Recent Results from Heavy ion collisions

Sadhana Dash
IIT Bombay

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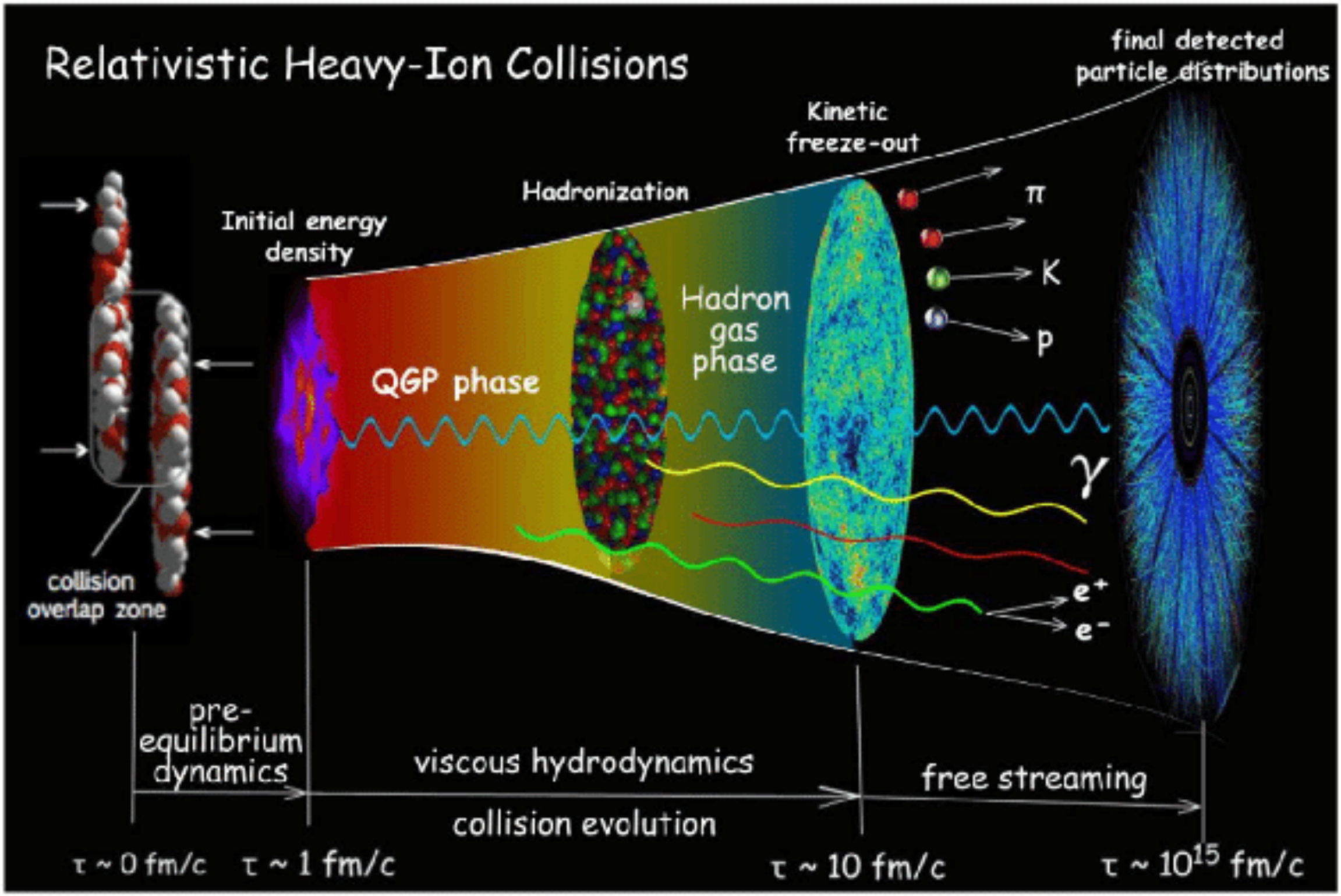
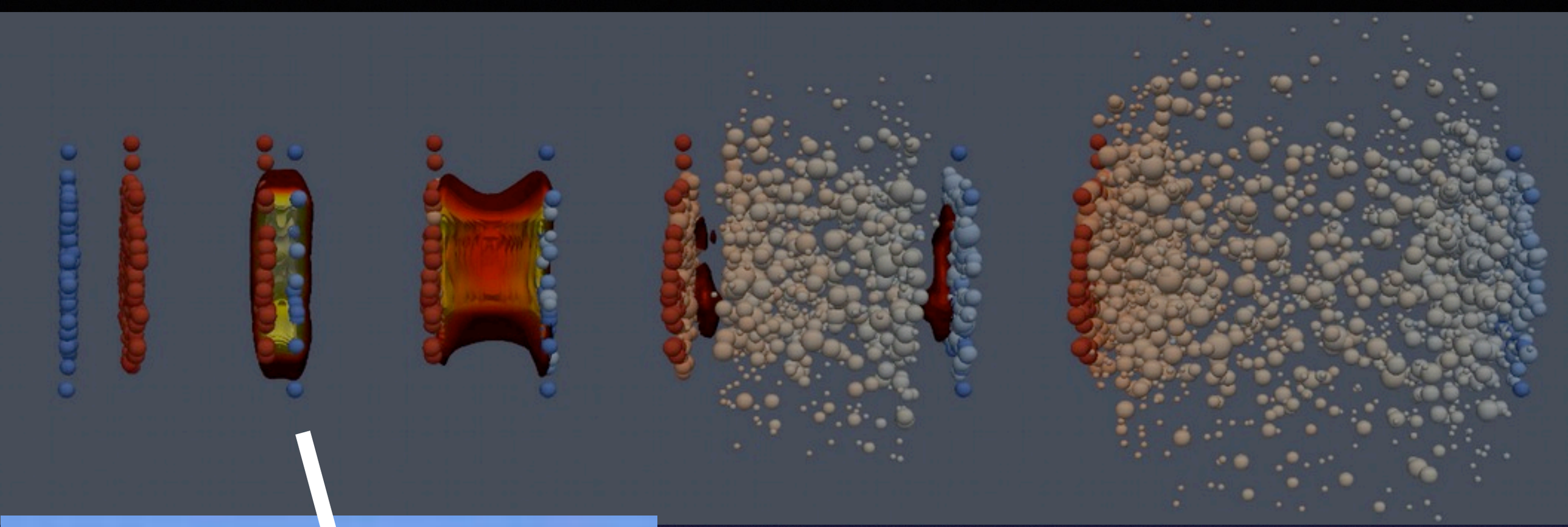
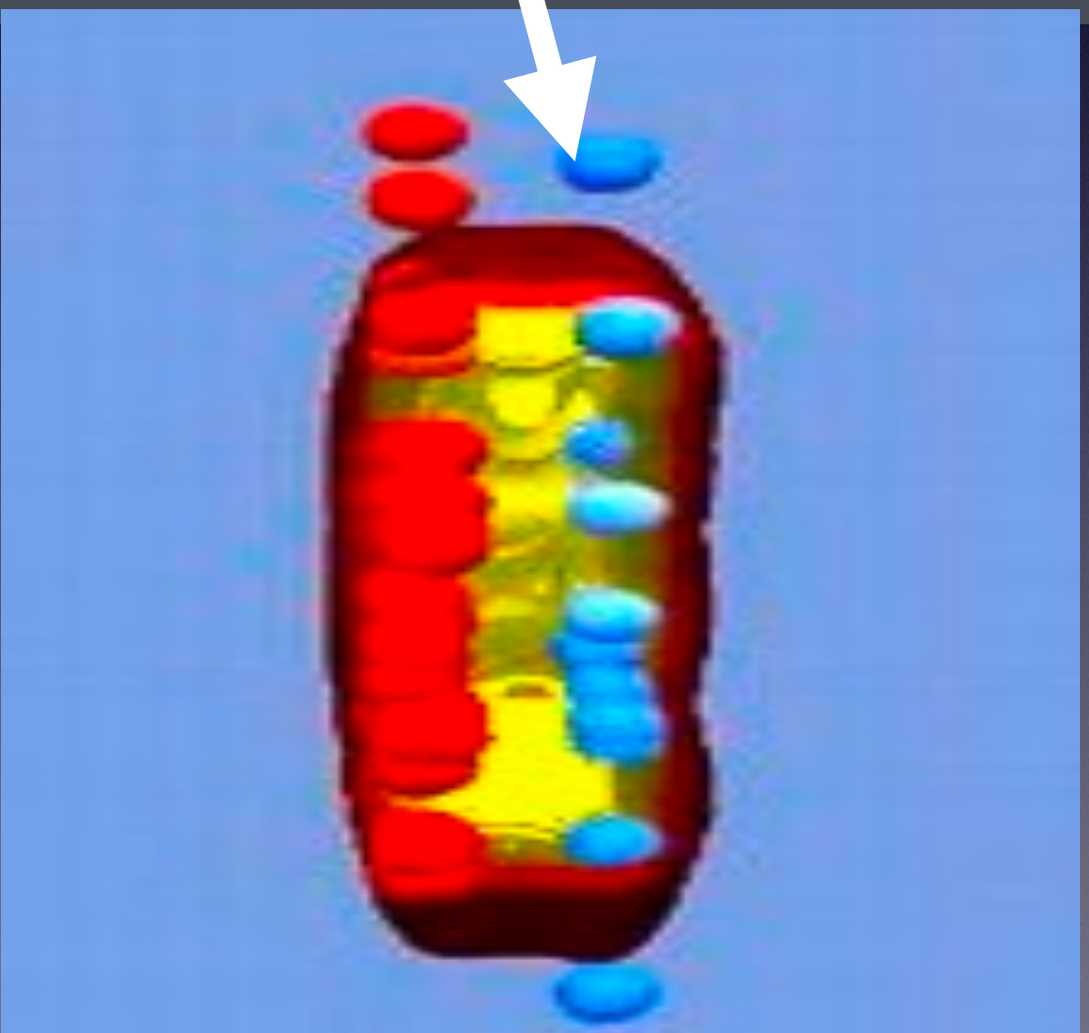
Relativistic Heavy Ion collisions

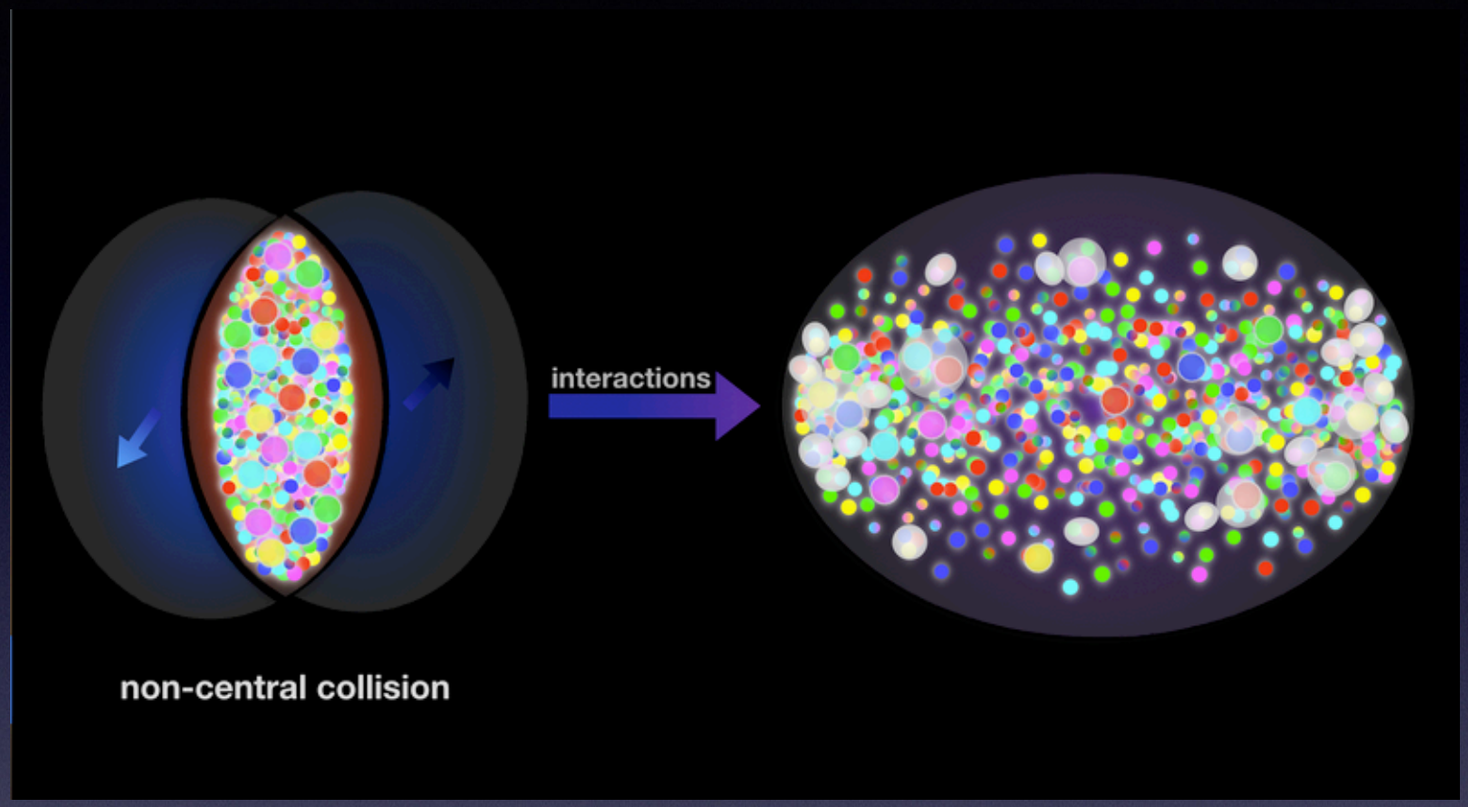






Initial stages

Explore initial state with Flow coefficients

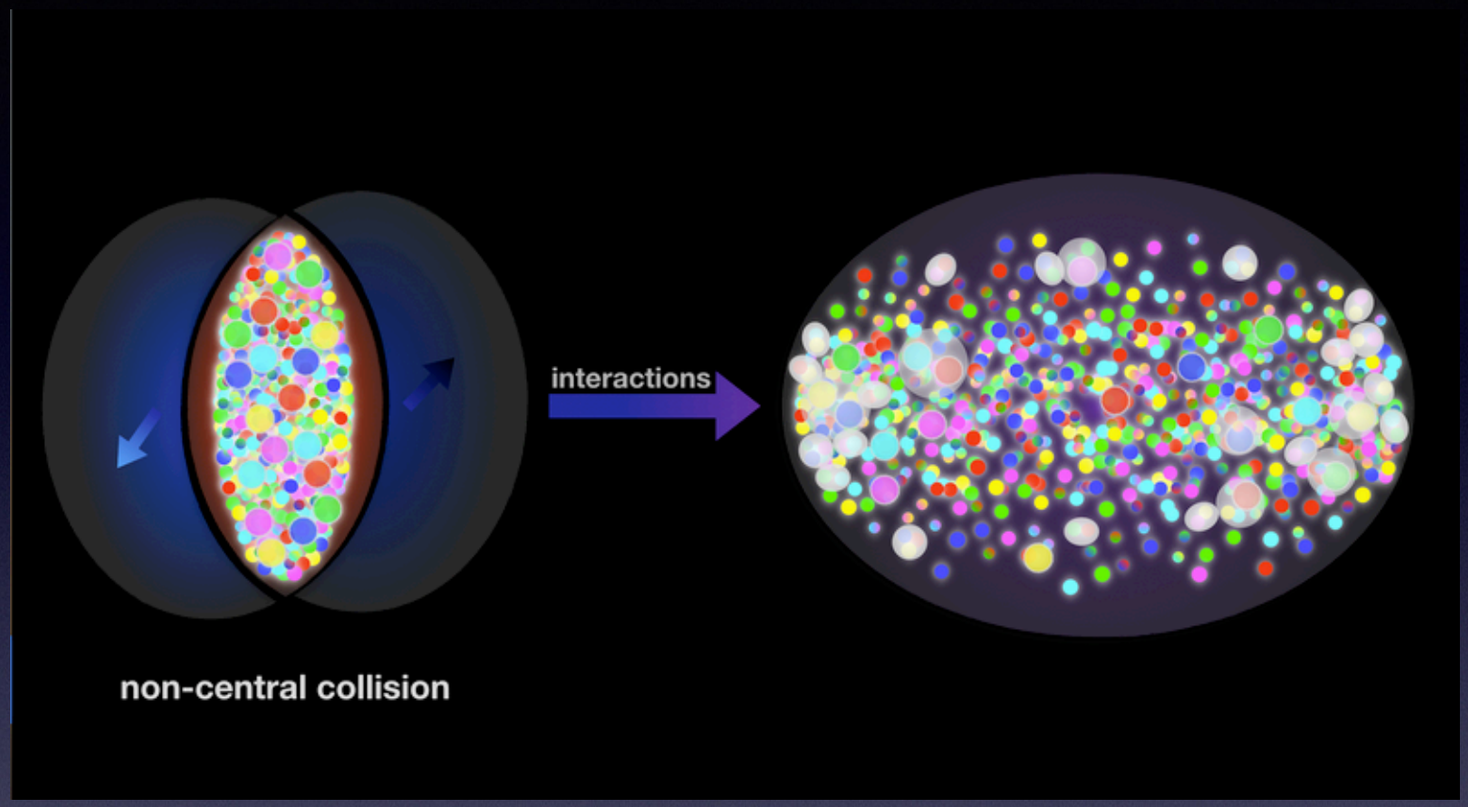


For non-central heavy ion collisions, overlap region is ellipsoid in shape.

Pressure gradient is largest along the shorter axis.

Initial spatial anisotropy manifests in final state momentum anisotropy

Explore initial state with Flow coefficients



For non-central heavy ion collisions, overlap region is ellipsoid in shape.

Pressure gradient is largest along the shorter axis.

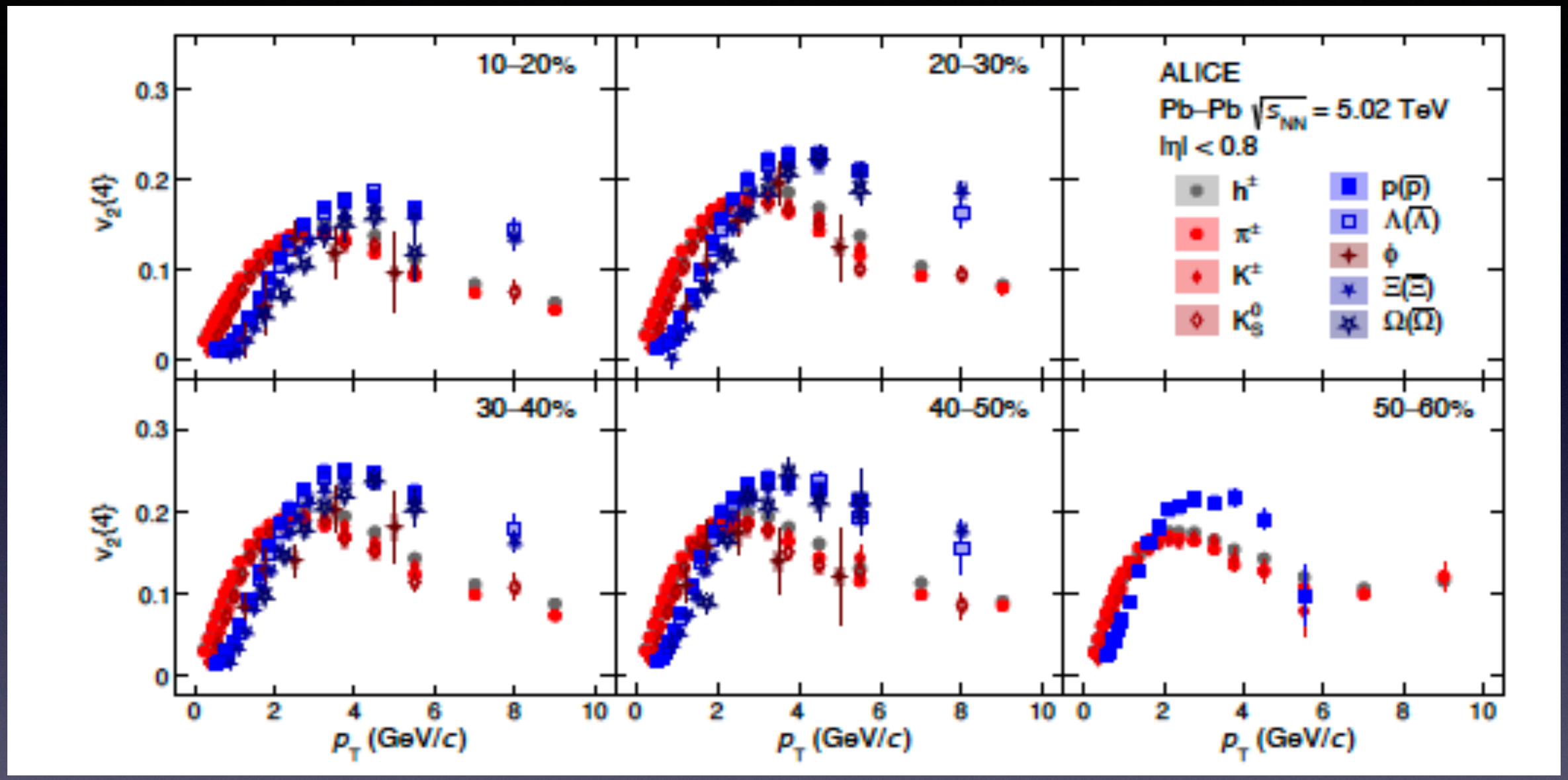
Initial spatial anisotropy manifests in final state momentum anisotropy

