Collective flow in small systems from parton scatterings

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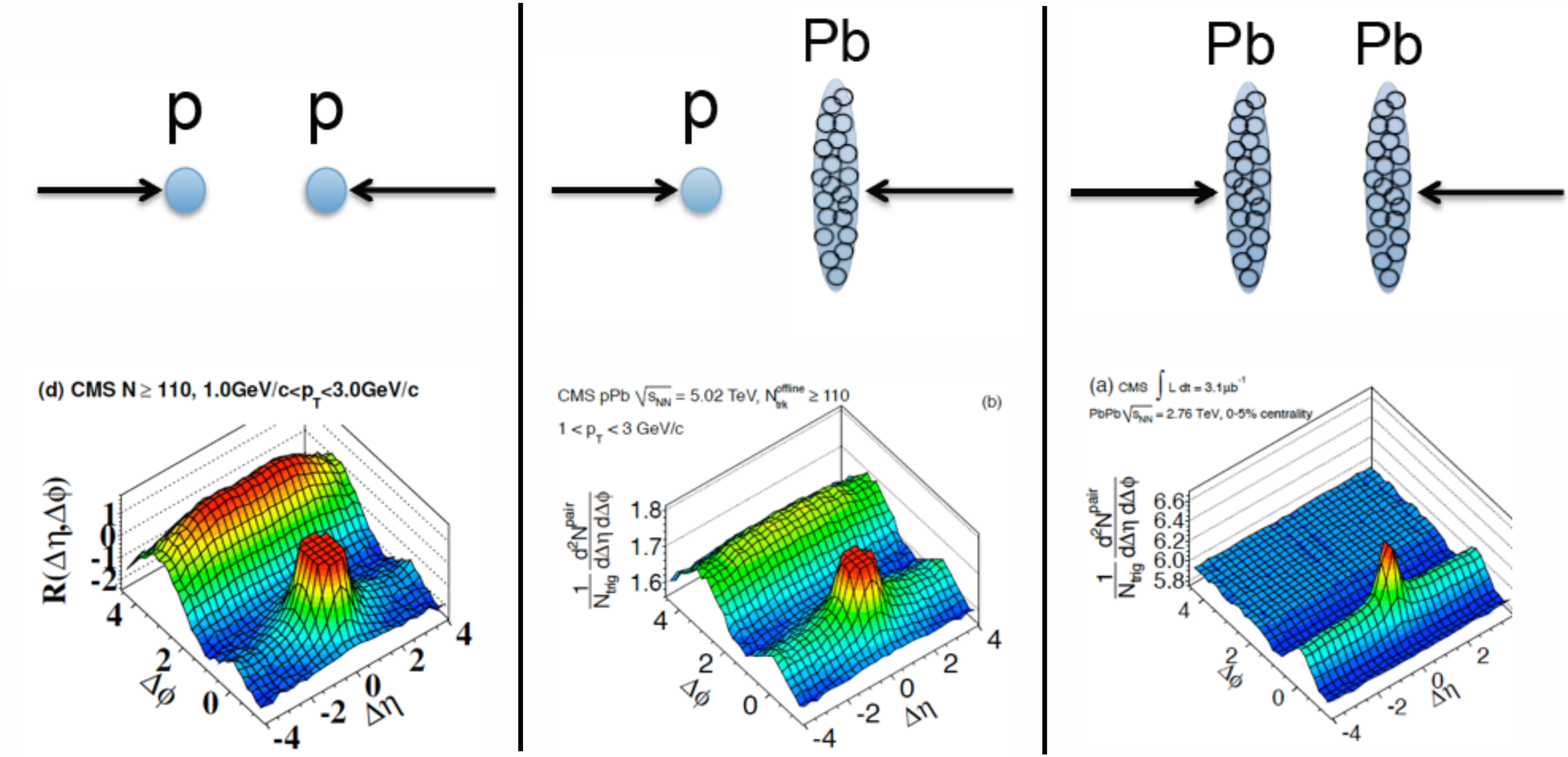
This work is in collaboration with Adam Bzdak (RBRC, BNL).

[1] G.-L. Ma and A. Bzdak, Phys. Lett. B 739, 209 (2014) [arXiv:1404.4129].
[2] A. Bzdak and G.-L. Ma, Accepted by Phys. Rev. Lett. [arXiv:1406.2804].

Outline

- **Introduction**
  - Motivation
  - The AMPT model
- **Results**
  - Long-range correlations in p+p and p+Pb
  - Flow in p+Pb vs Pb+Pb
- **Summary**

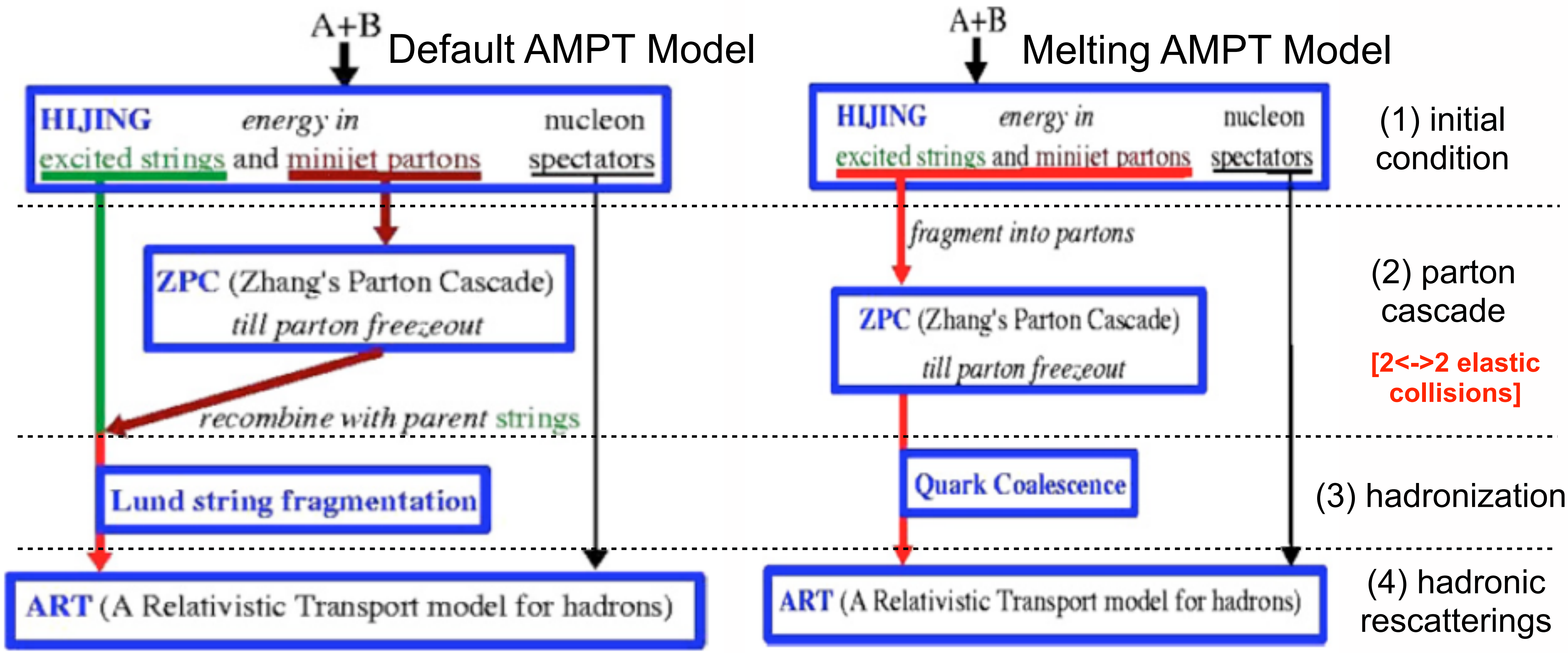
Long-range correlations in p+p, p+Pb, and Pb+Pb

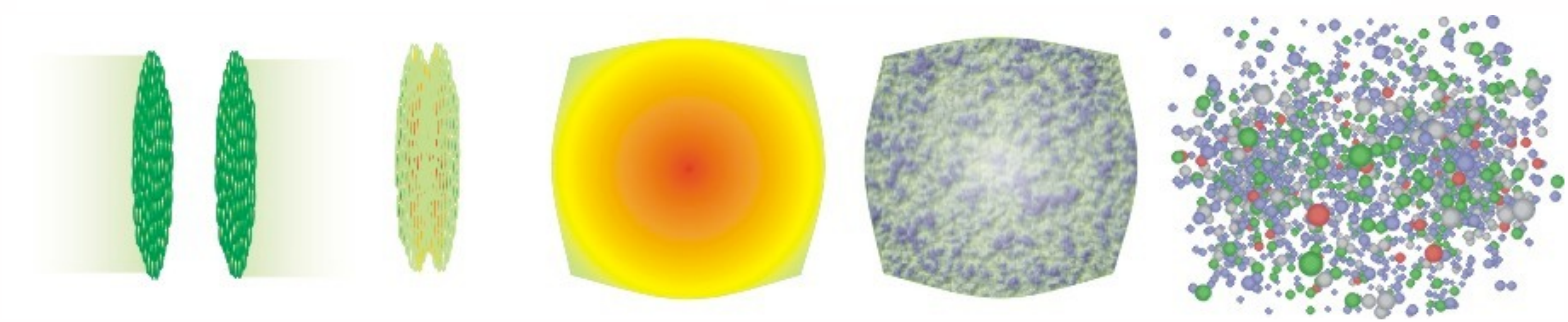


- Are the ‘ridges’ due to the same origin in p+p, p+Pb and Pb+Pb?

