Forward Backward multiplicity correlations in pp interactions at $\sqrt{s} = 0.9, 2.76, 7.0$ and 13.0 TeV

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Abstract

Forward-backward (FB) multiplicity correlations are investigated by analyzing the Monte Carlo simulated data corresponding to pp collisions at LHC energies and the findings are compared with those reported using the real data. Such a study would be an attempt to distinguish between various theoretical models and identify the model describing the features of the experimental data nicely. Monte Carlo event samples, each (comprising of 10^6 events) corresponding to pp collisions at 0.9, 2.76, 7.0 and 13.0 TeV are simulated using the codes AMPT-v1.21-v2.21 and HIJING-1.35. The dependence of the FB correlation coefficient, b$_{corr}$, on the pseudorapidity window width ($\Delta\eta$) and position (η_{sep}) in full and limited azimuthal acceptance are looked into. It is observed that the b$_{corr}$ decreases with increasing η_{sep}, whereas an increase of b$_{corr}$ with $\Delta\eta$ is seen. The findings also reveal that for a given width and separation, b$_{corr}$ increases with increasing collision energy which can not be explained exclusively by the increase of average particle multiplicities within the windows. It is observed that the values of b$_{corr}$ predicted by AMPT are closer to those estimated with the real data while HIJING predicted b$_{corr}$ values are significantly smaller. Furthermore, the strength of correlation is estimated in various configurations of two azimuthal sectors selected within the symmetric η-windows. Such an azimuthal cut is applied because of the idea that measurement of the FB multiplicity correlations between two small windows separated in pseudorapidity and azimuthal angle represents the two distinct contributions, coming from the short-range and the long-range correlations.

Introduction

Forward-Backward (FB) multiplicity correlations among the relativistic charged particles produced in different pseudorapidity, η bins are considered as a powerful tool for understanding the underlying mechanism of multiparticle production in hadron-hadron (hh), hadron-nucleus (hA) and nucleus-nucleus (A-A) collisions[1,2]. It has been reported[3] that the inclusive two particle correlations have two components: the short-range correlations (SRC) and the long-range correlations (LRC)[3,4]. The SRC have been observed to be localized over a region, $\eta \pm 1.0$ unit around mid-rapidity. Such correlations are expected to arise from the decay of resonances and (or) clusters and jet/mini-jet induced correlations[4]. On the other hand, LRC are expected to extend over a relatively longer range($>$2 units of η). These correlations are envisaged to arise due to event-by-event (ebe) fluctuations of overall partilce multiplicity. After the availability of the experimental data from the LHC, attempts were made to examine the particle correlations at LHC energies. A comparison of these available results with the predictions of various Monte Carlo models would provide interesting conclusions regarding the particle production. Therefore, the investigation of correlations between various observables, measured in two different, sufficiently separated η-intervals, is considered to be a powerful tool for the exploration of the initial conditions of hadronic interactions[5].

Details of Data

- Monte Carlo events samples (10^6 events) corresponding to LHC energies $\sqrt{s}$ = 0.9, 2.76, 7.0 and 13.0 TeV are simulated using codes AMPT-v1.21-v2.21 and HIJING-1.35.
- Events with n$_{ch} \geq 10$ are selected for the analysis.
- Pseudorapidity cut used: $0.8 \leq \eta_c \leq +0.8$
- p$_T$ cut used: $0.3 <$ p$_T < 1.5$ GeV/c

Formalism

F-B correlations are investigated by examining the linear dependence of mean charged particle multiplicity in the backward(B) hemisphere, $< n_b >$ on the multiplicity of the particles emitted in the forward (F) hemisphere, n$_f$:

$$< n_b >= a + b_{corr} \cdot n_f$$

For symmetric FB regions:

$$b_{corr} = \frac{< n_b n_f > - < n_b >< n_f >}{< n_f^2 > - < n_f >^2} = \frac{D_{bf}^2}{D_{ff}^2}$$

where D$_{ff}$ and D$_{bf}$ denote the forward-forward and backward-forward dispersions, respectively.

