Overview of the ATLAS ITk Strip System Tests

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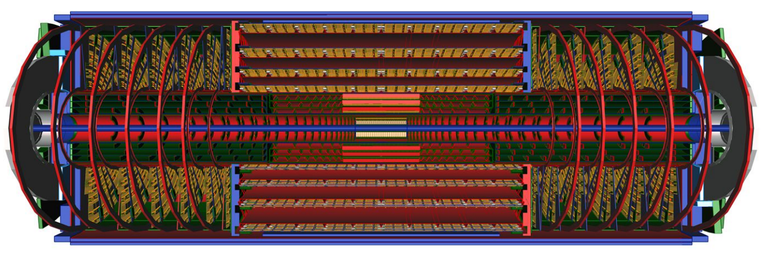
The Detector

» The ATLAS **Inner Tracker (ITk)** will replace the current inner tracking detector in the **HL-LHC** phase to cope with the challenging conditions (occupancy, radiation, etc)

» Tracker is an **all-silicon** detector with **pixel** and **strip** detectors arranged in a central **barrel** region and two **end-caps** in the forward regions



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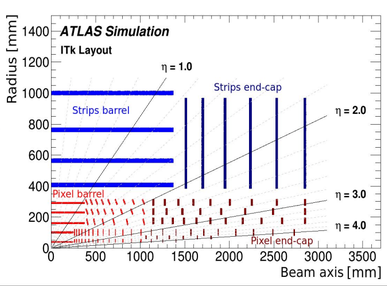
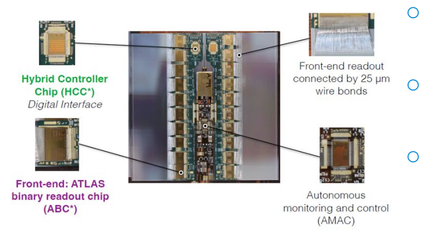
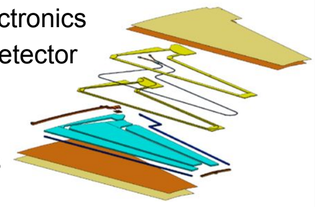
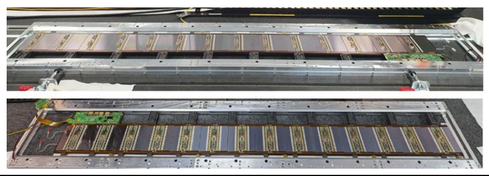


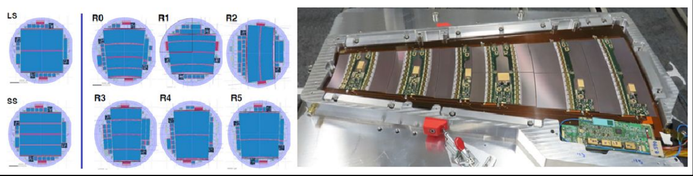
» Main building blocks are the **staves and petals** consisting of



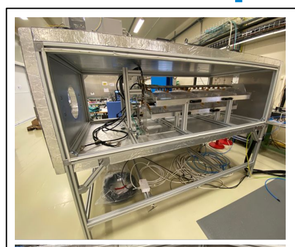
- Silicon microstrip detector **modules**: sensor with glued on readout and power electronics
- **End-of-Substructure** board as off-detector gateway for data, power and control
- Local support structure made of carbon-based materials called **cores**

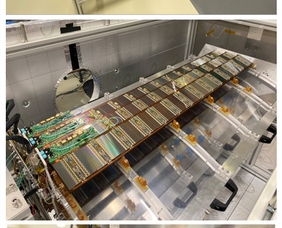


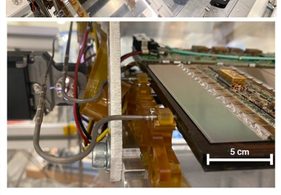


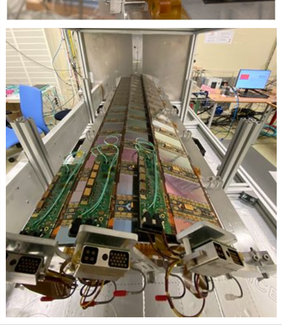


The Setup









» Construction of system tests for the **barrel** (at CERN) and **end-cap** (at DESY) sub-detector of the ITk strips detector

