
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

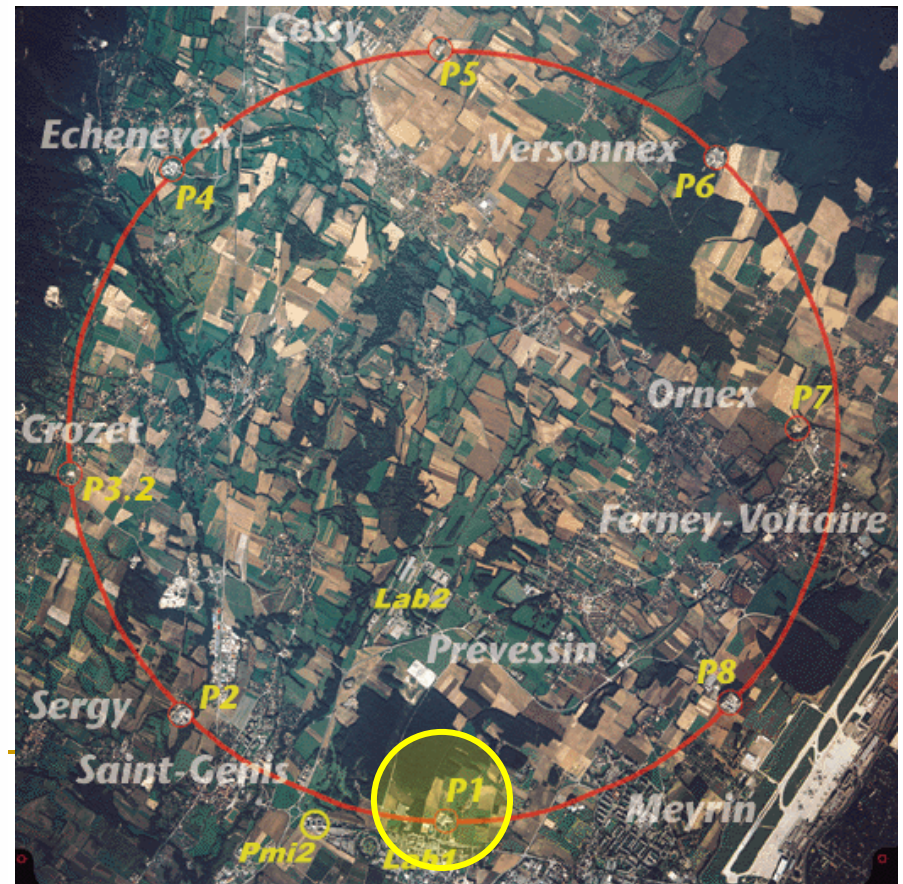
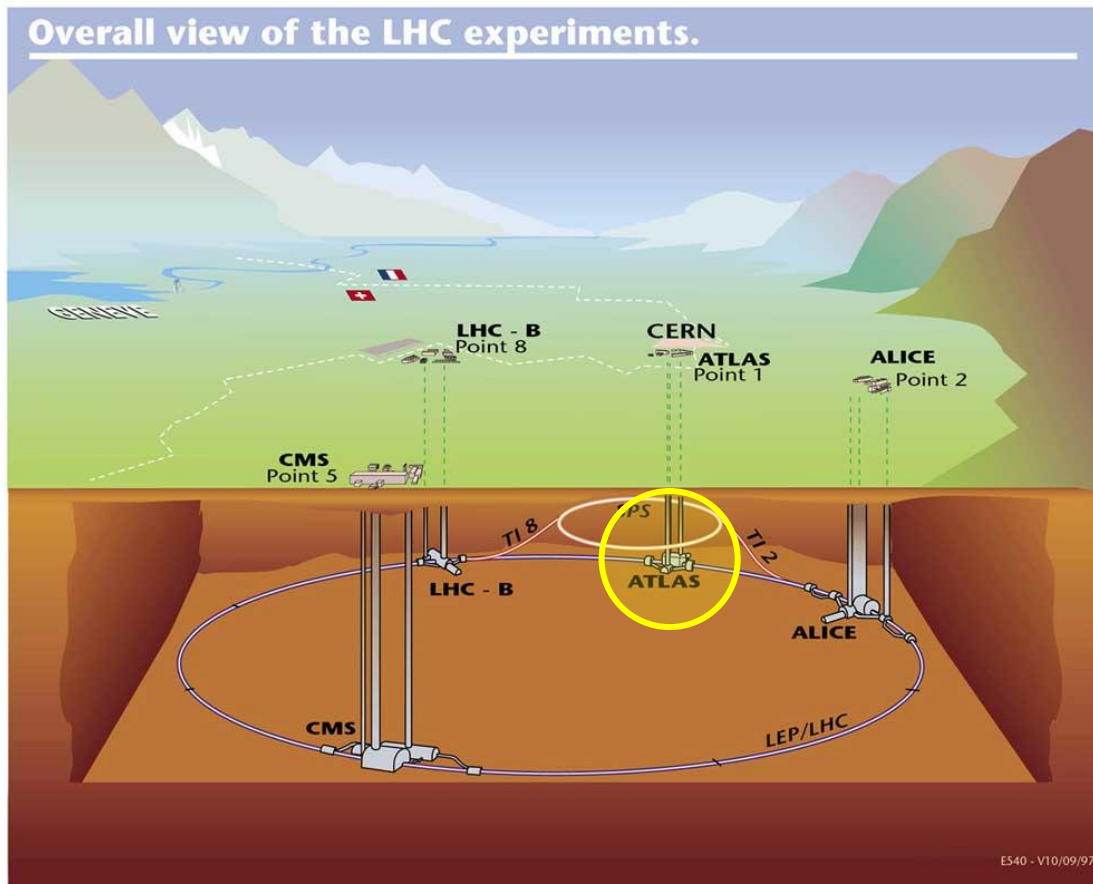


