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Lambda - Proton Correlation in Pion-Induced Reactions at 1.7 GeV/*c*

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Abstract.
World data on $\Lambda - p$ scattering in pion-induced redactions are quite scare. In 2014 the HADES Collaboration performed an experiment campaign with pion-nucleon reactions $\pi^- + A$ $(A = C, W)$ at 1.7 GeV/c. Hereby, the exclusive channel $\pi^- + p \rightarrow K^0 + \Lambda$ $(\Lambda + p \rightarrow \Lambda + p)$ may provide information on Λ proton scattering and moreover shed light on the short range interaction using dedicated simulations for comparison. The on-going analysis of the exclusive channel with especial emphasis on the event selection is outlined.

1 Introduction

The equation of state (EOS) for neutron stars got some special attention in the past due to the discovery of a two solar mass neutron star [1]. While different approaches and new findings ([2]) constrain the allowed parameter space for different EOS, the appearance of hyperons inside neutron stars is still a discussed topic [3]. In order to get a deeper understanding, constraints on the interaction between hyperons and normal nuclear matter are essential. The lightest hyperon, the Λ baryon, is therefore of special interest. While the attractive mid-range part of the ΛN potential has already been probed in various experiments (e.g. hypernuclei [4]), the predicted repulsive short-range interaction between the Λ and protons is until now only accessible by theory [5].
Our approach selects the exclusive production channel $\pi^- + p \rightarrow K^0 + \Lambda$, with an additional positively charged particle, as a proton candidate, in the same event. To get access to the processes inside the nucleus, the transport simulation package UrQMD has been used. Here, the different possible scenarios inside the nucleus can be selected providing templates that can be compared to experimental observations of the final state.
The selection procedure of events containing the exclusive ΛK^0 production channel with an simultaneous proton, without applying topological cuts is presented.

2 The HADES Experiment

The **H**igh-**A**cceptance **D**i-**E**lectron **S**pectrometer (HADES) [6] is a fixed target experiment located at SIS18/GSI. It features a six folded detector structure with different detector systems covering full azimuthal angle and polar angles from 10° to 85°. The tracking of the

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particles is performed by pairs of **M**ultwire **D**rift **C**hambers (MDC) before and after a superconducting toroidal magnet. The specific energy loss dE/dx in the MDCs can be used for particle identification. The data was recorded with a so called M2 trigger, requiring a T0 start signal in the target detector [7] and two hits in the **M**ultiplicity and **E**lectron **T**rigger **A**rray (META) wall consisting of two time-of-flight detectors, RPC and TOF detectors.
Overall 10×10^7 and 13×10^7 events have been collected in $\pi^- + C$ and $\pi^- + W$ collisions, respectively.

3 Event Selection

In order to shed light on the short range Λ-p interaction, the exclusive production channel $\pi^- + p \rightarrow K^0 + \Lambda$ is investigated. The hereby close to the surface [1] produced Λ can then eventually interact elastically with a proton inside the nucleus.
To isolate these particular process, illustrated in Fig. 1, we search for a charge pattern, meeting the following requirement: $\Lambda \rightarrow p + \pi^-, K^0 \rightarrow \pi^+ + \pi^-, p$, with four daughter particles and an additional proton in the final state.
Further, the identification of these charged particle species was achieved based on exploiting the characteristic energy-loss in the MDCs and the velocity β, measured in the TOF, in combination with the momentum. In addition very rough mass cuts around their nominal particle mass are applied for background reduction.
Caused by the multiple appearances of identified π^- and p in the final state an event hypothesis is necessary so assign these particles to their mother particle (Λ, K^0). The best combination is selected based on the simultaneously matching of the invariant mass. Hereby the difference of both invariant masses ($\pi^+\pi^-$,$\pi^- p$) to their hypothetical mother particle is calculated for each combination, resulting in a clear hierarchy. The resulting two dimensional invariant mass of $\pi^+\pi^-$ vs. $p\pi^-$ for the best combination subtracted by the PDG mass of K^0 and Λ, respectively, is shown in Fig. 2. By applying this method, approximately $2 \times 10^3 \Lambda - p$ elastic candidates in the $\pi^- + W$ system were extracted.

4 Outlook

The next step includes the creation of a complete set of simulated templates. The following scenarios have already been investigated based on the UrQMD collision file [2]:

- $\pi^- + p \rightarrow N^* \rightarrow \pi^- + p_1, \pi^- + p_2 \rightarrow \Lambda + K^0$ no Λp interaction
- $\pi^- + p \rightarrow N^* \rightarrow \Lambda + K^0, \Lambda + p \rightarrow \Lambda + p$ one Λp elastic scattering
- multiple elastic scattering

With a complete set of simulated scenarios we expect to describe our experimental data and will be able to disentangle the different contributions.

References

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[1] $\lambda_\pi \approx 1.5$ fm < 14 fm $\approx d_W$
[2] UrQMD specific summary table of all interactions inside the nucleus

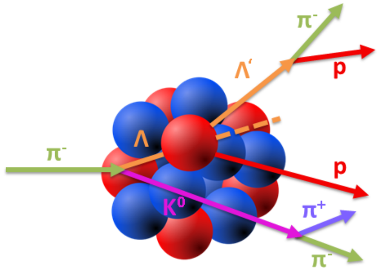

Figure 1. Schematic drawing of the event of interest. After the Λ is created it eventually can scatter elastically with a proton within the nucleus. As a result 5 charged particles are in the final state.

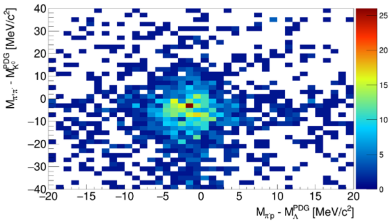

Figure 2. Best combination of the invariant mass of K^0 vs. Λ, both subtracted by their PDG mass, respectively. The sample features a high purity.

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