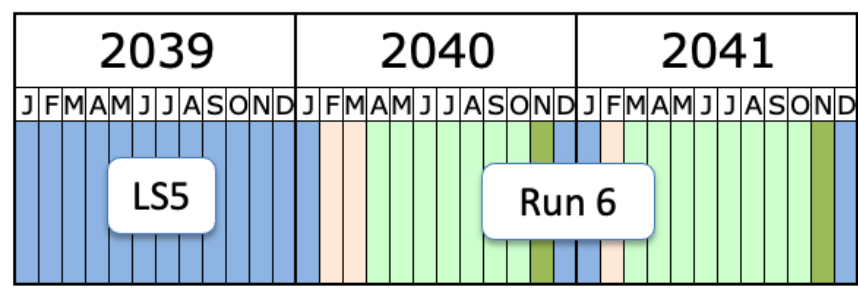
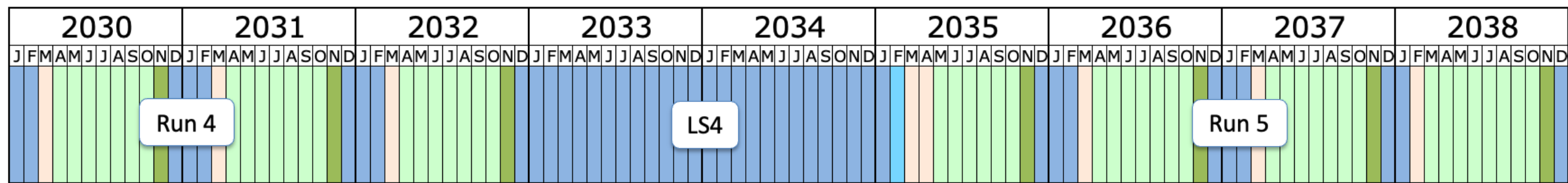
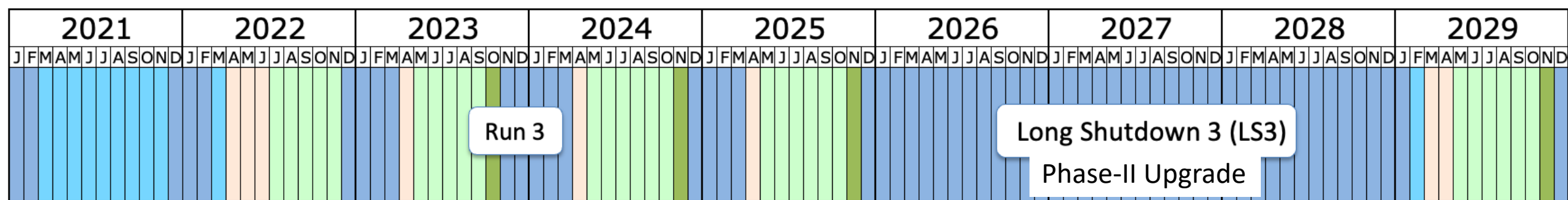


The ATLAS ITk Strip Detector System for the Phase-II LHC Upgrade

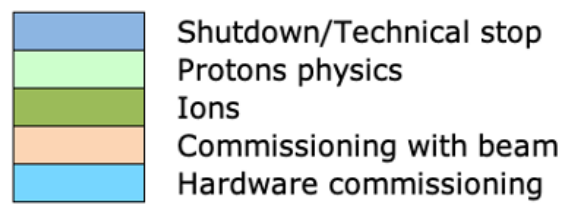
Seth Zenz, on behalf of the ITk Strip Community
8 September 2023

Overview

- High Luminosity HLC (HL-LHC)
- ATLAS Inner Tracker Upgrade (ITk)
- Sensors, Modules, Detector Layout
- Services, Cooling, Readout
- System Tests and Integration
- Production Status



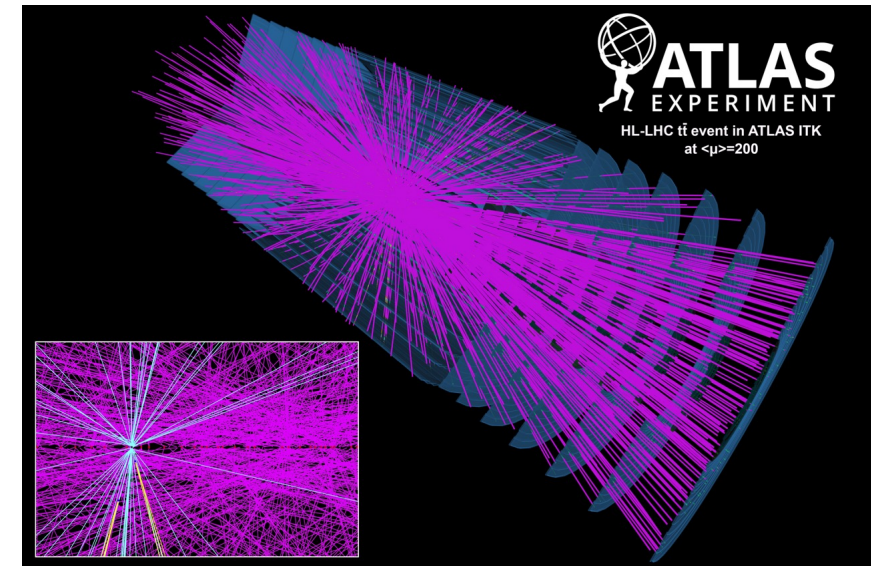
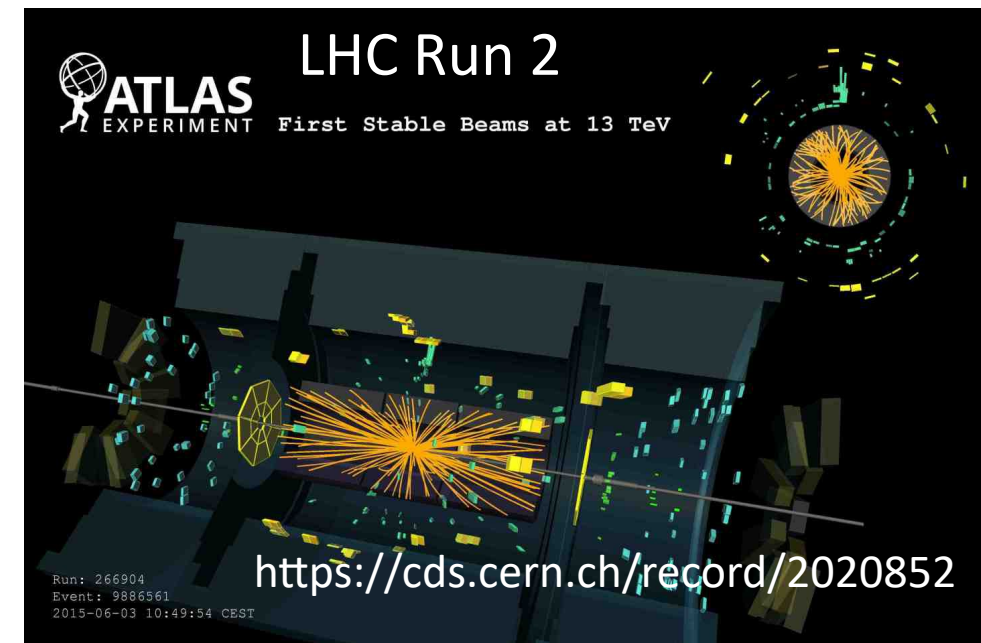
The LHC Programme



