The ATLAS Trigger system upgrade and performance in Run 2

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On behalf of the ATLAS collaboration

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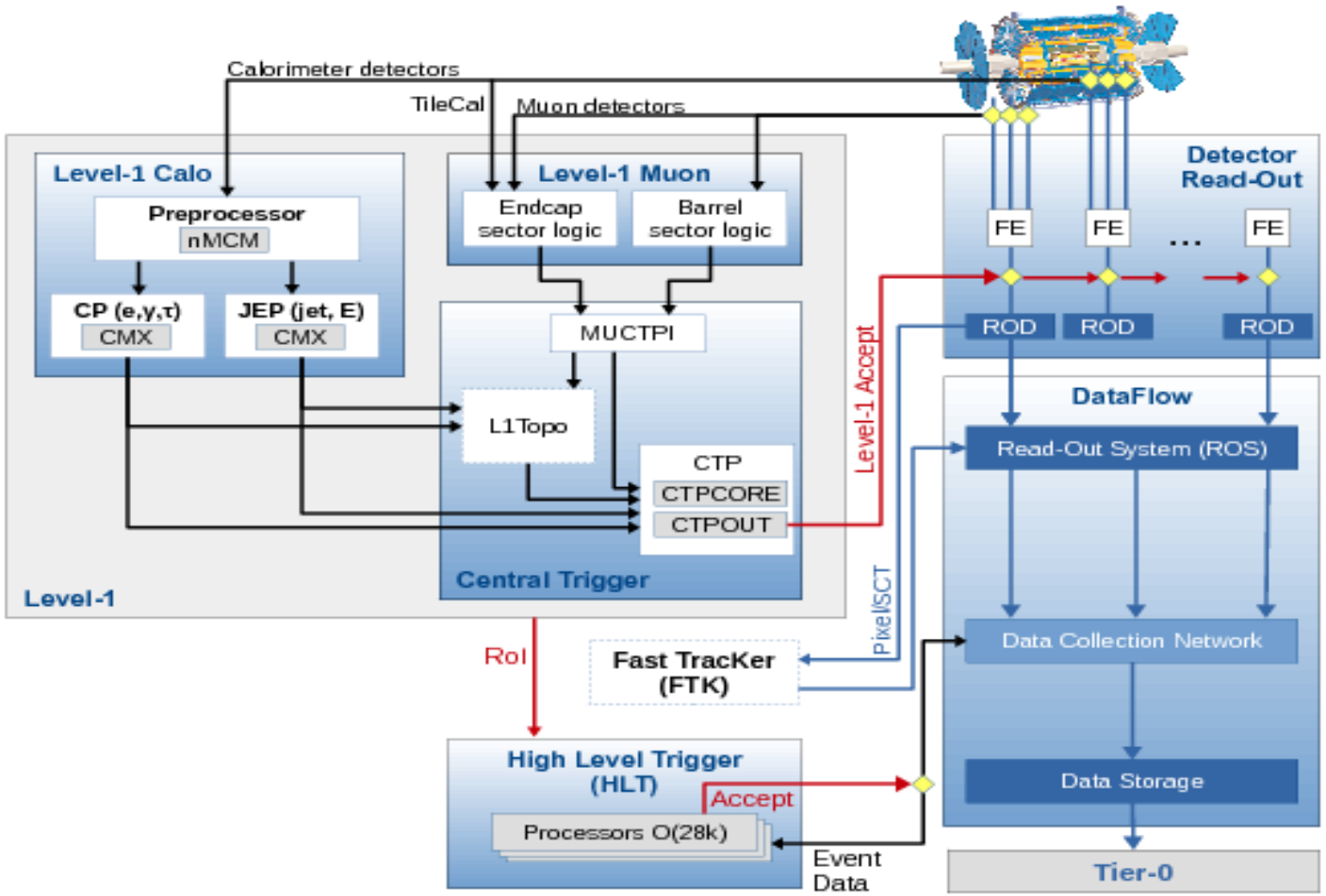
Introduction

- Trigger selects events of interest for wide range of physics processes studied by the ATLAS experiment.
- Need to be able to deal with ever changing conditions from LHC
  - Increasing luminosity and pile up increase rates
- Need to maintain a high efficiency over all different physics signatures while keeping within various constraints
  - Hardware limitations, finite computing resources (at trigger level and at offline reconstruction level)

