Contribution ID: **766** Type: **Poster**

Unfolding the effects of final-state interactions and quantum statistics in two-particle angular correlations

Wednesday, 6 April 2022 19:26 (4 minutes)

Angular correlations of identified particles measured in ultrarelativistic proton-proton (pp) and heavy-ion collisions exhibit a number of features which depend on the collision system and particle type under consideration. Those features are produced by mechanisms, such as (mini)jets, elliptic flow, resonance decays, and conservation laws. In addition, of particular importance are those related to the quantum statistics (QS) and final-state interactions (FSIs).

In our recent work [1] we show how to unfold the QS and FSI contributions in angular correlation functions by employing a Monte Carlo approach and using momentum correlations (femtoscopy), focusing on pp reactions. We validate the proposed method with PYTHIA 8 Monte Carlo simulations of pp collisions at $\sqrt{s} = 13$ TeV coupled to calculations of QS and FSI effects with the Lednický and Lyuboshitz formalism and provide predictions for the unfolded effects. In particular, we show how those effects modify the shape of the angular correlation function with emphasis on pions and protons. Most importantly, specific structures in the near-side region ($(\Delta\eta, \Delta\varphi) \approx (0, 0)$) of the two-baryon angular correlation function, namely a small enhancement in the middle of a depletion for proton-proton pairs in pp collisions at $\sqrt{s} = 7$ TeV, observed by ALICE [2], and a depletion for p$\overline{\mathrm{p}}$ pairs in Au-Au collisions at collision energies from $\sqrt{s_{\mathrm{NN}}} = 7.7$ GeV to $\sqrt{s_{\mathrm{NN}}} = 200$ GeV, observed by STAR [3], originating from the strong interaction, are unveiled with the proposed method. The unfolding of the FSI and QS effects is not able to explain the wide anticorrelation effect at near-side observed by ALICE universally for all baryon-baryon and corresponding antibaryon-antibaryon pairs (pp$\oplus\overline{\mathrm{pp}}$, p $\oplus\overline{\mathrm{p}}$- and $\oplus$ –).

The inverse unfolding procedure, from the angular space to the relative momentum space, is also possible. Our preliminary studies suggest that it can allow for a data-driven estimation of non-femtoscopic background in femtoscopic correlations using measured two-particle angular correlations instead of relying on Monte Carlo models.

[1] Ł. Graczykowski, M. Janik, Phys. Rev. C 104, 054909 (2021)
https://arxiv.org/abs/2108.00678
[2] J. Adam et al. (ALICE Collaboration), Eur. Phys. J. C77 (2017) 56
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[3] J. Adam et al. (STAR Collaboration), Phys. Rev. C 101, 014916 (2020)
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Session Classification: Poster Session 2 T07_2

Track Classification: Correlations and fluctuations