Study of bulk properties of the medium produced in heavy ion collisions at MPD

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Introduction

High-energy heavy-ion collisions envisage to probe the bulk properties of the medium[1] through the investigations pertaining to the identification of the particles emitted following such intense reactions. As a part of the preparatory experiments for the operation of the NICA collider with the MPD(Multi-purpose detector) setup, which has been designed specifically to investigate the dynamic properties of hot and dense nuclear matter, efforts were initiated to perform Monte Carlo (MC) based simulations pertaining to the particle production and their subsequent detection at relevant energies[2].

The parameters of interest are the **distance of closest approach(DCA), event selection, and particle identification to name a few** from the values reconstructed by the Time Projection Chamber(TPC). It is expected that this exercise would help to establish the required cuts so as to reject the background events and enhance the selection/identification of events of interest.

Experiment and Data analysis

The simulations were made for the Bi+Bi system at $\sqrt{s_{NN}} = 9.2$ GeV, as viewed by the MPD setup. At first, we studied the event selection for the collisions. The primary vertex for each event is defined by finding the most probable point of common origin of the tracks detected by the TPC. In order to reject the background events that originate following the beam interactions with the beam transport system, the event vertex radius is required to be within a certain optimal range of the center of MPD.

Then, the track selection criteria for the analysis are optimized. In order to suppress the admixture of tracks from secondary vertices, we need to find out the distance of the closest approach between each track and the event vertex. For track fitting, we need some maximum hits possible in the TPC as well, based on the conventional analysis methodology for the data acquired from the MPD. The results presented here are within rapidity of $|y| < 0.1$, which was arrived upon following the selection of a constant region of events and rapidity.

Furthermore, the identification of the charged particles in MPD is also performed using the TPC and time of flight detectors(TOF). We use TOF information to identify the particles having higher momentum. On the other hand, the TPC identifies low p_T particles well because, the peaks of pion, kaon, and proton distributions are well separated. However, at higher p_T these distributions overlap.

And that's how, the parameters for the results of TPC acceptance of pion($\pi^{\pm}$), kaons($K^{\pm}$), and protons(p, $\bar{p}$) with these standard cuts are arrived upon.

Results and Discussions

Finally, for the TPC acceptance, the selection criteria and standard cuts are:

1. In fig.[1] primary vertex<50 cm, so for the interactions with the beam pipe, we need the event vertex radius to be within 4 cm of the detector.

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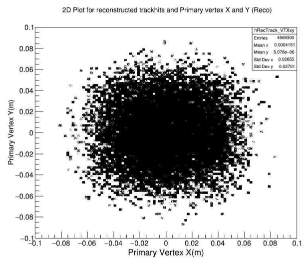

FIG. 1: Event vertex x and y of the reconstructed event.

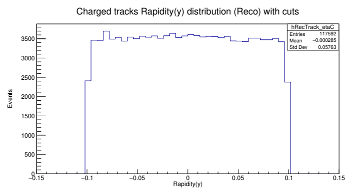

FIG. 2: Rapidity plot with cuts at $|y| < 0.1$ in 50 bins.

2. We are doing the cuts for rapidity in the $|y| < 0.1$ region, in fig.[2], because of its constant or steady nature, and the DCA is<3 cm in fig.[3].
3. No. of hits, min.= 10 and max.= 53, In fig.[4], we can see that tracks must have at least 10 points used in track fitting out of the max. of 53 hits possible in the TPC.
4. In fig.[5], at low momentum region, TPC can identify $\pi^{\pm}$(in -0.2 to -0.1 and 0.1 to 0.2), $K^{\pm}$(in -0.5 to -0.2 and 0.2 to 0.5), p(in 0.5 to 1), and $\bar{p}$ (in -1 to -0.5).

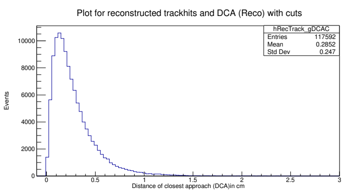

FIG. 3: Distributions of the DCA with cuts at $|y| < 0.1$ in 100 bins.

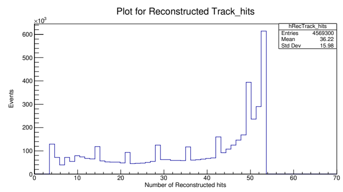

FIG. 4: Plot of the Number of hits which is showing the min.(10) and max.(53) number of hits.

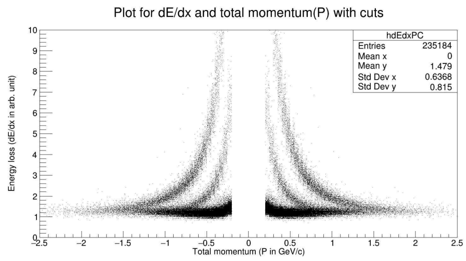

FIG. 5: The dE/dx of charged tracks with the total momentum with cuts at $|y| < 0.1$

Summary

Monte Carlo data of Bi+Bi heavy ion collisions in the center-of-mass energy range were analyzed at the collision energy $\sqrt{s_{NN}} = 9.2$GeV. Also, several other studies have been performed to improve the quality of particle identification and made some cuts for better results or analysis like DCA cuts, rapidity cuts, the minimum number of hits, etc. These preliminary results can lead us to the chemical and kinetic freeze-out dynamics, particle yields, and the relation between temperature and chemical potential for the phase diagram to search for the QCD phase transition.

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References

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