Hadron-hadron QCD interactions with ALICE

Georgy Kornakov on behalf of the
ALICE Collaboration

Faculty of Physics
WARSAW UNIVERSITY OF TECHNOLOGY

Scattering experiments

Exotic atoms and hypernuclei

Chiral effective field theories

Lattice QCD

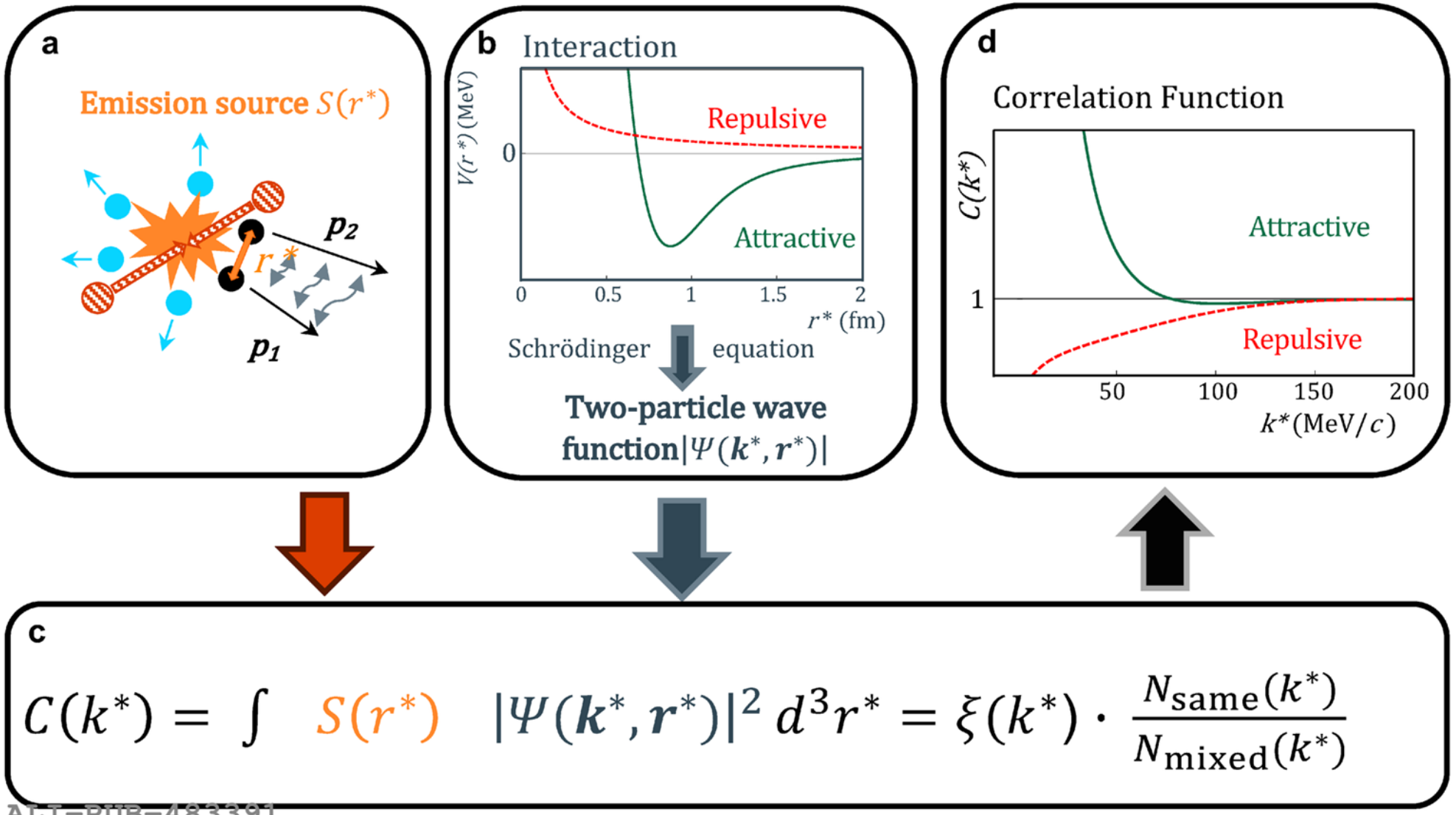
Final State Interactions of hadrons produced in pp, pA and AA collisions

Correlation analysis

Exceptional reconstruction and PID capabilities of ALICE

georgy.kornakov@pw.edu.pl

Correlation measurement of the strong interaction



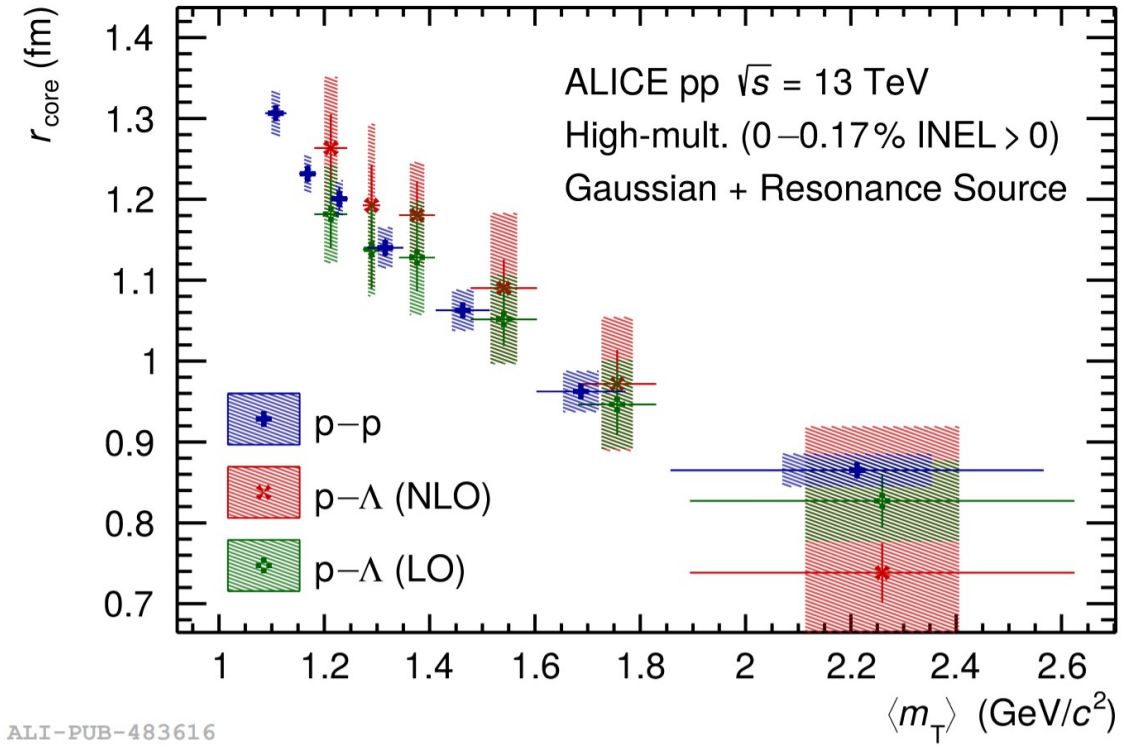
Nature 588 (2020) 232-238
arXiv:2005.11495

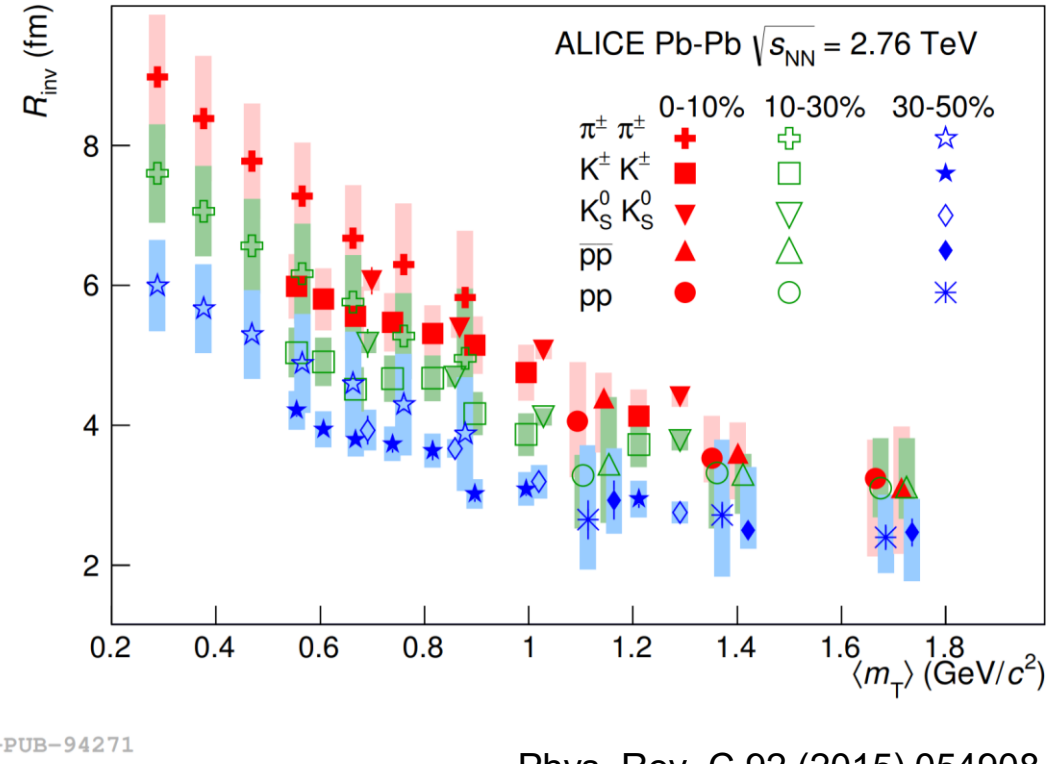
georgy.kornakov@pw.edu.pl

The source

$$C(k^*) = \int S(r^*)\, |\Psi(\boldsymbol{k}^*, \boldsymbol{r}^*)|^2\, d^3r^* = \xi(k^*) \cdot \frac{N_{\text{same}}(k^*)}{N_{\text{mixed}}(k^*)}$$

