Test Beam Studies of Barrel and End-Cap Modules for the ATLAS ITk Strip Detector before and after Irradiation

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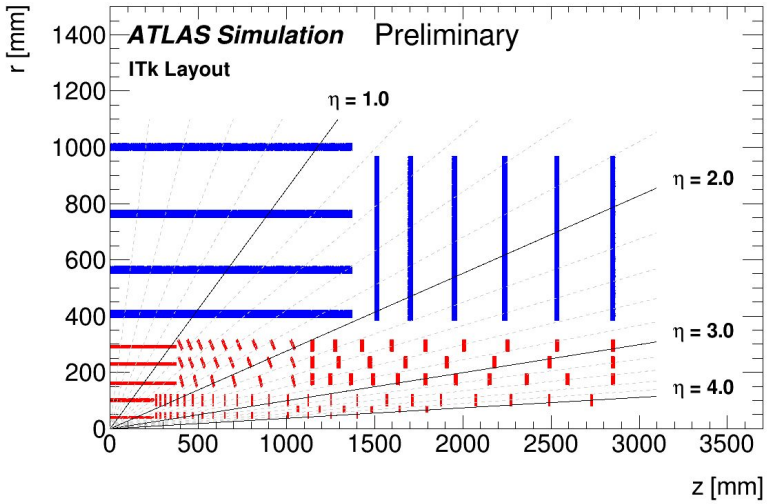
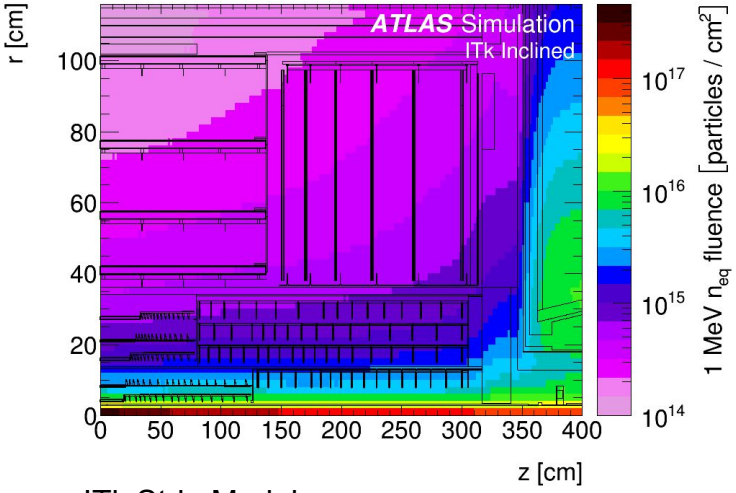
On behalf of the ATLAS ITk Strip Community

ATLAS Upgrade

- HL-LHC: ~ 4000 fb^{-1}
  - Requires increased radiation hardness
- Pile-up from ~50 to ~200
  - Requires increased granularity

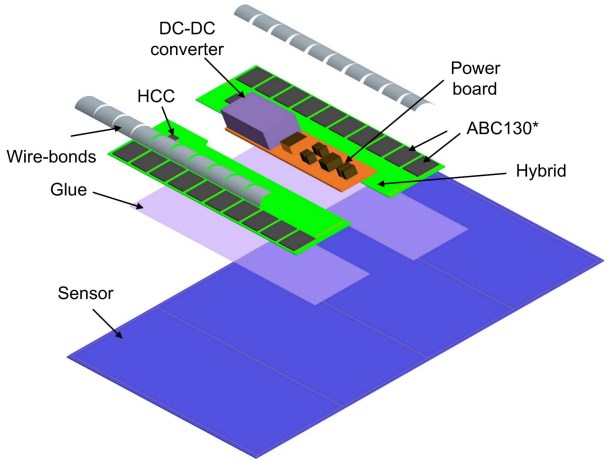
New tracker for the HL-LHC has to maintain the performance of the present Inner Detector under more difficult conditions **New all-silicon Inner Tracker (ITk)**

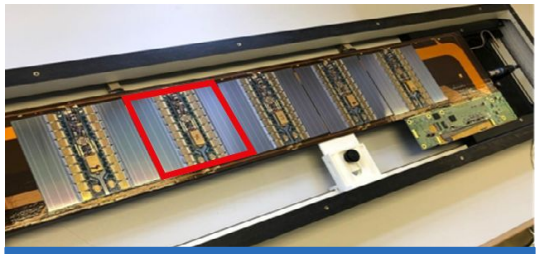




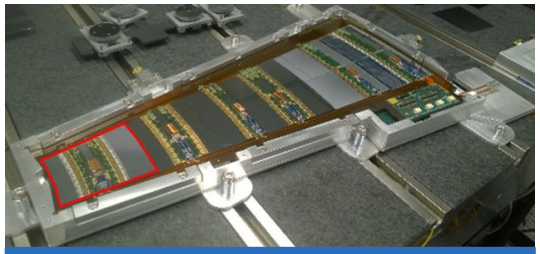
ITk Strip Module:

- One planar Si n^+-in-p sensor
- Low mass PCBs (hybrids)
- Power board with DC-DC conversion
- ABCStar and HCCStar as readout chips





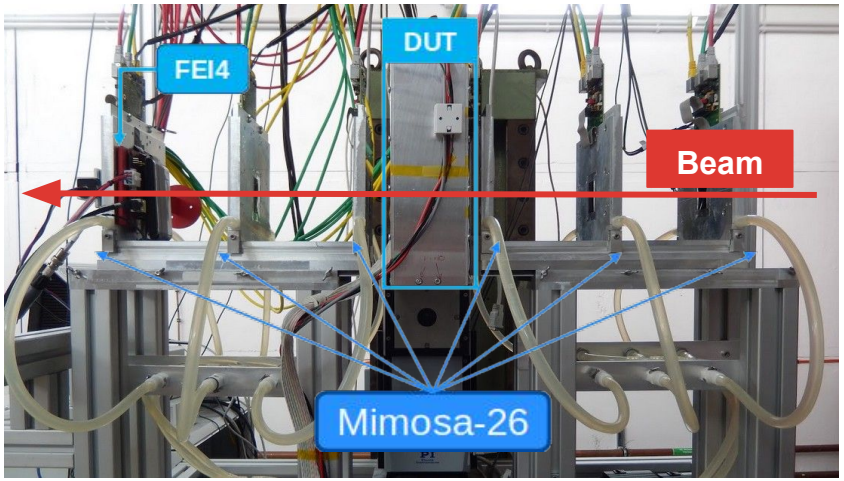
Barrel stave with rectangular sensors

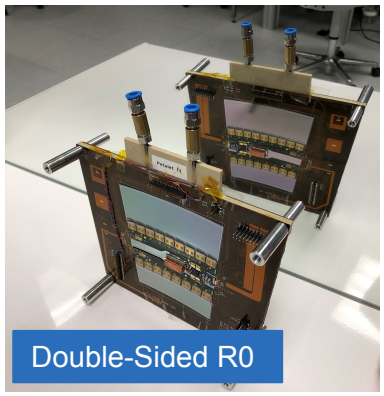


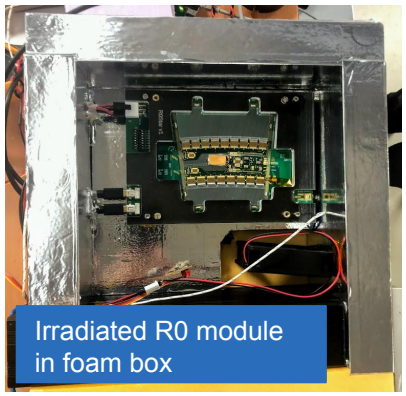
Endcap petal with annular sensors

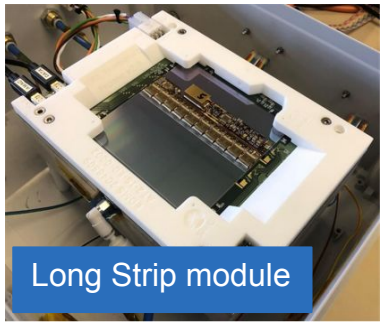
Test Beam

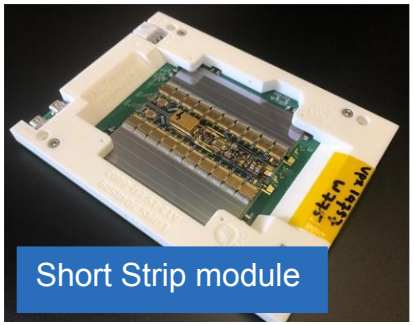
- Five test beam campaigns since 2018; two for irradiated modules
- 4 - 5.8 GeV electron beam @DESY
- 120 GeV pion beam @CERN SPS
- EUDET beam telescope
- Time tag of tracks from telescope with USBPix system with FE-I4 chip.
- Dry ice foam cooling box @DESY and MPI cooling box @CERN used for irradiated modules




Double-Sided R0


Irradiated R0 module in foam box


Long Strip module


Short Strip module

Double-sided R0 module (innermost Endcap nodule):

- **Carbon honeycomb core including services**
- **Two fully populated R0 modules are positioned by hand on each side of the core**
  - **Stereo angle of 31 mrad (target 40 mrad)**
- **Using unirradiated sensors**

