$^{12}_{\Lambda}$C spectroscopy and decays with FINUDA at DAΦNE

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On behalf of FINUDA Collaboration

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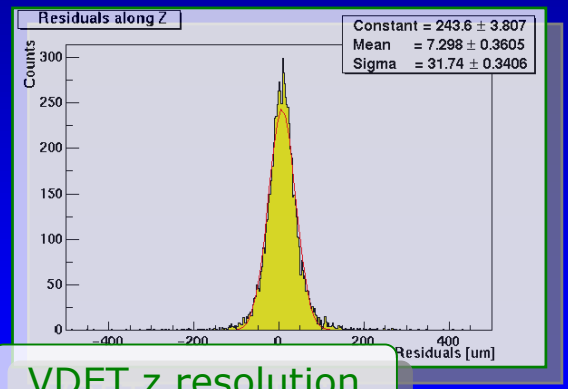
Talk topics

- $^{12}_{\Lambda}$C events selection and spectroscopy results
- Capture rates for $^{12}_{\Lambda}$C
- Non Mesonic Weak Decay (NMWD) methodology and results
- Conclusions

FINUDA detectors performances

- s.c. solenoid: B = 1.0 T; field homogeneity within 2%
- interaction/target region: K^+/K^- identification, hypernucleus production and detection

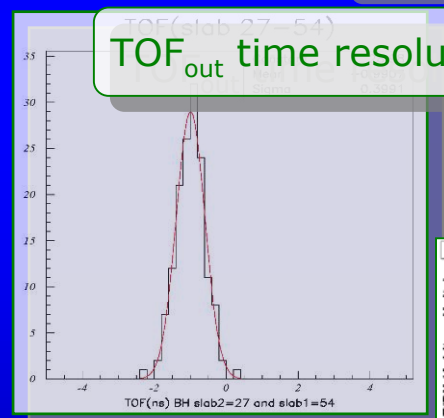
VDET: σ_z = 30 μm; ΔE = 25% FWHM (K)
TOF_{in}: σ_t = 250 ps



VDET z resolution

- tracking devices: measurement of trajectories and momenta of charged particles (Δp/p 5‰)

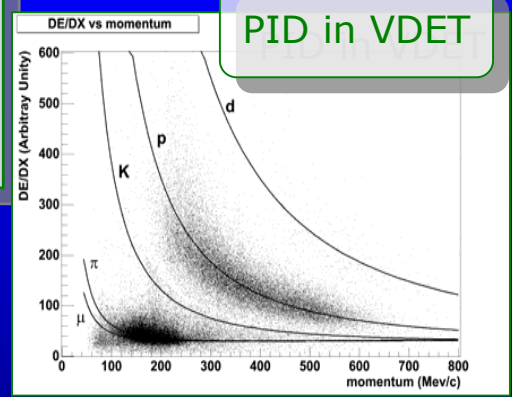
LMDC: σ(ρ, φ) = 150 μm; σ_z ≤ 1% wire length
STB: σ(ρ, φ) = 150 μm; σ_z 500 μm



TOF_{out} time resolution

- external scintillator barrel: trigger and neutron detection

TOF_{out}: σ_t = 500 ps FWHM
efficiency ≥ 10%; ΔE = 8 MeV

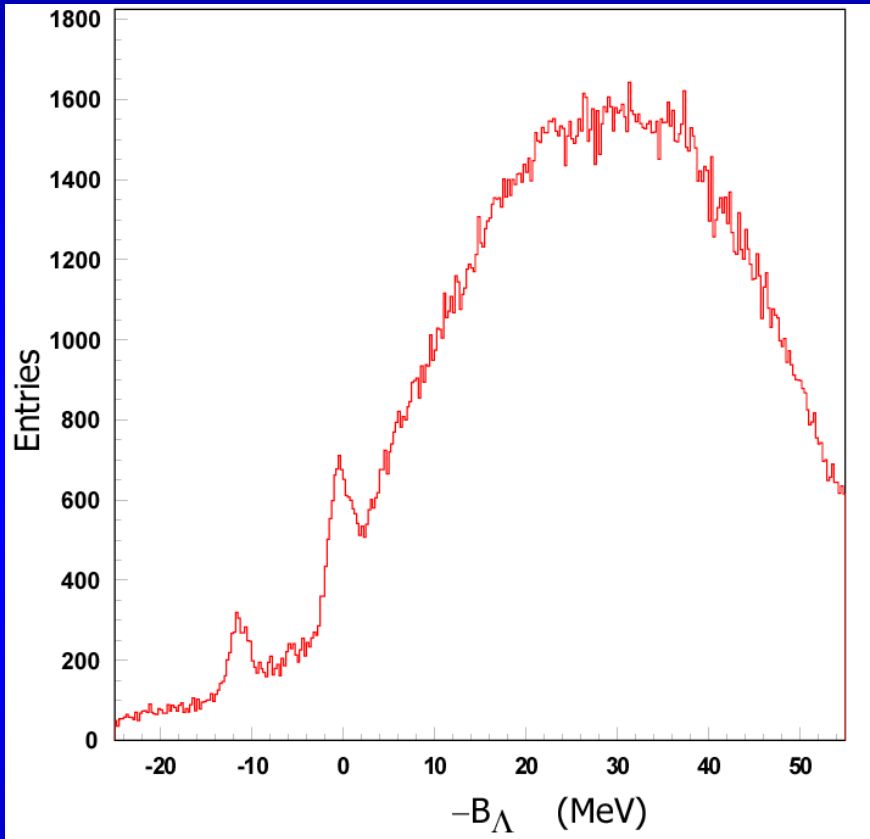


PID in VDET

- He chamber: minimization of particle multiple scattering

Δp/p: He atmosphere = 5‰
air = 2%

Events selections (1/3)



