Monte-Carlo study of long-range correlations of average transverse momentum and multiplicity for strange particles in pp-collisions at the LHC energies

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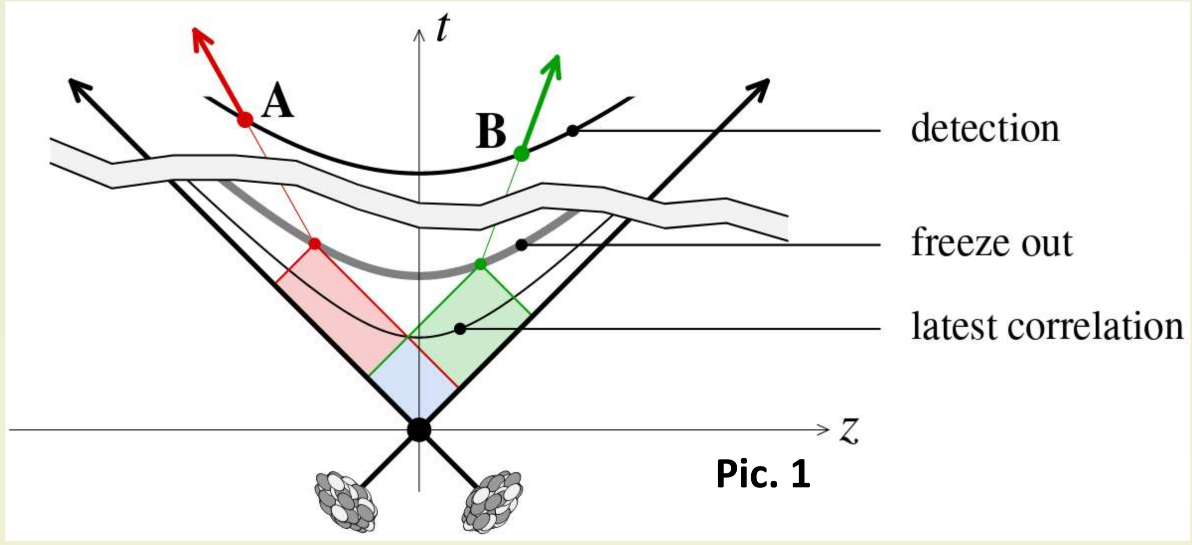
MOTIVATION

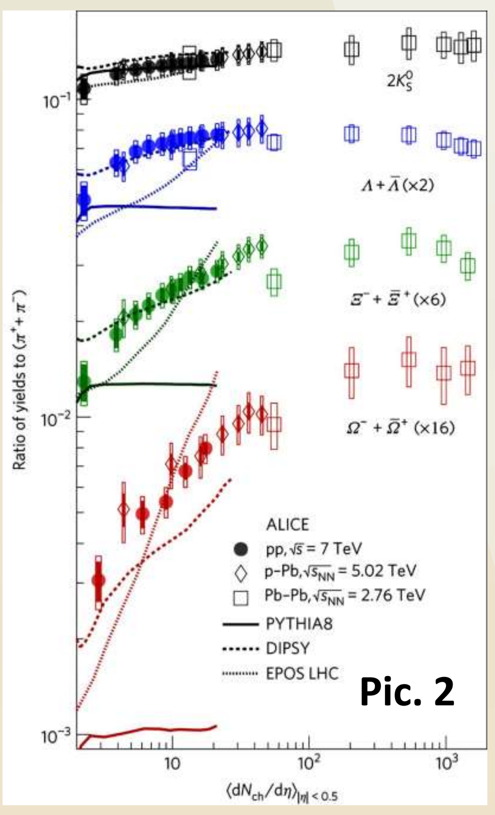
One of the main reasons of increasing interest to study high-energy pp-collisions is recently obtained enhancement of strange particles yield – the signal of the possible formation of quark-gluon plasma (QGP) [5] (pic. 2). We can get the explanation of this phenomena by the concept of color strings (tubes of color fields) stretched between the partons of the projectile and the target is one of the model approaches to describe the processes of multiparticle production in high energy hadron collisions. The observed particles are produced due to the decays (hadronization) of these strings. In case of high density, the color strings can overlap and interact with each other [1, 2]. As a result of this interaction in the form of fusion the increase of the average transverse momentum ($\langle p_T \rangle$) and the decrease of multiplicity (n) of particles produced in a single collision are expected [1, 2] along with the enhancement of strange particles yield. The experimental observation of the systems of interacting color string as a system, preceding QGP formation, are extremely interesting.



