# ITk Detector Overview

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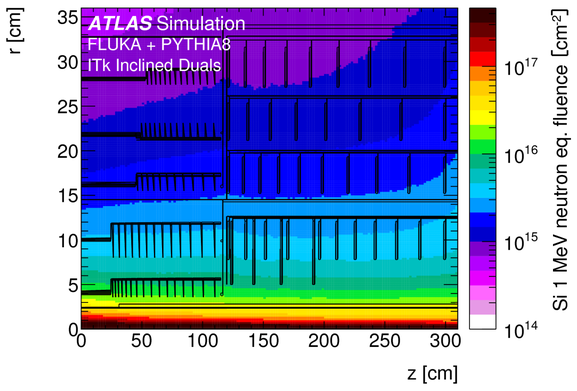
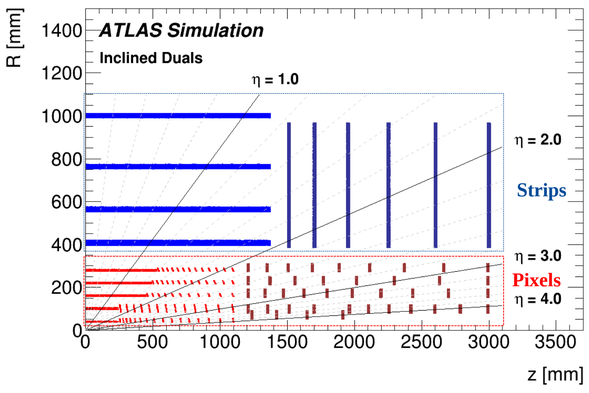
on behalf of the ATLAS ITk Collaboration

## ATLAS Inner Tracker for HL-LHC (ITk)

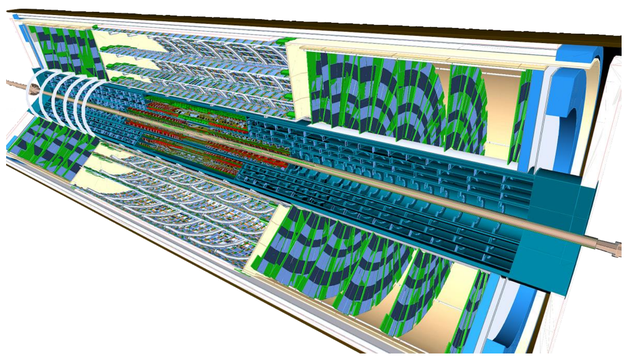
At the **HL-LHC** the **ITk** detector will face:

- **Radiation Damage**
  - HL-LHC should deliver ~ 4000 $fb^{-1}$ (current inner detector for IBL ~ 850 $fb^{-1}$)
  - New sensor design requires **increased radiation hardness**
- **Pileup** ~ 200
  - Keep current inner detector occupancy **granularity increased by ~10x**




- All silicon design
- Higher granularity
- Minimum material
- η coverage increased to 4 (currently ~ 2.5)
- $CO_2$ cooling



### ITk Pixel Detector:

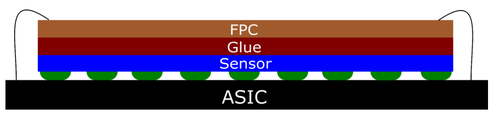
- 5 barrel layers: short barrel + inclined modules ($|\eta| < 1.4$) + endcap rings ($|\eta| < 4$)

### ITk Strip Detector:

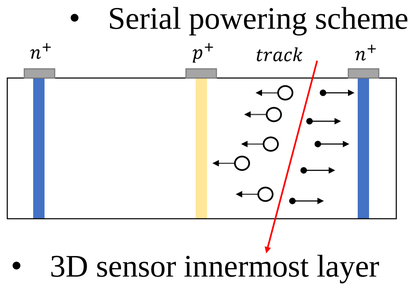
- 4 barrel layers + 2x6 endcap wheels ($|\eta| < 2.7$)

## ITk Pixel Detector

- Pixel Module development:
  - Si n-in-p technology, small pixel size
  - FE chip: Gbps readout capability
  - Flip-chip using bump bonding
  - Serial powering scheme



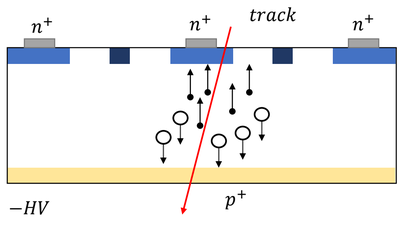

- Sequence development on going:
  - Attachment, wire bonding, encapsulation




- 3D sensor innermost layer

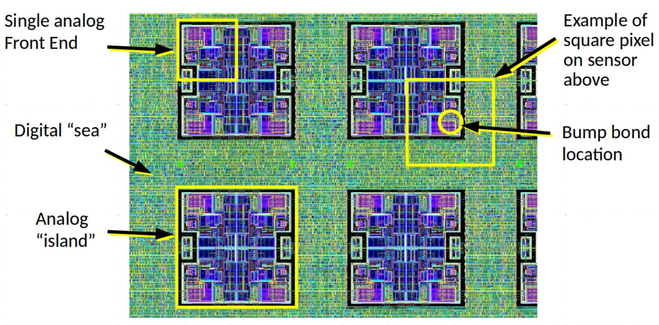
Pixel size: 50×50 $\mu m^2$ or 25 × 100 $\mu m^2$

