The ATLAS New Small Wheels for LHC Run3

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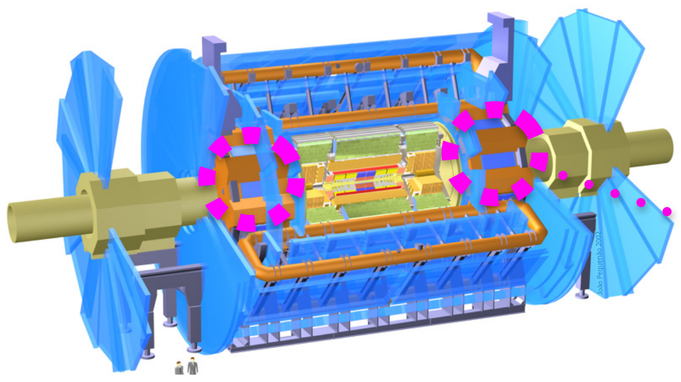
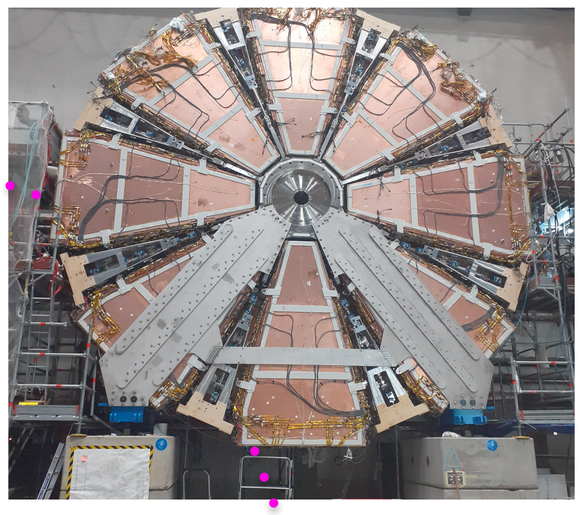
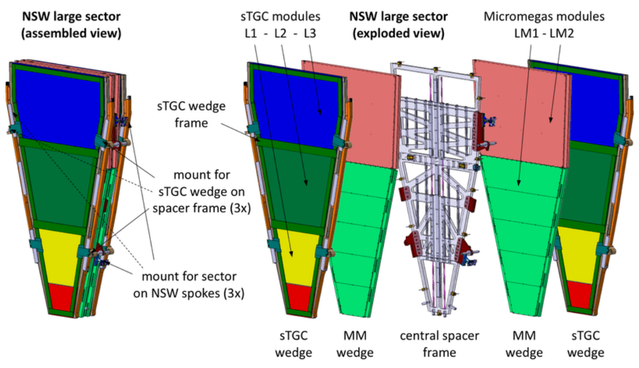
New Small Wheels for the ATLAS experiment





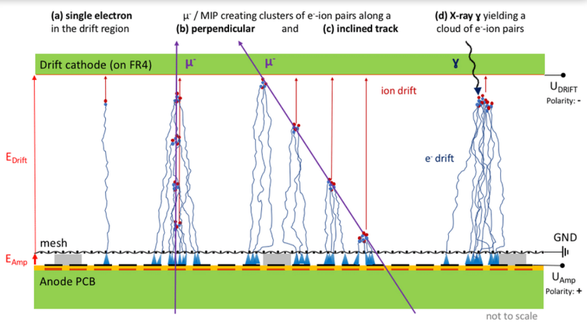
- ATLAS the largest volume detector ever constructed for a particle collider is a many-layered instrument designed to detect some of the tiniest yet most energetic particles ever created on earth. It consists of six different detecting subsystems wrapped concentrically in layers around the collision point to record the trajectory, momentum, and energy of particles, allowing them to be individually identified and measured.
- The New Small Wheel (NSW) is part of the ATLAS Muon System. They have been constructed and installed, replacing the old SWs, at the most forward region of the ATLAS muon spectrometer and they are the first new detectors in the experiment specifically designed to handle High Luminosity.
- The ATLAS New Small Wheel (NSW) upgrade motivation is to maintain excellent performance for High Luminosity LHC conditions, with luminosity up to 7.5 x 10^{34} $cm^{-2}s^{-1}$.



