Projected ATLAS Electron and Photon Trigger Performance in Run 3

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ATLAS EXPERIMENT

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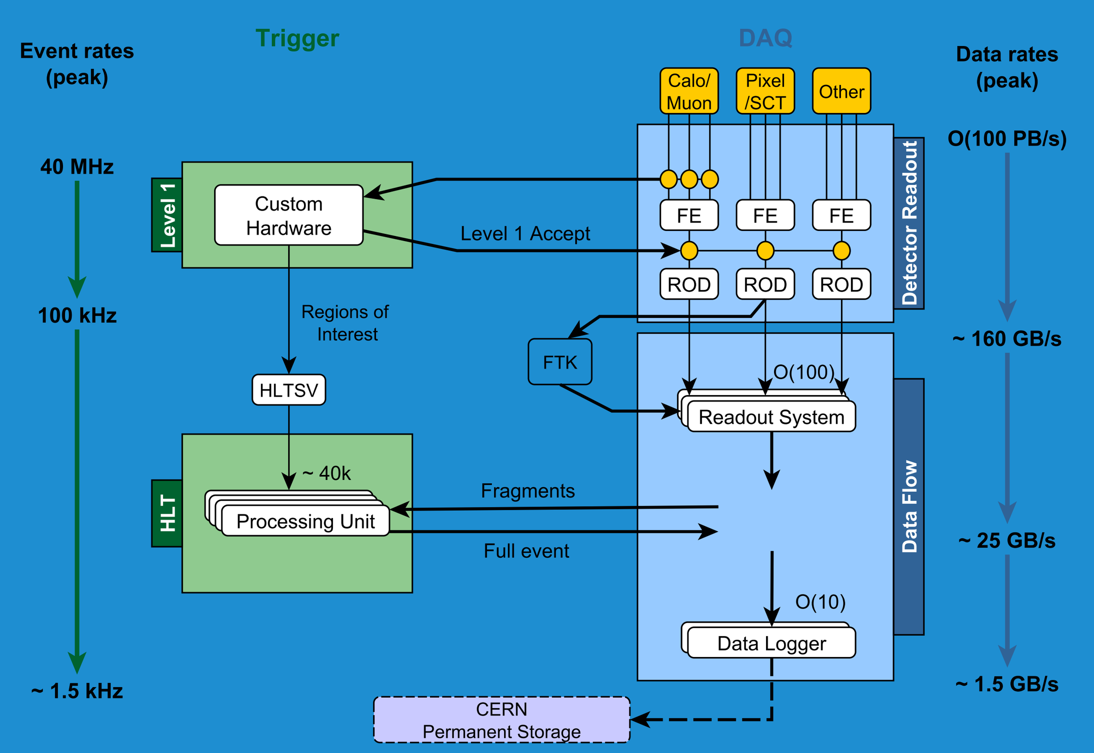
ATLAS electron and photon triggers covering transverse energies from 5 GeV to several TeV are essential to record signals for a wide variety of physics: from Standard Model processes to searches for new phenomena. During Run 3 (2021-2024), main triggers used for those physics studies will be a single-electron trigger with transverse energy threshold around 25 GeV, and a diphoton trigger with thresholds at 25 and 35 GeV. Relying on those simple, general-purpose triggers is a robust trigger strategy, tested already in Run 2 (2015-2018), at a cost of slightly higher trigger output rates, than to use a large number of analysis-specific triggers. In preparation for Run 3 data-taking, the ATLAS detector is undergoing an upgrade of the hardware-based Level-1 calorimeter trigger and the trigger software is being migrated to the multi-threaded framework AthenaMT. Impact from these modifications on the electron and photon triggers as well as their projected performance in Run 3 is presented.

ATLAS Trigger System

The ATLAS has a two-level Trigger system that reduces the bunch crossing rate of 40 MHz at the LHC to an average final event rate of ~1 kHz, of which around 20% are allocated to electron and photon triggers.

