

ATLAS phase II strip tracker upgrade

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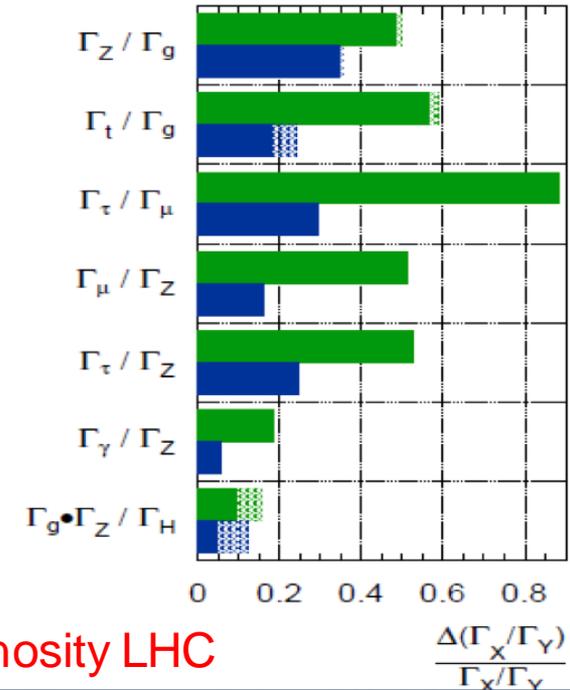
Outline

- Introduction to ATLAS tracker phase II upgrade
- ALTAS tracker phase II upgrade activity in China
 - Silicon strip detector module R & D
 - CMOS sensor R & D
- Summary

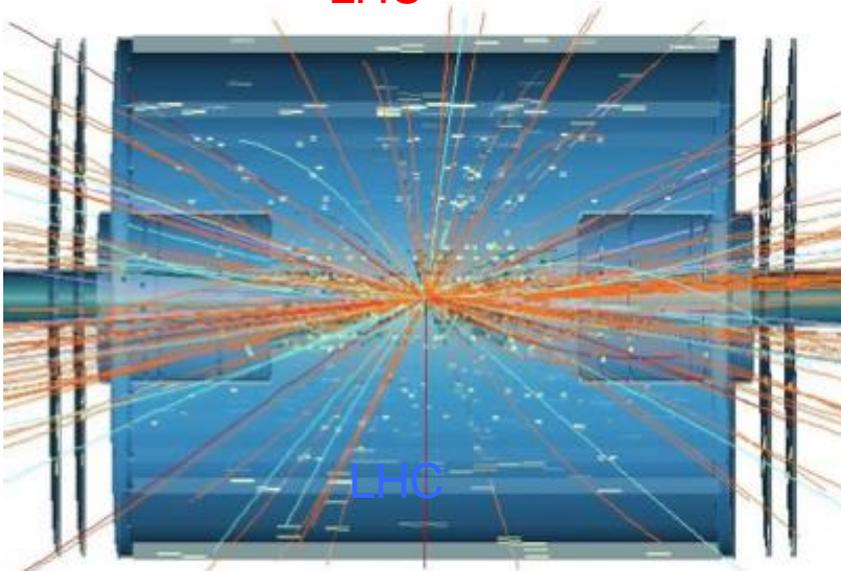
High luminosity LHC

- In ten year, CERN will upgrade Large Hadron collider (LHC) to high luminosity LHC
- Higgs precision measurements
- new physics search

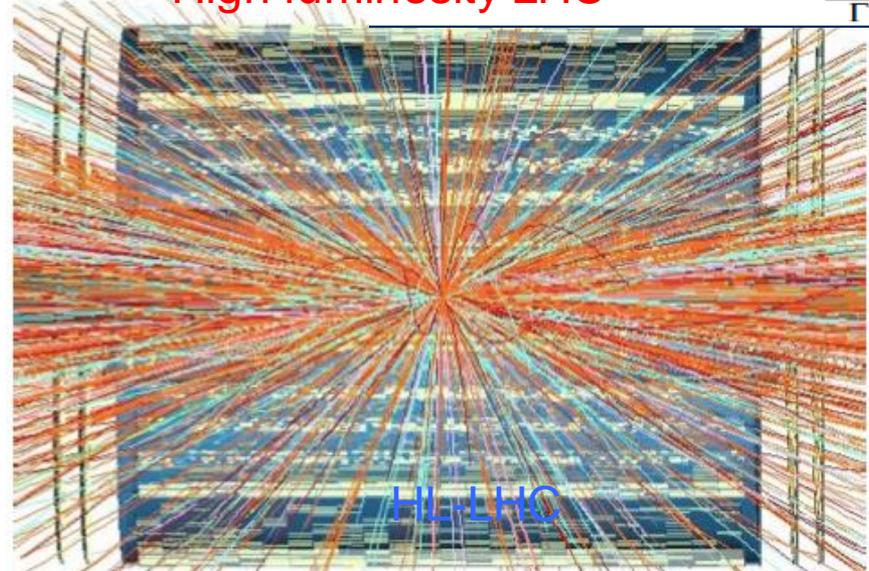
ATLAS Preliminary (Simulation)
 $\sqrt{s} = 14 \text{ TeV}$: $\int L dt = 300 \text{ fb}^{-1}$; $\int L dt = 3000 \text{ fb}^{-1}$



LHC



High Luminosity LHC

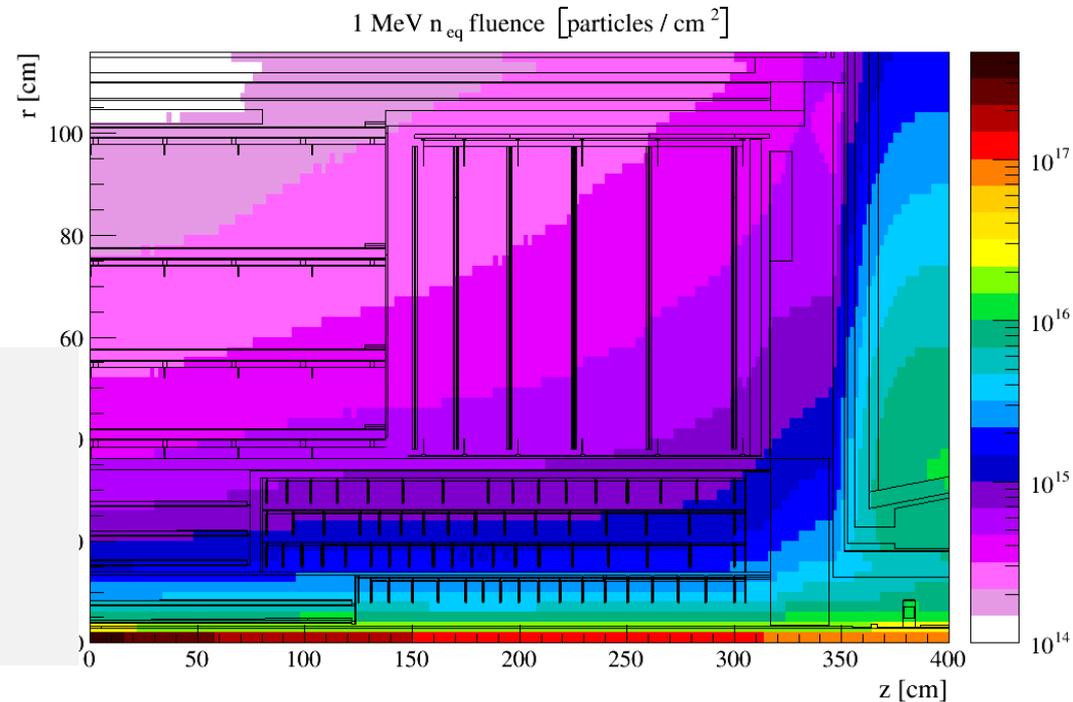


ATLAS tracker phase-II upgrade

- ATLAS need to build a new full-silicon tracking detector (ITK) to handle high luminosity LHC (HL-LHC) upgrade

