Recent results from FINUDA

FINUDA Collaboration

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Abstract

FINUDA (FIsica NUcleare a DAΦNE) is an experiment carried out at the DAΦNE e^+e^- ϕ-factory at the Frascati INFN laboratory. It was designed to produce and to study hypernuclei by stopping the low energy negative kaons from ϕ decay in different nuclear targets. The detector is a magnetic spectrometer optimized to have the maximum momentum resolution and acceptance for the π^- emitted in Λ-hypernucleus formation. At the same time the apparatus can also detect the formation and decay of strange hadronic systems. This work presents the detector performance and recent results obtained from the analysis of the first FINUDA data set.

Key words: FINUDA, Neutron Rich Λ-Hypernuclei, Kaon-nuclear states

1 Introduction

The FINUDA experiment is an unconventional example of a hypernuclear physics experiment. It joins the features of a fixed target experiment, and of an experiment at a collider. It is carried out at a ϕ meson factory DAΦNE, the e^+e^- collider operating at the Frascati National Laboratory of INFN. The electron and positron beams may collide in two distinct interaction points, located in the two straight sections of the machine (fig. 1), were the experimental apparatuses are installed. FINUDA is hasted in one of the two interaction regions. The two beams have an energy of 510 MeV and collide with an angle of about 25 mrad. The produced ϕ resonance ($\sigma \cong 3.26$ μb) decays with a BR=0.49 to K^+K^- pairs and these K^- are used by FINUDA to produce Λ-hypernuclei via the reaction: (K^-_{stop}, π^-).

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[2] This paper is dedicated to the memory of our colleague and friend Valerio Filippini

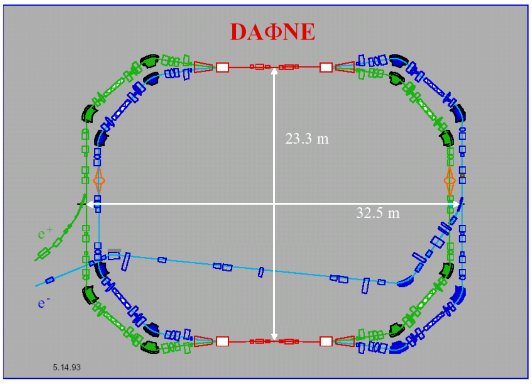


Fig. 1. Layout of the DAΦNE main rings (*top view*).

The FINUDA detector was designed to perform spectroscopy and non mesonic weak decay studies of Λ-hypernuclei. Nevertheless it is well suited to investigate a variety of strangeness physics topics. Thanks to its tracker, it is capable of performing a complete reconstruction of complex topologies.

2 The FINUDA experiment

Further details concerning the design and the performance of the FINUDA apparatus can be found in Ref. [1-3]. In this section the main features of the FINUDA apparatus, the spectrometer performance and the main topics of the scientific program are presented.

2.1 The Physics Program

The main idea is to use the low energy K^- ($\sim$ 16 MeV) from the ϕ decay, slowing them down to rest in thin targets, to study the formation and decay of different hypernuclei produced by the strangeness exchange reaction:

$$K^-_{stopped} + {}^{A}X_Z \rightarrow {}^{A}_{\Lambda}X_Z + \pi^-_{prompt} \tag{1}$$

where ${}^{A}X_Z$ indicates a target nucleus and ${}^{A}_{\Lambda}X_Z$ the produced hypernucleus (at a typical rate of some $10^{-3}/K^-_{stop}$). The prompt pions, following the elementary process of strangeness exchange that transforms a neutron into a Λ-particle, carries the information of the Λ binding energy (B_Λ) of the ${}^{A}_{\Lambda}X_Z$ system:

$$\mathrm{B}_\Lambda = M({}^{A-1}X_Z) + M(\Lambda) - M({}^{A}_{\Lambda}X_Z) \tag{2}$$

where $M({}^{A-1}X_Z)$, $M(\Lambda)$ and $M({}^{A}_{\Lambda}X_Z)$ are the mass of the residual nucleus, of the Λ hyperon and of the hypernucleus, respectively.

From equation (1) we can rewrite the hypernucleus mass as a function of the pion's energy and substituting it in (2) we finally get:

$$\mathrm{B}_\Lambda = M(^{A-1}X_Z)+M(\Lambda)-\sqrt{[M(K^-)+M(^{A}X_Z)-E(\pi^-_{prompt})]^2-[p(\pi^-_{prompt})]^2} \quad (3)$$

where $E(\pi^-_{prompt}) = \sqrt{(p(\pi^-_{prompt}))^2 + (m(\pi^-_{prompt}))^2}$ the pion's energy. Thus by measuring the pion momentum (p) we can obtain the Λ binding energy for each bound state.

