The ATLAS Inner Tracker Strip Detector System Tests

Development of DAQ and DCS

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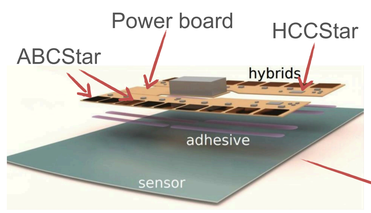
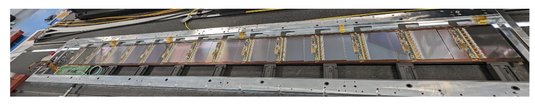
ATLAS Inner Tracker for HL-LHC

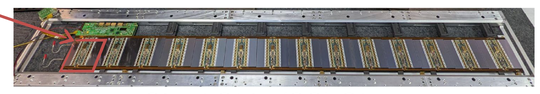
In preparation for the High Luminosity upgrade of LHC, the ATLAS experiment is replacing its current tracking detector with a new all-silicon **Inner Tracker** (**ITk**), including a pixel sub-detector surrounded by a strip sub-detector.
The **ITk strip detector** consists of a central **barrel** region with four cylindrical layers made of "**staves**", and two identical **end-cap** regions each with six disks made of "**petals**".



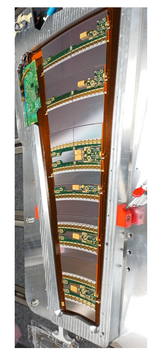
Exploded view of a short strip module



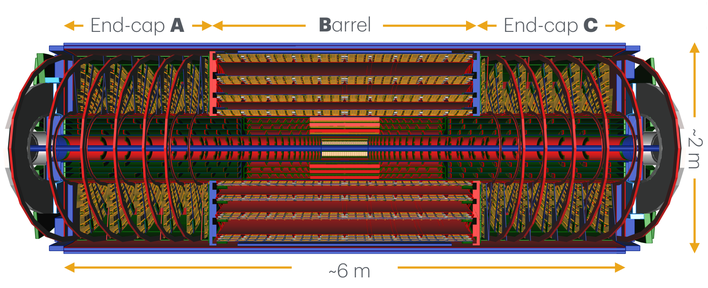
Long Strip (LS) Stave

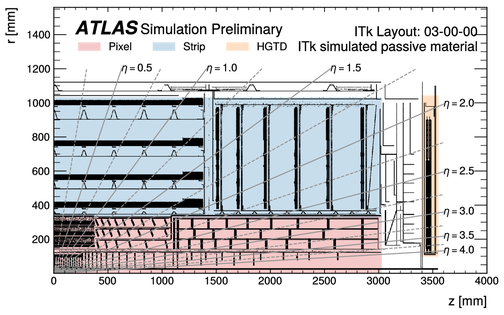


Short Strip (SS) Stave



End-cap petal



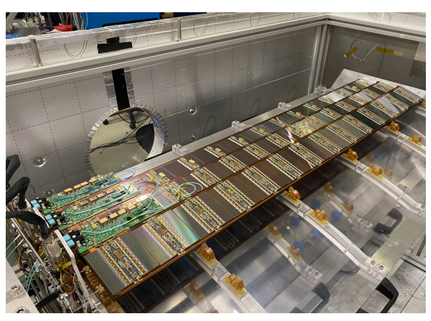


Each stave or petal comprises:

- **Modules**: custom ASIC sets glued directly to silicon sensors
- **Local support "Core"**: carbon fiber structure with built-in cooling and with modules glued to both sides
- **End-of-Substructure (EoS) card**: data and power interface between stave/petal and the off-detector electronics

System Test

The goal is to demonstrate full-system performance from close-to-final components using the complete service chain including power, data, and cooling. It provides a testbed for development and validation of the data acquisition (**DAQ**) and detector control and safety (**DCS**) system for detector integration.



Barrel Setup @ CERN

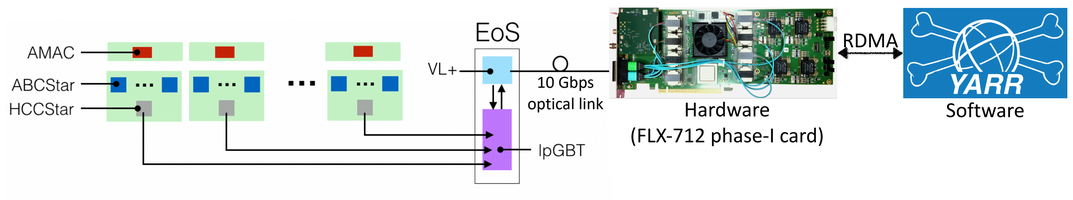
- Custom made barrel support structure designed to host 5 LS staves + 3 SS staves
- Currently populated with 4 fully-loaded pre-production staves (1 LS and 3 SS staves)
- CO_2 dual-phase cooling [+17°C, -25°C]

End-cap Setup @ DESY

- Realistic end-cap carbon-fiber support structures designed to host up to 12 petals
- Currently populated with 1 fully-loaded pre-production petal
- CO_2 dual-phase cooling [+17°C, -35°C]

- Thermal box with dry air and monitoring
- Complete power chain
- Hardware interlock at stave/petal level

Data Acquisition - DAQ



The main readout chain is based on the FELIX system targeting the final readout system.

