Performance of the ATLAS Tau Trigger in High Luminosity Scenarios

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1 The hadronic tau trigger in ATLAS

The ATLAS experiment at the Large Hadron Collider (LHC) at CERN has been motivated by the search for the Standard Model Higgs boson and for new physics, such as Supersymmetry and exotic heavy resonances. The sensitivity of those searches is enhanced when tau leptons decaying to hadrons are included. A key element in the selection of these events is the *hadronic tau trigger*, which has been commissioned to achieve a good rejection against QCD jets while maintaining a high efficiency for signal events (see e.g. [1], [2]). A tau trigger decision starts with a calorimeter seed at the hardware-based Level 1 (L1) trigger and passes on to software algorithms in Level 2 (L2) and Event Filter (EF) *chains* for several energy thresholds and quality requirements. Details on the performance of the tau trigger can be found in [3].

2 Tau trigger configuration for high luminosities

The study of final states with hadronic tau decays need specific fine-tuned triggers (see Fig. 1). The selection requirements at L2 and EF have to be tightened with increasing luminosities. In the process, also L1 thresholds might have to be raised due to the finite bandwidth at the lowest trigger level. In addition, different quality requirements (i.e. loose, medium and tight) are available for each tau trigger chain, corresponding to different tau identification efficiency working points. Chains with the loose requirements were used for single tau triggers at low luminosities but only appear in combined chains due to rate limitations. The same holds for the transverse energy thresholds.

Menu	Purpose	Trigger
Single Tau	H^+, SUSY	tau100_medium
Di-Tau	H^0, Z^0	2tau29_medium1
Tau + Lepton	H^0, top, Z^0	tau16_loose_mu15 tau16_loose_e15_medium
Tau + MET	H^+, $W \to \tau\nu$	tau29_medium_xe35_noMu tau29_loose_xs70_loose_noMu tau29_loose1_xs45_noMu_3L1J10

Figure 1: Tau triggers for instantaneous luminosities up to $2 \cdot 10^{33} cm^{-2} s^{-1}$ used in searches for Higgs and Supersymmetry (SUSY).

3 Rates and performance at high luminosities

Each trigger configuration is optimized with simulation and real data to maximize the efficiency while keeping the output bandwidth within limits. The rates in Fig. 2 shows a linear scaling with increasing instantaneous luminosity, also in combined tau trigger chains. All data was taken from several ATLAS runs at $\sqrt{s} = 7$ TeV in 2011. The achieved relative rejection of different L2 and EF tau trigger chains is shown in Fig. 3. The $Z \to \tau\tau$ signal efficiency w.r.t. offline reconstruction reaches about 75% for e.g. EF_tau29_medium1 (see Fig. 4).

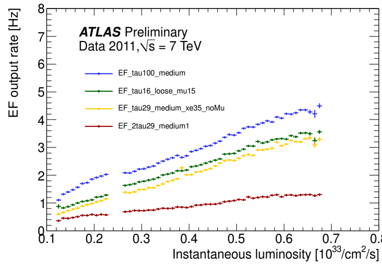

Figure 2: L2 and EF rates versus the instantaneous luminosity for tau trigger chains at high luminosities. The numbers in the item names correspond to transverse energy requirements.

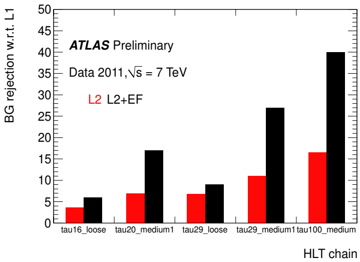

Figure 3: QCD jet rejection factors of different L2 and EF tau chains. The numbers given are with respect to the output of the associated L1 tau trigger item.

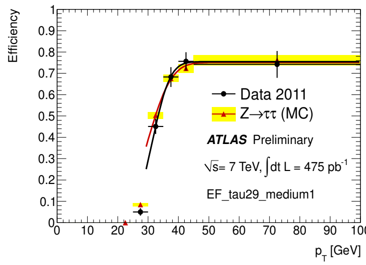

Figure 4: Efficiency of the EF_tau29_medium1 trigger chain with respect to offline reconstructed tau candidates, as a function of the offline p_T.

References

[1] Observation of $W \to \tau\nu$ Decays with the ATLAS Experiment, ATLAS-CONF-2010-097 (2010).

[2] Measurement of the $W \to \tau\nu$ Cross Section in pp Collisions at $\sqrt{s} = 7$ TeV with the ATLAS experiment, arXiv:1108.4101v1 (2011)

[3] Performance of the ATLAS Trigger System in 2010, arXiv:1110.1530 (2011).