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

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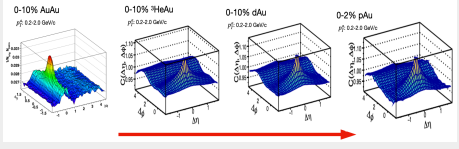
Abstract

Recent RHIC studies of small systems have shown a hierarchy of elliptic anisotropy coefficients (v_2(^{3}He+Au) ~ v_2(d+Au) > v_2(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? By triggering ultra-peripheral Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV, STAR accesses γ+Au events with a maximum photon-nucleon center-of-mass energy $W_{\gamma N}^{max} \approx 34.7$ GeV, slightly lower that d+Au collisions at $\sqrt{s_{NN}}$ = 39 GeV, previously performed at RHIC. For both γ+Au and d+Au, a similar multiplicity range is also accessible at STAR, making d+Au a suitable reference 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. We present preliminary measurements of two-particle correlations and associated Fourier coefficients in γ+Au collisions comparable in multiplicities to those of d+Au collisions. These measurements provide new insights into the role of initial-state effects and collective behavior in understanding the evolution of the medium in small systems at RHIC.

Introduction

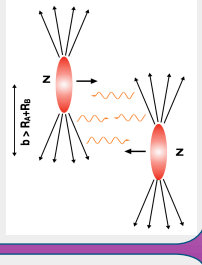


What about collective behaviour in even smaller systems?

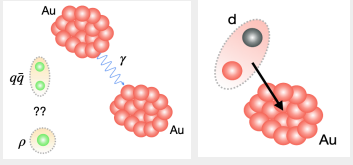
Do γ+A collisions show signs of collectivity?

Anisotropic flow observed in hadronic collisions

- Moving charged particles produce highly Lorentz contracted EM field: Large flux of virtual photons in ultra-relativistic heavy nuclei collisions
- **Ultra-peripheral collisions (UPC):** Interactions between nuclei at b>2R, dominated by **photo-nuclear processes (γA)** or two-photon interactions ($\gamma\gamma$)



Choice of dAu for Comparison



v_2(d+Au) ~ $v_2(\gamma \to q\bar{q}$+Au) OR **v_2(d+Au) > $v_2(\gamma \to \rho$+Au)**

- Measurements in γAu processes at $W_{\gamma N} \approx 34$ GeV, comparable to dAu collisions at $\sqrt{s_{NN}} = 39$ GeV
- Similar multiplicity range for dAu and γAu accessible at STAR

Methodology & Analysis Details

- Measure two-particle correlation using event-mixing technique
- Event classification based on N_{trk}^{TOF} (Uncorrected TPC tracks matched with Time of Flight detector)

$$\frac{dN}{d\Delta\phi} \propto 1 + \sum_n C_n\{2\}\cos(n\Delta\phi)$$

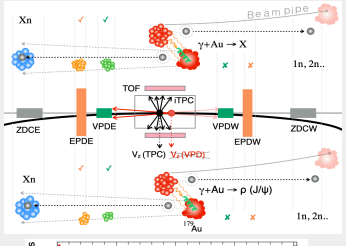
System	Run	Energy (GeV)
γ+Au	Run19 AuAu	200
d+Au	Run16 dAu	39

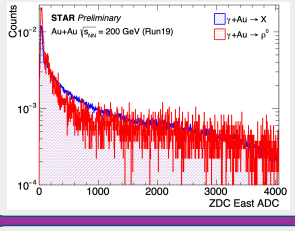
- Event Selection cuts & variations: ZDC (UPC 1nXn → UPC 3nXn), $\Delta\eta$, TPC-VPD Vz difference, TPC Vz, Distance of closest approach (DCA)

Summary

- Trigger inclusive γA process using exclusive ρ-production
- Small hadronic contamination in γAu events
- Reason for choosing dAu collisions as a baseline for γAu collisions
- C_n results comparable for γAu and dAu: No multiplicity dependence
- Dominant effect of non-flow

Triggering γAu Processes in AuAu UPC





- Photo-nuclear detection based on "standard candle": **Exclusive ρ -production as a trigger for inclusive γA process**
- Select γA events by putting asymmetric cuts on Zero-Degree calorimeter (ZDC), Event Plane Detector (EPD) and Time Projection Chamber (TPC)-Vertex Position Detector (VPD) Vz difference

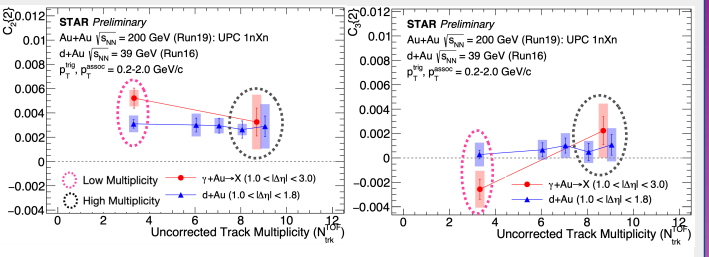
Purity of γAu collisions

ZDC neutron distribution of γ+Au → X closely resembles that of γ+Au → ρ^0

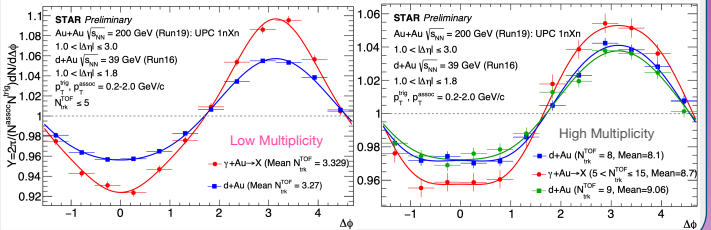
↓

Small hadronic contamination

Results & Conclusion



- **C_n results comparable for γAu and dAu**
- **Dominance of non-flow. No non-flow subtraction performed**



References

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

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