

ATLAS fast physics monitoring: TADA

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Abstract. The ATLAS experiment at the LHC has been recording data from proton-proton collisions with 13 TeV center-of-mass energy since spring 2015. The collaboration is using a fast physics monitoring framework (TADA) to automatically perform a broad range of fast searches for early signs of new physics and to monitor the data quality across the year with the full analysis level calibrations applied to the rapidly growing data. TADA is designed to provide fast feedback directly after the collected data has been fully calibrated and processed at the Tier-0. The system can monitor a large range of physics channels, offline data quality and physics performance quantities. TADA output is available on a website accessible by the whole collaboration. It gets updated twice a day with the data from newly processed runs. Hints of potentially interesting physics signals or performance issues identified in this way are reported to be followed up by physics or combined performance groups. The note reports as well about the technical aspects of TADA: the software structure to obtain the input TAG files, the framework workflow and structure, the webpage and its implementation.

1. Introduction

The ATLAS [1] fast physics TAG DATA (TADA) monitoring is a system to monitor a wide spectrum of new physics channels and aspects of offline data quality and physics performance. Since 2011 this system is operated as part of the ATLAS Tier-0 [2] [3] prompt data processing at CERN to allow for an early detection of anomalies in the different channels. TADA takes benefit from the full offline detector performance provided by the prompt reconstruction of the data after the calibration loop. Its task is to look for early signs of new physics in the data and it allows to monitor the quality of the data. The guiding principle of TADA search is to cover a broad spectrum of final states, while being inspired by the offline selections for the corresponding channels.

2. TADA

2.1. Data Format and TADA Workflow

In ATLAS the data collected from the High Level Filter (HLT) are sent to Tier-0 facility to be processed. A conditions database provides calibration and alignment for a first calibration loop on the data. After the calibration loop is performed there is a first pass processing which produces a chain of output file: $RDO \rightarrow ESD \rightarrow AOD \rightarrow TAG$.

RDO (Raw Data Object) files contain the full information of the detector response, ESD (Event



Summary Data) files contain output of detector reconstruction, AOD (Analysis Object Data) files contain a summary of all reconstructed objects. TAG files which are produced centrally at Tier-0 as part of prompt production chain are the input used by TADA. This file format has very condensed event information: leading 6 e, 6 μ , 4 τ , 4 γ , 10 jets, missing transverse energy (E_T^{miss}) information, trigger counters and global event info. The following is stored for each of the physics objects: kinematics, bit-encoded information on particle identification, quality, isolation.

The TAG based monitoring is using a hybrid software approach of C++ and python. The ntuple processing is done in C++ while python is used for job steering, metadata handling, bookkeeping, and web page generation.

The Figure 1 shows a schematic of the data flow for TADA. TADA uses the full analysis level

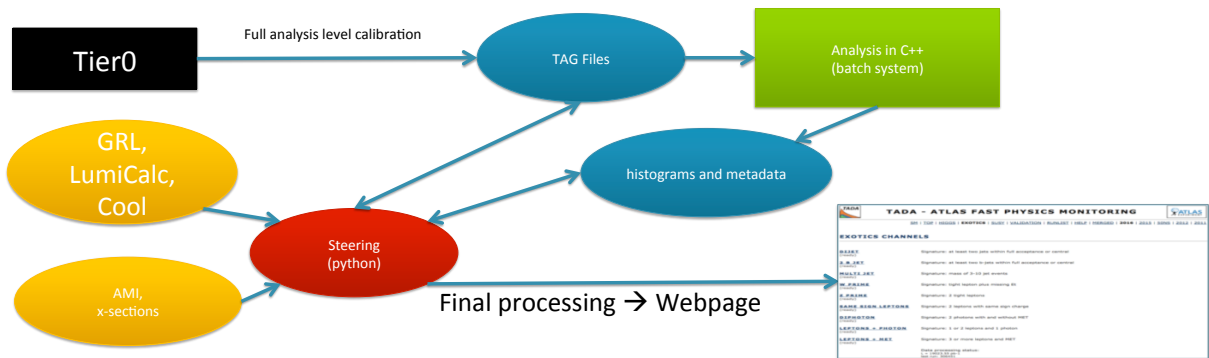


Figure 1. TADA workflow diagram

calibrations: this provides excellent quality in a quasi online framework. The framework uses cross sections and data luminosity to normalize the Monte Carlo (MC). TADA uses a wide range of MC simulations: each channel has a specific set of MC to optimize the Data-MC comparison. Scale factors and correction to MC normalization are applied as well. For physics measurement the collected data have to satisfy several quality constraints. The list of luminosity blocks with good data quality are stored in the Good Run List (GRL) in a .xml file. In TADA the data, selected GRL, are compared to Monte Carlo after pileup reweighting. Various codes are utilized in the TADA workflow:

- The luminosity is evaluated via the ATLAS Luminosity Calculation tool (LumiCalc) [4].
- Trigger pre-scales are obtained using COOL [5]
- The metadata on runs and files are obtained via the Atlas Metadata Interface [6](AMI).

