ATLAS ELECTRON AND PHOTON TRIGGER

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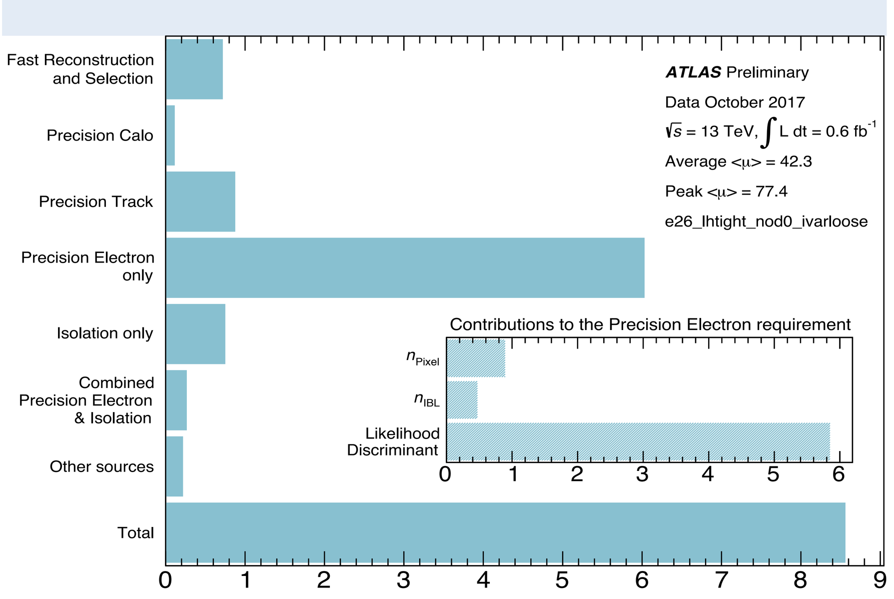
ABSTRACT

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. To cope with ever-increasing luminosity and more challenging pile-up conditions at a center-of-mass energy of 13 TeV, the trigger selections need to be optimized to control the rates and keep efficiencies high. The ATLAS electron and photon performance during the Run 2 is presented, including new techniques developed to maintain their high performance even in high pile-up conditions.

ATLAS Trigger System

- The ATLAS Trigger is a two-level system that reduces the LHC bunch crossing rate of 40 MHz to an average recorded event rate of ~1 kHz, of which around 20% are allocated to electron and photon trigger.
- The Level1 (L1) hardware trigger uses low granularity data from the calorimeters (trigger towers) and muon system to identify Regions of Interest (RoIs). Maximum output rate is 100 kHz.
- The High Level Trigger is software based and is often seeded by RoIs from L1. Performs reconstruction and identification with selection as close as possible to that of offline algorithms.

Source of Inefficiency for Electron Triggers



- Efficiency losses caused by differences in online and offline reconstruction and selection.
- These differences need to be minimized within HLT CPU and timing constrains.
- Precision tracking is the main source.

Triggering e/γ

L1 Calorimeter trigger makes RoI based on the electro-magnetic (EM) clusters formed around a local energy maximum with the sliding-window algorithm. Additional background rejection can be achieved by vetoing on the energy deposits in the hadronic calorimeter as well as in the ring of trigger towers surrounding the cluster.

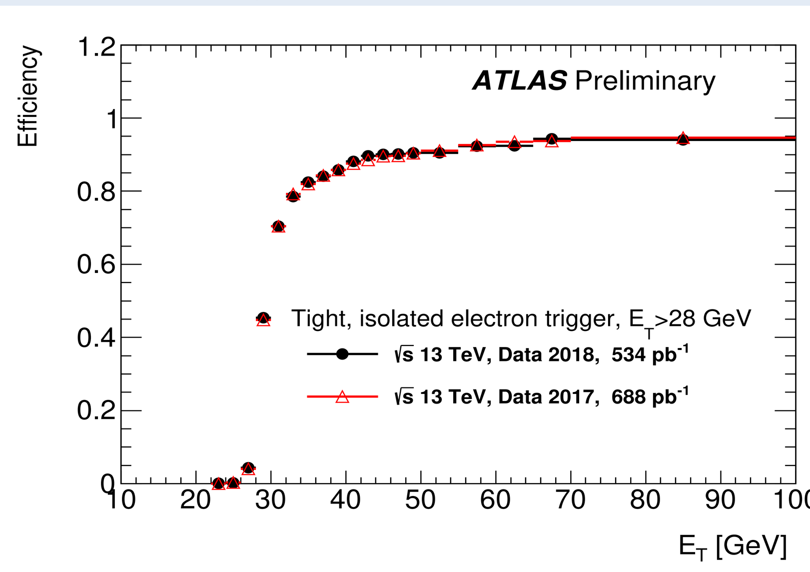
The following selection is performed at the HLT:

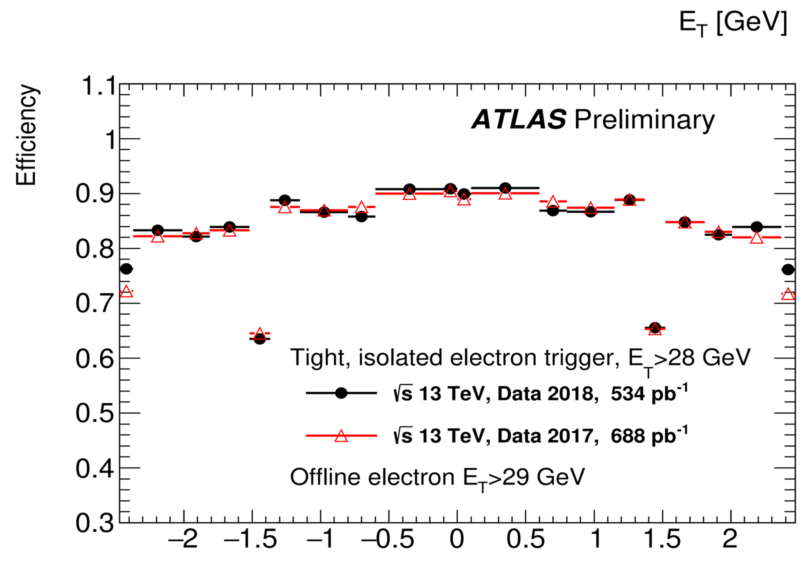
• Fast Step
– Cut-based selection using calorimeter variables of photons with transverse energy (E_T) above 5 GeV and electrons with 5 GeV < E_T <15GeV.
– Neural Network based selection of electron clusters in calorimeter for E_T > 15 GeV
– Loose association of tracks to clusters for electrons

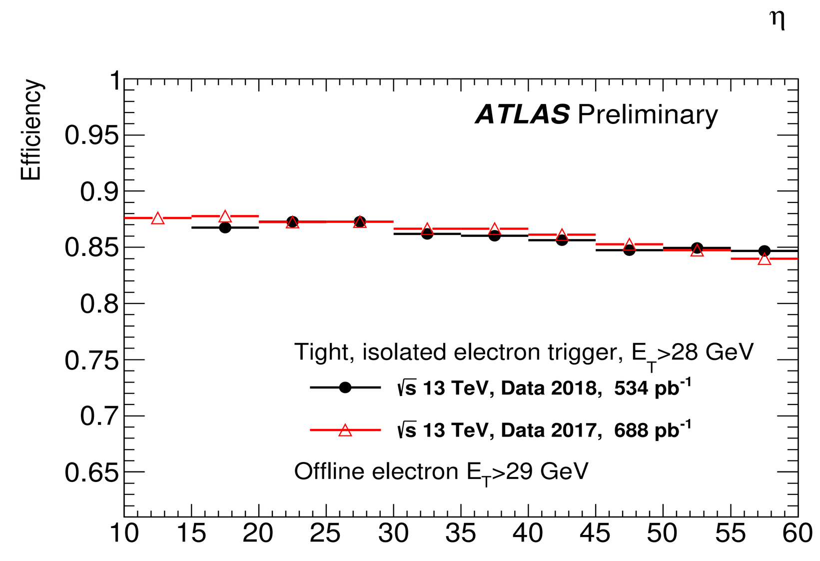
• Precise Step
– Cut-based identification of photons similar to offline algorithms (cluster variables)
– Likelihood identification of electrons similar to offline algorithms (cluster, track, and cluster-track matching variables)
– Isolation requirement is applied in some cases to further suppress backgrounds

Electron Trigger Performance 2018

- Efficiency measured using tag-and-probe method with Z → ee events
- Great agreement with 2017 data.

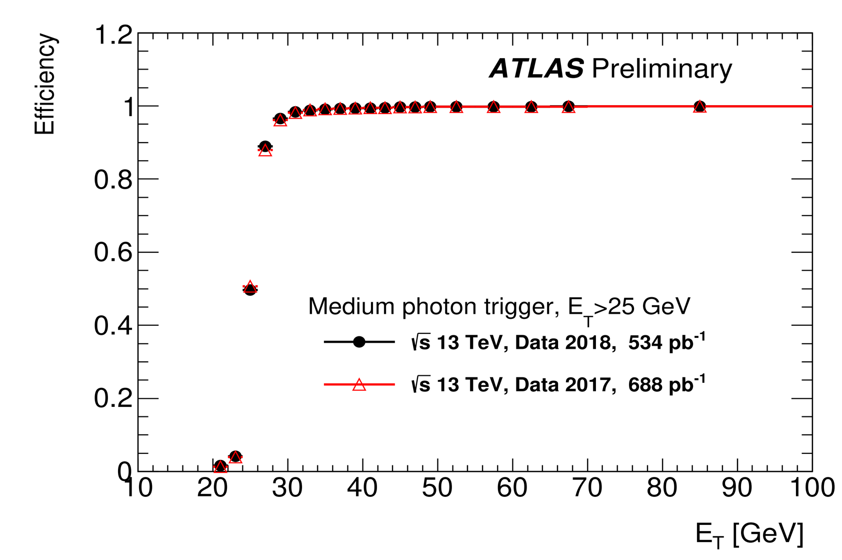




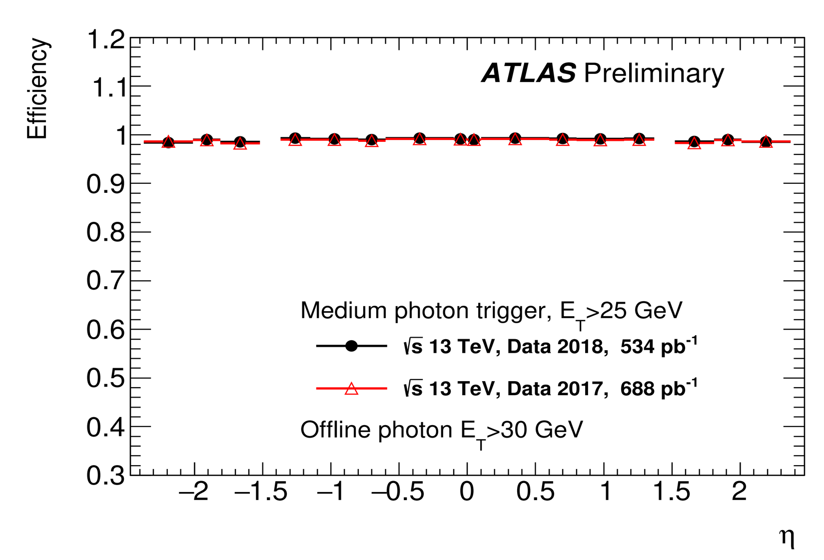


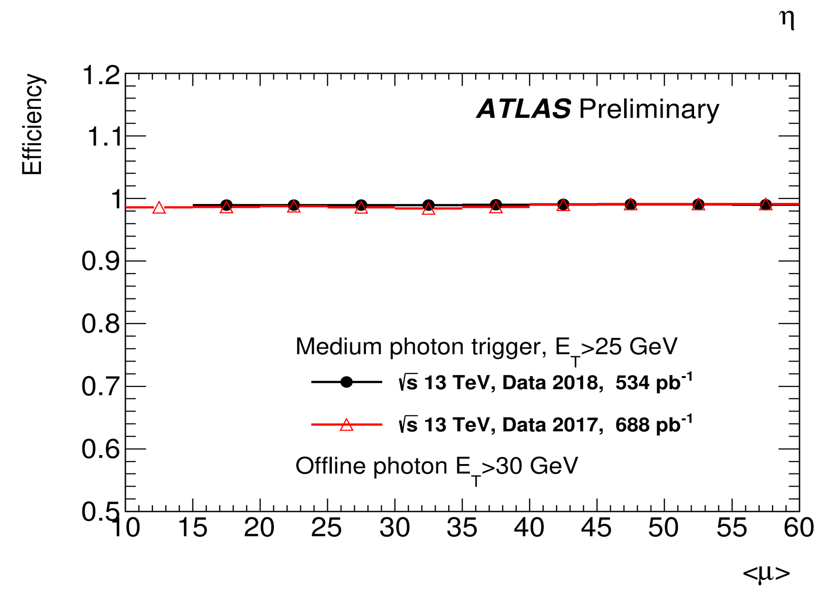
Photon Trigger Performance 2018

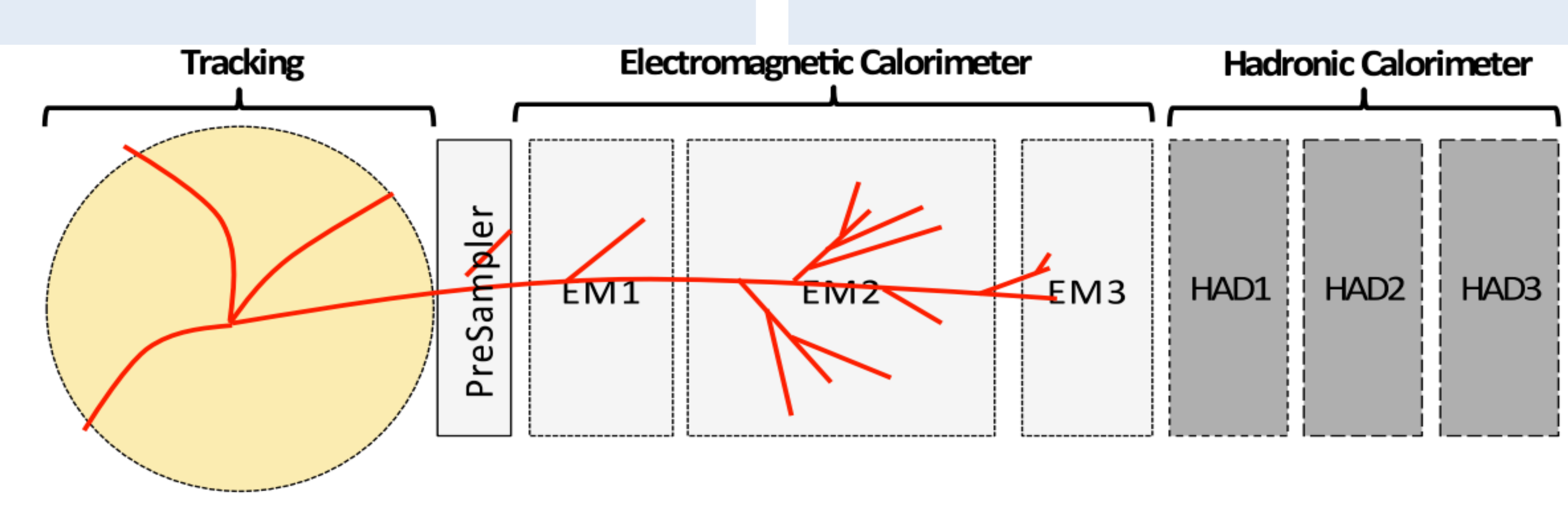
- Efficiency measured based on data-driven Bootstrap method with L1 trigger.
- Close to 100% efficiency at a few GeV above trigger threshold.
- Great agreement with 2017 data.

