ATLAS Level-1 Endcap Muon Trigger for Run-3

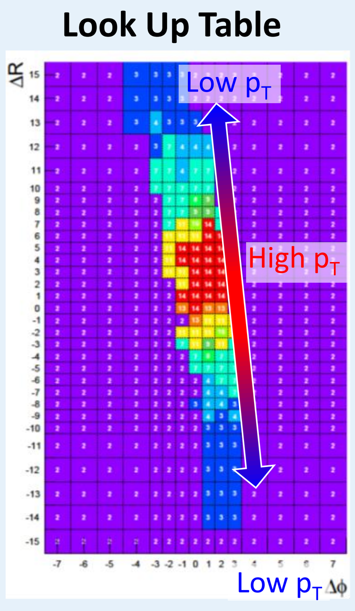
Hiroaki Hibi (Kobe University)
on behalf of the ATLAS collaboration

Abstract

This poster shows an upgrade of the level-1 endcap muon trigger for the ATLAS experiment at Run 3. In this upgrade, new detectors will be installed in the inner muon station. New hardwares have been developed to handle a large amount of inputs from the new detectors. Also, a new trigger algorithm has been developed. Especially, charge identification and algorithm with new detectors are focused on this poster.

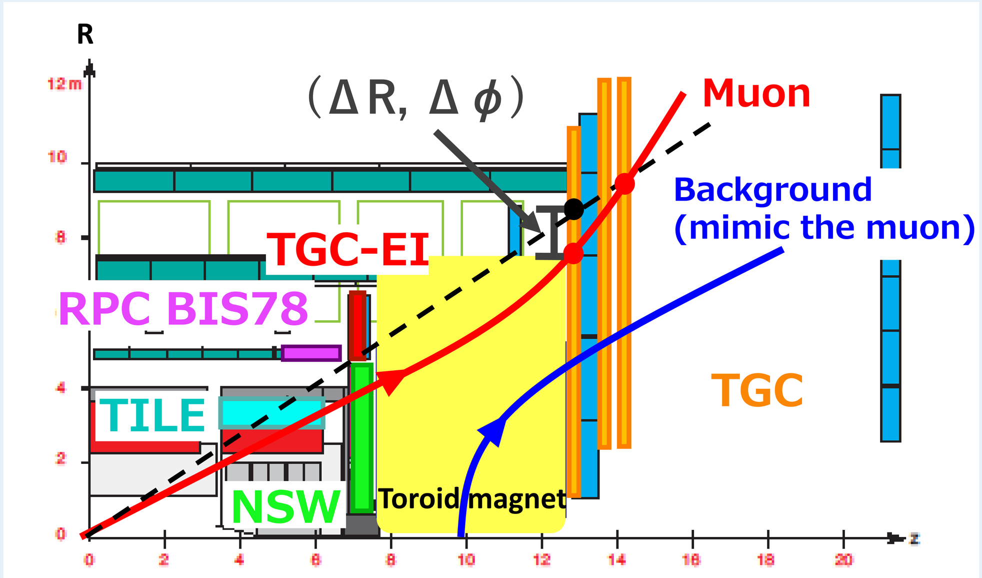
1. Level-1 Endcap Muon Trigger Upgrade

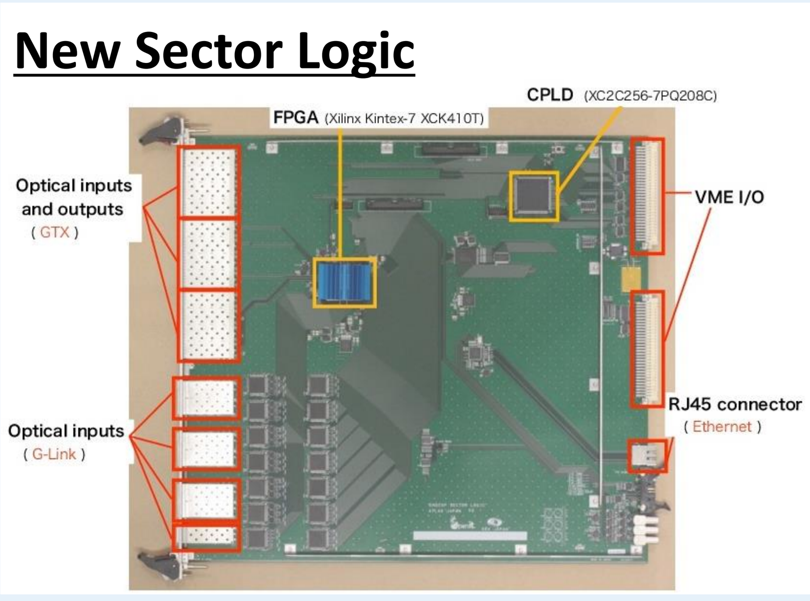
- **Level-1 Endcap Muon Trigger**
  - Hardware trigger: Big Wheel of Thin Gap Chamber (TGC-BW).
  - The coverage is $1.05 \leqq |\eta| \leqq 2.40$ and whole ϕ.
  - A muon transverse momentum (p_T) is defined by measurements of curvature in the magnetic field (ΔR, $\Delta\phi$)
  - The muon p_T is calculated with pre-defined **Look-Up-Tables (LUTs)**.
  - Beam-induced backgrounds, primarily from particles emanating from the endcap toroid or shielding, are a significant source of fake triggers.



