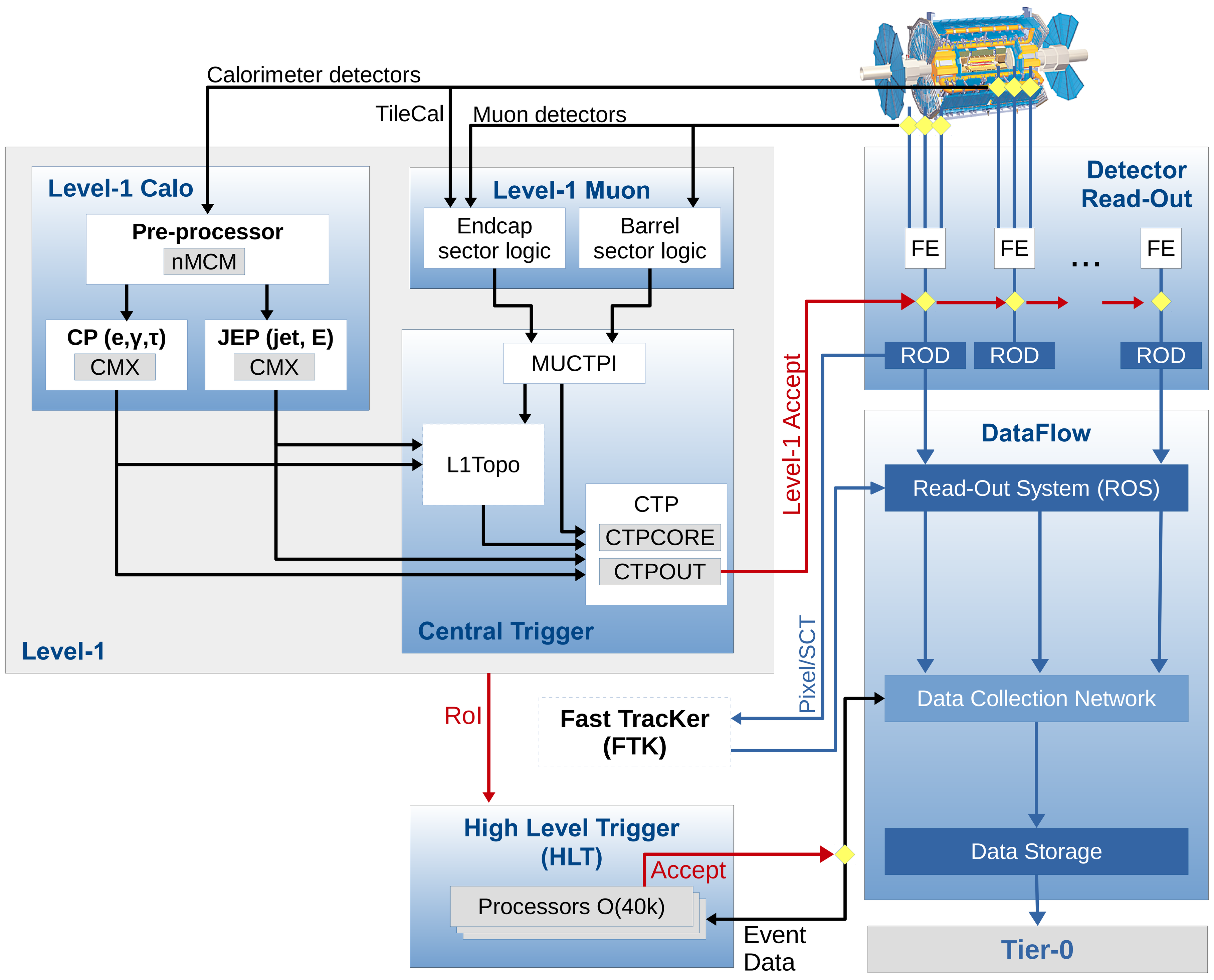
The ATLAS Run-2 Trigger Menu for higher luminosities: Design, Performance and Operational Aspects

ATLAS utilizes a two-level trigger system in Run-2 to reduce the bunch-crossing rate of 40 MHz to an average recording rate of about 1 kHz. Events are selected based on physics signatures such as presence of energetic leptons, photons, jets or large missing energy. Despite the limited time available for processing collision events the trigger system is able to exploit topological information, as well as using multi-variate methods.