- The NSW consists of Micromegas (MM) detectors and small-strip Thin Gap Chambers (sTGC) with both tracking and triggering capabilities.
- NSW have been constructed and installed, in the ATLAS underground cavern, at the most forward region of the ATLAS Muon Spectrometer at $1.3 < |\eta| < 2.7$, with expected background rate up to 20 kHz/cm^2 .

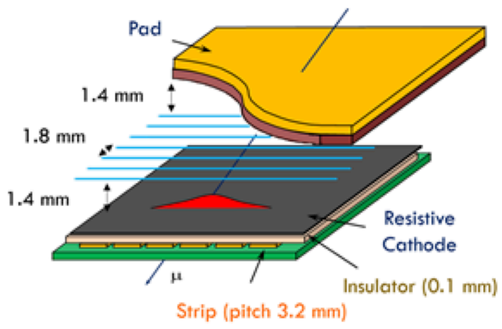
Micromegas and STGs detectors

- Micromegas gaseous detectors are able to track particles efficiently and precisely with resolution on the order of 100 μm/detection gap.
- A drift and amplification region, are filled with $Ar:CO_2:iC_4H_{10}$ 93:5:2 vol% and separated by a metal mesh.
- Free drift electrons arisen from gas ionization move in the electric field inducing signal on the readout strips by activating avalanche mechanism.
- Reconstruction of a muon track by known strip position, hit time and electrons drift velocity.



Micromegas detector.

- The basic sTGC structure consists of a grid of gold-plated tungsten wires sandwiched between two resistive cathode planes at a distance of 1.4mm from the wire plane.
- The precision cathode plane has strips with a 3.2mm pitch for precision readout relative to a precision brass insert outside the chamber, and the cathode plane on the other side has the pads for triggering.
- The gap is provided using 1.4mm ± 20μ m precision frames glued to the cathode boards.

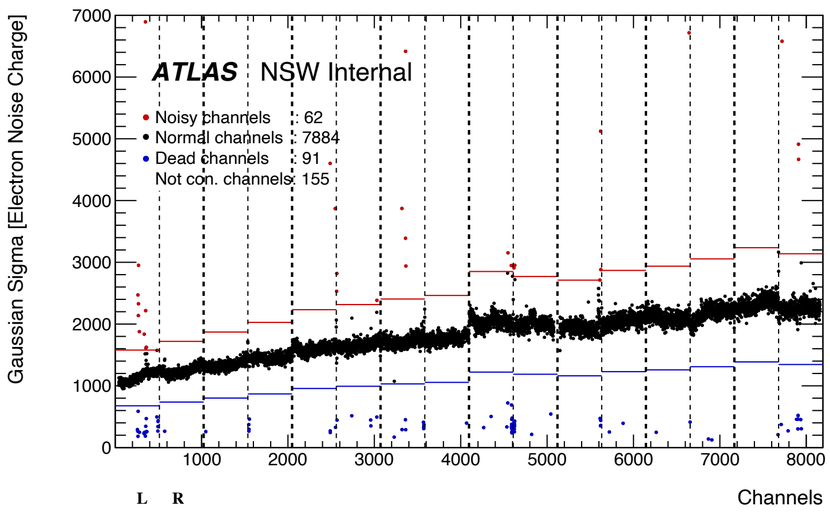


STGs detector.

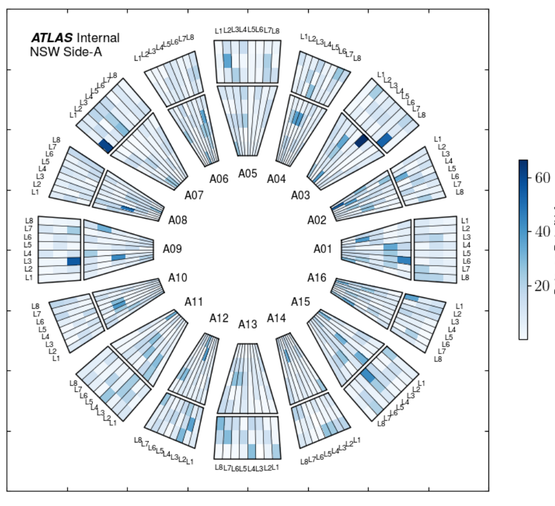
NSW Electronics validation

Many studies for NSW electronic validation have been taken place in order to clarify the noise levels of electronics, to specify the optimal calibration and to apply the proper thresholds. Some of these studies are the following:

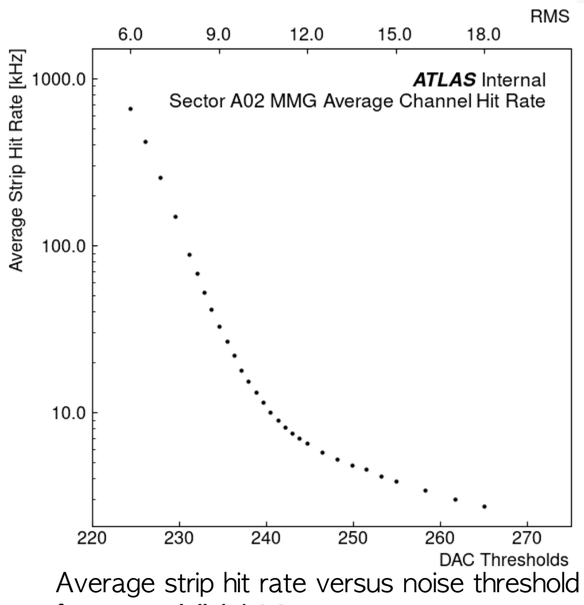
- Baselines RMS per strip per Front-End Application-Specific Integrated Circuit - ASIC (VMM) per front end board.
- Read-Out Controller - ROC internal clock calibration calibrates clock phase of the ROC communication with the VMM's. It also calibrates the clock phase of the ROC sampling the TimeTriggerControl stream.
- GigaBit Transceiver - GBTx clock phase calibration calibrates the clock phase of the GBTx sampling inputs from a variety of chips: ROC, SCA, PadTrigger, etc. It is performed with the GBTx phase aligner circuit, and the validated using a manual scan of the GBTx phase and checking data integrity.
- VMM Pulse Hight calibration calibrates the PDO values for various charges. It works by pulsing the VMM inputs at various amplitudes, and measuring the PDO.
- VMM threshold calibration sets the VMM hit threshold. It works by scanning over various DAC thresholds and selecting a threshold that corresponds to a desired maximum noise rate (in progress).



- Baseline RMS per strip for one eta layer of a MM Small Sector. The RMS value is increasing as a function of the strip number and the corresponding strip length.



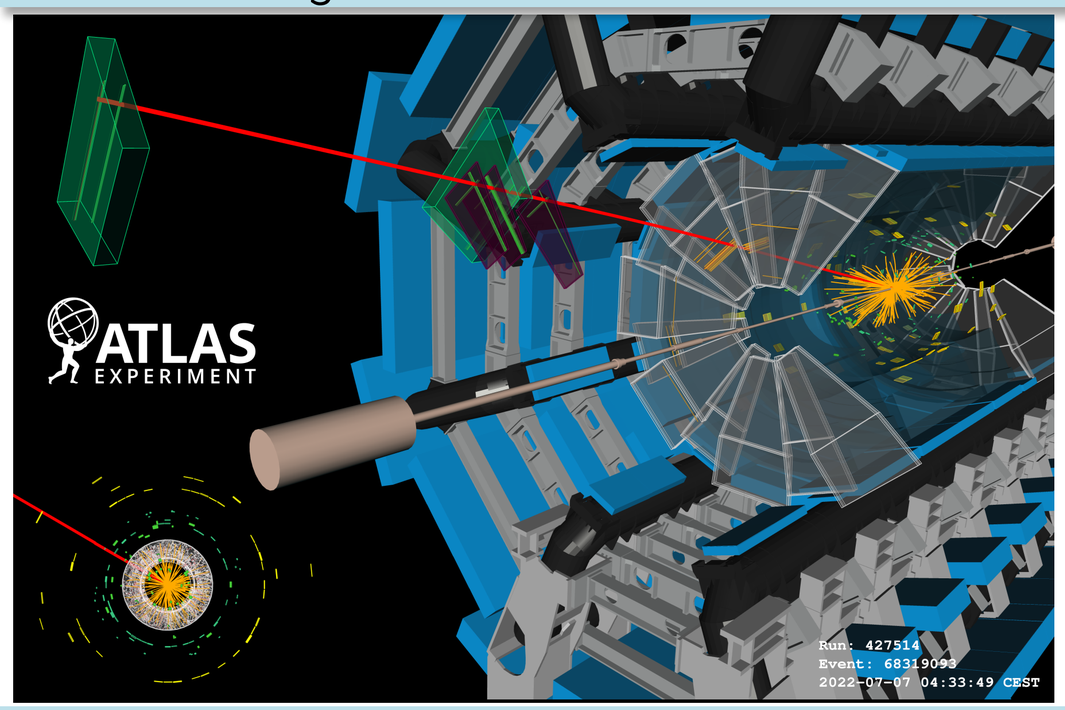
Measurement of the average MMG strip rate with respect to the VMM DAC thresholds.



