Simulation study of charged-neutral fluctuations in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV

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Introduction

One of the predicted signal to observe the chiral symmetry restoration is the enhanced fluctuations in the production of charged and neutral particles in heavy ion collisions at ultrarelativistic energies. The heavy ion collisions may provide the physical conditions essential for the formation of Disoriented Chiral Condensates (DCC) domains [1]. An event-by-event charged-neutral fluctuations is an important quantity to analyze the formation and decay of DCC domains. WA98 at SPS (Super Proton Synchrotron) investigated the charged-neutral fluctuations in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 158$ A GeV [2] using the Sliding Window Method [3]. The similar study has been performed by STAR experiment at RHIC (Relativistic Heavy Ion Collider) in Au+Au collisions at $\sqrt{s_{\rm NN}} = 200$ GeV [4] using the observables; ν_{dyn} and $r_{m,1}$ as a function of collision centrality and average multiplicity.
In order to understand the theoretical predictions of different physics topics, the simulation study plays an important role in ultrarelativistic heavy ion collisions. HIJING (Heavy Ion Jet INteraction Generator) is primarily focussed to study the wide range of possible initial conditions in heavy ion collisions [5]. It is extensively used for p-p, p-A, and A-A collisions. AMPT (A Multi Phase Transport Model) includes four fundamental parts: the initial conditions, partonic-level interactions, hadronization processes and hadronic rescattering. The detailed information of these processes can be found in ref. [6]. The Pb-Pb events generated from the HIJING and AMPT at $\sqrt{s_{\rm NN}} = 2.76$ TeV have been analyzed for different centralities from 0-70%. The neutral and charged particles are selected with pseudo rapidity interval $2.8 < \eta < 3.6$ over the full azimuthal angle $0 < \phi < 360°$.

Analysis Strategy

For the measurement of non-statistical fluctuations, an event-by-event study of charged-neutral fluctuations in Pb-Pb collisions is performed using $\nu_{dyn}^{\gamma-ch}$ observable. The multiplicity of charged particles and neutral particles are used for the estimation of $\nu_{dyn}^{\gamma-ch}$. The observale $\nu_{dyn}^{\gamma-ch}$ is expressed as,

$$\nu_{dyn}^{\gamma-ch} = \frac{\langle N_\gamma(N_\gamma-1)\rangle}{\langle N_\gamma\rangle^2} + \frac{\langle N_{ch}(N_{ch}-1)\rangle}{\langle N_{ch}\rangle^2} - 2\frac{\langle N_\gamma N_{ch}\rangle}{\langle N_\gamma\rangle\,\langle N_{ch}\rangle} \quad (1)$$

where N_γ and N_{ch} are the multiplicities of neutral and charged particles in an event, respectively. The brackets $\langle ....\rangle$ represent the averages of corresponding particles over all events in a sample. If the value of $\nu_{dyn}^{\gamma-ch} >$ 0, then it is clear from the Eq. 1 that the selfcorrelation terms (first term $(\gamma-\gamma)$ and second term $(ch-ch)$) dominates. If $\nu_{dyn}^{\gamma-ch} < 0$, the third term of Eq. 1 dominates which is the correlation between neutral and charged particles. The third possibility is $\nu_{dyn}^{\gamma-ch} = 0$ implies that the production of neutral and charged particles are independent of each other which is expected from the Poisson distribution. Also another variable, a robust observable $r_{m,1}$ is introduced by the Minimax collaboration [7] to measure the dynamical fluctuations in $(\gamma - ch)$ correlation. For DCC, $r_{m,1}$ varies as $1/(m+1)$ whereas for generic case, $r_{m,1} = 1$. Here, m is the order of factorial moments. The average multiplicity

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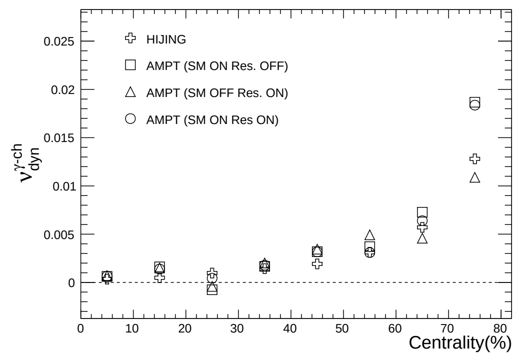

FIG. 1: $\nu_{dyn}^{\gamma-ch}$ as a function of collision centrality for different monte carlo models: HIJING and AMPT.

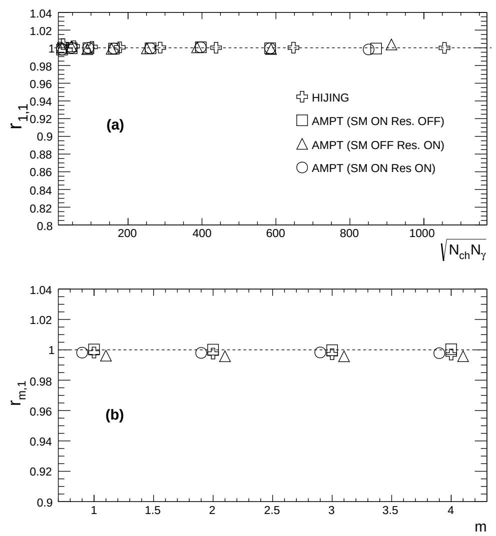

FIG. 2: Variation of robust variable $r_{1,1}$ as a function of average multiplicity (a) and $r_{m,1}$ as a function of higher moments (b) in Pb-Pb collisions at 2.76 TeV for HIJING and AMPT generated events.

dependence of factorial moments $r_{m,1}$ and the variation w.r.t higher moments is performed.

Results and Discussions

The two different observables are used for the estimation of $\gamma - ch$ correlation fluctuations over the full azimuth. The $\gamma - ch$ correlation in $\nu_{dyn}^{\gamma-ch}$ observable shows similar trend for different monte carlo models and matches with each other. One could expect the higher values of $\nu_{dyn}^{\gamma-ch}$ for experimental data of heavy-ion collisions. Fig. 2(a) represents the behaviour of $r_{1,1}$ for HIJING and AMPT events as a function of average multiplicity. All the data points follow the same trend as one moves from peripheral to central collisions. The results obtained for $r_{1,1}$ are constant around 1 which is expected for generic pion production. The $r_{m,1}$ dependence on higher moments for most central collision 0-10% is shown in Fig. 2(b). The values of $r_{m,1}$ also lies on 1 which indicates the presence of binomial distribution for all values of m as expected since there is no DCC domains in the HIJING and AMPT events. This study needs to be performed on the experimental data of Pb-Pb at $\sqrt{s_{\rm NN}} = 2.76$ TeV.

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