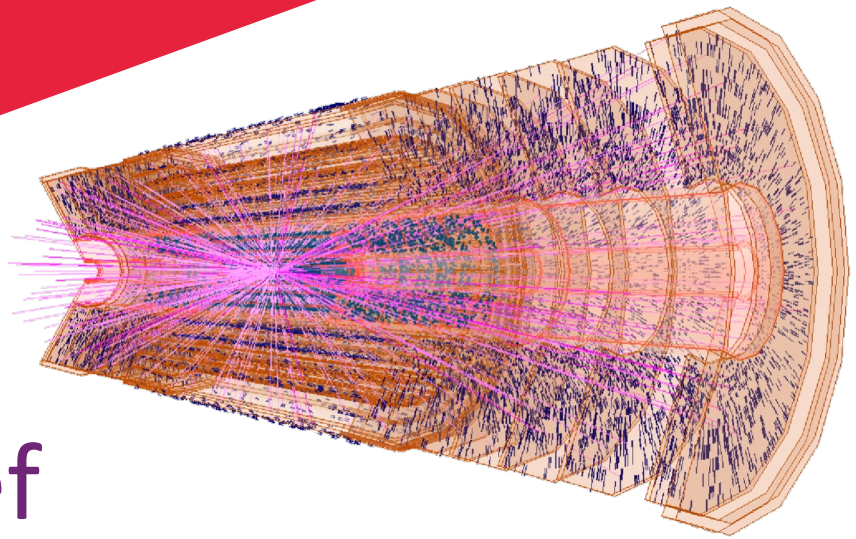


Overview of Nikhef ATLAS upgrade activities: Muon, TDAQ, HGTD, ITk

Andrea García Alonso

On behalf of the Nikhef ATLAS groups working on upgrades

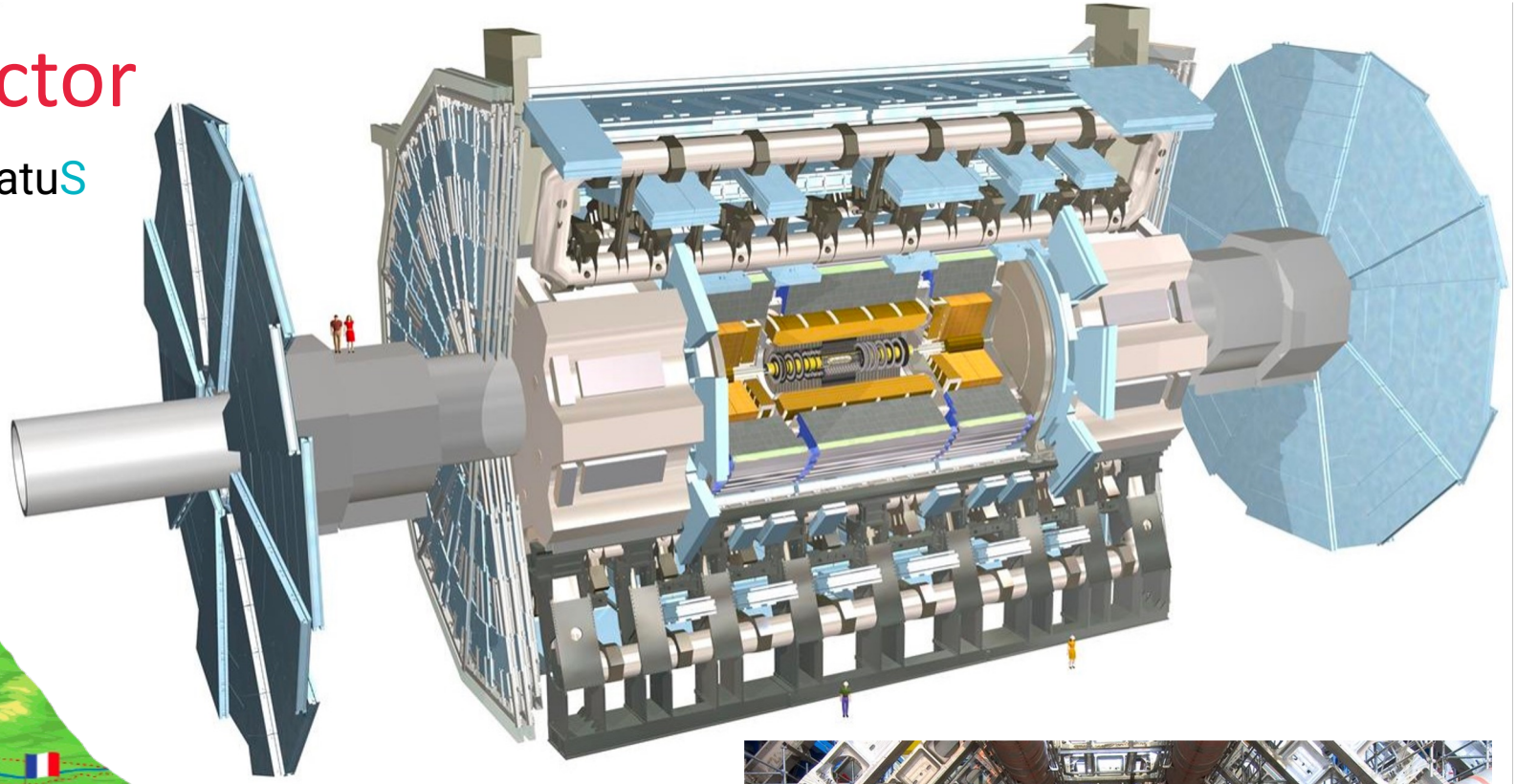
Nikhef Jamboree

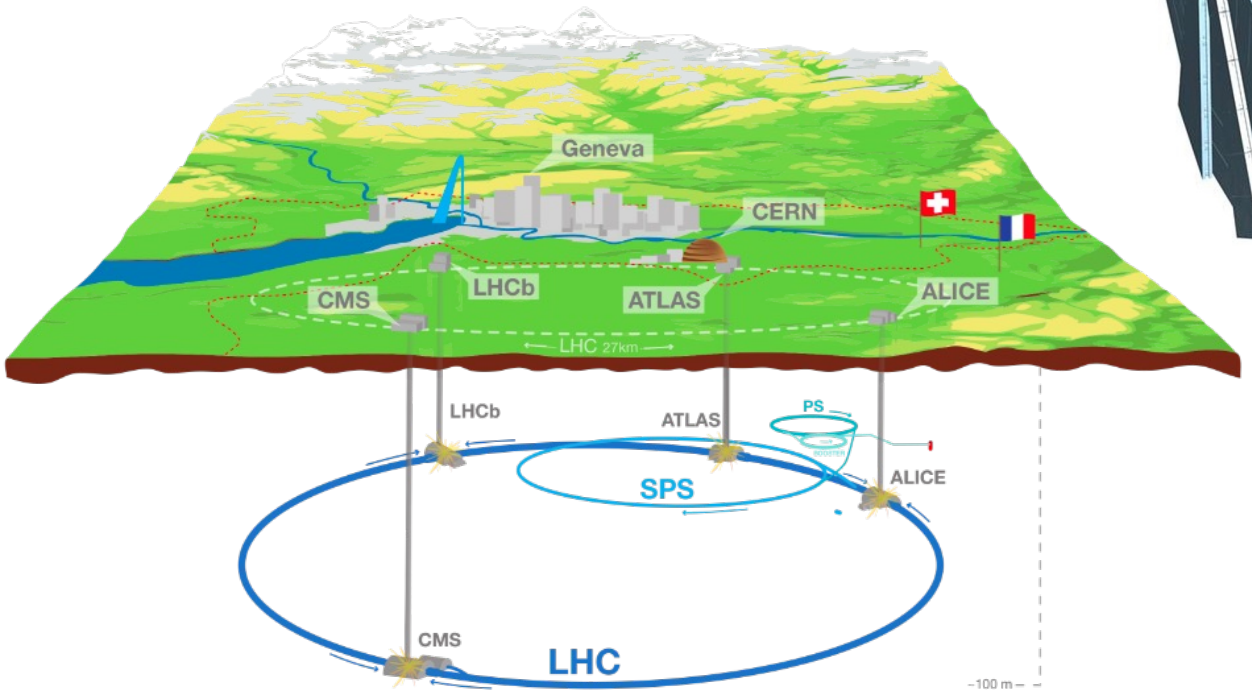
16th May 2023

Amsterdam, The Netherlands

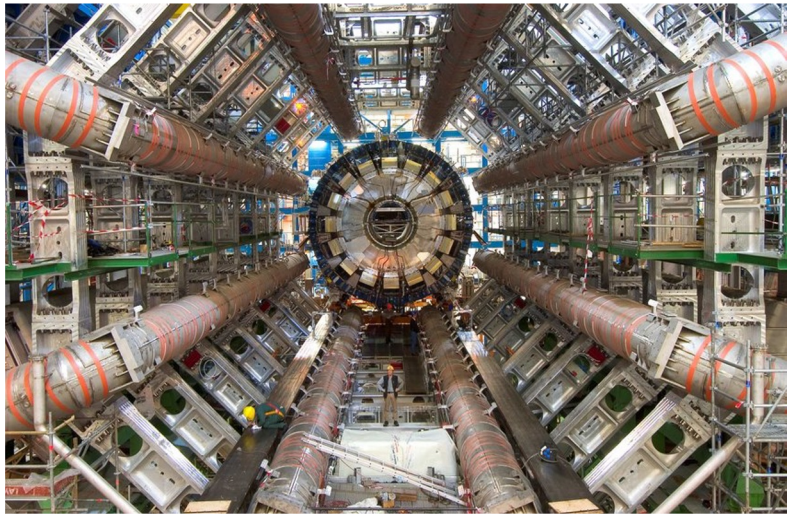
LHC and the ATLAS detector

A ToroidaL ApparatuS





Diameter: 25 m
Length: 46 m
Weight: 7000 tons



Upgrade to HL-LHC

Particle densities & radiation levels will exceed current levels by factor 10

Unprecedentedly high levels of radiation

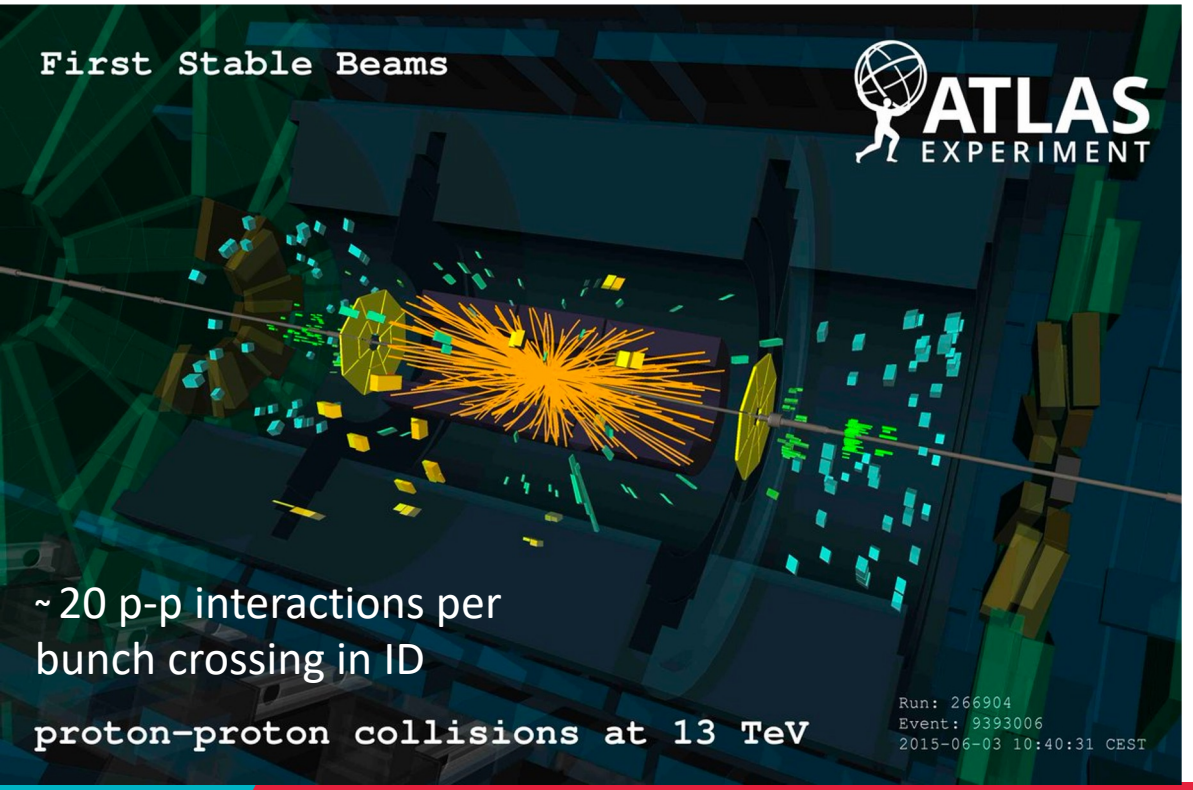
Large particle fluences

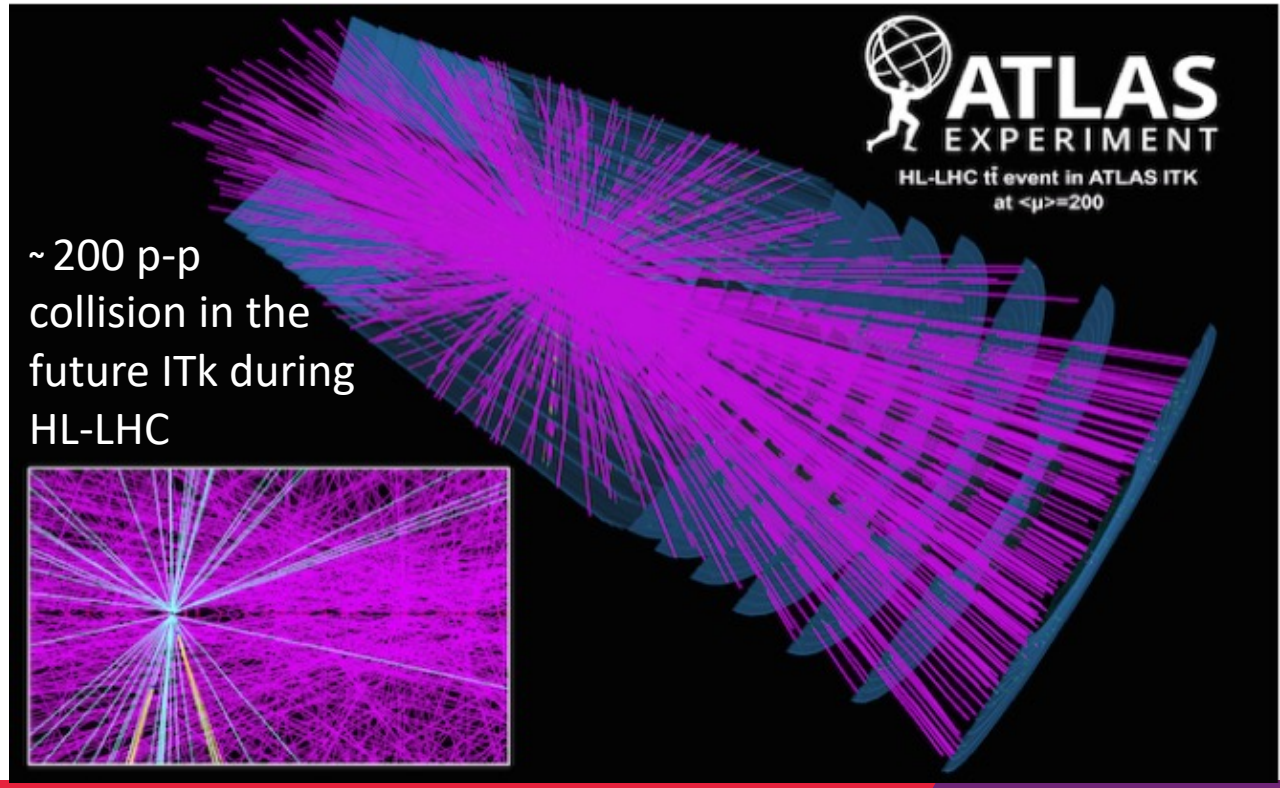
Pile-up

Must do list:

- → Higher radiation tolerance
- → Faster response
- → Higher granularity (keep low occupancy)
- → Reduced pitch (improve high p_T performance)
