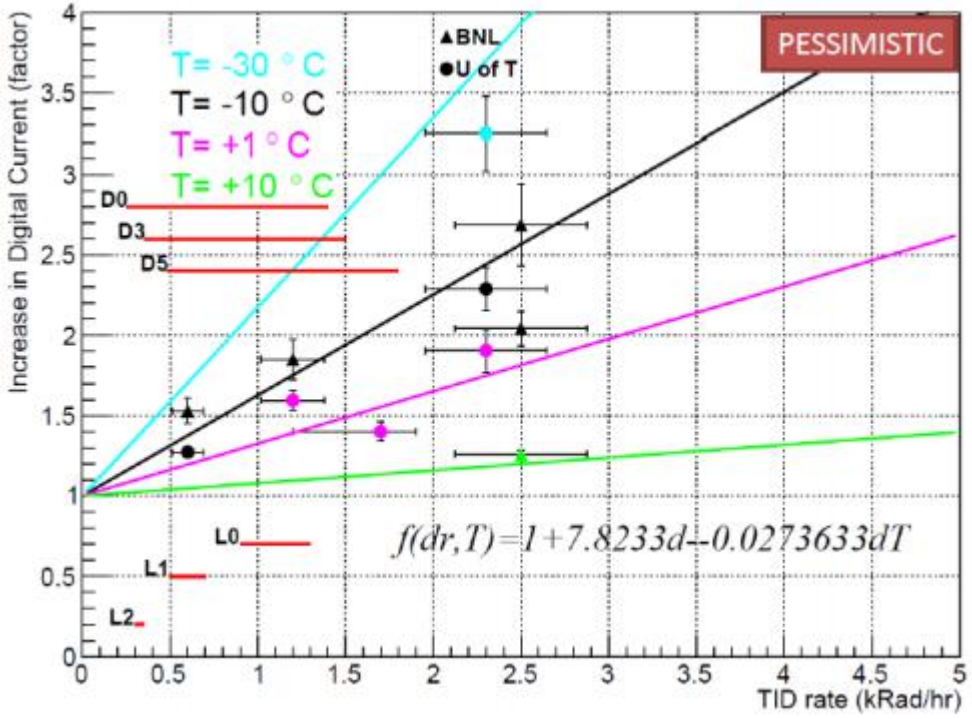
- after Global irradiation
  - RotColl out of the beam (no interference)
  - 1, 12 bunches (10^{11}protons).
- During RotColl operation
  - Secondaries impacting the test-box
- After RotColl 72, 288 bunches
- Detector dead after 288 bunches
  - Not responding to reconfiguration