Phys. Lett. B 811 (2020) 135849
arXiv:2004.08018





Phys. Rev. C 92 (2015) 054908
arXiv:1506.07884

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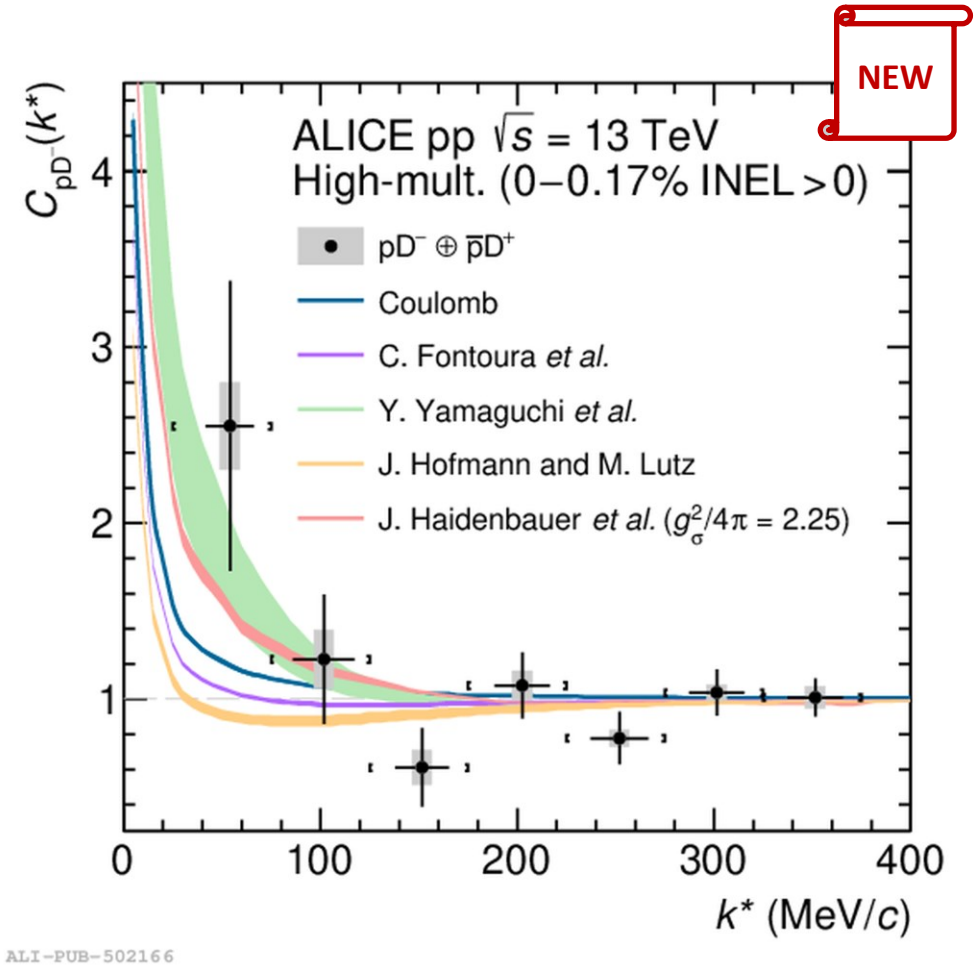
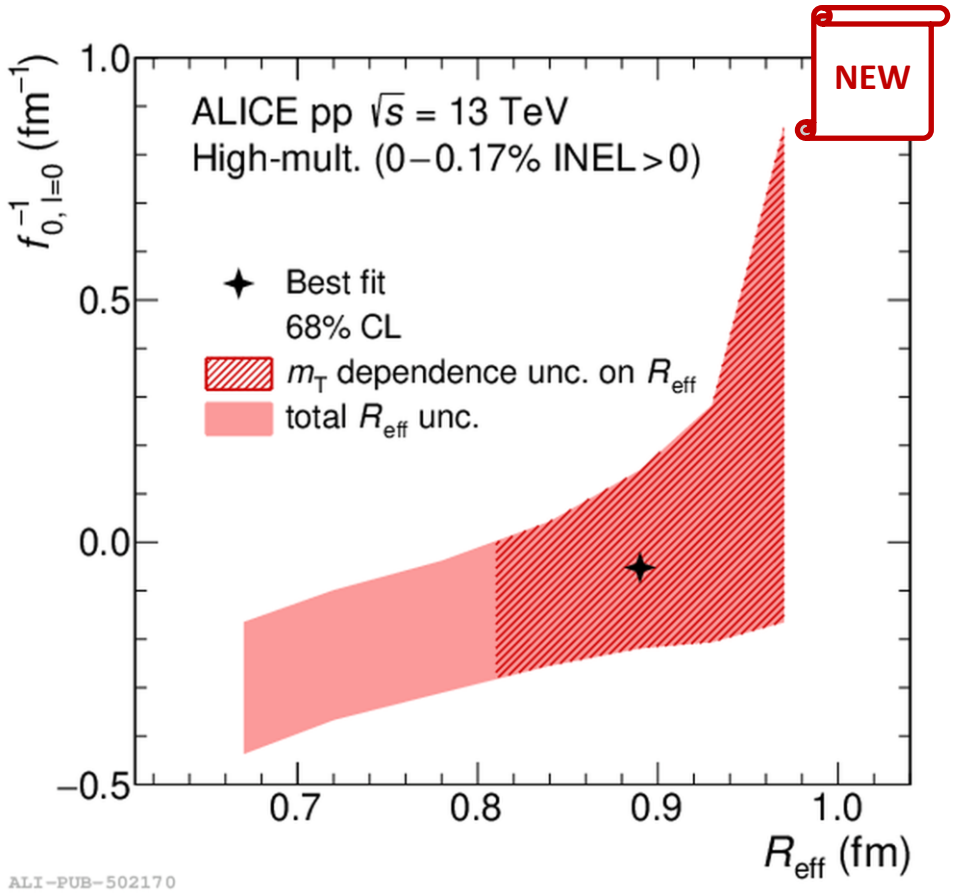
pD

First measurements of D mesons with light flavour hadrons (p, π, K)



arXiv:2201.05352



- Shallow interaction between charm mesons and nucleons
- Formation of a bound state is not excluded!

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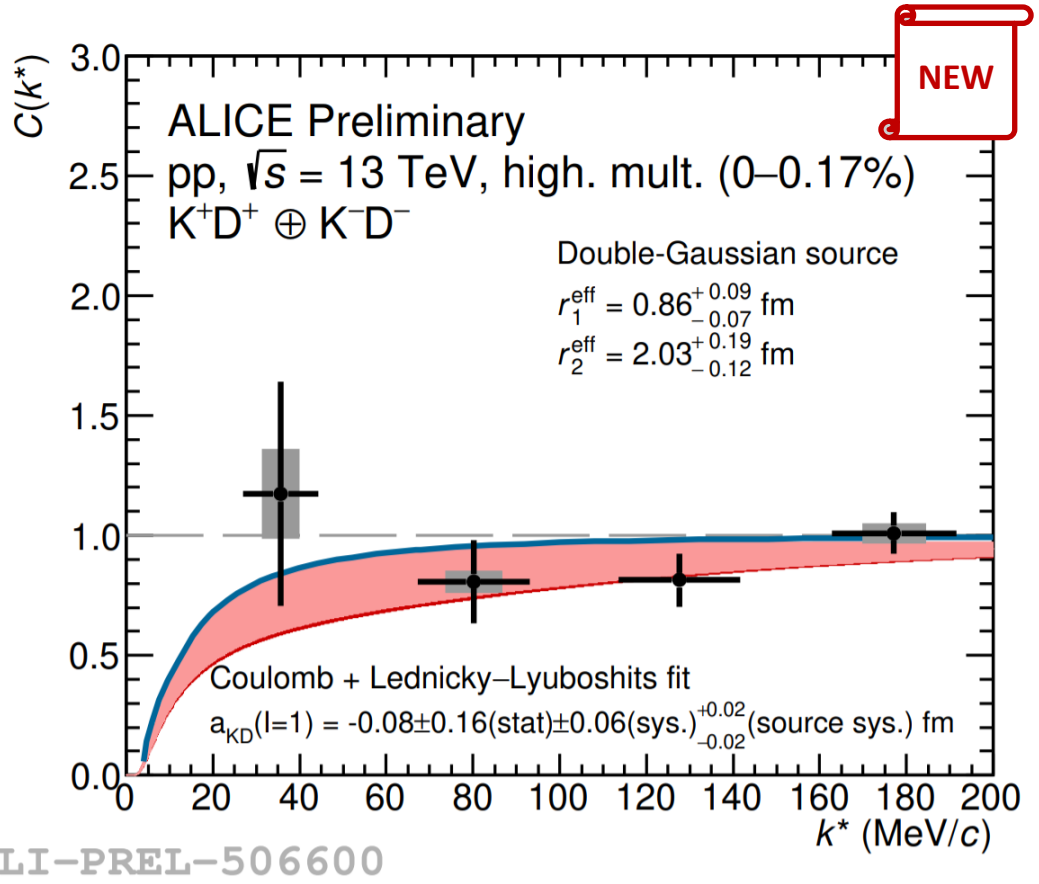
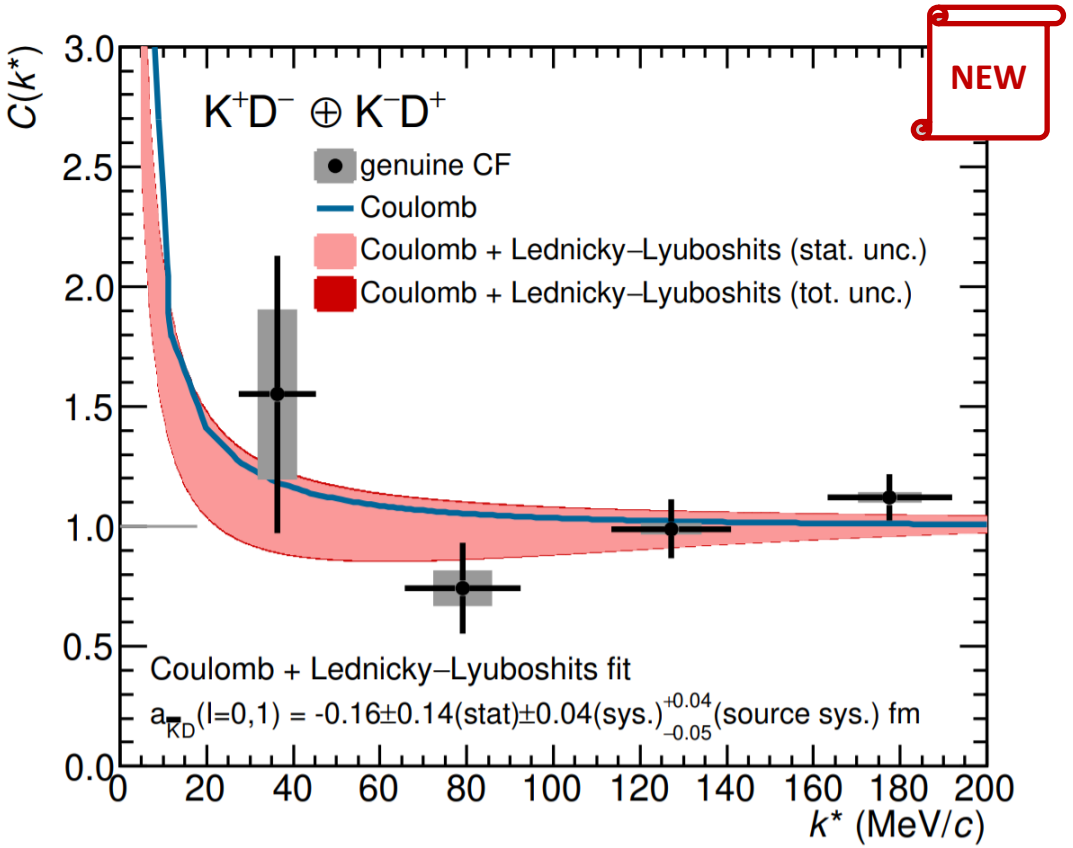
KD

