ATLAS Experiment
Muon Endcap Trigger Operation and Chamber Efficiency Study

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Presentation Outline

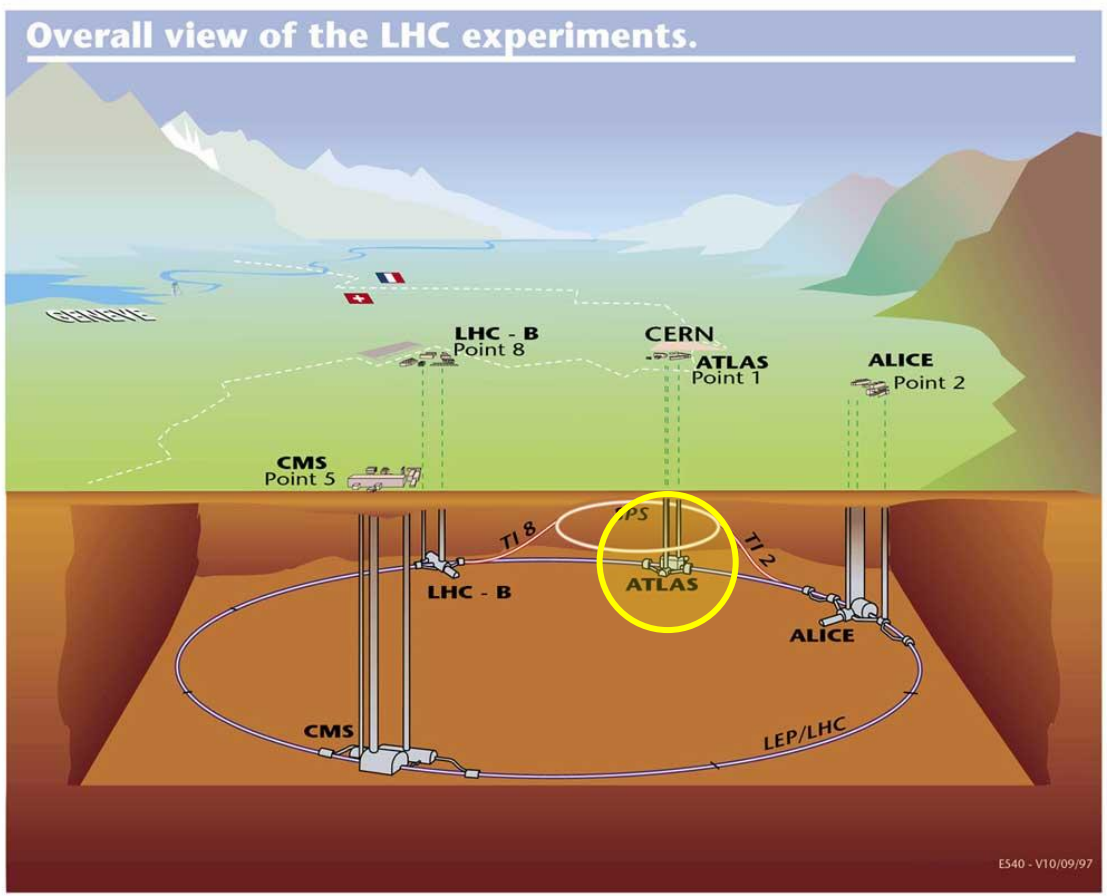
- Brief introduction to the LHC
- ATLAS experiment
  - Muon Detectors
- Muon Trigger
- TGC Efficiency Study
  - Study Justification
  - Method
  - TGC Efficiency Results
- Summary

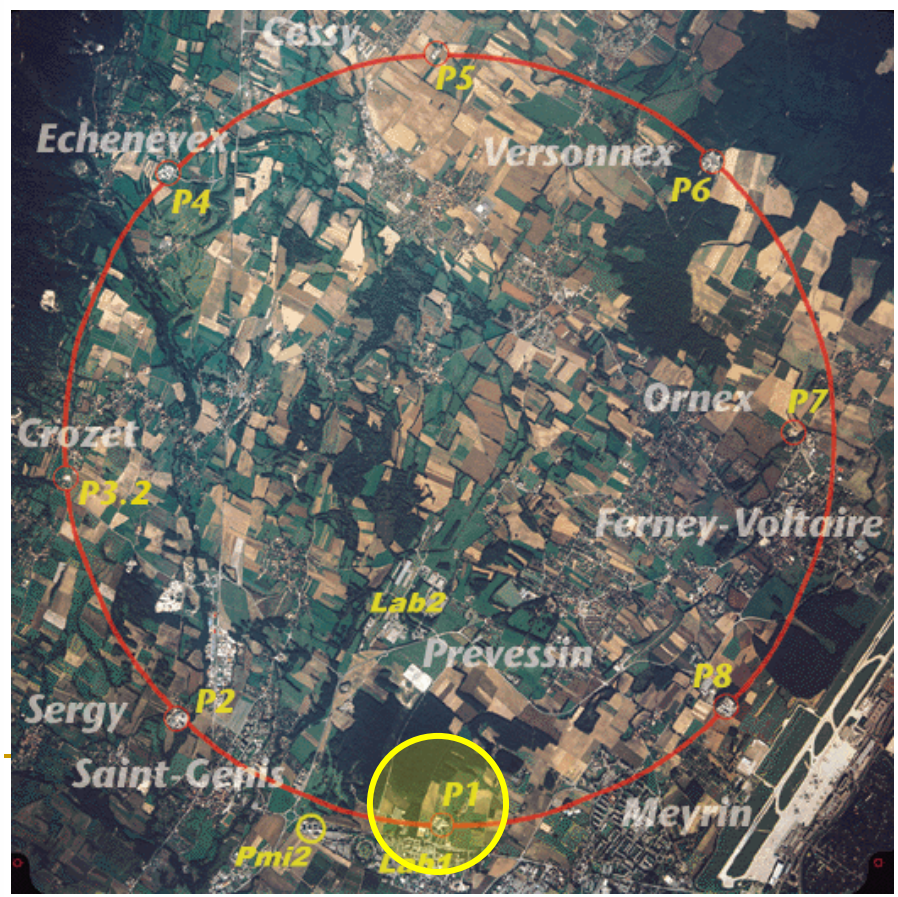
Introduction to LHC, ATLAS experiment and TGC Muon Detector

LHC and ATLAS

Large Hadron Collider (LHC)

