ALICE studies of proton-hyperon and hyperon-hyperon interactions via the femtoscopy method

B. Hohlweger on behalf of the ALICE collaboration

Technische Universität München, Physik Department E62 *Dense and Strange Hadronic Matter*, 85748 Garching
Excellence Cluster *Origin and Structure of the Universe*, 85748 Garching

Femtoscopy

Based on the correlation function

$$C(k^*) = \frac{P(\overrightarrow{p_a}, \overrightarrow{p_b})}{P(\overrightarrow{p_a})P(\overrightarrow{p_b})},$$

with $k^* = |\overrightarrow{p_a^*} - \overrightarrow{p_b^*}|$ and $\overrightarrow{p_a^*} + \overrightarrow{p_b^*} = 0$.

Experimentally obtained as

$$C(k^*) = \mathcal{N}\frac{N_{Same}(k^*)}{N_{Mixed}(k^*)}$$

and can be theoretically formulated as

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

Source: $S(\vec{r}, k)$ — Wave Function: $|\psi(\vec{r}, k)|^2$

Sensitivity to the interaction potential

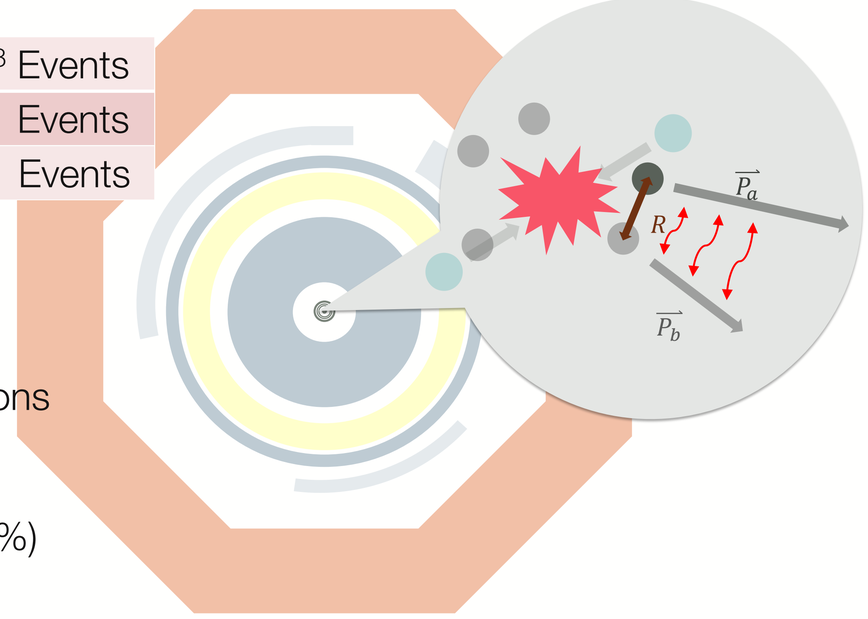
Assumption of a common source: Combined fit of the

Strong constraint: p-p, p-Λ, p-Ξ and Λ–Λ Correlation Functions

Data Analysis

➢ Datasets:

pp 7 TeV	$3.4 \cdot 10^8$ Events
pp 13 TeV	$10 \cdot 10^8$ Events
p-Pb 5.02 TeV	$60 \cdot 10^8$ Events



➢ Proton identification with TPC and TOF

➢ Reconstruction of hyperons

➢ $\Lambda \rightarrow p\pi^-$ (BR ~ 64%)

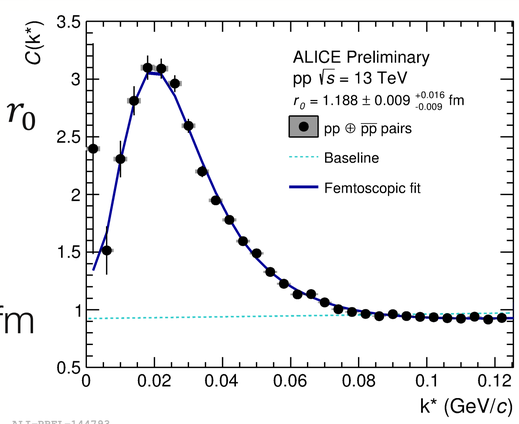
➢ $\Xi^- \rightarrow \Lambda\pi^-$ (BR ~ 100%)