First measurements of D mesons with light flavour hadrons (p, π, K)



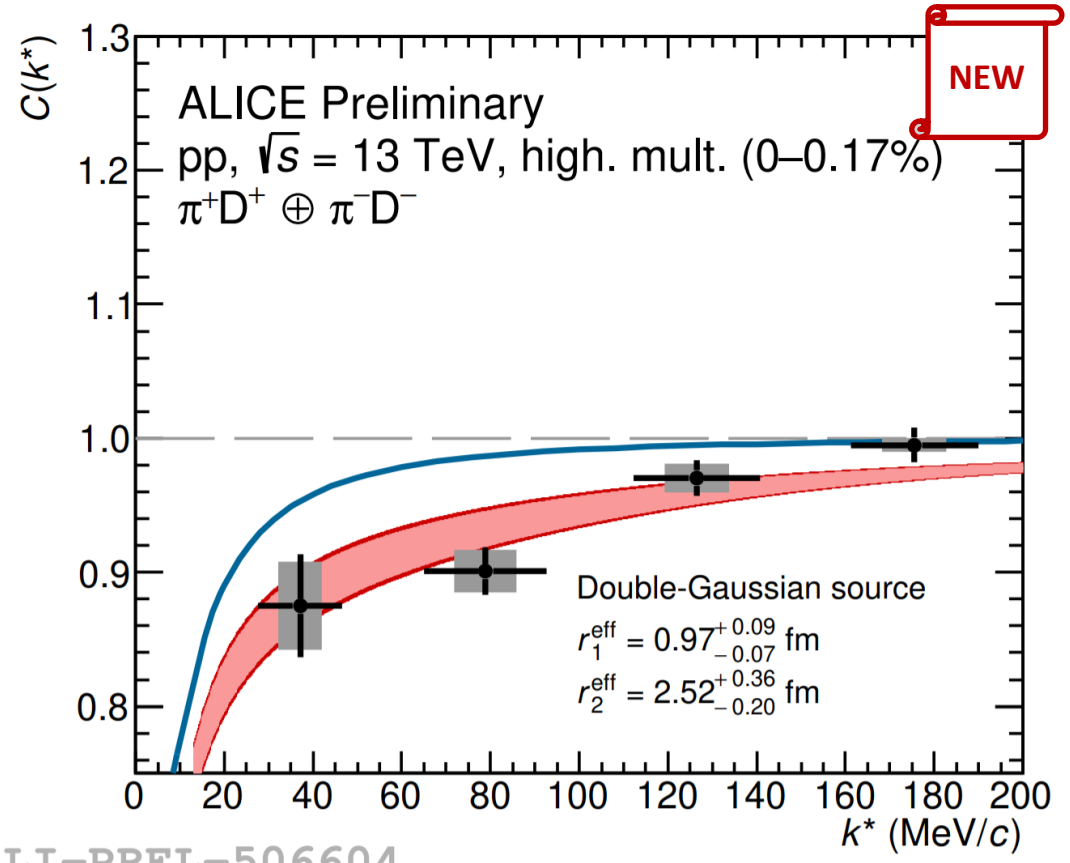


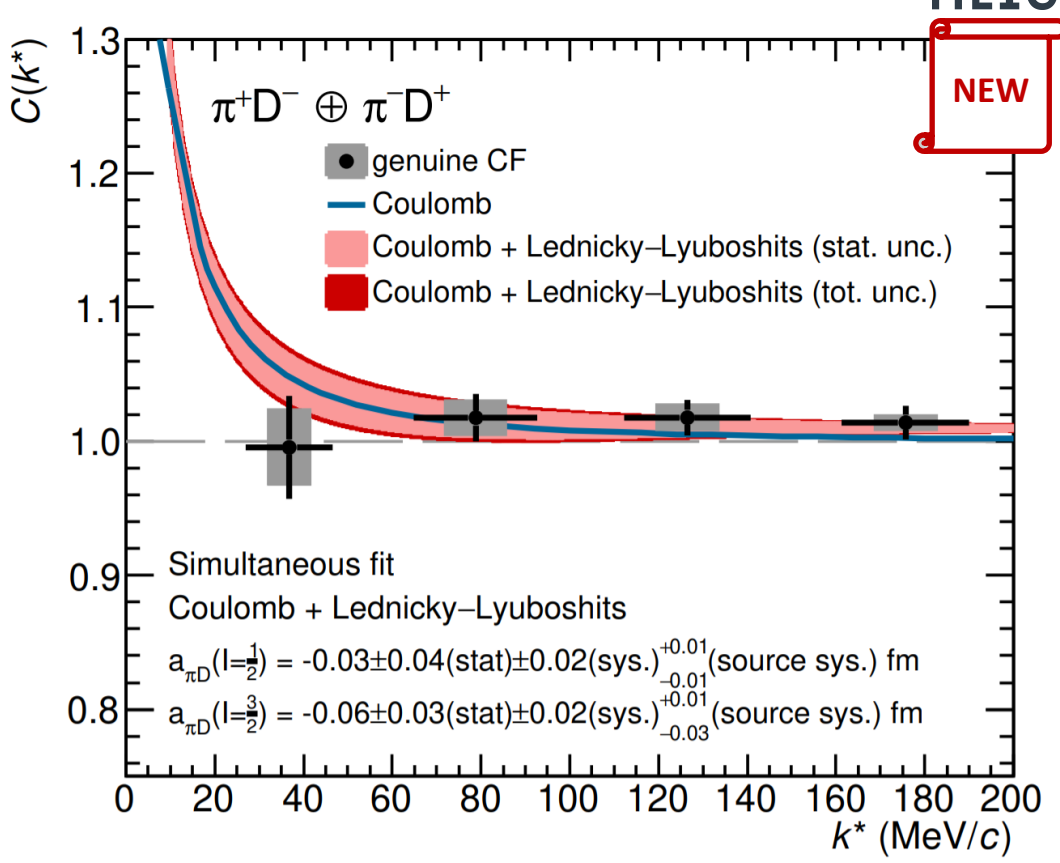
Shallow interaction between D mesons and kaons

georgy.kornakov@pw.edu.pl

First measurements of D mesons with light flavour hadrons (p, π, K)

πD





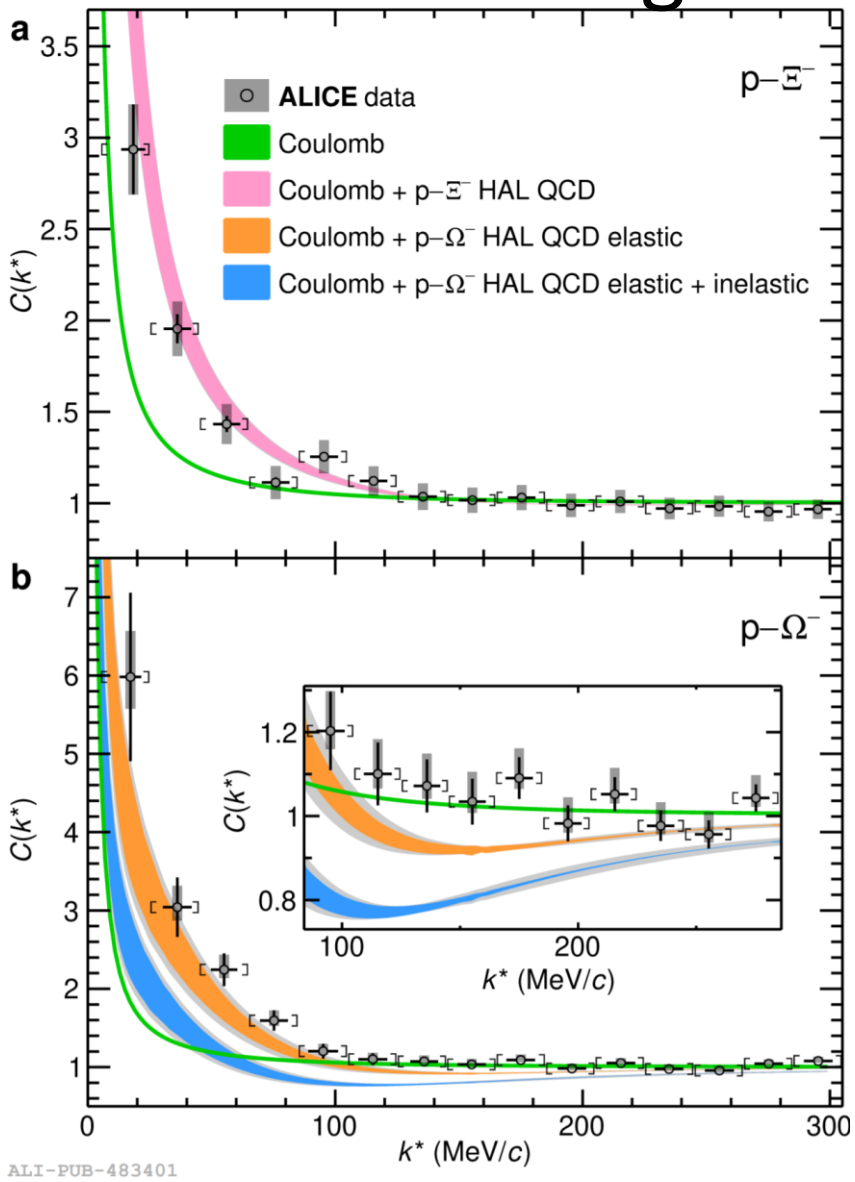
ALI-PREL-506604

- Simultaneous fit to both channels:
  - π^+D^+ only I=3/2
  - π^+D^- I=3/2 (33%) and I=1/2(66%)
- First studies show a shallow interaction between D mesons and light mesons
- Heavy flavour not affected significantly by rescattering

