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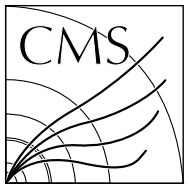

The Compact Muon Solenoid Experiment

CMS Performance Note

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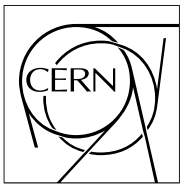

16 July 2024

CSC trigger primitive and segment efficiencies in 2024

CMS Collaboration

Abstract

This note contains Tag & Probe efficiency measurements for the CMS endcap muon CSCs from 2024 proton proton collisions data at 13.6 TeV. There is one plot for the tigger primitive efficiencies, and one for the reconstructed segment efficiencies.

CSC trigger primitive and segment efficiencies in 2024

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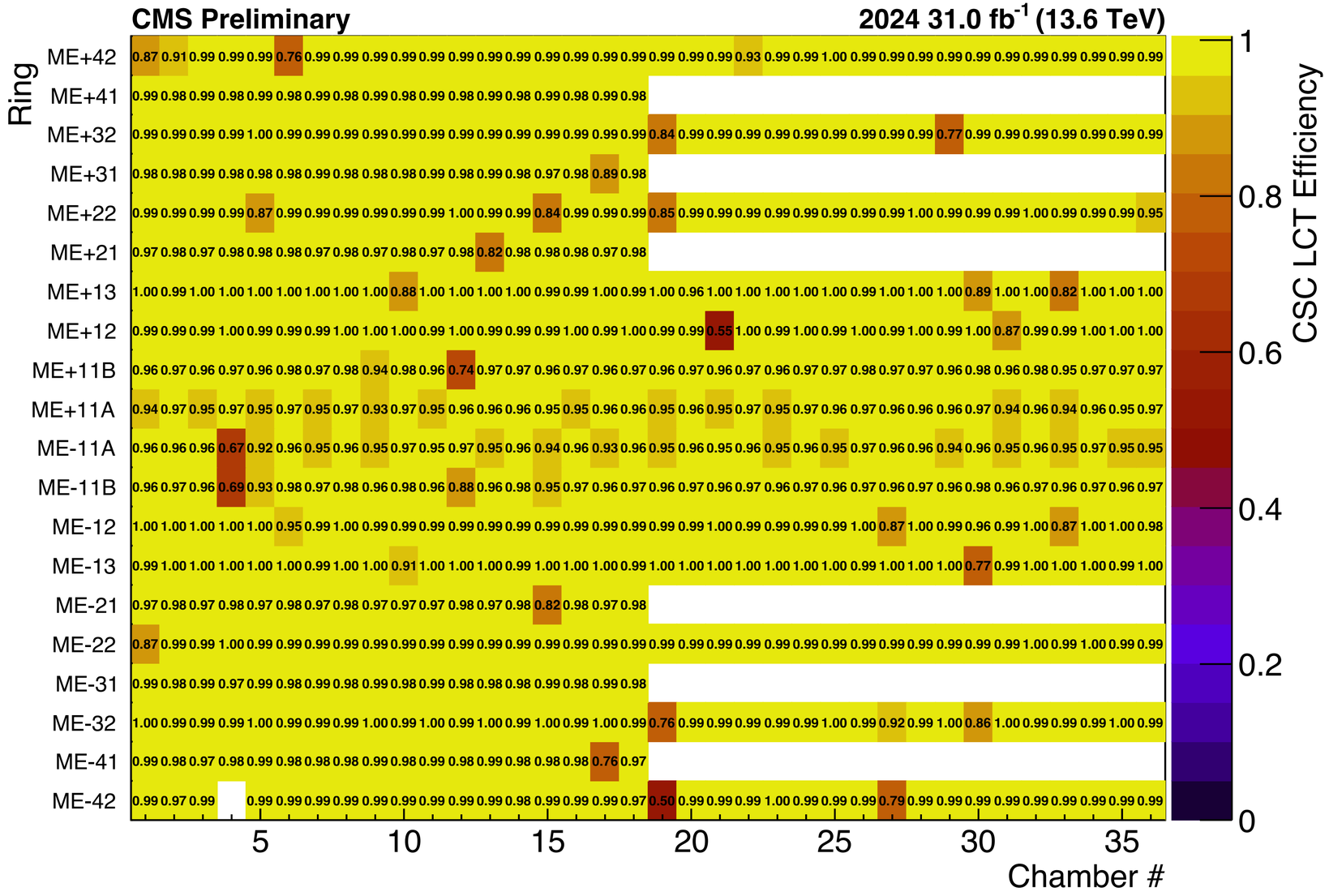
Introduction

