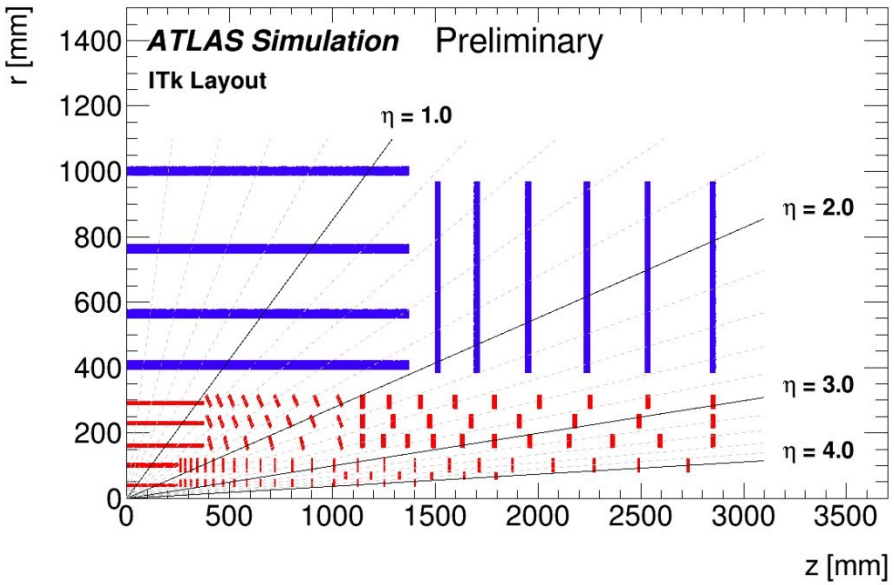
ATLAS ITk strip detector introduction



ITk Strip system will consist of:

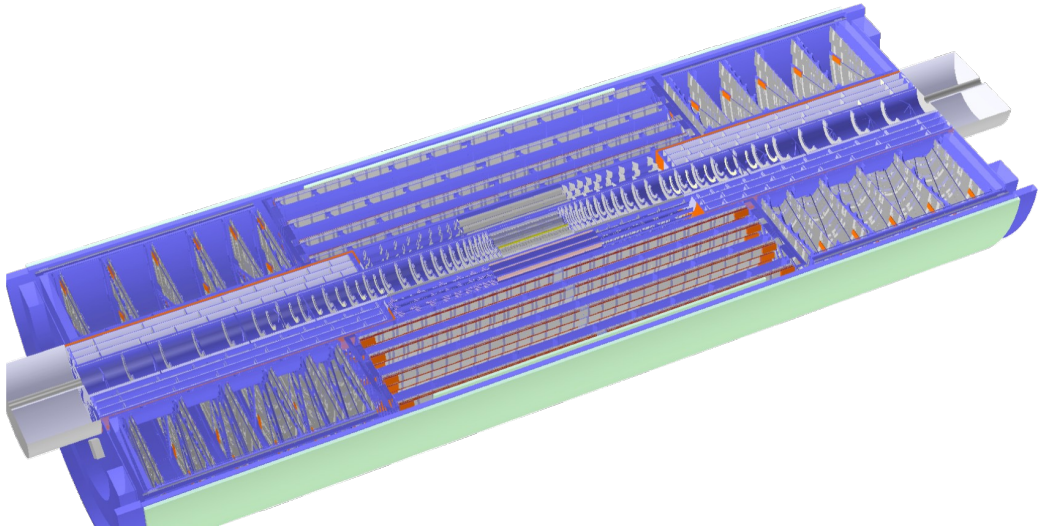
- 4 barrel cylinders and 6 disks per end cap
- 165 m^2 of silicon (current Inner Detector: 61 m^2)
- ~18 k modules (current: ~4k modules)
- ~60 million channels (current: ~6 million)

Main requirements for design:

- radiation hardness, high granularity, readout speed that meets increased trigger rates, low material budget

<u>Example of design choices made to meet requirements and schedule:</u>

- Local, on-module DC-DC
- Advanced cooling: Manifolded, CO_2-based
- Honeycomb structures for module support
- Industry standard design rules, simplified construction
- Assembly and testing happening at multiple sites worldwide



