Performance of the ATLAS tau-lepton trigger at the LHC in Run 2

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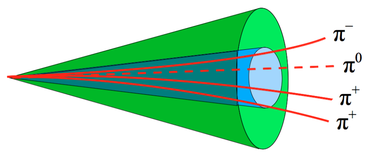
Taus - An Introduction

3rd generation lepton | 1777 MeV/c^2 | $c\tau = 87\mu m$

Decays: ~35% leptonically (ℓ, ν_ℓ, ν_τ, ℓ=e, μ)
~65% hadronically (π^0, π^-, π^+) $\rightarrow \tau_{\text{had-vis}}$



Detector signatures on:
↪ Calorimeters and Inner Tracker.

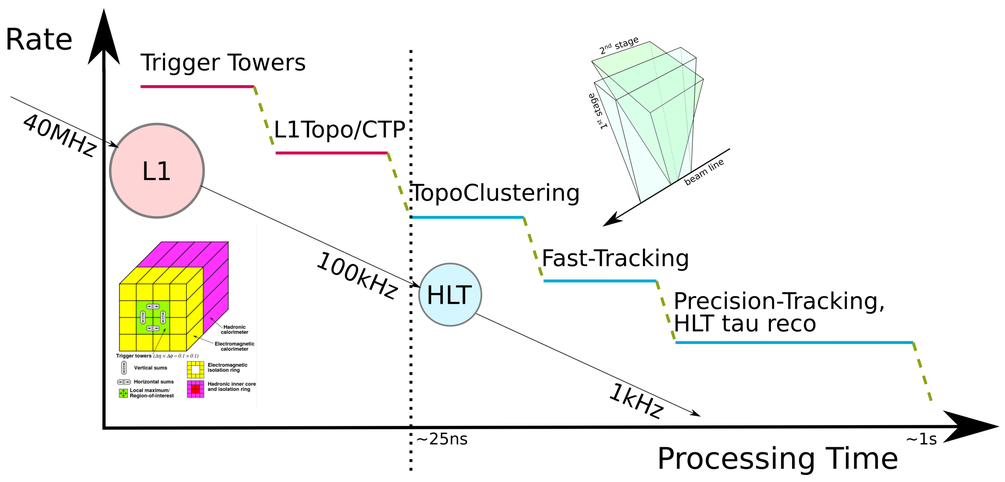
Possible contamination from hadronic jets.

Trigger definition for data acquisition

Level-1 (***L1***): Hardware trigger High Level Trigger (***HLT***): Software trigger

L1 $\rightarrow$ build Regions of Interest (*RoIs*)

- L1Calo $\rightarrow$ def RoIs
  - ↪ ***Core:*** EM 2×1, HAD 2×2
  - ↪ ***Isolation:*** EM 4×4 - 2×2
- L1Topo $\rightarrow$ perform $|\Delta R|$ cuts to remove overlapping RoIs, (used for combined triggers)



HLT $\rightarrow$ apply algorithms on RoIs

* based on: Boosted Decision Trees and Recurrent Neural Networks

- Topo-Clustering: clusters from RoIs
  - ↪ local hadronic calibration $\rightarrow$ ''jet seed'' ($\tau_{\text{had-vis}}$)
- Fast Track Finding (FTF - 2 stages) $\rightarrow$ track reconstruction
  - ↪ lead track:† $|\Delta R| < 0.1$ around $\tau_{\text{had-vis}}$, $|z| < 225$ mm
  - ↪ add. tracks: $|\Delta R| < 0.4$ around $\tau_{\text{had-vis}}$, $|z| < 7$ mm

† inefficiency if the 1st-stage track sel. is wrong $\Rightarrow$ studies on using BDT for the sel.

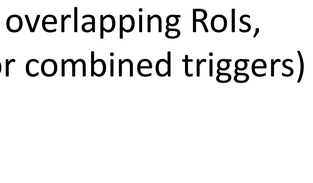
- Precision Track $\rightarrow$ Identification (ID) algorithms *
  - ↪ precision tracks (refit of FTF tracks) + calorimeter info
  - ↪ used for calculation of input variables of the identification algorithms
  - ↪ score for $\tau_{\text{had-vis}}$ candidate ID

Track counting: 2nd FTF stage and (2017 chains) / or (2018 chains) on precision tracks.
Track cuts: 0-3 tracks; 0-tracks recovery with RNN triggers & tight ID requirements

Run 2 performance

Trigger Performance

$\tau_{\text{had-vis}}$: lowest unprescaled trigger available $\tau_{\text{had-vis}}$: offline reconstruction



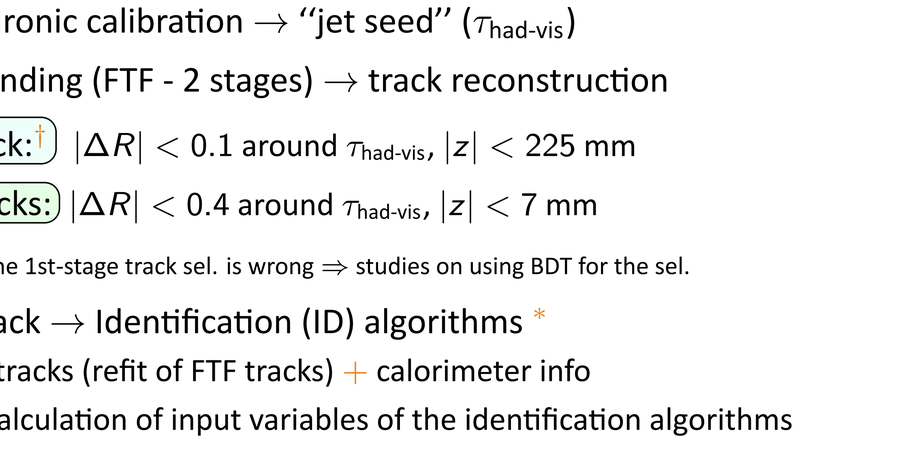
Evaluation: Use of the Tag & Probe method

