PROCEEDINGS OF SCIENCE

Commissioning the ATLAS reconstruction software with first LHC beam and cosmic ray data

Müge Karagöz[*] [†]
University of Oxford, Sub-department of Particle Physics, Denys Wilkinson Building, Keble Road, OX1 3RH, Oxford, UK
E-mail: muge.karagoz.unel@cern.ch

Looking towards first LHC collisions, the ATLAS detector is being commissioned using all data available: cosmic rays and events produced during a few days of LHC single beam operations. Commissioning of the full software chain is the main goal, not only to ensure that the reconstruction, monitoring and processing chains are ready to deal with LHC physics data, but also to understand the detector performance as a first step in achieving the ultimate physics expectations. The recorded data have allowed us to study the ATLAS detector in terms of efficiencies, detector integrity, alignment and calibrations. They have also allowed us to test and optimise the subsystem reconstruction as well as some combined algorithms, such as combined tracking tools. The status of the integration of the complete software chain will be presented and illustrated with data analysis results.

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[*]Speaker.
[†]on behalf of the ATLAS collaboration.

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1. Introduction

The ATLAS detector [1] at CERN's Large Hadron Collider is a general purpose detector designed to efficiently exploit the multi-TeV proton collisions of 40 MHz bunches. The major ATLAS subsystems are an Inner Detector tracker (ID) within a 2T solenoid B-field, electromagnetic (EM) and hadronic calorimeters and a muon spectrometer (MS) with its own toroidal B-field.

The ATLAS data are filtered in a 3-level trigger system, before they are sent to the CERN Tier-0 centre for processing by the offline reconstruction software. Data quality monitoring tools and the event display are run both offline and online to provide system feedback. Dedicated computing queues at CERN run on special streams for calibration and alignment of the subdetectors, providing a first-pass calibration for the bulk processing of Tier-0 data. Tier-0 also processes an express stream, which can be used in calibration chain. After validation, the new calibration is used for reprocessing at Tier-1s with further distribution to Tier-2 centres. During final physics object (e.g. muon) reconstruction from raw data, calibration and detector description databases are used. Reconstructed data are produced in all ATLAS supported formats, including dedicated filtered data streams (DPDs), which make the data easily available for GRID analyses.

2. Commissioning of the ATLAS online and offline software chain

Cosmic ray data are valuable for improving the detector performance. They are useful for tuning the detector, synchronising online systems, testing the offline software and processing chain and for providing feedback to simulation for improvement of the detector description.

Commissioning ATLAS in the experimental hall started more than 3 years ago using cosmic ray data with individual subsystems and continued in operational mode since Summer 2008. The ID was integrated into combined runs in autumn 2008 and cosmic tracks with various B-field combinations were collected. The latest combined run took place in Summer 2009. Figure 1 shows the processed data statistics for this run. In preparation for LHC beam, the online and offline data-taking chain were also stress-tested up to Tier-0 during 7-week long subsystem-dedicated "Slice week" runs from April 2009.

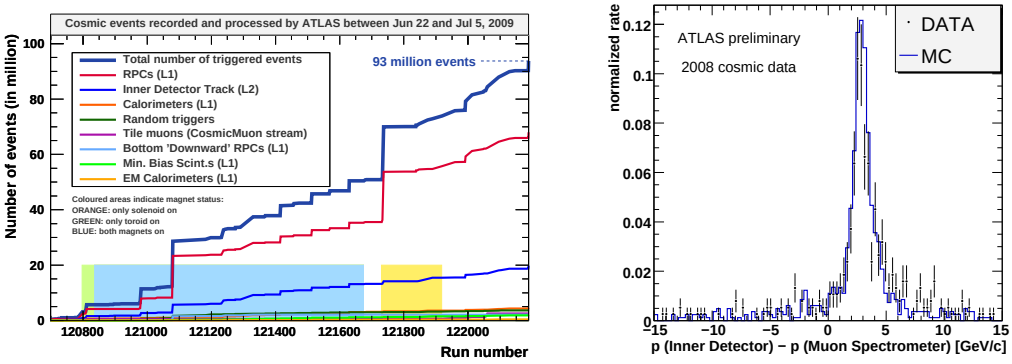

Figure 1: Summer 2009 data statistics (LHS). Track momentum difference in ID and MS (RHS).

