Performance of e/γ - based Triggers at the CMS Experiment

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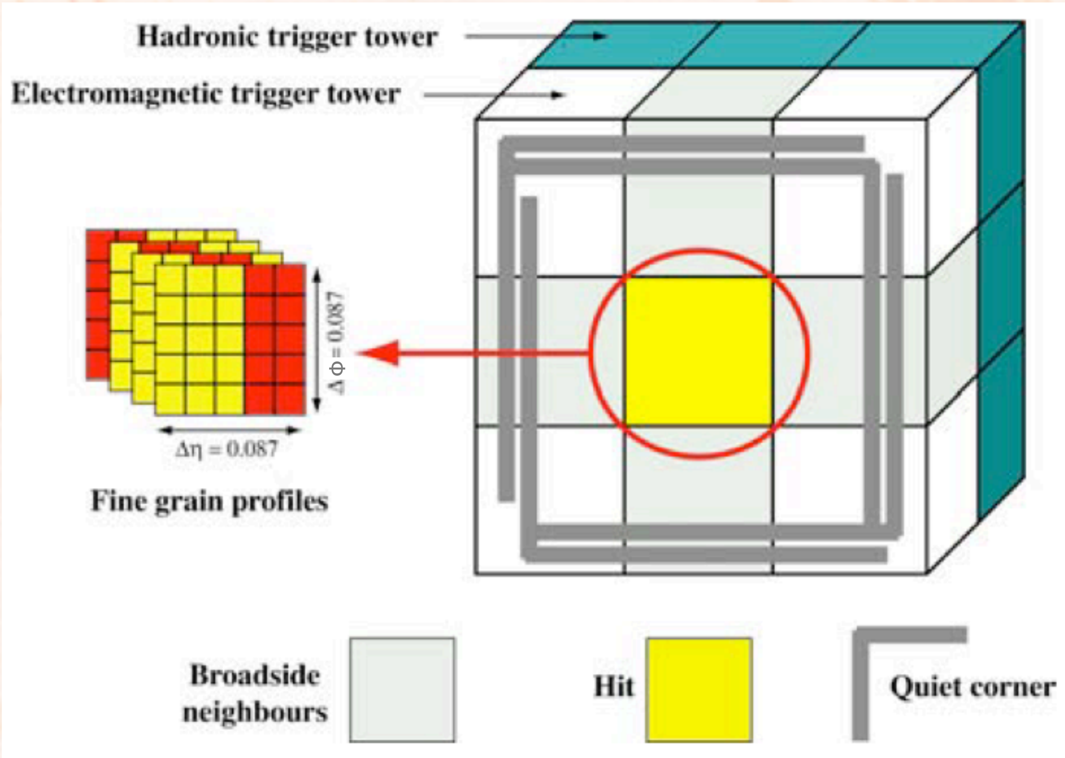
The CMS experiment is designed with a two-level trigger system: the Level 1 (L1) Trigger, implemented on custom-designed electronics, and the High Level Trigger (HLT), a streamlined version of the CMS reconstruction running on a computer farm. Here, we will present the algorithms used for the online reconstruction of electrons and photons (e/γ), both at L1 and HLT, and their performance and the planned improvements.

