Towards validating misalignment measurements of small-strip thin gap chambers for the ATLAS new small wheels

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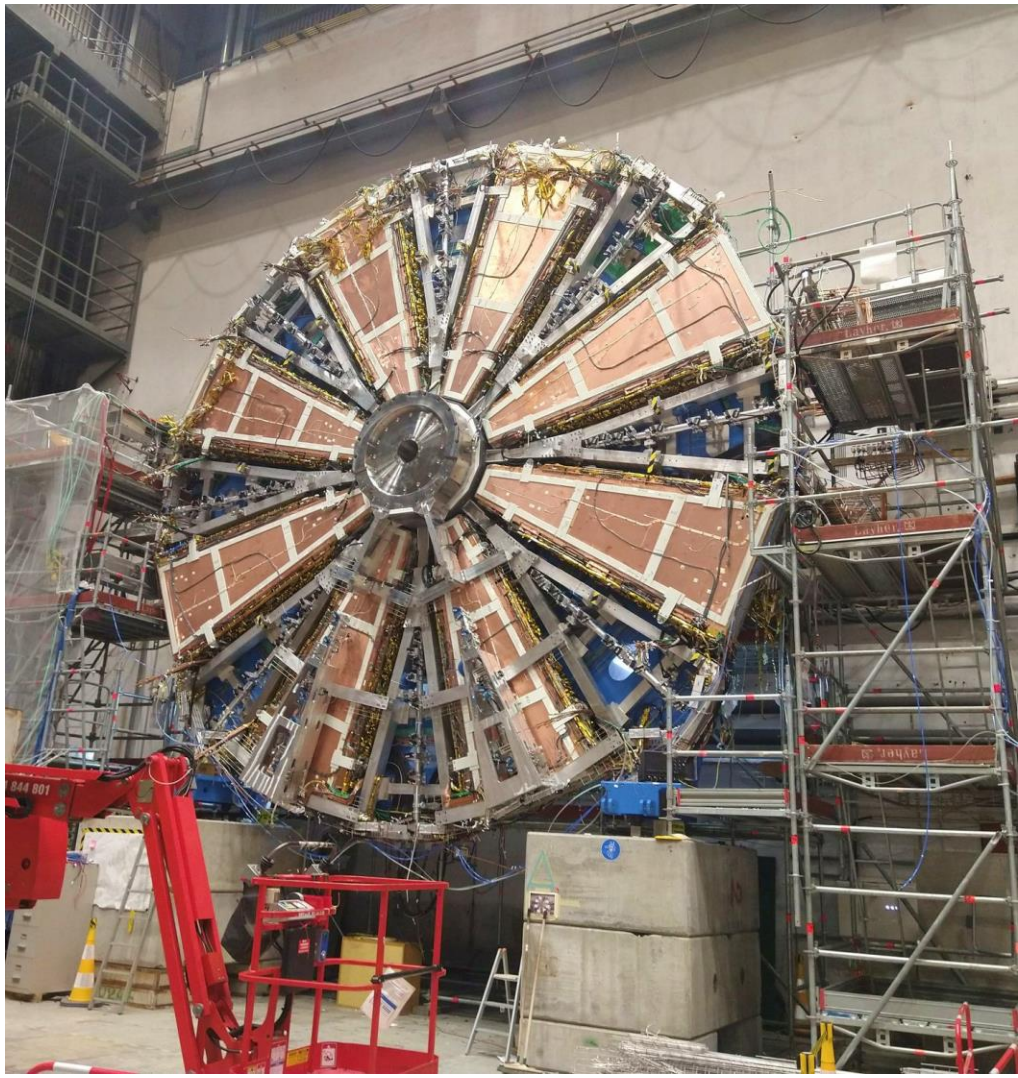
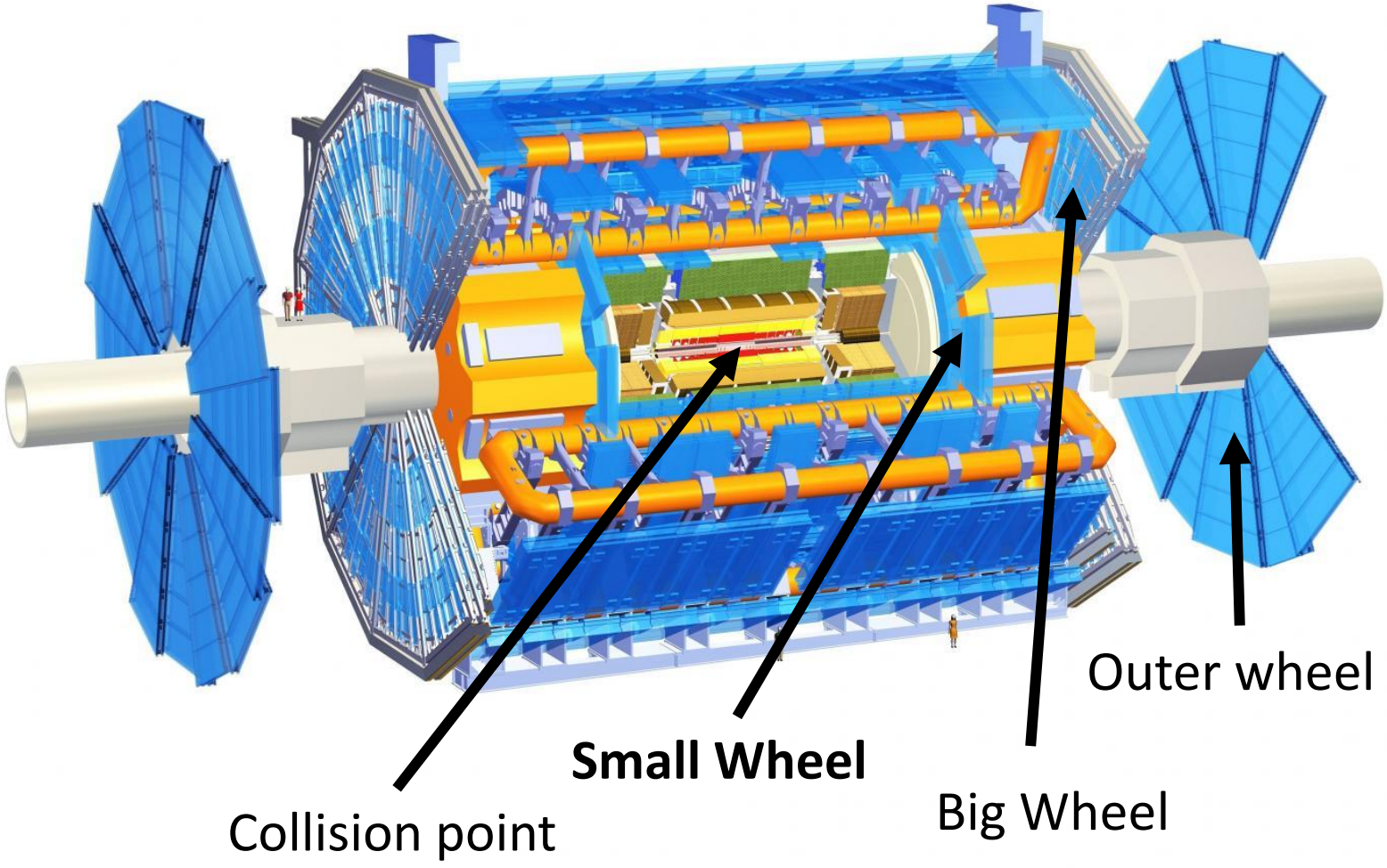