The large scale reprocessing of Autumn 2008 data took place at the end of 2008 at Tier-1s and a second reprocessing was performed in May 2009 on about 0.5 PB raw data. The Tier-1

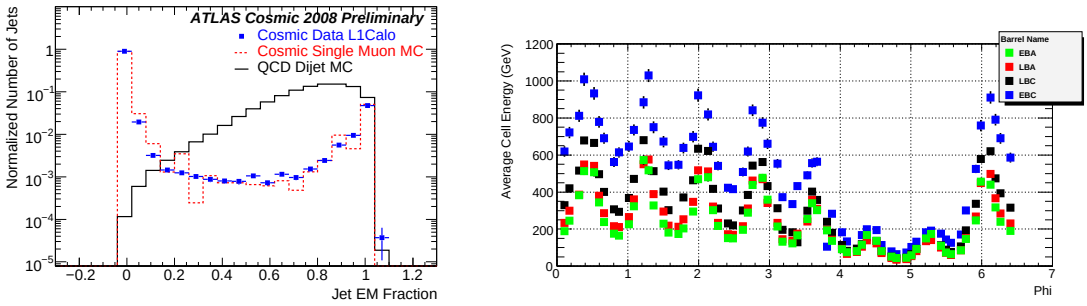

Figure 2: Jet EM fraction comparison (LHS). Hadronic Energy distribution of beam splash events (RHS).

reprocessing chain was thus tested with large event statistics. To ensure that all Tier-1s gave exactly the same results, site validations were performed. Compared to the original Tier-0 processing, the reprocessed data used the most recent calibration for improved reconstruction quality. Existing algorithms were updated and new ones added to enhance performance. The Summer 2009 data processing campaign is ongoing.

ATLAS also recorded LHC beam data in September 2008. Single proton bunches at 450 GeV were stopped by collimators at the entrance to ATLAS and approximately 70 high occupancy "splash" events were recorded together with "beam halo" events from circulating bunches. The high occupancy events provided a valuable means of testing the reliability of the offline infrastructure and of optimising the detector, e.g, in terms of detector timing.

3. Data analysis and performance

The online and offline reconstruction framework ran successfully on large samples of cosmic rays. Special cosmic ray simulation that matched the acceptance of the detector in accordance with downward moving cosmic rays in the cavern was employed. Combined algorithms and various identification tools, such as muon tracking, were run to test the software and also to perform commissioning analyses. Global monitoring and good run list databases were also utilised and tested. The ID alignment was shown to get close to ideal performance. Good progress has been made on electron, photon, and jet reconstruction as well as inter-subsystem alignment. Figure 1 shows track momentum difference in ID and MS subsystems, in agreement with the muon calorimeter energy deposition. Good separation between jets expected from proton collisions and fake jets from cosmic rays is observed in figure 2. Figure 2 also illustrates the hadronic calorimeter response to beam splash events modulated by the Endcap toroid magnet material. Although these events exceeded the expected collision occupancies, they were reconstructed successfully.

4. Summary and conclusions

Successful integration and operation of the ATLAS software chain has been achieved using cosmic ray and LHC beam data. The robustness and reliability of the offline infrastructure has been tested. With more than 300M cosmic ray events, operational experience up to Tier-2 centres has been gained. Data quality monitoring, calibration procedures and offline reprocessing at GRID centres have been tested. The ATLAS software chain is ready for the LHC collisions.

References

[1] The ATLAS Collaboration, The ATLAS experiment at the CERN LHC, J. Instrum. 3 (2008) S08003.