



Performance monitoring of the GE1/1 triple-GEM detectors for the CMS Muon System

9th edition of LHCP, 7-12th June 2021

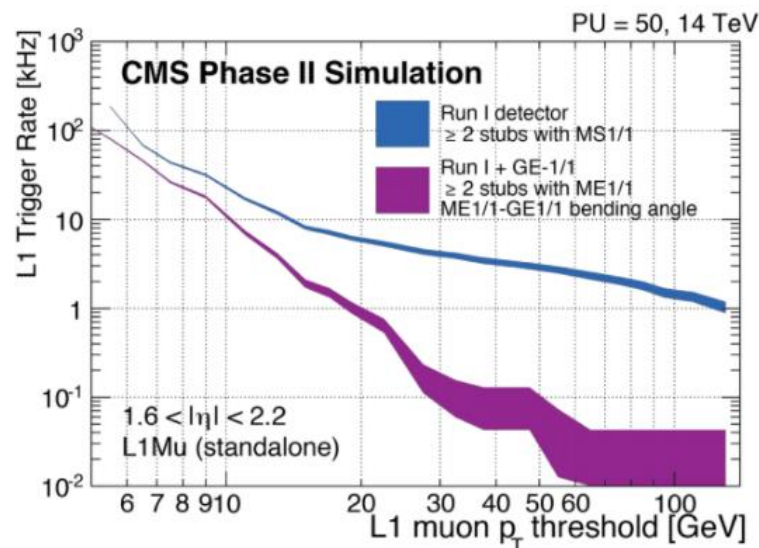
Gabriele Milella
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on behalf of the CMS collaboration

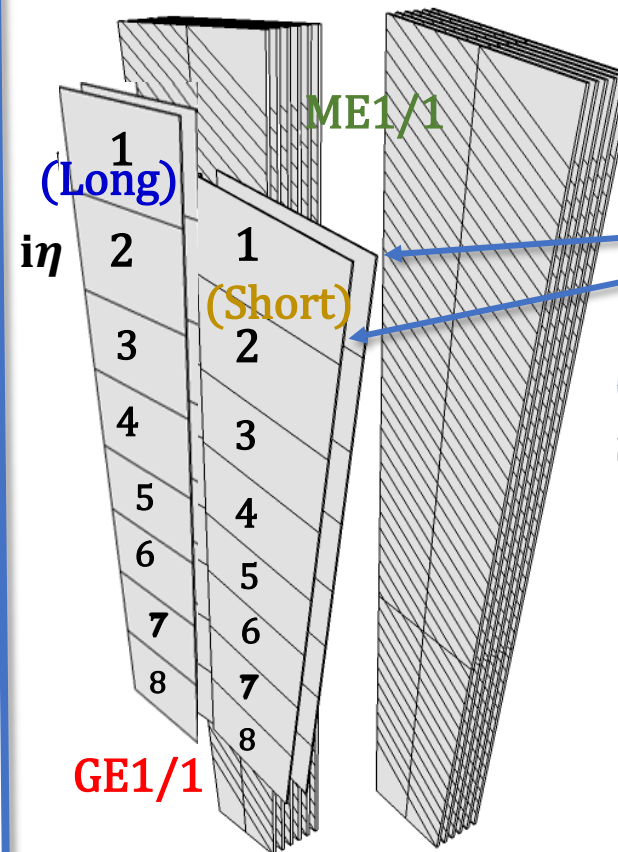
Motivations of GE1/1 project

GE1/1 detectors cope with the HL-LHC requirements (in terms of higher L1 trigger accept rate, L1 latency and DAQ transfer data) and allow:

- ❖ Two additional hits to muon reconstructed tracks
- ❖ Momentum measurements improvement (offline and L1 trigger)
- ❖ Reduction on the overall L1 trigger rate



