$\bar{K}N \rightarrow K\Xi$ reaction in chiral unitary models up to NLO

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MESON2014, Krakow, May 29-June 3, 2014

Outline

- Introduction
- State-of-the art of chiral unitary models for the meson-baryon interaction in the S=-1 sector
- The $\bar{K}N \rightarrow K\Xi$ reaction
- Production of Ξ in nuclei
- Conclusions

Describing the dynamics of hadrons at low energies from the QCD Lagrangian (*quark* and *gluon* d.o.f.) is a highly non-perturbative problem

One may address this problem through the modern perspective of Chiral Perturbation Theory (χPT): effective theory with hadron degrees of freedom which respects the symmetries of QCD, in particular the (spontaneously broken) chiral symmetry.

In ordinary χPT:

→ convergence restricted to low energy physics

→ not adequate close to bound-states (pole in the T-matrix)

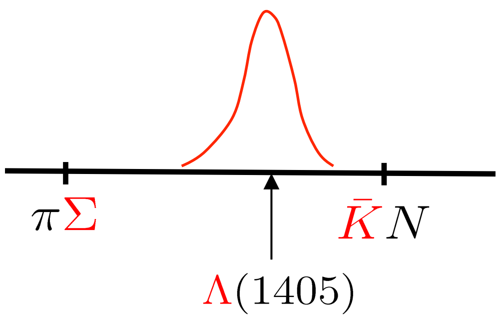
Unitarized non-perturbative schemes (UχPT) allow to extend the predictive power of the chiral theories.

With these non-perturbative methods several known resonances have been generated as poles in the scattering amplitude (quasi-bound states) and many hadron reaction cross sections have been nicely reproduced.

The case of the Λ(1405)

(a nice example of the success of non-perturbative chiral approaches)

Kbar-N scattering in the isospin I=0 channel is dominated by the presence of the Λ(1405), located only 27 MeV below the Kbar-N threshold



- Back in 1950, Dalitz and Tuan already proposed that the Kbar-N interaction is attractive enough to generate a quasi-bound state, the Λ(1405), below the Kbar-N threshold and embedded in the $\pi\Sigma$ continuum.
  R. H. Dalitz and S. F. Tuan, Phys. Rev. Lett. 2 (1959) 425.
  R. H. Dalitz and S. F. Tuan, Annals of Phys. 10 (1960) 307

- In 1995 Kaiser, Siegel and Weise reformulated the problem in terms of the effective chiral unitary theory in coupled channels.
  N. Kaiser, P. B. Siegel, and W. Weise, Nucl. Phys. A594 (1995) 325

- For the next 10 years (up to 2006) much work was devoted to this subject with various degrees of sophistication (more channels, NLO Lagrangian , s-channel, u-channel Born terms…), all of them obtaining in general similar features.

  E. Oset and A. Ramos, Nucl. Phys. A635 (1998) 99
  J.A. Oller and U.G. Meissner, Phys. Lett. B500 (2001) 263
  M.F.M. Lutz, E.E. Kolomeitsev, Nucl. Phys. A700 (2002) 193
  C.Garcia-Recio et al., Phys. Rev. D (2003) 07009
  B.Borasoy, R. Nissler, and W. Weise, Phys. Rev. Lett. 94, 213401 (2005); Eur. Phys. J. A25, 79 (2005)
  J.A. Oller, J. Prades, and M. Verbeni, Phys. Rev. Lett. 95, 172502 (2005)
  B. Borasoy, U. G. Meissner and R. Nissler, Phys. Rev. C74, 055201 (2006).

- Recently, the more precise, SIDDHARTA measurement of the energy shift ΔE and width Γ of the 1s state in kaonic hydrogen [M. Bazzi et al, Phys. Lett. B704 (2011) 113], clarifying the inconsistency between earlier KEK and DEAR experiments, has injected a renovated interest in the field ➔ the parameters of the NLO meson-baryon Lagrangian can be better constrained ➔ better knowledge of the Kbar N interaction.

  Y. Ikeda, T. Hyodo, W. Weise, Nucl.Phys. A881 (2012) 98-114,
  Z-H. Guo , J.A. Oller, Phys.Rev. C87 (2013) 3, 035202
  M. Mai, U-G. Meissner, Nucl.Phys. A900 (2013) 51 - 64
  V.K. Magas, A. Feijoo, A. Ramos, arXiv:1402.3971

Essence of the non-perturbative chiral approach

1. Meson-baryon effective chiral Lagrangian:

Lowest order (LO), O(q)

$$\mathcal{L}_{MB}^{(1)}(B,U) = \langle \bar{B} i\gamma^\mu \nabla_\mu B \rangle - M_B \langle \bar{B}B \rangle + \frac{1}{2} D \langle \bar{B}\gamma^\mu \gamma_5 \{u_\mu, B\} \rangle + \frac{1}{2} F \langle \bar{B}\gamma^\mu \gamma_5 [u_\mu, B] \rangle$$

$$\nabla_\mu B = \partial_\mu B + [\Gamma_\mu, B]$$

$$\Gamma_\mu = \frac{1}{2}(u^\dagger \partial_\mu u + u \partial_\mu u^\dagger)$$

$$U = u^2 = exp\left(\frac{i\sqrt{2}\Phi}{f}\right)$$

$$u_\mu = i u^\dagger \partial_\mu U u^\dagger$$

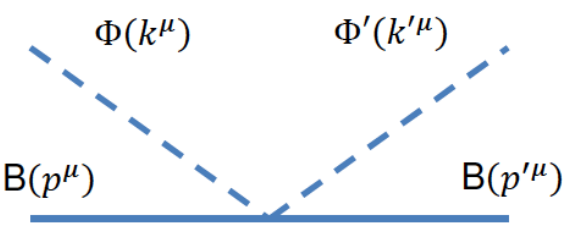
$$\Phi = \begin{pmatrix} \frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{6}}\eta_8 & \pi^+ & K^+ \\ \pi^- & -\frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{6}}\eta_8 & K^0 \\ K^- & \bar{K}^0 & -\frac{2}{\sqrt{6}}\eta_8 \end{pmatrix}$$

$$B = \begin{pmatrix} \frac{1}{\sqrt{2}}\Sigma^0 + \frac{1}{\sqrt{6}}\Lambda^0 & \Sigma^+ & p \\ \Sigma^- & -\frac{1}{\sqrt{2}}\Sigma^0 + \frac{1}{\sqrt{6}}\Lambda^0 & n \\ \Xi^- & \Xi^0 & -\frac{2}{\sqrt{6}}\Lambda^0 \end{pmatrix}$$

