Overview and performance of the ATLAS Level-1 Topological Trigger

Johannes Frederic Damp on behalf of the ATLAS Collaboration

Johannes Gutenberg-Universität Mainz, Institut für Physik

The ATLAS Level-1 Trigger

- ATLAS trigger: selects 1 kHz of collision data events for offline analysis
- Level-1 trigger: latency of 2.5 μs, maximum output rate of 100 kHz.
- Level-1 Topological Processor (L1Topo): part of the Level-1 trigger, developed to deal with increasing luminosity and energy.

2015-2018 LHC Collisions (40 MHz, 13 TeV, Lumi ≤ 2.14·10^{34} cm^{-2}s^{-1})

L1Topo gets inputs from the Level-1 Calorimeter Trigger and the Level-1 Muon Trigger containing information on jets, \( \epsilon, \gamma, \tau \) and missing energy. Its purpose is to provide trigger decisions based on topological algorithms already on the first trigger level.

Topological Algorithms

Some examples of topological algorithms currently implemented on L1Topo are shown below.

- \( \Delta \phi, \Delta \theta \)
- Isolation, overlap removal, b-tagging, ...
- \( H_T, M_{\text{miss}} \)
- Fat jets
- \( M_T, \Delta \phi(jet, \cancel{E_T}) \)

L1Topo triggers are used for different purposes, both for physics as well as for detector calibrations. Various examples with their physics use cases are listed below.

- Jet invariant mass cuts (VBF)
- \( \Delta R \) of muons (B-Physics)
- \( H_T \): scalar sum of jet \( \cancel{E_T} \) (Susy, Exotics)
- \( \eta-\phi \) window cuts (detector commissioning)

Simulation and Validation of Algorithms

Multiple levels of validation of the topological algorithms are performed:
- standalone VHDL simulation of the algorithms
- examine algorithm decisions for well defined input data
- comparison of hardware and simulation results for real events
- \( O(\%) \) mismatches: hardware behavior is very closely simulated

Conclusion

- L1Topo has been successfully installed in the first-level trigger of ATLAS
- It adds new capabilities, such as combining muon and calorimeter information at Level-1
- Many L1Topo triggers have been commissioned and validated successfully
- With L1Topo, the ATLAS trigger system is able to record data at high luminosities without losing signal efficiency
- L1Topo was routinely used in 2017 to trigger events, modified menu in 2018 includes more algorithms

For more information: