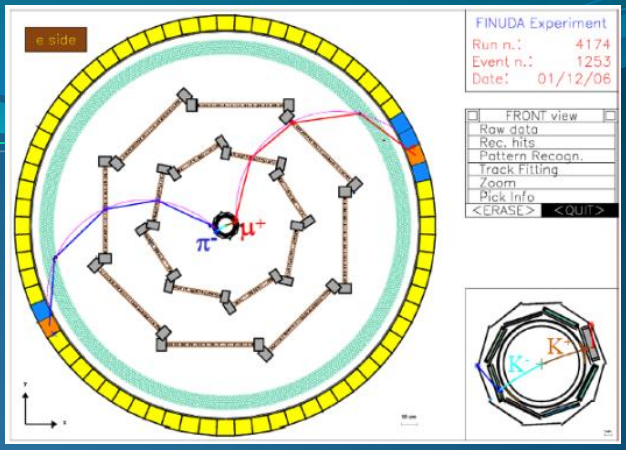
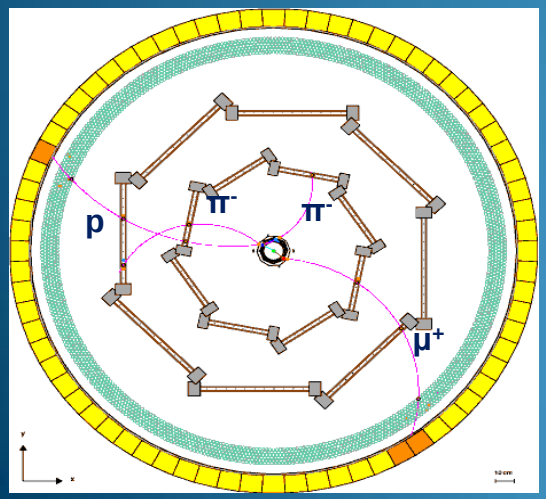
41st Meeting LNF SCIENTIFIC COMMITTEE
Open Session 22 November 2010



FINUDA

Analysis Status



Vincenzo Lucherini – LNF – INFN

Plan of the talk

Introduction

Results in Hypernuclear Physics
- **Spectroscopy**
- **Decay**

Results in K^-_{stop} absorption on multinucleon clusters in nuclei
- **Λ**
- **$\Sigma^{\pm}$**

Conclusions

LNF - INFN Frascati

Double Anular e^-e^+ collider optimized at $E_{c.m.}$ 1020 MeV, ϕ meson mass

DAΦNE

FIsica NUcleare a DAϕne

University of Victoria

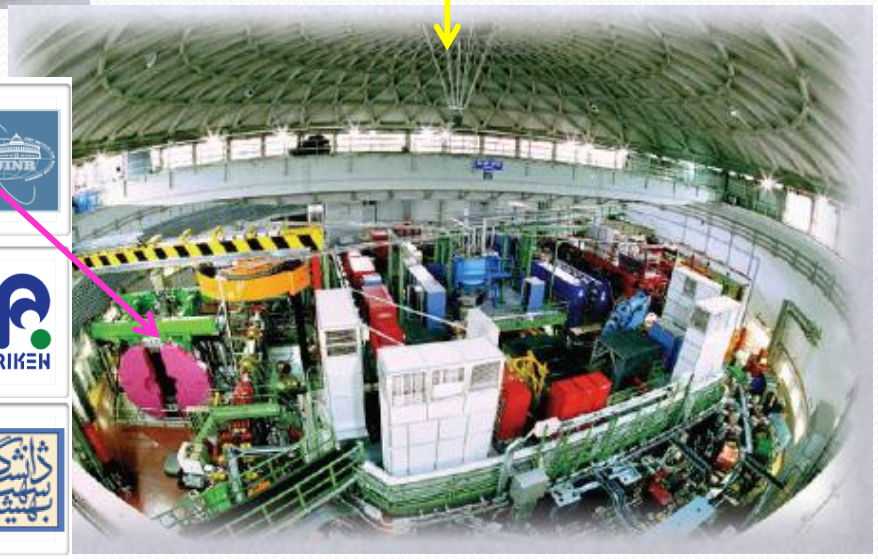
Seoul National University

JINR Dubna

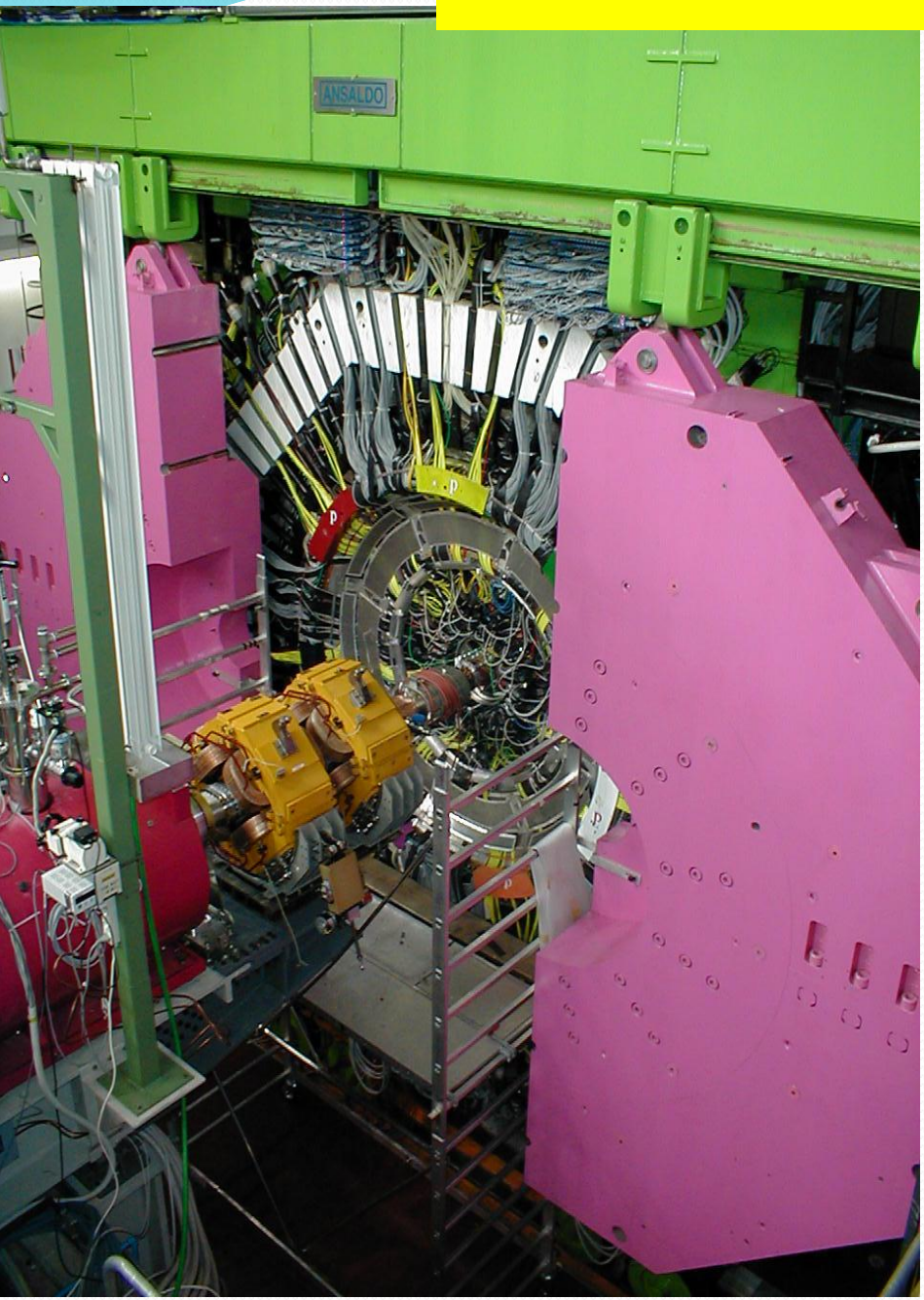
Bari University & INFN Bari
Brescia University & INFN Pavia
Pavia University & INFN Pavia
Torino Polytechnic & INFN Torino
Torino University & INFN Torino
Trieste University & INFN Trieste
L.N.F. / INFN Frascati

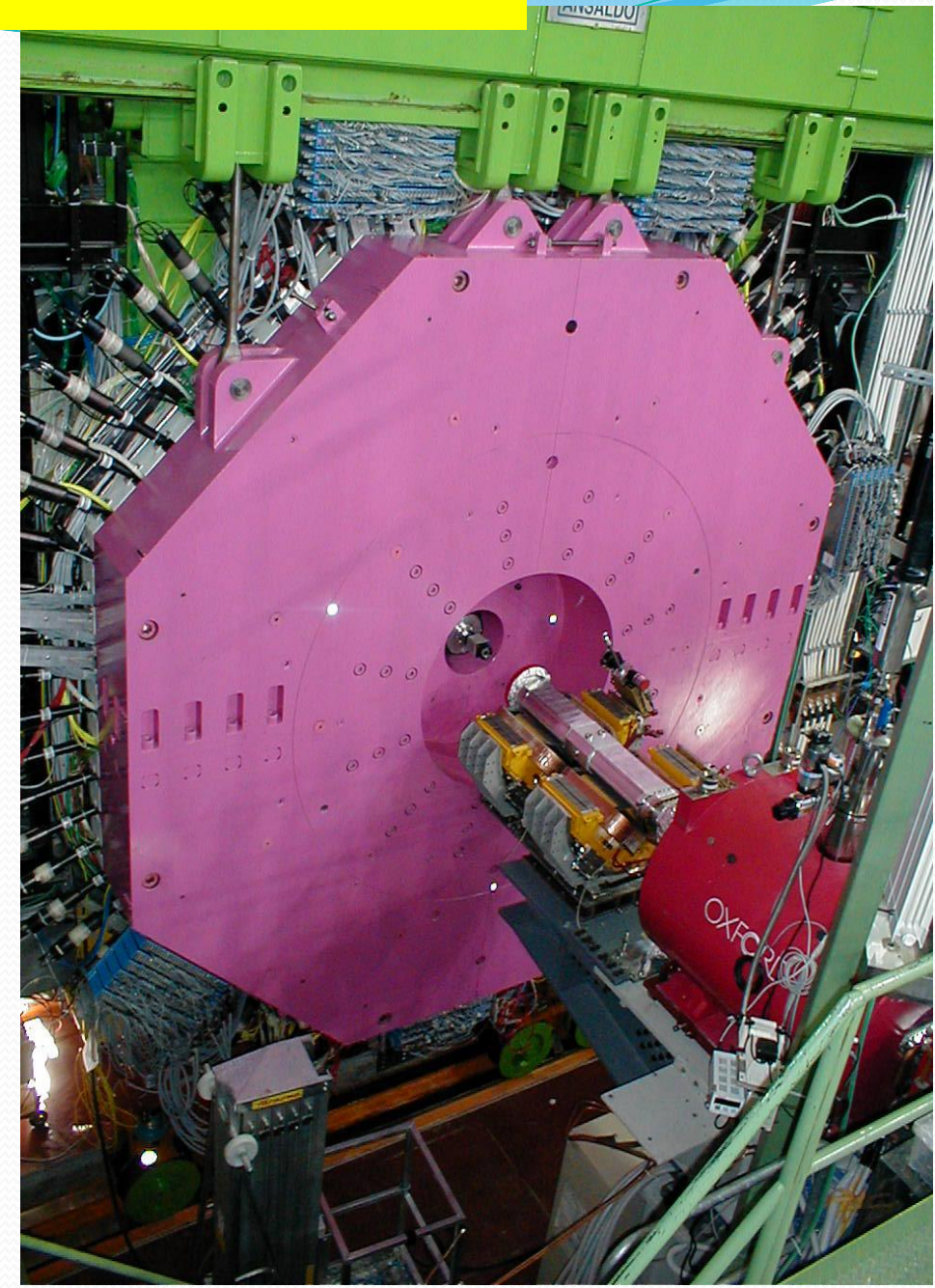
KEK
RIKEN

Teheran
Shahid Beheshty University



FINUDA on DAΦNE

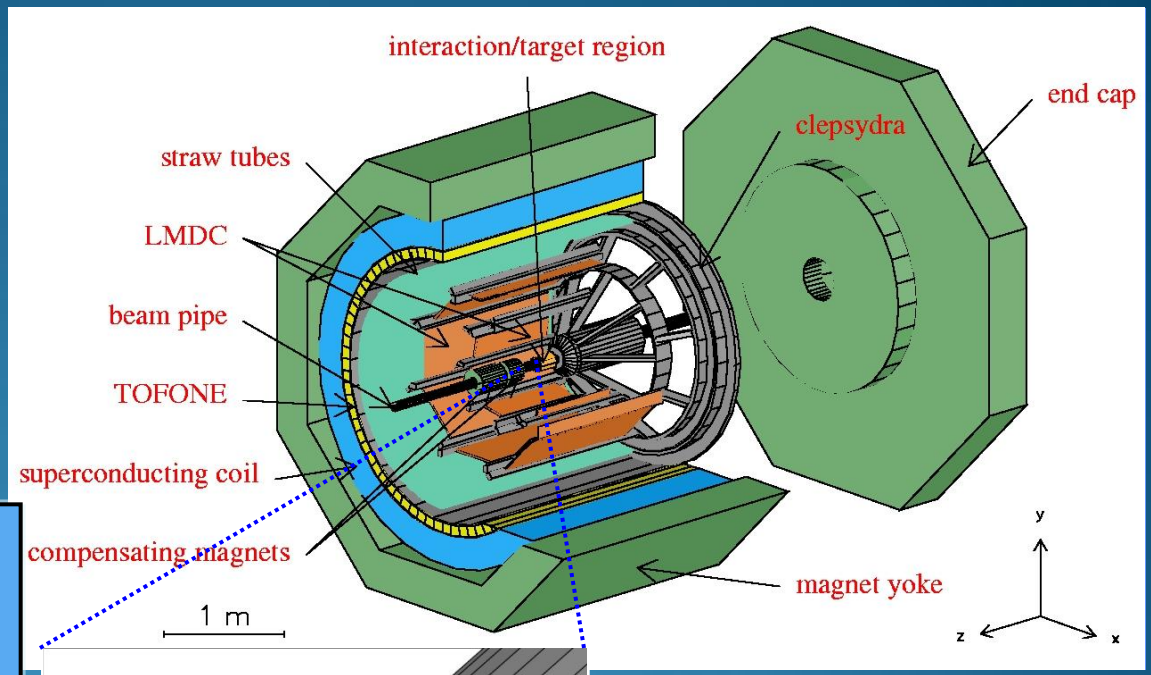




The FINUDA Detectors

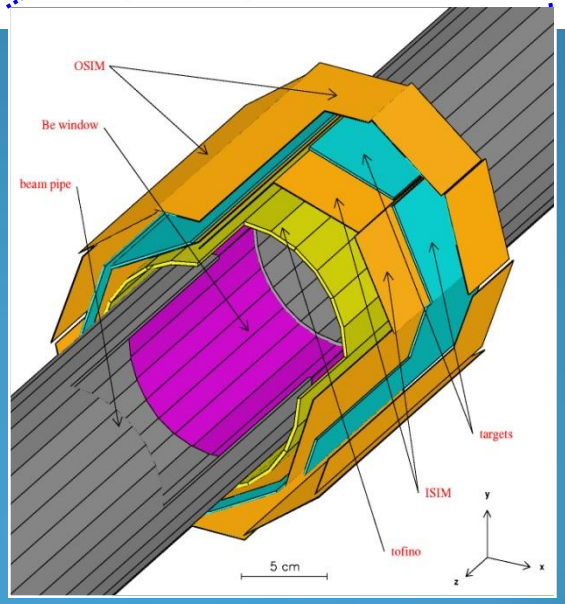
A large acceptance Spectromer immersed in a highly uniform 1 T magnetic field generated by a superconducting solenoid

The volumes between the external tracking detectors are filled by He to minimize multiple scattering effects.