Besides the hypernuclear spectroscopy, FINUDA is able to investigate the weak decays of Λ-Hypernuclei. When the Λ-particle is free, it decays mainly via the mesonic modes:

$$\Lambda \rightarrow p + \pi^- \qquad (\sim 64\%) \quad (4)$$

$$\Lambda \rightarrow n + \pi^0 \qquad (\sim 36\%) \quad (5)$$

When the Λ-particle is embedded in a non-light-nucleus, the mesonic decay is strongly inhibited by the Pauli principle due to the reduced phase space, and the Non Mesonic Weak Decay (NMWD) takes place [4]:

$$\Lambda + p \rightarrow n + p \quad (6)$$

$$\Lambda + n \rightarrow n + n \quad (7)$$

In addition, other kaon-nucleon interactions can be studied with the FINUDA spectrometer: **K^--bound states** and **neutron-rich Λ-hypernuclei**. Deeply Bound Kaon-nuclear States (DBKS) are aggregates formed by nucleons bound rather tightly by an anti-kaon.
Neutron rich Λ-hypernuclei are medium-light hypernuclei with a neutron to proton ratio larger than 2 and/or which have an unstable nuclear core. Recent results on each of these items will be discussed in next section.

2.2 The Apparatus

Fig. 2 show a global view of the apparatus. The layers of the tracker are contained inside a superconducting solenoid, which provides a highly homogeneous (better than 2%) magnetic field of 1.0 T over a cylindrical volume of 146 cm radius and 211 cm length. Three main regions can be distinguished inside the FINUDA apparatus.

- *the interaction/target region* where the highly ionizing (K^+K^-) pairs are detected by a barrel of 12 thin scintillator slabs (TOFINO) surrounding the beam pipe. The high energy back-to-back topology in the TOFINO detector is used for trigger purposes and time measurements. The kaons are then

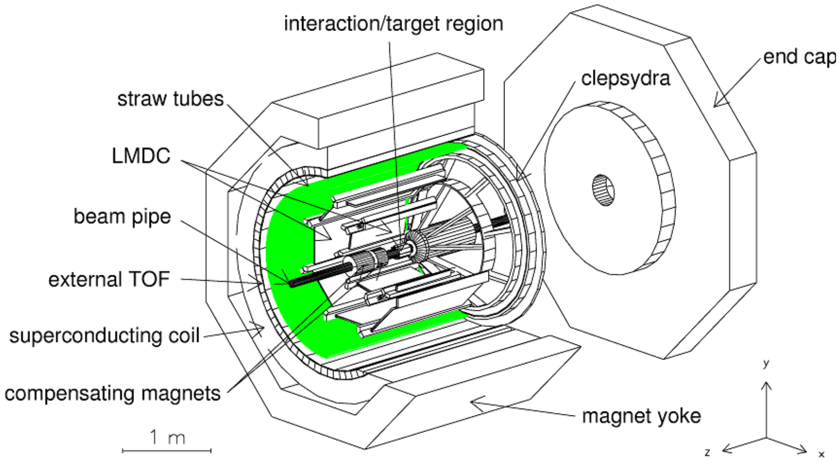


Fig. 2. Schematic view of the FINUDA spectrometer.

traced by means of an octagonal array of silicon microstrip detectors (ISIM) before entering the targets, which face the silicon detectors at a distance of a couple of millimeters. The spatial resolution of the ISIM detector is ∼30 μm and this allows to determine the interaction point of the kaons with a precision of ∼800 microns. This precision is essentially limited by the kaon range straggling at the end of their path. The silicon microstrip detector is also used for mass discrimination, having an energy resolution of ∼ 25% [5] for the kaons from ϕ decay.

- *The external tracking device* consists of four layers of position sensitive detectors, arranged with cylindrical symmetry around the beam pipe axis. The tracking volume is filled with He gas to reduce the effects of the multiple scattering. The trajectories of charged particles coming from the targets and crossing the tracking system are measured by: (i) a first array of ten double-sided silicon micro-strip modules (OSIM) placed close to the target modules; (ii) two arrays of eight planar low-mass drift chambers (LMDC), filled with a 70%He-30%C_4H_{10} mixture, featuring a spatial resolution of $\sigma_{\rho\phi}$ ∼ 150 μm and σ_z ∼ 1.0 cm [6]; (iii) a STRAW tubes detector assembly, composed of six layers of longitudinal and stereo tubes, which provides a spatial resolution of $\sigma_{\rho\phi} \sim 150$ μm and a $\sigma_z \sim 500$ μm [7]. The straw tubes are positioned at 1.1 m from the beams interaction point.
  In a 1.0 T magnetic field, the design momentum resolution of the spectrometer, for 270 MeV/c π^-'s, is $\Delta p/p = 0.4\%$ FWHM. It corresponds to an energy resolution better than 1.0 MeV on hypernuclear spectra and of about 1.6 MeV FWHM for the protons emitted in hypernuclear non-mesonic decay.
- *The external time of flight barrel* (TOFONE) is composed of 72 scintillator slabs, 10 cm thick and 255 cm long. It provides signals for the first level trigger and for the measurement of the time-of-flight of charged and neutral particles in the energy range from 10 up to 200 MeV, with a time resolution of a single slab σ ∼350 ps [8]. The detection of neutrons from the hypernucleus decay is performed with an efficiency of ∼ 10% and an energy