- → Novel powering solutions to power x10 more channels
- → Reduced material in tracking volume
- → Reduced sensor cost to cover larger areas
- → Trigger rates from 100 kHz to 1 MHz, bigger event size

and more…





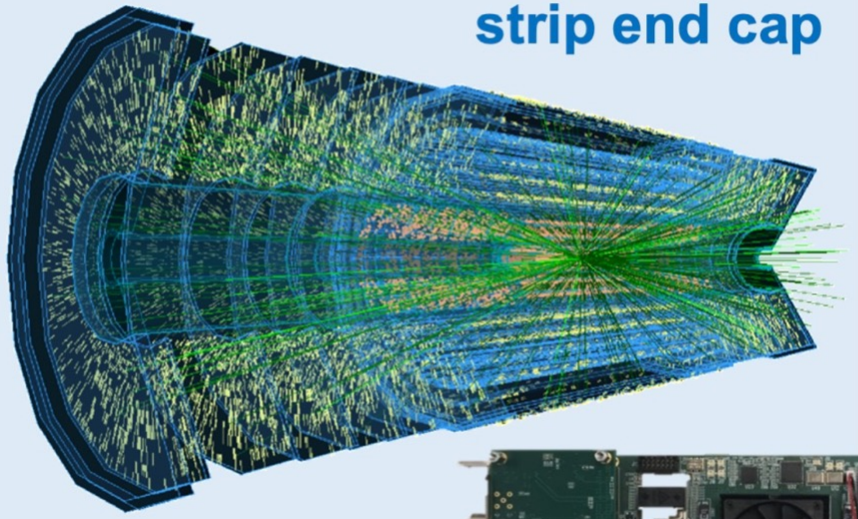
ATLAS upgrades at Nikhef

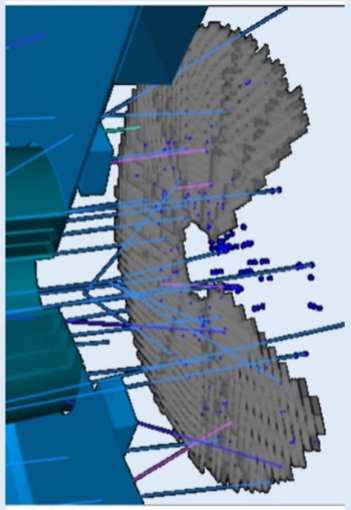
HL-LHC

LS2 | LHC Run-3 (300 fb^{-1}) | Long Shutdown 3 | Run4 | LS4 | Run5

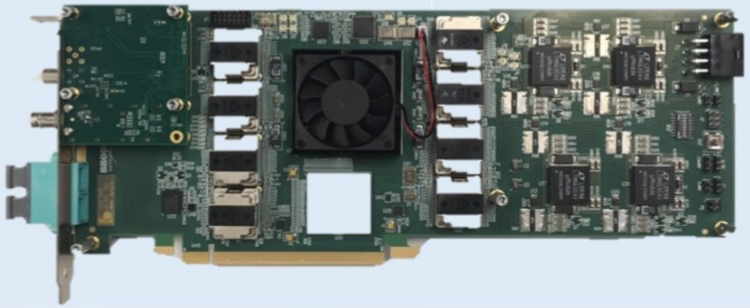
2022 | 2026 | 2029 | 2033 | 2035

Inner Tracker strip end cap





HGTD Fast Timing Detector



Felix DAQ for all of ATLAS

+ Muon Alignment & DCS

HGTD Upgrade

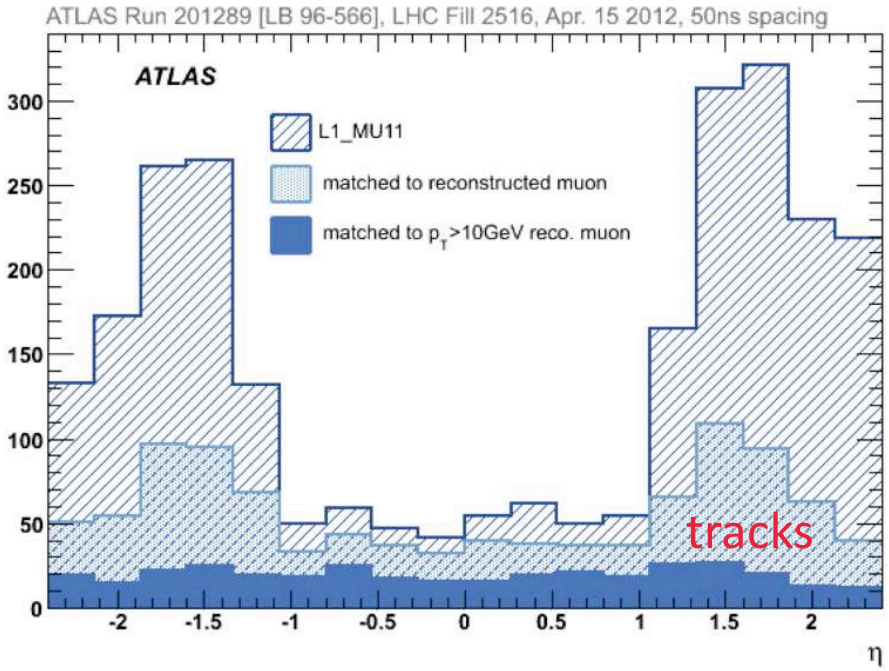
Inner Pixel Layer upgrade

Muon New Small Wheel NSW

Important for HL:

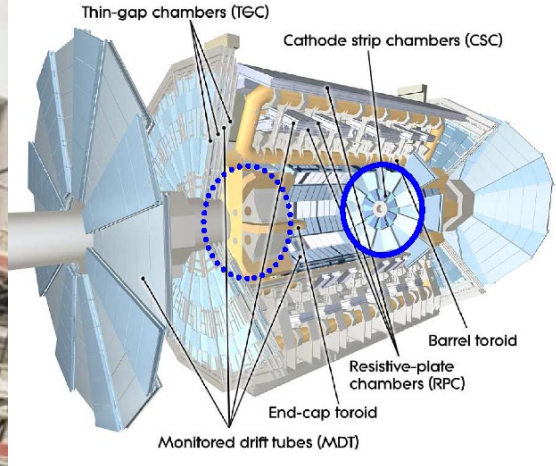
- L1 μ trigger rate dominated by fake (forward) muons → 8-9 times higher in end-caps than in barrel region

