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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1. ATLAS Level1 Trigger
2. Endcap muon trigger system
3. Global Commissioning Run (Milestone-3 run)
4. Results
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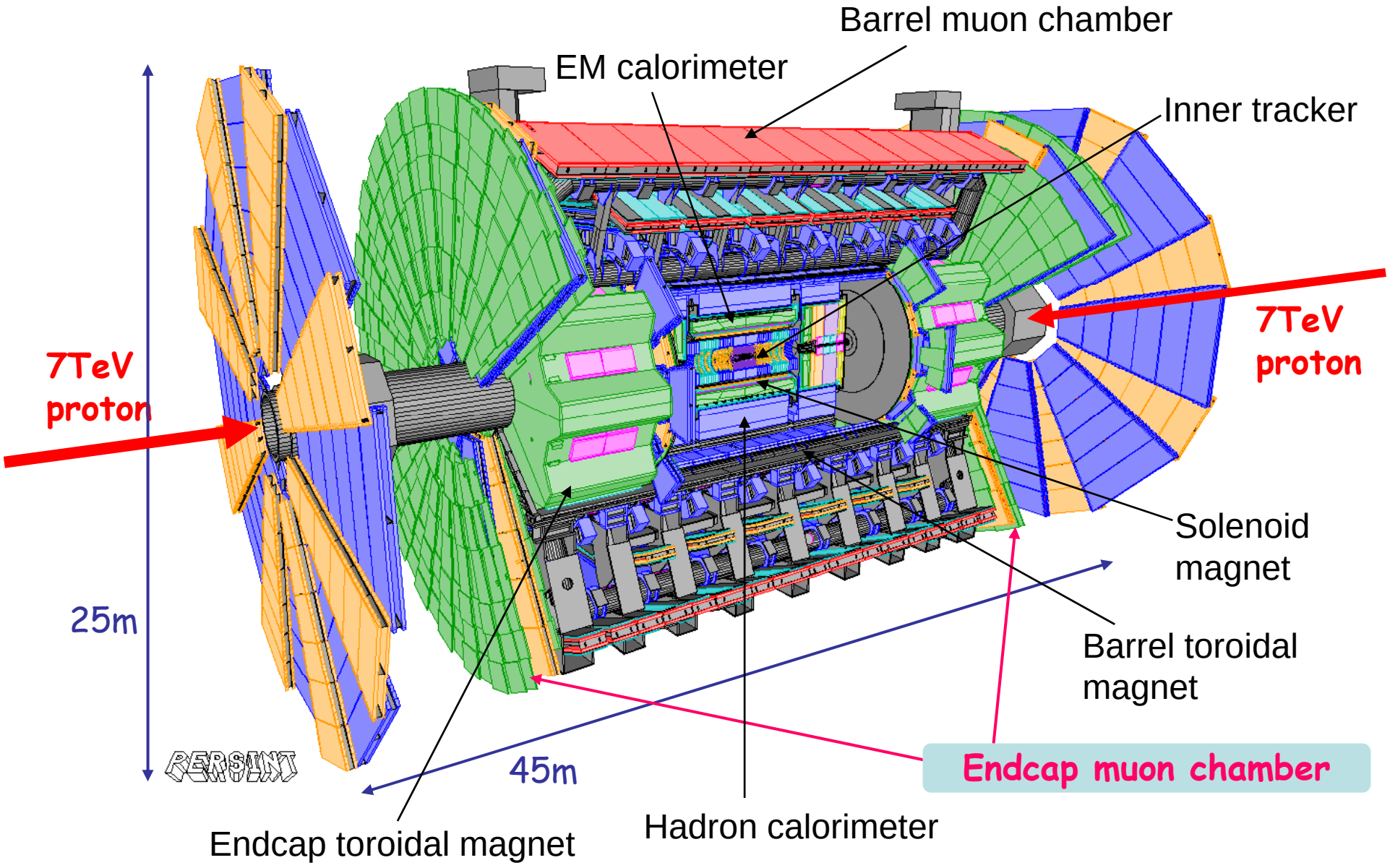
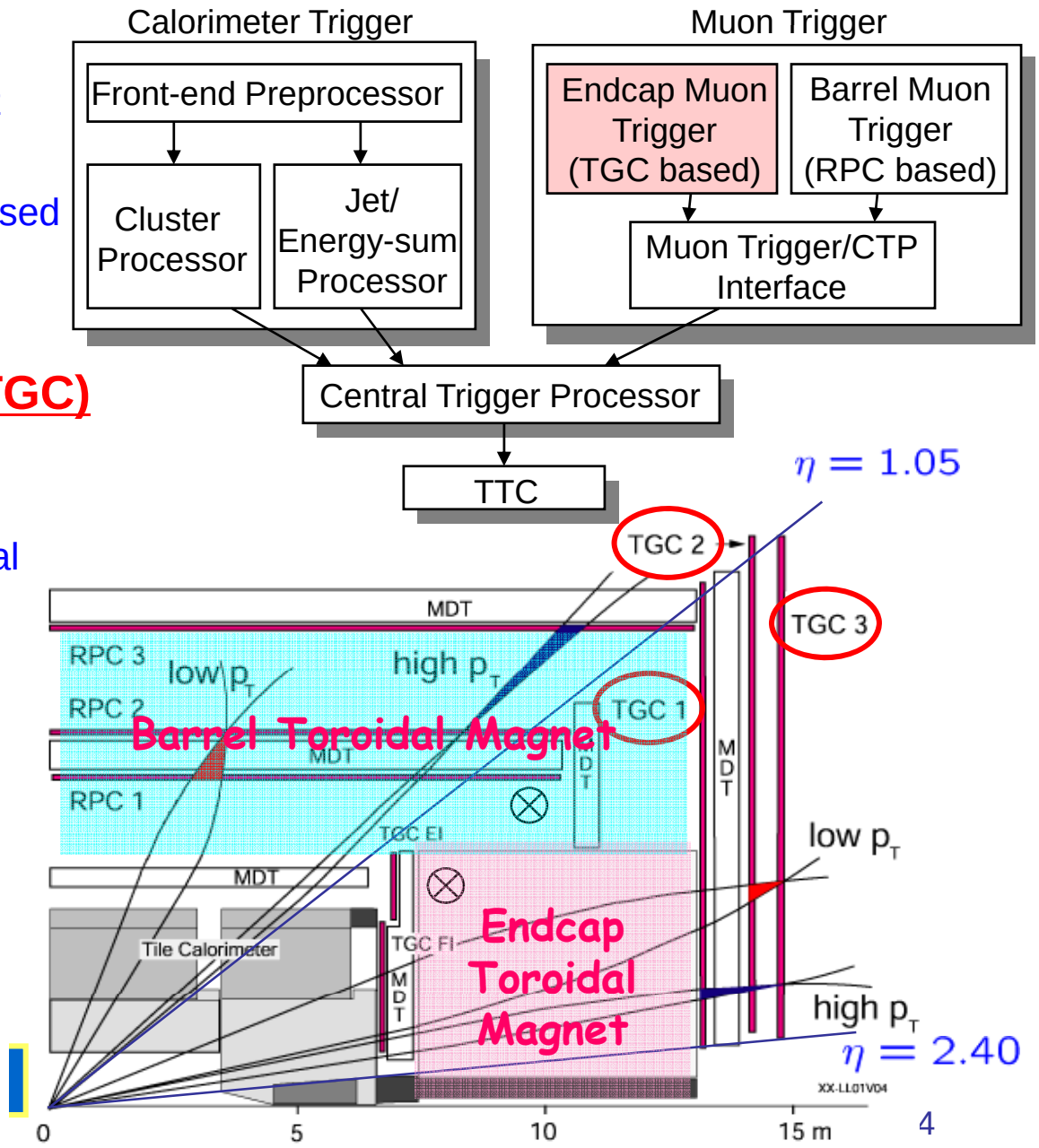
Introduction

LHC-ATLAS Experiment



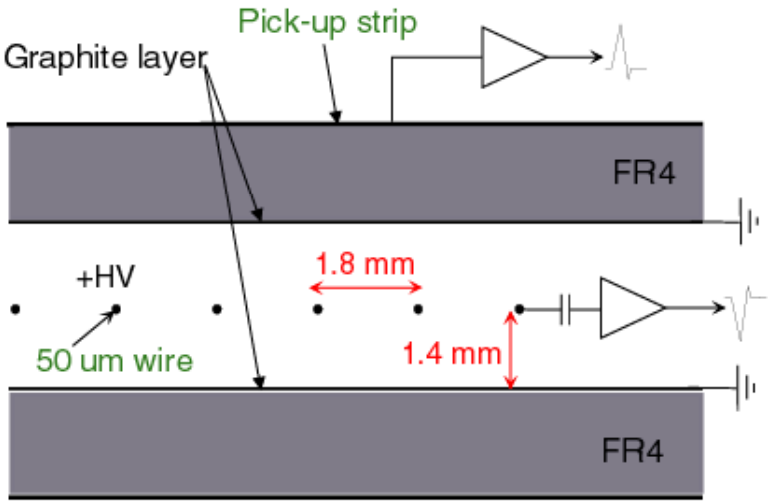
ATLAS Level1 Trigger

- 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/cm^2)
  - Trapezoidal shape (~2m^2)
- Operation condition
  - Gas : **CO_2 + n-C_5H_{12} (55:45)**
  - High Voltage : +2.9kV
  - Operation Mode : Limited Proportional
  - Gas Gain : ~10^6
- Production and Inspection
  - In total **3600 chambers** were produced in Japan (KEK), Israel (Weizmann) and China (1999 – 2006)



Endcap Muon Trigger System

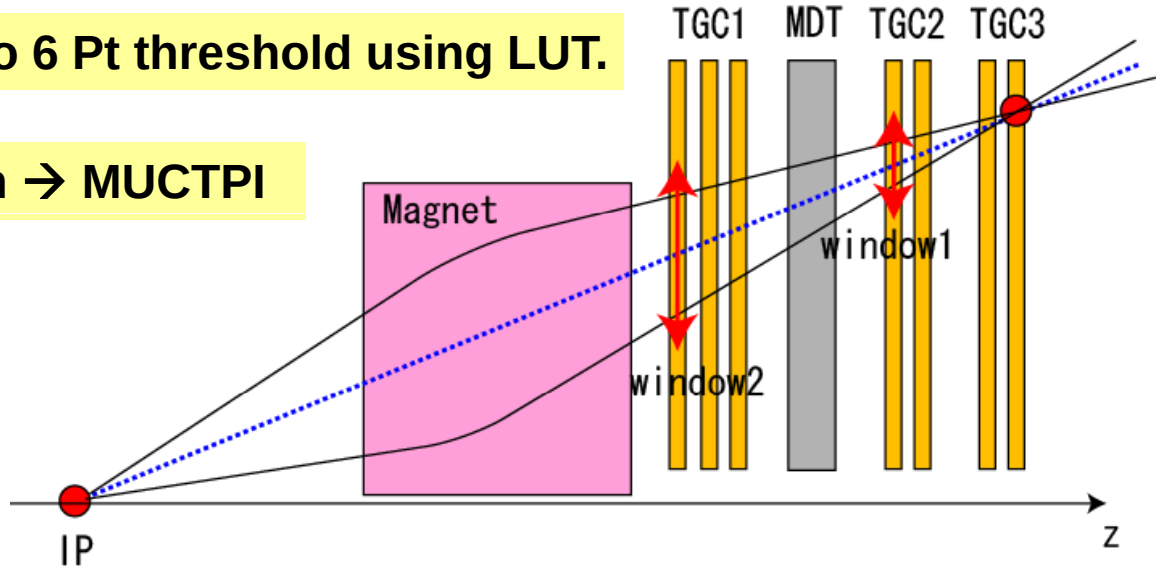
- Big Wheel
  - – **Triplet** (TGC1), **middle doublet** (TGC2) and **pivot doublet** (TGC3)
  - – Each BW consists of 12 sectors → **72 sectors** are required.
- Measurement items
  - – muon hit position
  - – Rough Pt momentum → trigger if Pt > 6GeV

