"ATLAS high-level calorimeter trigger algorithms performance with first LHC p p collisions"

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ABSTRACT

The proceedings describe the performance of the calorimeter HLT during the period of ATLAS early operation with 900 GeV and low-intensity 7 TeV collisions. The signature groups mentioned in the paper include e/gamma, jet, tau and missing Et trigger. Finally the comparison to the offline performance is discussed.

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Introduction

After the commissioning phase with beams at SPS injection energy (450 GeV) the LHC has recently been accelerated to the design physics program with 7 TeV collisions. Consequently, the ATLAS detector also entered its operation phase recording these collisions.

The ATLAS trigger system

The task of the trigger is to select 200 events out of 40 millions of those that are produced by the LHC. At L1, the trigger is based on the selection of jets characterized by the presence of 1 or 3 tracks, accompanied by a neutrino and possibly 0, 1, or 2 photons. At L2, the $\tau$ trigger uses the electromagnetic and hadronic calorimeter to find transverse energy deposit which passes the threshold (lowest is 5 GeV).

Performance in 900 GeV collisions

The most important variable for jet trigger is the transverse energy measured at L2, which only operates around the R0s but uses full calorimeter granularity, and the Event Filter (EF), which can explore R0s or the full detector using full granularity information. The L2 and the EF are altogether referred to as the High-Level Trigger (HLT) system. All trigger algorithms share a common data preparation step, optimized for fast trigger processing. During the initial data taking period, while the normal luminosity is not allowed to pass the trigger, the trigger system was accepting most of the the incoming events and L1 is performing most of the selections. The HLT is fast track operated in commissioning configuration in which the data is selected if and only if maximum recording rate is reached. Trigger is composed of several signature groups specialized in selecting different event types. The ones using data from the calorimeter are presented here.

Performance of the $\tau$ High-Level Trigger

The tau trigger is designed to select hadronic decays of the $\tau$ characterized by the presence of 1 or 3 tracks, accompanied by a neutrino and possibly 0, 1, or 2 photons. At L1, the $\tau$ trigger uses the electromagnetic and hadronic calorimeter to find transverse energy deposit which passes the threshold (lowest is 5 GeV). At L2, selection criteria are applied using tracking and calorimeter based information. This takes advantage of calorimeter cluster confinement and low track multiplicity to discriminate tau from the hadron background. Exploring the same characteristics, the EF uses different selection criteria for triggering and trusting more defined algorithms which are similar to the offline reconstruction algorithms.

Performance of the missing $E_T$ High-Level Trigger

The ATLAS can trigger also on events with considerable "missing $E_T$", or with large amount of total transverse energy deposited in calorimeters. That could play a crucial role in a new physics discoveries such as dark matter candidates. The vector $(\not{E}_T \gamma)$, with $\not{E}_T$ equal to the sum of all detector energy of all detector elements. At L1, $\not{E}_T$ is computed by adding the scalar sum of all muon momenta reconstructed at L1 to the calorimetric measurement done at L1. Note that $\not{E}_T$ is presently not able to access L2 energy measurement because by design it can access only input within R0s. At EF, the total $\not{E}_T$ and missing $\not{E}_T$ are again recalculated with more precise information from the L2 detector.

Comparison of HLT and offline reconstruction

In order to guarantee the quality of the information provided at the trigger level, some checks are performed with respect to the information obtained offline. One of the most important tests is the comparison of the energy of the clusters provided by the EF to the clusters produced by the offline code. Example for e/\gamma clusters is presented at Fig. 13. Those checks verify that the cell and cluster calculations are compatible at both levels. At L1, different choice of algorithms or parameters. In particular, offline reconstruction algorithms can use, as an input, the cell energies reconstructed by the detector hardware (using Digital Signal Processors - DSP) or, for the highest energy cells, the energies can be recomputed with higher precision. This special recalculation can only be performed offline due to the limited HLT processing time. Therefore, a special offline reconstruction was performed forcing the offline code to use only input from DSP. This makes HLT and offline more compatible and provide a meaningful comparison of the algorithms using the same cells input. The comparison between both EF and offline $\not{E}_T$ is shown in Fig. 14. The correlation between EF and offline $\not{E}_T$ is shown in Fig. 15.

References

[5] The ATLAS $\tau$ trigger is designed to select events with the presence of 1 or 3 tracks, accompanied by a neutrino and possibly 0, 1, or 2 photons. At L1, the $\tau$ trigger uses the electromagnetic and hadronic calorimeter to find transverse energy deposit which passes the threshold (lowest is 5 GeV). At L2, selection criteria are applied using tracking and calorimeter based information. This takes advantage of calorimeter cluster confinement and low track multiplicity to discriminate tau from the hadron background. Exploring the same characteristics, the EF uses different selection criteria for triggering and trusting more defined algorithms which are similar to the offline reconstruction algorithms.

