Performance of the CMS Level-1 Trigger during Run 2

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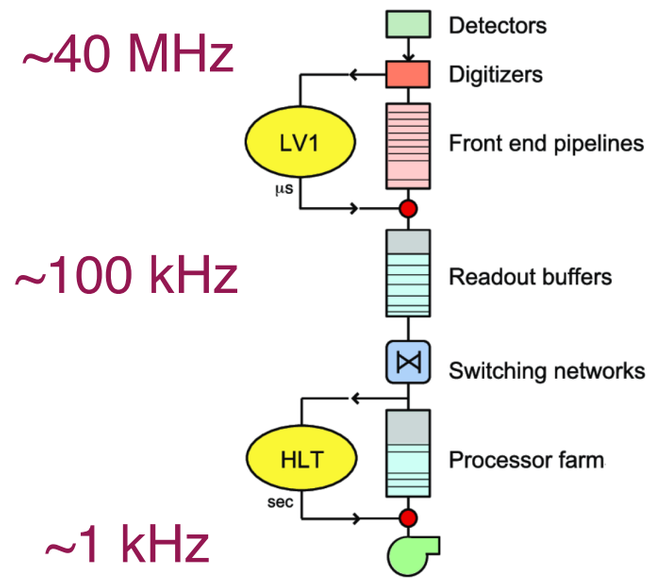
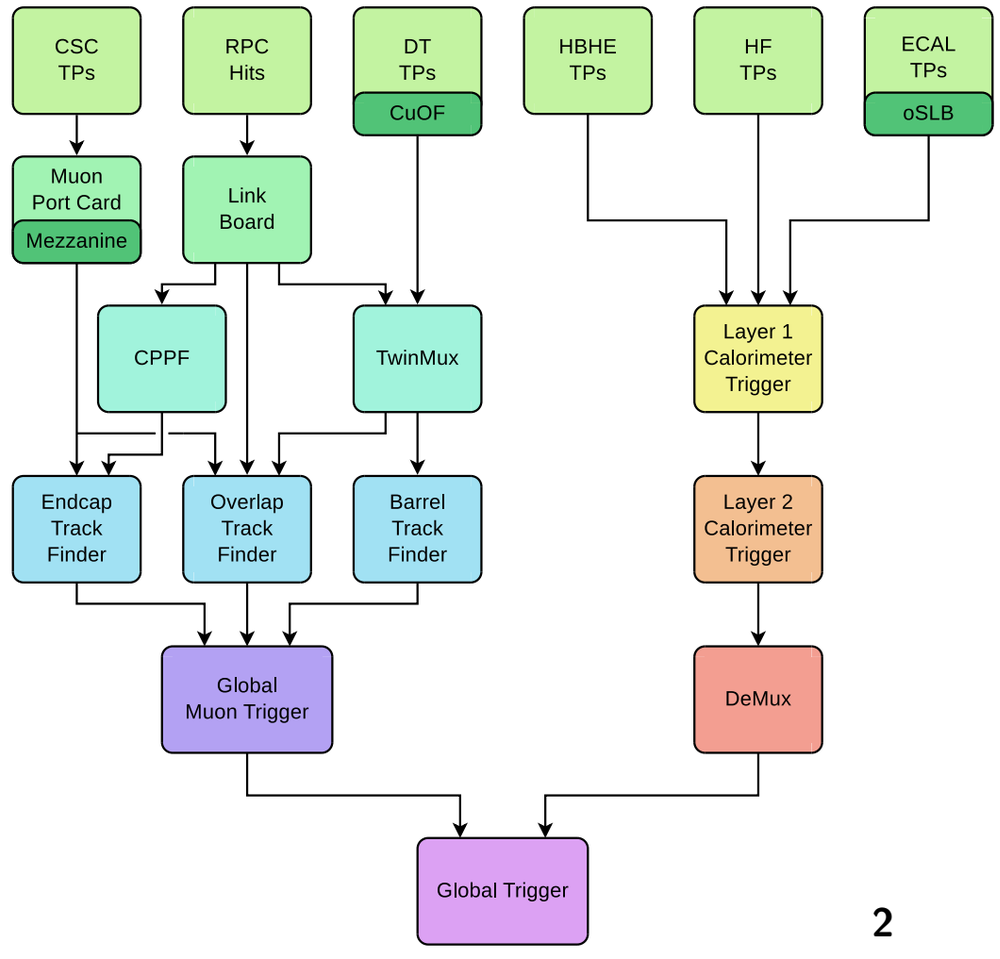
ICEHP 2020, Prague (Virtual Conference)
31 Jul 2020

