

System Tests of the ATLAS ITk Planar and 3D Pixel Modules

About the ATLAS Inner Tracker (ITk)

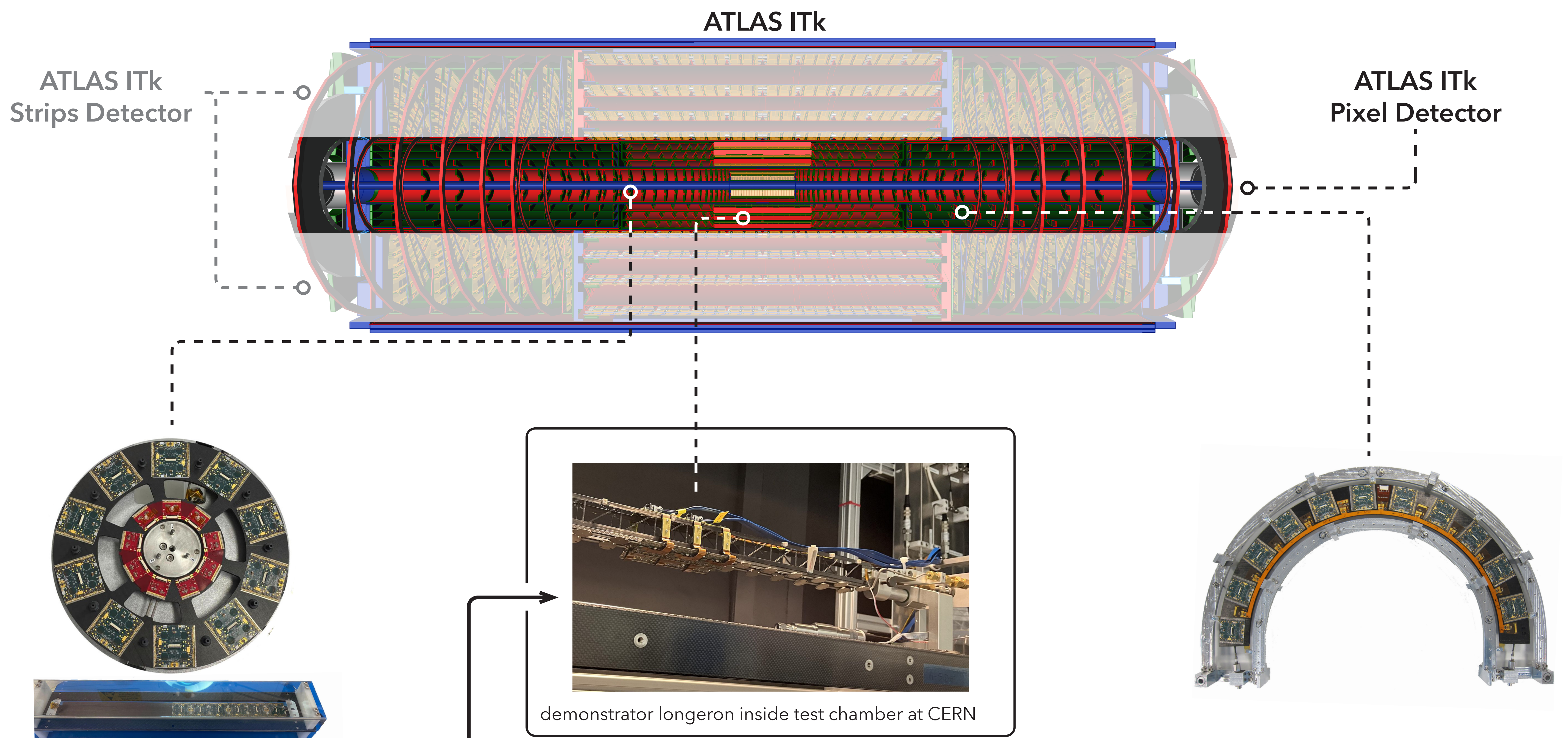
- Novel all-silicon tracker to replace the ATLAS Inner Detector for the High Luminosity LHC upgrade in ~2027
- Coverage increase to $\eta \leq 4.0$
- Lower material budget e.g. due to serial powering of modules and CO₂ cooling
- 5 innermost layers will consist of the Pixel Detector, surrounded by the Strips Detector

About the System Tests

- Intermediate step between individual modules and the full ITk detector → local support prototypes
- 3 test sites for the different local support prototypes Pixel sub-detectors
- Fully realistic read-out chain from modules (RD53 collaboration) to back-end with prototypes

Ongoing Activities

- Development of necessary infrastructure e.g. cooling, humidity control, interlock matrix, Detector Control System (DCS) and serial powering (SP)
- Data acquisition (DAQ) tests of the full data transmission chain for comparison before and after loading of support prototypes



Inner System Demonstrator - SLAC

- 1 fully loaded coupled ring prototype: L1 outer ring 10 planar modules, L0 inner ring 3 3D modules (triplets), each ring with 1 SP chain
- 2 half-loaded L1 staves, each with 6 modules and 1 SP chain
- Currently focused on loading the electrical services to the ring and mounting into demonstrator box.