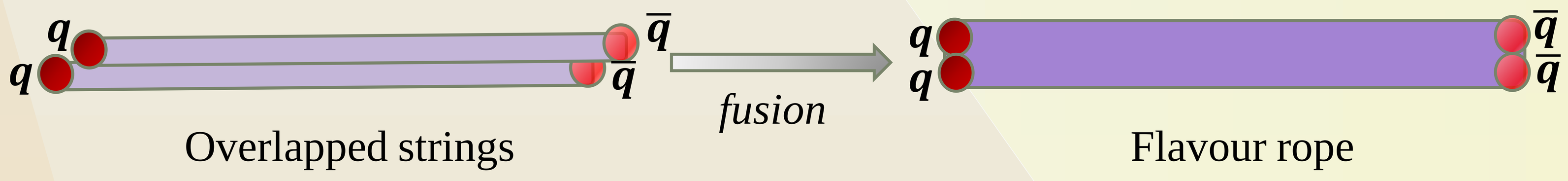
Pic. 1

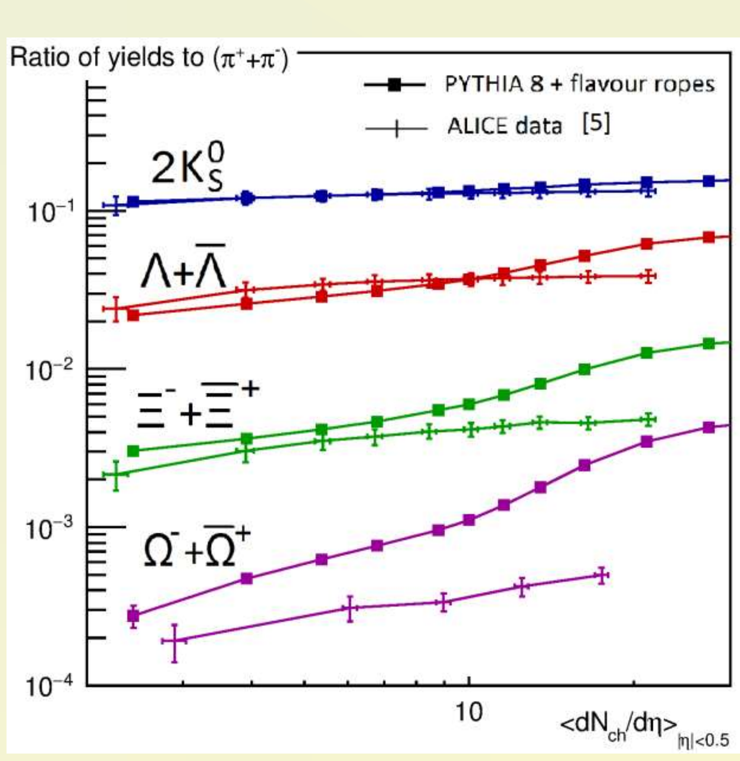
The space-time picture of color string hadronization [4].

