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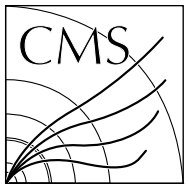
CMS DP -2024/125



The Compact Muon Solenoid Experiment

CMS Performance Note

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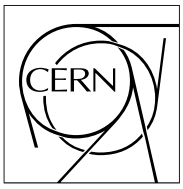


11 December 2024

GE1/1 Operation Plots

CMS Collaboration

Abstract

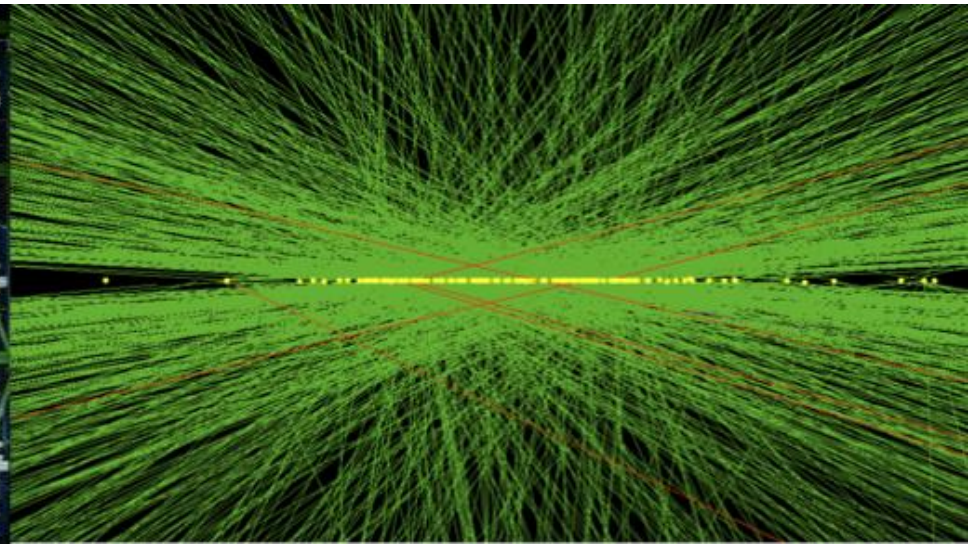
This document presents a study on the performance of the CMS GE1/1 chambers in daily operation. It shows efficiency results in 2024, also at very high granularity, the evolution of the short circuits in the detectors as well as details on the improvements applied to the trigger timing during the 2024 data taking period.

