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Estimation of non-femtoscopic effects in p+p and p+A collisions at RHIC energies using PYTHIA and HIJING generators

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Abstract

The spatial extents of particle emission source in high-energy collisions can be measured using two-particle femtoscopic correlations. In collisions with small multiplicities, such as proton-proton collisions, correlation functions can be distorted by non-femtoscopic effects, for example due to the correlations that caused by energy-momentum conservation laws, jets and mini-jets. To estimate these effects, a simulation of p+p collisions at $\sqrt{s}$=200 and $\sqrt{s}$=510 GeV using PYTHIA 6.4.28 and HIJING 1.383, and p+Au collisions at $\sqrt{s_{NN}}$=200 GeV using HIJING were performed. Charged pion and kaon correlation functions obtained from the Monte Carlo generators and their comparison to the experimental data are presented.

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1. Introduction

The spatio–temporal structures of particle emitting source in high-energy collisions are essentially defined by the dynamics of the collision processes [1]. The femtoscopy method allows to measure the spatial and temporal characteristics of emitting region in high-energy collisions. Such correlations arise from the quantum statistics, Coulomb and strong final state interactions.

In small system collisions, such as p+p collisions, Bose-Einstein correlations can be distorted by non-femtoscopic effects, for example, due to the correlations that caused by energy-momentum conservation laws, jets and mini-jets.

In this proceeding, estimation of jets (mini-jets) contribution to the correlation function of pions and kaons in p+p $\sqrt{s}$=200 and $\sqrt{s}$=510 GeV, and p+Au $\sqrt{s_{NN}}$=200 GeV collisions using PYTHIA 6.4.28 [2] and HIJING 1.383 [3] Monte-Carlo generators is presented.

2. Femtoscopy

The method of femtoscopy is created to measure the space-time extents of the particle emitting region at kinetic freeze-out. It is based on measurements of identical particle quantum statistical correlations. The femtoscopic correlations are calculated as a function of relative momentum, expressed as $Q_{inv} = |\mathbf{p_1} - \mathbf{p_2}|$. In order to estimate the particle emitting source parameters, one uses the correlation function, $C(Q_{inv})$ which is constructed as:

$$C(Q_{inv}) = \frac{A(Q_{inv})}{B(Q_{inv})}, \tag{1}$$

where $A(Q_{inv})$ is a distribution of two-particle relative momentum that contains quantum statistical correlations, and $B(Q_{inv})$ is the reference distribution that has all experimental effects as the first one except for the absence of the Bose-Einstein correlations.

One can study the dynamics of the collision evolution via measurement of the pair transverse momentum ($k_T = \frac{|\mathbf{p_{1T}} + \mathbf{p_{2T}}|}{2}$) dependence of the correlation function [4].

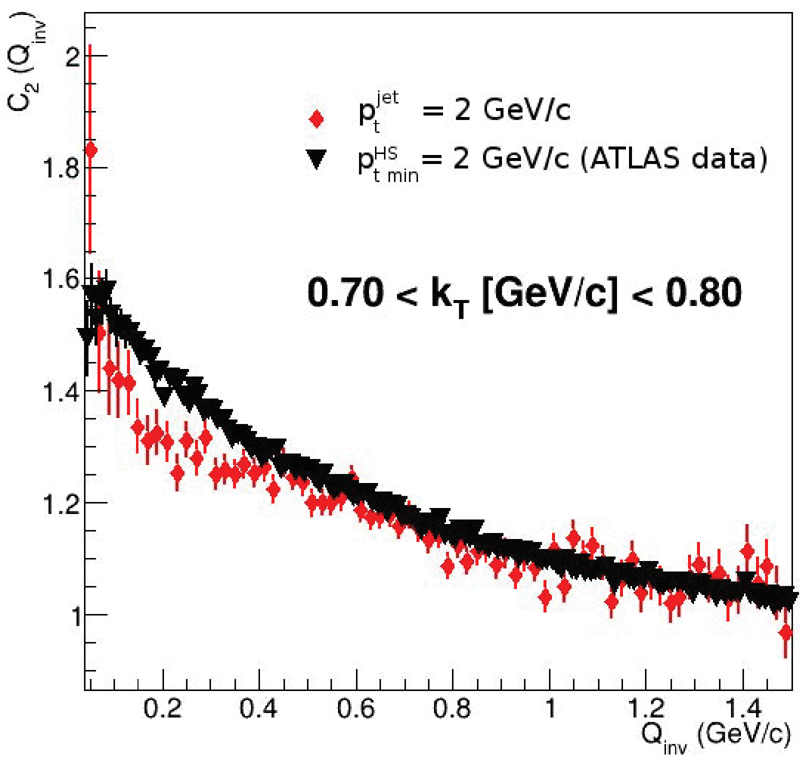

Figure 1: (Color online) Comparison of charged particle correlation functions obtained by the ATLAS Collaboration (black triangles) and in this analysis (red rhombus) from HIJING with transverse momentum $0.7 < k_T < 0.8$ GeV/c, using events with a generated multiplicity $26 < N_{trk} < 36$ [5].