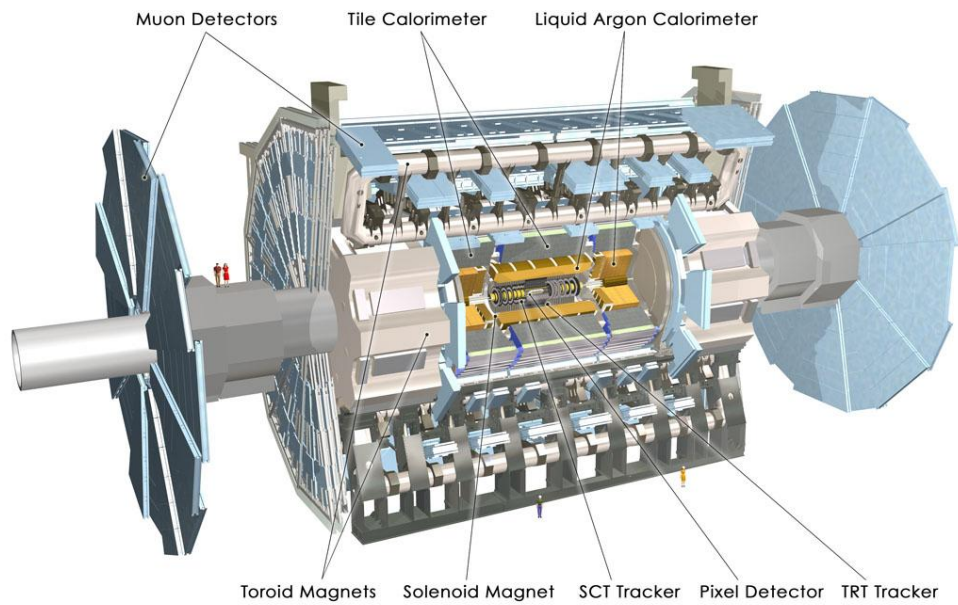
- World's largest and most powerful collider
  - Currently collides protons at 3.5TeV per beam
  - Design energy of 7TeV per beam
  - 8.6km in diameter





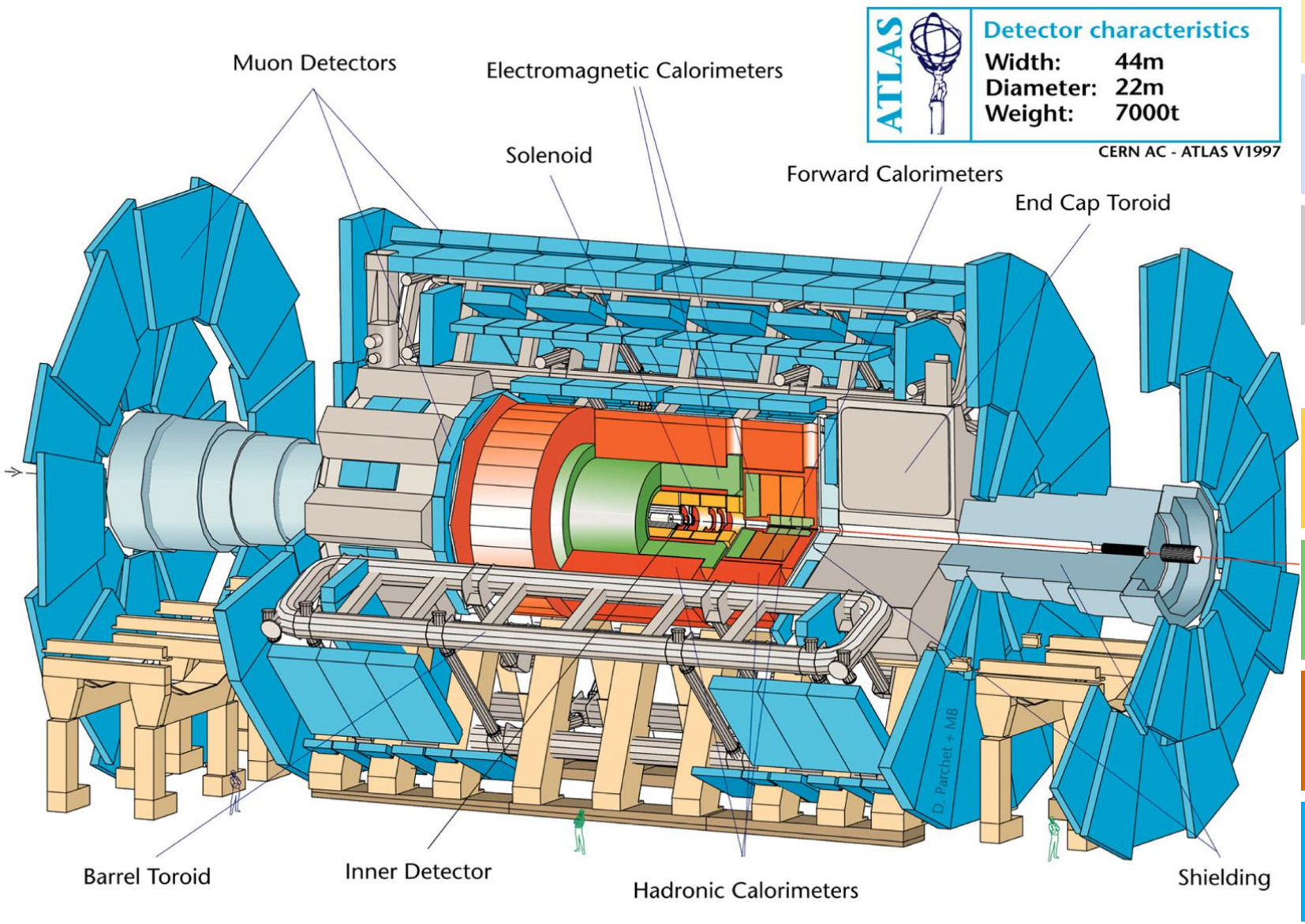
ATLAS Experiment

- One of the four experiments on the LHC
- Used in searches for:
  - Higgs Boson
  - Super Symmetry
  - Extra Dimensions
  - Top quark properties
  - etc…



- Detects ~1,000,000,000 collision events per second
  - Filters events using triggers to optimize quality of data actually recorded

