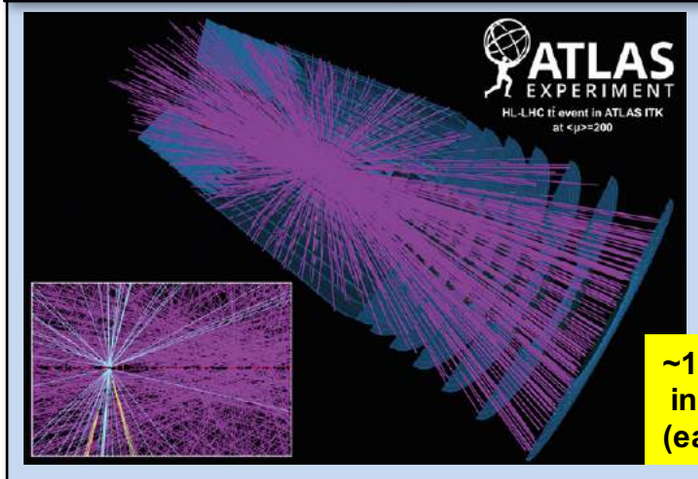
Setup of data acquisition for the construction of the pixel endcap of the new Inner Tracker (ITk) of ATLAS at HL-LHC

The High Luminosity-Large Hadron Collider (HL-LHC) is expected to start in 2026 and to provide an integrated luminosity of 3000 fb^{-1} in ten years, a factor 10 more than what will be collected by 2023. This high statistics will allow ATLAS to perform precise measurements in the Higgs sector and improve searches for new physics at the TeV scale. The instantaneous luminosity needed is L ~7.5×10^{34} cm^{-2} s^{-1}, corresponding to ~200 additional proton-proton pile-up interactions. To face such harsh environment the current inner detector will be replaced with a new full-silicon Inner Tracker (ITk).
Eight ATLAS italian groups are involved in the construction of one pixel endcap with a rich program and LNF is in charge of the final assembly and in the final system tests. In view of the production phase starting in 2019, a setup of the data acquisition to read the pixel modules is needed. We propose a thesis aimed at the setup of a data acquisition system for a pixel modules. The student will have the opportunity to deal with the cutting edge pixel technology and gain experience for a long-term project. He/she will be supervised by an ATLAS experimental physicists in collaboration with the ITk Bologna group.

Why a new ITk for HL-LHC?



The harsh environment at HL-LHC demands stringent requirements to the inner tracker to maintain high reconstruction performance.

~12000 tracks in the tracker acceptance (each 25 nsec)

LHC (current-2023) vs HL-LHC 2026-2036

Instantaneous Luminosity: 1×10^{34} → **7.5×10^{34} $cm^{-2}s^{-1}$**

pp interactions per crossing: 23-60 → **200**

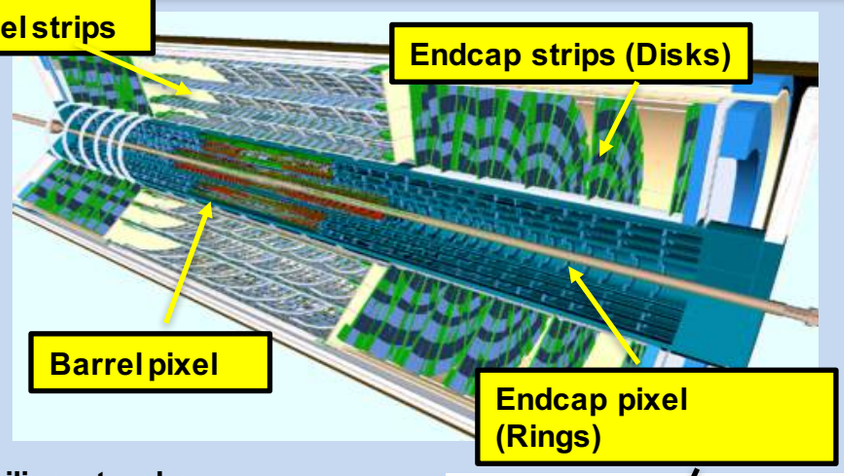
Integrated Luminosity: 300 fb^{-1} → **4000 fb^{-1}**

Higher Occupancy → **Finer segmentation**
- more and smaller channels
- All silicon inner tracker with strips and pixels

