The ATLAS Run-2 Trigger Menu

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The ATLAS trigger system selects events based on the presence of interesting physics objects (e.g. leptons, photons, jets, and missing transverse energy), reducing the event rate to cope with processing and storage limitations. In Run 2, the LHC reached a peak luminosity of 2.0 x 10^{34} cm⁻²s⁻¹ and a peak pileup of ~56 interactions per bunch crossing in typical proton-proton running. The ATLAS trigger menu has been designed to maximize the physics potential in this challenging environment by reducing the impact of pileup.



The ATLAS trigger system

Level-1 (L1) trigger

- Coarse selection based on limited detector information (calorimeter and muon systems only)
- Custom hardware with a latency of 2.5 µs

High-level trigger (HLT)

- Refined selection using full detector information
- 40k commercial CPU cores; processing time of up to ~400 ms

L1 trigger improvements at high pileup

- Level-1 topological trigger
- New for Run 2!
- Topological selections (angular observables, invariant mass, etc.)



Trigger menu

Two-level event selection

- ▶ ~500 L1 items
- ▶ ~1500 HLT chains

Rates

- Depend on luminosity and pileup
- Controlled via prescales
- Prescales are reduced at predefined luminosity points to maximize the available bandwidth and CPU usage

Streams

- Events recorded by a set of triggers for a particular purpose
- Main physics: primary (unprescaled) triggers for analysis
- Express: a small subset of the main stream; promptly processed for data quality checks
- Monitoring: events for online data quality checks
- Calibration: partial-event building using limited detector information, which permits a higher recording rate
- Trigger-level analysis: only HLT-reconstructed objects are recorded. Very small events allow for a very high rate!



2018 menu highlights

[kHz] ATLAS Trigger Operation HLT physics group rates (with overlaps) pp data, September 2018, $\sqrt{s} = 13$ TeV ate Main physics MET b-jet Combined Muon Photo Electro Ŧ 0.5 0.0 09:00 17:00 19:00 Time [h:m

reduce background rates without raising trigger thresholds



Level-1 muon trigger

 Requiring coincidence between end-cap muon chambers and tile calorimeter reduces beam background and achieves 10% rate reduction

Level-1 calorimeter trigger

- Missing transverse energy rates increase nonlinearly with pileup
- Dynamic pedestal subtraction corrects the impact of out-of time pileup due to overlapping signals from adjacent bunch crossings



Missing transverse energy

- New HLT algorithm removes clusters from pileup and adds a requirement on MET from calorimeter cells
- Reduces rate without increasing thresholds; negligible efficiency loss



Heavy ion physics

 Light-by-light scattering observed using re-optimized L1 thresholds to select events with two low-energy photons and little additional activity in the calorimeter



Tau

 Tau identification using a recurrent neural network (RNN) in the HLT improves jet background rejection and signal efficiency



References:

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/TriggerPublicResults https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ApprovedPlotsDAQ