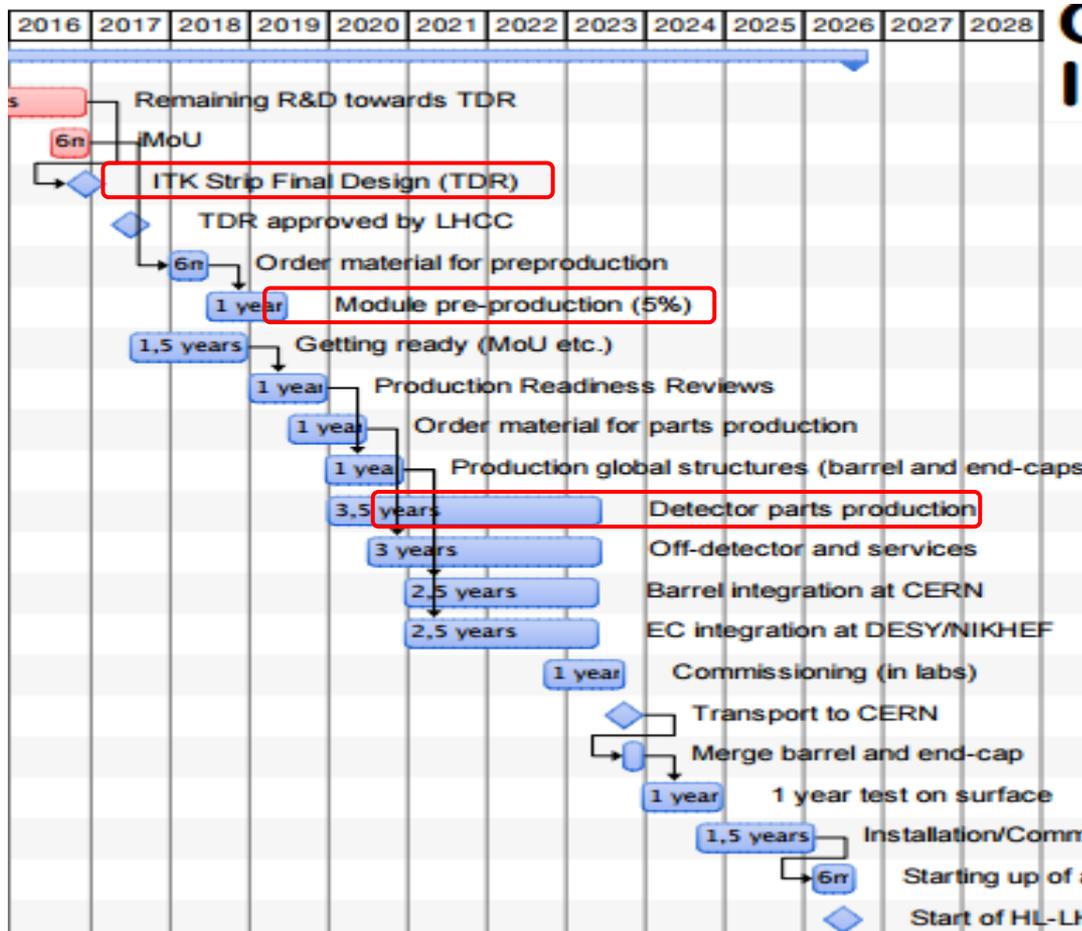
**Radiation hardness requirement
In ATLAS phase II upgrade
(Equivalent neutron flux)**

$2 \times 10^{15} \text{ Neq/cm}^2$



Present ATLAS strip detector is designed only up to $2 \times 10^{14} \text{ Neq/cm}^2$

Timeline of ATLAS strip detector upgrade



End of 2016 , technical design report (TDR)



2018-2019 pre-production



2020-2023 production

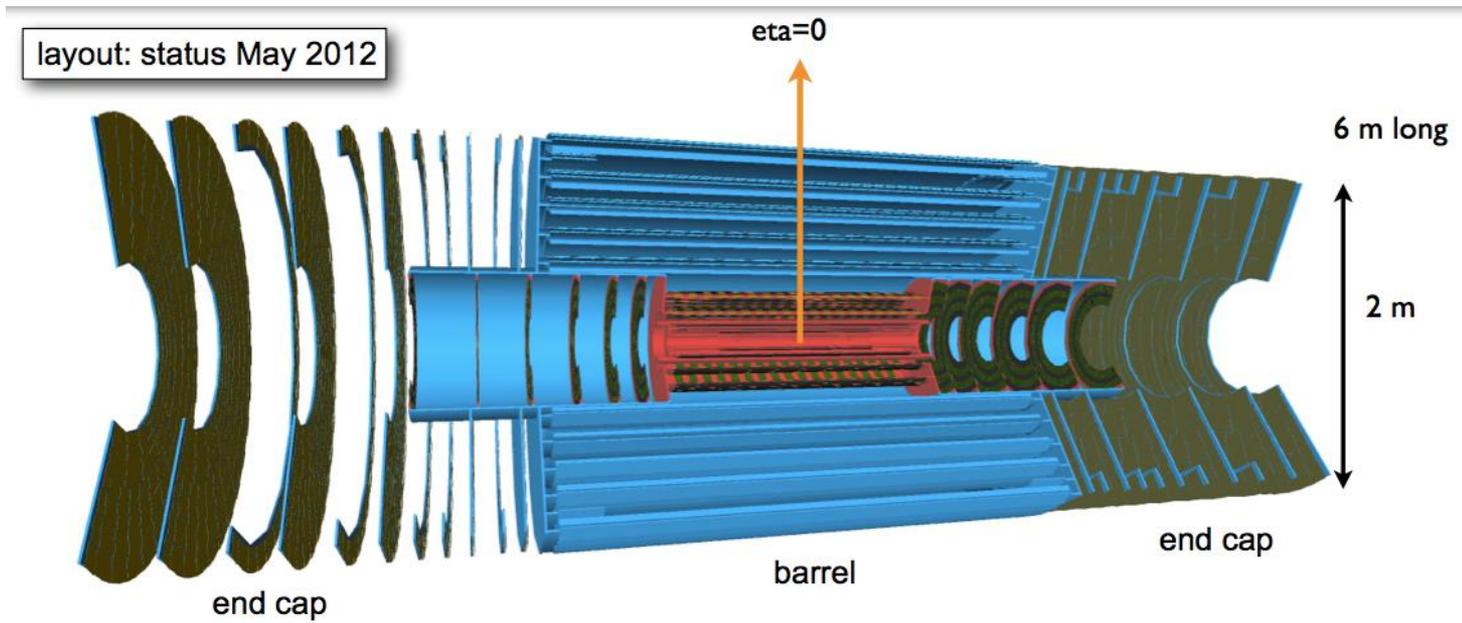
Research grant for ATLAS ITK phase II upgrade

- ATLAS China group got the research grant supported by Ministry of Science and Technology of China (MOST): **13 million Yuan**
- This grant covers the following R & D and small scale production:
Front-end electronic readout ASIC design for ATLAS strip detector
- Silicon strip detector module prototyping and production
- CMOS-based silicon strip detector performance study

Silicon Strip Detector Module Production

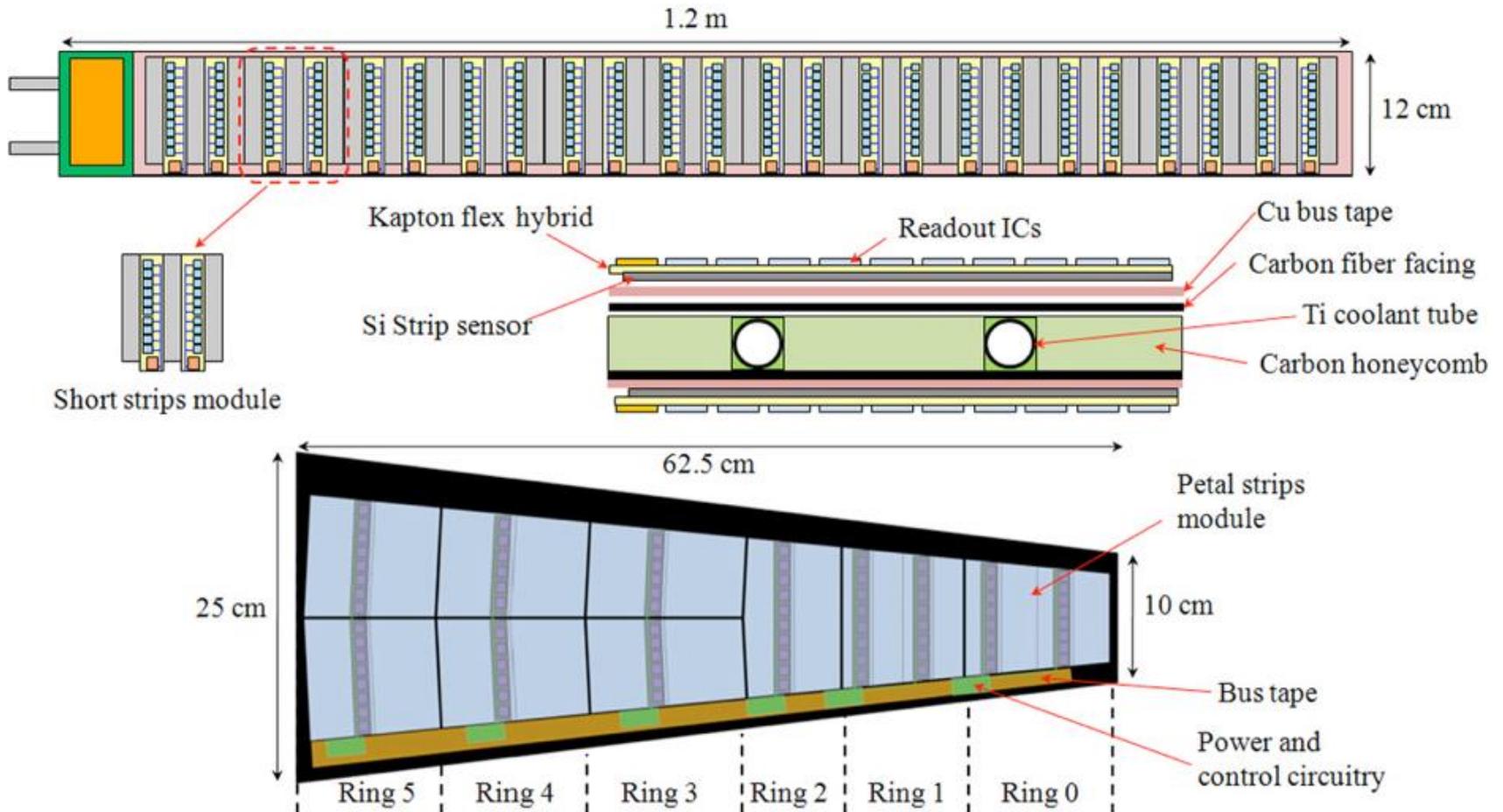
ATLAS Strip detector Phase 2 upgrade	total	ATLAS China group expected contribution
Area	190 m ²	10 m ²
Modules	20,000	1000

