Overview and performance of the ATLAS Level-1 Topological Trigger

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L1 Topological Processor (L1Topo)

- ATLAS Trigger system: Selection of interesting events
- Hardware-based first Level-1 Trigger
- L1 Topological Processor: trigger decision based on topological algorithms

**L1 Topological Processor**

![Diagram of L1 Muon, L1 Calo, Muons, Jets, e, y, Delta Phi, DeltaEta, AR, HT, Minv, Fat Jets leading to Central Trigger Processor]

LHC Collisions 40 MHz

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

L1Topo Hardware
L1Topo processes about 1 Tbit s⁻¹ of input data with a fixed latency of ~200 ns. The input data are received via optical fibres, transformed into electrical signals and then directed into the processor FPGA's (Xilinx Virtex7) where the topological algorithms are applied.

General Algorithm Structure
Two algorithm types are applied to reduce the number of input objects without losing important event information.
- A sort algorithm creates a list of the six leading particles
- A select algorithm creates a list of 10 particles above an E_T threshold.
These shortened lists are then flexibly combined into various topological decision algorithms. In this way, a total number of 113 triggers are implemented in 2016.

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

L1Topo Triggers Performance
L1Topo triggers allow to significantly reduce background rates while keeping a good signal efficiency without raising E_T thresholds. The rate reduction and trigger efficiency have been studied and are shown below for b-physics dimuon triggers. An overall rate reduction thanks to the L1Topo requirement of about four is achieved, while only small efficiency losses of approximately 12% have to be taken into account.

L1Topo in Action

Simulation and Validation of Algorithms
Multiple levels of validation of the topological algorithms are performed:
- Tree-level NEXEL simulation of the algorithms
- Examine algorithm decisions for well defined input data
- Comparison of hardware and simulation results for real events
- 0/1 mismatches: hardware behavior in 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 read 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:

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