



Study of non-mesonic weak decay of ${}^5_4\text{He}$ and ${}^7_4\text{Li}$ with FINUDA

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On behalf of the FINUDA Collaboration



OUTLOOK

- FINUDA Experiment at DAΦNE Collider
- Second Run Summary
- Target choice
- Study of Non Mesonic Weak decay for light targets
- Conclusions

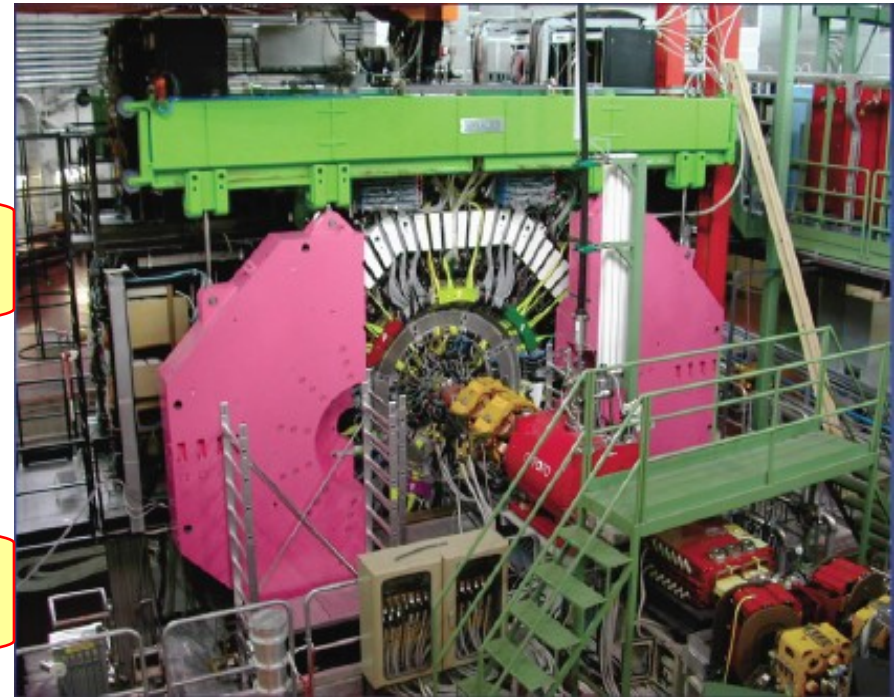
FINUDA Experiment at DAΦNE Collider

DAΦNE is a high luminosity Φ factory

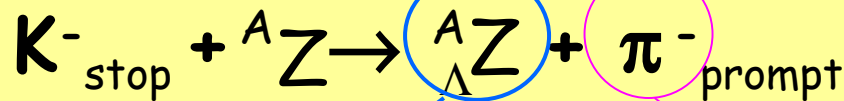
$$L_{\text{Peak}} \sim 1.4 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1} \longrightarrow 600 \Phi \text{ sec}^{-1}$$

Φ decay is a source of low energy kaons

$$e^+e^- \rightarrow \phi(1020) \rightarrow K^+K^-(49\%), K_S^+K_L^-(34\%), \rho\pi(13\%)$$



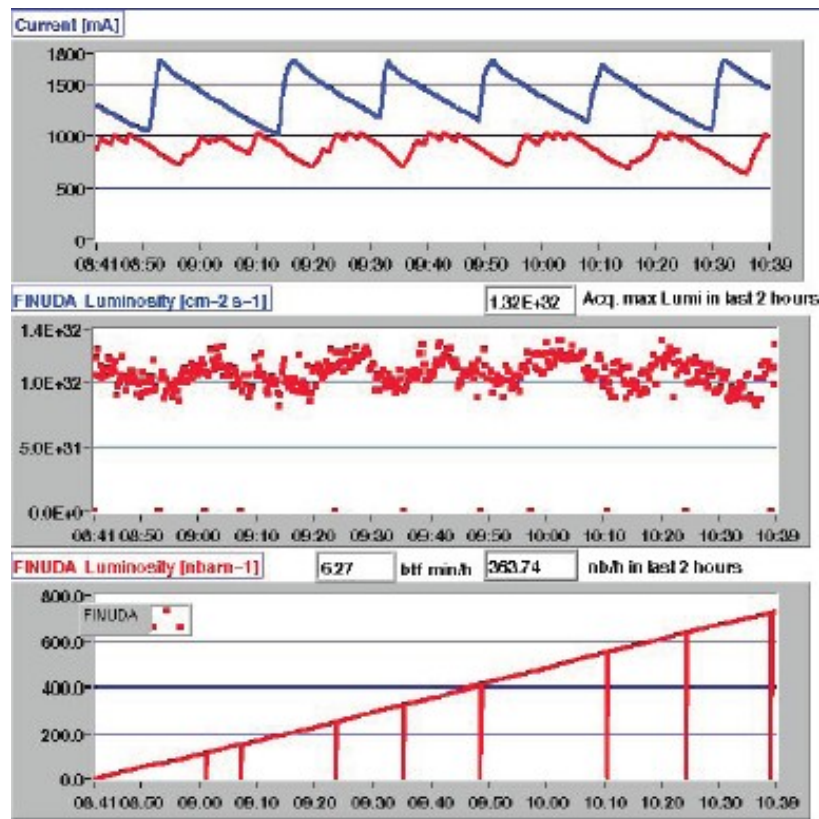
The K^- can be stopped in thin targets ($\sim 0.2 \div 0.3 \text{ g cm}^{-2}$) to produce hypernuclei



