Muons are measured in the Muon System and the Inner Tracker, providing two loosely correlated measurements. The Muon system consists of three gaseous detectors: Cathode Strip Chambers (CSCs) in the endcaps ($|\eta| < 2.4$), and Resistive Plate Chambers (RPCs) ($|\eta| < 1.6$ for triggering and $|\eta| < 1.8$ for reconstruction). The inner tracker is located at the innermost part of the CMS, and it covers a range of $|\eta| < 2.5$. It consists of pixel detectors close to the interaction vertex and outer layers of silicon strips.

### L3 Improvements for Run-II

The HLT trigger level (see “Muon trigger efficiency section”) can be divided into two software based reconstruction phases:

- **L2 Muon**: Track reconstructed using muon subdetectors.
- **L3 Muon**: Full track reconstructed using the inner silicon tracker and L2 muon.

The L3 reconstruction uses an algorithm called Cascade in which three algorithms are run in sequence, two of which start the tracking reconstruction from the outside of the tracker inwards and one which starts inside outwards. If a full track is successfully created from the L2 muon then the sequence stops and subsequent algorithms are not run. Quality filters on the tracker tracks used as part of the reconstruction were introduced for Run-II. The choice of the estimator in assigning hits to tracker tracks was also changed from using a $n \phi$ window to a $\Delta \phi$ measurement. The changes provide higher efficiencies with respect to the higher amounts of pileup expected in Run-II.

### Muon reconstruction improvements

The reconstruction efficiency has improved with respect to Run-I thanks to two additional muon-specific tracking iterations. An outside-in iteration, starting from the muon system, recovers the missing tracker tracks. An inside-out iteration reconstructs the muon tagged tracks with lower requirements to improve the hit collection efficiency.

### Muon reconstruction and identification efficiency (Tag and Probe method)

Tag and Probe is a data driven technique to perform efficiency estimation. To build the Z resonance a muon pair is reconstructed, which consists of:

- **Tag**: muon triggering the event passing a tight selection
- **Probe**: muon or track used for the efficiency measurement

The background is removed by performing a fit to the dimuon invariant mass distribution simultaneously on the probes passing and failing the selection under study.

### The dimuon invariant mass spectrum

The dimuon invariant mass spectrum consists of:
- **Level-1**: hardware-based, use information of the muon system exclusively.
- **HLT**: software based, combines informations from muon system, calorimeter and inner tracker.

Computation of isolation for single muon HLT triggers was updated with respect to 2012 configuration. Isolation computation strategy was updated, from single isolation cut combining tracker and calorimeter information, to sequential isolation cuts, tuned independently for tracker and calorimeter components. This results in a better rate-rejection vs efficiency trade-off.

### Muon isolation performance

Isolation: How the muon is isolated with respect to other particles next to its trajectory. Computed by summing all particles in a $\Delta R = (\Delta \eta)^2 + (\Delta \phi)^2$ cone around the muon.

### Muon trigger efficiency

The Muon triggers consists of the Level-1 and HLT trigger levels.

- **Level-1**: hardware-based, use information of the muon system exclusively.
- **HLT**: software based, combines informations from muon system, calorimeter and inner tracker.

References: