

# The Tracking Detector of the FASER Experiment

Presented by Savannah Shively, May 2022

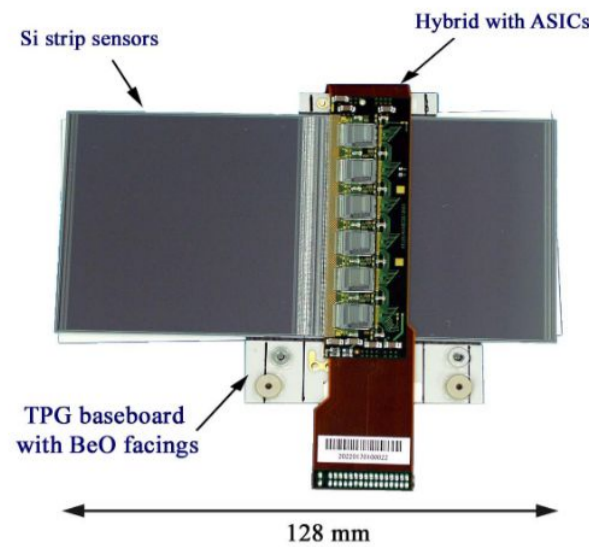
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 The Nancy and Corwin Evans Award

## Abstract

FASER is a new experiment designed to search for new light weakly-interacting long-lived particles (LLPs) and study high-energy neutrino interactions in the very forward region of the LHC collisions at CERN. The experimental apparatus is situated 480 m downstream of the ATLAS interaction-point aligned with the beam collision axis. The FASER detector includes four identical tracker stations constructed from silicon microstrip detectors. Three of the tracker stations form a tracking spectrometer, and enable FASER to detect the decay products of LLPs decaying inside the apparatus, whereas the fourth station is used for the neutrino analysis. The spectrometer has been installed in the LHC complex since March 2021, and the fourth station was installed in November 2021. FASER will start physics data taking when the LHC resumes operation in early 2022. This poster describes the design, construction and testing of the tracking spectrometer, including the associated components such as the mechanics, readout electronics, power supplies and cooling system.

