AMPT simulation of Φ−measure in Au+Au collision at 30*A* GeV

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Event-by-event (e-b-e) fluctuation of mean transverse momentum (p_T) of particles produced in high-energy heavy-ion (AB)collisions describes the dynamics of equilibriation [1]. Among several observables that can characterize such fluctuations [2, 3], we in this paper consider the so-called Φ-measure [1]. Let us introduce a single particle variable x and its deviation from the inclusive mean $\bar{x}$ as $z = x - \bar{x}$. A multiparticle analog of z is $Z = \sum_{i=1}^{N}(x_i - \bar{x})$, which is an event variable, where N is the number of particles in the event considered. The Φ measure of fluctuations in x is then defined as

$$\Phi_x = \sqrt{\frac{\langle Z^2 \rangle}{\langle N \rangle}} - \sqrt{\bar{z^2}}, \qquad (1)$$

where $\bar{z^2}$ is the variance of the single particle inclusive z distribution. The brackets $\langle \cdots \rangle$ represent averaging over events. In our inveatigation $x = p_T$ of a charged hadron falling within a rapidity cut $|y - y_0| < 1.0$, y_0 being the centroid of the overall y-distribution of charged hadrons. By construction Φ_{p_T} is not sensitive to the system size, and can filter out the dynamical part of p_T fluctuations. In the case of independent particle emission Φ_{p_T} vanishes. If an AB interaction is an incoherent superposition of many nucleon-nucleon (NN) interactions, the value of Φ would be independent of the centrality of collision [1].

We have analyzed a million Au+Au events at $E_{\rm lab} = 30A$ GeV generated by A Multi-Phase Transport (AMPT) model in its string melting version (AMPT-SM) [4]. Fig. 1 shows the distributions of event-wise mean transverse momentum $M(p_T) = M^{-1}\sum_{i=1}^{M} p_{T_i}$ of charged hadrons in three centrality classes. M is the charge hadron multiplicity of the event. The lines associated with data points represent the corresponding mixed-event predictions (statistical noise). The difference between the data and corresponding mixed-event prediction can therefore be regarded as the dynamical contribution to $M(p_T)$. In

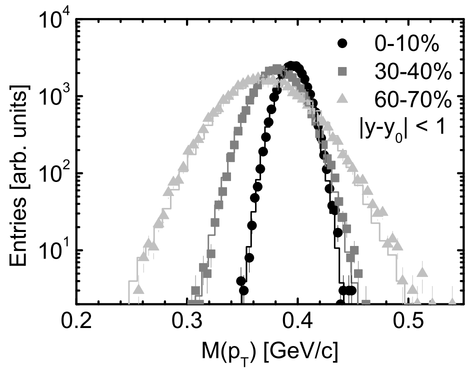

FIG. 1: Mean p_T distributions of charged hadrons for three centrality bins: 0-10%, 30-40% and 60-70%..

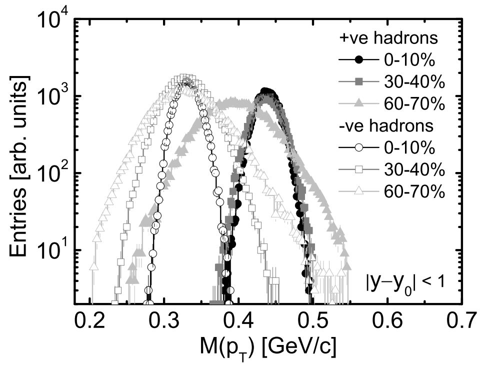

FIG. 2: Mean p_T distributions of positively and negatively charged hadrons for 0-10%, 30-40% and 60-70% centrality bins.

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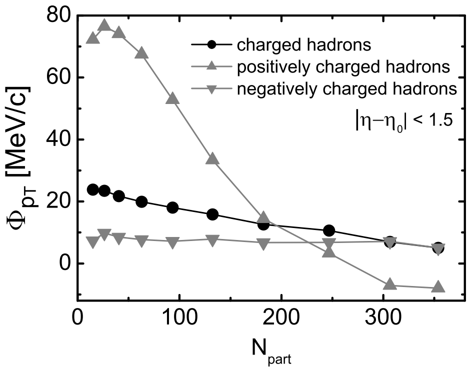

FIG. 3: Φ_{p_T} measure with centrality of collisions.

Fig. 2 we draw the $M(p_T)$ distributions for positively and negatively charged hadrons. We see that for positively charged hadrons, with increasing centrality the centroid of $M(p_T)$ distribution shifts from a higher to a lower value. While for negatively charged hadrons the distributions are centered more or less around the same $M(p_T)$ value at all centralities. The width of the distributions ($\sigma_{M(p_T)}$) increase with decreasing centrality, and the rate of increase is faster in the case of positively charged hadrons. The difference between the positive and negative hadrons is mostly due to the excess number of baryons (protons) over anti-baryons at our energy scale. If the protons and antiprotons are excluded, then no significant difference is observed between the $M(p_T)$ distributions of positively and negatively charged hadrons.

The Φ_{p_T} measure is graphically plotted in Fig. 3 against the number of nucleons N_{part} participating in Au+Au collisions. For positively charged hadrons Φ_{p_T} decreases monotonically with N_{part} to saturate to $\Phi_{p_T} \approx -7$ MeV/c near $0-10\%$ centrality. On the other hand for negatively charged hadrons Φ_{p_T} does not change significantly with N_{part}, fluctuating marginally around $\Phi_{p_T} \approx 7$ MeV/c. Excess protons present in the positive charge group pehaps induce some amount of (anti)correlation resulting thereby a negative Φ_{p_T}. The Φ_{p_T} measure for all charged hadrons decreases almost linearly with increasing N_{part}. The results suggest that the final state particles are not emitted independently from a single source, and an AB collision neither be considered an incoherent superposition of many NN collisions. The maximum (minimum) value of Φ_{p_T} is found to be $\sim 23\,(5)$ at $N_{part} \approx 26\,(353)$, which corresponds to 70-80% (0-5%) centrality class. For a fully thermally equilibrated system Φ_{p_T} should vanish [1]. The AMPT-SM model therefore does not predict a complete equilibriated system at the energy scale considered. Some amount of correlation survives even in the 5% most central Au+Au events. Our AMPT-SM estimation of Φ_{p_T} at $40A$ GeV qualitatively matches with the measurement of NA49 [2], and a quark-gluon string model simulation study for various collision systems as reported in [5].

Acknowledgment: IP and PM are financially supported by University of North Bengal.

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