…

A multiphase transport (AMPT) model

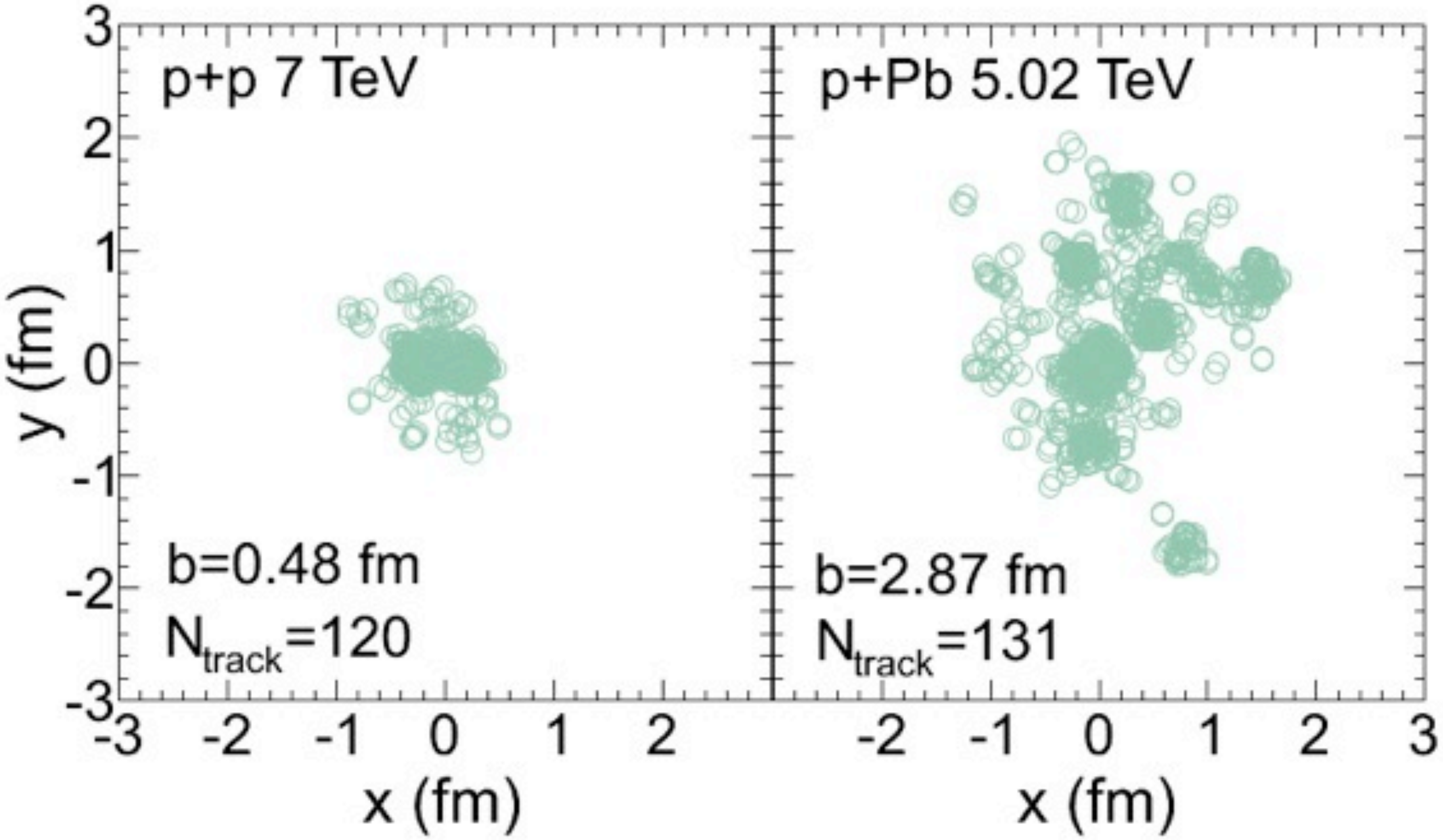


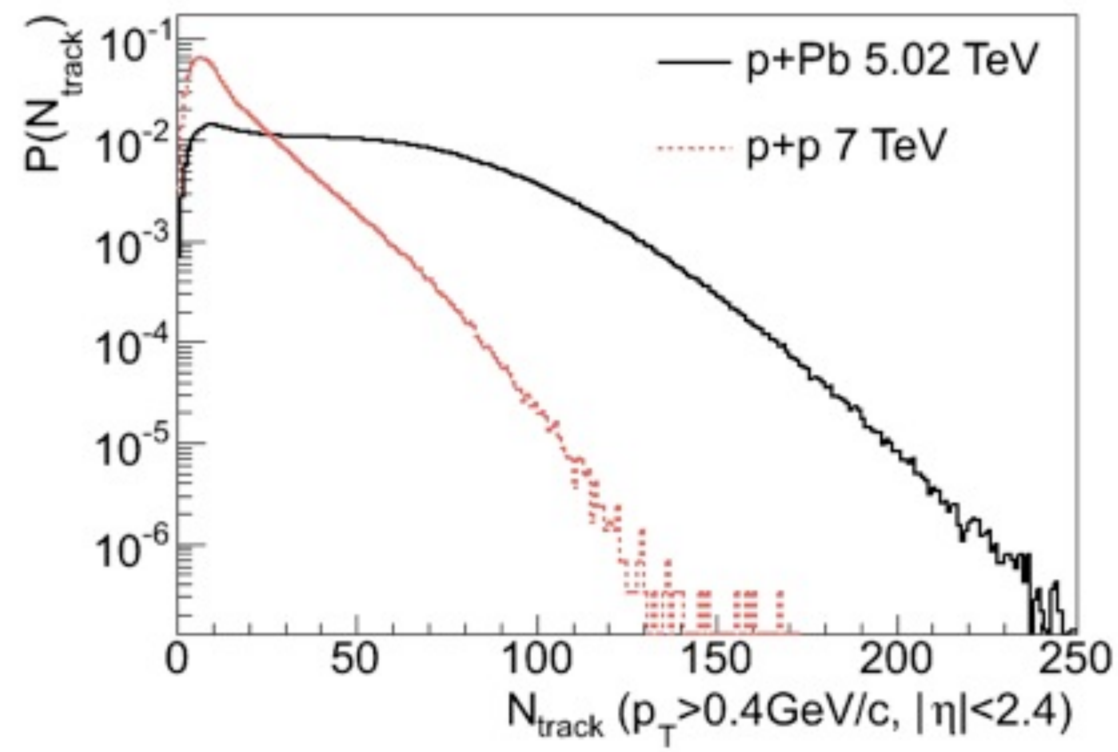


(1) initial condition (2) parton cascade (3) hadronization (4) hadronic rescatterings

p+p and p+Pb in the AMPT model

G.-L. Ma and A. Bzdak, PLB 739, 209 (2014)