- **Inner Coincidence**
  - The key to suppress the backgrounds is to require a coincidence between TGC-BW and detectors in the inner station.

  · TGC-EI , Tile Calorimeter (TILE).
  · New detectors for Run 3 ➡ New Small Wheel (NSW), RPC BIS78.





- **New Sector Logic**
  - Sufficient I/O ports to cope with the large amount of signals from the detectors in the inner station.
  - 20 times resource of FPGA

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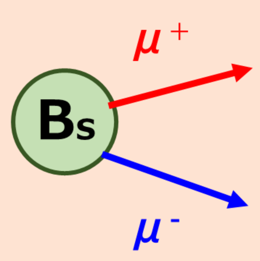
More complex and higher performance algorithm can be implemented.

2. Improvement of Muon Charge Identification

Motivation

Charge information is useful for development of the dedicated trigger chain.



e.g.) Bs → $\mu^+\mu^-$

The fake triggers of two muons, such as chance coincidence, can be reduced by the opposite charge-sign requirement.

- **Identification method**

The charge is identified from bending direction by ΔR and $\Delta\phi$

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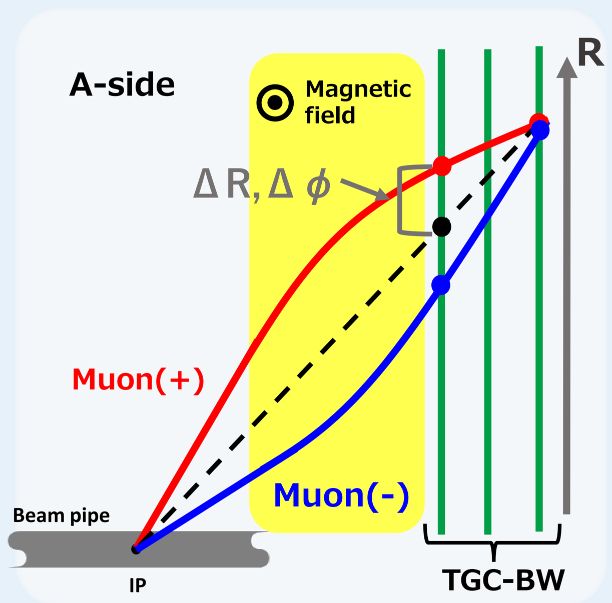
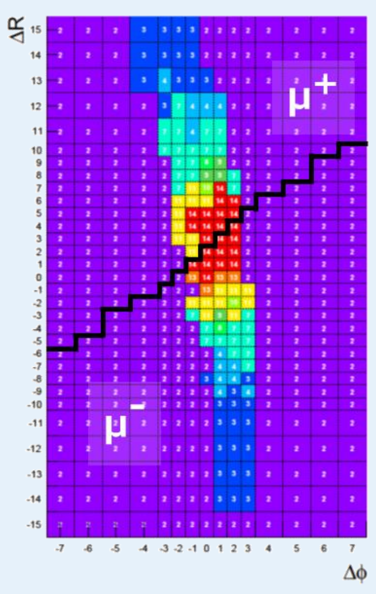
The accuracy is improved by making full use of ΔR-$\Delta\phi$ information implemented on LUT instead of the sign of ΔR only.