georgy.kornakov@pw.edu.pl

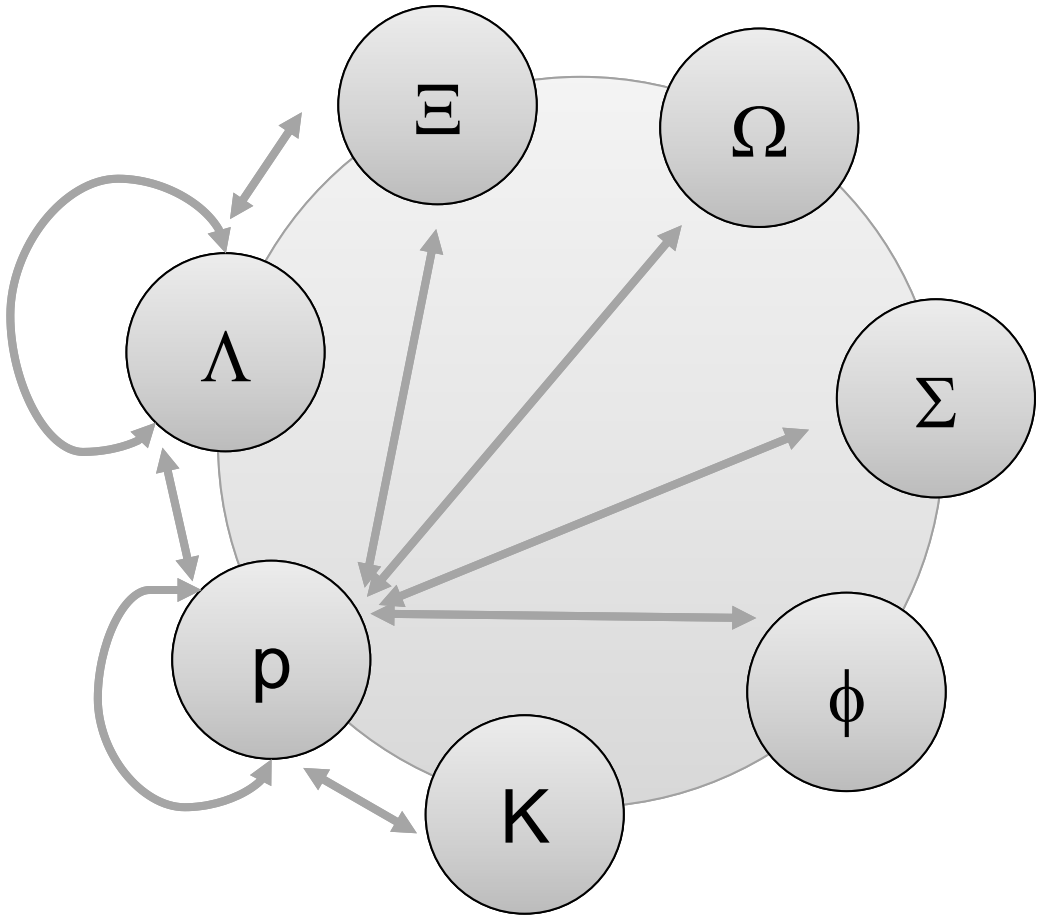
pΞ pΩ

Measurements of hadron-hadron interaction with strangeness



Nature 588 (2020) 232-238
arXiv:2005.11495

S = 1, 2, 3 and hidden



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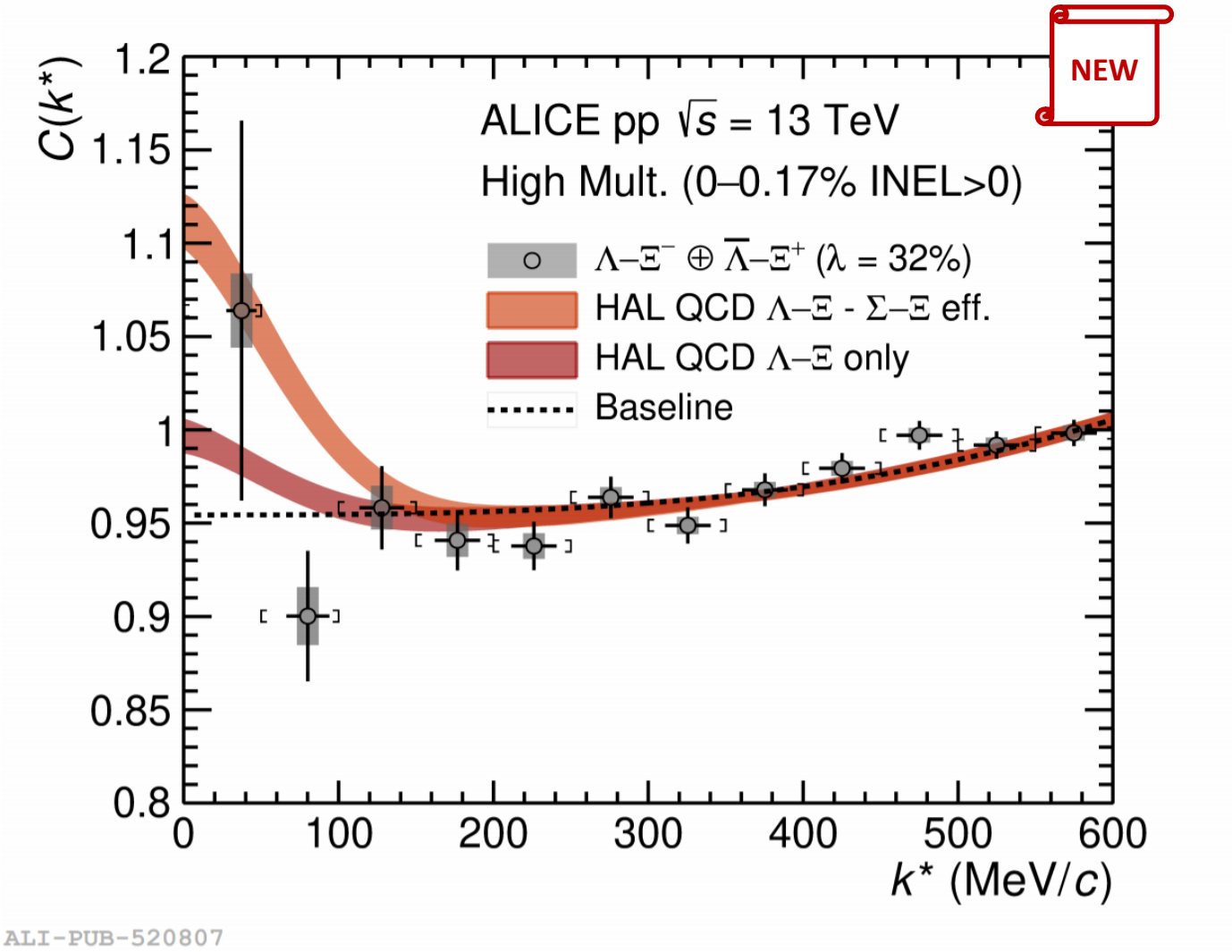
Measurements of hadron-hadron interaction with strangeness