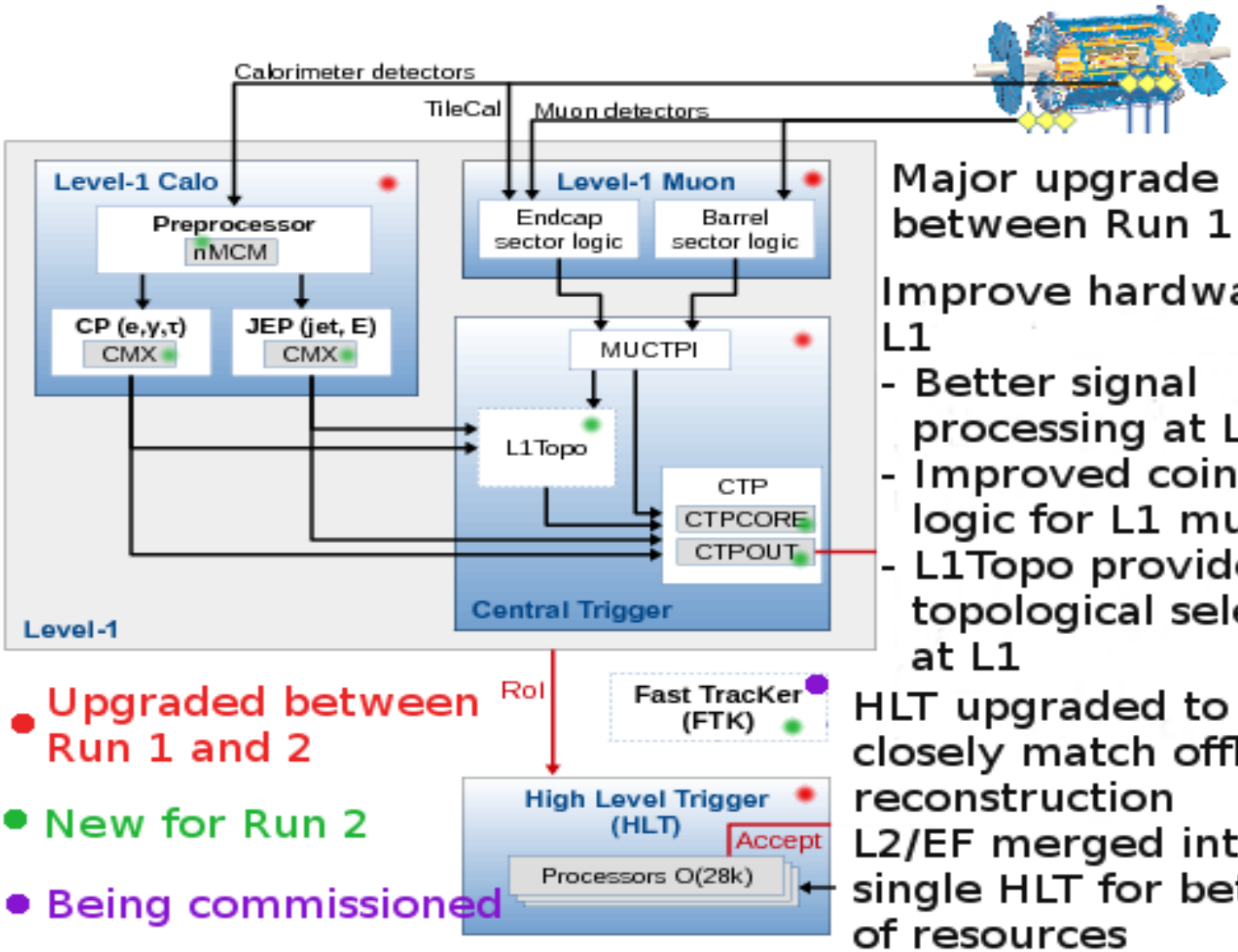
	$\sqrt{s}$ [TeV]	Peak luminosity $cm^{-2}s^{-1}$	Peak pileup
2012	8	0.77e34	35
2016	13	1.4e34	45
Expected 2017/18	13	2.0e34	60

Overview

- Trigger has two steps: hardware based Level 1 (L1) and software based High Level Trigger (HLT).



