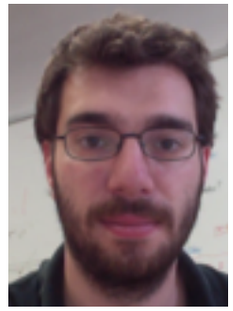
A proposed DT-seeded muon track trigger for the CMS experiment at the HL-LHC

Nicola Pozzobon, Sara Vanini, Pierluigi Zotto
Università degli Studi di Padova, INFN Padova
Ignazio Lazzizzera
Università di Trento, INFN TIFPA
on behalf of the CMS Collaboration



13th Pisa Meeting on Advanced Detectors

introduction

Any upgrade of the LHC experiments for the HL-LHC unprecedented luminosities must maintain the acceptance on electroweak processes that can lead to a detailed study of the properties of the candidate Higgs boson observed in 2012. The acceptance of the key lepton, photon and hadron triggers should be kept such that the overall physics acceptance, in particular for low-mass scale processes, can be the same as the one the experiments featured in 2012. In such a scenario, a new approach to early trigger implementation is needed, foreseeing the exploitation of high-granularity tracking sub-detectors, such as the CMS Silicon Tracker, in taking the early trigger decision.
This will be crucial in several tasks, including the confirmation of triggers in other subsystems, and the improvement of the on-line momentum measurement resolution, in order to keep the trigger rate sustainable.

1. build the DT seed from local trigger primitives

- a seed is a combination of local track segments providing global position (ϕ, θ) and local bending angle ϕ_B, built in the layers of Drift Tubes allowing a good measurement of the bending
- seeds can be high or low quality, according to the number of segments used in the single chamber where the seed is built

2. fiducial regions for matching

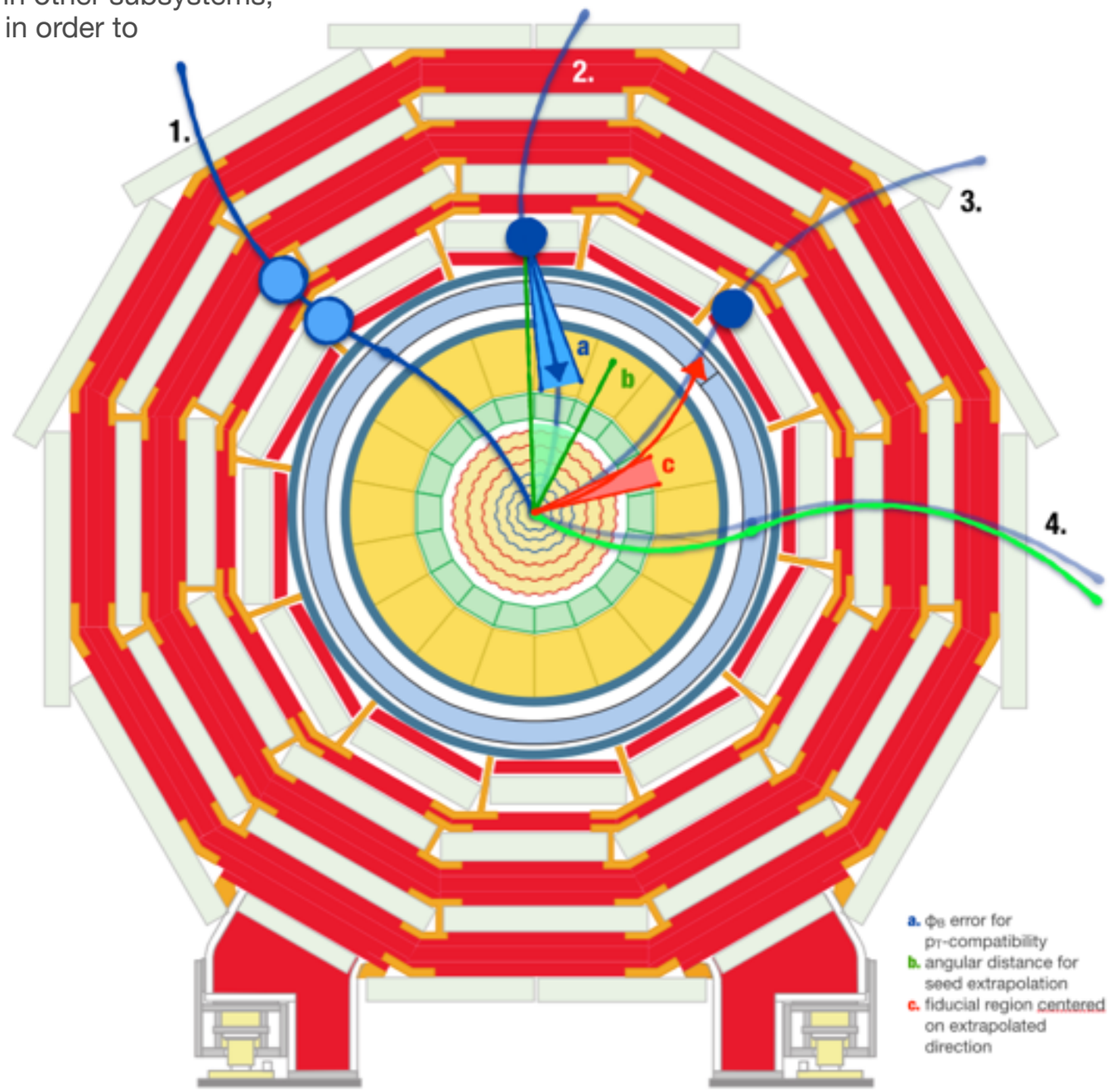
- given the seed position and direction, one can predict the direction at vertex of the track associated to the same muon in the silicon tracker, reconstructed at Level 1 as well
- the resolution of this extrapolation defines a fiducial region
- the extrapolation and matching algorithm is implemented with integer resolution and full parameterisation as a function of ϕ_B

