The $\bar{K}N \rightarrow K\Xi$ reaction in a chiral NLO model

Àngels Ramos

A. Feijoo, V.K. Magas, A. Ramos, Phys. Rev. C92 (2015) 1, 015206

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Physics with Neutral Kaon Beam at Jlab Workshop, February 1-3, 2016

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Outline

- Introduction
- State-of-the art of chiral unitary models for the meson-baryon interaction in the S=-1 sector
- The $\bar{K}N$ → $K\Xi$ reaction (→ important for NLO terms)
- Reactions providing I=0 or I=1 filters for the $\bar{K}N$ → $K\Xi$ reaction
- Conclusions

Chiral unitary approach

Describing the dynamics of hadrons at low energies from the QCD Lagrangian (*quarks* and *gluons* 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)

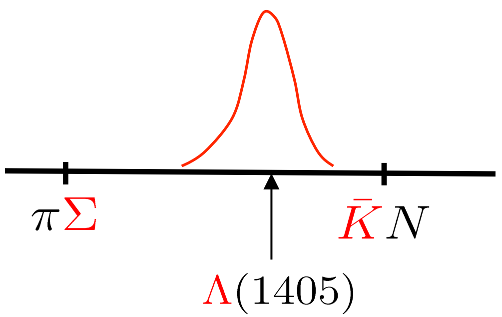
Unitarized non-perturbative schemes (UχPT) allow to extend the predictive power of the chiral theories.

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 and 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)

Essence of the non-perturbative chiral approach

1. Meson-baryon effective chiral Lagrangian:

Lowest order (LO), O(q)

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

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

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

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

$$u_{\mu} = iu^{\dagger}\partial_{\mu}Uu^{\dagger}$$

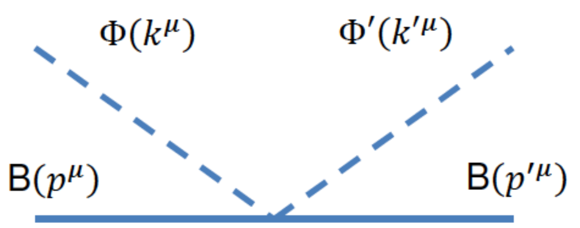
$$\Phi = \begin{pmatrix} \frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{6}}\eta_8 & \pi^+ & K^+ \\ \pi^- & -\frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{6}}\eta_8 & K^0 \\ K^- & \bar{K}^0 & -\frac{2}{\sqrt{6}}\eta_8 \end{pmatrix}$$

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

➔ 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), $O(q^2)$

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

derivative terms: d_1, d_2, d_3, d_4

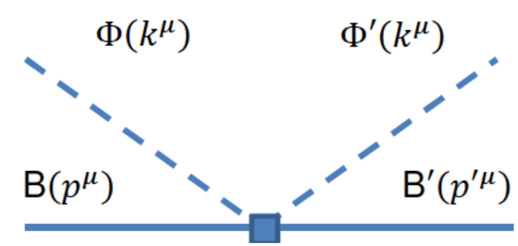
$$\chi_+ = -\frac{1}{4f^2}\{\Phi, \{\Phi, \chi\}\}$$

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:

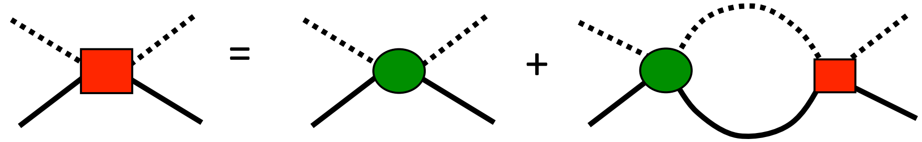
$$\tilde{V}_{ij} = \frac{1}{f^2}\left(D_{ij} - 2(k_\mu k'^\mu)L_{ij}\right)\sqrt{\frac{M_i+E_i}{2M_i}}\sqrt{\frac{M_j+E_j}{2M_j}}$$



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:

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

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

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

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

Parameters

- 1 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):

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

$$a_{\pi\Lambda}$$

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

$$a_{\eta\Lambda}$$

$$a_{\eta\Sigma}$$

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

Threshold observables

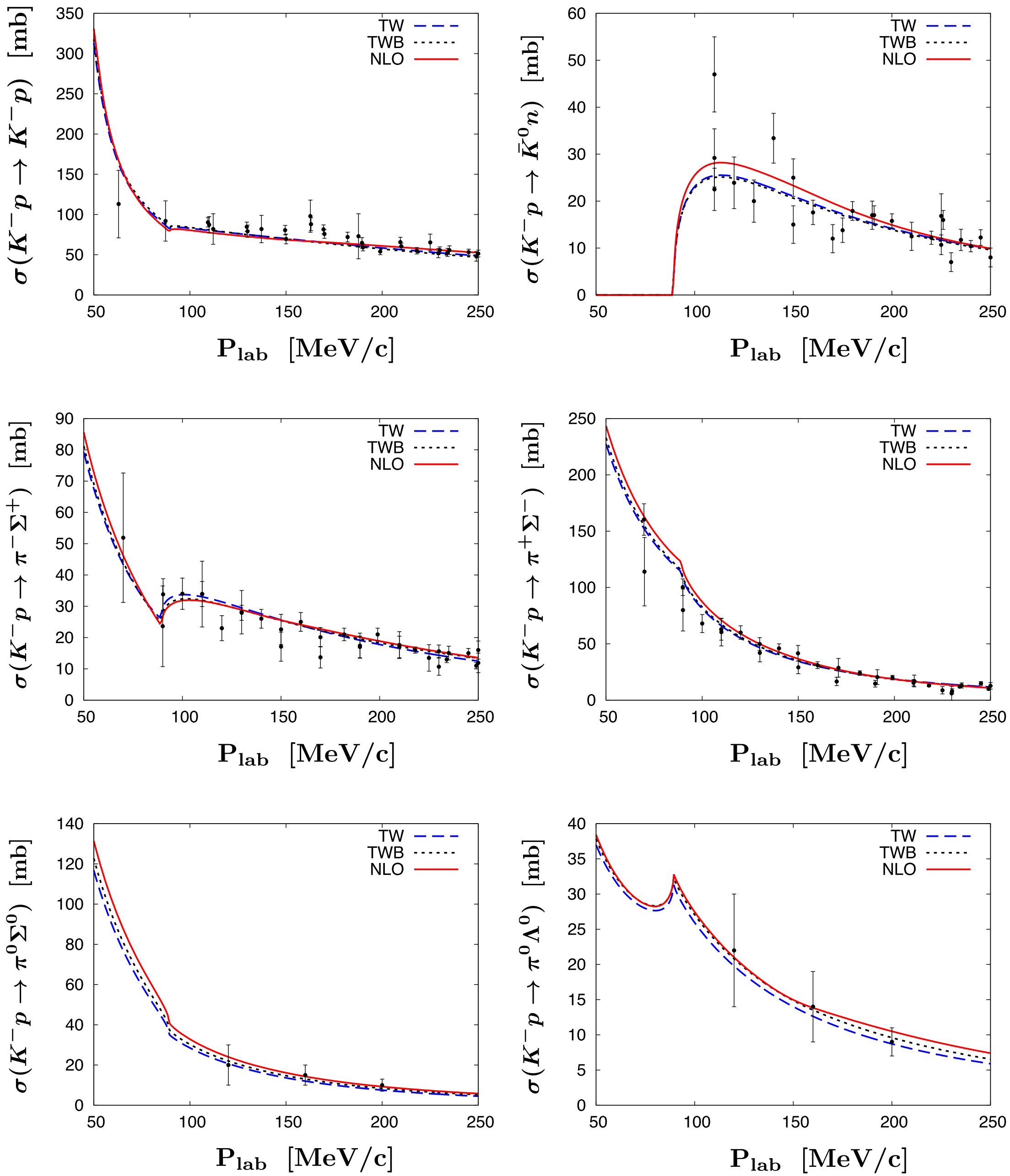
$$\gamma = \frac{\Gamma\left(K^- p \to \pi^+ \Sigma^-\right)}{\Gamma\left(K^- p \to \pi^- \Sigma^+\right)}$$

