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The ATLAS trigger muon "vertical slice"☆

Antonio Sidoti*[,1], for the ATLAS Muon Slice group

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Abstract

The muon trigger system is a fundamental component of the ATLAS detector at the LHC collider. In this paper we describe the ATLAS multi-level trigger selecting events with muons: the Muon Trigger Slice.

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1. Introduction

The ATLAS experiment at the LHC proton–proton collider at CERN is faced with several technological challenges. In particular, the trigger system has to reduce the rate from the 40 MHz of bunch crossing to the about 100–200 Hz event acquisition rate. Events with muon in the final states are of fundamental interest for the physics potential of the ATLAS experiment. In this paper we review the implementation and the integration of the muon trigger, in particular the first level of muon trigger (LVL1) and the High Level Trigger (HLT) composed by Level-2 (LVL2) and Event Filter (EF) algorithms and the performance of the combined trigger system.

2. Level-1

Muon trigger LVL1 is a synchronous process with a fixed latency of 2.5 μs. Using the full granularity of the Thin Gap Chambers (TGC) and Resistive Plate Chambers (RPC), respectively, for the endcap ($|\eta|>1$) and barrel regions ($|\eta|<1$) of the Muon Spectrometer (MS), it selects muons with transverse momentum above six programmable thresholds with a coarse evaluation of the pseudorapidity and azimuthal angle coordinates (respectively, η and ϕ) and associates the trigger candidate with the correct LHC bunch crossing. The algorithm looks for hit coincidences within different RPC or TGC detector layers inside the programmed geometrical roads which define the transverse momentum cut. A coincidence is required on both eta and phi projections. A tight time coincidence of the trigger detector hits is required as well. Regions where the muon track is found are called Region of Interest (RoI) corresponding to a $\Delta\eta \times \Delta\phi$ of 0.1×0.1. Data in RoI are further processed by LVL2 triggers. The combination of hits is made using a Coincidence Matrix ASICs [1,2]. The LVL1 event-decision part is implemented by the Central Trigger Processor that also resolves double counting of muons that traverse more than one detector region. This is crucial to avoid high rates of low-P_T di-muon states due to single muon states. The LVL1 trigger efficiencies at 6 GeV *plateau* are[2] ε_{LVL1}~83% and ε_{LVL1}~93% for, respectively, the barrel and end-cap regions.

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*Corresponding author.

E-mail address: antonio.sidoti@roma1.infn.it.

[1]M. Bellomo, M. Biglietti, G. Carlino, G. Cataldi, F. Conventi, T. Del Prete, A. Di Mattia, S. Falciano, E. Gorini, N. Kanaya, T. Kohno, A. Krasznahorkay, T. Lagouri, C. Luci, L. Luminari, F. Marzano, K. Nagano, A. Nisati, N. Panikashvili, E. Pasqualucci, M. Primavera, D.A. Scannicchio, A. Sidoti, S. Spagnolo, S. Tarem, Z. Tarem, K. Tokushuku, G. Usai, A. Ventura, V. Vercesi, Y. Yamazakifrom INFN Sezione RomaI, INFN Sezione di Pavia, INFN Sezione Napoli, INFN Sezione di Lecce, INFN Sezione di Pisa, University of Oxford, CERN, University of Debrecen, IPNP Charles University (Prague), Technion, KEK and University of Chicago.

[2]Including geometrical acceptance.

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3. High Level Trigger: LVL2 and Event Filter

The High Level Trigger system is composed by a LVL2 with a total latency of $\sim$10 ms that reduces the total LVL1 rate from $\sim$75(100) KHz to $\sim$1 KHz and an EF level with a total latency of $\sim 1-2$ s and a rate reduction from $\sim$1 KHz to the $\sim 100-200$ Hz of the final output.

3.1. Level 2

The fundamental algorithm of the muon LVL2 is *muFast* [3]. It runs on full granularity data within the RoI defined by LVL1. The strategy is to avoid lengthy calculations and heavy access to external services to reduce the execution time of the algorithm. After a pattern recognition driven by the RPC or TGC hits selecting Monitored Drift Tubes (MDT) crossed by the muon track, a track fit is performed using MDT drift time precision measurements. The P_T evaluation is performed using Look Up Tables. At LVL2 Inner Detector (ID) tracks can be combined to the tracks found by *muFast* by a fast combination algorithm (*muComb*) to further reduce the rates of muons coming from π/K in-flight decays. Expected rates for an instantaneous luminosity of $\mathscr{L} = 10^{33}\,\mathrm{cm^{-2}\,s^{-1}}$ for a 6 GeV muon trigger threshold drop from 11.0 KHz (LVL1 output) to 4.5 KHz (*muFast* output) to 2.13 KHz (*muComb* output) for the barrel region. Most of the rate reduction occurs dropping off π and K in-flight decays (respectively, 7.60 KHz at LVL1 output, 3.18 KHz at *muFast* output and 1.1 KHz at *muComb* output). Muon candidates can also be combined with calorimetric information in order to select isolated muons coming from W, Z bosons and top quarks. To cope with the high rates for low momentum muons, a Level 2 Dimuon Trigger is also implemented in order to select dimuon events coming from a J/ψ ($B \to J\psi X$).

3.2. Event Filter

The third level trigger, Event Filter (EF) accesses the full event with its full granularity. It can also combine information combining measurements from other ATLAS sub-detectors. Due to the larger allowed time latency, algorithms developed for the off-line reconstruction have been wrapped into the on-line framework in order to avoid any off-line dependencies [4]. The expected output rates for the combined muon system and Inner Detector EF algorithm with a 20 GeV P_T threshold for $\mathscr{L} = 10^{34}\,\mathrm{cm^{-2}\,s^{-1}}$ are $\sim$180 Hz.[3]

4. Conclusions

The trigger muon slice is ready to be integrated in the ATLAS TDAQ architecture. Cosmic data taking is on going to commission the whole system heading for a successful ATLAS physics programme.

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[3]Note that LVL2 *muComb* has not been used to further reduce the LVL2 output rate.