ATLAS ITk Strip Module QC-Electrical Test at IHEP

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On behalf of THU/IHEP ATLAS ITk Group

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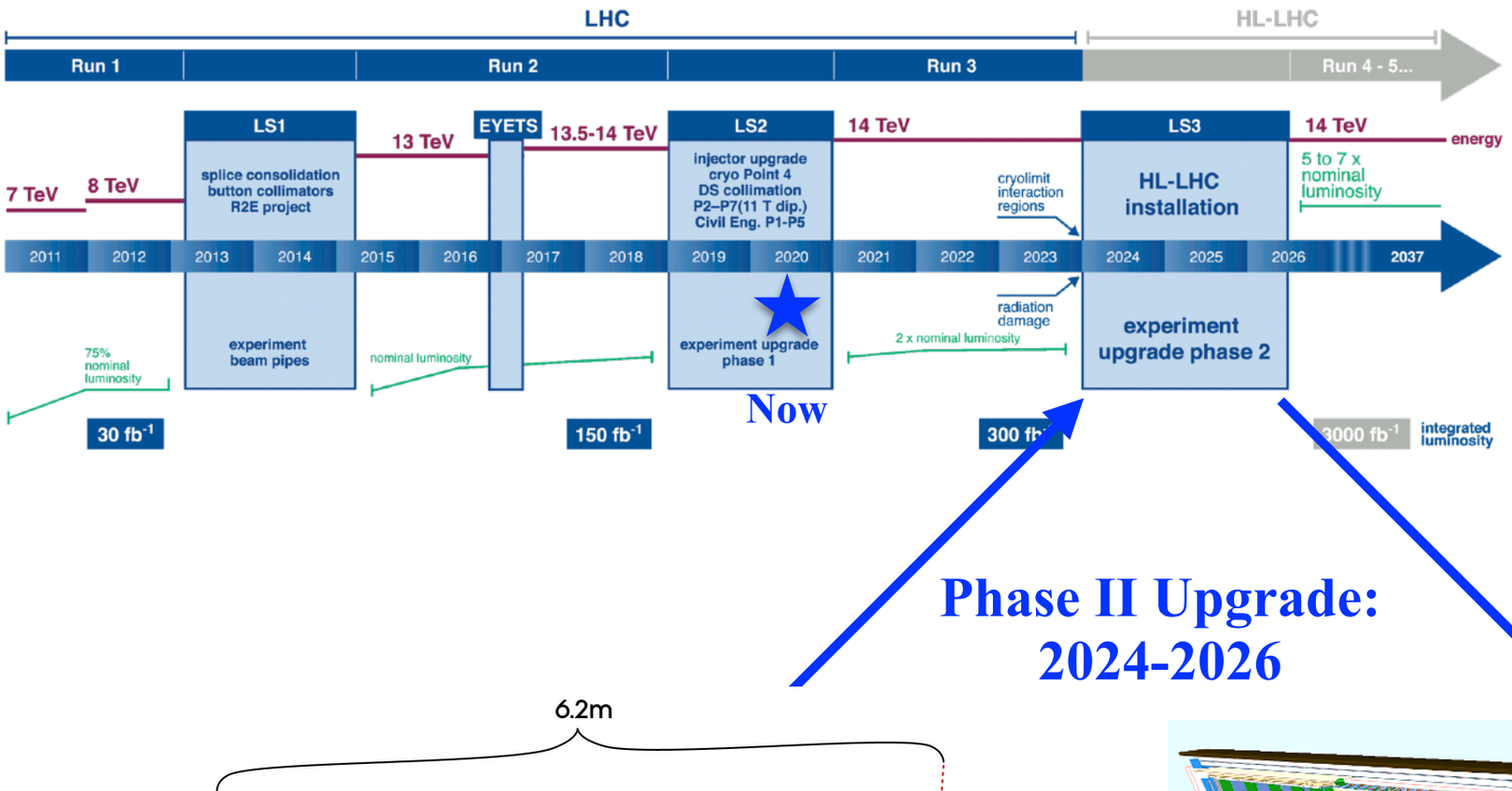
清華大學
Tsinghua University

LHC Detector Upgrade Workshop

Outline

- Introduction to ATLAS ITk Strip Detector
- Electrical Test on Hybrid
- Electrical Test on Strip Module
- Summary and Plan

ATLAS ITk Upgrade



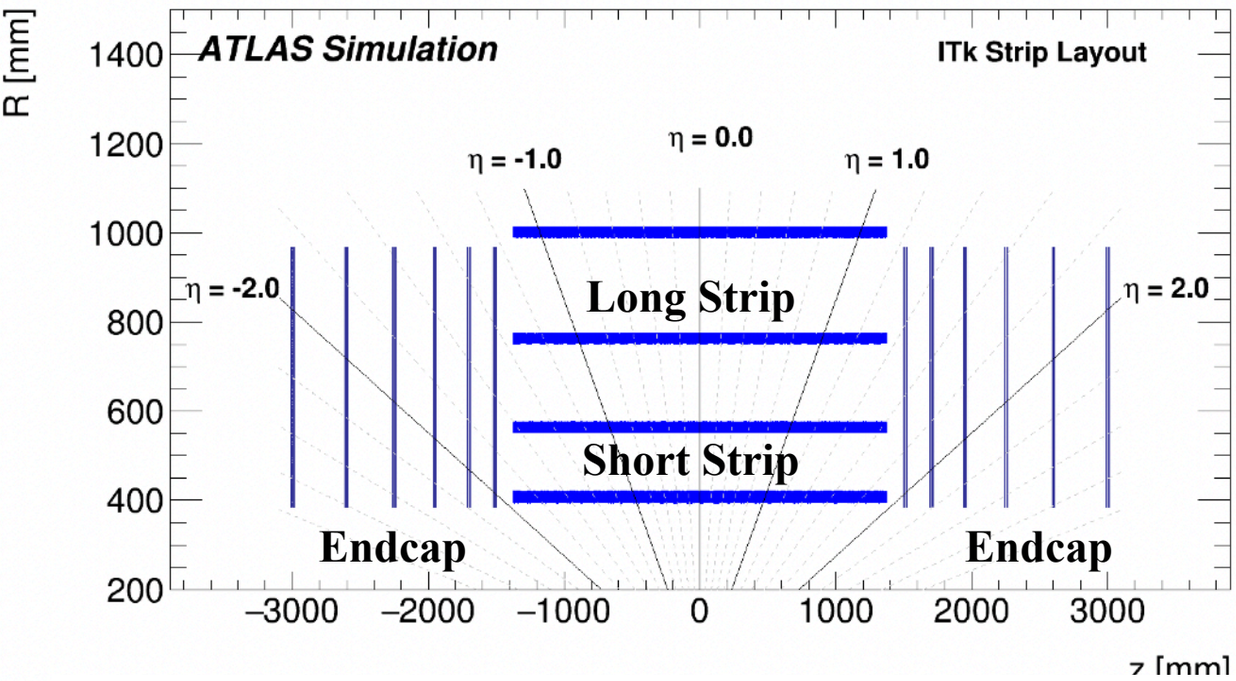
HL-LHC:

- $\mathscr{L}$=5-7.5×10^{34} $cm^{-2}s^{-1}$
- Max Pileup events: ~200
- 4000 fb^{-1} in >10 years
- >10 times radiation

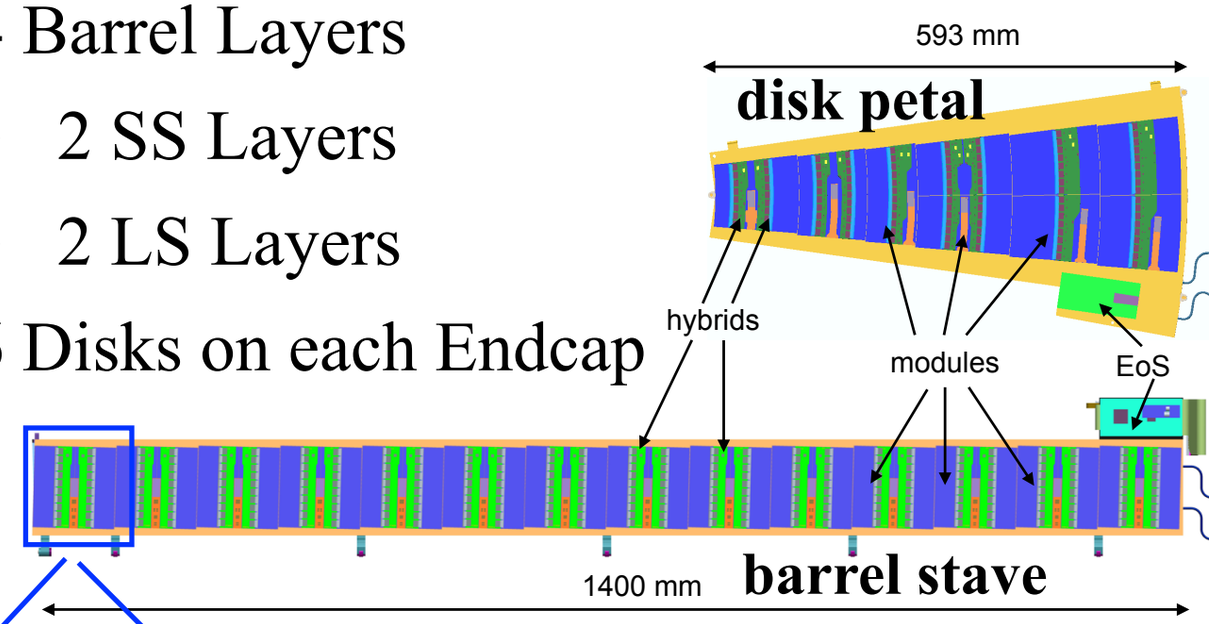
• Pixel • SCT • TRT

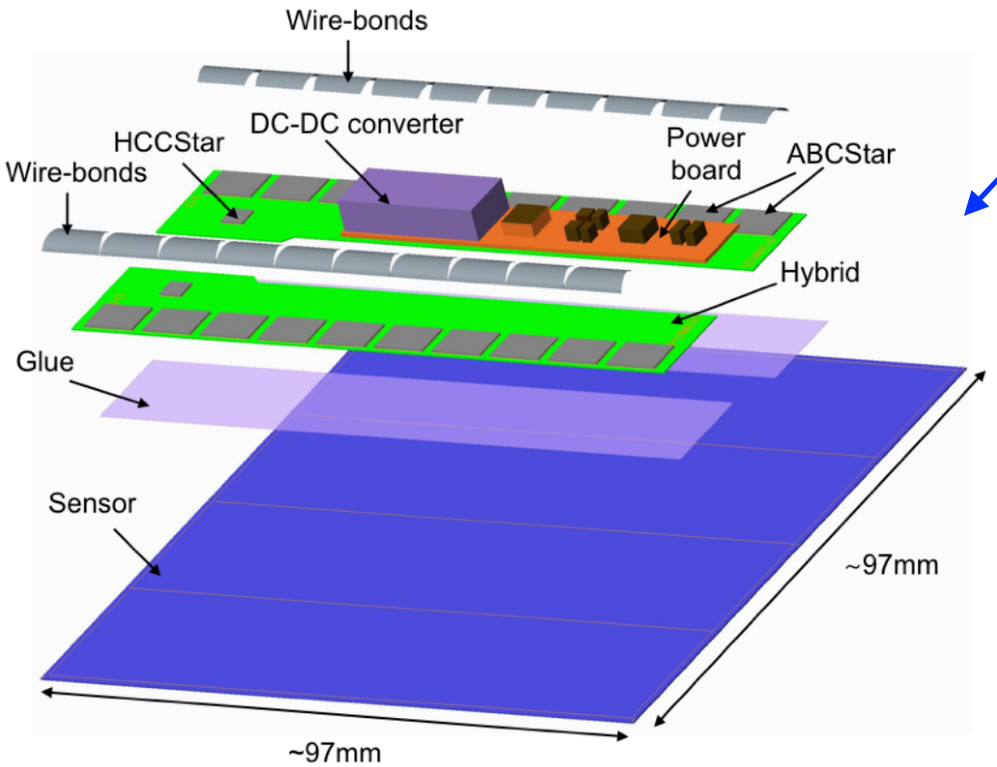
• ITk Pixel • ITk Strip

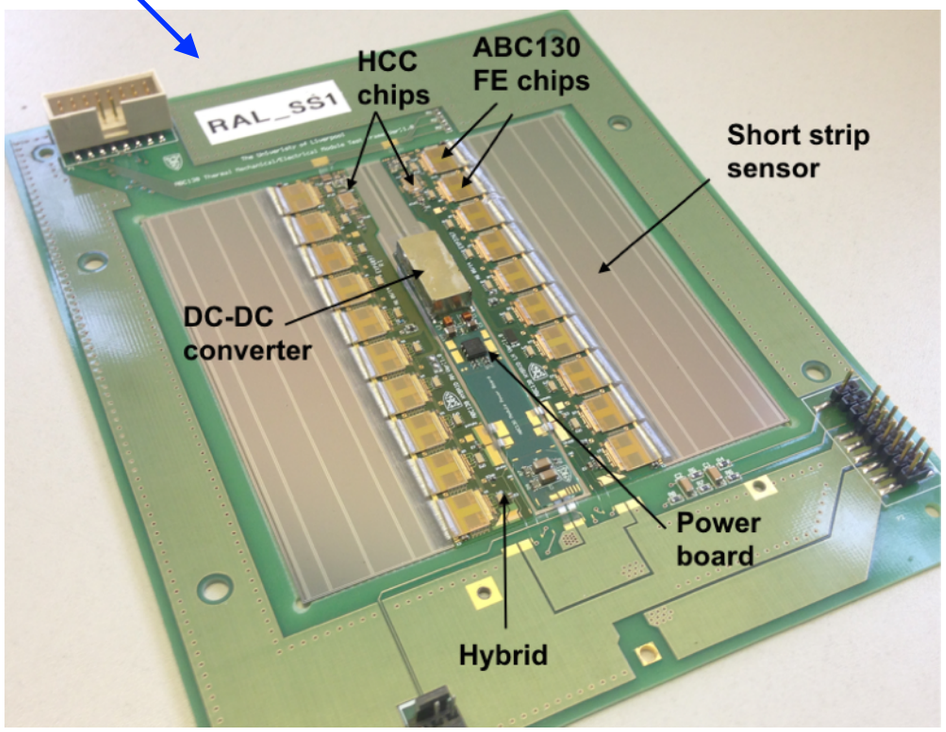
ATLAS ITk Strip Detector



- 4 Barrel Layers
  - 2 SS Layers
  - 2 LS Layers
- 6 Disks on each Endcap

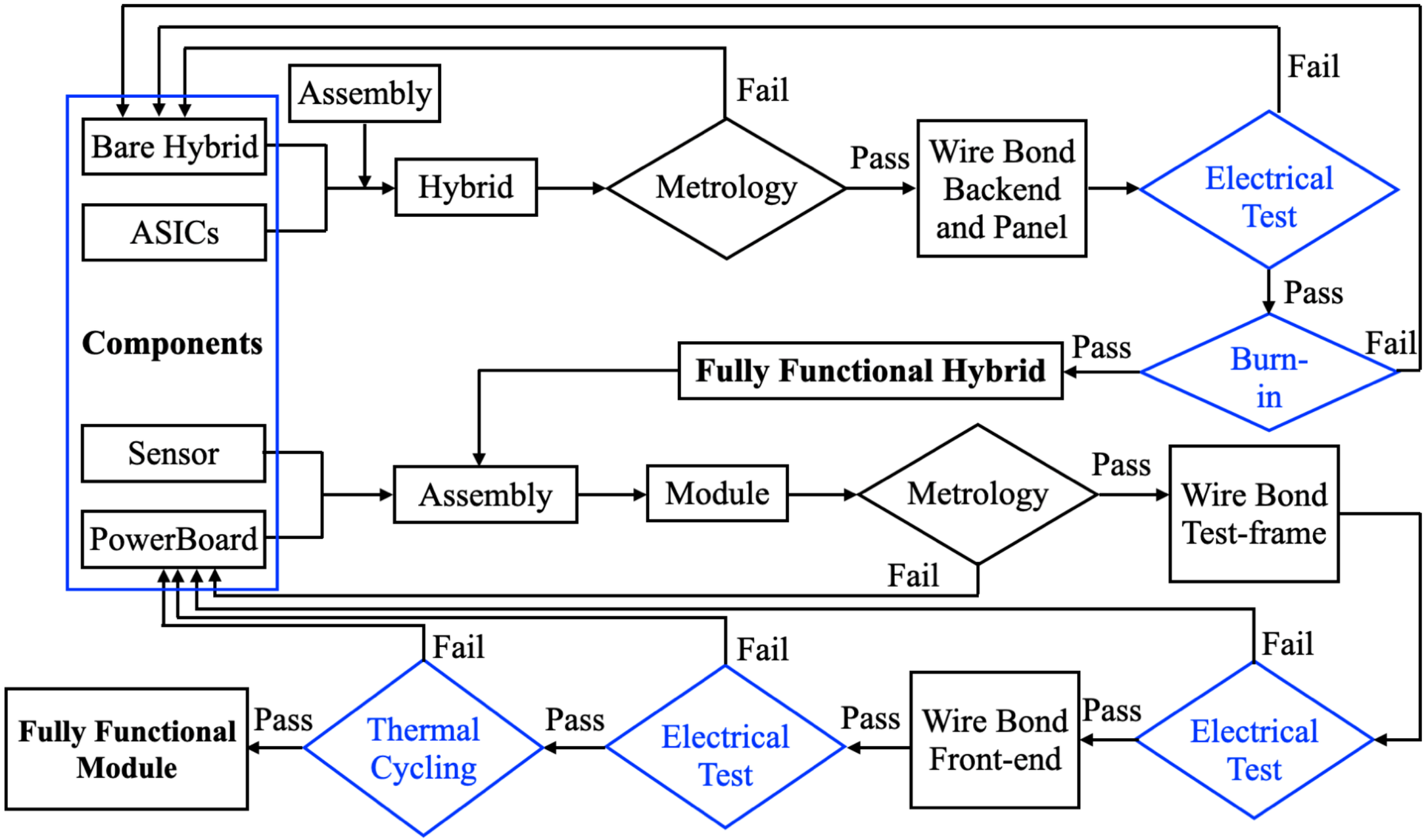






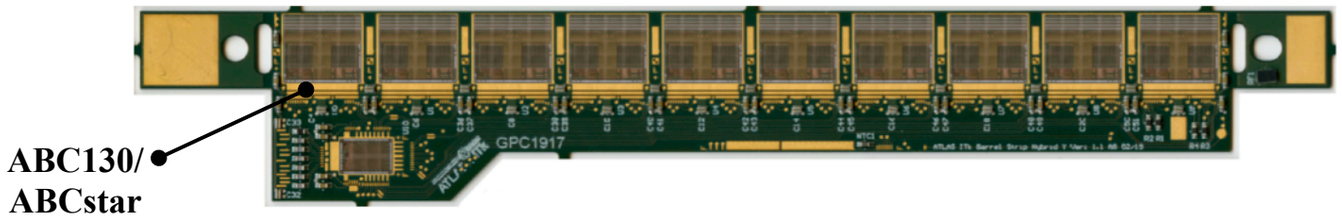
THU/IHEP will contribute 500 Strip Barrel Modules.