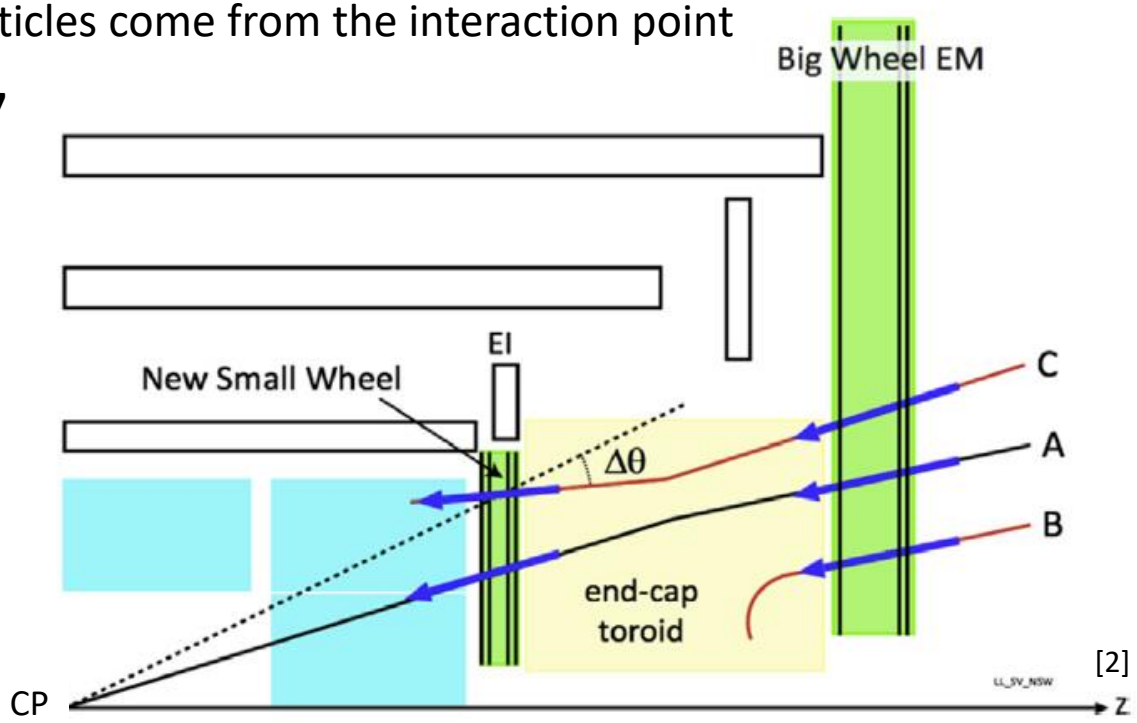
ATLAS Muon Spectrometer

- Three wheels responsible for muon tracking in forward region



Why Replace the Muon Small Wheel?

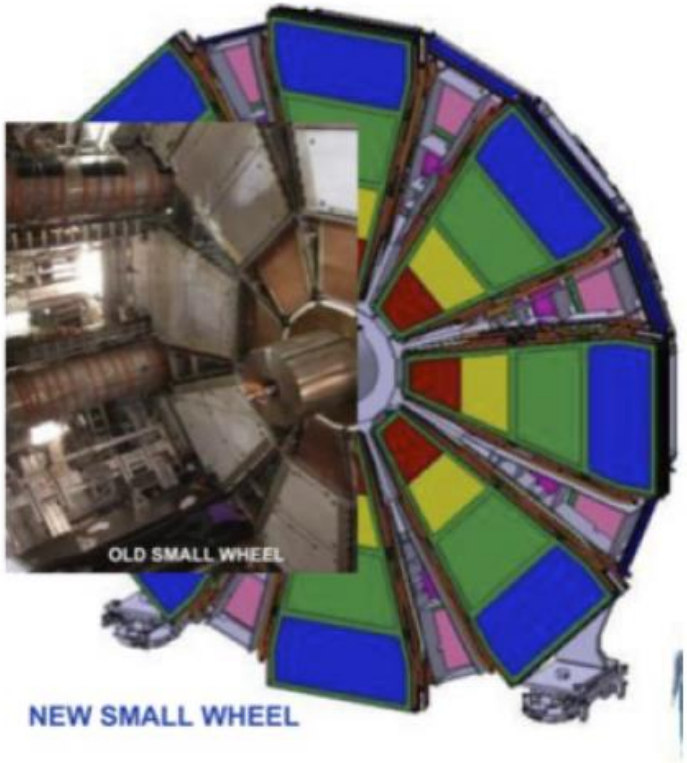
- Significant increase in luminosity achieved by High-Luminosity LHC project (2027)
- Current forward muon reconstruction has ≈ **90% fake rate** due to hits in the Small Wheel from secondary particles generated in the end-cap toroid magnet
- New Small Wheel (NSW) will provide track angle measurement that can be matched to the Big Wheel to ensure particles come from the interaction point
  - **Fake rate reduction by ≈ 7**

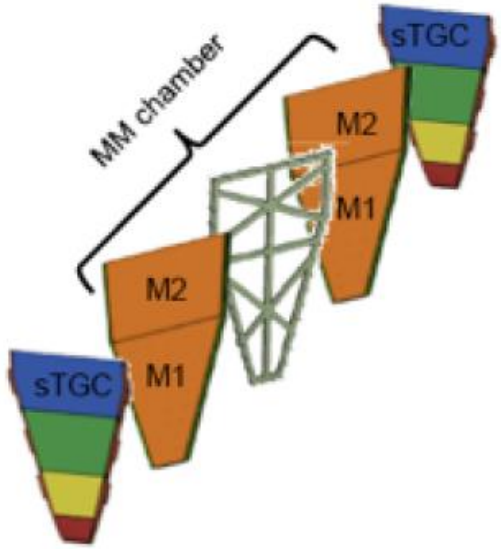


[2]

NSW and sTGC

- NSW = new small wheel
- sTGC = small-strip thin gap chamber
- Modules form wedges, wedges cover wheel

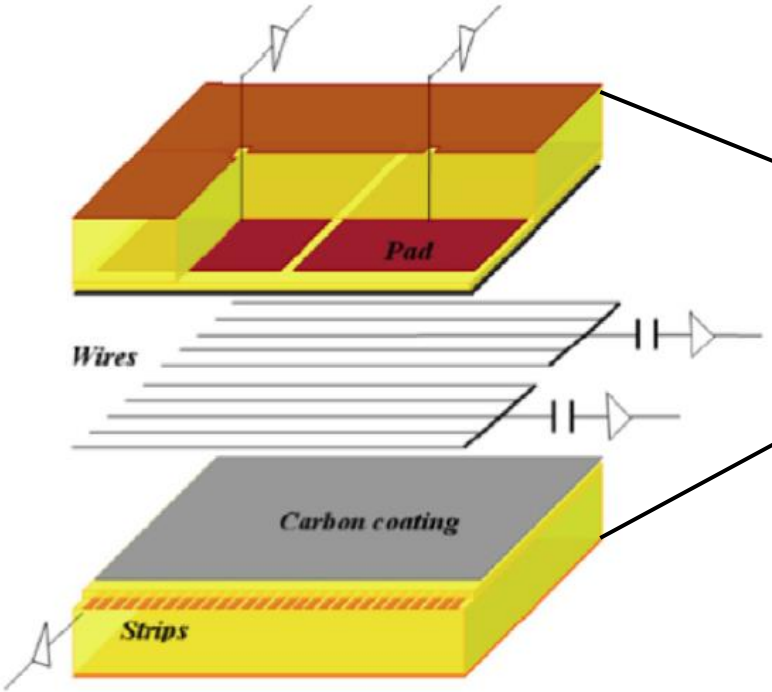




[1]

sTGC Internals

- sTGC are multi-wire gas proportional counter chambers
- Measurement of particle trajectory obtained using copper strips, with a pitch of 3.2 mm
- Each strip provides a measurement of the amplitude of charge deposited in the gas volume above it