arXiv:2204.10258

First measurement of the ΛΞ-interaction

constraints for lattice QCD calculations and chiral potentials

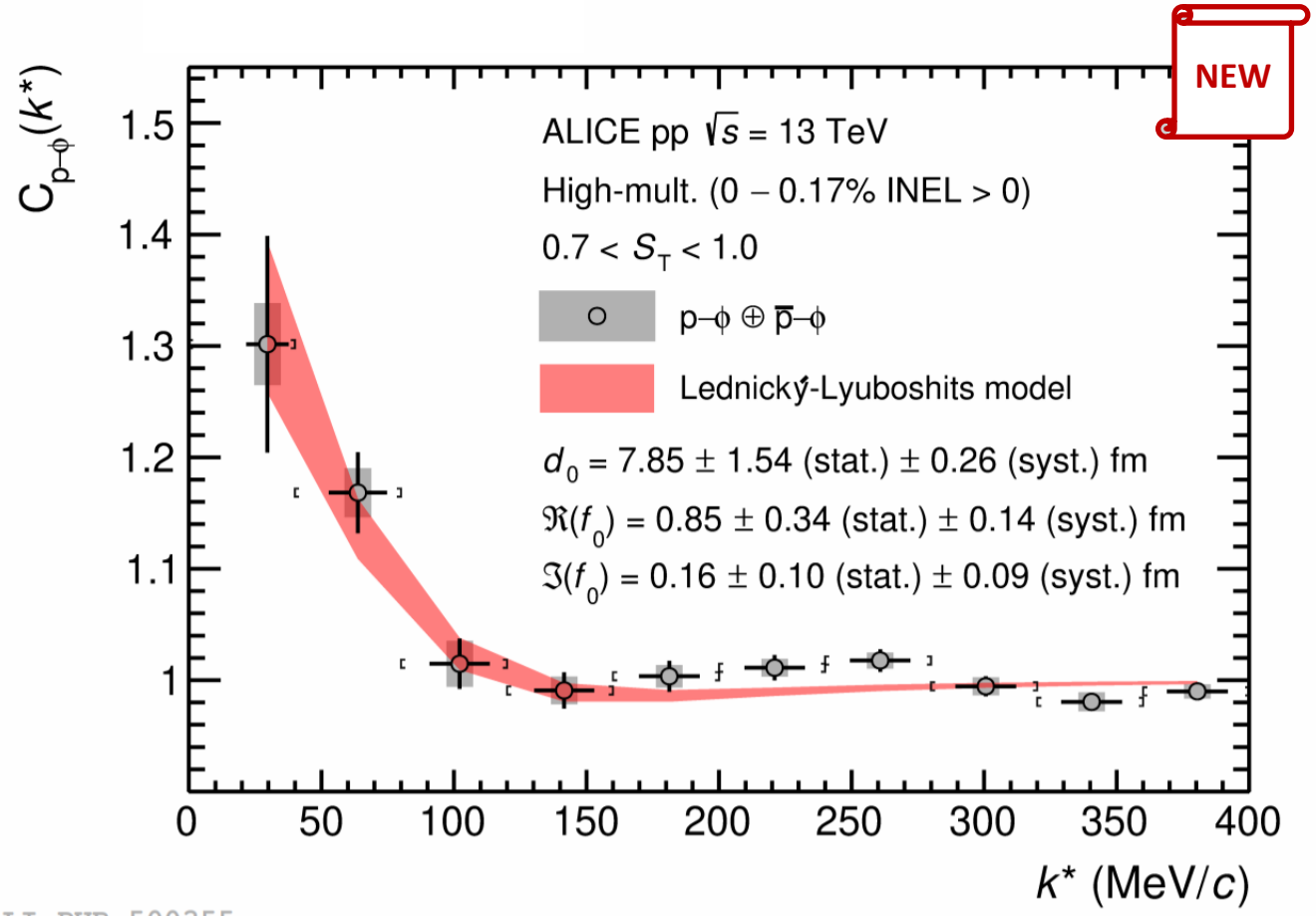
georgy.kornakov@pw.edu.pl

pϕ

Measurements of hadron-hadron interaction with strangeness

PRL 127 (2021) 172301
arXiv:2105.05578

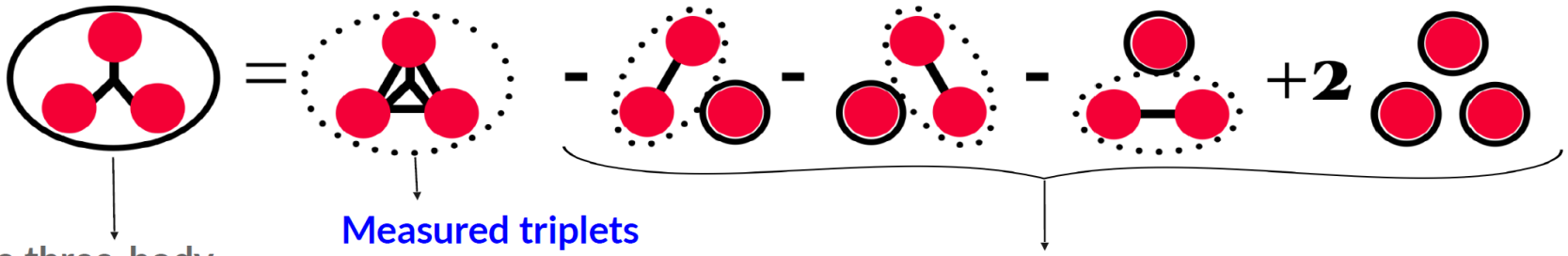
- The imaginary contribution to the scattering length vanishes indicating insignificant inelastic processes
- The p–ϕ interaction in vacuum is attractive and dominated by elastic scattering



ALI-PUB-500355

georgy.kornakov@pw.edu.pl

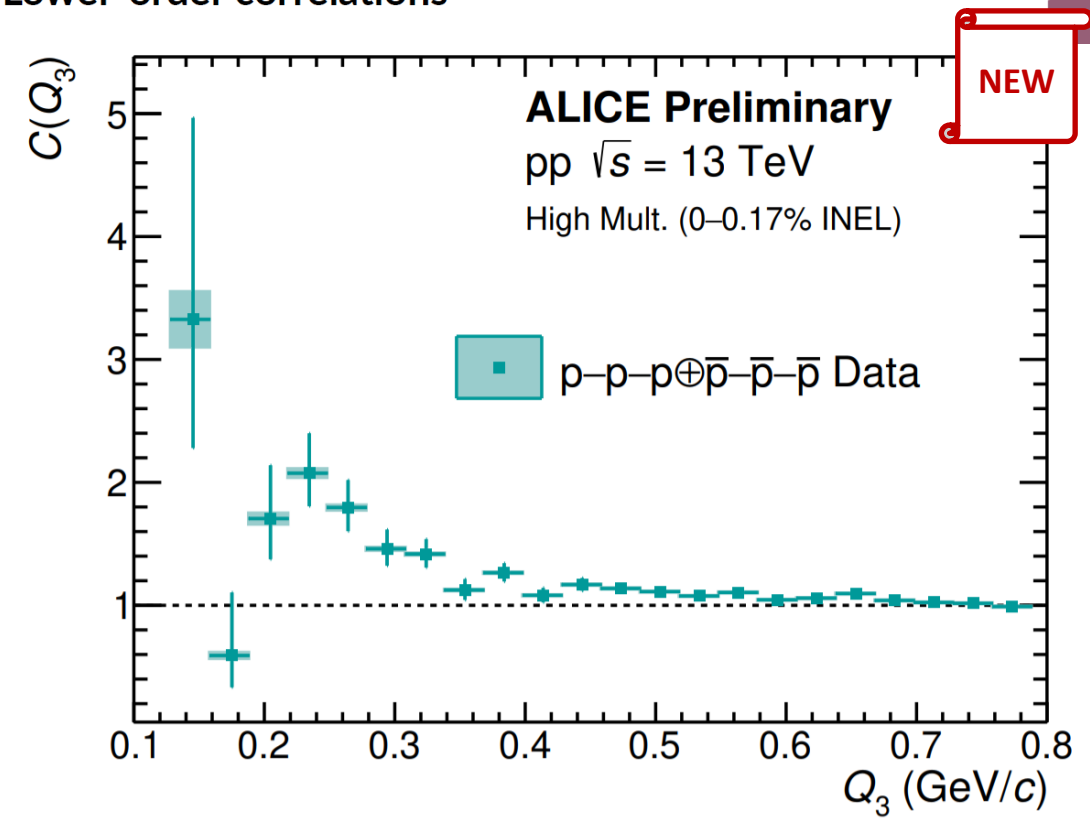
3 body



R. Del Grande et al., Eur. Phys. J. C 82, 244 (2022)
arXiv:2107.10227

- ALICE is pioneering new methods to explore the three body interactions
- First measurement of the genuine three-body interactions via cumulants

$$Q_3 = \sqrt{-q_{12}^2 - q_{23}^2 - q_{31}^2}$$



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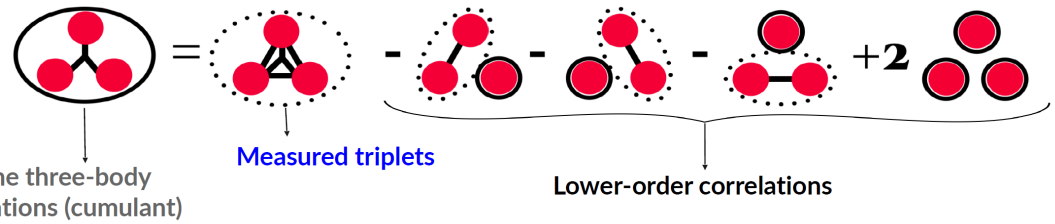
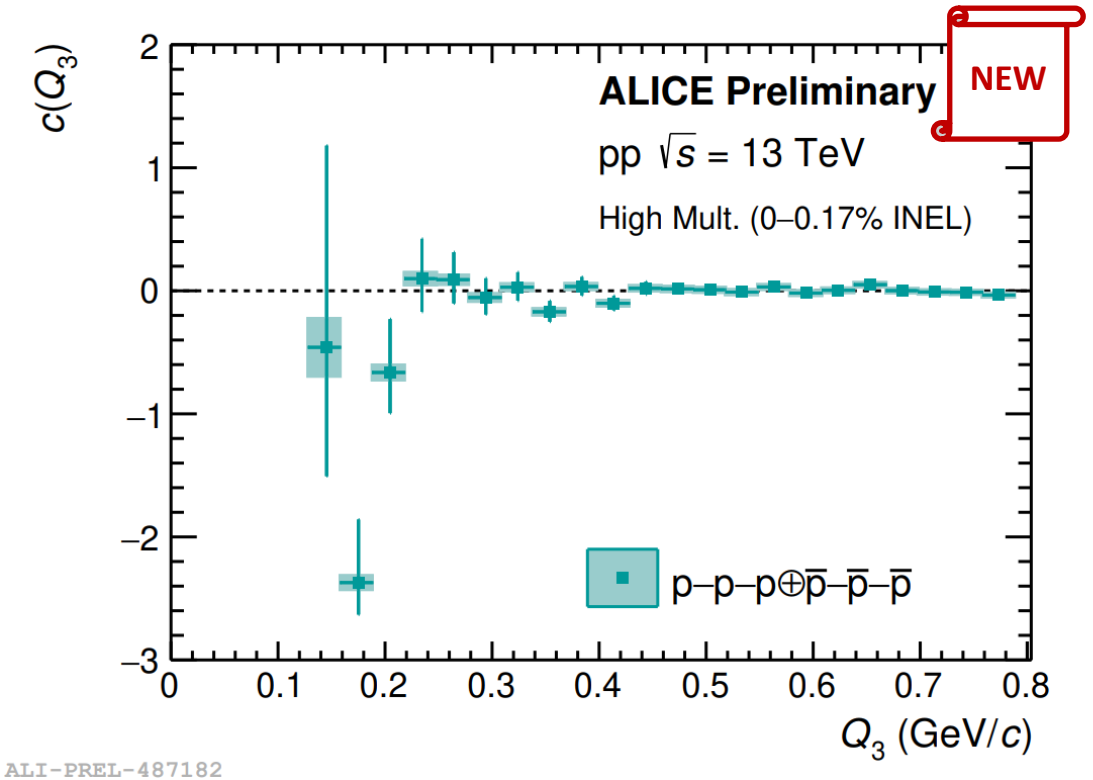
3 body ppp/Λ





