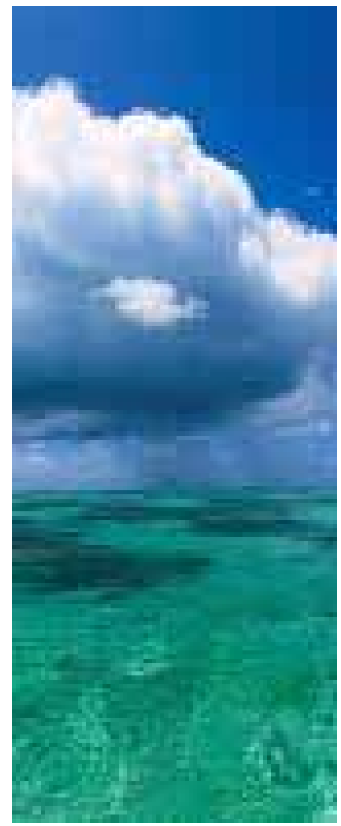
Recent Results on Kaon Absorption by FINUDA

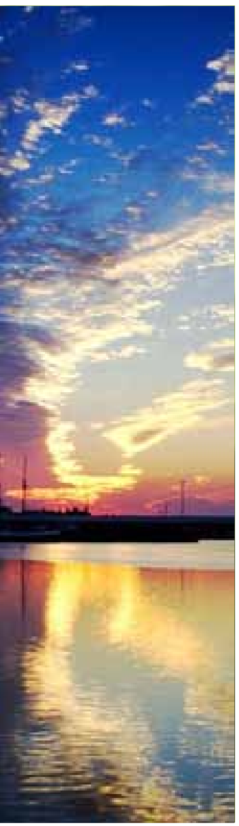
Alessandra Filippi
INFN Torino



Workshop on Advanced Studies in Low Energy QCD in the strangeness sector and possible implications in astrophysics
Laboratori Nazionali di Frascati, June 19-21, 2013

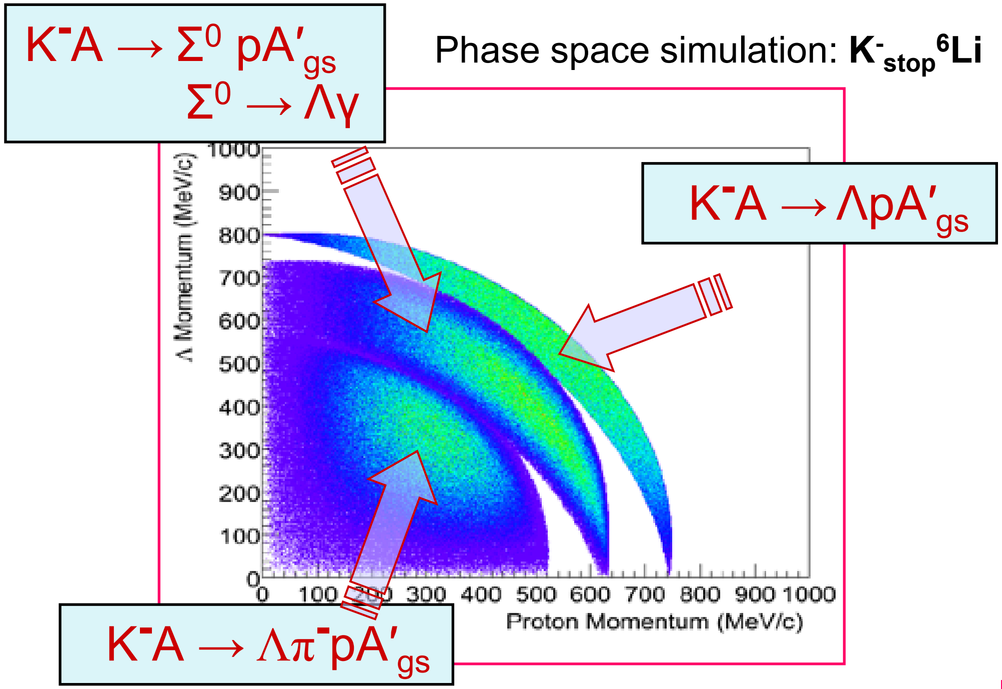
Outline

- Introduction
  - Studies of K^- absorption on single or few-nucleons by FINUDA
- Study of two-body absorption reactions
  - (pp) absorption: $K^- A \rightarrow \Lambda p A'$
  - (np) absorption: $K^- A \rightarrow \Sigma^- p A'$
- Outlook and conclusions

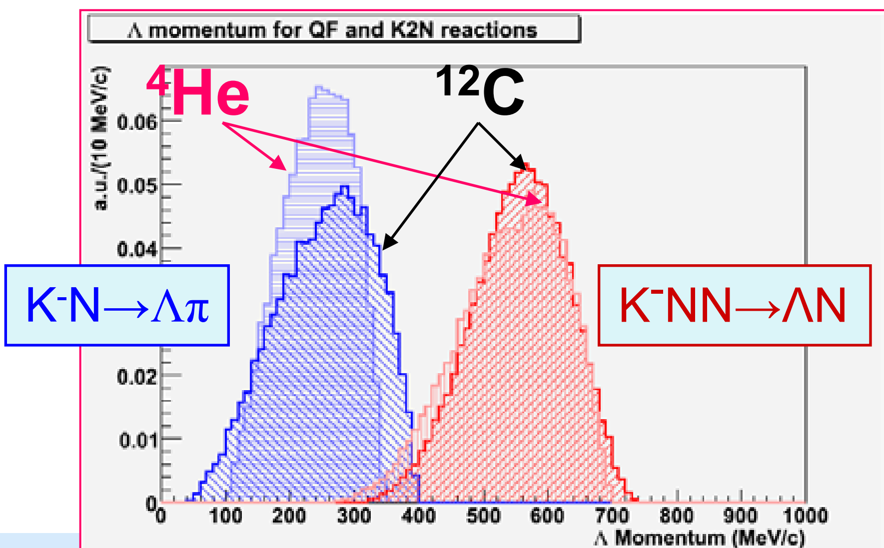


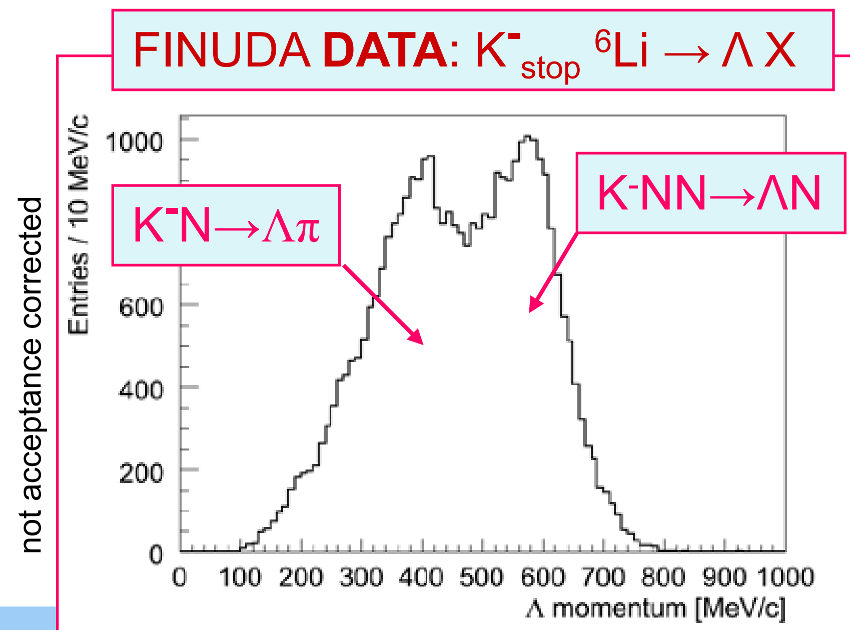
Studies of K^- absorptions on nuclei with FINUDA

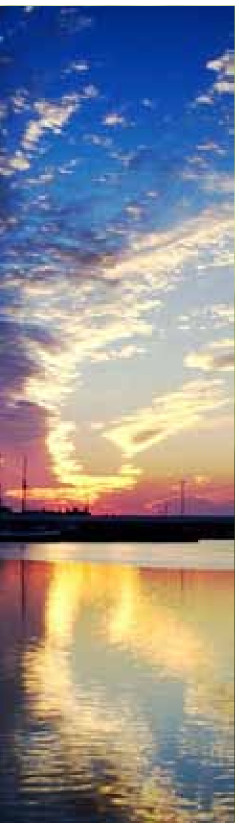
K^-_{stop} absorption by one vs many nucleons



Expected signatures:
in pionless reactions
emission of **high momentum nucleons**
(or light nuclei) and
hyperons







Studies of K^- absorptions on two nucleons: Λp (A-[pp]) final state

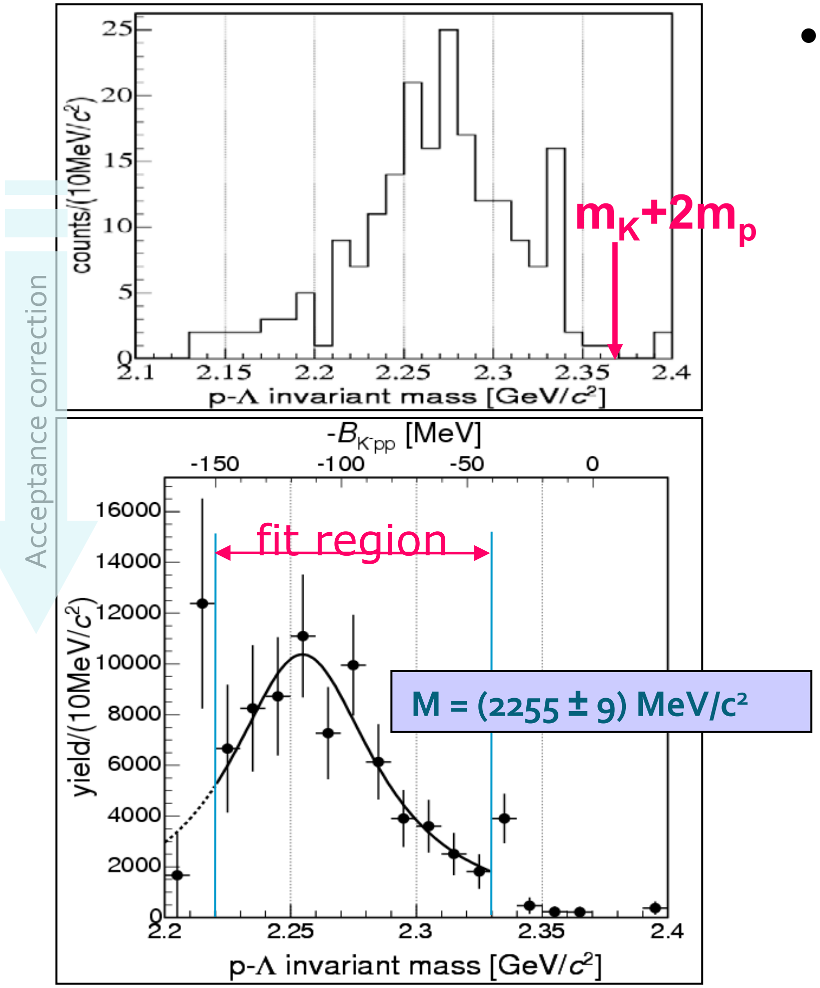
- Data selection and comparison w/ old data
- Acceptance correction
- Global fit to the data – ^{9}Be
  - method
  - basic hypotheses
  - add ons: nuclear fragmentation, …
- Global fit to the data – ^{6}Li

Λp invariant mass in FINUDA – light targets

~ 200 events, PRL94 (2005) 212303

SEMI-EXCLUSIVE ANALYSIS

2003-2004: 3x ^{12}C+2x ^{6}Li+1x ^{7}Li



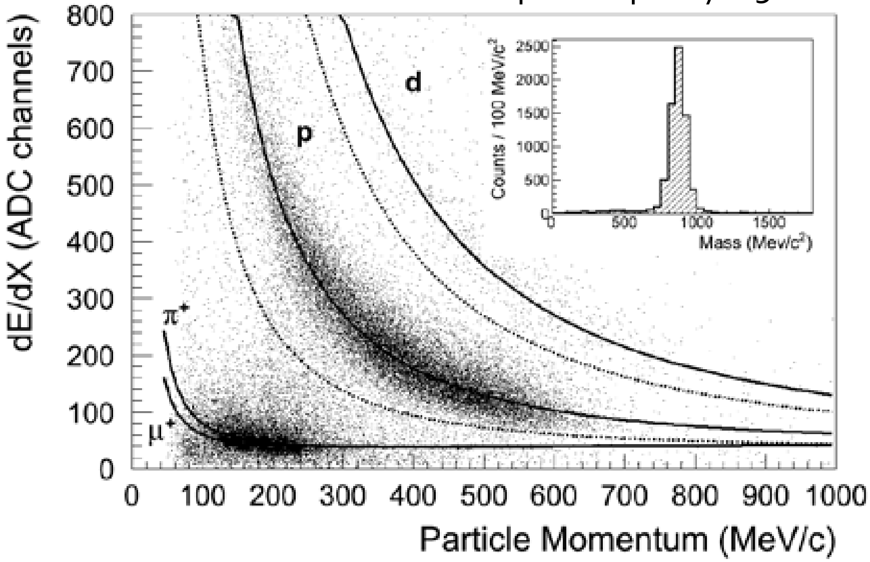
B = 115$^{+6}_{-5}$ (stat)$^{+3}_{-4}$ (sys) MeV
Γ= 67$^{+14}_{-11}$(stat)$^{+2}_{-3}$ (sys) MeV

