

Heavy Flavors

Part II - Quarkonium

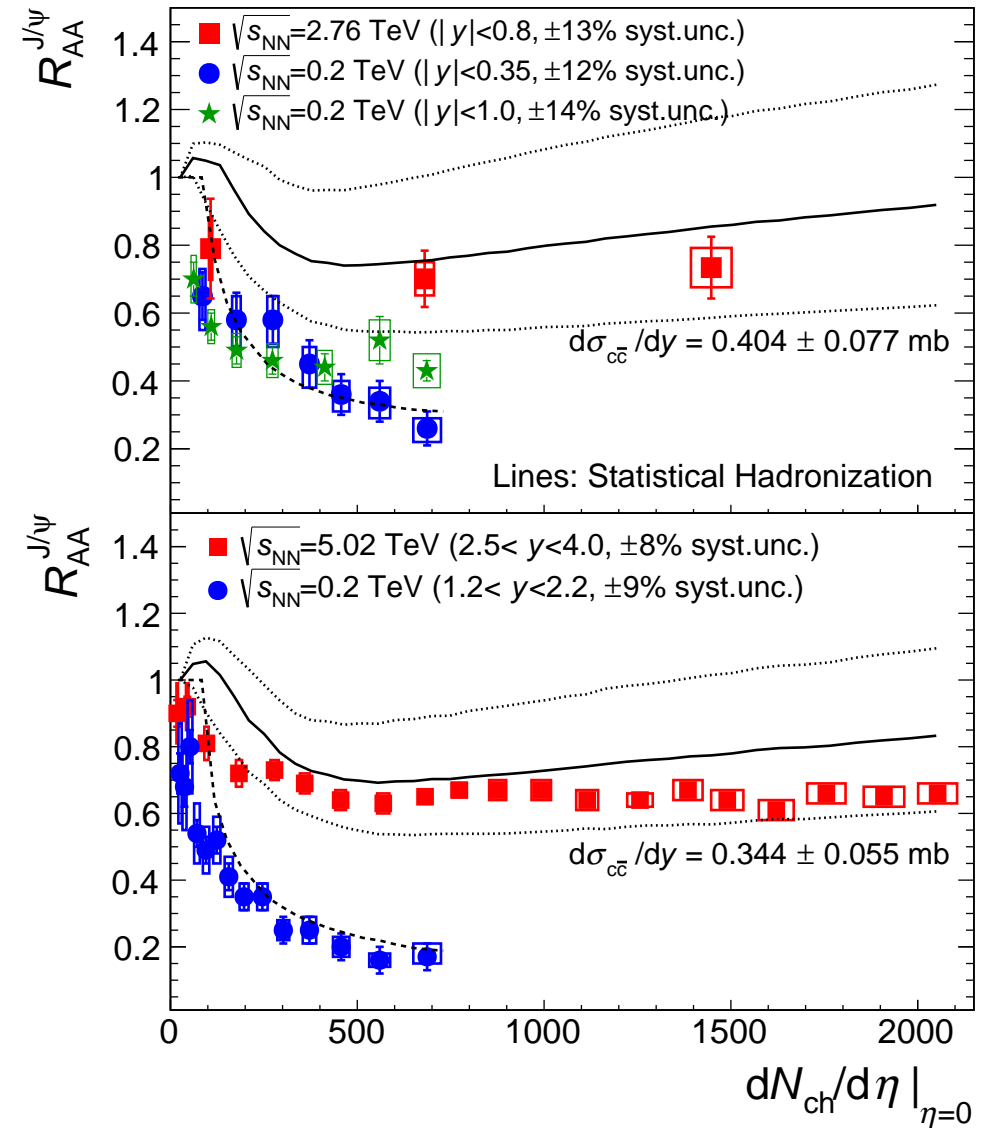
A. Andronic

H. van Hees

R. Rapp

A. Rossi

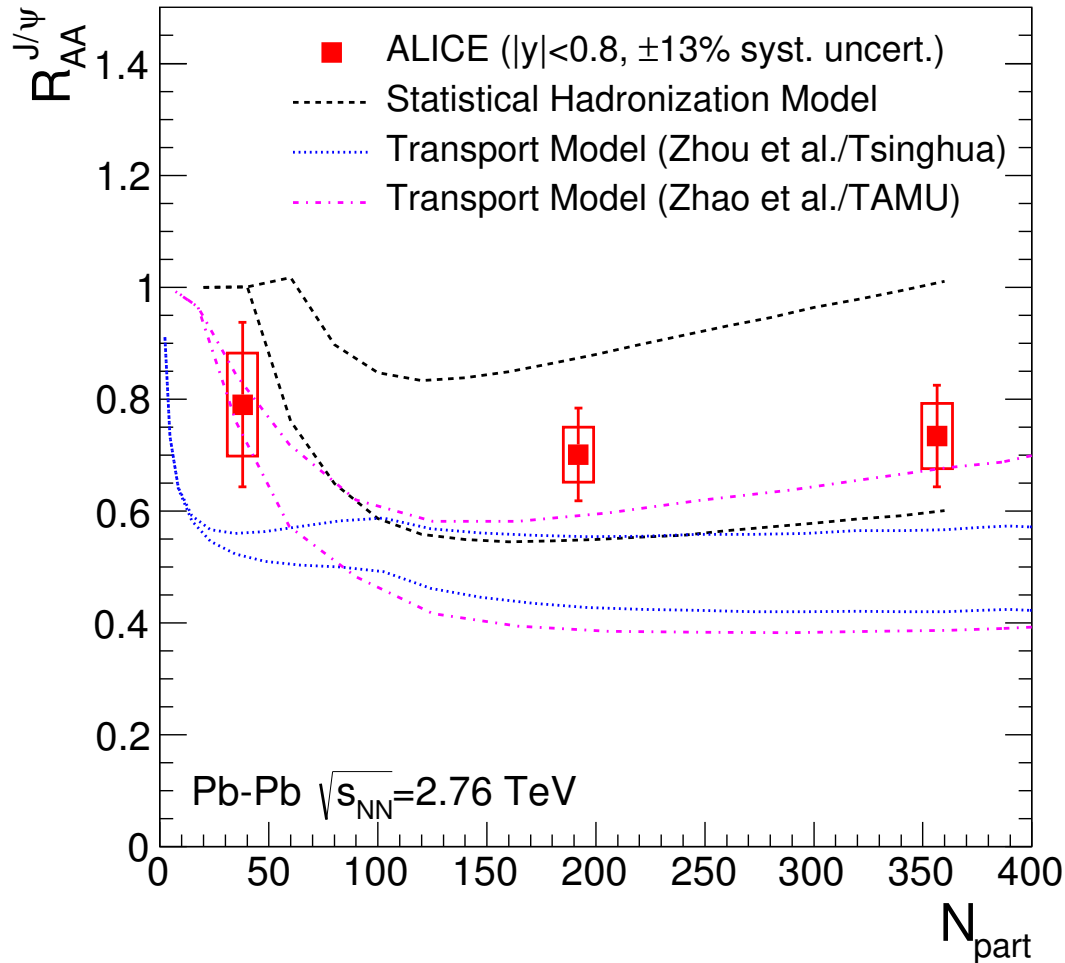
D. Silvermyr



Model comparisons for the LHC

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Both SHM and TM reproduce the data
... $d\sigma_{c\bar{c}}/dy$ values rather different:
Stat. Hadr.: 0.3-0.4 mb
Transport: 0.5-0.75 mb (TAMU),
0.65-0.8 mb (Tsinghua)
needs clarification
important role of Λ_c (and excited states)

