Higher-order $[p_{\mathrm{T}}]$ fluctuations as a probe of nuclear deformation in U+U and Au+Au collisions at STAR

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High-energy nuclear collisions can image the intrinsic shape of the colliding nuclei through the hydrodynamic response of the produced medium. Mean transverse momentum $[p_{\mathrm{T}}]$ fluctuations probe this geometry primarily through radial flow, since $[p_{\mathrm{T}}]$ correlates with transverse size of the overlap region [1, 2]. Cumulants of $[p_{\mathrm{T}}]$ carry progressively higher powers of the quadrupole deformation, and odd-order cumulants are sensitive to its sign and to the triaxiality γ—providing information that is inaccessible through the variance alone and has previously been probed through anisotropic flow [3]. In this poster, we present STAR measurements of the skewness and kurtosis of $[p_{\mathrm{T}}]$ in $^{238}\mathrm{U} + {}^{238}\mathrm{U}$ at $\sqrt{s_{\mathrm{NN}}} = 193$ GeV and $^{197}\mathrm{Au} + {}^{197}\mathrm{Au}$ at 200 GeV. Au+Au follows the independent-source scaling expected for a nearly spherical nucleus. $^{238}\mathrm{U}$+$^{238}\mathrm{U}$ departs from this baseline: the skewness is strongly enhanced toward ultra-central collisions, while the kurtosis stays positive to higher multiplicity before turning sharply negative in the most central events. Comparison with hydrodynamic calculations favours a large quadrupole deformation of $^{238}\mathrm{U}$, establishing higher-order $[p_{\mathrm{T}}]$ cumulants as an independent probe for nuclear shape imaging.

References

[1] STAR Collaboration, "Imaging shapes of atomic nuclei in high-energy nuclear collisions," *Nature* **635**, 67-72 (2024). https://doi.org/10.1038/s41586-024-08097-2.

[2] STAR Collaboration, "Imaging nuclear shape through anisotropic and radial flow in high-energy heavy-ion collisions," *Rep. Prog. Phys.* **88**, 108601 (2025). doi:10.1088/1361-6633/ae0fc3.

[3] J. Jia, "Probing triaxial deformation of atomic nuclei in high-energy heavy ion collisions," *Phys. Rev. C* **105**, 044905 (2022). doi:10.1103/PhysRevC.105.044905.