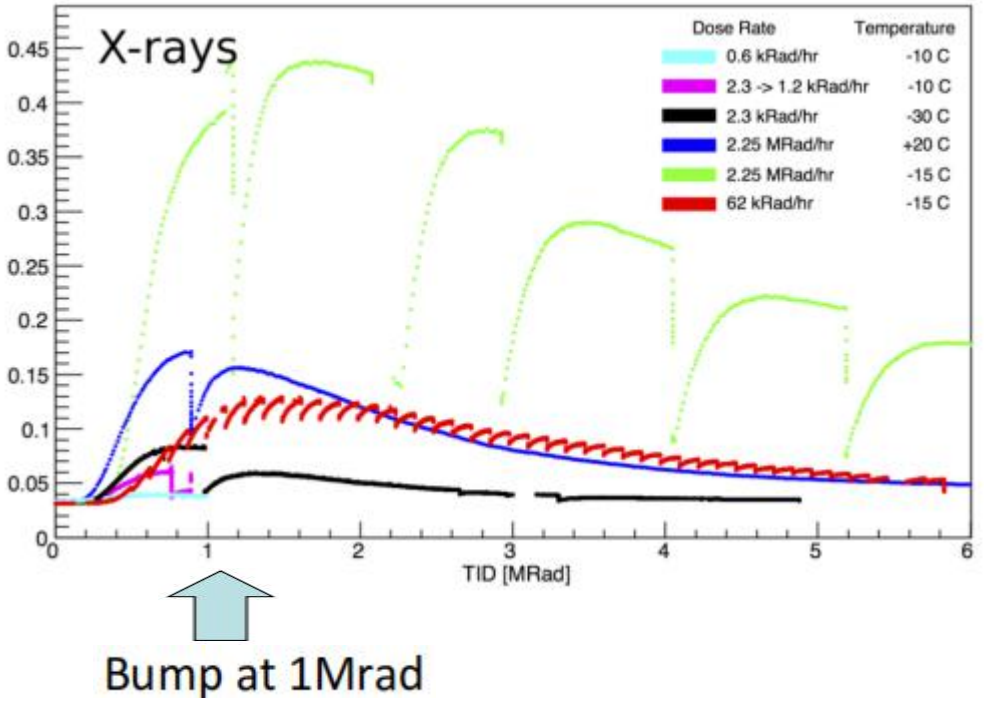




TID current bump in ASIC

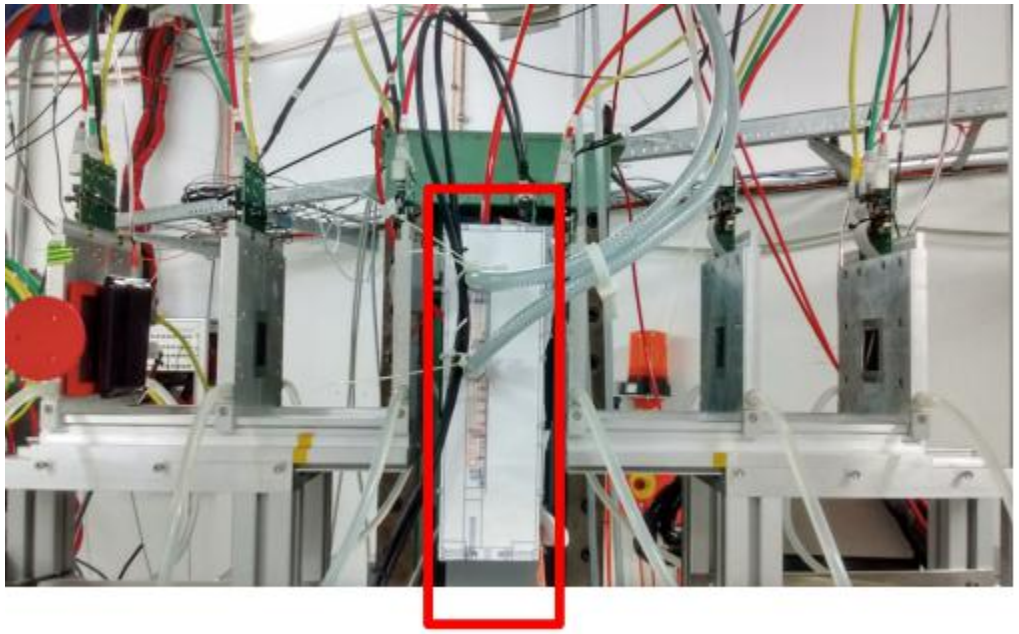
- ABC130 chip digital current increase after irradiation
- low rate, low temperature irradiations of ABC130 have been done
- expected the digital current increase by 100% after irradiation

