

ATLAS small-strip Thin Gap Chamber Signal Strength Studies

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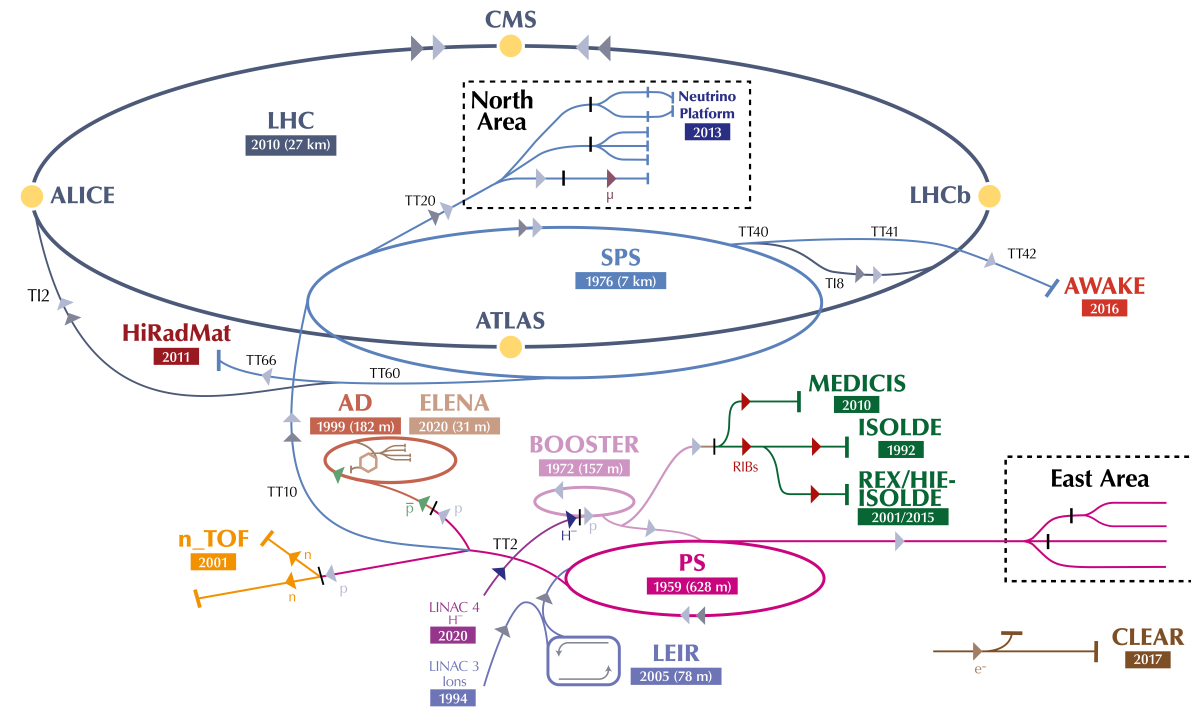