Improvements with respect to Run 1



Major upgrade between Run 1 and 2

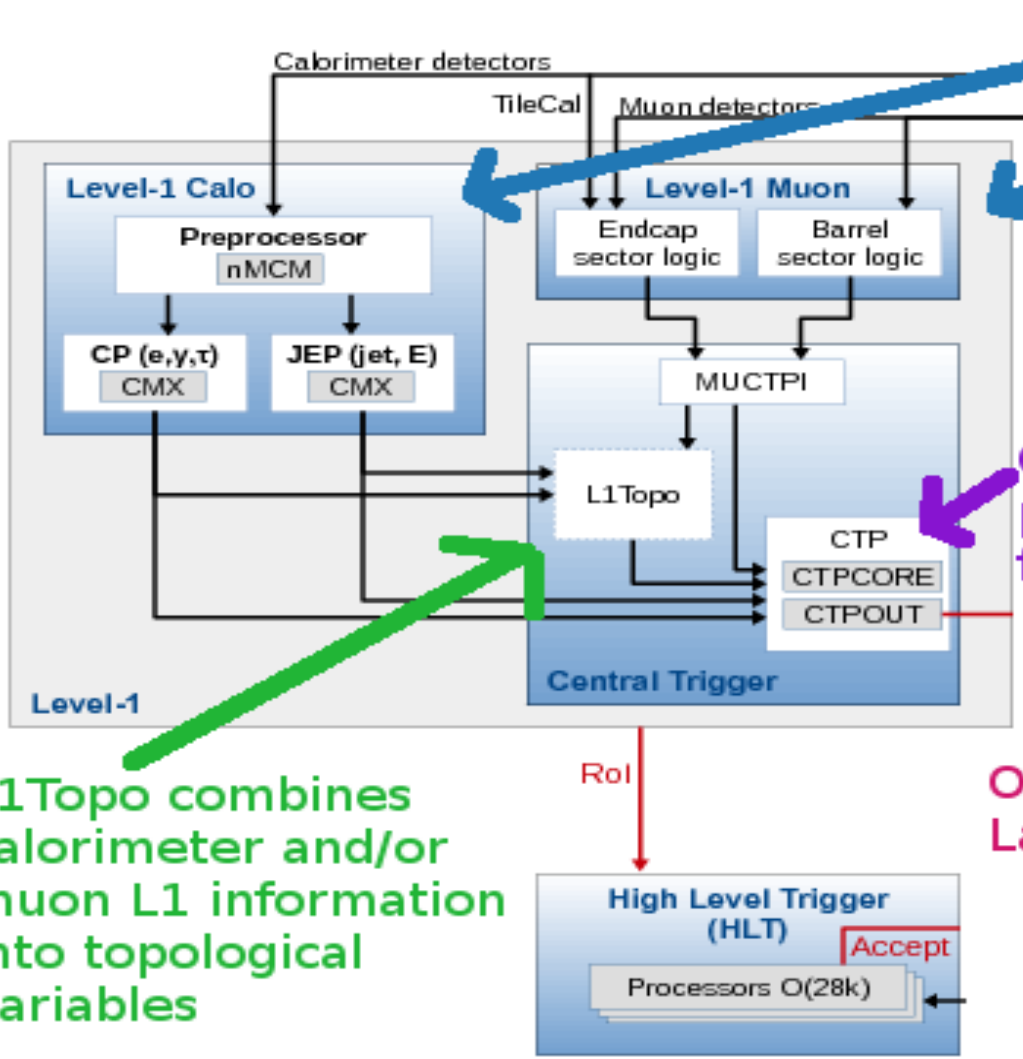
Improve hardware for L1

- Better signal processing at L1Calo
- Improved coincidence logic for L1 muons
- L1Topo provides topological selection at L1

HLT upgraded to more closely match offline reconstruction

L2/EF merged into single HLT for better use of resources

Level 1



Hardware based input from calorimeters and muon detectors

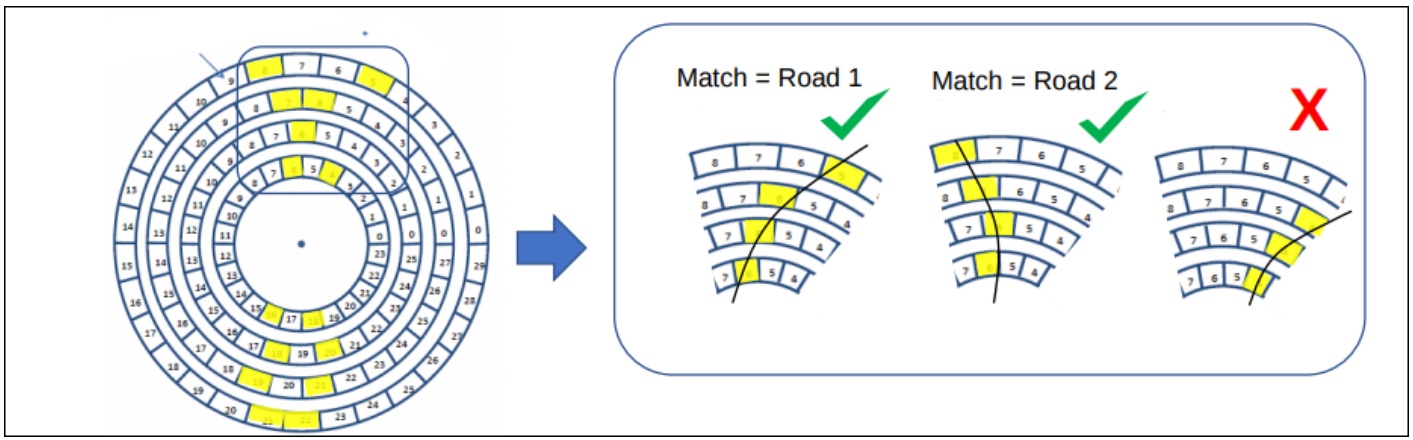
Central trigger processor (CTP) makes final L1 decision

L1Topo combines calorimeter and/or muon L1 information into topological variables

