Performance of the CMS L1 muon trigger standalone reconstruction in the overlap region for the Phase II HL-LHC upgrade

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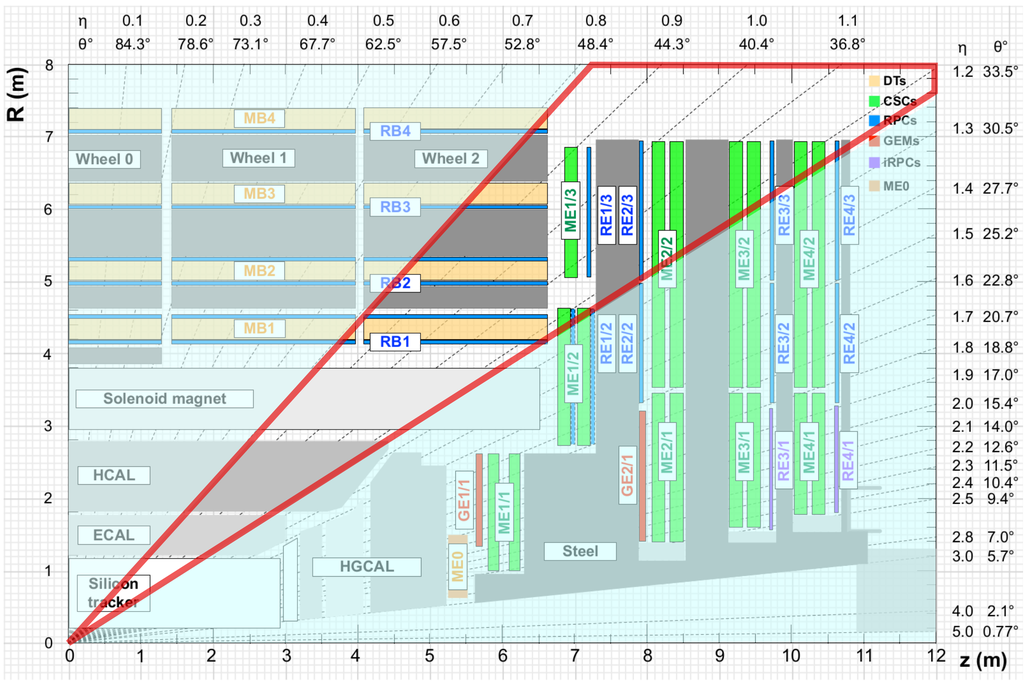
Challenges of the overlap region



"Overlap region": the region **between the barrel and endcap** muon systems at $0.8 < |\eta| < 1.2$. Contains part of the Drift Tubes (DT), Cathode Strip Chambers (CSC) and Resistive Plate Chambers (RPC) subsystems.

Muon reconstruction on the overlap relies on the precise **correlation of different locally reconstructed signals** (clusters, segments) from several subdetectors of different nature. The redundancy of the detectors is a key feature to obtain a good momentum resolution.

High radiation environment towards the endcap region introduces detector degradation effects. In consequence, **ageing effects** in the DT subsytems are expected to have significant impact at the external wheels. A succesfull HL-LHC algorithm needs to be resilient against such effects.

L1 trigger standalone reconstruction in the overlap

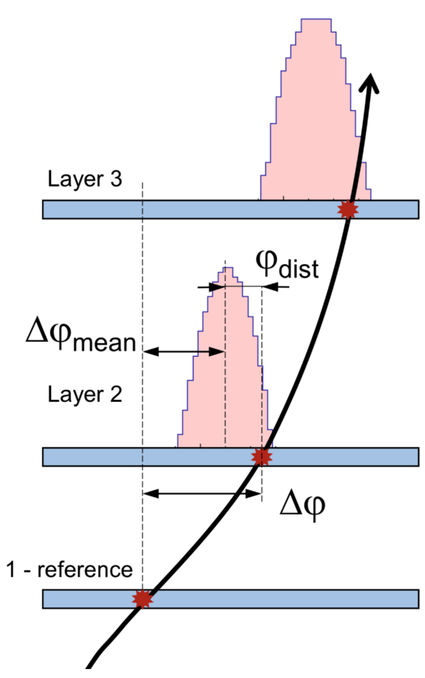
A dedicated algorithm has been developed for the standalone -using only information from the muon chambers- reconstruction in the overlap region.

- Detector signals are uniformized, each of them providing a **hit**in a given angular *position* ϕ. All positions are compared with a **reference** one, usually in one of the inner subdetectors, to measure **relative angles**: $\Delta\phi$.

- The resulting sets of $\Delta\phi$ are compared with a precomputed set of **patterns** corresponding to multiple values of muon p_T.

- The compatibility with each pattern is determined with a **Naïve Bayes classifier**: product of the likelihoods to obtain each measurement given the reference one.

- Most compatible pattern provides the **p_T estimation**.

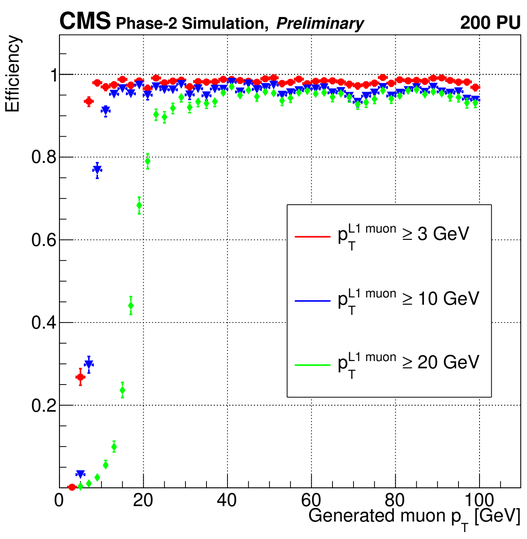


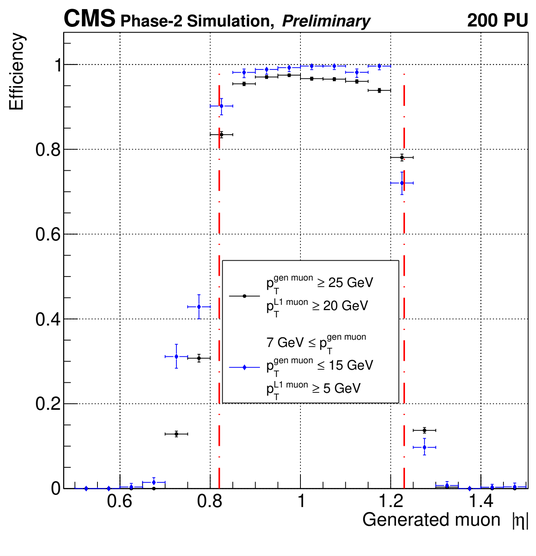
Overlap algorithm efficiency performance

The overlap algorithm performance is studied in HL-LHC like scenarios of high (200) mean pile up interactions.

High (**>95%**) **plateau efficiency** for standalone reconstruction of muons generated inside the overlap region.

Turn on widths of ~5 GeV for typical L1 seed p_T cuts with efficiency losses at the plateau kept at the 2-3% level.



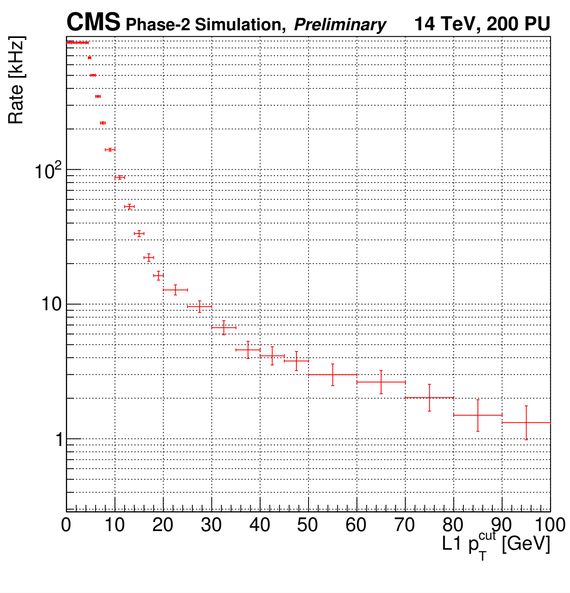


A *natural* reach in η appears due to the set of patterns used in the algorithm (no patterns for the innermost DT wheels).

The efficiency on the sensitive region is estable in η overall.

A **small dependance on muon bending** is seen: there is slightly more sensitivity towards the barrel for low p_T (high bending) and towards the endcap for high p_T (low bending) muons.

Trigger rate performance



The reduction of the L1 triggering rate is a fundamental need to decrease the load into further reconstruction steps of the CMS triggering system.

Patterns are generated with higher granularity at low p_T in order to have **increased resolution at the low momentum** (high rate) regime.

The rate for reconstructed p_T cuts typical of a single muon L1 trigger (>20 GeV) is at the 10 kHz level.

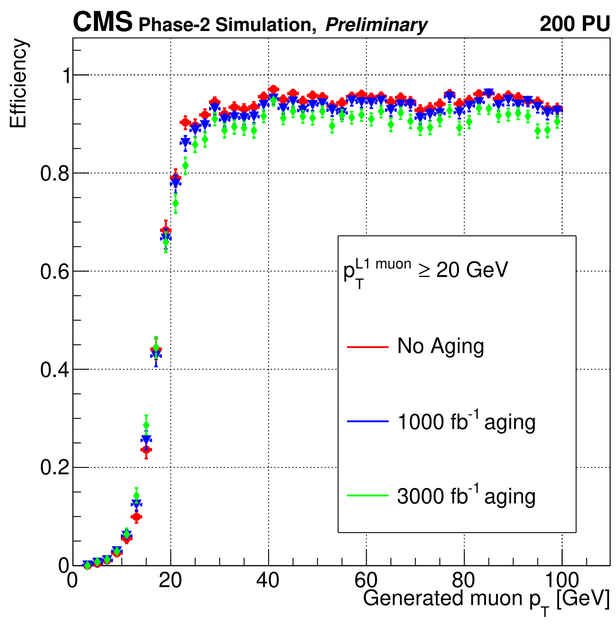
Algorithm performance under detector ageing conditions

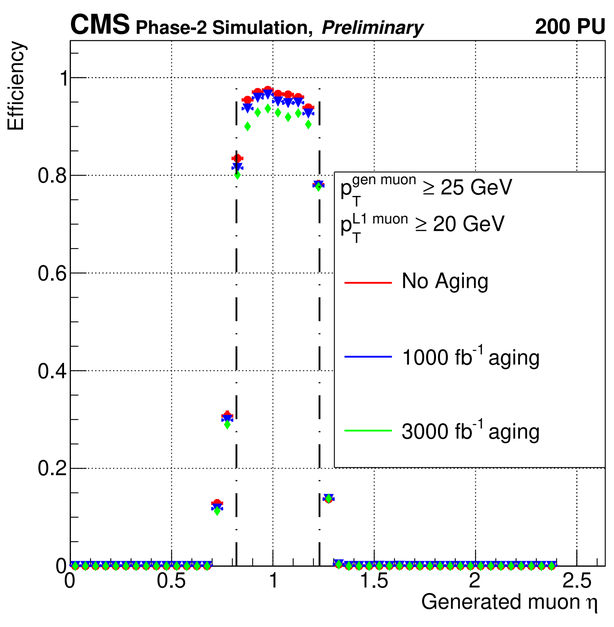
Ageing effects in the external DT wheels can reduce segment reconstruction efficiency to the 70% level (innermost stations).

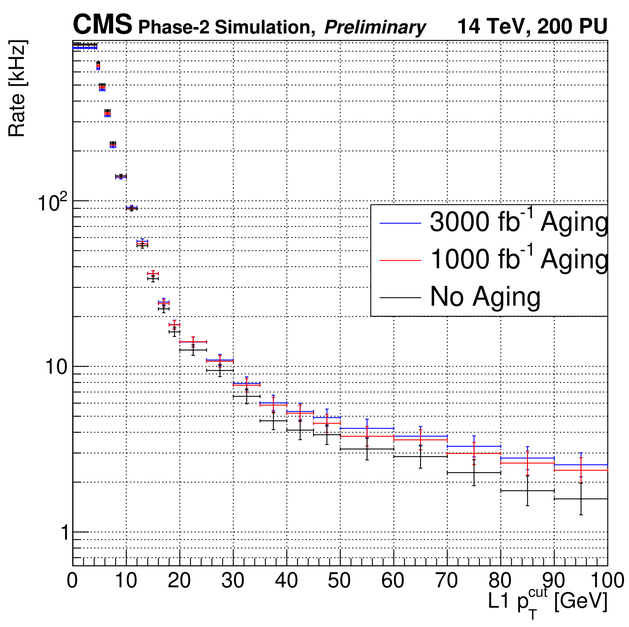
This effect is reproduced by filtering segments at simulation level based on hit loss probability for several scenarios of cumulated luminosity in the HL-LHC.

The global efficiency loss is reduced thanks to detector redundancy to a 2-3%, more accute at the low |η| values. Patterns seeded by other subdetectors able to recover efficiency.

Loss of p_T resolution under control, stable L1 rate level.







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