FLAVOUR ROPES AND PYTHIA 8

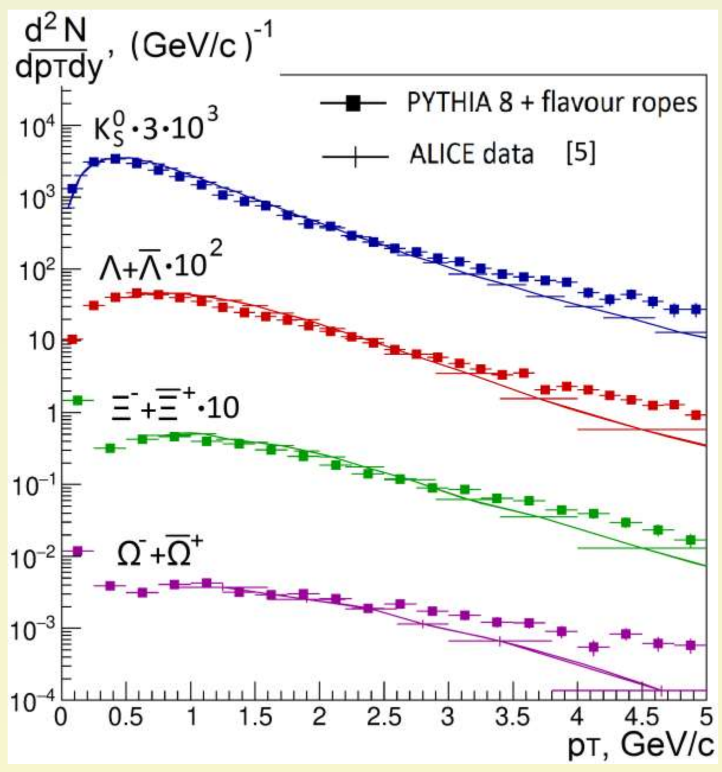

Pic. 2

We use long-range correlations (LRC) [1, 2] between $\langle p_T \rangle$ and n in two separated pseudorapidity intervals as the main tool to study the initial state color string fusion phenomena in the framework of Monte-Carlo event generator PYTHIA 8 [3]. *PYTHIA 8 event generator was modified recently to describe this phenomena by using an implementation of formation of a so-called “flavour rope”* (actually, these “flavor ropes” are the same objects as fused strings in the model of color strings fusion), which hadronize with a larger, effective string tension [6-8], providing the increase of strangeness yield.





Pic. 3



Pic. 4

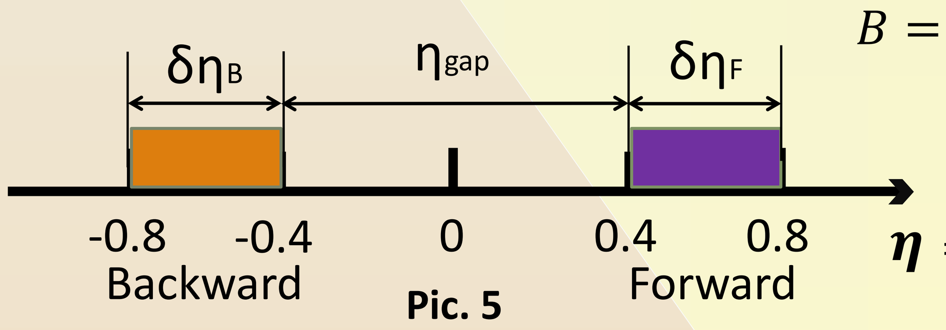
OBSERVABLES AND DETAILS OF ANALYSIS

LRC are usually measured between observables obtained in an event-by-event analysis in two separated (pseudo)rapidity intervals. In the present work, we study different types of correlations for n and $\langle p_T \rangle$ observables of the certain group of particles, calculated in a single event in one of the pseudorapidity windows, with the particles in the other pseudorapidity window.