» Demonstration of **full-system performance** from pre-production objects using the complete service chain (power, data, cooling)

» Development of various tools for detector **integration and operation** (DAQ and DCS) and training people for integration

Barrel system test @ CERN

» Custom made **barrel support structure**

» Offering locking brackets for up to **8 staves**

» Currently populated with **four fully loaded pre-production** staves: three short strip (SS) and one long strip (LS)

» Enclosed by a **thermal box** with dry air flushing and DCS monitoring

» Cooling with **CO_2 dual-phase cooling** [+17°C, -25°C] using demo plant in SR1

End-cap system test @ DESY

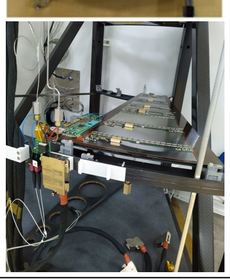
» Realistic end-cap structure (51° of full EC) as **global support** made out of carbon-fiber parts

» Offering locking points at 16 positions for up to **12 petals**

» Currently populated with **one fully loaded pre-production** petal

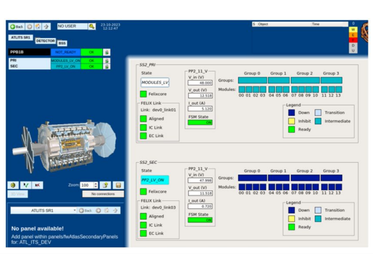
» Enclosed by a custom made **thermal box** with dry air flushing and environmental monitoring

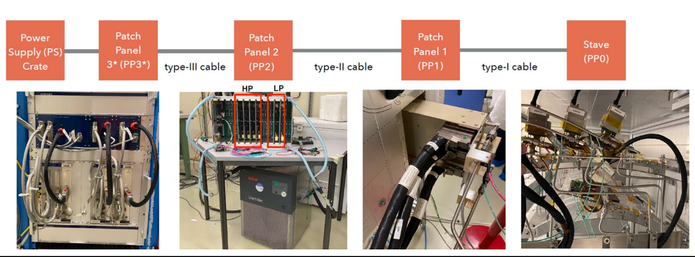
» Cooling with **CO_2 dual-phase cooling** [+17°C, -35°C] using LUCASZ cooling plant

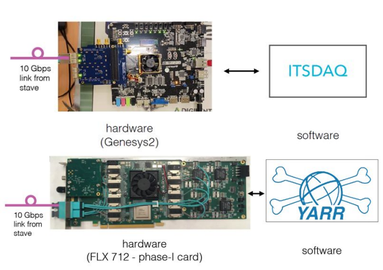


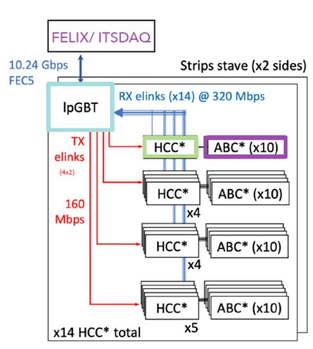
» Power delivered using complete **power chain** consisting of pre-production cables and patch panels

» Readout with two **DAQ** systems: Genesys-II/ITSDAQ (used for production) and FELIX/YARR (targets final online software)