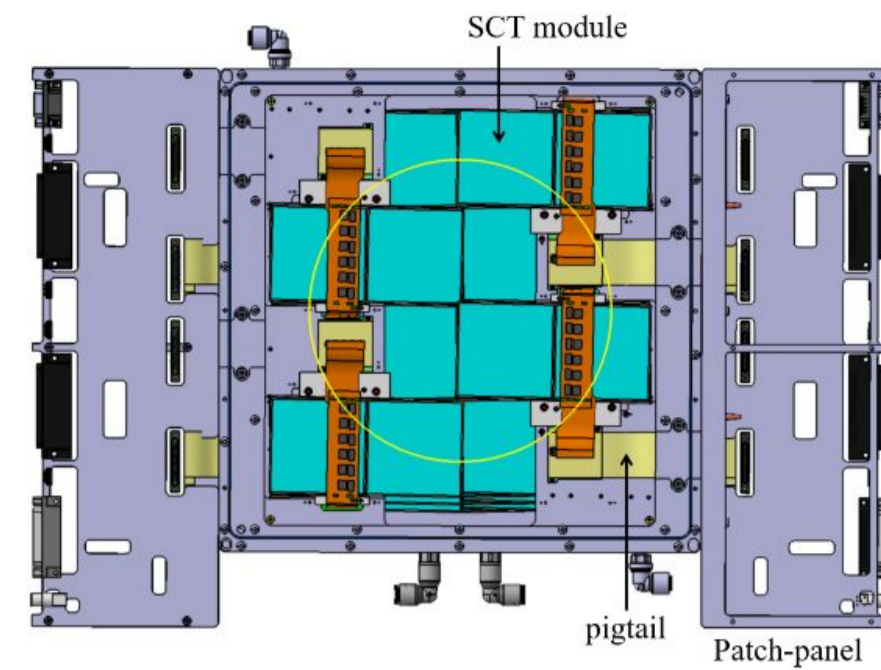
## The Tracker Stations

4 Stations → 3 Planes/Station → 8 Modules per plane



### Tracking Modules

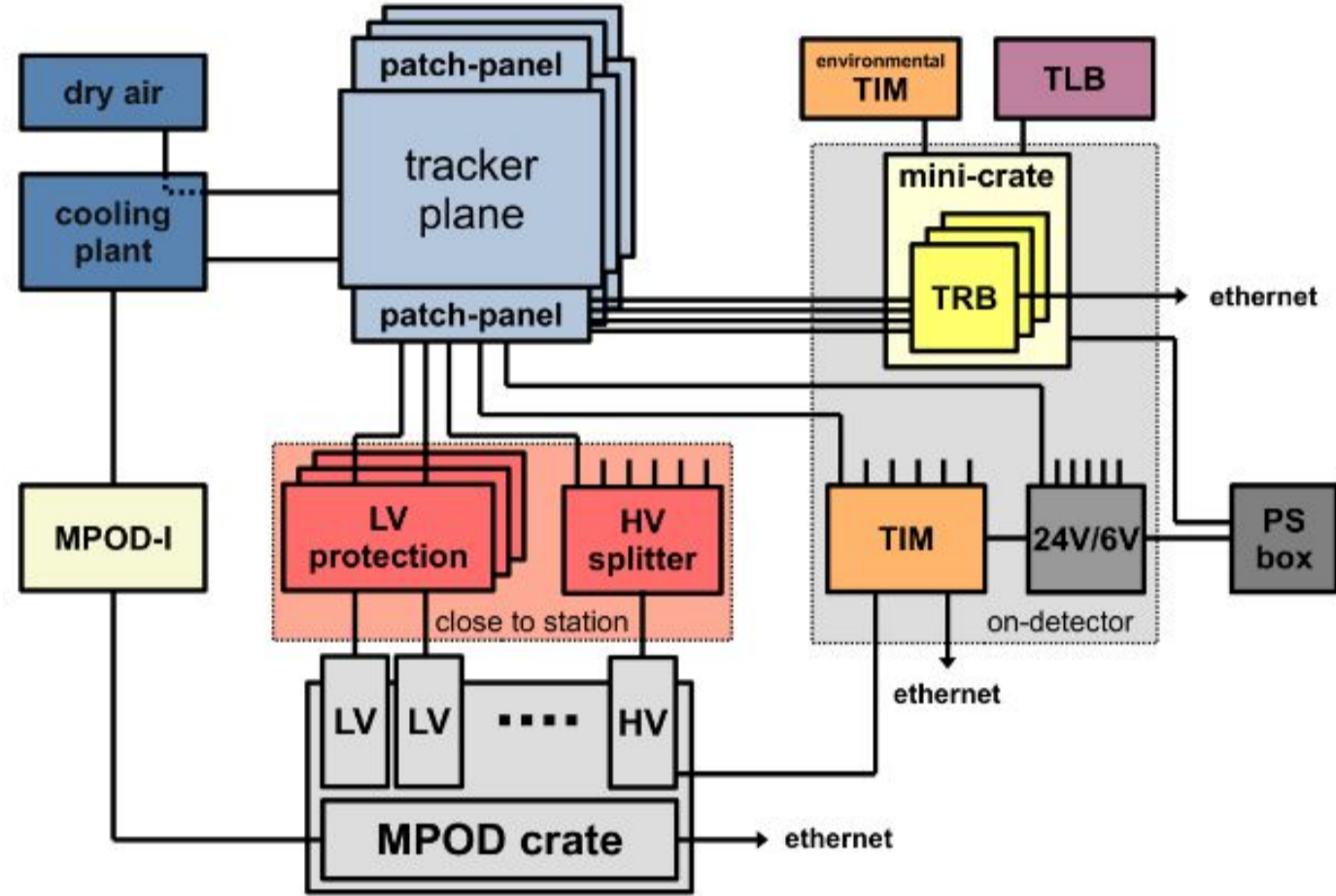
- > 6 chips per side,
- > 128 strips per chip
- > Donated by ATLAS
- > Semi-Conductor Tracker (SCT) barrel module
- > Silicon Microstrip



### Tracker Plane

- (8 modules)
- > Aluminium frame
  - > Active area covers collimated beam
  - > Direct-contact cooling channels
  - > Flexible circuits aka pigtailed connect inside modules to outside patch panels