Raw $-B_\Lambda$ spectrum:

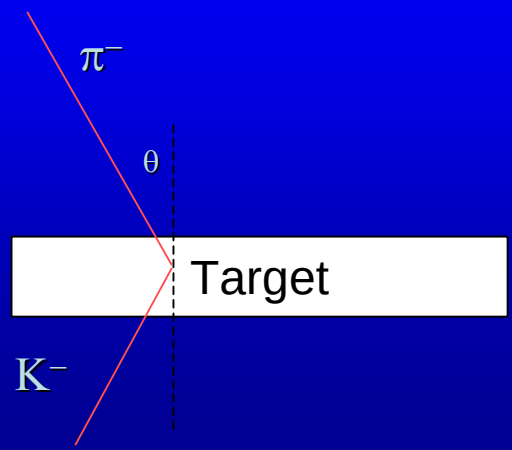
Total events: 295887

Quality track selection criteria:

- Track fit (fitemin=0)
- Extrapolated track (extrmin=1)
- Track stops in target (stopmin=1)
- χ^2 on track fitting stermin<100 dev2min<100 resdmin<0.05

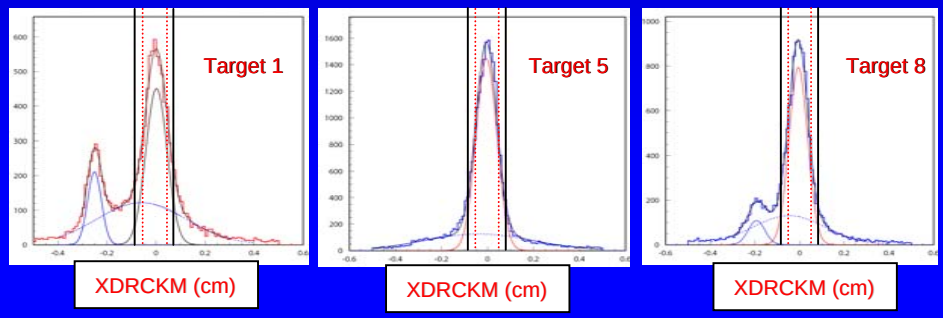
Topological selection criteria:

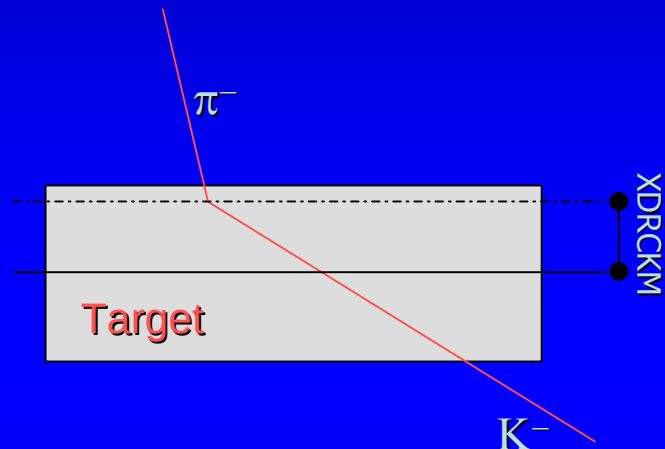
Angle of escaping pions θ<80 (0<normin<80)
→ only forwards events (reduced effects of multiple scattering)



Events selections (2/3)

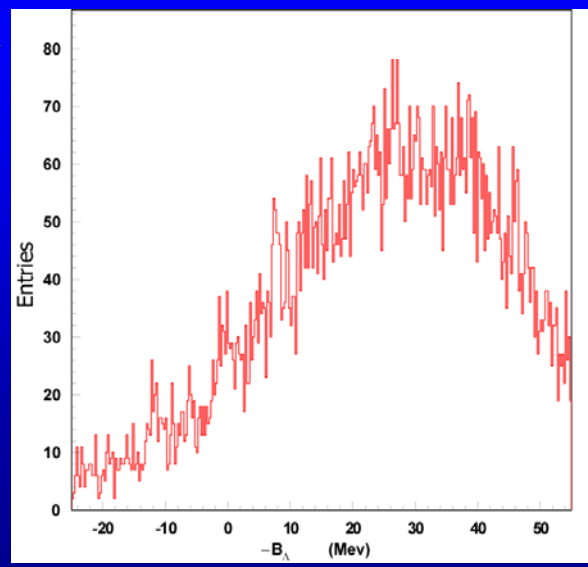
The XDRCKM distribution for the three carbon targets are fitted with 3 gaussian curves. If the small peak at about -0.25 cm are silicum events the must be removed.



