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Implementation and Performance of the ATLAS Jet Trigger

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ATLAS is one of the main experiments at the LHC. Its trigger system has been designed to be flexible in order to cover a wide range of physics topics, while reducing the rate from the nominal 40 MHz to about 200 Hz. In order to achieve this, the ATLAS trigger system searches for high p_T objects, like leptons, jets, photons, or missing transverse energy.
The jet trigger starts at the first level trigger with dedicated processors that search for high E_T hadronic energy depositions. At the second level trigger, the jet signatures are verified with the execution of a dedicated, fast cone reconstruction algorithm followed by a simple calibration scheme. In the third level trigger any of the offline jet reconstruction algorithms can be used.
In this paper we will present the challenges of the jet trigger, describing the implementation and the expected performance.

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1. Introduction

ATLAS[2] is a multipurpose detector designed for the LHC proton-proton collider. At the nominal LHC luminosity of 10^{34} cm^{-2}s^{-1}, the ATLAS collision rate will be 40 MHz, with a 25 ns proton bunch separation, imposing stringent requirements on the trigger system that has to be very efficient to select the interesting events, while reducing the rate to the 200 Hz storage rate. The trigger achieves this by identifying generic objects, like high p_T leptons or jets, for example.

The ATLAS jet trigger [3] has to be prepared to cover a wide variety of physics topics, ranging from Standard Model physics studies (QCD, top physics, VBF processes, ...) to searches for new physics (SUSY, extra dimensions, invisible Higgs, ...). At the LHC, the main background for jets are also jets. Therefore, the main difficulty of the jet triggers is an accurate energy (and to a lesser extent position) resolution. In order to fulfill the LHC requirements, the ATLAS trigger was divided in three levels, the first one being hardware based (LVL1) and the following two software based. The LVL1 was implemented in custom designed processors that operate with coarse granularity, applying a sliding window algorithm (0.8x0.8 in η, ϕ) that identifies local energy maxima in the calorimeter and selecting/rejecting events with 2 μs latency[1].

The second level trigger, LVL2, uses as a starting point the center of the energy clusters found at LVL1, reconstructing only a region of the detector, known as Region of Interest (RoI), around the LVL1 seed. It can operate with the full granularity or with a reduced granularity corresponding to energy sums per Front-End-Board (FEB), taking a decision in about 40 ms. It runs a simplified cone-like algorithm with radius R=0.4 in η, ϕ to determine the energy weighted center of the cluster. It ends with a simplified calibration scheme that applies a correction weight to the electromagnetic and hadronic calorimeter energy depositions depending on η and the total jet energy.

The third level trigger, called Event Filter (EF) uses offline-like algorithms that may operate in seeded mode or in full event access (unseeded mode), using the offline calibrations.

2. Performance of the ATLAS Jet Trigger

Detailed performance studies of the ATLAS Jet Trigger were done using MonteCarlo data [3], but only a summary of the main results will be presented here.

The LVL2 jet energy scale was studied for the large energy range spanned by the trigger, as it is shown in figure 1 (left) for the full granularity. The linearity with respect to the truth jet energy was found to be within 2% for all the η range covered by the jet trigger. The energy resolution was found to be moderately improved with respect to the non-calibrated LVL2 jets. The spatial resolution for the center of the jet is 0.03 in pseudo-rapidity and 0.01 in the azimuthal angle ϕ. Similar performance can be obtained using the reduced granularity.

Given the time limitations of the LVL2 trigger, detailed studies of the processing time spent by the LVL2 reconstruction algorithm were done in dedicated technical runs that test the trigger algorithms and infrastructure in similar conditions to the ones expected in real data. The average total processing time for the LVL2 jet algorithm was found to be 22 ms, dominated by the data collection, that accounts for 30% of the time, and the data preparation step (translation of the raw

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[1] Pseudorapidity is defined as $\eta = -\log\left(\tan\frac{\theta}{2}\right)$, where θ is the scattering angle from the incoming beam direction.

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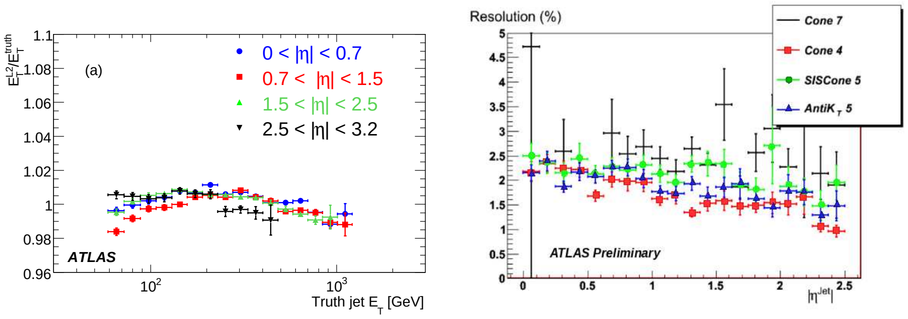

Figure 1: Left: Jet energy scale linearity versus jet transverse energy for the LVL2 jets, for four different pseudo-rapidity bins. Right: Resolution of different jet reconstruction algorithms run at the EF in seeded mode with respect to the offline reconstructed jets.

data received from the read out buffers into C++ objects used by the algorithms). Using the reduced LVL2 granularity speeds up the whole process by a factor of 2.

For the EF different offline jet algorithms were tested. Given the fact that in the current setup the reconstruction is limited to the RoI (1.6x1.6 in η,ϕ), jet energies may differ from the offline. The comparison of the energy resolutions of the EF jets measured with respect to offline jets for the ATLAS cone (with radius 0.7 and 0.4), SISCone (with radius 0.5) and anti-kt (radius parameter 0.5) algorithms as a function of η is shown in figure 1. The best resolution is obtained for cone 0.4 and anti-kt. The cone algorithm with largest radius has the worst resolution.

3. Summary and conclusions

A three level jet trigger has been developed in the ATLAS experiment, designed to cover a wide variety of physics topics. The trigger starts with the identification of large transverse energy depositions by the first hardware level, that are later refined at the following two software levels, each emplying larger processing times and more refined jet algorithms and calibrations. The performance of this trigger system has been studied in detail. The processing times of each step were measured and found to be well inside the stringent ATLAS trigger requirements. The jet energy can be reconstructed at the second trigger level with a linearity of 2% for the whole energy regime covered by the central jet trigger. At the third trigger level, several offline algorithms were compared. The best resolutions are obtained for the cone and anti-kt algorithms with smaller radius.

References

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