The ATLAS New Small Wheel Simulation and Reconstruction Software and Detector Performance Studies

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HELLENIC REPUBLIC
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The New Small Wheel (NSW) Project

The most complex and challenging Phase-1 Upgrade project of ATLAS.

The assembly of the NSW was concluded in November 2021.

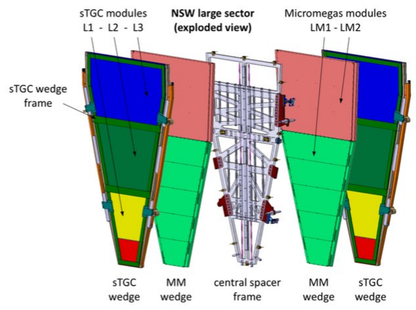
The NSW simulation and reconstruction software was finalized recently.

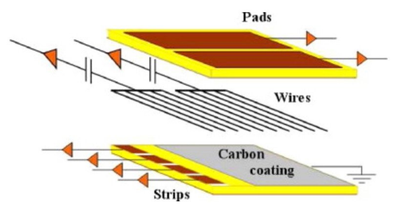
Both wheels are installed on the two endcap regions of the ATLAS detector

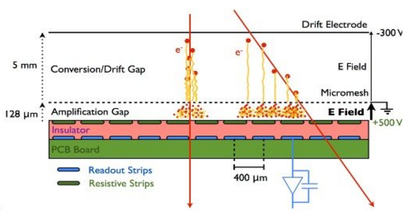
Layout of the Wheel

Each Wheel: 8 small and 8 large sectors.

Each sector: 8 layers of small-strip Thin Gap Chamber (sTGC), primarily for fast triggering, and 8 layers of Micromegas (MM) detectors, primarily for precision tracking.







sTGC:

Coarser pads define regions of interest for fast triggering.

Anode wires provide the transverse (φ) coordinate.

~3.2 mm pitch strips measure the precision (η) coordinate.

MM:

~400μm pitch strips provide excellent spatial resolution along the precision coordinate.

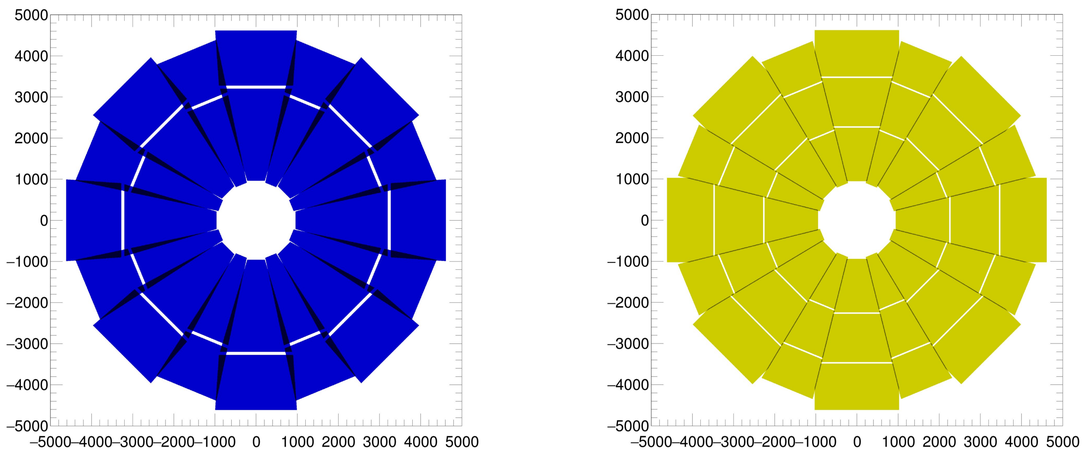
4-out-of-8 detection layers provide stereo reading (±1.5°) for the reconstruction of the transverse coordinate.

Contribute to the Level-1 trigger by providing the first above-threshold strip per 64 strips read out by the same VMM chip.

Simulation & Digitization

Interactions of particles with NSW material are simulated based on GEANT4 description.

Simulated particle hits are digitized according to the description of the readout geometry and converted into Raw Data Objects to follow the same reconstruction chain as data.



Schematic of the nominal active area of MMs (left) and sTGCs (right).

Conditions

Initial “As-Built” and time varying alignment and deformation conditions are monitored and uploaded on a dedicated *Conditions DB*.

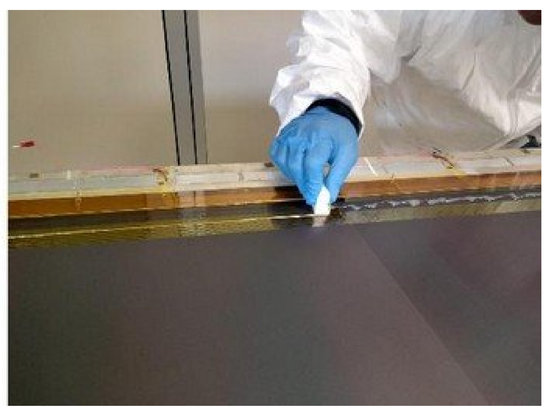
The Conditions DB is queried during data processing and the readout geometry description is updated when conditions change.

MM PCB Passivation

Thin layers of araldite along the edges of the MM PCBs protect from HV instabilities.

The passivated width (up to few cm) is different on each side of each PCB, making the active area asymmetric.

Passivation parameters reported by the construction sites are uploaded on the Conditions DB to correct the description of the readout geometry in digitization and reconstruction.



Reconstruction

The NSW is fully integrated into the ATLAS muon reconstruction software.

