**Performance of Muon-Based Triggers at the CMS High Level Trigger**

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The CMS experiment is designed with a two-level trigger system: the Level 1 (L1) Trigger, implemented on custom-designed electronics, and the High Level Trigger (HLT), a streamlined version of the CMS reconstruction running on a computer farm.

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### Overview of CMS Muon Trigger

**L1**: Hardware based, uses muon detectors only

**HLT**: Software based, uses muon, calorimeter, and tracker detectors

- **L1** builds muon tracks in system
  - 1. Build seed from patterns of DT and CSC segments
  - 2. Start reconstruction of track from seed, using measurements from all muon chambers
  - 3. Filter on L2 muon to reduce rate
  - 4. L3 builds full muon tracks from L2 tracks and tracker information

Exploits excellent momentum and vertexing resolution of tracker to improve momentum resolution at high pT.

- **Steps**:
  1. Build seed for trigger reconstruction, starting from L1 info
  2. Propagate track
  3. Match tracker track and L2 muon
  4. Try different seeding algorithms in the L3 cascade algorithm (see below)

Filter on L3 muon to reduce rate

Isolation: Can be measured by searching for tracks and calorimeter deposits in a cone around the L3 muon

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### Improvements for Run II: L3 Muon Triggers

**Motivation**: Recover efficiency loss for L3 muon triggers, at high pileup

- **Done by implementing changes in the L3 cascade algorithm**

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### Efficiency ofHLT_Mu40 in 2012

Compared with the 2 resonance tag and probe method, using $Z \rightarrow \mu\mu$ MC

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### Improvements for Run II: Muon Triggers Isolation

#### Single Muon Isolation

- **Motivation**: Recover efficiency loss at high pileup (PU) and reduce CPU time
- **Done by optimizing PU mitigation and tracking configurations**
- **Isolation improvements due to**:
  1. Tracking algorithm improvements
  2. PU subtraction algorithm improvements
  3. Efficiency computed with tag and probe method, using data from the end of 2012

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### Double Muon Isolation

- **Motivation**: Reduce rate of Double Muon trigger
- **Done by introducing loose tracker isolation**
- **Isolation including improvements due to**:
  1. Tracking algorithm improvements
  2. Rates and efficiencies are computed relative to a non-isolated muon HLT trigger, using data from the end of 2012

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### Efficiency for the L3 step

Before and after cascade algorithm improvements

- **Before**: using single MC
- **After**: using MC with pileup

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### References

1. CMS DP-2013/009 [Tight Muon ID definition, Loose Muon Isolation corresponds to the <0.2 isolation working point]
2. EPJC 73 (2013) 2677 [“Tight” muon definition used to study the isolated double muon triggers]
3. PRD 89 (2014) 102007 [“Loose” muon definition used to study the isolated double muon triggers]