Effects of Coulomb and kaon nuclear potentials on soft K^+ production from nuclei.

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K^+-meson production in pA collisions is of utmost importance to learn about either cooperative nuclear phenomena or high momentum components of the nuclear many-body wave function. If the incident beam energies are far below the free nucleon-nucleon threshold, kaons are produced with rather low momentum ($< 600\,\mathrm{MeV/c}$). Therefore, for a large part of the kaon momentum spectra consideration of the in-medium Coulomb and kaon potentials becomes essential. The importance of taking into account these potentials for pion and kaon production in pA interactions has been discussed by several groups [1, 2, 3]. Since most of the measurements resulted in high pion and kaon momenta, the experimental data are not very informative from the point of view of both Coulomb and kaon potentials. This has changed with ANKE, which is currently the only spectrometer which is able to measure kaons with momenta down to $150\,\mathrm{MeV/c}$. Classically, if a particle with mass m is produced at the edge of a nucleus of radius R, then as it escapes to infinity it must aquire the energy $T = V$ due to the repulsive potential V, so that it must have a minimum momentum of $p_{min} = \sqrt{2mV}$. In the absence of any nuclear kaon potentials, this momentum is fixed by the Coulomb energy and yields $p_{min} \approx 130\,\mathrm{MeV/c}$ for a gold target. The momentum shift for a carbon target is ≈ 3 times smaller. This effect should be observed in the heavy-to-light cross-section ratios as a steep rise starting at the p_{min} of the heavy target.

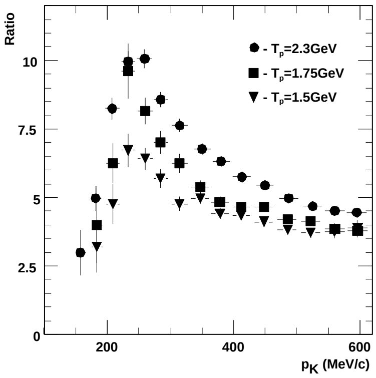

Fig. 1: Ratios of K^+ production cross sections for Au and C measured at different energies as a function of kaon momentum.

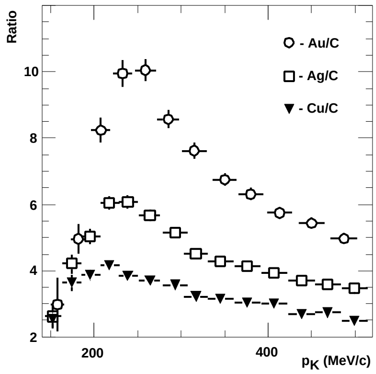

Fig. 2: Ratios of the K^+ production cross sections for the different targets (measured at $T_p = 2.3\,\mathrm{GeV}$) as a function of kaon momentum.

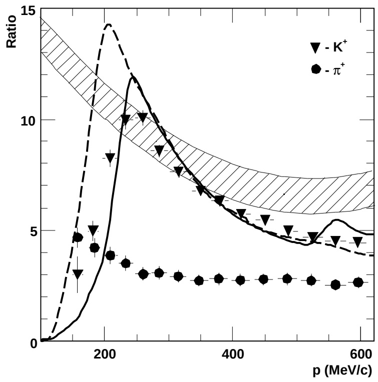

Fig. 3: Ratios of π^+ and K^+ production cross sections for Au/C at $T_p = 2.3\,\mathrm{GeV}$ as a function of meson momentum. The dashed line is obtained from CBUU calculations with Coulomb and baryon potentials included, the solid line shows the result with the kaon potential included in addition, while the shaded area corresponds to calculations without Coulomb and kaon potentials (width shows statistical theoretical uncertainty).

Ratios of kaon-production cross sections measured at different energies and with several target nuclei are presented in Fig. 1,2,3. All ratios exhibit similar shapes, rising with decreasing kaon momenta, passing a maximum and falling down at low momenta. The position of the maximum is practically independent of the incident proton beam energy (Fig. 1), but varies with the mass of the target nucleus, giving 245, 230, 205 MeV/c for Au/C, Ag/C and Cu/C, respectively (see Fig. 2).

The ratios for Au/C are compared to calculations made within the framework of the CBUU transport model, taking into account different mechanisms of the kaon production, rescattering effects and realistic density distributions (Fig. 3). Without including the Coulomb and kaon potentials (shaded area in Fig. 3) the ratio should exhibit a smooth momentum dependence with a steady increase towards low momenta, resulting from the stronger rescattering processes for heavy nuclei. This phenomenon is observed in pion production, where the influence of the Coulomb potential is expected to show up below $p_\pi \approx 80\,\mathrm{MeV/c}$. For kaons the Coulomb interaction leads to a distortion of the momentum spectrum and provides a maximum at $p \approx 200\,\mathrm{MeV/c}$ for Au/C, which is still lower than the experimental data. Finally, when the repulsive kaon potential of 20 MeV is also considered in the calculations, a reasonable agreement with the experiment is achieved (solid curve in Fig. 3). We expect that further analysis of the experimental data and more detailed comparison with CBUU calculations will permit us to measure the strength of the kaon potential more accurately.

References:

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