Last update: April 2023

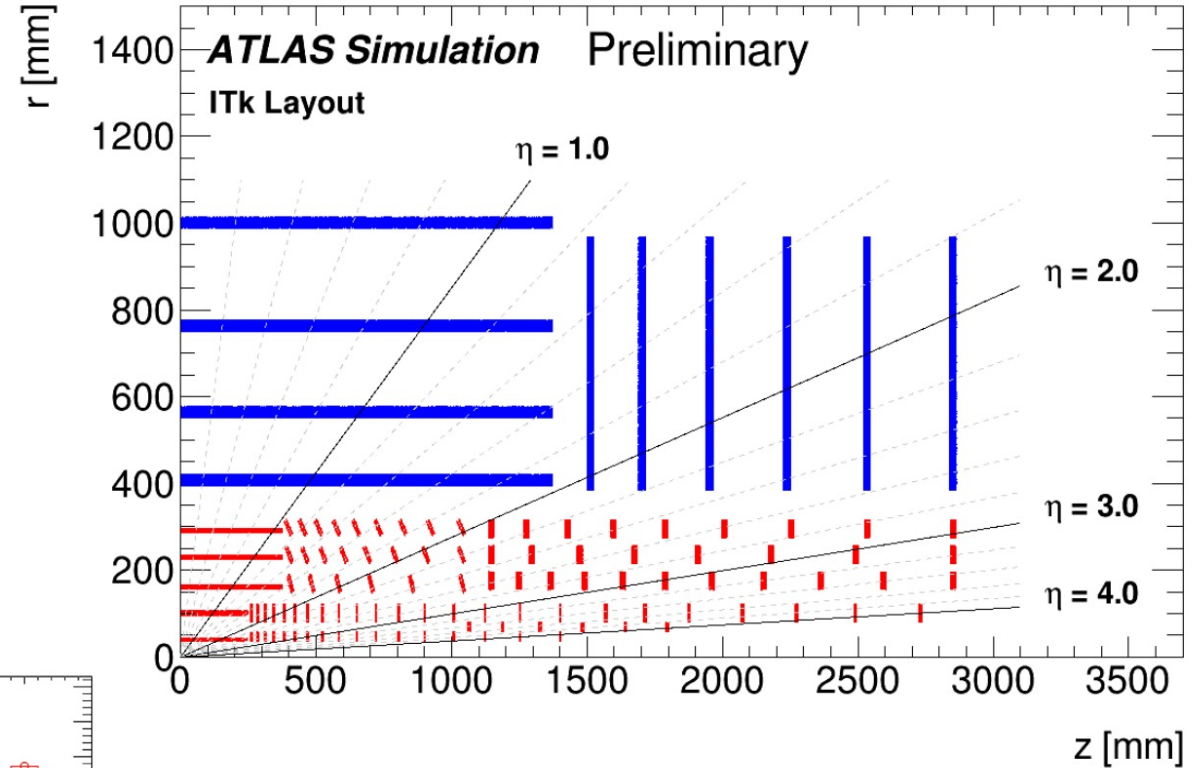
High Luminosity LHC

- Instantaneous Lumi. up to $7.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
- Integrated Lumi. up to 4000 fb^{-1} (10x)
- Energy 13.6-14.0 TeV
- 200 collisions / bunch crossing

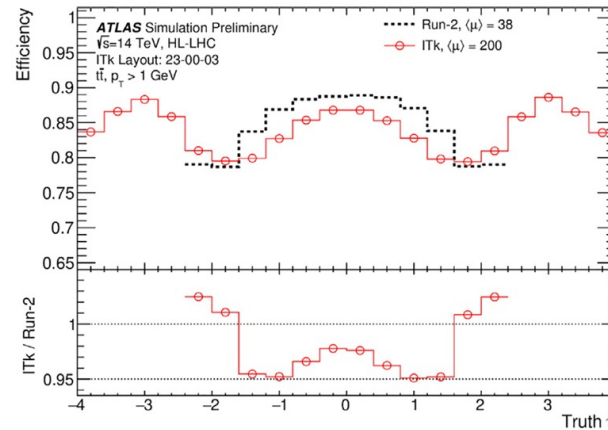
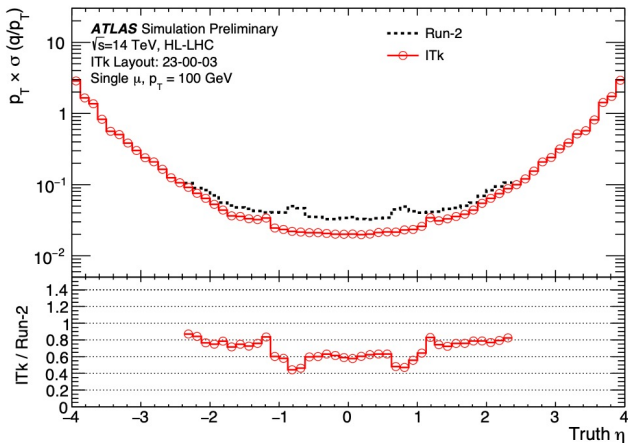


ATLAS ITk

- Full Silicon Detector
 - High radiation tolerance
 - Fine granularity
 - Faster response
 - More channels
 - Reduced tracking volume material

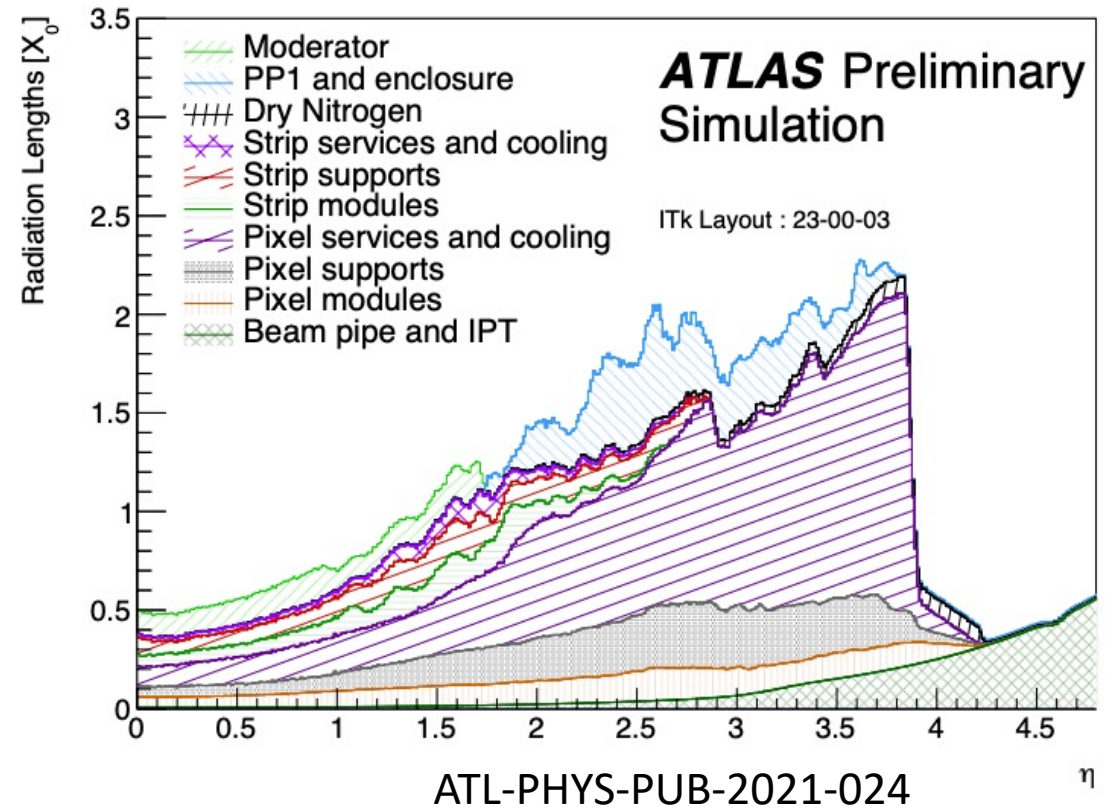
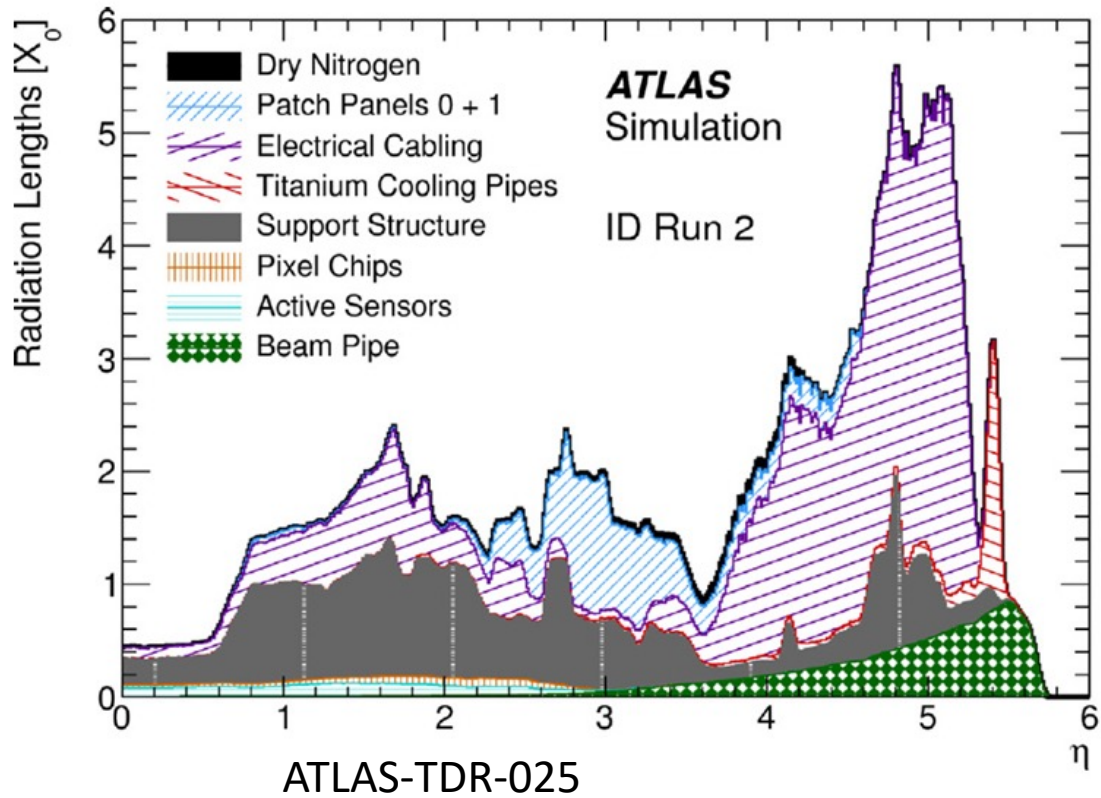