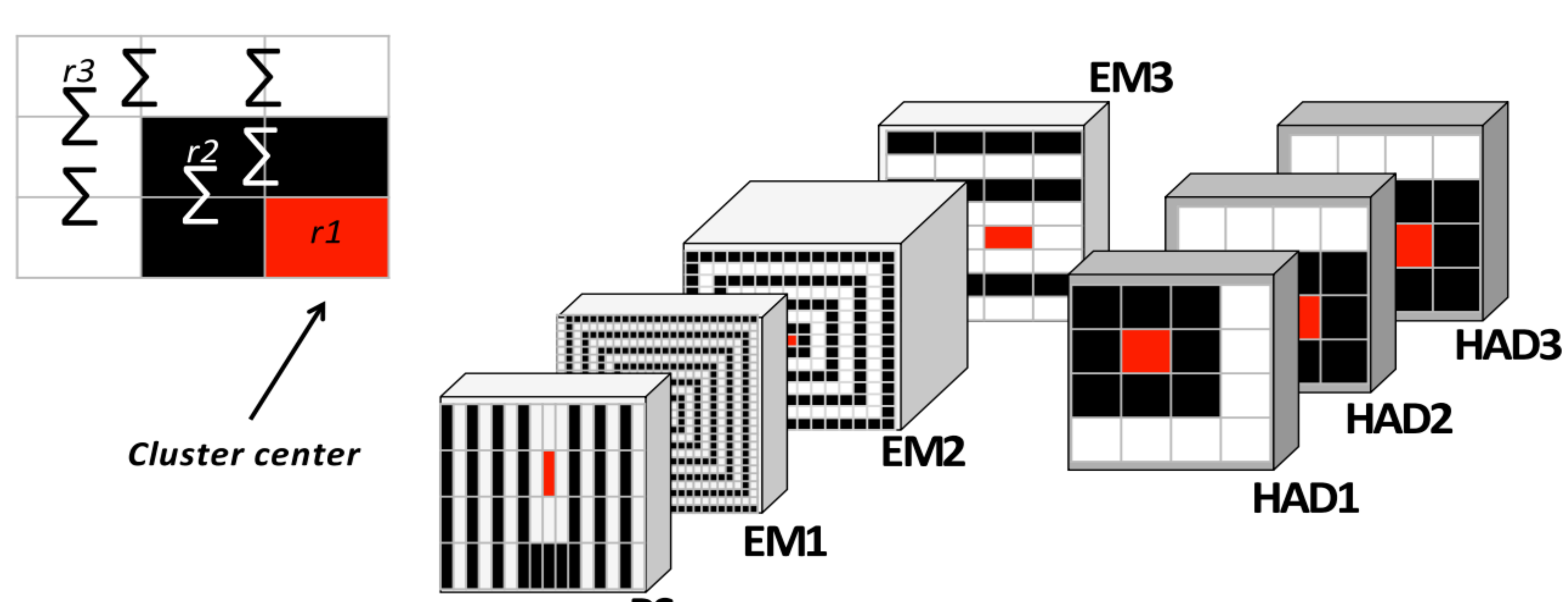


- Very uniform performance with respect to angle and pileup







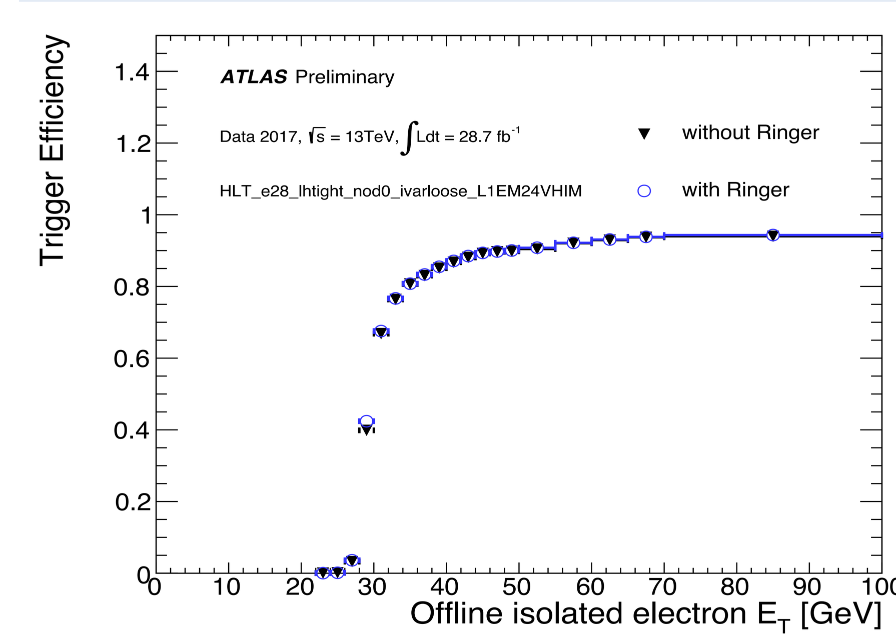


Improvements in Run 2

- Topological cluster based isolation for photons. Online since 2017.
- Neural Network based algorithm (Ringer) is implemented to improve fast calorimeter selection for the electron trigger chains.
- Likelihood selection and ID pileup correction for electron HLT is updated for 2018 data taking.
- PDFs were updated to data driven in 2017, and re-optimized for higher pileup conditions in 2018.

Ringer Algorithm

- Ringer algorithm is built using all calorimeter layers, centered in a window around the cluster barycenter.
- First ring in each layer is the cell closest to cluster barycenter.
- Each ring is the collection of cells around the previous one. Ring value is the sum ET of all cells of that ring.
- Same signal efficiency w.r.t cut-based fast calo step.



- Primary chain latency reduction: 200ms to ~100ms.
- High rejection power (~2-3X). Electron + photon slice: ~1/4 latency reduction.

João Victor da Fonseca Pinto and ATLAS Collaboration 2016 J. Phys.: Conf. Ser. 762 012049
ATL-COM-DAQ-2018-005 ATL-COM-DAQ-2018-007
ATL-COM-DAQ-2018-043 ATL-COM-DAQ-2018-049