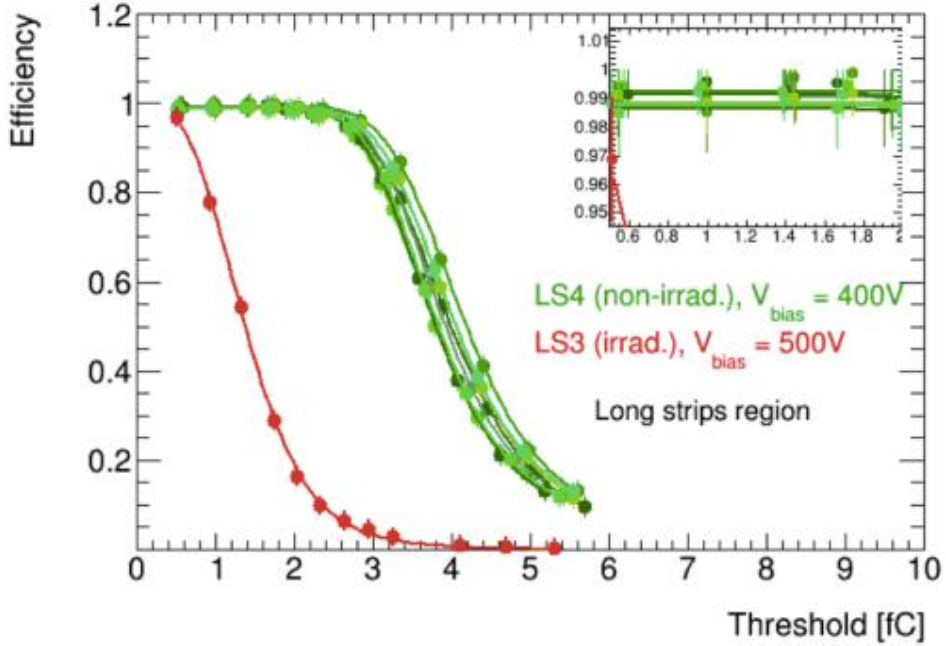




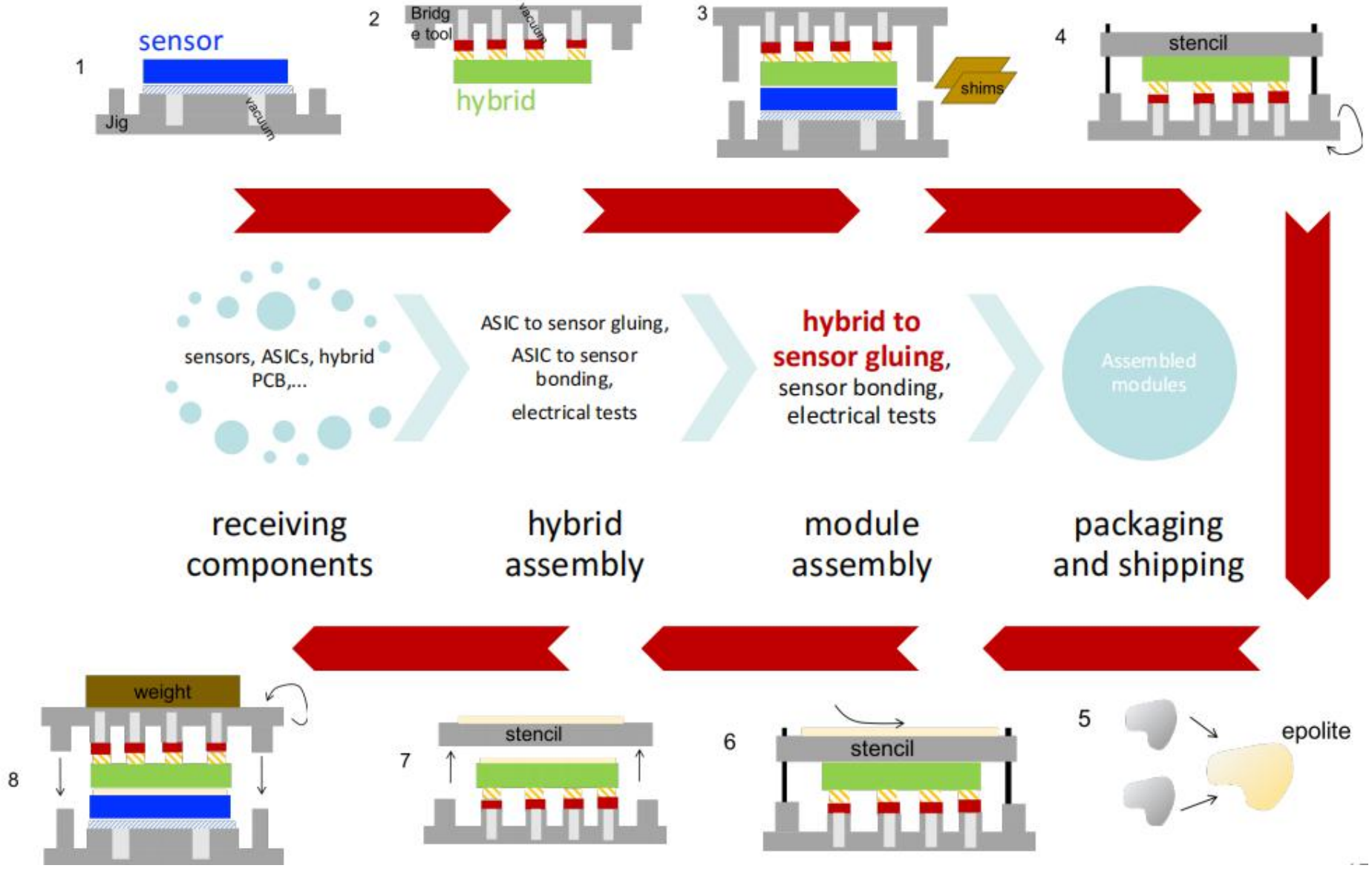
Module testbeam at DESY

- Contribution to module testbeam at DESY
  - Xiaocong Ai, Liejian Chen and Yi Liu
  - EUDAQ telescope DAQ support, data analysis, data taking shifts
- ATLAS R0 module and SS module test at E-lab in DESY May 2017
  - S/N > 20, detection efficiency > 99% after irradiation