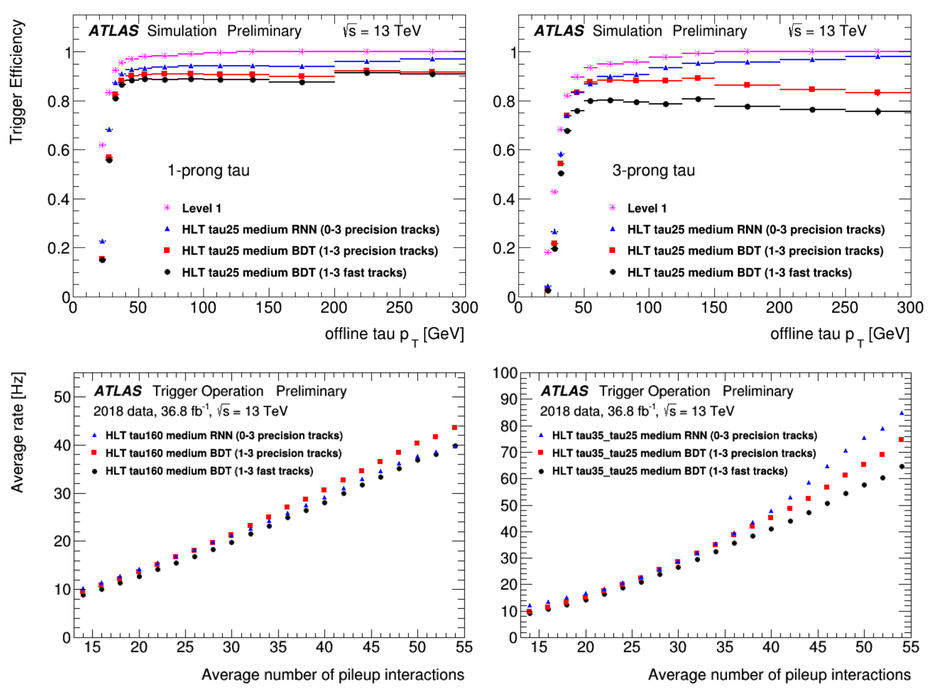
Process	*Notes*
$Z \rightarrow (\tau)(\tau) \rightarrow (\mu\ \nu_\mu\nu_\tau)(\tau_{\text{had-vis}}\ \nu_\tau)$	high statistics, good purity
$t\bar{t} \rightarrow (b\mu\nu_\mu)(b\tau_{\text{had-vis}}\nu_\tau\nu)$	higher p_T $\tau_{\text{had-vis}}$
Bkgr: misidentified jet as $\tau_{\text{had-vis}}$	modeling w. data-driven & MC-based methods

Modelling: Comparison of online $\tau_{\text{had-vis}}$ properties in MC and data
Selection: $|\Delta R|_{\text{wrt offline}} < 0.2$, @L1: $E_T > 12\ GeV$, @HLT: $p_T > 25\ GeV$
! bias of online candidate selection from offline selection (# of tracks, identification)

Efficiency: *def.* fraction of offline $\tau_{\text{had-vis}}$ probes that pass a tau trigger

Ex. HLT tau25 medium ID trigger:
@L1: isolated candidate w. $E_T > 12\ GeV$
@HLT: $p_T > 25\ GeV$, $N_{\text{tracks}} = 1, 3$, medium ID





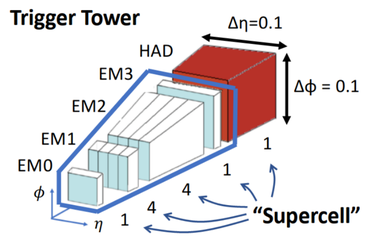
Improvements

- **Track association:** commisioning of new trigger chains types with:
  - track counting only on precision tracks, or
  - track selection with tighter $\Delta Z_{0,\text{lead-add.}}$ on the precision tracks
  - ↪ reduced fake track contamination at high pileup
- **Energy calibration:** use of Boosted Regression Trees (instead of pileup subtraction & calorimeter response corrections) for the calibration of the hadronic tau energy scale to the energy of the visible decay products
  - ↪ improved energy resolution, especially at low p_T
- **Identification algorithm:** deployed a Recurrent Neural Network algorithm
  - ↪ increased jet rejection

Run 3 outlook

Essential to address the higher Luminosity and pileup enviroments. Among the updates:

- L1Calo changes to increase detector granularity with use of ''Super Cells''
- Fast Hardware Tracker system (FTK)
  - ↪ full event track information available for HLT



References

[1] The ATLAS collaboration [ATLAS Collaboration], ATLAS-CONF-2017-061.

[2] ATLAS Tau Trigger Public Results: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/TauTriggerPublicResults