

Online Data Monitoring Software for ITk Strips DAQ Development

CAP Congress 2026

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UVVIC

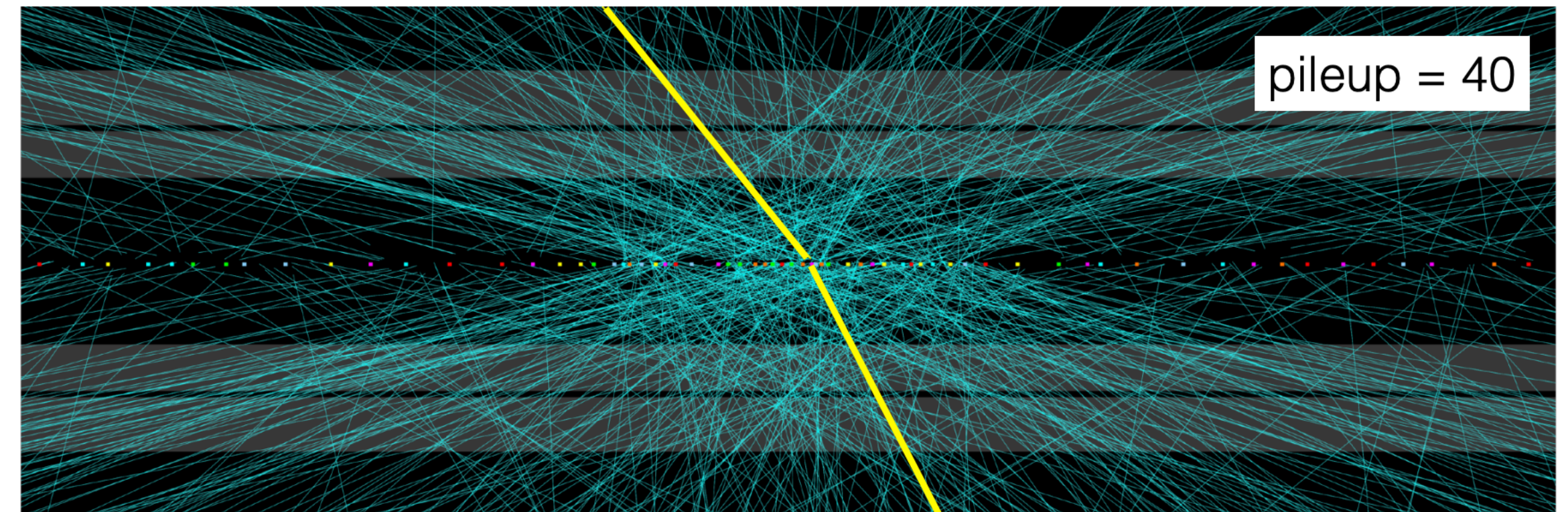


ATLAS
EXPERIMENT

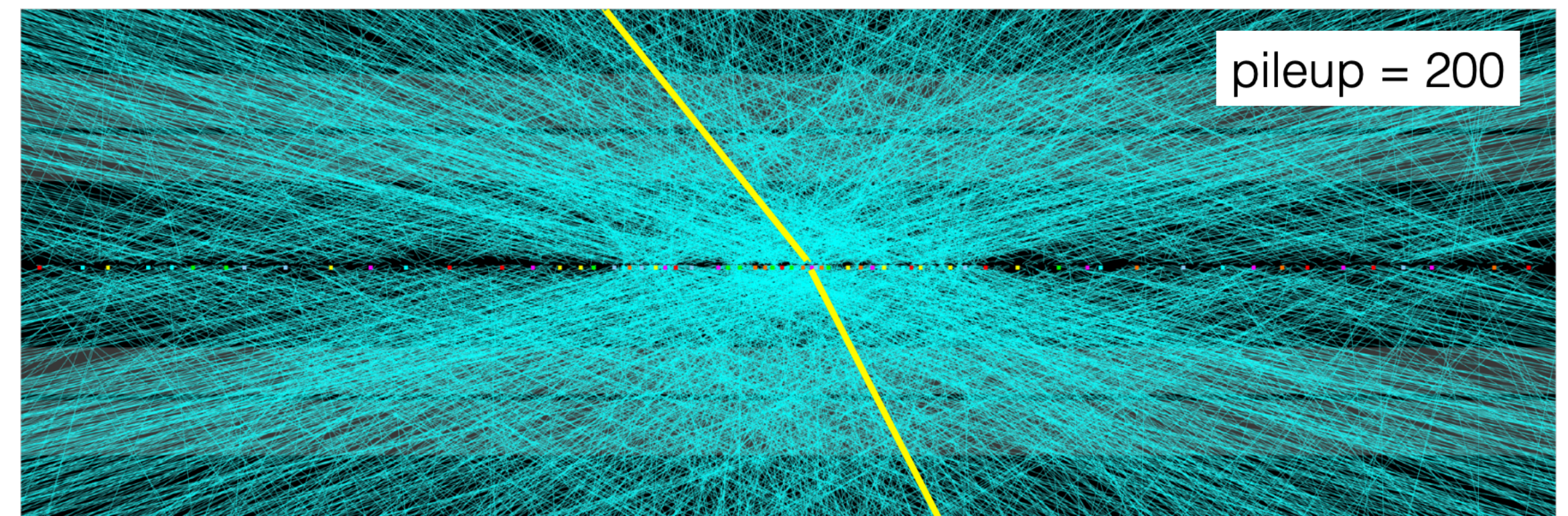
High-Luminosity LHC

- Starting in 2030, the large hadron collider will operate at high-luminosity (HL-LHC)
- ATLAS is expected to receive 3000 fb^{-1} of data, which has important physics potential^[1]
- However, ATLAS must be upgraded to handle ~ 200 interactions per bunch crossing^[1]

Run 2 (2015-2018) pileup conditions:

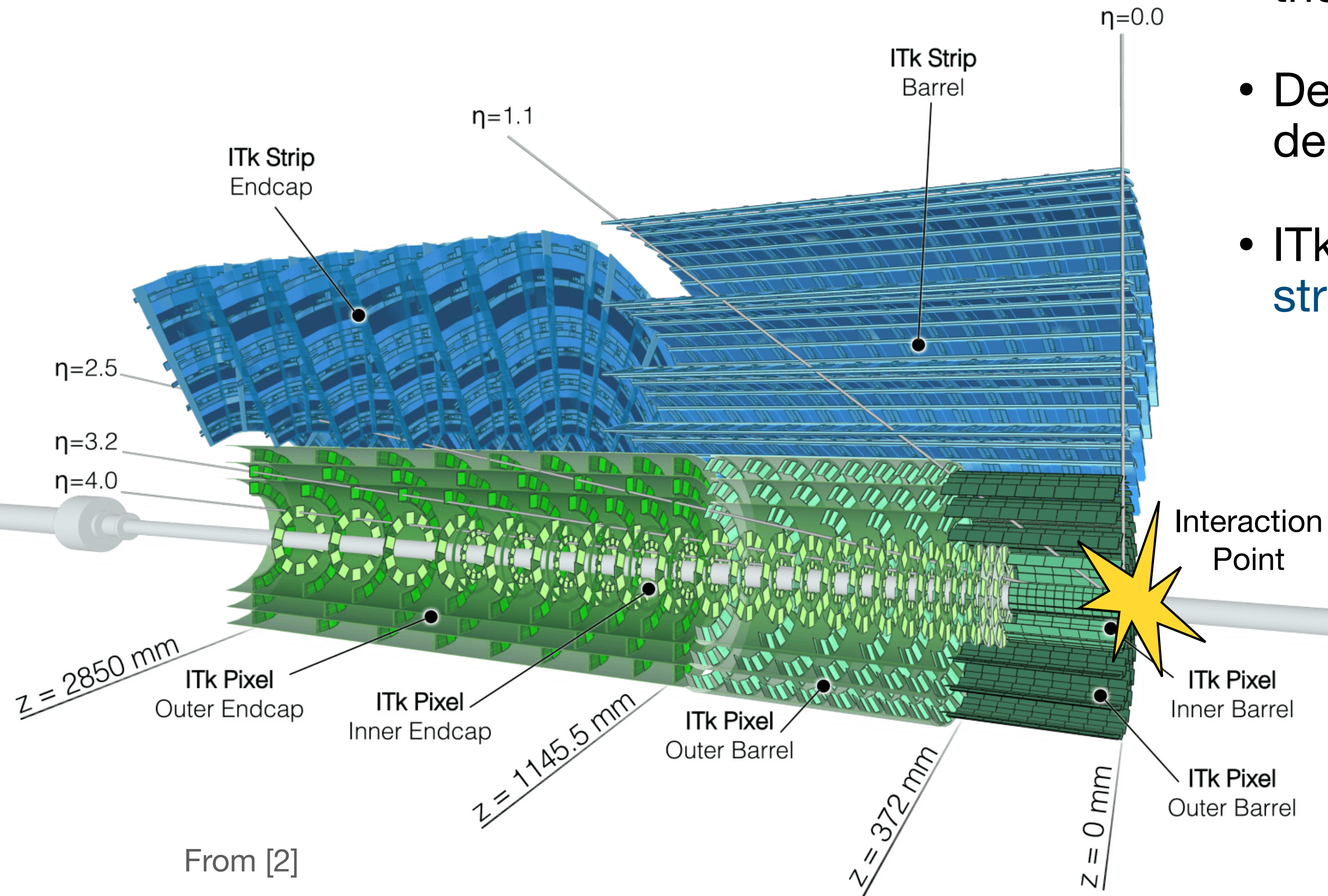


High-luminosity pileup conditions:



Inner Tracker

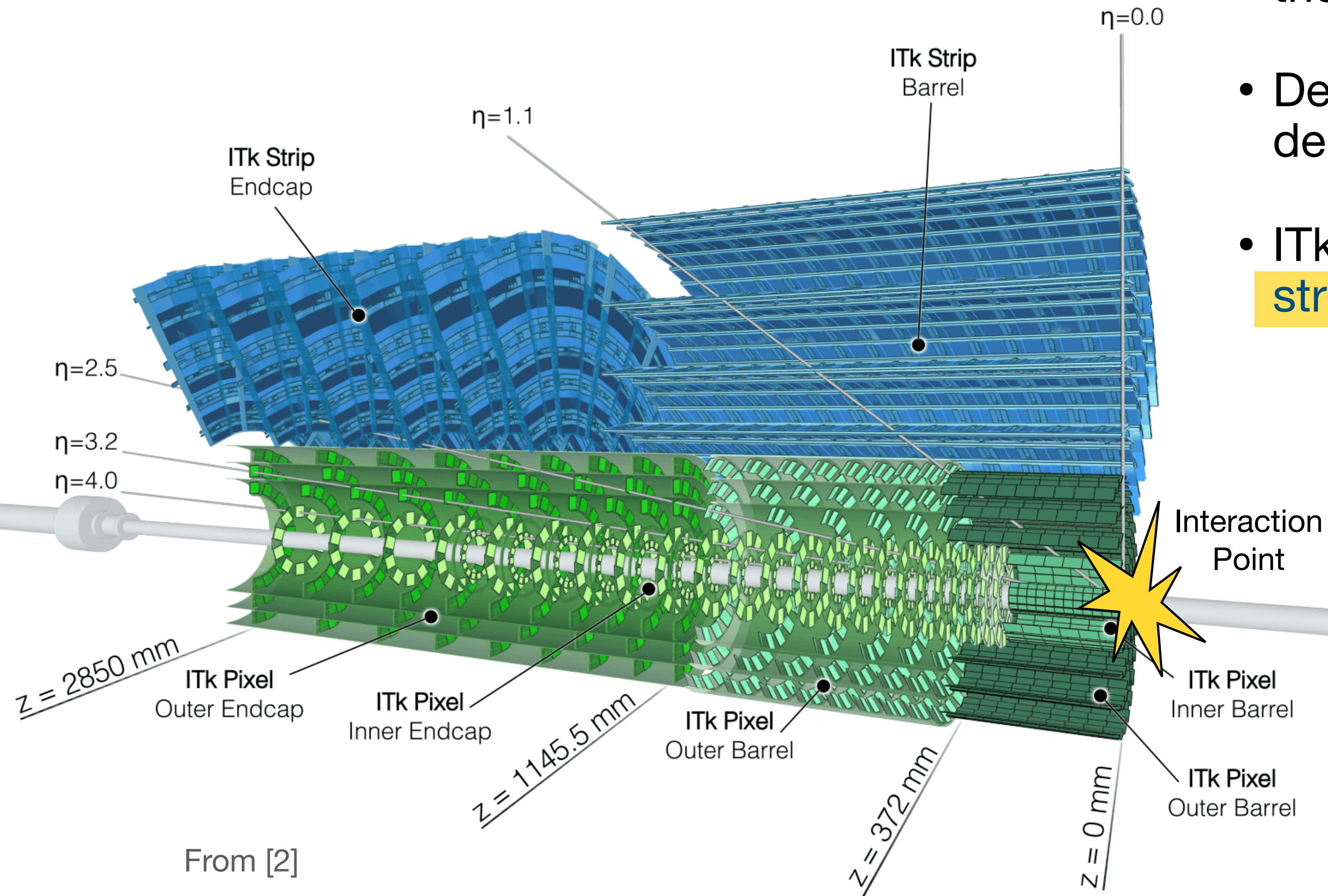
- The inner tracker (ITk) will replace the inner detector of ATLAS
- Designed to resolve the increased density of charged particle tracks
- ITk has two main subsystems: strips and pixels



