Hyperon-nucleons and Hyperon-pions final states in FINUDA

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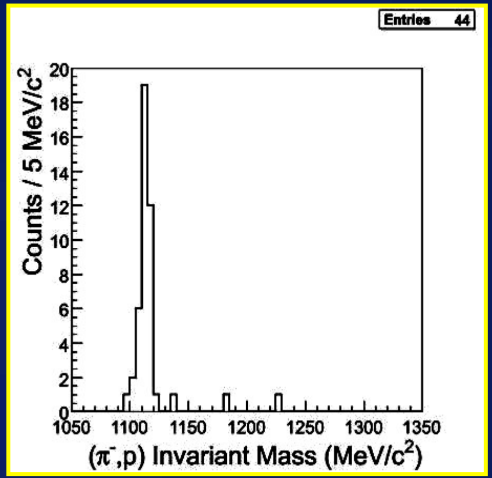
Outline of the talk

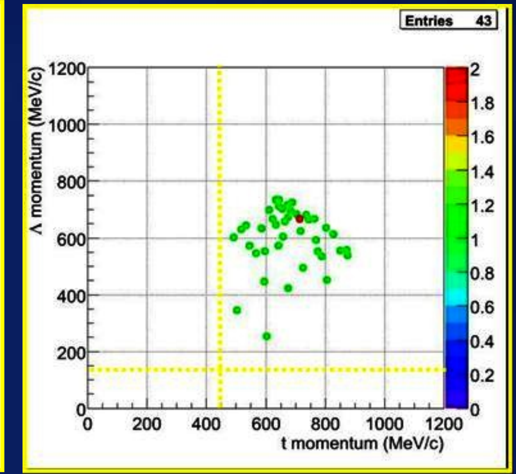
- Study of K^-– multinucleon absorptions
  - K^-(ppnn): Λt correlation on ^{6}Li, ^{7}Li and ^{9}Be targets
  - K^-(ppn): Λd on ^{6}Li targets
- Study of K^-p interaction: $\Sigma^\pm$ production and coincidences with $\pi^\mp$
  - First use of neutron detection information
  - $\pi^\pm$ coincidences: search for Σ^0(1385) and Λ(1405) possible signatures
    - $\Sigma^0(1385) \rightarrow \Sigma\pi$: B.R. = 18%, $\Gamma = 36$ MeV
    - $\Lambda(1405) \rightarrow \Sigma\pi$: two pole structure
      - » Higher mass: m = 1420 MeV, narrow (Γ~35-50 MeV), coupled to KN
      - » Lower mass: m = 1395 MeV, wide (Γ~65-130 MeV), coupled to $\Sigma\pi$
- Inclusive Λ momentum spectrum (→AMADEUS)

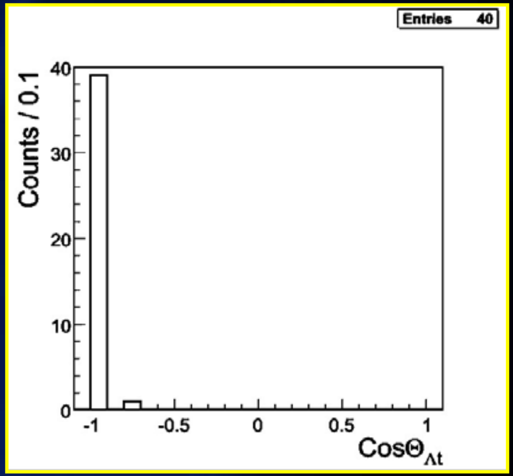
Study of Λt correlation
PLB 669 (2008), 229

$K^- A \rightarrow \Lambda\, t\, X$

(A = ^{6}Li, ^{7}Li, ^{9}Be)

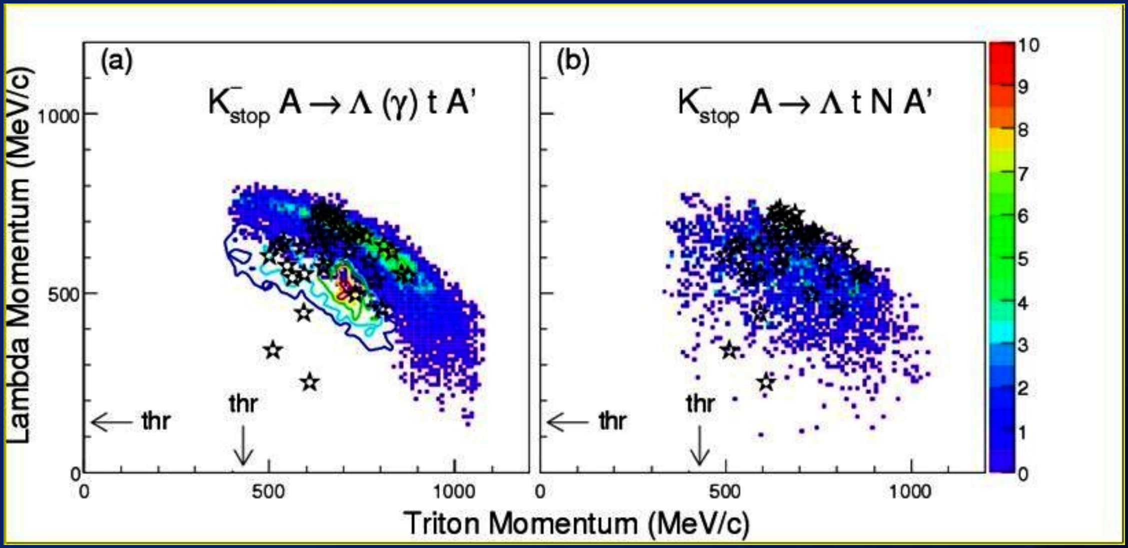






- Λ signal without background
- High momenta for both particles
- Clear angular (back-to-back) correlation

- 40 events on light targets
- Capture rate: $6\times10^{-4}/K^-_{stop}$

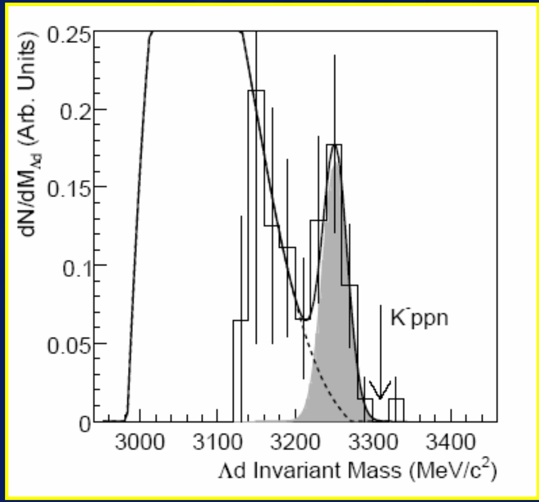


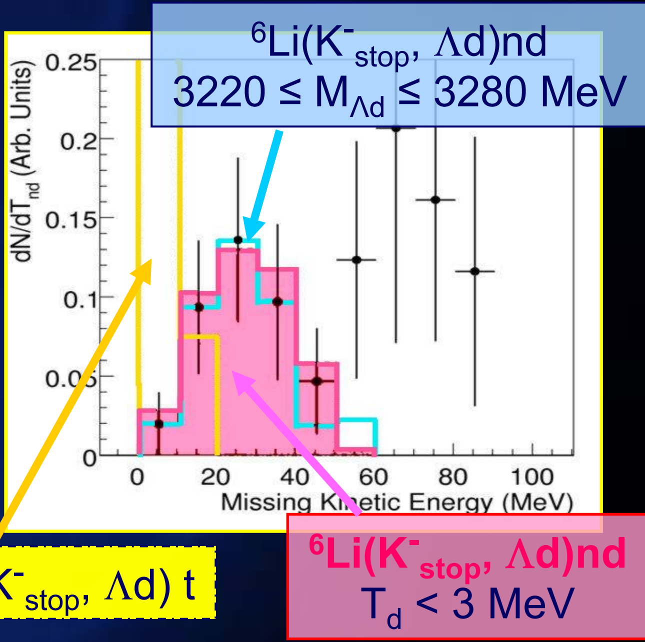
Λ and t momentum distribution compatible with:

- Four nucleon absorption on α with (Λt) or (Λt)N emission
- Four nucleon absorption with (Σt) emission
- 2-step pickup reaction (suppressed?)