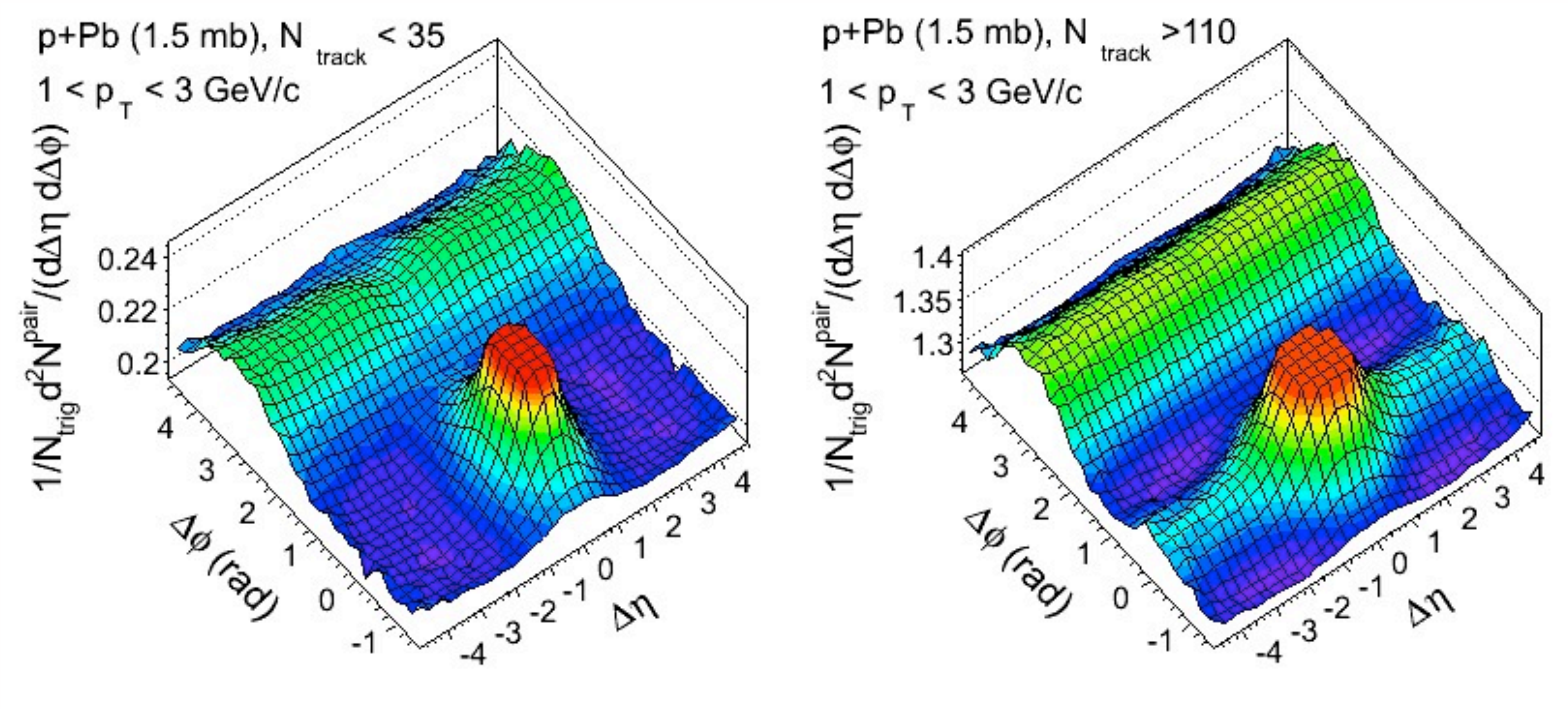




- One hot spot in p+p vs Several hot spots in p+Pb.
- ‘Centrality’ defined by using N_{track} distributions as the CMS.

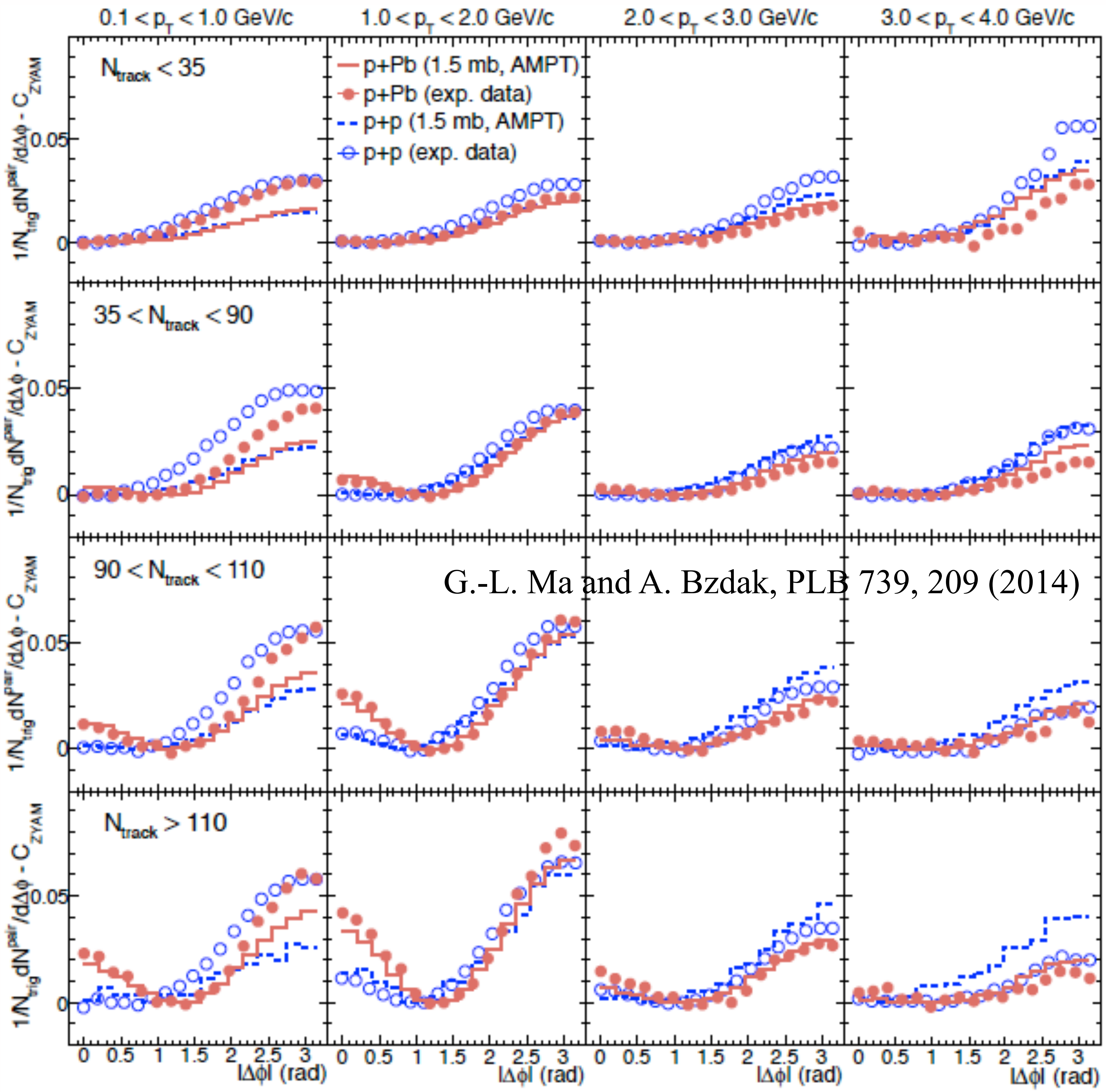
AMPT results on long-range correlations in p+Pb

G.-L. Ma and A. Bzdak, PLB 739, 209 (2014)



- No long-range correlation in low-multiplicity p+Pb.
- Clear long-range correlation in high-multiplicity p+Pb.

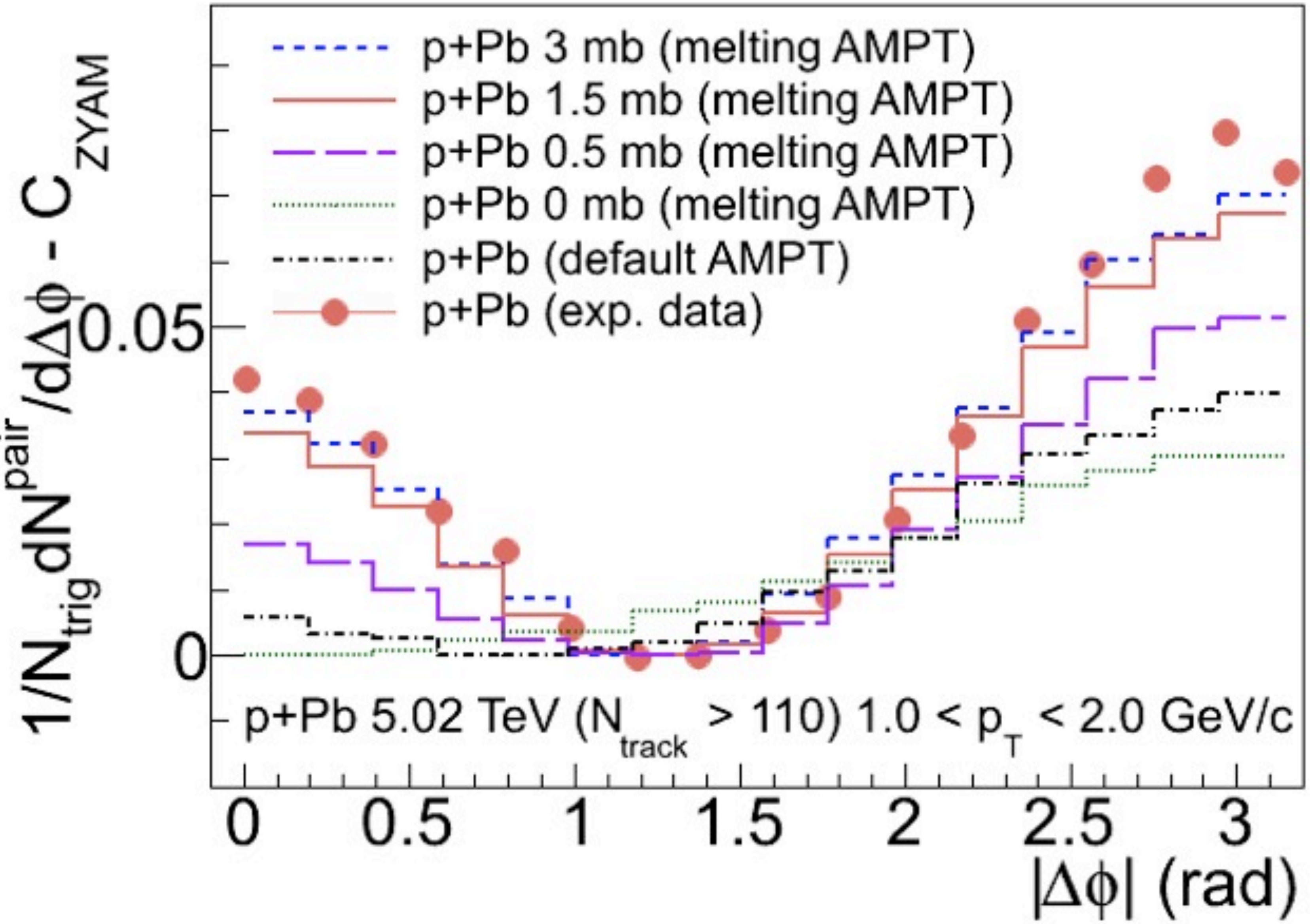
AMPT results on long-range correlations in p+p and p+Pb