From [2]

Inner Tracker

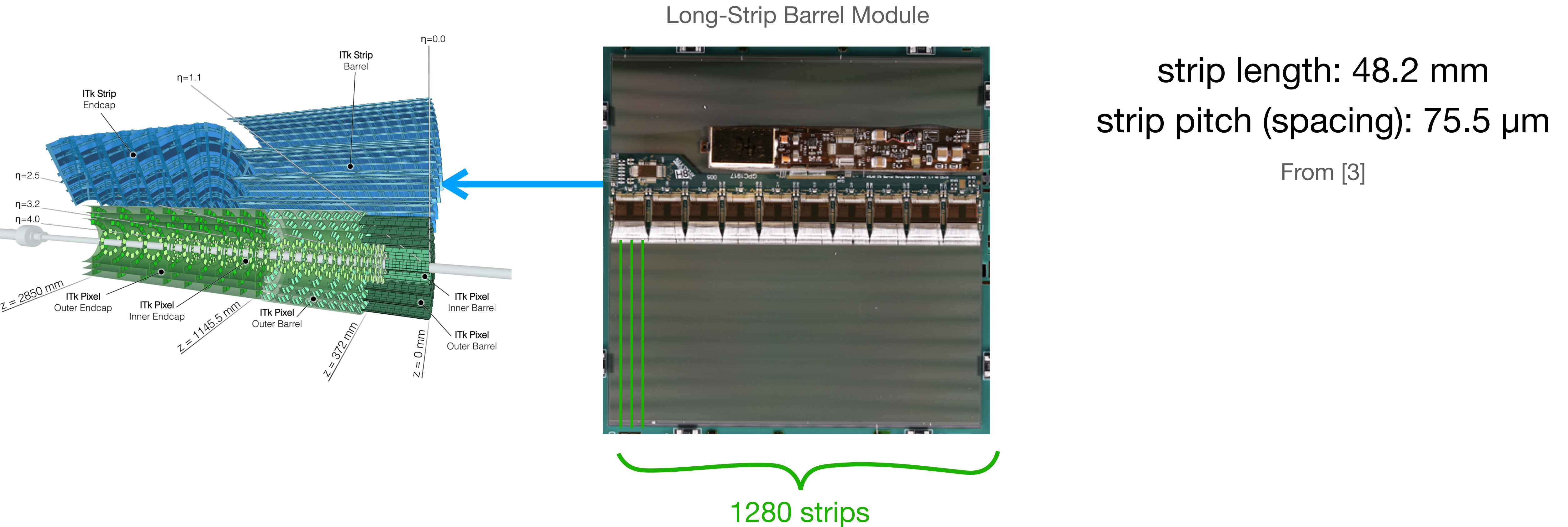
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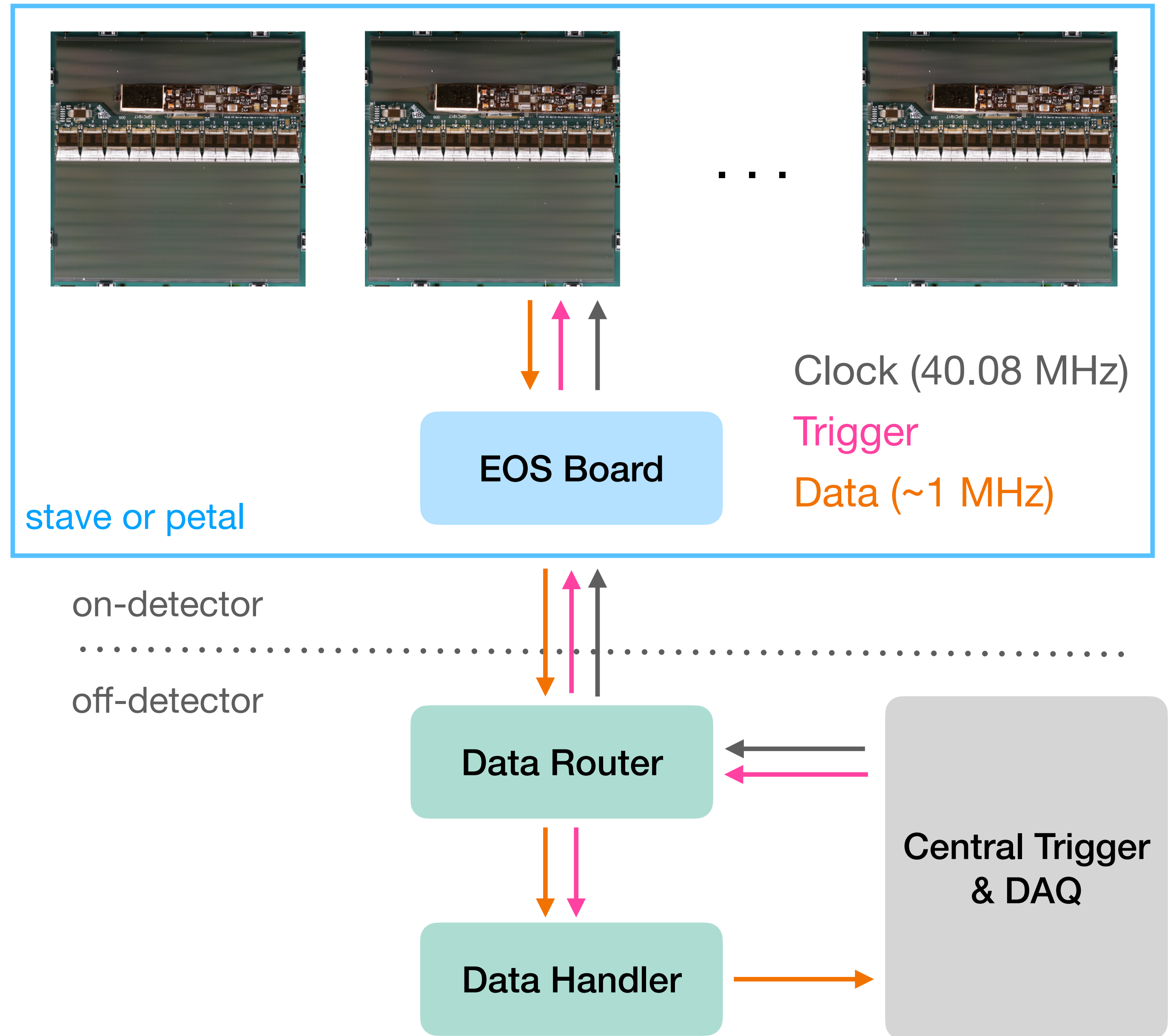
Inner Tracker Strips

- The strips subsystem is composed of modules which host silicon strip sensors and front-end chips to read out binary data (0 or 1) from the strips



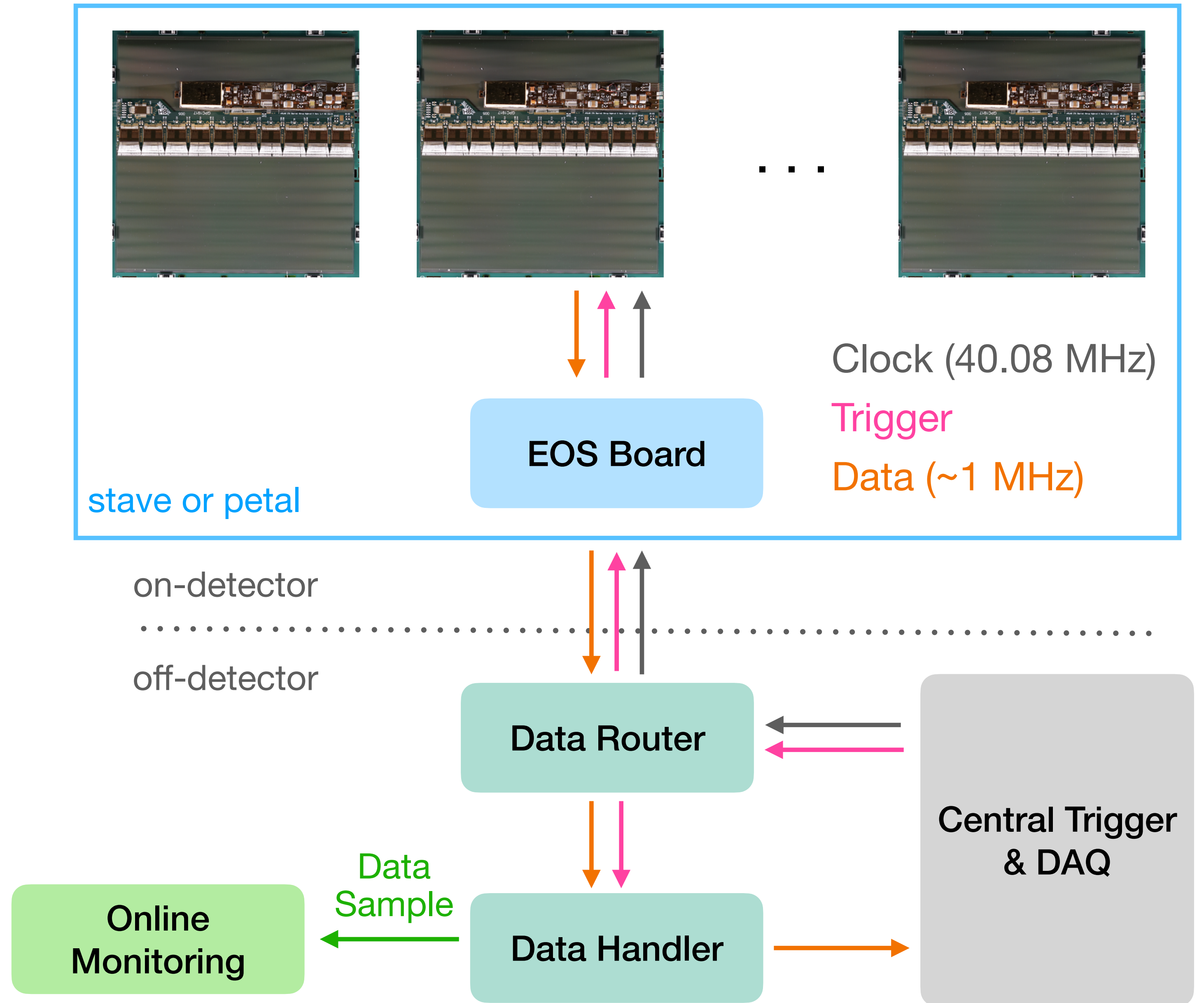
Strips DAQ

- The strips data acquisition (DAQ) system must accurately transmit 60 million data channels
- The performance of the DAQ system is verified during cold tests and test beams



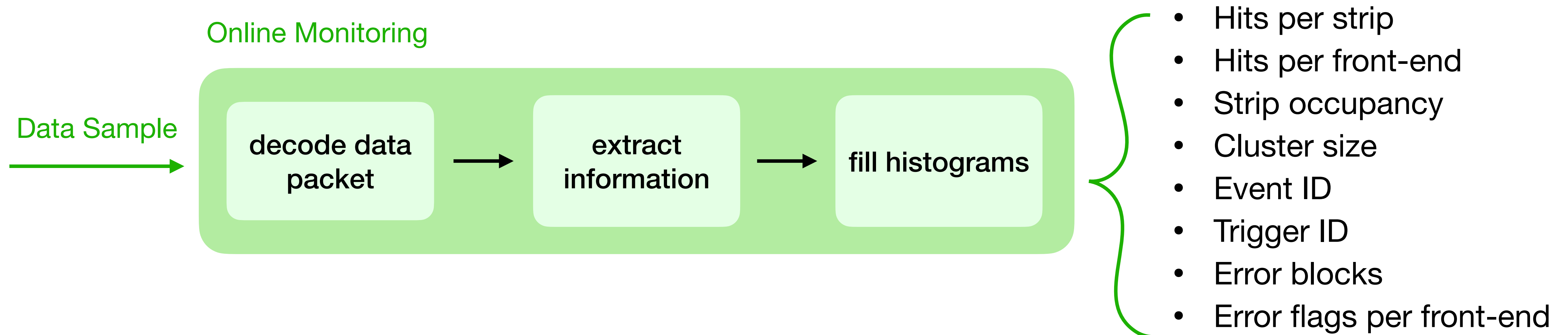
Strips DAQ

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- The performance of the DAQ system is verified during cold tests and test beams
- During these tests, we need to be able to “watch” the data packets