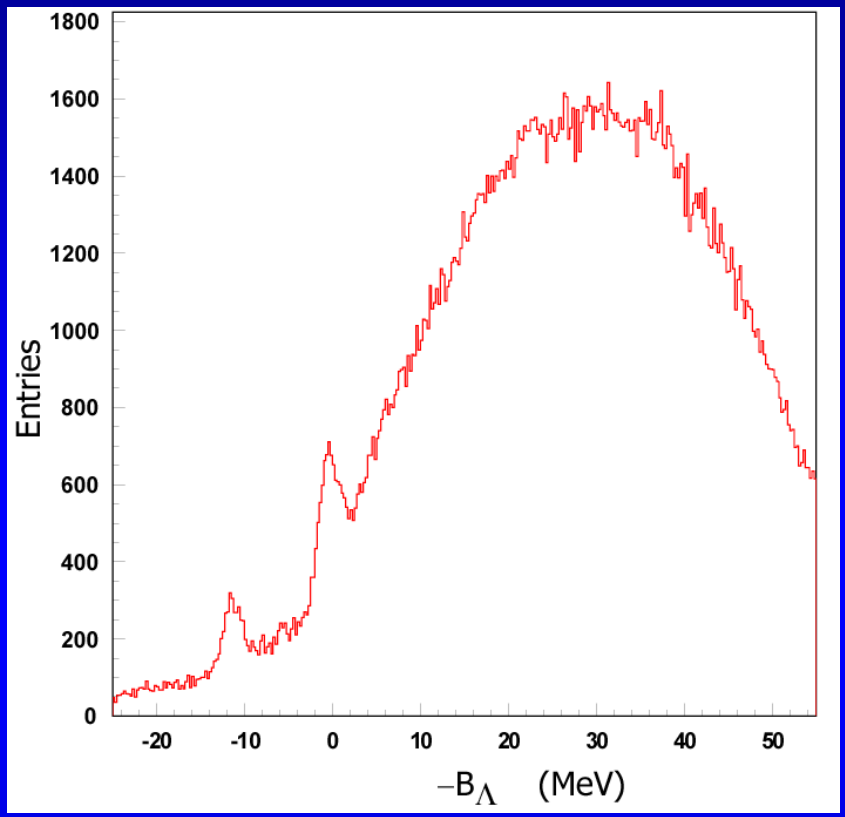


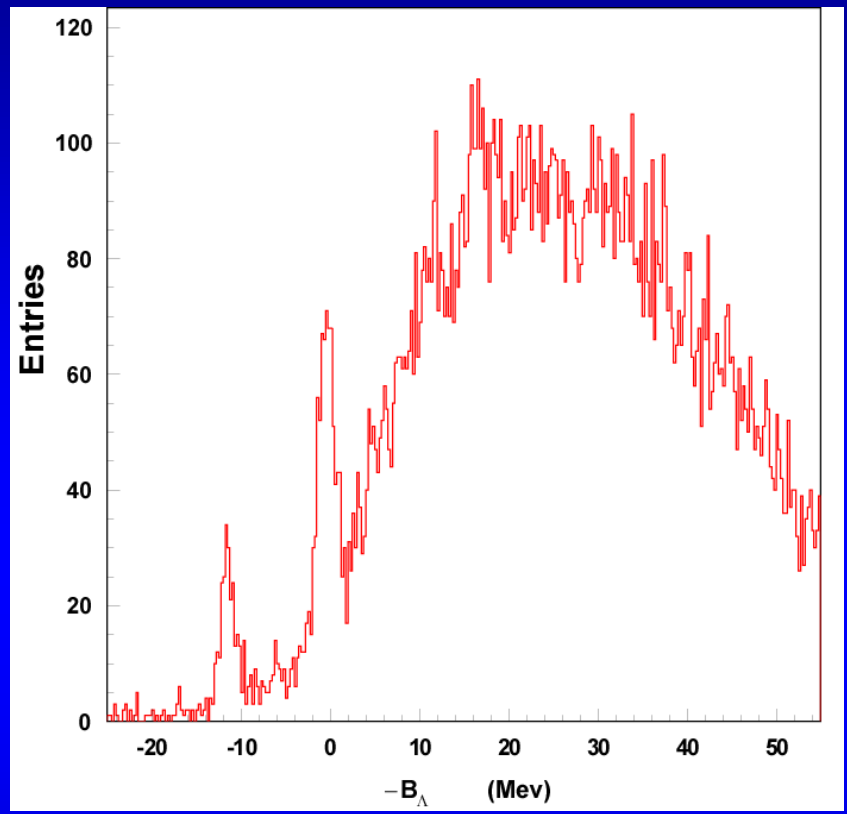
cut on |XDRCKM| as much as possible to remove events not "really" $^{12}_{\Lambda}$
Black vertical lines indicate physical target bounds 0.85 cm.
Dotted red lines indicate the cut applied: |XDRCKM| < 0.05 cm

Events outside selected regions do not presents hypernuclear peaks



Events selections (3/3)





Raw $-B_\Lambda$ spectrum:

Total events: 295887

Track selection criteria:

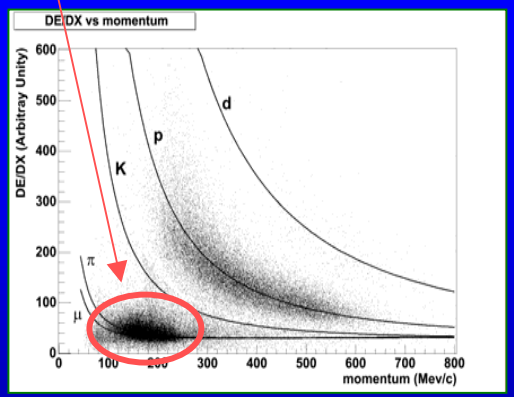
- Track fit (fitemin=0)
- Extrapolated track (extrmin=1)
- Track stops in target (stopmin=1)
- χ^2 on track fitting stermin<100 dev2min<100 resdmin<0.05
- Angle of escaping pions θ<80 (0<normin<80
- |XDRCKM|<0.05