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)

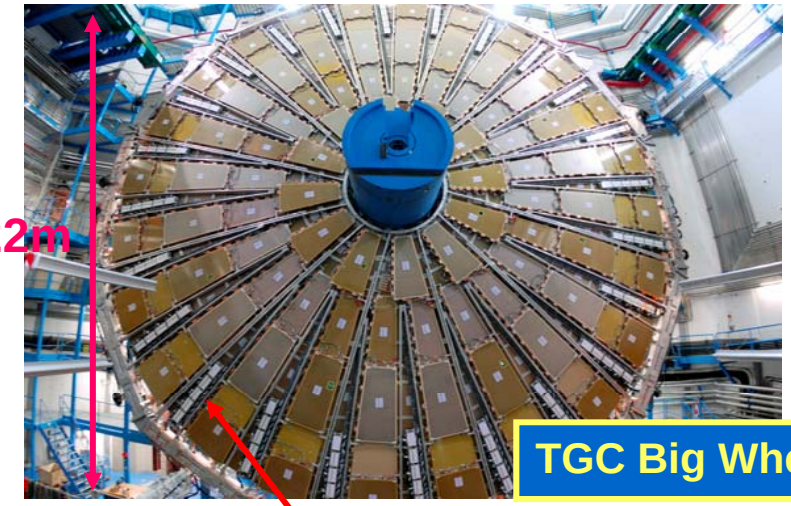
(detail→ T. Kubota's poster)

Sector Transportation

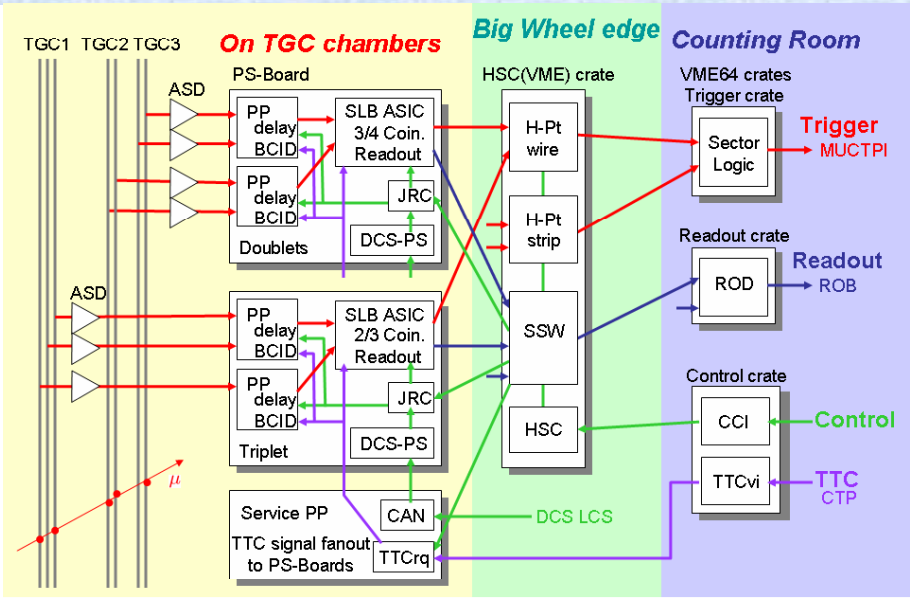
TGC Big Wheel Assembly (Jul. 2006~)

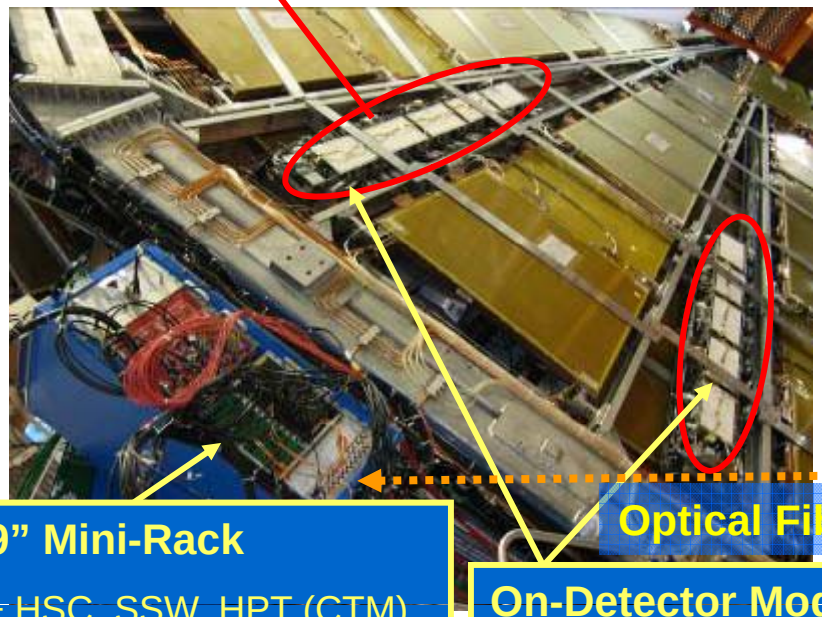
→ 5 wheels assembled

Installation of Electronics Modules

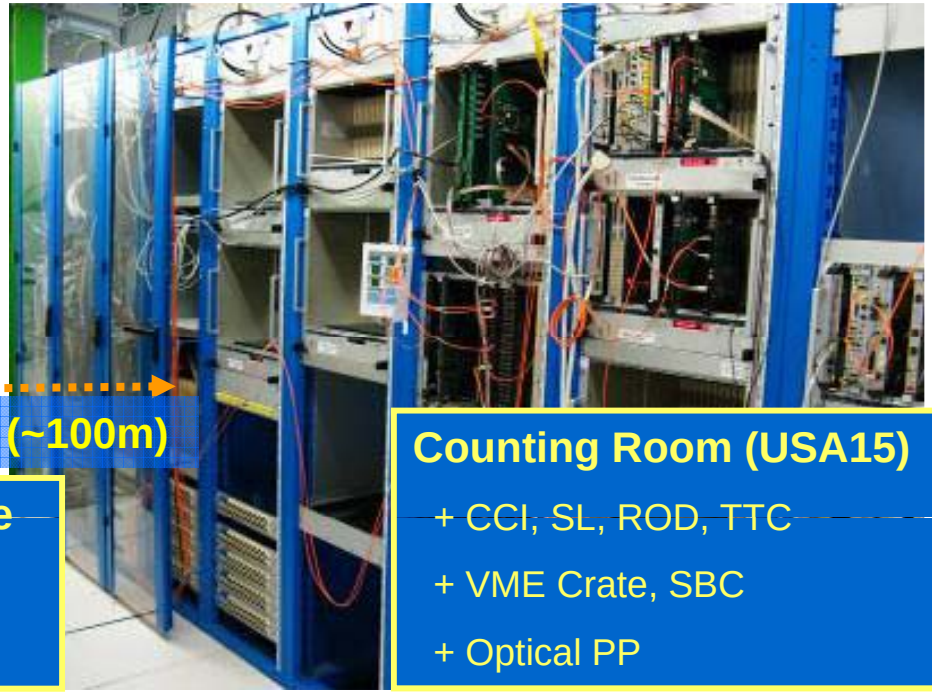


TGC Big Wheel





Optical Fiber (~100m)