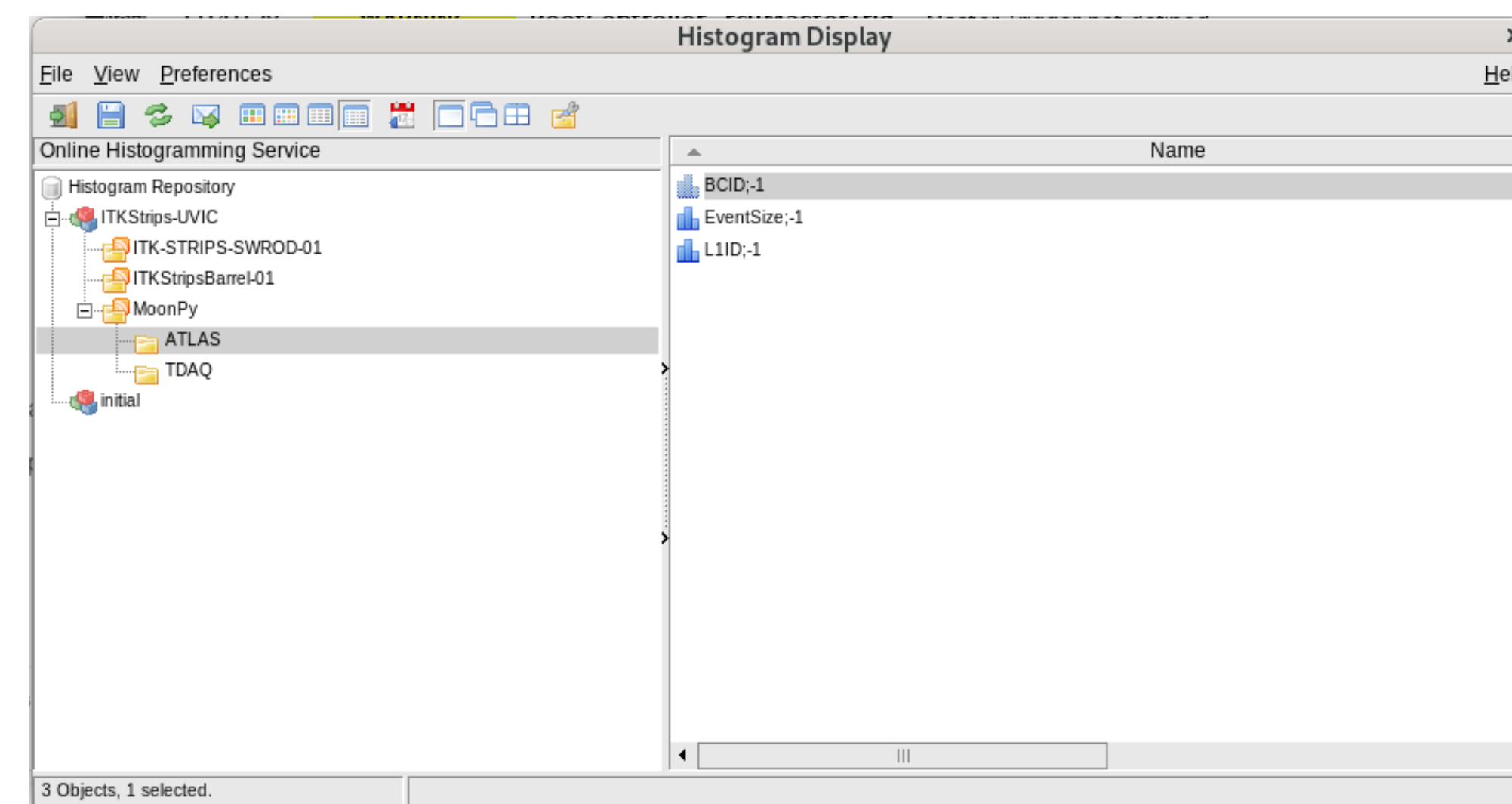
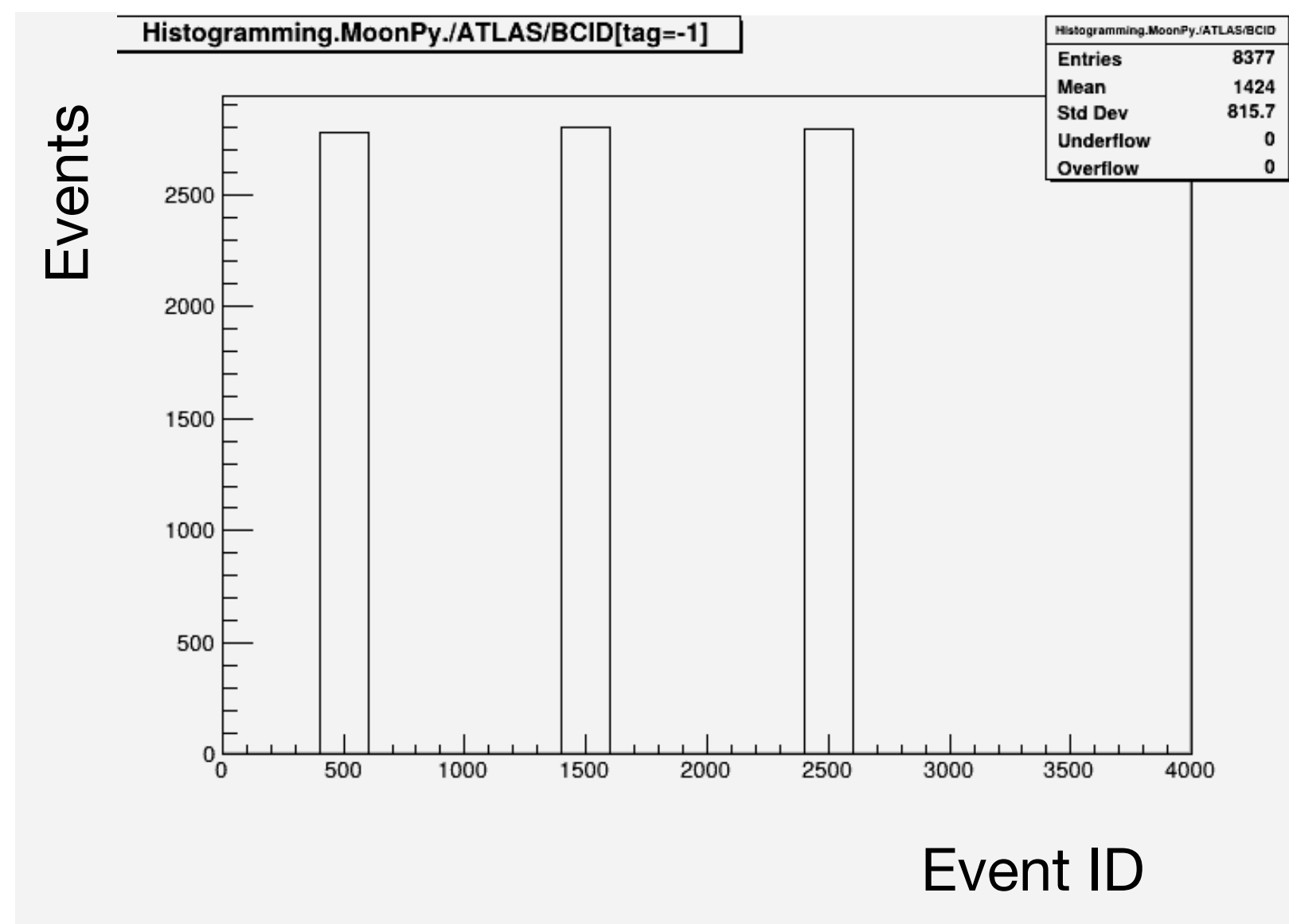
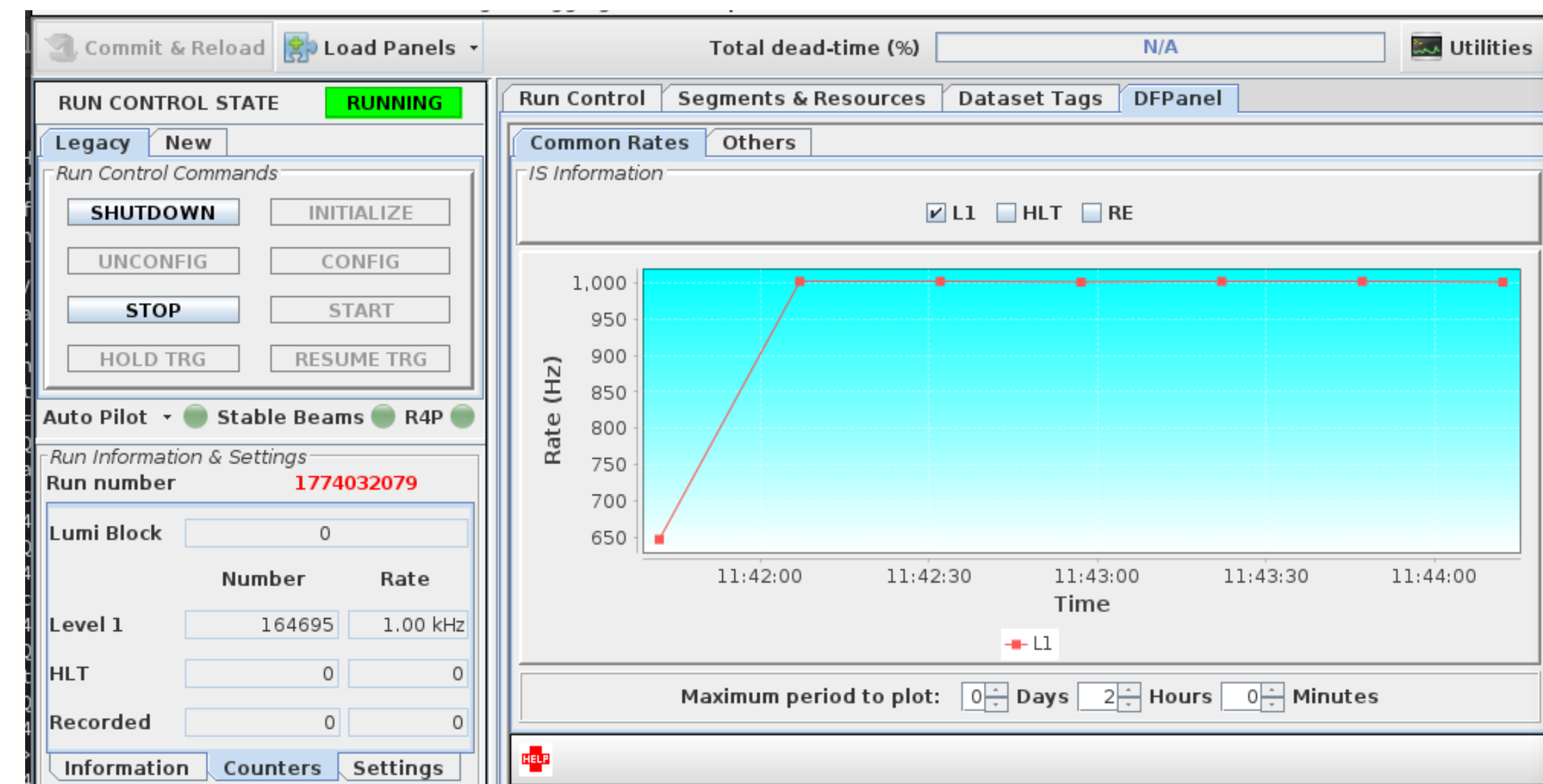
Online Monitoring

- Online monitoring provides real-time information about the incoming data
- Helps to answer key questions:
 - *What are the noise levels relative to the source/beam?*
 - *Are event and trigger IDs reasonable?*
 - *Are all front-end chips sending hits? Are any reporting errors?*