GE11 operation plots

https://cms-results.web.cern.ch/cms-results/public-results/detector-performance/

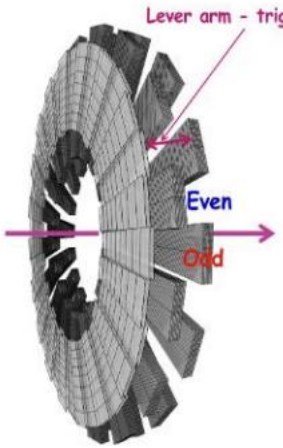
CMS Collaboration

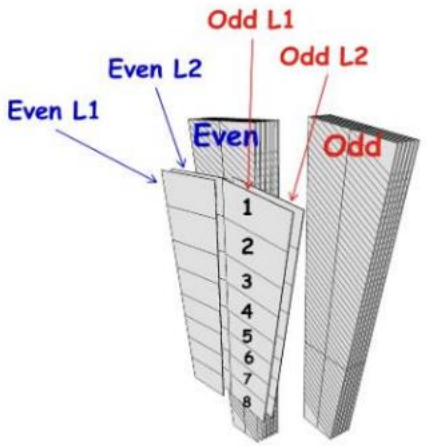
cms-dpg-conveners-gem@cern.ch



GE1/1 system

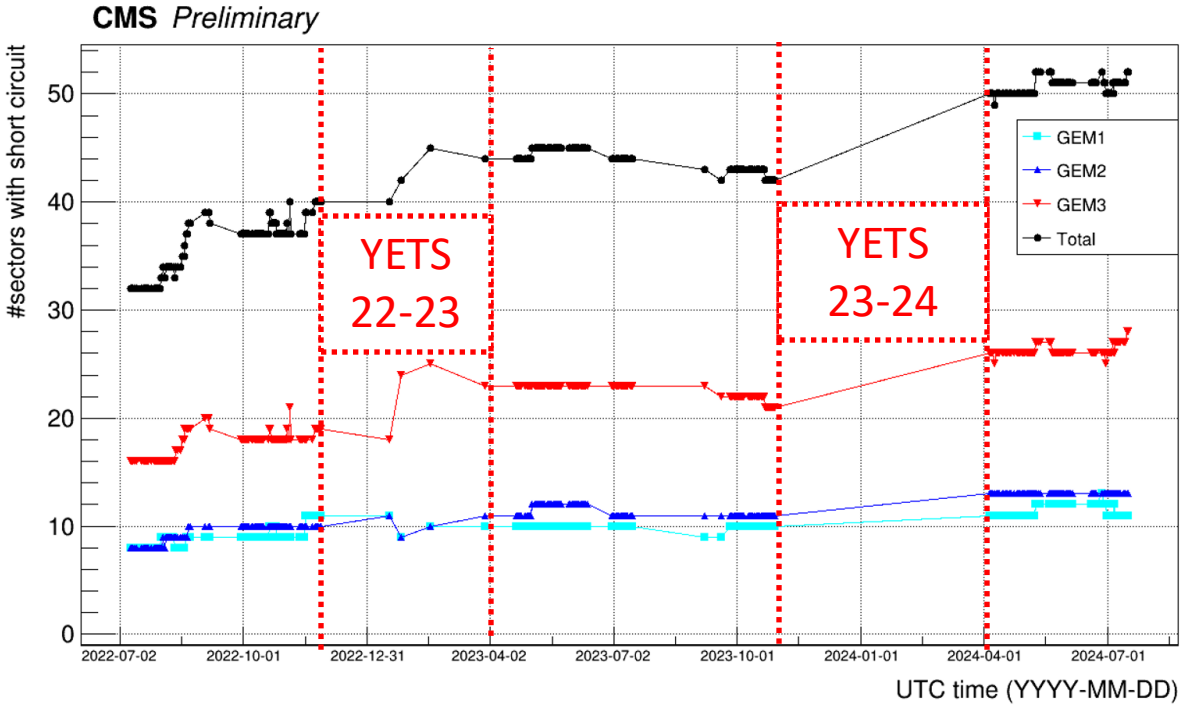
- Triple GEM (Gas Electron Multiplier) detectors
- Detectors organized in pairs of modules (two detectors define a GE1/1 Super-Chamber)
- The detectors in a pair are further distinguished according to the layer:
  - Layer 1 (the closest to the interaction point of beams)
  - Layer 2 (the module farther from the interaction point of beams)
- The GE1/1 station consists of 36 super-chambers
  - Short detectors (odd)
  - Long detectors (even)
  - Eta Coverage: $1.55 < \eta < 2.18$
- Each chamber is divided in 8 η-partitions