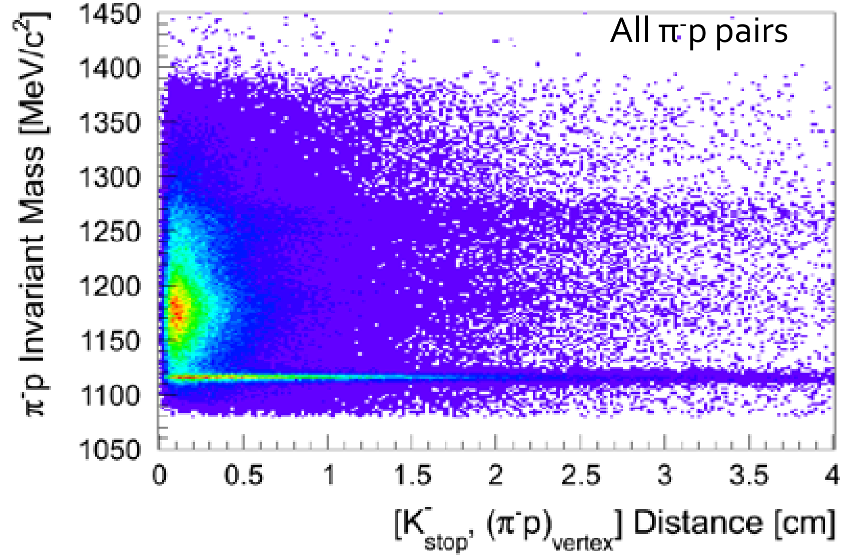
- Possible explanations:
  - $K^-pp \rightarrow \Lambda p$: [K-pp] bound state (FINUDA)
  - Decay of heavier kaonic nuclei (Mares et al.)
  - Quasi-Free Two Nucleon Absorptions:
    - $K^-pp \rightarrow \Lambda p$ followed by FSI (Magas et al.)
    - Dominance of Σ^0 production over Λ:
      $K^-pp \rightarrow \Sigma^0 p$ followed by $\Sigma^0 \rightarrow \Lambda\gamma$ decay
    - $K^-NN \rightarrow \Sigma N$ followed by $\Sigma N \rightarrow \Lambda N$ conversion reactions:

$K^-A \rightarrow \Sigma^{0,+} nX$	$K^-A \rightarrow \Sigma^{0,+}\pi^{0,-}X$	$K^-A \rightarrow \Sigma^{0,-} pX$
$\Sigma^0 p \rightarrow \Lambda p$	$\Sigma^0 p \rightarrow \Lambda p$	$\Sigma^0 n \rightarrow \Lambda n$
$\Sigma^+ n \rightarrow \Lambda p$	$\Sigma^+ n \rightarrow \Lambda p$	$\Sigma^- p \rightarrow \Lambda n$

Proton and Λ purity with FINUDA

proton purity > 98%





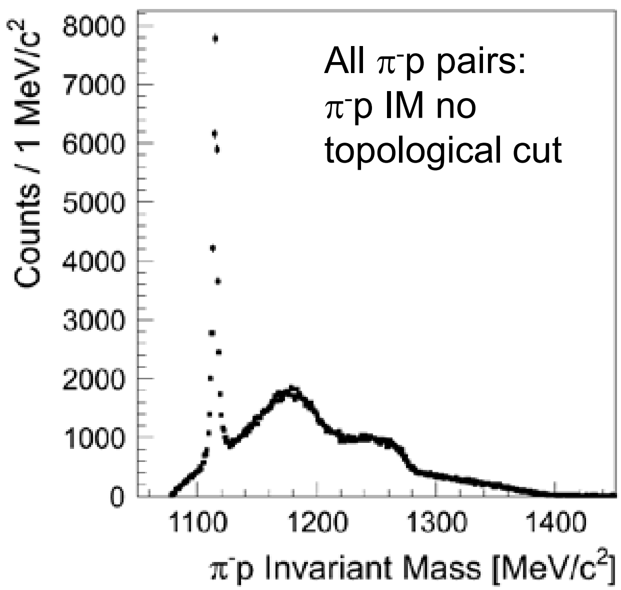
PID: at least 3 out of 4 layers (i.e., ISIM, OSIM, LMCD1 and LMDC2) deliver similar dE/dX values.

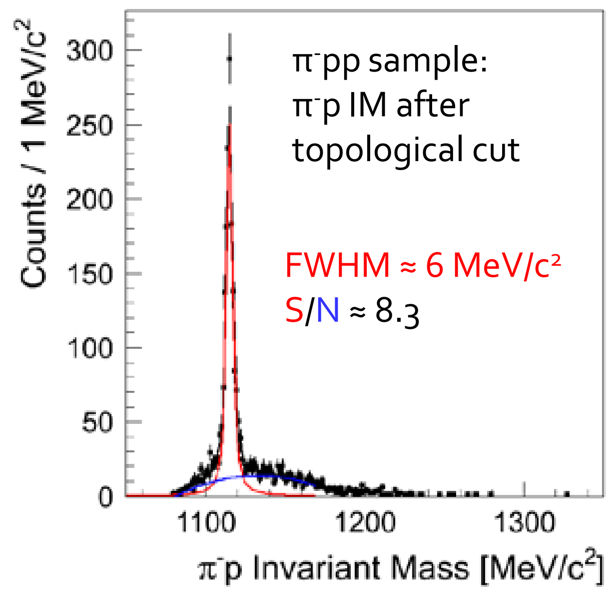
Proton purity > 98%

Topological cut on π-pp sample:

K^-_{stop} p primary vertex
π^- p secondary vertex

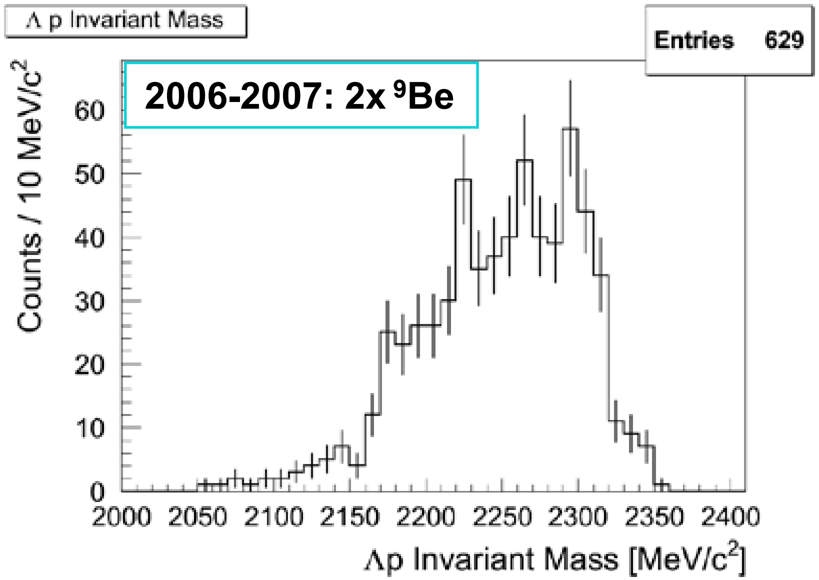
S/N > 8

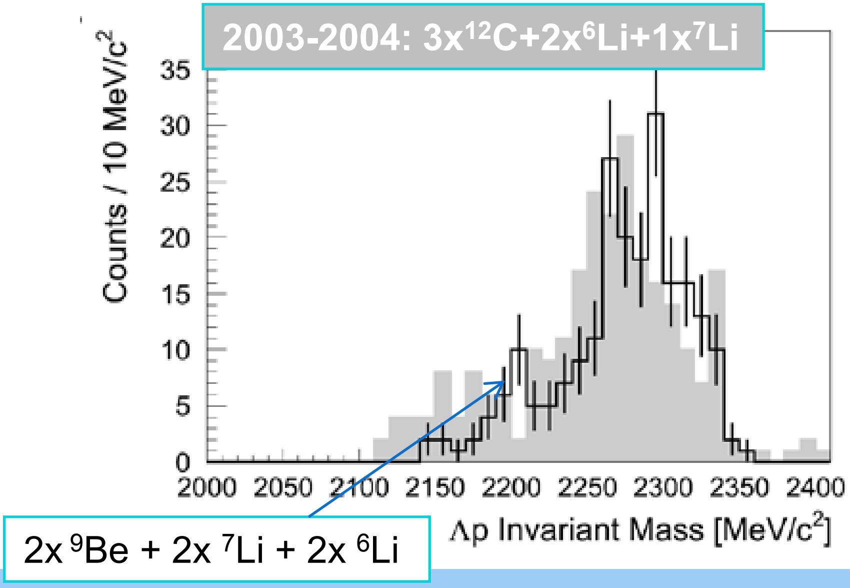




Λp invariant mass in FINUDA: ^{9}Be

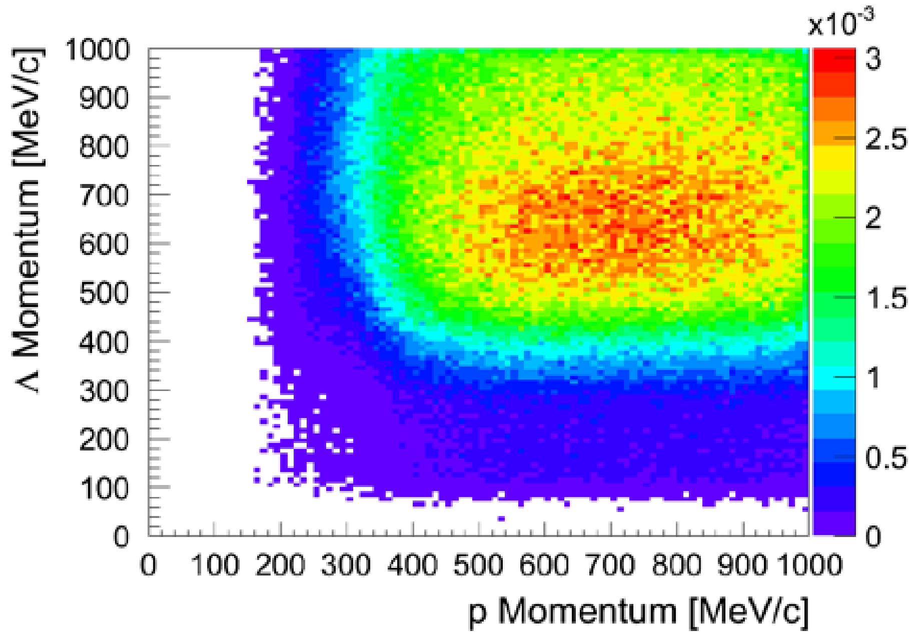
- 2^{nd} data taking, 960 fb^{-1}
  - p-shell targets ($^{6,7}Li$, ^{9}Be, ^{13}C, ^{16}O)
  - 8x collected statistics wrt 1^{st} run
  - Improvements:
    - tracking efficiency
    - Secondary vertex reconstruction
    - Extended range for reconstructed momenta
    - Selection criteria (missing mass)
  - Large enough statistics:
    - Study of K^- interactions on single nuclear species
    - Release of some selection cuts with potential distortions (angles)
      - Different shapes
      - Compatible if same cuts are applied

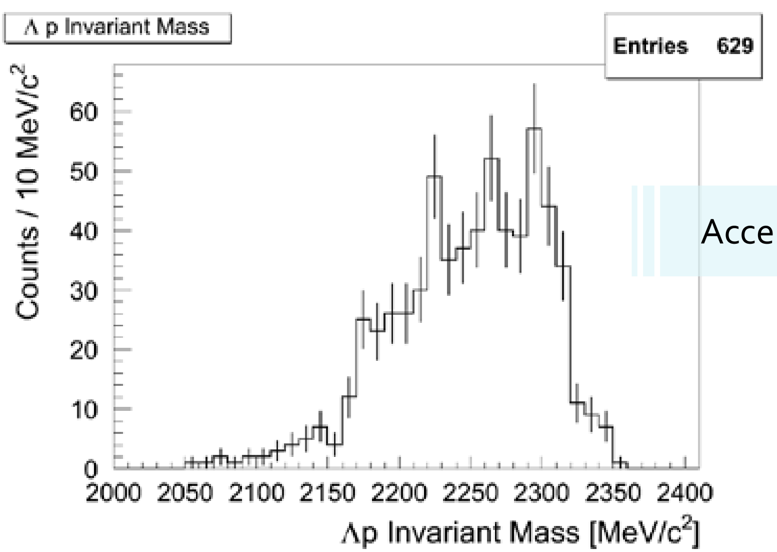




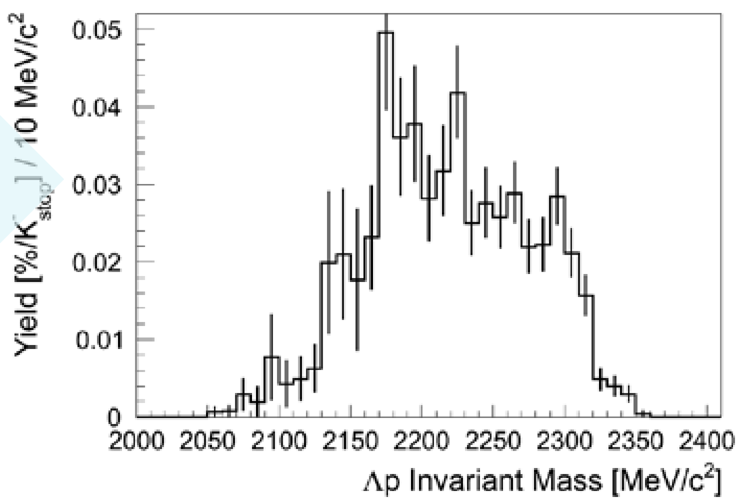
Acceptance correction in FINUDA: $^{9}Be(K^{-}_{stop}, \Lambda p)X$