T at generation:
SHM: 156 MeV
TM: 250 MeV (TAMU)

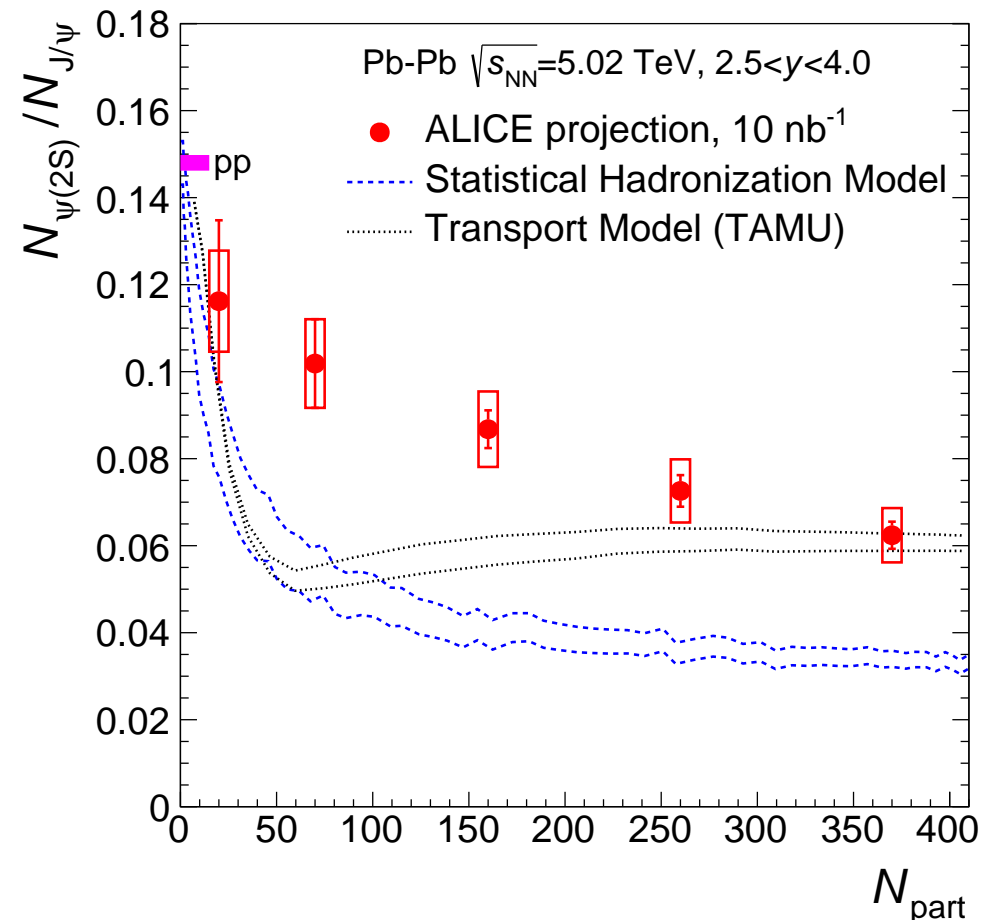
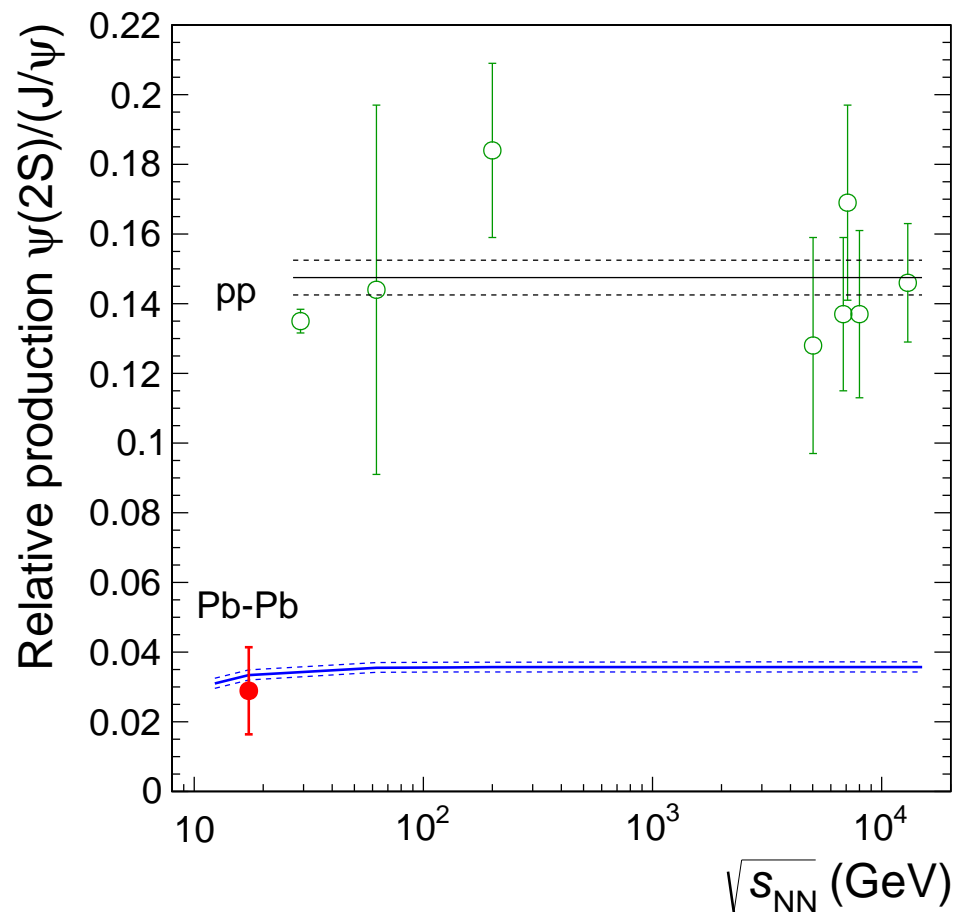
Discriminating the two pictures implies providing an answer to fundamental questions related to the fate of hadrons in a hot deconfined medium.