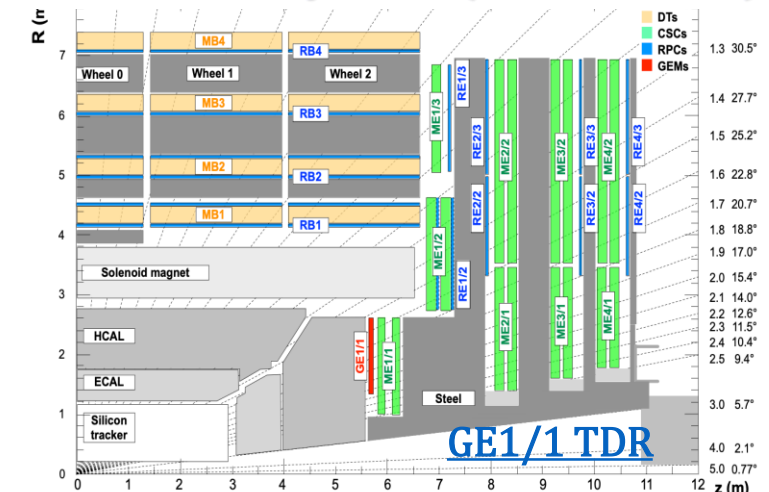
GE1/1 STATION:



Installation of the GE1/1 station:

- ❖ Based on **triple-GEM** technology
- ❖ **Coverage:** $1.55 < |\eta| < 2.2$, 10° in φ
- ❖ **144** GE1/1 chambers in total
- ❖ **36 superchambers** per endcap
- ❖ **Superchamber:** pair of triple-GEM chambers \rightarrow **2 GE1/1 layers**
- ❖ **Long/Short** \Rightarrow maximum η coverage
- ❖ Eight η sectors (“eta partitions”)

CMS Muon System (end of 2020)





GE1/1 Performance studies - MC $Z \rightarrow \mu\mu$ events

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Preliminary studies on GE1/1 performance with MC $Z \rightarrow \mu\mu$ events

Data sample characteristics:

- ❖ 13 TeV pp collisions
- ❖ Magnetic field ON
- ❖ No pile up events

GE1/1 parameters to investigate:

- ❖ Efficiency computation
- ❖ Residuals distribution



Total Events	Total muons	Propagated muons	Matched muons
484000	654644	116510	113950

Analysis workflow for the efficiency and residuals computation

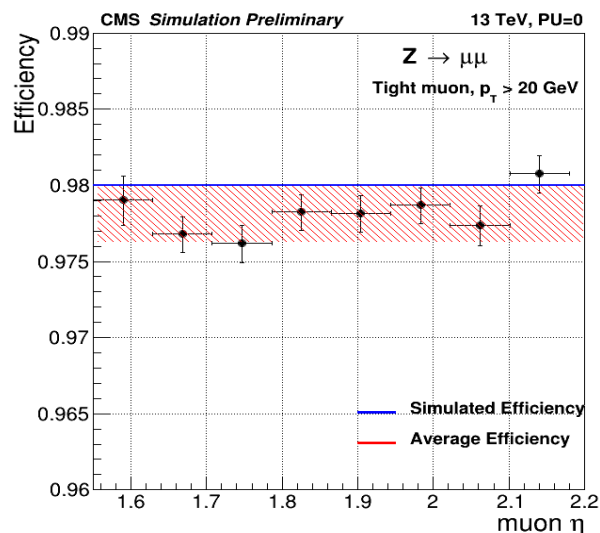
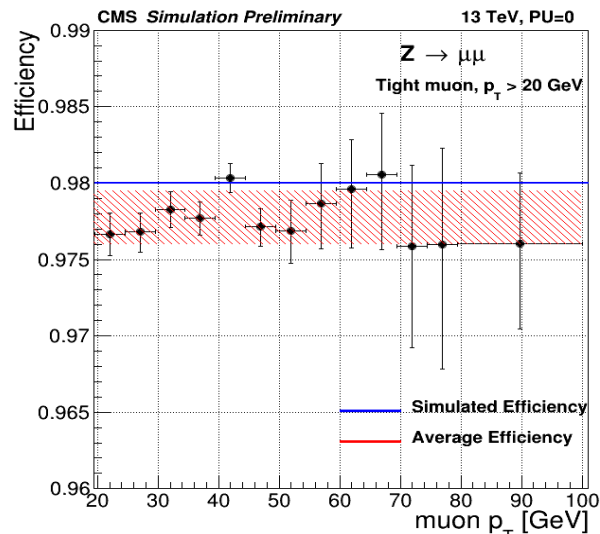
- ❖ Muon tracks reconstruction (muon system only):
 - ❖ Algorithm to find the best track (χ^2 -based fit) from hits of muon system subdetectors
- ❖ After quality muons selection, **propagation of the muon tracks from ME1/1 to GE1/1 surfaces** (only tracks with $p_T > 20$ GeV):
 - ❖ **Propagated hits** must be found in the GE1/1 fiducial region (removing 5 mrad in ϕ -coordinate, 1 cm in r-coordinate for each η edges)
- ❖ **Matching computation** between **propagated hits** and GE1/1 signals from the readout boards (**reconstructed hits** \rightarrow **recHit**) in $R\Delta\phi$:
 - ❖ R = R-coordinate of propagated hit
 - ❖ $\Delta\phi$ = difference in ϕ -coordinate between **recHit** and **propagated hit**
- ❖ If $R\Delta\phi$ is less than 1 cm:
 - ❖ **Efficiency:** $\frac{\text{\# of propagated hits that match with recHits}}{\text{\# of propagated hits}}$
 - ❖ **Residuals:** Distribution of $R\Delta\phi$ values