The strength of the LRC coefficient b_{corr} between observables in forward and backward pseudorapidity windows is determined by the expression (1):

$$b_{corr} = \frac{\langle FB \rangle - \langle F \rangle \langle B \rangle}{\langle F^2 \rangle - \langle F \rangle^2}$$

$$F = \begin{cases} n_F \\ \langle p_T \rangle_F = \frac{\sum_{i=1}^{n_F} p_T^{(i)}}{n_F} \end{cases} \qquad B = \begin{cases} n_B \\ \langle p_T \rangle_B = \frac{\sum_{i=1}^{n_B} p_T^{(i)}}{n_B} \end{cases}$$

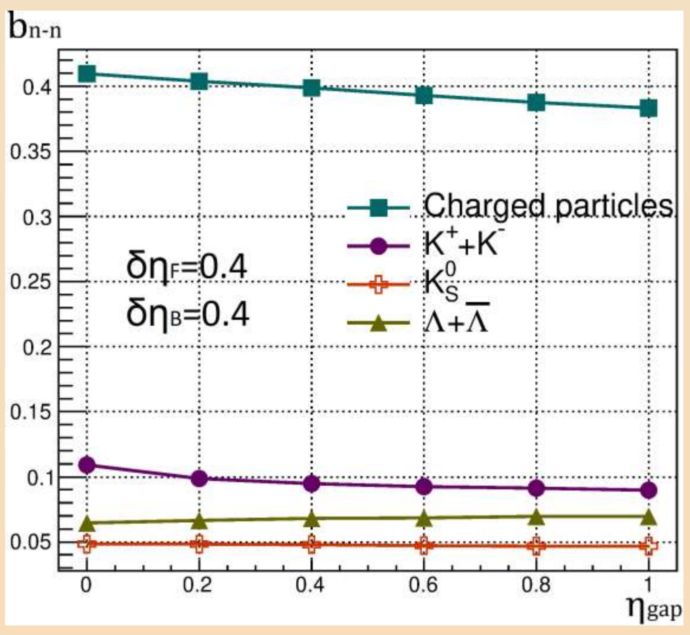


Pic. 5

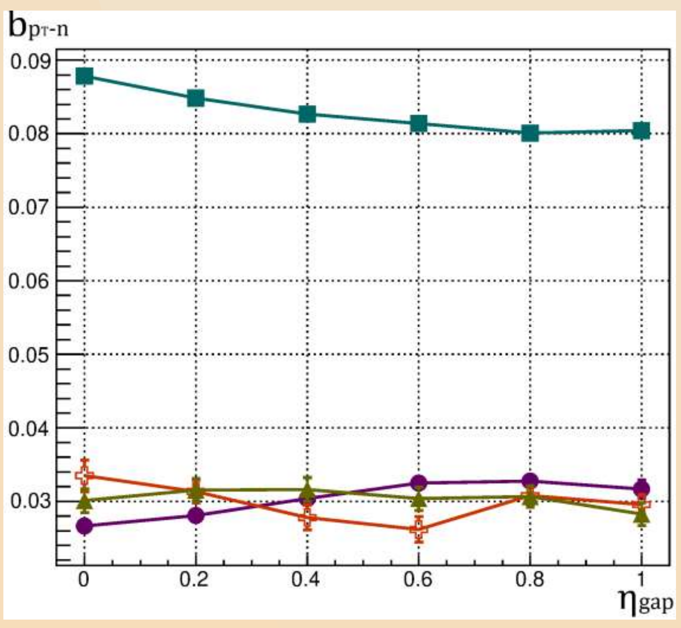
$$\eta = \frac{1}{2} \ln \frac{|\vec{p}| + p_z}{|\vec{p}| - p_z}$$

In this study, LRC are measured in pp-collisions at $\sqrt{s} = 7$ TeV simulated with PYTHIA 8 event generator. We consider particles produced on processes of inelastic scattering only. The number of generated events – $4{\times}10^6$. The considered groups of particles: charged particles, K_S^0 -mesons, $(K^{+}{+}K^{-})$ -mesons and $(\Lambda + \bar{\Lambda})$-hyperons.

