TWO-PARTICLE CORRELATIONS USING THERMINATOR MODEL FOR BES PROGRAM*

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The THERMINATOR model is dedicated to heavy-ion collisions. Its current description allows one to work with data for the highest collision energies achieved by the LHC and RHIC colliders. However, it is possible to adapt THERMINATOR model to the lower energy spectrum as is used in Beam Energy Scan (BES) program at RHIC. Femtoscopy of two particles investigates the properties of matter produced in heavy-ion collisions. It allows one to study the space-time characteristics of the medium. Single- and two-particle momentum distributions of particles generated for the energy spectrum for BES program are discussed. To verify how model predictions agree with experimental results, the correlation functions obtained for identical pions in Au+Au collisions at various collision energies are presented.

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1. Introduction

THERMINATOR [1] is a Monte Carlo event generator designed to study the particle production in relativistic heavy-ion collisions performed at such experimental facilities as the SPS, RHIC, or LHC. The program implements thermal models of particle production with single freeze out. BES program conducted at RHIC uses collisions of Au nuclei in order to study the phase diagram of nuclear matter. There are three main goals of this program: studies of the properties of first-order phase transition, detection of a critical point between cross-over area and first-order phase transition, and turning-off the QGP signals observed with collisions with higher collision energies. The THERMINATOR model is adapted to the BES program data and two-particle correlations of identical pions are considered. Femtoscopic results of identical mesons are compared with those obtained by the STAR experiment at RHIC.

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2. THERMINATOR model for BES program

In order to adapt THERMINATOR model to collision energies achieved with RHIC, two parameters: $\rho_{\max}$ (maximum transverse radius) and V_{T} (flow velocity) are estimated using transverse momentum spectra of all charge particles from STAR experiment. τ parameter (proper time at freeze-out) is fixed in these calculations. Momentum distributions of charge hadrons: pions, kaons and protons are taken into account.

Table I introduces parameters used to generate data with THERMINATOR model for BES program. Temperature and baryon chemical potentials are calculated using formulas from [2].

TABLE I

THERMINATOR parameters for BES program.

Energy $\sqrt{S_{NN}}$ [GeV]	T [MeV]	μ_B [MeV]	τ [fm]	$\rho_{\max}$ [fm]	V_{T}
7.7	160.9	406.90	8.55	2.10	1.590
11.5	161.0	304.00	8.55	2.75	1.575
19.6	161.0	197.30	8.55	4.60	1.547
27	161.0	149.44	8.55	5.42	1.510
39	161.0	107.00	8.55	4.25	1.300
62.4	161.0	69.10	8.55	5.76	1.230

3. Femtoscopy of identical pions

3.1. Data analysis

In order to determine three-dimensional correlation of identical pions, the most central collisions (0–5%) are taken into account. Only correlation of positive pions are considered. All generated data are divided into 4 k_{T} (half of the sum of transverse momentum of two particles) intervals. The Bertch–Pratt parametrization of correlation function is used [3].

For each collision energy and k_{T} interval, a calculated correlation function is fitted using standard formula taking into account only effects of Quantum Statistics. The Coulomb Final State Interaction is not included in calculation of three-dimensional correlation function. Fitting formula is presented in the equation

$$\mathrm{CF}(q_{\mathrm{out}}, q_{\mathrm{side}}, q_{\mathrm{long}}) = 1 + \lambda \exp\left(-q_{\mathrm{out}}^2 R_{\mathrm{out}}^2 - q_{\mathrm{side}}^2 R_{\mathrm{side}}^2 - q_{\mathrm{long}}^2 R_{\mathrm{long}}^2\right) .$$

3.2. k_{T} dependence of HBT parameters

Figure 1 shows dependence of HBT parameters as a function of k_{T}. All radii for each collision energy decrease with increase of k_{T}. λ parameters raise with k_{T}.