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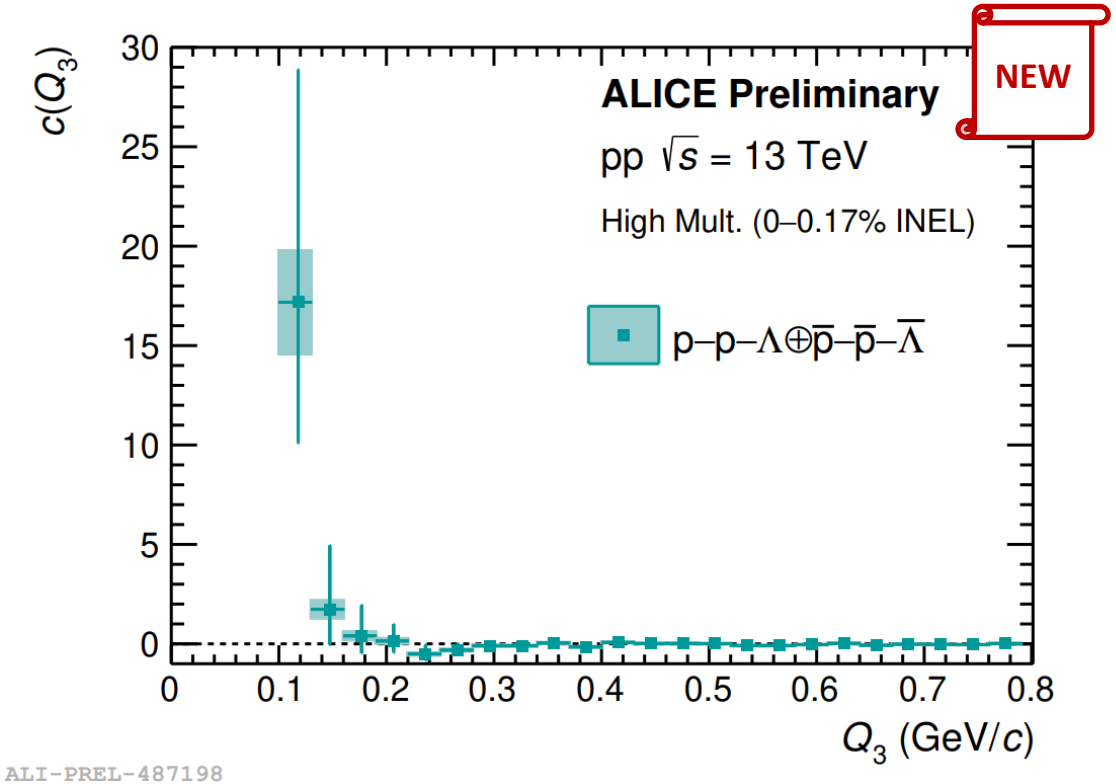


ALI-PREL-487198

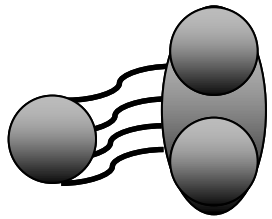
Three-body effect in ppp; could be due to:

- Pauli blocking at the three-particle level
- long-range Coulomb interaction effects
- three-body strong interaction

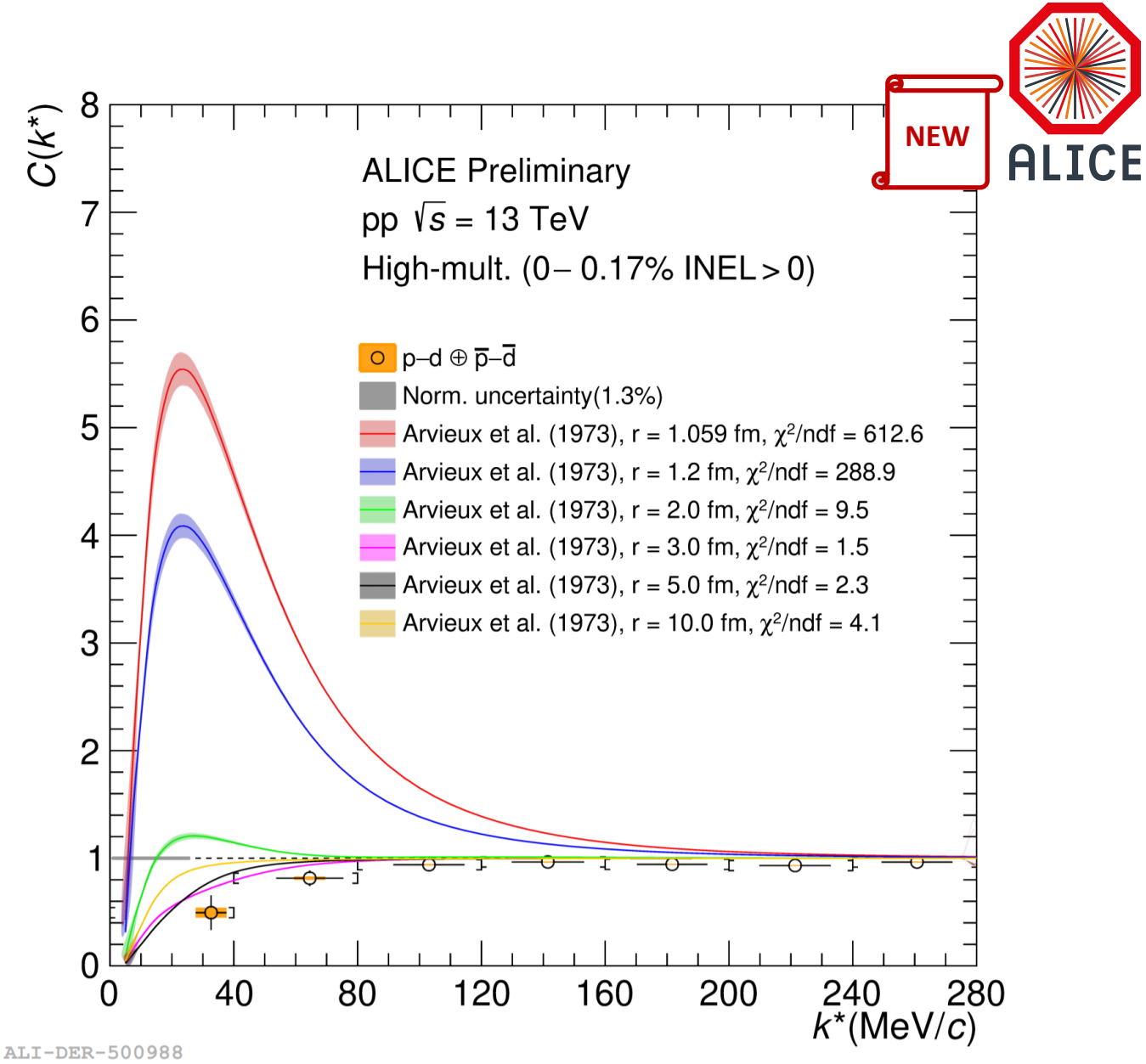
ppΛ no significant deviation observed from the null hypothesis

georgy.kornakov@pw.edu.pl

3 body; pd



- Discrepancy between the measured correlation function and the Lednický-Lyuboshits formalism prediction for small source radii
- The agreement improves with larger source sizes. Compatible with the delayed formation of deuterons in hadron-hadrons collisions

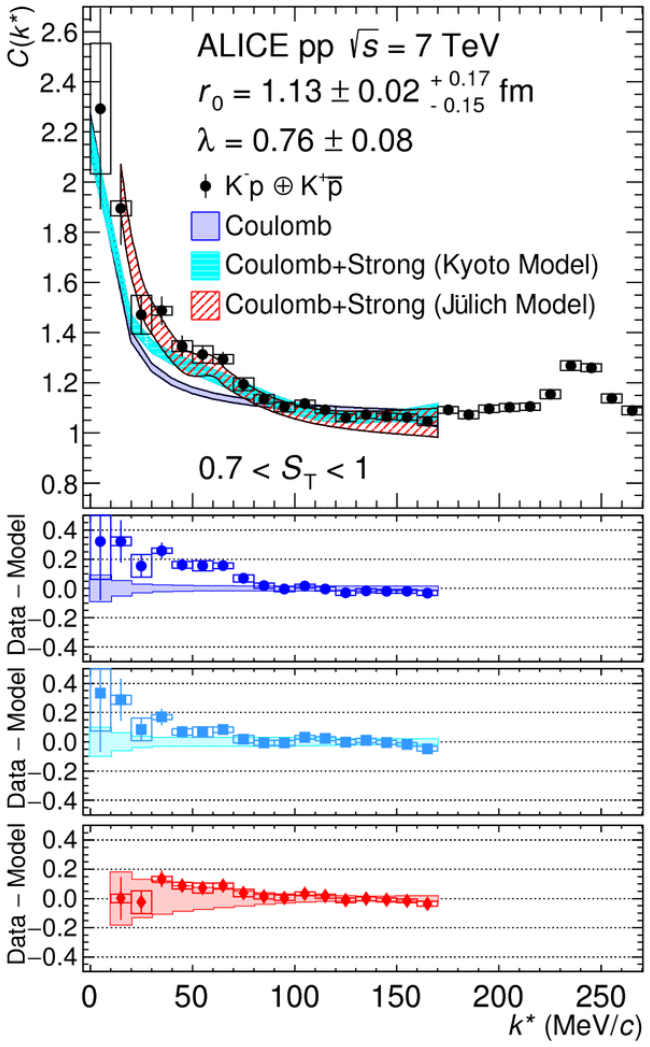


georgy.kornakov@pw.edu.pl

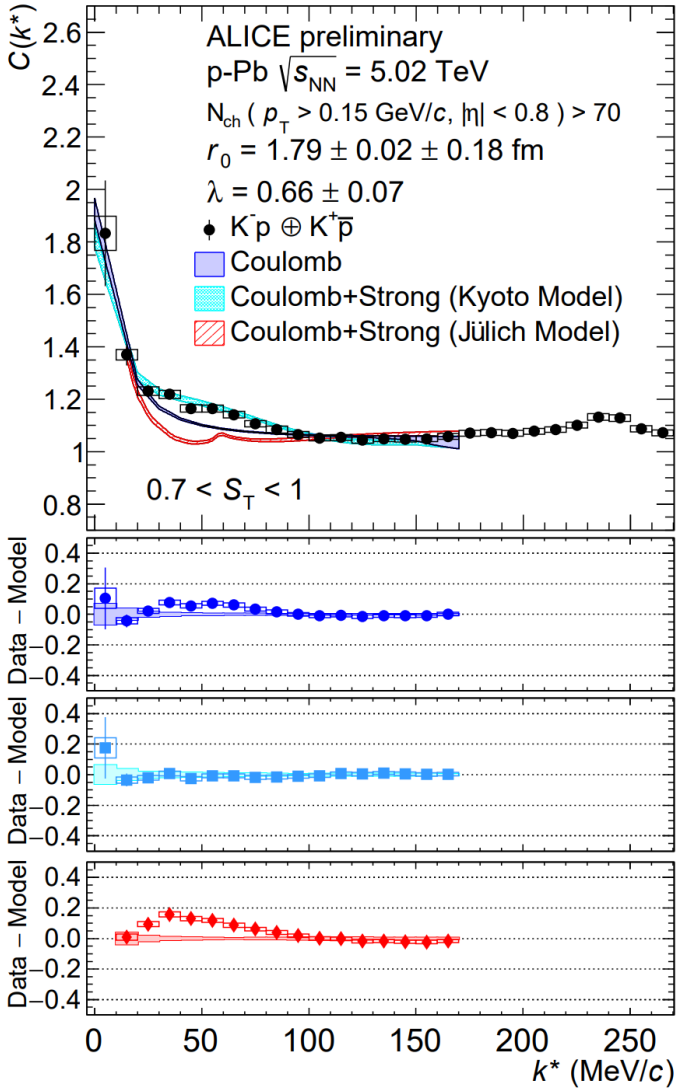
J. Arvieux et al., Nucl. Phys. A 221 253-268 (1973)

