The ATLAS Trigger System: Performance and Evolution

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THE ATLAS TRIGGER AND DATA ACQUISITION SYSTEM

The ATLAS Trigger and DAQ System reduces the LHC collision rate to an affordable recording rate. It is composed by a Level1 (L1) hardware implemented on custom build electronics and an High Level Trigger (HLT) implemented in software on a large PC farm. HLT runs on fine grained data and is divided in:

- Level2 (L2) where fast and *ad-hoc* designed algorithms run on a limited portion of the event read out.
- Event Filter (EF) where algorithms imported from the offline reconstruction run on full reconstructed events.

The performance of the ATLAS TDAQ system is exceeding its design

Event Rates

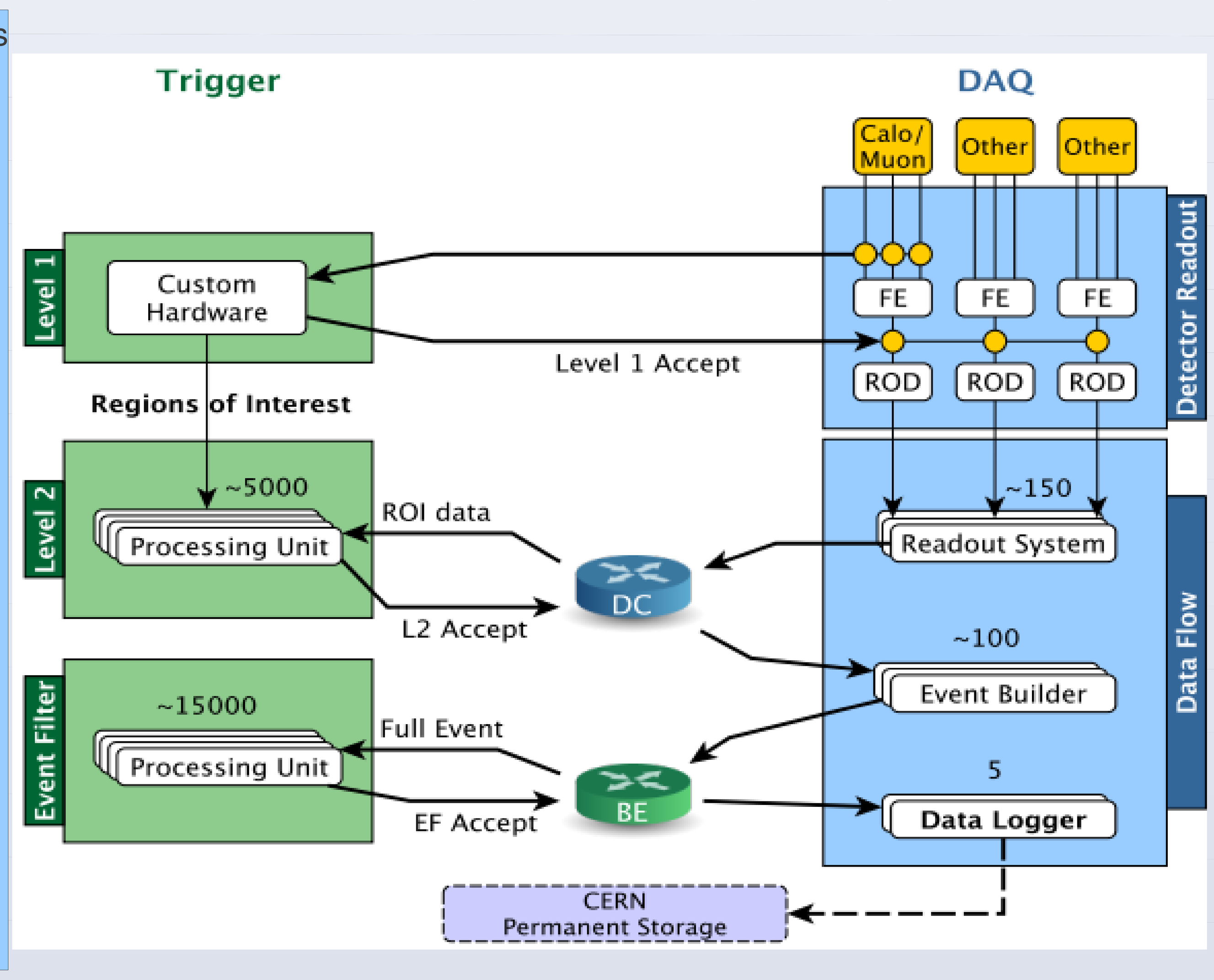
Design
2011 Peak

40 MHz
20 MHz

75 kHz
65 kHz

3 kHz