$$\frac{dN}{d\phi} \propto 1 + 2\sum v_n cos(n(\phi - \Psi_n))$$

v_2 : **Elliptic flow**

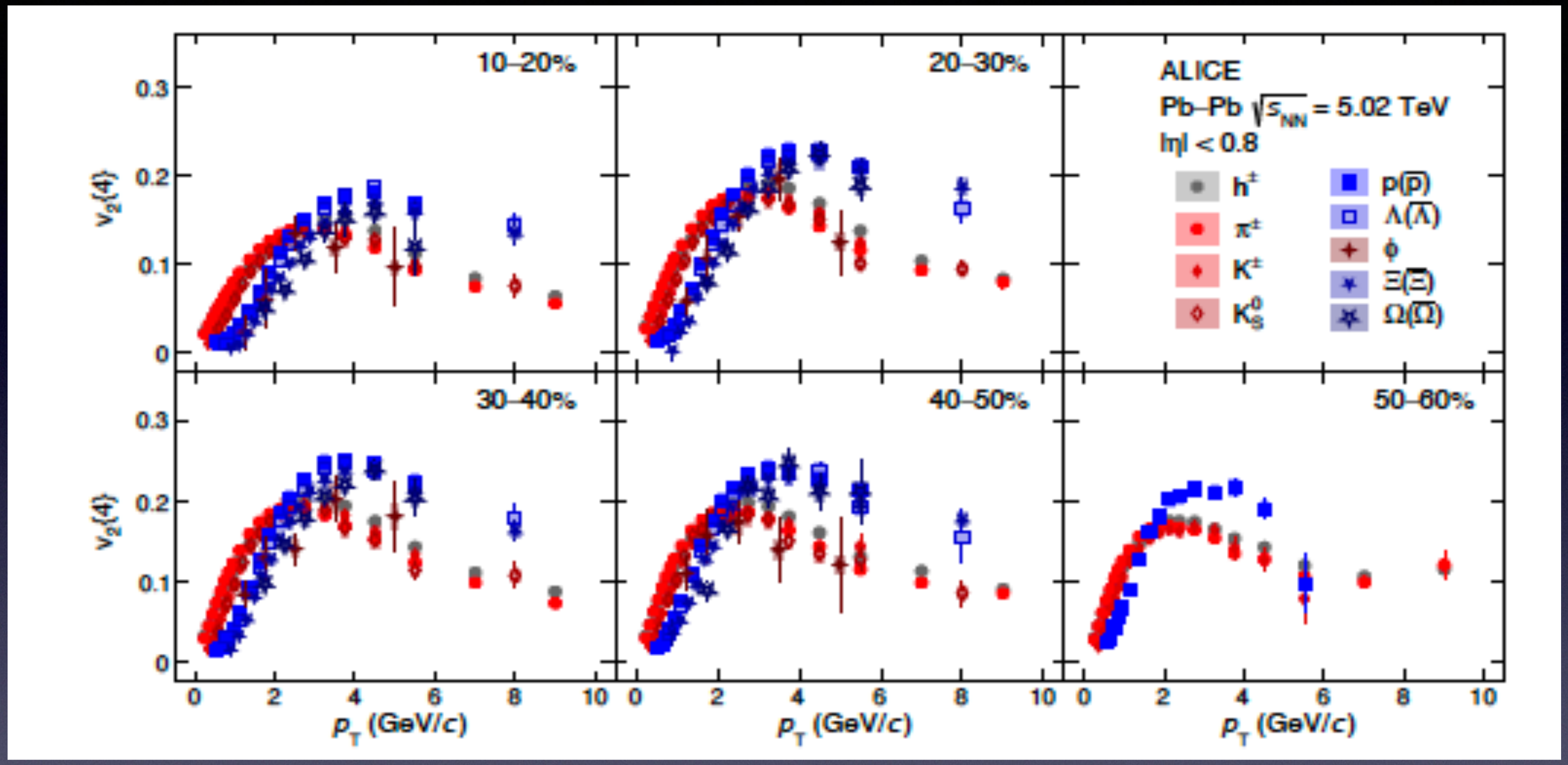
Explore initial state with Flow coefficients (I)

ALICE :arXiv: 2206.04587



Identified particle v_2 measurements using 4-particle cumulants

Explore initial state with Flow coefficients (I)



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Identified particle v_2 measurements using 4-particle cumulants

Presence of mass ordering and baryon-meson grouping

Explore initial state with Flow coefficients (I)

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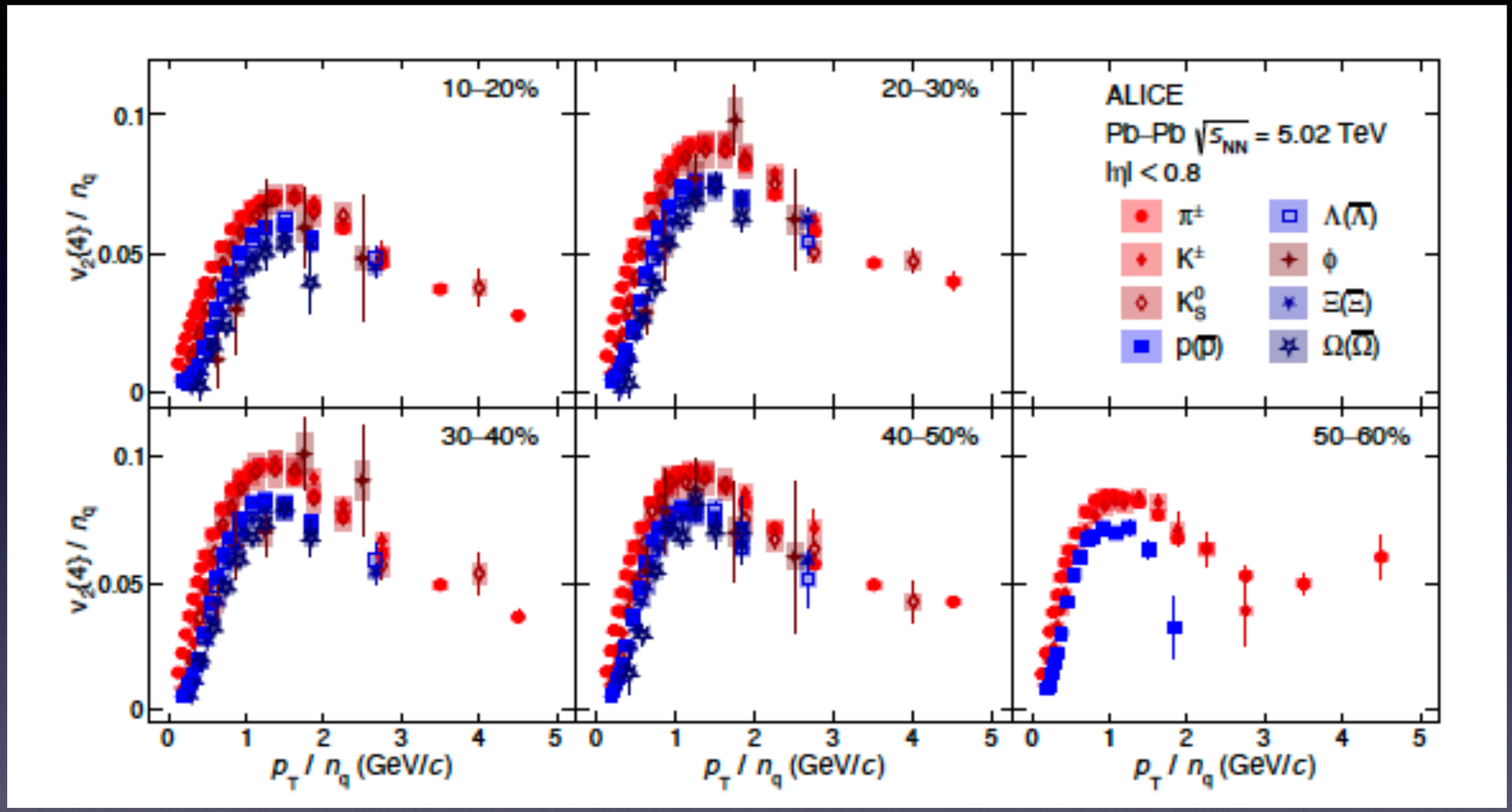


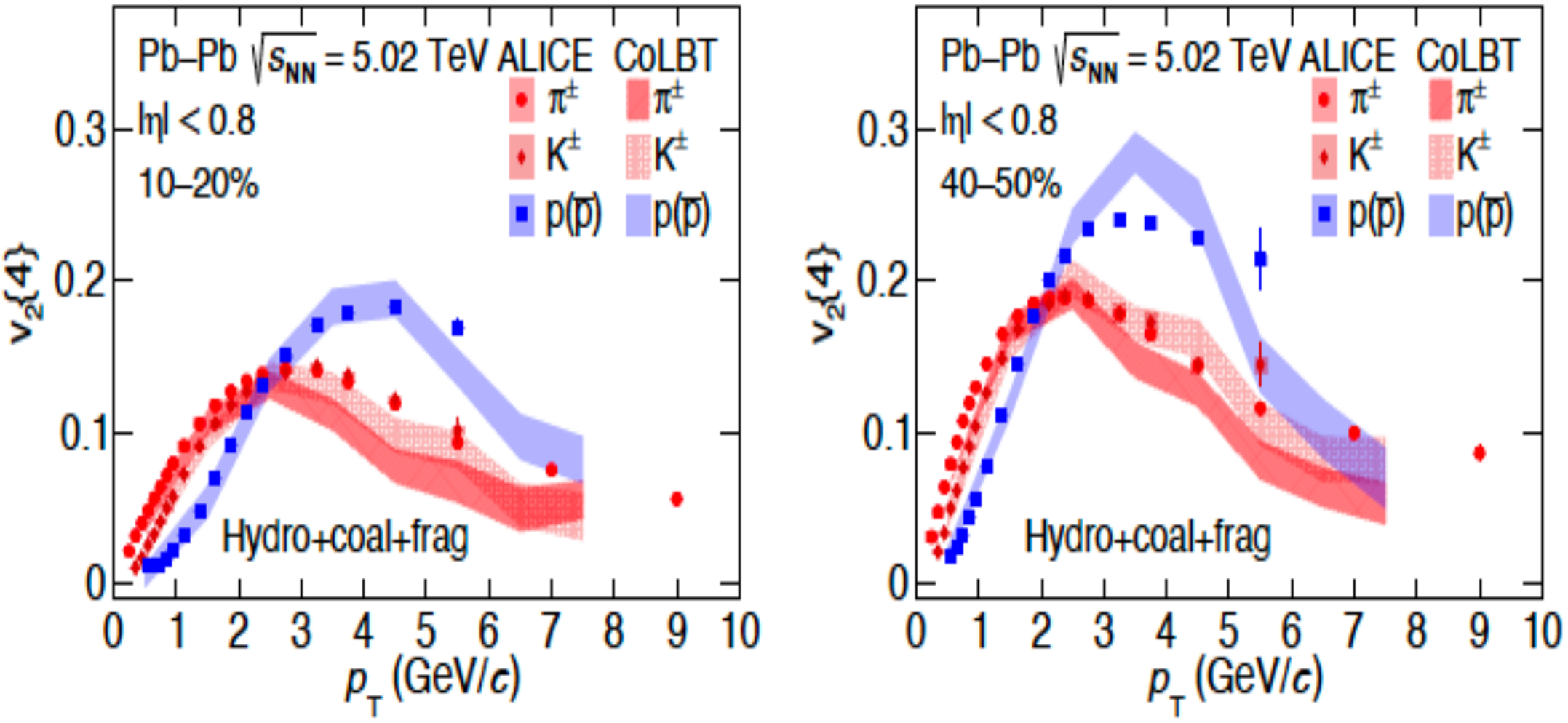
Identified particle v_2 measurements using 4-particle cumulants

Presence of mass ordering and baryon-meson grouping

Approximate NCQ (number of constituent quark) scaling

Explore initial state with Flow coefficients (I)

ALICE, arXiv: 2206.04587
CoLBT: PRL128 (2022) 022302



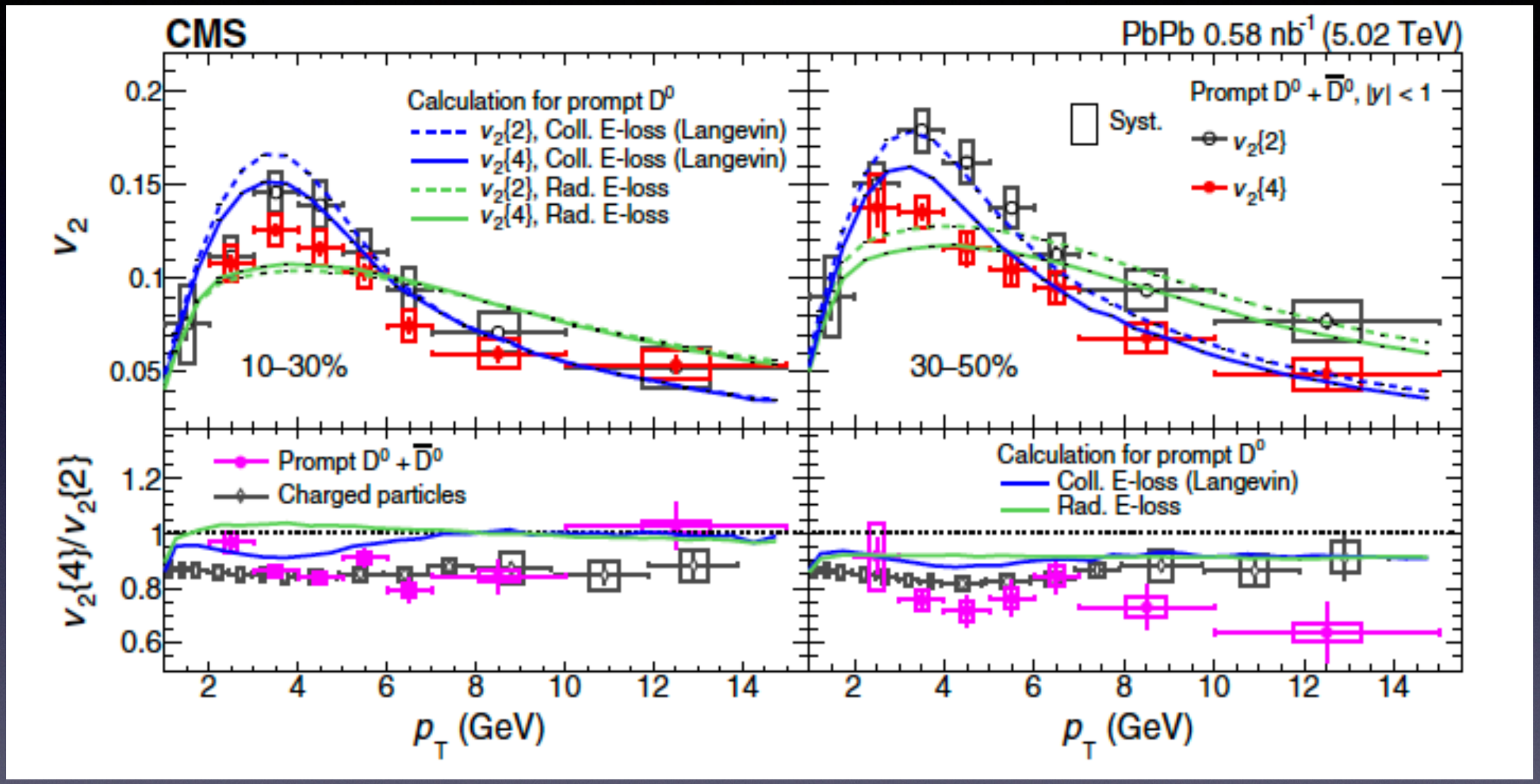
Identified particle v_2 measurements using 4-particle cumulants

Presence of mass ordering and baryon-meson grouping

Well described by CoLBT model

Explore initial state with Flow coefficients (II)

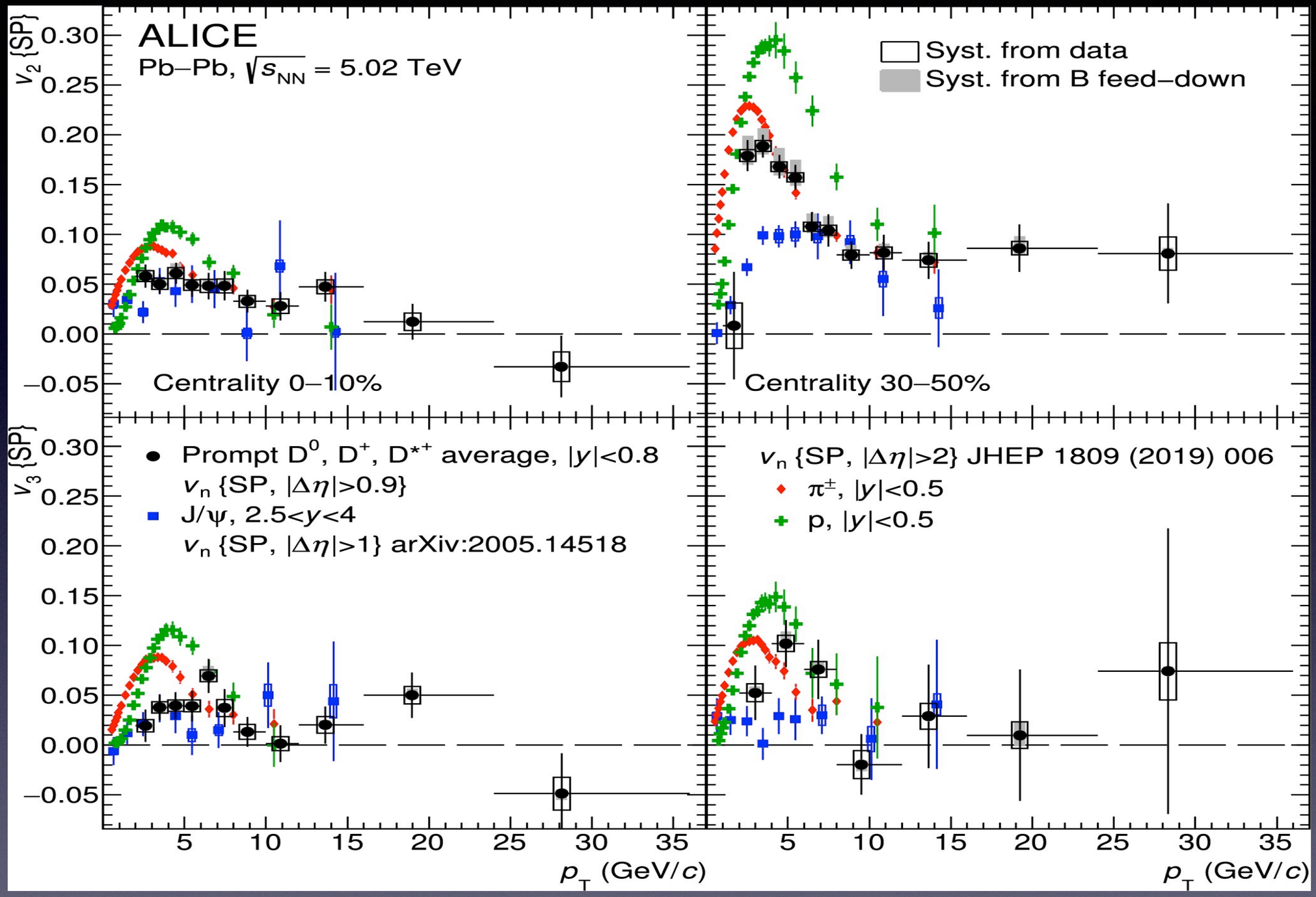
CMS: Phys.Rev.Letts 129, 022001 (2022)



First measurement of of D-meson flow using four particle cumulant method.

Explore initial state with Flow coefficients (II)

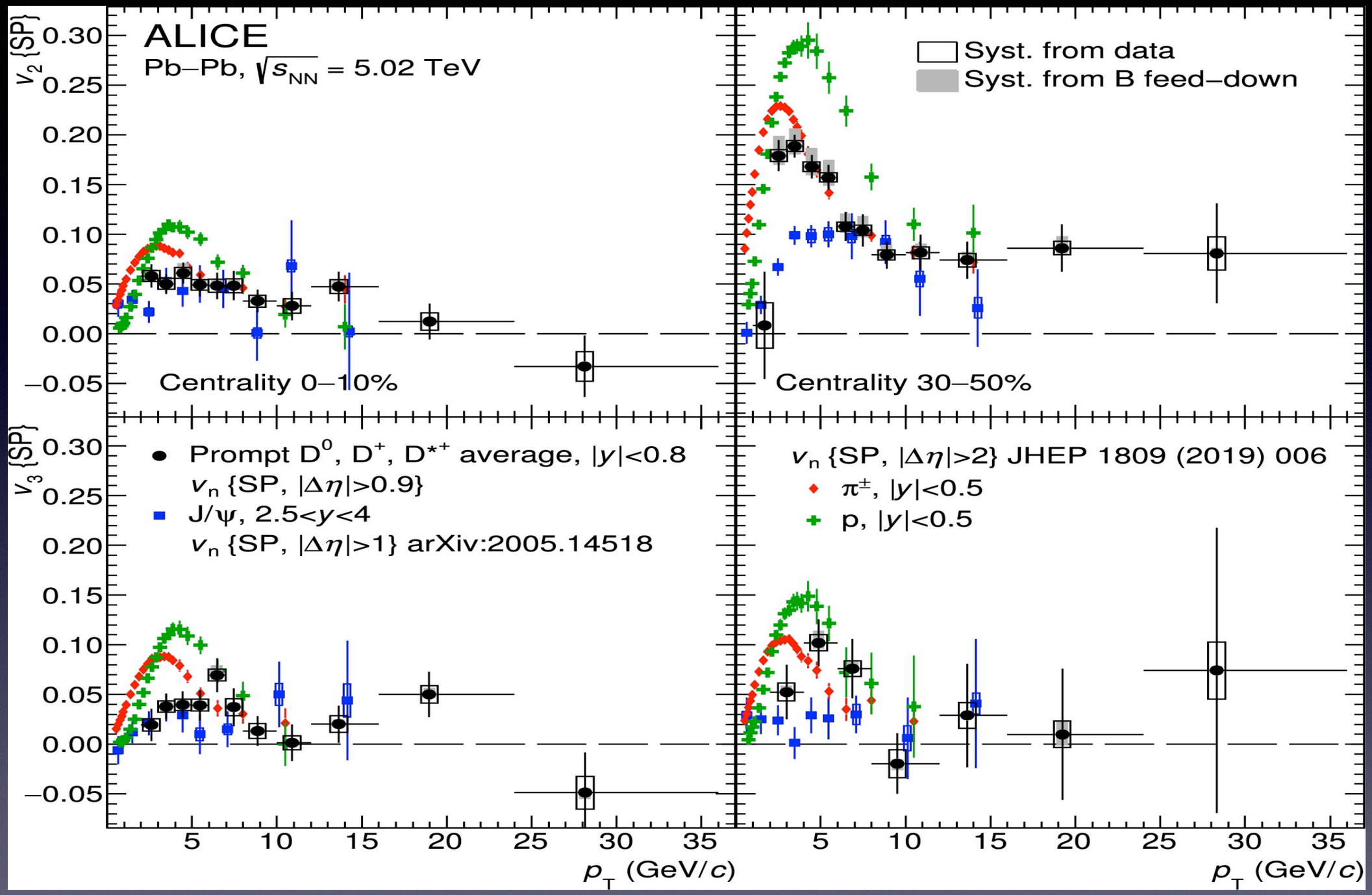
ALICE: Phys.Letts.B 813, 136054 (2021)



D-meson flow increases significantly from central to semi-central collisions.