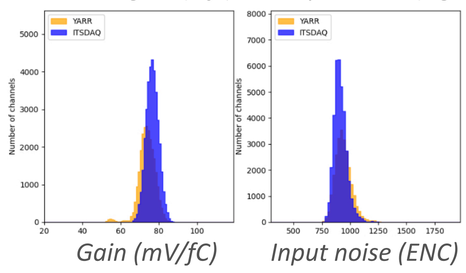
- **FELIX**: **F**ront **E**nd **LI**nk e**X**change
- **YARR** is the readout software used to send commands to and receive data from FELIX via Remote Direct Memory Access (RDMA)

Validation of the readout chain

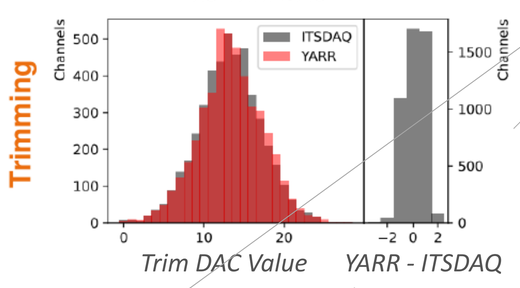
Calibration scan results are compared to the ones obtained from the readout system used during production (Genesys-II and ITSDAQ).

- Results are compatible between YARR and ITSDAQ.

LS stave gain (left) and input noise (right)



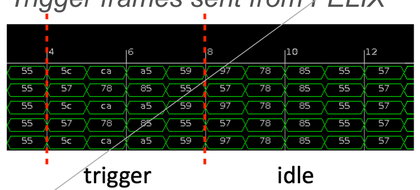
R5 Trim DAC



External triggering test

- External triggers provided by ALTI board from the ATLAS TTC system
- Verified triggers are indeed forwarded by FELIX to the front ends
- Updated FELIX firmware to pass trigger tags from ALTI properly

Trigger frames sent from FELIX



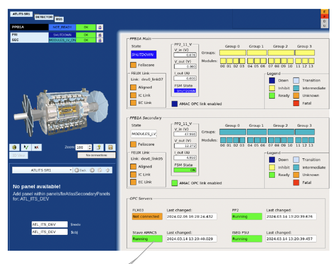
Trigger tags in received data packets correctly reflect L1IDs from the external trigger source

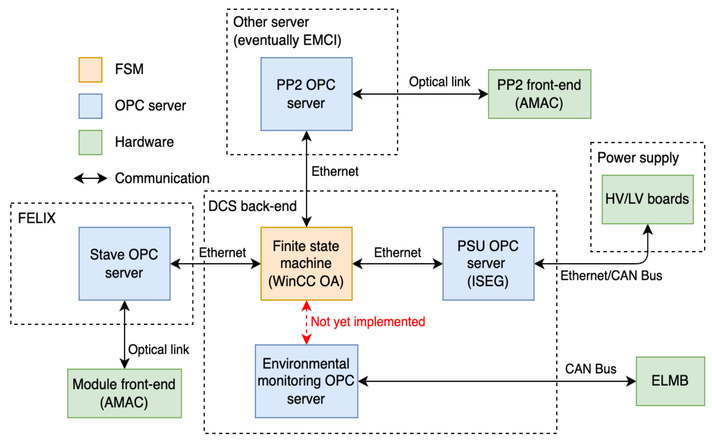
```
event.l1id|  event.bcid| event.tag|      event.hits.size()
41|                3|    000000101001|       1
42|                4|    000000101010|      69
43|                3|    000000101011|      49
45|                3|    000000101101|    2031
47|                3|    000000101111|    1473
```

Detector Control and Safety - DCS

The DCS system is responsible for powering, monitoring, interlocks, ensuring stable and safe operation of the system.

- OPC servers are in place to communicate with various power and monitoring units

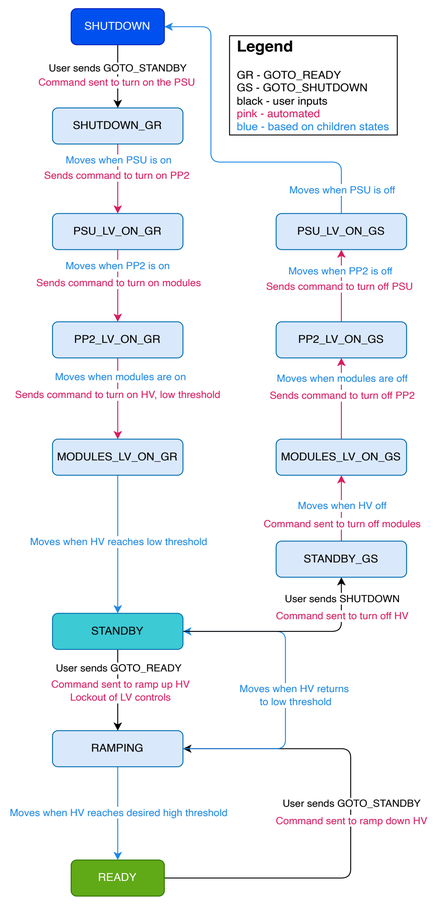




Automation with Finite-State Machine

State machine is in development for system control and monitoring.

- The goal is to be able to start or shutdown the system with one click.
- SHUTDOWN → STANDBY
- STANDBY → READY



What's next

- **Fully populate** the barrel and end-cap system test structures
- Test **scalability** of the DAQ system using **emulators**
- Implement software and module-level hardware **interlocks**
- Improve the **speed** and **reliability**
- **Coordinate** DAQ and DCS actions via FSM

Reference

- 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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