Realistic Muon Chamber (MuCh) geometry simulation for the CBM experiment at FAIR

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Introduction

The major objective of the Compressed Baryonic Matter (CBM) experiment [1] at FAIR accelerator complex in Darmstadt, Germany is to explore the QCD phase diagram in the region of high net baryonic densities and moderate temperatures. Di-muon ($\mu^+\mu^-$) measurements constitute a central part of the CBM research program, as they are very sensitive diagnostic probes of the conditions inside the fireball. The Muon Chamber (MuCh) system [2] is thus designed to identify muon pairs which are produced in high-energy heavy-ion collisions in the beam energy range from 4 to 40A GeV. The measurements would require a sophisticated muon detector system located down stream the dipole magnet housing Silicon Tracking System (STS), that determines particle momenta. The CBM strategy is to track the particles through a hadron absorber system, and to perform a momentum-dependent muon identification. This concept is realized by an instrumented hadron absorber, consisting of staggered absorber plates and tracking stations. The hadron absorbers vary in material and thickness, and the tracking stations consist of detector triplets based on different technologies. The MuCh system will be built in stages which are adapted to the beam energies available. Within the FAIR modularized start version the SIS100 ring will provide beams with energies up to 11A GeV for heavy ions and 29 GeV for protons. Thus a modular MuCh system is presently under development which can be easily upgraded according to the beam energies under investigation. Based on the beam energy and hardness of the muon tracks two configurations are presently investigated at SIS 100 energies. The optimum design of the first version of MuCh will comprise of 12 detector chambers with 3 chambers grouped as a station between two successive absorbers and enable the measurement of Low-Mass Vector Mesons (LMVMs) (ρ, ω, ϕ) in A + A collisions at 4-11A GeV. The detector chambers are filled with 3 mm argon gas as active detection volume. To perform physics performance simulations, related to the di-muon measurements, the detector geometry needs to be as realistic as possible. With this objective, recently 1 cm thick Aluminum plates have been added to each detector chamber of the simulated MuCh geometry, to provide the required cooling of the associated electronics and to act as chamber support. In the present paper, we discuss the effect of this additional material budget due to the cooling plates. In addition we also discuss our simulation results after implementing Drift and Readout PCBs to the realistic MuCh geometry.

Geometry Configurations

The muon detection system at SIS100 optimized for LMVM measurements, has 4 absorbers and 4 stations. Each station consists of 3 detector layers. The first absorber is made up of Graphite and a trapezoidal followed by parallelepiped in shape. Rest of the absorbers are made up of Iron and parallelepiped in shape. In present simulation three variants of MuCh geometry have been studied. The old geometry contains 1.5 cm rectangular plates made of Carbon plastic as a support structure but no arrangement for cooling. In the

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second version carbon plates are replaced by 1 cm thick Aluminum plates for support and cooling purpose. To make the geometry more realistic we derive the third version of MuCh, which contains 35 micron Copper and 3 mm G10 on both sides of active volume of the detector in addition to 1 cm Aluminum cooling plate. The full MuCh geometry and internal structure of each module as per the realistic geometry concern are shown in Fig. 1 and Fig. 2 respectively.

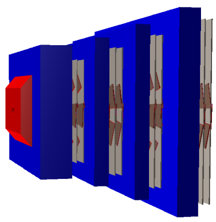

FIG. 1: A schematic view of realistic version of the muon detection system for dimuon measurements in the CBM experiment.

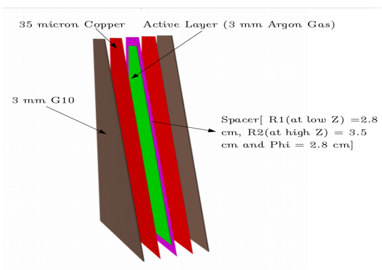

FIG. 2: Internal structure of each module in realistic MuCh geometry.

Results and Discussion

The simulations have been performed for central Au+Au collision at 10A GeV using 10^4 events generated by UrQMD [3] event generator. GEANT3 transport code has been used to transport all these particles through the CBM set up, for all three geometry configurations. The ratio of momentum distributions of primary particles at each station for each geometry configuration to carbon support geometry(oldest geometry) have been plotted in Fig. 3. As we are interested in the effect of the additional material budget introduced by drift and read-out PCBs and cooling plates, we have constructed the ratios by diving the momentum of the primary tracks for each version of MuCh geometry, with the old MuCh geometry without cooling plates and PCBs and Carbon as only support structure. As evident from the figures, an absorption of as much as 20% is seen for the primary tracks due to the additional material budget of cooling plates and PCBs. Our next aim is to perform full simulation and reconstruction to study the feasibility of di-muon measurements with realistic MuCh geometry.

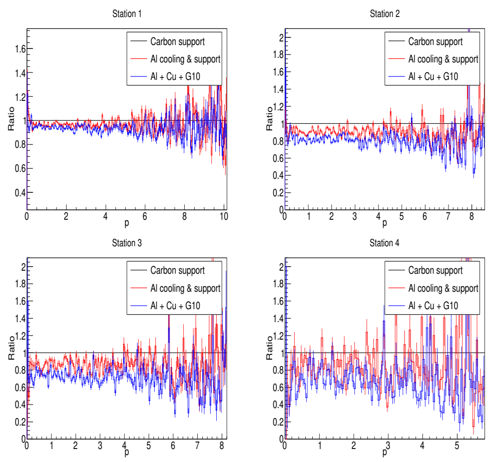

FIG. 3: Ratio of momentum distributions at each station of MuCh detector.

Acknowledgments

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