Simulations of Strange Particles Measurements with Pion-Induced Reactions

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Motivation

We investigated a possibility to measure production of strange particles in pion-proton reactions ($\pi^- p$) at a beam momentum of 1.75 GeV/c with the **H**igh **A**cceptance **D**ielectron **S**pectrometer (HADES) at the GSI Helmholtzzentrum. A number of strangeness production channels was studied with help of realistic full-scale simulations, taking into account all relevant background channels.

Measurements in pion-induced reactions are necessary for a better understanding of strangeness production in heavy-ion reactions. Moreover, pion-nucleus reactions offer a possibility to study in-medium properties of mesons with open and hidden strangeness, such as K^0, K^+ and ϕ at normal nuclear density.

Besides mesons, we investigate the reconstruction of strange baryons close to the $\bar{K}N$ threshold: $\Sigma(1385)$ and $\Lambda(1405)$. The latter particle is of particular interest, since the ambiguity in the current theoretical understanding of the $\Lambda(1405)$ resonance calls for new experimental efforts. It is predicted that the observed properties of the resonance (i.e. position of the pole and the lineshape) depend on both the production mechanism [1] (γ-, π-, kaon- or proton-induced reactions) and the decay mode ($\Sigma^{\pm}\pi^{\mp}$, $\Sigma^0\pi^0$).

Existing bubble-chamber measurements of the $\Lambda(1405)$ production in pion-induced reactions [2, 3, 4] have principal flaws. First of all, the neutral decay channel $\Lambda(1405) \rightarrow \Sigma^0\pi^0$ was never measured. Besides that, the $\Sigma(1385)^0$ contribution was not subtracted from the observed spectra.

$\Lambda(1405)$ reconstruction

In order to understand the properties and the production mechanisms of strange baryons such as $\Sigma(1385)$, $\Lambda(1405)$ a possibility to detect various decay modes, including decays into neutral particles, is important. Though in the present configuration the HADES setup is not capable of photon detection, an installation of an electromagnetic calorimeter is foreseen [5].

A detailed study of the $\Lambda(1405)$ reconstruction feasibility employing the standard HADES set-up plus the electromagnetic calorimeter was performed in the reaction channel

$$\pi^- + p \rightarrow \Lambda(1405) + K^0.$$

A number of analyses strategies was examined. The study showed that a semi-exclusive reconstruction requiring a single photon or a π^0 in the final state is the most promising with respect to background considerations.

As an example, in the decay chain $\Lambda(1405) \rightarrow \Sigma^+ + \pi^-$, $\Sigma^+ \rightarrow p + \pi^0$, $\pi^0 \rightarrow \gamma\gamma$ the final $p\pi^-\gamma\gamma$ state was reconstructed. After applying necessary selection cuts, an invariant mass spectra (Fig. 1) shows a clear signal of the $\Lambda(1405)$. In this way, about 800 $\Lambda(1405)$'s can be reconstructed in a 25 days beamtime, given a beam intensity of $1.2{\cdot}10^6$ pions/spill. The analysis of this decay mode will be compared with the $\Lambda(1405) \rightarrow \Sigma^- + \pi^+$ analysis, where only charged particle reconstruction is sufficient, in order to study isospin interference effects.

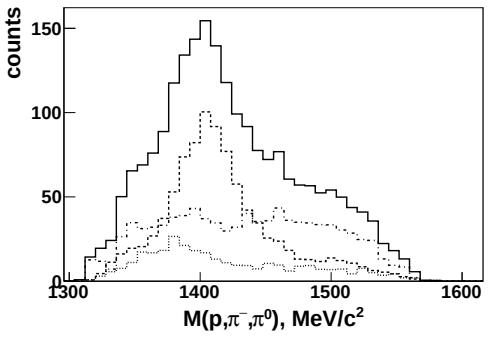

Figure 1: (Simulated) invariant mass spectra of p, π^-, π^0. Contributions are: $\Lambda(1405)$ (dashed curve) reconstructed in its $\Sigma^+\pi^-$ decay channel, $\Sigma(1385)$ (dotted curve) and the non-resonant production of the $\Sigma^+\pi^-K^0$ final state (dash-dotted curve). Sum of all contributions is shown by a solid curve. Counts on the y-axis correspond to the expected yield.

Realistic simulations have shown that the HADES experiment is well suited for the strange particles measurements in pion-induced reactions. Of particular interest is an exclusive reconstruction of the $\Lambda(1405)$ resonance in all of its decay channels.

References

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