PROCEEDINGS OF SCIENCE

Transverse spherocity and multiplicity dependence of R_2 and P_2 correlation functions in pp collisions

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Transverse spherocity(S_0) has evolved as a powerful tool to separate soft and hard contributions in an event in small collision systems. We used two-particle differential-number correlation functions, R_2, and transverse momentum correlation functions, P_2, of charged particles produced in pp collisions at $\sqrt{s}$ = 7 TeV with the PYTHIA model to understand this phenomena. The $\Delta\varphi$-dependance of these correlation functions in different multiplicity and S_0 classes are studied. In addition, mean-p_{T} of charged particles for low-S_0, high-S_0 and S_0-integrated are discussed. Finally, it was observed that S_0 should be a good observable as compared to multiplicity to disentangle jetty and isotropic events in a small collision system.

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1. Introduction

The number correlations (R_2) and momentum correlations (P_2) are sensitive to the particle production mechanisms and transverse momentum fluctuations, respectively. In this work, spherocity and V0M dependent results for R_2 and P_2 for different percentile classes were compared in order to discremenate the hard and soft process contributions in an event.

2. Analysis Details

In this work, the events are selected at mid-rapidity ($|\eta| < 0.8$) with a minimum constraint of 15 charged particles in the p_T range 0.15 - 10 GeV/c in pp collisions at $\sqrt{s}$ = 7 TeV in the PYTHIA8 Color-Reconnection(CR) mode. Observables used in this work are discussed as mentioned below.

2.1 Correlation functions definition

The R_2 and P_2 correlation functions are constructed by using single, $\rho_1(\eta, \varphi)$, - and two, $\rho_2(\eta_1, \varphi_1, \eta_2, \varphi_2)$, - particle densities as a function of relative pseudo-rapidity $\Delta\eta$ $(= \eta_1 - \eta_2)$ and azimuthal angle $\Delta\varphi$ $(= \varphi_1 - \varphi_2)$ [1] .

The R_2 is defined as a two-particle cumulant normalized by the product of single-particle densities as follows

$$R_2(\Delta\eta, \Delta\varphi) = \frac{\rho_2(\Delta\eta, \Delta\varphi)}{\rho_1 \times \rho_1(\Delta\eta, \Delta\varphi)} - 1. \tag{1}$$

while the P_2 is defined as the ratio of differential correlator $\langle \Delta p_T \Delta p_T \rangle$ to the square of the average transverse momentum, p_T, to make it dimensionless like R_2, as follows

$$\begin{aligned} P_2(\Delta\eta, \Delta\varphi) &= \frac{\langle \Delta p_T \Delta p_T \rangle(\Delta\eta, \Delta\varphi)}{\langle p_T \rangle^2} \\ &= \frac{1}{\langle p_T \rangle^2} \times \frac{\int_{p_{T,\min}}^{p_{T,\max}} \mathrm{d}p_{T,1} \mathrm{d}p_{T,2} \rho_2(\vec{p}_1, \vec{p}_2) \Delta p_{T,1} \Delta p_{T,2}}{\int_{p_{T,\min}}^{p_{T,\max}} \mathrm{d}p_{T,1} \mathrm{d}p_{T,2} \rho_2(\vec{p}_1, \vec{p}_2)}. \end{aligned} \tag{2}$$

where $\Delta p_{T,i} = p_{T,i} - \langle p_T \rangle$ and $\langle p_T \rangle$ is the inclusive mean transverse momentum.

P_2 is governed by the momentum of the correlated particles, which is interesting in comparison to R_2 due to angular and transverse momentum ordering in the production of pariticles from jets and hadronic resonance decays.

