First Double-Sided End-Cap Strip Module for the ATLAS High-Luminosity Upgrade

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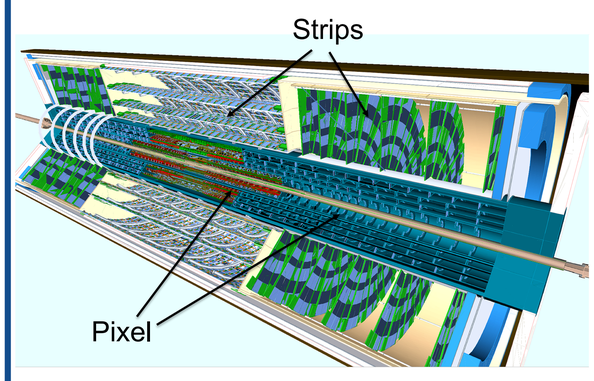
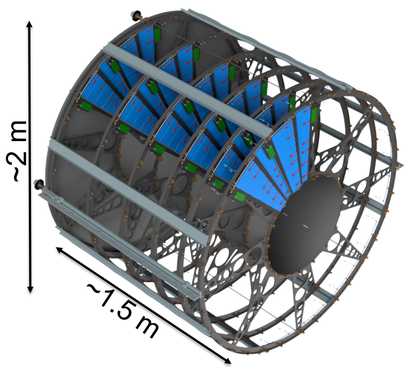
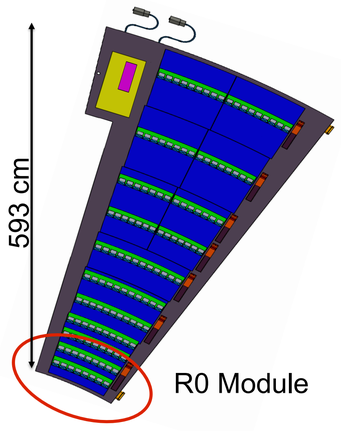
The ATLAS Inner Tracker Upgrade



Inner Tracker Layout: barrel and end-cap, showing pixel and strip systems



End-cap layout: 6 discs with 32 petals each, in global support structure



Petal with 9 sensors

New all silicon Inner Tracker planned for 2026:
- Highly integrated design concept:
- 5 barrel pixel layers
- Up to 11 half-rings in pixel end-caps
- 4 strip barrel layers
- 6 strip end-cap discs on each side
- About 70 million readout channels
- Strip modules arranged in large support structures with integrated cooling and services, called petals for end-cap
- Each petal equipped with 9 radial symmetric sensors on either side
- Arranged in 6 rings (R0-R5), innermost ring R0 module

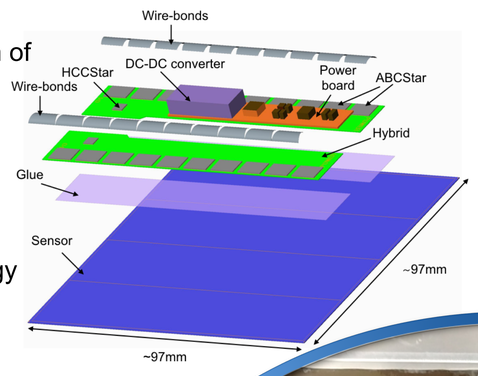
R0 Module Concept

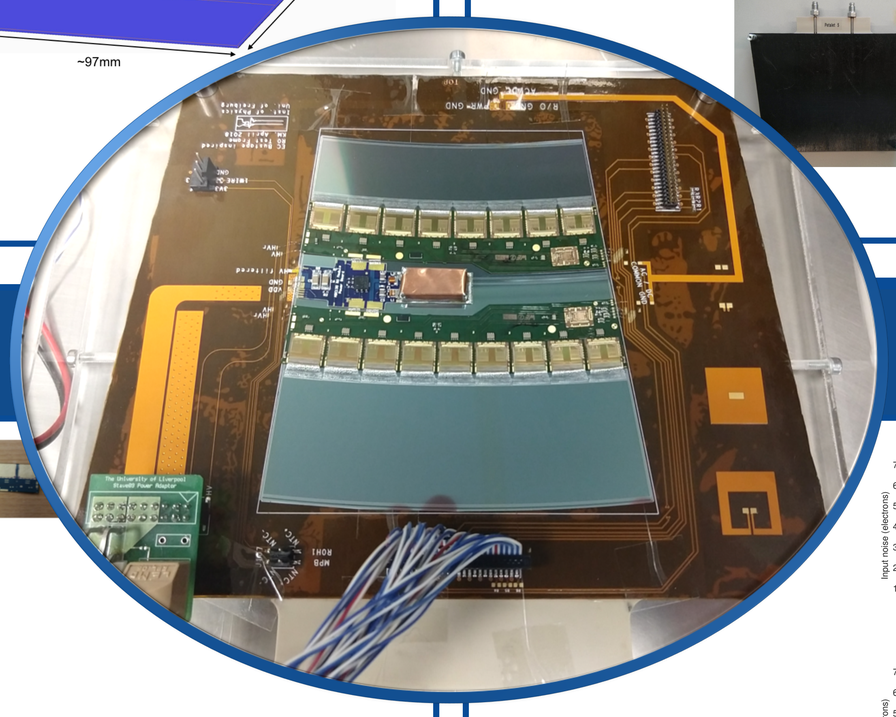
R0 silicon strip sensor:
- Wedge shaped, n-type silicon
- Azimuthal orientation with a small stereo rotation of the strips (20 mrad)
- Four rows of strips (4352 active strips)

