Recent results on the $K^-_{stop} + A \rightarrow \Sigma^{\pm} + \pi^{\mp} + A'$ reaction with FINUDA

Stefano Piano

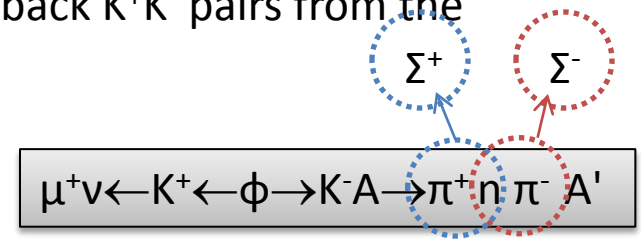
INFN sez. Trieste

Finuda Collaboration

Study of the K^-_{stop} A→ΣπA' Reaction at DAϕNE

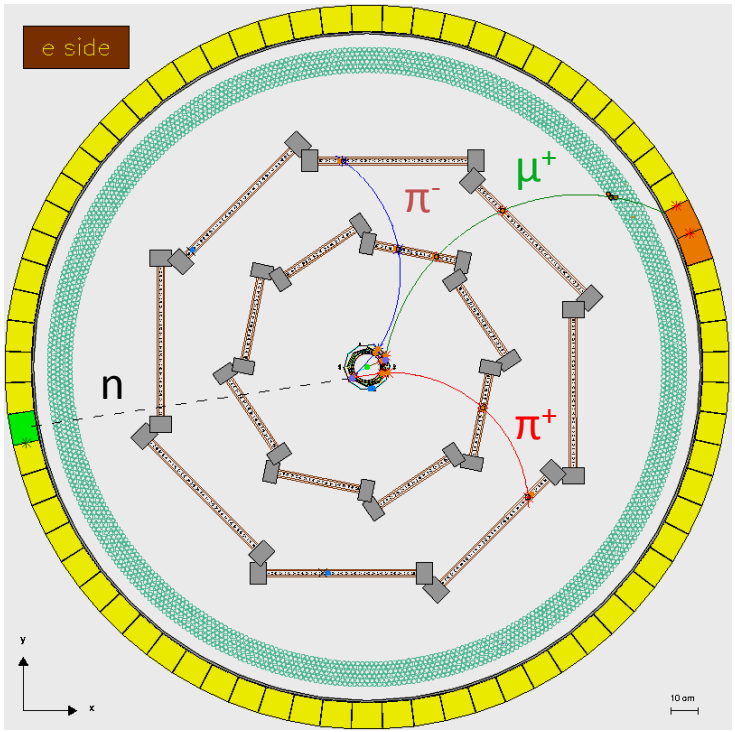
The DAΦNE e^+ - e^- collider provides ~16 MeV nearly back-to-back K^+K^- pairs from the Φ(1020) decay.

FINUDA studied the Σ production via the quasi-exclusive K^-_{stop} A→ $n\pi^+\pi^-$A' reaction.

