

# ATLAS Trigger Menu for Early Data-Taking

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## 1 Introduction

The ATLAS trigger system is based on three levels of events selection that selects the physics of interests from an initial bunch crossing rate of 40 MHz. During nominal LHC operation at a luminosity of  $10^{34}\text{cm}^{-2}\text{s}^{-1}$ , decisions must be taken every 25 ns with each bunch crossing containing about 23 interactions [1]. The selections in the three trigger levels must provide sufficient rejection to reduce the rate down to 200 Hz to be compatible with the offline computing power and storage capacity [2], [3]. The LHC is expected to begin operation in spring 2009 with a peak luminosity of  $10^{31}\text{cm}^{-2}\text{s}^{-1}$  with a reduced number of bunches. Operations are expected to quickly ramp up to higher luminosities, hence the trigger needs to adapt to the changing beam conditions while preserving the interesting physics and detector requirements.

We present the status of the preparation of the trigger menu for early data taking and show how we plan to deploy the trigger system from the first collision to the nominal luminosity. We also show expected rates and physics performance obtained from simulated data.

## 2 Trigger system

The ATLAS trigger system comprises of three levels (LVL1, LVL2, and EF) and selects events of physics interest while reducing the rate from the 40 MHz collision rate to approximately 200 Hz.

The level-1 trigger (LVL1) is a hardware trigger using data from the calorimeter and the muon trigger chambers. The LVL1 central trigger processor (CTP) receives the

multiplicity of objects above a certain threshold (e.g. muon, electromagnetic cluster, jet and missing transverse energy) identified by the sub-systems. The CTP makes a decision based on the multiplicity of various thresholds. Threshold values and the logic used in the CTP are configurable. However, the number of different thresholds for each type of objects and the number of independent trigger logic (trigger item) is fixed by hardware design to a maximum of 256.

The level-2 trigger (LVL2) is a software-based trigger running on  $\sim 1000$  computing nodes. The LVL2 system receives the results of the LVL1 trigger items and the threshold information. The threshold information is used to identify the region of interest (RoI) where the LVL1 observed interesting objects. Execution of algorithms at LVL2 is controlled by the HLT steering software which runs the algorithm on each RoI. Algorithms then request data from the detector readout system belonging to the RoI. The average execution time per event must be below  $\sim 40$  ms.

The event filter (EF) execution is also controlled by the HLT steering. At EF, algorithms similar to the ones in the offline reconstruction are executed after the event building has finished. This feature allows algorithms to access the full event data. The event processing time must be less than a few seconds at this stage.

Events passing the event filter selection are directed to different streams depending on which trigger chain accepted the event. Events assigned to different streams will be written out into different files to allow for separate offline reprocessing of events based on the event type. Event streaming is done inclusively, i.e. if an event passes several triggers in different streams, that same event will be written into several streams.

A fraction of the collected data goes to the calibration stream to record a sample dedicated to detector calibration, or for express stream. The express stream will be used for fast reconstruction to validate data.

### 3 Physics program

The physics program in ATLAS extends to a broad range of physics. Measurements of the Standard Model of particle physics will be possible at much higher energies than at any other particle collider. Hence, Quantum Chromodynamics (QCD) jet productions, electroweak processes (e.g. W/Z production), B-Physics, top-quarks, etc. will all be studied in great details [1].

However, the experiment must also be sensitive to other possible physics beyond the Standard Model (SM) (e.g. SUSY, Extra-dimension models, etc.) or to other predictions from the SM that have not yet been observed, such as the Higgs particle.

The three-level trigger must thus collect a wide range of physics processes ranging from low-transverse momentum events, such as in B-physics, to high-transverse momentum events, such as in beyond SM searches with various final states.

During early data-taking, it will be crucial to record a wide variety of events in order to calibrate the trigger system, and to understand the trigger response. To accomplish this task, the trigger reconstructs basic physics objects: muons, electrons, photons, hadronic  $\tau$ 's, jets/b-jets, energy sum, missing energy, B-physics and minimum bias signatures. In order to improve the selection of events and reduce the acceptance rates, the trigger also includes requirements based several basic objects.