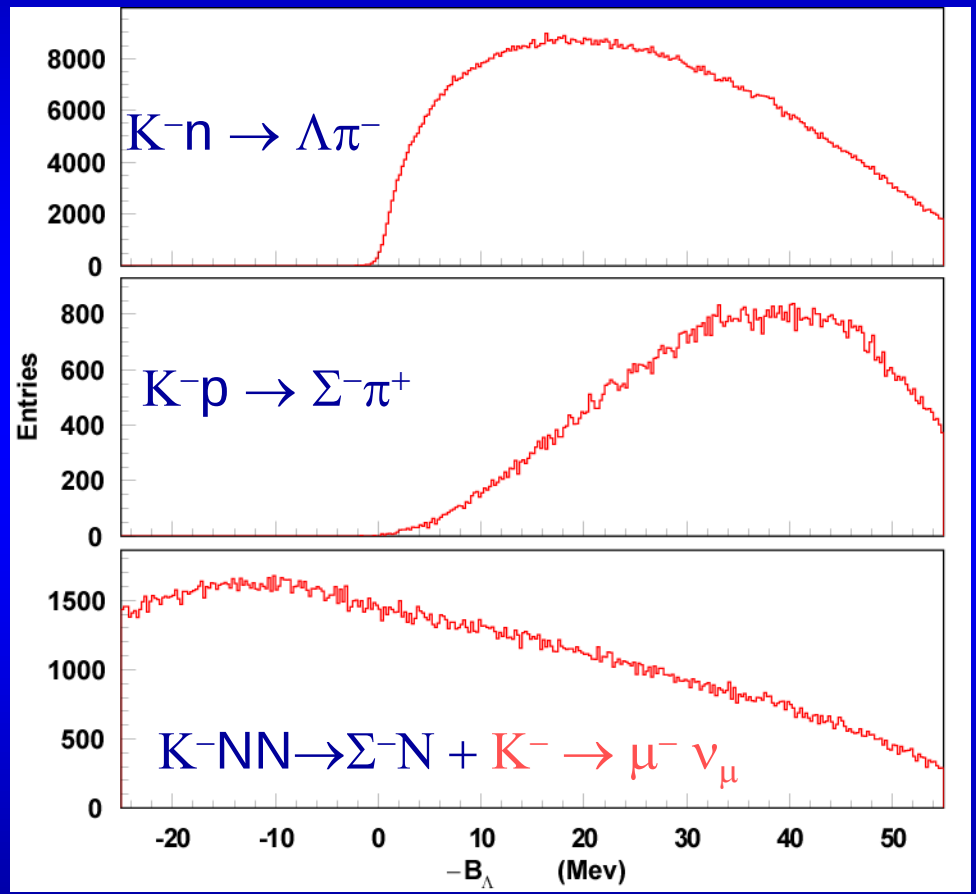
Final number of events 17245

Background Simulations

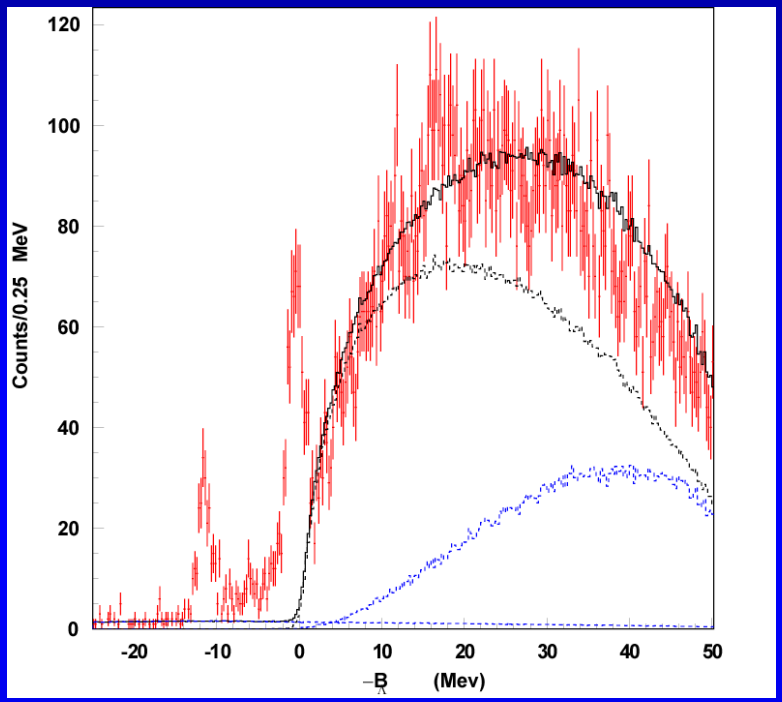
Below signal region we expect 4 possible source of $\pi-$