GE1/1 Performance studies - MC $Z \rightarrow \mu\mu$ events

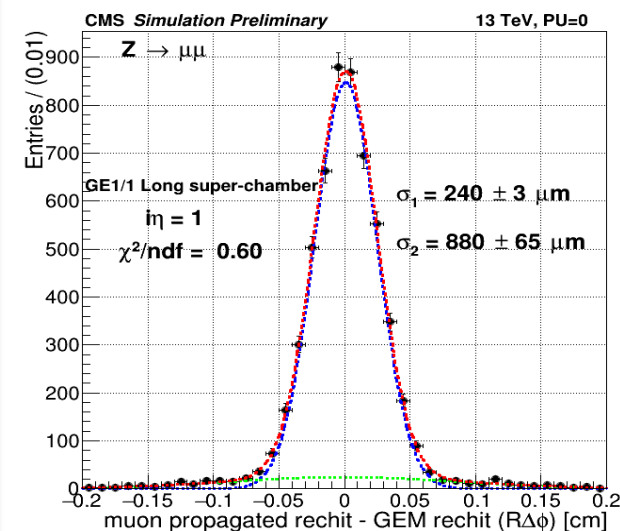
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Results with Monte Carlo $Z \rightarrow \mu\mu$ events



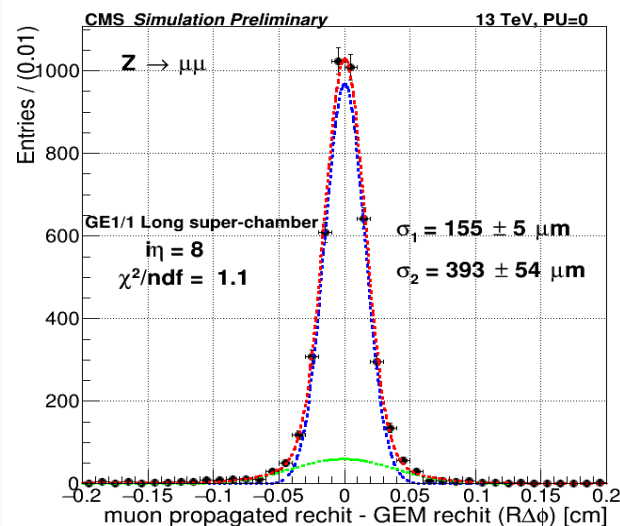
Efficiency computed as a function of muon p_T and η to be compatible with the simulated efficiency of GE1/1 chambers (98 %):

- ❖ **Simulated efficiency:** blue curve \rightarrow reflecting the results from test beams
- ❖ **Average efficiency:** red band $\rightarrow 3\sigma$ range of statistics uncertainty. Efficiency drop related to the simulated GE1/1 electronics noise and to large angle scattered tracks.



$R\Delta\phi$ residual distributions of the GE1/1 eta partition 1 and 8 of long super-chambers

The distribution is fitted with two Gaussian functions and an exponential function.



Red curve \rightarrow cumulative fit
Blue and green \rightarrow two Gaussian functions.