Detector capabilities:

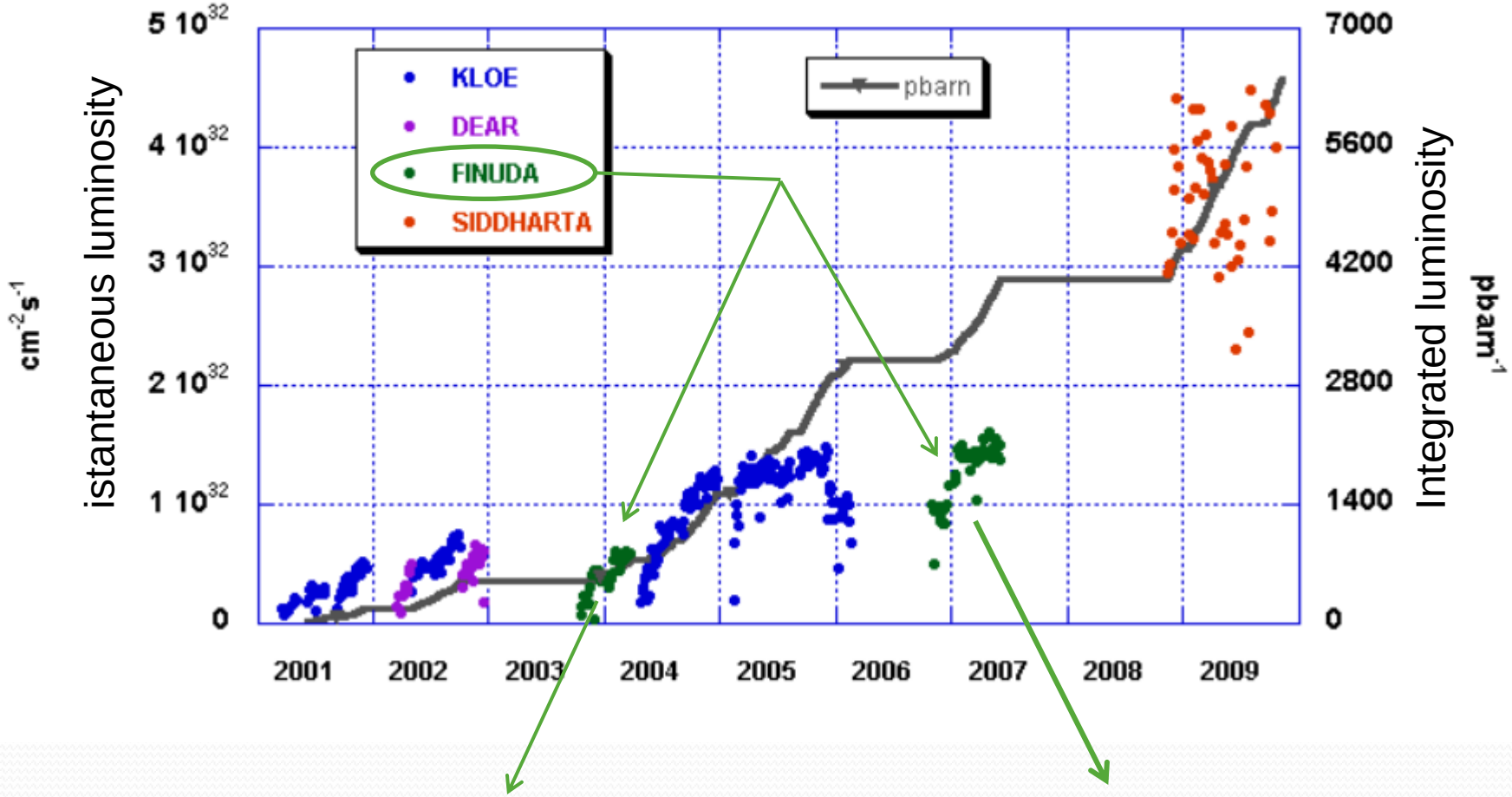
- ❖ **Selective trigger** based on fast scintillation detectors (TOFINO, TOFONE)
- ❖ Clean K^- **vertex identification** (ISIM P.ID.+ *x,y,z* resolution + K^+ tagging)
- ❖ π, K, p, d, t … P.I.D. (d*E*/d*x*)
- ❖ **High momentum resolution** (6‰ FWHM) tracker resolution+Hebag+thin targets
- ❖ **Time-Of-Flight** (TOFONE-TOFINO)
- ❖ **Neutron detection** (TOFONE)



$K^{\pm}$ flux from ϕ decay @ $L = 10^{32}$ cm^{-2}s^{-1}:
$0.5*(\sigma_\phi \times L) = 220$ s^{-1}

$K^{\pm}$ from ϕ decay at rest: $\sin^2(\Theta)$ respect to the beam pipe axis

Experiments on DAΦNE at a glance *and* FINUDA share



2x ^{6}Li, *1x* ^{7}Li, *3x* ^{12}C, *1x* ^{27}Al, *1x* ^{51}V

$\int L$: 200 pb^{-1}

2x ^{6}Li, *2x* ^{7}Li, *2x* ^{9}Be, *1x* ^{13}C, *1x* ^{16}O

$\int L$: 960 pb^{-1}

FINUDA physics program

- Λ HYPERNUCLEAR SPECTROSCOPY
  essential tool for testing :
- theoretical models of Λ-N potentials
- single particle nuclear model predictions
- bound states with strangeness

SIMULTANEOUSLY

- Λ HYPERNUCLEAR DECAYS
- study of baryon-baryon weak processes in nuclear matter: $\Lambda \rightarrow \pi N$ and $\Lambda N \rightarrow NN$ and more…
- hypernuclei rare decays

and

and, moreover:

ON DIFFERENT NUCLEI

- **STUDY OF:**
- K^- multi-nucleon absorption
- $\Sigma^{+/-}$ production

FINUDA: Λ-hypernuclei spectroscopy

$$K^-_{stop} + {}^A Z \rightarrow {}^A_\Lambda Z + \pi^-$$

$$K^- + n \rightarrow \Lambda + \pi^-$$ strangeness exchange reaction

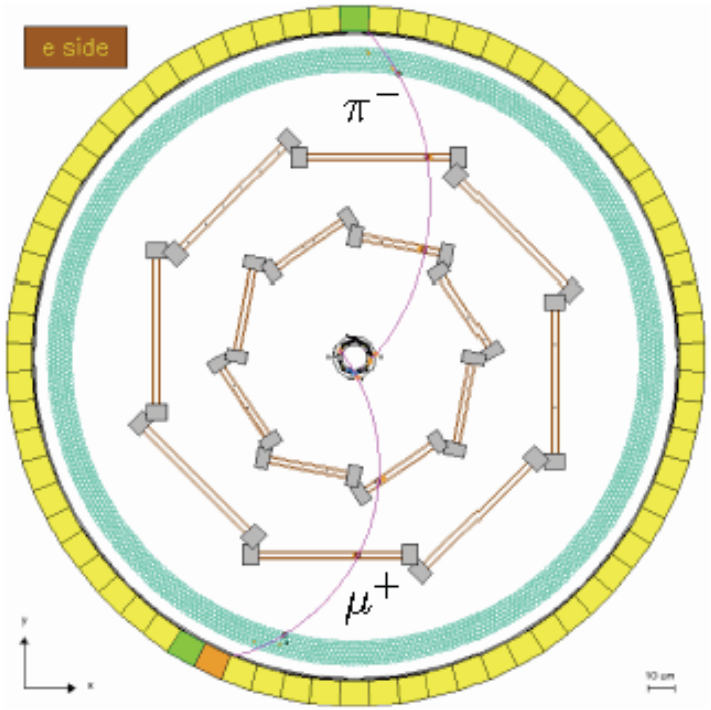
Measurement of the (*prompt*) π^- momentum.

1

HYPERNUCLEI PRODUCTION

hypernucleus

$$K^-_{stop} + {}^A Z \rightarrow {}^A_\Lambda Z + \pi^-$$



key features of the spectrometer

very thin targets (0.1 ÷ 0.3 g/cm²)
transparency ➥ high resolution spectroscopy

different targets in the same run
➥ reduced systematic errors

simultaneous tracking of μ⁺ from the K⁺ decay
$K^+ \rightarrow \mu^+ \nu_\mu$ ➥ energy and rate calibration

Hypernuclear spectroscopy

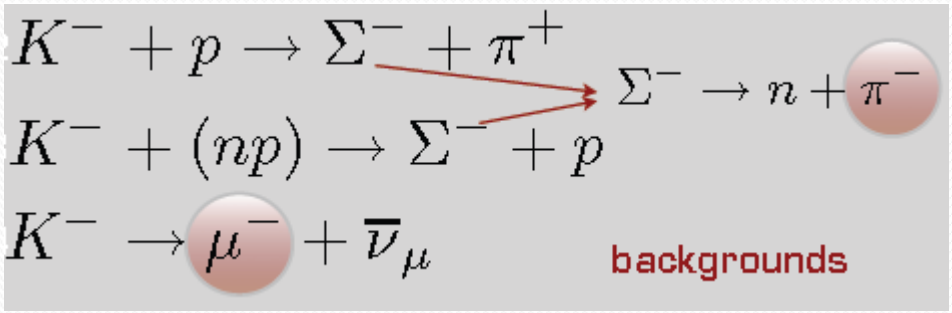
The analysis on Λ-hypernuclei spectroscopy is finished.

Final results published

- **for $^{12}_{\Lambda}$C; PLB 622 (2005) 35**

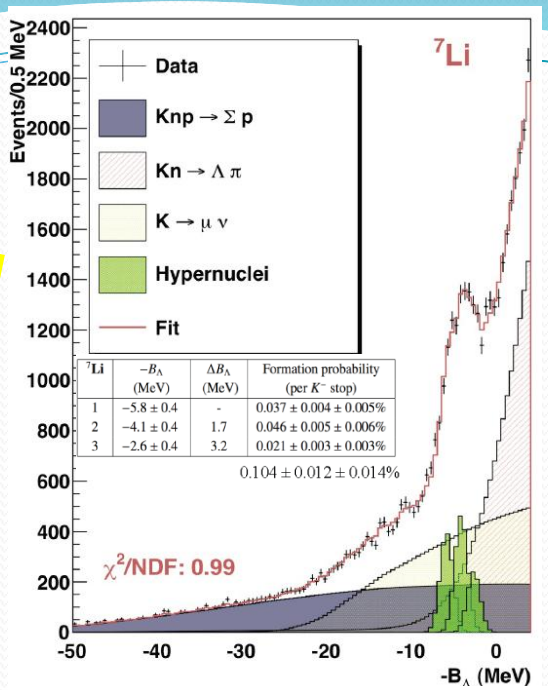
- **for $^{7}_{\Lambda}$Li, $^{9}_{\Lambda}$Be, $^{13}_{\Lambda}$C, $^{16}_{\Lambda}$O; Submitted to PLB on 11 Nov 2010**
  preprint: arXiv:1011.2695v1 [nucl-ex]

Long and accurate activity to extract the hypernuclei level peaks and capture rates off the physical ***backgrounds*** *by extensive and intensive use of MC simulations*

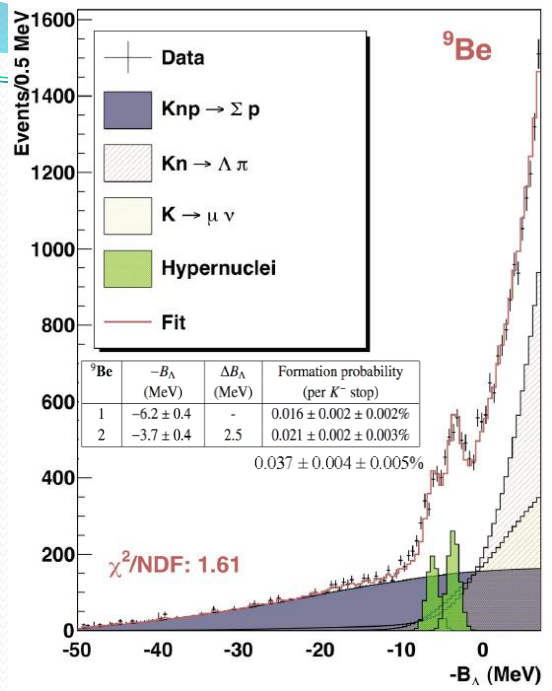


FINUDA final resutls for spectroscopy and capture rates

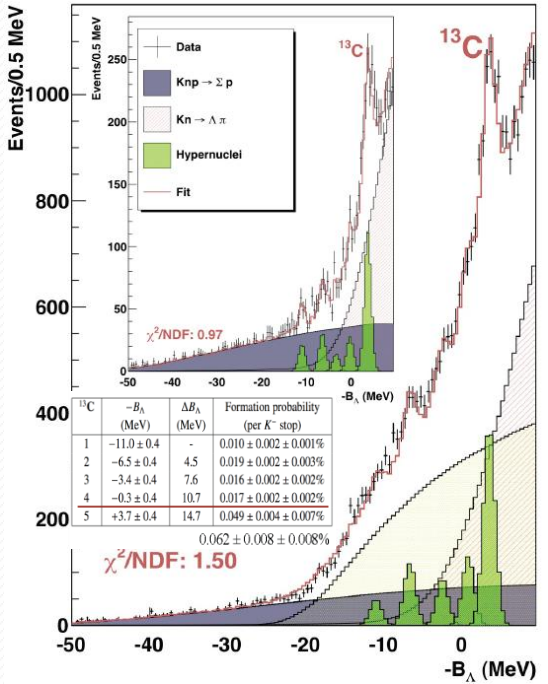
arXiv:1011.2695v1 [nucl-ex] 11 Nov 2010
Submitted to PLB