Considering CMOS for outermost layer




- Planar n-in-p type other layers
- Thinned to ~150µm

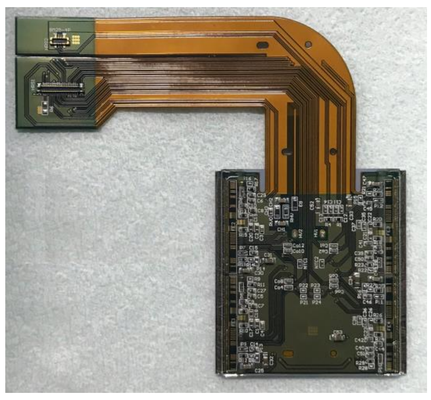
### ASIC rad hard 65nm CMOS: Joint ATLAS & CMS project within RD53 collaboration



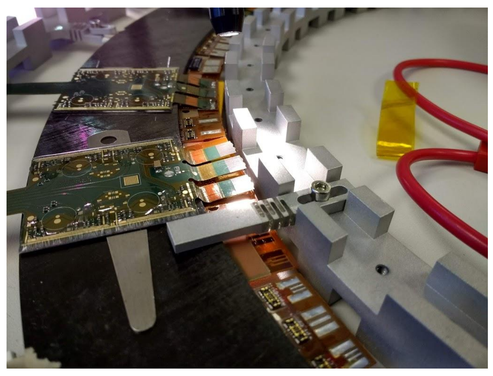

- Data rate ~1.28 Gbps
- Noise rate ($<10^{-6}$, 600 $e^-$)
- RD53A first prototype of the final readout ASIC

http://rd53.web.cern.ch/rd53/

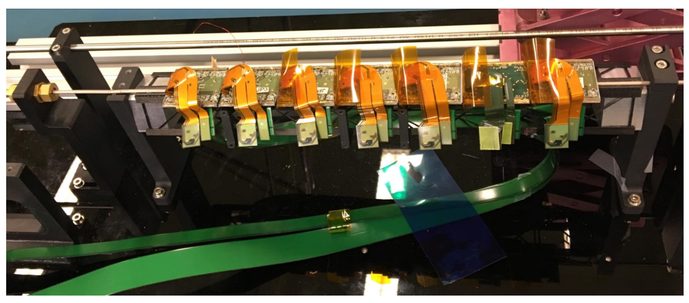

Quad module for outer endcaps



Quad barrel module



Loading tests with modules on Endcap ring local support



7 loaded FE-I4 quad modules on outer barrel stave prototype

## ITk Strip Detector

### ITk Strip Module:

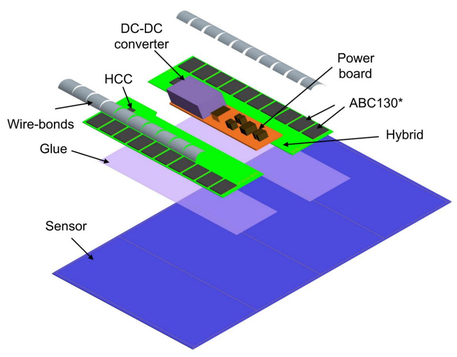
- One sensor
  - Planar Si n-in-p
- Low mass PCBs (hybrids)
- Power board with DC-DC
- ASICs ABC 130 nm CMOS

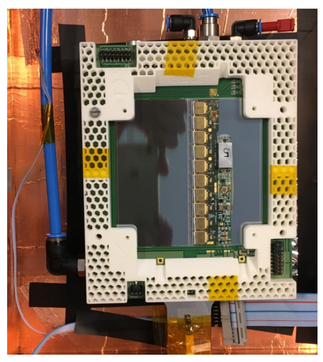
### Barrel Module:

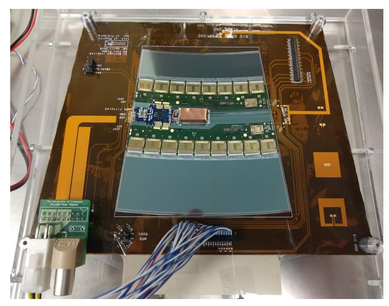
- Rectangular geometry
  - Strip length 2.4 – 4.8 cm
  - Pitch 75.5 µm
  - Stereo angle 52 mrad
- 2 different modules

### Endcap Module:

- Radial geometry
  - Strip length 1.9 – 6 cm
  - Pitch 69.9 – 80.7 µm
  - Stereo angle 40 mrad
- 6 different modules