3. seed extrapolation and matching

- seed is then associated to a L1 Track: ambiguous association are reduced requiring p_T-compatibility between seed and L1 Track

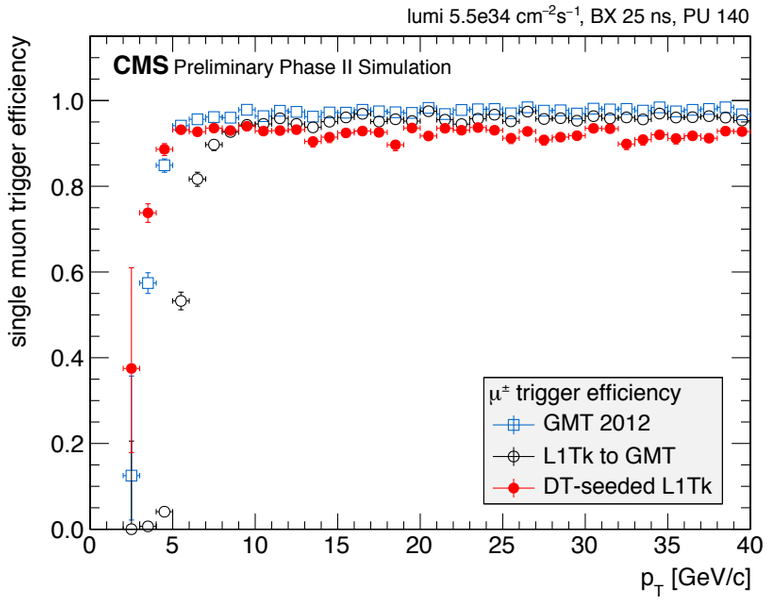
4. p_T assignment

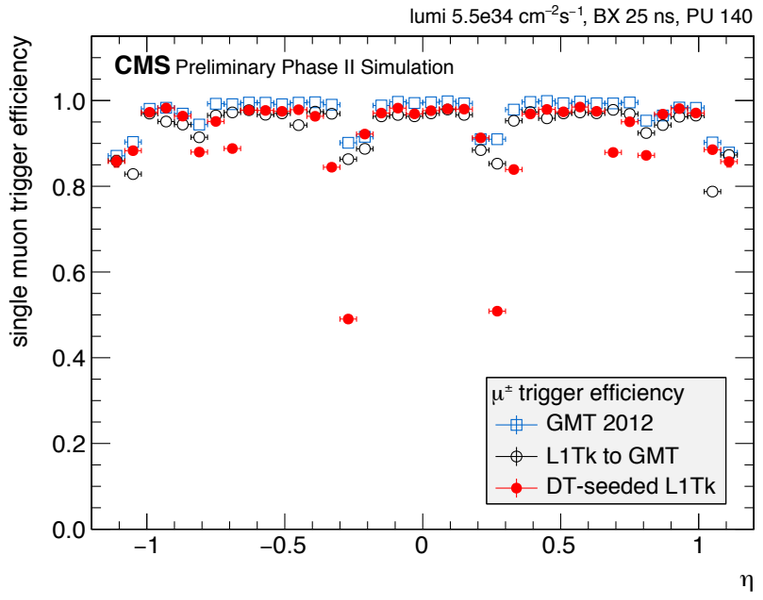
- the candidate muon p_T is assigned by the L1 Track associated to the seed