5.5 kHz

200 Hz
600 Hz



Data Flow

Design
2011 Peak

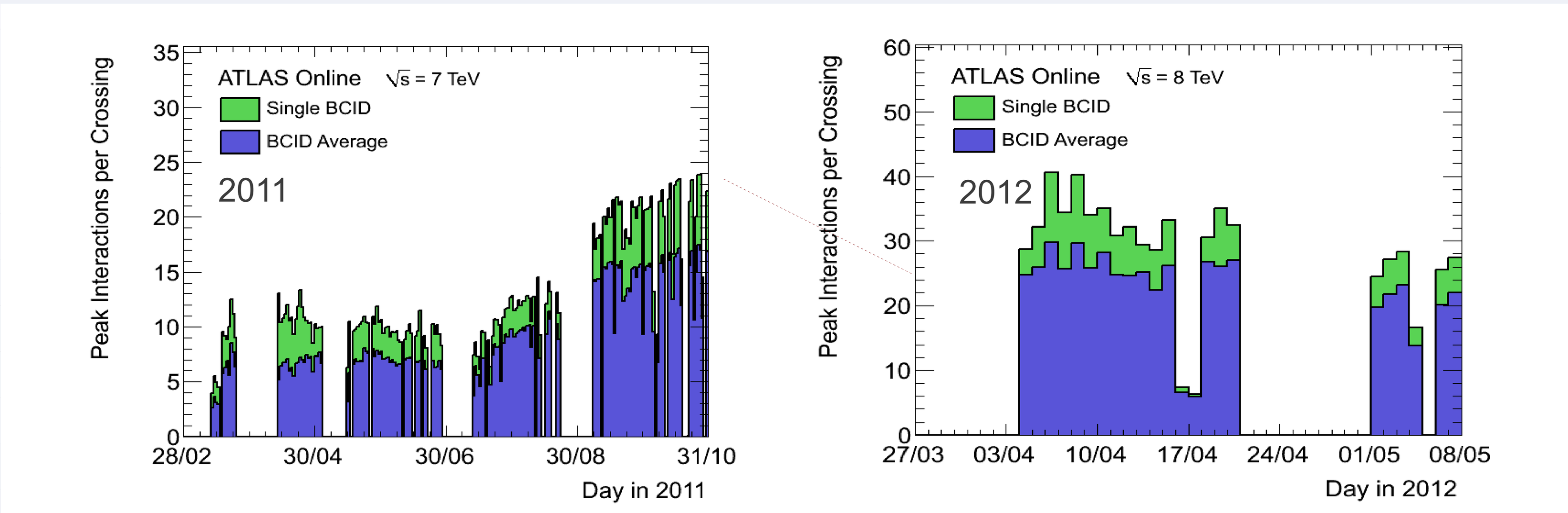
1.5 MB/25 ns
1.2 MB/50 ns

110 GB/s
85 GB/s

4.5 GB/s
6.5 GB/s

300 MB/s
700 MB/s

LHC AND ATLAS: 2011 *VS* 2012



Pile up <μ> has constantly increased during 2011 and 2012 causing:

- Rapid rate increase for low momentum objects (i.e. more then linearly)
- Selections have to be pileup robust → Carefully check inclusion of isolation

Running with √s=8TeV in 2012 increases the rates by ~20% because of the production cross section increase

TDAQ rate capability was gained with a limited improvement of the hardware.

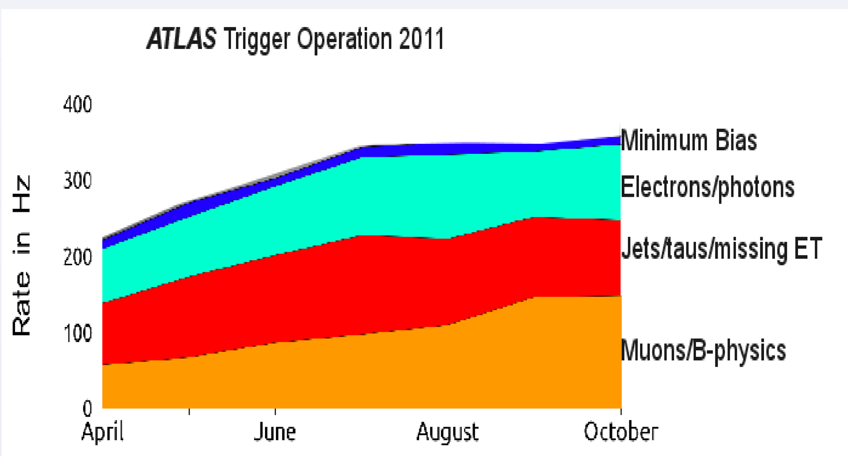
- Read Out Server (ROS) refurbishing allowing increase the access rate from HLT farms from 22kHz to ~40 kHz
- Replacement of 16 HLT racks with more performing processing nodes and more cores

