Azimuthal angular decorrelation of dijets in UPC PbPb collisions at 5.02 TeV with CMS

CMS-HIN-18-011

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On behalf of the CMS Collaboration

Strangeness in Quark Matter 2022: 14th June 2022, Busan, Korea

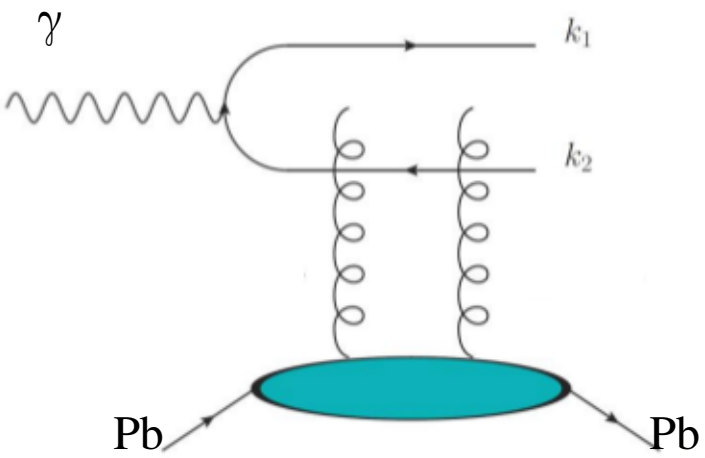
Outline

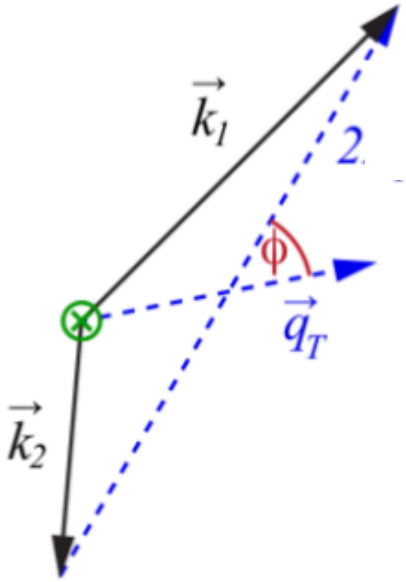
- **Exclusive dijet photoproduction in UPC PbPb @5 TeV**
- Motivation
  - First step to access novel features of gluon distributions
- CMS Detector and analysis selections
- Results
  - Comparison with recent theoretical calculations

Motivation

Exclusive dijet photoproduction is directly sensitive to the Wigner and Husimi gluon distributions describing the **multidimensional structure of the gluons** (Hatta, et al, *PRL 116, 202301 (2016)*)

Elliptically polarized gluons: ↔ **Dijet azimuthal angular correlations**





Vector sum of 2 jets:

$$\vec{Q}_T = \vec{k}_1 + \vec{k}_2$$

Vector difference of 2 jets:

$$\vec{P}_T = \frac{1}{2}(\vec{k}_1 - \vec{k}_2)$$

Second Fourier harmonic of the azimuthal distribution

$$v_2 = \langle \cos(2\phi) \rangle,$$

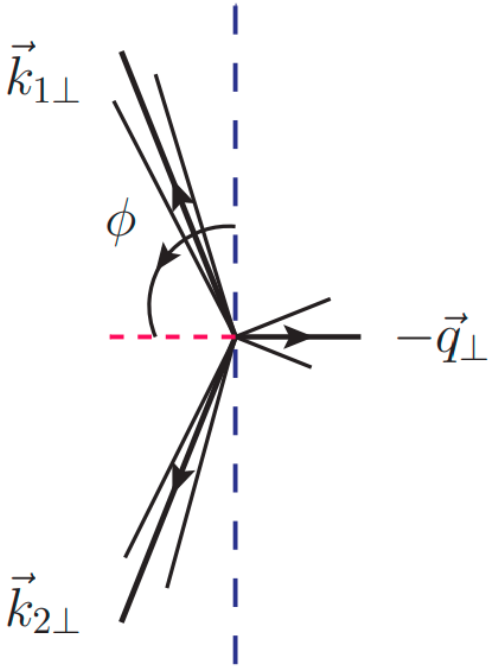
where φ is the angle between P_T and Q_T:

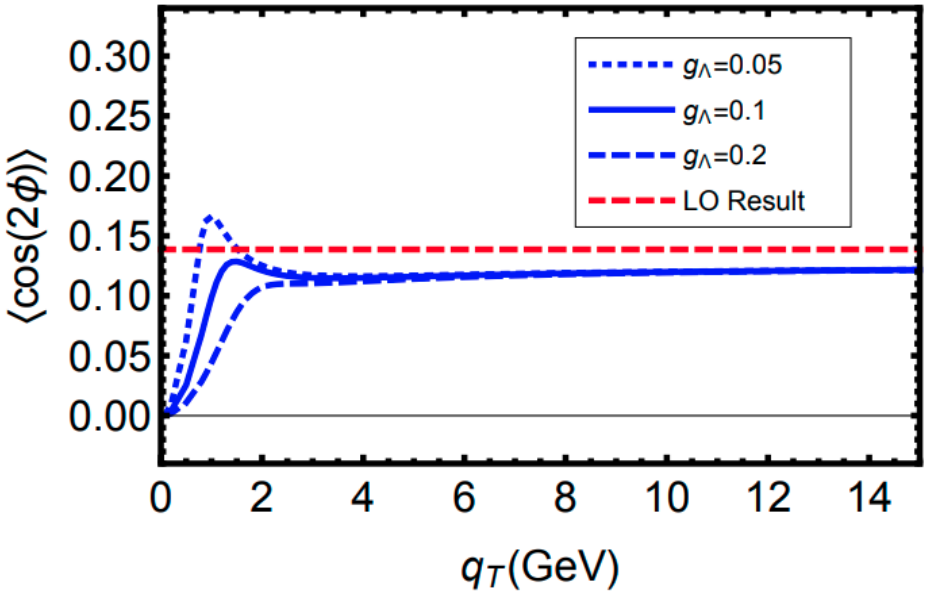
$$\cos(\phi) = \vec{Q}_T \cdot \vec{P}_T / (|| \vec{Q}_T || \cdot || \vec{P}_T ||)$$