Explore the interaction for different radii

Phys. Rev. Lett. 124, 092301 (2020)
arXiv:1905.13470

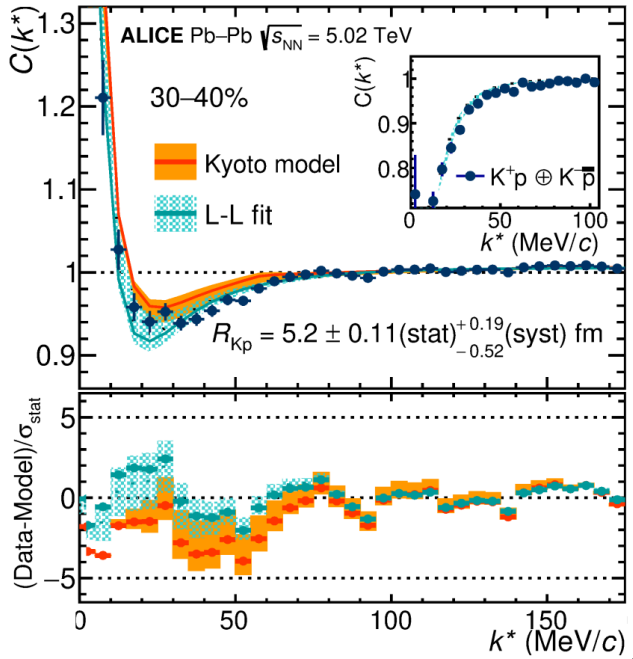


ALI-PUB-322449

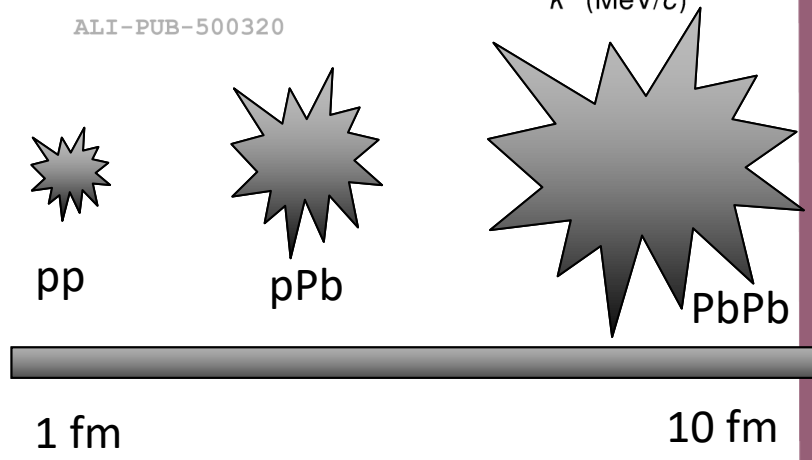


ALI-PREL-316315

Phys. Lett. B 822 (2021) 136708
arXiv:2105.05683



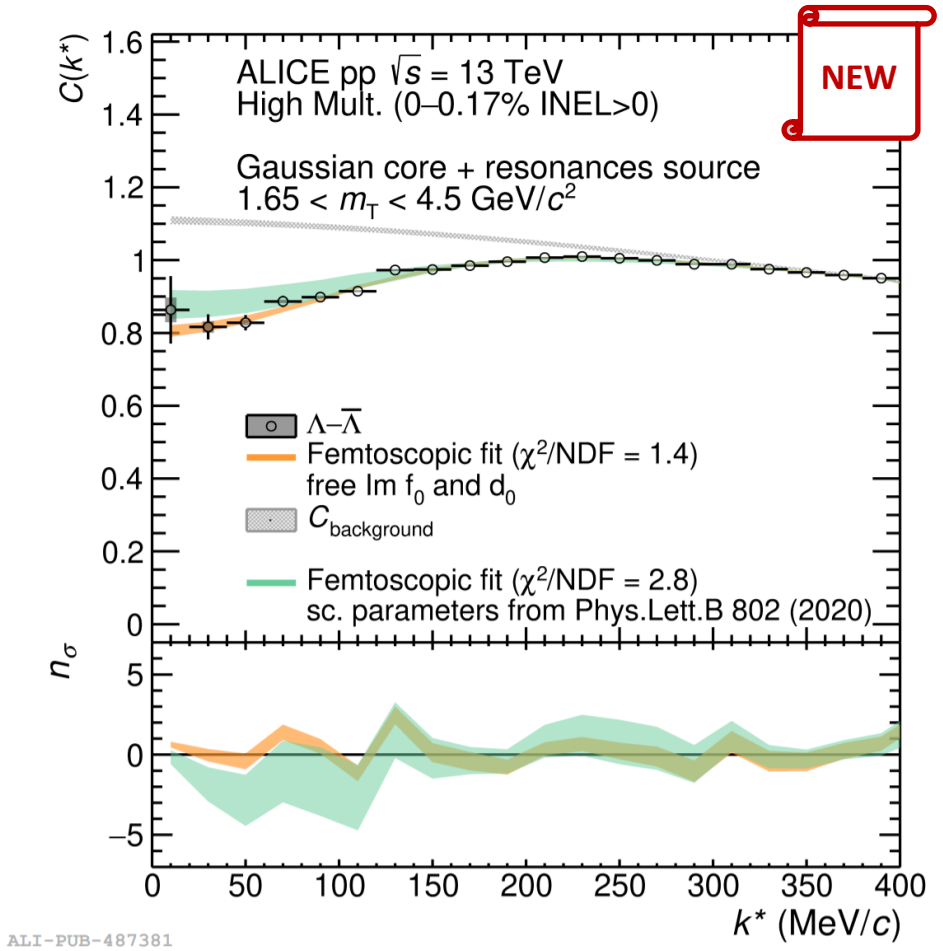
ALI-PUB-500320



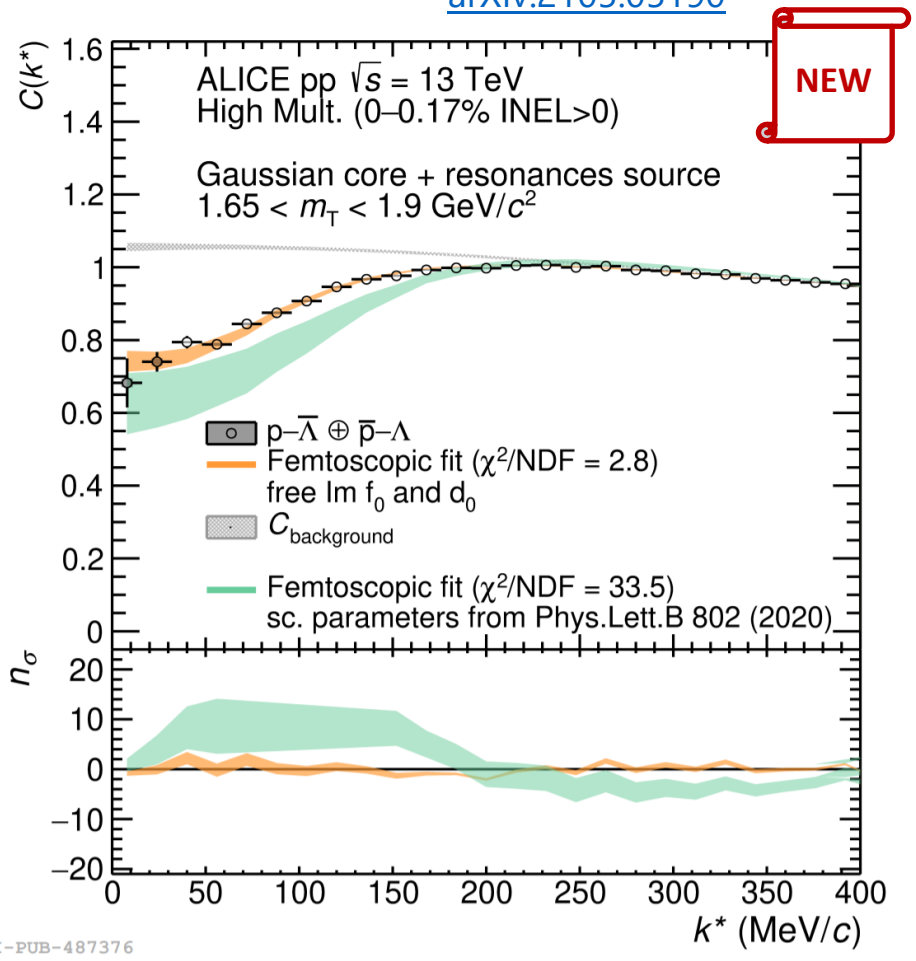
georgy.kornakov@pw.edu.pl

Baryon antibaryon correlations

Phys. Lett. B 829 (2022) 137060
arXiv:2105.05190



Λ–Λ correlation as observed with large radii in PbPb



p–Λ correlation needs an increased Im(f_0) with respect to PbPb

georgy.kornakov@pw.edu.pl

Conclusions and outlook

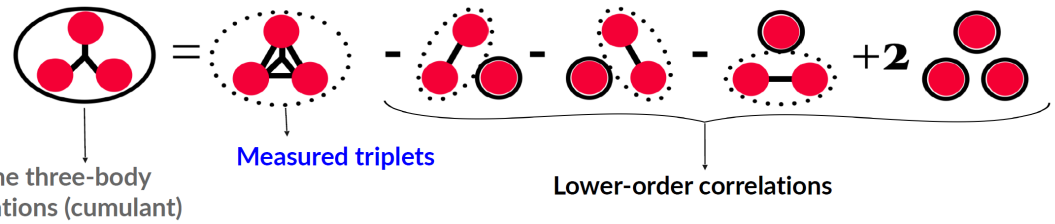
- The exceptional reconstruction and PID capabilities of ALICE enable the precise measurement of the residual strong force between hadrons using femtoscopy
- First measurement of charm hadron interaction with mesons and baryons
  - Shallow interaction between charm mesons and nucleons
- Measurement of a genuine 3-body interaction
  - **p-p-p:** negative cumulant
  - **p-p-Λ:** no significant deviation from 0 in Run 2 data
  - **p-p-K+** and **p-p-K-:** cumulants compatible with 0
- Precise control of the source allows one to observe couplings in great detail
- More precision studies within reach in Run 3 and 4!