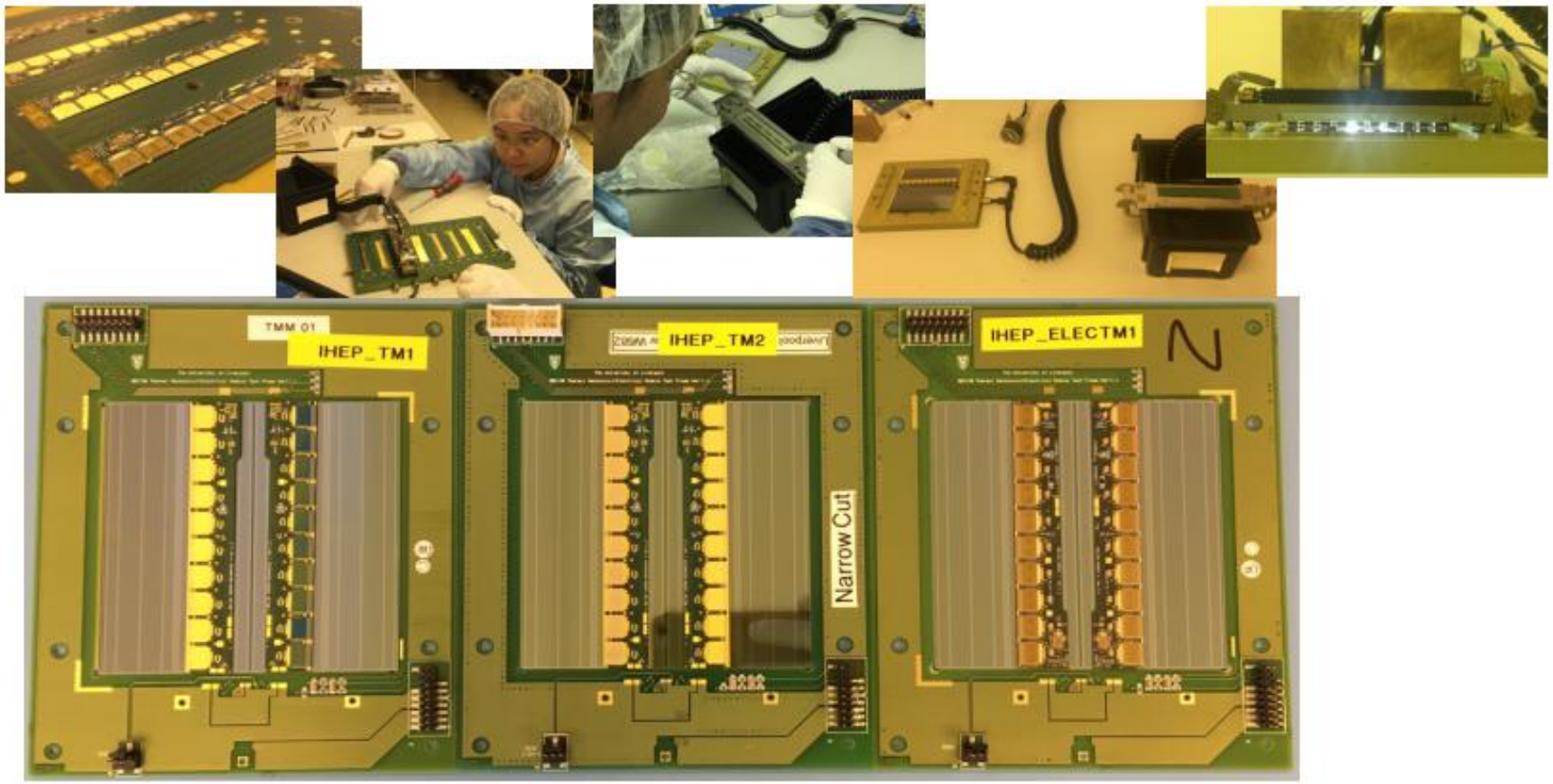


Module production workflow



Module production at RAL

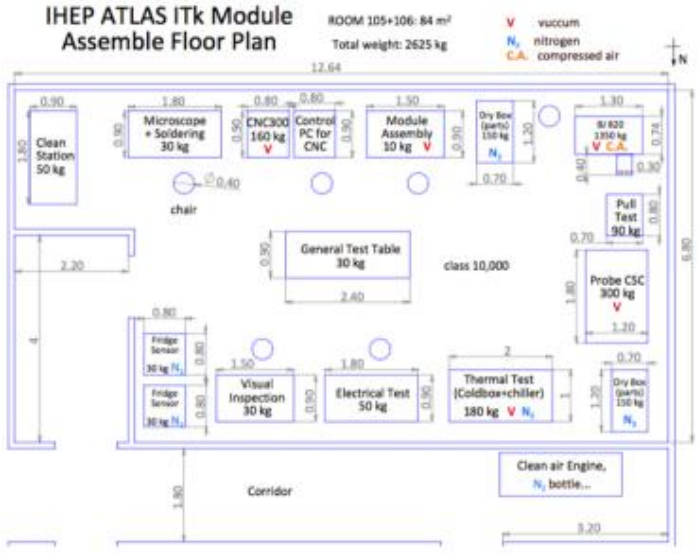
- Glued 3 modules(2 thermal mechanical and 1 electrical)
- Passed electrical test after wire bonding



IHEP Lab for module production

- An existing class 1000 cleanroom with 150m²

- A new class 10000 clearoom with 80m² is on the way



OGP Flash CNC 300

Smart scope

Visual inspections

Flash CNC 300

Hesse BondJet820

