Nuclear physics
Heavy ion physics

Correlations between multiplicities and transverse momenta in nucleus-nucleus collisions from model with cluster of fused color strings

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It's me!

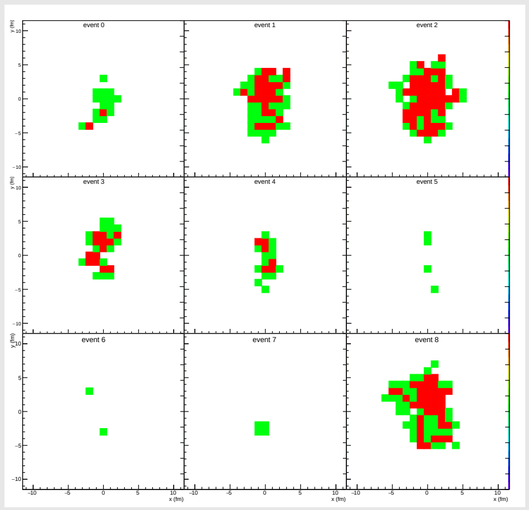
Abstract

The long-range rapidity correlations between the multiplicities (n-n) and the transverse momentum and the multiplicity (p_T-n) of charge particles are analyzed in the framework of the simple string inspired model with two types of sources. The sources of the first type correspond to the initial strings formed in a hadronic collision. The sources of the second type imitate the appearance of the emitters of a new kind resulting from interaction (fusion) of the initial strings. The model enabled to describe effectively the influence of the string fusion effects on the strength both the n-n and the p_T-n correlations. Modification of the model to the analogue of the "core-corona" mechanism allows to take into account event selection criteria based on centrality and perform a comparison with existing experimental data on correlation measurements in nucleus-nucleus collisions at LHC energies. It is shown that string fusion effects leads to change of a sign of the p_T-n correlation coefficient with decrease of a centrality interval width.

Toy model description

- Generation of nucleons within two nuclei and partons within nucleons.
- Formation of quark-gluon strings [1,2] - particle sources - via parton-parton interactions [3].
- Strings interaction in a high density region of the transverse plane [4,5].
- The transverse plane is split into cells, a cell with the number of strings larger than a threshold value - a "core", less than this threshold value - a "corona" [6]. It is assumed that strings are interacting in the core and are independent in the corona.
- Independent Poissonian particle production from the core and the corona. All the produced particles are identical.

Core-corona



Examples of the core (red)-corona (green) configurations

List of parameters

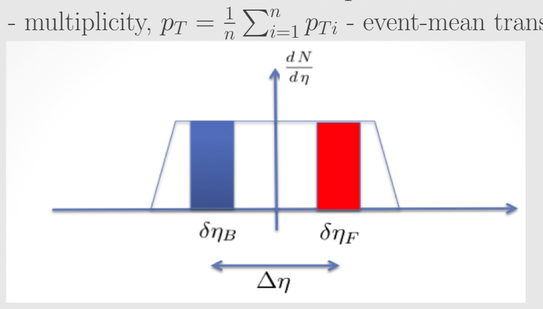
- Nuclei: Pb^{208}, the Woods-Saxon radius is 6.62 fm, $a = 0.546$ fm.
- Collision energy 2.76 TeV.
- Partons are spread in the transverse plane with the 2D-Gauss law with $\sigma_{xy} = 0.4$ fm.
- Number of partons in a nucleon is generated according to the Poisson distribution with the mean value of 10.
- Interaction of partons for distances smaller than 0.35 fm.
- Pseudorapidity window size - 0.5.
- Mean multiplicity in observation window from one string 0.5, from cell with w interacting strings $0.5 \cdot \sqrt{w}$ [4].
- Mean transverse momentum of particles in observation window from one string 0.3 GeV/c, from cell with w interacting strings $0.3 \cdot \sqrt[4]{w}$ GeV/c [4].
- Threshold value of strings number in a cell for core-corona separation is 5.
- Mean multiplicity in full V0 acceptance from one string 2.58, from cell with w interacting strings $2.58 \cdot \sqrt{w}$ [4].

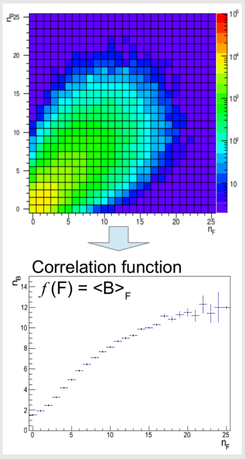
Forward-backward correlations

We consider two types of correlations between observables in two separated pseudorapidity intervals:

- $b^{rel}_{n-n} = \frac{\langle n_F \rangle}{\langle n_B \rangle} \cdot \frac{\langle n_F n_B \rangle - \langle n_F \rangle \langle n_B \rangle}{\langle n_F^2 \rangle - \langle n_F \rangle^2}$
- $b^{rel}_{p_T-n} = \frac{\langle n_F \rangle}{\langle p_{TB} \rangle} \cdot \frac{\langle n_F p_{TB} \rangle - \langle n_F \rangle \langle p_{TB} \rangle}{\langle n_F^2 \rangle - \langle n_F \rangle^2}$

Here, n - multiplicity, $p_T = \frac{1}{n}\sum_{i=1}^{n} p_{Ti}$ - event-mean transverse momentum.





