Accessing the strong interaction between Λ baryons and strange hadrons with femtoscopy at LHC

V. Mantovani Sarti (TUM) on behalf of the ALICE Collaboration

MESON, Kraków 22-27 June 2023

Based on:
ALICE Coll. arXiv: 2305.19093

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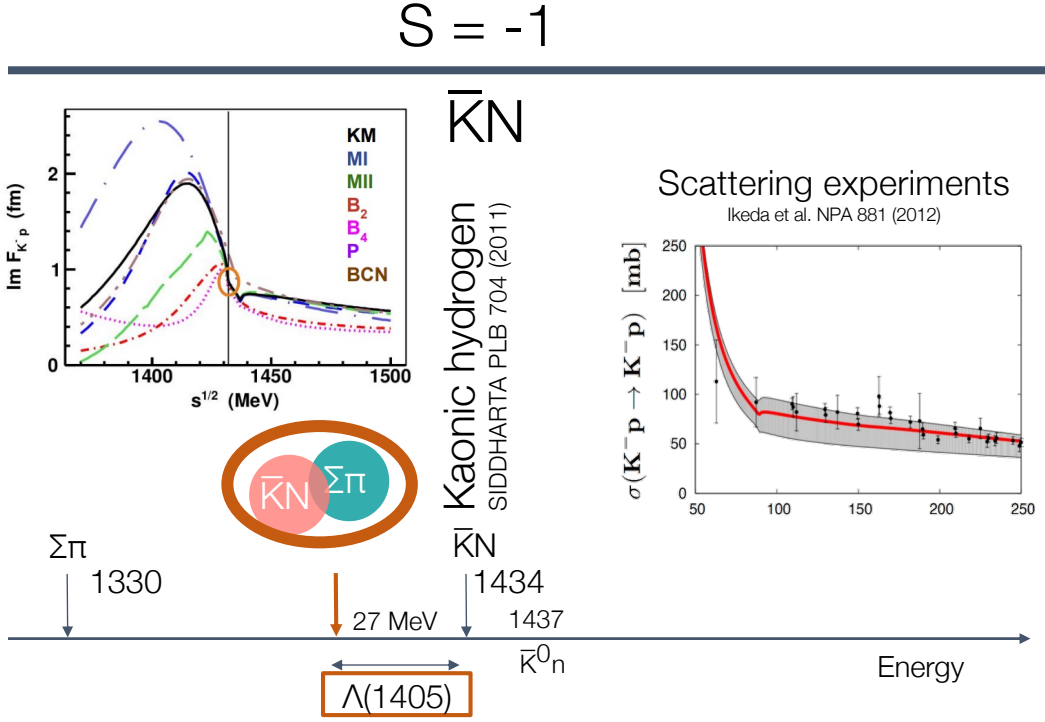
Meson-baryon interactions with strangeness

- Playground for many facets of low-energy QCD → Inelastic channels, bound and resonant states
- Still rather poorly constrained experimentally



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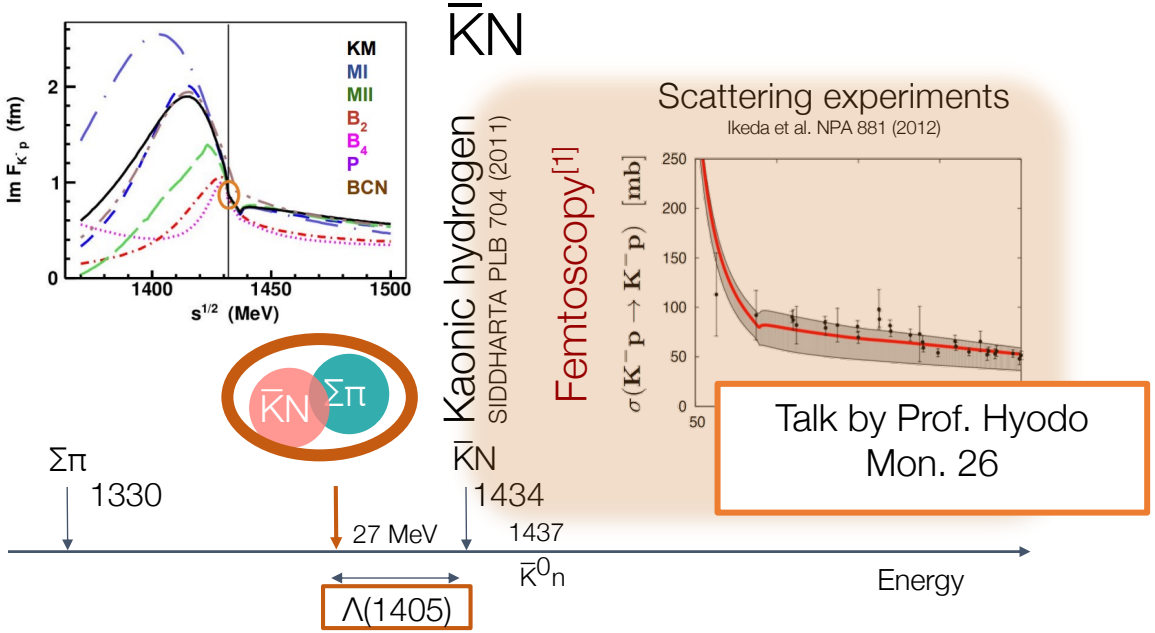

K̄N

Kaonic hydrogen
SIDDHARTA PLB 704 (2011)

Femtoscopy[1]

Scattering experiments
Ikeda et al. NPA 881 (2012)

Talk by Prof. Hyodo
Mon. 26

K⁻p correlations in different colliding systems (pp,p–Pb, Pb–Pb)
→ Improve understanding of **Λ(1405) molecular state**[2]

[1]pp: ALICE Coll. PRL 124 (2020)
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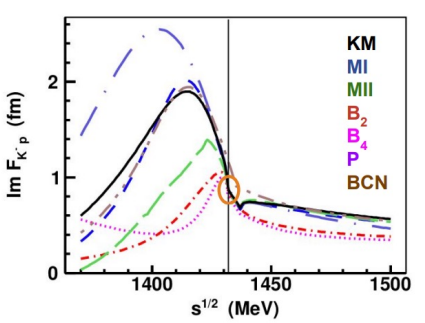

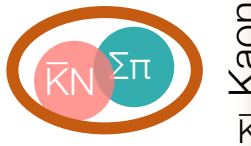

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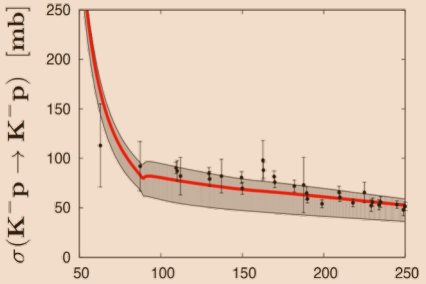

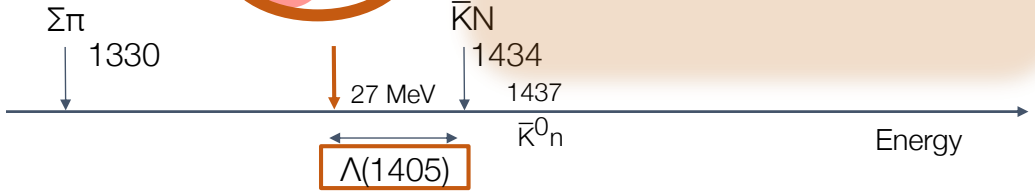

K^-p correlations in different colliding systems (pp,p–Pb, Pb–Pb)
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$K\Lambda$

Scattering experiments
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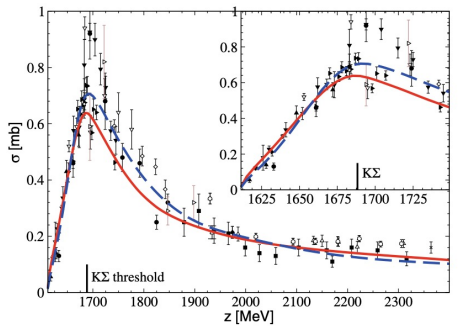
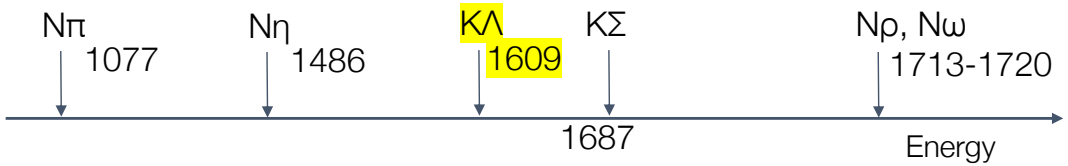
$\pi^-p \to \Lambda K^0$





Coupled-channel dynamics important for the rich N* and Δ resonance spectrum
→ Mainly driven by large amount of Nπ data

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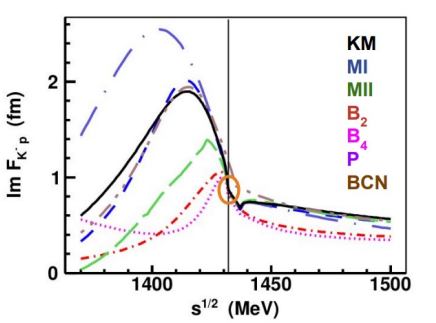

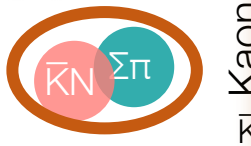

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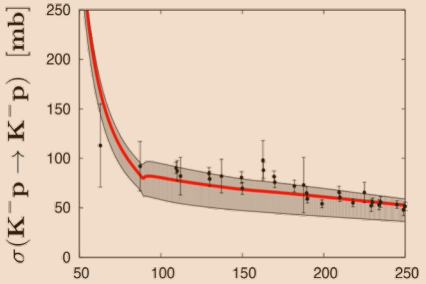

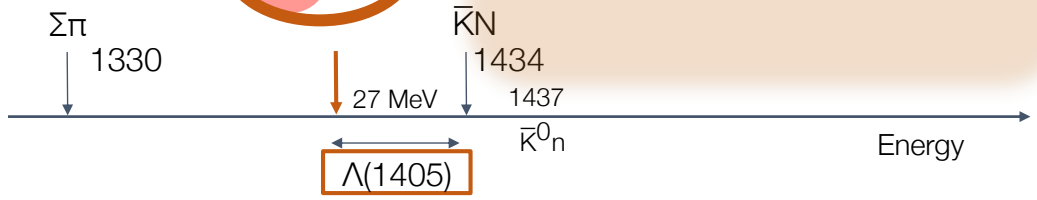

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KΛ

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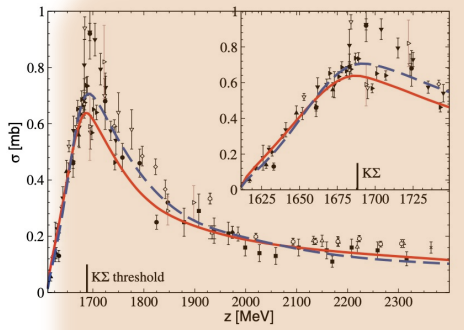
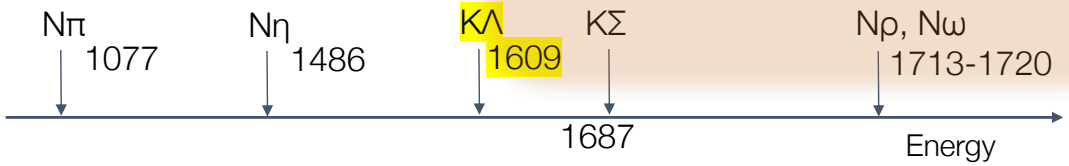


$\pi^-p \to \Lambda K^0$

Femtoscopy in Pb-Pb[3]



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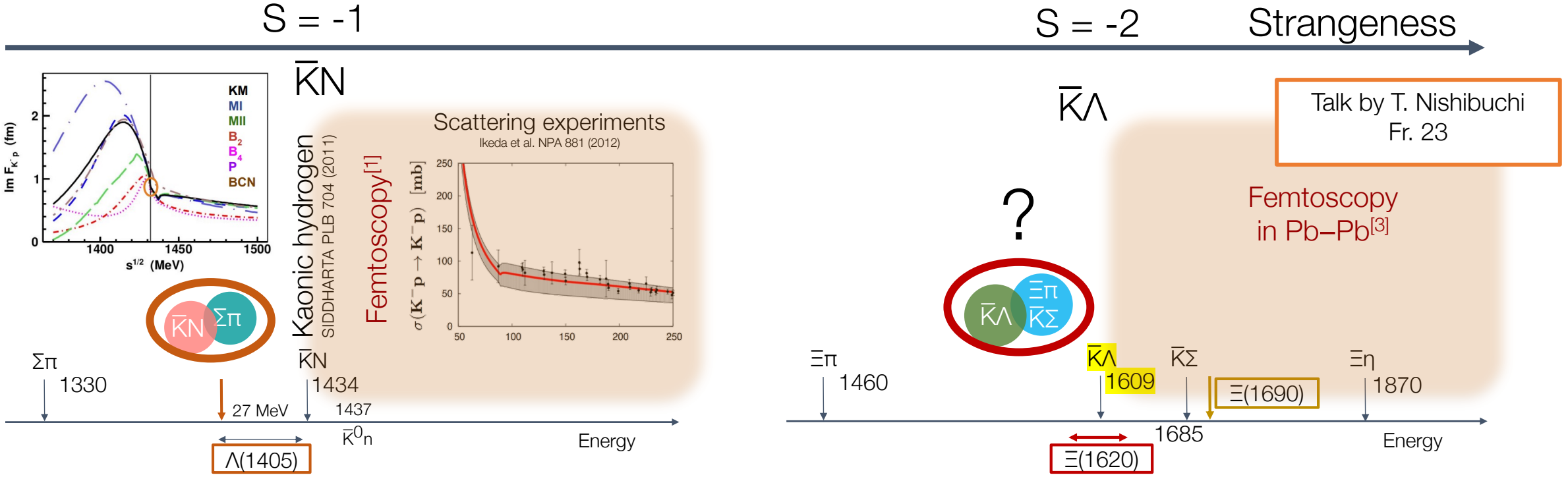

K⁻p correlations in different colliding systems (pp,p–Pb, Pb–Pb)
→ Improve understanding of **Λ(1405) molecular state**[2]

Similar scenario for **Ξ(1620)** state?
→ Poorly known, only observed in πΞ decay [4]
→ Shed light on the nature of this state

[1]pp: ALICE Coll. PRL 124 (2020)
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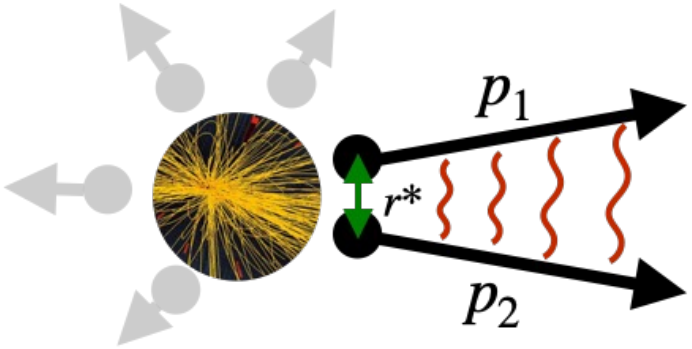
[2] M. Mai EPJ.ST 230 (2021), 6, 1593-1607
[3] ALICE Coll. PRC 103 (2021),CMS Coll. arXiv:2301.05290
[4] Belle Coll. PRL 122 (2019)

