Software Development and Performance Studies of New Small Wheel in ATLAS for LHC Run3

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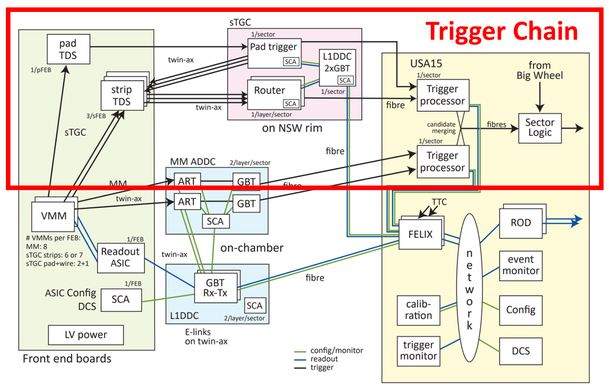
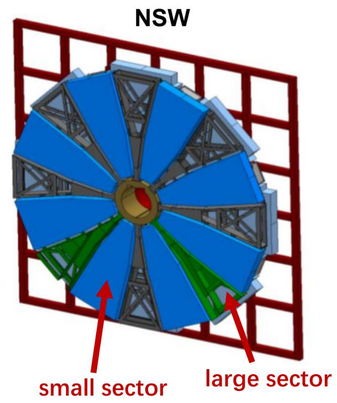
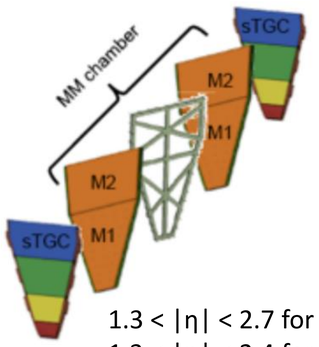
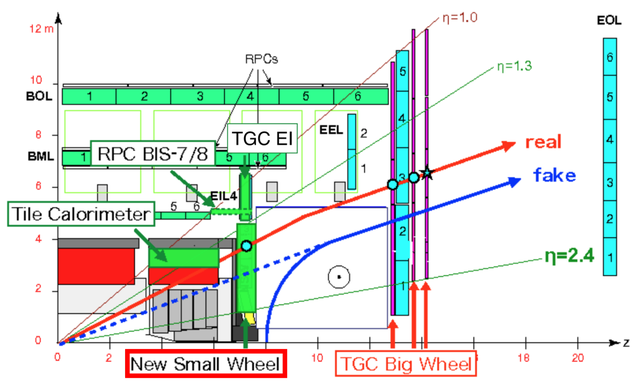






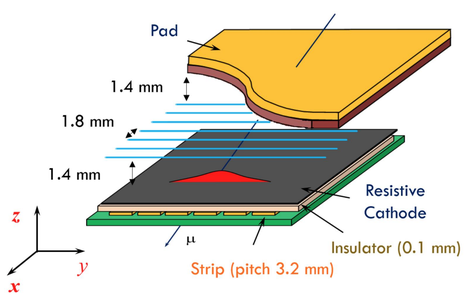
1.3 < |η| < 2.7 for muon tracking
1.3 < |η| < 2.4 for Level-1 trigger



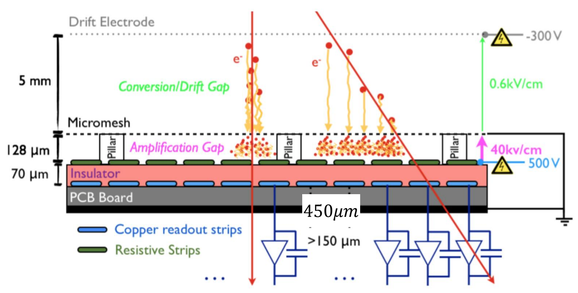
NSW Electronics System

VMM for charge amplification, discrimination, neighbour logic, amplitude and timing measurements, analog-to-digital conversions
ROC filter data based on L0 trigger which identifies BC of interest)
GBTX recovers and generates a clock to sample the incoming data
FELIX is the gateway between dedicated links (connecting to detectors and trigger electronics) and a commodity network for configuration, control, monitoring and calibration

