Two-particle angular correlations in heavy ion collisions from an extended multiphase transport model

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Based on PRC 99, 054904 (arXiv:1904.08603),
and on PRC 98, 034912 (arXiv:1808.10641)

In collaboration with Jinhui Chen, Ziwei Lin, Yugang Ma and Song Zhang

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Outline

- Background
- Extended AMPT model
- Current progress
- Summary

● Background:

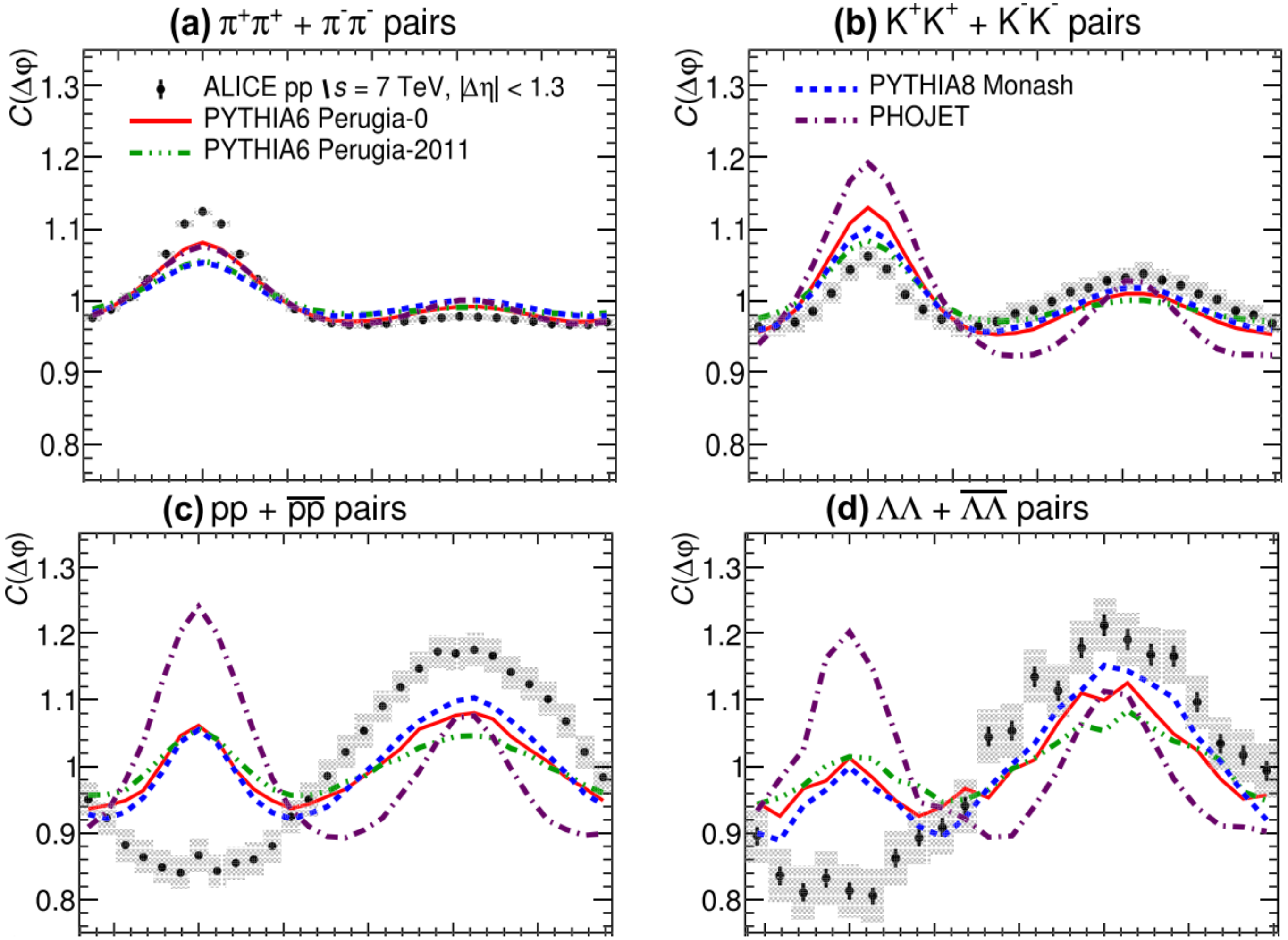
Meson-meson: peak at (Δη,ΔΦ) ~ (0,0)

well reproduced by general purpose Monte Carlo generators.

Generally, the peak is a combination of several effects: fragmentations of hard-scattered partons, higher mass resonance decays, and HBT.

Baryon-baryon: anti-correlation instead of peak .

presents a challenge to Monte Carlo models.



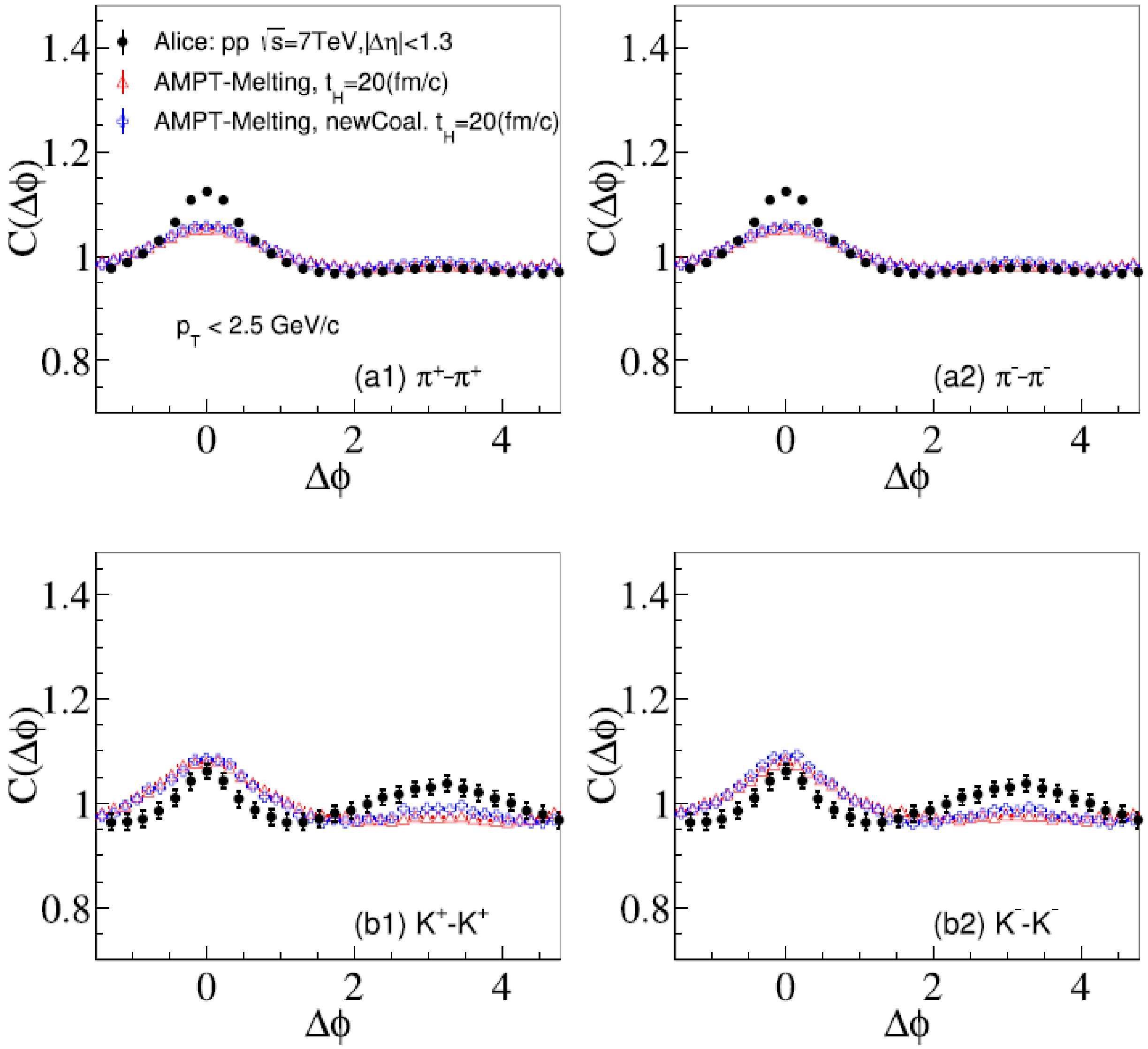
Eur. Phys. J.C(2017)77,569

PRC 98, 034912 (2018)

➢ Meson-meson correlations in pp collisions from AMPT model

For π-π and K-K correlations, the effect between the different quark coalescence model is negligible.

