Triggering on hadronic signatures in the ATLAS experiment

Developments for 2017 and 2018

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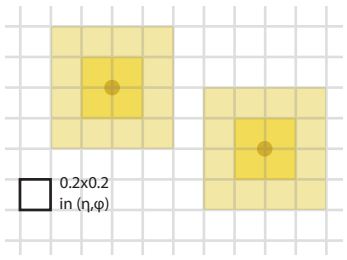
CHEP 2018 Sofia, Bulgaria

Triggering on jet signatures at the LHC requires dealing with the massive production of QCD multijet events, which the ATLAS jet trigger should be able to suppress in favour of more interesting processes for the physics program of the experiment.

Missing transverse energy (MET) is a key signature in many new physics scenarios, but the measurement of this quantity at the trigger level is particularly sensitive to secondary interactions in the same bunch crossing (pile-up).

For both signatures, these challenges were aggravated by the high luminosity conditions during the run 2 of the LHC.
The main developments employed in the jet and MET triggers by the ATLAS experiment for 2017 and 2018 data taking are summarized in this poster.

Level 1 jet trigger

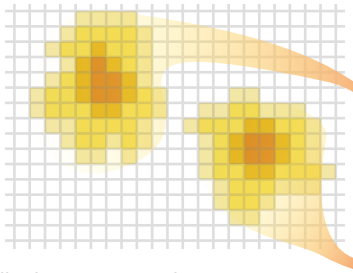


Coarse-granularity calorimeter information, projected in (η,φ) plane

0.8x0.8 regions of interest containing E_T maxima. Total E_T inside a region used for trigger decision

High level jet trigger

Jet reconstruction



Full calorimeter granularity

3D topological clusters from cells using their signal-to-noise ratio

EM-scale topological clusters → No weights applied → Anti-k_t R=0.4 → Small-R jets

EM-scale topological clusters → Apply local cluster weights → Anti-k_t R=1.0 → Large-R jets

Jet calibration

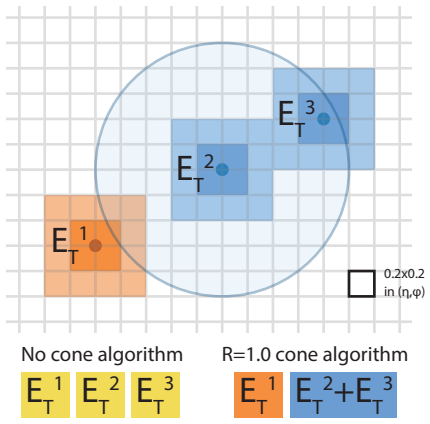
Small-R jets:

- **Pile-up subtraction** — Jet area based, no residual correction
- **MC-based Jet Energy Scale** — Recover energy of initiating particle, no origin correction
- **Global Sequential Calibration** — Use shower shape to reduce flavour dependence, tracking not always available
- **In-situ** — Data-driven, includes jet response correction as function of η

Large-R jets:

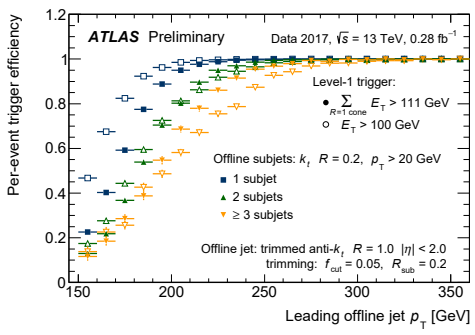
- **Trimming** — Reduce impact of soft radiation by rejecting low-p_T subjets, fcut=0.04
- **MC-based Jet Energy Scale** — Recover energy of initiating particle
- **MC-based mass calibration** — Recover mass of decaying particle

Level 1 jet cone algorithm



Usual 0.8x0.8 window fails to capture large-R jets with substructure. Cone algorithm with R=1.0 adds up E_T of close-by regions

Efficiency turn-on curves (▼) without and with the cone algorithm. In events with multiple subjets, full efficiency is attained at lower p_T with the algorithm, while keeping a constant trigger rate [1]



Pile-up fitting (pufit) MET algorithm

Gather topological clusters into 112 towers with size 0.7x0.7

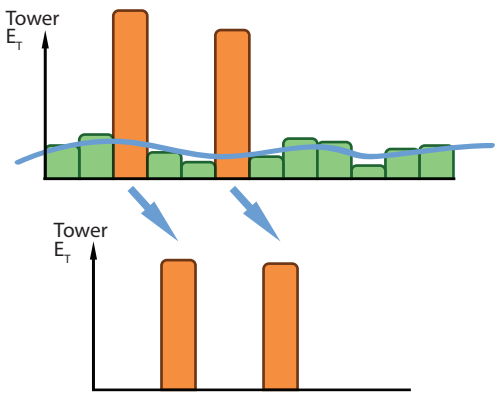
Split into high-E_T and low-E_T towers

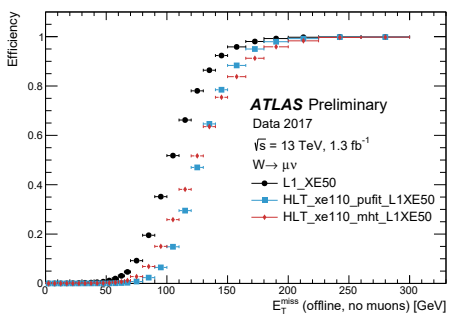
Get pile-up estimate from fit to low-E_T towers

