



Elliptic flow in small collisional systems

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C. Zhang, C. Marquet, G.Y. Qin, S.Y. Wei, B.W. Xiao. Phys.Rev.Lett.122, 172302 (2019).

C. Zhang, C. Marquet, G.Y. Qin, Y. Shi, L. Wang, S.Y. Wei, B.W. Xiao. PRD102, 034010 (2020).

Y. Shi, L. Wang, S.Y. Wei, B.W. Xiao, L. Zheng. Phys.Rev.D103, 054017 (2021).

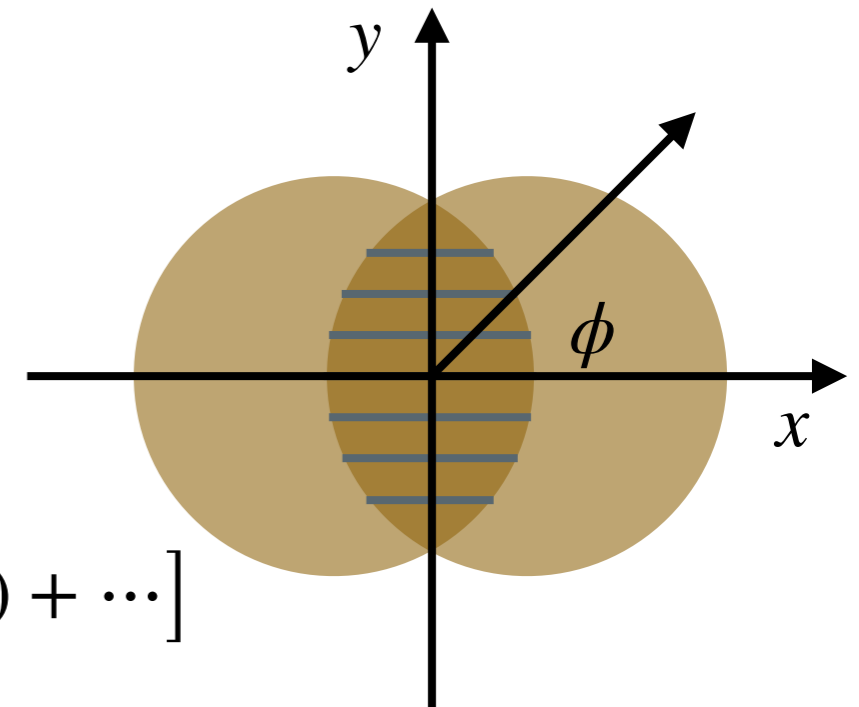
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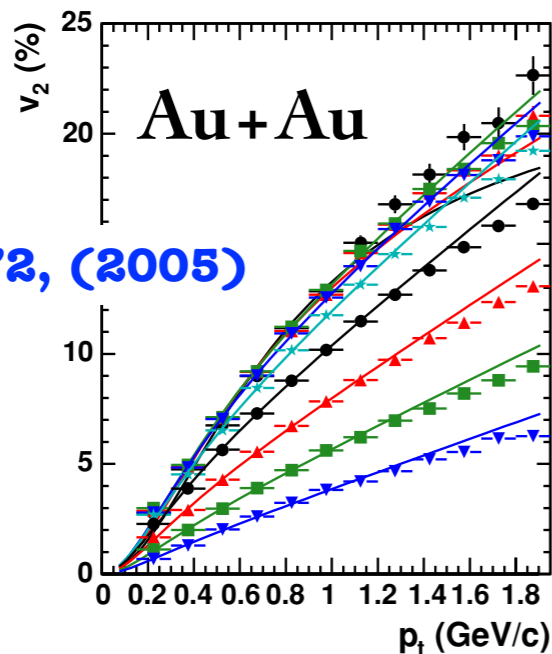
Anisotropy in the relativistic heavy-ion collisions

$$\frac{dN}{d\phi} = \frac{N}{2\pi} \left[1 + 2 \sum_{n=1}^{\infty} v_n \cos(n\phi - \Phi_n) \right]$$

$$= \frac{N}{2\pi} \left[1 + 2v_1 \cos(\phi - \Phi_1) + 2v_2 \cos(2\phi - \Phi_2) + \dots \right]$$



Event plane method



STAR, PRC72, (2005)