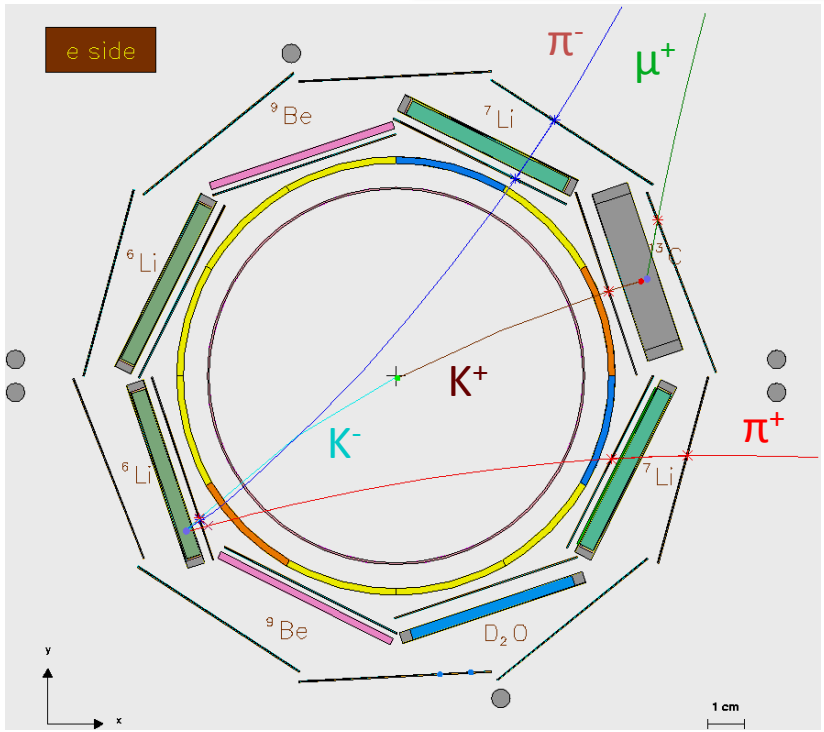


TGTS: 2×^{6}Li, 2×^{7}Li, ^{13}C, 2×^{9}Be, D_2O

FINUDA spectrometer

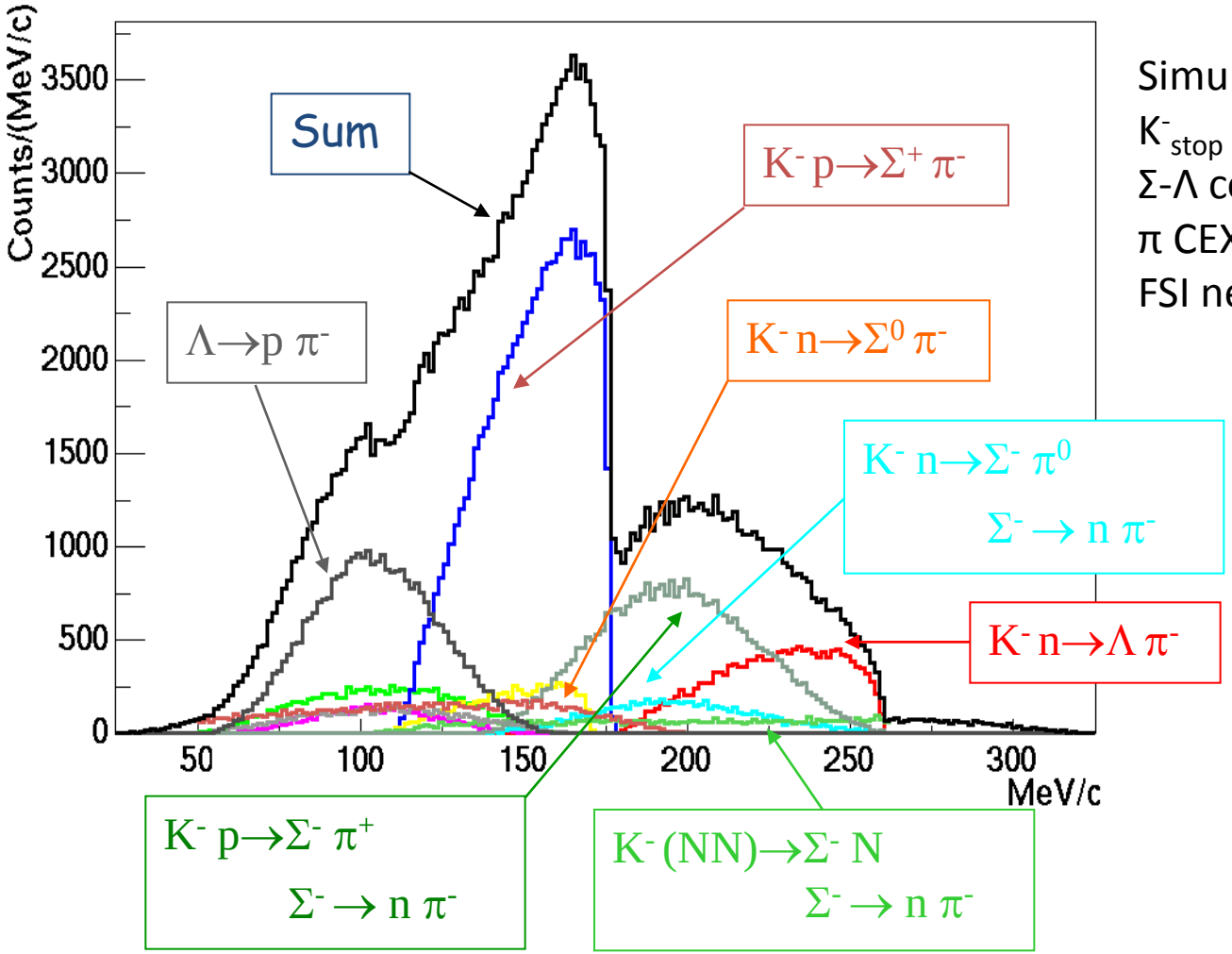


Central region



Inclusive vs quasi-exclusive π^- spectra

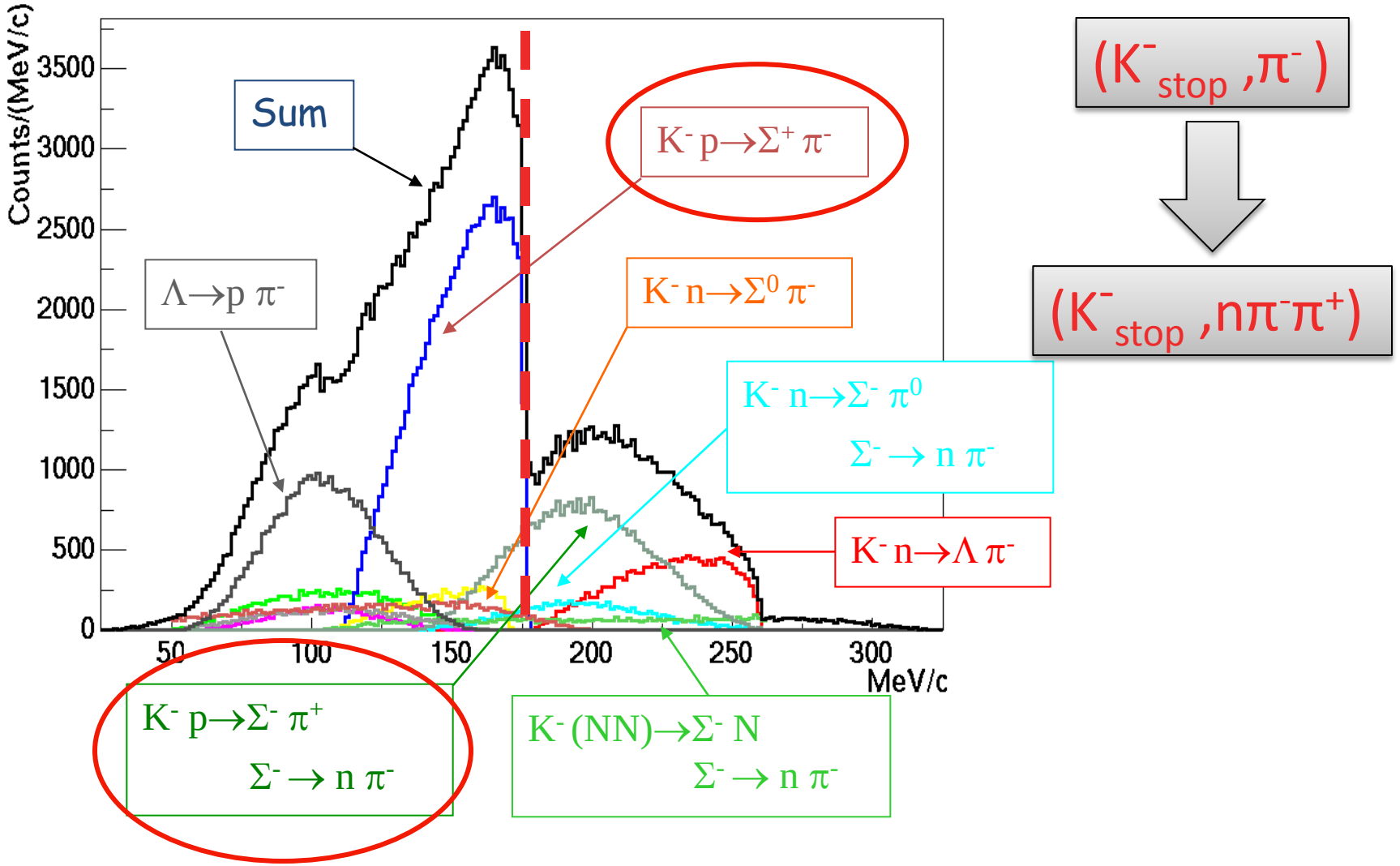
π^- momenta from ^{12}C (K^-_{stop} , π^-) quasifree reactions (simulated)



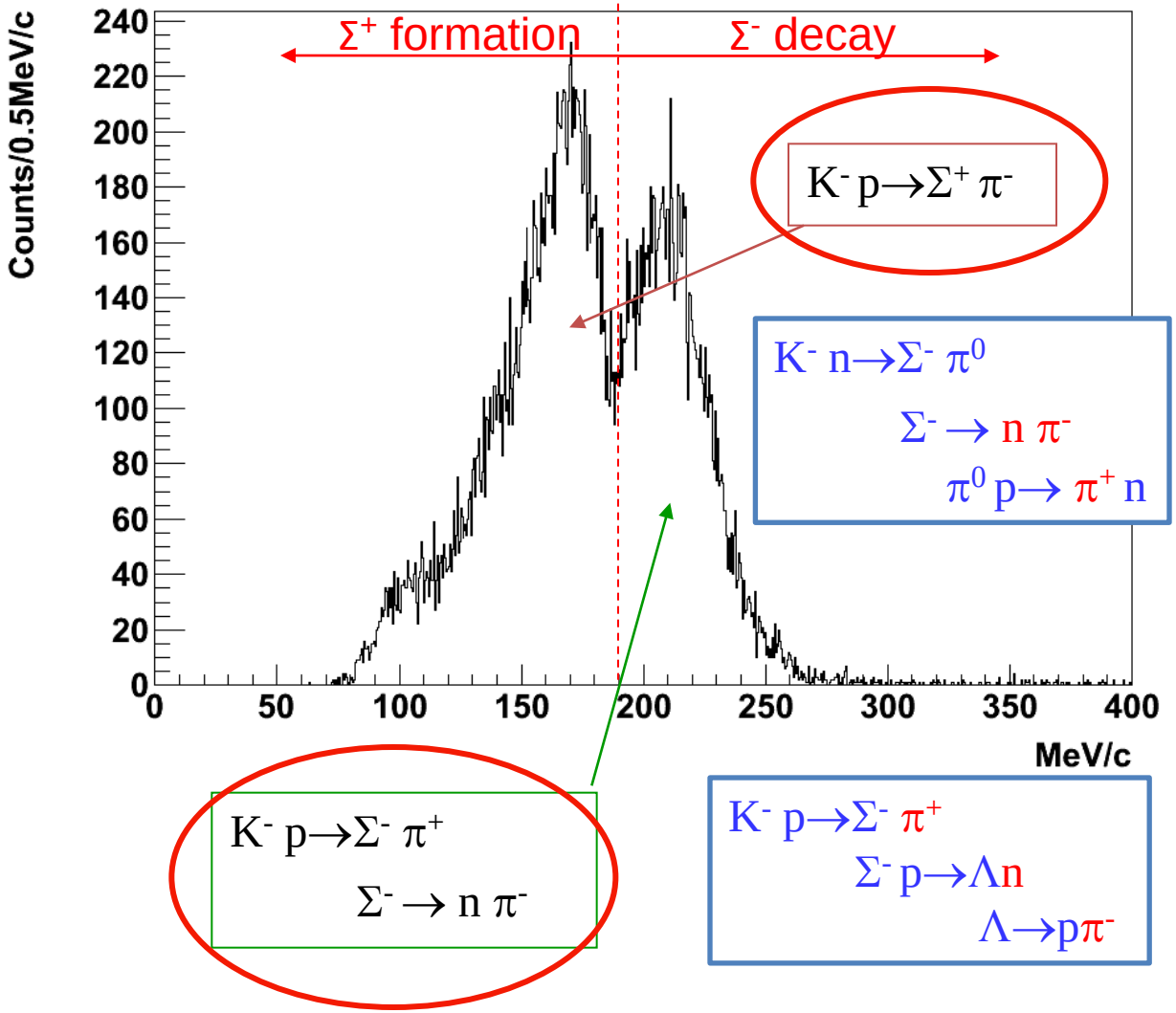
Simulation of:
K^-_{stop} Q.F. reactions on ^{12}C
Σ-Λ conversion neglected
π CEX neglected
FSI neglected

Inclusive vs quasi-exclusive π^- spectra

π^- momenta from ^{12}C (K^-_{stop} , π^-) quasifree reactions (simulated)



π^- momenta from K^-_{stop} ^{6}Li→ $n\pi^+\pi^-X$ with FINUDA



Main contributions to π^- spectrum:
Σ production and decay

Background from **2-step reactions,** involving:

Σ N → Λ N (conversion reaction)

π N → π' N (single charge exchange, others)

$K^- {}^6Li \rightarrow n\pi^+\pi^- X$

Aim: study of the $\Sigma^\pm$ emission in nuclear matter

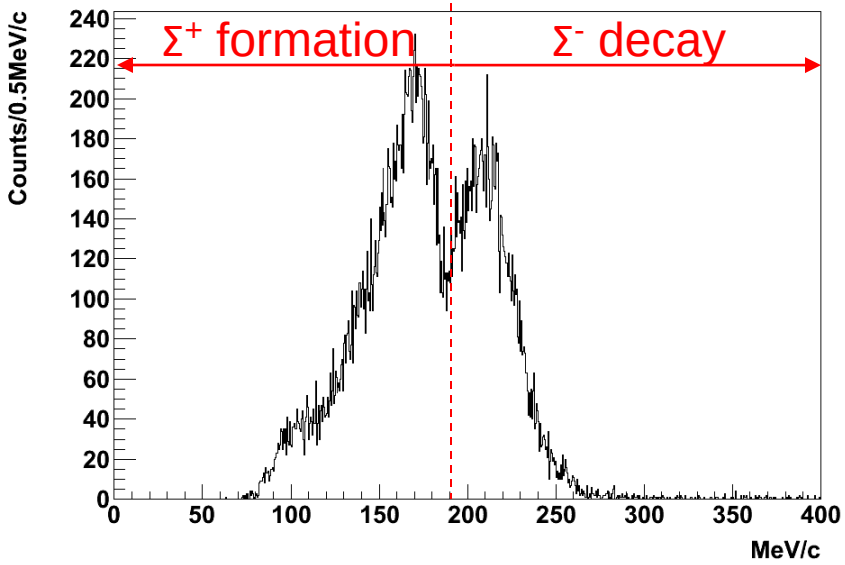
Need

- clean Σ formation pion spectra from other backgrounds

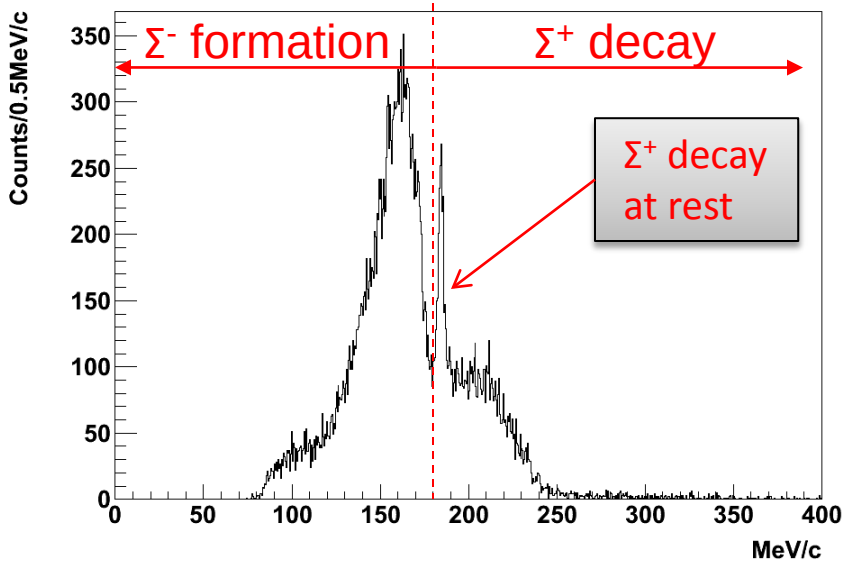
Method

- Quality cuts on formation pions
- Topological (vertex) and phase space cuts on Σ-decay pions.
- Identification of Σ's with high Signal/Background ratio