Results & Discussion

Dependence of b$_{corr}$ on $\Delta\eta$

η distributions of charged particles is divided into two parts with respect to its centre of symmetry, η_c. The region having values $\eta < \eta_c$ is referred to as the backward (B) region while the region having $\eta > \eta_c$ is termed as forward (F) region. The number of charged particles emitted in F and B regions, n$_f$ and n$_b$ are counted on event-by-event (ebe) basis varying η_{sep}. In order to examine the F-B correlation strength in η- windows of different widths, two small windows each of width $\Delta\eta = 0.2$ are placed adjacent to each other with respect to η_c such that the charged particles having η values in the range $\eta_c \leq \eta < \eta_c + \Delta\eta$ are counted as n$_f$ while those having their η values lying in the interval $\eta_c > \eta \geq \eta_c - \Delta\eta$ are counted as n$_b$ and the value of correlation strength, b$_{corr}$ is computed. The width, $\Delta\eta$ is then increased in step of 0.2 until almost entire η region is covered. Variations of b$_{corr}$ with $\Delta\eta$ for the MC and experimental data[4] are shown in Fig.1. It may be noted from the figure that the correlation coefficient increases non-linearly with $\Delta\eta$ for all collision energies.

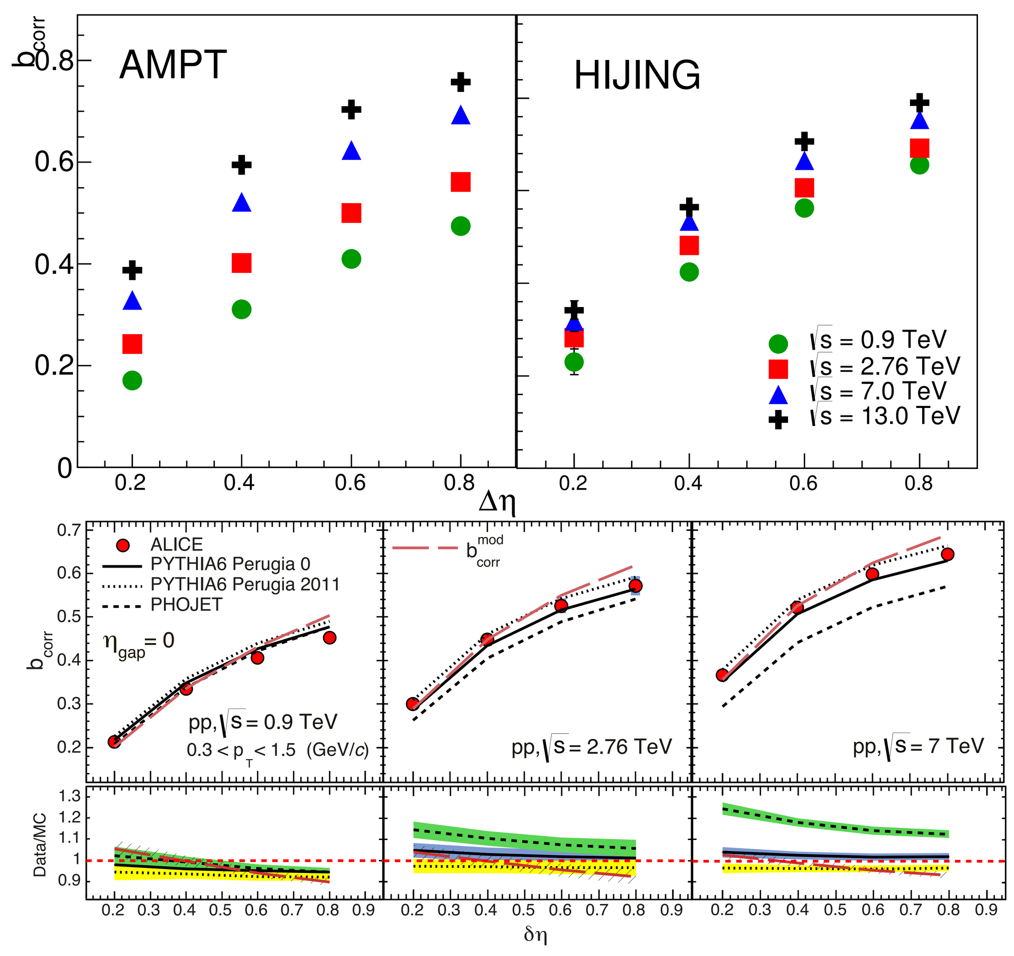

Figure 1: Variation of b$_{corr}$ as a function of $\Delta\eta$ for η_{sep}=0 in pp collisions at $\sqrt{s}$ = 0.9, 2.76, 7.0 and 13.0 TeV for the AMPT and HIJING(top) and for the real data(bottom); fig. have their ref.[4].

