

Resolution of Standalone Muon Reconstruction with and without GE1/1

Hyokyu Choi, WooHyeon Heo, Ian James Watson, Jason Lee, Department of Physics, University of Seoul on behalf of the CMS collaboration



Introduction

- The GE1/1 detectors are triple-GEM chambers which were installed in the forward region at 2017.
- At present, GEM rechits are included in only tracker muon reconstruction.
- To maintain excellent track reconstruction under the high-pileup conditions of HL-LHC, GEM rechits will be used for standalone muon reconstruction.
- By analyzing MC samples, we evaluate how the inclusion of GE1/1 hits in standalone muon reconstruction improves resolution.

GE1/1 System

Gas Electron Multiplier (GEM)
– Micro-Pattern Gaseous Detector

CMSSW Setup

- CMSSW provide a framework and data model to configure and run CMS simulation, reconstruction and analysis.
- A CMSSW version compatible with the data and detector geometry is required.
- CMSSW Setup
 - CMSSW version: CMSSW_14_0_14
 - Muon gun samples: TenMu simulation
 - * 50000 Events of TenMu sim
 - * Particle gun generate ($0 \le E \le 200$), ($1.53 \le \eta \le 2.82$) muon
 - * 10 Muon simTrack are created for each event
 - * muons in +region, anti-muons in -region
- The primary electrons are generated and accelerate in drift aria.
- Ionized electrons are amplified in high electric fields across the GEM foils.
- Triple-GEM detectors are used in CMS muon system.





- Muon System
 - Muon System consist of Drift Tubes(DT), Cathode Strip Chambers(CSC), Resistive Plate Chambers(RPC) and GEM
 - The main purposes of muon system are muon identification, momentum measurement and triggering in CMS detector.
- GE1/1 System
- GE1/1 is the very first GEM detectors and installed in CMS endcap.
- GE1/1 consist of 36 super-chamber, cover $1.55 < |\eta| < 2.18$

- Conditions: Run3, phase1_2024_realistic
- Run step3 (RECO step) 2 times. with GEM and without GEM
- Muon matched with same simTrack and reco::Muon

Results

residual distribution



 Primarily used to generate L1 muon trigger primitives and to supplement global and standalone muon reconstruction.



Type of Muon Reconstruction



- Tracker Muon
 - Takes inner detector tracks, propagates to find compatible muon hits.
 - This includes GEM rechits, but a tracker muon is only made if it also finds

$$-\frac{\sigma_{p_T}^{\text{GEM}}}{\sigma_{p_T}^{\text{noGEM}}} = 0.90, \quad \frac{\sigma_{\eta}^{\text{GEM}}}{\sigma_{\eta}^{\text{noGEM}}} = 0.98, \quad \frac{\sigma_{\phi}^{\text{GEM}}}{\sigma_{\phi}^{\text{noGEM}}} = 0.93$$

- In standalone muon reconstruction, p_T resolution is relatively worse compared to the η or ϕ resolutions.
- The inclusion of GEM rechits in standalone muon reconstruction improves the $p_T(\sim 10\%)$, $\eta(\sim 2\%)$ and $\phi(\sim 7\%)$ resolutions.

Summary

- The analysis was performed using TenMu simulation muon events with a $(0 \text{ GeV} \le E \le 200 \text{ GeV})$
- We evaluated the performance improvement in standalone muon reconstruction by analyzing the p_T , η , and ϕ resolutions using MC samples with and without the inclusion of GEM rechits.
- Including GEM rechits into standalone muon reconstruction improves resolution.
- This shows that including GEM rechits in standalone muon reconstruction

another type of hit.

Standalone Muon

- Constructs tracks from the muon system detector alone.
- Global Muon
 - Matched Standalone and Tracker, refits the track with all hits.
- GEM rechit
- Reconstructed measurement of a muon hit's position and time in a GEM chamber.
- Local Reconstruction
 - Reconstruction of hits and track segments inside a chambers.

is important under high-pileup conditions in HL-LHC.

References

- [1] M. Abbas et al., Performance of a Triple-GEM Demonstrator in pp collision at the CMS Detector, JINST 16 (2021) 11, P11014
- [2] Ilaria Vai, The GEM (GE1/1) Phase II Upgrade for the CMS muon system, 2019
- [3] M. Abbas et al., Benchmarking LHC background particle simulation with the CMS triple-GEM detector, JINST 16 (2021) 16, P12026
- [4] F. Ivone, "Commissioning Results and Operational Experience of the First Triple-GEM Station of the CMS Muon System," 2022 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC), Italy, 2022



E-mail: chlgyrb111@uos.ac.kr Computational physics lab, University of Seoul Tel. 02-6490-5361

KSHEP 2025 Spring Meeting

May 22–24, 2025