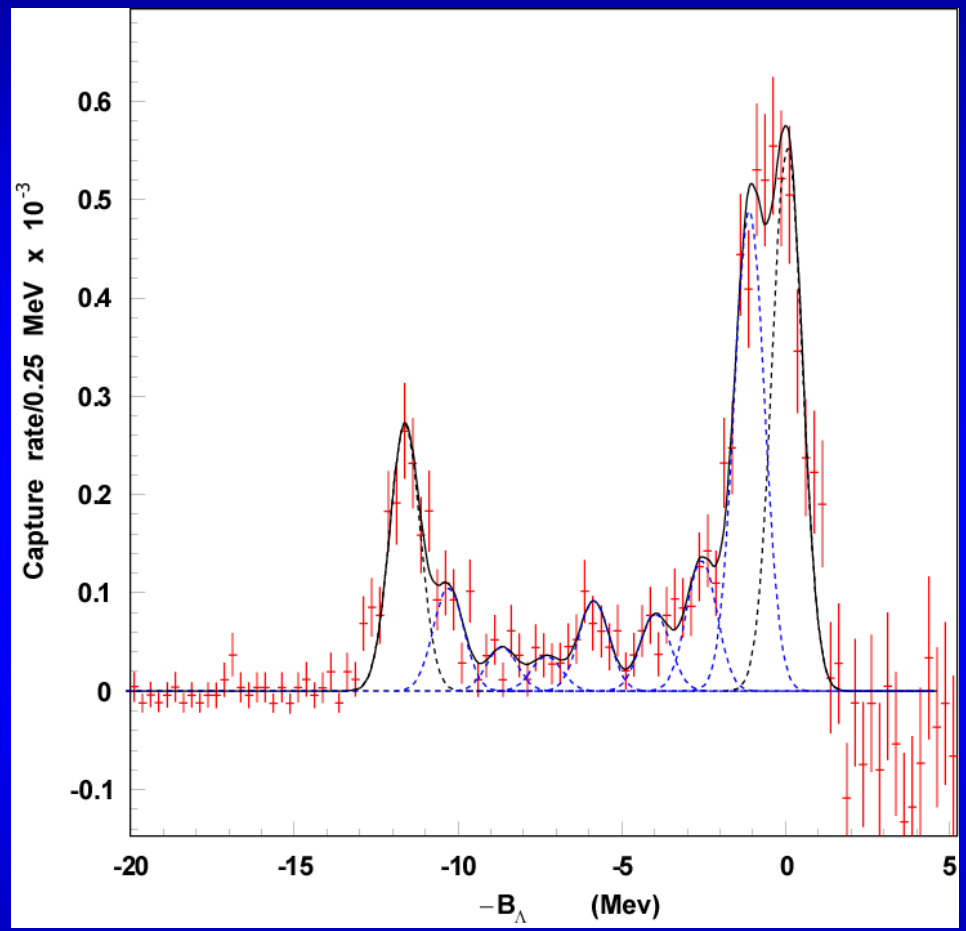
- $K^-n \rightarrow \Lambda\pi^-$
- $K^-NN \rightarrow \Sigma^-N$
- $K^-p \rightarrow \Sigma^-\pi^+$
- $K^- \rightarrow \mu^- \nu_\mu$ (wrong identification of μ^-)





Fit of hypernuclear levels





Fit procedure:

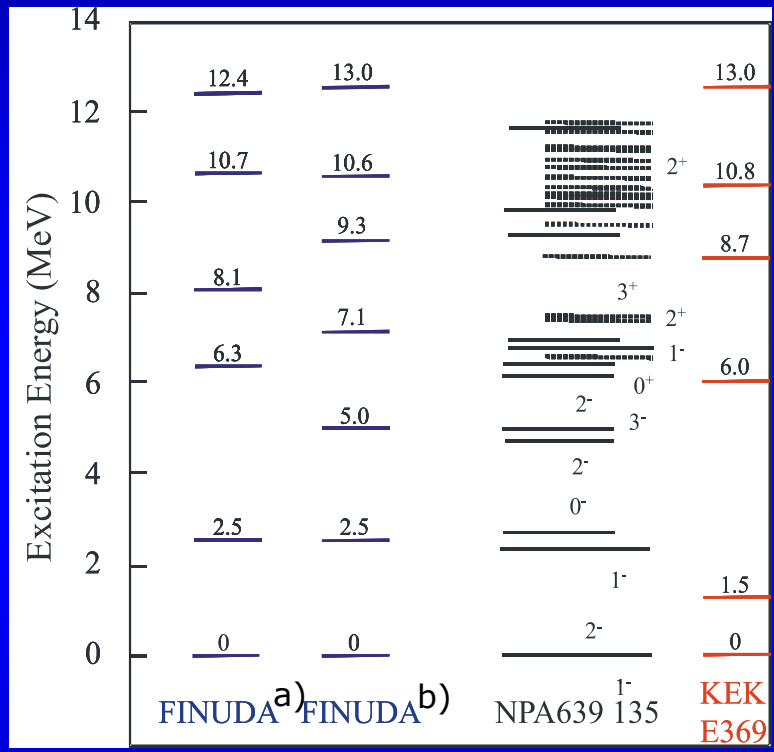
1) Selected experimental events fit with the 3 MC distribution (excluding signal region)

2) Signal region fit using 9 gaussian curves by means of a likelihood function. Same width for all gassians free to vary

^{12}C excitation spectrum

$\sigma = 0.46 \pm 0.02$ → 0.43% $\Delta p/p$ (design 0.35 $\Delta p/p$)

Peak gauss #1 = −11.74 ± 0.06
Peak gauss #2 = −10.4 ± 0.1
Peak gauss #7 = −8.8 ± 0.2
Peak gauss #6 = −7.4 ± 0.2
Peak gauss #3 = −6.0 ± 0.1
Peak gauss #4 = −4.1 ± 0.2
Peak gauss #5 = −2.7 ± 0.2
Peak gauss #8 = −1.23 ± 0.07
Peak gauss #9 = −0.07 ± 0.05



Excitation Energy Ex = B_Λ - B_Λ g.s.