Future of charmonium in Pb–Pb

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Need: experimentally: better uncertainty for $d\sigma_{c\bar{c}}/dy$ (in Pb–Pb);
access to excited states and hopefully also exotic states, like X(3872)



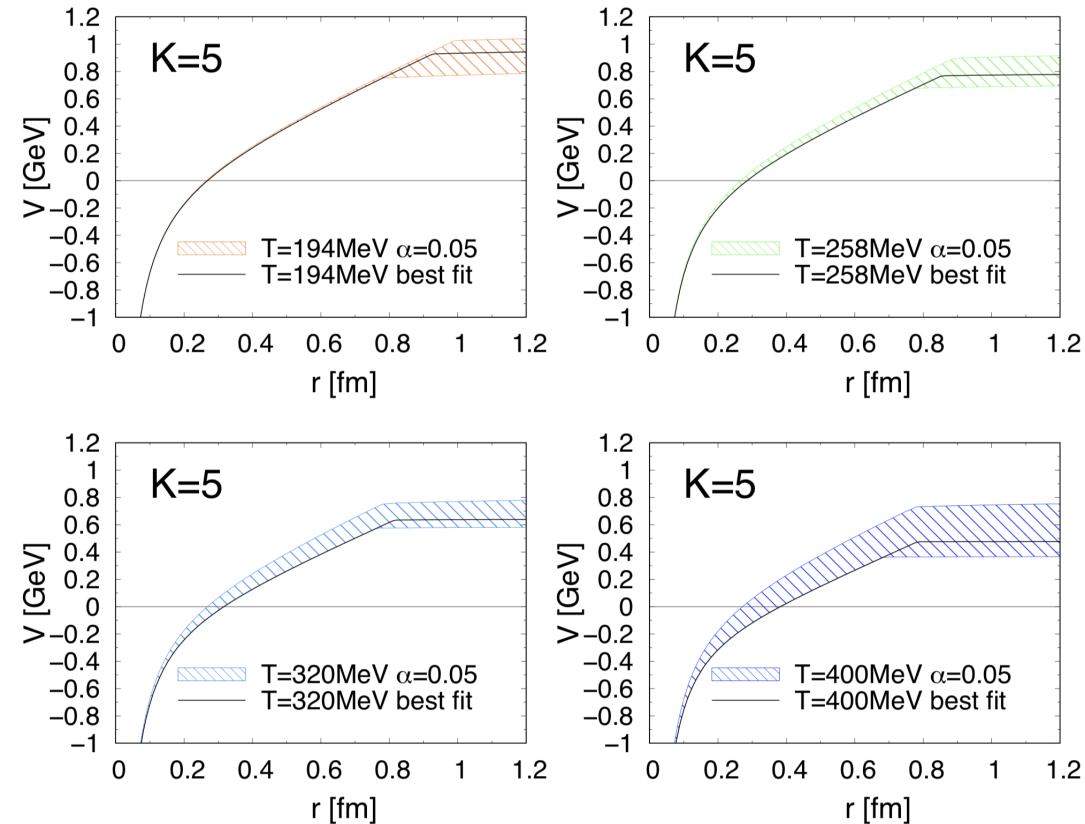
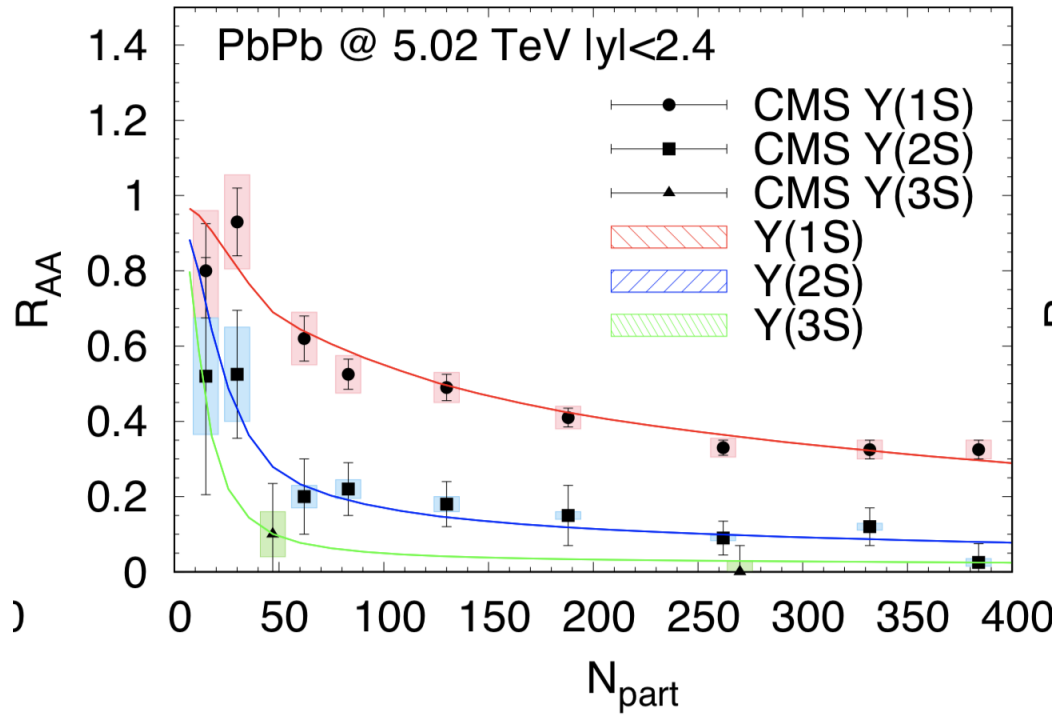
Theoretical direction: quantum treatment (charmonium and bottomonium)

Υ in Pb–Pb

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...allows extraction of in-medium (Cornell) potential



