π^- - hyperon momentum correlations : New perspectives for charged channels

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Advanced studies in the low – energy QCD in the strangeness sector and possible implications in astrophysics

Dedicated to the memory of Paul Kienle

19-21 June 2013 Laboratori Nazionali di Frascati

Scientific case

Charged chanels $\Sigma^+\pi^-$ / $\Sigma^-\pi^+$ investigation :

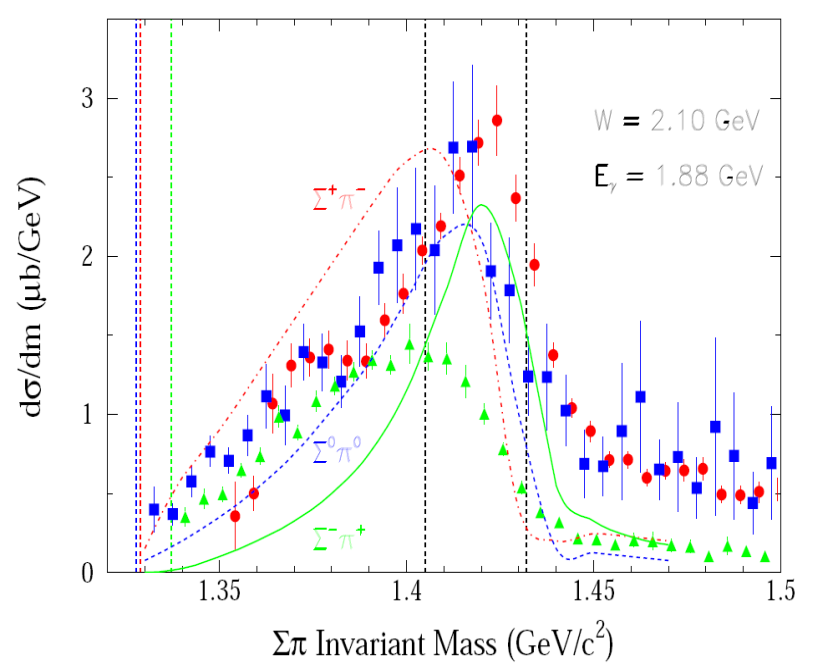
- important test of the isospin mixing in the invariant mass lineshape

$$\frac{d\sigma(\Sigma^-\pi^+)}{dM} \propto \frac{1}{3}|T^0|^2 + \frac{1}{2}|T^1|^2 + \frac{2}{\sqrt{6}}Re(T^0T^{1*})$$

$$\frac{d\sigma(\Sigma^0\pi^0)}{dM} \propto \frac{1}{3}|T^0|^2$$

$$\frac{d\sigma(\Sigma^+\pi^-)}{dM} \propto \frac{1}{3}|T^0|^2 + \frac{1}{2}|T^1|^2 - \frac{2}{\sqrt{6}}Re(T^0T^{1*})$$

K. Moriya, et al., (Clas Collaboration) Phys. Rev. C 87, 035206 (2013)



- branching ratio modifications in different nuclear targets and possible BR(ρ) modifications as a test of the Λ(1405) nature

(L. R. Staronski, S. Wycech, Nucl. Phys. 13 (1987) 1361, A. Ohnishi et al., Phys. Rev. C 56 5 (1997) 2767, E. Friedman, A. Gal, arXiv:1211.6336v3 [nucl-th] 2013)

If the s-wave, I=0, Λ(1405) state has an N bound state component

(R.H. Dalitz et al., Phys. Rev. 153, 1617 (1967), P.B. Siegel & W. Weise, Phys. Rev. C 38, 2221 (1988))

an upward shift of the Λ(1405) mass is expected.

Moreover ...

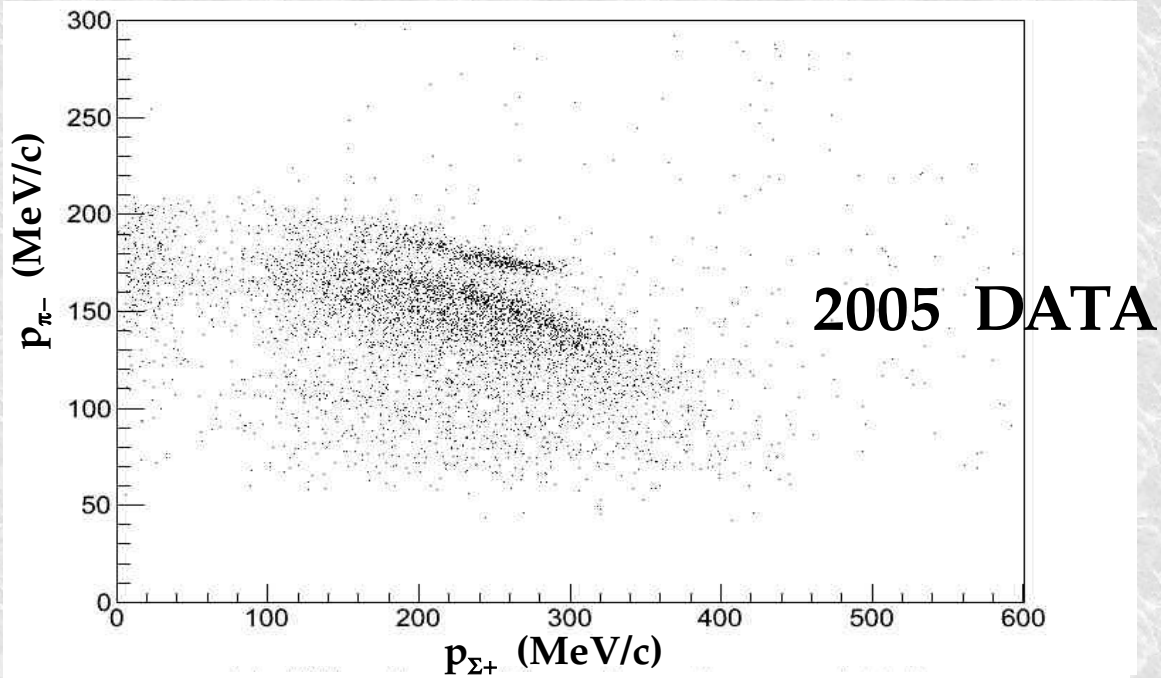
…

Thanks to the excellent resolution of the KLOE Drift Chamber (DC) for charged pions momentum new fascinating perspectives are opened:

- Possibility to clearly disentangle the different nuclear targets in KLOE materials
- Clear separation of at-rest from in-flight absorptions in direct Σ/Λ N production → tool to separate resonant from non-resonant production
- Evidence for internal conversion $\Sigma n \rightarrow \Lambda n'$ events → possibility to measure conversion rate in different nuclear targets

$\Sigma^+ \pi^-$ channel

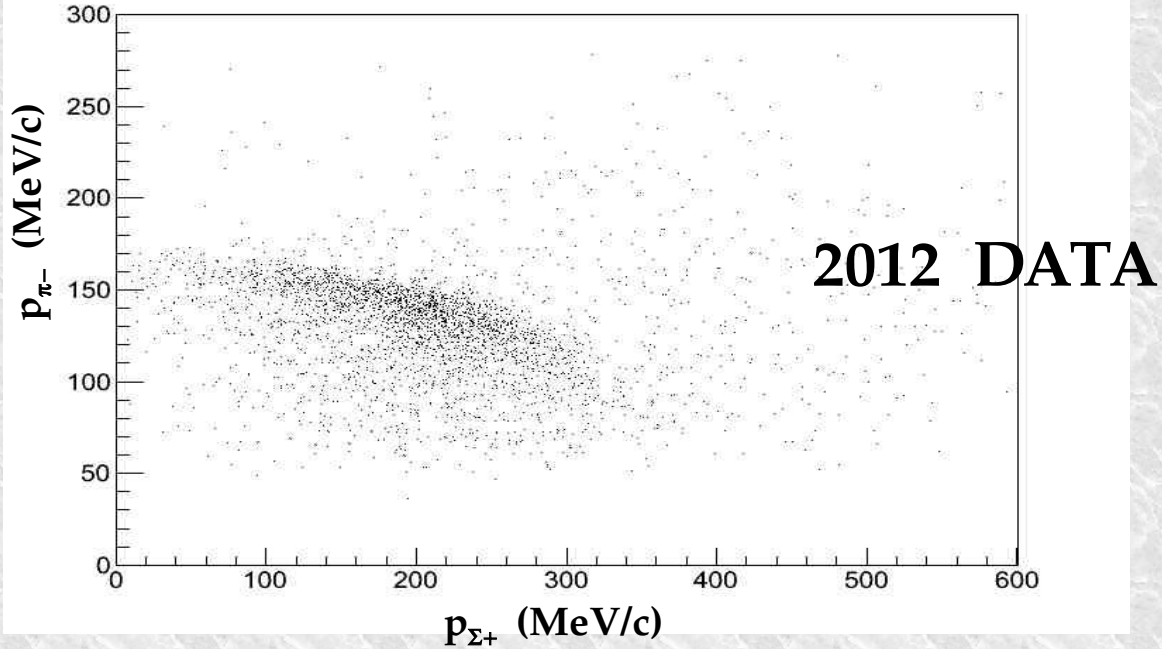
$K^- p \rightarrow \Sigma^+ \pi^-$ detected via: $(p\pi^0)\ \pi^-$



2005 DATA

In the DC entrance wall K^-H and K^-C

Absorptions can be clearly distinguished



2012 DATA

in-flight components evidenced by the excellent $p_{\pi-}$ resolution

In 2012 data only K^-C at rest reactions remain ...

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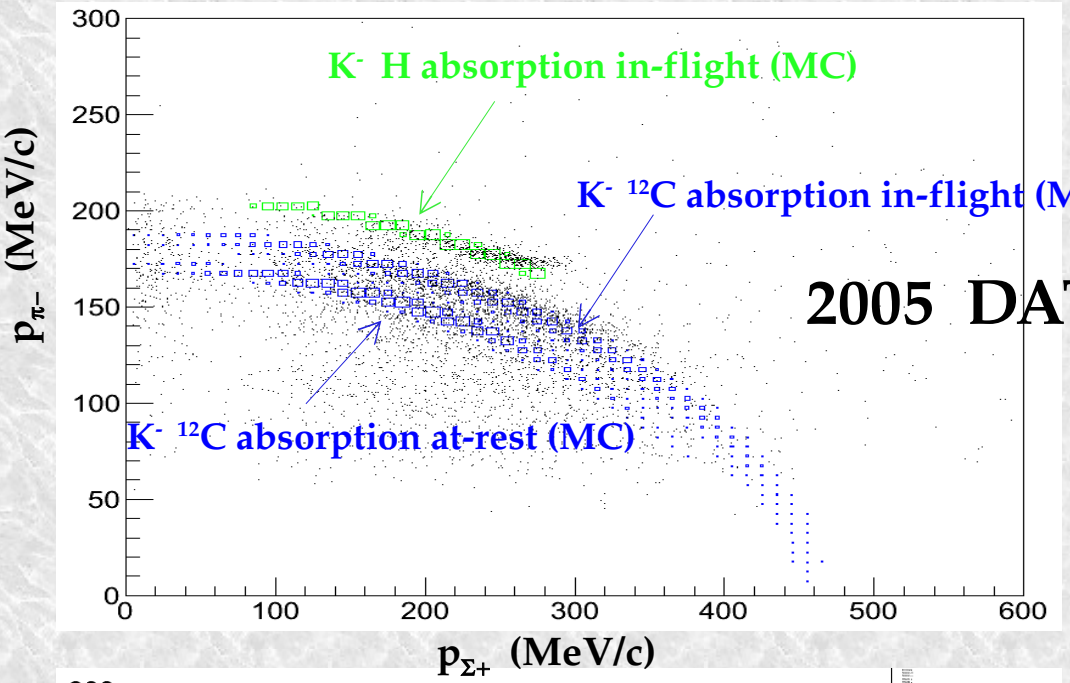

