Search for Collectivity in Photo-nuclear Processes at RHIC using STAR Detector

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Abstract

Investigating collective behavior due to the formation of a fluid-like medium in small collision systems has been a significant focus in the field. A tell-tale signature of this would be the medium's response to the initial state in small collision systems, as predicted by fluid-dynamic models.

Recent RHIC studies of small systems have shown a hierarchy of elliptic anisotropy coefficients ($v_2(^3\text{He+Au}) \sim v_2(\text{d+Au}) > v_2(\text{p+Au})$) suggesting fluid-dynamic behavior even in the smallest systems. This raises the question: could a photo-nuclear collision, such as γ+Au also exhibit signatures of collectivity? Notably, signatures of collectivity have been investigated in high-multiplicity, high energy γ+p/Pb collisions at the LHC.

In this work, we explore anisotropic flow in γ+Au processes at RHIC by triggering ultra-peripheral Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. At this collision energy, the maximum photon-nucleon center of mass energy $W_{\gamma N}^{\max} \approx 34.7$ GeV [1], an energy between d+Au collisions at $\sqrt{s_{NN}} = 19$ GeV and $\sqrt{s_{NN}} = 39$ GeV, previously performed at RHIC. For both γ+Au and d+Au collisions, a similar multiplicity range is accessible at STAR, making d+Au a suitable baseline system for comparison. Furthermore, the STAR detector's extended rapidity coverage, with mid and forward rapidity upgrades ($|\eta| < 1.5$ and $2.1 < |\eta| < 5.1$) enables the triggering and analysis of photo-nuclear processes. Preliminary measurements of v_2 and v_3 in γ+Au collisions have been conducted at multiplicities and energy levels comparable to those observed in d+Au collisions, where collective behavior has already been established. These results will provide new insights into collectivity in small collision systems, emphasizing the role of initial-state effects and collective behavior in understanding the evolution of the fluid-like medium created in various collision systems at RHIC.

References

[1] A.J. Baltz et al. The physics of ultraperipheral collisions at the lhc. *Physics Reports*, 458(1):1–171, 2008.