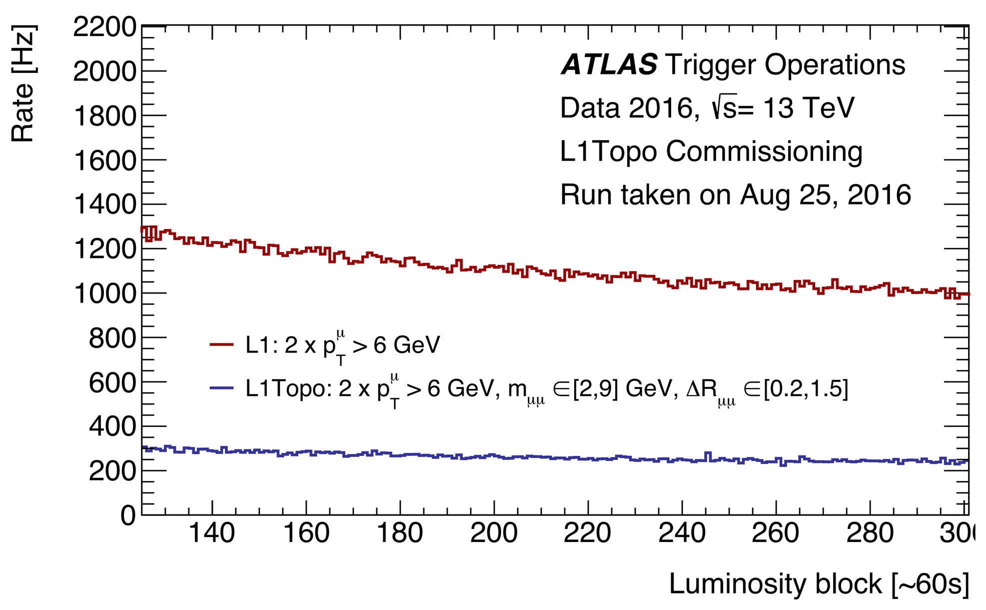
The ATLAS trigger menu specifies which triggers are used during data taking and how much rate a given trigger is allocated. For 2017 data taking, the trigger selections and menus have been improved to handle expected higher luminosities of up to 2×10^{34} $cm^{-2}s^{-1}$ and to ensure robustness in the presence of multiple interactions per bunch crossing ("pileup").

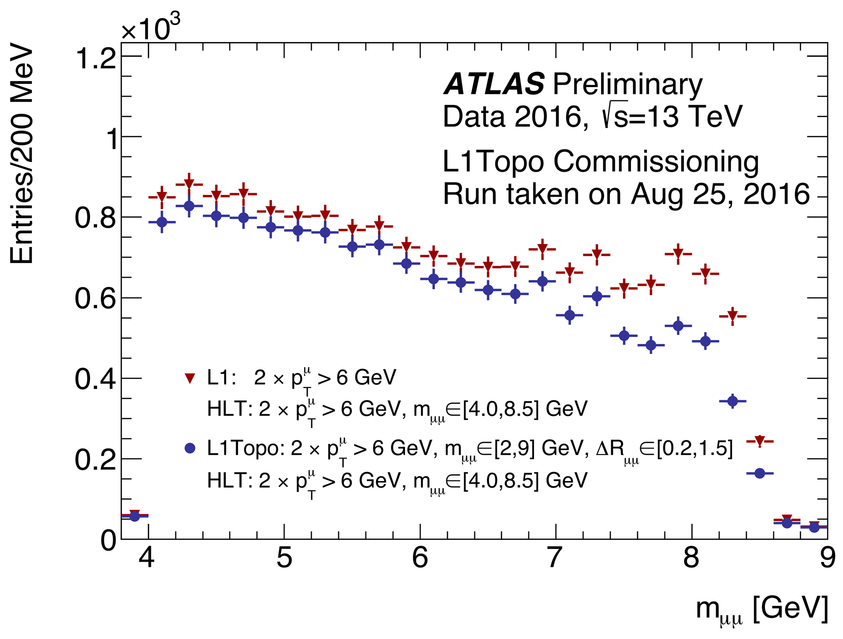
ATLAS Run 2 Trigger and Data Acquisition