ATLAS ITk Pixel Overview, M Togawa, Mon 4 Sep

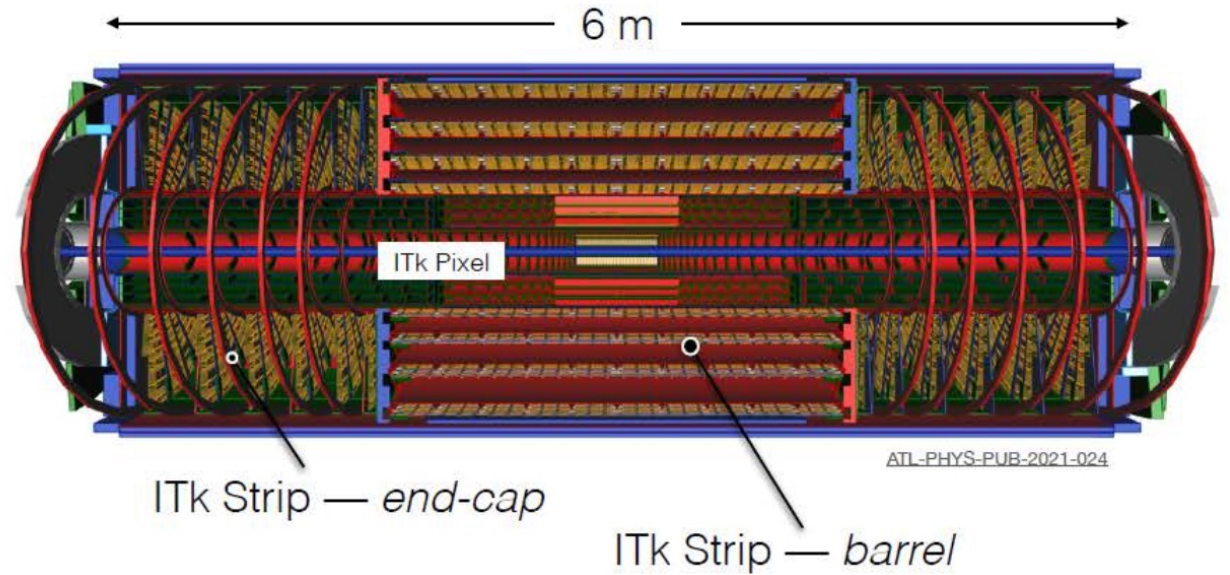
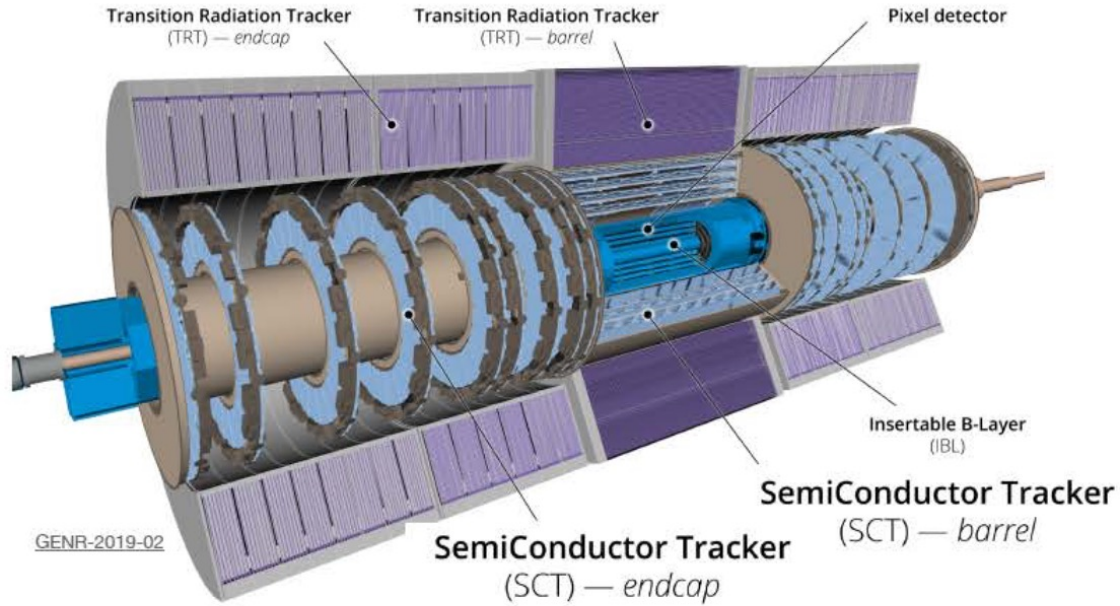


ATL-PHYS-PUB-2021-024

Left: Relative transverse momentum resolution as a function of η for 100 GeV muons without pileup, compared between the Run 2 detector the ITk
Right: Tracking efficiency for $t\bar{t}$ events at $\langle\mu\rangle=200$ with the ITk compared with the Run 2 detector at $\langle\mu\rangle=38$.



Radiation lengths vs. pseudorapidity for current detector (left) and ITk (right). Note different y axis scales.



- Inner Detector SCT (Strips)

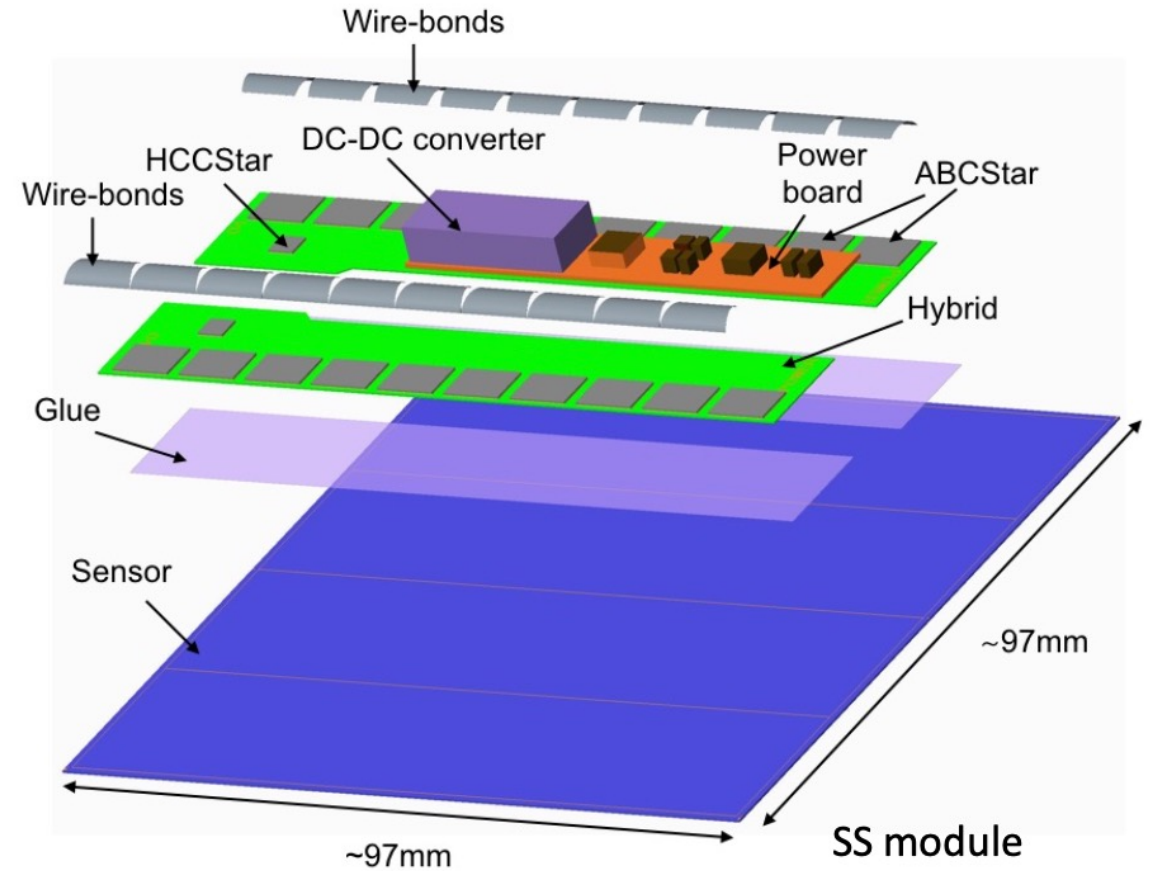
- 4088 sensors
- 61 m² of silicon
- Strip length: 12.8 cm
- 6 million strips
- Dose: up to 3.8 Mrad