TADA discovers newly processed runs at Tier-0 and produces histograms and metadata files. The final pass processing creates plots, cut flows, event dumps and updates webpages with all results.

2.2. Webpage

The information produced by TADA are shown in a webpage that provides results for 2015 and 2016 data, as well as their combination. The webpage, updated twice a day, contains several categories of physics channel and validation pages: 322 different selections are applied to fill approximately two thousands histograms.

Each channel provides:

- Main selections: inspired by full analysis selection.

- Plots grouped by mode: for a given selection the most important variables are plotted.
- Event dumps : all the significant information (run number, event number, lumi block, kinematic) of interesting events is displayed.
- 3D views for interesting events (Figure 2)
- Cut flows : Event yields after each step of the selection are provided.

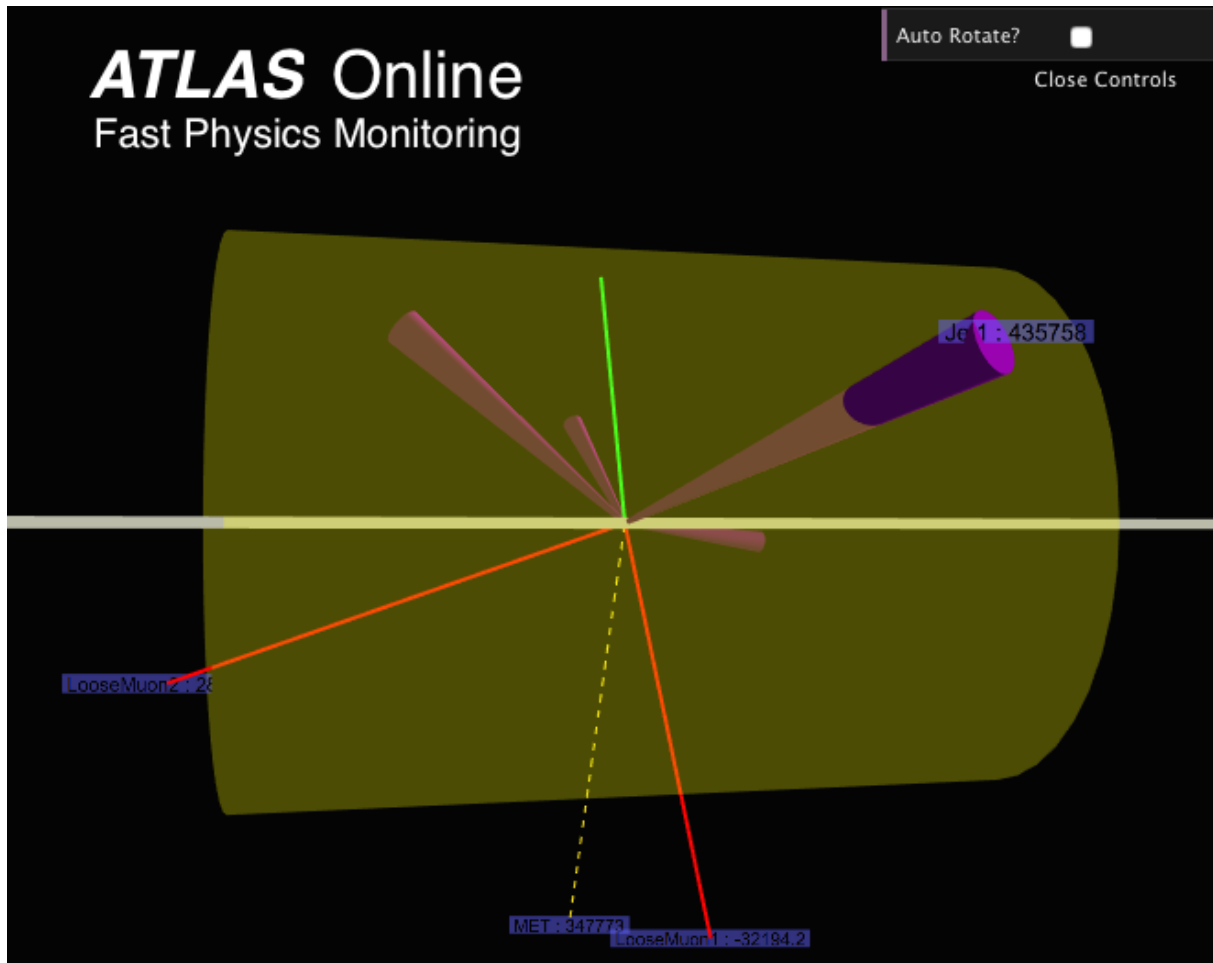


Figure 2. 3D view of an event selected in TADA. The yellow thick horizontal line represents the beam pipe, the purple cones represent the reconstructed jets, the continuous thin lines (red and green) represent reconstructed leptons (muons and electrons) and the dotted yellow line the missing energy. The opaque yellow cylinder is a representation of the ATLAS detector.