L1 Topological trigger

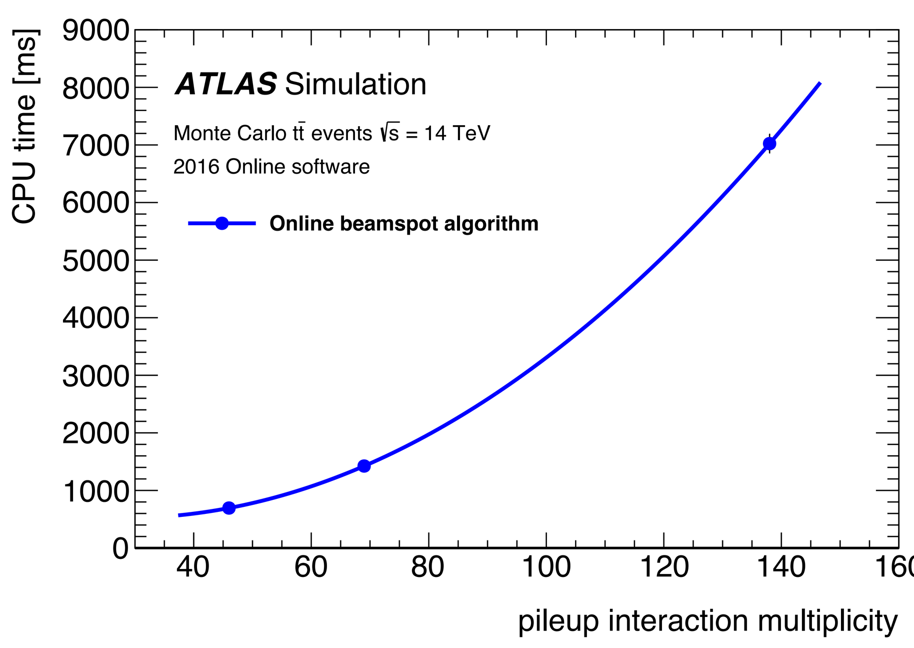
- **L1 Topo:** new system commissioned in 2016, exploits topological information in order to greatly reduce L1 rates with minimal impact on physics
- Can exploit angular distances, di-object mass, transverse mass, etc.
- Example: di-muon trigger with additional $\Delta R_{\mu\mu}$ and $m_{\mu\mu}$ cut achieves a factor 4 rate reduction with only ~10% loss in efficiency selecting B-hadron candidates