University
of Victoria

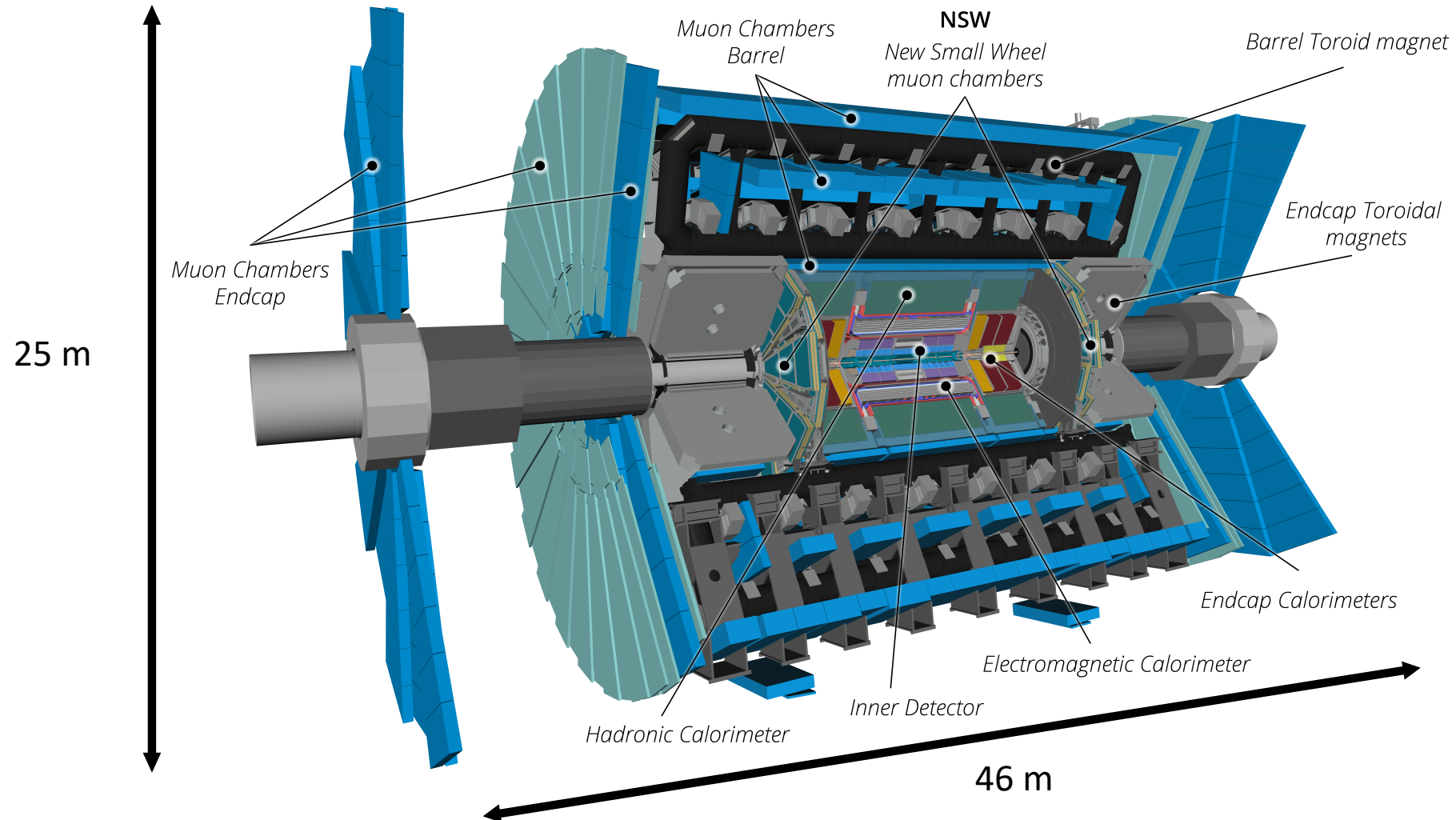


CERN Accelerator Complex

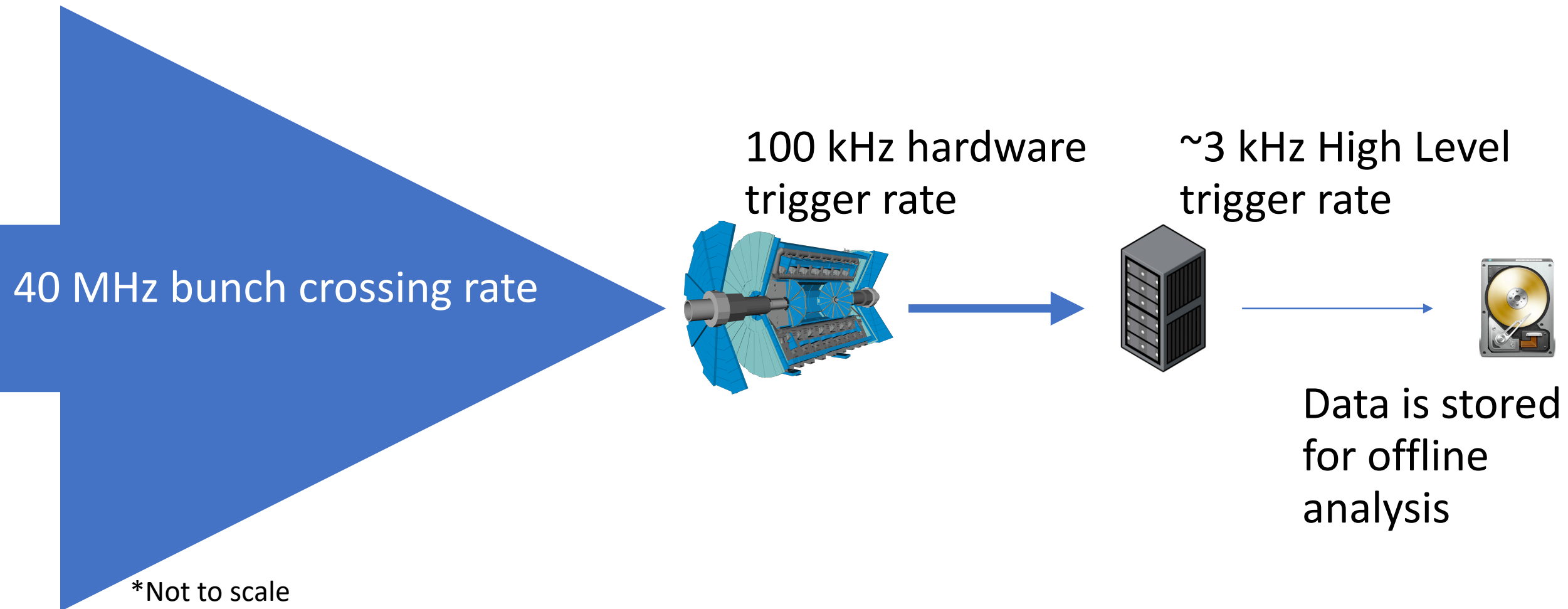
- Large Hadron Collider
 - 27 km circumference proton-proton collider
 - Run 3 (2022-2026) p-p centre-of-mass energy 13.6 TeV