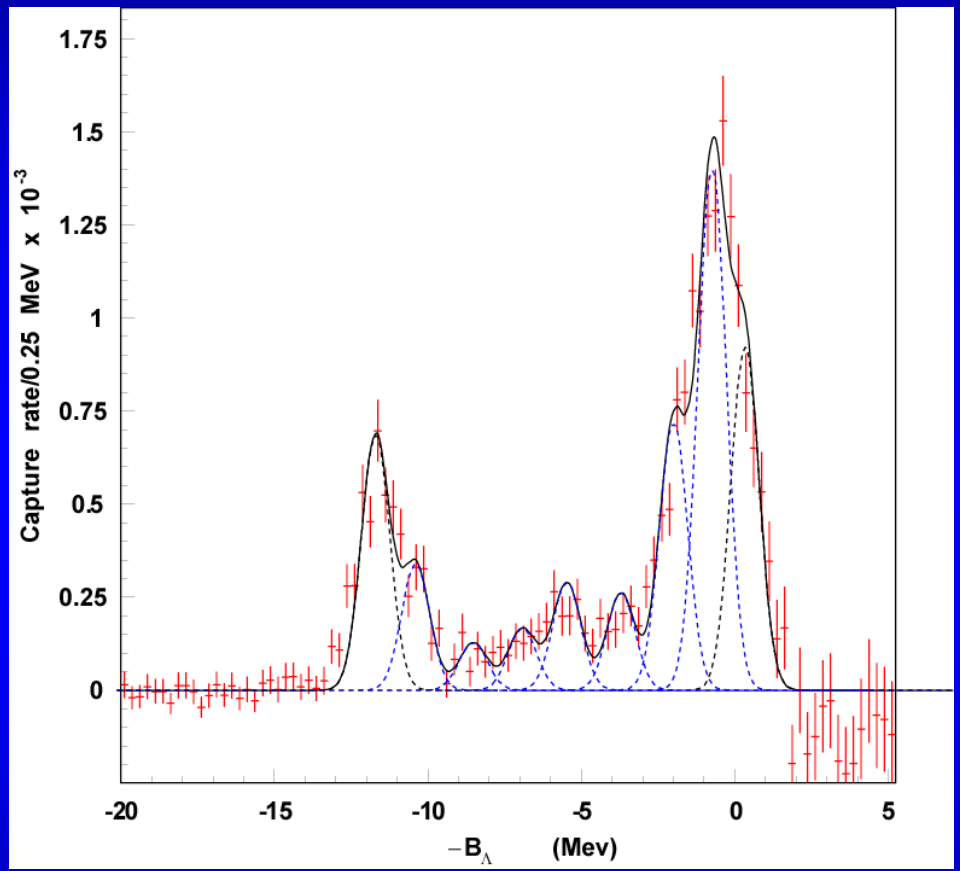
$^{12}_{\Lambda}$C Capture rates

To determine μ^+ and π^- efficiencies we generated 30×10^6 MonteCarlo events with

- 1 hypernuclear peak @ 270 MeV/c with production rate $10^{-3}/K^-_{stop}$
- complete background spectrum from K^- interaction
- usual K^+ decays

MC events reconstructed to take care of geometrical acceptance and trigger efficiency