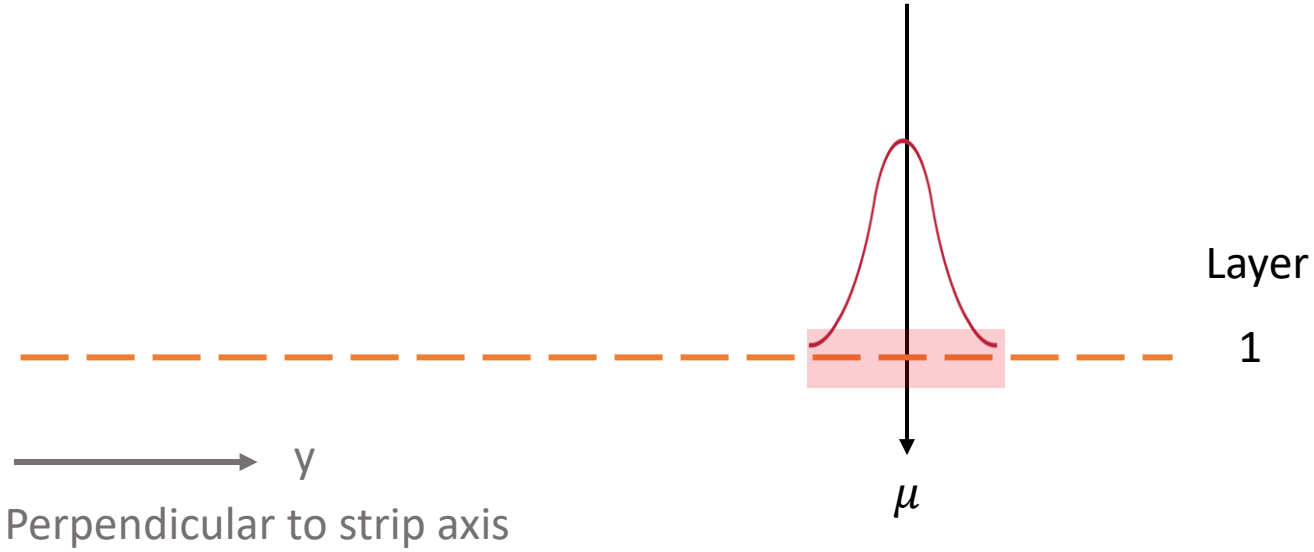


[2]

Quad

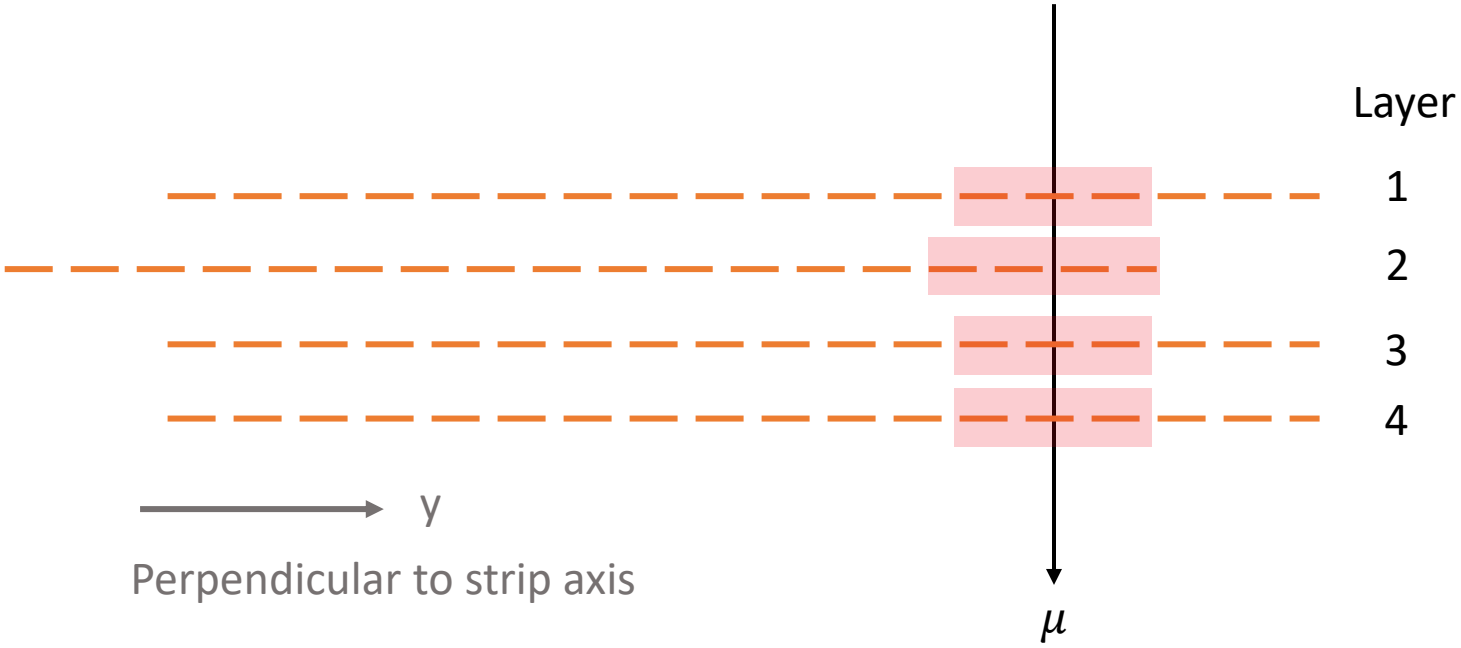
Reconstructing Position from Strips

- Current induced on 3-5 strips closest to muon track
- Highlighted area: strips contributing to output charge distribution
- Frame of reference depicted: physical position of strips