Module Production Flow

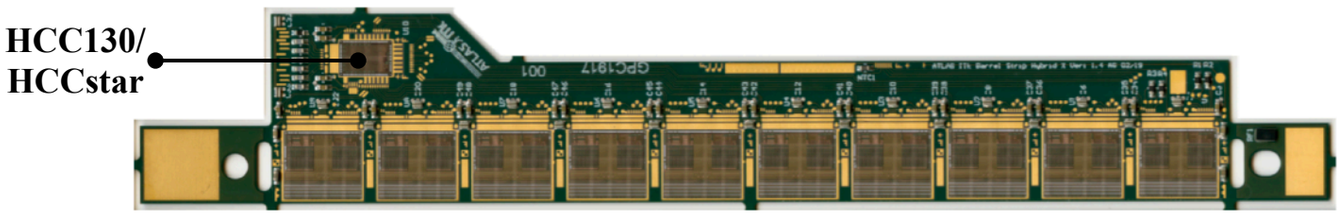


Hybrid

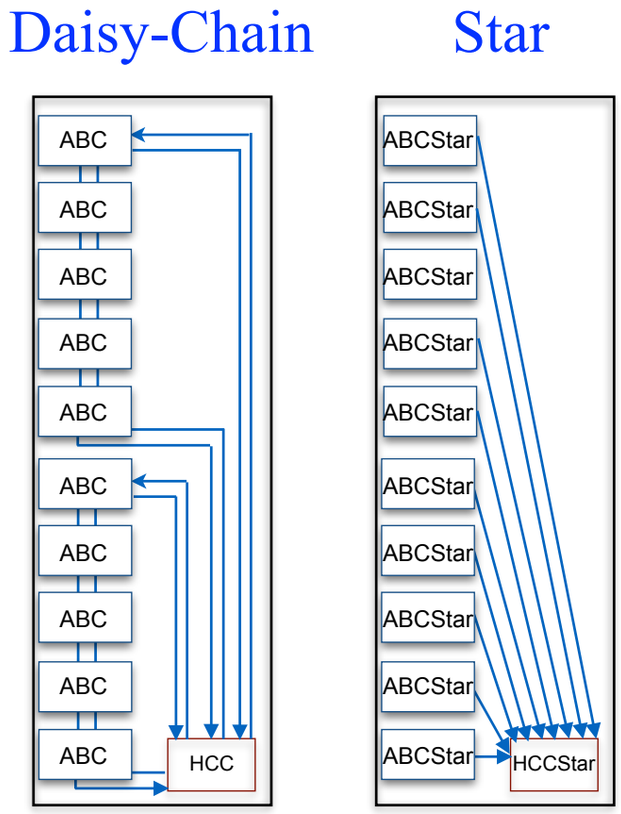
- The hybrid is a flexible PCB retaining the required circuitry,
- Two types: X-Type, Y-Type,
- Two types of custom ASICs: 10 ABCs and 1 HCC:
  - HCC/ABC130(prototype), daisy-chain architecture,
  - HCC/ABCStar(production), star architecture



(a) Y barrel hybrid.

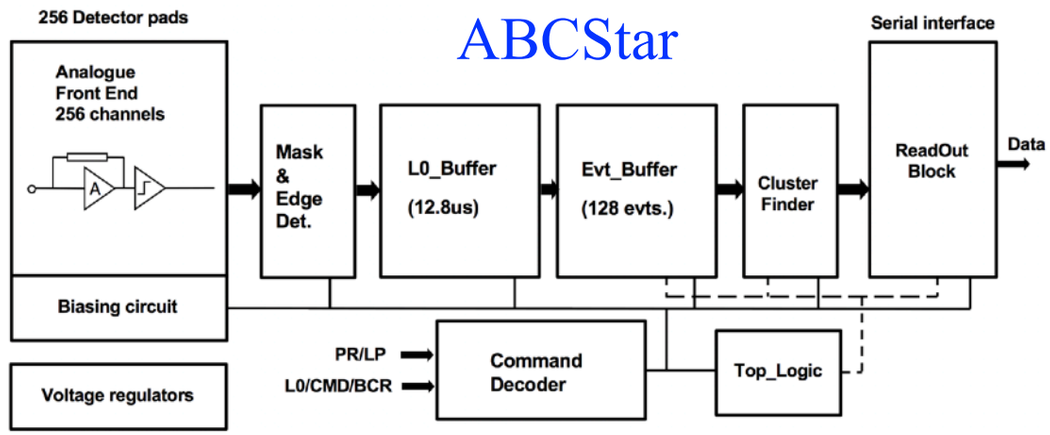


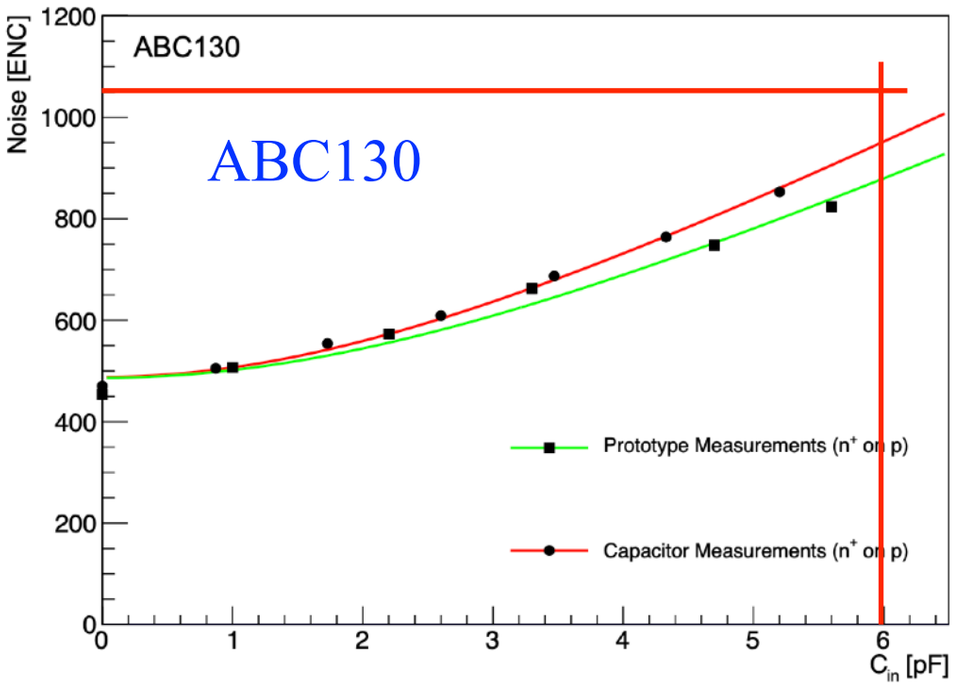
(b) X barrel hybrid.

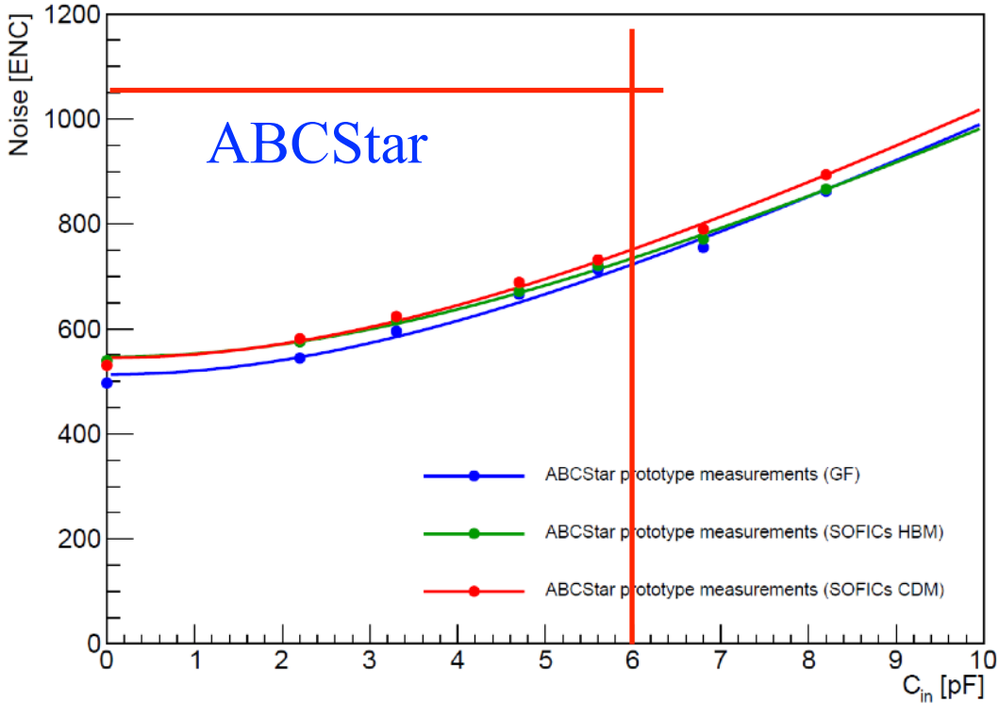


ASIC-ABC(ATLAS Binary Chip)

- Converting incoming charge signal information into hit information,
- Processes signals from 256 strips of a silicon strip detector.
- ENC<900 e- @Cin=3.5pF (SS Module)
- ENC<1050 e- @Cin=6 pF (LS Module)

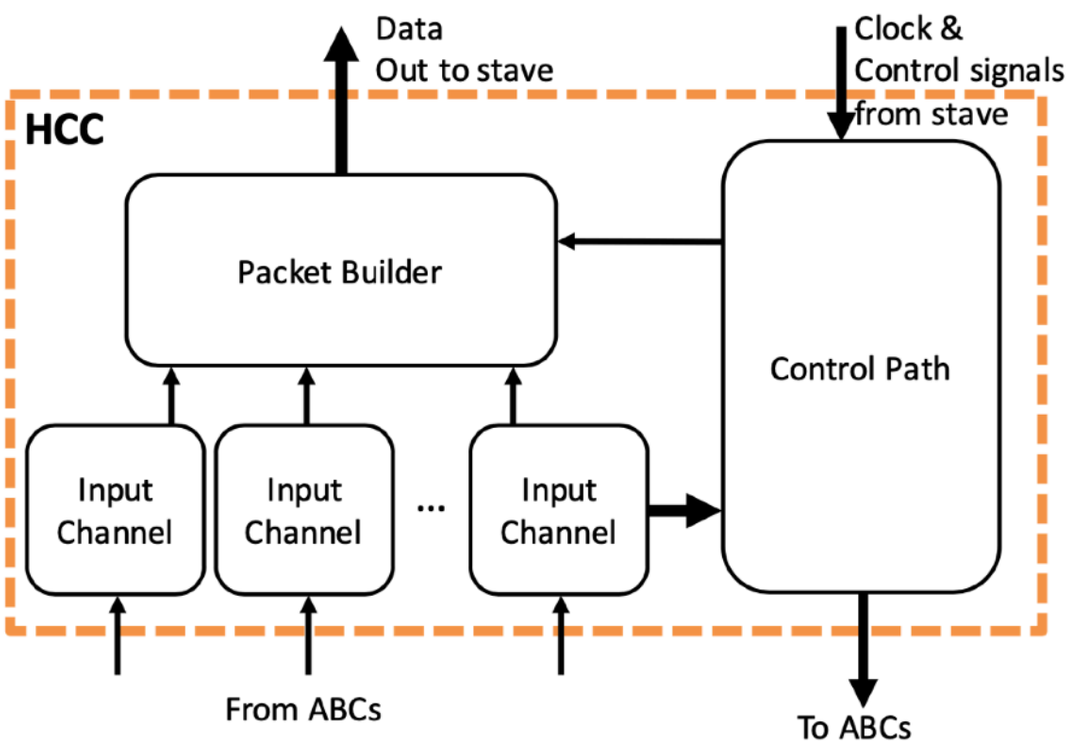


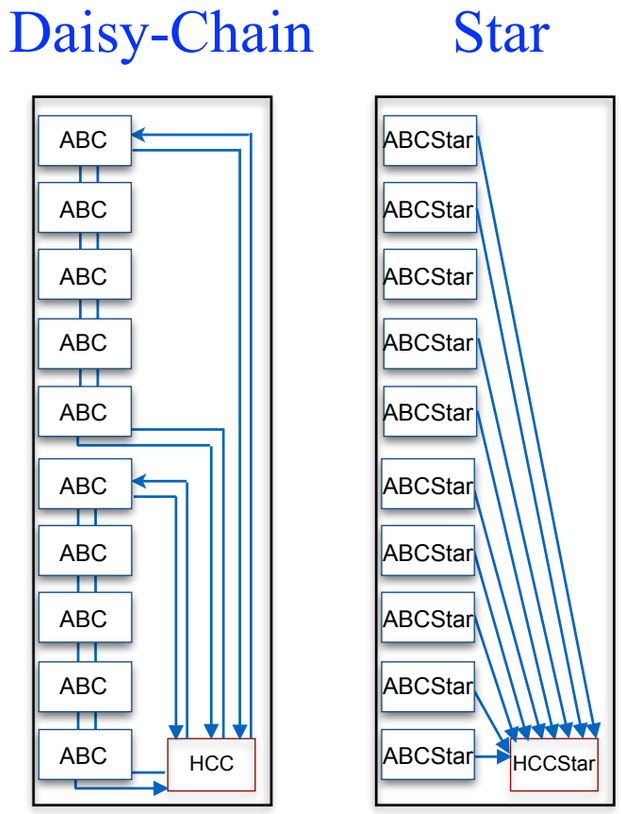




ASIC-HCC(Hybrid Controller Chip)

- Interface between stave/petal service bus and the front-end ASICs,
- Receives the signals from the ABCs, builds packets and transmit to EoS,
- Receives the clock and control signals (TTC) and distributes to the ABCs,
- More inputs from ABCStars to HCCStar.

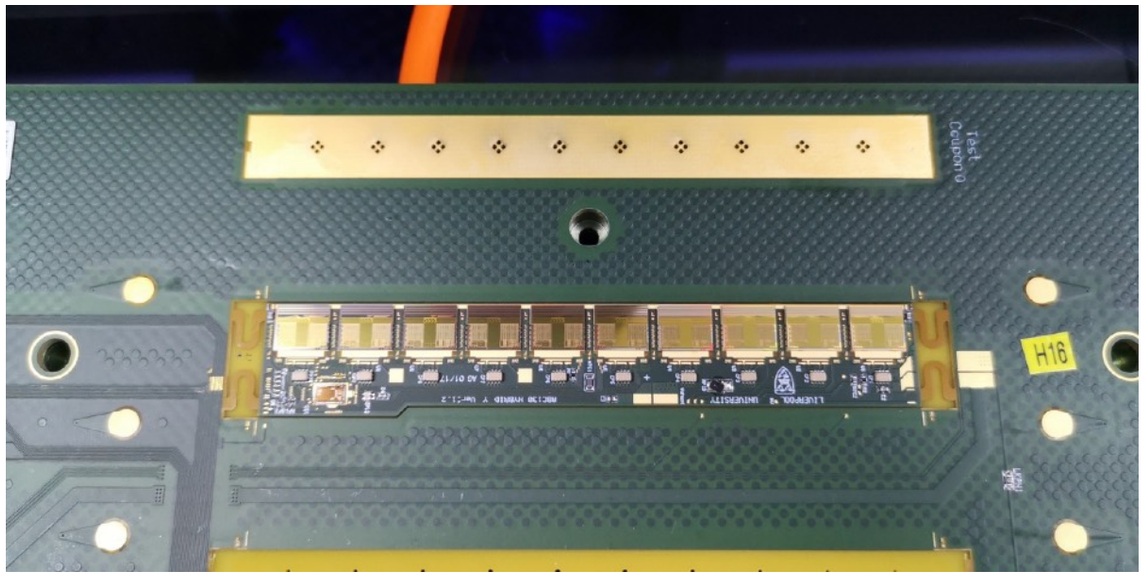




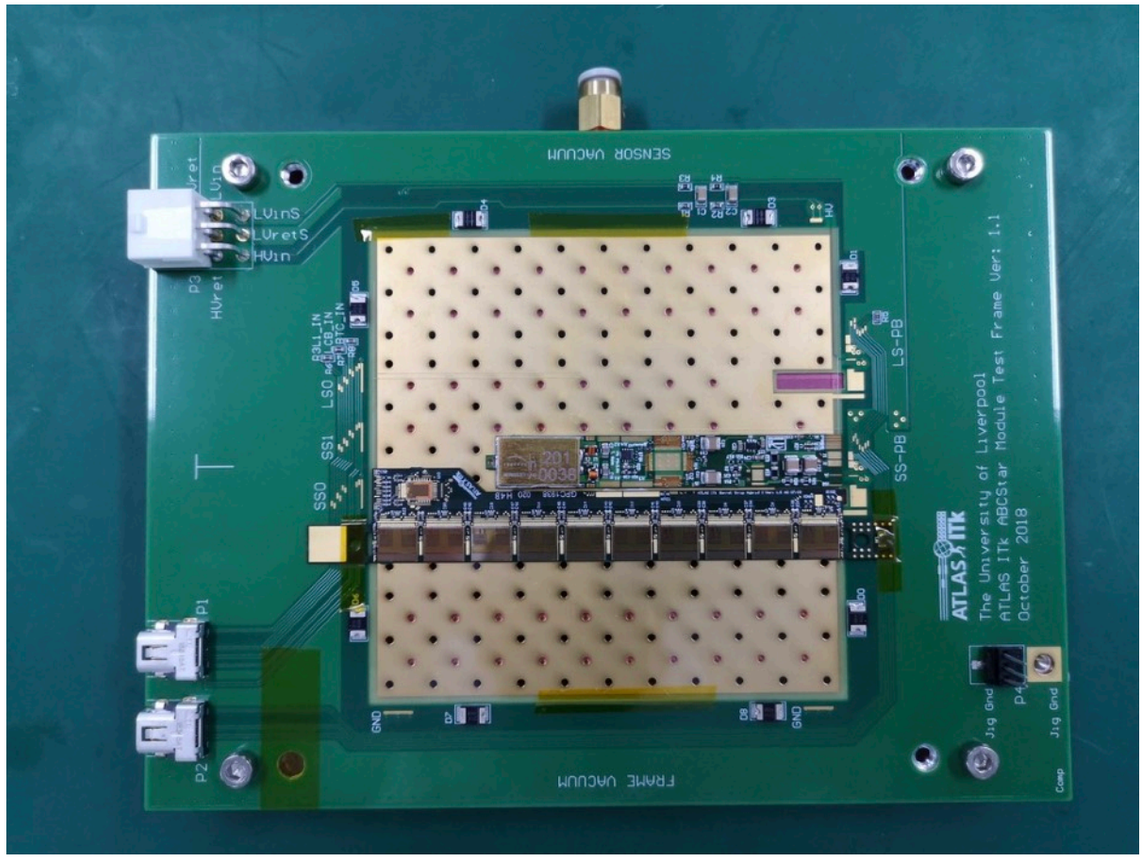
Electrical Hybrids at IHEP

- Two X-Hybrids and two Y-Hybrids with ABC/HCC130,
- Three X-Hybrids with ABC/HCCStar.