Fast auto wire bonder

HESSE BJ820

Local production: Radiation-hard ASICs Import issue

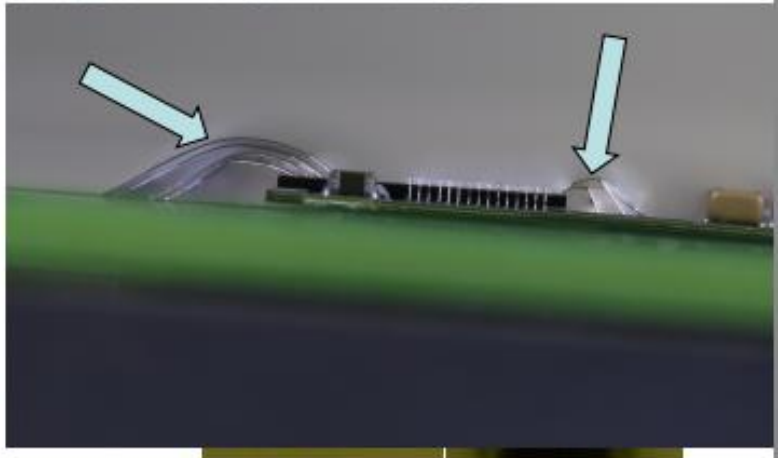
- **Rad-hard ASICs under export control → obstacle**
- **Main driving factors:**
  - China's deeper involvements in operation, upgrade and analyses
- Discussion with ATLAS and CERN
  - obtained export license from US DoC
    - Overall package (valid for ATLAS/CMS projects), valid for seven years
    - Obtained SECO for ABC130 (Swiss export license)

