Insights into Nuclear Modification Factors in O-O collisions at LHC energies with a transport model

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Outline:

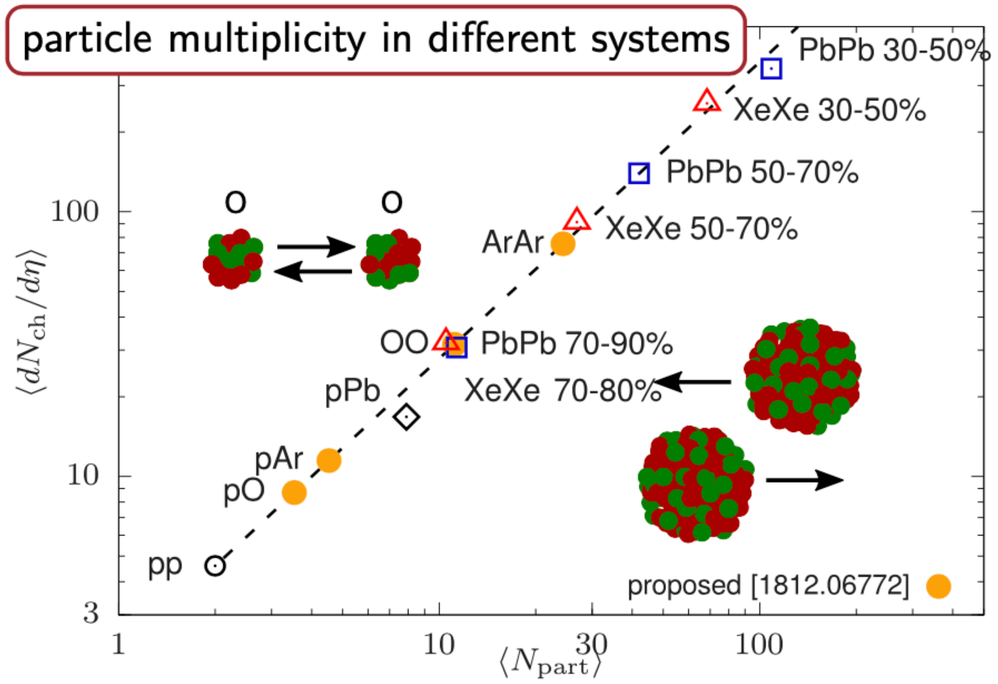
1. Physics motivation
2. Global observables
3. Anisotropic flow
4. Nuclear modification factor
5. Results
6. Summary

Physics Motivation:

- *Special interest to Oxygen-Oxygen collisions as:*
  1. It may help to investigate the origin of small system collectivity
  2. It may help to probe the signatures of exotic **α-cluster** structure
  3. Particle production mechanism in a multiplicity range that bridges pp and p-Pb on the lower side, and Xe-Xe and Pb-Pb on the higher side of the multiplicity

- Investigating nuclear modification factor (R_{AA}) in the multiplicity range similar to O-O and Pb-Pb collisions

- Effect of density profiles on R_{AA} in O-O collisions

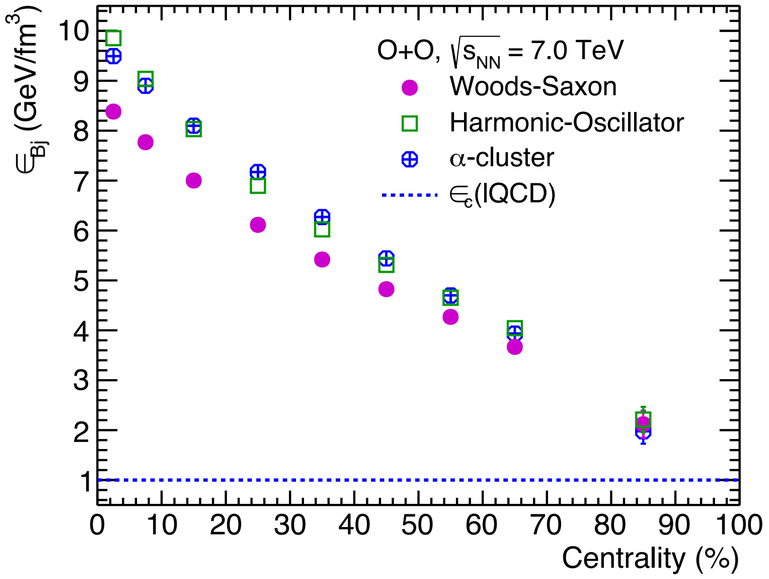


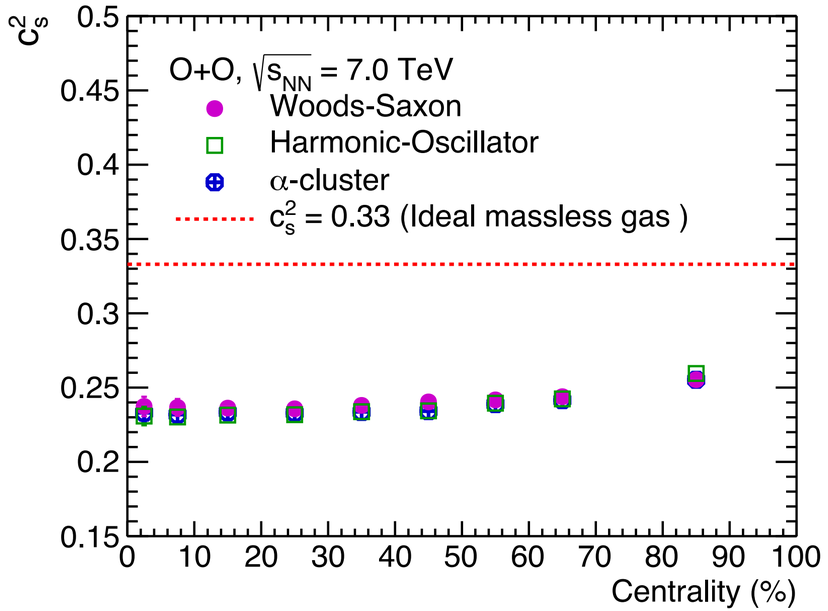
System size scan with light-ion collisions at LHC