Explore initial state with Flow coefficients (II)

ALICE: Phys.Letts.B 813, 136054 (2021)

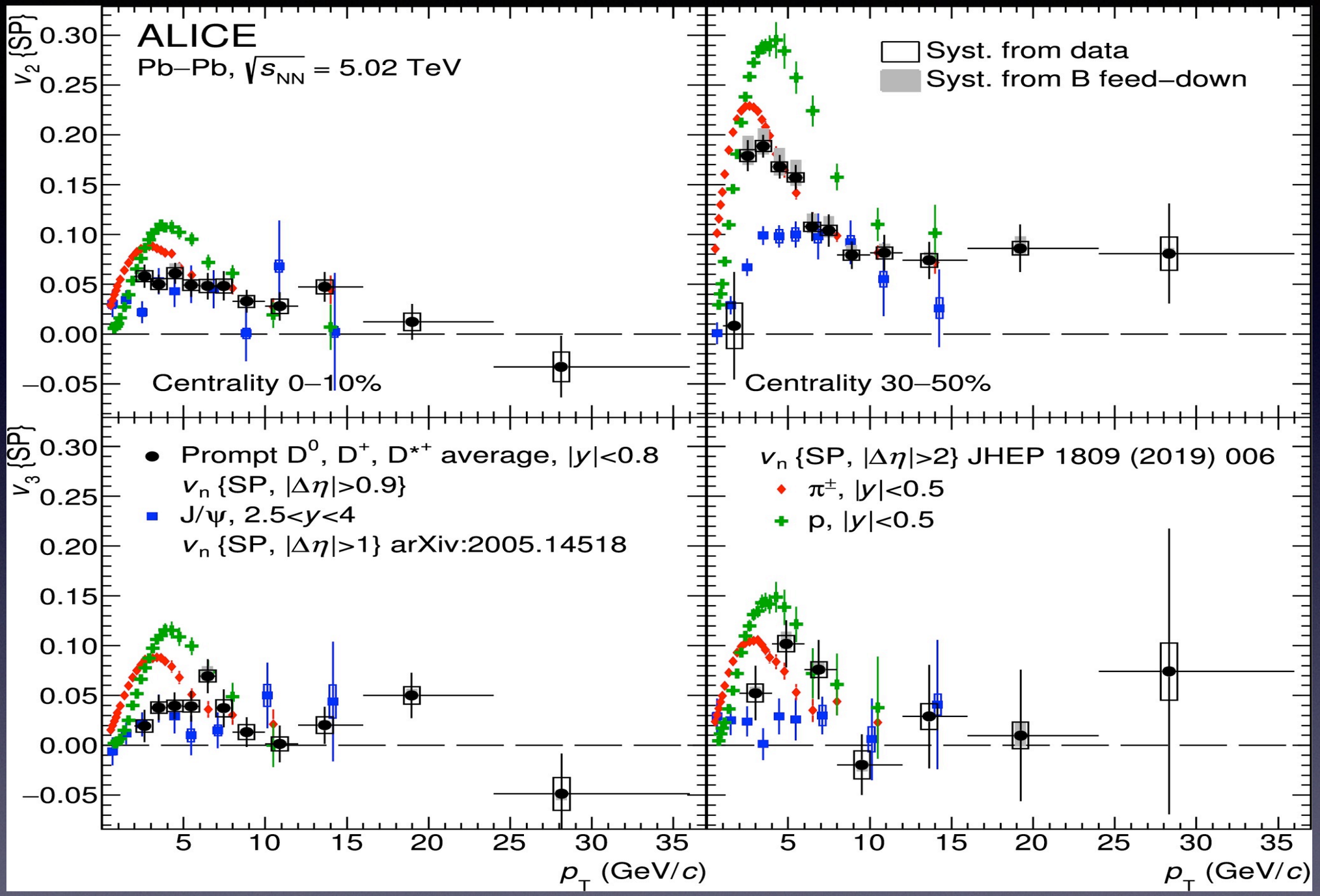


Mass hierarchy observed in the low p_T region

$$v_n(D) < v_n(p) < v_n(\pi)$$

Explore initial state with Flow coefficients (II)

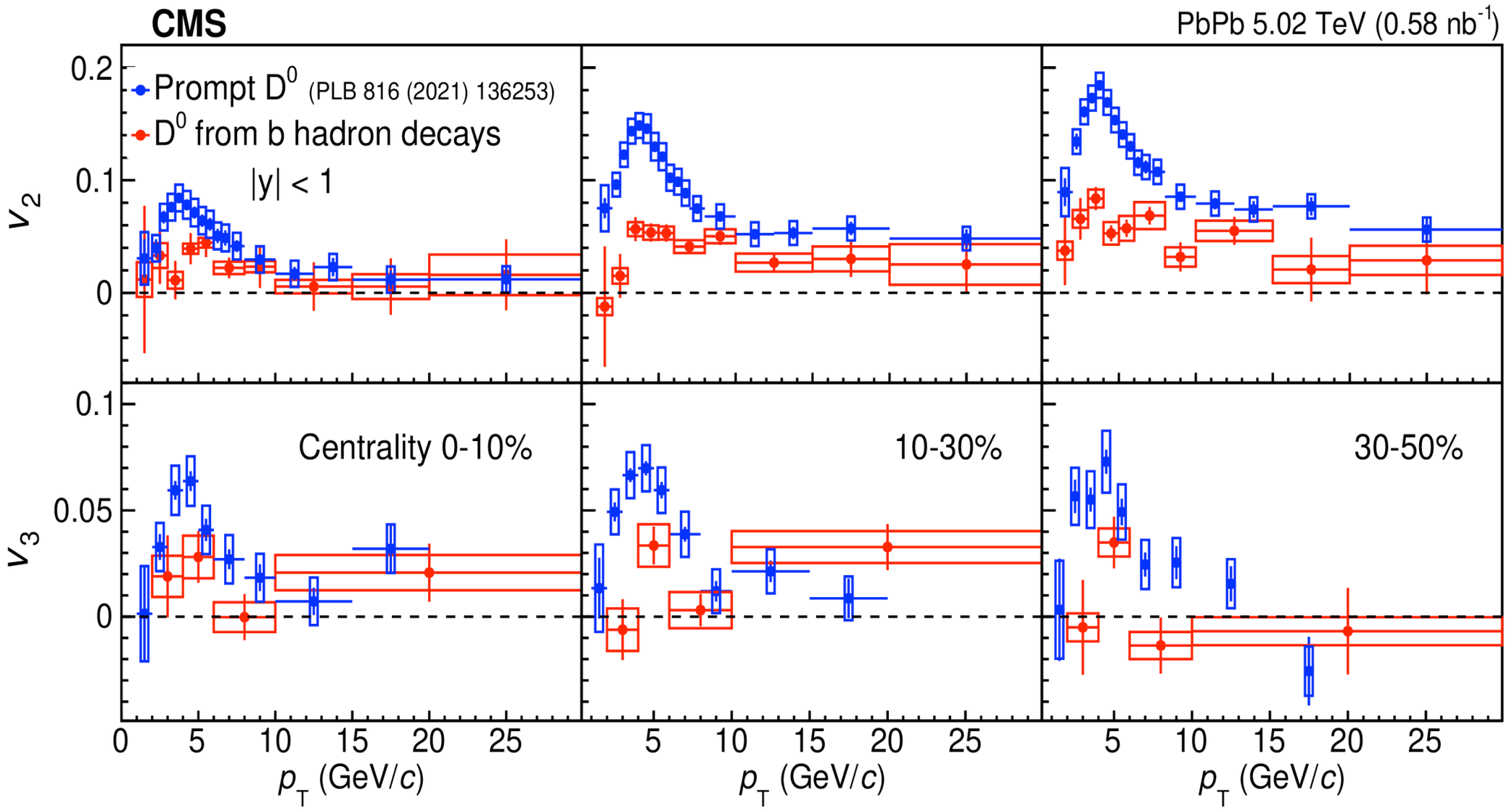
ALICE: Phys.Letts.B 813, 136054 (2021)



Quark coalescence in the intermediate p_T region as D meson flow comparable to pions

Explore initial state with Flow coefficients (II)

CMS: Phys.Rev.Lett 129, 022001 (2022)



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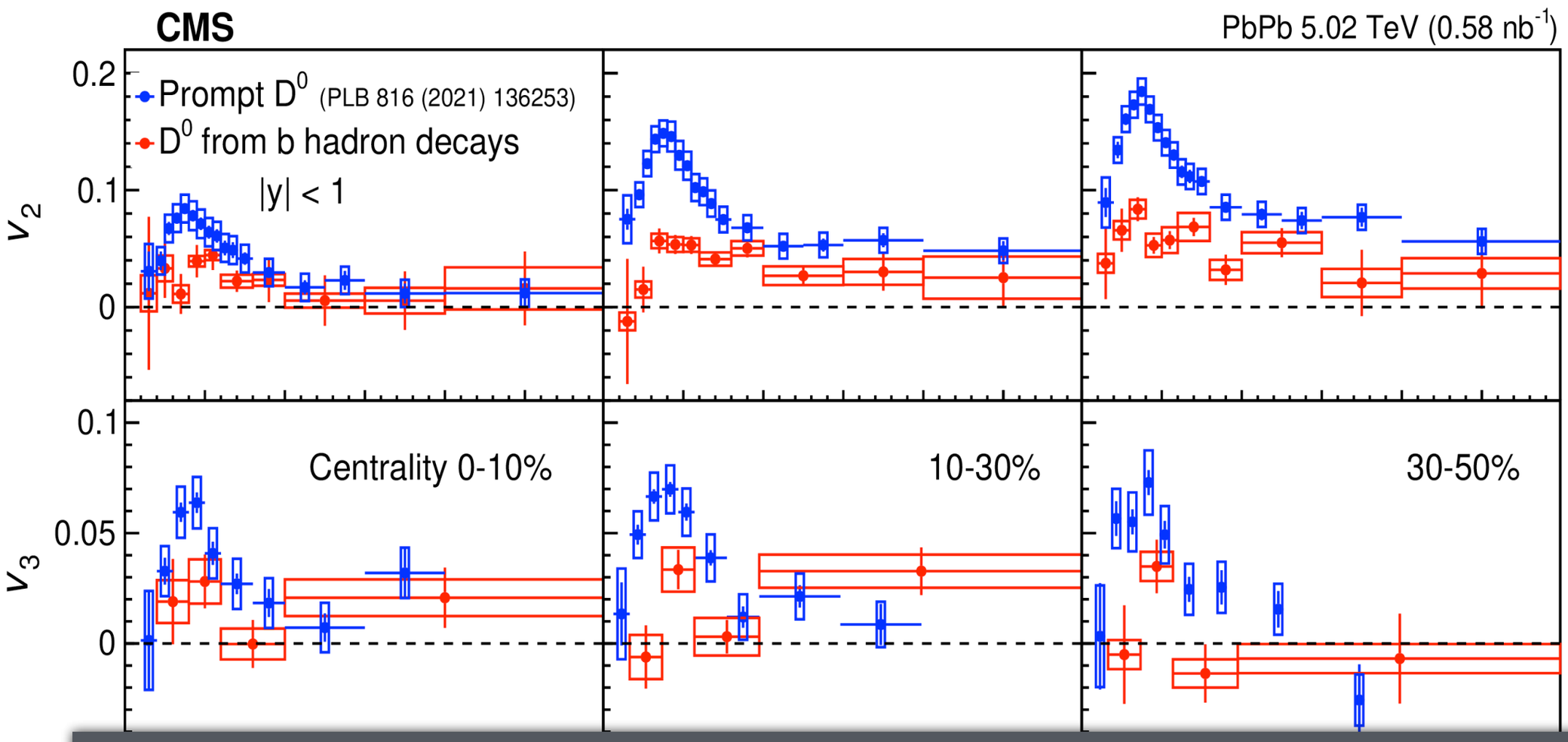
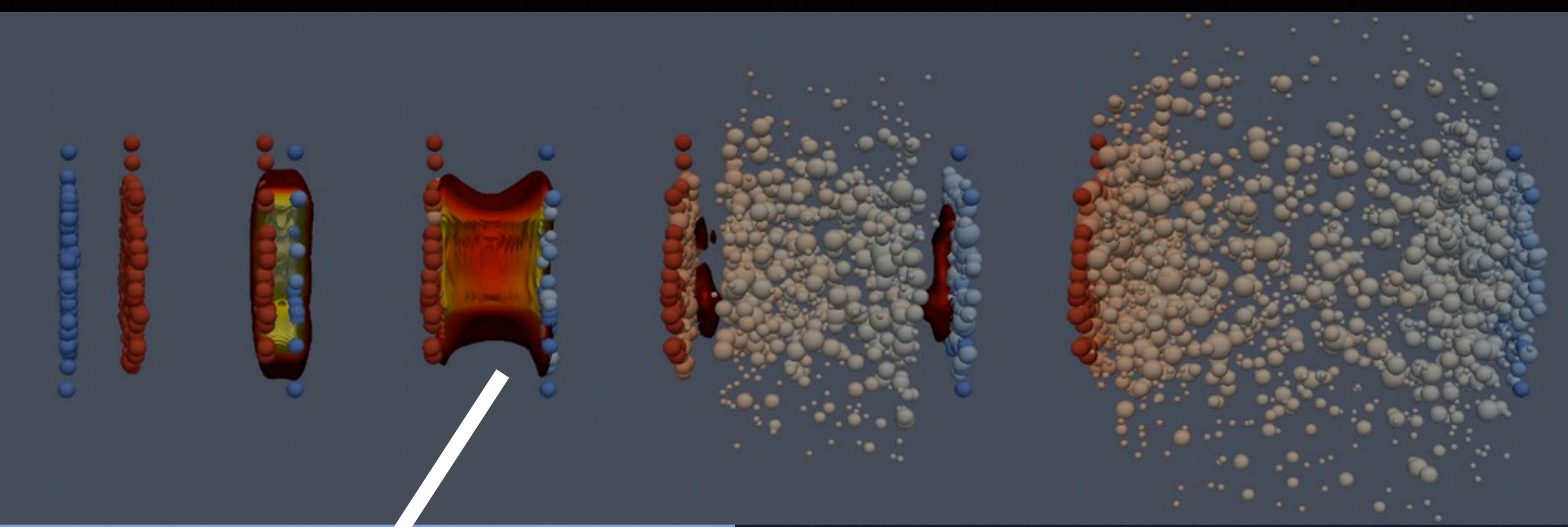
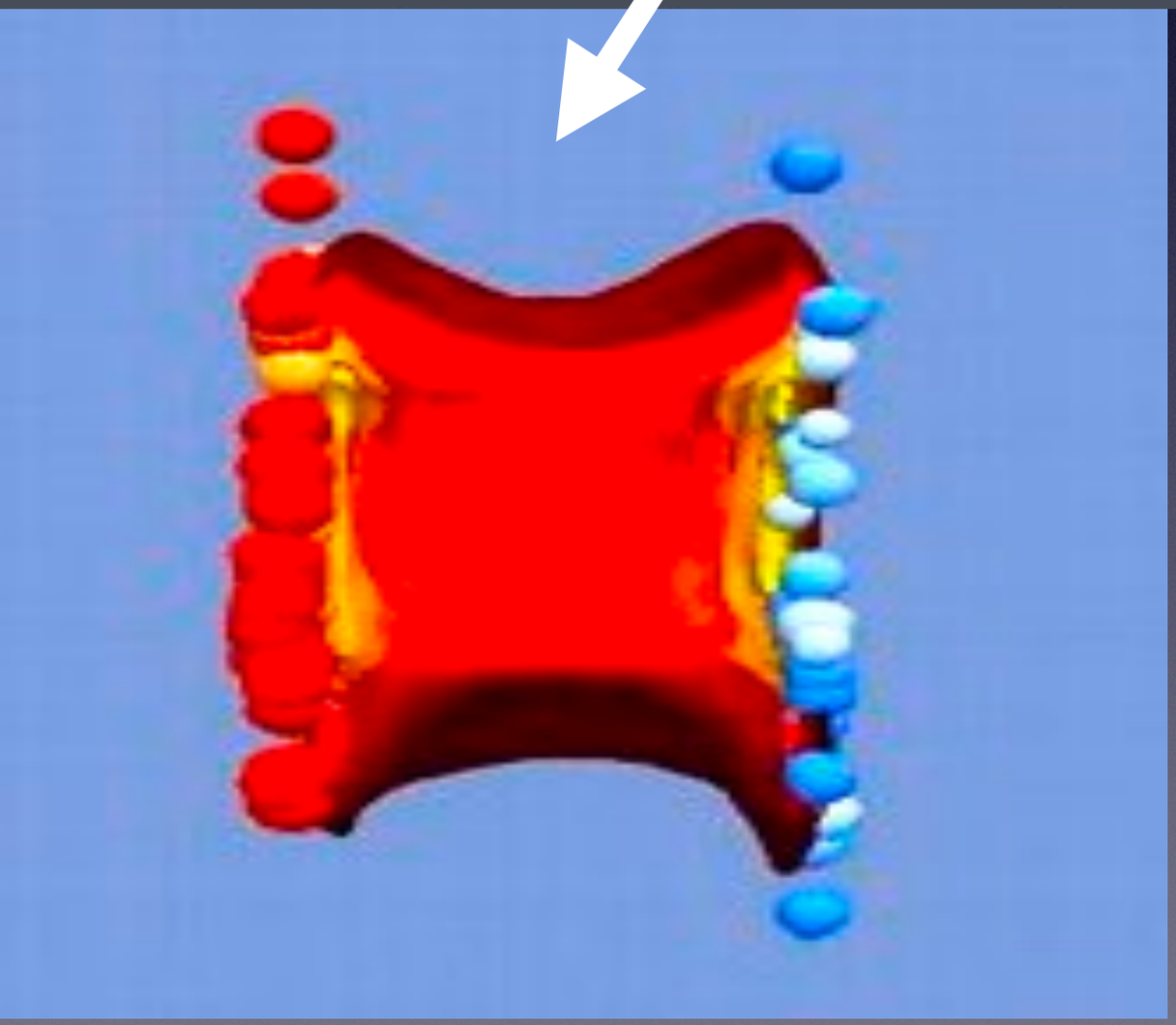


CMS: Phys.Rev.Letts 129, 022001 (2022)

Magnitudes of flow coefficients are lower for non-prompt D0.

Suggests mass-hierarchy in quark interactions with QGP.





