The CMS Detector
- The Compact Muon Solenoid (CMS) experiment is a general-purpose detector operating at the LHC (CERN, Switzerland).
- CMS was designed to study proton-proton and heavy ion collisions at \( \sqrt{s} = 14 \text{ TeV} \), primarily to search for new particles and physics processes.

The CMS Electromagnetic calorimeter (ECAL)
- The CMS ECAL is a hermetic system designed for measuring precisely the energies of electrons and photons.
- It is made of scintillating lead tungstate crystals and is equipped with fast electronics.
- The L1 e/γ trigger is based on trigger towers (TT) of the ECAL and the hadronic calorimeter (HCAL).

CMS Trigger System
- The CMS Detector has a sophisticated two-level trigger system that reduces the input data rate by a factor of 10^5. The CMS Trigger is designed for a fast selection of interesting physics events.
- The Level-1 (L1) trigger is implemented in custom hardware and its inputs are the data from the calorimeters and muon systems. The L1 trigger latency is 3.8 µs.
- The High Level Trigger (HLT) runs on a massive computer farm and uses refined algorithms exploiting the full detector granularity; its latency is 200 ms.

L1EG Trigger Algorithm

Identification of e/γ candidates
- **Jet requirement**
  - Based on \( E_{\text{Jet}}^{\text{ECAL}} / E_{\text{T}} \) ratio for the seed TT.
  - Cut optimized to give high efficiency for T&P selected electrons.
- **Extended H/E**
  - Extension of H/E criteria including neighboring towers used in clustering.
  - Minimal loss of efficiency.
  - Rate decrease about 20%.
- **Shape identification**
  - Exploits full granularity of e/γ cluster.
  - Based on LUT with \( E_{\text{Jet}} \) and cluster shape as inputs.
  - Designed to have increasing efficiency with \( E_{\text{Jet}} \) (no requirement for \( E_{\text{Jet}} > 70 \text{ GeV} \)).

Examples of cluster shapes

Efficiency
- **L1 Trigger efficiency for an e/γ object measured with Tag&Probe**.
- High plateau efficiency.
- Sharp increase in efficiency reflects good energy resolution.
- Combination of thresholds increases the acceptance for equal total rate.

Isolation
- **Cut on energy in an isolation region around cluster**:
  - \( E_{\text{iso}}(\text{or} H_{\text{iso}}) < \text{iso cut} \)
- The isolation cut value depends on \( E_{\text{Jet}}, \eta \) and a pile-up estimator.
- Pile-up is estimated from the number of TTs with \( E_{\text{Jet}} > 0 \) in the central calorimeter.
- Cut implemented via a LUT.
- Two isolation working points are used; they correspond to two different relaxation schemes (Loose, Tight) as a function of \( E_{\text{Jet}} \).

Performance of the L1 e/γ Trigger in 2017 data

The CMS Level-1 trigger for electrons and photons has delivered very high performance at the high luminosity and associated pile-up conditions of 2017.

References