Quenching of resonance production in nuclear collisions around 1 AGeV

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Pion production in heavy-ion collisions is relatively well studied both theoretically and experimentally. There is still, however, a longstanding open question: Why pion multiplicities produced by transport models like BUU and QMD overestimate the experimental data? The largest discrepancy is observed for central Au+Au collisions at 1 AGeV [1]. In this system pions are mostly produced through the Δ-resonance excitations in a two-step process: $NN \to N\Delta$, $\Delta \to N\pi$. Since this process happens in nuclear matter, in-medium effects (besides evident Pauli blocking of the nucleons in final states) cannot be excluded.

We have studied the effect of possible in-medium modification of the cross sections for the processes $NN \leftrightarrow NR$ on the pion observables. The calculations have been done within the BUU model [2] employing the SM mean field (K=220 MeV). The in-medium spin-averaged matrix element squared for the resonance R production/absorption was parametrized as $\overline{|\mathcal{M}_{NN\leftrightarrow NR}|^2} = \kappa(\rho)\overline{|\mathcal{M}^{vac}_{NN\leftrightarrow NR}|^2}$, where $\overline{|\mathcal{M}^{vac}_{NN\leftrightarrow NR}|^2}$ is the vacuum matrix element squared and $\kappa(\rho)$ is a density-dependent function to be determined from a fit of the experimental data. The function $\kappa(\rho)$ is for simplicity supposed to be the same for all baryon resonances. Fig. 1 shows the π^- multiplicity vs time for a central Au+Au collision at 1.06 AGeV for the three choices of $\kappa(\rho)$: $\kappa(\rho) = 1$ – standard (dashed line), $\kappa(\rho) = 1 + 3\rho/\rho_0$ – amplified (dotted line) and $\kappa(\rho) = \min(1, \max(0, 1 - 2(\rho/\rho_0 - 1)))$ – quenched (solid line). There is a reduction of the pion yield in both

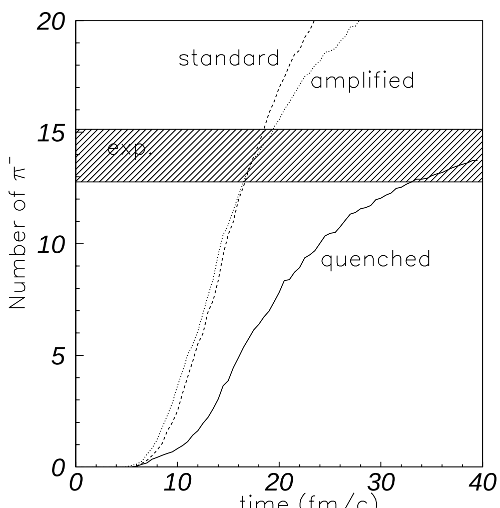

Fig. 1

cases, but the experimental data are only well fitted for the quenched choice of $\kappa(\rho)$. We checked that a further increase of the amplification factor will not modify the pion multiplicity essentially: it always overpredicts the data at least by 30% [3]. The quenching scenario assumes that at $\rho \leq \rho_0$ the in-medium modifications are absent, at $\rho_0 < \rho \leq 1.5\rho_0$ the resonance production/absorption matrix elements decrease linearly with density and at $\rho \geq 1.5\rho_0$ the matrix elements become zero, i.e. at high density resonances do not experience any elastic or inelastic scatterings with nucleons. They can, however, decay or be produced in processes $R \leftrightarrow N\pi$.

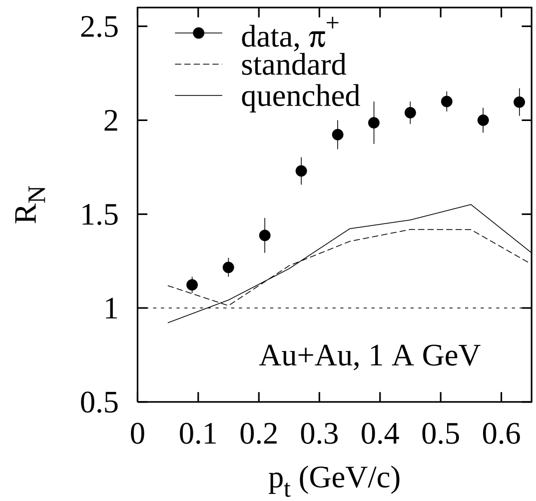

Fig. 2

We show in [3] that for Au+Au at 1 AGeV the quenching results in a vertical downward shift of the pion p_t-spectra, thus improving the agreement with the data [1, 4]. For the light system C+C at 0.8÷2 AGeV, both standard and quenched calculations produce practically the same m_t-spectra of π^o's [3], since in the lighter system medium modifications are weaker.

Both, transverse in-plane and out-of-plane pion flows are weakly influenced by the quenching. There is a good agreement of our calculations with the data on the in-plane $\pi^\pm$ flow [5] (see [3] for details). However, we underpredict the high-p_t π^+ squeeze-out ratio $R_N := (N_{\pi^+}(90^o) + N_{\pi^+}(270^o))/(N_{\pi^+}(0^o) + N_{\pi^+}(180^o))$ [6] as shown in Fig. 2. Therefore, in order to describe the pion squeeze-out some additional effects have to be taken into account. We expect, that the introduction of a momentum-dependent pion potential as well as further modifications of the resonance life time will improve the agreement with data on pion squeeze-out in analogy to the case of nucleon squeeze-out [7].

References

[1] D. Pelte et al., Z. Phys. A **357**, 215 (1997).
[2] M. Effenberger, E.L. Bratkovskaya, and U. Mosel, Phys. Rev. C **60**, 044614 (1999).
[3] A.B. Larionov et al., in preparation.
[4] O. Schwalb et al., Phys. Lett. B **321**, 20 (1994).
[5] J.C. Kintner et al., Phys. Rev. Lett. **78**, 4165 (1997).
[6] Y. Shin et al., Phys. Rev. Lett. **98**, 1576 (1998).
[7] A.B. Larionov et al., Phys. Rev. C **62**, 064611 (2000).

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