

High-energy experimental imaging of nuclear shapes for precise constraints on QGP initial conditions

Chunjian Zhang

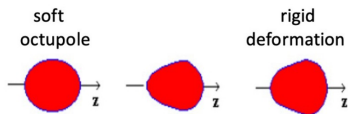
Fudan University

September 8, 2025, Wuhan

Precision Frontier of QCD Matter: Inference and Uncertainty Quantification

Probe $\beta_{3,U}$ and its fluctuation

Octupole collectivity



$$\langle \beta_3^2 \rangle = \bar{\beta}_3^2 + \sigma_{\beta_3}^2$$

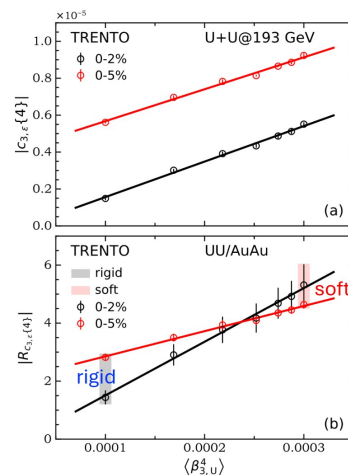
$$c_{n,\epsilon}\{2\} = \langle \epsilon_n^2 \rangle \approx \langle \epsilon_{n,0}^2 \rangle + \langle p_n p_n^* \rangle \langle \beta_n^2 \rangle$$

$$c_{n,\epsilon}\{4\} = \langle \epsilon_n^4 \rangle - 2\langle \epsilon_n^2 \rangle^2 \approx \langle \epsilon_{n,0}^4 \rangle - 2\langle \epsilon_{n,0}^2 \rangle^2 + \langle p_n^2 p_n^{2*} \rangle \langle \beta_n^4 \rangle - 2\langle p_n p_n^* \rangle^2 \langle \beta_n^2 \rangle^2$$

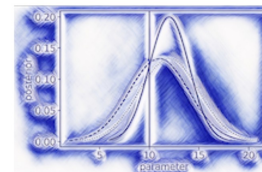
Four-particle correlation is linearly scaled to $\langle \beta_{3,U}^4 \rangle$.

A way to discriminate between static and dynamic collective modes in high-energy nuclear collisions

L. Liu, C. Zhang, J. Chen, J. Jia, X. Huang, Y. Ma, to appear



Statistical Analysis of Energy Loss Across System Size



Coleridge Faraday

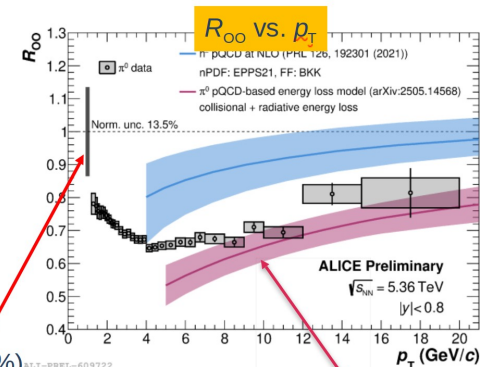
University of Cape Town, South Africa

Precision Frontier of QCD Matter: Inference and Uncertainty Quantification

Based on CF and W. A. Horowitz, arXiv:2505.14568 [hep-ph] (2025); and CF and W. A. Horowitz, Phys. Lett. B **864**, 139437 (2025).

Predictions for light ions

Just presented this morning at initial stages!
(taken from Jan-Fiete's slides)



will go down
(expectation: 5%)

Our model

Click to add Text

On different collision systems in HIC

1. Nuclear structure in HIC: what can we do from the theory side?
2. How to use the nuclear structure theory input?
How to talk to nuclear structure community?
3. Uncertainty in energy deposition model?
4. How will hard processes help in answering these question? Many energy loss models.
5. What to do to help propose new collision systems?