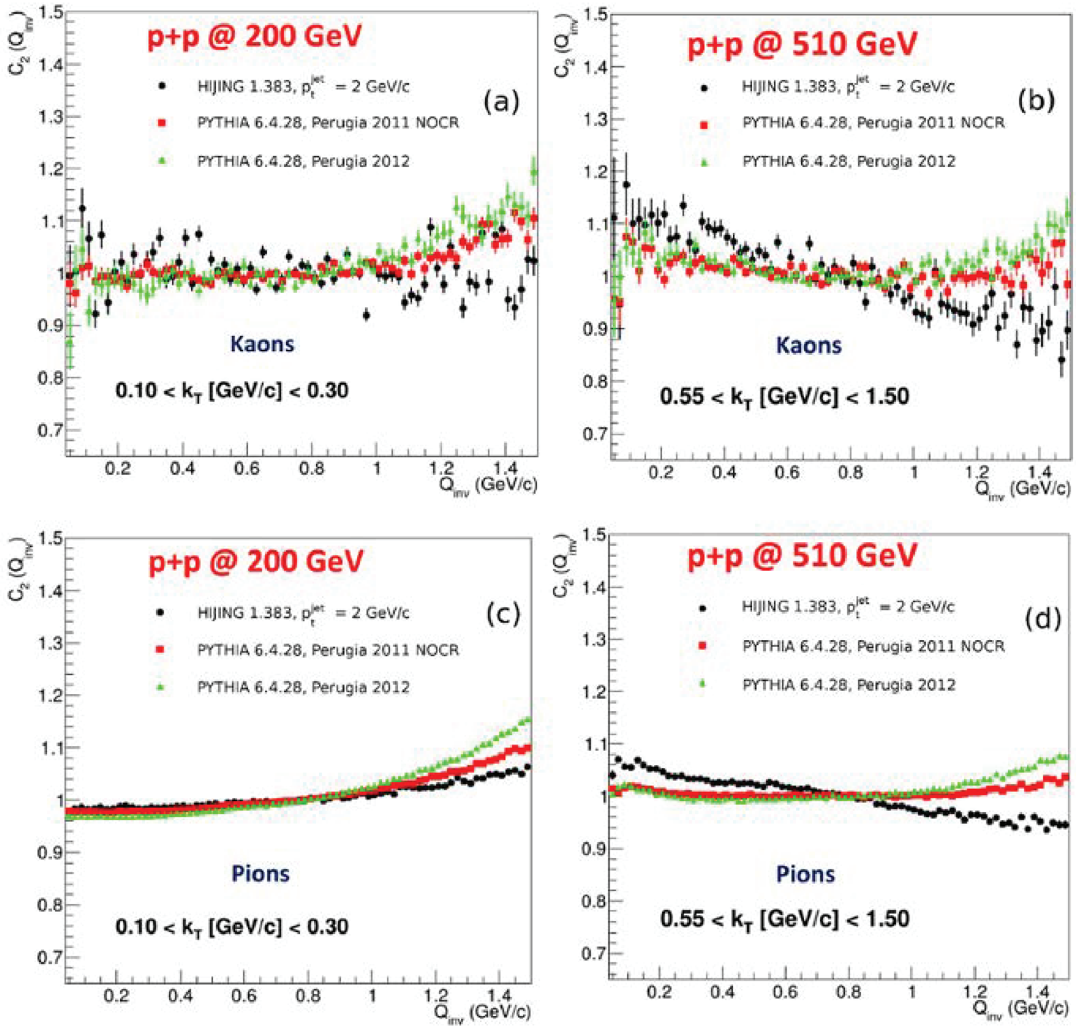

Figure 2: (Color online) Comparison of the two-kaon (a,b) and two-pion (c,d) correlation functions in p+p collisions at $\sqrt{s}$ =200 GeV (a,c) and $\sqrt{s}$ =510 GeV (b,d). Black circles, red squares and green triangles represent HIJING, PYTHIA Perugia 2011 and Perugia 2012 tunes, respectively.

3. Results and Discussions

For estimation of non-femtoscopic effects the HIJING and PYTHIA with Perugia 2011 (no color reconnection) and Perugia 2012 tunes were used.

