Search for neutron rich Λ hypernuclei with FINUDA

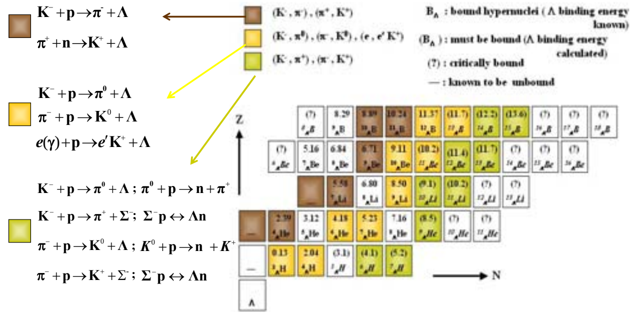
Barbara Dalena *(Bari University and INFN Bari, Italy) on behalf of the* *FINUDA Collaboration*

Based on [1]

Introduction

The existence of hypernuclei with a large neutron excess (NRΛH) was first stressed by Majling [2]. A Λ-hypernucleus is more stable than an ordinary nucleus due to the compression of the nuclear core and to the addition of an *extra* binding energy from the Λ (Λ "*glue-like*" role).

They are not yet clearly observed, except for 40 events spread in the whole bound region of the missing-mass spectrum for the reaction $^{10}B(\pi^-,K^+)^{10}{}_{\Lambda}Li$ [3]. NRΛH observation is relevant for many studies, for instance: ΛN interaction at low energy, nuclear halo phenomena, equation of state of nuclear matter, neutron stars.

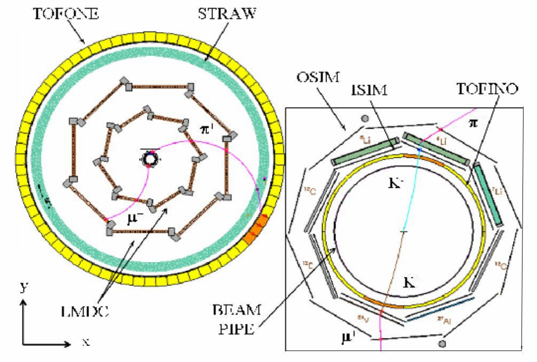


Production mechanisms[4]

1) Double charge exchange: $\mathbf{K^- + p \to \Lambda + \pi^0;\ \pi^0 + p \to n + \pi^+}$

2) Strangeness exchange & Σ-Λ coupling: $\mathbf{K^- + p \to \Sigma^- + \pi^+;\ \Sigma^- + p \leftrightarrow \Lambda + n}$

Calculated Production Rate per K^-_{stop} of ▢ is ~ 3 order of magnitude less than the measured one of ▢ (~ 10^{-3}).



In the target nuclei employed in the first FINUDA data taking **we search for**:

$^{12}{}_{\Lambda}Be$ (N/Z = 7/4) from $^{12}C(K^-_{stop},\pi^+)^{12}{}_{\Lambda}Be$

$^{6}{}_{\Lambda}H$ (N/Z = 4) from $^{6}Li(K^-_{stop},\pi^+)^{6}{}_{\Lambda}H$

$^{7}{}_{\Lambda}H$ (N/Z = 5) from $^{7}Li(K^-_{stop},\pi^+)^{7}{}_{\Lambda}H$.

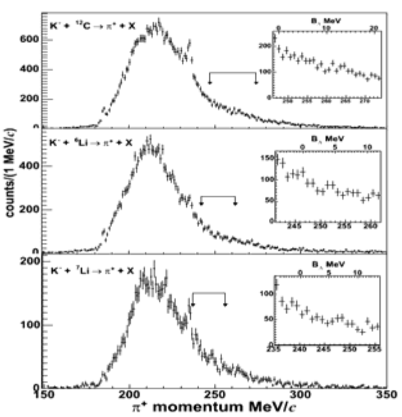
π^+ momentum is related to the Λ binding energy (B_Λ)

	B_Λ (MeV)	p_π (MeV/c)
$^{12}{}_{\Lambda}Be$	11.4[2]	262
$^{7}{}_{\Lambda}H$	5.2[2]	246
$^{6}{}_{\Lambda}H$	4.1[5]	252

Data analysis

Reconstruction of a π+ with a momentum value in the hypernucleus bound region

P.ID. made using d*E*/dx from OSIM and TOF from TOFINO & TOFONE.



Background:

- $K^- + p \to \Sigma^+ + \pi^-$
  $\Sigma^+ \to \pi^+ + n$
  ($130 < p_\pi < 250$ MeV/c)
- $K^- + pp \to \Sigma^+ + n$
  $\Sigma^+ \to \pi^+ + n$
  ($100 < p_\pi < 320$ MeV/c)

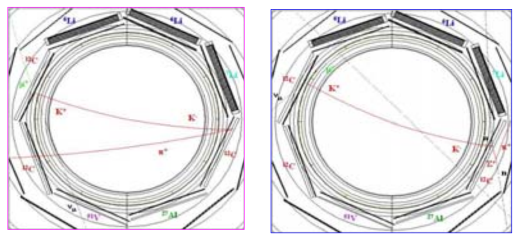
Contaminations:

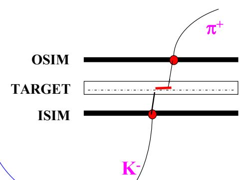
- μ^+ K^+ decay (@~235MeV/c)
- p Λ/Σ decay

Background reduction

Simulated NRΛH production event (FINUDA vertex view)

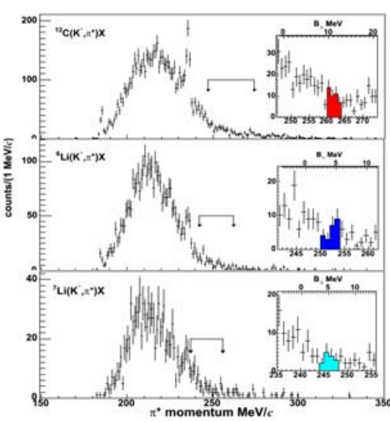
$K^- + pp \to \Sigma^+ + n$
$\Sigma^+ \to \pi^+ + n$





The reconstructed distance between the origin point of π^+ and the K^- stopping point is broader (up to 8mm) for a π^+ coming from Σ^+ decay than for the signal (peaked at less than 1mm).

Final spectra and U.L. evaluation



NRΛH	Rate / stopped K^- (90% C.L. Upper Limit)	
	FINUDA [1] (10^{-5})	Previous best published value
$^{12}{}_{\Lambda}Be$	$2.0 \pm 0.4(stat)^{+0.3}_{-0.1}(sys)$	$6.1 \cdot 10^{-5}$
$^{6}{}_{\Lambda}H$	$2.5 \pm 0.4(stat)^{+0.4}_{-0.1}(sys)$	NEW
$^{7}{}_{\Lambda}H$	$4.5 \pm 0.9(stat)^{+0.4}_{-0.1}(sys)$	NEW

Rate /K_{stop} in the ROI and Upper Limit

ROI = $\pm 2\sigma_p \approx \pm 2$MeV/c

$$R_{ROI} = \frac{N_{\pi^+}}{N_{\mu^+}} \cdot \frac{K^+_{stop}}{K^-_{stop}} \cdot \frac{\varepsilon_D(\mu^+)}{\varepsilon_D(\pi^+)} \cdot \frac{\varepsilon_G(\mu^+)}{\varepsilon_G(\pi^+)} \cdot BR(K_{\mu 2})$$

- N_π = number of π^+ in the region of interest.
- N_μ = number of μ^+.
- K^+_{stop}, K^-_{stop} = number of stopped kaons in target.
- $\varepsilon_D(\pi^+) \cong \varepsilon_D(\mu^+)$.
- $\varepsilon_G(\pi^+) = \alpha_G(\pi^+)\cdot\varepsilon_T(\pi^+)$, MC/RC.
- $\varepsilon_G(\mu^+) = \alpha_G(\mu^+)\cdot\varepsilon_T(\mu^+)\cdot\alpha_T(\mu^+)$, MC/RC.
- $BR(K_{\mu 2}) = 0.6343$.

$$\mathbf{U.L.} = x \cdot R_{ROI}$$

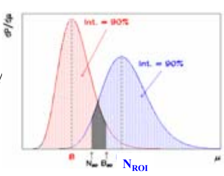
✓ S = signal, B = background : $N_{ROI} = S + B$

✓ $x = \frac{S}{N_{ROI}}$ maximum fraction of N_{ROI} that may be ascribed to NR/ at fixed C.L. (90%).

✓ $S = N_{ROI} - B$

✓ $\int_{N_{C.L.}}^{\infty} \frac{\mu^{N_{ROI}} e^{-\mu}}{N_{ROI}!} d\mu = C.L.$

$\int_0^{B_{C.L.}} \frac{\mu^{B} e^{-\mu}}{B!} d\mu = C.L.;\quad B_{C.L.} \geq N_{C.L.}$



Conclusions

The first FINUDA data taking established the best U.L. 90% C.L. for $^{12}{}_{\Lambda}Be$ production rate/stopped K^- and determined this value for $^{6}{}_{\Lambda}H$ and $^{7}{}_{\Lambda}H$ for the first time. FINUDA run 2006/2007 will improve of a factor 4 this U.L. value of $^{6}{}_{\Lambda}H$ (expected U.L. 6.5×10^{-6}) and of $^{7}{}_{\Lambda}H$ (expected U.L. 6.9×10^{-6}).

$^{9}{}_{\Lambda}He$, $^{13}{}_{\Lambda}Be$ and $^{16}{}_{\Lambda}C$ can be studied (expected U.L. 6.7×10^{-6}, 1.1×10^{-5} and 8.5×10^{-6}).

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References

[1] M. Agnello et al. Phys. Lett. B 640 (2006) 145.
[2]L. Majling, Nucl.Phys. A 585 (1995) 211c.
[3] P.K. Saha et al. Phys.Rev.Lett. 94 (2005) 052502.
[4] T. Yu. Tretyakova and D.E. Lanskoy, Proc. of Workshop "Recent progress in strangeness nuclear physics ", H. Outa et al. eds., KEK (2003) 80.
[5] Y. Akaishi, Frascati Phys. Series,Vol. XVI (1999) 59 .

INFN Istituto Nazionale di Fisica Nucleare Sezione di Bari