Introduction to LHC, ATLAS experiment and TGC Muon Detector

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

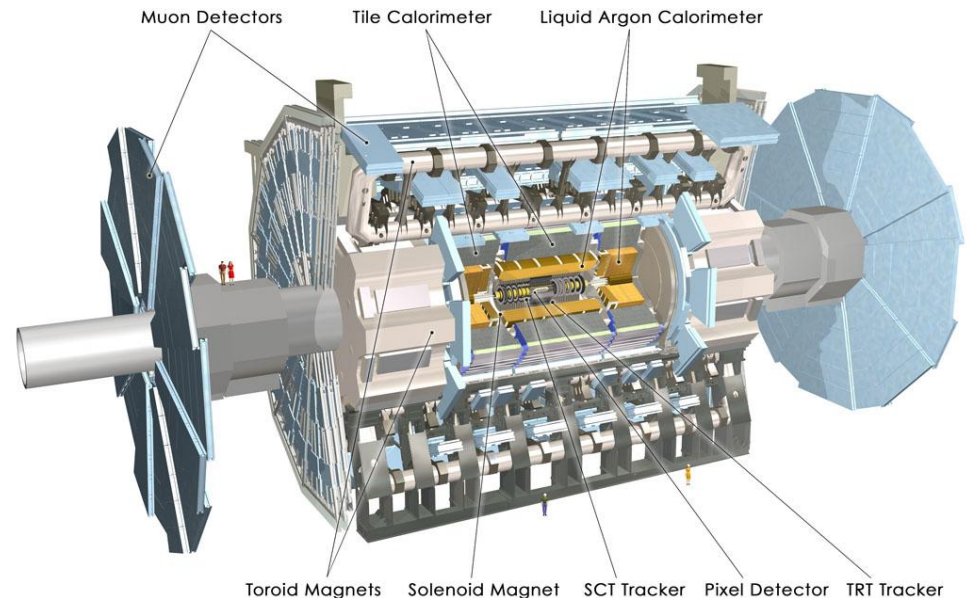


ATLAS Experiment

- One of the four experiments on the LHC

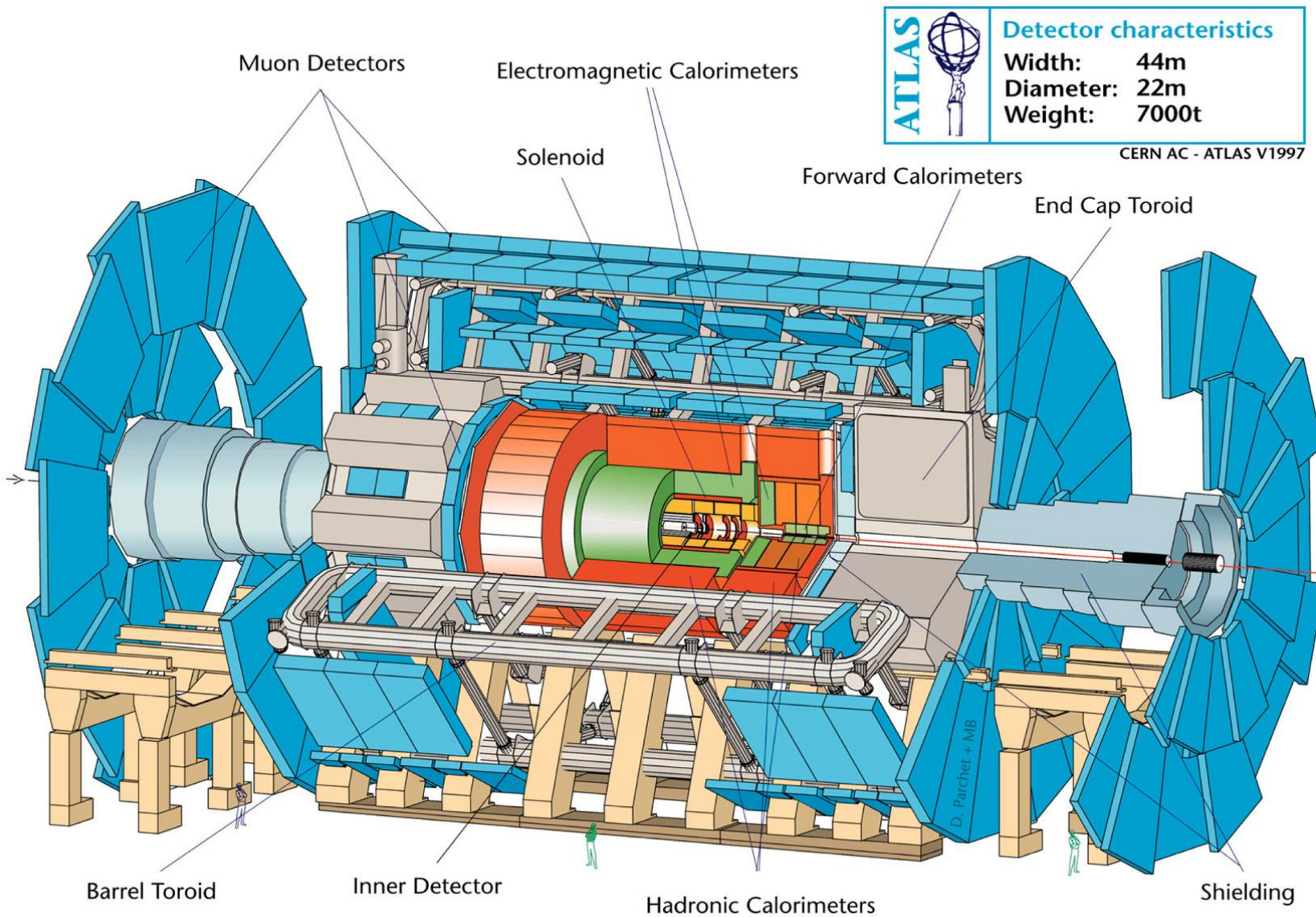
- Used in searches for:

- ❑ 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

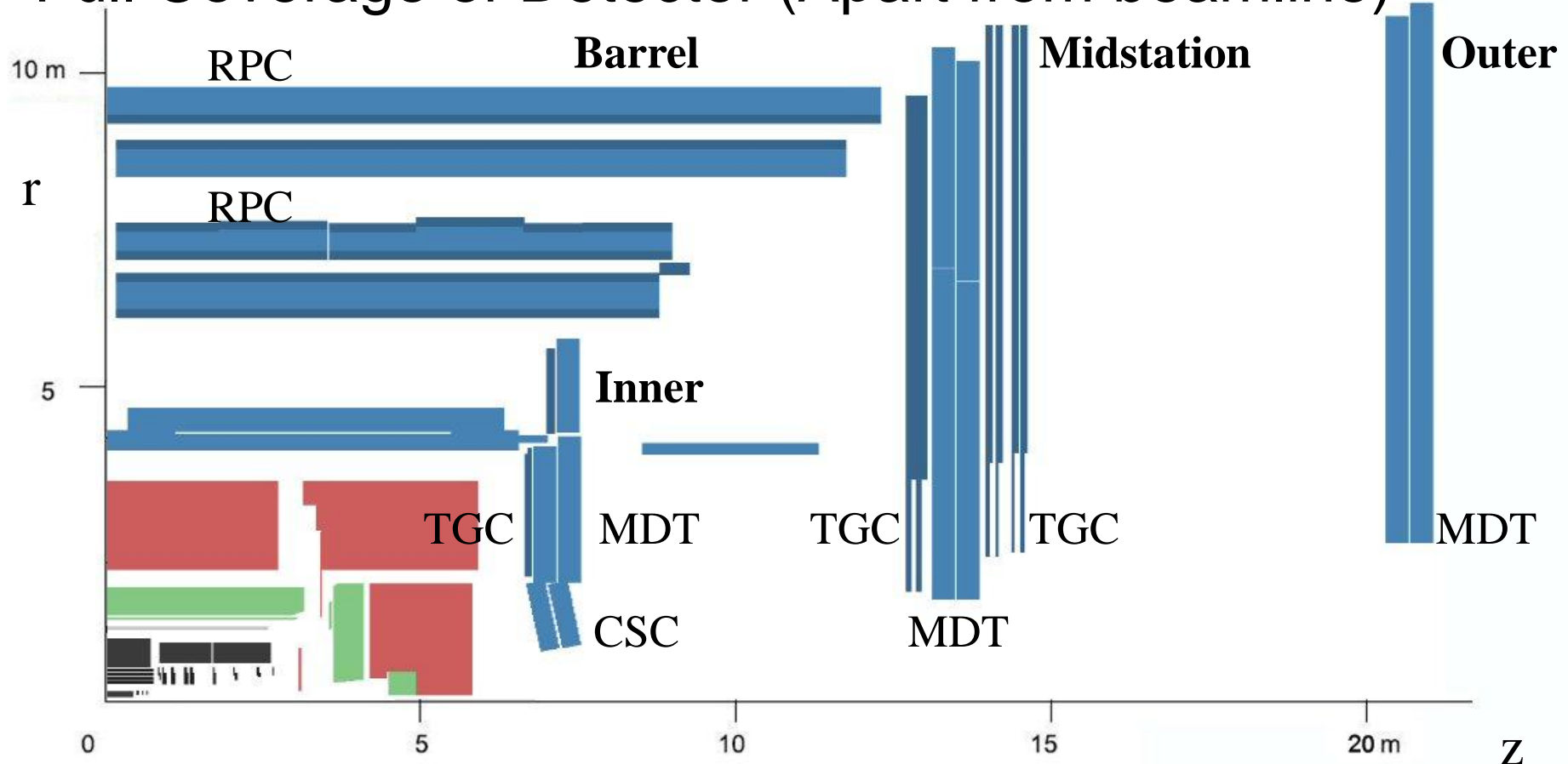
■ Barrel region

- Resistive Plate Chambers (RPC)

■ Endcap Region

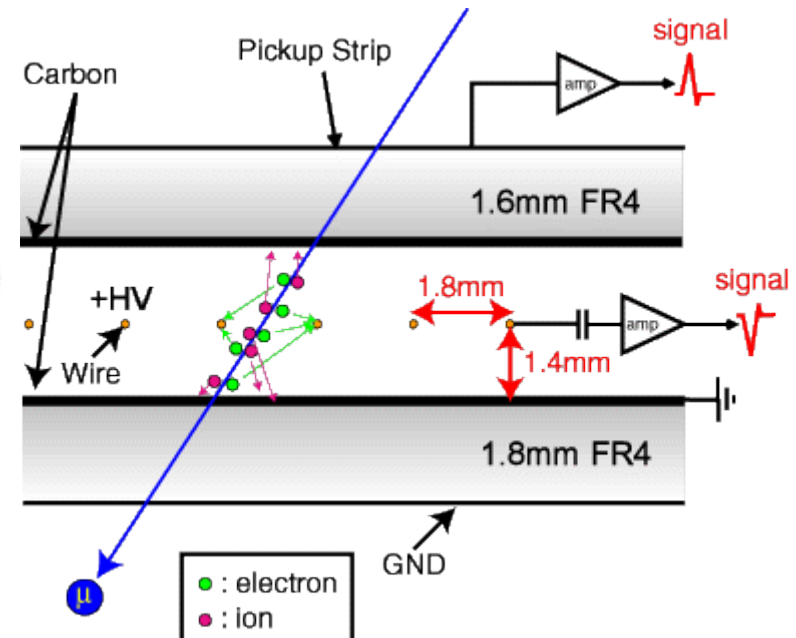
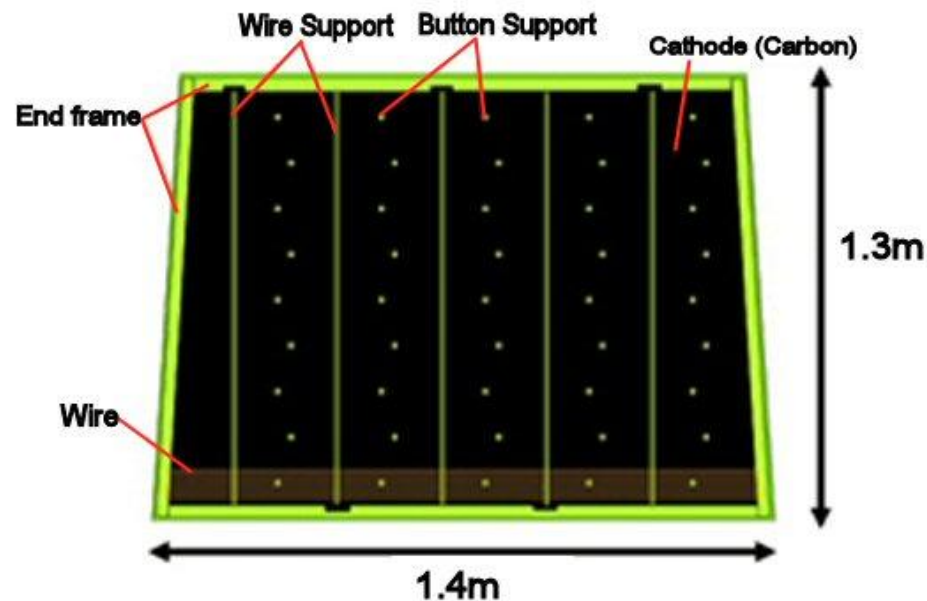
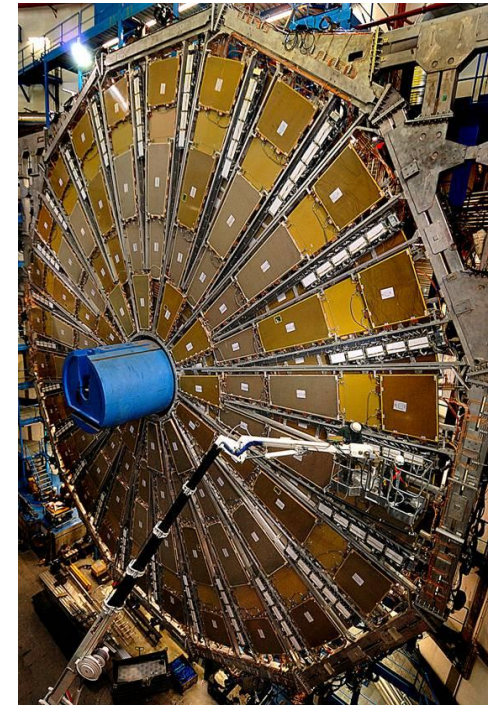
- Monitored Drift Tubes (MDT)
- Thin Gap Chambers (TGC)
- Cathode Strip Chambers (CSC)