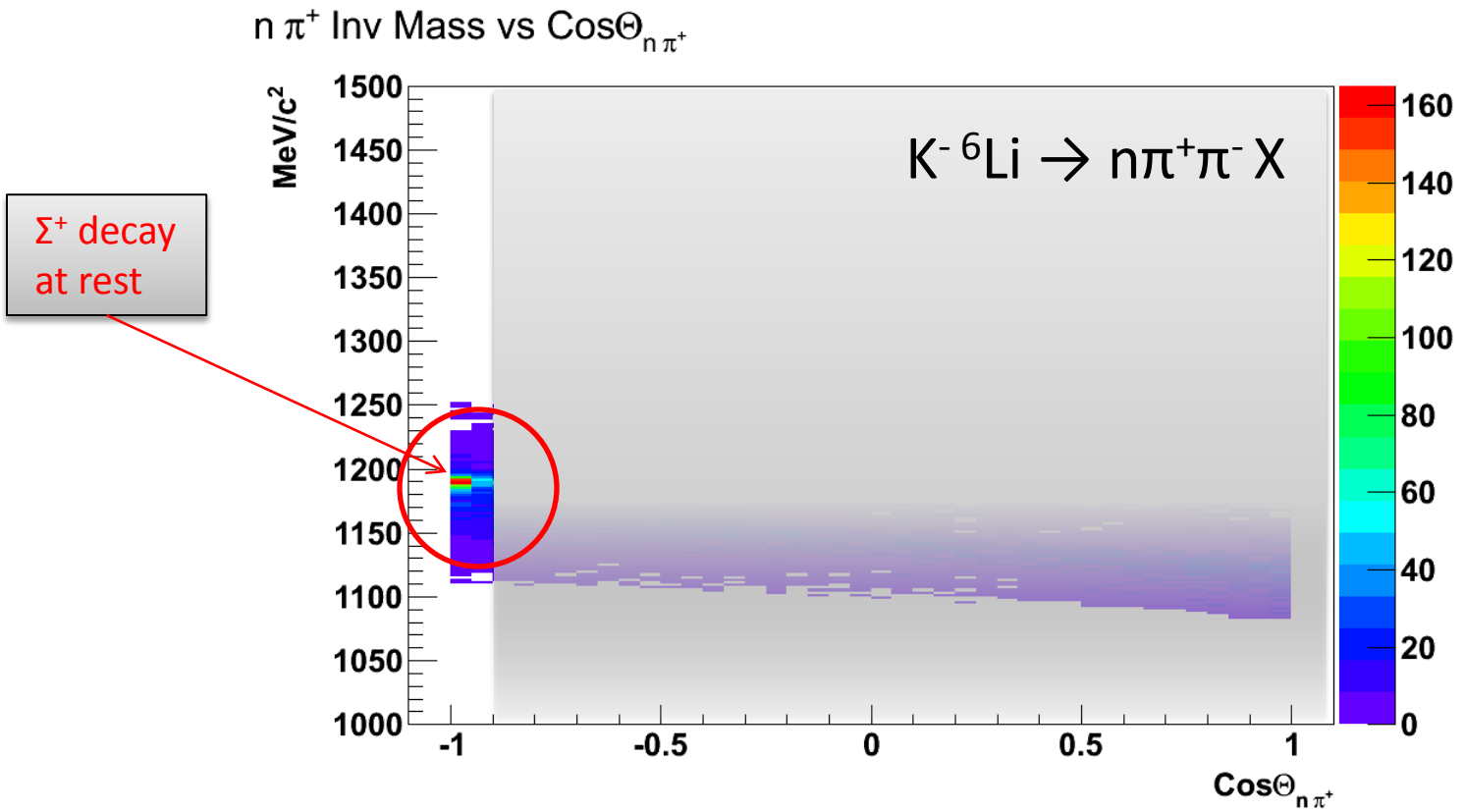
π^- momentum



π^+ momentum

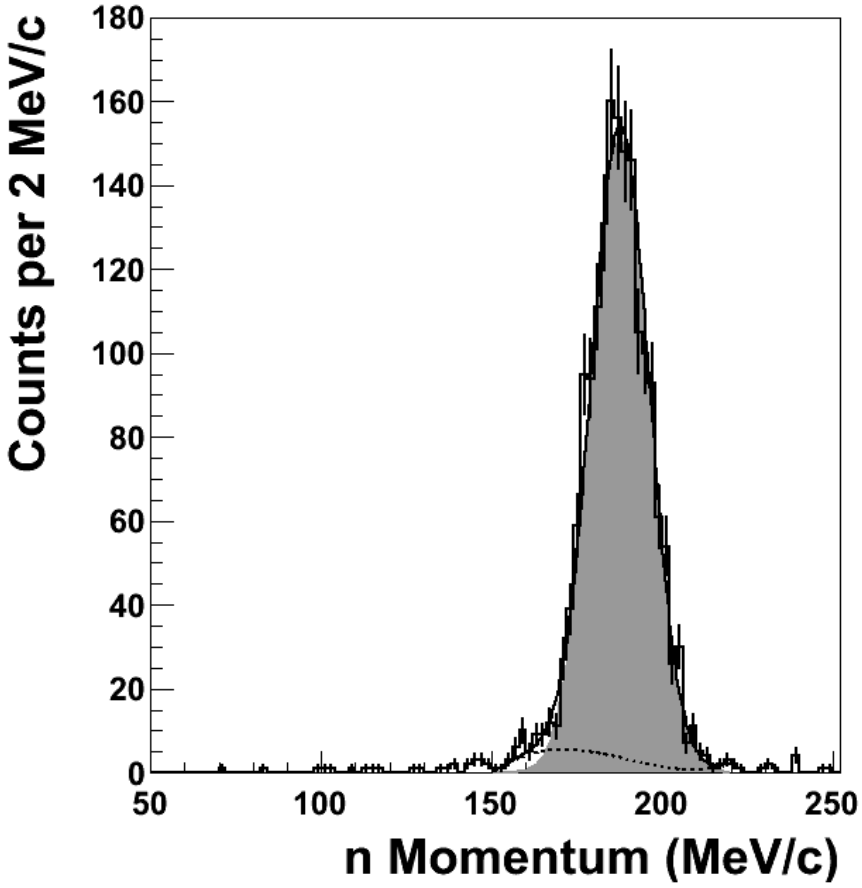


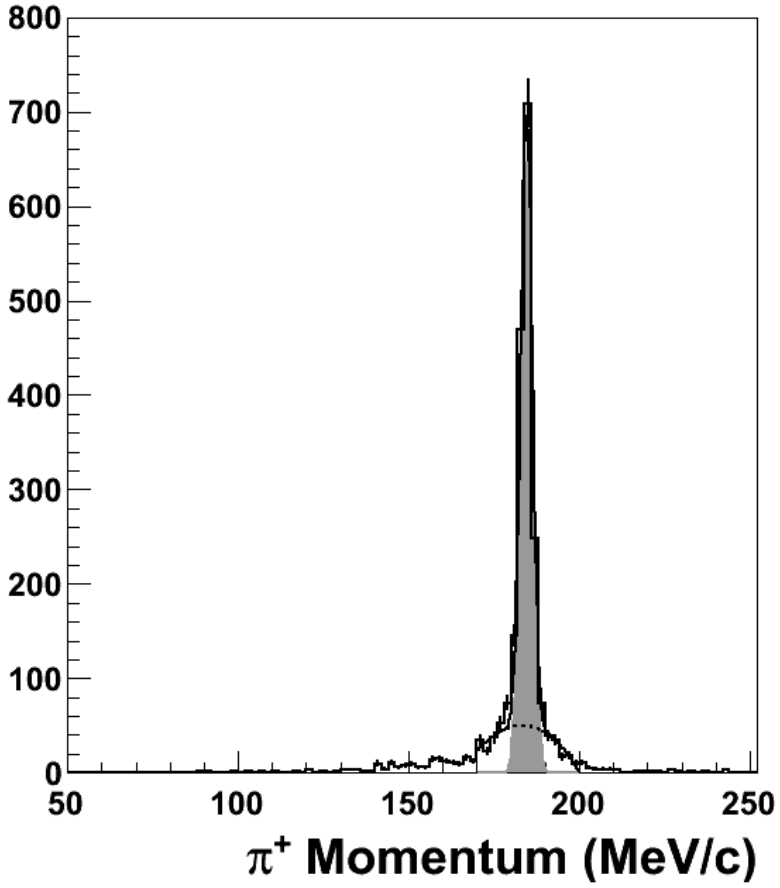
$n\pi^+$ invariant mass vs cos $\theta_{n\pi+}$



Easy identification of n π^+ pairs from Σ^+ decay at rest
Useful for calibration of n and π^+