## Power & Cooling

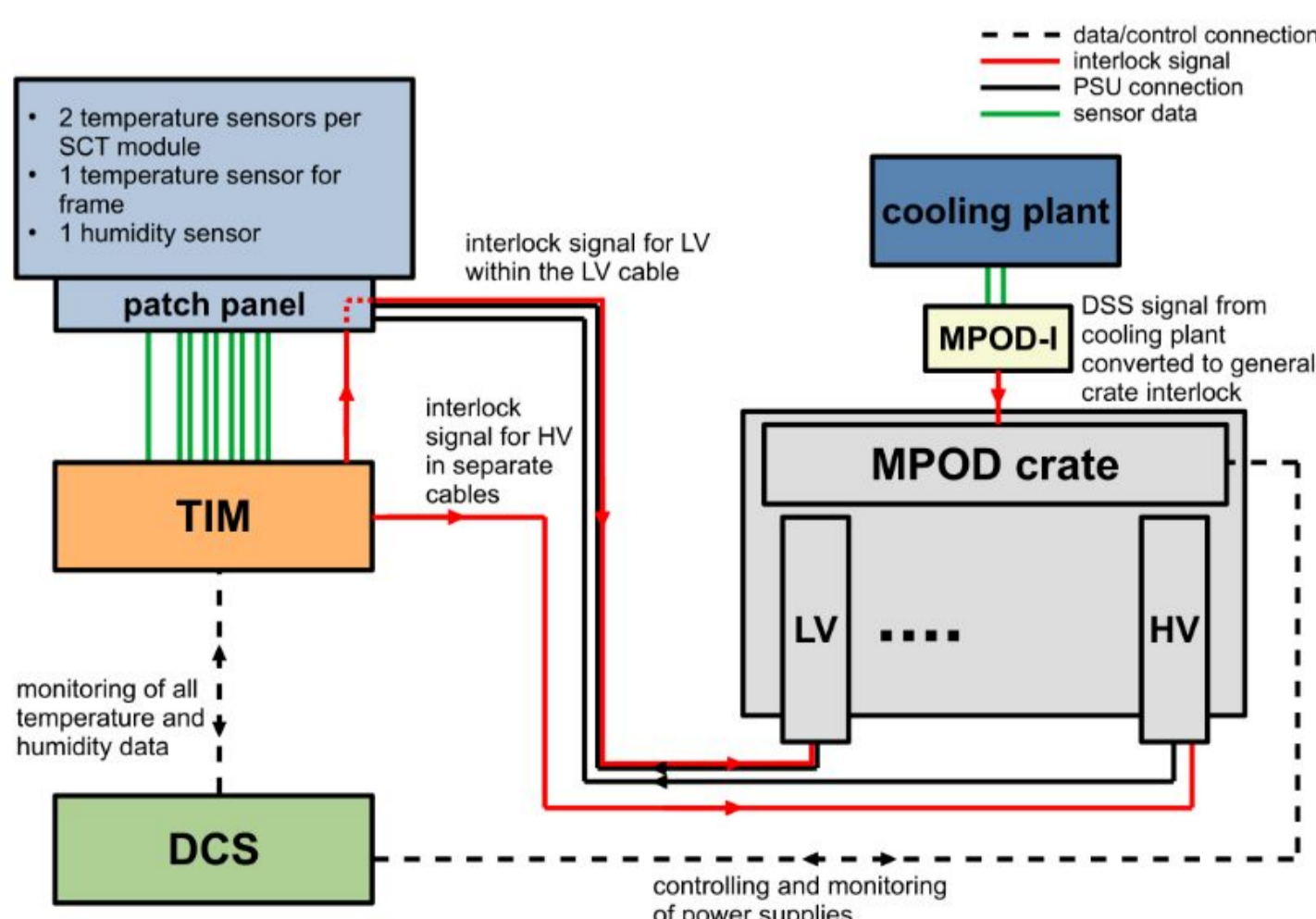


- **Powering SCTs:**  
4 HV & 24 LV power modules
- Station HV channels → **HV splitter board** → HV patch panel power
- **LV protection board** - integrated circuit; protection from overvoltage from T112 radiation
- **24/6 V board** - supplies voltage to (Tracker Interlock and Monitoring Board (TIM) & patch panels.

