UNIVERSITÀ DEGLI STUDI DI BRESCIA

ALICE

Femtoscopic analysis of K^0_S-p pairs in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE

Marta Urioni

Motivation

- **KN** and **$\overline{K}$N** interaction is fundamental for the study of **low energy QCD**
- K and $\overline{K}$ interaction with nucleons is usually studied by means of $K^+(K^-)$-N scattering experiments:
  - few experimental measurements with big uncertainties and not at low energy $p_{lab} < 50$ MeV/c

Two particle momentum correlation:

- accessing information on strong interaction down to p≃0 MeV/c
- In this analysis:
  - study of the strong interaction of **K^0_S-p** and **K^0_S-$\overline{p}$** pairs analysing the data produced in **proton-proton** collisions at **$\sqrt{s}$ = 13 TeV** and detected by ALICE
    - Linear combination of KN and $\overline{K}$N
    - presence of coupled channels (CC) below threshold
- **Correlation function:**
  - Theoretical:

Source function — Pair wave function (interaction dependance)

$$C(\mathbf{k}^*) = \int d^3r^* S(r^*) |\psi(\mathbf{r}^*, \mathbf{k}^*)|^2 \qquad \mathbf{k}^* = (\mathbf{p}_1^* - \mathbf{p}_2^*)/2$$

  - Experimental:

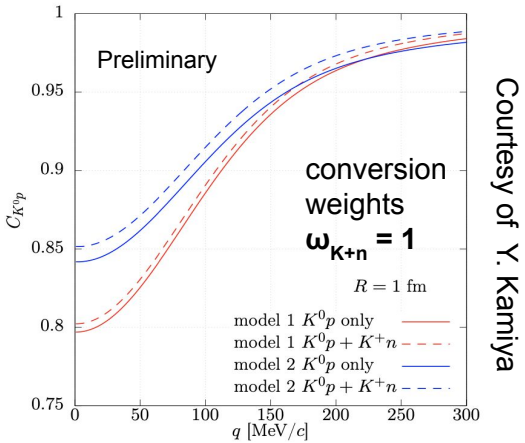
$$C(k^*) = N \frac{A(k^*)}{B(k^*)}$$

same event — normalization — mixed event

The K^0_s - p system

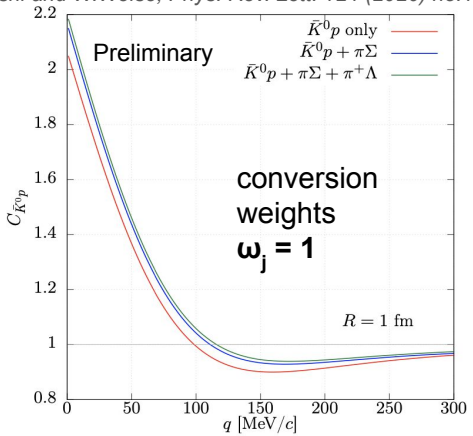
- Combination of strong eigenstates $|K^0_s p\rangle = \frac{1}{\sqrt{2}}\left[|K^0 p\rangle - |\bar{K}^0 p\rangle\right]$, $\Rightarrow C_{K^0_s p} = \frac{1}{2}\left[C_{K^0 p} + C_{\bar{K}^0 p}\right]$

- Weak strong repulsion
- 1 CC below threshold: K^+n
  - predicted to be a weak coupling
- Calculations from **A**oki-**J**ido Chiral Effective Field Theory (χEFT) model for KN *K. Aoki and D. Jido, PTEP 2019, 013D01 (2019), 1806.00925.*



