The ATLAS Inner Detector Trigger performance in pp collisions at 13 TeV during LHC Run 2

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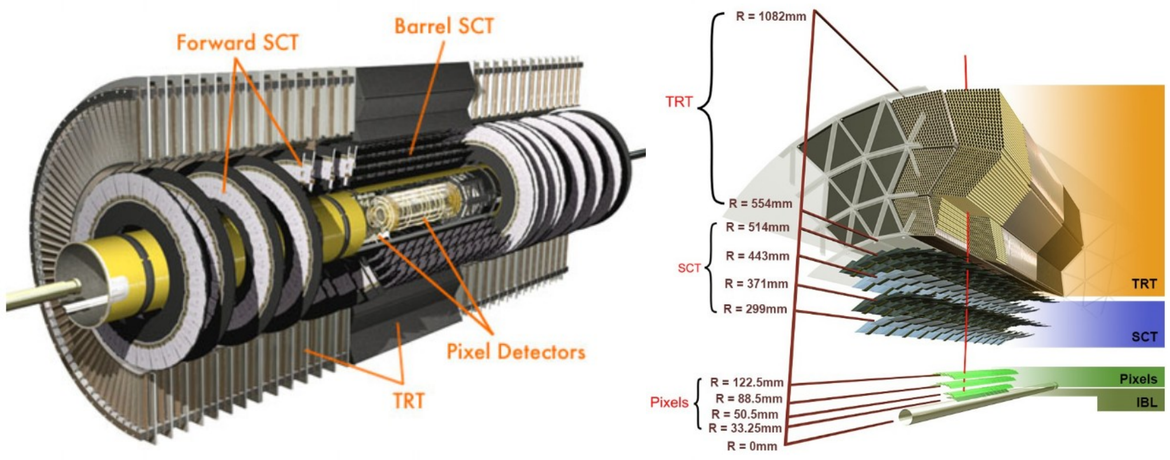
1. Overview

- The LHC in Run 2 provided the ATLAS experiment with pp collisions at 13 TeV and $2 \cdot 10^{34}$ $cm^{-2}s^{-1}$ peak luminosity
- The Inner Detector (ID) Trigger plays an essential role in the ATLAS Trigger system:
  - Enables the **fast and high-purity reconstruction** of physics objects, among which: electrons, muons, taus, b-jet candidates
  - Ensures high tracking performance also in **extreme pile-up conditions**

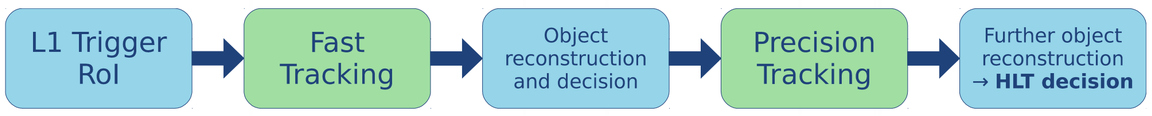
2. The ATLAS Inner Detector



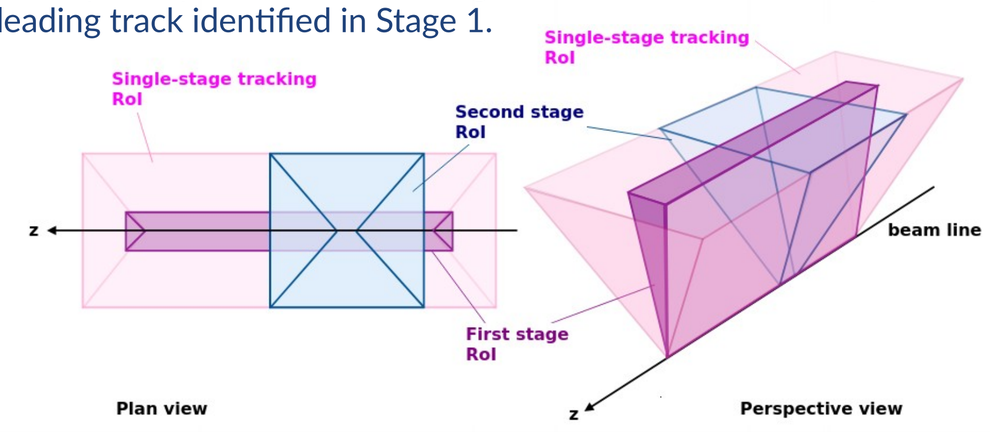
- The closest sub-detector to the beam line
- Provides the hits used to reconstruct charged particle tracks within the pseudorapidity range $|\eta|<2.5$
- Subcomponents:
  - **Insertable B-Layer (IBL)**: innermost pixel layer added for Run 2 to improve tracking and vertex reconstruction
  - **High-granularity Silicon detectors**: **Pixel** and **Microstrip (SCT)**
  - Straw Tube **Transition Radiation Tracker (TRT)**

