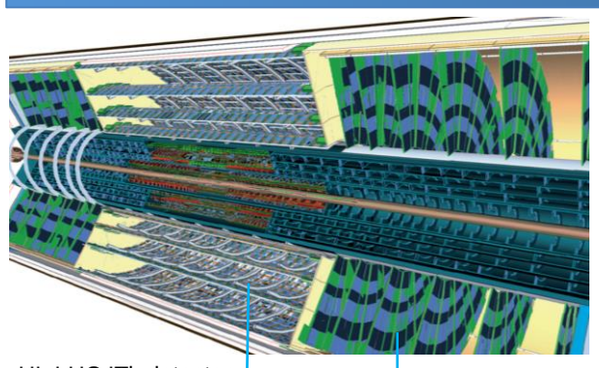
LHCC Poster Session – CERN, 2021

Thermal and Electrical Performance of ATLAS ITk Strip Module Testing Setup at BNL

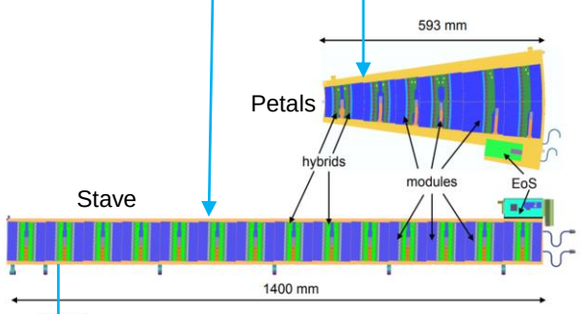
Introduction

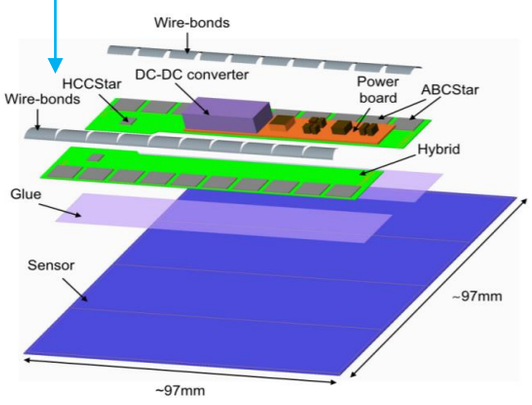
- The new all Silicon, ATLAS Inner Tracker (ITk) will replace the current ATLAS inner Detector for the High Luminosity LHC.
- HL-LHC : nominal luminosity $\mathcal{L}_{peak}$ ~ 7*10^{34} s^{-1} cm^{-2}, $\mathcal{L}_{Integrated}$ ~ 3000(4000) fb^{-1} and Pileup of ~200 per 25 ns.
- The ITk is made up of barrels and endcaps centered around the interaction point, covering the pseudo rapidity range from -4 to +4

HL-LHC ATLAS ITk Detector (1)



HL LHC ITk detector





ITk Pixel Detector

- 5-barrel layers with inclined sensors
- End-Cap system with individually located rings

ITk Strip Detector

- 4-barrel layers
- End-Cap(EC) system with 6 rings on both sides

ITk Strip Staves & Petals

- Staves (Barrel) and Petals (End-cap) are the support structure for the modules.
- It hosts the common electrical, optical connections and cooling services.
- 28 Barrel modules on each stave (14 modules per side)
- 18 End-Caps modules on each petal (9 modules per side, R0-R5)