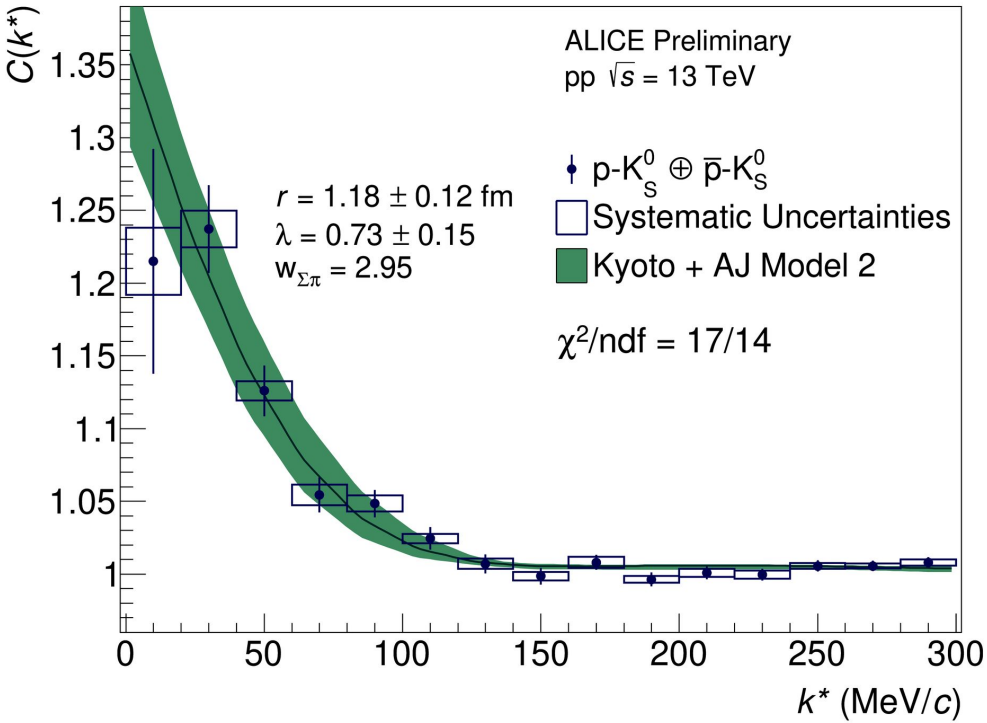
Courtesy of Y. Kamiya

- Moderate attraction
- 3 CC below threshold: $\pi^0\Sigma^+$, $\pi^+\Sigma^0$, $\pi^+\Lambda$
  - large $\pi\Sigma$ coupling (as in K^-p)
- Calculations from **Kyoto** χEFT model for $\bar{K}N$ used for K^-p *(K. Miyahara, T. Hyodo, and W. Weise, Phys. Rev. C98, 025201 (2018), 1804.08269; Y.Kamiya, T.Hyodo, K.Morita, A.Ohnishi and W.Weise, Phys. Rev. Lett. 124 (2020) no.13,132501)*



Courtesy of Y. Kamiya

$K^0_S p$ correlation function fit with χEFT



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- Green band: theoretical function obtained using CATS *(D. L. Mihaylov et al. Eur.Phys.J.C 78 (2018) 5, 394)*:
  - **Gaussian source** function with r=1.18±0.12 fm *(ALICE Collaboration, Phys. Rev. Lett. 124, 092301 (2020))*
  - theoretical **wave functions** for the **K^0p** and **$\bar{K}^0p$** and coupled channels provided by Chiral Effective Theory group (Y. Kamiya et T. Hyodo)
  - Conversions **weights ω = 1** for K^0p, K^+n, and $\pi^+\Lambda$; **$\omega_{\Sigma\pi}$ = 2.95** *(Y.Kamiya, T.Hyodo, K.Morita, A.Ohnishi and W.Weise, Phys. Rev. Lett. 124 (2020) no.13,132501)*
- **Model describes data within 2σ between 0 and 300 MeV/*c***

$K^0_S p$ correlation function fit with Lednický-Lyuboshitz

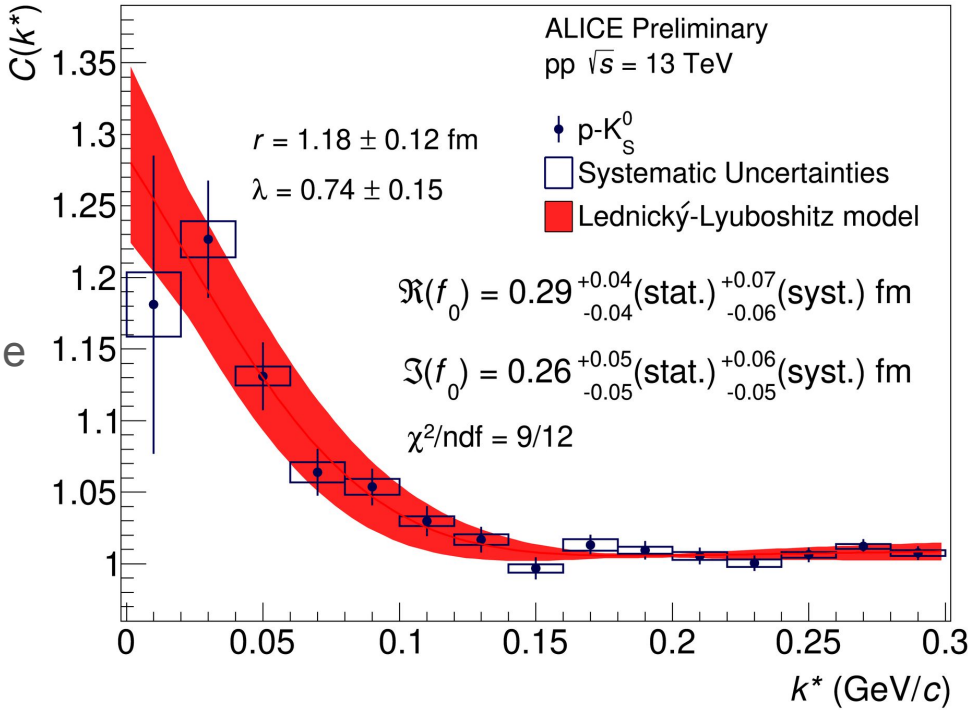
$$C_{FSI}(k^*) = \sum_S \rho_S \left[\frac{1}{2} \left| \frac{f(k^*)}{R} \right|^2 \left(1 - \frac{d_0}{2\sqrt{\pi} R} \right) + \frac{2\Re f(k^*)}{\sqrt{\pi} R} F_1(2k^* R) - \frac{\Im f(k^*)}{R} F_2(2k^* R) \right]$$

$$C_{Lednicky}(k^*) = 1 + C_{FSI}(k^*)$$

Scattering amplitude:

$$f(k^*) = \left(\frac{1}{f_0} + \frac{1}{2} d_0 k^{*2} - ik^* \right)^{-1}$$

- f_0 scattering length, d_0 effective range of interaction
  - $\Re f_0$, $\Im f_0$ estimated parameters
- **$\Re f_0$ >0 : attractive interaction**
- **$\Im f_0$ ≠0 : presence of annihilation processes**



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Conclusions

- χEFT fit:
  - The correlation function can be decomposed into the $\bar{K}^0p$ and K^0p components
  - State of the art theory well describes the experimental data
- Lednický fit shows:
  - There are annihilation processes in the K^0_S-p interaction
  - The interaction between K^0_S and p is attractive:
    - The dominant component is the $\bar{K}^0p$ one