elliptic flow

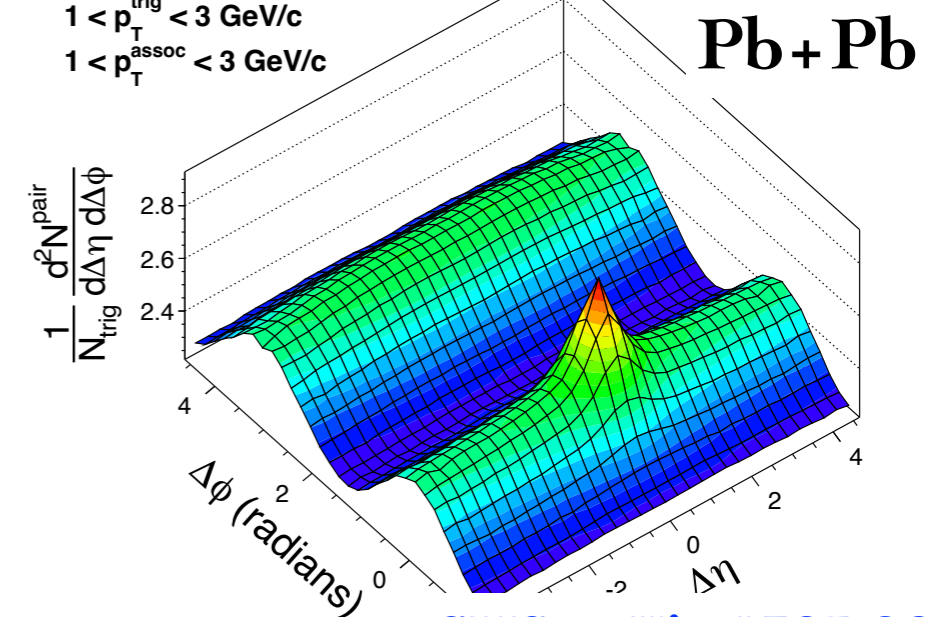
Strongly interacting QGP

2-particle correlation method

(a) CMS PbPb $\sqrt{s_{NN}} = 2.76$ TeV, $220 \leq N_{trk}^{offline} < 260$

$1 < p_T^{trig} < 3$ GeV/c

$1 < p_T^{assoc} < 3$ GeV/c

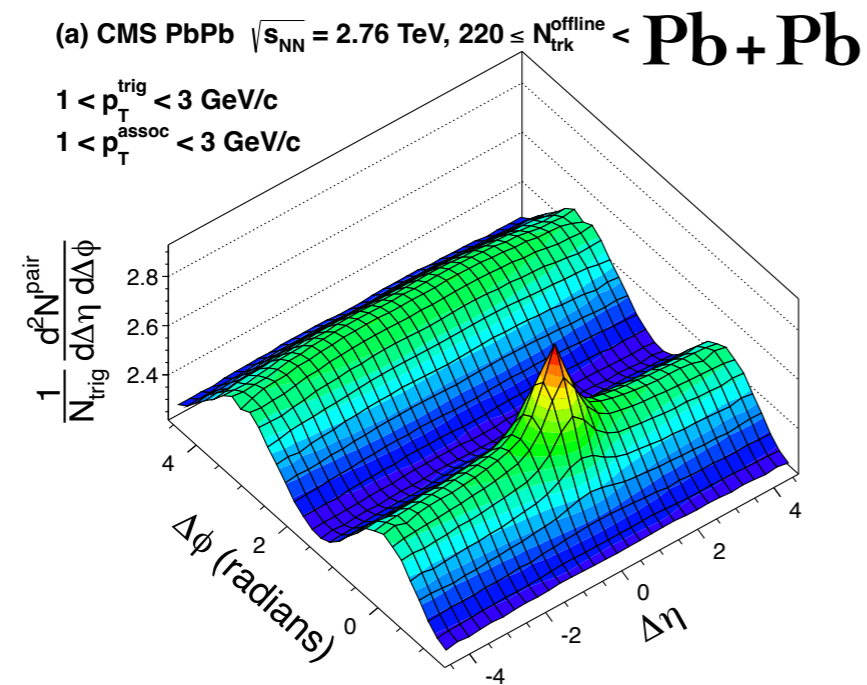


CMS, arXiv:1305.0609

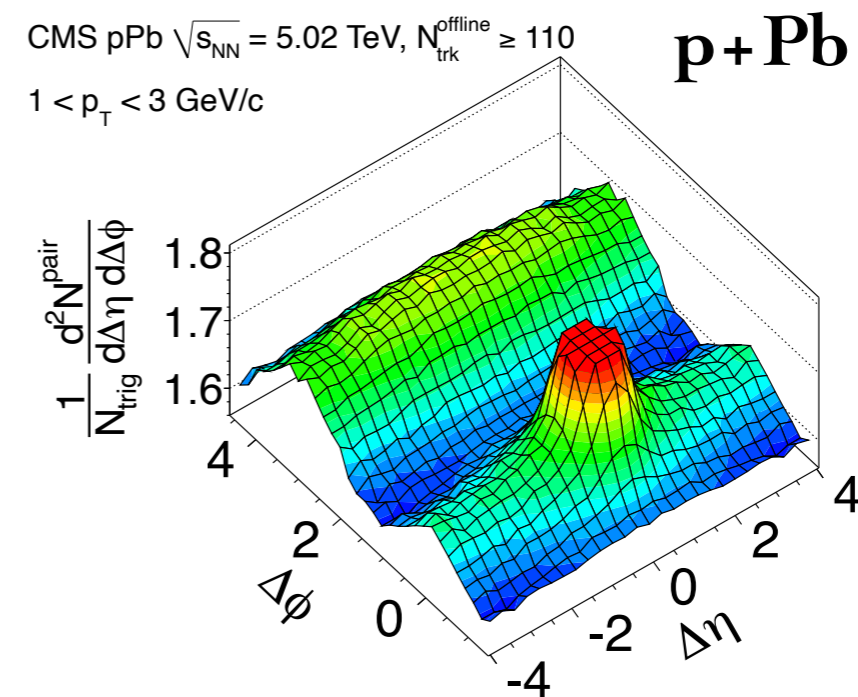
FIG. 4. (Color online) Charged hadron v_2 vs. p_T for the centrality bins (bottom to top) 5 to 10% and in steps of 10% starting at 10, 20, 30, 40, 50, 60, and 70 up to 80%. The solid lines are blast-wave fits.

Elliptic flow in small collisional system

high multiplicity events

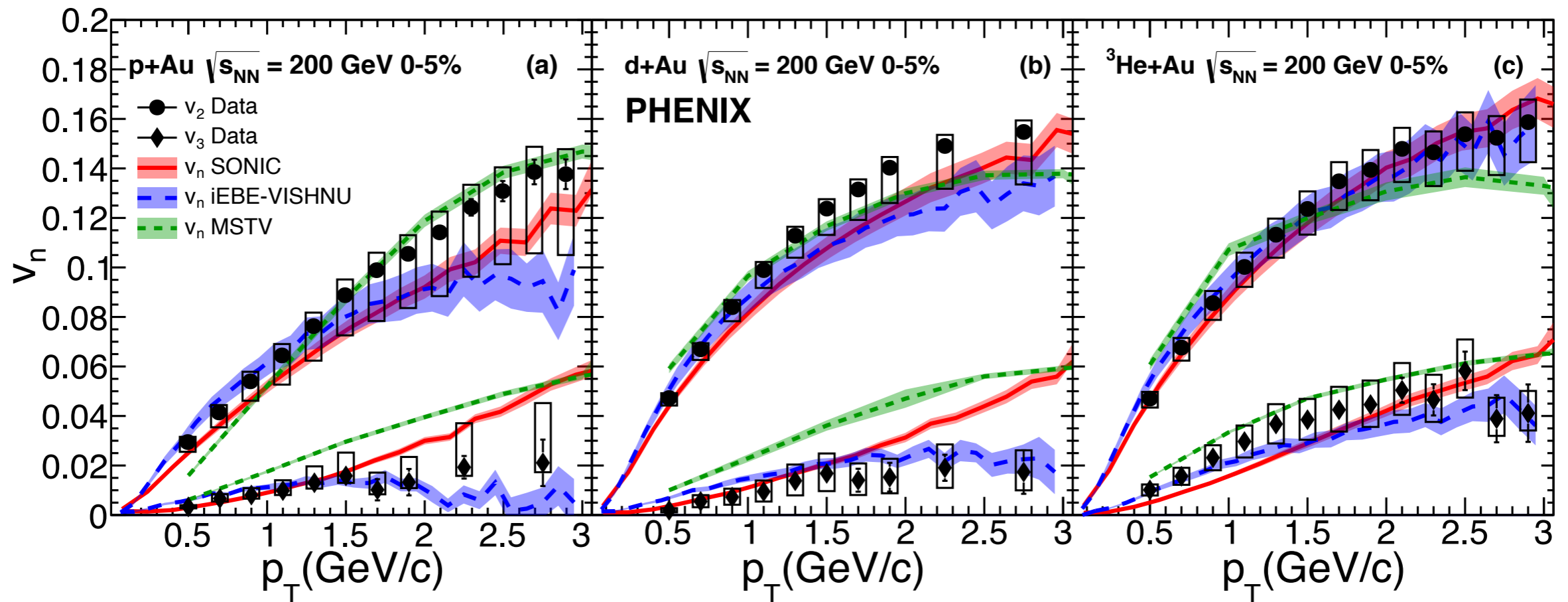


CMS, arXiv:1305.0609



CMS, arXiv:1210.5482

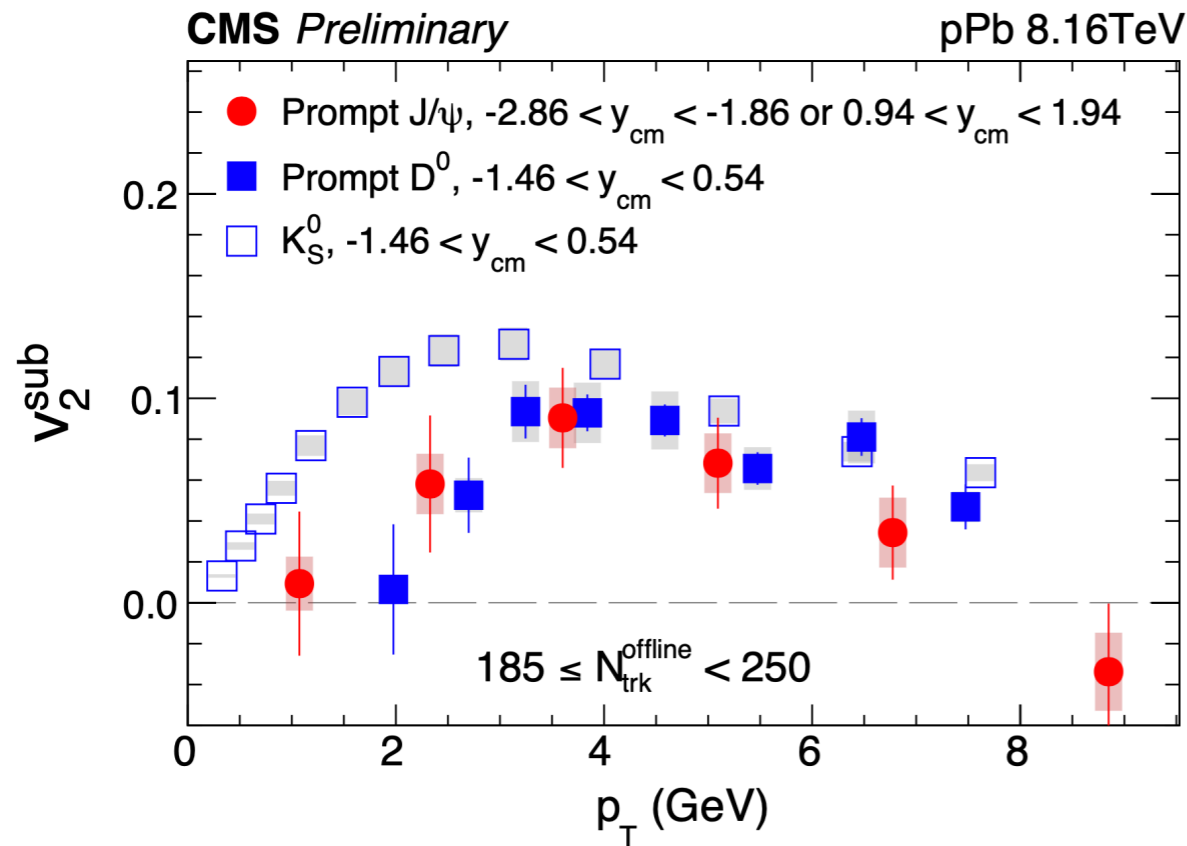
Elliptic flow in small collisional system



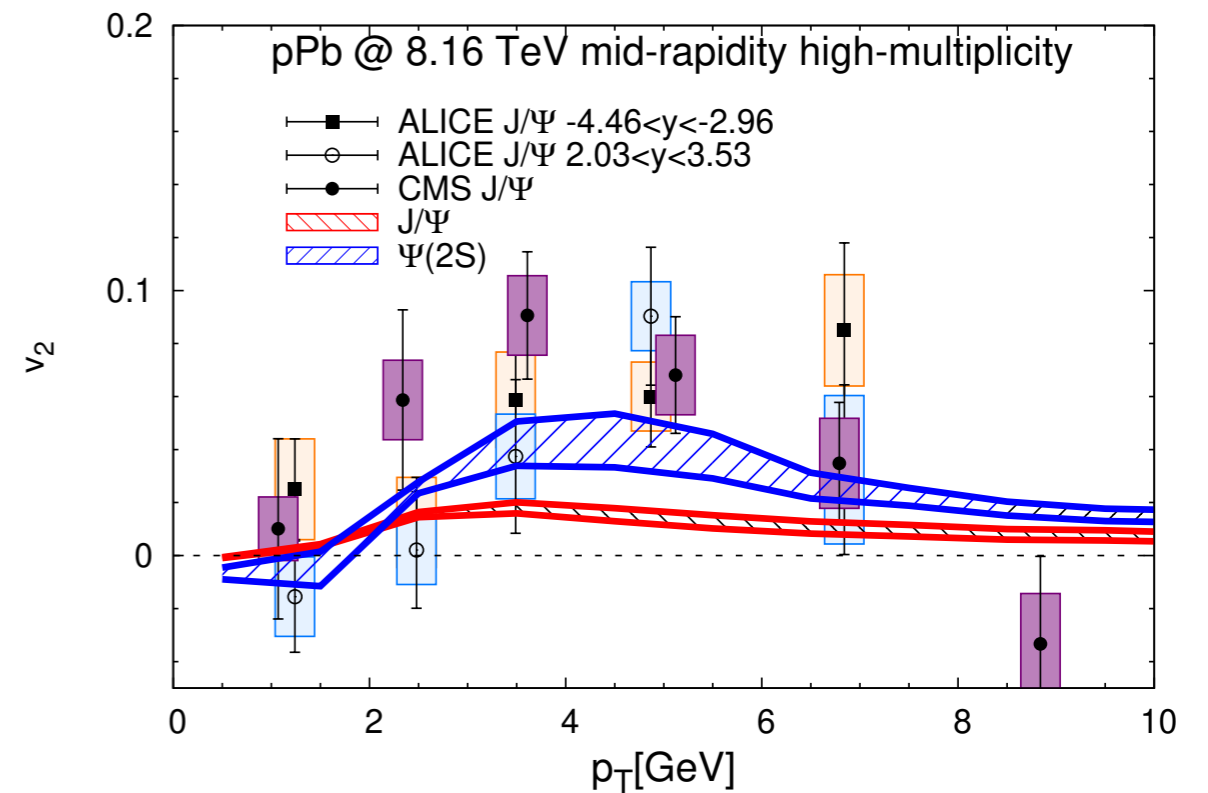
Excellent agreement between hydrodynamics approach and light hadron flow harmonics at both RHIC and LHC