ATLAS Structure



Supports

Shielding

Toroids

Inner Detector

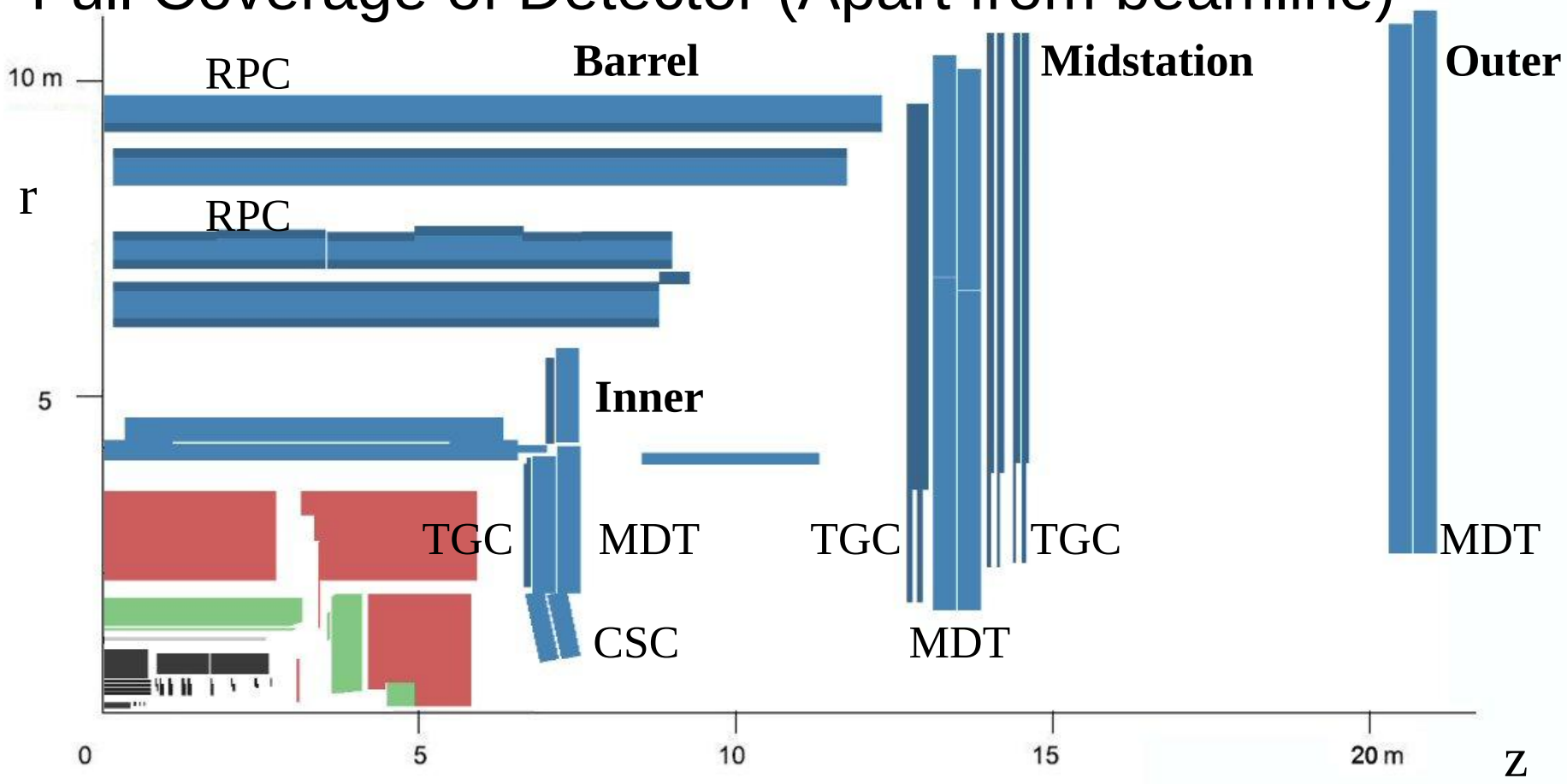
Electromagnetic Calorimeters

Hadron Calorimeters

Muon Detectors

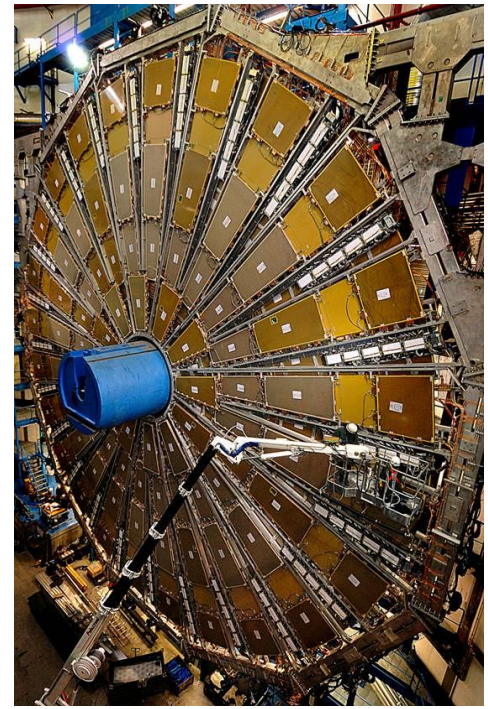
Muon Detectors

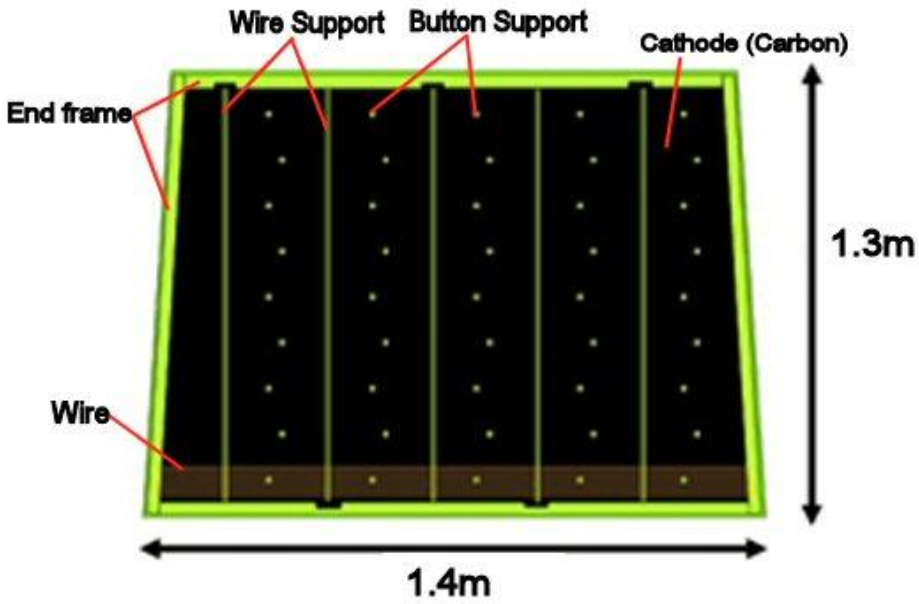
- Barrel region
  - Resistive Plate Chambers (RPC)
- Endcap Region
  - Monitored Drift Tubes (MDT)
  - Thin Gap Chambers (TGC)
  - Cathode Strip Chambers (CSC)
- Full Coverage of Detector (Apart from beamline)

