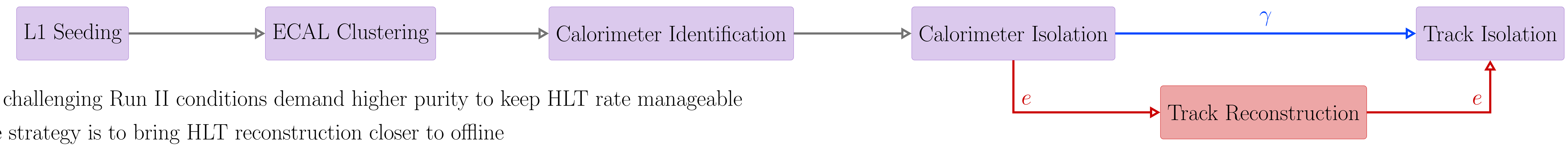
Electrons and photons at High Level Trigger in CMS for Run II

Afiq A. Anuar on behalf of the CMS collaboration

National Center for Particle Physics, University of Malaya, Malaysia

Introduction

- Reconstruction of electrons/photons (e/γ) at the CMS High Level Trigger (HLT) is done in these steps:



- More challenging Run II conditions demand higher purity to keep HLT rate manageable
  - The strategy is to bring HLT reconstruction closer to offline

L1 Seeding

- Hardware-based selection on calorimeter energy deposit
- Rate reduction achieved through the use of isolation and pseudorapidity requirements

ECAL Clustering

- Grouping-together of ECAL crystals to collect the full e/γ energy deposit
- New clustering algorithm combining all sub-detector inputs (called Particle Flow, PF) improves energy containment at low p_T
- *Multifit* timing algorithm to reduce the impact of additional 'pile-up' collisions (PU)
- Energy corrections had a large impact in Run I; will be applied weekly on every crystal in Run II to account for transparency loss over time

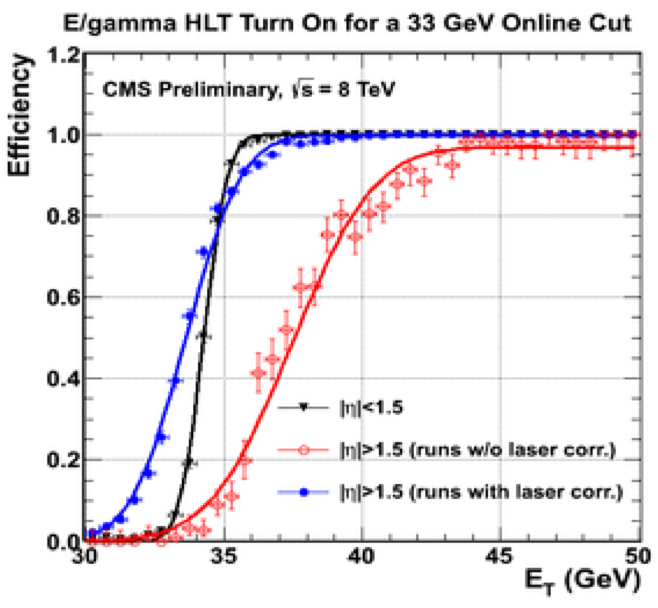


Figure 1: Impact of laser correction in Run I

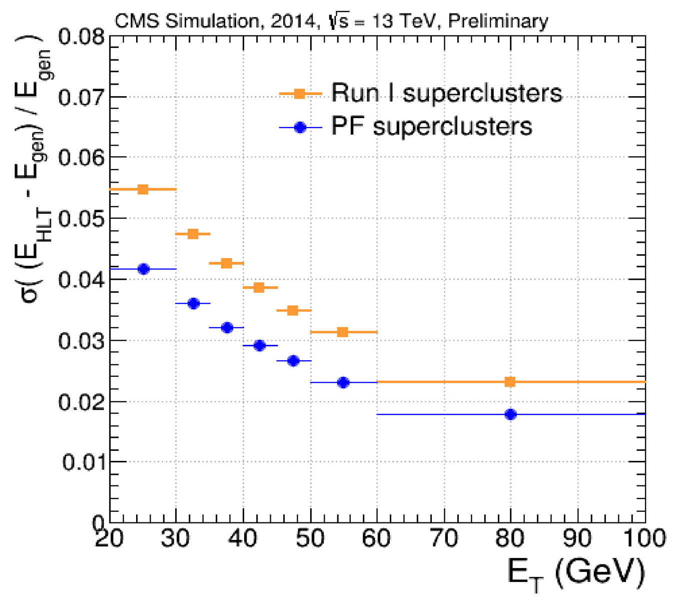


Figure 2: Comparing the energy resolution of Run I and Run II clustering algorithms