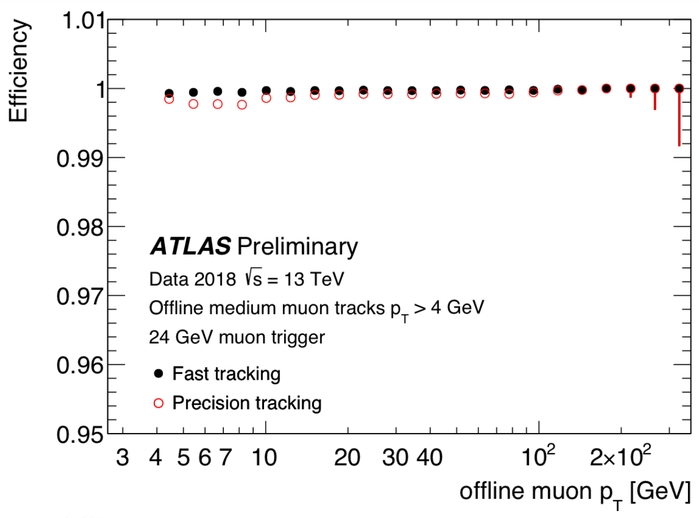
3. The Inner Detector Trigger

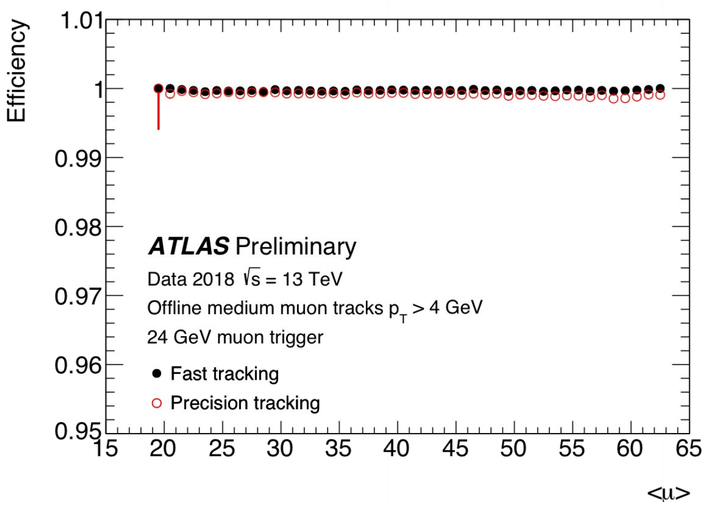
- The ATLAS Trigger system consists of:
  - **Level-1 (L1)**: hardware-based pipelined trigger on coarse granularity data from the calorimeter, and muon spectrometer to identify **Regions of Interest (RoIs)** → reduction to only 2-6% of the data volume to be processed by the HLT for each event
  - **High Level Trigger (HLT)**: software based; each L1 RoI used to seed full granularity reconstruction → first place ID information is available
- The **ID Trigger** runs track reconstruction – customised for each physics signature – divided into several stages:

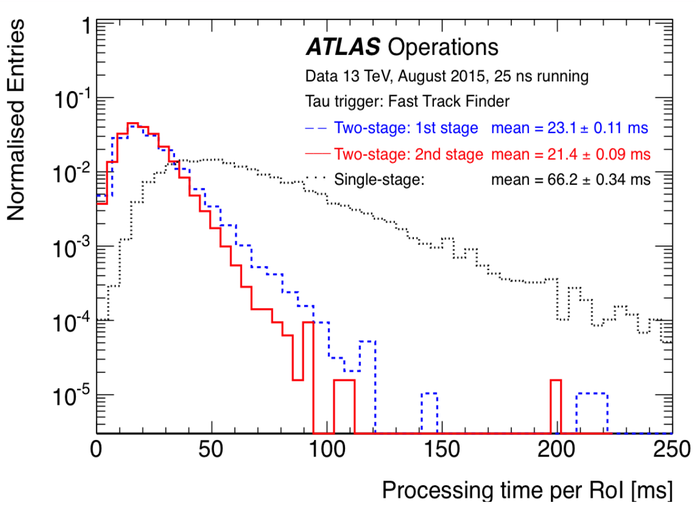


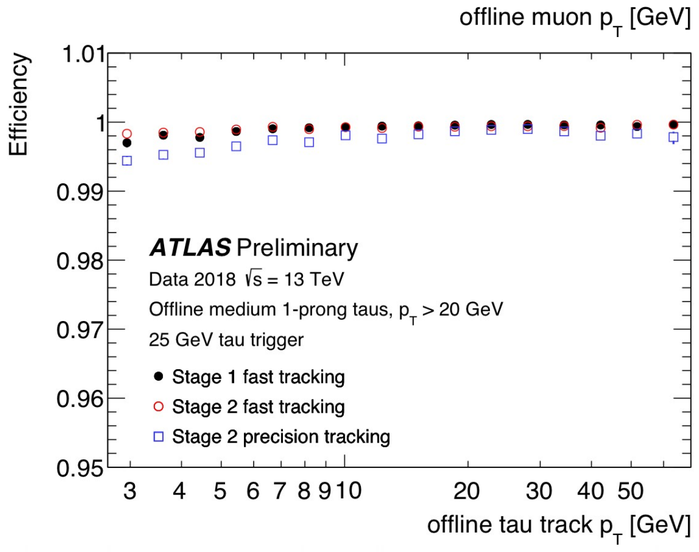
  - **Fast Track Finder (FTF)**: Fast custom pattern recognition and track reconstruction seeded by L1 RoIs
  - **Precision Tracking**: uses FTF tracks to seed the higher purity offline track fitting code modified to run in the trigger
- A **multi-stage approach** is adopted for some signatures – e.g. hadronic taus – to significantly improve the tracking timing
  - Stage 1: FTF is executed in a RoI that is narrow in (η,φ) and elongated in z
  - Stage 2: a second FTF and Precision Tracking stage runs in a wider RoI in both η and φ, but narrow z-ranged and centred on the z position of the leading track identified in Stage 1.

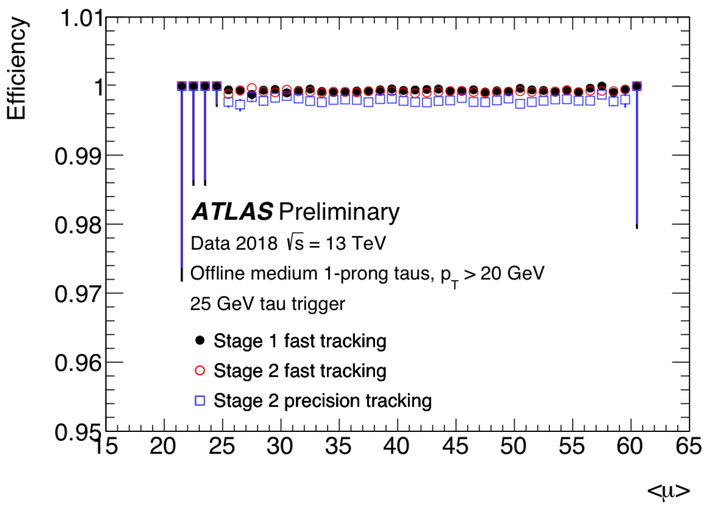


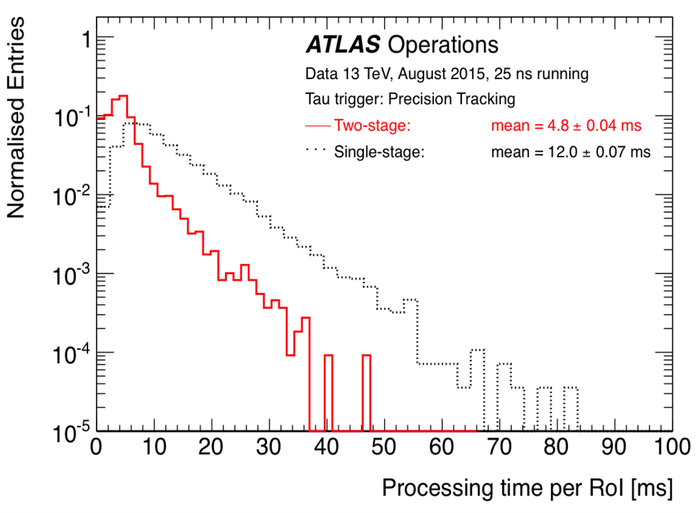












4. Run 2 Performance Results

- For unbiased measurements, the performance of the ID Trigger with respect to offline reconstructed objects is evaluated using dedicated triggers which do not select on the trigger tracks themselves
- The track reconstruction **efficiency** for the **muon** (*top*) and **tau** (*bottom*) is better than 99%
- The efficiencies are shown here as a function of the transverse momentum, p_T (*left*), and mean number of pp interactions per bunch cross crossing, $<\mu>$ (*middle*)
- The processing time for the combined multi-stage tau tracking is significantly less than the single stage tracking in the wider RoI which it replaces – for FTF (*top-right*) and Precision Tracking stages (*bottom-right*)

5. Closing Remarks

- For Run 3 starting in 2021, the trigger is being redesigned to run multithreaded reconstruction, and new track-based signatures
- The continued excellent performance of the ID Trigger continues to be central to the successful fulfilment of the ATLAS physics programme

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[1] The ATLAS Collaboration; The ATLAS Experiment at the CERN Large Hadron Collided, JINST 3 (2008) no. 08, S08003
[2] Performance of the ATLAS Trigger System in 2015, Eur. Phys. J. C 77 , 5 (2017) 317, https://arxiv.org/abs/1611.09661
[3] https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HLTTrackingPublicResults