The ATLAS Experiment

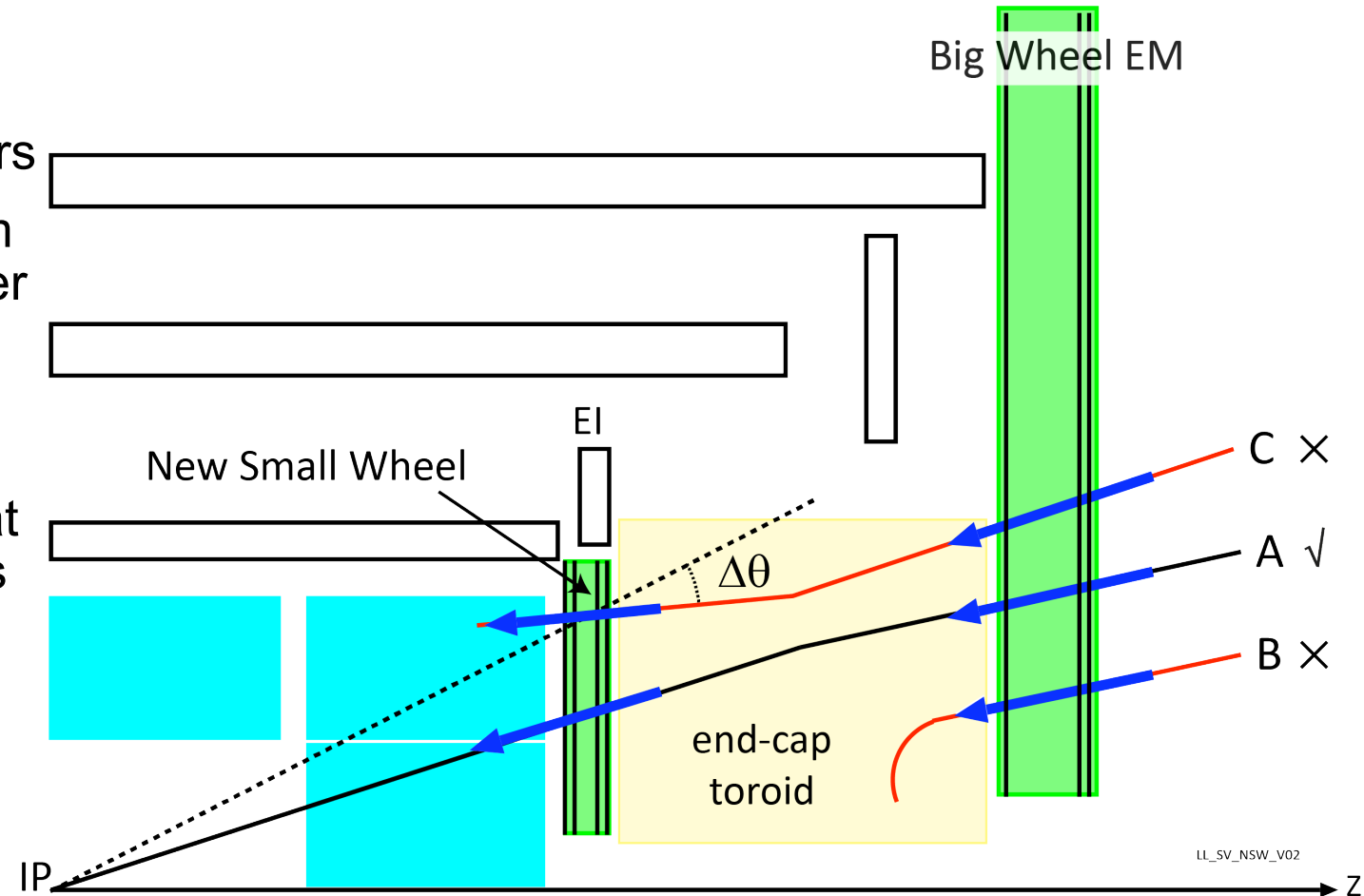


ATLAS Data & Trigger Rates



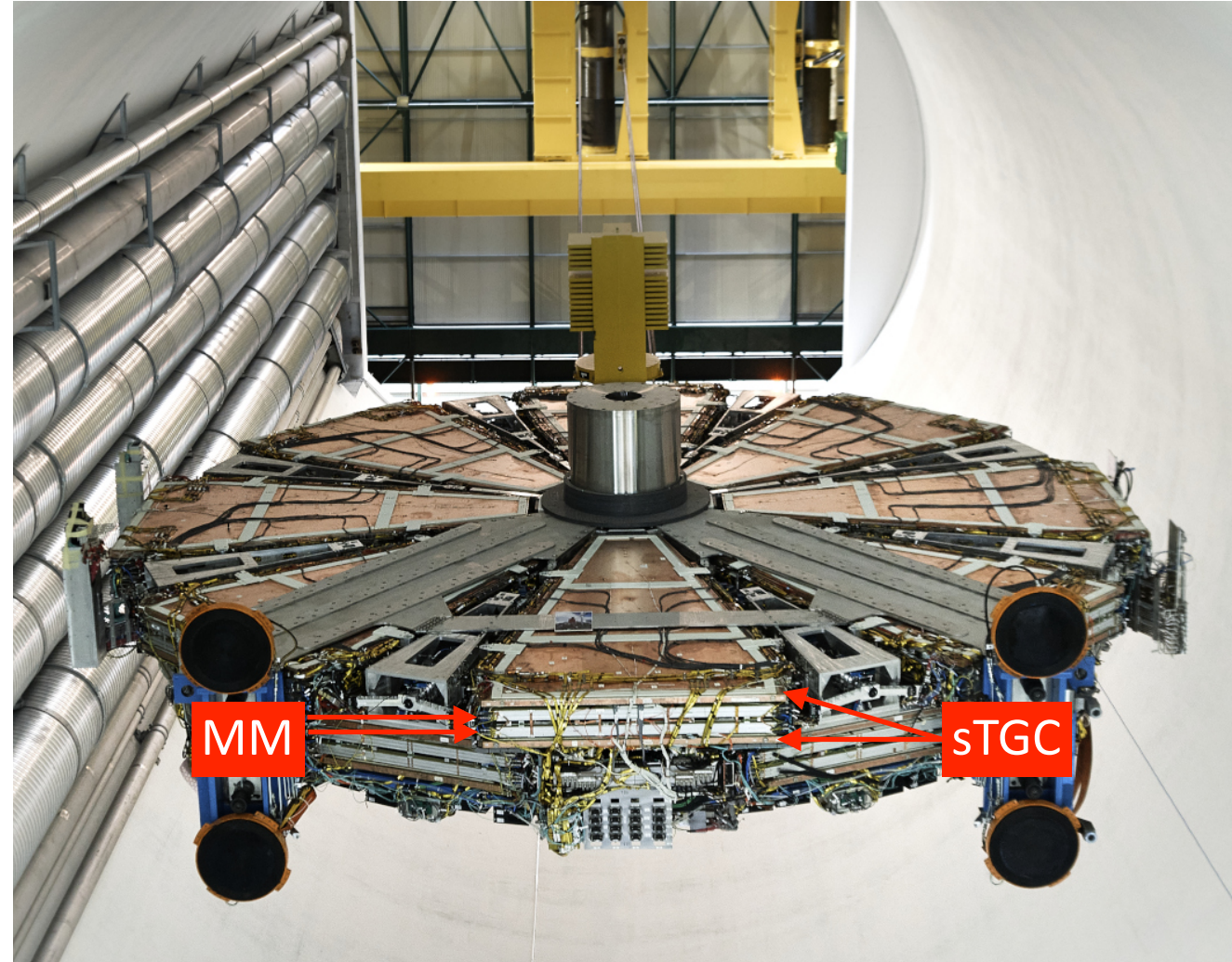
Fake Muon Triggers

- High rate of 'fake' muon tracks in middle end-cap muon trigger chambers
 - Low-energy charged particles from hadronic showers in shielding enter end-cap toroid cryostats without passing through inner end-cap muon chambers.
 - Paths are bent into trajectories that mimic muons from p-p interactions



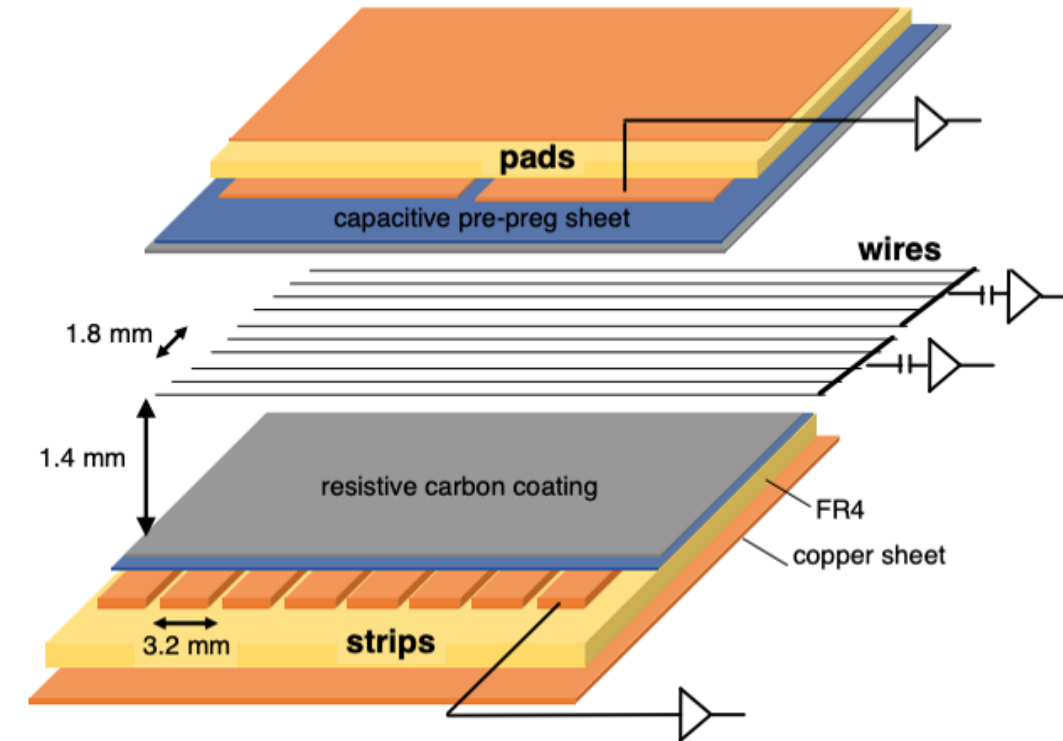
New Small Wheel

- NSW designed to reduce false-trigger rate
 - Veto muon tracks without a matching inner end-cap track segment
- 2 technologies:
 - **MicroMegas (MM)**
 - **small-strip Thin Gap Chambers (sTGC)**



Small-strip Thin Gap Chambers

- Fine anode wires centred between grounded cathode planes
- Filled with CO₂ n-pentane mixture
- Quadruplets consist of 4 layers of sTGCs
- Pads provide initial hardware trigger by hits in coincidence on multiple layers
- sTGCs are similar to the TGCs used in the Big Wheel
 - TGCs only have readout strips (no pads)
 - sTGC strips are thinner than TGC strips