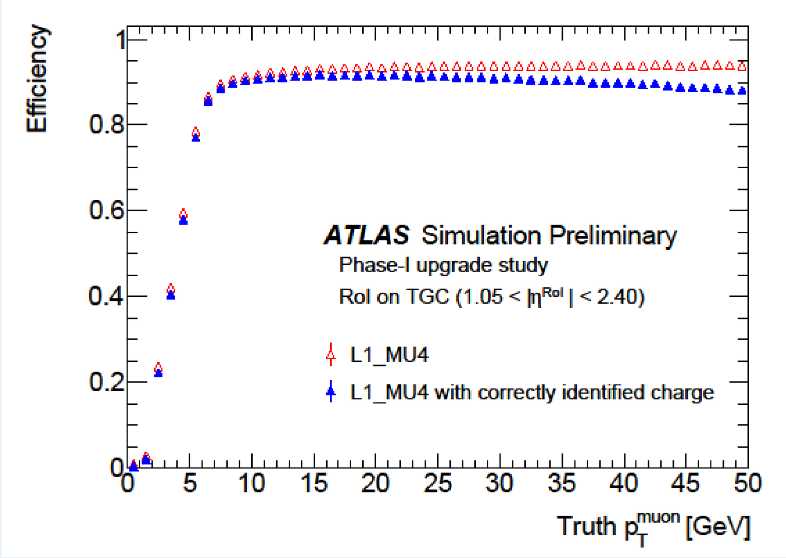




- **Performance**
  - The accuracy is estimated from a simulation study.
  - Identification accuracy: **>98%** in pT < 30 GeV.

(The charge identification is not important for high p_T single muon trigger)