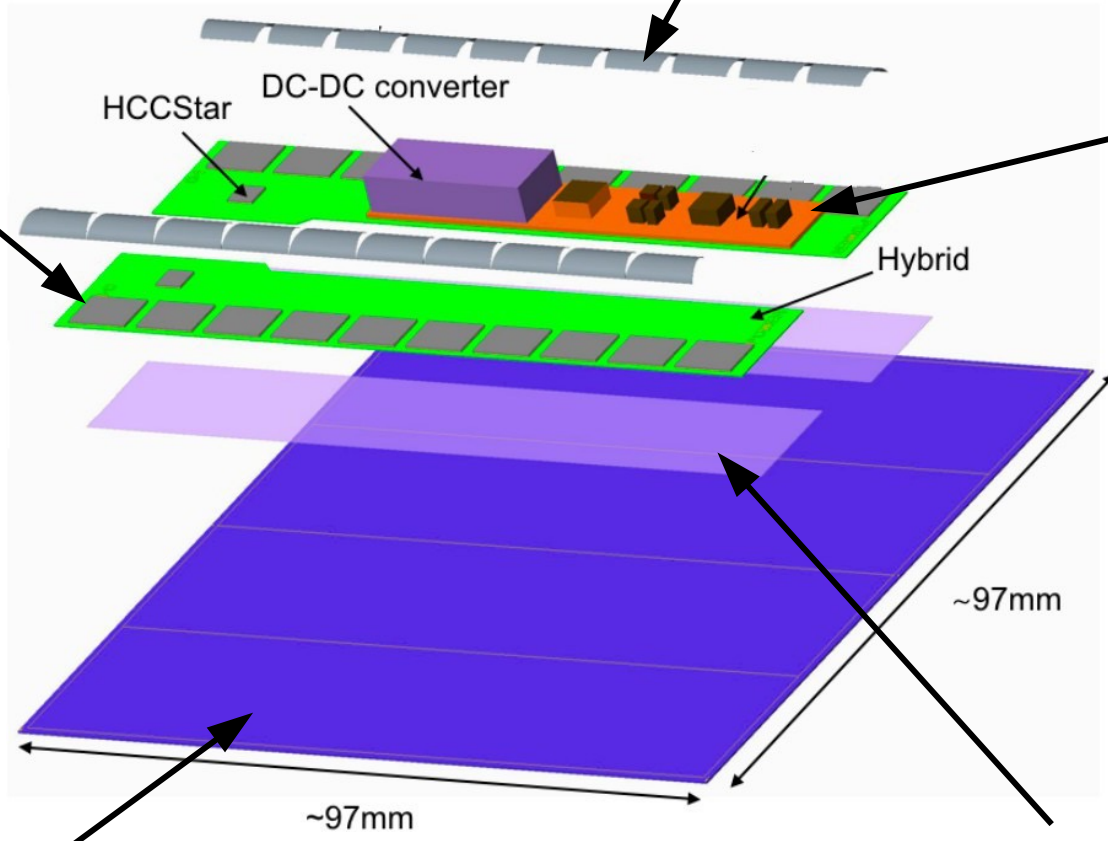
ITk strip detector introduction II

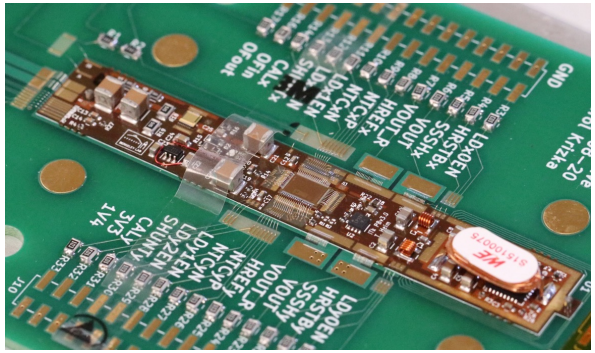
ASICs: 130nm CMOS technology readout chips, attached with UV glue

4 row wirebonding for data readout

Power board: DC-DC converter, dedicated power control ASIC

HV MUX switch for switching off individual modules



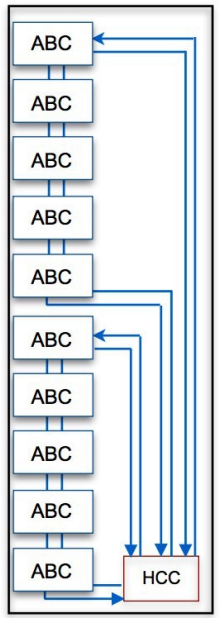


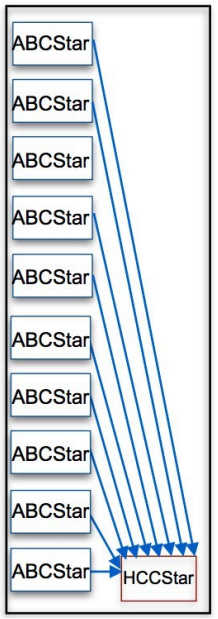
Sensor: AC-coupled n-type strip implants in a p-type float-zone silicon bulk

Radiation hard two component epoxy glue

ASICs

- ABCStar & HCCStar: data readout & control on the hybrids
- AMAC: monitoring and control chip for power board
- Star → latest ASIC generation with central readout scheme for higher trigger rate/bandwidth
- Chips fabricated at Global Foundries in 130 nm CMOS technology
- 640 MHz clock, 256 channel per ASIC, Region Of Interest trigger options, unloaded noise ~400 electrons

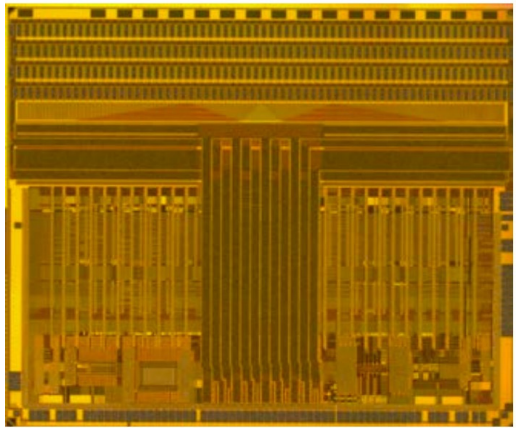




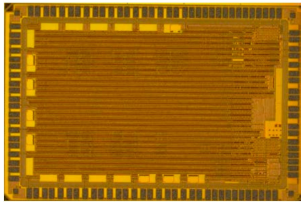
<u>Quality Control/Quality Assurance tasks</u>

- Reception quality control (wafer probing) to identify good dies
- Metrology and visual inspection of diced ASICs
- Irradiation qualification of ASICs for new designs

