Nuclear modification factors of (anti-)hadrons and light (anti-)nuclei in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV

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Introduction

As an essential measurement, nuclear modification factor R_{AA} of transverse momentum p_T, can be used to investigated the jet quenching effect (parton energy loss) which is the main probe to explore the quark-gluon plasma (QGP) in nucleus-nucleus collisions at RHIC and LHC energies. Also, high energy collision systems can povide information on (anti-)hadrons and (anti-)nuclei production, which is applied as references to study the matter-antimatter asymmetry mechanisms. Experimentally, recent measurement data of R_{AA} in Pb-Pb collision from ALICE and CMS experiments have been published in succession.As for numerical model aspect, PACIAE+DCPC model was developed to simulate dfferent collsion physics systems, can study the quark, hadron and nucleus level. Here we choose this model to first study the R_{AA} of (anti-)hadrons and (anti-)nuclei in nucleus-nucleus collisions.

PACIAE model

Comput. Phys. Commun.**183**, 333 (2012)

（Parton and hadron cascade model）

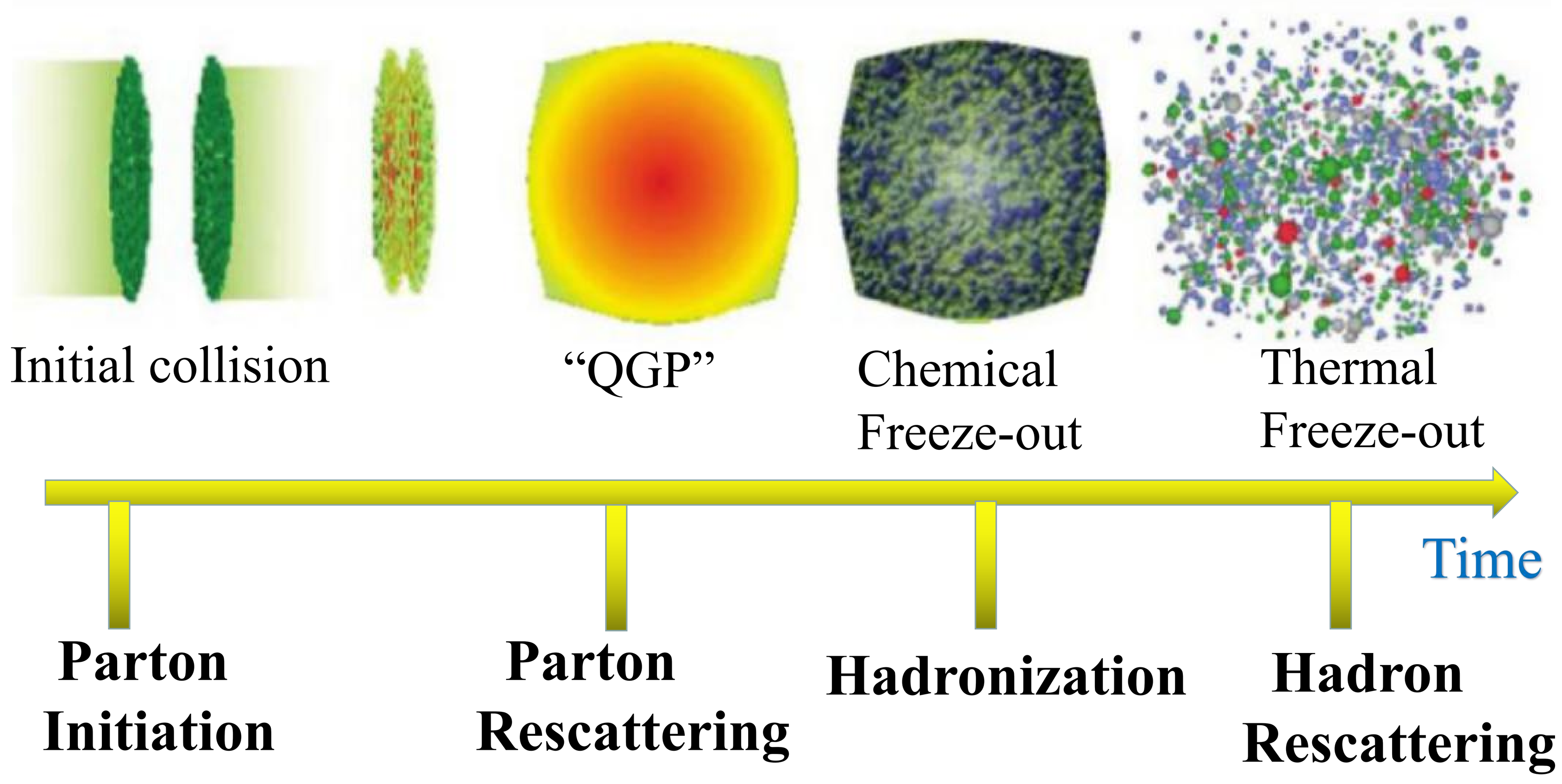

Fig.1 Cartoon of a relativistic heavy-ion collision

DCPC model

Phys. Rev. C**86**, 054910 (2012)