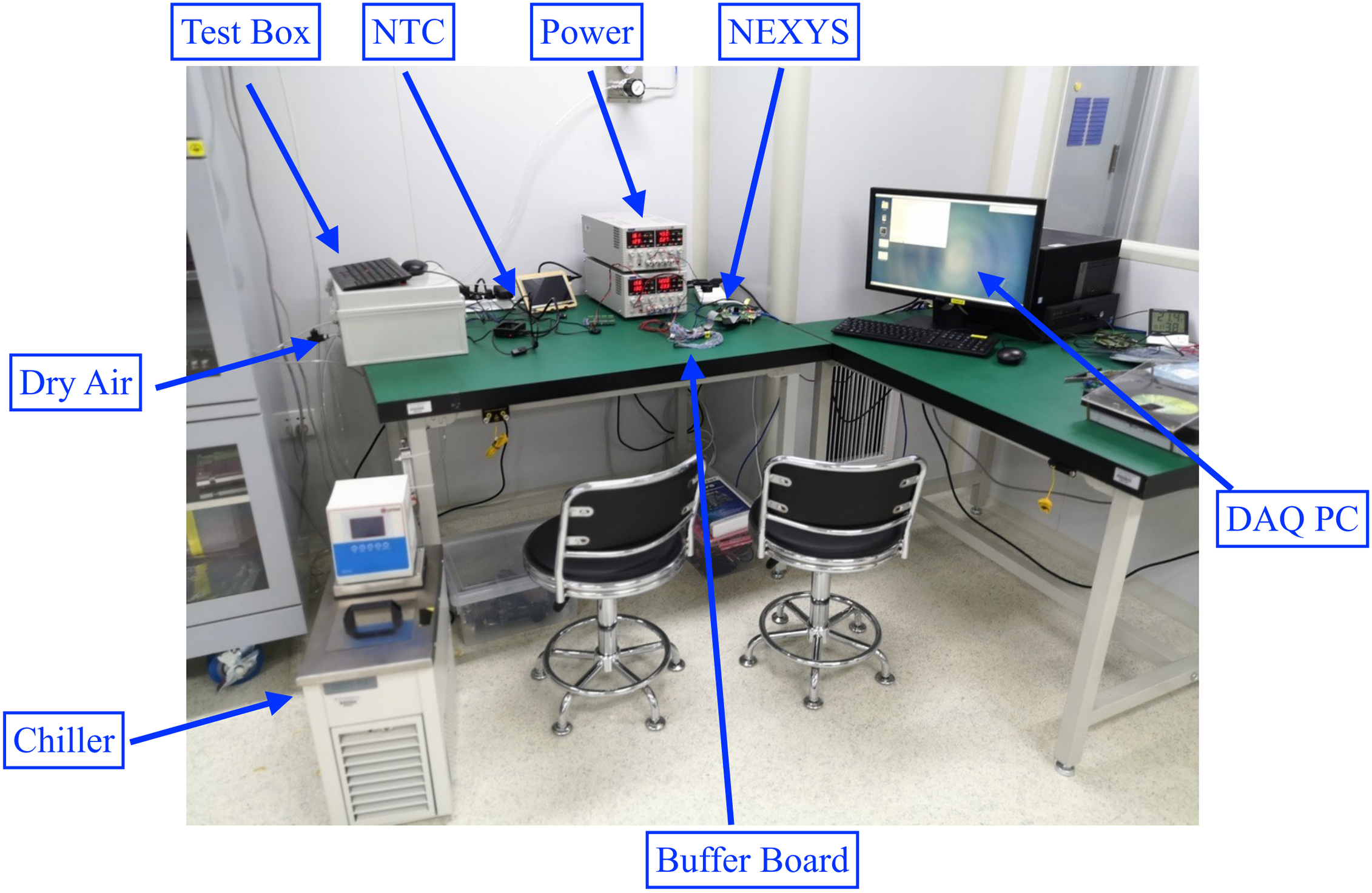
Hybrid with ABC/HCC130



Hybrid with ABC/HCCStar

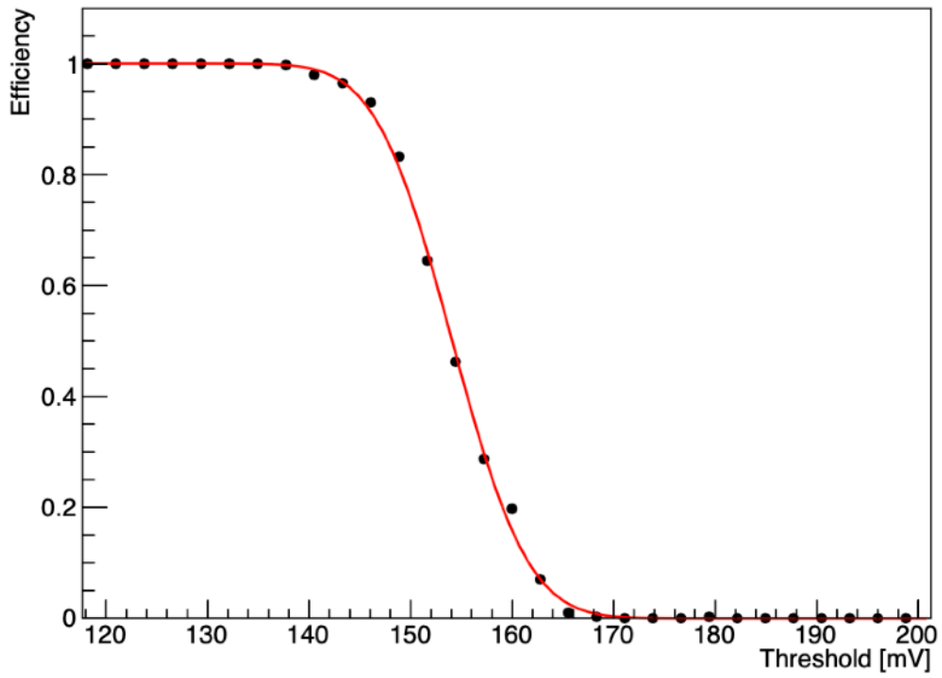


Electrical Test Setup

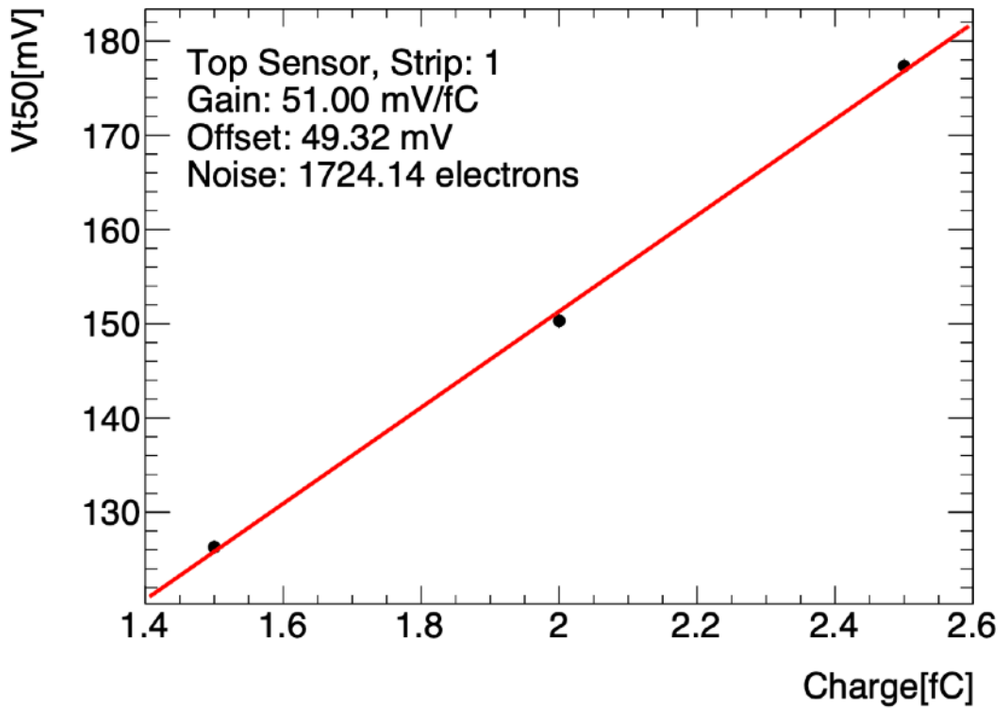


Hybrid Electrical Test

- Check for front-end chip functionality:
  - Chip Communication,
  - Strobe delay to determine the delay of the injecting and arrival time of signal,
  - Three Point Gain to determine discriminator offset, channel gain and input noise,
  - Noise Occupancy to measure the noise occupancy as a function of threshold.



S-Curve to determine Vt50 and sigma



Response Curve to determine offset, gain, noise

Electrical Test on Hybrid with 130 ASICs

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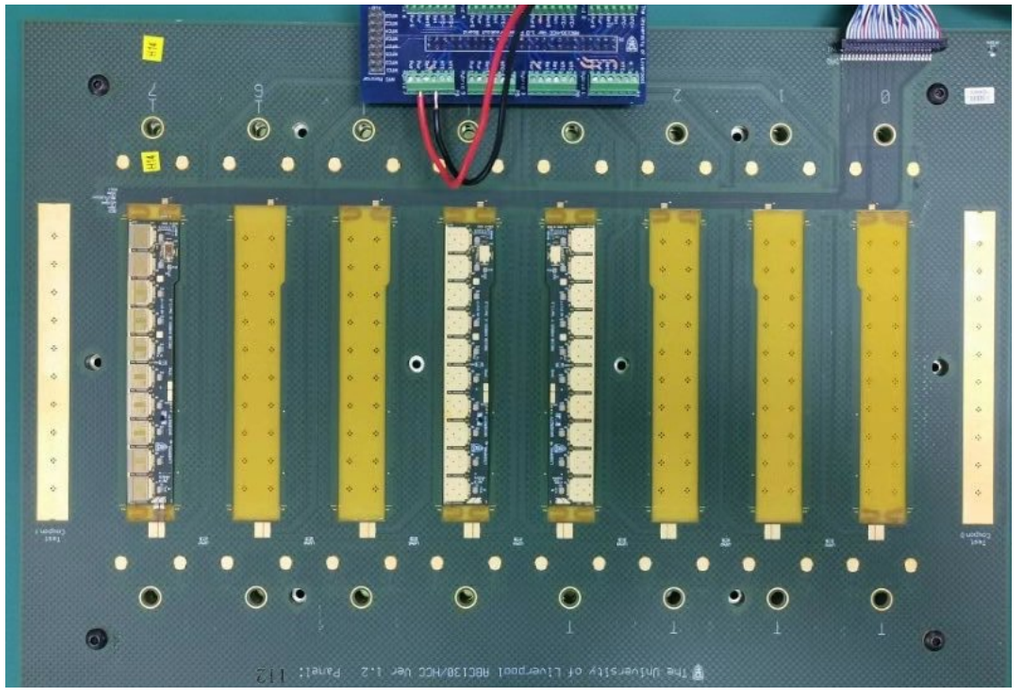
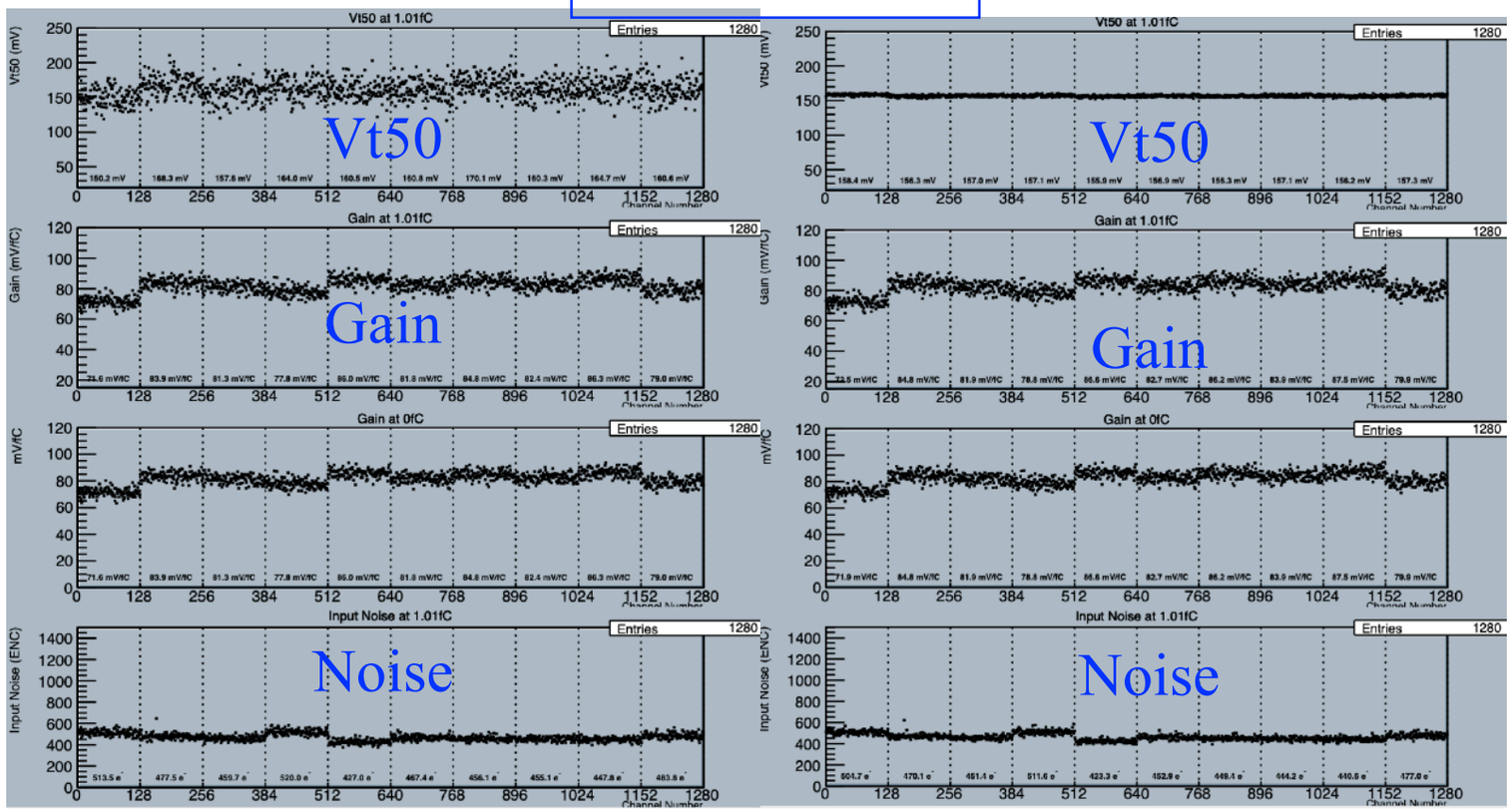
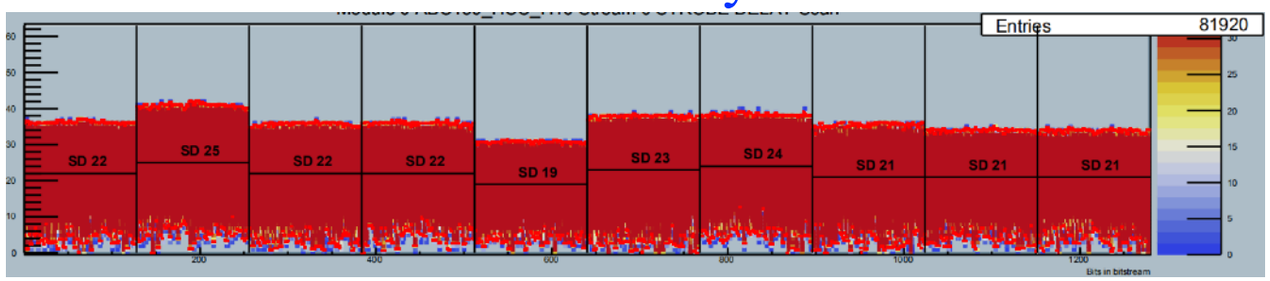


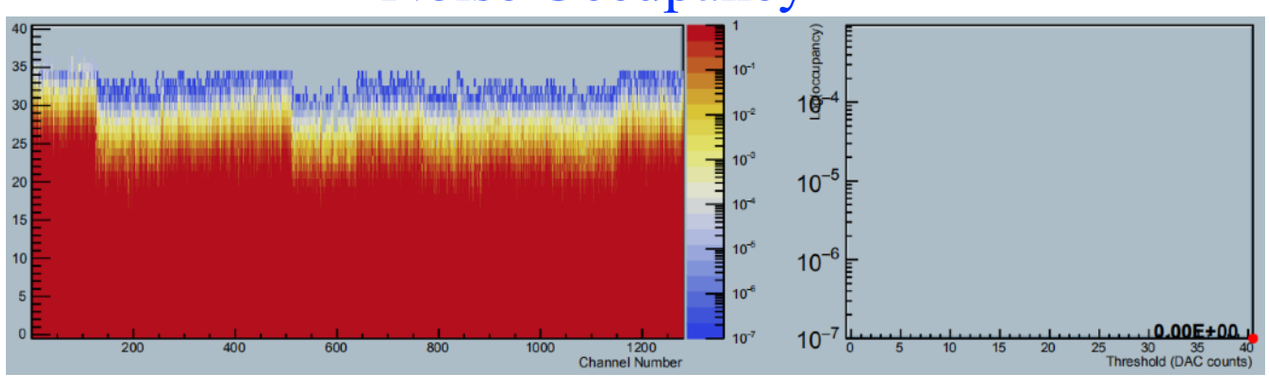
Before Trim | 3 Points Gain | After Trim



