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
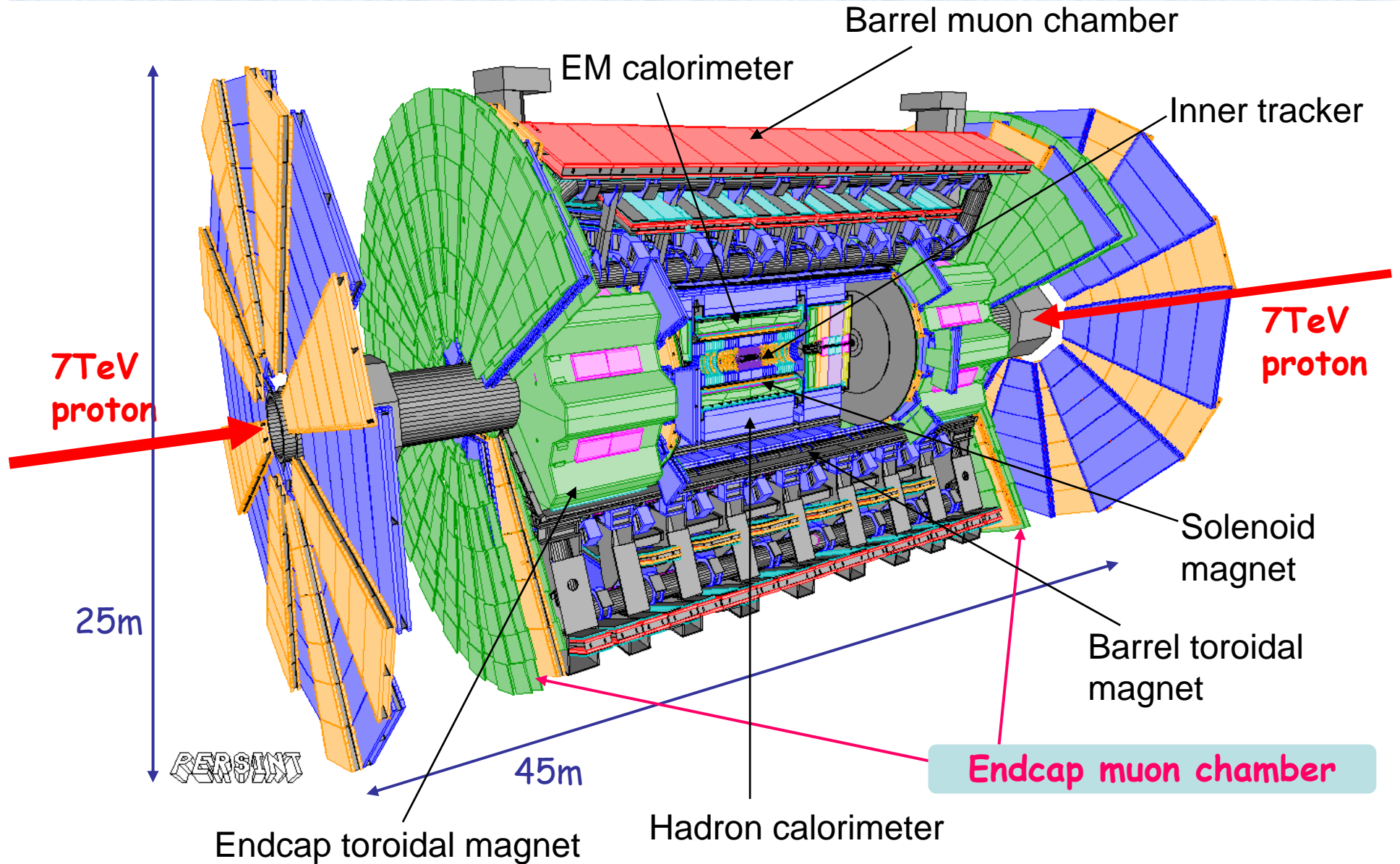
~ Contents ~

1. ATLAS Level1 Trigger

2. Endcap muon trigger system

3. Global Commissioning Run (Milestone-3 run)

4. Results

5. Summary
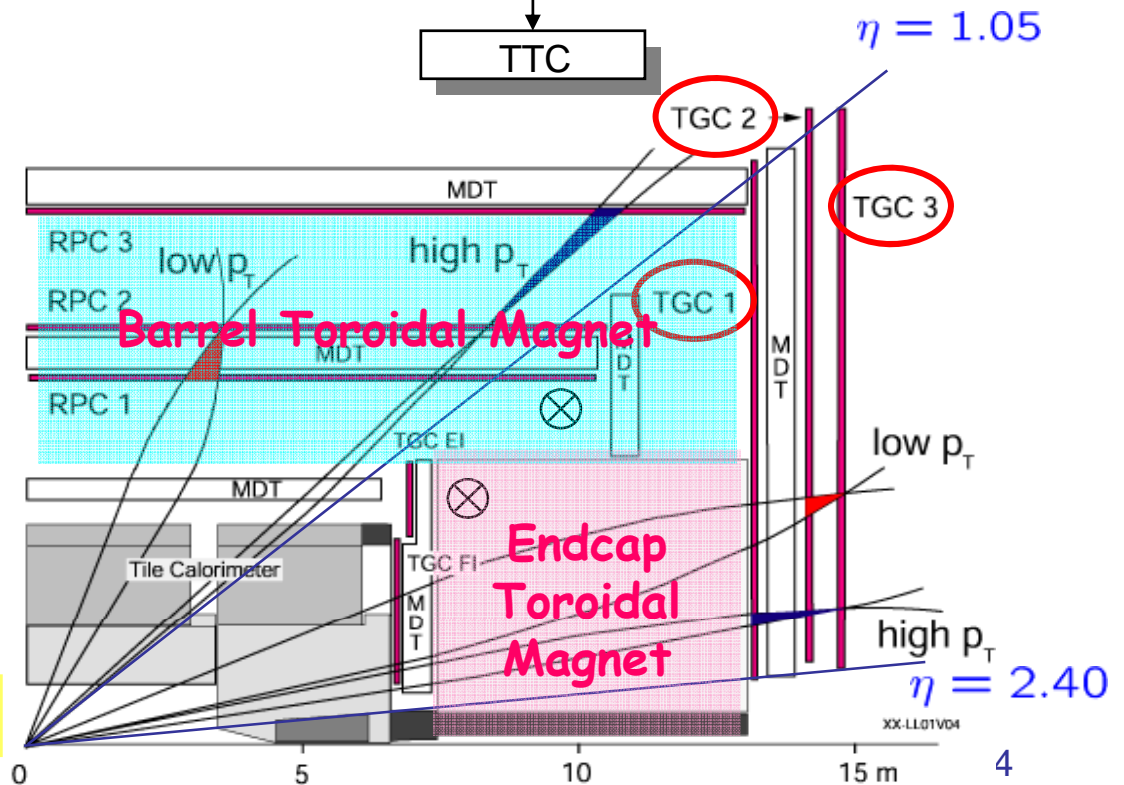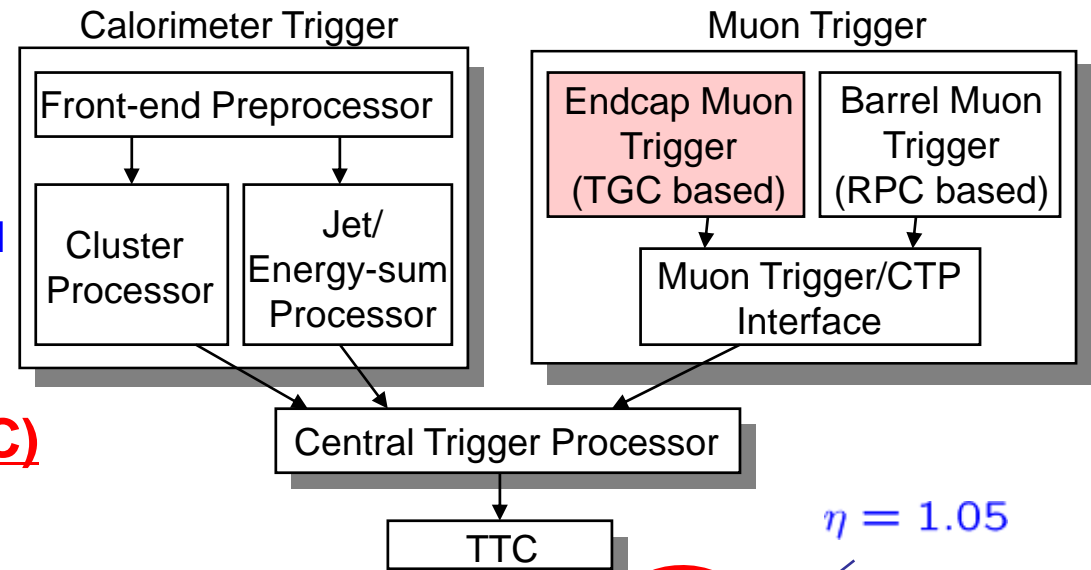
Introduction

LHC-ATLAS Experiment

Barrel muon chamber

EM calorimeter

Inner tracker

7TeV proton

7TeV proton

25m

45m

Solenoid magnet

Barrel toroidal magnet

Endcap muon chamber

Endcap toroidal magnet

Hadron calorimeter

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)