The website is accessible to the whole ATLAS collaboration.

2.3. Fast search for new physics and data quality monitoring

TADA monitors various physics channels, which are grouped into five categories: Standard Model, top, Higgs, exotics and SUSY searches. Distributions for different channels, like invariant mass of dilepton and dijet events, are displayed on the webpage as show in Figure 3 and 4.

TADA is used to spot interesting events, e.g. 8.8 TeV dijet events in 2015 as shown in Figure 5. This event was the highest invariant mass dijet event in the early data taking in 2015.

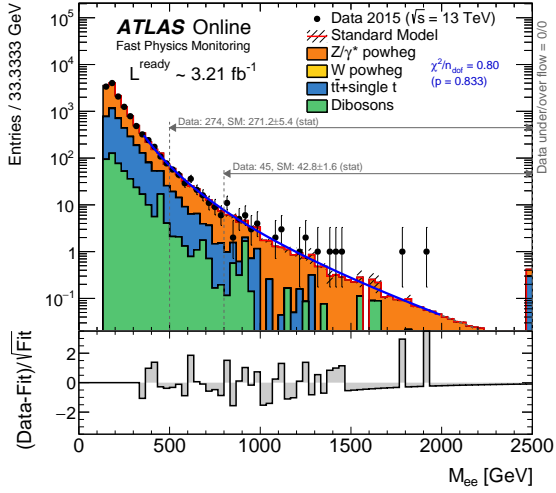


Figure 3. Di-electron invariant mass.

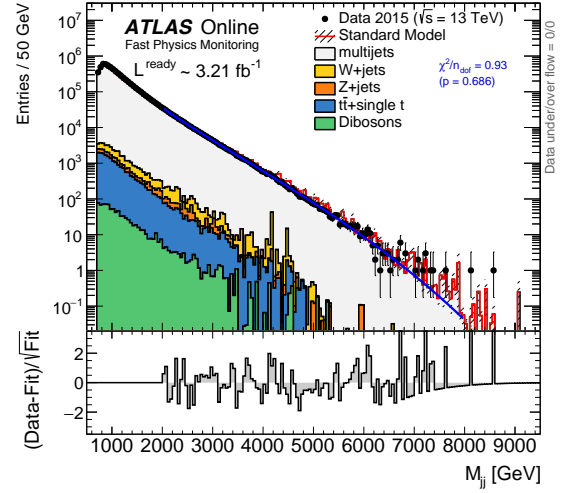


Figure 4. Dijets invariant mass

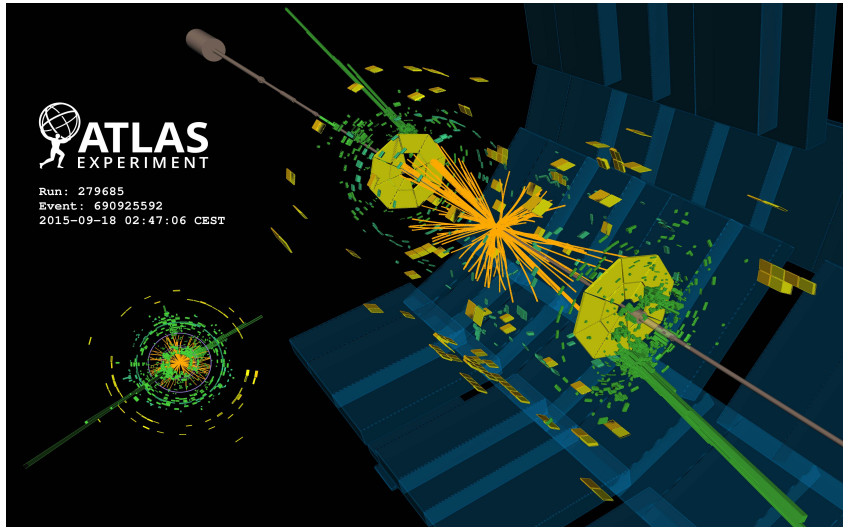


Figure 5. Display for 8.8 TeV di-jet event, highest invariant mass dijet event in early 2015 data taking

