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Performance of the ATLAS tau trigger with 7 TeV collision data at the LHC

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Tau leptons are a fundamental ingredient in the discovery of new physics at the LHC. The reconstruction of hadronic tau decays at the trigger level, although a very challenging task in proton-proton collision environments, allows us to double the sample of tau decays collected, and provides additional discovery power to final states which include tau leptons. In this contribution we show the understanding of the tau trigger system using data collected with the ATLAS detector at the LHC in proton-proton collisions at a center-of-mass energy of 7 TeV. We present the most relevant quantities used in the different stages of the trigger selection, and the trigger efficiencies as a function of E_T using tau-like QCD events passing the offline reconstruction and identification selection.

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1. The ATLAS Tau Trigger

The ATLAS trigger system is designed to reduce the input rate of events by selecting interesting events for physics analysis. It is a three step system, with a hardware-based Level 1 (L1), followed by the software-based High Level Trigger (HLT) composed of steps called Level 2 (L2) and Event Filter (EF). Geometrical Regions of Interest (RoI) found at L1 are input to the higher level trigger algorithms. The LHC bunch crossing rate of 40 MHz is reduced to a L1 output rate less than 75 kHz. Level 2 then analyzes the data seeded by the RoI at L1 using the full granularity of the detector with regional detector readout. At EF, events accepted by L2 are analyzed using algorithms based on the offline reconstruction. Data is accessed as necessary from the whole detector. The average EF output rate was designed to be 200 Hz [1].

The tau trigger system is designed to capitalize on the characteristic low track multiplicity, isolation, and narrowness of a typical hadronic tau decay. Level 1 of the tau trigger uses electromagnetic (EM) and hadronic calorimeter trigger towers and identifies taus based on the energy in a core and an isolation region. Tracks are reconstructed beginning at L2 of the tau trigger. The characteristic narrowness and low track multiplicity of the tau jet is used to discriminate against background. At EF tau candidates are reconstructed through algorithms derived from the offline reconstruction [2]. The EF tau candidates provide a wide range of identification variables refined with respect to L2. Rejection of jets at L2 and EF is of the order 10 or more, depending on the p_T range and tightness of selection.

2. L1 Trigger Rates in 7 TeV Data

The cumulative L1 tau trigger rate as a function of the L1 tau object E_T threshold is shown in Fig. 1. The data shown in Fig. 1 corresponds to an average instantaneous luminosity of $3.7 \times 10^{26} cm^{-2} s^{-1}$. While in 900 GeV data almost all triggers occurred below 20 GeV, in 7 TeV data statistics have improved significantly for high energy clusters.

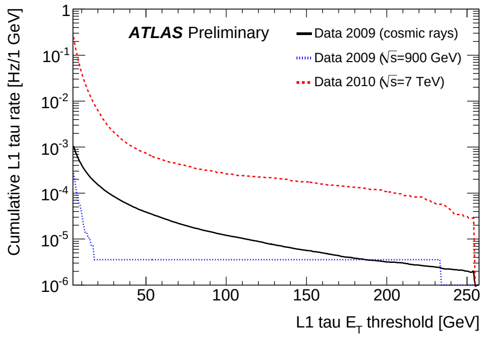

Figure 1: Level 1 tau trigger rate as a function of the L1 tau object E_T threshold.

3. Evaluation of Tau Trigger Performance in 7 TeV Data

A clean sample of real hadronic tau decays will not be available in early data, therefore the first step of commissioning the tau trigger starts with fake taus which are copiously produced in multijet events [3]. Fig. 2 provides a comparison between 7 TeV data and Minimum Bias Monte Carlo simulation for distributions of important tau candidate selection criteria at each level of the tau trigger. The level of agreement between Monte Carlo (MC) simulation and data indicates how well the tau trigger is understood. As can be seen in Fig. 2, the EM radius distribution of the tau candidates exibits a shift of the peak for the 7 TeV data with respect to the Minimum Bias MC simulation. This shift has also been observed in the corresponding variable reconstructed offline and is attributed to insufficient tuning of MC simulation to 7 TeV collision data.

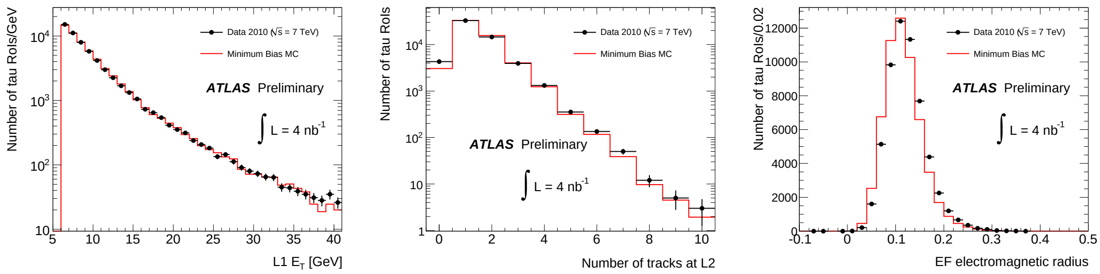

Figure 2: Left: E_T distribution of the tau candidates at L1. Middle: Number of tracks distribution of the tau candidates at L2. Right: EM radius distribution of the tau candidates at EF.

4. Measurement of Tau Trigger Efficiency in 7 TeV Data

The probability that the tau trigger accepts an event when a tau candidate was reconstructed by the offline algorithms is called the tau trigger efficiency with respect to offline reconstruction.

For early data (where no real taus are expected), an estimate of tau trigger efficiency can be made by counting tau triggers on fake taus from QCD jets that pass offline reconstruction. Fig. 3 shows the efficiency of offline tau candidates passing the L1 tau trigger E_T threshold of 5 GeV as a function of the offline E_T for both minimum bias MC simulation and 7 TeV data.

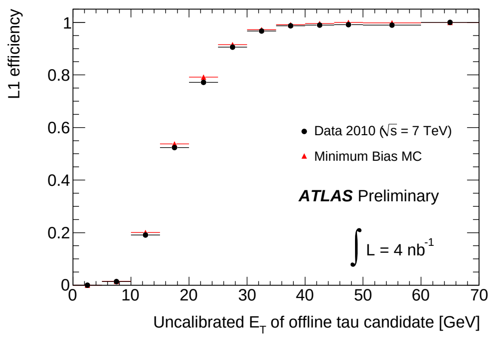

Figure 3: Fraction of the offline tau candidates matched to a L1 trigger object with $E_T > 5$ GeV as a function of the E_T of the offline tau candidate.

Several methods, including tag and probe with Z events, and top events for tau + MET trigger, are foreseen to determine tau trigger efficiency using a sample of real taus in data once more statistics become available[4].

References

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