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/c² | cτ = 87 µm

Decays:
- ~35% leptonically (ℓ, νℓ, ντ, ℓ = e, µ)
- ~65% hadronically (had-vis → τhad-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 → build Regions of Interest (RoIs)
- L1Calo → def RoIs
  - Core: EM 2×1, had-vis 2×2
  - Isolation: EM 4×4 - 2×2
- L1Topo → perform |ΔR| cuts to remove overlapping RoIs, (used for combined triggers)

HLT → apply algorithms on RoIs
- Topo-Clustering: clusters from RoIs
  - local hadronic calibration → “jet seed” (had-vis)
- Fast Track Finding (FST - 2 stages) → track reconstruction
  - lead track: |ΔR| < 0.1 around had-vis, |z| < 225 mm
  - add. tracks: |ΔR| < 0.4 around had-vis, |z| < 7 mm
- Precision Track → Identification (ID) algorithms
  - precision tracks (refit of FTF tracks) + calorimeter info
  - used for calculation of input variables of the identification algorithms
  - score for 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
- Lowest unprescaled trigger available
- Offline reconstruction

Evaluation: Use of the Tag & Probe method

<table>
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<tr>
<th>Process</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Z → (νν) → (ℓν, ℓνν, ℓhad-vis)(had-vis)</td>
<td>high statistics, good purity</td>
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<tr>
<td>τT → (νννννν, νhad-vis, ℓhad-vis)</td>
<td>higher PT had-vis</td>
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Bkg: misidentified jet as had-vis
- Modeling w. data-driven & MC-based methods

Modelling: Comparison of offline had-vis properties in MC and data
- Selection: |ΔR|<0.2, @L1: Et > 12 GeV, @HLT: PT > 25 GeV

Efficiency: def. fraction of offline had-vis probes that pass a tau trigger
- Ex. HLT tau25 medium ID trigger:
  - @L1: isolated candidate w. Et > 12 GeV
  - @HLT: PT > 25 GeV, Ntracks = 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 E#calo,had, had-vis, 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 PT
- Identification algorithm: deployed a Recurrent Neural Network algorithm
  - increased jet rejection

Run 3 outlook

Essential to address the higher Luminosity and pileup environments. 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