Data Quality Monitoring of the CMS Tracker

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Abstract. The Physics and Data Quality Monitoring (DQM) framework aims at providing a homogeneous monitoring environment across various applications related to data taking at the CMS experiment. It has been designed to be used during online data taking as well as during offline reconstruction. The goal of the online system is to monitor detector performance and identify problems very efficiently during data collection so that proper actions can be taken. On the other hand the reconstruction or calibration problems can be detected during offline processing using the same tool. The monitoring is performed with histograms, which are filled with information from raw and reconstructed data. All histograms can then be displayed both in the central CMS DQM graphical user interface (GUI), as well as in Tracker specific expert GUIs and so-called Tracker Maps. Applications are in place to further process the information from these basic histograms by summarizing them in overview plots, by evaluating them with automated statistical tests, and by extracting their main qualities and filling them into trend plots, which monitor the behaviour of the detector over time. We describe the CMS Data Quality Monitoring system of the Silicon Strip and Pixel Tracker of CMS, as well as first experience from the cosmic ray data and collision data taking periods.

Keywords: CMS, Tracker, Pixel, Silicon Strips, Data, Quality, Monitoring
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INTRODUCTION

The DQM [1] framework is the main tool in CMS [2] to ensure high quality data taking. It ensures optimal working of a detector and certifies the quality of the data for physics analysis. It also serves the purpose of long term monitoring of the detector. It needs to be robust, reliable, and fast in order to detect problems and take proper actions quickly and efficiently. It must work throughout the experiment's lifetime.

DQM ARCHITECTURE

The DQM consists of a set of programs running on various levels of data reconstruction and for different detector granularities. Their basic task is to fill histograms with monitoring quantities.

The online system running in the CMS control room receives a fraction of the live data stream (configurable rate of up to ~ 25 Hz) and further selection is possible using High Level Trigger bits [4]. It operates with full detector granularity (15148 Silicon Strip modules plus 1440 Pixel modules for the CMS Tracker). The offline DQM applications are part of the data reprocessing process. They run on full statistics and with full event reconstruction, but with a reduced granularity (due to computing limitations). During the 2009 cosmic run, an "express stream" was set up. This stream allows a quick processing of a subset of the data in order to extract alignment and calibration constants early on, which are then fed back for the full reconstruction.

Both systems save histograms and other information in centrally achieved ROOT files. These are accessed using the central web-based CMS DQM GUI [5]. In addition, Pixel and Silicon Strip Tracker experts use another, custom-made, GUI that is capable of interacting with the Pixel and Strip DQM processes. The expert GUI is very useful for fast problem investigation during data taking. In particular, Tracker Maps which provide an overview of the entire Tracker detector that consists of interactive SVG [6] maps that can be used to pin-point problems in minutes.

DATA QUALITY MONITORING

The following quantities are monitored to asses the quality of the Tracker data:

- Data corruption during raw data unpacking;
- Errors in the front end readout electronics;
- Raw charge from individual pixels or strips (so-called digis);
- Charge, size and occupancy of gain calibrated clusters;
- Charge, size and occupancy of Lorentz-drift and impact angle corrected reconstructed hits;
- Clusters located on or off reconstructed tracks.

Online, the error and digi monitoring are the most important quantities to monitor, since they give immediate feedback about mis-configuration, data corruption and the pixel or strip response to injected charge. They also allow instant detection of components that are broken, dead, noisy or fire at much higher rate than the average. These can then be subsequently masked for future data taking.

Offline, the main feedback for reconstruction algorithms and the state of calibration and alignment comes from monitoring clusters, both on and off track, as well as reconstructed hits. The larger statistics also allow to detect smaller scale detector problems.

LONG TERM MONITORING

In addition to monitoring every single run of data taking (for a few minutes to several hours), we extract the most important quantities for every run. These are stored in a database and are used to fill trend plots monitoring the detector over large periods of time (up to many months). This monitoring is performed both on a coarse granularity and on a module by module basis, depending on the needs.

DATA CERTIFICATION

To verify the Tracker data for subsequent physics analysis, an automated scheme of statistical tests, comparison to reference plots, and the application of cuts to key distributions is performed by the offline DQM system. The result of this automated certification is a good run flag for each of the Tracker sub-systems. It is stored on a run by run basis in a database, where it is available for every physics analysis in CMS.

SUMMARY

The CMS Tracker DQM system has been developed to ensure high quality data taking with high efficiency. It monitors readout errors, raw charge deposition information, as well as reconstructed hits and even tracks. It thus allows to detect, both with fast turn-around (online) as well as high precision (offline), data corruption, mis-configuration and mis-calibration of the detector, as well as newly broken modules and dead or noisy strips and pixels. This highly automated process requires minimal human interaction when things go smoothly but is versatile enough for fast expert investigation in case of problems. It has been extensively used and tested during cosmic ray data taking in 2008 and 2009, and is ready for collision data.

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