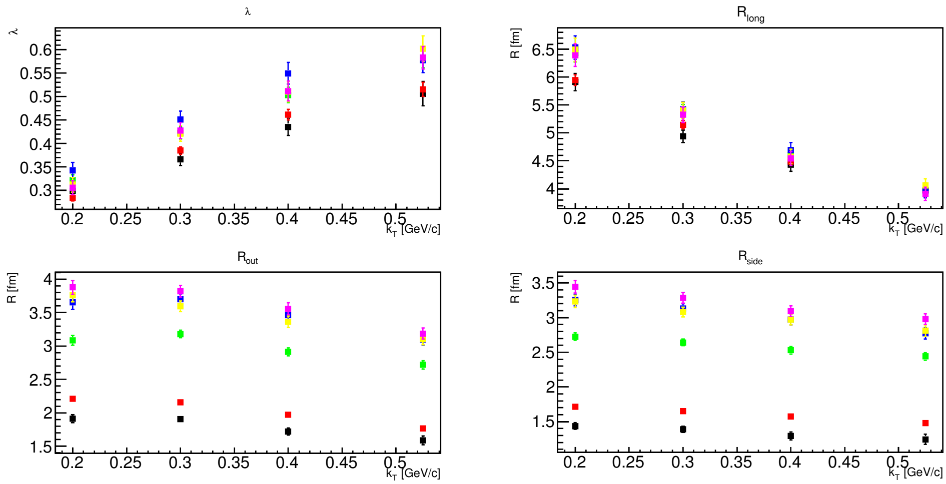

Fig. 1. HBT parameters as a function of k_{T}.

3.3. Energy dependence of HBT parameters

Figure 2 shows dependence of HBT parameters as a function of collision energy. All radii for each k_{T} interval increase with the increase of $\sqrt{s_{NN}}$. λ parameters raise as well.

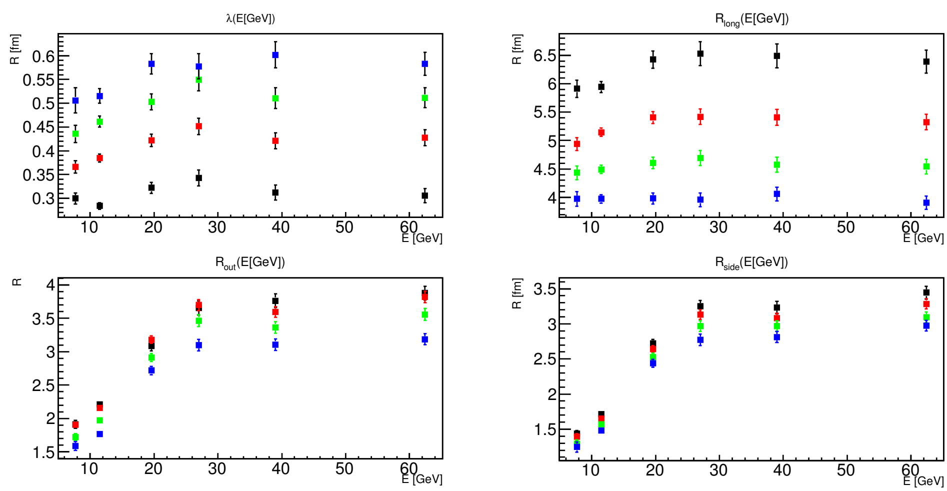

Fig. 2. HBT parameters as a function of collision energies.

3.4. Discussion of HBT parameters

Results of HBT $R_{\rm out}$ and $R_{\rm side}$ radii obtained with THERMINATOR model are within the range of $[1.5, 3.5]$ fm. Results for $R_{\rm long}$ are within $[5.0, 6.5]$ fm. Comparing to results from STAR experiment [4], bigger dependencies on collision energy are observed in THERMINATOR. Parameters of $R_{\rm long}$ are bigger comparing to $R_{\rm side}$ and $R_{\rm out}$, however, sizes for $R_{\rm side}$ and $R_{\rm out}$ are smaller than in STAR. It can be interpreted as a result of not taking into consideration hydrodynamical description of source evolution.

4. Summary

In this work, the THERMINATOR model is adapted to the lower energy spectrum as is used in BES program at RHIC. To verify how model predictions agree with experimental results, the correlation functions obtained for identical pions in Au+Au collisions at various collision energies are presented. Femtoscopic results from THERMINATOR are compared with those obtained by the STAR experiment. Detected discrepancies can be interpreted as a result of not including the hydrodynamical description of source evolution. An update of this work is planned.

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REFERENCES

[1] A. Kisiel, T. Taluc, W. Broniowski, W. Florkowski, *Comput. Phys. Commun.* **174**, 669 (2006).

[2] A. Andronic, P. Braun-Munzinger, J. Stachel, *Nucl. Phys. A* **772**, 167 (2006).

[3] G. Bertsch *et al.*, *Phys. Rev. C* **37**, 1896 (1988).

[4] L. Adamczyk *et al.* [STAR Collabotarion], *Phys. Rev. C* **92**, 14904 (2015).