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Online Data Monitoring of the ATLAS Muon System and Commissioning of the New Small Wheel (NSW) Data Quality System

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In order to efficiently handle the increased luminosity that will be provided by the High-Luminosity LHC (HL-LHC) [1], the ATLAS [2] Muon System was upgraded by replacing its first end-cap station (Small Wheel system) with a New Small Wheel (NSW) detector [3]. The NSW detector provides high-precision muon track reconstruction, as well as information to the ATLAS Level-1 (L1) trigger for data recording. The data collected by the NSW along with other subsystems must be scrutinized to ensure the integrity of the detector, before making it available as "certified data" for "Physics Analyses". This is achieved through the monitoring of detector-level quantities and reconstructed collision event characteristics at key stages of the data processing chain, using several Data Quality (DQ) tools. This paper, therefore, summarizes the development of the NSW DQ system and presents preliminary DQ monitoring results obtained from the early detector operation during the preparation of the Run3.

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1. Motivation

In order to efficiently handle the increased luminosity that will be provided by the High-Luminosity LHC (HL-LHC), the first station of the ATLAS muon end-cap system (Small Wheel, SW) will need to be replaced. The NSW will have to operate in a high background radiation region (up to 22 kHz/cm^2), while reconstructing muon tracks with high precision as well as information for the L1 trigger. The detector technologies used come from the family of gaseous detectors, the first is called small-strip Thin Gap Chambers (sTGCs), and the second comes from the category of micro-pattern gas detectors and is named Micromesh Gaseous Structure (Micromegas (MM)). The experimental layout of the NSW is shown in figure 1. The sTGC detectors are designed to provide fast trigger and high precision muon tracking under the HL-LHC conditions. On the other hand, MM detectors have a small conversion region and fine strip pitch resulting in excellent spatial resolution and are primarily used for precise tracking.

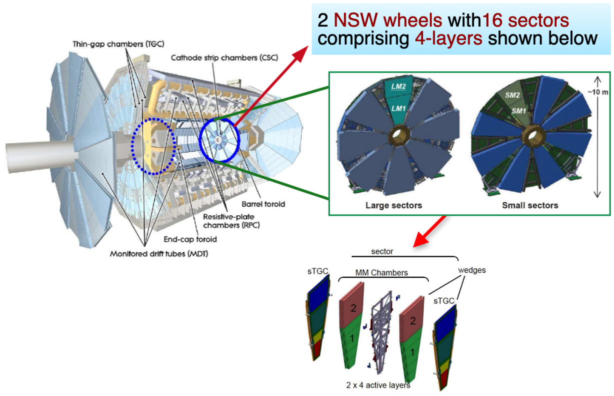


Figure 1: NSW layout.

2. An overview of the Data Quality (DQ) monitoring tools

The operational status of detector hardware components is controlled and monitored by the Detector Control System (DCS) [4], which includes information about the component temperatures, high-voltage values and operational capacity. To monitor the low-level detector information at various stages of the data-flow a lightweight tool called "GNAM" [5] is used to create a set of monitoring histograms. To store the interesting events during data-taking, the trigger system constantly monitors the data passed by the L1 trigger and the High Level Trigger (HLT) algorithms [4]. Furthermore, full event reconstruction is run on a small subset of HLT accepted events and histograms are produced in a ATLAS offline framework ATHENA during the offline processing. The Information Service (IS) [4] is a backbone of the monitoring system and is used to retrieve monitoring data from the Trigger and Data Acquisition (TDAQ) [4] system. To catch problems early during data-taking, an automated checks are carried out on the produced histograms using the Data Quality Monitoring Framework (DQMF) [6]. The algorithms that run in the DQMF are lightweight, written and tested independently of the online data-taking so that they comply with data-processing time

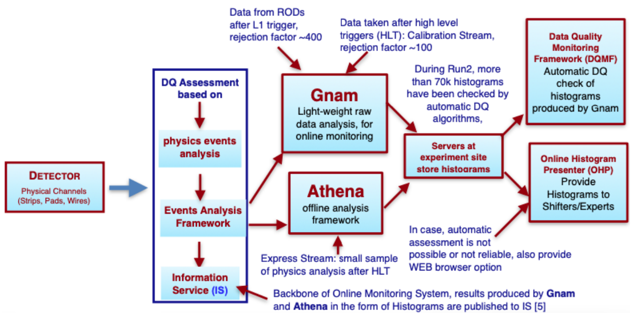
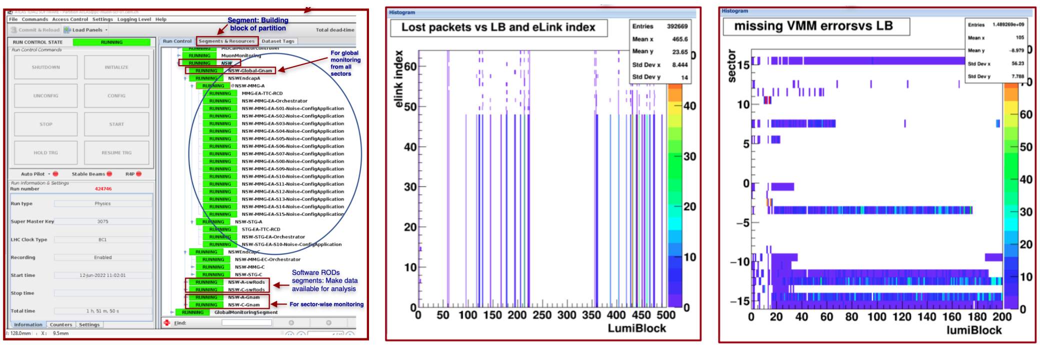