Strobe Delay



Noise Occupancy



- Noise Occupancy for thresholds (0.5-2.0 fC):
  - <1×10-3
  - at least one order less than the hit occupancy(1%)

Electrical Test on Hybrid with Star ASICs

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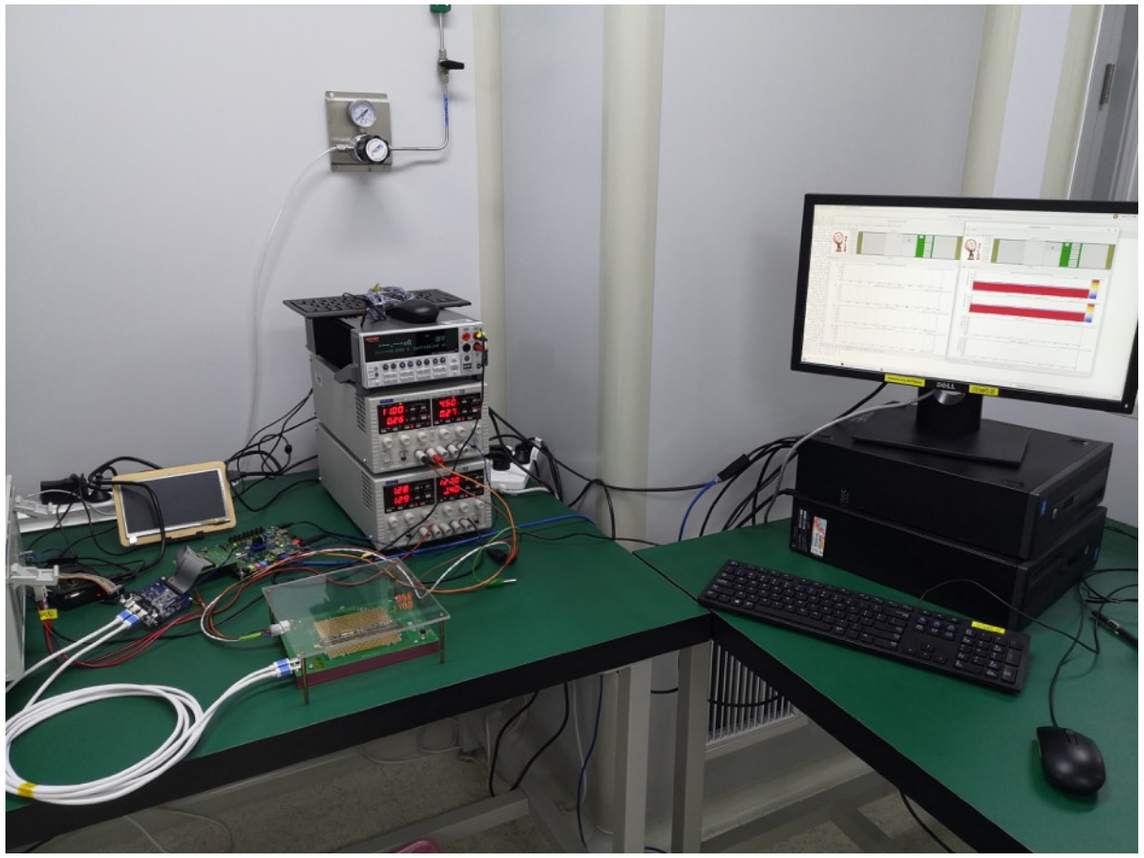
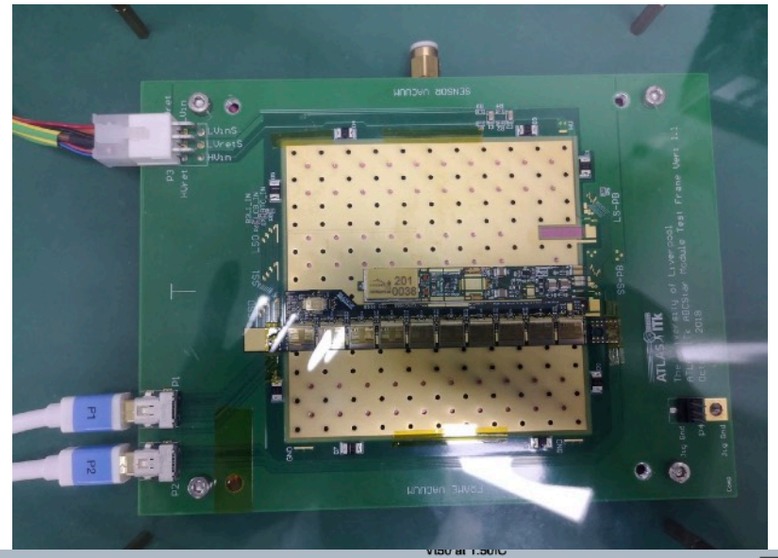
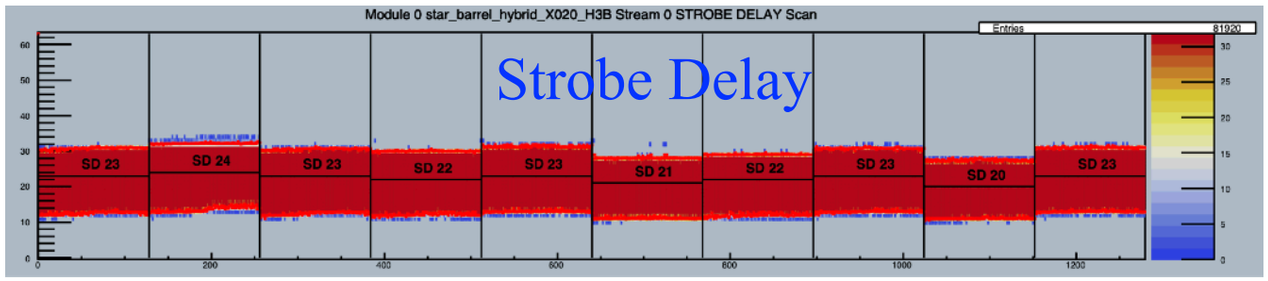
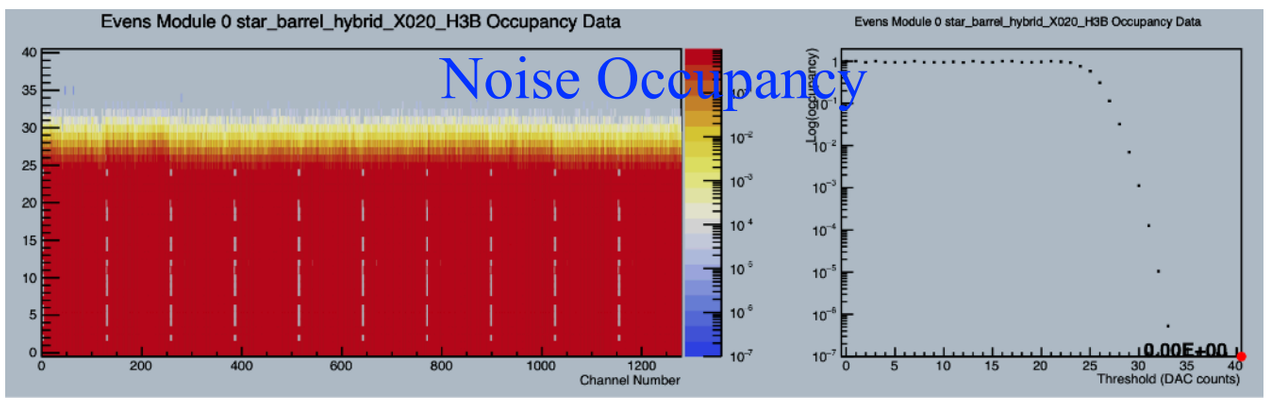


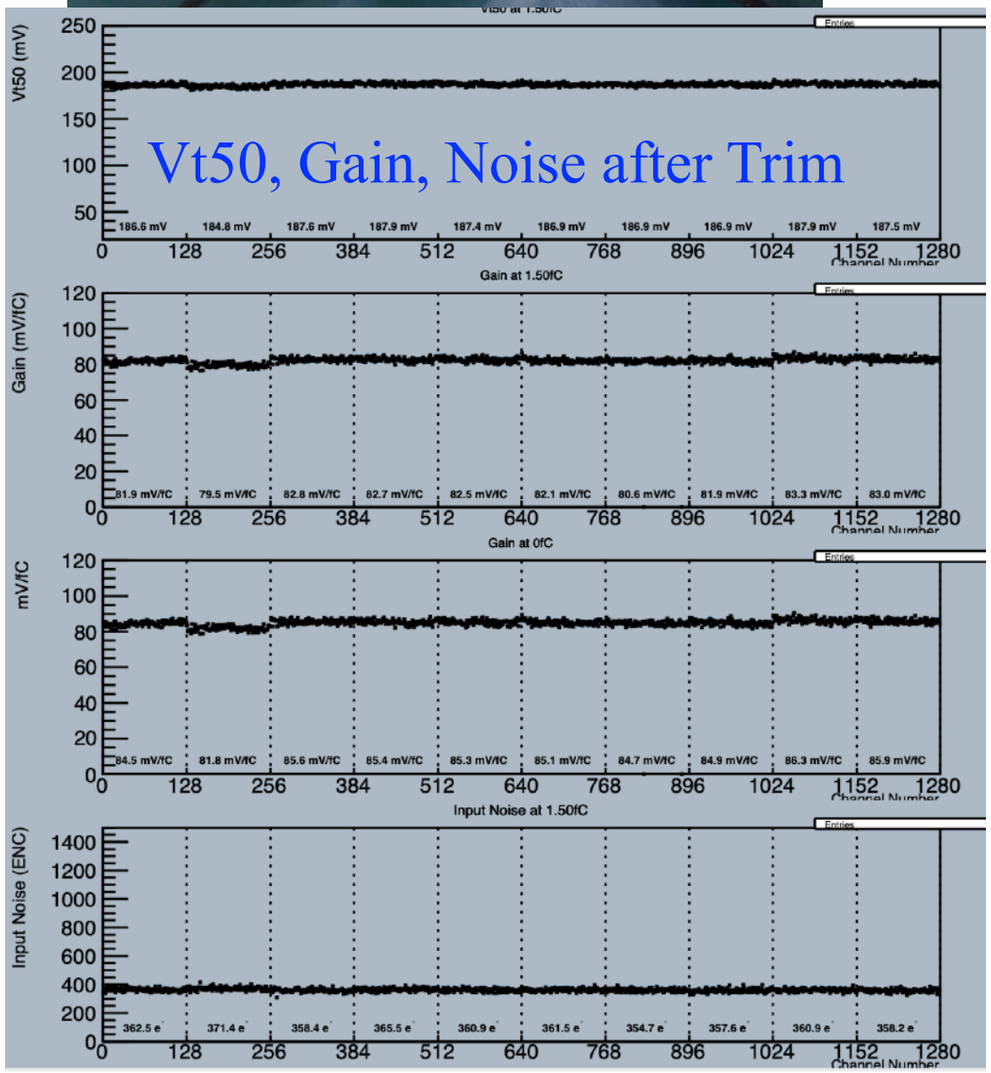




Strobe Delay



Noise Occupancy



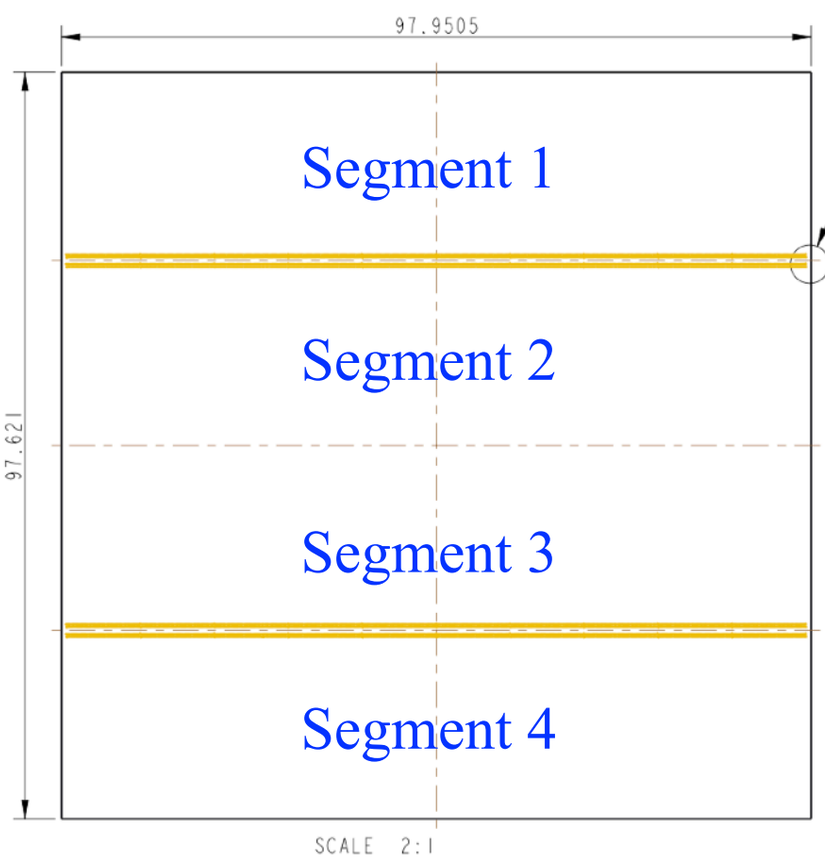
Hybrid Burn-in

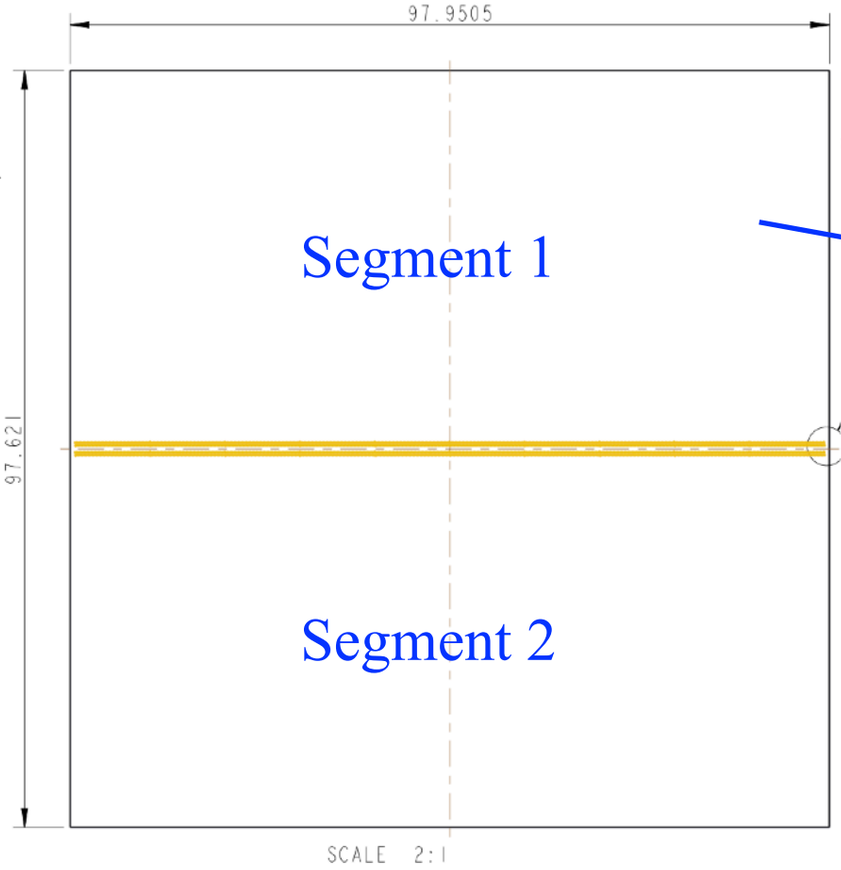
- Check for early ASIC death,
- Long term (> 100 h) tests on hybrids at ~40 °C,
- Missing the Burn-in Crate(host 6 Hybrid Panels/36 Hybrids).