- ITk Strips

- 17,888 sensors
- 165 m² of silicon
- Strip length: 1.4 – 6 cm
- 60 million strips
- Dose: up to 50 Mrad

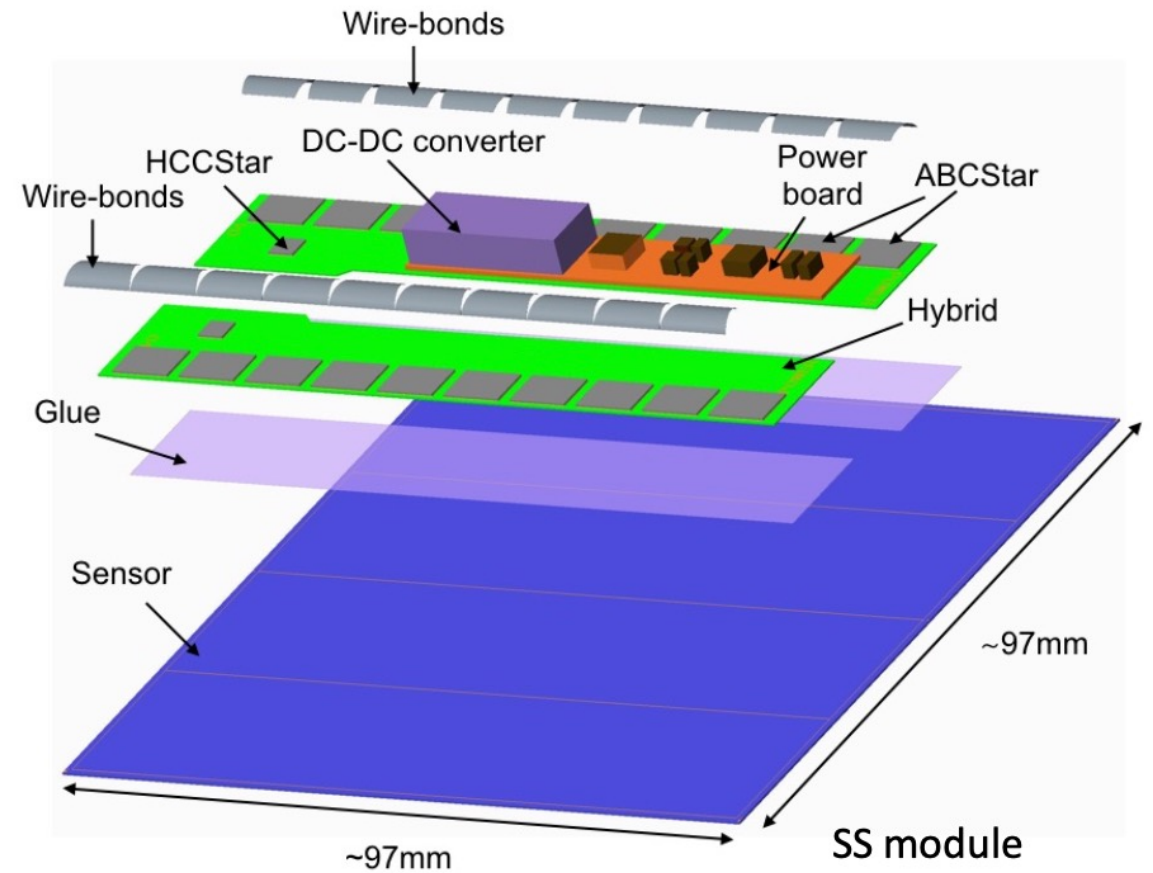
Sensors

- Barrel sensors – square geometry
 - Single sided microstrips
 - Sensor pitch $75.5\ \mu\text{m}$
 - Short strips (SS) 24.1 mm long
 - Long strips (LS): 48.3 mm long
- Endcap sensors: trapezoidal
 - 6 sensor geometries
 - Pitch 70-80 μm
 - Strip length: 15-60 mm depending on radius



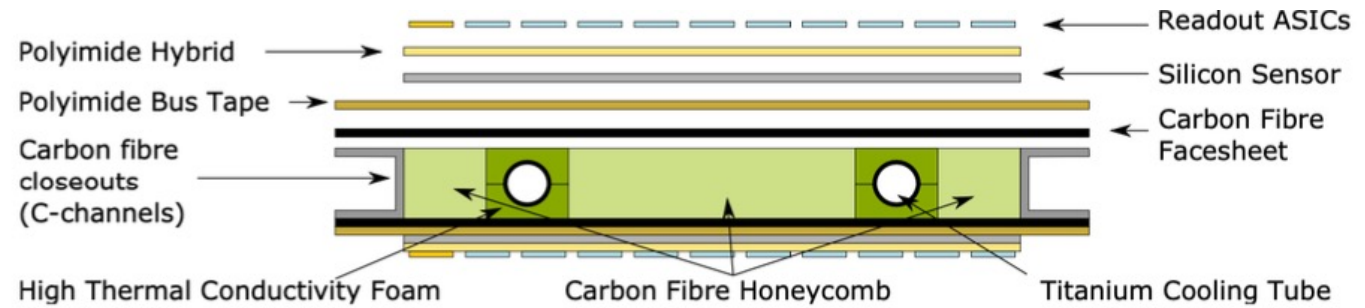
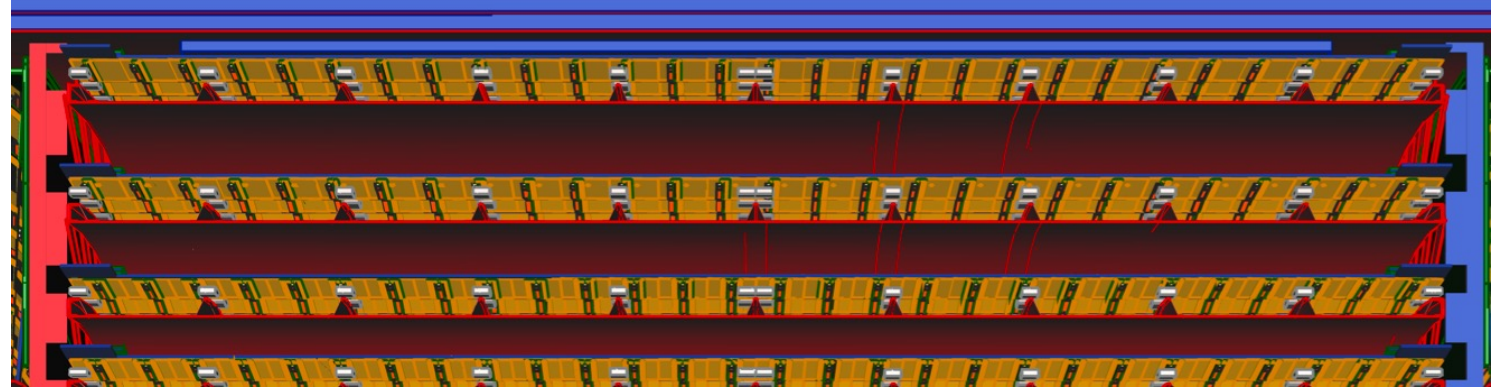
Modules

- Hybrid: Readout PCB
 - ATLAS Binary Readout chips (ABCStar)
 - Hybrid Controller Chips (HCCStar)
- Power Board:
 - Autonomous Monitor and Control Chip (AMAC)

