Performance of electron, photon and muon selections at the CMS High Level Trigger

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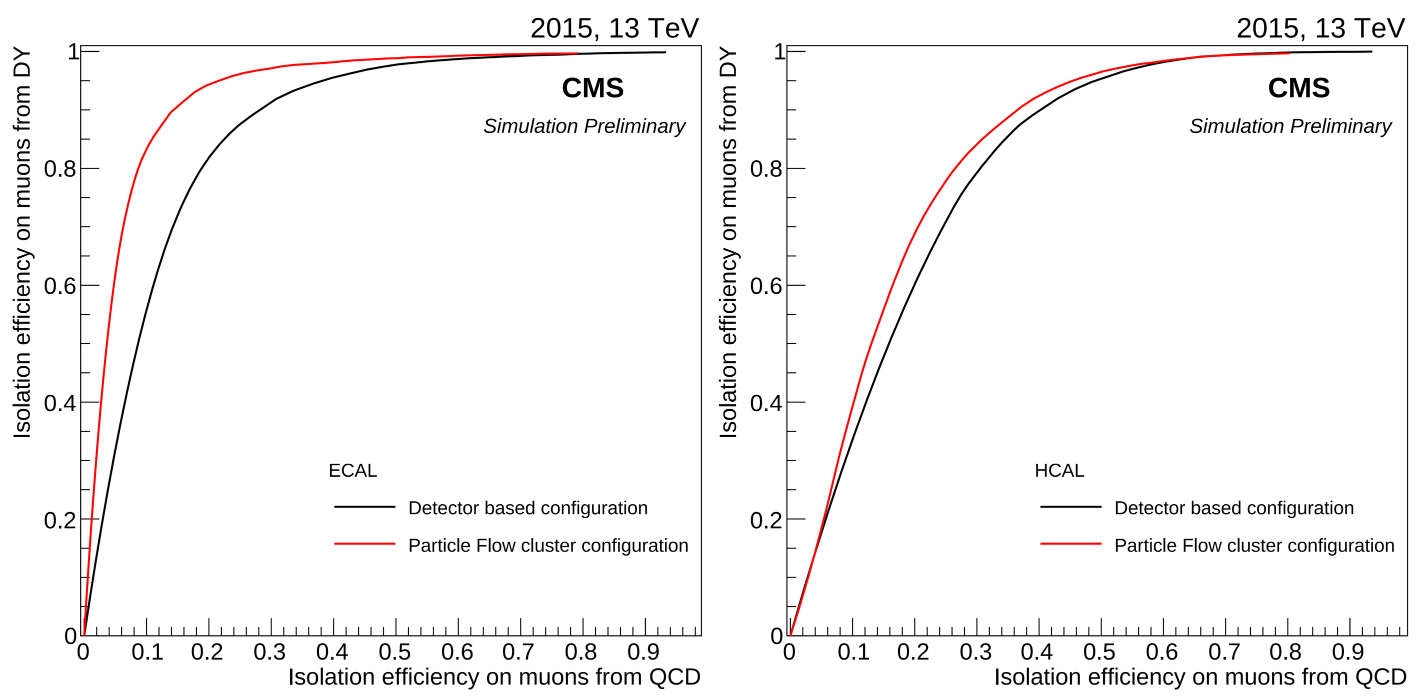
Overview

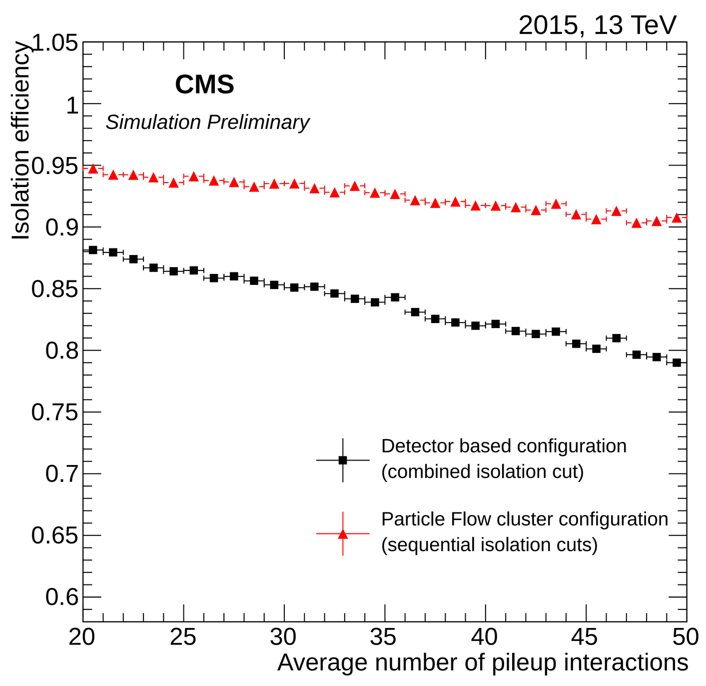
The CMS on-line selection system is implemented in two steps: the Level-1 Trigger, implemented on custom-made hardware and dedicated to analyse the detector information at a coarse-grained scale; and the High Level Trigger (HLT), implemented as a series of software algorithms, running in a processor farm, that have access to the full detector information. The HLT algorithms have to optimise the trade-off between signal selection efficiency and background rejection, within the constraints of a hard limit on processing time. Here we present some of the improvements made to the CMS High Level Trigger for the LHC Run 2 for electrons, muons, and photons.