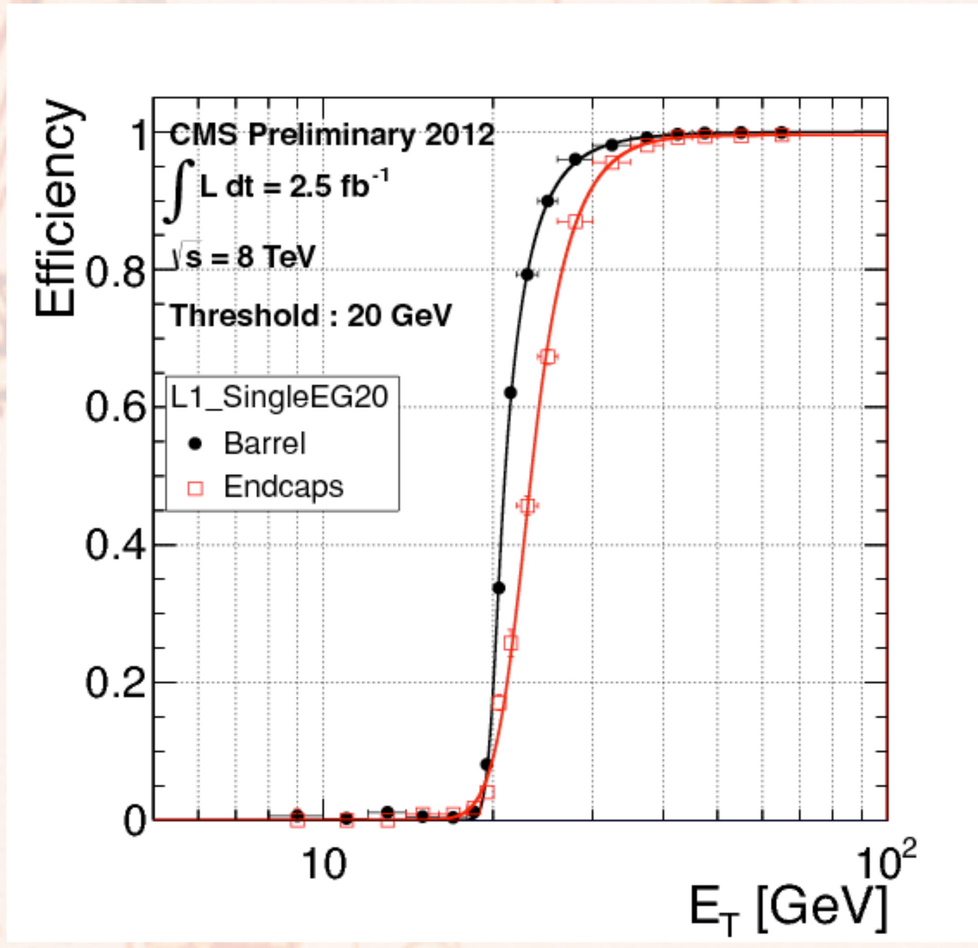
THE LEVEL-1 TRIGGER ALGORITHMS

- The e/γ L1 trigger algorithm uses a sliding window of 3 × 3 trigger towers (TTs). The transverse energy of the e/γ candidate is given by the energy deposit of the central tower summed with the largest deposit in one of its 4 neighbor towers.
- Only candidates in which 2 adjacent strips (5 crystals in φ are called a strip) of the central tower contain 90% of the tower energy are kept.
- The associated HCAL energy contribution is required to be less than 5% of the ECAL energy.
- To qualify as an isolated candidate, at least 5 of the 8 adjacent TTs must have transverse energy below a certain threshold.