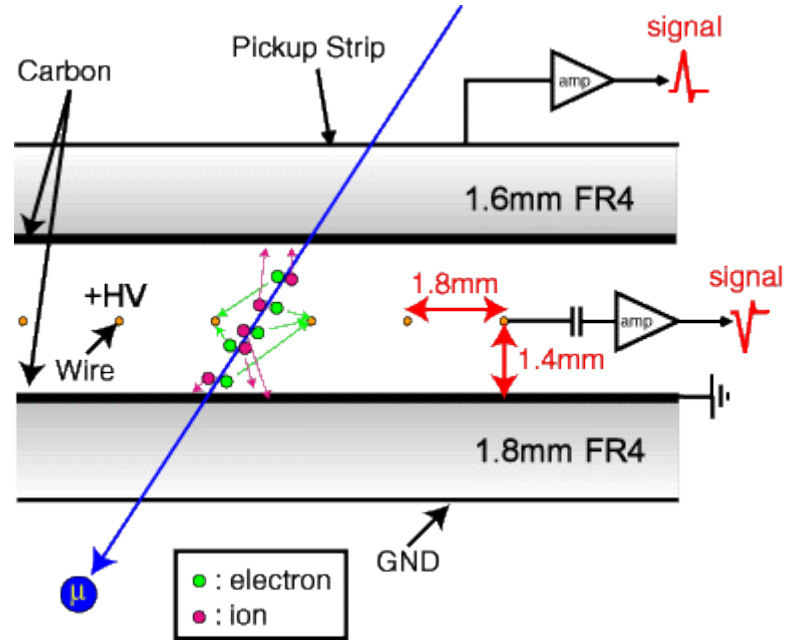


Thin Gap Chamber (TGC)

- Detects ionization of gas as particle passed through detector
- Detector split into two components
  - Wires detect position in r
  - Strips detect position in Φ





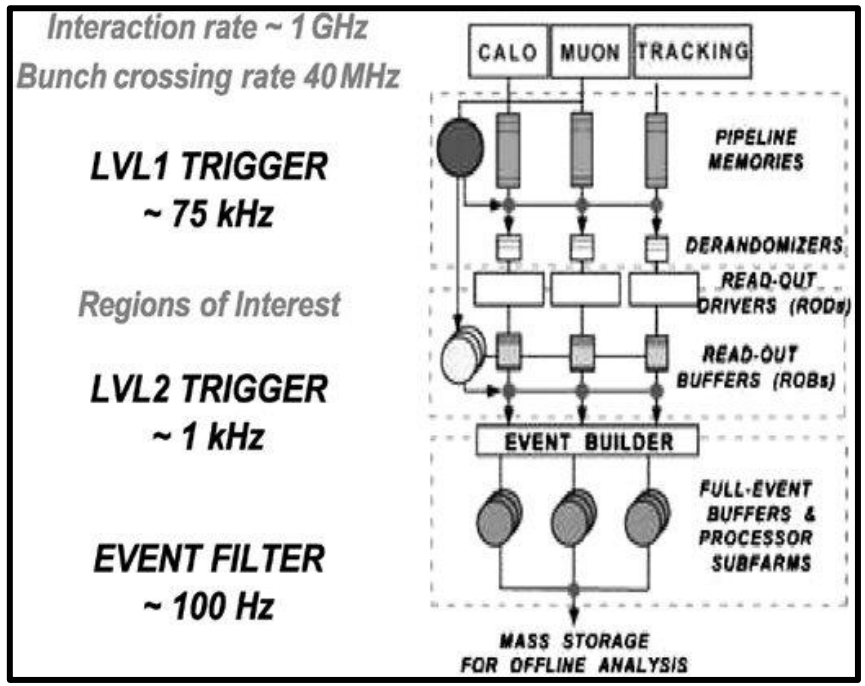


Triggers in the ATLAS experiment, LVL1 Muon Trigger System

Event Trigger System

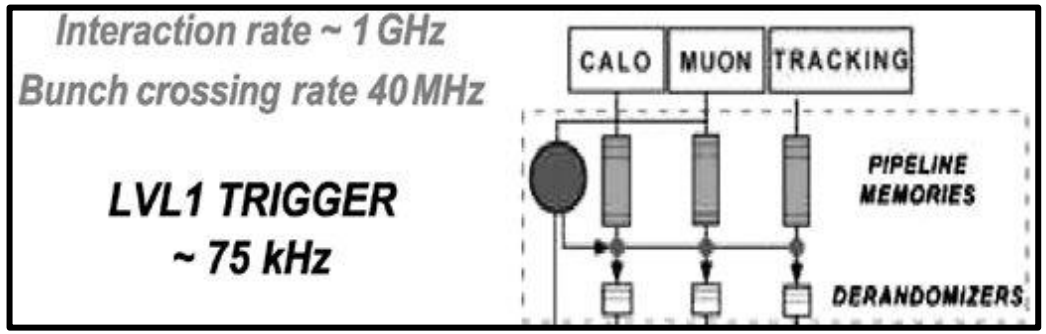
Requirement for triggers

- ATLAS collides protons at a rate of ~1GHz
- Raw data size for each event is ~1.6MB
  - ➡ Would require data flow capacity of 1.6PB/s to record everything
- Actual capacity is several 100MB/s
  - ➡ Require events to be filtered to ~100Hz
- Done using 3 trigger levels
  - First of these is the LVL1 trigger



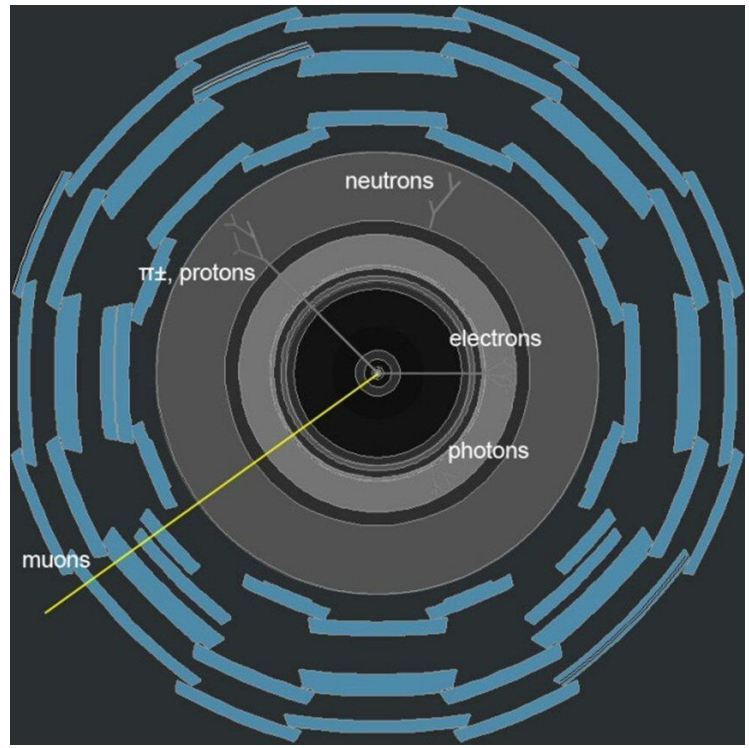
LVL1 Trigger

- Needs to reduce events from ~1GHz to ~75kHz
  - Requires very low latency (~2μs)
  - Hardware based (LVL2 onwards is software based)



- Triggers on events with characteristics of useful interactions
  - High transverse momentum particles
  - Large missing transverse momentum
  - etc…
- LVL1 trigger uses 2 of the 3 Trigger systems
  - Muon detectors contain muon trigger

LVL1 Muon Trigger



- Muons pass through the entire detector
  - ➡ Muons are the only detectable particle to reliably do this
  - ➡ Muons can be detected separately from other particles

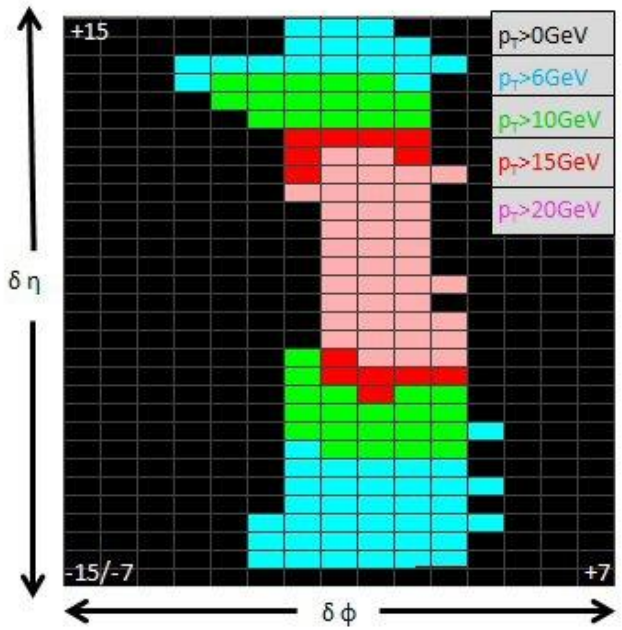
    Useful for fast analysis of events
- If muons with high transverse momentum (p_T) are detected:
  - Higher chance of interesting process

➡ Activate Trigger

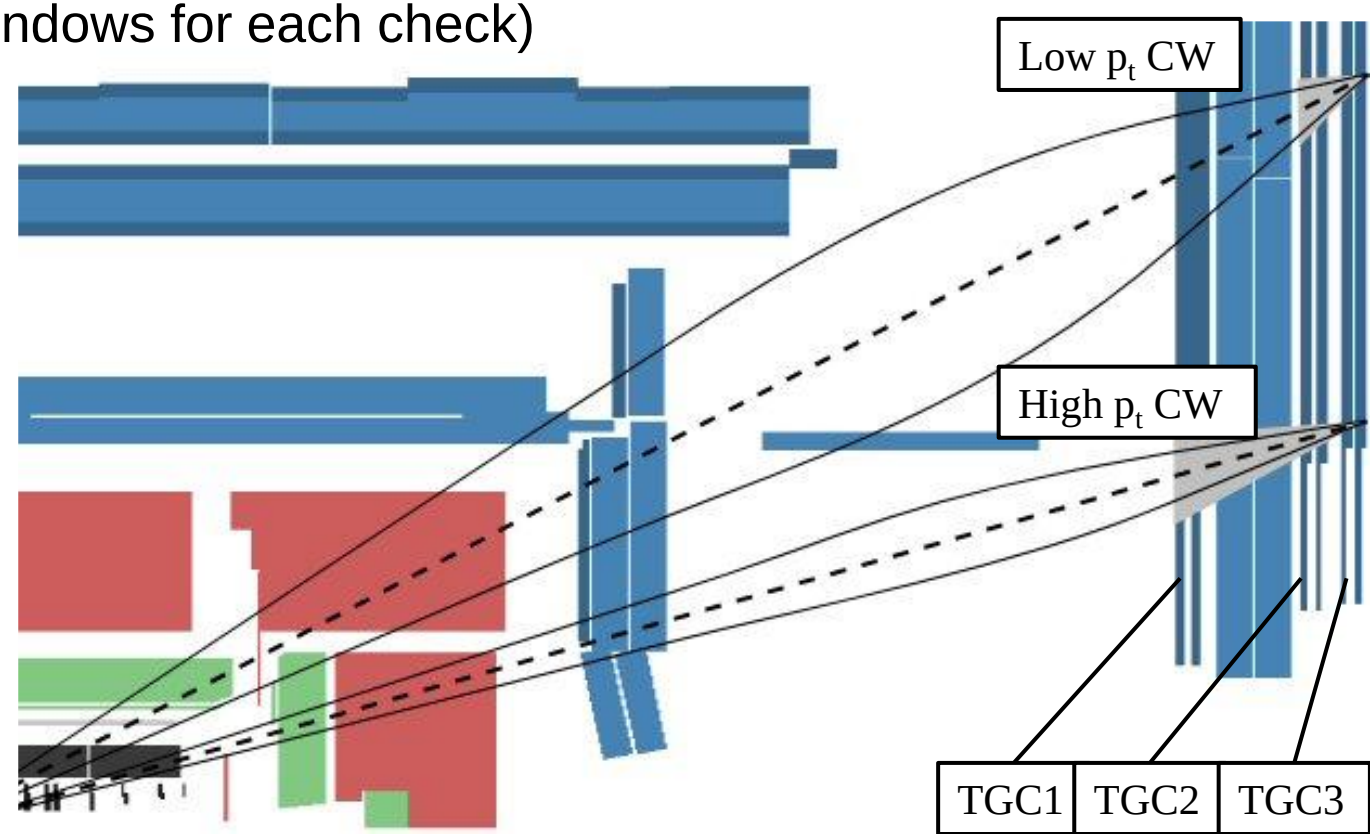
LVL1 Muon Trigger

- Muon p_T is analysed quickly using coincidence windows
  - Compared with muons' sagitta from bending
- Triggering starts when a signal is detected in TGC3
- Low p_T is first established by searching for signals in TGC2 inside the coincidence window
- High p_T is then established using another window on TGC1

(Different coincidence windows for each check)