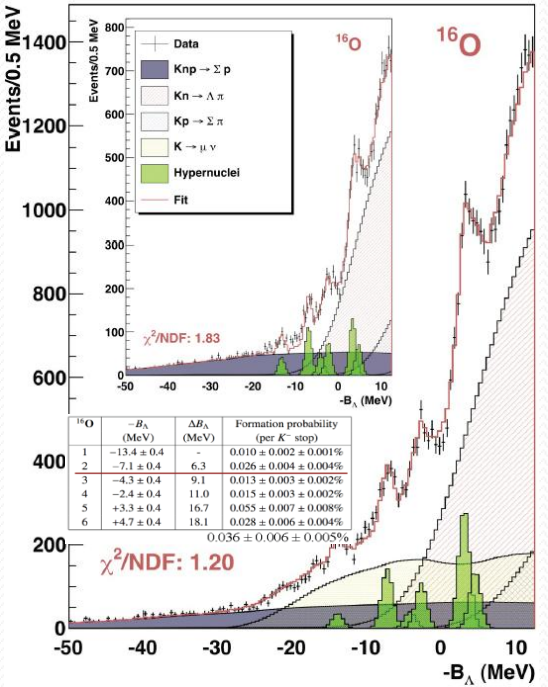
^{7}Li	$-B_\Lambda$ (MeV)	ΔB_Λ (MeV)	Formation probability (per K^- stop)
1	−5.8 ± 0.4	-	0.037 ± 0.004 ± 0.005%
2	−4.1 ± 0.4	1.7	0.046 ± 0.005 ± 0.006%
3	−2.6 ± 0.4	3.2	0.021 ± 0.003 ± 0.003%



^{9}Be	$-B_\Lambda$ (MeV)	ΔB_Λ (MeV)	Formation probability (per K^- stop)
1	−6.2 ± 0.4	-	0.016 ± 0.002 ± 0.002%
2	−3.7 ± 0.4	2.5	0.021 ± 0.002 ± 0.003%



^{13}C	$-B_\Lambda$ (MeV)	ΔB_Λ (MeV)	Formation probability (per K^- stop)
1	−11.0 ± 0.4	-	0.010 ± 0.002 ± 0.001%
2	−6.5 ± 0.4	4.5	0.019 ± 0.002 ± 0.003%
3	−3.4 ± 0.4	7.6	0.016 ± 0.002 ± 0.002%
4	−0.3 ± 0.4	10.7	0.017 ± 0.002 ± 0.002%
5	+3.7 ± 0.4	14.7	0.049 ± 0.004 ± 0.007%

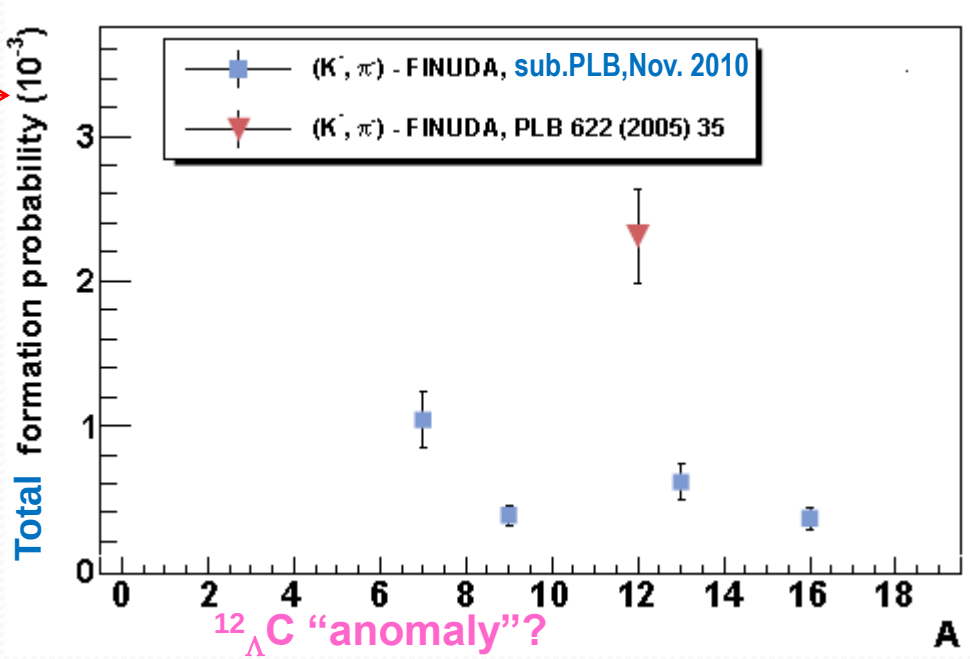


^{16}O	$-B_\Lambda$ (MeV)	ΔB_Λ (MeV)	Formation probability (per K^- stop)
1	−13.4 ± 0.4	-	0.010 ± 0.002 ± 0.001%
2	−7.1 ± 0.4	6.3	0.026 ± 0.004 ± 0.004%
3	−4.3 ± 0.4	9.1	0.013 ± 0.003 ± 0.002%
4	−2.4 ± 0.4	11.0	0.015 ± 0.003 ± 0.002%
5	+3.3 ± 0.4	16.7	0.055 ± 0.007 ± 0.008%
6	+4.7 ± 0.4	18.1	0.028 ± 0.006 ± 0.004%

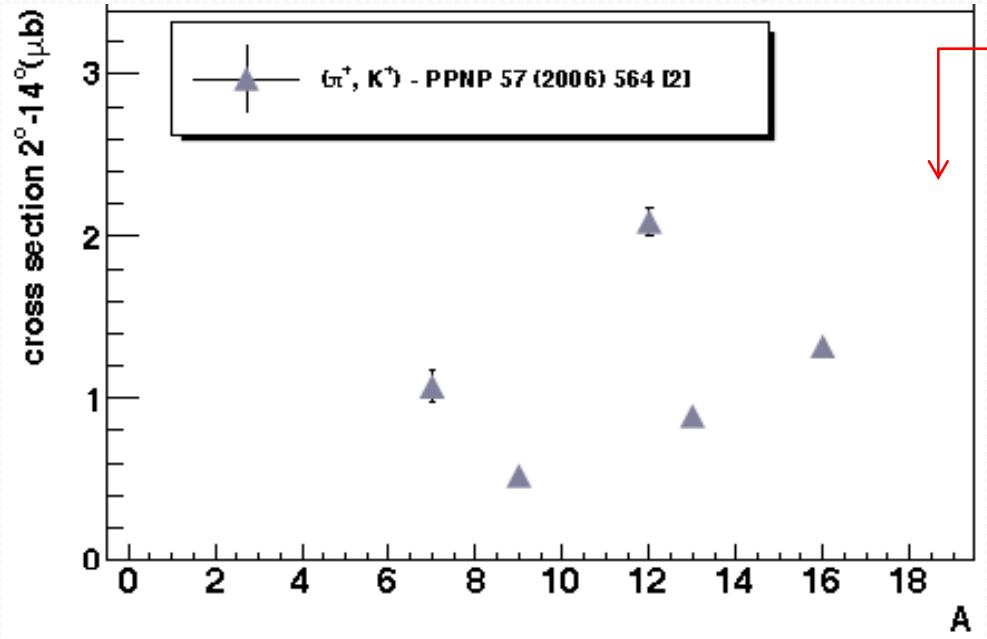
FINUDA (K^-,π^-) "total bound" capture rate & (π^+, K^+) cross section vs. A

"Need to compare the A dependence of the measured formation rates with theoretical predictions that depend primarly on the depth of the K^- potential governing the capture of K^- mesons from the initial atomic state."

V. Krejčiřík, A. Cieplý and A. Gal,
Phys. Rev. C **82** (2010) 024609



$^{12}_{\Lambda}$C "anomaly"?



"Very recently constraints were reported on the threshold K^- nuclear potential, based on the FINUDA measured values."

PLB (submitted)

A. Cieply, , E. Friedman, A. Gal and V. Krejcirik

Hypernuclear weak decay study in FINUDA

Coincidence measurements

charged Mesonic channel

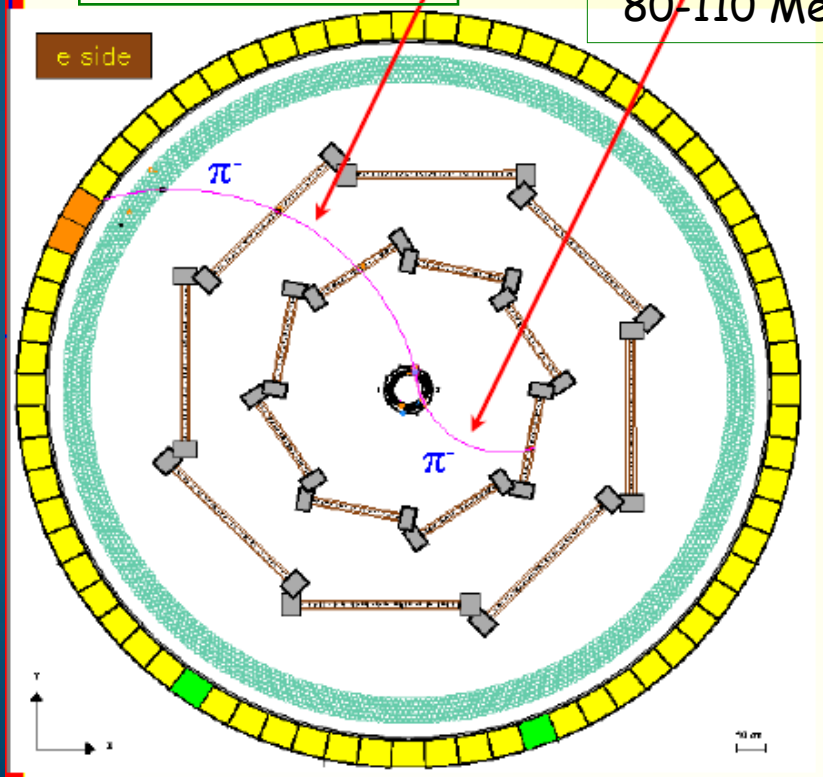
MWD

K^- stop + $^{A}_{Z} \rightarrow {}^{A}_{\Lambda}Z + \pi^-$ (prompt)

${}^{A}_{\Lambda}Z \rightarrow {}^{A}_{(Z+1)} + \pi^-$ (decay)

St.-EX
260-280 MeV/c

MWD
80-110 MeV/c



charged Non-Mesonic channel

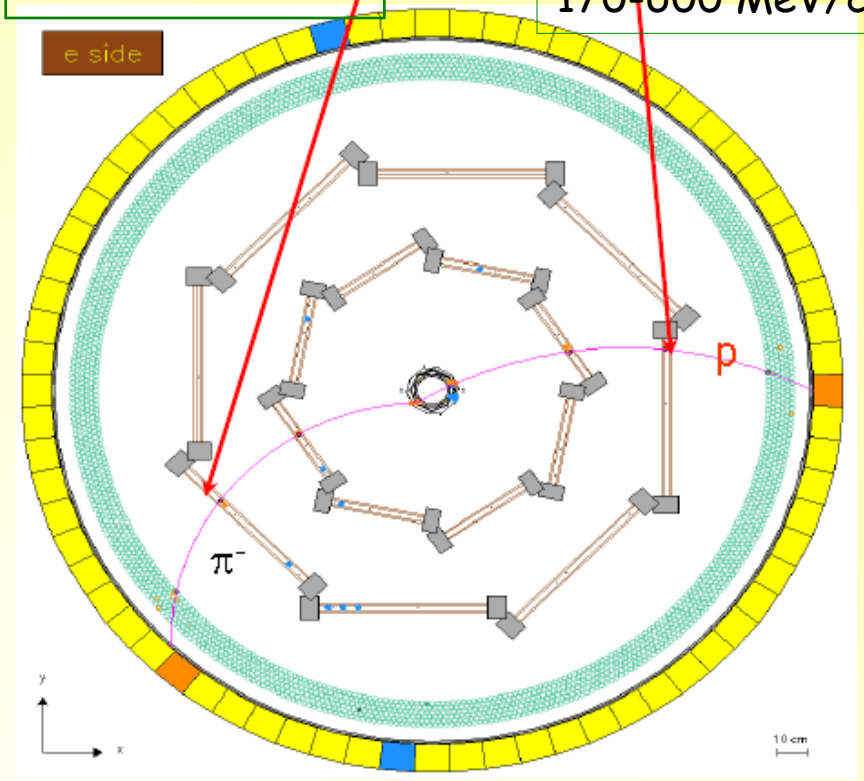
NMWD

K^- stop + $^{A}_{Z} \rightarrow {}^{A}_{\Lambda}Z + \pi^-$ (prompt)

${}^{A}_{\Lambda}Z \rightarrow {}^{A-2}_{(Z-1)} + p + n$ (decay)