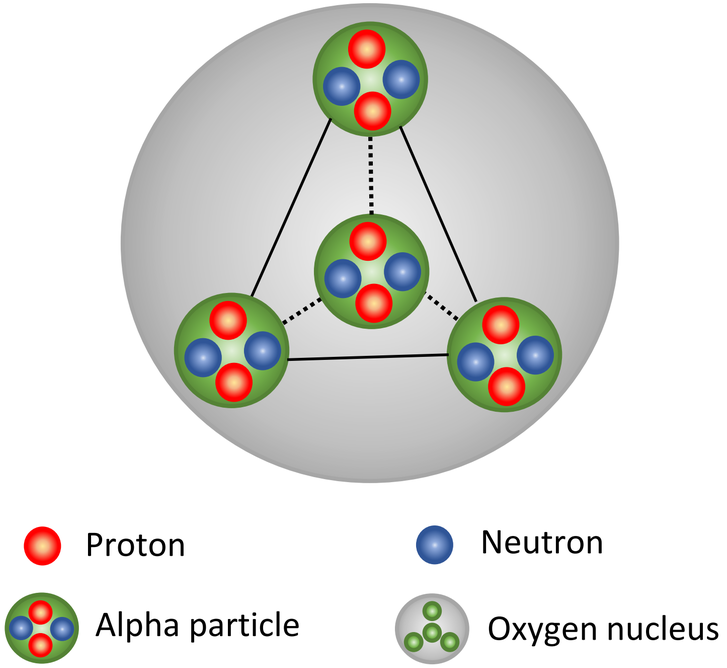
Z. Citron, A. Dainese et al, arXiv:1812.06772

Global observables:

- ϵ_{Bj} is found to be higher for most central collisions and linearly decreases from central to peripheral collisions
- Within uncertainty c_s^2 is found to be similar as a function of centrality for three density profiles



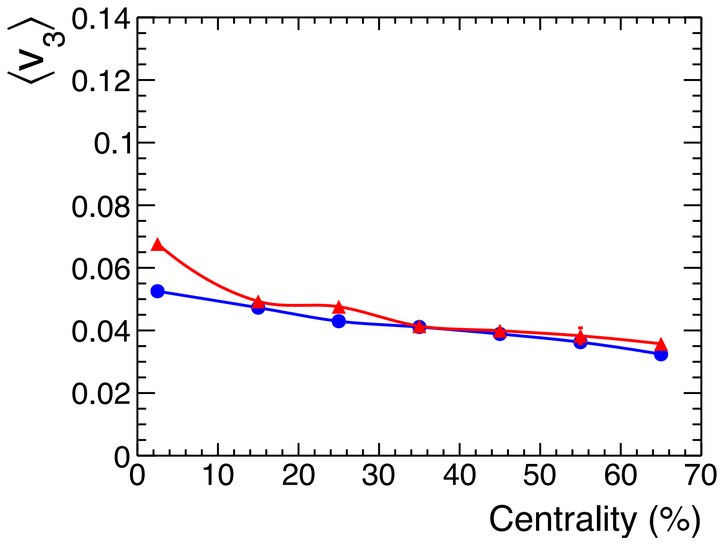


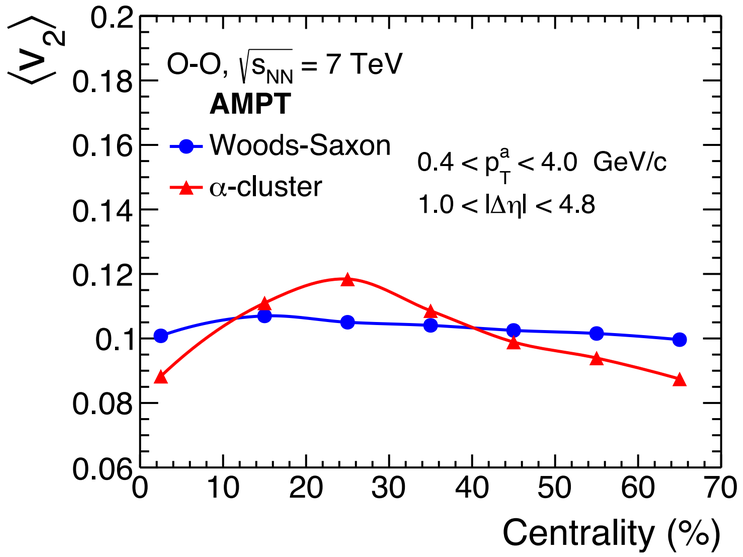


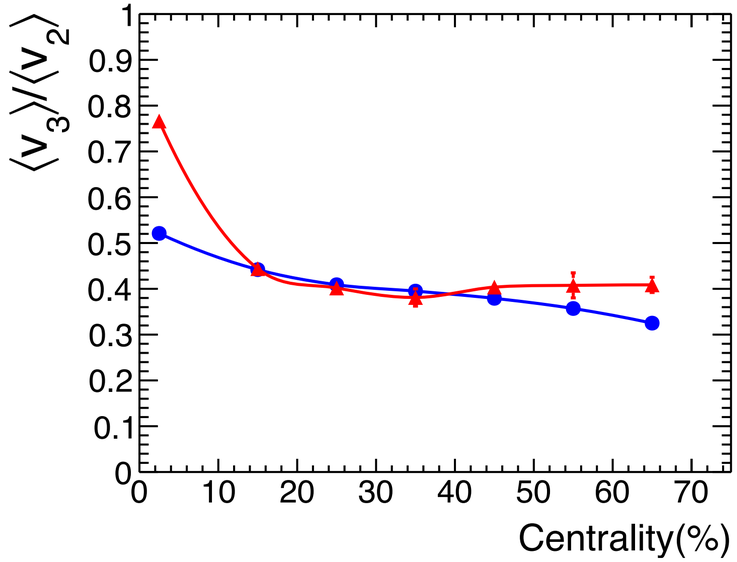
[D. Behera, N. Mallick, S. Tripathy, S. Prasad, A.N. Mishra, and R. Sahoo, Eur. Phys. J. A , 58, 175 (2022)]

Anisotropic flow:

- Elliptic flow is found to depend weakly on the centrality of the collisions for Woods-Saxon density profile, however in α-clustered nucleus, it increases from increases from central to mid-central collisions and then decreases while moving from mid to peripheral collisions
- Enhancement in the $\langle v_3 \rangle / \langle v_2 \rangle$ towards the most central collisions for the α–clustered nucleus than the Woods-Saxon case