n, π^+ resolution @ 185 MeV/c

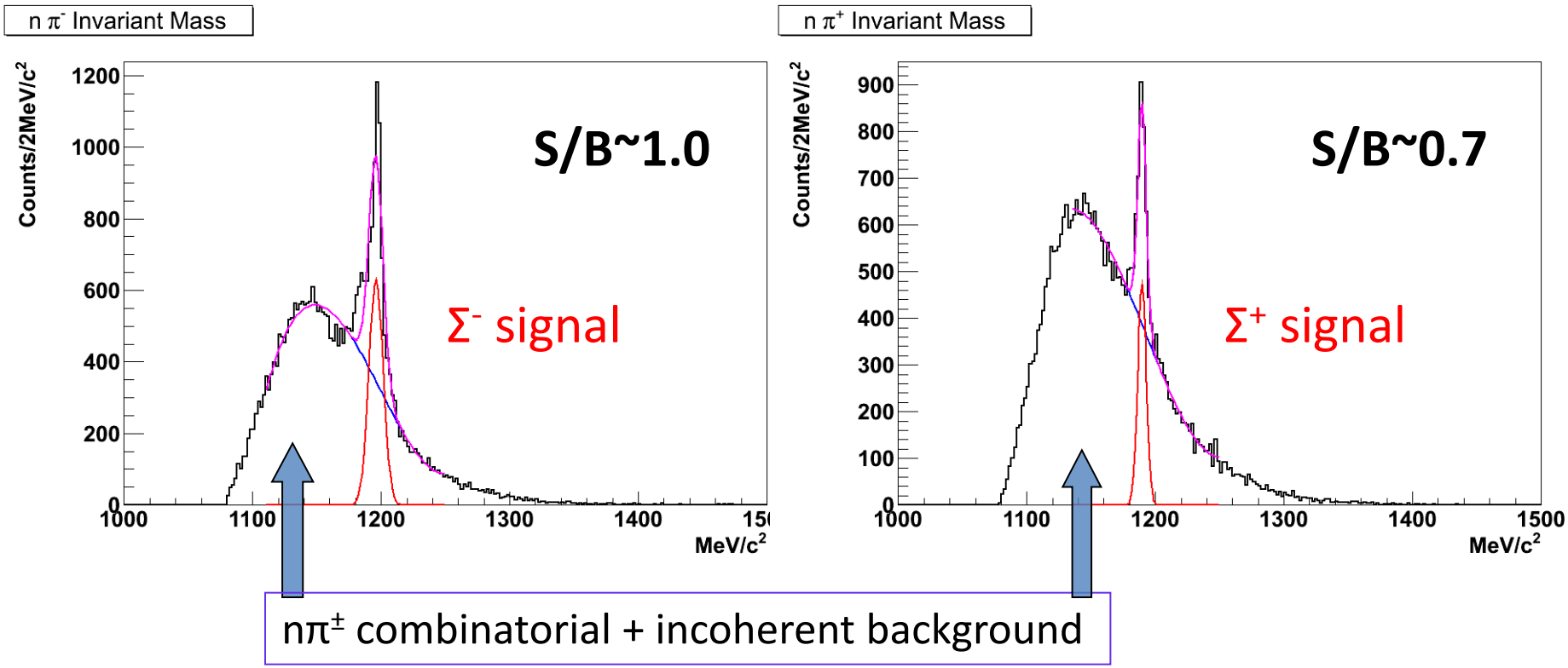




$\sigma_n = 8.4 \pm 0.2$ MeV/c

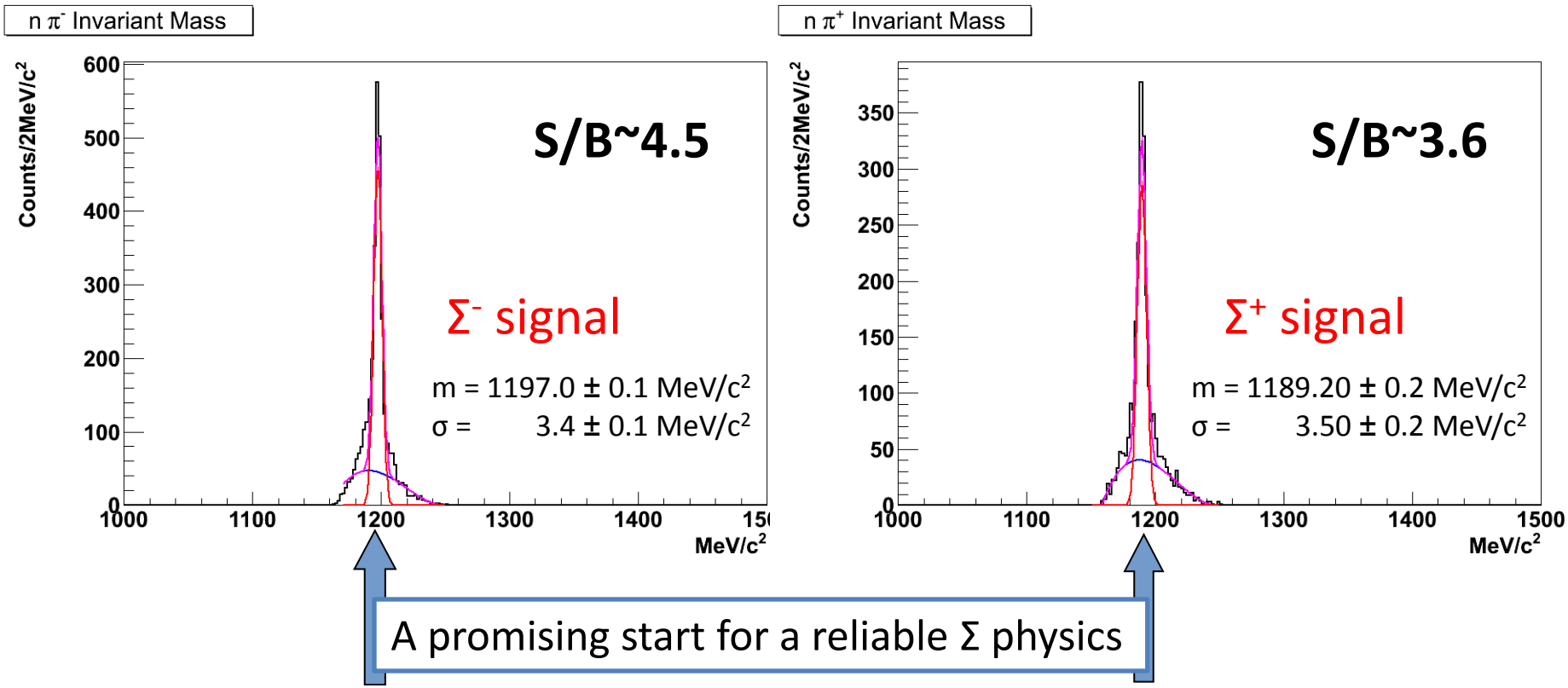
$\sigma_{\pi+} = 1.72 \pm 0.06$ MeV/c

$K^- {}^6Li \rightarrow n\pi^+\pi^- X$, $\Sigma^\pm$ identification



1. Discard events with unphysical missing mass (ex., γ contamination, scattered neutrons)
2. Σ^- : remove π^- from Σ^+ production and Σ^+ : remove π^+ from Σ^- production
3. Σ^- : cos $\theta_{n\pi-}$ <-0.2 and Σ^+ : cos $\theta_{n\pi+}$ <-0.2
4. Quality cuts on track fitting and vertex selection

$K^- {}^6Li \rightarrow n\pi^+\pi^- X$, $\Sigma^\pm$ identification



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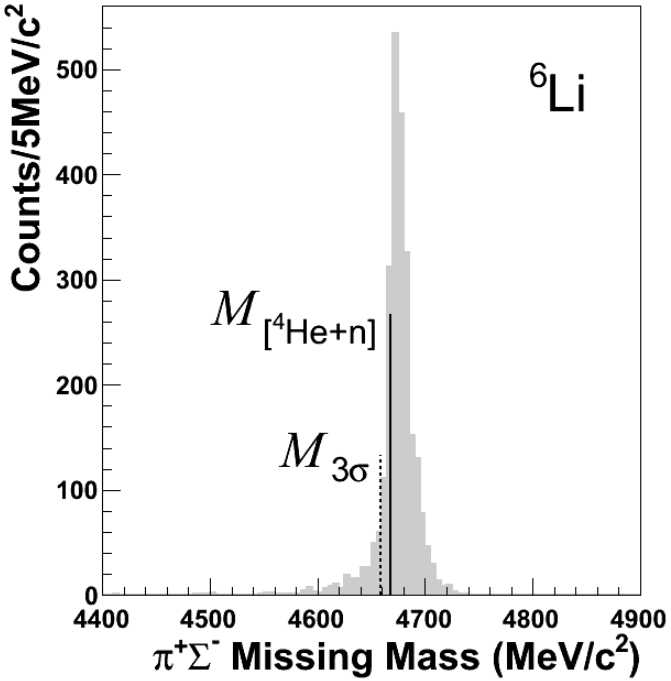
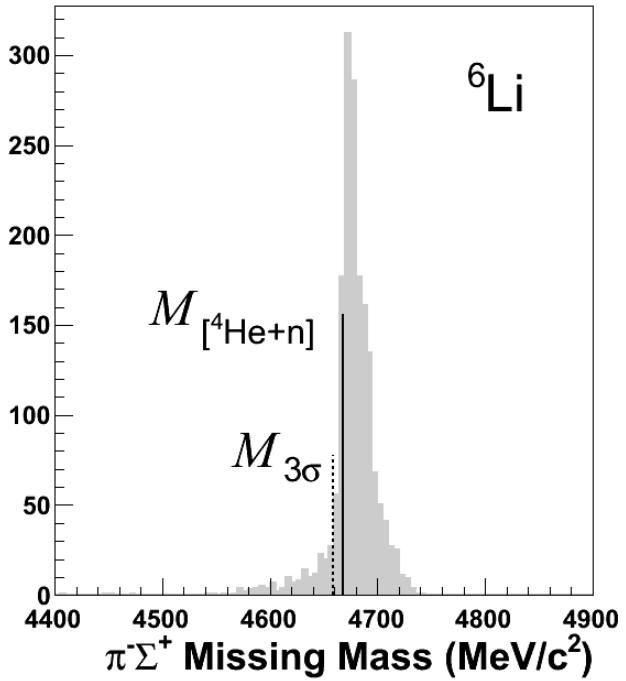
Σπ missing mass for ^{6}Li





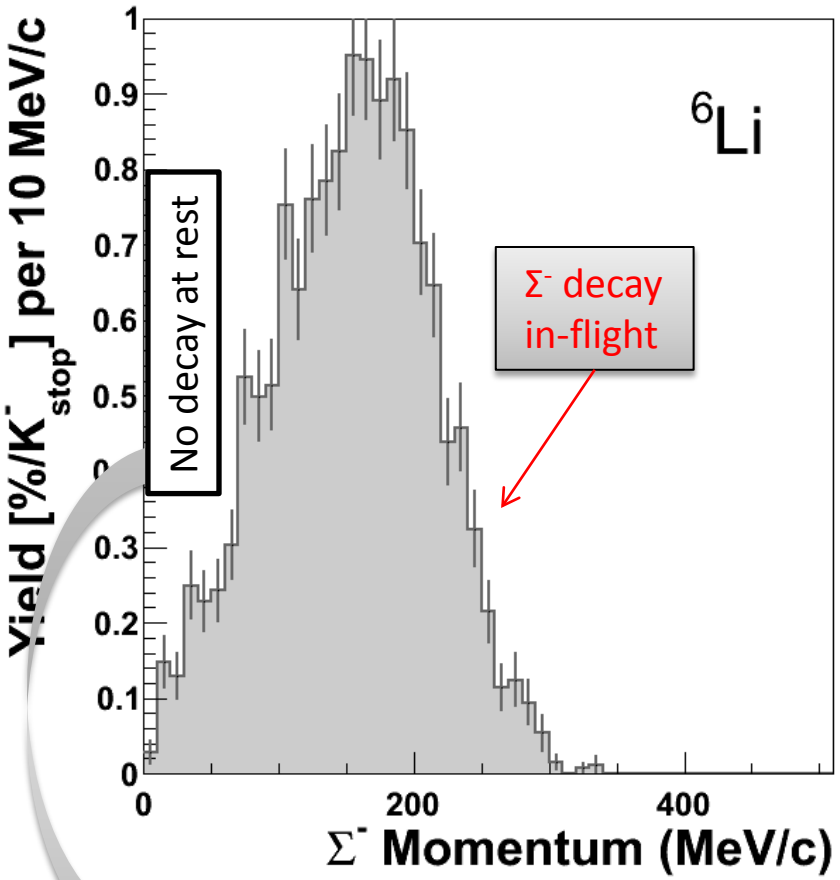
✓ Width ~20MeV (FWHM)