- Tracking degradation (efficiency and resolution) due to occupancy



Status:

- LS2 extension (2022) made it possible to install both NSWs in ATLAS

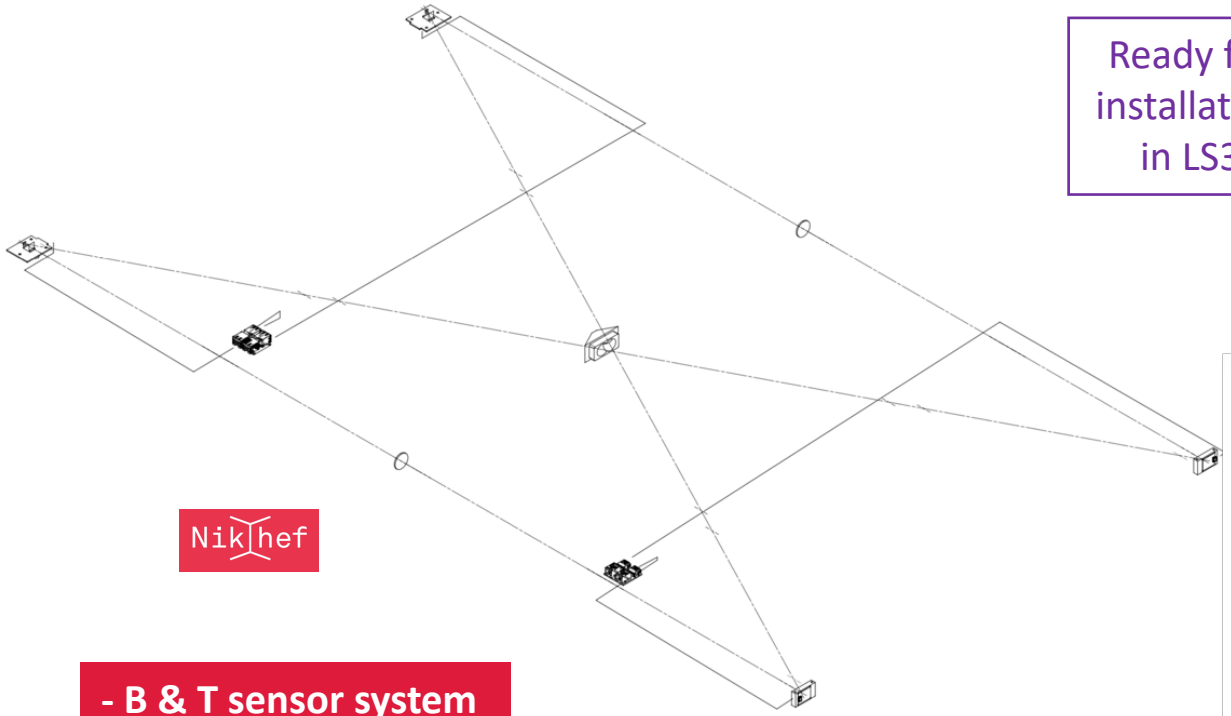


- NSW μ triggers expected to be deployed in 2023

- Ongoing integration in tracking

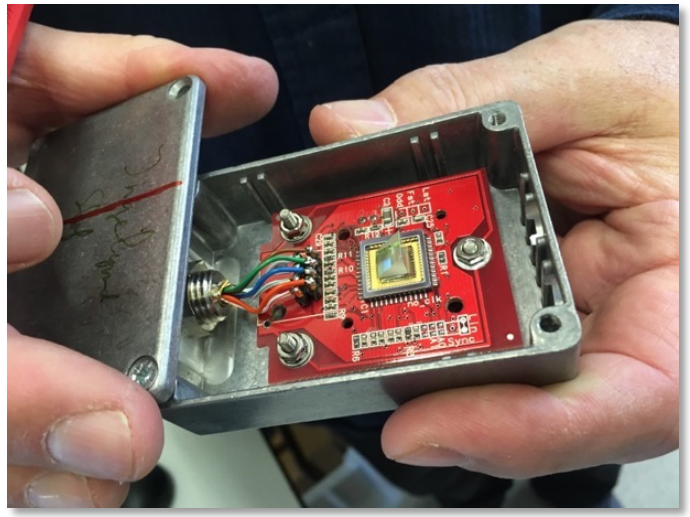
Muon upgrades

RASNIK alignment system for sBIS chambers 1-6
Modernized & adapted to more confined space



- **B & T sensor system**
- **FELIX DAQ system**
- Implementation in simulation software

Ready for installation in LS3



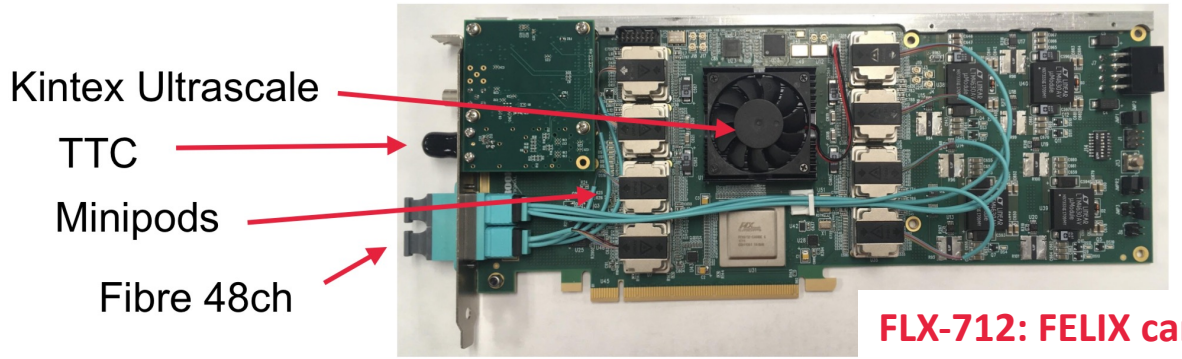
- Radiation hard electronics, compatible with existing readout
- New lenses & LEDs

ELMB → ELMB2:
- Monitoring of T & B
- Radiation tolerant controllers
- No longer needed for configuration of FE electronics

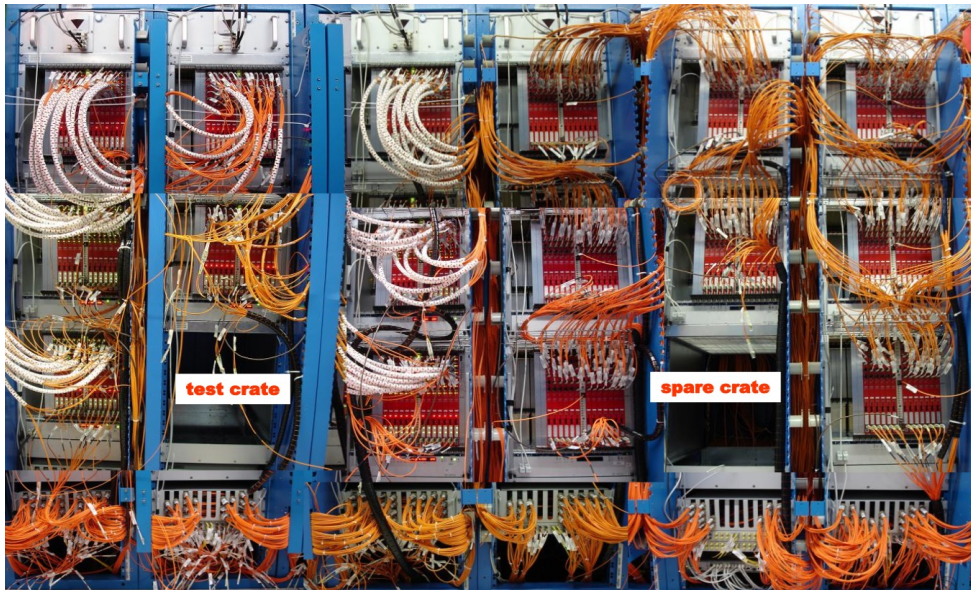
Radiation tests successful, procurement done (Nikhef + CERN)

TDAQ: Front-End Link EXchange

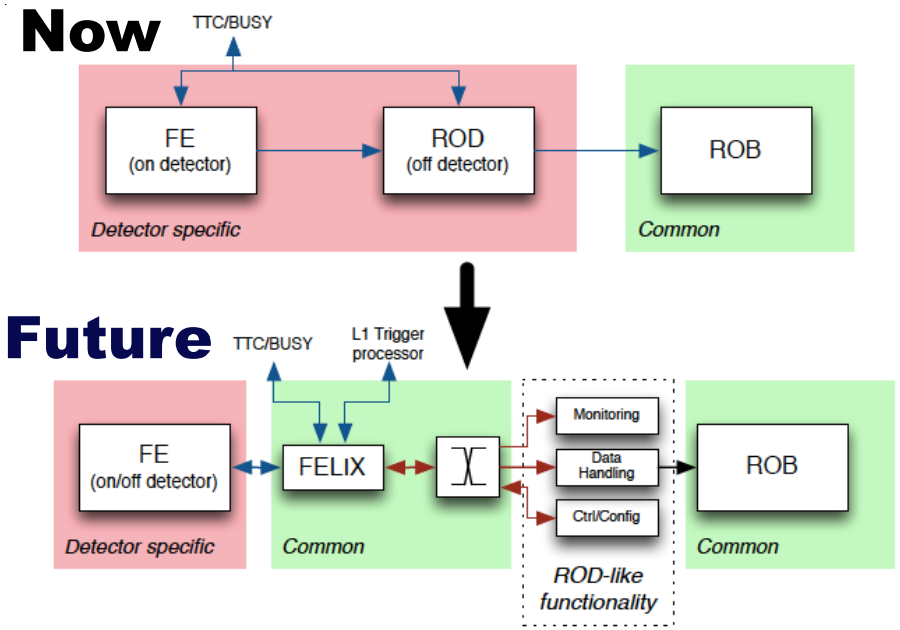
FELIX: flexible, modular, universal DAQ system for event data, timing and trigger control



FLX-712: FELIX card for Phase-I



Skip custom hardware layer of RODs



Detectors link directly to FELIX

ATLAS Coordinator roles:

FELIX firmware - Frans

FELIX software - Mark

TDAQ: FELIX status

Phase I: NSW (ready for 1 MHz readout), BIS7/8 RPC, LAr and L1Calo
Phase II: use FELIX throughout ATLAS