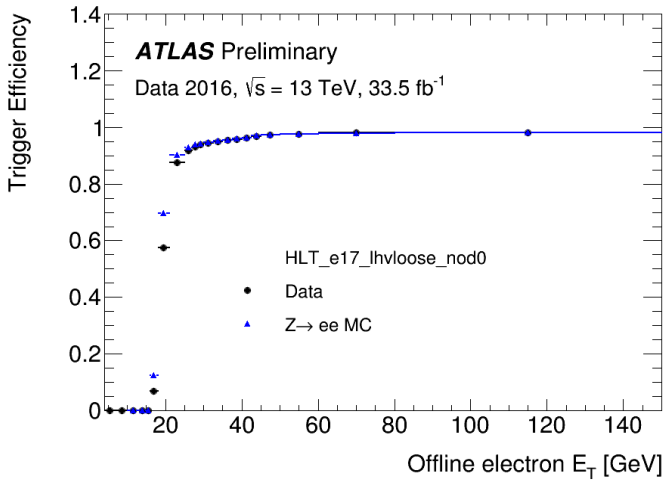
Output rate ~100 kHz
Latency ~2.5 us

HLT

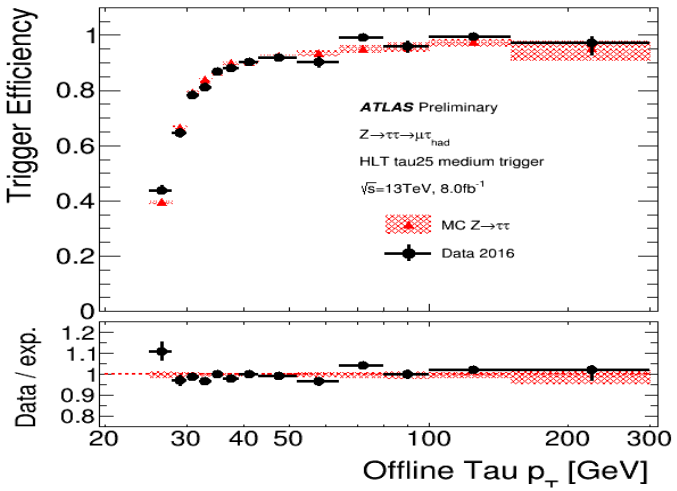
- Input from L1 in form of region of interest
  - Geometric region in η and ϕ with information about object type and passed thresholds
- Combines information from multiple subdetectors
- Software based, runs similar algorithms as offline reconstruction on a dedicated computing farm ($\sim$ 40k cores)
- $\sim$ 1 kHz output rate, latency $\sim$300 ms.
- Fast Tracker (FTK) currently being commissioned
  - Hardware based full event tracking
  - Can be used in place of CPU intensive HLT tracking