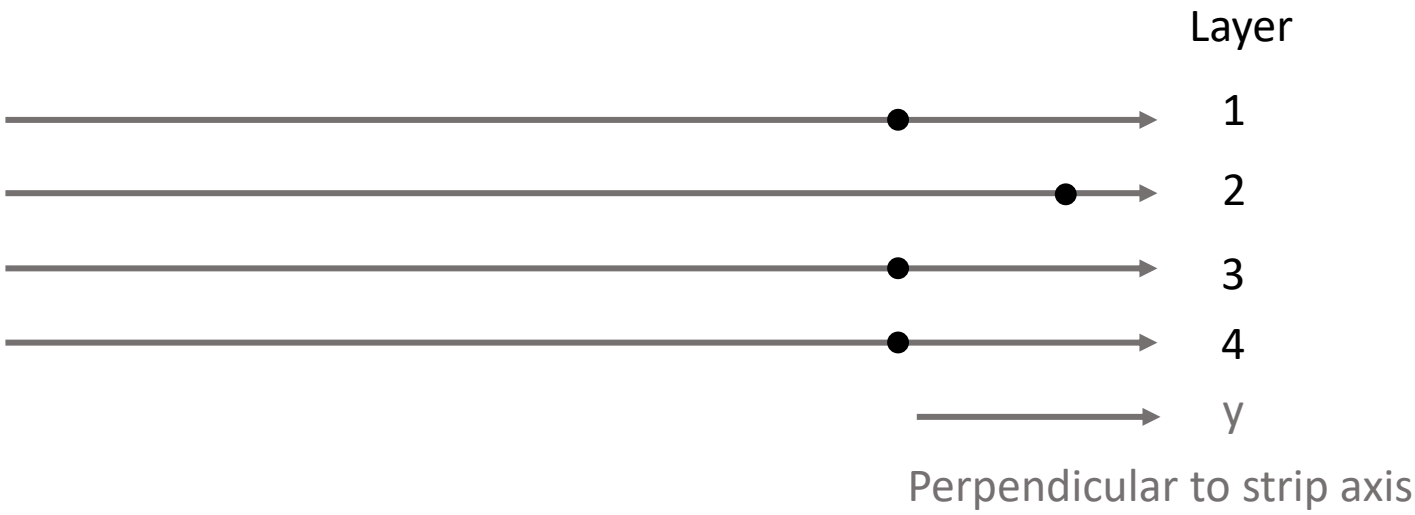
Effect of Misalignments

- Highlighted area: strips contributing to charge distribution
- Vertical muon track
- Layer 2 misaligned
- Frame of reference depicted: physical position of strips



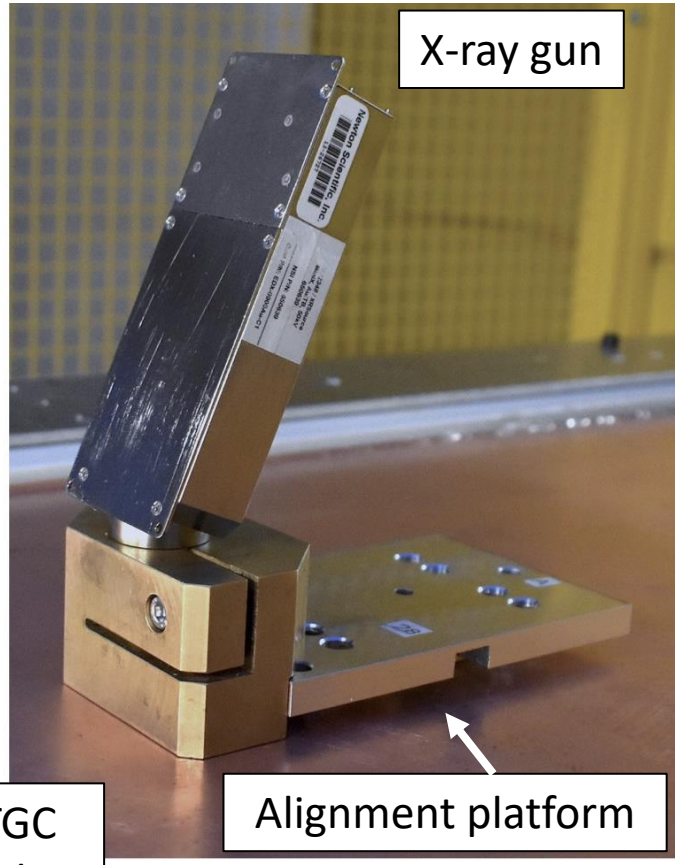
Effect of Misalignments

- Vertical muon track
- Layer 2 misaligned
- Frame of reference depicted: **software output**



X-Ray Measurements of Alignment

- X-ray gun mounted to alignment platform on sTGC wedge
- For each event,
  - Fit a Gaussian to charge distribution recorded on strips below x-ray
  - Centroid calculated *w.r.t.* to platform
- Fit Gaussian to centroids
- Compared to nominal value to get local offsets



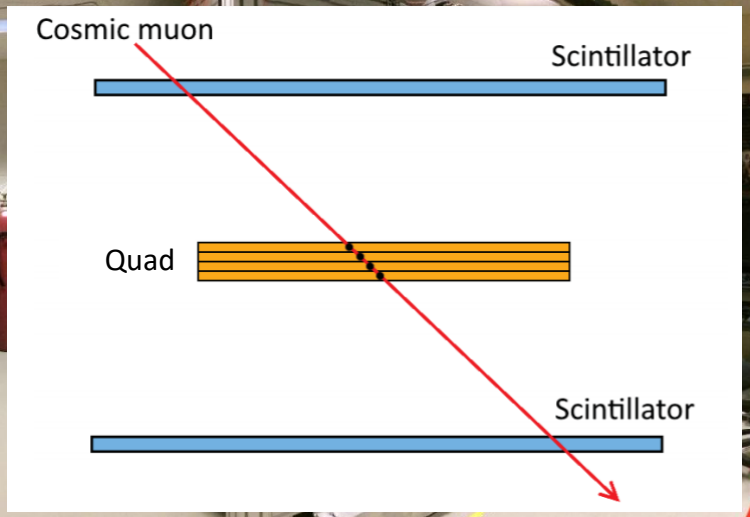
[3]

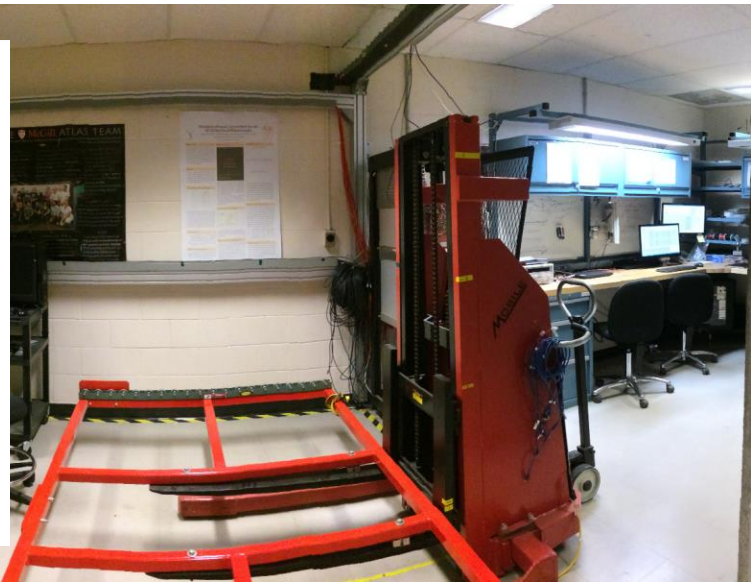
McGill Cosmics Test Stand

Gas system Hodoscope Forklift Slow control

- Use cosmics muons to test, validate and characterize Canadian-made sTGC chambers