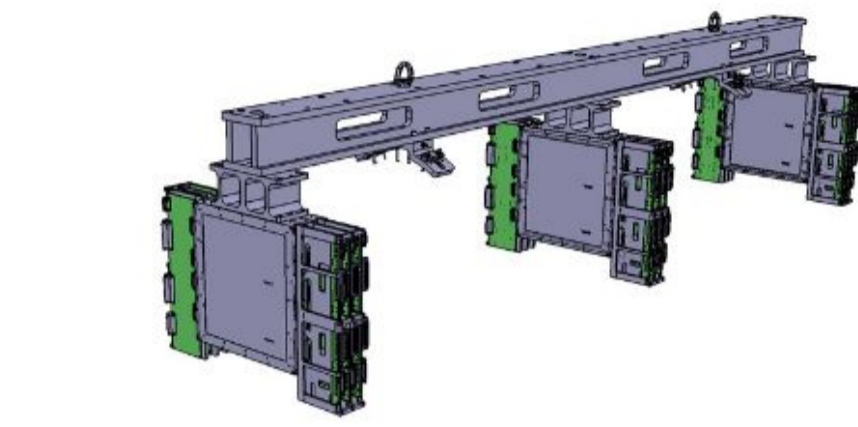
## Readout System

- 1 **Tracker Readout Board (TRB)** per plane (12 TRBs total in tracker)
  - GPIO - provides 5.0, 3.3 and 2.5 V to various active devices
  - Adapter card - interface to the patch-panel and the Trigger Logic Board (TLB)
- **TLB** - central trigger board
  - Trigger & DAQ system
  - Receives input from calorimeter & scintillator systems
  - Sends L1A trigger signal to TRB, prompting data readout
  - Communicates with surface DAQ PC via ethernet

## Interlock, Control, Safety

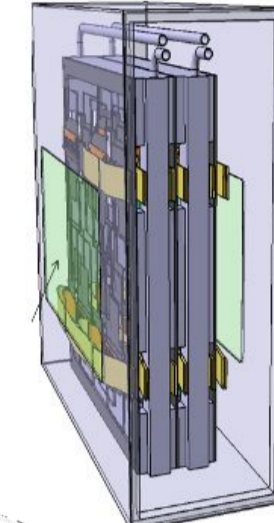


- 2 air-cooled water chillers at 15C
- Distributed by manifold
- Dew point -40C; dry air from by LHC Point 8
- Cooling malfunction triggers interlock