- The two-particle correlations in p+p and p+Pb are well reproduced by AMPT model (1.5mb).
- Long-range correlation ($\Delta\phi \sim 0$) appears in high-multiplicity p+p and p+Pb.
- For signal strength, p+p <p+Pb.

Cross section dependence of long-range correlation in p+Pb

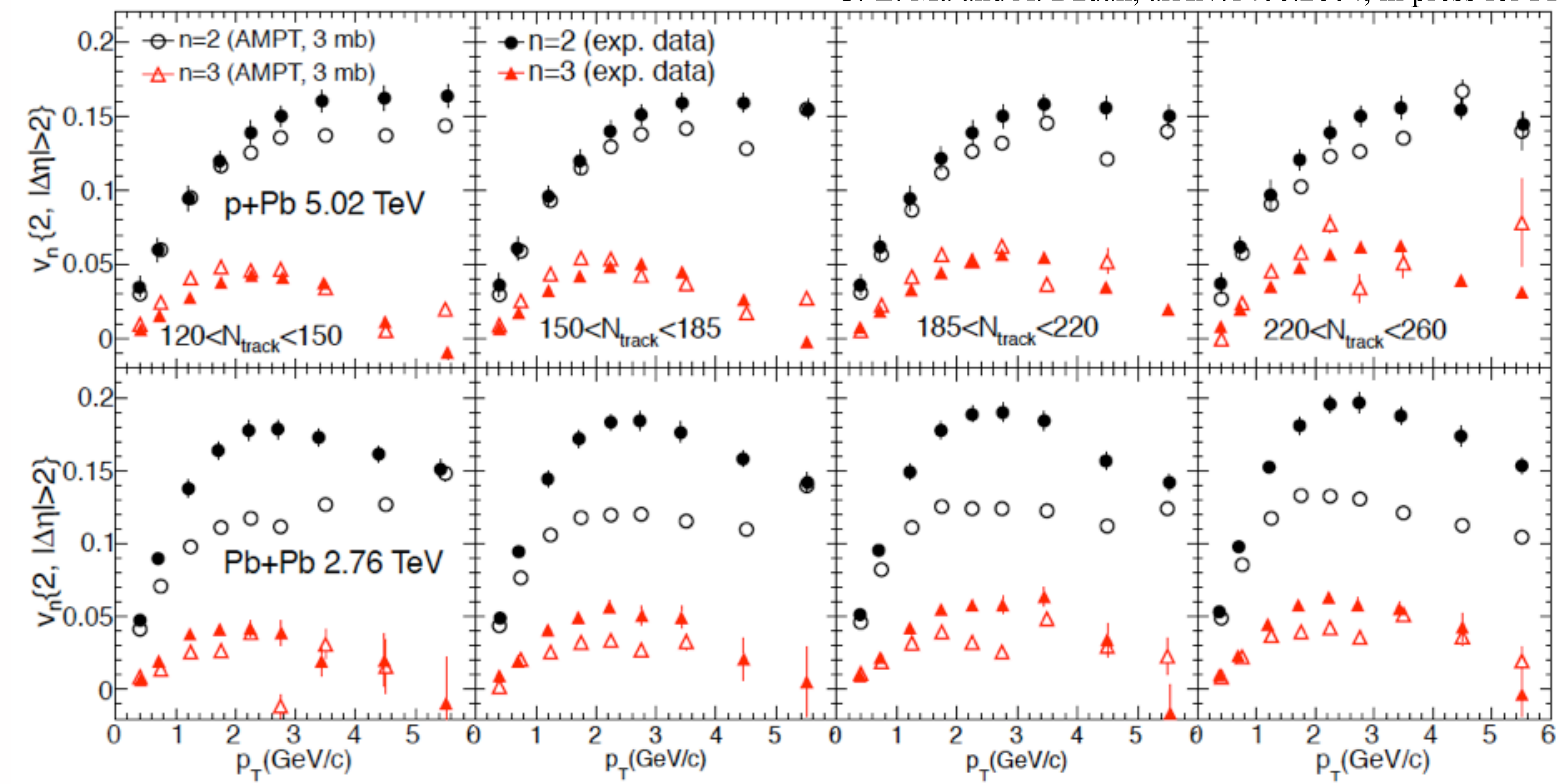
G.-L. Ma and A. Bzdak, PLB 739, 209 (2014)



- The two-particle correlations in p+Pb can be well described by σ=1.5-3 mb.
- The strength of the signal gradually increases with growing σ and the signal vanishes completely for σ = 0 mb.
- No visible long-range signal in the default AMPT model.

AMPT results on vn(pT) in p+Pb vs Pb+Pb

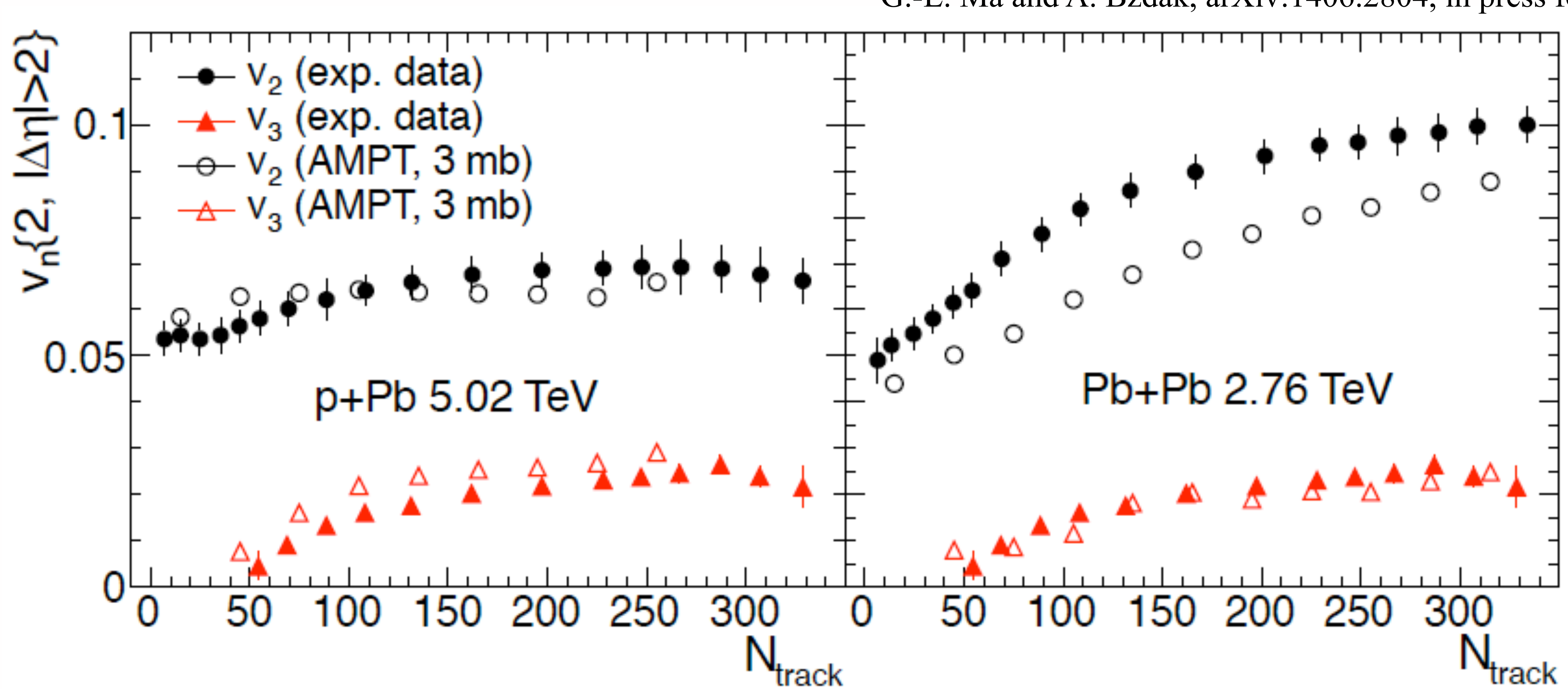
G.-L. Ma and A. Bzdak, arXiv:1406.2804, in press for PRL



- For p+Pb, AMPT (3 mb) reproduces the measured v2 and v3.
- For Pb+Pb, AMPT (3 mb) reproduces the measured v3 for all pT, but underestimates v2 especially for high pT.