$$R_n = \frac{\Gamma\left(K^- p \to \pi^0 \Lambda\right)}{\Gamma\left(K^- p \to \text{neutral states}\right)}$$

$$R_c = \frac{\Gamma\left(K^- p \to \pi^+ \Sigma^-, \pi^- \Sigma^+\right)}{\Gamma\left(K^- p \to \text{all inelastic channels}\right)}$$

γ	R_n	R_c
2.36 ± 0.04	0.189 ± 0.015	0.664 ± 0.011

Cross sections



The two-pole structure of the Λ(1405)

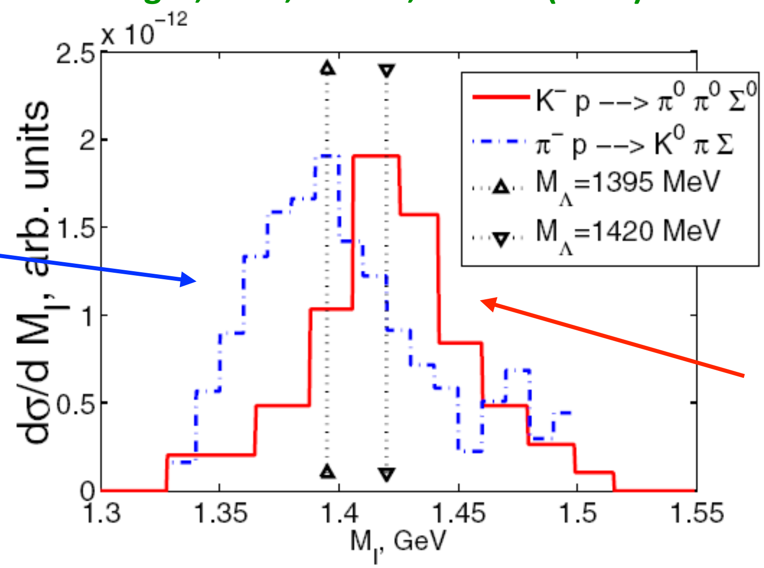
T-matrix poles and couplings to physical states with I=0

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



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

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

$M \sim 1385$ MeV
$\Gamma \sim 50$ MeV

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

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

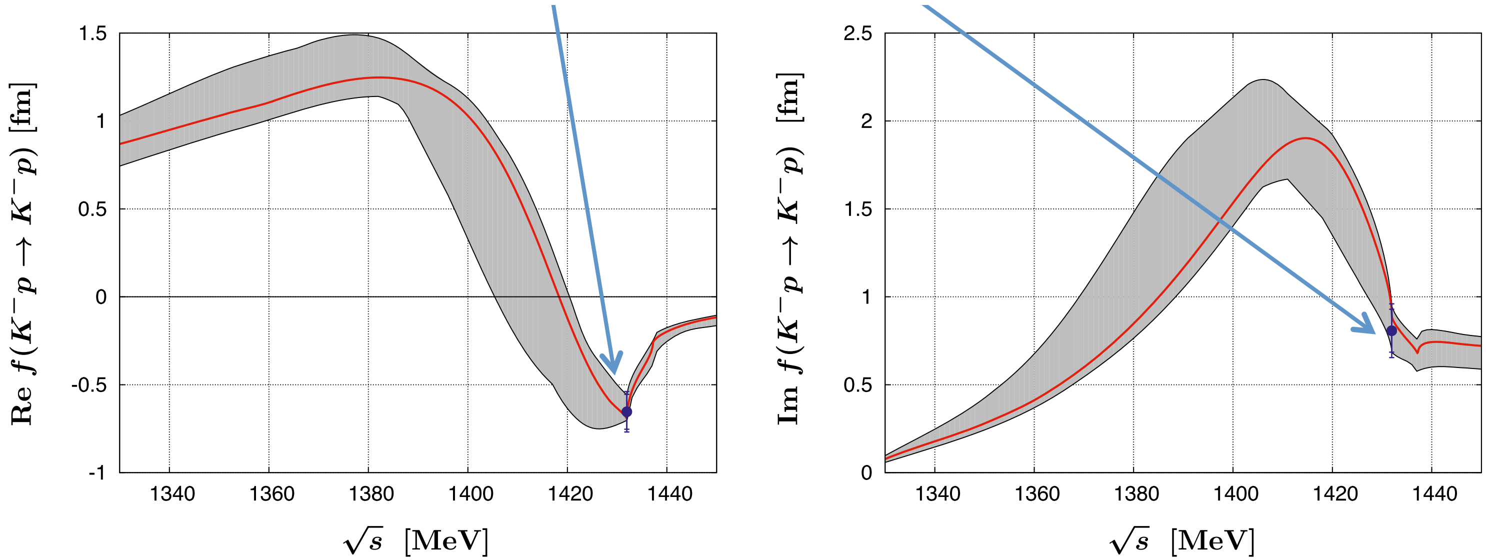
$M \sim 1420$ MeV
$\Gamma \sim 38$ MeV

→ The Λ(1405) resonance shows different properties (position, width) in different reactions
→ Success of meson-baryon coupled-channel models!

- Recently, the more precise SIDDHARTA measurement of the energy shift ΔE and width Γ of the 1s state in kaonic hydrogen, clarifying the inconsistency between earlier KEK and DEAR experiments, has injected a renovated interest in the field

M. Bazzi et al. Phys. Lett. B704 (2011) 113

ΔE [eV]	Γ [eV]
$283 \pm 36 \pm 6$	$541 \pm 89 \pm 22$



➔ the parameters of the NLO meson-baryon Lagrangian can be better constrained

➔ better knowledge of the KbarN interaction

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

Z-H. Guo , J.A. Oller, Phys.Rev. C87 (2013) 3, 035202

M. Mai, U-G. Meissner, Nucl.Phys. A900 (2013) 51; Eur. Phys. J. A51 (2015) 3, 30

V.K. Magas, A. Feijoo, A. Ramos, Phys. Rev. C92 (2015) 1, 015206

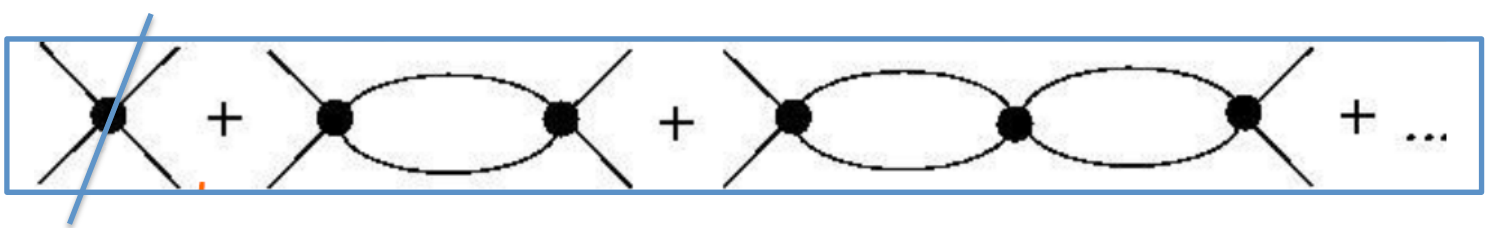
$K^- p \rightarrow K\,\Xi$ channels

V.K. Magas, A. Feijoo, A. Ramos, Phys. Rev. C92 (2015) 1, 015206

- Differently than the other chiral unitary fits, we incorporate the data on the $K^- p \rightarrow K^+\Xi^-$, $K^0\Xi^0$ reactions