The femtoscopy technique at ALICE

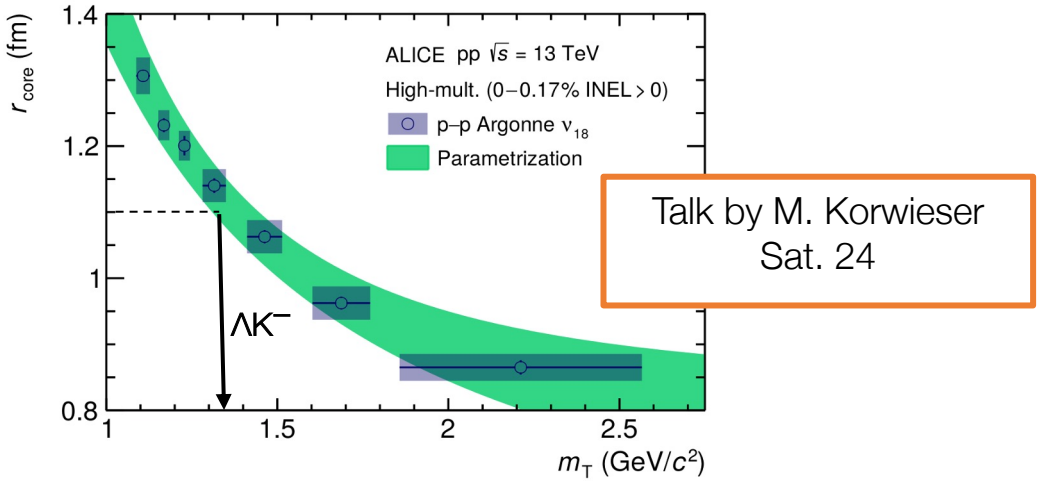


- Access to the **short-range dynamics** between hadrons[1,2]:

$$C(k^*) = \int S(\vec{r}^*)\left|\psi(\vec{k}^*,\vec{r}^*)\right|^2 d^3\vec{r}^* = \mathcal{N}(k^*)\frac{N_{\text{same}}(k^*)}{N_{\text{mixed}}(k^*)}$$

ALICE measurements shown today in high-multiplicity pp collisions at 13 TeV
→ **Emitting source anchored to p-p correlation data** [3]
→ Interparticle distances ~1-2 fm in pp collisions

- Long-lived strongly decaying resonances feeding to Λ and K ($\langle c\tau \rangle_{\Lambda,K}$~4-5 fm)
  → Effective double Gaussian



Talk by M. Korwieser
Sat. 24

[1] M.Lisa, S. Pratt et al, Ann.Rev.Nucl.Part.Sci. 55 (2005), 357-402
[2] L. Fabbietti, VMS and O. Vazquez Doce ARNPS 71 (2021), 377-402
[3] ALICE Coll., PLB 811 (2020), 135849

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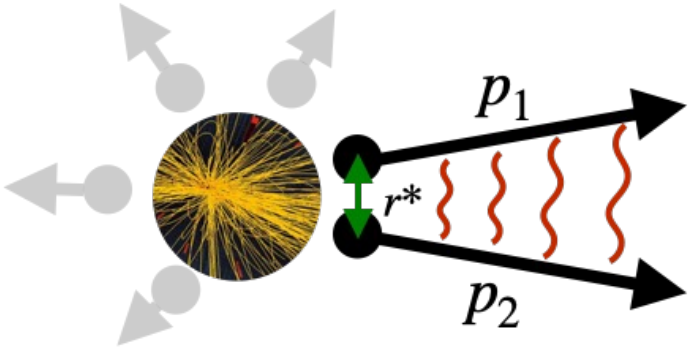

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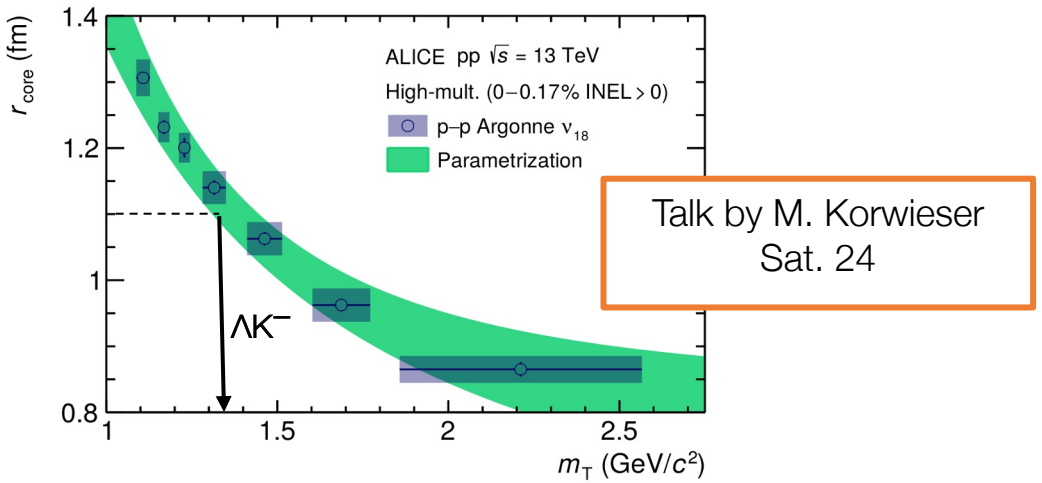
Two-particle wave function[4]
→ Profile of $C(k^*)$ vs nature of the interaction

Beyond 2-body
Talk by Prof. Fabbietti
Mon. 26



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$$C(k^*)\begin{cases} > 1 & \text{Attractive} \\ < 1 & \text{Repulsive} \\ \gtrless 1 & \text{Bound state} \end{cases}$$

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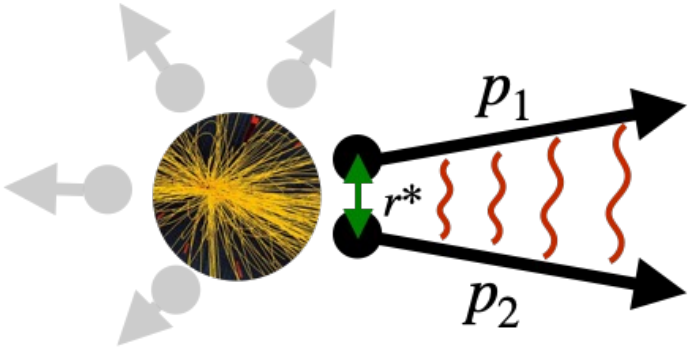
Hadron-hadron interactions harvest in Run 2



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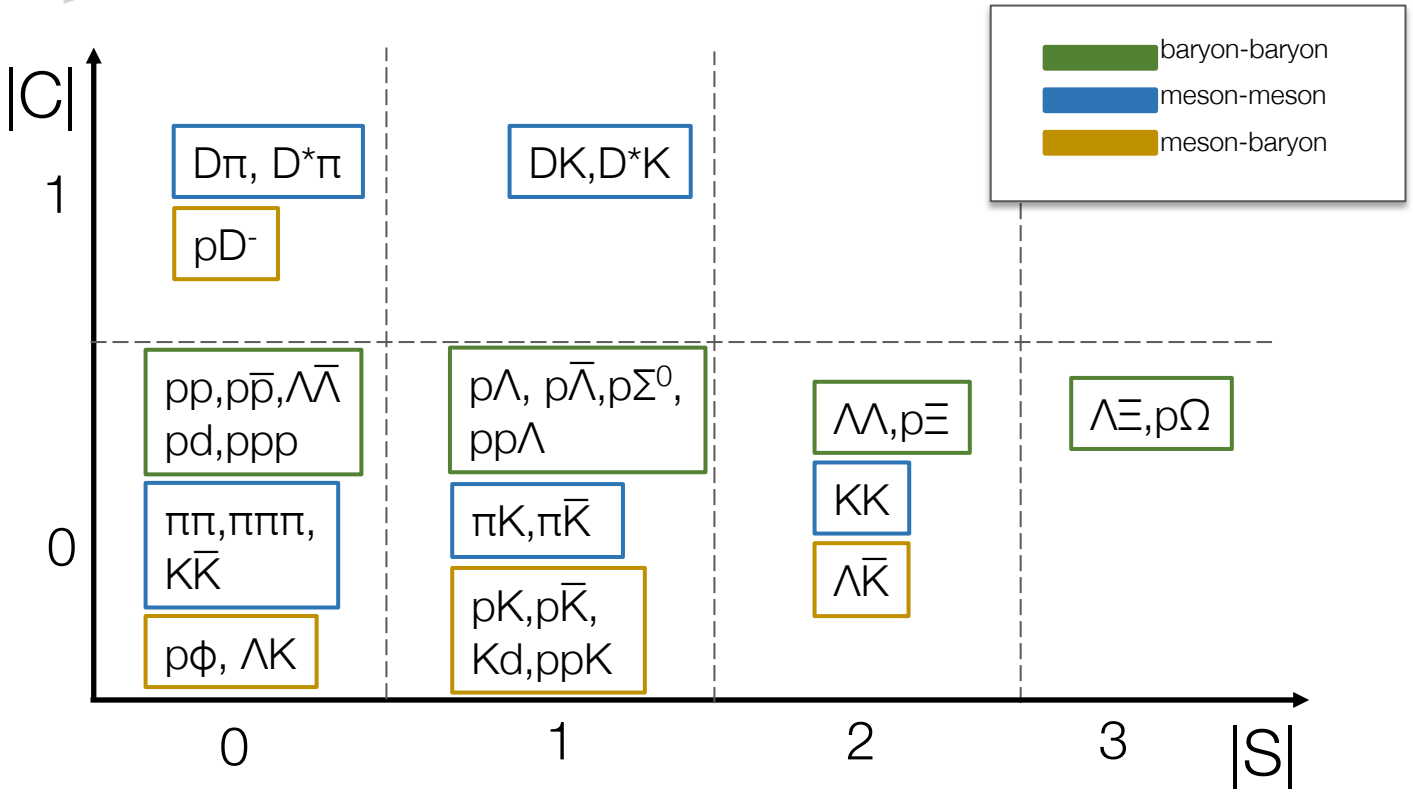


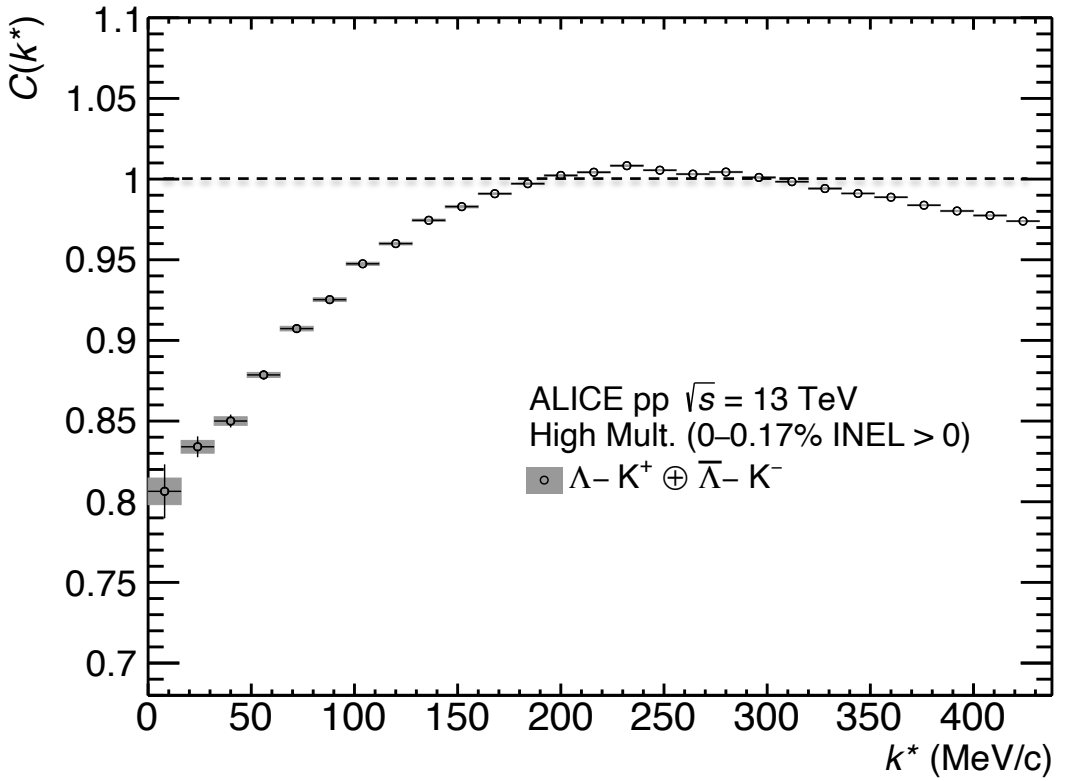
ALICE Collaboration:

PRC 99 (2019) 2, 024001
PLB 797 (2019) 134822
PRL 123 (2019) 112002
PRL 124 (2020) 09230
PLB 805 (2020) 135419
PLB 811 (2020) 135849
Nature 588 (2020) 232-238
PRL 127 (2021), 172301
PLB 822 (2021), 136708
PRC 103 (2021) 5, 055201
PLB 833 (2022), 137272
PLB 829 (2022), 137060
PRD 106 (2022), 5, 05201
arXiv:2204.10258 [nucl-ex], accepted in PLB
arXiv:2206.03344 [nucl-ex], accepted in EPJA
arXiv:2305.19093 [nucl-ex], submitted to PLB
… and more to come.

The ΛK⁺ correlation in pp collisions

ALICE Coll. arXiv: 2305.19093

- Correlation below unity at low k* → Repulsive interaction



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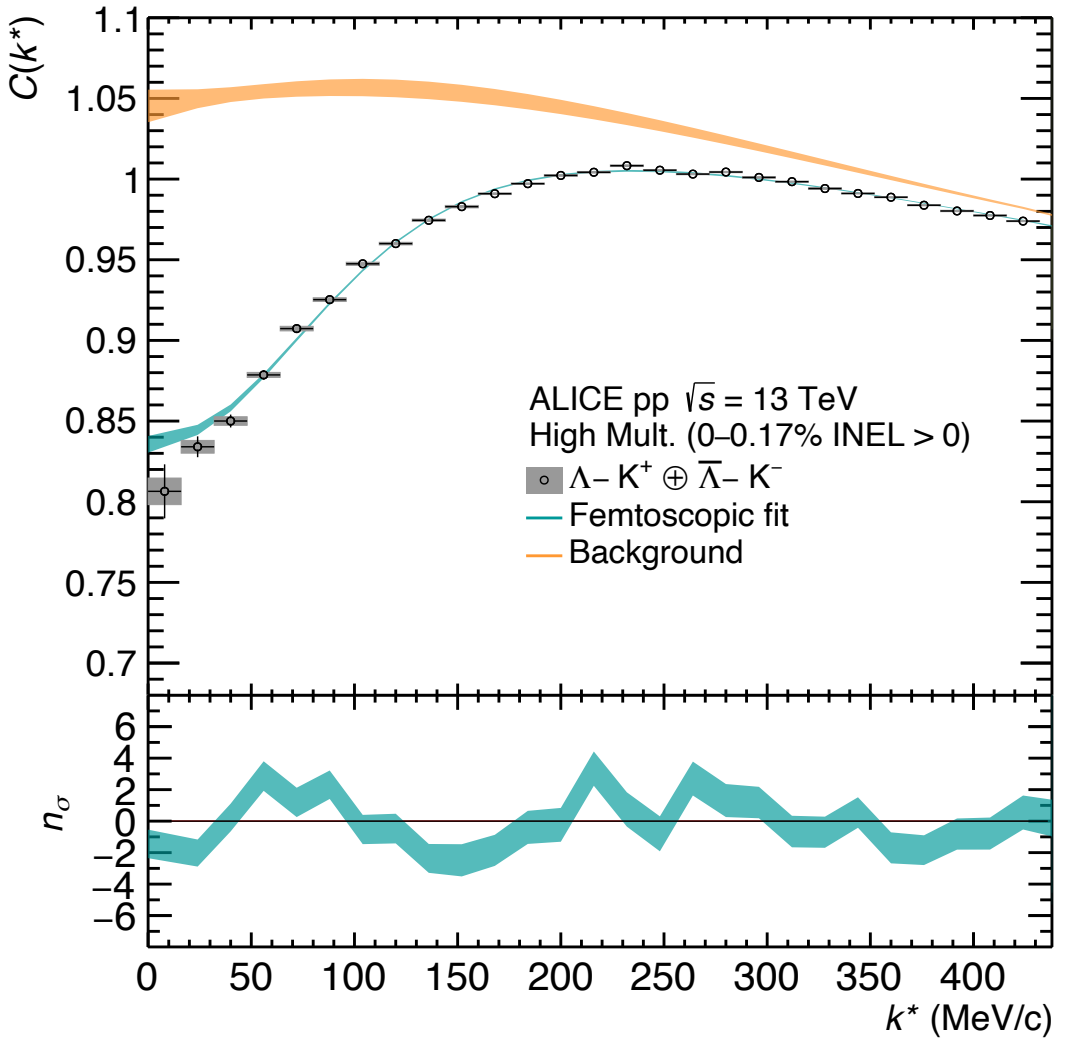
$$C(k^*) = N_D \cdot C_{model}(k^*) \cdot C_{bckg}(k^*)$$

- Residual background due to initial parton scattering
  → Typically observed in meson-baryon and baryon-antibaryon correlations[1,2]
  → Modeled using **Monte-carlo simulations**[2]