AMPT results on integrated vn

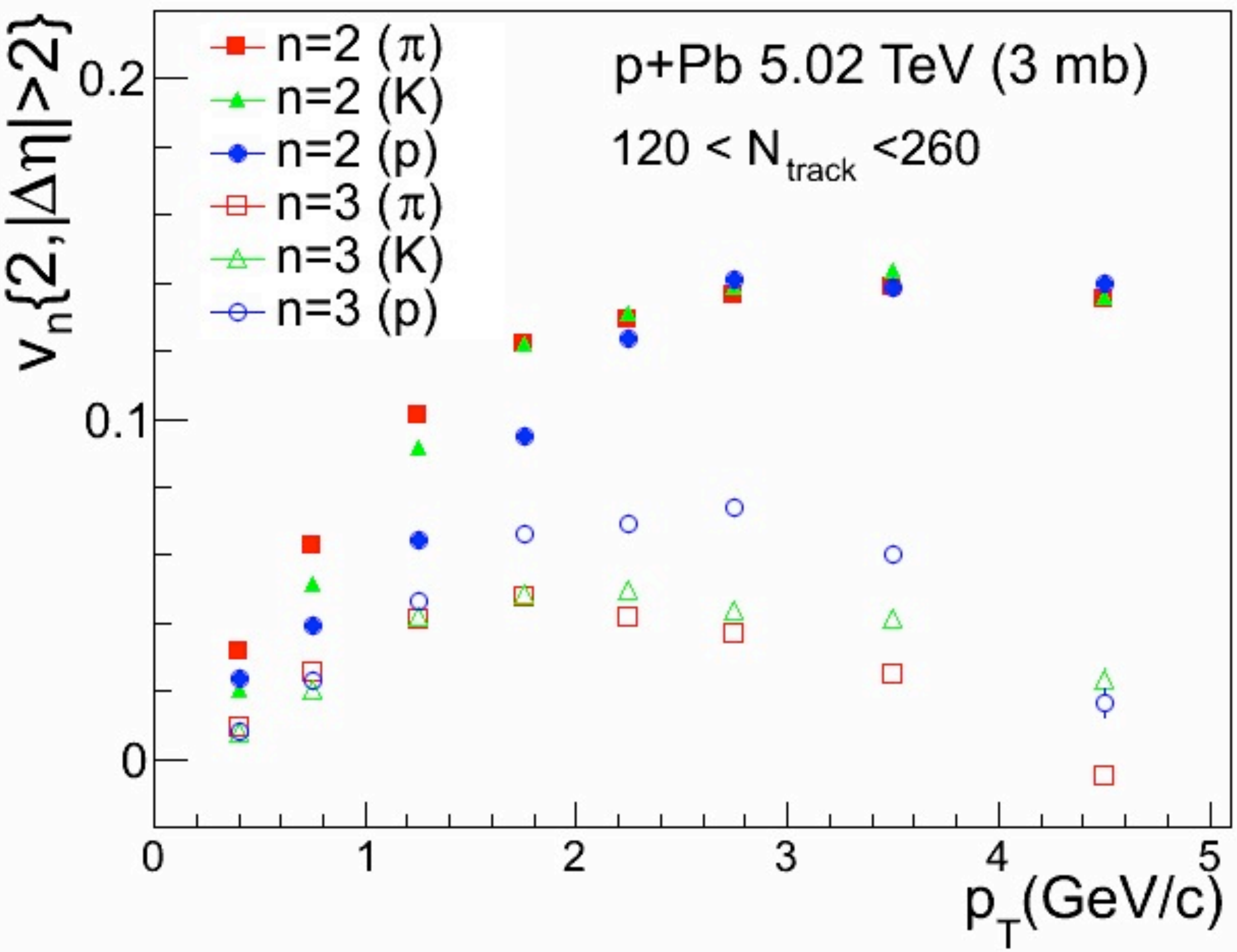
G.-L. Ma and A. Bzdak, arXiv:1406.2804, in press for PRL

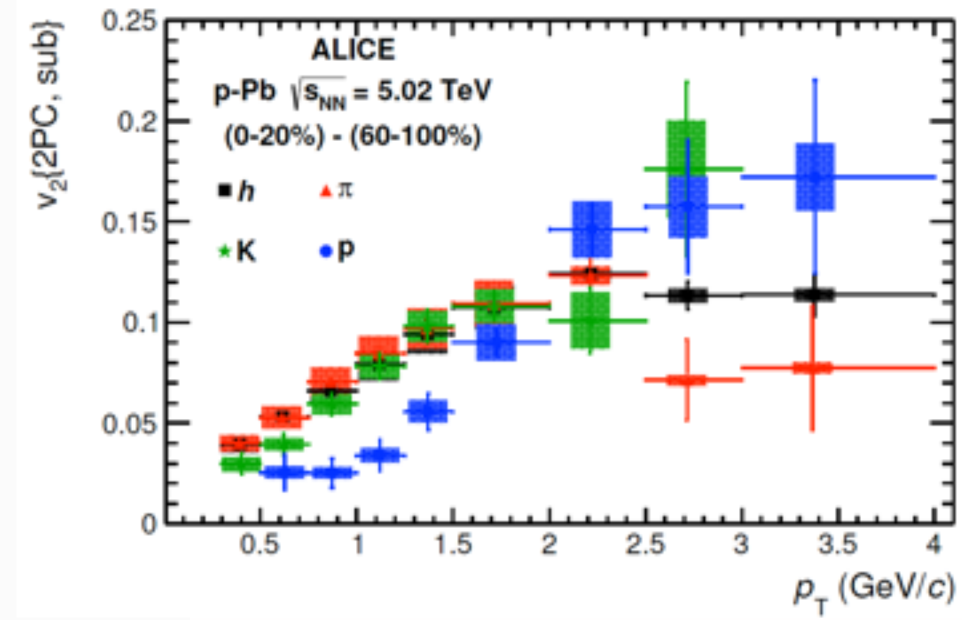


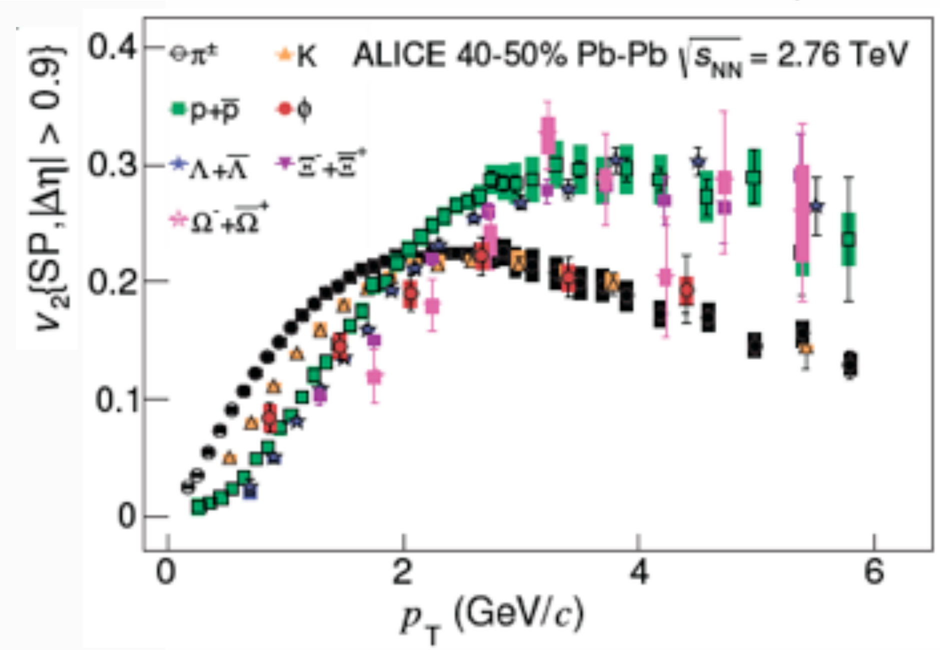
- For p+Pb, AMPT (3 mb) reproduces the integrated v2 and v3.
- For Pb+Pb, AMPT (3 mb) reproduces the integrated v3, but underestimates the integrated v2 by ~20%.
- AMPT (3 mb) shows similar v3 between p+Pb and Pb+Pb.