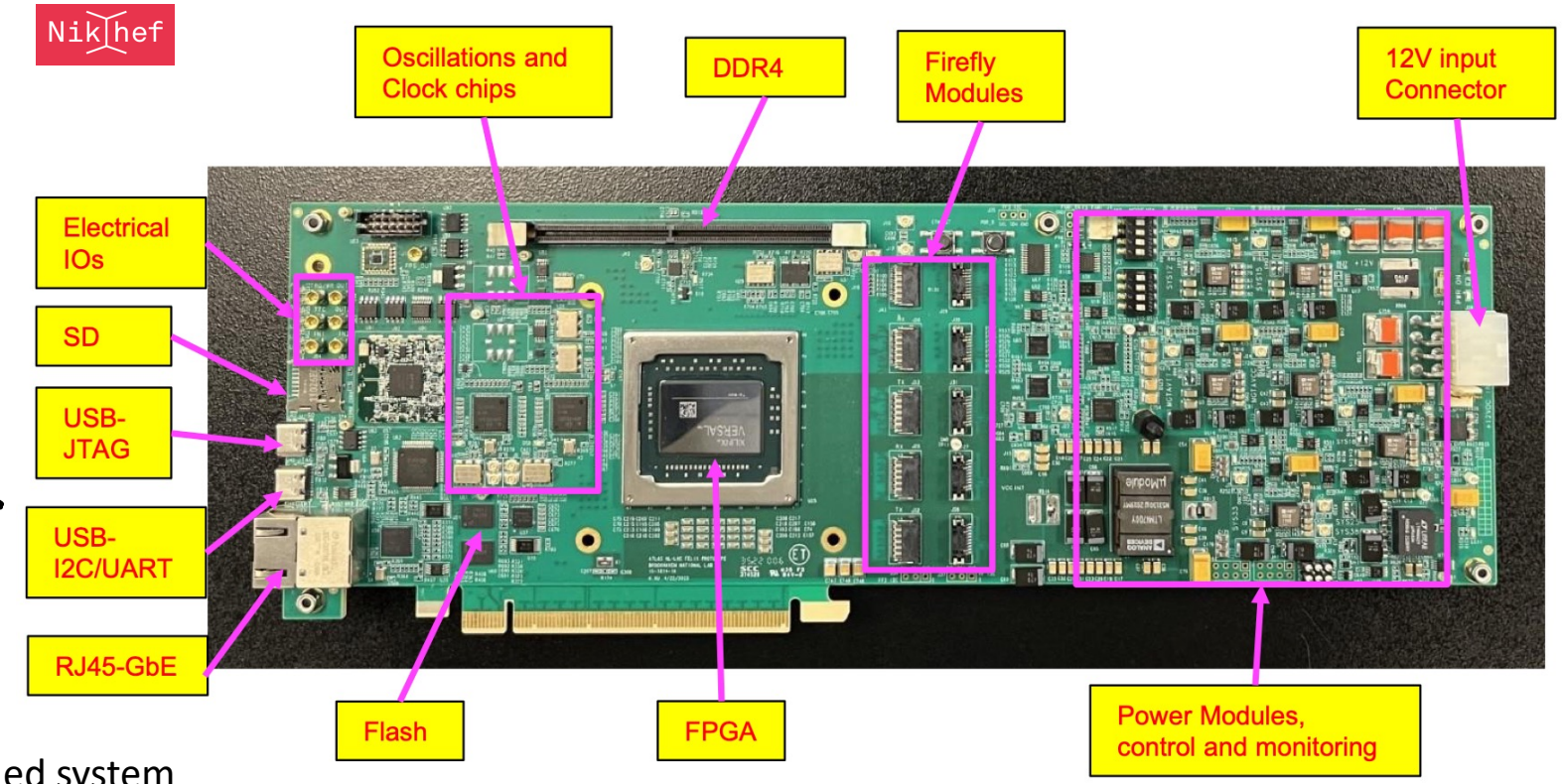
Phase I

Status:
286 cards delivered, 4 with problems
Successfully used for readout of newly installed detectors
& trigger systems

Phase II

Scope:
639 FELIX cards
Challenge: 10 times higher readout rates → upgraded system
Ongoing f/w R&D at Nikhef (incorporating lessons learned from Phase-I deployment)

Status:
hardware review end 2023



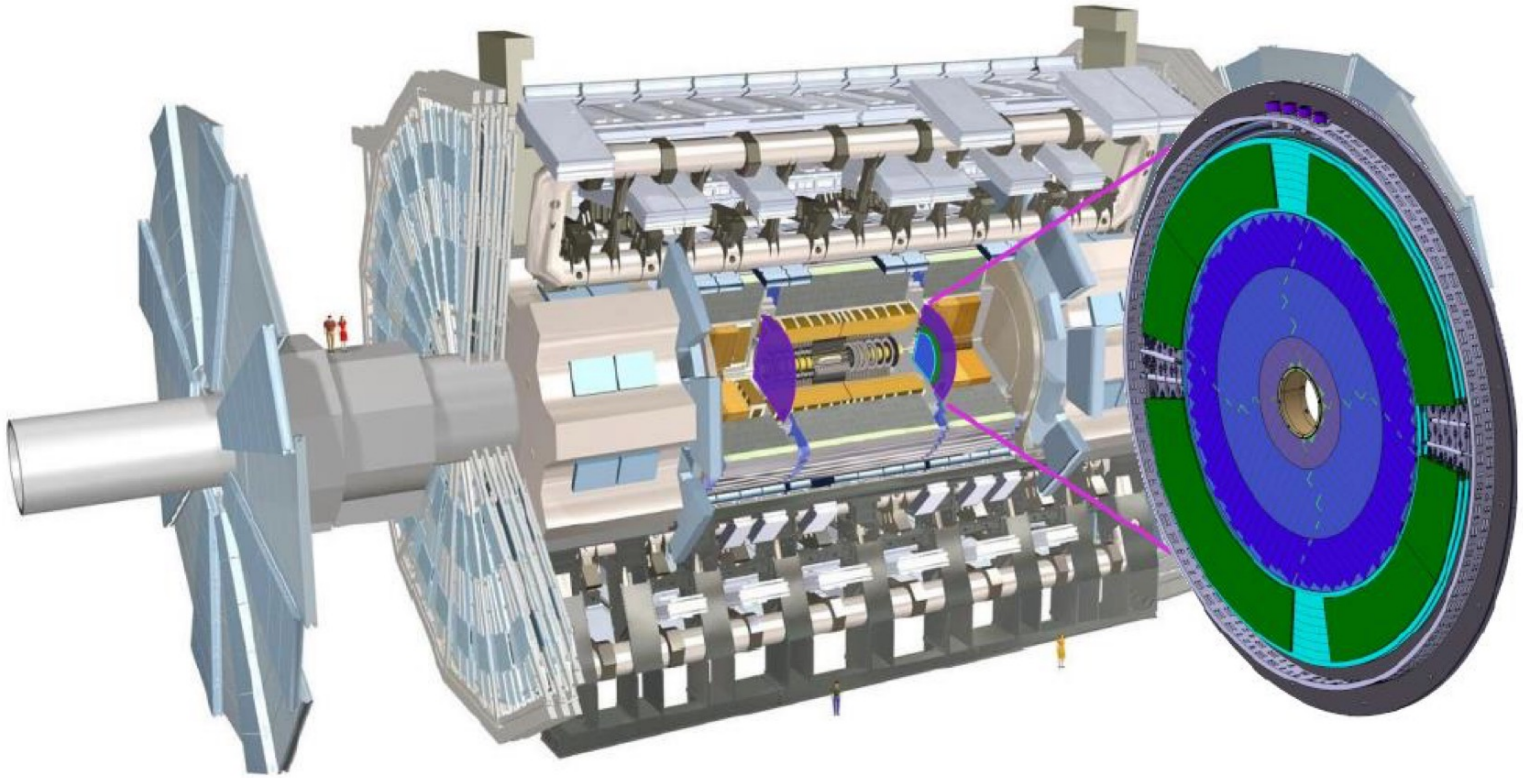
FLX-181: FELIX card for Phase-II

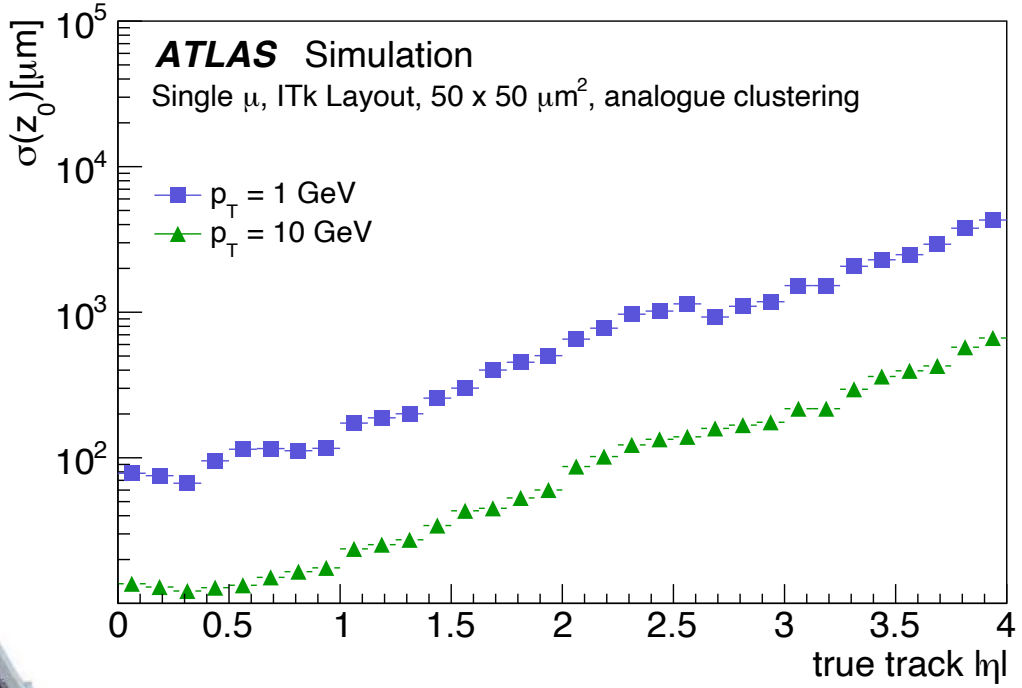
High Granularity Timing Detector

Bring up 4D information (tens of ps) to zoom in the single event picture:

Reduce pileup in forward region complementing ITk

Enhance performance of physics object reconstruction





Nikhef

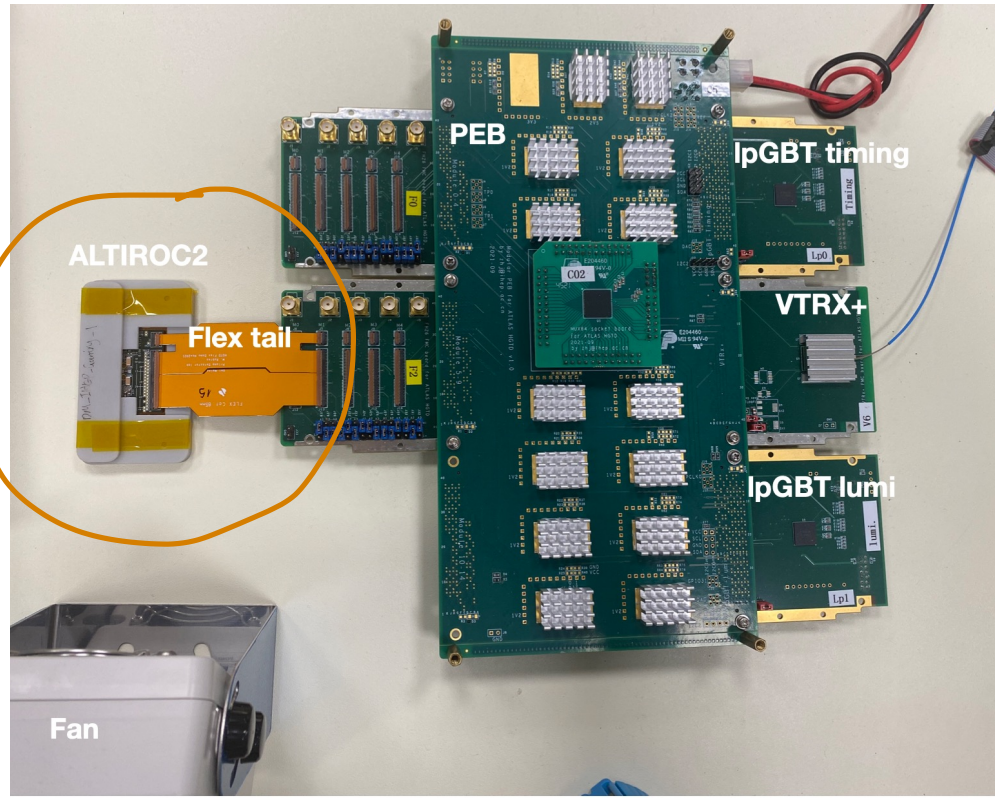
ATLAS Coordinator roles:

Electronics - Frank

DAQ/Lumi/Control - Mengqing

High Granularity Timing Detector HGTD

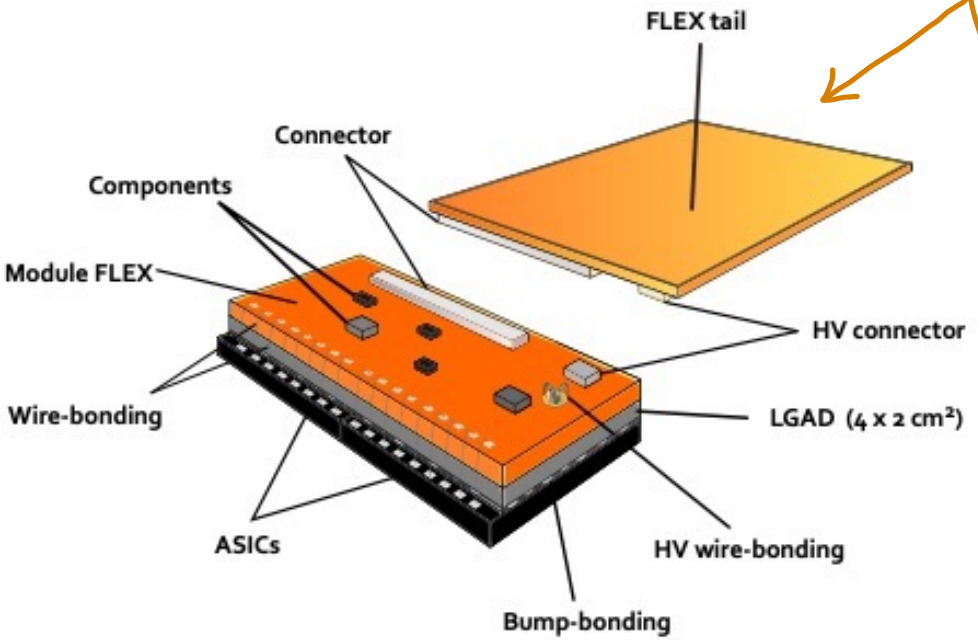
DAQ demonstrator at CERN



Nikhef

DAQ development: Demonstrator
test beam + data analysis
simulation of signal digitization

Full Demonstrator test at the end of 2023



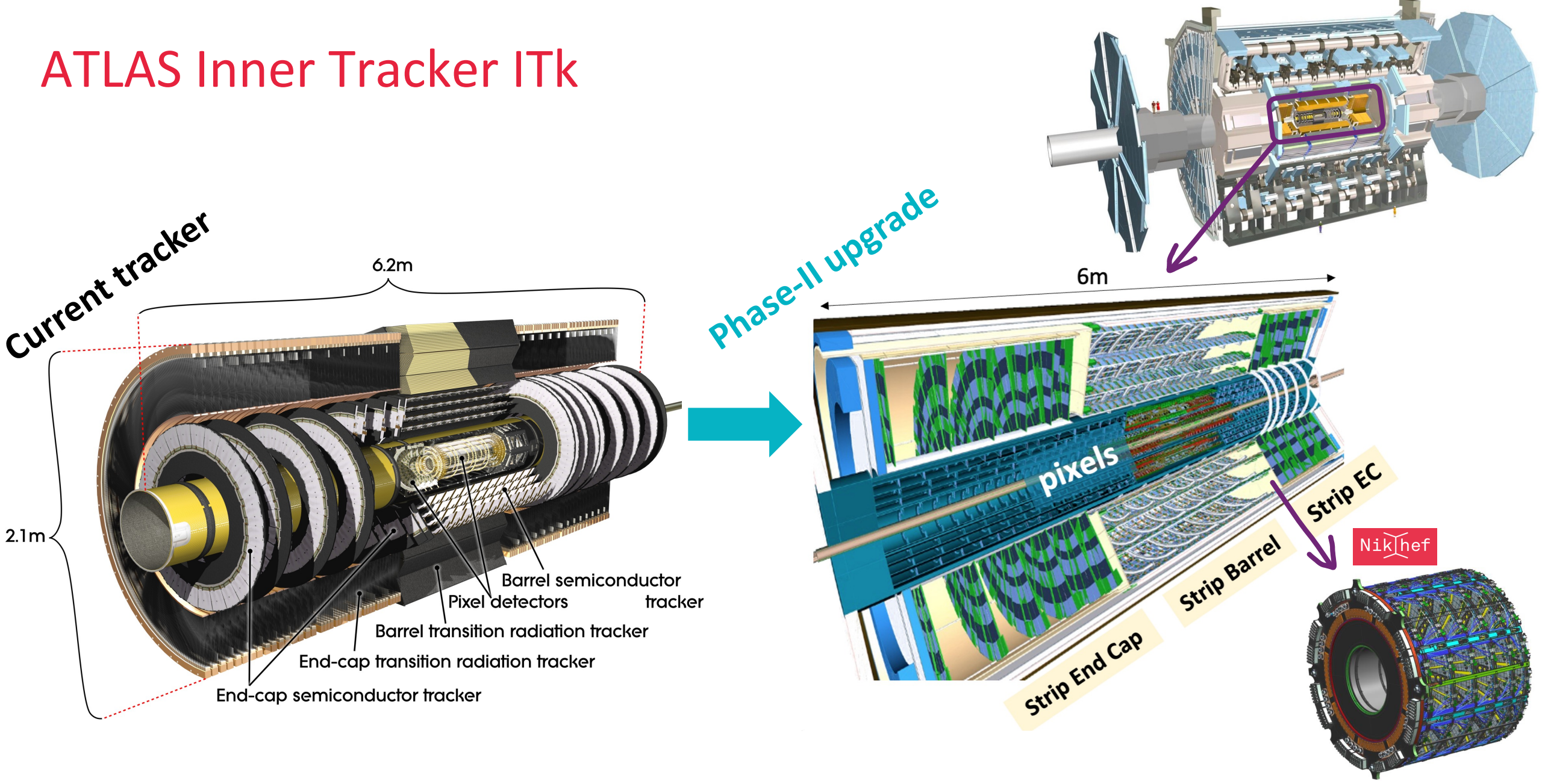
15 x 15-pad sensors,
1.3 x 1.3 mm^2 LGAD pads
4 measurement layers,

ALTIROC ASIC:
Time Of Arrival (20 ps bins)
Time Over Threshold (120 ps bins)

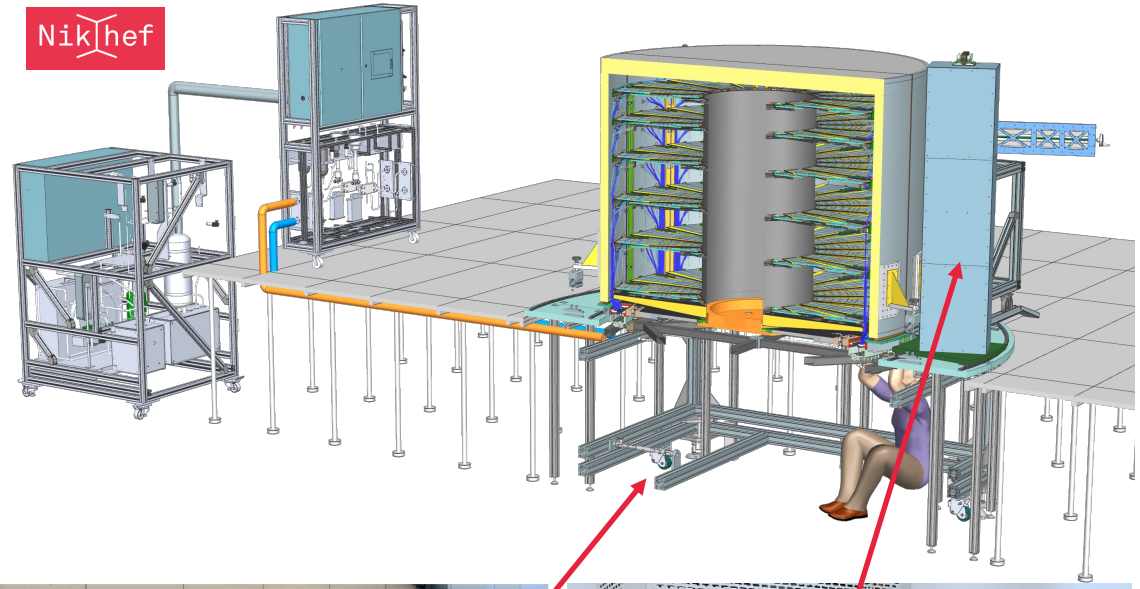
Nikhef

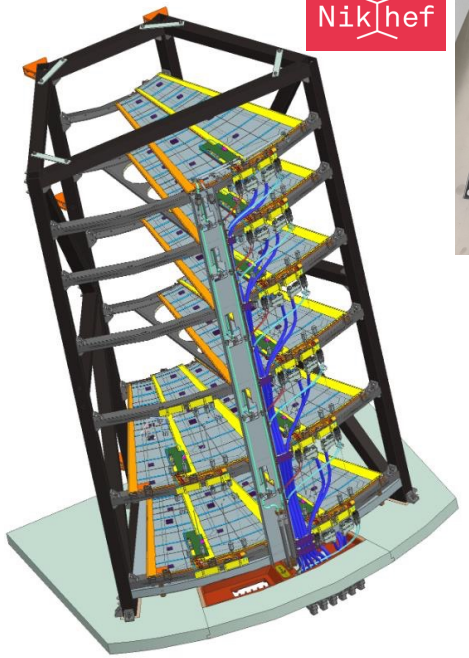
Test/debug readout: DONE
Develop HGTD DAQ s/w: in progress