- Lower momentum thresholds:
  - p_{Λ} > 70 MeV/c
  - p_p > 130 MeV/c
- Large acceptance corrections: p_p , p_{Λ} < 300 MeV/c
  - Data selection:
    - p_p > 300 MeV/c
    - p_{Λ} > 300 MeV/c
    - No angular cuts





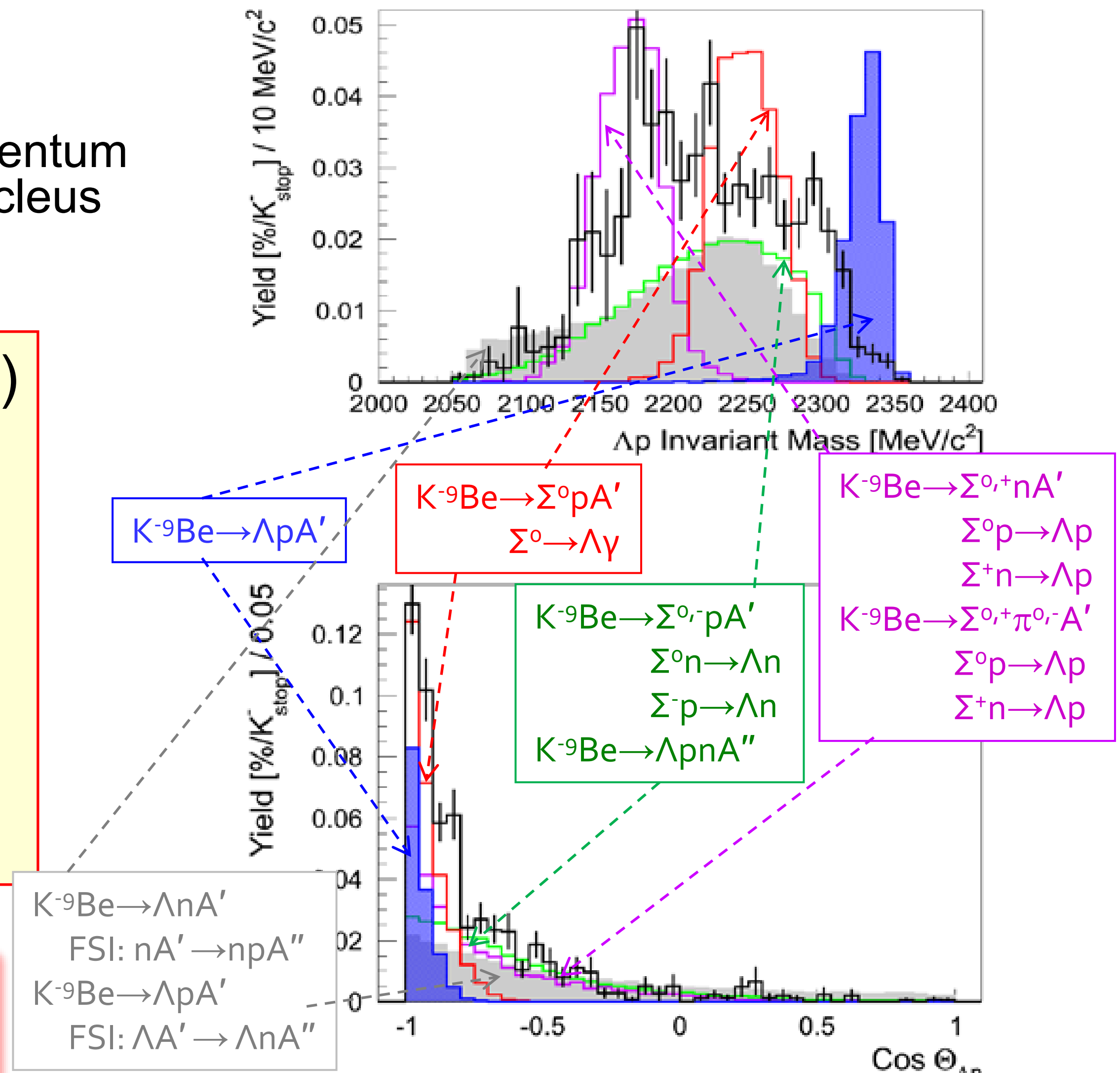
Acceptance correction



$^{9}Be(K^{-}_{stop},\Lambda p)X$: spectral composition analysis

- Several QF-2N absorption reactions simulated (+ acceptance correction)
  - Nucleon pairs with Fermi momentum recoiling against A' residual nucleus in its *ground state*

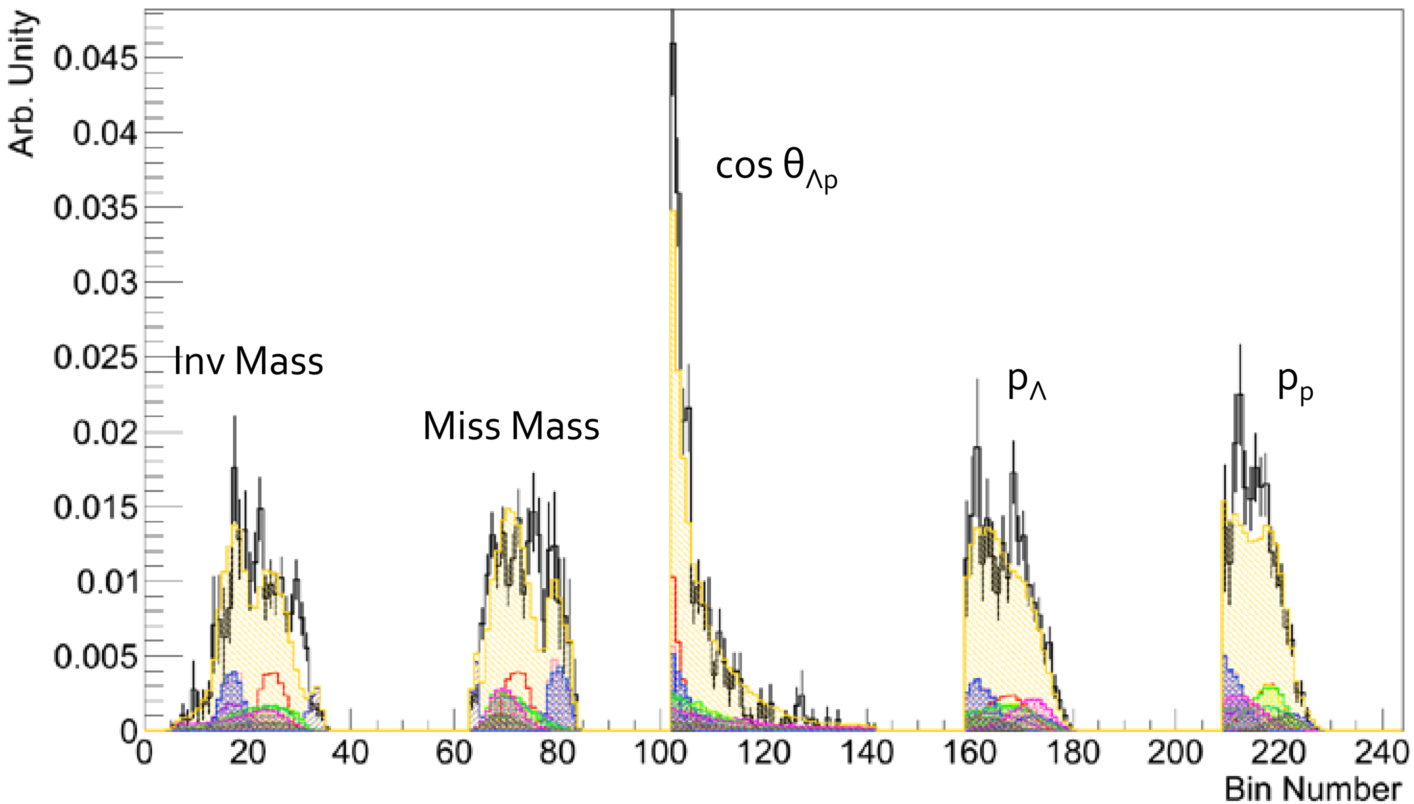
- Standard set: (hypothesis I)
  - $K^{-}\,{}^{9}Be \rightarrow \Lambda p\, A'$
  - $K^{-}\,{}^{9}Be \rightarrow \Sigma^{0} p\, A'$
  - $K^{-}\,{}^{9}Be \rightarrow \Sigma^{0,+} n\, A' + \Sigma\Lambda$ C.R.
  - $K^{-}\,{}^{9}Be \rightarrow \Sigma^{0,+}\pi^{0,-} A' + \Sigma\Lambda$ C.R.
  - $K^{-}\,{}^{9}Be \rightarrow \Sigma^{0,-} p\, A' + \Sigma\Lambda$ C.R.
  - $K^{-}\,{}^{9}Be \rightarrow \Lambda p n\, A''$
  - $K^{-}\,{}^{9}Be \rightarrow \Lambda n\, A' + n$ FSI
  - $K^{-}\,{}^{9}Be \rightarrow \Lambda p\, A' + \Lambda$ FSI



Problem: how to adapt all simulated contributions to several exp spectra?

Spectral Analysis technique: global fit

- Several experimental distributions are required to be fitted at the same time by the sum of many QF reactions, through a binned likelihood fit on the global shape
  - 5 experimental distributions: (Λp) inv. mass, miss. mass, $\cos\theta_{\Lambda p}$, p_Λ, p_p
  - ≥10 QF reactions to be modeled
  - Output from the fit: fraction of each background reaction



Global fit results: hypothesis I

- The sum of 10 QF background reactions (standard set) explains ~90% of the experimental spectra: $\chi^2_{NDF} = 3.2$ *- not satisfactory*
- The best fit cannot explain neither the (Λp) inv. mass excess at ~ 2300 MeV/c^2, nor the angular distribution for back-to-back angles

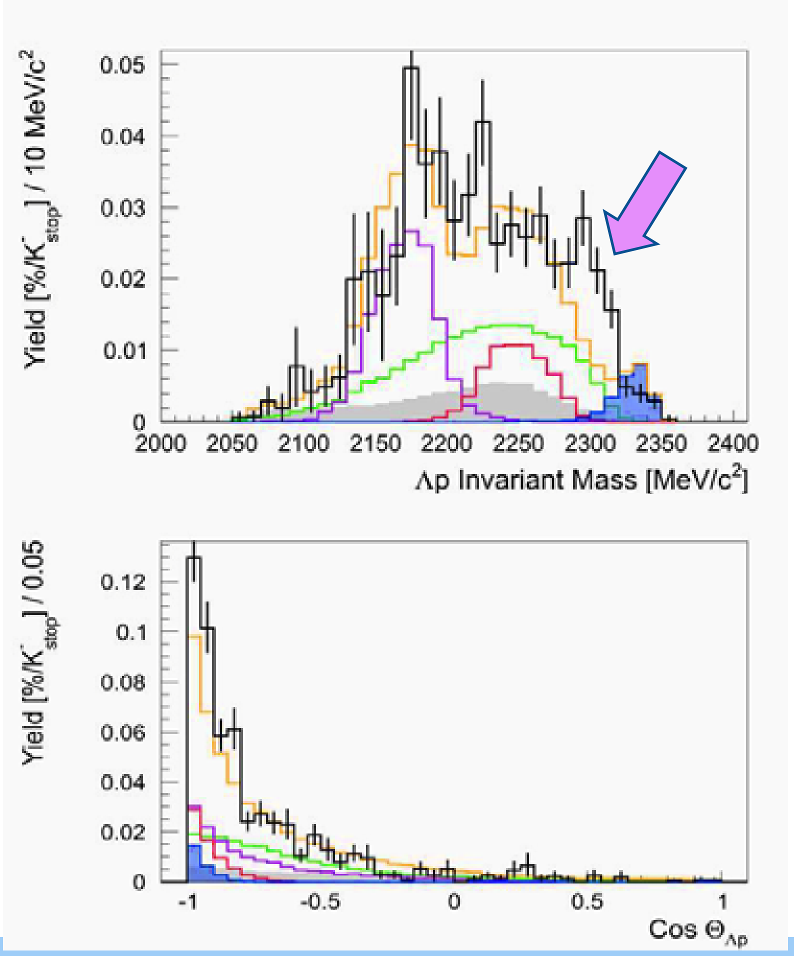
$K^-\,{}^9Be \to \Lambda p\,A'$: **0.048 ± 0.004**

