Searching for Ring and Jet-like structures for pp collision at LHC Energy

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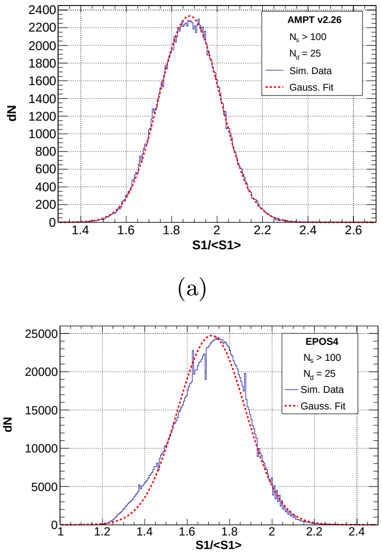
Introduction

Physicists are searching for a deconfined state of quark and gluon, known as quark-gluon plasma (QGP), through relativistic heavy-ion collisions. If this state exists, a probable transition from QGP to the final state of hadronic matter may be manifested through large dynamical fluctuations in produced particles [1]. When a partonic jet travels through the nuclear medium, it generates conical gluonic radiation, which could be a reason for observing such large density fluctuations within narrow intervals of phase space. If the initial parton direction is the same as that of the incident beam direction and the number of gluons, each capable of emitting a minijet is large, one may observe ring-like structures in the distribution of particles that are clustered within a narrow region of pseudorapidity (η), but are distributed more or less uniformly over the entire azimuthal angle (ϕ) range $(0, 2\pi)$. On the other hand, if the number of jet-emitting gluons is small, it is more likely that several jets, each restricted to narrow intervals in both η and ϕ, will be formed, resulting in jet-like structures in the distribution of final state hadrons.

Method of analysis

Here to study ring and jet-like structures we have adopted the method described in Ref.[2]. For an individual event, we start with a fixed number $m\,(< m_s)$ of particles and each m tuple of particles is arranged consicutively along η axis with a size $\Delta\eta = |\eta_{(m+i-1)} - \eta_i|$; $i = 1, \cdots, m_s$ and density $\rho = m/\eta$. Thus all subgroups have the same multiplicity and can easily be compared. The azimuthal structure of a particular subgroup can be parameterized as, $S_1 = -\sum_{i=1}^{m} \ln(\Delta\phi_i)$ and $S_2 = \sum_{i=1}^{m} (\Delta\phi_i)^2$ here ϕ_i is the difference between i^{th} and $(i+1)^{th}$ particles belonging to a particular subgroup. The expection value of the S-parameters $\langle S_1\rangle = m\sum_{k=1}^{m-1}\frac{1}{k}$ and $\langle S_2\rangle = \frac{2}{m+1}$ when the independently emitted particles have no correlation. Presence of jet-like structures would result in a peak to the right of the mean in S_1 and S_2 distributions, whereas for ring structures, the peaks would be to the left of the mean.



(a)

(b)

FIG. 1: Distributions of the $S_1/\langle S_1\rangle$ for pp collisions at $\sqrt{s} = 13$ TeV for (a) AMPT v2.26 and (b) EPOS4.

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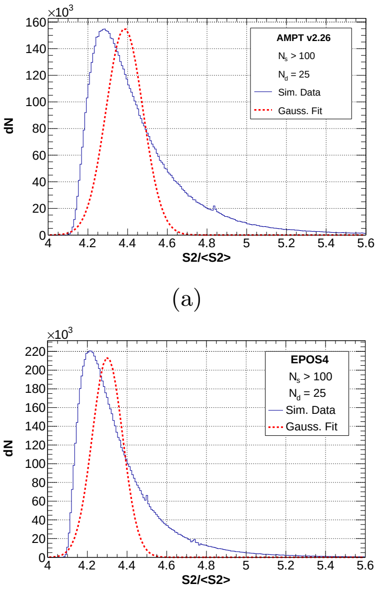
Result and discussion

In this analysis, to study the presence of ring and jet-like structures for *pp* collisions at $\sqrt{s} = 13$ TeV, we have used the data sets of 10^6 events generated by AMPT v2.26 (with string melting) and EPOS4 (with hydro) model. All selected parameters during data generation are adopted for AMPT from Ref.[3] and for EPOS4 from Ref.[4] also for a detailed description of the models, one can go through the same references.

We have chosen events having $m_s > 100$ with the choice of $m = 25$ for both AMPT and EPOS4 generated events and the corresponding stochastic values are $\langle S_1 \rangle \approx 94.4$ and $\langle S_2 \rangle \approx 0.077$. In this case, our focus is on the azimuthal plane. For ring-like emissions, the tracks would be distributed almost isotropically. However, for jet-like events, some of the tracks should be clustered within a narrow ϕ, with each cluster well separated from the others.



(a)

(b)

FIG. 2: Distributions of the $S_2/\langle S_2 \rangle$ for *pp* collisions at $\sqrt{s} = 13$ TeV for (a) AMPT v2.26 and (b) EPOS4.

Distributions of the S_1 parameter normalized by its stochastic expectation value $\langle S_1 \rangle$ for both data sets are plotted in the form of histograms in Fig. 1 and similary the distributions of the S_2 normalized by $\langle S_2 \rangle$ is plotted in Fig.2. Form Fig.1(a) the distribution for AMPT is well fitted with Gaussian but for (b) the distribution for EPOS4 is a little right skewed. Although from Fig.2 the $S_2/\langle S_2 \rangle$ distributions are more or less are similar in nature and quite left skewed with respected to the Gaussian fit. As shown in Ref. [1, 2], a distinction could be made between the ring and jet structure by separately plotting distributions with $S_2/\langle S_2 \rangle < 1$ and $S_2/\langle S_2 \rangle > 1$. More precisely in the region $S_2/\langle S_2 \rangle < 0.95$ ring like effects dominate and in $S_2/\langle S_2 \rangle > 1.1$ jet-like structures dominates whereas the region between 0.95 to 1.1 is the region of statistical background.

But in our analysis, we find that the total distribution of $S_2/\langle S_2 \rangle$ is distributed in the region $S_2/\langle S_2 \rangle > 4.0$ for both AMPT v2.26 and EPOS4 which indicates a stiff presence of jet-like structures in *pp* collisions at $\sqrt{s} = 13$ TeV but no strong indication regarding ring-like structure can be seen from the average behavior of S_1 and S_2 parameters. Our observation in this regard is similar to Ref.[2].

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