resolution of 8-11 MeV FWHM for neutrons of 65-80 MeV.

2.3 FINUDA detector main performance

Many experimental tests were performed during the data taking in order to monitor the machine performance as well as to calibrate the spectrometer. FINUDA apparatus can trigger on Bhabha events ($e^+ + e^- \rightarrow e^+ + e^-$) and ($e^+ + e^- \rightarrow e^+ + e^- + \gamma$), *i.e.* elastic and inelastic (e^+, e^-) scattering. The aim is to exploit these well known processes to perform an in-beam calibration of the apparatus. FINUDA measures the (e^+, e^-) collision spot, the total beam energy, the beam crossing angle and evaluates the luminosity delivered by the machine [9]. Using Bhabha events an average luminosity of $\mathcal{L}$=4× 10^{31} $cm^{-2}s^{-1}$ has been measured [9], and the timing resolution (σ) of the TOFONE barrel, defined as the time difference between the two slabs fired by the e^+e^- pairs, has been found to be ≅ 500 ps (see fig. 3).

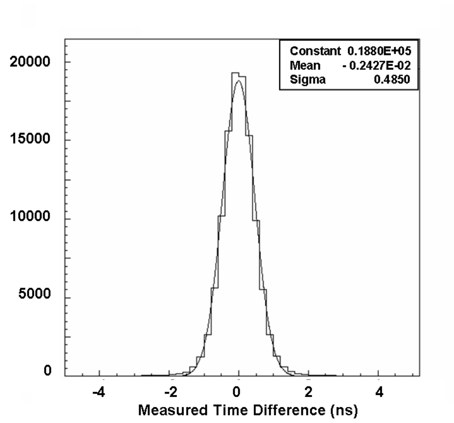


Fig. 3. Overall TOFONE distribution of the measured time differences between two slabs fired by e^+e^- pairs.

The trigger selecting the hypernuclear events requires two fired back-to-back TOFINO slabs, with signal amplitudes above the energy threshold accounting for the high ionization of slow kaons, and a multiplicity between 2 and 8 in the TOFONE barrel. This allows (K^+K^-) pairs selection, together with the products of K^- interaction hitting the external scintillator barrel to be selected against the physical background coming from other ϕ decays or against "fake" events generated by the accelerator electromagnetic background.
The (K^+K^-) trajectories and stopping points are computed by a tracking procedure based on the GEANE package [10]. This procedure accounts for the geometrical structure and the material composition of the FINUDA interaction region. In addition, it uses the information from ISIM on the K^+K^-

crossing points as input to determine the ϕ-formation vertex and the kaon momenta [8].

Since positive kaons are selected together with hypernuclear events by the hypernuclear trigger, K^+ allow to perform an accurate and continuous calibration of the FINUDA detector.
The K^+ stopping in the target array decay at rest with a mean life of 12.38 ns. The two main two-body decays $K^+ \to \mu^+\nu_\mu(63.43\%)$ and $K^+ \to \pi^+\pi^0(21.16\%)$ are sources of monochromatic particle (235.5 MeV/c for μ^+ and 205.1 MeV/c for π^+) fully crossing the spectrometer. These events are used to calibrate the absolute scale of the momenta with a precision better than 0.2 MeV/c, which can be assumed as a systematic error on the measurement of the particles momenta in the range between 200 and 300 MeV/c. Fig. 4 shows the momentum distribution of the positive tracks coming from the stopped K^+ vertex after the geometrical alignment of the 2003/2004 data set. The two peaks at 236 MeV/c and 205 MeV/c correspond to the previously mentioned decays. From the width of the μ^+ peak the momentum resolution of the apparatus can be estimated to be $\Delta p/p \cong 0.5\%$ FWHM, which correspond to 1.1 MeV FWHM for the hypernuclear levels (Fig. 5).