## 4 Startup strategy

The LHC accelerator and the ATLAS experiment are expected to start operation in fall 2009. We expect to have the first  $pp$ -collision at the LHC by summer 2009. The first LHC operation will be done at low luminosity ( $\mathcal{L}=10^{31}\text{cm}^{-2}\text{s}^{-1}$  or less), quickly ramping up to higher luminosities (up to  $\mathcal{L}=10^{33}\text{cm}^{-2}\text{s}^{-1}$ ). The ATLAS experiment is preparing several trigger menus from the first collision to higher luminosity running, namely for the luminosity of  $10^{31}$ ,  $10^{32}$  and  $10^{33}\text{cm}^{-2}\text{s}^{-1}$ . Different prescale sets are being prepared for each menu to deal with the luminosity changes during the run.

During the early LHC running period at low luminosity, the trigger can be run with many low threshold items in order to understand the HLT selection algorithm performance with real data. To this end, when possible the HLT algorithms are executed but events are accepted regardless of the algorithms' decision.

## 5 Trigger performance for $\mathcal{L}=10^{31}\text{cm}^{-2}\text{s}^{-1}$

In order to probe the lower energy range of the full spectrum of collision events obtained at the LHC, the trigger uses low-threshold but prescaled triggers. However, for physics searches unrescaled triggers are required.

The strategy of sampling the lower energy range of the physics spectrum available in the events can be observed in the selected jets distribution (figure 1). In this figure, the lower energy plateau of accepted jets is selected with prescaled triggers, while the higher energy tail is unrescaled so as to be used in physics analysis. Figure 2 shows the approximated individual and cumulative rates at which events are recorded by different groups of triggers based on Monte Carlo simulations.

## 6 Summary

A trigger menu for initial collisions is being prepared, and will be used as a solid starting point for recording first collisions at the LHC. Although the menu will initially need to evolve very quickly, the experience and tools resulting from the current trigger menu studies will be essential to cope with the stringent demands that the LHC will

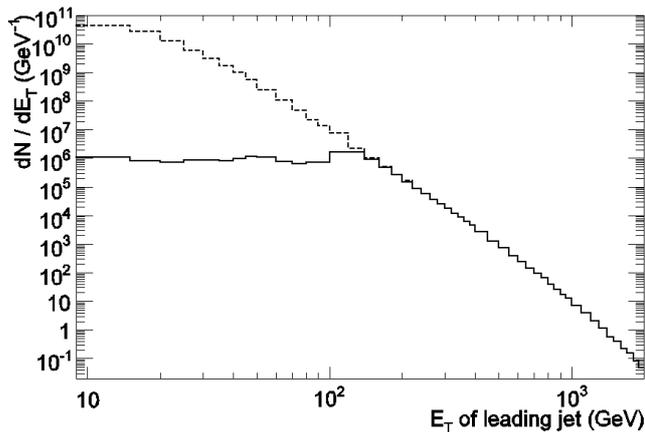


Figure 1: The transverse momentum spectrum of jets selected by the jet triggers (solid line), and of the full spectrum of jets in the Monte Carlo simulation (dashed line).

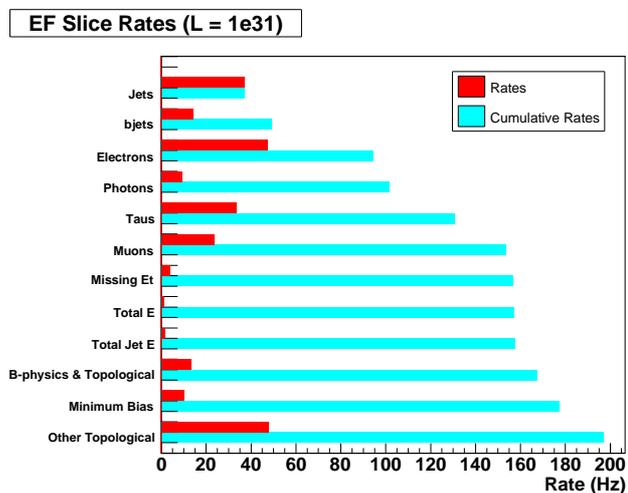


Figure 2: The overall approximated output rates of the EF for different groups of triggers for a luminosity of  $10^{31} \text{cm}^{-2} \text{s}^{-1}$ .

impose on both software and hardware used in this experiment.

## References

- [1] [ATLAS Collaboration], “ATLAS: Detector and physics performance technical design report. Volume 1”
- [2] R. Goncalo [ATLAS TDAQ Collaboration], J. Phys. Conf. Ser. **110**, 092013 (2008).
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