Preliminary studies on GE1/1 performance with cosmic rays muon data

Data collected during the **Middle-Week Global Run (MWGR)**:

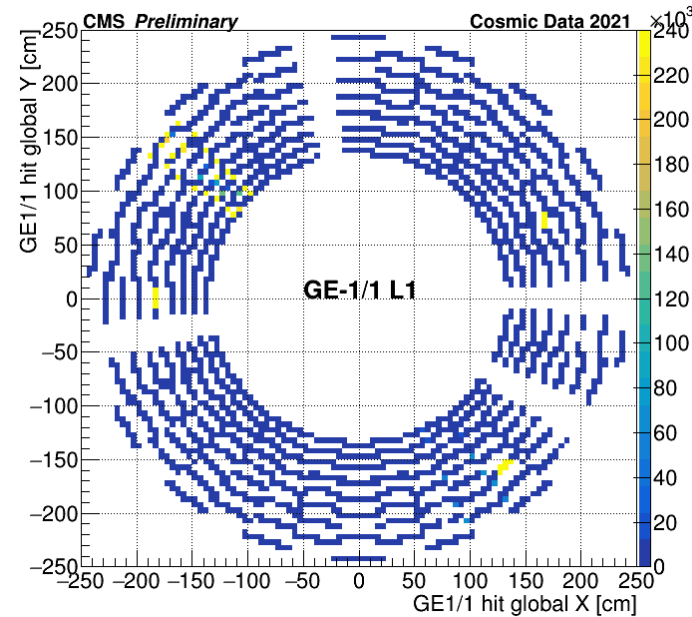
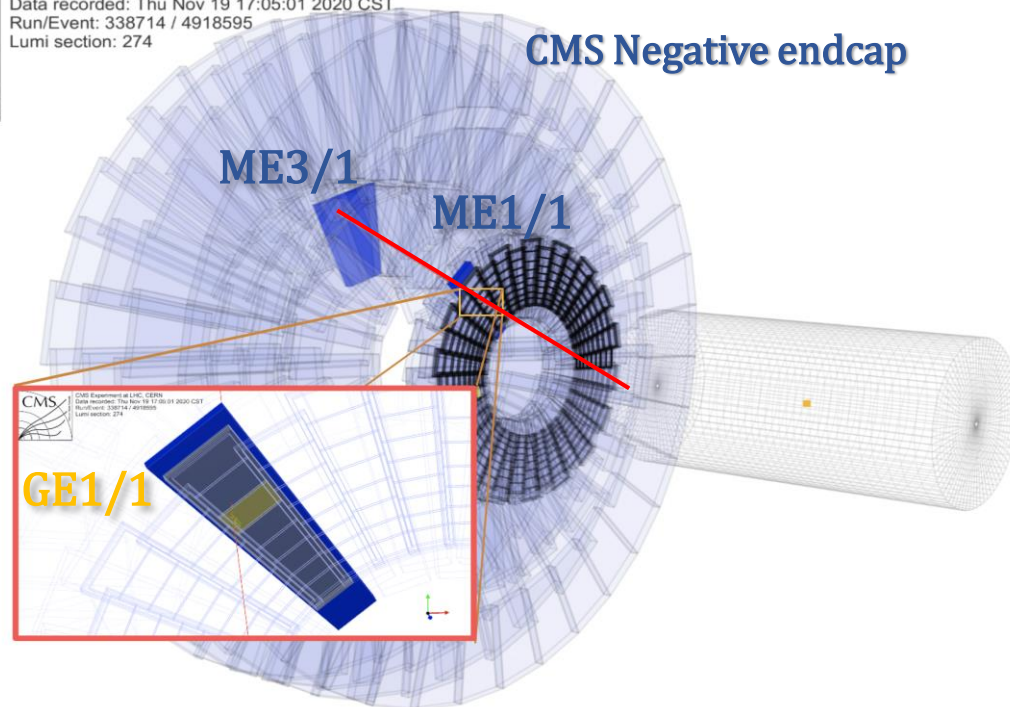
- ❖ Time window of 3-4 days
- ❖ Monitoring the CMS sub-systems with cosmic muons

Cosmic ray muon candidate– November 2020



CMS Experiment at LHC, CERN
Data recorded: Thu Nov 19 17:05:01 2020 CST
Run/Event: 338714 / 4918595
Lumi section: 274

CMS Negative endcap



GE1/1 Station – Layer 1, Negative endcap

Occupancy plots of reconstructed hits in the GE1/1 stations– April 2021

- ❖ 137 out of 144 chambers (or 3288 VFAT readout chips out of 3456) successfully readout
- ❖ Seven chambers not configured in the DAQ → not powered on
- ❖ Approximately 0.4% of the active 3288 chips noisy → exhibiting higher occupancies

Conclusions and Perspectives

- ❖ Validation of the workflow
- ❖ First result shown for GE1/1 performances
- ❖ Preparation for extended studies at:
 - ❖ CRUZET (July-August 2021)
 - ❖ CRAFT (September 2021)
 - ❖ Early Run3 collisions (2022)