TADA monitors a lot of physics, trigger, detector performance aspects in different channels involving jets, photons, W, Z, top, missing energy et cetera. The γ -jet balance method allows to monitor the stability of the jet energy calibration. The topology of back-to-back γ -jet events are a standard handle on assess jet energy calibration. This is due to the fact that to conserve energy in the transverse plane, the ratio of the p_T of the two object is supposed to be equal to 1. A selection of γ -jet events is implemented in TADA to monitor the p_T balance defined as $\frac{p_T^{jet}}{p_T^\gamma \cdot \cos(\Delta\phi)}$, where p_T^{jet} is the transverse momentum of the jet, p_T^γ is the transverse momentum of the photon and $\Delta\phi$ the angular difference between the two object, where ϕ is the azimuthal angle in the transverse plane (respect to the beam direction). The mean of the p_T balance distribution vs p_T^γ and data taking run are shown in Figures 6 and 7. The plot shows a good p_T balance: the slope in low p_T is due to misidentified γ + jet + additional radiative processes.

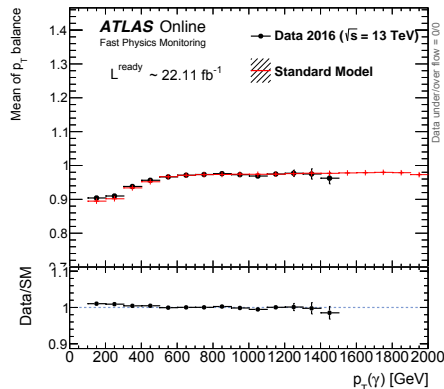


Figure 6. Mean of p_T balance vs p_T^γ

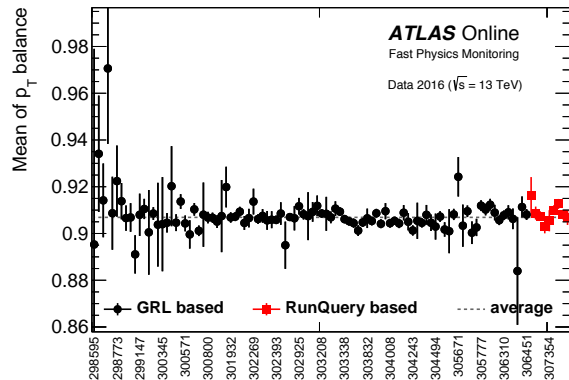


Figure 7. Mean of p_T balance vs run number

2.3.1. Physics performance stability As a fast physics monitoring system, TADA can check the stability of the physics performance across the data taking period. The mean of $Z \rightarrow \mu\mu$ mass vs run number, shown in Figure 8, is a good control plot due to its sensitivity to mis-alignment effects. We can see from the plot that there is no recognizable trend and that the mean is stable across the various runs. Another control plot, shown in Figure 9, monitors the yield of leptonic top pair events normalized to luminosity vs run number. The channel shown has final state: $e\mu + (b)jets + E_T^{miss}$. Also in this case the yield is stable across the run number.

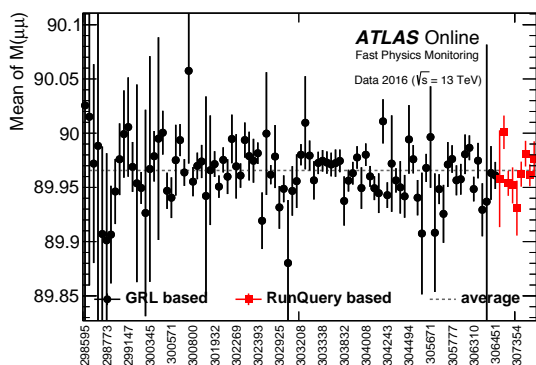


Figure 8. Mean of $Z \rightarrow \mu\mu$ vs run number

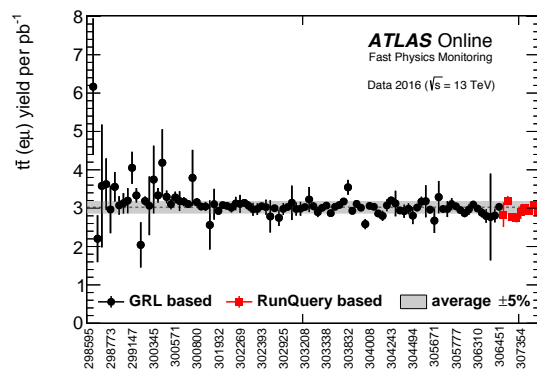


Figure 9. Yield of leptonic ($e\mu$) top pair events vs run number

3. Conclusions

In this note we outline the fast physics monitoring ATLAS system (TADA). The system performed data quality monitoring and searches for new physics for Run1 and it is now analyzing the Run2 data (up to $33 fb^{-1}$ as January 2016). The framework had a huge impact in the first months of Run2 in the ATLAS Collaboration and it was widely used for several studies, some of which are described in this note.

References

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