Trigger efficiency with pT threshold of 4 GeV

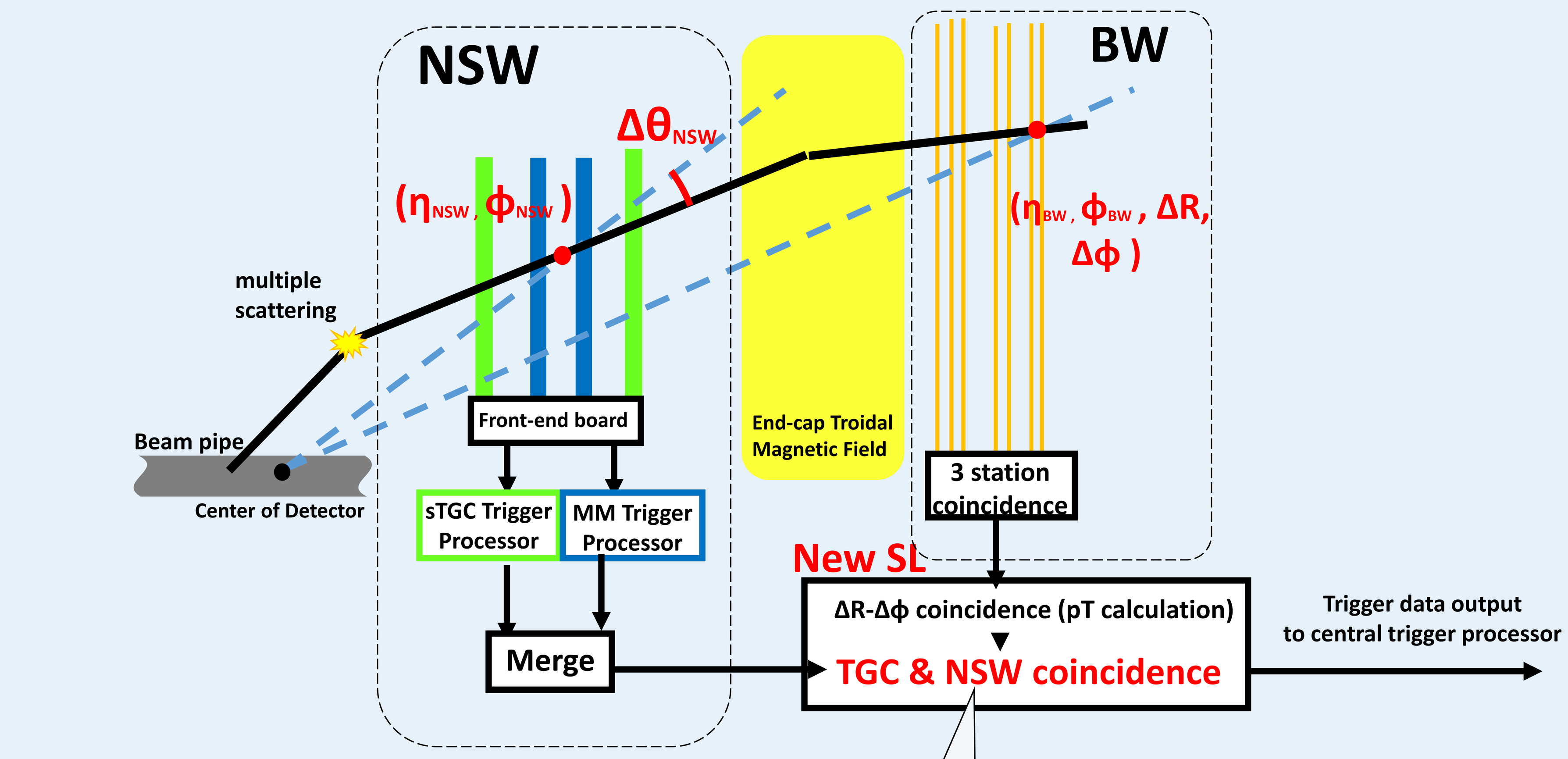


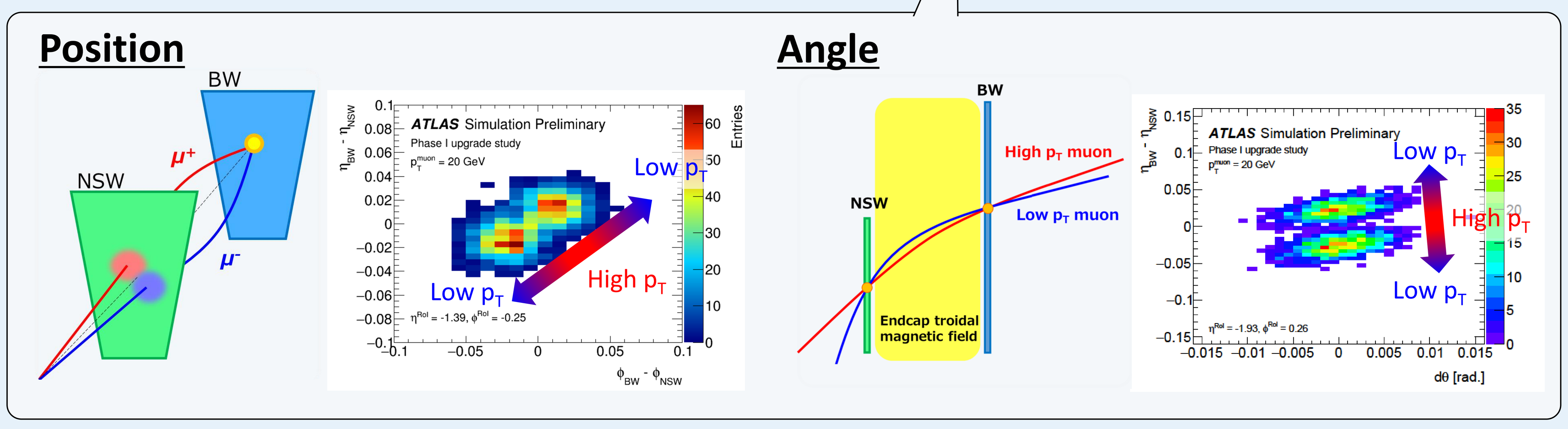
3. TGC-BW & NSW coincidence

Motivation

・to reduce fake triggers.
・to improve the transverse momentum (p_T) resolution.

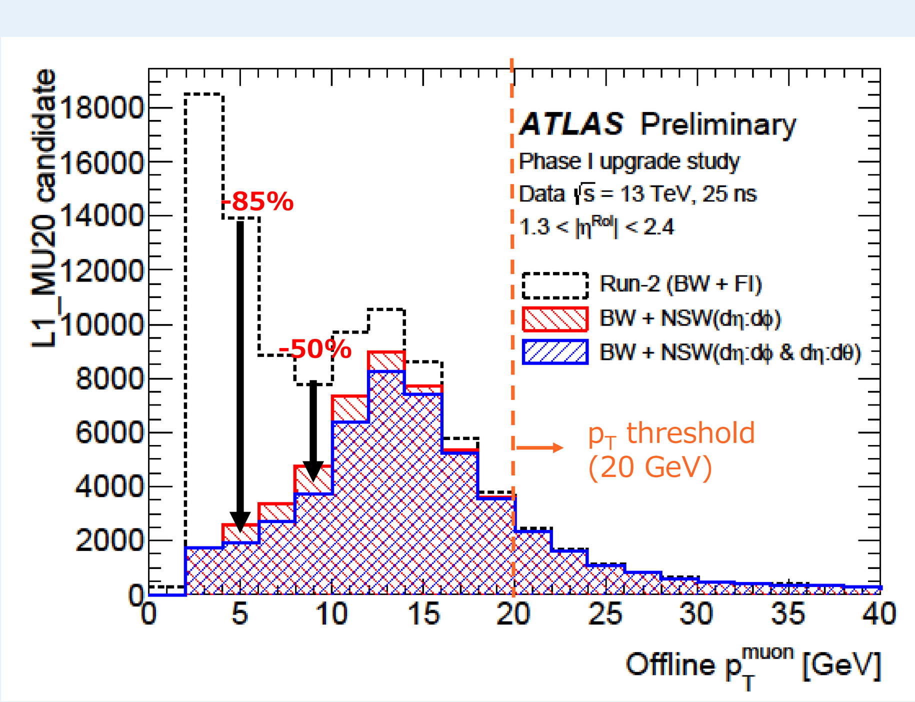
- **Trigger scheme with TGC-BW & NSW coincidence**