- Genuine correlation modeled with the Lednicky-Lyuboshits formula[2,3]
  → Assuming the **scattering amplitude** within the **effective range expansion**



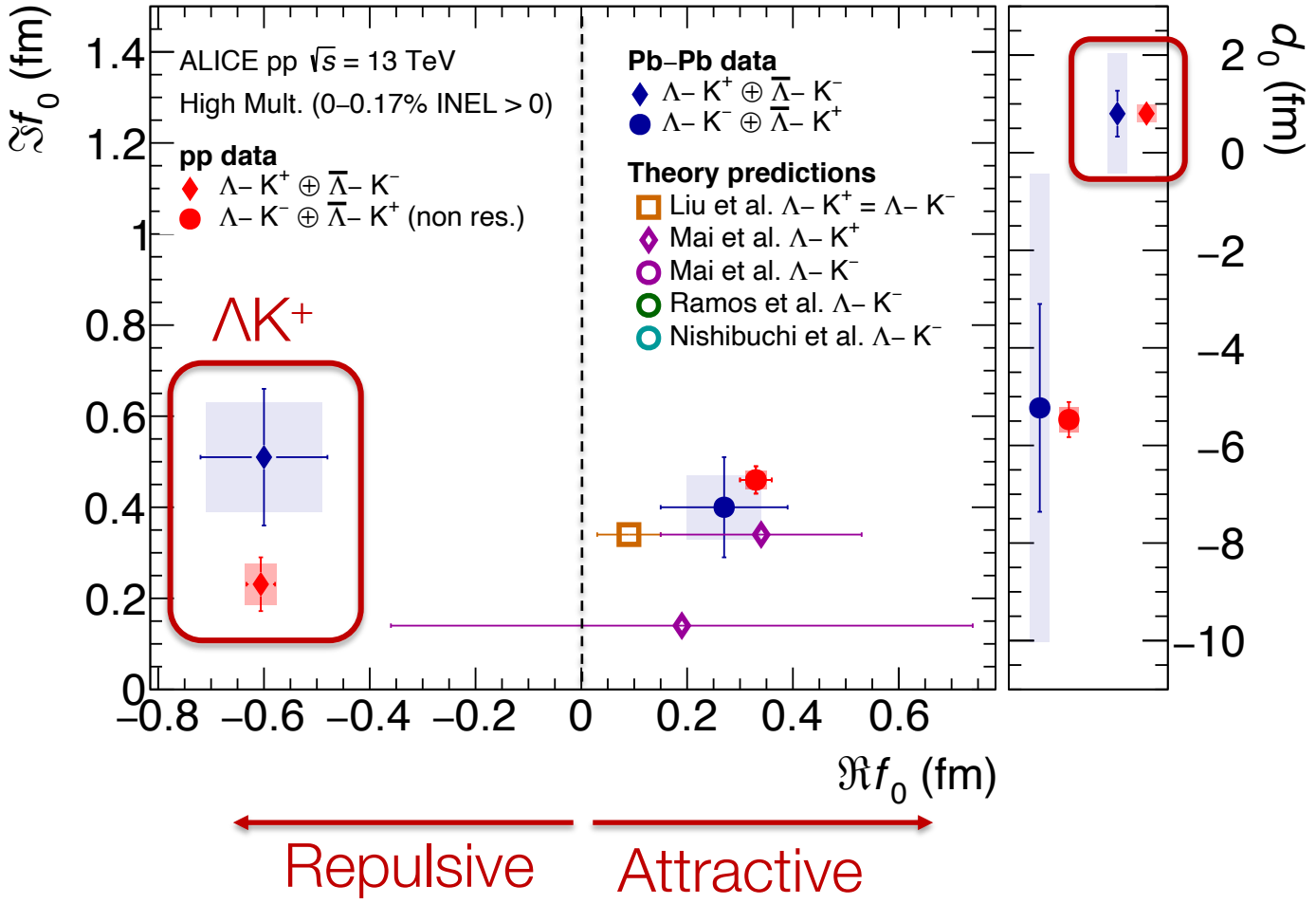
[1] ALICE Coll. Phys.Rev.Lett. 124 (2020)
[2] ALICE Coll. PLB 829 (2022)

Scattering parameters for the ΛK⁺ interaction

- Extracted scattering parameters
  → In agreement with ALICE Pb-Pb results[1]
- Available models mainly indicating an attractive interaction
  → Parameters fixed based on SU(3) flavour symmetry, isospin symmetry

  → Mainly anchored to πN or $\bar{K}$N data
- High-precision data to be used to constrain effective chiral theories

ALICE Coll. arXiv: 2305.19093



χPT at NLO: Liu et al. PRD 75 (2007), Mai et al. PRD 80 (2009)

The ΛK$^-$ correlation in pp collisions

- Correlation overall above 1 → Attractive interaction

$$C(k^*) = N_D \cdot C_{model}(k^*) \cdot C_{bckg}(k^*)$$

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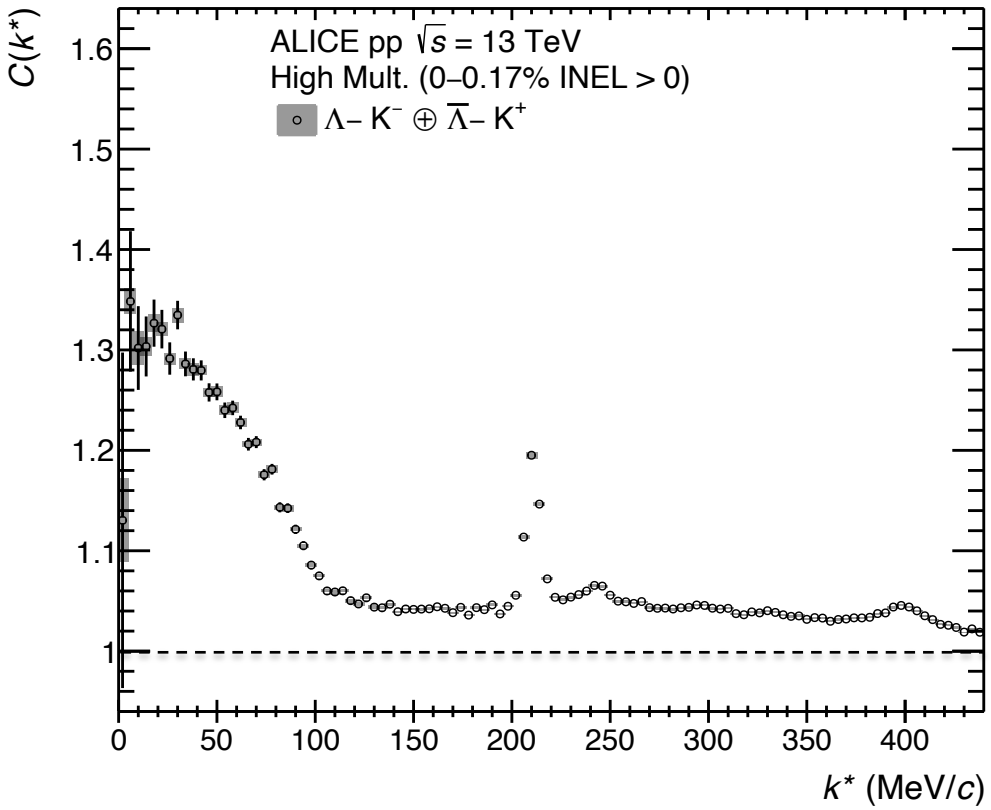


The ΛK⁻ correlation in pp collisions

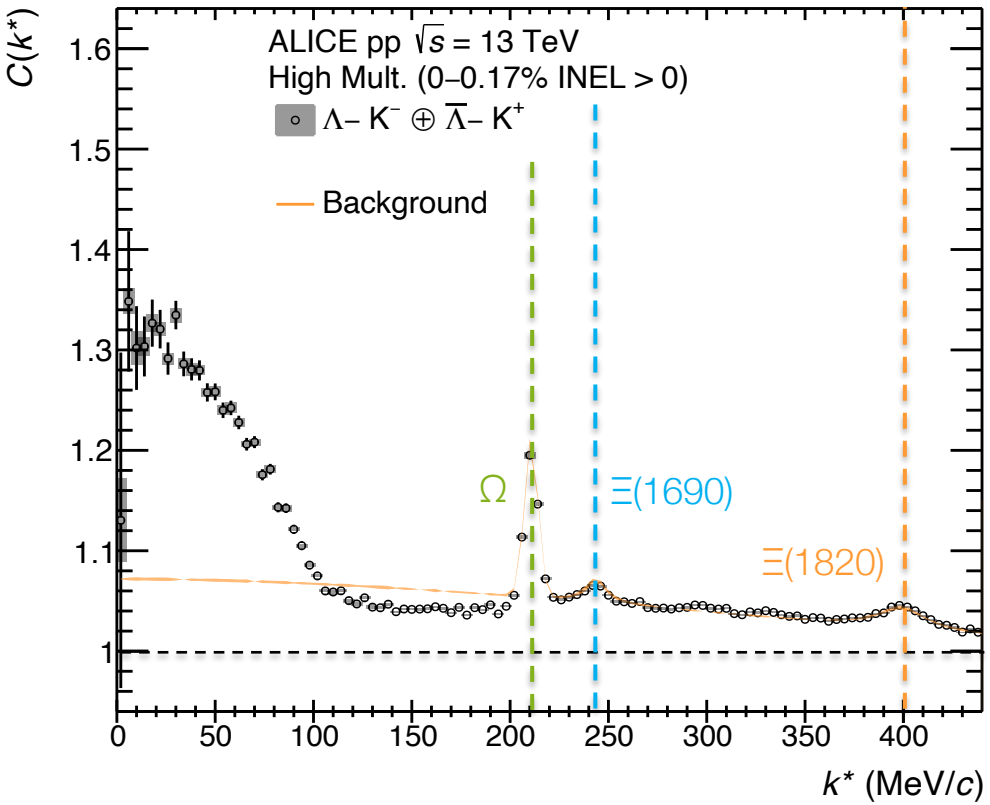
- Correlation overall above 1 → Attractive interaction

$$C(k^*) = N_D \cdot C_{model}(k^*) \cdot C_{bckg}(k^*)$$

- Several peak structures in the measured correlation at k* > 200 MeV/*c*
  → Ω, Ξ(1690) and Ξ(1820) included in the background

- Residual background due to initial parton scattering
  → Modeled using Monte-carlo simulations

ALICE Coll. arXiv: 2305.19093



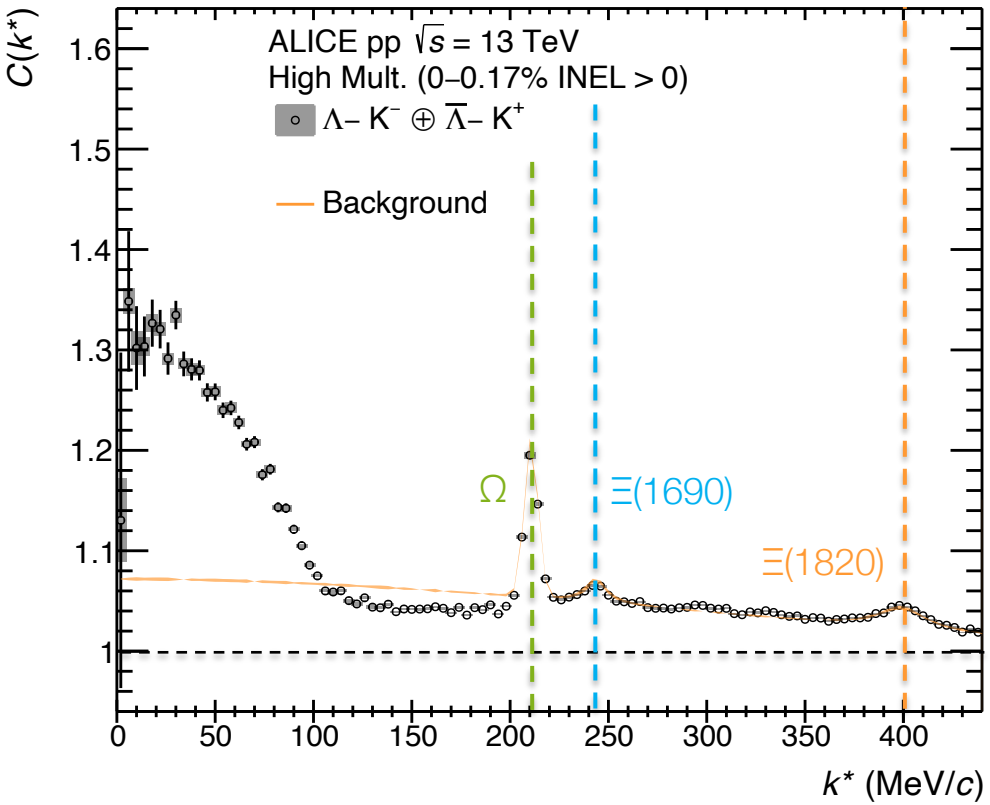
The ΛK⁻ correlation in pp collisions

- Correlation overall above 1 → Attractive interaction

$$C(k^*) = N_D \cdot C_{model}(k^*) \cdot C_{bckg}(k^*)$$

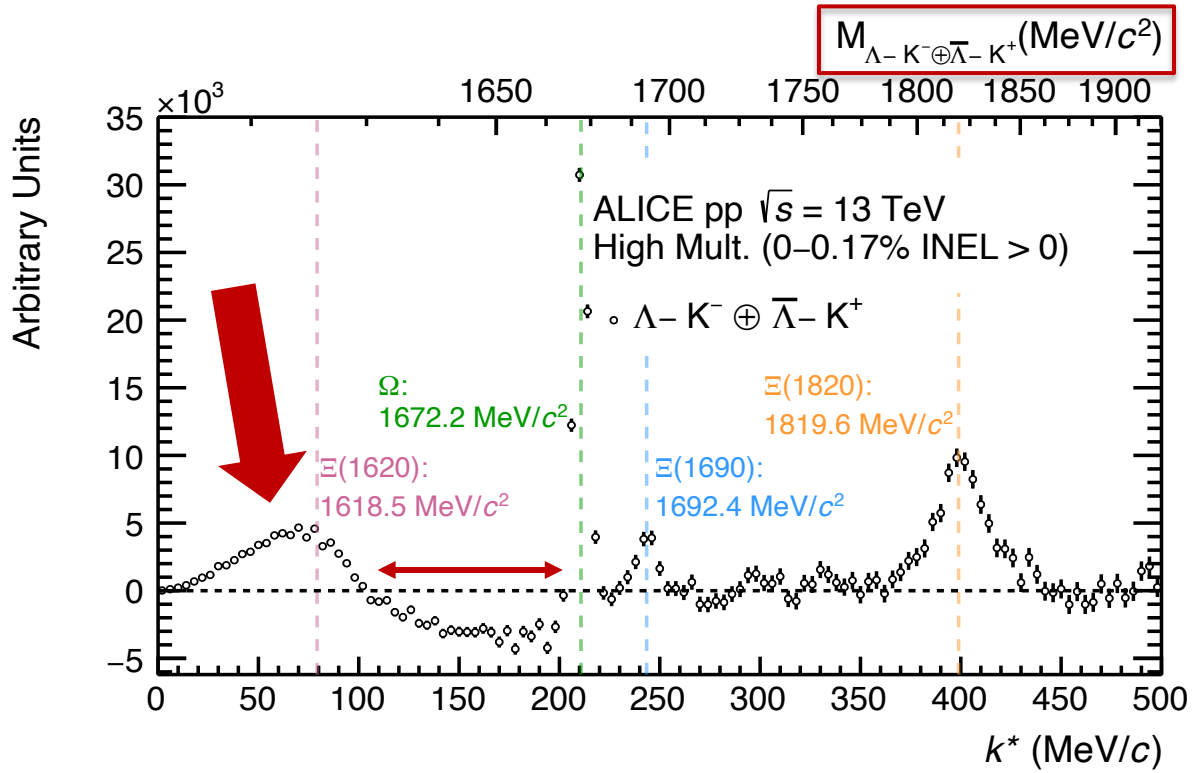
- To understand how to model the genuine part we need to understand the signal at low k*!