- These transitions 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

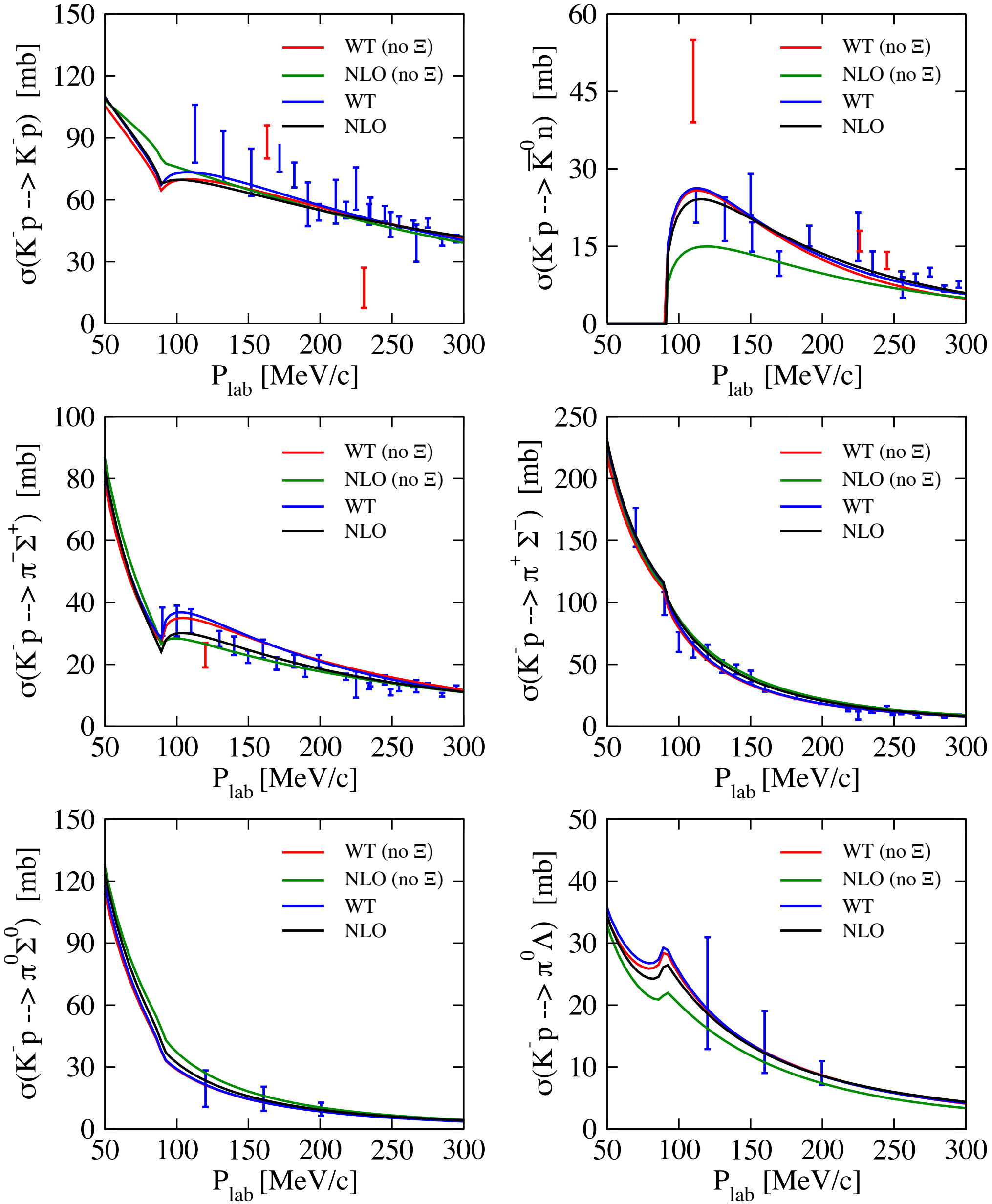
D_{ij} coefficients

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

L_{ij} coefficients

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

Results



2 models do not use KΞ data:

WT(no Ξ)

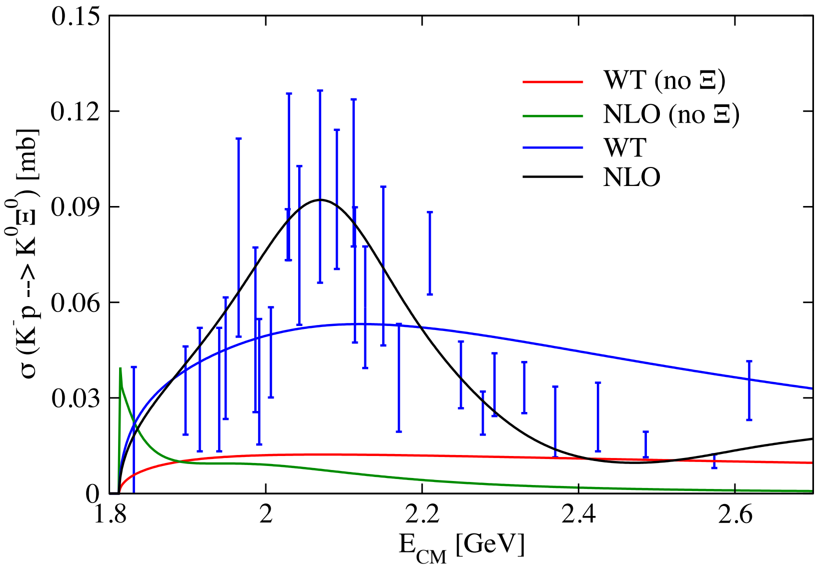
NLO (no Ξ)

