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# ATLAS Offline Data Quality System Upgrade

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**Abstract.** The ATLAS data quality software infrastructure provides tools for prompt investigation of and feedback on collected data and propagation of these results to analysis users. Both manual and automatic inputs are used in this system. In 2011, we upgraded our framework to record all issues affecting the quality of the data in a manner which allows users to extract as much information (of the data) for their particular analyses as possible. By improving the recording of issues, we are able to reassess the impact of the quality of the data on different physics measurements and adapt accordingly. We have gained significant experience with collision data operations and analysis; we have used this experience to improve the data quality system, particularly in areas of scaling and user interface. This document describes the experience gained in assessing and recording of the data quality of ATLAS and subsequent benefits to the analysis users.

## 1. Introduction

Data quality (DQ) monitoring and reporting are integral aspects of ATLAS[1] operations. Physics analyzers require a reliable and robust infrastructure for properly dealing with detector hardware and software problems as well as reconstruction issues. These needs are met by introducing a suite of tools and software libraries for monitoring the data and propagating that information to the analyzers.

The essential aspects to the system[2]:

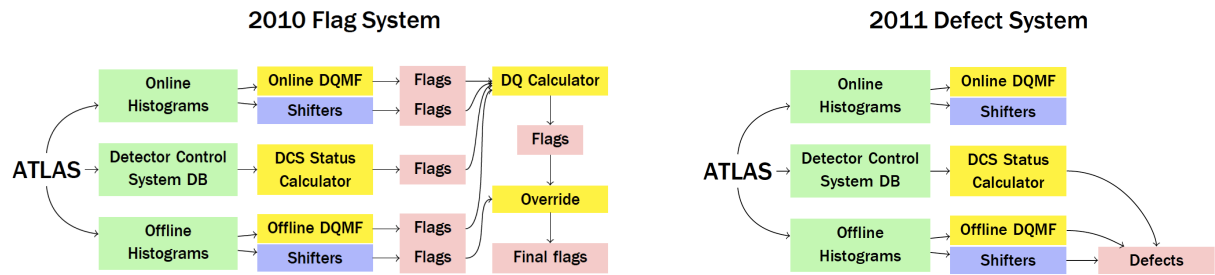
- The **Data Quality Monitoring Framework (DQMF)** has tools for making monitoring plots online and offline;
- The **Detector Control System (DCS)** Calculator uses conditions database information to automatically determine the status of subdetector components and calculate defects;
- The **Defect Database** allows for categorization and storage of detector problems for a dynamic and flexible quality assessment.

## 2. Upgrades

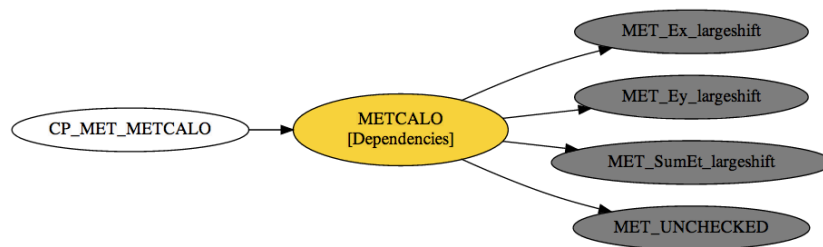
For data collection with the ATLAS detector in 2011, the framework for storing detector quality information was upgraded based on lessons learned in 2010. An illustration of the system components for 2010 and 2011 is shown in Figure 1.

### 2.1. 2010 approach: Detector Flags

The initial approach to store DQ information was a system based on detector flags[3]. These flags represented DQ decisions for each subsystem and could be set as good, bad, or caution.



**Figure 1.** The old flag system (left) and the new defect system (right) for assessing data quality.



**Figure 2.** Illustration of virtual defect logic. Combined performance virtual defect for calorimeter measurement of missing transverse energy (left) depends on virtual defect METCALO (center) which depends on MET primary defects (right).

The system had some limitations. The flags were not very dynamic or flexible, nor were they informative about the sources of detector problems.

### 2.2. 2011 approach: Detector Defects

In the new system, the detector flags were replaced with defects[2]. A defect represents a specific problem with the detector rather than a final DQ decision. Defects only have two states: present or absent. They come in two types:

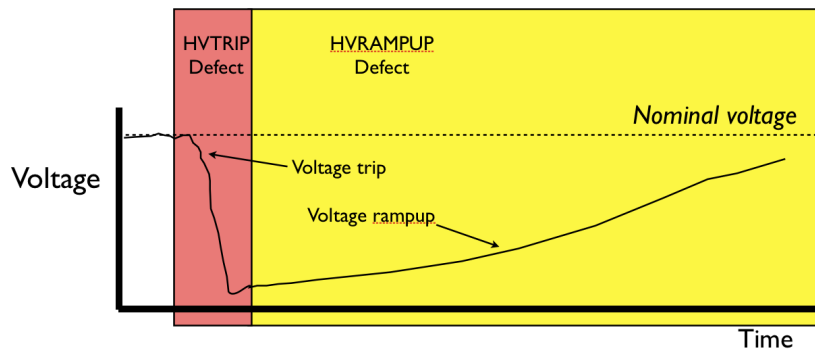
- **Primary defects** are made directly from detector conditions;
- **Virtual defects** are logical combinations of primary and other virtual defects.