Study of $^{6}Li(K^{-},\Lambda d)X$: further steps

- 1^{st} run data analysis: PLB654 (2007), 80
  - Exclusive analysis: Λd invariant mass
  - Use of ^{6}Li target: low background and small FSI effects
    - ^{6}Li = [α+d] cluster
    - Bump observed at $M_{\Lambda d}$= 3251 MeV, $\Gamma_{\Lambda d}$=37 MeV
    - Back-to-back Λd pairs





- 2^{nd} run data analysis
  - 8x statistics on ^{6}Li (^{7}Li, ^{9}Be)
  - Further selections can be applied:
    - missing mass cut to separate Λd from $\Sigma^{0}(\Lambda\gamma)d$ contributions
  - Method applied by E549 in $^{4}He(K^{-}_{stop}, d)$

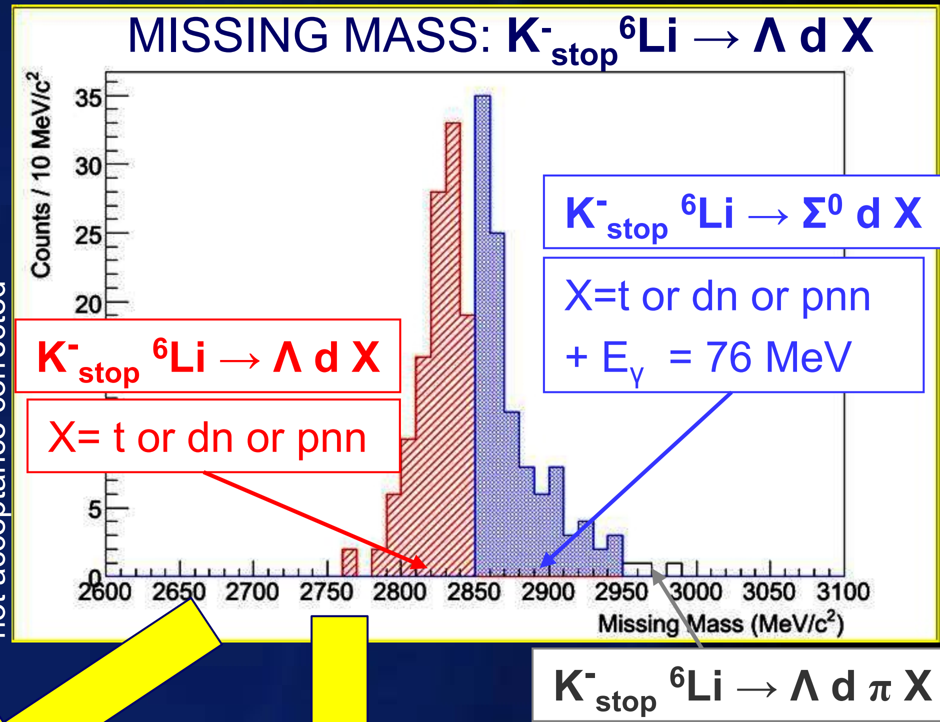
signal compatible with an absorption on α with a spectator deuteron and emission of a 25 MeV neutron:

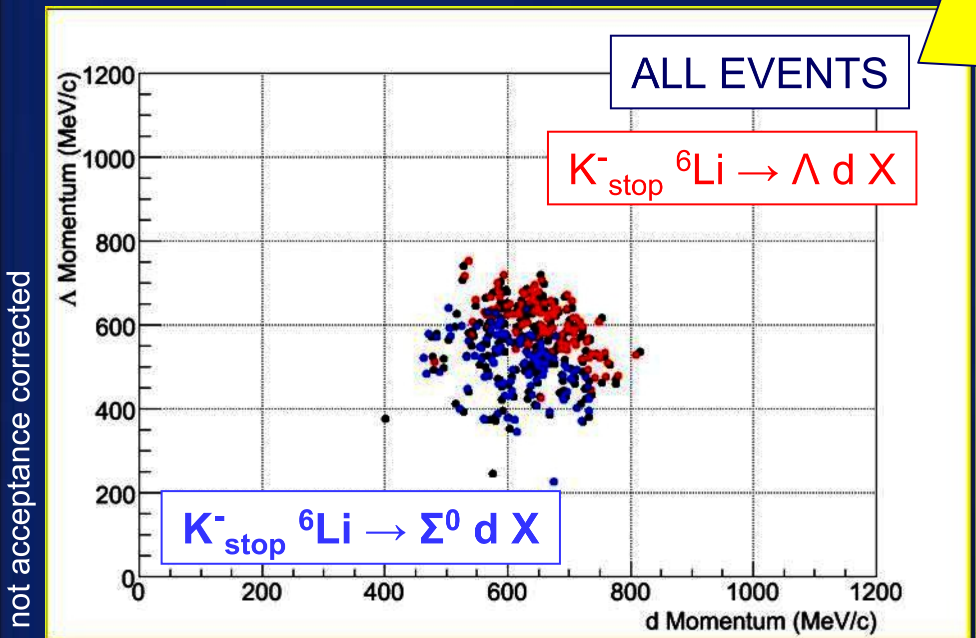
$^{6}Li(K^{-}_{stop}, \Lambda d)nd$

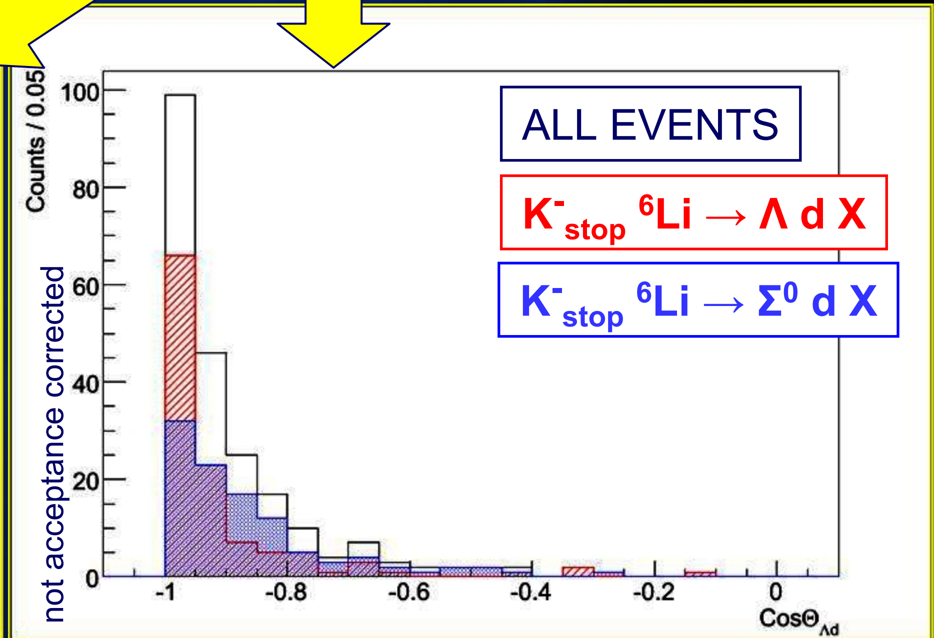
$K^-_{stop}\,{}^6Li \rightarrow \Lambda d X$ missing mass studies