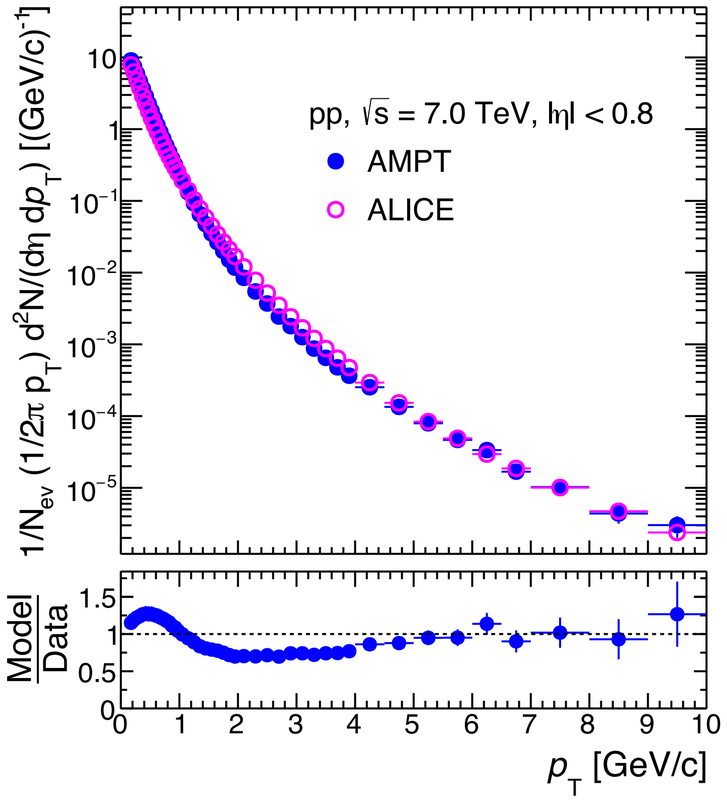


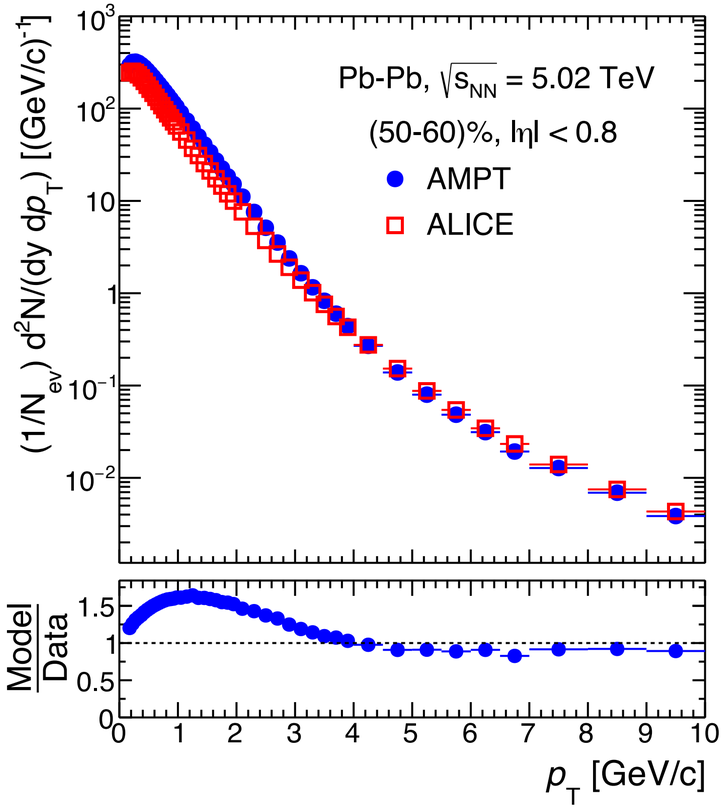


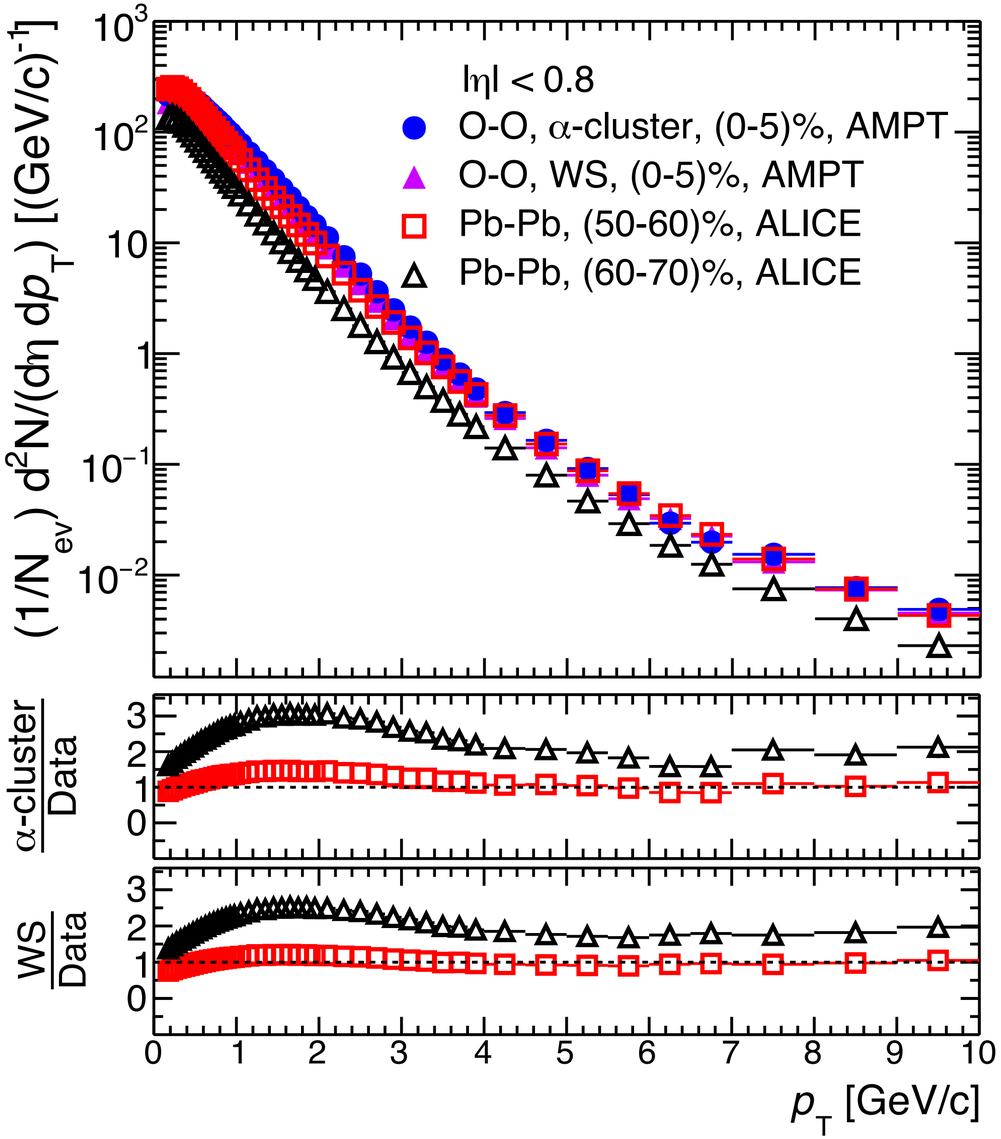


[D. Behera, S. Prasad, N. Mallick, and R. Sahoo, Phys. Rev. D 108, 054022 (2023)]

Transverse momentum spectra:







- O-O collisions corresponding to (0-5)% centrality approximately agrees with (50-60)% centrality of Pb-Pb collisions

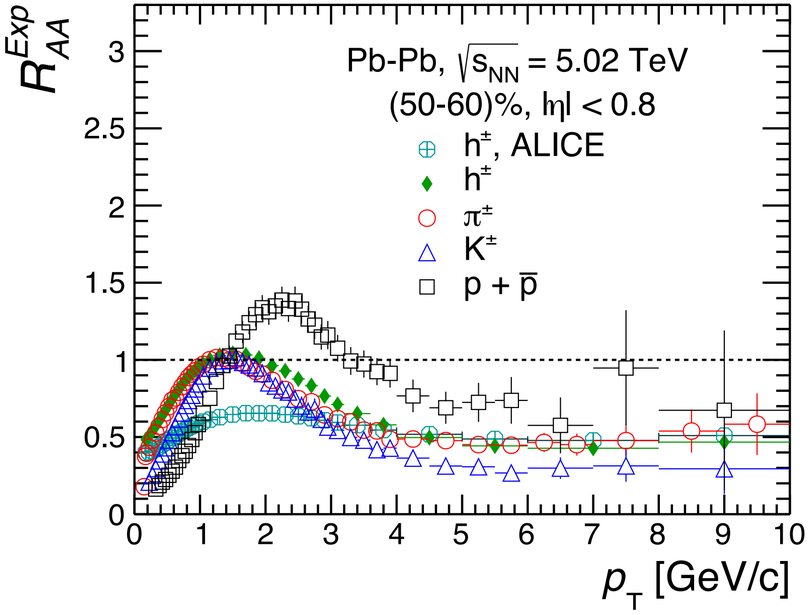
Nuclear modification factor:

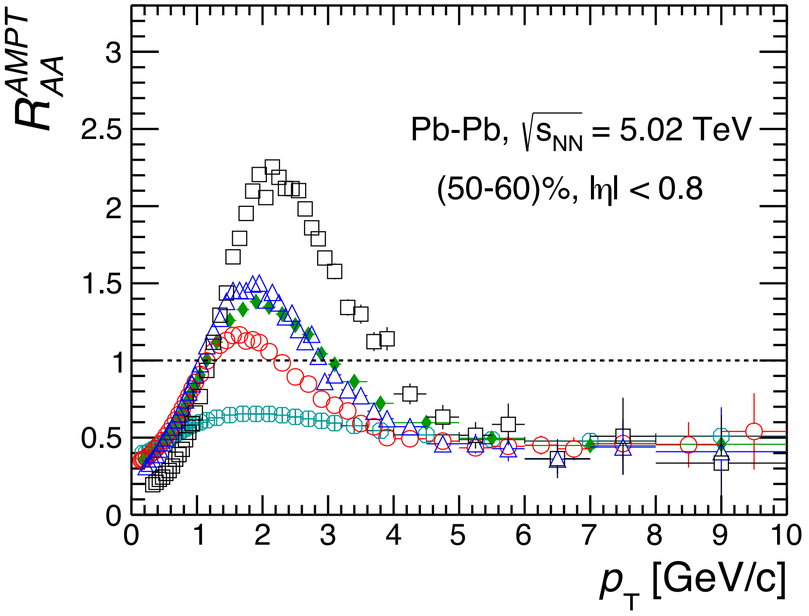
Nuclear modification factor (R_{AA}):

$$R_{AA} = \frac{d^2N^{AA}/dp_T d\eta}{\langle N_{coll}\rangle d^2N^{pp}/dp_T d\eta}$$

N^{AA} and N^{pp} are the charged particle yields in AA and pp collisions, $\langle N_{coll}\rangle$ is the mean number of binary collisions

- R_{AA} = 1 : Particle production in the heavy-ion collision is the same as expected from scaled pp collisions, indicating no nuclear modification
- R_{AA} < 1: Suppression of particle production in the heavy-ion collision
- R_{AA} > 1: Enhancement of particle production