ALICE Coll. arXiv: 2305.19093



The ΛK⁻ correlation in pp collisions

- Correlation overall above 1 → Attractive interaction
- Invariant mass from same and mixed event distributions used to build the correlation
  - Ξ(1620) just above the threshold
    → First experimental evidence of decay into ΛK^{-}



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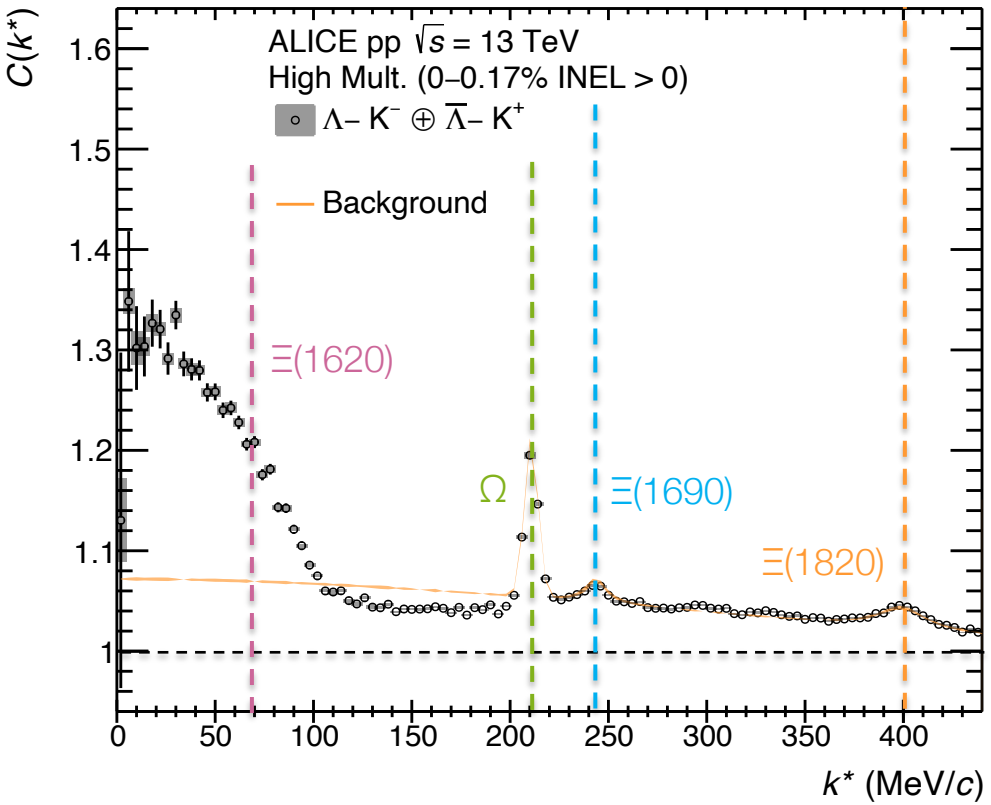
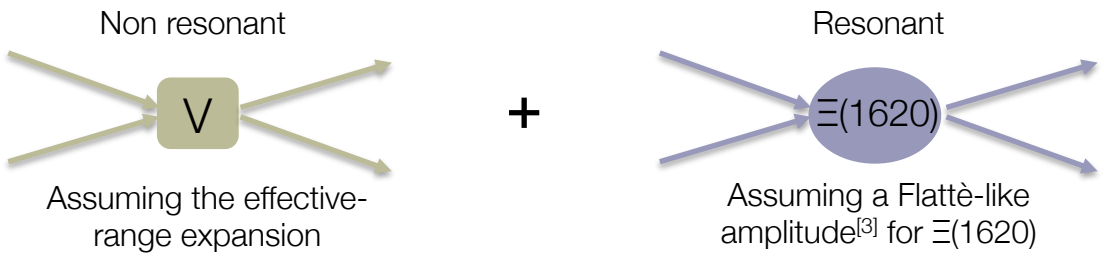


The ΛK⁻ correlation in pp collisions

- Correlation overall above 1 → Attractive interaction

$$C(k^*) = N_D \cdot C_{model}(k^*) \cdot C_{bckg}(k^*)$$

- Genuine correlation of interest as weighted sum
  → Modeled with the Lednicky-Lyuboshits formula[1,2]



Talk by Prof. Giacosa
Th. 22

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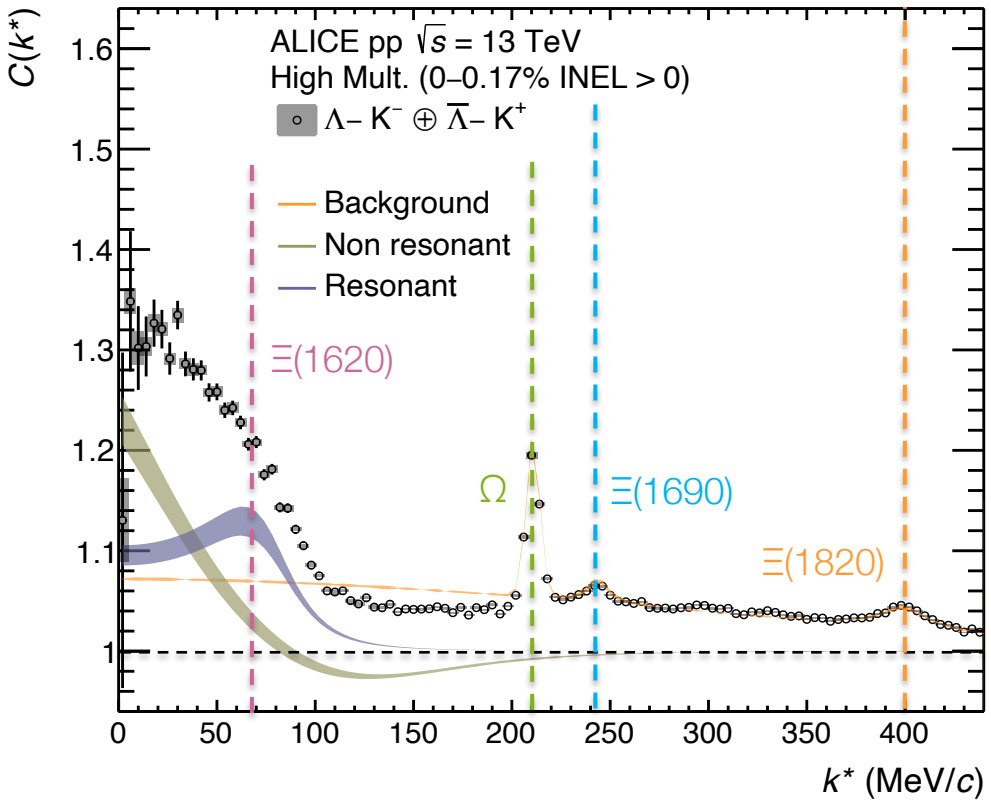


[1] R. Lednicky, V. Lyuboshits SJNP 35 (1982)
[2] CATS: D. Mihaylov et al., EPJC 78 (2018), 5, 394
[3] F. Giacosa et al. EPJA 57 (2021), 12, 336

The ΛK⁻ correlation in pp collisions

ALICE Coll. arXiv: 2305.19093

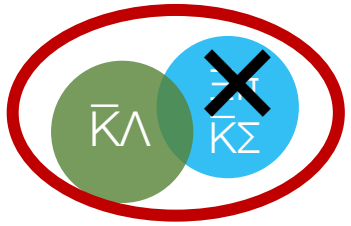
- Most precise data on ΛK̄ interaction at low momenta

- LL model well reproduces the data in the whole k* region
  → Interplay between resonant and non-resonant interaction
  → Non-resonant scattering parameters in agreement with Pb–Pb measurements

- **Ξ(1620) properties**
  → Mass in agreement with Belle[1]

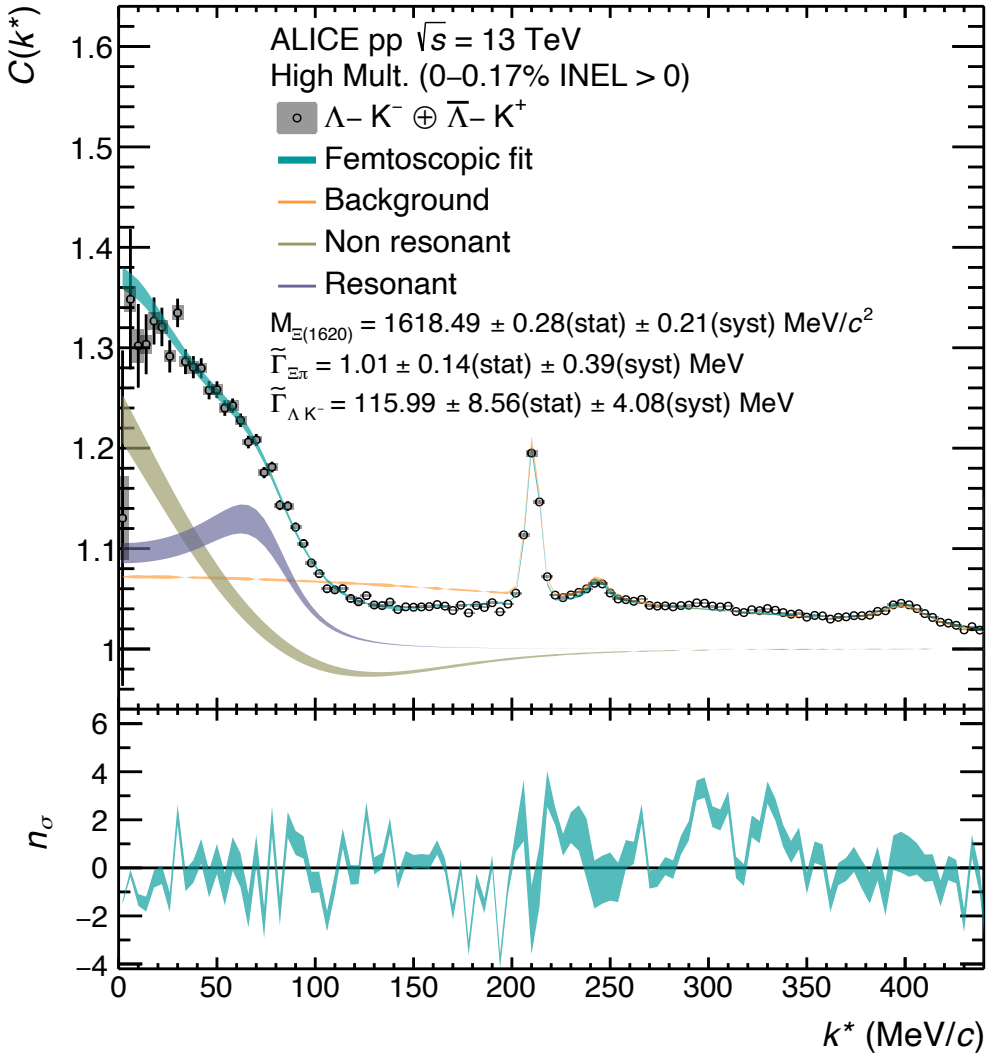
$$M_{\Xi(1620)} = 1618.49^{\pm 0.28(stat)}_{\pm 0.21(syst)}\ \text{MeV/c}^2$$

  → Indication of a large coupling of Ξ(1620) to ΛK⁻2]



?

Can we use these femtoscopic data to constrain low-energy QCD models?



[1] Belle Coll. PRL 122 (2019), 7, 07250

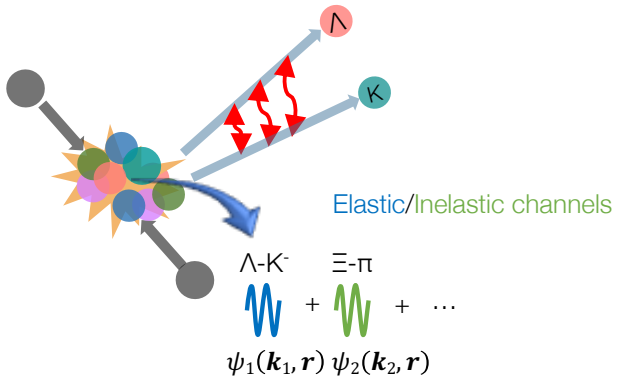
Coupled-channels in the S=-2 meson-baryon sector

- Model the genuine ΛK⁻ part including the coupled-channel dynamics

$$C(k^*) = \int S_1(\vec{r}^*) \left|\psi_{1\to1}(\vec{k}^*, \vec{r}^*)\right|^2 d^3r^* + \sum_{j\neq1} \omega_j^{prod.} \int S_j(\vec{r}^*) \left|\psi_{j\to1}(\vec{k}_j^*, \vec{r}^*)\right| d^3r^*$$

elastic
ΛK⁻ → ΛK⁻

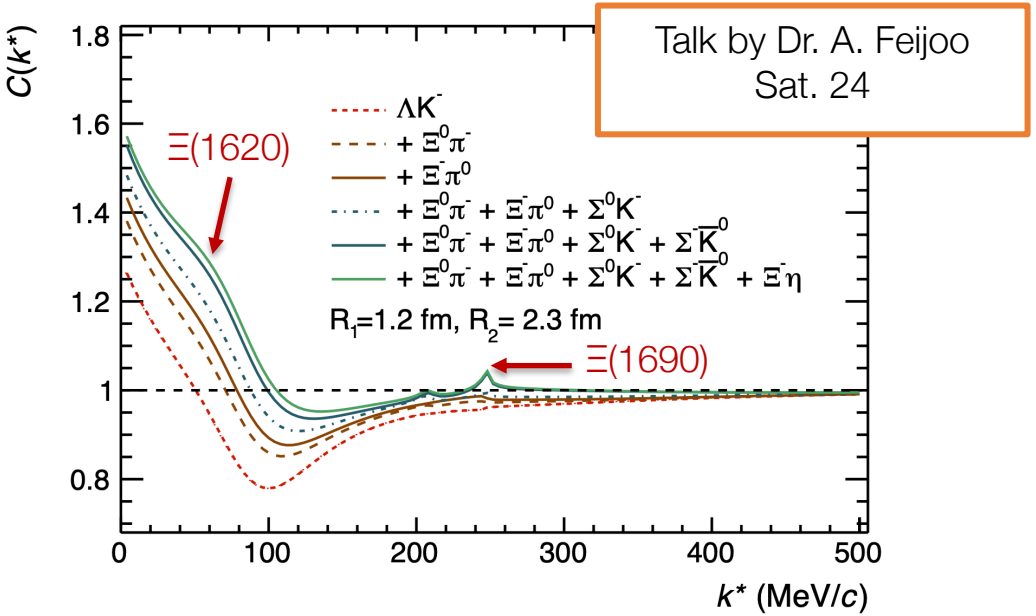
inelastic
Ξπ,Σ$\bar{K}$,Ξη → ΛK⁻



- Conversion weights ω_j^{prod} [1]
  - How many Ξπ,Σ$\bar{K}$,Ξη are produced as initial states?
- Wave functions $\psi_{1,j\to1}(k_j^*, r^*)$
  - State-of-the-art UχPT at NLO in CC formalism[2]
    → Above threshold: modify the shape of CF
    → Below threshold: increase the strength of CF
  - Ξ(1620) and Ξ(1690) dynamically generated states

Femtoscopic data used to fix input parameters of the model!

Talk by Dr. A. Feijoo
Sat. 24



[1] ALICE Coll. Eur.Phys.J.C 83 (2023) 4, L. Fabbietti, VMS, O. Vazquez Doce Ann.Rev.Nucl.Part.Sci. 71 (2021)
[2] A. Feijoo et al., PLB 841 (2023)

Femtoscopy era in the S=-2 meson-baryon sector

- Fit LECs and SCs to the measured ALICE ΛK⁻ correlation
- How does the Ξ(1620) pole scenario look like?