➔ LO meson-baryon potential in s-wave (contact term):

$$V_{ij} = -C_{ij}\frac{1}{4f^2}\bar{u}(p)\gamma^\mu u(p)(k_\mu + k'_\mu)$$

One parameter: f



Next to leading order (NLO), O(q²)

$$\mathcal{L}_{MB}^{(2)}(B,U) = b_D\langle\bar{B}\{\chi_+,B\}\rangle + b_F\langle\bar{B}[\chi_+,B]\rangle + b_0\langle\bar{B}B\rangle\langle\chi_+\rangle + d_1\langle\bar{B}\{u_\mu,[u^\mu,B]\}\rangle + d_2\langle\bar{B}\left[u_\mu,[u^\mu,B]\right]\rangle + d_3\langle\bar{B}u_\mu\rangle\langle u^\mu B\rangle + d_4\langle\bar{B}B\rangle\langle u^\mu u_\mu\rangle$$

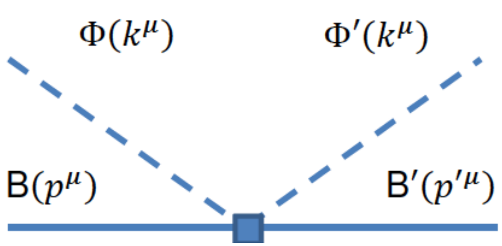
d_1,d_2,d_3,d_4: two-derivative terms

$$\chi_+ = -\frac{1}{4f^2}\{\Phi,\{\Phi,\chi\}\}$$

explicit chiral symmetry breaking terms: b_D, b_F, b_0

$$\chi = \begin{pmatrix} m_\pi^2 & 0 & 0 \\ 0 & m_\pi^2 & 0 \\ 0 & 0 & 2m_K^2 - m_\pi^2 \end{pmatrix}$$

➔ NLO contribution to the meson-baryon potential:

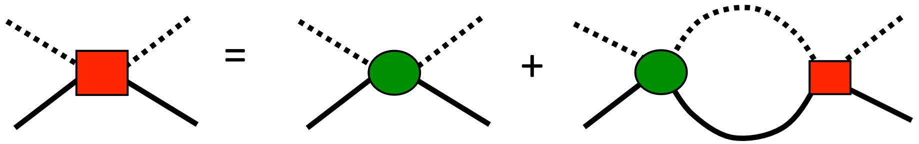


$$\tilde{V}_{ij} = \frac{1}{f^2}\left(D_{ij} - 2(k_\mu k'^\mu)L_{ij}\right)\sqrt{\frac{M_i+E_i}{2M_i}}\sqrt{\frac{M_j+E_j}{2M_j}}$$

D_{ij}, L_{ij}: matrices which depend on the 7 NLO parameters: b_D, b_F, b_0,d_1,d_2,d_3,d_4

2. Unitarization:

N/D, Bethe-Salpeter…



$$T_{ij} = V_{ij} + V_{il}\, G_l\, T_{lj}$$

Coupled channels in S=-1 meson-baryon sector:

$$K^- p, \bar{K}^0 n, \pi^0\Lambda, \pi^0\Sigma^0, \pi^+\Sigma^-, \pi^-\Sigma^+, \eta\Lambda,\ \eta\Sigma^0, K^+\Xi^-, K^0\Xi^0$$

3. Regularization of loop function:

$$G_l = i2M_l \int \frac{d^4q}{(2\pi)^4} \frac{1}{(P-q)^2 - M_l^2 + i\epsilon} \frac{1}{q^2 - m_l^2 + i\epsilon}$$

Dimensional regularization :

$$G_l = \frac{2M_l}{16\pi^2} \Big\{ a_l(\mu) + \ln \frac{M_l^2}{\mu^2} + \frac{m_l^2 - M_l^2 + s}{2s} \ln \frac{m_l^2}{M_l^2} + \frac{\bar{q}_l}{\sqrt{s}} \Big[\ln(s - (M_l^2 - m_l^2) + 2\bar{q}_l\sqrt{s}) + \ln(s + (M_l^2 - m_l^2) + 2\bar{q}_l\sqrt{s}) - \ln(-s + (M_l^2 - m_l^2) + 2\bar{q}_l\sqrt{s}) - \ln(-s - (M_l^2 - m_l^2) + 2\bar{q}_l\sqrt{s}) \Big] \Big\}$$

subtraction constants (to be fitted)

$a_l(\mu) \simeq -2$ "natural size (μ~700 MeV)

J.A. Oller and U.G. Meissner, Phys. Lett. B500 (2001) 263

Parameters

- Decay constant *f*

- 7 parameters of the NLO Lagrangian: b_D, b_F, b_0,d_1,d_2,d_3,d_4

- 6 subtraction constants (isospin symmetry)