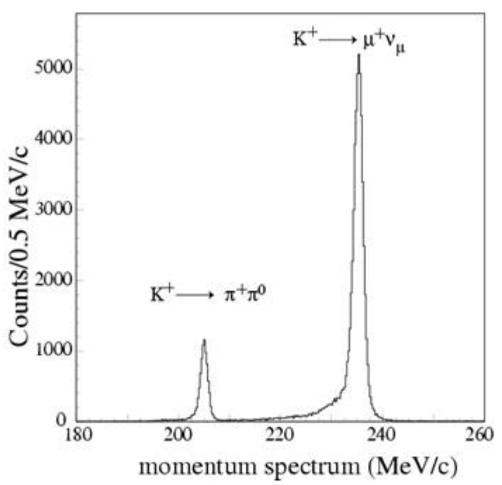


Fig. 4. Momentum distribution of the positive tracks coming from the stopped K^+. The peak at 236 MeV/c corresponds to the two body decay $K^+ \to \mu^+\nu_\mu$, the peak at 205 MeV/c corresponds to the two body decay $K^+ \to \pi^+\pi^0$.

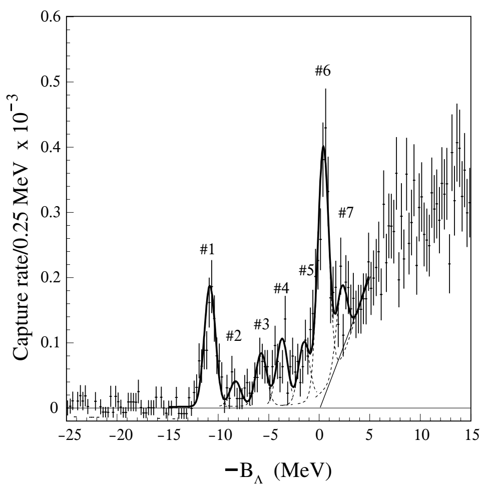
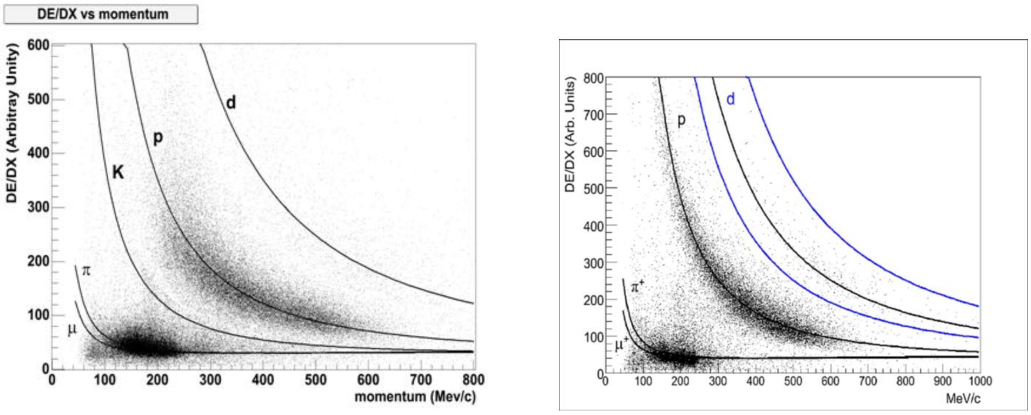


Fig. 5. ${}^{12}_{\Lambda}$C hypernuclear spectrum measured by FINUDA [8]. The x-axis shows the Λ binding energy evaluated through Eq. 3.

Fig. 6 shows how FINUDA can identify the charged particles (*p.id.*) by means of the OSIM detector, without further selections (a) and using further information by other tracking layers (b). The FINUDA *p.id.* assured a good separation of pions from protons and protons from deuterons, while muons are not discriminated against pions.



(a) (b)

Fig. 6. (a) Energy loss, of positive tracks coming from K^- stopped in the eight different targets versus their reconstructed momenta, measured by OSIM detector only. (b) Energy loss of positive tracks coming from K^- stopped in the eight different targets versus their reconstructed momenta, measured by OSIM with further selection by other sub-detectors information.

In fig. 7 the invariant mass of the π^- p system is shown and a mass resolution of 6 MeV/c^2 FWHM results from the fit of the Λ peak.

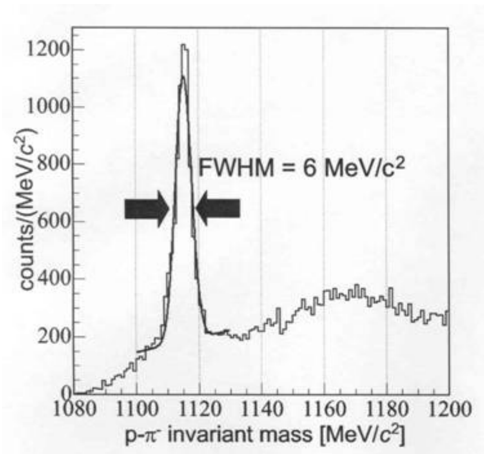


Fig. 7. Invariant mass of the π^-p events distribution. The peak corresponding to the Λ mass has a resolution of 6 MeV/c^2 FWHM.