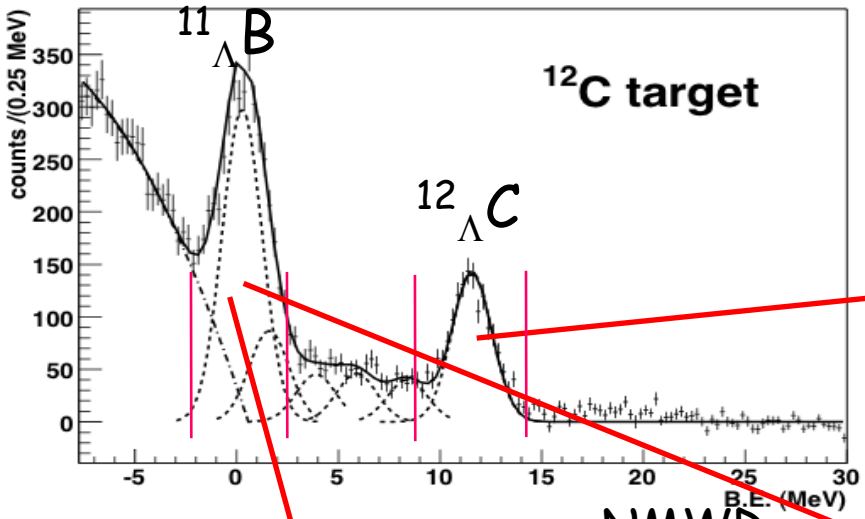
St.-EX
260-280 MeV/c

NMWD
170-600 MeV/c

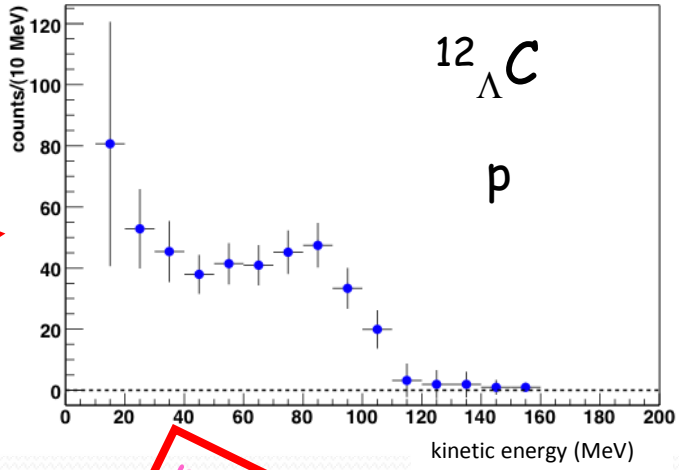


MWD & NMWD in FINUDA: strategy

Inclusive production π^- spectra
K^-np background corrected



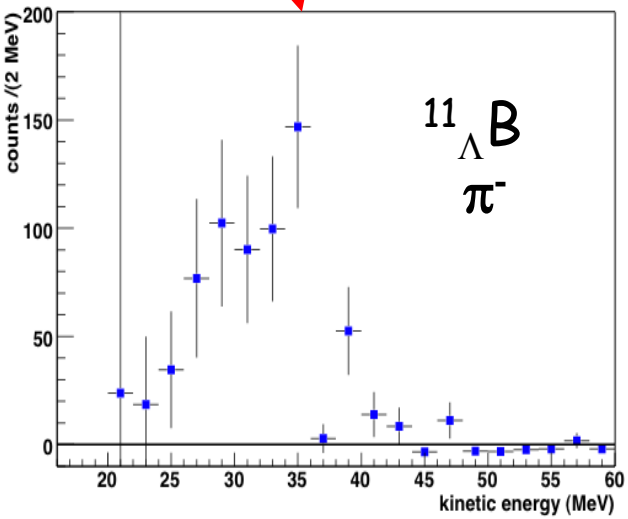
NMWD

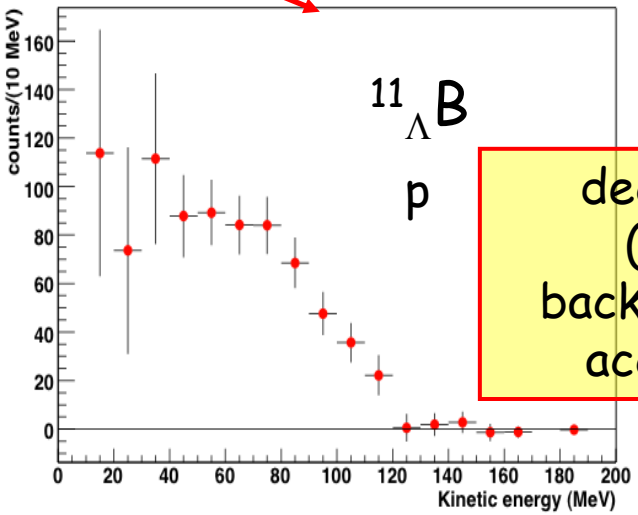


MWD

NMWD

magnetic analysis !!





decay π^- and p spectra
(Λ_{qf} decay) / K^-np
background subtracted &
acceptance corrected

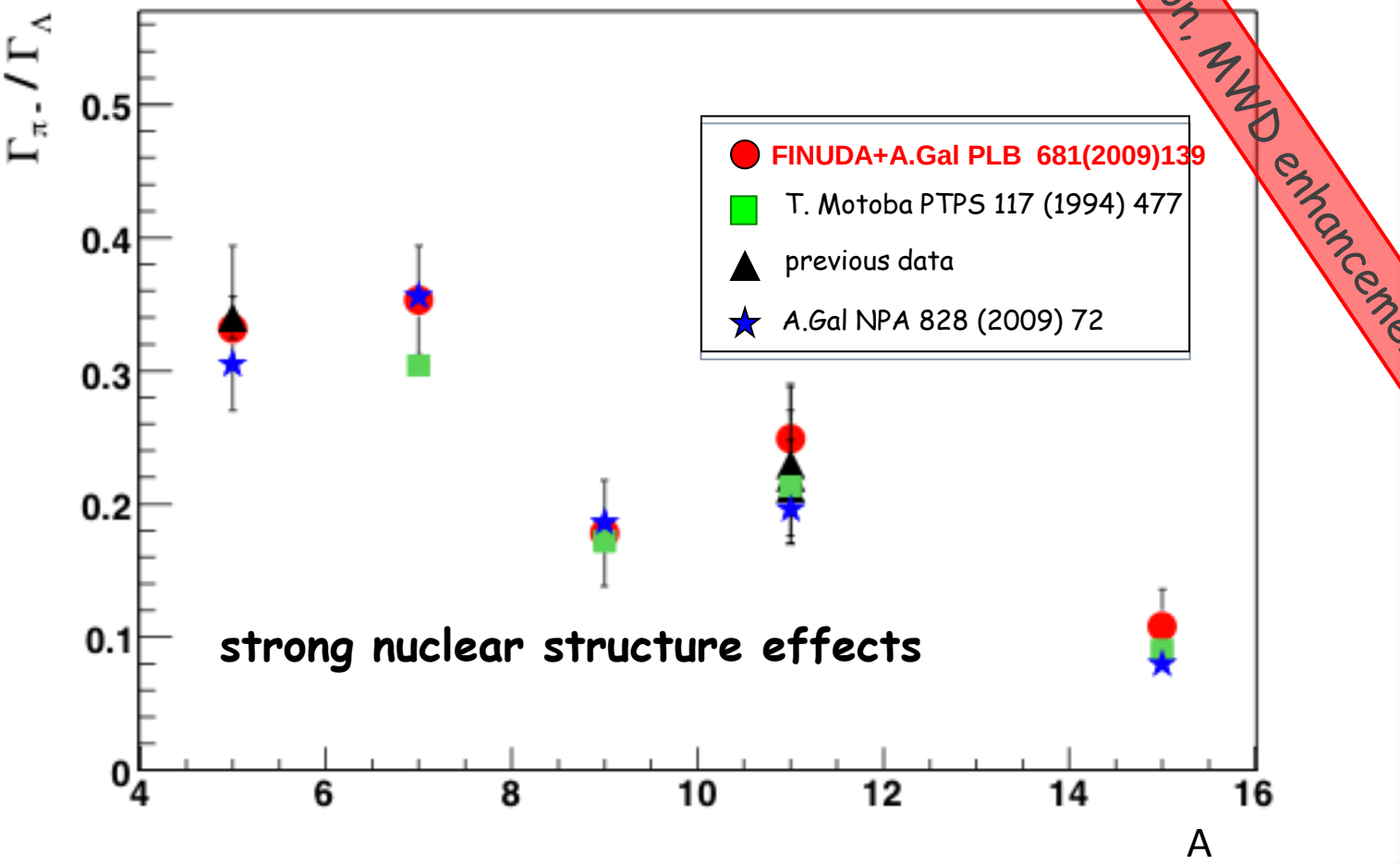
Mesonic Decay, FINUDA results: *ratio* $\Gamma_{\pi^-} / \Gamma_\Lambda$

$$\Gamma_{\pi^-} / \Gamma_\Lambda = \Gamma_{tot} / \Gamma_\Lambda \bullet \quad BR_{\pi^-}$$

$$\Gamma_{tot} / \Gamma_\Lambda = (0.990 \pm 0.094) + (0.018 \pm 0.010) \times A$$

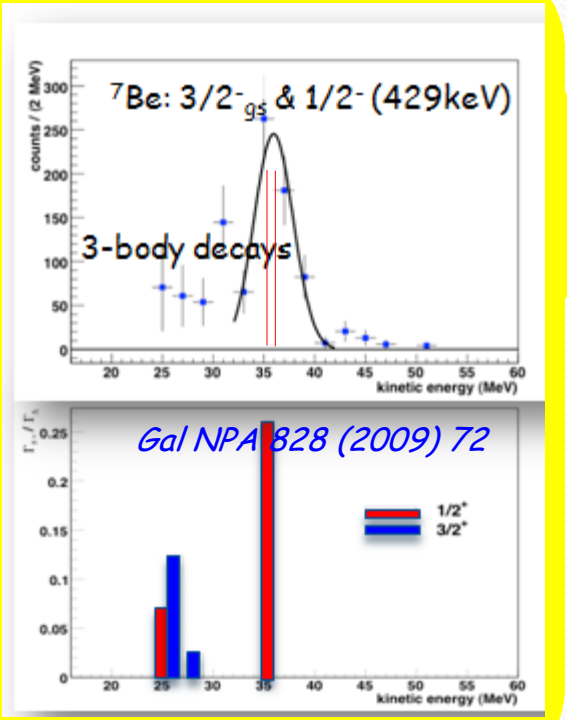
fit from measured values for A=4-12 hypernuclei

π distortion, MWD enhancement proved !



FINUDA J^{π} assignment for Λ-Hyp. g.s.

FINUDA + A. Gal, PLB 681 (2009) 139

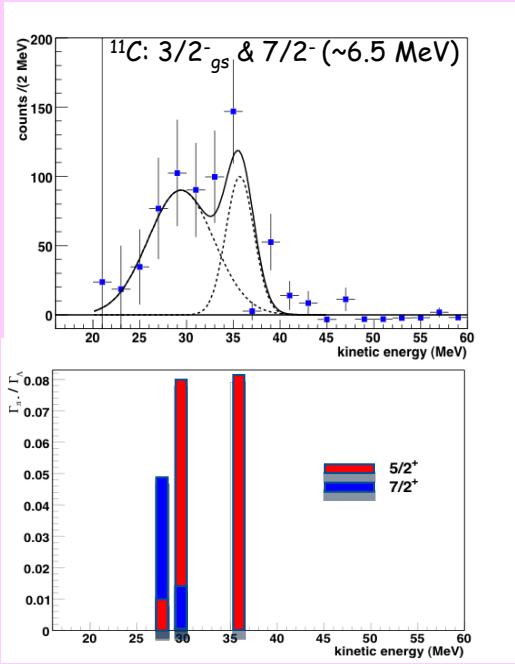


$^{7}_{\Lambda}$Li: 1/2^{+}

$^{9}_{\Lambda}$Be: 1/2^{+}

$^{11}_{\Lambda}$B: 5/2^{+}

$^{15}_{\Lambda}$N: 3/2^{+}



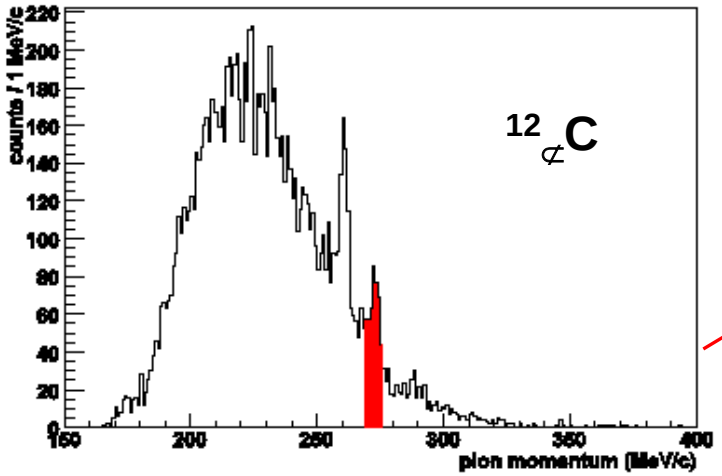
First time measurement *(from decay π spectrum shape* ***AND*** *π decay rate)*

Fruitful collaboration with leading theoreticians of the field (A. Gal, T. Motoba)

NMWD: p spectra @ FINUDA

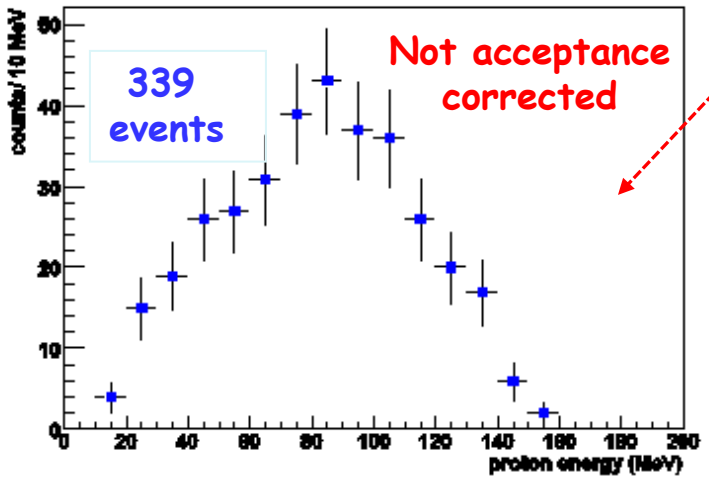
coincidence measurement: the method I

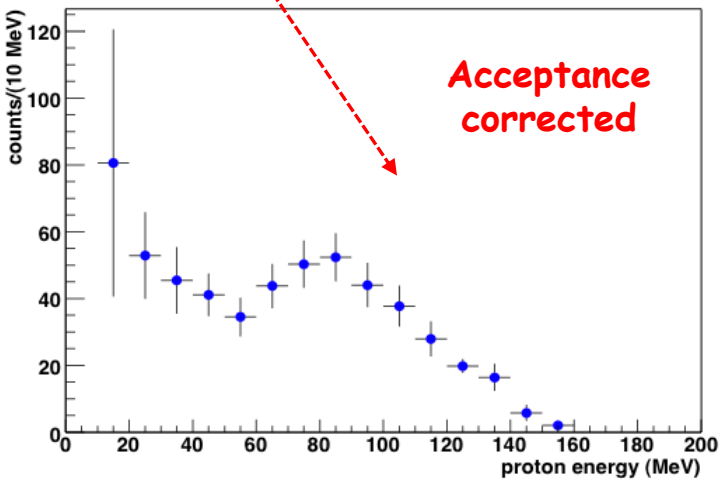
M.Agnello et al., NPA 804 (2008) 151



- Spectrum of negative pions for events in which a proton is detected in coincidence with a π^-
- Asking for the proton coincidence a clear peak emerges at 272 MeV/c (ground state)

Proton energy spectrum from $^{12}_{\Lambda}$C π-induced NMWD before and after the acceptance correction