decay

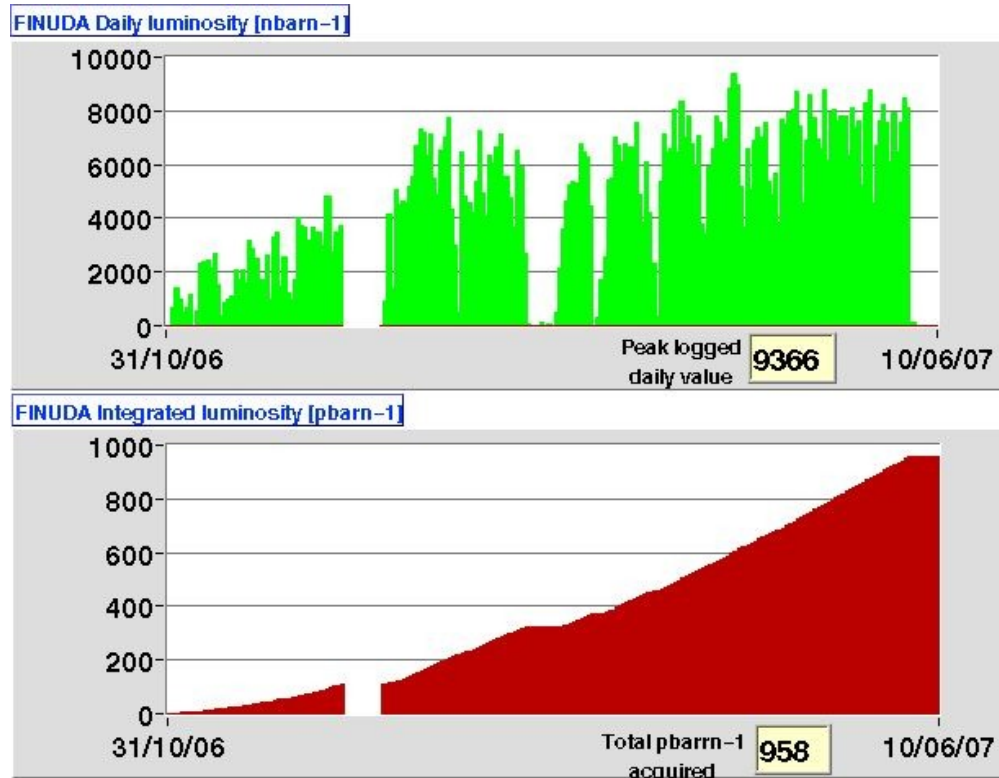
High resolution
spectroscopy

Run-2 Summary

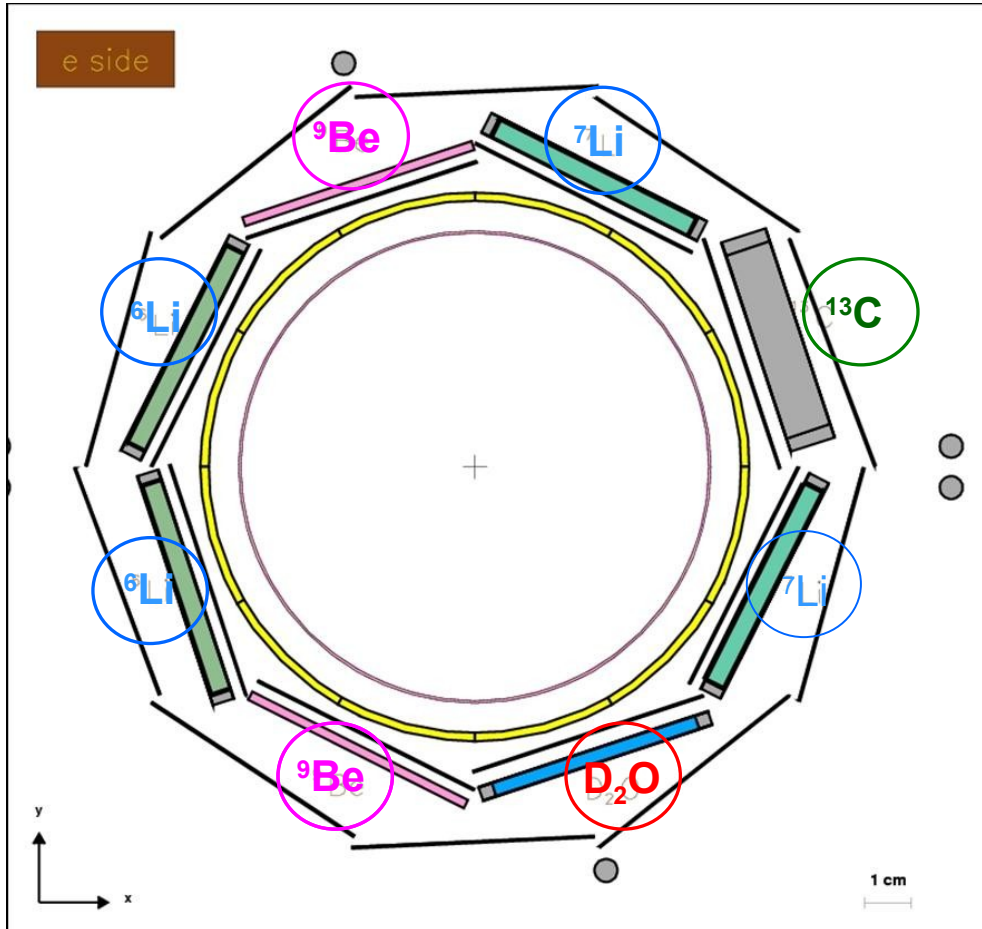


*Total integrated luminosity 964
pb⁻¹*

*Average daily integrated
luminosity ~ 7 pb⁻¹*



Target Choice

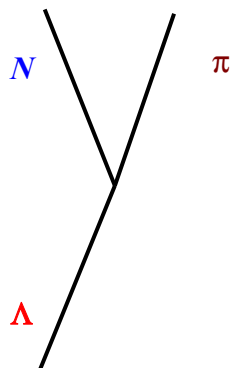


- ${}^6\text{Li}$ and ${}^7\text{Li}$:
study of non mesonic weak decay;
- ${}^9\text{Be}$:
 - hypernuclear spectroscopy with high resolution and high statistics
 - weak decays
- D_2O : important comparison with "quasi" deuteron in ${}^6\text{Li}$.
 - hypernuclear spectroscopy with high resolution and high statistics
- ${}^{13}\text{C}$:
 - hypernuclear spectroscopy with high resolution and high statistics
 - Comparison with ${}^{12}\text{C}$ from the first data taking

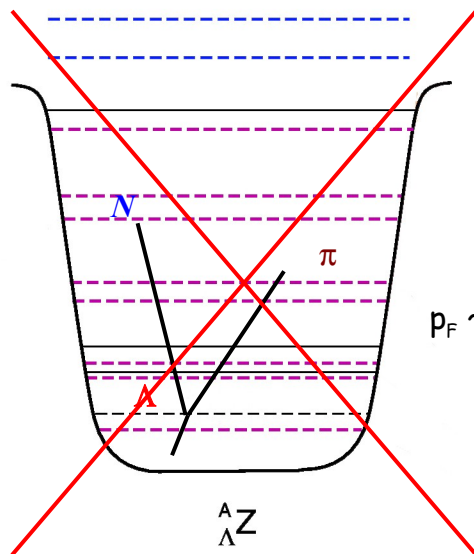
Λ -hypernucleus decay

free Λ decay

$p_N \sim 100 \text{ MeV}/c$



hypernucleus
mesonic decay



$p_F \sim 270 \text{ MeV}/c$

$$\Lambda \rightarrow n + \pi^0 + 41 \text{ MeV} (36\%)$$

$$\Lambda \rightarrow p + \pi^- + 38 \text{ MeV} (64\%)$$

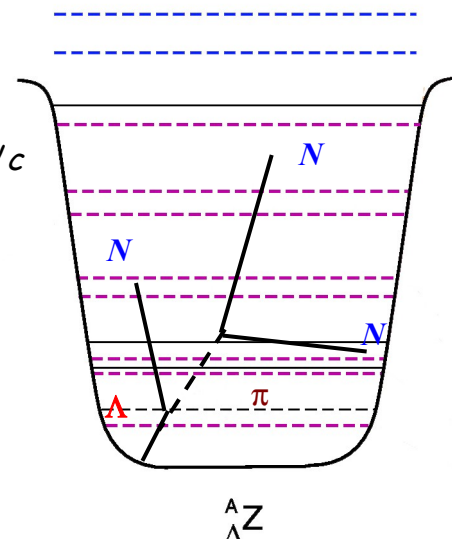
$$\tau_\Lambda = 263 \text{ ps}$$

suppressed by
Pauli blocking

$\Delta I = \frac{1}{2}$ rule
(not understood)