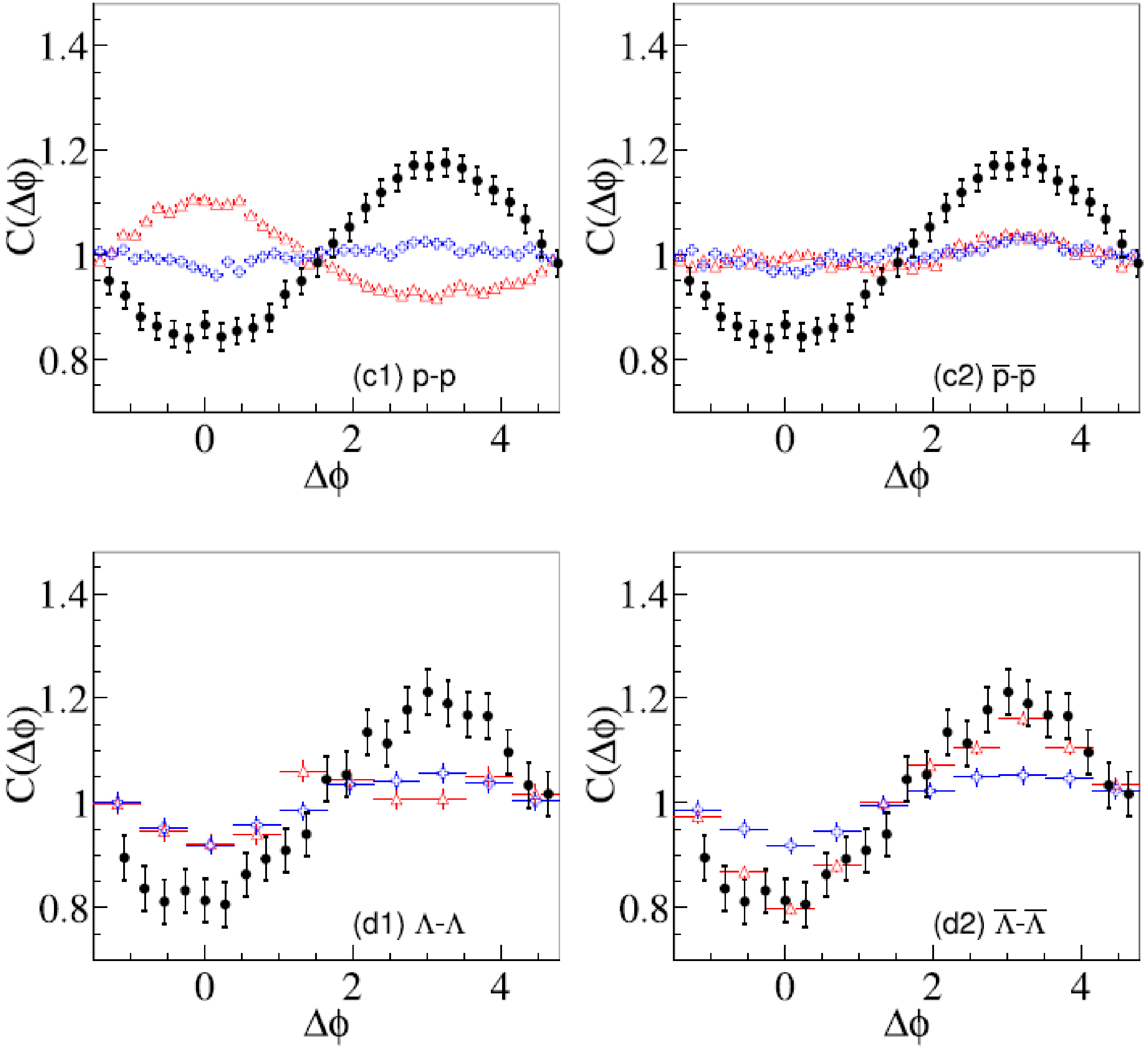
$$C(\Delta\eta,\Delta\Phi) = \frac{S(\Delta\eta,\Delta\Phi)/N_{pairs}^{signal}}{B(\Delta\eta,\Delta\Phi)/N_{pairs}^{mixed}}$$



Correlation functions of pair with the same charge

PRC 98, 034912 (2018)

- Baryon-baryon & anti-baryon-anti-baryon correlations



For baryon-baryon && antibaryon-antibaryon correlations, the new quark coalescence lead to different results.

Extended AMPT model

AMPT(old-Coal):

- searching for a meson partner before searching for baryon or antibaryon partners.
- forcing the numbers of mesons, baryons, and antibaryons in an event to be separately conserved.

AMPT(new-Coal):

- A quark could form either a meson or a baryon depending on the distance to its coalescence partner(s).
- Only the net-baryon number needs to be conserved.

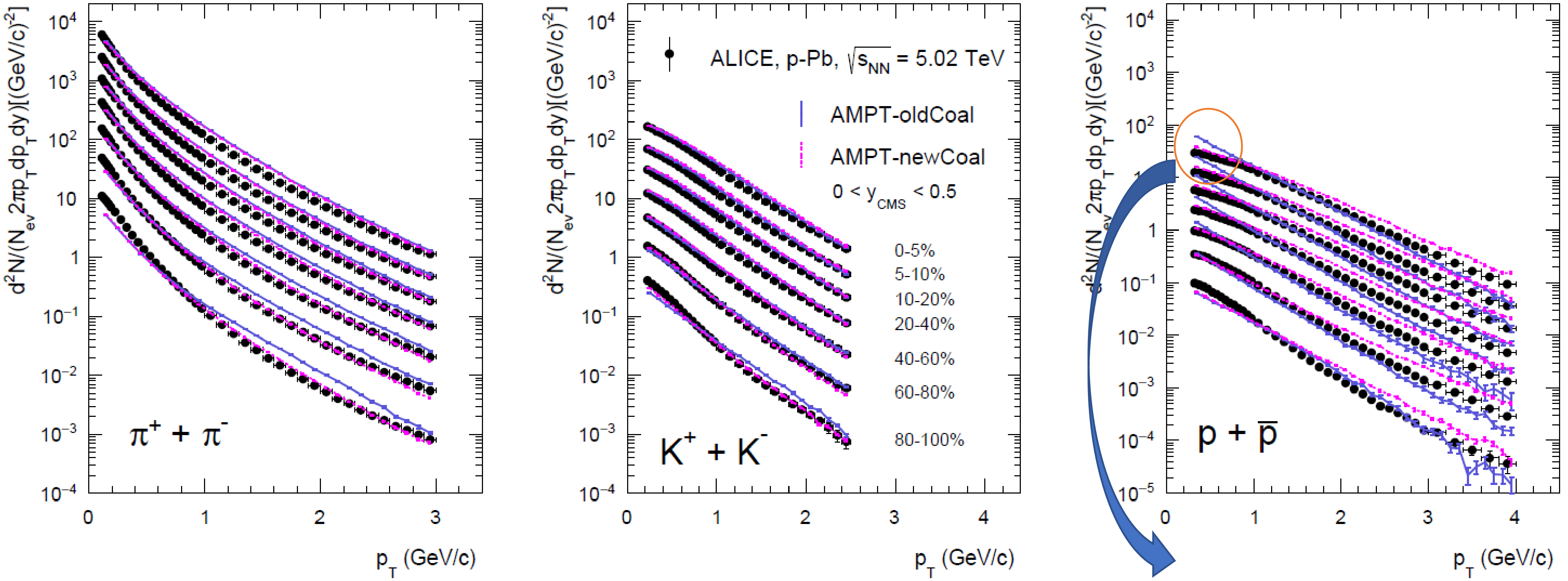
$$d_B < d_M * r_{BM} \ : \text{form a baryon;}$$
$$\text{otherwise} \ : \text{form a meson,}$$

Yuncun He and Zi-Wei Lin, PRC 96, 014910 (2017)