The CMS Level-1 trigger architecture

- The CMS experiment implements a sophisticated two-level trigger system which reduces event rate by a factor of 10^5
  - **Level-1 (L1) trigger** : The L1 trigger operates at hardware level and uses the information of the calorimeters and the muon chambers. The L1 trigger latency is 3.8 μs
  - High-Level-Trigger (HLT) : The HLT runs on a massive computer software farm with more sophisticated algorithms



- Diagram of the Level-1 trigger system during Run 2
  - The calorimeter trigger consists of 2 layers:
    Layer-1 receives, calibrates, and sorts the local energy deposits ("trigger primitives" = TP)
    Layer-2 uses these calibrated TPs to reconstruct and calibrate the physics objects (e.g. electrons, jets, ..)
  - The muon trigger includes 3 muon track finders (MTF) and send them to global muon trigger (μGMT) for final muon selection
  - The global trigger (μGT) combines information from both the μGMT and the calorimeter trigger



Level-1 calorimeter trigger

e/γ trigger

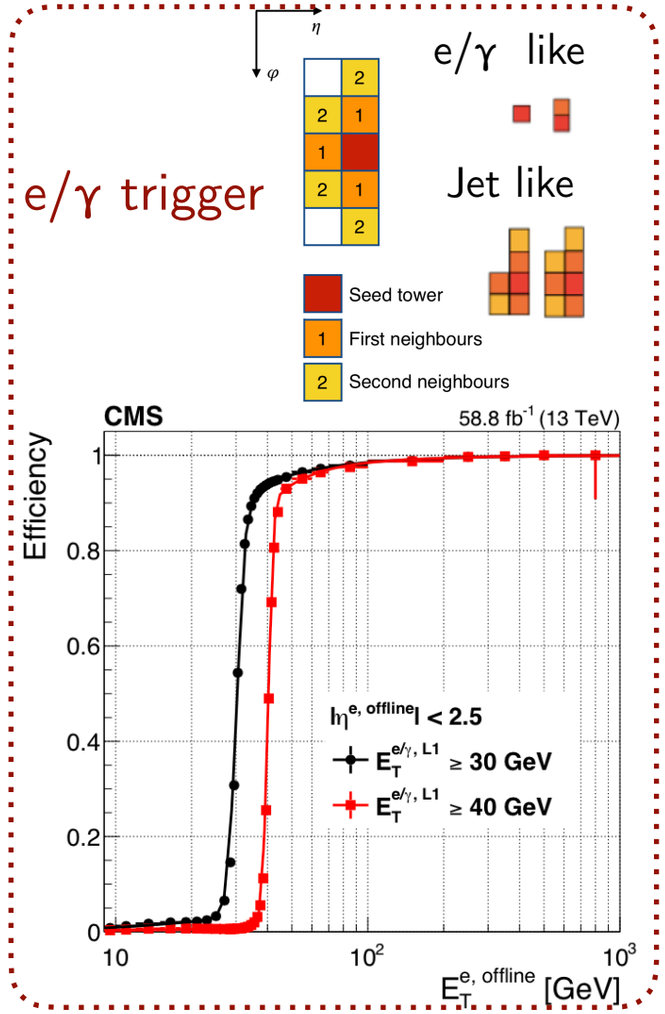
- Dynamic clustering around seed (local maximum), extension of the cluster in φ direction to recover bremsstrahlung
- Calibration depends on E_T, η and shape of cluster
- Efficiency curve vs reconstructed electron E_T. High plateau efficiency and sharp turn-on reflects good energy resolution