(re)generation important for $Y(2S)$

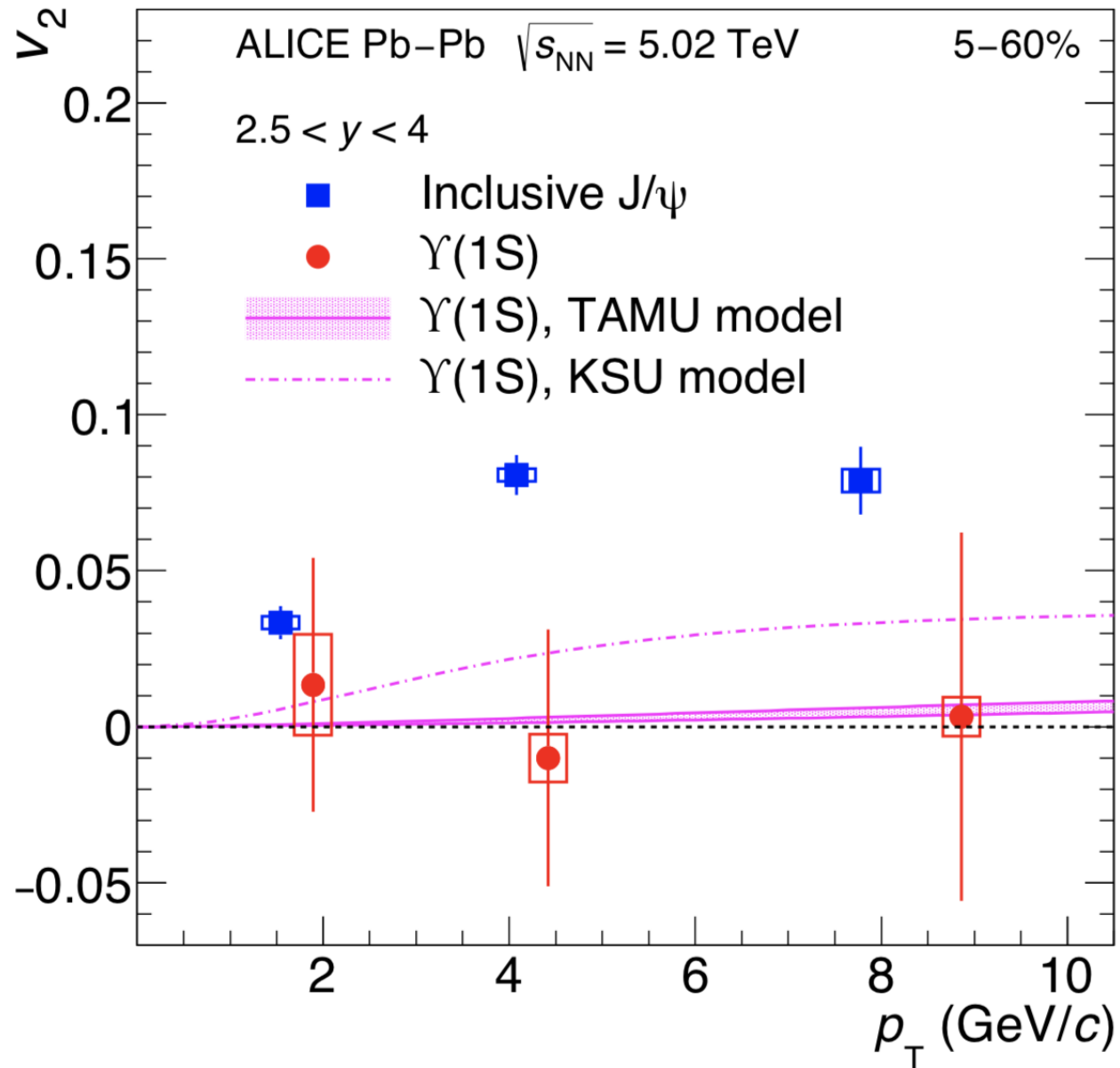
Transport Model (TAMU), Du, Liu, Rapp, [Phys. Lett. B 796 \(2019\) 20](#)

Substantial remnants of the long-range color confining force in QGP

Υ in Pb–Pb ...does it flow?

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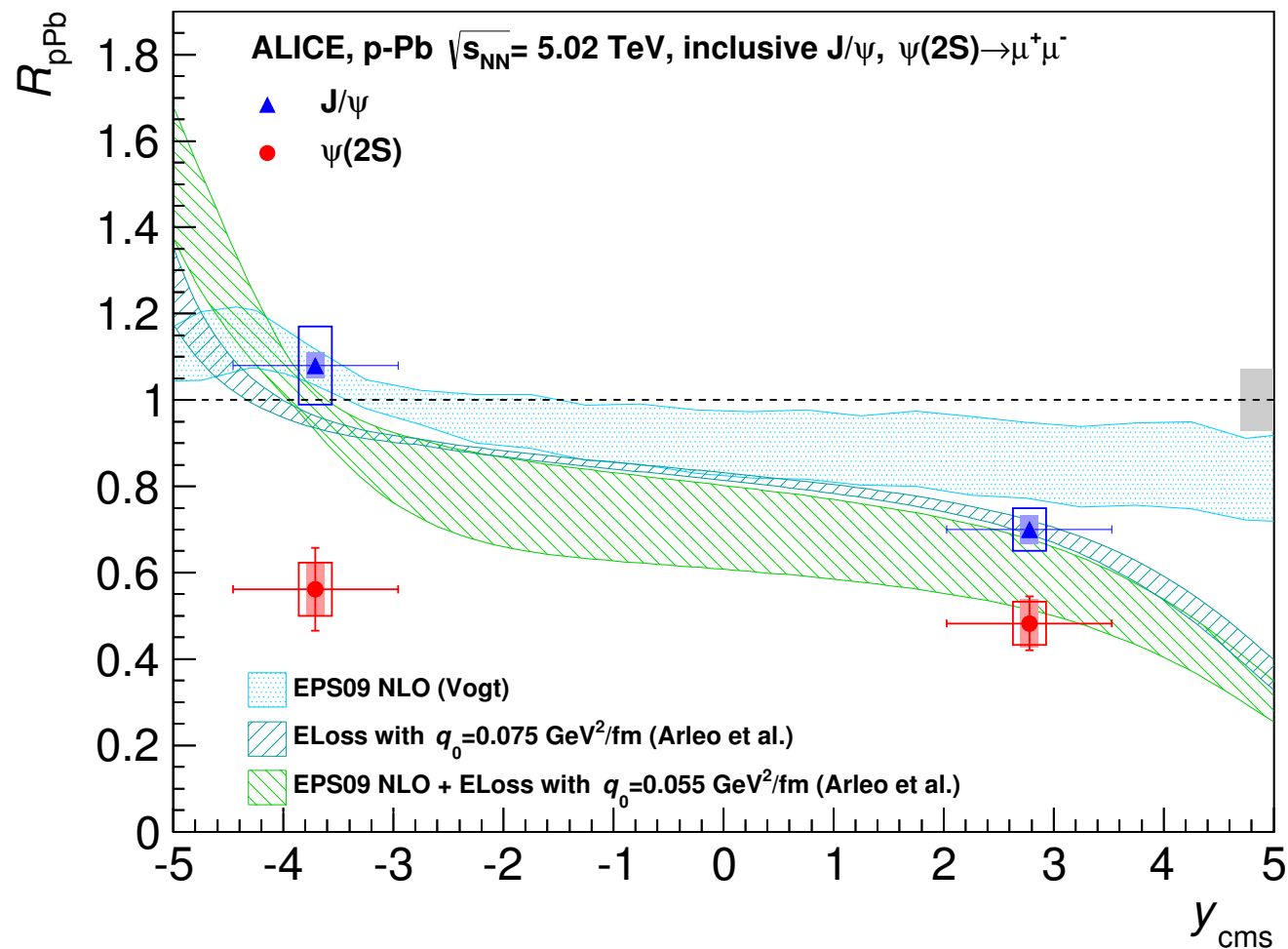
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J/ψ and ψ(2S) production in p–Pb collisions

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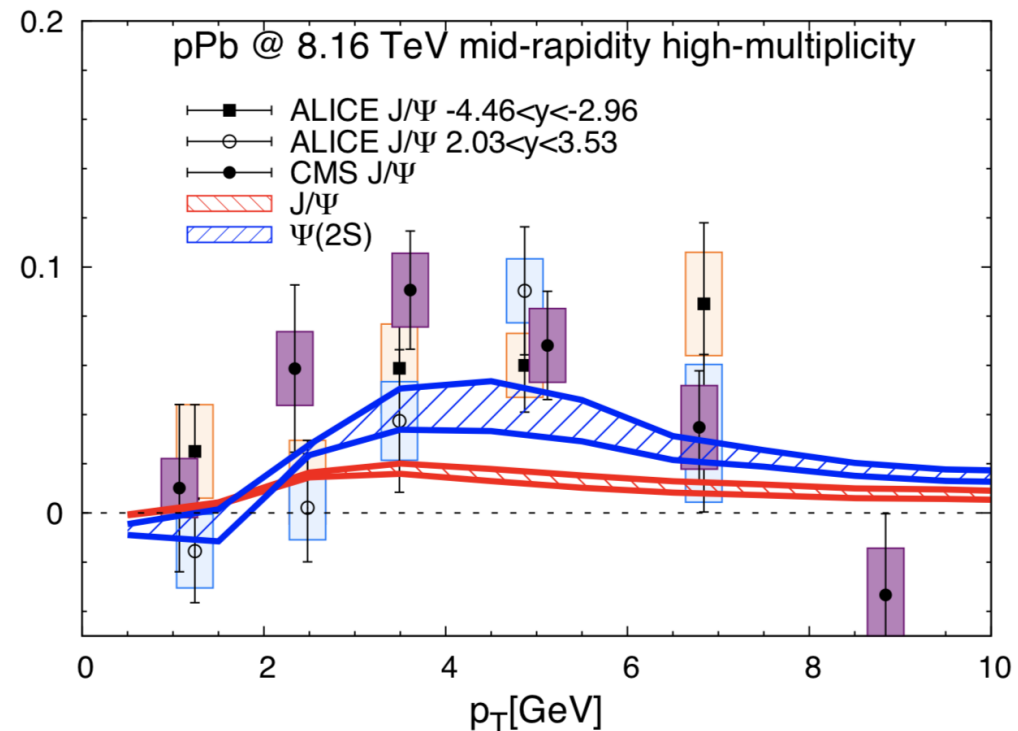
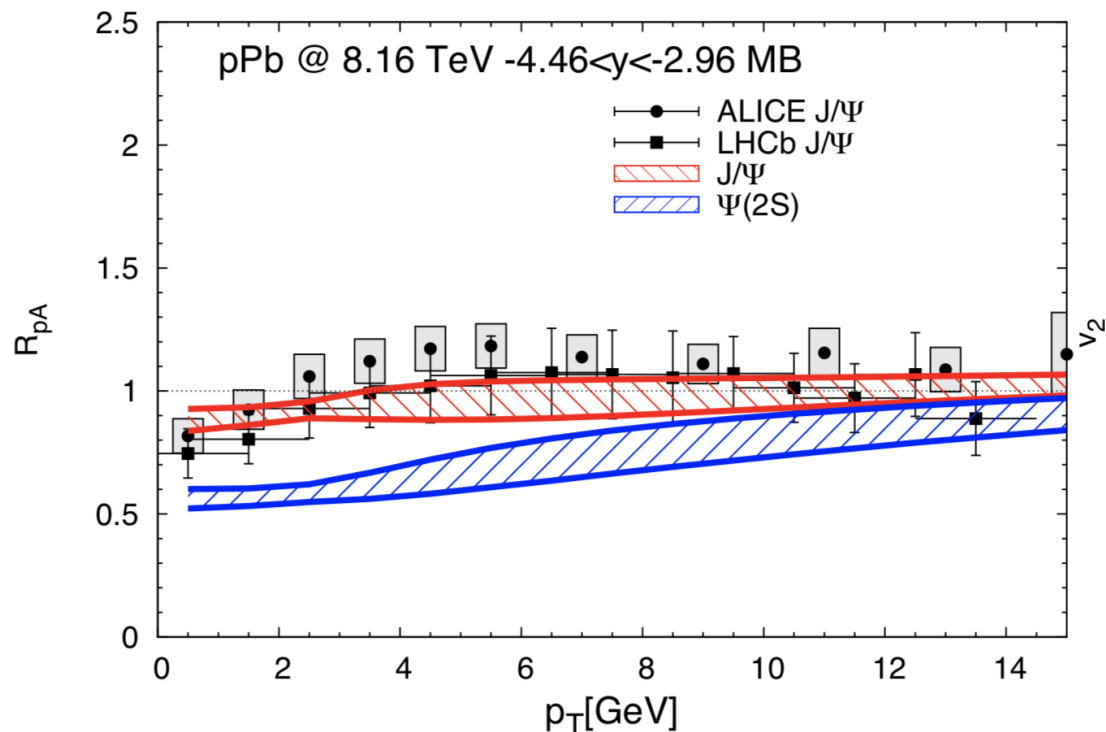
ALICE, JHEP 12 (2014) 073

(at least in first order) models give same result for ψ(2S) as for J/ψ
difference predominant at low p_T ; final state effect? ...TM, TAMU: yes

...but no final state effect for J/ψ ?

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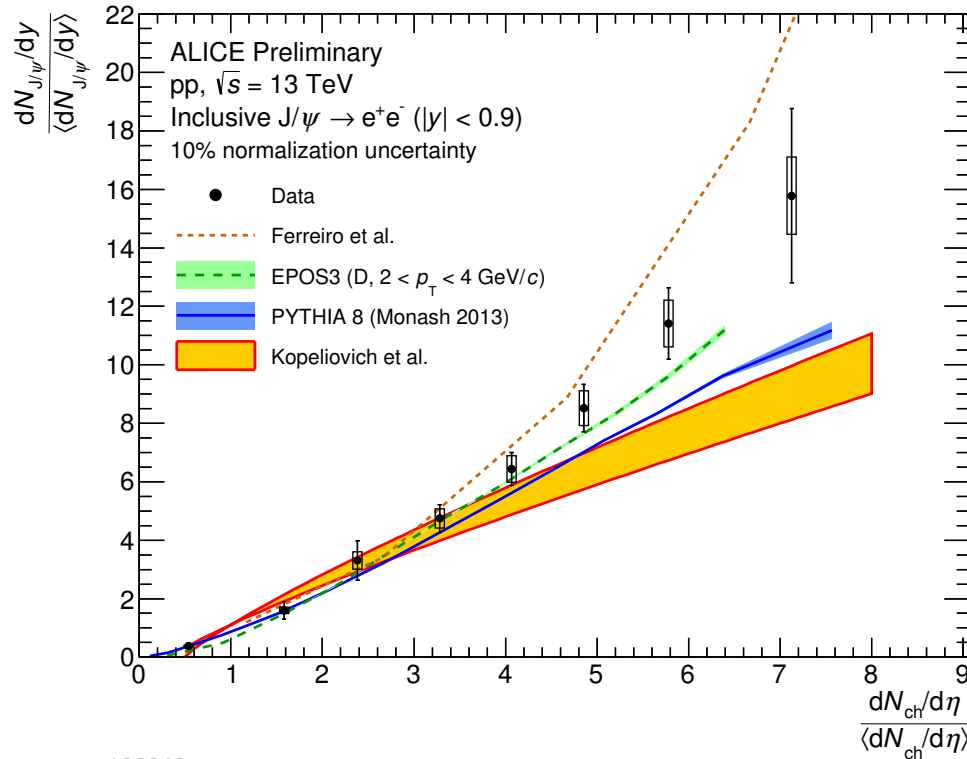
Transport Model (TAMU), Du, Rapp, [JHEP 1903 \(2019\) 015](#)

Need experimentally (in reach for Run 3,4): better precision; also v_3 ;
separate B component; v_2 of $\psi(2S)$?