Higher Data rate → **Faster readout & more storage**
- Upgraded readout (ASICs & Detector)
- Track Trigger

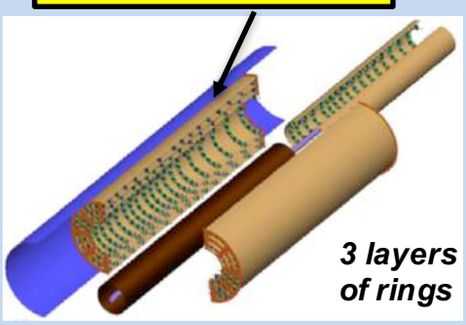
Radiation damage → **Increase radiation hardness**: new sensors & front-end

ITk Layout



All-silicon tracker.
- Pixel/Strip Barrel layers
- Endcap: Pixel rings / Strip disks
- Dimension: R~1m, L~7m

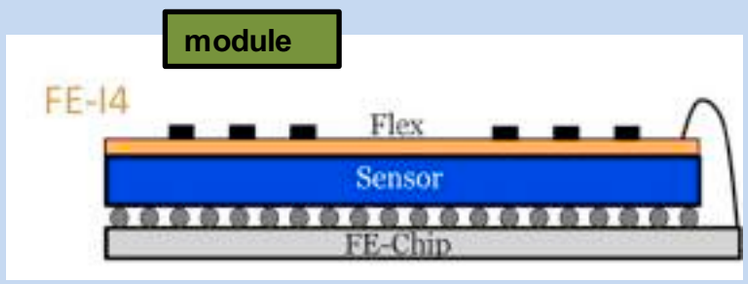
Pixel system:
- Active area: 12.7 m^2
- Pixel size: 50x50 (or 25x100) μm^2
- # of modules: 10276
- # of FE chips: 33184
- # of channels: ~5×10^9



- ITk Construction 2019-2023
- ***Italy is in charge of the construction of one pixel endcap***

Sensors, Front-End & Modules

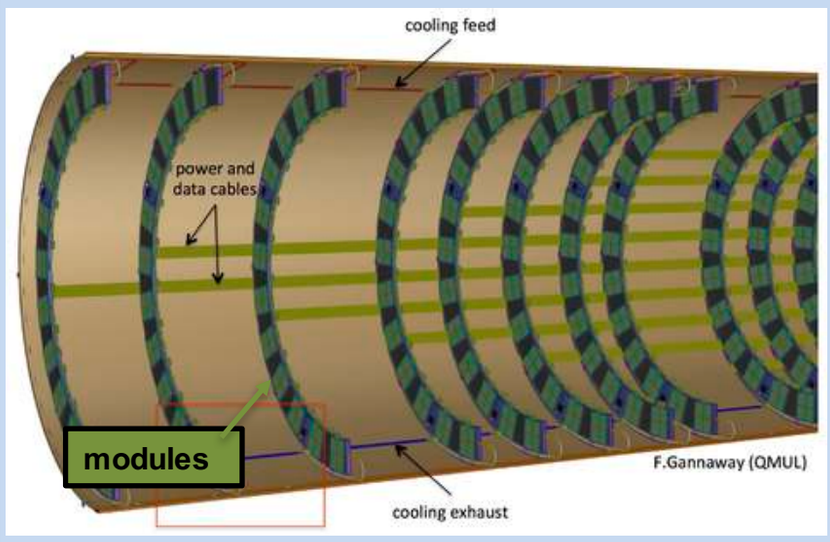
- **Planar Sensors for endcap**: Reduced thickness 100-150μm (currently 200um): →high charge collection efficiency after irradiation
- **Font-End chip:** 65nm technology for better radiation hardness
- Sensors and FE chip are joined using a high density connection technique (bump-bonding)
- **Module** (basic building block, replicated many times to cover the detector surface) requires dressing with flex circuits for I/O



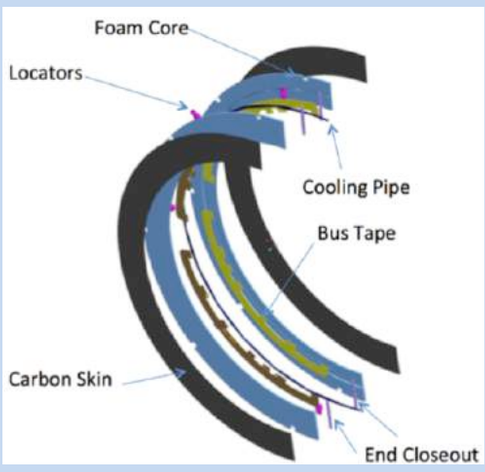
ITk Outer Endcap assembly at LNF

LNF is the integration site for the assembly of one endcap pixel.