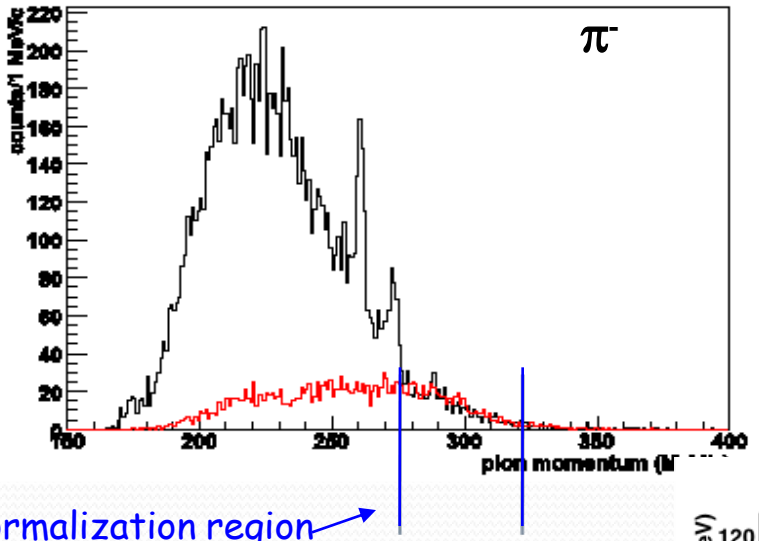
NMWD. Coincidence measurementthe method II

background reaction: $K^- np \rightarrow \Sigma^- p$

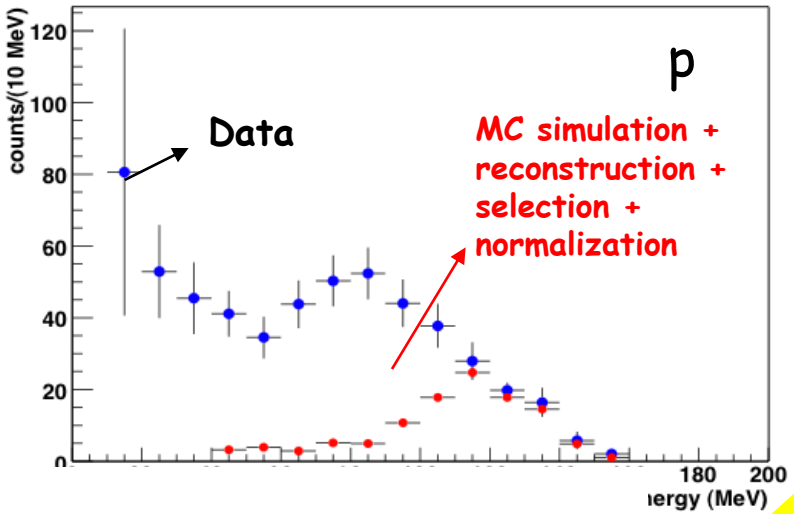
$\Sigma^- \rightarrow n \pi^-$

coincidence

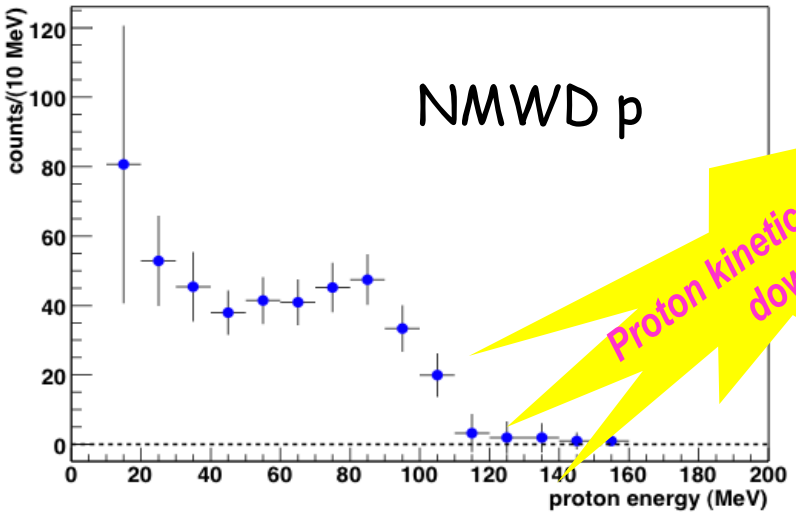
Coincidence spectra: $^{12}_{\Lambda}C$



normalization region



Back. subtraction



Proton kinetic energy measured down to 15 MeV

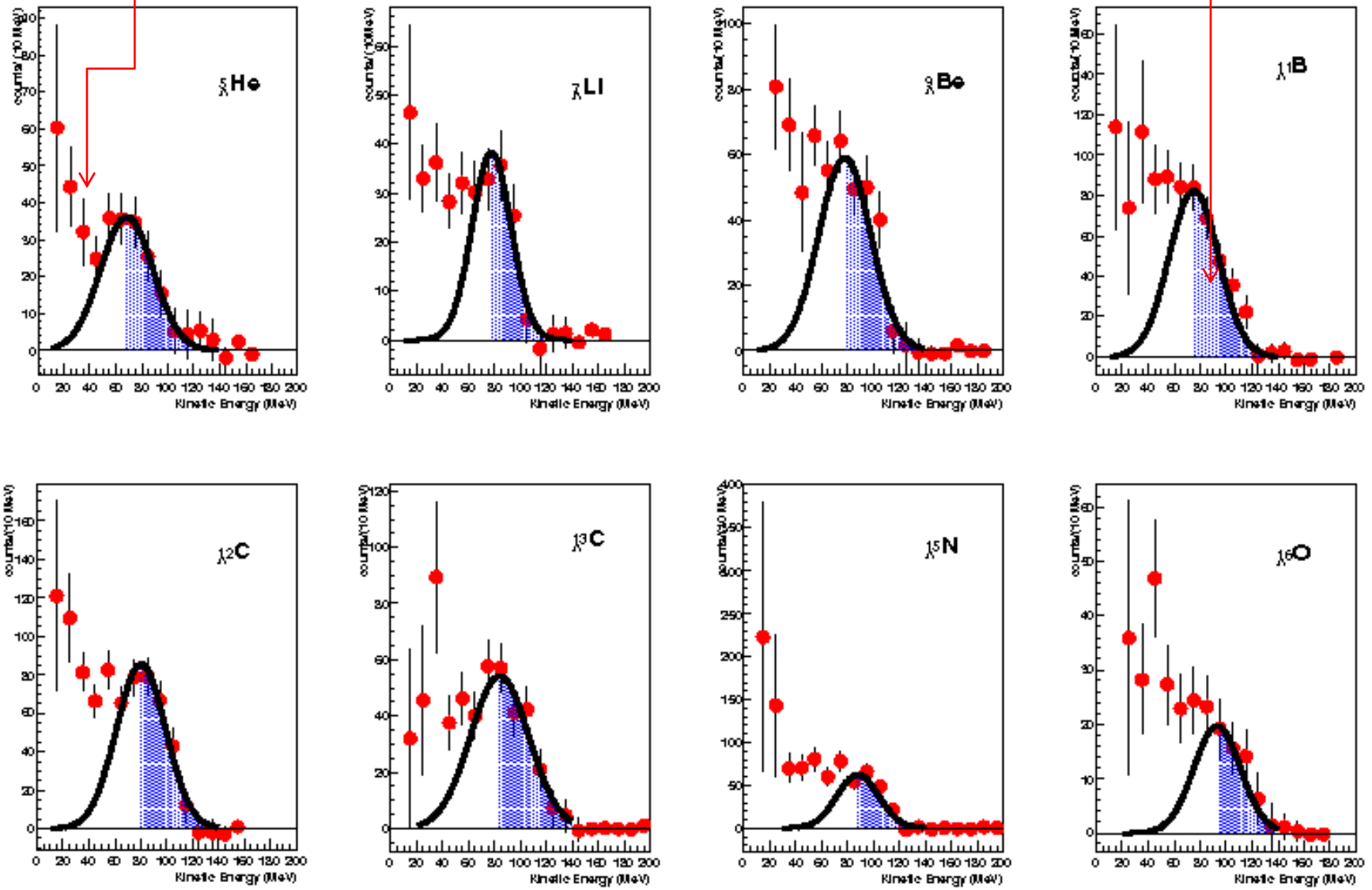
FINUDA

M. Agnello et al., NPA 804 (2008), 151

FINUDA NMWD: 1N ($\Lambda p \rightarrow np$), 2N ($\Lambda np \rightarrow nnp$) & FSI

A_{low} = 0.5 1N + 2N + $N_p^{FSI\text{-}low}$ | Q_{value}(1N): $T_p \approx 80$ MeV | A_{high} = 0.5 1N + $N_p^{FSI\text{-}high}$

Measured proton kinetic energy spectra

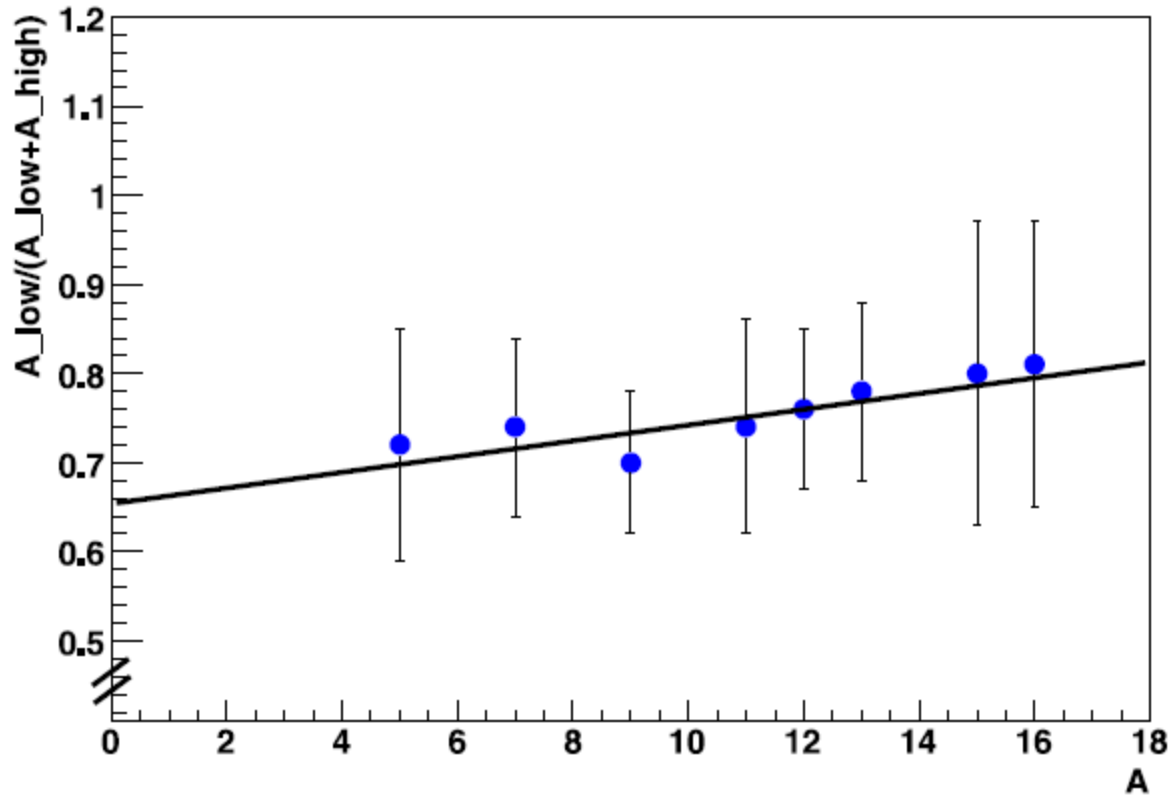


The **black line** is the gaussian fit of the spectra using the data above 80 MeV

NMWD: FSI & Anp evaluation

$$R \equiv \frac{A_{\text{low}}}{A_{\text{low}} + A_{\text{high}}}$$

$$= \frac{0.5N(\Lambda p \to np) + N(\Lambda np \to nnp) + N_p^{\text{FSI-low}}}{N(\Lambda p \to np) + N(\Lambda np \to nnp) + N_p^{\text{FSI-low}} + N_p^{\text{FSI-high}}}.$$



Using accepted assumptions and known results (from data and calculations), one gets, finally:

$$\frac{\Gamma_2}{\Gamma_p} = 0.43 \pm 0.25.$$

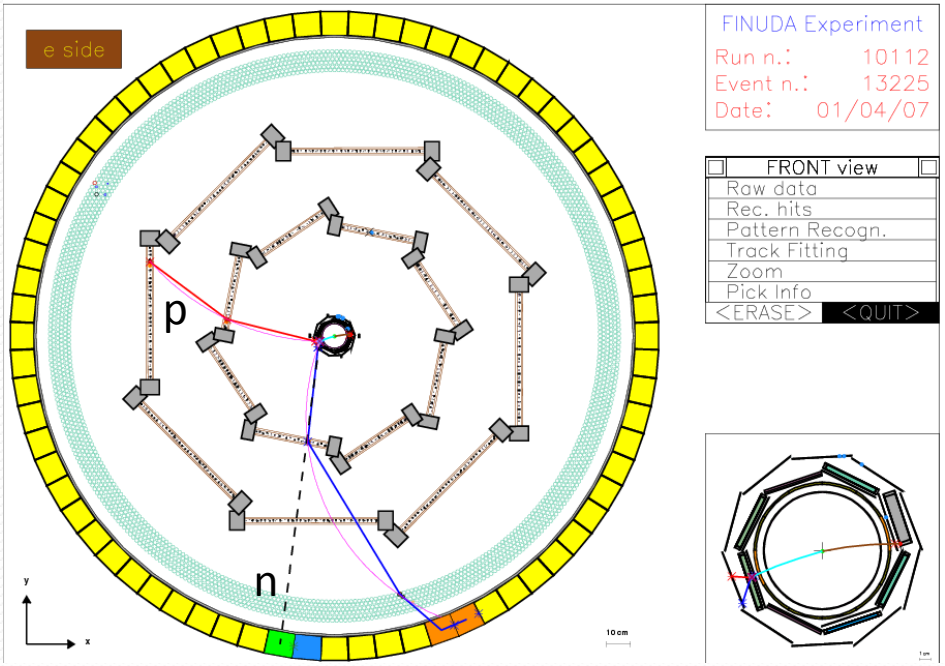
$$\frac{\Gamma_2}{\Gamma_{\text{NMWD}}} = 0.24 \pm 0.10.$$

FINUDA + G. Garbarino: Physics Letters B 685 (2010) 247–252

NMWD and neutrons in FINUDA

FINUDA has a 9% eff. to detect neutrons and is exploting this capability to deepen the study of NMWD

N(Λp → np)

