Data Quality Monitoring for the ATLAS trigger System during the first data taking period of the Large Hadron Collider

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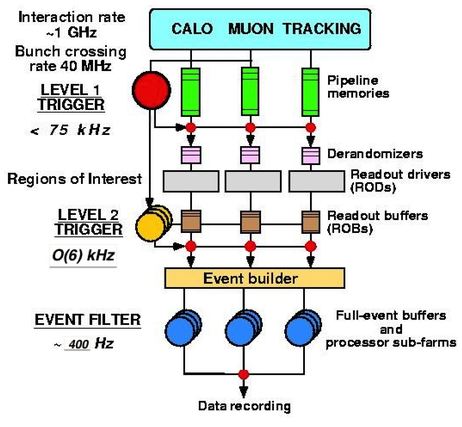
Introduction

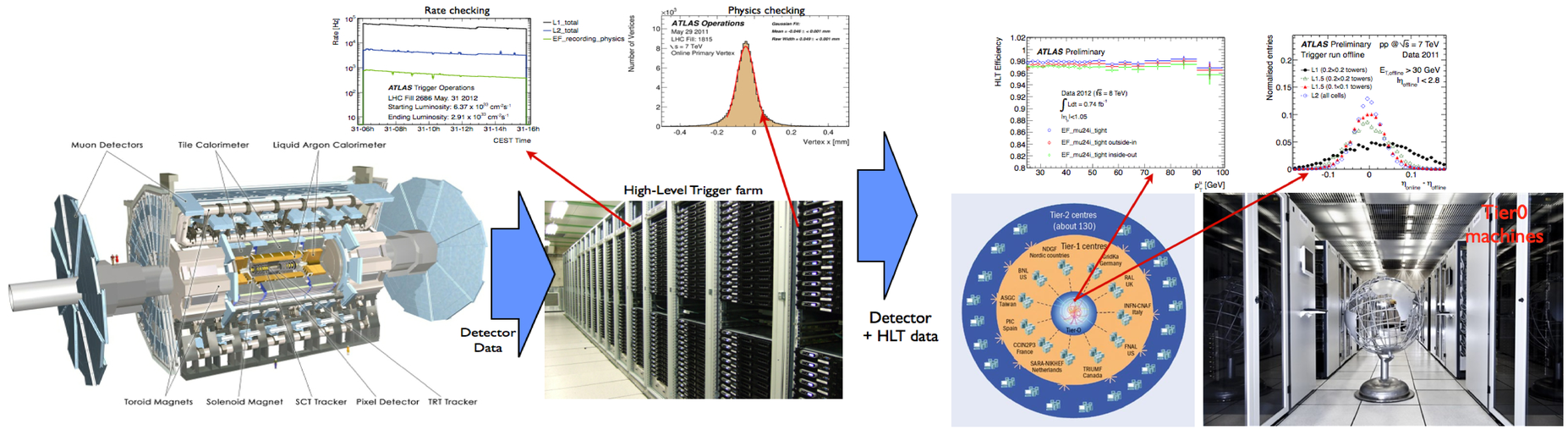
- The first long period of data taking of the Large Hadron Collider was finished after 3 years in February 2013. The detector operated producing very high data quality despite an increase of the instantaneous luminosity by more than six orders of magnitude.
- To ensure a reliable monitoring and data quality assessment of the trigger's point of view, a flexible software framework was used.
- The trigger data quality assessment is performed for the hardware based trigger (Muon, Calo and Central Trigger Processor) and the physics related groups (electron, photon, muon, tau, MET, jet, b-jet, Minimum Bias).
- 3% of data were rejected by trigger data quality in 2011. In 2012, this was reduced to 1%.

ATLAS & Trigger System

- The ATLAS detector[1] is composed of a complex system of detectors (tracking systems, calorimeters and muon detectors).
- The ATLAS trigger system[2] uses data from all these detectors to perform a highly efficiency selection of events in three levels.
- The first one (L1) runs in custom-build hardware whilst the two others (L2 - and Event Filter - EF) run in a computer farm. Out of the more than 20 million events produced per second, less than a thousand are recorded.



Description of the System



Online Monitoring

More than 15 thousand processing nodes run Trigger algorithms.There are histograms related to :

- Physics Quantities : spacial distribution of triggered objects, transverse energy of electromagnetic clusters, quality measure of tracks fitting and muon occupancy, etc.
- Technical information : Algorithms proccessing time, memory occupancy, etc.
- Rate information per trigger level or for each selection algorithm.

Some tools support shifter data quality assessment :

- Online Histogram Presenter : small number (<8) histograms per physics (electrons, jets, etc) or detector (calorimeter, tracking) groups. References available to "guide" shifters.
- Data Quality Monitoring Framework : hundreds of histograms, evaluated by comparison algorithms (such as Kolmogorov tests) against reference ones. Automatic flags (green, yellow, red) allow to spot deviating histograms.
- Rate Presenter : shows global trigger rates per level or for selected trigger criteria.

Offline Monitoring

- A representative fraction of data is recorded and processed immediately at CERN for data quality evaluation. Comparison of trigger and offline quantities is now possible, as well as some primitive efficiency plots.
- DQMF-flagged environment is used also to assess data performance. Only after this data is deemed of good quality by experts, the rest of the data is processed for physics analysis.
- The few events (tens after hours of operation) that caused a processor to fail are saved during data taking and the trigger is re-run for debugging.
- Also, before any new piece of software is used in the online farm, consistency checks are made by re-running the trigger in old data (using an inclusive sample).

References

[1] The ATLAS Collaboration. *The ATLAS Experiment at the CERN Large Hadron Collider*. JINST v. 3:S08003 p. 1-437. 2008.

[2] The ATLAS HLT, DAQ and DCS Technical Design Report, October 2003. ATL-TDR-016.

Data Quality Assessment

The data quality assessment of ATLAS is performed daily in the following steps :

- Online shift crew produces a report with any possible issue using the Online Monitoring.
- Experts use such report and the Offline Monitoring to verify data quality. First discussions within the trigger-related groups. Communication with detector groups is also essential. Data defects can be set by experts.
- Trigger Expert discusses findings in a global ATLAS sub-systems meeting.
- Ok flag for processing of all data.

Final data quality efficiencies for the 2011 trigger are summarized in the table below for the hardware (L1) and software (HLT) triggers.

L1			HLT						
Muon	Calo	CTP	electron	photon	muon	tau	jet	b-jet	missing E_T
99.0	100	99.8	99.3	99.3	100	99.9	98.6	99.9	99.3

Luminosity weighted relative relative fraction of good trigger data quality delivery during 2011 stable beams in pp collisions at √s=7 TeV between 13 March and 30 October (in %).

This high efficiency is a reflection of careful planning and dedication of many different groups that ensured a smooth detector operation.