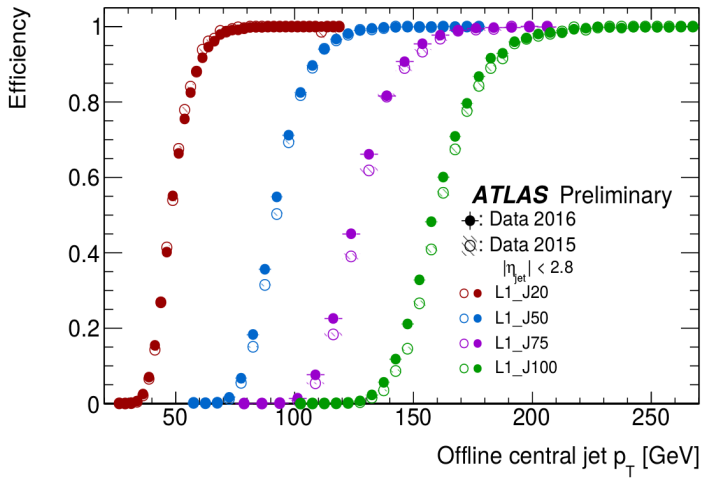
2016 Performance



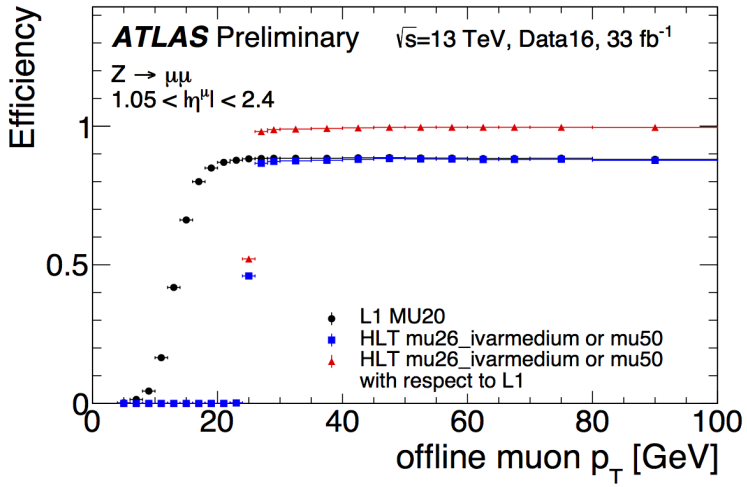
(a) Electron



(b) Tau



(c) Jet



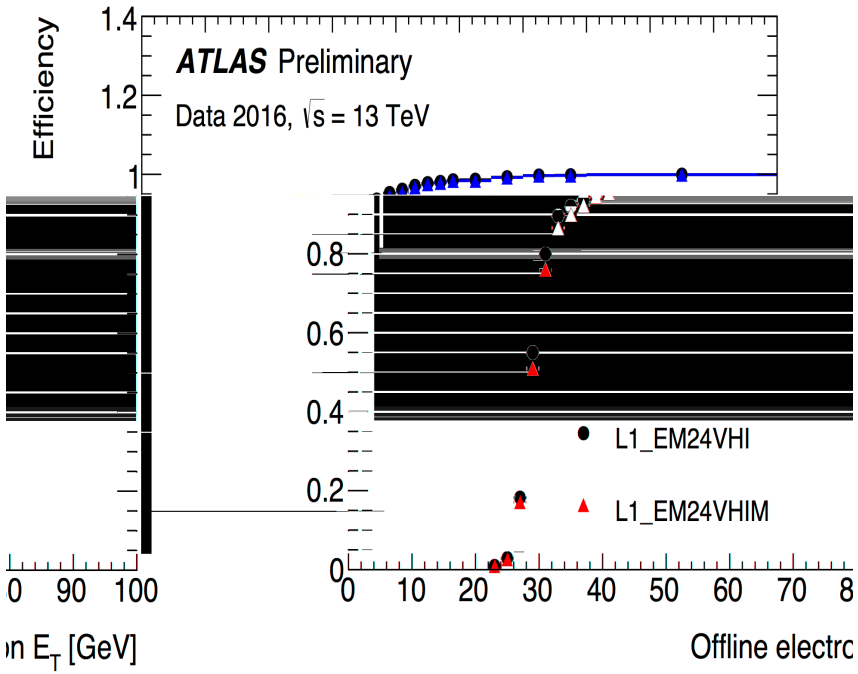
(d) Muon

Updates for 2017

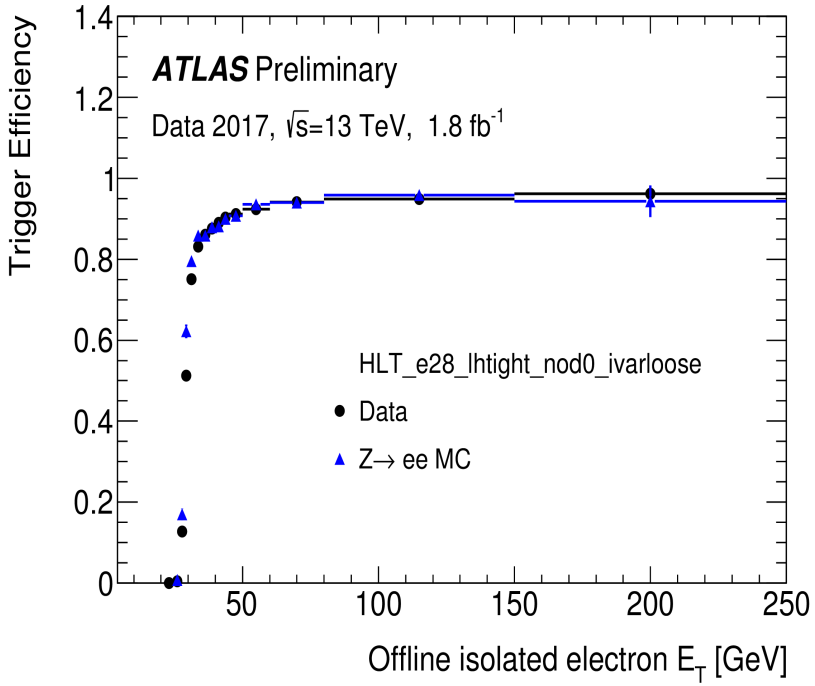
- In order to cope with higher luminosity and pileup several improvements implemented across different signatures.
- Ultimate goal to reduce rates (to keep thresholds as low as possible) and CPU time, and to reduce pile up dependence on rates, while maintaining a high efficiency.

Electron and Photon Improvements and Performance

- Tighter EM isolation at L1 to keep thresholds low
  - 10-15% reduction in rate without losing efficiency
- Improved likelihood tunes using 2016 data
- Isolation added at L1 and HLT for photon triggers
  - Keeps thresholds low for low mass di-photon searches