$K^-\,{}^9Be \to \Sigma^0 p\,A'$: **0.129 ± 0.013**

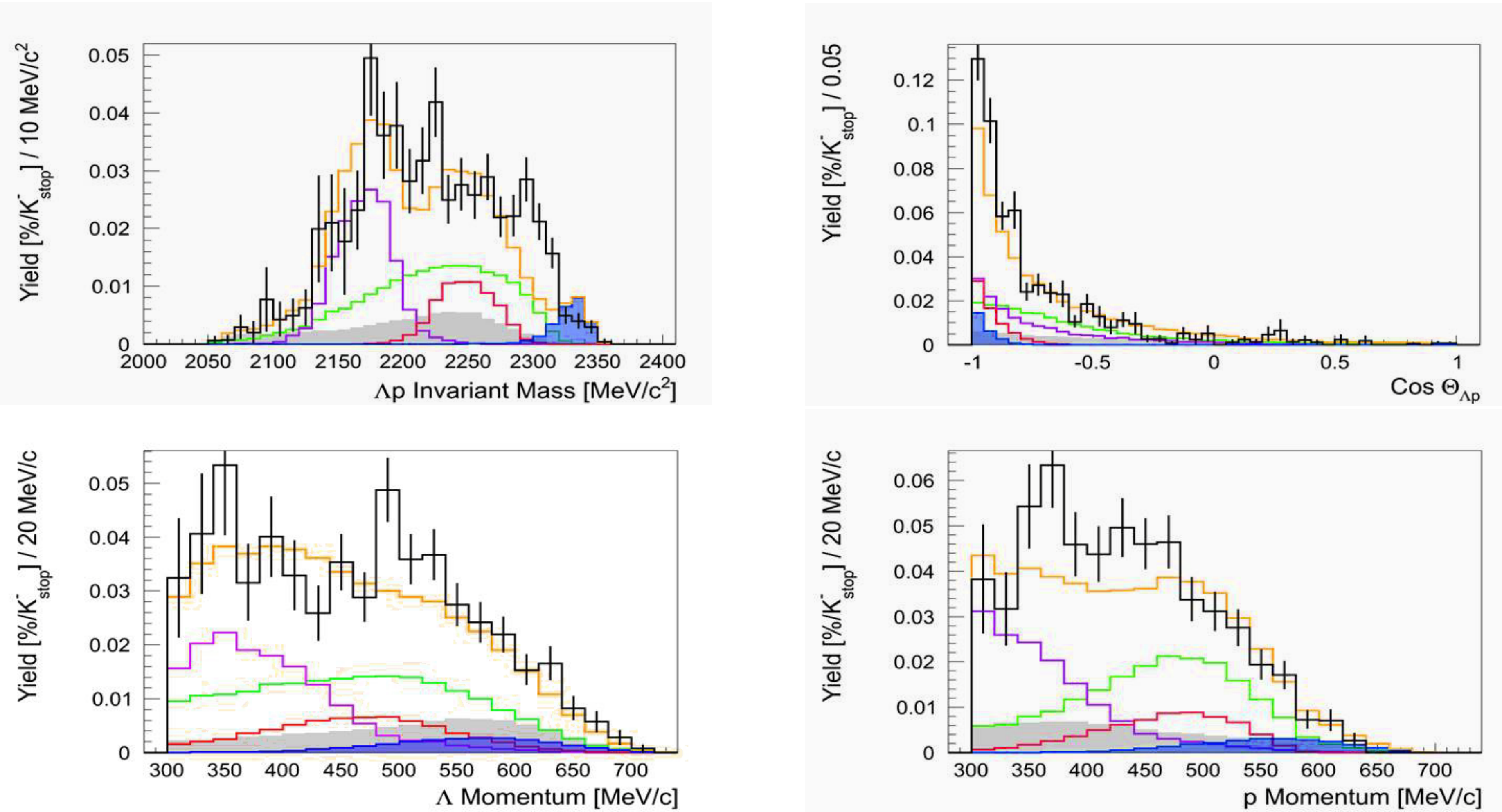
$K^-\,{}^9Be \to \Sigma^{0,+} n\,A' + \Sigma\Lambda$ C.R.
(+ $\Sigma^0 p \to \Lambda p$, + $\Sigma^+ n \to \Lambda p$): 0.073 ± 0.013
$K^-\,{}^9Be \to \Sigma^{0,+} \pi^{0,-} A' + \Sigma\Lambda$ C.R.
(+ $\Sigma^0 p \to \Lambda p$, + $\Sigma^+ n \to \Lambda p$): **0.220 ± 0.027**

$K^-\,{}^9Be \to \Sigma^{0,-} p\,A' + \Sigma\Lambda$ C.R.
(+ $\Sigma^0 n \to \Lambda n$, + $\Sigma^- p \to \Lambda n$): **0.259 ± 0.024**
$K^-\,{}^9Be \to \Lambda p n\,A''$: 0.123 ± 0.017

$K^-\,{}^9Be \to \Lambda n\,A'$ + n FSI
$K^-\,{}^9Be \to \Lambda p\,A'$ + Λ FSI
(+ n(Λ) A′ → n p(Λ) A″): 0.147 ± 0.016



Global fit results: hypothesis I



Exp. Data — Best Fit

$K^- {}^9Be \rightarrow \Lambda p A'$

$K^- {}^9Be \rightarrow \Sigma^0 p A'$

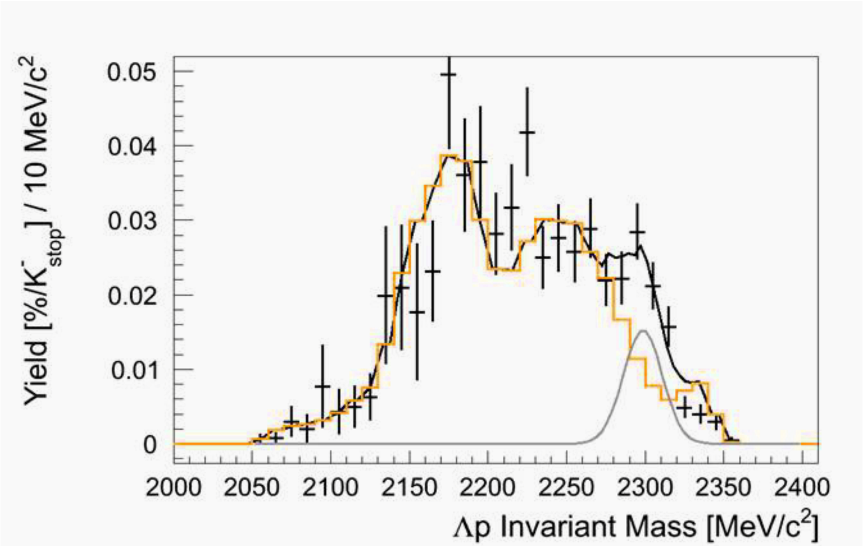
$K^- {}^9Be \rightarrow \Sigma^{0,+} n A' + \Sigma\Lambda$ C.R. && $K^- {}^9Be \rightarrow \Sigma^{0,+}\pi^{0,-} A' + \Sigma\Lambda$ C.R.

$K^- {}^9Be \rightarrow \Sigma^{0,-} p A' + \Sigma\Lambda$ C.R. && $K^- {}^9Be \rightarrow \Lambda p n A''$

$K^- {}^9Be \rightarrow \Lambda n A'$ + n FSI && $K^- {}^9Be \rightarrow \Lambda p A' + \Lambda$ FSI

Hypothesis II: additional (Λp) resonant state

- Additional contribution to fill the missing strength: (Λp) bound state with given $m_{\Lambda p}$ and $\Gamma_{\Lambda p}$
- First step: fit of the (Λp) invariant mass spectrum with an additional gaussian function, added to best fit



m : 2298 ± 2 MeV/c²
σ: 12.2 ± 2.1 MeV

Only valid for the invariant mass projection!

- Second step: simulation of (Λp) signal (+ reconstruction, acceptance correction) over a discrete grid of $m_{\Lambda p}$ and $\Gamma_{\Lambda p}$ values
- Series of global fits to find the likelihood minimum $\Rightarrow$ best fit

Hypothesis III: (Yp) + recoiling nucleus in excited state

- The kaon might be absorbed by a nucleon pair not on the nucleus surface, but inside the nucleus
  - The recoiling nucleus might be left in an excited state, and then fragment
  - The energy available for the (Yp) system could be lower
  - Sizeable energy difference in heavier nuclei (^{9}Be vs ^{6}Li)

^{6}Li	A – [pp]	^{4}H	t + n	d + 2n	p + 3n
	Mass(MeV)	**3751.37**	3748.49	3754.76	**3756.97**

^{7}Li	A – [pp]	^{5}H	^{4}H + n	t + 2n	d + 3n	p+4n
	Mass(MeV)	**4689.85**	4690.93	4688.05	4694.32	**4696.53**

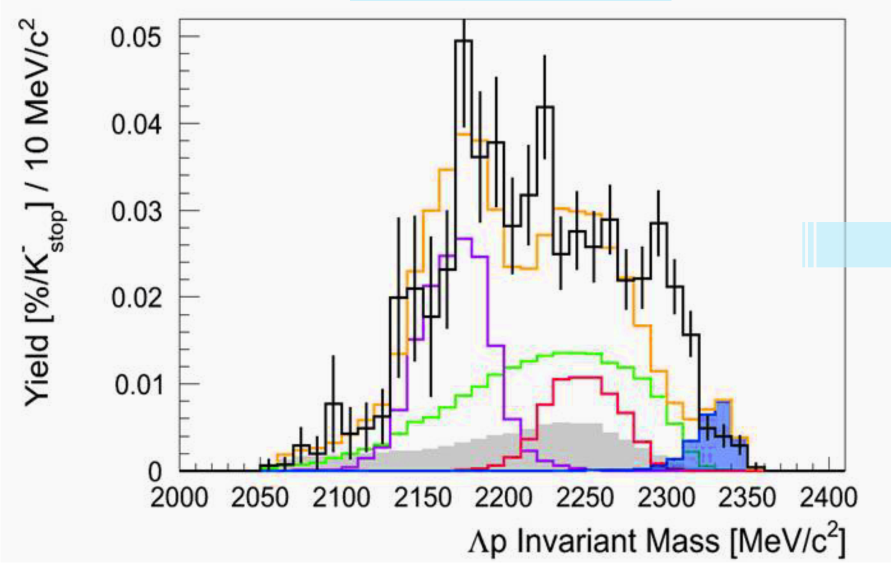
^{9}Be	A – [pp]	^{7}He	^{6}He + n	^{5}He + 2n	^{4}He + 3n	t+p+3n	d+p+4n	2p+5n
	Mass(MeV)	**6545.54**	6545.09	6546.96	6546.08	6565.89	6572.16	**6574.37**

- New fits with an additional component: QF-2N (Y+p)+A”, followed by A” fragmentation according to phase space

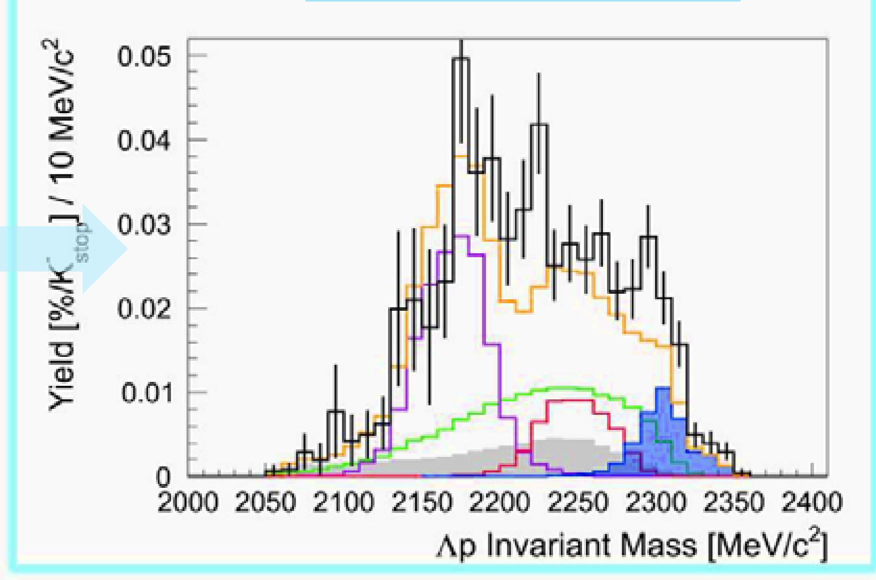
(Λp) + recoiling nucleus in ground vs excited state: comparison

- The (Λp) invariant mass for the QF Λp reaction moves to lower values and helps filling the region around 2300 MeV/c^2 (but is still not enough)

QF (Λp) + $A'_{g.s.}$



QF (Λp) + $A'_{g.s.}$ or A″



- Sizeable fraction of QF Λp reaction recoiling against an excited nucleus

Global fit results ^{9}Be: hypothesis I+II+III

- Best fit values on a discrete grid

$m_{\Lambda p}$= (2298 ± 7) MeV/c^2, $\Gamma_{\Lambda p}$ = (67 ± 18) MeV

K^- ^{9}Be → Λp $A'_{g.s.}$: **0.013 ± 0.003**
K^- ^{9}Be → Λp A” : **0.055 ± 0.008**