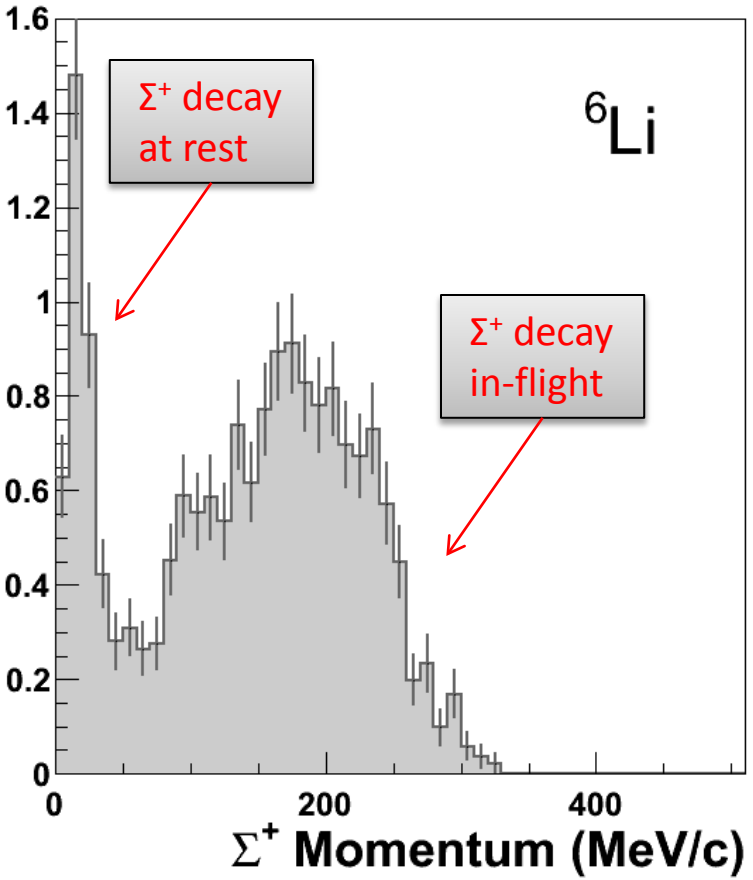
✓ Peaked at ~10 MeV above physical threshold

➢ Essentially pure Quasi-Free Σ formation, [^{4}He + n] little unseen energy (excitation of remnant nucleus, energy loss of outgoing Σ,…).

➢ No missing pions nor unseen energetic particles(~exclusive measurement)

Σ momentum spectra for ^{6}Li

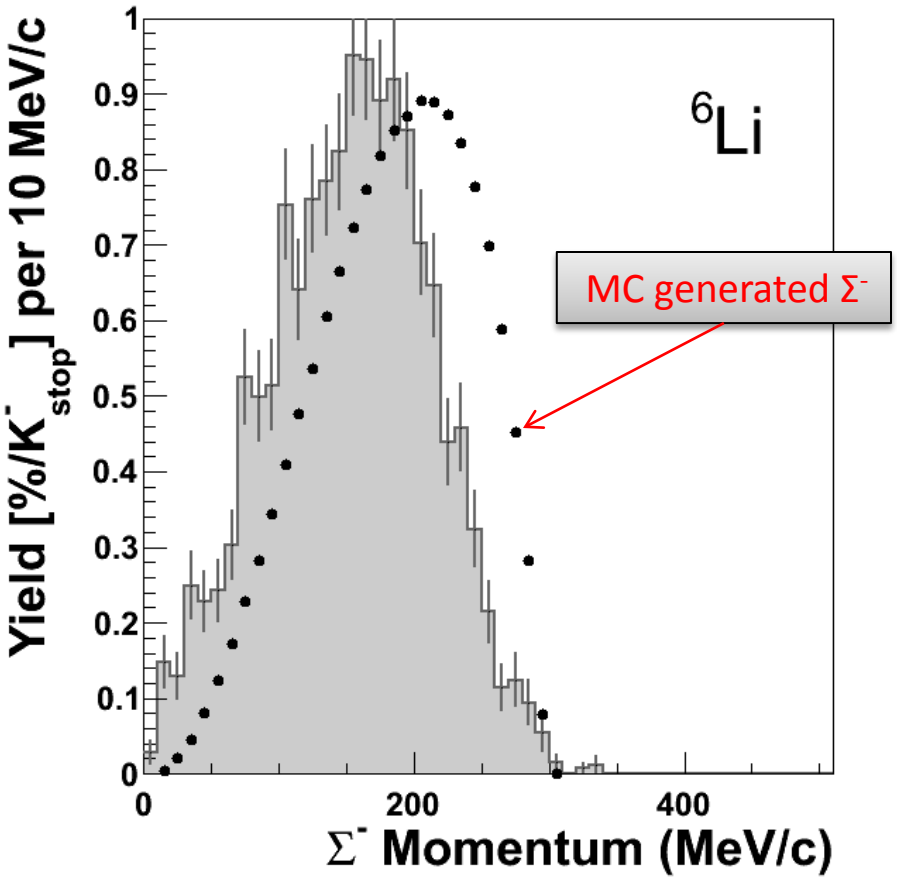


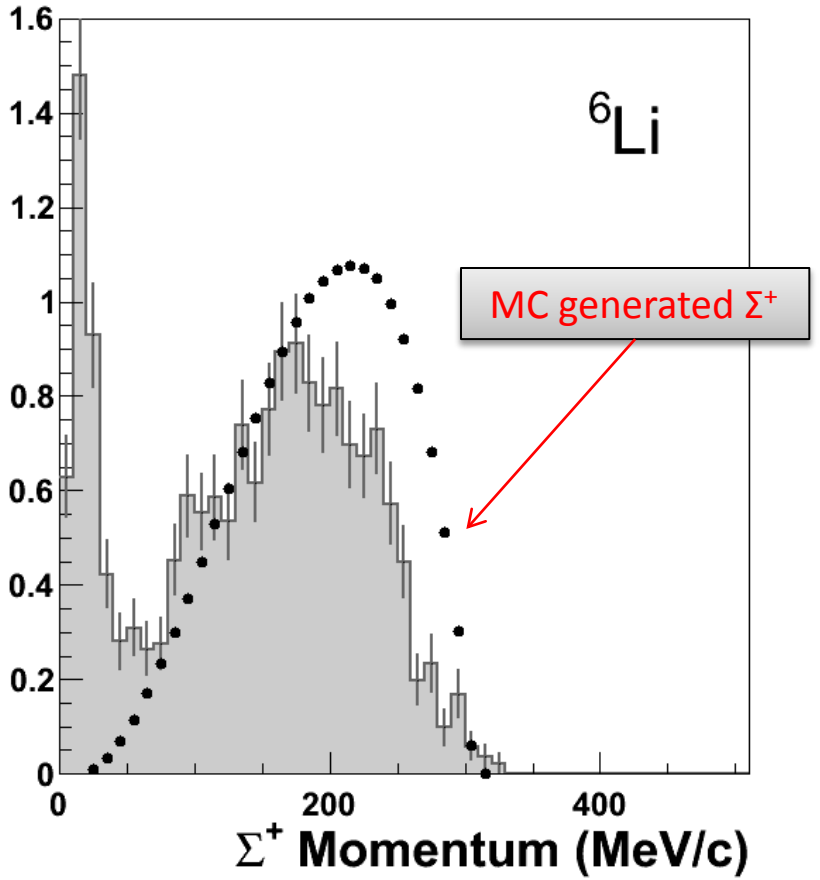


$\Sigma^-_{stop} \Rightarrow$ absorbed by "external" conversion: $\Sigma^- p \rightarrow \Lambda n$

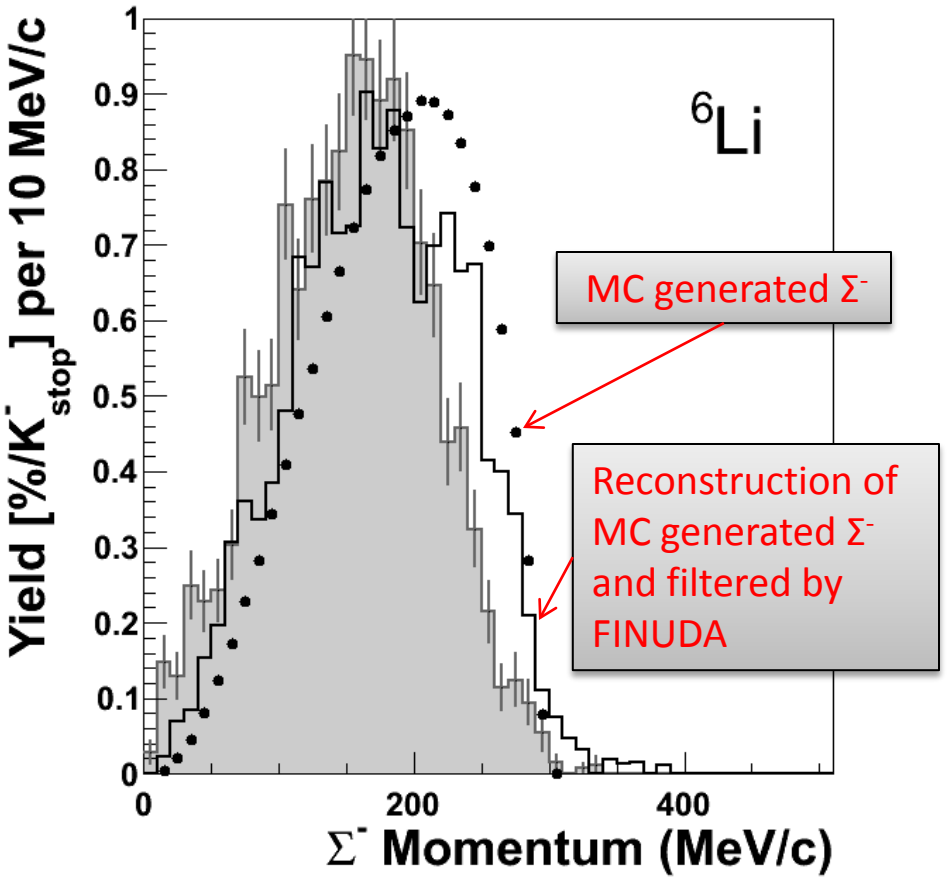
$\Sigma^-_{loss} / \Sigma^-_{in\text{-}flight} \approx \Sigma^+_{stop} / \Sigma^+_{in\text{-}flight}$