Calorimeter Trigger	Muon Trigger

```
Calorimeter Trigger
  Front-end Preprocessor
    Cluster Processor        Jet/Energy-sum Processor

Muon Trigger
  Endcap Muon Trigger (TGC based)    Barrel Muon Trigger (RPC based)
    Muon Trigger/CTP Interface

Central Trigger Processor
  TTC
```


$\eta = 1.05$

$\eta = 2.40$

4

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 ($\sim M\Omega/cm^2$)
  - Trapezoidal shape ($\sim 2m^2$)

- **Operation condition**
  - Gas : **$CO_2 + n\text{-}C_5H_{12}$ (55:45)**
  - High Voltage : +2.9kV
  - Operation Mode : Limited Proportional
  - Gas Gain : $\sim 10^6$

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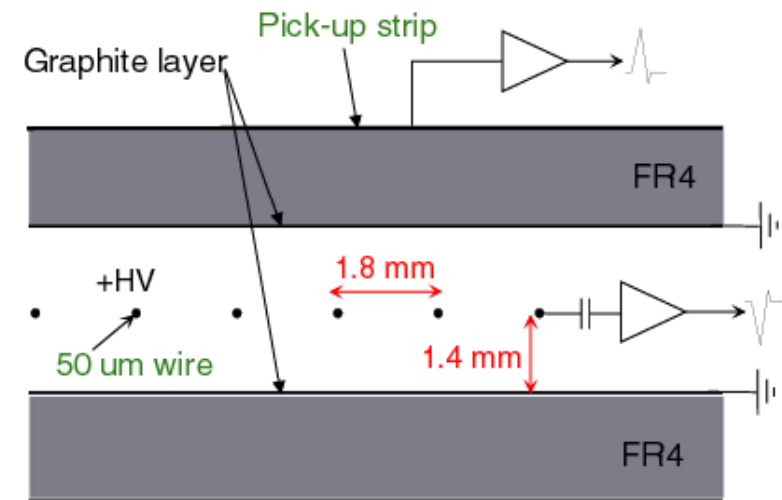
Endcap Muon Trigger System

- 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
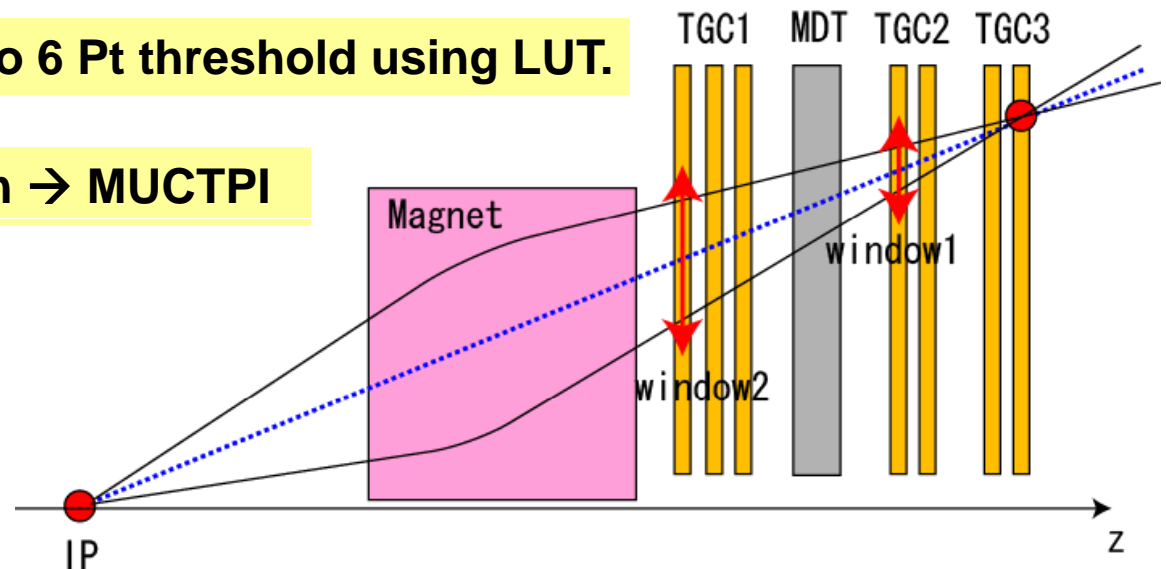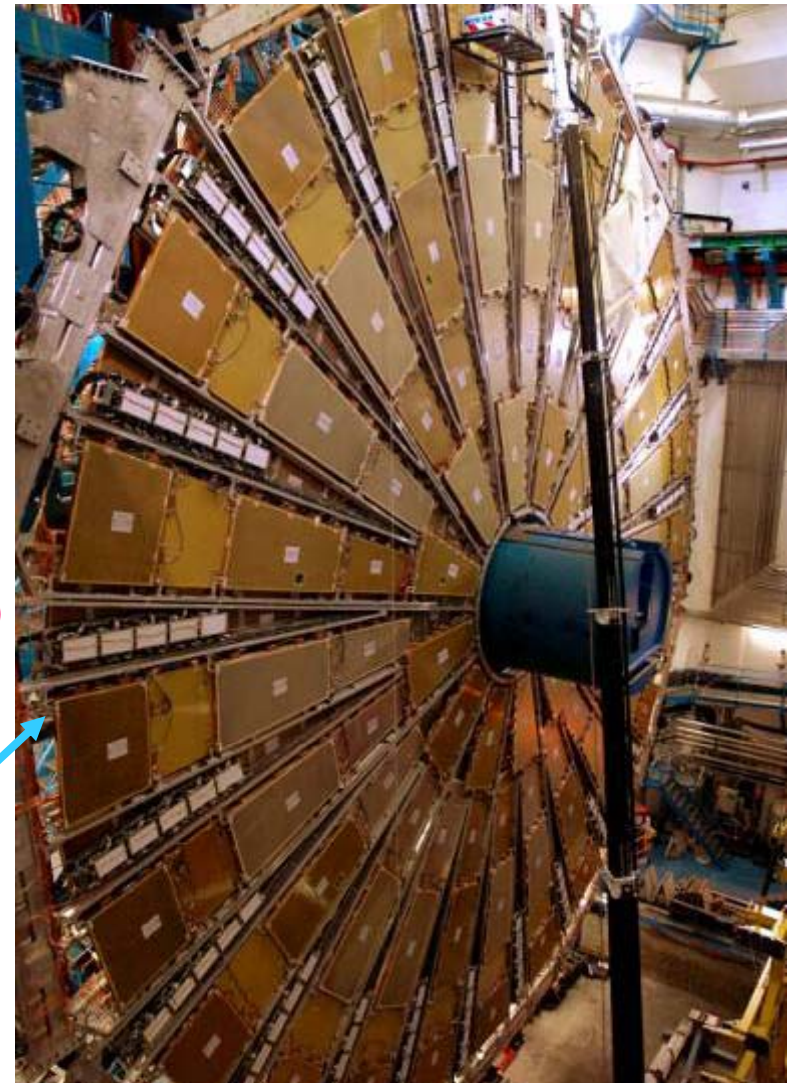
TGC Assembly at CERN