We select observational windows to be separated so that short-range correlation effects (resonance decays, Coulomb interaction, Bose-Einstein correlations etc.) can be ignored.
Correlations in this model arise from fluctuations in the number of strings and in the fraction of core/corona cells. Moreover, p_T-n correlations are present only when there are both core and corona cells.

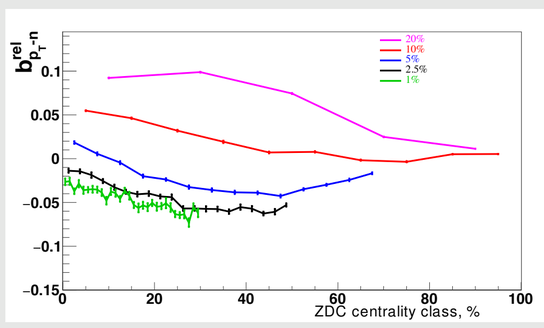
Experimental centrality estimators

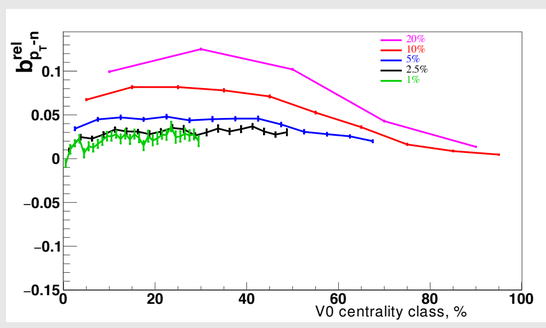
Experimentally correlations are studied in classes of events characterized by different centralities. As an impact parameter is inaccessible, estimators based on multiplicity or energy in some experimental acceptance are considered.
In the ALICE experiment these estimators are [3]

- V0 signal (multiplicity type estimator)
- ZDC signal (energy of nucleons spectators type estimator)

In order to mimic these selection criteria we generate a number of particles that are produced within V0 acceptance region and count number of nucleons-spectators that should hit ZDC detectors event-by-event.

Results: p_T-n correlations

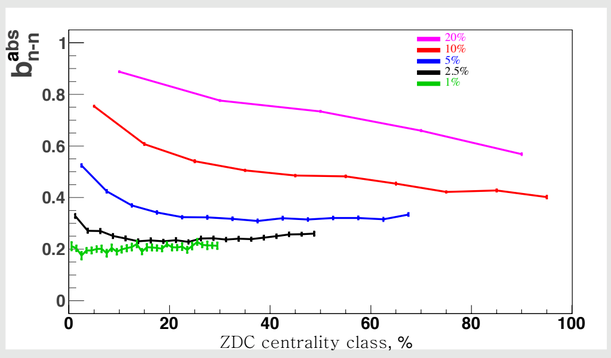


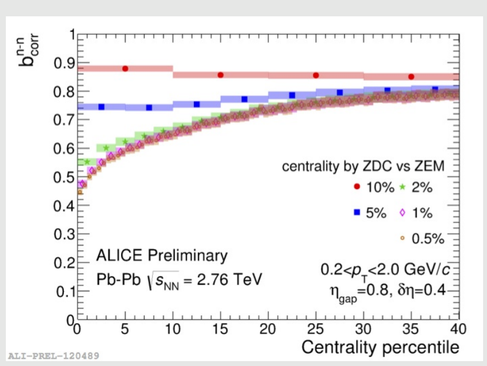


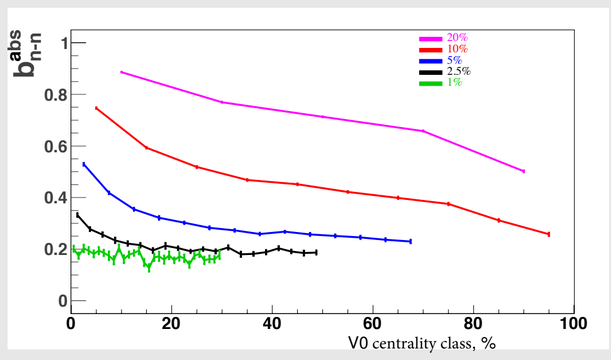
Transition from the negative values of the correlation coefficient for narrow centrality class to the positive values for broad is predicted in both cases.

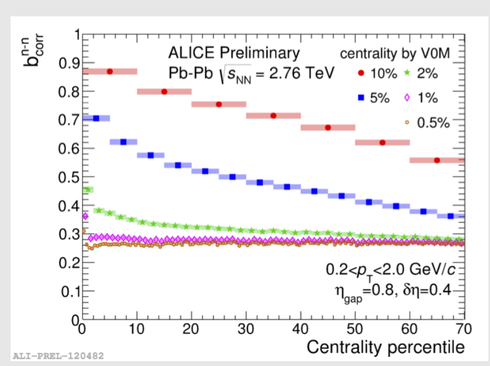
Results: n-n correlations

Model | Experiment | Model | Experiment









1) Different centrality dependence for different estimators 2) Decrease of correlation coefficient with decrease of centrality interval width 3) Qualitative agreement with data 4) Some discrepancy can be seen for ZDC case, it can be caused by not taking into account resolution of ZDC detectors.

References

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Conclusions and acknowledgement

Predictions for (n-n) and (p_T-n) correlation coefficients were made within the model with interacting quark-gluon strings. Qualitative agreement with available experimental data on (n-n) is observed.

It was shown that centrality estimation procedure significantly modify correlation coefficients, especially in (p_T-n) case.

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