Hot Medium properties

Explore medium with R_{AA}

R_{AA} : Nuclear modification factor

$$R_{AA}(p_T) = \frac{1}{\langle N_{coll} \rangle} \frac{dN_{AA}/dp_T}{dN_{pp}/dp_T}$$

Explore medium with R_{AA}

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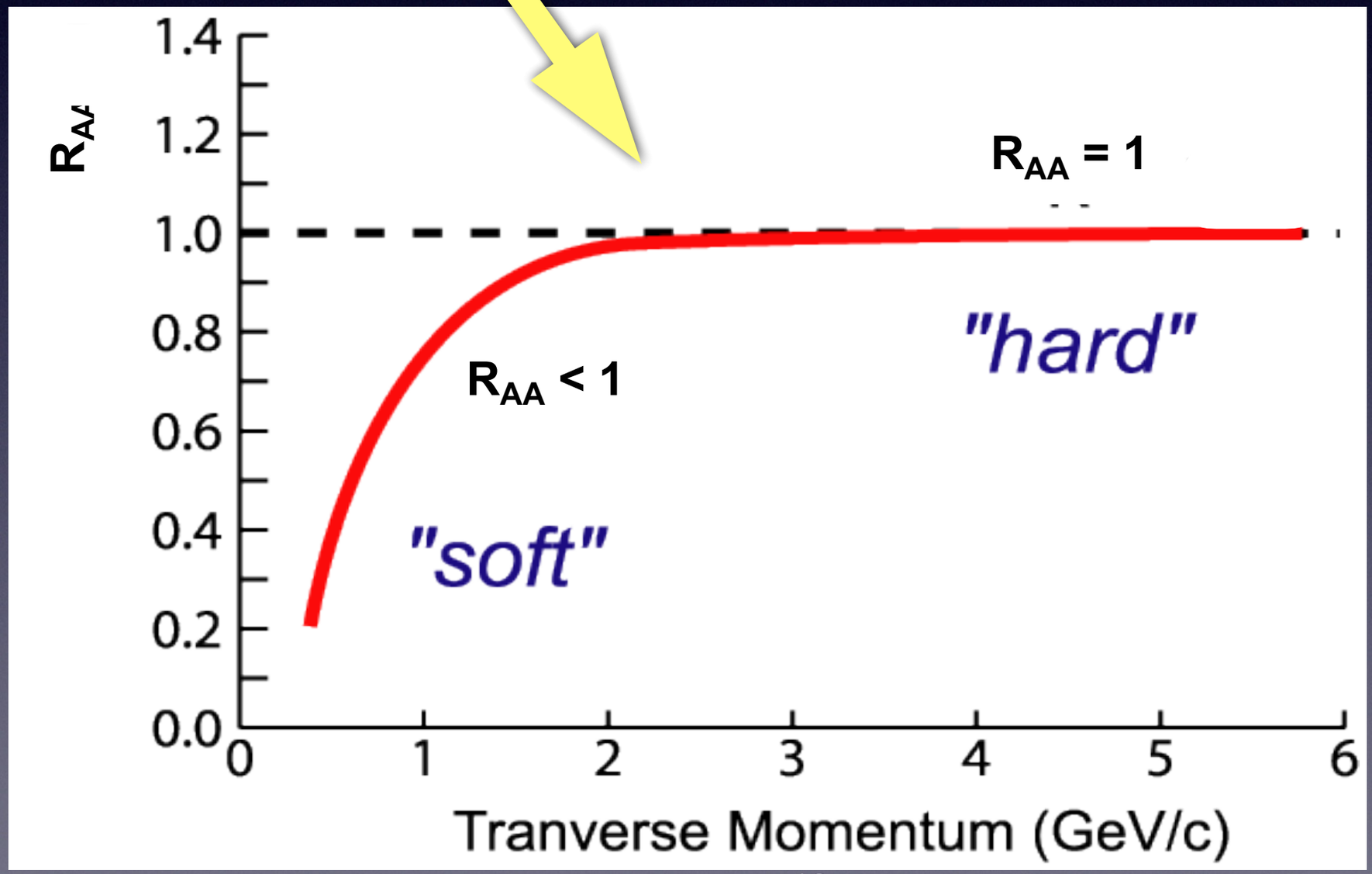
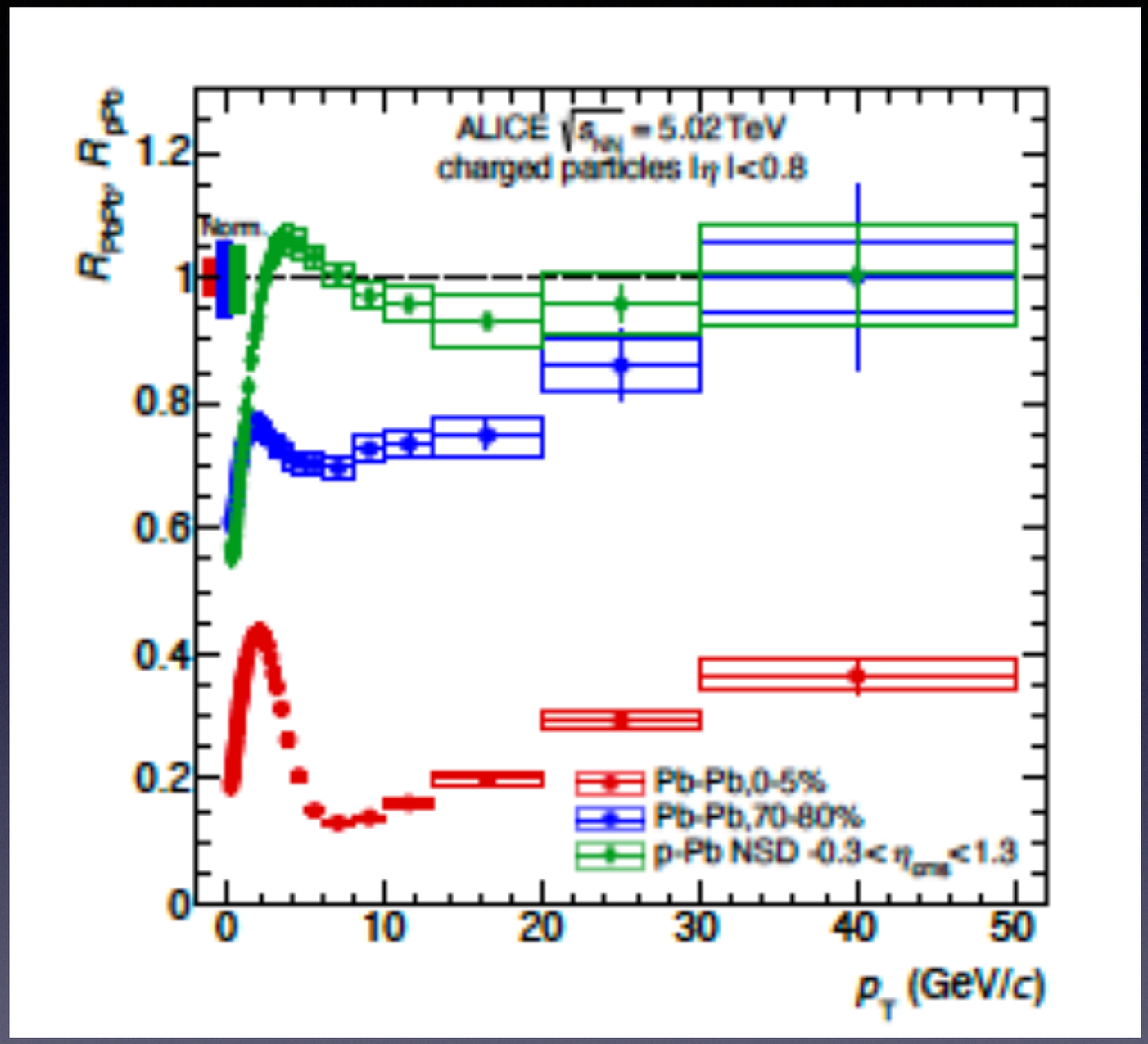


Explore medium with R_{AA} : light flavours

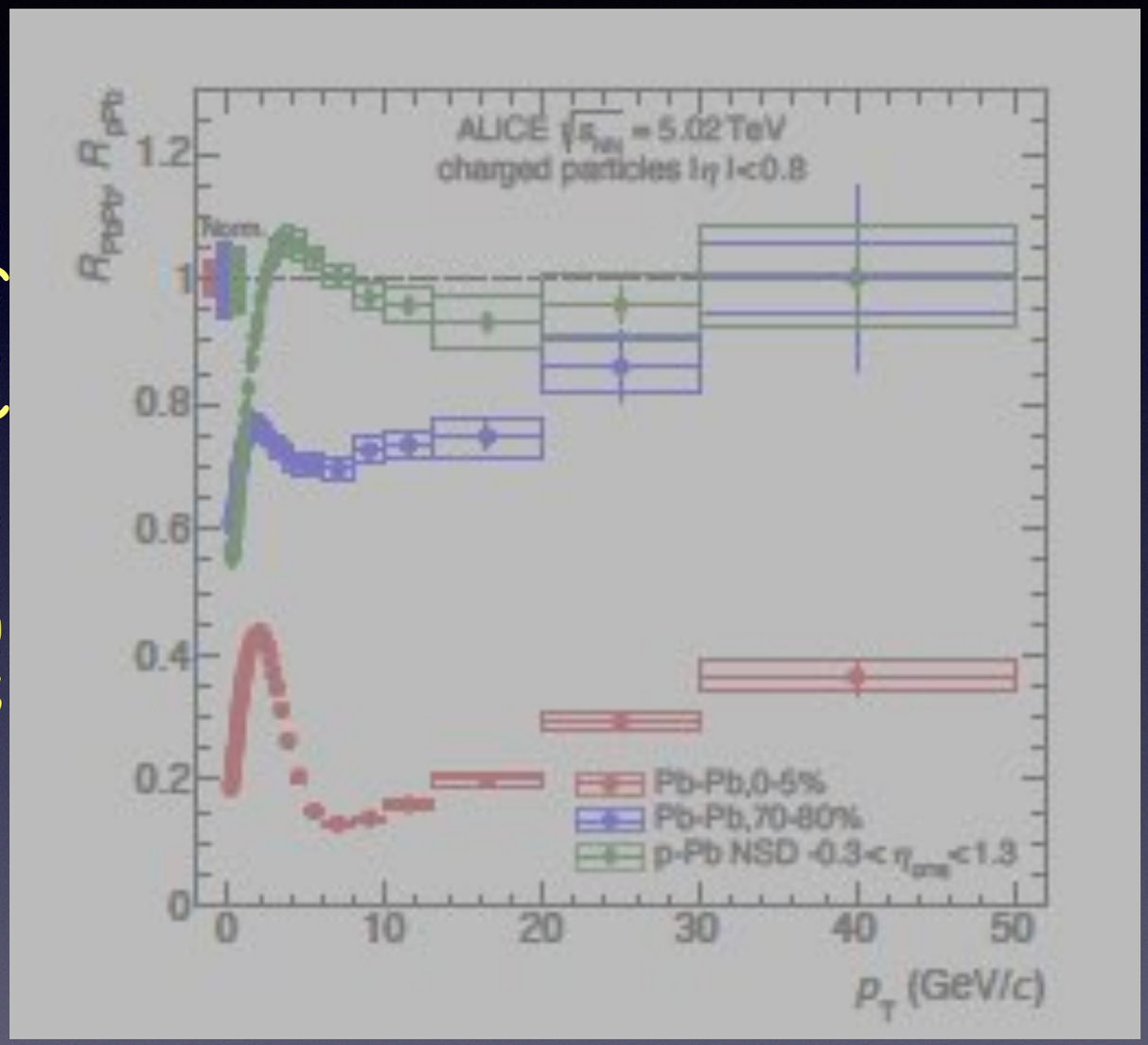
JHEP 1811 (2018) 013



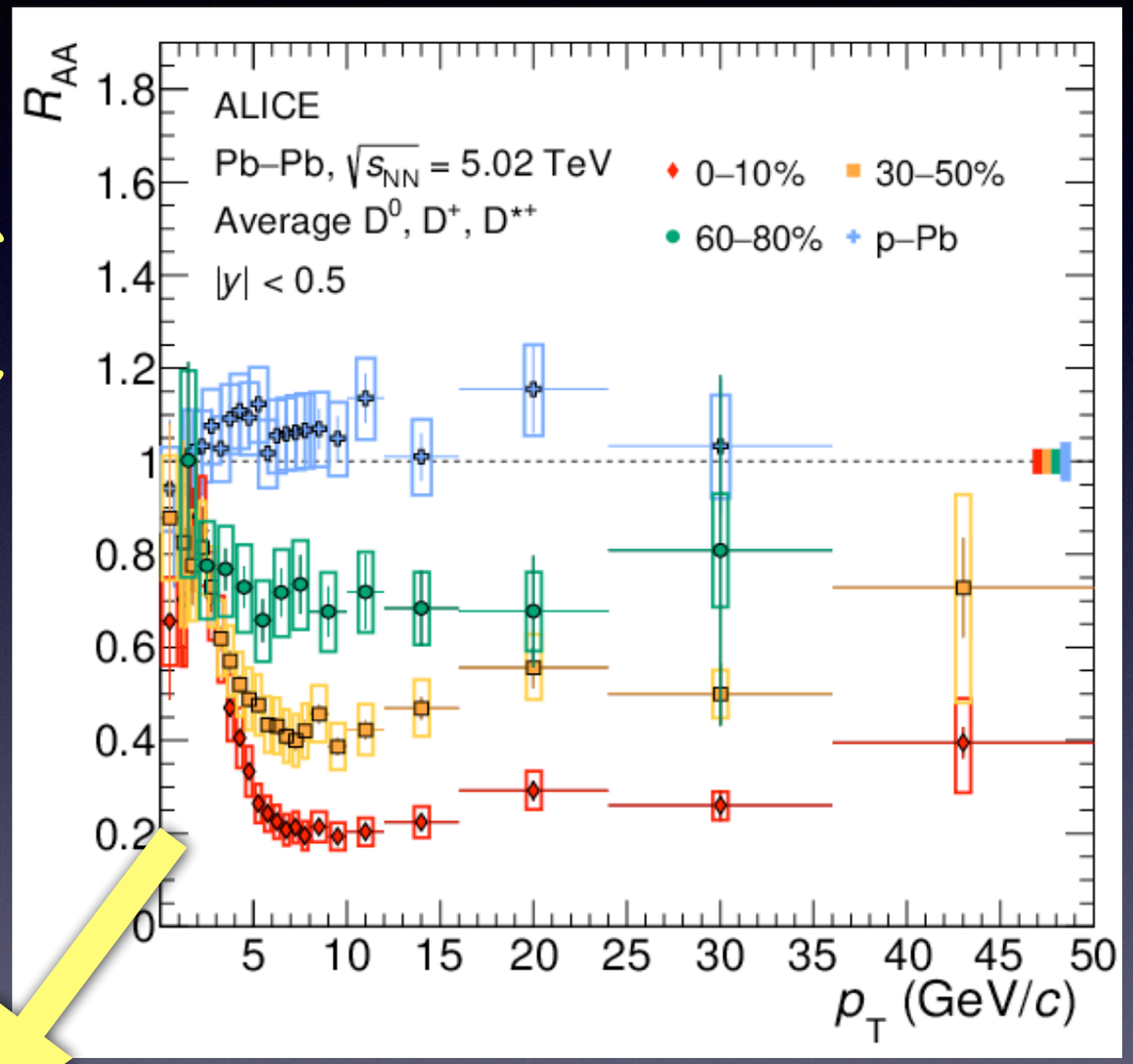
R_{AA} shows a strong centrality dependence