2.2 Transverse Spherocity

Transverse spherocity, simply known as spherocity, is an event shape observable which is used to distinguish between hard and soft processes. The spherocity [2] is given by

$$S_0 = \frac{\pi^2}{4} \min_{\hat{n}} \left(\frac{\sum_i |\vec{p_{T,i}} \times \hat{n}|}{\sum_i p_{T,i}} \right)^2 \tag{3}$$

where $\hat{n}(n_T, 0)$ is the unit vector which minimizes S_0. S_0 varied from 0 for pencil like jetty events (dijet is dominant due to hard processess), to a maximum of 1 for spherical isotropic events (MPI is dominant due to soft processess) by multiplying $\pi^2/4$.

R_2 and P_2 correlation functions are analysed for ten equal percentile classes in spherocity as well as in V0M in order to better understand the spherocity observable.

3. Results

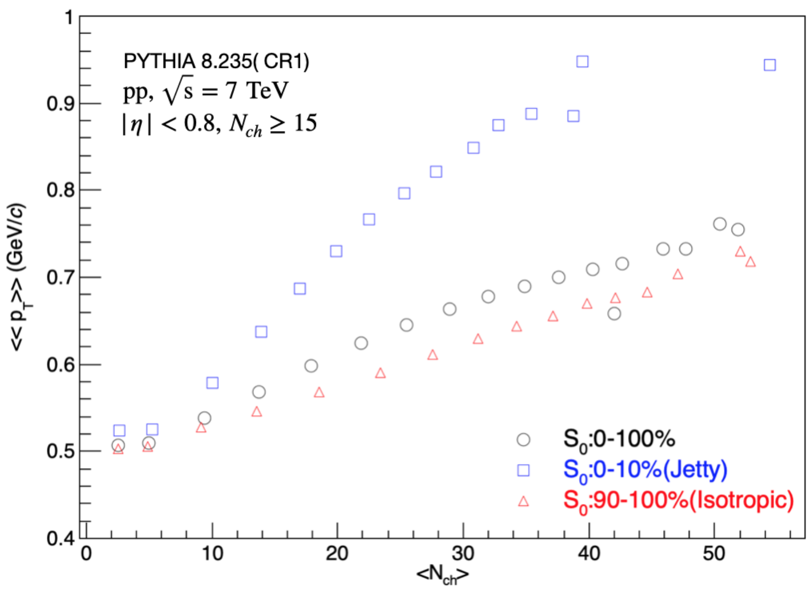

Figure 1: $\langle p_T \rangle$ of charged hadrons as a function of mean charged multiplicity for 0-10%(Jetty) (blue markers), 90-100%(Isotropic) (red markers) and 0-100%(spherocity-integrated) (black markers) classes in pp collisions at $\sqrt{s}$ = 7 TeV using PYTHIA8.

Figure 1 shows the mean-p_T [3] of charged hadrons as a function of mean charged multiplicity for 0-10%(Jetty), 90-100%(Isotropic) and 0-100%(spherocity-integrated) classes. When compared to the spherocity-integrated class, jetty events have a higher mean-p_T, whereas isotropic events have a lower mean-p_T.

Figures 2 and 3 show $\Delta\varphi$ projection of R_2 and P_2 correlation functions, respectively, for different multiplicity classes (left panel) and spherocity classes (right panel). The near-and away-side peak of R_2 and P_2 are more prominent and distinuishable for spherocity classes as compared to multiplicity classes. Again, P_2 has a smaller width than R_2 due to *angular ordering* [4] of the p_T of jet constituents.

4. Summary

The multiplicity and spherocity dependent study of the two-particle differential- number correlation functions R_2, and transverse momentum correlation functions P_2 has been investigated in pp collisions at $\sqrt{s}$ = 7 TeV using QCD based CR mode of PYTHIA8 event generator.The mean-p_T