（Dynamically constrained phase space coalescence model）

- Uncertainty principle: $$\Delta\vec{q}\Delta\vec{p} \geqslant h^3 \quad (1)$$

The yield of a single particle: $$Y_1 = \int_{H \leqslant E} \frac{d\vec{q}\,d\vec{p}}{h^3} \quad (2)$$

The yield of N particles cluster: $$Y_N = \int \cdots \int_{H \leqslant E} \frac{d\vec{q}_1\,d\vec{p}_1 \cdots d\vec{q}_N\,d\vec{p}_N}{h^{3N}} \quad (3)$$

- Constraint conditions: $$m_0 \leqslant m_{inv} \leqslant m_0 + \Delta m \quad (4)$$

$$q_{ij} \leqslant D_0 (\ i \neq j; j = 1, 2, ..., N) \quad (5)$$

Conclusions

- The PACIAE+DCPC model can be sccessfully applied to reproduce the spectra of (anti-)hadrons and (anti-)nuclei up to 6.0 GeV/c in high energy collisions.
- The NFM distributions of (anti-)particles show the similar trend with p_T increase for different centrality bins when $0 < p_T < 6.0$ GeV/c, i.e., first increase, reach a peak, and then decrease.
- The NFM of hadrons and nuclei, p_T ratio and double ratio R_{AA}^{D} of p-to-pion and d-to-p, all behave the same with those of their corresponding anti-particles in Pb-Pb collisions.

Appendices

- Nuclear modification factor (NFM)

$$R_{AA}(p_T) = \frac{d^2N_{ch}^{AA}/d\eta dp_T}{\langle T_{AA}\rangle d^2\sigma_{ch}^{pp}/d\eta dp_T}$$

$\langle T_{AA} \rangle$: nuclear overlap function by Glauber model;

d^2N_{ch} : charged particles yield per event in A-A collision;

$d^2\sigma_{ch}$: charged particle cross section in pp collision;

η : pseudorapidity, $\eta = -\ln[\tan(\theta/2)]$

Results

PLB**754**,360; PRC**93**,024917; 034913(2016); PRC**97**,024615(2018)