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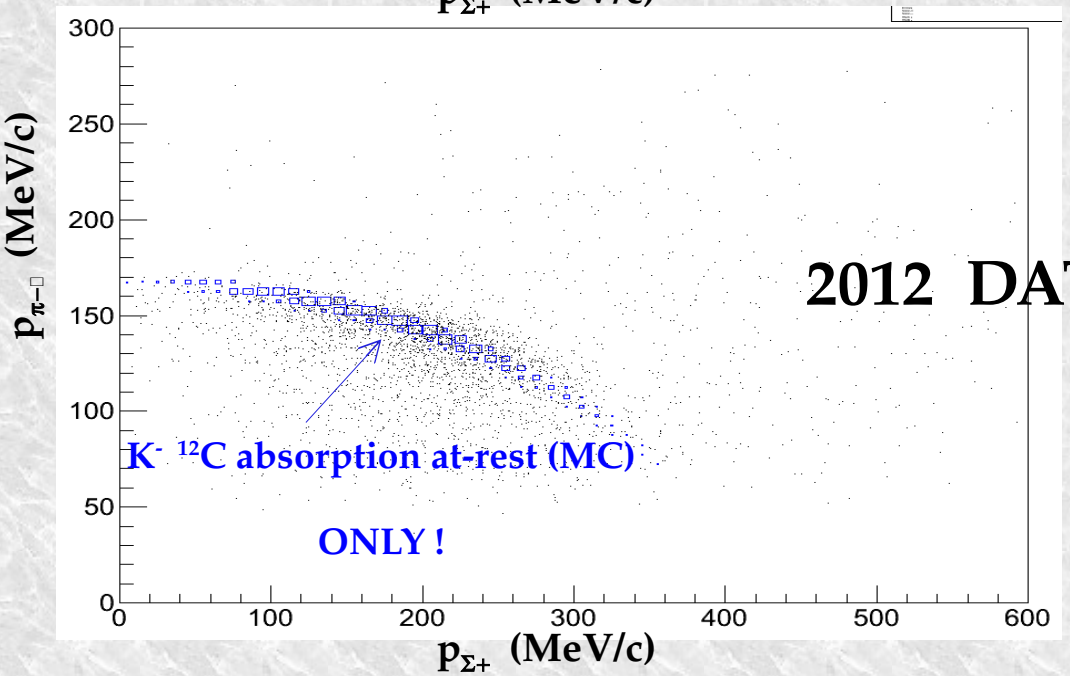