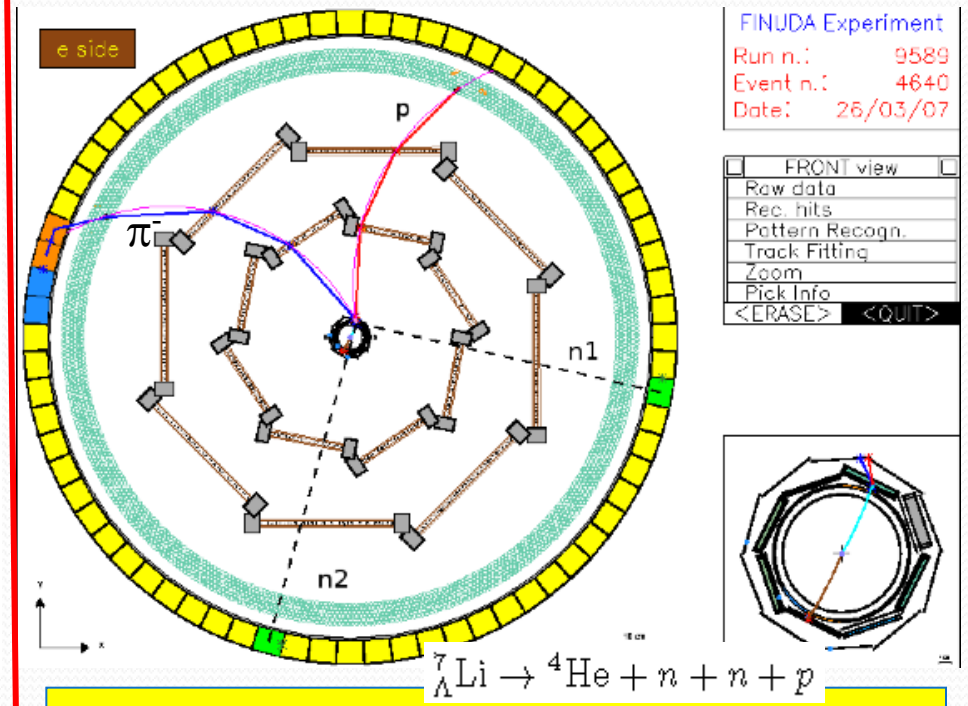


103 events seen:
Analysis of the data to evaluate the 1N contribution vs A : done

$\Gamma_2/\Gamma_p = 0.36 \pm 0.07$ [sys. (+0.04) -(0.03)]

$\Gamma_2/\Gamma_{NM} = 0.20 \pm 0.03$ [sys. (+0.02) -(0.01)]

N(Λnp→nnp)



$^{7}_{\Lambda}\mathrm{Li} \rightarrow {}^{4}\mathrm{He} + n + n + p$

3 events seen!
First experimental evidence of such a process.

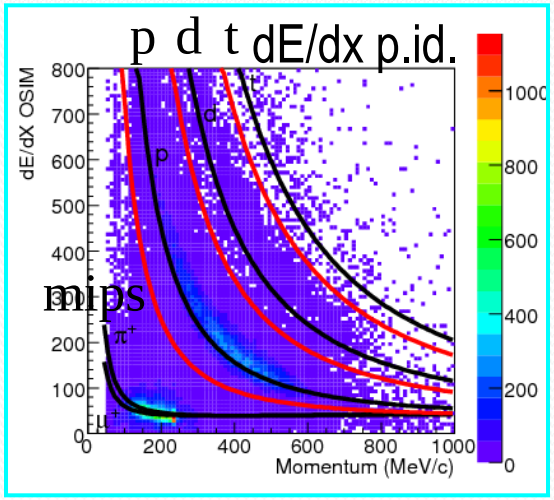
Analysis being finalized for submission to PLB

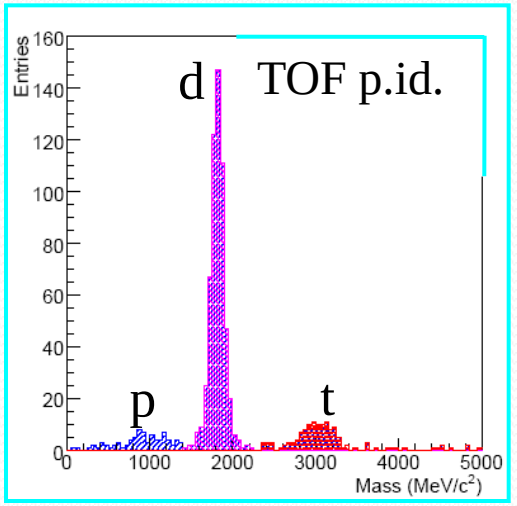
Light hypernuclei rare decays in FINUDA

Very few and sparse observations

New data from E549 (not published yet)

- large angular coverage (~4π)
- Excellent particle identification for charged hadrons
- Good momentum resolution
- Capability to fully reconstruct the event topologies
  - Set of several targets allowing the production of different hypernuclei and **hypernuclear fragments**





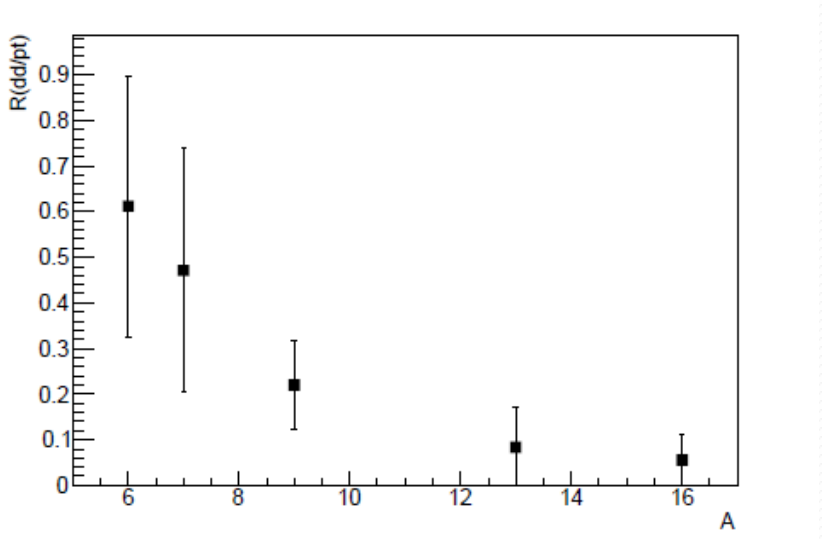
- **$^{4}_{\Lambda}$He hyperfragments** production, from all targets
  - $^{4}_{\Lambda}$He → dd
    - d momentum: 570 MeV/c
  - $^{4}_{\Lambda}$He → pt
    - p momentum: 508 MeV/c
- **$^{5}_{\Lambda}$He hypernucleus formation**
  - From ^{6}Li targets: **K^{-} ^{6}Li → $^{5}_{\Lambda}$He + p + π^{-}** (π^{-} momentum: 275.15 MeV/c)
  - From ^{7}Li targets: **K^{-} ^{7}Li → $^{5}_{\Lambda}$He + d + π^{-}**
  - NM two-body decay: $^{5}_{\Lambda}$He → dt
    - d momentum: 597 MeV/c

arXiv:10105616 nucl-ex 27 Oct 2010
submitted to PLB

${}^{4}_{\Lambda}\mathrm{He} \rightarrow$ d+d vs ${}^{4}_{\Lambda}\mathrm{He} \rightarrow$ p+t yields

target	*dd* Events	Yield $\times 10^{-5}/(K^-_{stop})$	*pt* Events	Yield $\times 10^{-5}/(K^-_{stop})$
^{6}Li	12 ± 3	$3.0 \pm 1.3_{stat} \pm 0.9_{sys}$	1 ± 1	< 16.8 (90%C.L.)
^{7}Li	7 ± 3	$2.4 \pm 1.3_{stat} \pm 0.8_{sys}$	1 ± 1	< 14.3 (90%C.L.)
^{9}Be	10 ± 3	$3.3 \pm 1.4_{stat} \pm 0.4_{sys}$	5 ± 2	$14.9 \pm 3.1_{stat} \pm 0.9_{sys}$
^{13}C	1 ± 1	< 2.3 (90%C.L.)	1 ± 1	< 30.5 (90%C.L.)
^{16}O	1 ± 1	< 2.7 (90%C.L.)	2 ± 1	$10.4 \pm 2.0_{stat} \pm 0.2_{sys}$

- Dominance of pt decay channel vs dd one
- Largest dominance for higher A (FSI?)

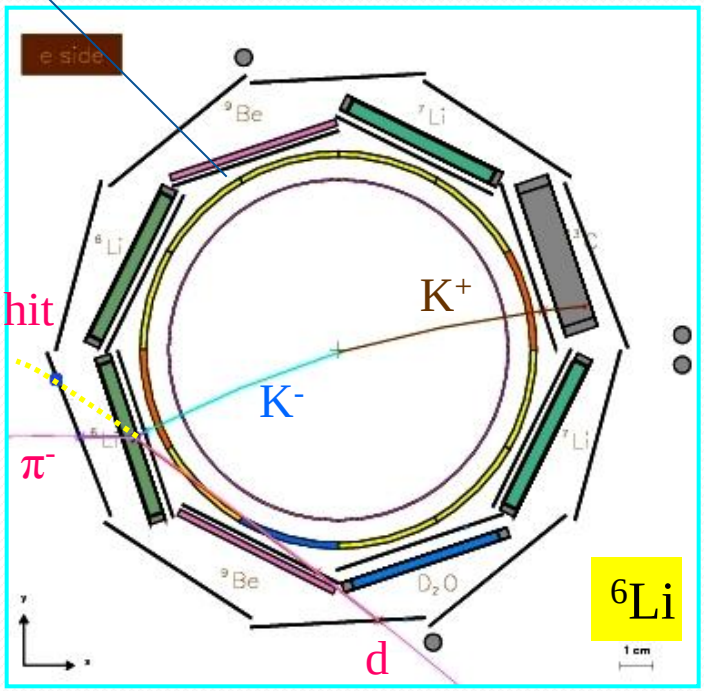


$^{5}_{\Lambda}$He → d + t (inclusive analysis)

- missing triton (597 MeV/c) – missing mass cut
- detected deuteron in the range (570-630) MeV/c
- π^- momentum signalling the $^{5}_{\Lambda}$He formation (267-273 MeV/c)
- large contribution from K2N $\Sigma^- p$ absorption: S/N > 0.20

target	Number of events	Yield $\times 10^{-4}/(K^-_{stop})$
^{6}Li	4 ± 2	$1.83 \pm 0.93_{stat} \pm 0.12_{sys}$
^{7}Li	5 ± 2	$1.12 \pm 0.51_{stat} \pm 0.08_{sys}$
^{9}Be	13 ± 4	$1.23 \pm 0.38_{stat} \pm 0.02_{sys}$
^{13}C	7 ± 3	$2.25 \pm 0.87_{stat} \pm 0.04_{sys}$
^{16}O	11 ± 3	$1.58 \pm 0.50_{stat} \pm 0.03_{sys}$

$^{5}_{\Lambda}$He → d + t ("exclusive")



3 events from "exclusive" analysis

- d+π^- detection
- High energy release from triton on opposite silicon detectors
- 3 good events found
  - 1x ^{6}Li, 2x ^{7}Li
  - No background (no good events in side bins)
  - Branching ratio:
    - $(2.8 \pm 1.4) \times 10^{-3}$
    - O(1/100) ordinary NM branching ratio

K^- absorption by few nucleons in nuclei

- Absorption by few nucleons (with Λ, Σ detection)
  - **Two** nucleon absorption
    - **K^-(2N)** $\rightarrow$ **NY** $\Rightarrow$ $K^-A \rightarrow \Lambda(\Sigma)\, pX$, $K^-A \rightarrow \Lambda(\Sigma)\, n\, X$
  - **Three** nucleon absorption
    - **K^-(3N)** $\rightarrow$ **NNY** $\Rightarrow$ $K^-A \rightarrow \Lambda(\Sigma)\, d\, X$
  - **Four** nucleon absorption
    - **K^-(4N)** $\rightarrow$ **NNNY** $\Rightarrow$ $K^-A \rightarrow \Lambda(\Sigma)\, t\, X$

Relevant processes for the study of possible kaon-nucleons bound clusters

$\Rightarrow$ with FINUDA the study of different absorption features on nuclei of different A was possible

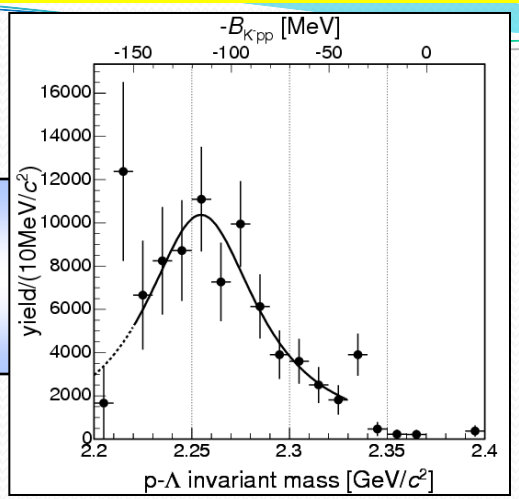
Λ "high momentum" component related to the most interesting findings

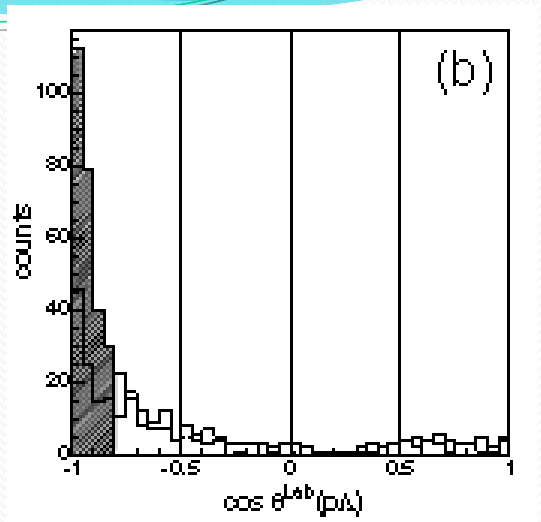
A(K⁻,Λp)X

(A: 2x ^{6}Li + 1x ^{7}Li + 3x ^{13}C)