McGill Cosmics Test Stand



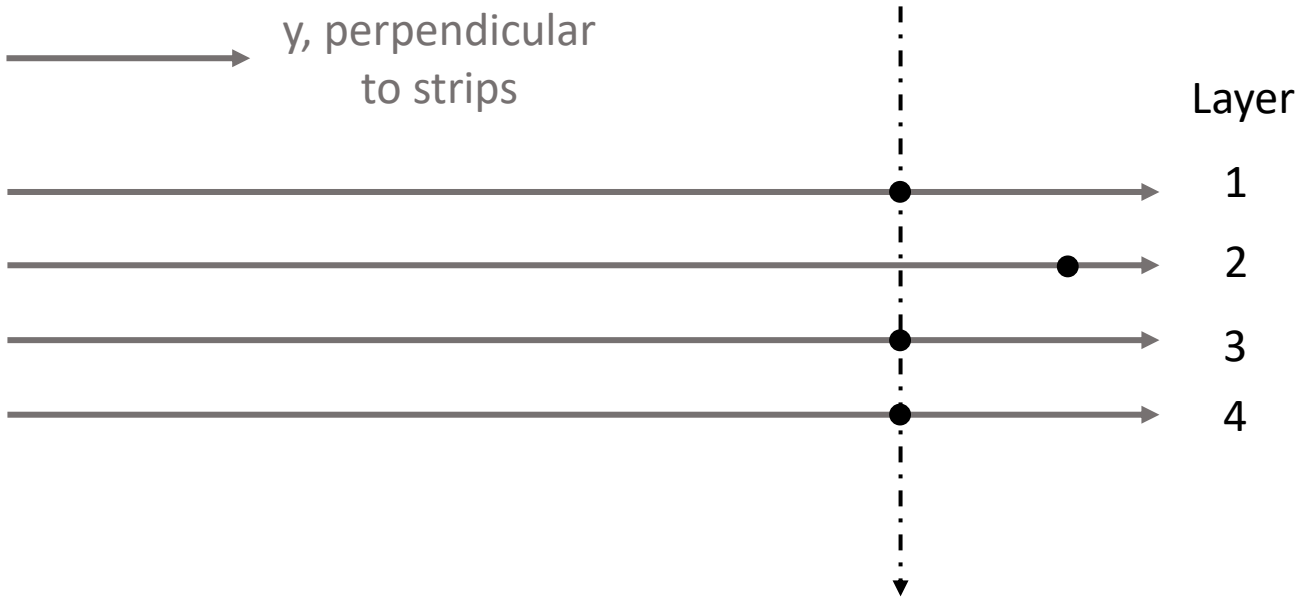


Gas system Hodoscope Forklift Slow control

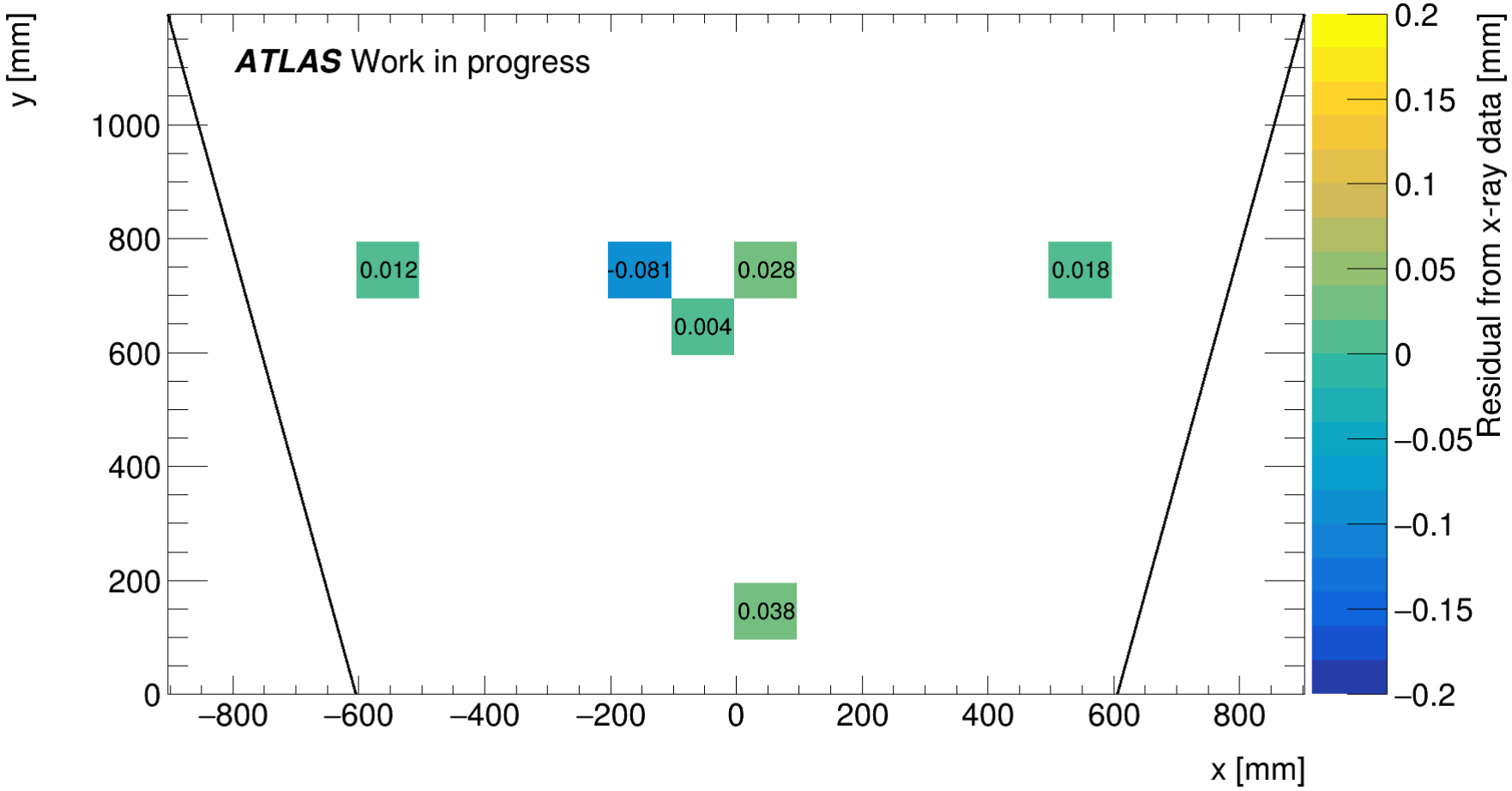
- Use cosmics muons to test, validate and characterize Canadian-made sTGC chambers
- Coincidence in scintillators provides trigger to readout sTGC layers
- **Goal of project: Validate and improve misalignment measurements provided by x-ray methodology with cosmics data**
- Challenge with using cosmics data for alignment studies: no absolute coordinate system