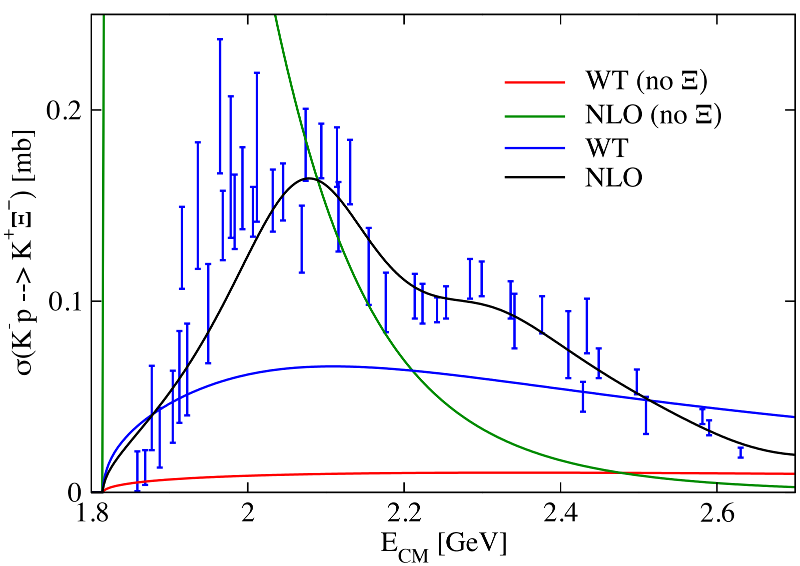
2 models include KΞ data:

WT

NLO

Results





2 models do not use KΞ data:
- WT(no Ξ)
- NLO (no Ξ)

2 models include KΞ data:
- WT
- NLO

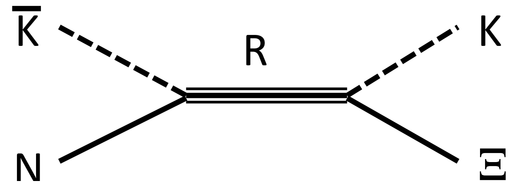
✓ The NLO terms are determinant for a reasonable description of data!

✓ There are still some resonant structures not accounted for!

➔ Explore the additional effect of resonances!

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)

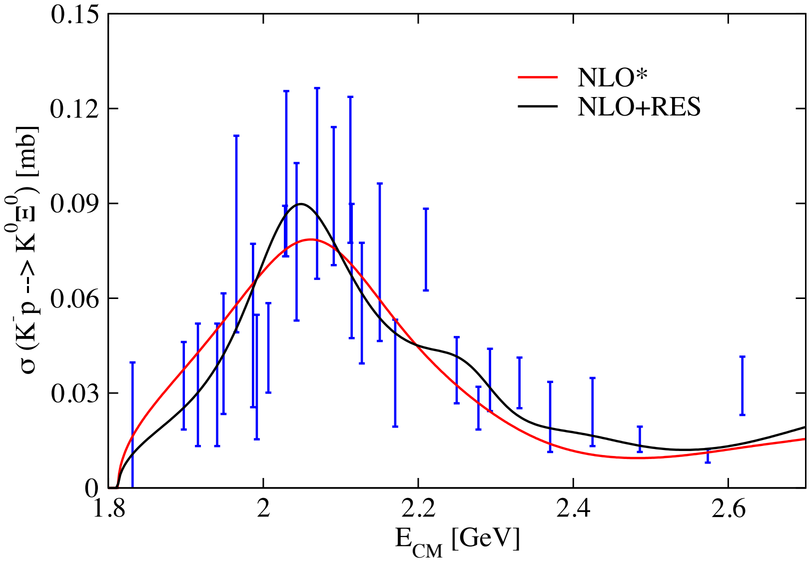
K. Shing Man, Y. Oh, K. Nakayama,, Phys. Rev. C83, 055201 (2011)

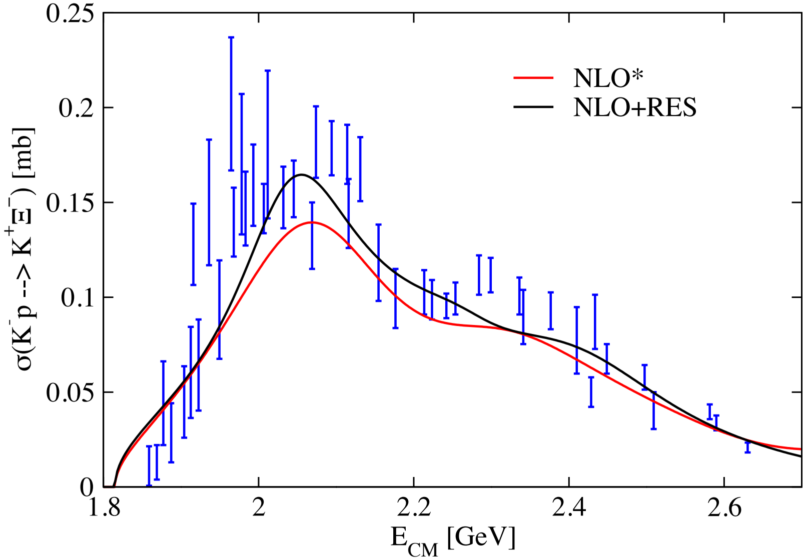
➔ We suplement the LO+NLO Lagrangian with two resonances:

$J^P=7/2^+$ $M_R \sim 2030$ MeV

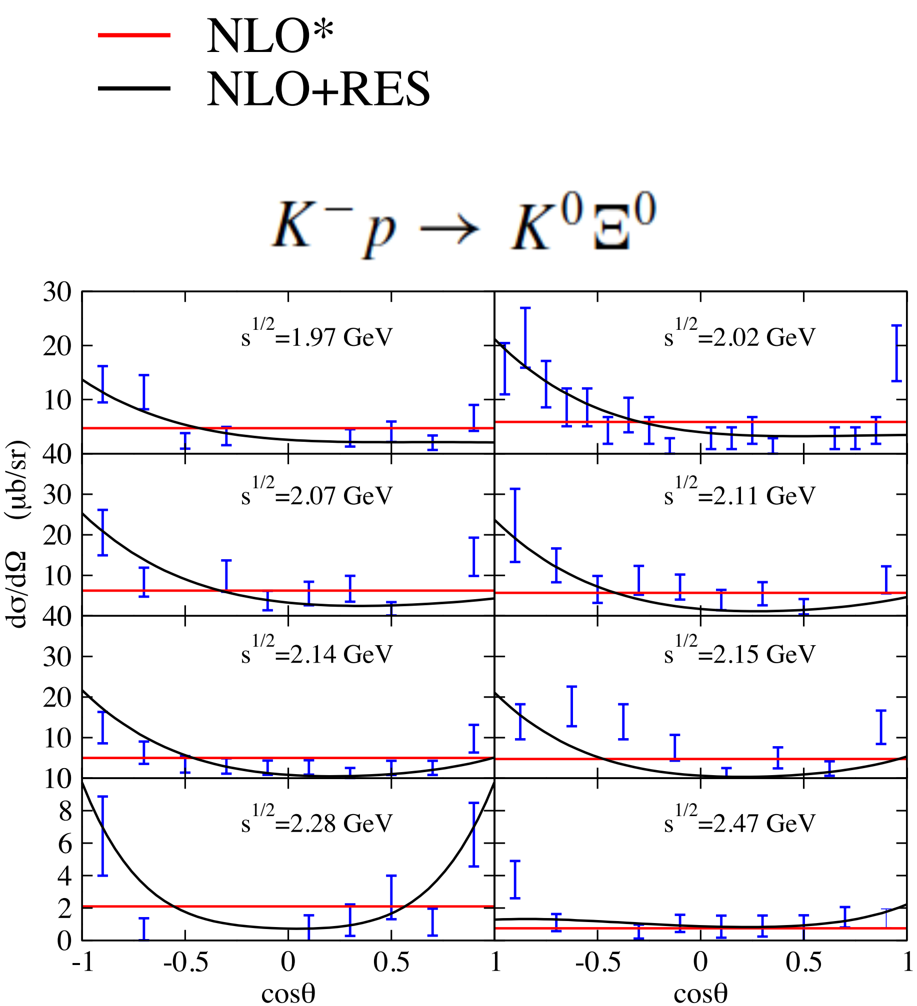
$J^P=5/2^-$ $M_R \sim 2250$ MeV

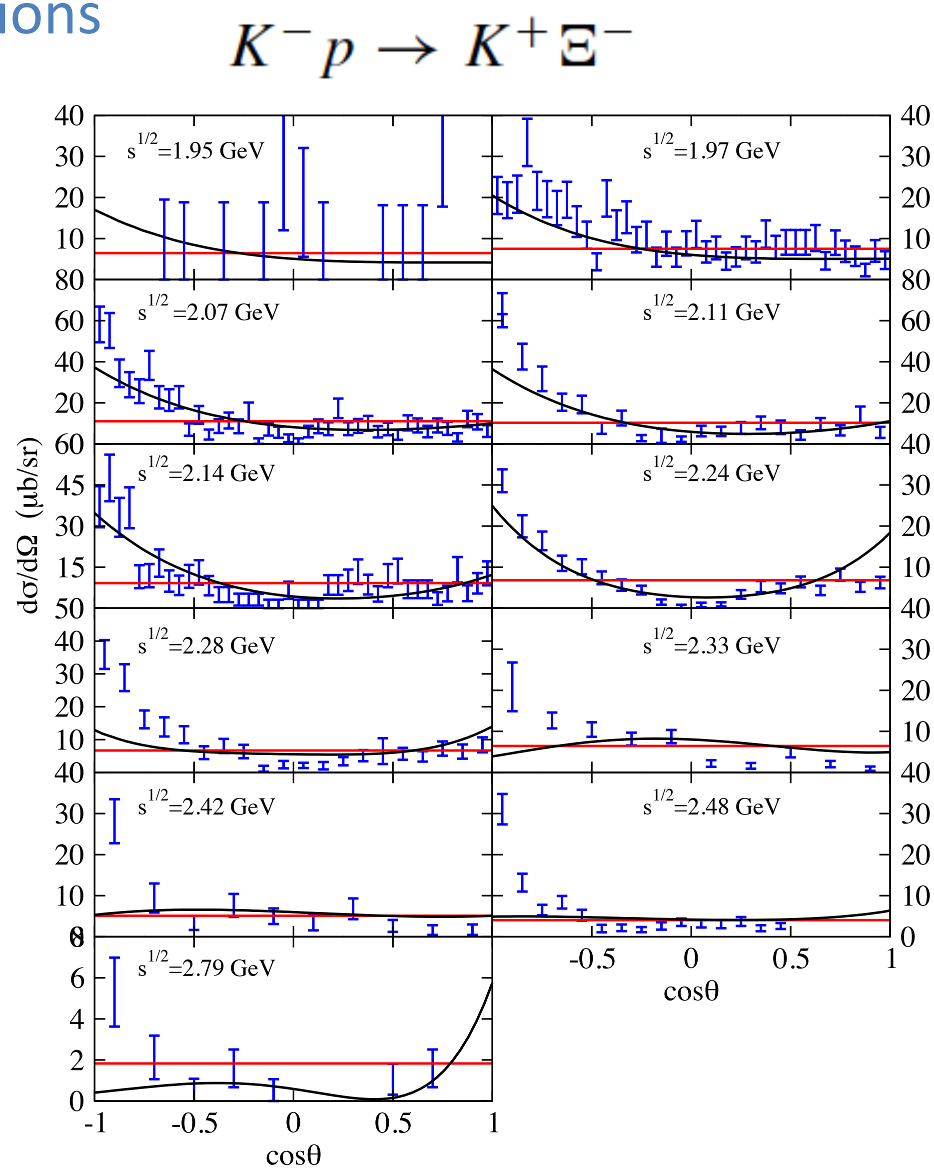
➔ the fit determines their masses, widths and couplings