● Current progress

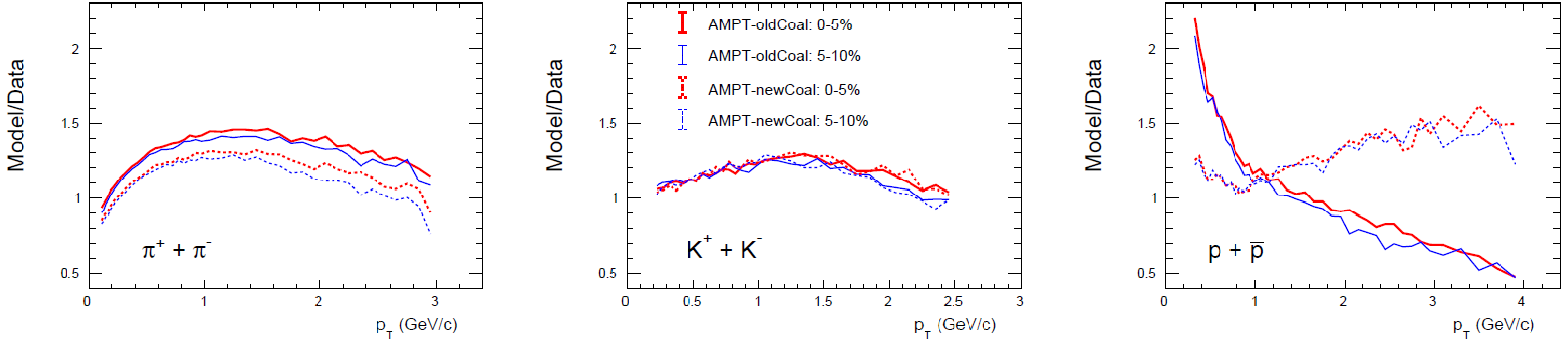
The validity of the AMPT model with new quark coalescence

➢ p_T spectra in p-Pb



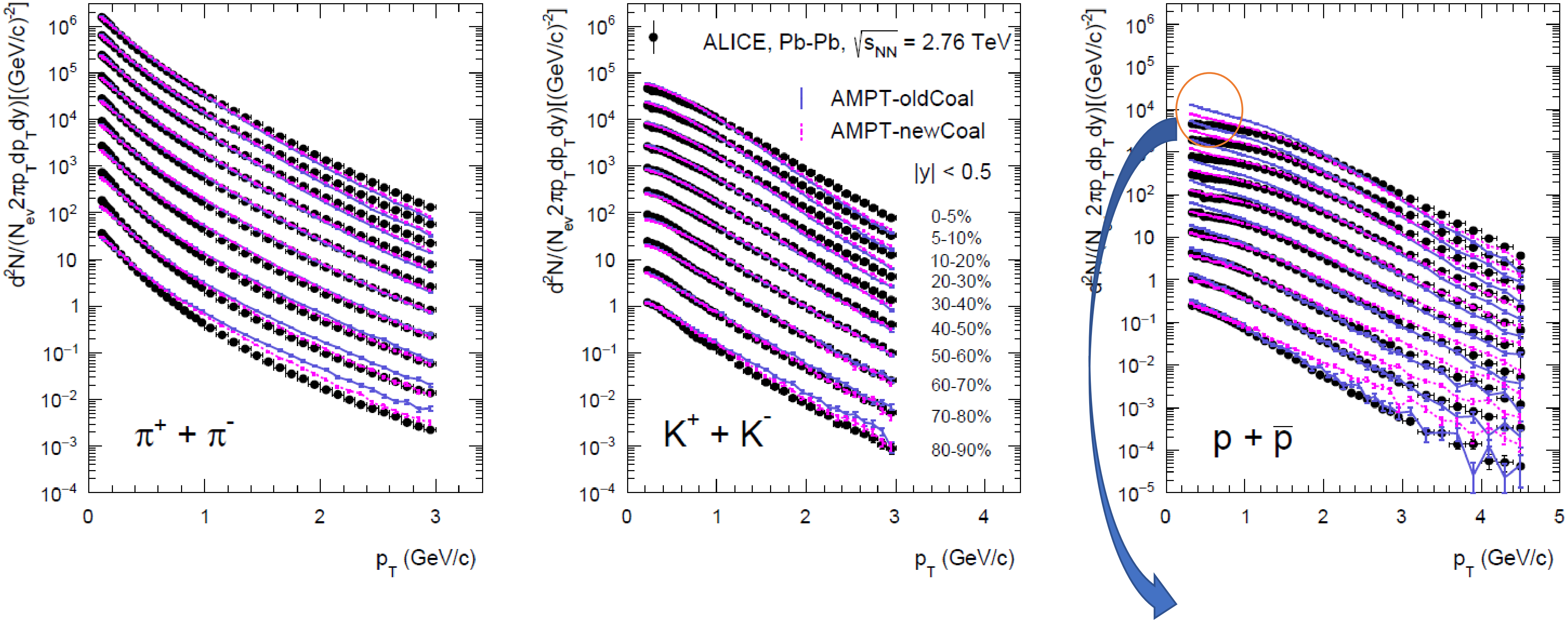
More close to the experimental data for the AMPT model with new quark coalescence

The ratios of AMPT to the experimental data in p-Pb collisions



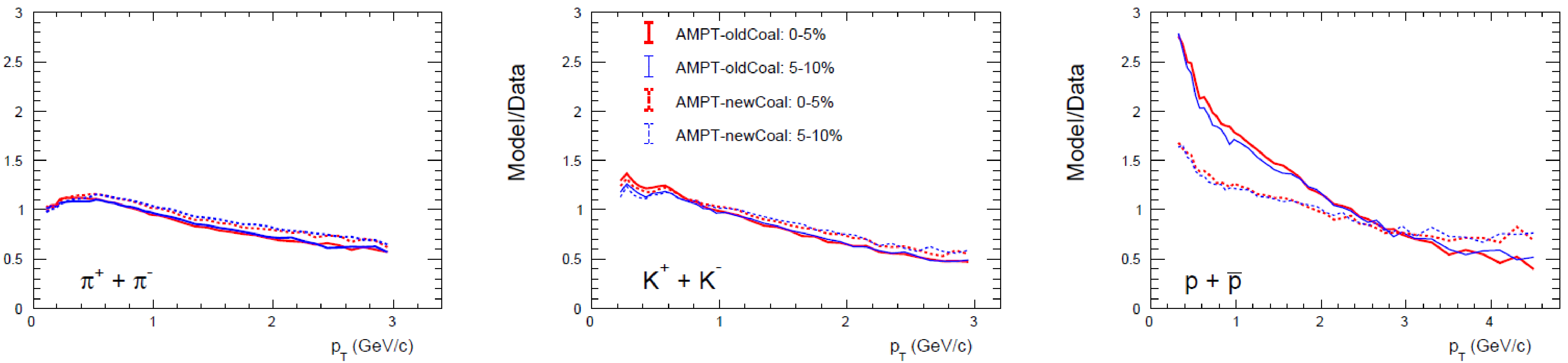
More close to the experimental data for the AMPT model with new quark coalescence

