The ATLAS ITk Strip Detector for the Phase-II LHC Upgrade

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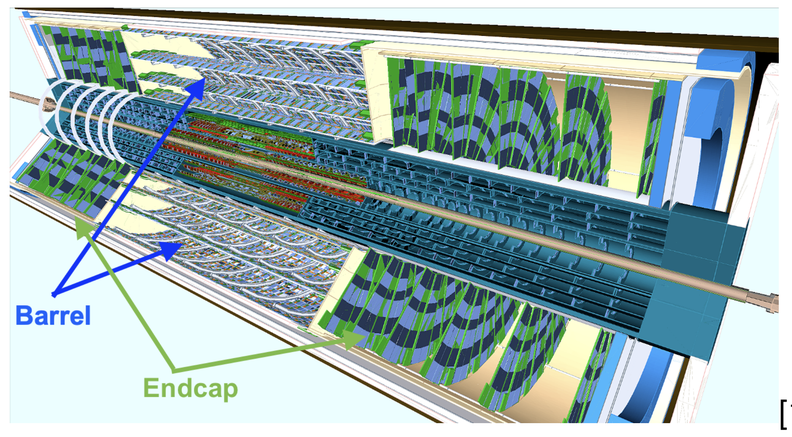
ATLAS ITk

Bundesministerium für Bildung und Forschung

ATLAS ITk strips Phase-II upgrade

- The current inner detector of the ATLAS experiment has been designed to function in the environment of the Large Hadron Collider (LHC)
- The next upgrade of the LHC will result in 200 proton-proton interactions per bunch crossing, a 10x increase of instantaneous luminosity
- For the ATLAS Phase-II Upgrade the inner tracker of the ATLAS detector was redesigned and will be rebuild completely.
- The new detectors must be faster and highly segmented, radiation resistant and they will require much greater power
- The ATLAS Upgrade Inner Tracker (ITk) consist of several layers of silicon pixel and strip detectors
- Microstrip sensors are distributed in two parts
  1. Barrel: central part of the detector
  2. End-caps: covering the forward regions of the strip tracker, they consist of six disks per side
- The strip detector will be cooled at $-35\,^{\circ}\mathrm{C}$ with a biphase CO_2 flow



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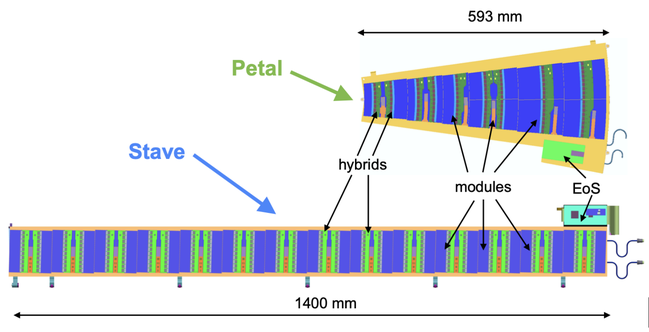
Barrel

- The Barrel consists of 4 layers of staves
  - each stave containing 14 modules each side arranged in a cylindrical shape that encloses the beam
- All modules have a rectangular shape
- The strips sensors have two strip lengths:
  1. $\sim 2.5\,\mathrm{cm} \rightarrow$ SS (short strip)
  2. $\sim 5\,\mathrm{cm} \rightarrow$ LS (long strip)



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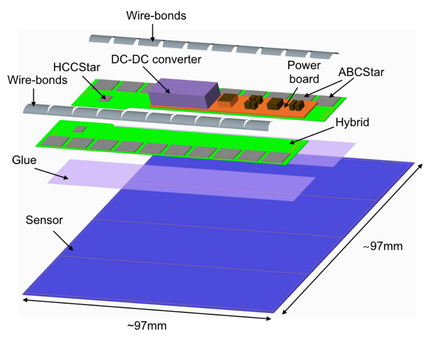
Endcap

- The Endcap consists of 6 discs per forward region, so a total of 12 discs
- Each disc contains 32 petals, a wedge shaped support structure
- Each petal holds 6 modules (3 single modules and 3 split modules) to cover a radial area
- 6 different sensors shapes for the 6 different modules

Module assembly

- The module is the structure that has the strip sensor and its electronics:
  - power board glued to the strip sensor
  - hybrid that has the the ATLAS binary chips (ABC) for the readout electronics glued on the strip sensor
- The ABC chips, once glued, need to be wire bonded to the strips individually
- Modules have to be assembled with the required glue thickness and position
- A bonded tab (HV-tab) to connect the backplane of the sensor is bonded