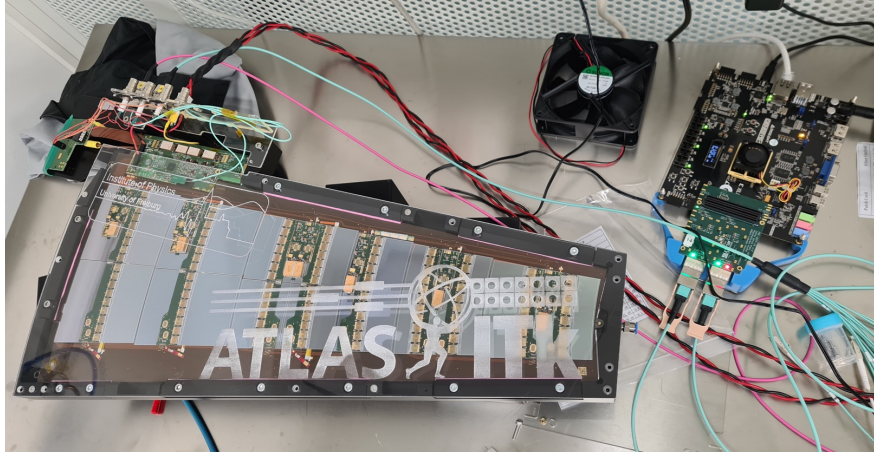
ATLAS Inner Tracker ITk

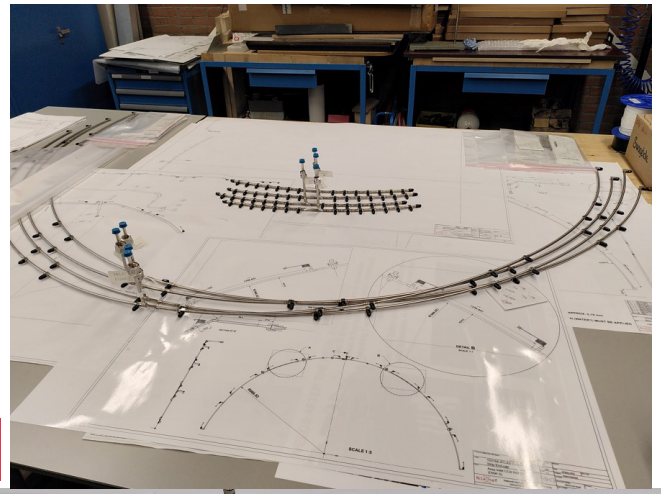


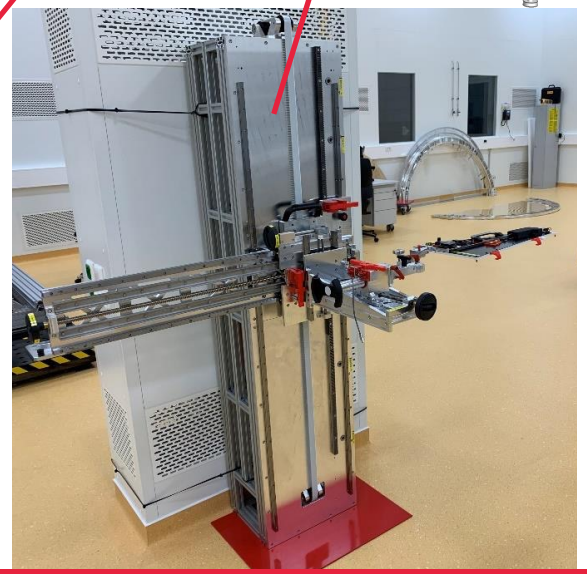
ITk End-caps. Integration & installation