➢ p_T spectra in Pb-Pb



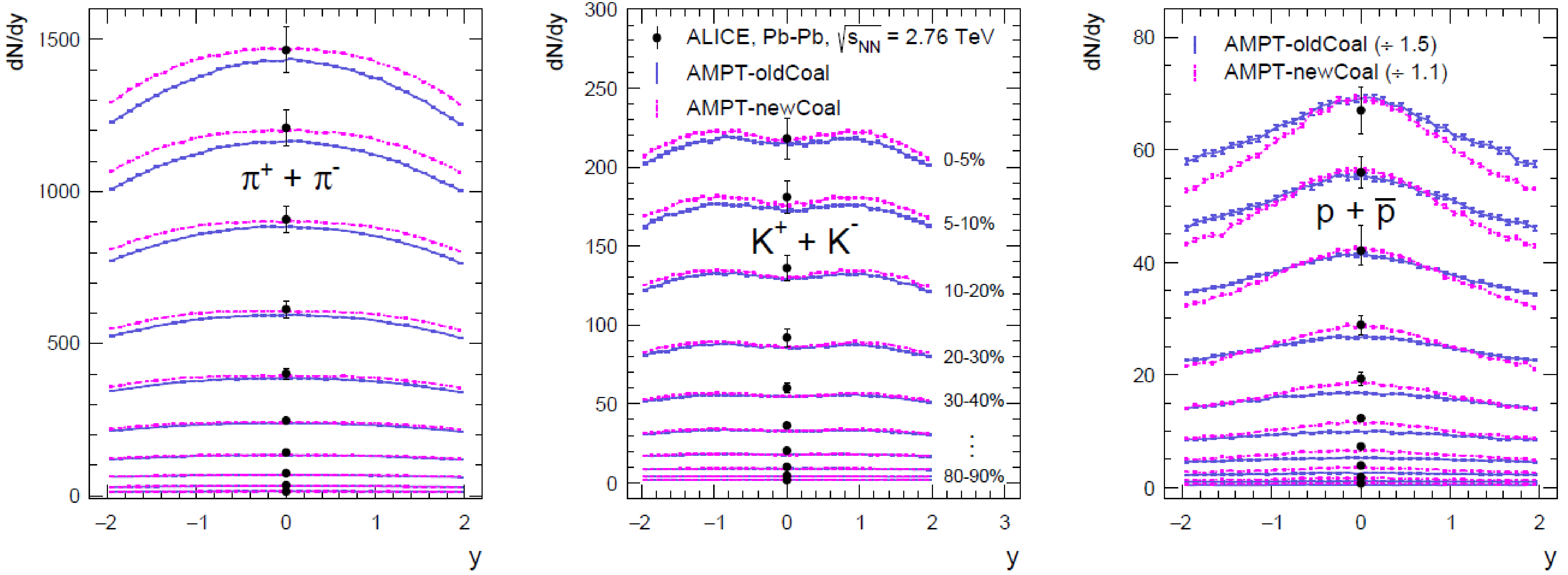
More close to the experimental data for the AMPT model with new quark coalescence

The ratios of AMPT to the experimental data in Pb-Pb collisions



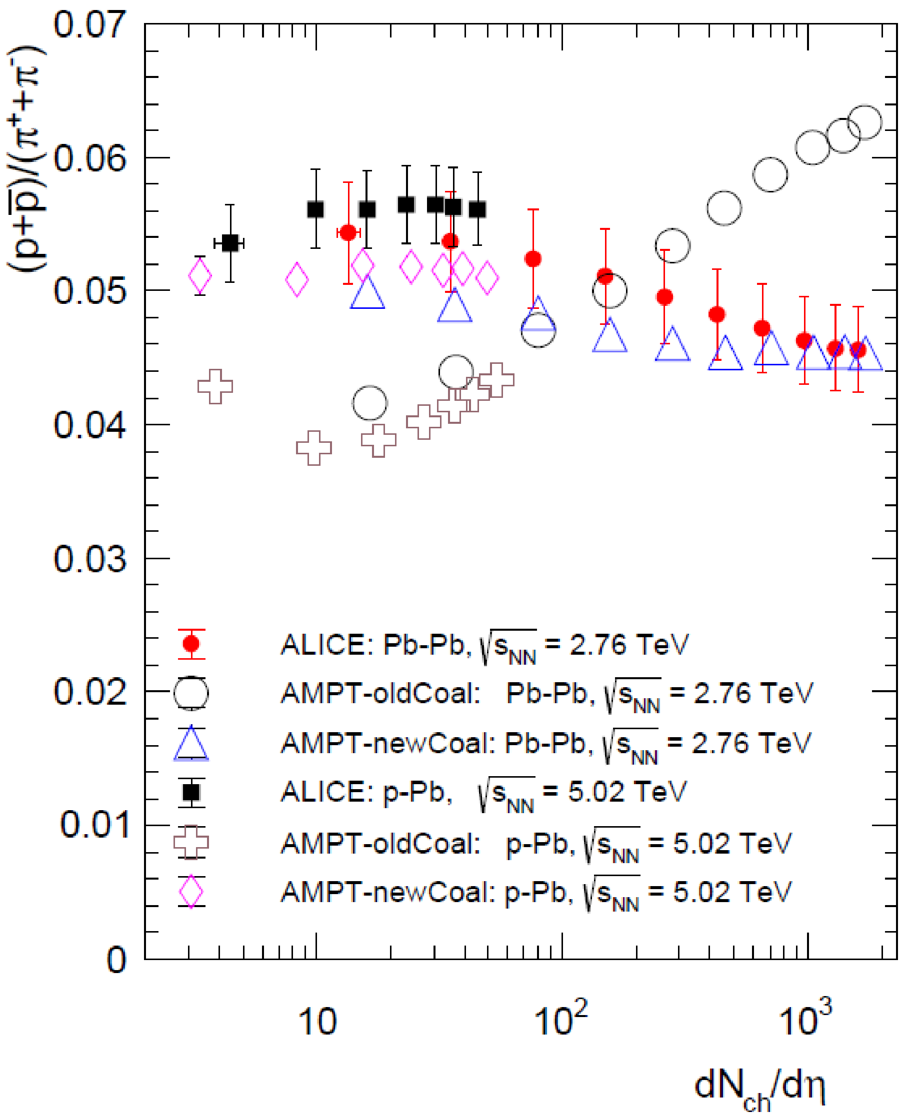
More close to the experimental data for the AMPT model with new quark coalescence

➢ Rapidity density



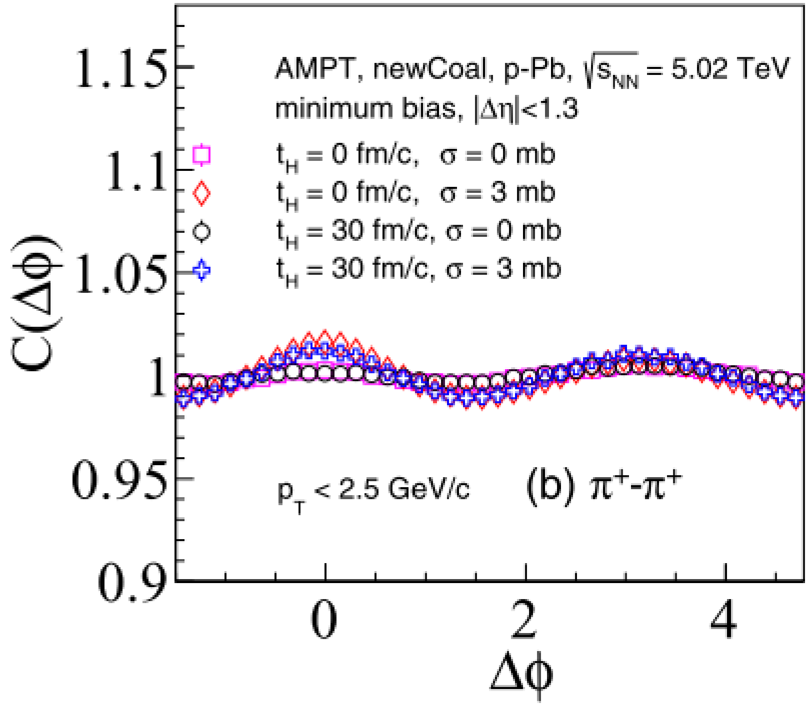
The AMPT model with new quark coalescence is in better agreement with the experimental data at midrapidity than with the old quark coalescence