Dependence of b$_{corr}$ on η_{sep}

In order to check the presence of LRC, windows of equal width, $\Delta\eta$ are placed in F and B regions such that they are separated by equal distances η_{sep}, (in η units) with respect to η_c. The window width is then increased in steps of 0.2 till the region η-region considered is covered. The values of b$_{corr}$ for each η_{sep} are computed and the variations of b$_{corr}$ with η_{sep} for AMPT data seta at different energies are plotted in Fig.2 for the window widths = 0.2, 0.4, 0.6 and 0.8. Similar trends of variations of b$_{corr}$ with η_{sep} are also observed with the HIJING simulated events at different energies. These findings are similar to those observed[4] with the real data. It may be observed from Fig.2 that, the FB correlation strength decreases slowly with increasing η_{sep}, while maintaining a substantial pedestal value throughout the full η_{sep}. Moreover, the pedestal value of b$_{corr}$ increases with $\sqrt{s}$, while the slope of the b$_{corr}$ on η_{sep} does not affect. This indicates that the contribution of the short-range correlations has a very weak $\sqrt{s}$-dependence, while the long-range multiplicity correlations play a dominant role in pp collisions and their strength increases with collision energy.

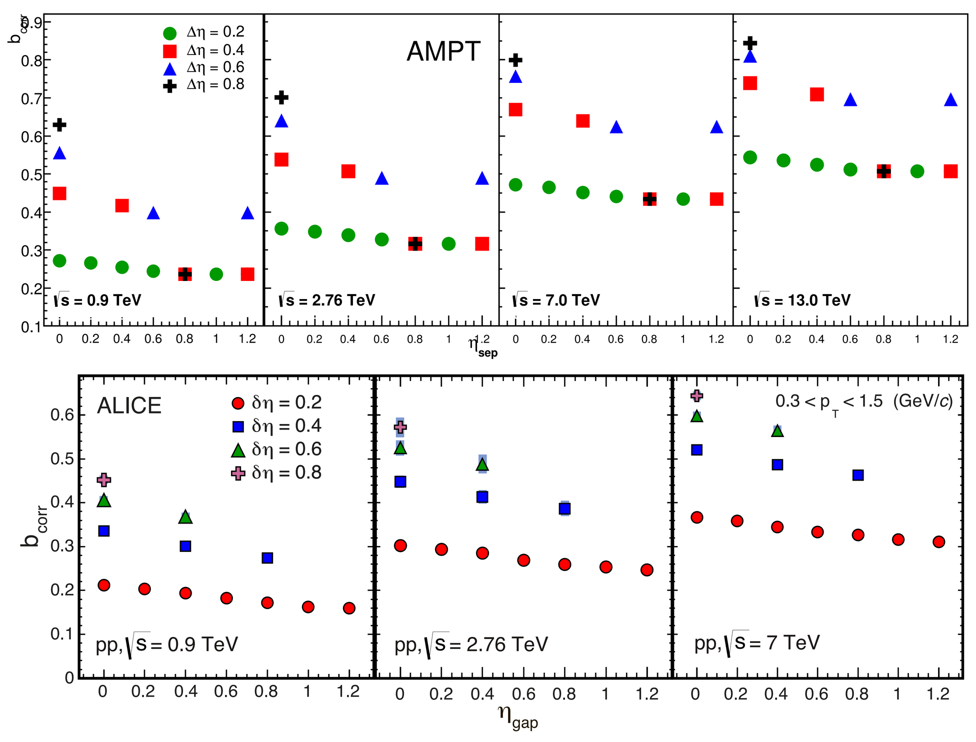

Figure 2: Value of b$_{corr}$ with η_{sep} for windows widths $\Delta\eta$ = 0.2, 0.4, 0.6 and 0.8 at $\sqrt{s}$ = 0.9, 2.76, 7.0 and 13.0 TeV are compared with ALICE results[4].

