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FEMTOSCOPY STUDIES AT NICA ENERGY SCALE*

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One of the main goals in study of strongly interacting matter with the Multi-Purpose Detector (MPD) is an observation of signatures of phase transition between hadronic matter and the Quark–Gluon Plasma (QGP). It is expected that below a certain collision energy, the type of the phase transition is changed from a crossover to a first order phase transition. Such change should affect space-time evolution of the created system. A possibility to distinguish between types of the phase transition using the 3-dimensional pion correlation measurements is discussed. Also, a feasibility of using hybrid models at the NICA energies is considered.

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1. Introduction

The MPD is a detector planned to be a part of the NICA facility in JINR [1]. The MPD is dedicated to study heavy-ion collisions at low energies ($\sqrt{s_{NN}}$ = 4–11 GeV). A statistics to be collected should be sufficient in order to clarify the issue on kind of the phase transition (PT) taking place at the NICA energies. To perform a feasibility study of the future

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measurements within the MPD, models that reproduce well existing experimental data are required. As candidates to be used in the simulations, the UrQMD3.4 and the vHLLE+UrQMD were chosen. The simulations were performed at $\sqrt{s_{NN}} = 9$, 11 GeV (UrQMD3.4) and $\sqrt{s_{NN}} = 7.7$, 11.5 GeV (vHLLE+UrQMD), and aimed at checking whether the models reproduce correctly available femtoscopy data. Also, an influence of the used Equation of State (EoS) and a possibility to see the observed differences depending on the EoS were studied. For the analysis, the NicaFemto software was used. It is a code developed for femtoscopy analysis in the MPD [7], however, the software can also be used for a simple flow or spectrum analysis in experiments that use the FairRoot framework as a base [8].

2. Results and discussion

The m_{T}-distributions of charged pions and kaons obtained with the UrQMD3.4 and the vHLLE+UrQMD are presented in this section. The NA49 data [6] were used as a reference. Results are presented in Fig. 1. In the case of the UrQMD3.4, the chiral EoS corresponding to crossover was used, while for vHLLE+UrQMD two EoSes corresponding to the first order PT and crossover, respectively, were used. One can see that the models reasonably describe the transverse momentum spectra of pions.

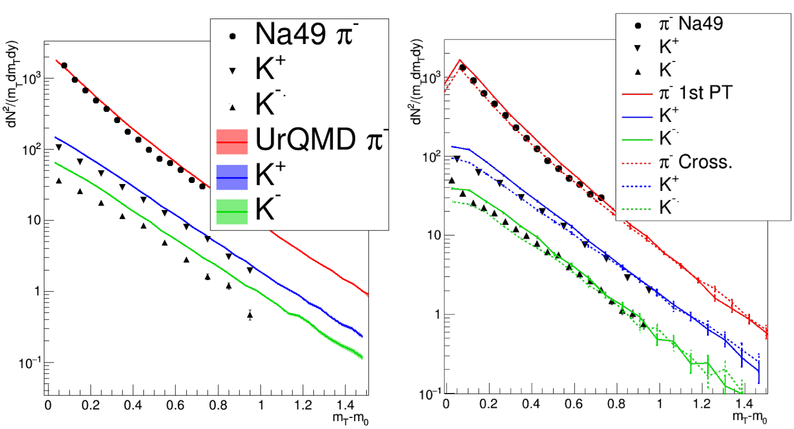

Fig. 1. The m_{T}-distributions of charged pions and kaons. UrQMD3.4, AuAu at $\sqrt{s_{NN}} = 9$ GeV; NA49 data, PbPb at $\sqrt{s_{NN}} = 8.7$ GeV (left panel). vHLLE+UrQMD, AuAu at $\sqrt{s_{NN}} = 7.7$ GeV; NA49 data, AuAu at $\sqrt{s_{NN}} = 7.6$ GeV (right panel).

In the case of femtoscopy measurement, data obtained by the STAR Collaboration were used as a reference [5]. Results obtained with the UrQMD3.4 are shown in Fig. 2. The vHLLE+UrQMD events were simulated with the first order PT and crossover EoSes for the most central events (0–5% centrality). The obtained data from the vHLLE+UrQMD without rescatterings in hadron phase and resonance decays were also analyzed. The obtained results are shown in Fig. 3.