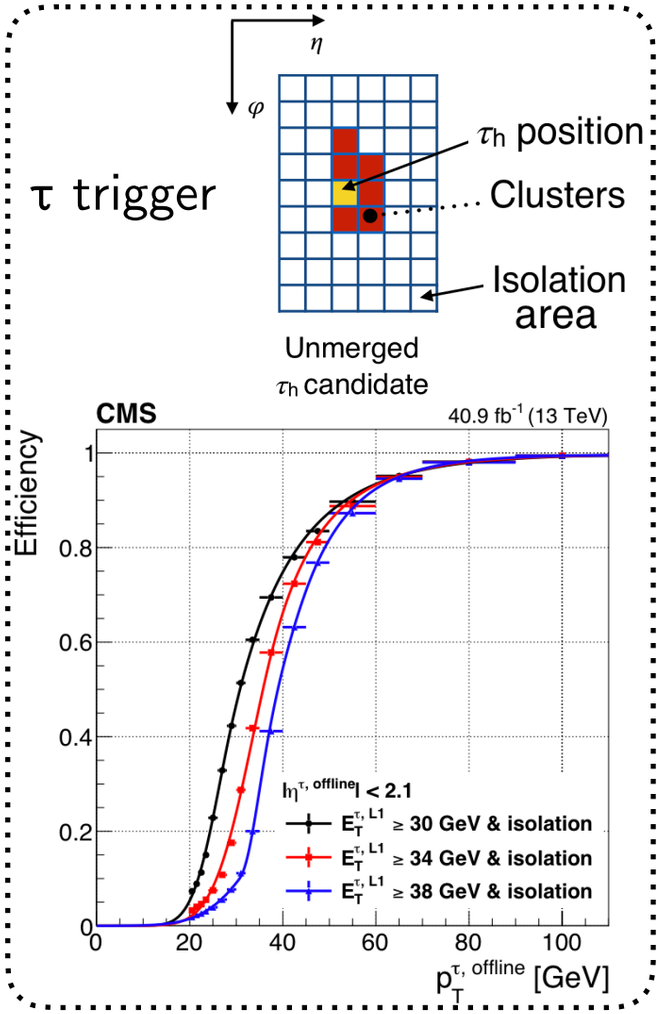
τ trigger

- e/γ dynamic clustering as baseline
- Considered as isolated if the E_T in isolation area is smaller than a chosen value
- Excellent performance in L1 isolated τ trigger efficiency for the typical L1 thresholds