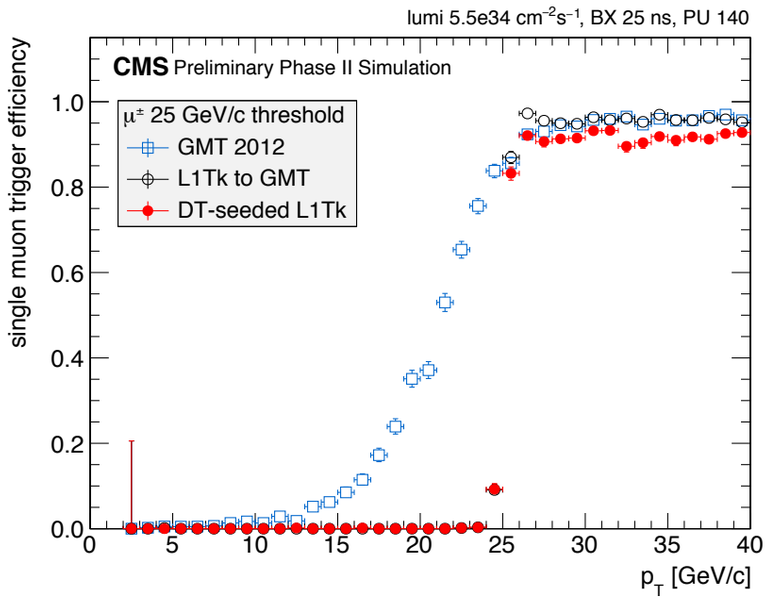
… further details in the poster!

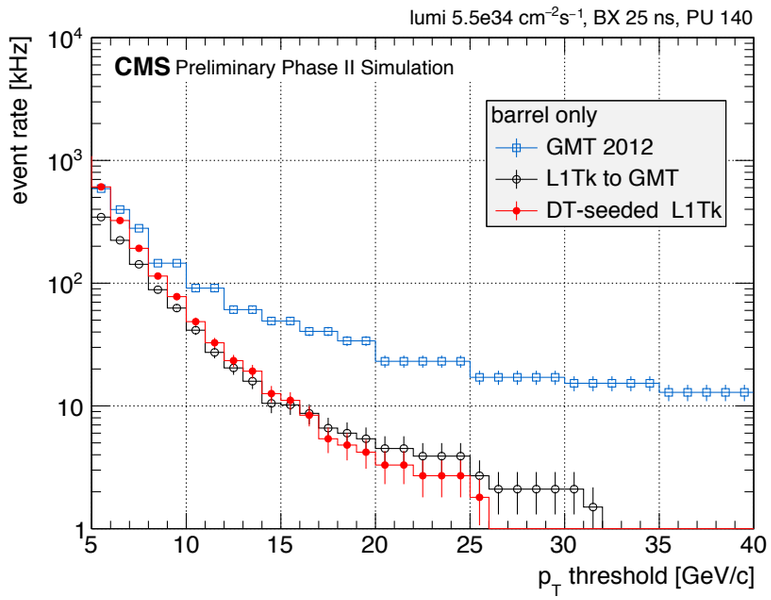
A proposed DT-seeded muon track trigger for the CMS experiment at the HL-LHC





Trigger efficiency for muons ionising the gas mixture in the DT chambers, as a function of the generated muon p_T (left) and η (right). Generated muons with flat p_T distribution in the 2—160 GeV/c range are superimposed to minimum-bias background at the average pile-up of 140 with 25 ns bunch separation [✱]. The performance of the DT-seeded algorithm (red) is compared to those of the Run 1 Global Muon Trigger (blue) and inside-out muon track trigger (black), only for candidates built from signals collected in the barrel [❖]. The track preselection of the inside-out muon track trigger can still be tuned up to improve the efficiency at low p_T. Gaps in η are due to the geometry of the DT system: they are more significant for the DT-seeded algorithm as it does not make use of all four stations and seeding does not combine different wheels.





Efficiency of a single muon trigger with p_T threshold at 25 GeV/c for muons ionising the gas mixture in the DT chambers, as a function of the generated muon p_T (left) [✱] and expected background rate as a function of the threshold for single muon trigger, at the average pile-up of 140, with 25 ns bunch separation and 0.75 fill factor (right) [❖].

expected performance

The proposed algorithm is compared to the Run 1 muon trigger and to a proposed inside-out matching of L1 Tracks to comprehensive muon triggers in the barrel region

- both the proposed triggers for the HL-LHC improve momentum assignment using the silicon tracker with full resolution, in particular if compared to the Run 1 configuration which relies on the standalone muon system

specific benefits of a DT-seeded muon track trigger

- small amount of extrapolations (no need of minimum p_T threshold, no need to extrapolate also non-muon tracks)
- shorter latency than L1 Tracks, so seed extrapolation can be parallel to L1 Track finding: matching is possible as soon as L1 Track are found

general remarks

- the CMS silicon tracker features a much better resolution, future muon triggers must then provide good spatial information to enhance the association with L1 Tracks
- the proposed DT-seeded muon track trigger features sharp threshold, reduced contamination from low-momentum muons
- expected rate reduction of a factor 5 to 10 at typical thresholds with respect to an upgrade-less scenario (Run 1 configuration)