- China is going to build **1000** strip modules in phase 2 upgrade
 - Contribute **5%** of ATLAS phase 2 strip detector
 - covers large area of detector : **10m²**



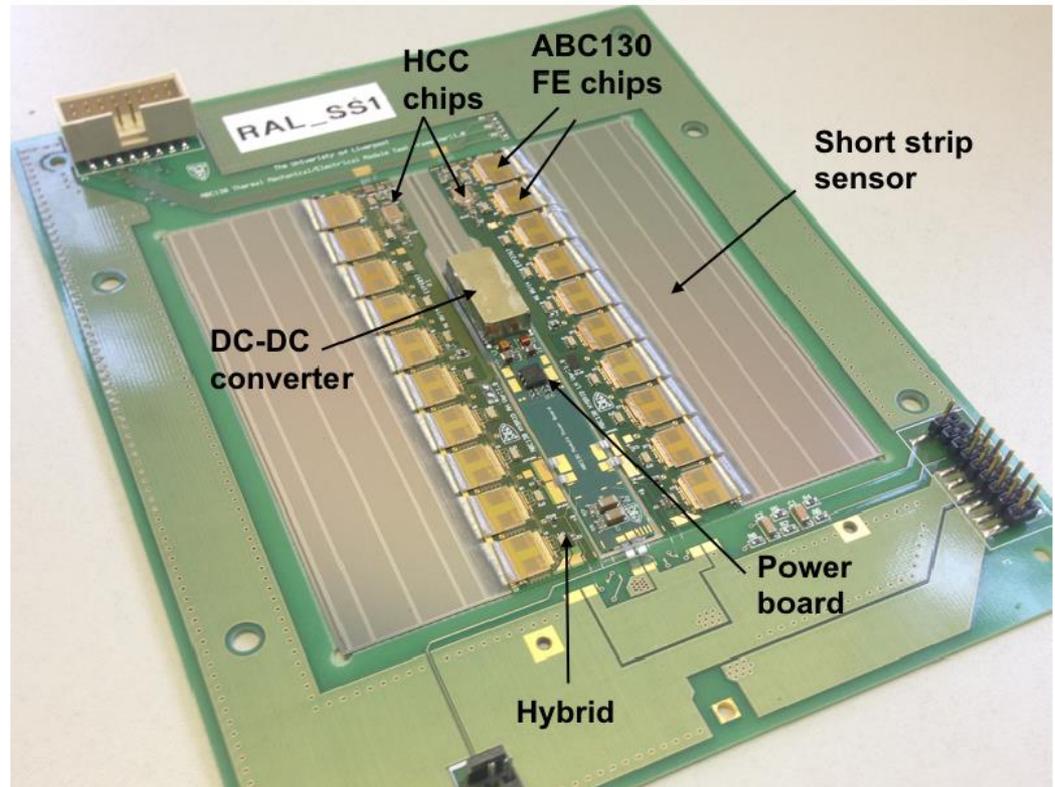
Stave/Petal concept

- Stave/Petal concept



Silicon detector module

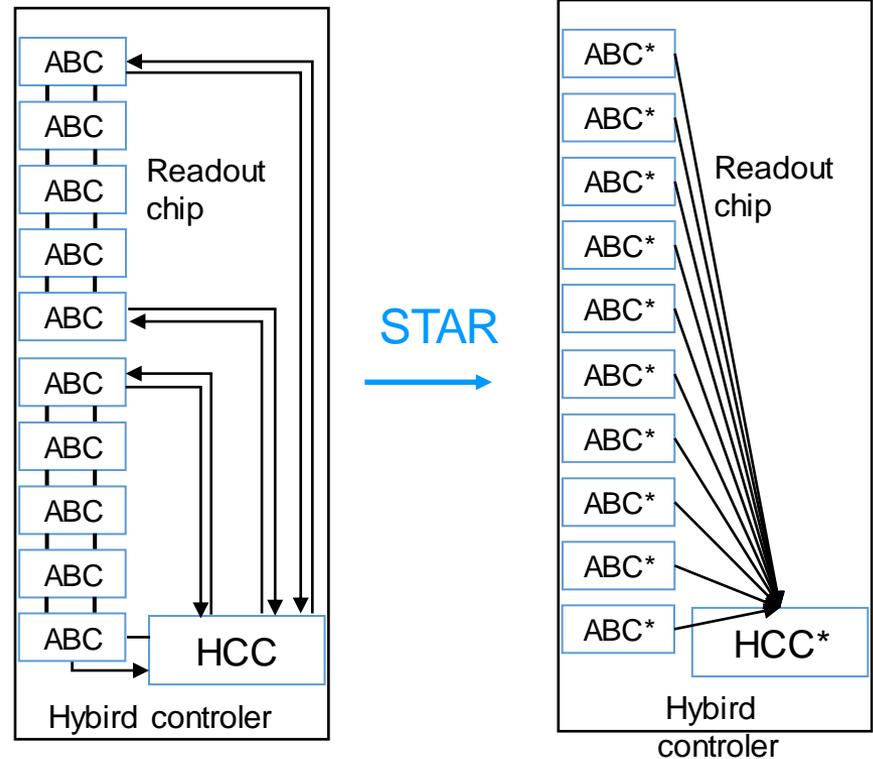
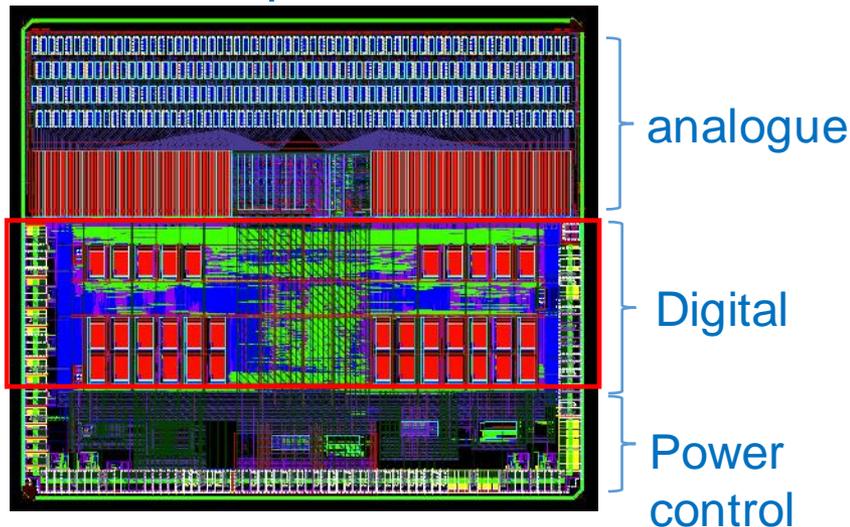
- Basic unit of strip detector: module
 - Silicon sensor
 - PCB hybrid controller (readout ASIC + controller electronic)
 - Power board