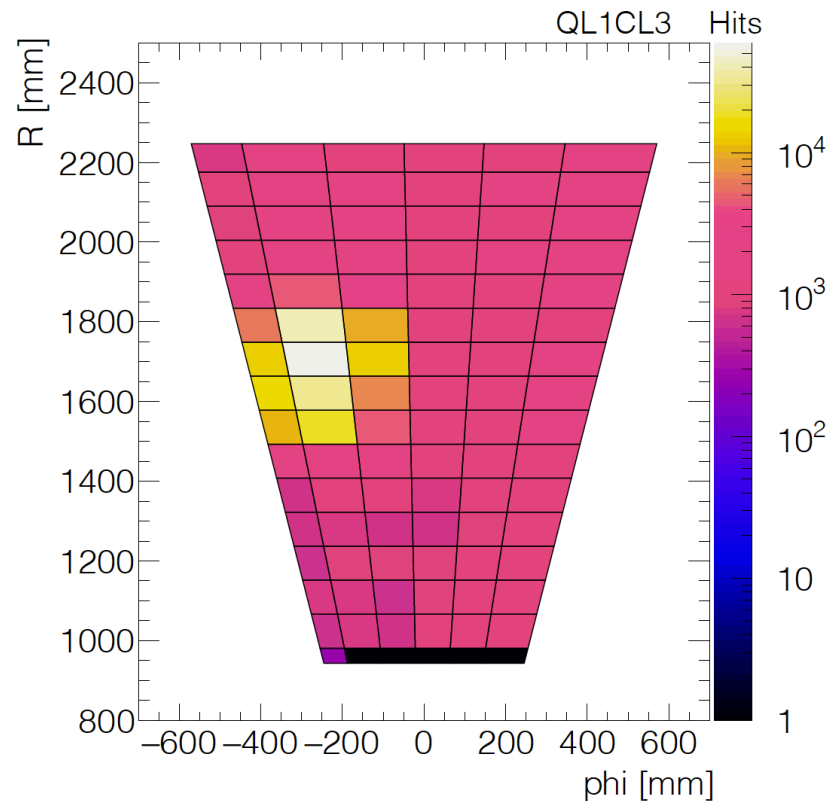
2021 NSW Test Beam

- CERN Gamma Irradiation Facility (GIF++)
- Muon beam line with momentum ≤ 100 GeV/c
- Cesium-137 gamma source
- Gamma rate moderated by shielding plates
 - Max rate on sTGC quadruplet: 13 kHz/cm²
- Triggered on muon beam coincidences from pair of 40x40 cm² scintillators outside the test bunker
- Tested sTGC efficiency and performance at varying background rates, high voltage settings, and digitization settings