$^{12}_{\Lambda}$C Capture rates

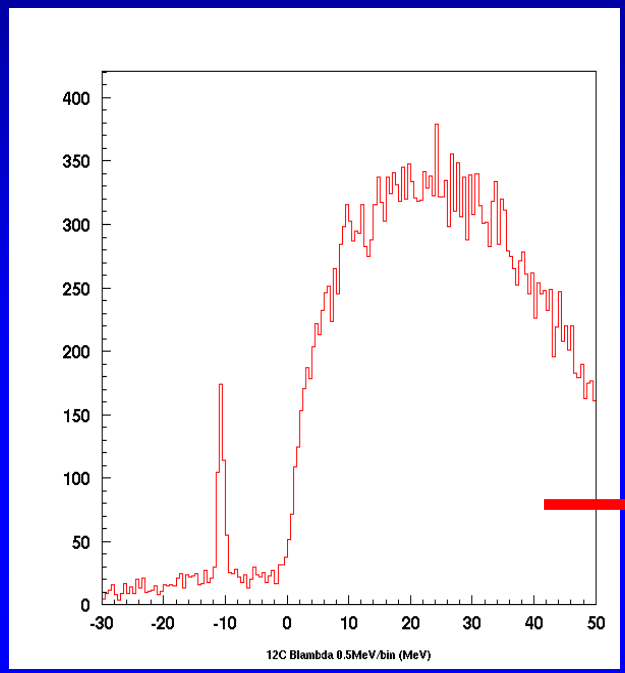


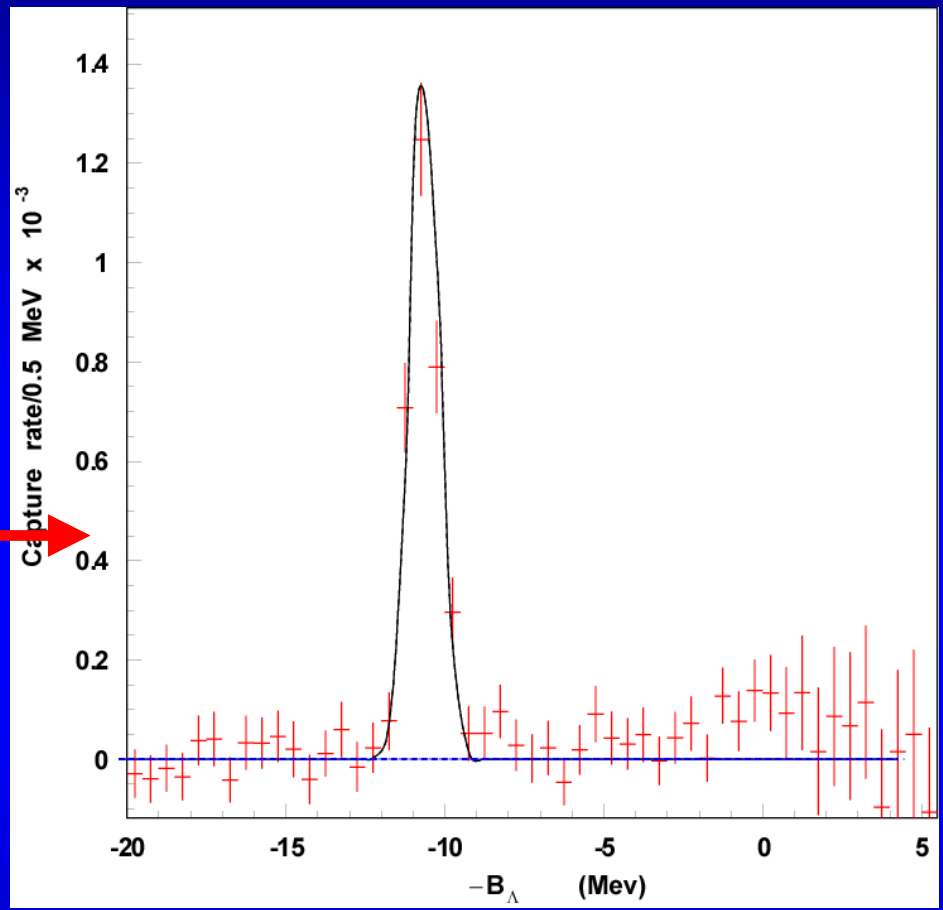
Events selection criteria:

- 0<normin<80
- stermin<200
- dev2min<100
- resdmin<0.1
- Inpxm <0.17cm

width fixed at 0.46 MeV σ
Events in G.S.= 374±23
Events in Bound Region =2769±52

^{12}C MC





MC treated as data :
background subtraction,
fit with width fixed at 0.46 MeV σ

Events in g.s. = 398 ± 20

C12 g.s. Capture Rate

experimental data: N_μ , N_π , $N(K^+)$,$N(K^-)$
MC determination of $\varepsilon_\pi, \varepsilon_\mu$

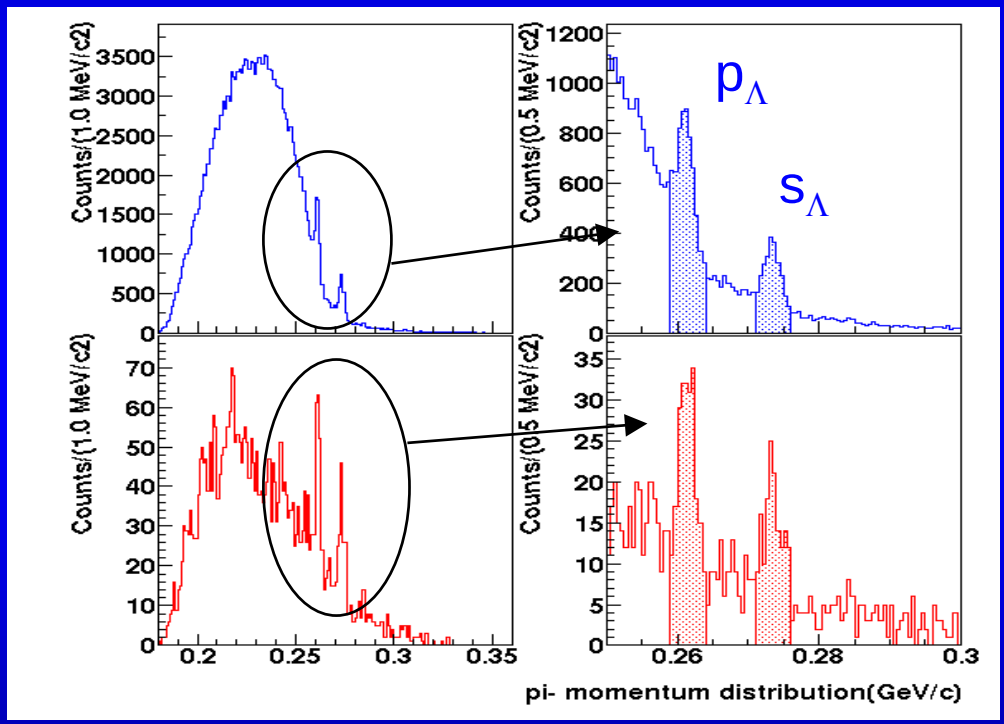
$$R(^{12}_{\Lambda}C) = \left[\frac{N^{^{12}_{\Lambda}C}_{\pi^-_{g.s.}}}{N^{^{12}_{\Lambda}C}_{K^-}} \frac{N^{^{12}_{\Lambda}C}_{K^+}}{N^{^{12}_{\Lambda}C}_{\mu}}\right]_{data} \left[\frac{\varepsilon_\mu}{\varepsilon_\pi}\right]_{MC}$$

$R(^{12}_{\Lambda}C)=(0.50 \pm 0.04 \pm 0.11) \times 10^{-3}/K^-_{stop})$

THEORY= 0.33 ×10^{-3}, 0.23 ×10^{-3}, 0.12 ×10^{-3} /K$^-$stop

$^{12}_{\Lambda}$C Non Mesonic Weak Decay

In medium-heavy hypernuclei mesonic decays ($\Lambda \rightarrow p\pi^-$; $\Lambda \rightarrow n\pi^o$) are suppressed due to Pauli blocking; non-mesonic weak interaction ($\Lambda p \rightarrow np$; $\Lambda n \rightarrow nn$) are then more favored



Pion momentum from $^{12}_{\Lambda}$C formation

Pion momentum from $^{12}_{\Lambda}$C formation **in coincidence with proton** from decay $^{12}_{\Lambda}$C : s_Λ and p_Λ clearly show up with better S/N.