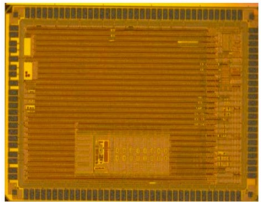
ABCStar



HCCStar

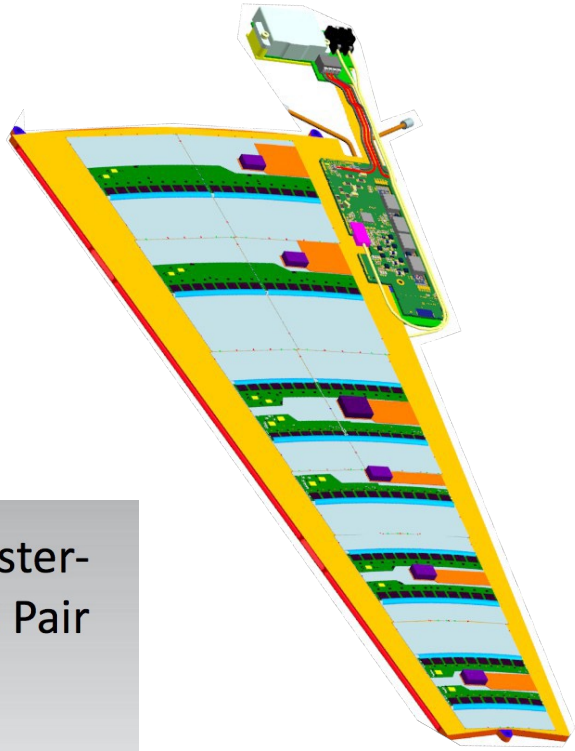


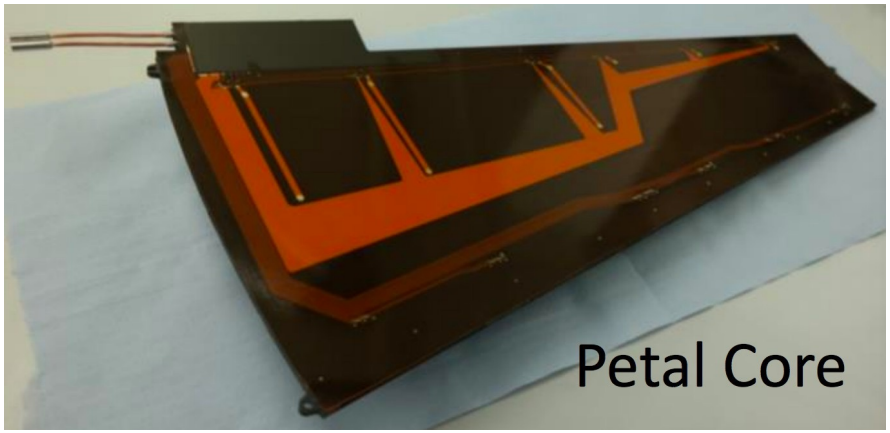
AMACv2a

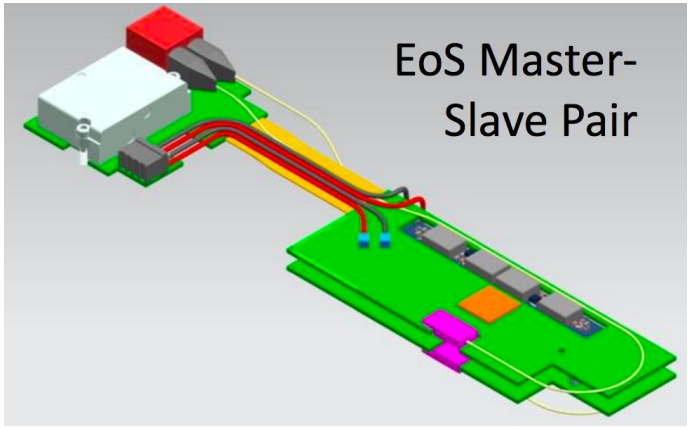


ITk strip detector introduction II

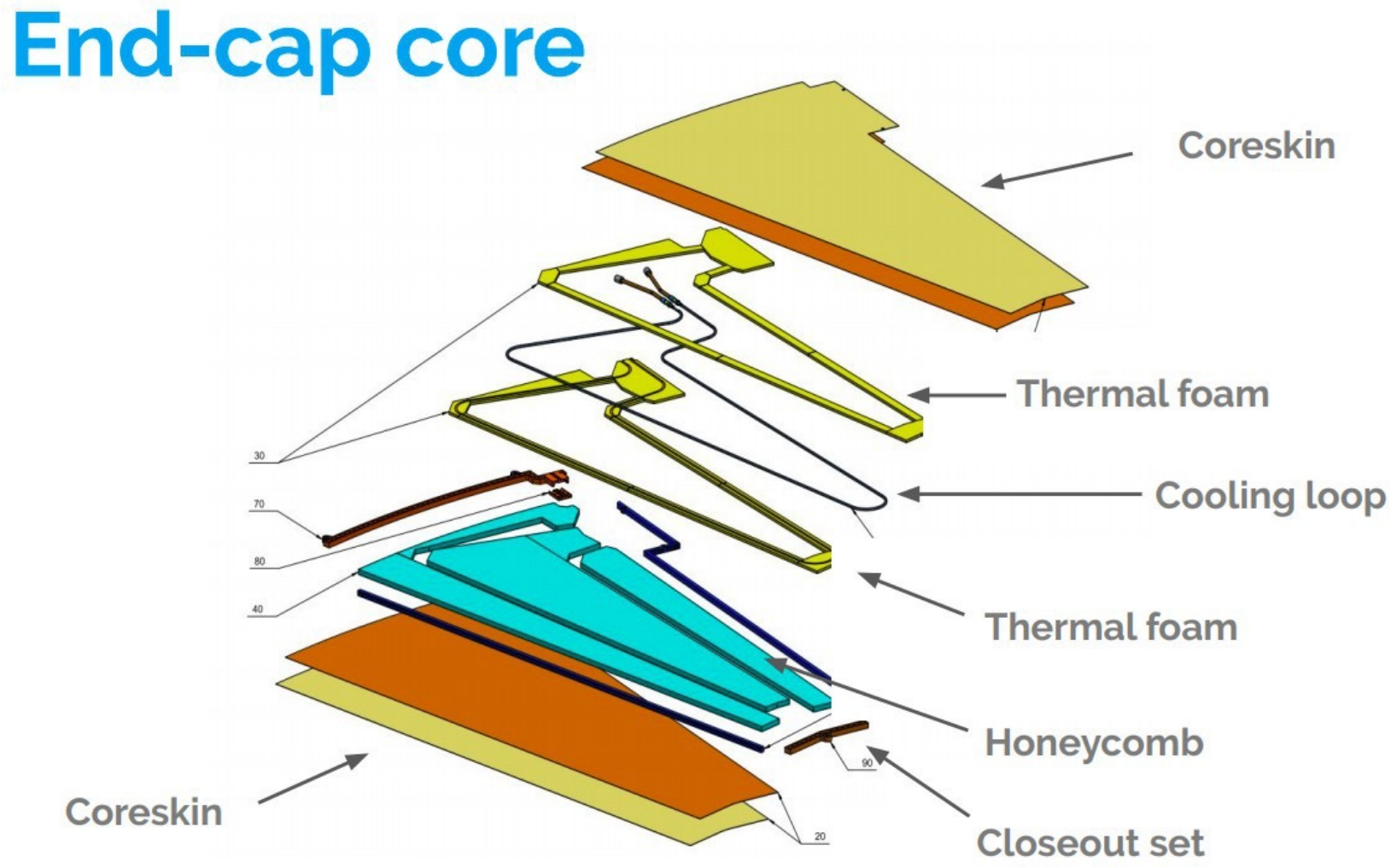
- Substructure for barrel cylinders called staves, endcap disks made of petals
- These local structures (LS) provide mechanical support & cooling (cores) + powering & readout (bus tapes)