The Level-1 (L1) hardware trigger uses:

- Low granularity data from the calorimeters and the muon system to identify Regions of Interest (RoIs).
- The maximum output rate is 100 kHz.



The High-Level Trigger (HLT) is software based:

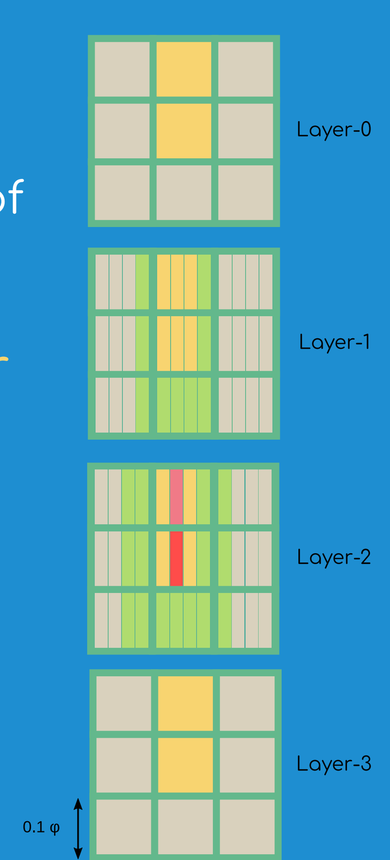
- Seeded by RoIs from L1.
- Performs reconstruction and identification similar to offline.

L1 upgrade for Run 3

Run 2: A 4x4 window in cells of φ and η (tower), where energy was reconstructed in a 2x2 core region.

Run 3: Upgrade to Supercells, a 10 folded cell with 1-4-4-1 longitudinal/transverse segmentation (new granularity in Layer 1 and 2).

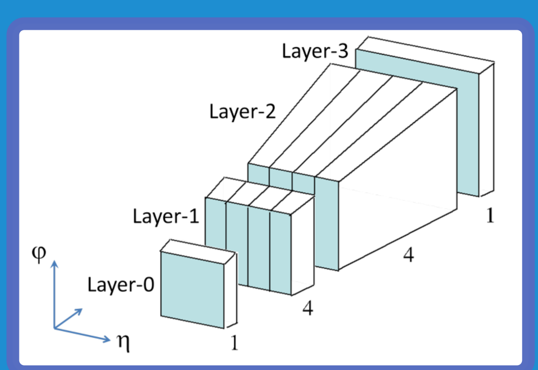
- New electron Feature EXtractor (eFEX) processor reconstruction algorithms use a 3x3 window.
- Seeding: finds the local maximum in the 2nd layer of the Electromagnetic Calorimeter.
- Clustering: finds most energetic φ neighbor, cluster 3x2 in fine layers, 3x1 in coarse layers.
- Isolation: for $E_T^{e,\gamma} < 60$ GeV cut on 3 variables:



$$R_\eta = 1 - \left(\frac{E_T^{3\times2}}{E_T^{7\times3}}\right)_{L2}$$

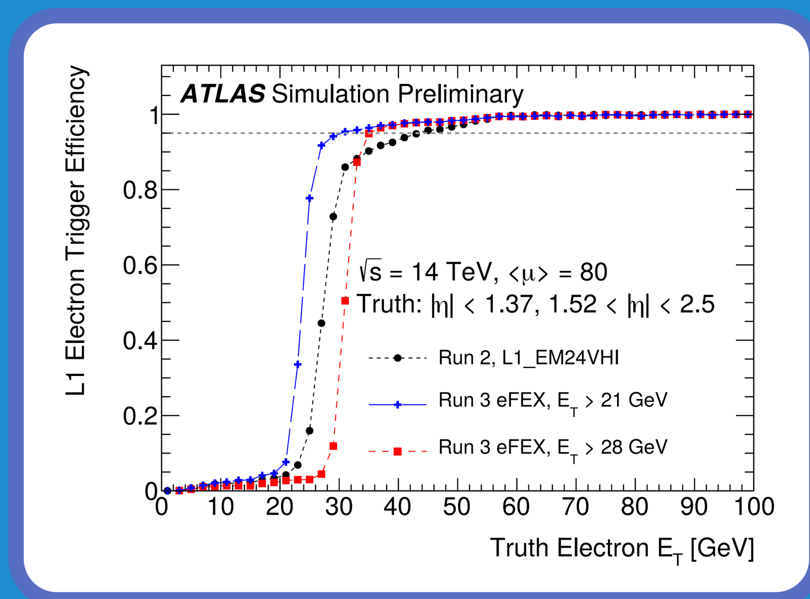
$$R_{Had} = \frac{E_T^{Had}}{E_T^{tot}}$$

