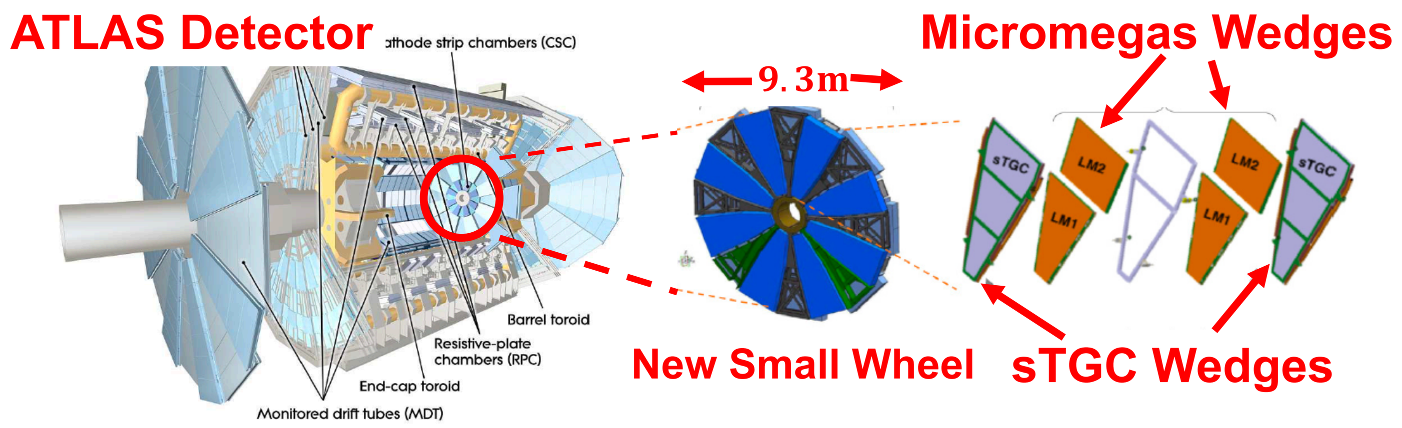
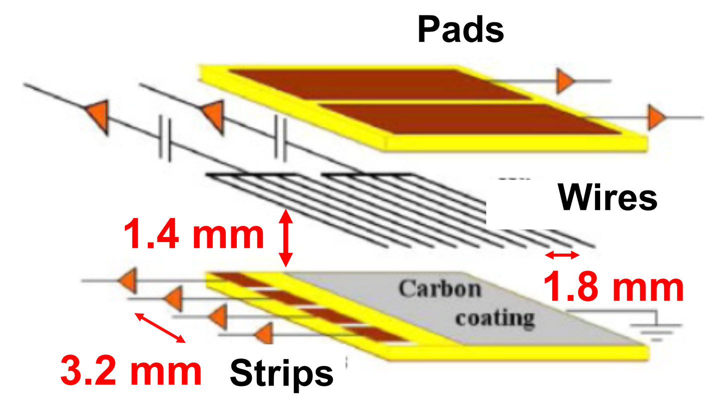
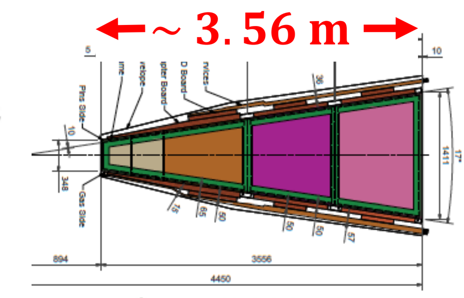
Integration and Commissioning of the ATLAS small-strip Thin Gap Chambers

Prachi Arvind Atmasiddha, University of Michigan, Ann Arbor, USA
(On Behalf Of The ATLAS Muon Collaboration)