19" Mini-Rack

+ HSC, SSW, HPT (CTM)
+ LV, HV
+ Optical PP

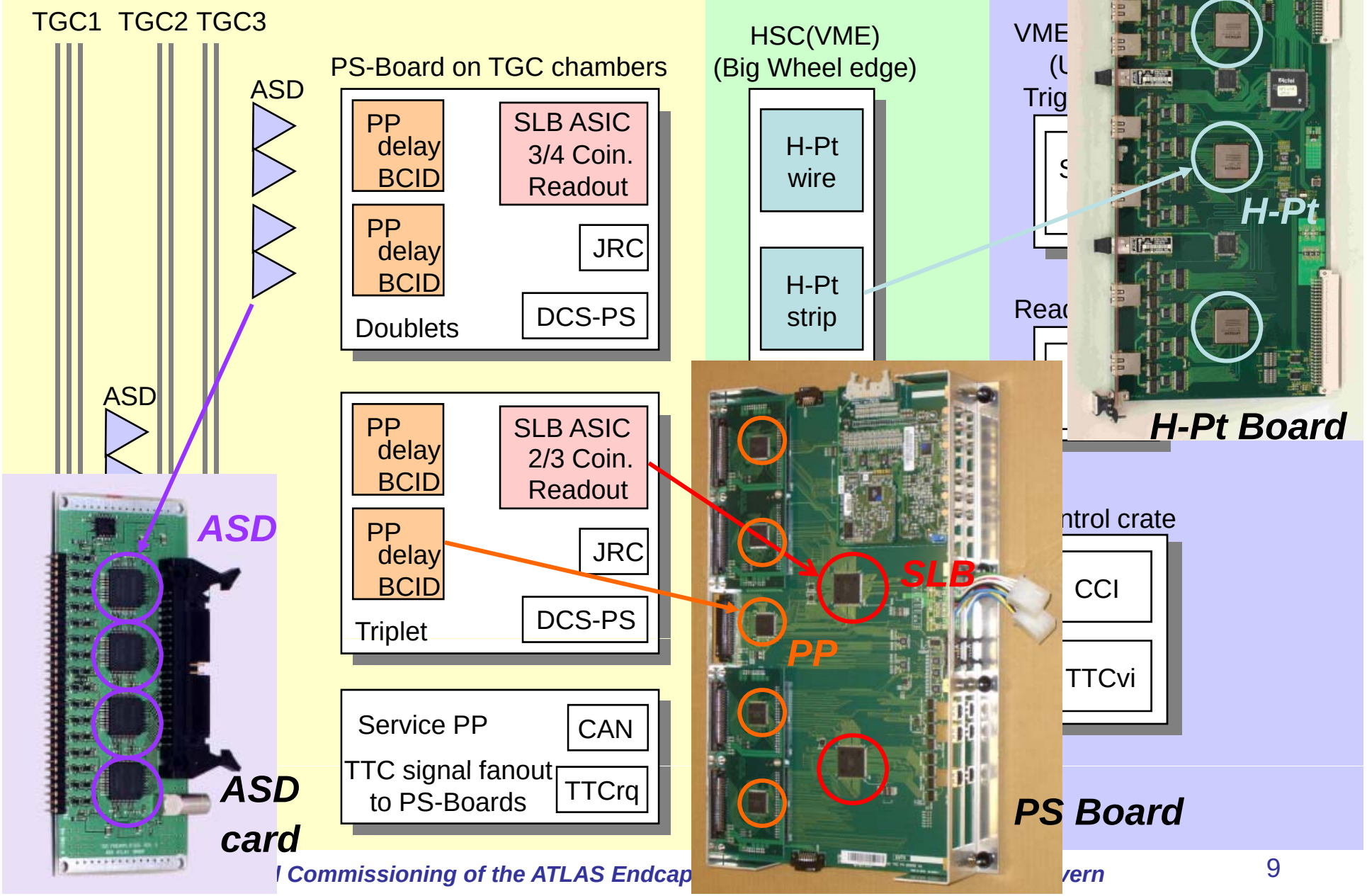
On-Detector Module

+ SPP, PP, SLB
+ DCS modules

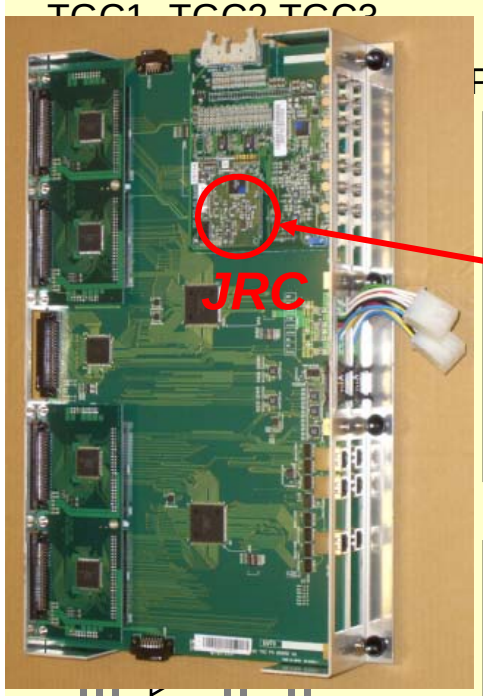
Counting Room (USA15)

+ CCI, SL, ROD, TTC
+ VME Crate, SBC
+ Optical PP

ASICs for TGC Electronics



Antifuse FPGAs for TGC Electronics



PS Board

PS-Board on TGC chambers

PP delay BCID

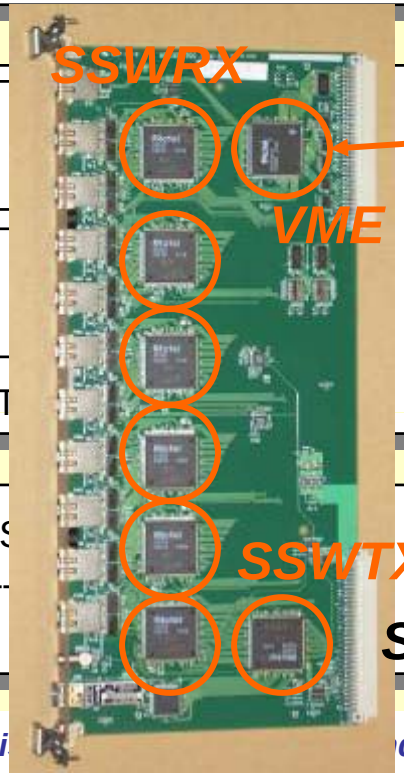
SLB ASIC 3/4 Coin. Readout

PP delay BCID

JRC

Doublets

DCS-PS



SSW Board

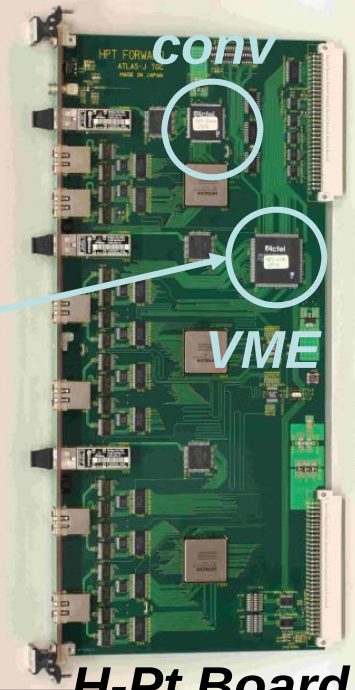
HSC(VME)
(Big Wheel edge)

H-Pt wire

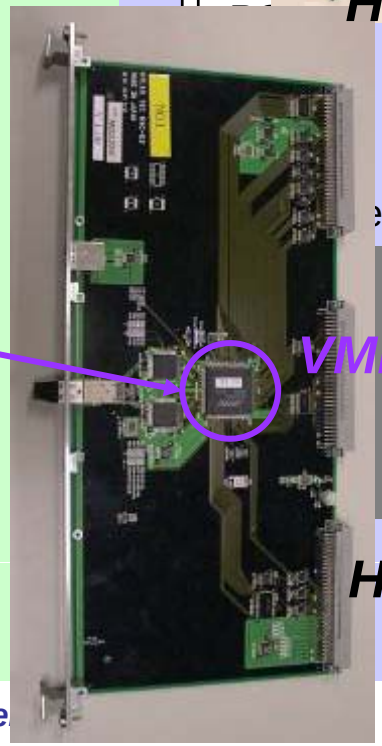
H-Pt strip

SSW

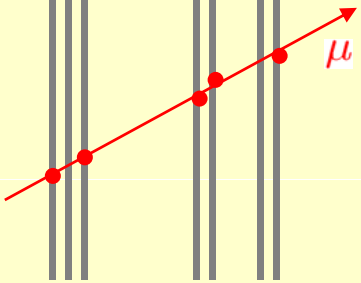
HSC



H-Pt Board



HSC Board

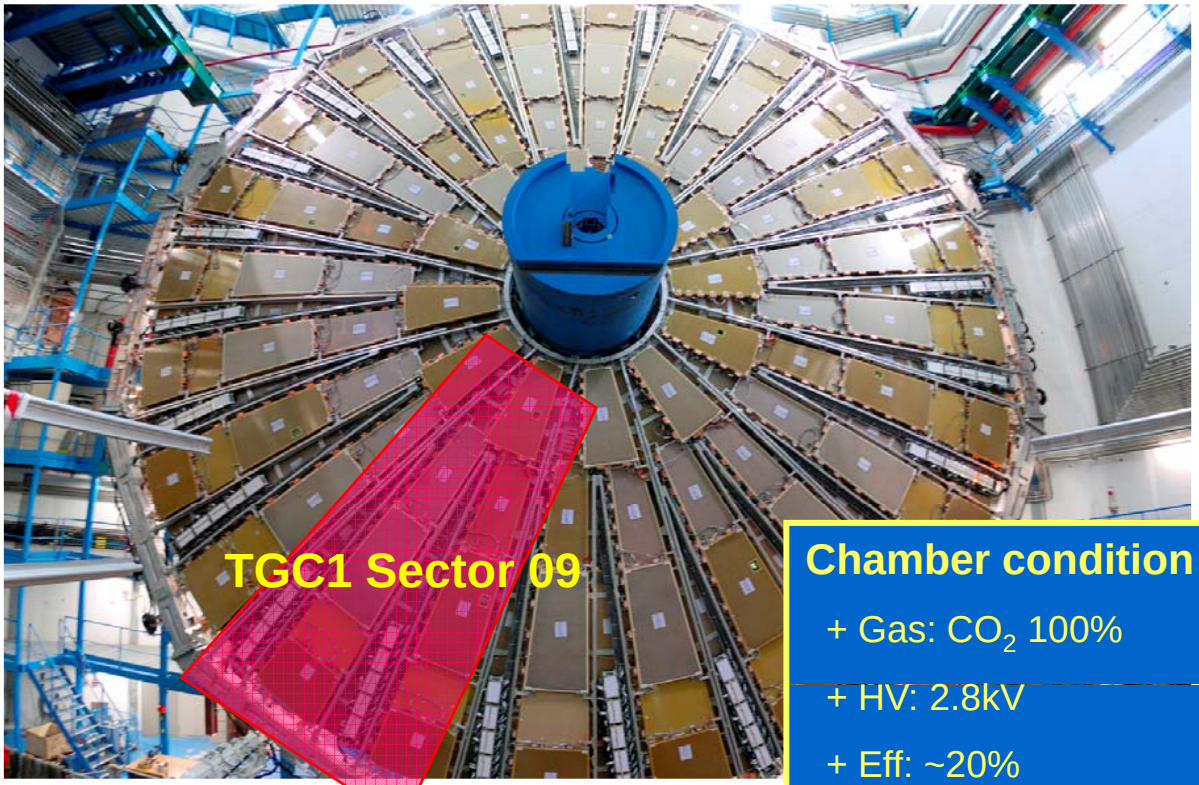


Global Commissioning

TGC for Global Commissioning Run

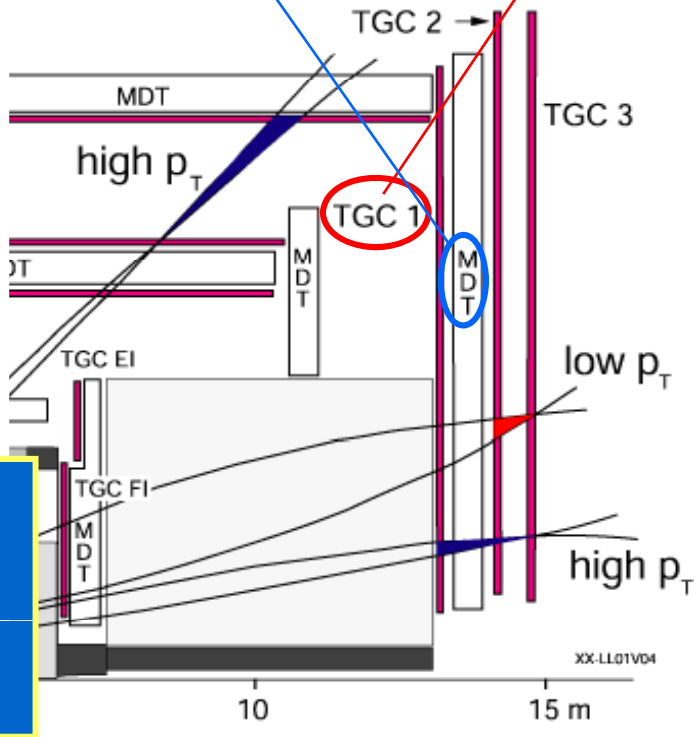
<Main purpose of Global Commissioning>

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

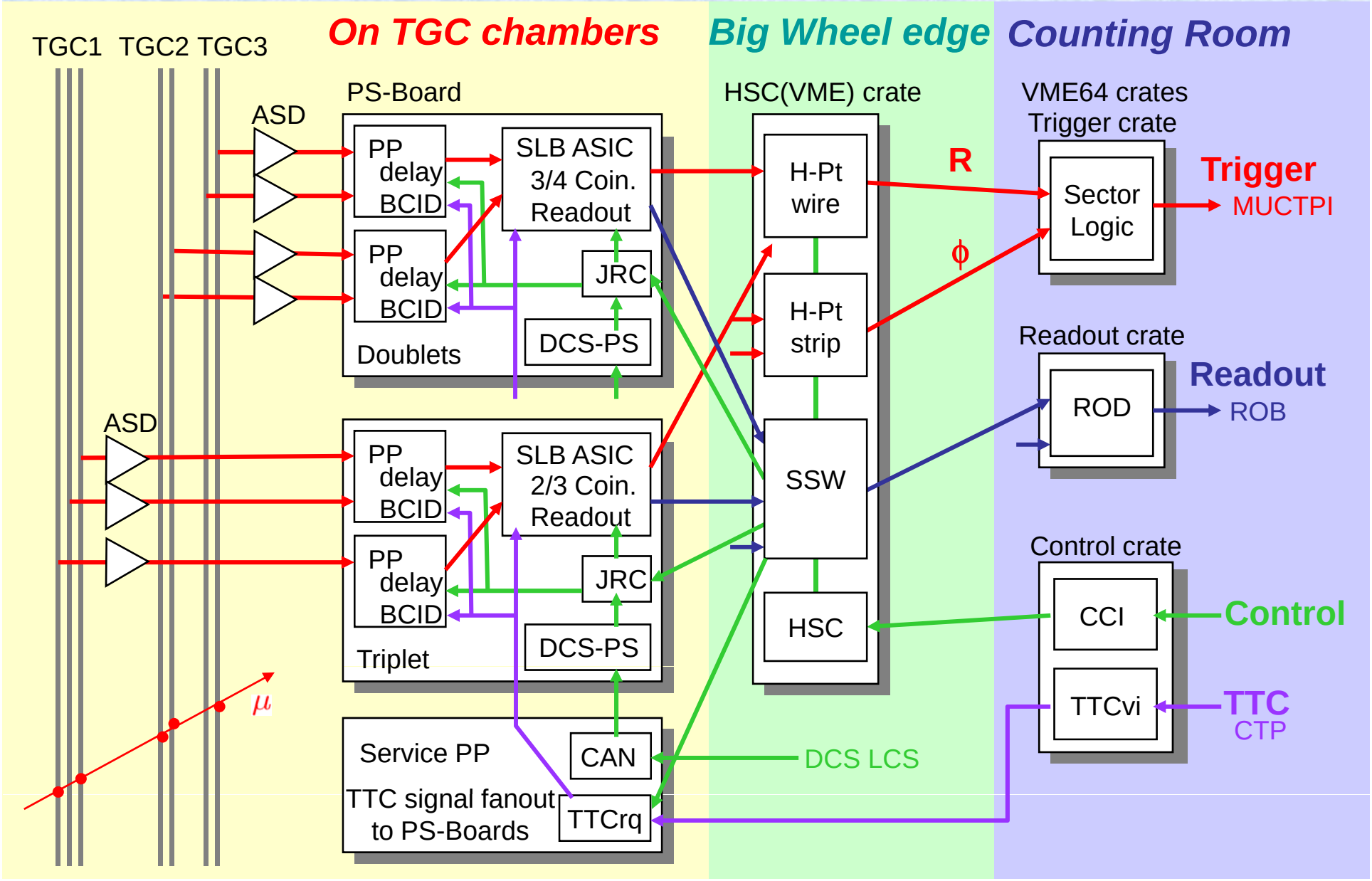


Chamber condition

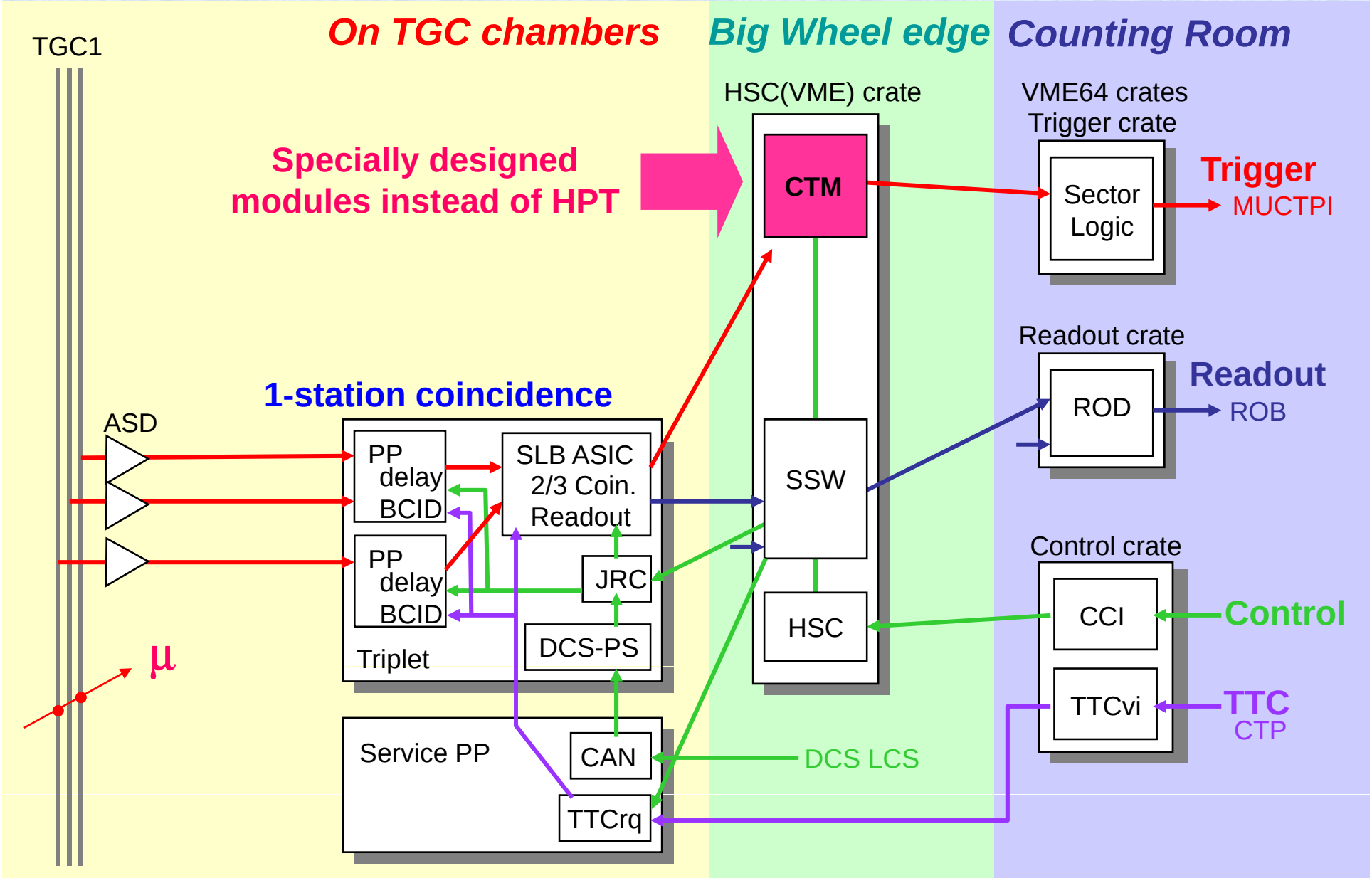
+ Gas: CO_2 100%
+ HV: 2.8kV
+ Eff: ~20%



TGC Electronics



Setup for Global Commissioning

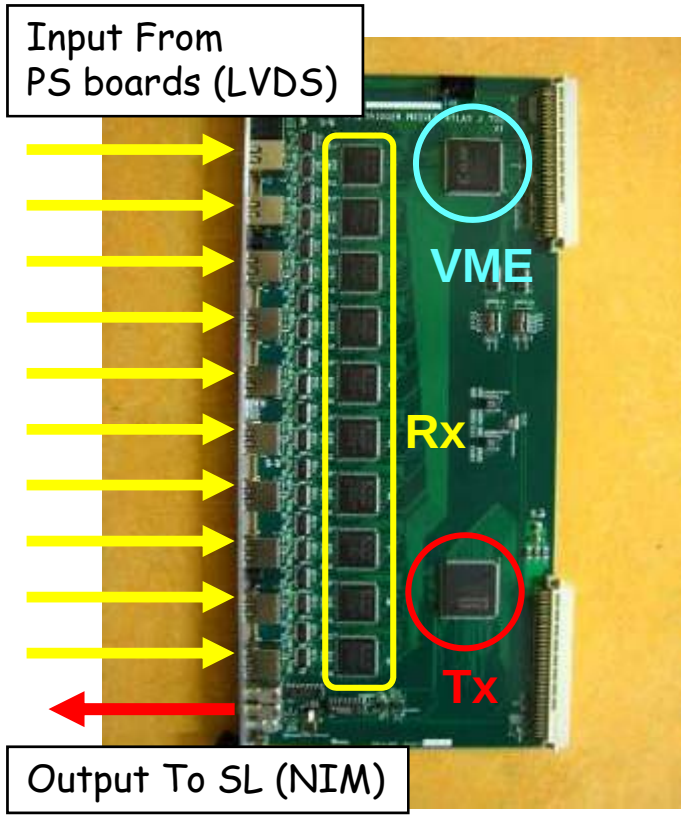


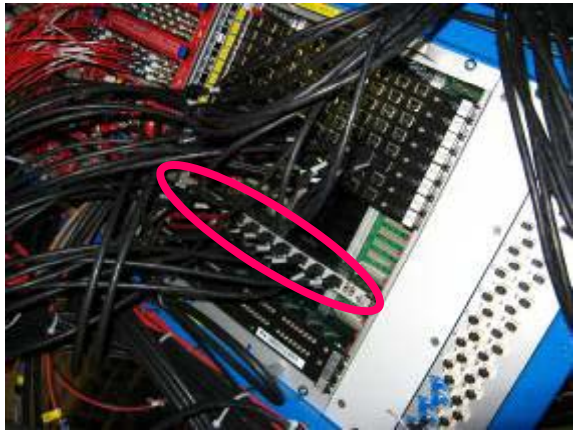
Commissioning Trigger Module (CTM)

- 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

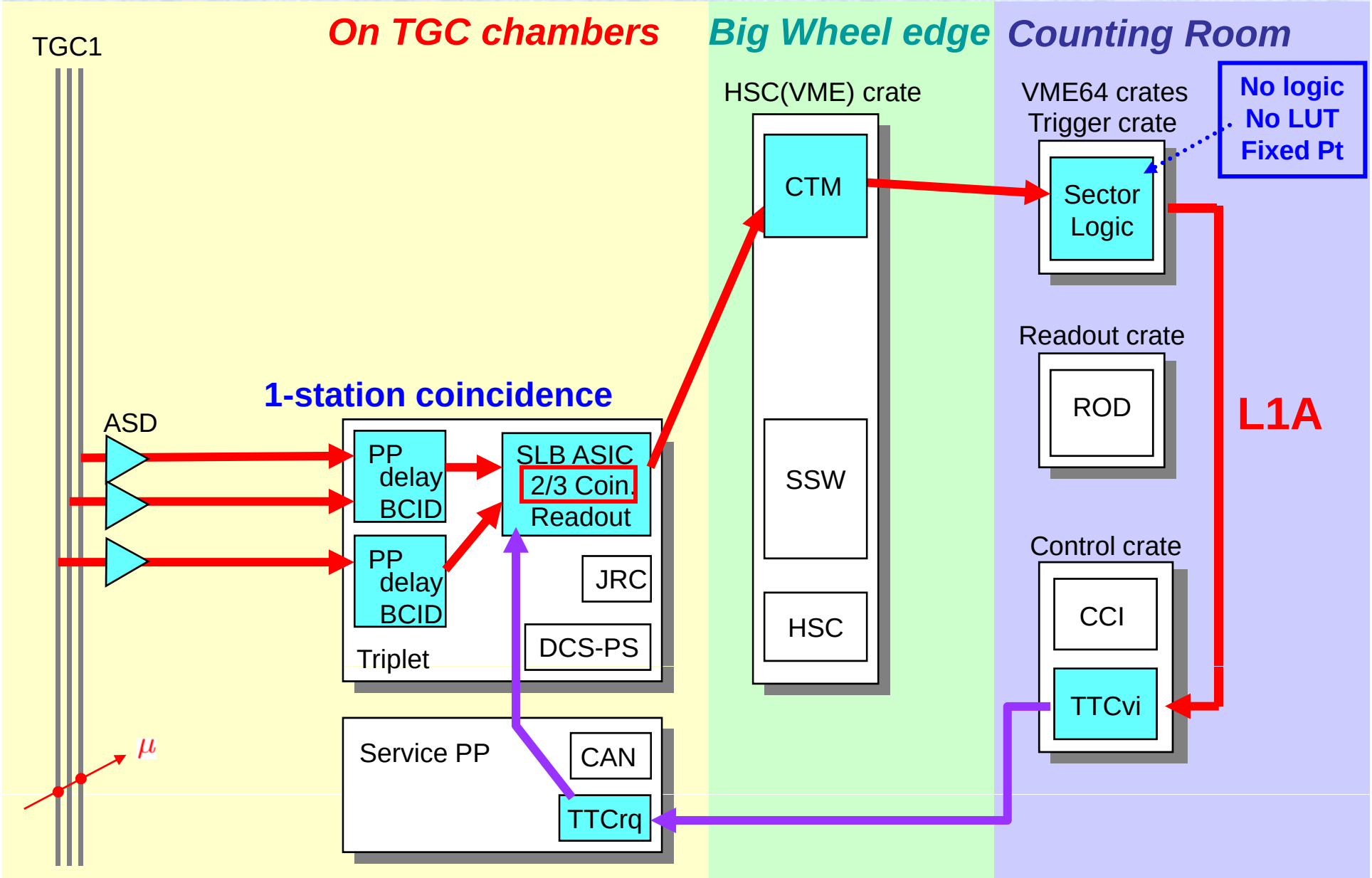
- Purpose
  - Trigger output is asserted by **all trigger matrices on SLB ASIC.**
  - Usable to give 1-station trigger signal

    → It is impossible for HPT
  - Various trigger pattern by input mask
    - wire only / strip only / wire & strip