Creating a Relative Coordinate System

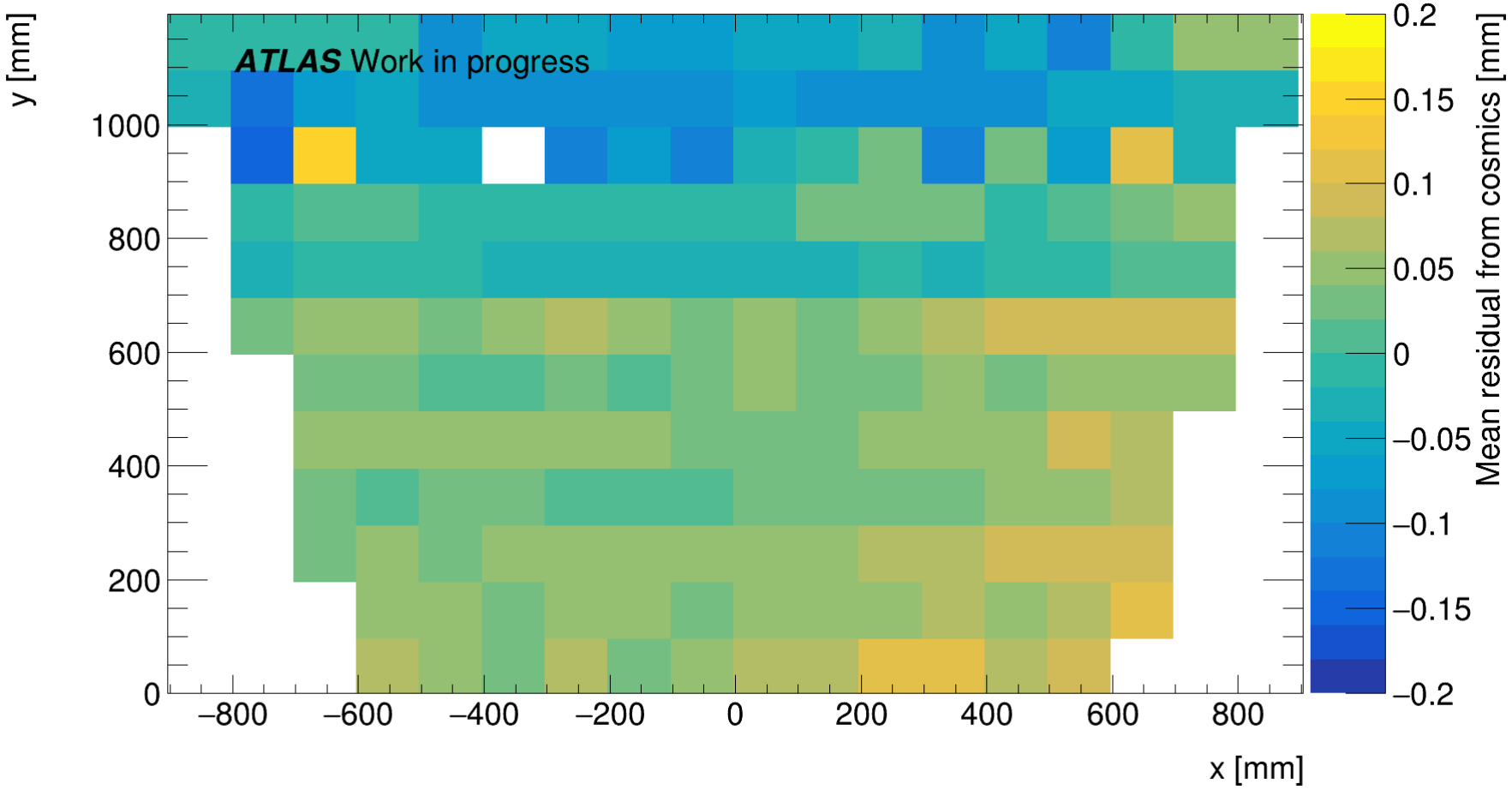
- Frame of reference depicted: layers 1 and 4
- Create track from hits on layers 1 and 4
- Calculate residual (hit position – track position) on layer 2
- **Applicable to both x-ray and cosmics data**



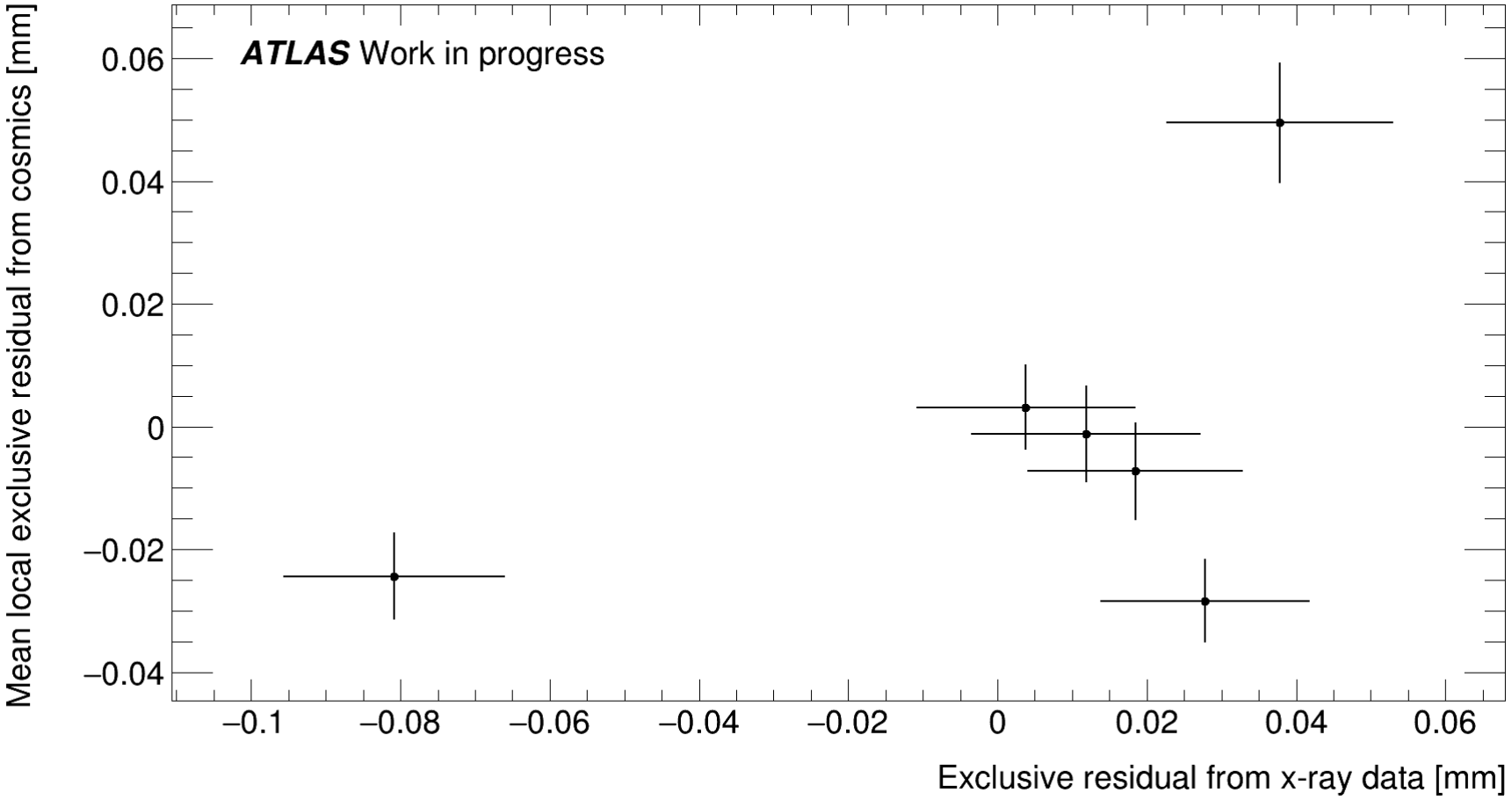
X-ray residuals for QL2.P.8, layer 2, fixed layers 1, 4



