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
The 1st Result of Global Commissioning of the ATLAS Endcap Muon Trigger System in ATLAS Cavern
ATLAS Level1 Trigger

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

• Muon Trigger System
  – Endcap (1.05<|h|<2.4)
    • Thin Gap Chamber (TGC)
      – Barrel (|h|<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-dimentional 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
TGC Assembly at CERN

1/12 sector Assembly (Oct. 2005 ~ Aug. 2007)
(detail→ T. Kubota’s poster)

Sector Transportation

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

The 1st Result of Global Commissioning of the ATLAS Endcap Muon Trigger System in ATAS Cavern
Installation of Electronics Modules

22m

TGC Big Wheel

Optical Fiber (~100m)

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

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

Counting Room (USA15)
+ CCI, SL, ROD, TTC
+ VME Crate, SBC
+ Optical PP
ASICs for TGC Electronics

TGC1 TGC2 TGC3

PS-Board on TGC chambers

PP delay BCID
SLB ASIC 3/4 Coin. Readout
Doublets

HSC(VME) (Big Wheel edge)

H-Pt wire
H-Pt strip

PS Board

ASD card

TTC signal fanout to PS-Boards
CAN TTCrq

H-Pt Board

Service PP

DCS-PS

VME crate

Trigger crate

USA15

PP SLB ASIC

HSC(VME) (Big Wheel edge) PS-Board on TGC chambers

ASD

TGC1 TGC2 TGC3

PP delay BCID
SLB ASIC 2/3 Coin. Readout
Triplet

DCS-PS

JRC

The 1st Result of Global Commissioning of the ATLAS Endcap Muon Trigger System in ATLAS Cavern
Antifuse FPGAs for TGC Electronics

- **TGC1, TGC2, TGC3**
- **PS-Board on TGC chambers**
- **VME64X Crates**
- **HSC(VME)** (Big Wheel edge)
- **SLB ASIC**
- **3/4 Coin. Readout**
- **JRC**
- **VME**
- **H-Pt Board**
- **SSW Board**

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

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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

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

The 1st Result of Global Commissioning of the ATLAS Endcap Muon Trigger System
Local Trigger Path

On TGC chambers

TGC1

Big Wheel edge

HSC(VME) crate

CTM

SSW

HSC

1-station coincidence

1-station coincidence

PP delay BCID

SLB ASIC

2/3 Coin.

Readout

PP delay BCID

Triplet

Service PP

SD

μ

CTM

Sector Logic

ROD

CCI

TTCvi

L1A

Counting Room

VME64 crates

Trigger crate

No logic

No LUT

Fixed Pt

The 1st Result of Global Commissioning of the ATLAS Endcap Muon Trigger System in ATAS Cavern
Vth vs Trigger Rate

- half sector
- 2/3 coincidence (wire)
- Gas: CO₂ 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

Counting Room

- CCI-HSC Link (optical)
- Standard VME Protocol
- Control crate
- VME64 crates
  - Trigger crate
  - Sector Logic
  - Readout crate
  - ROD
  - Control crate

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

On TGC chambers

- TGC1
- ASD
- PP delay
- BCID
- SLB ASIC
- 2/3 Coin.
- Readout

Big Wheel edge

- HSC(VME) crate
- CTM
- SSW
- HSC

Counting Room

- VME64 crates
- Trigger crate
- Sector Logic
- MUCTPI
- Readout crate
- ROD
- CTP
- Control crate
- CCI
- TTCvi

No logic
- No LUT
- Fixed Pt

L1A Clock
- MDI-EC
- TTCrq
- L1A Clock
- CAN
- JRC
- DCS-PS

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The TDC distribution of MDT is shown, with a graph comparing TGC triggered events and RPC triggered events. The equation \( \Delta t = t_{\text{TGC}} - t_{\text{RPC}} - t_{\text{TOF}} \approx 130\text{nsec} \) is presented. The slide concludes with the statement: "Provide Trigger to whole ATLAS system!!"
Track Reconstruction by MDT

The 1st Result of Global Commissioning of the ATLAS Endcap Muon Trigger System in ATAS Cavern
Local readout system
- Special dump module for SSW data (spy mode)
- Used for quick check w/o ROD
Measurement of L1A latency

Test Pulse with Track Pattern

L1A Signal

L1Buffer → SSW → Local Readout system

2/3

SL

SLB ASIC

TTC

MUCTPI → CTP + TTC

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

Estimation: 75clk (by O. Sasaki, 2004)

The 1st Result of Global Commissioning of the ATLAS Endcap Muon Trigger System in ATLAS Cavern
Hit Profile for cosmic-ray test

Wire Hit Profile of Endcap Region

- Layer 1
  - T5
  - T6
  - T7
  - T8

- Layer 2
- Layer 3

- 2/3 coincidence (wire)
- $V_{th} = 100\text{mV}$
- Gas: CO$_2$ 100%
- HV: 2.8kV

Strip Hit Profile of Endcap Region

- Layer 1
  - T5
  - T6
  - T7
  - T8

- Layer 2

- 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
Trigger Logic
Multiplicity Distribution (events triggered by TGC)

- Wire + Strip
- Wire
- Strip
  - running with CO2
  - reasonable
- Wire + Strip
  - (log)