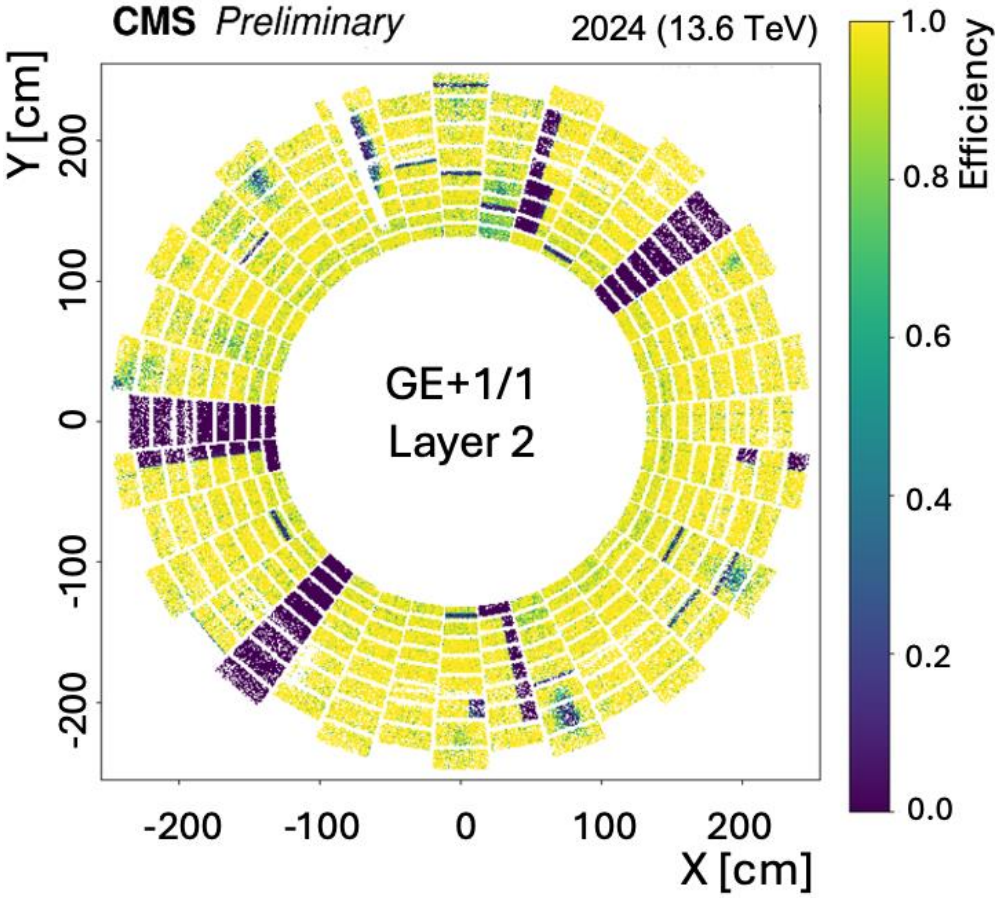
HV short evolution

- Evolution in the number of HV sectors affected by a short circuit in GE1/1 detectors during 2022-2024 data-taking period and detector commissioning activities (YETS). The 3 GEM foils are segmented in 40 (47) HV sectors for the 72 short (long) modules. Due to the regular maintenance activities avoiding regular runs, no points were added during YETS 23-24. The total number of HV sectors in the GEM foils for the whole GE1/1 station is 18792. More detailed information about HV short circuits are discussed in the performance notes DP2023_038 and DP2024_050.



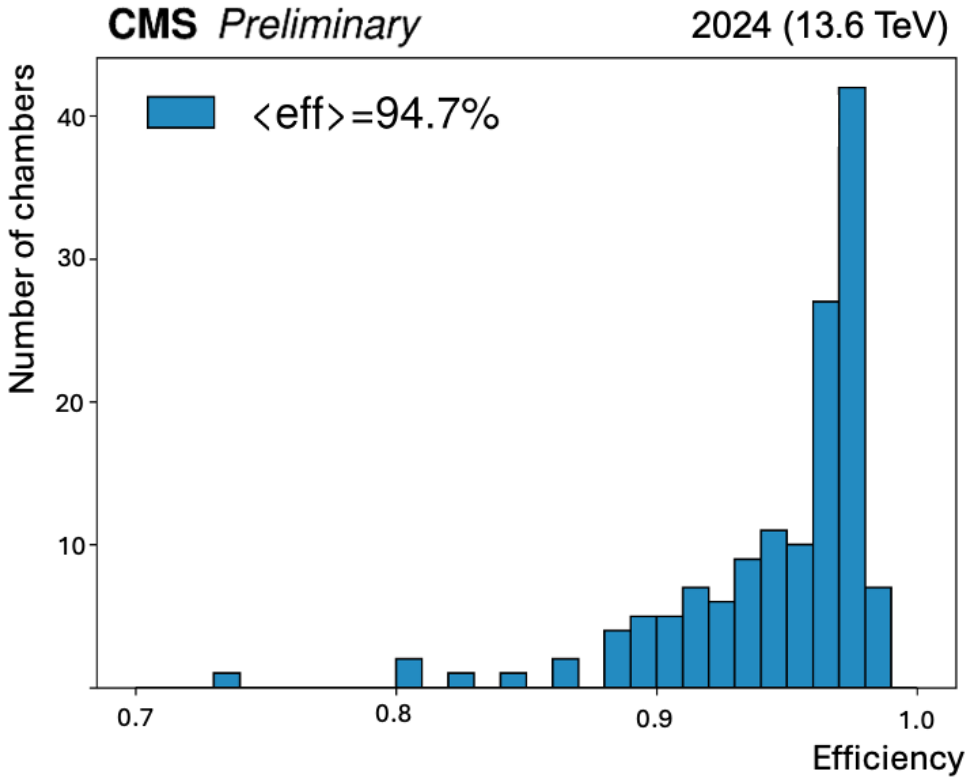
Efficiency wheel

- High resolution efficiency plot of the GE+1/1 layer 2 chambers in 2024. The overall efficiency is high, but the chambers with communication issues (fully purple) or HV shorts (purple lines) are visible. On some of the long chambers one can also see an efficiency drop along the wide side due to the bending of the printed circuit boards. Muons used in the calculation: muons reconstructed by muon detectors only with at least 15 hits (at least 1 in the CSC ME1/1), $\chi^2 < 5$, $p_T > 10$ GeV. Fiducial cuts on the detector : region of 1.5 cm from the border of the iη partition and 0.0075 rad from the lateral edges of the chamber. The position is given by the extrapolated position of the muons to the GE1/1 chambers.