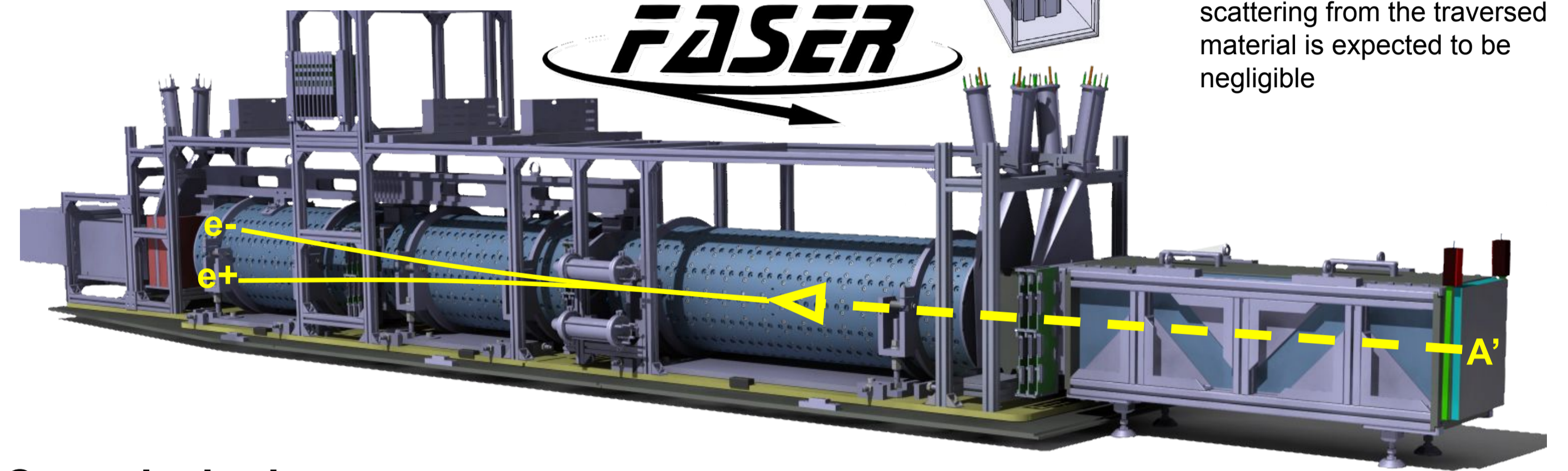
### The Backbone

- > Supports 3 stations
- > For handling and transportation
- > Fine adjustment of global tracker position

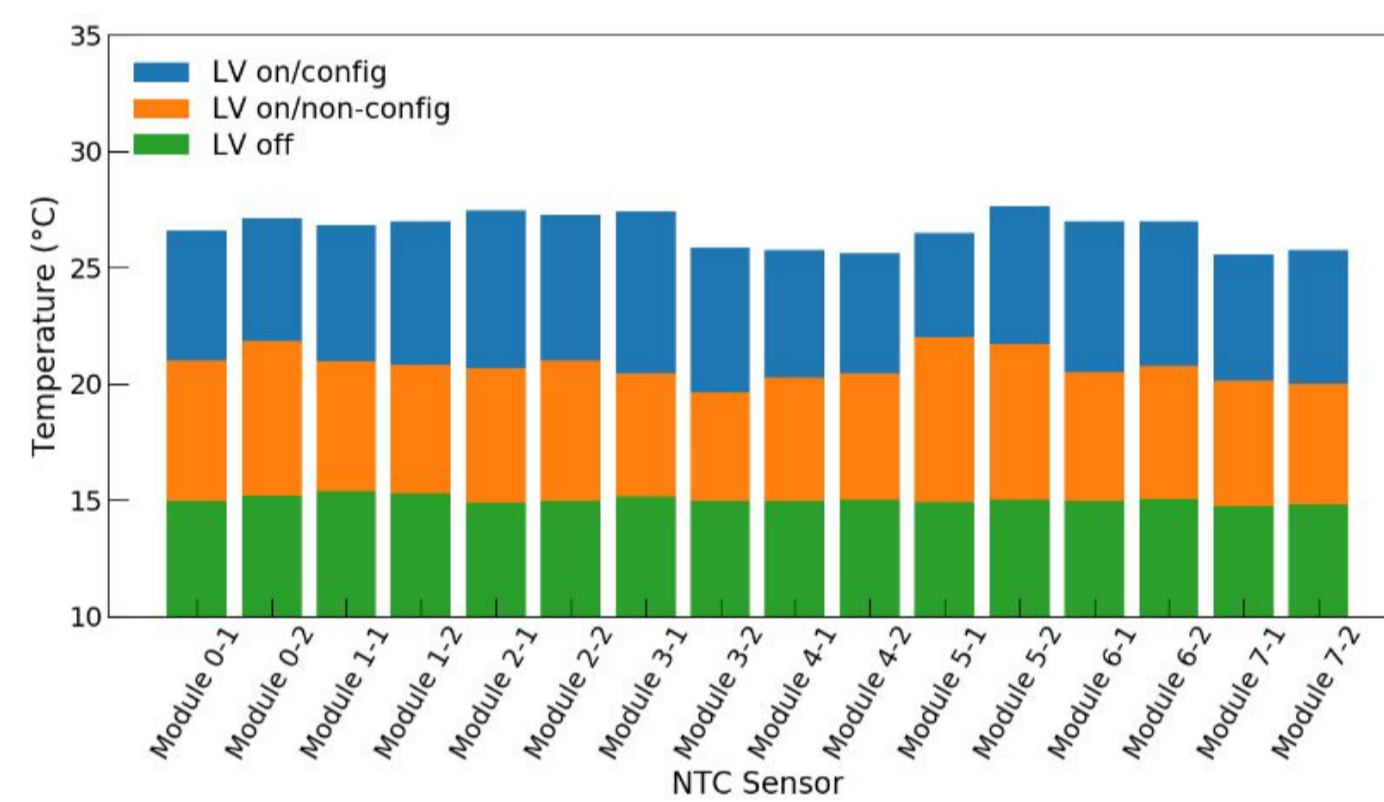


### Tracking Station

- (3 Planes)
- > Flushed with dry air
  - > 2.1% radiation length in active region for dark photon decay
  - > Contribution of multiple scattering from the traversed material is expected to be negligible