Explore medium with R_{AA} (II): heavy quarks

JHEP 1811 (2018) 013

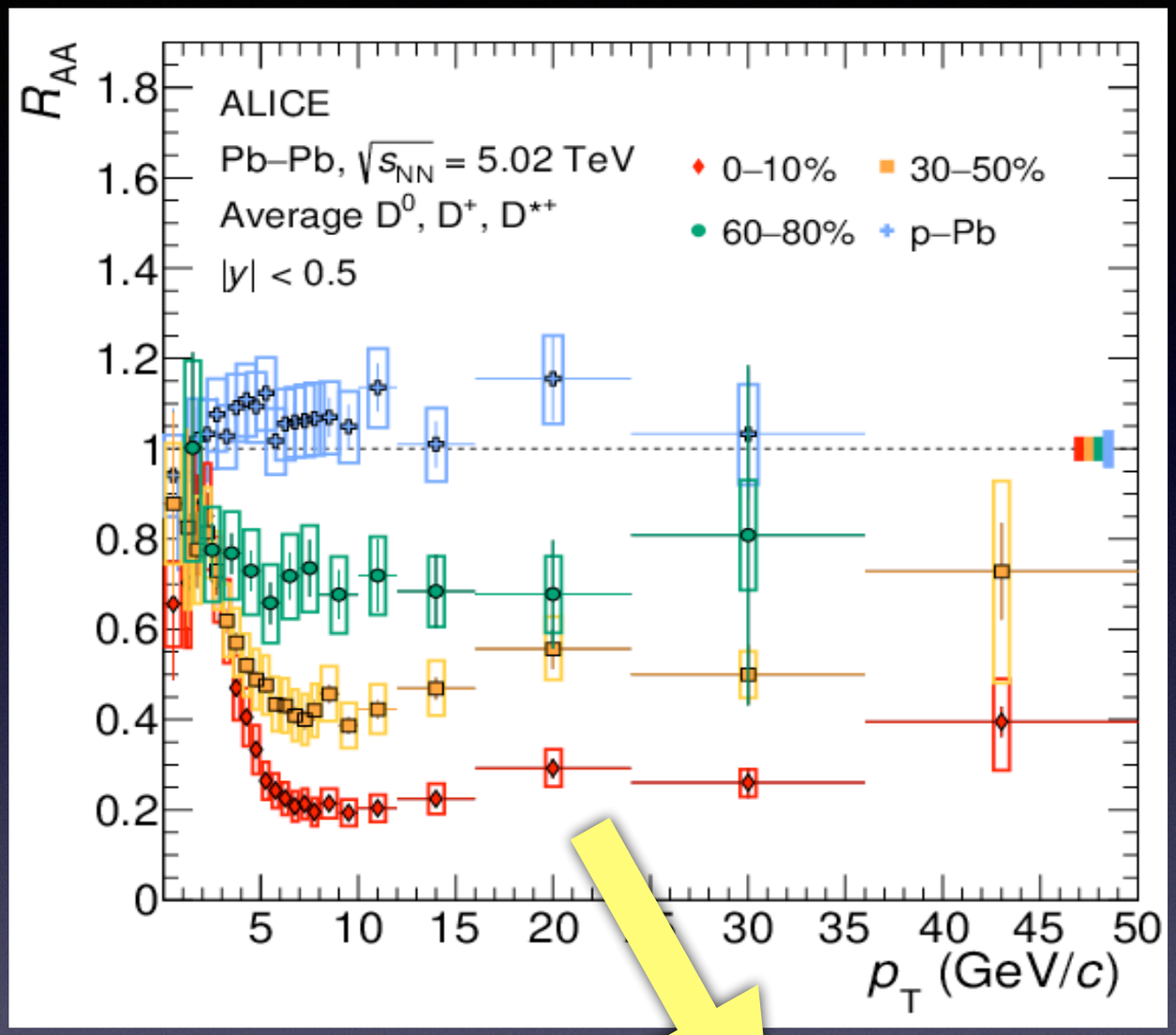


JHEP 1744 (2022) 01



R_{AA} of D mesons shows a strong centrality dependence

Explore medium with R_{AA} (II): heavy quarks



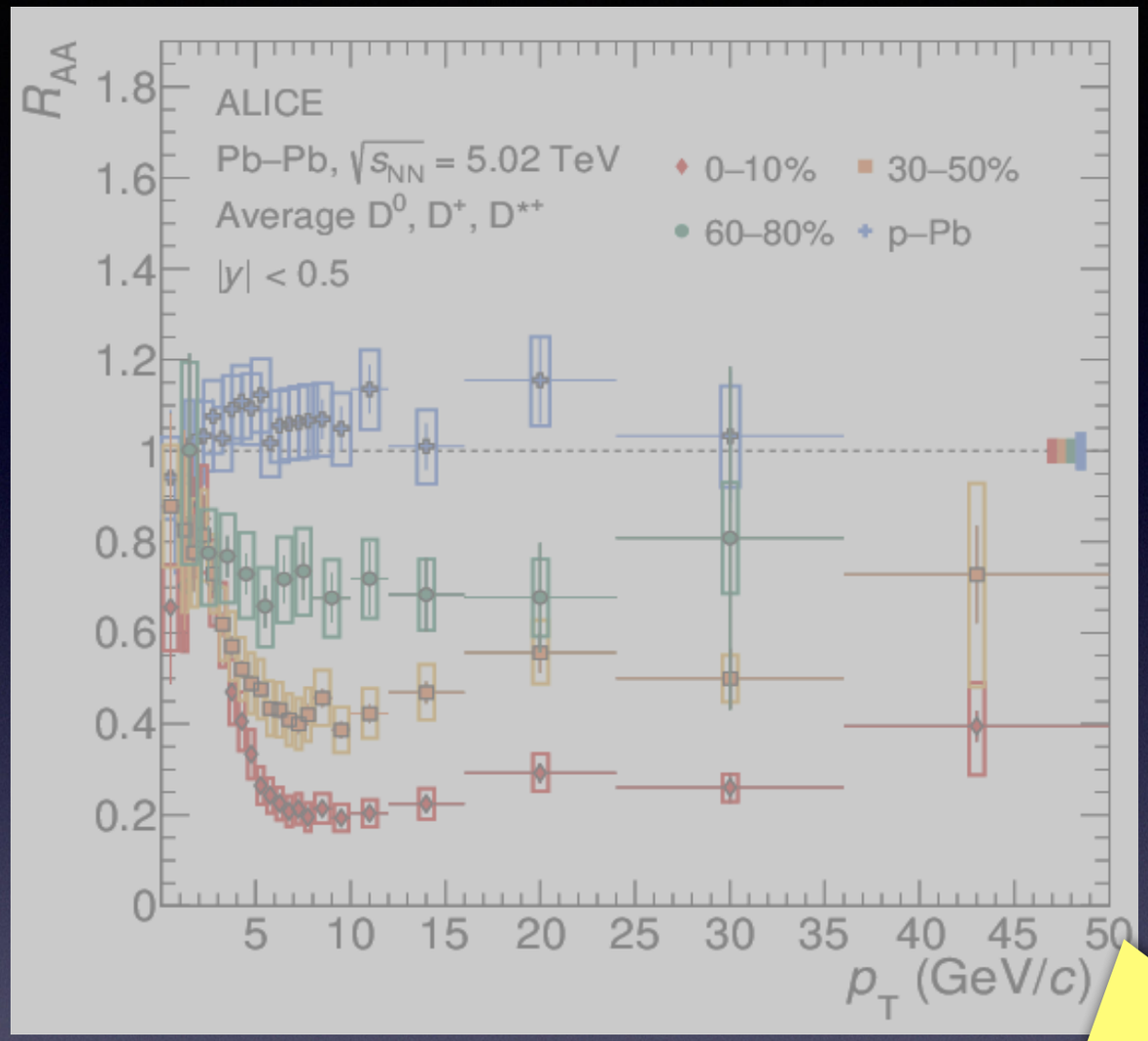
JHEP 174 (2022) 01

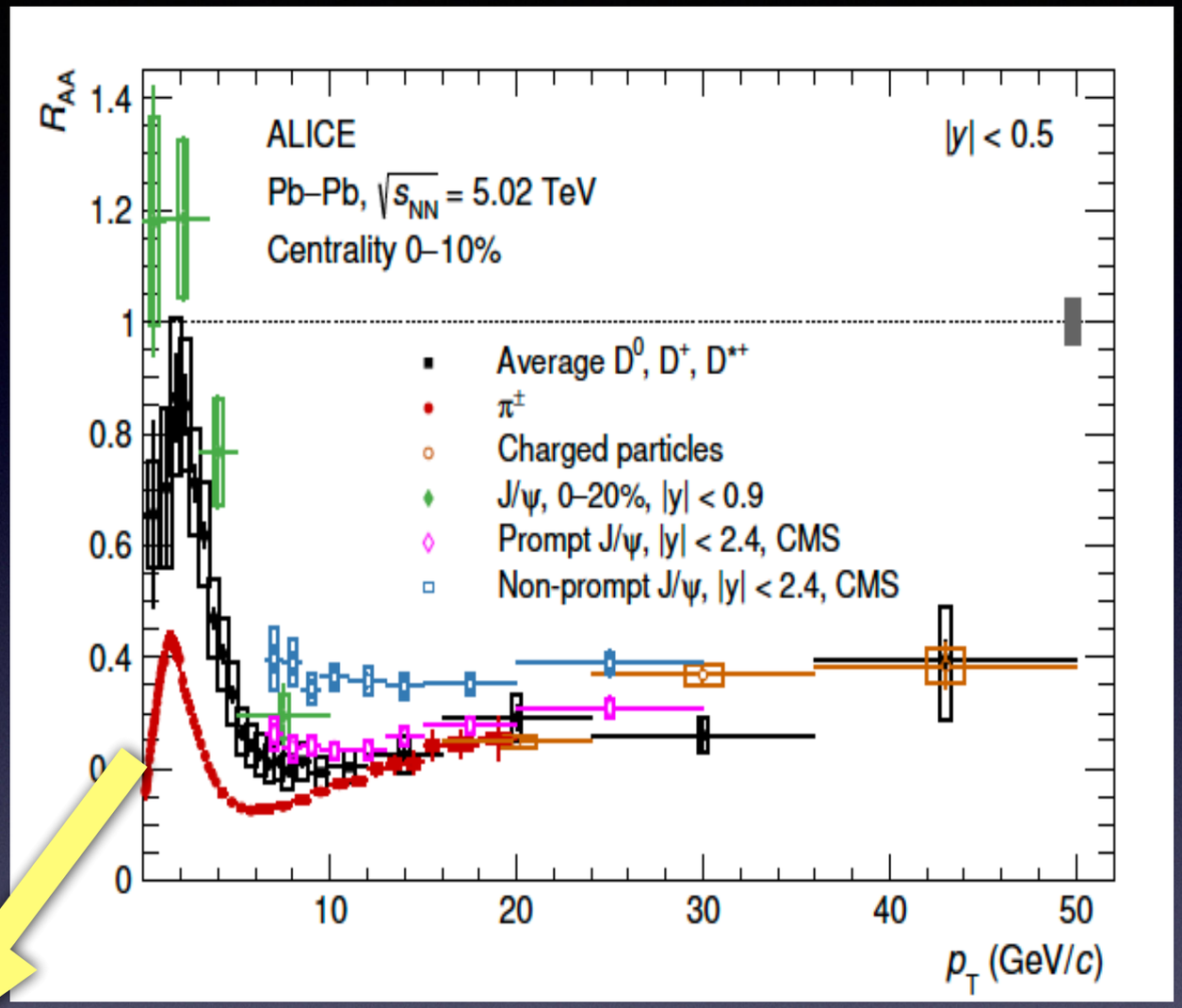
Suppression increases from peripheral to central collisions

Suppression observed in Pb-Pb collisions due to final state effects induced by the medium

Explore medium with R_{AA} (II): heavy quarks

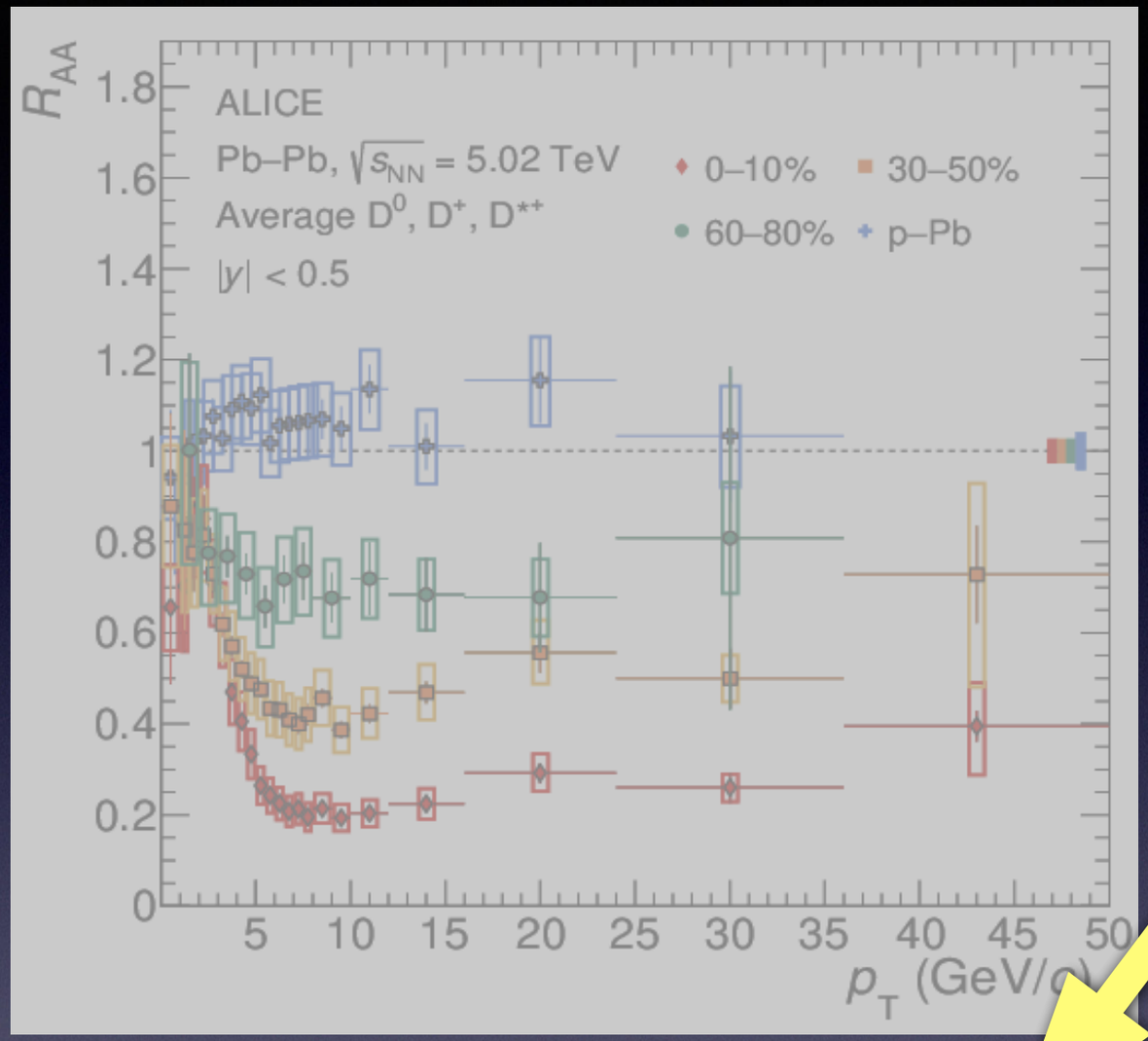
JHEP 174 (2022) 01

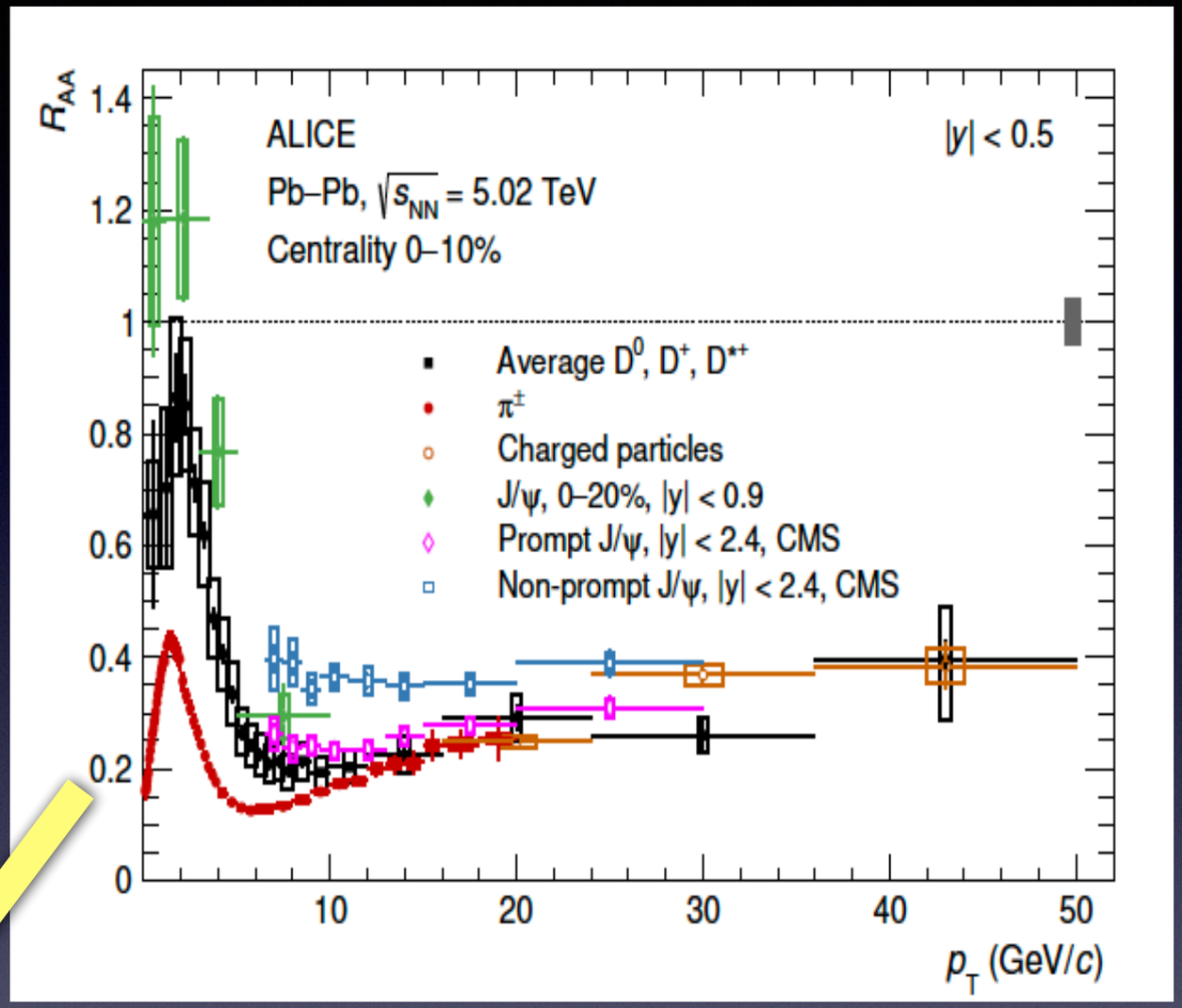




Different R_{AA} of D mesons and light flavored mesons

Explore medium with R_{AA} (II): heavy quarks





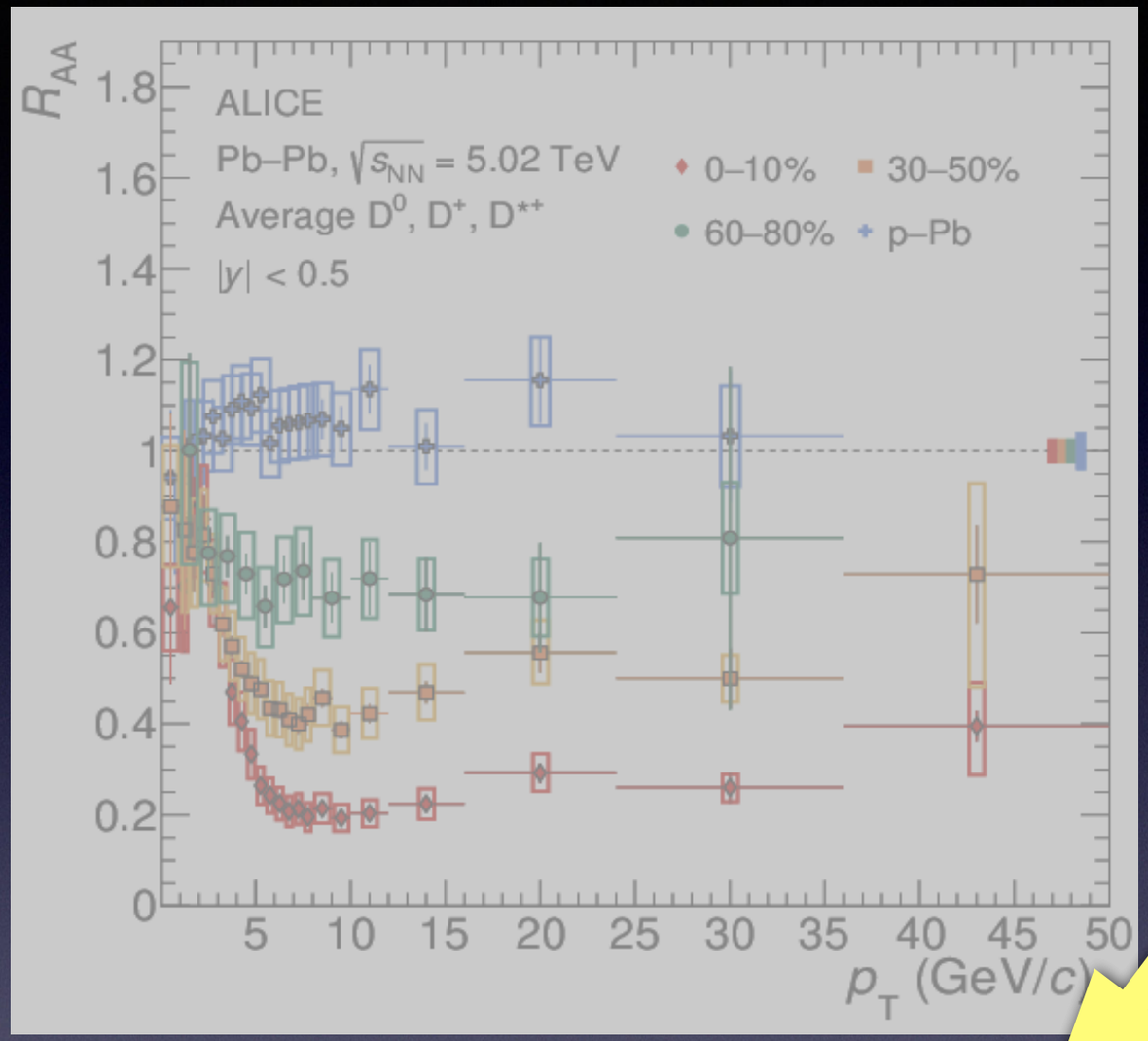
JHEP 174 (2022) 01

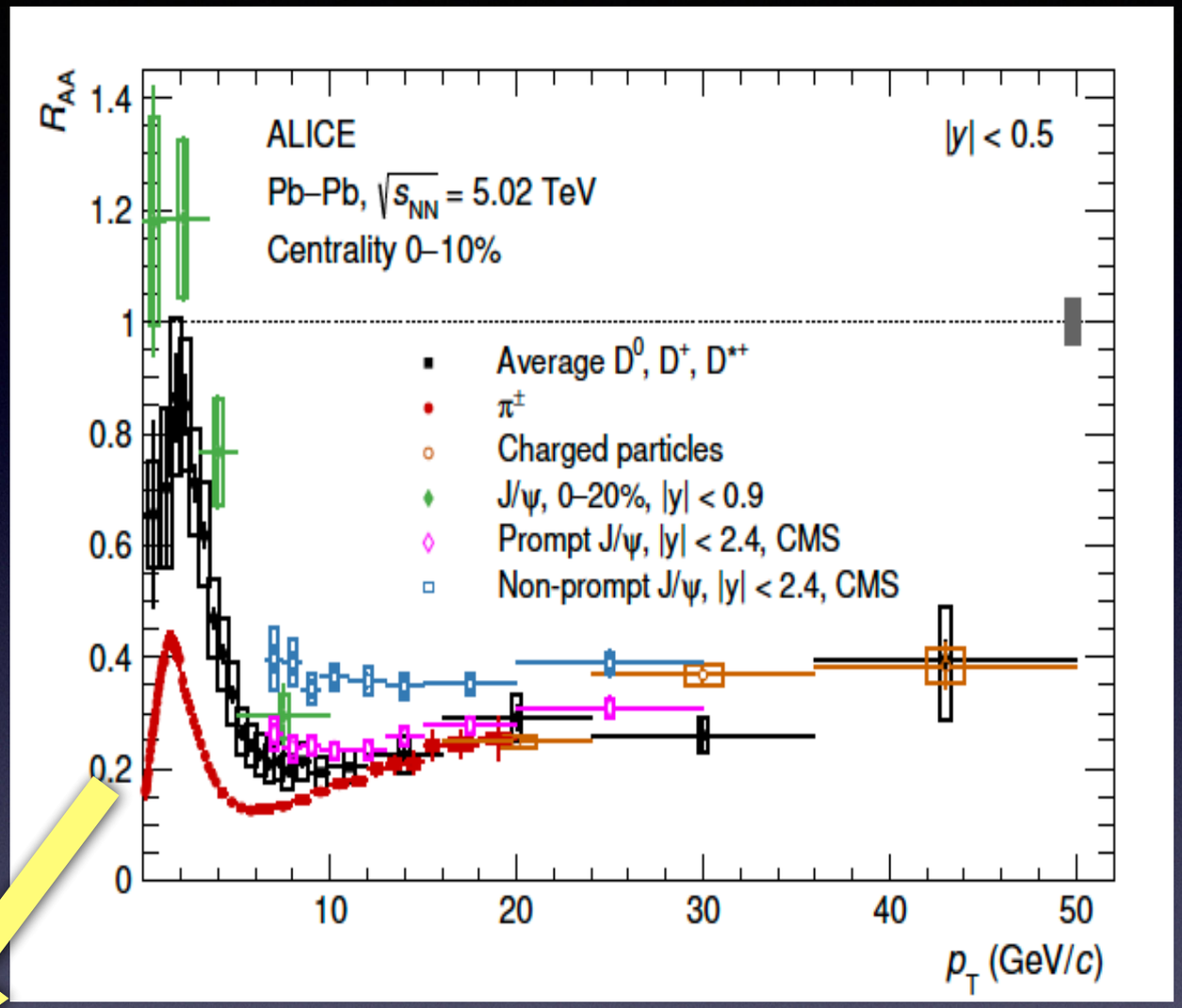
Different R_{AA} of D mesons and light flavored mesons

R_{AA} of D mesons and prompt J/Ψ signals interplay of different QGP effects in charm sector.

