Towards the construction of the ATLAS ITk Pixel innermost layer

Simone Ravera – INFN & University of Genova
simone.ravera@cern.ch

1. The ATLAS ITk Pixel Inner System

The ITk Pixel Inner System made by
- Layer 0 - 34 mm from IP
- Layer 1 – 99 mm from IP

Hybrid Pixel Modules
- **Pixel Sensors**
- Sensors **3D-technology in Layer-0**
- Planar pixel sensors in all Layer-1
- **Readout Electronics**
- ITkPix chip in 65 nm technology

Carbon fiber supports
- Staves in the Barrel layers
- Couple Rings / Rings in the End-Caps

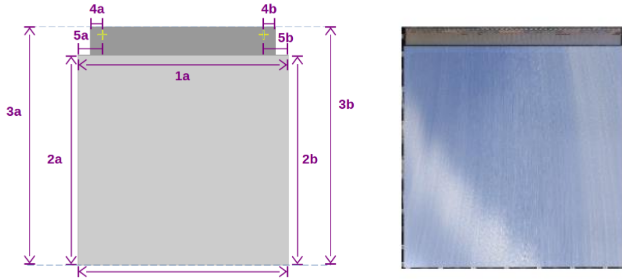
Design	Staves /Rings	Modules needed	Assembly sites
Barrel L0	12	96	Barcellona
End-Caps R0	30	180	Norway
End-Caps R0.5	12	120	Genova/Milano

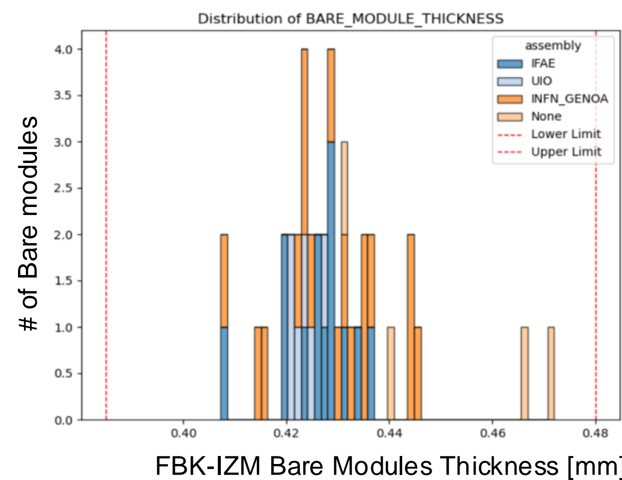
2. Layer-0 Bare Modules

Layer-0 bare modules in **single tiles ~2x2 cm²**
Pixel 3D sensors are produced by
- *Fondazione Bruno Kesler* (**FBK, Italy)**
- *Stiftelsen for industriell og teknisk forskning* (**Sintef, Norway**)

Hybridisation so far
- ***Leonardo SPA***, Italy
- *Fraunhofer Institute for Reliability and Microintegration* (**IZM**), Germany

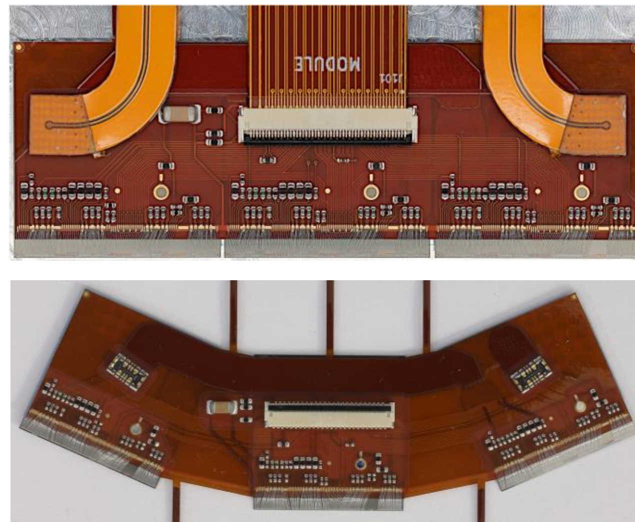
Bare modules dimensions are checked before the hybridisation, since space constrains are particularly critical, especially in Layer-0 (Barrel)





3. The Triplet Modules

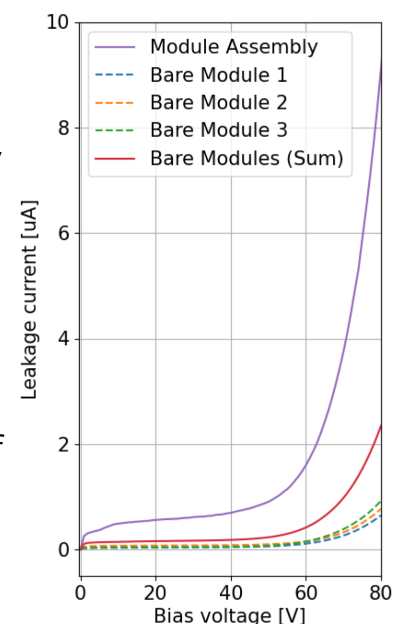
In a Triplet module the single bare modules are glued togheter with a common flexible PCB to distribute the power and for data transmission



4. IV curve

IV curves are measured at sensor-wafer level, after dicing and hybridization and after module assembly