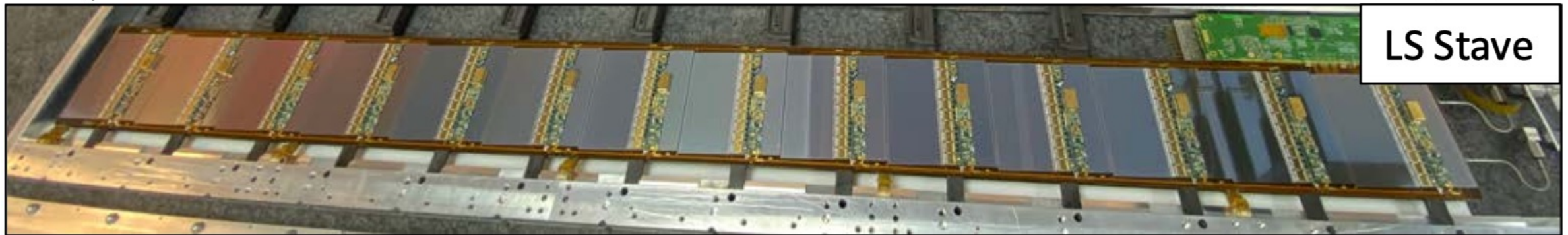


Barrel Staves

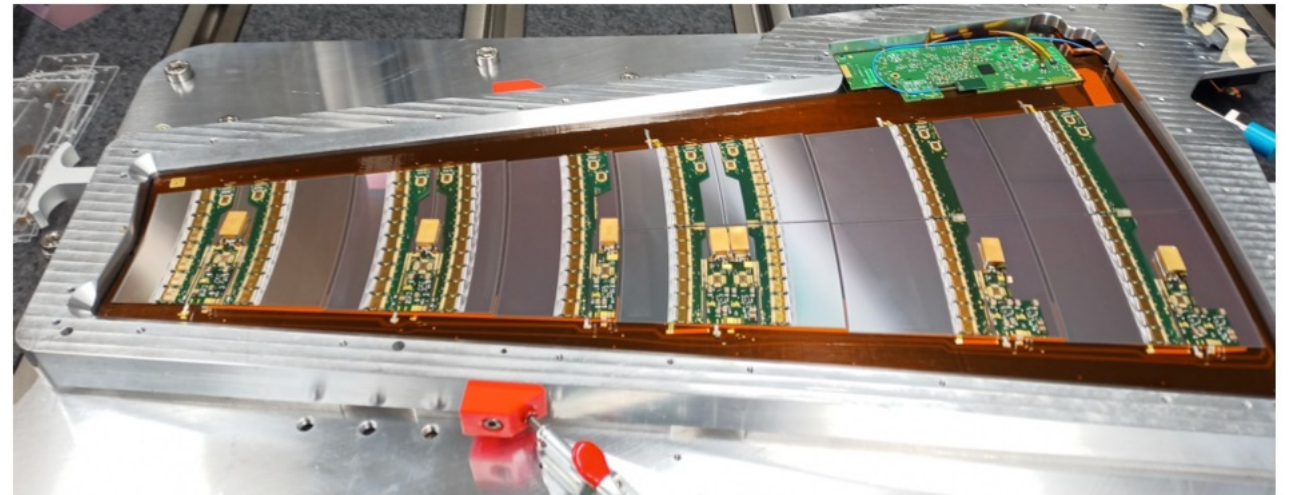
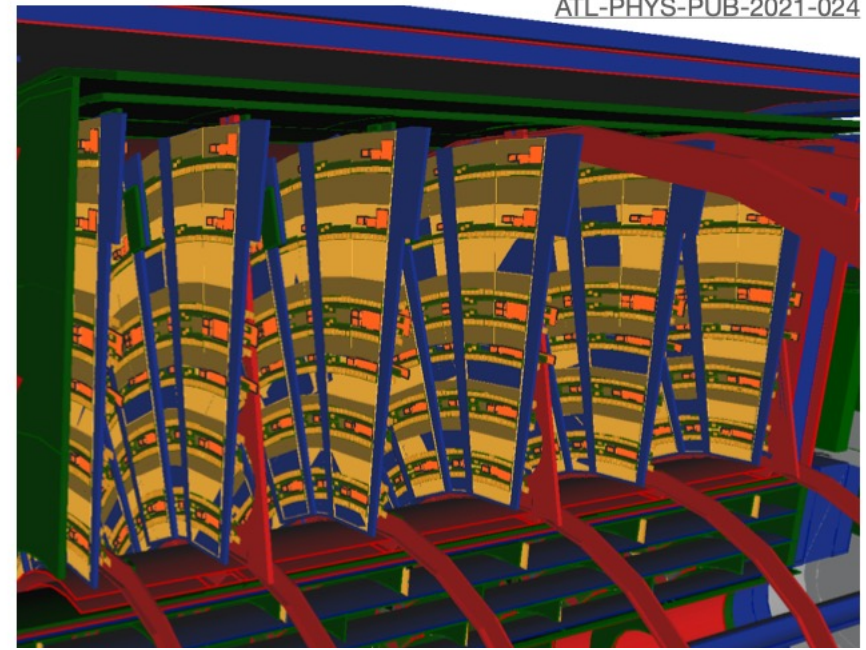
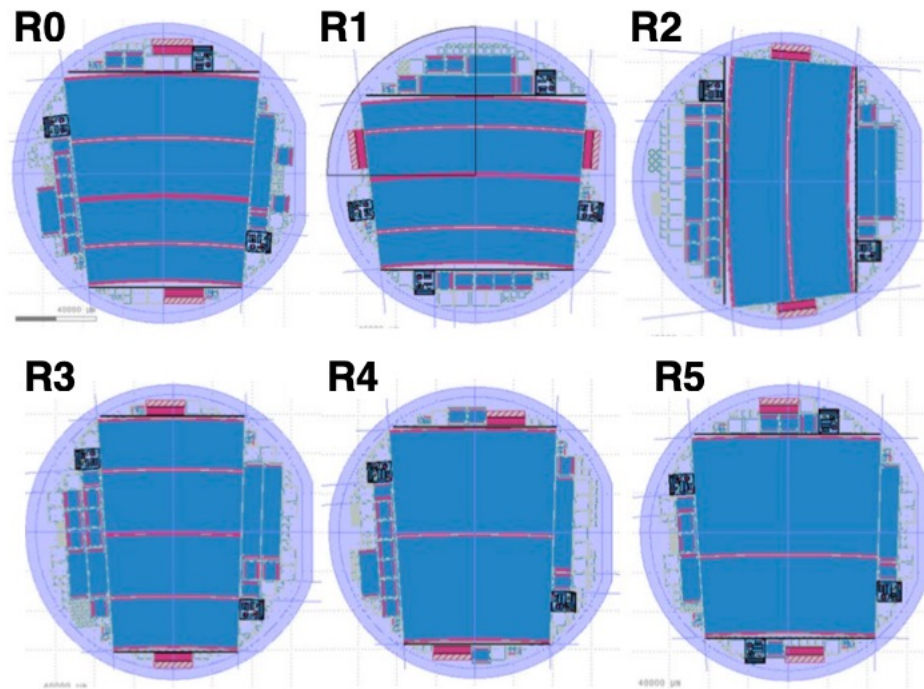
- LS: Outer 2 Layers
- SS: Inner 2 Layers



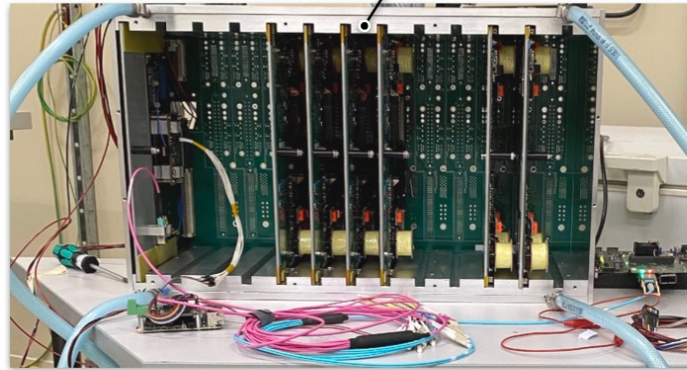
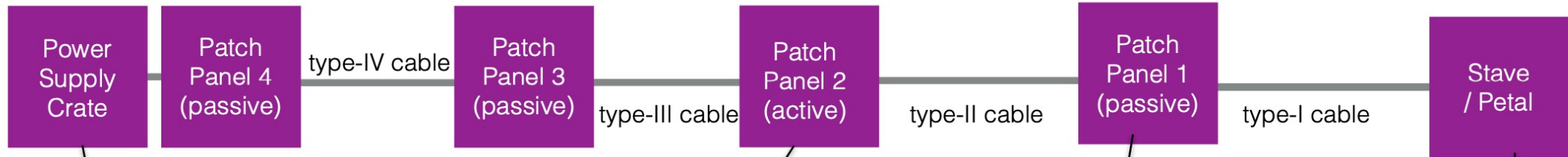
1.4m



