View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by CERN Document Server

ATL-DAQ-PROC-2009-030
14 October 2009

Optimization and Performance of the ATLAS Tau Trigger with Cosmics Data

Mansoora Shamim
On behalf of the ATLAS Collaboration

Department of Physics, 1274 University of Oregon,
Eugene, OR 97403-1274, USA
E-mail: mshamim@uoregon.edu

Tau lepton, being the heaviest of all known leptons ($m_\tau = 1776.84 \pm 0.17$MeV), is of special importance. Due to its short lifetime, with ($c\tau = 87.11\mu$m), it decays inside the beam pipe. The identification of tau is, therefore, done through its decay products inside the detector. A tau jet can be identified through the presence of a well collimated calorimeter cluster with a small number of associated tracks.
The tau lepton decays into electron or muons 35% of the time, while 65% of its decays include hadrons, mostly pions. The events where tau decays into leptons can be triggered by low E_T threshold electron or muon trigger. A dedicated tau trigger has been designed and implemented at the ATLAS experiment to select events where a tau lepton decays into hadrons. Triggering on tau events will not only help in understanding the standard model (SM) processes during early running but will also increase the discovery potential of the ATLAS detector through searches for Higgs boson and supersymmetric particles at high luminosities.
The cosmics-ray data at ATLAS have provided a valuable handle to optimize and commission the ATLAS detector before beam collisions. In this process the ATLAS tau trigger algorithms have been exercised and the hardware-based first level rates studied.

Keywords: ATLAS; Tau; Trigger.

1. ATLAS Detector

ATLAS [1] is a general purpose detector comprised of several subsystems. The innermost part is the tracking system which consists of pixel detectors, silicon micro-strip tracker (SCT) and transition radiation tracker (TRT). The whole tracking system is placed inside a solenoid that has 2T magnetic field. Outside the inner detector is the calorimeter which is used to identify and measure the energy of electrons, photons, and jets. It consists of electromagnetic (EM) and hadronic (HAD) calorimeters. The EM calorimeter uses liquid Argon (LAr) while the hadronic calorimeter uses scintillating tiles in the barrel region and LAr in end caps (EC). Muon spectrometer is the outermost component of the ATLAS detector which is used for the identification and momentum measurement of muons. One barrel and two EC toroids provide the magnetic field for the muon detection system.

2. ATLAS Trigger System

ATLAS trigger system [2] is divided into a hardware-based component, level 1 (L1), and software-based parts level 2 (L2) and event filter (EF). L2 and EF are referred together as high level trigger (HLT). The L1 trigger identifies the regions-of-interest (RoI) using the information from calorimeter and muon systems. The decision time at L1 is $\sim 2.5\ \mu$s. L2 takes these RoIs as input and refines the object identification using the information from all the subsystems. The latency at L2 is $\sim$ 40 ms. At EF, the algorithms, similar to the offline reconstruction ones, are run to select interesting events. The allowed processing time at EF is approximately 4s.

3. ATLAS Tau Trigger

Tau trigger, an important component of the ATLAS trigger system, is designed to select hadronic decays of tau. These decays are characterized by the presence of one or three charged pions accompanied by a neutrino and possibly neutral pions. It is challenging to keep the rates for these triggers low due to the high production rate of multi-jet events. Nevertheless it is advantageous to implement tau triggers to increase the sensitivity of searches for new physics. The details of the ATLAS tau trigger can be found in [2,3].

Table 1. A part of the tau trigger menu for $\mathcal{L} = 10^{31}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ at 10 TeV. In the name tauX+xeY, X and Y denote the tau E_T and MET (xe) thresholds, respectively, applied at EF.

Menu	Goal	Trigger	Unprescaled Rate [Hz]
Single Tau	Searches at high P_T	tau50_loose	0.89±0.45
tau+lepton	$Z \to \tau\tau$	tau12_loose_e10_loose	2.01±0.67
tau+MET	$W \to \tau\nu$, $t\bar{t}$, $Z \to \tau\tau$	tau16_loose+xe25	6.92±1.24
tau+jets	$t\bar{t}$	tau16i_loose+3j40	2.23±0.71

4. Prospects for Early Running

In order to have the background rates under control while keeping the signal efficiency high, the current studies done using fully simulated events show that the tau trigger at ATLAS should either be used with high energy thresholds or with relaxed requirements combined with missing transverse energy (MET) and other triggers. A proposed tau trigger menu for early running is shown in Tab. 1 highlighting different signatures and rates.