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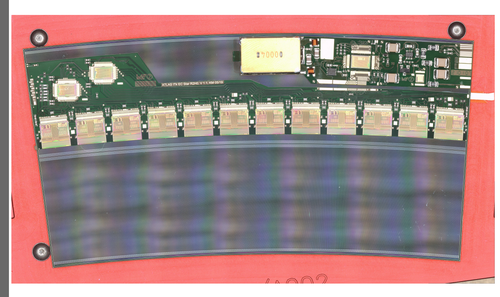
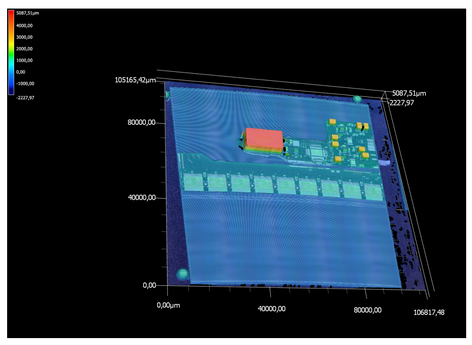


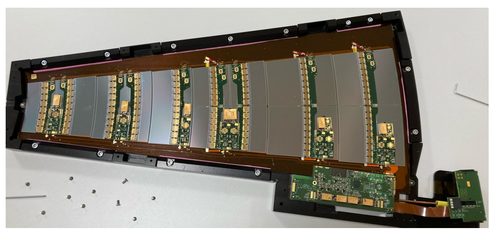
- Glue vendor discontinued the glue chosen for production and the second glue candidate is being used for module assembly
- A 3rd glue is being tested as a possible candidate
- Currently barrel modules are starting production and endcap modules are ready for production

QC/QA for modules

- Tests for module quality assurance include:
  - Precise weighing (the amount of glue)
  - Metrology (position and height of all components)
  - Visual inspection
  - Current voltage characterization
  - Electrical tests (room temperature and at $-35\,^{\circ}\mathrm{C}$)



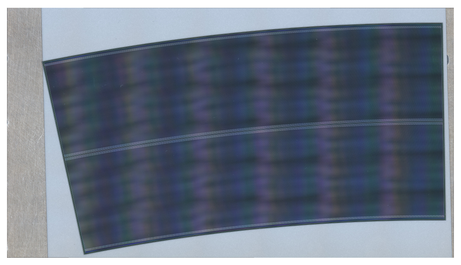
Module loading and system test



- First staves and petals are being populated with the built modules, and tested to check the performance
- Barrel system test was successful
- First petals are being loaded for system test $\rightarrow$ Endcap system test to be done soon

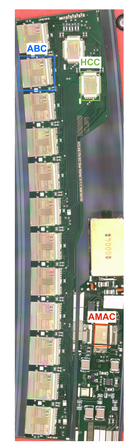
Sensor production

- Despite initial delay, sensors are being produced by the foundry according to schedule
- Production of the sensors has almost reached 50%
- Strip isolation reduced due to high electrostatic charge on surface of the sensors
  $\rightarrow$ Mitigation strategies:
  - ionizing blower
  - UV light exposure

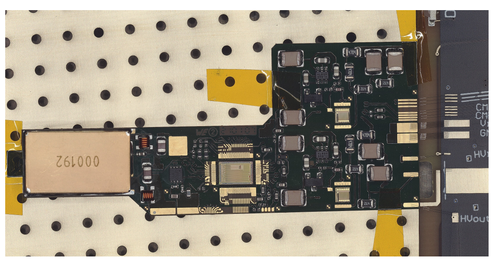


ASICs for modules

- ASICs are fully in production of the final versions:
  - AMACStar (Autonomous Monitor and Control chip)
  - HCCStar (Hybrid Control Chip)
  - ABCStar (ATLAS Binary Chip)
- ASICs production flow[2]:
  Manufacture $\rightarrow$ Probe $\rightarrow$ Dice $\rightarrow$ Pre-irradiate $\rightarrow$ Distribute
- Hit loss due to issue writing to SRAM:
  - Mitigation strategy: invert clock polarity
  - Cross input wirebonds to hybrid control chip (HCC)
- Finalization of contract with new pre-irradiation vendor



Power board



- Power board final design:
  - Barrel final design mitigates cold noise (noise observed during thermal cycles)
  - Endcap final design reduces noise
- Currently final design is finished and they are being produced

Conclusions

- Sensor production is reaching 50 %
- ASICs are in final version production and final designs of the power board being approved
- ITk strip module production is ready to start for barrel and soon for endcap
- System test for the barrel finished successfully and endcap system test is on a finalizing stage

Acknowledgements

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References

[1] Technical Design Report for the ATLAS Inner Tracker Strip Detector, CERN-LHCC-2017-005 , ATLAS-TDR-025, 2017

[2] J. John John, P. Keener, ASICs Update, ATLAS Upgrade Week 2023

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