Endcap Petals



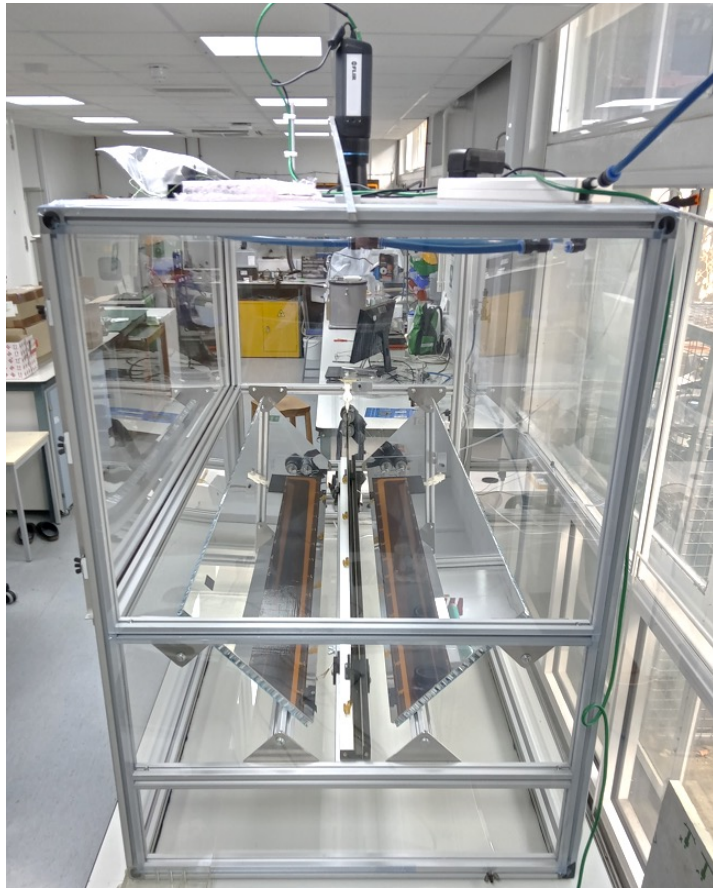
Powering Scheme



Cooling

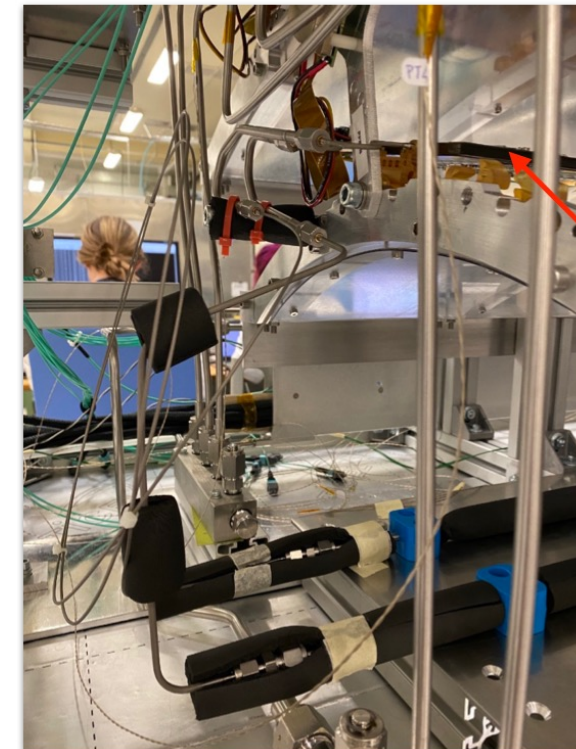
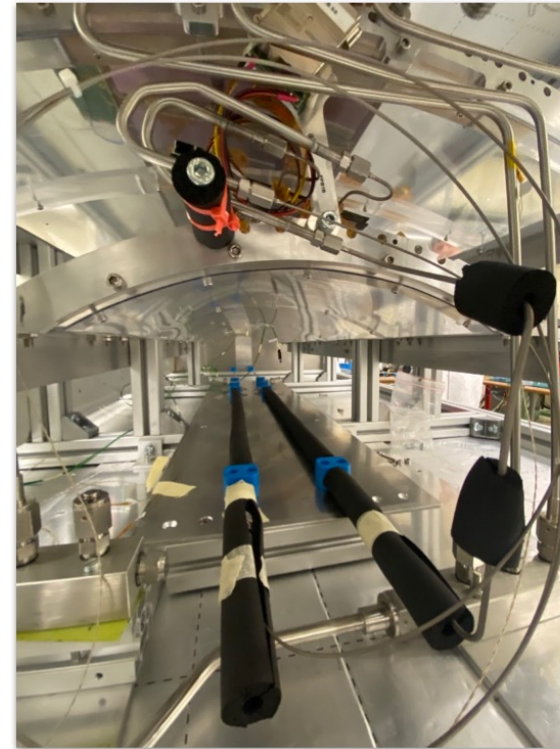
- Dual-phase CO₂ Cooling to -35°C

- Each Stave: 88W
- Each petal: 68W

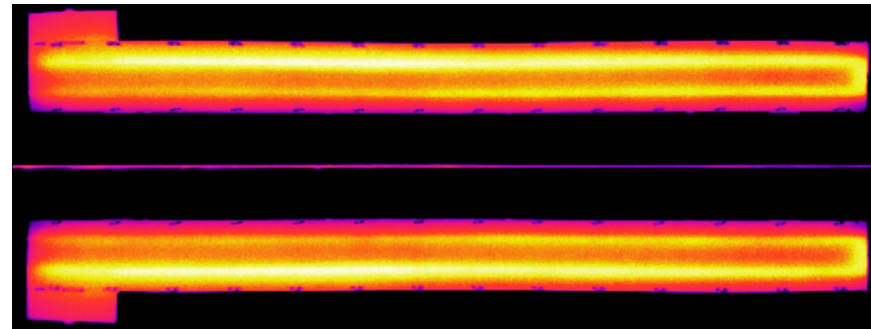


Stave core thermal measurement setup

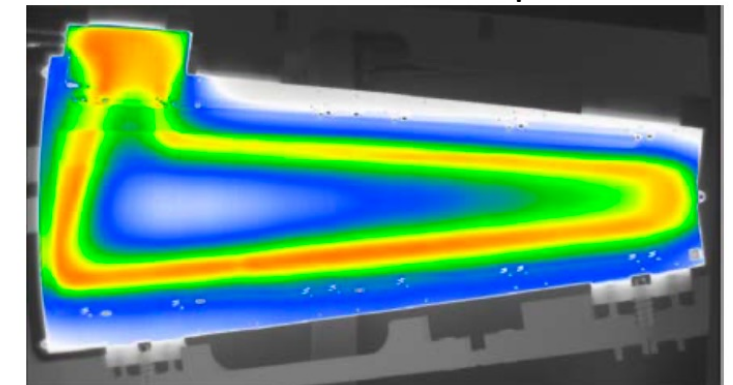
CO₂ cooling setup for single stave in system tests