3 Recent results

As described in the previous section, the FINUDA research program can span over different fields. A review of recent FINUDA results will be presented in the following, as obtained so far by analyzing the 200 pb^{-1} statistics collected from October 2003 to March 2004, with a reference to the improvements that could be expected with the new high statistics data set.

3.1 Hypernuclear spectroscopy and decay

The spectroscopy of Λ-hypernuclei has proven to be a powerful tool to study the ΛN interaction if compared with difficult and low statistics ΛN scattering experiments. This field received a boost by the production of high precision data coming from Ge-detector experiments measuring γ-ray transitions of hypernuclear levels. Thanks to them, the spin-dependent contributions to the ΛN interaction have been finally measured .

FINUDA has not an energy resolution such as to compete with these measurements, but it can deliver complementary information combining the spectroscopic studies with the investigation of the decay modes of hypernuclear states. With the first set of data, FINUDA produced good spectroscopy results for ${}^{12}_{\Lambda}$C and ${}^{7}{}_{\Lambda}$Li hypernuclear systems. The detailed description of the analyses, and of the obtained results can be found elsewhere in [9,11].

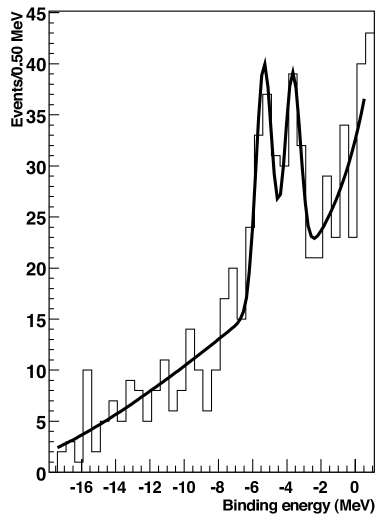


Fig. 8. ${}^{7}{}_{\Lambda}$Li binding energy spectrum measured by FINUDA.

Fig. 8 shows ${}^{7}{}_{\Lambda}$Li hypernuclear spectrum measured by FINUDA in which two separate states are clearly detected.
${}^{7}{}_{\Lambda}$Li is one of the most studied hypernucleus with the large acceptance Germanium array Hyperball. Recently, the experiments E419 at KEK and E930 at BNL performed high resolution spectroscopy of ${}^{7}{}_{\Lambda}$Li defining precisely the level scheme, and the energies of bound states [12]. We have tried to locate the two observed peaks in the level scheme fixed by the Hyperball detector. The first (left) peak could be a mixture of the ground state with the first $3/2^+$

excited state, since its energy value lies between the two. In the same way the second (right) peak can be the $5/2^+$ or the $7/2^+$ state, or a mixture of the two.

Concerning the decay of Λ hypernuclei, the statistics collected so far allows only to start the investigation of $^{12}_{\Lambda}$C, since three carbon targets were mounted in the spectrometer. The FINUDA spectrum of protons from NMWD is reported in fig. 9. The proton energy distribution is centered around 80 MeV with a width of $\sim$ 60 MeV. The low energy bin is probably due to Final State Interactions of the outgoing particles and/or to the contribution of the two nucleon induced reaction Λ(np)→nnp. The shape of the distribution is also consistent with early theoretical works [13], but it's completely different from an high statistic spectrum measured at KEK by the E462/E508 experiments [14]. The scenario will be better understood with new high statistic measurements [15].

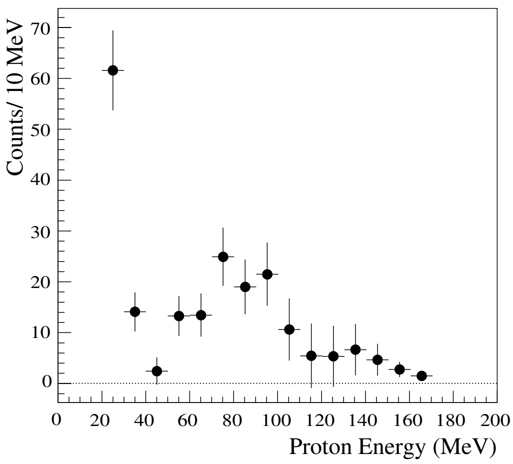


Fig. 9. Energy spectrum of the protons from NMWD of $^{12}_{\Lambda}$C hypernucleus.