2^{nd} Fourier harmonic and theoretical calculation

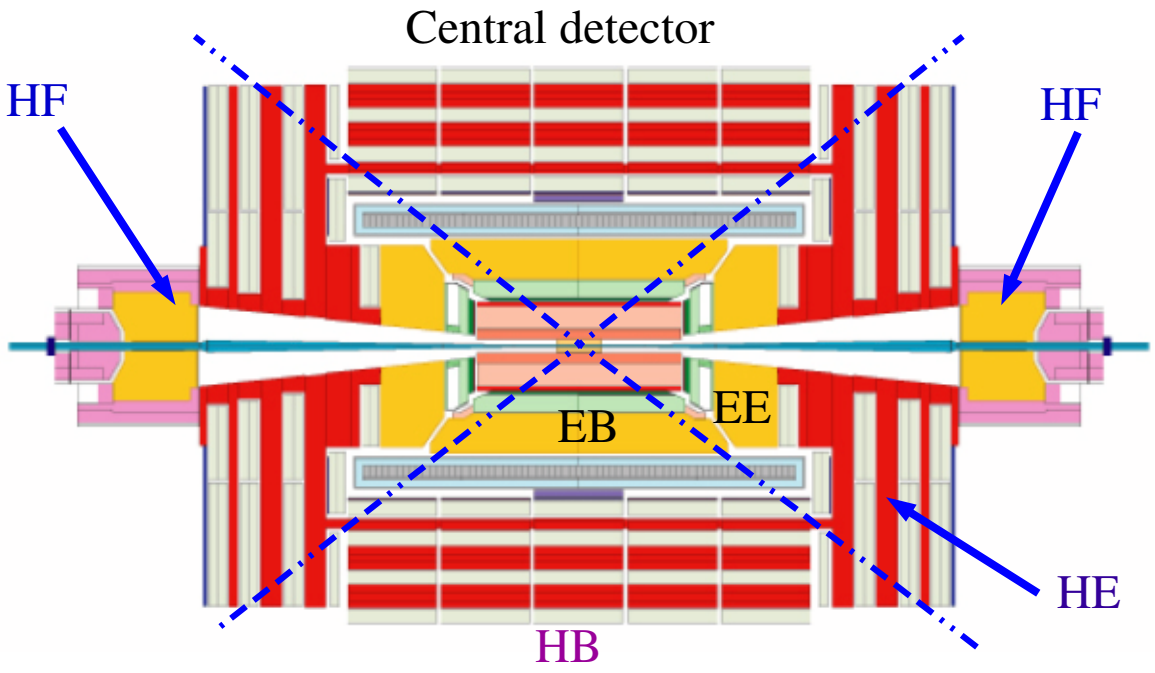
Recent theoretical calculations by *Y. Hatta et al. PRL 126, 142001 (2021)* performed following the our preliminary results.

- The standard TMD framework is used for resummation.
- Soft gluon emission from the final state jets results in a positive <cos(2φ)>
- Wigner gluon distributions are neglected
- Photoproduced dijets (Q_T << P_T)