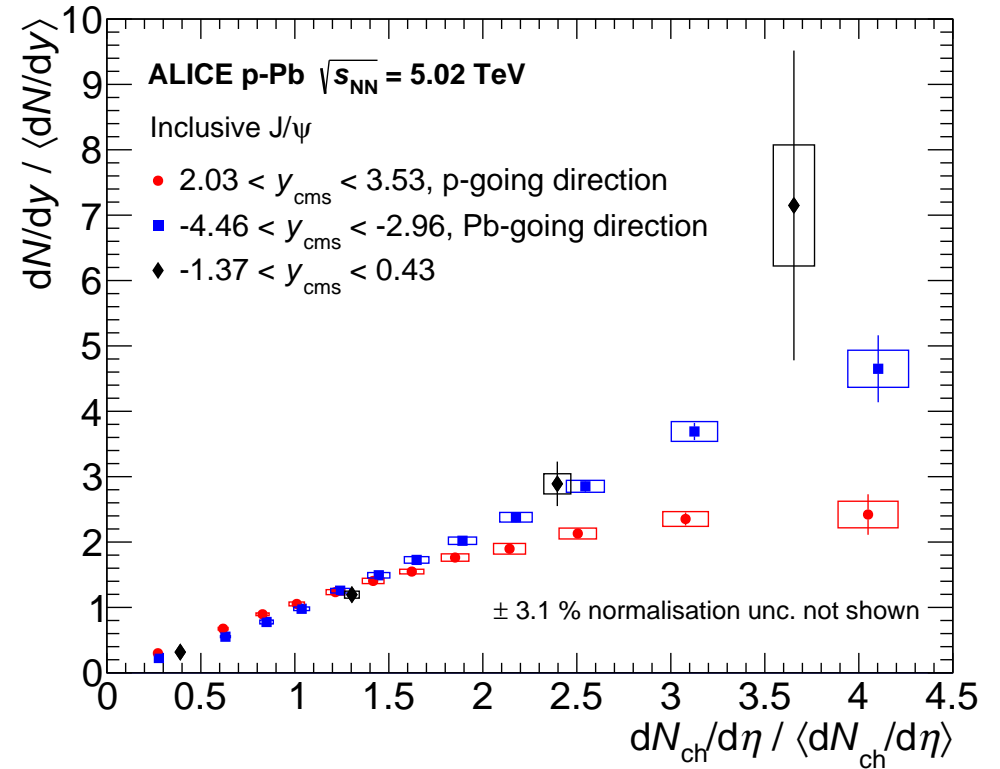
J/ψ vs. event activity

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ALI-PREL-128843

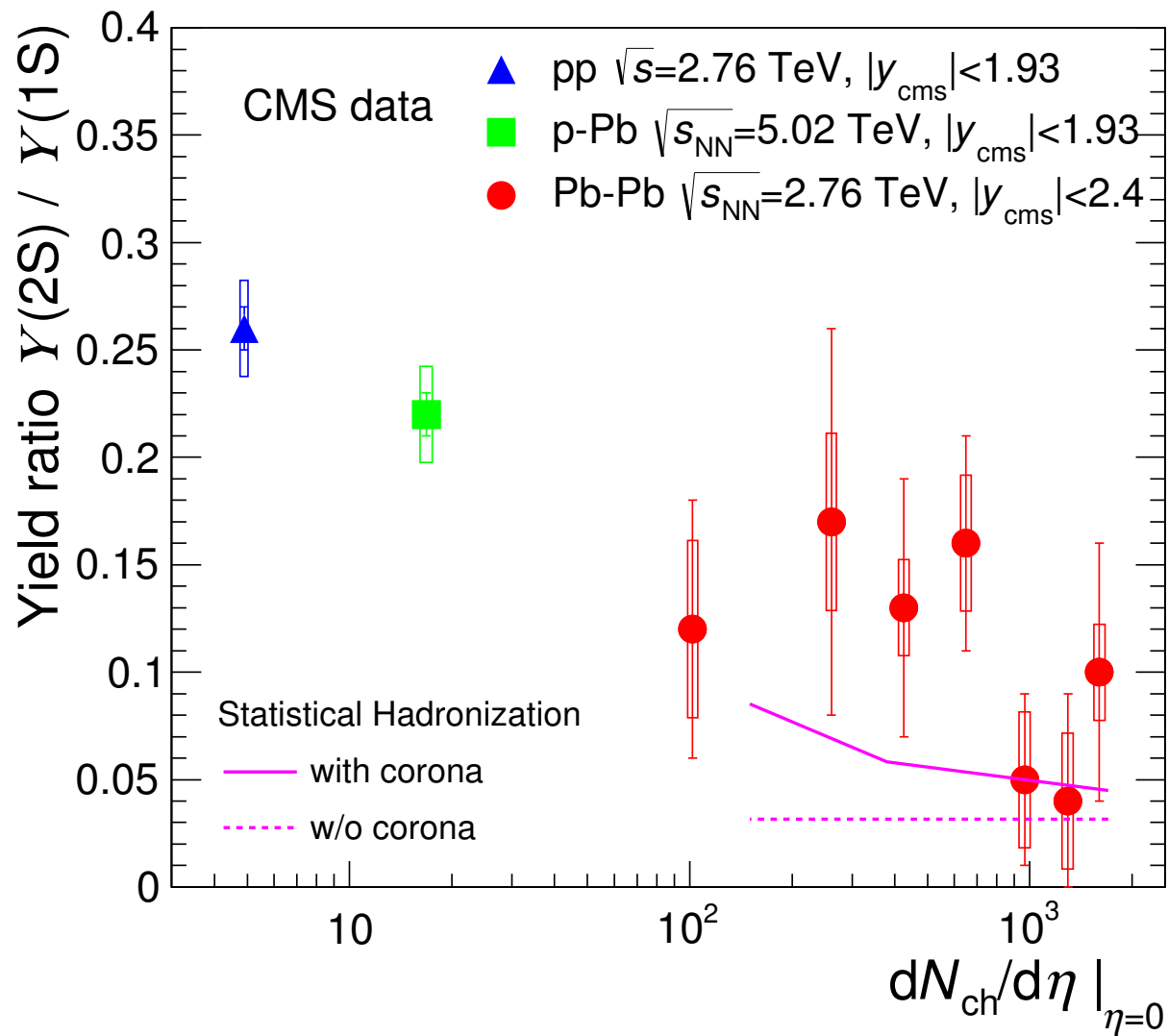


What is trivial here? (1st diagonal?) ...auto-correlation effects clearly there
"Energy cost" similar for MB event ($\Delta y=1$) and J/ψ ($\simeq 6$ GeV)

Similar behaviour measured for D mesons; Υ; charged part. $p_T=5-6$ GeV/c

What does this teach us about quarkonium (HF) production (hadronization)?

Bottomonium at the LHC



The data approach the thermal limit for central Pb-Pb coll.

fair description by SHM

also for R_{AA} of $\Upsilon(1S)$

Supplementary slides

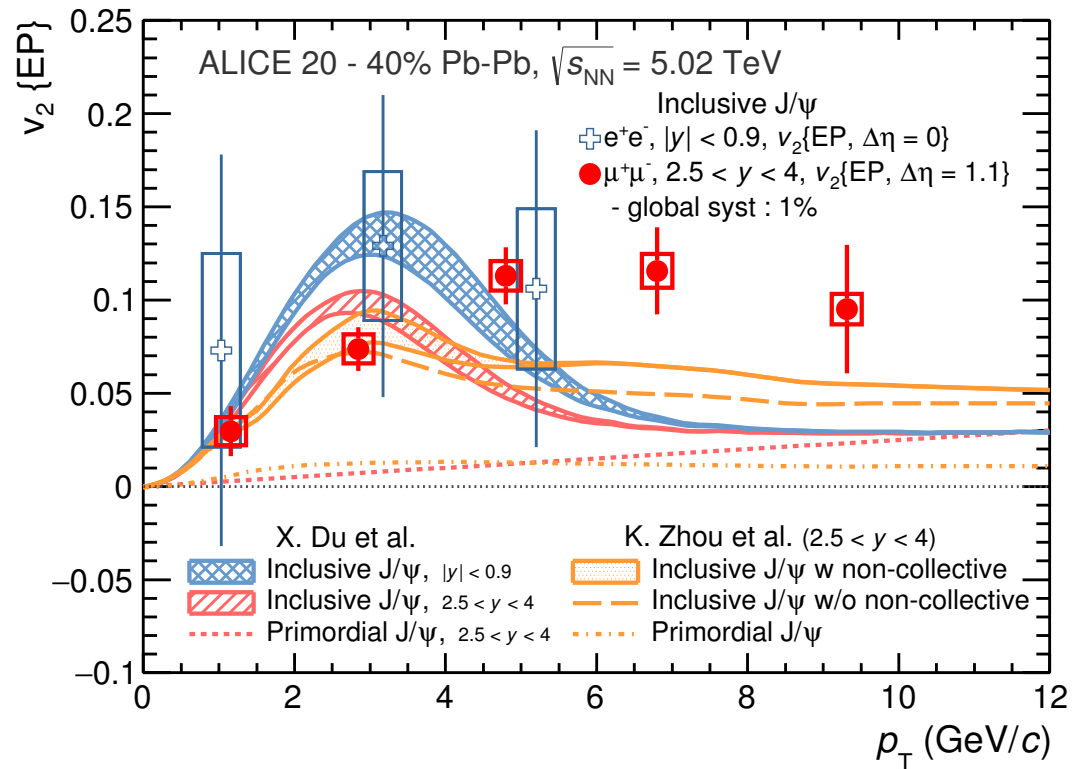
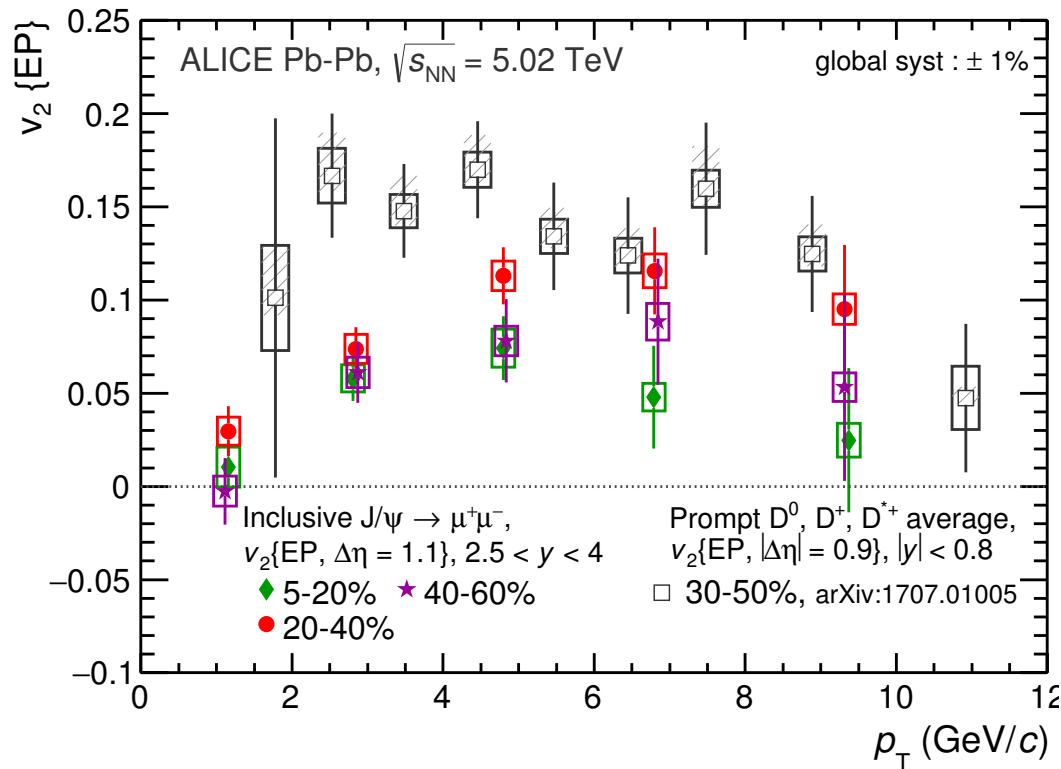
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J/ ψ (and D) mesons exhibit collective flow

