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 LHC-ATLAS Experiment

- Barrel muon chamber
- EM calorimeter
- Inner tracker
- Barrel toroidal magnet
- Endcap toroidal magnet
- Hadron calorimeter
- 7 TeV proton
- 25 m
- 45 m

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-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
TGC Assembly at CERN

1/12 sector Assembly (Oct. 2005 ~ Aug. 2007)
(details 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

- On TGC chambers
  - PS-Board
  - SLB ASIC 3/4 Coin. Readout
  - SLB ASIC 2/3 Coin. Readout
  - DCS-PS
  - H-Pl strip
  - H-Pl wire
  - SSW
  - HSC
- Big Wheel edge
  - VME crate
  - Trigger crate
  - Sector Logic
  - Control crate
- Counting Room
  - LV, HV
  - Optical PP

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

- Optical Fiber (~100m)

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

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

- PS-Board on TGC chambers
  - PP delay BCID
  - SLB ASIC 3/4 Coin. Readout
  - PP delay BCID
  - JRC
  - Doublets
  - DCS-PS
  - PP delay BCID
  - SLB ASIC 2/3 Coin. Readout
  - PP delay BCID
  - JRC
  - Triplet
  - DCS-PS
  - Service PP TTC signal fanout to PS-Boards
  - CAN TTCreq

- HSC(VME) (Big Wheel edge)
  - H-Pt wire
  - H-Pt strip
  - PS-Board

- Trigger crate
  - VME64 Crates
  - USA15

- Readout crate
  - ASD
  - TGC1 TGC2 TGC3
  - Sector Logic
  - H-Pt Board
  - 1st Result of Global Commissioning of the ATLAS Endcap Muon Trigger System in ATLAS Cavern

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Antifuse FPGAs for TGC Electronics

TGC1, TGC2, TGC3

PS-Board on TGC chambers

SLB ASIC
3/4 Coin. Readout

PP delay
BCID

JRC

TTC signal fanout

VME64x
Trigger crate

HSC(VME)
(Big Wheel edge)

H-Pt wire

BCID

JRC

DCS-PS

H-Pt strip

Doublets

JRC

H-Pt Board

SSWRX

H-Pt Board

SSWTX

HSC Board

PS Board

SSWRX

VME

SSWTX

VME

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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%

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

On TGC chambers

- Specially designed modules instead of HPT

Big Wheel edge

- 1-station coincidence

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

Counting Room

- HSC(VME) crate
- VME64 crates Trigger crate
- Sector Logic
- Trigger
- MUCTPI
- Readout crate
- Readout
- ROB
- Control crate
- Control
- TTC
- CTP

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

On TGC chambers

Big Wheel edge

Counting Room

1-station coincidence

- TGC1
- ASD
- Service PP
- PP delay BCID
- PP delay BCID
- Triplet
- SLB ASIC
- 2/3 Coin Readout
- JRC
- DCS-PS
- CAN
- TTCreq
- 1-station coincidence
- HSC(VME) crate
- CTM
- SSW
- HSC
- VME64 crates
- Trigger crate
- Sector Logic
- No logic
- No LUT
- Fixed Pt
- Readout crate
- ROD
- Control crate
- CCI
- TTCvi
- \( \mu, \tau \)

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

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

**Counting Room**

- VME64 crates
- Trigger crate
- Sector Logic
- Readout crate
- Control crate
- Control

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Δt = t_{TGC} – t_{RPC} – t_{TOF} \sim 130\text{nsec}

→ Provide Trigger to whole ATLAS system!!
Track Reconstruction by MDT

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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

HSC(VME) crate

CTM

SSW

HSC

Counting Room

VME64 crates

Trigger crate

Sector Logic

Readout crate

ROD

ROB

Readout crate

Local Readout

Control crate

CCI

TTCvi

CTP

The 1st Result of Global Commissioning of the ATLAS Endcap Muon Trigger System in ATAS Cavern
Measurement of L1A latency

Test Pulse with *Track Pattern*

L1A Signal

- PP
- L1Buffer
- SSW
- Local Readout system
- CTM
- SL
- SLB ASIC
- 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 ATAS Cavern
Hit Profile for cosmic-ray test

Wire Hit Profile of Endcap Region

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

Layer 1

Layer 2

Layer 3

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.
    - 1 station 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 (1.9 μsec)
    - MDT reconstructed the cosmic muon trajectory using TGC trigger.

- Plan toward Physics Run
  - Extend number of operational sectors
    - 3 station 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

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