Two polyimide flex hybrids:
- 4 –layers of flex
- Equipped with front end-ASICS
- ATLAS Binary Chips in 130 nm CMOS technology
- Hybrid Controller Chip (HCC)

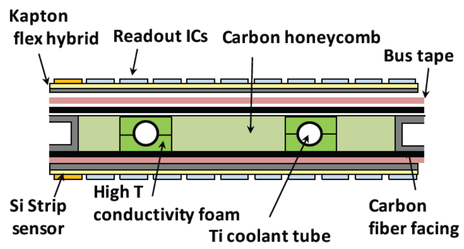
- **One power board:**
- Use DC-DC conversion

- Wire-bonds from sensor to readout ASIC using four row bonding





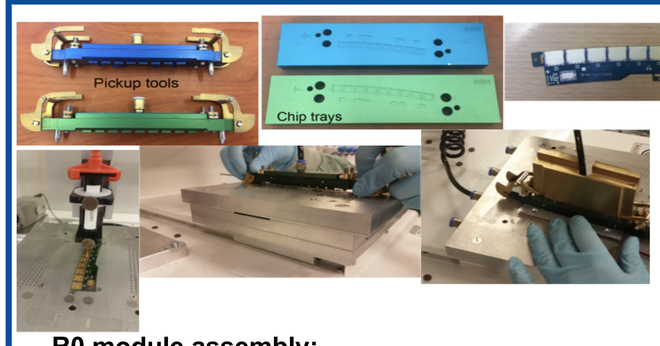
Petalet Core and Bus Tape



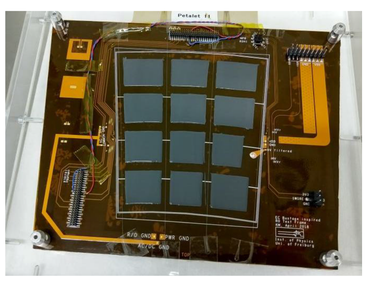
Petalet Core:
- Small scale prototype petal
- Height including bus-tape 5.4 mm, weight 77g
- Made of carbon foam and carbon honeycomb material
- Embedded titanium cooling pipes for CO_2
- Good heat transfer
- Sandwich construction provides high structural rigidity at low mass
- Silicon modules directly bonded to cooled carbon fibre substrate

Bus tape:
- Specially designed R0 bus tape made in flex
- Services integrated into substrate including power, control and data transmission
- Readout of active modules

Double-Sided Module Assembly

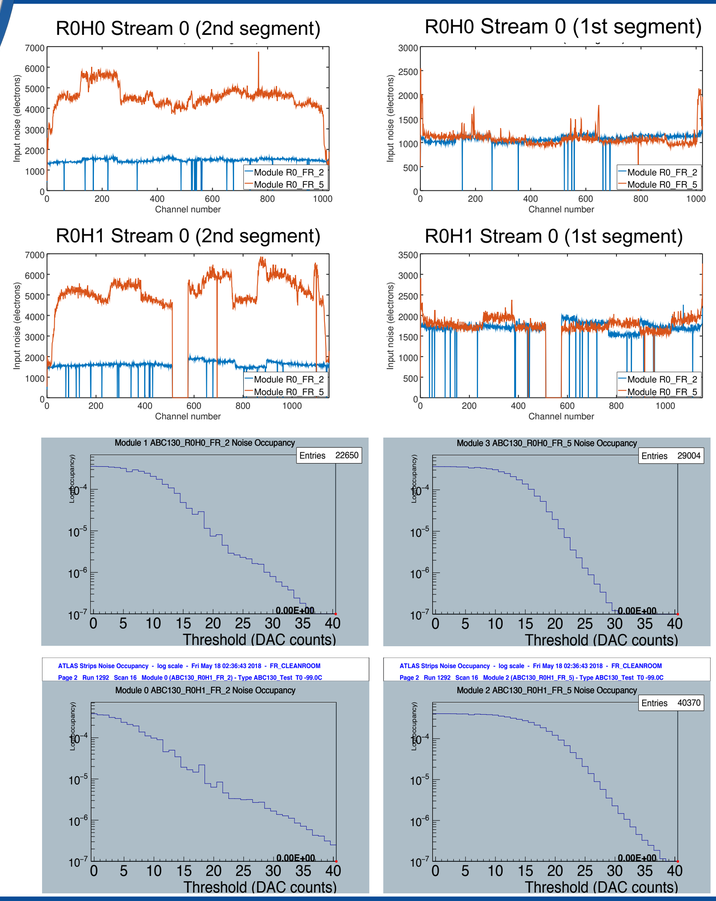


R0 module assembly:
- Hybrid assembly using custom built precision tools
  - ASIC glued with robot using UV glue
  - Wire bonding and testing of hybrids
- Hybrid glued directly on R0 sensor surface using epoxy based glue with 12 hrs curing time
- Gluing and wirebonding of DC-DC power board
- Electrical testing of each individual module



Support structure assembly:
- Epoxy glue for bus tape to petalet core attachment
- Silicon based glue for module-to-core gluing providing good heat transfer

Initial Electrical Tests of DS-Module



Electrical evaluation of combined module:
- Simultaneous -readout of both sides (FR_2 and FR_5)
- Determine equivalent noise charge and noise occupancy
- Excessive noise in stream 0 of FR_2, attributed to sensor breakdown, mostly recovered.
- Noise occupancy shows good performance for FR_5 sensor and reasonable results for FR_2
- Evaluated response curve

Outlook and Conclusion

- First double sided end-cap module successfully built and tested
- Assembly procedure well understood
- Simultaneous readout of both sides
- Generally expected electrical performance
- Slight noise increase observed on one side, attributed to sensor breakdown issues
- Further characterisation of the module in beam test

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