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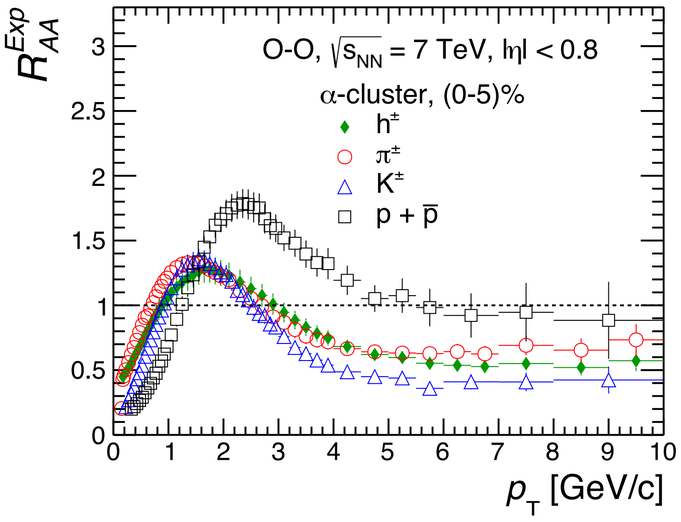
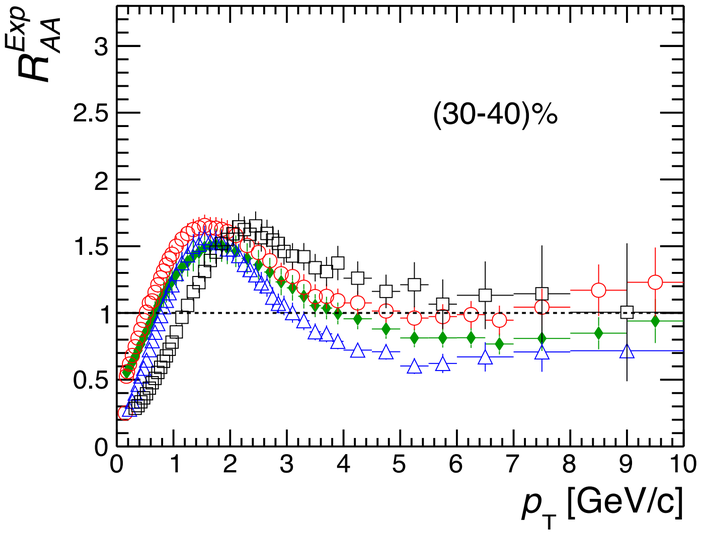
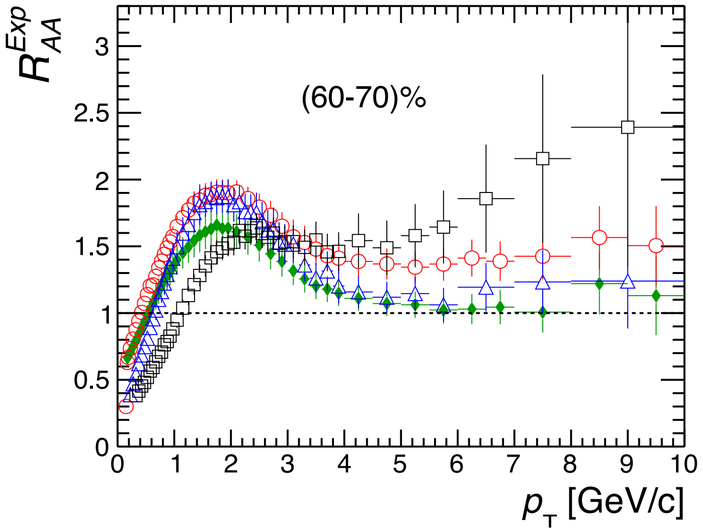
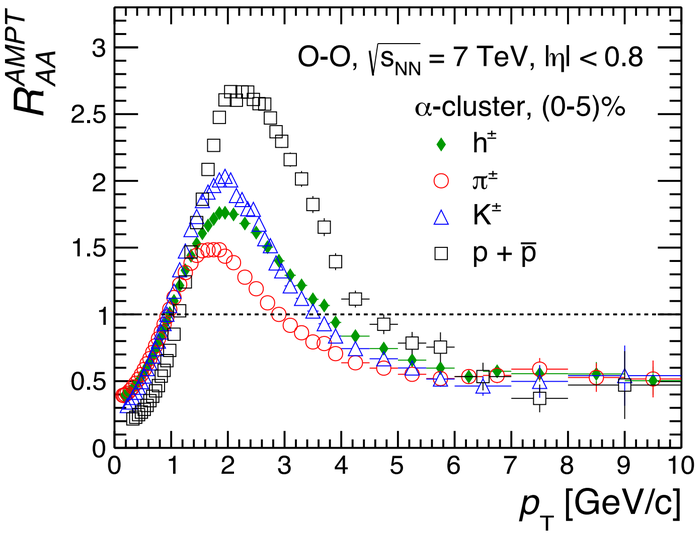
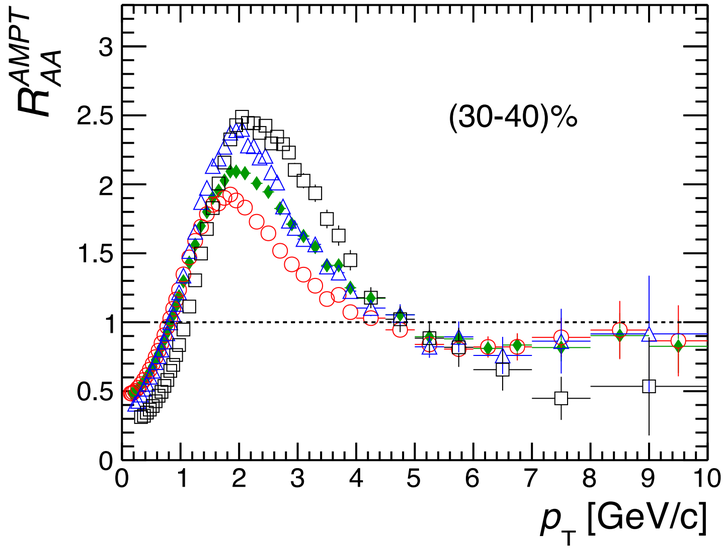
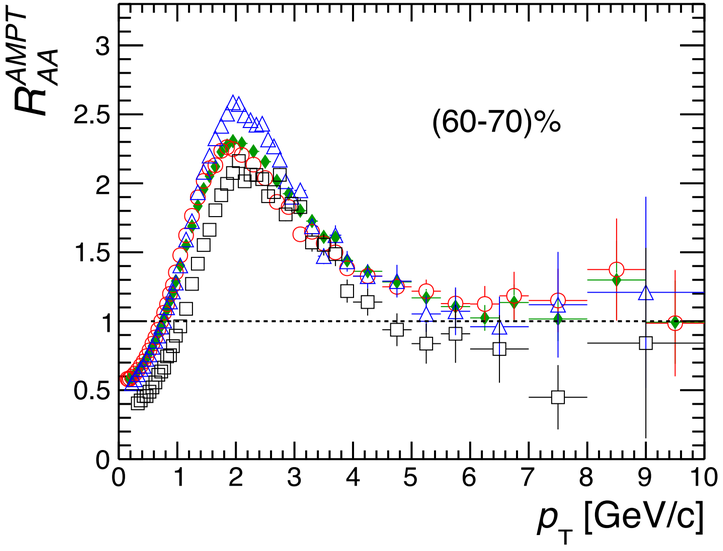