Gamma Background Rejection

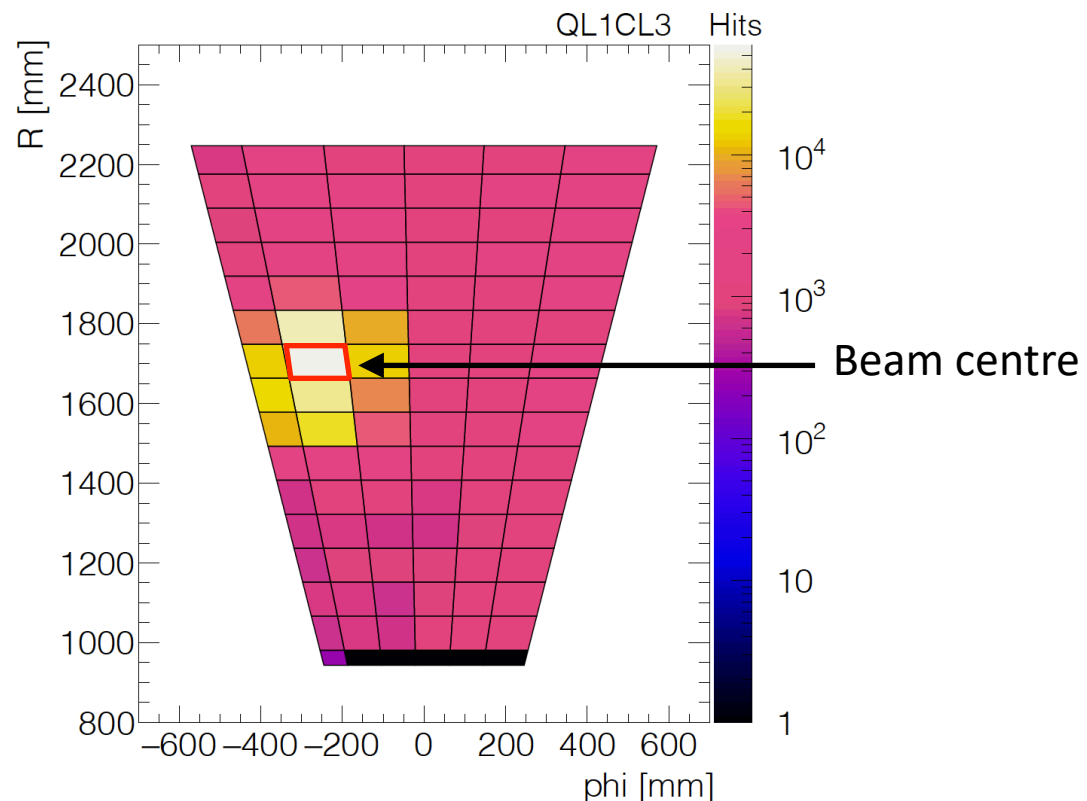
All pad hits on the layer



Gamma rate 0.13 kHz/cm²

Gamma Background Rejection

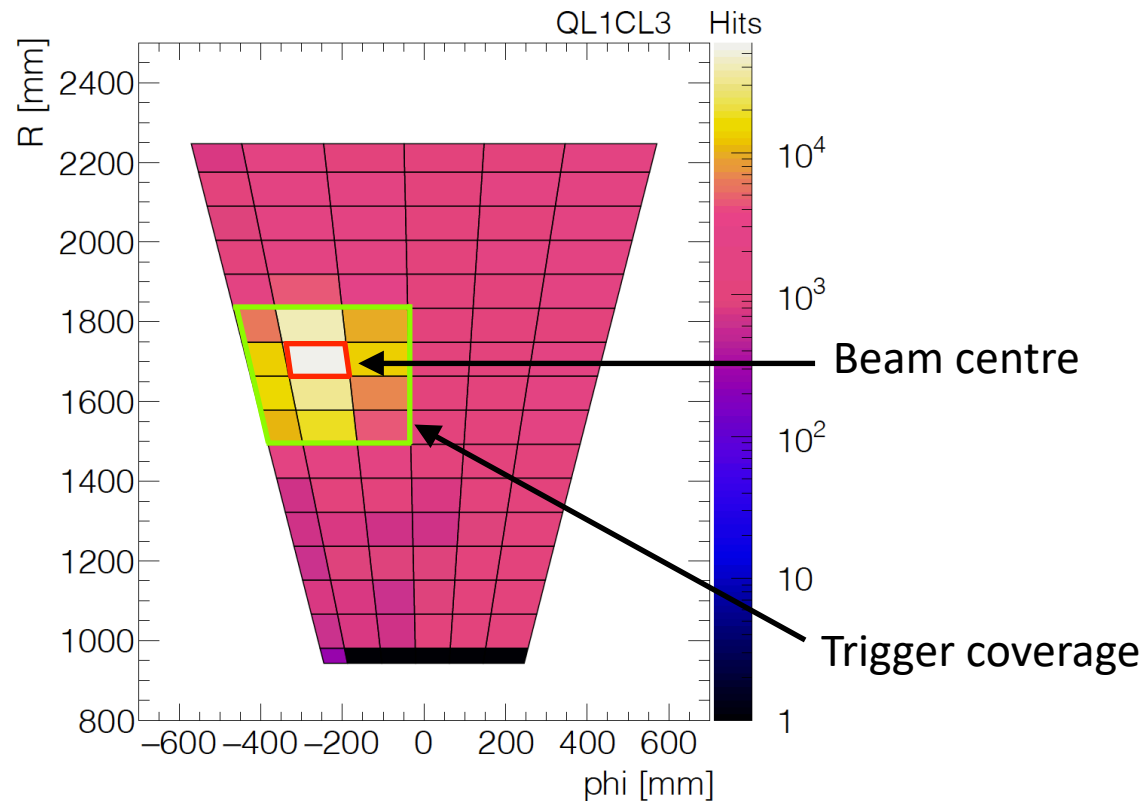
All pad hits on the layer



Muon beam line with momentum ≤ 100 GeV/c

Gamma Background Rejection

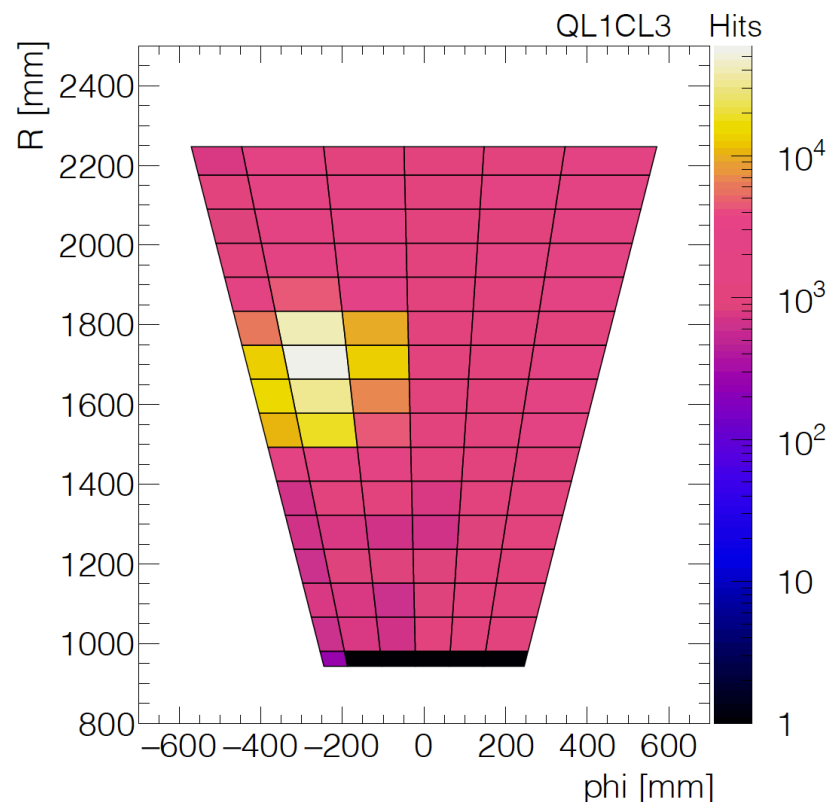
All pad hits on the layer



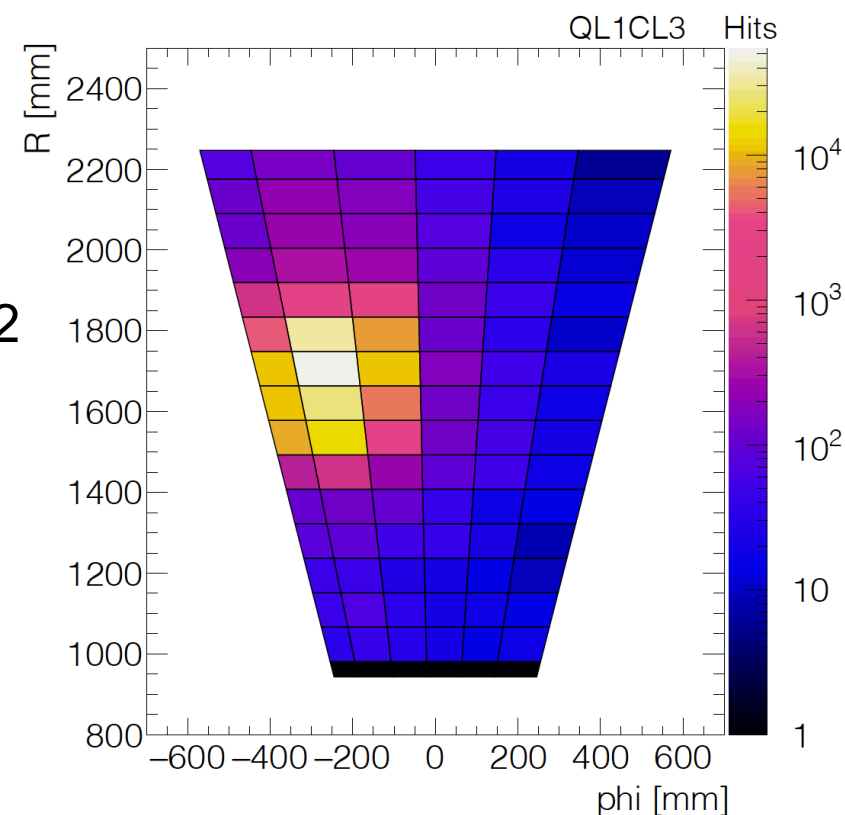
Triggered on muon beam coincidences from pair of 40x40 cm² scintillators outside the test bunker