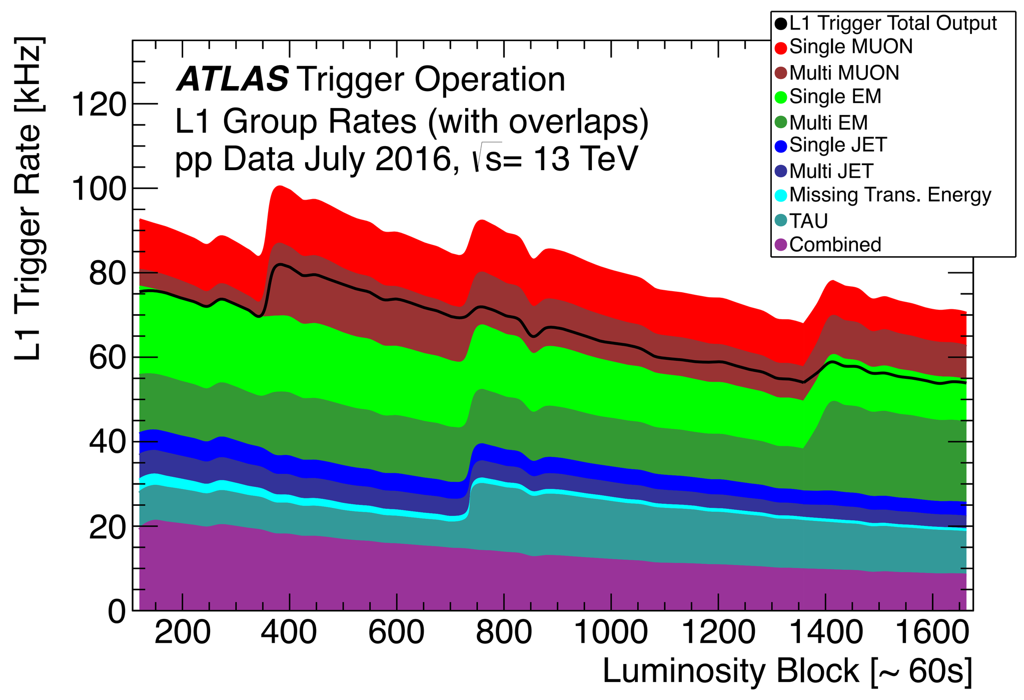
CPU consumption at high pileup

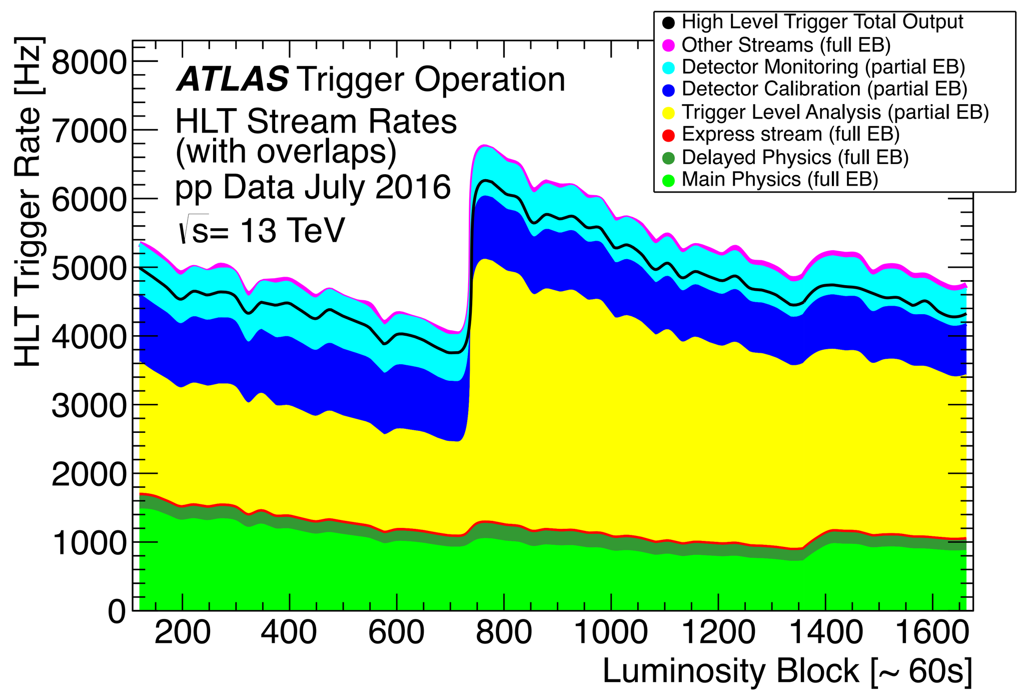
- Increasingly complex algorithms are deployed in order to keep low thresholds for main physics chains, lead to heavy CPU consumption
- Some algorithms scale exponentially with pileup
- Large campaign in winter 2017 to reduce CPU consumption to a sustainable level
  - Technical improvements to the code
  - Trigger menu optimisations to maximize caching and shared algorithms
  - Algorithm optimisations to improve or reduce usage of slow algorithms