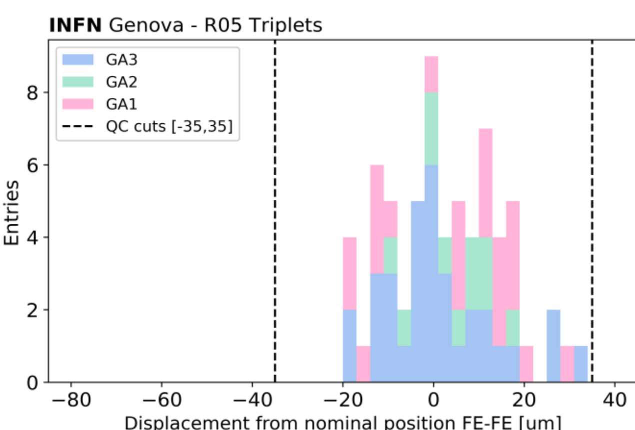
For good modules, the increase of the leakage current after hybridization and module assembly is within specs, however we are observing about 15% of sensors with early breakdown voltage after hybridization for FBK sensors

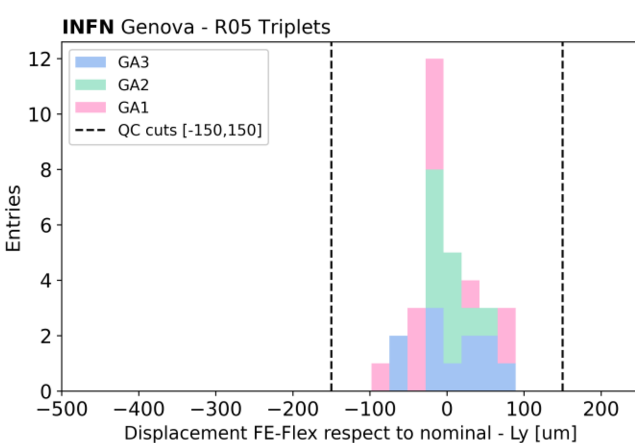


5. Triplet modules assembly

The assembly sites use to two types of approach for the module assembly (flip-chip machine, "bridges", pick&place)

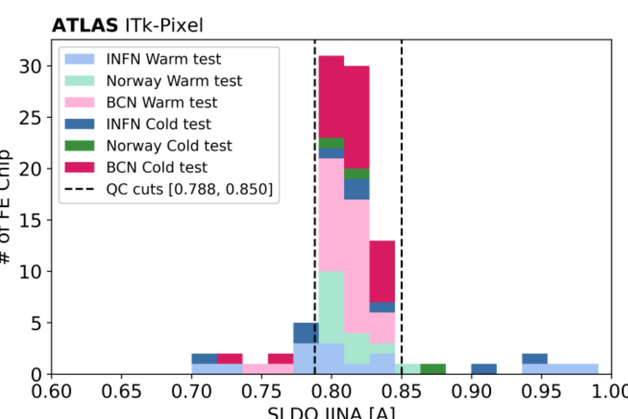
Metrology of the assembled modules is measured by **checking the relative position of Fiducial Markers** carved into the Front-Ends and in the Flex PCB

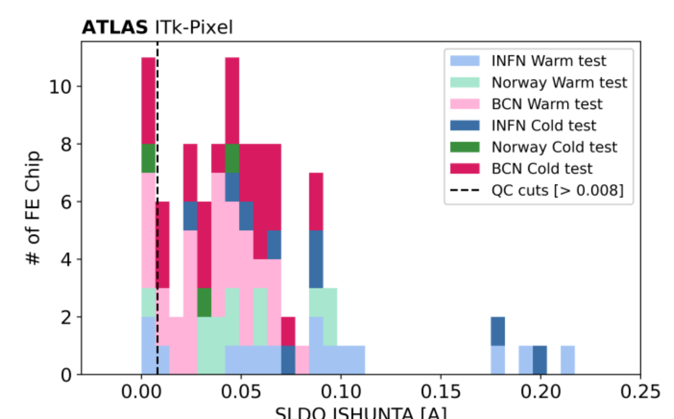




6. Electrical testing – Shunt LDO powering

During modules QC we need to determine that the module will work well in an SP chain, without actually running it in an SP chain.
Each of the chips must have enough current to supply its internal circuits with regulated voltages, which means the shunt current cannot be zero (Undershunt condition)

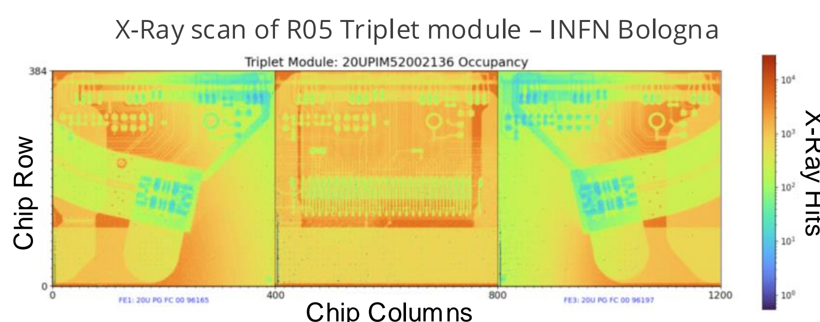




7. Bump-bonding quality

After module assembly is important to check the quality of the **bump-bonding**. Three strategies are used
- **Noise** of the electronics (via threshold scan)
- Measure the **crosstalk** threshold
- **X-ray scan**

X-Ray scan of R05 Triplet module – INFN Bologna



8. Delamination studies

Linear and Ring modules loaded on fake carbon fiber supports to mimic staves and rings
Modules will undergo about 1000 Thermal Cycles (TC) to study any possibile delamination of the bumps
So far, after 800 TC, there is no sign of bumps delamination.

L0 & R05 Triplet loaded on carbon fibre at SLAC

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Università di Genova
INFN GENOVA
ATLAS EXPERIMENT