TRIGGER SIGNATURES

Trigger selections are organized in inclusive physics signatures: e.g. Electron/gamma, muon, tau, jet, MissingET, B-jet, B-physics, MinBias

Lowest threshold unprescaled trigger *per* signatures are usually the primary trigger selection for physics measurements

In 2011 although the luminosity was increasing, TDAQ managed to keep the rates below ~400 Hz. With 2012 further luminosity increase TDAQ had to modify trigger selections



- Small increase of momentum thresholds. Larger increase are not possible since they would reduce too much the efficiency.
- Tighter selection with hadronic rejection (electron/gamma) and isolation (electron/muon). Since these are pile up sensitive, their effect has to be carefully checked.

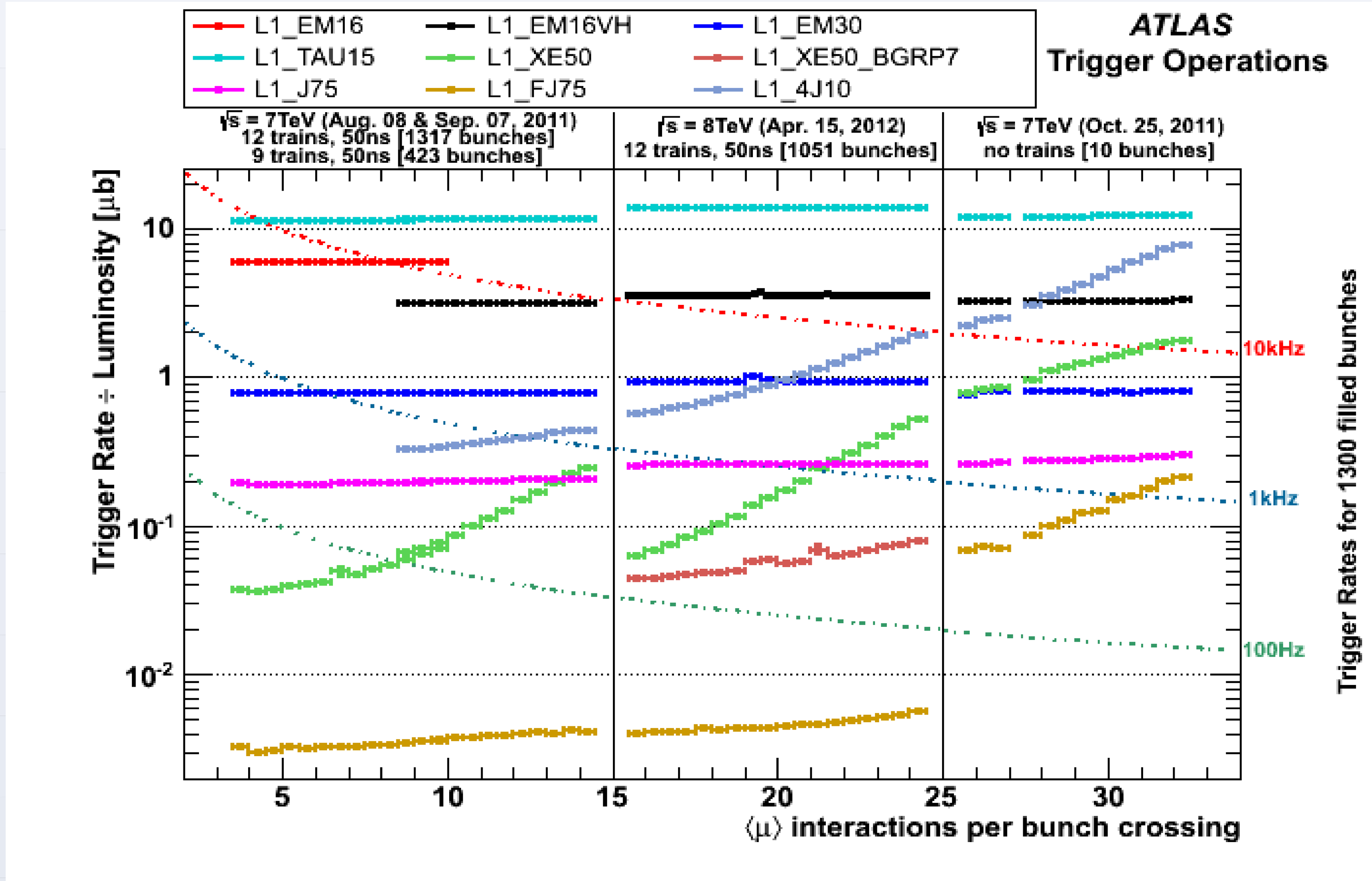
Thresholds of the lowest unprescaled chain selection *per* signature.