3.2 Search for neutron rich Λ-hypernuclei

As pointed out by Majling [16], Λ-hypernuclei may be even better candidates than ordinary nuclei to exhibit unusually large values of N/Z and halo phenomena. In fact, a Λ-hypernucleus is more stable than an ordinary nucleus due to the compression of the nuclear core and to the addition of extra binding energy from the Λ hyperon (playing the so called "glue-like role of the Λ") [17]. From the hypernuclear physics point of view, the attempt to extend our knowledge towards the limits of nuclear stability, exploring strange systems with high N/Z ratio, can provide more information both on baryon-baryon interactions and on the role of the three-body ΛNN force related to the "coherent Λ-Σ coupling" in connection with nuclear astrophysics [18]. In

particular, there is great interest in the possible existence of ${}^{6}_{\Lambda}$H, since theoretical calculations predict the existence of a stable single-particle state with a binding energy of 5.8 MeV from the ^{5}H + Λ threshold (+1.7 MeV [19]) when the Λ-Σ coupling term is considered. Without this coupling force the state would be very close to the ${}^{4}_{\Lambda}$H $+2n$ threshold [7-8].
Experimentally, the production of neutron rich Λ-hypernuclei is more difficult than standard Λ-hypernuclei, whose one-step direct production reactions, such as (K^-, π^-) and (π^+, K^+), access only a limited region in the hypernuclear chart, rather close to the stability region. On the contrary, neutron rich Λ-hypernuclei can be produced by means of different reactions based on the double charge-exchange (DCX) mechanism, such as (π^-, K^+) and (K^-, π^+). The latter reaction proceeds through the following two elementary reactions:

$$K^- + p \to \Lambda + \pi^0; \quad \pi^0 + p \to n + \pi^+ \tag{8}$$

$$K^- + p \to \Sigma^- + \pi^+; \qquad \Sigma^- \; p \leftrightarrow \Lambda \; n \tag{9}$$

the first process is a two step reaction in which a strangeness exchange is followed by a pion charge exchange. The second process is a single step reaction with a Σ^- admixture (due to the $\Sigma^- \; p \leftrightarrow \Lambda \; n$ coupling [20]). Owing to these features, both processes usually have lower cross sections than one step reactions.
The first experimental attempt to produce neutron rich Λ-hypernuclei via the (K^-_{stop},π^+) reaction was carried out at KEK [21]. An upper production limit (per stopped kaon) was obtained for ${}^{12}_{\Lambda}$Be, ${}^{9}_{\Lambda}$He and ${}^{16}_{\Lambda}$C hypernuclei. The results are in the range (0.6÷2) $\times$ 10^{-4}. Recently, a KEK experiment [22] claimed to have observed the production of ${}^{10}_{\Lambda}$Li in the (π^-, K^+) reaction on a ^{10}B target. The published results are not directly comparable with theoretical predictions since no discrete structure was observed, and the production cross section has been integrated over the whole bound region ($0 < B_\Lambda < 20$ MeV). Furthermore, the experimental trend of the cross section energy dependence strongly disagrees with theoretical predictions [23].
This circumstance has stimulated a renewed interest in neutron rich Λ-hypernuclei, in particular in ${}^{6}_{\Lambda}$H and ${}^{7}_{\Lambda}$H. Their production rates have neither theoretical predictions nor experimental measurements.
Neutron rich Λ-hypernuclei can be produced in the FINUDA experiment through processes (8) and (9) with a K^- at rest. In both cases a final state with a π^+ and a Λ-hypernucleus is produced. The overall production reaction is:

$$K^-_{stop} +^A (Z) \to^A_\Lambda (Z-2) + \pi^+. \tag{10}$$

The residual Λ-hypernucleus has two protons less, and one neutron more than the target nucleus. The emitted π^+ momenta are related to the Λ binding

energies B_Λ of the hypernuclear ground state of ${}^{6}_{\Lambda}$H (B_Λ=4.1 MeV [24]) and of ${}^{7}_{\Lambda}$H (B_Λ=5.2 MeV [16]) through momentum and energy conservation, and are $\sim$ 252 and $\sim$ 246 MeV/c respectively. In Ref. [25] the analysis of the π^+ inclusive momentum spectra (fig. 10), of data taken in the first FINUDA run, is presented and discussed. The analysis shows no evidence of neutron rich Λ hypernuclear production. Nevertheless it evaluates, for the first time, the upper limits for the production rates of ${}^{6}{}_{\Lambda}$H ($2.5\pm0.4_{stat}{}^{+0.4}_{-0.1 syst} \times10^{-5}/\mathrm{K}^-_{stop}$) and ${}^{7}{}_{\Lambda}$H ($4.5\pm0.9_{stat}{}^{+0.4}_{-0.1 syst} \times 10^{-5}/\mathrm{K}^-_{stop}$) at 90% C.L., in the ($K^-_{stop}$,$\pi^+$) reaction and improves the ${}^{12}_{\Lambda}$Be best published [21] upper production rate limit by a factor 3 ($2.0\pm0.4_{stat}{}^{+0.3}_{-0.1 syst}\times10^{-5}/\mathrm{K}^-_{stop}$) .
The new target setup for the 2006/2007 FINUDA data taking will allow us to search again for ${}^{6}_{\Lambda}$H and ${}^{7}_{\Lambda}$H, with a factor $\sim$4 more statistics, and at the same time to study the following reactions: ^{9}Be(K^-_{stop},π^+)${}^{9}{}_{\Lambda}$He, ^{13}C(K^-_{stop},π^+)${}^{13}_{\Lambda}$Be and ^{16}O(K^-_{stop},π^+)${}^{16}_{\Lambda}$C.