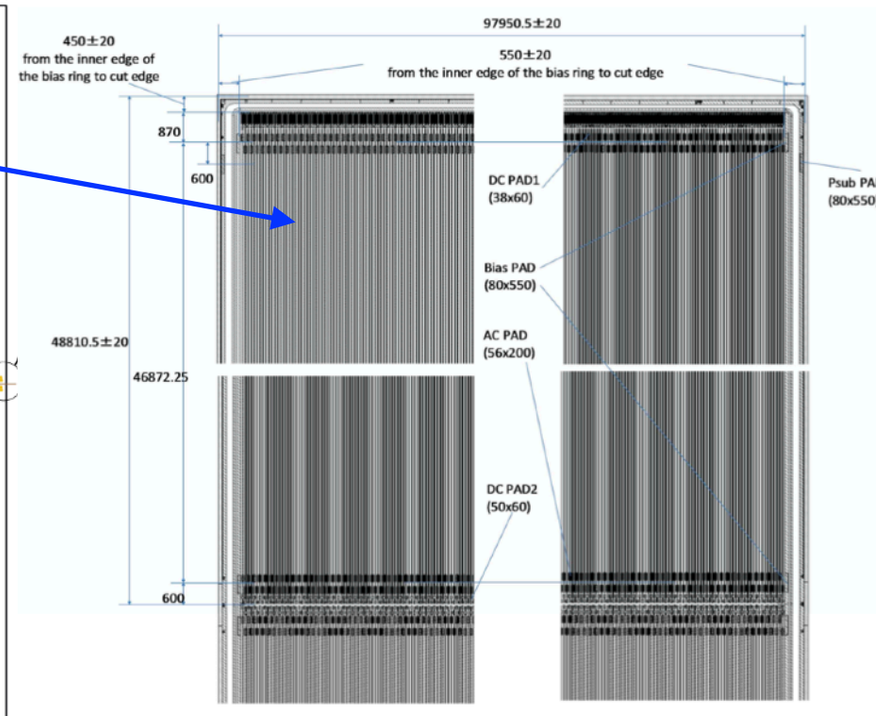
Hybrid Burn-in Crate

H&T Chamber at IHEP

Main Sensor





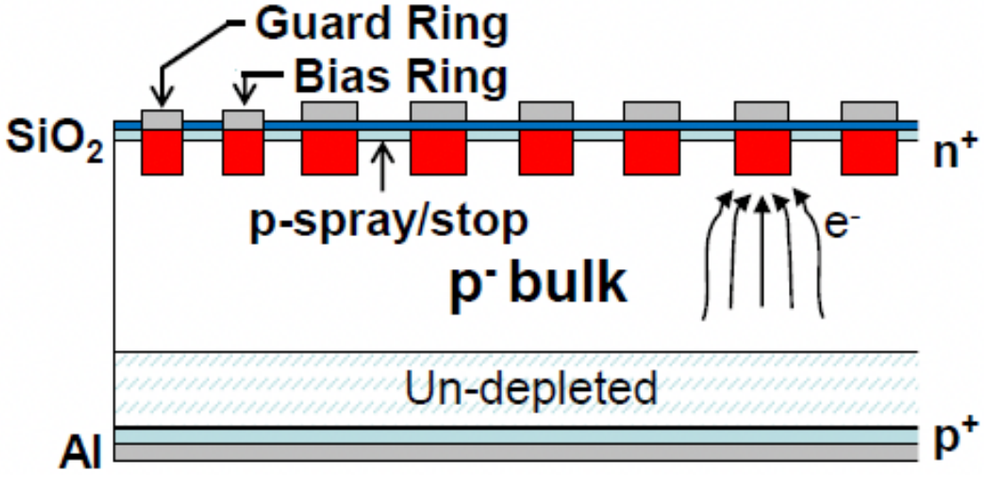


Short Strip Sensor:

- Four Segments
- Strip Length: 2.4 cm
- 5120 read-out strips

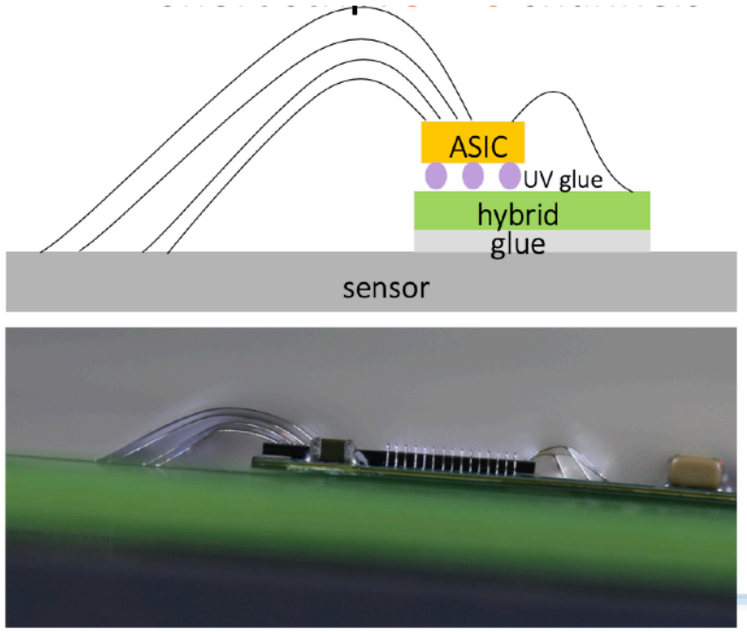
Long Strip Sensor:

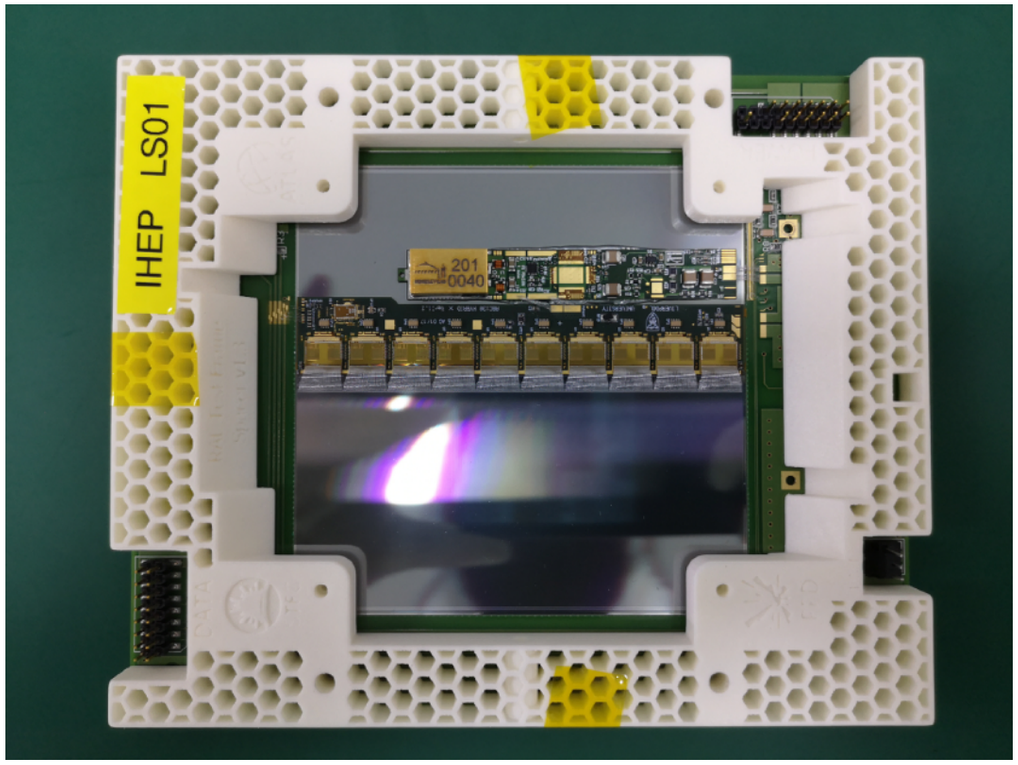
- Two Segments
- Strip Length: 4.8 cm
- 2560 read-out strips



Electrical Modules at IHEP

- Two LS Modules with ABC/HCC130,
- Two LS Modules with ABC/HCCStar.



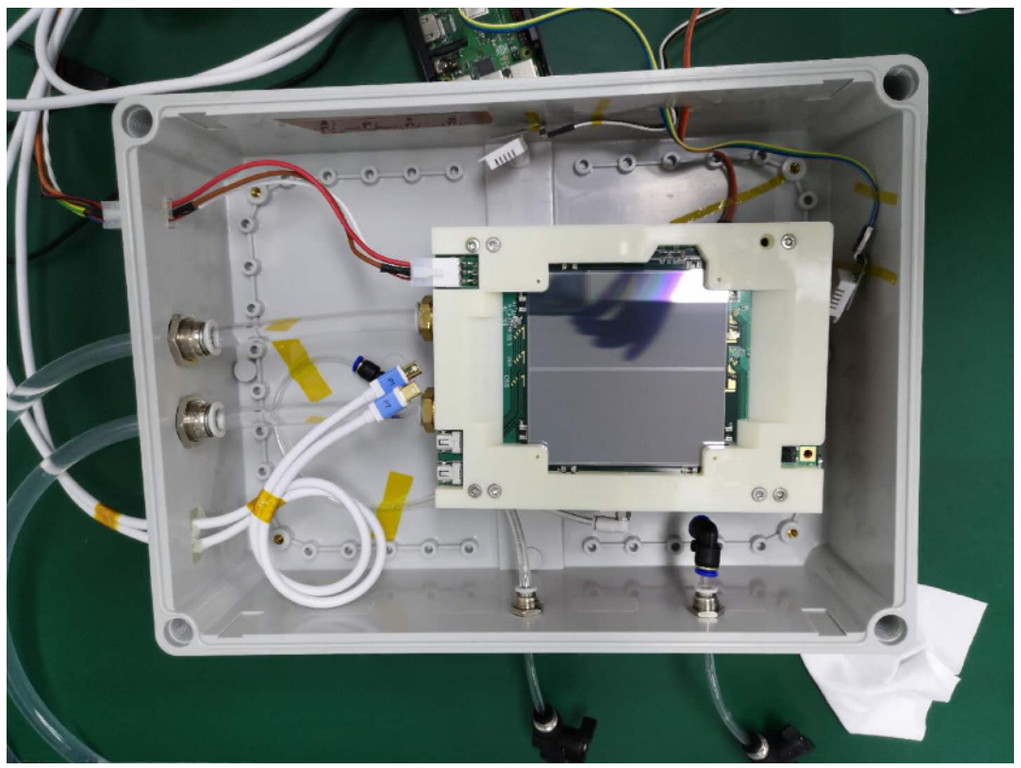


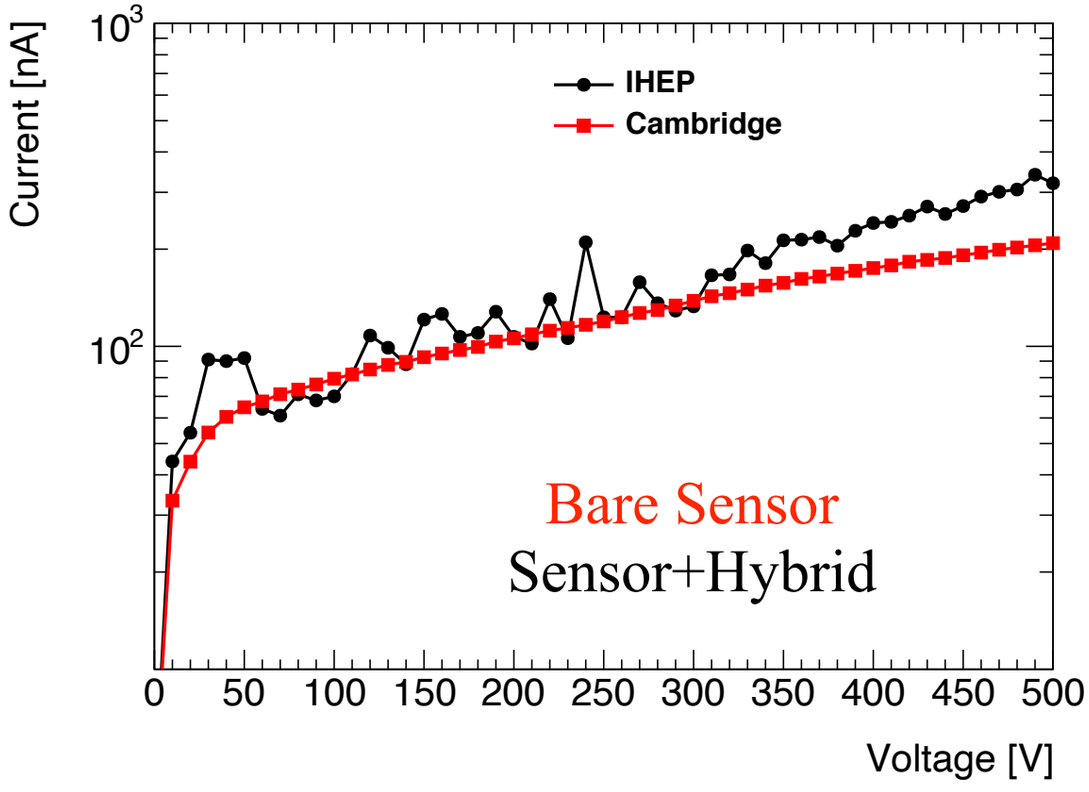
Electrical Module with ABC/HCC130

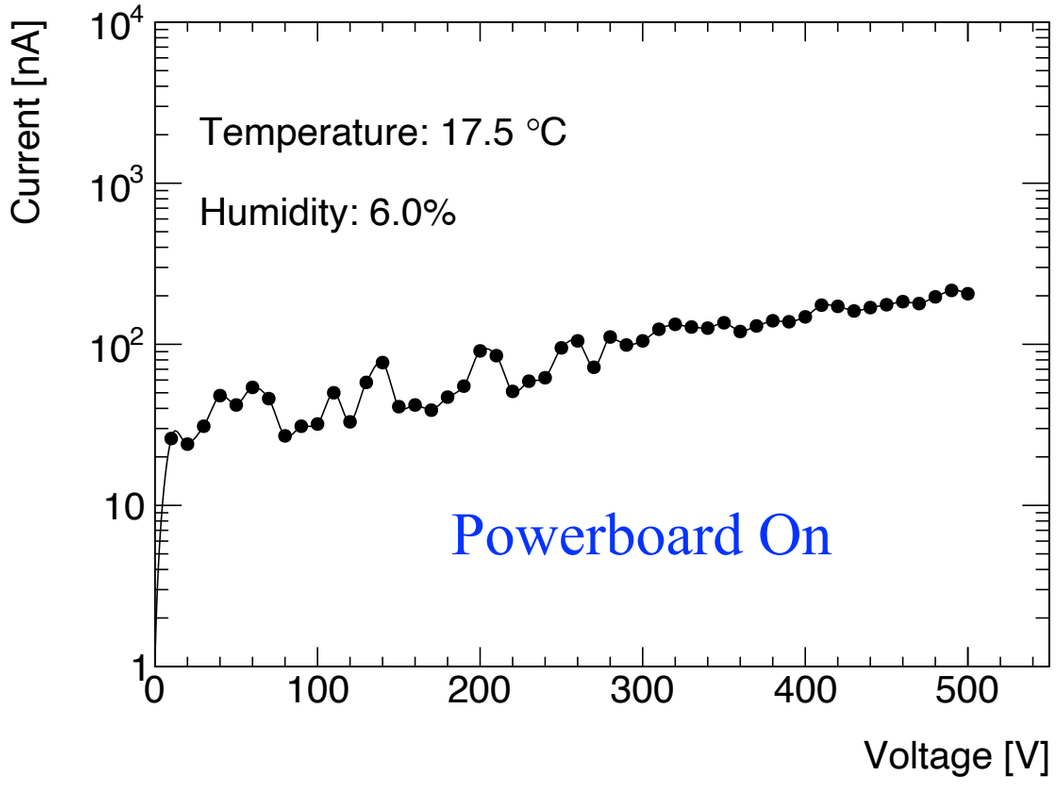
Electrical Module with ABC/HCCStar

Electrical Test on Module with ABC/HCC130

- Dark environment,
- T: ~17 °C, H: <10%,
- IV characteristics of sensor before and after assembly should be consistent.