p-p

Resulting source sizes r_0 of the combined fit

pp: $r_0 = 1.188 \pm 0.009^{+0.016}_{-0.009}$fm

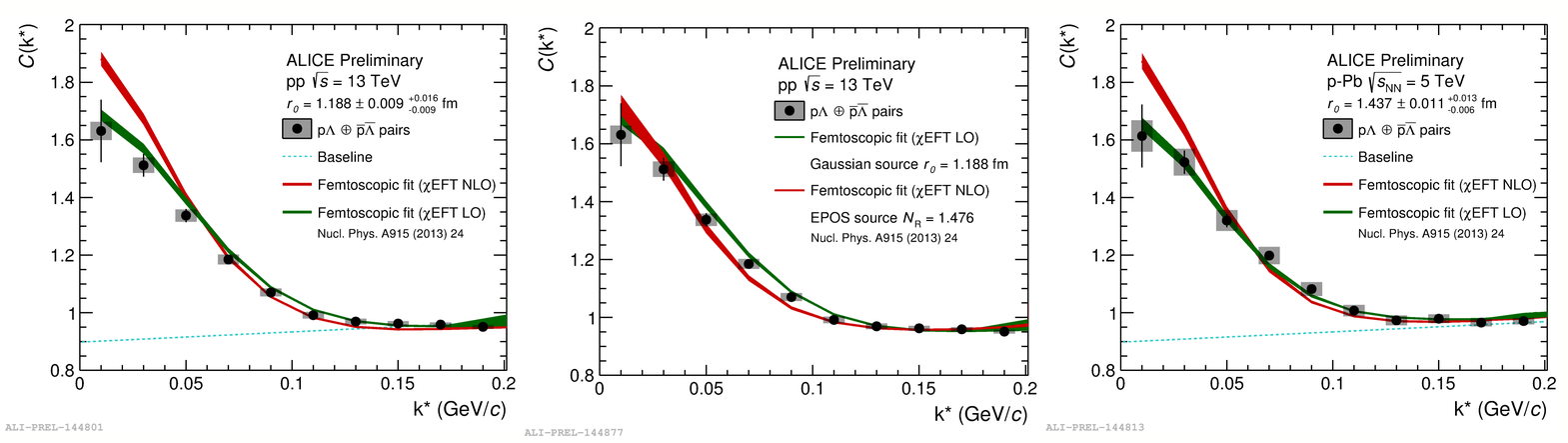
p-Pb: $r_0 = 1.437 \pm 0.011^{+0.013}_{-0.006}$fm



➢ Fitted by using the CATS [1] framework, a Gaussian source and the Argonne ν_{18} potential

➢ Constraints on the particle emitting source

p-Λ

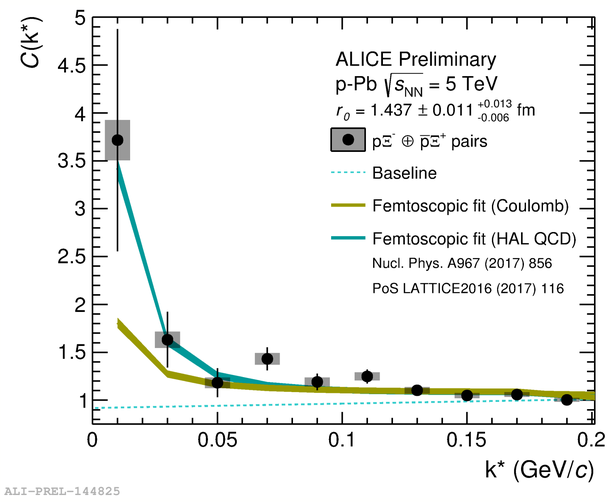


➢ Gaussian source: Data agrees with χEFT [2] calculations in Leading-Order (LO)

➢ EPOS source: Data described by χEFT [2] calculations in Next-To-Leading order (NLO)