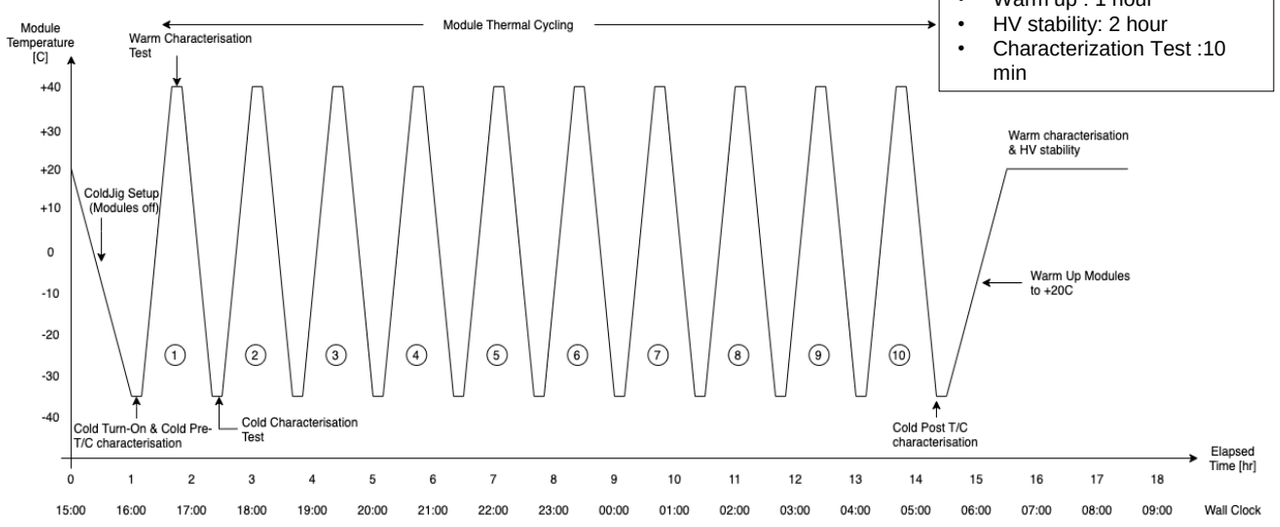
ITk Strip Modules

- Building blocks of the ITk strip detector.
- Consists of the sensor, one (for long strip, LS) or two (for short strip, SS) PCBs called Hybrid and one Power board .
- The hybrid hosts the readout ASICs: the ABCStar and the HCCStar.

Module QA/QC Requirements & Testing Setup (2)

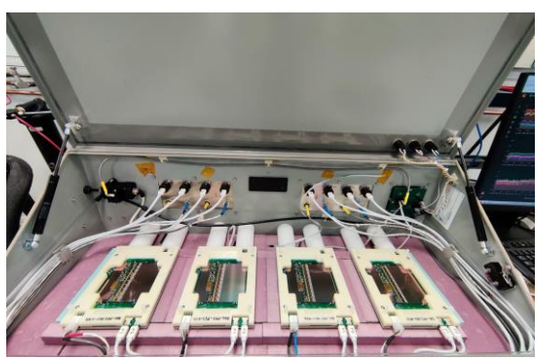
ITk Strips Module QC Thermal Cycle Sequence

04 May 2021



Timing Assumptions
- Cool down : 1 hour
- Warm up : 1 hour
- HV stability: 2 hour
- Characterization Test :10 min

- Between Module production and Stave assembly, each Module undergoes electrical and thermal quality control (QC) testing.
- Each module will be thermal-cycled 10 times from -35 °C to +40 °C to -35 °C, as measured by the Hybrid NTC.
- At each temperature change, **DAQ tests (Strobe Delay, 3-point gain, Noise Occupancy, IV scan)** are performed to evaluate the module.
- Modules that don't qualify with these tests are handled accordingly and tested again if possible after repair.



US Thermal Cycling Setup (Coldbox)

- It has chucks [0:3], modules are tightly screwed down through the frame for a good thermal contact.
- Each chuck has an 10k NTC and chuck 1,2 have SHT85s placed strategically to probe the coldest air in the box.
- 2 floating 10k NTCs and an Airflow meter to measure the ambient air temperature and airflow, respectively.
- A Python based software for control and readout.

Thermal & Electrical Performance (3)

Thermal Performance

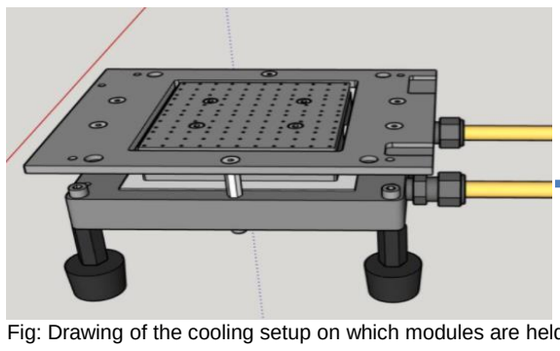


Fig: Drawing of the cooling setup on which modules are held.