Gamma Background Rejection

All pad hits on the layer



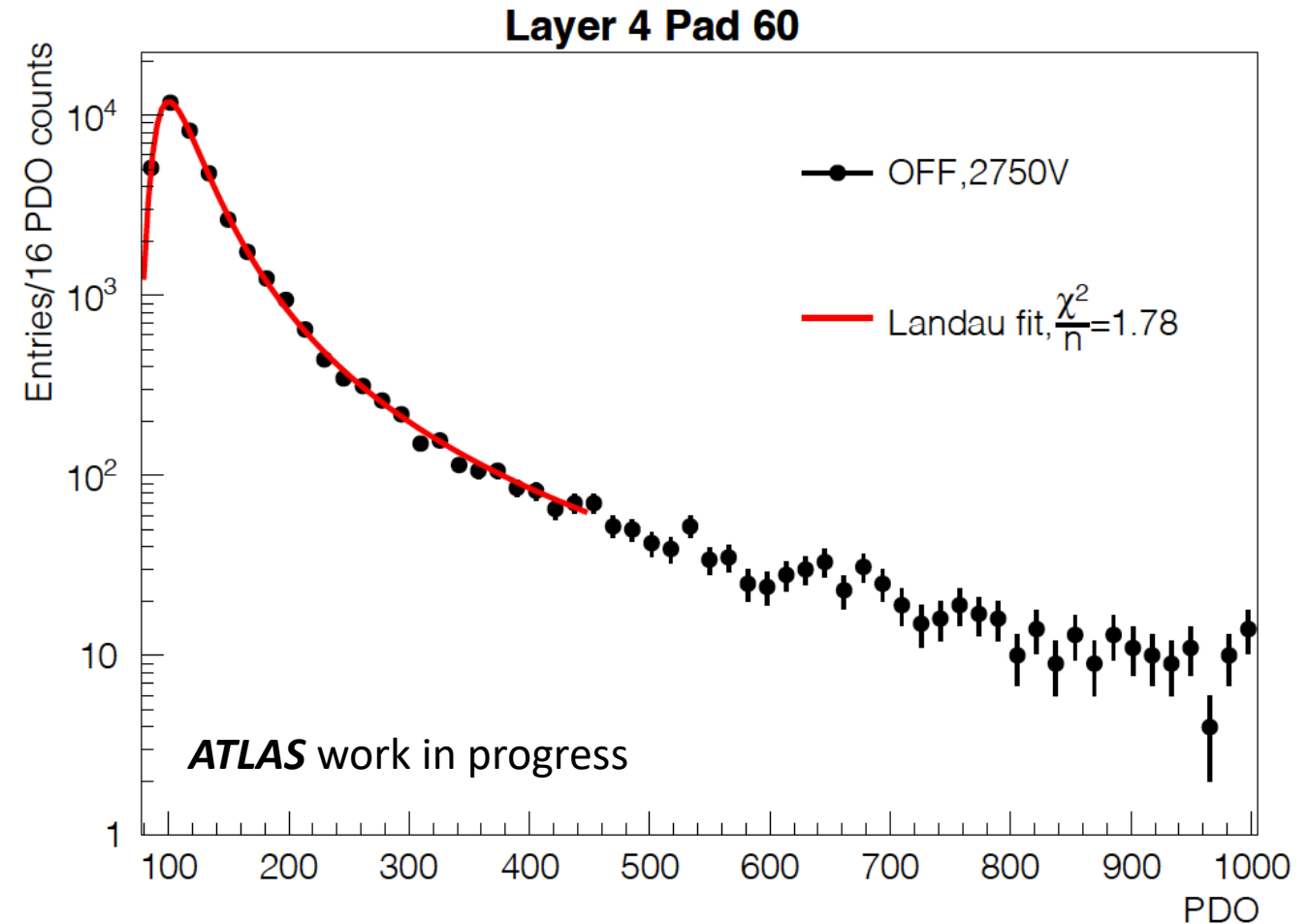
Hits in 3 or 4 layer coincidences



Background reduced by 2 orders of magnitude

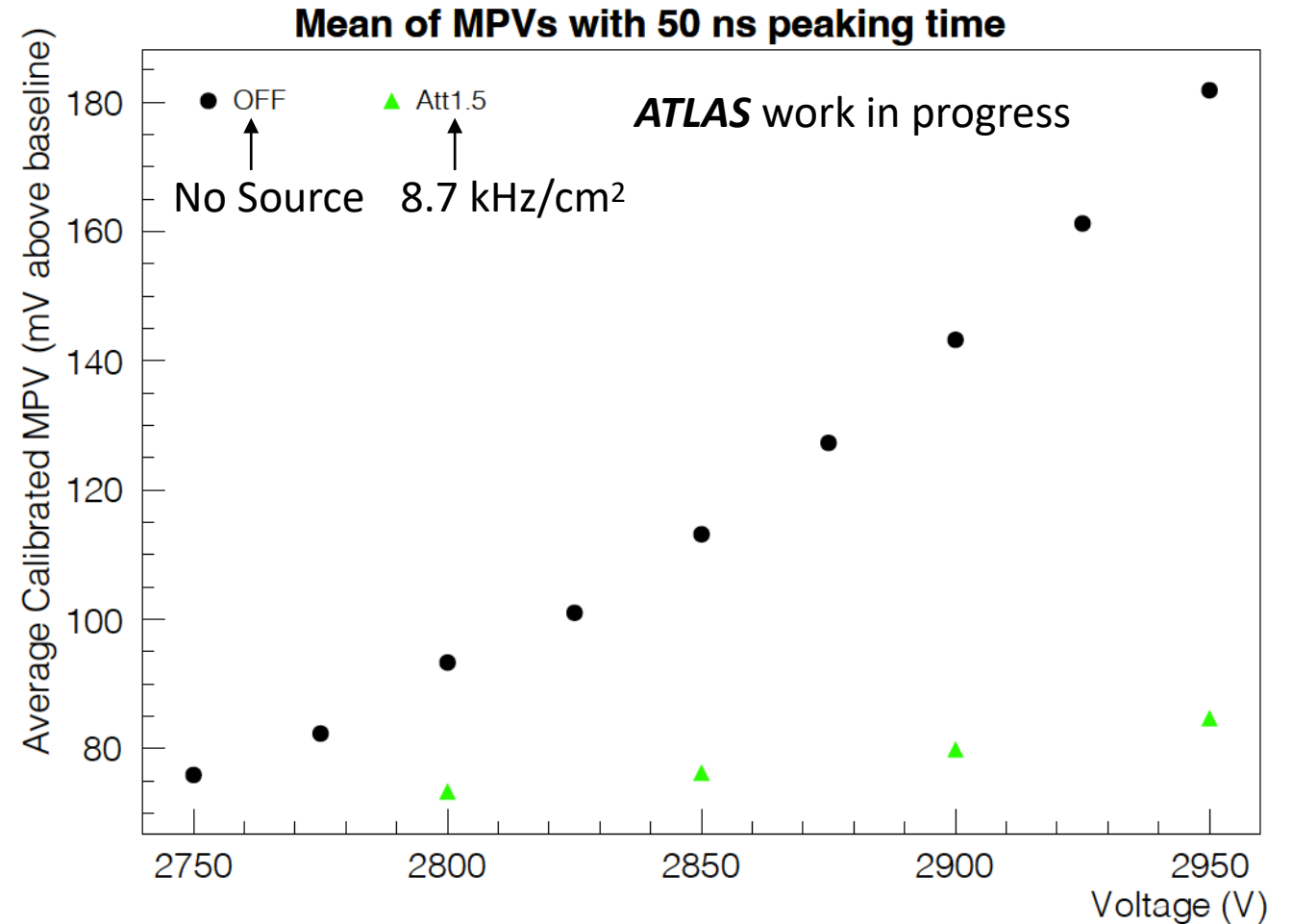
Distribution of Signal Strength

- Charge deposition in sTGC is proportional to pulse height
- Digitized by a 10-bit ADC as Peak Detector Output (**PDO**)
- Landau distributions characterize charge deposition by minimum ionizing particles passing through thin absorber
 - Peak of distribution: Most Probable Value (**MPV**)
- PDO values were binned into histograms and fit to a Landau function



MPV & High Voltage

- MPV rose as the high voltage was increased
 - High voltage provides larger signal gain
- Less significant gain in a high background environment
 - Produces an effective voltage drop
- Working sTGC HV setting is 2800 V



Conclusions

- sTGCs are able to operate in a high background environment.
- Selecting pad hits in coincidence vetos background.
- Increasing high voltage can compensate for loss in signal strength from charge build-up on the cathodes due to background.