■ 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

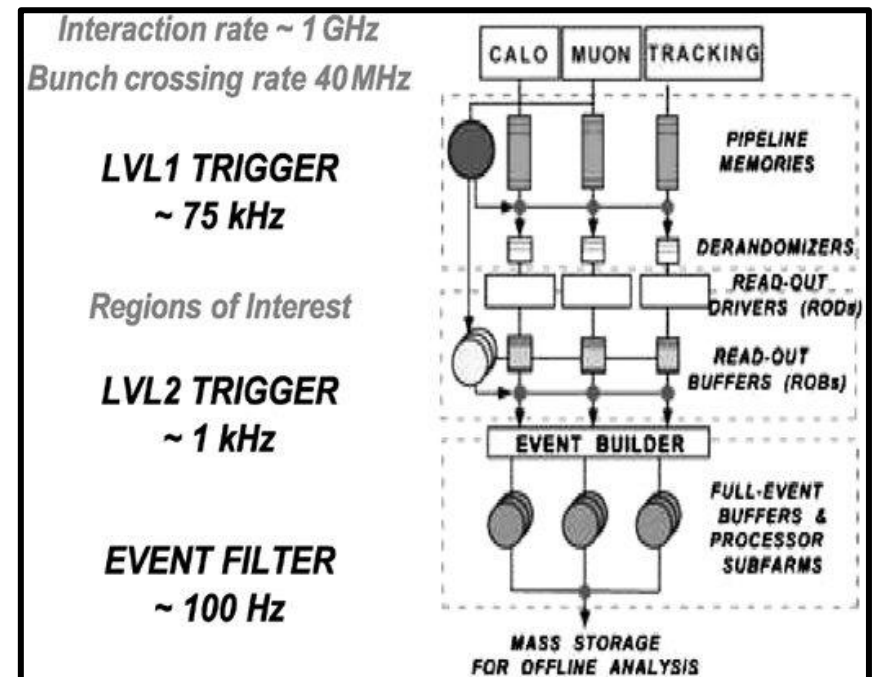


Triggers in the ATLAS experiment, LVL1 Muon Trigger System

Event Trigger System

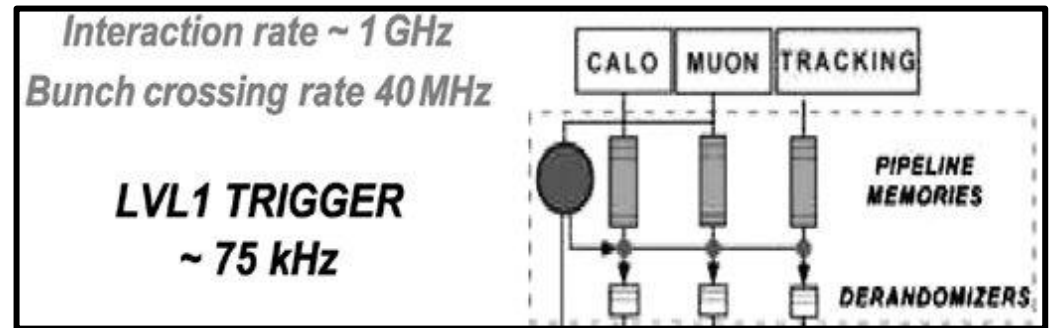
Requirement for triggers

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



LVL1 Trigger

- Needs to reduce events from $\sim 1\text{GHz}$ to $\sim 75\text{kHz}$
 - Requires very low latency ($\sim 2\mu\text{s}$)
 - 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