Example of a coincidence window



Study into the efficiency of TGC sectors using MDT Segments as reference

TGC Efficiency Study

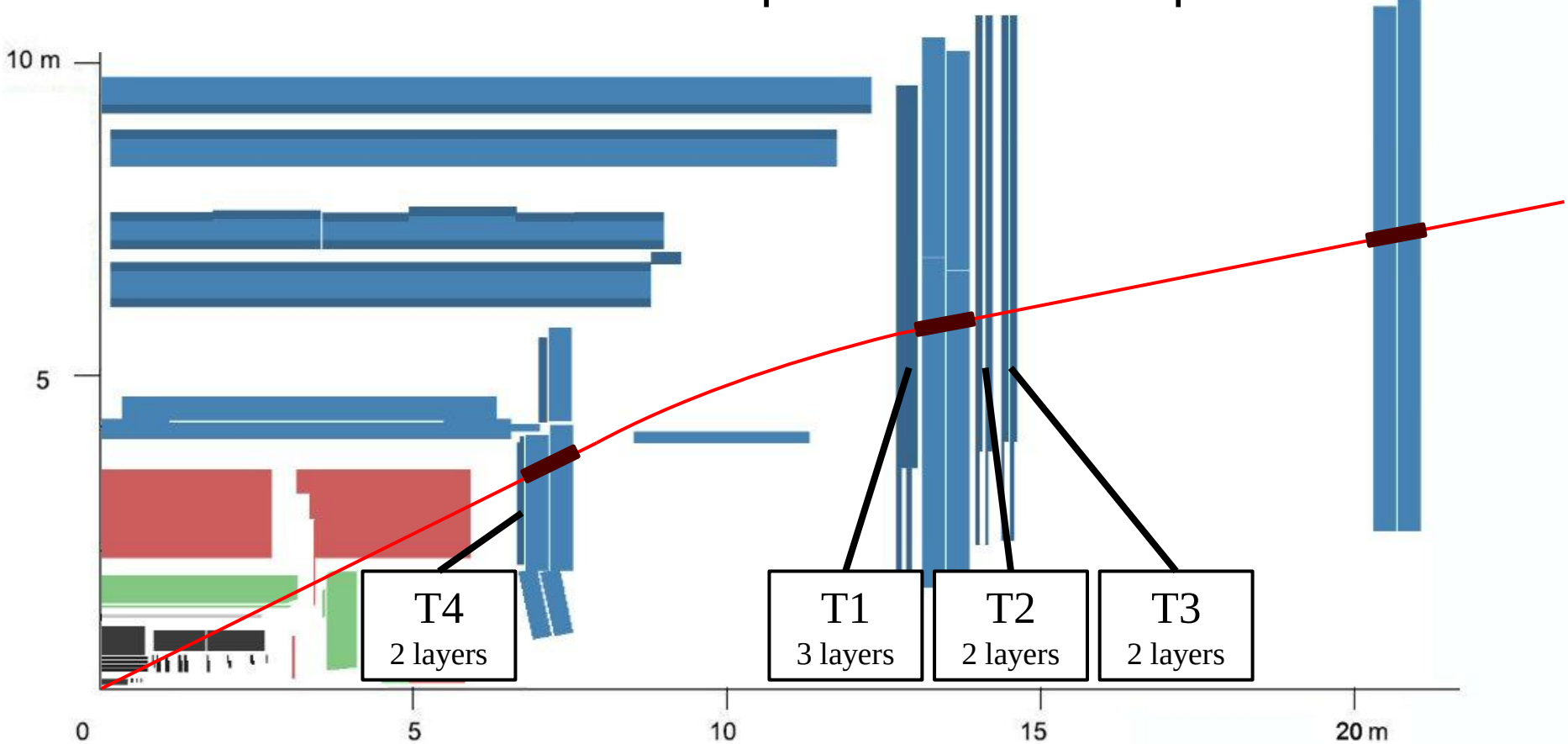
TGC Efficiency Study

Introduction

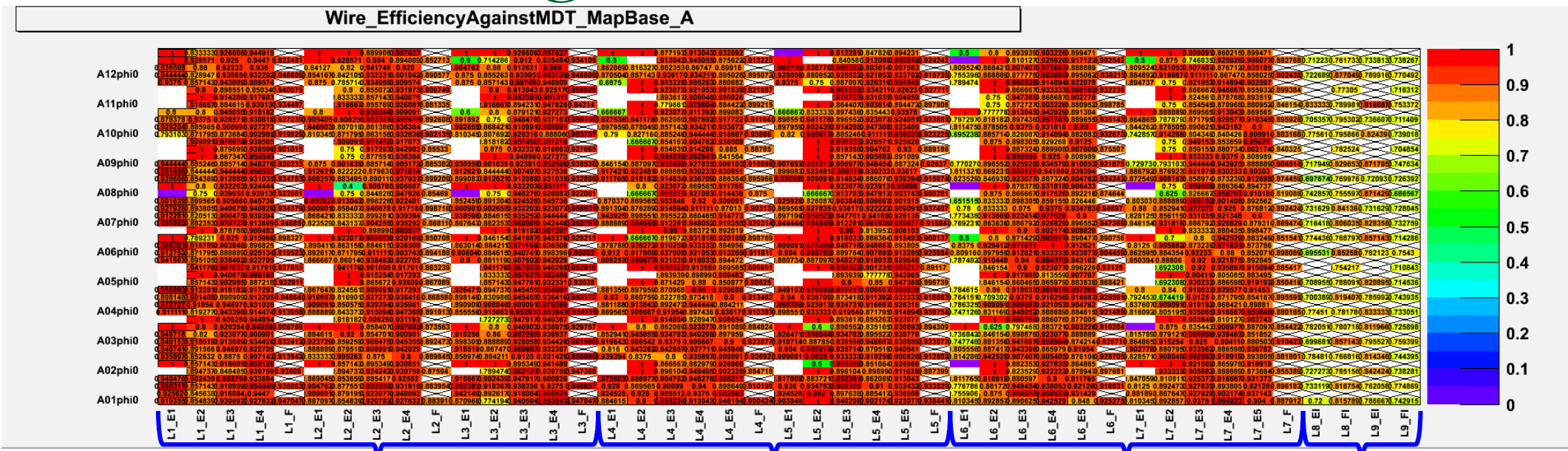
- Detector efficiency information is important for Data Quality (DQ) purposes
  - Shows reliability of signals from detector
  - Highlights hardware problems
- Previous methods for analyzing TGC efficiency only worked on the Midstation TGC detectors
  - Large number of layers ⇒ Can use muon signals confirmed from other layers to check against for any given layer
  - Inner has only 2 layers ⇒ Cannot reliably check against a single other layer
- Want efficiency map of entire detector
- Decided upon study using muons detected with MDT to check TGC readings

Study Method

- Form tracks from high quality MDT segments
  - MDT segments are collections of correlating MDT hits
  - Match segments using position and direction
  - Require 2 or more segments for a track
- Extrapolate tracks to TGC detector planes
- Search for TGC wire and strip hits at the extrapolated locations