## Commissioning

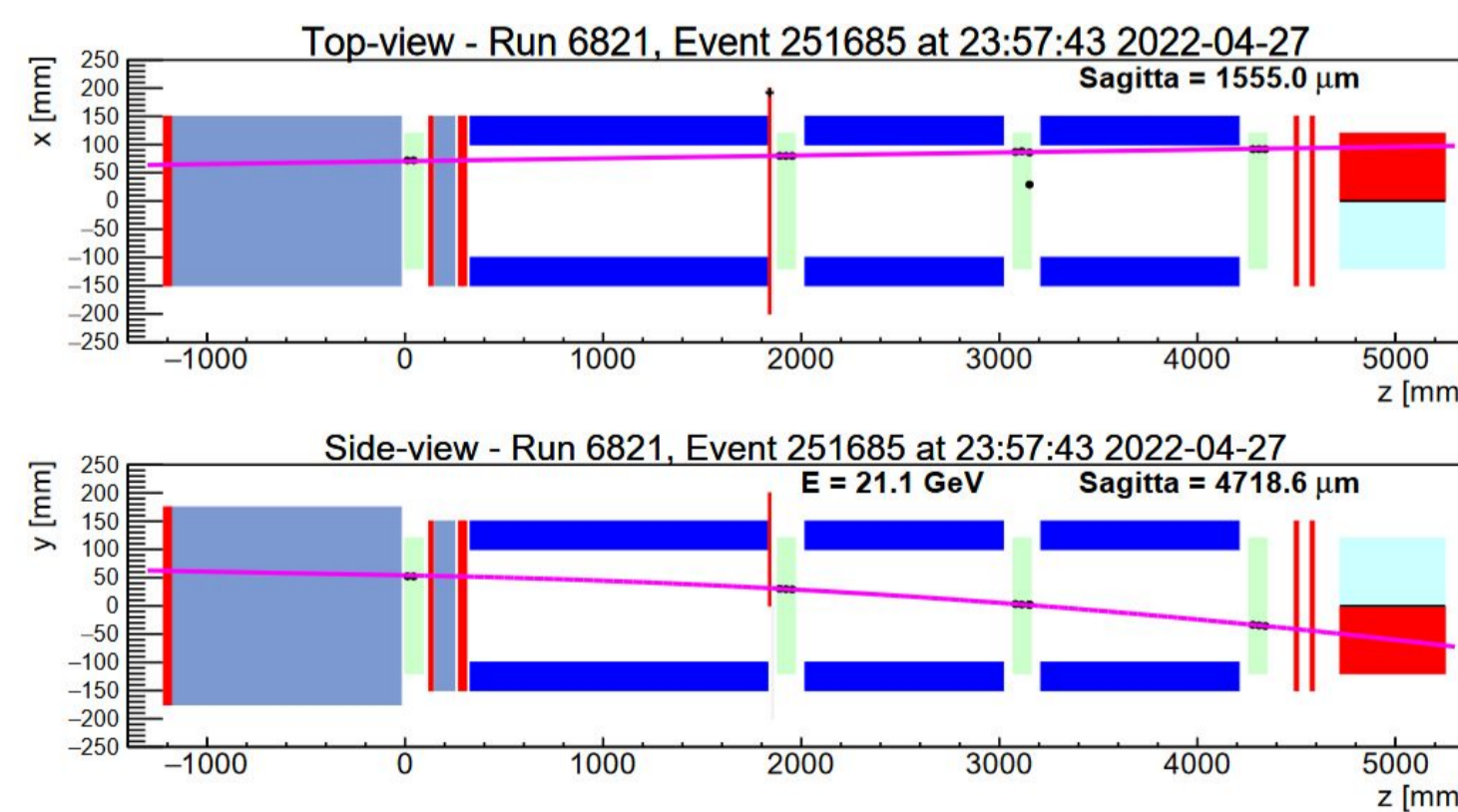
