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ATLAS fast physics monitoring

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Abstract. The ATLAS experiment at the Large Hadron Collider is recording data from proton–proton collisions at a centre-of-mass energy of 7 TeV since the spring of 2010. The integrated luminosity has grown nearly exponentially since then and continues to rise fast. The ATLAS Collaboration has set up a framework to automatically process the rapidly growing dataset and produce performance and physics plots for the most interesting analyses. The system is designed to give fast feedback. The histograms are produced within hours of data reconstruction (2–3 days after data taking). Hints of potentially interesting physics signals obtained this way are followed up by physics groups.

Keywords. ATLAS; physics; monitoring.

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1. Introduction

The LHC [1] and the ATLAS [2] experiments were built for uncovering so far unseen phenomena of nature. Uncovering possible new phenomena depends highly on the integrated luminosity. The integrated luminosity delivered by the LHC is rapidly increasing, and therefore the time to double the data remained short throughout 2011. In contrast, physics analyses are often performed on a somewhat fixed dataset for practical reasons. It is therefore important to monitor many topologies and final states as quickly as possible in an unbiased way and independently from the regular physics analyses in order to be aware of interesting signatures developing in a timely manner. This fast physics monitoring (FPM) is complementary to data quality monitoring as problems may look like 'new physics' signals. Experts from the relevant detector, performance, and physics groups are promptly notified in case an interesting signature is shown by this FPM programme in order to quickly gain an understanding of the unexpected signature.

2. General considerations

In order to successfully complete the task of FPM, it is imperative to use new collision data recorded by the ATLAS experiment as quickly as possible. The data are provided by

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Tier 0 as soon as the main reconstruction is finished [3]. The software framework that produces the final histograms must be flexible enough to allow for easy addition of new signatures and allow for very frequent processing. For simplicity reasons, GEANT4-simulated events are taken without additional next-to-leading order K factors or smearing corrections and no data-driven background estimations are employed. The final results of FPM are summarized on ATLAS-internal web pages and updated at least every night.

3. Implementation

Two standard file types are used by the FPM and produced directly at Tier 0: the analysis object data (AOD) and the TAG files [3]. The AOD is the standard data format from where physics analyses generally start. It contains all reconstructed data objects that are needed for most physics analyses. On the other hand, TAG files contain only a limited number of particle candidates with very condensed information. Two complementary FPM approaches have been developed based on these two types of datasets.

3.1 *AOD-based monitoring*

The analysis of multiple signatures of interest is performed directly on the AOD utilizing the full power of the ATLAS software framework Athena [4] and the availability of the full event information. Thus, the event selection and calculation of quantities of interest can be done in the same way as the corresponding full analyses. Care is taken to limit the impact on the central processing unit (CPU) utilization of the Tier 0 to a minimum in order to not interfere with standard reconstruction. This analysis step results in a single ROOT [5] file containing multiple TTrees, one per signature. A python-based framework has been developed to process these ROOT files, apply the final signature-specific selection, including analysis-specific data quality criteria, calculate the new integrated luminosity of all processed data based on the best-known calibrations and produce the final histograms of interest. These data histograms are overlaid with properly weighted, signature-specific histograms from GEANT4-based simulated events, including the signal process of interest, and finally published on an ATLAS-internal web page. An example of this is shown in figure 1. The processing of the above-mentioned custom ROOT files for all of the recorded 2011 data is done at least once per night and takes less than 1 h to complete on a single machine.

3.2 *TAG-based monitoring*

TAG files are produced at Tier 0 as an integral part of the ATLAS computing model [3]. A C++ framework is used to perform the analysis of all signatures of interest in one pass on all TAG files available for 2011 using the CERN batch computing farm. Events are accepted for data periods where all ATLAS subdetectors were operational. As in the case of the AOD-based monitoring, the final histograms are merged, overlaid with histograms from GEANT4-simulated events, and published on an ATLAS-internal web page. An example of this is shown in figure 1. In some cases, fully detailed or high-multiplicity studies are not possible due to the limited content of the TAG files. However, the big

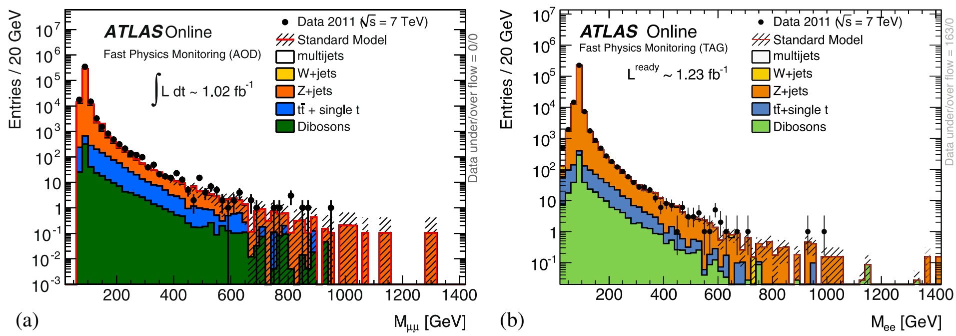

Figure 1. Example figures obtained from the FPM automatic framework. (**a**) Invariant dimuon mass spectrum based on AOD files. (**b**) Invariant dielectron mass spectrum based on TAG files. The data shown correspond to the same data sample presented at EPS2011 and published in [6], except that the TAG-based histogram uses all events passing the data quality flag 'ATLAS Ready'. The background estimations come solely from uncorrected GEANT4-simulated events and the given total uncertainty bands represent statistical uncertainties only.

advantage over the AOD-based monitoring is its flexibility and fast response time. The full chain from devising a new signature of interest to the final histograms appearing on the web page for the full 2011 data can be done in less than 1 h.

4. Summary

To summarize, a new two-fold software framework has been devised with the purpose to monitor interesting physics signatures as quickly as possible and thus provide prompt physics-oriented data quality monitoring. The two-fold approach provides rather complementary benefits. While the AOD-based monitoring profits from the full event information, the TAG-based monitoring profits from its flexibility to quickly add new signatures and fast processing. Finally, monitoring histograms are updated every night and published on an ATLAS-internal web page.

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