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

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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 reconstructing the charged particle tracks. Due to the large centre-of-mass energy, luminosity and number of proton-proton interactions (pileup), a very fast and accurate event reconstruction is required for an efficient triggering of final states objects.

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 $|\eta| < 2.5$
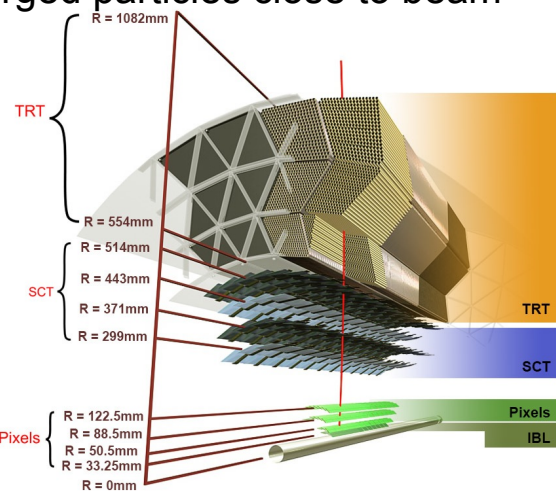
3 Run 2 Trigger System [1]

❖ 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

HIGH LEVEL TRIGGER (HLT)
❖ 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]
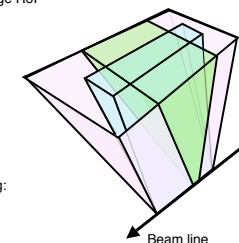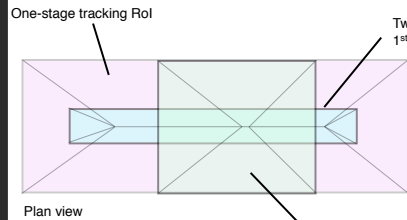
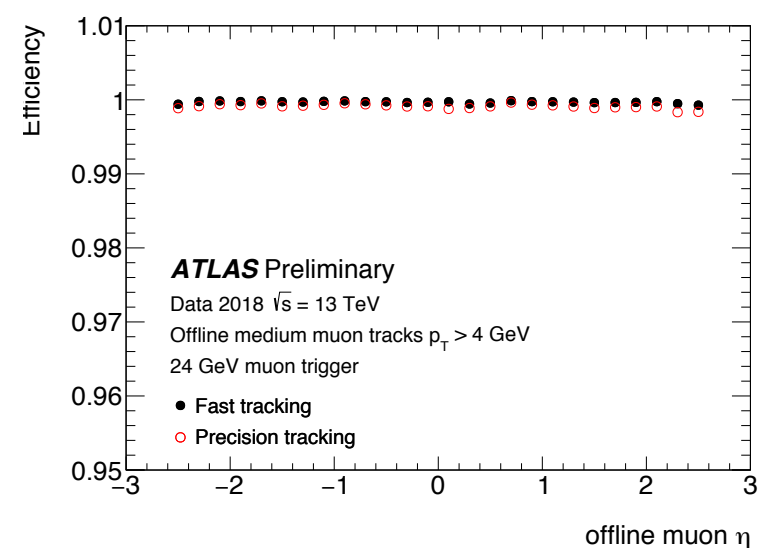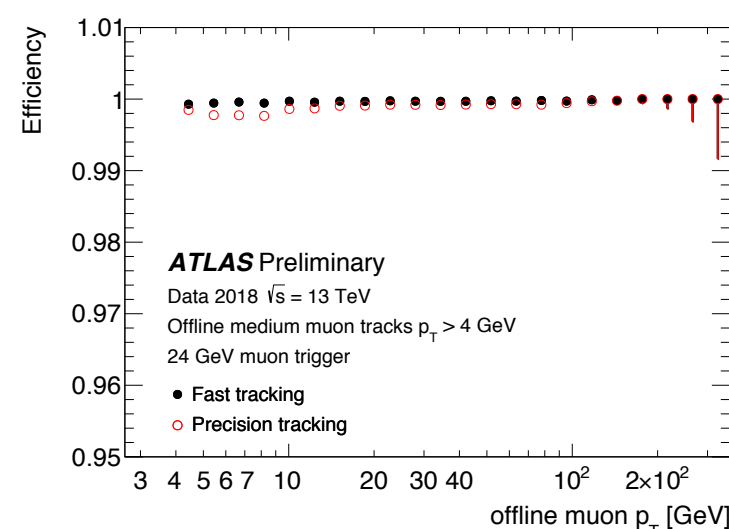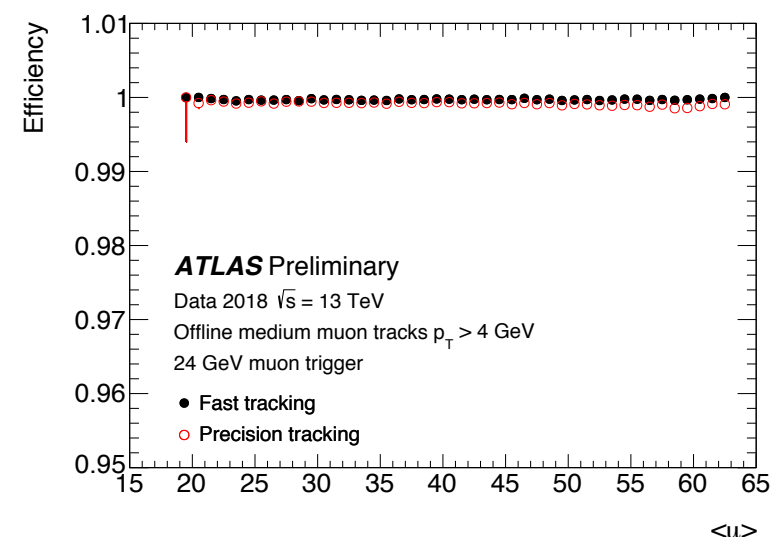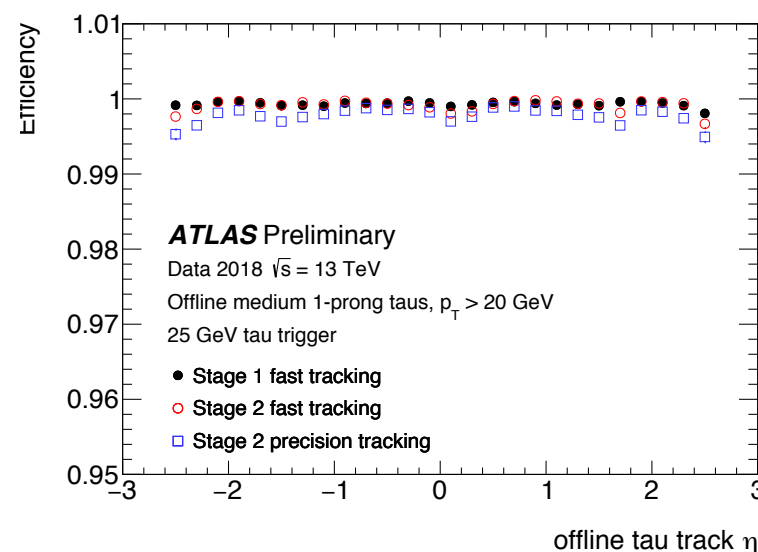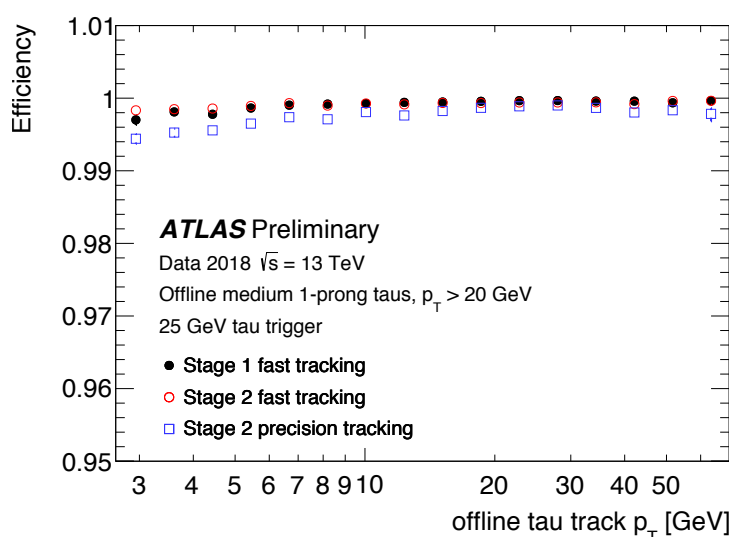a wider RoI in η and Φ but narrow in z along the beam line

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

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

6 RUN 2 PERFORMANCE RESULTS FROM 2018 [3]

ATLAS Preliminary
Data 2018 √s = 13 TeV
Offline medium 1-prong taus, p$_T$ > 20 GeV
25 GeV tau trigger
● Stage 1 fast tracking
○ Stage 2 fast tracking
□ Stage 2 precision tracking

ATLAS Preliminary
Data 2018 √s = 13 TeV
Offline medium muon tracks p$_T$ > 4 GeV
24 GeV muon trigger
● Fast tracking
○ Precision tracking

❖ 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 |η| (top middle) compared to 2017 efficiencies
❖ Efficiencies greater than 99% even at low p$_T$ and high |η|.
❖ 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 |η|
❖ Efficiency with mean number of pileup interactions (top right) very high for all pileup range, with efficiencies well above 99% 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 significantly improved efficiencies 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

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