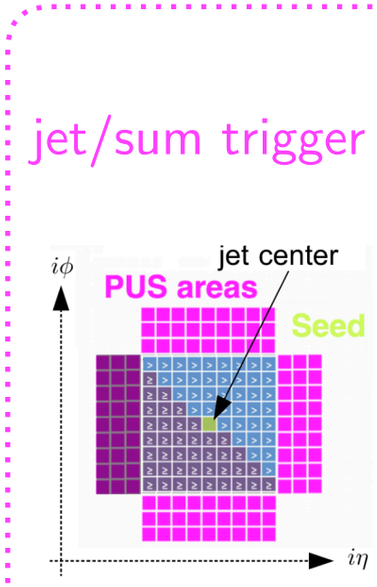
Jet/Energy sum trigger

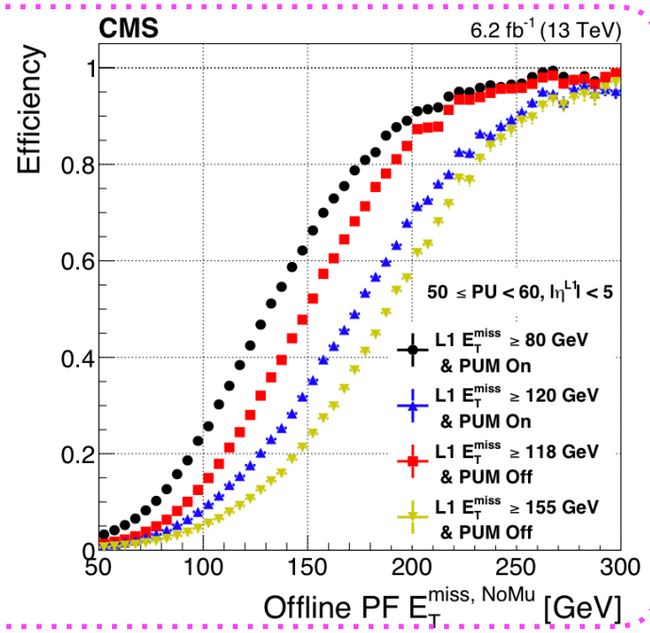
- 9x9 trigger tower sliding window centered on jet seed
- Local pileup subtraction (PUS) technique called 'Chunky donut' is applied
- MET (E_T^{miss}) is the vector sum of E_T of trigger towers in the event
- Improvement in L1 MET trigger efficiency using pileup mitigation algorithm (PUM)