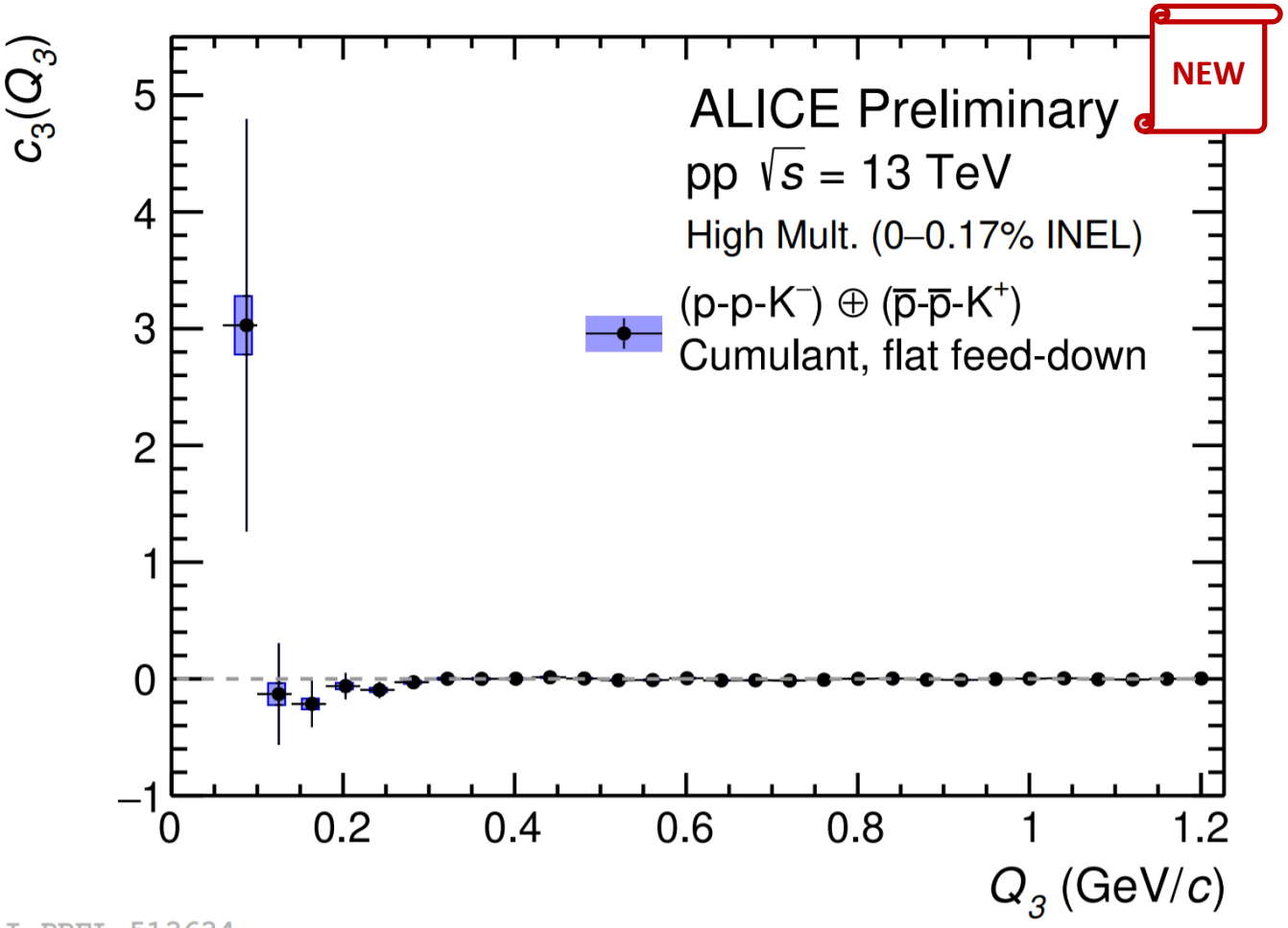
georgy.kornakov@pw.edu.pl

Thank you!

georgy.kornakov@pw.edu.pl

3 body ppK



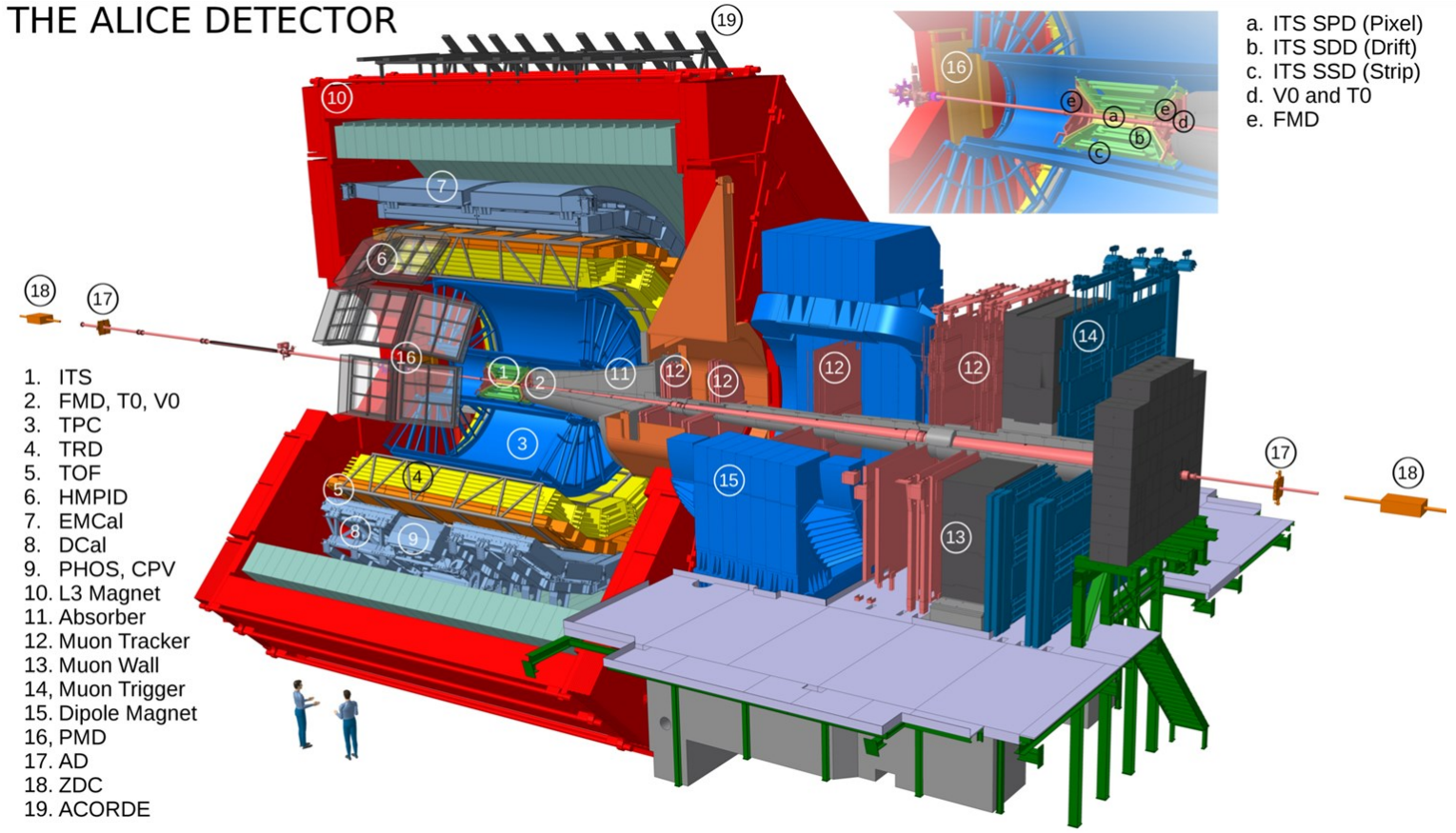


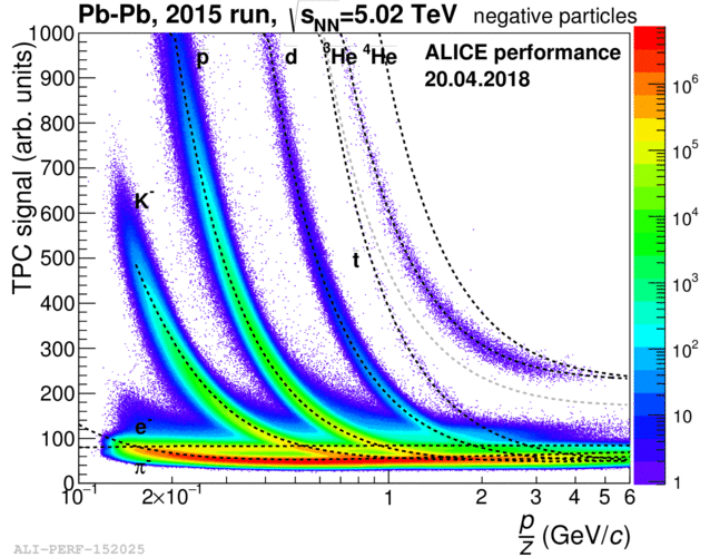
- three-body effects are found to be not significant in systems
- three-body strong interaction is not relevant in the formation of the exotic kaonic bound states

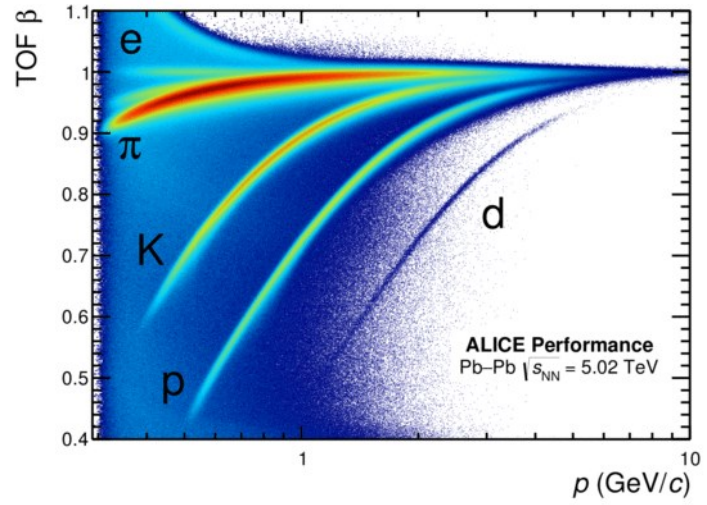
georgy.kornakov@pw.edu.pl

ALI-PREL-513634

Data analysis







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