Clean separation of Λd and $\Sigma^0(\rightarrow\Lambda\gamma)d$ components

Miss. Mass resolution: ~6 MeV

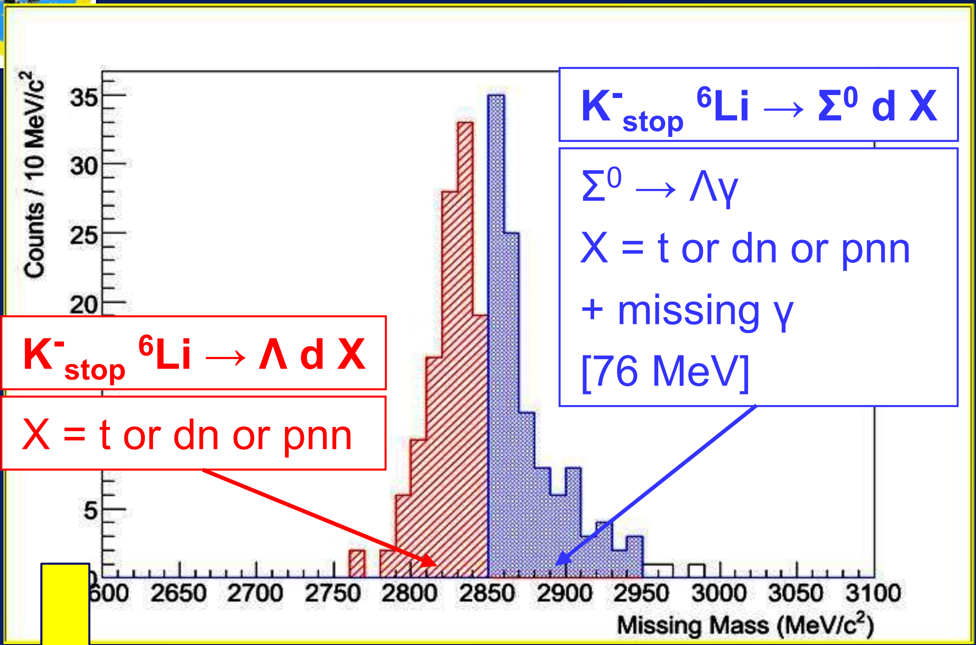






$K^-_{stop}\,^6Li \rightarrow \Lambda d X$ invariant mass with missing mass selection

no acceptance correction



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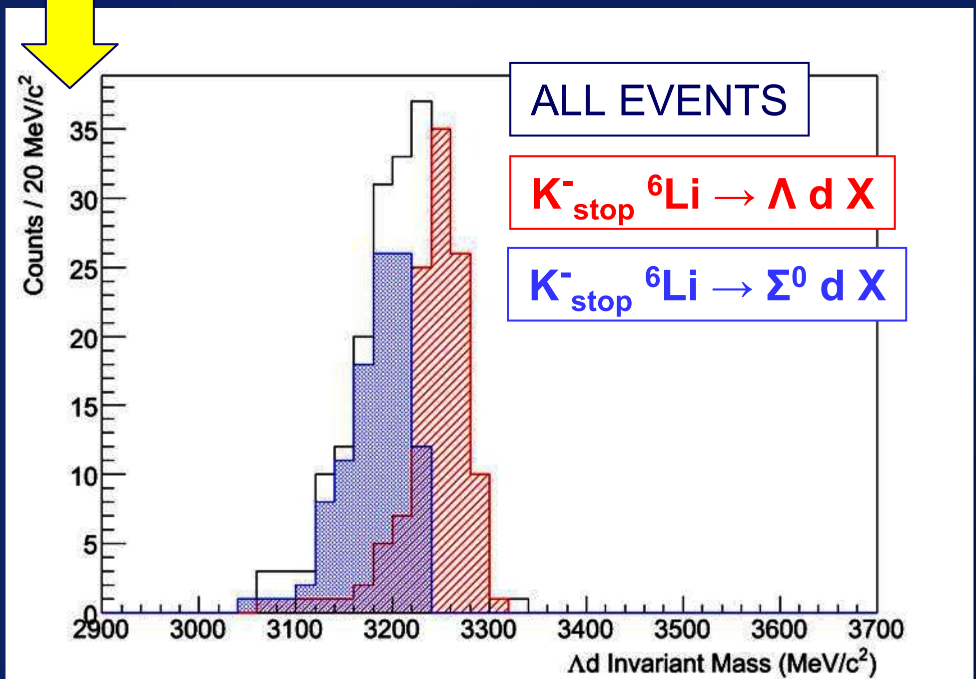
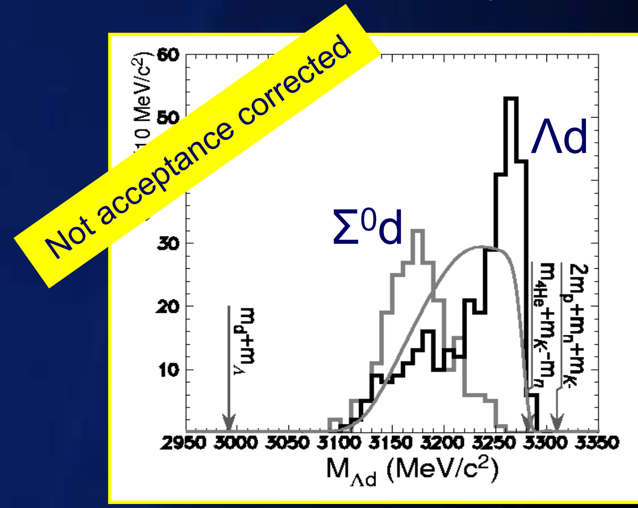


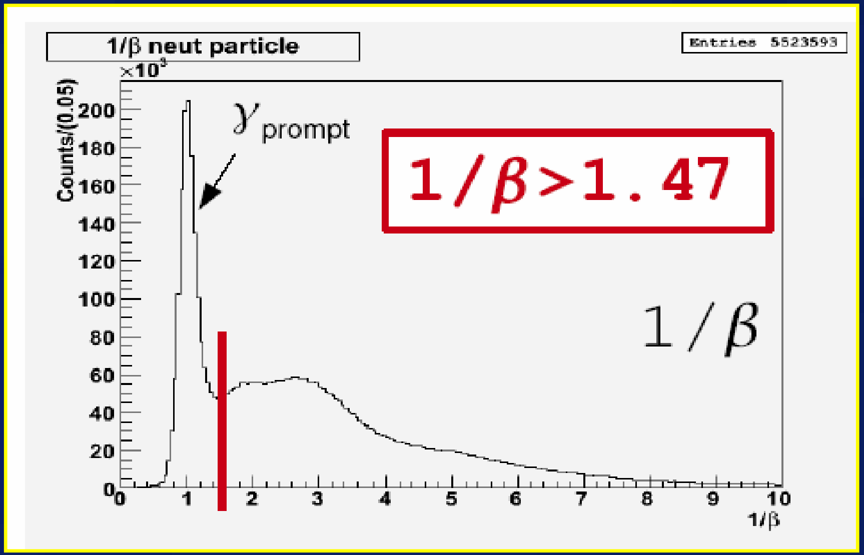
- Agreement with E549 results (^4He)
  K^- is absorbed on "α" ($^6Li = \alpha + d$)



PRC 76(2007)068202

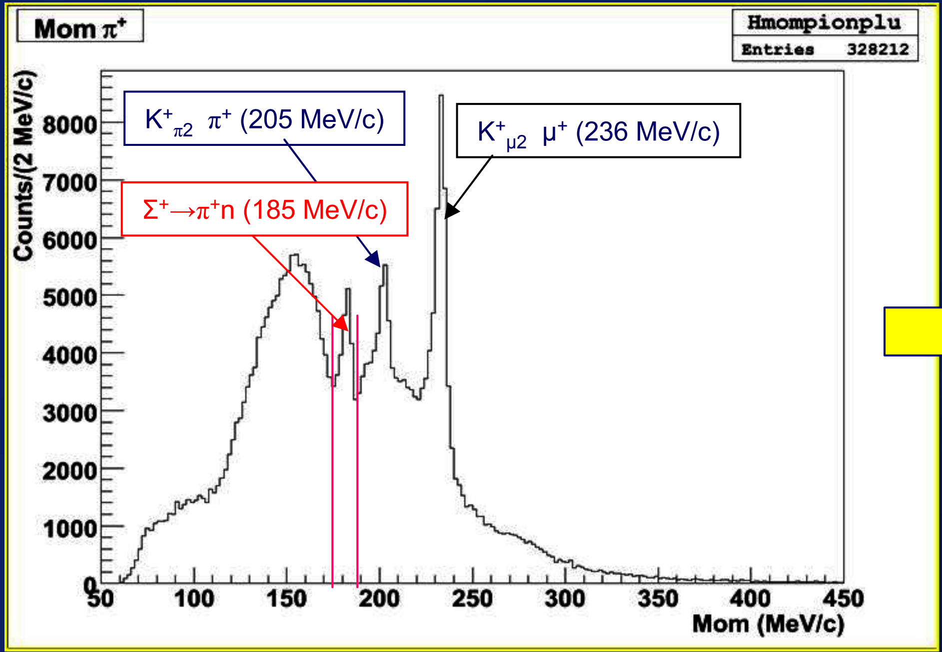
- FINUDA can detect n with Λd pairs:
  $K^-_{stop}\,^6Li \rightarrow \Lambda\,(\Sigma^0)\,d\,n\,X$
  accounts for ~90% "$\Lambda\,(\Sigma^0)\,d$" data
- Disagreement with Katz results
  The role of Σ^0 is not negligible
- Disagreement with Roosen results
  No data for $M_{\Lambda d} < 3100$ MeV/c²

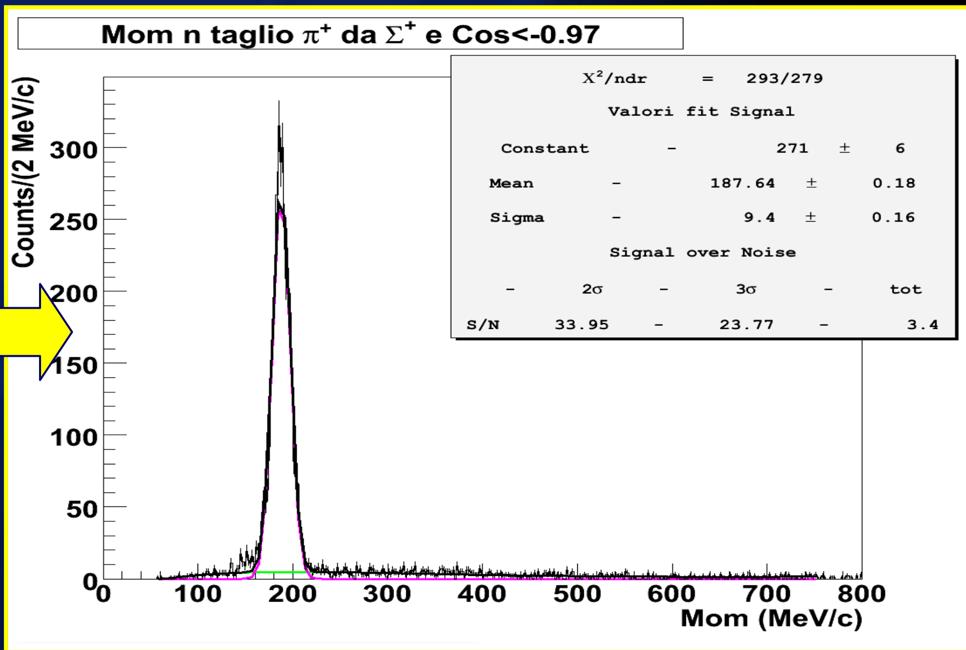
Neutrons from Σ^+ in FINUDA



- n/γ signal discrimination by TOFONE
- π^+ identification by all p.id. layers
- Neutron selection:
  - π^+ momentum in the $\Sigma^+ \rightarrow n\pi^+$ window
  - Back-to-back ($n\pi^+$) pair: $\cos\theta_{\pi n} < -0.97$
    - **p_n = 187.6 ± 0.2 MeV/c**
    - **$\sigma(p_n)$ = 9.4 MeV/c**

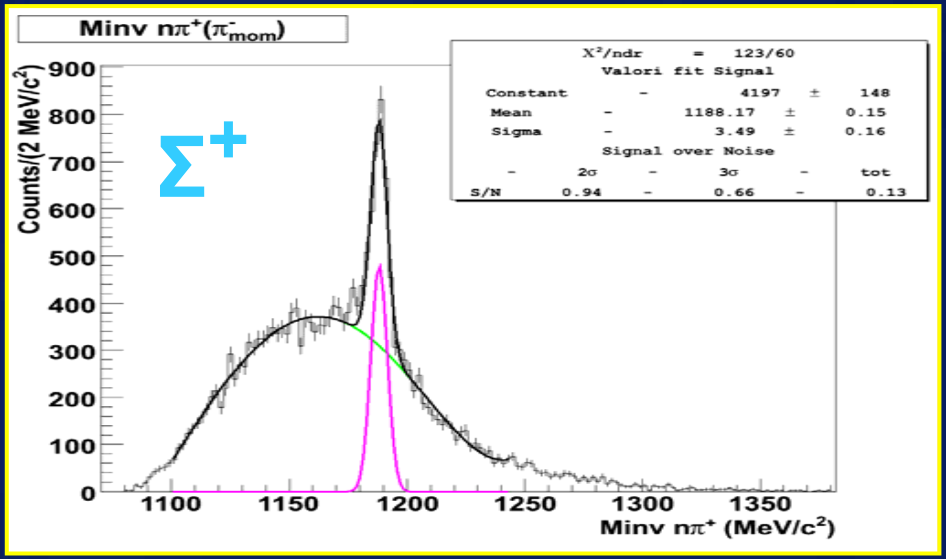
    (cfr 185 MeV/c for Σ decay at rest)

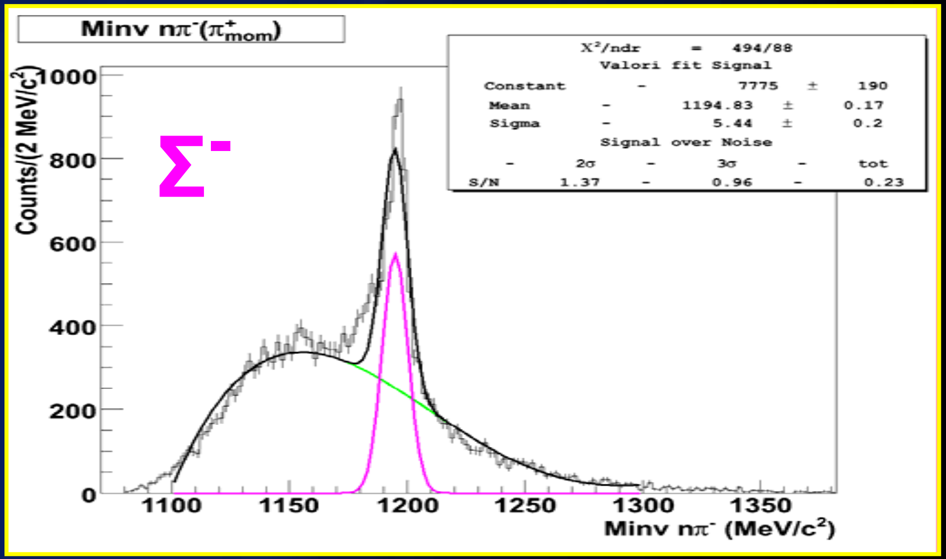


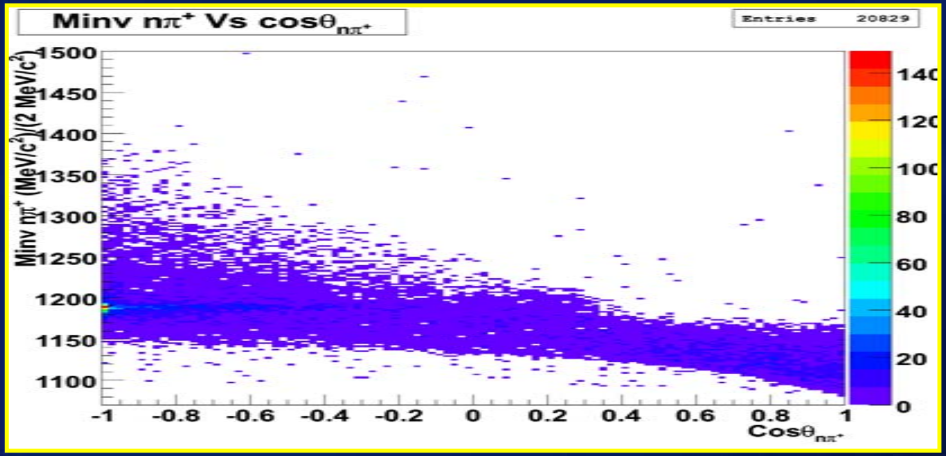


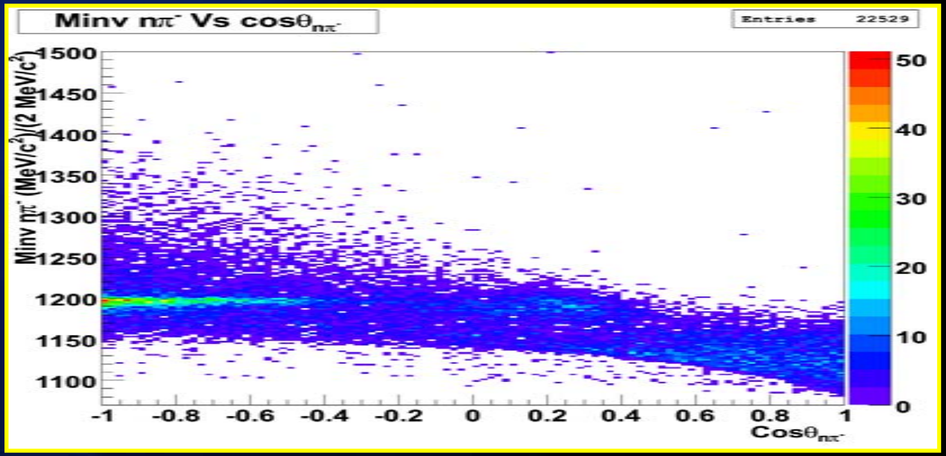
Σ^+ and Σ^- identification in $(n\pi^-\pi^+)$ events