Table 3: Poles, couplings and compositeness for model WT+NLO

$0^- \oplus \frac{1}{2}^+$ interaction in the $(I, S) = (0, -2)$ sector

$M = 1615.46$ MeV
$\Gamma = 20.92$ MeV
$(-,-,+,+) \rightarrow$ pole

	$\lvert g_i \rvert$	$\lvert g_i^2 dG/dE \rvert$
$\pi\Xi(1456)$	0.631	0.021
$\bar{K}\Lambda(1611)$	0.919	0.168
$\bar{K}\Sigma(1689)$	2.15	0.287
$\eta\Xi(1866)$	2.75	0.209

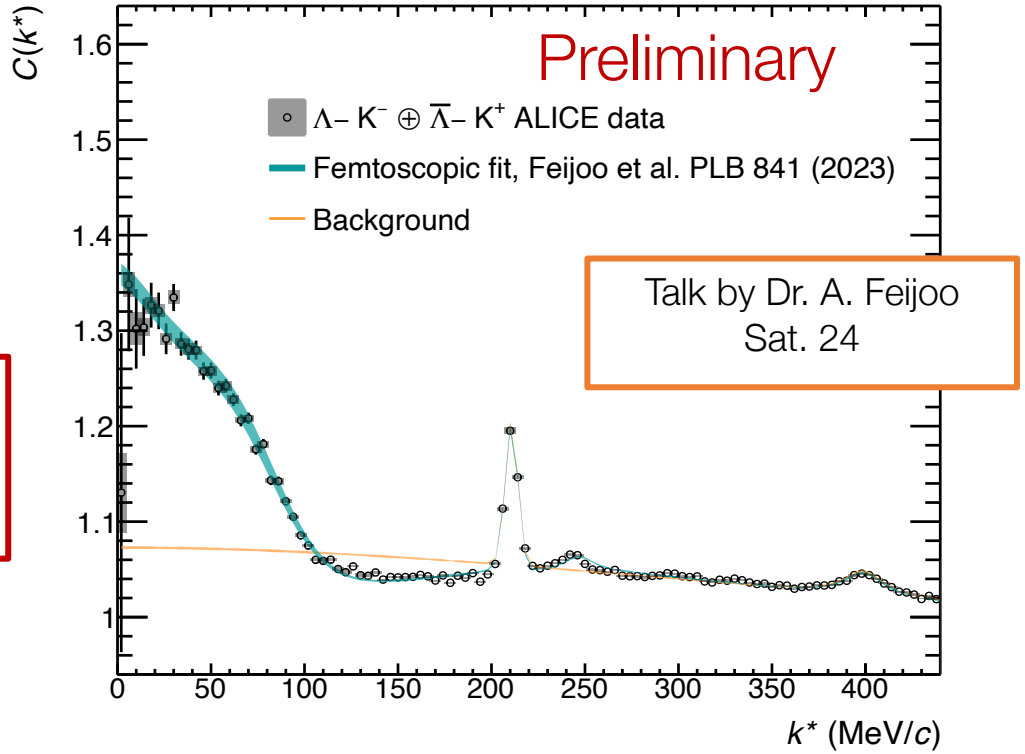
$M = 1687.69$ MeV
$\Gamma = 17.16$ MeV
$(+,+,-,+) \rightarrow$ virtual

	$\lvert g_i \rvert$	$\lvert g_i^2 dG/dE \rvert$
$\pi\Xi(1456)$	0.581	0.016
$\bar{K}\Lambda(1611)$	0.576	0.026
$\bar{K}\Sigma(1689)$	1.54	0.548
$\eta\Xi(1866)$	0.727	0.019

Ξ(1620) pole
Mainly molecular nature
composed of $\bar{K}\Sigma$
NEW PARADIGM!

Ξ(1690) pole
Virtual state
Mainly coupled to $\bar{K}\Sigma$

Paper in preparation



Talk by Dr. A. Feijoo
Sat. 24

Work in collaboration with:
Dr. A. Feijoo, Dr. I. Vidana, Prof. A. Ramos,
Prof. F. Giacosa,
Prof. T. Hyodo and Dr. Y. Kamiya

Conclusions and Outlooks

- Femtoscopy as a complementary tool to access the strange sector of meson-baryon interaction
  → Most precise ΛK^+ and ΛK^- data at low momenta and first evidence of $\Xi(1620)$ in the ΛK^- decay channel

- First use of femtoscopic data to tune chiral effective potentials
  → Possibility to constrain the QCD low energy sector for interactions not experimentally available before

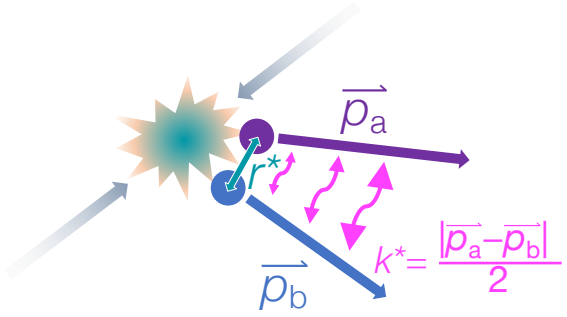
- Extend the measurements in pp collisions to $\pi\Xi$
  → Provide additional constraints to models and check consistency with other available measurements

Femtoscopy@Meson 2023

- *"Towards many body nuclear interaction studies at the LHC"*, Prof. L. Fabbietti Mon. 26
- *"Towards a common particle-emitting source in small systems for mesons and baryons with ALICE"*, M. Korwieser Sat. 24
- *"Correlation Function constraints on S=-2 meson-baryon interaction from UChPT"*, Dr. A. Feijoo Sat. 24
- *"A study of K^-d and K^+d interactions via femtoscopy technique"*, W. Rzesa Sat.24
- *"Femtoscopy of $p-\Lambda$ system obtained in heavy-ion collision in the HADES experiment"*, Narendra Rathod Sat. 24

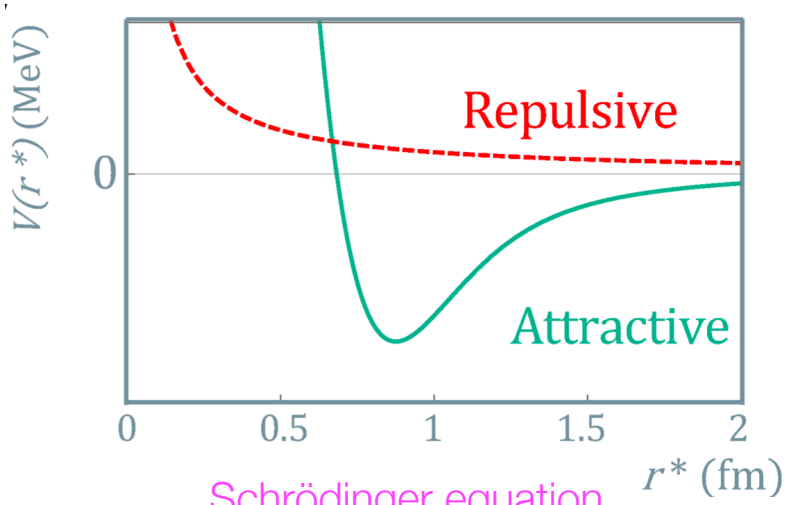
Additional slides

The femtoscopy technique at ALICE



Emission source S(r*)

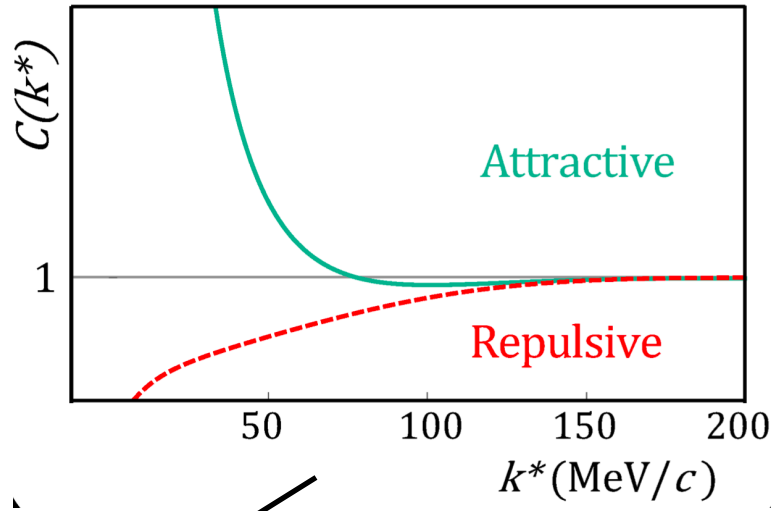
Interacting potential



Schrödinger equation

Two-particle wave function

Correlation function



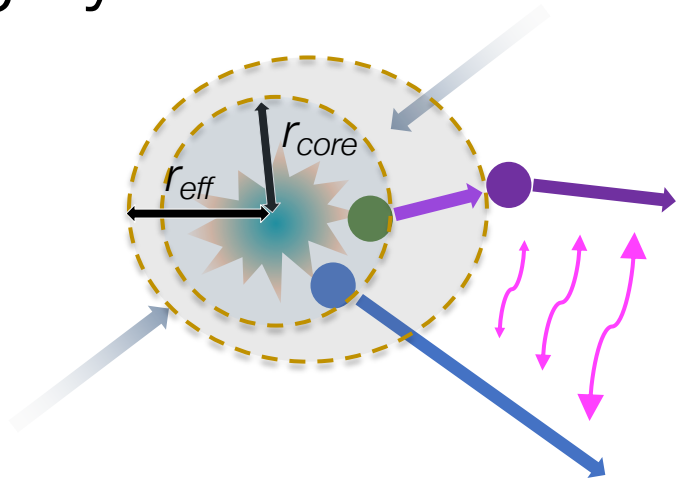
$$C(k^*) = \int S(\vec{r}^*)\left|\psi(\vec{k}^*, \vec{r}^*)\right|^2 d^3\vec{r}^* = \mathcal{N}(k^*)\frac{N_{\text{same}}(k^*)}{N_{\text{mixed}}(k^*)}$$

Measuring ***C(k*)***, fixing the source **S(r*)**, study the interaction

CATS Framework: D. Mihaylov et al., Eur. Phys. J. C78 (2018) 394

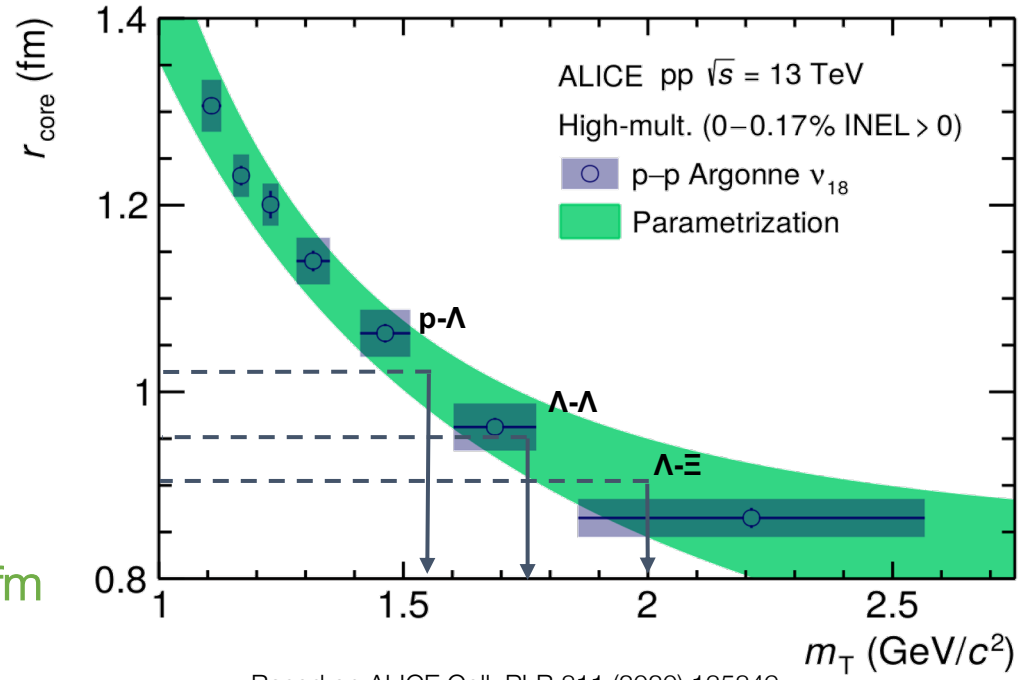
The emitting source in small colliding systems

- Data-driven analysis on p-p and p-Λ pairs
  - Possible presence of collective effects → m_T scaling of the core radius
  - Contribution of **strongly decaying resonances with cτ ~1 fm** (*)
- Common universal core source for baryons
- Core constrained from p-p pairs
  - Fixing of the source at corresponding <m_T> ⟹ direct access to the interaction



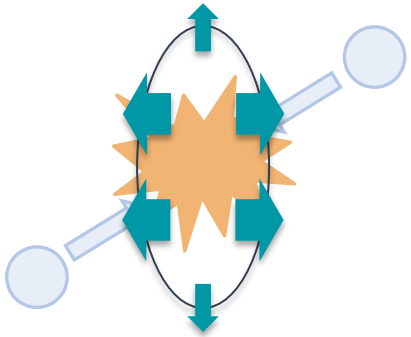
Particle	Res.	<cτ> (fm)
p	Δ,N*	1.6
Λ	Σ,Σ*	4.7

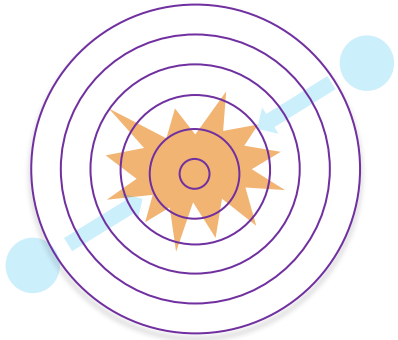
r_{eff} = 1 - 1.25 fm



Based on ALICE Coll. PLB 811 (2020) 135849
(*) U. A. Wiedemann, U. W. Heinz, Phys.Rept. 319, 145-230 (1999)

A source to rule them all





Anisotropic + pressure gradients

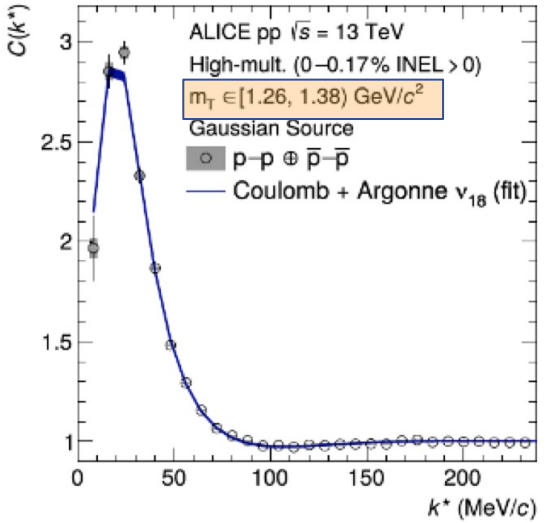
Radial

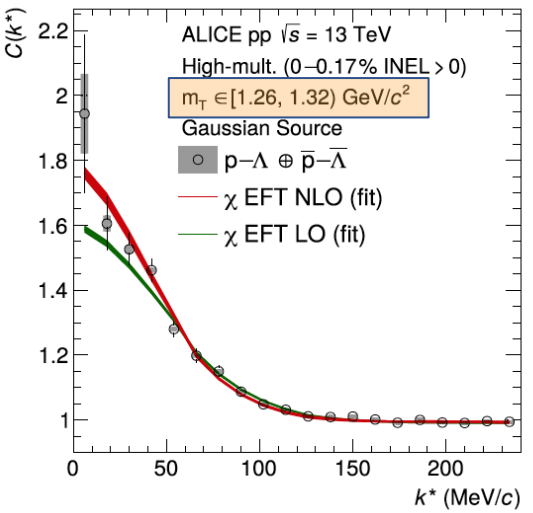
Different effect on different masses

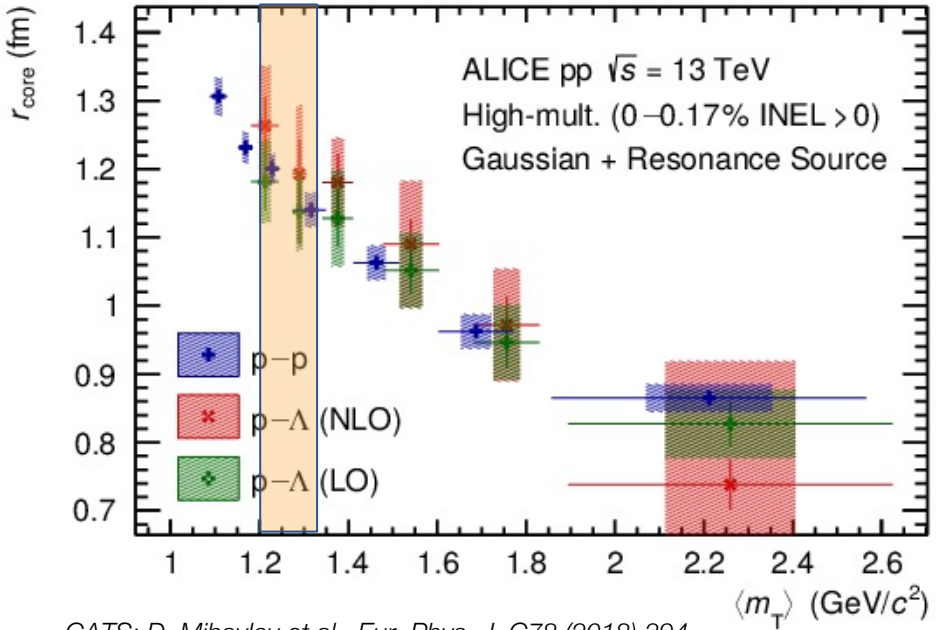
$$C(k^*) = \int \boxed{S(r)} \left|\psi(\vec{k}^*, \vec{r})\right|^2 d^3r$$

$$S(r) = G(r, r_{core}(m_T)) = \frac{1}{(4\pi r_{core}^2)^{3/2}} \exp\left(-\frac{r^2}{4r_{core}^2}\right) \otimes \frac{1}{s} \exp\left(-\frac{r}{s}\right)$$