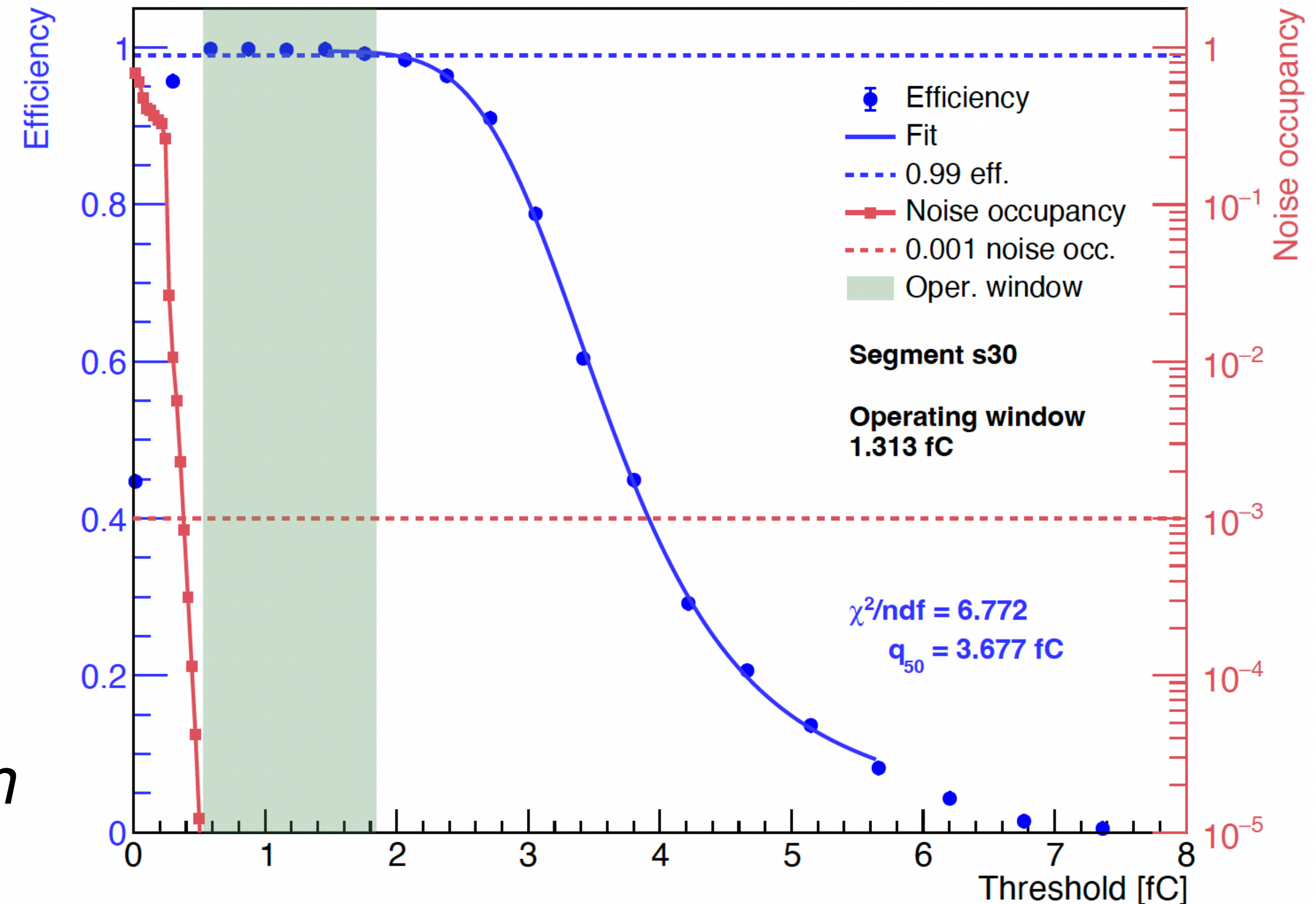
Online Monitoring w/ MoonPy

- Online monitoring implemented using MoonPy software package
- MoonPy publishes histograms directly into the TDAQ run control GUI



Strips test beam studies

- Strips sensors must have an operating window that satisfies two criteria:
 1. detection efficiency $> 99\%$
 2. noise occupancy $< 0.1\%$
 - i.e. signal-to-noise ratio > 10
- Studies at DESY II test beam with a strips module and *slow readout system* have shown that strips sensors can meet this criteria



From [4] <https://arxiv.org/abs/2506.16053>

Objectives of May test beam at DESY

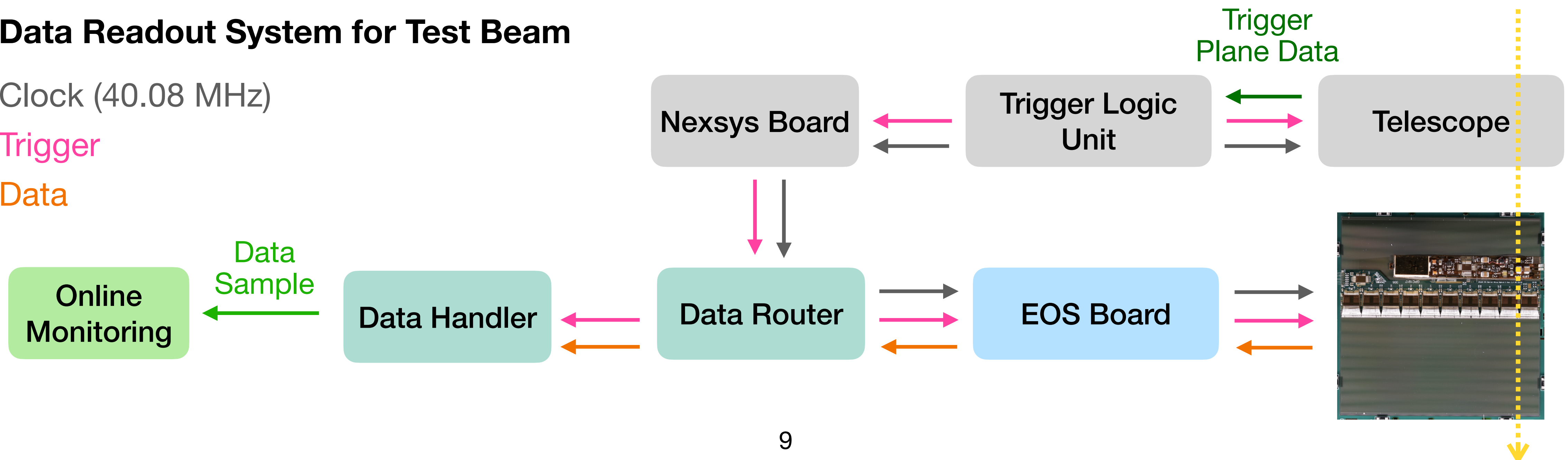
1. Verify the performance of the *fast readout system* by reproducing the threshold scan
 2. Inform and prepare for test beam with an endcap petal in August
- Provided first opportunity to test and use online monitoring in intended use case

Data Readout System for Test Beam

Clock (40.08 MHz)

Trigger

Data



Test beam setup

cylinders of dry ice maintain temperature below -40 C

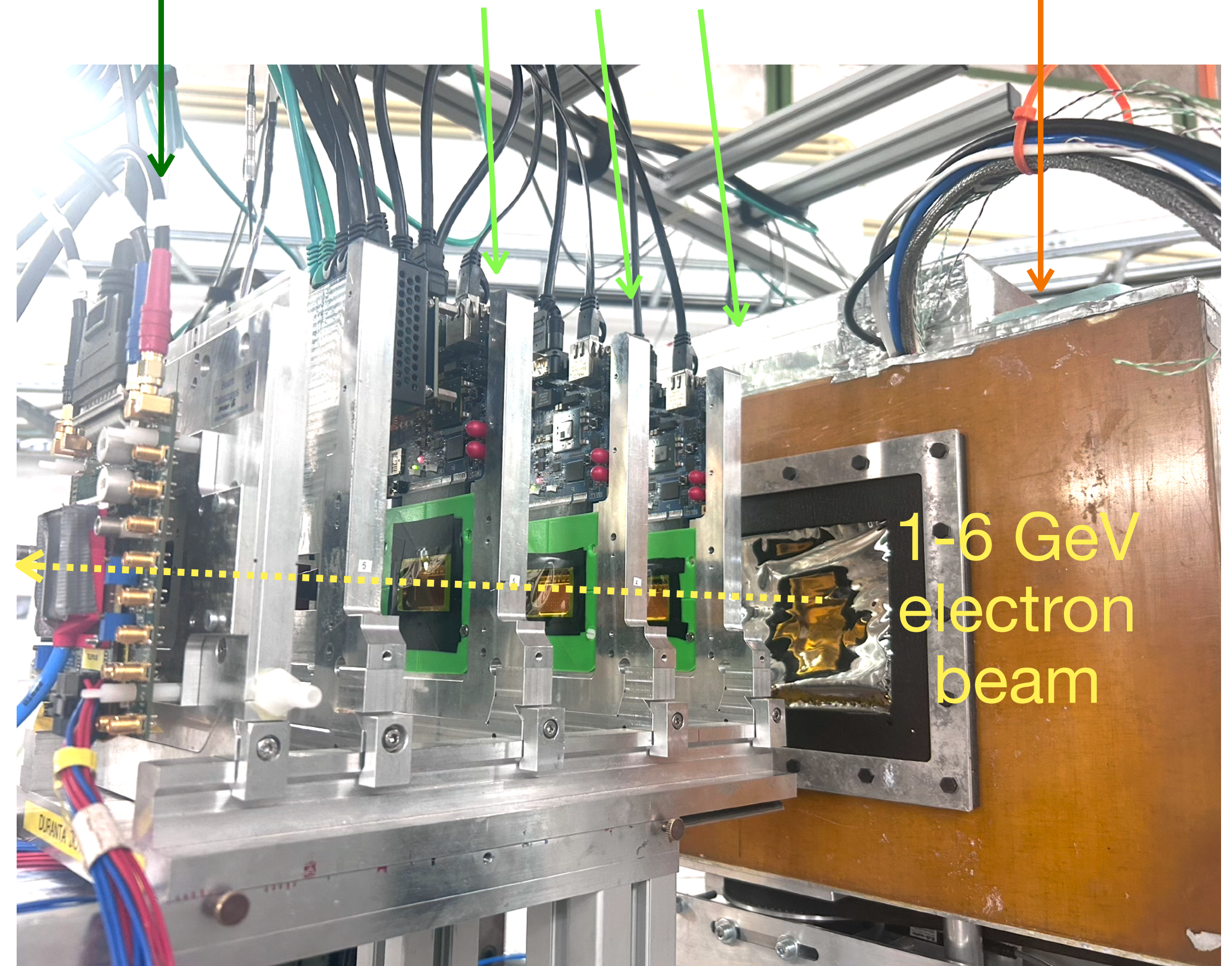
strips module biased at -350 V



timing plane

cold box

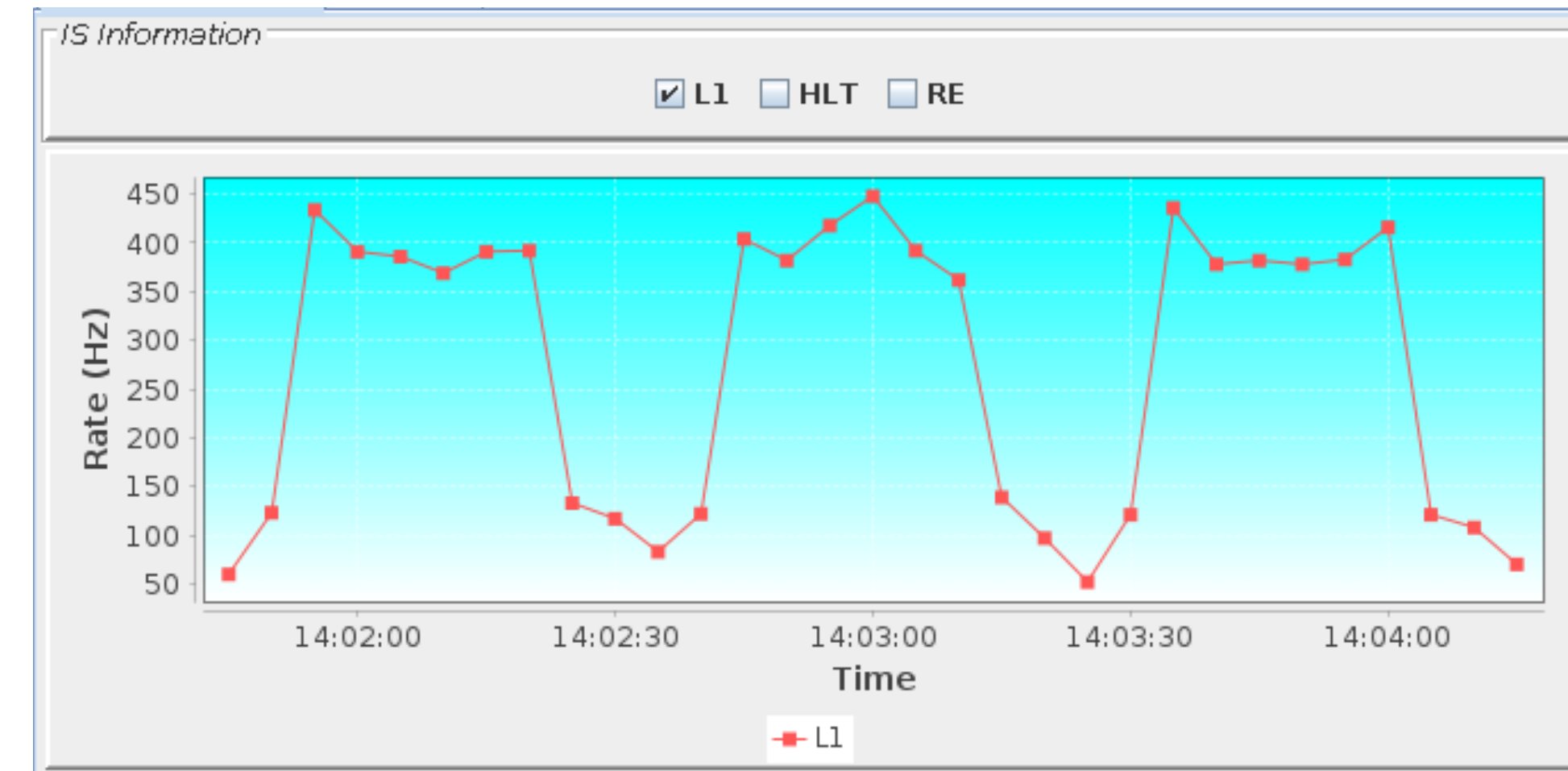
telescope planes for track reconstruction