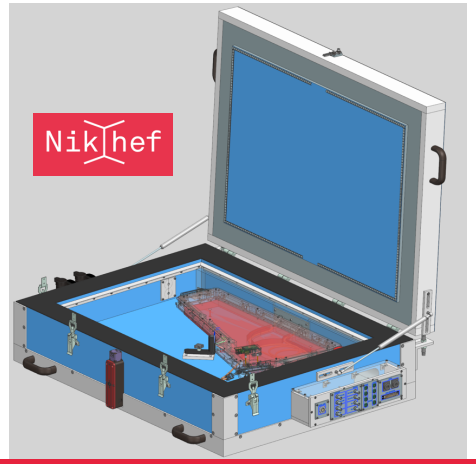


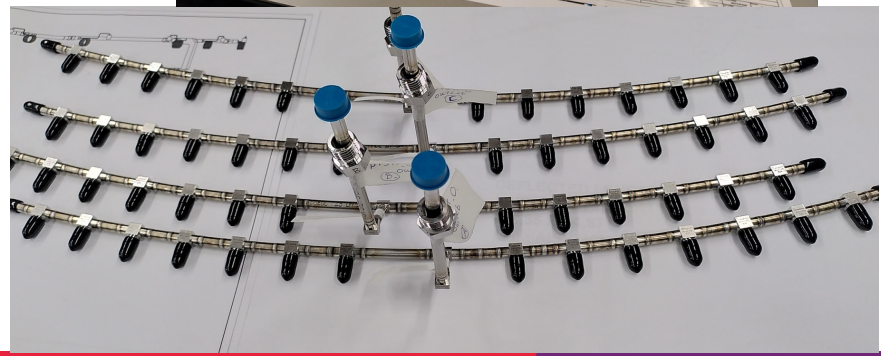




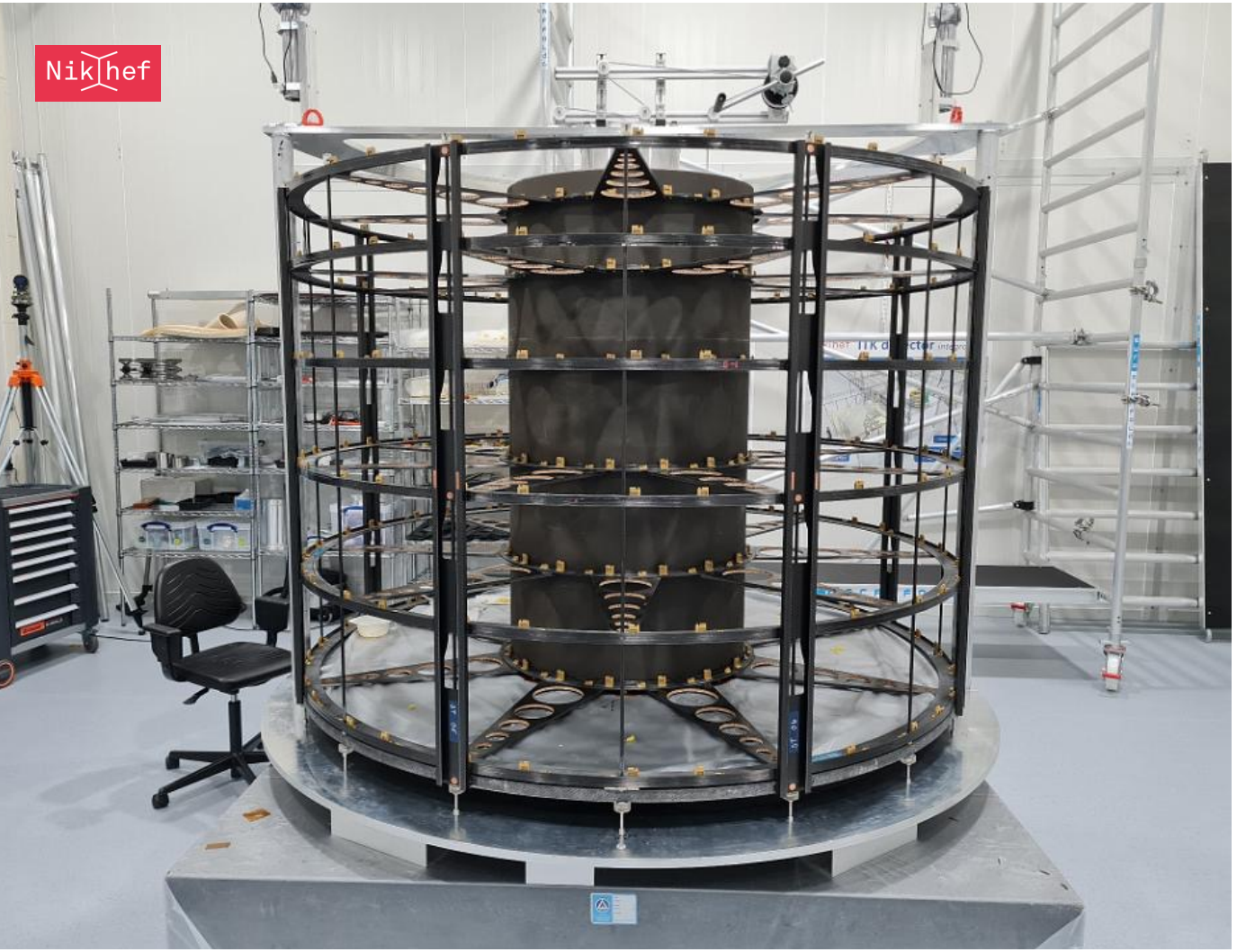


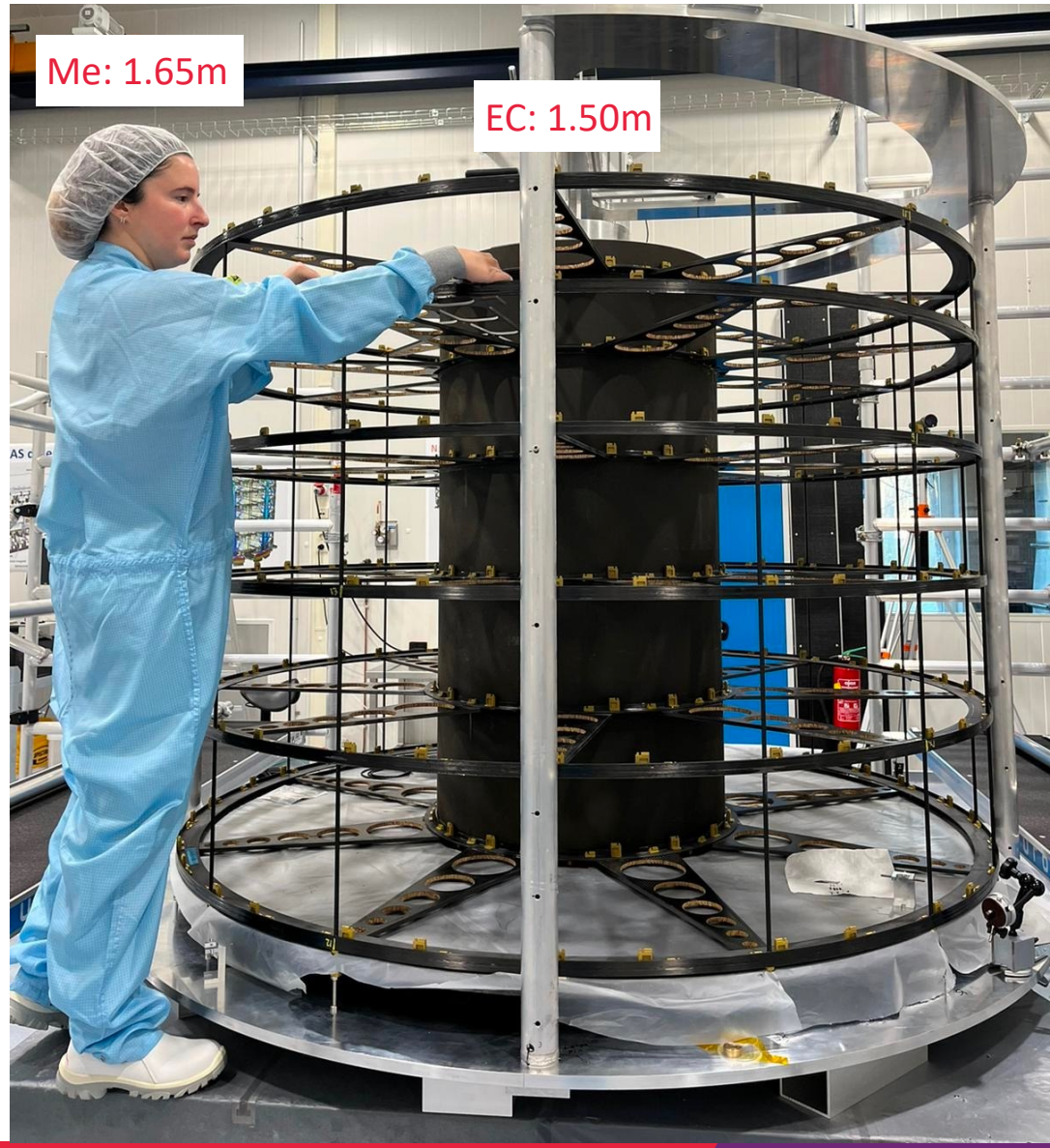






ITk End-caps. Integration & installation





At Nikhef, the construction of the 1st end-cap structure is finished

CONCLUSION

Making great progress contributing to the ATLAS upgrade towards LHC Run 4

THANKS FOR YOUR ATTENTION

aalonso@nikhef.nl

BACKUP

Upgrade to HL-LHC

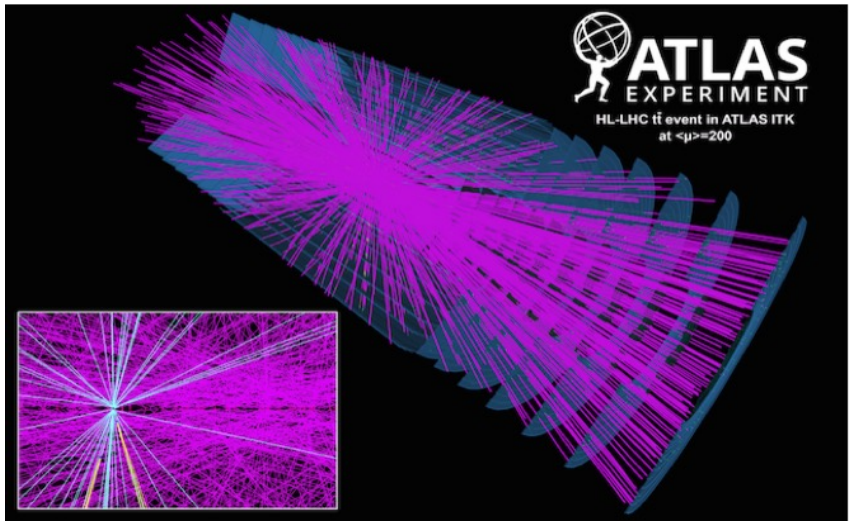
In the High-Luminosity LHC, particle densities and radiation levels will exceed current levels by a factor of 10

Instantaneous luminosity will reach unprecedented values: 7×10^{34} s^{-1} cm^{-2}, up to 200 p-p interactions per bunch crossing

The ATLAS detector will operate after exposure to large particle fluences

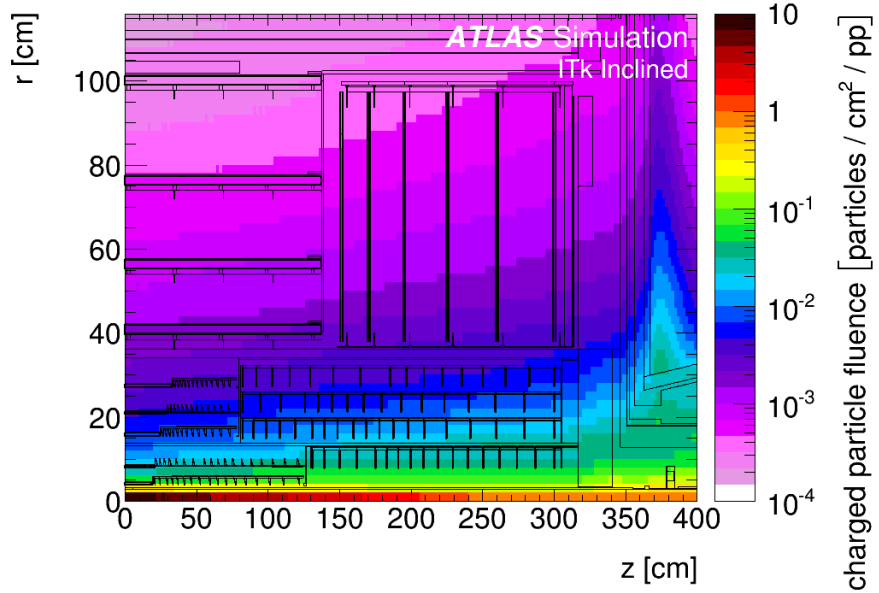
Upgrading is required to guarantee a working detector in these conditions

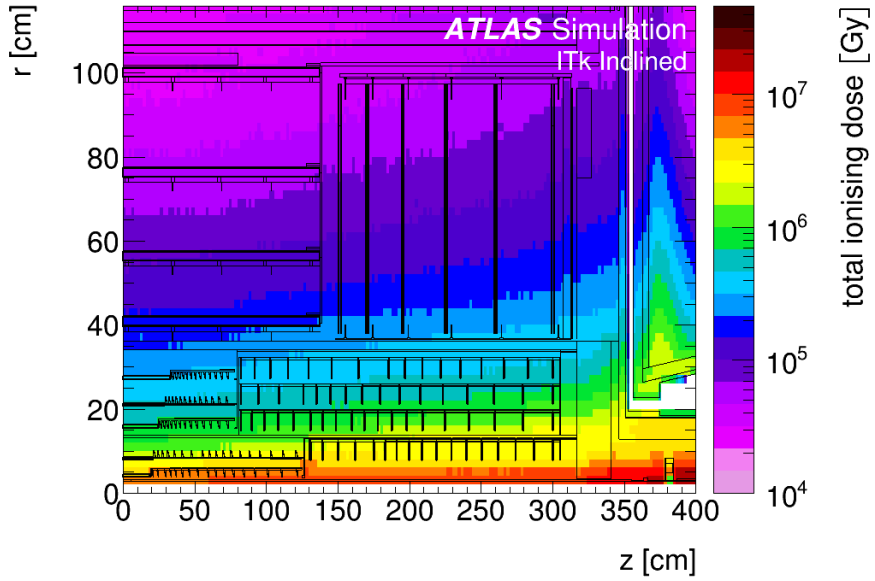
The current tracking detector will be completely replaced to deal with the unprecedentedly high levels of radiation and pile-up of the collider



Proton-proton collision in the future ATLAS inner tracker, during HL-LHC

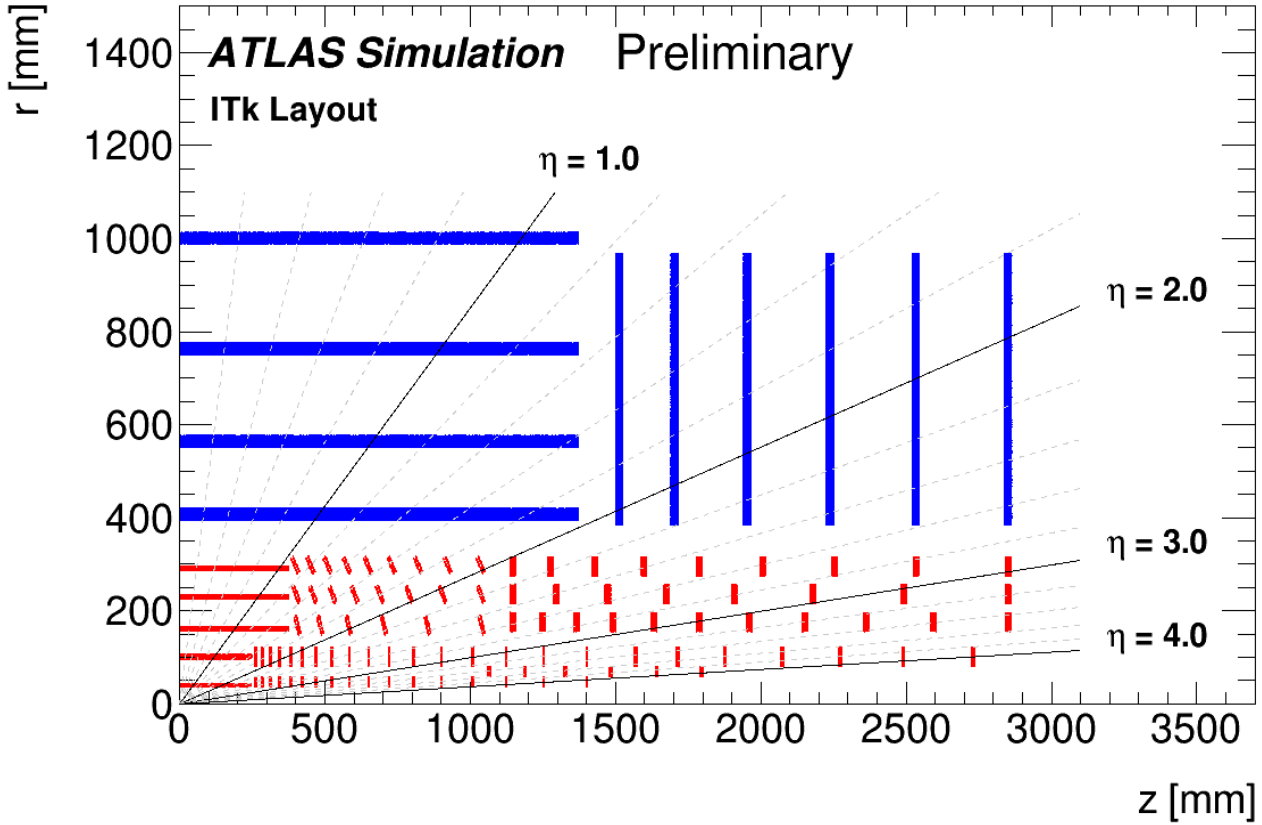
Plot from: Technical Design Report for the ATLAS Inner Tracker Strip Detector. ATLAS-TDR-025