AMPT results on PID vn

G.-L. Ma and A. Bzdak, arXiv:1406.2804, in press for PRL

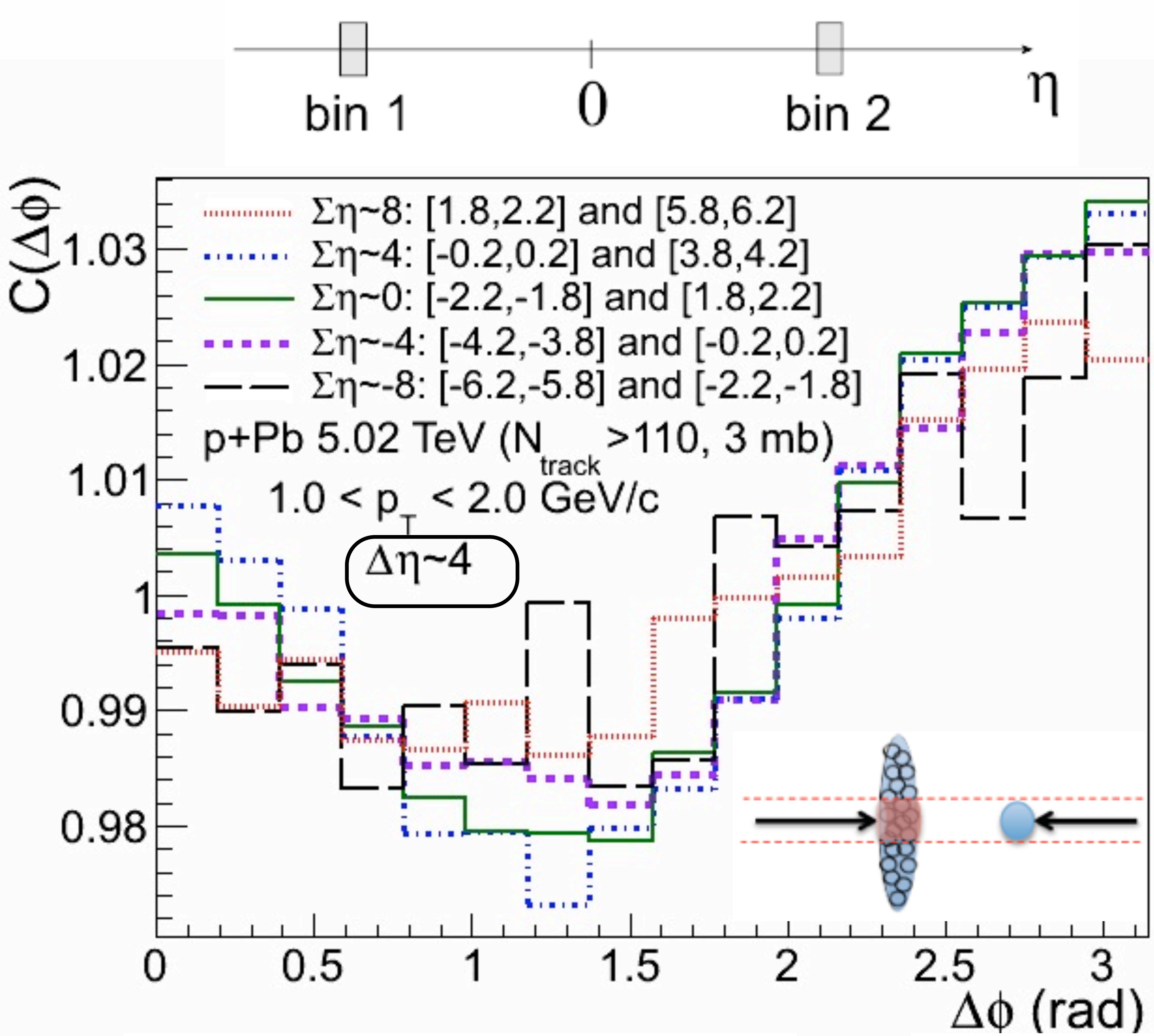




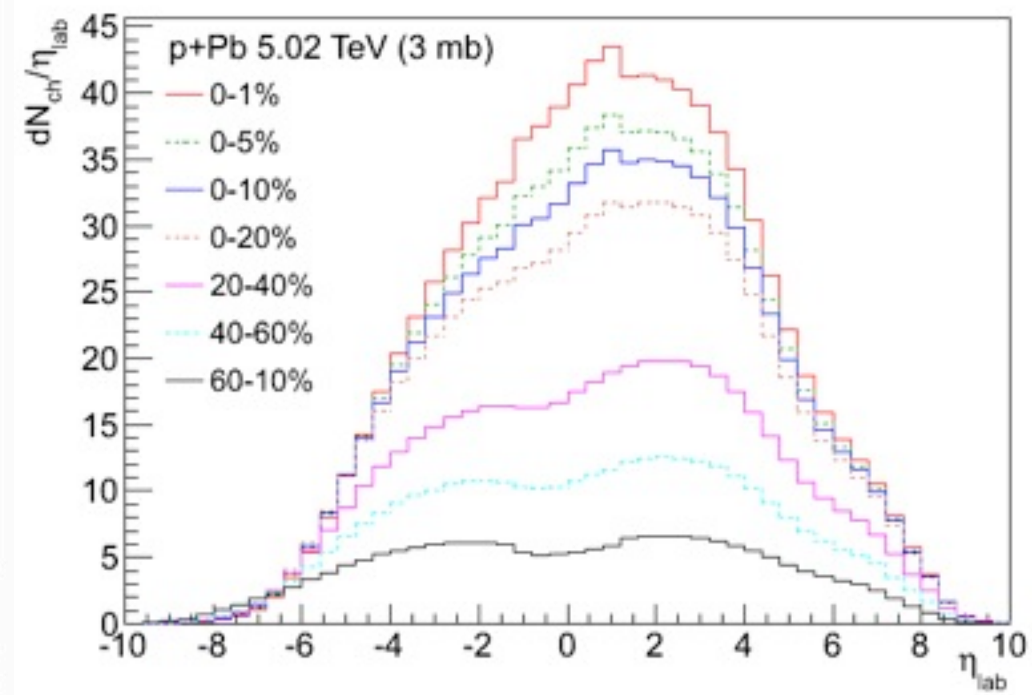


- v2 mass ordering in p+Pb ~ that in Pb+Pb==> Collectivity in p+Pb?
- The mass ordering of v2 is observed in p+Pb, as seen in data.
- No such a mass ordering of v3 in p+Pb.

A proposed observable



∑η	bin 1	bin 2
-8	[−6.2, −5.8]	[−2.2, −1.8]
-4	[−4.2, −3.8]	[−0.2, 0.2]
0	[−2.2, −1.8]	[1.8, 2.2]
4	[−0.2, 0.2]	[3.8, 4.2]
8	[1.8, 2.2]	[5.8, 6.2]



$$C(\Delta\phi) \equiv \frac{Y_{\mathrm{Same}}(\Delta\phi)}{Y_{\mathrm{Mixed}}(\Delta\phi)} \times \frac{\int Y_{\mathrm{Mixed}}(\Delta\phi)d\Delta\phi}{\int Y_{\mathrm{Same}}(\Delta\phi)d\Delta\phi}$$