hypernucleus
non-mesonic decay

$p_N \sim 400 \text{ MeV}/c$



$$\Lambda + n \rightarrow n + n + 176 \text{ MeV} (\Gamma_n)$$

$$\Lambda + p \rightarrow n + p + 176 \text{ MeV} (\Gamma_p)$$

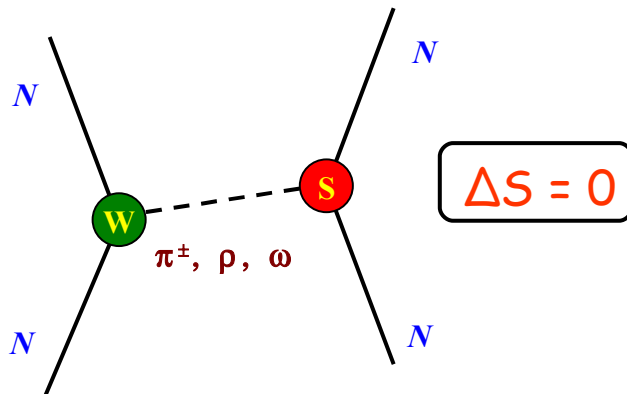
$$\Lambda NN \rightarrow nNN (\Gamma_2)$$

dominant in all
but the lightest
hypernuclei

4 baryon weak interaction

The hypernucleus **non-mesonic decay** provides primary means of studying the **baryon-baryon weak interaction**

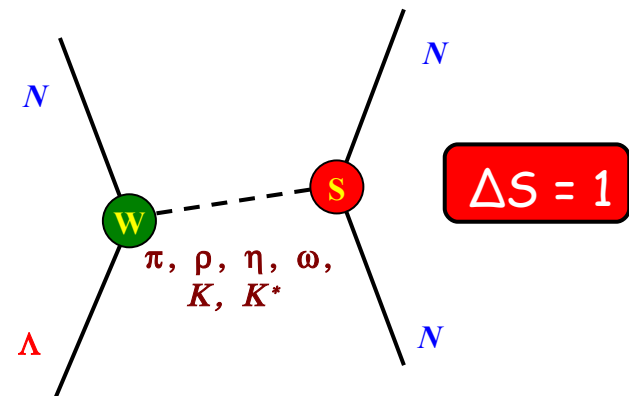
N-N scattering



- ❖ **only** information on the **parity violating** part of weak interaction is accessible
- ❖ **parity conserving** part is **masked** by strong interaction

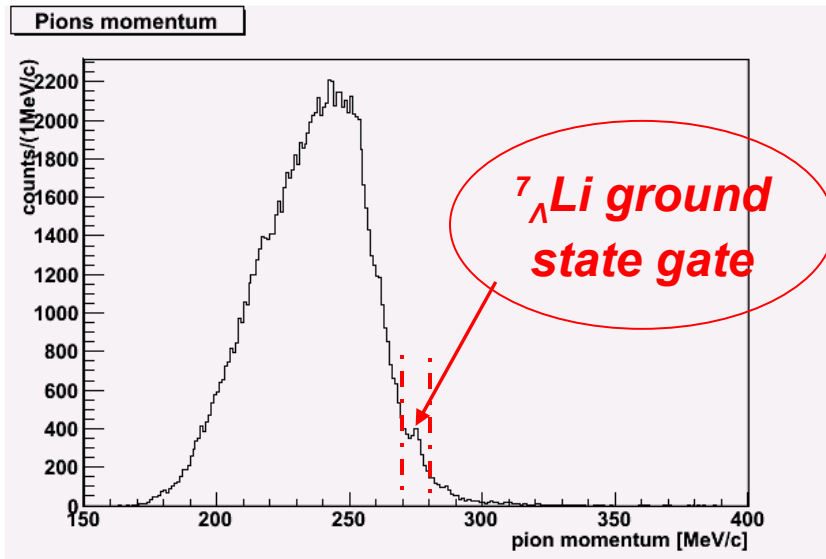
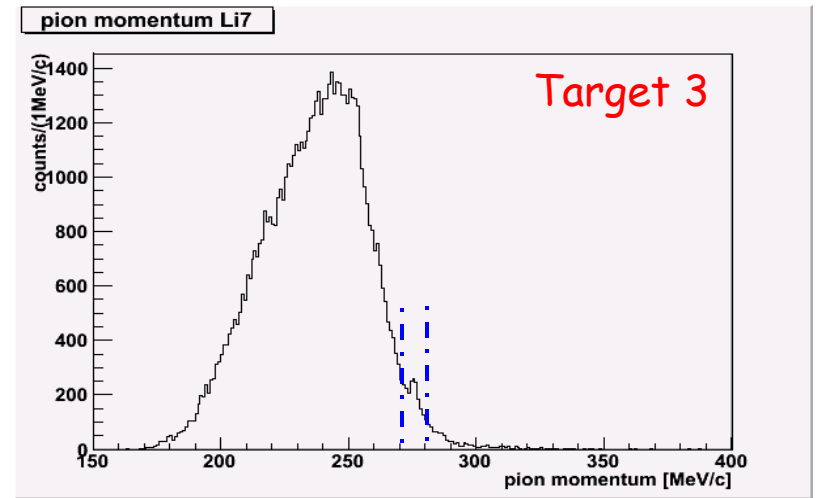
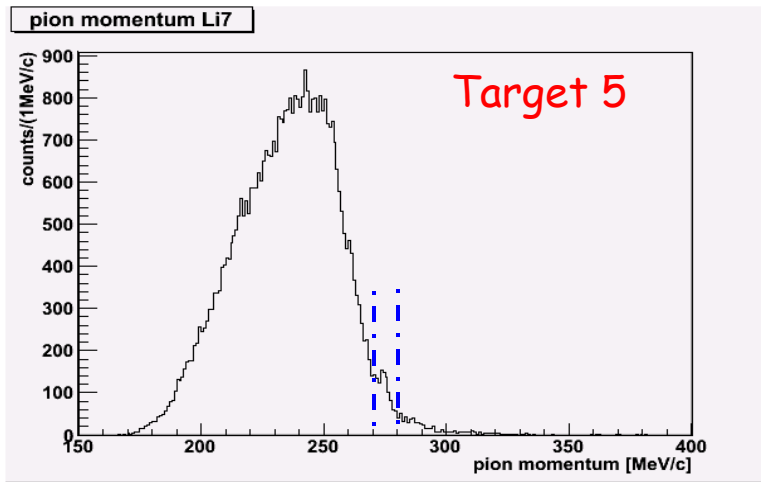
$\Lambda + N \rightarrow N + N$

in nuclear medium
only



- ❖ **both** information on the **parity violating** and **parity conserving** parts of weak interaction can be extracted
- ❖ $q \sim 400 \text{ MeV}/c \Rightarrow$ probes **short distance**