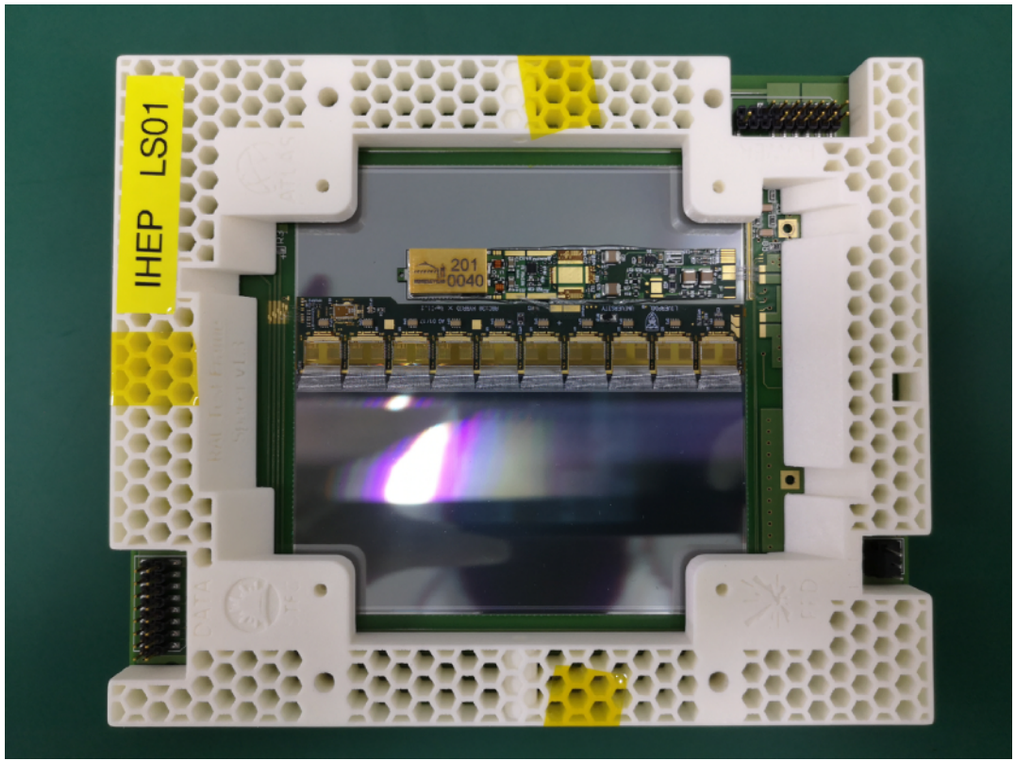


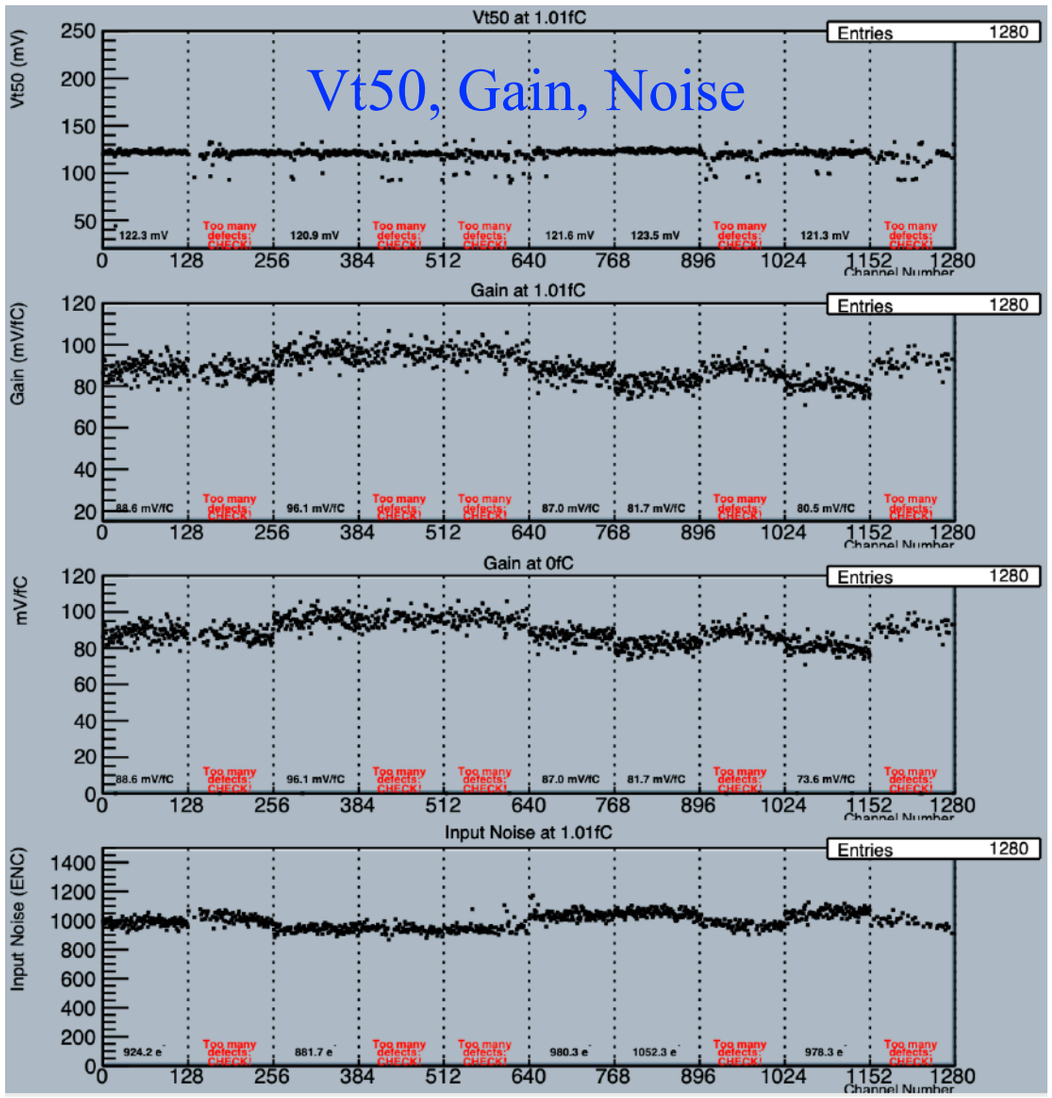


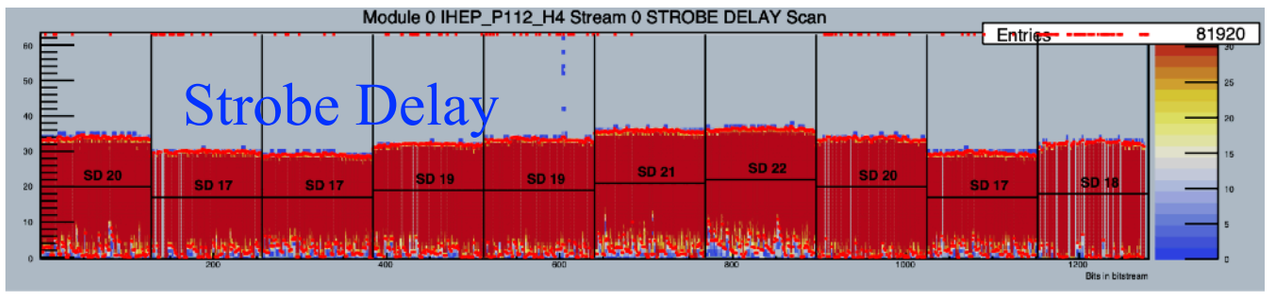


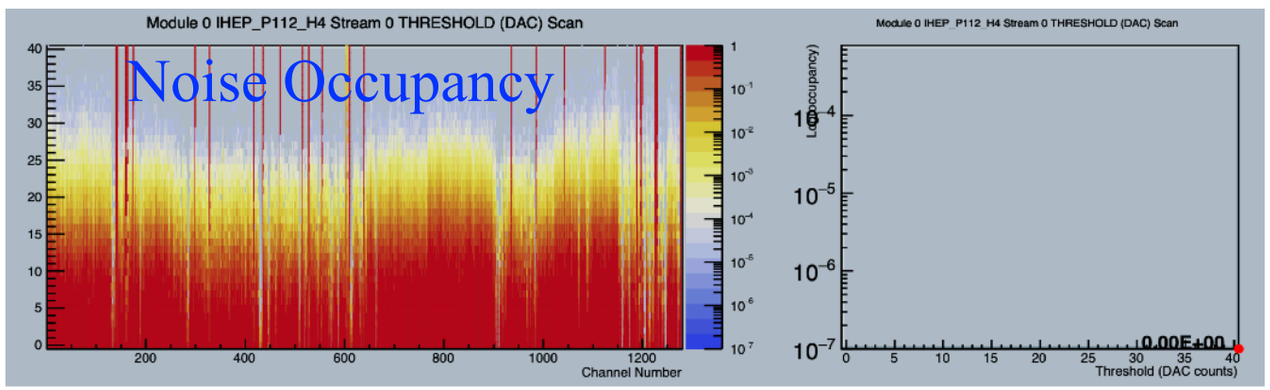
Electrical Test on Module with ABC/HCC130

- First Electrical Module at IHEP,
- IHEP_LS01 with 130 ASICs,
- Testbox: Dark, T: ~17 °C, H: <10%.



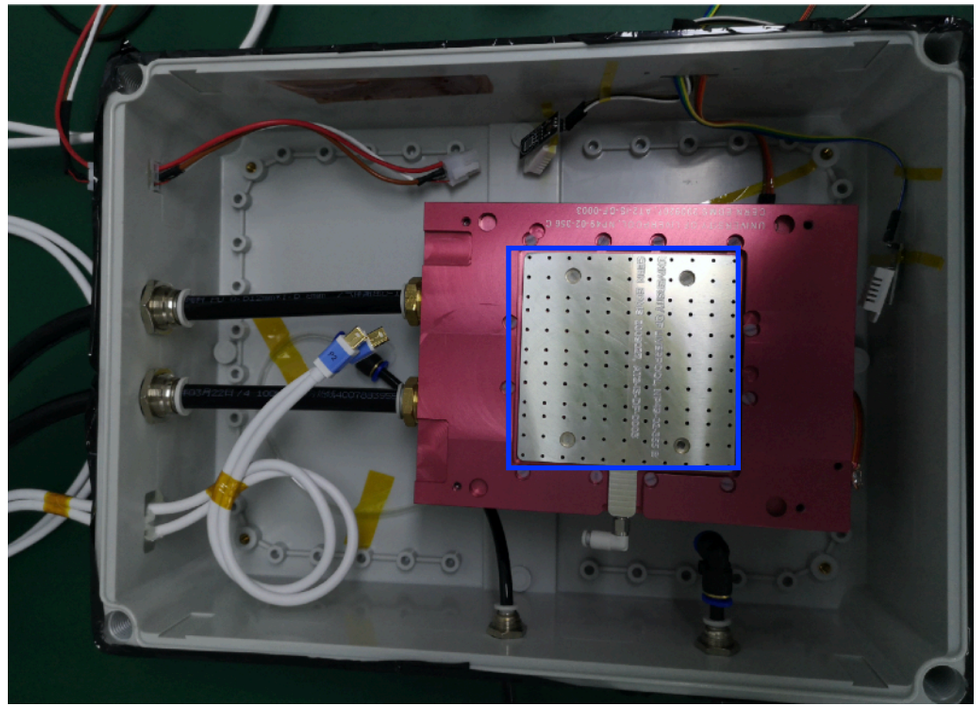


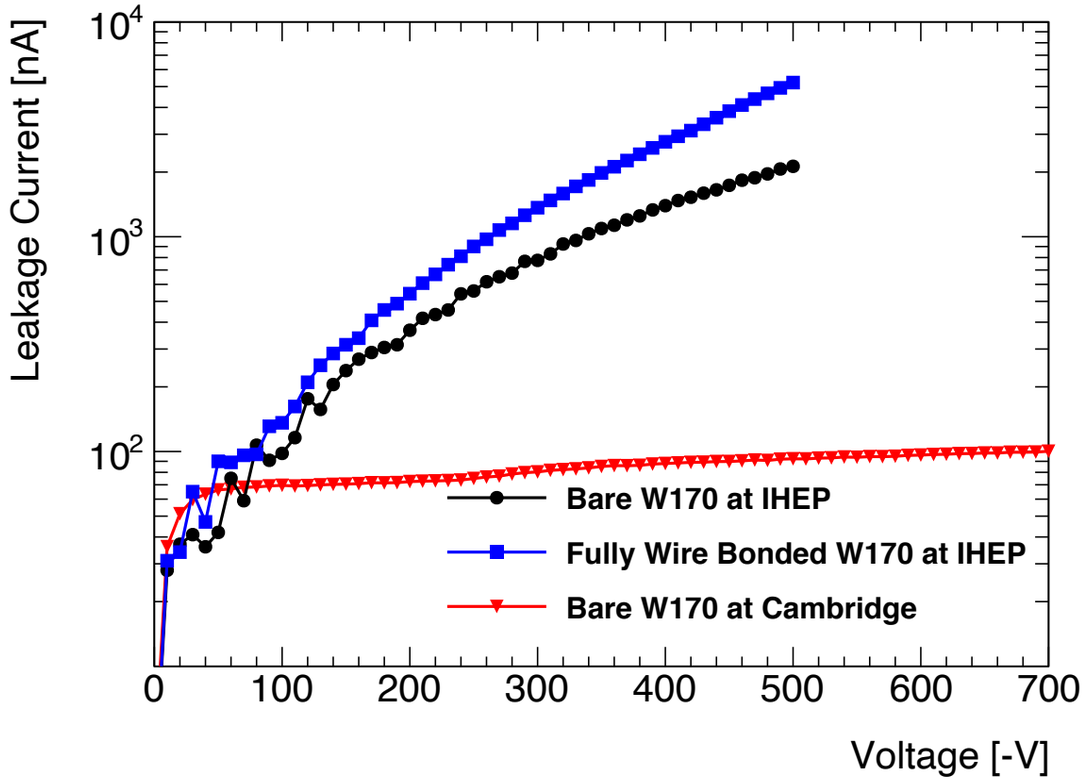




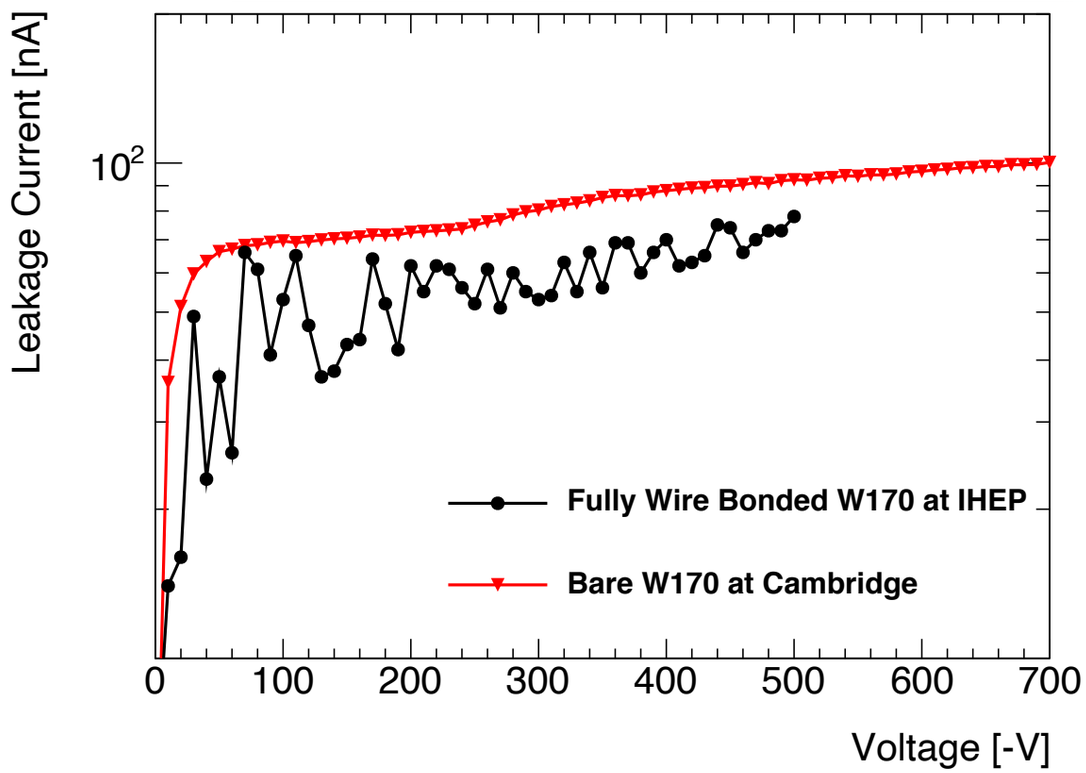
Electrical Test on Module with ABC/HCCStar

- Leakage current due to the poor insulation between HV plate of test chuck.
- Insulate HV plate(the blue area) and test chuck(add a layer of Kapton tape).





Before



After

Electrical Test on Module with ABC/HCCStar

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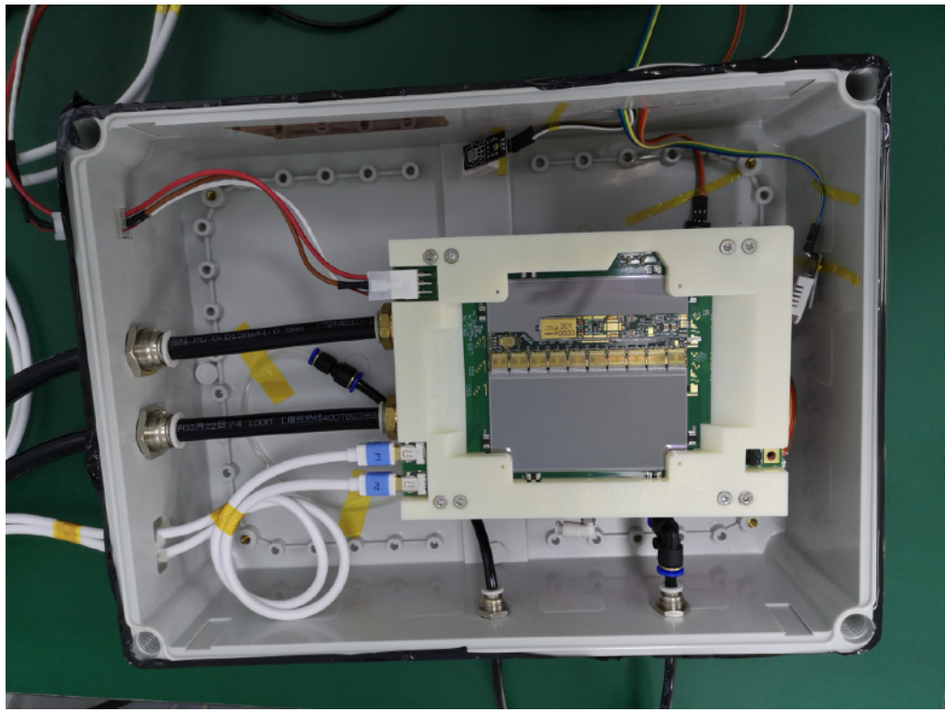
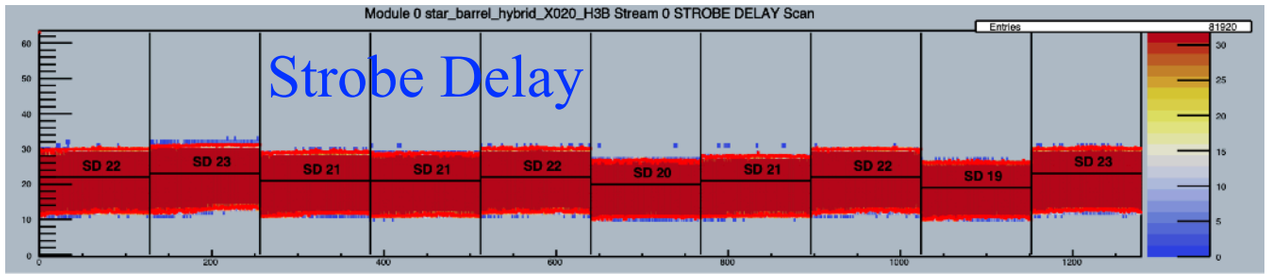
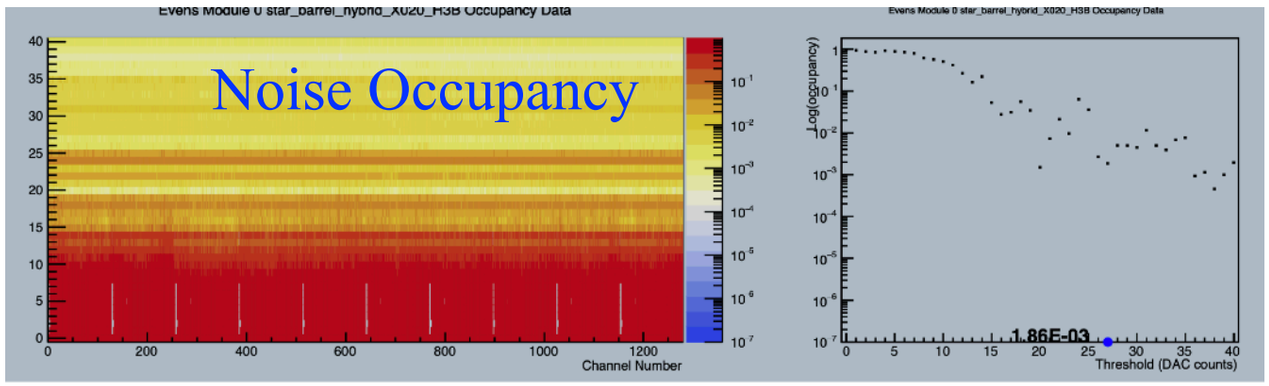
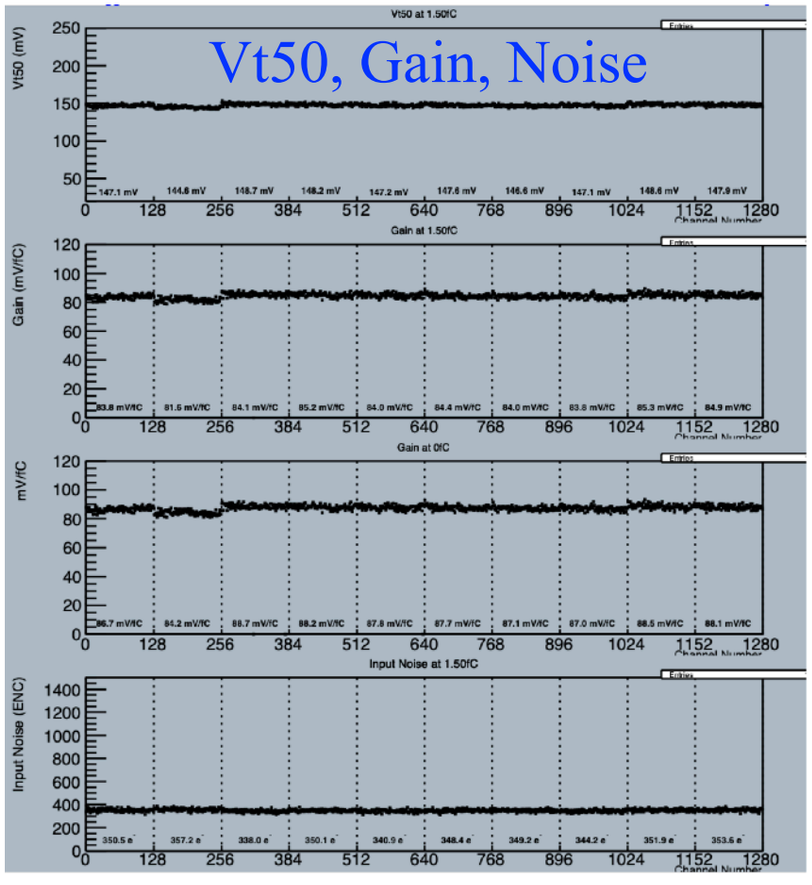
- First fully functional star module at IHEP,
- Plan to mount on stave for system test.