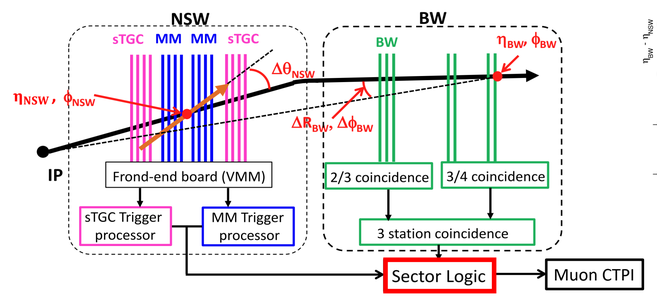
New Small Wheel (NSW) is the Inner most muon endcap station in ATLAS, newly upgraded for LHC Run3, the sTGC-MM redundant combination is designed for providing high efficiency and good real-time resolution $(95\%, 1\text{mrad}, 100\mu m, 12\text{ns})$ to discriminate the large fake backgrounds, ensuring the low p_T threshold (20GeV) could be used for the good acceptance of enormous interesting physics processes (Higgs, SUSY, …) with the Level-1 rate manageable (15 kHz for endcap muon)

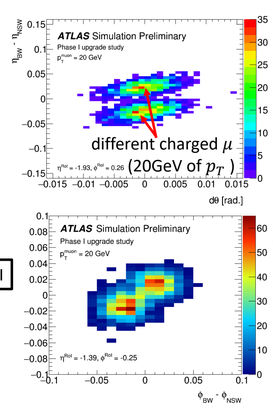


small-strip Thin Gap Chambers (sTGC)



Micromegas detector (MM)

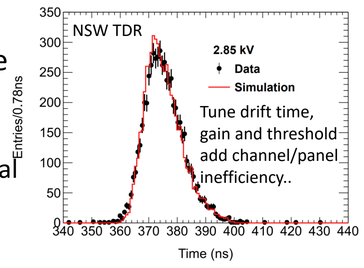




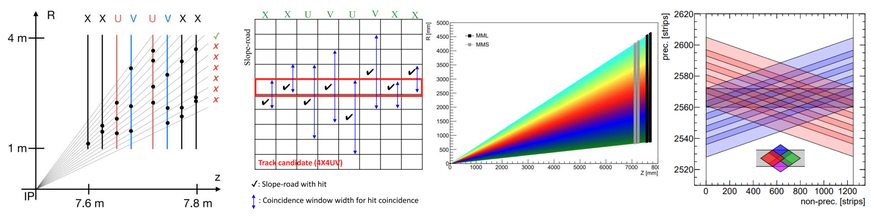
Coincident with Big Wheel

Simulation/Digitization

Simulate ionization, drift, diffusion, avalanche, charge sharing and B effect
Include realistic detector effect
Various comparisons against real data (cosmic ray, test beam)



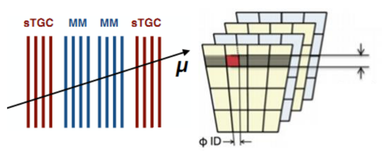
Tigger



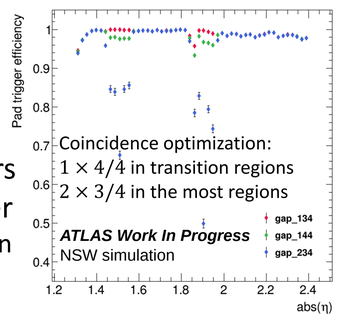
Endcap muon L1

NSW provides up to 8 track segment triggers/BC to Sector Logic, where the triggers from NSW and BW are coincident according to spatial variables, $\Delta\eta_{BW-NSW}$, $\Delta\phi_{BW-NSW}$, $\Delta\theta$, shown in right plots