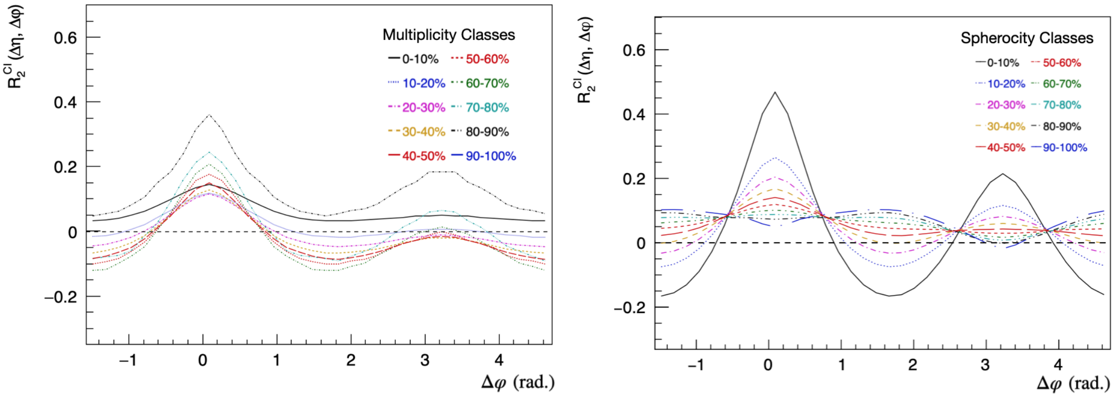

Figure 2: Correlation functions R_2 for multiplicity classes (left panel) and spherocity classes (right panel) of charged hadrons in pp collisions at $\sqrt{s}$ = 7 TeV using PYTHIA8.

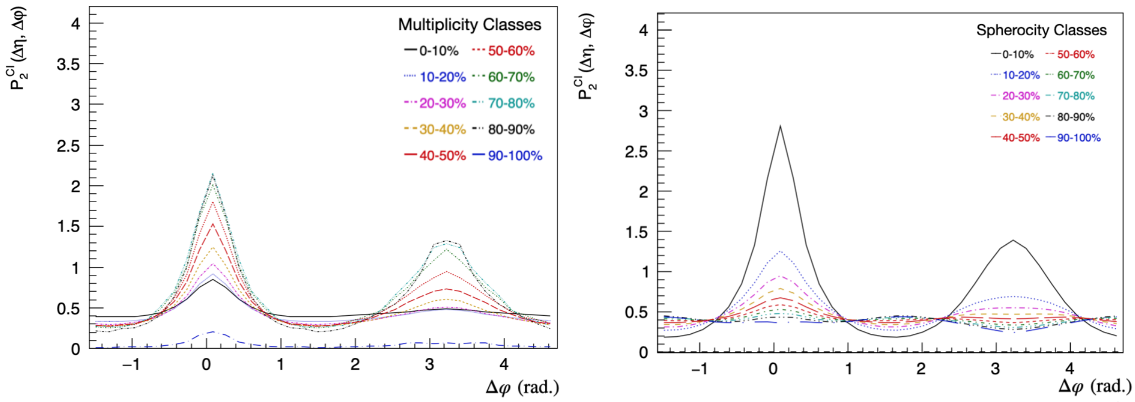

Figure 3: Correlation functions P_2 for multiplicity classes (left panel) and spherocity classes (right panel) of charged hadrons in pp collisions at $\sqrt{s}$ = 7 TeV using PYTHIA8.

of charged hadrons were observed to be higher for most jet-like(0-10%) to isotropic(90-100%) events, as well as spherocity-integrated(0-100%) events. The magnitude of the modulation strongly correlates with spherocity classes as compared to multiplicity classes for both R_2 and P_2.

References

[1] C. Pruneau, S. Gavin, and S. Voloshin, Phys. Rev. **C66**, 044904 (2002).

[2] Banfi, Andrea and Salam, Gavin P. and Zanderighi, Giulia, **JHEP 038**, 2010.

[3] S. Adler et al. (PHENIX Collaboration), Phys. Rev. **C71**, 034908 (2005).

[4] B. Sahoo, B.K. Nandi, P. Pujahari, S. Basu and C. Pruneau, Phys. Rev. **C100**, 024909 (2019).