Performance of the e/\gamma High-Level Trigger

The aim of the e/\gamma trigger is to select events with electrons or photons in final state. At L1, a threshold is set on minimal $E_T$ deposit in electromagnetic calorimeter (it was 3 GeV in the commissioning period). At L2, fast algorithms for calorimeter reconstruction are run and fast tracking is used to reconstruct electron L2 objects. Already at this level it is possible to use the fine granularity of the first layer of the EM calorimeter to distinguish between primary $e$ and secondary $\gamma$ coming from it. At EF, the reconstruction algorithms very similar to ones used offline are applied.

Performance in 900 GeV and 7 TeV collisions

Figure 7 shows the $\tau$ electron transverse energy for both 900 GeV and 7 TeV collisions. Note agreement with MC shown on $\eta$ distribution (Fig. 8). The incomplete simulation of the commissioning configuration of L1/Calo hardware explains the discrepancy between data and MC observed at $|\eta| < 1.45$. Important for shower shape variables is called $E_T$ and is the normalized difference between the first and second highest energetic cell in the first calorimeter layer (Fig. 9). For single $\tau$ its takes values around 1, while for $\gamma$ pair from $E_T$ the distribution close to 0.

Performance in 900 GeV collisions

The ones using data from the calorimeter are presented here.

Performance in 7 TeV collisions

Figure 11 shows the turn on curve for missing $E_T$, threshold of 5 GeV at EF measured from 7 TeV data collision candidates after applying ATLAS standard jet reconstruction algorithms. The efficiency is calculated with respect to offline reconstructed missing $E_T$. The comparison of minimum bias MC and measured missing $E_T$ measured at EF is presented at Fig. 12.

Performance in 900 GeV collisions

The ones using data from the calorimeter are presented here.

Performance of the jet High-Level Trigger

The ATLAS jet trigger is based on the selection of jets colliding to their transverse energy. If a L1 jet candidate, a given $E_T$ threshold (lowest is 5 GeV), the L2 jet candidate is selected by requesting calorimeter data around the L1 position and run a set of jet algorithms. The EF jet algorithm is based on the offline reconstruction algorithm using calorimeter "towers" projecting towards collision center.

Performance in 900 GeV collisions

The High Level Triger (HLT) system is characterized by the presence of 1 or 3 tracks, accompanied by a neutrino and possibly 0, 1, or 2 photons. At L1, the $\tau$ trigger uses the electromagnetic and hadronic calorimeter to find transverse energy deposit which passes the threshold (lowest is 5 GeV). At L2, selection criteria are applied using tracking and calorimeter based information. This takes advantage of calorimeter cluster confinement and low track multiplicity to discriminate tau from the hadron background. Exploring the same characteristics, the EF uses different selection criteria for triggering and trusting more defined algorithms which are similar to the offline reconstruction algorithms.

Fig. 1: Scheme of the ATLAS trigger system

Fig. 2: Illustration of RoI concept

Fig. 3: Transverse energy measured at L1

Fig. 4: Radius in EM calorimeter measured at EF

Fig. 5: Jet transverse energy measured at EF

Fig. 6: $\tau$-trigger candidates characterized by the presence of 1 or 3 tracks, accompanied by a neutrino and possibly 0, 1, or 2 photons. At L1, the $\tau$ trigger uses the electromagnetic and hadronic calorimeter to find transverse energy deposit which passes the threshold (lowest is 5 GeV).

Fig. 7: $\tau$-trigger efficiency as a function of $E_T$ measured by HLT and Offline reconstruction

Fig. 8: Comparison of HLT and offline $\gamma$-trigger candidates. Offline reconstruction was forced to use input from DSP, i.e. as the same as HLT. False that offline was not fireable are coming from "fake" $\tau$ candidates that would not survive offline cuts.

Fig. 9: Comparison of EF and offline e/\gamma trigger candidates. Offline reconstruction was forced to use input from DSP, i.e. as the same as HLT. False that offline was not fireable are coming from "fake" e/\gamma candidates that would not survive offline cuts.

Fig. 10: Energy distribution at EF

Fig. 11: $\tau$-trigger efficiency as a function of $E_T$ measured by HLT and Offline reconstruction

Fig. 12: Missing $E_T$ measured by EF

Fig. 13: Comparison of E_T measured by HLT and Offline reconstruction

Fig. 14: Comparison of missing $E_T$, threshold of 5 GeV at EF measured from 7 TeV data collision candidates after applying ATLAS standard jet reconstruction algorithms. The efficiency is calculated with respect to offline reconstructed missing $E_T$. The comparison of minimum bias MC and measured missing $E_T$ measured at EF is presented at Fig. 12.