π spectra for ${}^7\text{Li}$ targets

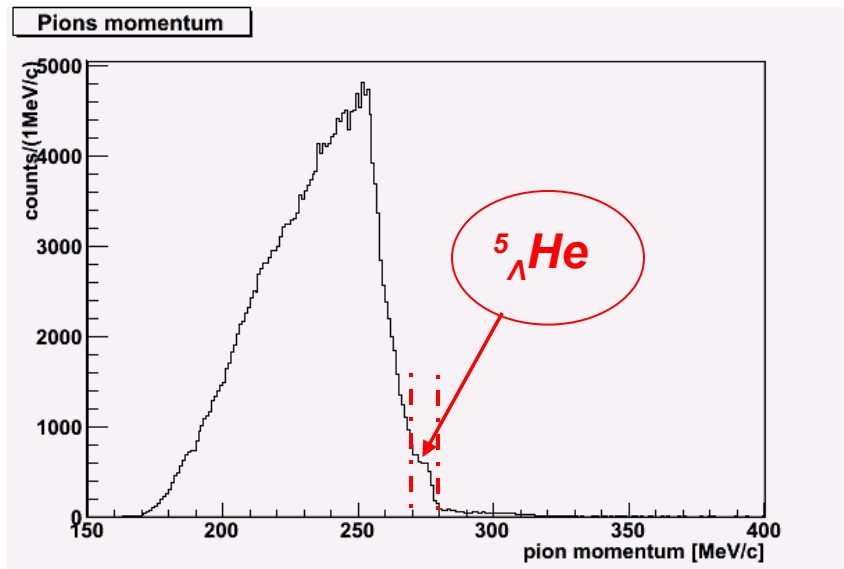
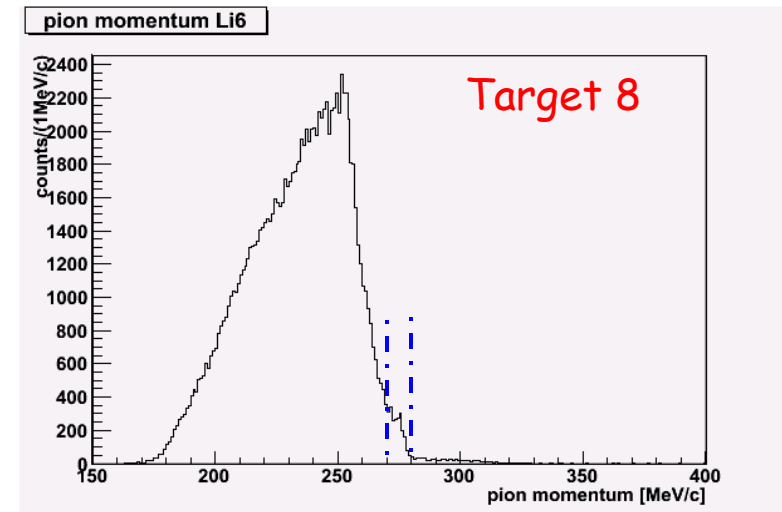
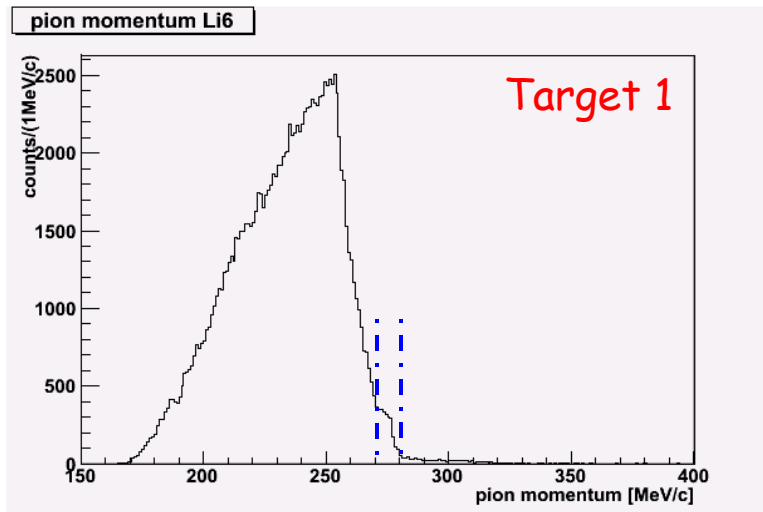


The top panels show the **inclusive spectrum of negative pions** for each ${}^7\text{Li}$ target and the bottom panel shows the sum of the two spectra.

Pion momentum reconstructed and corrected for energy loss in the crossed materials and quality cut on track fitting

The momentum regions selected correspond to the ${}^7\text{Li}$ **ground state** formation.

π spectra for ${}^6\text{Li}$ targets



The top panels show the **inclusive spectrum of negative pions** for each ${}^6\text{Li}$ target and the bottom panel shows the sum of the two spectra.

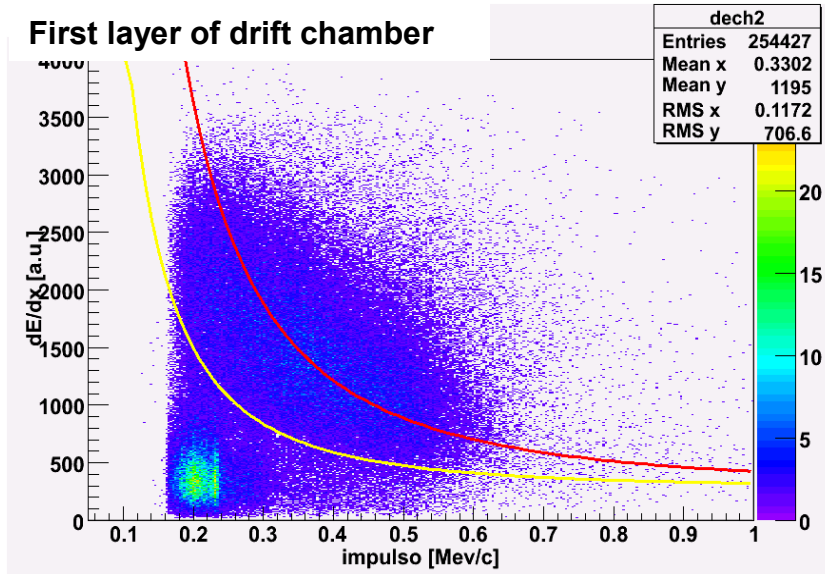
The momentum regions selected correspond to the ${}^6_{\Lambda}\text{Li}$ **ground state** formation.