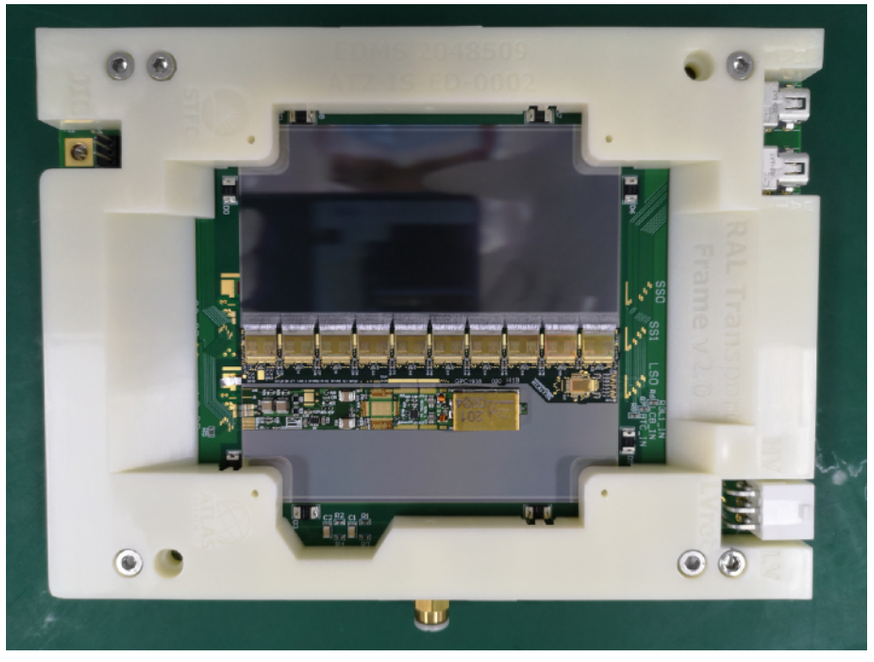


- Higher Noise Occupancy due to poor insulation between HV plate and test chuck.(Fixed)

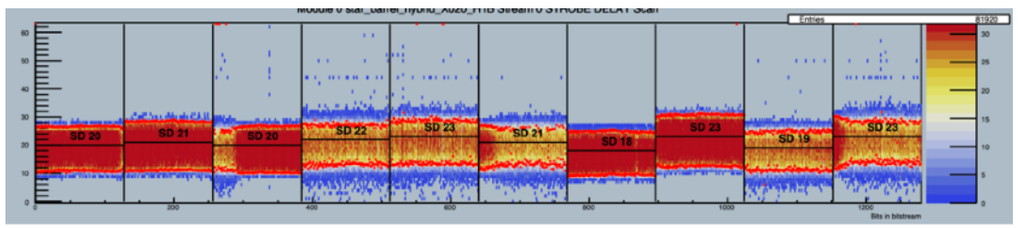


Electrical Test on Module with ABC/HCCStar

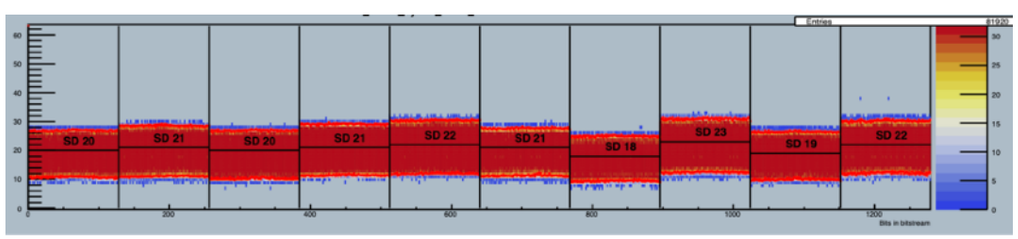
- Second Star LS Module
- Electrical Test:
  - Stream 1 fully functional,
  - Stream 0 not stable, failed Strobe Delay and RC



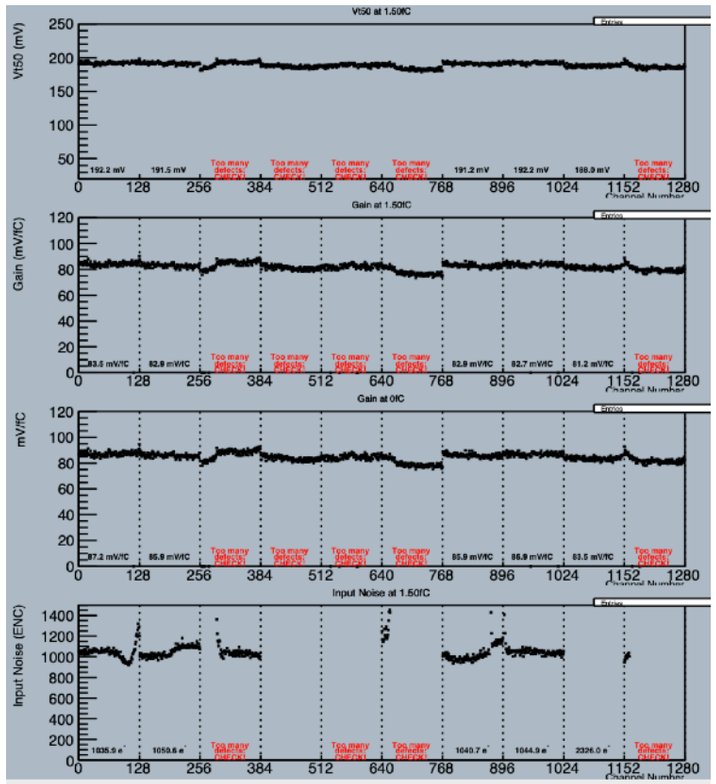
Stream 0



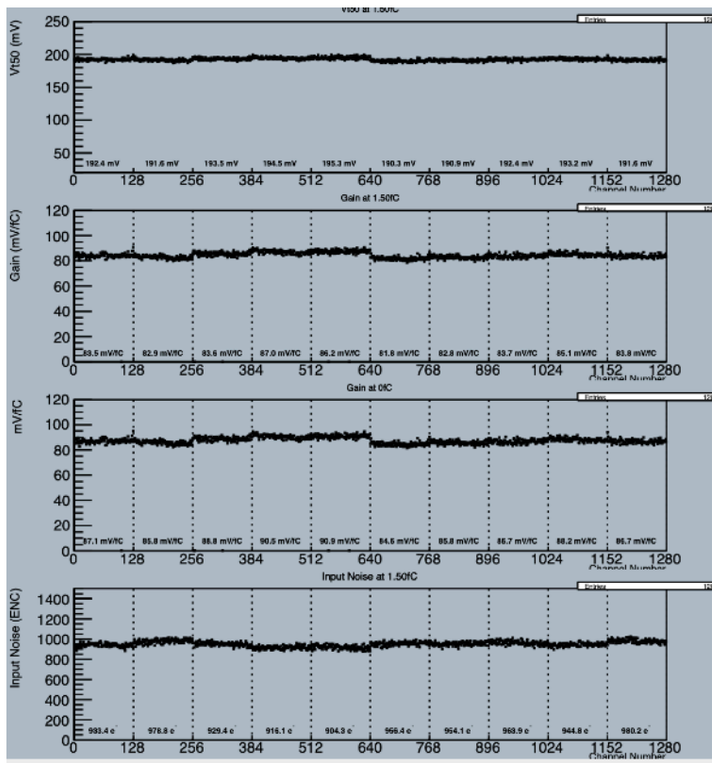
Stream 1



Stream 0

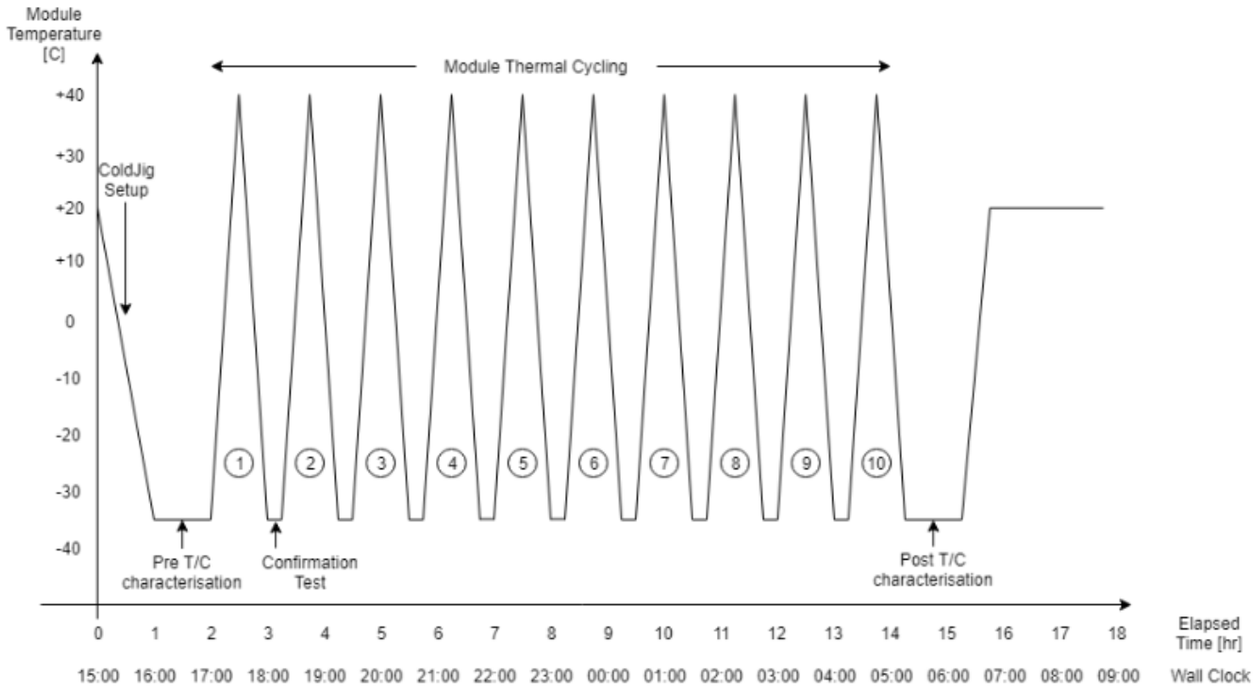


Stream 1

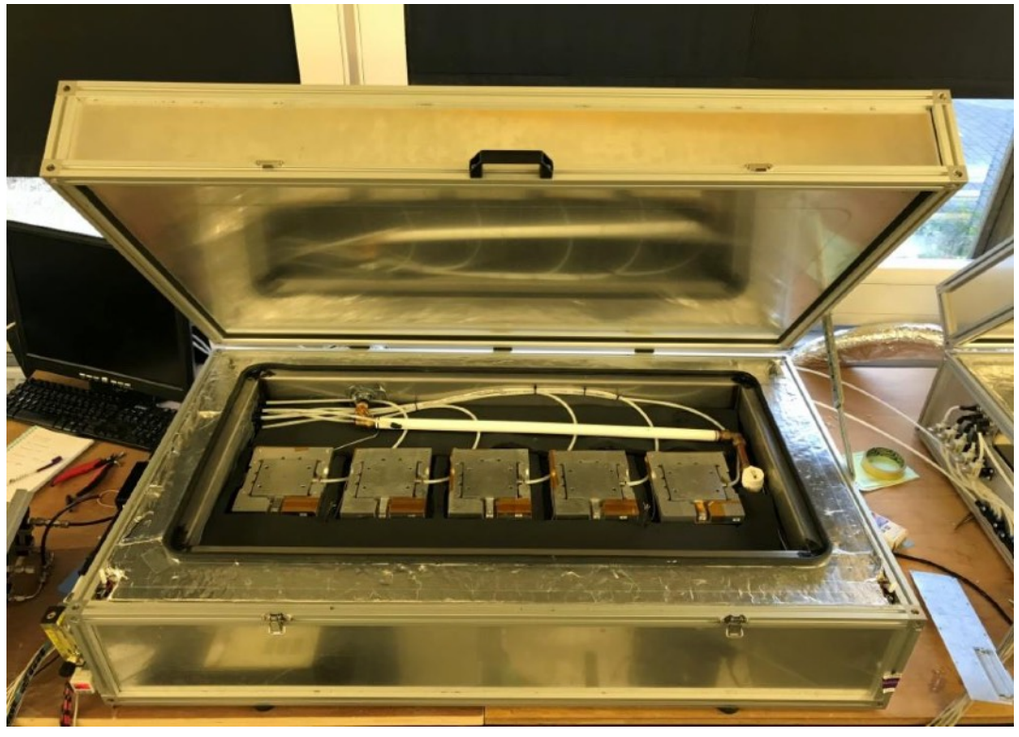


Module Thermal Cycling

- Thermal-cycling between -35 °C to +40 °C, 10 times over 12 hours,
- Module test before and after the thermal cycling period, and between each thermal cycle,
- Expect to get ColdJig at the end of October.