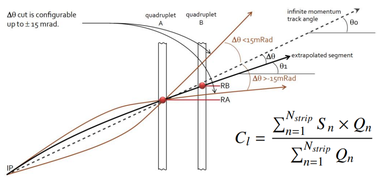
Pad Trigger



Pads are staggered in 8 layers
ROI formed by the pad tower requiring some geometry pattern



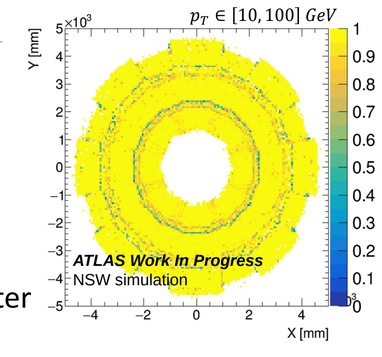
Strip Trigger



$$C_l = \frac{\sum_{n=1}^{N_{strip}} S_n \times Q_n}{\sum_{n=1}^{N_{strip}} Q_n}$$

A band of strips under pad trigger road are read out

Form charge weighted cluster from strip digits per wedge



Form track segment from 2 clusters with η requirement
the segment finding efficiency is shown right, ~ 98%

Diamond algorithm

Segment the space into slope roads, which point back to the IP

Allow the necessary overlap for roads avoiding the efficiency loss in boundary

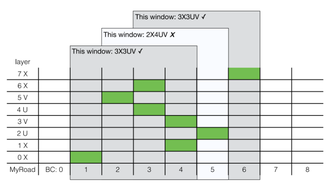
1-to-1 correspondence between slope and strip defined road by applying a window-shift

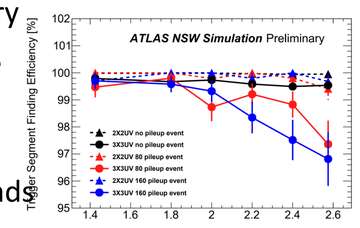
Find the diamond (ROI) crossed by roads from 4X(strips parallel to η direction), 2U(strips tilted by +1.5°), 2V(strips tilted by -1.5°) layer

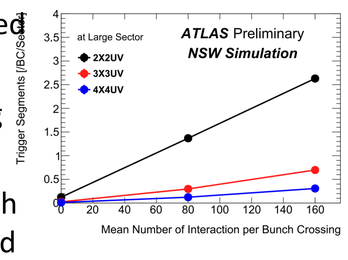
Triggers for a ROI are made with sliding window with 4 BC width

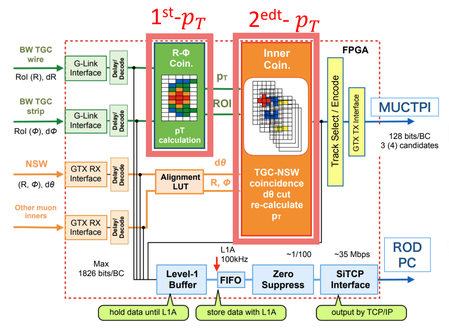
The optimal coincidence is 3X3UV,which has high efficiency even in very forward region and keep low trigger rate along with the increasing of <μ>

One muon can make many triggers-duplicates







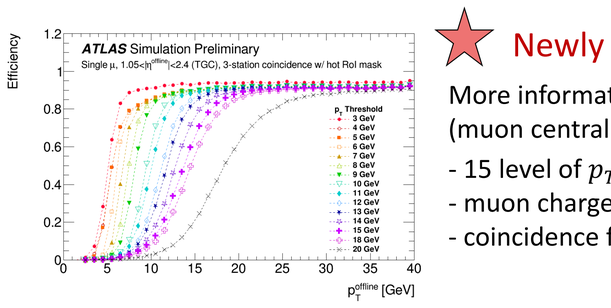


Muon Endcap L1 Logics:

Fast calculation of p_T through 2 LUT
- take R and ϕ coincidence in TGC
- take coincidence with NSW