The ground state of ${}^6_{\Lambda}\text{Li}$ is **proton unbound** so it will immediately decay

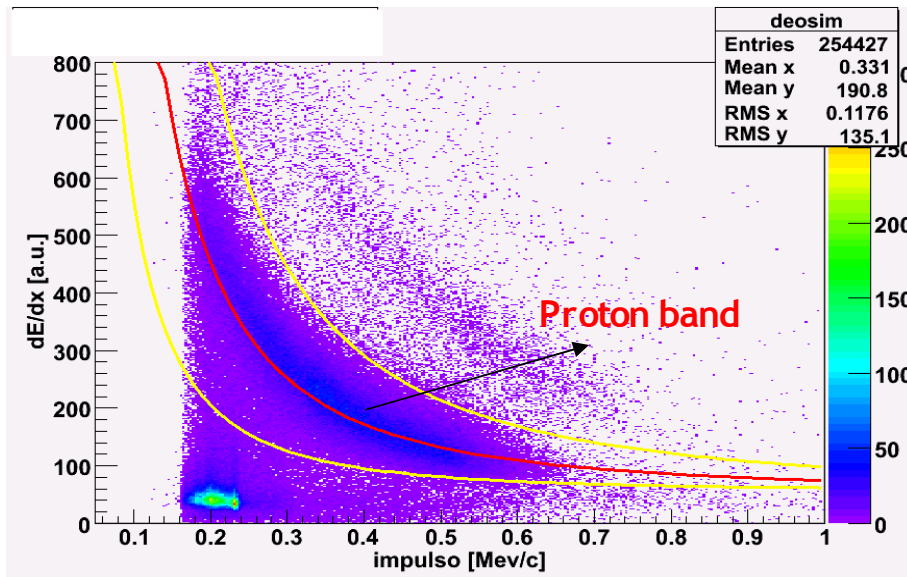
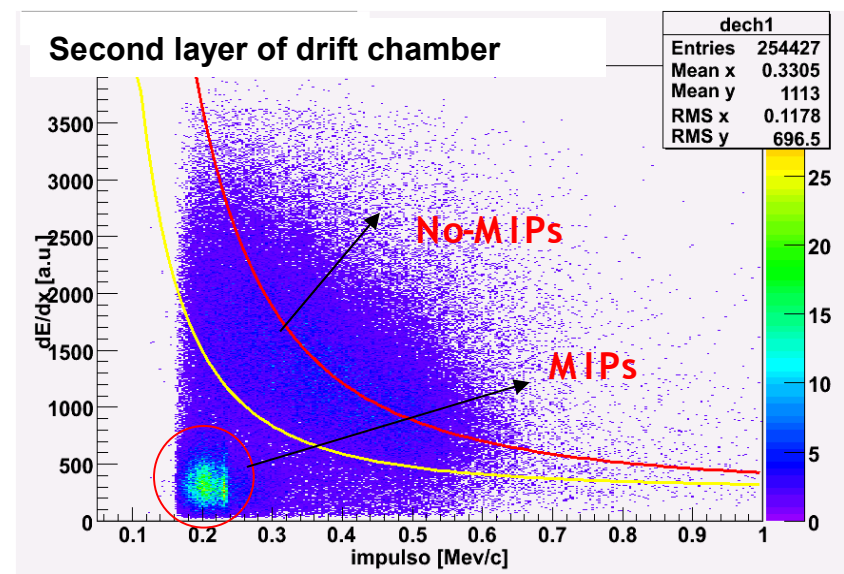


Proton identification

First layer of drift chamber

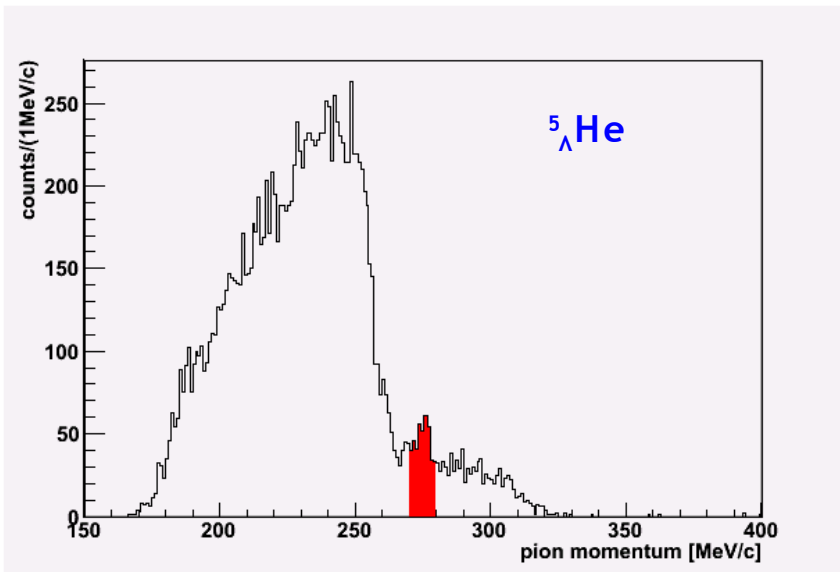


Second layer of drift chamber



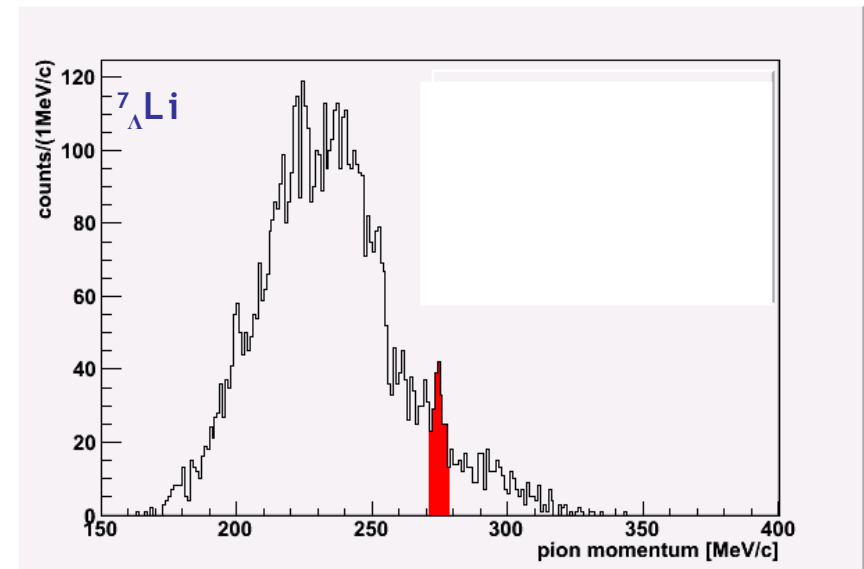
Proton selection asking the coincidence of protons identified with the two layers of drift chamber and the outer layer of silicon detector

π spectra in coincidence with a proton

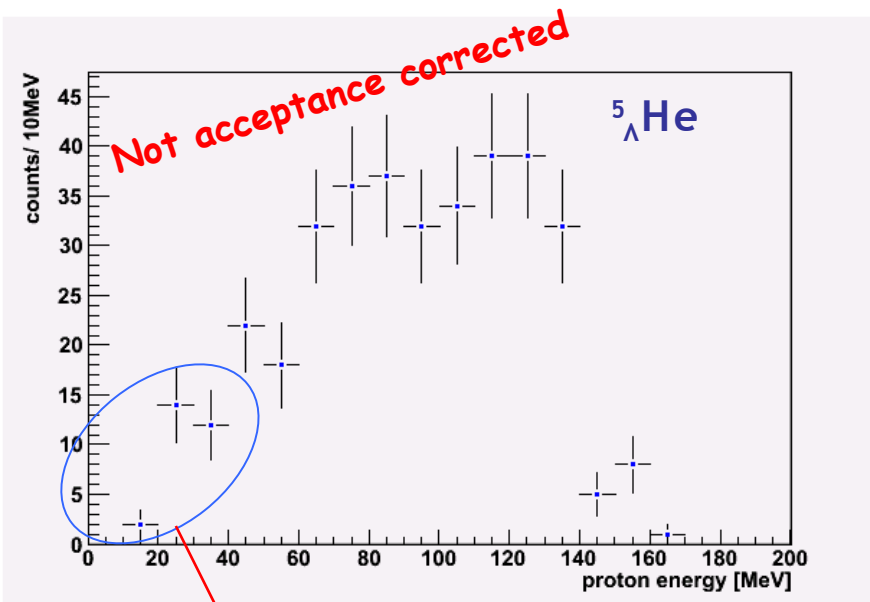


Pion momentum from ${}^6_{\Lambda}\text{Li}$ formation in coincidence with a proton from decay of ${}^5_{\Lambda}\text{He}$
Red momentum region corresponds to the ground state