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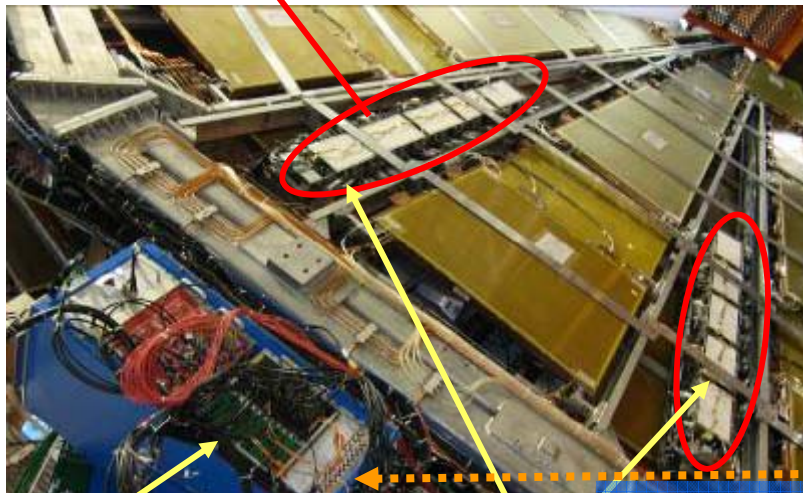
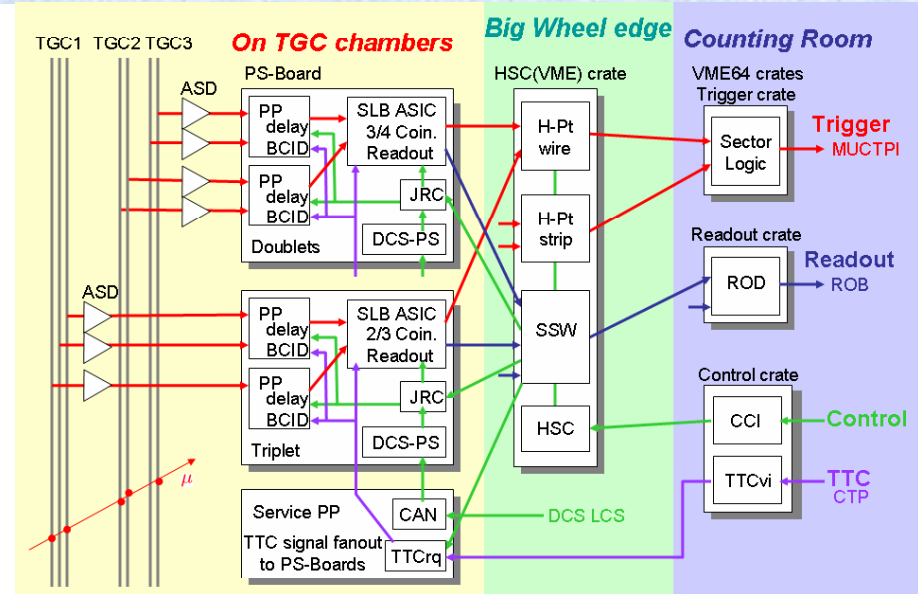**(detail→ T. Kubota's poster)**

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

On TGC chambers — Big Wheel edge — Counting Room

TGC1 TGC2 TGC3

PS-Board

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

Doublets

ASD — PP delay BCID — SLB ASIC 2/3 Coin. Readout — JRC — DCS-PS

Triplet

Service PP — CAN
TTC signal fanout to PS-Boards — TTCrq

HSC(VME) crate — H-Pt wire — H-Pt strip — SSW — HSC

DCS LCS

VME64 crates Trigger crate — Sector Logic — **Trigger** MUCTPI

Readout crate — ROD — **Readout** ROB

Control crate — CCI — **Control** ; TTCvi — **TTC** CTP

Optical Fiber (~100m)

19" Mini-Rack

+ HSC, SSW, HPT (CTM)

+ LV, HV

+ Optical PP

On-Detector Module

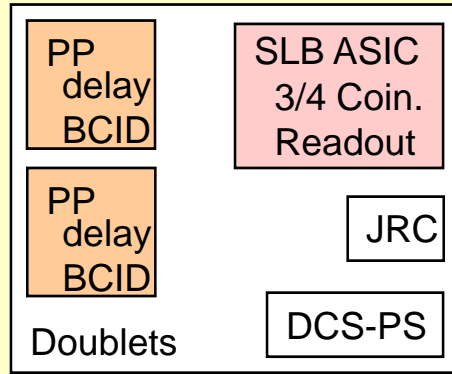+ SPP, PP, SLB

+ DCS modules

Counting Room (USA15)

+ CCI, SL, ROD, TTC

+ VME Crate, SBC

+ Optical PP

ASICs for TGC Electronics
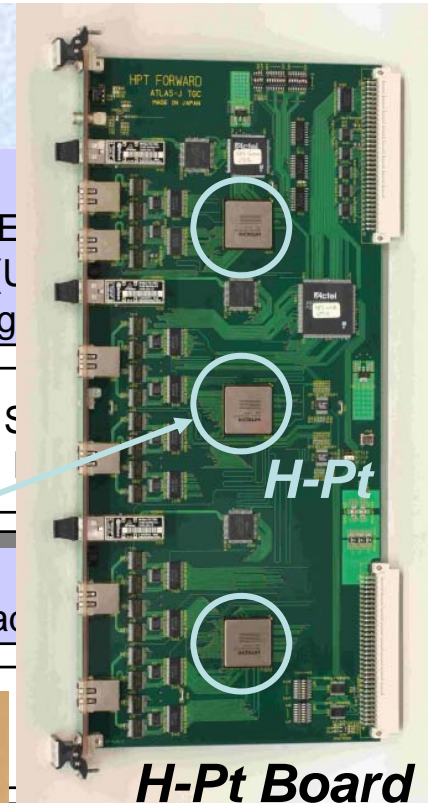
TGC1 TGC2 TGC3

ASD

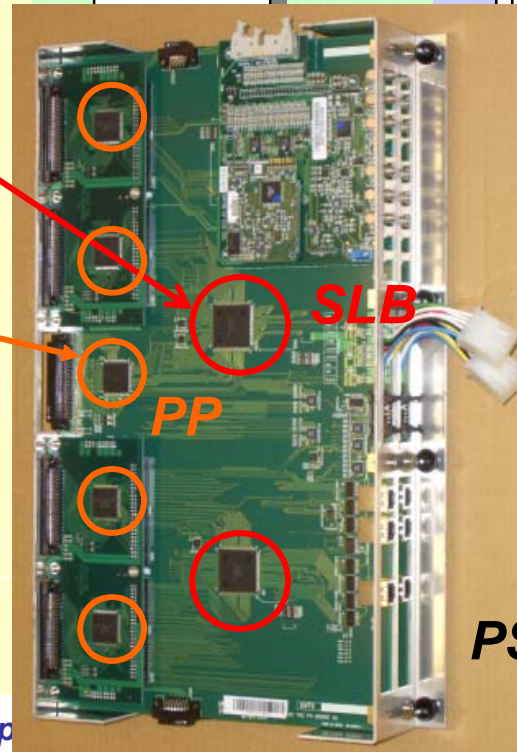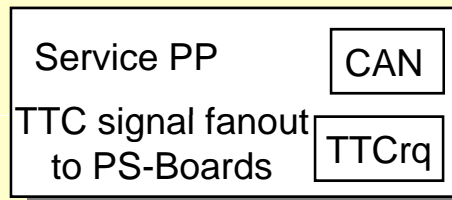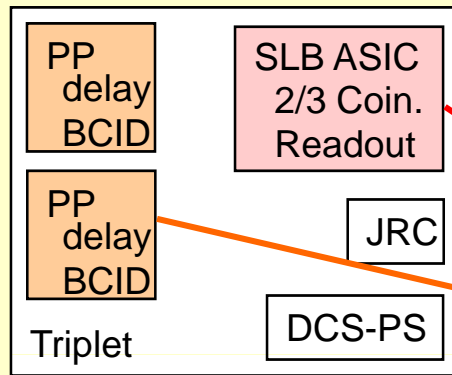PS-Board on TGC chambers

HSC(VME)
(Big Wheel edge)