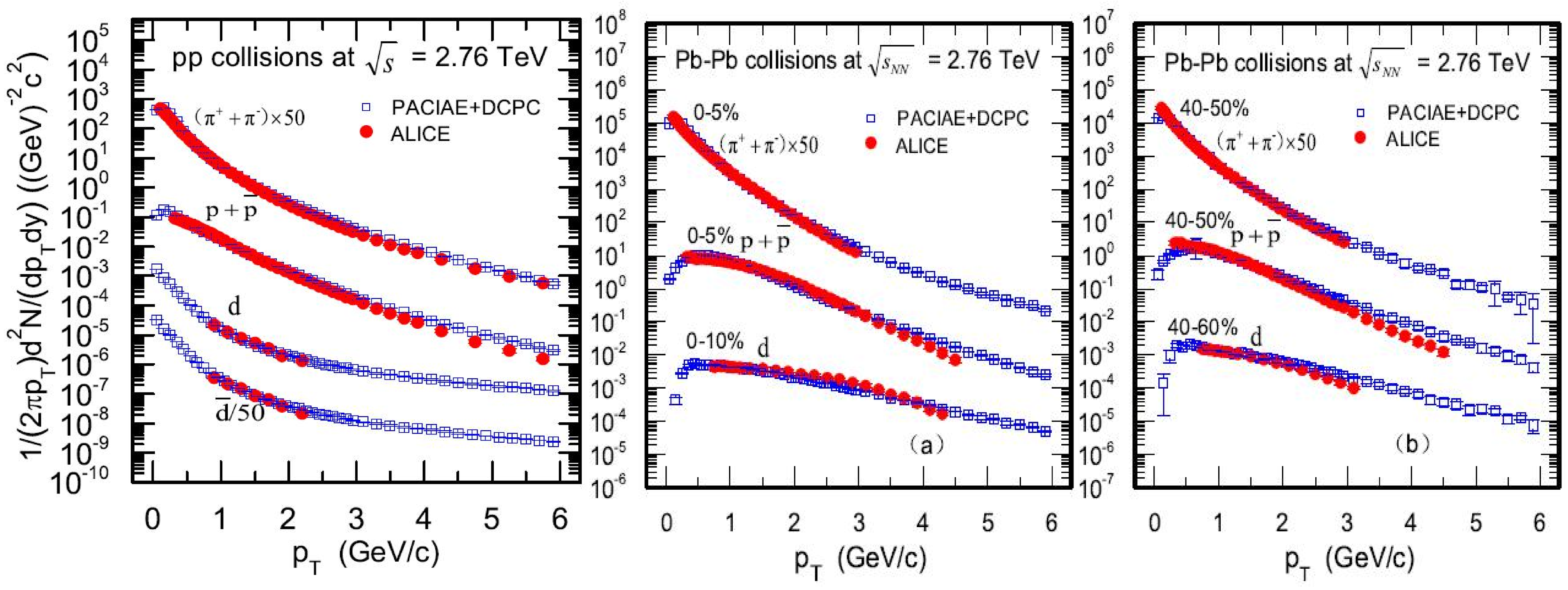

Fig.2 The transverse momentum spectra of π, p and d in pp and Pb-Pb collisions at $\sqrt{s_{NN}}$ =2.76 TeV for different centrality bins.The PACIAE+DCPC model results are compatible with the ALICE data.