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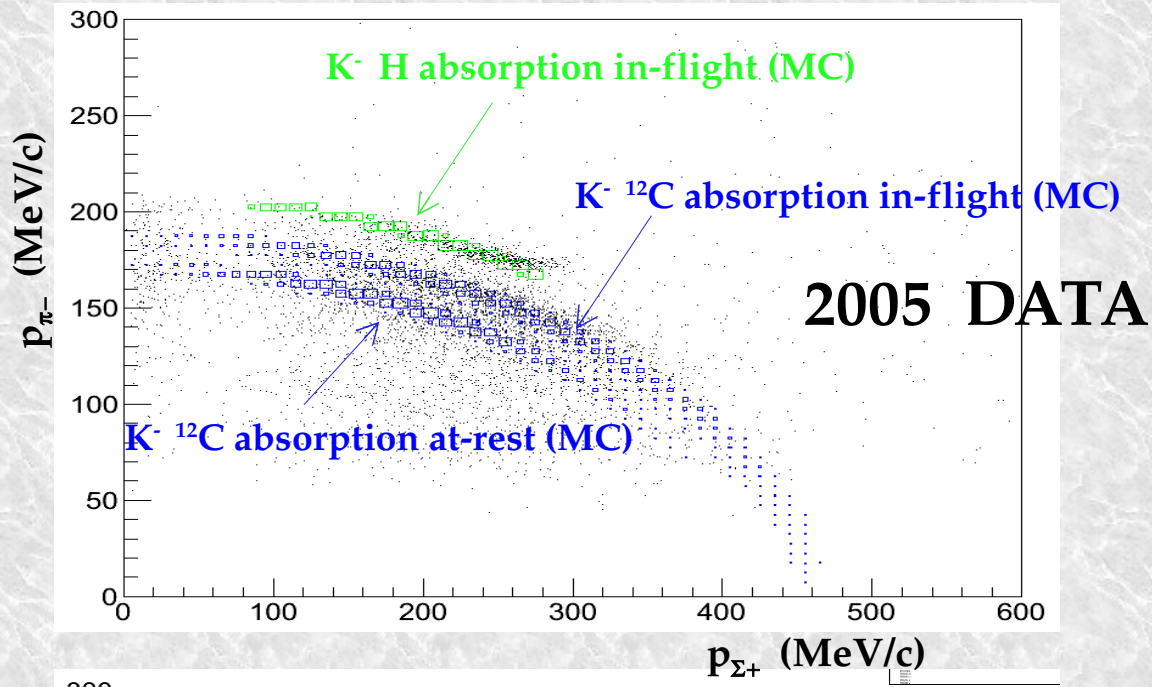
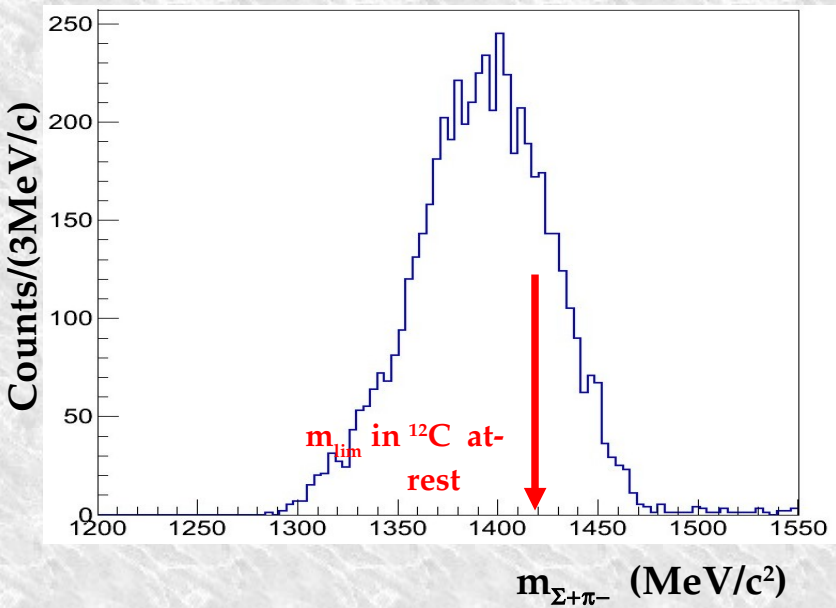
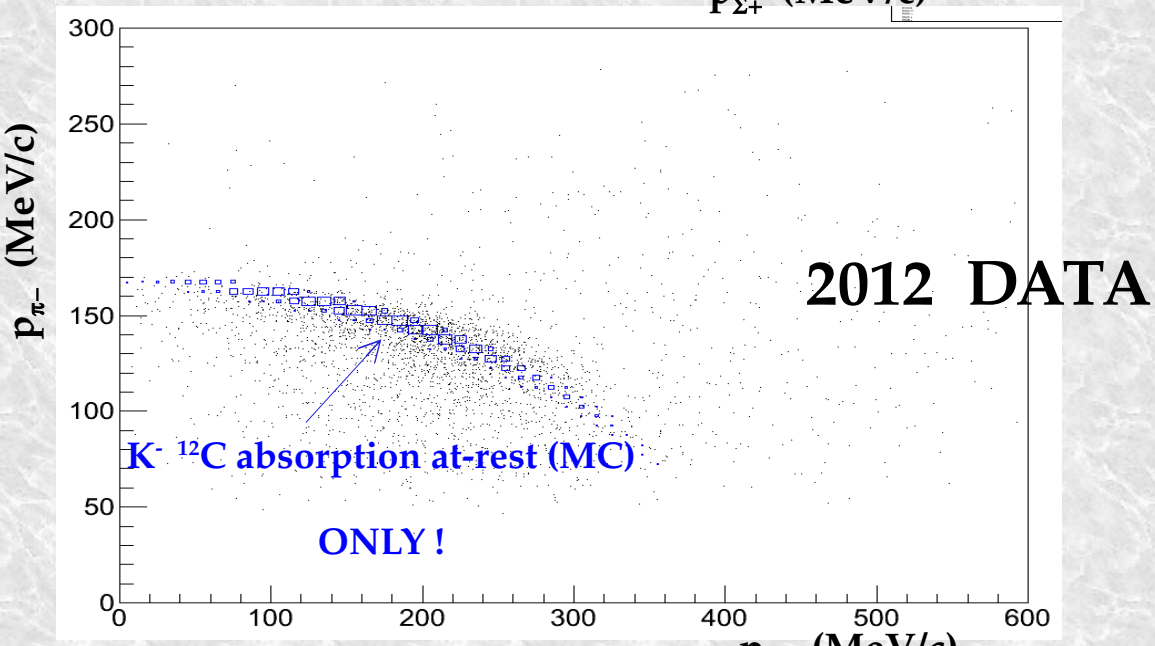
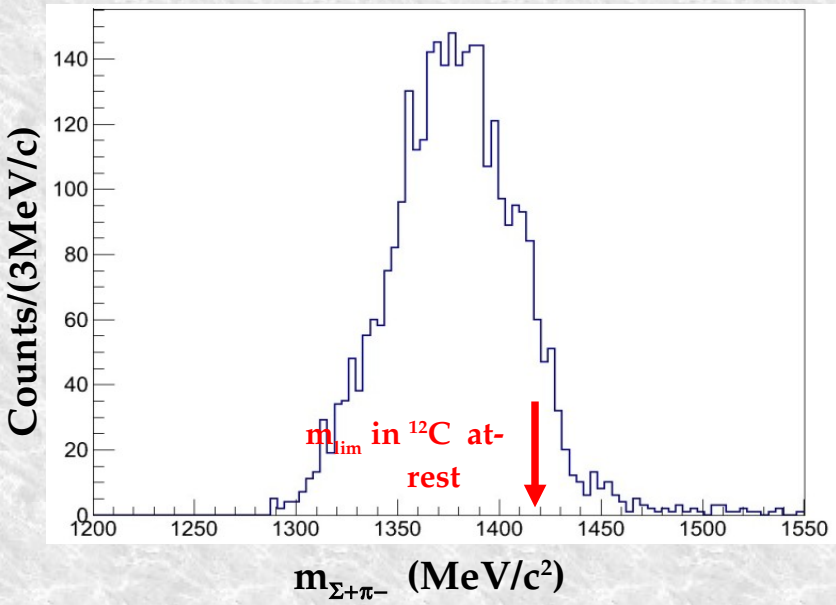