[PHENIX, arXiv:1805.02973](#)

Elliptic flow in small collisional system



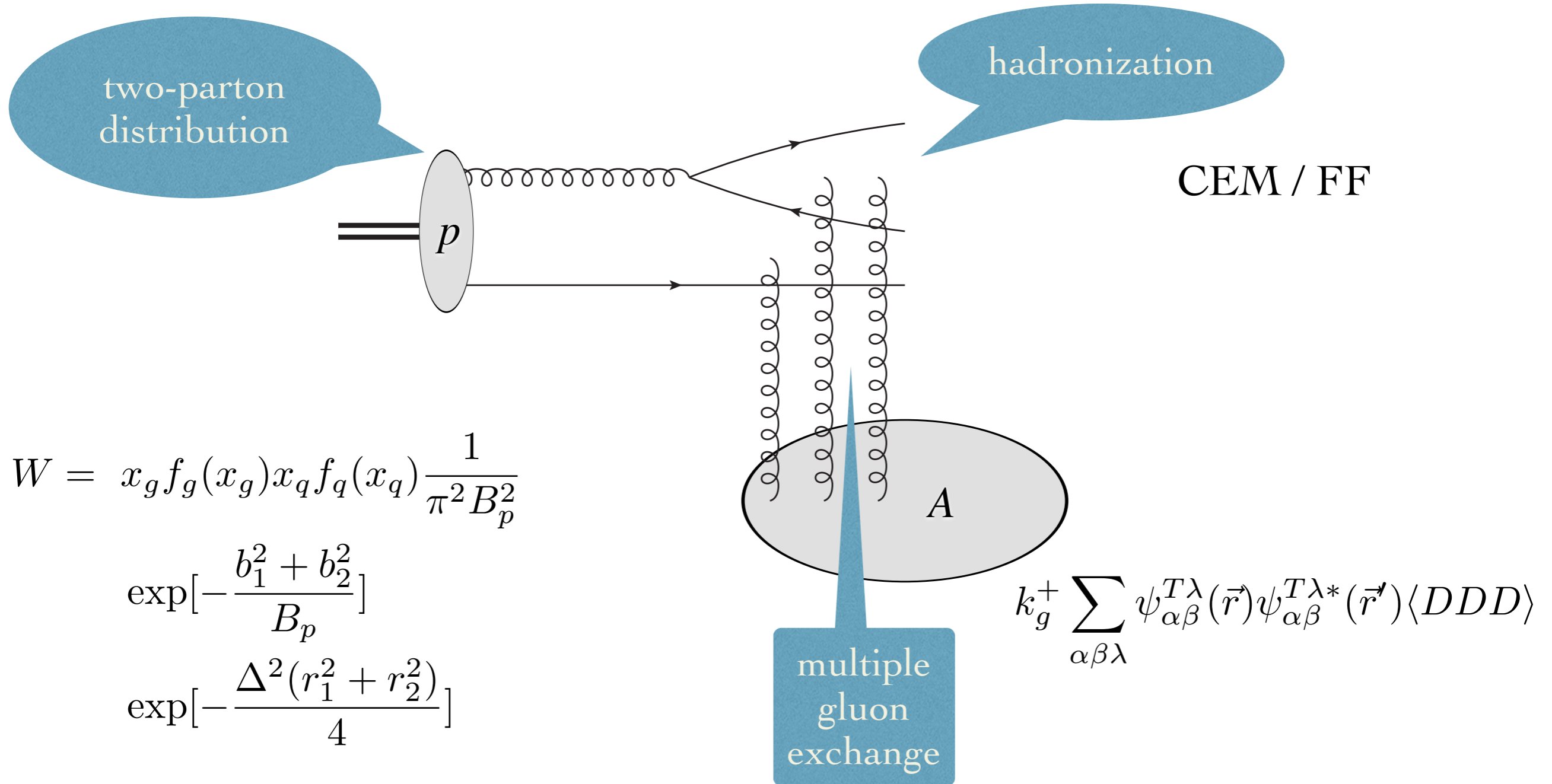
[CMS-PAS-HIN-18-010, 2018](#)



[Du, Rapp, arXiv:1808.10014](#)