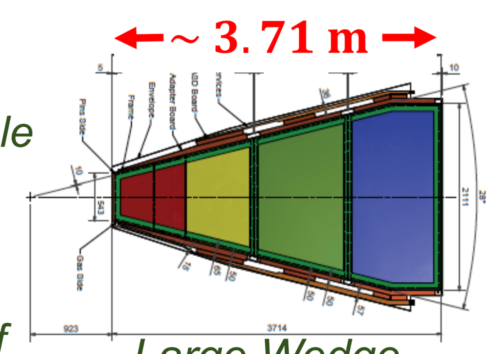
INTRODUCTION







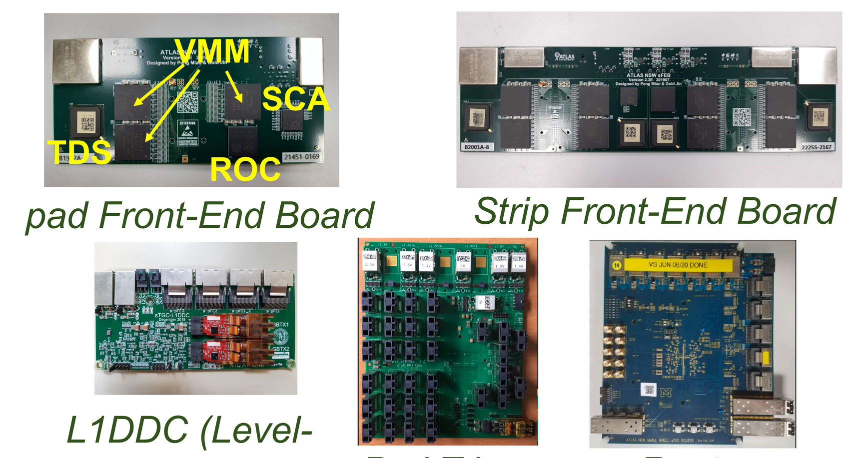
Small Wedge



Large Wedge

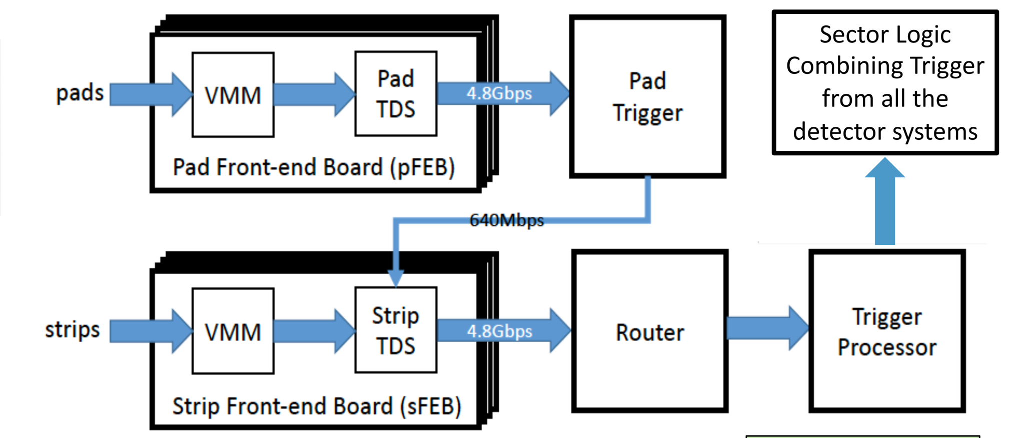
The Large Hadron Collider (LHC) will reach an instantaneous luminosity of $5-7.5\times10^{34}\text{cm}^{-2}\text{s}^{-1}$ (~2027 onward)[1]. This necessitates the upgrade of the ATLAS Muon Spectrometer. The innermost station of the muon end-cap system, the Small Wheel, will be replaced by the New Small Wheel (NSW). The NSW is required to improve the trigger selectivity in a high background environment (up to $20\,kHz\,cm^{-2}$). The small-strip Thin Gap Chambers (sTGC) sub-system will be the primary trigger detector for the NSW. It is expected that the sTGC should provide hardware-based online track segment measurements with a pointing accuracy of 1 mrad for the muon Level-1 trigger in the end-cap region. The sTGC detector system is equipped with several types of radiation tolerant ASICs, electronics cards and FPGA based back-end processors to move a large volume of both trigger and Level-1 readout data from ~400k active channels off the NSW. We present the status and the results from the surface integration and commissioning of the sTGC sub-system at CERN. sTGC detector is in the form of wedges. Each wedge has 3 multilayered modules (quadruplets). Total 64 such wedges need to be assembled and tested.