Explore medium with R_{AA} (II): heavy quarks

JHEP 174 (2022) 01



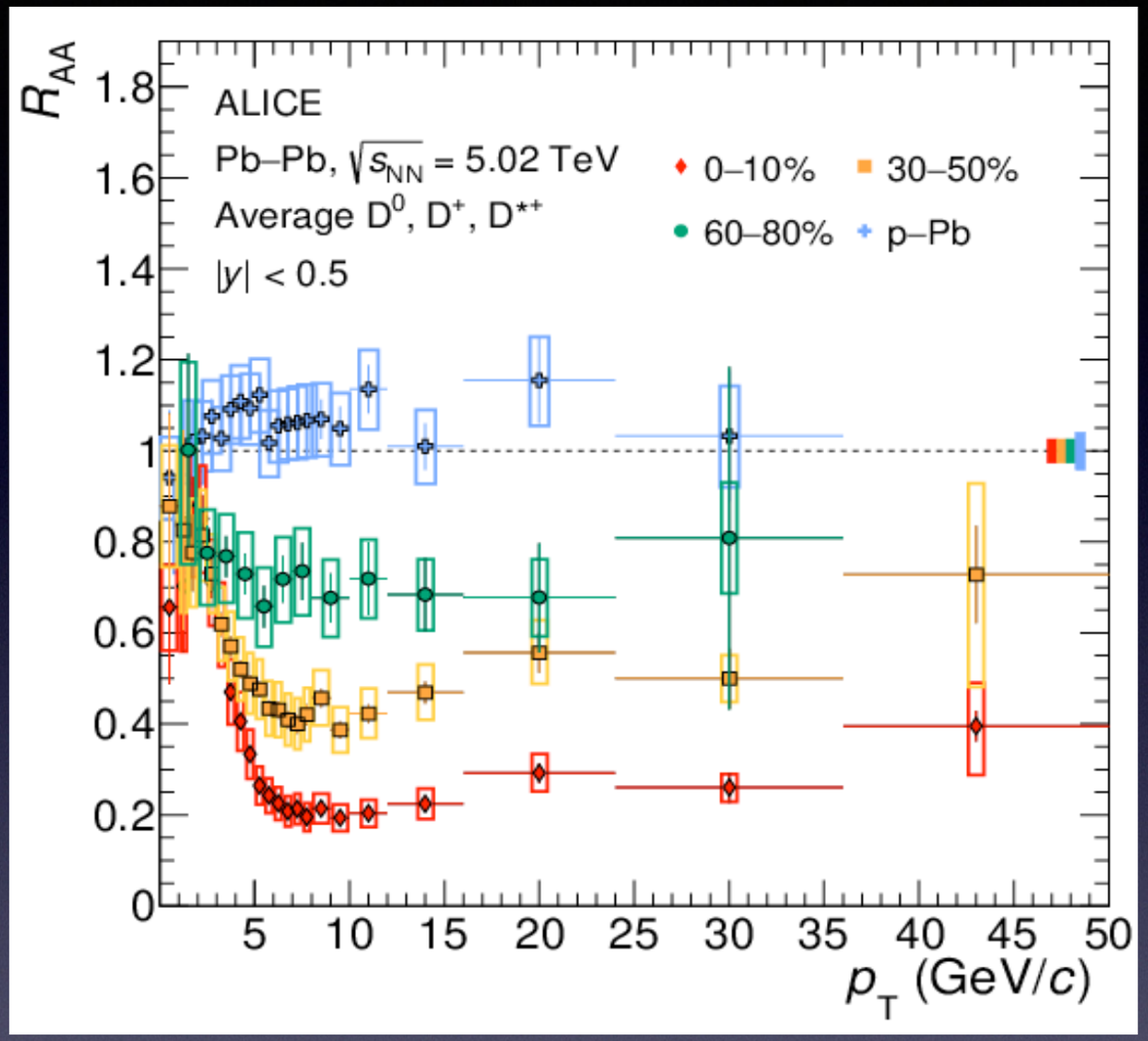


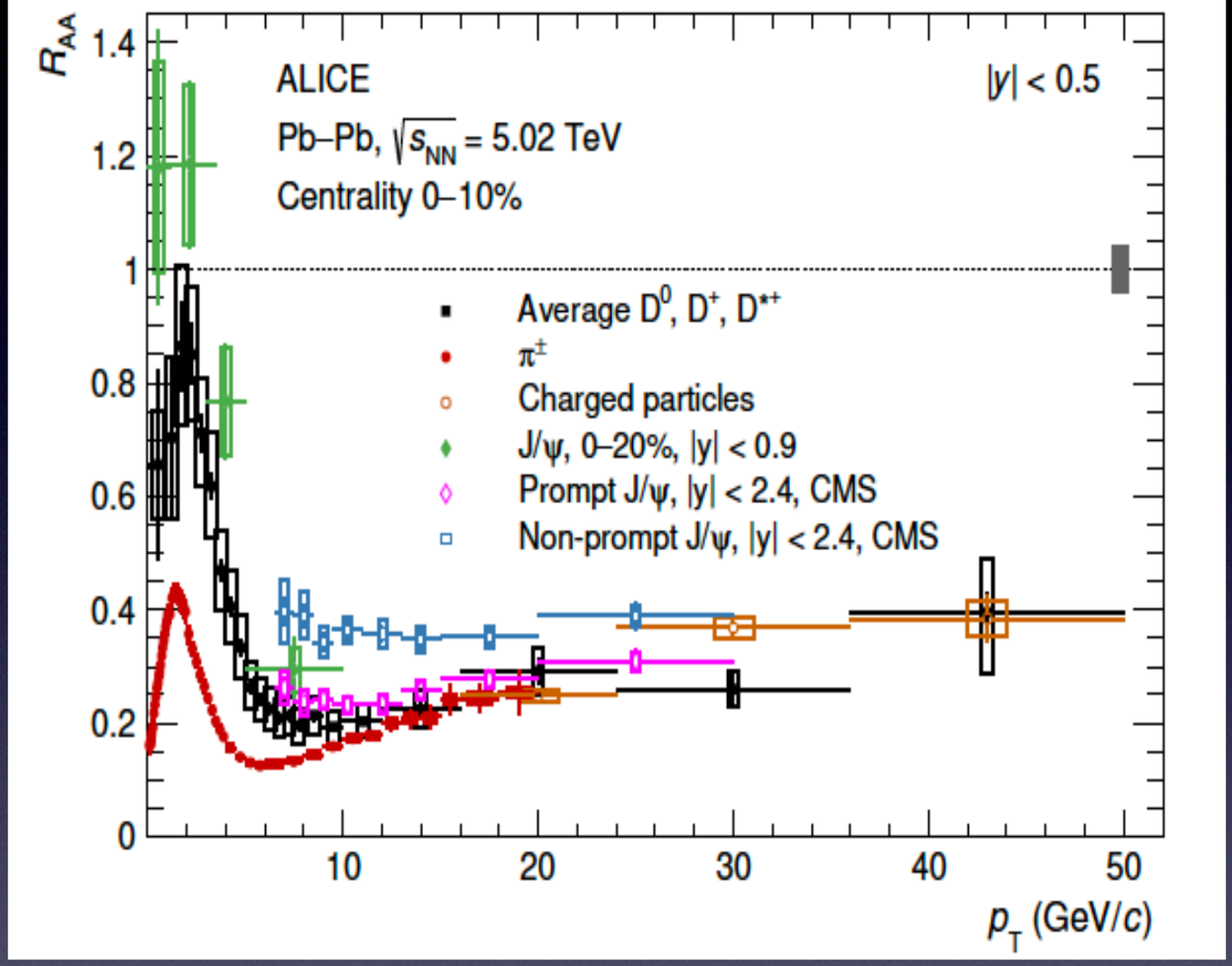
Different R_{AA} of D mesons and light flavored mesons

R_{AA} of D mesons and prompt J/Ψ signals interplay of different QGP effects in charm sector.

Different R_{AA} of D mesons and non-prompt J/Ψ from beauty hadron decays signals quark mass dependence of in-medium energy loss .

Explore medium with R_{AA} (II): heavy quarks



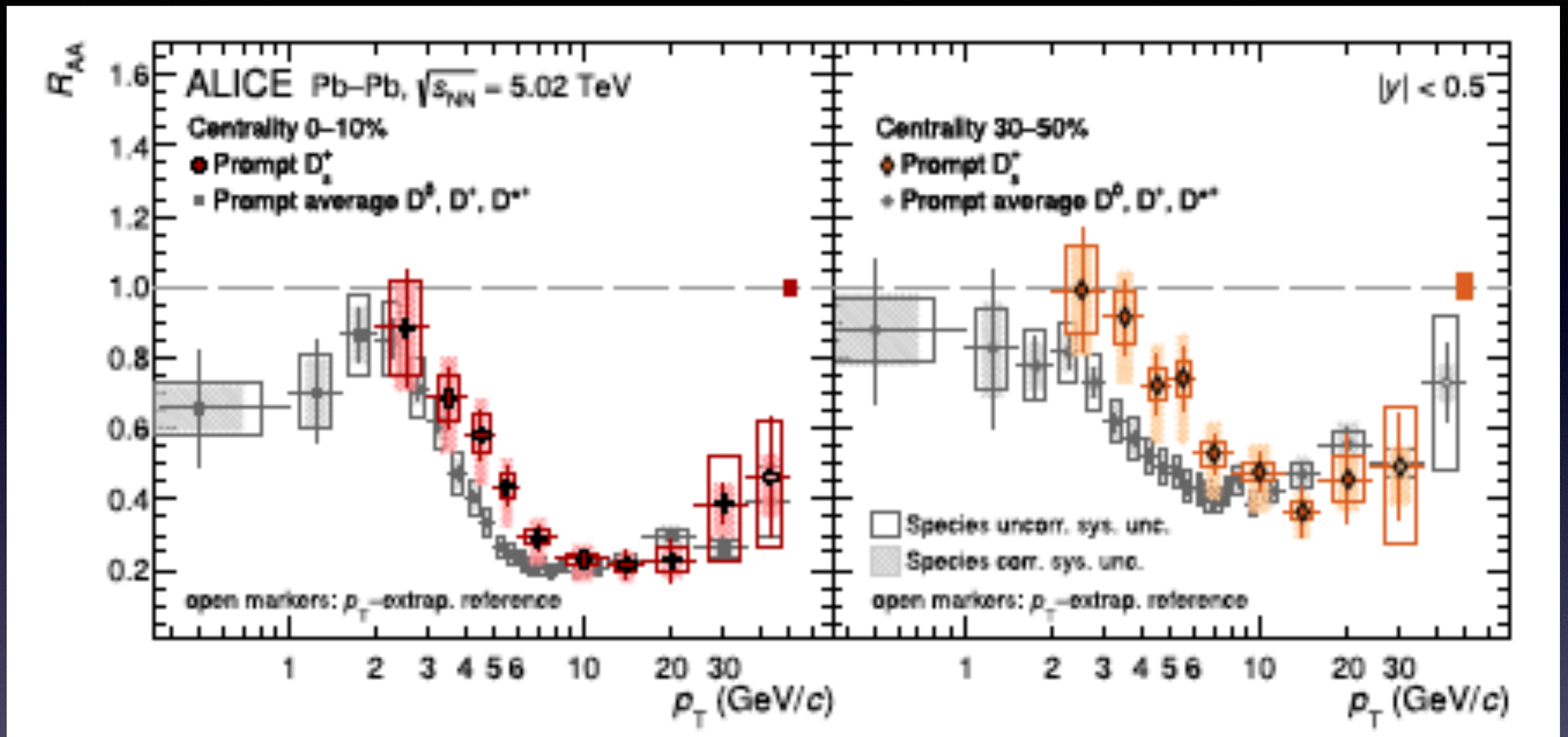


Suppression increases from peripheral to central collisions

Suppression observed in Pb-Pb collisions due to final state effects induced by the medium

Explore medium with R_{AA} (II) : heavy+strange

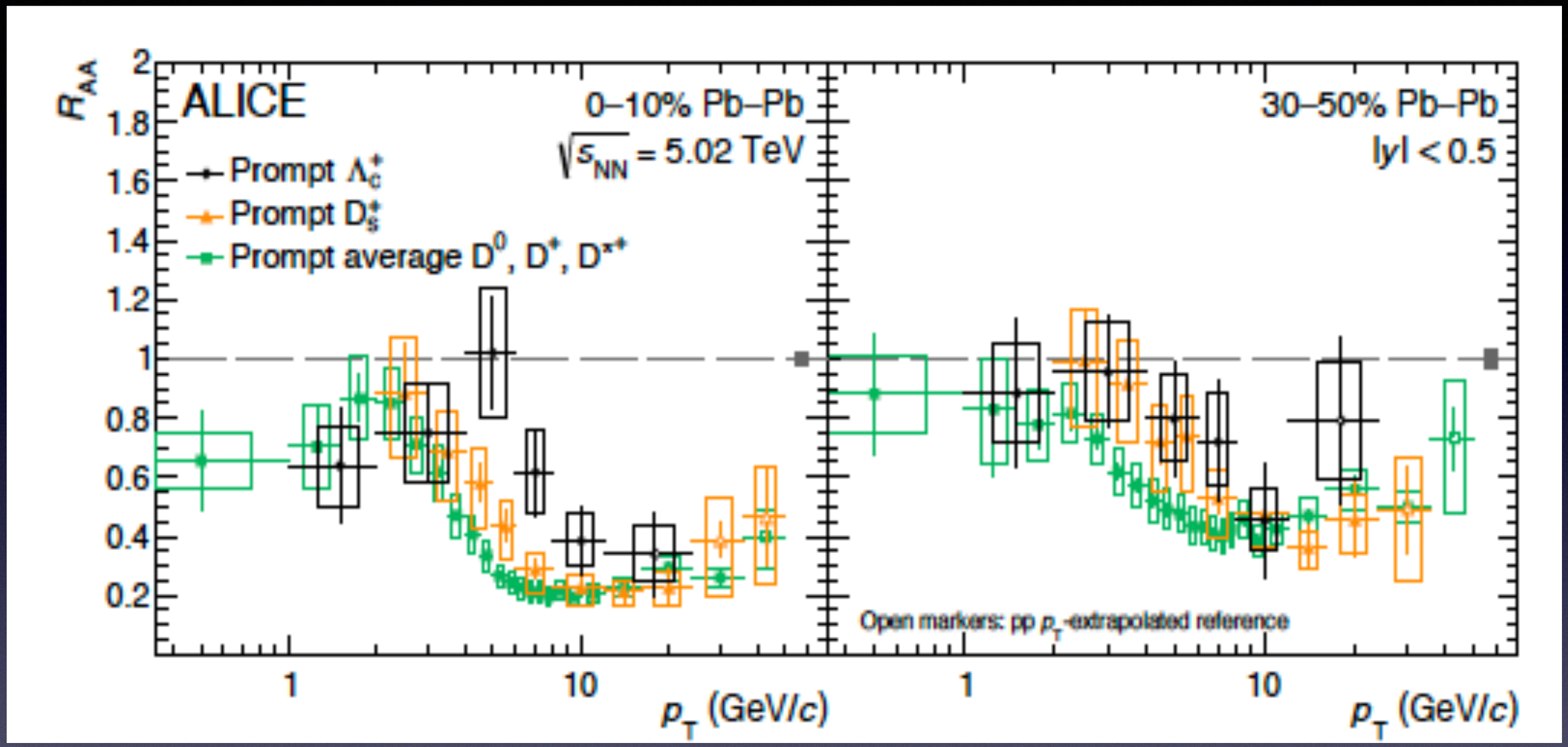
Phys. Lett. B 827 (2022) 136986



Strong suppression of D_S^+ reaching a minimum at pT ~ 10 GeV/c

Explore medium with R_{AA} (II) : heavy+strange

ALICE, arXiv:2112.08156



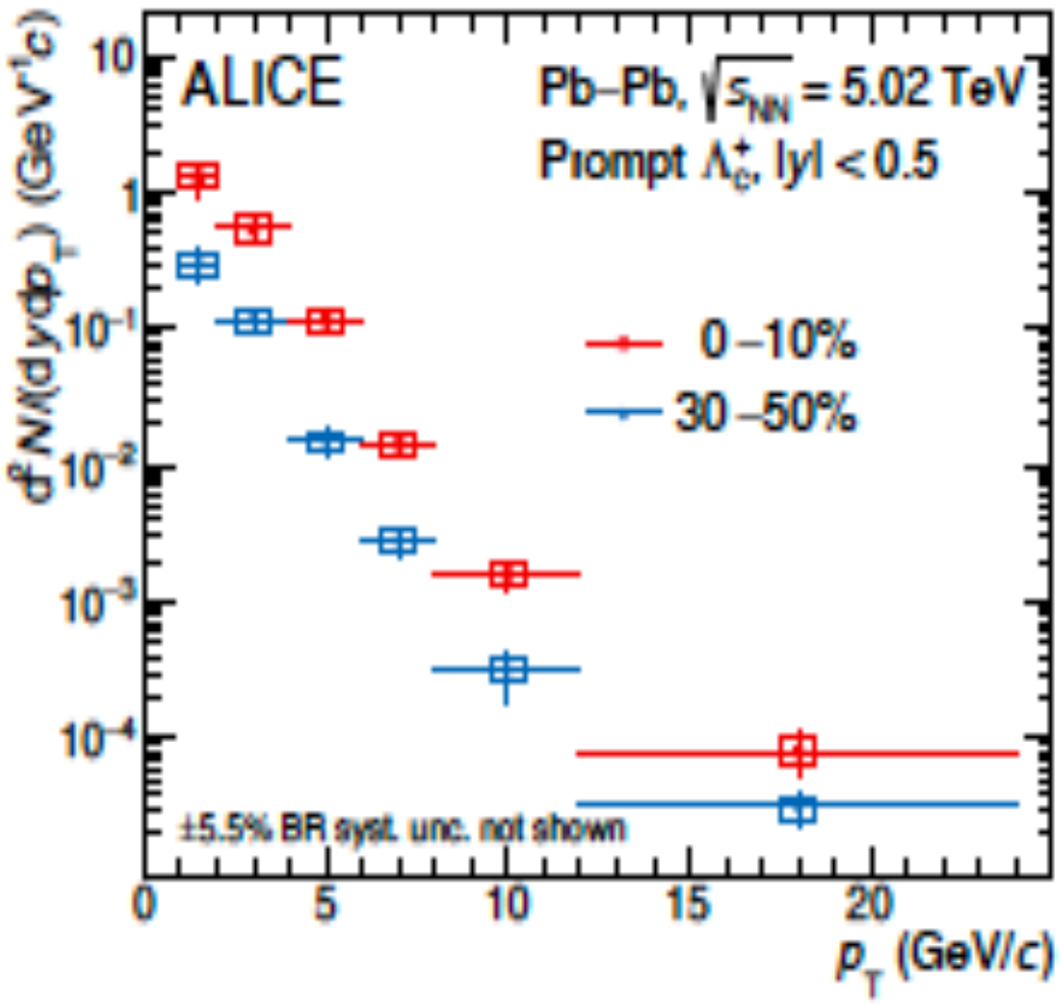
Suppression of Λ_c^+ at pT > 6 GeV/c

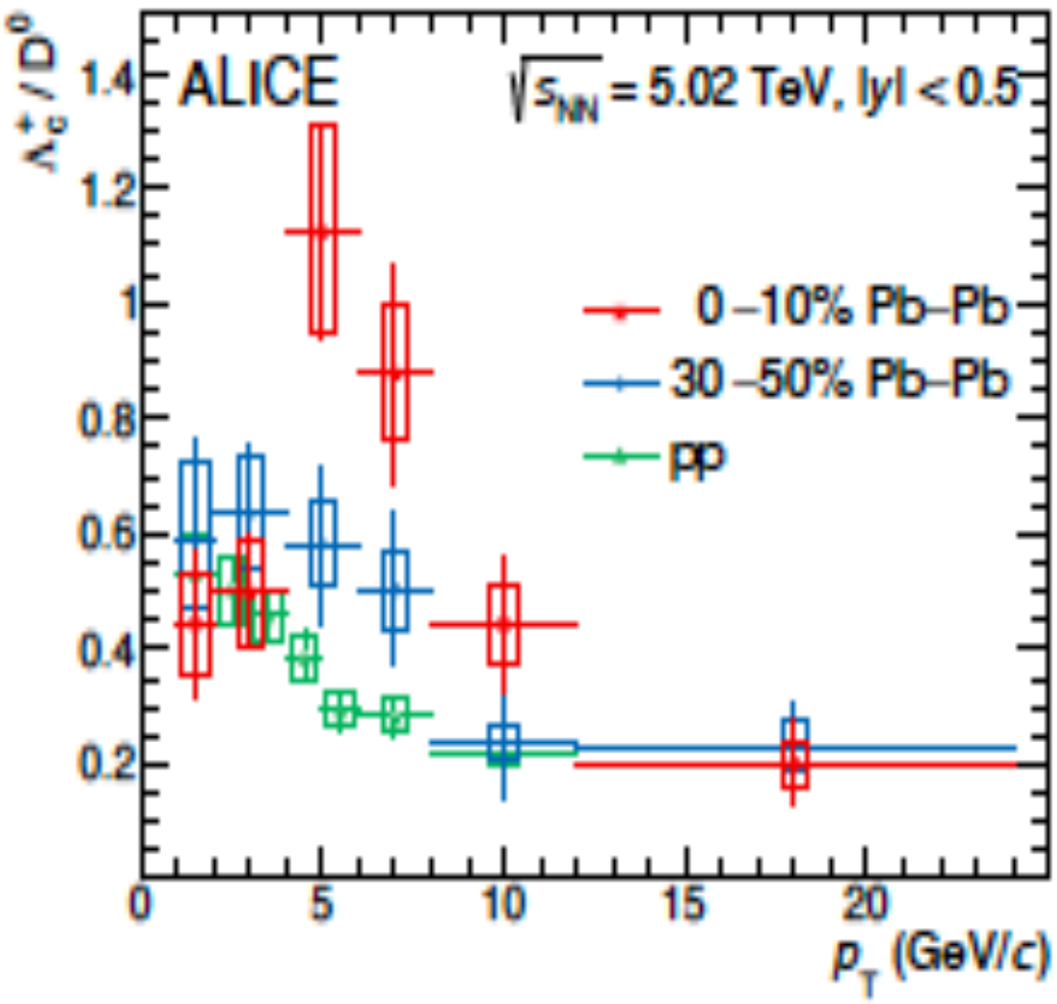
Hierarchy R_{AA} (Λ_c) > R_{AA} (D_S) > R_{AA}(D) for pT > 4.5 GeV

