

Modification of hadron properties at normal nuclear matter density investigated in pion-induced reactions with FOPI spectrometer. *

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The behavior of strangeness and anti-strangeness in nuclear matter is a subject of various theoretical and experimental debates. Theoretical models (and experimental evidence) suggest that production and dynamics of strange particles in nuclear medium is connected to fundamental properties of Quantum Chromo Dynamics [1]. In particular - the partial restoration of chiral symmetry in dense matter results in the modifications of particles' properties such as mass, lifetime and consequently a change of production and absorption cross sections are expected.

The ϕ vector meson is a pure $s\bar{s}$ state with a free mass of 1019.5 MeV/c². In nuclear medium, already at normal nuclear matter density, the spectral function of ϕ mesons is predicted to change, showing a mass shift of a few MeV/c² and a significant broadening [2]. Experimental evidence for the in-medium modification of the ϕN cross section [3, 4] and mass modification [5, 6] have been published, however the findings disagree with theoretical predictions.

The FOPI Collaboration in cooperation with the GEM-TPC Collaboration has recorded about 5.5M collisions for each $\pi^- + {}^{208}\text{Pb}$ and $\pi^- + {}^{12}\text{C}$ systems in the S339 experiment. The chosen incident beam momentum of $p_\pi = 1.7$ GeV/c is slightly above the threshold momentum for the reaction $\pi^- + p \rightarrow \phi + n$ ($p_{th} = 1.56$ GeV/c). The ϕ mesons are produced with small momenta and have a reasonable probability to decay inside the target. These experimental conditions make the observation of possible in-medium modifications at $\rho = \rho_0$ feasible.

The ϕ meson decays preferentially into kaons:

$$\begin{aligned} \phi(1020) &\rightarrow K^+ K^- \quad (49.2\%) \\ &\rightarrow K_L^0 K_S^0 \quad (34\%) \end{aligned} \quad (1)$$

With the FOPI detector system the charged kaons final state is accessible.

Fig.1 shows the invariant mass distribution of correlated K^+K^- pairs produced in carbon and lead targets. Blue points represent the mass distribution of uncorrelated K^+K^- pairs from different events, and therefore describe the combinatorial background. In both targets a clear excess is visible at the nominal mass of the ϕ meson.

From the evaluation of different selection criteria and background description strategies the ratio of ϕ mesons produced per event in lead to carbon targets is obtained:

$$\frac{N_{Pb}}{N_C} = 0.512 \pm 0.079(\text{stat.}) \quad (2)$$

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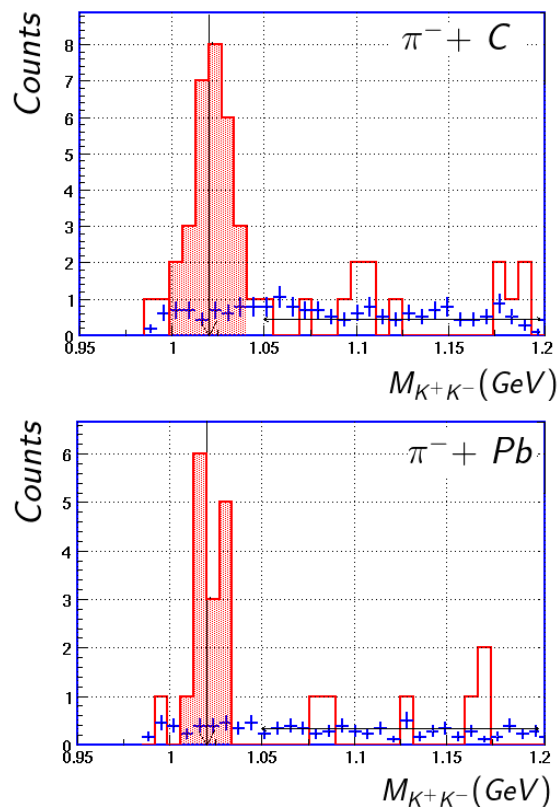


Figure 1: Invariant mass spectrum of correlated K^+K^- pairs (red) and the combinatorial background (blue).

This ratio can be interpreted as an indication for the suppression of ϕ mesons in nuclear matter. However, a detailed understanding of (anti-)strangeness production and exchange in the considered systems is crucial to conclude on the influence from the nuclear medium. The evaluation of other strange and anti-strange particles (i.e. K^+ , K^- , K^0 , Λ) is in progress.

References

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