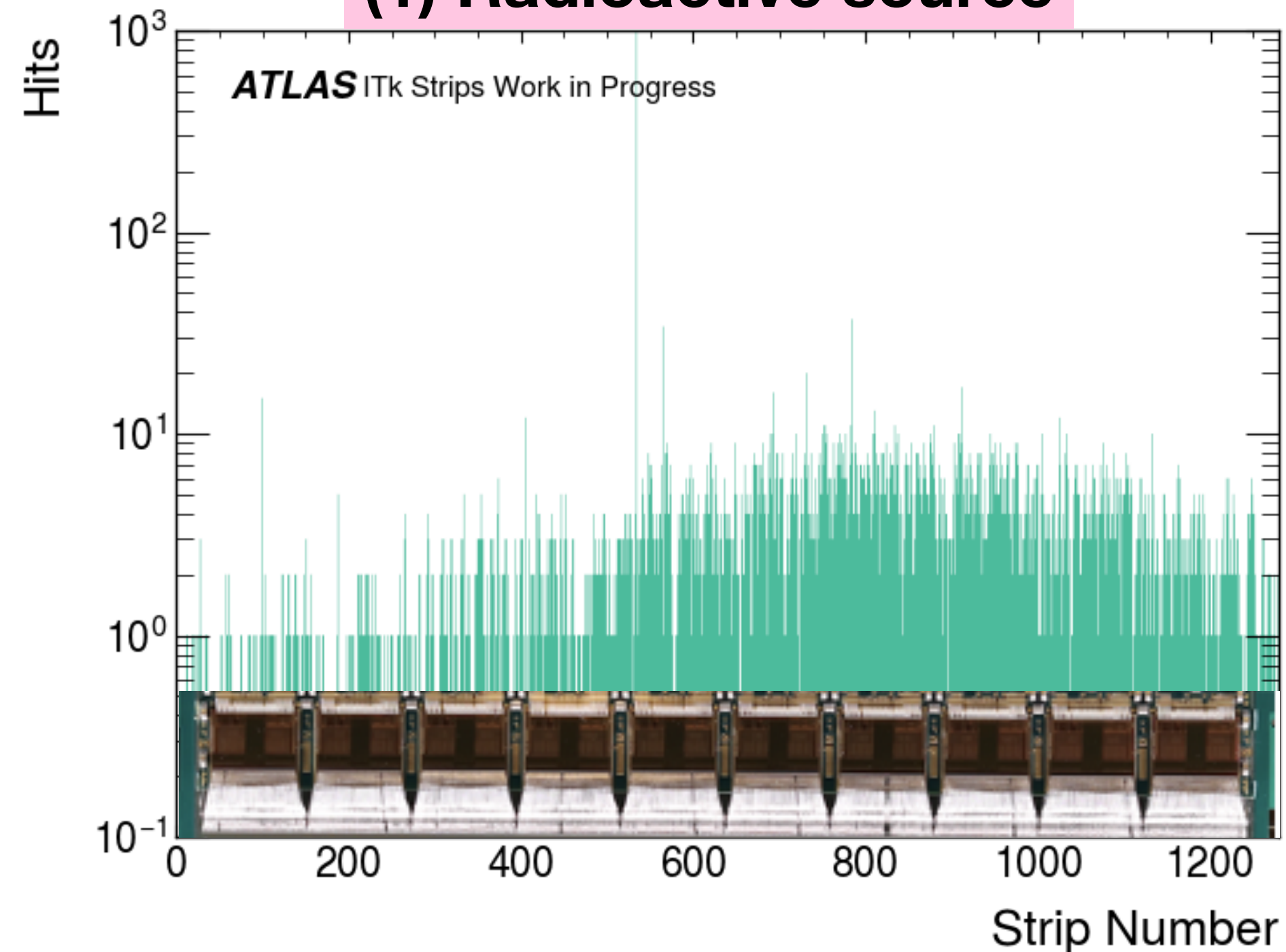
Preliminary tests

- Used a small scintillator to detect particles and generate triggers for the Trigger Logic Unit
- Online monitoring showed that triggering and data readout produced expected beam profiles

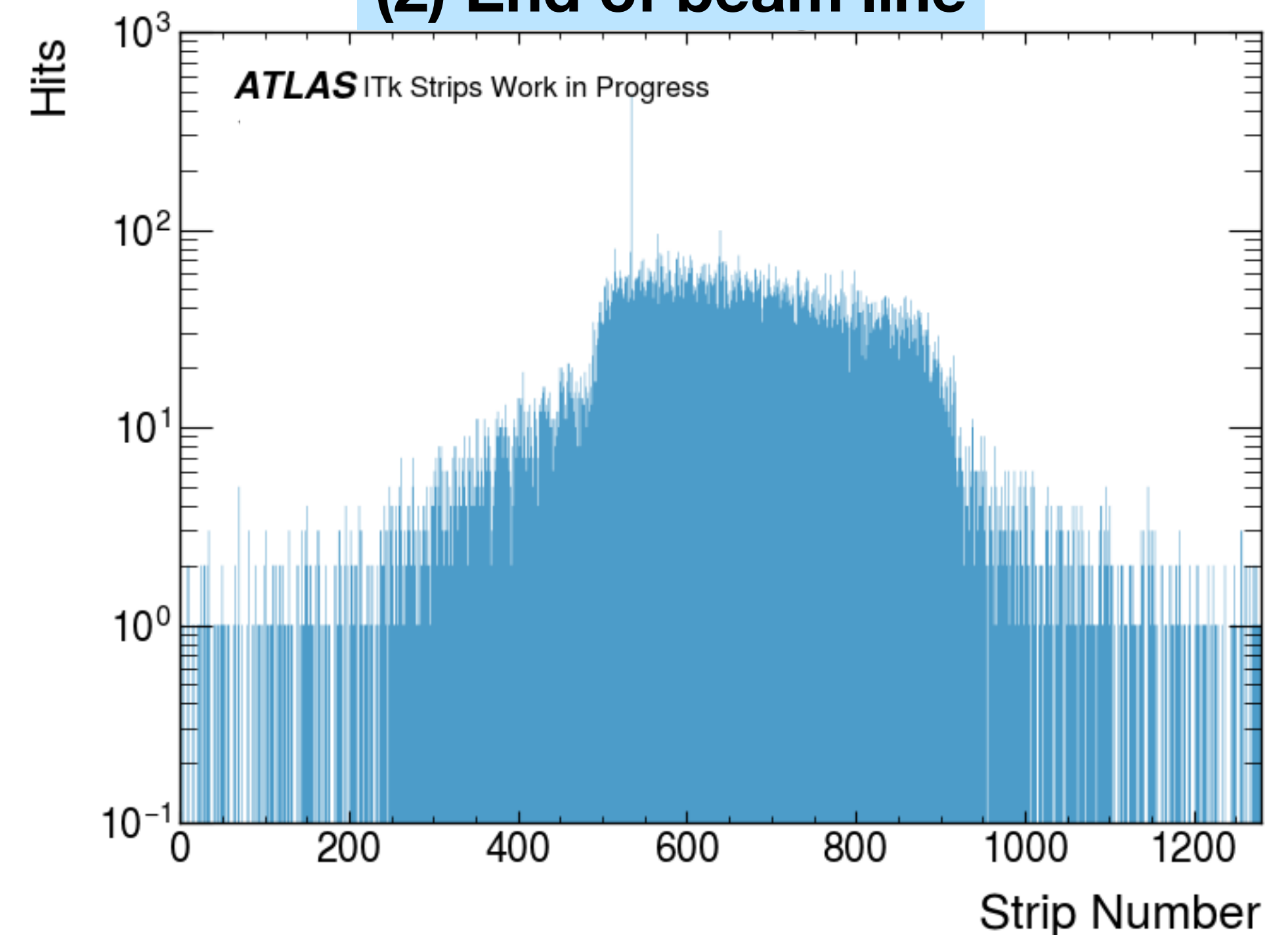
Trigger rates in beam line:



(1) Radioactive source

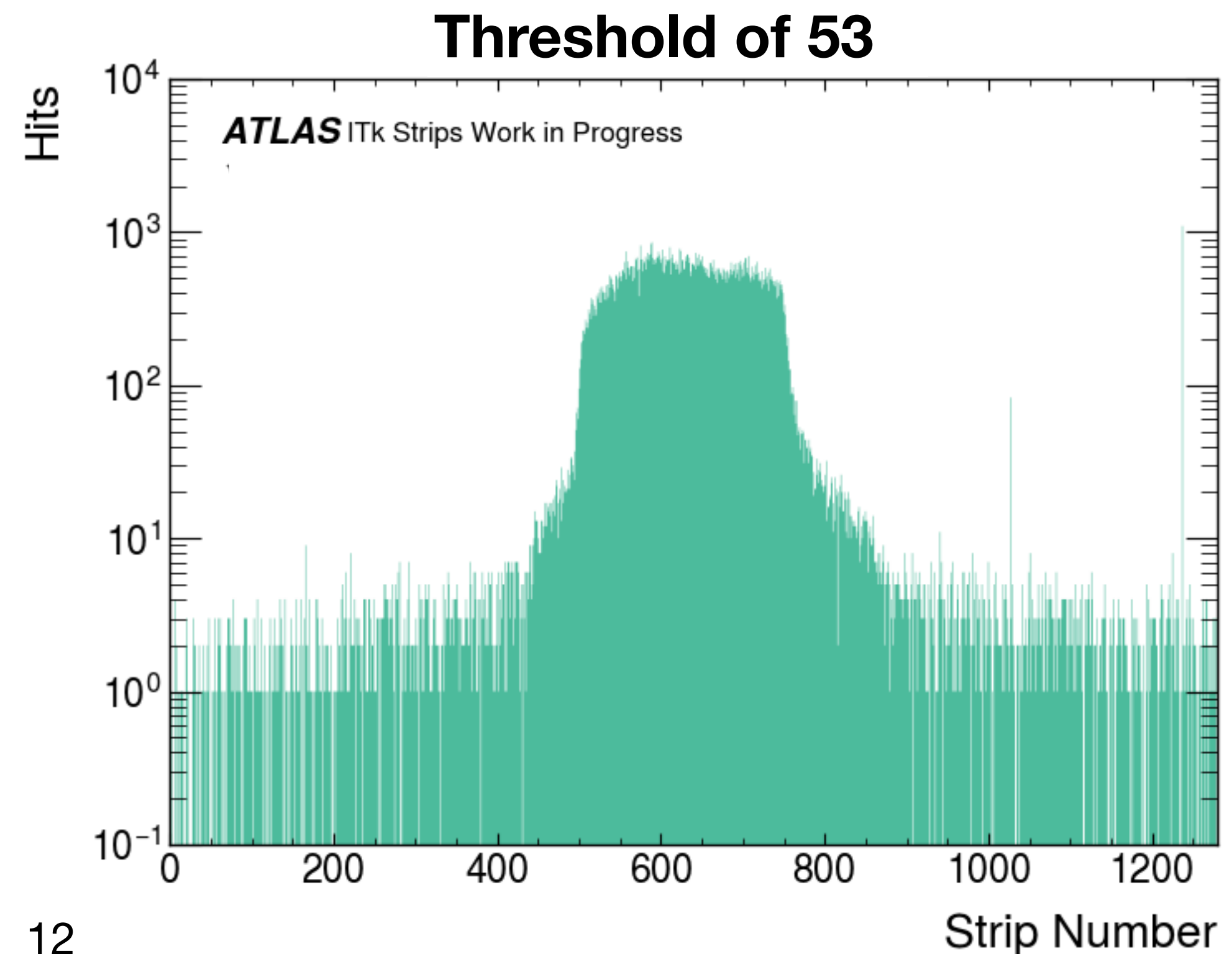
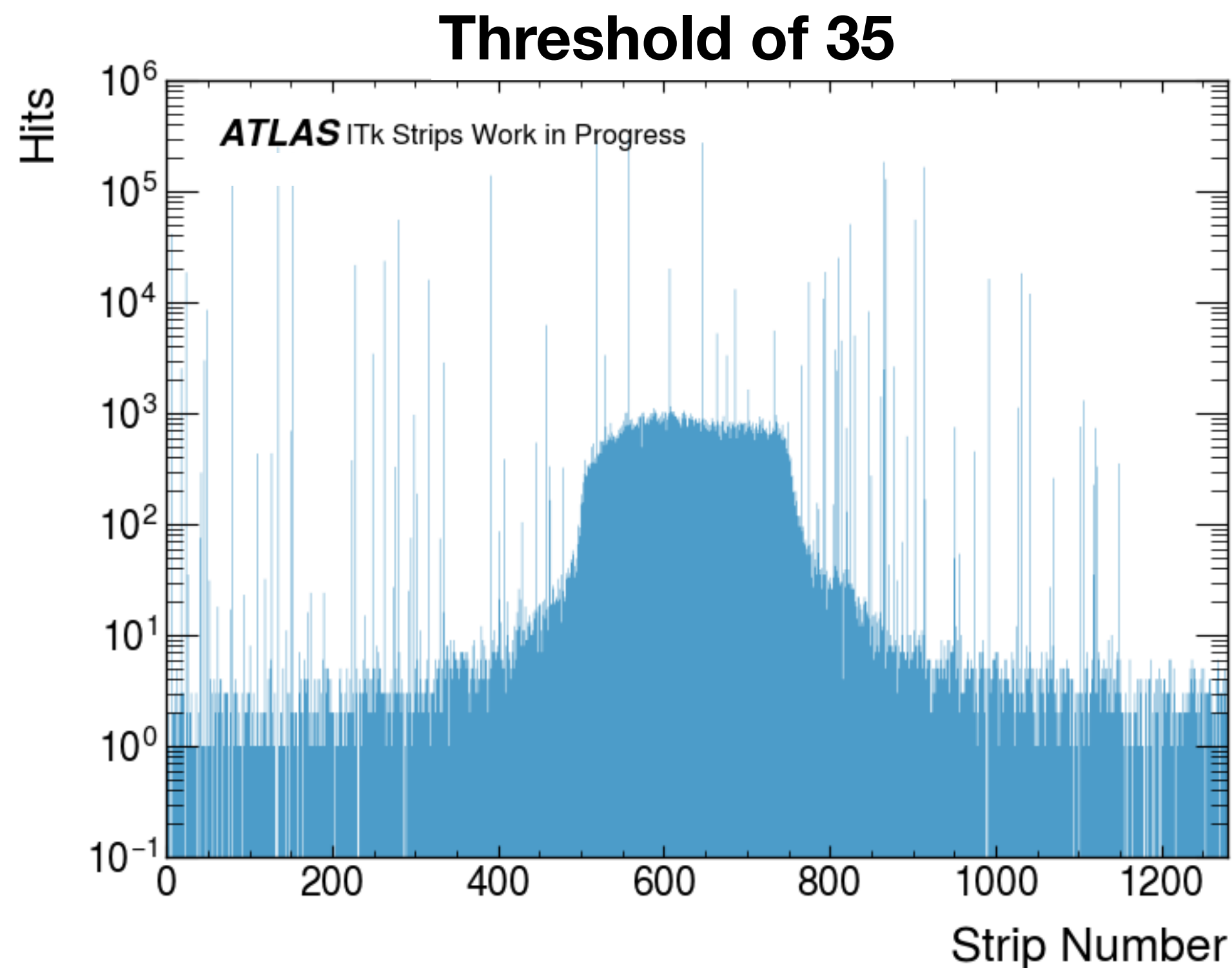
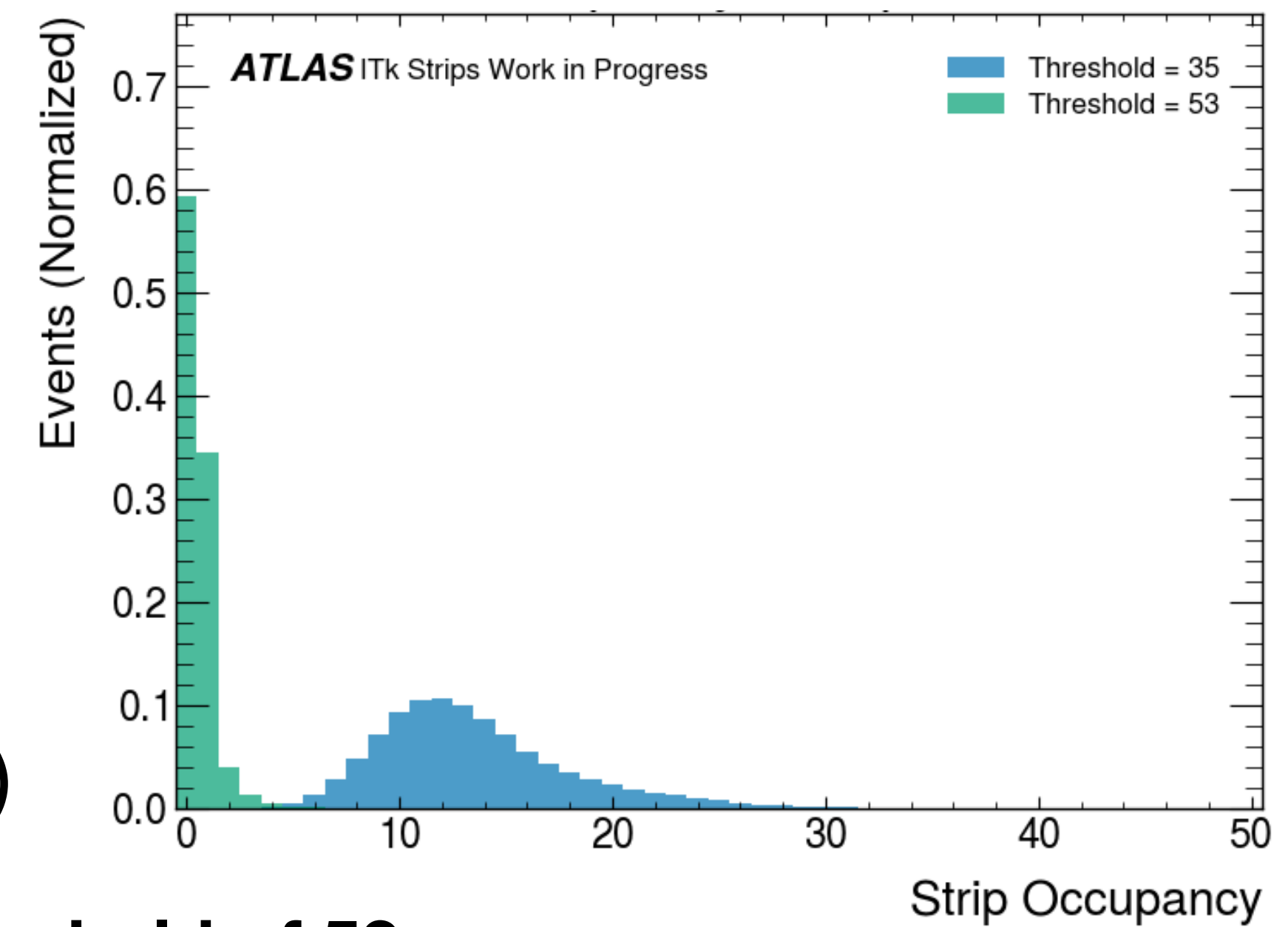


(2) End of beam line



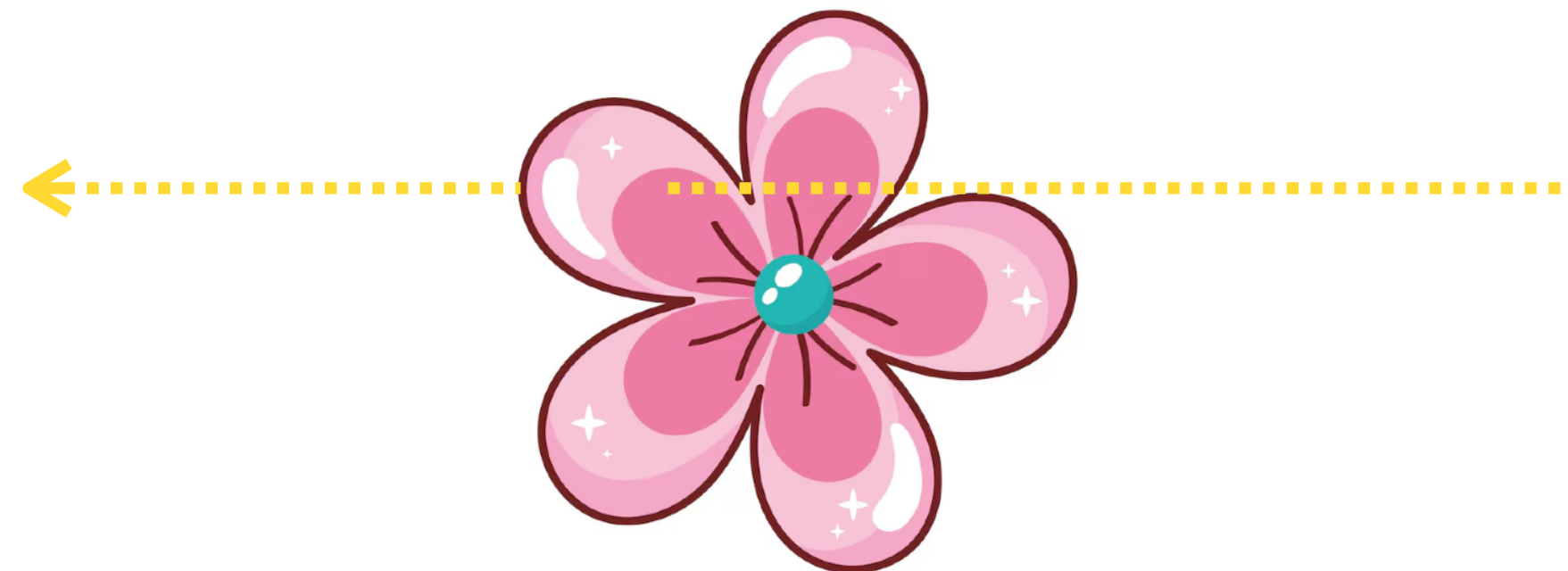
Test beam observations

- Online monitoring showed high noise levels could be controlled by tuning latencies and voltage thresholds
- Observed strong coincidence between strip hits and reconstructed particle tracks but low efficiency (~40-60%)



Conclusion

- Online monitoring software provides important real-time information during critical tests of the ITk strips data acquisition system
- The recent test beam campaign at DESY was useful for identifying future improvements for online monitoring software
- Complete data analysis and investigation into test beam results is ongoing
- In August, an endcap petal will be used in test beam!

