THE DESIGN AND PERFORMANCE OF THE ATLAS INNER DETECTOR TRIGGER IN HIGH PILEUP COLLISIONS AT 13 TEV AT THE LARGE HADRON COLLIDER

UNIVERSITY OF SUSSEX

Mario Grandi, on behalf on the ATLAS Collaboration

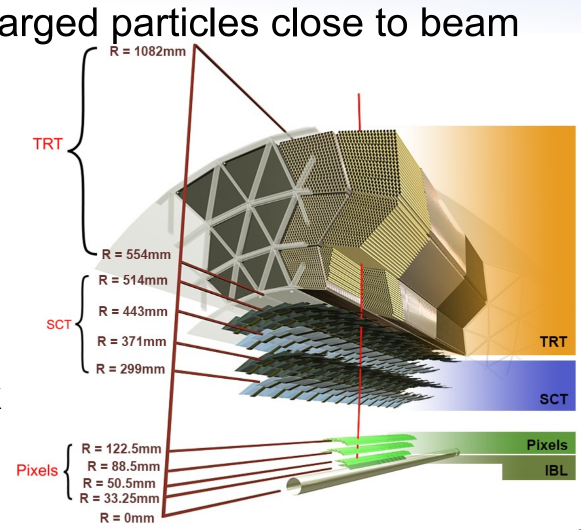
Supervisor: Fabrizio Salvatore

1

The LHC in Run 2 provides the ATLAS experiment with collisions at 13 TeV energy and $2 \cdot 10^{34}$ $cm^{-2}s^{-1}$ peak luminosity. The ATLAS Inner Detector Trigger reconstruction has the task of rapidly and accurately reconstruct the charged particle tracks to efficiently trigger on final state objects for interesting events for even higher centre-of-mass energy, luminosity and number of proton-proton interactions (pileup).

2 The Inner Detector (ID)

- ❖Insertable B-Layer (IBL): innermost pixel layer added for Run 2 significantly improves tracking and vertex reconstruction
- ❖Pixel Detector (Pixel) : detects charged particles close to beam pipe
- ❖Silicon Microstrip Detector (SCT): detects charged particles at intermediate radii
- ❖Transition Radiation Tracker (TRT): detects charged particles at larger radii
- ❖The Inner Detector provides track reconstruction with $|\eta| < 2.5$



3 Run 2 Trigger System [1]

❖The LHC collides bunches at 40 MHz, the trigger system is used to reduce the rate to < 1 kHz output, without losing interesting events

LEVEL 1 (L1)

- ❖Hardware based pipelined trigger
- ❖< 2.5 μs decision
- ❖100 kHz output
- ❖Topological trigger (L1Topo) used for combined object, event level triggering

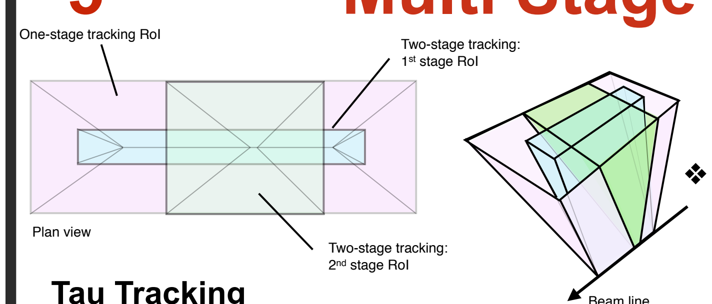
- ❖Hardware Fast Tracker stage (FTK) - runs on L1 accepted events
  - ❖Under commission
- ❖HLT CPU farm - single node per event
- ❖~200 ms decision time
- ❖1 kHz output rate

- ❖Runs reconstruction of physics objects using calorimeter reconstruction, track reconstruction and particle ID
- ❖Runs physics selection algorithm

4 The Inner Detector Trigger

- ❖The ID trigger reconstructs tracks for the selection of physics objects (electrons, muons, taus, *b*-jets etc) for use in the overall trigger decision to select events to be retained and stored offline
- ❖First runs a Fast Track Finder (FTF) for trigger specific track seeding, followed by Precision Tracking, using aspects of the offline tracking
- ❖The ID trigger runs in a single stage or multiple stages depending on the physics signature - multistage tracking used in hadronic tau, and b-jet triggers