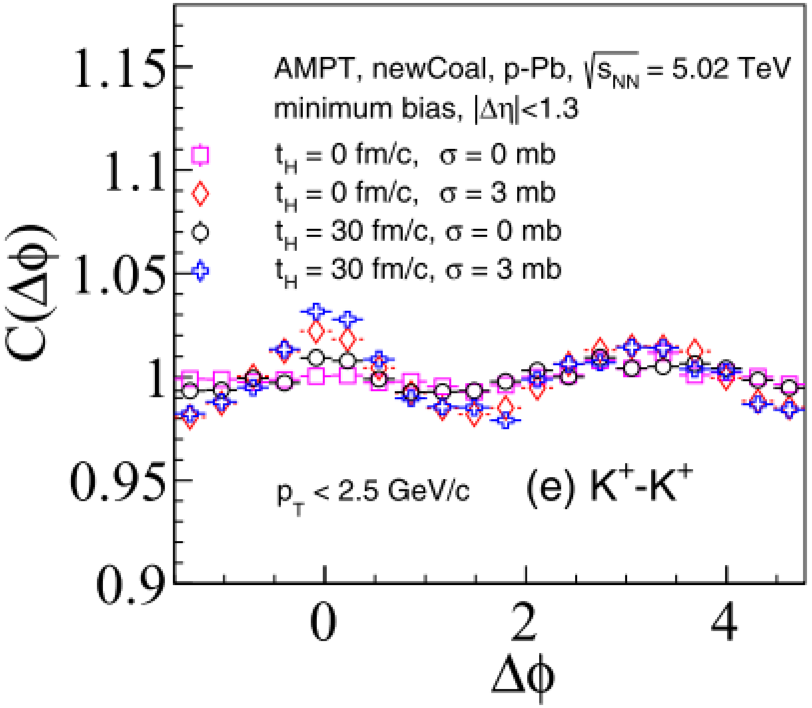
➢ Particle ratios



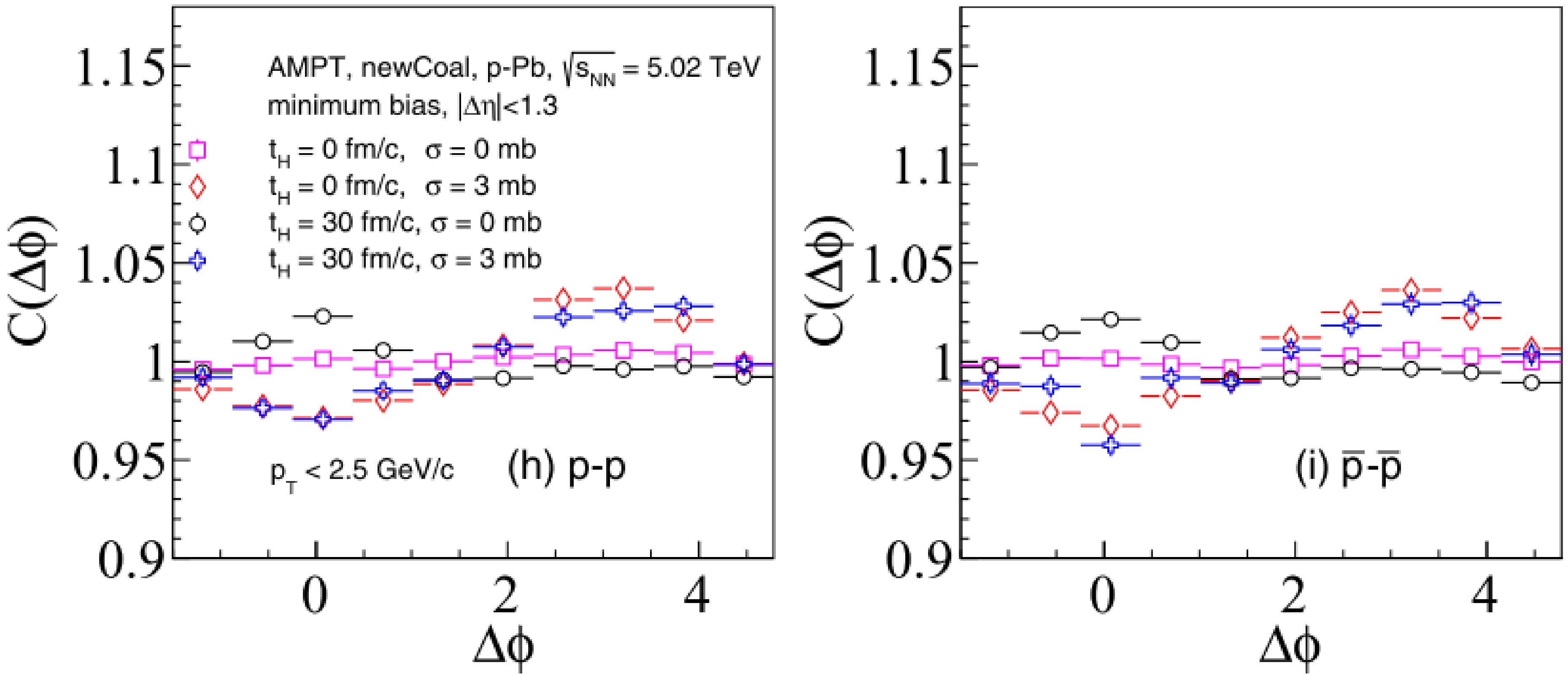
The AMPT model results with new quark coalescence provide a significant improvement

Two-particle angular correlations in p-Pb collisions





For the same-charge meson-meson correlation functions:
the hadronic cascade effect is negligible.
the parton cascade effect is dominated.

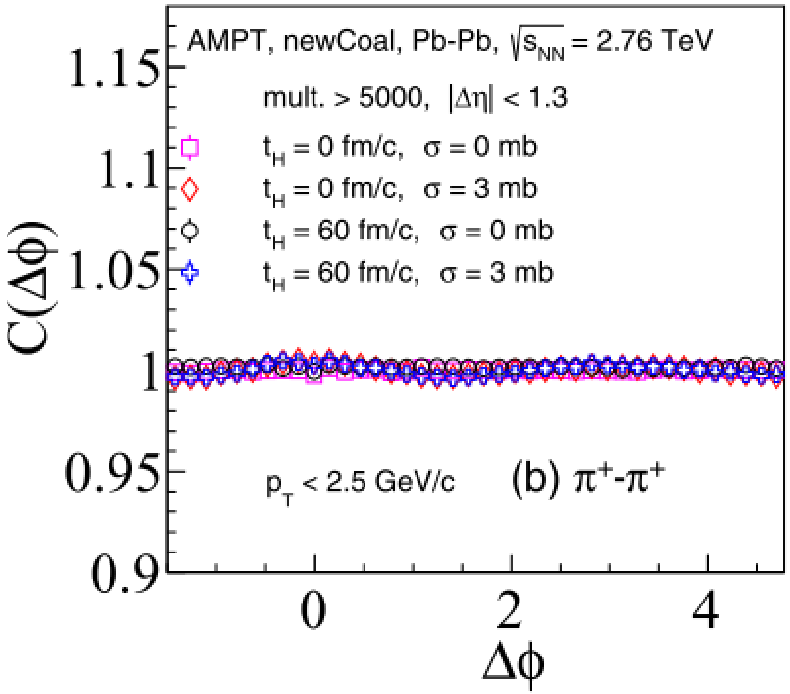


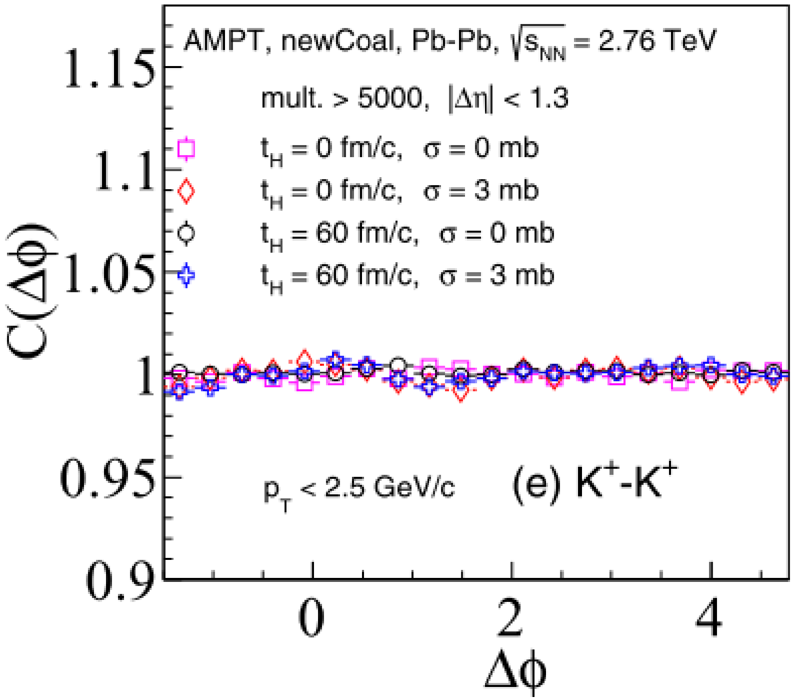
A pronounced depression on near side same-charge baryon-baryon and antibaryon-antibaryon correlation functions with parton cascade.