Mean residuals from cosmics for QL2.P.8, layer 2, fixed layers 1, 4

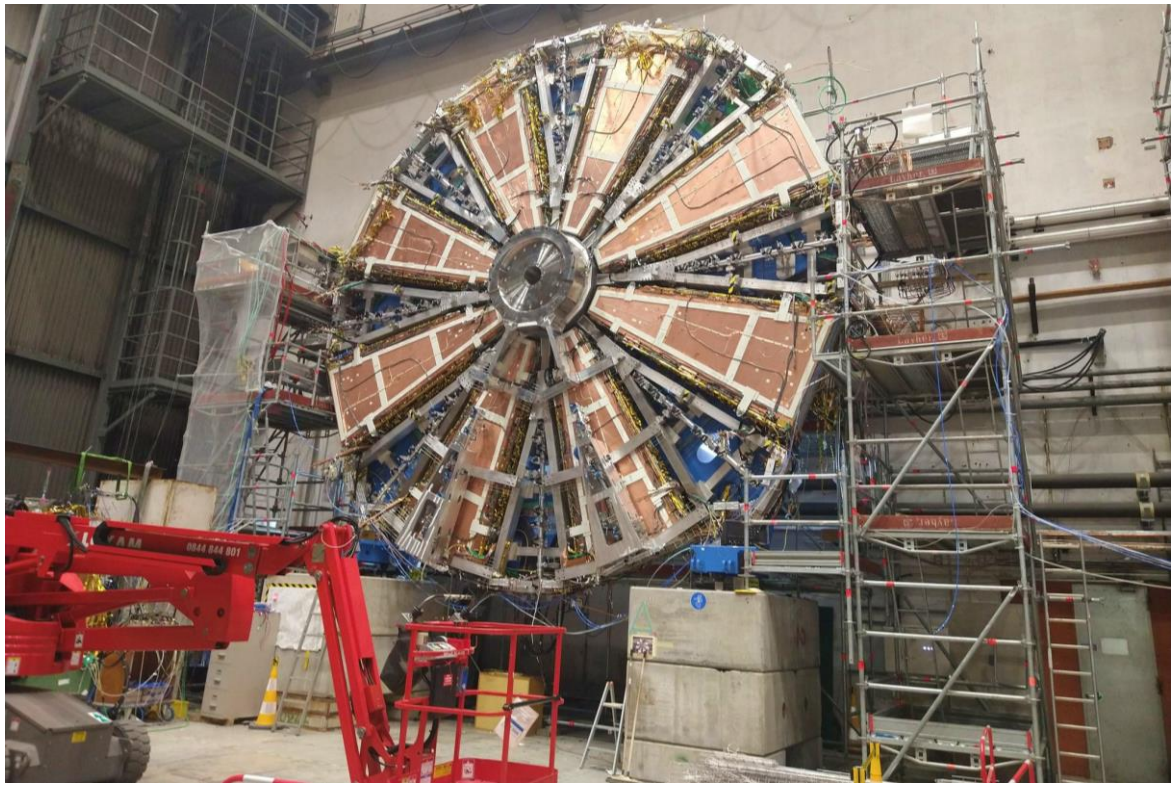


Correlation Plot



Next Steps

- Study systematics of both methodologies
- **New:** x-ray data has been combined with coordinate measurements of strip boards before assembly to create a complete misalignment model per strip layer
    - Move towards validating the complete model with cosmics data



References

[1] B. Stelzer, Nucl. Part. Phys. Proc. **273–275**, 1160 (2016).

[2] E. Perez Codina, Nucl. Instrum. Methods Phys. Res. Sect. Accel. Spectrometers Detect. Assoc. Equip. **824**, 559 (2016).

[3] B. Lefebvre, Precision Survey of the Readout Strips of Small-Strip Thin Gap Chambers Using X-Rays for the Muon Spectrometer Upgrade of the ATLAS Experiment, J. Instrum. **15**, C07013 (2020).