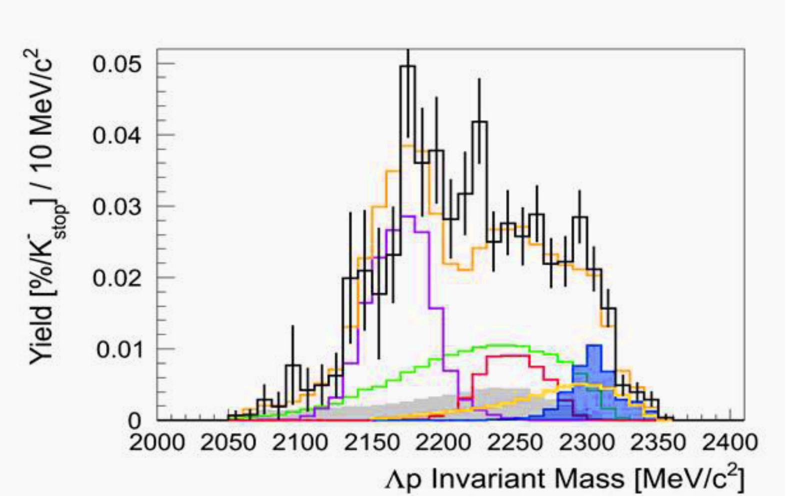
K^- ^{9}Be → Σ^0p A′: **0.101 ± 0.011**

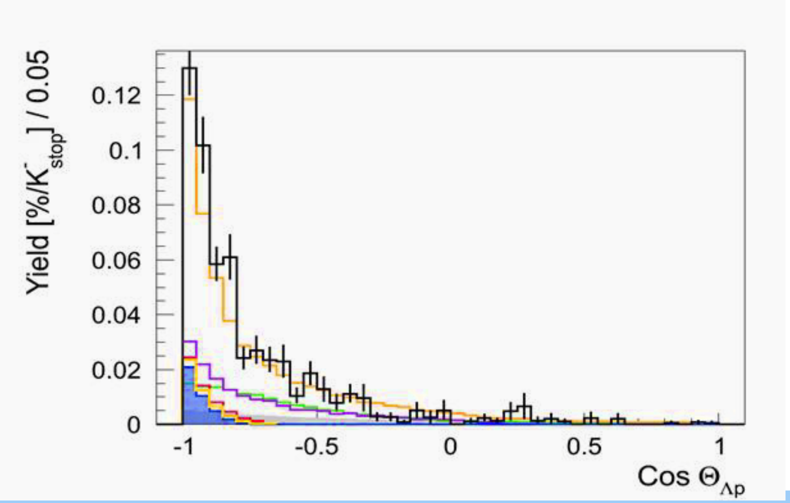
K^- ^{9}Be → $\Sigma^{0,+}$n A′ + ΣΛ C.R.
(+ Σ^0p→Λp, + Σ^+n→Λp): 0.091 ± 0.013
K^- ^{9}Be → $\Sigma^{0,+}\pi^{0,-}$ A′ + ΣΛ C.R.
(+ Σ^0p→Λp, + Σ^+n→Λp): 0.099 ± 0.017

K^- ^{9}Be → $\Sigma^{0,-}$p A′ + ΣΛ C.R.
(+ Σ^0n→Λn, + Σ^-p→Λn): 0.176 ± 0.020
K^- ^{9}Be → Λpn A″: 0.093 ± 0.016

K^- ^{9}Be → Λn A′ + n FSI
K^- ^{9}Be → Λp A′ + Λ FSI
(+ n(Λ) A′ → n p(Λ) A″): 0.087 ± 0.013

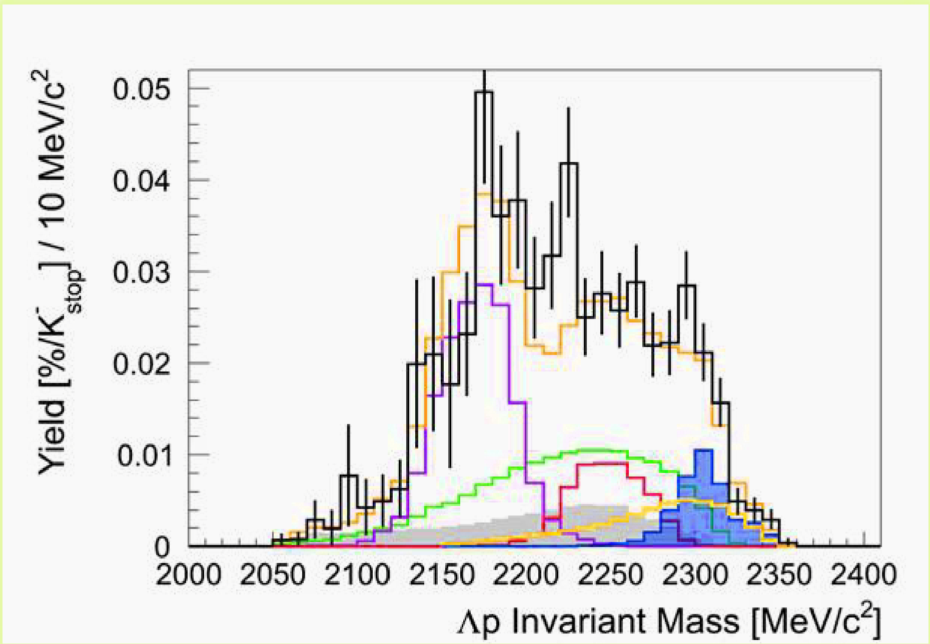
K^- ^{9}Be → XA’ → Λp A′ : 0.077 ± 0.011

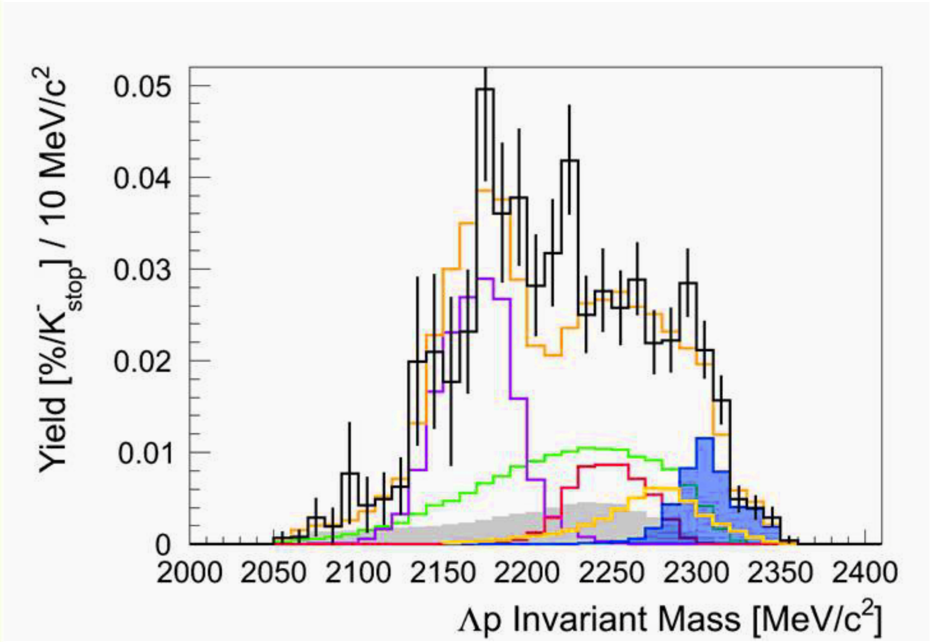




Fits with narrower resonance: worse

- Narrower signals reproduce in a worse way the spectrum at 2300 MeV/c^2 and above





$m_{\Lambda p}$ = 2298 MeV/c^2
$\Gamma_{\Lambda p}$ = 67 MeV
$\chi^2 = 240 \Rightarrow \chi^2_{NDF} = 2.16$

$m_{\Lambda p}$ = 2276 MeV/c^2
$\Gamma_{\Lambda p}$ = 47 MeV
$\chi^2 = 244 \Rightarrow \chi^2_{NDF} = 2.21$

$^6Li(K^-_{stop},\Lambda p)X$: global fit with resonant state

- Not sensitive to excited states emission and fragmentation processes ($^6Li = \alpha + d$)
- Best fit values on a discrete grid for a (Λp) resonant state: same as for ^9Be

$m_{\Lambda p} = (2298\ ^{+6}_{-7})$ MeV/c^2, $\Gamma_{\Lambda p} = (67\ ^{+14}_{-13})$ MeV

$K^-\,{}^6Li \rightarrow \Lambda p A'$: 0.027 ± 0.004

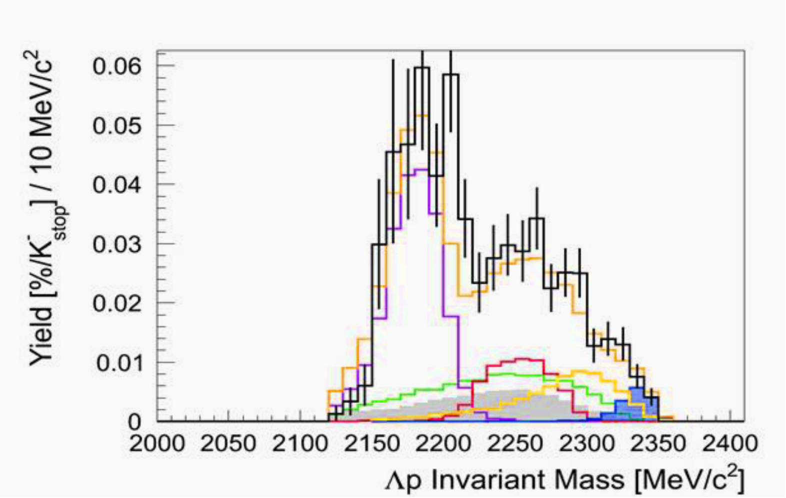
$K^-\,{}^6Li \rightarrow \Sigma^0 p A'$: 0.112 ± 0.013

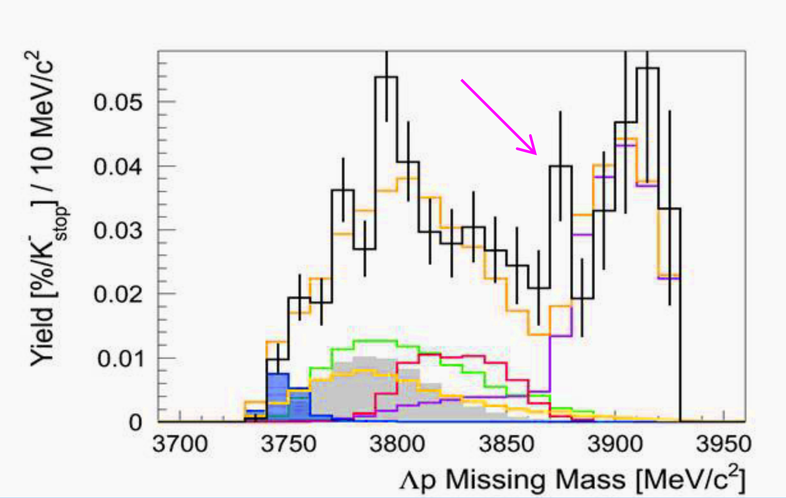
$K^-\,{}^6Li \rightarrow \Sigma^{0,+} n A' + \Sigma\Lambda$ C.R.
(+ $\Sigma^0 p \rightarrow \Lambda p$, + $\Sigma^+ n \rightarrow \Lambda p$): 0.052 ± 0.010
$K^-\,{}^6Li \rightarrow \Sigma^{0,+} \pi^{0,-} A' + \Sigma\Lambda$ C.R.
(+ $\Sigma^0 p \rightarrow \Lambda p$, + $\Sigma^+ n \rightarrow \Lambda p$): 0.157 ± 0.019

$K^-\,{}^6Li \rightarrow \Sigma^{0,-} p A' + \Sigma\Lambda$ C.R.
(+ $\Sigma^0 n \rightarrow \Lambda n$, + $\Sigma^- p \rightarrow \Lambda n$): 0.117 ± 0.020
$K^-\,{}^6Li \rightarrow \Lambda p n A''$: 0.071 ± 0.016

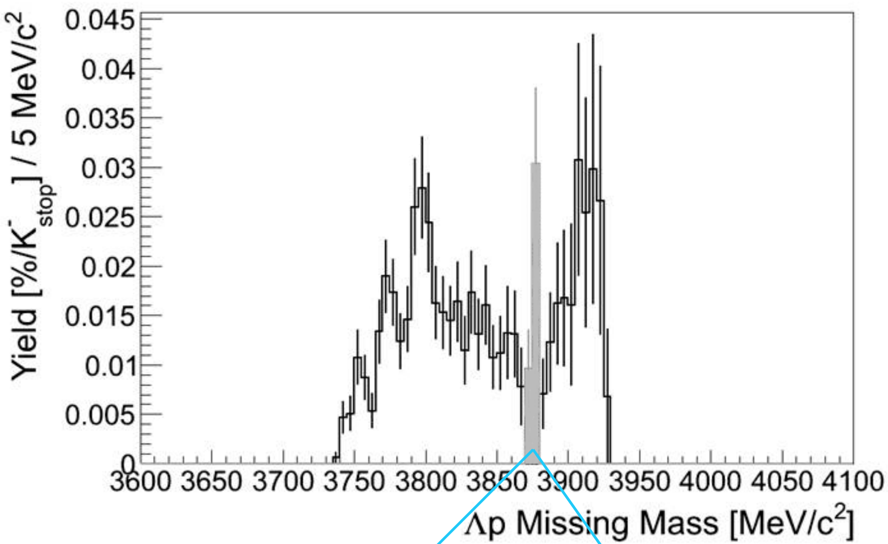
$K^-\,{}^6Li \rightarrow \Lambda n A' + n$ FSI
$K^-\,{}^6Li \rightarrow \Lambda p A' + \Lambda$ FSI
(+ $n(\Lambda) A' \rightarrow n\, p(\Lambda) A''$): 0.106 ± 0.024