✓ The parton cascade is important.

✓ New quark coalescence is important.

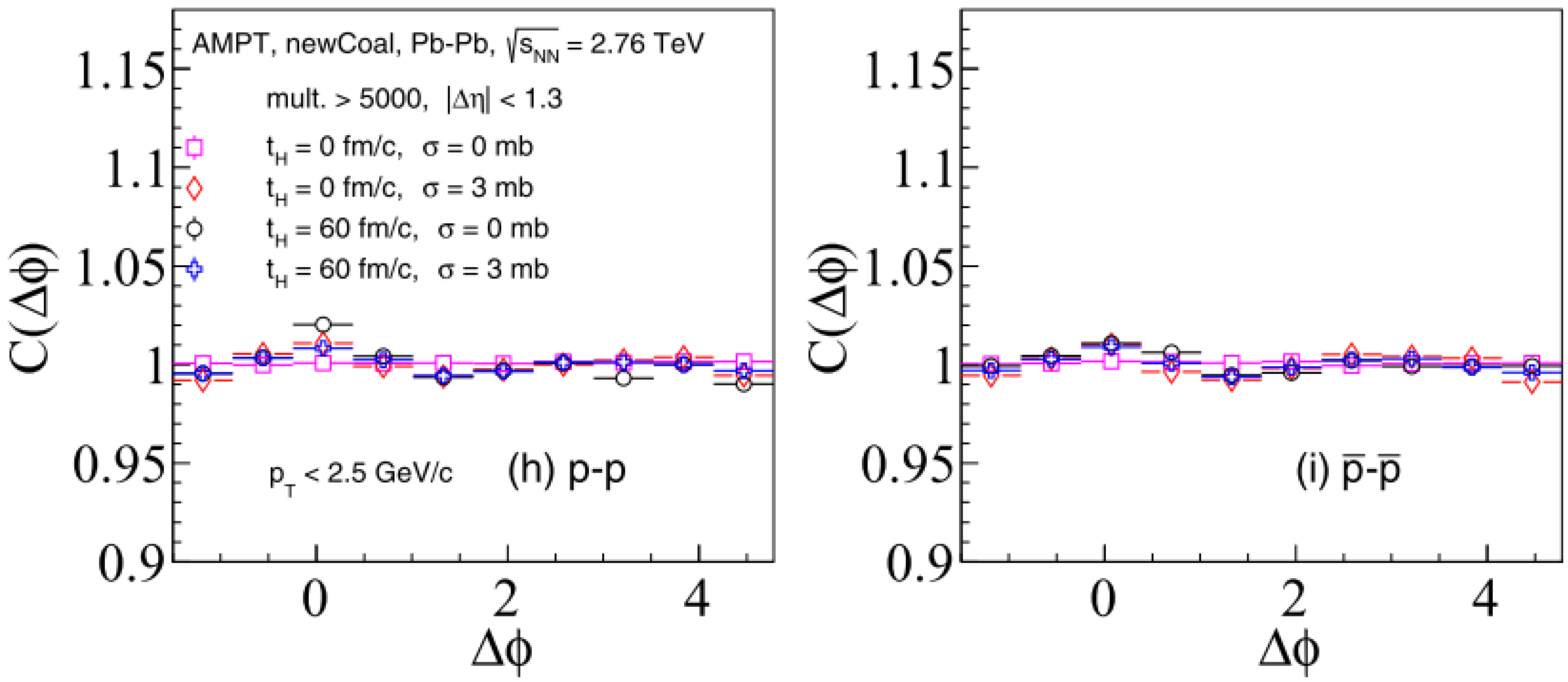
Two-particle angular correlations for central and semi-central Pb-Pb collisions





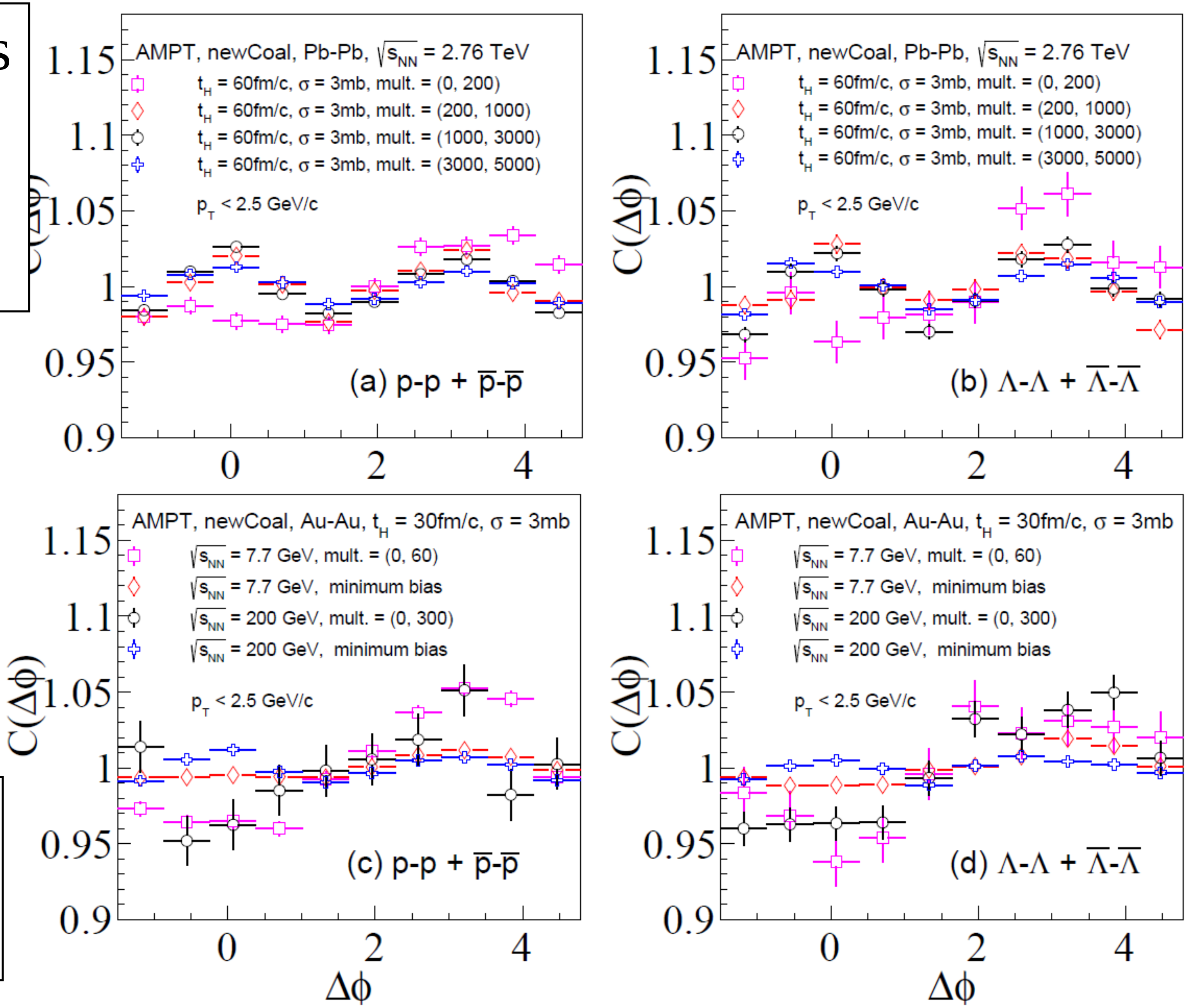
Lower amplitude:

- ✓ There are more uncorrelated particles in events at high multiplicity
- ✓ Particles among the minijets are becoming more uniform in the azimuthal direction.