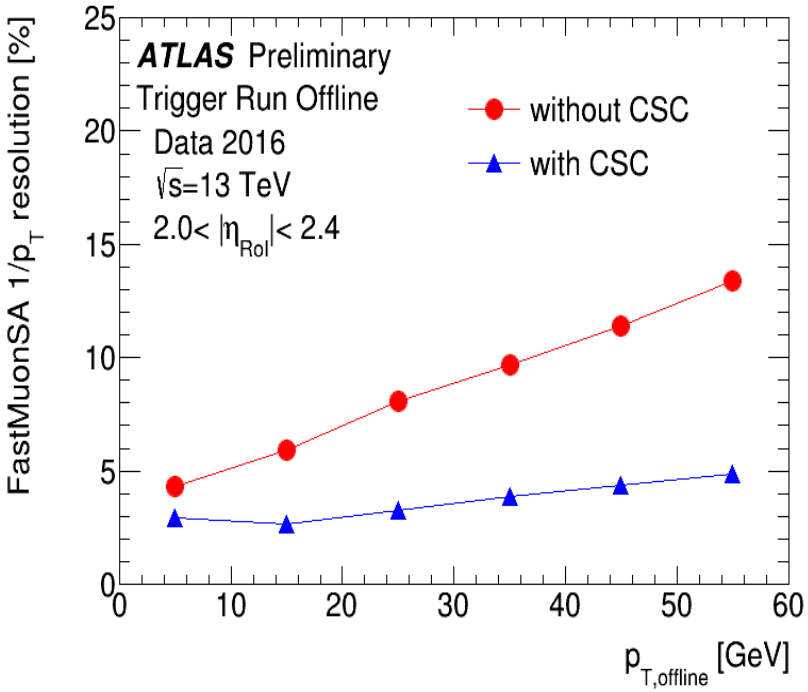
(a) L1 isolation comparison

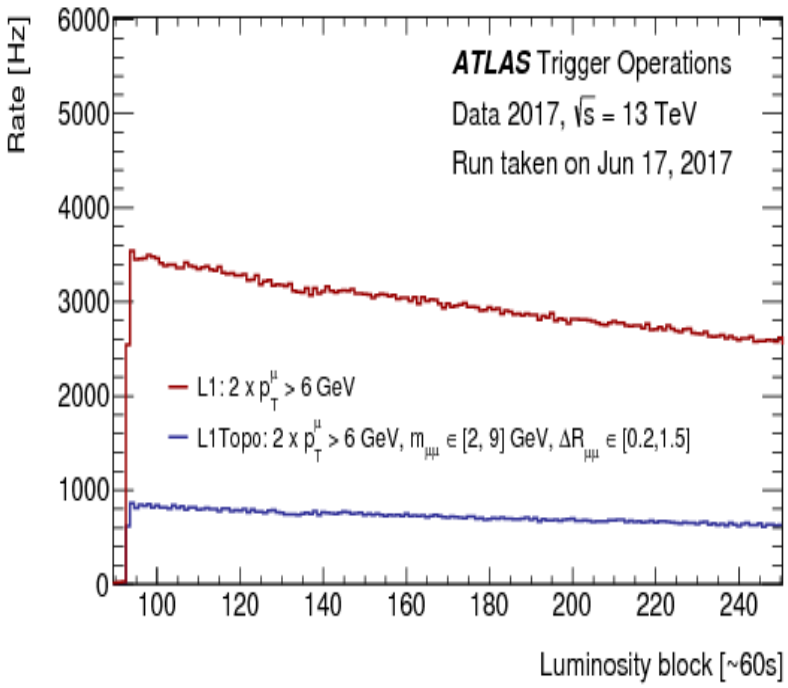


(b) HLT efficiency

Muon and B-physics Improvements and Performance

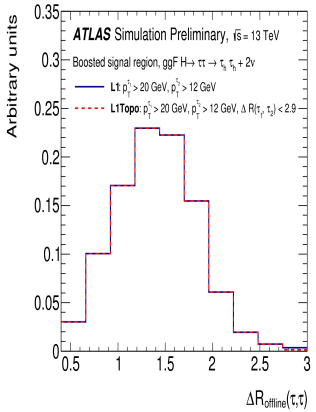
- Optimized coincidence of hits between different layers of the muon spectrometer, and overlap removal to keep rates at L1 low
- Improved fast muon finding resolution for forward muons
  - Improves early rejection of events, which cuts down the frequency with which more precise and more CPU intensive muon finding runs
- L1Topo triggers reduce rate for B-physics triggers.
  - Allows for lower thresholds of dimuon triggers at L1
  - Reduces rate at which HLT is run.



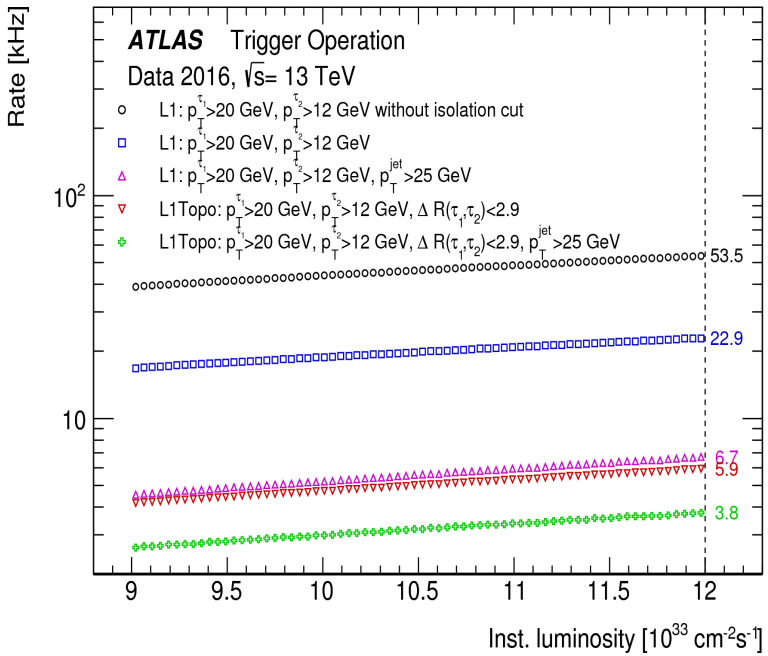


Tau and B-Jet Improvements and Performance

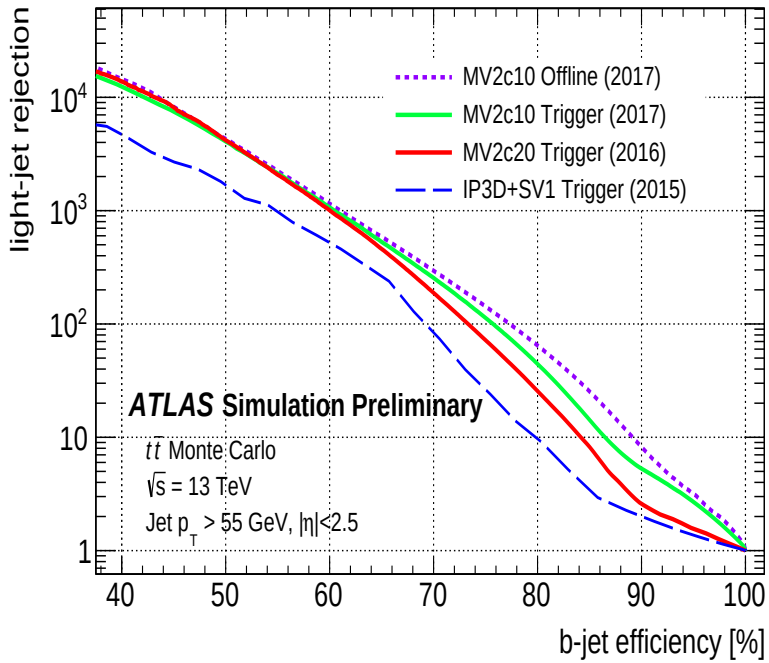
- L1Topo used for di-tau and tau+lepton triggers