VME
(U
Trig

H-Pt

Doublets

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

H-Pt wire

H-Pt strip

S

Rea

H-Pt Board

ASD

Triplet

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

SLB

PP

ntrol crate

CCI

TTCvi

ASD

Service PP | CAN
TTC signal fanout to PS-Boards | TTCrq

PS Board

ASD card

Antifuse FPGAs for TGC Electronics

conv

TGC1 TGC2 TGC3

PS-Board on TGC chambers

HSC(VME)
(Big Wheel edge)

VME64
(USA
Trigger

VME

JRC

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

H-Pt wire

H-Pt strip

Sec
Log

H-Pt Board

PS Board

SSWRX

VME

SSW

Readout

μ
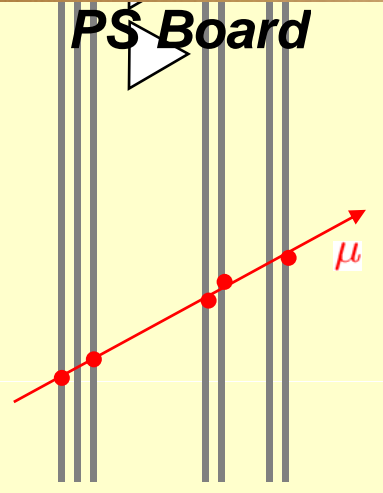
VME

SSWTX

HSC
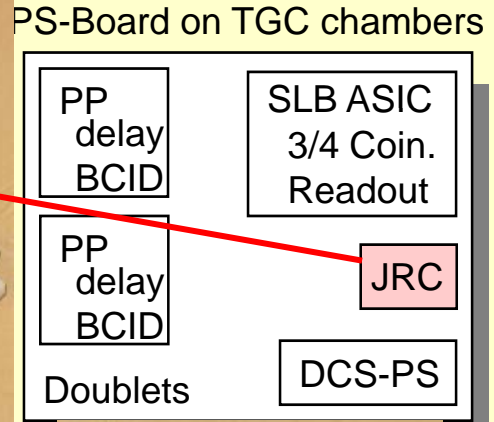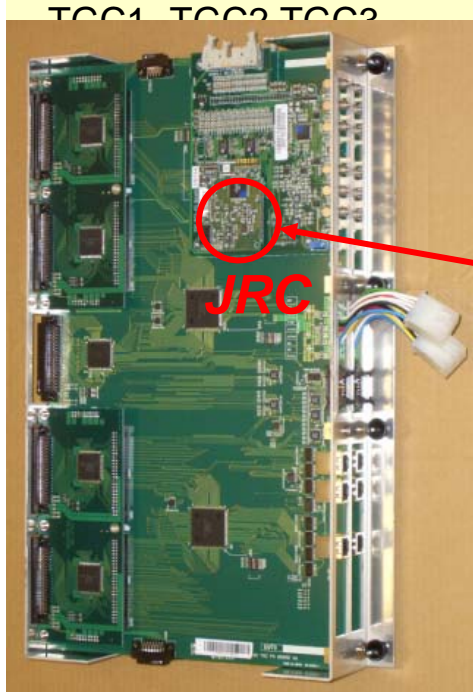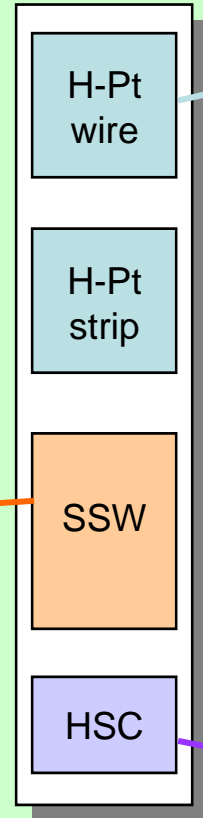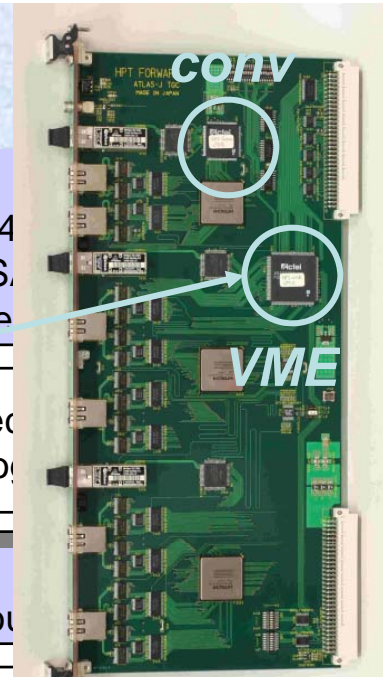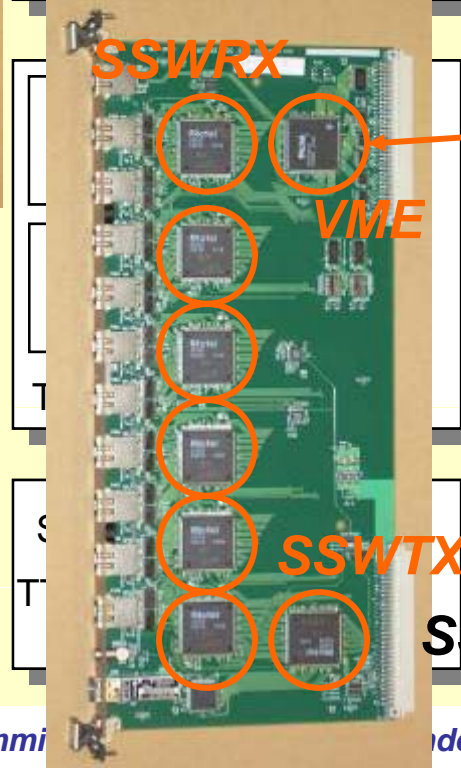
SSW Board
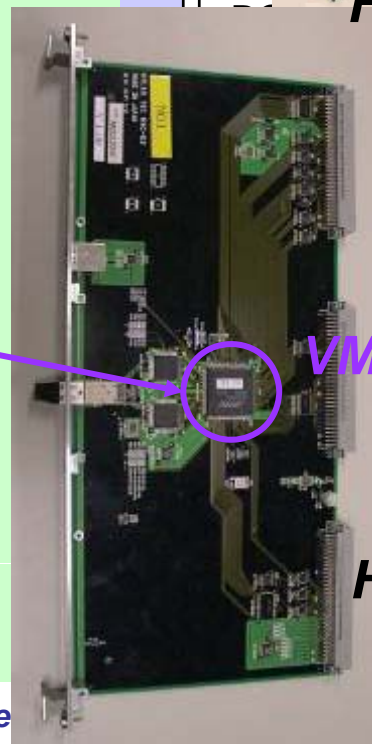
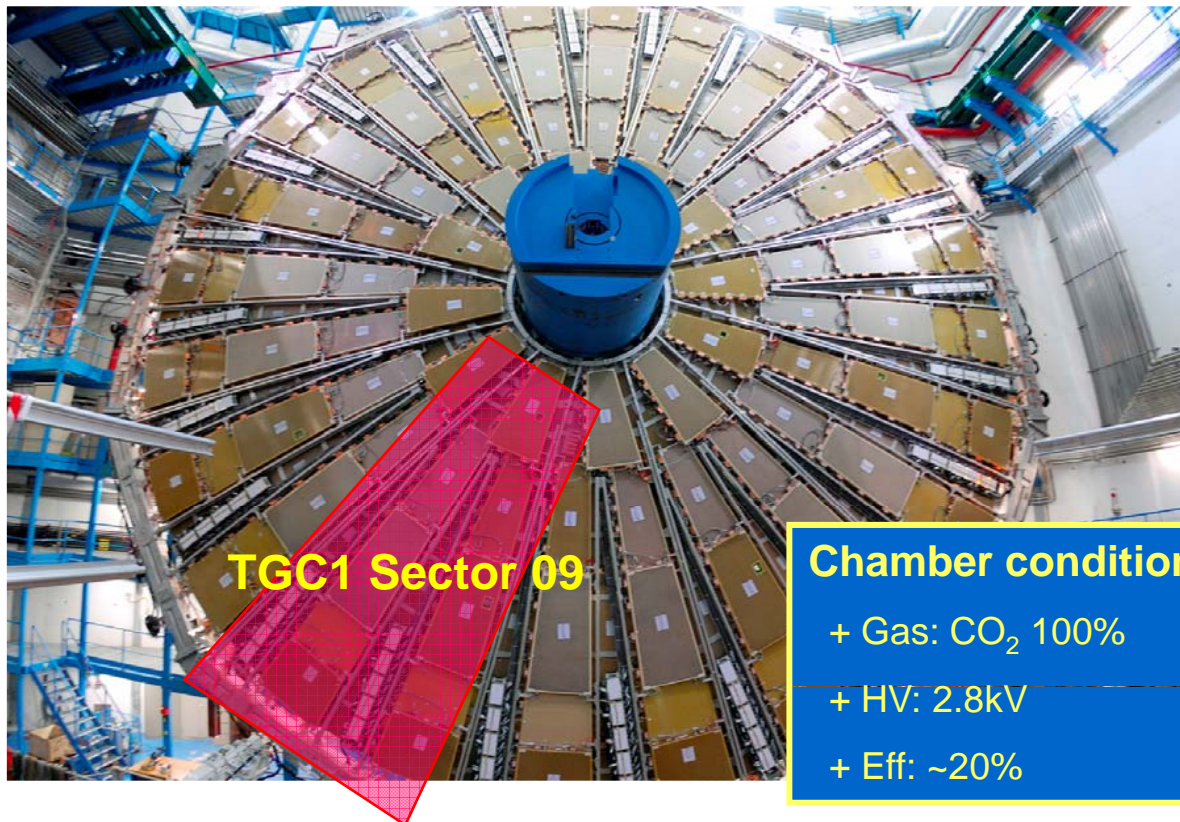**HSC Board**

