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The onset of jet quenching phenomenon

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The small size systems formed in proton-proton (p-p) collisions were simulated in order to study the onset of jet quenching measurements of the Quark Gluon Plasma (QGP) formed in large size systems (nucleus-nucleus) at top central collisions. The formation of QGP medium has been indicated via different observations such as the suppression of hadron spectra [1–5], while the electromagnetically interacting particles (direct photon) and weakly interacting particles (Z^0 and $W^{\pm}$) spectra in central nucleus-nucleus collisions compared to p-p collisions at Relativistic Heavy Ion Collider (RHIC) and Large Hadron Collider (LHC) [6–9], were unity. In addition to the suppression of the away-side yield per trigger particle in central A-A collisions compared to the peripheral A-A and p-p collisions [1]. However, due to the absence of different level of suppressions for light quarks vs heavy quarks [10, 11], and for quarks vs gluon jets [12], in contrast to the Quantum Chromodynamics (QCD) predictions, indicate the needs for more sensitive observables in order to better quantify and constrain the medium parameters. Moreover, observations such as long-range ridge-like structure [13, 14] and strangeness enhancement [15] in high multiplicity events in p-p collisions have stimulated the search for similar phenomena, e.g., jet quenching in the high multiplicity events regardless of the size of the colliding systems. Previous simulated data using PYTHIA [13, 16] have shown similar patterns for some of the observables as in the central heavy ion collisions, which might indicate a nontrivial contributions for the commonly adopted measured observables from the underlying particle production mechanisms in QCD.

In order to search for the onset of the jet quenching in the high multiplicity events, the two-particle azimuthal correlation functions are constructed and the associated yield per trigger particle has been extracted for the high and low multiplicity events in p-p collisions at both energies of RHIC and LHC. The associated particles yield, $D(z_T) = \frac{1}{N_{\rm trg}}\frac{dN}{d(\Delta\phi)}$, has been compared between the low and high multiplicity events as a function of the hadron fractional energy z_T where $z_T = p_T^{\rm assoc}/p_T^{\rm trig}$. In order to quantify the multiplicity effects, if any, the ratio between the near-side yields at high and low multiplicities (I_{HL}^N), and away-side yields at high and low multiplicities (I_{HL}^A), where:

$$\begin{aligned} I_{HL}^N(z_T) &= \frac{D_{\text{near-side}}^{\text{high-mult}}(z_T)}{D_{\text{near-side}}^{\text{low-mult}}(z_T)}; \\ I_{HL}^A(z_T) &= \frac{D_{\text{away-side}}^{\text{high-mult}}(z_T)}{D_{\text{away-side}}^{\text{low-mult}}(z_T)} \end{aligned} \quad (1)$$

have been calculated and plotted for both energies, as a function of z_T, as shown in Fig. 1.

At both energies, the values of I_{HL}^N and I_{HL}^A were less than unity, and of trivial dependence on z_T. The values of I_{HL}^A are always less than these of I_{HL}^N at the same multiplicity and energy, and both quantities show a pattern of systematic decreases with the multiplicity. Such multiplicity dependence cannot be used neither to exclude the jet quenching nor to prove it in the high multiplicity events in p-p collisions, as the suppressions have been found at both sides, near and away of the high-p_T particle. The fact that the near-side shows a suppression in the high multiplicity events in p-p collisions is not consistent with the surface bias emission as reported by various experiments, and accordingly such suppression at both sides shown in this analysis could be due to 1) the evolution of the parton distribution functions on the trigger particle momentum, 2) parton energy loss in the high multiplicity events, or 3) a combination of both effects 1) and 2). More future studies at higher transverse momenta

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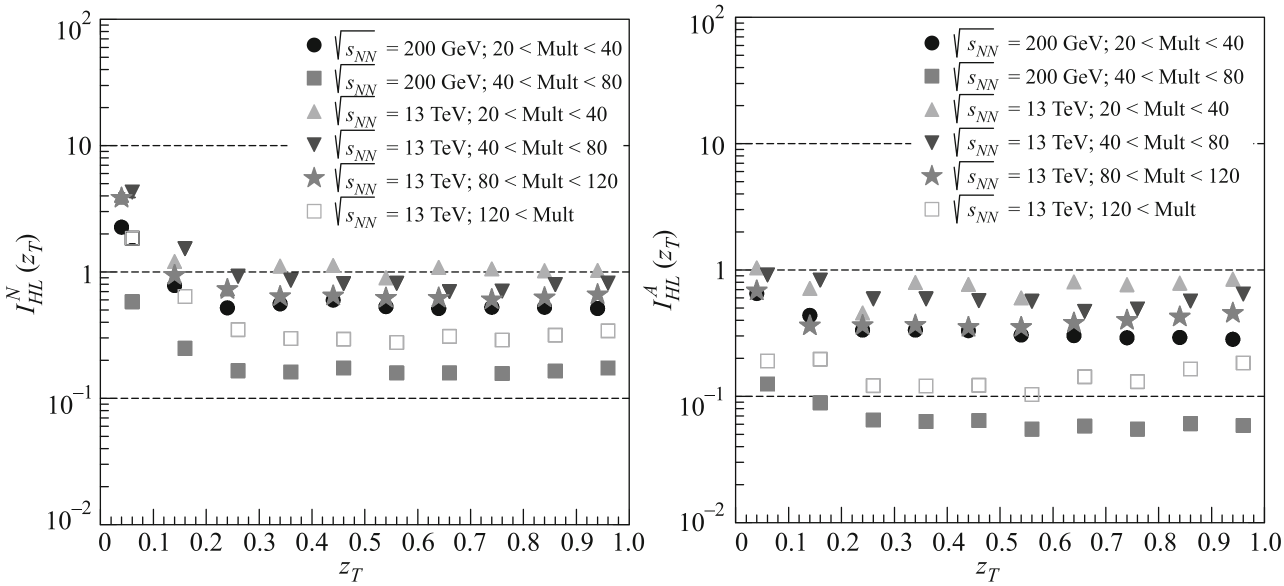

Fig. 1. (Color online) The z_T dependence of (a) I^N_{HL} and (b) I^A_{HL} for different multiplicity at $\sqrt{s_{NN}} = 200\,\text{GeV}$ and $\sqrt{s_{NN}} = 13\,\text{TeV}$

could be used to either rule out or to confirm the multiplicities dependence for the jet quenching commonly adopted observables.

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