

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

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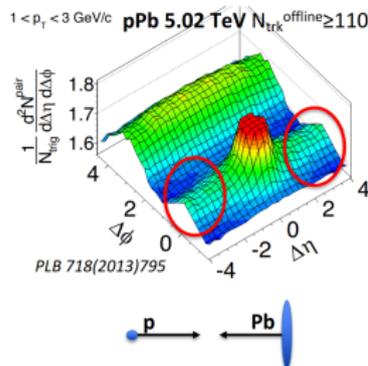
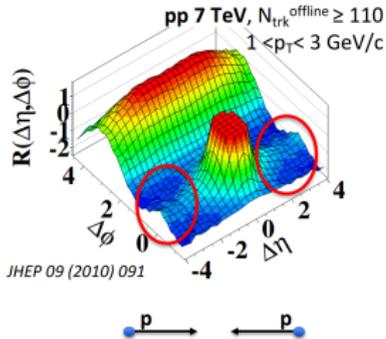
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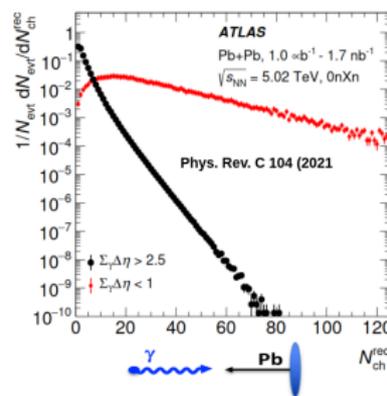
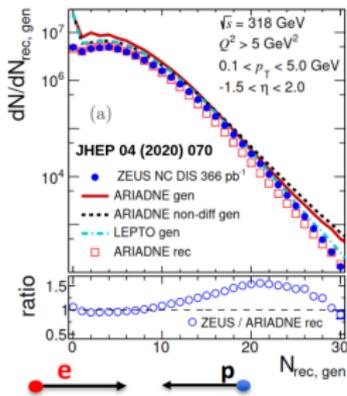
## The ridge and collectivity evidence

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

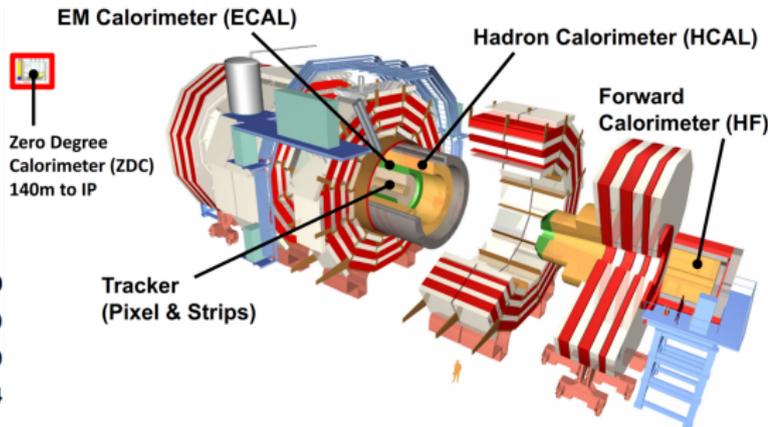
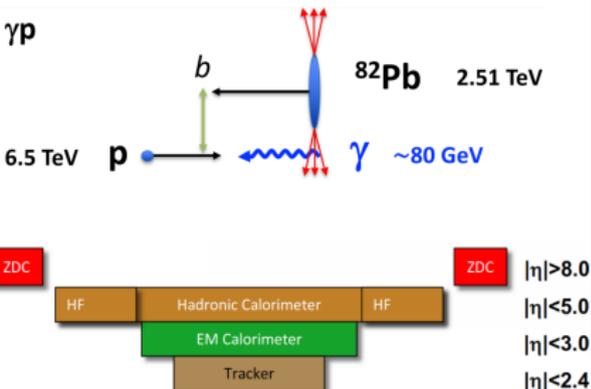
**ep** and  **$\gamma$ Pb** systems have been explored by **ZEUS** and **ATLAS** experiments, finding no significant long-range correlations and no collectivity. These smaller systems are characterised by very limited track multiplicity ( $N_{\text{trk}}$ ).



## Zero Degree (ZDC) and Hadronic Forward (HF) calorimeters

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 <sup>a</sup>.

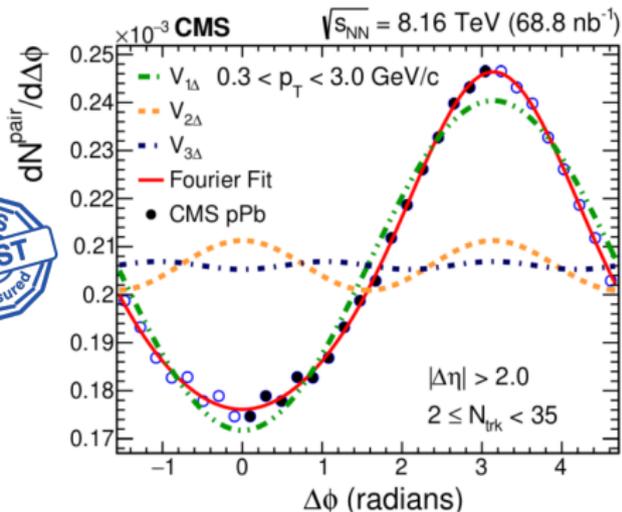
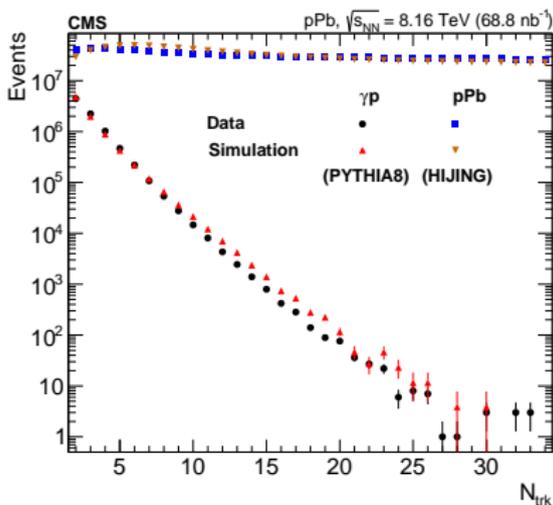
<sup>a</sup>Paper CMS HIN-18-008 (to be submitted to Phys. Lett. B)



## Agreement between data and simulation

For in  $\gamma p$  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  $\gamma p$  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  $\gamma p$  or MB samples within this  $N_{\text{trk}}$  range <sup>a</sup>.

<sup>a</sup>Paper CMS HIN-18-008 (to be submitted to Phys. Lett. B)





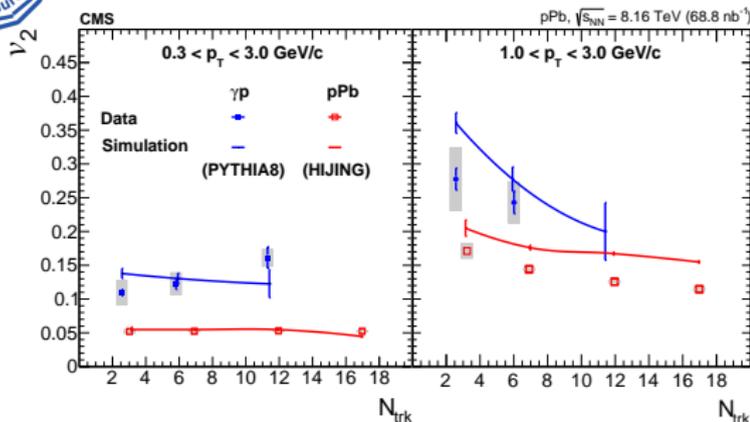
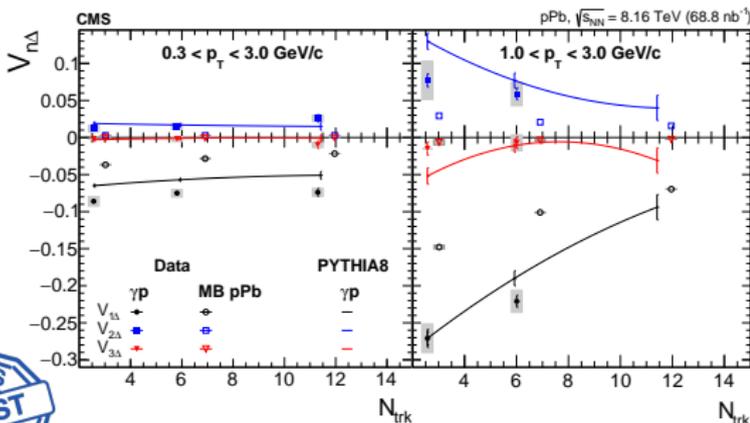
# Measurement of elliptic flow coefficient

## 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.

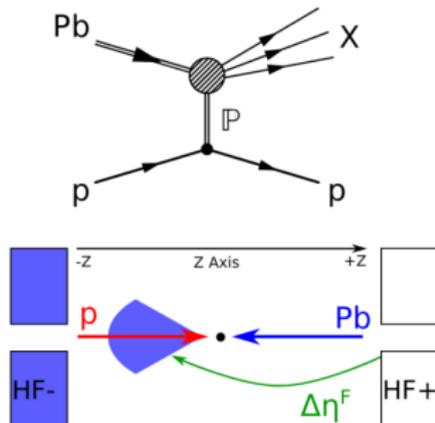


## Summary and outlook

- ▶ 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.

## pomeron-lead (PPb) system

Neutral and colorless objects named pomerons ( $\mathbb{P}$ ), 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