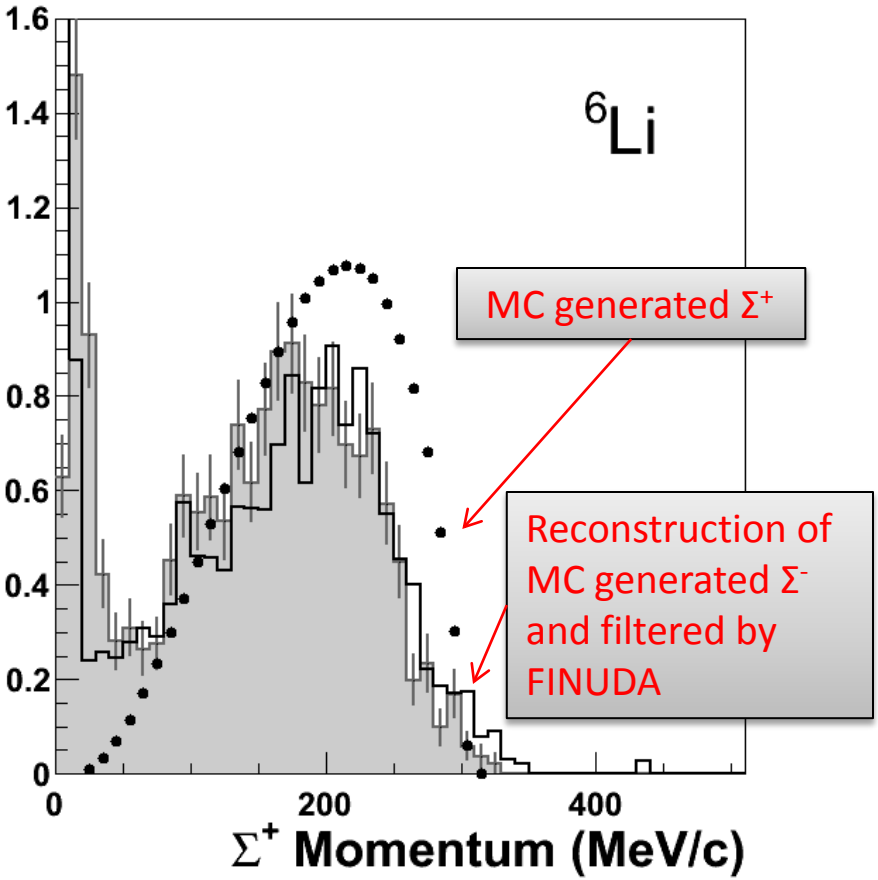
$K^{-}\,{}^{6}Li \rightarrow \Sigma\pi X$, Σ momentum spectra





K^- $^6Li \rightarrow \Sigma\pi X$, Σ momentum spectra



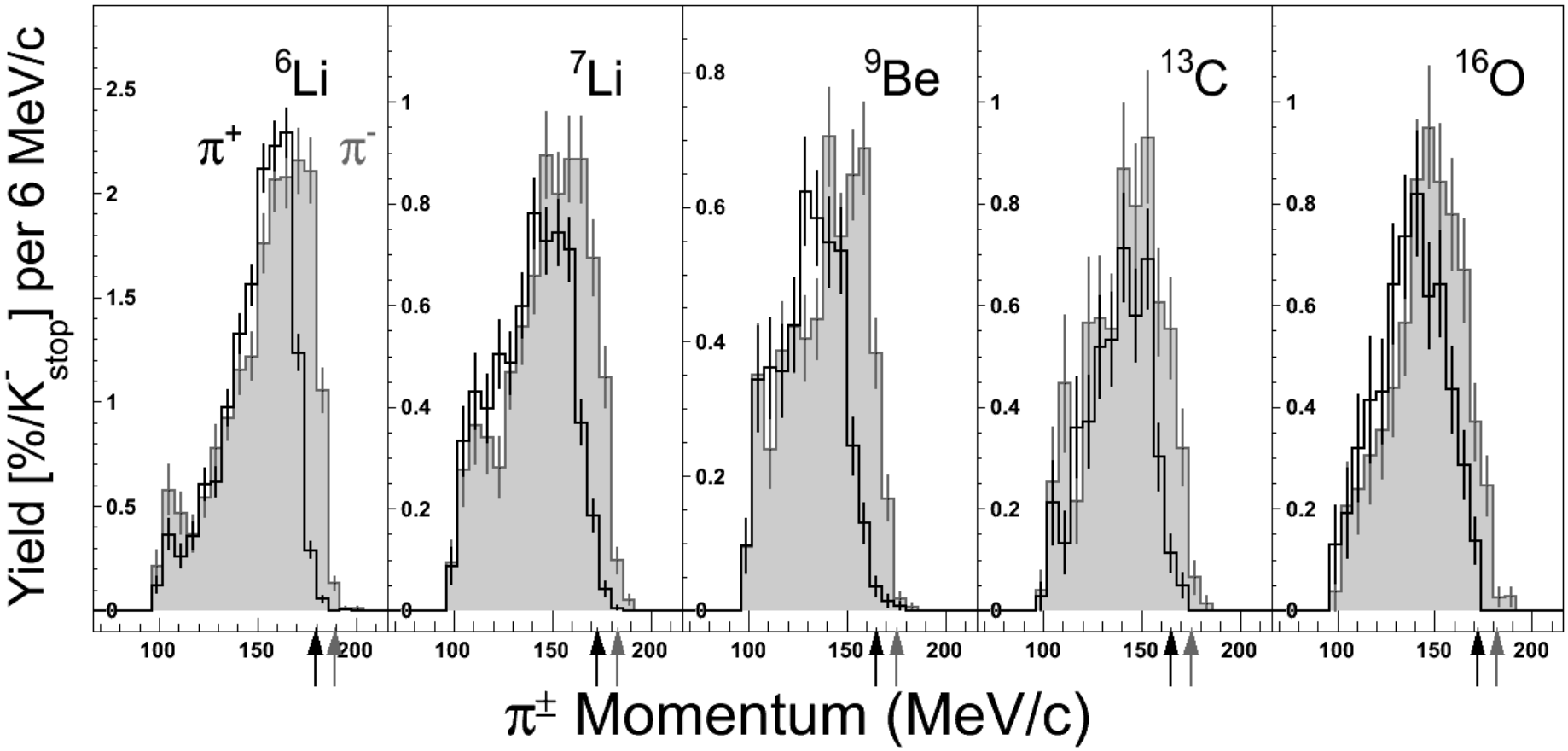


✓Monte Carlo code: generation of $K^-_{stop} + A \Rightarrow \Sigma^\pm + \pi^\mp + A'$ quasi-free reactions

✓Reconstruction of generated $\Sigma^\pm$ filtered through FINUDA geometry

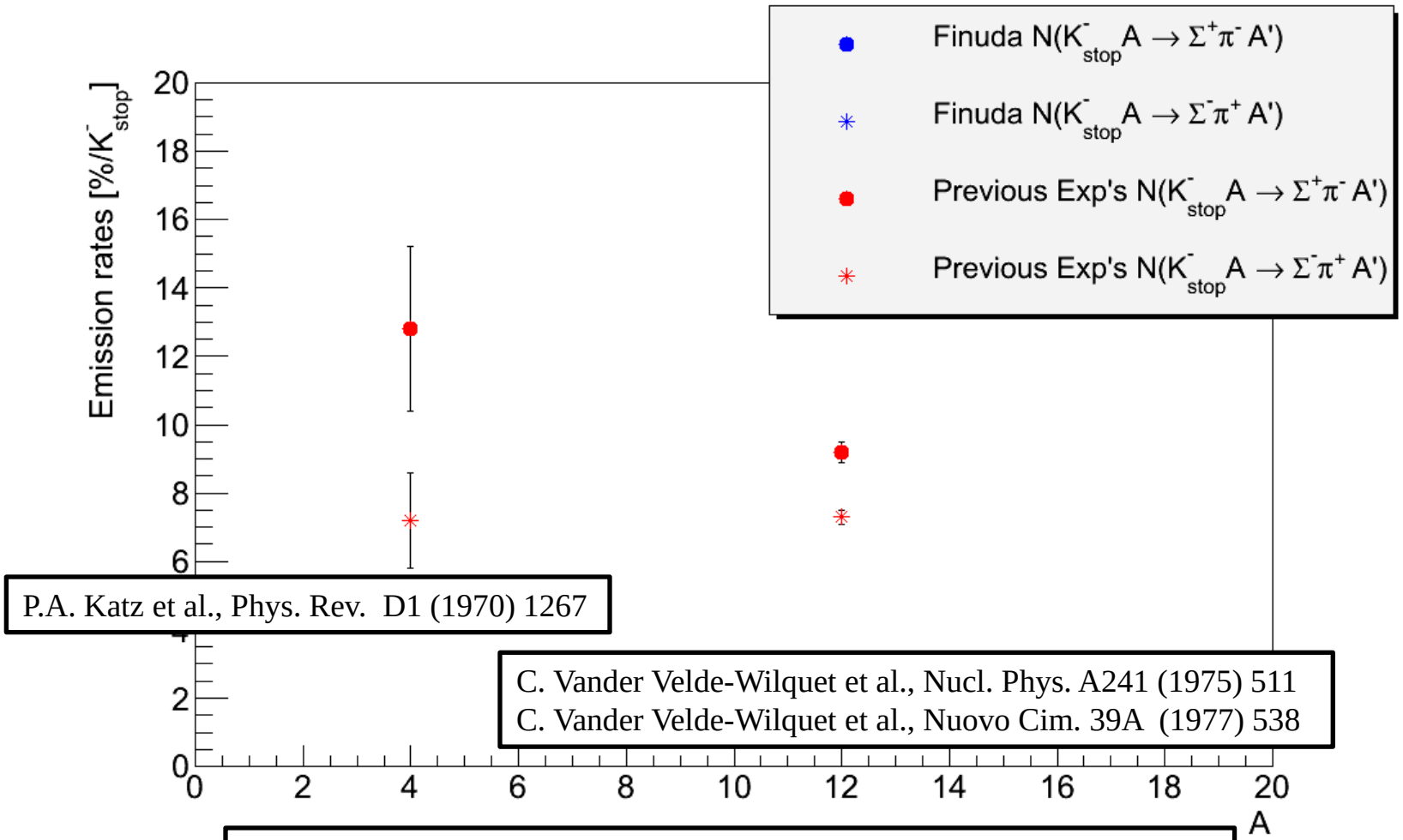
➢ $\Sigma^\pm$ momentum distributions distorted by target media (also $\Sigma\pi$ inv mass and $\Sigma\pi$ tot mom)

$K^- A \rightarrow \Sigma\pi X$, pion momentum spectra



- ✓ π spectra die sharply at threshold
- ✓ lower momentum cut 100 MeV/c
- ✓ π momentum does not suffer for the Σ distorsion, no analysis cut bias
- ➢ good test for models

Emission rates [%/K^-_{stop}]