Dependence of b$_{corr}$ in windows separated in pseudorapidity and azimuth

Multiplicity correlations are also studied in different configurations of forward and backward azimuthal sectors. These sectors are chosen in separated forward and backward pseudorapidity windows of width $\Delta\eta$=0.2 and $\Delta\Phi = \pi/4$, resulting in 5 pairs i.e. Φ_{sep} = 0, $\pi/4$, $\pi/2$, $3\pi/4$ and π. Fig.3 shows the azimuthal dependence of b$_{corr}$ as a function of different η_{sep}, for the AMPT and HIJING at 13.0 TeV, respectively. The findings are compared with the experimental result obtained in pp collisions at 7.0 TeV. It has been reported[4] that the correlation strength for various configurations of azimuthal sectors enable the distinction of two contributions: short-range (SR) and long-range (LR) correlations. A weak dependence on the collision energy is observed for the SR component while the LR component has a strong dependence. This trend of variation is not supported by the AMPT and HIJING model.

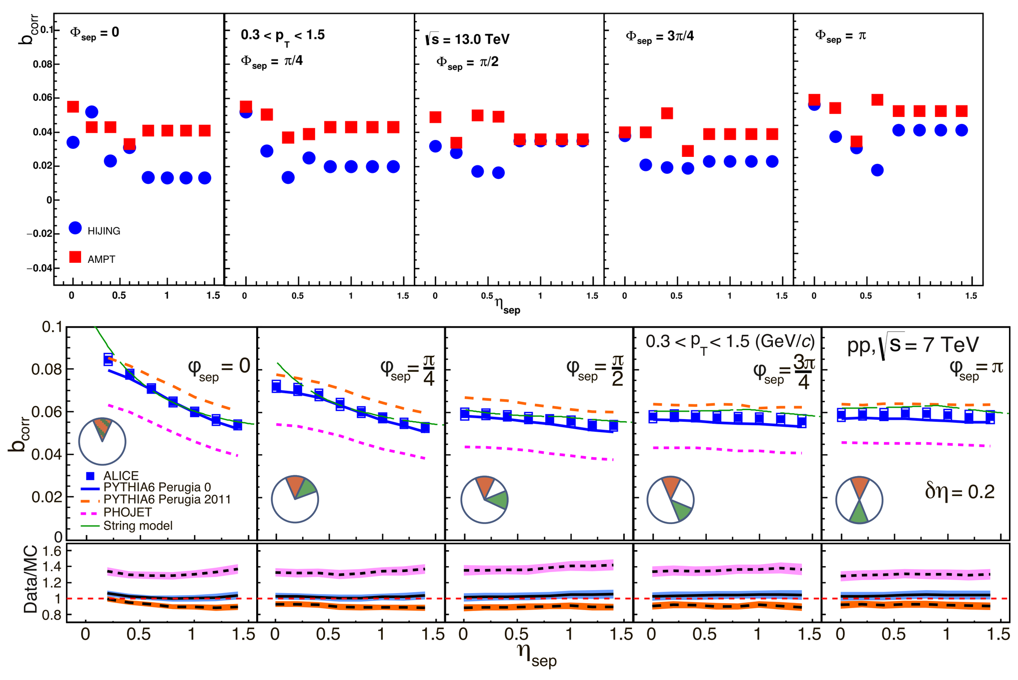

Figure 3: Correlation strength b$_{corr}$ for separated η-Φ window pairs at $\sqrt{s}$ = 13.0 TeV as a function of η_{sep}, with fixed window width $\Delta\eta$=0.2 and $\Delta\Phi$=π/4 for AMPT and HIJING. The results are compared with thw $\sqrt{s}$ = 7TeV pp data[4].

Conclusions

- Strong non-linear dependence of the FB multiplicity correlation coefficient on the width of the pseudorapidity windows is observed.
- A considerable increase of the FB correlation strength is observed with the increase in collision energy from $\sqrt{s}$ = 0.9, 2.76, 7.0 and 13.0 TeV.
- The correlation strength for various configurations of azimuthal sectors enable weak dependence on the collision energy for the SRC component while the LRC component has a strong dependence.
- The MC event generators AMPT and HIJING are able to describe the general trends of b$_{corr}$ as a function of $\Delta\eta$, η_{sep} and Φ_{sep} and its dependence on the collision energy. However, HIJING predicts somewhat smaller values as compare to AMPT.

References

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