5 Multi Stage Tracking [2]



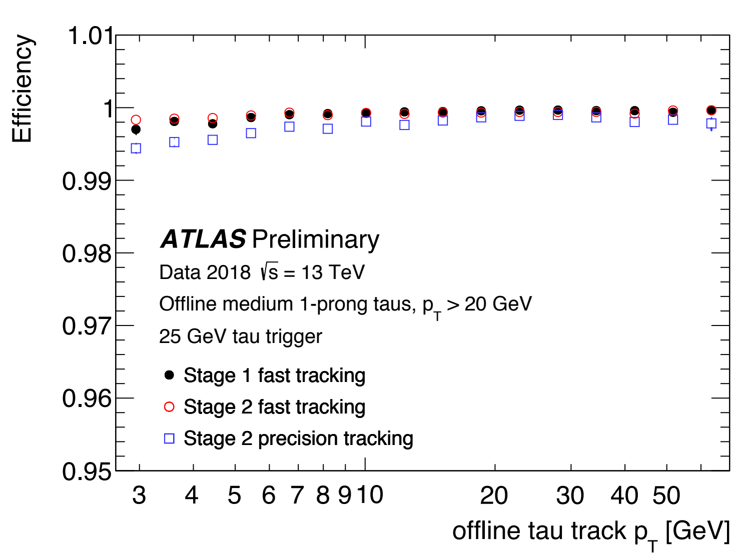
Tau Tracking

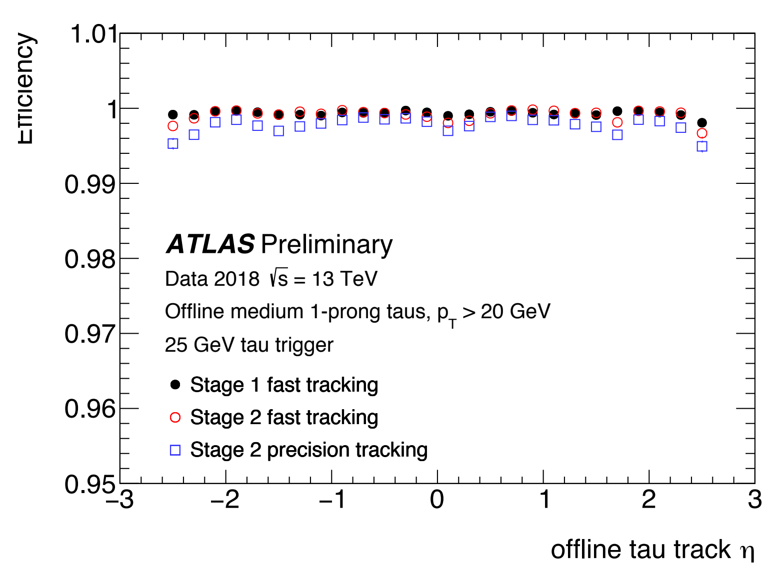
- ❖First stage tau trigger, the FTF reconstructs the leading track in narrow Region of interest (RoI) extended along the full luminous region
- ❖Second stage runs full tracking (FTF And Precision Tracking) for tracks from close to the leading track z position but within a wider RoI in η and Φ but narrow in z along the beam line