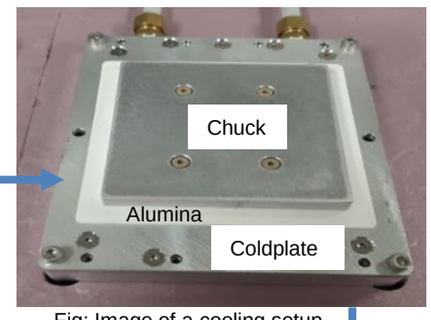


Fig: Image of a cooling setup

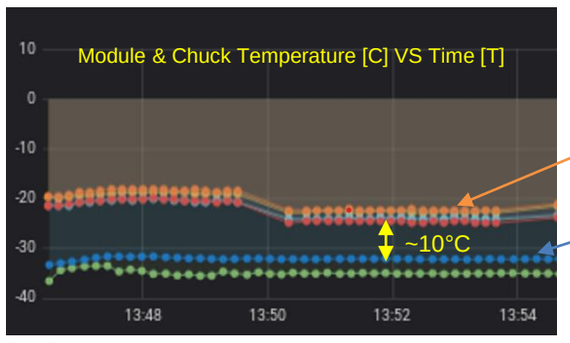


Fig: Grafana plot for 4 hybrids and chuck temperatures.

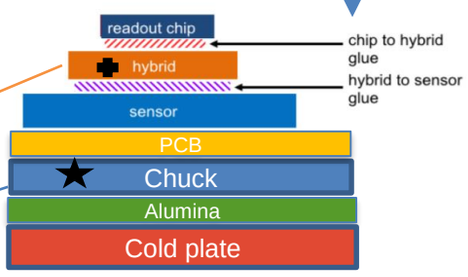
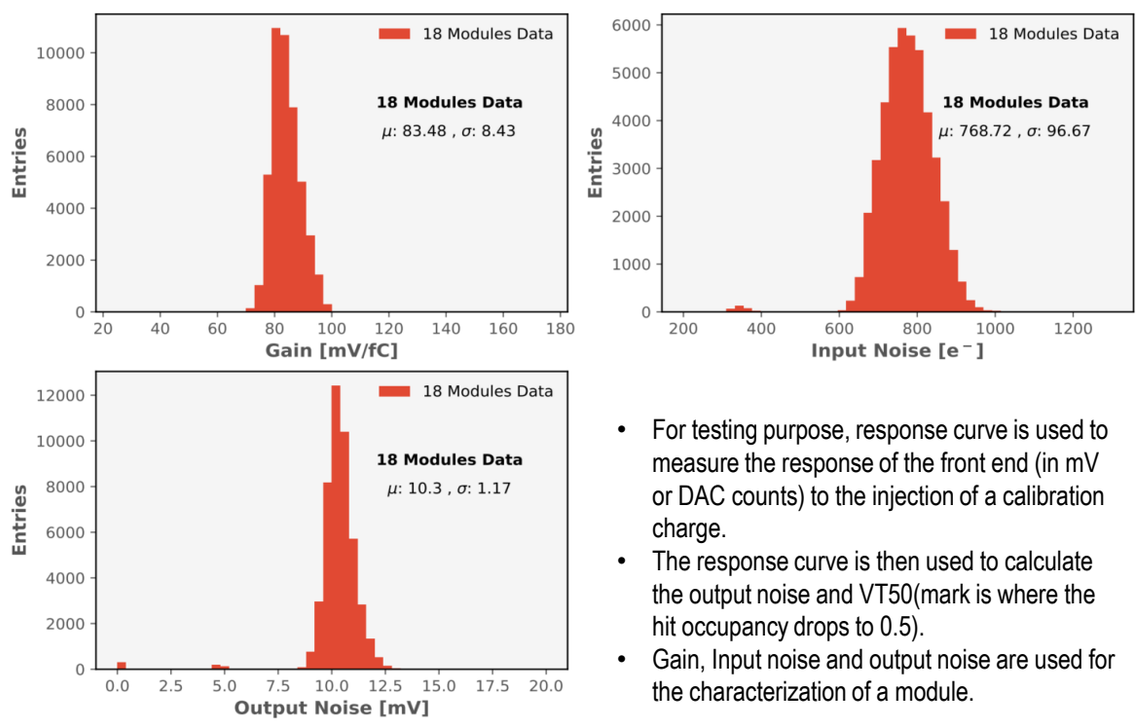


Fig: Drawing of the cooling setup with a module on top

- We have been able to thermal cycle modules from +40°C to -35°C and do DAQ scans at each step.
- When cold (~ -35°C chiller temperature), we observed that the hybrid is ~10°C warmer than the chuck.