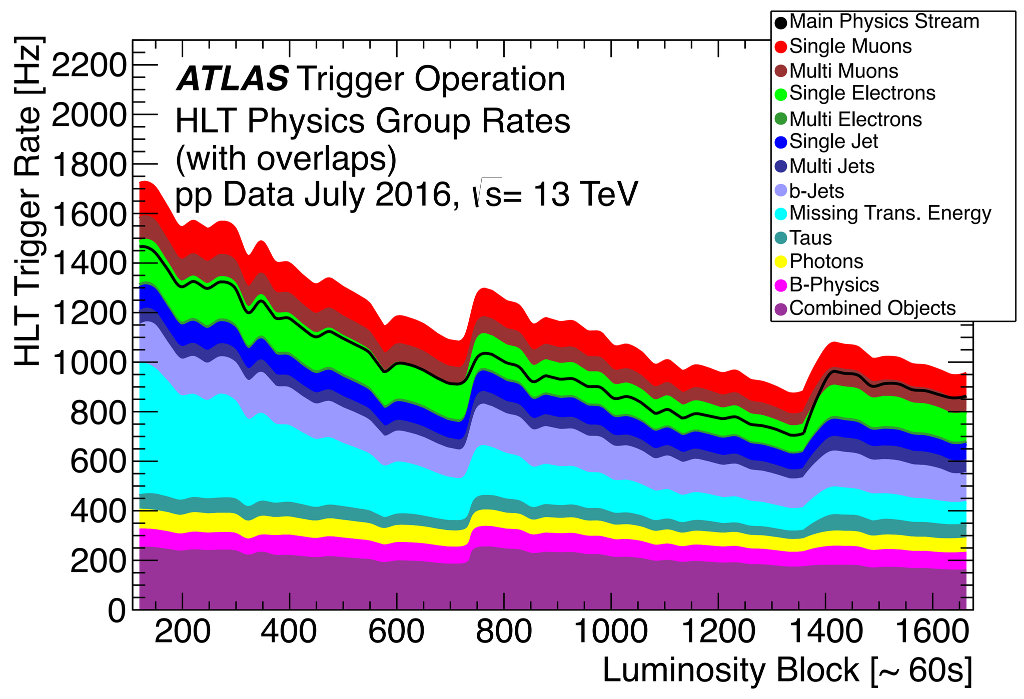


Trigger rates and bandwidth

- **L1 menu** consists of 512 trigger items (single signatures and combinations)
  - E.g. MU15, 2EM12, 4J15
- Rates are controlled via prescale sets, computed for fixed values of the instantaneous luminosity
- As luminosity decreases prescale sets get activated at predefined points to maximize bandwidth given to different triggers
- **HLT menu** has ~1000 active chains
- Each chain can trigger either full Event Building [EB] or just partial sub-detector data to be recorded into different *Streams*
- Majority of chains record to *Main* stream with full EB
- *Express* stream is reconstructed first, providing calibration data
- *Delayed* stream is reconstructed with some delay, to ease demands on prompt reconstruction computing
- *Trigger Level Analysis*: high rate (3 kHz) of just the trigger data. Used in e.g. dijet resonance searches
- Chains, primary and support, are grouped into signatures
- For 2017, prescale sets are defined up to $L=2\times10^{34}$ $cm^{-2}s^{-1}$