- Staves and petals are connected to off-detector electronics through an End-Of-Substructure (EoS) board







Petal core


End-cap core
Coreskin
Thermal foam
Cooling loop
Thermal foam
Honeycomb
Closeout set
Coreskin
30
70
80
40
90
20

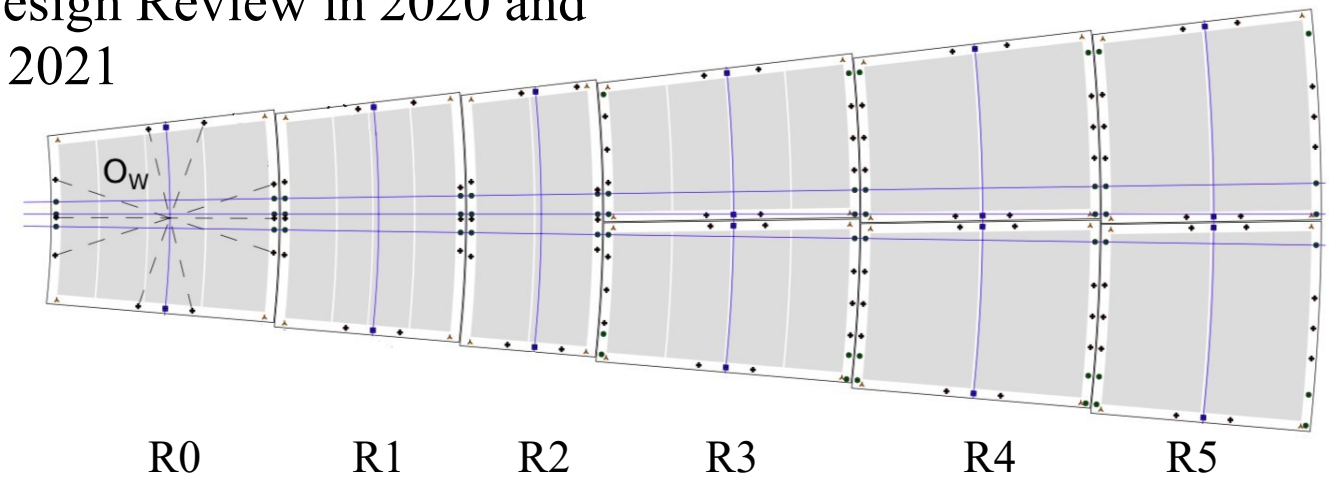
Sensors

- p-type FZ silicon with n-type strip implants
- depletion voltage ≤ 350V, maximum operation voltage 500V, slim edge of ~500 µm for higher track acceptance

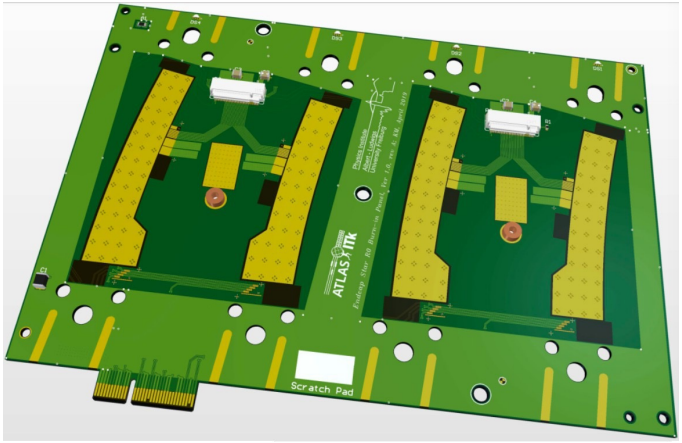
Intensive testing campaign to verify prototype design:

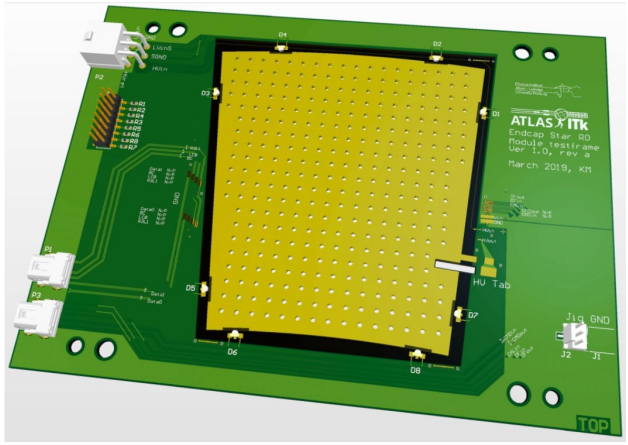
- Testing of various designs developed over more than 10 years
- 5 Irradiation sources, 15 institutes testing the sensors
- 8 different shapes of sensor (2 barrel, 6 endcap)
-

Successfully passed Final Design Review in 2020 and in production since summer 2021



Hybrids and test frames

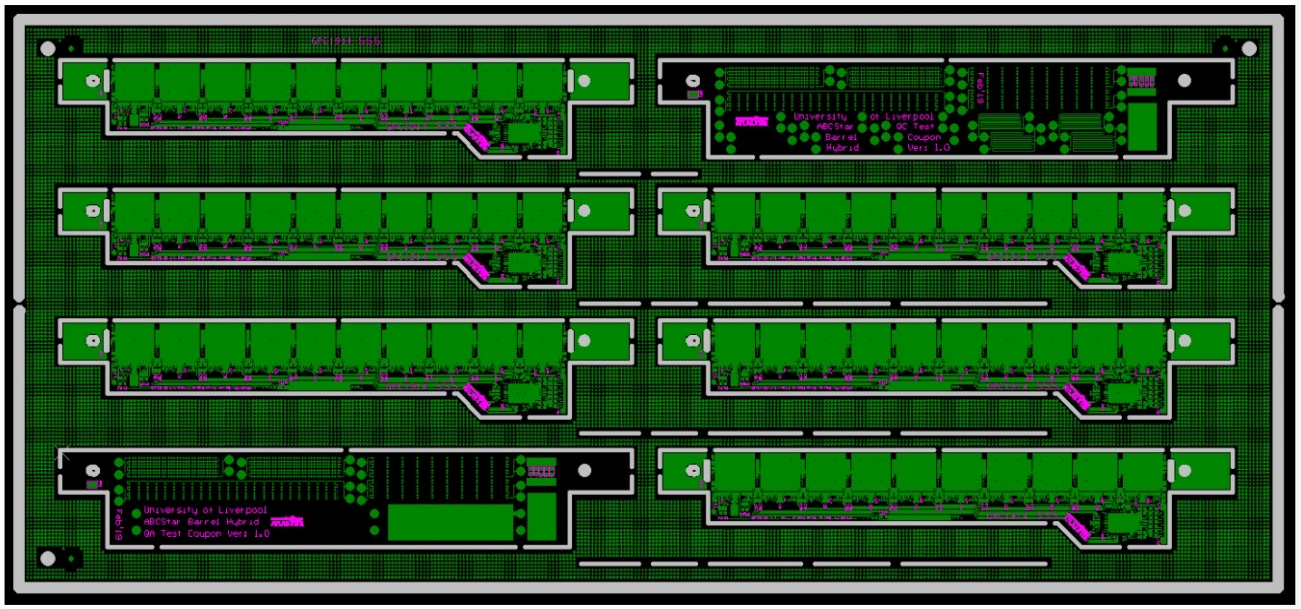




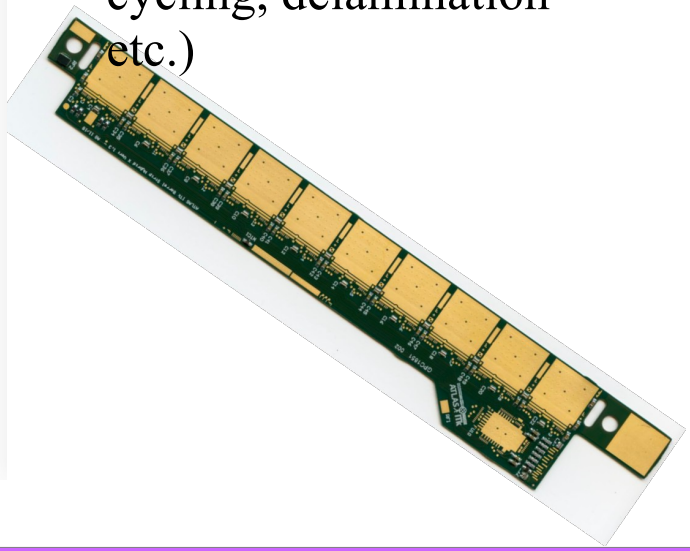
- Hybrid (4 layer flex circuit), test frame and burn-in panel designs now final
- 15 different hybrid types
  - 2 barrel
  - 13 endcap

Test coupons allow tQA/QC measurements (thickness, resistance, bond pull tests, thermal cycling, delamination etc.)

