Search for azimuthal anisotropy in γp interactions within ultra-peripheral pPb collisions at $\sqrt{s_{NN}} = 8.16$ TeV

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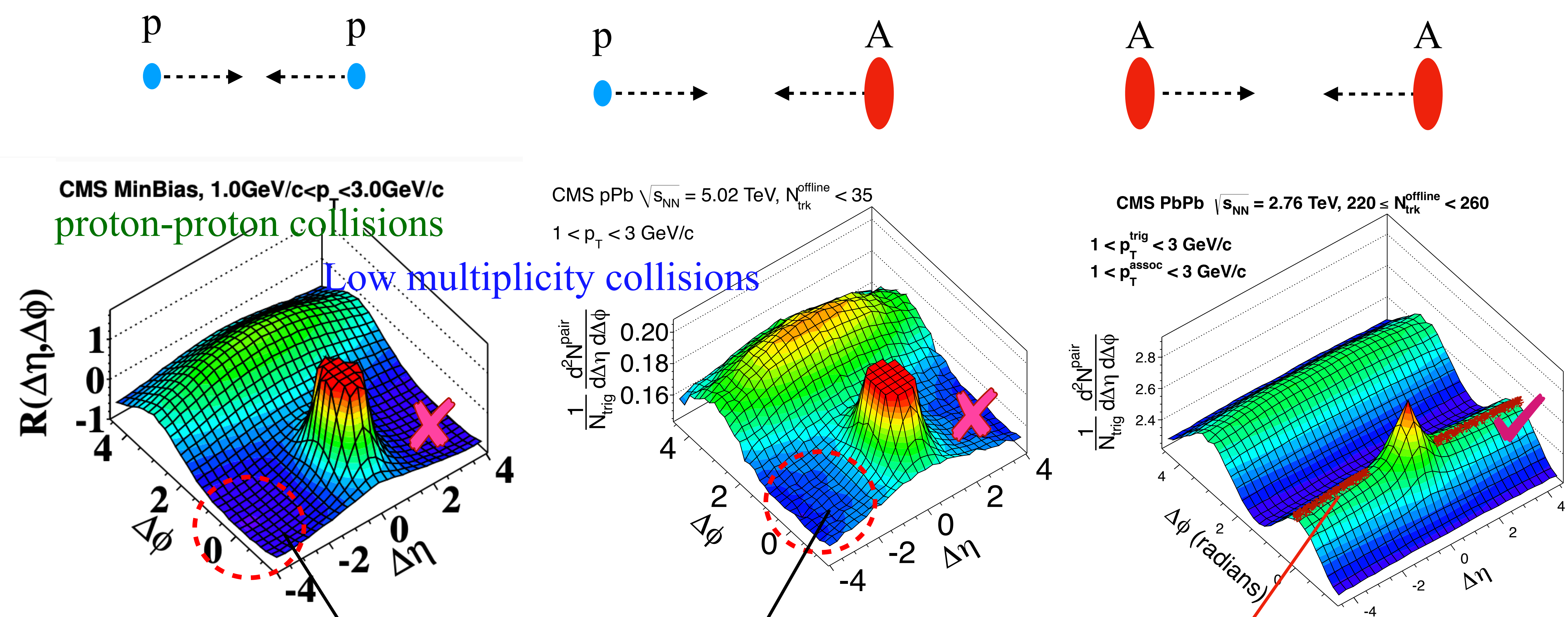
Outline

- Introduction
- CMS detector
- Selection requirement
- Correlation functions in γp interaction
- Results
- Summary

Long range near-side ridge structure

✓ Appearance in two-particle charged-hadron correlations



JHEP09 (2010) 091

PLB 718 (2013) 795

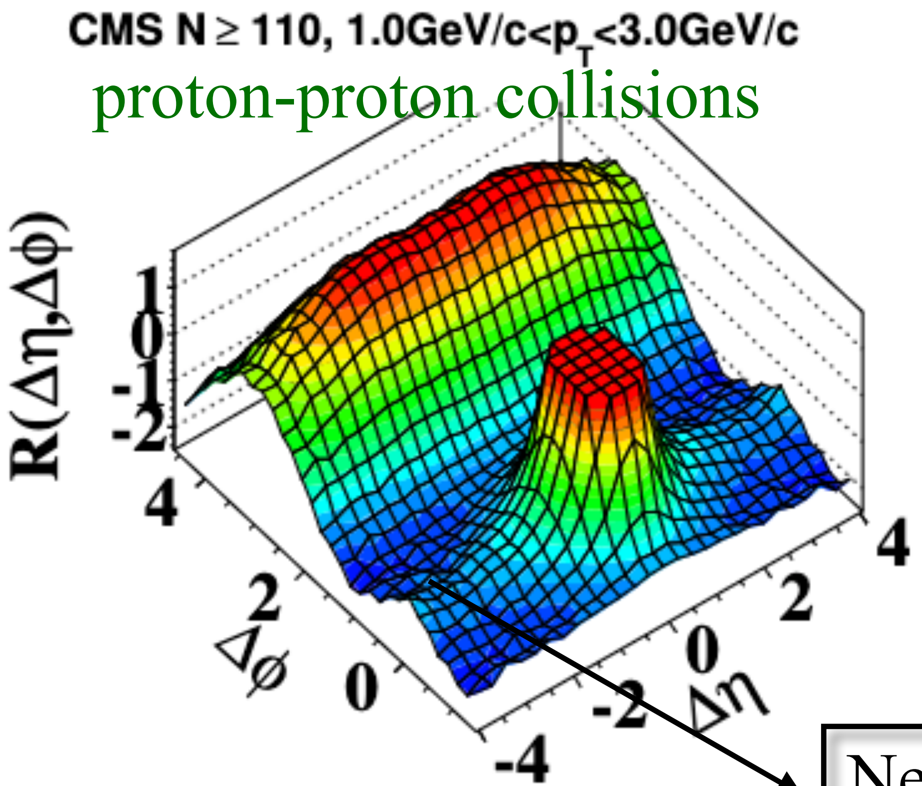
Phys. Lett. B 724 (2013) 213

"Ridge"-like structure is absent in minimum bias pp and pA system

Evidence of collectivity and one of the signatures of QGP

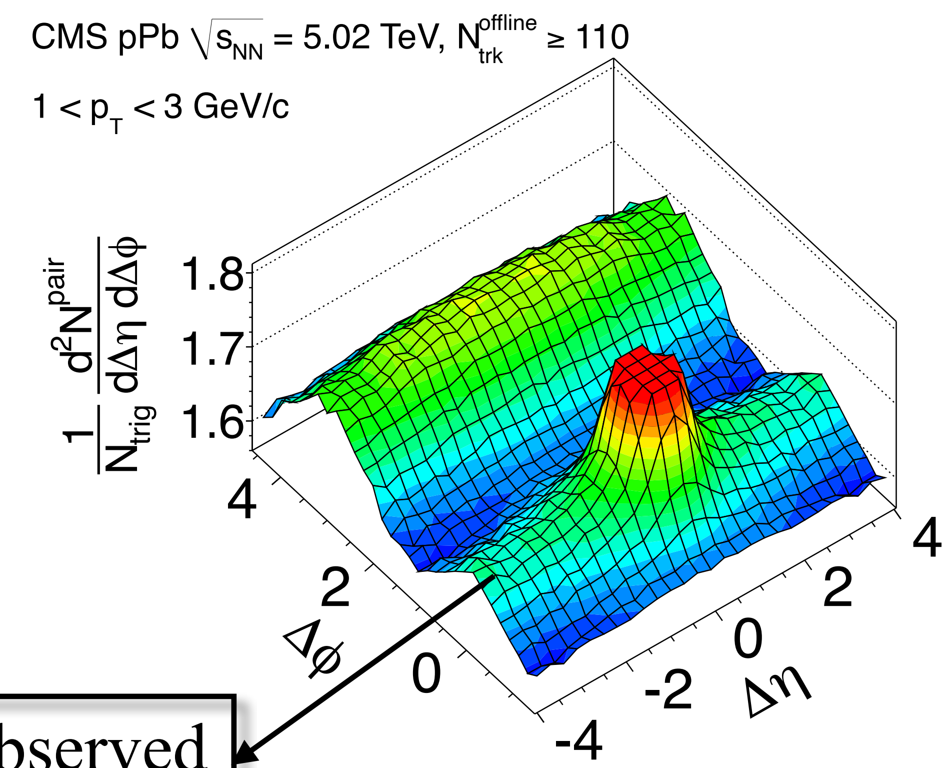
Discovery: collectivity in small system

JHEP09 (2010) 091

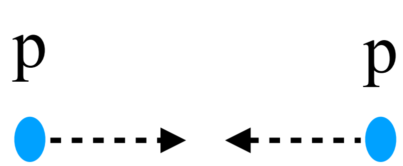


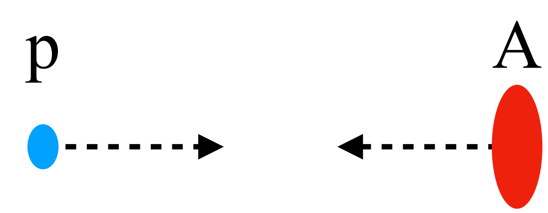
High multiplicity collisions

PLB 718 (2013) 795



Near side "ridge" structure is observed





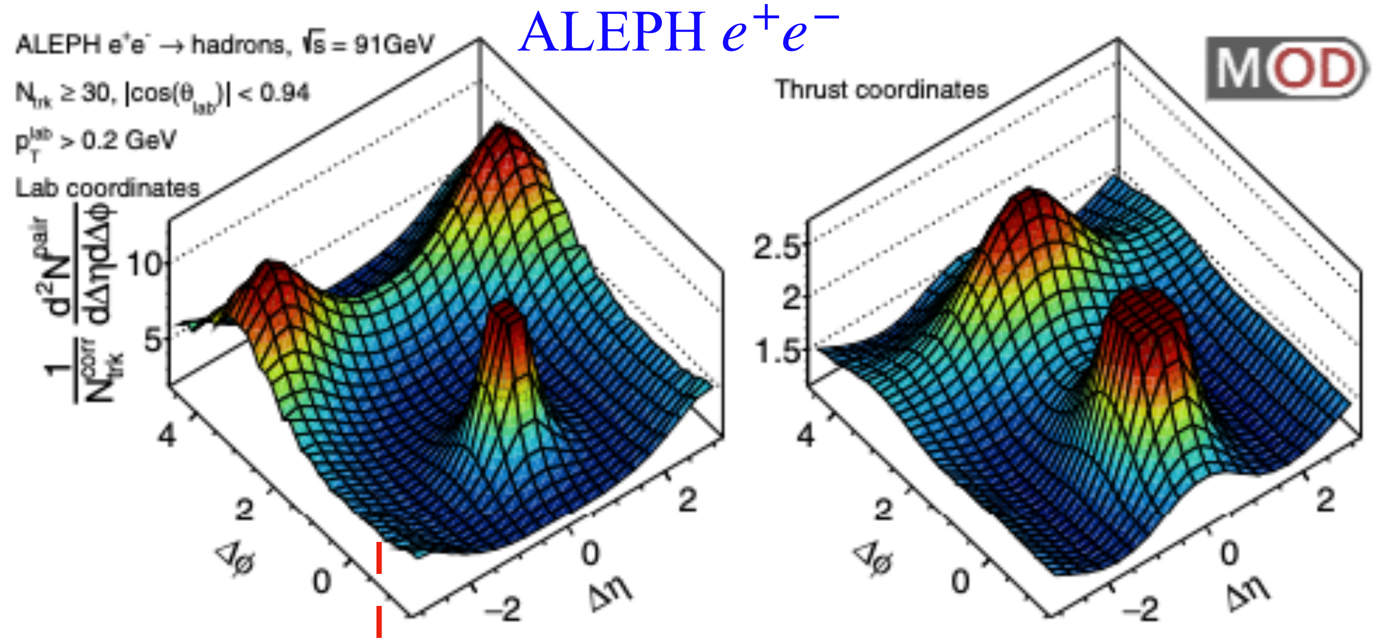
✓ Observed collectivity in small collision system (pPb and pp) for high multiplicity events.

1. What is origin of collectivity is small systems?

2. Does the collectivity observed in all collision system have a common source of origin?

Further going down in system size

ALEPH e^+e^-

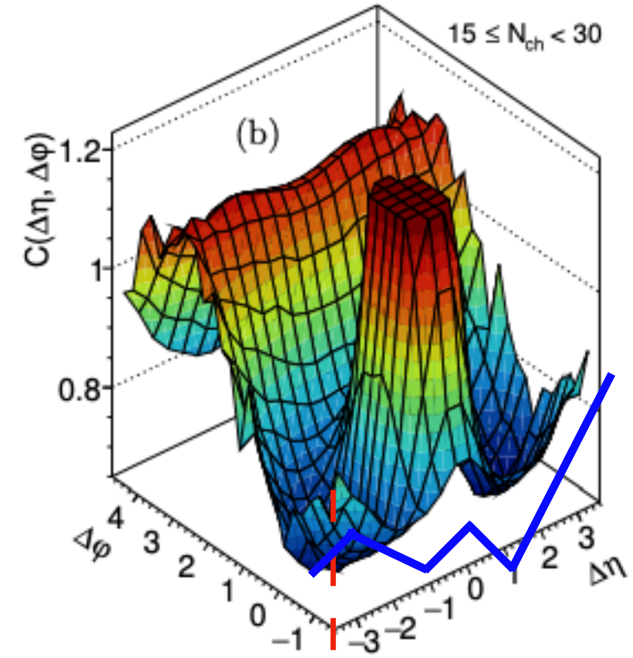


e^+ ⟶ ⟵ e^-

PRL123(2020)212002

Anthony Badea and et al., using archived ALEPH data

No significant nearside long-range correlations

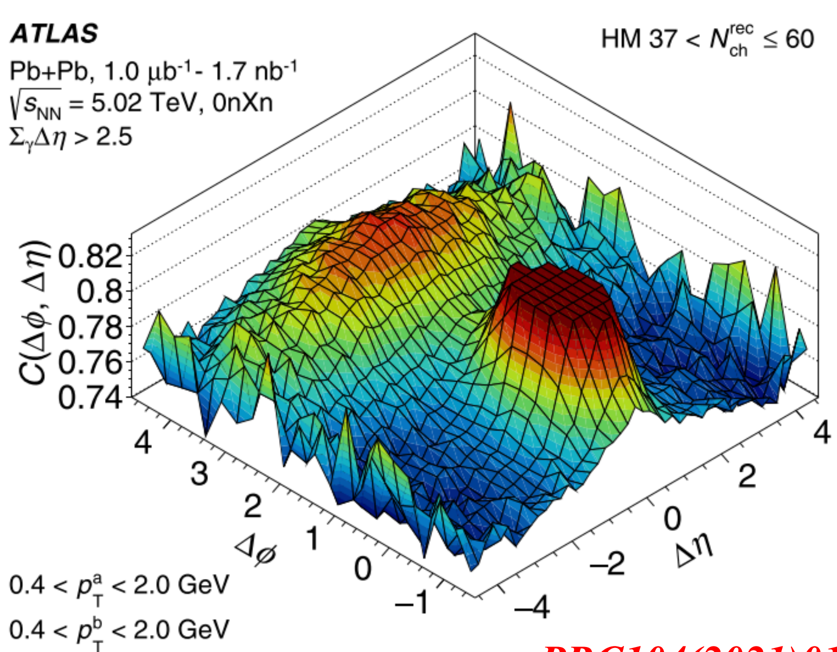


ZEUS ep

JHEP04(2020)070

e^- ⟶ ⟵ p

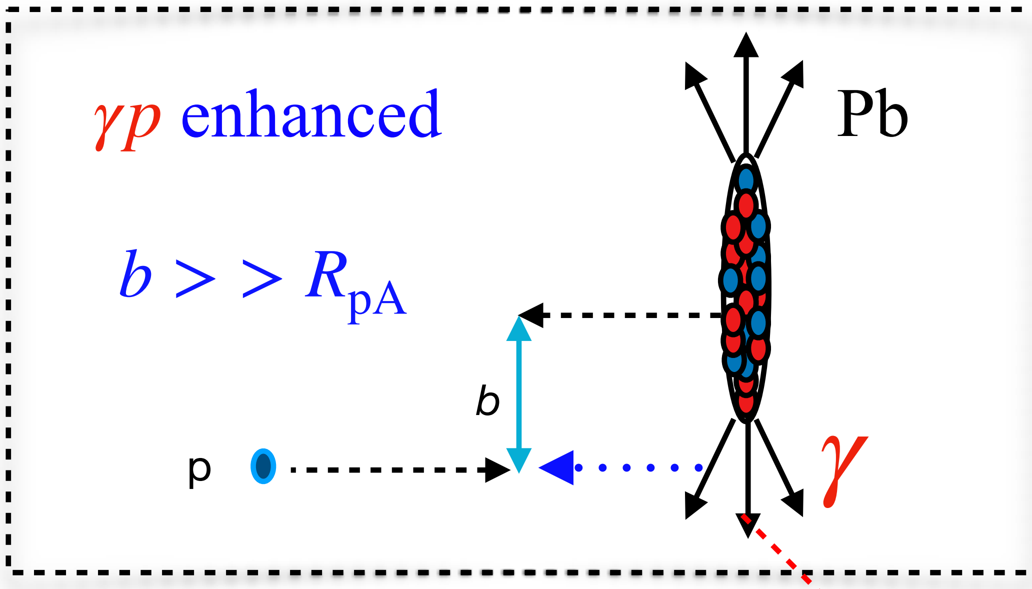
Mainly dominated by contributions from multijet production

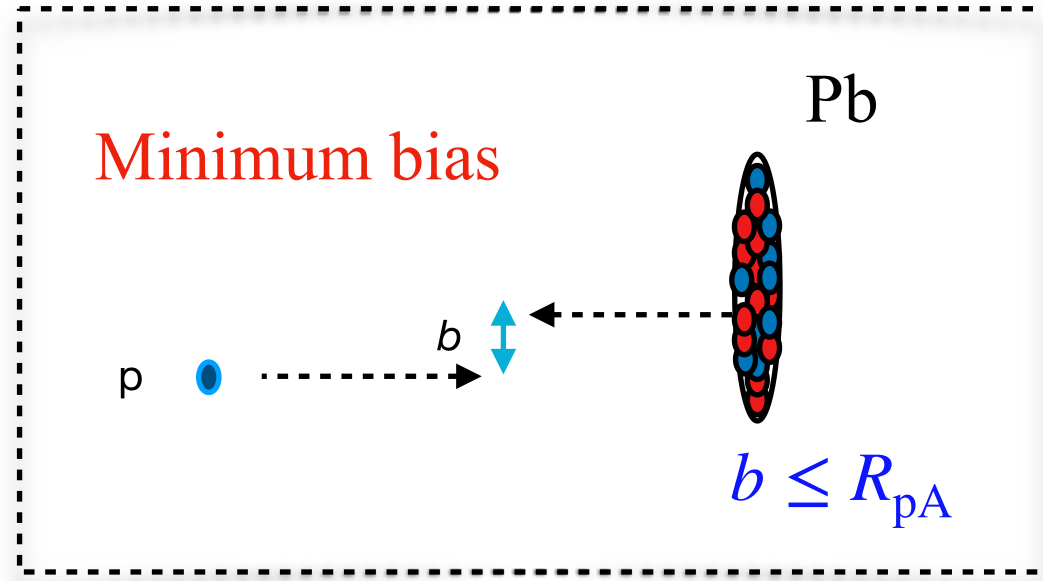


PRC104(2021)014903

γ ⟶ ⟵ Pb

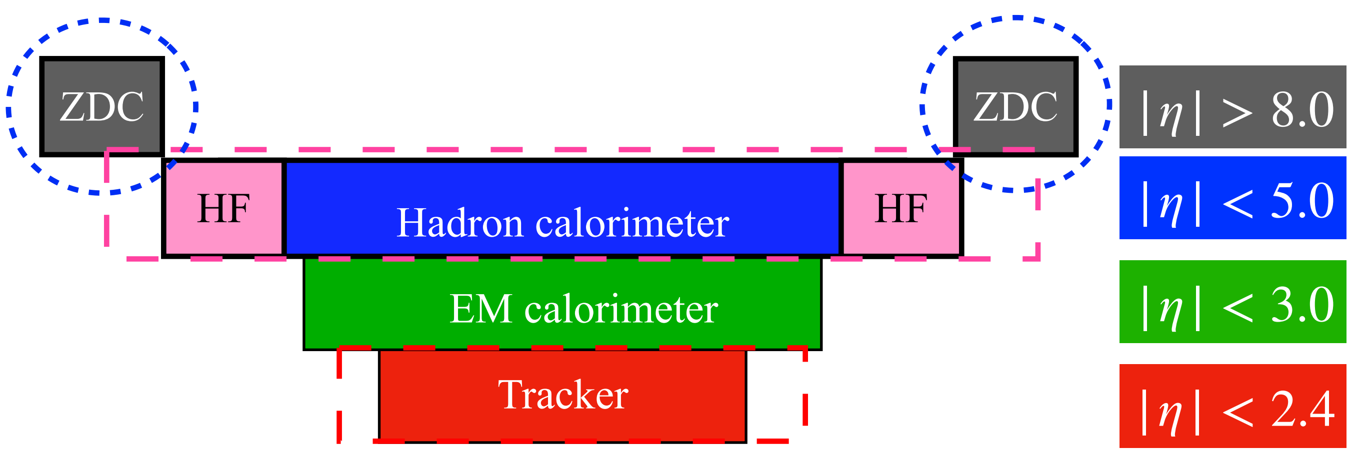
- ✓ Electron-proton and electron-positron systems been explored by ZEUS and ALEPH.
- ✓ A significant non-zero v_2 is observed from template fitting.

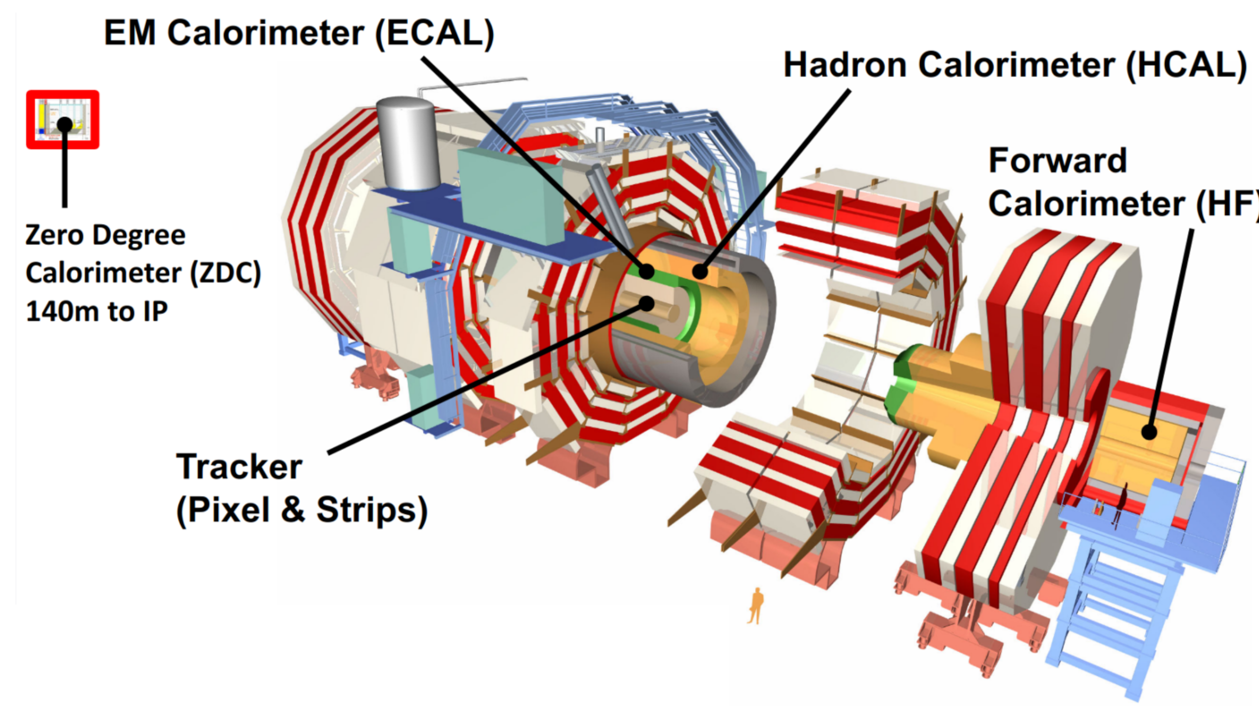




EM wave can be viewed as a source of quasi real photon.

✓ Relativistic nuclei interact electromagnetically by physically missing each other.

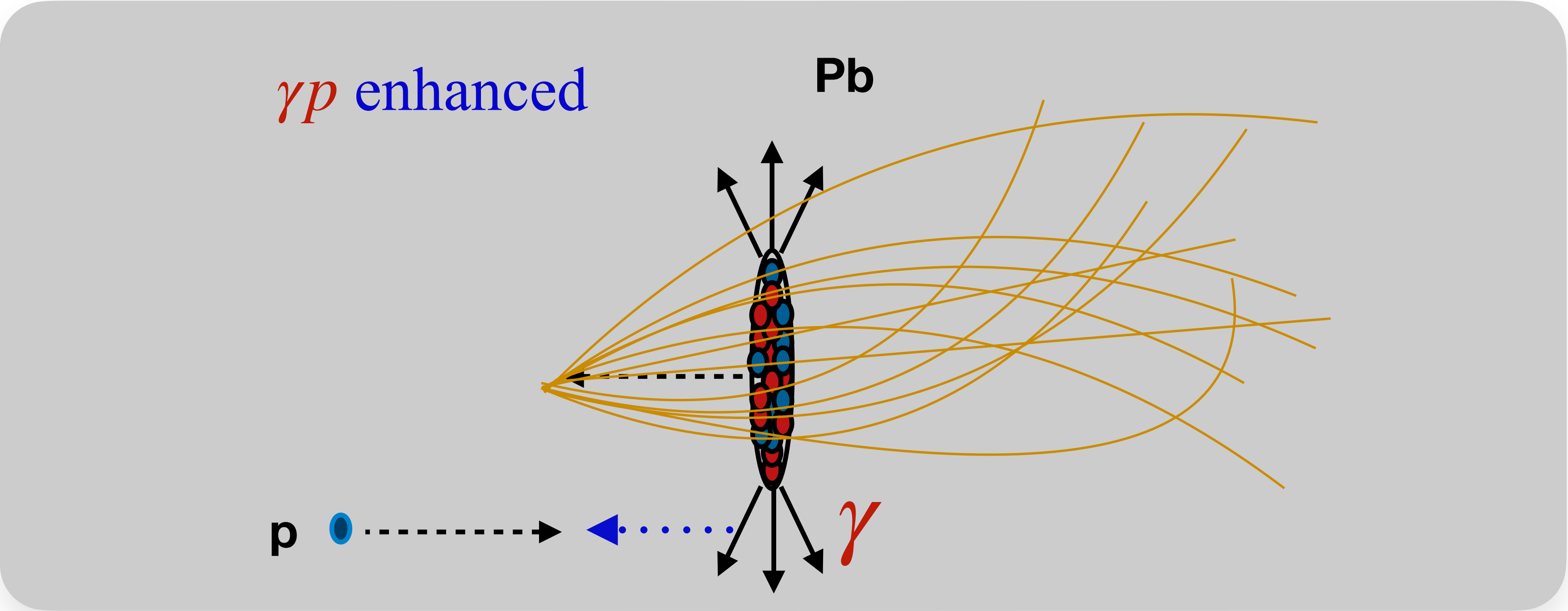




Why CMS Detector?

- Good precision
- Large rapidity coverage

Selection requirement



ZDC

$b >> R_{pA}$

Pb going-side

✓ No neutron detected by ZDC (Pb nucleus is not dissociate)

✓ No activity in Pb side using particle flow and tracks (rapidity gap)

p going-side

✓ HF ensures the tower energy at least > 10 GeV

Track selections requirement

✓ Significance of z separation : $d_z/\sigma(z) < 3$

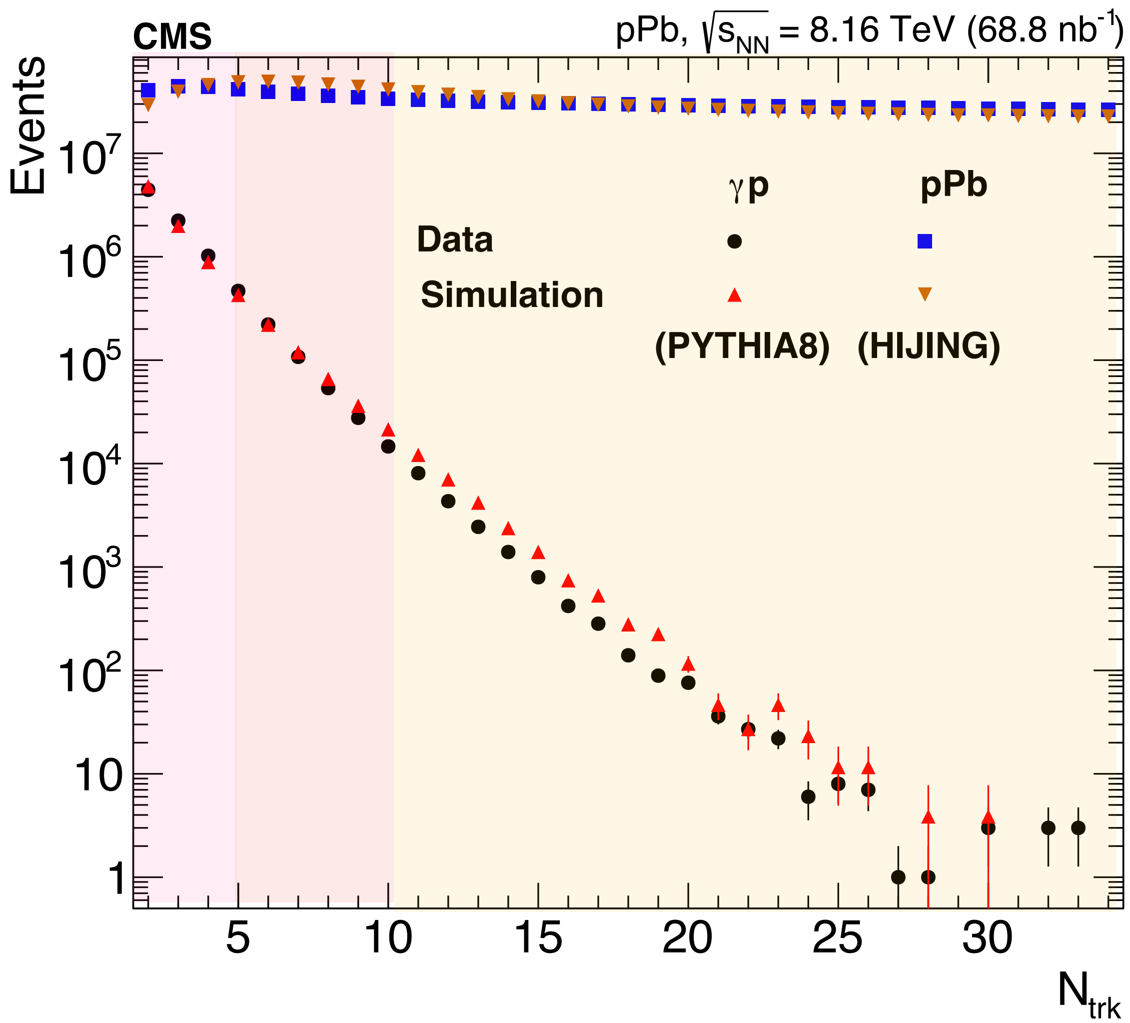
✓ Impact parameter significance : $d_0/\sigma(0) < 3$

✓ Momentum uncertainty: $\sigma(p_T)/p_T < 0.1$

Kinematic selections:

$|\eta| < 2.4$ and $p_T > 0.4$ GeV

Track multiplicity distribution in γp interaction



$2 < N_{trk} < 5$

$5 < N_{trk} < 10$

$10 < N_{trk} < 35$

✓ N_{trk} distribution from the γp-enhanced and MB data samples along with simulations from the PYTHIA8 and HIJING event generators.

✓ Three N_{trk} bins are used to analyze the γp-enhanced events: $2 < N_{trk} < 5$, $5 < N_{trk} < 10$, $10 < N_{trk} < 35$.

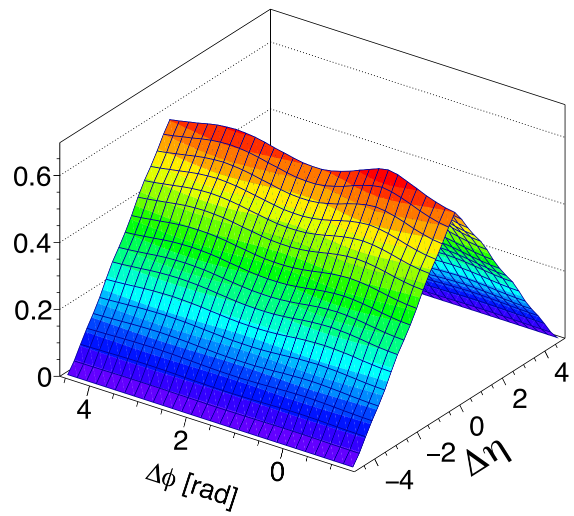
arXiv:2204.13486v1 Submitted to PLB

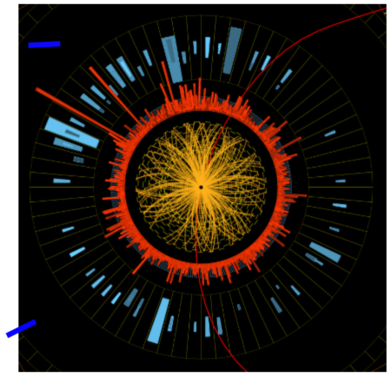
Two-particle correlation

$$S(\Delta\eta, \Delta\varphi) = \frac{1}{N_{trig}} \frac{d^2 N_{same}}{d\Delta\eta \, d\Delta\varphi}$$

Same event pairs

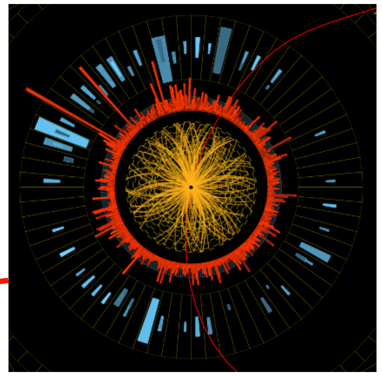
Signal





Event-1

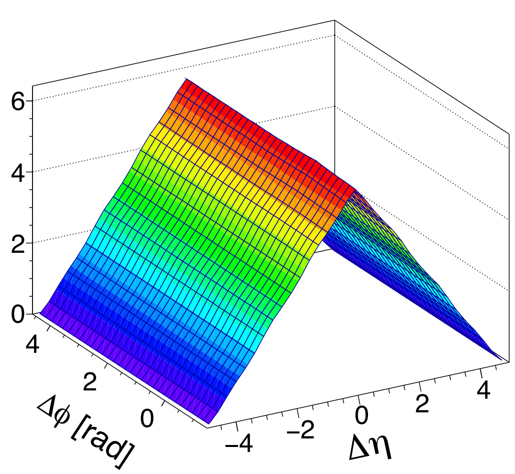
Mixed event pairs



Event-2

$$B(\Delta\eta, \Delta\varphi) = \frac{1}{N_{trig}} \frac{d^2 N_{mix}}{d\Delta\eta \, d\Delta\varphi}$$

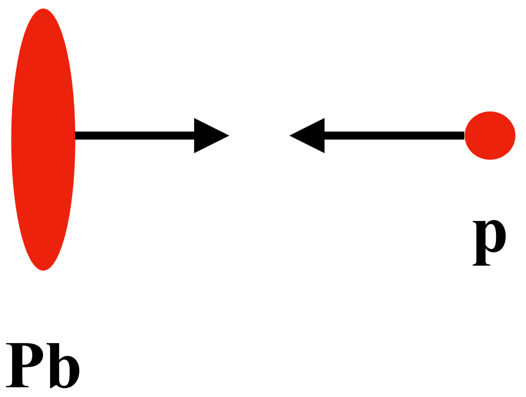
Background



Correlation function

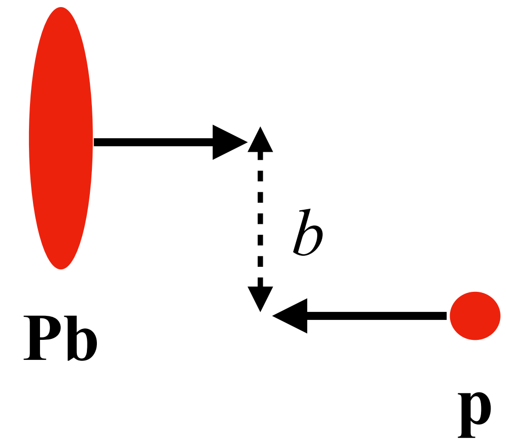
$$\frac{1}{N_{trig}} \frac{d^2 N_{pair}}{d\Delta\eta \, d\Delta\varphi} = B(0,0) \frac{S(\Delta\eta, \Delta\varphi)}{B(\Delta\eta, \Delta\varphi)}$$

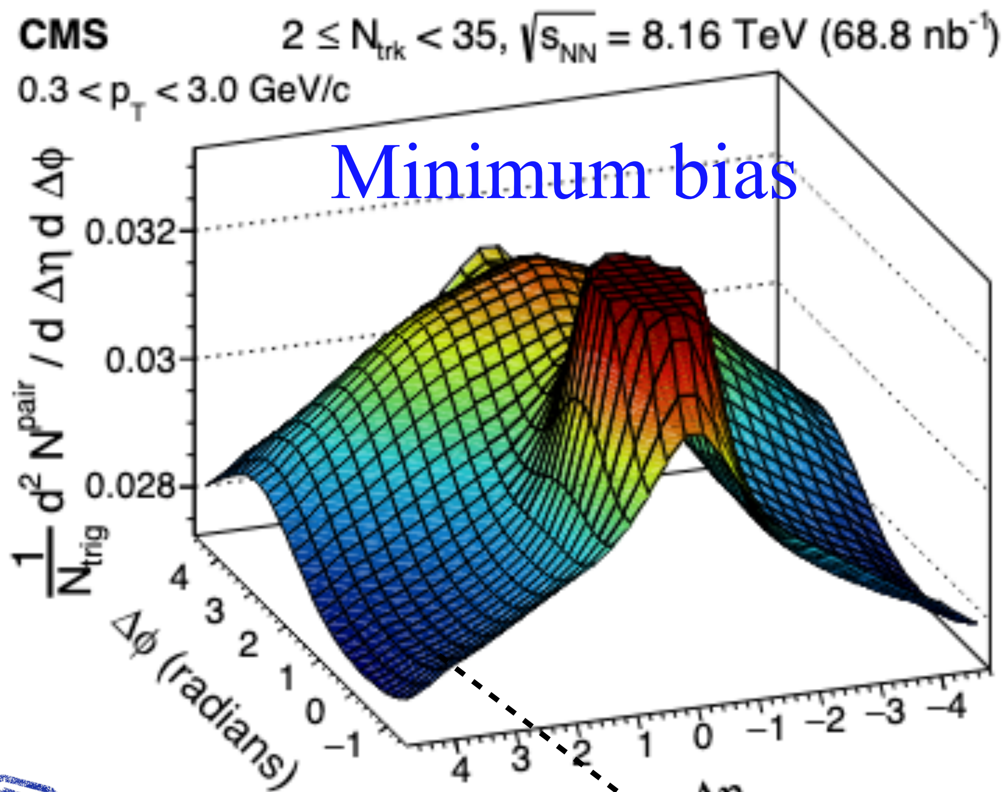
$$\eta_{trig} - \eta_{asso} = \Delta\eta$$
$$\varphi_{trig} - \varphi_{asso} = \Delta\varphi$$

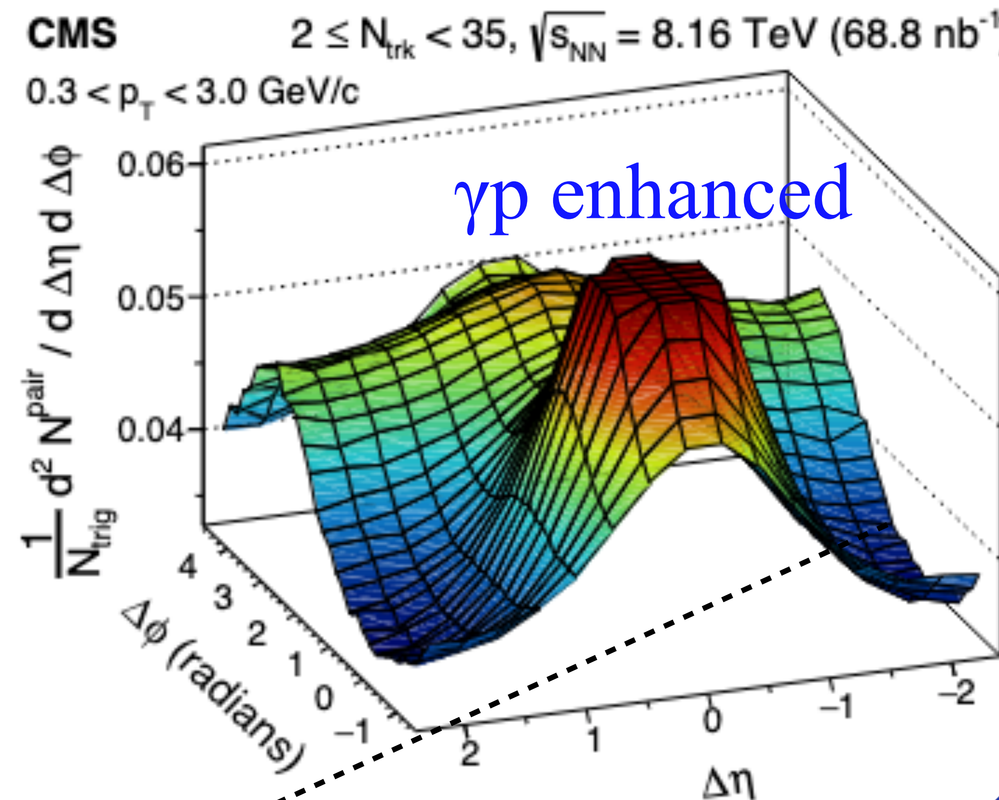


$$\frac{1}{N_{\rm trig}}\frac{d^2N_{pair}}{d\Delta\eta\, d\Delta\varphi} = B(0,0)\frac{S(\Delta\eta,\Delta\varphi)}{B(\Delta\eta,\Delta\varphi)}$$

Correlation in smaller system







CMS FINAL HP23

No evidence of ridge structure

CMS FINAL HP23

✓ No ridge like structure is observed in minimum-bias pPb and γp enhanced system.

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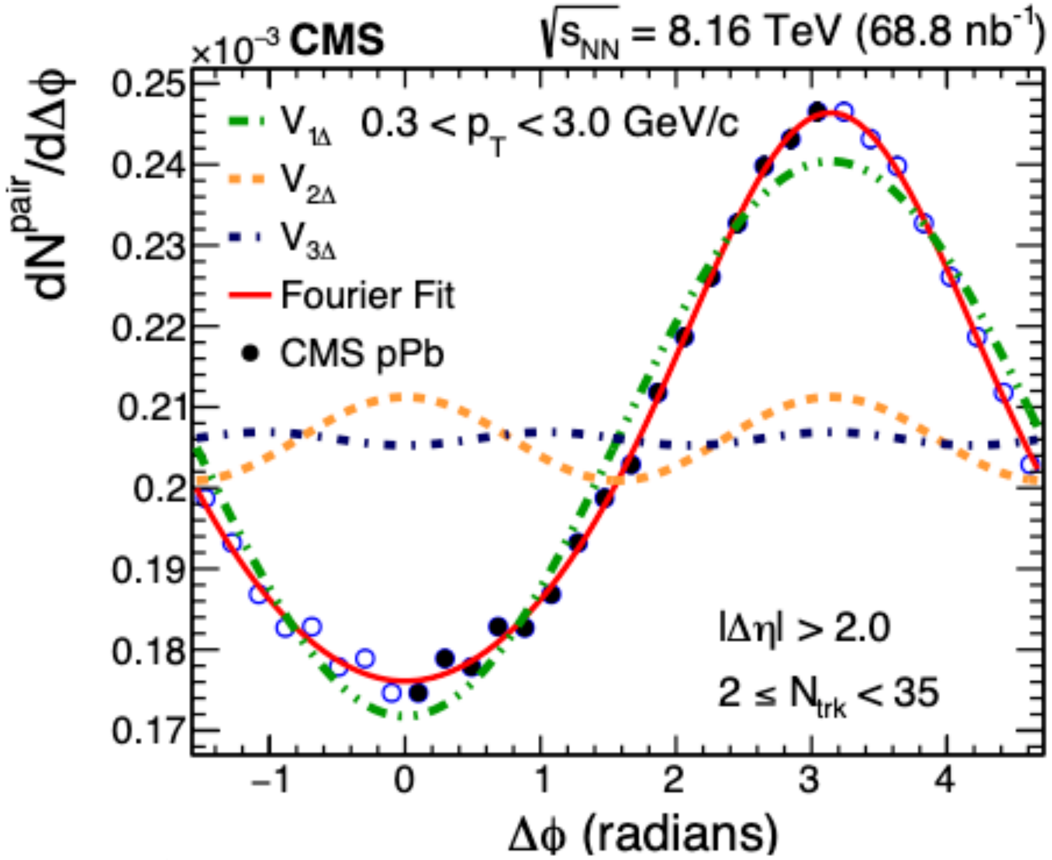
Fourier decomposition

✓ The Fourier coefficient $V_{n\Delta}$ is estimated from the decomposition fit

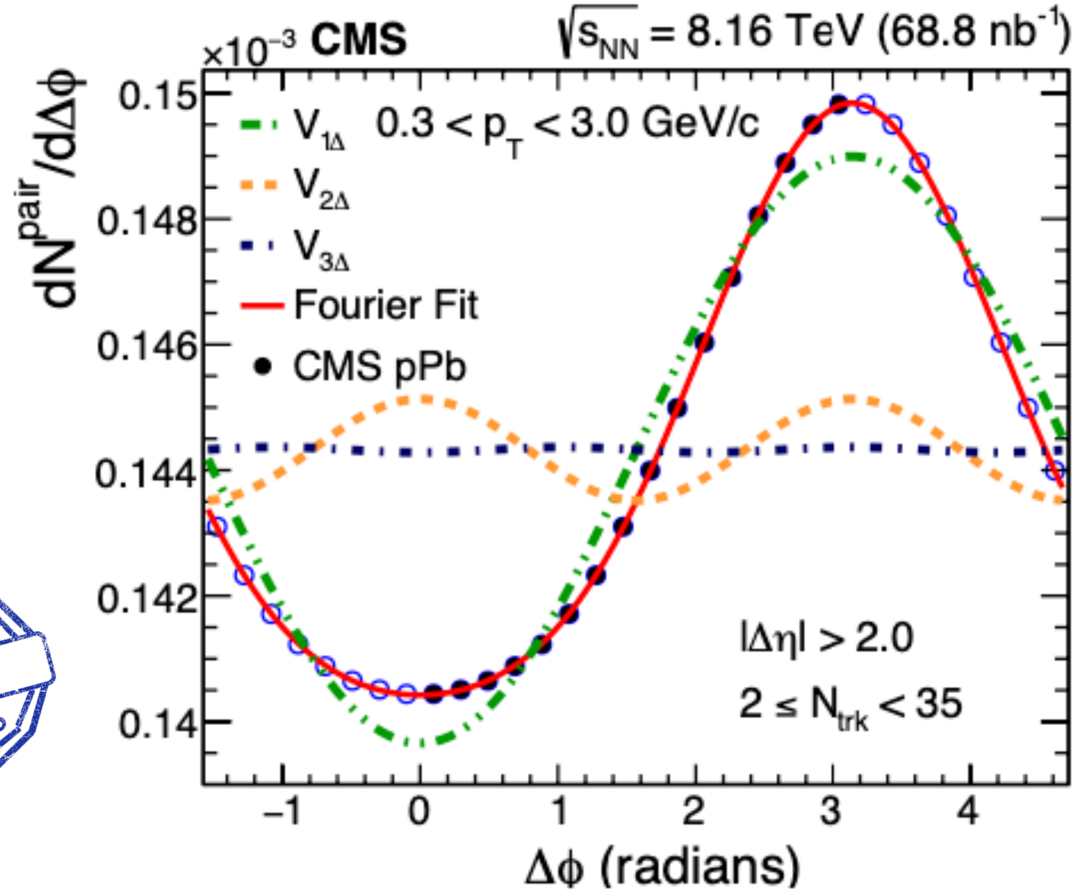
✓ Azimuthal distribution is calculated for $|\Delta\eta| > 2.0$

$$\frac{1}{N_{trig}} \frac{dN_{pair}}{d\Delta\varphi} = \frac{N_{asso}}{2\pi}[1 + \Sigma\, 2\, V_{n\Delta} cos(n\Delta\varphi)] \qquad n = 1,2.3,..$$

γp enhanced



Minimum bias



CMS FINAL HP23

✓ Fourier fit explained data well upto third order coefficient.

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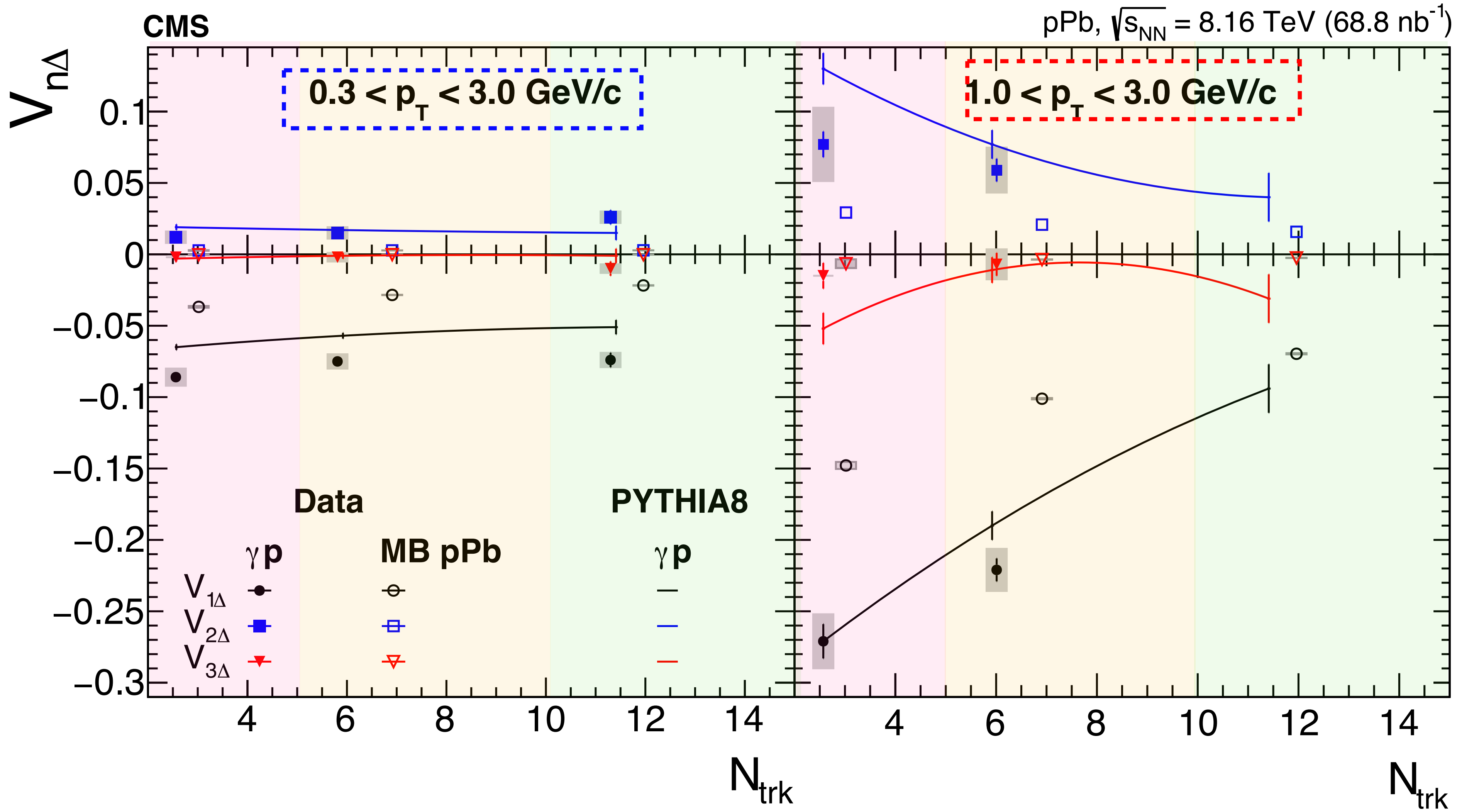
Fourier coefficient: $V_{n\Delta}$

✓ The $V_{2\Delta}$ coefficient is positive while $V_{1\Delta}$ is negative suggesting a strong effect of jet-like correlations.



$2 < N_{trk} < 5$

$5 < N_{trk} < 10$

$10 < N_{trk} < 35$

✓ The predictions of $V_{2\Delta}$ and $V_{3\Delta}$ from PYTHIA8 are reasonably consistent with data.

✓ The $V_{1\Delta}$ prediction is smaller in magnitude than the measured values for the low p_T.

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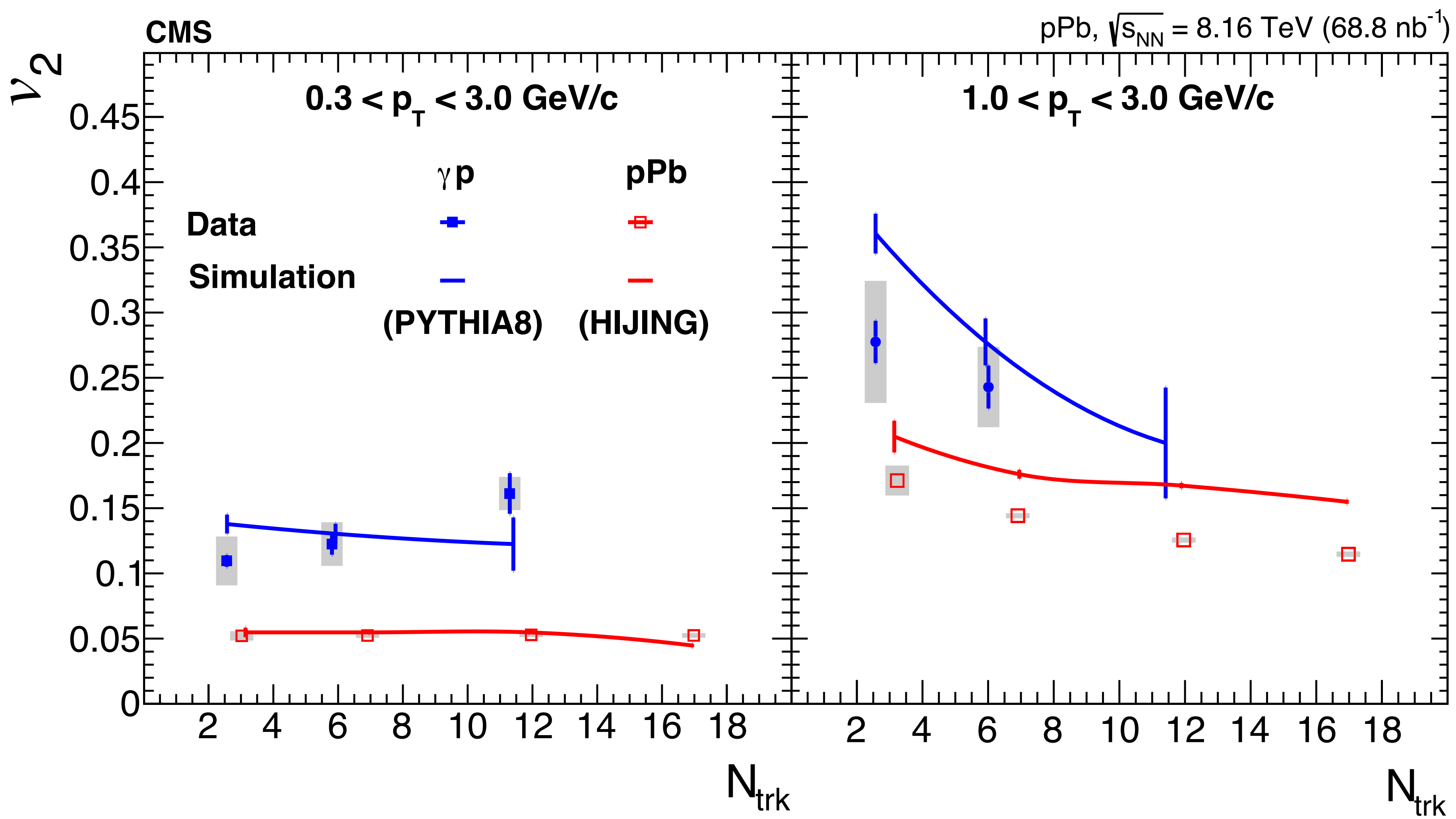
Fourier coefficient v_2

✓ The single-particle azimuthal anisotropy Fourier coefficients extracted as $v_n = \sqrt{V_{n\Delta}}$



✓ The flow coefficient v_2 increases with p_T and larger for γp.

✓ Predictions from the models describe well the γp and pPb MB data at low p_T.

✓ Models prediction suggest the absence of collectivity in the γp system over the multiplicity range explored in this work.

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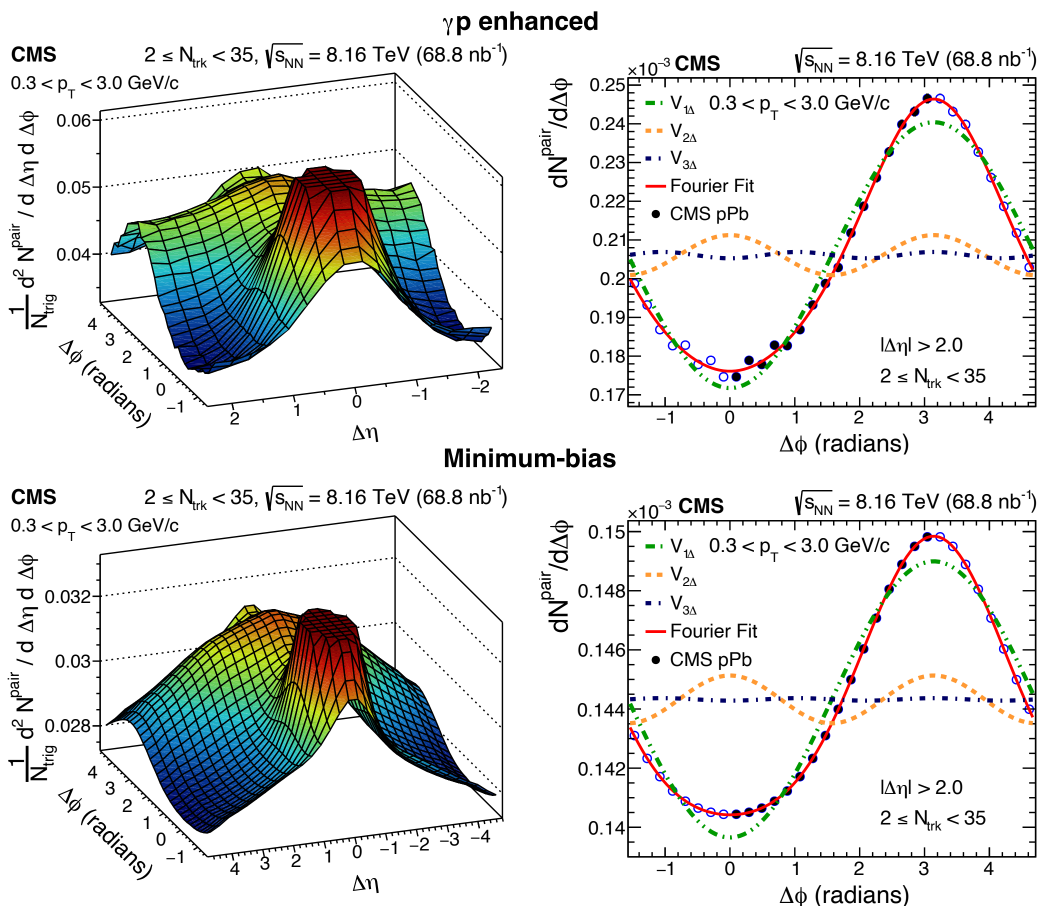
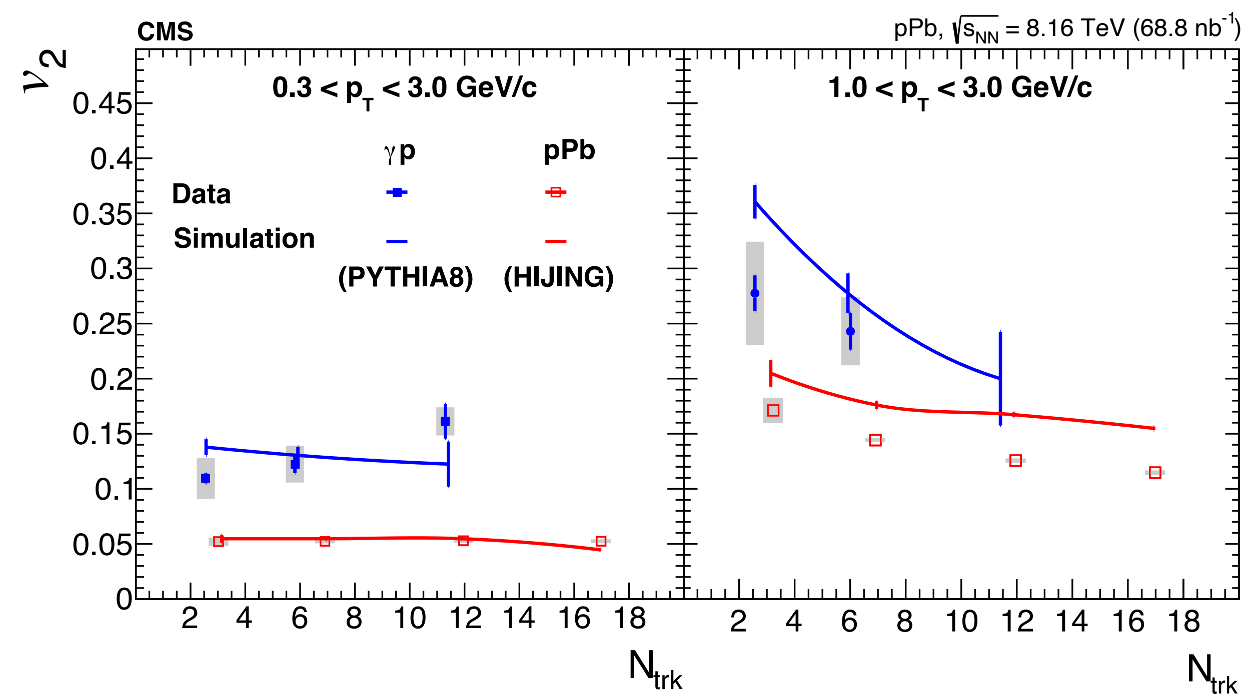
✓ The long-range two particle correlations has been extended to photon-proton (γp) interactions first time in CMS. Similarities studies over electron-proton system.



✓ No evidence of ridge structure is observed in γp or pPb MB hadronic collisions.



✓ The γp data are consistent with model predictions that have no collective within the sensitivity of the measurement effects thus suggesting the absence of collectivity in the γp system over the multiplicity range explored in this work.

Thank you!