Calculate p_T 2 times during process

Zoom in Sector Logic



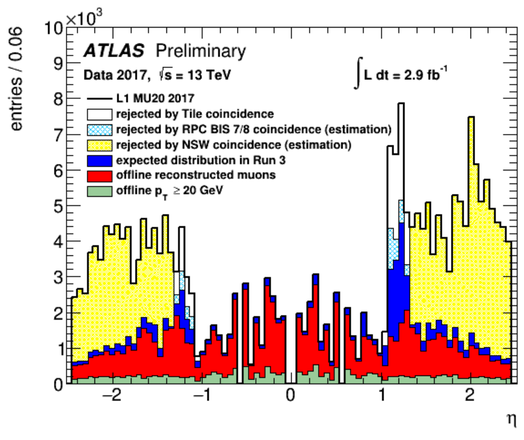
★ Newly developed!

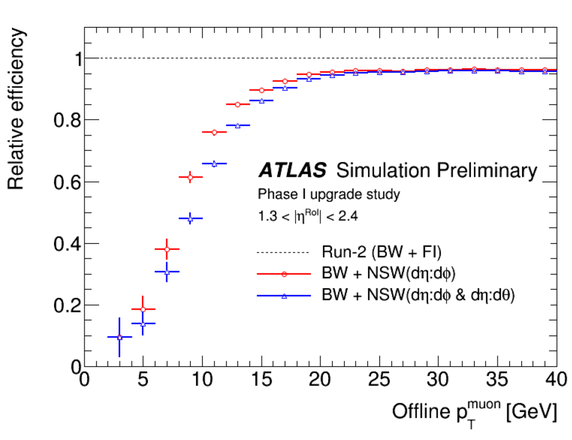
More information sent to MUCTPI (muon central trigger processor):
- 15 level of p_T (3GeV→20GeV)
- muon charge information
- coincidence flag

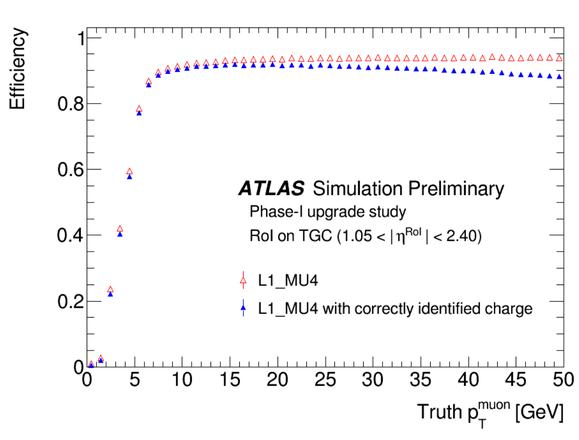
L1 rate for endcap muon 28kHZ ⇒ 13KHz

The new Sector Logics rejects 2 times fake triggers than using Run2 system, assuming $\mathcal{L} = 3 \times 10^{34} cm^{-2} s^{-1}$

High level Trigger/Reconstruction/Calibration







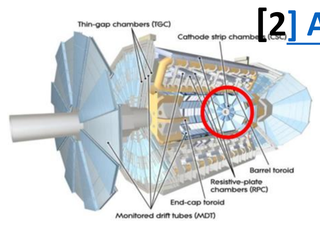
Performance

- NSW largely improves the rejection power for fake triggers in forward region ($1.3 < \eta < 2.4$) by 3 times, enable to provide low p_T threshold single muon trigger (20GeV)
- The efficiency loss for muon of p_T > 20 GeV is below 5%, mainly from the segment finding inefficiency in NSW
- The accuracy of muon charge identification can be 98% up to 50 GeV, using bending direction in the magnetic field, can provide other dimension for new trigger design (SS)

Conclusion

The software chain of NSW is fully prepared, including detector simulation and digitization, trigger implementation, reconstruction, and calibration, which is under the final validation phase with fresh Run3 data. That could be expected which, consuming enormous efforts in the past ten years, will participate in the ATLAS analysis soon.

Reference [1] NSW Technical Design Report
[2] ATLAS L1 muon public results



ATLAS EXPERIMENT