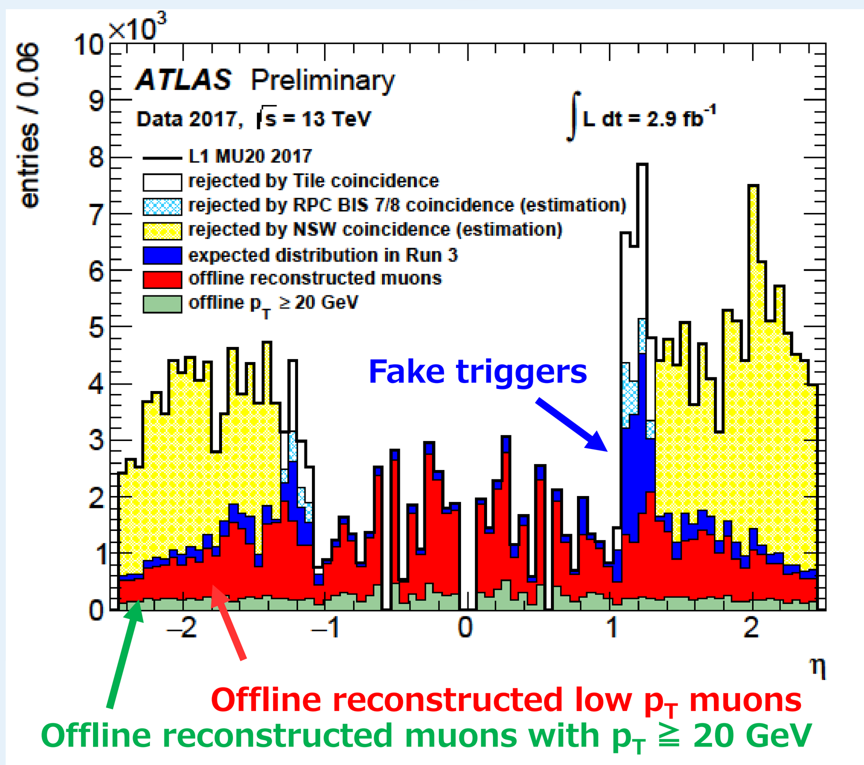




- Calculate muon p_T using position and angle correlation between TGC-BW and NSW.
  - by position (η_{BW}-η_{NSW}, ϕ_{BW}-ϕ_{NSW})
  - by angle ($\Delta\theta_{NSW}$, η_{BW}-η_{NSW})
- LUTs are defined by hit maps of the position and angle generated by simulation.

- **Performance** (Single muon trigger of 20 GeV threshold : L1_MU20)





p_T resolution

- The p_T resolution is improved due to high granularity of NSW.
- Reduction of low p_T candidates in L1_MU20 : 50% for p_T = 10 GeV, 85% for p_T = 5 GeV

Rate reduction

The rate reduction of L1_MU20 is estimated using Run 2 real data.

- >90% of fake triggers are rejected.
- ~45% rate reduction is expected for the L1_MU20 trigger

4. Summary

- The level-1 endcap muon trigger will be upgraded with new detectors and electronics.
- Many upgrade ideas will be implemented on the FPGA of new Sector Logic.
  - Accurate charge identification (>98% at p_T < 30 GeV)
  - Powerful rate reduction with negligible efficiency loss (~45% in L1_MU20)

Reference

L1 Muon Trigger Public Results (https://twiki.cern.ch/twiki/bin/view/AtlasPublic/L1MuonTriggerPublicResults)

The 29th International Symposium on Lepton Photon Interactions at High Energies @ Toronto