Assembly:
- Insertion of half-rings into cilyndrical shells
- Cabling: powering, cooling, data



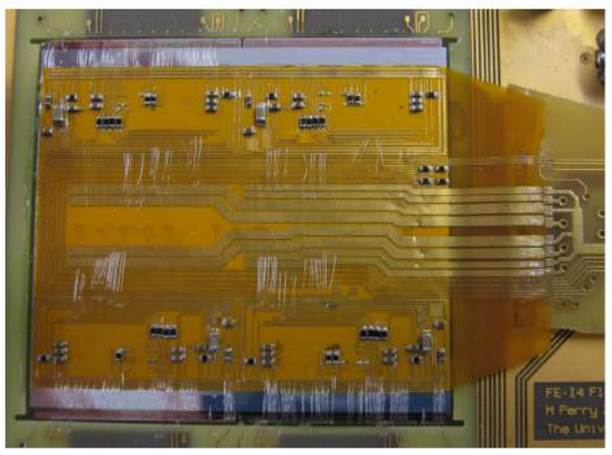
System test:
- electrical functionality
- termo-mechanical stress
- **<u>Readout 10% of the endcap</u>**



Cooling pipe and power lines running inside a thermally conductive carbon foam sandwiched between two half-rings

Thesis proposal

The aim of thesis will be to setup the data acquisition for a module (FEi4 or RD53A) using a Xpressk7 board. He/she is expected to learn the how to communicate with the module and perform standard operations, like tuning the threshold and the time over threshold and current-voltage characterization. Experience in electronics and data acquisition, while not mandatory, is preferable.



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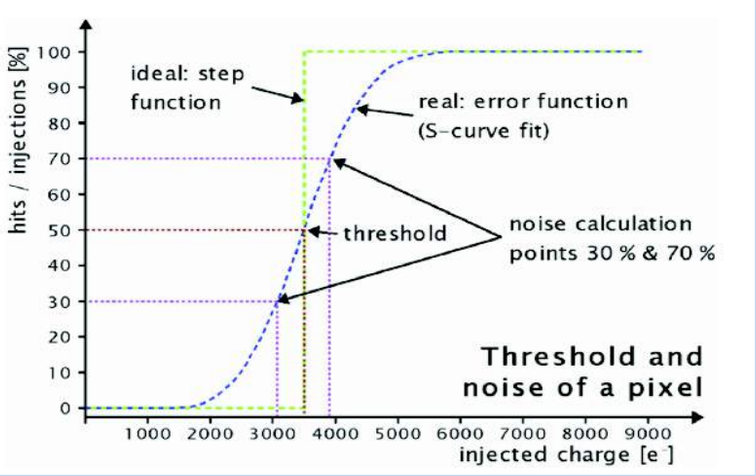

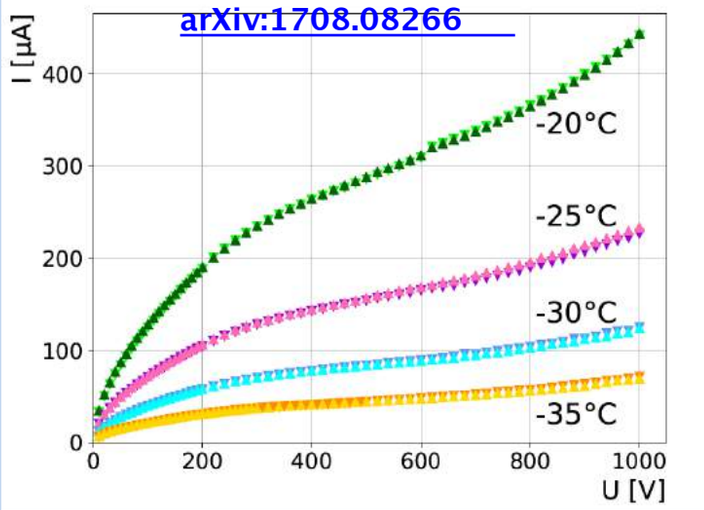

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