X-ray cluster centroids

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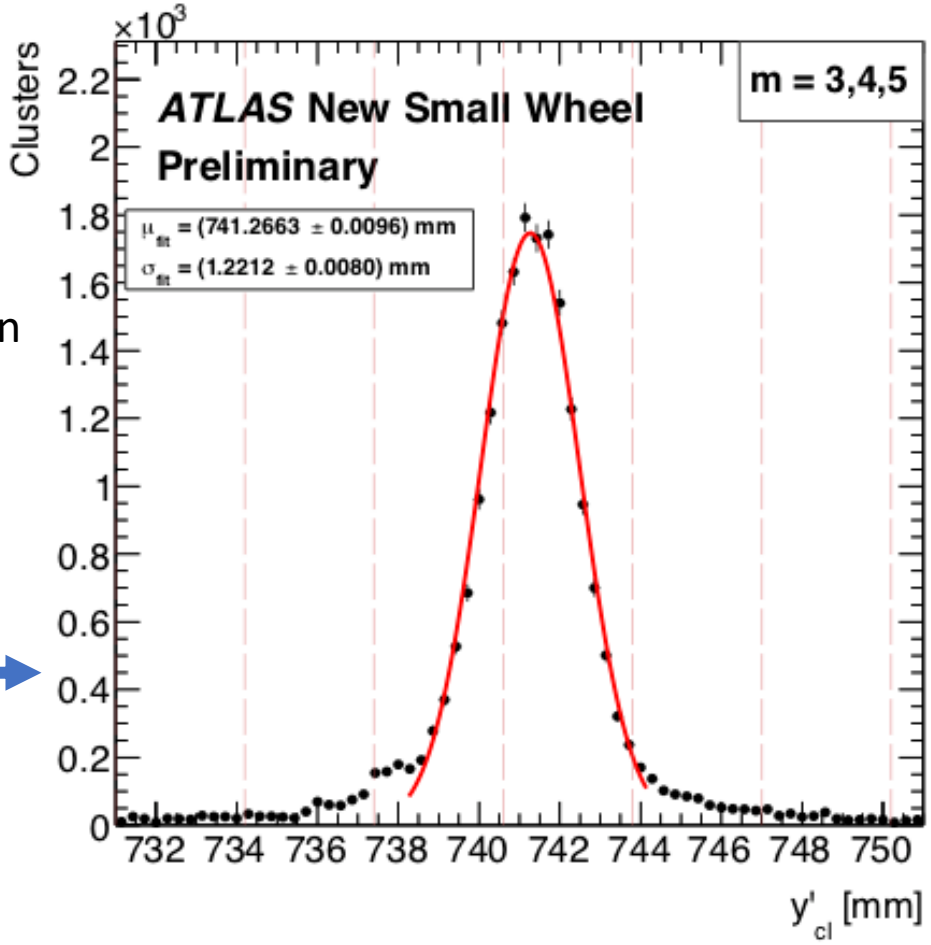
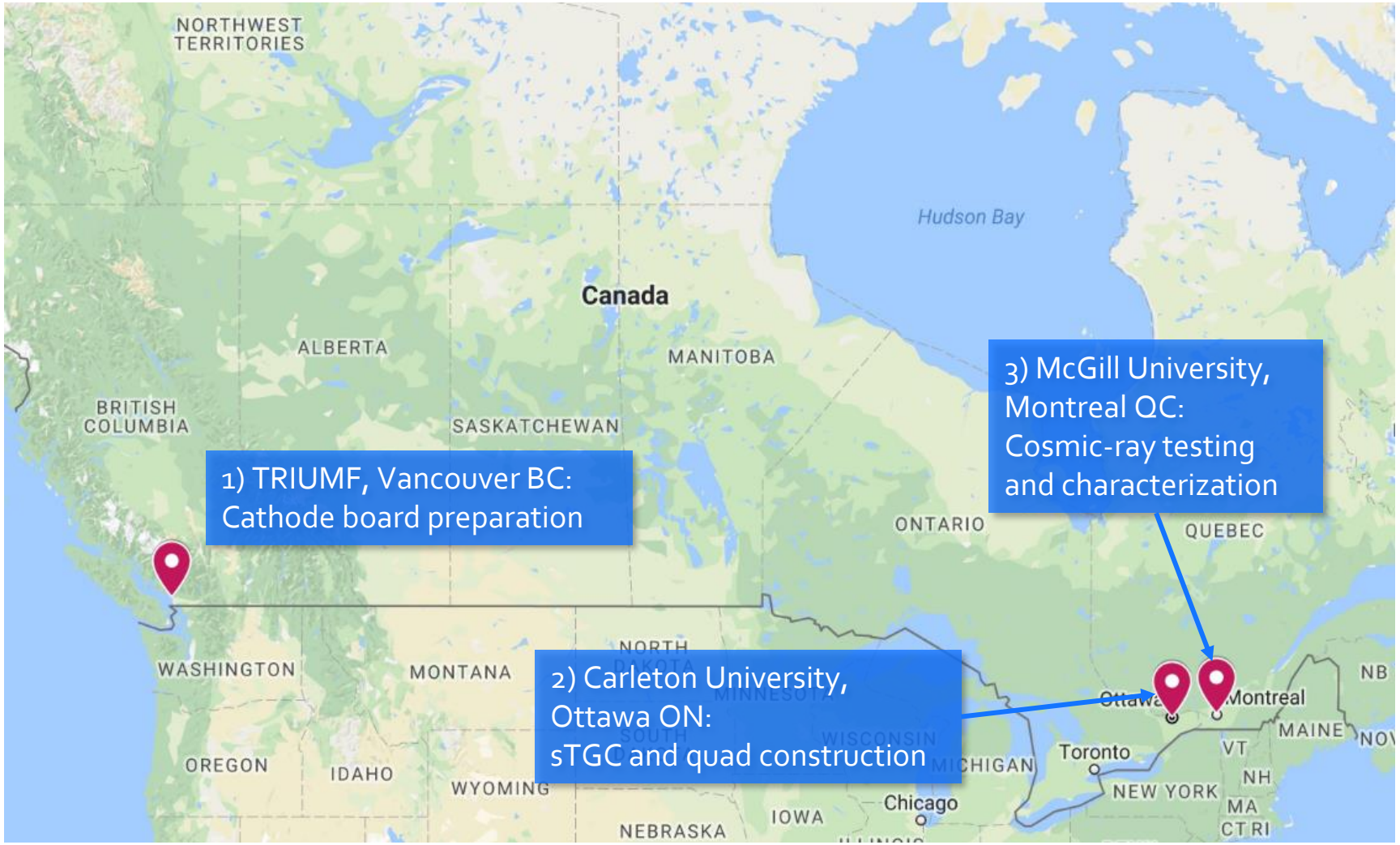
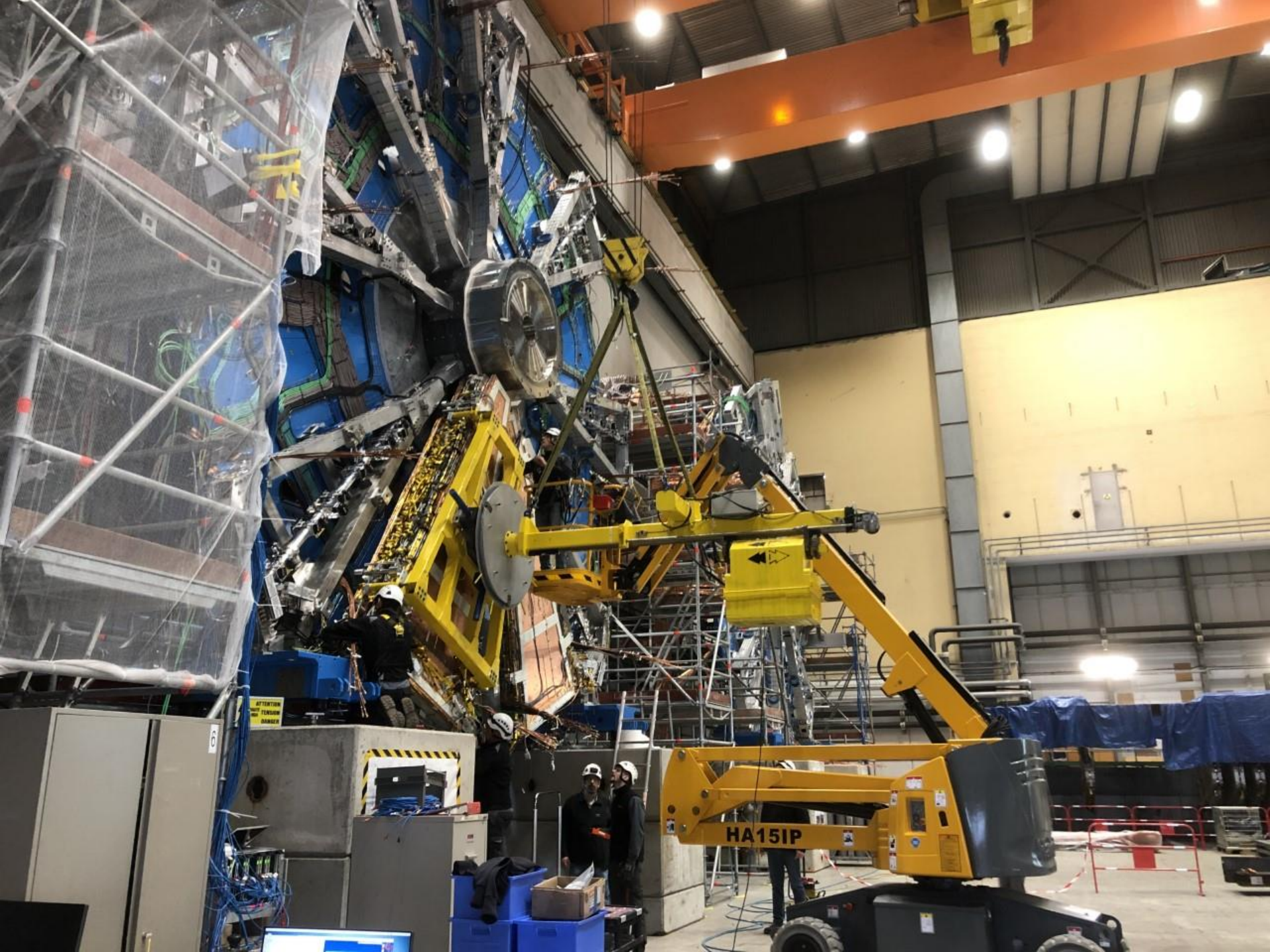


Countries Producing sTGCs

- Canada, Chile, China, Israel, Russia

Journey of Canadian Quads

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