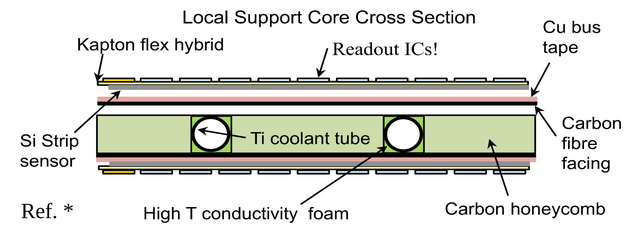


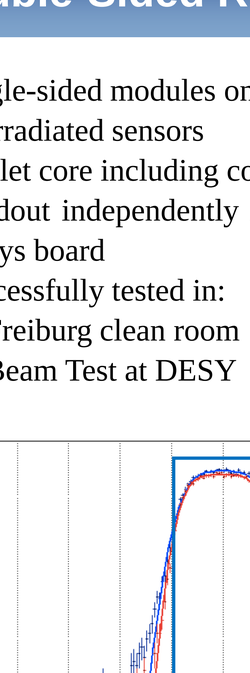





### Local Support:

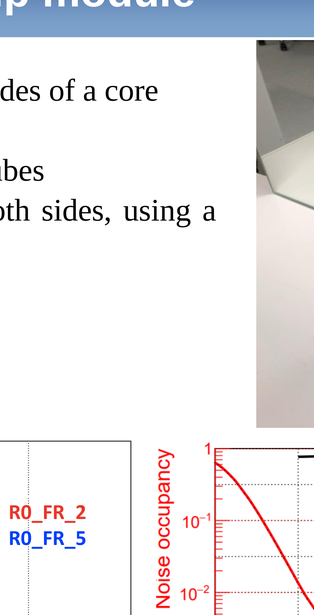
- Mechanical stability requirement: Barrel and endcap z, R ( 20 µm ), φ (2µm)
- Titanium cooling pipes
- Electrical services



Barrel staves

Basic building units



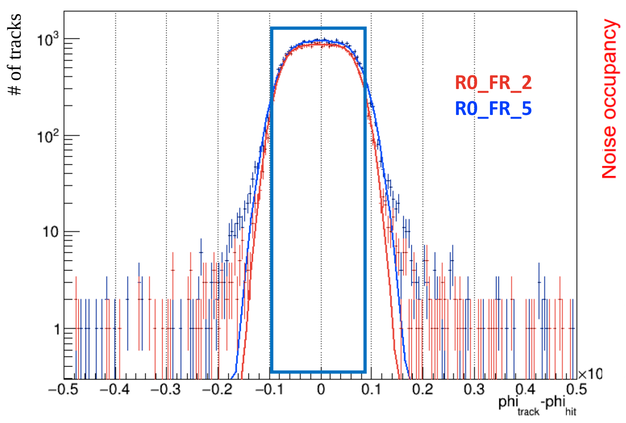

Endcap petals

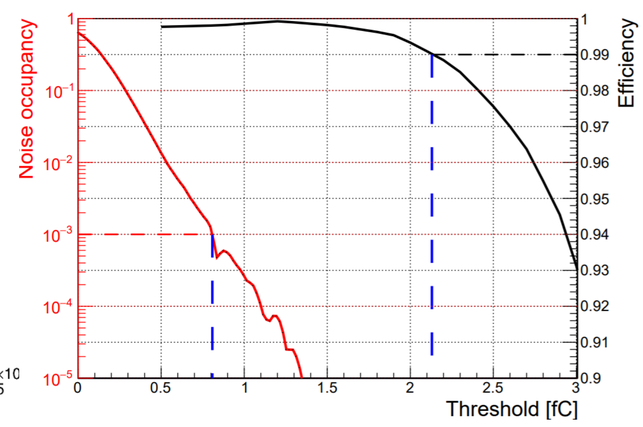
## Double-Sided R0 strip module

- Single-sided modules on both sides of a core
- Unirradiated sensors
- Petalet core including coolant tubes
- Readout independently from both sides, using a Nexys board
- Successfully tested in:
  - Freiburg clean room
  - Beam Test at DESY



DS R0 module facing a mirror




Residual distributions of hits with respect to tracks for either side of the double-side with blue box indicating strip pitch (left). Noise occupancy and efficiency as a function of applied threshold in fC (right). Defining operation requirements as efficiency > 99% and noise occupancy < $10^{-3}$. The module can be operated using a threshold between 0.8 – 2.1 fC

References: **Technical Design Report for the ATLAS Inner Tracker Strip Detector (CERN-LHCC-2017-005)**
**Technical Design Report for the ATLAS Inner Tracker Pixel Detector (CERN-LHCC-2017-021)**

***A double-sided, shield-less stave prototype for the ATLAS Upgrade strip tracker for the High Luminosity LHC (https://cds.cern.ch/record/2003050)**