Primary defects may be tolerable. The role of the virtual defect is to encapsulate the higher level logic which combines primary defects and leads to the production of good run lists for analyzers. As an example, the logic for a defect representing problems with the calorimeter measurement of missing transverse energy is illustrated in Figure 2.

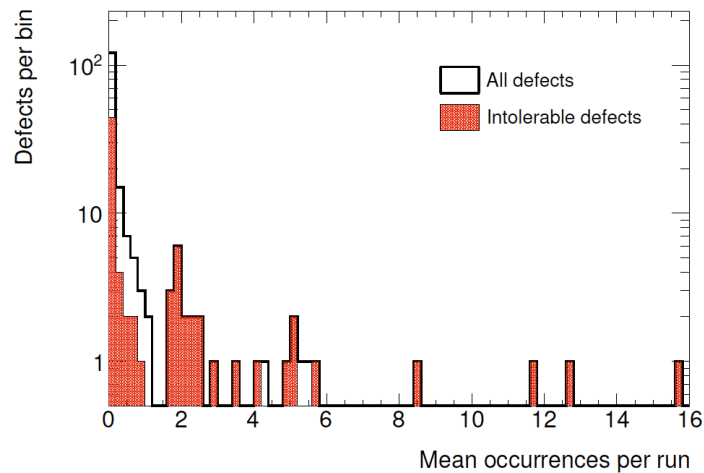
The new system is dynamic. Primary defects are uploaded to the database immediately as problems are discovered. Virtual defect logic can easily change as detector experts and analyzers provide feedback. Primary and virtual defects are versioned independently to ensure flexibility and reproducibility.

### 3. Benefits of the defect system

The defect system gives analyzers the power to perform studies investigating the impact of specific detector problems on their analysis. These results can then be reviewed by subdetector experts and lead to improvements in the handling of detector problems. For example, the study of the impact of High Voltage Trips in the LAr Calorimeter[4] led to the realization that the



**Figure 3.** The High Voltage Trip is an example LAr calorimeter problem in which the high voltage level is lost. After the trip, the voltage ramps back up to its nominal level. Defects allow analysts to study the impact of these effects separately.



**Figure 4.** Mean number of occurrences recorded for each defect between March and June 2011.

voltage ramp-up period after the trip may be useable by some analyses, resulting in a few percent gain in DQ efficiency. Figure 3 shows an illustration of how defects are used to provide details about the status of the detector in this situation.

Analysts in 2011 took advantage of the defect system to veto specific defects that impact the analysis. The amount of data used in published results varied by 6%. This demonstrates that the ability to choose defects which impact an analysis has a significant effect on DQ efficiency.

Figure 4 shows the mean number of occurrences for each primary defect in the data taken between March and June 2011. Most defects occur rarely but this figure also shows an excess in defects at two occurrences per run. These defects are due to detector components being in a standby state at the beginning and end of a run.

#### 4. Conclusions

Upgrades to the Data Quality system have allowed for a significant improvement in the handling of detector problems. The defect based approach in 2011 was shown to be robust, dynamic, and flexible. The improved database made way for more detailed studies on the impacts of detector problems and ways to improve handling them. Figure 5 shows that the DQ efficiency of all

<b>ATLAS 2011 p-p run</b>												
Inner Tracking			Calorimeters				Muon Detectors				Magnets	
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.8	99.6	99.2	97.5	99.2	99.5	99.2	99.4	98.8	99.4	99.1	99.8	99.3
Luminosity weighted relative detector uptime and good quality data delivery during 2011 stable beams in pp collisions at $\sqrt{s}=7$ TeV between March 13 <sup>th</sup> and October 30 <sup>th</sup> (in %), after the summer 2011 reprocessing campaign												

**Figure 5.** DQ efficiency for all subdetectors during the full 2011  $5.23 \text{ fb}^{-1}$  dataset. Subdetector components are all above 97% efficiency.

subdetector components for the full 2011 dataset is higher than 97%, a testament to the hard work of the Data Quality and subdetector teams.

## References

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