Acknowledgments

- Supervisor: Isabel Trigger (TRIUMF & UVic)
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- sTGC Test Beam analysis team

Thank you!
Merci!

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- The Large Hadron Collider. <https://home.cern/science/accelerators/large-hadron-collider>
- The ATLAS Collaboration. The ATLAS Experiment at the CERN Large Hadron Collider: A Description of the Detector Configuration for Run 3.
- T. Kawamoto et al. New Small Wheel Technical Design Report. Technical Report CERN-LHCC-2013-006. ATLAS-TDR-020, CERN, Jun 2013.
- Leesa Brown. ATLAS New Small Wheel sTGC Pad Efficiency and Signal Strength. <https://cds.cern.ch/record/2846384>, 2022. Thesis, University of Victoria.

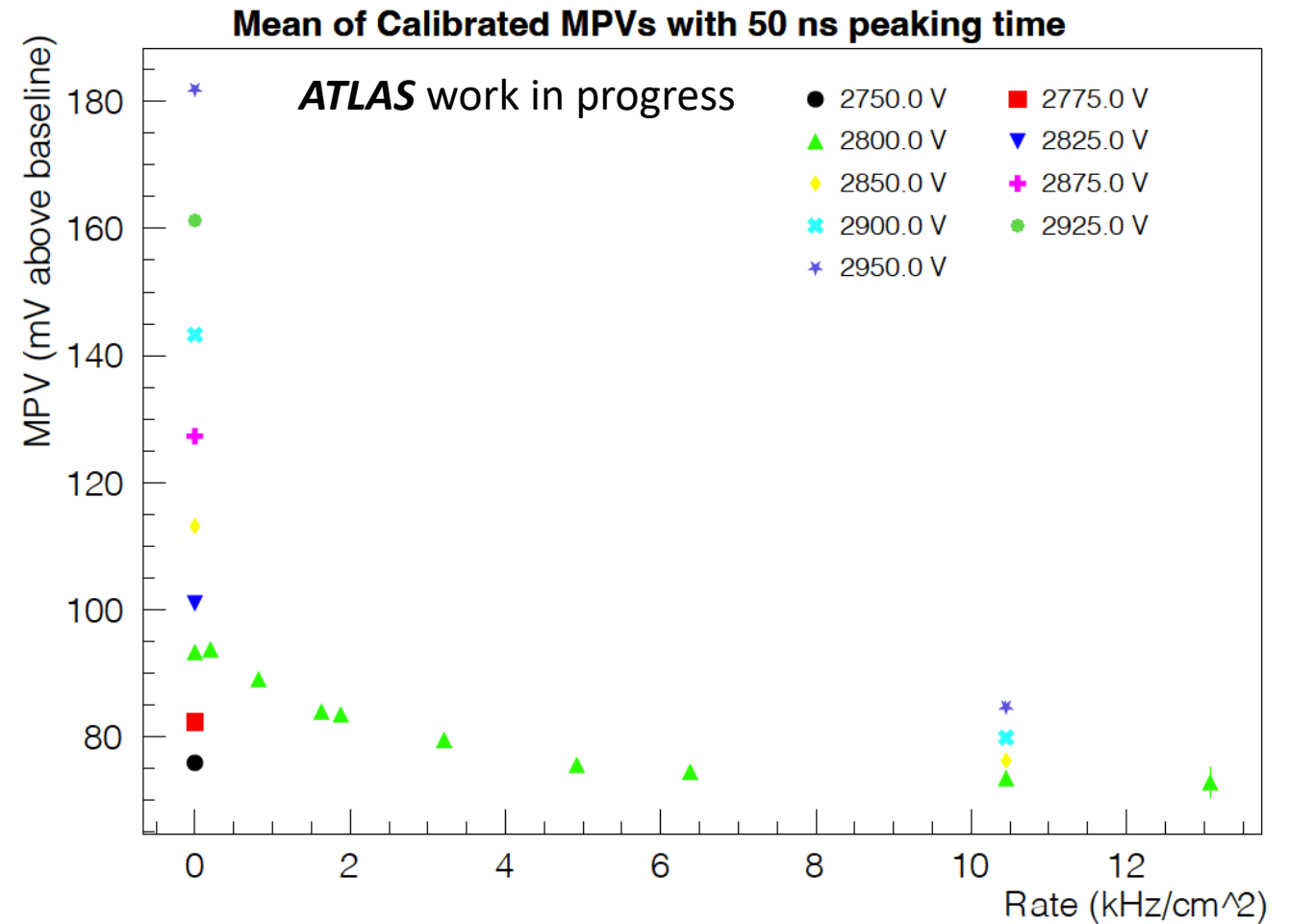
- Clip art:
 - <http://clipart-library.com/clipart/n822540.htm>
 - <http://clipart-library.com/clipart/n766545.htm>

Backup slides



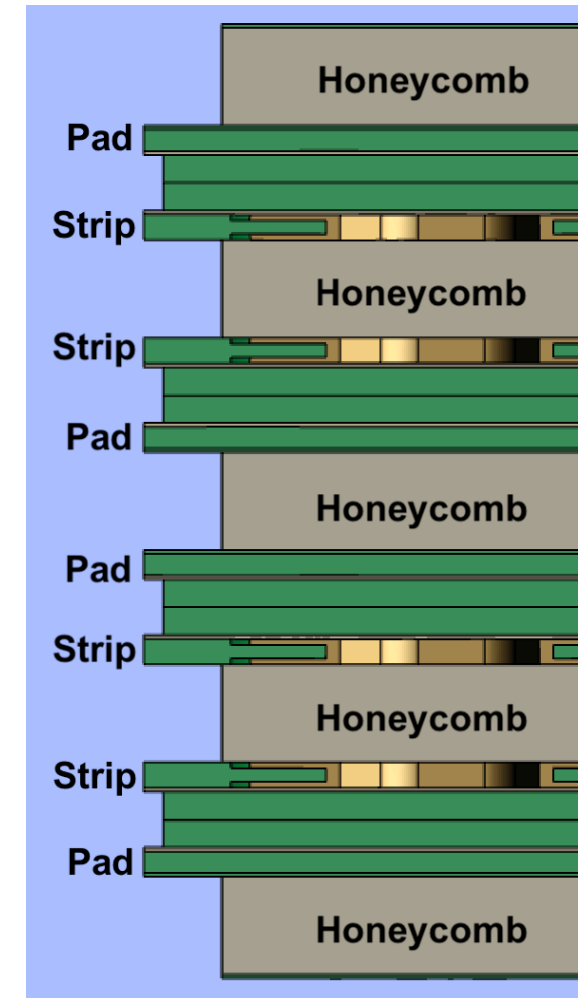
MPV & Background Rate

- MPV falls as background increases



sTGC modules

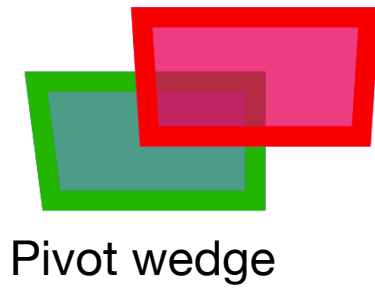
- Modules composed of 4 gas volumes/layers
- Pad trigger uses pad hits in coincidence on 3 out of 4 layers