$$a_{K^-p} = a_{\bar{K}^0 n} = a_{\bar{K}N}$$

$$a_{\pi\Lambda}$$

$$a_{\pi^+\Sigma^-} = a_{\pi^-\Sigma^+} = a_{\pi^0\Sigma^0} = a_{\pi\Sigma}$$

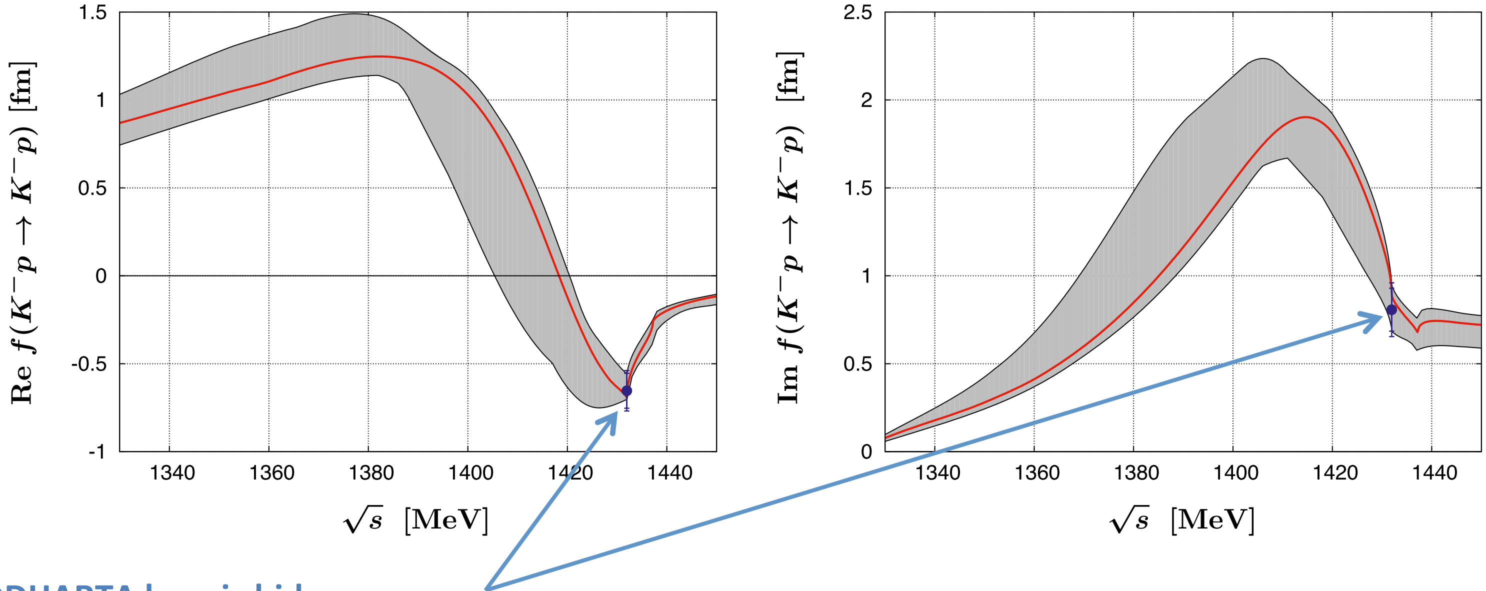
$$a_{\eta\Lambda}$$

$$a_{\eta\Sigma}$$

$$a_{K^+\Xi^-} = a_{K^0\Xi^0} = a_{K\Xi}$$

Observables (threshold)

$$\gamma = \frac{\Gamma(K^- p \to \pi^+ \Sigma^-)}{\Gamma(K^- p \to \pi^- \Sigma^+)} \qquad R_n = \frac{\Gamma(K^- p \to \pi^0 \Lambda)}{\Gamma(K^- p \to \text{neutral states})} \qquad R_c = \frac{\Gamma(K^- p \to \pi^+ \Sigma^-, \pi^- \Sigma^+)}{\Gamma(K^- p \to \text{all inelastic channels})}$$



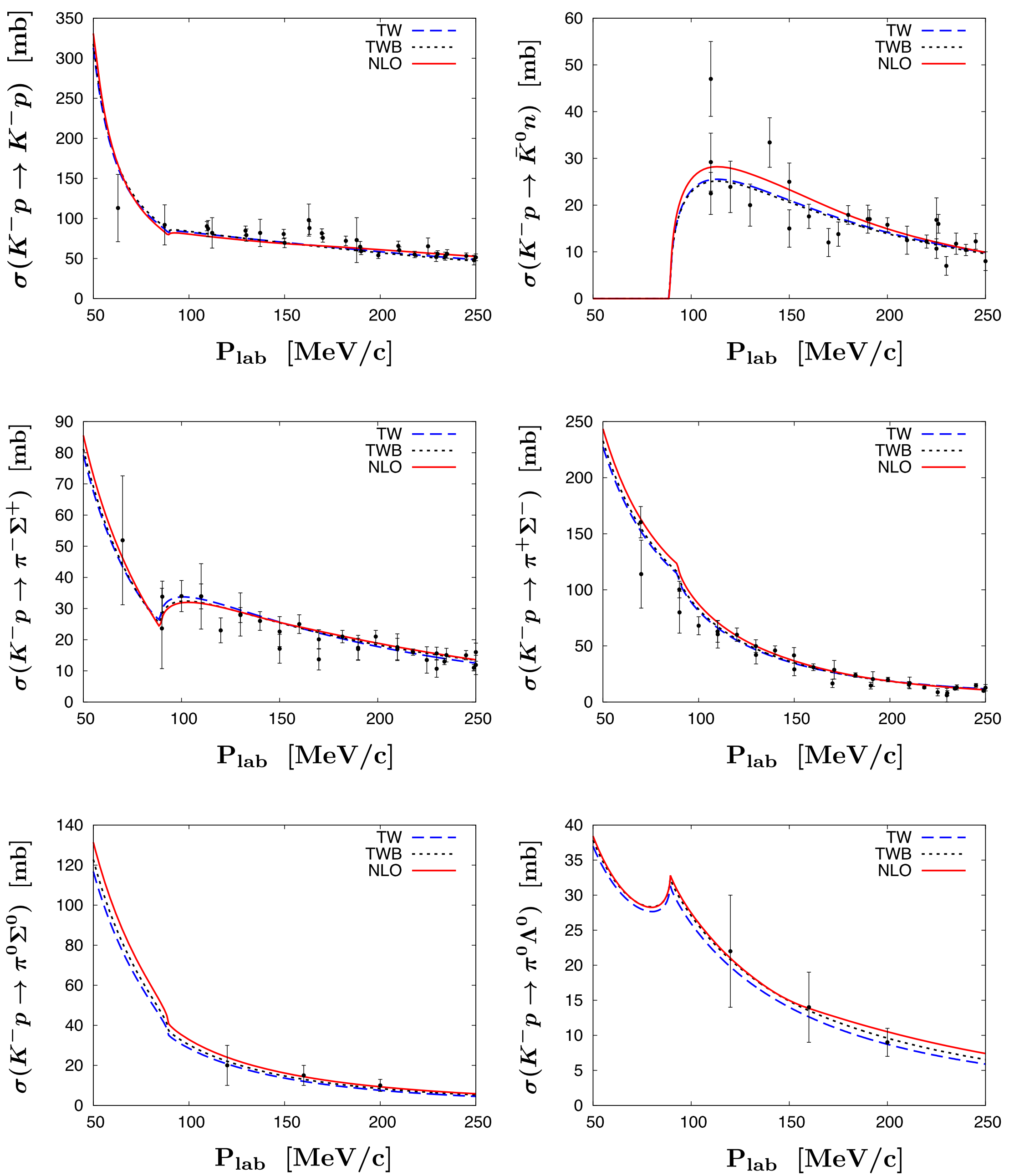
SIDDHARTA kaonic hidrogen,
M. Bazzi et al. Phys. Lett. B704 (2011) 113

Branching ratios:

	ΔE [eV]	Γ [eV]	γ	R_n	R_c
EXP:	$283 \pm 36 \pm 6$	$541 \pm 89 \pm 22$	2.36 ± 0.04	0.189 ± 0.015	0.664 ± 0.011
THEO:	306	591	2.37	0.19	0.66

Y. Ikeda, T. Hyodo and W. Weise, Nucl.Phys. A881 (2012) 98

Observables (beyond threshold)



The two-pole structure of the $\Lambda(1405)$

T-matrix poles and couplings to physical states with I=0

z_R (I=0)	1390 - 66i $\lvert g_i \rvert$	1426 - 16i $\lvert g_i \rvert$
$\pi\Sigma$	2.9	1.5
$\bar{K}N$	2.1	2.7
$\eta\Lambda$	0.77	1.4
$K\Xi$	0.61	0.35

$$T_{ij} = \frac{g_i g_j}{\sqrt{s} - M_R + i\Gamma/2},$$

Experimental evidence

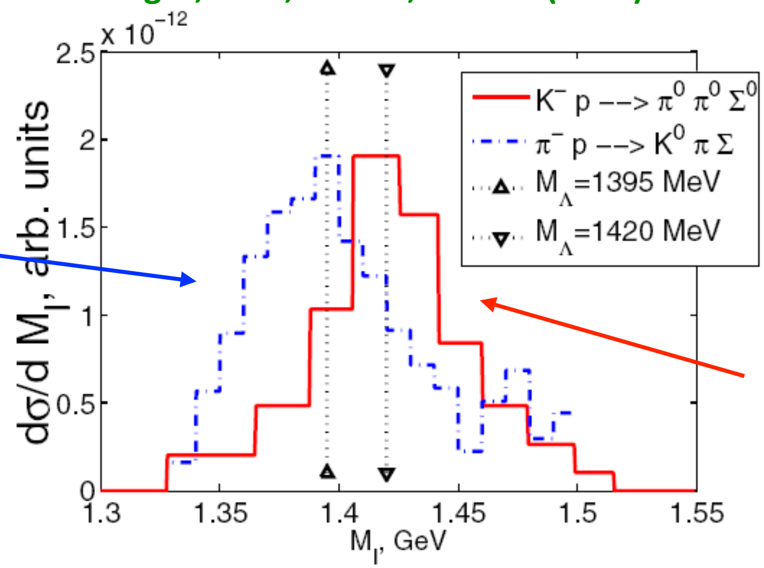
Magas, Oset, Ramos, PRL 95 (2005) 052301

$\pi^- p \to K^0 \pi\Sigma$

D.W.Thomas et al.
Nucl. Phys. B56, 15 (1973)

$M \sim 1385$ MeV

$\Gamma \sim 50$ MeV



$K^- p \to \pi^0\pi^0\Sigma^0$

S. Prakhov et al.,
Phys.Rev. C70,034605 (2004)

$M \sim 1420$ MeV

$\Gamma \sim 38$ MeV

→ The $\Lambda(1405)$ resonance shows different properties (position, width) in different reactions

→ Success of meson-baryon coupled-channel models!

$K^- p \to K\Xi$ channels

V.K. Magas, A. Feijoo, A. Ramos, arXiv:1402.3971

- Differently than the other works, we incorporate the $K\Xi$ channels in the NLO fit
- They are particularly interesting because the LO (Weinberg-Tomozawa) terms are zero

	K^-p	$\bar{K}^0 n$	$\pi^0\Lambda$	$\pi^0\Sigma^0$	$\eta\Lambda$	$\eta\Sigma^0$	$\pi^+\Sigma^-$	$\pi^-\Sigma^+$	$K^+\Xi^-$	$K^0\Xi^0$
K^-p	2	1	$\sqrt{3}/2$	$1/2$	$3/2$	$\sqrt{3}/2$	0	1	0	0
$\bar{K}^0 n$		2	$-\sqrt{3}/2$	$1/2$	$3/2$	$-\sqrt{3}/2$	1	0	0	0
$\pi^0\Lambda$			0	0	0	0	0	0	$\sqrt{3}/2$	$-\sqrt{3}/2$
$\pi^0\Sigma^0$				0	0	0	2	2	$1/2$	$1/2$
$\eta\Lambda$					0	0	0	0	$3/2$	$3/2$
$\eta\Sigma^0$						0	0	0	$\sqrt{3}/2$	$-\sqrt{3}/2$
$\pi^+\Sigma^-$							2	0	1	0
$\pi^-\Sigma^+$								2	0	1
$K^+\Xi^-$									2	1
$K^0\Xi^0$										2

➔ Therefore, these channels are especially sensitive to NLO parameters !!

NLO coefficients

D_{ij}

	K^-p	$\bar{K}^0n$	$\pi^0\Lambda$	$\pi^0\Sigma^0$	$\eta\Lambda$	$\eta\Sigma^0$	$\pi^+\Sigma^-$	$\pi^-\Sigma^+$	$K^+\Xi^-$	$K^0\Xi^0$
K^-p	$4(b_0+b_D)m_K^2$	$2(b_D+b_F)m_K^2$	$\frac{-(b_D+3b_F)\mu_1^2}{2\sqrt{3}}$	$\frac{(b_D-b_F)\mu_1^2}{2}$	0	$(b_D-b_F)\mu_1^2$	$\frac{(b_D+3b_F)\mu_2^2}{6}$	$-\frac{(b_D-b_F)\mu_2^2}{2\sqrt{3}}$	0	0
$\bar{K}^0n$		$4(b_0+b_D)m_K^2$	$\frac{(b_D+3b_F)\mu_1^2}{2\sqrt{3}}$	$\frac{(b_D-b_F)\mu_1^2}{2}$	$(b_D-b_F)\mu_1^2$	0	$\frac{(b_D+3b_F)\mu_2^2}{6}$	$\frac{(b_D-b_F)\mu_2^2}{2\sqrt{3}}$	0	0
$\pi^0\Lambda$			$\frac{4(3b_0+b_D)m_\pi^2}{3}$	0	0	0	0	$\frac{4b_Dm_\pi^2}{3}$	$-\frac{(b_D-3b_F)\mu_1^2}{2\sqrt{3}}$	$\frac{(b_D-3b_F)\mu_1^2}{2\sqrt{3}}$
$\pi^0\Sigma^0$				$4(b_0+b_D)m_\pi^2$	0	0	$\frac{4b_Dm_\pi^2}{3}$	0	$\frac{(b_D+b_F)\mu_1^2}{2}$	$\frac{(b_D+b_F)\mu_1^2}{2}$
$\eta\Lambda$					$4(b_0+b_D)m_\pi^2$	0	$\frac{4b_Dm_\pi^2}{3}$	$\frac{4b_Fm_\pi^2}{\sqrt{3}}$	$(b_D+b_F)\mu_1^2$	0
$\eta\Sigma^0$						$4(b_0+b_D)m_\pi^2$	$\frac{4b_Dm_\pi^2}{3}$	$-\frac{4b_Fm_\pi^2}{\sqrt{3}}$	0	$(b_D+b_F)\mu_1^2$
$\pi^+\Sigma^-$							$\frac{4(3b_0\mu_3^2+b_D\mu_4^2)}{9}$	0	$\frac{(b_D-3b_F)\mu_2^2}{6}$	$\frac{(b_D-3b_F)\mu_2^2}{6}$
$\pi^-\Sigma^+$								$\frac{4(b_0\mu_3^2+b_Dm_\pi^2)}{3}$	$\frac{(b_D+b_F)\mu_2^2}{2\sqrt{3}}$	$\frac{(b_D+b_F)\mu_2^2}{2\sqrt{3}}$
$K^+\Xi^-$									$4(b_0+b_D)m_K^2$	$2(b_D-b_F)m_K^2$
$K^0\Xi^0$										$4(b_0+b_D)m_K^2$