Hadronization

Baryon to meson anomaly in charm sector

ALICE, arXiv:2112.08156





Baryon to meson anomaly in charm sector

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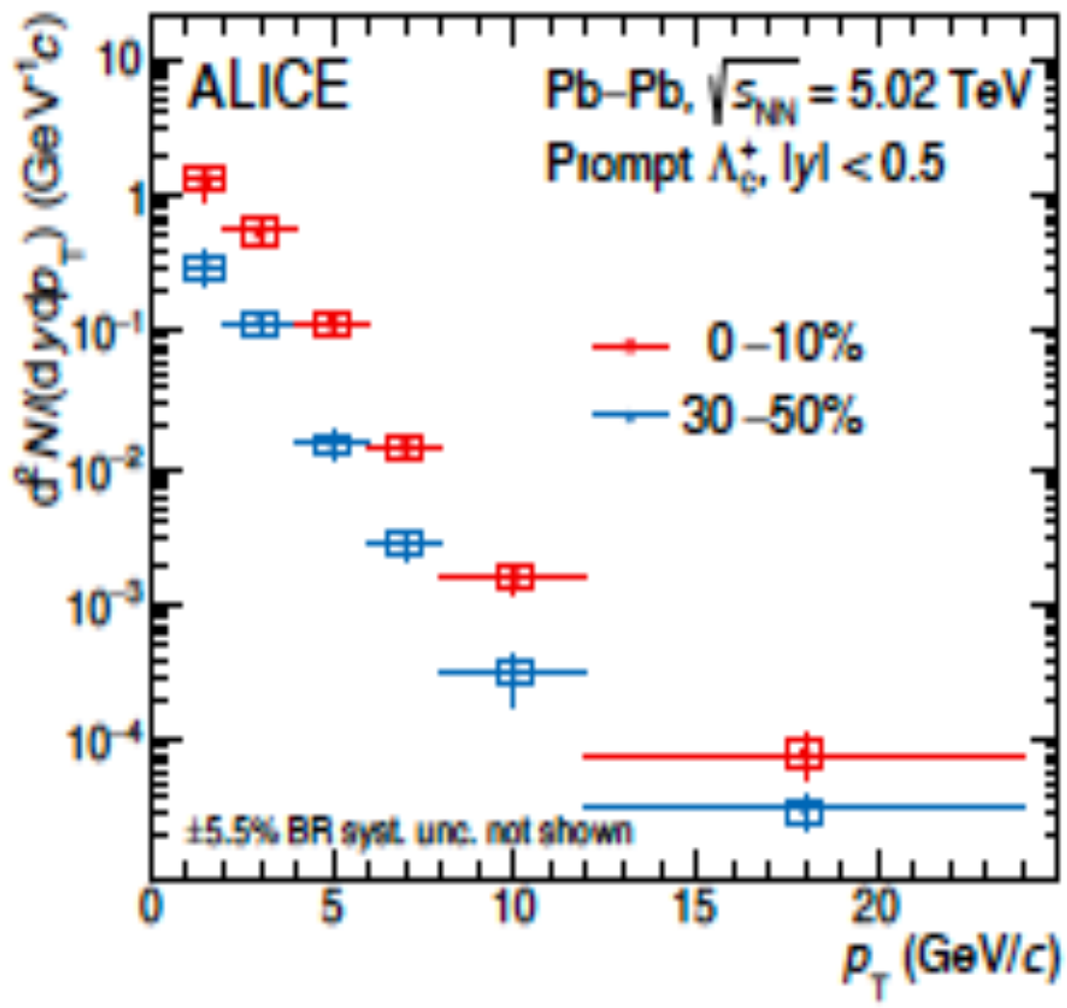
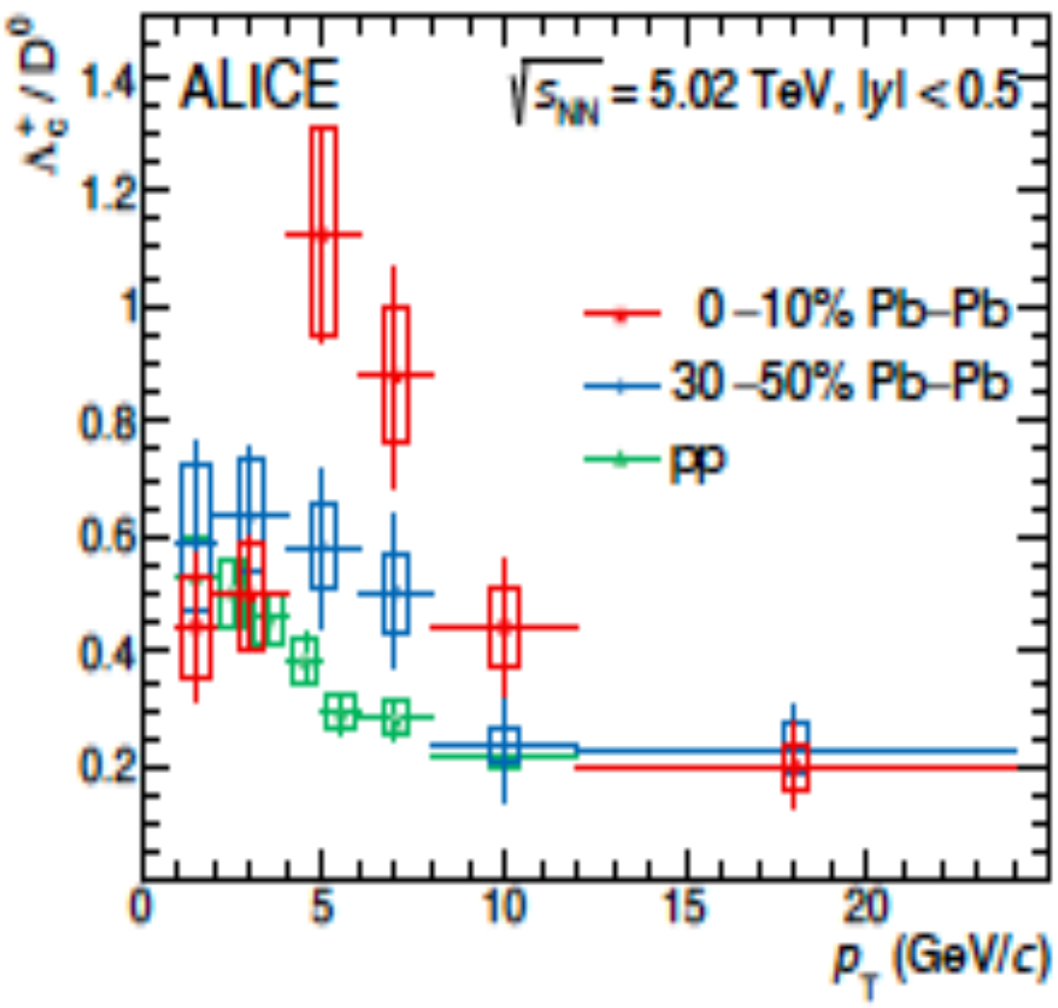
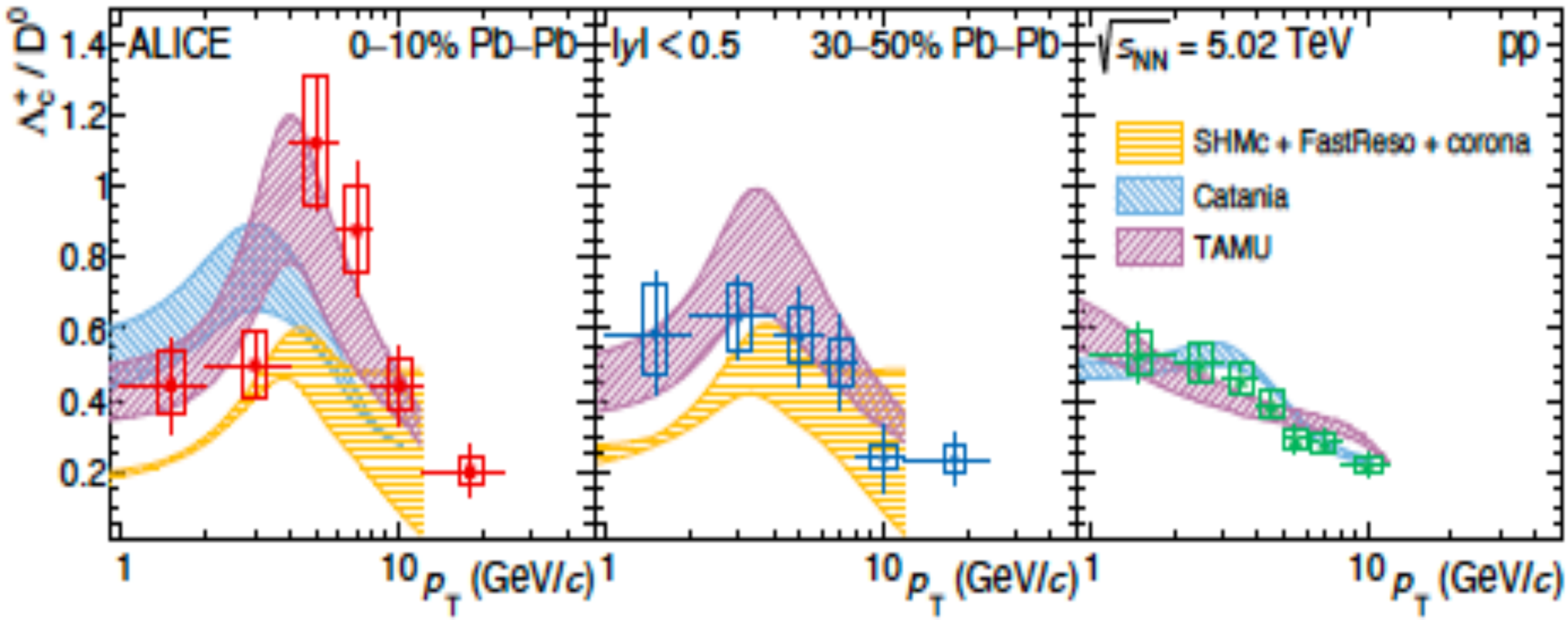




Enhancement of Λ_c/D^0 at intermediate p_T.

This observation is similar to that observed for light flavour sector

Baryon to meson anomaly in charm sector



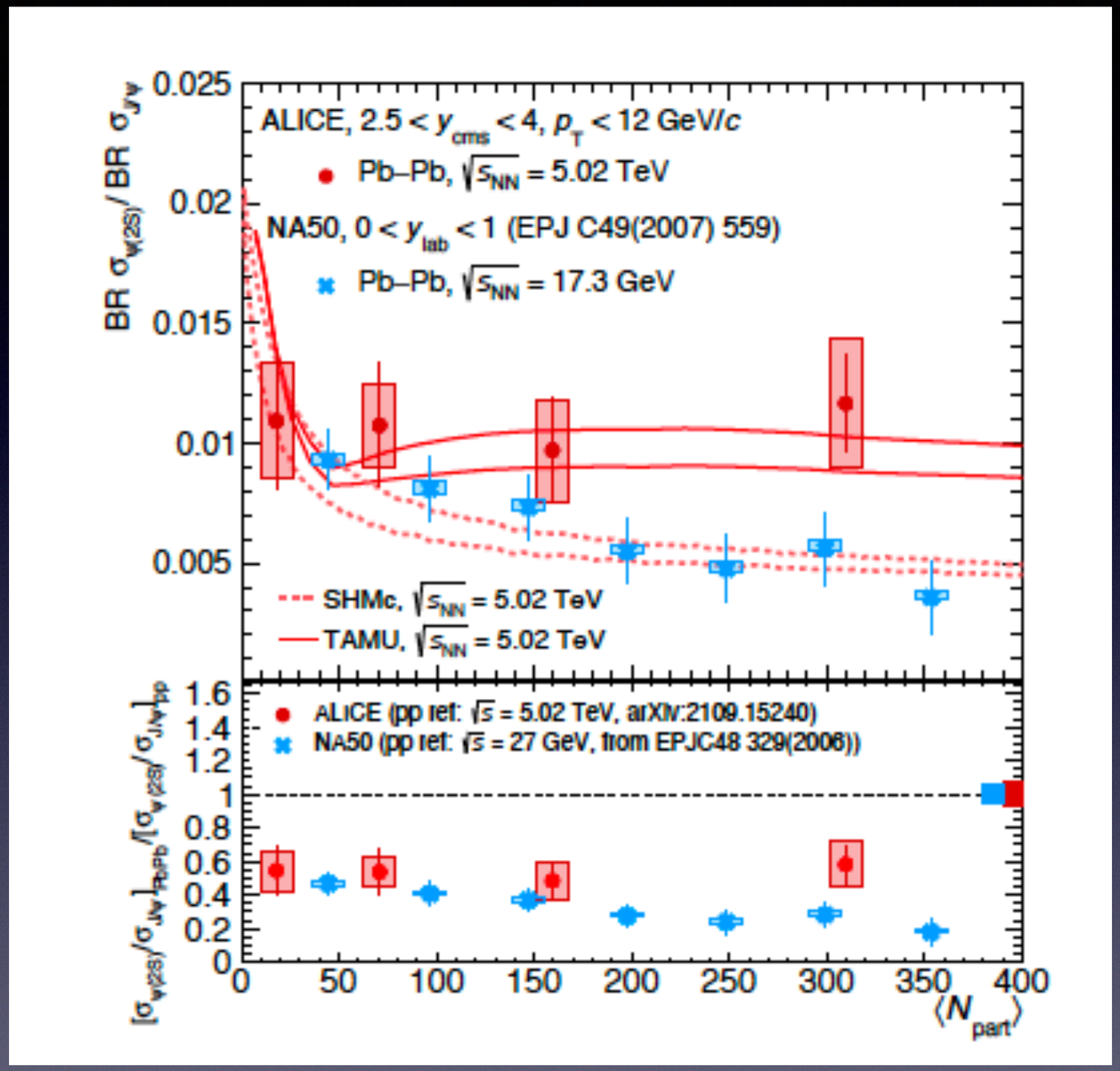
ALICE, arXiv:2112.08156

Ratio increases from pp to central Pb-Pb collisions

Compatible with theoretical models that include both fragmentation and coalescence mechanism of hadronization.

$\Psi(2S)$ production in Pb-Pb

ALICE: arXiv:2210.08893



First measurement in LHC down to zero p_T

$\Psi(2S)$ production in Pb-Pb

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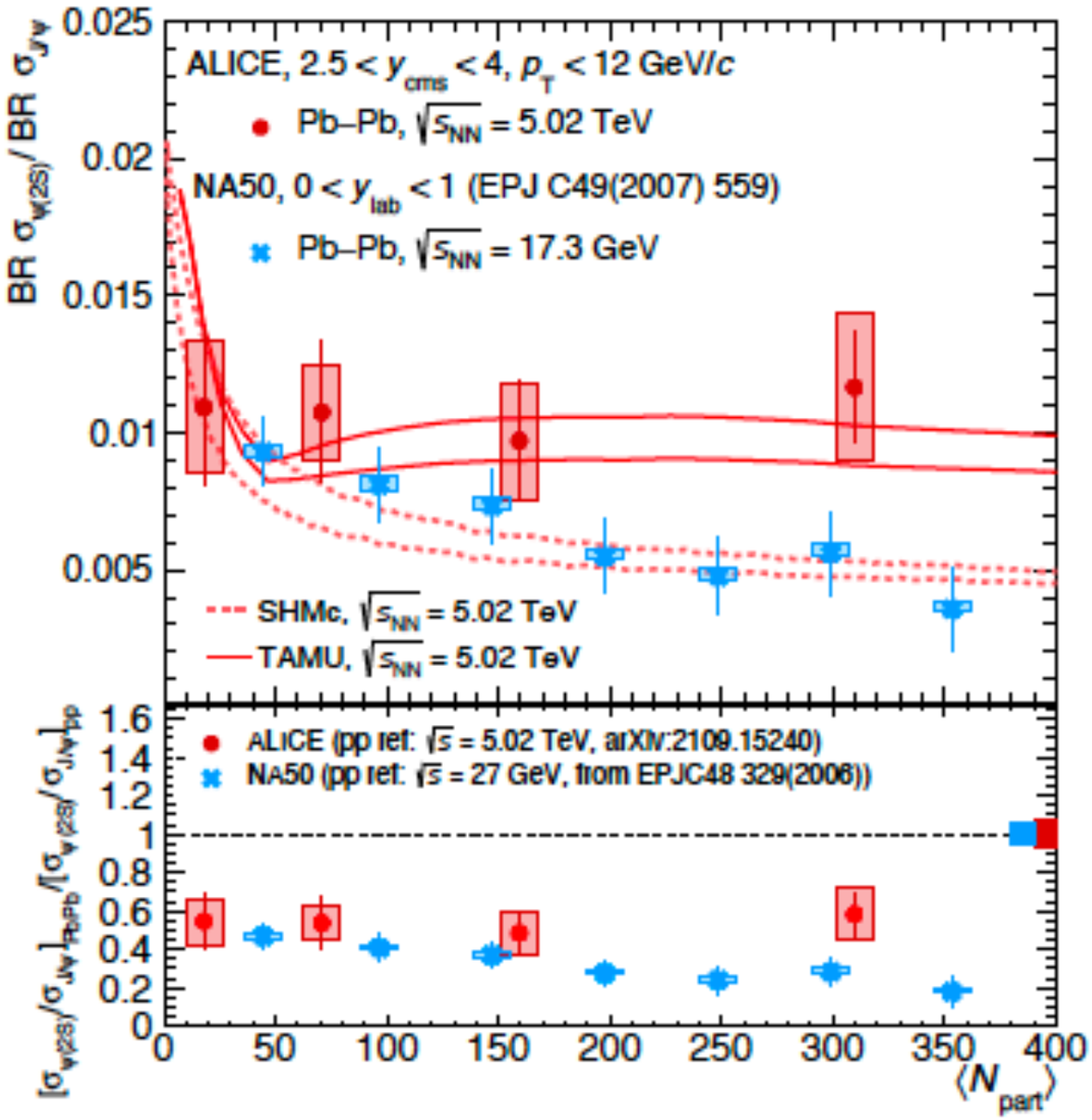
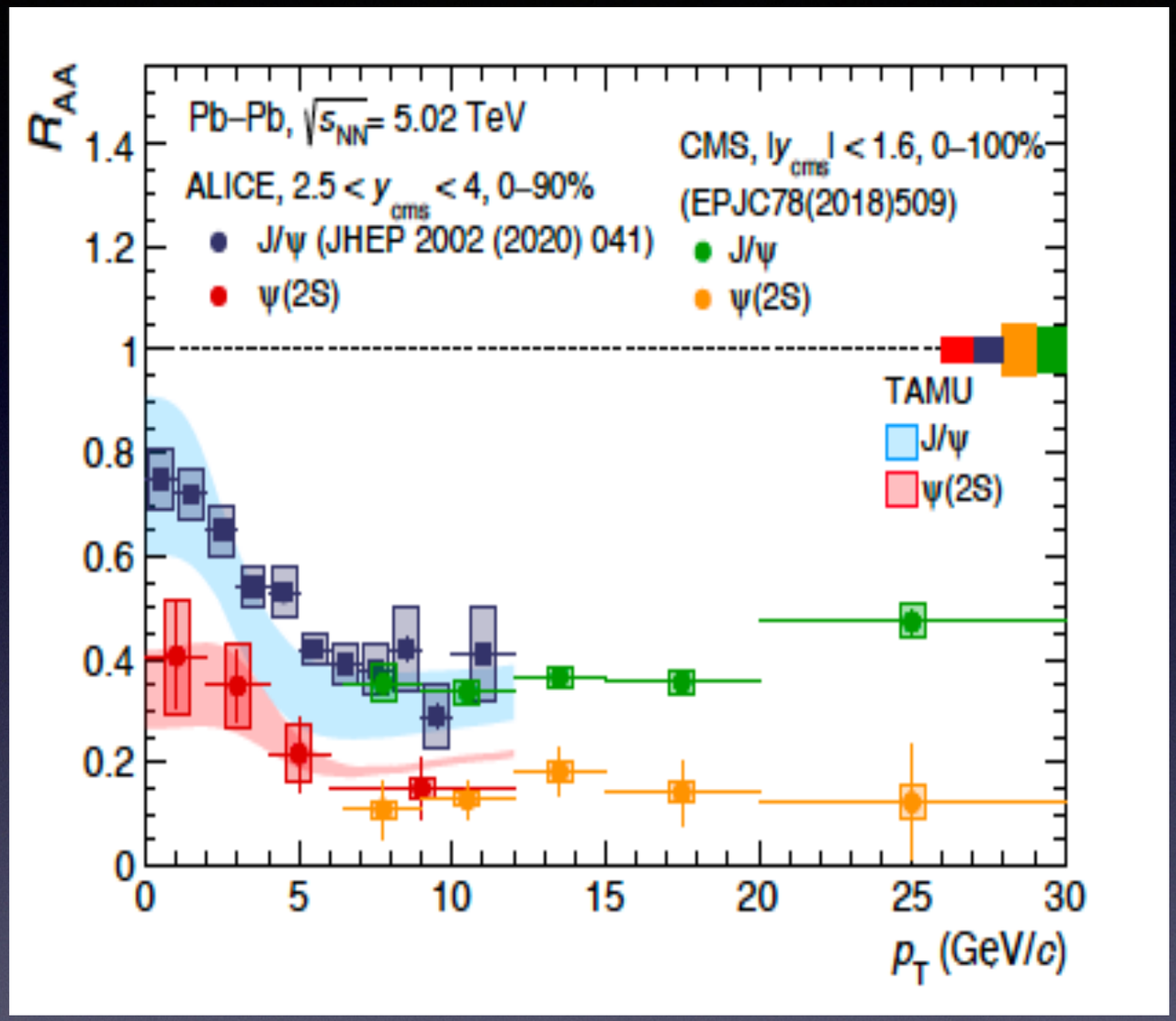


Centrality dependence of $\Psi(2S)/J/\Psi$ production well described by TAMU and slightly underestimated by SHMc

First measurement in LHC down to zero p_T

$\Psi(2S)$ production in Pb-Pb



Stronger suppression of of $\Psi(2S)$ compared to J/Ψ.