Result Histograms



Legend

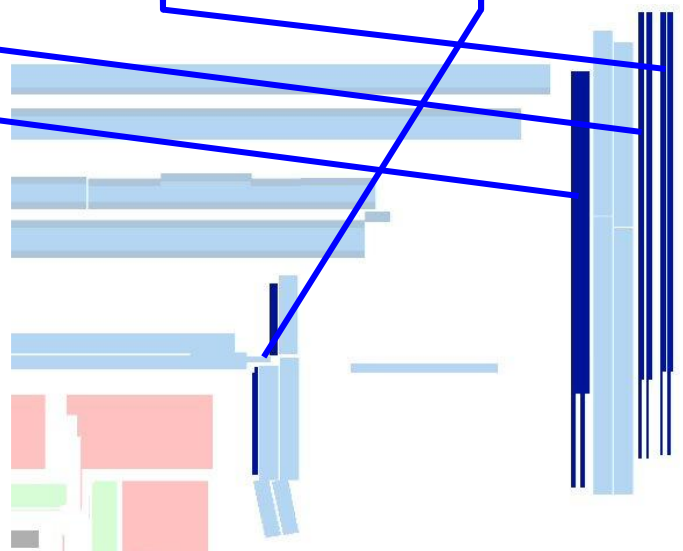
Each cell represents a TGC sector

x-axis is TGC layers and eta positions in that layer

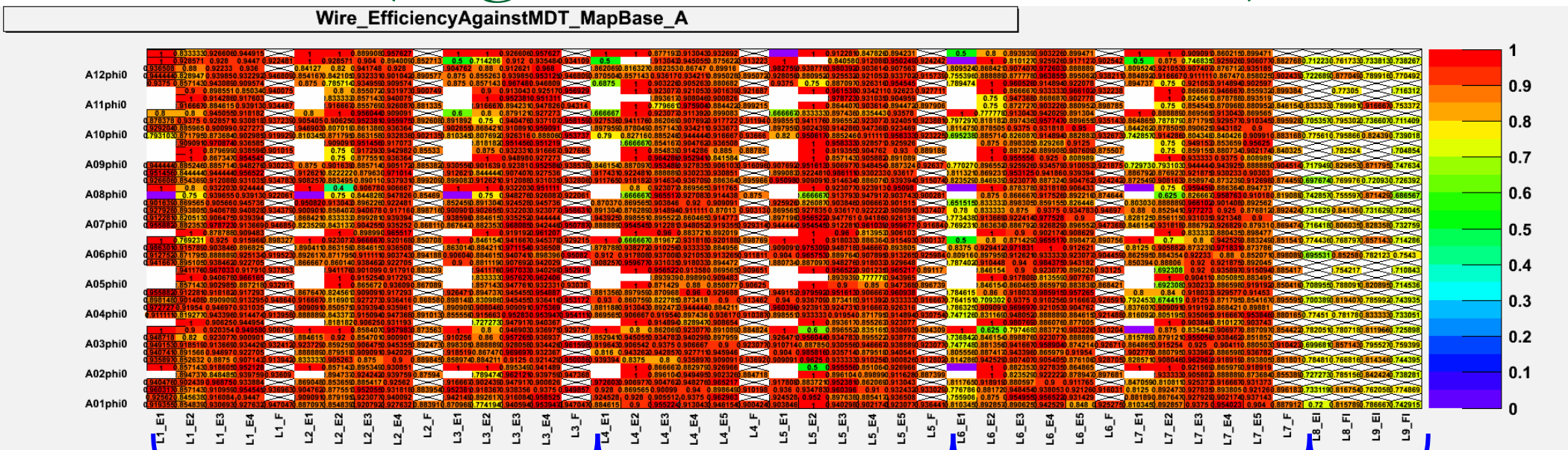
y-axis is TGC phi positions

indicates no tracks were detected

indicates no detector is present



Results (Segment Track Method)

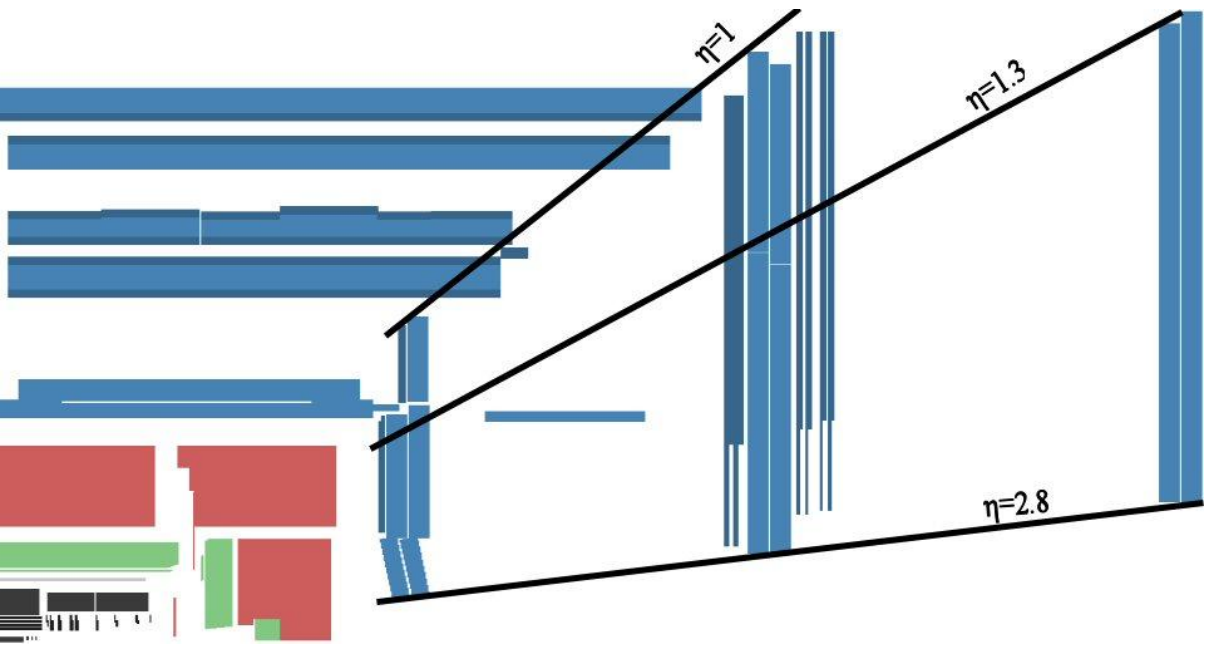


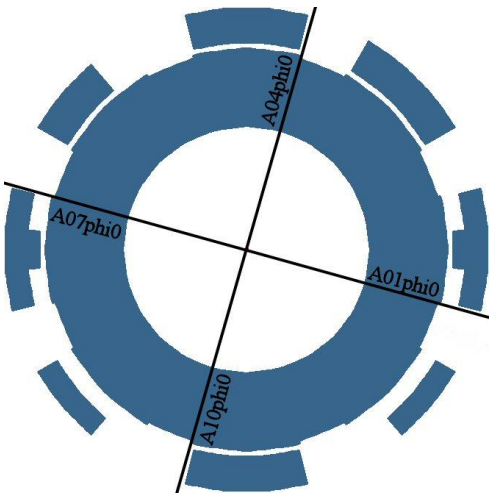
Results show :

- Good efficiency in Midstation sectors covered
- Lower efficiency in Inner (~80%)
- Gaps in distribution at outer edge of Midstation
  - Due to gaps in Inner Station coverage

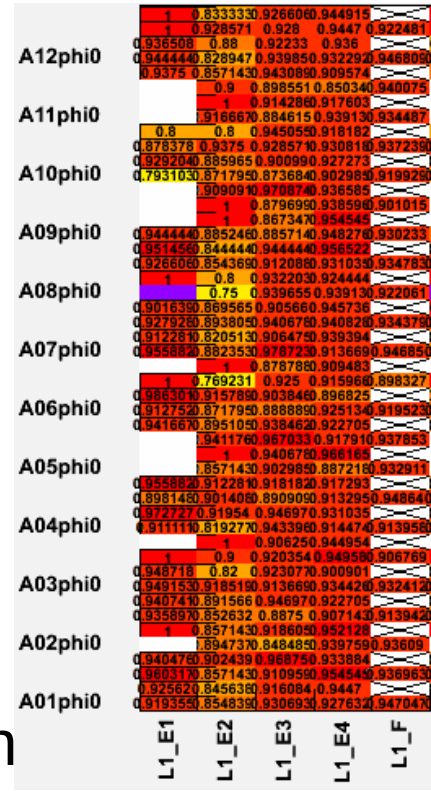
Gaps in Segment Track Method

- Outer edge of Inner station has gaps at some phi values
- Only Midstation covers these phi values between η≈1.3 & η=1