- BDTs to distinguish b-jets from light jets and c-jets re-tuned for 2017



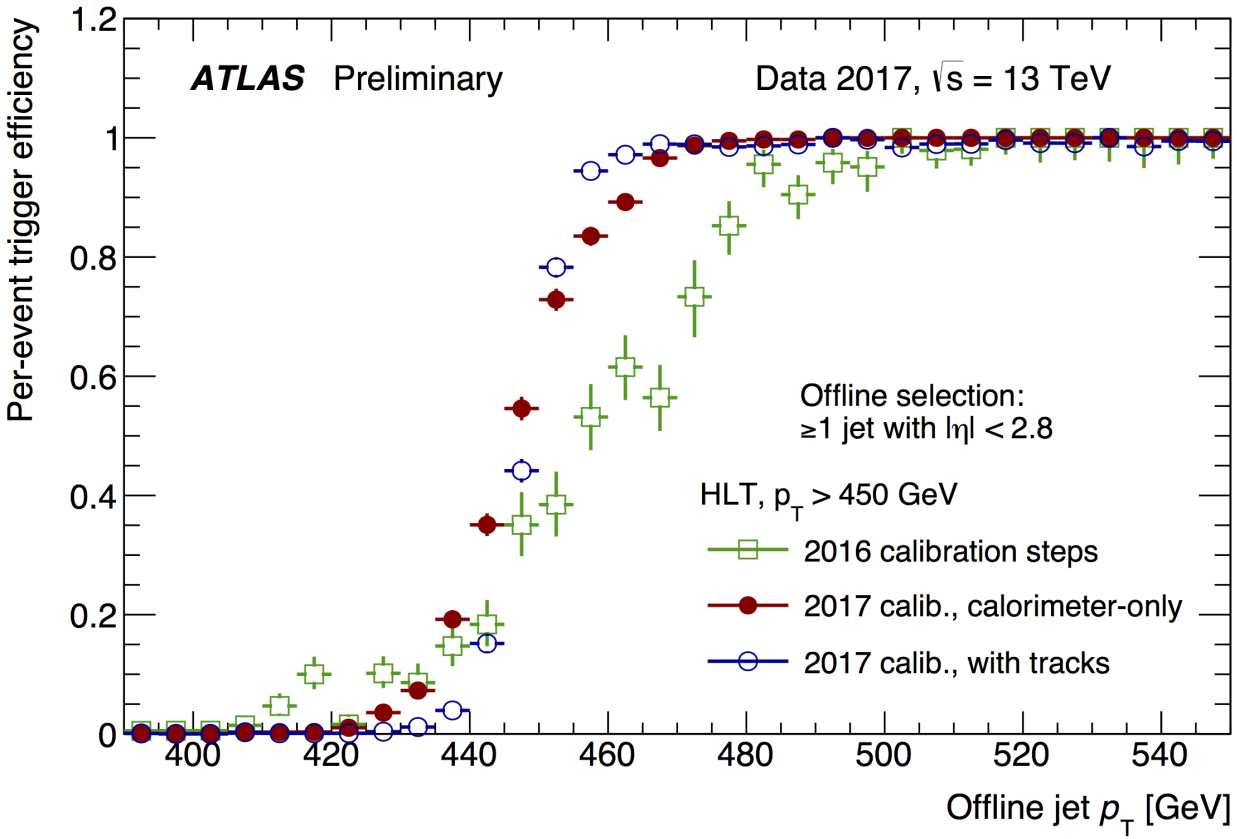
(a) Tau efficiency



(b) Bjet efficiency

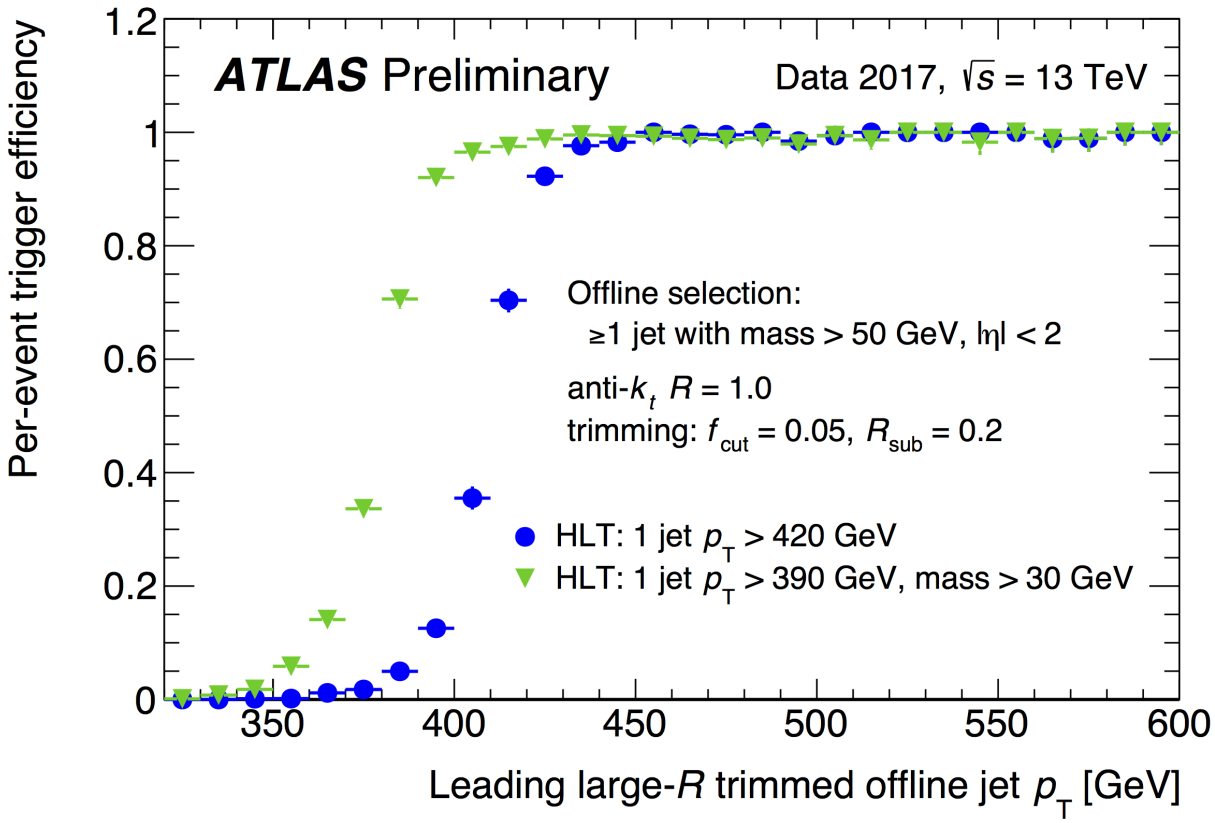
Jets Improvements and Performance

- Additional jet energy scale calibration applied for most jet (R=0.4) triggers
  - Uses tracking and jet shape information
  - Improves resolution of jets at HLT relative to offline
    - Can reach full efficiency at lower pT without increasing rate



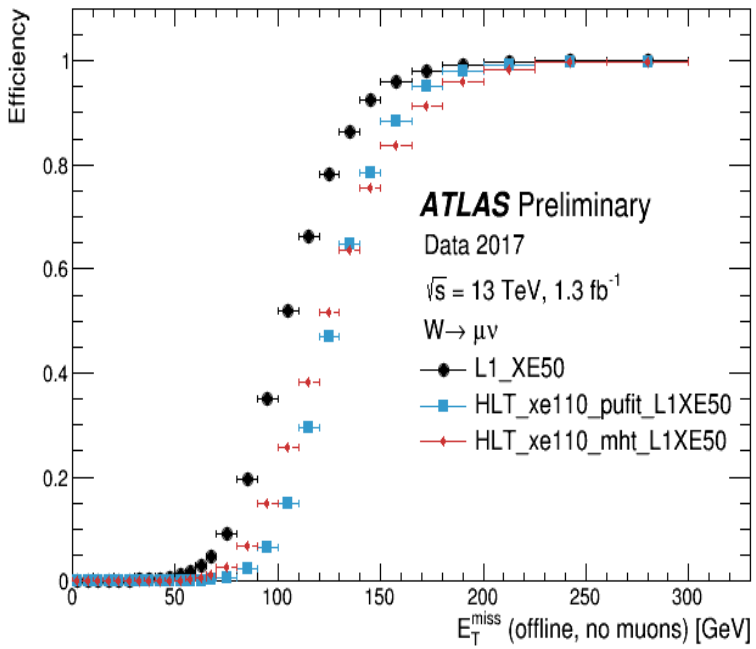
Jets Improvements and Performance

- Large R (R=1.0) jet triggers include jet grooming techniques to reduce rate dependence on pile up
  - Trimming reclusters jet constituents into subjets which are removed if the fraction of subjet pT is too low
  - Mass cut added to distinguish between jets from QCD vs jets from W/Z/H