$$C(\Delta\phi) = 1 + \sum_n 2v_n^2 \cos(n\Delta\phi)$$

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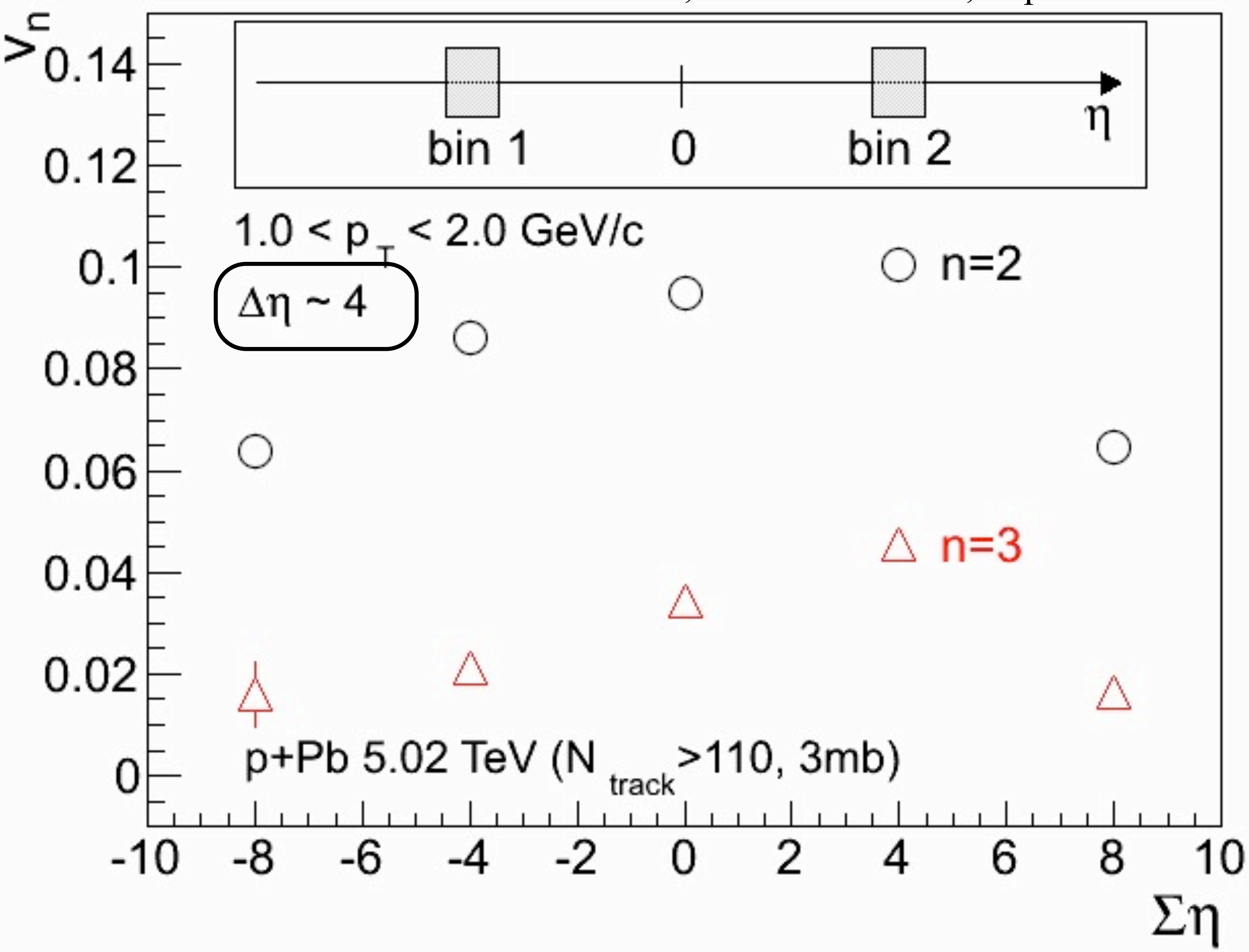

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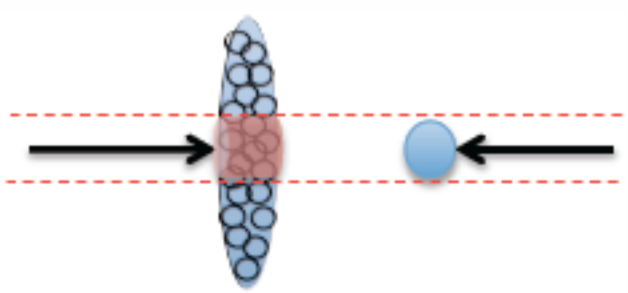
8	[1.8, 2.2]	[5.8, 6.2]

- v2 and v3 increase when going from a proton side to a Pb-nucleus side.
- CGC predictions are warranted.



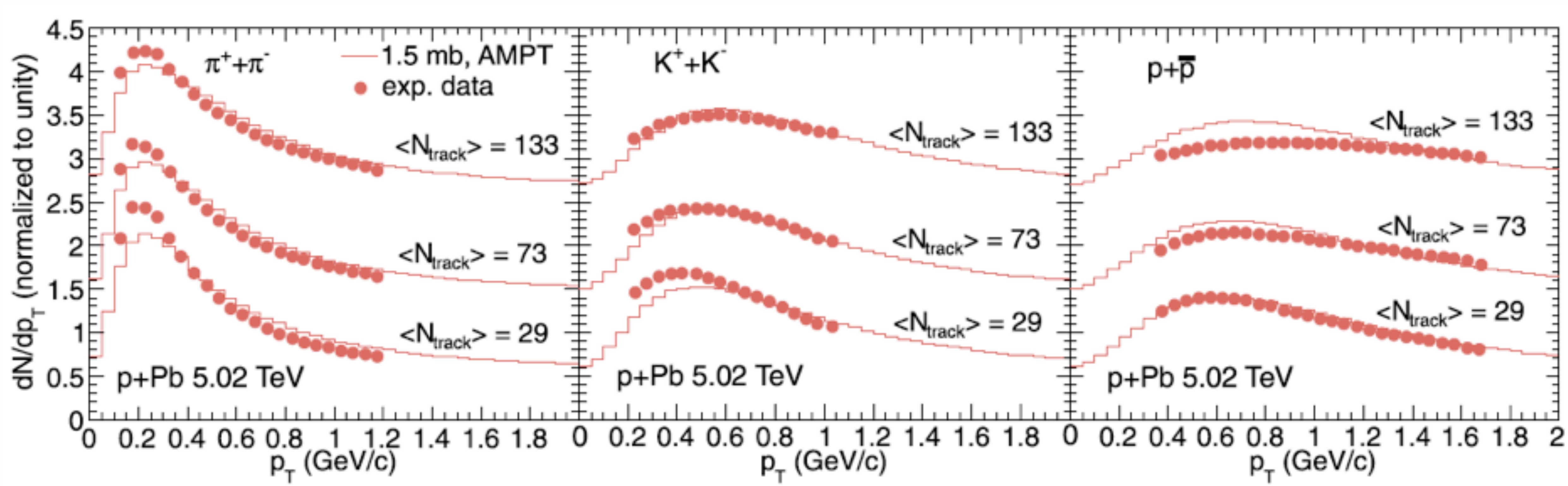
Summary

- The incoherent elastic scattering of partons, with σ =1.5-3mb, naturally explains the long-range correlations in p+p and p+Pb.
- v3 are in a good agreement with the CMS data. v2 is very well described in p+Pb and underestimated for higher pT in Pb+Pb.
- The mass ordering of v2 is reproduced whereas for v3 such ordering is not observed in p+Pb.
- v2 and v3 are gradually growing when going from a proton side to a Pb-nucleus side.
- They indicate an emergence of collectivity in p+p, p+Pb and peripheral Pb+Pb from parton scatterings.

Thanks!