- Σ^+: $(n\pi^+)$ invariant mass + $p_{\pi+}$ < 189 MeV/c (+ $p_{\pi-}$ > 140 MeV/c)
  - m = (1188.17 ± 0.15) MeV/c^2 , Γ = (8.20 ± 0.38) MeV, S/N(2σ) ~ 0.94
- Σ^-: $(n\pi^-)$ invariant mass + $p_{\pi-}$ < 192 MeV/c (+ $p_{\pi+}$ > 150 MeV/c)
  - m = (1194.83 ± 0.17) MeV/c^2, Γ = (12.78 ± 0.47) MeV, S/N(2σ) ~ 1.37







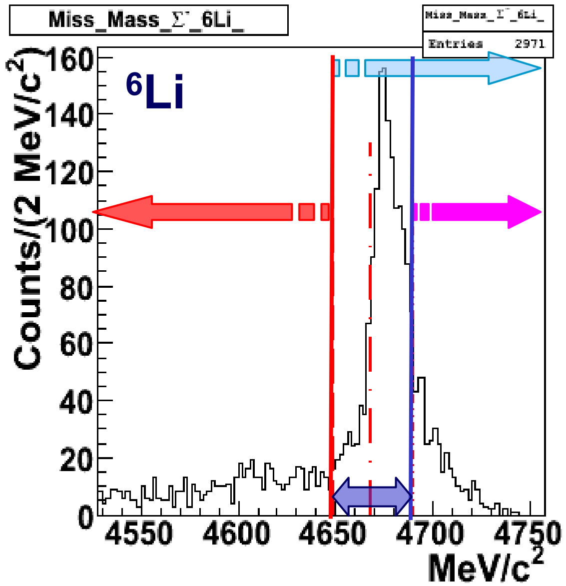


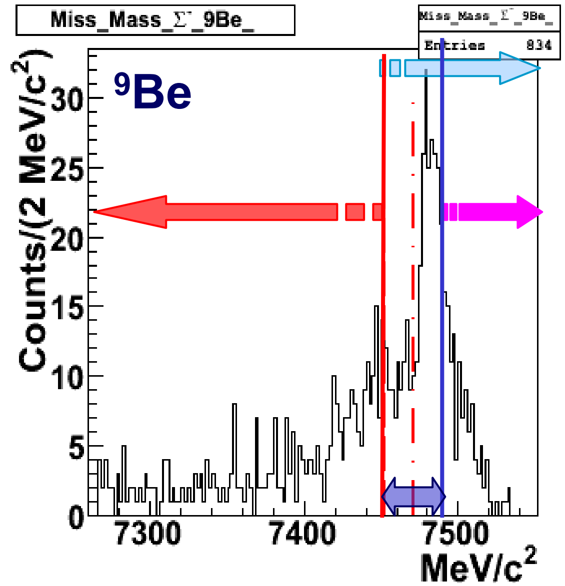
Study of the ($\Sigma^- \pi^+$) system: missing mass

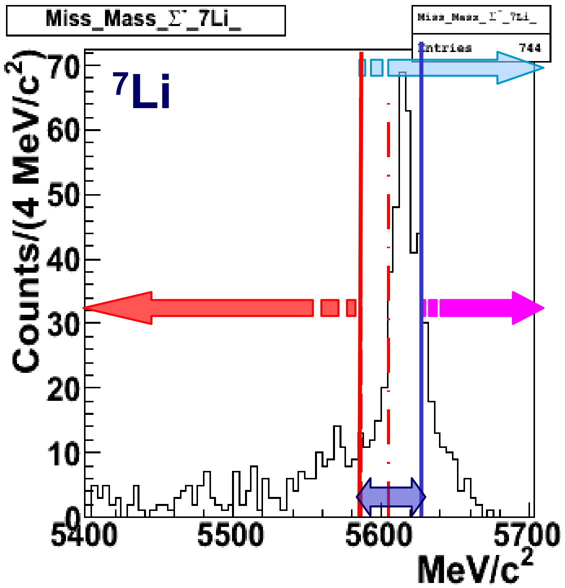
- central peak: $\Sigma^-\pi^+$ production on one nucleon
  $K^- \, {}^{Z}A \rightarrow \Sigma^-\pi^+ + {}^{Z-1}(A-1)$

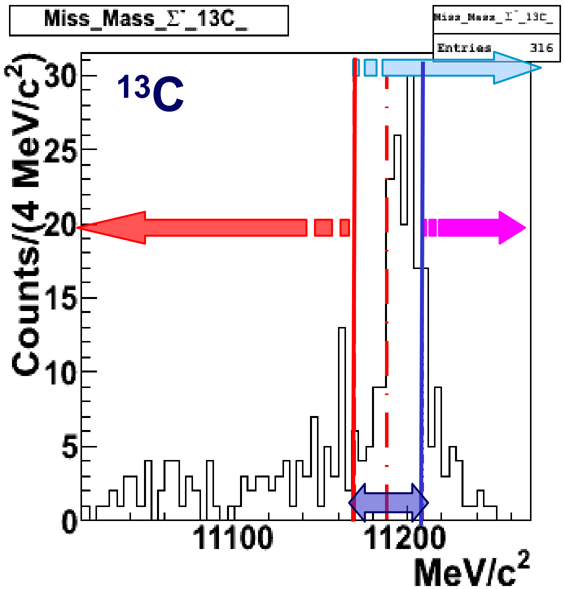
- right: $\Sigma^-\pi^+$ production on two nucleons

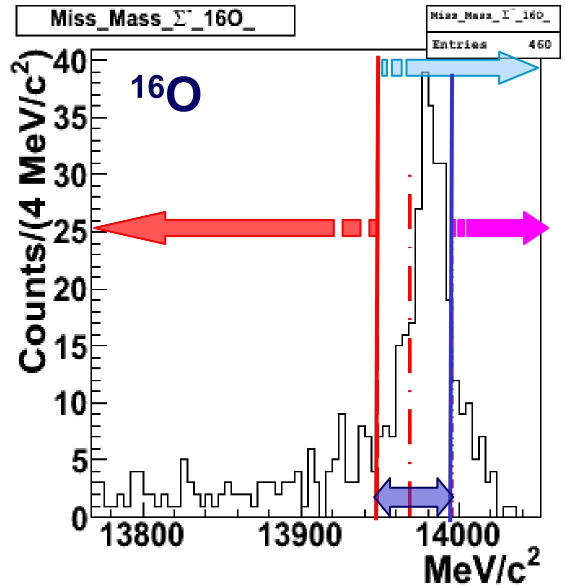
- left: misidentified Σ^- (γ background)