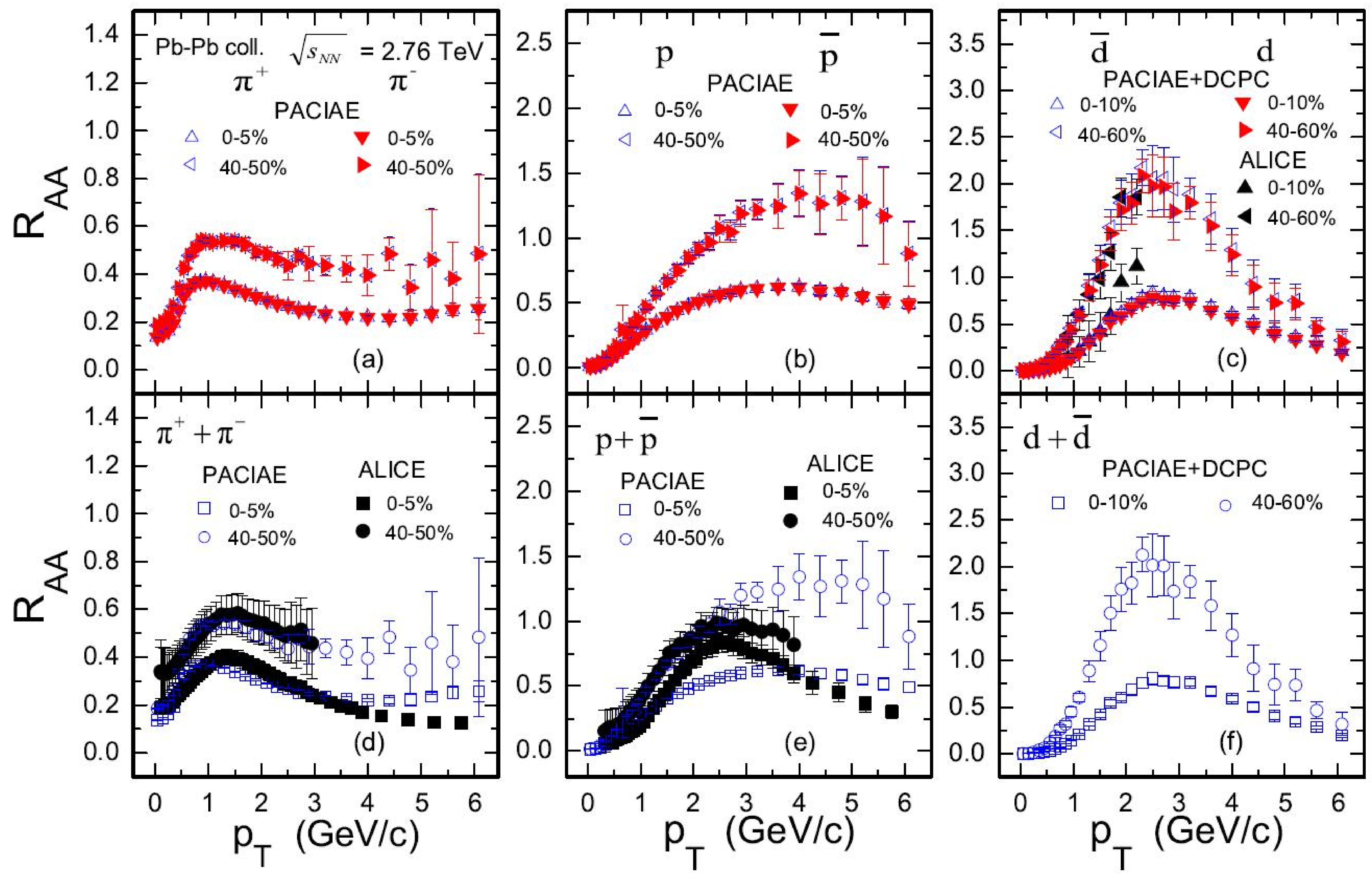

Fig.3 The nuclear modification factor R_{AA} of (anti-)hadrons and (anti-)nuclei first increases, reaches a peak, and then decreases with p_T for all centralities at p_T < 6.0 GeV/c. The behaviors R_{AA} of antiparticles with corresponding particles are found to be similar. The NMF ratios in central collision events are more suppressed than in peripheral collision events.

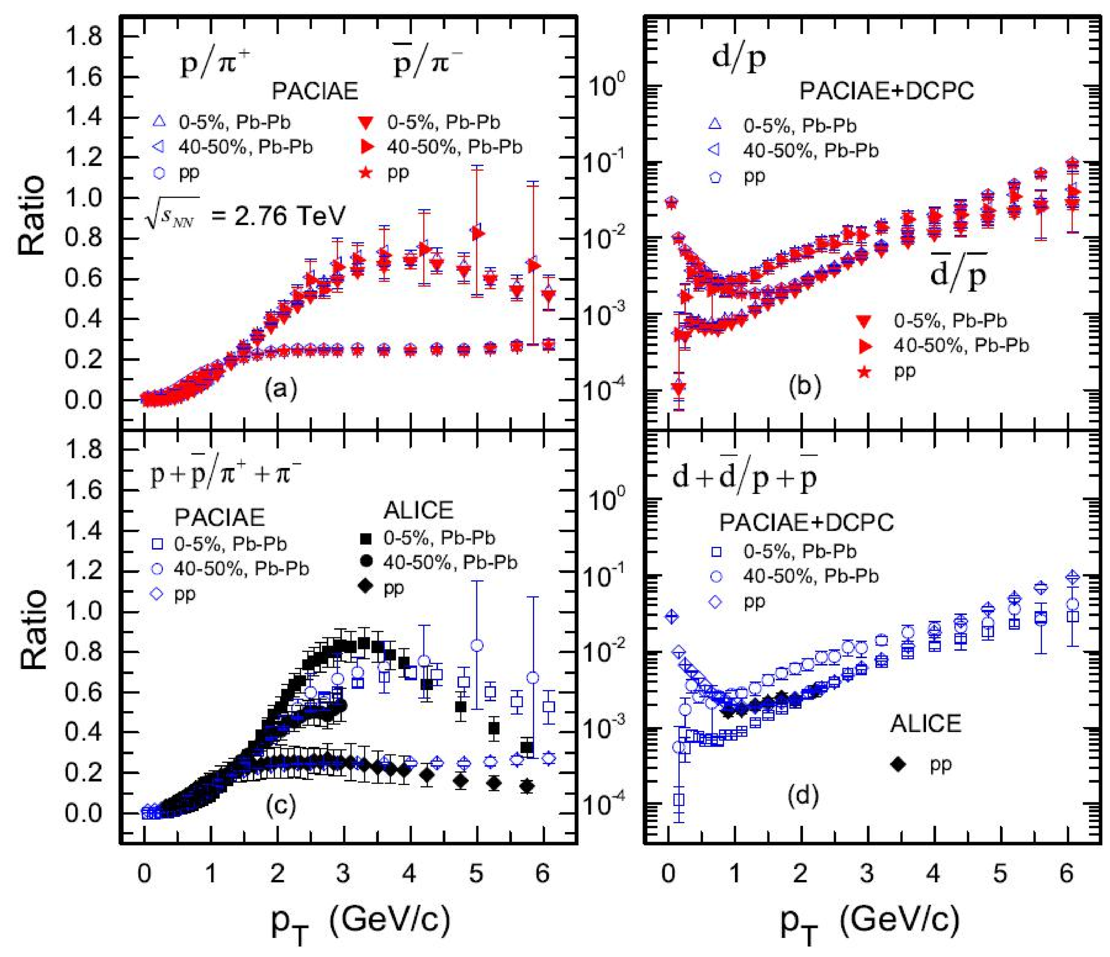

Fig.4 The p_T spectra ratios of proton-to- pion and deuteron-to-proton by PACIAE+DCPC model are similar with ALICE data in pp and each different centrality Pb-Pb collisions.