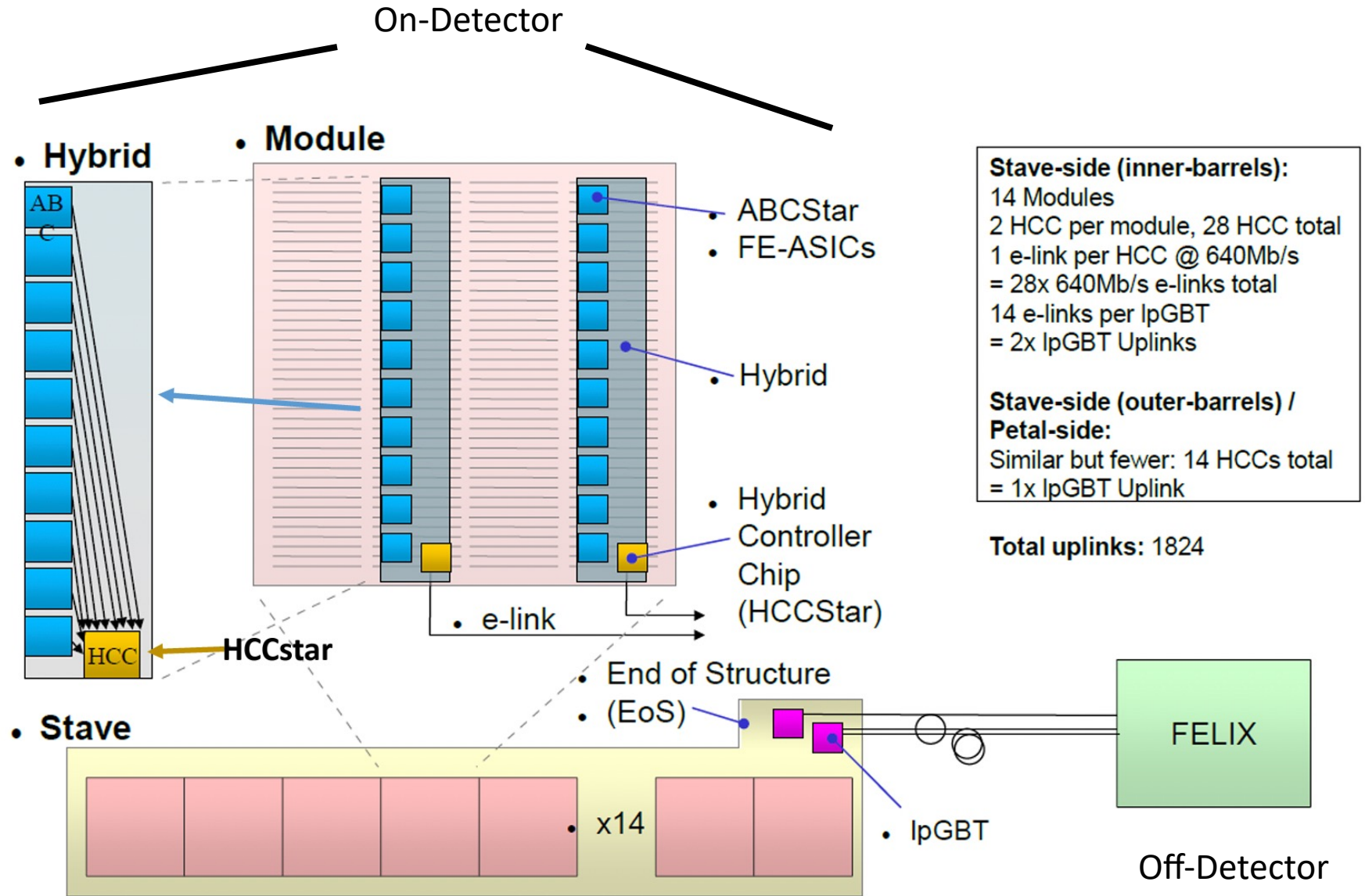
Stave core surface temperature



Petal core surface temperature



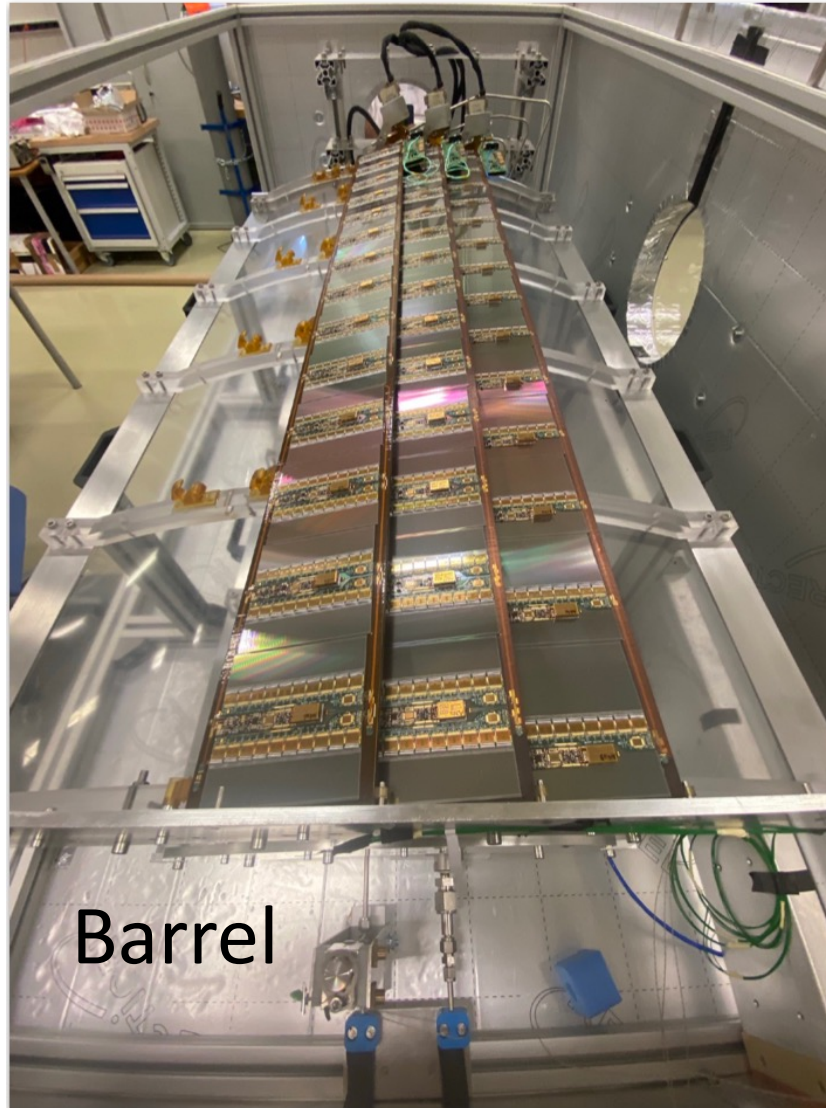
Readout



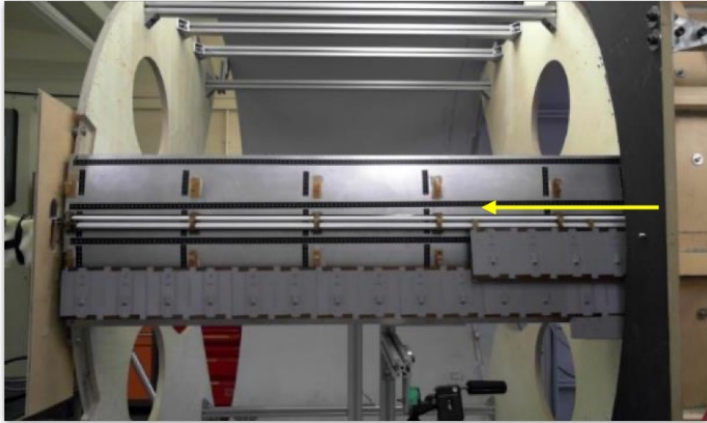
<https://indico.cern.ch/event/688153/contributions/2964638/>

System Tests

- Validate production chain of full system
 - Powering
 - Cooling
 - Readout
 - Control
- Barrel: majority of infrastructure in place, 1st cold tests done
- Endcap: mechanical, power, and cooling are ready, 1st petal in progress