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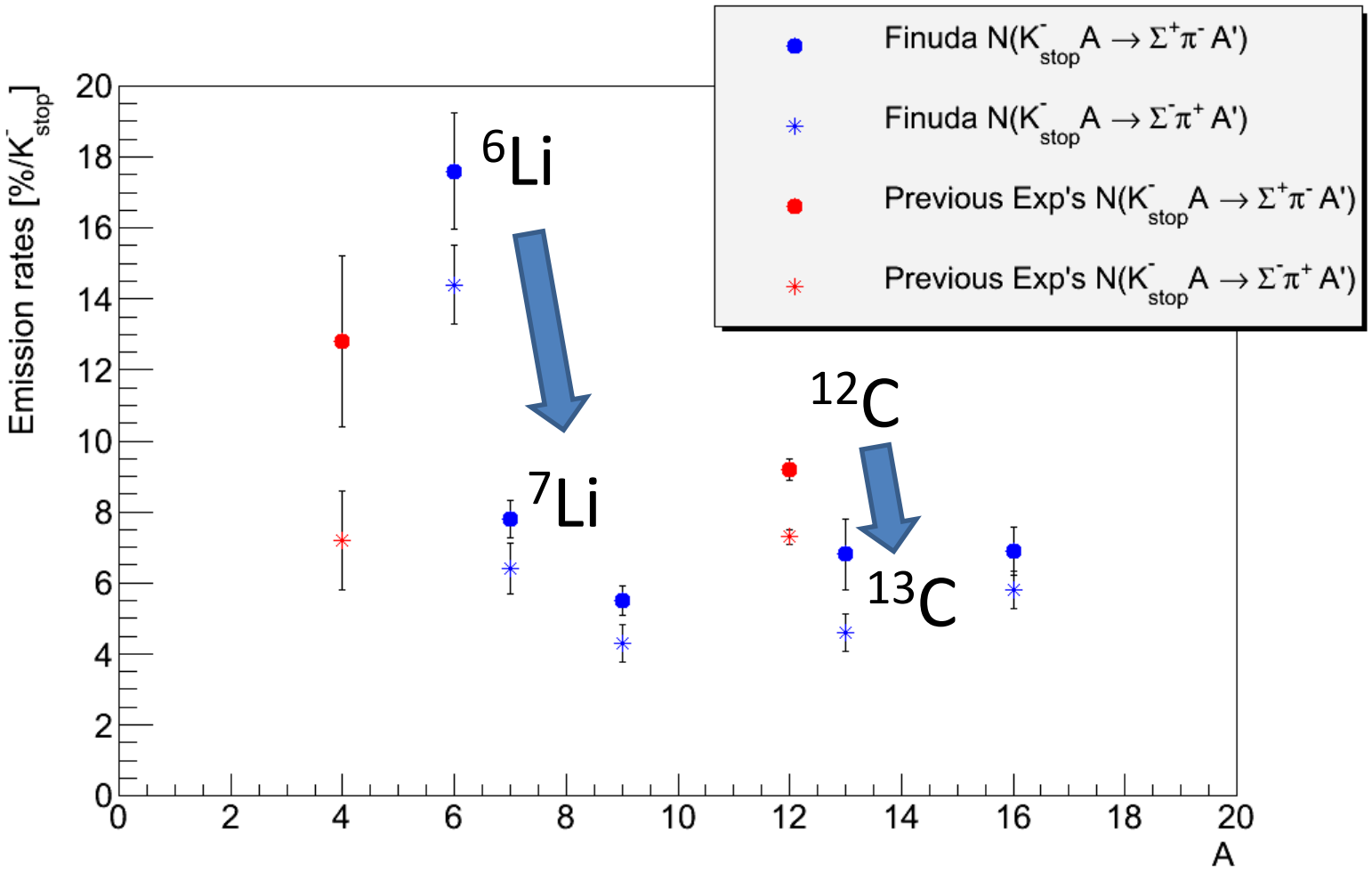
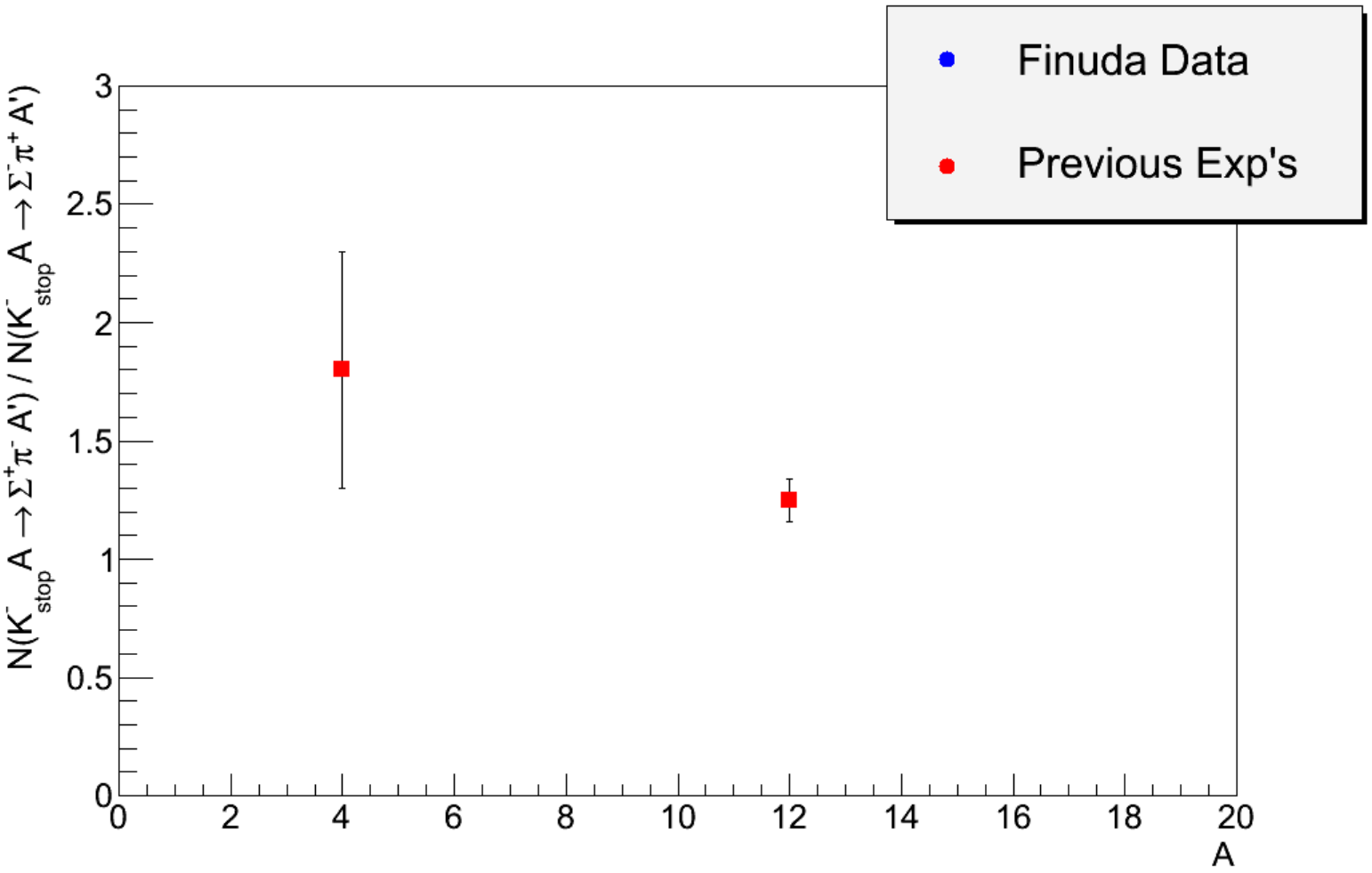
Emission rates [%/K^-_{stop}]



Ratios [$\Sigma^+\pi^-/\Sigma^-\pi^+$]



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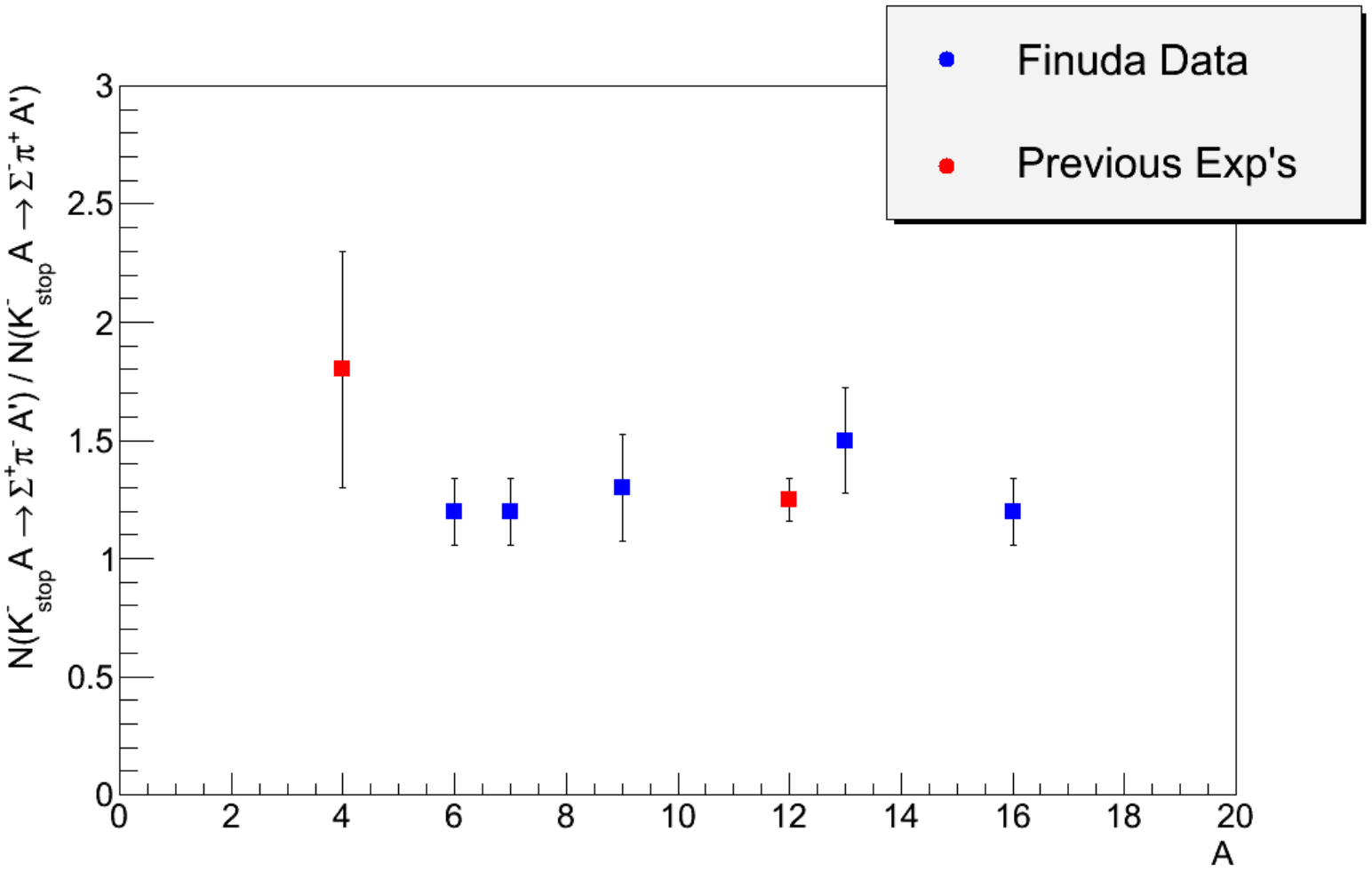