Remove pile-up estimate from high-E_T towers

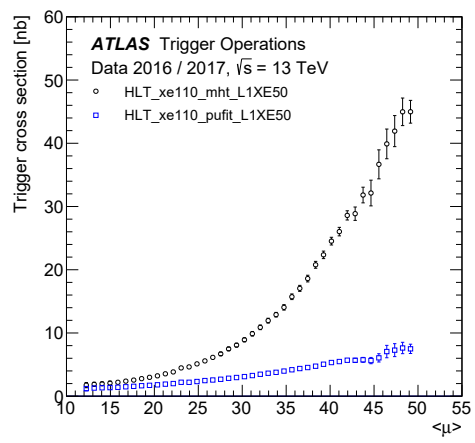
MET = negative of the vector sum of E_T of corrected high-E_T towers

In the previously used algorithm (mht), MET was computed from trigger jets instead of towers





Efficiency of MET triggers as a function of offline MET (▲). The pufit algorithm is compared with the previously used algorithm (mht). The improved resolution is reflected in the steeper turn-on [2]

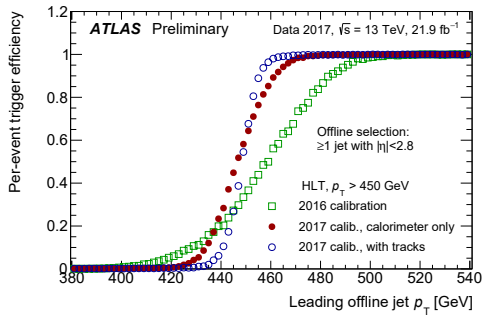


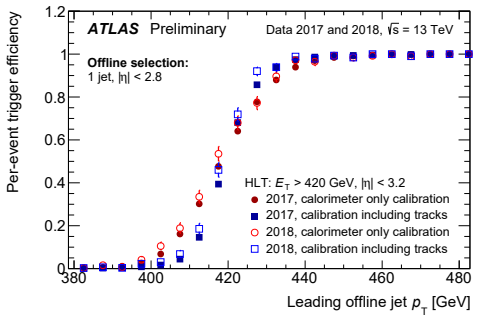
Trigger rate as a function of mean number of interactions per bunch crossing (▲). The pufit algorithm is compared with the previously used algorithm (mht). The rate is lower and increases more slowly for pufit [2]

Improved jet calibration

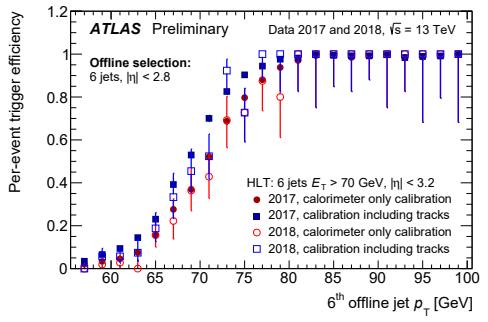
Global Sequential Calibration and in-situ calibration steps added to the jet trigger for 2017 data taking

Efficiency turn-on curves for an unprescaled single jet trigger comparing 2016 and 2017 calibrations (▶). Tracking information was not available in the trigger for 2017 data taking [1]





Efficiency turn-on curves for an unprescaled single jet (▲) trigger, including 2017 and 2018 data. Track information improves performance, but will not always be available [1]



Efficiency turn-on curves for an unprescaled six jets (▲) trigger, including 2017 and 2018 data. Track information improves performance, but will not always be available [1]

Mass cut in large-R trimmed jets

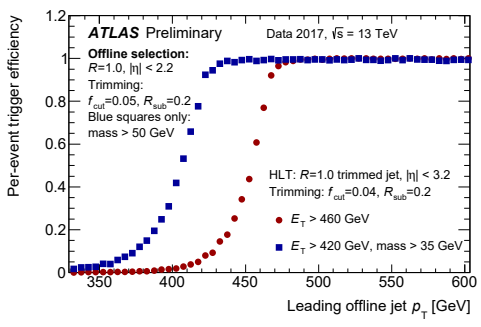
Trimming reduces the impact of pile-up on large-R jets

Remove small-R subjets from large-R jets if they contribute less than a fraction fcut for the large-R jet p_T

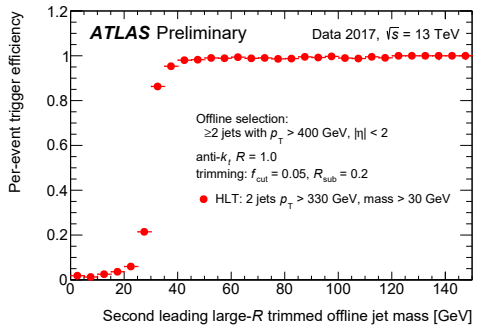
Offline uses fcut=0.05, trigger uses fcut=0.04

Mass cut rejects QCD background, while keeping most signal-like jets

Interest in large-R jets mostly as candidates for hadronically decaying resonances (t, W, Z, H, BSM)



Efficiency of single trimmed-jet triggers as a function of offline jet p_T, with and without the mass cut (▲). The mass cut allows a lower p_T threshold to be applied while keeping the total rate [1]



Efficiency of a two trimmed-jets trigger with a 30 GeV mass cut on both jets, as a function of the 2nd leading offline jet mass (▲). Full efficiency is attained around 50 GeV [1]

References

[1] ATLAS jet trigger public results: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/JetTriggerPublicResults
[2] ATLAS missing E_T trigger public results: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/MissingEtTriggerPublicResults

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FCT Fundação para a Ciência e a Tecnologia
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REPÚBLICA PORTUGUESA
Co-funded by European Social Fund

E. Gouveia funded by Fundação para a Ciência e Tecnologia, through grant PD/BD/128231/2016