Simulation of Muon Chamber detector for mini CBM experiemt at SIS18 FAIR

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Introduction

The Compressed Baryonic Matter (CBM) experiment, as described in [1], is designed to explore the QCD phase diagram in regions of high net baryon density. Currently under construction at the FAIR accelerator facility in Darmstadt, Germany, the CBM experiment will utilize the SIS-100 accelerator ring, which is designed to deliver beam energies of up to 30 GeV for protons, 15A GeV for light ions (such as C, Ca, Ni...), and 12A GeV for heavy ions (including Pb, Au, In...).

The CBM experimental setup includes several key detectors designed to handle particle rates up to 10 MHz. The Silicon Tracking System (STS) reconstructs particle tracks and determines charged particle momentum. For dilepton measurements (e^+e^- and $\mu^+\mu^-$), the Muon Chamber (MuCh) identifies muons, while the Ring Imaging Cherenkov (RICH) detector identifies electrons. The Transition Radiation Detector (TRD) identifies secondary electrons, and the Time of Flight (TOF) detector aids in hadron identification. Lastly, the Forward Spectator Detector (FSD) determines the centrality of collisions.

This report focuses on the simulation of the GEM detectors, which were installed during the mini-CBM experiment conducted at the SIS-18 accelerator ring at FAIR.

The SIS-18 accelerator ring is currently operating with beam energies of 1.23 AGeV for Au^{79+} ions and 4.5 GeV for protons. The mini-CBM experiment is being carried out to test and optimize detectors that will be used in the full CBM experiment. This article focuses on the implementation of the Muon Chamber (MuCh) detector as outlined in [2], which includes the GEM1 and GEM2 modules for the mini-CBM experiment run in June 2024 at the SIS-18 accelerator ring. The experimen-

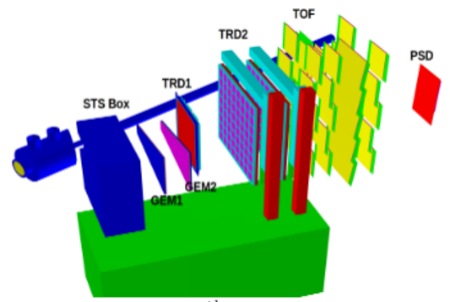

FIG. 1: mini CBM 16^{th} June 2024 Uranium run experimental setup

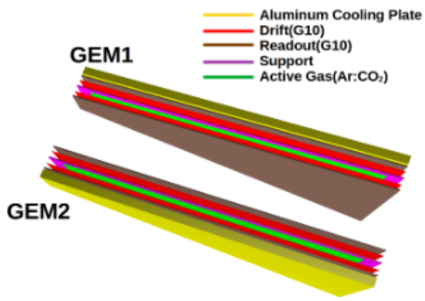

FIG. 2: GEM1 and GEM2 layer with cooling plate, G10 material, Drift volume, Support structure.

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tal setup for mini-CBM features the Silicon Tracking System (STS), with the GEM1 and GEM2 modules positioned after the STS box detector. Following these are the Transition Radiation Detector (TRD), Time of Flight (TOF) detector, and the Projectile Spectator Detector (PSD) at the end of the setup. This study employs *much_v24a_mcbm* geometry for GEM1 and GEM2 detector of MuCh, corresponding to experimental run number 3196, conducted during the mini-CBM experiment on June 23, 2024.

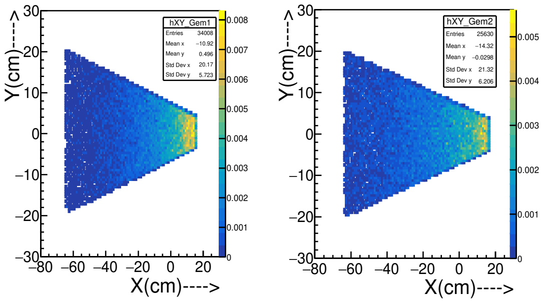

FIG. 3: XY distribution of MC Points for GEM1 on left panel and for GEM2 on right panel.

The GEM1 and GEM2 layers are composed of multiple components, including an aluminum cooling plate, G10 material, a drift volume, and a support frame, all arranged within a trapezoidal structure, as shown in Fig. 2. In this simulation process, only the drift volume of the GEM is modeled as the active medium with a thickness of 3 mm, using a gas mixture of argon (Ar) and CO_2 in a 70:30 ratio. Additionally, a 1 cm thick aluminum plate is used for cooling and providing structural support to the modules. It also includes a drift and readout section made of 3 mm thick G10 material.

In this simulation, a collision scenario involving 10,000 minimum-bias Au-Au particles at 1.23 AGeV is analyzed. These particles traverse the *much_v24a_mcbm* detector geometry using the GEANT3 transport engine, generating Monte Carlo points within the active gas volume.

The GEM1 and GEM2 detectors are positioned 77 cm and 98 cm away from the interaction point, respectively. Both modules span from 15 cm to -65 cm along the X-axis, while along the Y-axis, they extend from -20 cm at the bottom to 20 cm at the top, as illustrated in Fig. 3.

The most probable energy loss within GEM1 and GEM2 is approximately 2 keV, as shown in Fig. 4. Most of the particles detected in the Muon Chamber are nuclear fragments, predominantly protons, pions, and electrons.

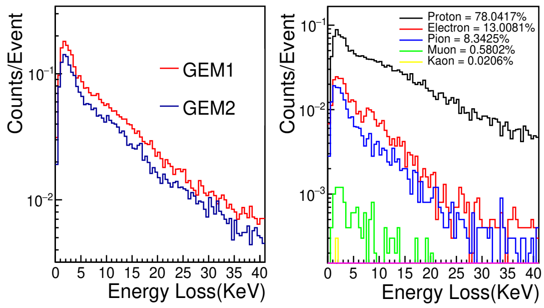

FIG. 4: Energy of particle inside GEM1 and GEM2 detector on the left panel and Energy loss of variuos particle inside GEM1 detector on the right.

The momentum distribution of particles losing energy within the GEM1 and GEM2 detectors is shown in Fig. 5. Work is under

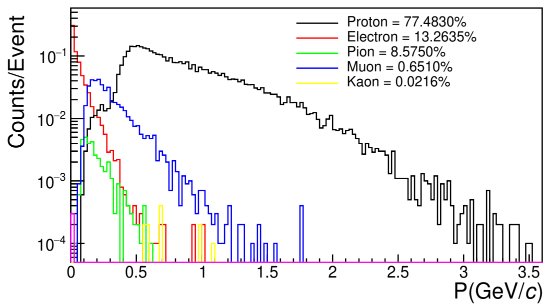

FIG. 5: Momentum distribution of the particles.

progress to apply digitization and the hit reconstruction of the GEM detectors.

References

[1] The CBM physics book: Compressed baryonic matter in laboratory experiments, DOI :10.1007/978-3-642-13293-3

[2] Technical Design Report for the CBM Muon Chambers (MuCh), Friese, Volker and *et. al.*.