Calorimeter Identification

- Prompt e/γ candidates deposit their energy in narrow showers, a handle against jets
- Define quantitative measures of the spread of energy deposit; energy-weighted cluster shape ($\sigma_{i\eta i\eta}$) for e and the ratio between 3×3 and supercluster energy deposit (R9) for γ

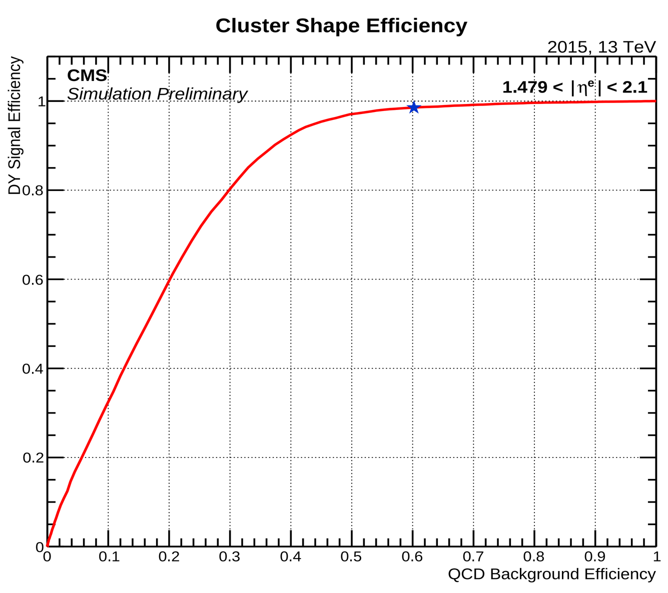


Figure 3: Efficiency of $\sigma_{i\eta i\eta}$ selection criterion in endcap region

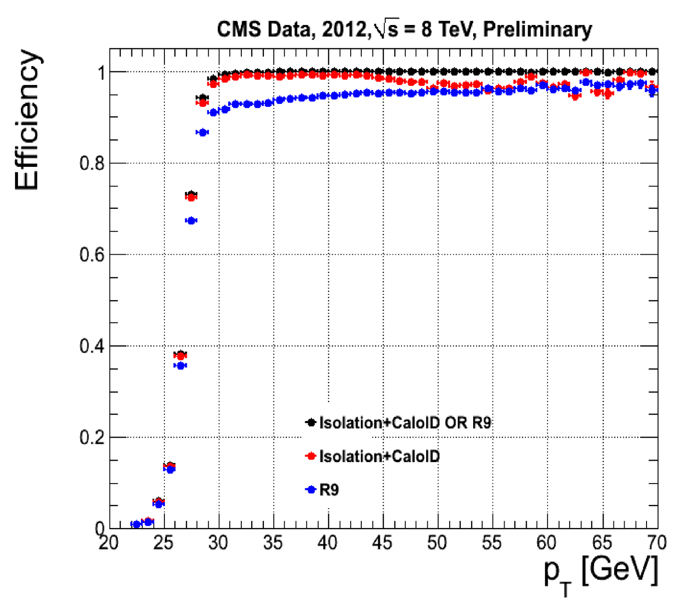


Figure 4: Efficiency of the isolation, identification and R9 selection criteria as a function of p_T^{γ}

Calorimeter Isolation

- Isolation is an important handle in prompt e/γ discrimination which is defined as the sum of all cluster E_T within a $\Delta R < 0.3$ cone
- Run II isolation algorithm takes PF clusters as input instead of calorimeter energy deposit
- This strategy improves HLT isolation performance and brings it on par with offline while fitting within the HLT timing budget