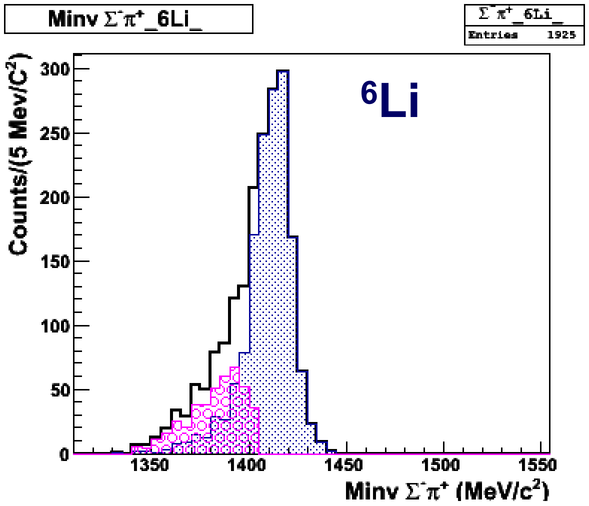


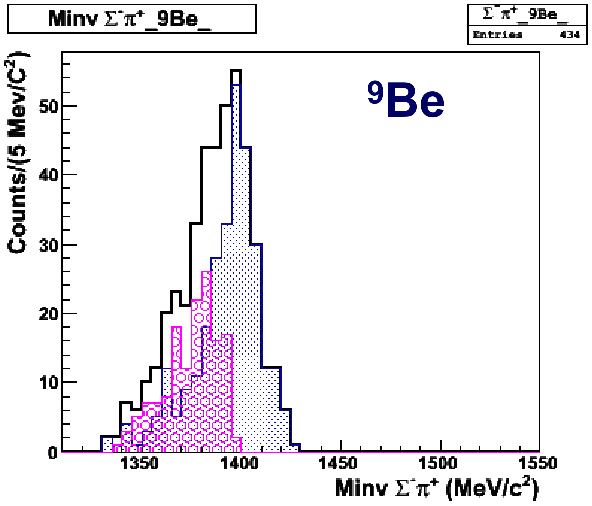
$(\Sigma^- \pi^+)$ invariant mass

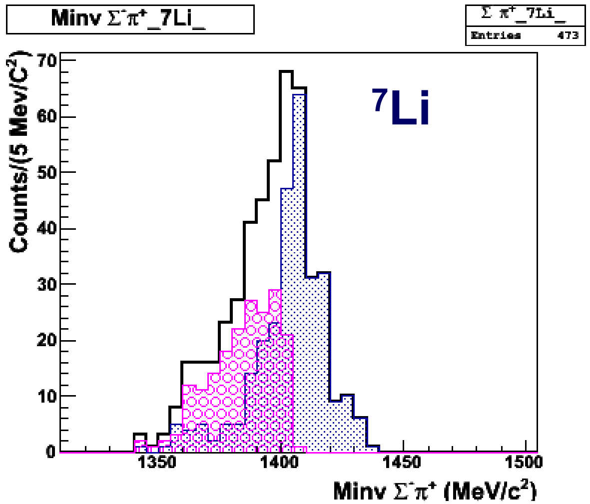
$\Sigma^-\pi^+$ production on one nucleon:

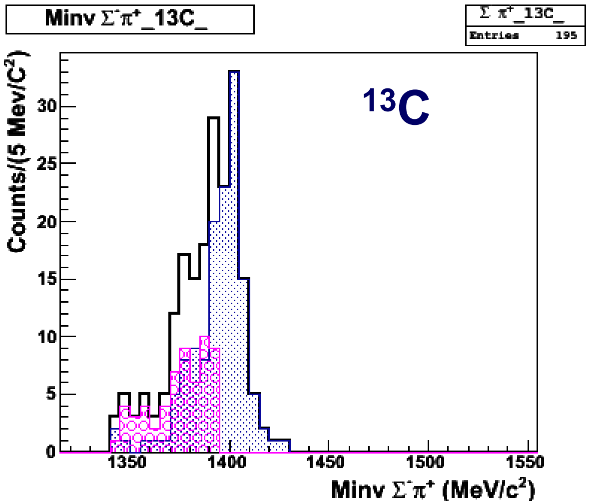
QF reaction?

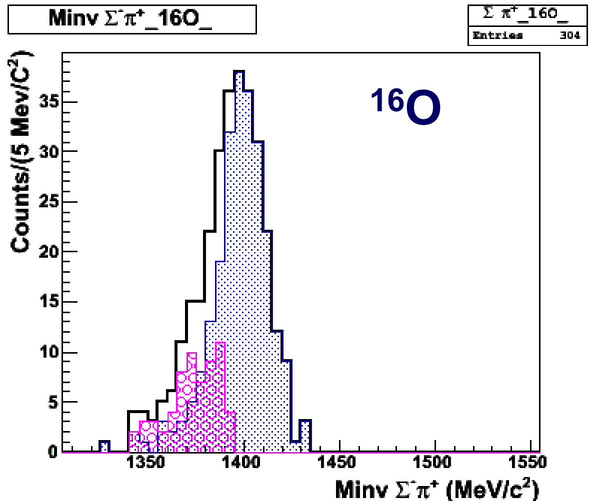
$\Lambda(1405)$–higher mass pole (~1420 MeV/c^2) signal?









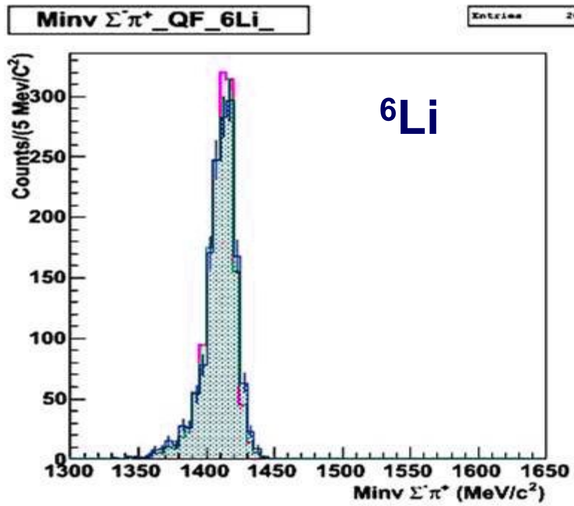


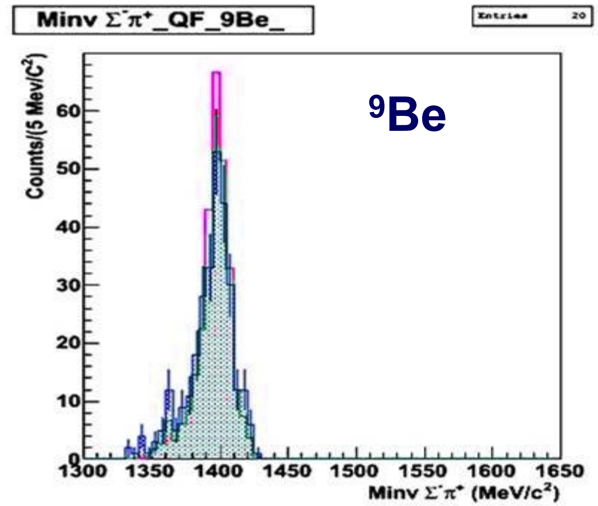
Montecarlo simulation: signal from QF $K^-A \rightarrow \Sigma^-\pi^+A'$ reaction

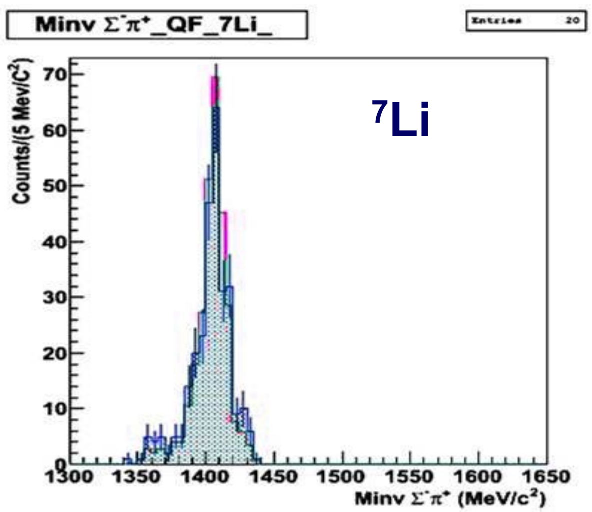
The simulation of the $\Sigma^-\pi^+$ QF production covers perfectly the i.m. region around 1400 MeV