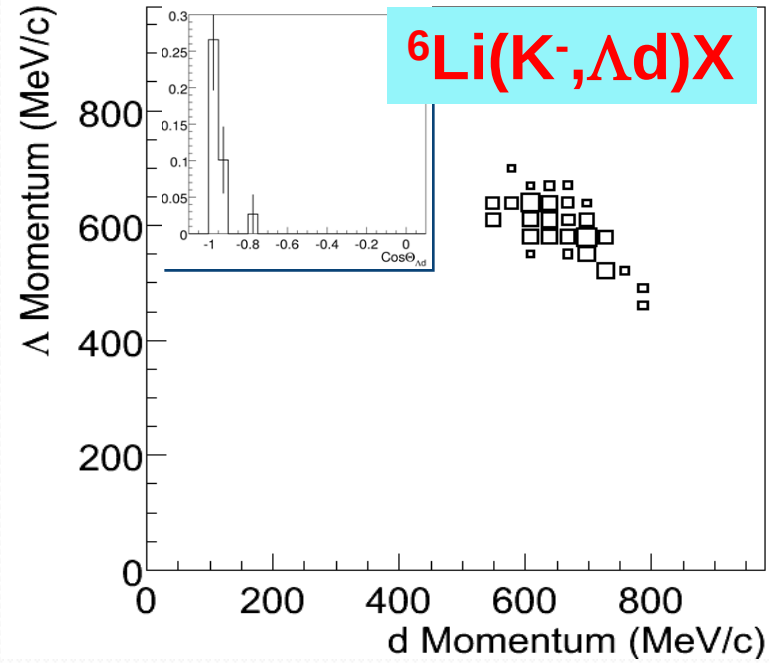
B = 115^{+6}_{-5}(stat)$^{+3}_{-4}$(sys) MeV
Γ= 67^{+14}_{-11}(stat)$^{+2}_{-3}$(sys) MeV
Yield ≈ 0.1%/stopped K⁻

FINUDA Coll., PRL 94 (2005) 212303



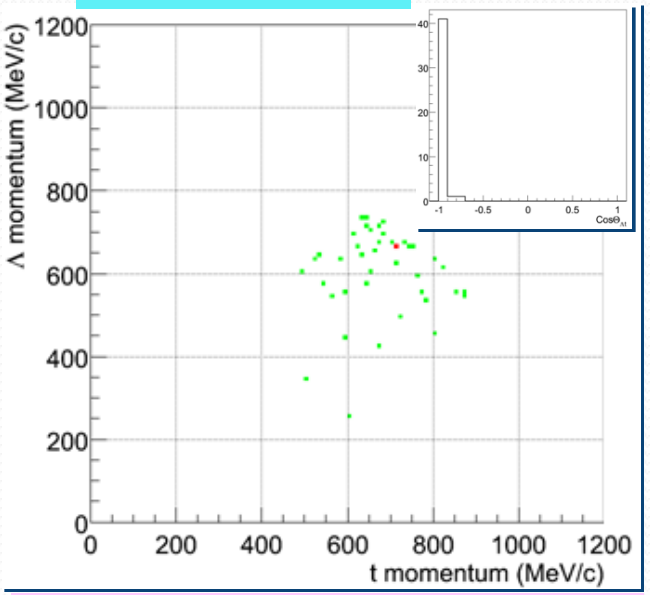


^{6}Li(K⁻,Λd)X



FINUDA Coll., PLB 654 (2007) 80

A(K⁻,Λt)X



FINUDA Coll., PLB 669 (2008) 229

The new data confirm the previous FINUDA findings

A(K⁻,Λp)X

2006-07 data

2003-04 data

The much higher statistics of the 2006-07 data taking respect to the 2003-04 allows to study separately the single nuclei. This increase is not only due to higher Integrated Luminosity, but also to the inclusion, thanks to the improved reconstruction algorithm, of the "short tracks" → *new calculation of the acceptance needed*.

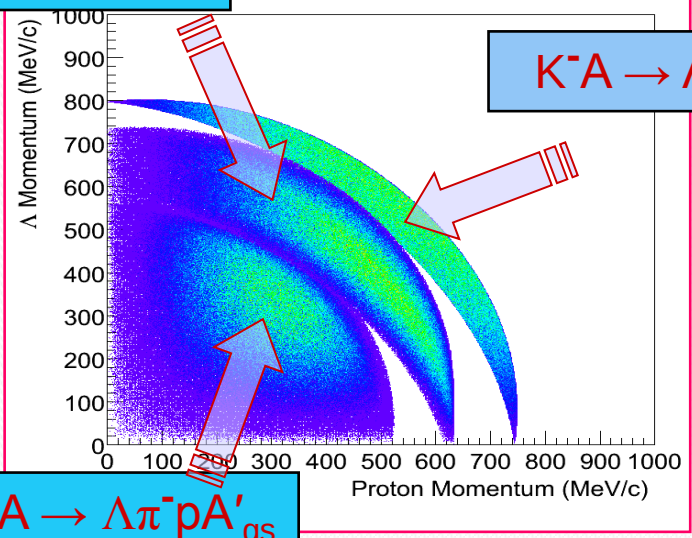
The increased statistics and the develpment of a sophisticated MC simulation of the involved physical processes allow to disentangle also the different reaction channels contributing to the measured spectra.

→ possibility to perform ***missing mass analysis***

(K^-_{stop},Λ) absorption by one or more nucleons

Phase space simulation: $K^-_{stop}{}^6Li$

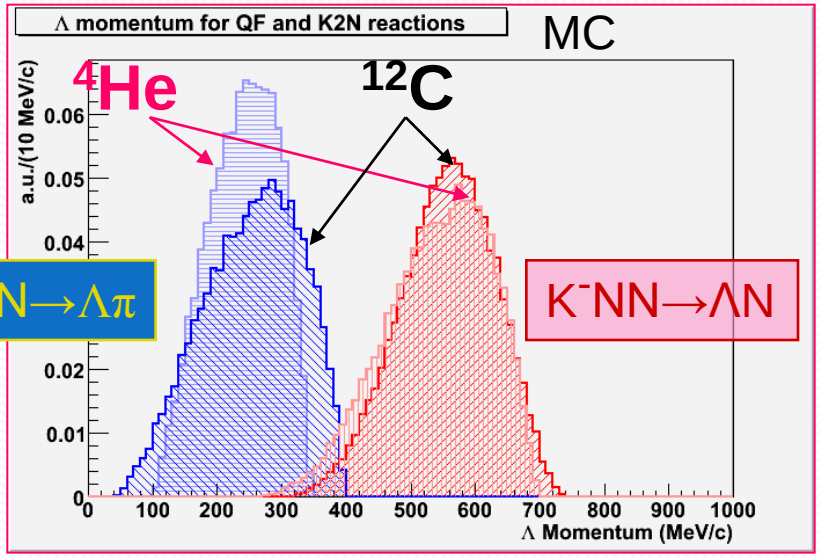
$K^-A \rightarrow \Sigma^0 pA'_{gs}$
$\Sigma^0 \rightarrow \Lambda\gamma$



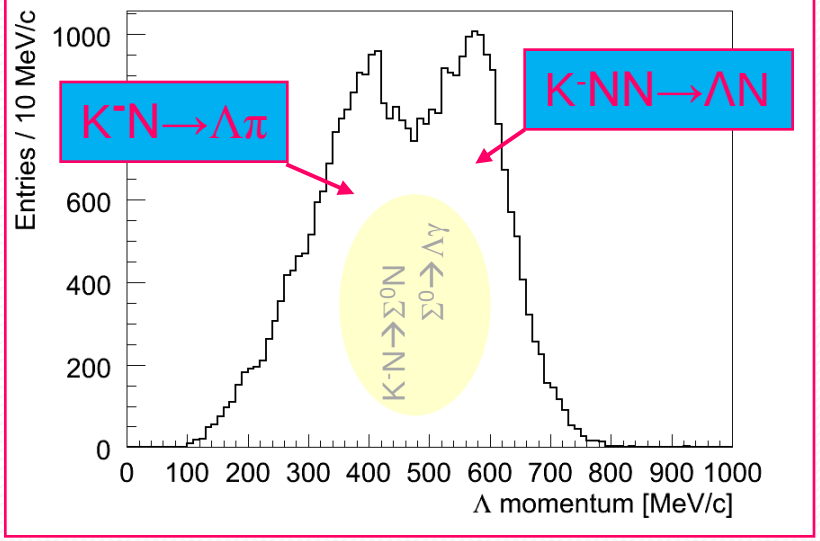
$K^-A \rightarrow \Lambda pA'_{gs}$

$K^-A \rightarrow \Lambda\pi^- pA'_{gs}$

Pionless reactions: emission of **high momentum nucleons** (or light nuclei) and **hyperons**

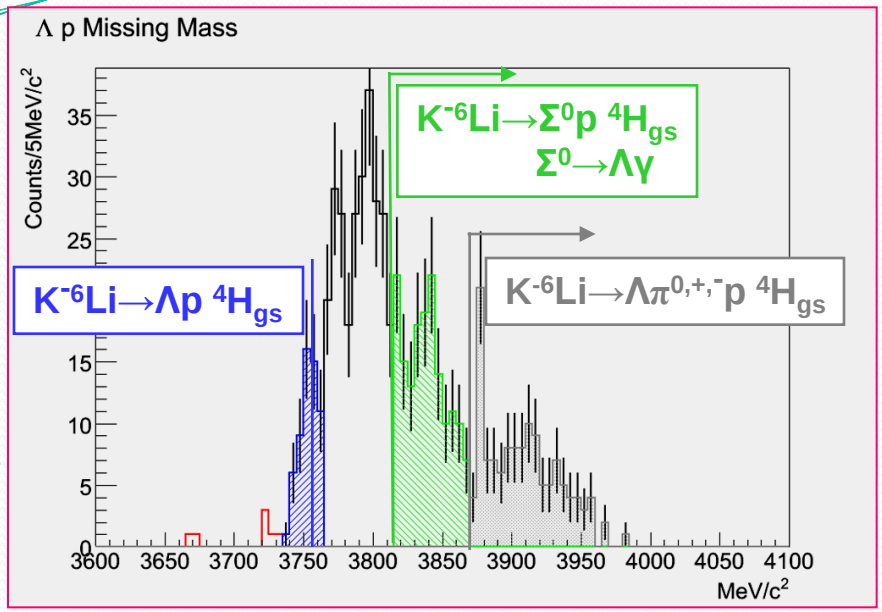


FINUDA **DATA**: $K^-_{stop}\ ^6Li \rightarrow \Lambda X$

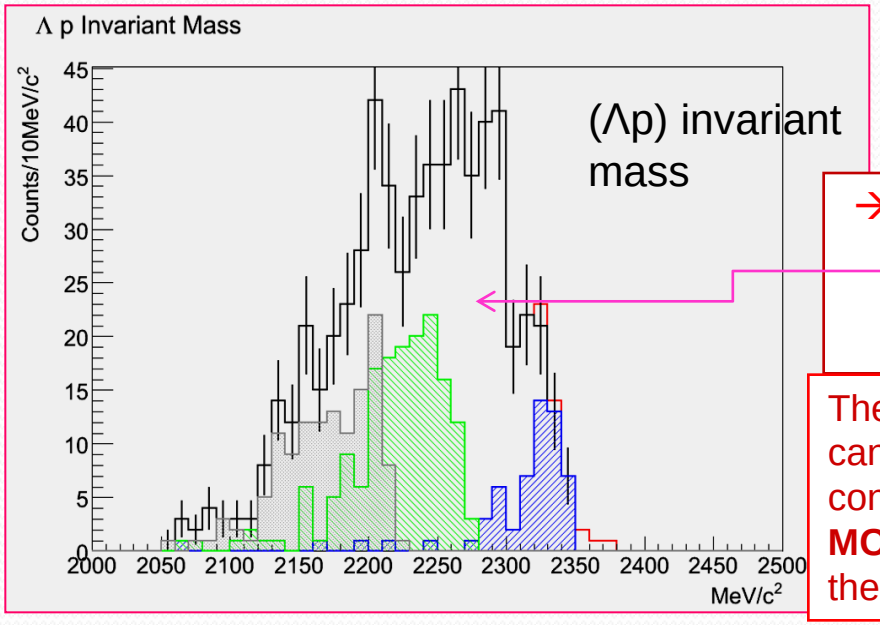


$^{6}Li(K^{-}_{stop}, \Lambda p)X$

Different final states can be disentangled through missing mass study



not acceptance corrected

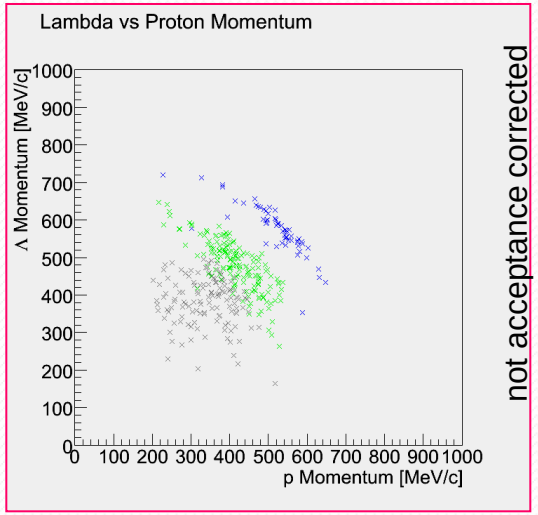


not acceptance corrected

QF-2NA
$K^{-}A \rightarrow \Lambda p\ X$

QF-2NA
$K^{-}A \rightarrow \Sigma^{0} p\ X$

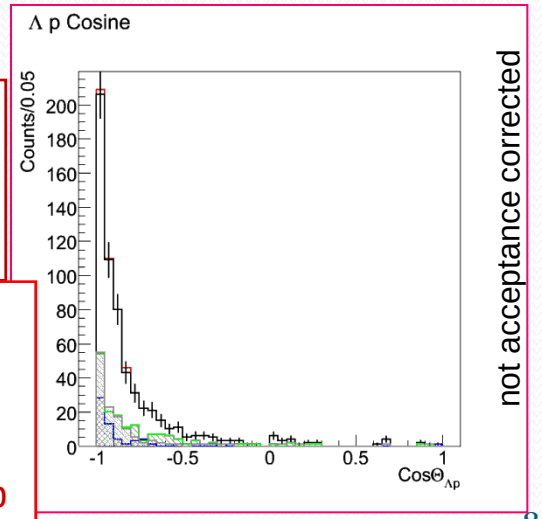
QF-2NA
$K^{-}A \rightarrow \Lambda \pi p\ X$



not acceptance corrected

→ Only a small fraction of the **bump** can be associated to **K^{-} $pp \rightarrow \Sigma^{0} p \rightarrow \Lambda\gamma$**

The Missing Mass selection cannot exclude $\Sigma N \rightarrow \Lambda N$ conversion reactions: but **MC** simulations rule-out their contribution to the bump



not acceptance corrected

Alternative interpretations of Λp bump

- K-pp→[K-pp]→Λp: [K-pp] bound state (FINUDA)
- ~~QF-TNA K-pp→Λp followed by FSI (Magas et al.)~~
- ~~Dominance of Σ^0 production over Λ:~~
  ~~QF-TNA K-pp→Σ^0p followed by $\Sigma^0 \rightarrow \Lambda\gamma$ decay~~
- ~~QF-TNA K-NN→ΣN followed by ΣN→ΛN conversion reaction:~~

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

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

~~$K^-A \rightarrow \Sigma^{0,-}pX$~~
~~$\Sigma^0 n \rightarrow \Lambda n$~~
~~$\Sigma^- p \rightarrow \Lambda n$~~