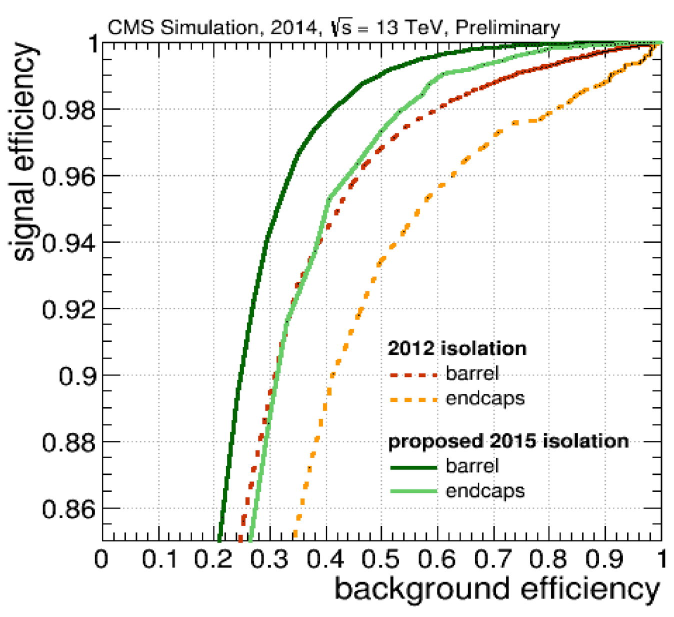


Figure 5: Comparing the old and new HLT isolation algorithms

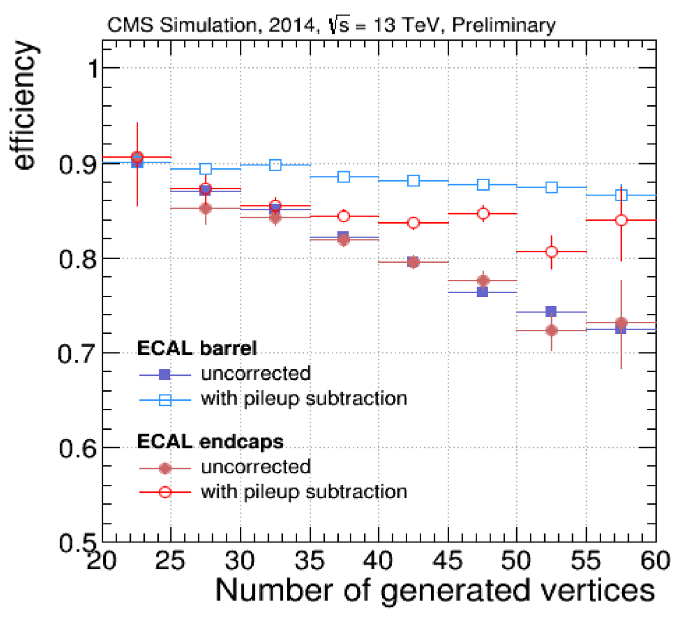


Figure 6: Impact of PU correction on e isolation efficiency

Track Reconstruction and Identification

- To ensure only relevant tracks are reconstructed, match the track seeds with supercluster

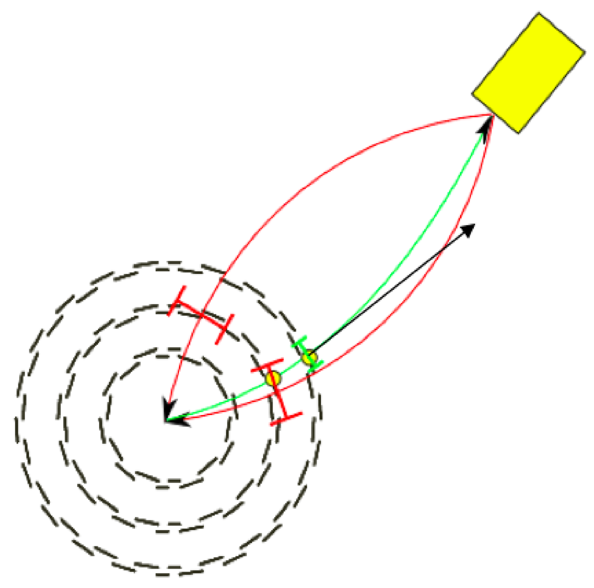


Figure 7: Schematic diagram of the pixel matching procedure

- This is done by imposing a selection based on a compatibility variable s:

$$s = \sqrt{\left(\frac{\Delta\phi_1}{a_{\phi_1}}\right)^2 + \left(\frac{\Delta\phi_2}{a_{\phi_2}}\right)^2 + \left(\frac{\Delta z_2}{a_{z_2}}\right)^2} \quad (1)$$

- e tracks are then reconstructed with the Gaussian-Sum Filter (GSF): a non-linear generalization of the Kalman Filter (KF)
  - This is necessary as KF is not adequate to model bremsstrahlung energy loss
- Following the track reconstruction, remove non-e tracks by imposing identification criteria:
  - Difference between inverse of energy and momentum exploiting the small mass of e
  - Geometrical compatibility between track and supercluster