Muon Triggers

Muon candidates coming from weak boson processes have the characteristic of being isolated from the rest of the activity in the event. A new approach to isolation has been developed for Run 2, based on Particle Flow clusters (exploring the whole detector granularity) and sequential isolation (having separate isolation definitions for ECAL, HCAL and the tracker). Those improvements allow to maximise the selection efficiency for isolated muons while keeping similar kinematic thresholds as those used at the end of Run 1.



Performance of the ECAL (left) and HCAL (right) calorimeter isolation for the detector based setup (black) and the Particle Flow (red) algorithm proposed for the 2015 configuration. The signal is from Z→ $\mu\mu$ events, the background from multijet events. The efficiency is estimated with average pileup of 40 and 25ns bunch spacing.

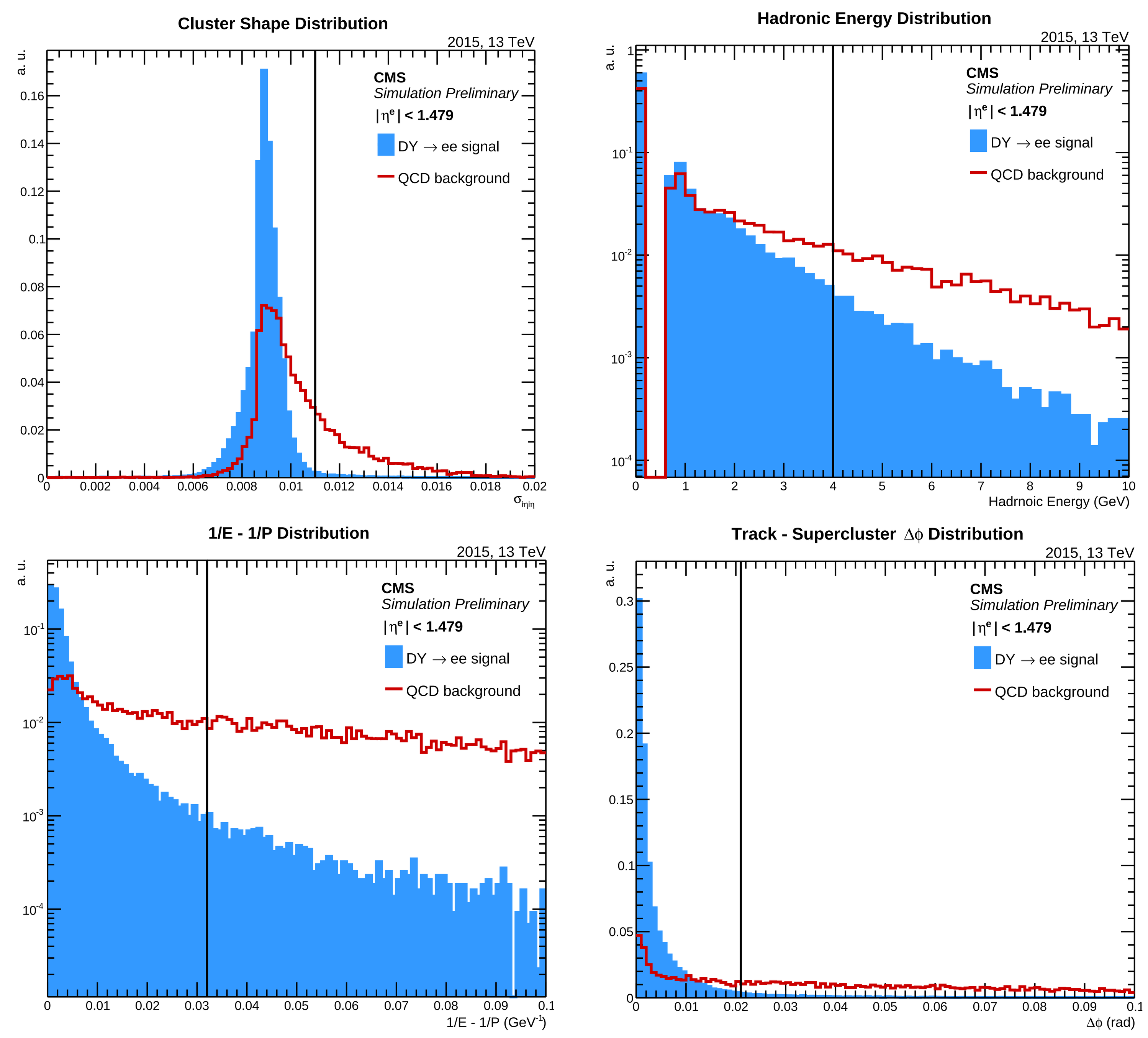


Overall isolation efficiency as a function of the average number of pileup interactions for two working points giving a similar rate reduction, computed with respect to generated muons. The working point for the new configuration is the one that is implemented in the 2015 menu. Black: detector based isolation. Red: current isolation configuration for the 2015 run. The simulation has pileup from 20 to 50 and 25ns bunch spacing.

Electron-Photon Triggers

The identification of electrons and photons at CMS relies on the granularity of ECAL and on the high performance of the tracker, both during off-line reconstruction and at the HLT. The main handles to separate prompt electrons and photons from jets particularly rich in electromagnetic (EM) component are:

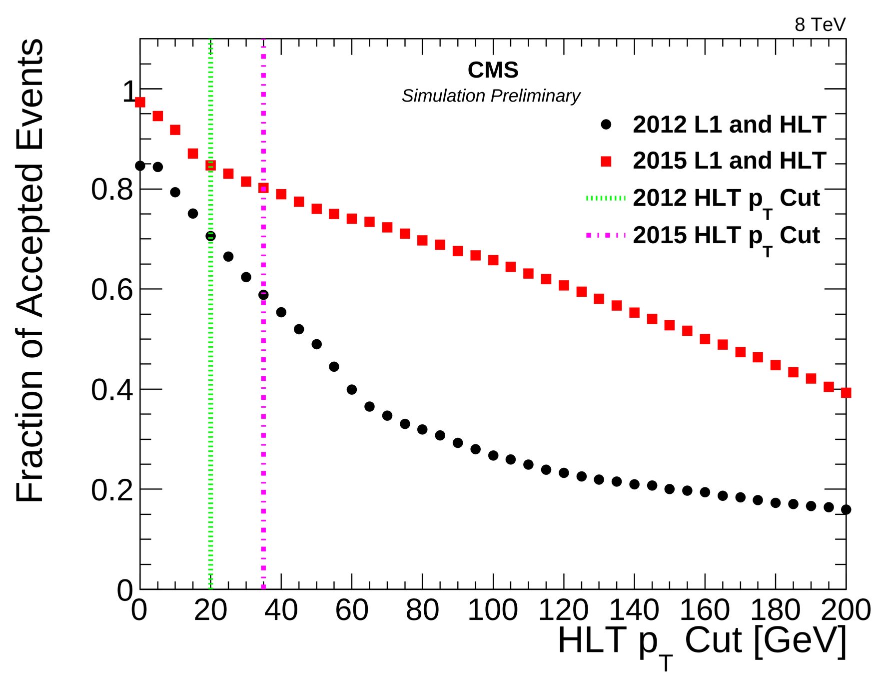
- The energy weighted pseudorapidity-width σ_η of the EM cluster
- The hadronic energy deposit behind the EM cluster, and the ratio H/E of those energies
- The difference between the inverses of the EM cluster energy and of the associated electron track momentum ($1/E - 1/p$)
- The absolute values of pseudorapidity and azimuthal angle of the difference between the electron's cluster and track ($\Delta\eta$ and $\Delta\phi$)



Distribution of the identification variables for events from Drell-Yan processes (blue full histograms) and for multijet background processes (red line histograms). Further identification techniques are available for the design of triggers, such as matching between the EM cluster and the pixel seed, number of expected missing hits in active tracker layers and lepton isolation.

Displaced Leptons

Displaced leptons can arise from some Beyond Standard Model processes where a heavy, long-lived neutral particle decays far away from the luminous region. Generally, photon triggers are reasonably efficient for displaced electrons, while for muons special provisions must be in place to ensure proper p_T estimation. The figure to the right shows the fraction of simulated signal events passing the special-purpose trigger, as a function of the HLT p_T requirement for the trigger configuration in 2012 (black) and the configuration being used in 2015 (red). The trigger selects displaced and out-of-time muons, and the 2015 configuration improves the p_T resolution for such muons. The trigger rate is kept under control through the usage of bunch-crossing veto bits.



Acknowledgements

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