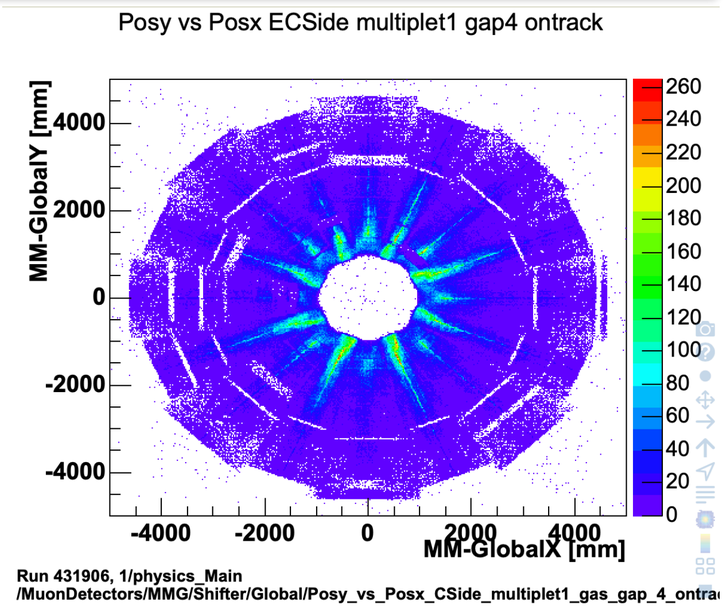
Average strip hit rate versus noise threshold for sector MM A02.

- For a given sector (and layer/front-end board/channel), we measure the average strip rate across different RMSx noise thresholds.
- As the noise threshold increases, the average strip hit rate decreases.

Data taking LHC- Run3



Event display (Run 427514, Event 68319093) of a collision event recorded in ATLAS on July 7th 2022, when stable beams of protons at the energy of 6.8 TeV were delivered to ATLAS by the LHC. The red line shows a muon candidate reconstructed using information from the inner tracking detectors and the ATLAS Muon Spectrometer end-cap. The muon candidate was among the first reconstructed using hits in the Micromegas (MM) chambers of the New Small Wheel (NSW) on side C. The NSW, installed during the long shutdown between Runs 2 and 3, is outlined in white and the MM hits are shown as orange lines. Additional muon chambers associated with the track are shown as green (MDT endcap) and purple (TGC endcap) boxes. Also shown in the figure are the tracks of charged particles as they are reconstructed in the inner detector (orange tracks), as well as the energy deposits in the electromagnetic (green boxes) and hadronic (yellow/orange boxes) calorimeters. The bottom-left view is a projection of the same event onto the transverse plane, showing in addition the hits in the TRT detector in white (red) for hits (high-threshold hits).



Number of muon hits on a track for MM side C layer 3, Run3 data.

* 11th Conference of the Balkan Physical Union (BPU11 Congress)