Frontend electronic

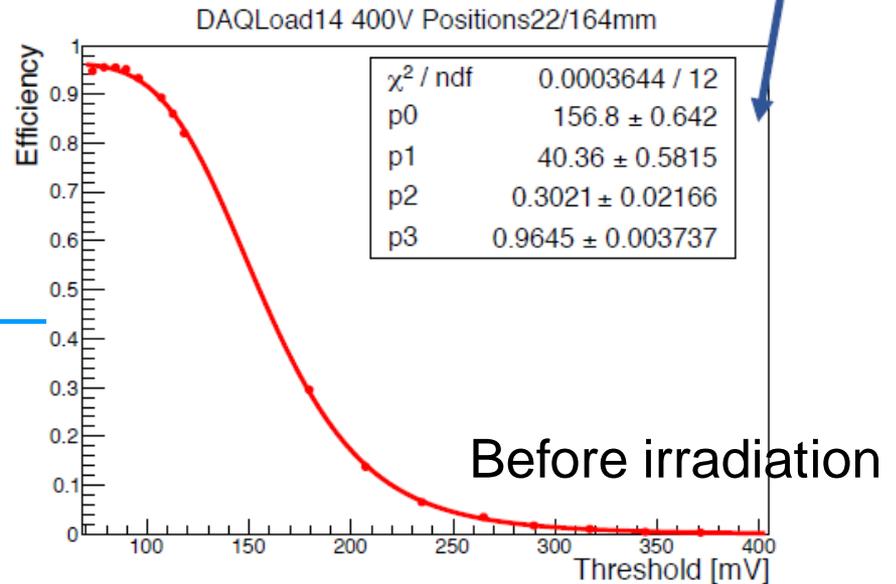
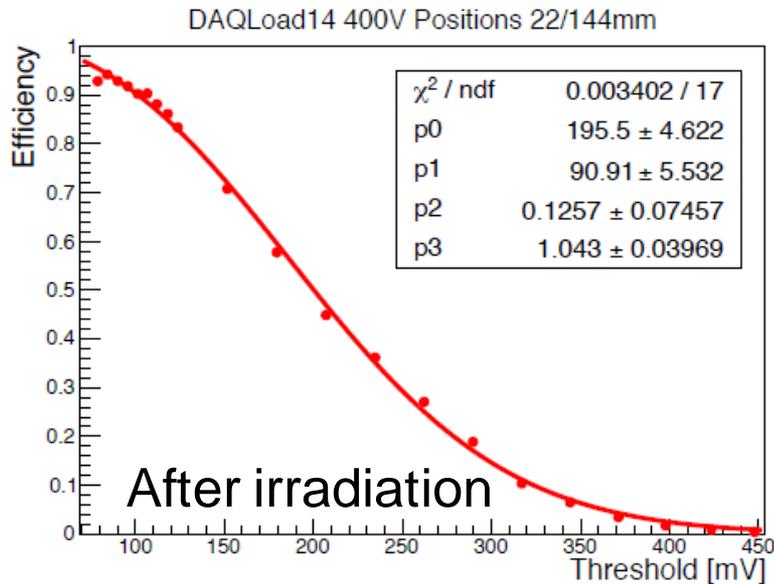
- China contribute to the readout ASIC prototyping
 - L0 trigger has higher requirement on trigger rate
 - Redesign the digital part of readout ASIC
 - Collaborate with CERN electronics group and University of Pennsylvania
 - More details in Weiguo's talk

prototype of readout ASIC:
ABCN130 chip



Beam test for ATLAS upgrade

- contribute to beam test DAQ framework development (EU-DAQ)
- Active in beam test study : measure S-curve of module and hit efficiency

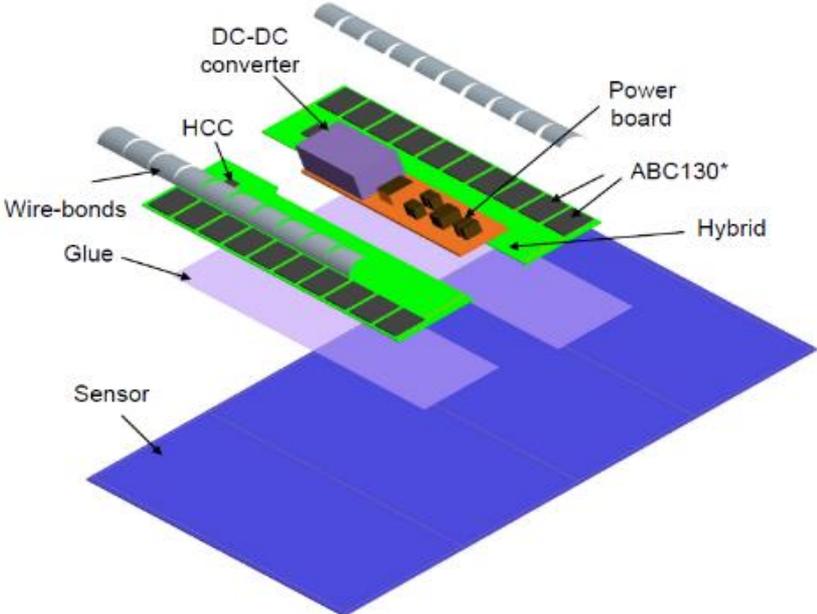
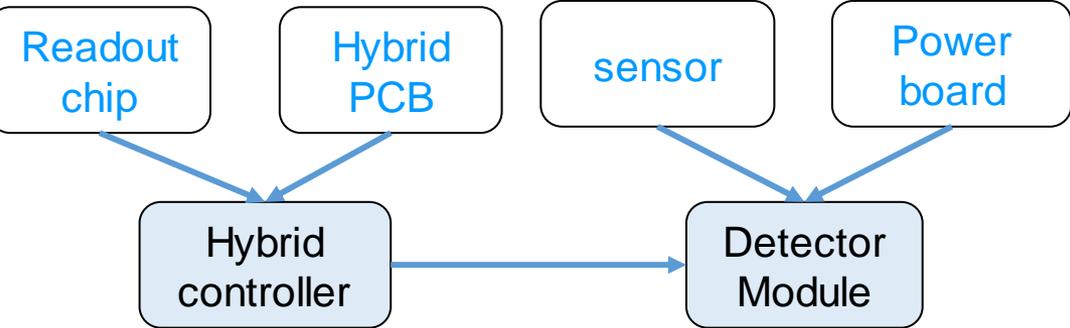


S-curve of strip module before/after irradiation

- beam test result from ATLAS China included in ATLAS upgrade TDR.
S/N after irradiation is estimated to be about 20

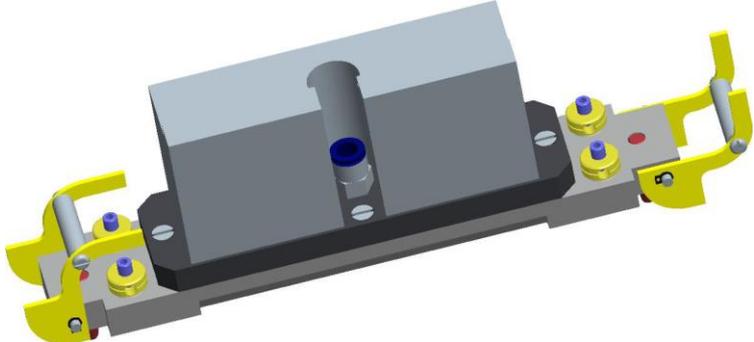
Silicon strip detector module prototyping and production