2005 data

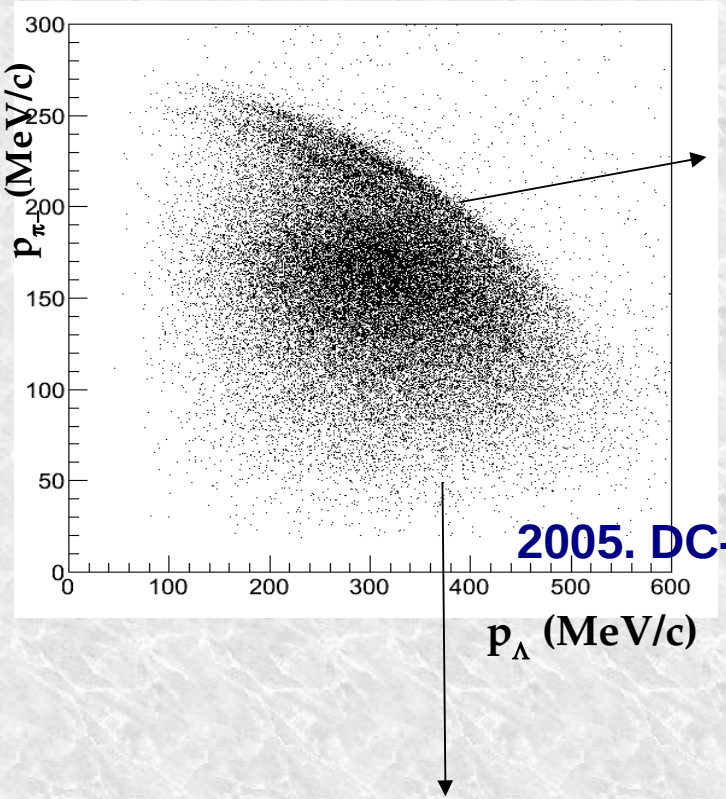




2012 Carbon target



Σ / Λ conversion in nuclear medium

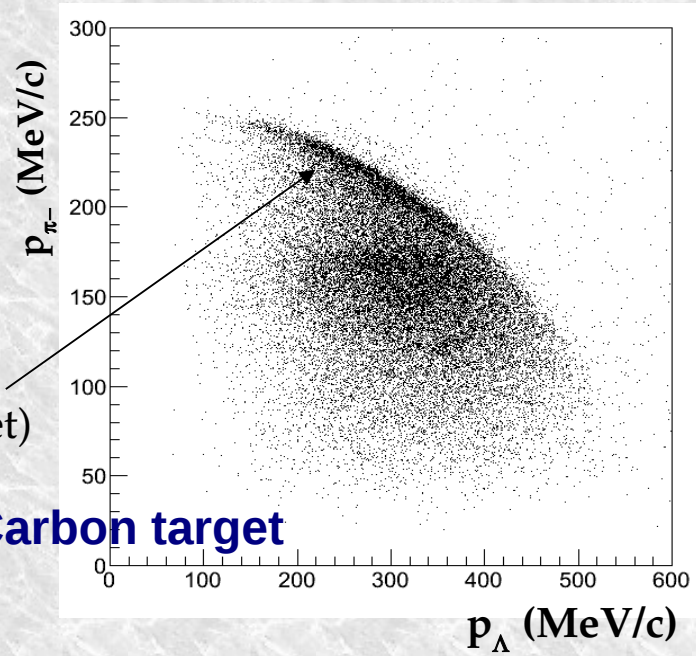


Direct formation $K^- n \rightarrow \Lambda\pi^-$

Clearly visible the 2 bands:

- **in flight**
- **at rest**

(only events at rest in Carbon Target)



2005. DC-wall carbon

2012 Carbon target

2 step process: $\Lambda\pi^-$

production follows Σ^+ / Σ^0 **production**

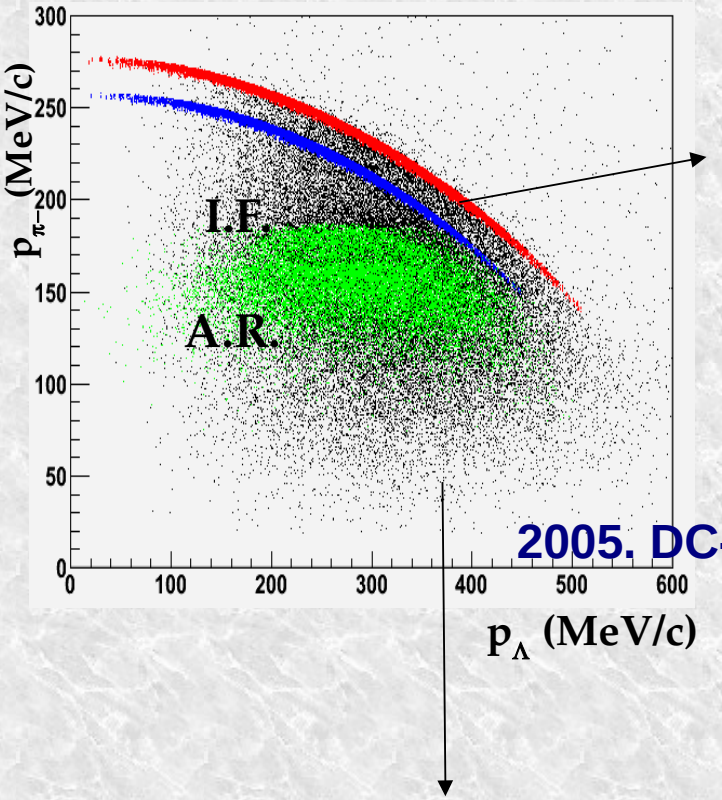
Main contribution from internal conversion