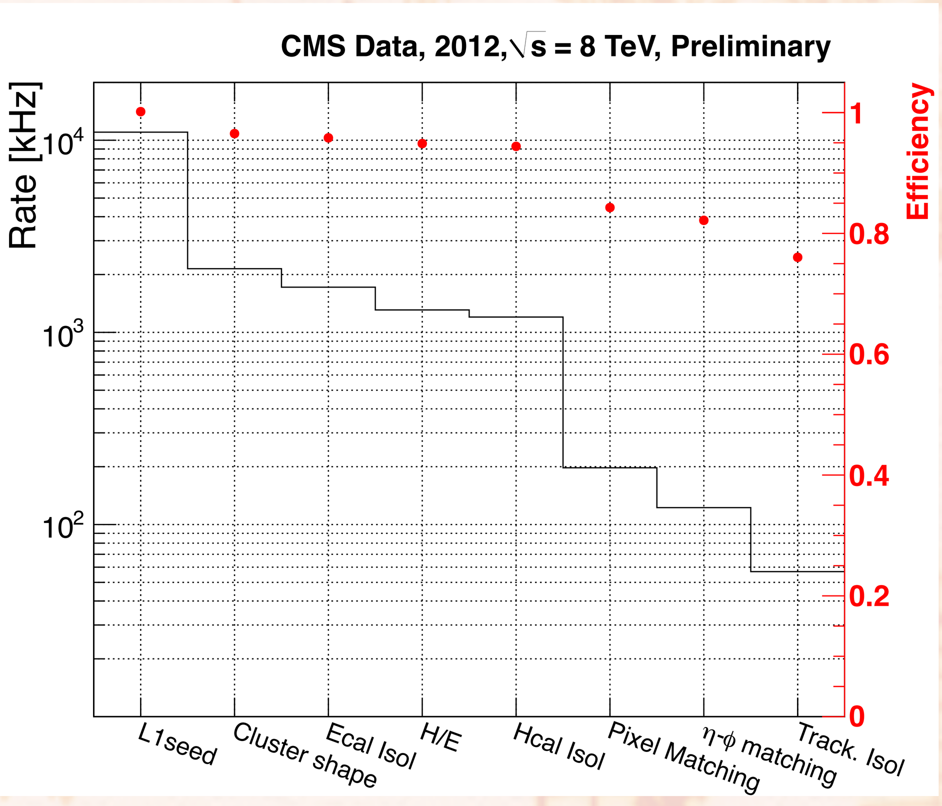
THE LEVEL-1 TRIGGER PERFORMANCE

- The trigger efficiency is measured with Z(ee) events using a tag and probe method.
- Efficiency of the 20 GeV e/γ trigger as a function of offline ET, shown separately for barrel and endcap.
- The widths of the turn-on curves are affected by the coarse trigger granularity, which decreases the energy resolution at L1. In the ECAL endcap (EE) region the larger amount of material in front of ECAL causes more bremsstrahlung than in the ECAL barrel (EB) region, leading to a wider turn-on curve.



THE HLT ALGORITHMS

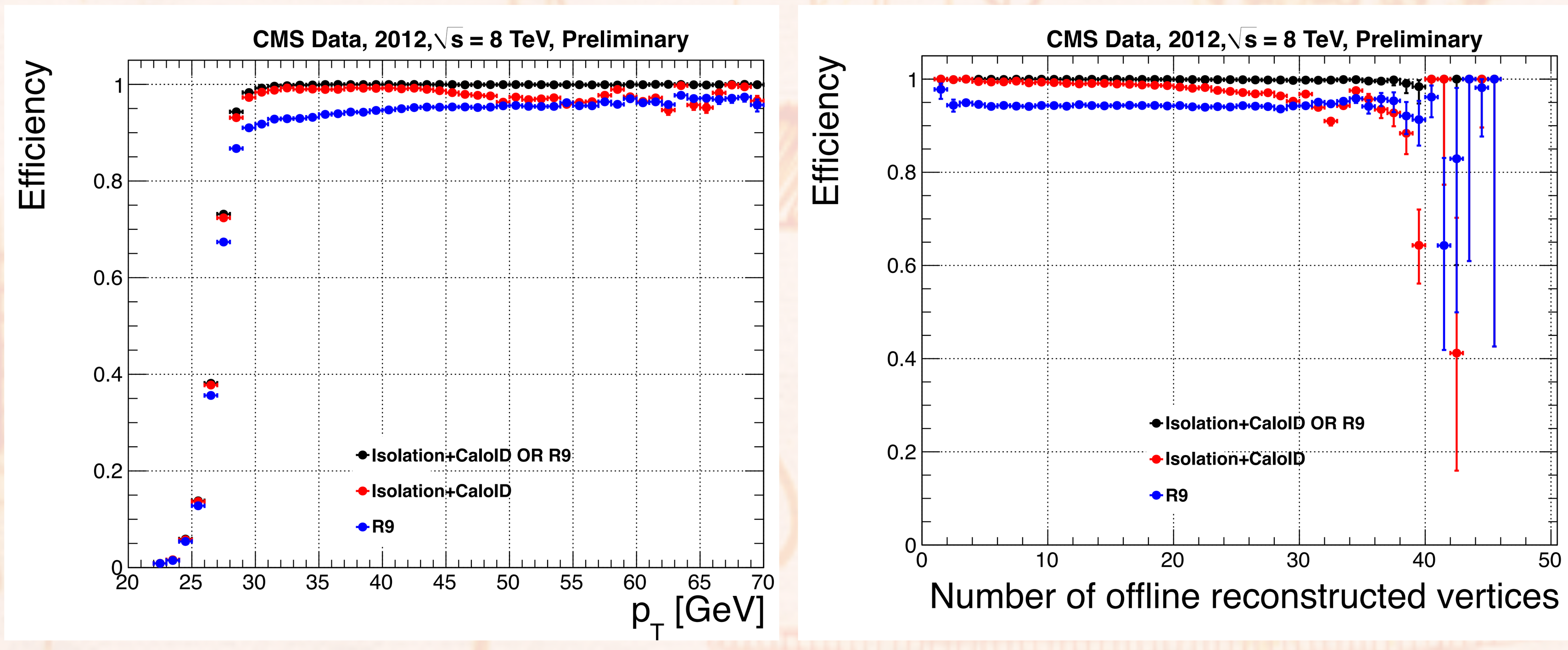
- HLT algorithms for e/γ form Super Clusters (SC) around L1 candidates and account for the spread of bremsstrahlung energy in the φ direction due to the magnetic field.
- Further identification criteria using calorimeter information such as cluster shape and isolation variables are applied.
- A track compatible with the SC distinguishes electrons from photons. The energy and position of the SC are used to search for compatible hits in the pixel detector.
- The reconstruction of electron tracks can be improved with a Gaussian-Sum Filtering (GSF) algorithm, to parametrize the highly non-Gaussian loss of energy