$K^-\,{}^6Li \rightarrow X A' \rightarrow \Lambda p A'$: 0.112 ± 0.012

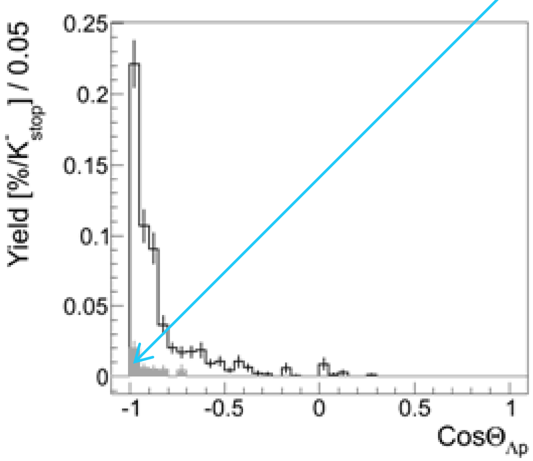


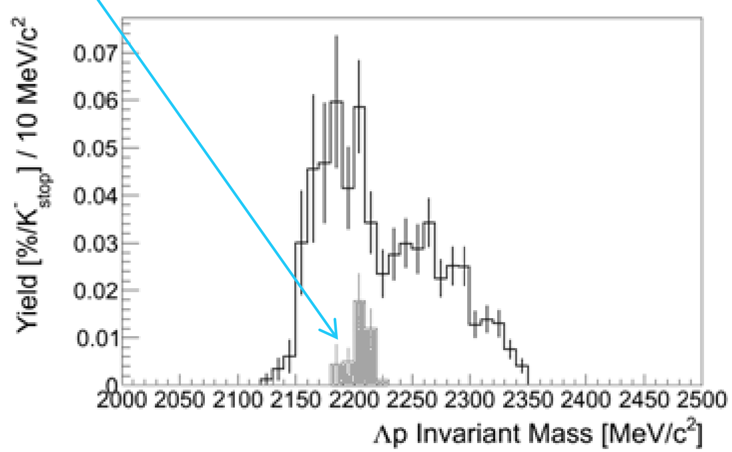


$^6Li(K^-_{stop},\Lambda p)X$ Missing Mass



- Sharp peak in the missing mass spectrum for the $^6Li(K^-_{stop},\Lambda p)X$ reaction
  - Close to Λp□ threshold
  - Kinematics compatible with deeply bound "pionic" state
  - Early predicted by J.Nieves and E.Oset, Z. Phys. A **343** (1992) 477
    - Deeply bound pionic states formed in the (Σ^-, Λ) reaction
    - Fraction from the fit: ~ 15%





Λp fits: summary and outlook

- From the present best fits it is necessary:
  - to introduce a QF Λp production recoiling against an excited state + fragmentation
    - >5 times larger than QF Λp against g.s.
  - to introduce a (Λp) resonant state
    - its features are similar to the first FINUDA observations:
      - same (large) width: ~ 65 MeV
      - higher mass (30-40 MeV/c^2)

- Additional component to be further studied: (Σ^0p) recoiling against an excited nucleus
  - preliminary results:
    - Fit fills most of the spectrum in 2300 MeV/c^2 region
    - Sizeable reduction of the width of the (Λp) resonant state (but it is still needed)

Studies of K^- absorptions on two nucleons: $\Sigma^- p$ (A-[pn]) final state

- Introduction
- Data selection
- Global fit to the data – ^{6}Li
  - method
  - basic hypotheses
  - (preliminar) add ons
- Global fit to the data – ^{9}Be, ^{13}C, ^{16}O

K^-2N absorption: Λp vs Σ^-p

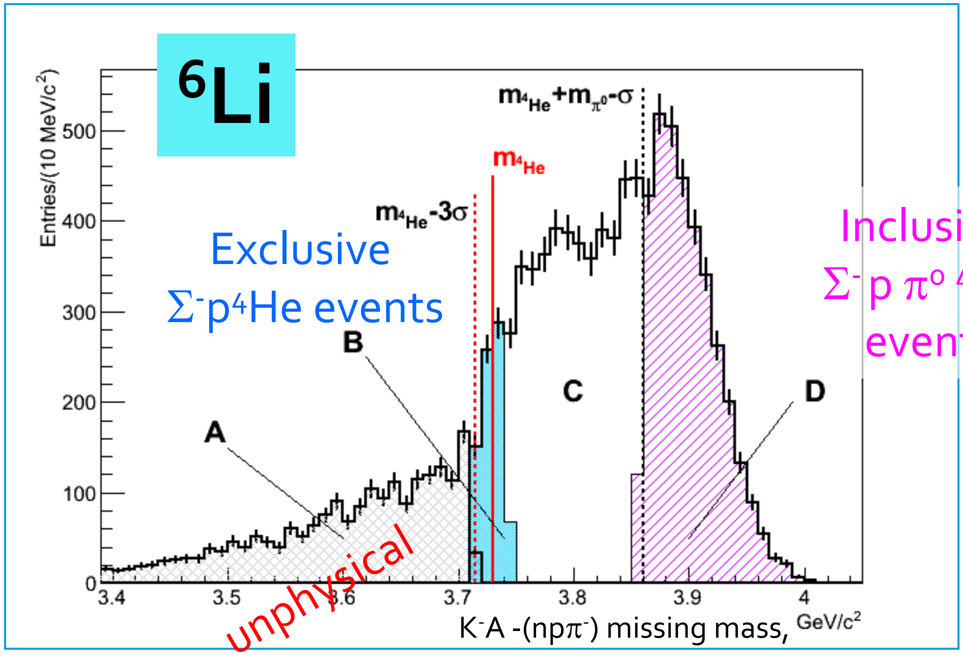
- Initial state: K^-[pp] vs K^-[np]
  - statistical weight: favored absorption on [np], factor **2N/(Z-1)**

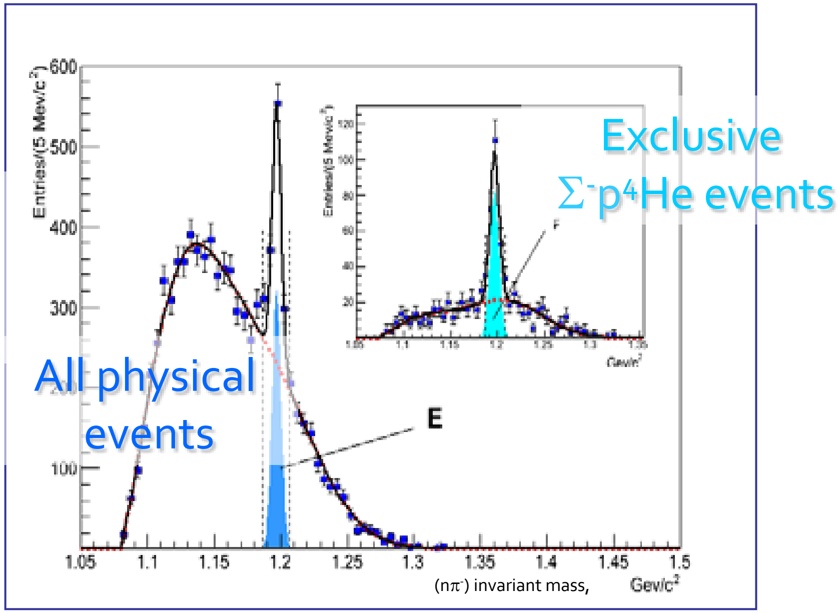
- Final state: total isospin I=0 vs I=1 (additional term in the YN potential)
  - Different interaction of the baryons in a nucleus
    - ΛN: attractive potential
    - Σ^-N:
      - Real part: attractive shallow potential only in a small region outside the nuclear surface + strong repulsive potential inside the nucleus
      - Isovector + Coulombian term: further repulsion
        - no observation of Σ hypernuclei
        - poor penetration of Σ^- into the nucleus ⇒ $\Lambda\Sigma^-$ conversion
  - Different Final State Interactions of Λ and Σ^-
    - Coulombian component

Σ^{-}p event selection

- Events with one proton, one π^{-}, one neutron in coincidence
- Unphysical events: cut in missing mass of $A(K^{-}_{stop}, n\pi^{-}p)A'$ reaction
- Σ^{-} signal in $(n\pi^{-})$ invariant mass:
  - S/B > 0.8
  - Exclusive events: S/B > 2.4

particle	Momentum resolution (σ)	Detection efficiency
proton	1%	75%
π^{-}	0.6%	73%
neutron	5%	8%

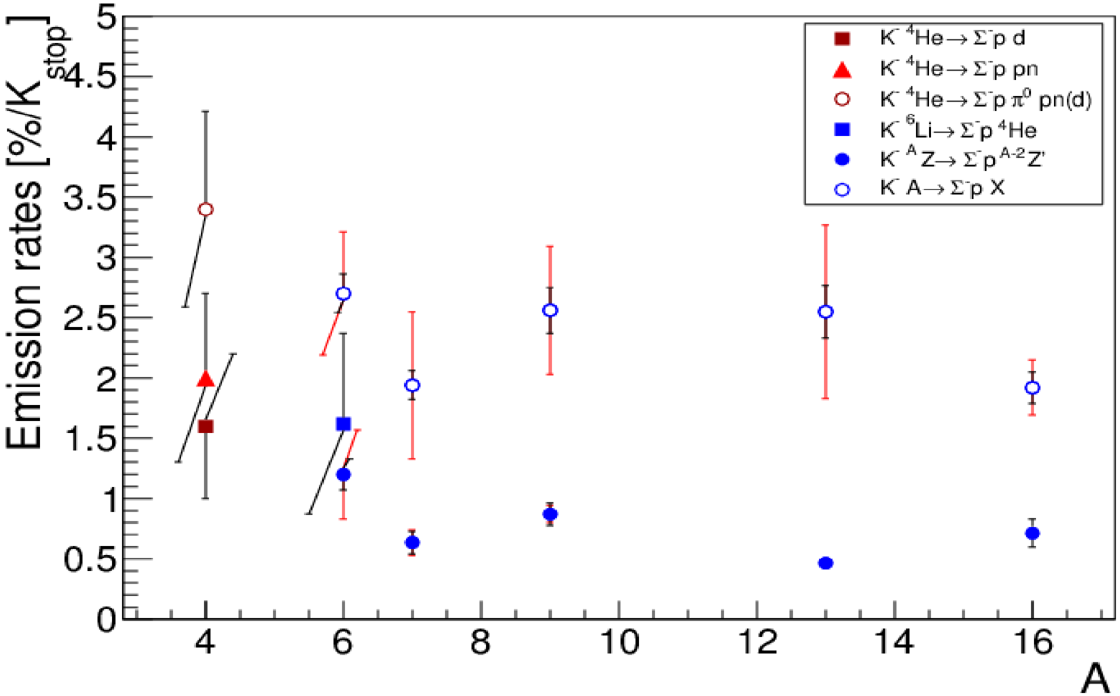




Σ^-p emission rates in p-shell nuclei

- Emission rates: from the number of events in the Σ^- peak
  - both for the inclusive and the exclusive sample
  - corrected for the fraction of Σ^-'s lost for nuclear capture

- Measured rates are in agreement with older (few) data
  - New measurements for A > 6



$\Sigma^- p$ spectra global fit – the method

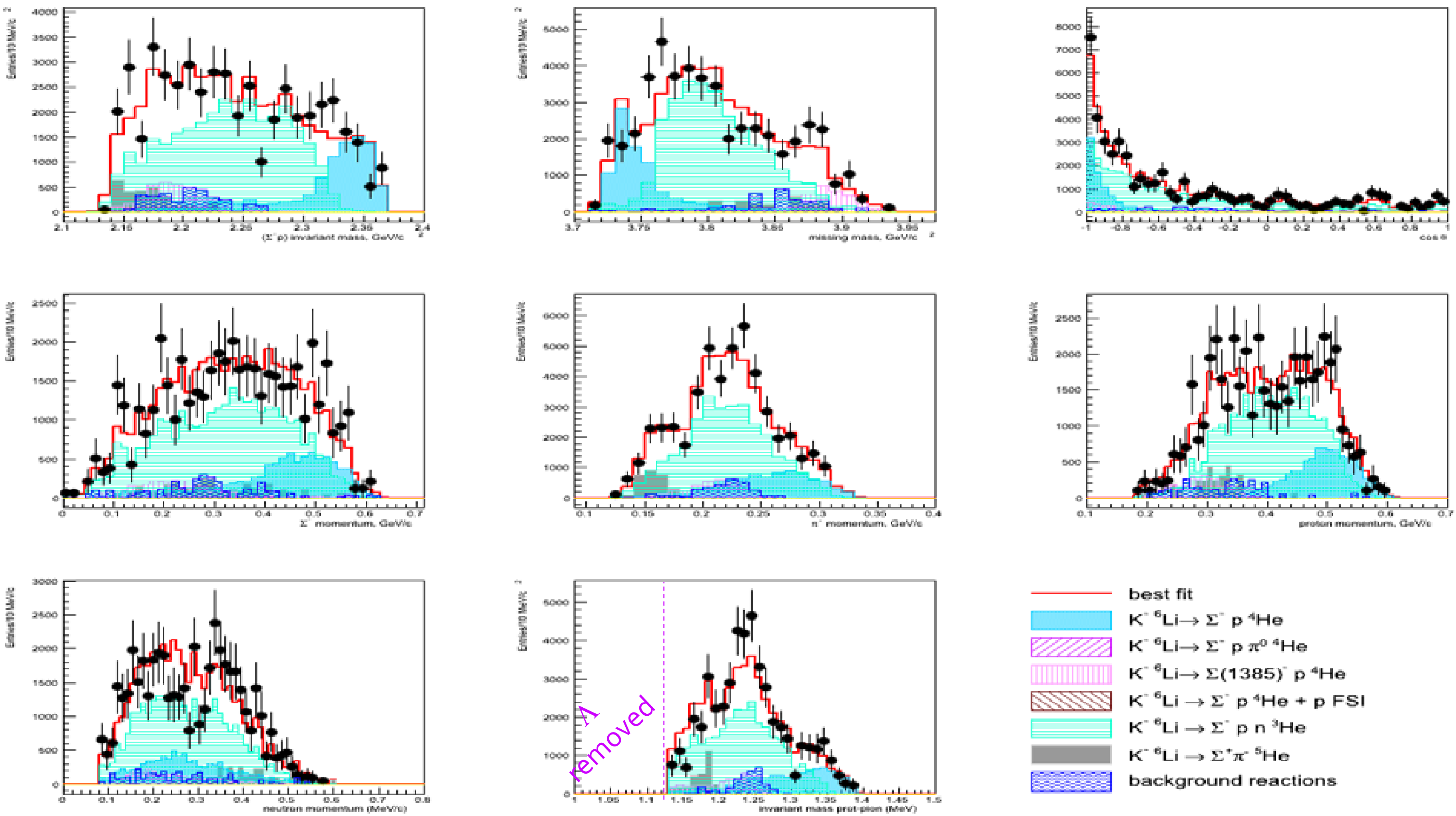
- Two classes of QF reactions are considered:
  - physical reactions with ($\Sigma^- p$) pairs in the final state, recoiling against a nucleus in its *ground state*
    - $K^-_{stop}\ {}^{A}Z \to \Sigma^- p\ {}^{A-2}(Z-1)$
    - $K^-_{stop}\ {}^{A}Z \to \Sigma(1385)^- p\ {}^{A-2}(Z-1) \to \Sigma^- p\ \pi^0\ {}^{A-2}(Z-1)$
    - $K^-_{stop}\ {}^{A}Z \to \Sigma^- p\ \pi^0\ {}^{A-2}(Z-1)$
    - $K^-_{stop}\ {}^{A}Z \to \Sigma^- p\ \pi^+\ {}^{A-2}(Z-2)$ (on pp pair)
    - $K^-_{stop}\ {}^{A}Z \to \Sigma^- p\ {}^{A-2}(Z-1)$ + p rescattering
    - $K^-_{stop}\ {}^{A}Z \to \Sigma^- pn\ {}^{A-3}(Z-2)$ (on 3N or np pair in ^{3}H substructure)
  - background reactions leading to ($n\pi^- p$) in the final state, leaking through the selection criteria and entering the Σ^- mass window
    - $K^-_{stop}\ {}^{Z}A \to \Sigma^+\pi^-\ {}^{A-1}(Z-1)$ (π^+/p misidentif.)
    - $K^-_{stop}\ {}^{Z}A \to \Sigma^0\pi^0\ {}^{A-1}(Z-1)$ (γ/n misidentif.)
    - $K^-_{stop}\ {}^{Z}A \to \Sigma^+\pi^-\ n\ {}^{A-2}(Z-1)$ (2N absorption)
    - $K^-_{stop}\ {}^{Z}A \to \Lambda n\ {}^{A-2}(Z-1)$
    - $K^-_{stop}\ {}^{Z}A \to \Sigma^0 n\ {}^{A-2}(Z-1) \to \Lambda n \gamma\ {}^{A-2}(Z-1)$
    - $K^-_{stop}\ {}^{Z}A \to \Sigma^0 n\ {}^{A-2}(Z-1) \to \Lambda n p\ {}^{A-3}(Z-2)$
    - $K^-_{stop}\ {}^{Z}A \to \Sigma^0 n\ {}^{A-2}(Z-1) \to \Lambda n n\ {}^{A-3}(Z-1)$
    - $K^-_{stop}\ {}^{Z}A \to \Sigma^- n\ {}^{A-2}Z \to \Lambda n n\ {}^{A-2}Z$

