

## Triggering on Hadronic Signatures in ATLAS: Developments for 2017 and 2018 data

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The ATLAS trigger system is tasked with selecting the roughly 1000 most interesting events out of the up to 40 million LHC bunch crossings that occur every second during data-taking. Triggers aimed at hadronic physics, which are responsible for selecting events containing jets,  $b$ -jets, and missing transverse momentum, have received significant algorithmic improvements in preparation for the 2017 and 2018 data-taking periods. These changes have been made to account for the continuously changing LHC beam conditions, and particularly for the the average number of simultaneous  $pp$  collisions per bunch crossing, which is increasing every year and which poses a significant challenge for hadronic triggers. These hadronic trigger developments have allowed the ATLAS trigger system to both continue to operate in increasingly difficult conditions and to increase the diversity of the recorded events, therefore supporting and extending the ATLAS physics program.

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## 1. Overview

The ATLAS [1] trigger system for the 2015-2018 data taking period is comprised of two stages: a hardware-based Level-1 (L1) trigger and a software-based High Level Trigger (HLT) [2]. The L1 trigger makes a fast decision for every LHC bunch crossing, reducing the event rate from an input of up to 40MHz to roughly 100kHz. The HLT then uses similar software algorithms as are used for physics analysis to select the roughly 1 kHz of events which are written to disk.

The ATLAS trigger system records many different types of events, supported by a diverse set of trigger items. The set of *hadronic triggers* refers to any item aimed at selecting events with jets, *b*-tagged jets, or missing transverse momentum  $E_T^{\text{miss}}$ . There are a variety of L1 and HLT algorithms designed to identify such events, including new developments for 2017 and 2018 data [3].

## 2. New developments in hadronic triggers

The online trigger jet calibration was substantially improved between 2016 and 2017, bringing it much closer to what is used for offline physics analysis. Jets are first built using only calorimeter information and are required to have a transverse momentum  $p_T$  above a lower threshold. Tracks are then reconstructed in the jet's proximity, which are used to refine the jet calibration before applying a higher  $p_T$  threshold. This two-stage approach drastically improves the jet resolution, reducing the full efficiency point for  $p_T^{\text{HLT}} > 450\text{GeV}$  from  $p_T^{\text{offline}} > 510\text{GeV}$  to  $p_T^{\text{offline}} > 470\text{GeV}$ .

The 2017 data-taking period came with a significant increase in the amount of simultaneous  $pp$  collisions per bunch crossing, which leads to an increased amount of spurious signals in the detector. The calculation of the  $E_T^{\text{miss}}$  is very sensitive to such spurious signals, as they lead to event imbalances which are interpreted as particles not interacting with the detector. A new  $E_T^{\text{miss}}$  trigger algorithm was deployed to counteract this challenge, and was found to not only decrease the trigger rate by roughly an order of magnitude in events with 50 simultaneous  $pp$  collisions, but to also identify a larger number of events containing genuine weakly-interacting particles.

The identification of *b*-jets was re-optimized for 2017 data-taking, bringing the online flavour tagger closer to what is used for physics analysis. This led to greatly improved *b*-jet identification, both in increasing the number of properly-identified events in the trigger, and in bringing the trigger and offline *b*-jet identification efficiencies for a given *b*-tagging working point much closer together.

## 3. Summary

The ATLAS trigger system is constantly evolving to cope with the changing LHC data-taking conditions. Recent hadronic trigger developments in 2017 and 2018 have been instrumental in continuing and even extending the capabilities of the ATLAS trigger system, thus supporting the ATLAS hadronic physics program under increasingly challenging data-taking environments.

## References

- [1] ATLAS collaboration, *ATLAS Experiment at the CERN Large Hadron Collider*, *JINST* **3** (2008) 003.
- [2] ATLAS collaboration, *Performance of the ATLAS Trigger System in 2015*, *Eur. Phys. J.* **C77** (2017) 317.
- [3] ATLAS collaboration, *Trigger Menu in 2017*, *ATL-DAQ-PUB-2018-002* (2018) .