- A major component of the CMS endcap muon detector is a system of 540 Cathode Strip Chambers (CSCs).
- A CSC is a multiwire proportional chamber in which the cathode signal is also read out and which can be used for precise determination of the position at which a charged particle crosses the chamber.
- Each chamber contains 6 layers of anode and cathode planes so a traversing muon typically leaves a straight-line pattern of 6 hits per CSC. From the cathode and anode signals recorded by a CSC 'hits' are reconstructed, corresponding to the positions through which a muon track passes.
- The CSC system contains 4 stations of 2 or 3 rings of CSCs, in each endcap (labelled -z and +z), with each station positioned at different z values (along the beam line). Stations in each endcap are labelled 1–4 from closest to the pp collision region, and are labelled + in the +z endcap and - in the -z endcap. For example, ME+i/j means ring j (=1-3) of CSCs in station i (=1-4) of the +z endcap.
- In rings ME2/1, 3/1, and 4/1 each chamber covers 20° in ϕ; all other chambers cover 10° in ϕ.
- For more details see 'Performance of the CMS muon detector and muon reconstruction with proton-proton collisions at $\sqrt{s}$= 13 TeV' - CMS MUO-16-001 - published in JINST **13** P06015 (2018): https://cds.cern.ch/record/2313130

CSC Trigger Primitive Efficiency

- An important function of the CSC system is to supply 'Trigger Primitives' to the Level-1 muon trigger system of CMS.
- A Trigger Primitive, or 'LCT' = Local Charged Track, in a CSC is a pattern of hits consistent with arising from a muon track crossing the chamber.
- The CSC Trigger Primitive efficiency is defined as the ratio between number of observed trigger primitives and the expected number of trigger primitives. These efficiencies are measured using a Tag & Probe technique in which $Z \rightarrow \mu^{+}\mu^{-}$ candidates are selected from events collected with a muon trigger, according to the invariant mass of the combination of a reconstructed muon (tag) with a reconstructed track (probe). The tag is a silicon Tracker track matched to at least two segments in the muon detectors; the probe is a high quality silicon Tracker track, and the invariant mass of the pair, considered as muons, should be near that of the Z. The probe track is projected into the CSC system and a nearby trigger primitive is searched for in each CSC the track traverses. A matching trigger primitive must be found within 10 cm or 10σ (where σ is the uncertainty in the position measurement). To reduce backgrounds and ensure the probe actually enters the CSC under consideration, compatible hits in a CSC downstream are also required.
- The plot shows the measured Trigger Primitive efficiency per CSC in the system, labelled by ring, and chamber number within each ring. The plot contains about 8M Z candidates (with the probe muon in the CSC system). There are a few (out of the total 540) chambers with known inefficiency usually due to one or more failed electronics boards which cannot be repaired without major intervention and dismantling of the system. There are also occasional temporary failures of electronics boards, lasting from periods of hours to days, which can be recovered without major intervention. The trigger primitive efficiency averaged over all CSCs is 97.7%.
- The high efficiency and redundant design of the CSC muon detector results in no significant loss in muon trigger efficiency in the endcap region.

CSC Trigger Primitive Efficiency



CSC Segment Efficiency

- A segment in a CSC is a straight-line track segment reconstructed from the hits on the 6 layers of the CSC.
- Segments are used as seeds for the full CMS muon track reconstruction algorithm, in combination with tracks reconstructed in the Silicon Tracker, in both the CMS High-Level Trigger (HLT) and CMS offline muon reconstruction.
- The CSC Segment efficiency is defined as the ratio between number of observed segments and the expected number of segments. These efficiencies are obtained using a Tag & Probe technique in which $Z \rightarrow \mu^{+}\mu^{-}$ candidates are selected from events collected with a muon trigger, according to the invariant mass of the combination of a reconstructed muon (tag) with a reconstructed track (probe). The tag is a silicon tracker track matched to at least two segments in the muon detectors, the probe is a high quality silicon tracker track, and the invariant mass of the pair, considered as muons, should be near that of the Z. The probe track is projected into the CSC system and a matching segment is searched for in each CSC the track traverses. To reduce backgrounds and ensure the probe actually enters the CSC under consideration, compatible hits are also required in a downstream CSC.
- The plot shows the measured Segment efficiency per CSC in the system, labelled by ring, and chamber number within each ring. The plot contains about 8M Z candidates (with the probe muon in the CSC system). There are a few (out of the total 540) chambers with known inefficiency usually due to one or more failed electronics boards which cannot be repaired without major intervention and dismantling of the system. There are also occasional temporary failures of electronics boards, lasting from periods of hours to days, which can be recovered without major intervention. The segment efficiency averaged over all CSCs is 98.2%.
- The high efficiency and redundant design of the CSC muon detector results in no significant loss in segment reconstruction efficiency in the endcap region.

CSC Segment Efficiency