Hit Matching between the MTD and ME0 System for Muon Identification in the High-η Endcap region

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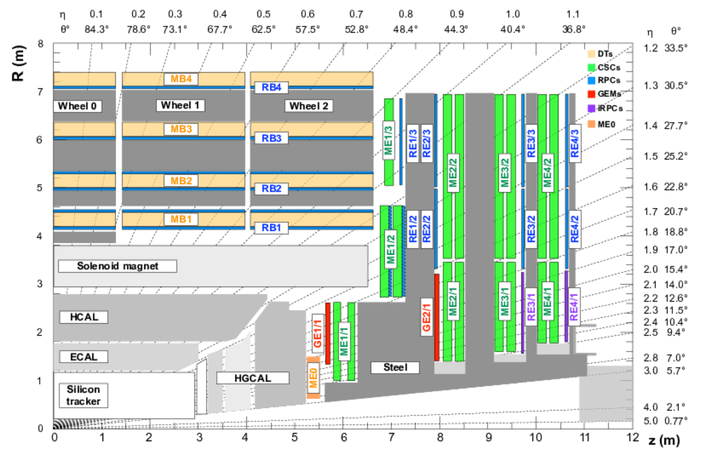
Introduction

- **In high-η endcap region(|η| > 2.4), there is no dedicated muon detector except ME0. Thus, we aim to associate hits from the MTD with those ME0 to improve muon identification in this region.**
- **Both the MTD and ME0 are new detector components to be implemented in CMS Phase-2 upgrade. As there is no real experimental data yet, we explore the feasibility of hit matching based on Geant4 simulation data in the high-η region.**
- **Hit matching between ME0 and MTD is expected to enhance muon identification efficiency and reduce the fake rate in high-η region, where conventional muon tracking coverage is limited.**



ME0 GEM Detector

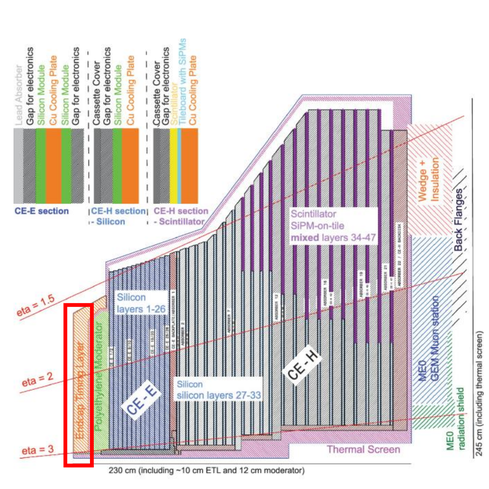
- **ME0 is designed to enhance muon reconstruction in HL-LHC environment, and address challenges such as aging hardware, reduced resolution, and efficiency loss in the forward region.**
- **ME0 coverage is 2.0 < |η| < 2.8.**
- **6-layer triple-GEM stack, and each stack covers an angular region of Δϕ ≈ 20°.**
- **In particular, the region 2.4 < |η| < 2.8 extends muon acceptance beyond the current muon system's coverage.**

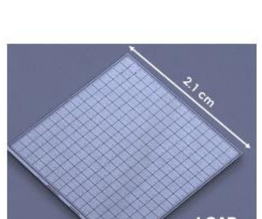
MIP Timing Detector

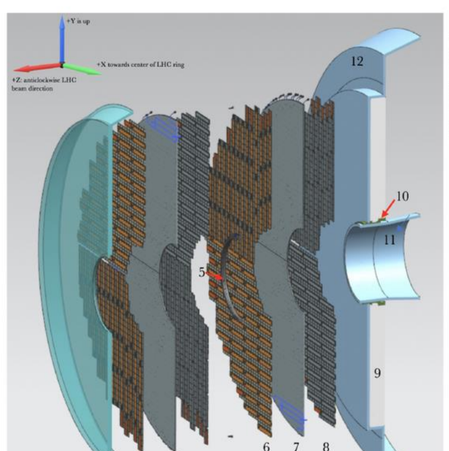
- **At the HL-LHC, each bunch crossing is expected to produce an average of 200 collisions, making it difficult to identify hard interaction and increasing the rate of false triggers.**
- **MTD is designed to address the challenges of the HL-LHC by providing precision timing and vertex information**
- **Thus, MTD enables the separation of overlap collisions, reduces the rate of false triggers and improves pileup rejection.**

Endcap Timing Layer

- **The MTD is a thin layer between the tracker and calorimeters, divided into barrel and endcap regions. (BTL for |η| < 1.5 and the ETL up to |η| ≈ 3.0)**
- **The Endcap Timing Layer (ETL) is composed of two double-sided LGAD disks, to cover 1.6 < |η| < 3.0.**
- **LGAD is a fast-timing silicon sensor with internal gain, capable of precise timing measurements in the range of 30-50 ps.**
- **Also it can maintain its performance even under the radiation levels expected by end of HL-LHC operation.**







Current Status

- **Goal**
  - **Hit matching between MTD and ME0 using η–ϕ coordinates.**
  - **Determine whether the matched hits originate from the same muon**
- **Dataset**

  :Simulation dataset generated using CMSSW, based on Pythia event generation and Geant4 detector simulation.
- **Current Status**
  - **Simulated data has been generated**
  - **Currently analyzing MTD reconstructed hit position plots.**
- **Expected Challenges**
  - **The MTD hit position resolution, and some muons fail to leave MTD hits across both disks due to modules or structures placed between the disks.**
  - **It is necessary to verify that the timing information from ME0 and MTD is at comparable scale.**
- **Next Steps and Plan**
  - **Convert MTD hit positions to η–ϕ coordinates and Compare them with ME0 hits positions.**
  - **Implement matching algorithm between MTD and ME0 hits.**
  - **Use additional information (e.g., timing, track direction) to determine if the matched hits are from same muon.**

Summary

- **This study focus on hit matching between MTD and ME0 in high- η region of the CMS Phase-2 upgrade.**
- **MTD designed to separate pile up interactions at HL-LHC.**
- **The goal is to match MTD and ME0 hits based on η–ϕ coordinates and verify the hits originate from the same muon using precise timing and position information.**

Reference

C. Collaboration, "Technical proposal for a mip timing detector in the cms experiment phase 2 upgrade," tech. rep., 2017.

The CMS Muon Endcap (ME0) GEM Detector - Tanvi Sheokand on behalf of the CMS collaboration

KSHEP

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