The CMS experiment at the LHC

During Run-2, the LHC has successfully delivered ~140 fb⁻¹ of p-p collision data, under harsh experimental conditions, that include a peak luminosity of 2.1x10³⁷ cm⁻²s⁻¹ as well as a PU of up to 80.

- The CMS detector is a general purpose instrument with a broad physics programme.
- The L1 e/γ trigger uses information from the Electromagnetic (ECAL) and the Hadronic (HCAL) calorimeters.
- The CMS Triggering System

CMS uses a two-level triggering system to achieve a rejection of ~10⁹.
- The triggering system is composed of the Level-1 Hardware Trigger (L1T), and the software High-Level-Trigger (HLT).
- The L1T uses as inputs trigger primitives (TP) from the calorimeters (ECAL and HCAL) and muon detectors and has a fixed latency of ~4μs.
- The HLT processing is based on offline-like reconstruction algorithms and has a latency of ~200 ms.

The L1 e/γ trigger is a two- to layer calorimeter based trigger:
- Layer-1: Combines inputs from ECAL (5x5 crystals) and HCAL into trigger towers (TT) and applies position and energy - dependent calibrations.
- Layer-2: Uses Layer-1 information to reconstruct objects such as jets, muons & e/γ and to compute global quantities such as missing transverse energy. Pileup subtraction and object-based global quantities such as missing transverse objects such as jets, muons & e/γ and to compute

Layer-2: (TT) and HCAL into trigger towers (TT) and

Efficiency for the analyses.

The energy resolution of the electrons in the barrel region is better by a factor of 2, compared to the energy resolution of the EE electrons.

The CMS Triggering System

L1 e/γ Trigger Algorithm

The L1 e/γ Algorithm is responsible for the identification of L1 e/γ candidates and is implemented in four main steps:

- **Dynamic Clustering**
  - The Trigger Tower (TT) with local energy maximum (Eₜ, ≥ 2GeV) is used as the seed for clustering.
  - Neighboring energy deposits (Eₜ, ≥ 1GeV) are then added to the cluster.
- **Trimming of L1 e/γ cluster**
  - The energy distribution within a cluster is used to compute a refined position of the L1 e/γ candidate.
- **Calibration**
  - Energy corrections are used to correct the L1 e/γ candidate energy. They depend on η, ET and shape information and are encoded into a Look-Up Table (LUT).
  - Fine-grain veto (FG) uses the energy distribution within the seed to reject e/γ candidates with a shower profile not compatible with electromagnetic objects.
  - Cut on the H/E (Eₑ/ₚₚ, Eₑ/ₚₚ) ratio, that rejects candidates with a large hadronic energy deposit, that usually are QCD-induced jets
  - Shape identification based on LUT using η, ET and shape information.
  - Isolation requirements (vs. jets) which depend on PU and η and are relaxed with Eₜ for maximal efficiency.

L1 e/γ efficiency via Tag & Probe

A data-driven Tag and Probe method is used to measure the L1 e/γ trigger efficiency: it utilizes the characteristic signature of Z→ee decays in order to yield a clean unbiased sample of electrons.

- All electrons must reside inside the ECAL fiducial volume
- T&P electron invariant mass 60 < mₑₑ < 120 GeV
- Electrons must have opposite charge (OS)
- ΔR(Probe,L1 e/γ candidate) > 0.6

Tag electron is required to:

- Pass medium electron ID
- Eₜ > 30 GeV
- Be matched to the HLT electron triggering the event

Probing electron is required to:

- Pass Loose electron ID
- (ΔR(Probe,L1 e/γ candidate)) < 0.3

L1 e/γTrigger Performance of the 2018 data

Requiring the L1 e/γ candidates to be tightly isolated allows to reduce the trigger rate and hence to reduce the trigger Eₑₜ threshold, ensuring better efficiency for the analyses.

Similarly, requiring L1 e/γ candidates to be loosely isolated allows to reduce the trigger rate and hence to reduce the Double e/γ trigger Eₑₜ threshold(s).

The efficiency of the Level-1 e/γ algorithm is stable versus PU.

The CMS Level-1 e/γ trigger has delivered high performance during Run-2.

IIts performance measured in the 2018 dataset, corresponding to an integrated luminosity of 58.8 fb⁻¹, has been shown.

Intense work ongoing for further improvements on efficiency, resolution and monitoring for Run III

Outlook

References:

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