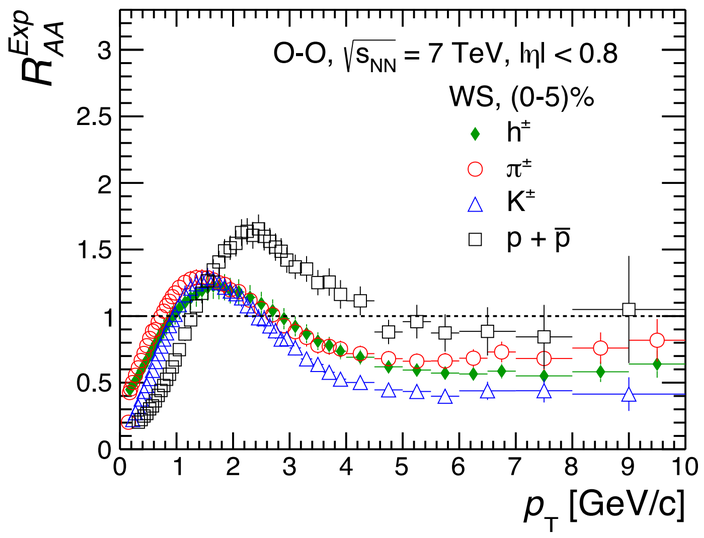


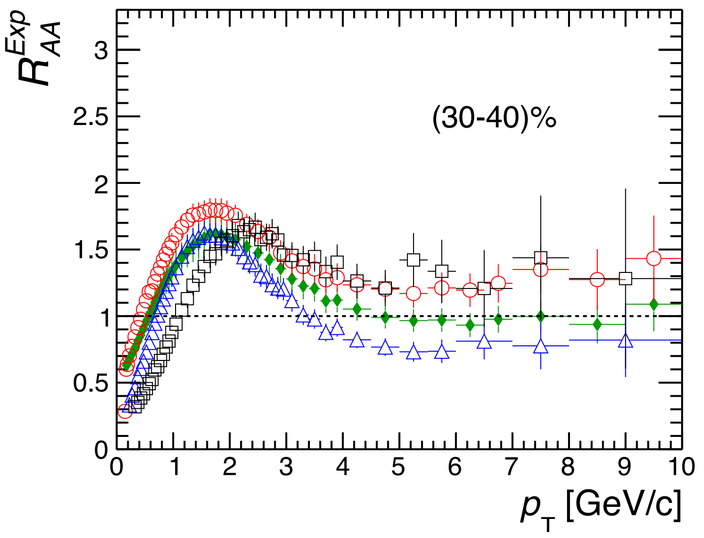


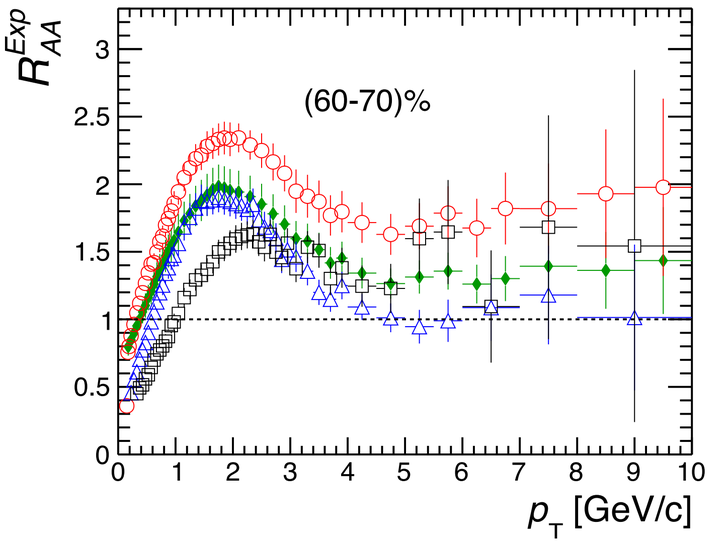
- R_{AA} values estimated using p_T spectra of *pp* collisions from AMPT show a higher value than that obtained considering ALICE

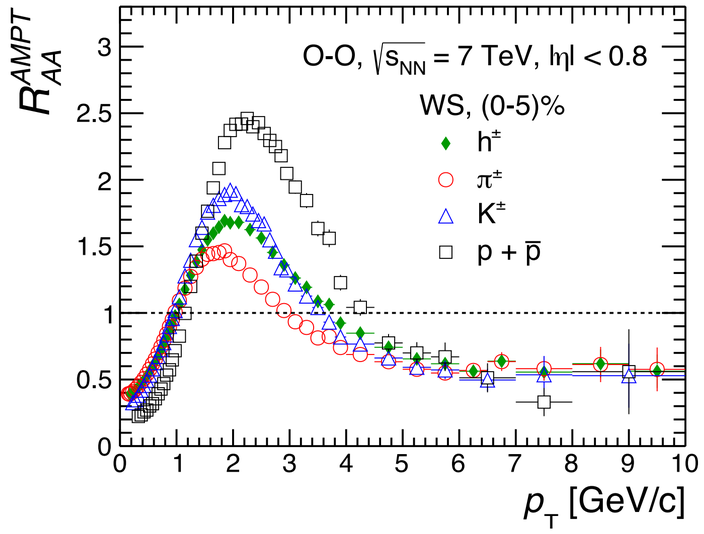
[D. Behera, S. Deb, C.R. Singh, and R. Sahoo, Phys. Rev. C 109, 014902 (2024)]