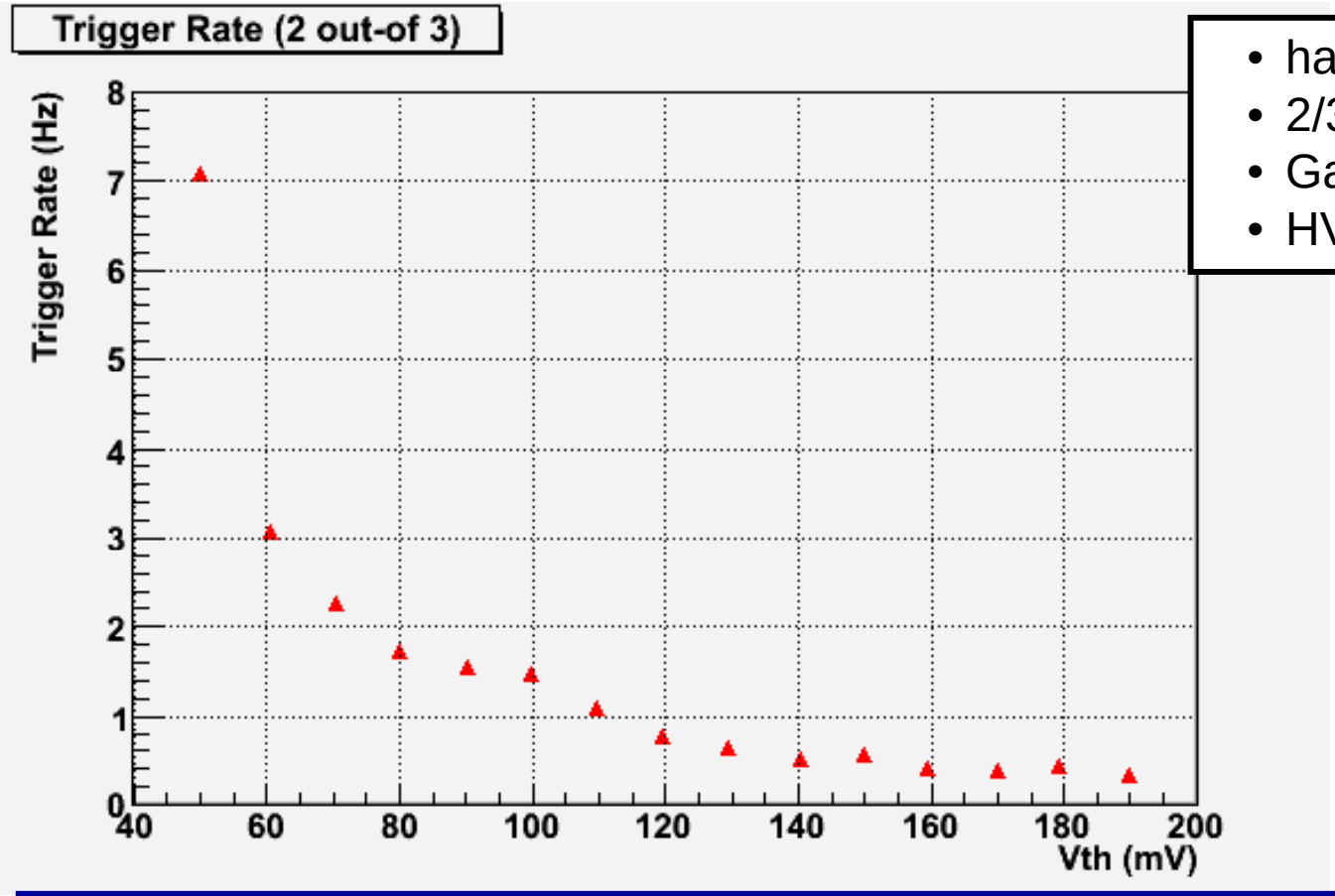




Local Trigger Path



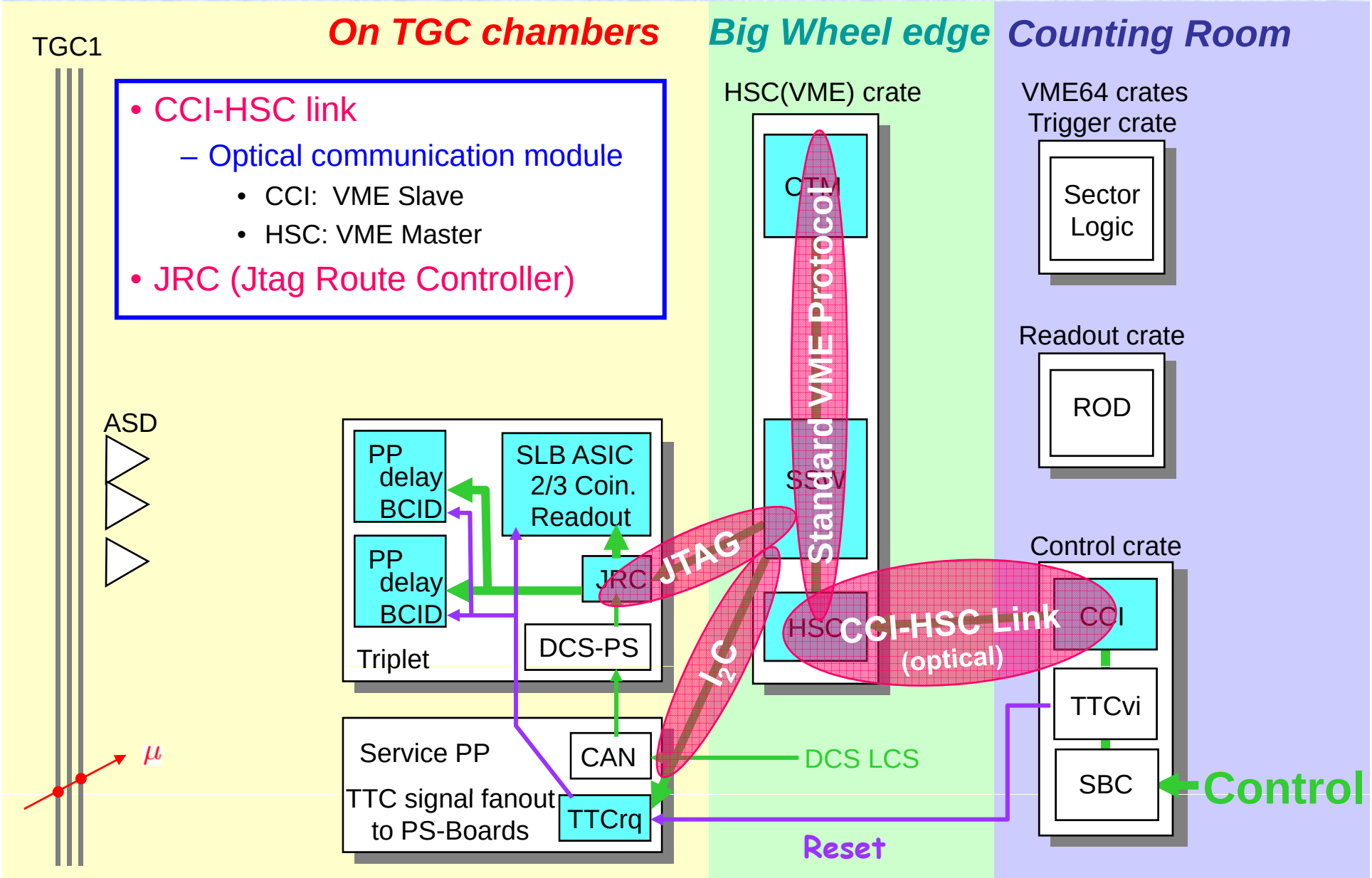
Vth vs Trigger Rate



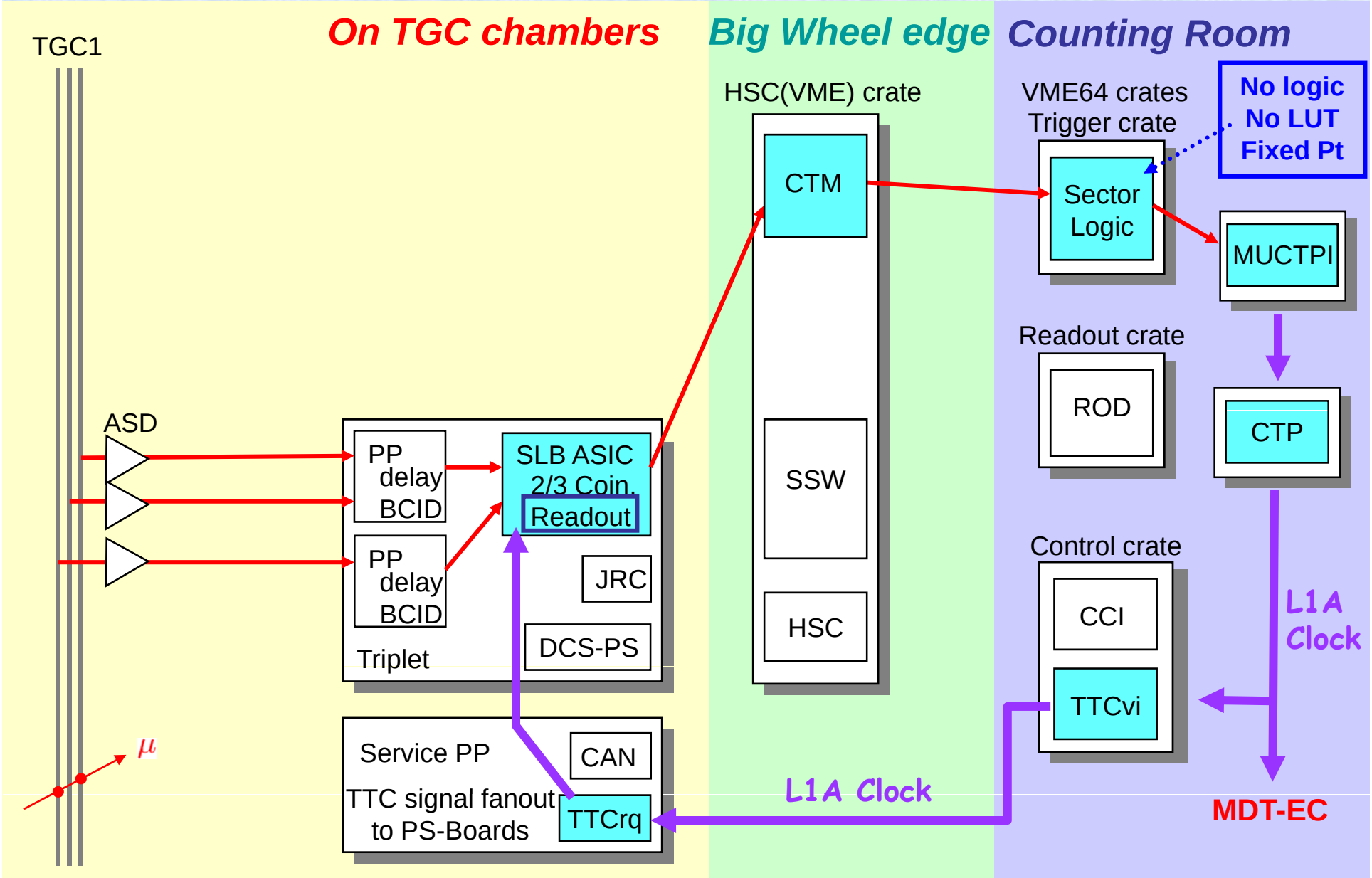
- half sector
- 2/3 coincidence (wire)
- Gas: CO_2 100%
- HV: 2.8kV

- 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)