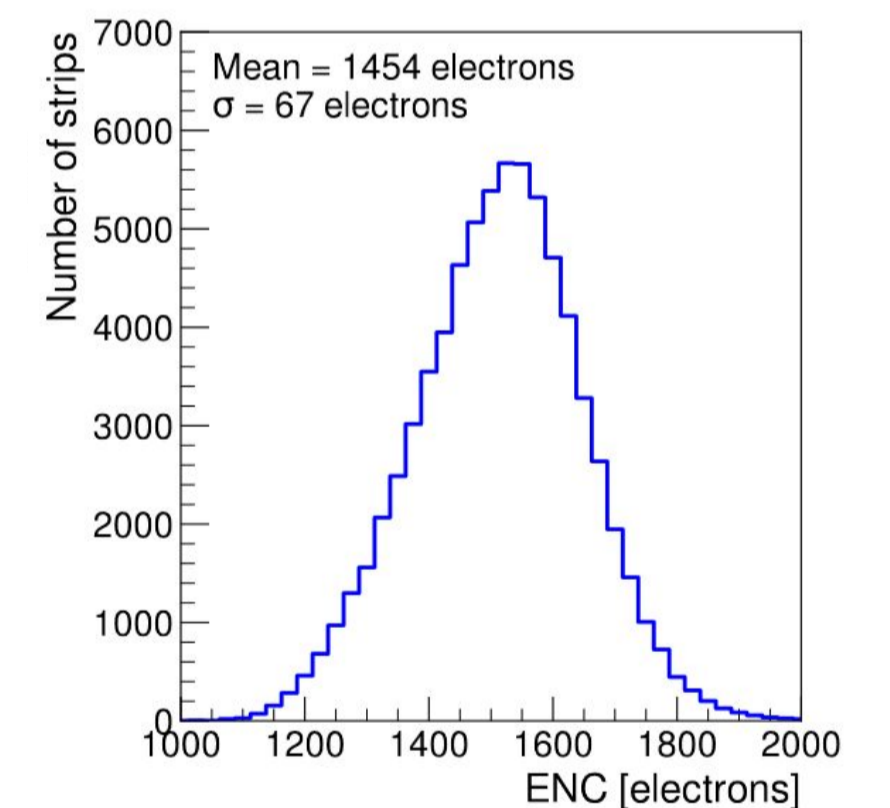
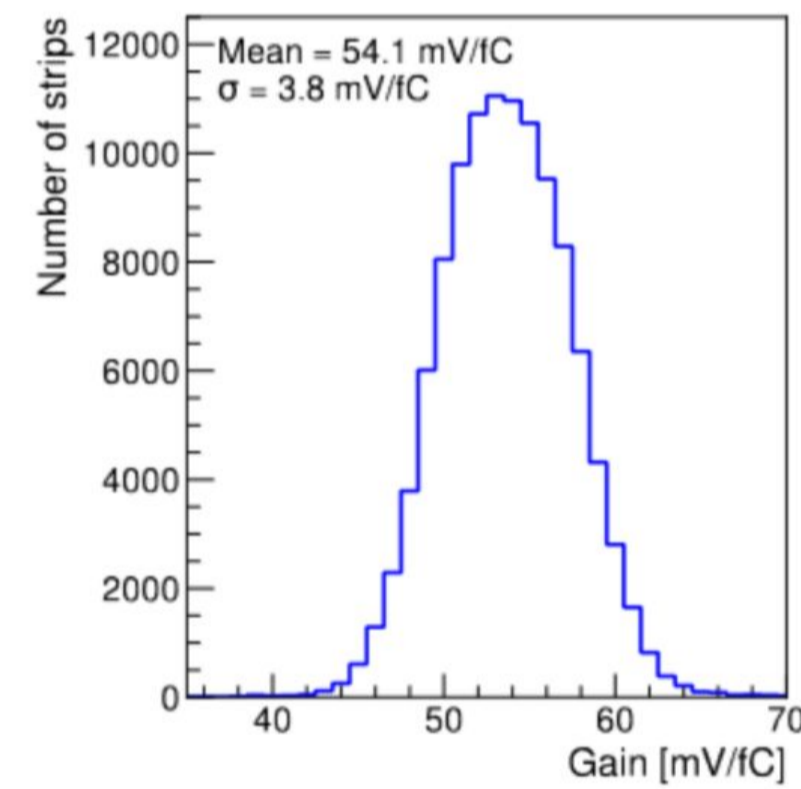