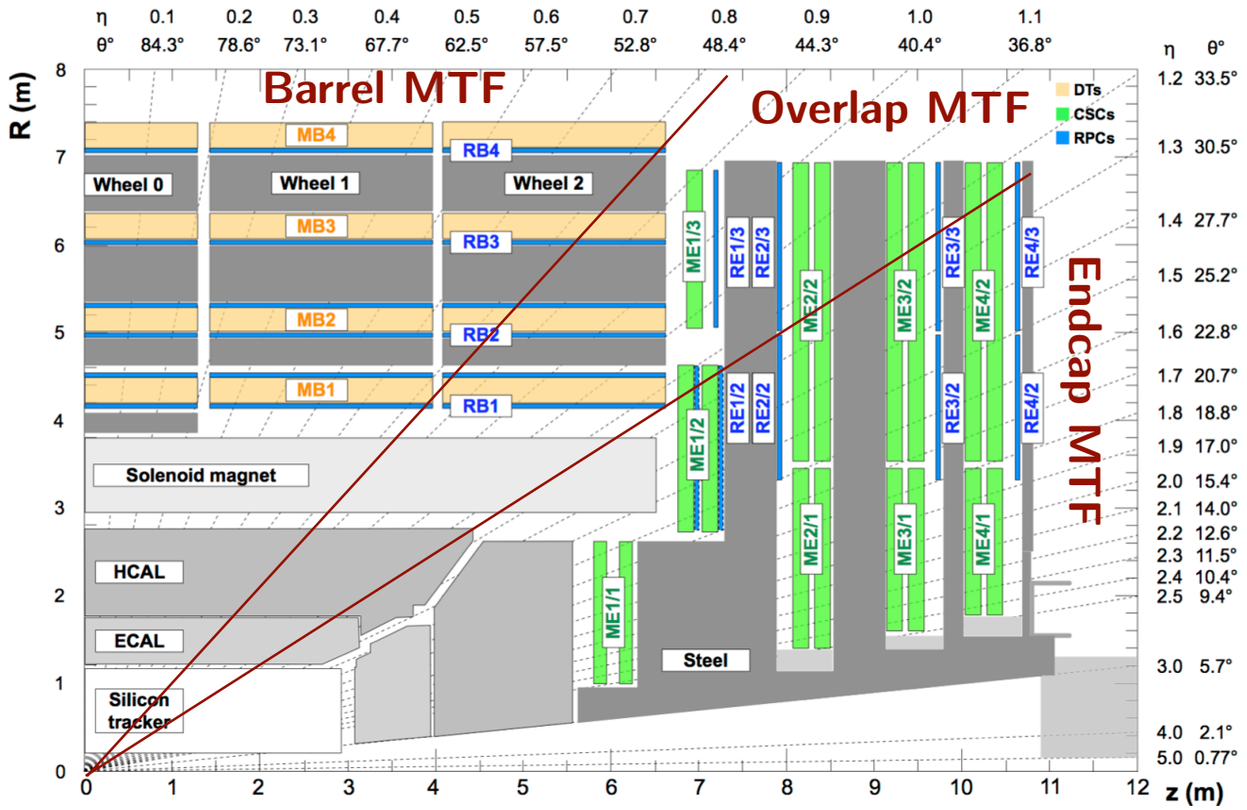


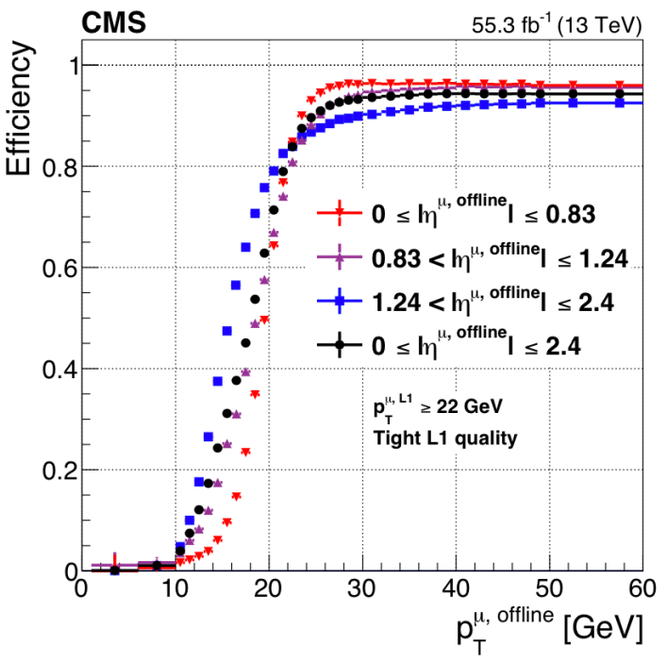
Reference: CMS TRG-17-001



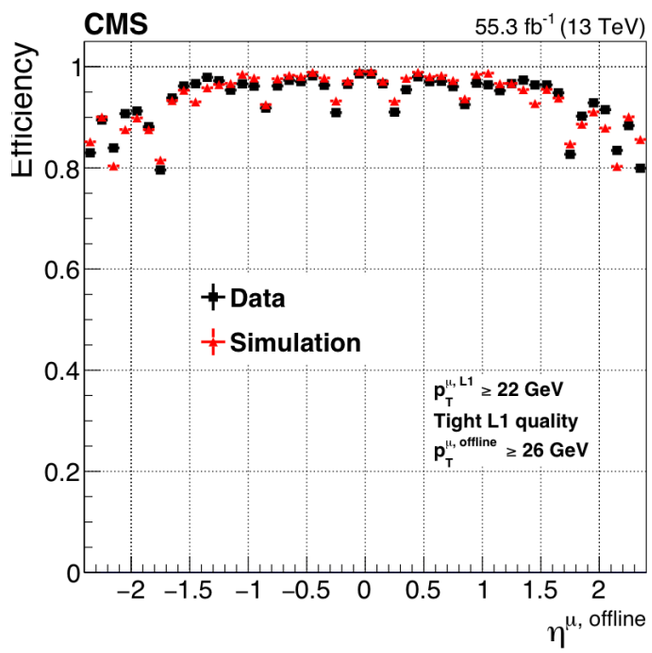


Level-1 muon trigger





- Efficiency for each η region: barrel, overlap, endcap, total



- Efficiency for data and simulation vs η

- The CMS muon system consists of 3 types of muon detectors: Drift Tube (DT) chambers, Resistive Plate Chambers (RPC) and Cathode Strip Chambers (CSC)
- L1 muon trigger combines information from 3 distinct pseudorapidity regions, improving resolution and redundancy
  - BMTF: road search extrapolation track finder is used
  - OMTF & EMTF: pattern-based track finder is used. p_T assignment with look-up table is based on an a MVA for EMTF
- MTFs are sent to global muon trigger where duplicate candidates are removed
- Efficiency for typical L1 single muon trigger threshold (> 22GeV). High efficiency on the plateau and sharp turn-on curve especially for barrel region due to good momentum resolution

Reference: CMS TRG-17-001