Pion momentum from ${}^7_{\Lambda}\text{Li}$ formation in coincidence with a proton from decay of ${}^7_{\Lambda}\text{Li}$
Red momentum region corresponds to the ground state

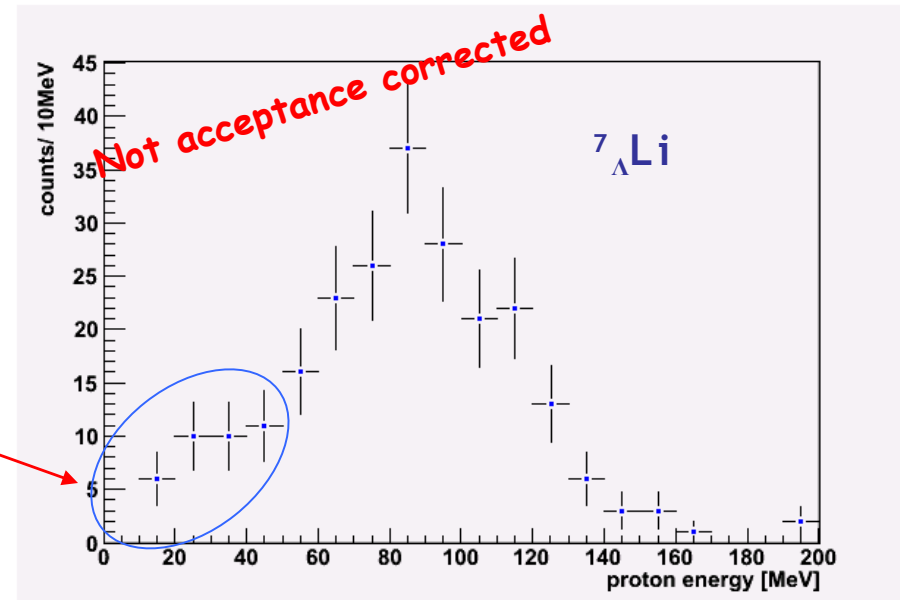


Proton energy spectra (1)

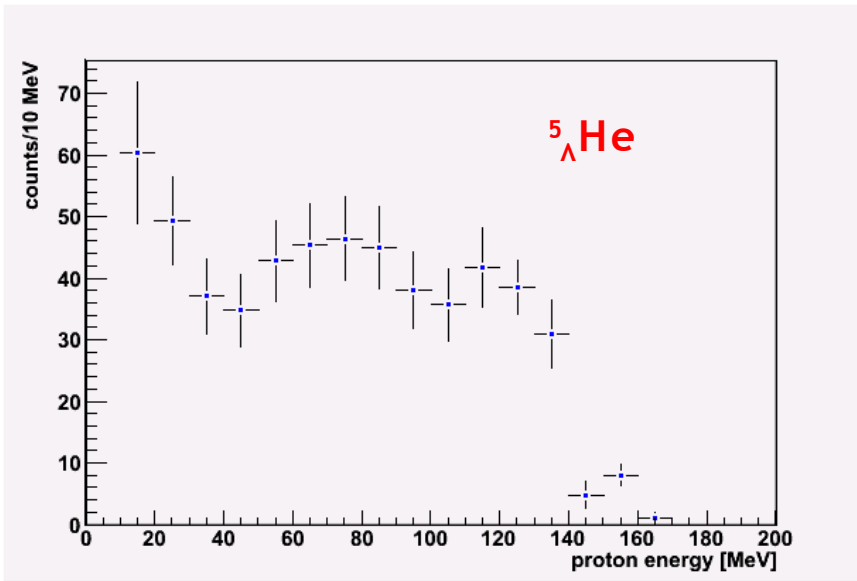


FINUDA Proton energy spectra in coincidence with a π^- from hypernucleus formation in the g.s. region .

Thanks to **thin target** FINUDA has reduced the **Ep low energy threshold**. Spectrum shape at **20-40MeV** important for **FSI** nucleon induced effects.

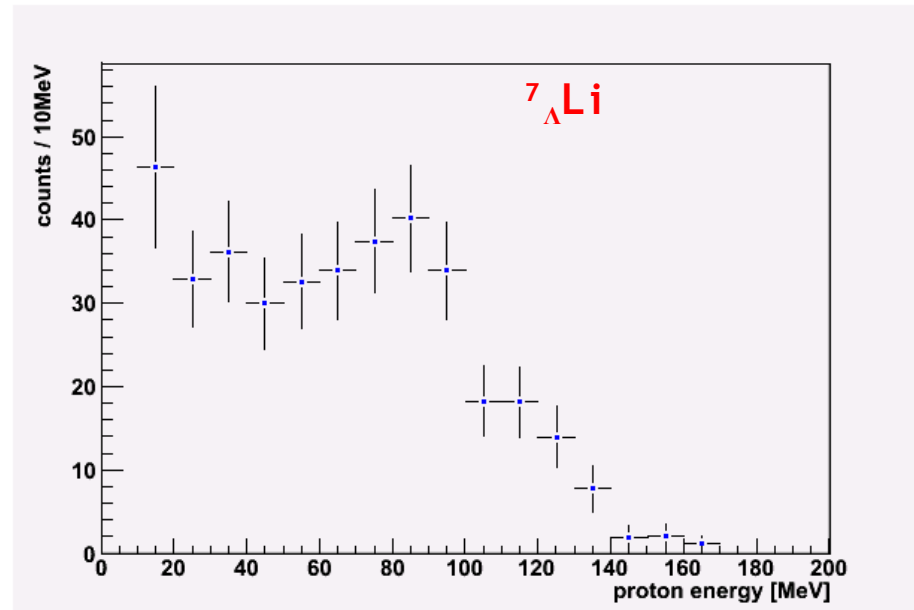


Proton energy spectra (2)