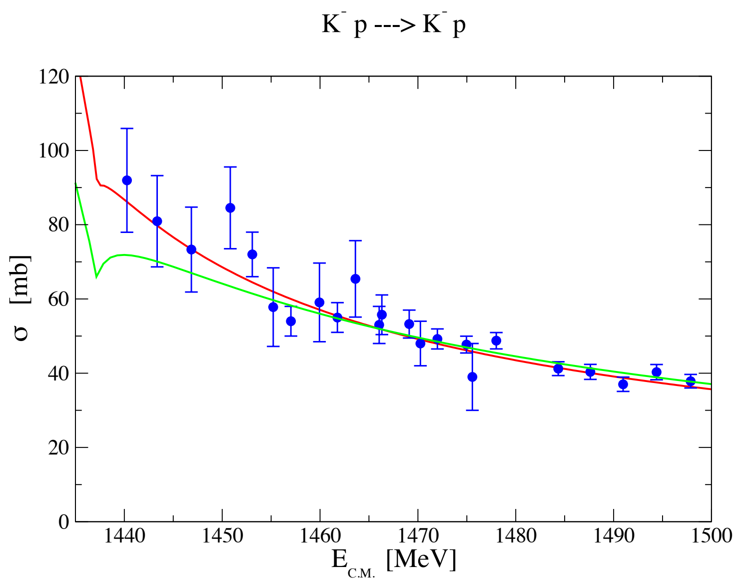
L_{ij}

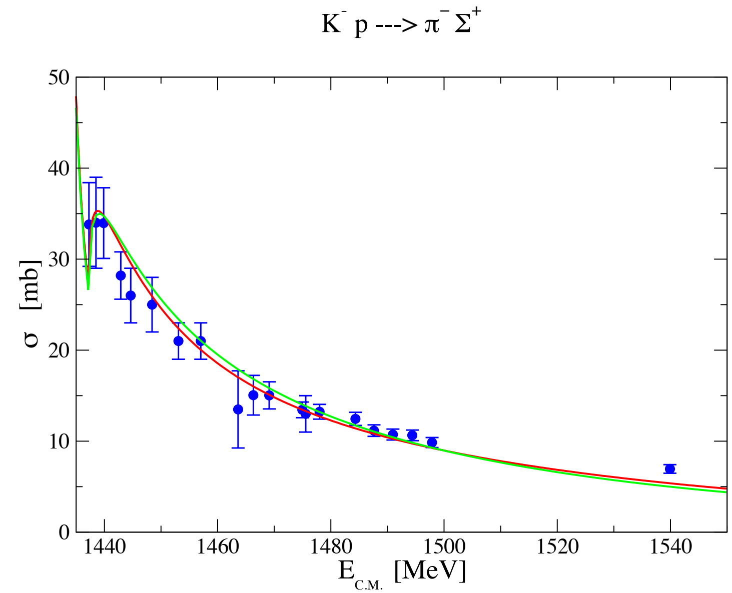
	K^-p	$\bar{K}^0n$	$\pi^0\Lambda$	$\pi^0\Sigma^0$	$\eta\Lambda$	$\eta\Sigma^0$	$\pi^+\Sigma^-$	$\pi^-\Sigma^+$	$K^+\Xi^-$	$K^0\Xi^0$
K^-p	$2d_2+d_3+2d_4$	$d_1+d_2+d_3$	$-\frac{\sqrt{3}(d_1+d_2}{2}$	$\frac{-d_1-d_2+2d_3}{2}$	$-2d_2+d_3$	$-d_1+d_2+d_3$	$\frac{d_1-3d_2+2d_3}{2}$	$\frac{d_1-3d_2}{2\sqrt{3}}$	$-4d_2+2d_3$	$-2d_2+d_3$
$\bar{K}^0n$		$2d_2+d_3+2d_4$	$\frac{\sqrt{3}(d_1+d_2)}{2}$	$\frac{-d_1-d_2+2d_3}{2}$	$-d_1+d_2+d_3$	$-2d_2+d_3$	$\frac{d_1-3d_2+2d_3}{2}$	$-\frac{(d_1-3d_2)}{2\sqrt{3}}$	$-2d_2+d_3$	$-4d_2+2d_3$
$\pi^0\Lambda$			$2d_4$	0	0	0	0	d_3	$\frac{\sqrt{3}(d_1-d_2)}{2}$	$-\frac{\sqrt{3}(d_1-d_2)}{2}$
$\pi^0\Sigma^0$				$2(d_3+d_4)$	$-2d_2+d_3$	$-2d_2+d_3$	d_3	0	$\frac{d_1-d_2+2d_3}{2}$	$\frac{d_1-d_2+2d_3}{2}$
$\eta\Lambda$					$2d_2+d_3+2d_4$	$-4d_2+2d_3$	d_3	$\frac{2d_1}{\sqrt{3}}$	$d_1+d_2+d_3$	$-2d_2+d_3$
$\eta\Sigma^0$						$2d_2+d_3+2d_4$	d_3	$-\frac{2d_1}{\sqrt{3}}$	$-2d_2+d_3$	$d_1+d_2+d_3$
$\pi^+\Sigma^-$							$2(d_3+d_4)$	0	$\frac{-d_1-3d_2+2d_3}{2}$	$\frac{-d_1-3d_2+2d_3}{2}$
$\pi^-\Sigma^+$								$2d_4$	$-\frac{(d_1+3d_2)}{2\sqrt{3}}$	$\frac{d_1+3d_2}{2\sqrt{3}}$
$K^+\Xi^-$									$2d_2+d_3+2d_4$	$-d_1+d_2+d_3$
$K^0\Xi^0$										$2d_2+d_3+2d_4$