5. Measurement of Tau Trigger Efficiency

All single tau triggers are optimized, using MC simulation, to select truth matched reconstructed taus above certain E_T thresholds. Figure 1 shows the fraction of these taus in a $Z \rightarrow \tau\tau$ MC sample passing different triggers, as a function of their true visible E_T.[a] Tau trigger efficiency can be measured

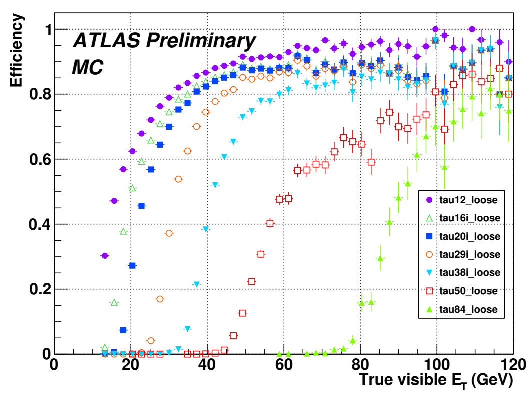

Fig. 1. Efficiency for different tau triggers.

with first collision data using the tag-and-probe method. For a single tau trigger in the medium E_T range, $Z \rightarrow \tau(\rightarrow e/\mu)\tau(\rightarrow had)$ events passing a single electron or muon trigger are selected. The fraction of hadronically decaying taus that passes the tau trigger gives the efficiency. Another method to measure the tau trigger efficiency is to select semi-leptonically decaying

[a]True visible E_T represents the true energy of tau after the energy of neutrino, coming from tau decay, has been subtracted off.

$t\bar{t}$ events containing hadronic taus from events collected by a 4-jet trigger. The tau-leptonic decay products are used as a probe for the efficiency measurement.

6. Tau Trigger and Cosmics Data in ATLAS

The ATLAS detector was fully commissioned and ready for data taking in August 2008. With the fully operational detector, about 600 M events have been collected in global cosmic runs during August-October 2008 and in June 2009. ATLAS also recorded single beam events on September 10, 2008. The analysis of cosmic data has been helpful in identifying and fixing different problems seen in sub-detectors. The cosmics events have also been used to understand and calibrate different components of the system.
Tau triggers has been exercised with cosmics events. Figure 2 shows the display of a cosmic-ray event triggered by the tau trigger. This event has at least 5 GeV energy deposition at L1. Furthermore, a track, pointing to the nominal interaction point, was reconstructed within the RoI. Thus these events form the closest proxy we have to tau events and allow us to partially commission the tau trigger software and compare the trigger output with offline reconstructed tau candidates.

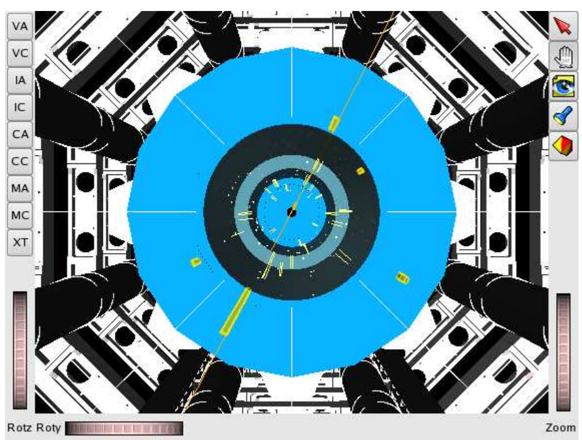

Fig. 2. ATLAS cosmic event display with a minimum deposition of 5 GeV at L1, and a track in the HLT system.

7. Tau Trigger Data Quality

In the tau trigger, the L1 system uses the calorimeter information, while reconstruction at HLT is based on information from calorimeters and tracking systems. This provides a good motivation to set up online data quality (DQ) monitoring histograms in which errors in cabling, calibration or configuration can be spotted immediately. Figure 3 shows the distribution of transverse energy at L2 deposited in the calorimeter. Reference plot, shown in light grey, is for a good run, while a run with calibration problems is shown in dark grey.

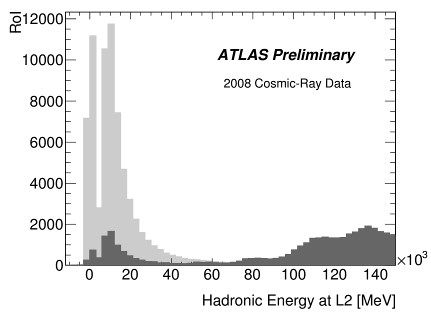

Fig. 3. Online Data Quality distributions of the transverse energy of L2 tau candidates for a good run (light grey) and for a run with miscalibration (dark grey).

8. Conclusion

Cosmics events at ATLAS have provided a valuable handle to understand and calibrate the whole detector and verify the expectations of trigger algorithms. In particular, tau triggers have been exercised with these events, and the rates of the L1 trigger measured. The system needs to be exercised with first collisions, which are expected at the end of 2009.

References

1. ATLAS Collaboration, G. Aad et al., The ATLAS Experiment at the CERN Large Hadron Collider, JINST 3, S08003, 2008
2. ATLAS Collaboration, G. Aad et al., Expected Performance of the ATLAS Experiment, Detector, Trigger and Physics, CERN report CERN-OPEN-2008-020, Geneva, 2008.
3. http://villaolmo.mib.infn.it/ICATPP10th_2007/High%20Energy%20Physics%20Experiments/Xella.pdf