The 1st Result of Global Commissioning of the ATALS Endcap Muon Trigger System in ATLAS Cavern

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On behalf of TGC Group

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Introduction
ATLAS Level1 Trigger

- Characteristics
  - Rate reduction: 1GHz → 100kHz
  - Decision time: < 2.5μs
  - Only raw electronic signals are used

- Muon Trigger System
  - Endcap (1.05<|\eta|<2.4)
    - Thin Gap Chamber (TGC)
      - Barrel (|\eta|<1.05)
        - Resistive Plate Chamber (RPC)
      - Air-core super-conducting toroidal magnet (Endcap and Barrel)
Thin Gap Chamber

- **Structure**
  - Similar to MWPC
  - Wire: 50μm gold-plated Tungsten
  - Anode-Cathode Gap: 1.4mm
  - Wire-Wire Gap: 1.8mm
  - 2-dimensional readout (wire, strip)
  - Cathode plane: carbon (~MΩ/cm²)
  - Trapezoidal shape (~2m²)

- **Operation condition**
  - Gas: CO₂ + n-C₅H₁₂ (55:45)
  - High Voltage: +2.9kV
  - Operation Mode: Limited Proportional
  - Gas Gain: ~10⁶

- **Production and Inspection**
  - In total **3600 chambers** were produced in
    Japan (KEK), Israel (Weizmann) and China (1999 – 2006)
Endcap Muon Trigger System

• Big Wheel
  – *Triplet* (TGC1), *middle doublet* (TGC2) and *pivot doublet* (TGC3)
  – Each BW consists of 12 sectors → **72 sectors** are required.

• Measurement items
  – muon hit position
  – Rough Pt momentum → trigger if Pt > 6GeV

1. Connect the IP and hit point on TGC3 → Infinite momentum track

2. Hit signal on TGC1&2 is found in window1&2. → Pt > 6GeV

3. Pt information is divided into 6 Pt threshold using LUT.

4. Pt threshold and hit position → MUCTPI
1/12 sector Assembly (Oct. 2005 ~ Aug. 2007)
(detail ➔ T. Kubota’s poster)

Sector Transportation
T. Sugimoto (Nagoya-U)

TGC Big Wheel Assembly (Jul. 2006~)
➔ 5 wheels assembled

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Installation of Electronics Modules

**On TGC chambers**
- PS-Board
- SLB ASIC 3/4 Coin. Readout
- DCS-PS
- H-Pl wire
- H-Pl strip
- SSW
- HSC

**Big Wheel edge**
- Sector Logic
- ROD
- Readout crate
- Control crate
- VME64 crates
- Trigger crate

**Counting Room (USA15)**
- CCI, SL, ROD, TTC
- VME Crate, SBC
- Optical PP

**19” Mini-Rack**
- HSC, SSW, HPT (CTM)
- LV, HV
- Optical PP

**On-Detector Module**
- SPP, PP, SLB
- DCS modules

**Optical Fiber (~100m)**

**TGC Big Wheel**

**Counting Room**
- Trigger
- MUCTPI
- ROB
- TTC
- CTP
ASICs for TGC Electronics

TGC1  TGC2  TGC3

PS-Board on TGC chambers

- PP delay BCID
- SLB ASIC 3/4 Coin. Readout
- PP delay BCID
- JRC
- Doublets
- DCS-PS

HSC(VME) (Big Wheel edge)

- H-Pt wire
- H-Pt strip

PP delay BCID
SLB ASIC 2/3 Coin. Readout

PP delay BCID
JRC

Triplet
DCS-PS

Service PP
CAN

TTC signal fanout to PS-Boards
TTCrq
Antifuse FPGAs for TGC Electronics

PS-Board on TGC chambers
- SLB ASIC
- 3/4 Coin. Readout
- H-Pt wire
- H-Pt strip
- SSW
- HSC

VME64X (USA15) Trigger crate
- SLB ASIC
- 2/3 Coin. Readout

HSC(VME) (Big Wheel edge)
- PP delay
- BCID
- Doublets
- DCS-PS
- H-Pt Board
- HSC Board
- SSW TX
- SSW RX

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Global Commissioning
<Main purpose of Global Commissioning>
1. Provide *Trigger Signal* to whole sub-detectors
   → mainly MDT EndCap
2. Read out TGC data via ROD-ROS link
3. Join TGC segment to the ATLAS central DAQ system

Chamber condition
+ Gas: CO₂ 100%
+ HV: 2.8kV
+ Eff: ~20%
TGC Electronics

On TGC chambers
- TGC1, TGC2, TGC3
- PS-Board
- SLB ASIC
  - 3/4 Coin. Readout
- Doublets
- PP delay
  - BCID
- Triplets
- PP delay
  - BCID
- Service PP
- TTC signal fanout to PS-Boards
- JRC
- DCS-PS
- CAN
- TTCrq
- TTCvi
- CCI
- Control crate
- DCS LCS
- TTC CTP
- Service PP
- TTC signal fanout to PS-Boards

Big Wheel edge
- HSC(VME) crate
- H-Pt wire
- H-Pt strip
- SSW
- HSC
- JRC
- DCS-PS
- Doublets
- TGC chambers
- Big Wheel edge
- Counting Room