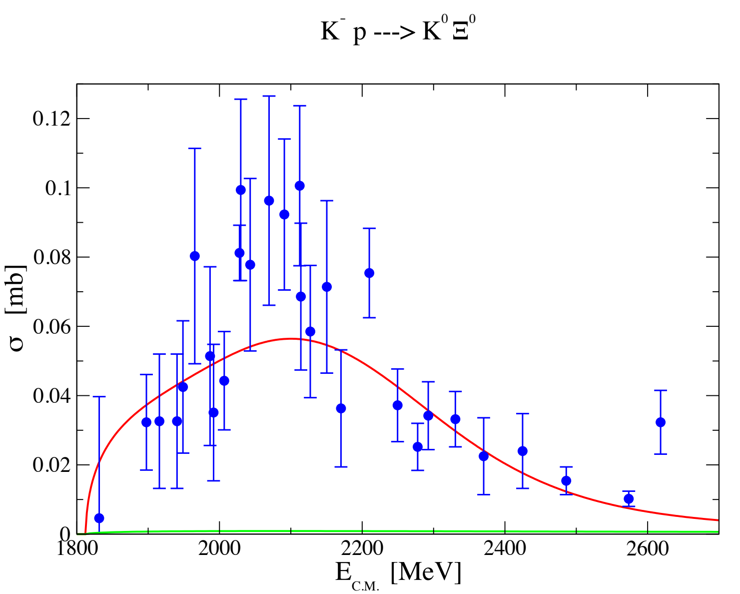
Results

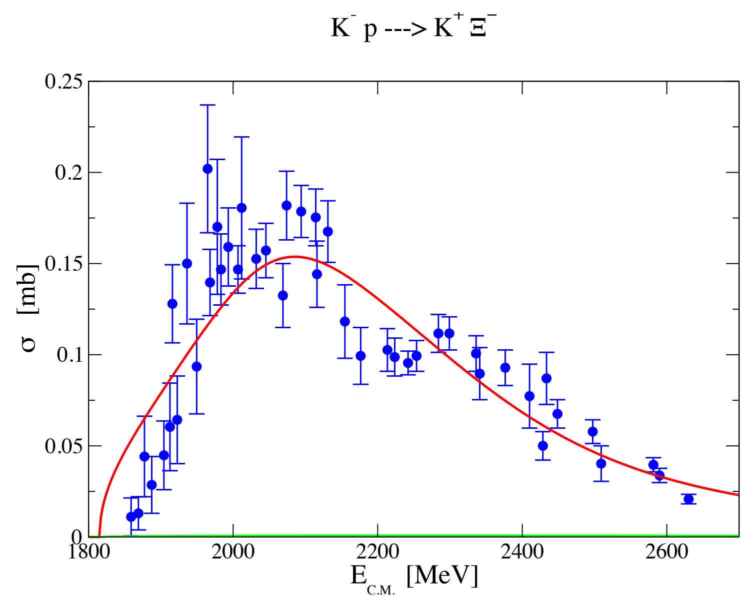
LO fit

LO + NLO (including KΞ channels)

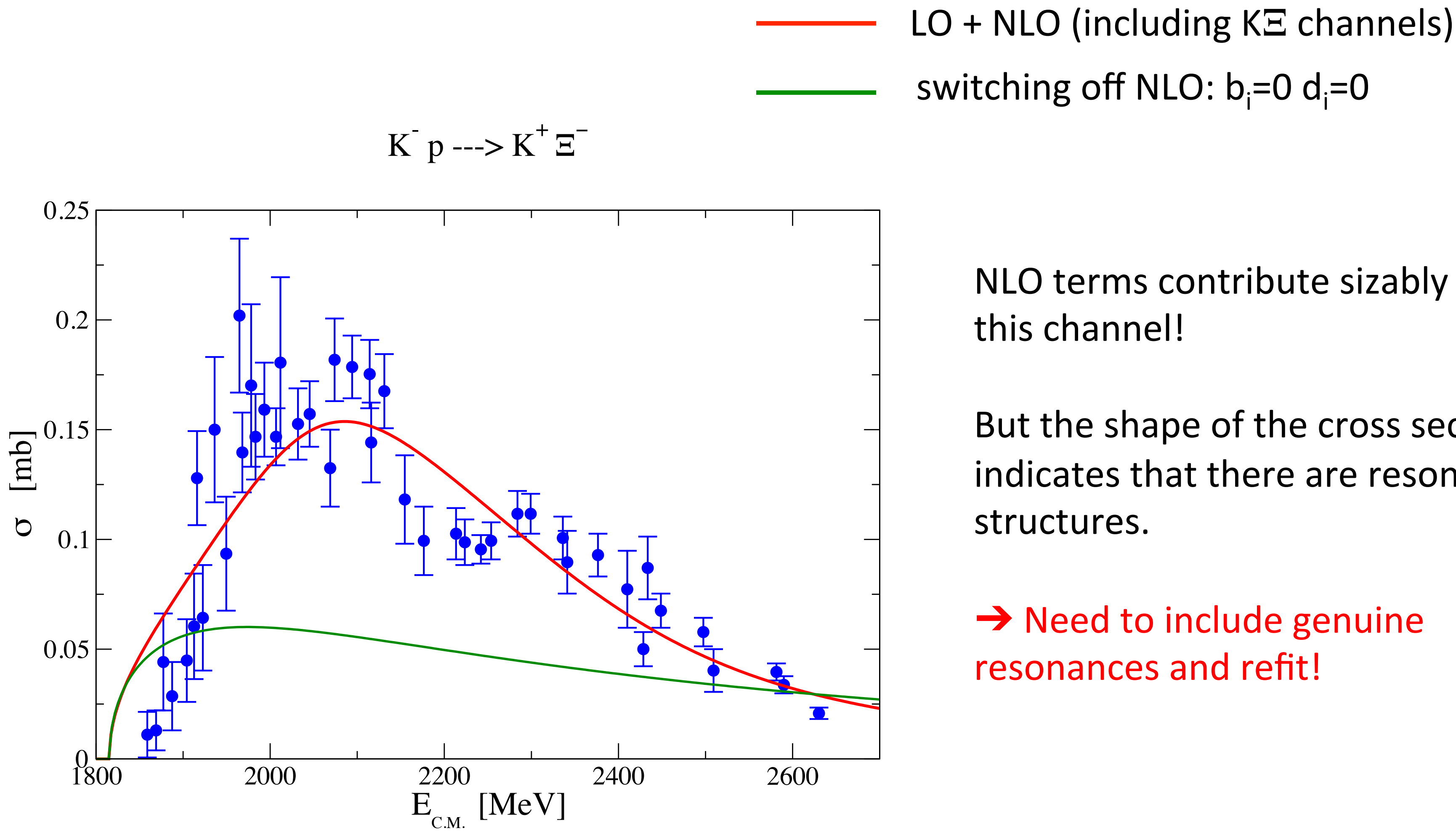








$K^- p \to K^+ \Xi^-$

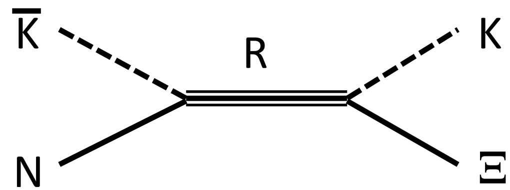


NLO terms contribute sizably in this channel!

But the shape of the cross section indicates that there are resonant structures.

➔ Need to include genuine resonances and refit!

Resonances in KΞ channels



From the PDG we see many 3* and 4* resonances in the region of interest!