已获得芯片

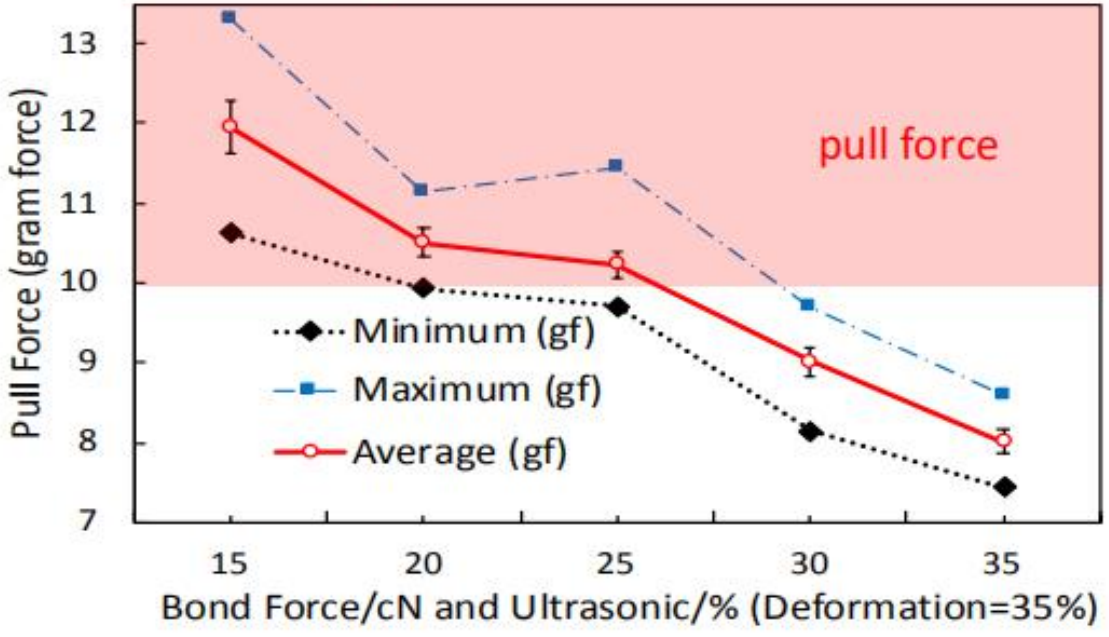
抗辐照芯片	实验项目	工艺	主要功能
VMM	ATLAS NSW （一期升级）	IBM 130nm CMOS	快速前方、成形、甄别前端芯片
SCA		130 nm CMOS	慢控芯片
FEAST		AMS 0.35um HV-CMOS	供电控制芯片
ABC130	ATLAS ITk-Strip（二期升级）	IBM 130nm CMOS	硅微条前端读出芯片
CHESS 2		AMS 0.35um HV-CMOS	集成模拟、部分数字电路
HGCROC（正在办理）	CMS HGCAL（二期升级）	TSMC 130nm CMOS	高粒度量能器读出芯片

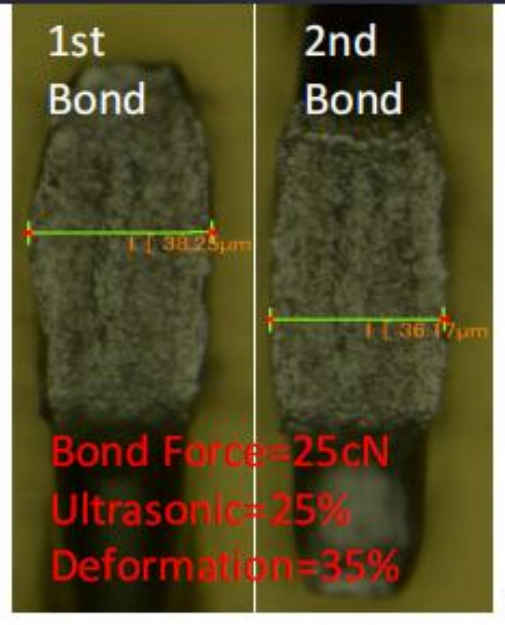
Wire bonding study for module production

- Wire bonding is one of key issue for module production
  - key parameter study: deformation, ultrasonic and force
- How to evaluate the quality ?
  - pull test : important step in QA/QC