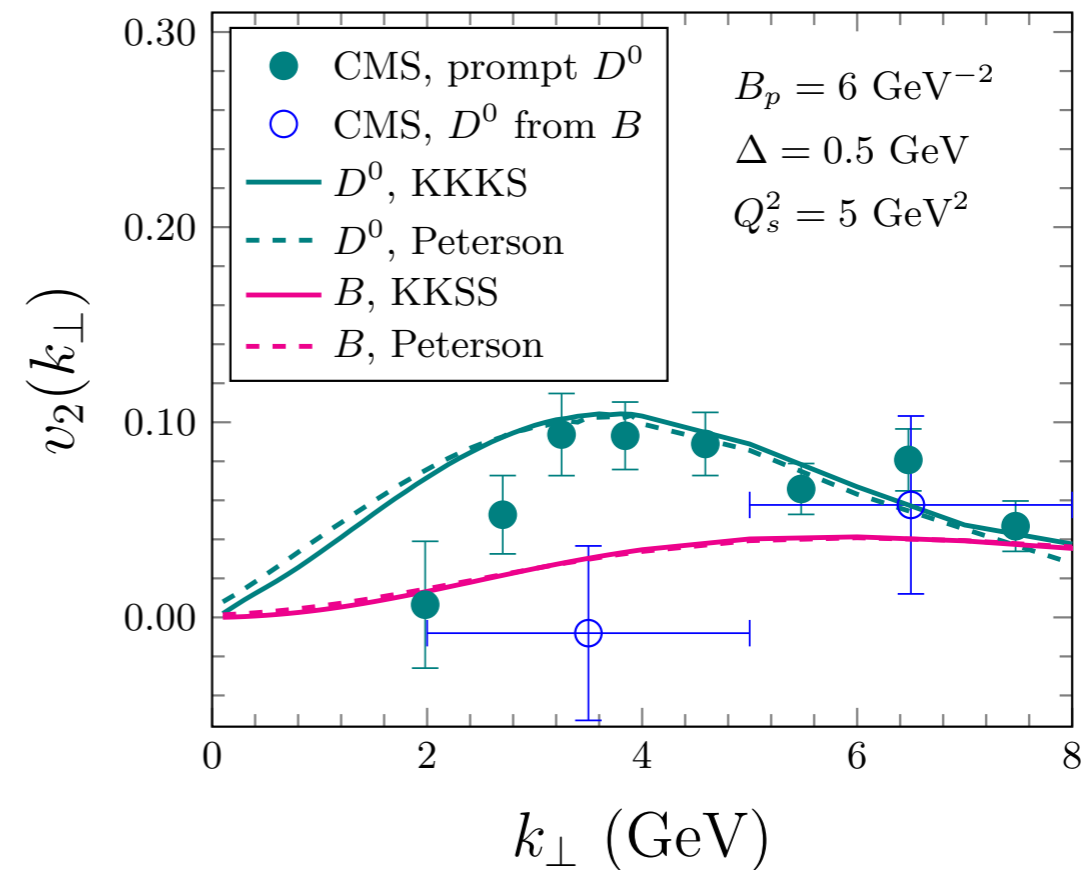
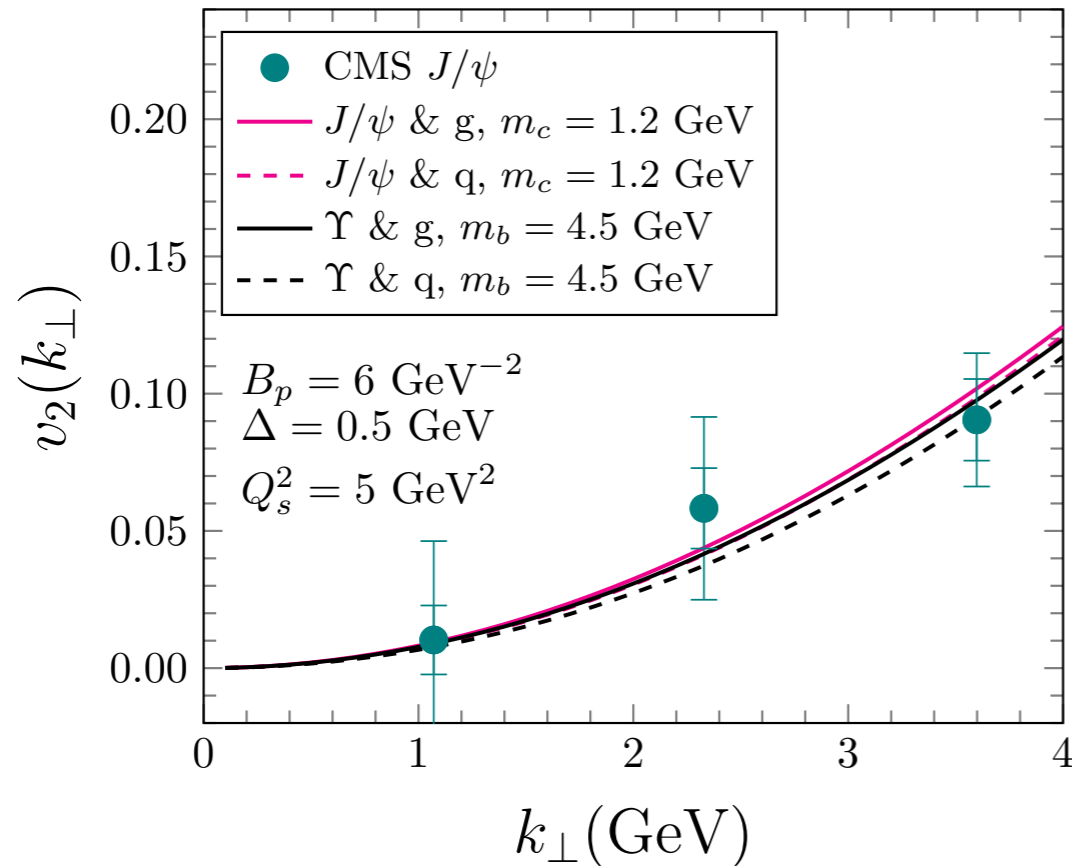
- FSI only provides a small fraction of v_2 for J/ψ mesons
- heavy meson v_2 cannot come from Final State Interaction alone