CMS Detector



Electromagnetic Barrel Calorimeter (EB): $|\eta| < 1.5$

Electromagnetic Endcap Calorimeter (EB): $1.5 < |\eta| < 3.0$

Hadron Barrel Calorimeter (HB): $|\eta| < 1.3$

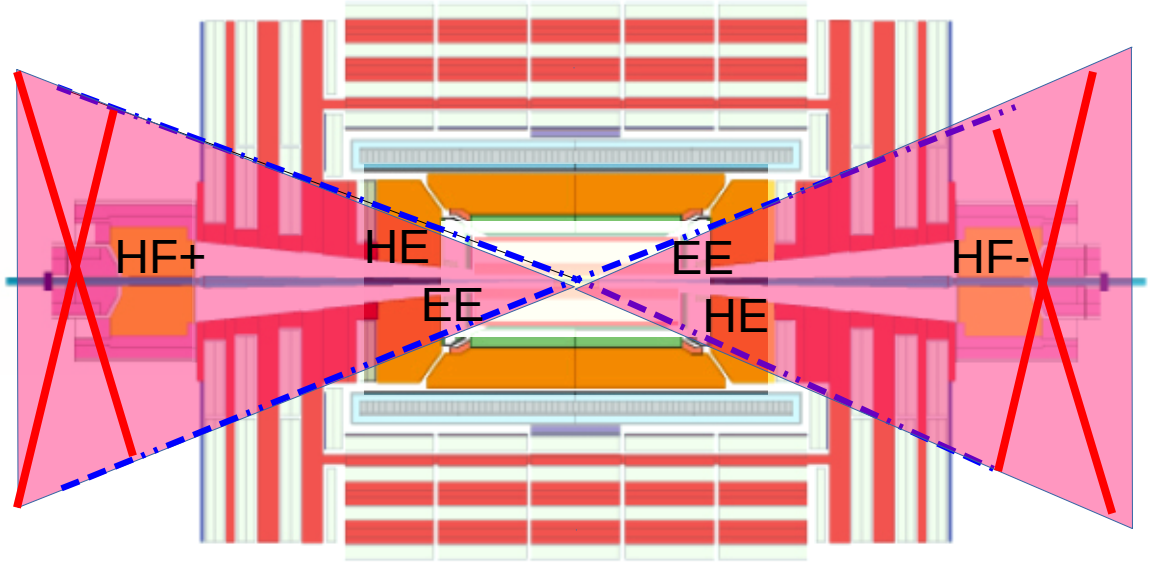
Hadron Endcap Calorimeter (HE): $1.3 < |\eta| < 3.0$

Hadron Forward Calorimeter (HF): $3.0 < |\eta| < 5.2$

CMS offers perfect rapidity coverage to measure jets

Analysis selections

- At least one track in the central tracker
- Particle flow jets using the anti-k_t algorithm with R=0.4
- Only two jets $|\eta_{lab}| < 2.4$, $p_{T,1} > 30$ GeV, $p_{T,2} > 20$ GeV
- Veto activity in the forward region ($2.8 < |\eta| < 5.2$): HF, HE and EE calorimeters



RAPGAP MC extensively exploited for **ep** collisions at HERA
is used for modelling exclusive dijet photoproduction via photon-gluon fusion

Rapidity Gap Selection

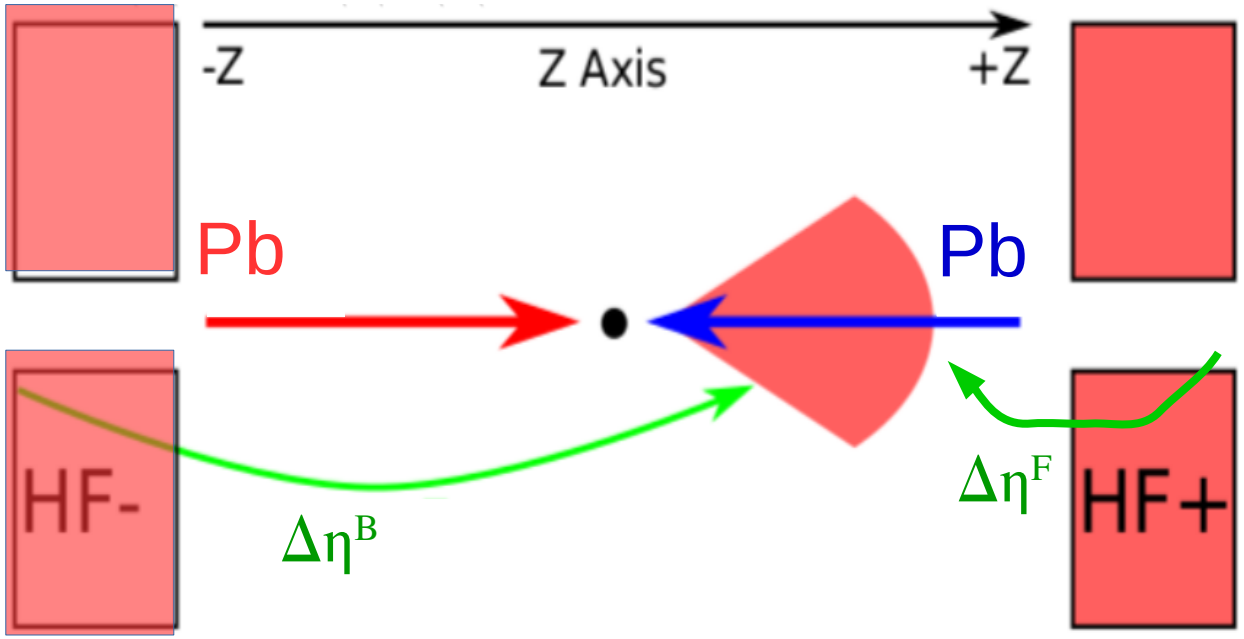
γ + Pb → jet + jet + Pb* events are asymmetric in dijet rapidity (according to RAPGAP MC).

- Rapidity Gap Selection:

  Forward Rapidity Gap, $\Delta\eta^F = 2.4 - \eta_{max,}\ \eta_{max}$ – high-purity track with $\mathbf{p_T > 0.2\ GeV}$

- Two separate data sets are defined:

  Backward Rapidity Gap $\Delta\eta^B > \Delta\eta^F$, and the other $\Delta\eta^F > \Delta\eta^B$

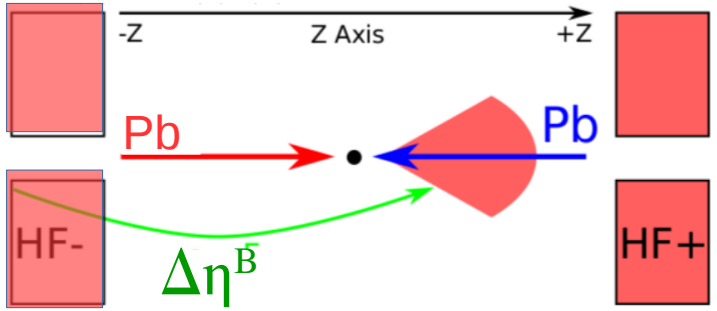


- Samples are merged by changing the rapidity sign of the jets in the $\Delta\eta^F > \Delta\eta^B$ dataset.

Exclusivity requirements

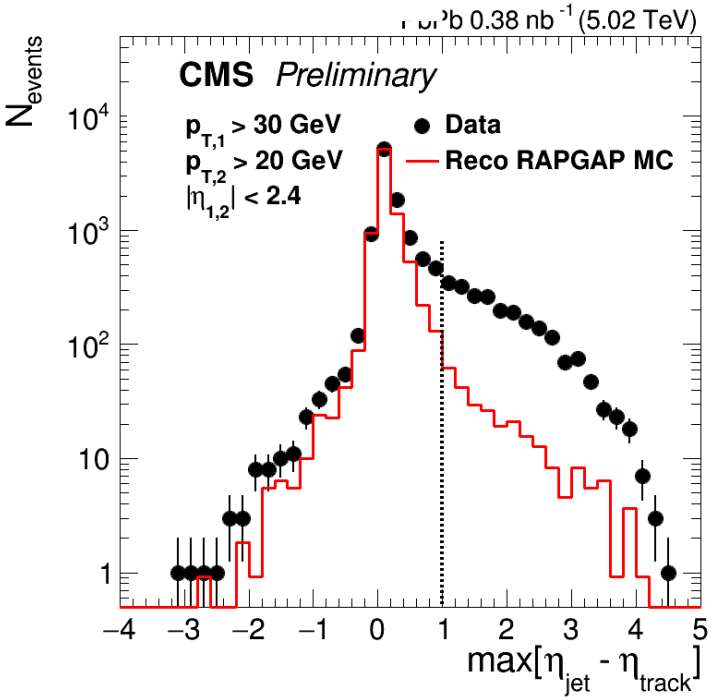
HIN-18-011, *submitted to PRL,* *arXiv:2205.00045 [hep-ex]*

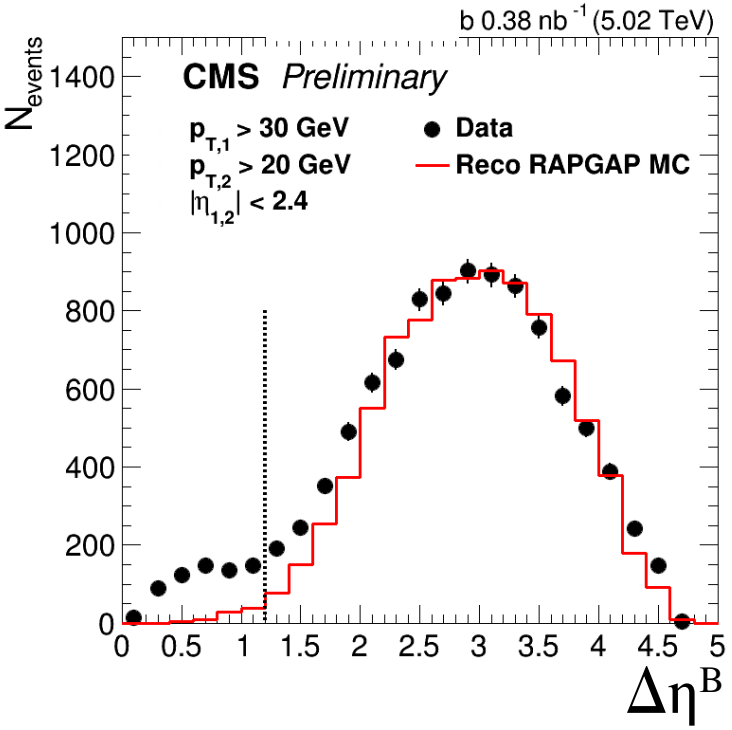
https://cms-results.web.cern.ch/cms-results/public-results/publications/HIN-18-011/



No tracker activity far from the jets to reject non-exclusive and two-photon processes.

- $\max[\eta_{jet} - \eta_{track}] < 1$
- $\Delta\eta^B > 1.2$





These selections keep 99% of signal (according to RAPGAP MC) and significantly reduce the remaining non-exclusive background

Dijet kinematics

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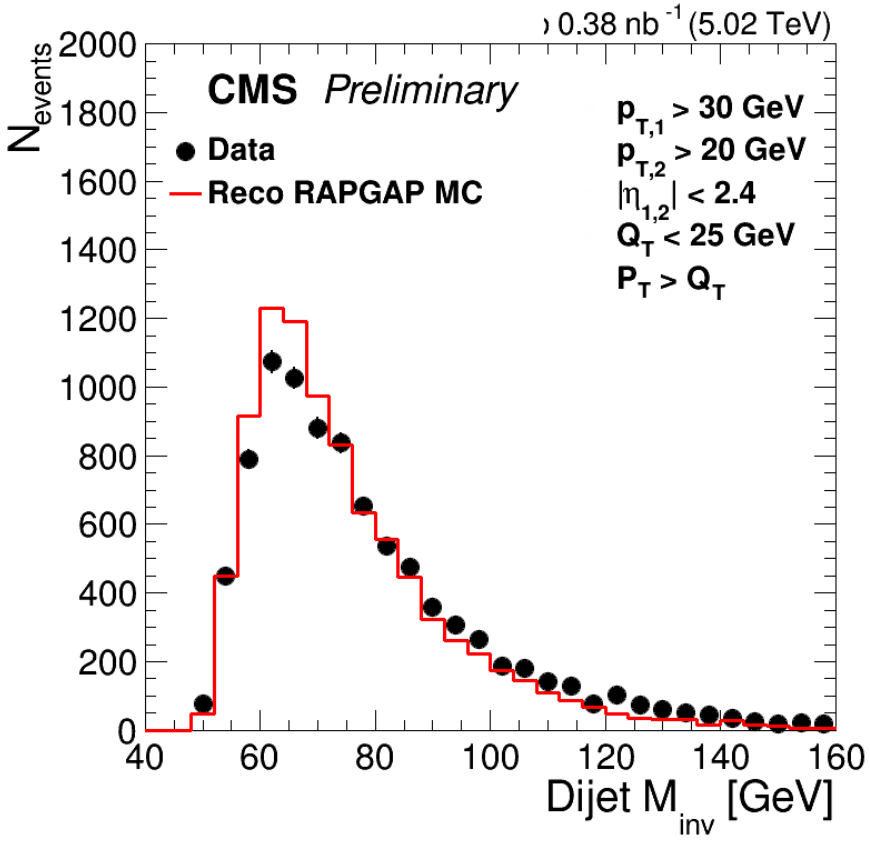

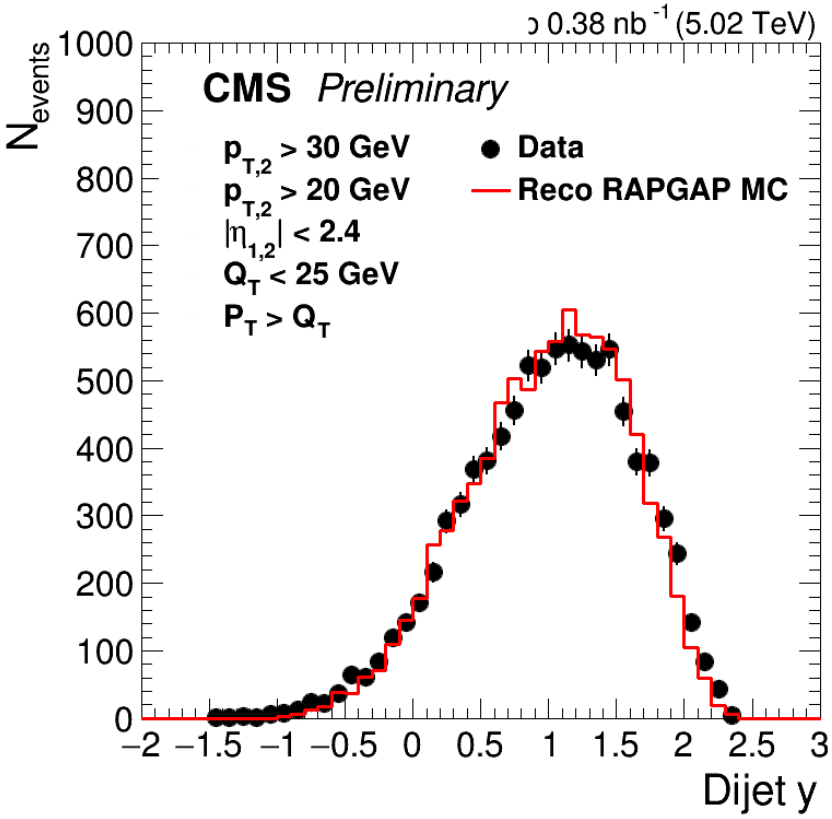

- Good agreement between data and MC.
- ➔ Photon flux in RAPGAP correctly reproduced for the UPC γPb data.

Dijet kinematics

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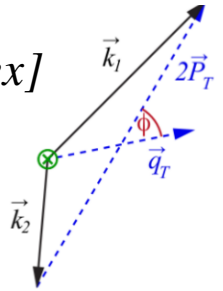

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Vector difference of 2 jets

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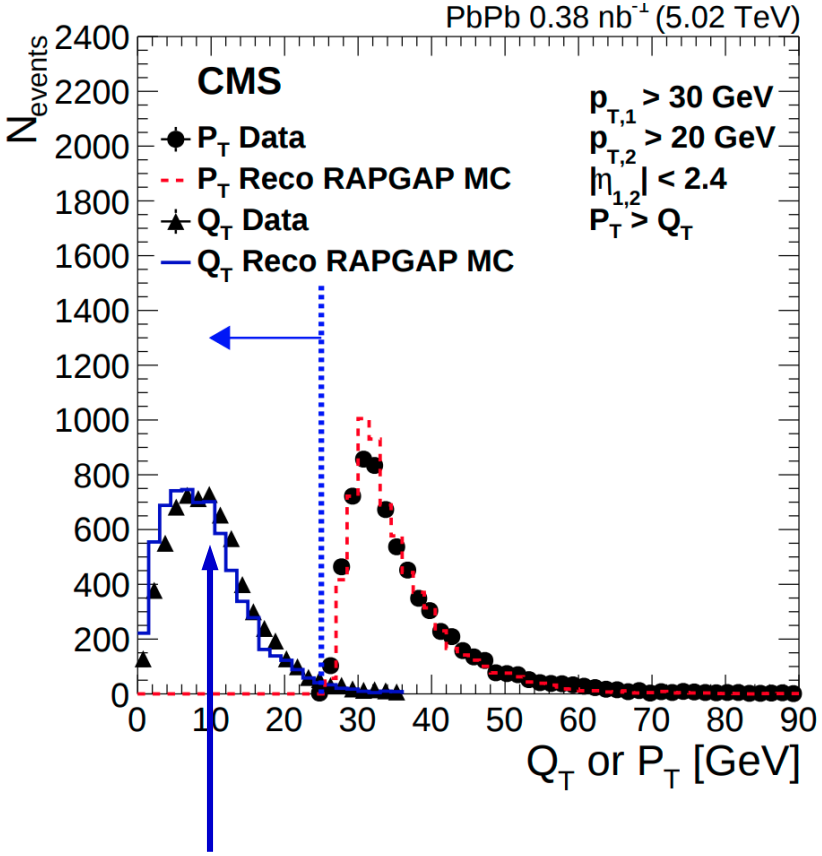

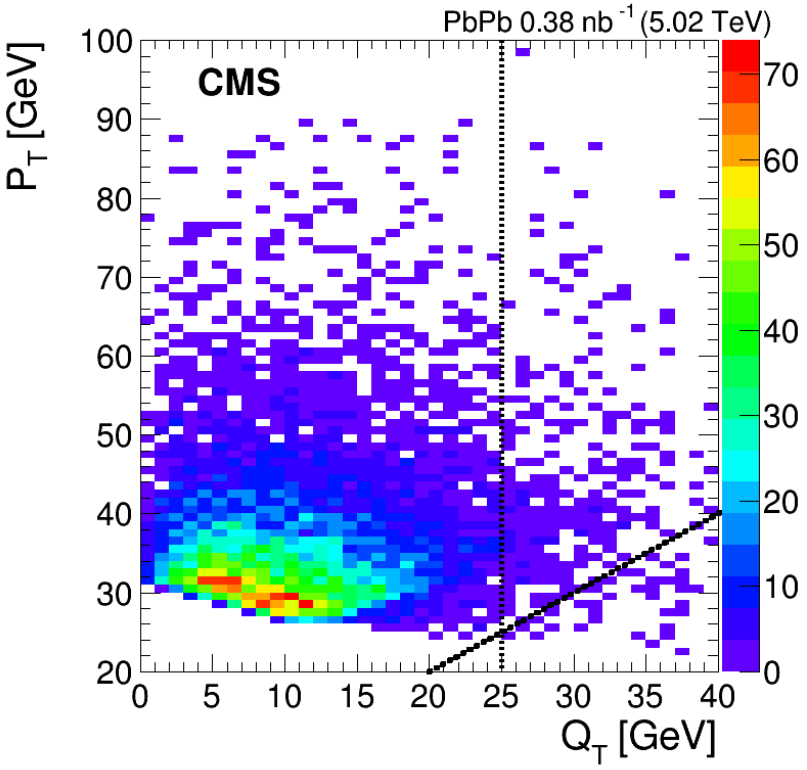

Large momentum transfer regime (DIS-type)

- The measurement is performed in $Q_T < 25$ GeV
- ➔ ***6785*** dijet events pass all analysis selections.

- $P_T > Q_T$: "back-to-back limit"

Dijet angular distribution and 2nd Fourier harmonic: Analysis cross checks

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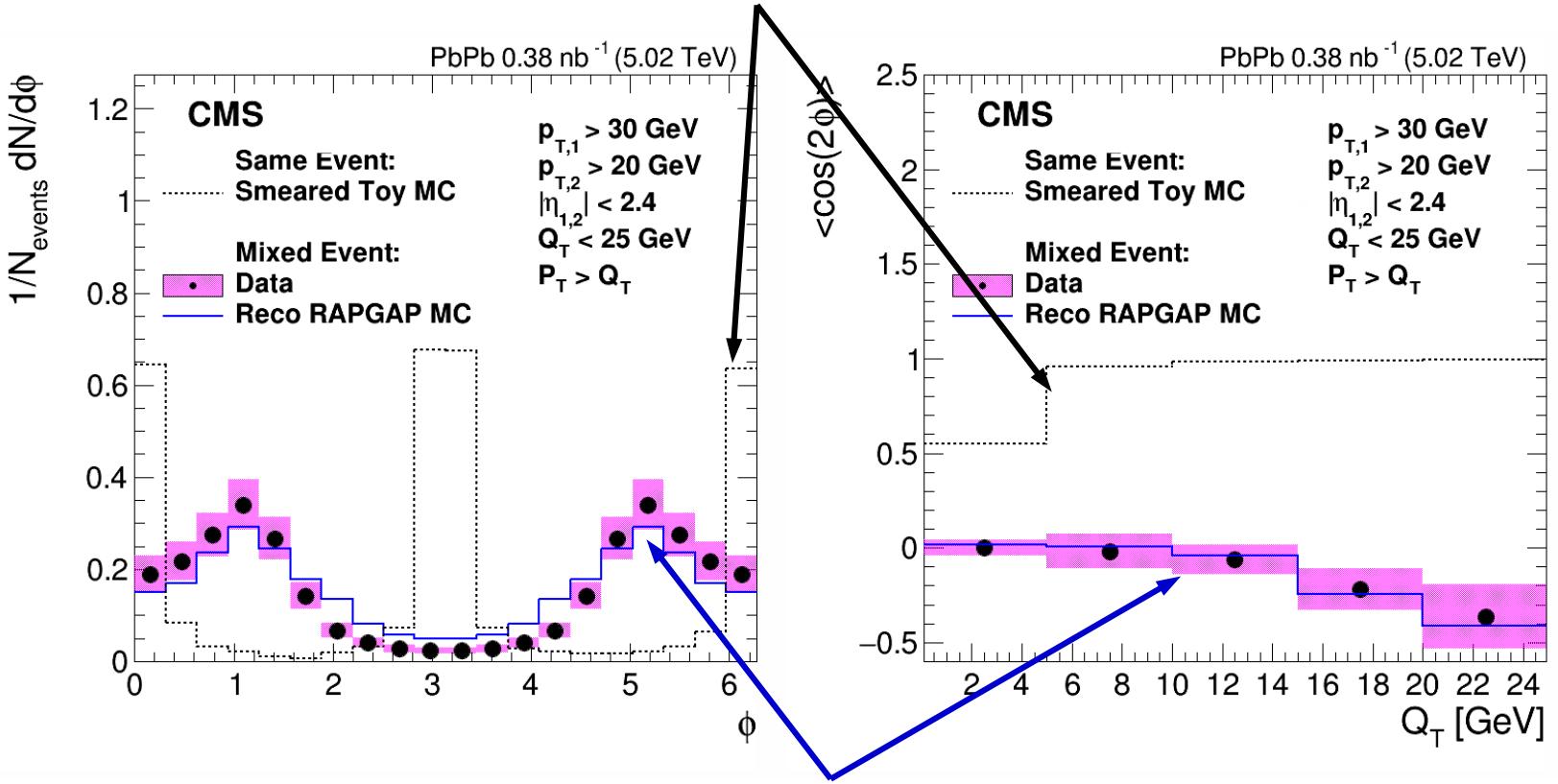
- **Toy MC**: back-to-back jets with detector resolution effects <cos(2φ)> → 1

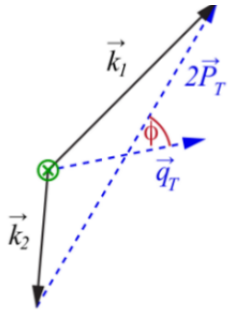


- **Mixed events** have no physical correlation: negative <cos(2φ)> value

Unfolded angular distribution and 2nd Fourier harmonic

HIN-18-011 ***submitted to PRL,***

arXiv:2205.00045 [hep-ex]



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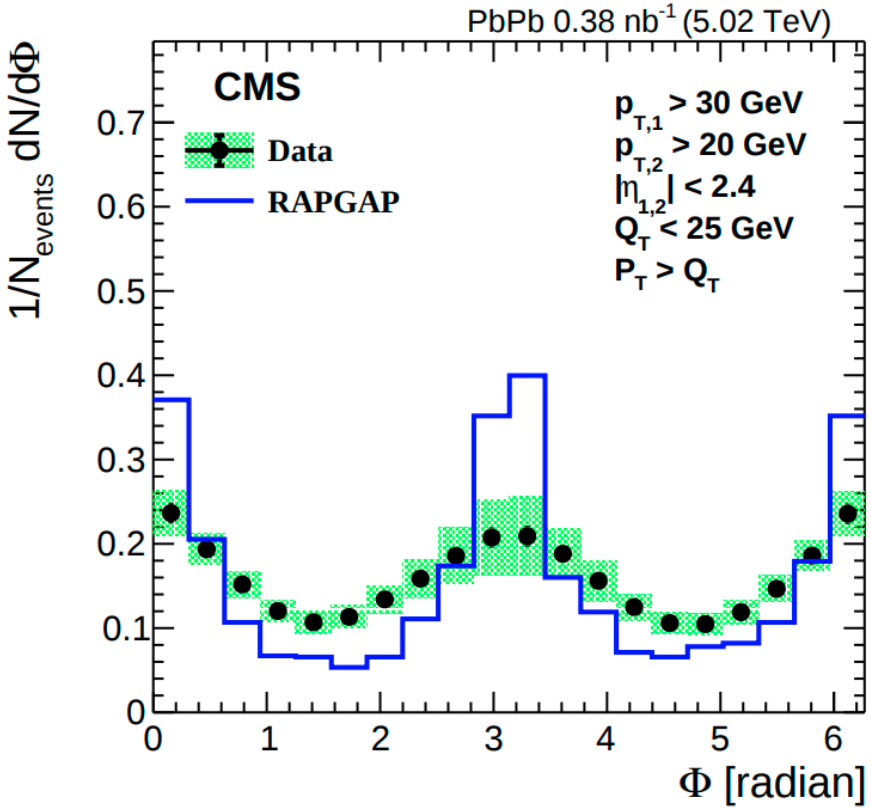
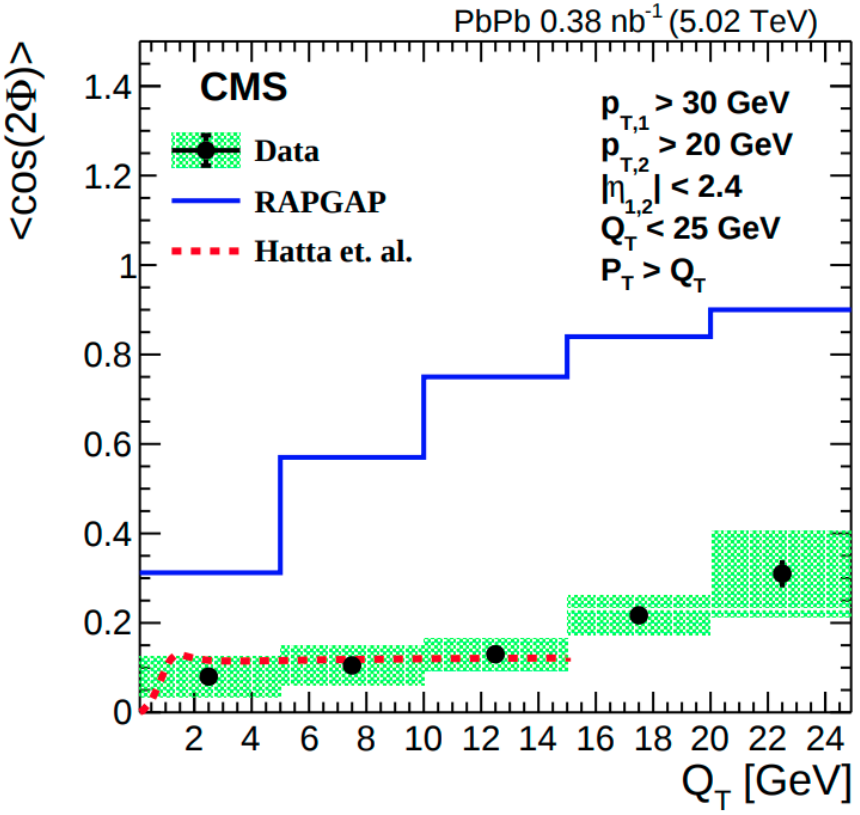
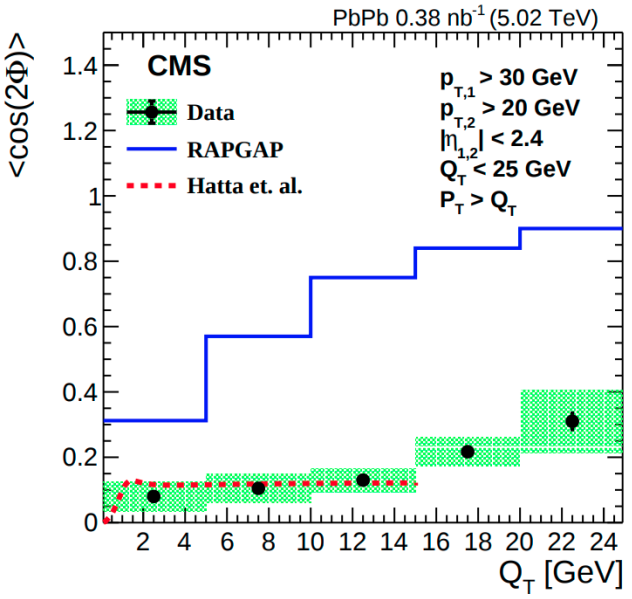




- <cos(2φ)> in data is below back-to-back expectation and RAPGAP prediction
- <cos(2φ)> rises steadily in the data in contrast to a constant value after Q_T > 2 GeV in the theory: DIS vs Photoproduction regime?

Summary

- **First measurement of azimuthal anisotropy from UPC Dijets in PbPb at 5 TeV**
- First measurement of <cos(2φ)> connected to the gluon Wigner/Husimi distribution, believed to be the most fundamental gluon distribution
- RAPGAP MC (ep expectation) overestimates the strength of the correlations
  - The data are compared to the latest theory calculation by Y. Hatta *et al.* (soft-gluon radiation from final-state jets):
  - Good agreement in the average magnitude of the correlations for dijet momentum less than 15 GeV
  - This calculation exhibits a rapid plateau, in contrast of the steady rise observed in the data.



Thank you for your attention!

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Exclusive dijets in UPC PbPb @5 TeV

(CMS-HIN-18-011)

Systematic uncertainties:

- Jet Energy Scale Correction (JES): ±2%
- Jet Energy Scale non-closure (JESnc): -5%
- Jet Energy Resolution (JER): 15% for 20 GeV jets
- Jet Angular Resolution (JAR): 0.03 for 20 GeV jets
- Rapidity Gap Selection (PUR): BRG > [0,2]
- Trigger Efficiency (TR)

Q_T [GeV]	JES	JESnc	JER	JAR	PUR	TR	Total
0-5	0.042	0.011	0.008	0.009	0.002	0.009	0.046
5-10	0.036	0.021	0.004	0.006	0.008	0.008	0.044
10-15	0.027	0.017	0.007	0.004	0.007	0.009	0.035
15-20	0.021	0.020	0.032	0.003	0.001	0.006	0.044
20-25	0.008	0.029	0.091	0.002	0.006	0.008	0.096