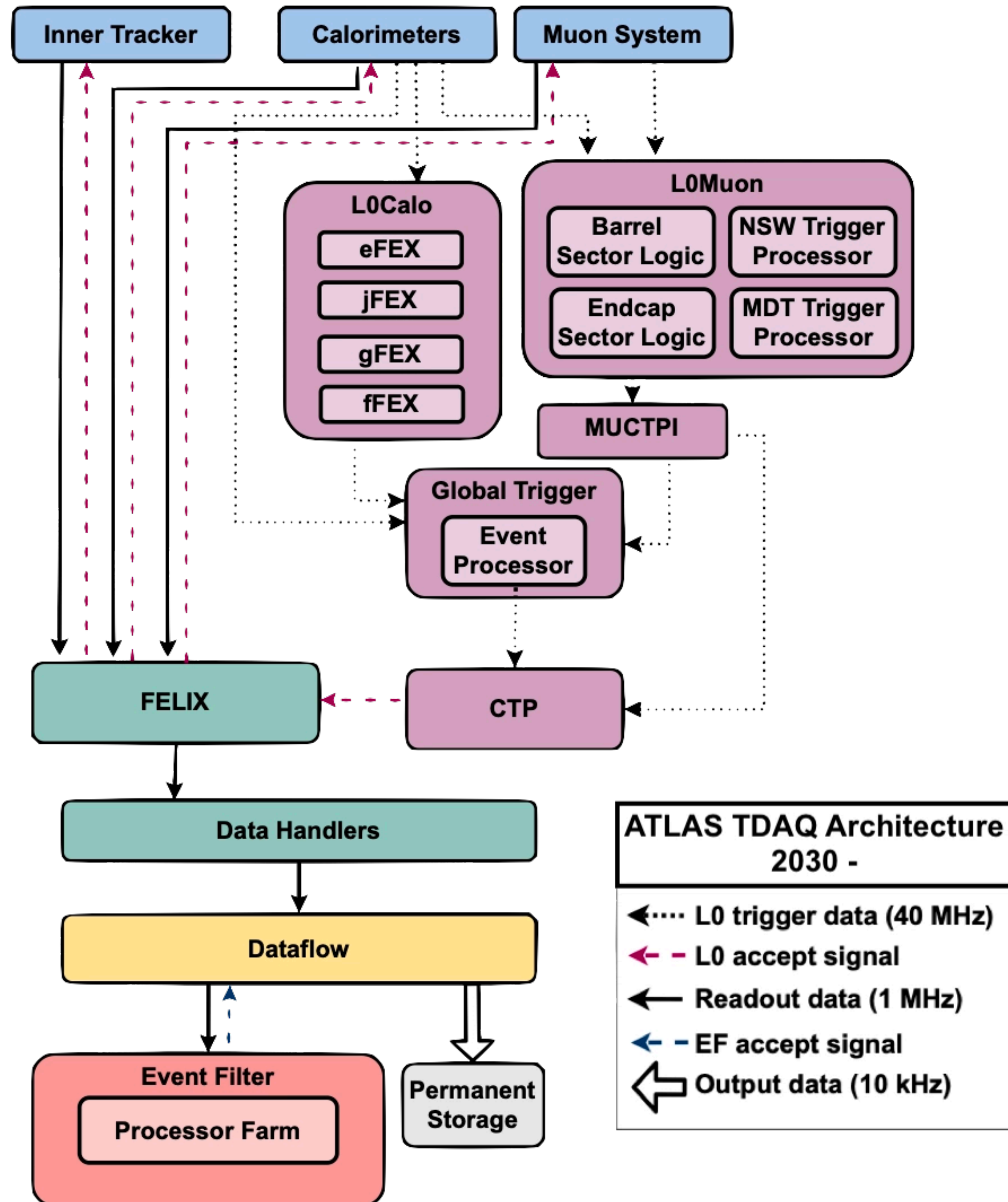


References

1. ATLAS Collaboration. The ATLAS Upgrade for the HL-LHC. ATL-UPGRADE-PUB-2025-001.
2. ATLAS Collaboration. Expected Tracking Performance of the ATLAS Inner Tracker at the High-Luminosity LHC. *JINST* 20 (2025). <https://arxiv.org/pdf/2412.15090>.
3. ATLAS Collaboration. ATLAS Inner Tracker Strip Detector: Technical Design Report (2017). <https://cds.cern.ch/record/2257755/files/ATLAS-TDR-025.pdf>
4. J.-H. Arling, P. Federic, Y. He, C. M. Helling, N. Hessey, L. Huth, G. Jain, C. Jessiman, S. Manson, L. Poley, J. S. Keller, J. Kroll, J. Kvasnicka, R. Privara, P. Speers, P. Tuma. Test beam measurements and computer simulations of the ATLAS ITk R2 silicon strip detector. *JINST* 20 (2025). <https://arxiv.org/abs/2506.16053>

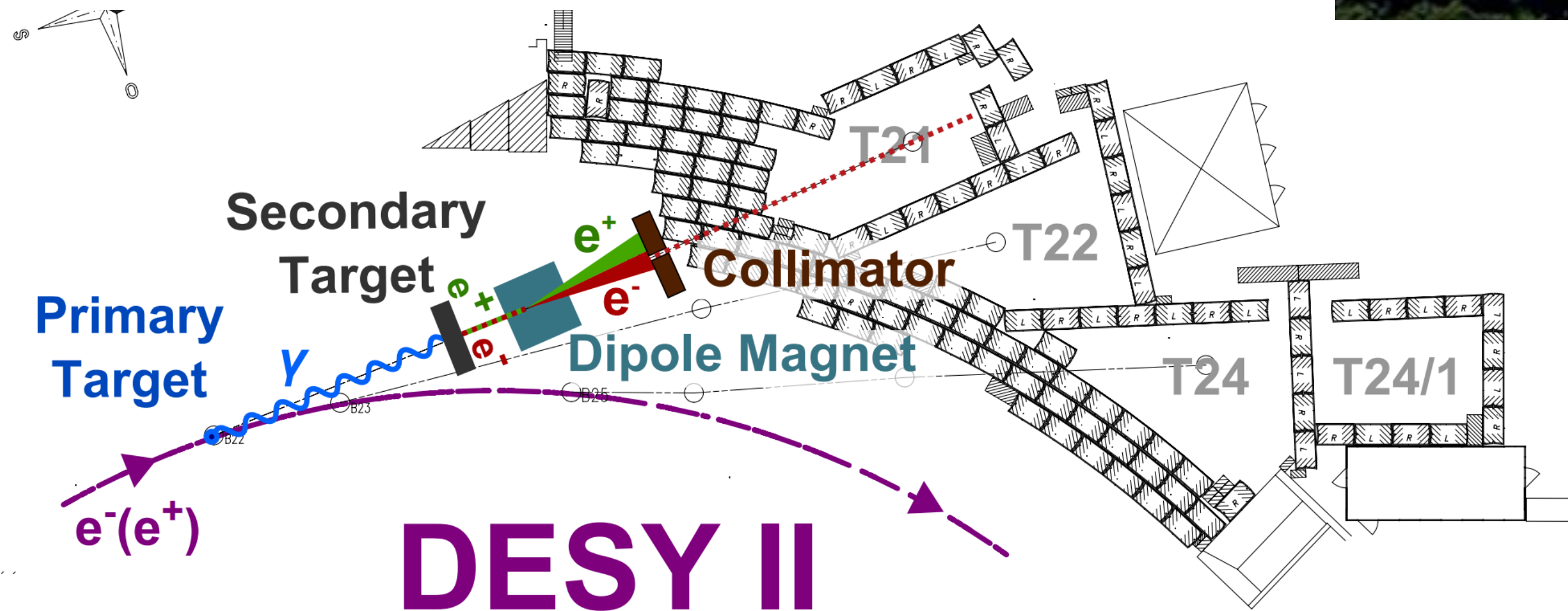
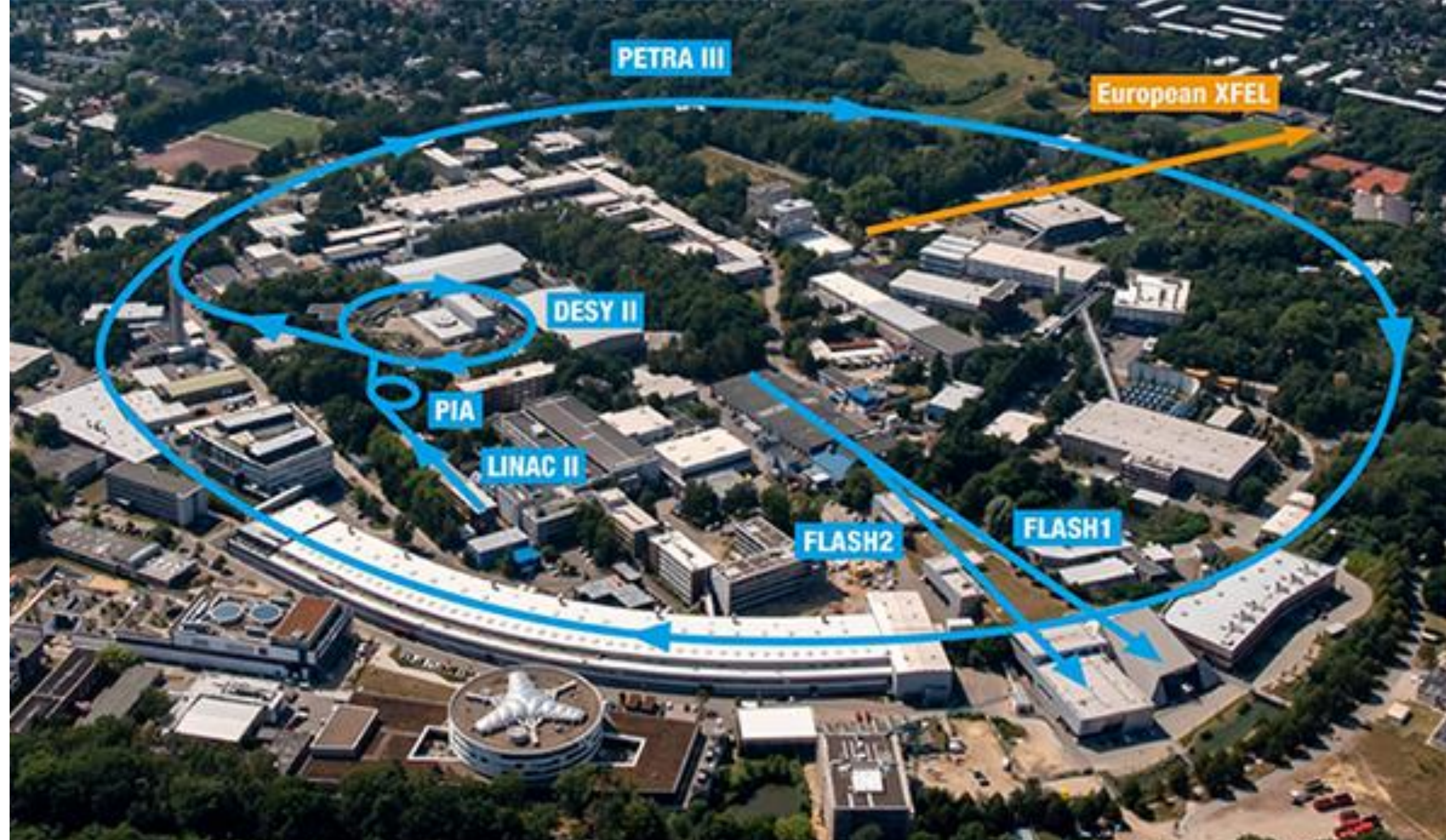
Backup Slides

ATLAS TDAQ



DESY II Test Beam

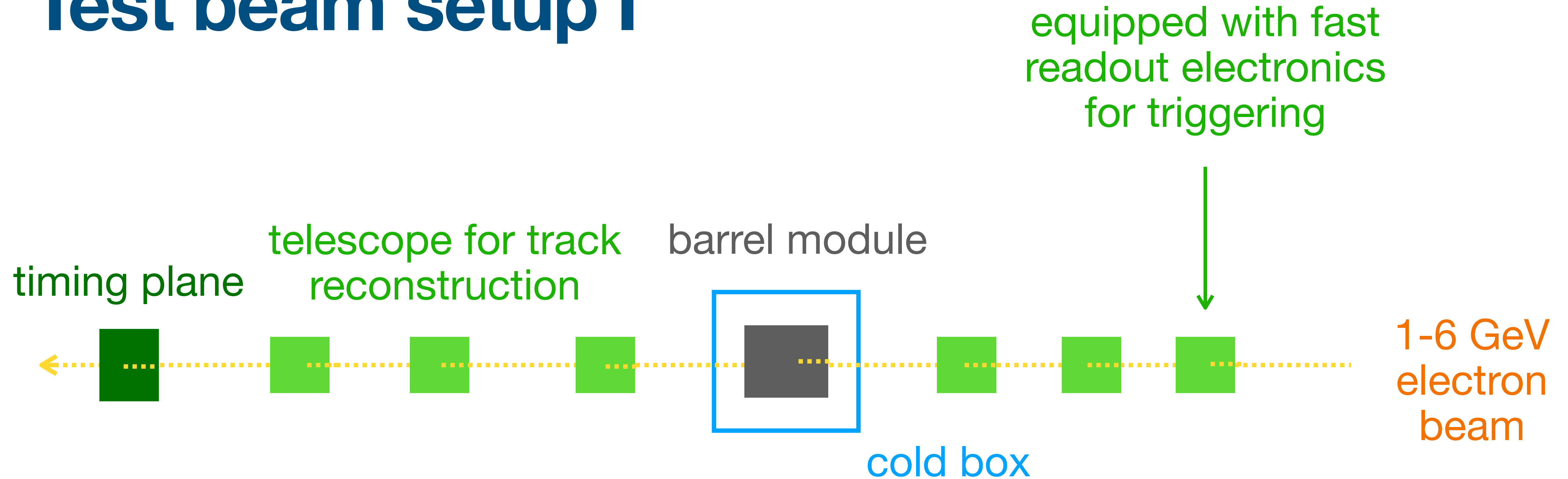
- DESY II synchrotron provides electron beams with tuneable momentum between 1 and 6 GeV