Resonancia	$I(J^P)$	Mass (MeV)	Γ (MeV)	Fraction ($\Gamma_{K\Xi}/\Gamma$)
$\Lambda(1890)$	$0\left(\frac{3}{2}^+\right)$	$1850-1910$	$60-200$	_
$\Lambda(2100)$	$0\left(\frac{7}{2}^-\right)$	$2090-2110$	$100-250$	$<3\%$
$\Lambda(2110)$	$0\left(\frac{5}{2}^+\right)$	$2090-2140$	$150-250$	_
$\Lambda(2350)$	$0\left(\frac{9}{2}^+\right)$	$2340-2370$	$100-250$	_
$\Sigma(1915)$	$1\left(\frac{5}{2}^+\right)$	$1900-1935$	$80-160$	_
$\Sigma(1940)$	$1\left(\frac{3}{2}^-\right)$	$1900-1950$	$150-300$	_
$\Sigma(2030)$	$1\left(\frac{7}{2}^+\right)$	$2025-2040$	$150-200$	$<2\%$
$\Sigma(2250)$	$1(?^?)$ $\left(\frac{5}{2}^-\right)$	$2210-2280$	$60-150$	_

In the resonant model of **Sharov, Korotkikh, Lanskoy, EPJA 47 (2011) 109** for the $\bar{K}N \rightarrow K\Xi$ reaction several combinations were tested → Σ(2030) and Σ(2250) were the more relevant!

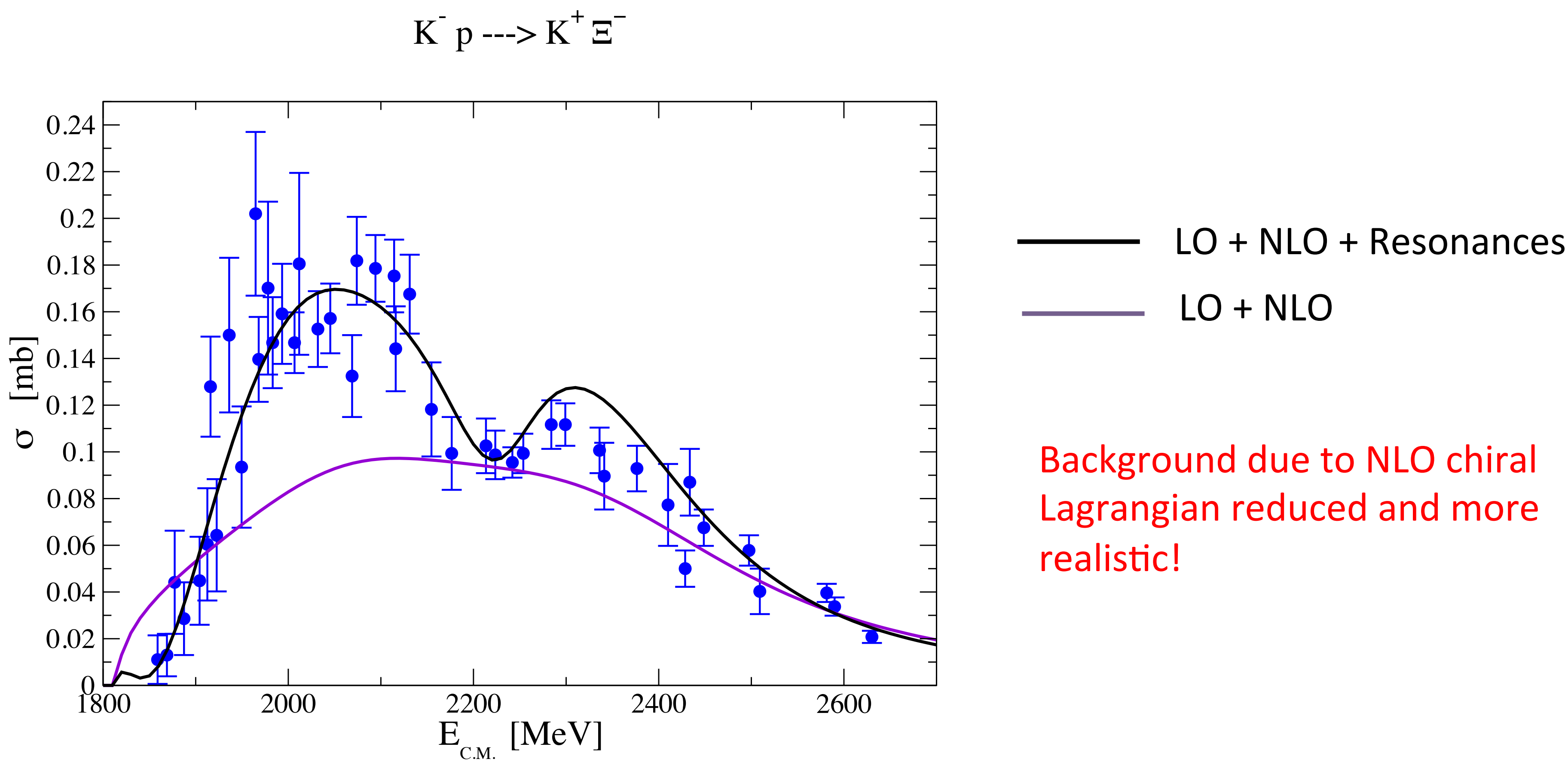
The Σ(2030) also plays a relevant role in the $\gamma\, p \rightarrow K^+ K^+ \Sigma^-$ reaction