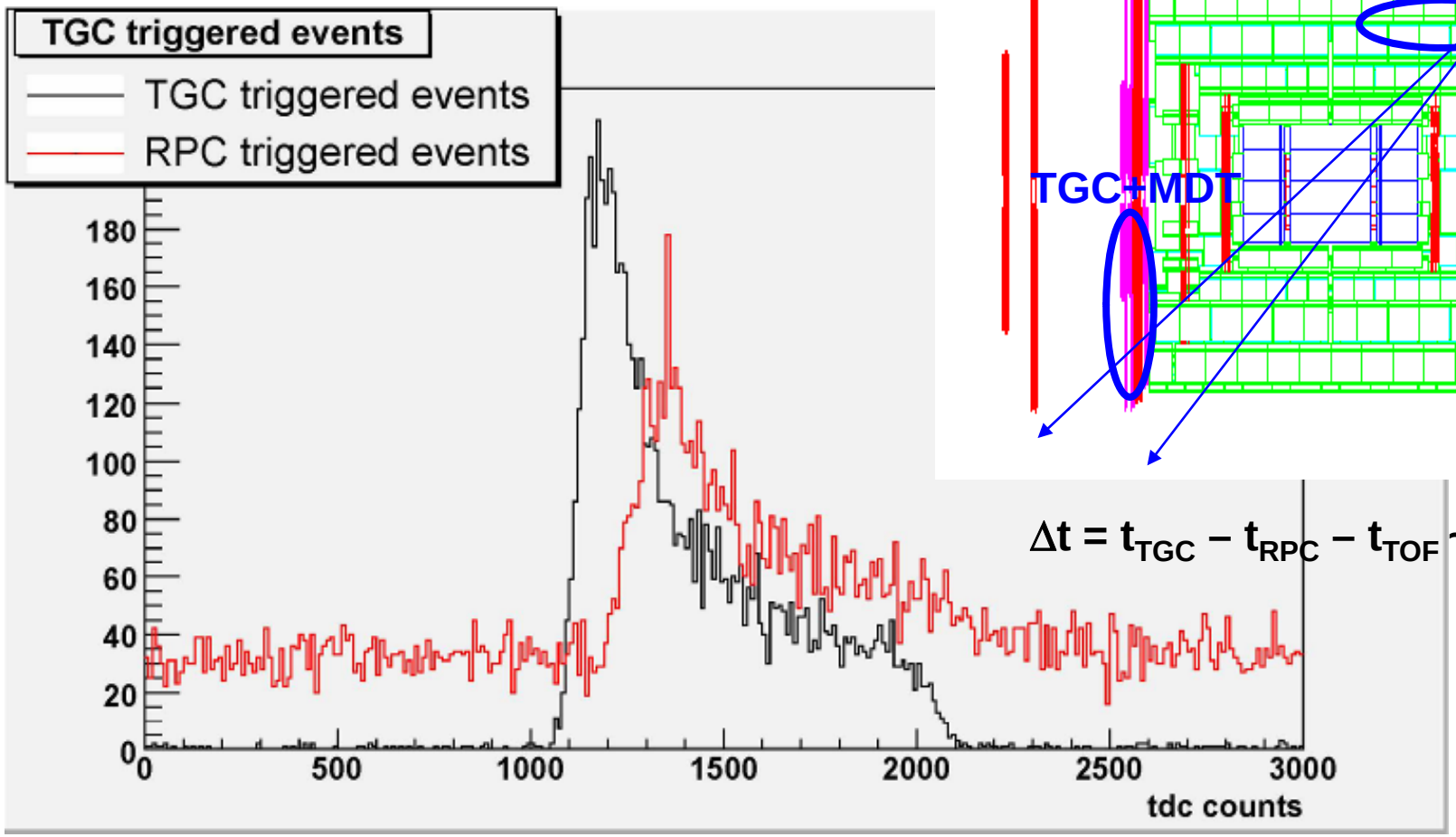
Control Path

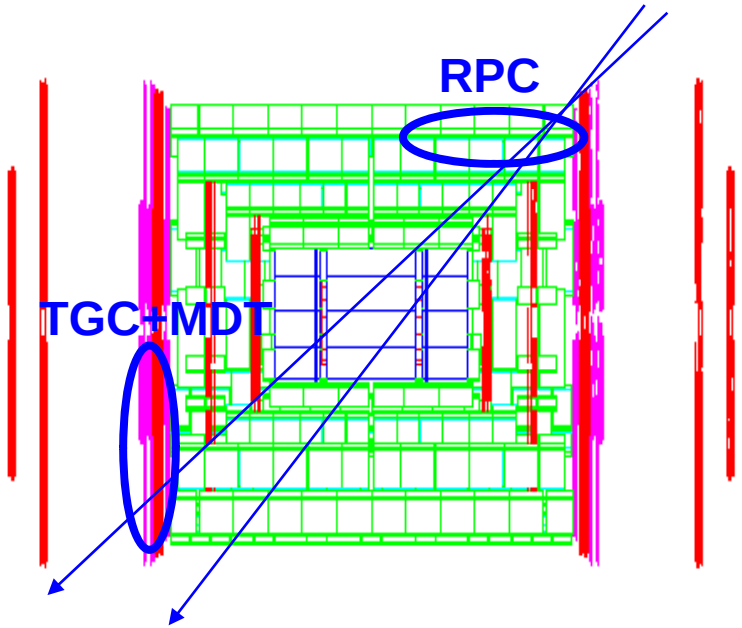


Global Trigger Path



TDC Distribution of MDT

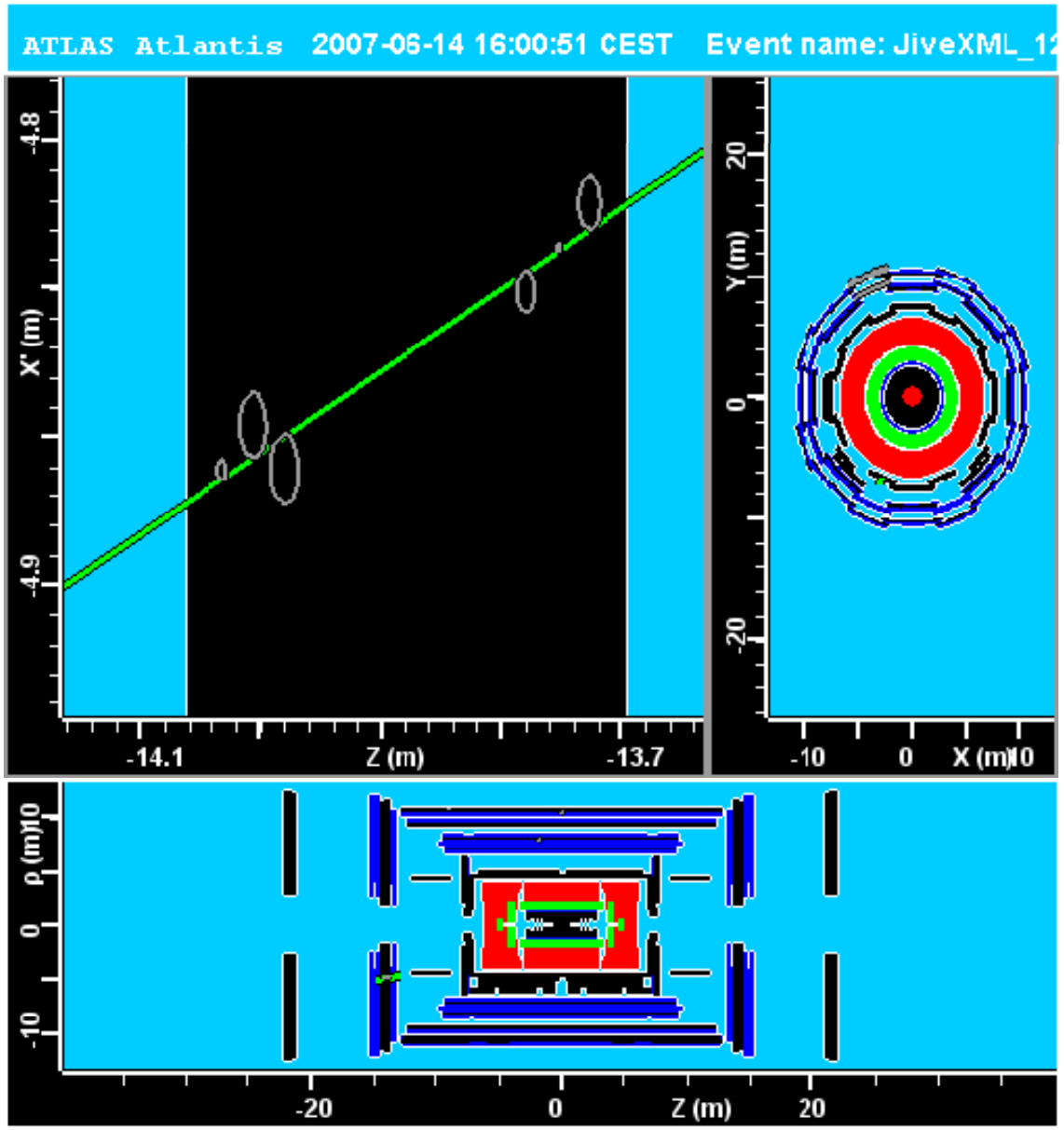




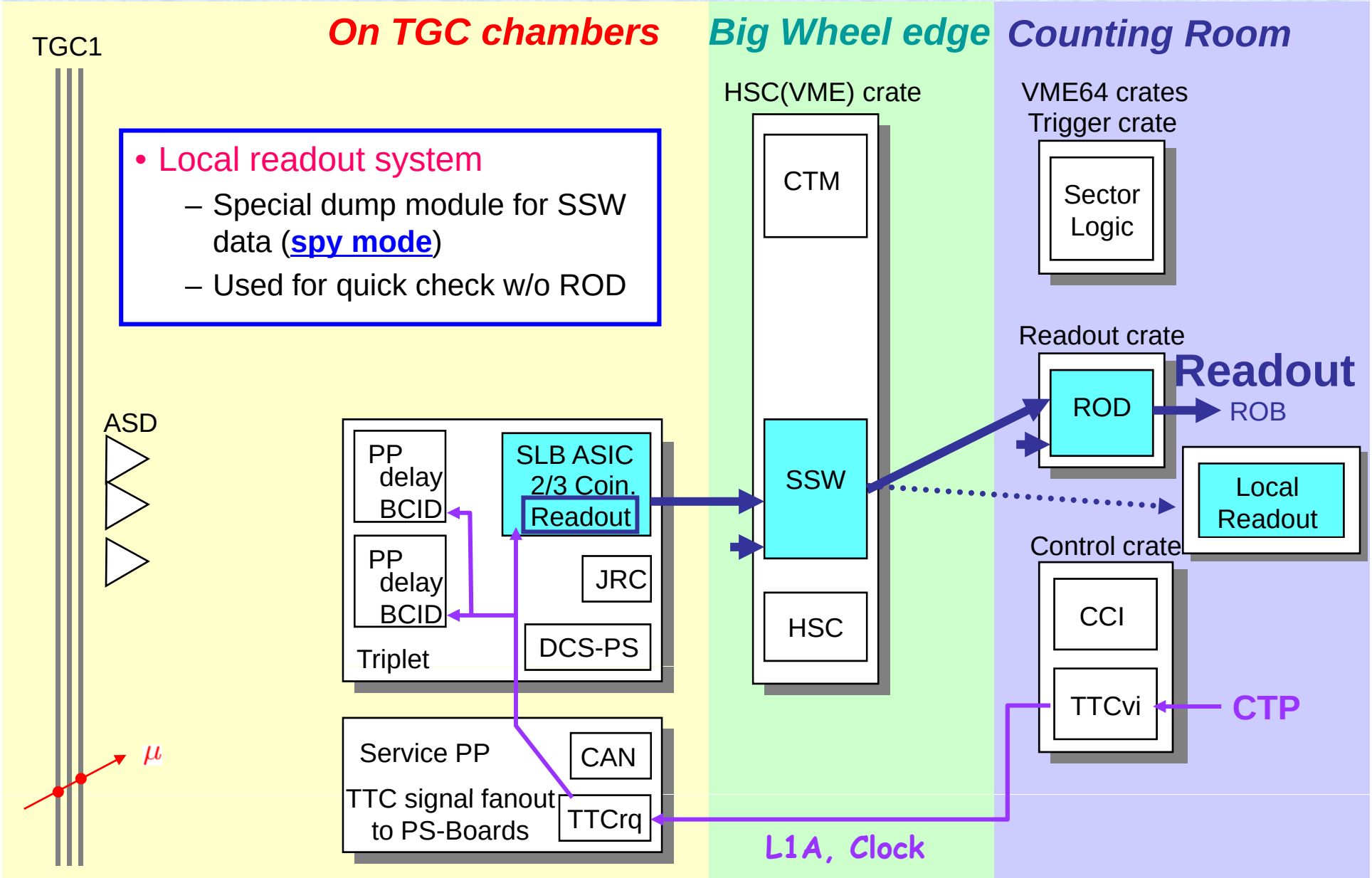
$\Delta t = t_{TGC} - t_{RPC} - t_{TOF}$ ~ 130nsec