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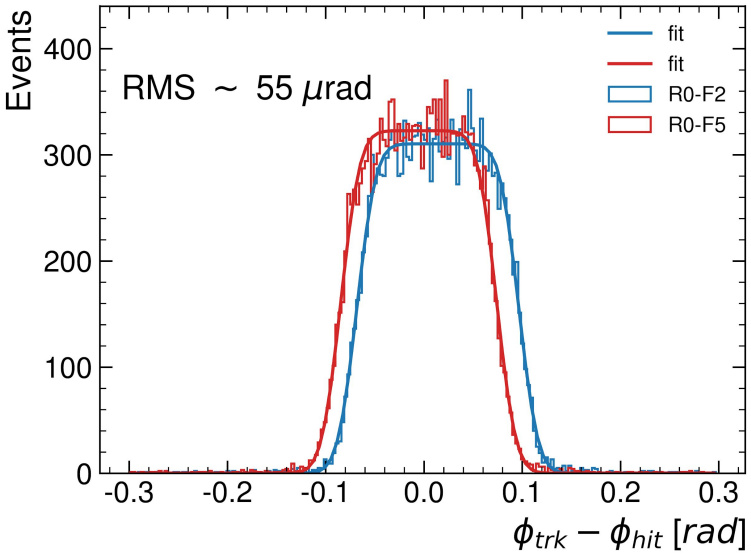
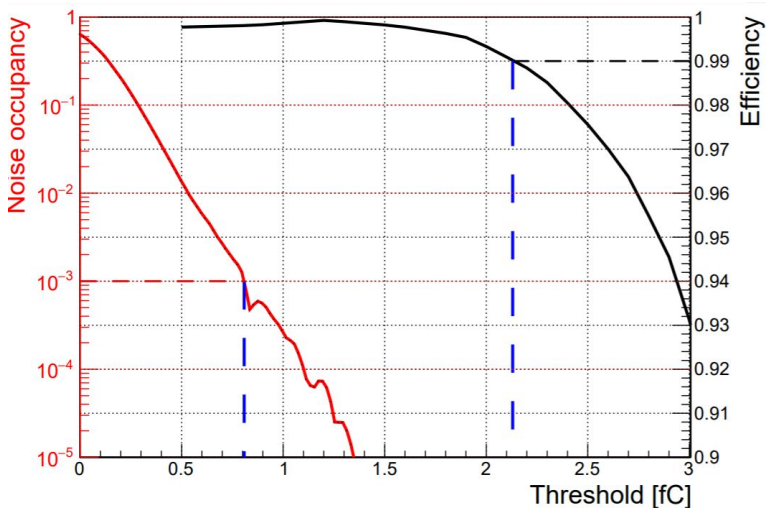
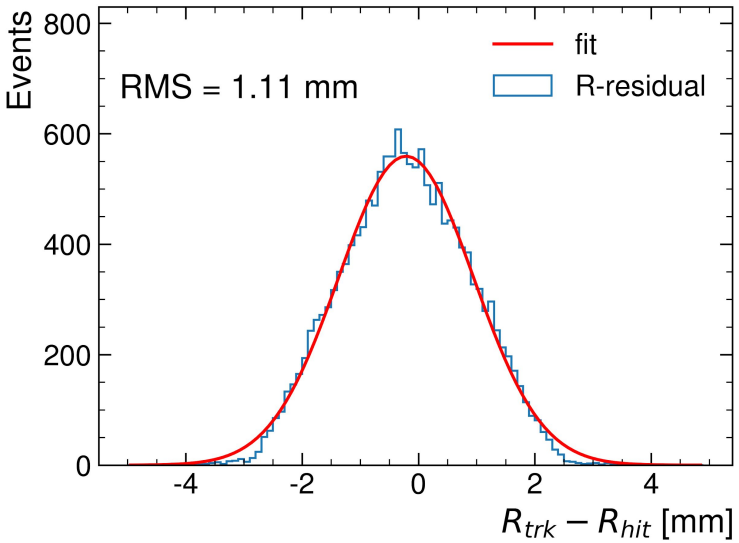
Efficiency and tracking resolution for Double-Sided R0

Resolution transversal to strips





Resolution along strips



- Tracking resolutions along the strips and transversal to them agree with expectation
- ITk requirements:
  - Signal higher than 99 %
  - Noise occupancy smaller than 0.1 %
  - Equivalent S/N > 10
  - Easily satisfied for a large range of thresholds for unirradiated modules
- Unirradiated R0 module S/N = 29.3
- Unirradiated Long Strip module S/N = 23.8
- Irradiated R0 module @ 500 V S/N = 14.8
- Irradiated Long Strip module @ 500 V S/N = 15.9

More details can be found:

➢ ATLAS ITk Strip TDR, HSTD12, INSTR20