QC Test Coupon



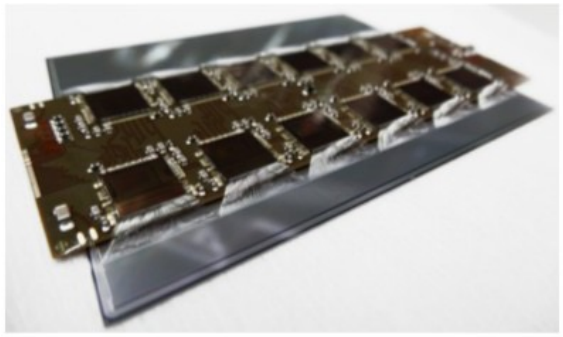
QA Test Coupon

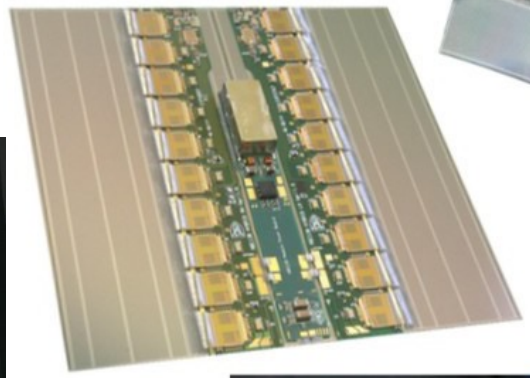


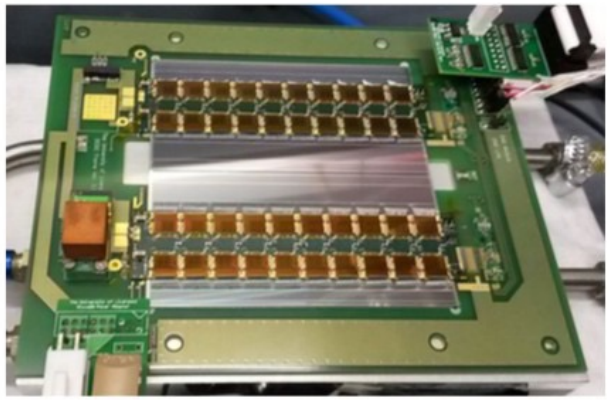
Modules – History of Prototyping

Module assembly has developed over past few years

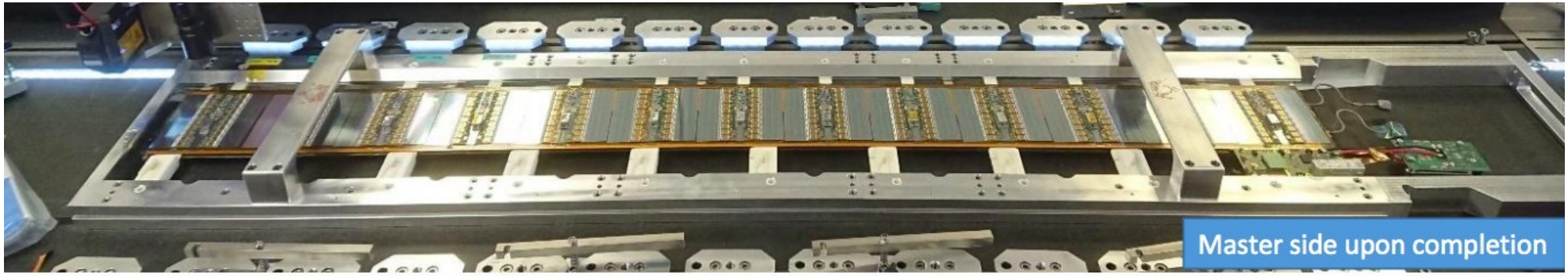
- ABCN modules (2008-2016)
  - ~ 50 barrel modules
  - ~ 30 petalet modules
- ABC130 modules (2015-2019)
  - ~ 80 barrel modules
  - ~ 30 Endcap modules
- Countless trials with plastic and glass dummies
- ABCStar modules (2019-onwards)
  - 50 LS & 100 SS barrel modules
  - 30 Endcap modules