Elliptic flow in pA collisions



Zhang, et al, 2019, 2020

Elliptic flow in pA collisions

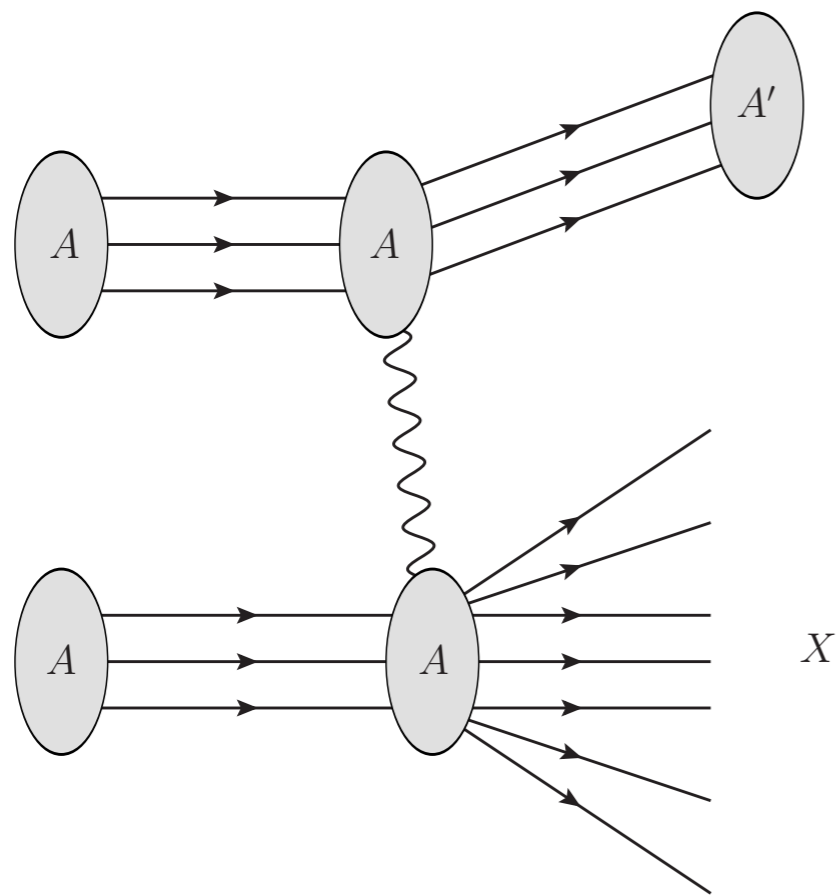


☑ Initial state effect offers a competitive explanation for v_2 in small system

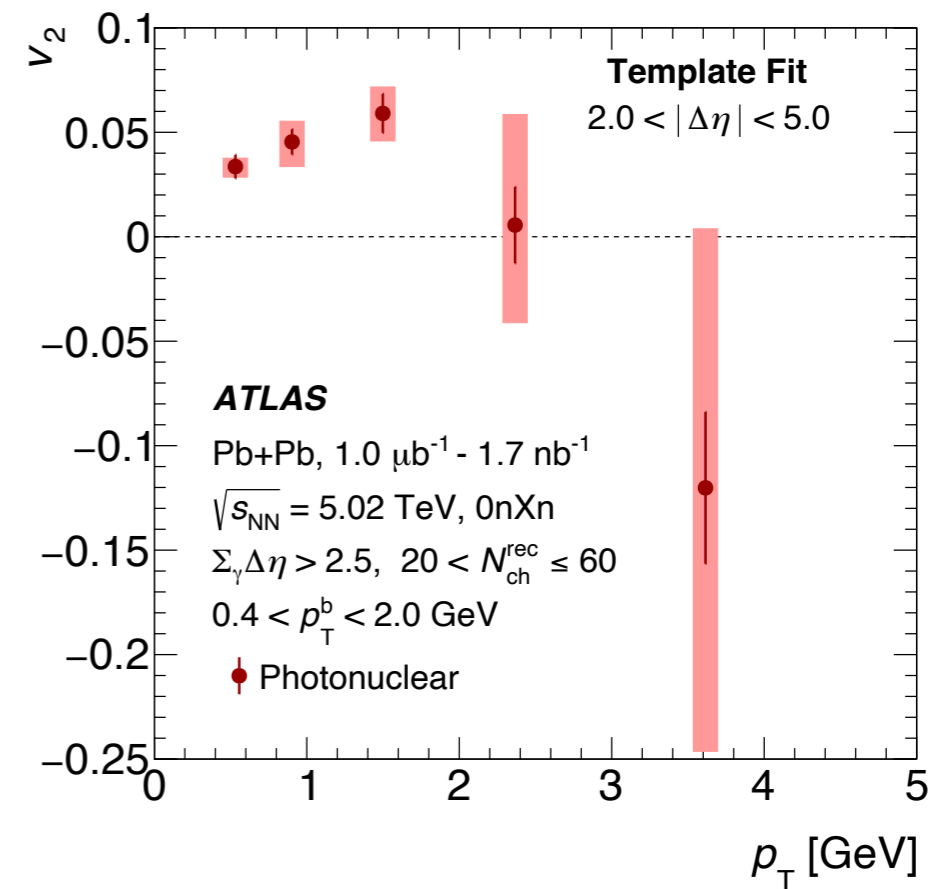
Zhang, et al, 2019, 2020

Elliptic flow in UPC

Ultra-Peripheral Collisions = Photon-Nucleus Collisions



high multiplicity events



ATLAS, arXiv:2101.10771

Initial state effect

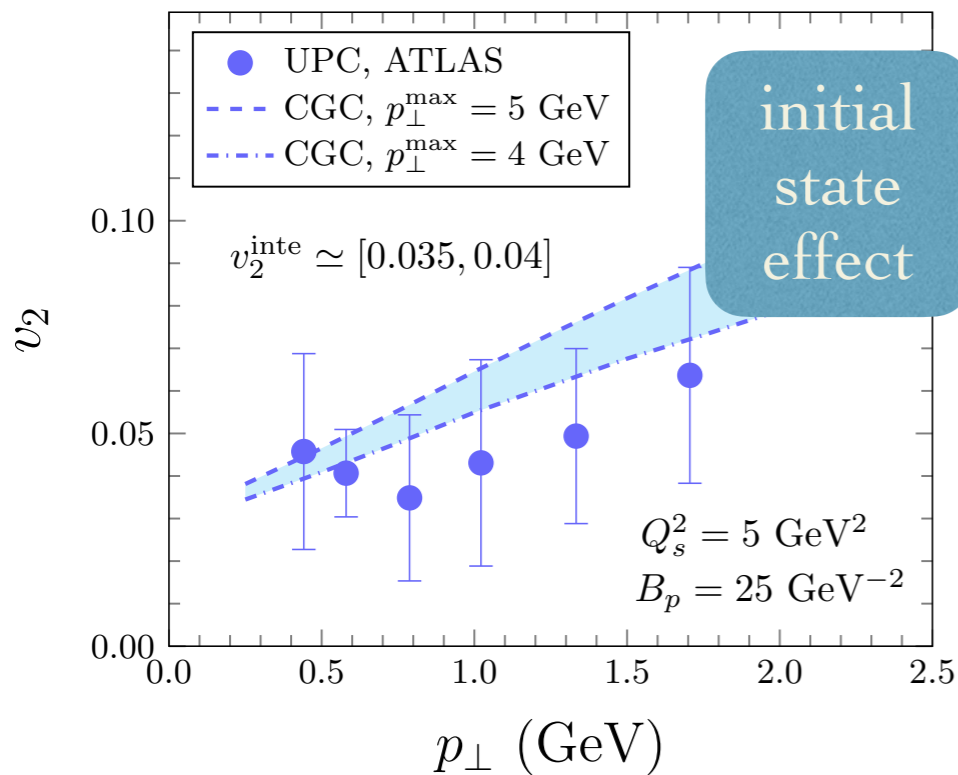
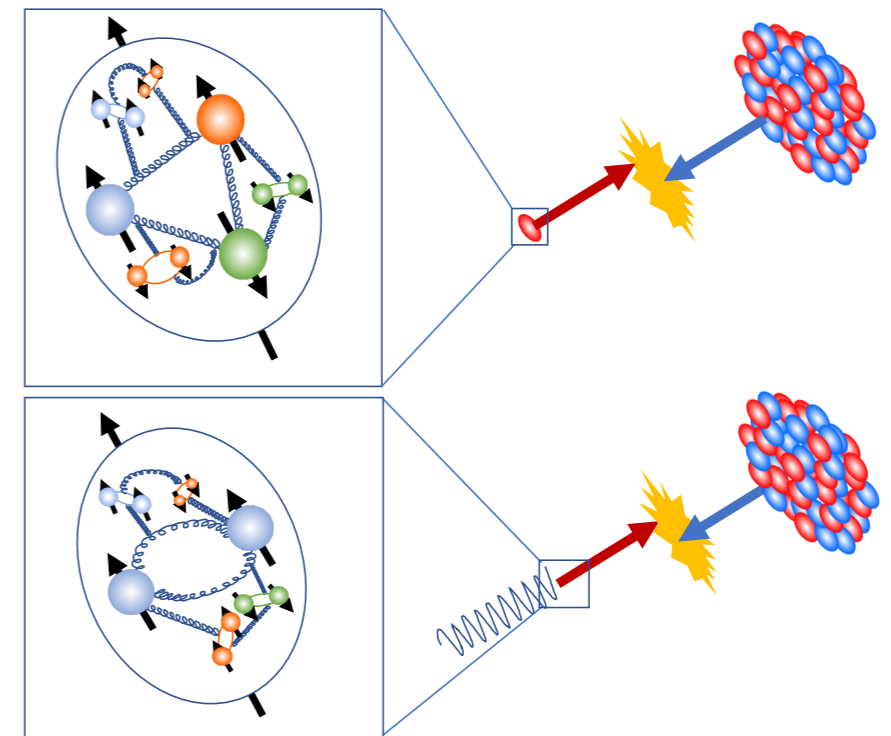
Elliptic flow in UPC

UPC: γ exchange

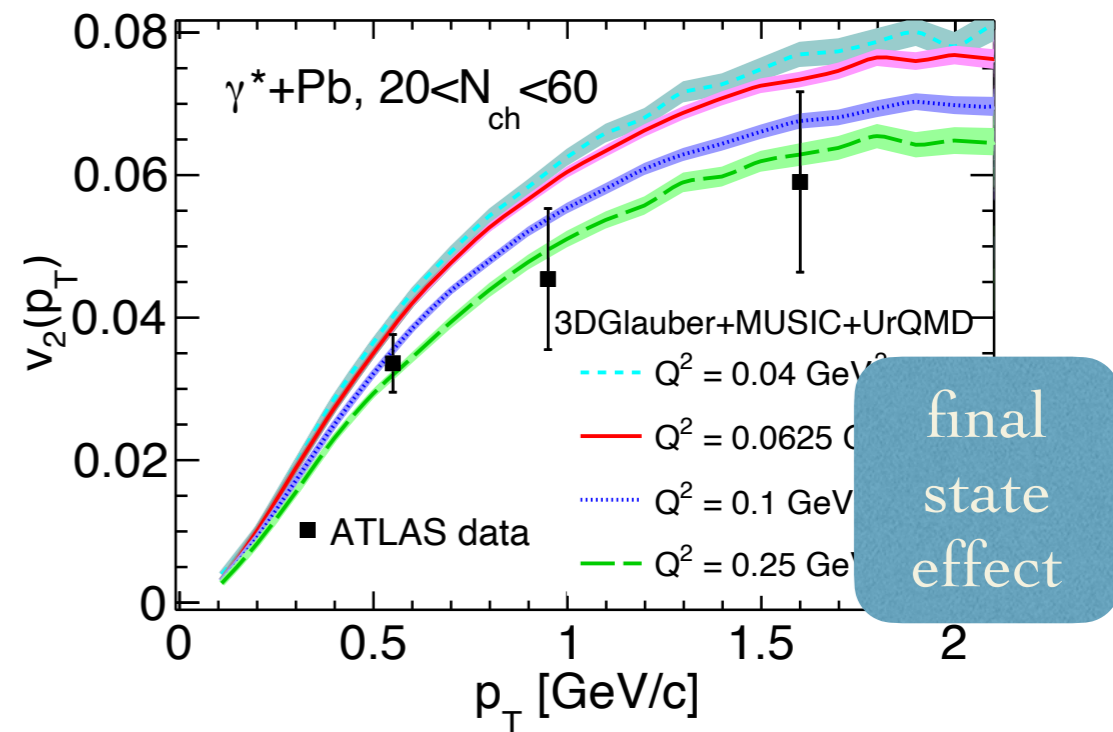
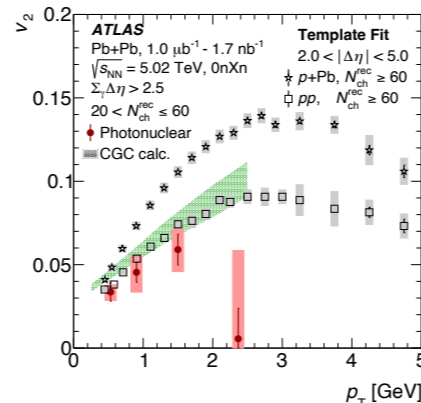


partonic state

high multiplicity events

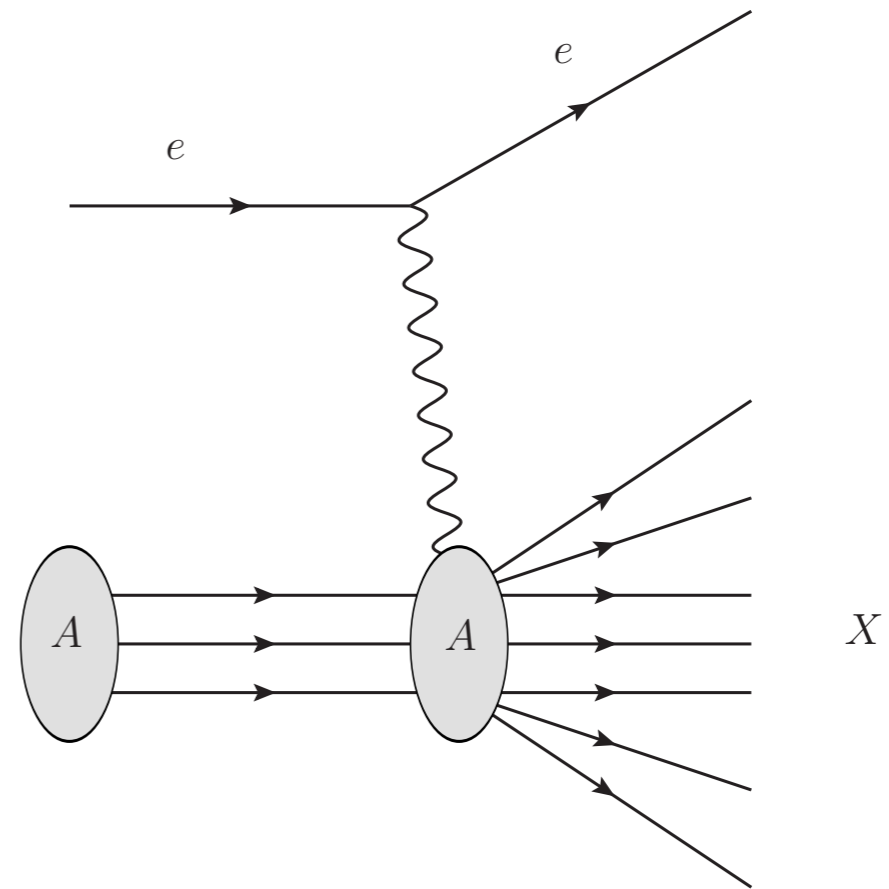
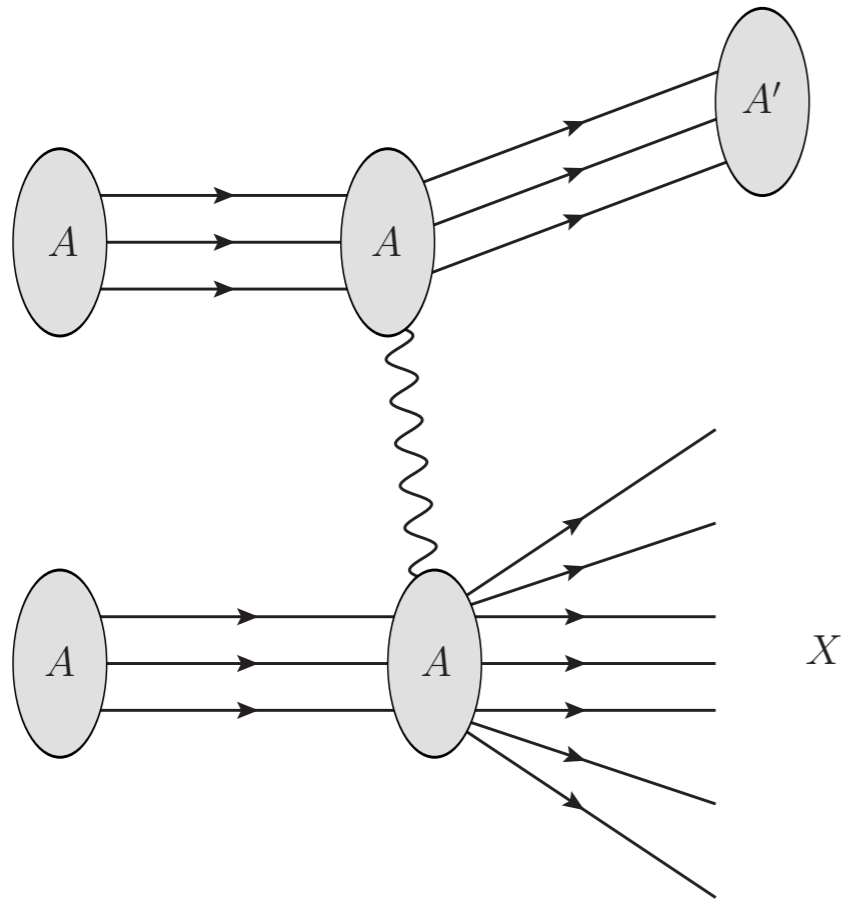