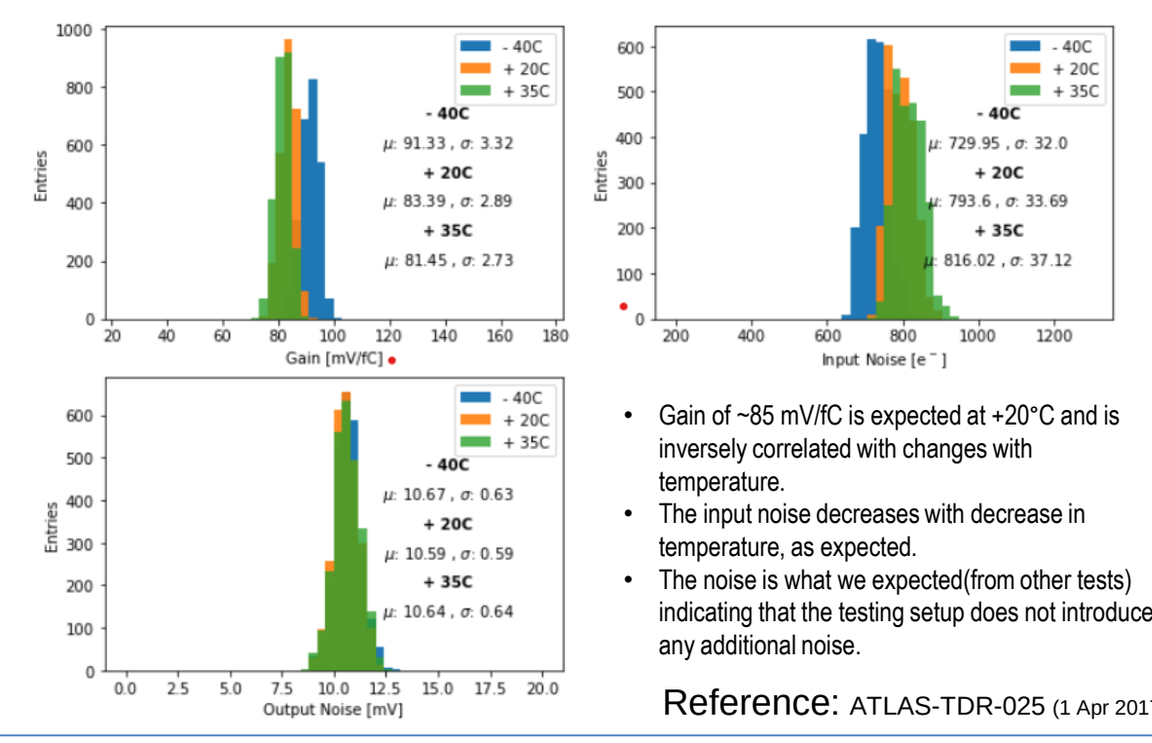
Electrical Performance

Noise and Gain from 18 modules tested at +20°C



- For testing purpose, response curve is used to measure the response of the front end (in mV or DAC counts) to the injection of a calibration charge.
- The response curve is then used to calculate the output noise and VT50(mark is where the hit occupancy drops to 0.5).
- Gain, Input noise and output noise are used for the characterization of a module.

Single Module Tested at Different Temperatures



- Gain of ~85 mV/fC is expected at +20°C and is inversely correlated with changes with temperature.
- The input noise decreases with decrease in temperature, as expected.
- The noise is what we expected(from other tests) indicating that the testing setup does not introduce any additional noise.

Reference: ATLAS-TDR-025 (1 Apr 2017)

Punit Sharma (The University of Iowa)
on behalf of the **ATLAS Collaboration**

Brookhaven National Laboratory

IOWA

ATLAS EXPERIMENT