NSW triggering and tracking

- sTGC pads initiate first stage of NSW triggering
- Charge deposits on strips are reconstructed into tracks
- Track segments combined with MM

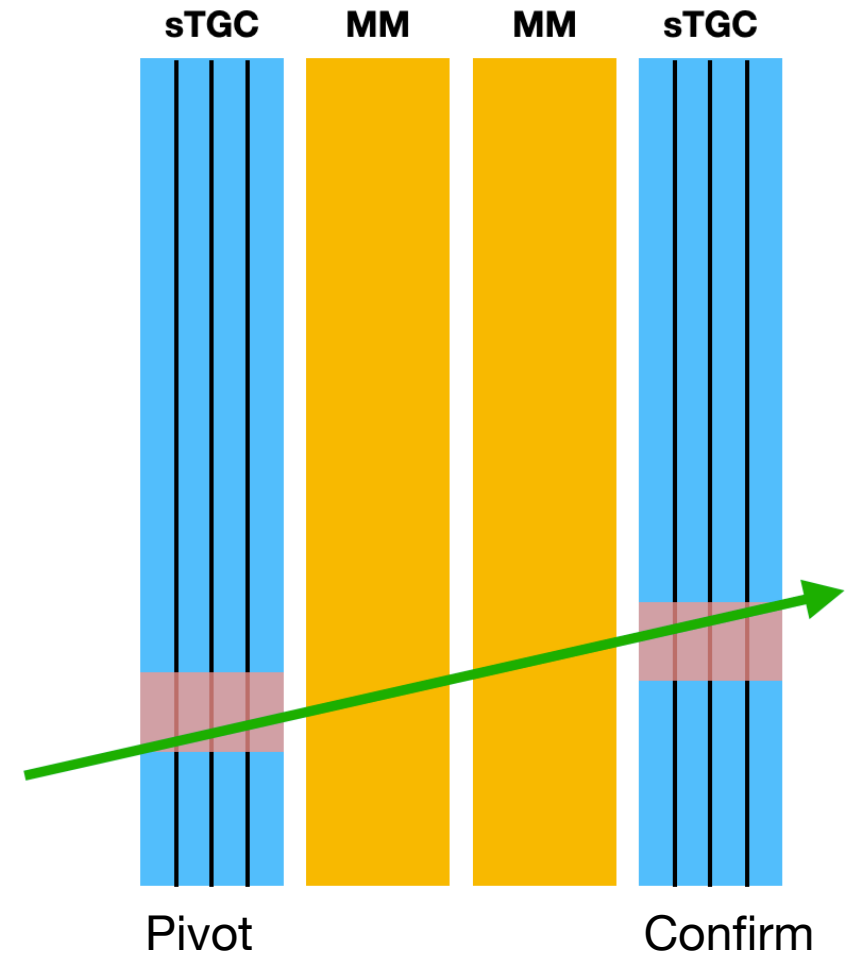
Layer 1
Layer 2
Layer 3
Layer 4



Pivot wedge

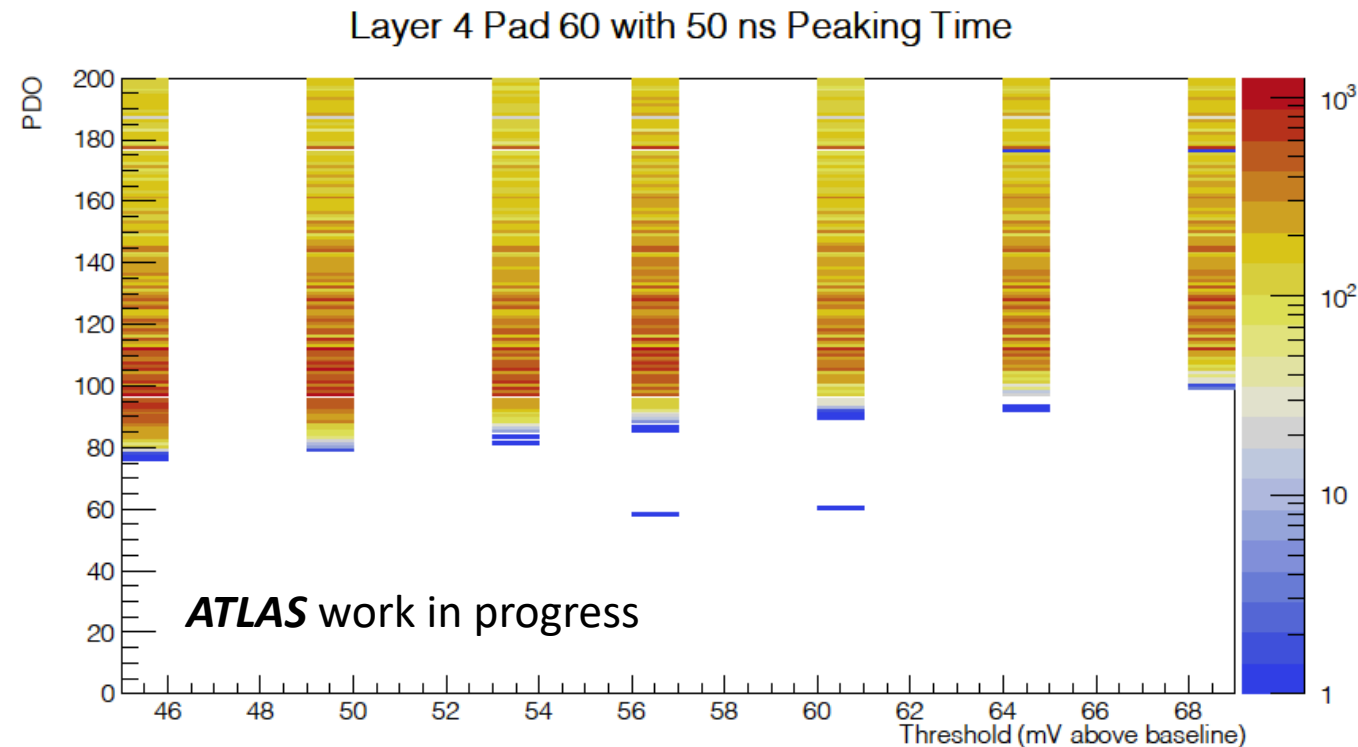


Confirm wedge



PDO calibration

- Data was collected at 7 different pad threshold values from approximately 45 to 70 mV at a background rate of 8.7 kHz/cm²
- Thresholds in PDO were set as the lowest values that had hits and the sequential value also had hits



PDO calibration

- Min. PDO vs threshold values were fit to obtain calibration
- The calibration from PDO to mV is $(\text{PDO-intercept})/\text{slope}$
- Uncertainties on PDO are converted to mV by dividing by the slope