effects by Bond Force & Ultrasonic





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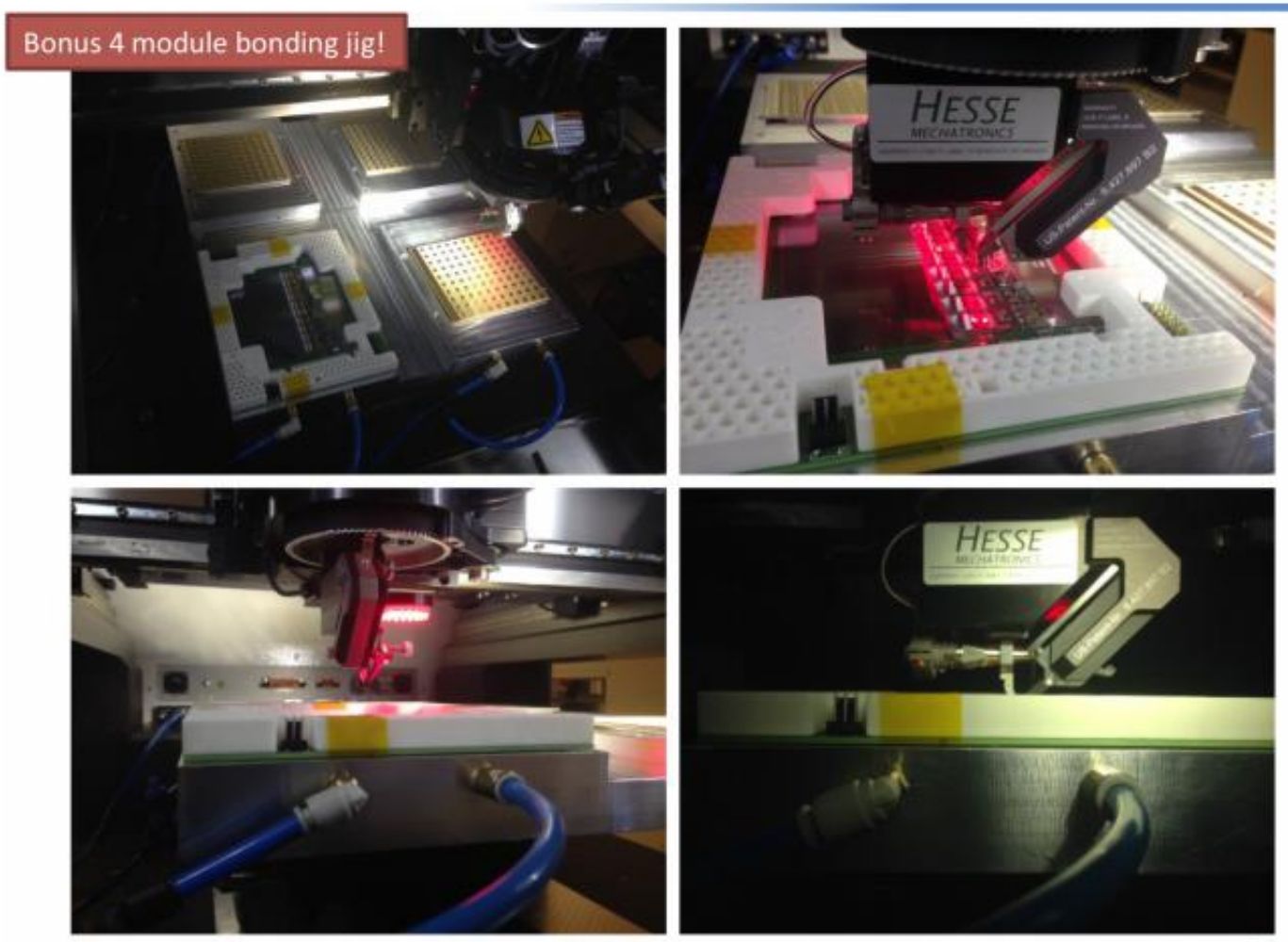
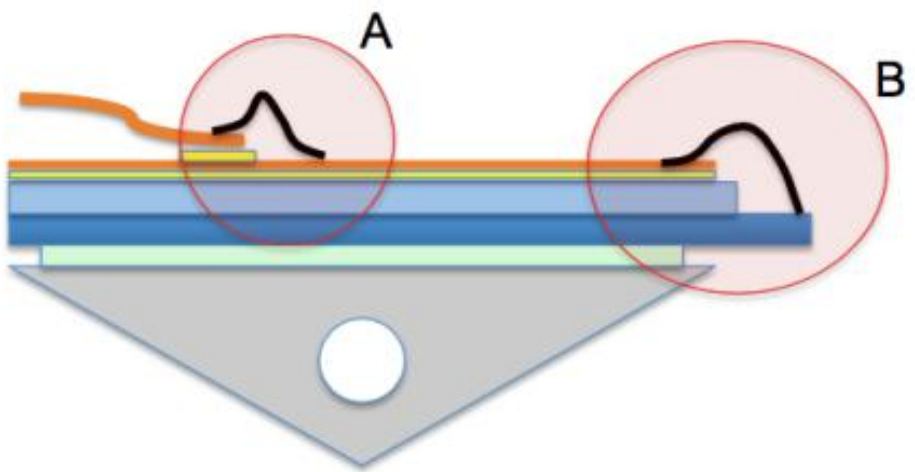
New Module production tool by IHEP: 2X2 jig