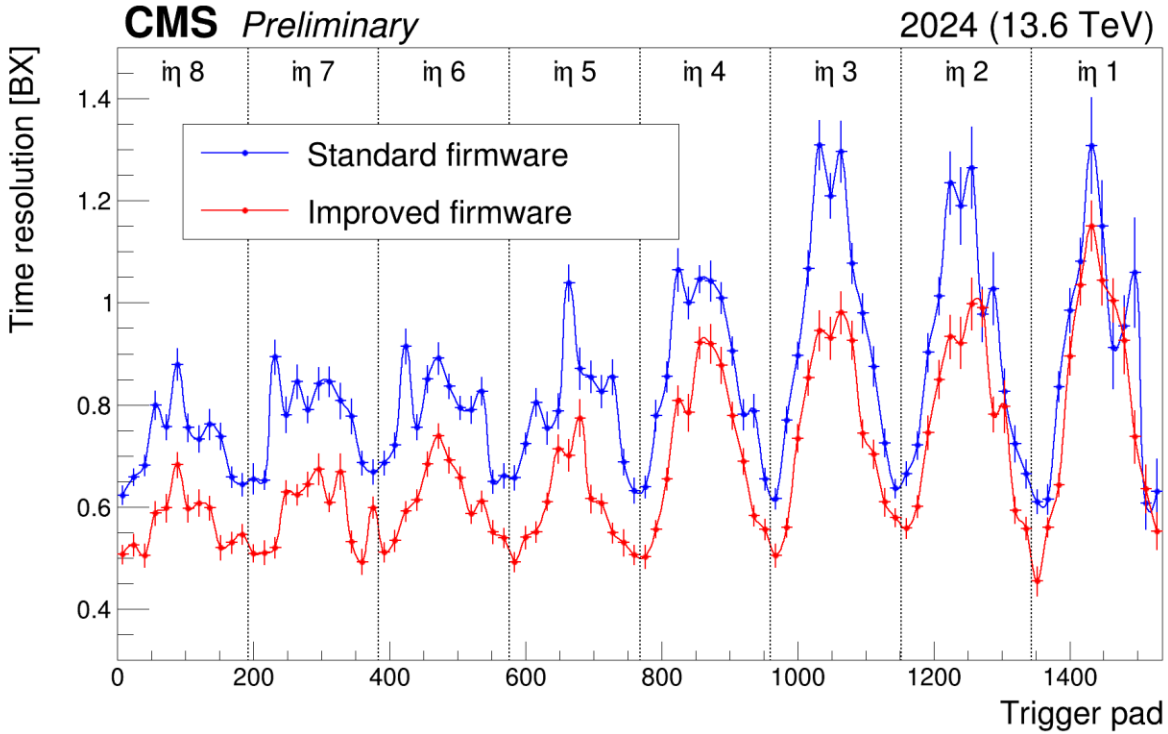
Efficiency in 2024

- Efficiency of 140 GE1/1 chambers with HV in 2024 after performing optimization studies. The efficiency is calculated for chambers properly communicating and operating at optimized HV settings (not the same for every detector). Muons used in the calculation: muons reconstructed by muon detectors only with at least 15 hits (at least 1 in CSC ME1/1), $\chi^2 < 5$, $p_T > 10$ GeV. A few chambers have much lower efficiency due to noise issues or too many HV short circuits. Fiducial cuts on the detector : region of 1.5 cm from the border of the η partition and 0.0075 rad from the lateral edges of the chamber. This is an updated version of the efficiency plot presented in CMS DP-2024/073 showing the situation at the end of 2024 after all the optimization.



Timing plots

- Distribution of the time resolution as a function of the trigger pad (pair of two readout strips) for a long GE1/1 chamber, with different firmware versions. Each entry represents the width of the time distribution of a group of 16 trigger pads (one quarter of a GE1/1 readout sector). The new on-chamber electronics (OptoHybrid) FPGA firmware has a feature that is called “x-talk suppression”. It consists in cancelling the hits coming from the inter-readout-strip x-talk, which are assigned an earlier Bunch Crossing (BX) with respect to the muon hit. The plot shows results from collision runs with both the new and standard firmware versions. For all runs, the selected GEM hits are the ones matching to a muon track with pT > 10 GeV. The time resolution is clearly improved for the new firmware. In the low iη area of the detector, the time resolution worsens significantly, due to the bending of the printed circuit boards in the GE1/1 chambers.



Timing plots

- Distribution of the average arrival time as a function of the trigger pad (pair of two readout strips) for a long GE1/1 chamber. Each entry represents the width of the time distribution of a group of 16 trigger pads (one quarter of a GE1/1 readout sector). For all runs, the selected GEM hits are the ones matching to a muon track with $p_T > 10$ GeV. The large spread in arrival time is partially mitigated by delaying earlier hits to later ones. Before applying any corrections, the arrival times span 4 BXs (of 25 ns). These corrections with BX granularity are applied to groups of 16 strips. Therefore, after applying the corrections, all arrival times end up in the same BX, but the signals are delayed in general and so the latency of the system increased.