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# $\Lambda p$ correlated production from low energy $K^{-12}C$ interactions by AMADEUS

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**Abstract.** The main steps for the analysis of the  $\Lambda p$  correlated production in low-energy  $K^{-}$  captures on Carbon nuclei, performed by the AMADEUS collaboration, are presented. The goal is to perform the first comprehensive study of the  $K^{-}$  absorption on two, three and four nucleons, exploiting the low-momentum  $K^{-}$ s ( $p_K \sim 127$  MeV/c) produced at the DAΦNE collider, and to measure the low-energy cross sections and branching ratios of the  $K^{-}$  multi-nucleon absorption processes in both the  $\Lambda p$  and  $\Sigma^0 p$  channels. An integrated luminosity of  $1.74 \text{ fb}^{-1}$  collected during the KLOE 2004/2005 data campaign is analysed by reconstructing the  $\Lambda p$  final state.

## 1 Introduction

The study of the  $K^{-}$  multi-nucleon absorption processes at low-energies represents a fundamental tile for the comprehension of the non-perturbative QCD in the strangeness sector.

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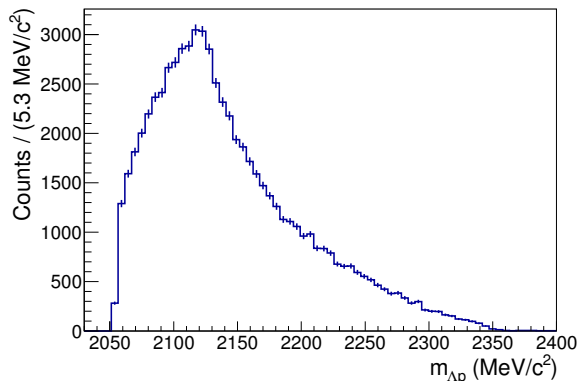
The measurement of their yield is essential to investigate the in-medium modification of the  $K^-$  potential, whose behaviour in the  $\bar{K}N$  sub-threshold region is theoretically debated with implications on the possible existence of exotic  $\bar{K}$  multi-nucleon bound states and on the controversial  $\Lambda(1405)$  nature (for a review see Ref. [1]). In kaon induced reactions the possible exotic states formation overlaps with the multi-nucleon absorption processes over a broad range of phase space rendering the measurements of the latter mandatory [2–5]. Moreover, in heavy-ion collision the exclusive measurement of the low-energy cross sections of antikaons off nuclei is crucial to constraint the theoretical interpretation of the data [6].

The AMADEUS collaboration is performing the analysis of the  $\Lambda p$  final state, exploiting stopped and in-flight  $K^-$  captures ( $p_K \sim 100$  MeV/c) on  $^{12}\text{C}$  nuclei, with the aim to measure the low-energy cross sections and branching ratios (BR) of the  $K^-$  two, three and four nucleon absorptions (2NA, 3NA and 4NA) for both direct  $\Lambda$  production and  $\Sigma^0$  production followed by  $\Sigma^0 \rightarrow \Lambda\gamma$  decay. The signal emitted by the intermediate formation of the exotic  $K^-pp$  bound state, decaying through the  $\Lambda p$  channel, is also investigated. An integrated luminosity of  $1.74 \text{ fb}^{-1}$ , collected by the KLOE collaboration [7] at the DAΦNE collider [8] during the 2004/2005 data campaign, is analysed. The main steps of the data analysis are presented in this work.

## 2 Events selection and data analysis procedure

The DAΦNE collider [8] is a  $\phi$  meson factory, able to produce low-momentum charged kaons from the  $\phi$  decay nearly at-rest. The KLOE detector [7] is centred around the interaction point of DAΦNE; it consists of a large cylindrical Drift Chamber (DC) [9] and a fine sampling lead-scintillating fibres calorimeter [10], all immersed in an axial magnetic field of 0.52 T provided by a superconducting solenoid.

The first step of the analysis is represented by the  $\Lambda(1116)$  identification through the  $p\pi^-$  decay (BR =  $(63.9 \pm 0.5)\%$  [11]) according to the procedure described in Refs. [5, 12]. The primary proton, produced in the hadronic interaction, is identified using the same selection adopted for the proton from the  $\Lambda$  decay. A common vertex between the  $\Lambda$  path and the primary proton track, representing the hadronic interaction vertex, is extrapolated as done in Ref. [5] and its position is used to select the  $K^-$  captures on the KLOE Drift Chamber entrance wall, which is mainly composed of Carbon fibre and is used as an active target. The obtained  $\Lambda p$  invariant mass spectrum is shown in Fig. 1.



**Figure 1.** The  $\Lambda p$  invariant mass spectrum for the selected data sample.

BRs and cross sections of the  $K^-$  multi-nucleon absorptions on two, three and four nucleons (2NA, 3NA and 4NA) are obtained by means of a simultaneous fit of the  $\Lambda p$  invariant mass,  $\Lambda p$  angular correlation,  $\Lambda$  and proton momenta to the simulated distributions for both direct  $\Lambda$  production and  $\Sigma^0$  production followed by  $\Sigma^0 \rightarrow \Lambda \gamma$  decay. The  $K^-$  nuclear capture are calculated for stopped and in-flight interactions according to the model described in Refs. [13, 14]. In the first case the absorption from atomic 2p state is assumed. Fragmentations of the residual nucleus following the hadronic interaction are also considered. For the 2NA the important contributions of both final state interactions (FSI) of the  $\Lambda$  and the proton are taken into account, as well as the conversion of primary produced sigma particles ( $\Sigma N \rightarrow \Lambda N'$ ), which allows to disentangle the quasi-free (QF) production.

The contribution from a possible  $K^- pp$  bound state is also investigated as done in Ref. [5]. A further selection of back-to-back  $\Lambda p$  production is performed by selecting  $\cos \theta_{\Lambda p} < -0.8$  in order to make a direct comparison with the corresponding FINUDA measurement [15].

### 3 Conclusions

The study of the  $\Lambda p$  final state in low-energy  $K^-$  interactions with light nuclei allows to make significant steps forward in the comprehension of the low-energy strong interaction in the strangeness sector, offering the opportunity to simultaneously investigate the  $K^-$  multi-nucleon absorptions in both the  $\Lambda p$  and  $\Sigma^0 p$  channels, as well as to explore the possible formation of the exotic  $K^- pp$  bound state. The  $\Lambda p$  data analysis procedure, which is presently being performed by the AMADEUS collaboration, has been presented in this paper; the results of the analysis will be published in a forthcoming dedicated article.

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