Global Commissioning

TGC for Global Commissioning Run
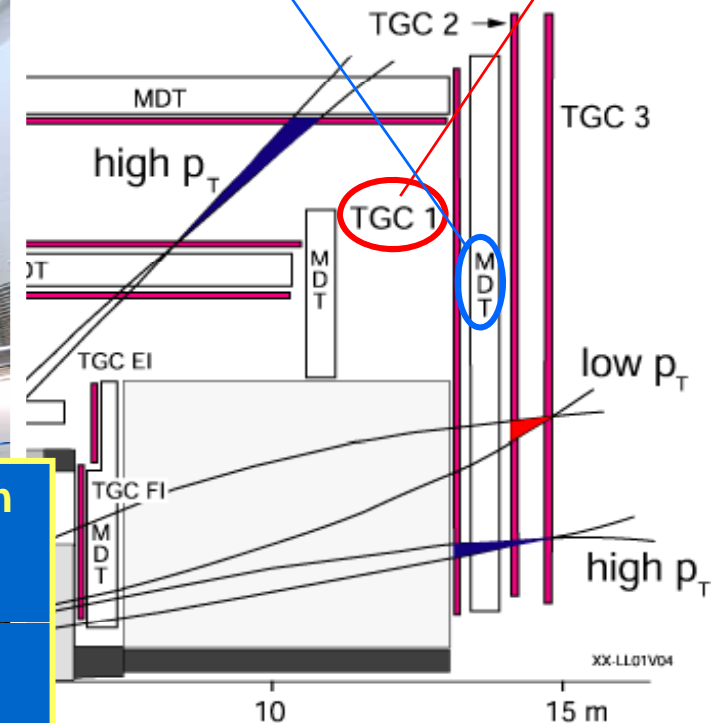
<Main purpose of Global Commissioning>

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

MDT   TGC1

TGC1 Sector 09

Chamber condition

+ Gas: CO_2 100%

+ HV: 2.8kV

+ Eff: ~20%

TGC 2 →

MDT

high p_T

TGC 1

TGC 3

MDT

TGC EI

low p_T

TGC FI

MDT

high p_T

10   15 m

XX-LL01V04

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

12

TGC Electronics

Setup for Global Commissioning

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

TGC1

HSC(VME) crate

VME64 crates
Trigger crate

Specially designed modules instead of HPT

CTM

Sector Logic

Trigger
MUCTPI

ASD

1-station coincidence

PP delay BCID

SLB ASIC 2/3 Coin. Readout

PP delay BCID

JRC

DCS-PS

Triplet

SSW

HSC

ROD
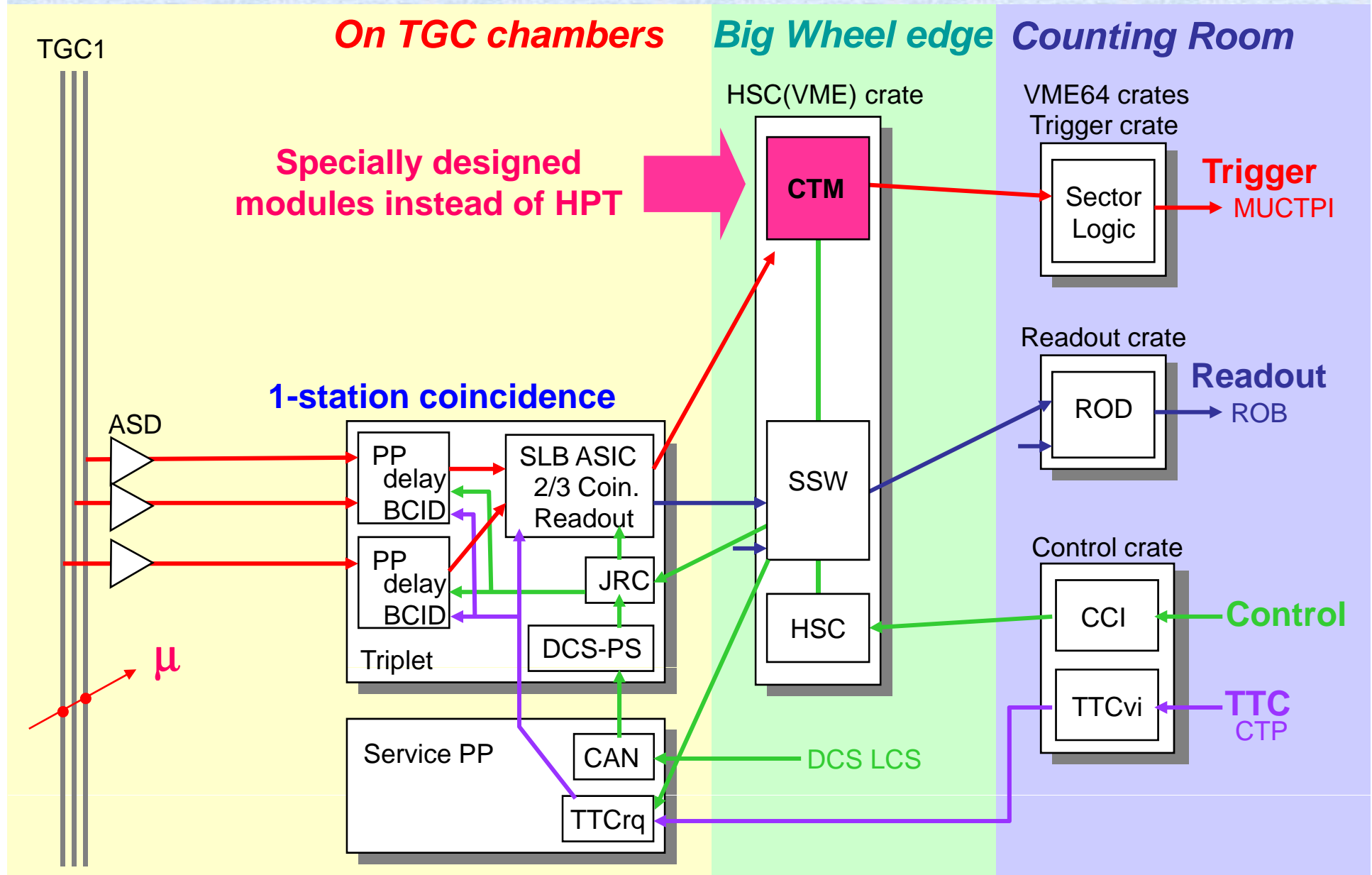
Readout
ROB

CCI

Control

TTCvi

TTC
CTP

μ

Service PP

CAN

TTCrq

DCS LCS

Readout crate

Control crate

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

14

Commissioning Trigger Module (CTM)