Trigger Signatures (multiplicities)	2011 L1 Thresholds (GeV)	2011 HLT Thresholds (GeV)	2012 L1 Thresholds (GeV)	2012 HLT Thresholds (GeV)
Electron (1)	16, had	20/22 had	18, had 30	24, had, iso 60
Electron (2)	2 x 10, had	2 x 12	2 x 10, had	2 x 12, had
Gamma (1)	30	80	30	120
Gamma (2)	2 x 12	2 x 20	2 x 10, had 12 + 16	2 x 20, had 30 + 20
Muon (1)	11	18	15 15	24 iso 36
Muon (2)	2 x 4	2 x 10	2 x 6	2 x 13
Tau (1)	30	100/125	40	125
Tau (2)	2 x 11	29 + 20	11 + 15, iso	29 + 20, iso
Jet (1)	75	240	75	360
Jet (5)	5 x 10	5 x 30	4 x 15	45 x 55
MET (Global)	50	60	60 (50)	80

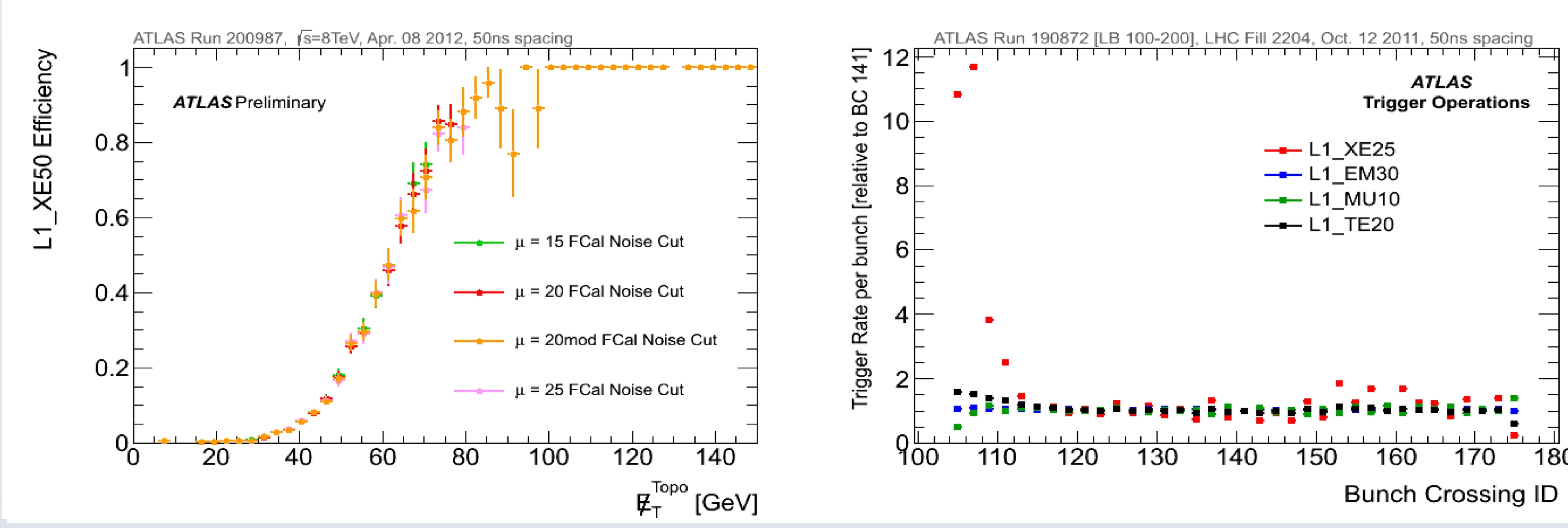
SUMMARY

The ATLAS TDAQ system worked with excellent performances in 2011. To keep the same achievements in 2012, with more severe LHC conditions (pile up and luminosity), some improvements had to be implemented . First, tighter algorithms have been used, having in mind that they need to be robust against pile up. Then, a continuous campaign of smooth hardware upgrades allowed to run TDAQ with larger rates.