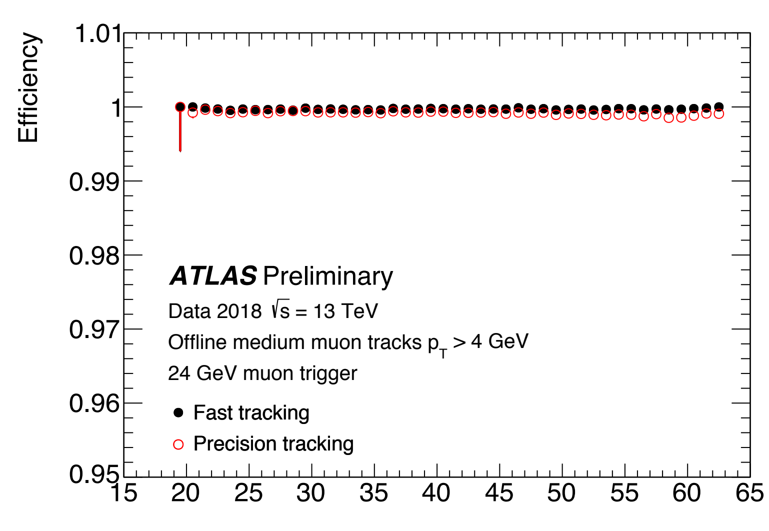
b-Jet Tracking

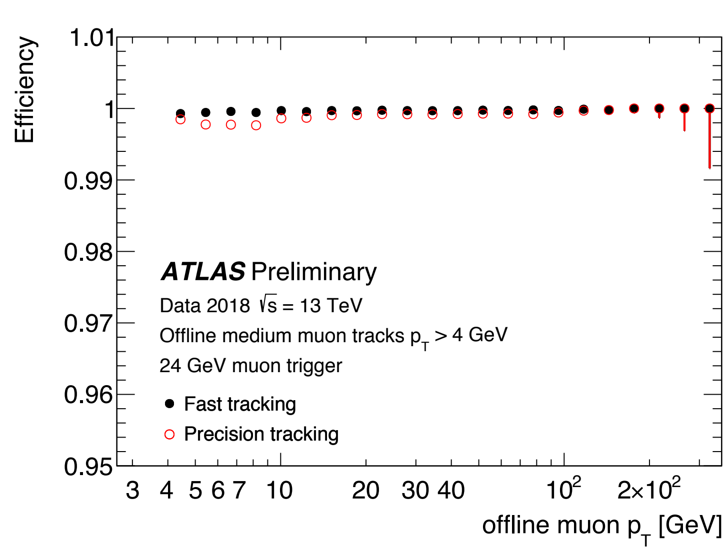
- ❖ First stage b-*jet* tracking run the FTF to reconstruct leading tracks in narrow region about the jet axis, and uses these to reconstruct the event vertex
- ❖ Second stage runs full fast and Precision Tracking, in wider RoIs about each jet axis, for tracks originating from the vertex found in first stage
- ❖ b-tagging and track based jet energy calibration is then performed for tracks from second stage

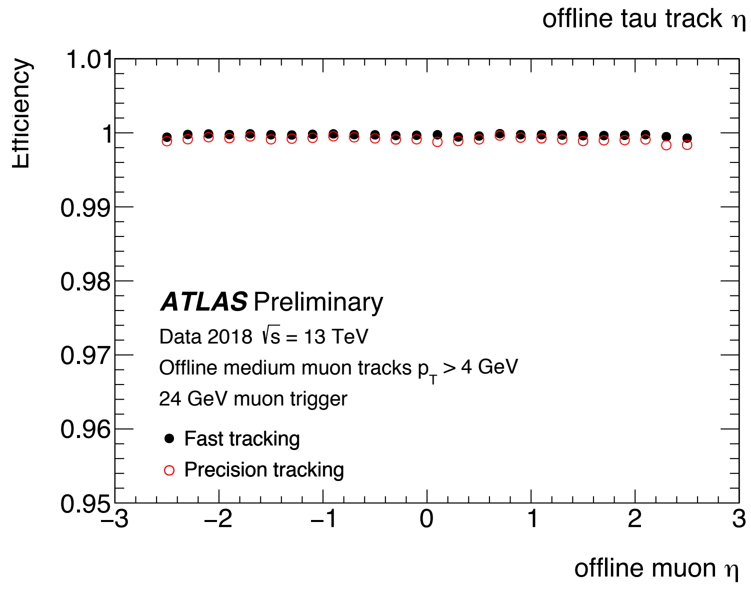
6 RUN 2 PERFORMANCE RESULTS FROM 2018 [3]











- ❖Tracking efficiencies with respect to well reconstructed offline tracks for muon and tau signatures
- ❖New seeding for second stage processing in 2018 which significantly improve efficiency in p_T (top left) and $|\eta|$ (middle top) compared to 2017 efficiencies
- ❖Efficiencies greater than 99% even at low p_T and high $|\eta|$.
- ❖Muons very well reconstructed, with efficiencies generally much greater than 99%
- ❖p_T efficiency (bottom left) significantly better than 99% across all p_T range for both fast and precision tracking.
- ❖Efficiency flat with pseudo-rapidity (bottom right) and consistently above 99% with very small drop at high $|\eta|$
- ❖Efficiency with mean number of pileup interactions (top right) very high for all pileup range, with efficiencies well above 99% at even at high pileup values reached with 2018 data

7 Closing Remarks

The ID Trigger continues to play an essential role for all trigger signatures. It continues to perform well at the high luminosity running so far in 2018, and has demonstrated improvements in efficiency with respect to 2017 results.

References

[1] Tech. Rep. ATL-PHYS-PUB-2015-018;
[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

LHCP 2018, Bologna 4th-9th June

University of Sussex

ATLAS EXPERIMENT