The Results

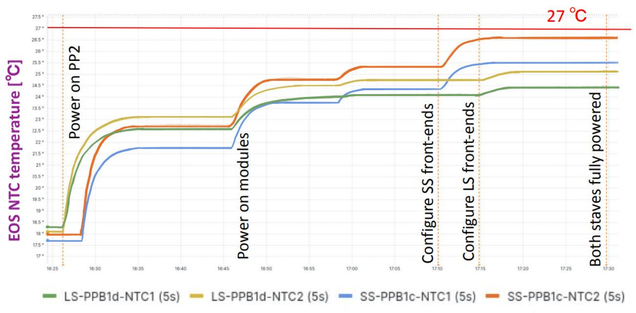
Stave temperatures with CO_2 cooling:

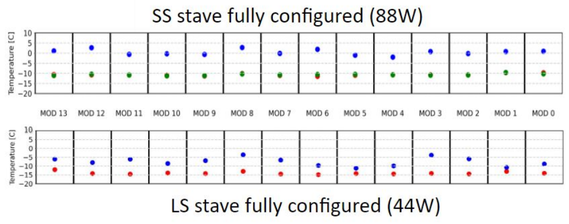
» Goal: Study stave-level temperatures measured on **EoS NTCs** while powering up the stave

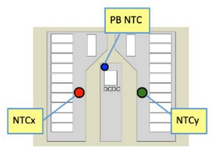
- In each step, the power increases while **configuring** the modules

» After full configuration, LS and SS staves at **similar temperatures**

- Capillary design allows ~half the flow is delivered to LS compared to SS







» Measuring on **module temperatures** by NTCs for SS and LS staves at CO_2 temperature of -25°C

- Powerboard always warmer than hybrid

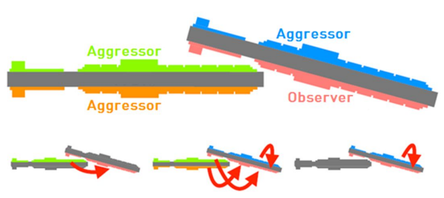
Stave noise crosstalk tests

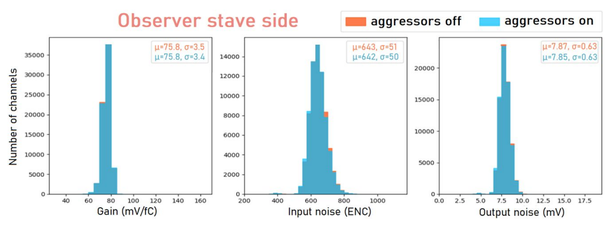
» Goal: test for electrical noise on stave due to **crosstalk between neighboring staves**

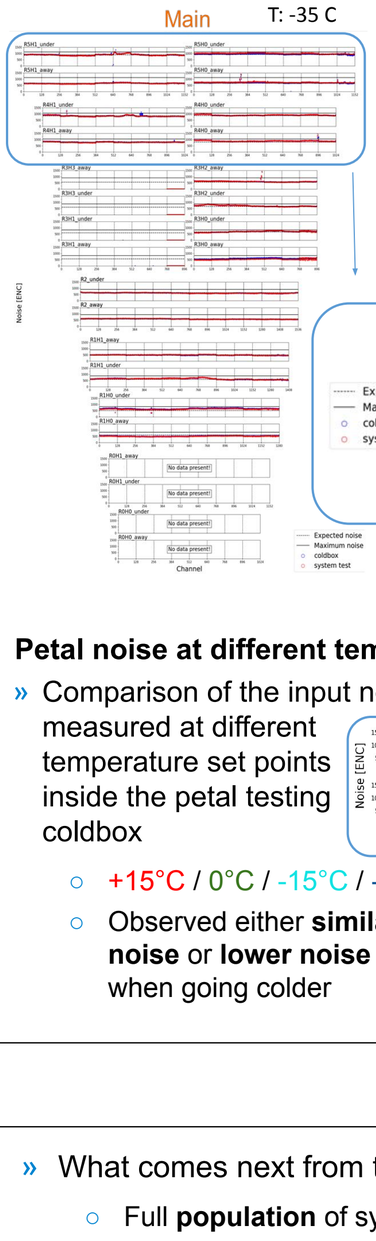
» Setup: perform calibration scans on one stave side (**observer**) with different powering configurations on neighboring stave sides (**aggressors**)