Shi, et al, arXiv: 2008.03569

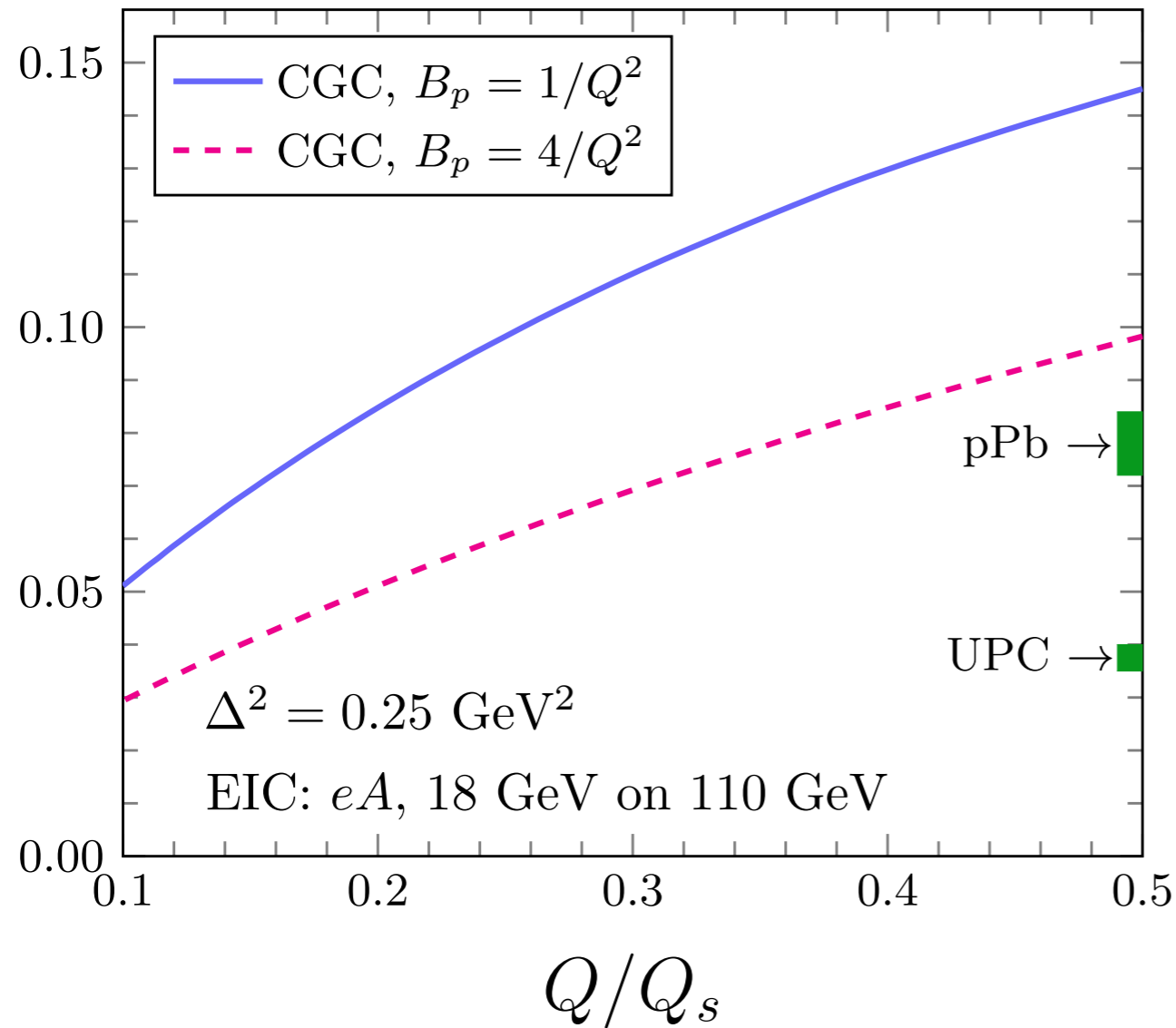


Zhao, Shen, Schenke, arXiv:2203.06094

From UPC to DIS



From UPC to DIS



Size of the virtual photon

$$B_p \sim \frac{1}{Q^2}$$

Saturation scale

$$Q_s^2 = 4\text{GeV}^2$$

- Low Q^2 photon
- High multiplicity events

[Shi, et al, arXiv: 2008.03569](#)

- ☑ Initial state effect offers a competitive explanation for v_2 in small collisional systems
- ☑ Elliptic flow can be observed in low Q^2 , high multiplicity events at the future EicC.

Thanks for your attention!

The End