- Rate is also tuneable - but drops at regular intervals when DESY II refills Petra III

From <https://arxiv.org/pdf/1807.09328>

Test beam setup I

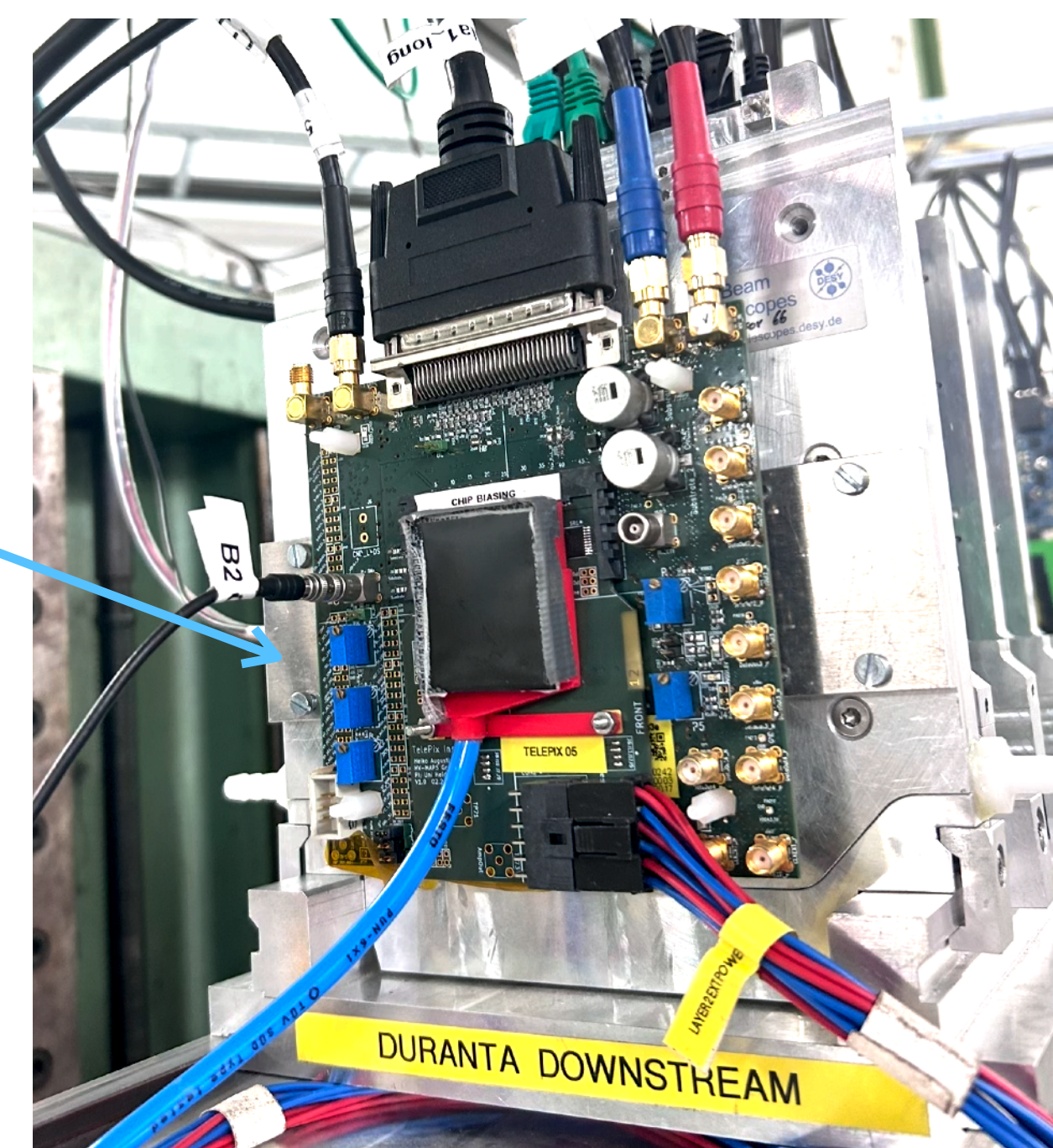


Efficiency is the % of tracks reconstructed by the telescope that pass through the module that are also detected by the module

Test beam setup II

fast readout
electronics for
triggering

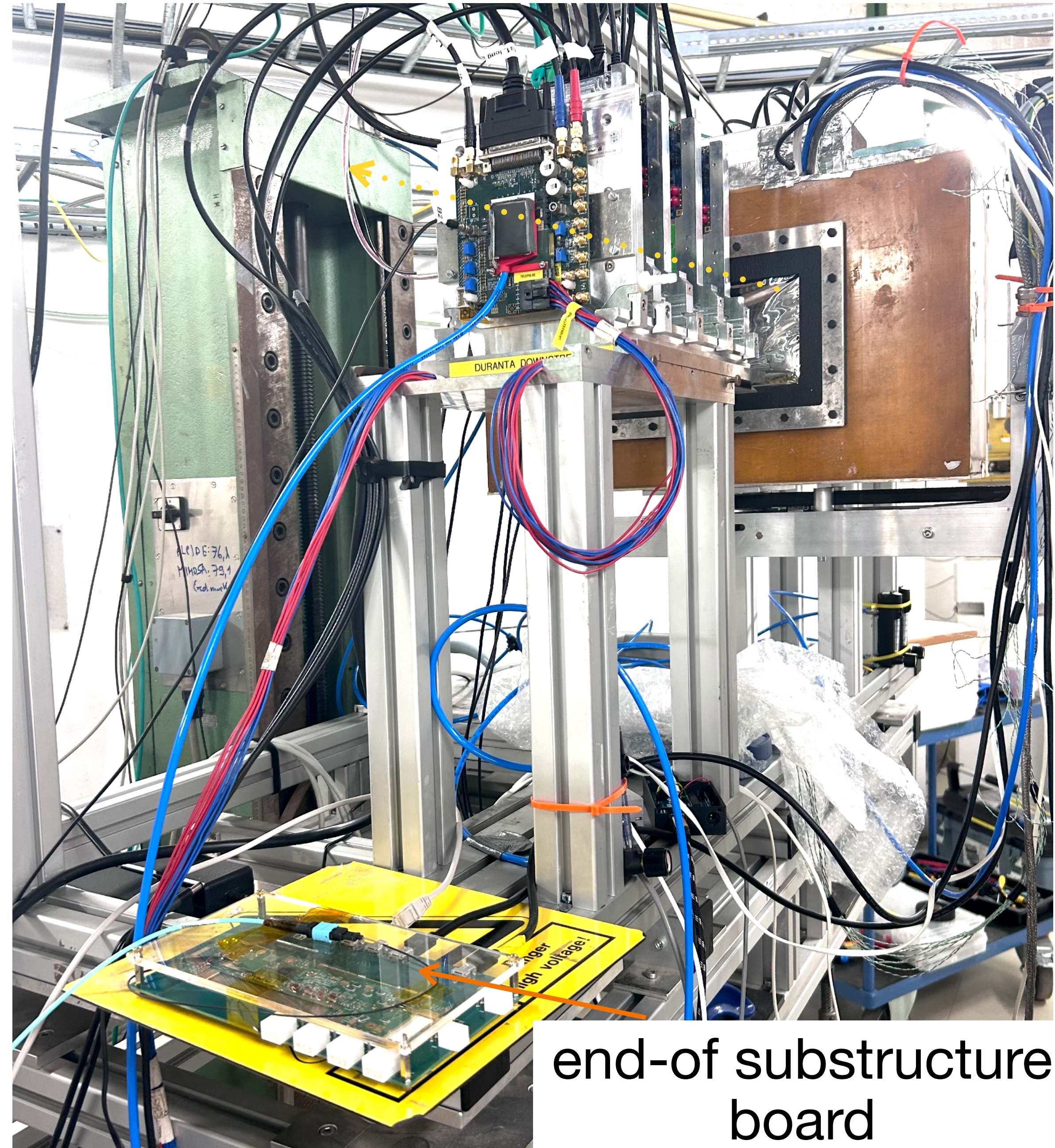
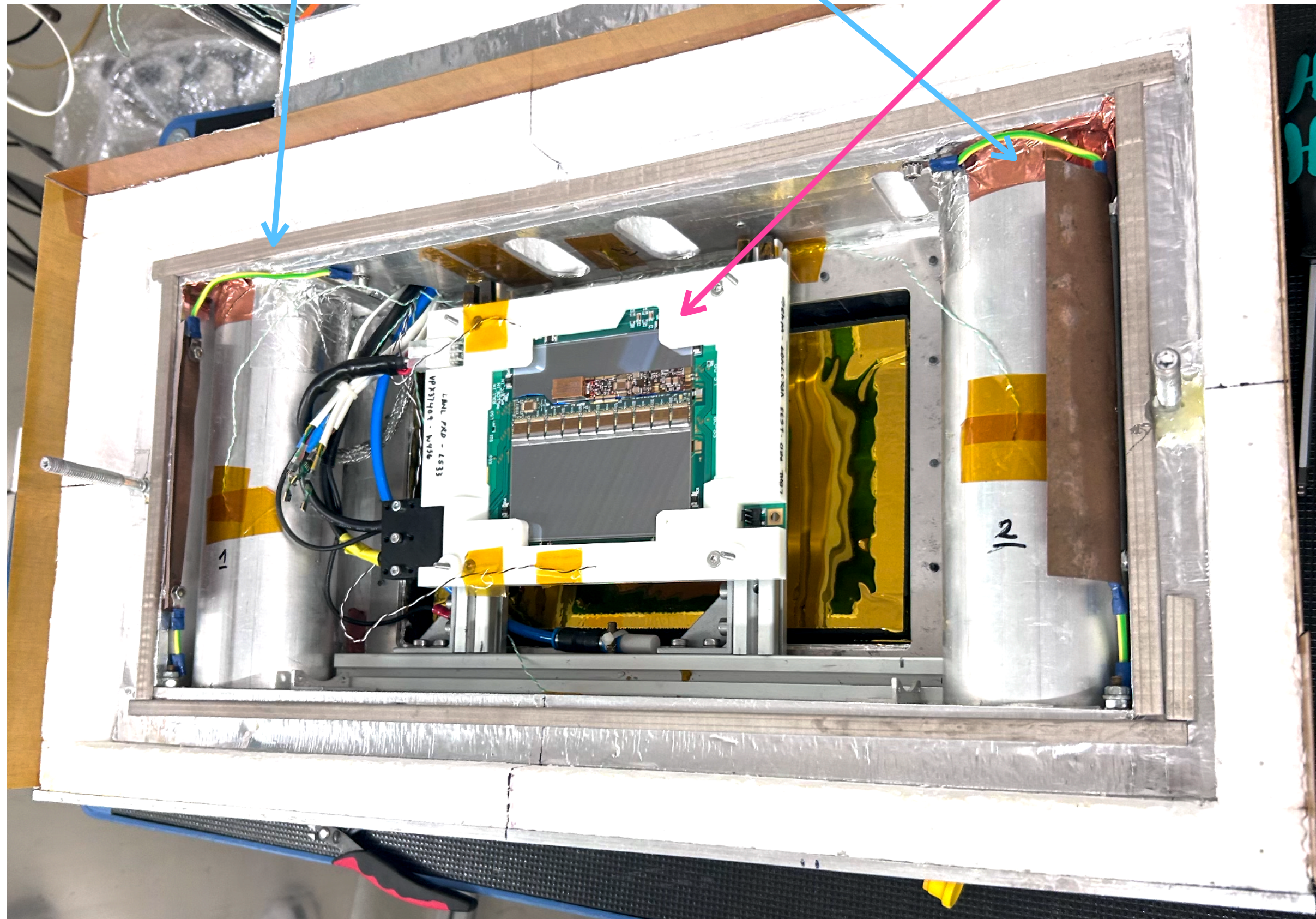
timing plane



Test beam setup III

cylinders full of dry ice

long strip barrel module



end-of substructure board