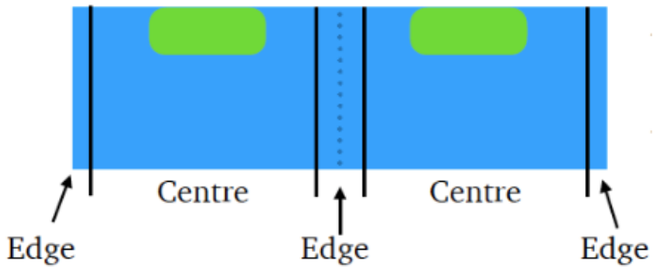
Thermal Cycling Timeline

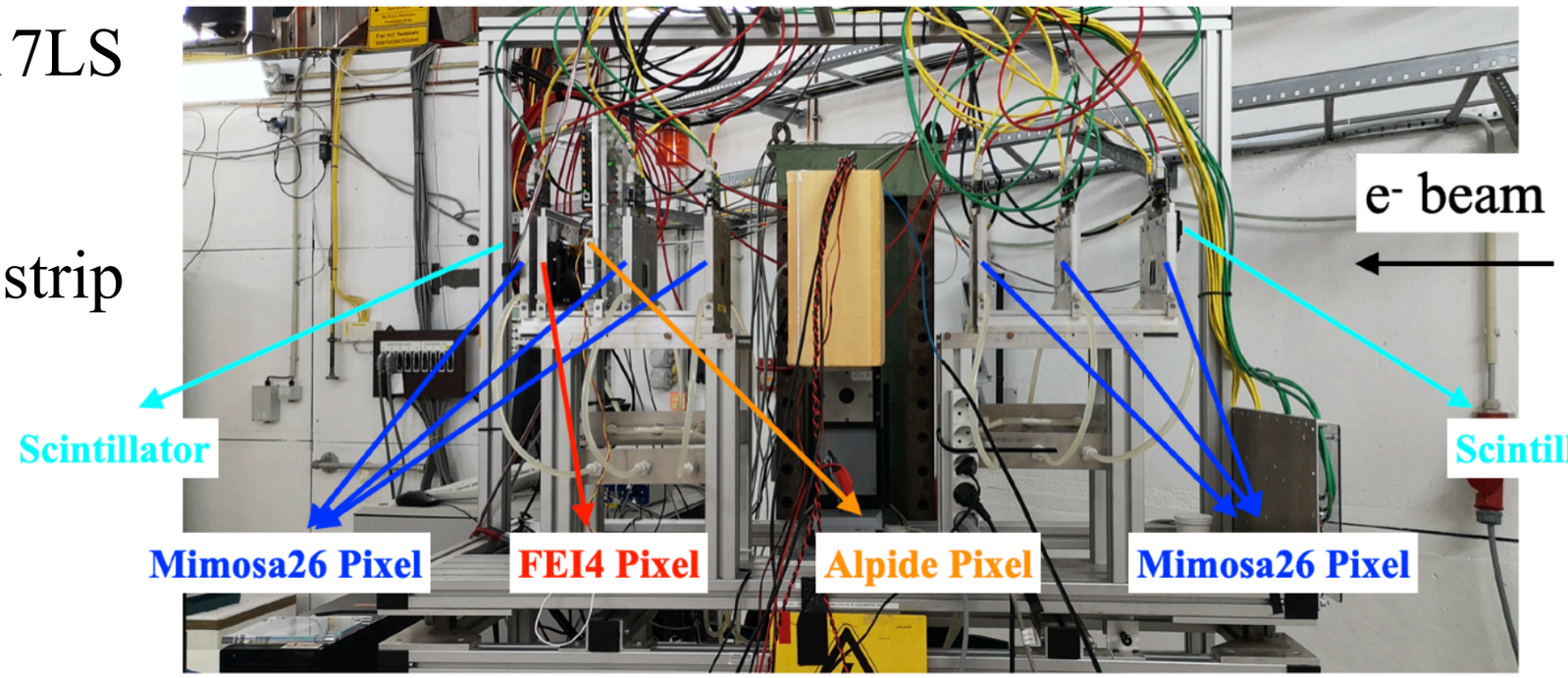


ColdJig at Warwick

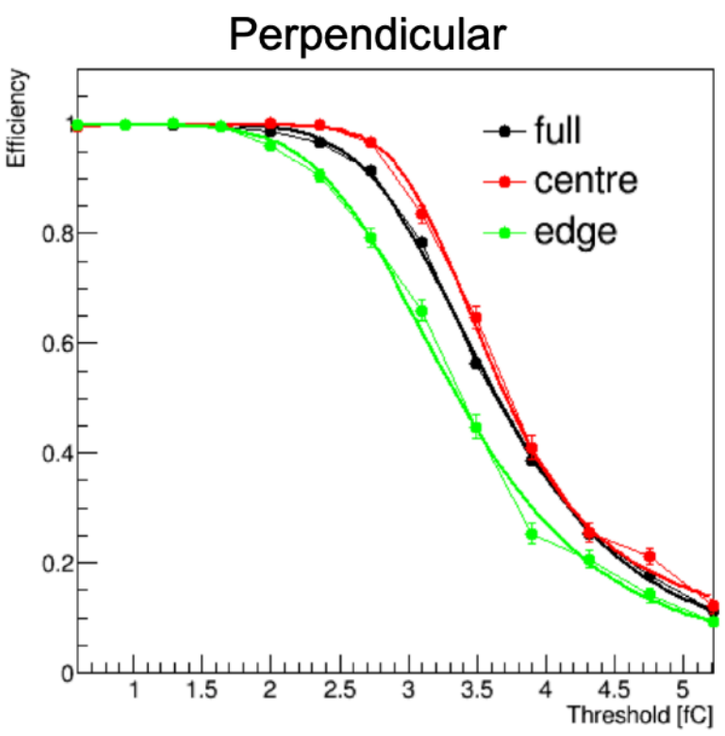
Beam Test

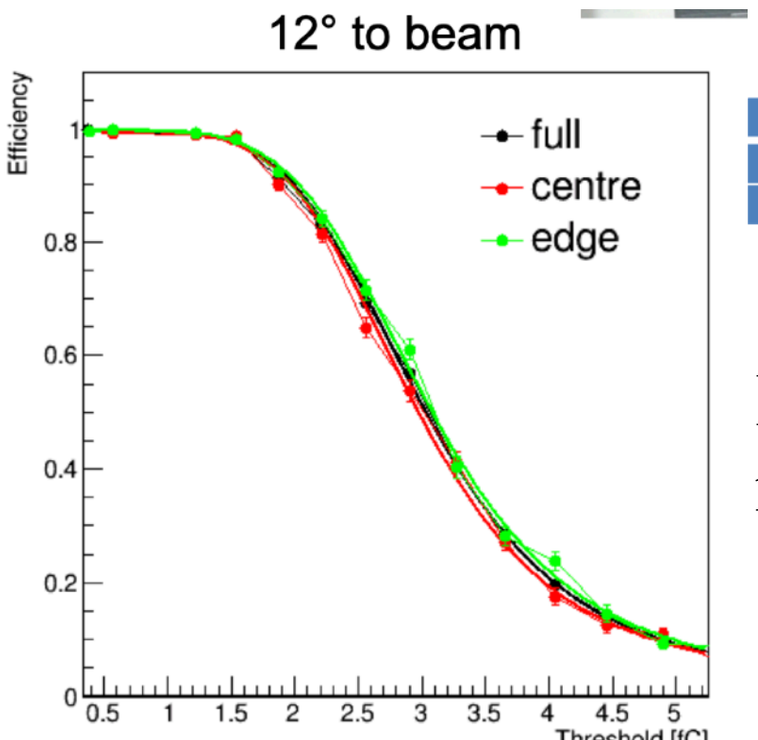
- Module built using ATLAS17LS sensor and star-chipset
- Define “edge” of strip/inter-strip region of 15 μm





EUDET-type telescope

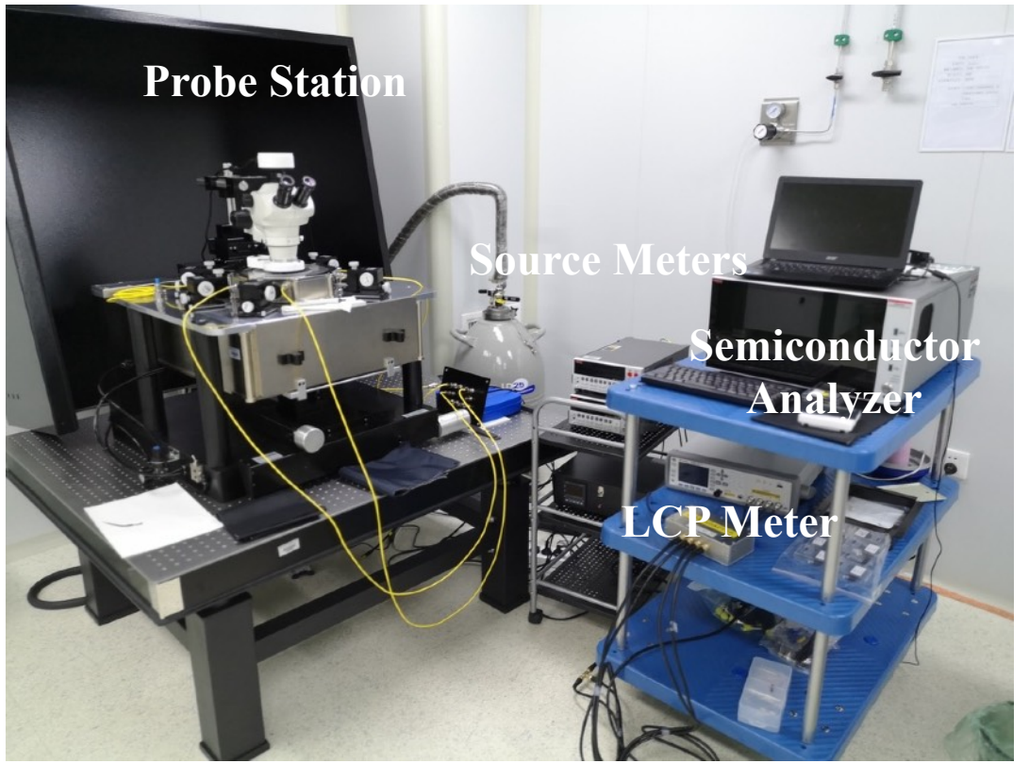


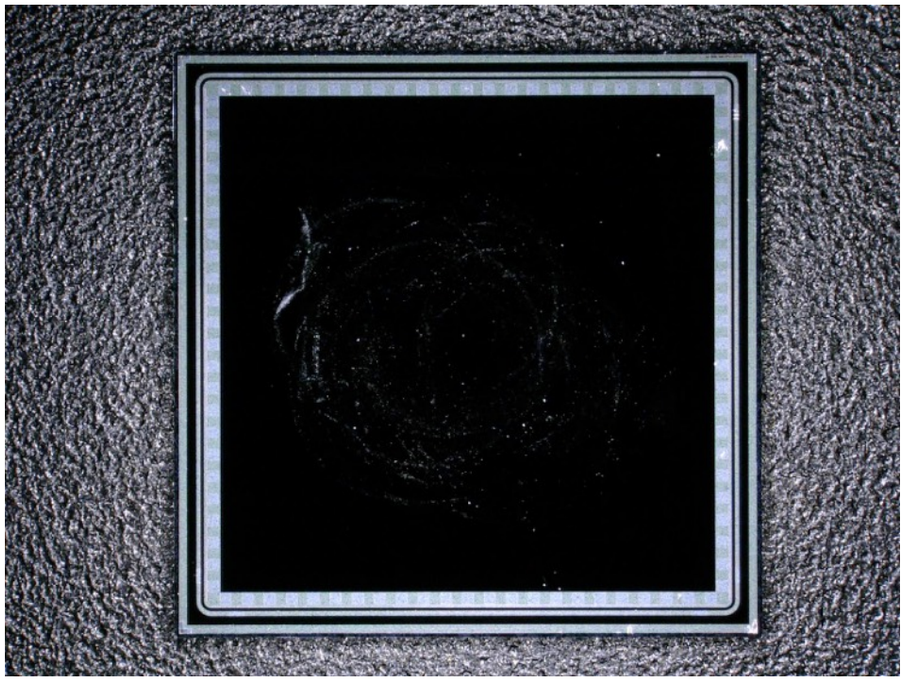


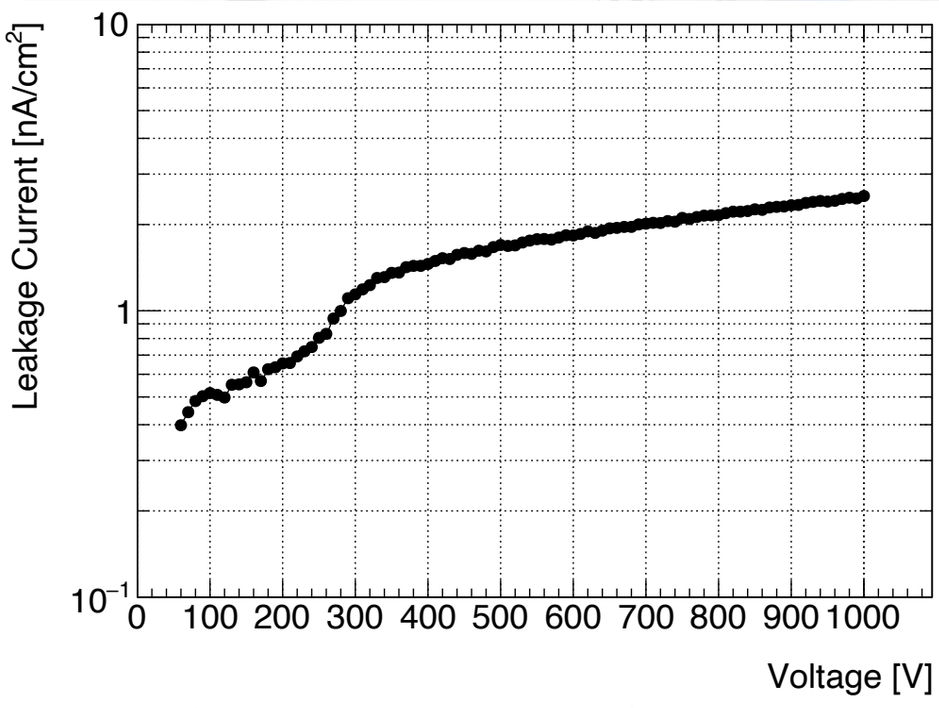
Median charge	Overall	Centre	Edge
Perpendicular to beam	3.65 fC	3.72 fC	3.37 fC
12° to beam	3.03 fC	2.97 fC	3.08 fC

Lower efficiency for inter-strip region mainly due to charge sharing between strips

Mini Sensor Studies

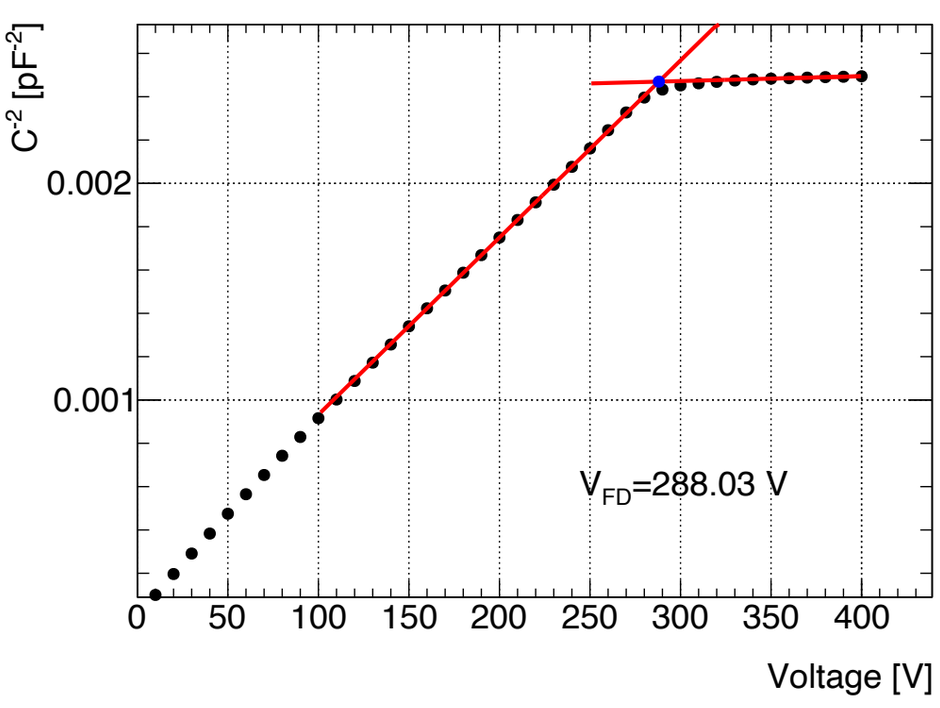






Leakage Current<0.1 μA/cm^2 at 500 V

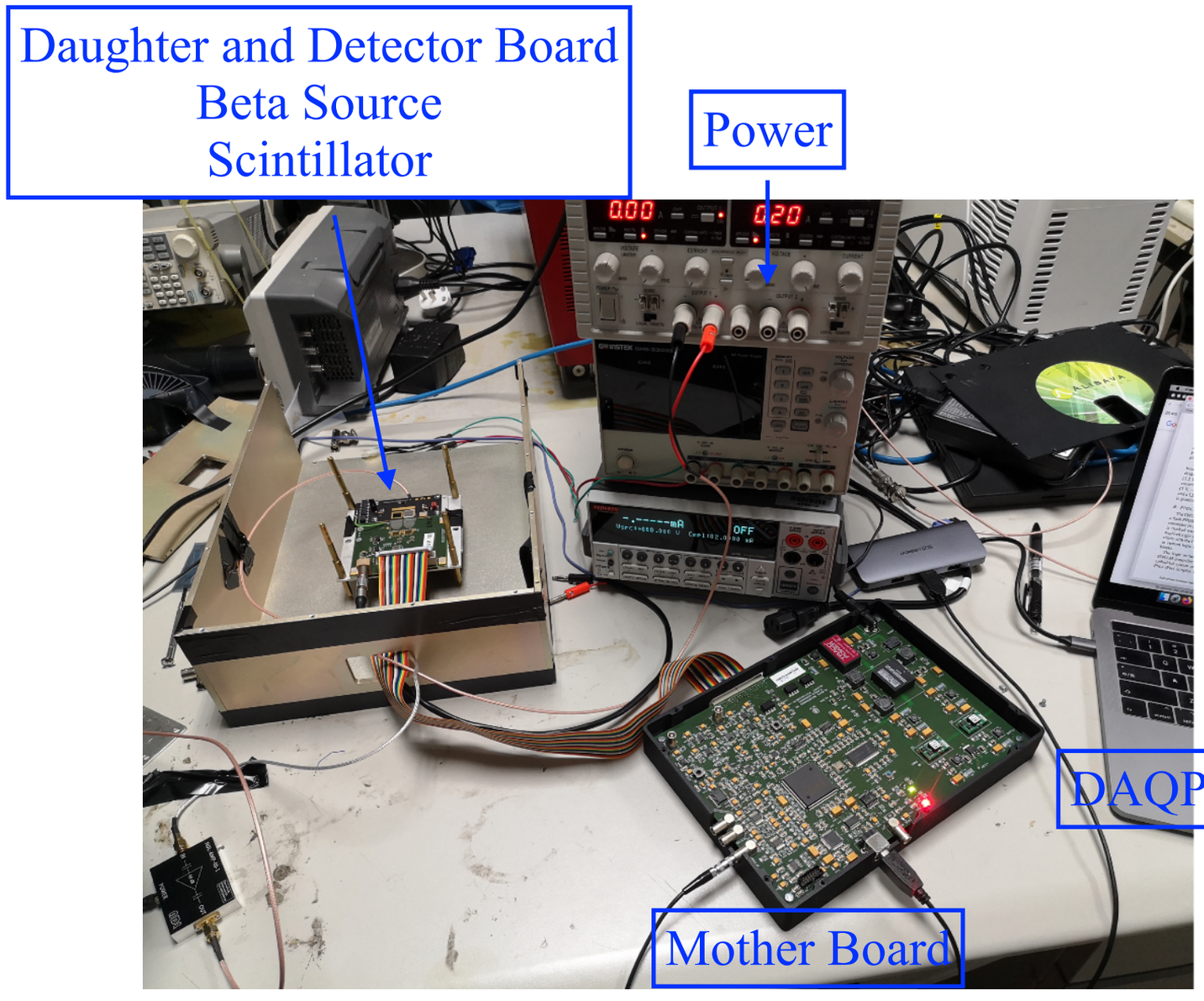
Onset of micro-discharge Voltage>500 V



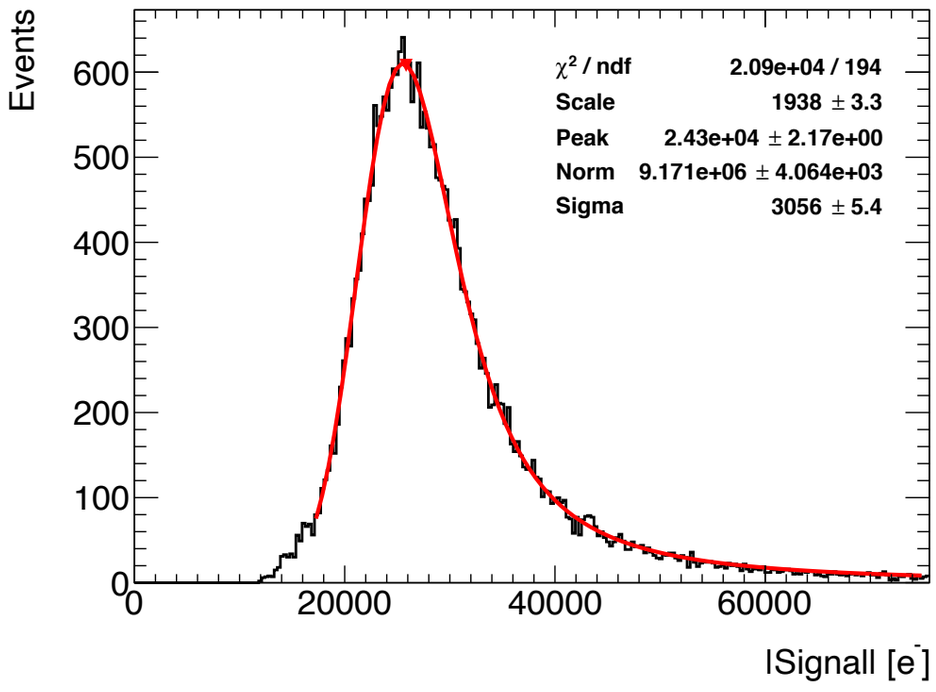
V_{FD}<350 V

Mini sensor studies with ALiBaVa System

- Set up the ALiBaVa system,
- Study the properties of mini sensor w/o irradiation using beta source.



Signal Shape



More details in Yebo's talk.

Summary and Plan

- Assembled several electrical Hybrids and Modules,
- Performed electrical test on Hybrids, Sensors and Modules.
- Plan:
  - Expect more sensors and ASICs,
  - Waiting for the Hybrid burn-in and Module thermal cycling setups.

Thanks