- Functionality
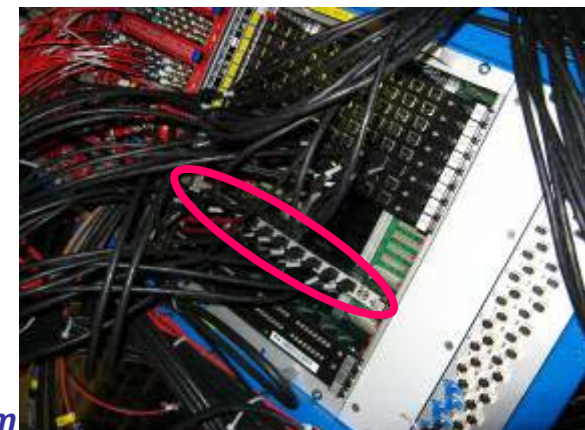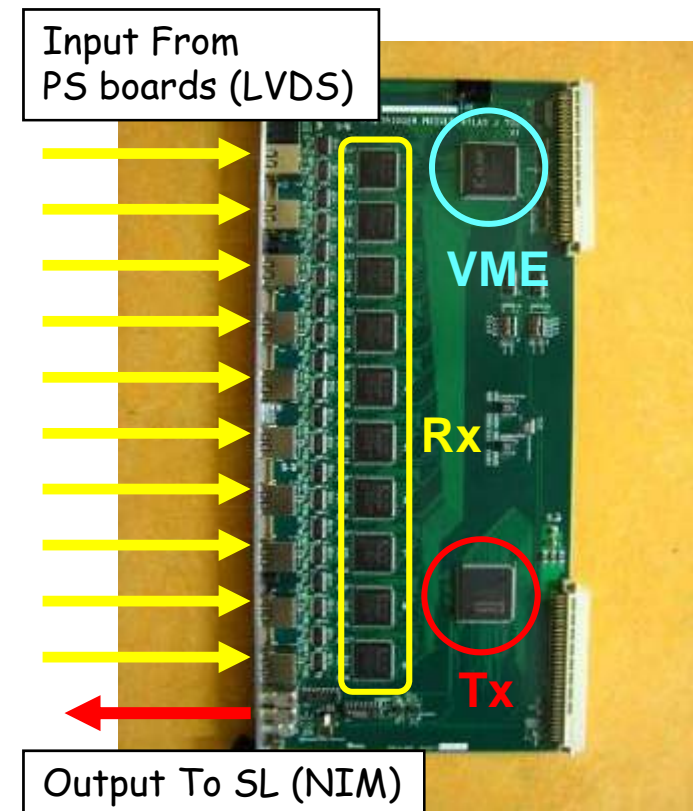 - 11 FPGAs
    - XILINX SPARTAN XC2S50E
    - 10 are used for Rx (LVDS).
      - Take all OR , mask any inputs
    - 1 is used for Tx (NIM).
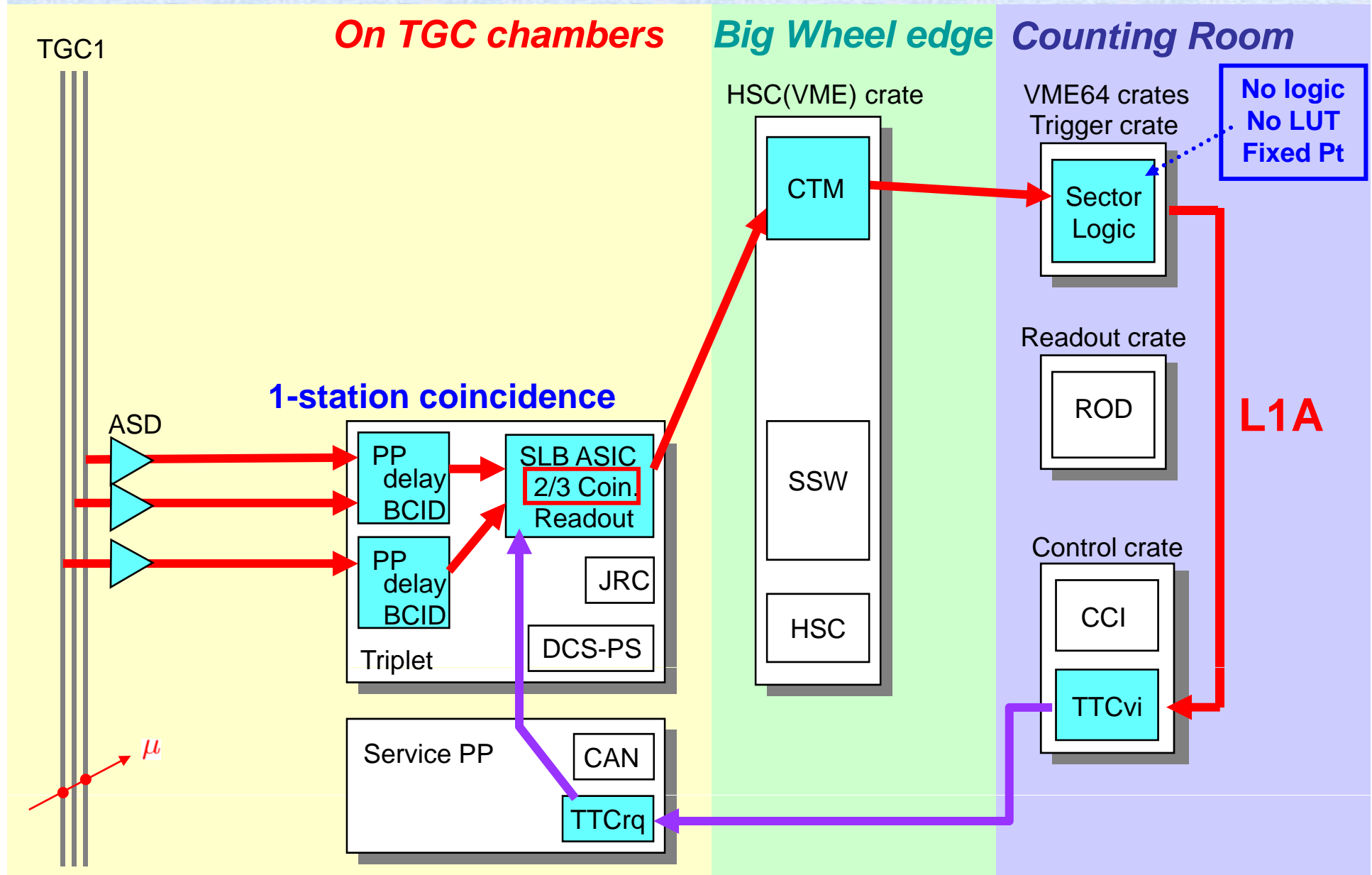 - CPLD: VME control.
    - XILINX XC2C256P
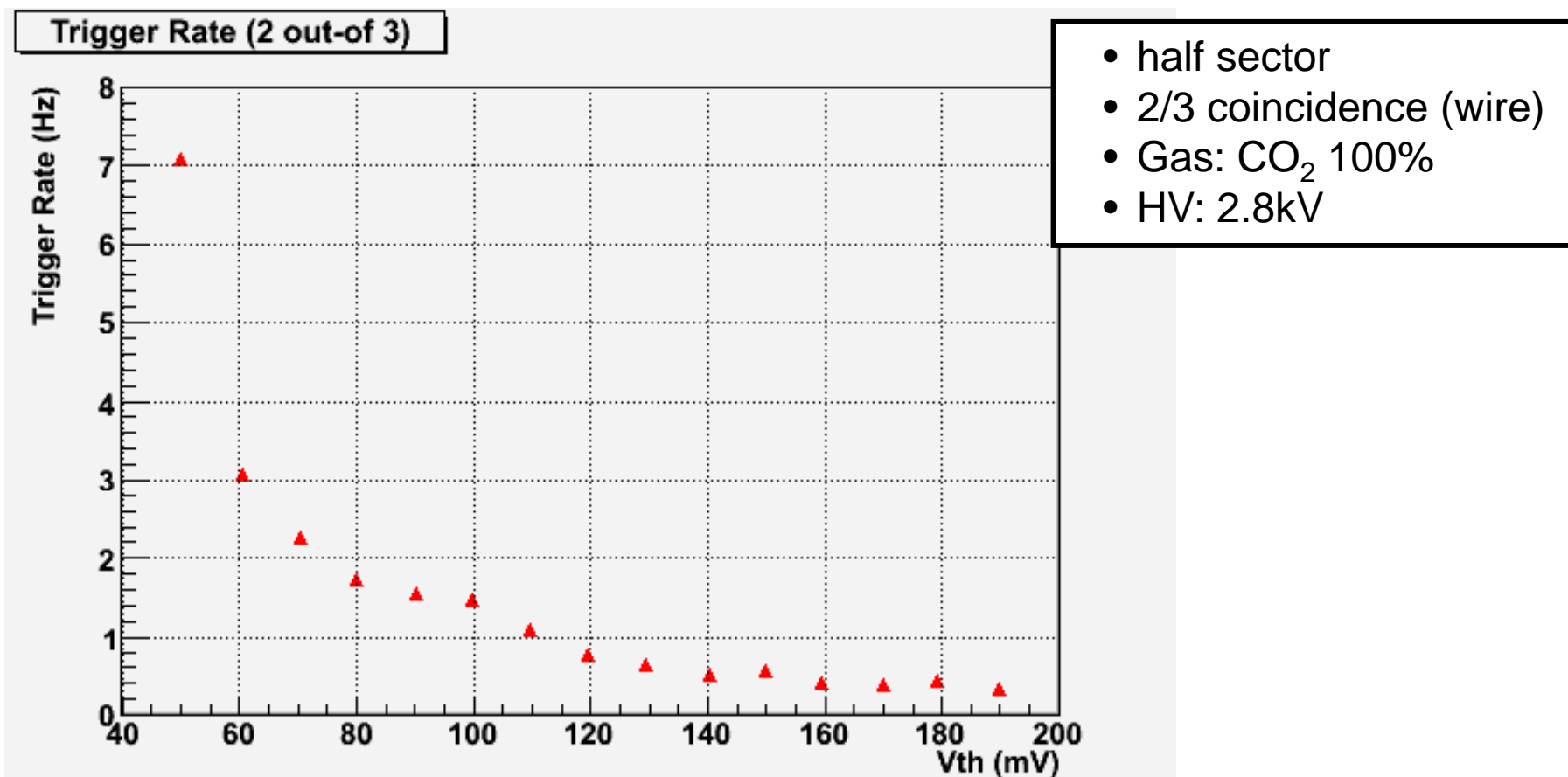
- Purpose
  - Trigger output is asserted by **all trigger matrices on SLB ASIC.**
  - Usable to give 1-station trigger signal
    - → It is impossible for HPT
  - Various trigger pattern by input mask
    - wire only / strip only / wire & strip