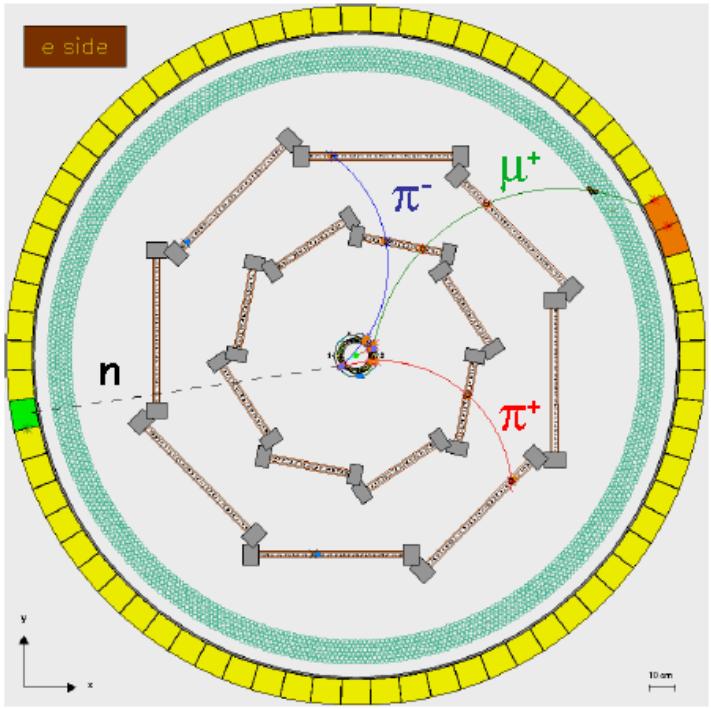
- Decay of heavier kaonic nuclei (Mares, Friedman, Gal)

Similar conclusions for the Λd case

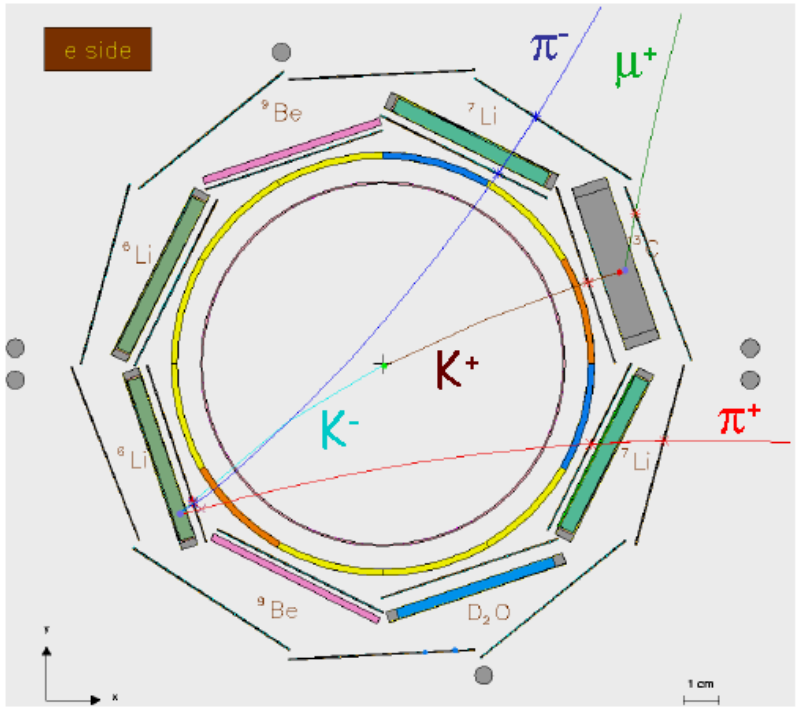
Σ^+, Σ^- selection in FINUDA

Topology of a $n\pi^+\pi^-$ event

FINUDA spectrometer



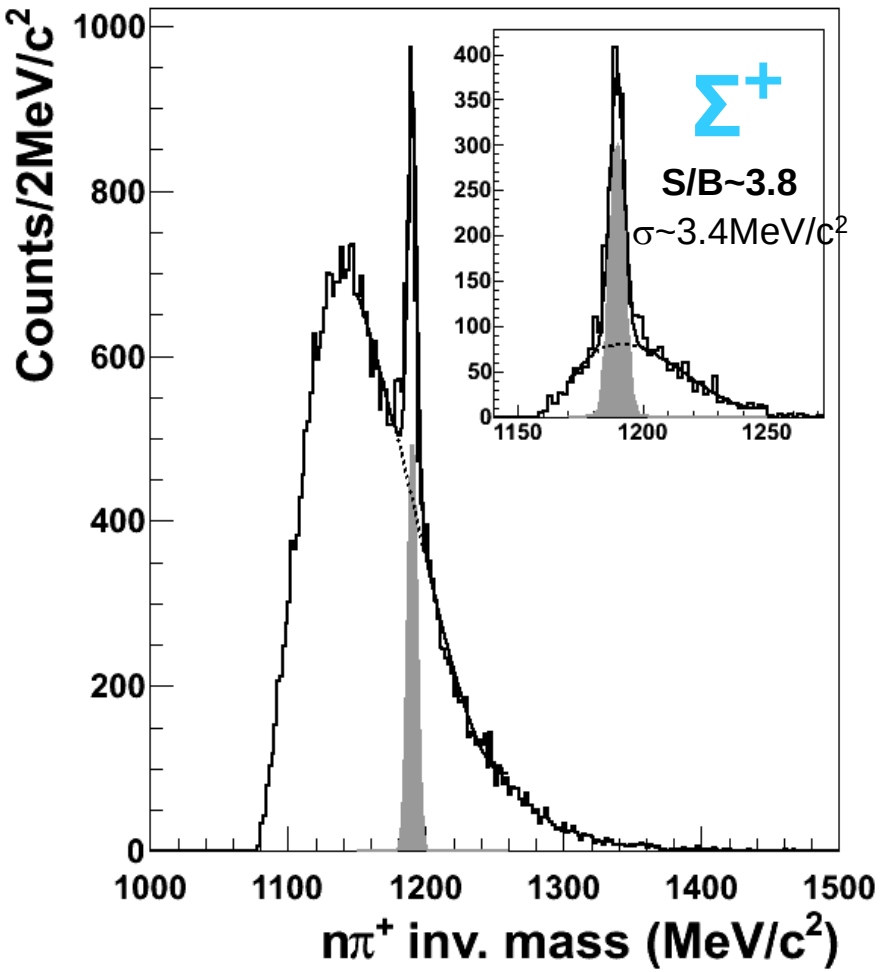
Central region

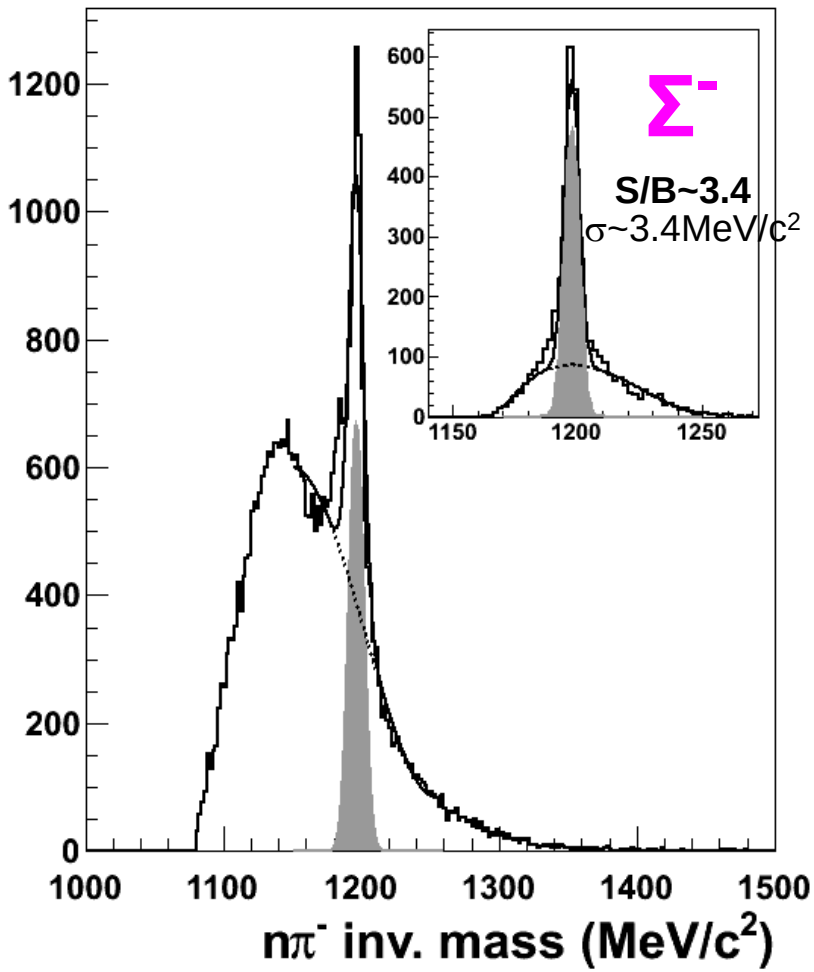


$$\mu^+ \nu \leftarrow K^+ \leftarrow \Phi \rightarrow K^- A \rightarrow \pi^- \; \pi^+ n \; A'$$

Σ^- Σ^+

Σ^- and Σ^+ identification in K^- ^{6}Li $\Rightarrow$ $(n\pi^+\pi^-)X$ events

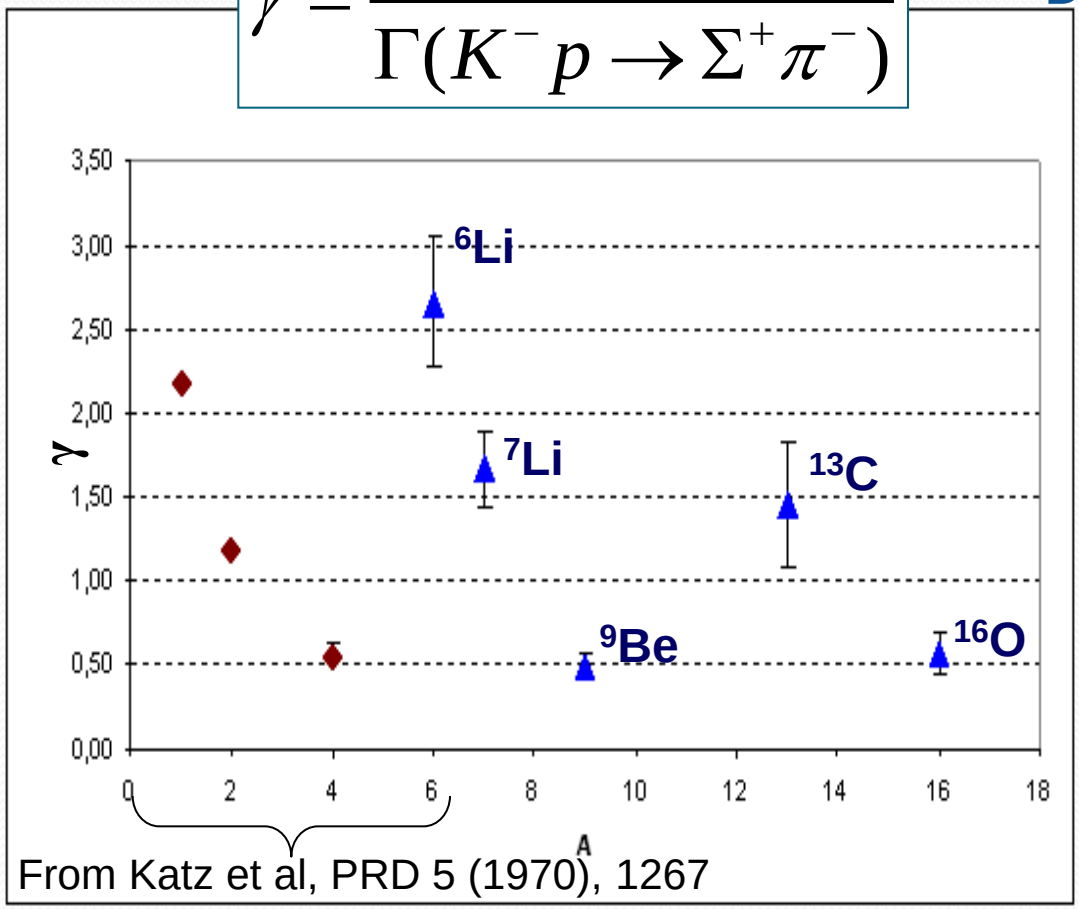




The insets are obtained after applying selection cuts (angular and momentum correlations, track quality, missing mass criteria…)

$(\Sigma^-\pi^+)$ vs $(\Sigma^+\pi^-)$ QF production strength

$$\gamma = \frac{\Gamma(K^- p \to \Sigma^- \pi^+)}{\Gamma(K^- p \to \Sigma^+ \pi^-)}$$



From Katz et al, PRD 5 (1970), 1267

Dominance of $\Sigma^+\pi^-$ QF production channel over $\Sigma^-\pi^+$ on all targets

- Expected value for K^-p at threshold (integrated on all decay channels):

  $\gamma = (2.36 \pm 0.04)$
- Sizeable in-medium interactions: $\Sigma^-p \to \Lambda n$
- The Σ^+ "feels" less the nuclear medium (decay at rest)
- Larger in-medium interaction (conversion reactions) of Σ^- in heavier nuclei

- Acceptances of the two channels largely factorize away:

(same $n\pi^+\pi^-$ sample) & different nuclei measured simultaneously

Acceptance calculations are anyway running to finalize the results

FINUDA: the time evolution

1993 FINUDA experiment proposal (preprint LNF-93/021, 11 May 1993)

.....

2003-04 FINUDA 1st data taking (200 pb^{-1} integrated luminosity)

2006-07 FINUDA 2nd data taking (968 pb^{-1} integrated luminosity)

2008 FINUDA 3rd data taking proposed for 2009 (1 fb^{-1} integr. lum.)

The proposed 3rd data taking could not find room in the LNF planning nor in 2009 nor in a foreseable future

As a consequence, at beginning of 2009, the Collaboration took the decision to de-commission the experiment

CONCLUSIONS

Hypernuclear Physics
- Spectroscopy
- Decay

Data analysis completed & results published

K^-_{stop} absorption on multinucleons clusters in nuclei
- Λ
- $\Sigma^{\pm}$

Data analysis completed.
Calculations running for acceptance corrections

In overall, **close to *100%*** of the original *FINUDA* program in hypernuclear physics was succesfully completed. New, unforeseen, reactions could also be studied and original results obtained: in this respect, it can be said that *FINUDA* ***opened the path*** for new experiments.