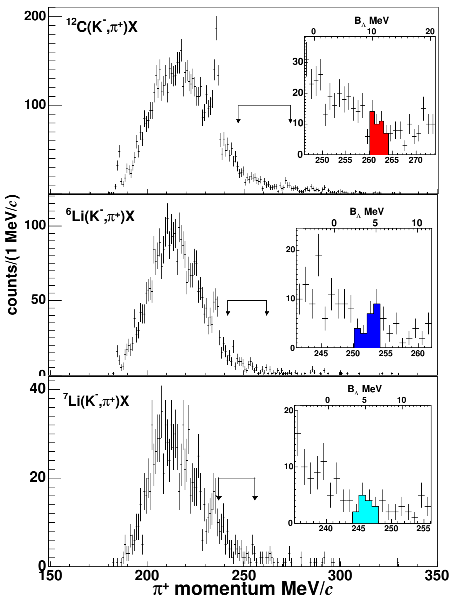


Fig. 10. Inclusive π^+ spectra of ^{6}Li, ^{7}Li and ^{12}C targets. The inset show an enlarged view of the Λ bound region, the colors correspond to the expected ground states.

3.3 Studies of K-nuclear bound states

From a theoretical point of view the existence of K^--nucleons or K^--nucleus aggregates is quite controversial. From one side, new phenomenological approaches have been developed claiming for the existence of very strongly bound systems, rather narrow and therefore easily detectable. The model asserting the existence of such states was developed by Akaishi and Yamazaki [26]. As a result, the $\overline{K}$N interaction in the I = 0 configuration is found to be very attractive, with a strength which allows for the existence of kaon-multinucleon

aggregates bound from 86 MeV (in the case of ^{3}He + K$^-$) to 113 MeV (in the case of ^{8}Be+K$^-$), with very narrow widths (20 MeV for ^{3}He + K$^-$, 38 MeV for ^{8}Be+K$^-$).
Other theoretical models foresee shallower potentials, admitting the existence of the kaon-nuclear aggregates but with weaker binding (-ReV$_{opt}$ ≅ 50-75 MeV against 150-200 MeV) and with a width large enough to elude their experimental observation [27]. However, according to a dynamical approach [28], the kaon-nuclear potential could be density dependent, and rather narrow states, less than 50 MeV wide, could in principle be formed in nuclei heavier than ^{12}C, with a deep binding energy in the range $B_{\overline{K}} \cong$ 100-200 MeV. Other theoretical arguments against the existence of deeply bound kaon nuclear states have been put forward, based on chiral approaches [30].

FINUDA already observed a few hints of a possible signal of [K$^-$pp] state with some features almost compatible with those expected for a deeply bound kaonic state, assuming it could decay (almost at rest) into the Λp channel [31]. The possibility to study the [K$^-$np] system with FINUDA has been explored too. Only a few tens of events have been selected. Since neutrons are identified in FINUDA with a detection efficiency of roughly 10%, the available statistics for events in which the coincidence with one neutron is asked is rather poor.
Stimulated by first KEK results in the reaction ^{4}He(K$^-_{stop}$,N)X [29], we consider the possibility to study the dynamics of [K$^-$NNN] clusters (or tri-baryon nuclear state) in ^{6}Li. FINUDA has not a He target, nevertheless it is well known that ^{6}Li has a di-cluster structure, namely it can be seen as formed by a "quasi"-deuteron and a "quasi"-α particle. Thus the incoming kaon can undergo a true K$^-$"d" or a true K$^-$"α" absorption.
In the proton inclusive spectrum we observe a signal at ∼500 MeV/c (shown