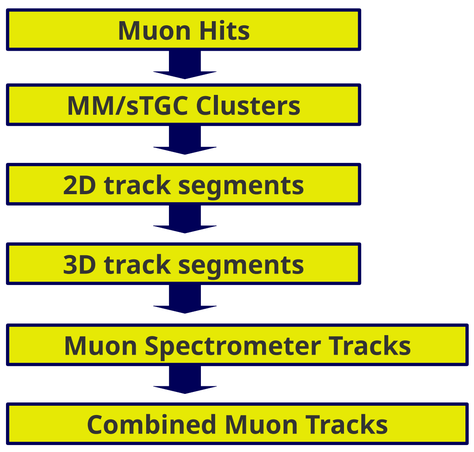
Clusterization of hits above the noise threshold on adjacent strips.

Pattern finding in the precision coordinate.

Transverse coordinate seeded from sTGC wires/pads and MM stereo strips.

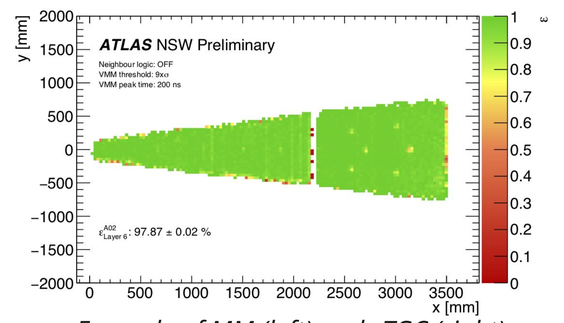
Combination of segments in different muon stations (MDTs, TGCs).

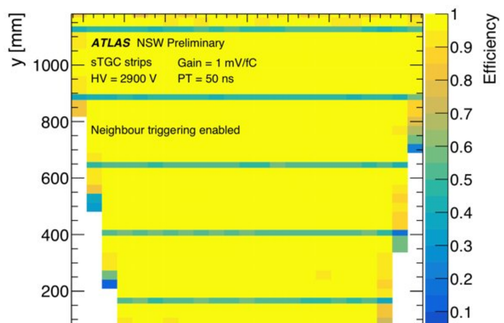
Combination with track-segment on the ATLAS inner detector



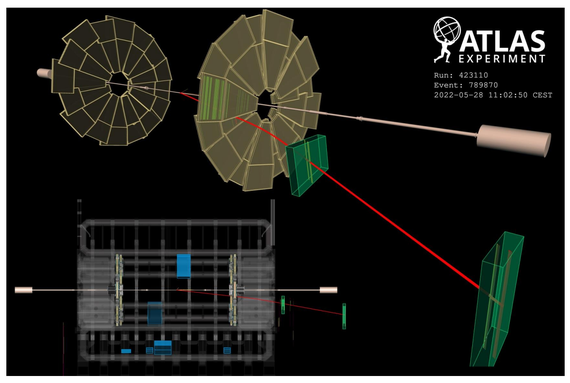
Performance

MM and sTGC performance has been validated with simulations, cosmic rays and test beams. **So far, the NSW performance has been found to be within specifications**. Presently, work on timing aspects is in progress, along with final validation of the NSW software, using data from LHC beams.

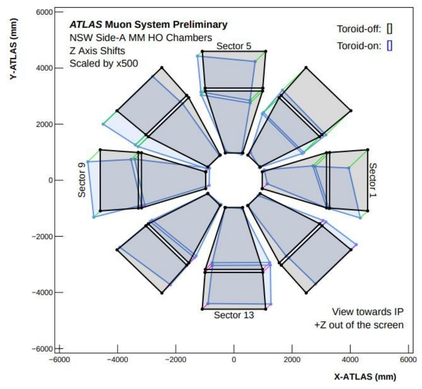




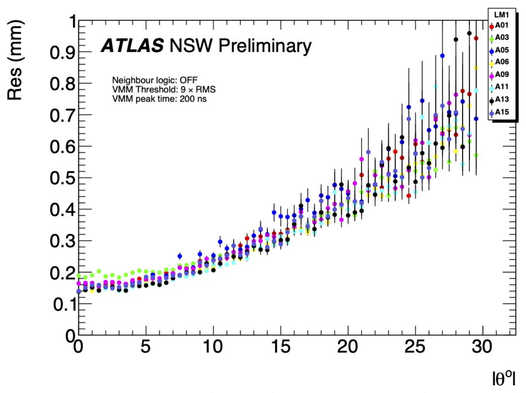
Example of MM (left) and sTGC (right) efficiency maps measured with cosmic rays.



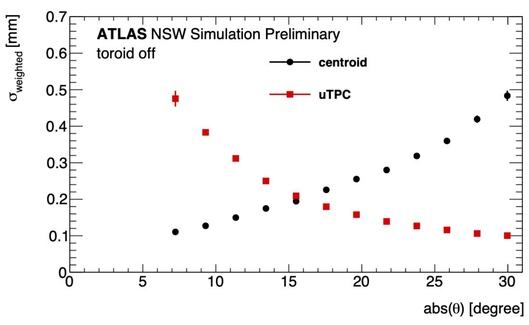
Muon candidate (red line) reconstructed using hits on the MM chambers. The NSW is shown together with the MDT chambers (green) used to reconstruct the muon track.



Change in large sector z-positions (1mm on average) between toroid-off and toroid-on, measured with the NSW alignment system.



MM spatial resolution vs incident angle measured with cosmic rays, using only the centroid method for position estimation.



Simulation: truth resolution of even MM eta layers for different clusterization methods.

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NSW Public Results:
https://twiki.cern.ch/twiki/bin/view/AtlasPublic/NSWPublicResults