The PYTHIA program is a standard tool for the generation of events in high-energy collisions between elementary particles, comprising a coherent set of physics models for the evolution from a few-body hard-scattering process to a complex multiparticle final state. The HIJING is a Monte Carlo event generator is designed in particular to study jet and mini-jet production and associated particle production in high energy p+p, p+A and A+A collisions. The HIJING generator was running in the jet trigger mode with the transverse momentum of hard and semi-hard scattering of p_t^{jet} = 2 GeV/c. To test the procedure, we compared our calculations with ones performed by the

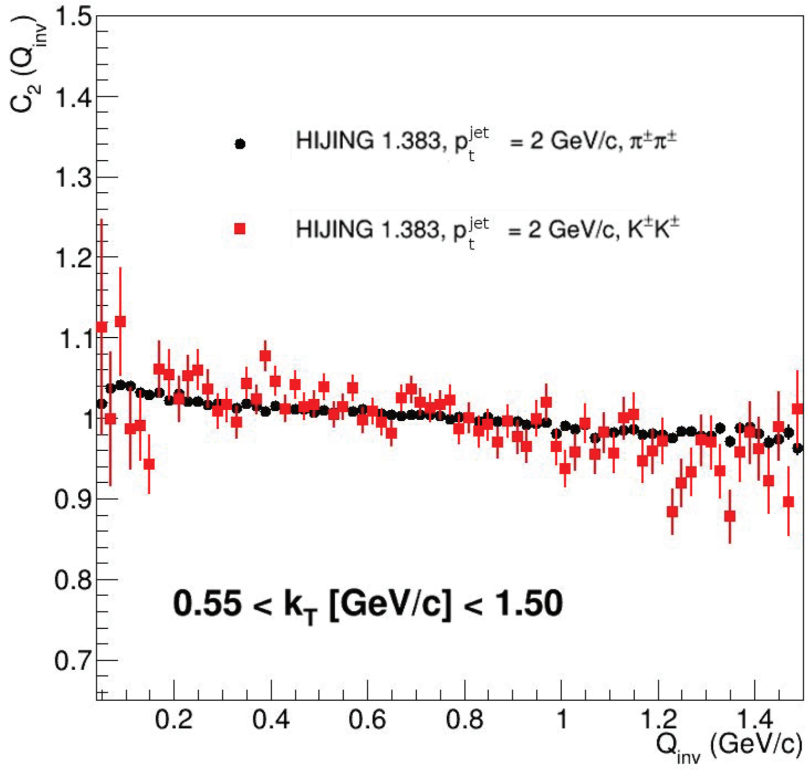

Figure 3: (Color online) Comparison of the two-kaon (black circles) and two-pion (red squares) correlation functions in p+Au collisions at $\sqrt{s_{NN}}$ =200 GeV obtained from the HIJING generator.

ATLAS collaboration [5]. The comparison was performed in the multiplicity region of $26 < N_{trk} < 36$ and pair transverse momentum $0.7 < k_T < 0.8$ GeV/c. Fig. 1 shows the comparison of charged particle correlation functions obtained by the ATLAS Collaboration (black triangles) and our simulations (red rombs). One can see, that our calculations are consistent with published data by the ATLAS Collaboration.

In Fig. 2 one can see the calculated two-kaon and two-pion correlation functions at different k_T bins in p+p collisions at $\sqrt{s}$ =200 and $\sqrt{s}$ =510 GeV.

It is seen that HIJING and PYTHIA shows similar contribution of jets (mini-jets) to the correlation functions of pions and kaons. At low k_T PYTHIA generator and HIJING give similar description of non-femtoscopic correlations for both p+p at $\sqrt{s}$ =200 GeV and $\sqrt{s}$ =510 GeV. At high k_T correlation functions obtained from HIJING show enhancement at low Q_{inv} due to larger than PYTHIA jet (mini-jet) contribution.

The collision system dependence of the non-femtoscopic effects and especially jets and mini-jets contribution to the correlation function is also very important. Fig. 3 shows the two-pion and two-kaon correlation functions in p+Au collisions at 200 GeV obtained from the HIJING generator.

One can see that at high k_T correlation functions of charged pions obtained from HIJING show similar trends for both p+p (Fig. 2(c)) and p+Au (Fig. 3) collisions. In p+Au collisions charged pions and kaons shows similar behavior of the correlation functions.

4. Conclusions

The HIJING 1.383 and PYTHIA 6.4.28 is used to estimate the correlation functions of like-sign pions and like-sign kaons in p+p collisions at $\sqrt{s}$ =200 GeV and $\sqrt{s}$ =510 GeV and p+Au at $\sqrt{s_{NN}}$ =200 GeV. At low k_T PYTHIA and HIJING generators give similar description of non-femtoscopic correlations for both p+p $\sqrt{s}$ =200 GeV and $\sqrt{s}$ =510 GeV. At high k_T correlation functions obtained from HIJING generator shows enhancement at low Q_{inv} due to larger then PYTHIA jet (mini-jet) contribution. In p+Au collisions charged pions and kaons show similar behavior of the correlation functions.

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