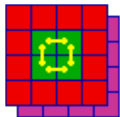


# Overview and performance of the ATLAS Level-1 Topological Trigger



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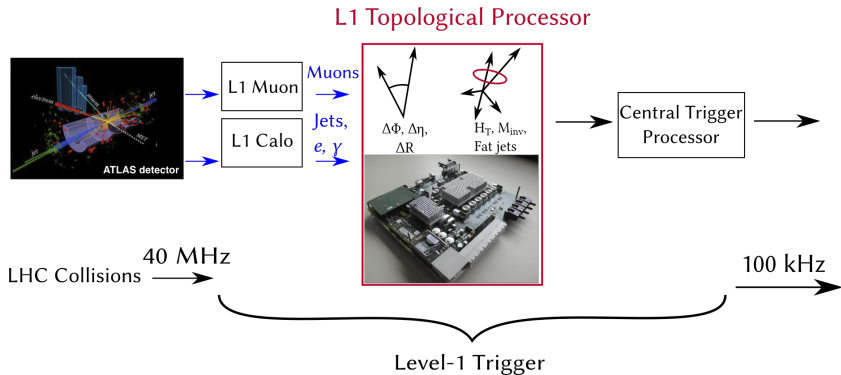
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# L1 Topological Trigger Processor (L1Topo)

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



## L1 Topo Functionality and Hardware

### The ATLAS Level-1 Trigger

- ATLAS trigger: selects 1 kbit of collision data events for offline analysis
- Level-1 trigger: latency of 2.5 ns, maximum output rate of 200 kHz
- Level-1 Topological Processor (L1Topo): part of the Level-1 trigger, developed to deal with increasing luminosity and energy

2015-2018 LHC Collisions (at 36.1, 35.9, Lumin = 2.34 10<sup>34</sup> cm<sup>-2</sup>s<sup>-1</sup>)

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

### L1Topo Hardware

L1Topo processes about 1 Tera<sup>+</sup> 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 (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 algorithm structures. In this way, a total number of 113 triggers are implemented in 2018.

## Topological Algorithms

### Topological Algorithms

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

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)
- $\Delta E_T$  of muons (B-Physics)
- $M_T$ : scalar sum of jet  $E_T$  (Susy, Exotics)
- $e$ - $\mu$  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
- combine algorithm decisions for well defined input data
- comparison of hardware and simulation results for real events
- QVM mismatches: hardware behavior is very cloudy simulated

## L1Topo in Action

### L1Topo Triggers Performance

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

ATLAS Trigger Operations  
 Data 2017, 40 - 13 TeV  
 Run between on Jun 17, 2017

ATLAS Preliminary  
 Data 2018, 40-13 TeV  
 L1Topo Commissioning  
 Run between on Aug 25, 2018

### Conclusion

- L1Topo has been successfully installed as 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 of high luminosities without losing signal efficiency
- L1Topo was routinely used in 2017 to trigger events, modified menus in 2018 includes more algorithms

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For more information:

- [1] J. Rin, *The ATLAS Level-1 Topological Trigger performance in Run 2*, ATL-DAQ-PROC-2017-002(2017)
- [2] ATLAS Collaboration, <https://cern.ch/atlas/bio/view/AtlasPublic/TriggerOperation/PublicResults>