Search for elliptic azimuthal anisotropies in photon-proton and pomeron-Pb interactions with ultraperipheral pPb collisions with the CMS experiment

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29th International Conference on Ultrarelativistic Nucleus-Nucleus Collisions

Kraków, Poland
4-10 April 2022
Introduction

The ridge and collectivity evidence

A long-range, near-side ridge structure emerges in two-particle correlation functions in high-multiplicity events in multiple hadronic collision systems such as lead-lead (PbPb), proton-proton (pp) and proton-lead (pPb). It is a feature of the Quark Gluon Plasma and an evidence of collectivity.

Recent probes with smaller systems

ep and γPb systems have been explored by ZEUS and ATLAS experiments, finding no significant long-range correlations and no collectivity. These smaller systems are characterised by very limited track multiplicity ($N_{\text{trk}}$).
High-energy pPb ultraperipheral collisions, where the impact parameter is larger than the nucleus radius, provide a new system at the LHC to extend the search of long-range correlations to $\gamma p$ collisions. HF ensures activity on the proton side while the ZDC calorimeter ensures no neutrons are detected in the intact Pb nucleus side that is the source of the $\gamma$ flux. Additionally, the tracker system is used to identify the presence of a rapidity gap that characterises these events.

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$^a$Paper CMS HIN-18-008 (to be submitted to Phys. Lett. B)
Photon-proton (γp) interactions

Agreement between data and simulation

For in γp interactions, $N_{\text{trk}}$ from the primary vertex with $p_T > 0.4$ GeV and $|\eta| < 2.4$ is limited to $< 35$ as seen at left of the figure. The mean $p_T$ of charged particles is smaller in the γp sample than for hadronic minimum bias pPb (MB) collisions within the same $N_{\text{trk}}$ range. No evidence for a long-range near-side ridge-like structure was found for either the γp or MB samples within this $N_{\text{trk}}$ range.

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aPaper CMS HIN-18-008 (to be submitted to Phys. Lett. B)
Measurement of elliptic flow coefficient

Fourier components \((V_{n\Delta})\)

The two-particle azimuthal correlations can be characterized by their Fourier components \((V_{n\Delta})\), where \(n\) represents the order of the moment.

\(\gamma p\) and MB \(pPb\) differ in \(v_2\) magnitude

The single-particle azimuthal anisotropy Fourier coefficients \(v_n\) can be extracted as \(v_n = \sqrt{V_{n\Delta}}\). The figure below shows the \(v_2\) dependence on \(N_{\text{trk}}\) for two \(p_T\) categories. Predictions from the PYTHIA8 and HIJING generators are also shown for \(\gamma p\) and MB \(pPb\) interactions (blue and red lines), respectively. None of the models include collective effects, thus suggesting the absence of collectivity in the \(\gamma p\) system over the multiplicity range explored in this work.
Study of two-particle correlations ($V_{1\Delta}$, $V_{2\Delta}$, $V_{3\Delta}$) and azimuthal anisotropies ($v_2$) in small systems has been expanded to $\gamma p$ showing similarities with studies over ep system.

For both the $\gamma p$ and pPb samples, $V_{1\Delta}$ is negative, $V_{2\Delta}$ is positive, and $V_{3\Delta}$ consistent with 0.

The $\gamma p$ data are consistent with model predictions that have no collective effects thus suggesting the absence of collectivity in the $\gamma p$ system over the multiplicity range explored in this work.

Neutral and colorless objects named pomerons ($\Pi$), associated with an intact p within pPb collisions interact with a Pb nucleus as indicated in the figure. Diffractive components of these interactions are characterised by the presence of a rapidity gap and are currently under study.

Thanks for your attention