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Kaon in-medium potential probed in proton-nucleus reactions*

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Insight into the fundamental properties of the strong interaction in the low energy domain — confinement and broken chiral symmetry — might be gained with measurements of hadron in-medium properties. Of particular interest in this context are light vector mesons (ρ, ω, ϕ) and (anti)kaons. Modifications of the kaon (K^+, K^0) spectral function in a baryonic environment do not show substantial broadening and are characterized by a positive and density dependent mass shift reaching 25-35 MeV at nuclear ground state density [1].

A number of experiments recently addressed this issue and deduced a repulsive potential of 25 to 40 MeV based on a comparison of data to microscopic transport model calculations [2, 3]. Thus, the magnitude of the kaon potential remains unsettled in spite of relative simplicity of the underlying kaon-nucleon interaction.

The HADES collaboration addressed the issue of the momentum-dependent kaon potential with the high-statistics data on neutral kaon production (reconstructed via the short-lived component K^0_S) collected in proton-niobium collisions at a beam energy of 3.5 GeV. As a reference measurement data obtained in proton-proton reactions at the same beam energy have been used.

Kinematical distributions of kaons were measured in a broad region of the phase space. Figure 1 shows the (efficiency corrected and normalized) transverse momentum spectrum in a selected rapidity bin (the complete rapidity span amounts to $y_{CM} \in (-0.85, 0.35)$).

The effect of the kaon potential as follows from ChPT was studied by comparing the data to results obtained with the GiBUU transport model [4], parameters of which (kaon production cross sections) were tuned to reproduce the reference proton-proton measurement. Two sets of calculations (with and without the kaon potential) are shown in Fig. 1. The strength of the ChPT potential at normal nuclear density for the kaon at rest is ≈ 35 MeV.

The comparison was done in all rapidity bins and the agreement of the experimental data with the transport model simulations was quantified by means of a χ^2-analysis. Simulations including the ChPT potential deliver a significantly lower χ^2 value as compared to calculations without potential. Moreover, and this is a distinct feature of the present study, variations of the uncertain parameters of the model (such as, for example, kaon yield in neutron-proton reactions) have been performed. For each set of physical parameters, calculations that include the potential consistently result in lower χ^2-values.

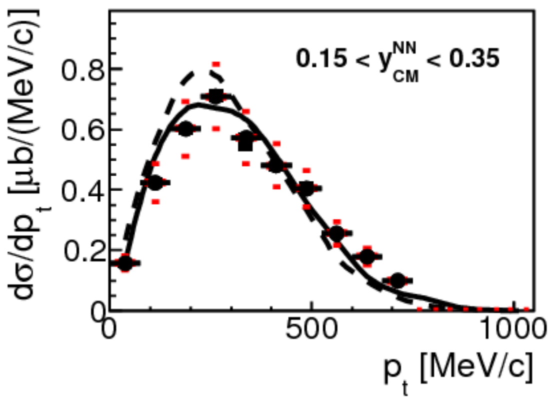

Figure 1: K^0 transverse momentum spectrum reconstructed in proton-niobium collisions in a selected rapidity bin. Experimental data are shown with black markers. GiBUU calculations without and with the kaon ChPT potential are shown by dashed and solid curve, respectively.

To summarize, the K^0 kinematical distributions reconstructed in proton-niobium collisions favour the GiBUU transport model calculations that incorporates the ChPT prediction for the potential.

References

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