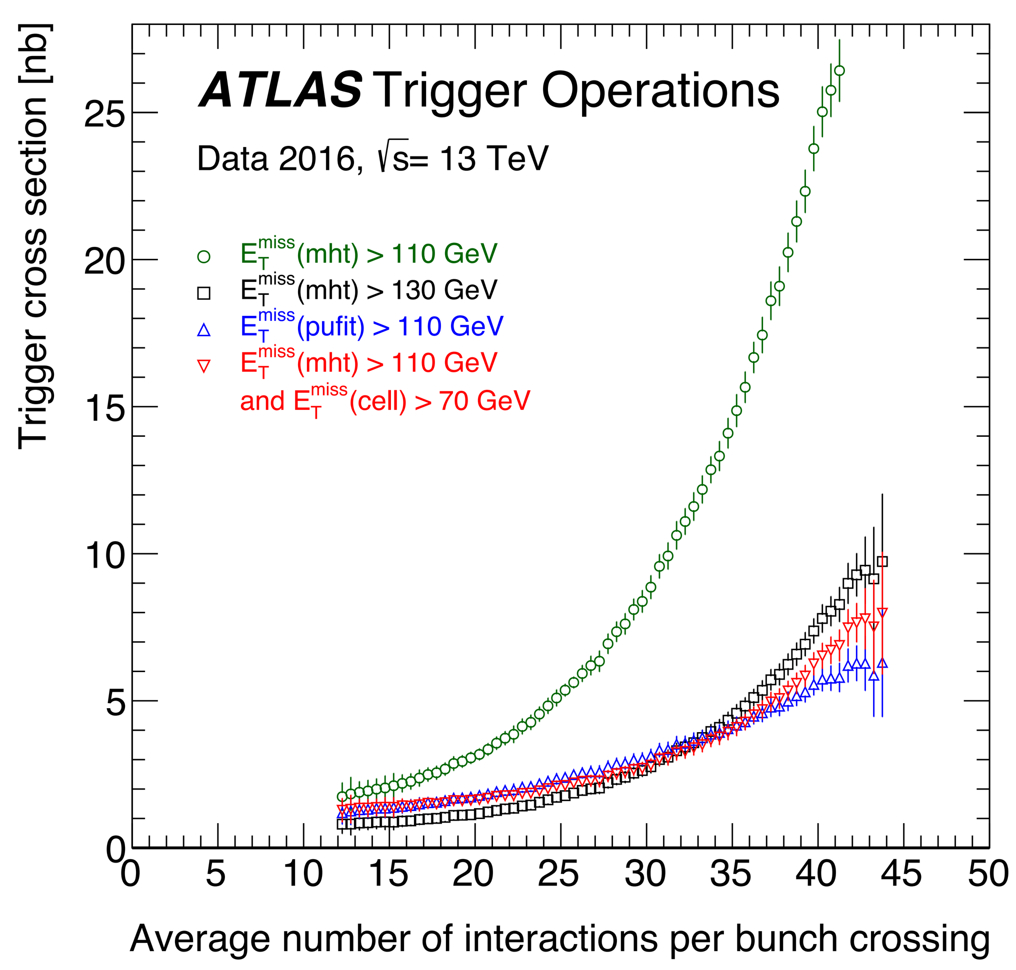






Trigger rates at high pileup

- Increases in the thresholds and/or tighter identification criteria are introduced to allow the main physics chains to remain unprescaled up to $L=2\times10^{34}$ $cm^{-2}s^{-1}$
- E_T^{miss} chains exhibit the strongest pileup dependency, with large differences depending on the algorithm used to reconstruct the E_T^{miss}
  - *pufit*: E_T^{miss} reconstructed from hard-scatter clusters. Identify clusters as hard-scatter or pileup based on a threshold based on total event energy
  - *mht*: E_T^{miss} reconstructed from calibrated jets
  - *cell*: E_T^{miss} reconstructed from calorimeter cells above noise threshold
  - *mht and cell*: use mht-E_T^{miss} with additional cut on cell-E_T^{miss} to suppress pileup contribution
- New algorithm (*pufit*) will become the default in 2017 as it exhibits a much weaker dependence with pileup



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