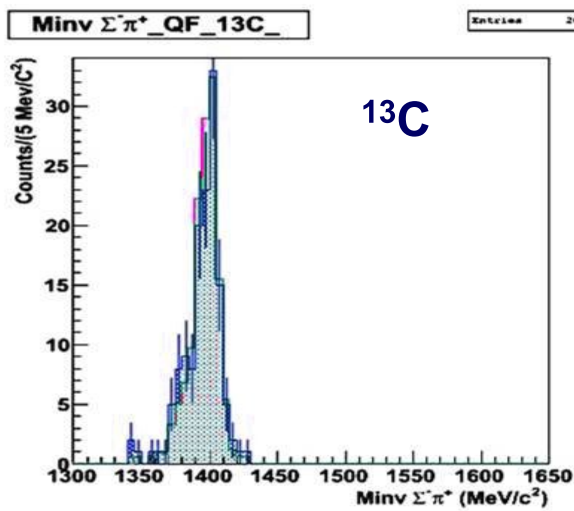
$K^-p \rightarrow \Sigma^-\pi^+$

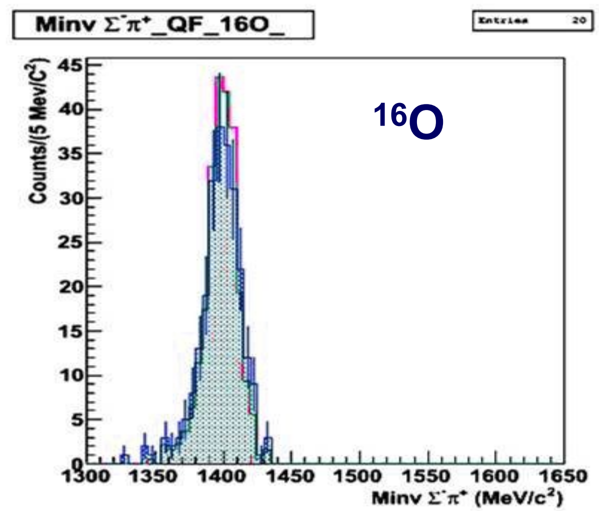
$K^-A \rightarrow \Sigma^-\pi^+ A'$









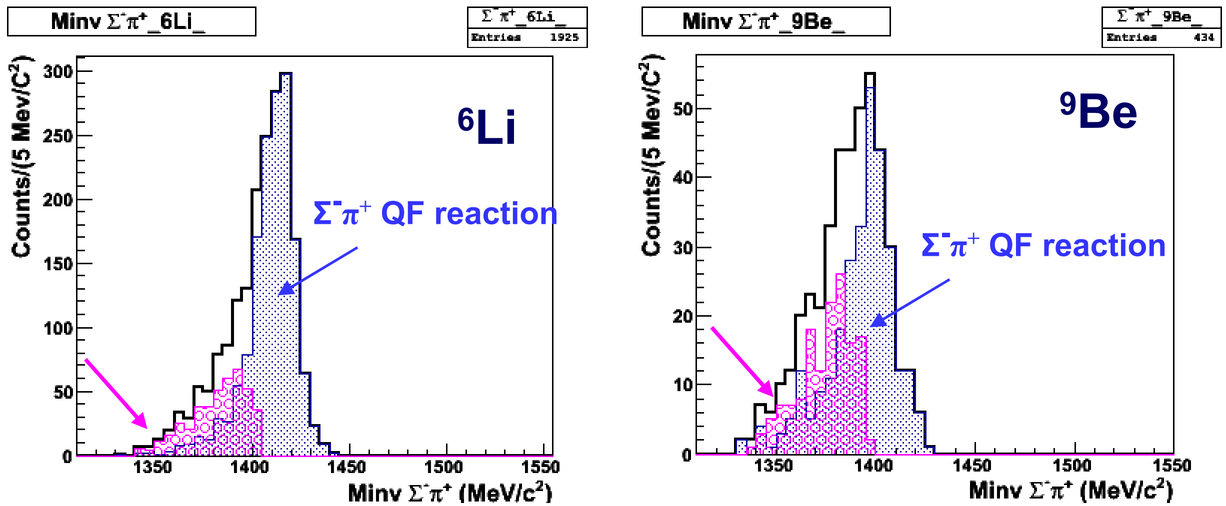


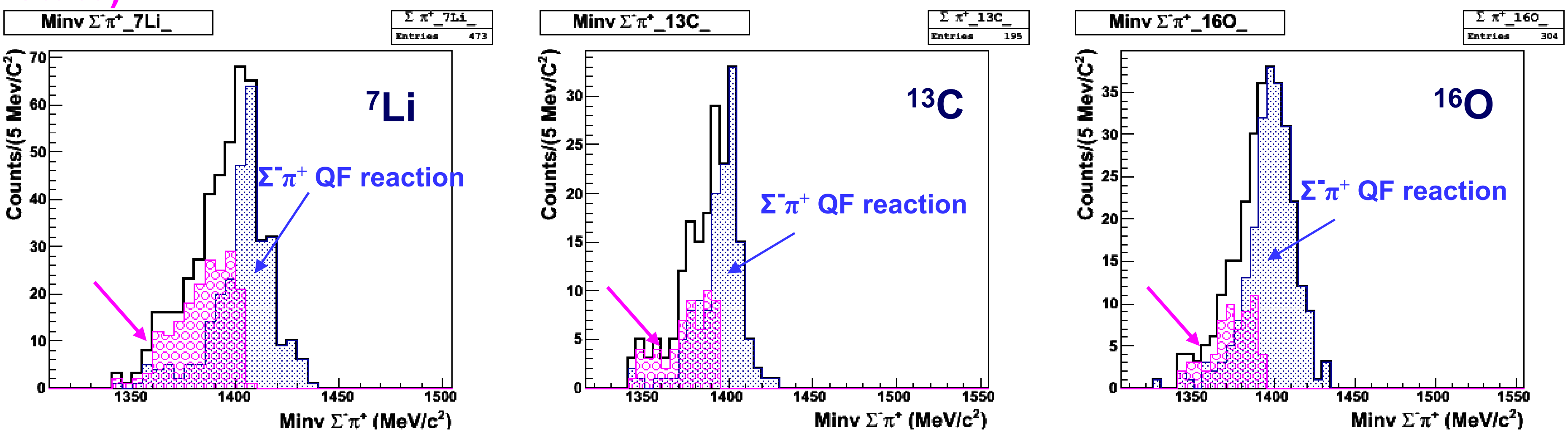
No need to introduce the higher mass Λ(1405)-pole signal to reproduce the data!

$(\Sigma^- \pi^+)$ invariant mass

$\Sigma^-\pi^+$ production on one nucleon:
QF reaction? YES!
~~Λ(1405) signal?~~ NO!

$\Sigma^-\pi^+$ production on two nucleons (one missing nucleon in the final state)