$K^- p \rightarrow \Sigma^+\pi^-$, $\Sigma^+ n \rightarrow \Lambda p$

- The data in this channel is of great value to confirm the predicted branching ratio modifications in medium

- Σ/Λ internal conversion rates can be obtained as well in function of Z

Σ / Λ conversion in nuclear medium



Direct formation $K^- n \rightarrow \Lambda\pi^-$

Clearly visible the 2 bands:

- **in flight**
- **at rest**

(only events at rest in Carbon Target)

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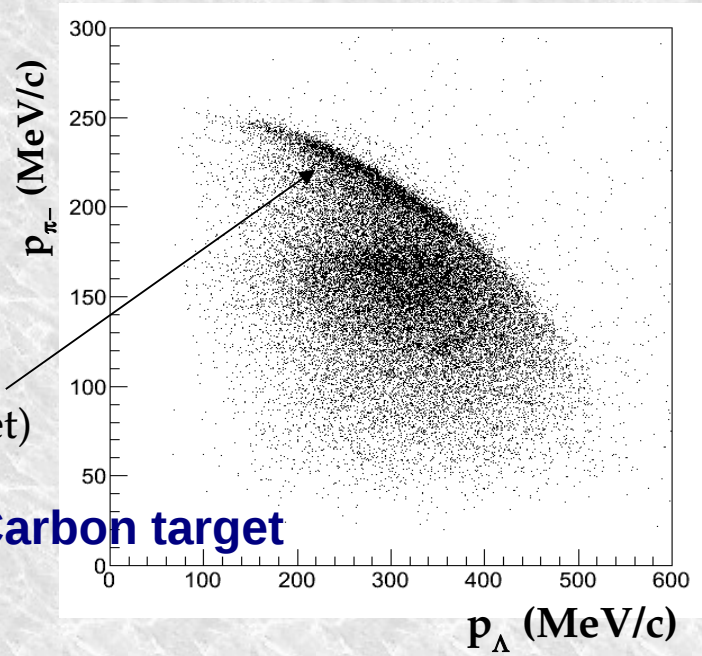

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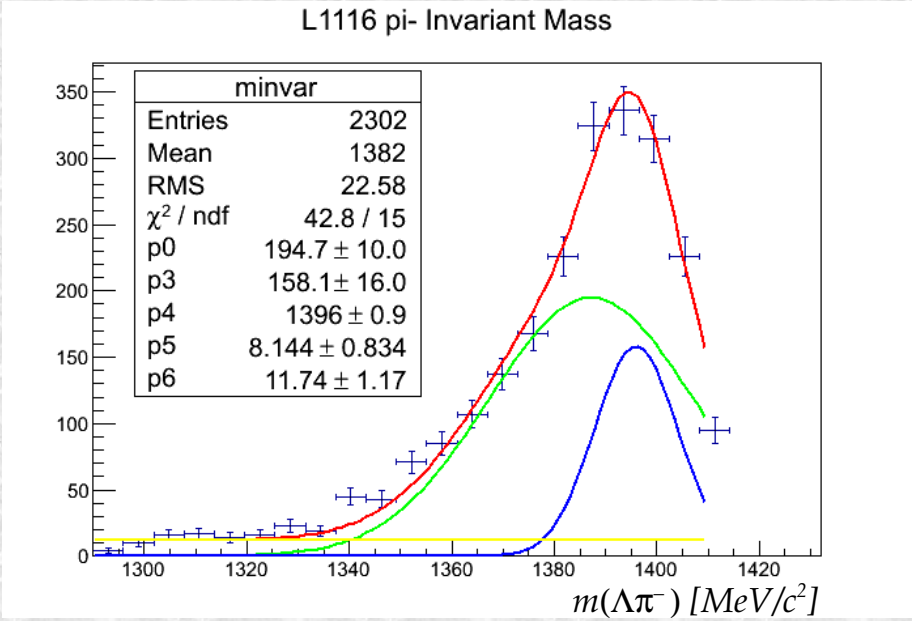
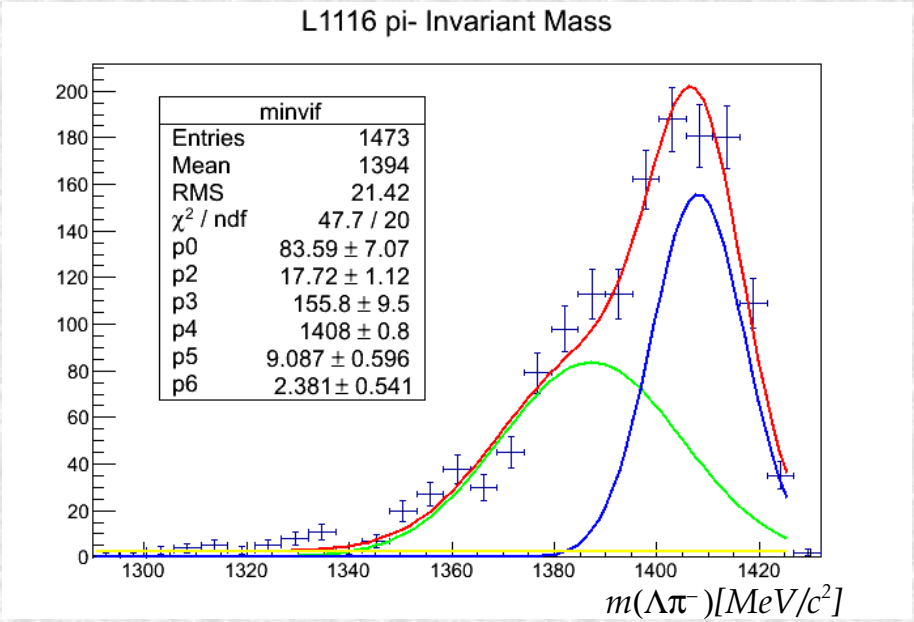
$K^- \ ^{12}C \rightarrow \Lambda(1116)\pi^- + \ ^{11}C$
resonant & non-resonant contribution