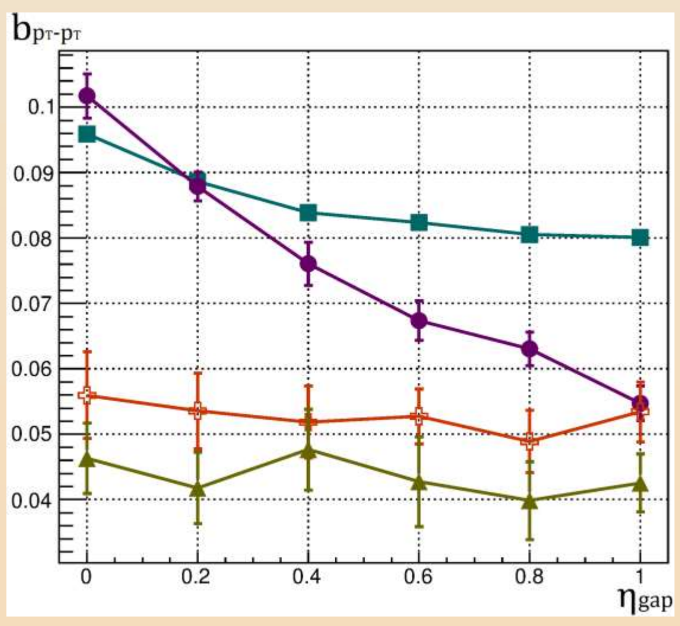
LRC COEFFICIENTS – η_{gap} DEPENDENCE



Pic. 6



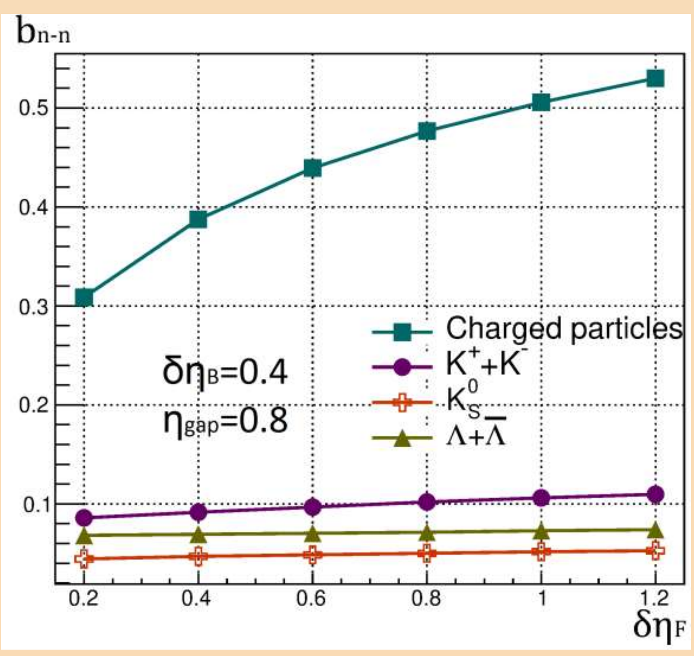
Pic. 7



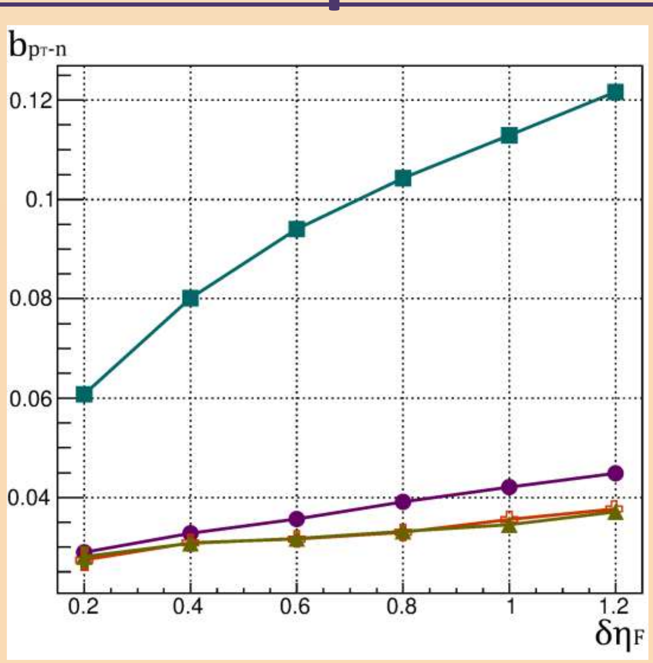
Pic. 8

For all considered types of particles, positive LRC coefficients are observed. The LRC coefficients of strange particles are substantially smaller than the LRC coefficients of charge particles, which is probably due to the fact that *strange particles are emitted mainly by the new type of sources, namely by a flavour ropes* (e.g. fused strings). Also unlike charged particles, the LRC coefficients of strange particles depend on η_{gap} negligibly, that means a small yield of strange particles in processes-contributors of short-range correlations (resonance decays, jet formation and other). *The only one exception is $b_{p_T - p_T}$ of charged kaons (pic. 8), which behavior is significantly different* (this phenomenon requires additional study).

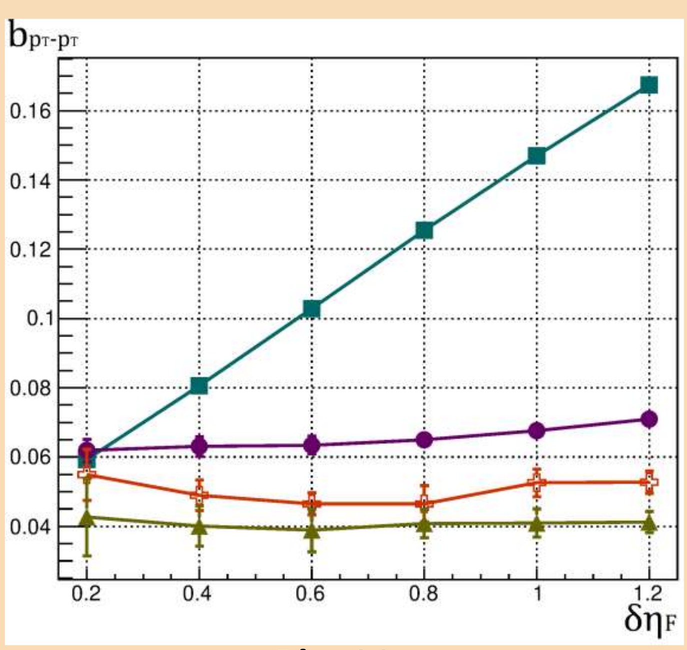
LRC COEFFICIENTS – $\delta\eta_F$ DEPENDENCE



Pic. 9



Pic. 10



Pic. 11

The behavior of the LRC coefficients of strange and charged particles is also noticeably different. While the LRC coefficients of charged particles depend on $\delta\eta_F$ strongly, in case of strange particles this dependence is much weaker. This is due to the fact that the yield of a strange particle in high-energy pp-collisions is much less than the yield of charged particles (see pic. 2, 3). Hence, increasing of pseudorapidity windows width for strange particles does not lead to significant increase of the amount of considered particles and, hence, does not change correlations coefficients strongly.

CONCLUSIONS

- The implementation of “flavour ropes formation” mechanism into PYTHIA 8 gives us an enhancement of yield of strange particles, which is observed in experiments;
- The positive LRC coefficients are observed for all considered types of particles;
- The dependence of LRC coefficients on η_{gap} and $\delta\eta_F$ for strange particles are significantly different. That fact is probably due to the fact that strange particles are emitted mainly by the new type of sources – a flavour ropes;
- Unexpected strong dependence of $b_{p_T - p_T}$ of charged kaons on η_{gap} is to be investigated further.

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