- contribute to module R & D
- Manufacturing module building tool



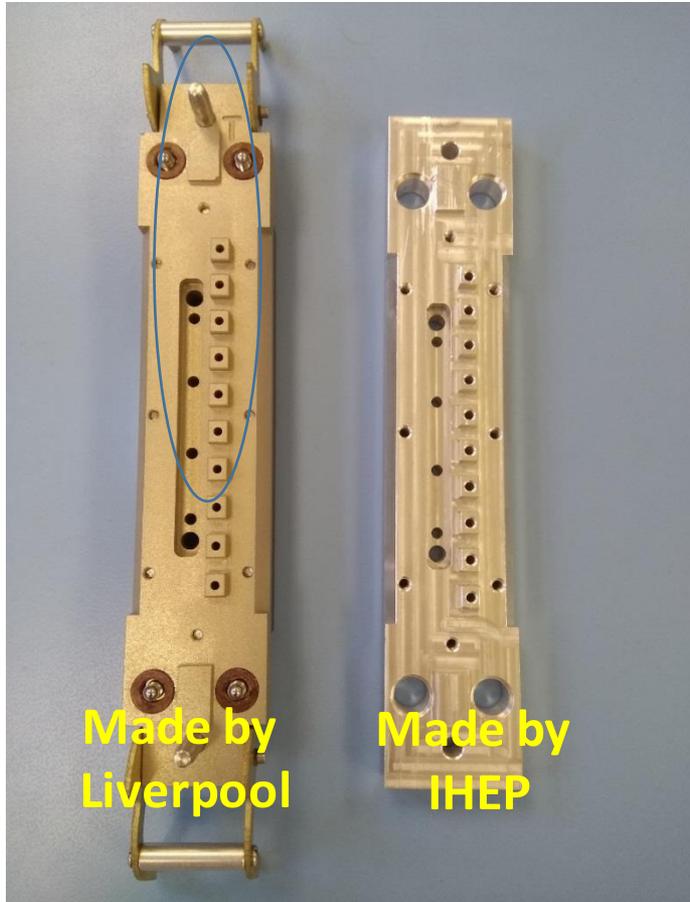
ASIC Pickup tool

Detector module

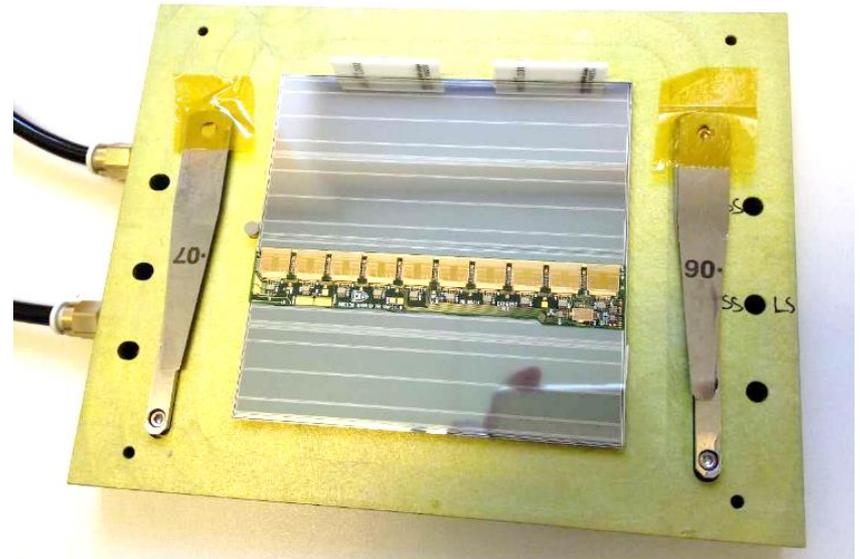


Silicon strip detector module prototyping

- participate in module tooling R & D
 - The planarity tool made in China is within $20\ \mu\text{m}$
 - Meet the design requirement
- Contribute to module prototyping.



Prototype module made by China group



Export control

- Key Radiation hard chip, embargo against China
 - Frontend readout chip ABC130
 - hybrid control chip HCC,
 - monitoring chip AMAC,
 - DC-DC chip FESAT
- Embargo exemption :
 - CERN hires layers to apply for embargo exemption for many countries.
 - Prof Joao Costa is contact for about embargo exemption application for China
- International Collaboration :
 - Make use of facility aboard from our collaborators to train our people.
 - Learn the key technology

International Collaboration

- collaborate with Rutherford Appleton Lab(RAL) in module R & D
- ATLAS China group visit RAL in 19 Sep,2016
 - Discuss the collaboration in ATLAS upgrade project



Laboratory

- State key lab has a 150 m² Thousand grade clean room
- With probe station, wire bonder for detector R & D



BJ 820

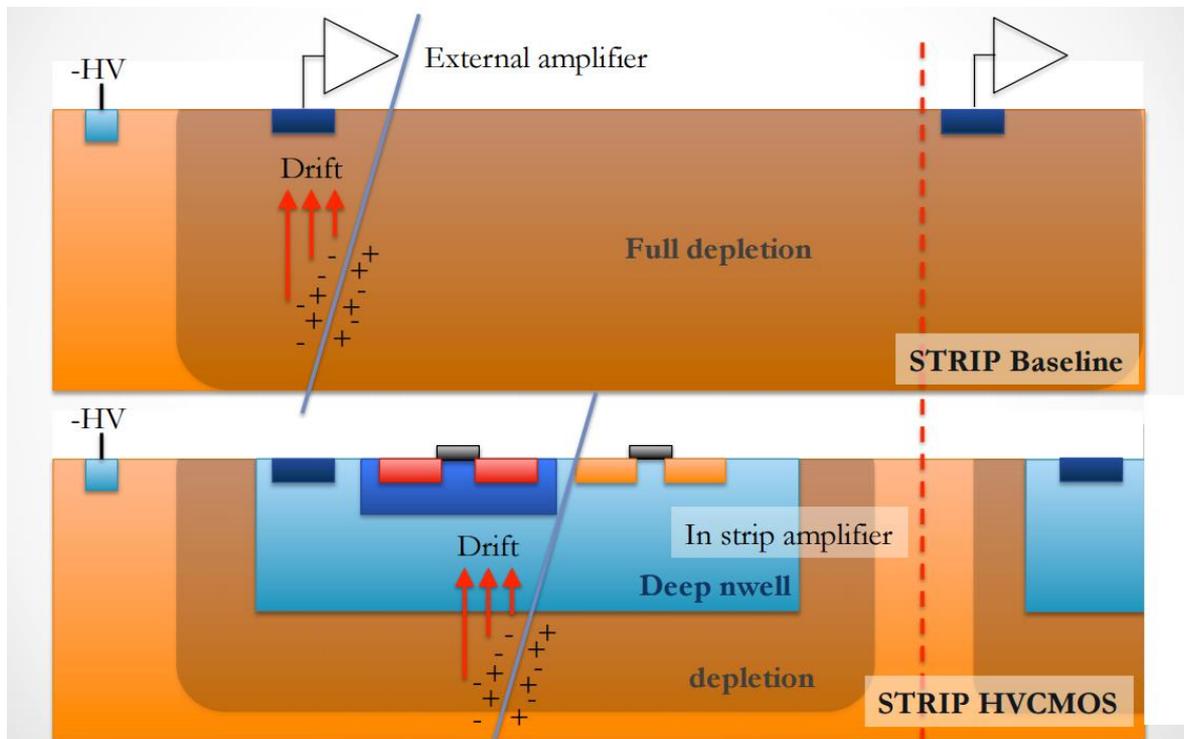


Flash CNC 300



CMOS silicon strip sensor R & D

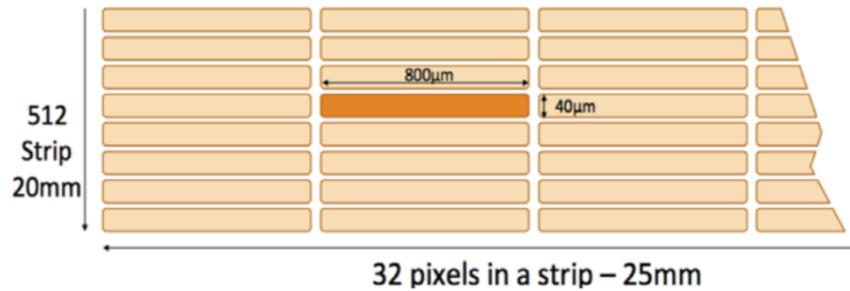
- China contribute to new detector technology R & D: CMOS strip sensor
 - CMOS technology has been widely used in digital camera, cell phone
 - The advantage of CMOS sensor:
 - Lower material budget, Monolithic, has potential to reduce the cost
- CMOS sensor is the alternative solution for ATLAS strip upgrade
 - First time using CMOS technology in Strip tracker