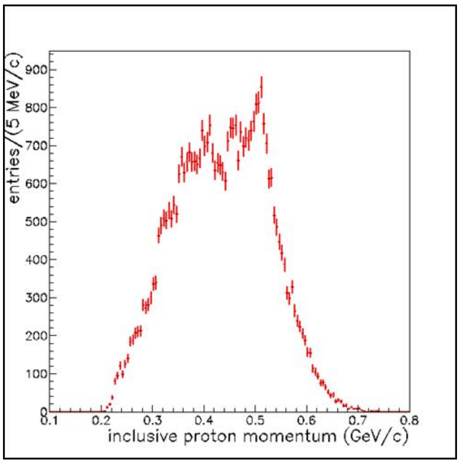


Fig. 11. Inclusive momentum spectrum of protons emitted in K$^-_{stop}$ induced reactions in the FINUDA ^{6}Li targets.

in fig. 11) similar to the one observed by E471 in the ^{4}He(K$^-_{stop}$,p)X reaction and interpreted as a tri-baryon [K$^-$npp] state. This signal was found to be enhanced in events where a fast π^- in coincidence was detected ($p_{\pi^-} > 275$ MeV/c), as in the case of KEK-E471. However, no deeply bound kaon-nucleons structure needs to be invoked as the observed signal can easily be interpreted as due to the K^- "d" $\rightarrow \Sigma^-$ p absorption reaction on the quasi deuteron component of the structure of ^{6}Li (the detail of this analysis can be found in Ref. [32]).

The possible formation of a [K^-nnp] aggregates has been studied too. We pursued this study by investigating the invariant mass spectrum of Λd pairs, produced in the kaon absorption reaction K^-_{stop}A $\rightarrow \Lambda$d A′, where A = ^{6}Li and A′ represent the residual nucleons, which may be bound or not. The few deuteron events, selected as shown in fig. 6(b) are found to be very well correlated with a Λ. A peak-like structure at around 3243 MeV/c^2 is visible in the Λd invariant mass spectrum (shown in fig. 12).
The 25 events belonging to the peak-like structure have a Λd angular distribution almost back-to-back, and are correlated with a bump at ∼25 MeV in the spectrum of the missing kinetic energy of the reaction, (*i.e.* the kinetic energy of the residual 3 nucleons) [33].

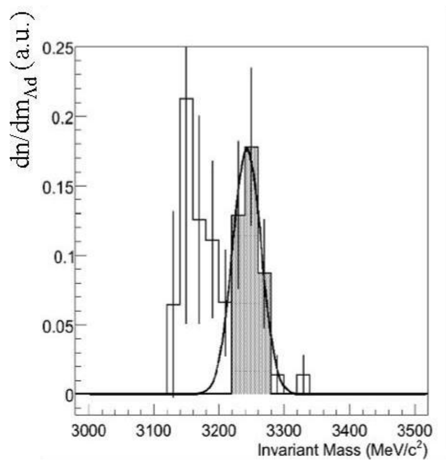


Fig. 12. Invariant mass distribution of Λd pairs from the ^{6}Li(K^-_{stop},Λd)A′ reaction (open diagram). The curve is a normal distribution fitting to the peak-like structure.

The correlation of the three observables (*i.e.* the (Λ d) peaked invariant mass distribution, the almost back-to-back angular distribution and the missing kinetic energy with a bump at 25 MeV) can be explained by a K^- absorption at rest on the "α" cluster of the ^{6}Li nucleus with a prompt neutron emission leaving a [K^-nnp] system of mass 3243 MeV/c^2 that decays almost at rest into a Λ and a deuteron together with a spectator deuteron filling the kinetic energy balance of the reaction [33].
When [K^-NNN] clusters are discussed in the framework of $\overline{K}$ bound states, the nuclear ground state of [$\overline{K}^3$He] is predicted to be 108 MeV deep and 20 MeV wide [34]. In this framework similar quantities can be determined by assuming

that [K$^-$pd]≡[$\overline{K}^3$He]. For the [K$^-$pd] it turns out to be B$_{K^-pd}$=($m_{K^-} + m_p + m_d$)-$m_{\Lambda d}$=64±5.3 MeV and $\Gamma_{\Lambda d}$=36.8±9.7 MeV/c^2. The agreement between theory and experiment is poor, thus we cannot draw any conclusion on the nature of the observed signal.
In the next data taking FINUDA will improve the statistical significance of the 3243 MeV/c^2 peak-structure from 2.5σ to 7.2σ. Moreover the increased statistics will allow to study the background with greater detail, and to investigate the neutron momentum in coincidence with the Λd particles (about 30 events expected).

4 Conclusions

The peculiar idea of FINUDA to exploit the low energy negative kaons of DAΦNE to produce hypernuclei has proved to be winning. The analysis of the first ∼200 pb^{-1} data has produced many quality results thanks to the detector's excellent versatility. With the new data taking presently going on more than 150 million events (corresponding to an integrated luminosity ∼ 1fb^{-1}) will be stored allowing a sizable step forward in many fields of hypernuclear physics.

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