First measurement in LHC down to zero p_T

ALICE: arXiv:2210.08893

$\Psi(2S)$ production in Pb-Pb

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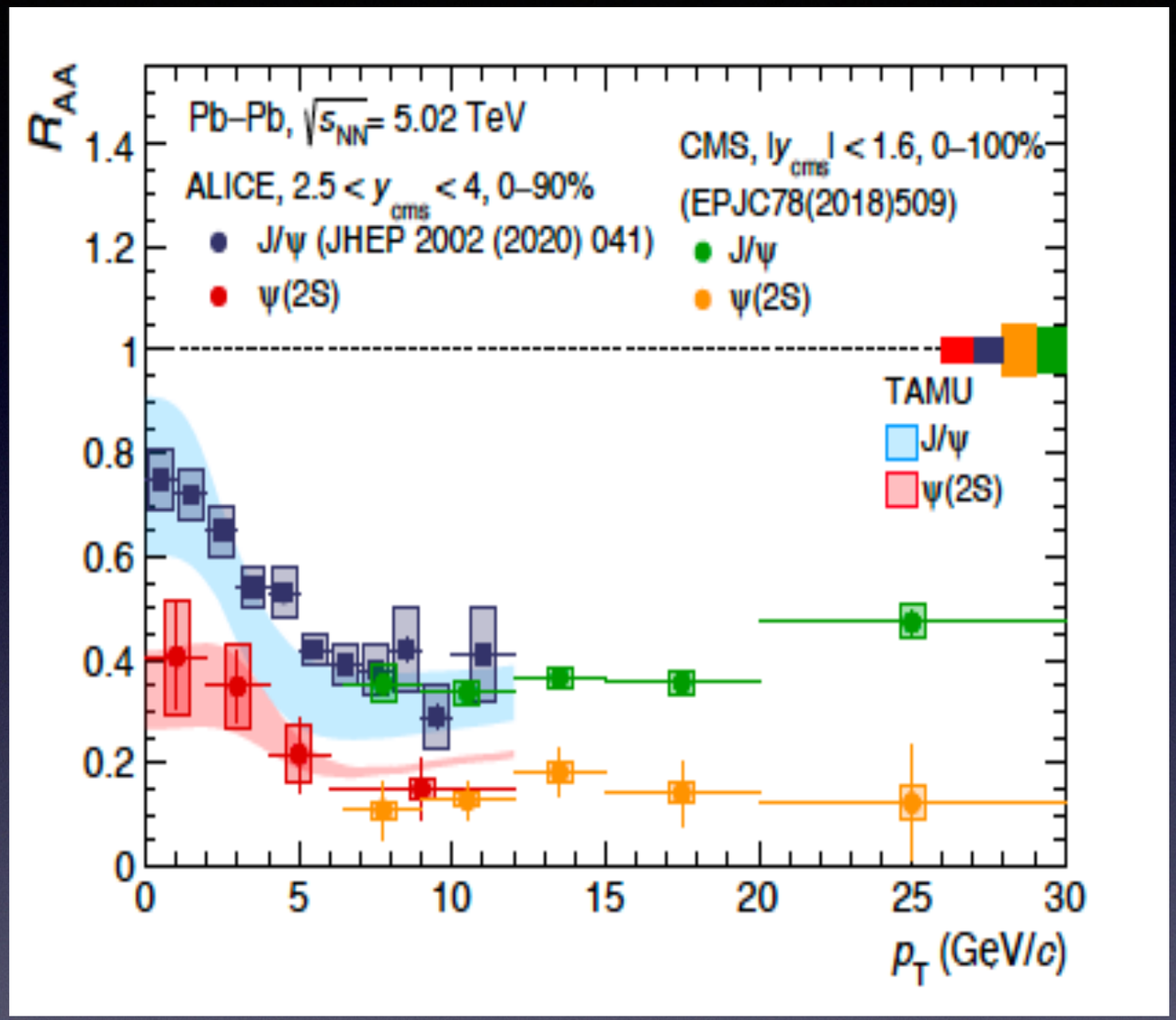
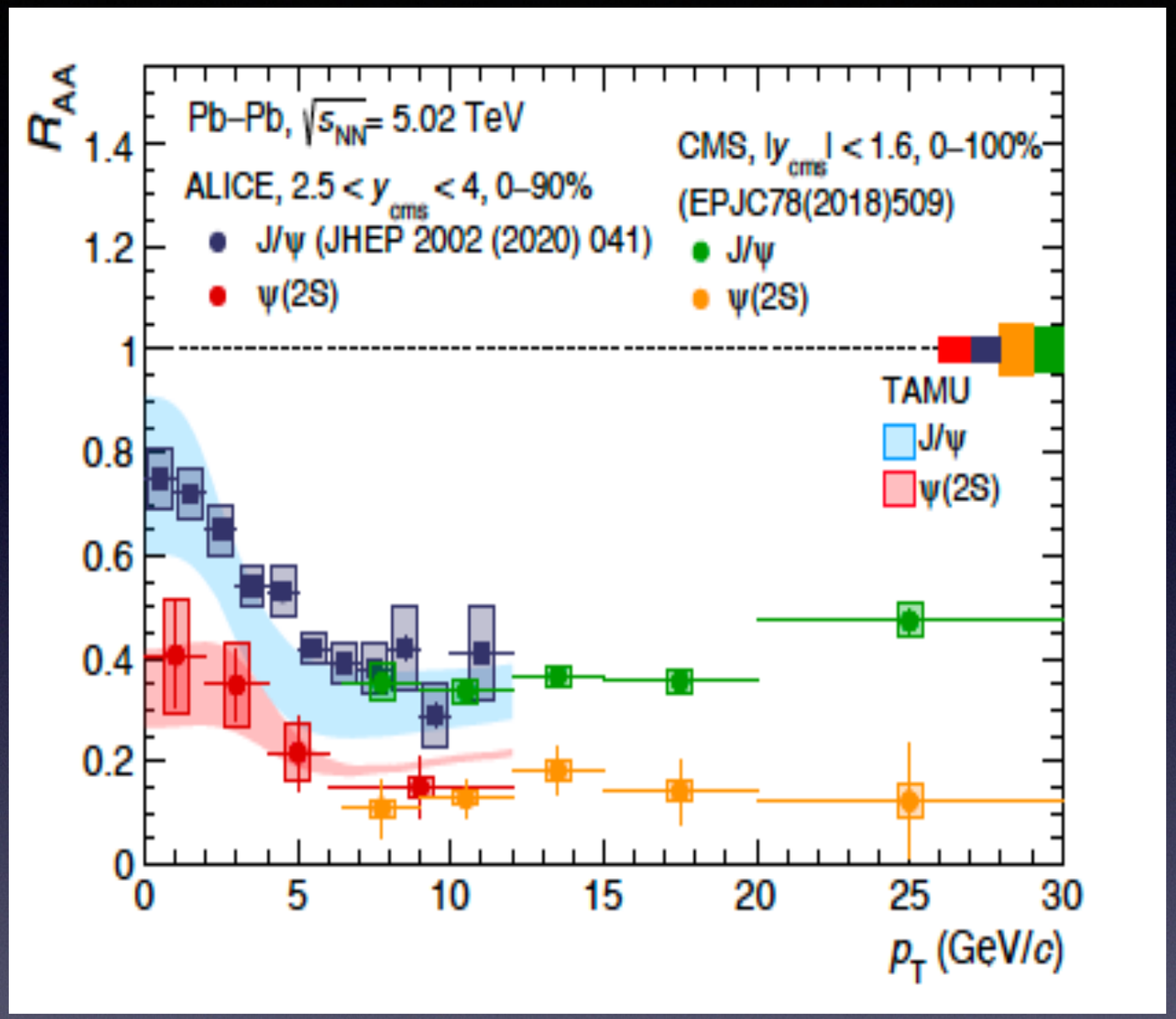


Stronger suppression of of $\Psi(2S)$ compared to J/Ψ.

Increasing trend of R_{AA} towards low p_T for $\Psi(2S)$

First measurement in LHC down to zero p_T

$\Psi(2S)$ production in Pb-Pb



ALICE: arXiv:2210.08893

Stronger suppression of of $\Psi(2S)$ compared to J/Ψ.

Increasing trend of R_{AA} towards low p_T for $\Psi(2S)$

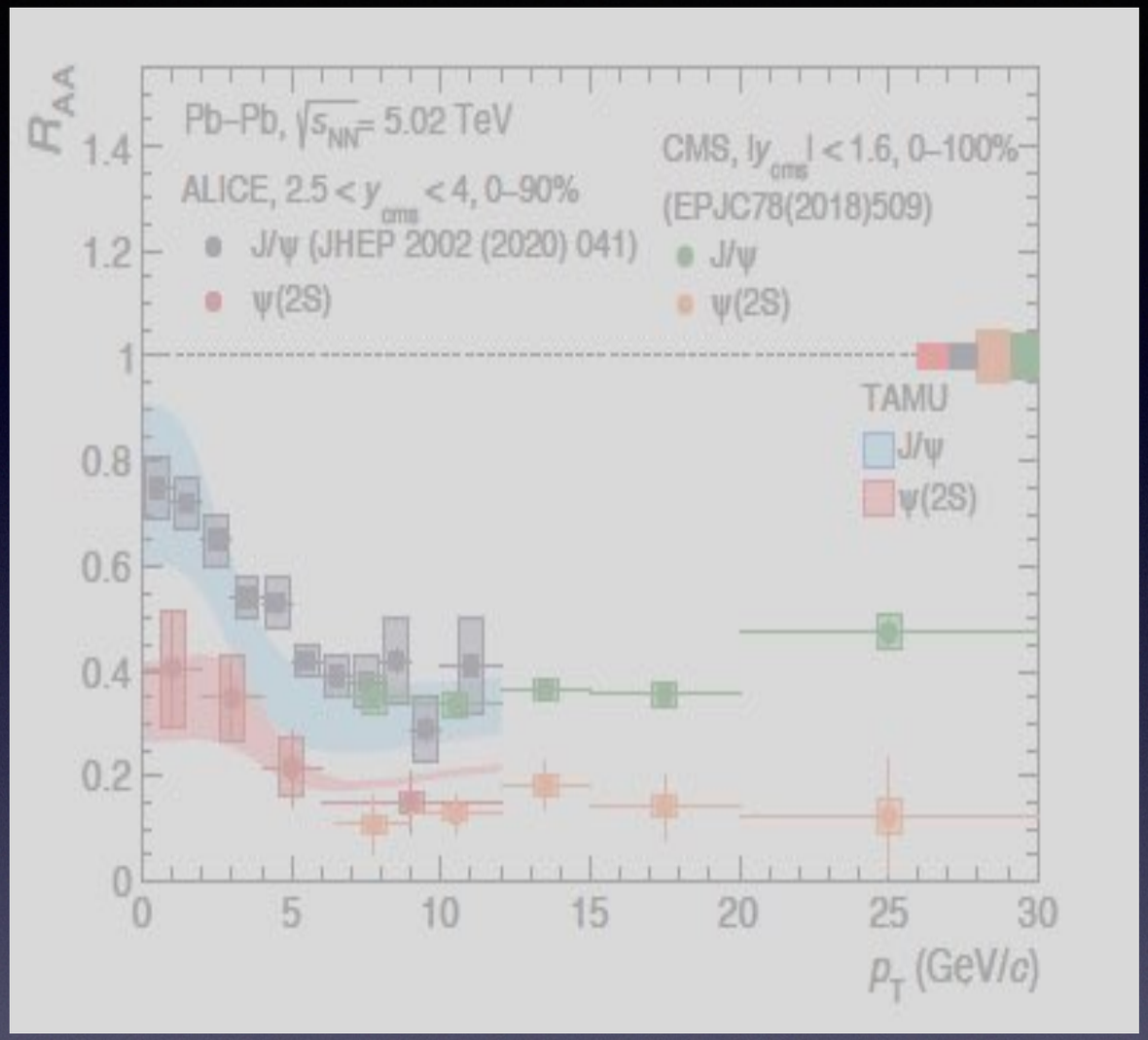
Compatible with midrapidity CMS results in common pT range

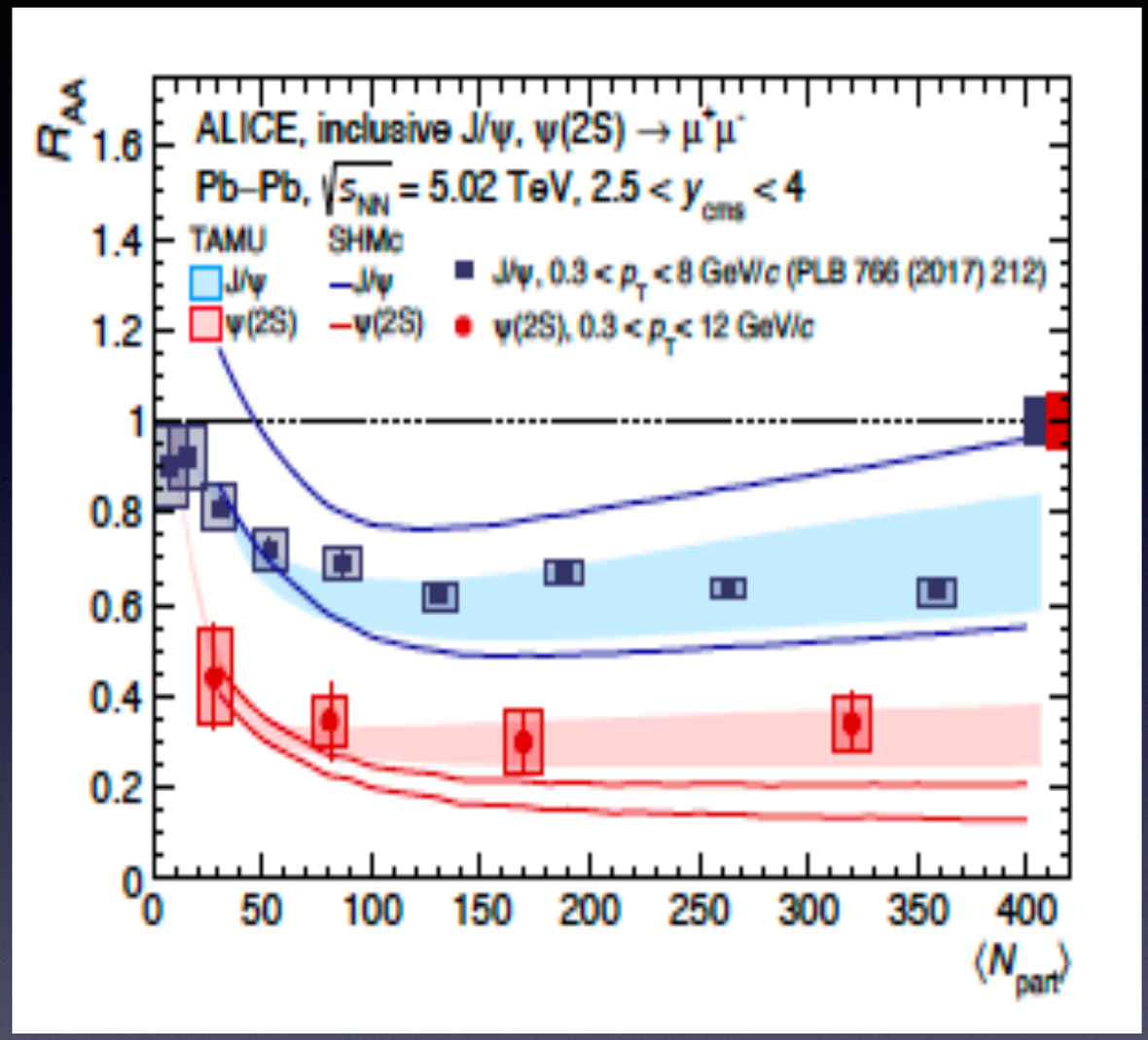
p_T dependence of R_{AA} reproduced by TAMU

First measurement in LHC down to zero p_T

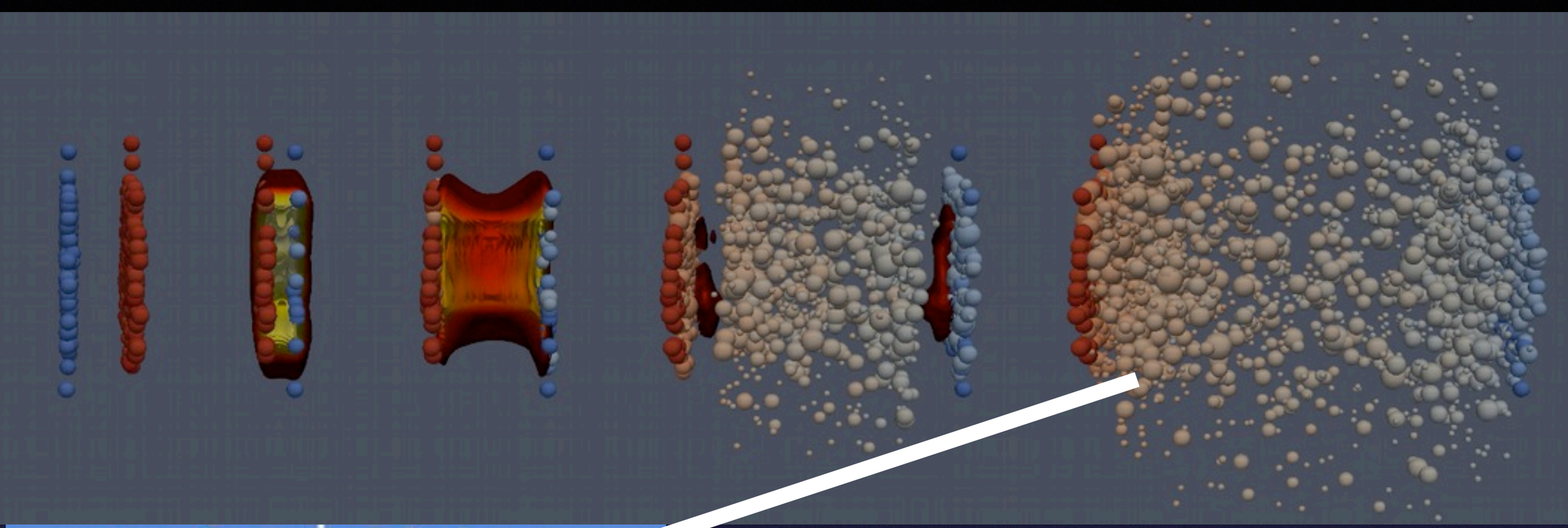
$\Psi(2S)$ production in Pb-Pb

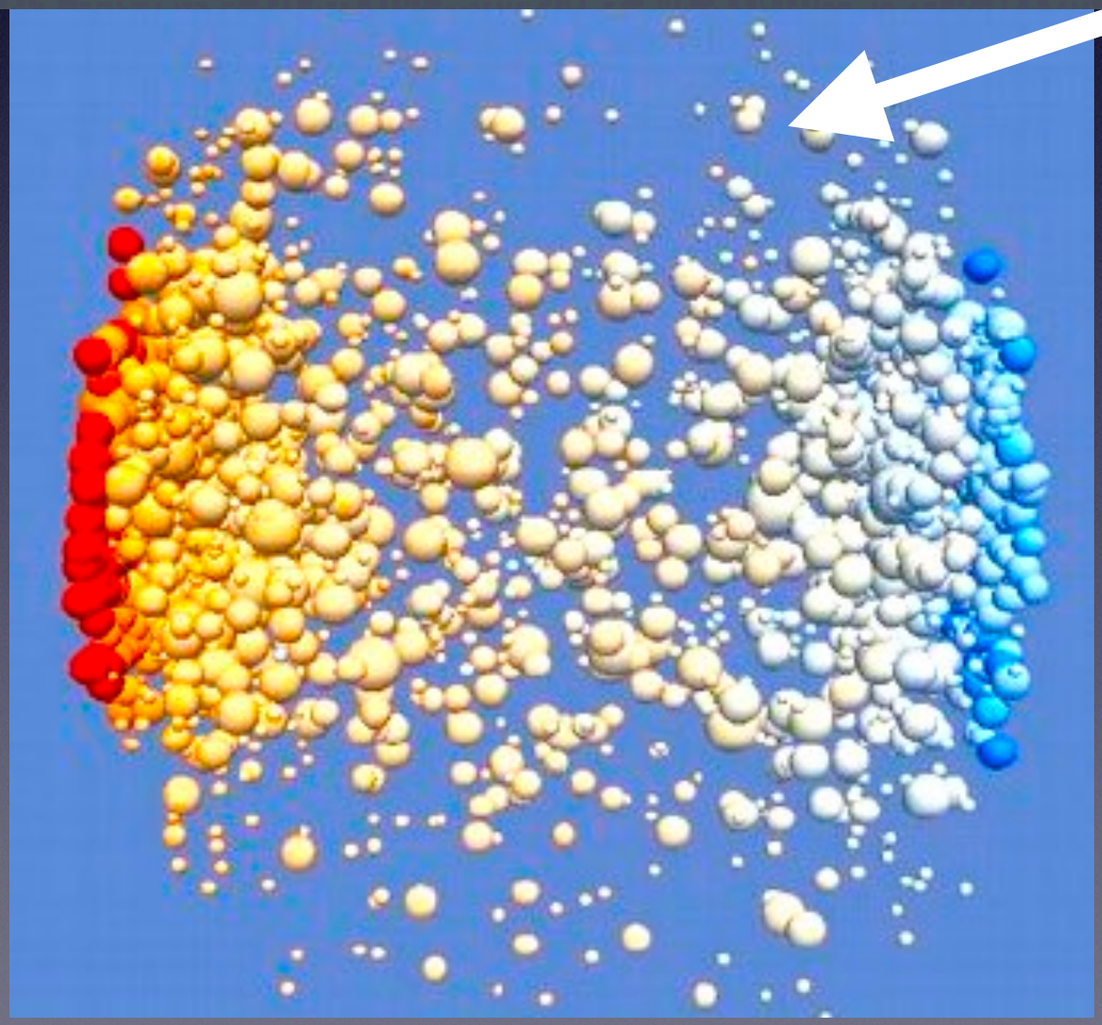
ALICE: arXiv:2210.08893





Transport models (including recombination of charm quarks in QGP) describe the data well in central events





Freeze out and Rescattering

Summary

Heavy ion collisions are our door to study the properties of strong interactions at very high energy densities.

The various facilities from a few GeV to a few TeV centre of mass energies provided a lot of results which demonstrates a strong sensitivity to the properties of the medium.

The medium formed in such collisions has the characteristics foreseen for a quark gluon Plasma, behaves like a fluid and has spectacular effects on hard probes.

The vibrant experimental programs with precision measurements have been answering long standing questions driving heavy ion physics to the multi messenger era.