Very preliminary





at - rest

resonant ~ 73%

non - resonant ~ 27%

full fit

res $(\Sigma^{*-}(1385))$

non – res $(\Lambda(1116)\pi^-)$

non – res misidentification bkg

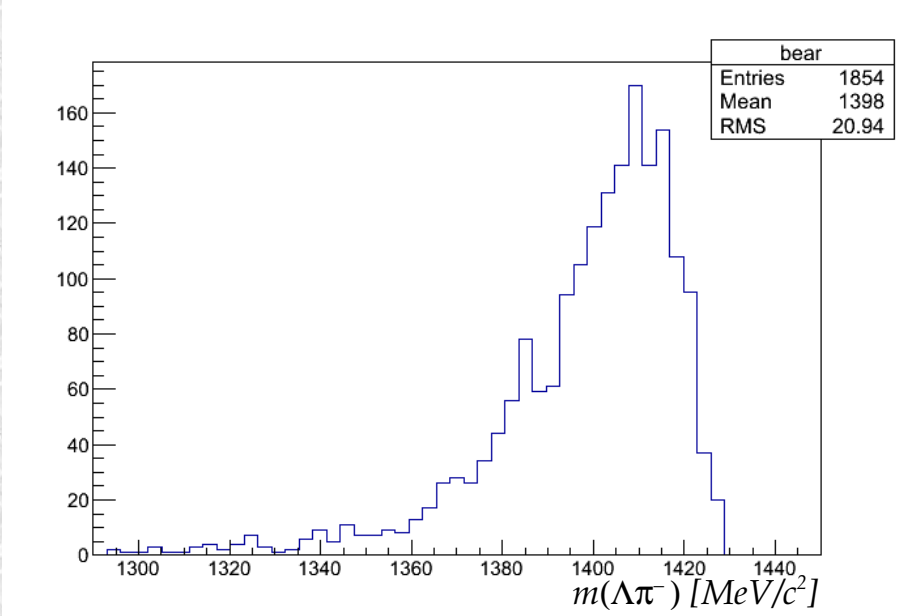
in - flight

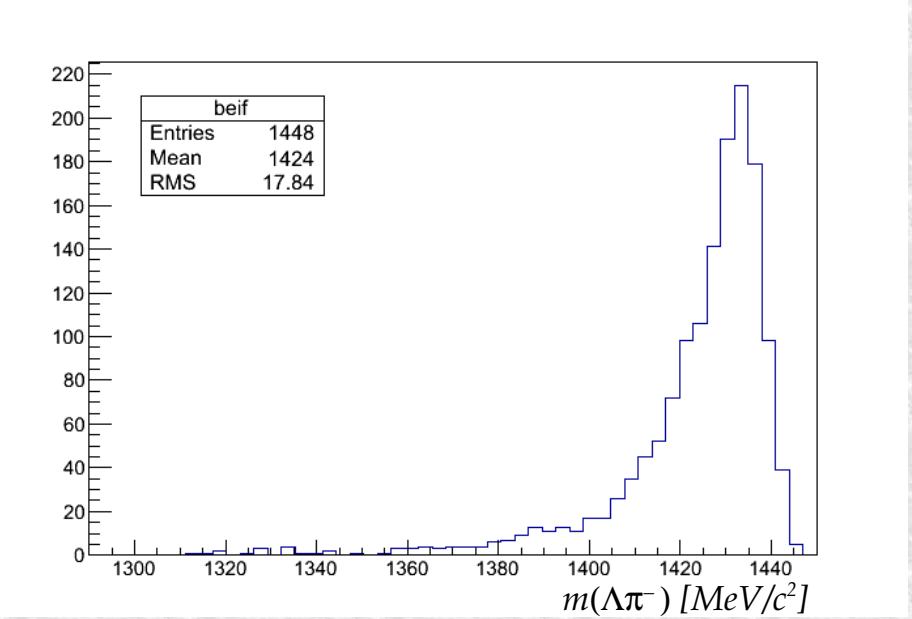
resonant ~ 51%

non - resonant ~ 49%

$K^- \ ^9Be \rightarrow \Lambda(1116)\pi^- + \ ^8Be$
resonant & non-resonant contribution