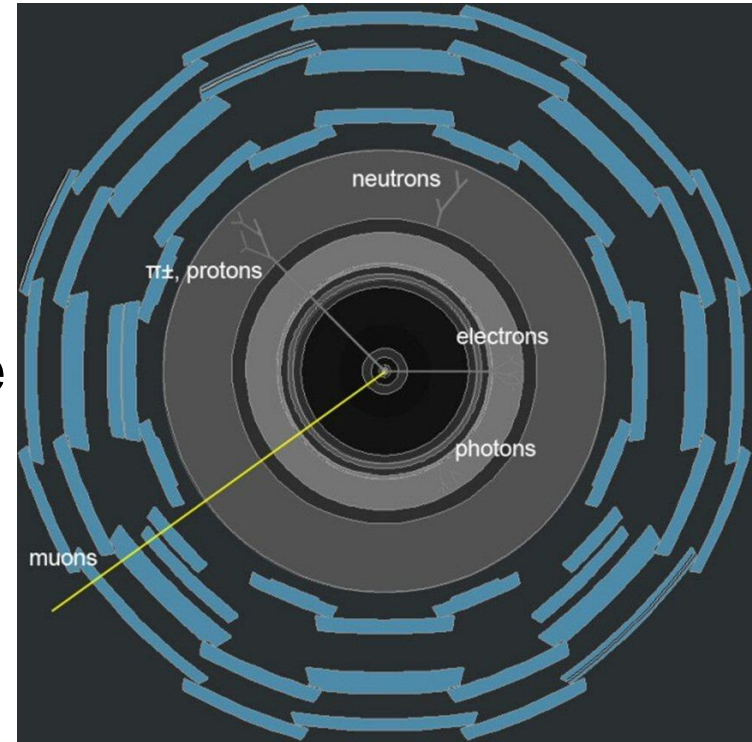
LVL1 Muon Trigger

- 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

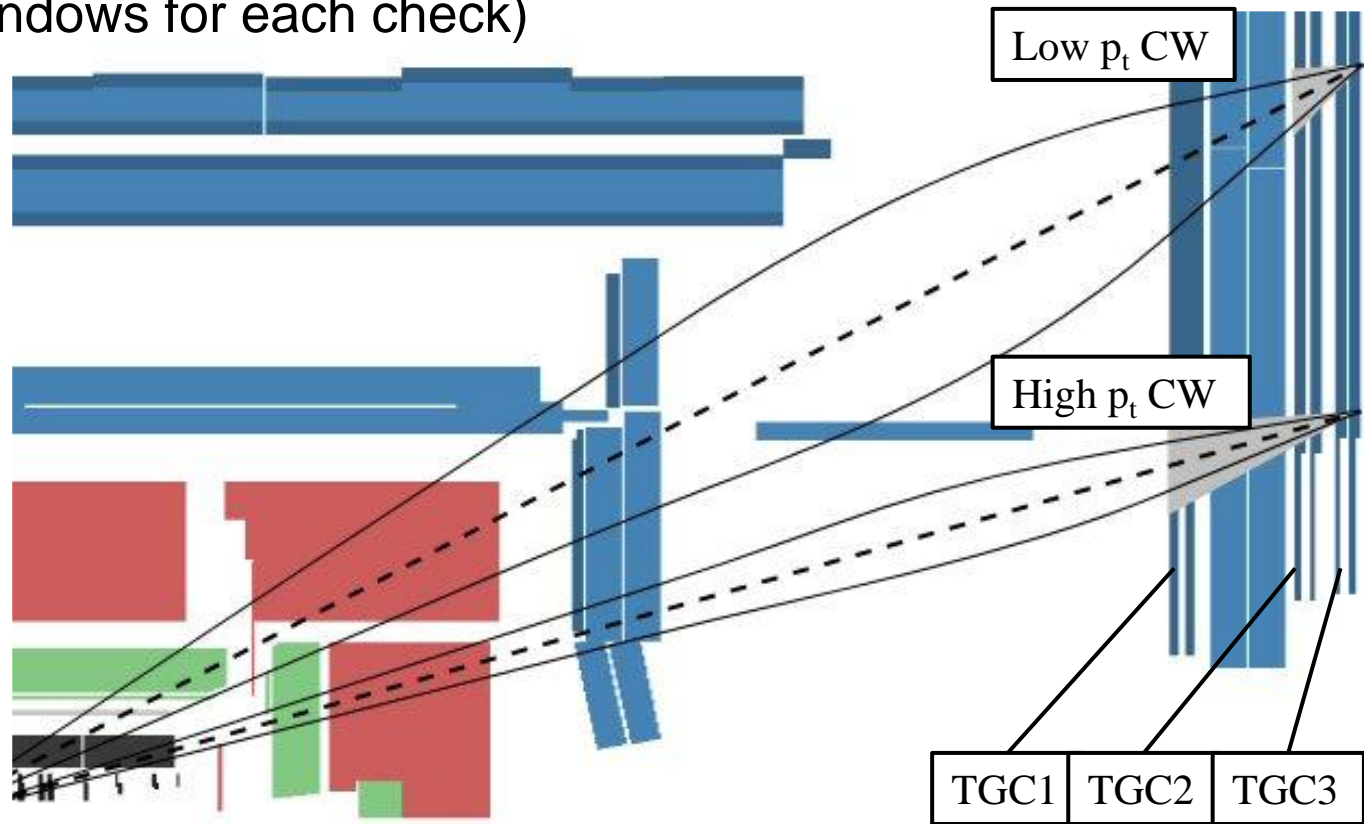
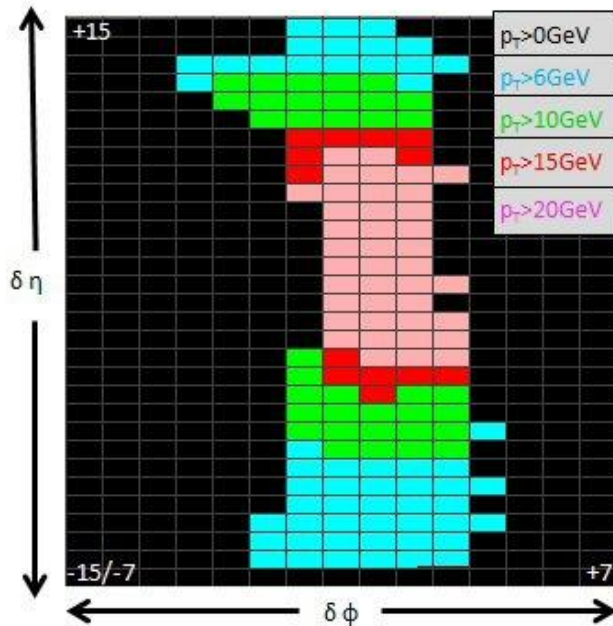
- If muons with high transverse momentum (p_T) are detected:
 - Higher chance of interesting process

➔ 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)