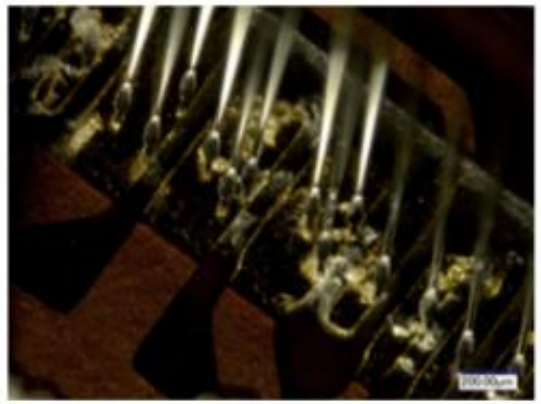
- IHEP developed new tool to improve the module production efficiency
  - One module each time -> 4 module each time (by Yuzhen)



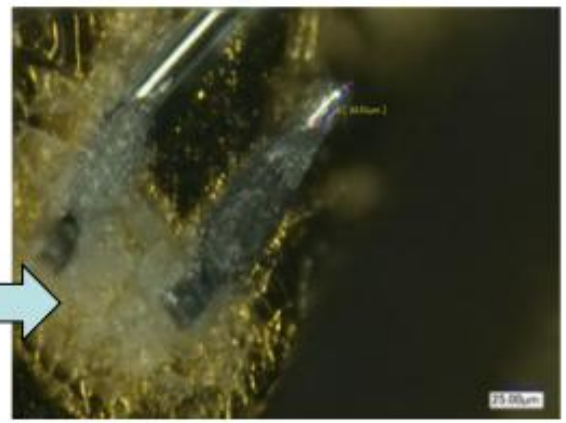
Issue in production: wire bond corrosion

- Lesson from IBL pixel detector:
  - Al wire Bond Corrosion due to humidity
  - White remnants which are likely Al(OH)3
  - Humidity control became most important step in quality control
    - Humidity at <5%





White remnants which are likely Al(OH)3



Issue in production: wire bond protection (encapsulation)

- Another way to protect wire bond: encapsulation
- IHEP/THU group with Oxford contribute to this R & D.
  - Fully encapsulate ASIC back-end wires (ASIC to hybrid)
  - More tests on going check the performance before and after

Glue dispenser to perform
The encapsulation R & D

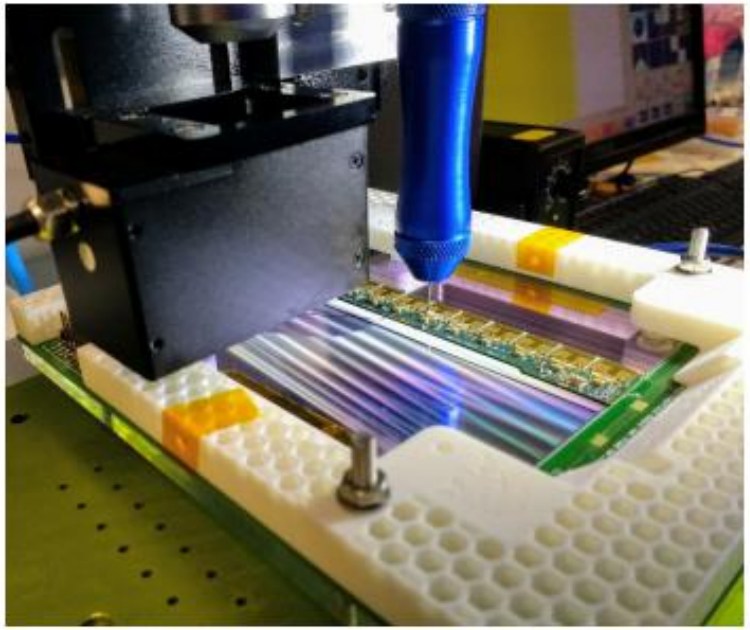


Photo of wire bond
encapsulation