Response simulation of the GEM detector for the CBM experiment

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Introduction The Compressed Baryonic Matter (CBM) experiment at FAIR, the upcoming accelerator facility at Darmstadt, Germany endows us with the unique opportunity to investigate the phase structures of the strongly interacting matter in the region of moderate temperatures and high net baryon densities. The proposed key observables include the measurement of muon pairs originating from the decay of low mass vector mesons (lmvm) and charmonia. The experimental groups from India and Russia jointly hold the responsibility of designing, building and operating a muon detector system to enable dimuon measurements [1]. An optimized version of the muon detection system (MUCH) has already been designed through simulations. It includes 6 iron absorbers and 6 tracking stations. Each tracking station consists of three chambers located in the air gap between two successive absorbers. The total absorber length in the current design amounts to 2.25 m of iron. For inclusion of a realistic scenario, modular structure has been implemented in simulation. Each detector layer has been divided in several trapezoidal sectors and filled with an argon based gas mixture as the active medium. The muon tracking chambers will be under conditions of high hit density and large event rates (10^7 events/s) to enable the muon measurements. Conventional Multi wire proportional chamber (MWPC) like gas detectors can not cope with such high rate. Modern micro-pattern gas detectors like Gas Electron Multiplier (GEM) and micromegas are expected to meet up these requirements. In the present paper we report the detailed simulation of the GEM response to the minimum ionizing particles in CBM-MUCH environment.

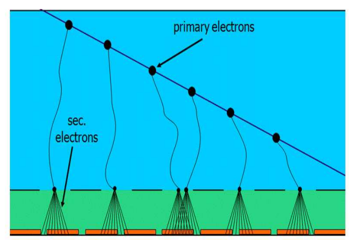

FIG. 1: A schematic view of the primary ionization and secondary multiplication due to the incident radiation in the active gas gap inside GEM chamber.

In recent days, GEM based detectors have found wide spread applications in different fields with a major share in high energy physics experiments. The micropattern detectors of this particular type are widely used following their reported good time resolutions coupled to an excellent rate handling capability.

Feasibility study

For simulation of detector response, each detector chamber is filled with argon gas as the active medium. The gas thickness is set to 8 mm. The process of detection inside a gaseous detector includes the primary ionization created by the incident ionizing radiation, avalanche multiplication and charge deposition on the read-out pads as shown schematically in Fig. 1. Inside the gas volume, the

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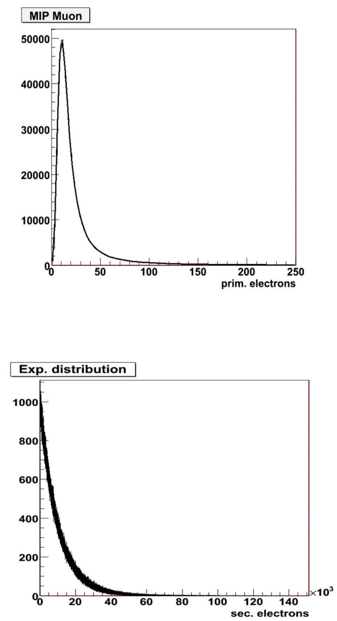

FIG. 2: (top) Distribution of primary electron multiplicity for incident muons inside the gas volume; (bottom) distribution of secondary electron multiplicity. Average gas gain is set to 10^4.

distribution of the number of primary electrons is simulated using HEED [2] package and fitted to two parameter Landau function. Thus obtained parameterizations of expectation value and variance as functions of logarithm of kinetic energy of the ionizing particles are used for the random simulation of the number of primary electrons, which depends on the track length of the incident particle inside the muon chamber. The primary electrons are then distributed according to Poisson distribution. The gas gain for each primary electron fluctuates according to an exponential distribution with a mean value set to 10^4. The distribution of primary and secondary electrons are shown in Fig. 2.

The transversal diffusion of the avalanche which gives the measure of the spot size is assumed to be constant. It is tunable parameter and takes different values depending

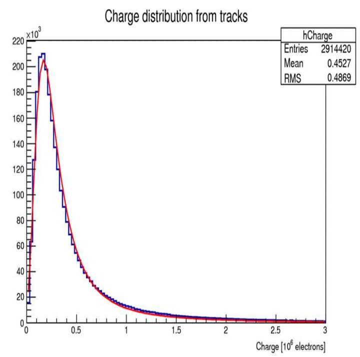

FIG. 3: Charge distribution from the incident tracks.

on the exact micro pattern detector technology (GEM/micromegas). The spot radius in the present case is set to 600 micron. The avalanche spot for each primary electron is projected to the pad plane and and the sum of charges at each pad is calculated. With the currently implemented pad design, typically 1.4 pads are fired by a primary track, while the highly inclined secondary particles cover relatively larger number of pads. Final step of detector response simulation includes the analysis of charge distributions collected in the read-out plane. The reconstructed charge distribution of the incident tracks for 25 GeV Au+Au collisions is shown in in Fig. 3. As expected the charge distribution shows a Landau spectra.

References

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[2] http://ismirnov.web.cern.ch/ismirnov/heed.html