Input From PS boards (LVDS)

VME

Rx

Tx

Output To SL (NIM)

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

Local Trigger Path

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

TGC1

ASD

1-station coincidence

PP delay BCID

PP delay BCID

SLB ASIC
2/3 Coin.
Readout

JRC

DCS-PS

Triplet

Service PP

CAN

TTCrq

HSC(VME) crate

CTM

SSW

HSC

VME64 crates
Trigger crate

Sector Logic

**No logic
No LUT
Fixed Pt**

Readout crate

ROD

L1A

Control crate

CCI

TTCvi

μ

Vth vs Trigger Rate

Trigger Rate (2 out-of 3)

- 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)
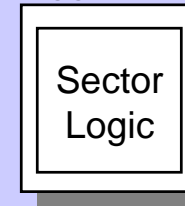
Control Path

Global Trigger Path

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

TGC1

ASD

μ

PP delay BCID

PP delay BCID

Triplet

SLB ASIC 2/3 Coin. Readout

JRC

DCS-PS

Service PP

TTC signal fanout to PS-Boards

CAN

TTCrq

HSC(VME) crate

CTM

SSW

HSC

VME64 crates Trigger crate

Sector Logic

No logic No LUT Fixed Pt

MUCTPI

Readout crate

ROD

CTP

Control crate

CCI

TTCvi

L1A Clock

L1A Clock

MDT-EC

TDC Distribution of MDT

$\Delta t = t_{TGC} - t_{RPC} - t_{TOF} \sim 130nsec$

→ **Provide Trigger to whole ATLAS system!!**

Track Reconstruction by MDT

Readout Path

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

TGC1

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

HSC(VME) crate

CTM

VME64 crates
Trigger crate

Sector Logic

Readout crate

Readout

ROD → ROB

ASD

PP delay BCID

SLB ASIC 2/3 Coin.
Readout

SSW

Local Readout

JRC

PP delay BCID

DCS-PS

Triplet

HSC

Control crate

CCI

Service PP

CAN

TTC signal fanout to PS-Boards

TTCrq

TTCvi ← **CTP**

L1A, Clock

μ

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

Measurement of L1A latency

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

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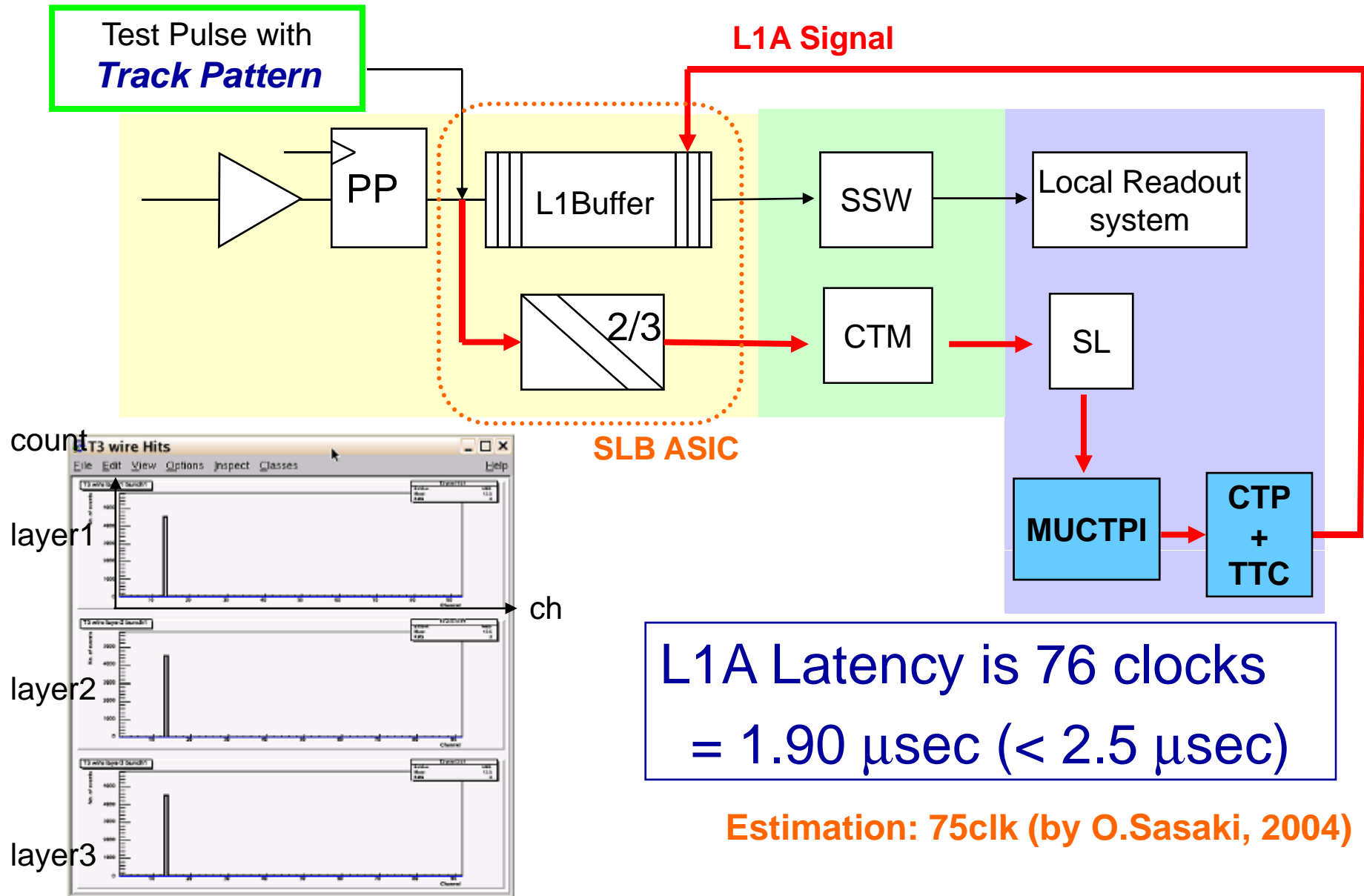
Hit Profile for cosmic-ray test