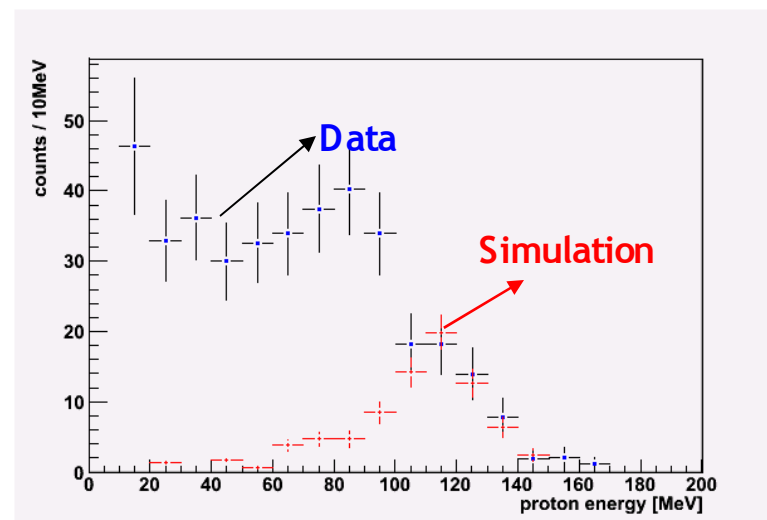
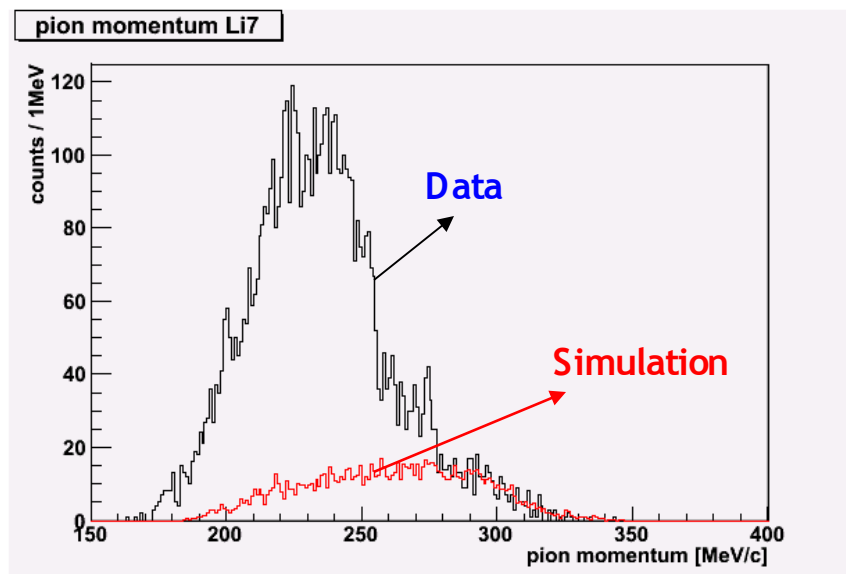


The FSI process and the possible multi-nucleon induced process tend to enhance the low-energy region in the nucleon energy spectra.

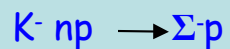
After the acceptance correction, as expected, is clearly visible the peak around 80 MeV.



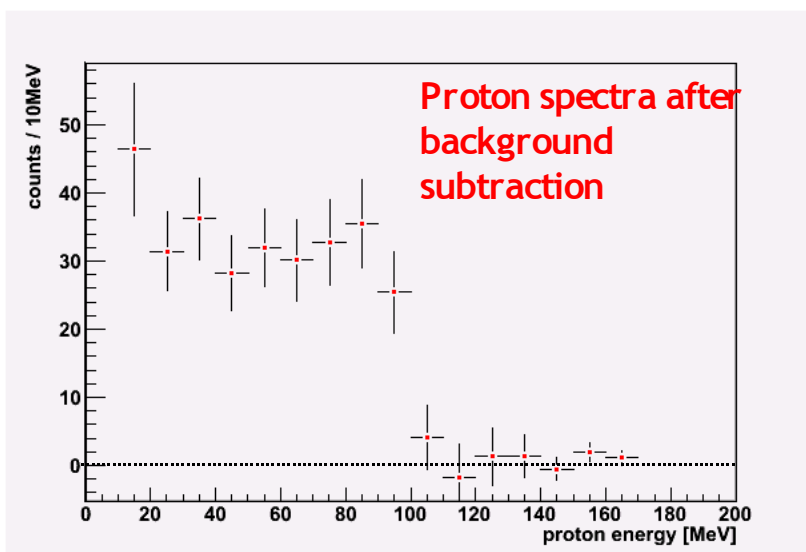
Background study for ${}^7_{\Lambda}\text{Li}$



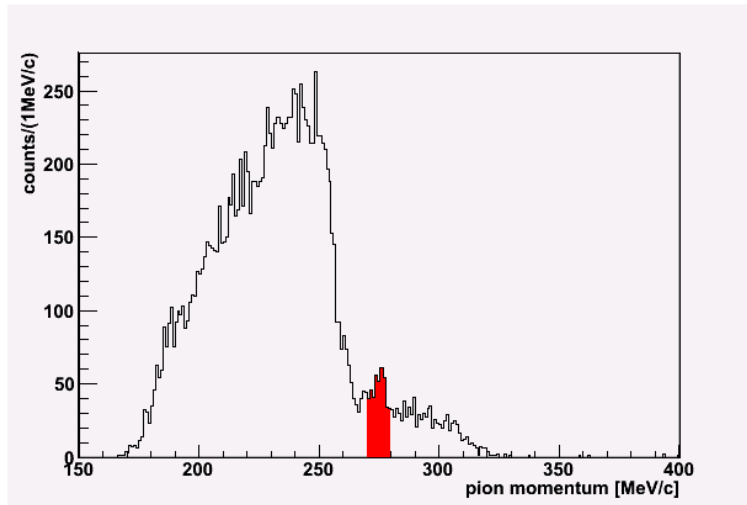
In the pion spectrum in coincidence
with a proton the background
corresponds to the reaction