Differential cross sections

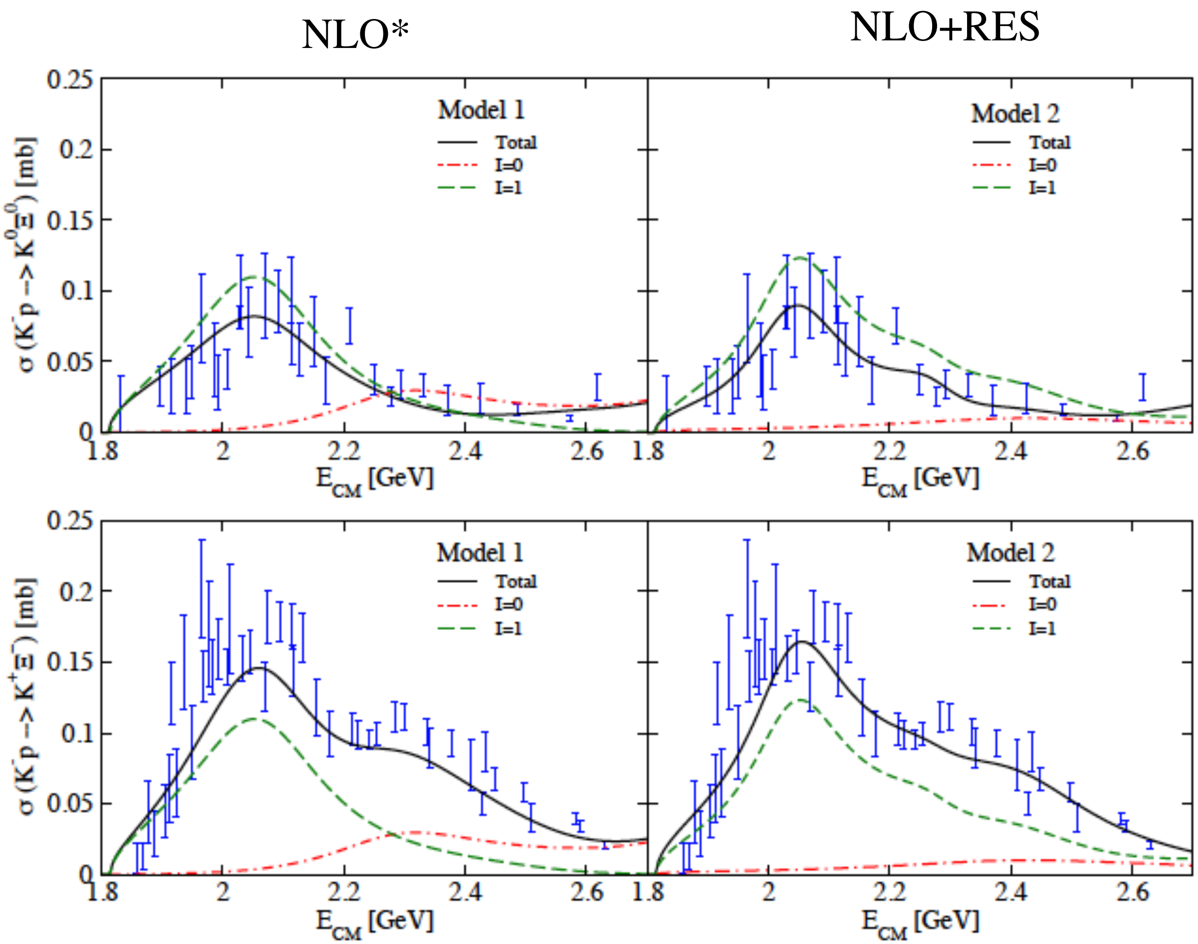




Parameters

	NLO*	NLO+RES
$a_{\bar{K}N}$ (10^{-3})	6.799 ± 0.701	6.157 ± 0.090
$a_{\pi\Lambda}$ (10^{-3})	50.93 ± 9.18	59.10 ± 3.01
$a_{\pi\Sigma}$ (10^{-3})	−3.167 ± 1.978	−1.172 ± 0.296
$a_{\eta\Lambda}$ (10^{-3})	−15.16 ± 12.32	−6.987 ± 0.381
$a_{\eta\Sigma}$ (10^{-3})	−5.325 ± 0.111	−5.791 ± 0.034
$a_{K\Xi}$ (10^{-3})	31.00 ± 9.441	32.60 ± 11.65
f/f_π	1.197 ± 0.011	1.193 ± 0.003
b_0 (GeV^{-1})	−1.158 ± 0.021	−0.907 ± 0.004
b_D (GeV^{-1})	0.082 ± 0.050	−0.151 ± 0.008
b_F (GeV^{-1})	0.294 ± 0.149	0.535 ± 0.047
d_1 (GeV^{-1})	−0.071 ± 0.069	−0.055 ± 0.055
d_2 (GeV^{-1})	0.634 ± 0.023	0.383 ± 0.014
d_3 (GeV^{-1})	2.819 ± 0.058	2.180 ± 0.011
d_4 (GeV^{-1})	−2.036 ± 0.035	−1.429 ± 0.006
$g_{\Xi Y_{5/2} K}\, g_{N Y_{5/2} \bar{K}}$		8.82 ± 5.72
$g_{\Xi Y_{7/2} K}\, g_{N Y_{7/2} \bar{K}}$		0.06 ± 0.20
$\Lambda_{5/2}$ (MeV)		522.7 ± 43.8
$\Lambda_{7/2}$ (MeV)		999.0 ± 288.0
$M_{Y_{5/2}}$ (MeV)		2278.8 ± 67.4
$M_{Y_{7/2}}$ (MeV)		2040.0 ± 9.4
$\Gamma_{5/2}$ (MeV)		150.0 ± 54.4
$\Gamma_{7/2}$ (MeV)		200.0 ± 32.3
$\chi^2_{\mathrm{d.o.f.}}$	1.48	1.05

Analysis of isospin contributions



$$\langle K^- p \mid T \mid K^0 \Xi^0 \rangle = -\frac{1}{2}\left[\langle \bar{K} N \mid T^{I=1} \mid K \Xi \rangle + \langle \bar{K} N \mid T^{I=0} \mid K \Xi \rangle \right]$$

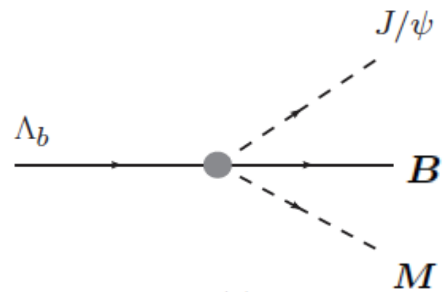
$$\langle K^- p \mid T \mid K^+ \Xi^- \rangle = \frac{1}{2}\left[\langle \bar{K} N \mid T^{I=1} \mid K \Xi \rangle - \langle \bar{K} N \mid T^{I=0} \mid K \Xi \rangle \right]$$

- ✓ Our unitarized calculations produce stronger I=1 amplitudes than I=0 ones
- ✓ This tendency is enhanced when I=1 resonances are included (NLO+RES)

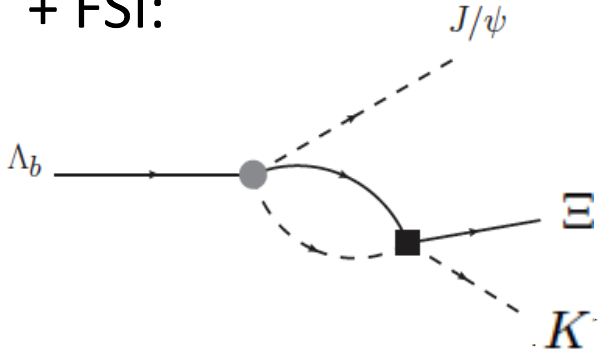
Different theoretical models predict different isospin decompositions, see e.g. **. C. Jackson, Y. Oh, H. Haberzettl, and K. Nakayama, Phys. Rev. C 91, 065208 (2015)**

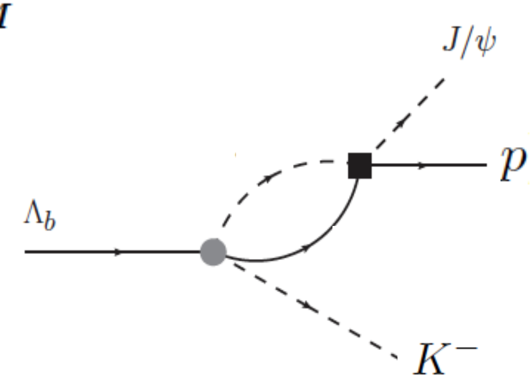
An I=0 filter for KΞ amplitudes: the decay $\Lambda_b \to J/\Psi\ K\ \Xi$

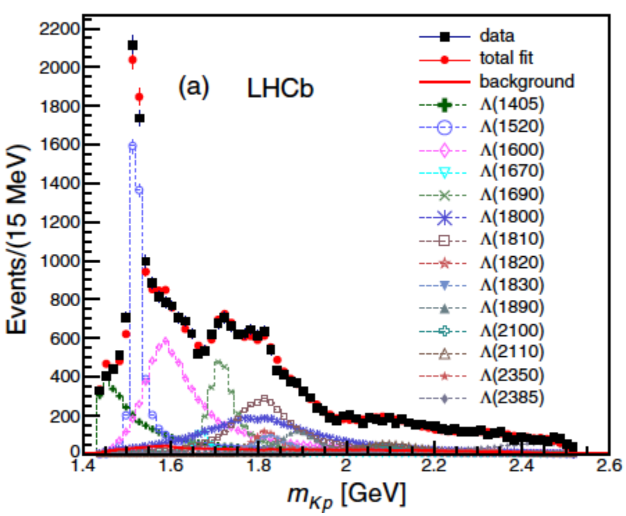
A. Feijoo, V.K. Magas, A. Ramos, E. Oset, Phys.Rev. D92 (2015) 076015

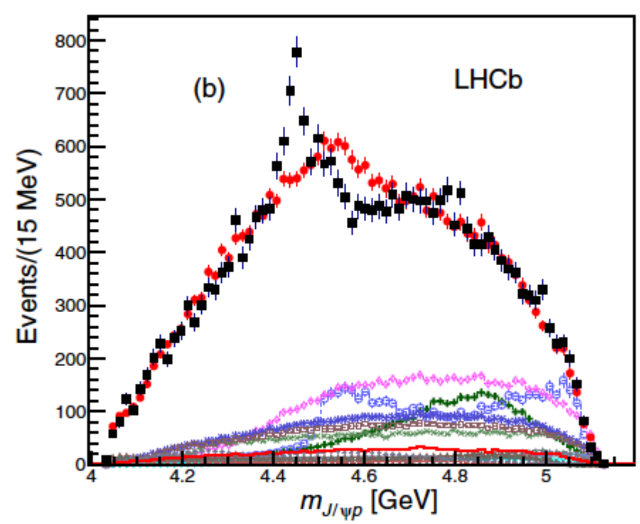


+ FSI:







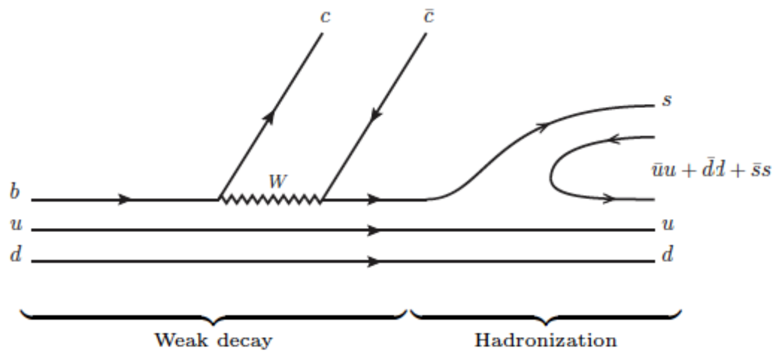


P_c^+ states:

$4380 \pm 8 \pm 29$ MeV

$4449.8 \pm 1.7 \pm 2.5$ MeV

R. Aaij et al. LHCb coll. PRL 115, 072001 (2015)

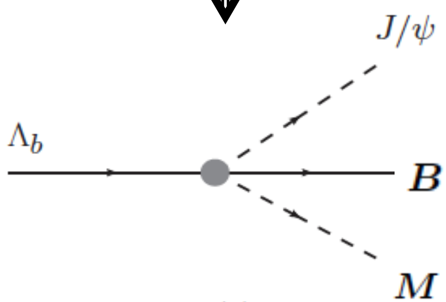


W. H. Liang and E. Oset, Phys. Lett. B 737, 70 (2014)

L. Roca, M. Mai, E. Oset and U. G. Meissner, Eur. Phys. J. C75, 218 (2015)

$$|H\rangle = |K^- p\rangle + |\bar{K}^0 n\rangle - \frac{\sqrt{2}}{3}|\eta\Lambda\rangle + \frac{2}{3}|\eta'\Lambda\rangle$$

Meson-Baryon in I=0 !



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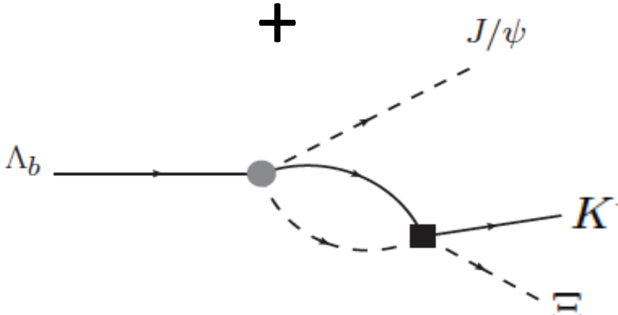
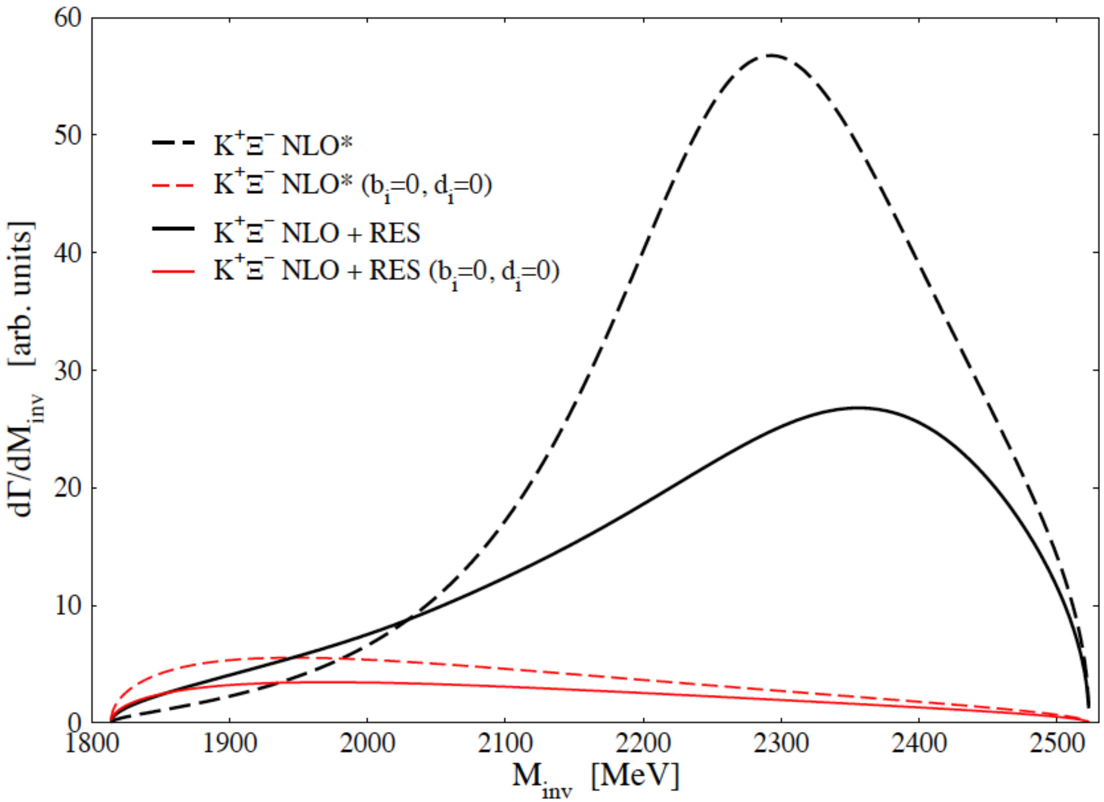


$$\mathcal{M}_j(M_{\rm inv}) = V_p \left(h_j + \sum_i h_i G_i(M_{\rm inv})\, t_{ij}(M_{\rm inv}) \right)$$

$$\frac{d\Gamma_j}{dM_{\rm inv}}(M_{\rm inv}) = \frac{1}{(2\pi)^3}\frac{M_j}{M_{\Lambda_b}} p_{J/\psi}\, p_j \left|\mathcal{M}_j(M_{\rm inv})\right|^2$$

K+Ξ^- invariant mass distribution from the decay $\Lambda_b \to J/\Psi\, K^+\, \Xi^-$

(I=0 filter)!