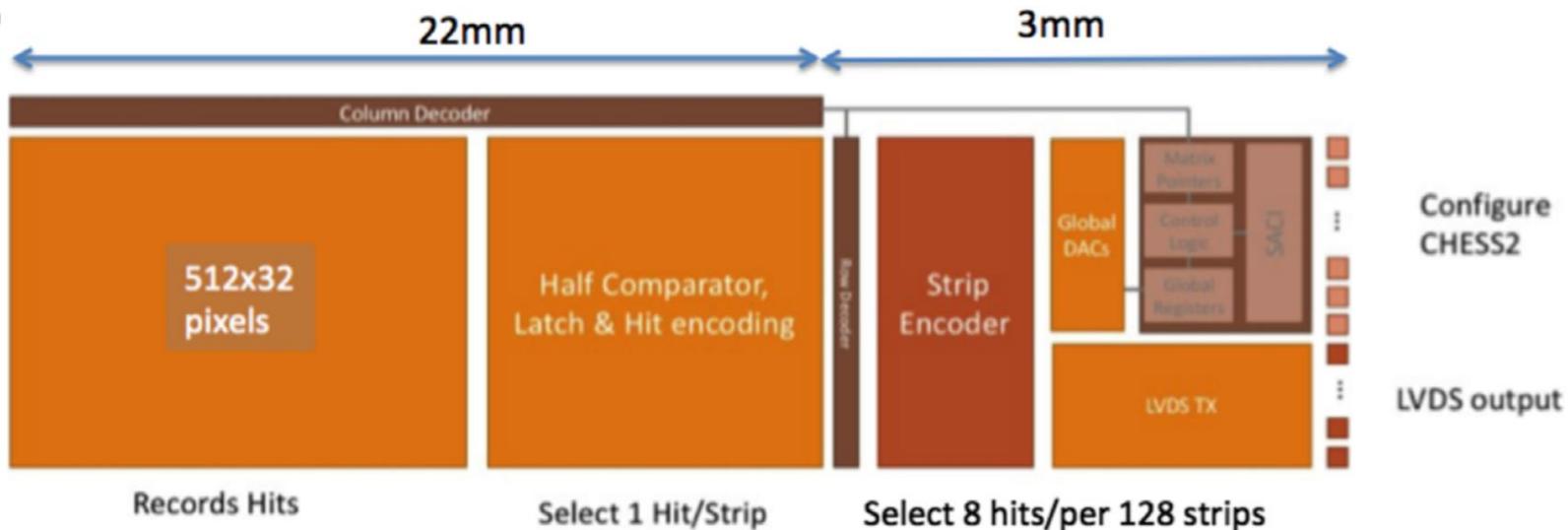
CMOS silicon strip sensor R & D

- AMS 350 technology
 - Pixel size: 40X800 μm
 - Digital readout
 - Frontend electronic (Amplifier) intergated on sensor

a



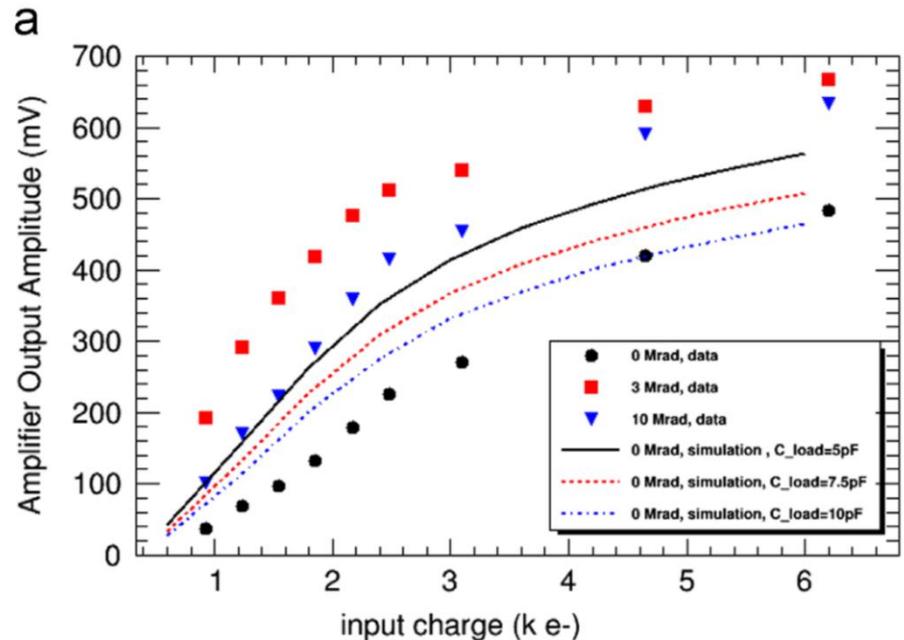
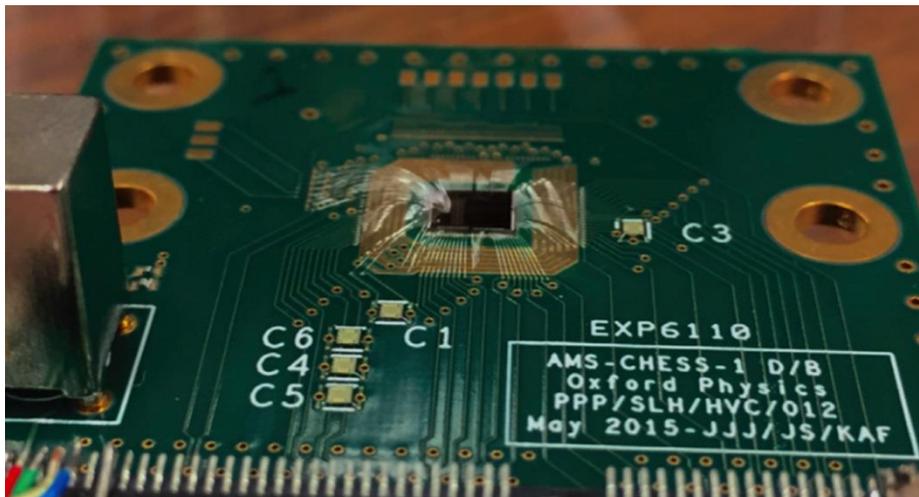
b



CMOS silicon strip sensor R & D

- Contribute to testing CMOS sensor
 - First measurement on CMOS amplifier performance after irradiation.
 - ATLAS china group member is the first author and corresponding author

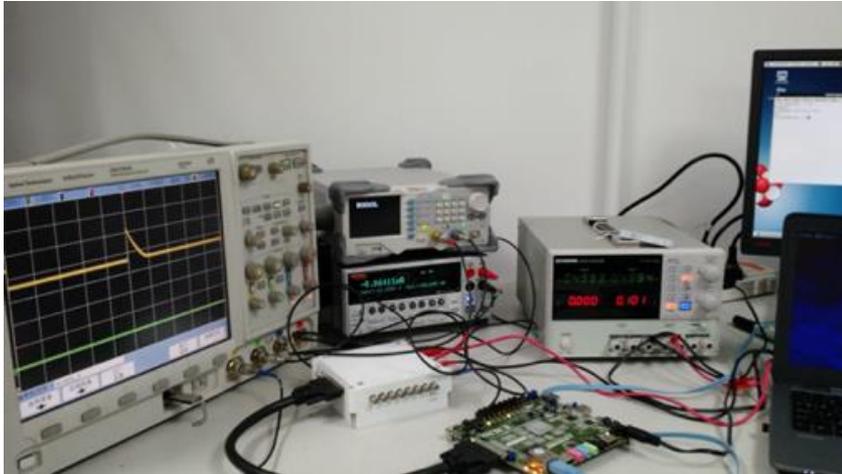
Nuclear Instruments and Methods in Physics
Research A 831 (2016) 156–160



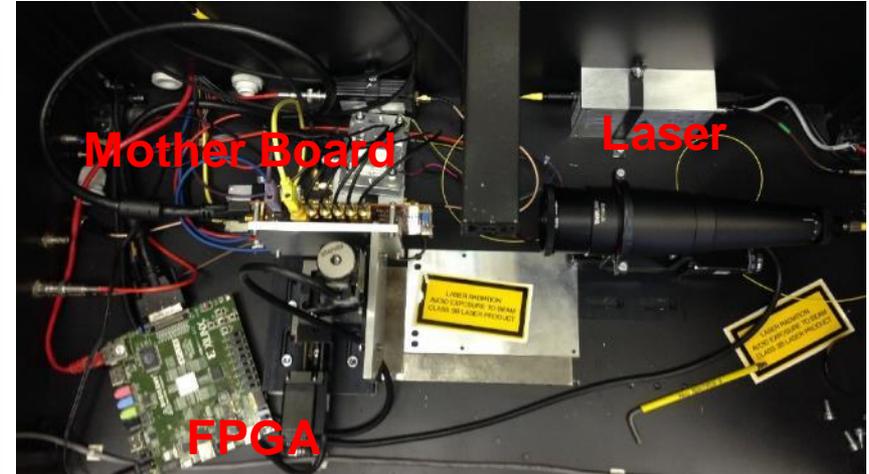
CMOS silicon strip sensor R & D

- CMOS testing in local lab
- Laser induced Scanning Transient Current Technique (Laser TCT)
- Testing CMOS strip sensor with laser TCT in Laboratory