$$w_{stot} = \left(\sqrt{\frac{\sum E_{T,i}(\eta_i - \eta_{max})^2}{\sum E_{T,i}}}\right)_{L1,5\times3}$$



Performance of L1 triggers

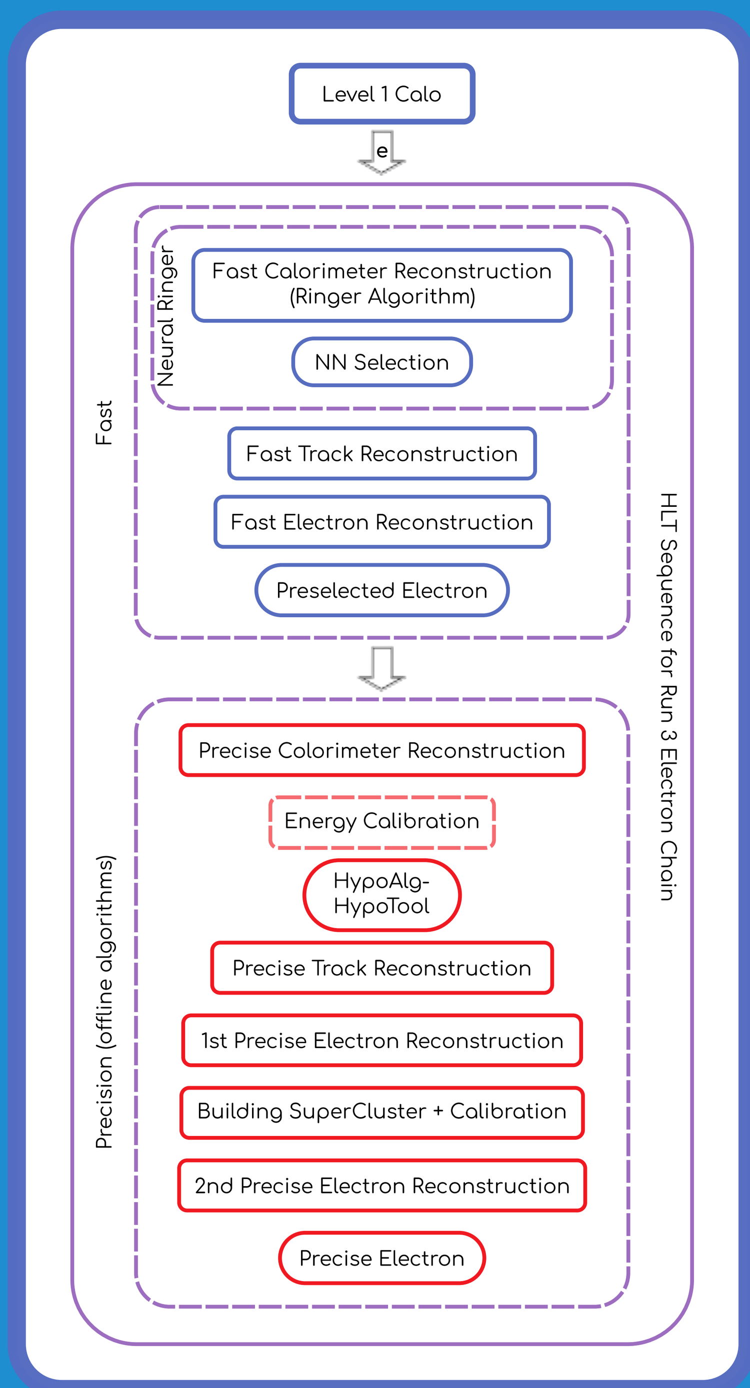
- Trigger performance curves. Blue curve has same rate as black curve, while red curve has a half of that rate.
- Allows to reduce the rates or reduce the E_T threshold.