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

TGC Efficiency Study

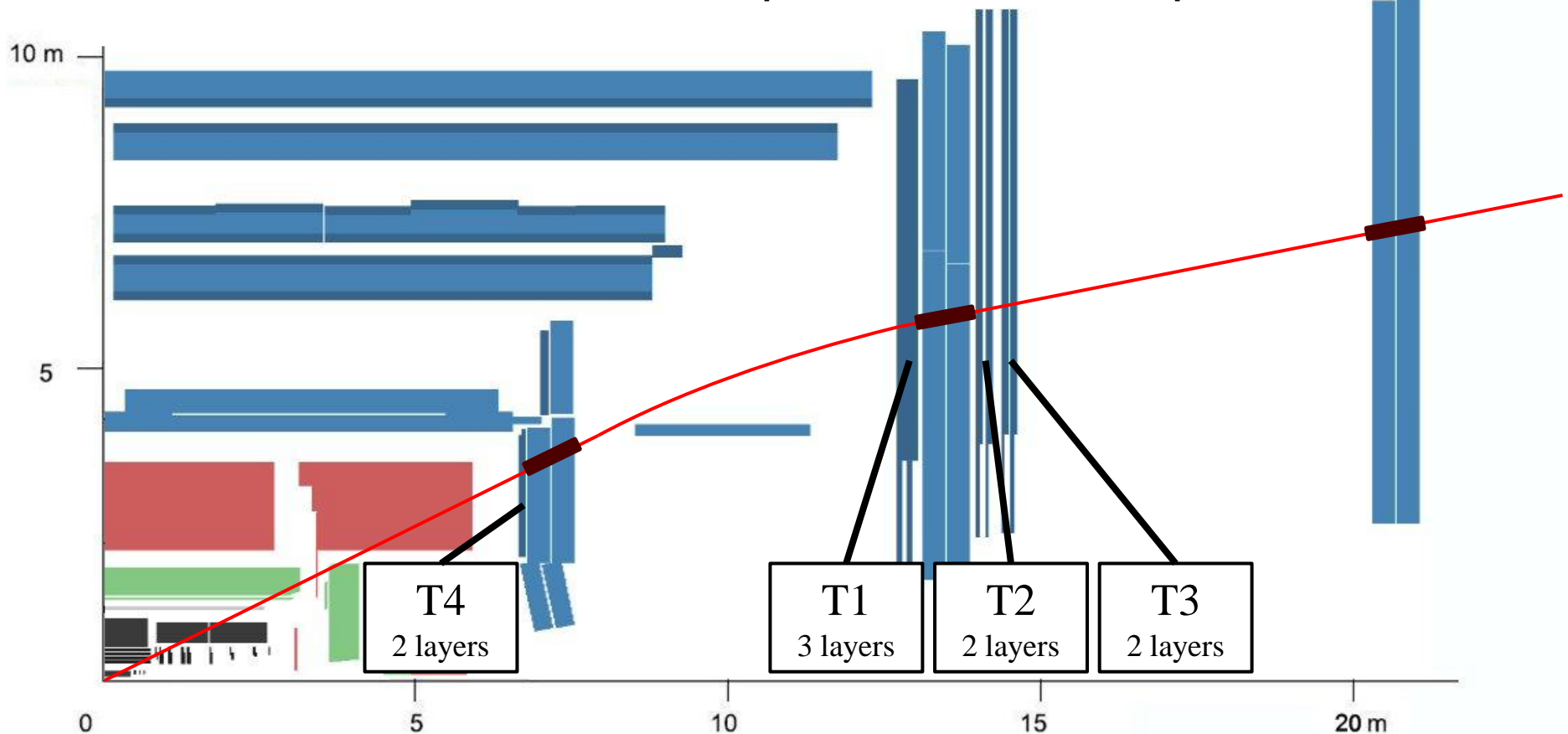
TGC Efficiency Study

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

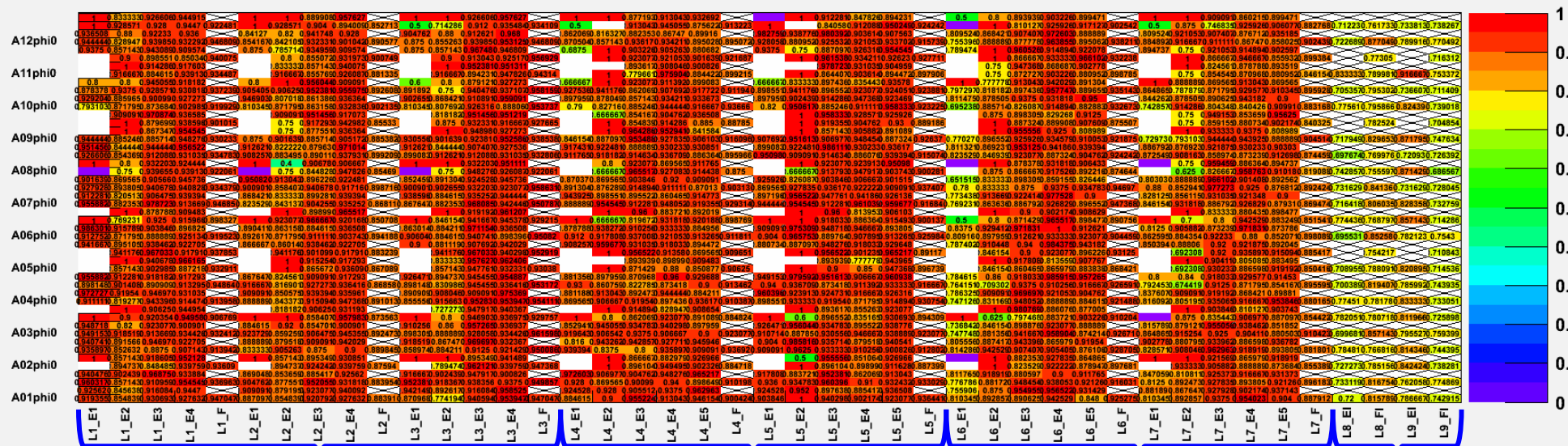
Study Method

- 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

Wire_EfficiencyAgainstMDT_MapBase_A



Legend

Each cell represents a TGC sector

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

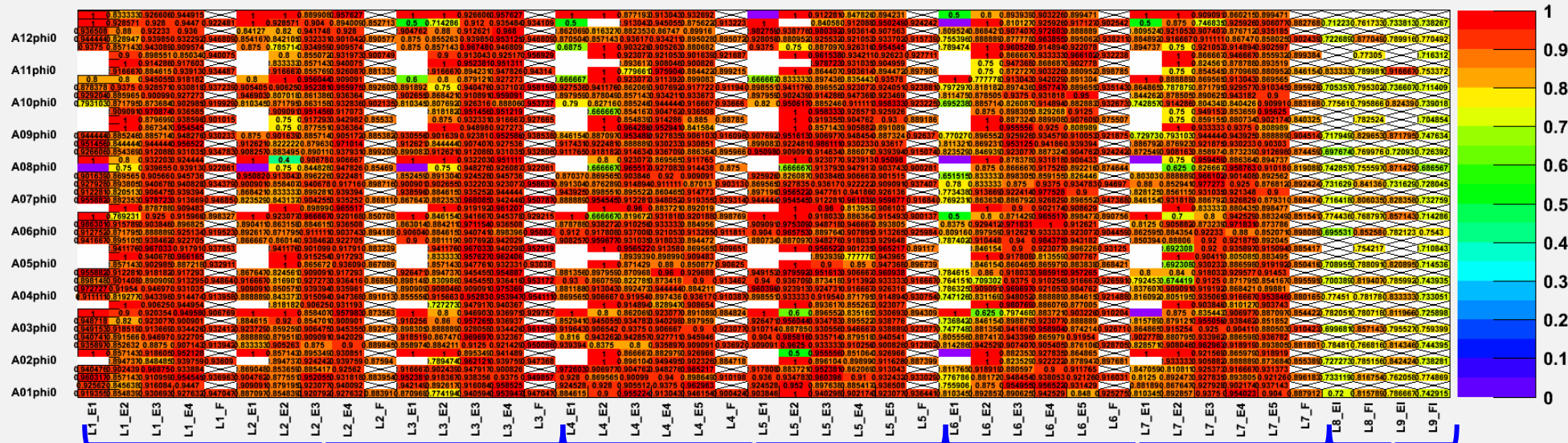
y-axis is TGC phi positions

□ indicates no tracks were detected

□ indicates no detector is present

Results (Segment Track Method)