ALICE Coll., PLB, 811 (2020)







CATS: D. Mihaylov et al., Eur. Phys. J. C78 (2018) 394

Fixing the source

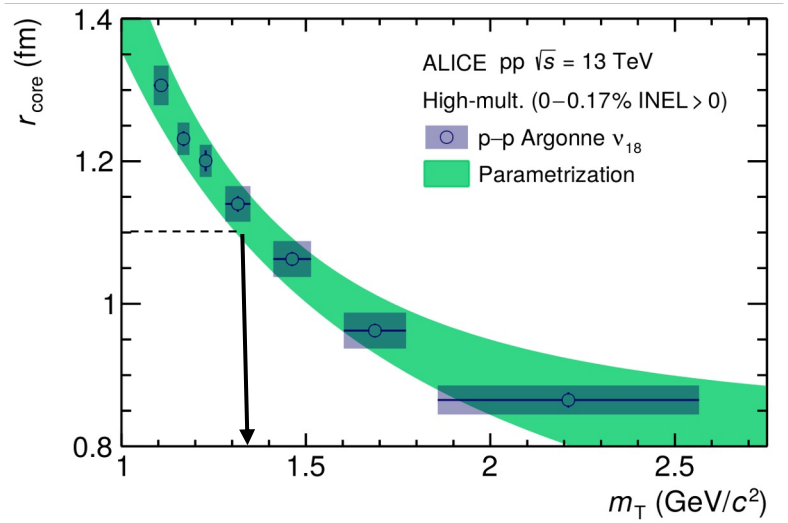
- Core-halo resonance model anchored to p-p CF
  - r_{core} = 1.11 ± 0.04 ($\langle m_T \rangle_{\Lambda K}$ = 1.35 GeV/c^2)

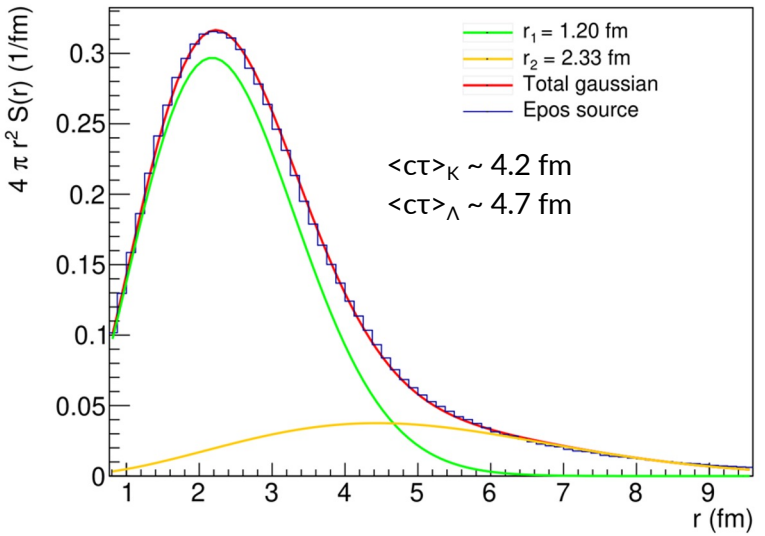
- Long-lived strongly decaying resonances feeding to Λ
  - fit with effective double gaussian

$$S_{tot}(r) = \lambda_s [\omega_S \cdot S(r_1) + (1-\omega_S) \cdot S(r_2)]$$

Parameter	Value
r_{core} [fm]	$1.11^{+0.04}_{-0.04}$
$r_{1,eff}$ [fm]	$1.202^{+0.043}_{-0.042}$
$r_{2,eff}$ [fm]	$2.330^{+0.050}_{-0.045}$
ω	$0.7993^{+0.0037}_{-0.0027}$
λ	$0.9806^{+0.0006}_{-0.0008}$

ALICE Collaboration Phys. Lett. B 811





Overview on S=-2 meson-baryon sector

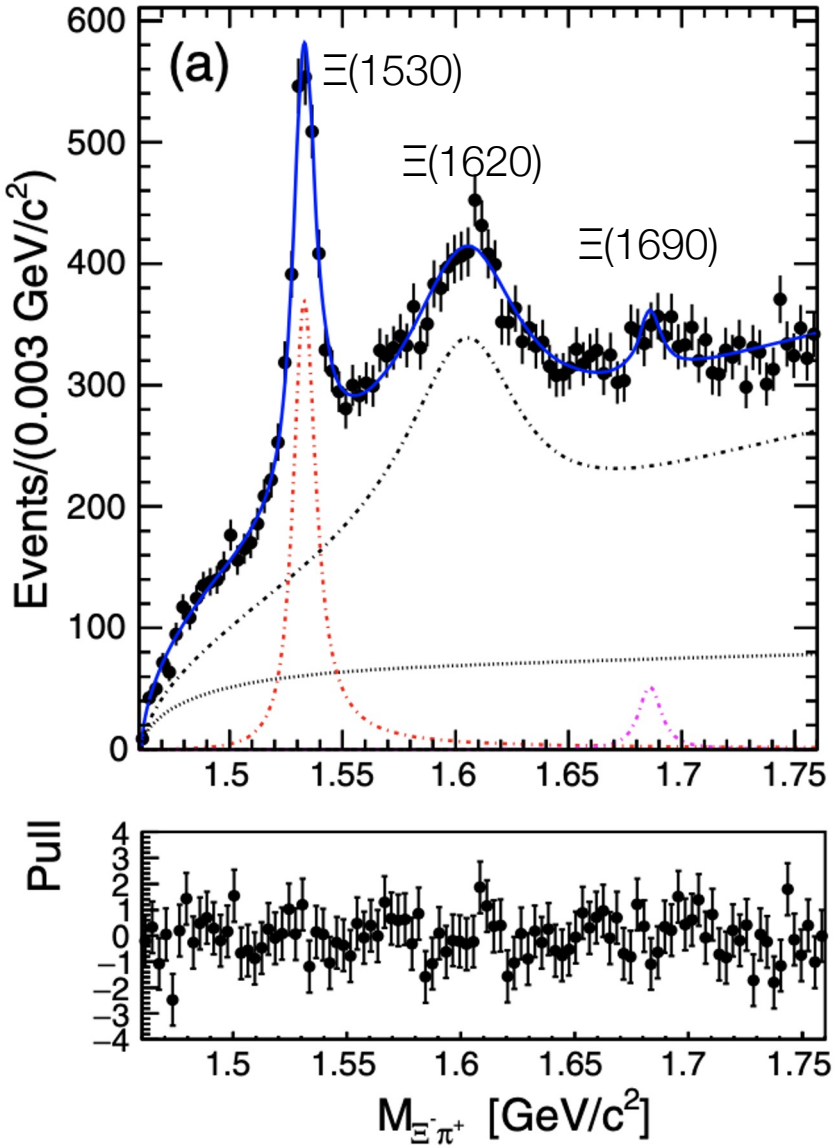
- **Poorly constrained experimentally**
  → Effective lagrangians anchored to S=-1 sector[1]

- **Ξ(1620)** and Ξ(1690)[2] dynamically generated states within coupled-channel approaches
  → Ξ(1620) observed by Belle in πΞ decay but currently only **1 star in PDG**

- Recent development of chiral calculations at NLO[3]

Need for high-precision data to constrain models´ parameters

Belle Coll. PRL 122 (2019)



[1] A. Ramos er al. PRL 89 (2002)
[2] LHCb Coll. Sci.Bull. 66 (2021)
[3] A. Feijoo et al. PLB 841 (2023)

LO χPT calculations:
C. Garcia-Recio et al. PLB 582 (2004)
D. Gamermann et al. PRD 84 (2011)
T. Sekihara PTEP 2015 (9) (2015)
T. Nishibuchi and T. Hyodo, EPJ Web Conf 271 (2022)

The ΛK⁻ correlation in large colliding systems

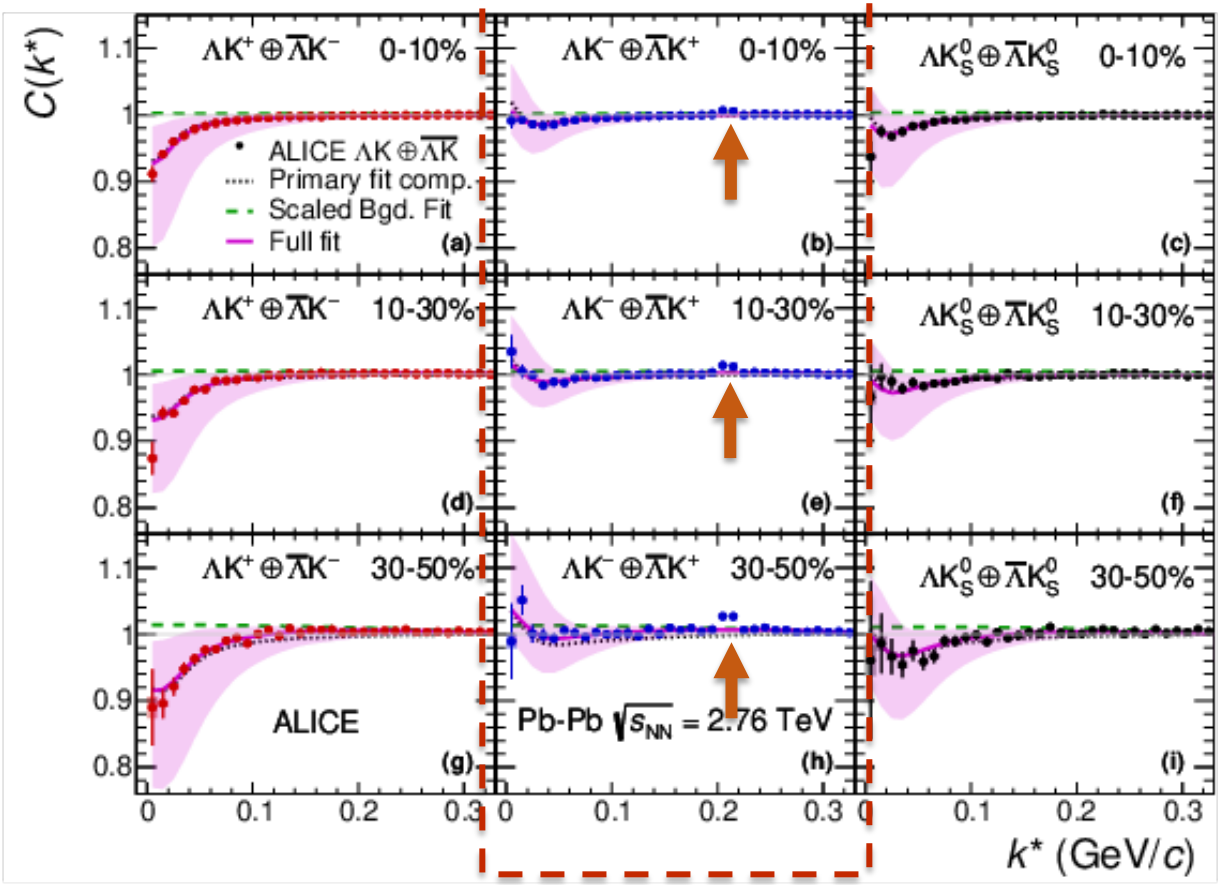
- Delivered the first measured scattering parameters

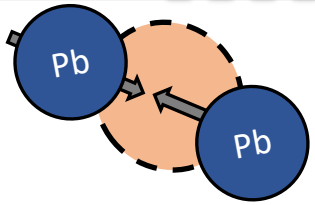
- Femtoscopy in large colliding systems as Pb–Pb
  → Negligible effects of inelastic channels
  → Presence of resonances suppressed
  (evidence of Ω only in most periph. events)

How does the correlation look like in pp collisions?

Presence of Ξ(1620) and Ξ(1690)?

ALICE Coll. PRC 103 (2021)





r~4-10 fm

The ΛK⁻ correlation in pp collisions

- Correlation overall above 1 → Attractive interaction

$$C(k^*) = N_D \cdot C_{model}(k^*) \cdot C_{bckg}(k^*)$$

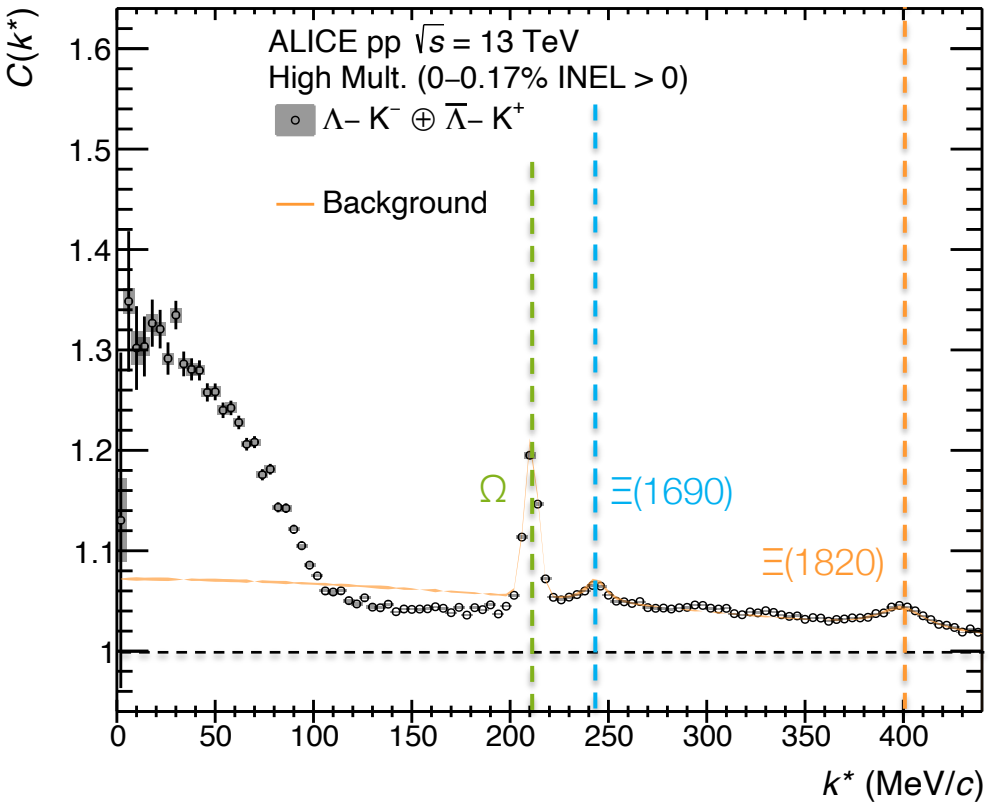
$$\lambda_0 C_0(k^*) + \lambda_1 C_1(k^*) + \lambda_2 C_1(k^*) + \cdots$$ [1]

λ_0=51%

K⁻ Λ K⁻ Λ K⁻ $\bar{\Lambda}$

$\Xi^{0,-}, \Sigma^0$

ALICE Coll. arXiv: 2305.19093



- Contributions from secondaries, impurities, etc..
  → Modeled when possible[2] or assumed flat

- To understand how to model the genuine part we need to understand the signal at low k*