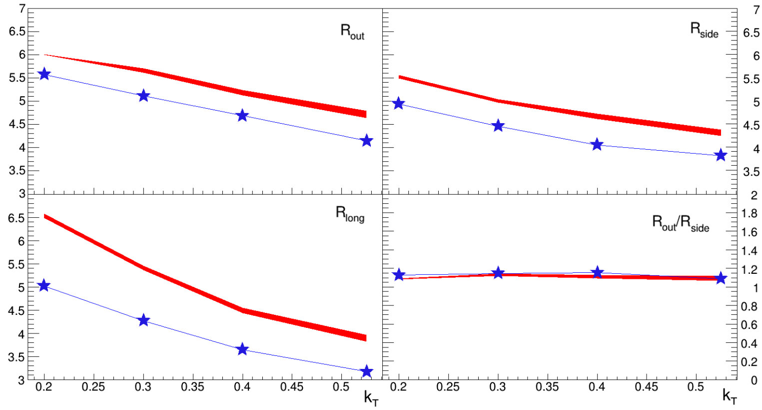

Fig. 2. Comparison of the femtoscopy radii measured by the STAR Collaboration ($\sqrt{s_{NN}} = 7.7$ GeV, 0–5% of centrality) with the ones obtained from the UrQMD3.4 ($\sqrt{s_{NN}} = 7$ GeV, 0–5% of centrality).

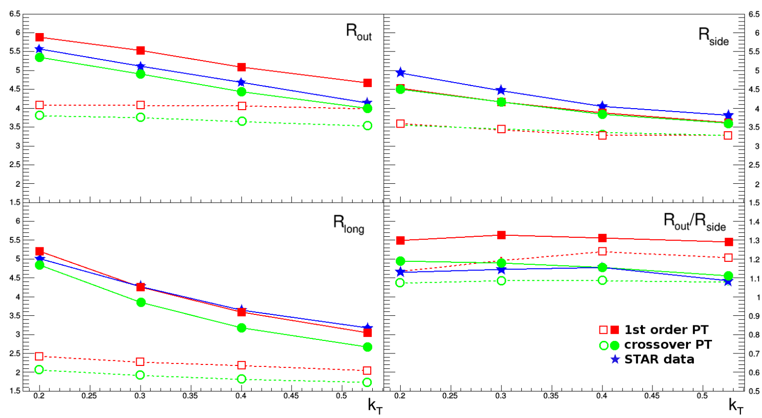

Fig. 3. The femtoscopy radii measured by the STAR Collaboration ($\sqrt{s_{NN}} = 7.7$ GeV, 0–5% of centrality) with the ones obtained from the vHLLE+UrQMD ($\sqrt{s_{NN}} = 7.7$ GeV, 0–5% of centrality). Dotted lines correspond to the simulations without the cascade processes involved.

Both models describe the data quite well, but vHLLE+UrQMD seems to reproduce experimental data better, whereas UrQMD3.4 tends to overestimate the radii. However, both models have many parameters that can be used for tuning their output. Nevertheless, one can arrive at two main conclusions that can be seen from the presented simulations performed with the vHLLE+UrQMD. The first one, as it was expected [2], type of EoS affects $R_{\rm long}$ and $R_{\rm out}$, but not $R_{\rm side}$. It results in increasing of $R_{\rm out}/R_{\rm side}$ ratio. However, this effect is not so strong as it was predicted. The second one is that all the observed effects are not fully smeared by cascade processes or resonance decays. Presence of those processes were considered as a possible explanation to the question why a clear signal of the critical point has not been observed in available experimental data [9].

3. Conclusions

It is presented how the chosen models describe available experimental data. One can see that hydrodynamic EoSes with different types of the PT affect femtoscopy observables and the influence can be observed in the considered energy range. However, these signals are not conclusive, therefore, other methods (such as "source imaging") are necessary as an independent observation of the PT effects in the EoS of the hot and dense nuclear matter.

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