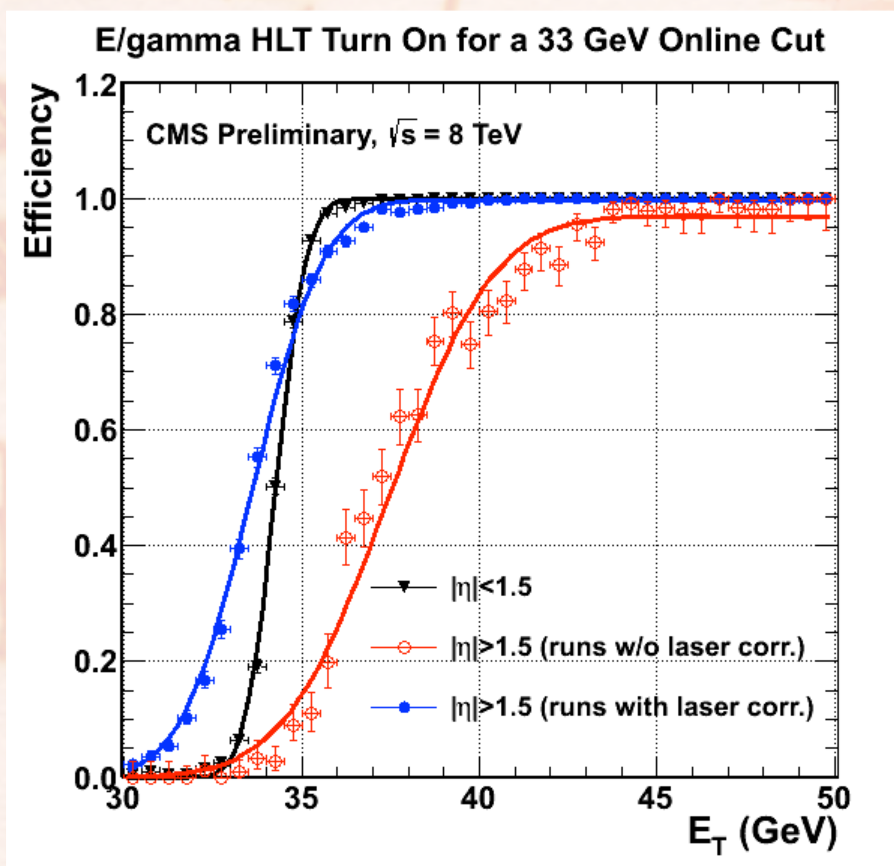
- The lowest threshold single electron path at the end of 2012, had an E_T threshold of 27 GeV, with a rate of 50 Hz. The plot shows how the rate is gradually reduced by the filtering steps of this trigger along with the efficiency on electrons.

THE HLT PERFORMANCE

- The efficiency of electron and photon HLT paths can be measured on data using electrons from Z decays. The efficiency measurement of the double photon trigger used in the H to γγ analysis uses the tag and probe method, where the probe electrons are treated as photons.