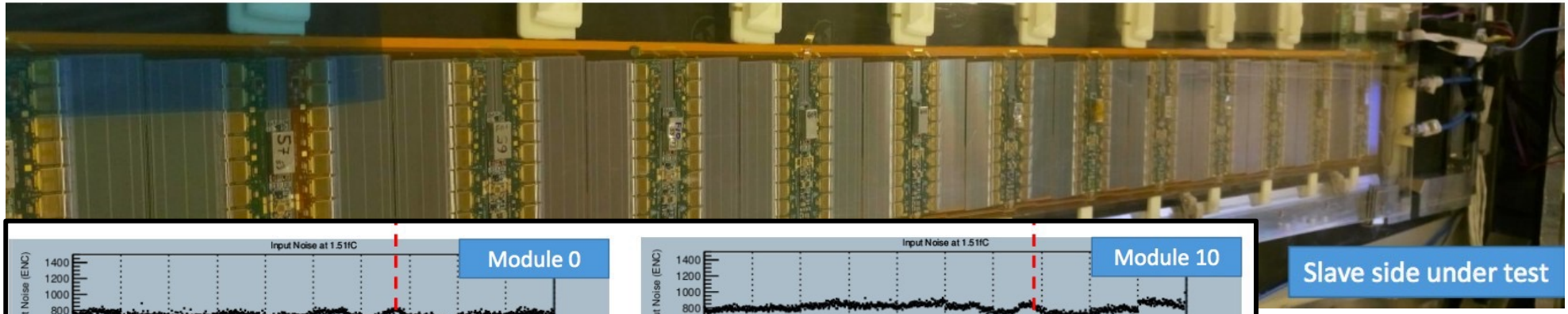


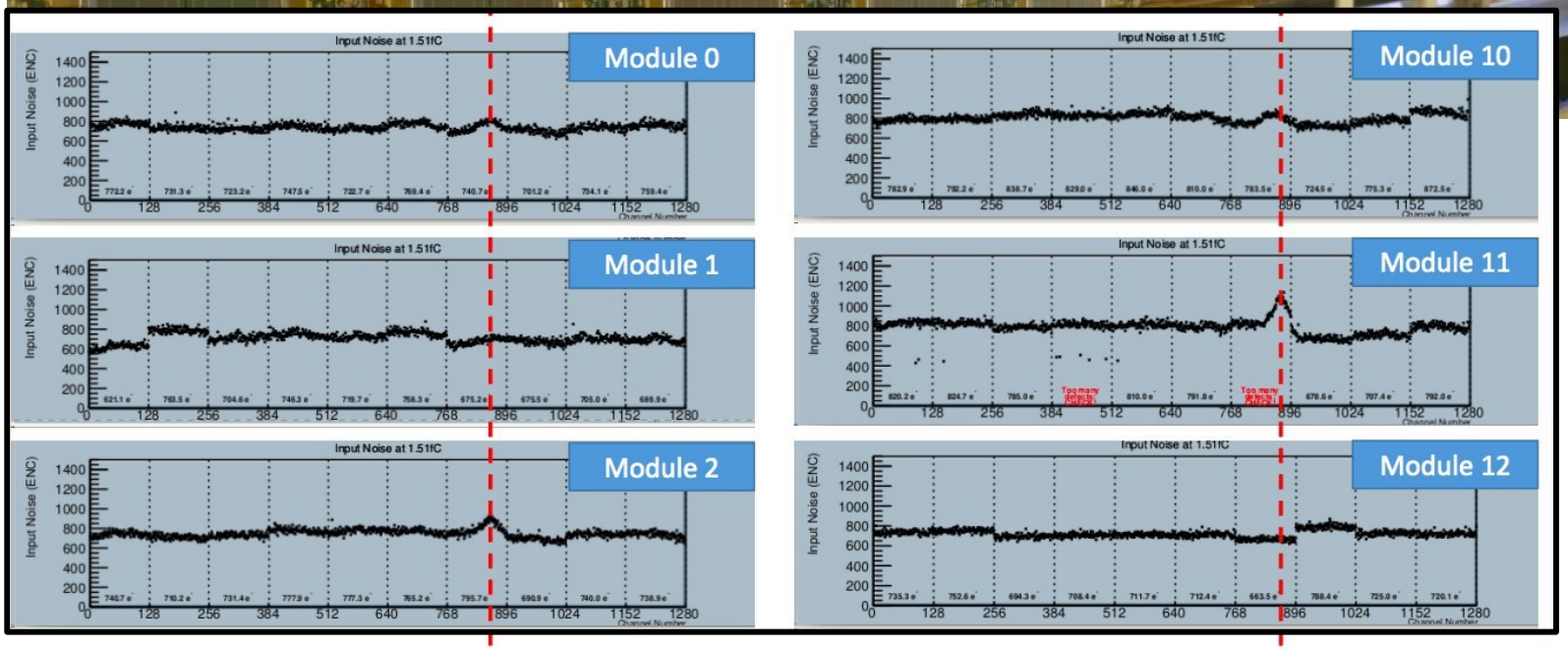




System test





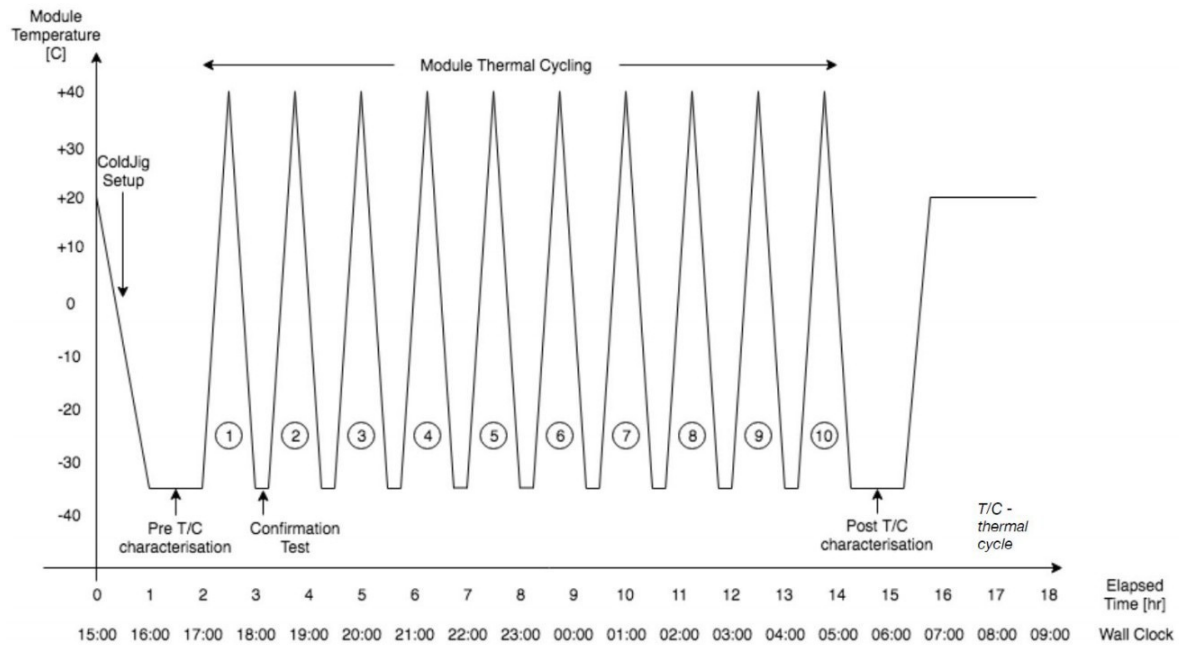


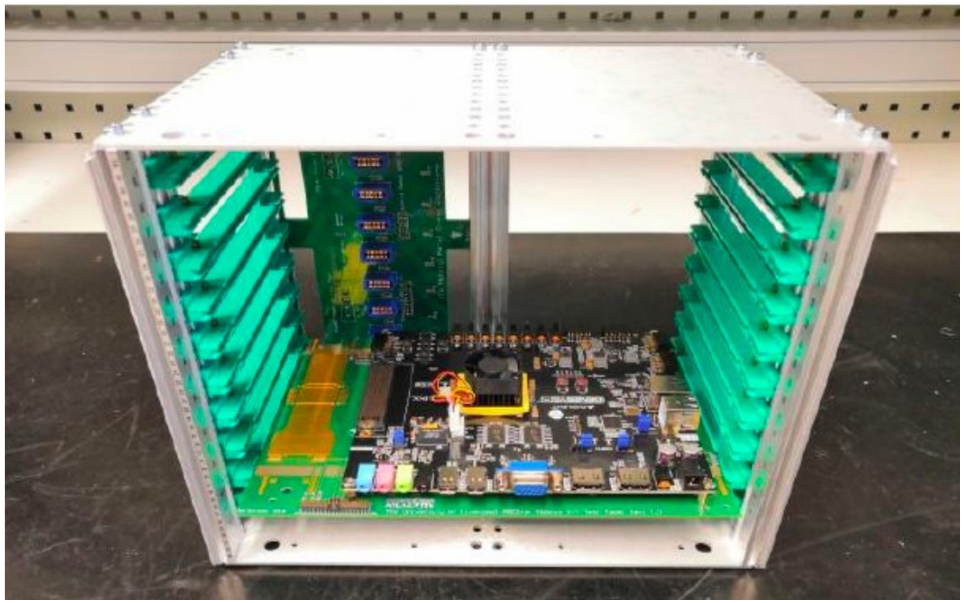
- First double sided stave
- Check: powering, fibre optics, DAQ systems, cooling, mechanical supports, interlocks and control

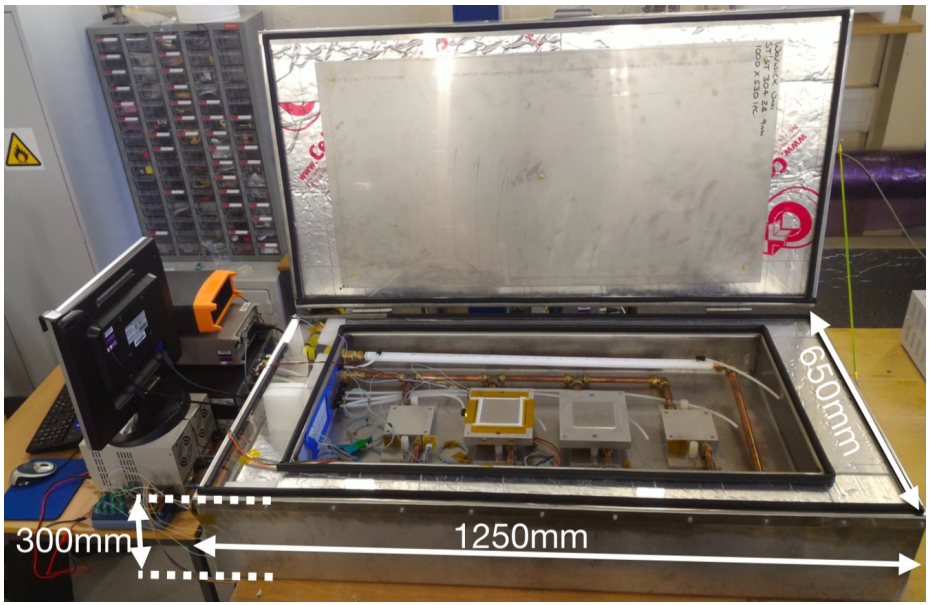
Module QC

QC for modules

- Hybrid crate for 100 hour burn-in (now operating here)
- Module test box for thermal cycling of modules (operating at UofT)
- Pre-production almost finished in hand and being tested
- Production readiness review in July 2023 ➔ start of production







Project organisation

- Complex production model with 51 institutes worldwide building & testing detector parts Need
- to closely keep track of procedures and scheduling
- Exercising about 75% of this parts flow in pre-production

  Remaining sites will come online through end of 2023.
- Celestica/UofT ready to start production when parts released (after final review)
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