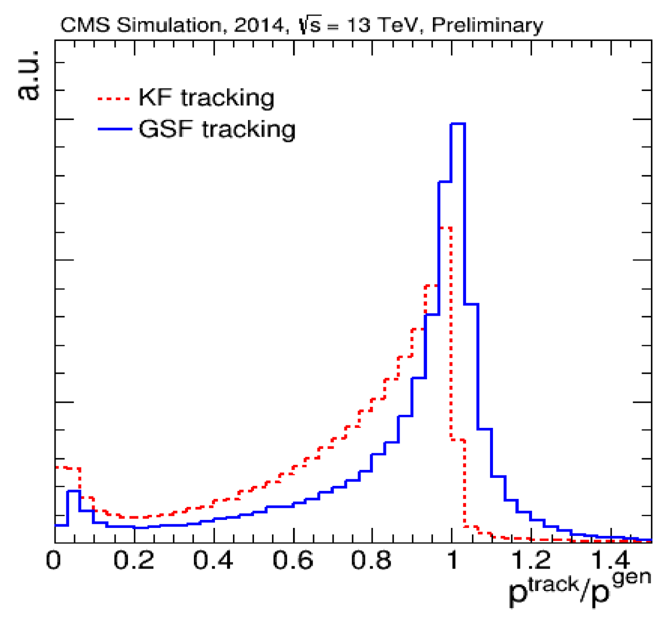


Figure 8: Momentum resolution of the GSF and KF algorithms

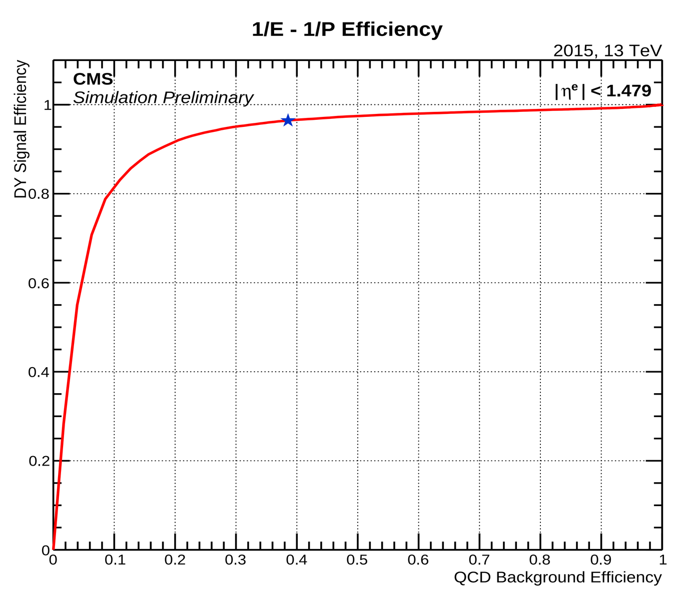


Figure 9: Efficiency of the difference between inverse of energy and momentum selection criterion in barrel region

Track Isolation

- Executed last in the chain as it is the most time intensive step
- Construct all tracks within a cone around the e/γ candidate to compute the isolation sum
- A very important handle for discriminating prompt e/γ candidates from jets

Expected Performance

- Working points optimized based on physics needs of the trigger
  - Single e $p_T > 32$ GeV for top physics: 90% signal efficiency at 157 Hz
  - Double γ $p_T > 34$, 18 GeV for Higgs physics: 100% signal efficiency at 41 Hz
- Rate estimation assumes an instantaneous luminosity of 1.4×10^{34} cm^{-2} s^{-1} and PU 40

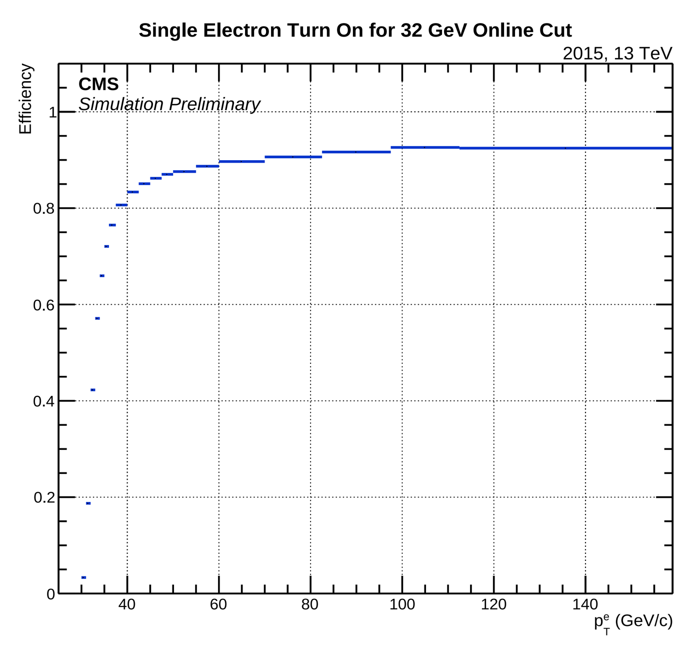


Figure 10: Efficiency of single e trigger using simulated Z boson decaying to e pair events

CHEP2015, Okinawa, Japan, April 13 - 17 2015