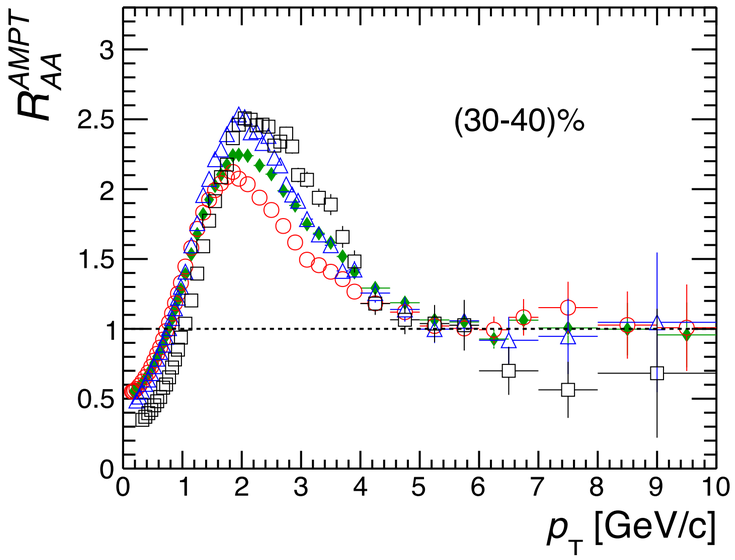
Nuclear modification factor:

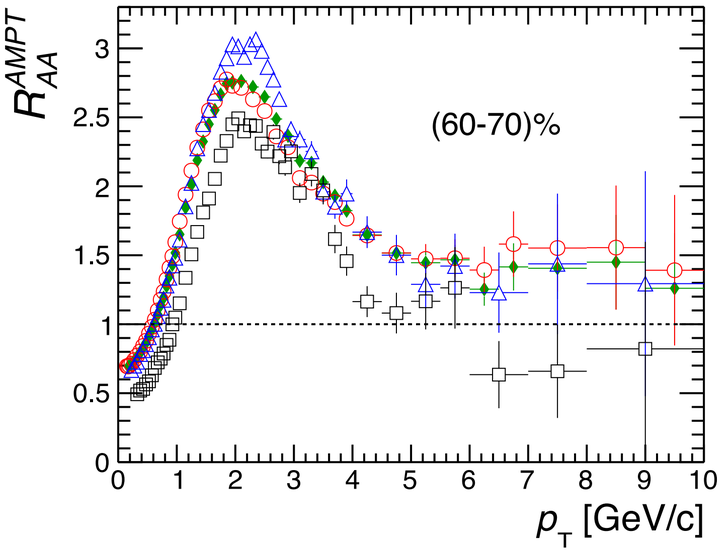








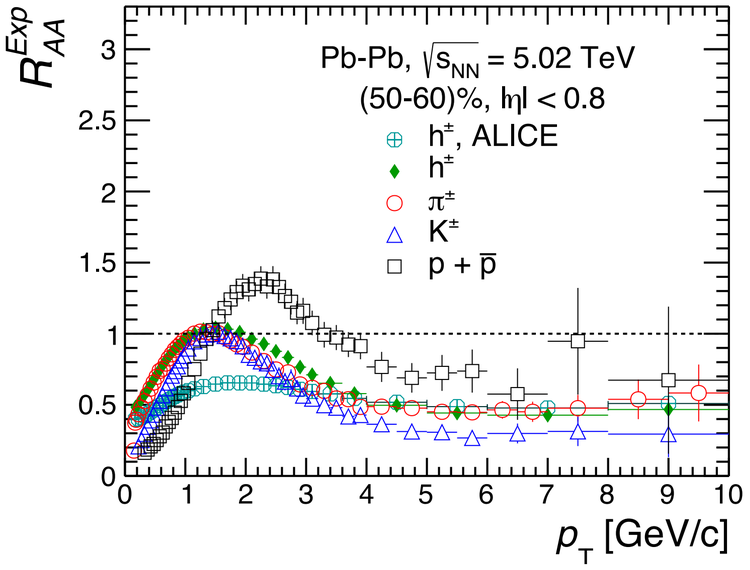


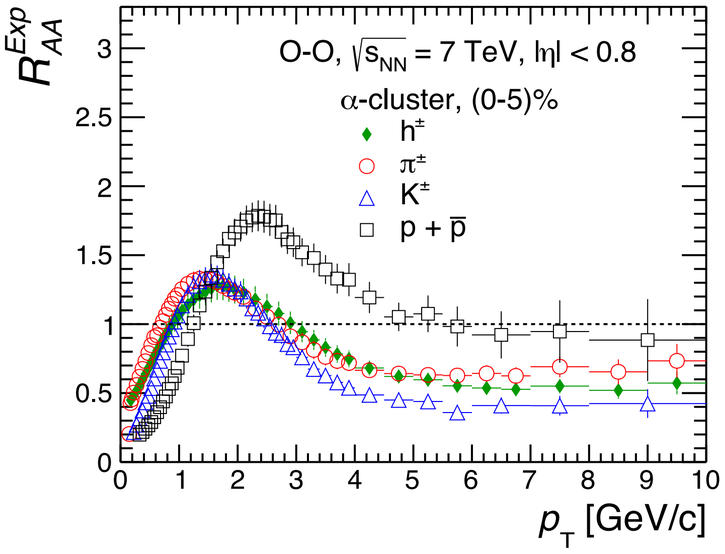


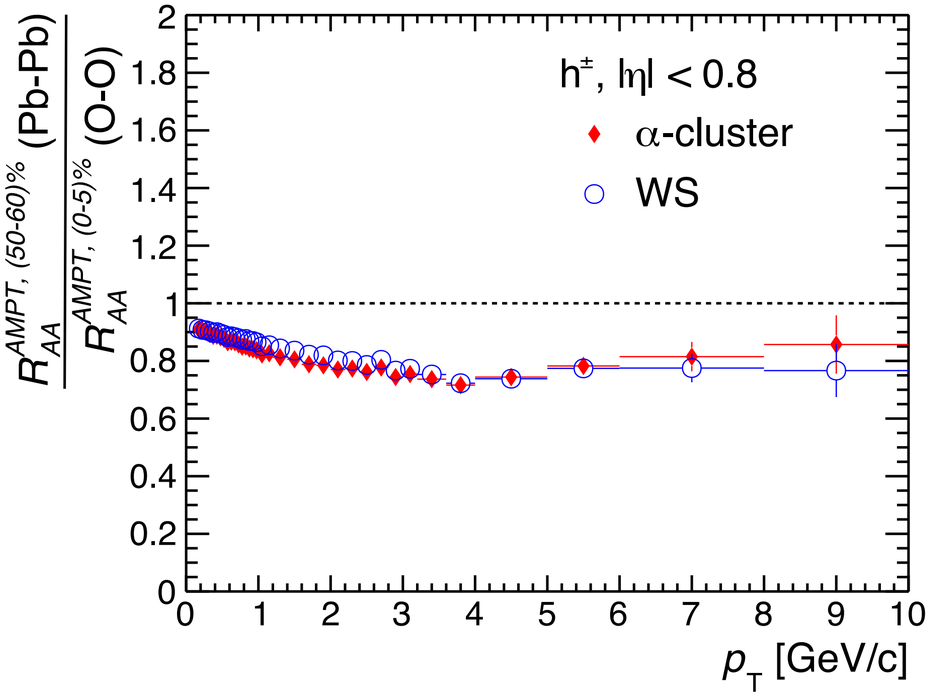
- Suppression is more pronounced in most central collisions compared to peripheral collisions
- Mass ordering between $\pi^{\pm}$, $K^{\pm}$, and protons remains conserved toward p_T < 2 GeV, despite changes in density profiles or centralities