Wire_EfficiencyAgainstMDT_MapBase_A

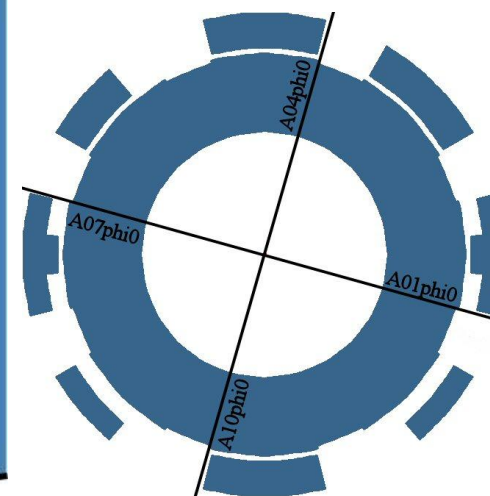
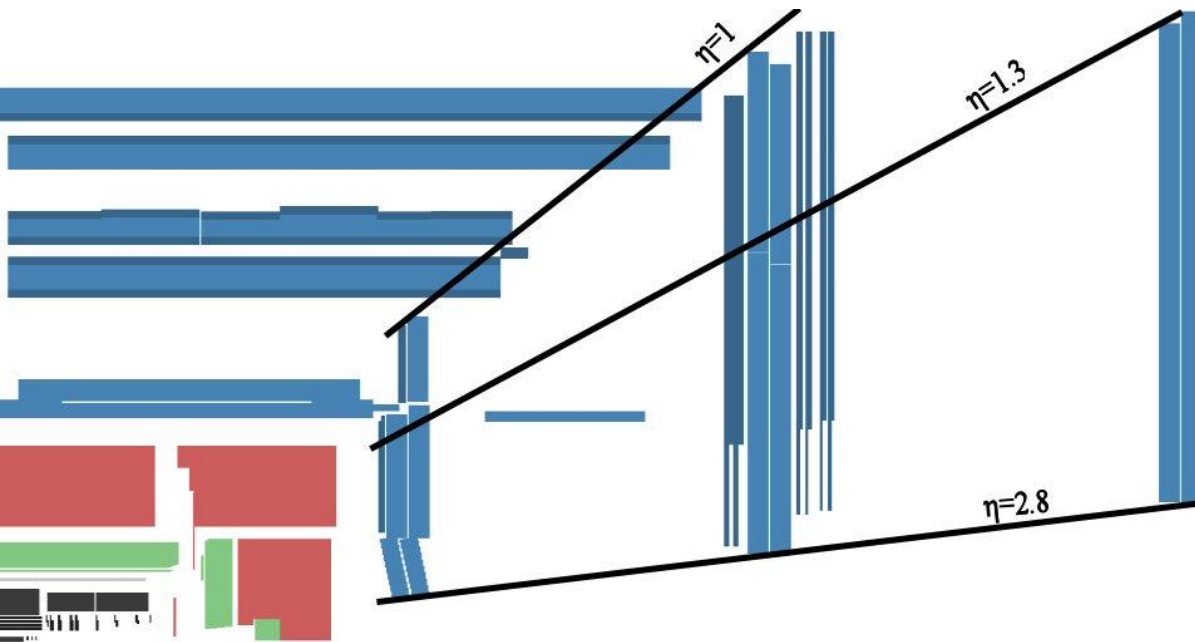


Results show :

- 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 $\eta \approx 1.3$ & $\eta = 1$