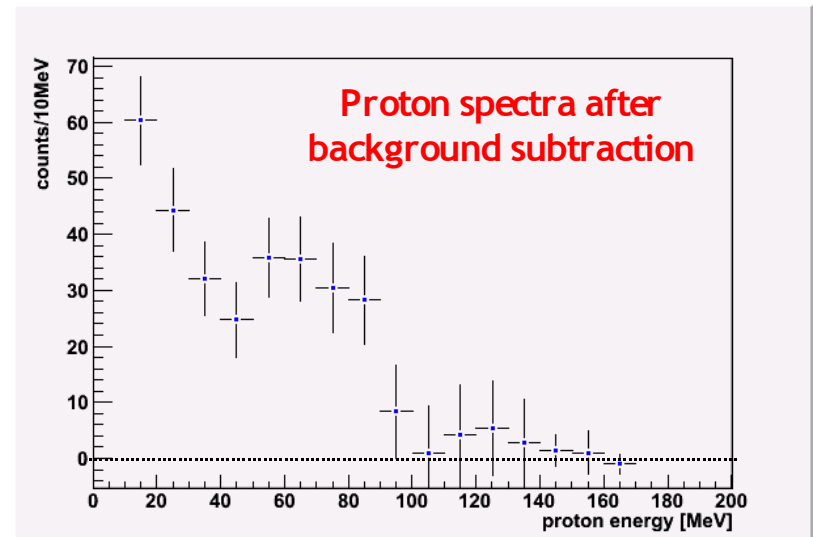
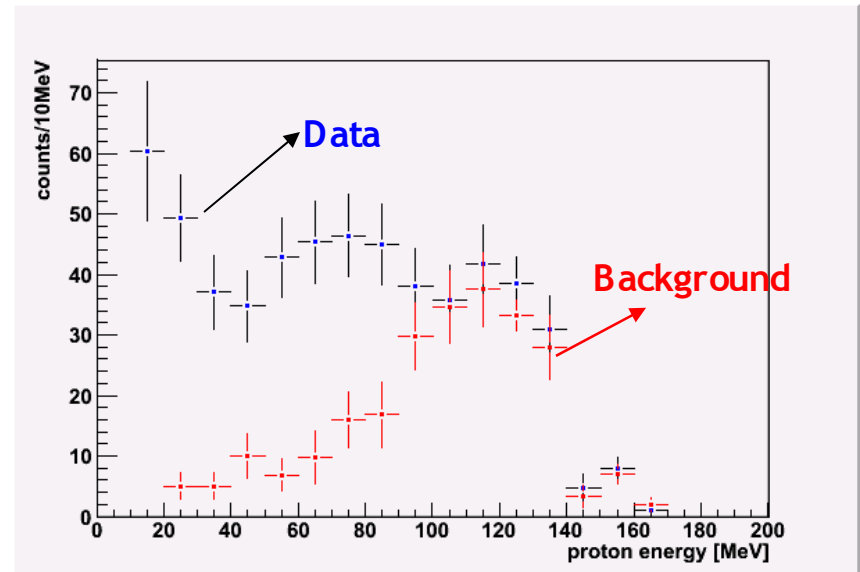
Followed by the decay



Background study for ${}^5_{\Lambda}\text{He}$



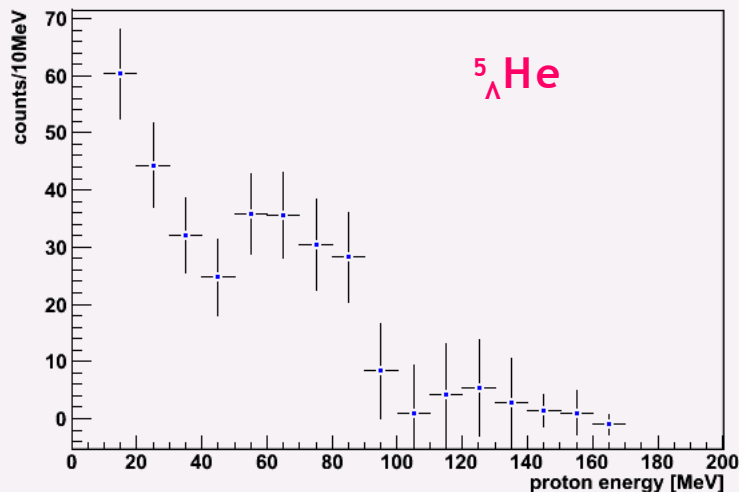
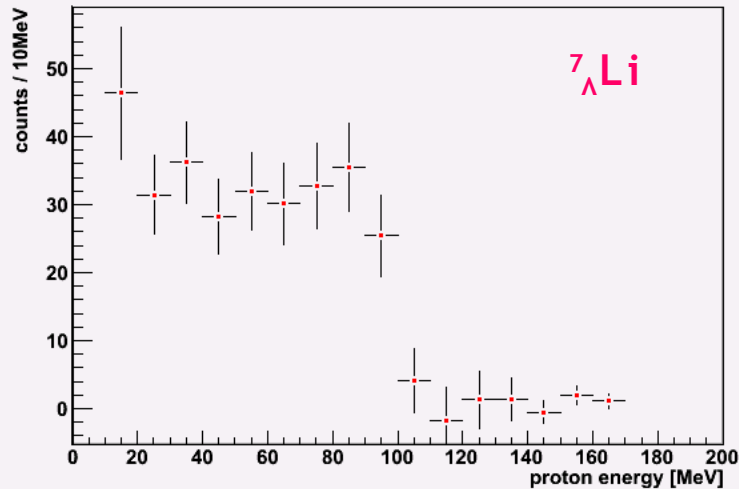
The background for the ${}^5_{\Lambda}\text{He}$ has been evaluated by subtracting the proton spectrum in correspondence to the side-bins of the π^- spectrum (280-288 MeV/c)



Non Mesonic Weak Decay

$$\Gamma_p \sim (0.30 \pm 0.08) \text{ in } 1s \text{ for } {}^5_{\Lambda}\text{He}$$

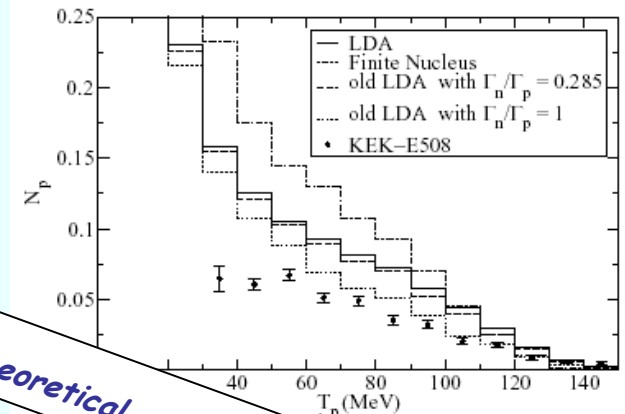
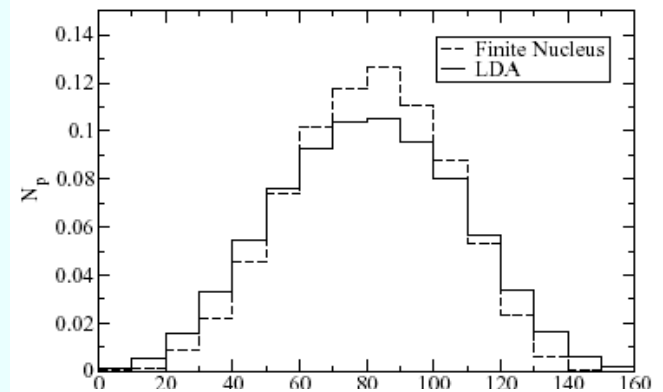
$$\Gamma_p \sim (0.35 \pm 0.10) \text{ in } 1s \text{ for } {}^7_{\Lambda}\text{Li}$$



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

Theoretical calculation of E_p without (top) and with (bottom) **FSI effects**.

${}^{12}_{\Lambda}\text{C}$ data from KEK-E508



Theoretical calculation

Conclusions

- FINUDA has successfully completed the second data taking collecting a total integrated luminosity $\sim 1 \text{ fb}^{-1}$
- Thanks to thin target FINUDA has reduced the E_p low energy threshold respect to the other experiments.
- Spectrum shape at 20-40 MeV is very important for FSI nucleon induced effects.
- First result on Non Mesonic Weak Decay of the ${}^7_\Lambda\text{Li}$
- Proton energy spectra for ${}^7_\Lambda\text{Li}$ and ${}^5_\Lambda\text{He}$ show the same trend with a peak around 80 MeV and an enhancement in the low energy part of the spectrum due to the FSI.