## Thermal Tests

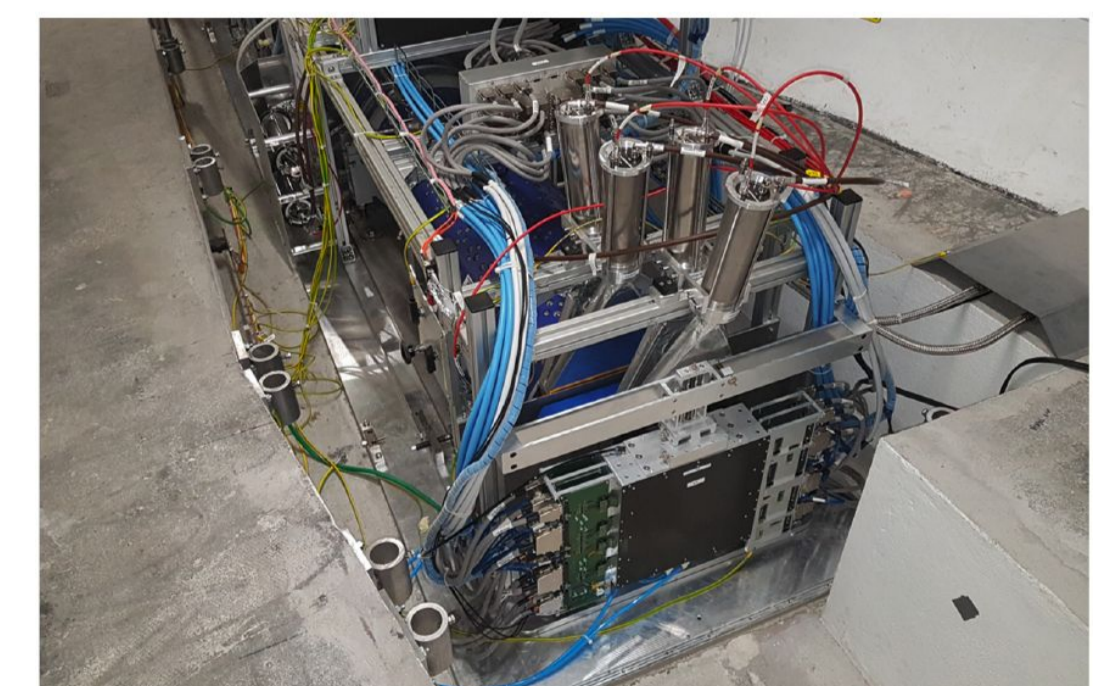
- (Left) Results of one plane during surface testing, comparing behavior with different states of LV activation
- Ensures modules operating at safe and expected temperatures prior to installation
- Compared to results from ATLAS SCT module production

## Electrical Performance

- For realizing high track efficiency & hit efficiency by quantifying noisy strips
- (Left) **Gain Distributions** of the strip gain in each station.
- (Right) **Equivalent Noise**
- **Charge (ENC)** of all strips in all tracker stations



(Above-Left) **TI12 Event Display** - showing a reconstructed track (pink) of a charged particle passing through all four tracking stations (pale green) and arriving in the calorimeter (red/light blue).



(Above Right) **Interface Tracker (IFT)** installed in TI12 prior to the installation of the FASERnu calorimeter, in front of the veto station.

## Current Status

Installed in TI12 tunnel, taking data. First splashes seen April 2022. Tracker paper is in-press for Nucl. Instrum. Methods Phys. Res. A

## References

NIMA (2022) 166825 <https://doi.org/10.1016/j.nima.2022.166825>