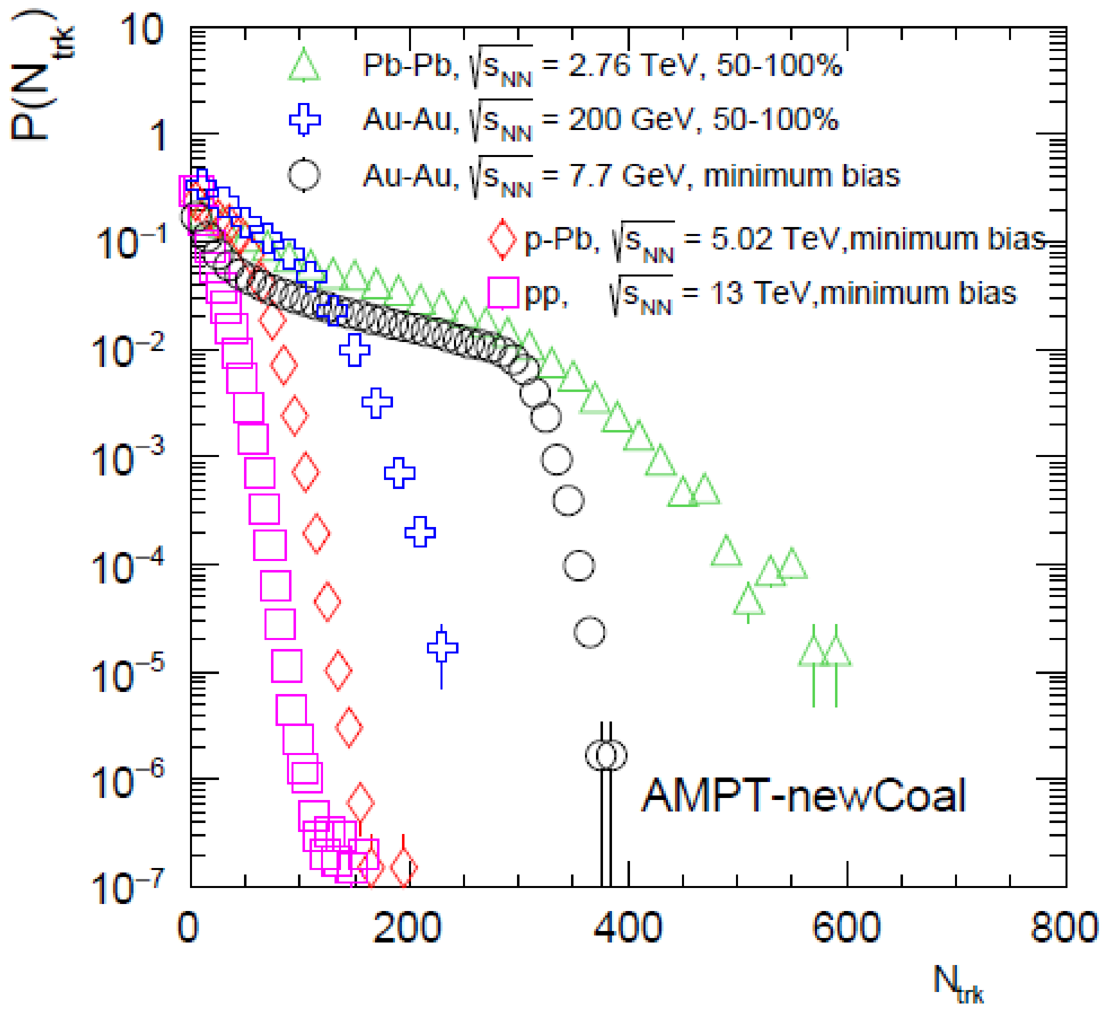
There is no depression in near side.
Hypothesis: baryon-baryon correlations strongly depend on the multiplicity ?

Baryon-baryon correlations in the Pb-Pb/Au-Au collisions within multiplicity intervals