K. Nakayama, Y. Oh, H. Habertzettl, Phys. Rev. C74, 035205 (2006)

K. Shing Man, Y. Oh, K. Nakayama,, Phys. Rev. C83, 055201 (2011)

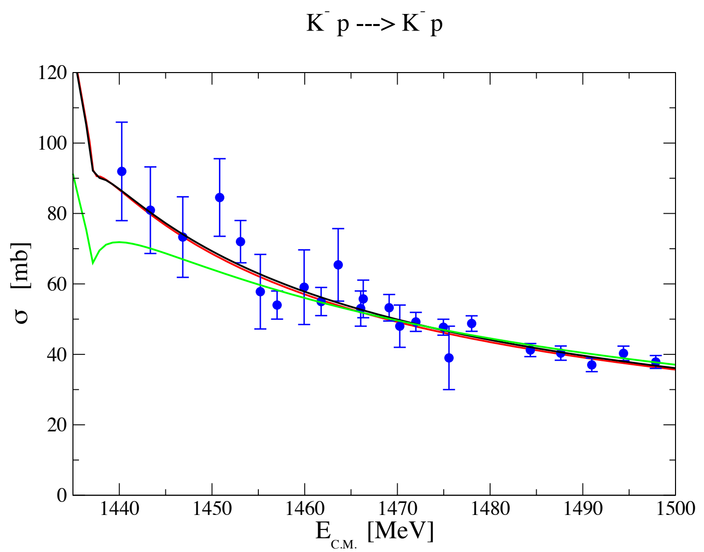
$K^- p \rightarrow K^+ \Xi^-$

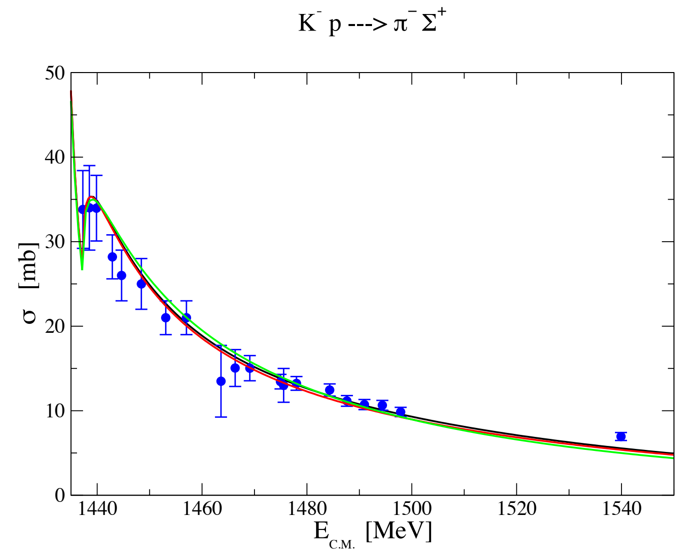
We suplement the LO+NLO Lagrangian with two resonances:
One of $J^P=7/2^+$ around 2030 MeV and one of $J^P=5/2^-$ around 2250 MeV
➔ the fit determines masses, widths and couplings of resonances



Background due to NLO chiral Lagrangian reduced and more realistic!

The incorporation of these resonances in the fitting procedure does not alter the other cross sections (black lines: LO+NLO+resonances),





nor the threshold ratios:

Ramos-Magas-Feijoo MODEL	γ	R_n	R_c
WT	2.34	0.185	0.665
WT+ NLO + Ξ channels	2.36	0.197	0.659
WT+NLO+Ξ channels + Resonances	2.36	0.193	0.661
Experimental	2.36 ± 0.04	0.189 ± 0.015	0.664 ± 0.011

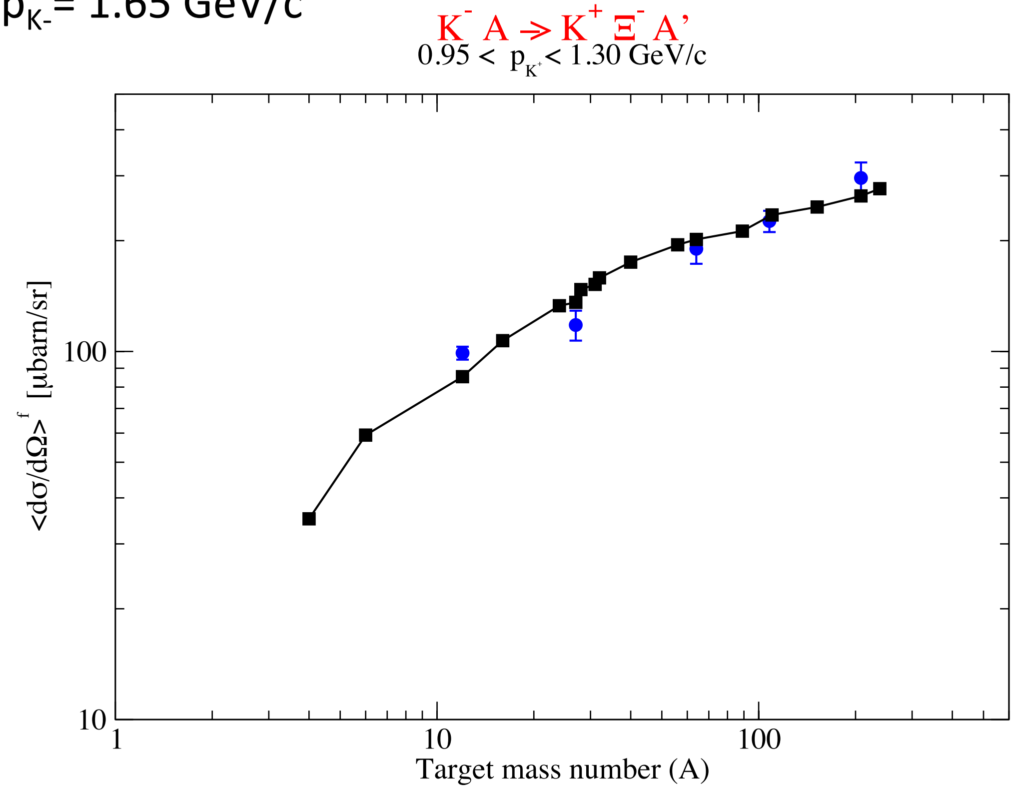
Parameters (Preliminary!)

	WT	WT+NLO+ Ξ chann.	WT+NLO+Ξ chann. + Resonances
$a_{\bar{K}N}$ (10^{-3})	-1.79	4.64	4.72
$a_{\pi\Lambda}$ (10^{-3})	-39.83	24.52	26.01
$a_{\pi\Sigma}$ (10^{-3})	0.06	2.06	2.27
$a_{\eta\Lambda}$ (10^{-3})	1.18	-9.10	-7.82
$a_{\eta\Sigma}$ (10^{-3})	38.04	-8.43	-7.68
$a_{K\Xi}$ (10^{-3})	239.00	37.54	42.90
f (MeV)	$1.21 f_\pi$	$1.19 f_\pi$	$1.2 f_\pi$
b_0 (GeV^{-1})	-	-0.37	-0.44
b_D (GeV^{-1})	-	-0.04	-0.05
b_F (GeV^{-1})	-	0.37	0.37
d_1 (GeV^{-1})	-	0.24	0.22
d_2 (GeV^{-1})	-	0.41	0.40
d_3 (GeV^{-1})	-	0.74	0.76
d_4 (GeV^{-1})	-	-0.58	-0.60
f_{KYB5}	-	-	-2.72
f_{KYB7}	-	-	402.05
$\Lambda_{5/2}$ (MeV)	-	-	720.02
$\Lambda_{7/2}$ (MeV)	-	-	298.13
$M_{5/2}$ (MeV)	-	-	2216.4
$M_{7/2}$ (MeV)	-	-	2040.0
$\Gamma_{5/2}$ (MeV)	-	-	146.24
$\Gamma_{7/2}$ (MeV)	-	-	150.00
$X_{d.o.f}$	1.23 (no Ξ)	1.88	0.73

Production of Ξ in nuclei: (K^-,K^+) reaction on nuclear targets

- These reactions are employed to produce double Λ hypernuclei
- They may inform us on the size of the Ξ optical potential in the nucleus

p_{K^-}= 1.65 GeV/c



Blue points: **T.Iijima et al. Nucl.Phys. A546 (1992) 588**

Conclusions

- Chiral Perturbation Theory with unitarization in coupled channels is a very powerful technique to describe low energy hadron dynamics.
- More precise data has become available ➔ NLO calculations become more meaningful (NLO terms in the Lagrangian do improve agreement with data)
- The $\bar{K}N \to K\Xi$ reaction is very interesting and important for fitting NLO parameters (Work in progres …)