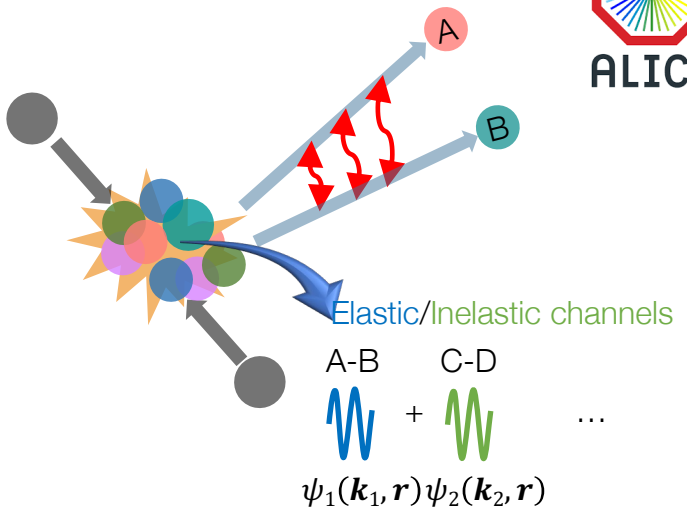
[1] ALICE Coll. Phys.Rev. C99 (2019)
[2] CATS: D. Mihaylov et al., EPJC 78 (2018), 5, 394

Coupled-channels in femtoscopy

$$C(k^*) = \int S(\vec{r}^*)\ \left|\psi_{1\to1}(\vec{k}^*, \vec{r}^*)\right|^2 d^3r^* + \sum_{j\neq1} w_j \int S(\vec{r}^*)\left|\psi_{j\to1}(\vec{k}_j^*, \vec{r}^*)\right| d^3r^*$$

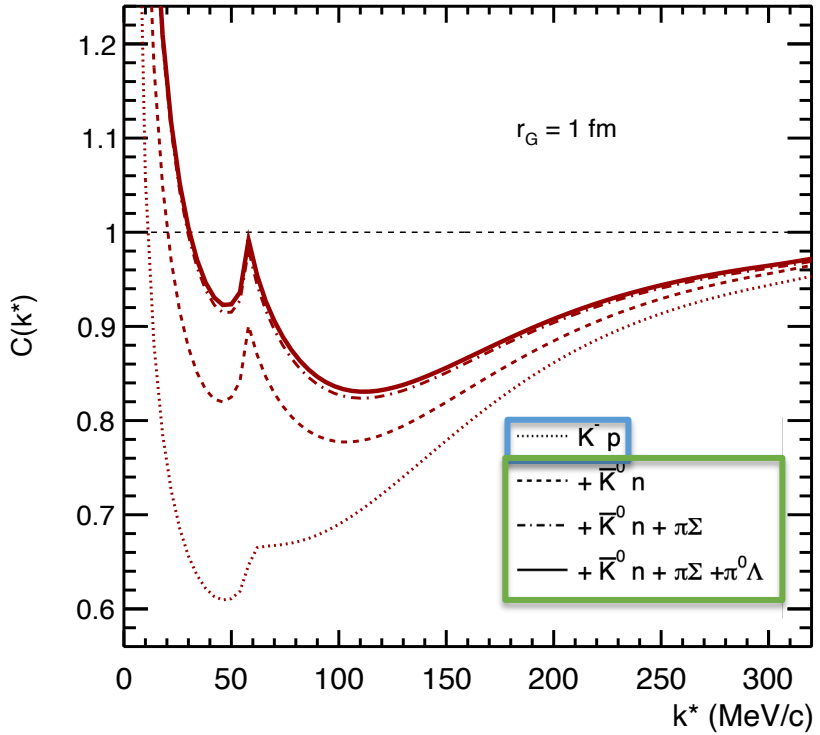
elastic
A-B → A-B

inelastic
C-D → A-B, …



- Wave functions $\psi_{j\to1}\left(k_j^*, r^*\right)$
  - Above threshold: modify the shape of CF
    → cusp structure e.g. $\bar{K}^0 n$
  - Below threshold: increase the strength of CF
    → shift upward of CF e.g. $\Sigma\pi$

How does this scenario changes with the source size?



L. Fabbietti, VMS, O. Vazquez-Doce., Ann.Rev.Nucl.Part.Sci. 71 (2021)

Modeling of the correlation function

- Lednicky-Lyuboshits analytical formula
  - assuming a gaussian source
  - relies on the asymptotic behaviour of wf
    → scattering parameters as inputs, eff.

$$C_{\mathrm{LL}}(k^*) = 1 + \frac{1}{2}\left|\frac{f}{r_0}\right|^2\left[1 - \frac{d_0}{2\sqrt{\pi}r_0}\right] + \frac{2\mathcal{R}[f]F_1(2k^*r_0)}{\sqrt{\pi}r_0} - \frac{\mathcal{I}[f]F_2(2k^*r_0)}{r_0}$$

$$f(k^*) \approx \left(f_0^{-1} + \frac{1}{2}d_0k^{*2} - ik^*\right)^{-1}$$

  - might break down for small sources
    widely used in large colliding systems

R. Lednicky, V.L. Lyuboshits Sov. J. Nucl. Phys. 35 (1982)

- CATS framework
  - local potentials, wavefunctions, gaussian and beyond sources
  - relies on the exact wavefunction
    → behaviour at short-distances

$$\Psi_k(\vec{r}) = R_k(r)Y(\theta),$$

$$C_{\mathrm{th}}(k^*) = \int S(\vec{k}^*, \vec{r}^*)\left|\Psi(\vec{k}^*, \vec{r}^*)\right|^2 d^3r^*.$$

  - works for small and large sources

CATS Framework: D. Mihaylov et al., Eur. Phys. J. C78 (2018) 394

Scattering parameters for ΛK⁻

ALICE Coll. arXiv: 2305.19093

- Indication of an attractive non-resonant interaction
  → In agreement with ALICE Pb–Pb results[1]

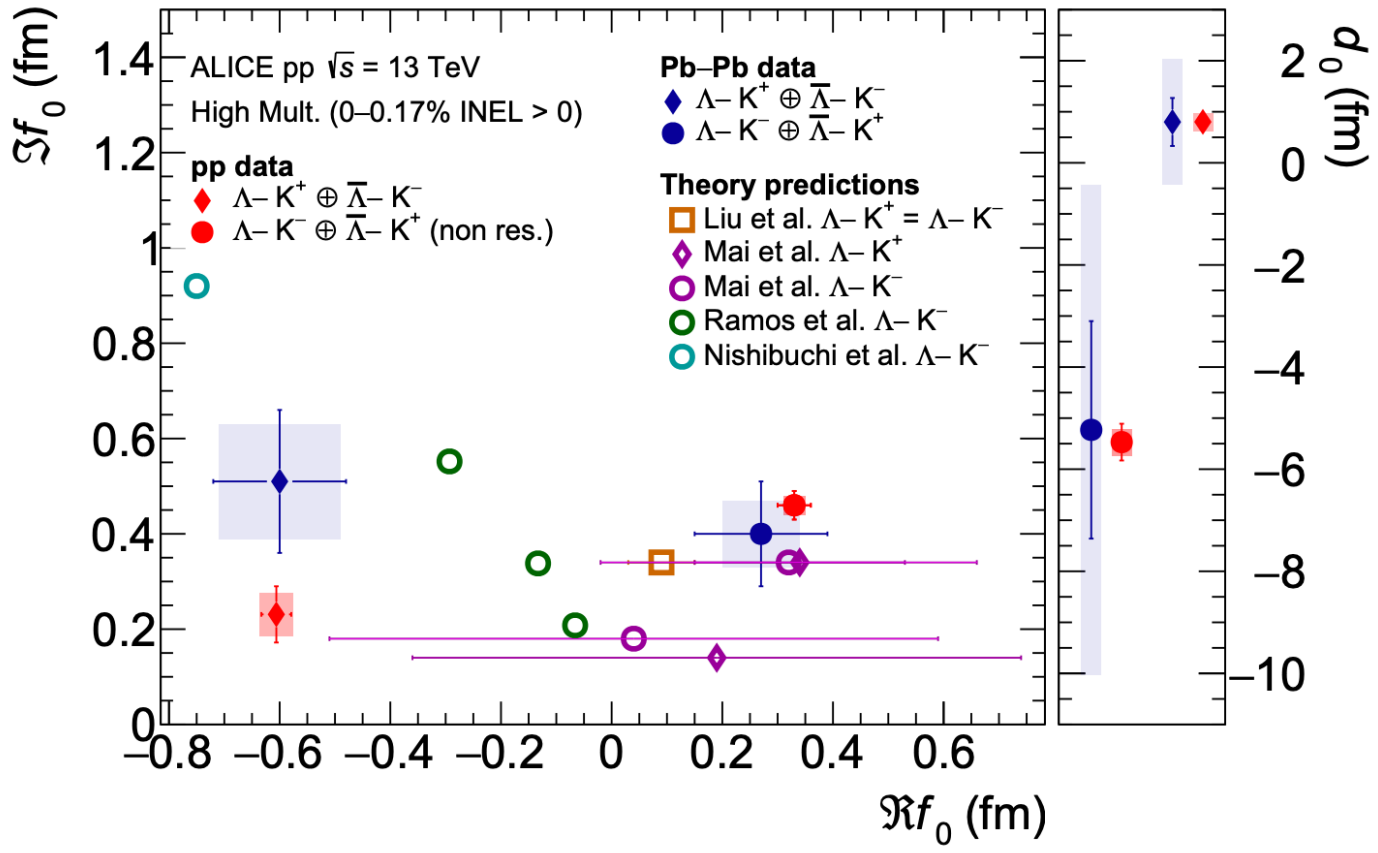
- Available models far from converging on similar results

  → Parameters fixed based on SU(3) flavour symmetry, isospin symmetry

  → Mainly anchored to πN or $\bar{K}$N data

  → Ξ(1620) typically lying below threshold

- High-precision data to constrain effective chiral theories and to understand the Ξ(1620) nature



UχPT at LO: Ramos et al. PRL 89 (2002), Nishibuchi et al. EPJ Web Conf 271 (2022)
χPT at NLO: Liu et al. PRD 75 (2007), Mai et al. PRD 80 (2009)

Creating an invariant mass plot

The approach adopted is the same as in a typical resonance analysis:

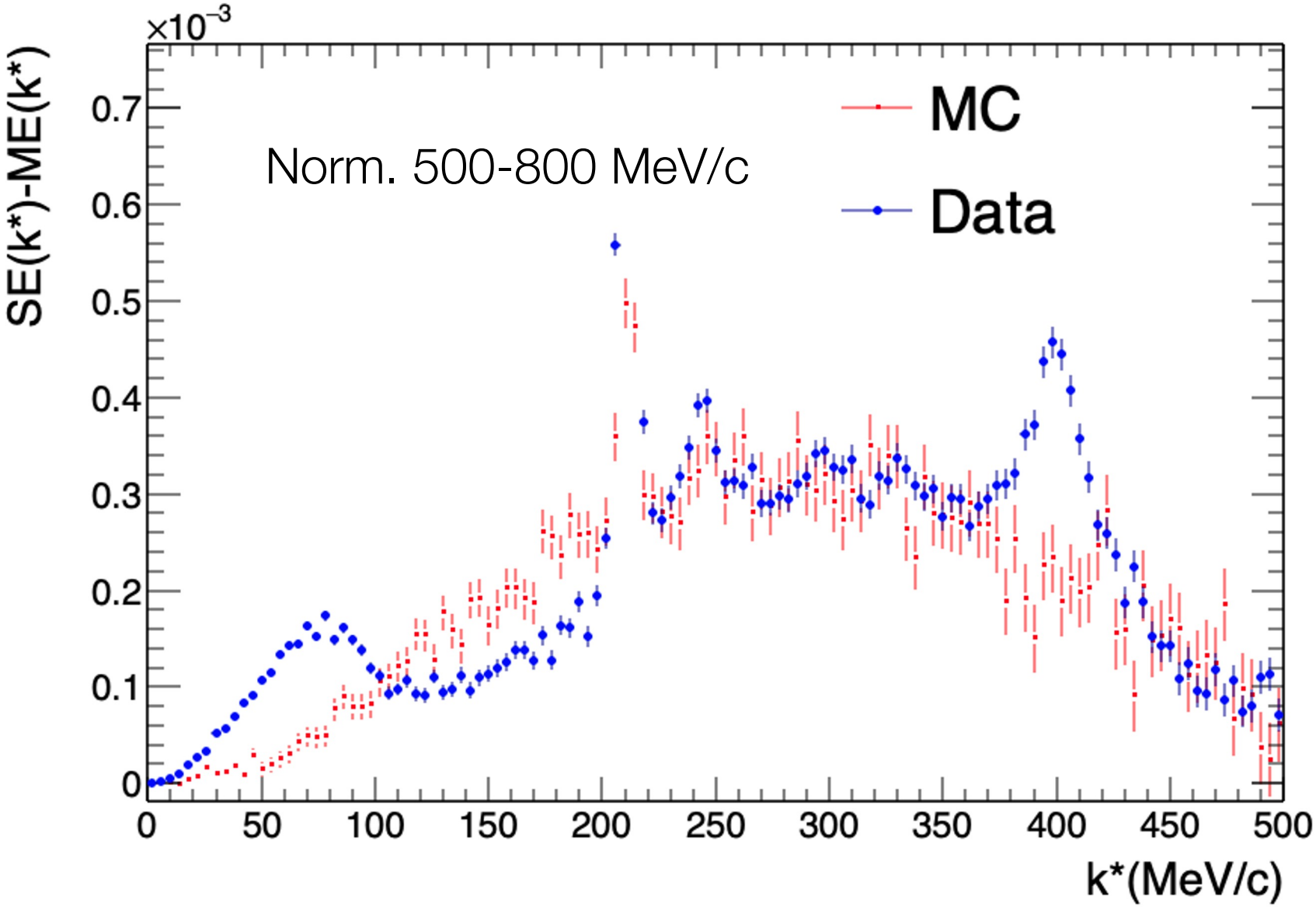
1. Raw signal: Pair (ΛK-) and AntiPair (antiΛK+) for SE data
2. Subtract the uncorrelated background: as in resonance analysis we use the ME data, normalized to SE in a region outside the signal (k* in 500-800 MeV/c)
3. Subtract the uncorrelated background
   a. $(SE\text{-}ME)_{data}$
4. The residual background from mini-jet is left, and we can use MC to subtract it
   a. as done for data we obtain $(SE\text{-}ME)_{MC}$
   b. fitting $(SE\text{-}ME)_{MC}$ with Pol4 and subtracting it from $(SE\text{-}ME)_{data}$
5. Obtaining the final IM spectrum as a function of the energy

A look to resonances: Sill + ERE fit

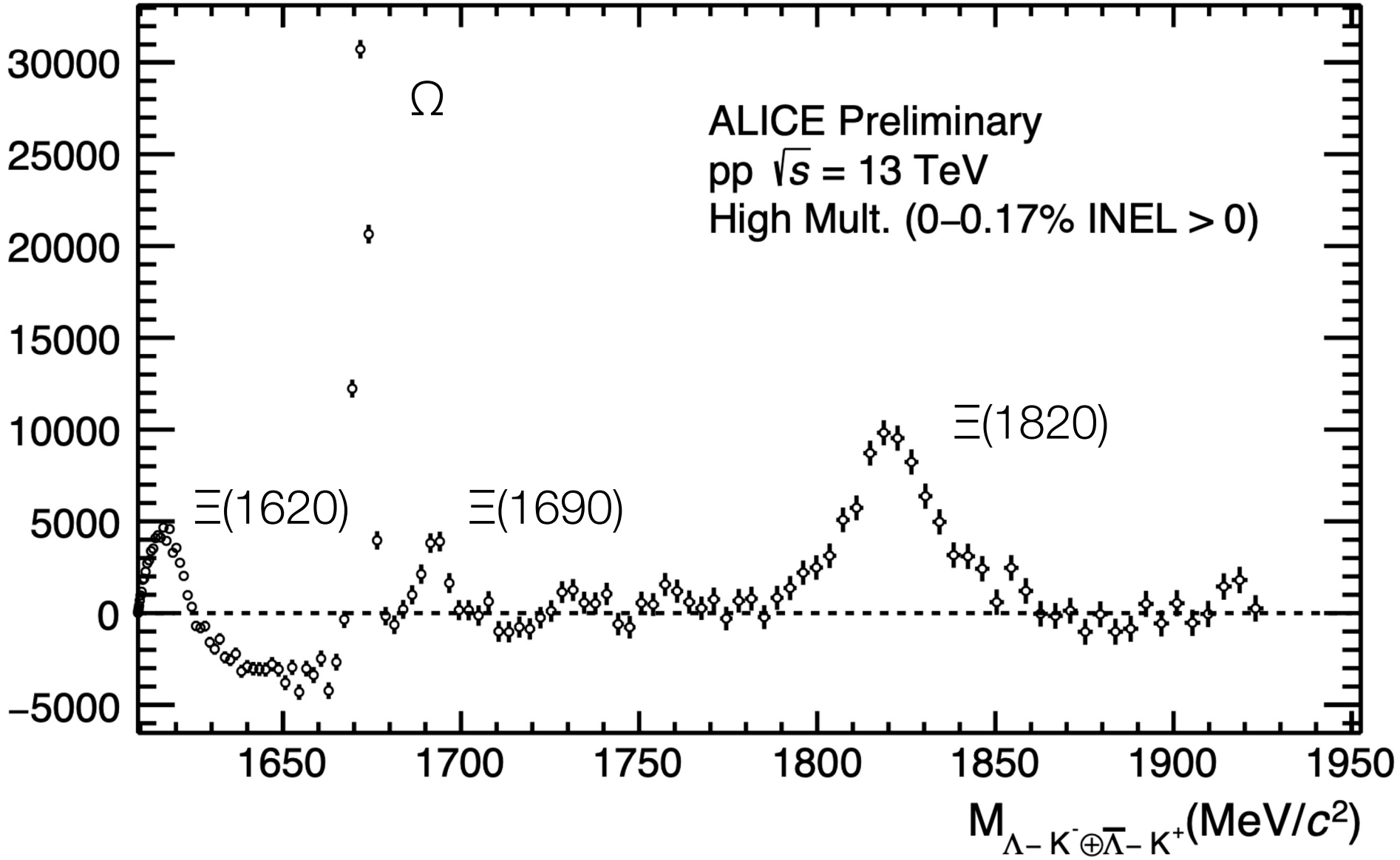
- Values in agreement with PDG and recent measurements
  - Ξ(1690)/Ξ(1820) in $\Xi_b \rightarrow J/\Psi\ \Lambda K^-$ by *LHCb Coll. Sci.Bull. 66 (2021) 1278-1287*
  - Ξ(1820) by *BESIII Phys. Rev. Lett. 124 (2020)*
  - Ξ(1820) preliminary ALICE Coll. in pp HM

