L1 Muon Endcap Trigger
Phase-0 & Phase-1 Upgrade

Takuya Tashiro
Kyoto Univ.
Current trigger detectors in the Endcap

- TGC1
- TGC2
- TGC3

Big Wheel (BW)

2/3 coin. hit position

3/4 coin. track position and deviation

H-pT Board

R, dR, Φ, dΦ

Sector Logic
R-Φ coin.
pT calculation

Monday, 9 July 2012
present TGC muon trigger scheme

- Deviation from infinite momentum track \((dR, d\Phi)\) is measured with 3 TGC stations

- Coincidence Window is used to calculate \(p_T\)
  - implemented in Sector Logic
  - each \((dR, d\Phi)\) corresponds to \(p_T[1,6]\)

Coincidence Window Example
Phase-0 upgrade

- require hit in muon Endcap Inner station (EI/FI)
- take EI/FI - BW coincidence in Sector Logic

EI/FI

- particle production at the beam pipe is the dominant source of the background.

white : L1 trigger
blue: L1 trigger with offline track

L1μ triggered the gap between white & Blue
Phase - 0 trigger scheme in the Endcap

Small Wheel
MDT + CSC
TGC Inner

Big Wheel (BW)

1/2 coin.
hit position
(VERY COARSE)

2/3 coin.
hit position

3/4 coin.
track position and deviation

H-pT Board

R, dR, φ, dφ

(R, φ)
coarse hit information

Sector Logic
R-φ coin.
pT calculation

introduced
for Phase - 0

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Upgrade on Sector Logic

- New function is introduced to take BW-EI/FI coincidence.

- New function - with 2 operating modes.
Current Status of Sector Logic Upgrade

• New coincidence logic is implemented (Done)
  - tested at the testbench system

• New control registers are prepared (Done)
  - to determine which pT and ROI to require EL/FI hit
  - to select operating mode
    * ”flagging mode” : NOT change trigger result
    * ”main mode” : change trigger result

• Additional flag is introduced in R/O information.
  - to monitor SL behaviour in flagging mode.
    * flag = 1 : candidate is rejected in “main mode”
    * flag = 0 : candidate is NOT rejected in “main mode”
Trigger efficiency study in Phase-0

- El/Fi does not cover all the BW region.

<table>
<thead>
<tr>
<th>Coverage</th>
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<tbody>
<tr>
<td>BW : ( \eta = 1.05 - 2.4 )</td>
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<tr>
<td>FI : ( \eta = 1.3 - 1.9 )</td>
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<tr>
<td>El : ( \eta = 1 \sim 1.3 ) (but missing in ( \Phi ))</td>
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- ROI to take coincidence should be chosen carefully.

- Efficiency study using single muon MC

- Efficiency = \{trigger with hit in El/Fi\} / trigger

- El is quite complicated

(Tani, Kobe)
Trigger rate reduction in Phase-0

LI-MU11 in data 2011 → emulate phase-0 logic

Trigger rate reduction in Phase-0

Trigger rate is suppressed by 27%

hit in EI/Fl = detected in both EI/Fl wire and strip

(Tamagawa, Shinshu)
Phase I Upgrade

- New detectors are installed
  - sTGC
  - MicroMegas
  New Small Wheel (NSW)

- Small Wheel coverage will be extended
  - $\eta = 1.3 - 2.4$ (for trigger)

- Incidence angle is measured
  with $\sim 0.1$ mrad resolution
  - $d\theta$: the incident angle deviated from the track pointing to IP
  - clean up tracks not pointing to IP.

(Chizelev, KEK)

$\mu$

1.8 $< \eta < 2.0$

$\mu$ in offline muon measured by SW

1.8 $< \eta < 2.0$

$\mu$ in L1 triggered

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Phase 1 detectors

- Precision Detector
  - $\sigma < 100\mu m$
  - $\phi$-information

- Level-1 Trigger
  - Resolution of incidence angle
  - $< 1 \text{ mrad}$
  - BCID, LVL1 latency

- Track fitting
  - track position ($R, \phi$)
  - $d\theta$ : deviation of incidence angle from infinite $pT$ muons
  - Coarse $d\theta$-cut

- Small Wheel

- Take Coincidence

- BW

- NSW

- TGC1
- TGC2
- TGC3

- 2/3 coin. hit position
- 3/4 coin. track position and deviation

- H-pT Board

- Sector Logic
  - $R-\phi$ coin. track fitting crossing angle : $\beta$
  - $pT$ calculation

- Phase-1 upgrade

- measure
- position
- $d\theta$
New Sector Logic Board

2-steps of LUT

- SL spends 10 clocks
  - present SL spends 7
New Small Wheel (NSW)

- **hit data**
  - 16 bit / track
    * position : 10 bit
    * $d\theta$ : 5 bit
    * hit flag : 1 bit
    * total : 16 bit
  - 4 tracks / fibre

- **Connection NSW - New SL**
  - $[3(\text{Large}) + 2(\text{Small})] \times 8 \times 2 = 80$ fibers
  - 2 input / sector for spare
Requirements to Trigger Processor of NSW detector

- Outputs to Sector Logic should be fully synchronous to 40 MHz clock.

- NSW detectors should combine track information (MM-sTGC) before SL.

- Latency to Sector Logic should be shorter than 44 clocks.
Summary

• Phase-0 upgrade
  - New coincidence logic, EL/FI - BW : Done
  - optimisation of trigger condition : ongoing
  - preparation to install in ATLAS : ongoing
  - trigger rate reduction in simple condition is 27%

• Phase-1 upgrade
  - A trigger scheme has been studied. (dθ info.)
  - Data format between NSW - New SL is under discussion.