BRANCHING FRACTION in agreement with previous results

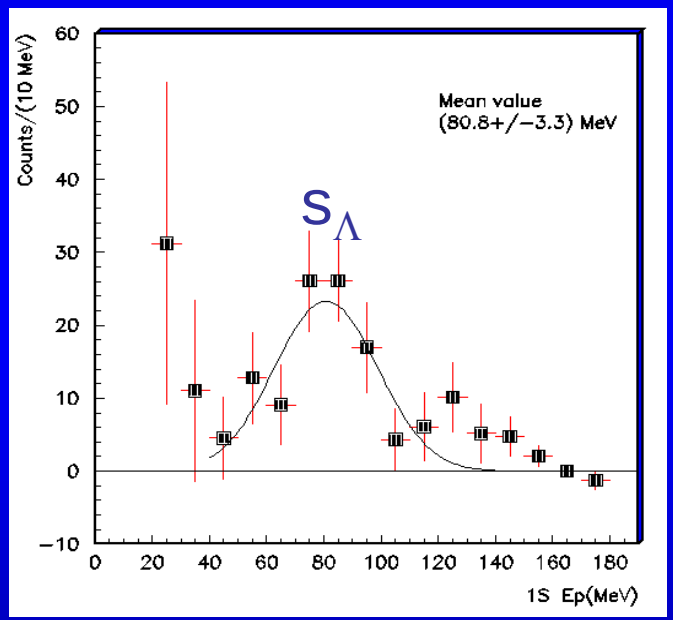
$\Gamma_p \sim (0.38 \pm 0.10)$ in 1s, (0.23 ± 0.06) in 1p

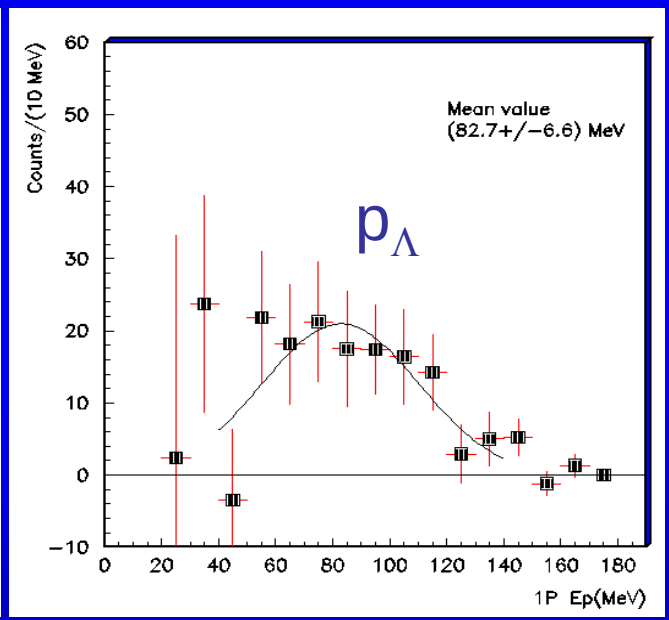
Proton energy spectrum

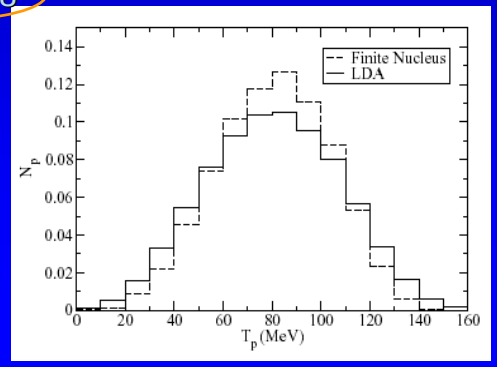
E.Bauer, Ramos et al., 2006:nucl-th/0602066:

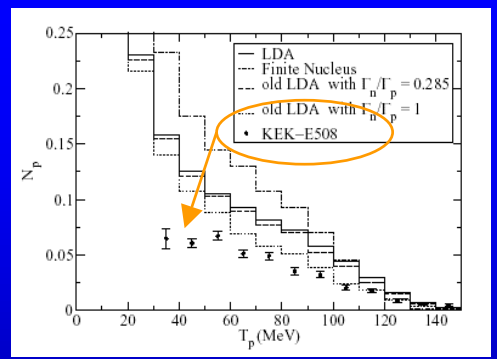
Theoretical calculation of Ep without (top) and with (bottom) FSI effects. Data are from KEK-E508

Proton energy spectra in coincidence with a π^- from hypernucleus formation in the s_Λ, p_Λ region.









Thanks to its thin target FINUDA has reduced the E_p low energy threshold. Spectrum shape at 20 ÷ 40MeV is important for evaluating FSI contribution. More statistics is needed

Conclusion

- The $^{12}_{\Lambda}$C spectroscopy analysis is completed.
- FINUDA spectroscopy resolution is 0.46 MeV corresponding to 0.43% $\Delta p/p$ (design = 0.35% $\Delta p/p$)
- The capture rate of $^{12}_{\Lambda}$C g.s. (1s) is found to be $(0.50 \pm 0.04 \pm 0.11) \times 10^{-3}/K^-_{stop}$
- Studies on $^{12}_{\Lambda}$C NMWC on 1s and 1p hypernuclear levels done.
  More statistics is needed to better evaluate F.S.I. contribution.