PROCEEDINGS OF SCIENCE

Atlas trigger for first physics and beyond

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ATLAS is a multi-purpose spectrometer built to perform precision measurements of Standard Model parameters and is aiming at discovery of Higgs particle, Super Symmetry and possible other physics channels beyond Standard Model. Operating at 14 TeV center of mass energy ATLAS will see 40 million events per second at nominal luminosity with about 25 overlapping interactions. Most of the events are inelastic proton-proton interactions with only few W, Z bosons or ttbar pairs produced each second, and expectations for Higgs or SUSY production cross-section are much smaller than that. ATLAS trigger has a difficult task to select one out of 10^5 events online and to ensure that most physics channels of interests are preserved for analysis. In this talk we will review the design of ATLAS trigger system, the trigger menu prepared for initial LHC run as well as for high luminosity run. The expected trigger performance of the base-line ATLAS physics programs will be reviewed and first results from the commissioning period will be given. The methods to measure trigger efficiencies and biases directly from data will be discussed.

ATL-DAQ-PROC-2009-004
17 February 2009

Physics at LHC 2008
29 September - October 4, 2008
Split, Croatia

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†The ATLAS TDAQ Collaboration, ATLAS Note, ATL-DAQ-PUB-2008-004, 2008.

1. Introduction, the ATLAS trigger

ATLAS is a general purpose particle physics detector which is described in [1] and [2]. It will detect proton-proton collisions in the Large Hadron Collider (LHC). Its primary goals are to understand the mechanism for electroweak symmetry breaking and to search for new physics beyond the Standard Model. The LHC will eventually provide proton-proton collisions at a center of mass energy of about 14 TeV, a design luminosity of $10^{34} cm^{-2} s^{-1}$ and a bunch-crossing rate of 40MHz. Due to the limits on our capability to store data the ATLAS trigger is expected to have a rejection power of $\sim 10^5$ while being efficient for the interesting events.

ATLAS trigger is structured in three levels. The First Level (L1) uses custom built electronics. It reduces the trigger rate in ~ 3 orders of magnitude, giving a response in less than $2.5 \mu s$ It receives coarse data from the Calorimeter and muon sub-detectors. The so-called High Level Trigger (HLT) is software-based, it is composed by a Second Level Trigger (L2) and a third level trigger called Event Filter (EF). HLT has access to the full detector granularity data inside a Region of Interest (RoI) that has been defined by the previous trigger level. L2 uses algorithms specifically written for the trigger to accomplish the hard speed limits required at this level. EF uses offline reconstruction algorithms as much as possible in the online trigger environment.

2. The ATLAS Trigger Menu & Performance

The ATLAS trigger menus are built based in the identification of potential candidates for interesting objects as: electrons, photons, taus, muons, jets, b-tagged jets, B-physics objects, missing transverse energy, etc.

Inclusive triggers for each of these objects are included in the menu as much as they are allowed by rate limitations. Main handle to limit rates are the selection of events above a given transverse energy (E_T) threshold and the possibility to apply isolation criteria. The trigger menus also contain more sophisticated signatures in which two or more of the previous mentioned trigger objects are combined (for example: tau + missing E_T signature). Detailed studies of trigger performance based on signal efficiency and background rejection have been performed using full detector Monte Carlo simulation. For details check the trigger chapter in Ref. [3], as an example, the trigger efficiency with respect to offline reconstructed objects versus their transverse energy is shown for muon triggers in Fig. 1

3. Trigger efficiency determination from data

Methods are being developed to determine trigger efficiency from data, minimizing dependencies on Monte Carlo simulation. This is crucial for analysis, trigger data taking monitoring as well as Monte Carlo simulation validation and tuning. The key of these methods is to define a 'clean' data sample of a specific particle to be used as a reference to determine trigger efficiency for the corresponding trigger object. A typical example is the use of $Z \to e^+e^-$ and $Z \to \mu^+\mu^-$ decays. The control sample is defined by one lepton trigger plus the offline reconstruction of both leptons satisfying the Z invariant mass requirement. The second lepton is then used to study the trigger efficiency performance [3]. Studies are ongoing to extrapolate this measured trigger efficiency to

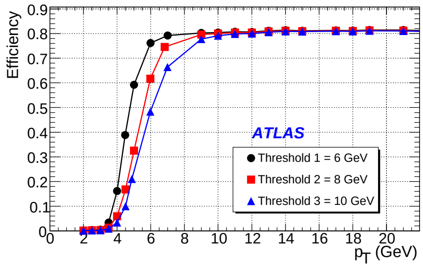

Figure 1: Trigger efficiency versus transverse momentum (p_T) curves for three of the lower muon trigger p_T thresholds.

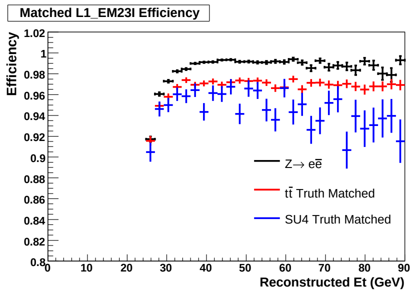

Figure 2: Comparison of L1 isolated electron trigger efficiency as a function of E_T for different Monte Carlo simulation samples ($Z \to e^+e^-$, ttbar and susy).

different event topologies, as can be seen in Fig. 2 Trigger efficiency will also be determined with respect to offline identified objects using as control samples 'Boot-strap' techniques (use looser trigger selections to study performance of tighter ones) and 'Orthogonal' triggers (Ex. use muon trigger to study performance of missing E_T trigger).

4. Commissioning

The trigger system is now continuously used during cosmic ray runs to exercise the full trigger chain and read-out of sub-detectors. Since few months the L1 central trigger has been running in its final configuration receiving all foreseen trigger inputs and providing trigger signals to all sub-detectors. HLT is periodically integrated in the cosmic runs. ATLAS received the first single beam in September 2009. The proton bunch sent onto the beam collimators originated the very first beam events to trigger on. Next phase was to have beam circulating for several turns. The time alignment for different trigger items was studied taking the Beam Pick-ups trigger as the time reference of the passage of a bunch in the ATLAS detector. The L1 decision of each trigger item in a time window of ± 15 bunch crossing has been recorded and analyzed.

5. Conclusions

The ATLAS trigger is on a good track to have a successful performance for proton collisions at LHC. Methods are being developed to determine trigger efficiency from data. The full trigger system is used in cosmic ray runs. The L1 trigger performed successfully with single beam.

References

[1] Jenni, P et al *1999 ATLAS detector and physics performance Technical Design Report, ser. Technical Design Report ATLAS* (Geneva: CERN)

[2] The ATLAS Collaboration, G. Aad et al., *"The ATLAS Experiment at the CERN Large Hadron Collider"*, *JINST* 3 **(2008)** S08003

[3] ATLAS Collaboration, *"Expected Performance of the ATLAS Experiment,* Detector, Trigger and Physics" CERN-OPEN-2008-020, Geneva, **2008**