Outer Barrel Demonstrator - CERN

- 1 longeron with 2 SP chains (6 and 12 modules)
- 1 inclined half-ring with 1 SP chain (11 modules)
- Currently first tests with Sr-90 sources on 6 installed planar modules

Outer End-Caps Demonstrator - ULiv

- 1 Fully loaded ring prototype with 1 SP chain (11 modules) per side
- Currently commissioning of modules and DCS

3 m Twinax cables
Data 1.28 Gb/s
Command 160 Mb/s
electrical transmission

Infrastructure

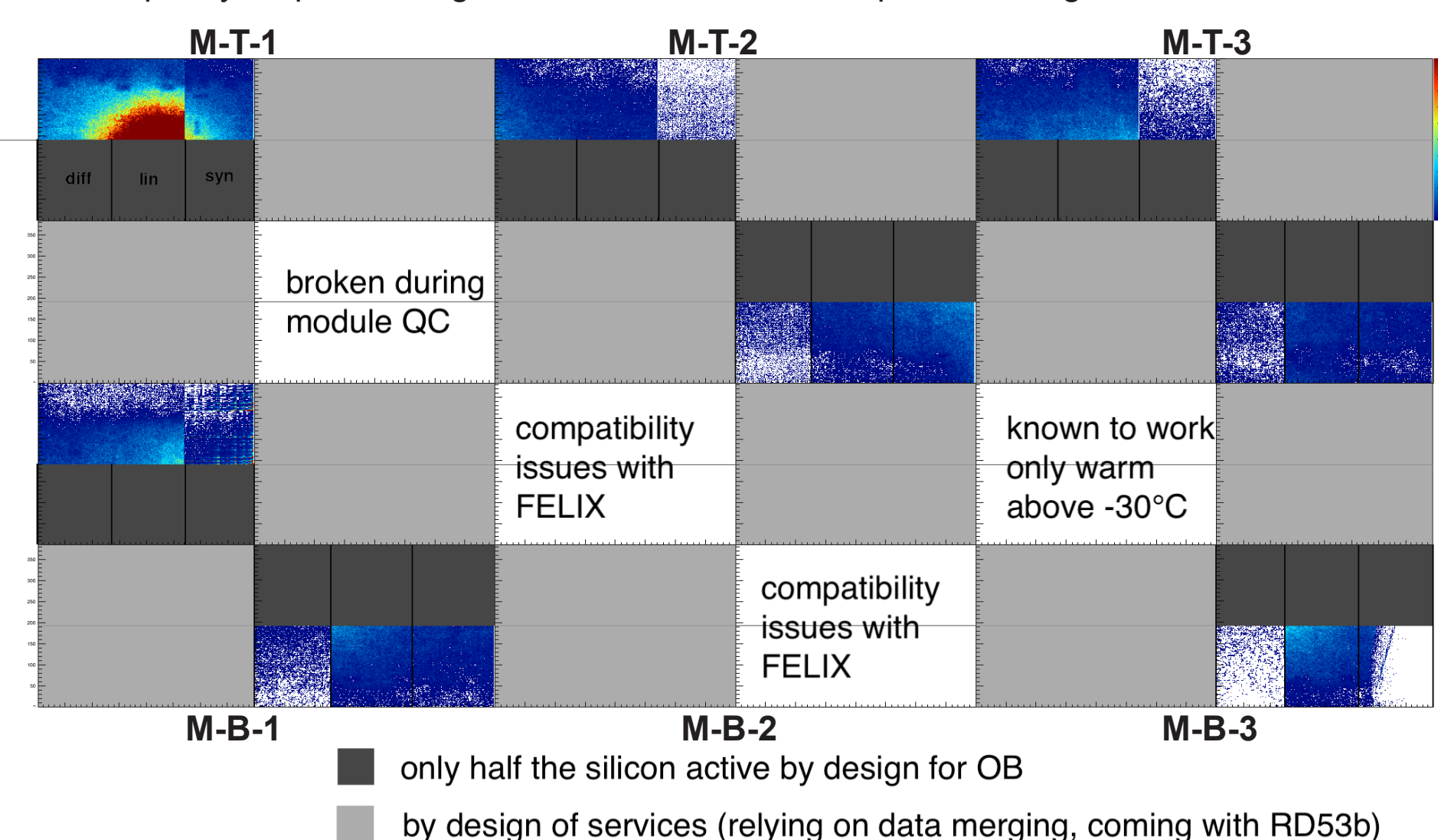
- Readout front-ends are serial powered, but the sensors will be connected in parallel to a common bias voltage line
- CO₂ cooling going down to -30° C, humidity controlled with interlock system

Focus: Optobox Prototype Panel

- Heart of the data transmission chain, electrical-optical conversion stage
- (De)-serialising of data and command/control: up to 6x1.28 Gb/s twinax cables to 1x10.24 Gb/s fibre. Command/control 2.56 Gb/s fibre to up to 8x160 Mb/s twinax cables
- 7 Optoboards hosting each up to 4 GBCR, 4 IpGBT and 1 VTRx+ with the capability to read out the full OB longeron and half ring

~65 m fibre trunk cables
Data 10.24 Gb/s
Command 2.56 Gb/s
optical transmission

occupancy map - OB longeron view from interaction point, looking towards module flex



First Results with Source Scans

- Scan with Sr-90 source on commissioned OB longeron with 6 modules
- Prototype modules (RD53a) for OB have only half of the Silicon active by design
- FE1, FE3 of each module disabled by design of the services (relying on data merging which will come only with RD53b/ITkPixV1.1)
- Occupancy map results proof the complete read-out of the ITk Pixel Detector data transmission chain
- Next steps are commissioning more modules of the demonstrator and improving the data taking

DAQ and DCS Back-end

- Control and command of front-end modules with FELIX servers and browser-based GUI to control the full read-out chain
- DCS diagnostics, control, feedback and safety handled by a central (WinCC-based) system. Input from on-detector ASICs Monitor Of Pixel System (MOPS) that monitor voltages and temperatures → successfully commissioned!
- Interlock system to ensure safety of prototypes and operators