Very very preliminary





at – rest

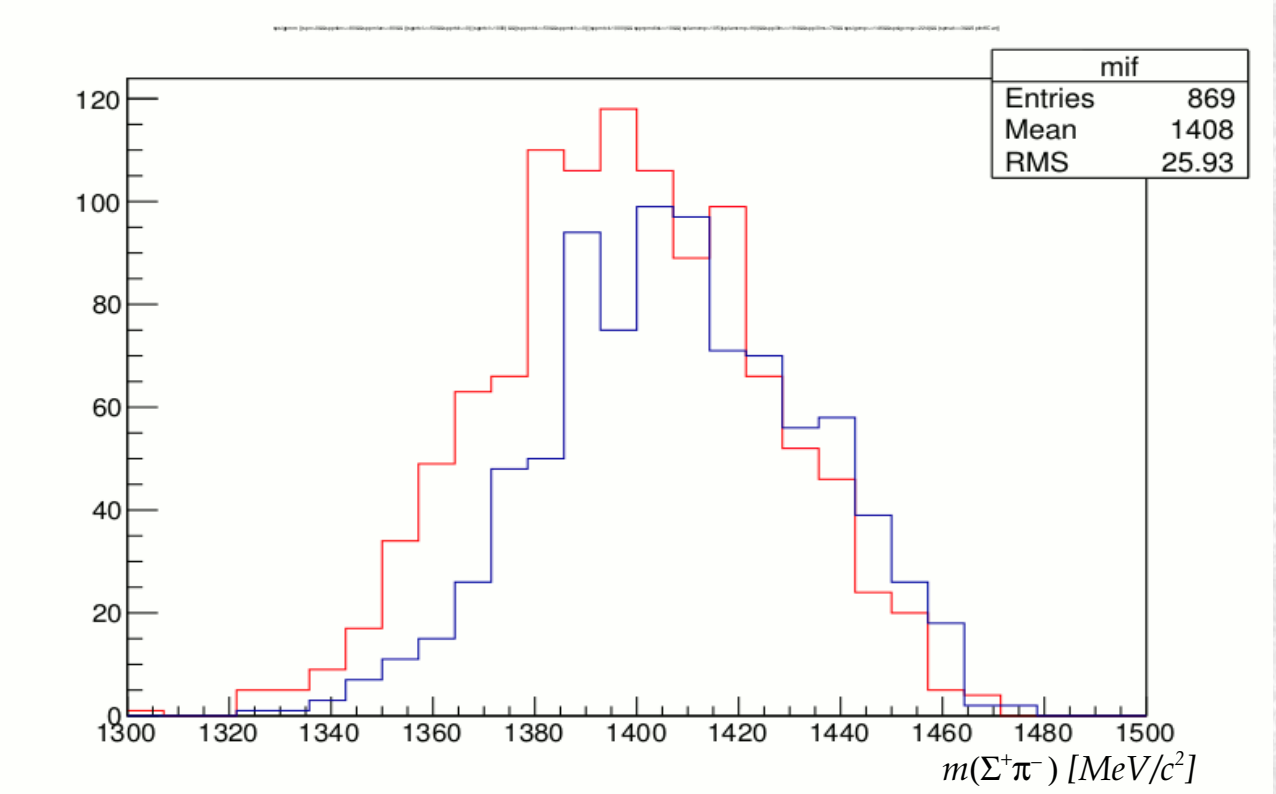
resonant ~ 41%
non - resonant ~ 59%

B.E. of last neutron only 1.7 MeV/c^2
K^- N absorption almost at threshold

in - flight

resonant ~ 5%
non - resonant ~ 95%

Mass spectrum of $\Sigma^+\pi^-$



at rest

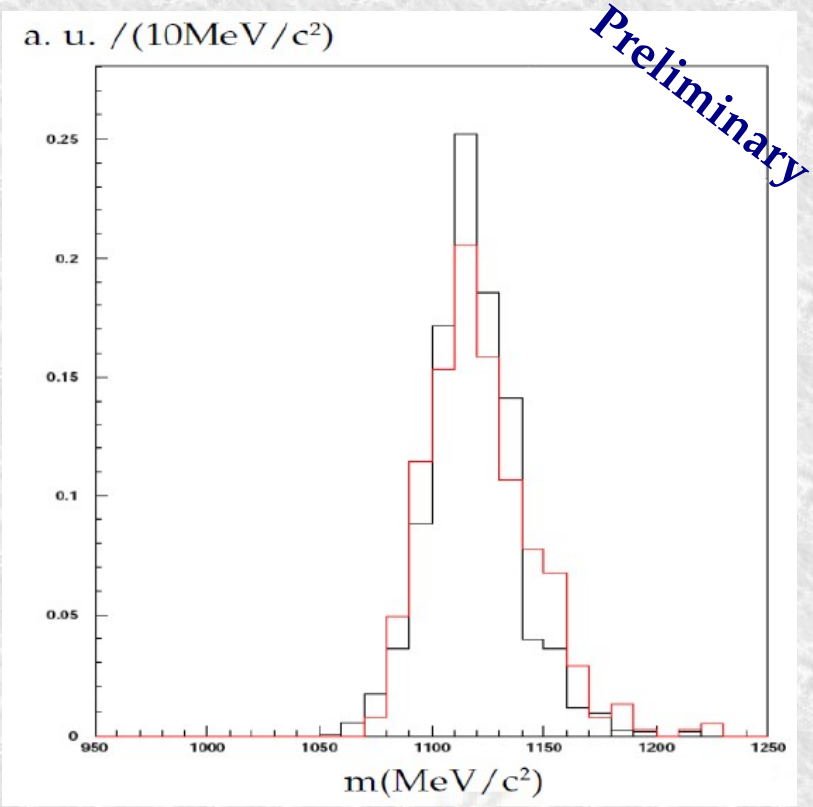
in flight

A carefull fit is required: 3 components → $\Lambda(1405)$; $\Sigma^*(1385)^-$; non-resonant $\Lambda(1116)\pi^-$
to observe a possible mass shift in the I=0 component

Future perspectives

- finalize $\Sigma^+\pi^-$ analysis
- start $\Sigma^-\pi^+$ analysis (difficulty **($\Sigma^-\pi^+ \rightarrow (n\pi^-)\ \pi^+$)** of neutrons)

  First detection of neutron clusters in KLOE **$\Lambda \rightarrow n\ \pi^0$**



Future perspectives

Possible test for in-medium modifications of $\Lambda(1405)$:

- explore branching ratio modifications in different targets (see A. Ohnishi et al., Phys. Rev. C 56 5 (1997) 2767)
- explore density dependence of $m_{\Sigma\pi}$ and $p_{\Sigma\pi}$ (see L. R. Staronski, S. Wycech, Nucl. Phys. 13 (1987) 1361 / E. Friedman, A. Gal, arXiv:1211.6336v3 [nucl-th] 2013)

Investigation of Σ/Λ conversion and measurements of conversion rate in different nuclear targets