Wire Hit Profile of Endcap Region

layer1

layer2

layer3

T5   T6   T7   T8

ch (= R)
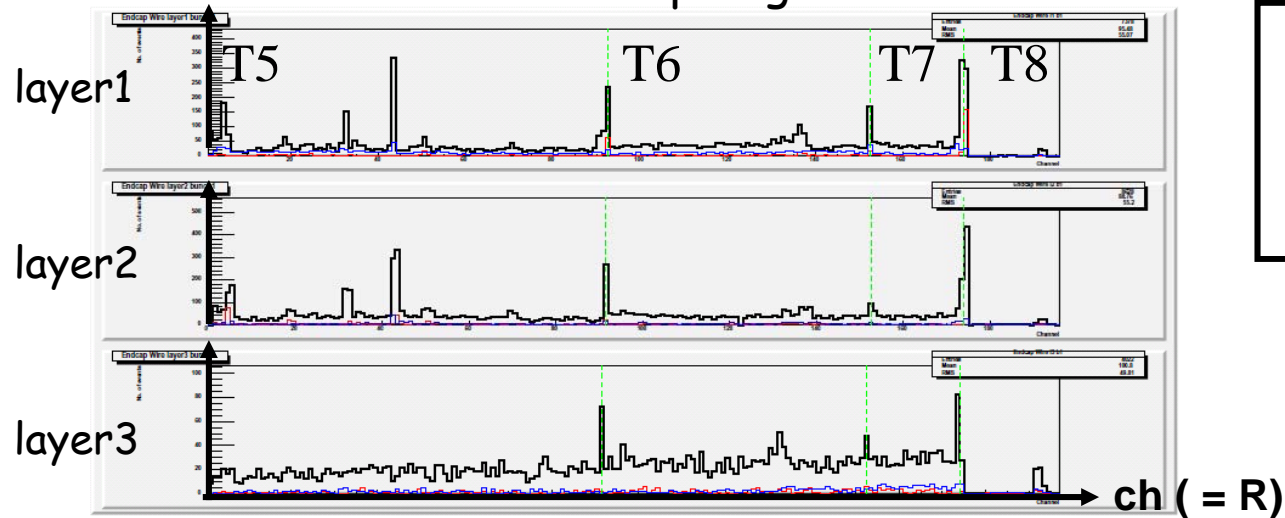
- 2/3 coincidence (wire)
- Vth = 100mV
- Gas: CO_2 100%
- HV: 2.8kV

Strip Hit Profile of Endcap Region

layer1

layer2

T5   T6   T7   T8
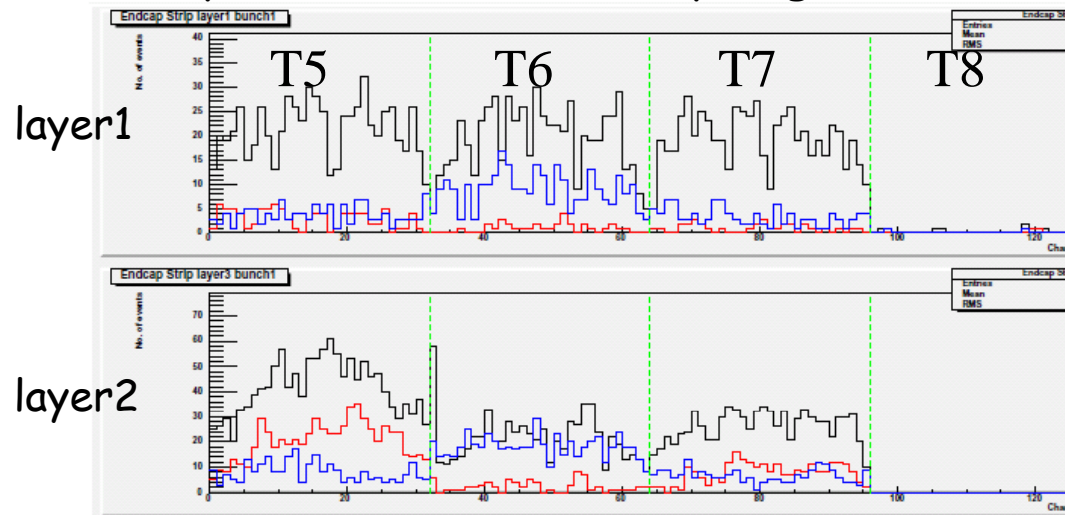
- first data taken by
  local Readout path

- 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 ($1.9\mu sec$)
    - 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
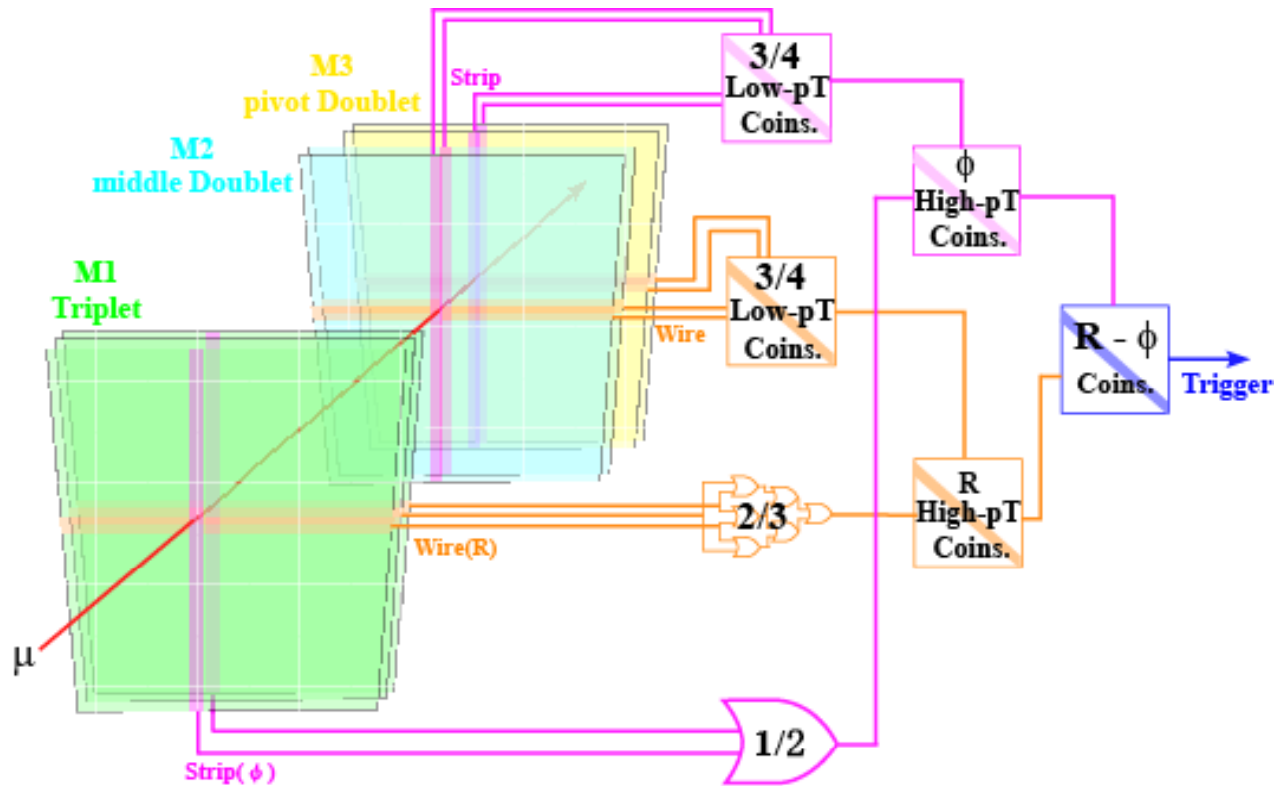
Multiplicity Distribution (events triggered by TGC)