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

ATLAS EXPERIMENT

LHCP 2022 – Online format – 16-20 May 2022

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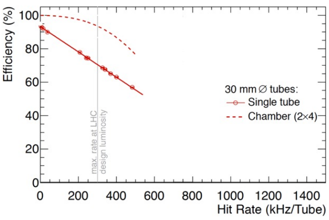
Why a New Small Wheel (NSW)?

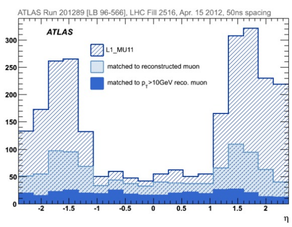
At high luminosity values → Increase of the rate in the forward region [1]

2 main problems:

Deterioration of tracking performances	High rate of fake Level-1 triggers



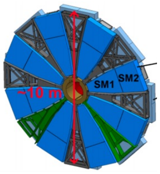
Efficiency for MDT tube hit (solid) and track segment (dashed) VS tube rate (L = 1 × 10^{34} cm^{-2} s^{-1})



η distribution for the Level-1 trigger, for muon with p_T > 10 GeV

GOAL: angular resolution ~ 1mrad, spatial resolution ~ 100 µm

NSW layout

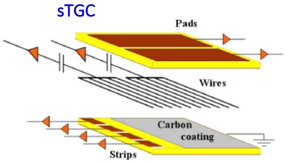


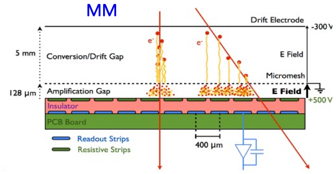
Small-strip Thin Gas Chambers (sTGC) → strips with pitch~3.2 mm, pads and wires

MicroMegas (MM) → strips with pitch~400 µm

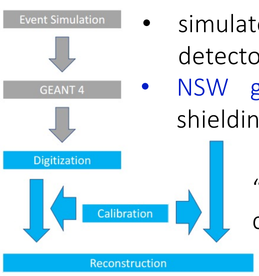
- Based on gas ionization by charged particle
- Charge induced on readout strips

A NSW has 16 trapezoidal **sectors**, detectors arranged in 4-layers multiplets in the order: sTGC – MM – MM - sTGC



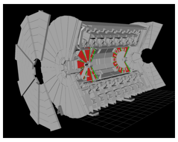


Simulation



- simulate interactions of particles with detector (GEANT4)
- NSW geometry fully simulated (support, shielding and active material)

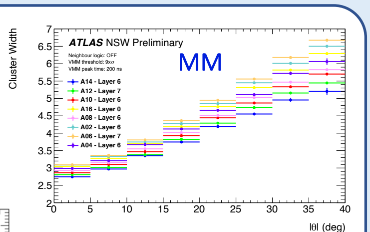
"Parameter books" collect all information

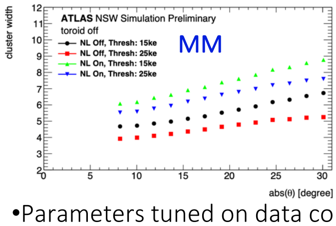


Digitization

Simulation of detector active area interactions and electronic signal formation

Also takes into account electronics response.





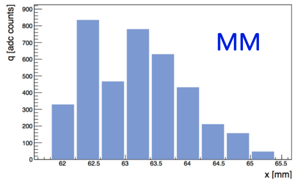
- **MM digitization**: analytical approach
- **sTGC digitization**: parameterization approach

- Parameters tuned on data collected from cosmic tests

Reconstruction

- Takes into account as-built parameters and alignment
- Hit position reconstructed from **clusterization**

- **Clusters**: groups of consecutive firing strips
- Charge threshold to exclude detector noise

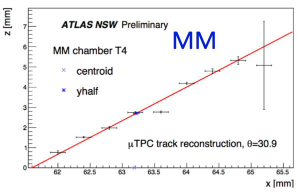


Different algorithms

- **Centroid**: applied to both MM and sTGC

$$x_{\text{clus}} = \frac{\sum_{\text{strips}} x \cdot q}{Q_{\text{tot}}}$$

- **µTPC**: used for MM

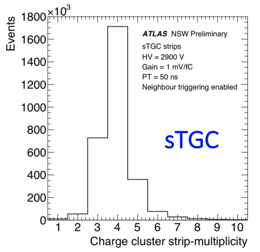


- **Caruana method**: gaussian fit used for sTGC

Tracking

Hits used to reconstruct tracks. Different steps applied:

- **Pattern finding**
- Fit of muon track in the Muon Spectrometer
- Combination with track in ATLAS inner tracker

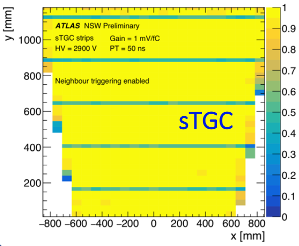


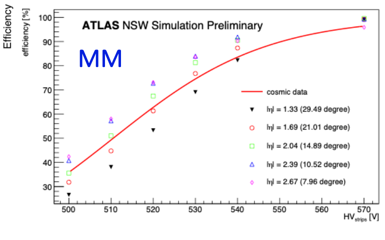
Performance

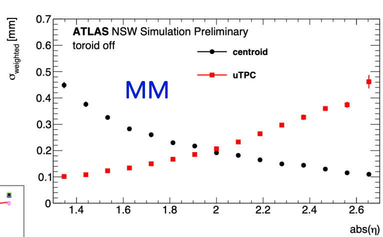
- MM and sTGC performances tested with cosmic rays or test beams, to ensure they meet required specifications

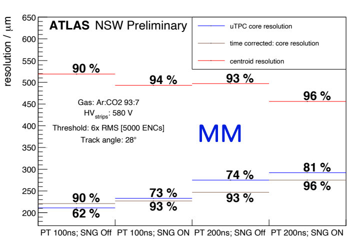
- Studied in terms of spatial resolution and efficiency maps

- Data used to validate simulation results









- High single layer efficiency important to ensure a large number of hits enter the track fit

- Good spatial resolution fundamental to achieve the required resolution on muon transverse momentum (15% at 1 TeV) [1]

[1]: CERN-LHCC-2013-006, [2] ATLAS Collaboration, NSW Public Results:https://twiki.cern.ch/twiki/bin/view/AtlasPublic/NSWPublicResults