Different models fitted to K-p → $K^+\Xi^-$, $K^0\, \Xi^0$ scattering data predict different I=0 distributions

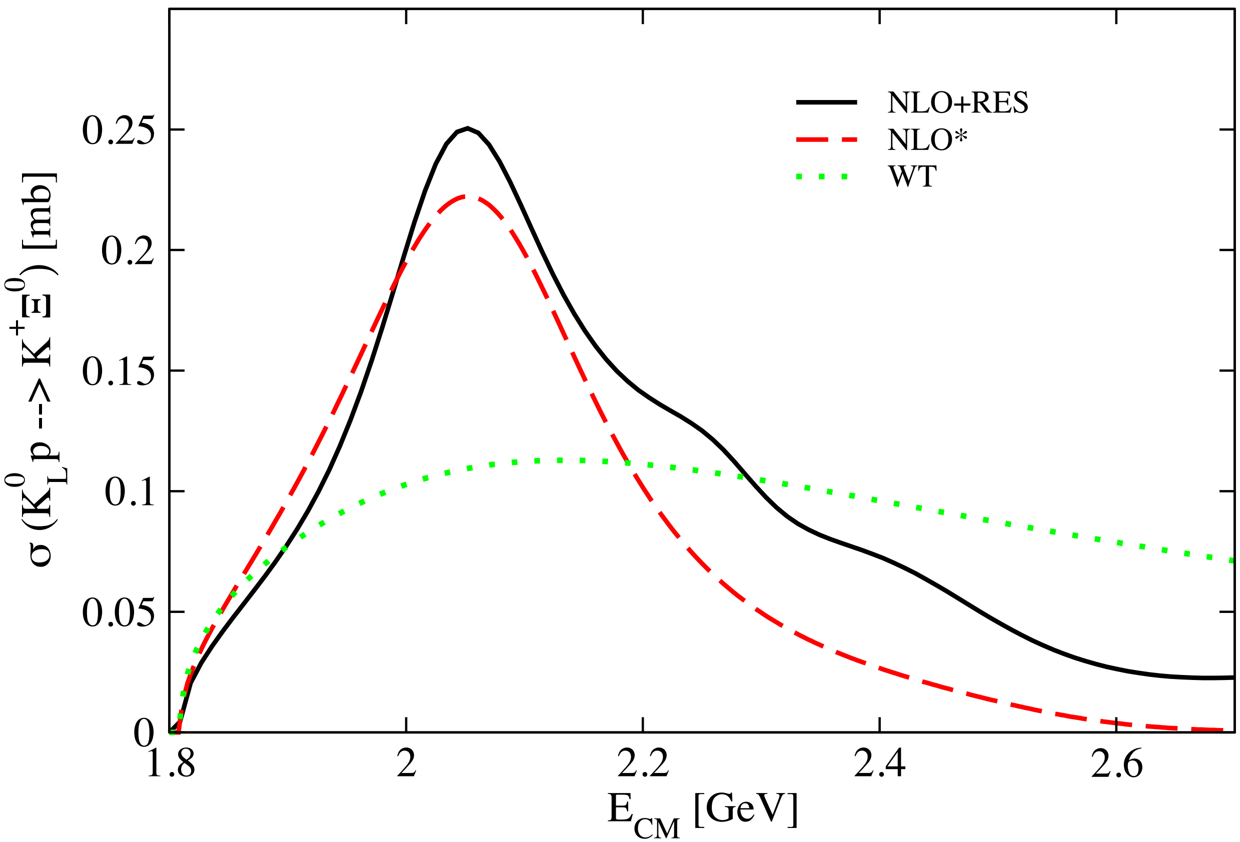
The NLO terms of the Lagrangian are dominant

I=1 filter from the Secondary K^0_L beam at Jlab

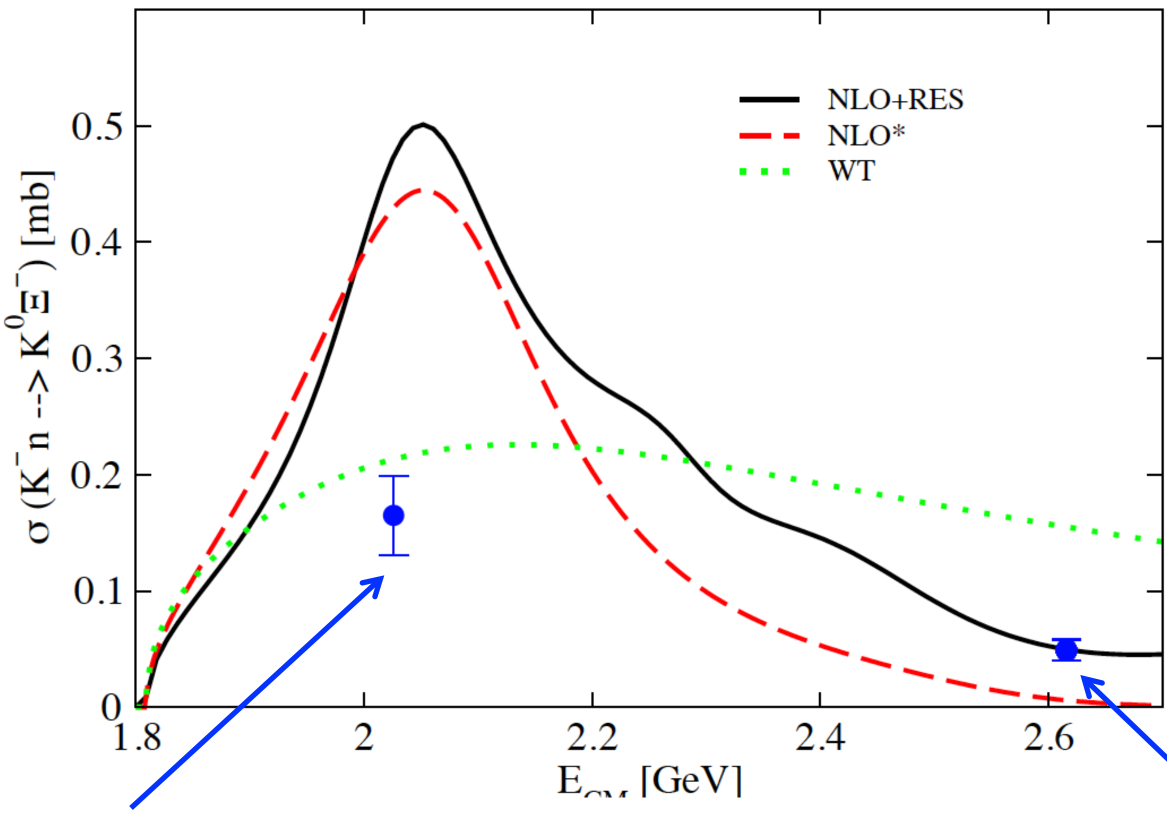
$$K^0_L + p \to K^+ \Xi^0$$

(S=-1, I=1)

It proceeds through the $\bar{K}^0$ component of the K^0_L



I=1 reaction: $K^- n \rightarrow K^0 \Xi^-$



J. P. Berge et al.
Phys. Rev. 147, 945 (1966).

S.A.B.R.E. Collaboration,
J. C. Scheuer et al.
Nucl. Phys. B 33, 61 (1971).

Data from the secondary K^0_L beam at Jlab will be very valuable to constrain the models of the S=-1 meson-baryon interaction!

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 in K^-p scattering ➔ NLO calculations become more meaningful

- The $K^- p$ ➔ $K^+ \Xi^-$, $K^0 \Xi^0$ reactions are very sensitive to the NLO parameters

- Explicit inclusion of resonances improves the precision of the fitted parameters

- An isospin decomposition of the $\bar{K}N$ ➔ $K\Xi$ reactions would help constrain better the S=-1 meson-baryon interaction

- Data from the secondary K^0_L beam at Jlab will be very valuable!