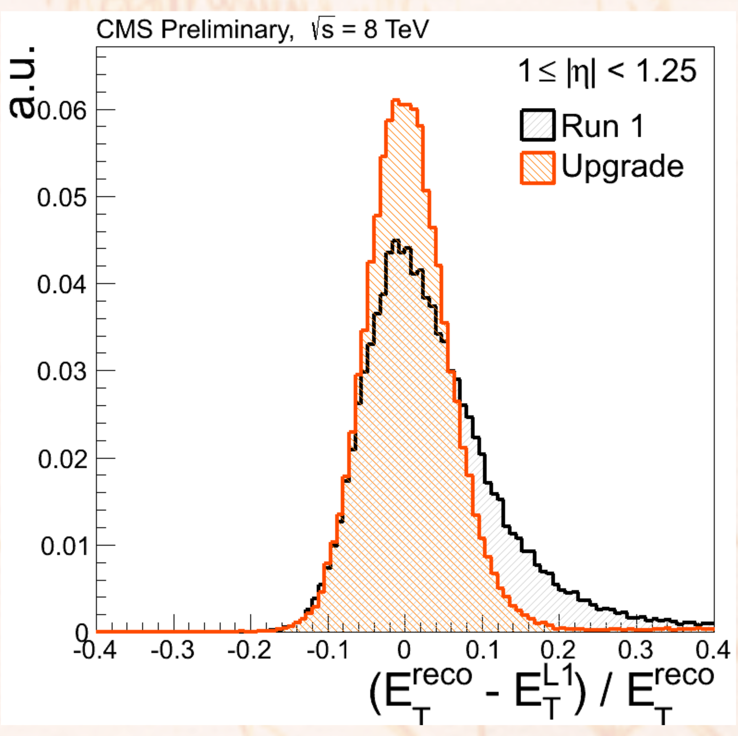


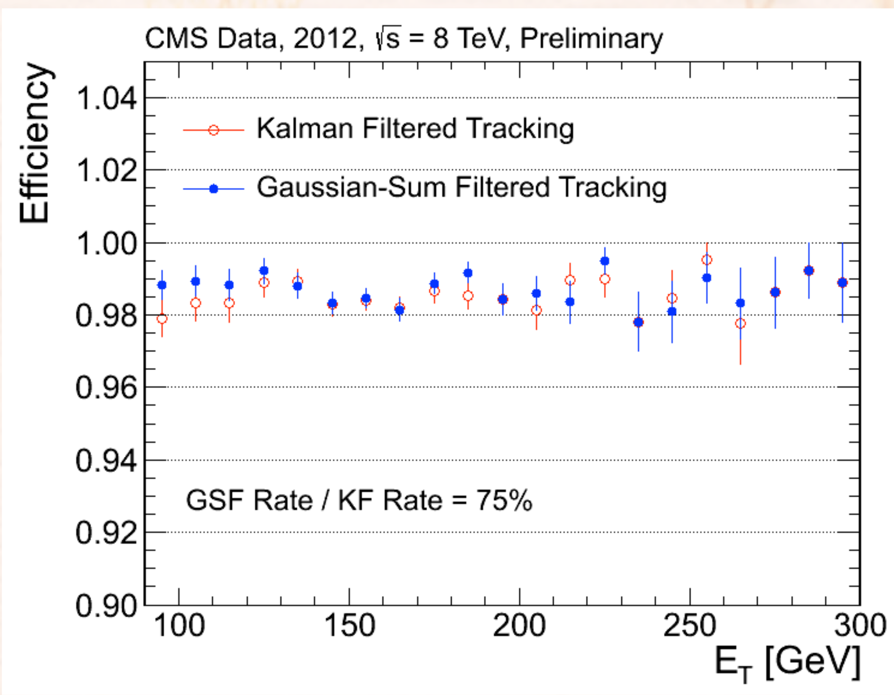
- Efficiencies of the leading leg for the double photon trigger as a function of the photon pT and the number of reconstructed vertices in the event, using only the isolation and calorimeter identification cut (red), only the R9 ratio of energies of E3x3/ESC (blue), and the OR of the two criteria (black).



- Under irradiation the ECAL crystals become less transparent.
- The transparency of each crystal is monitored by a laser system, in order to derive and apply corrections to the measured energies.
- Electron efficiency as a function of offline E_T for an online cut of E_T > 33 GeV in the EB (|η|<1.5), and EE (|η|>1.5) before and after the transparency corrections were introduced in the HLT.

UPGRADE





- The upgraded L1 trigger performs a dynamic clustering at the TT level which improves the energy resolution and gives a rate reduction up-to 40%.
- Reducing the number of gaussian components used in the GSF refitting allows it to be used as the default tracking algorithm for electrons. This results in 25% rate reduction with no efficiency loss.

REFRENCES

- CMS Collaboration, PoS ICHEP2012 (2013) 508
- Pascal Paganini, Journal of Physics: Conference Series160 (2009) 012062
- CMS Trigger TDR