➢ Detailed study of the source is necessary

p-Ξ⁻

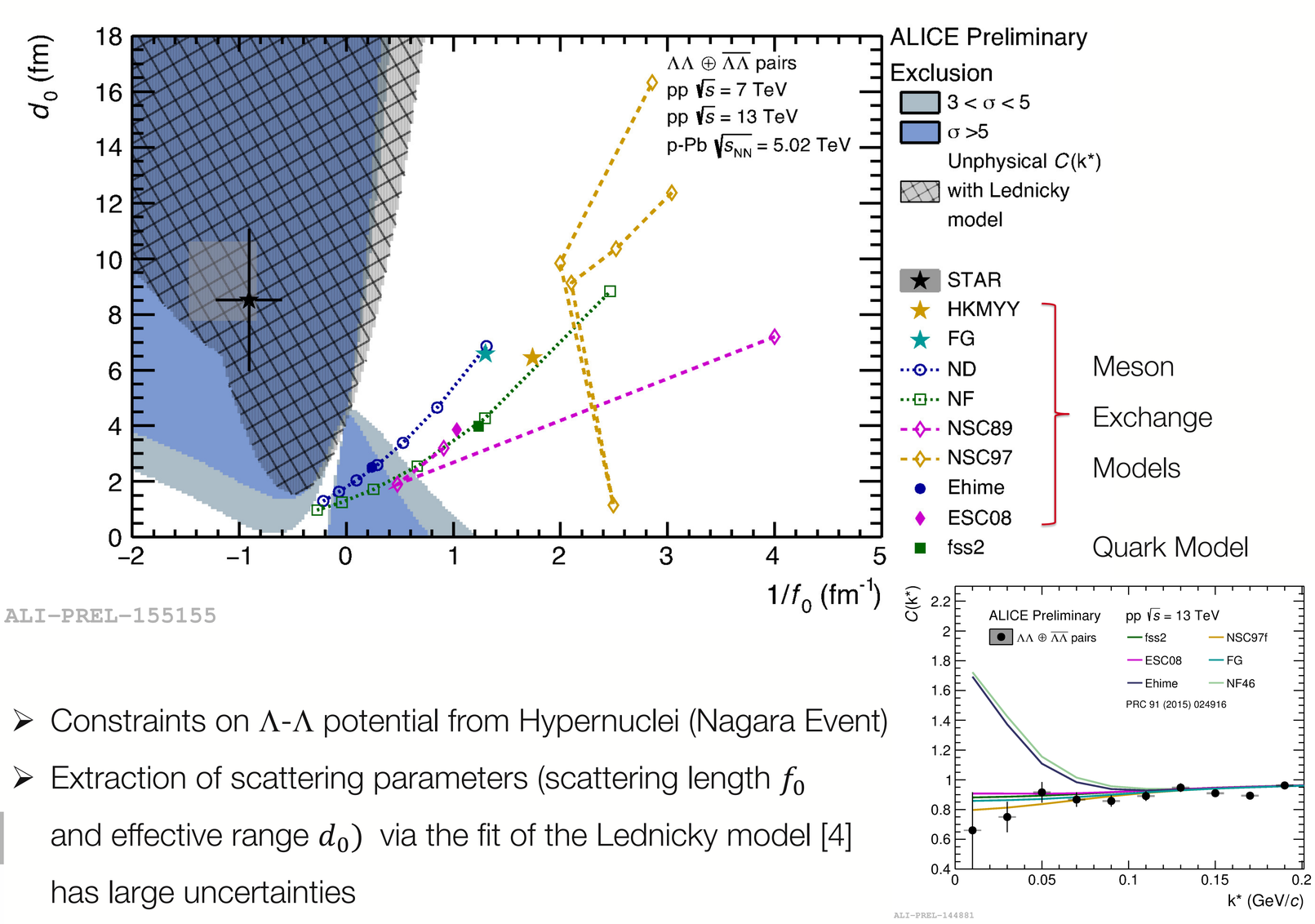


p-Value: with and without strong potential (Coulomb only): 0.055 vs. 0.004

➢ For the first time the strong interaction of p-Ξ⁻ can be seen in the correlation function obtained from the analysis of p-Pb data

➢ Makes it possible to test model calculations e.g. the preliminary QCD Strong potential by the HAL QCD collaboration [3]

Λ-Λ



➢ Constraints on Λ-Λ potential from Hypernuclei (Nagara Event)

➢ Extraction of scattering parameters (scattering length f_0 and effective range d_0) via the fit of the Lednicky model [4] has large uncertainties

➢ Scattering parameters can be tested against the combined data from all analysis

➢ Lednicky yields unphysical $C(k^*)$ for large d_0 and $f_0 < 0$

References

[1] D.L. Mihaylov et. al., A femtoscopic Analysis Tool using the Schrödinger Equation (CATS), arXiv:1802.08481
[2] J. Haidenbauer et. al., Nucl. Phys. A 915 (2013) 24-58
[3] Kenji Sasaki et. al., Baryon interactions from lattice QCD with physical masses – S = -2 sector, arXiv:1702.06241
[4] R. Lednicky et. al., Sov. J. Nucl. Phys. 35, 770 (1982)

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