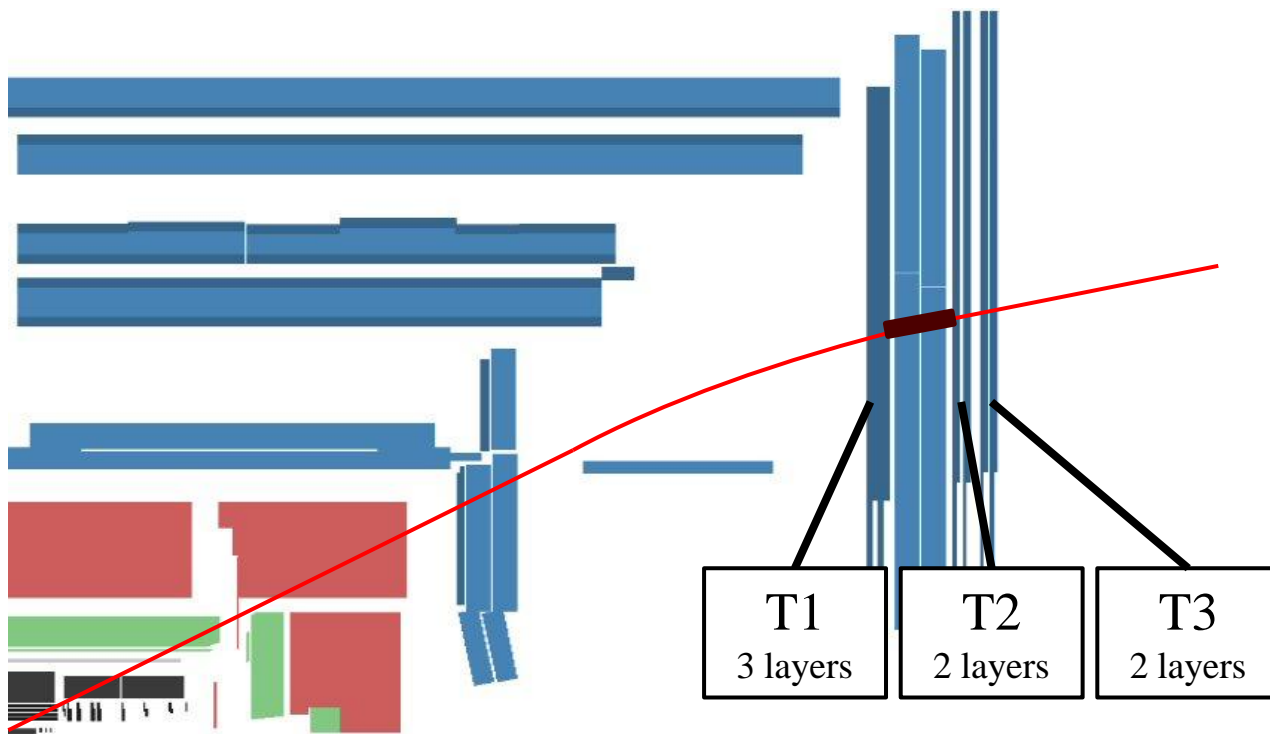
Inner detector cross section

	L1_E1	L1_E2	L1_E3	L1_E4	L1_F
A12phi0	0.833333	0.926600	0.944915	0.922481	0.922481
A11phi0	0.928571	0.928	0.9447	0.922481	0.922481
A10phi0	0.936508	0.88	0.92233	0.936	0.936
A09phi0	0.944444	0.828947	0.939850	0.922292	0.948800
A08phi0	0.9375	0.857143	0.943080	0.909574	0.940075
A07phi0	0.9	0.898551	0.850340	0.940075	0.940075
A06phi0	0.914286	0.917603	0.917603	0.917603	0.917603
A05phi0	0.866667	0.846150	0.939130	0.934487	0.934487
A04phi0	0.8	0.8	0.945055	0.918182	0.918182
A03phi0	0.878378	0.9375	0.928571	0.930810	0.937230
A02phi0	0.929204	0.885965	0.900990	0.927273	0.927273
A01phi0	0.793103	0.871790	0.873684	0.902980	0.919920
	0.909091	0.970874	0.936585	0.936585	0.936585
	0.879690	0.938590	0.901015	0.901015	0.901015
	0.867347	0.954545	0.954545	0.954545	0.954545
	0.844444	0.885240	0.885714	0.948270	0.930233
	0.951456	0.844444	0.944444	0.956522	0.956522
	0.926600	0.854360	0.912060	0.931030	0.934703
	0.932203	0.924444	0.924444	0.924444	0.924444
	0.75	0.939655	0.939130	0.922061	0.922061
	0.901630	0.869565	0.905660	0.945736	0.945736
	0.927920	0.893800	0.940670	0.940820	0.943700
	0.912280	0.820510	0.906470	0.939394	0.939394
	0.955880	0.882350	0.978720	0.913690	0.946850
	0.878780	0.909483	0.909483	0.909483	0.909483
	0.769231	0.925	0.915960	0.898327	0.898327
	0.986300	0.915780	0.903840	0.896825	0.896825
	0.912750	0.871790	0.888880	0.925130	0.919520
	0.941660	0.895100	0.938460	0.922705	0.922705
	0.941160	0.867030	0.917910	0.937680	0.937680
	0.940670	0.866165	0.866165	0.866165	0.866165
	0.857143	0.902980	0.872100	0.932911	0.932911
	0.955080	0.912280	0.918182	0.917293	0.917293
	0.898140	0.901400	0.890900	0.913290	0.948640
	0.972727	0.91954	0.946970	0.931035	0.931035
	0.911110	0.919270	0.943390	0.914470	0.913950
	0.906250	0.944954	0.944954	0.944954	0.944954
	0.9	0.920354	0.940580	0.906780	0.906780
	0.948718	0.82	0.923070	0.900901	0.900901
	0.949150	0.918510	0.913660	0.934420	0.932412
	0.940740	0.891568	0.946970	0.922705	0.922705
	0.935890	0.852632	0.8875	0.907140	0.913942
	0.857143	0.918600	0.952128	0.952128	0.952128
	0.894730	0.848480	0.939750	0.93600	0.93600
	0.940470	0.902430	0.968750	0.933884	0.933884
	0.960310	0.857143	0.910950	0.954540	0.938960
	0.925620	0.845630	0.916084	0.9447	0.9447
	0.919350	0.854830	0.930690	0.927632	0.947040

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

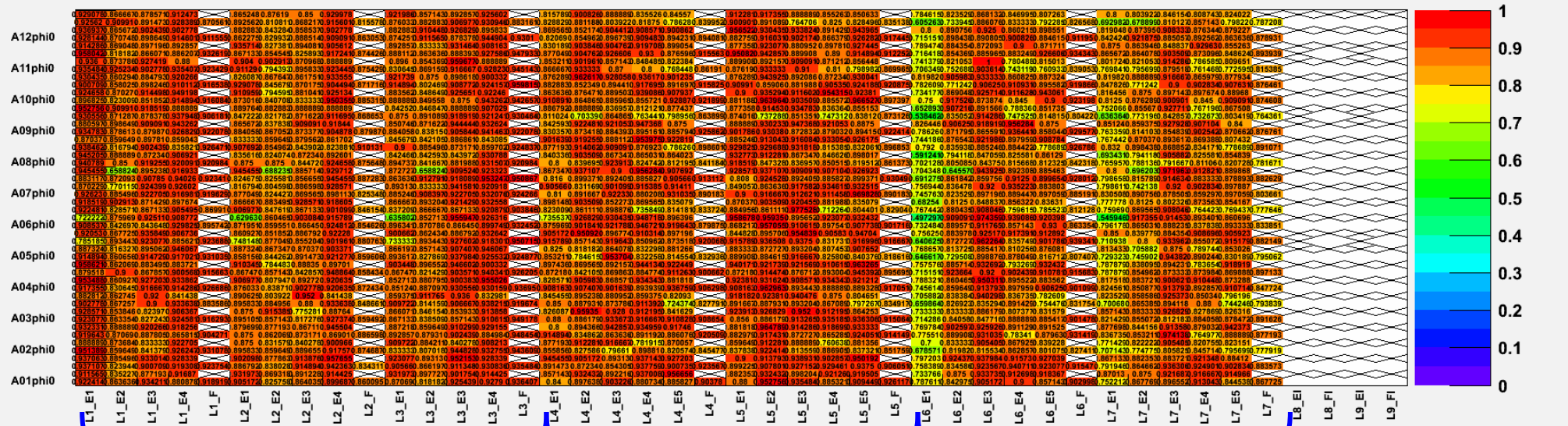
Midstation Segment only Method

- 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)

Wire_EfficiencyAgainstMDTv0_MapMid_A



- 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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