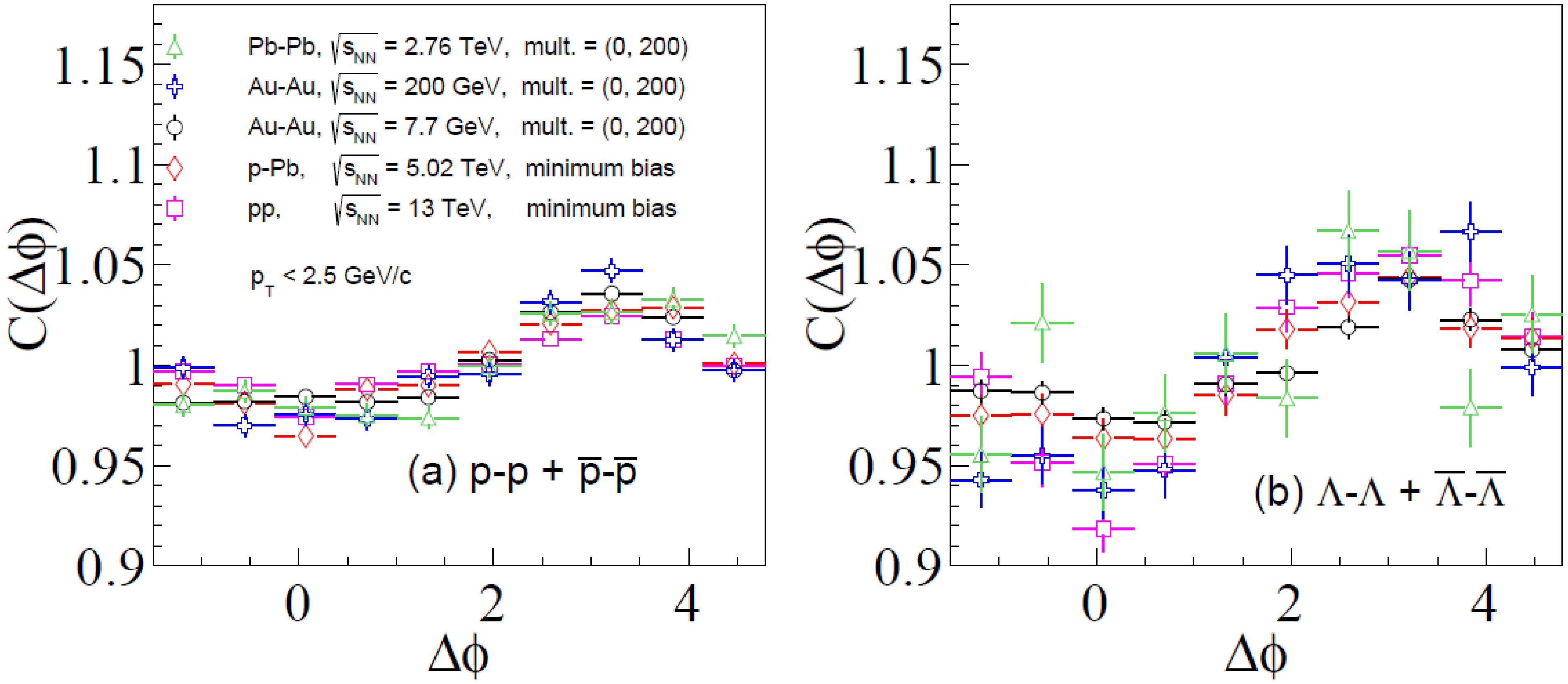


Depression is observed in very peripheral Pb-Pb/Au-Au collisions

The multiplicity distributions



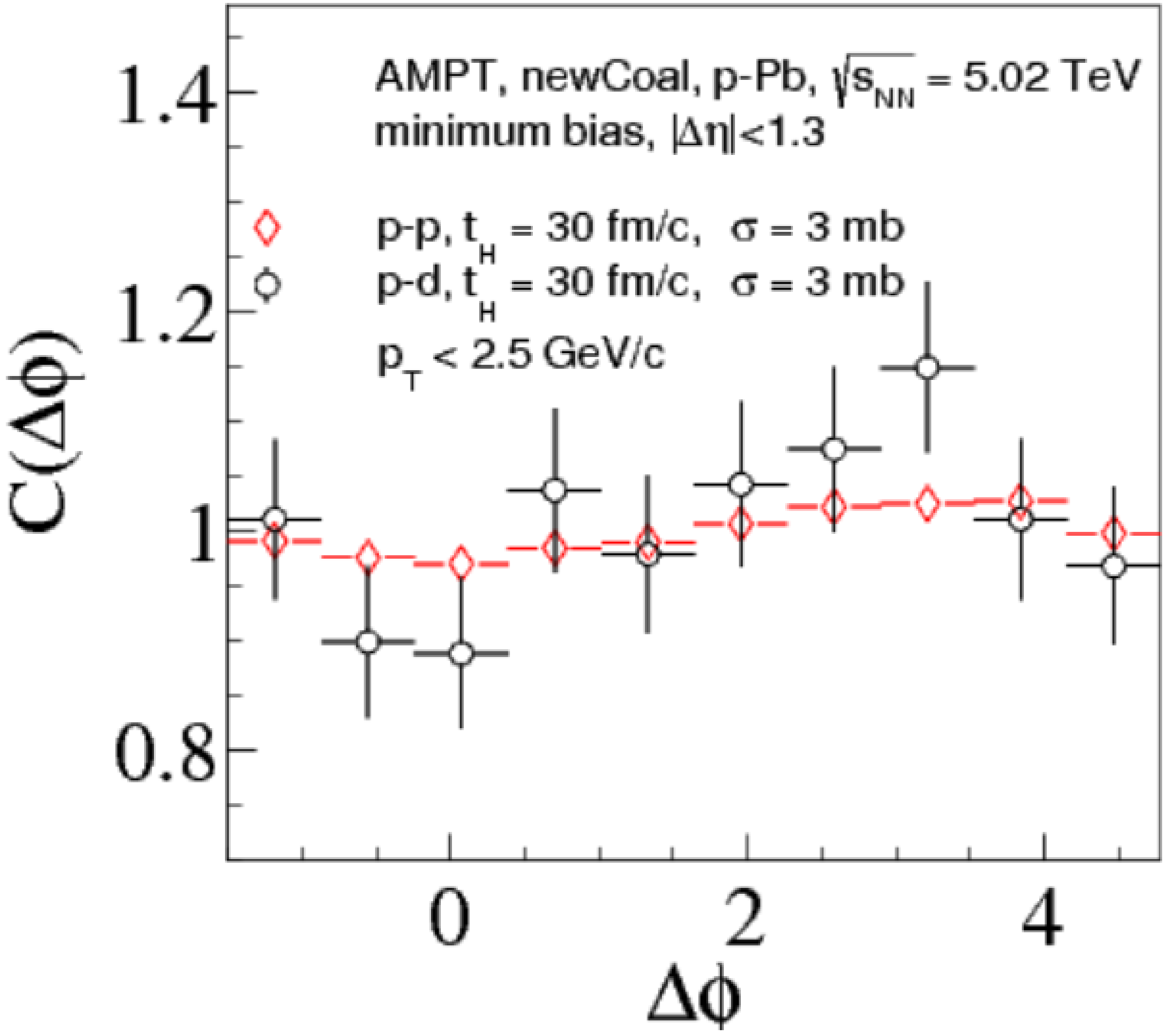
The multiplicity distributions in different collision systems at LHC and RHIC energies share the range of (0,200).



p-p ($\bar{p}$- $\bar{p}$) and Λ-Λ ($\bar{\Lambda}$- $\bar{\Lambda}$) angular correlations from these very different collision systems are very similar and all show the anticorrelation feature.

“if you have an equal mix of q and anti-q and take out of a local volume 3 quarks to form a baryon, you have less quarks than antiquarks left in the local volume and therefore the probability to form, in close neighborhood, baryon is reduced.

-- discussion from Jurgen Schukraft and Zi-Wei lin.



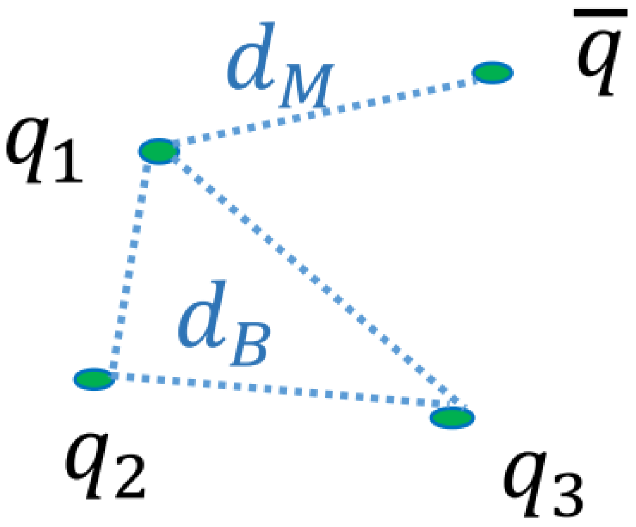
Statistically speaking, the possibility to get a proton is bigger than to get a deuteron for a proton to form a pair in same direction.

Summary:

I. Parton interactions are essential to describe the particle productions in collisions at LHC energies.

II. The new quark coalescence is the important component to lead to the depression structure in baryon-baryon pair angular correlations.

Thanks!



For example, for a quark q_1:

d_M: the closest distance to an antiquark

d_B: the average distance among the 3 quarks after finding closest q_2 & q_3.

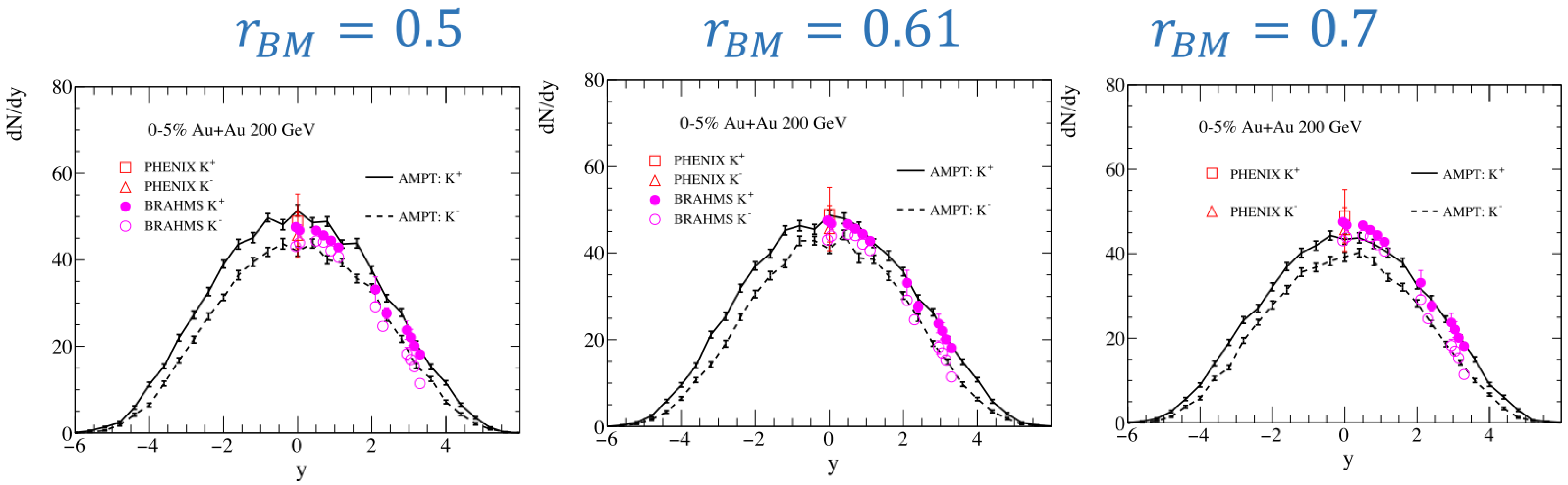
If $d_B < d_M * r_{BM}$, q_1 will coalesce to a baryon;

otherwise, q_1 will coalesce to a meson.

New coalescence parameter r_{BM}

Yuncun He and Zi-Wei Lin

New coalescence



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● Analysis method: two particle correlation

: where $S(\Delta\eta,\Delta\Phi)$ is the distribution of correlated pairs and B(Δη,ΔΦ is the reference distribution

$$S(\Delta\eta,\Delta\Phi) = \frac{d^2 N_{paris}^{signal}}{d\Delta\eta\Delta\Phi}$$

: where N_{paris}^{signal} is the number of pairs of particles.

$$B(\Delta\eta,\Delta\Phi) = \frac{d^2 N_{paris}^{mixed}}{d\Delta\eta\Delta\Phi}$$

: where N_{paris}^{mixed} is the number of pairs of particles.

$$C(\Delta\Phi) = A \times \frac{\int S(\Delta\eta,\Delta\Phi)\Delta\eta}{\int B(\Delta\eta,\Delta\Phi)\Delta\eta}$$

: normalization constant A is determined by $N_{paris}^{signal} / N_{paris}^{mixed}$