» Result: no change in distributions of gain, input and output noise observed

→ **no indication of crosstalk between modules and stave sides**



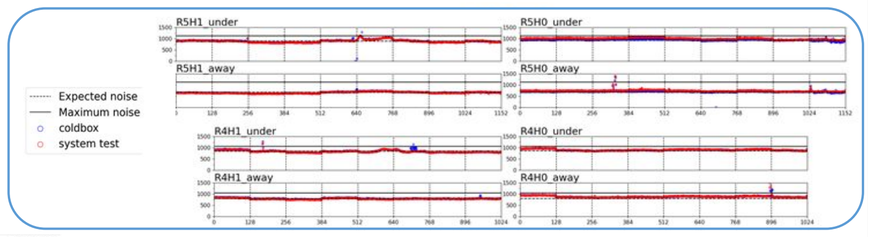




Petal noise comparison in system test

» Comparison of the input noise distributions for all petal modules (R0 to R5) measured inside the petal testing coldbox and inside the system test coldbox with full powering chain at temperature set point of -35°C

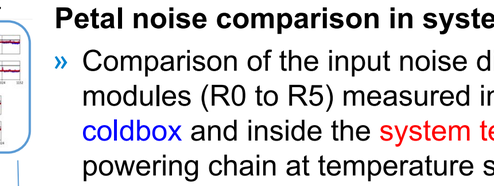
- Petal **fully functional** after petal insertion process
- **No additional noise** due to power chain is observed

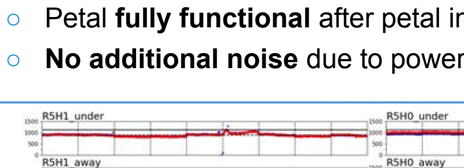


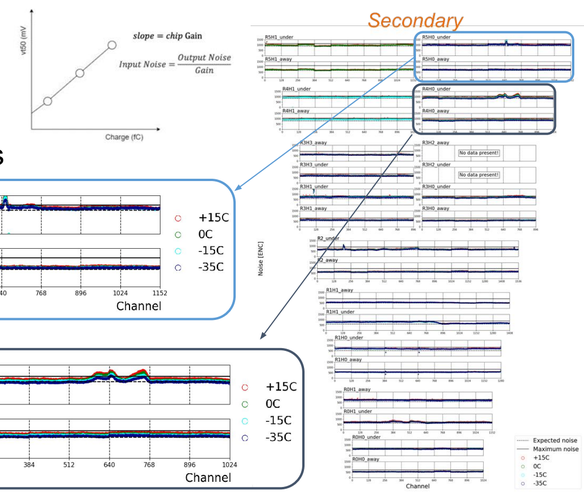
Petal noise at different temperatures

» Comparison of the input noise distributions measured at different temperature set points inside the petal testing coldbox

- +15°C / 0°C / -15°C / -35°C
- Observed either **similar noise** or **lower noise** when going colder







The Closing

» Both system tests for the ITk Strips detector are fully operational

- Needed **infrastructure** (services, cooling, DAQ) is available and set up
- Motivated **teams** at both sites are working together and exchange a lot
- Several **results** for the detector performance are already produced
- Important **tools**, e.g. for DCS, are being developed and tested at system tests

» What comes next from the system tests for the ITk Strips detector?

- Full **population** of system tests with final amount of staves and petals
- Running further **performance measurements** to evaluate noise characteristics and to check for potential crosstalk effects
- Development of **DAQ and DCS** for detector readiness and integration work

References

- ATLAS Collaboration, Technical Design Report for the ATLAS Inner Tracker Strip Detector, ATLAS-TDR-025 (2017)
- J.-H. Arling, Development of the system tests for the ATLAS Inner Tracker strip detector, NIM A Vol. 1064 169427 (2024)

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