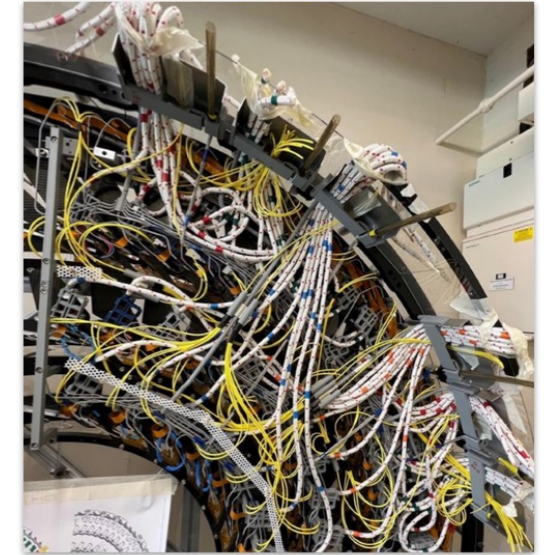
Stave Insertion Tooling



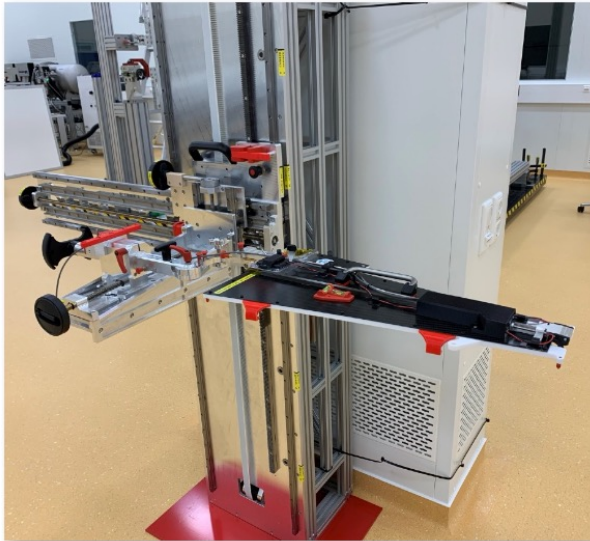
ITk integration area @ CERN



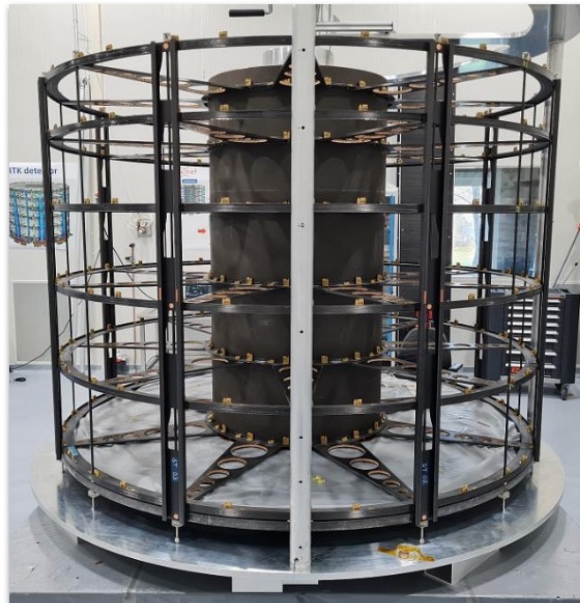
Barrel service module mockup
(Power, cooling, readout)



Petal Insertion Tooling



Construction of the 1st
end-cap structure



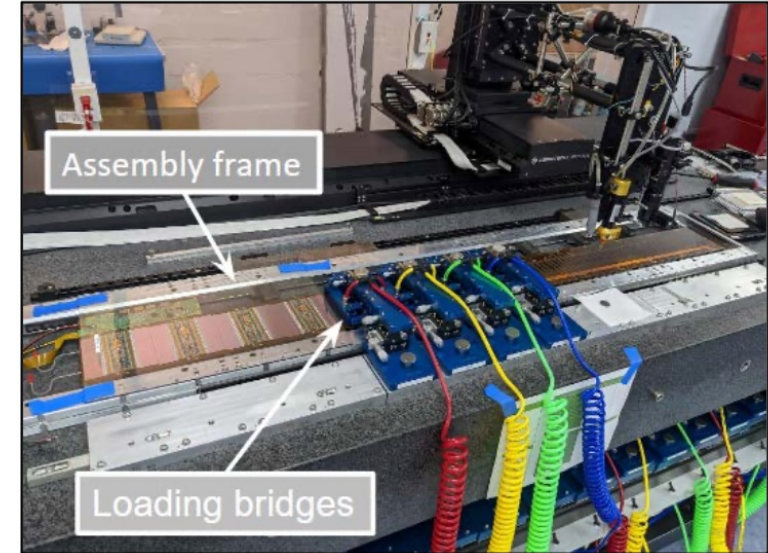
Barrel cylinder



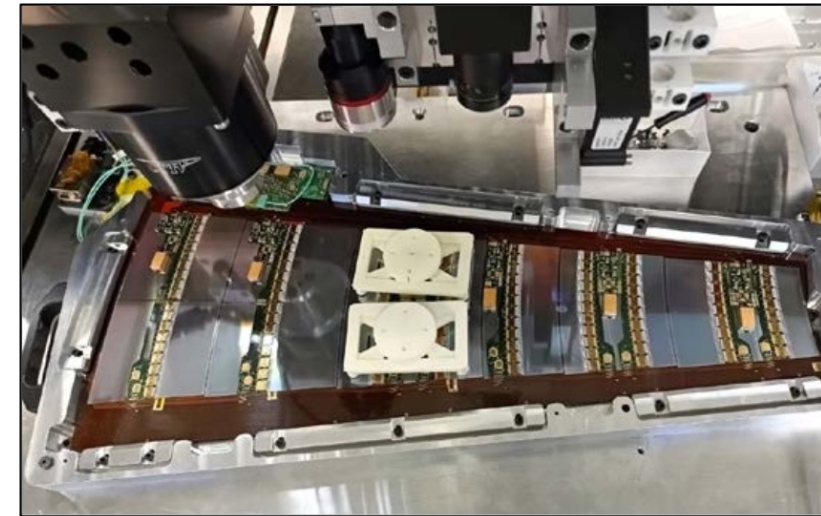
Production Status

- Sensors and Chips in Production
 - Over 50% of sensors received
 - Rate accelerating to catch up with schedule soon
 - Over 90% of ASICS received
- Modules Beginning Production
- Stave and Petal Loading: pre-production ongoing

Barrel Loading System

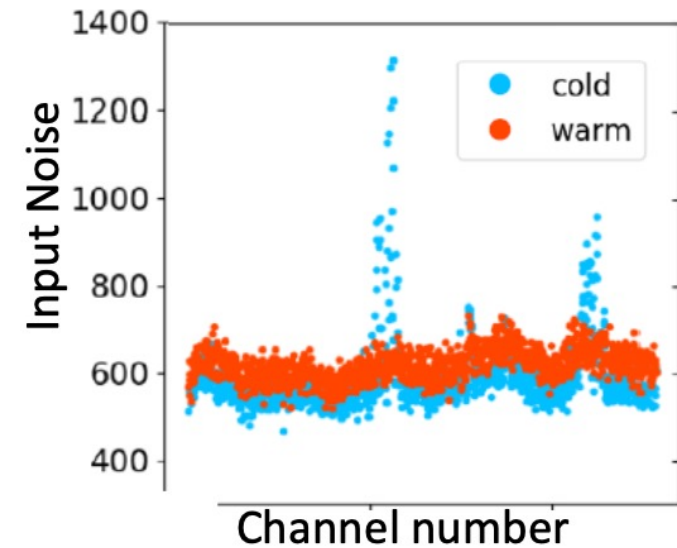


Endcap Loading System

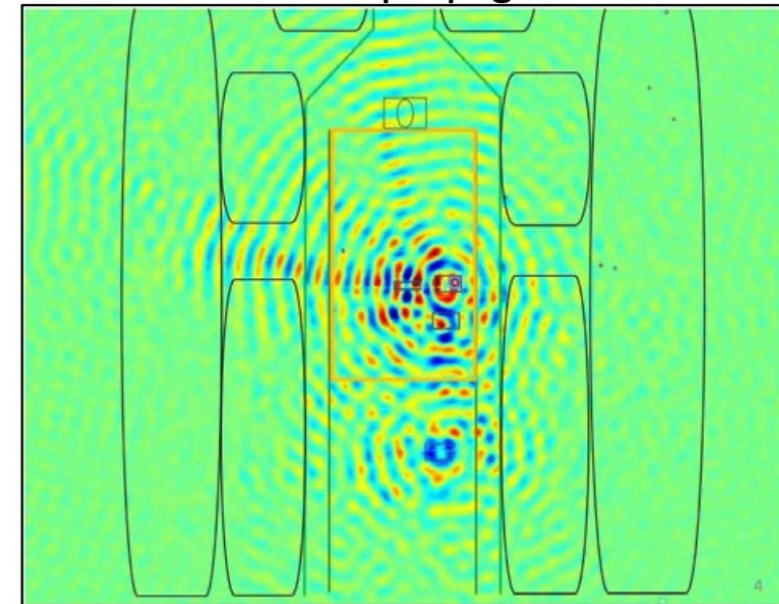


Cold Noise

- Recent challenge: increased noise observed during pre-production module QC at low temperatures ("Cold Noise")
- Year-long investigation revealed this is caused by mechanical vibrations in the powerboard
- Barrel LS modules: glue choice can prevent noise
- Barrel SS modules: under investigation
 - New powerboard? Thicker glue?
- Not present for endcaps



Vibration propagation



Conclusions

- ITk Strip Detector will provide excellent particle tracking in the extremely high density HL-LHC environment, maintaining or improving performance
- High granularity, radiation hardness, low material budget
- Many challenges overcome
- Production proceeding smoothly, on track for installation as part of the integrated ITk system in 2026-8