HLT upgrade for Run 3

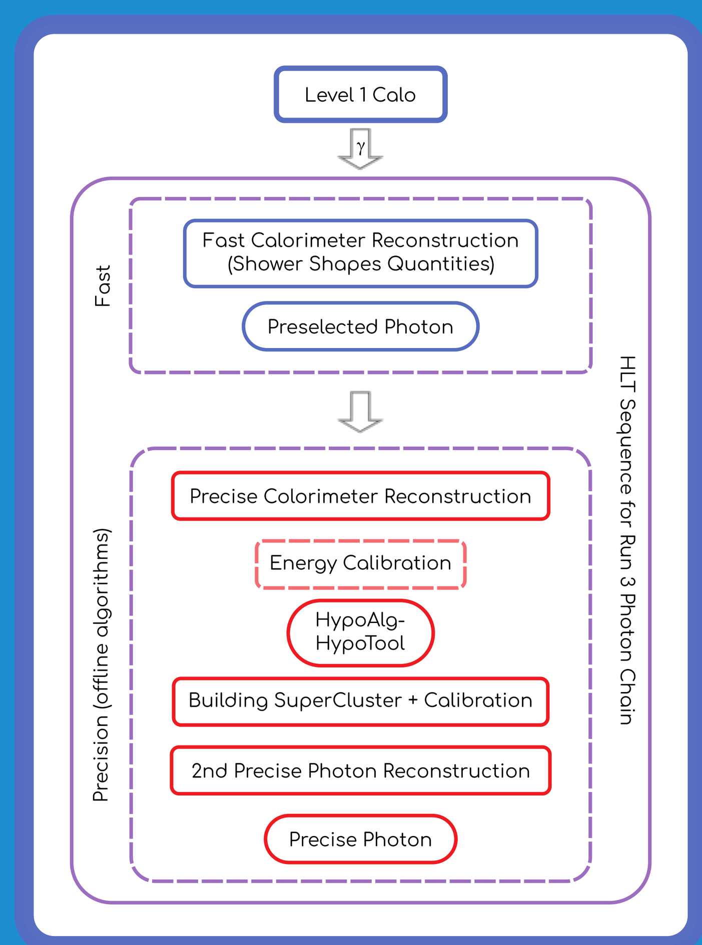
Run 3 trigger algorithms will run in a multi-threaded environment of the Athena framework (AthenaMT). Offline reconstruction algorithms are run in the Precision step.

- In replacement of the sliding-window algorithm, with fixed-size clusters of calorimeter cells, the reconstruction has been improved to use dynamic, variable-size clusters, called superclusters (same as offline).



- Ringer algorithm is a neural-network (NN) based fast-calorimeter reconstruction algorithm. Achieves same signal efficiency as the cut-based method but with a 50% reduction in CPU demand for the lowest unprescaled single electron trigger.

For Run 2, Ringer was implemented only for triggers with $E_T > 15$ GeV. Now for Run 3, will be used for all triggers.



- References: ATLAS Collaboration, Eur. Phys. J. C 80 (2020) 47; ATLAS-TDR-023; https://twiki.cern.ch/twiki/bin/view/AtlasPublic/L1CaloTriggerPublicResults