[D. Behera, S. Deb, C.R. Singh, and R. Sahoo, Phys. Rev. C 109, 014902 (2024)]

Nuclear modification factor:







- Pb-Pb collisions exhibit **60% larger** radius than O−O collisions at a similar multiplicity [Phys. Rev. C 100, 024904 (2019)]
- (50-60)% centrality class of Pb-Pb collisions displays **greater suppression** than the (0-5)% centrality class of O-O collisions

[D. Behera, S. Deb, C.R. Singh, and R. Sahoo, Phys. Rev. C 109, 014902 (2024)]

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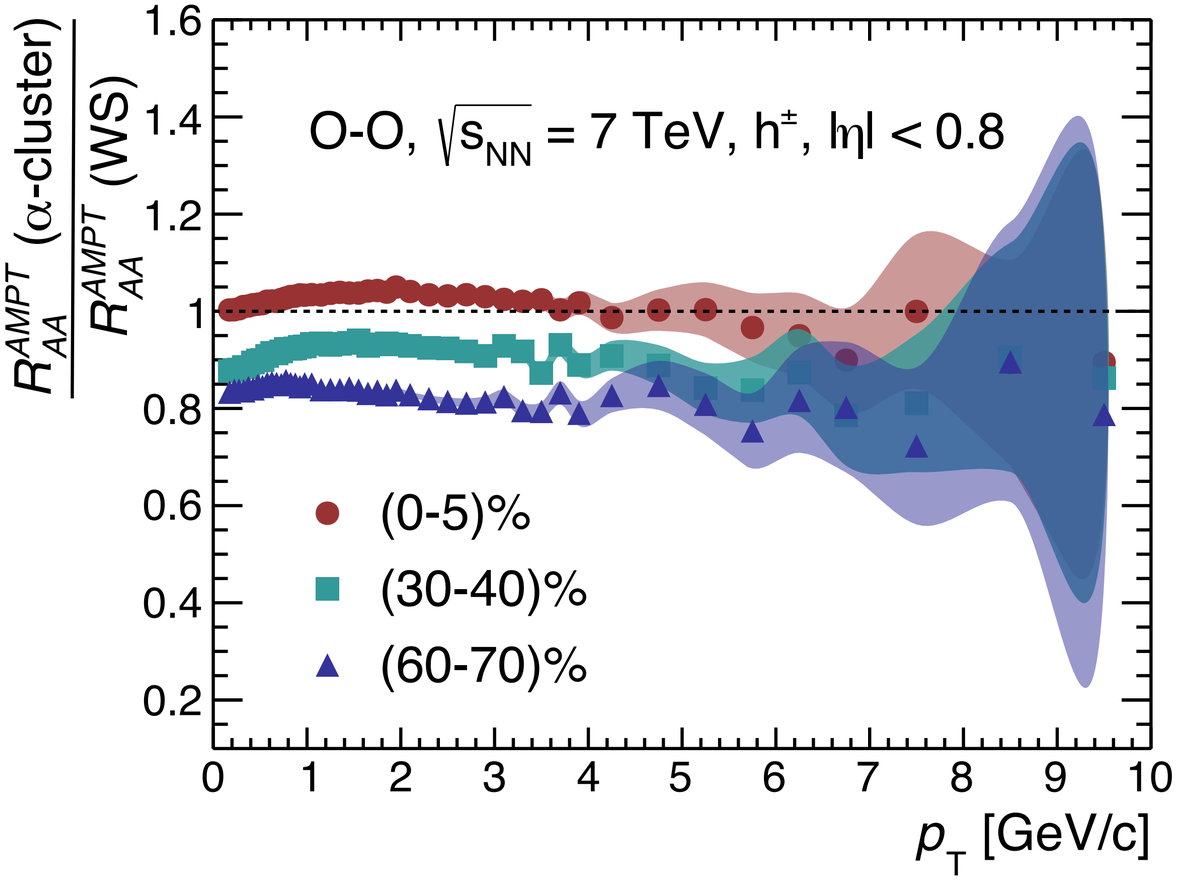

- Most central collisions [(0–5)%], the effects of α -clustered and Woods-Saxon density profiles on charged hadrons yield are approximately the same
- The effect of α-clustered density profiles on particle production is stronger in mid-central and peripheral collisions than in the most central collisions, unlike the Woods-Saxon profile
- α-clustered structure creates a compact and denser fireball, particularly in relatively non-central collisions in comparison with the Woods-Saxon density profile

[D. Behera, S. Deb, C.R. Singh, and R. Sahoo, Phys. Rev. C 109, 014902 (2024)]

Summary:

- We have shown global properties [Bjorken energy density, speed of sound] and also studied the effect of density profile in anisotropic flow in O-O collisions at $\sqrt{s_{NN}}$ = 7 TeV
- Nuclear modification factor (R_{AA}) is studied for charged and identified hadrons in the O-O collisions using AMPT
- Behaviour of R_{AA} is studied at similar multiplicity environment between O-O and Pb-Pb collisions
- Pb-Pb exhibits more suppression as compared to O-O collisions at similar multiplicity environment
- Density profile study is more effective for mid-central and peripheral collisions as compared to central collisions

Thank you!