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

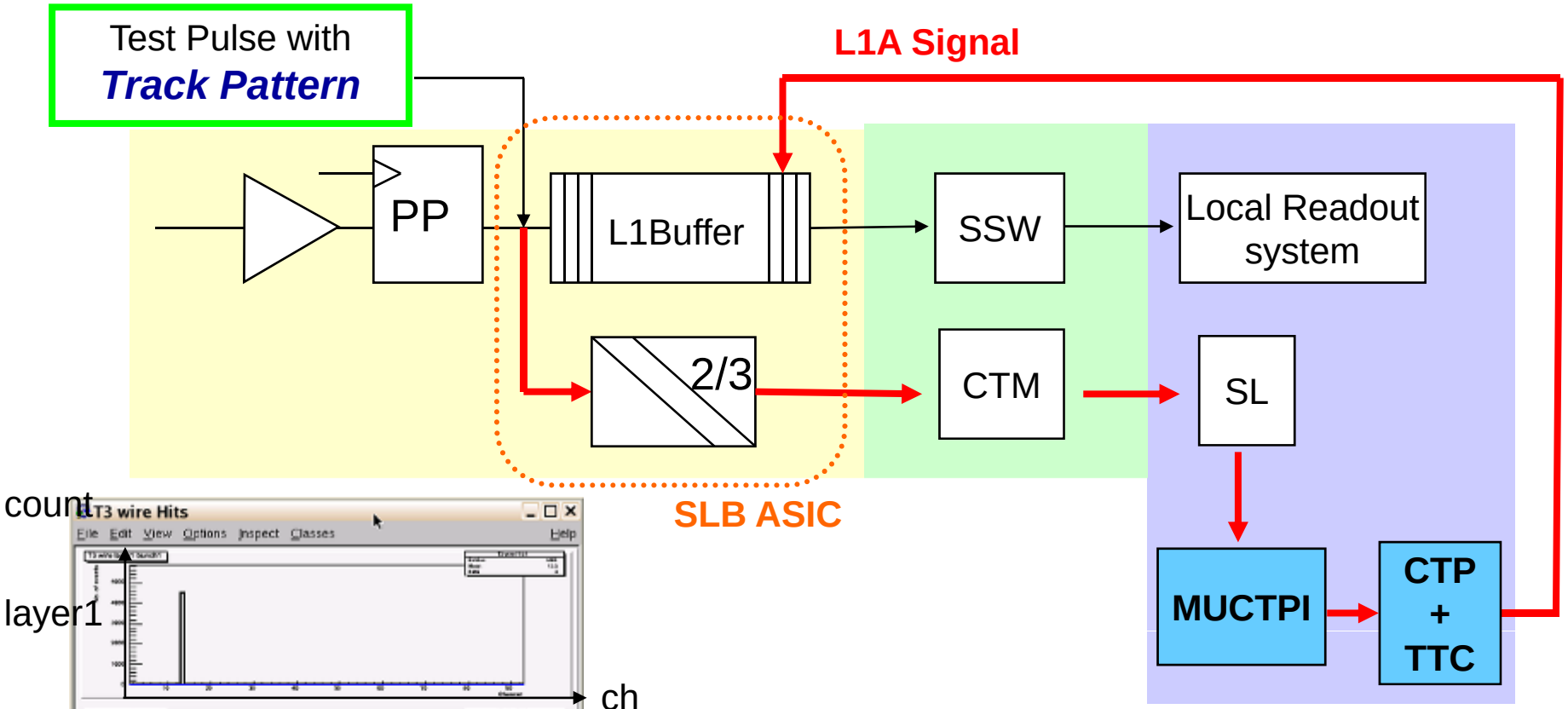
Track Reconstruction by MDT

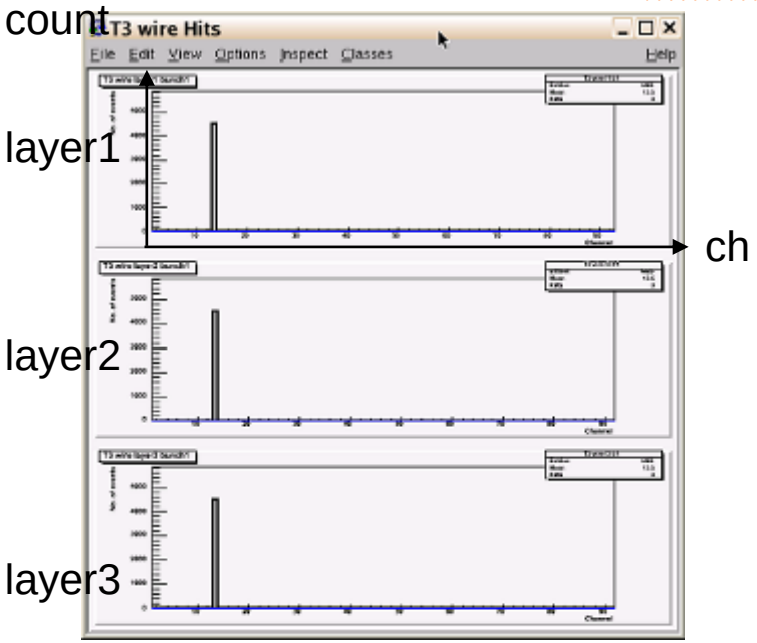


Readout Path



Measurement of L1A latency



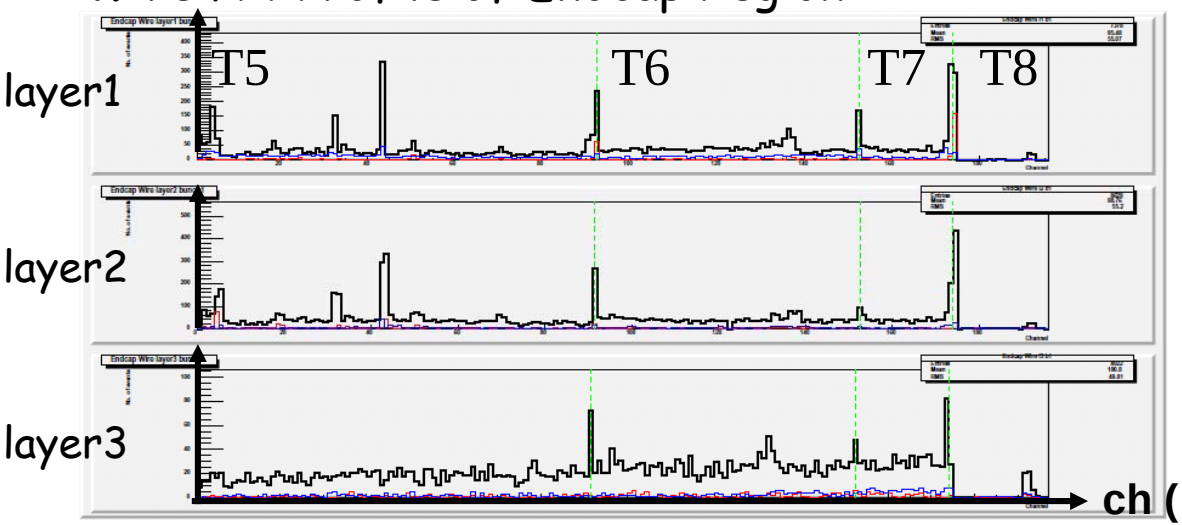


L1A Latency is 76 clocks
= 1.90 μsec (< 2.5 μsec)

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

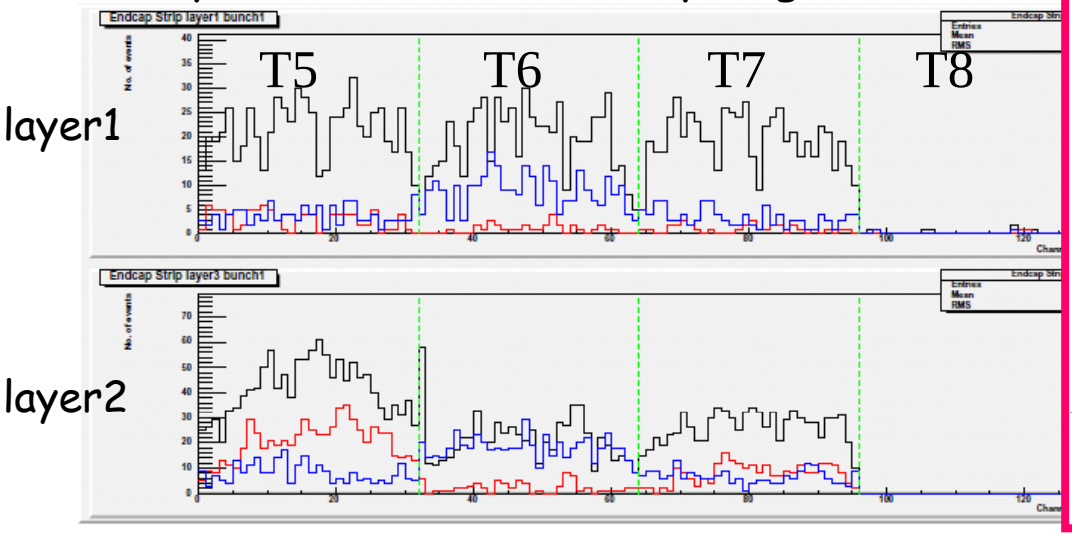
Hit Profile for cosmic-ray test

Wire Hit Profile of Endcap Region



- 2/3 coincidence (wire)
- Vth = 100mV
- Gas: CO_2 100%
- 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 !!

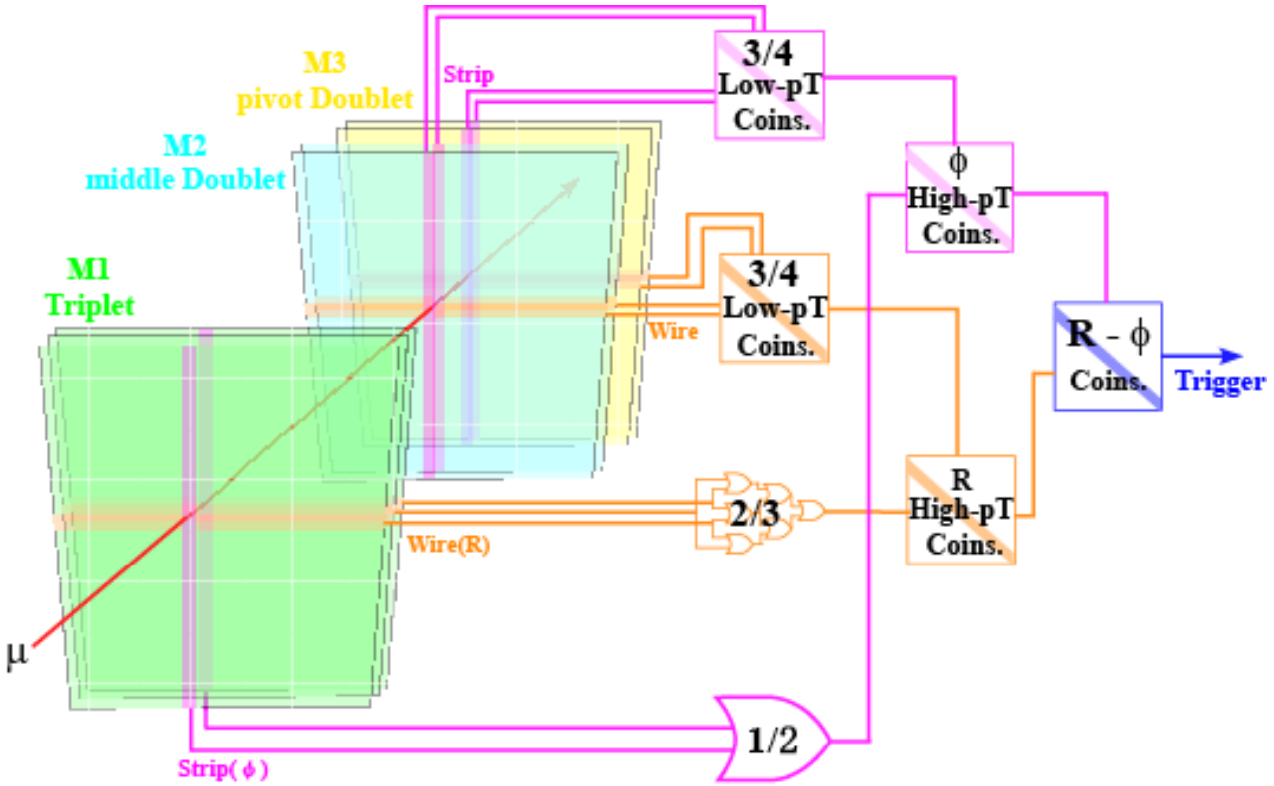
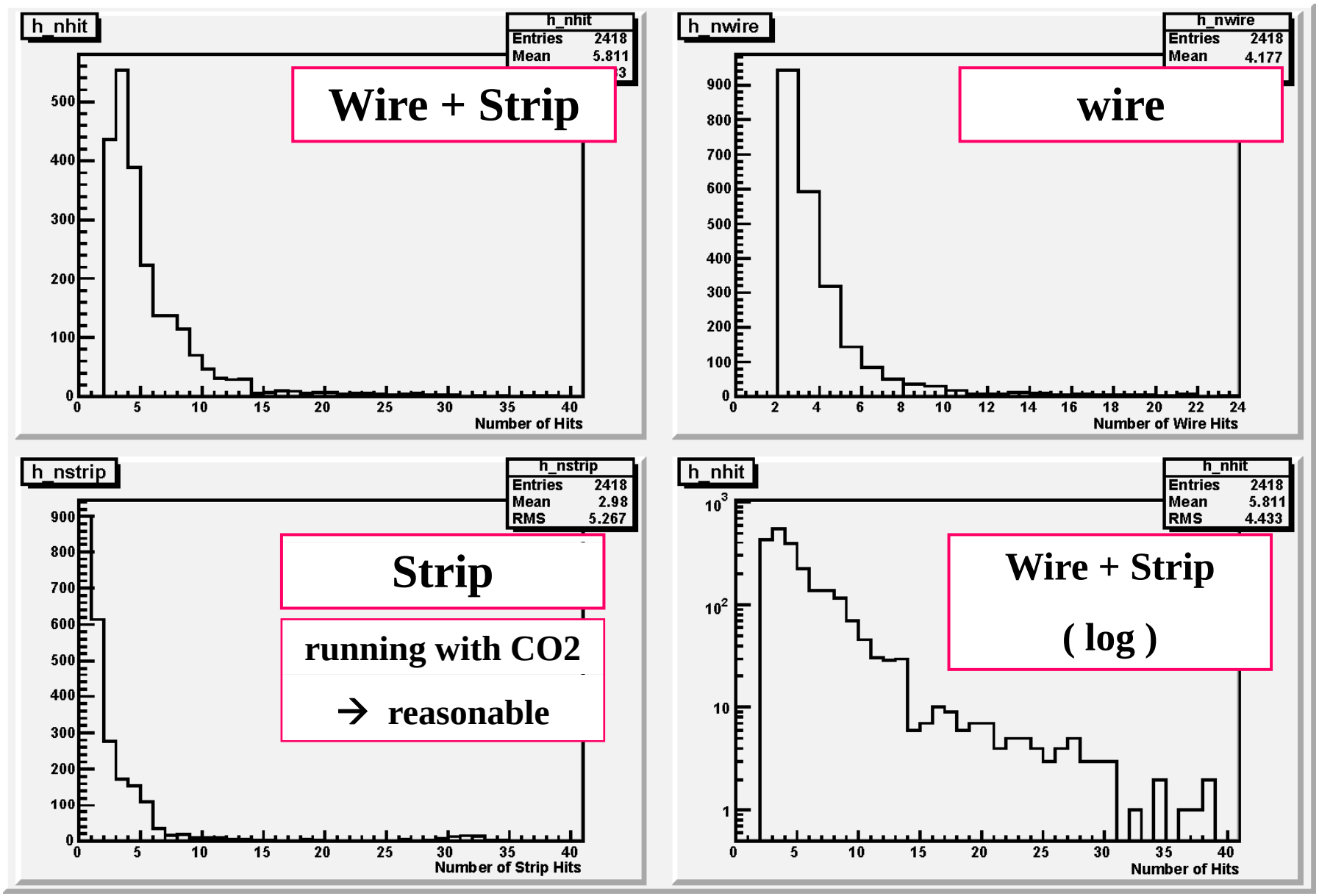
Summary

- 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

Trigger Logic



Multiplicity Distribution (events triggered by TGC)