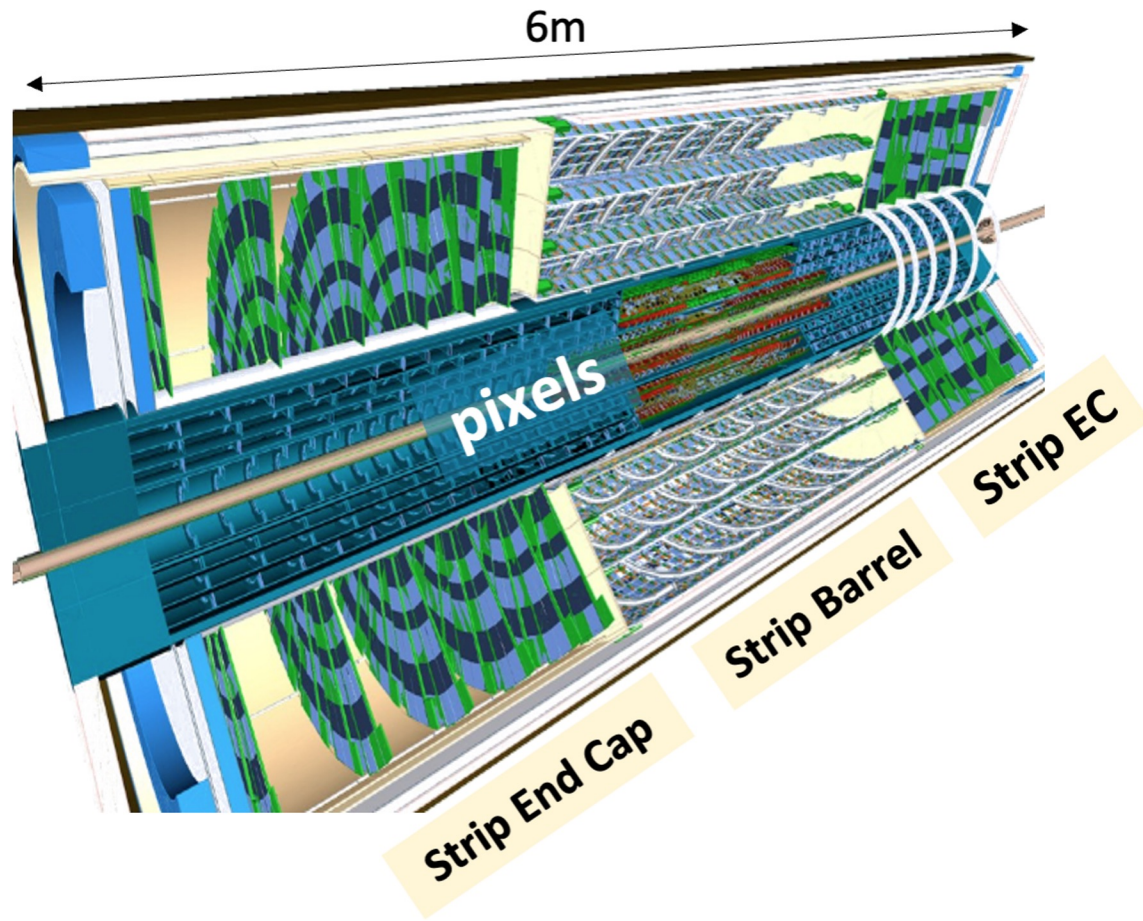




ATLAS ITk

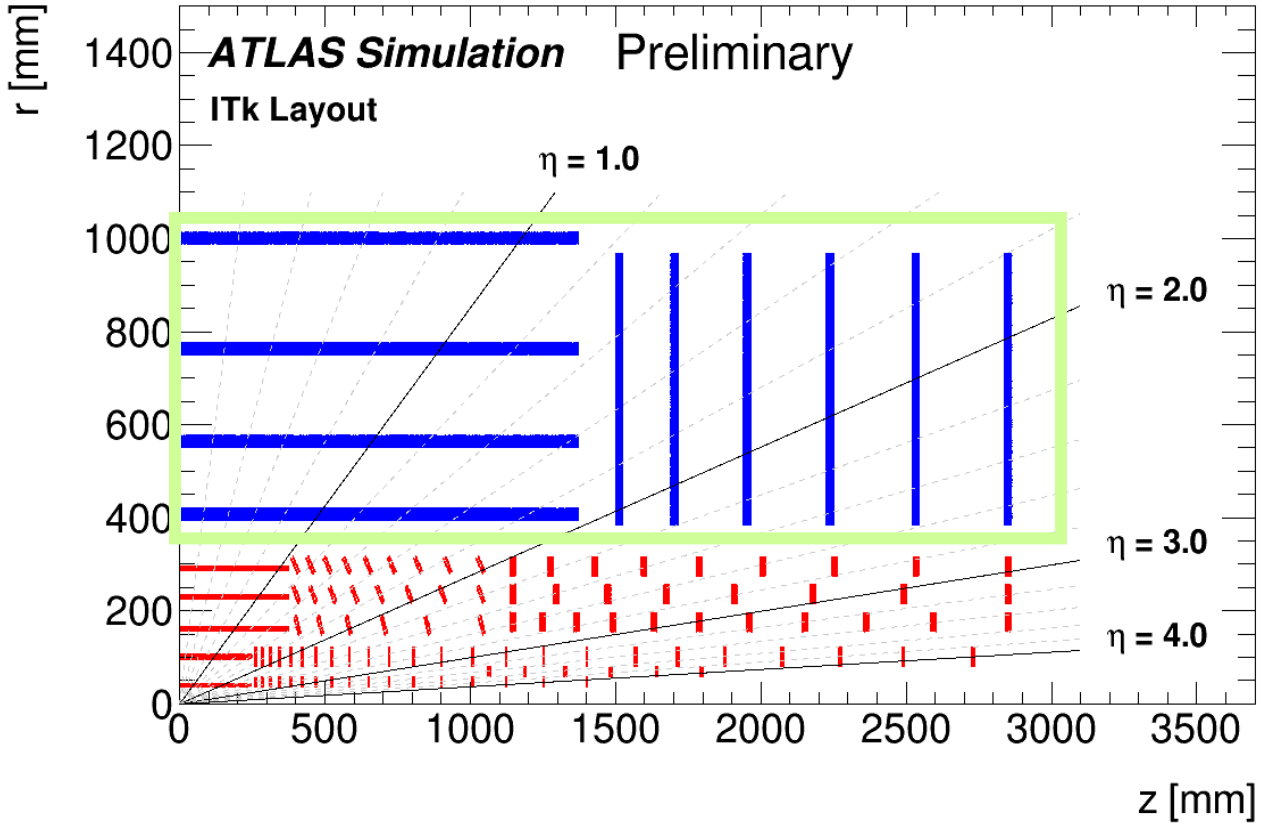
The *Inner Tracker* (ITk) will be a full-silicon detector with pixel (inner radii) and strip (outer radii) sensors
The ITk is divided in a central region called *Barrel* and two lateral wheels called *End-caps*

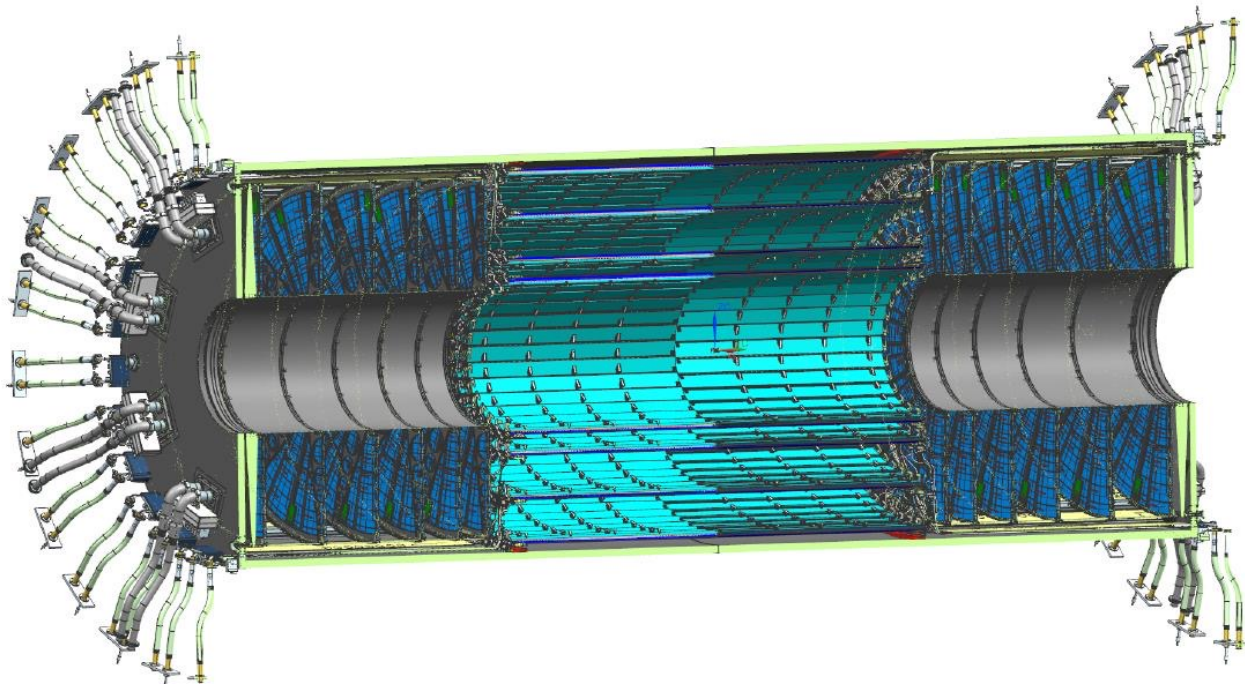




ATLAS ITk: the strip detector

The ITk-Strip detector covers pseudorapidity (η) range of $|\eta| < 2.7$
About 18,000 modules and 60 M strip channels



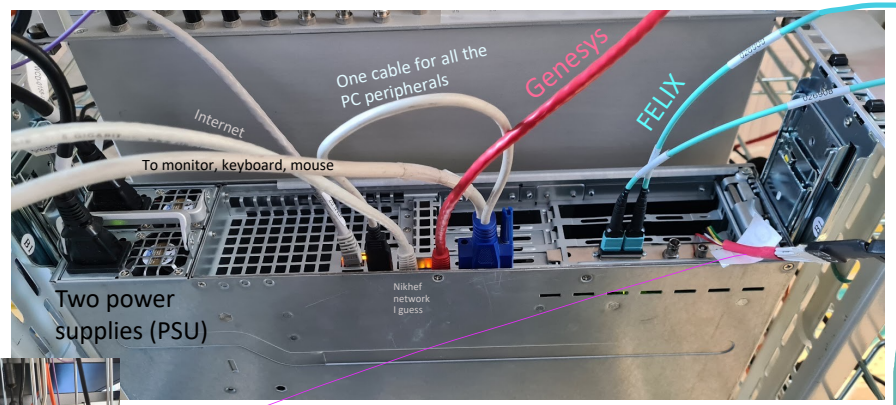


More info about the pixel detector in the ATLAS ITk Pixel Detector talk by Leonardo Vannoli

DAQ activities. FELIX

- The module is an old R0 barrel without AMAC chip, with one HCC star and one ABC star
- Communication is reached, links are aligned, all dependencies for scans are working in the ITk-server
- readout hybrids with
  - front-end chips (ABCStar)
  - Hybrid Controller Chip (HCCStar)
- Autonomous Monitor And Control ASIC (AMAC) (for control and monitoring)

ITk-server



To this common computer for flashing firmware to the FELIX card