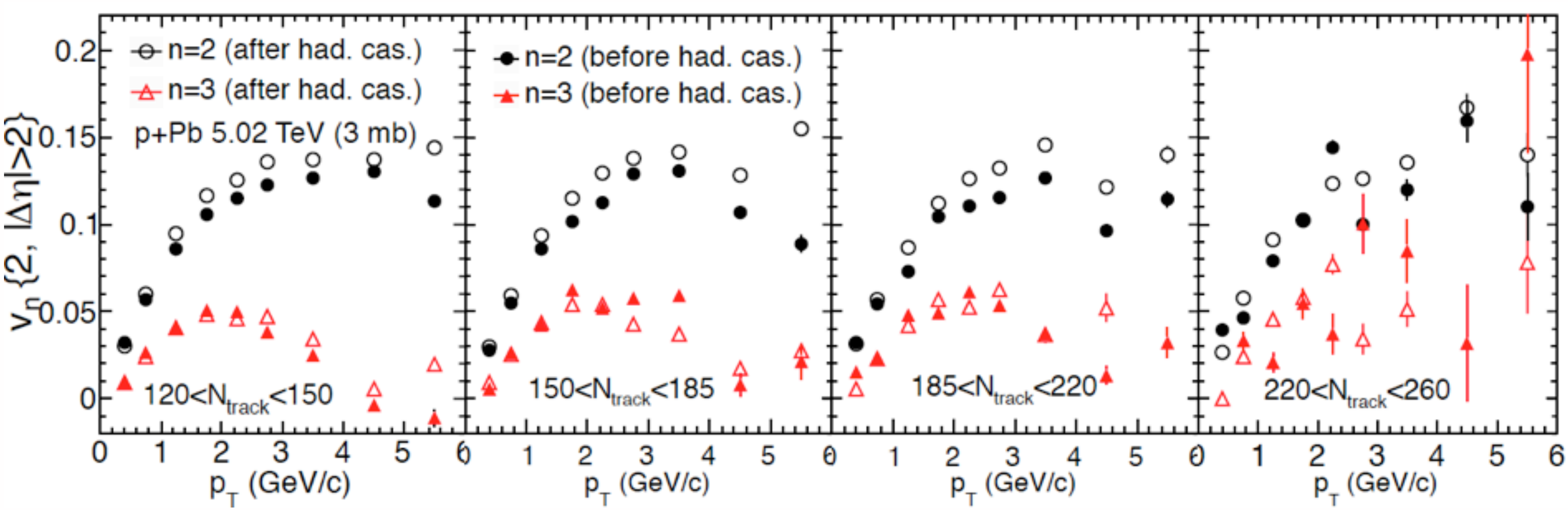
Back up

PID pT spectra in p+Pb



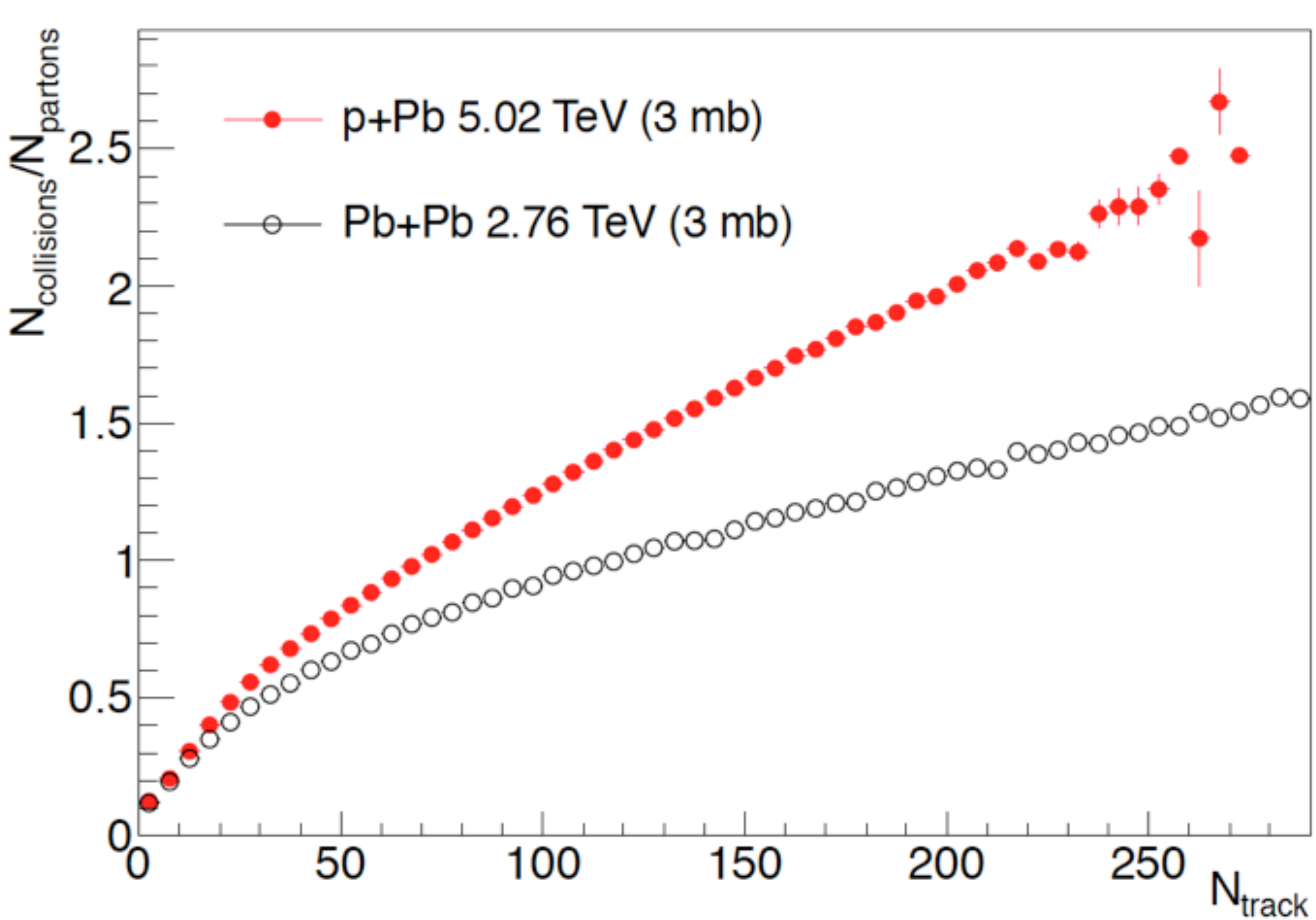
- The AMPT model reproduces the CMS data for pT spectra of pion, Kaon, and proton, within the accuracy of 20%.

Hadron cascade effect



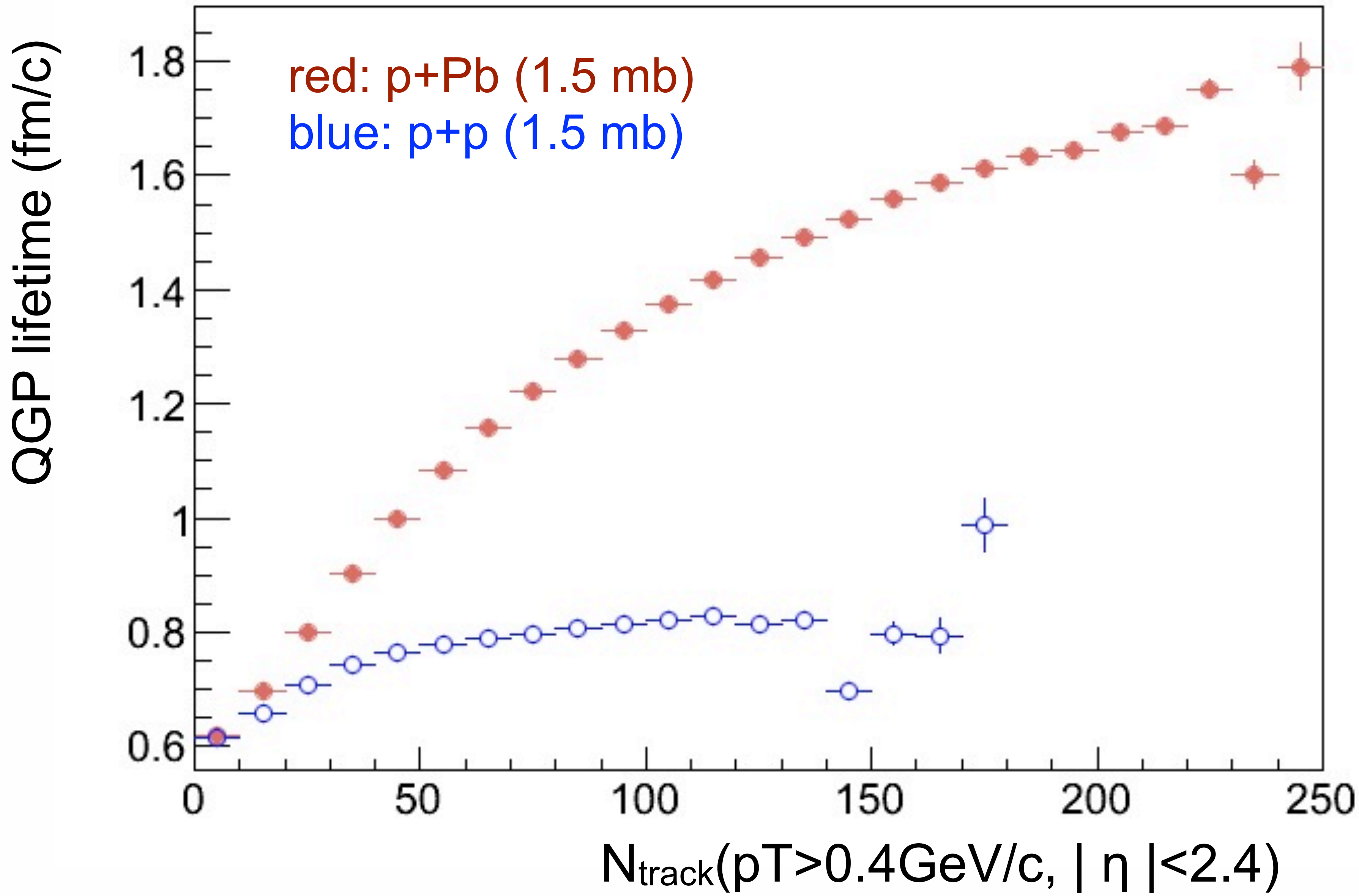
- Hadron cascade has a negligible effect on the p+Pb results.

Elastic scatterings per parton



- The average number of elastic scatterings per parton is ~2 for Ntrack~200 in p+Pb, and changes monotonically with Ntrack.

QGP lifetime in p+p vs p+Pb



- The QGP lifetime is longer for p+Pb than for p+p.