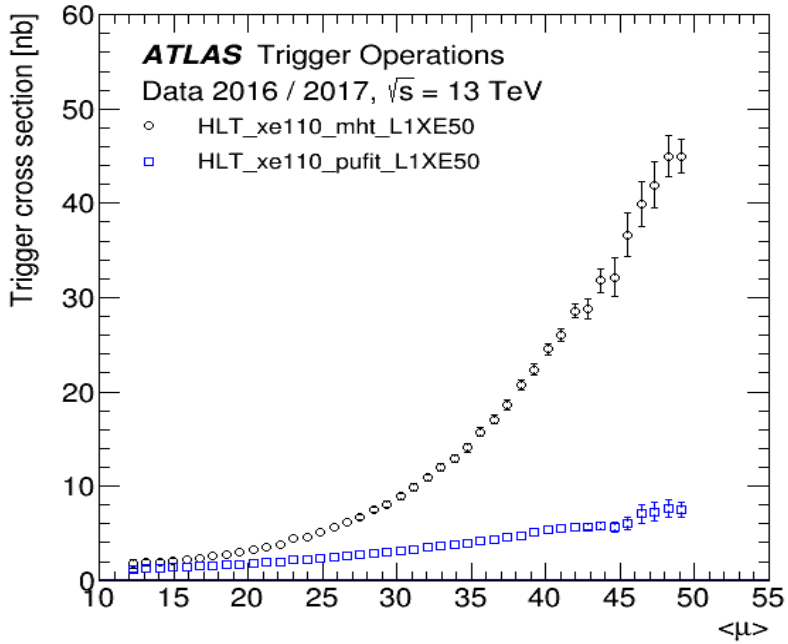


Missing E_T Improvements and Performance

- New algorithm, PUFit, to reduce pile up dependence of MET rate
  - MET calculated as negative sum of E_T of all topological calorimeter clusters is corrected for pile up on an event-by-event basis
    - Topoclusters grouped into towers and split into low and high pT towers.
    - Pileup contribution to high pT towers determined by fitting low pT tower, subtracted from high pT towers
  - Can keep lower thresholds at higher luminosity



(a) efficiency



(b) cross section

Summary

- ATLAS trigger operating smoothly throughout Run 2, collecting events suitable for a wide range of physics interests
- Many improvements to continue coping with increasing luminosity and pile up
  - Maintain high efficiency and keep thresholds low

Extra Information

Backup