→ Pads – Used for "pre-Level 1 trigger". Coincidences from multiple layers of pads will define smaller regions of interest.
→ Strips – for precise position measurement using the regions of interest defined by the pads. For strips good alignment precision is important.

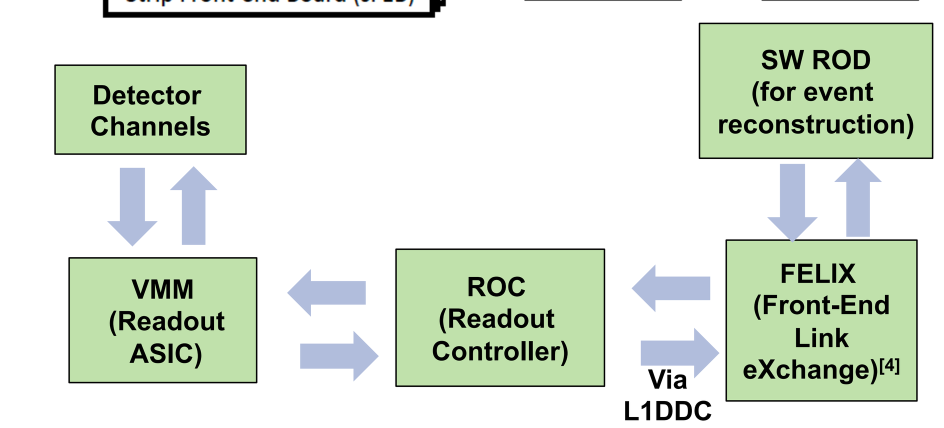


pad Front-End Board *Strip Front-End Board* *L1DDC (Level-1 Data Driver Card)* *Pad Trigger Board* *Router*

Several custom-made front-end and back-end electronics needed for establishing trigger and readout data flow.



Trigger Chain Flow (trigger generation and propagation)



Readout Chain Flow (full readout and reconstruction of triggered events)

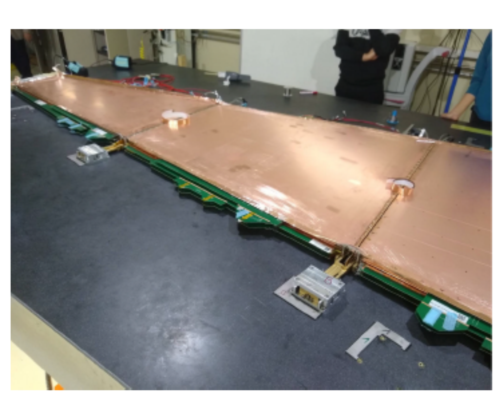
CHALLENGES FOR STGC INTEGRATION AND COMMISSIONING

- Achieving good alignment precision between different quadruplet-layers during assembly.
- Arrange active cooling system, data cables, Front-Ends and other electronics in a very tight space on the detector.
- Ground optimization and noise control for the large area detectors.
- Validation of the Front-End electronics connectivity with complex readout & trigger data flows at high speed.

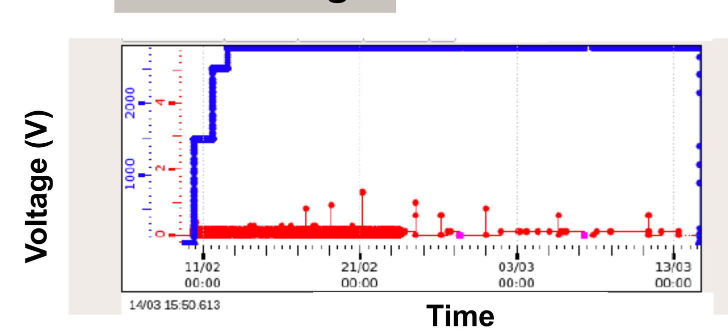
STGC WEDGE ASSEMBLY & X-RAY SURVEY

sTGC Detector Assembly:

Reception tests (Pulser and high radiation tests) ➜ Assembly into a wedge ➜ Alignment platform installation, Faraday cage mounting ➜ Gas Leak And Long Term High Voltage Test

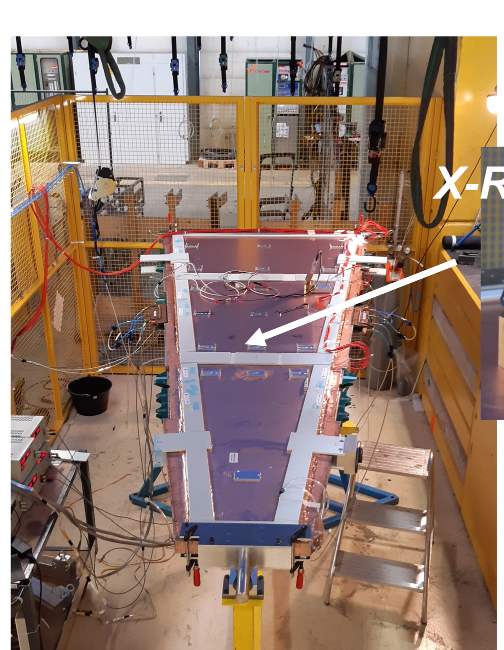


Gluing of the quadruplets

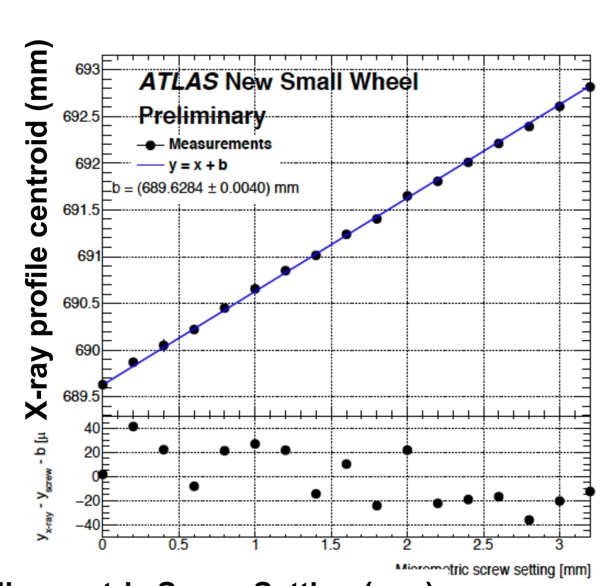


Long term High Voltage tests (Blue – Voltage)

X-Ray Strip Alignment Survey:



X-Ray survey station



Measurements of the collimated x-ray profile to determine the layer-to-layer strip alignment with a precision better than 40 μm[5].

INSTALLATION OF THE STGC DETECTOR SERVICES & ELECTRONICS TESTS

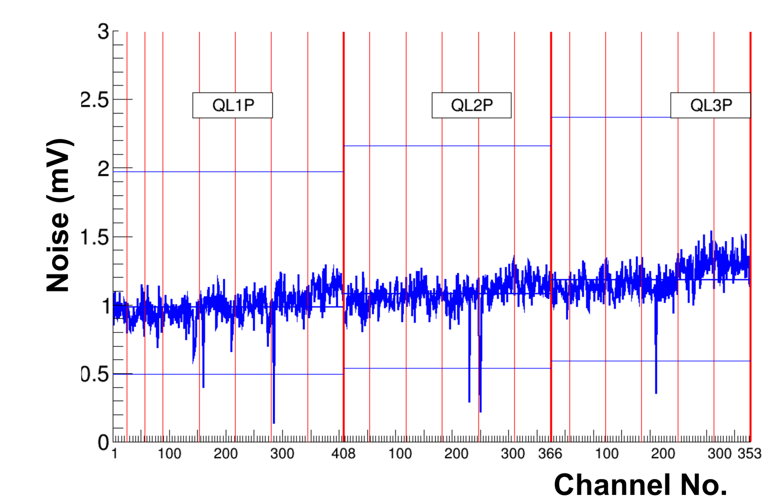
Service Installation:

Fitting data cables + Front-End boards in a very tight space

After Installation of the Services (cooling system, data cables, Front-Ends, etc)

Noise Measurement:

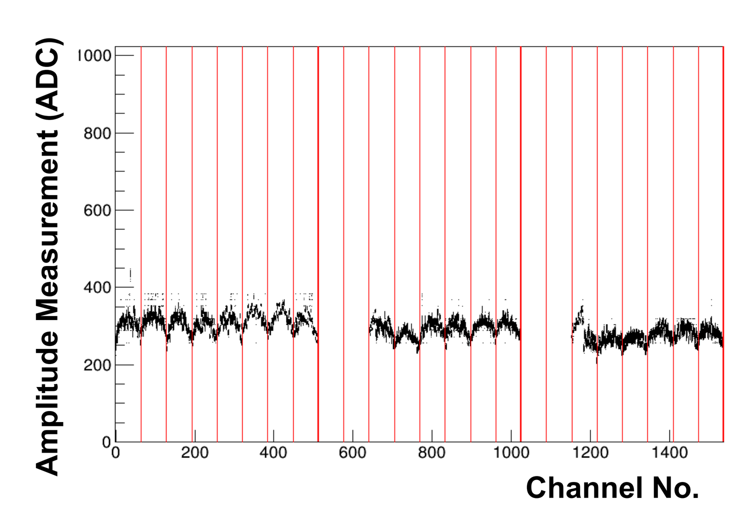
- For verifying the connectivity between physical and electronics channels.
- Using an oscilloscope and Analog-To-Digital Converter on the Front-End Boards. Problematic channels: typically <2%



Noise ∝ Strip Length ∝ Capacitance

Trigger and Readout:

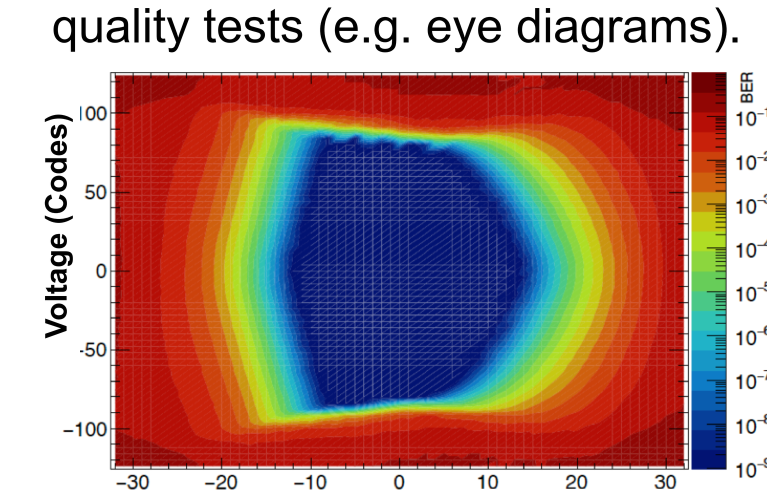
The trigger and readout data connections are checked.



Amplitude measurement vs channel for the test-pulse readout on one wedge layer (3 quadruplets together).

Data Quality & Synchronization:

Tuning and calibration of a large number of clock phases from the on-wedge electronics for the proper data alignment and synchronization. Other signal quality tests (e.g. eye diagrams).



Eye-diagram for signal transmission at 4.8 Gbps.

CONCLUSION

The New Small Wheel Side-A

- The Integration and Commissioning for sTGC detectors is ongoing at CERN for the installation during the LHC Long Shutdown 2 (LS2) period with assembly and successful checking of the trigger and the readout data links.
- The fully tested sTGC wedges are being mounted on the New Small Wheel along with the Micromegas detector wedges.

REFERENCES

[1] https://project-hl-lhc-industry.web.cern.ch/content/project-schedule
[2] Kawamoto, T; ATLAS Collaboration (ATLAS-TDR-020).
[3] P. Gkountoumis, JINST12, no.01, C01088(2017)
[4] W. Wu, IEEE Transactions on Nuclear Science, vol. 66, no. 7, pp.986-992, July 2019.
[5] Lefebvre, benoit , JINST 15 (2020) C07013