IHEP Laboratory



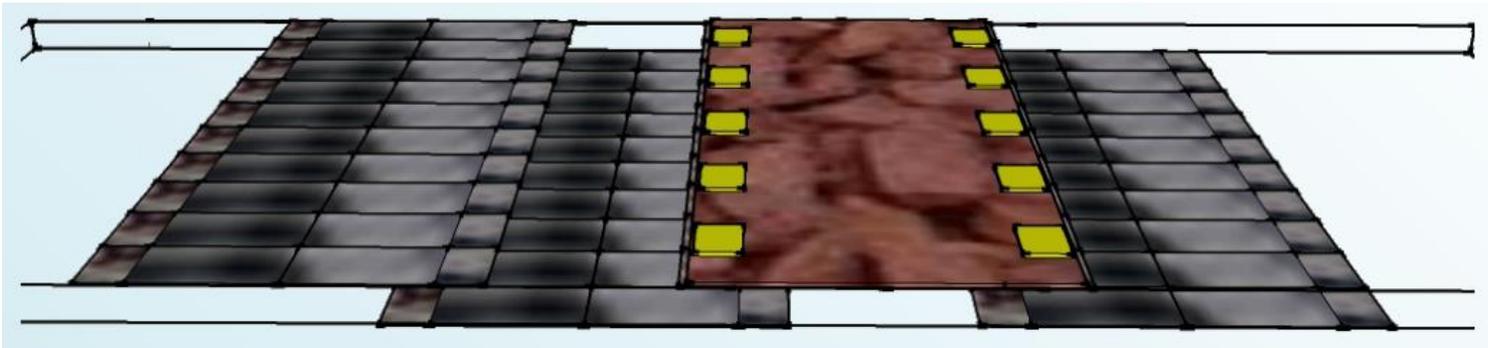
Electronic and DAQ system



Laser TCT system

ABCN' readout chip and prototype module for CMOS sensor

- Prototyping a CMOS strip detector module in next two year.
- Need a new readout chip ABCN'
 - Mainly to handle buffering of data
- 3 interested parties: Oxford, IHEP, UBC



ABCN' FPGA emulator 1/2

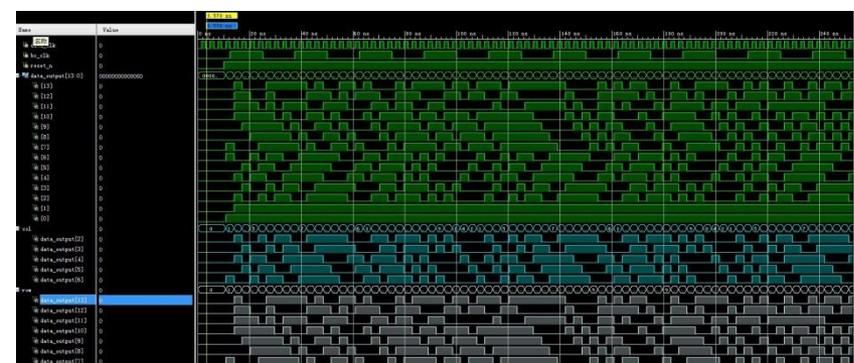
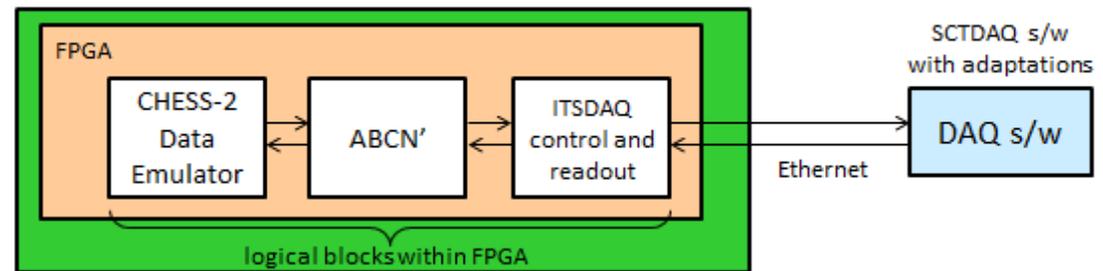
- ABCN' readout chip R & D, Before CMOS sensor is ready
 - We need to emulator to emulate the CMOS sensor output

IHEP and USTC team make FPGA emulator : Two versions

Fixed pattern: put out the same pattern of hits every 25ns

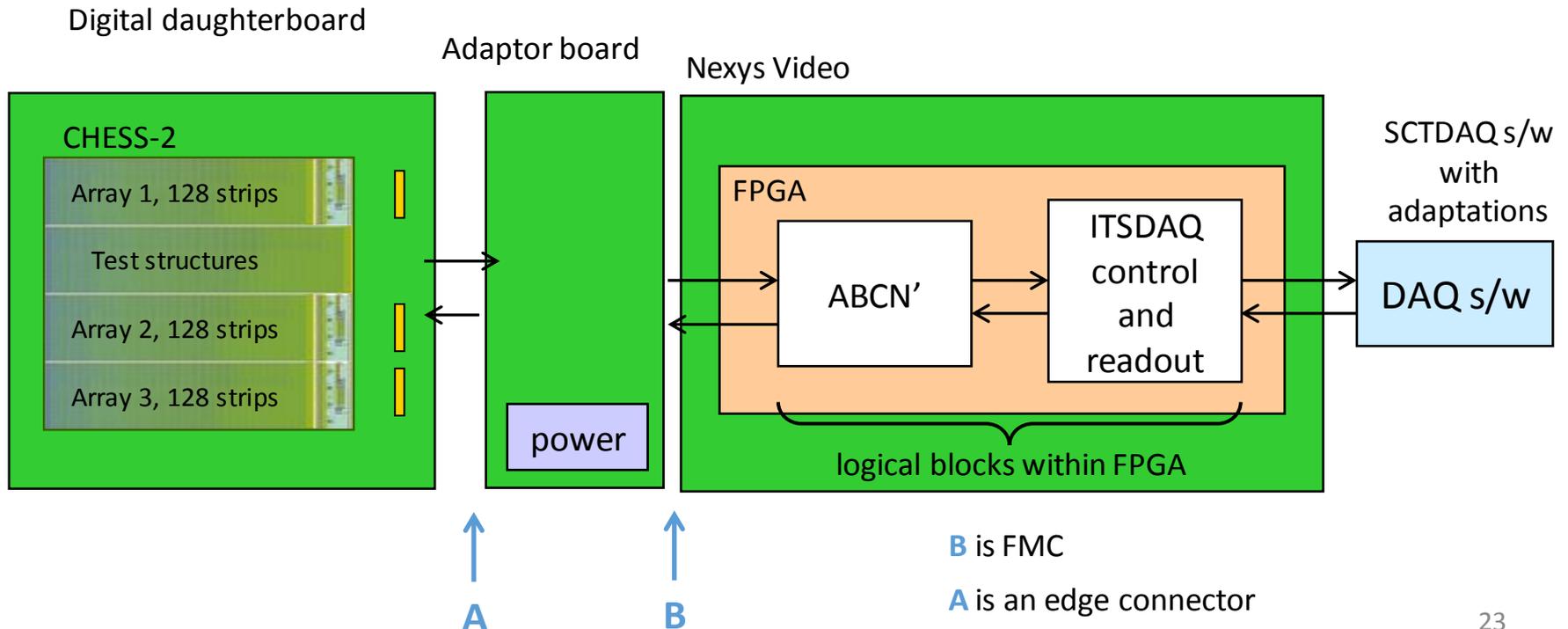
Pseudo-random pattern: generate random hit pattern

Nexys Video



ABCN' frontend readout chip

- China contribute to ABCN' chip development
 - Buffering the digital data from CMOS sensor
 - Full Digital readout chip
 - Back-end readout : Nexys Video FPGA



Summary

- ATLAS tracker upgrade activity in China
 - R & D for key technology
 - High spatial resolution
 - Large area detector
 - Radiation hardness
 - Plan to make significant contribution in ATLAS upgrade project

Backup

- IHEP activity in ATLAS tracker upgrade
- Front-end electronic readout ASIC design for ATLAS strip detector
- Silicon strip detector module prototyping and production
- CMOS-based silicon strip detector performance study