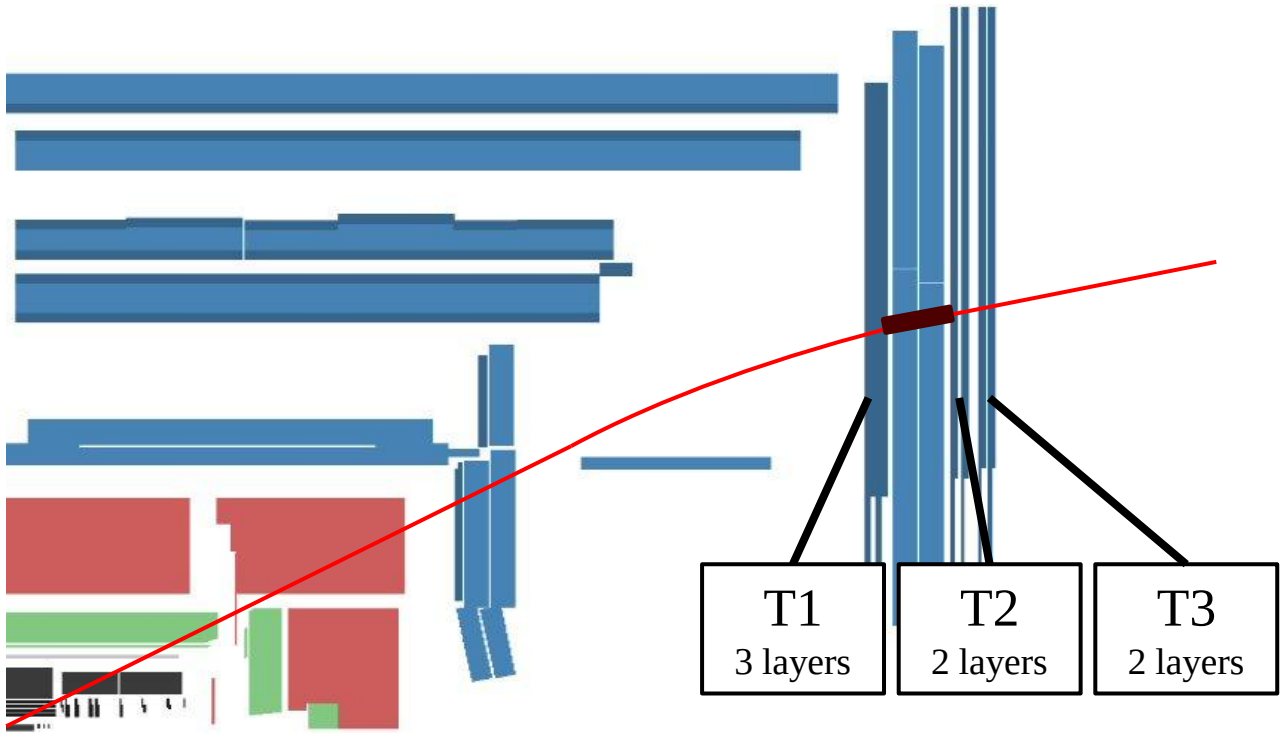
Inner detector cross section



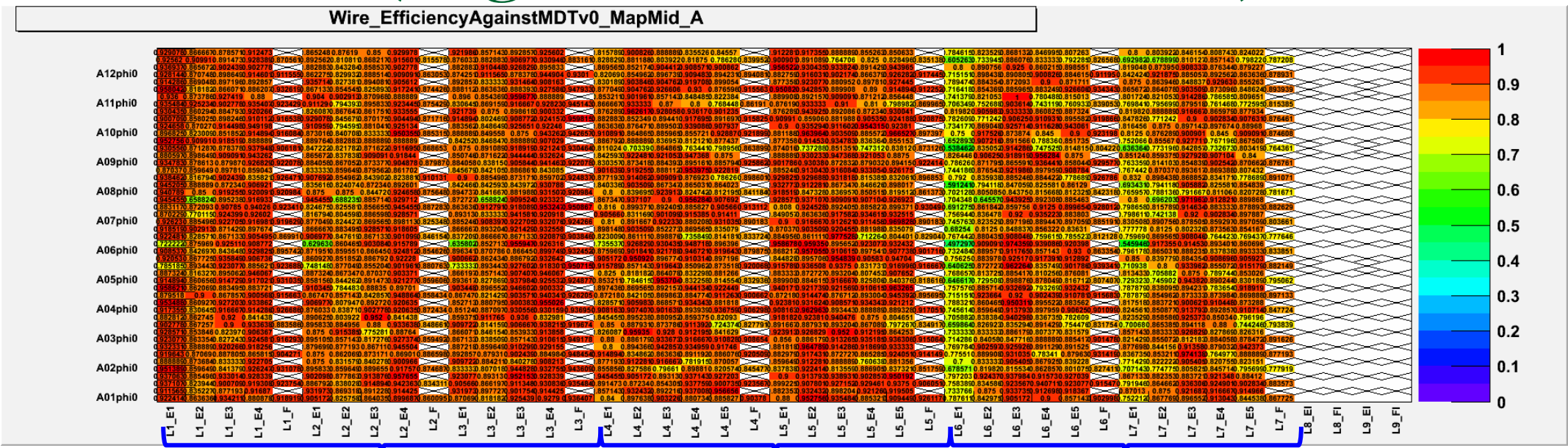
- Need similar method that covers the entire Midstation
- Use Midstation Segments alone to check Midstation efficiency again

Midstation Segment only Method

- Using single segments means lower signal certainty
- Use TGC readings from other TGC stations to verify a segment when checking a station
- Cannot be used on the Inner as there are only 2 TGC layers



Results (Segment Track Method)



- Generally lower efficiency result than Segment Track Method
  - More fake signals produced
  - Good enough for DQ purposes
- Layers 6&7 (T3) have noticeably lower efficiency than the other layers

Summary

- LHC and ATLAS hopefully introduced
- ATLAS's requirement for and operation of TGC muon trigger system also introduced

- Results of efficiency study
  - TGC efficiency is generally good
  - Some stations not operating as efficiently as others
    - Particularly the Inner station
    - Reason for this is currently unknown
  - Efficiency histograms will continue to be made automatically with ongoing data taking
  - Results are being used for monitoring the TGC as experiment progresses

Questions

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