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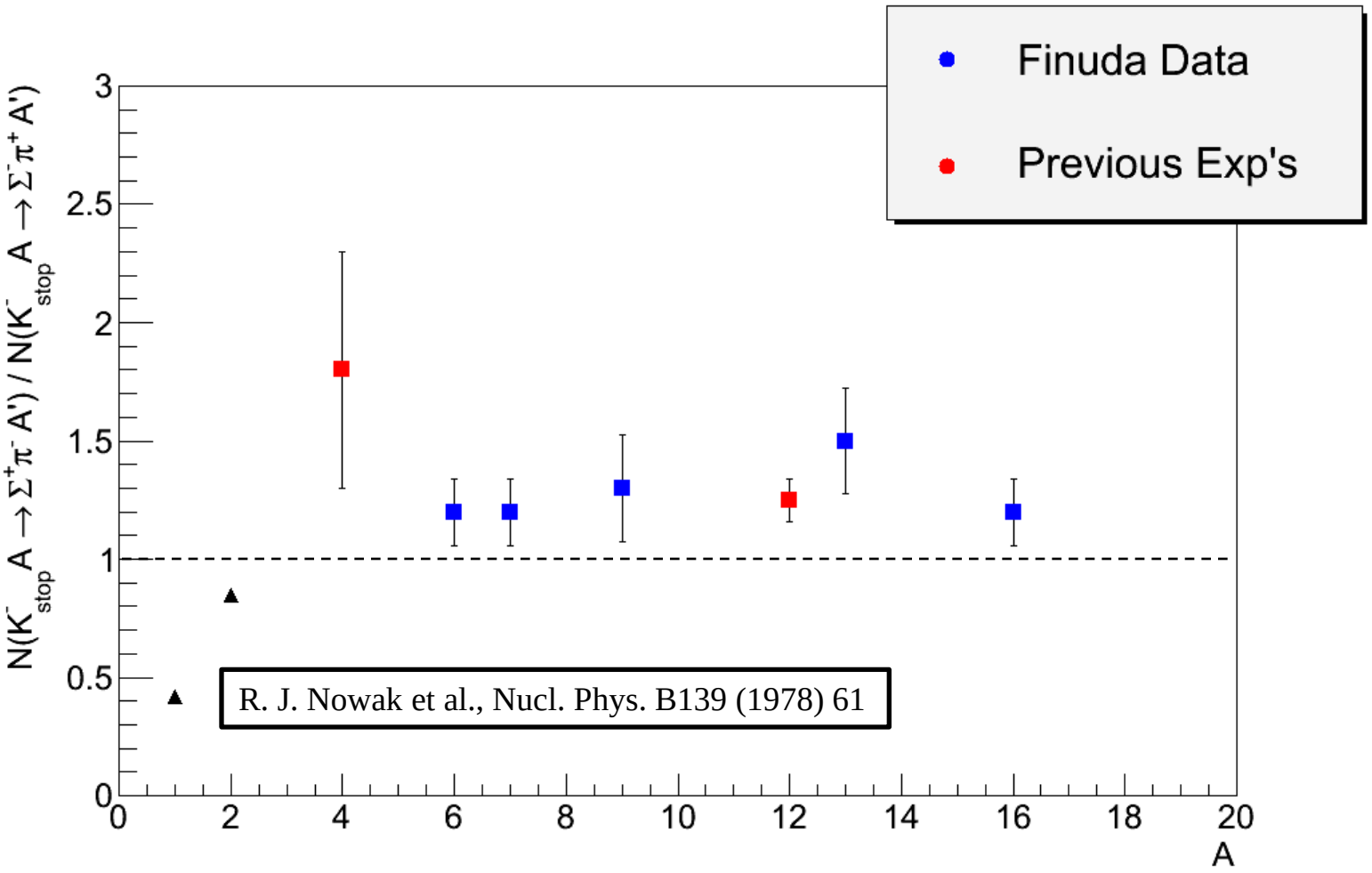


Emission rates [%/K^-_{stop}] and ratios

A	$\pi^-\Sigma^+$	$\pi^+\Sigma^-$	Σ^-_{loss}	R_{+-}
4He	12.8±2.4	7.2±1.4	-	1.8±0.5
6Li	17.6±1.0±1.3	14.4±1.1±0.2	30±2	1.2±0.1±0.1
7Li	7.8±0.5±0.2	6.4±0.4±0.6	26±2	1.2±0.1±0.1
9Be	5.5±0.3±0.3	4.3±0.3±0.5	38±3	1.3±0.1±0.2
12C	9.2±0.3	7.3±0.2	-	1.25±0.09
13C	6.8±0.8±0.6	4.6±0.5±0.2	12±1	1.5±0.2±0.1
16O	6.9±0.6±0.3	5.8±0.5±0.3	36±3	1.2±0.1±0.1

$\pi^-\Sigma^+$ and $\pi^+\Sigma^-$ emission rates:

data are not corrected for the pion attenuation nor for Σ-Λ conversion

$\pi^+\Sigma^-$ values account for Σ^-_{loss}

$R_{+-} = \pi^-\Sigma^+ / \pi^+\Sigma^-$

from free proton (R_{+-} = 0.42) to a bound proton (R_{+-} > 1):

subthreshold modification of the $\bar{K}N$ interaction

agreement with S. Wycech, Nucl. Phys. B28 (1971) 541 predictions

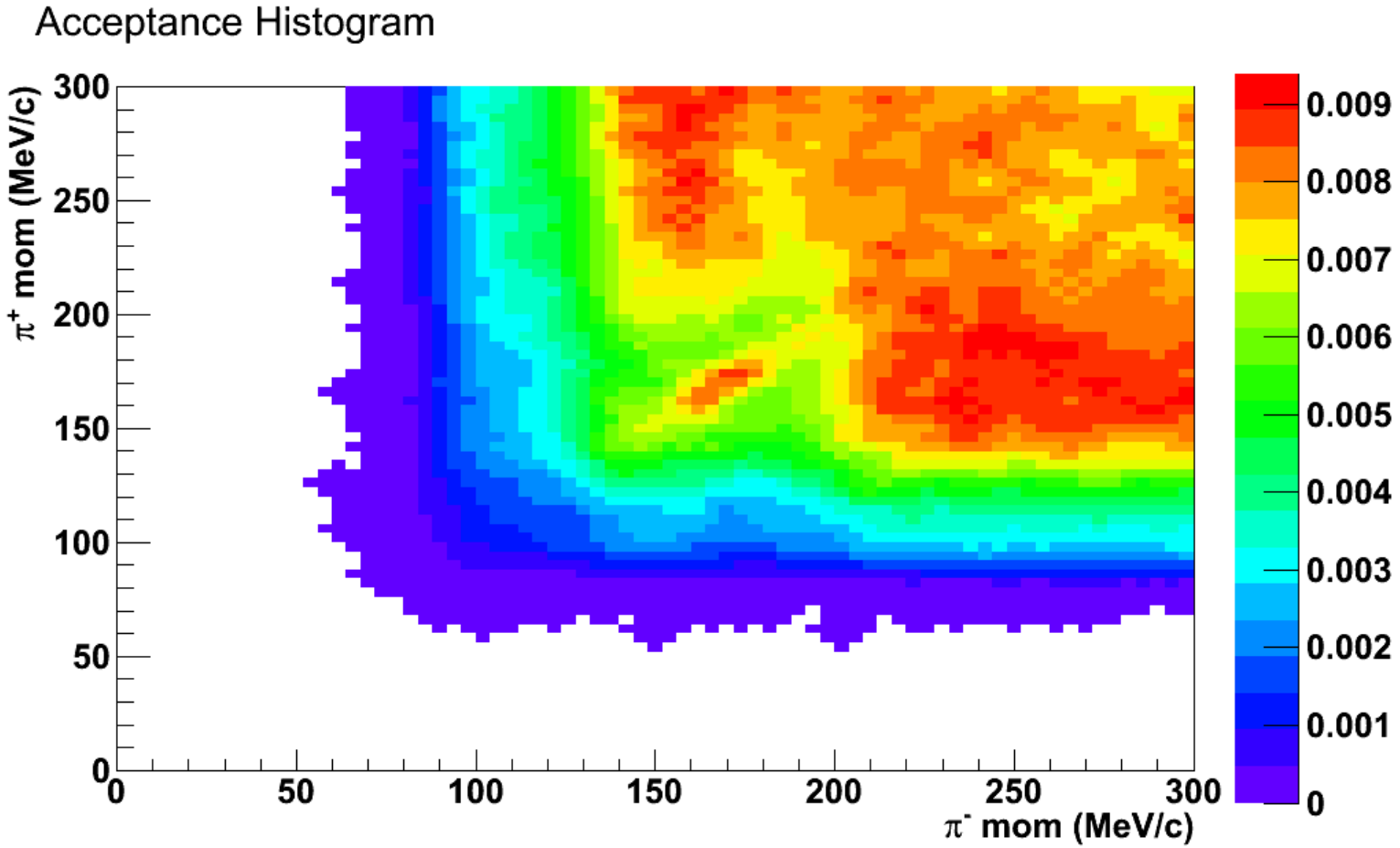
Summary and conclusions

- The $K^-_{stop}A \rightarrow n\pi^+\pi^-X$ reaction was studied with FINUDA@DAFNE on $A=^6Li,^7Li,^9Be,\ ^{13}C,\ ^{16}O$, and the $\pi^{\mp}\Sigma^{\pm}$ channel analyzed.

- For the first time was measured:
  1) the $\pi^{\mp}$ prompt in coincidence with the $\Sigma^{\pm}$ ($\rightarrow n\pi^{\pm}$)
  2) the elementary process $K^-_{stop}\ p \rightarrow \Sigma\pi$ with p bound in A
  3) emission rates from A=6 to A=16

- Background effectively suppressed
- Study no suitable for $_{\Sigma}$A states

Acceptance


Acceptance Histogram
π⁺ mom (MeV/c)
300
250
200
150
100
50
0
0
50
100
150
200
250
300
π⁻ mom (MeV/c)
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0