Res.	Mass (MeV)	Width	PDG
Ω	1672.19±0.06(stat)±0.02(syst)	3.5±0.06(stat)±0.01(syst)	M=1672.45±0.29
Ξ(1690)	1692.39±0.6(stat)±0.18(syst)	14.17±2.8(stat)±1.1(syst)	M=1690±10 Γ=20±15
Ξ(1820)	1819.57±0.6(stat)±0.2(syst)	31.73±2.8(stat)±1.9(syst)	M=1823±5 $\Gamma=24^{+15}_{-10}$

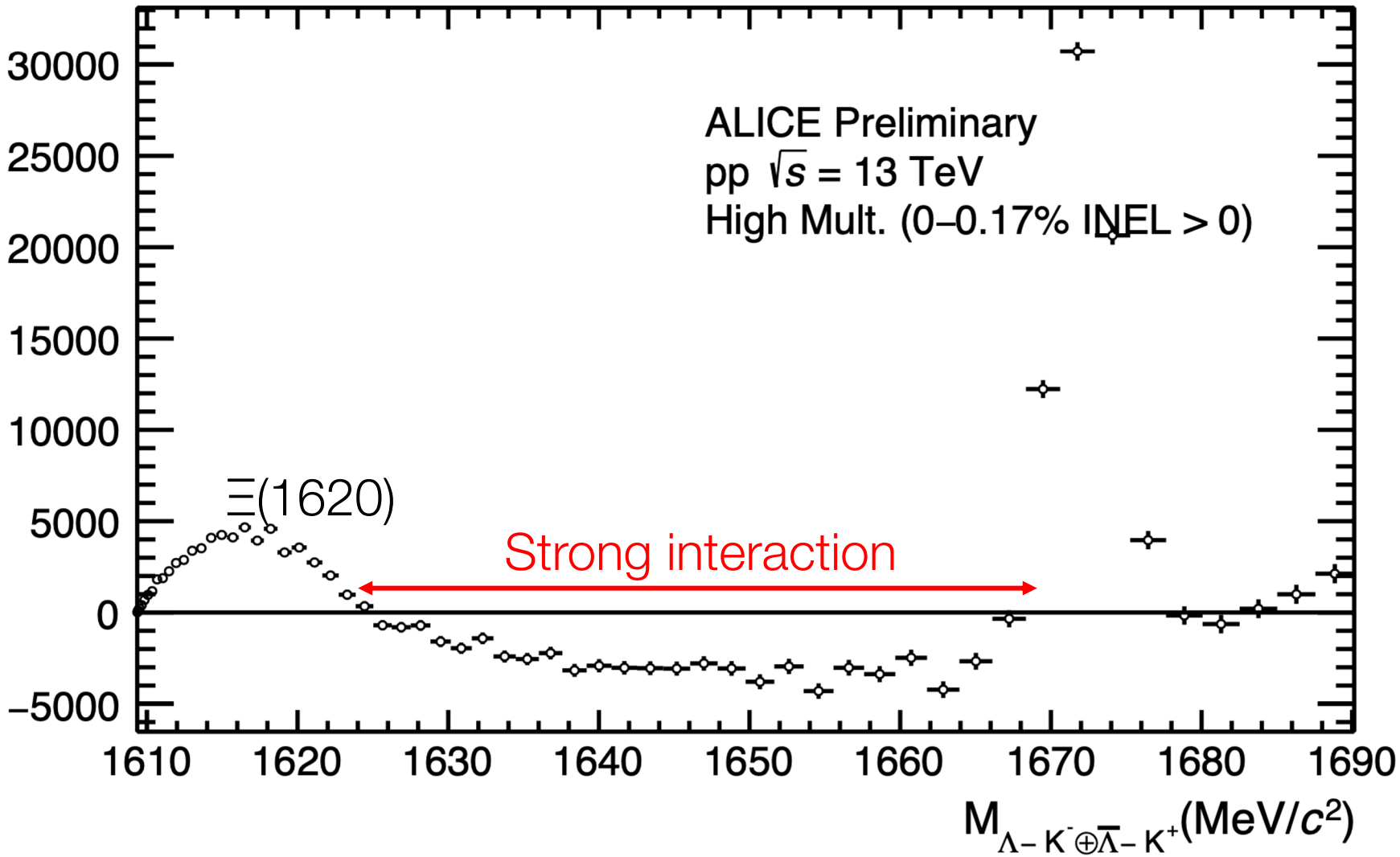
Invariant mass in k* with residual background



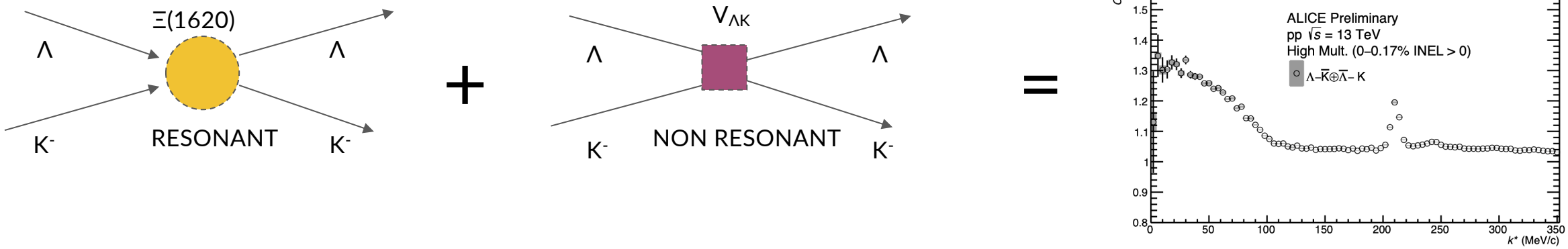
Invariant mass spectrum



Invariant mass spectrum zoom



ΛK⁻ correlation: including the Ξ(1620) resonance



$$C_{model}(k^*) = \lambda_{gen} C_{gen}(k^*) + \lambda_{\Xi K} C_{\Xi K}(k^*) + \lambda_{flat}$$

- Modeled with Lednicky-Lyuboshits analytical formula

$$C_{gen}(k^*) = w C_{non-res}(k^*) + (1-w) C_{res}(k^*)$$

- $C_{non\text{-}res}$ → LL with ERE scatt. amplitude
- C_{res} → LL with Flattè-like scatt. amplitude (F. Giacosa et al. Eur.Phys.J.A 57 (2021) 12, 336)

$$f(k^*) = \frac{-2\tilde{\Gamma}_2}{E^2 - M^2 + i\tilde{\Gamma}_1\sqrt{E^2 - E^2_{thr.1}} + i\tilde{\Gamma}_2\sqrt{E^2 - E^2_{thr.2}}}$$

ch. 1 = πΞ
ch. 2 = ΛK⁻

Thanks to Prof. F. Giacosa for the discussion

Constraining the S=-2 meson-baryon sector

- State-of-the-art UχPT at NLO available[1]
  - Low energy constants (LECs) fixed to S=-1 sector[2]
  - Two sets of subtraction constants (SCs) values
  - Widths of Ξ(1620) too large wrt to Belle´s results[3]

Use the high-precision femtoscopic data to fix LECs and SCs!

Work in collaboration with:
Dr. A. Feijoo, Dr. I. Vidana, Prof. A. Ramos,
Prof. F. Giacosa,
Prof. T. Hyodo and Dr. Y. Kamiya

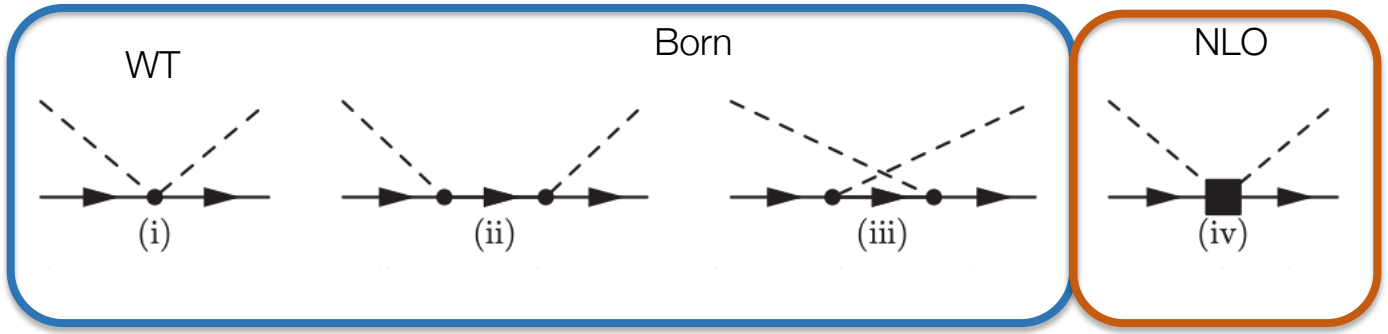
[1] A. Feijoo et al., PLB 841 (2023)

Table 3: Comparison of the pole positions between the models: Model I and Model II (in MeV) with their couplings g_i and the corresponding modulus found in $J^P = \frac{1}{2}^-$, $(I,S) = (\frac{1}{2}, -2)$.

Model I	Ξ(1620)		Ξ(1690)	
M [MeV]	1599.95		1683.04	
Γ [MeV]	158.88		11.51	
	g_i	$\lvert g_i\rvert$	g_i	$\lvert g_i\rvert$
$\pi\Xi$	$2.09 + i1.00$	2.32	$-0.30 - i0.12$	0.33
$\bar{K}\Lambda$	$-2.11 - i0.09$	2.11	$-0.49 + i0.05$	0.50
$\bar{K}\Sigma$	$-0.90 + i0.34$	0.97	$1.57 - i0.24$	1.59
$\eta\Xi$	$-0.23 + i0.13$	0.26	$0.74 - i0.11$	0.74
Model II	Ξ(1620)		Ξ(1690)	
M [MeV]	1608.51		1686.17	
Γ [MeV]	170.00		29.72	
	g_i	$\lvert g_i\rvert$	g_i	$\lvert g_i\rvert$
$\pi\Xi$	$2.11 + i1.07$	2.37	$-0.36 - i0.24$	0.43
$\bar{K}\Lambda$	$-2.10 - i0.09$	2.10	$-0.81 + i0.02$	0.81
$\bar{K}\Sigma$	$-0.86 + i0.38$	0.94	$2.26 + i0.03$	2.26
$\eta\Xi$	$-0.19 + i0.12$	0.23	$1.04 - i0.07$	1.04

[2] A.Feijoo et al PRC 99 (2019)
[3] Belle Coll. PRL 122 (2019)

Fantastic LECs and SCs and where to find them



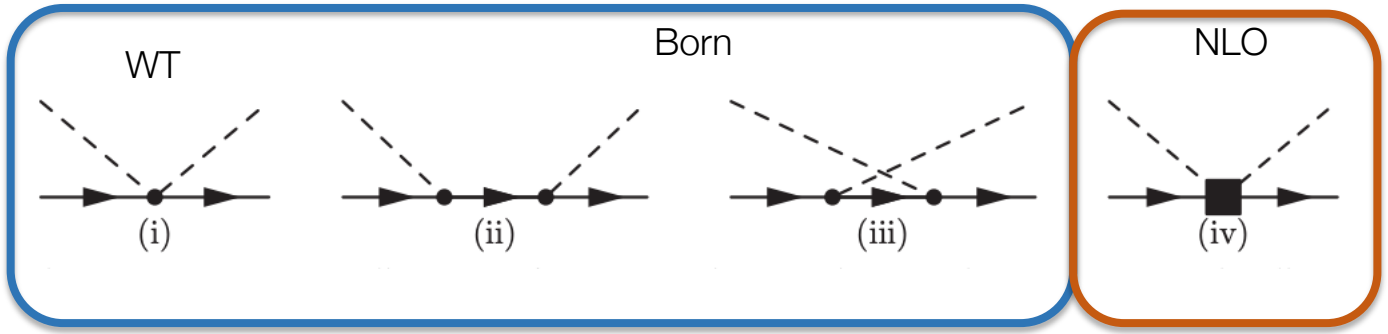
$$\mathcal{L}^{(1)}_{\phi B} = i\langle \bar{B}\gamma_\mu [D^\mu, B]\rangle - M_0\langle \bar{B}B\rangle - \frac{1}{2}D\langle \bar{B}\gamma_\mu\gamma_5\{u^\mu, B\}\rangle - \frac{1}{2}F\langle \bar{B}\gamma_\mu\gamma_5[u^\mu, B]\rangle ,$$

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

Talk by Dr. A. Feijoo
Sat. 24

[1] A. Feijoo et al., PLB 841 (2023)

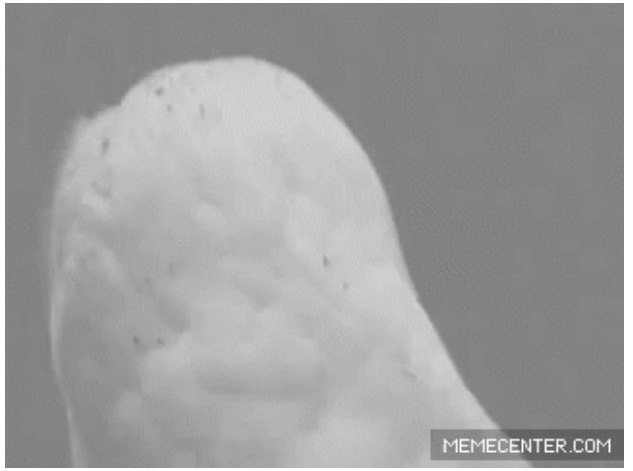
Fantastic LECs and SCs and where to find them



$$\mathcal{L}^{(1)}_{\phi B} = i\langle \bar{B}\gamma_\mu [D^\mu, B]\rangle - M_0\langle \bar{B}B\rangle - \frac{1}{2}D\langle \bar{B}\gamma_\mu\gamma_5\{u^\mu, B\}\rangle - \frac{1}{2}F\langle \bar{B}\gamma_\mu\gamma_5[u^\mu, B]\rangle ,$$

$$\begin{aligned}\mathcal{L}^{(2)}_{\phi B} = {} & b_D\langle \bar{B}\{\chi_+, B\}\rangle + b_F\langle \bar{B}[\chi_+, B]\rangle + b_0\langle \bar{B}B\rangle\langle \chi_+\rangle \\ & + d_1\langle \bar{B}\{u_\mu, [u^\mu, B]\}\rangle + d_2\langle \bar{B}[u_\mu, [u^\mu, B]]\rangle \\ & + d_3\langle \bar{B}u_\mu\rangle\langle u^\mu B\rangle + d_4\langle \bar{B}B\rangle\langle u^\mu u_\mu\rangle .\end{aligned}$$

Overall 12 input parameters to be fixed!



[1] A. Feijoo et al., PLB 841 (2023)