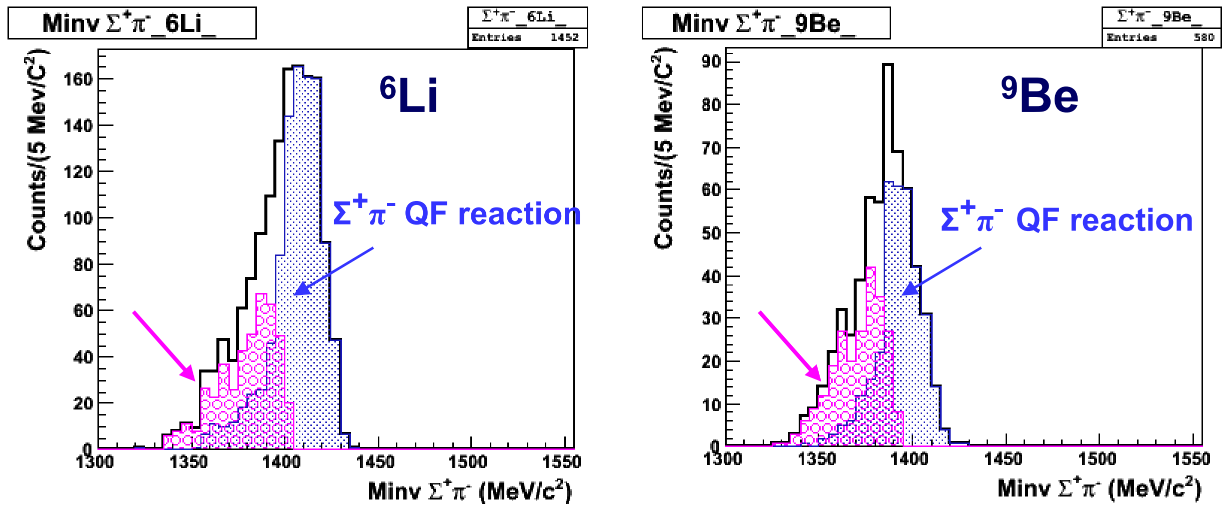


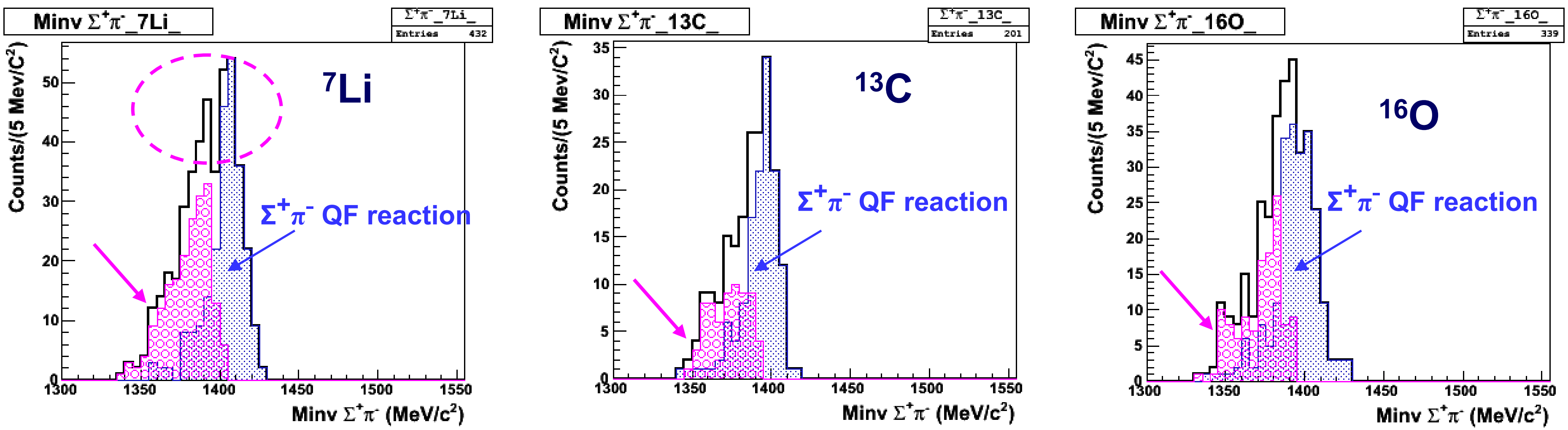
Evidence for a low mass component produced together a missing nucleon:
$\Sigma^0(1385)$ *or* **Λ(1405)** lower mass pole (~1395 MeV/c^2)
$K^-A \rightarrow \Sigma^0(1385)$ / Λ(1405) NA'
└→ **$\Sigma^-\pi^+$**

$(\Sigma^+ \pi^-)$ invariant mass

$\Sigma^+\pi^-$ production on one nucleon: QF reaction

$\Sigma^+\pi^-$ production on two nucleons





Evidence for a low mass component produced together a missing nucleon:

$\Sigma^0(1385)$ *or* **$\Lambda(1405)$** lower mass pole (~1395 MeV/c^2)

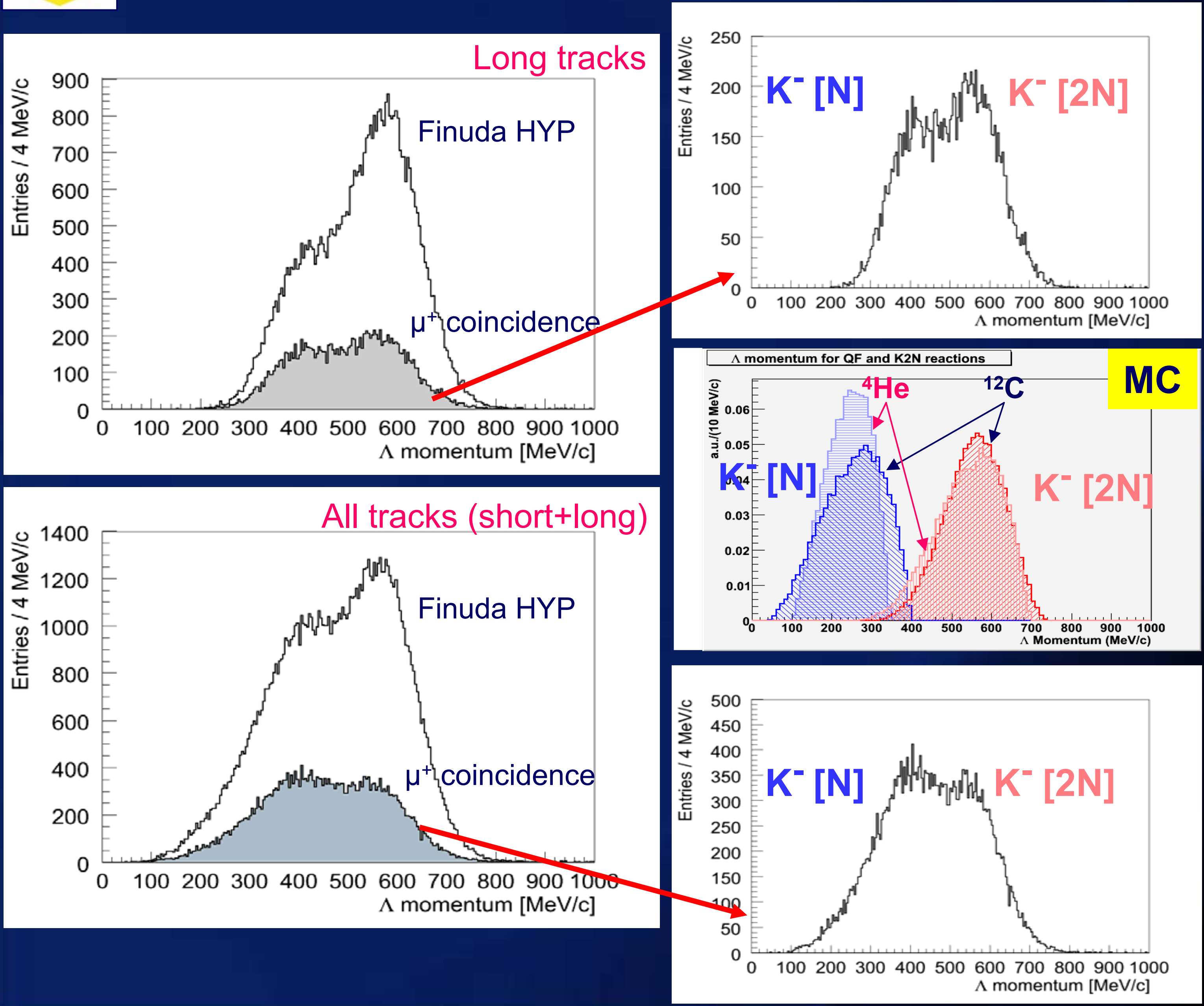
$K^- A \rightarrow \Sigma^0(1385) / \Lambda(1405)\ NA'$

$\hookrightarrow \Sigma^+\pi^-$

Conclusions

- Λd correlation study: sizeable steps further in the analysis
  - Use of full available statistics, more stringent cuts can be applied (missing mass studies)
  - Sizeable (and unexpected) contribution from the Σ^0d channel
  - Neutron coincidence selections (work started and in progress)
- Good capabilities of FINUDA to identify charged Σ hyperons with high statistics
  - Excellent π p.id. efficiency
  - Neutron identification by TOF
  - Study of ($\Sigma\pi$) coincidence events
    - Missing mass cut to discard background and identify production sources
      - Production on one nucleon
        - » Quasi-free reaction
        - » No evidence of Λ(1405) (higher pole)
      - Production on two nucleons
        - » Clear signal of an excitation at ~1380 together with a nucleon: Σ(1385) or contribution from the lowest Λ(1405) pole
- Last but not least…

Λ Momentum: FINUDA inclusive spectra



Inclusive Λ momentum spectra on all targets, NOT acceptance corrected

The requirement of a μ^+ coincidence eliminates possible distortions due to the applied trigger

The two component structure remains

- K^- [N]
- K^- [NN]