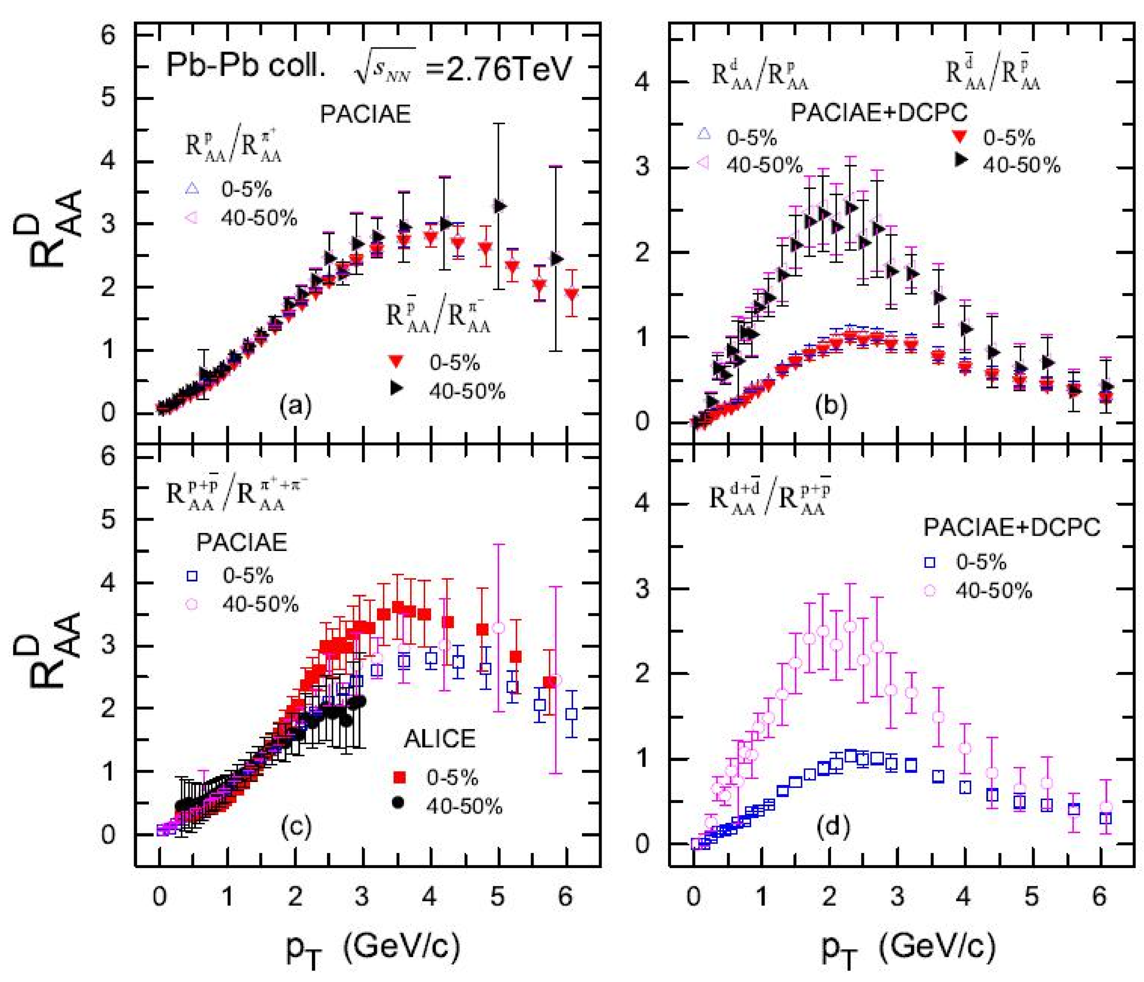

Fig.5 The double NMF ratio R_{AA}^{D} for p-to-π and d-to-p predicted by the PACIAE + DCPC model are similar with their corresponding anti-matters in different centrality bins.

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