LEVEL 1



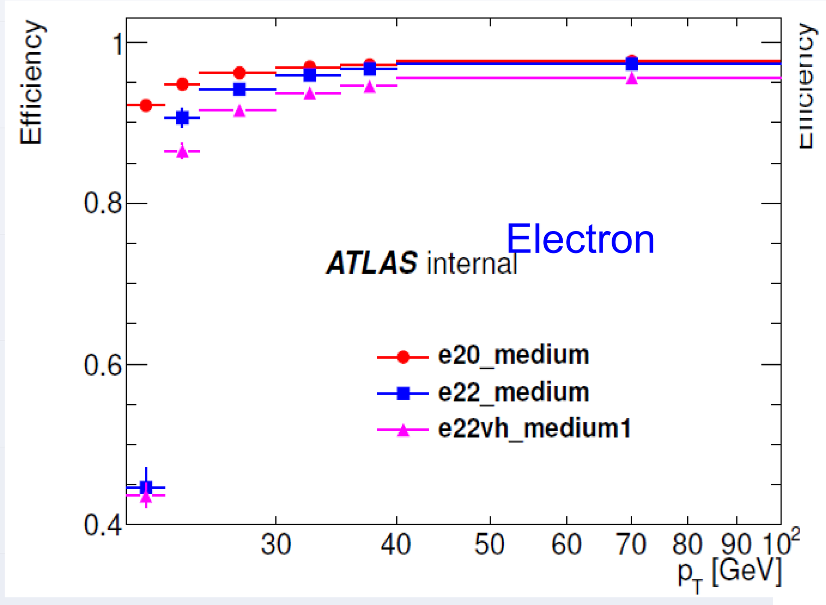
L1 Trigger cross sections *vs* pile up (2011 and 2012 data). The chains affected by pile up are mostly calorimetric items.
Many efforts in 2012 to keep L1 rates under control

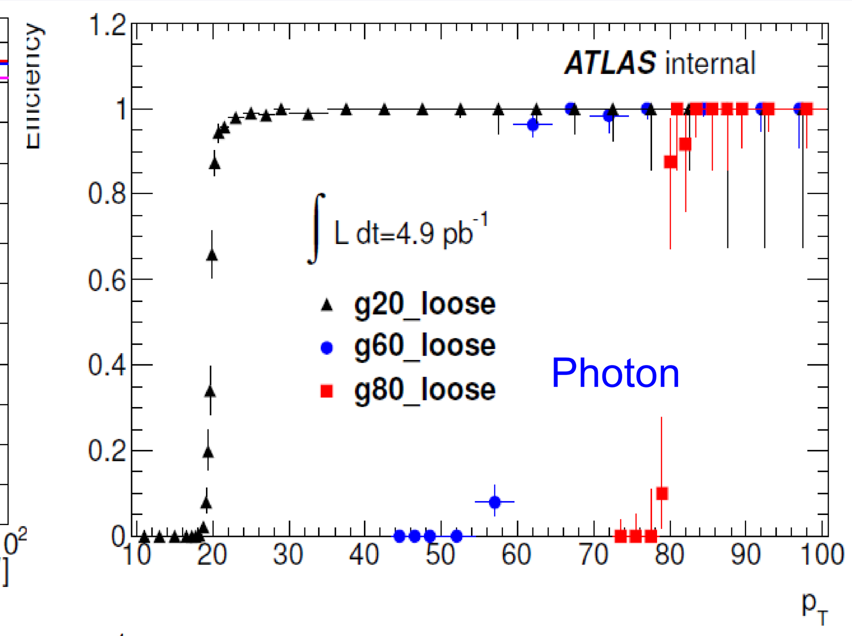


Main improvements for 2012:

- Applied stronger calorimeter noise cuts in particular in the forward regions → Checks that L1 efficiencies are only marginally <μ> dependent
- Some L1 triggers (L1_XE25 which requires ME_T>25 GeV) have significant larger rates near the start of bunch trains due to the unbalanced overlaying of bipolar calorimeter trigger signals shapes from neighboring bunches→ Veto triggers on first bunches with a small impact on luminosity collected (-~8%)
- HLT now access L1 trigger towers and global information (for ME_T and Total Energy triggers) directly from Front-End electronics Boards allowing a larger L1 ME_T rate input to HLT.