Counting Room
- VME64 crates
  - Trigger crate
  - Sector Logic
- Trigger
  - MUCTPI
- Readout
  - ROD
  - ROB
- Control
  - CCI
  - TTCvi
- Control crate
- TTC signal fanout to PS-Boards

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Setup for Global Commissioning

**On TGC chambers**
- Big Wheel edge
- Counting Room

Specially designed modules instead of HPT

1-station coincidence
- PP delay
- BCID
- Triplet
- Service PP
- SLB ASIC
- 2/3 Coin.
- Readout
- JRC
- DCS-PS
- CAN
- TTCrq

**Big Wheel edge**
- HSC(VME) crate
- CTM
- SSW
- HSC
- Control crate
- CCI
- TTCvi

**Counting Room**
- VME64 crates
- Trigger crate
- Sector Logic
- MUCTPI
- Readout crate
- ROD
- ROB
- Control
- TTCCTP

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Commissioning Trigger Module (CTM)

• Functionality
  – 11 FPGAs
    • XILINX SPARTAN XC2S50E
    • 10 are used for Rx (LVDS).
      – Take all OR, mask any inputs
    • 1 is used for Tx (NIM).
  – CPLD: VME control.
    • XILINX XC2C256P

• Purpose
  – Trigger output is asserted by all trigger matrices on SLB ASIC.
  – Usable to give 1-station trigger signal
    → It is impossible for HPT
  – Various trigger pattern by input mask
    • wire only / strip only / wire & strip
Local Trigger Path

On TGC chambers

Big Wheel edge

Counting Room

No logic
No LUT
Fixed Pt

1-station coincidence

16/25
Vth vs Trigger Rate

- half sector
- 2/3 coincidence (wire)
- Gas: CO$_2$ 100%
- HV: 2.8kV

- good separation between S/N with threshold of 100mV
- finally, we got stable 8Hz of trigger from FULL TGC1 sector9 and fed them to CTP (they found it in their system)
**Control Path**

**On TGC chambers**
- CCI-HSC link
  - Optical communication module
    - CCI: VME Slave
    - HSC: VME Master
- JRC (Jtag Route Controller)

**Big Wheel edge**
- HSC (VME) crate
- JRC (Jtag Route Controller)
- CCI-HSC Link (optical)

**Counting Room**
- VME64 crates
- Trigger crate
- Sector Logic
- Readout crate
- Control crate
- TTC signal fanout to PS-Boards
- DCS LCS
- JTAG

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Global Trigger Path

On TGC chambers

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Big Wheel edge

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Counting Room

No logic
No LUT
Fixed Pt

TGC1

ASD

PP delay BCID

PP delay BCID

Triplet

SLB ASIC 2/3 Coin. Readout

Service PP

TTC signal fanout to PS-Boards

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CTM

SSW

HSC

Sector Logic

ROD

CTP

Control crate

CCI

TTCvi

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L1A Clock

L1A Clock

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TTC signal fanout
to PS-Boards

MDT-EC

L1A Clock
TDC Distribution of MDT

\[ \Delta t = t_{\text{TGC}} - t_{\text{RPC}} - t_{\text{TOF}} \approx 130 \text{nsec} \]

\( \Rightarrow \) Provide Trigger to whole ATLAS system!!
Track Reconstruction by MDT
Readout Path

On TGC chambers

- Local readout system
  - Special dump module for SSW data (spy mode)
  - Used for quick check w/o ROD

Big Wheel edge

Counting Room

VME64 crates
Trigge crate

Sector Logic

Readout crate

ROD

ROB

Readout crate

Local Readout

Control crate

CCI

TTCvi

CTP

TTC signal fanout to PS-Boards

Service PP

TTC signal fanout to PS-Boards

SLB ASIC 2/3 Coin. Readout

PP delay BCID

PP delay BCID

Triplet

JRC

DCS-PS

CTM

HSC

SSW

HSC(VME) crate

L1A, Clock

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Measurement of L1A latency

Test Pulse with *Track Pattern*

L1A Signal

SSW → Local Readout system

CTM → SL

SLB ASIC

MUCTPI → CTP + TTC

L1A Latency is 76 clocks
= 1.90 μsec (< 2.5 μsec)

Estimation: 75clk (by O.Sasaki, 2004)
Hit Profile for cosmic-ray test

Wire Hit Profile of Endcap Region

- 2/3 coincidence (wire)
- Vth = 100mV
- Gas: CO₂ 100%
- HV: 2.8kV

Strip Hit Profile of Endcap Region

- first data taken by local Readout path
- chambers are working fine
- We are triggering cosmic-muons
- trigger & readout path are working fine !!
Summary

• Provide trigger signal to ATLAS global DAQ system
  – TGC1 sector was used.
    • 1station coincidence → CTM board instead of HPT board
  – Cosmic ray muons are triggered successfully in ATLAS cavern.
    • Trigger & Readout path are working fine.
    • Measured latency is consistent with estimated value (1.9μsec)
    • MDT reconstructed the cosmic muon trajectory using TGC trigger.

• Plan toward Physics Run
  – Extend number of operational sectors
    • 3station coincidence run → done during the latest commissioning run
  – Timing Adjustment between stations.
  – Beam halo & single beam run

  Full system operation should be tested before starting physics run!!
Backup slides
Multiplicity Distribution (events triggered by TGC)

Wire + Strip

Strip
running with CO2
→ reasonable

wire

Wire + Strip
(log)