Figure 2: An overview of the DQ operational workflow.

restrictions. In addition to this, histograms created by GNAM, and results from the DQMF, are sent to IS and can be retrieved to be rendered by dedicated monitoring display tools. The monitoring display tools provide an interface for the crew of shifters, to monitor data-taking in real time. The Data Quality Monitoring Display (DQMD) and the Online Histogram Presenter (OHP) are two major displays [6]. The DQMD uses the results from the DQMF and provides a global view of the detector status with coloured status flags indicating the quality of the data according to the DQMF results. The OHP is a highly configurable histogram presenter, which can be used to display a large number of histograms to be monitored by subsystem DQ experts or shifters. Figure 2 is illustrating a schematic view of the DQ tools and the operational workflow.

3. Commissioning of NSW DQ System

The NSW GNAM is commissioned in a standalone partition (self-contained TDAQ system) and later included in the ATLAS partition as a segment for the Run3 data-taking as shown in figure 3a. Two shared libraries, one for monitoring the data from each sector called "sector-wise" GNAM and another one to monitor data globally from all sectors known as "Global" GNAM, are provided. A huge set of histograms is produced by GNAM to monitor characteristics of every reconstructed event during collisions. For example, figure 3b represents 2D-Histogram of missing data packets (or lost elinks) versus lumiblock (LB) produced by single sector GNAM for sTGC. The event contribution of each elink is one packet, and there are 64 elinks for sTGC and 160 elinks for MM. Some packets can be lost when these elinks are disabled by TDAQ or when the packet has the wrong L1ID or arrives too late at the software readout drivers (swROD). This causes loss of data from that particular elink. Similarly, figure 3c shows number of packets with missingVMM versus LB for all the sectors produced by Global GNAM for MM. A data packet has 8 missingVMM flags that are normally not set. Packets with one or more flags set have no channel data at all. In ideal case, all bins should be zero. Thus these key histograms are important to spot the problems globally as well as from individual sector during data-taking.



(a) NSW GNAM **(b)** sTGC: from sector-wise GNAM **(c)** MM: from Global GNAM

Figure 3: An example of a sTGC (b) and MM (c) histogram produced by NSW GNAM (a).

In order to reduce the risk of data loss and fix problem early while taking data, a sub-set of histograms produced by GNAM is added to DQMF. DQMF is designed to check key histograms automatically by running DQ algorithms on raw histograms produced by GNAM and flag the histograms depending upon the quality of the data. In the ATLAS control room, shifters are trained to keep an eye on these histograms during data-taking and communicate with experts in case of major problems. Thus, key histograms added in DQMF are used as an essential tool to catch problem and mitigate data loss during data-taking period. The preliminary set of histograms for sTGC and MM is added in the DQMF for basic DQ check. An overview of the NSW DQMF display is shown in figure 4.

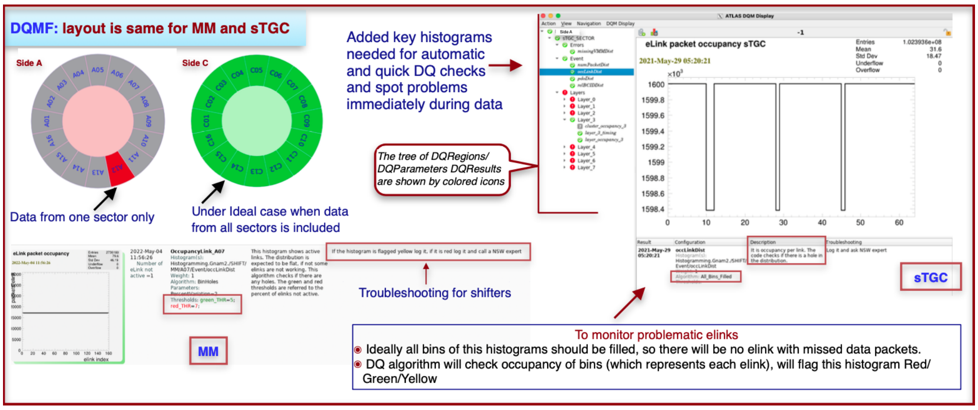


Figure 4: An overview of the NSW DQMF layout.

4. Conclusions

The overall premise of DQ monitoring is to provide the good data for “Physics Analyses”, using online DQ tools as a "first line of defense" in order to catch problems early and mitigate the data loss during data-taking. The first version of NSW DQ tools is integrated in ATLAS TDAQ and has been running successfully in the Run3 data-taking period. Some developments in the current configuration are still ongoing, by having the first look at the data collected by ATLAS during ongoing Run3 data-taking operations.

References

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