The ATLAS Trigger Menu: Design and Performance

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ATLAS Trigger & DAQ System

The ATLAS trigger is a three-tiered system designed to select events of interest for the diverse ATLAS physics program and for all detector calibrations and monitoring with a high efficiency. At the same time physics groups, Higgs searches and backgrounds are important. ATLAS physics requirements and in close collaboration with ATLAS physics program has a wide variety of final states and cross-sections. Major physics analysis groups are dedicated to Standard Model physics, Higgs searches and measurements, top physics, B-physics, SUSY and exotic processes. Baseline 10th menu has been designed based on physics requirements and in close collaboration with physics groups. Bandwidth allocation for various signatures designed for luminosity of 1-5x10^34 cm^-2 s^-1. Trigger menu has to cope with increasing luminosities and pile-up during the year.

2012 Menu for L = 10^{34} cm^-2 s^-1 at 8 TeV

Design strategy
- ATLAS physics program has a wide variety of final states and cross-sections.
- Major physics analysis groups are dedicated to Standard Model physics, Higgs searches and measurements, top physics, B-physics, SUSY and exotic processes.
- Baseline 10th menu has been designed based on physics requirements and in close collaboration with physics groups.
- Bandwidth allocation for various signatures designed for luminosity of 1-5x10^34 cm^-2 s^-1.
- Trigger menu has to cope with increasing luminosities and pile-up during the year.

Rate prediction
- Rates are predicted offline by running the trigger on “enhanced bias” data sets collected with only L1 triggers.
- First rate predictions for start-up menu by extrapolation of 2011 enhanced-bias data recorded at \( \sqrt{s} = 7 \) TeV with L = 3x10^34 cm^-2 s^-1.
- In particular, the rate predictions for jet and E_t^{miss} triggers are challenging due to non-linear behaviour with increasing pile-up.

Improvements and changes over 2011 menu
- Algorithm improvements.
- More pile-up robust algorithms.
- Broader use of combined chains.
- i.e. jet(s)b-jet(s)E_t^{miss}, lepton+E_t^{miss} for exclusive signal topologies of SUSY and Higgs.
- Trigger menu to keep thresholds low.
- Delayed streams.
- Optimise the use of bandwidth.
- Will be reconstructed in 2013.
- Isolation for single lepton triggers.

Monitoring of the Trigger System

Overview
- Powerful and sensitive monitoring of the ATLAS trigger performance is extremely important.
- Discover and address any processing failures, performance problem of selection algorithms immediately.
- Monitoring can be roughly divided into online and offline monitoring.
  - Online monitoring calculates and displays rates at every trigger level, evaluates up to 3000 data quality histograms.
  - Offline monitoring ensures quality of recorded data.
  - Trigger reprocessing and analysis of events in debug stream ensure smooth running and constant improvement of the trigger.

Online monitoring
- Various tools available to monitor the status of trigger system online as well as remotely.
  - In particular, the following visualisation tools (amongst various others) are useful for monitoring the performance of the trigger w.r.t. the trigger menu and algorithms running online:
    - Data quality monitoring display (DQMD): presents the DQ results to the shifter helping to focus on bad histograms.
    - Online Histogram Presenter (OHP): highly configurable, interactive histogram presenter showing set of various distributions for the various signatures.
    - Trigger Rate Presenter (TRP): specialized tool to mainly displaying trigger rates, rate predictions and high-level trigger farms status.

Offline monitoring
- Data quality assessment.
  - Performed with express stream: ~10 Hz of data is immediately reconstructed.
  - Defects set for deficiencies caused by trigger algorithms, incorporated into the physics analyses.

Trigger Menu, Chains & Operation

Trigger Chain
- Sequence of reconstruction/selection algorithms to select a specific signal.

Trigger Signature
- Group of closely related trigger chains, e.g. muon, e/\gamma, jet, tau missing ET, MinBias.
- Each has primary (un-prescaled), backup and supporting chains.
- Experts associated to each signature for development and support.

Trigger Stream
- Signature recorded to the same dataset (e.g. physics streams: muon, e/\gamma, Jet/tau/E_t^{miss}, MinBias).
- Overlap between streams is minimised (~10-15%).

Trigger Menu Operation Strategy
- Primary triggers kept stable as long as possible over long data periods, highly desirable for analyses.
- Triggers for background studies enabled with decreasing luminosity in a fill.
- Supporting and monitoring triggers kept at fixed output rate.
- Rate adjustment due to decreasing luminosity during fill with “prescale sets” without stop/start of run.

ATLAS Trigger Operations
LHC Fill 2898 May 31, 2012
Starting Luminosity 9.37 x 10^{33} cm^-2 s^-1
Ending Luminosity 2.59 x 10^{33} cm^-2 s^-1

ATLAS Physics Operations
Run 2011037 Aug 25, 2012

Performance
- Successful deployment and start-up of menu in April 2012.
- Rates as predicted and within DAQ limits.
- Fine-adjustments made throughout the year.
- Menu expected to work for luminosities up to L=10^{34} cm^-2 s^-1 at \( \sqrt{s} = 8 \) TeV.

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