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Novel multi-particle correlations for the heavy-ion study: tools for the new decade

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Multi-particle correlations have been compelling tools to probe the properties of the Quark-Gluon Plasma (QGP) created in the ultra-relativistic heavy-ion collisions and the search for the QGP in small collision systems at the LHC. However, only very few of them are available and studied in theoretical calculations and experimental measurements, while the rest are generally very interesting, but their direct implementation was not feasible.

In this talk, I will present the newly developed generic recursive algorithm for multi-particle correlation, enabling the calculation of arbitrary order single and mixed harmonic multi-particle cumulants. Among them, the new 10-, 12-, 14-, and 16-particle cumulants of a single harmonic and the corresponding v_n coefficients, can be studied for the first time. With the same algorithm, the correlations between various flow coefficients v_k, v_l and v_n in their different moments, will be studied based on mixed harmonic cumulants. Such a new correlation shed additional insight into correlations and fluctuations of the eccentricity coefficients in the initial state and the non-linear hydrodynamic response of the deconfined matter. Furthermore, I will show the most recent development of novel correlations between mean transverse momentum and anisotropic flow coefficients $\rho(\langle p_{\mathrm{T}} \rangle, v_n^2)$ and also the higher-order $\rho(\langle p_{\mathrm{T}} \rangle, v_n^2, v_m^2)$ with both between experimental data, hydrodynamic and transport model calculations in Pb–Pb and Xe–Xe collisions at the LHC. This comparison could significantly improve the understanding of the initial conditions (including the nucleon structure) and also the dynamic properties of the QGP.

Preferred track

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