2011 TRIGGER PERFORMANCE

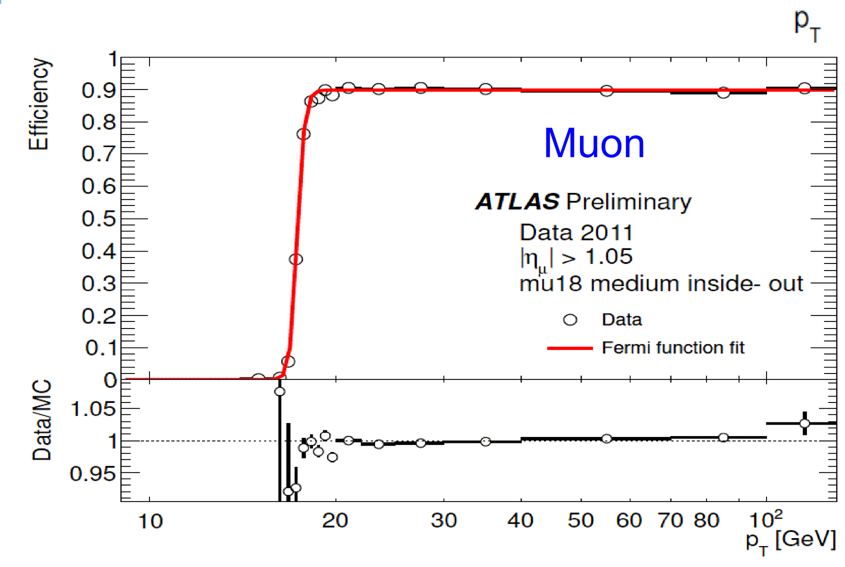




Trigger efficiencies are measured from data *wrt* offline selection. They are displayed as a function of offline reconstructed P_T/E_T

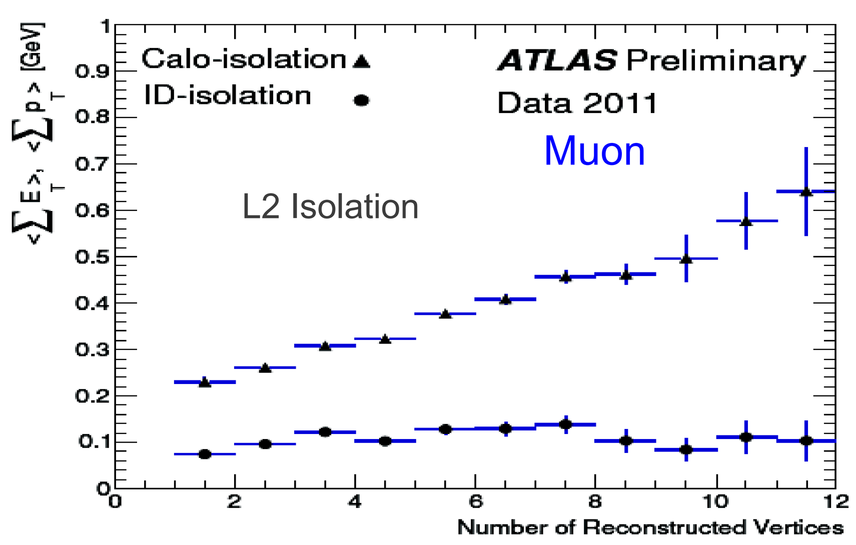
- Electron and Muon trigger efficiencies are measured with the *Tag & Probe* method (with Z → ee, Z → μ μ)
- Photon efficiencies are measured with the *bootstrap* method . First, the L1 efficiency of events collected by an orthogonal trigger (muon,jet,minimum bias) is measured *wrt* offline selection cuts. Then the HLT selection efficiency is measured wrt events that pass L1 and offline requirements such that:

Eff (gamma|offline) =
Eff(L1|offline&MinBias) x Eff(HLT|L1&offline)



Muon trigger *plateau* efficiency is limited by geometrical acceptance

Muon and electron trigger efficiencies are marginally dependent on isolation (Calorimetric isolation is more affected by pile up than ID tracking isolation)



Electron and muon trigger efficiencies are marginally affected by pile up (further improved in 2012)