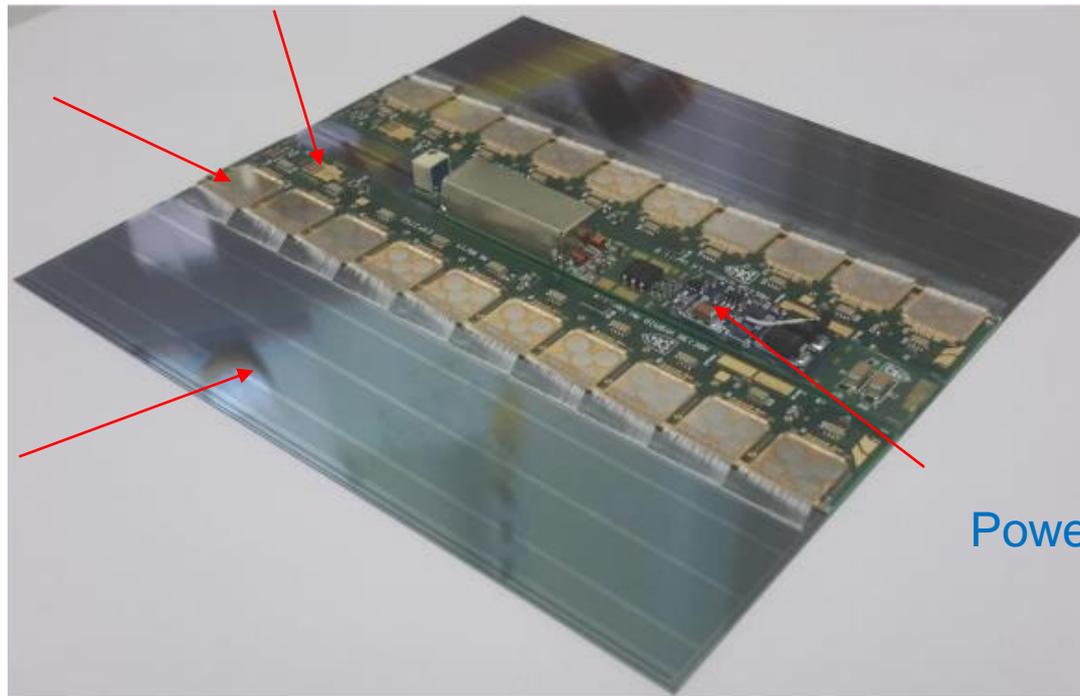
Silicon detector module

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Module controller

Readout
ASIC

Silicon sensor



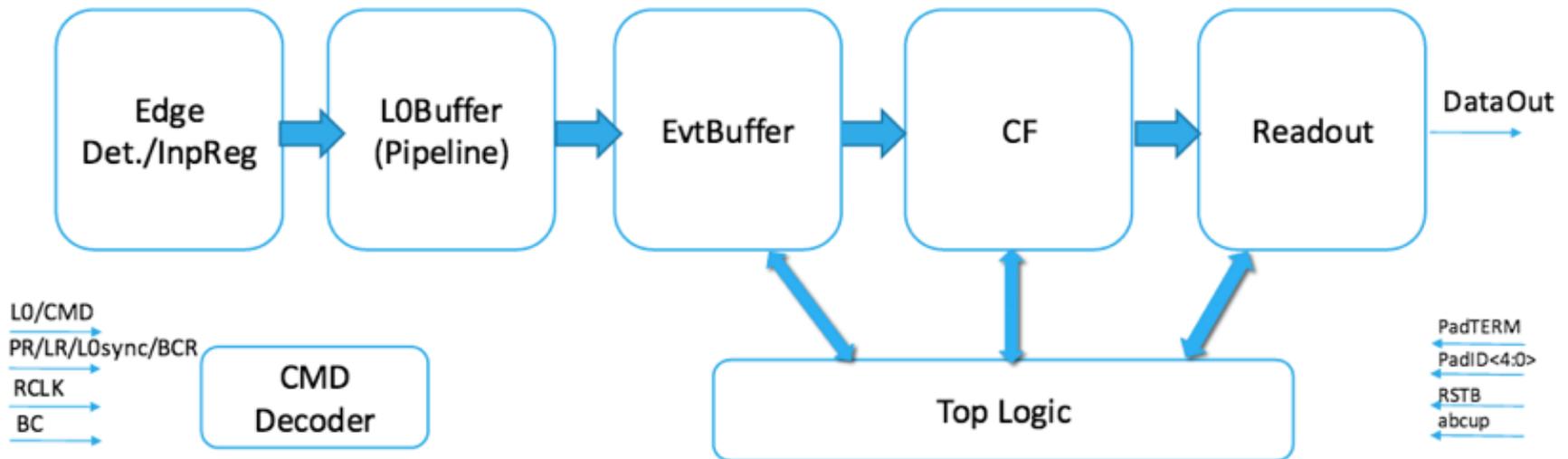
Power board

Digital electronic design in readout ASIC

IEEE RT2016 poster (Libo Cheng)

TWEPP2016 talk (Weiguo Lu)

- IHEP contribute to redesign of digital part of readout ASIC chip
- setup verification system to verify the ASIC design (based on



Next steps :

1. finalizing the digital part of ASIC design and simulation
2. Plan to test the performance of readout ASIC next year

芯片禁运问题

- 目前硅微条探测器模块芯片，包括读出芯片**ABC**、控制芯片**HCC**、电流监控芯片**AMAC**、**DC-DC**芯片**FESAT**以及高压转换芯片因为抗辐照原因，均对中国禁运。
- **积极申请禁运豁免**：**ATLAS**和**CMS**合作组内多个国家面临相同问题，**CERN**专门聘用律师统一协调针对技术（**GF/IBM CMOS**工艺）申请禁运豁免（出口许可）。高能所为**ATLAS**合作组代表单位，高能所**Joao Costa**教授被任命为**ATLAS**方联络人。
- **国际合作**：在禁运问题完全解决之前，积极利用国际合作，借用国外合作单位先进设施开展预研工作。充分锻炼人才队伍，为后期回到国内开展建造任务奠定扎实基础。

硅微条探测器模块

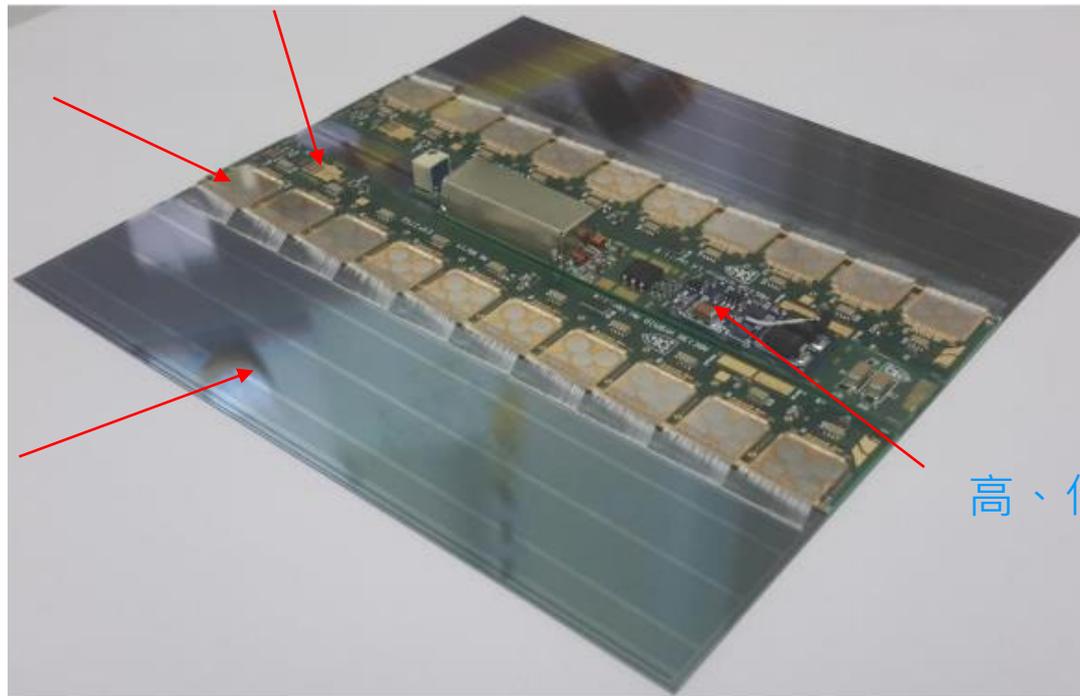
- 硅微条径迹探测器最基本机械单元，由硅微条传感器、复合PCB控制板（读出电子学ASIC芯片+控制芯片）、电源板等构成，使用银胶或紫外凝胶粘合，通过打线实现电气连接。

模块控制芯片

硅微条探测器模块及主要组件

前端读出电子学ASIC芯片

硅微条传感器



高、低压电源控制板