    (last four: Σ - Λ conv. react.)

$\Sigma^{-}p$ spectra global fit – backgrounds

- Fit to 11 1-d experimental distributions
  - Wide redundance in binned max likelihood fit
- Larger systematic errors expected wrt Λp
  - Larger background contamination due to $n/\pi^0/\gamma$ misidentification
    - Similar detection+reconstruction efficiency for all neutrals:
      - $\varepsilon_n = 3.5 \times 10^{-2}$
      - $\varepsilon_{\pi 0} = (2.16 \pm 0.01) \times 10^{-2}$
      - $\varepsilon_{\gamma} = (2.33 \pm 0.01) \times 10^{-2}$
  - Kinematic cuts reduce the contamination of each background reaction to the level of $10^{-7}/K^{-}_{stop}$
  - The only sizeable contribution from background reactions given by one-nucleon absorption: $K^{-}_{stop}\ {}^{Z}A \rightarrow \Sigma^{+}\pi^{-}\ {}^{A-1}(Z-1)$
  - No inverse $\Lambda\Sigma$ conversion taken into account (suppressed)
  - Incoherent background component: mixture of QF reactions + conversion and/or rescattering not leading to $\Sigma^{-}p$ in the final state

^{6}Li: best fit - $\chi^2_{NDF} = 1.29$

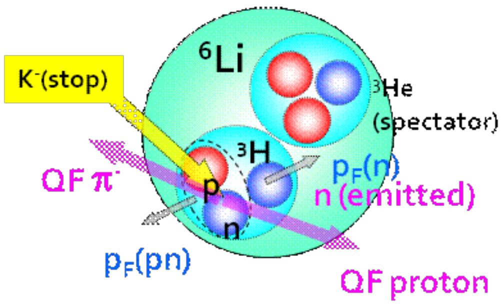


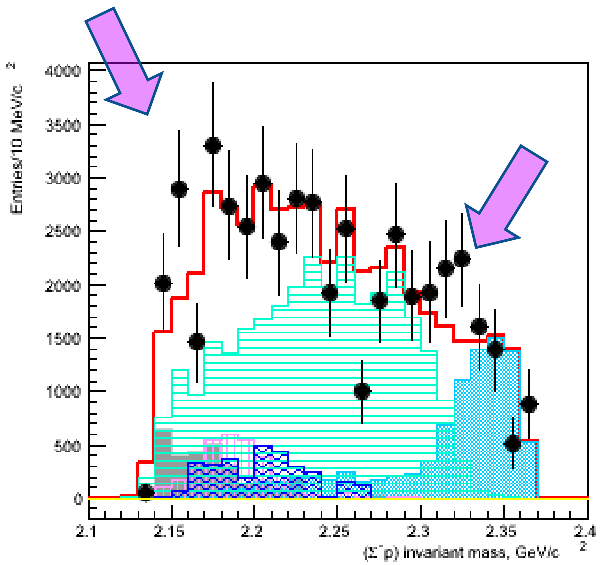
- 4 main reactions describe most of the spectra – incoherent background at 6% level
- Not sensitive enough to separate $\Sigma^- p \pi^0$ and $\Sigma(1385)^- p$ contributions
- **Sizeable contribution from $\Sigma^- pn$ final state - Missing strength at 2300 MeV/c^2**

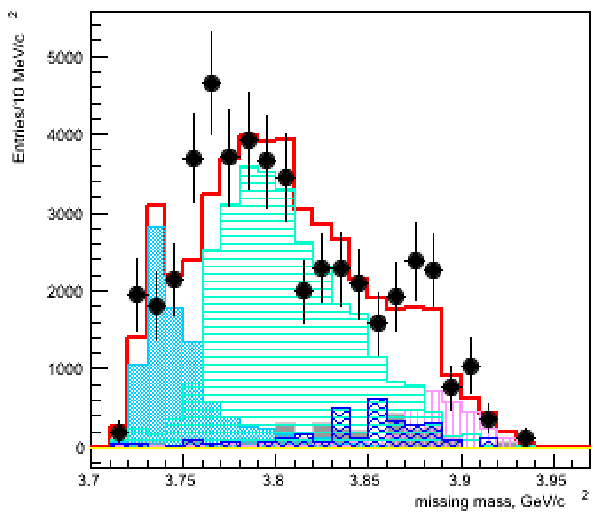
^{6}Li: best fit - fractions

reaction	Relative abundance (%)
$K^-_{stop}\ ^6Li \rightarrow \Sigma^- p\ ^{A-2}(Z-1)$	18.6 ± 1.5
$K^-_{stop}\ ^6Li \rightarrow \Sigma^- p\ \pi^0\ ^{A-2}(Z-1)$	6.6 ± 0.8
$K^-_{stop}\ ^6Li \rightarrow \Sigma(1385)^- p\ ^{A-2}(Z-1)$	
$K^-_{stop}\ ^6Li \rightarrow \Sigma^- p\ ^{A-2}(Z-1)$ + p FSI	0.0 ± 0.2
$K^-_{stop}\ ^6Li \rightarrow \Sigma^- p\ n\ ^{A-3}(Z-2)$	62.1 ± 4.5
$K^-_{stop}\ ^6Li \rightarrow \Sigma^+ \pi^-\ ^{A-1}(Z-1)$	6.3 ± 0.5
bck reactions, sum	6.0 ± 0.2

- $\Sigma^- p\ n$ final state reached through 3N kaon absorption or 2N absorption on t:

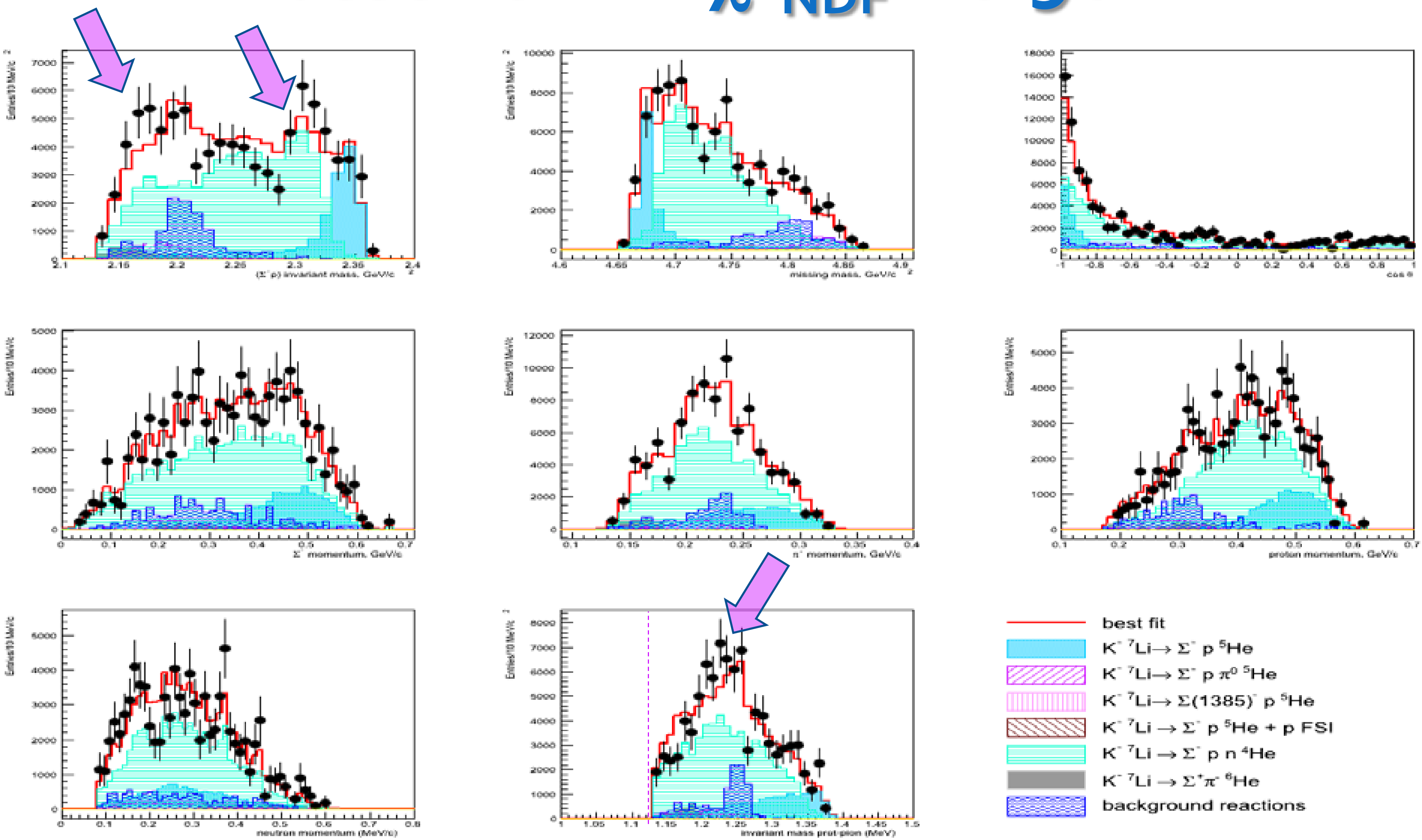






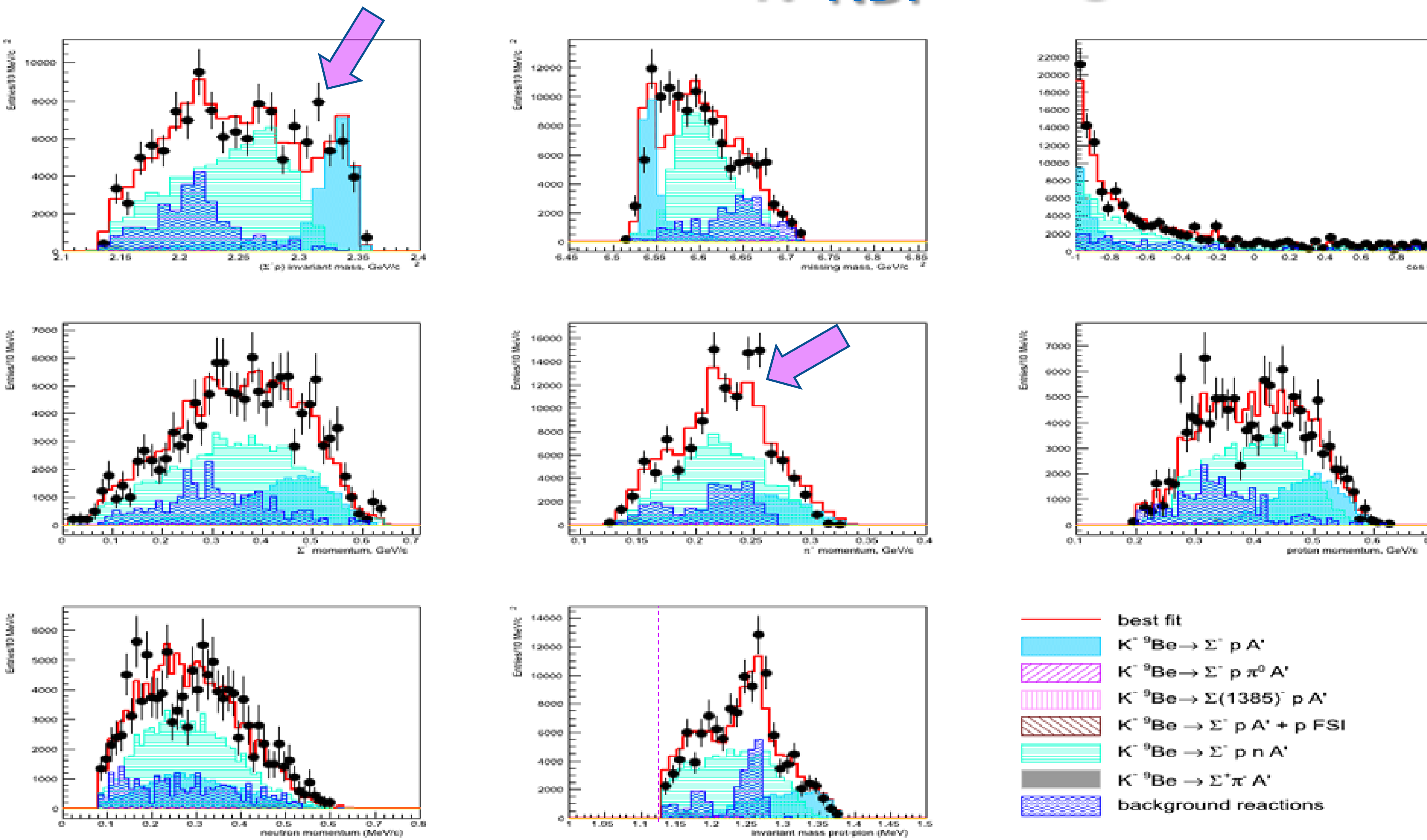
Missing strengths: low (Σ^-p) mass, and above 2300 MeV/c²

^{7}Li: best fit - $\chi^2_{NDF} = 0.90$



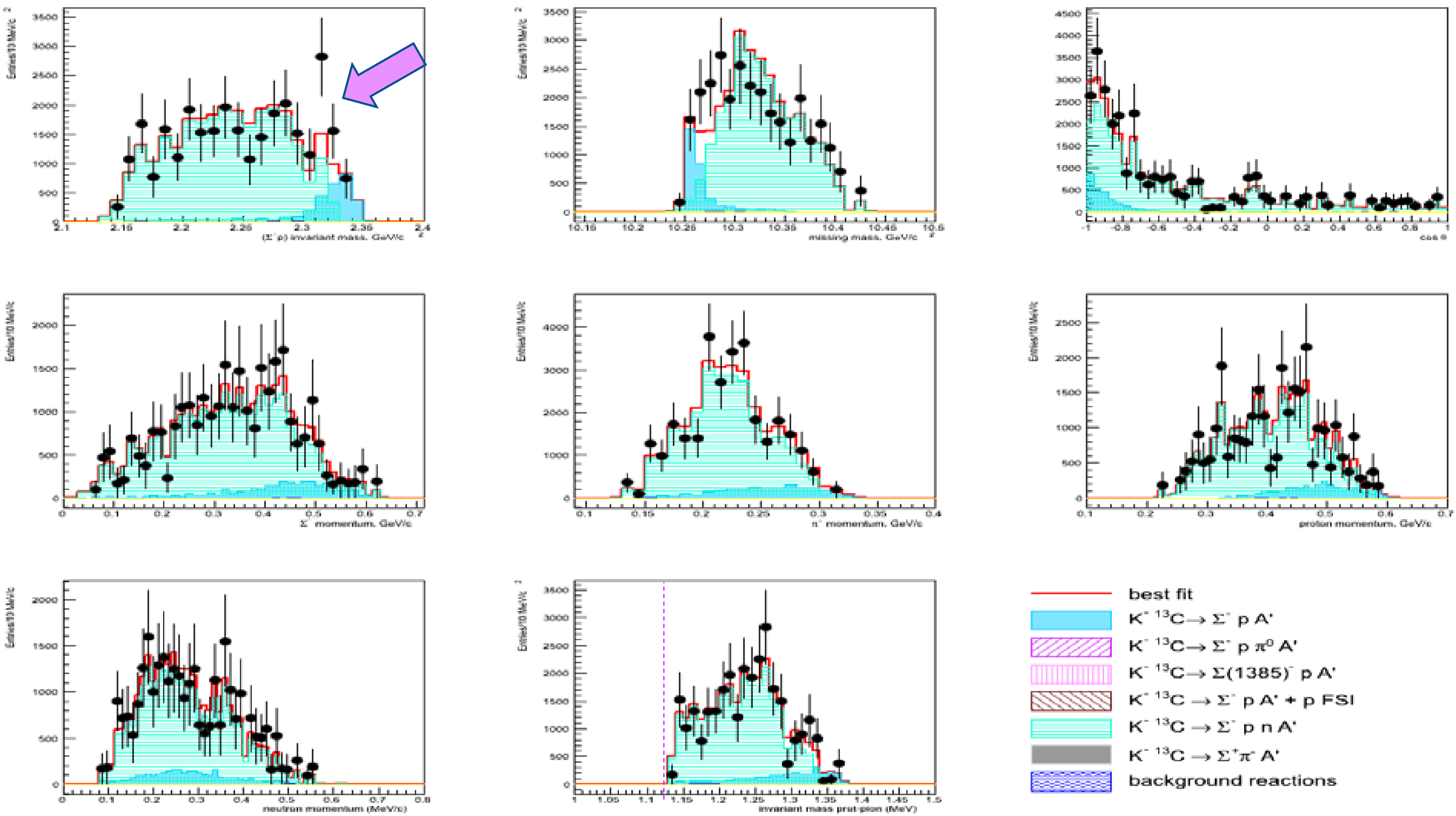
- 4 main reactions describe most of the spectra – incoherent background at 12% level
- **Sizeable contribution from Σ^-pn final state - Missing strength at 2300 MeV/c^2**
- Problems in fitting the (π^-p) invariant mass

^{9}Be: best fit - $\chi^2_{NDF} = 0.90$



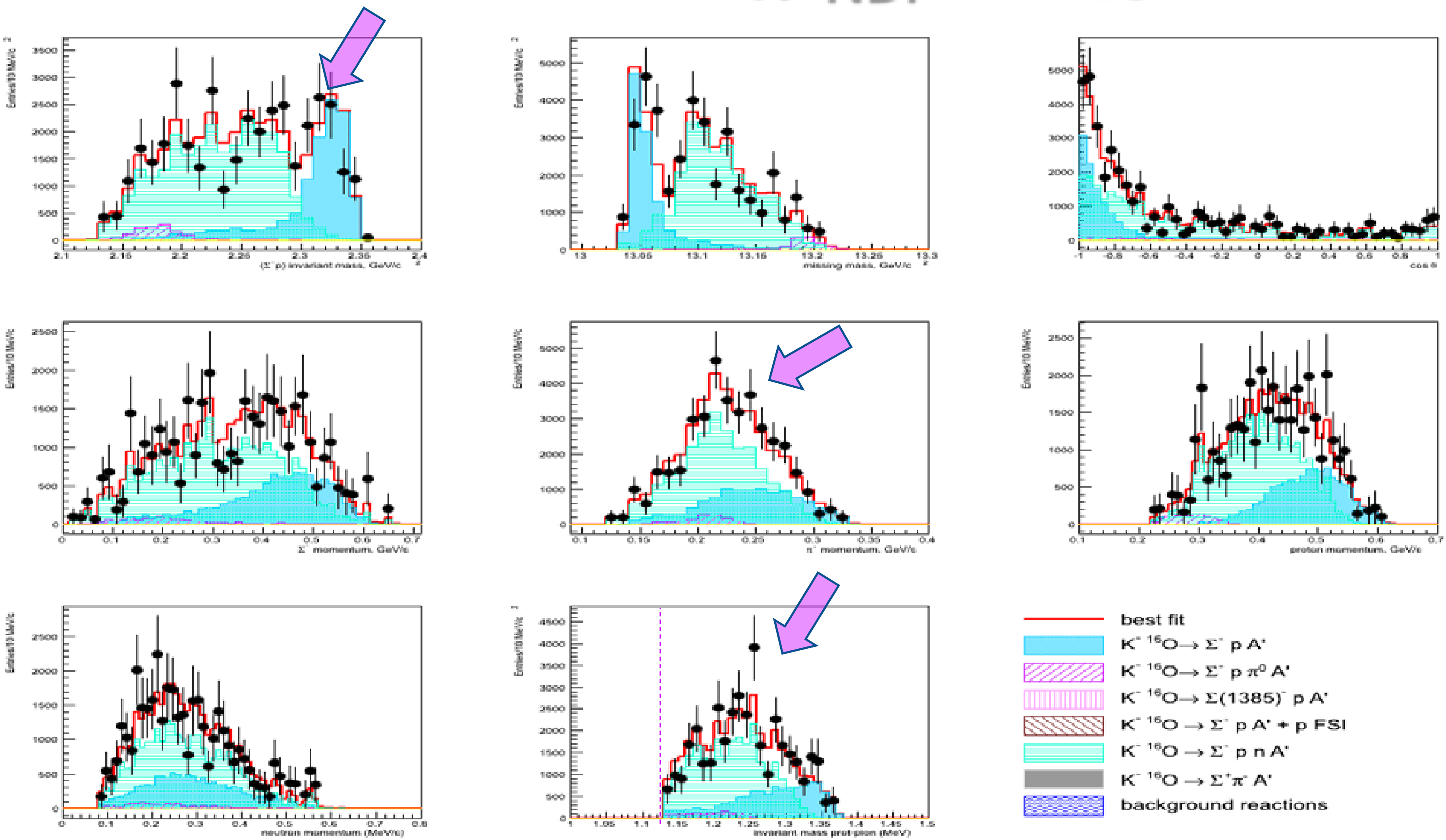
- no contribution from 1N absorption) - incoherent background at 12% level
- **Sizeable contribution from Σ^-pn final state - Missing strength at 2300 MeV/c^2**
- Problems in fitting satisfactorily the p momentum spectrum ~ 250 MeV/c

^{13}C: best fit - $\chi^2_{NDF} = 1.04$



- LOW STATISTICS - 2 reactions only useful to describe most of the spectra
- **Sizeable contribution from Σ^-pn final state** (incoherent background rejected)
- Missing strength at ~ 2320 MeV/c^2 in (Σ^-p) invariant mass

^{16}O: best fit - $\chi^2_{NDF} = 1.49$



- LOW STATISTICS - 3 main reactions describe most of the spectra
- **Sizeable contribution from Σ^-pn final state** (incoherent background rejected)
- Problems in fitting satisfactorily the (π^-p) invariant mass AND p momentum ~ 270 MeV/c

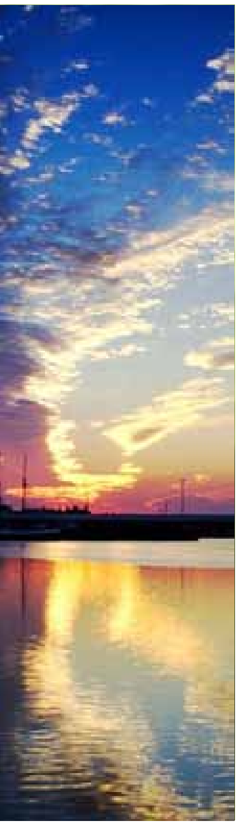
Σ^-p fits: common traits

- Global fit with several QF reactions with spectator nucleus in its *ground state*
- Dominant amplitude: Σ^-pn (with a missing neutron)
  - 2N absorption on triton favored with respect to 3N absorption (with phase space emission)
  - Fraction: > 60%
  - Worse fits if replaced by QF Σ^-p + p rescattering

- Common missing strengths:
  - In (Σ^-p) invariant mass: at ~ 2320 MeV/c^2, narrow (1 bin ~ 10 MeV)
  - In (π^-p) invariant mass: at ~ 1230 MeV/c^2
  - In p momentum spectrum: at ~ 250 MeV/c

- Missing (Σ^-p) resonant state? I=1 DBKS?
- Effect of excited recoiling nucleus?
- Other sources of incoherent background?

} Further studies still needed



Summary and Outlook

Summary and outlook

- Progress in the study of spectral composition in two-nucleon kaon absorptions on some p-shell nuclei

- **$K^-[pp] \rightarrow \Lambda p$ in ^{9}Be and ^{6}Li**
  - Detailed study of QF contributions to experimental spectra: global fit
    - Non negligible recoil against excited nuclei
    - Need of additional component at 2300 MeV/c^2 to reproduce the spectra

- **$K^-[pn] \rightarrow \Sigma^- p$ in several targets**
  - Detailed study of QF contributions to experimental spectra:global fits
    - imperfect fits: additional component needed
      - resonance in the (Σ^-p) system?
        - Unlikely.... but some indications in ^{6}Li
      - fragmentation/excited recoling nucleus effect?
      - further studies on incoherent background shape?
        - Tests underway