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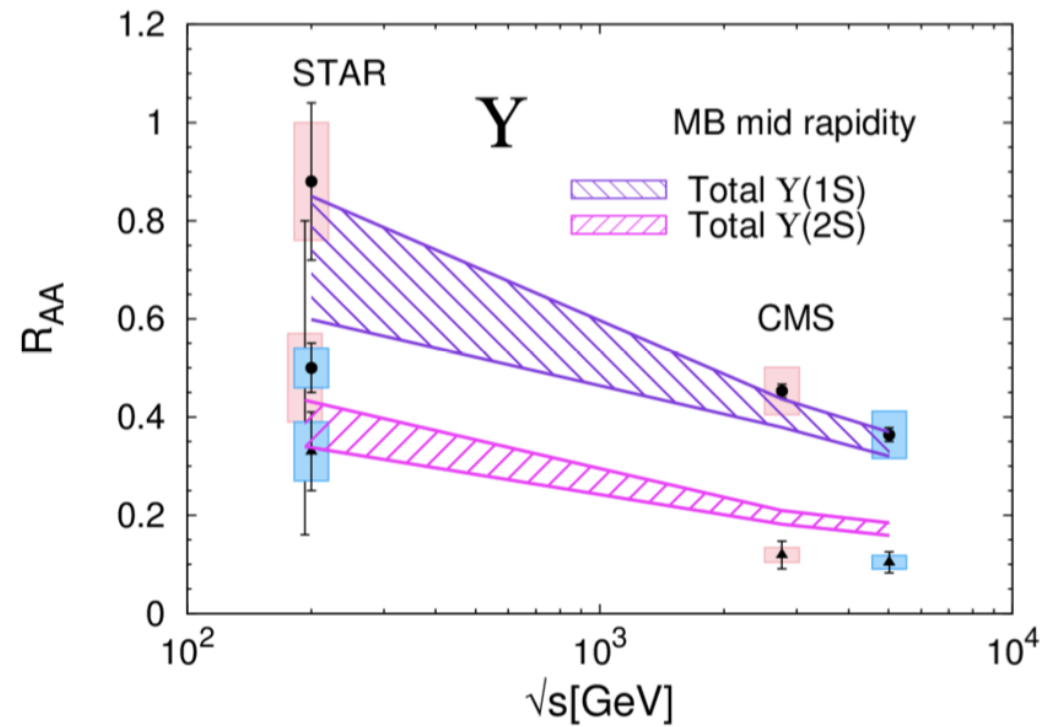
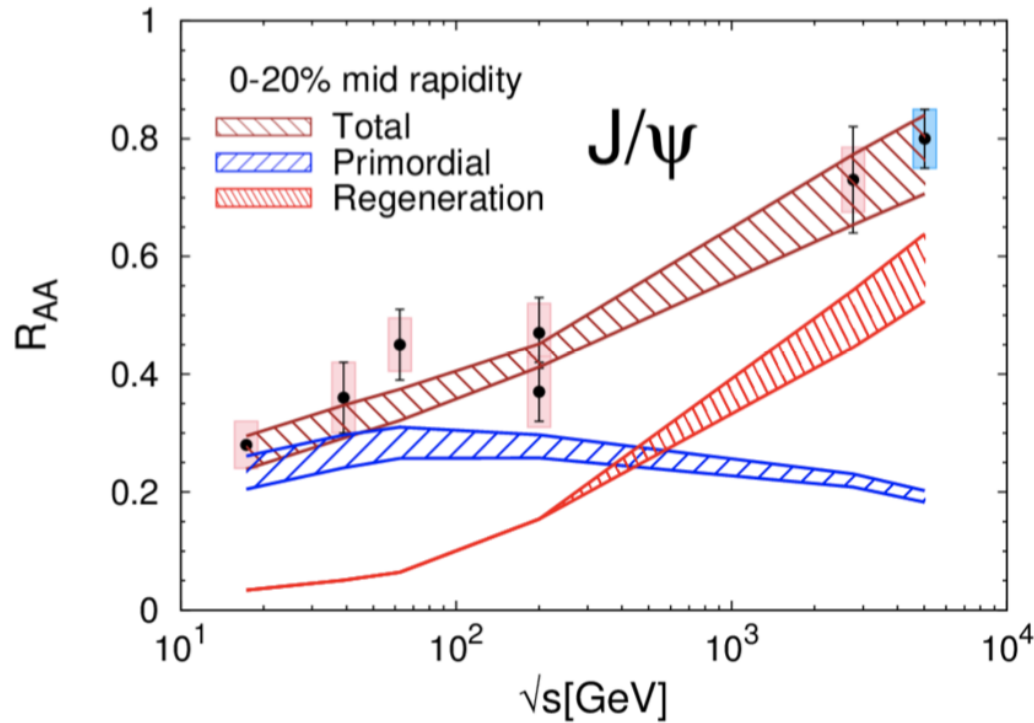
ALICE, PRL 119 (2017) 242301

Implies thermalization of charm quarks ...full thermalization? (high- p_T ?)

Fractions primordial, (re)generated - energy dependence

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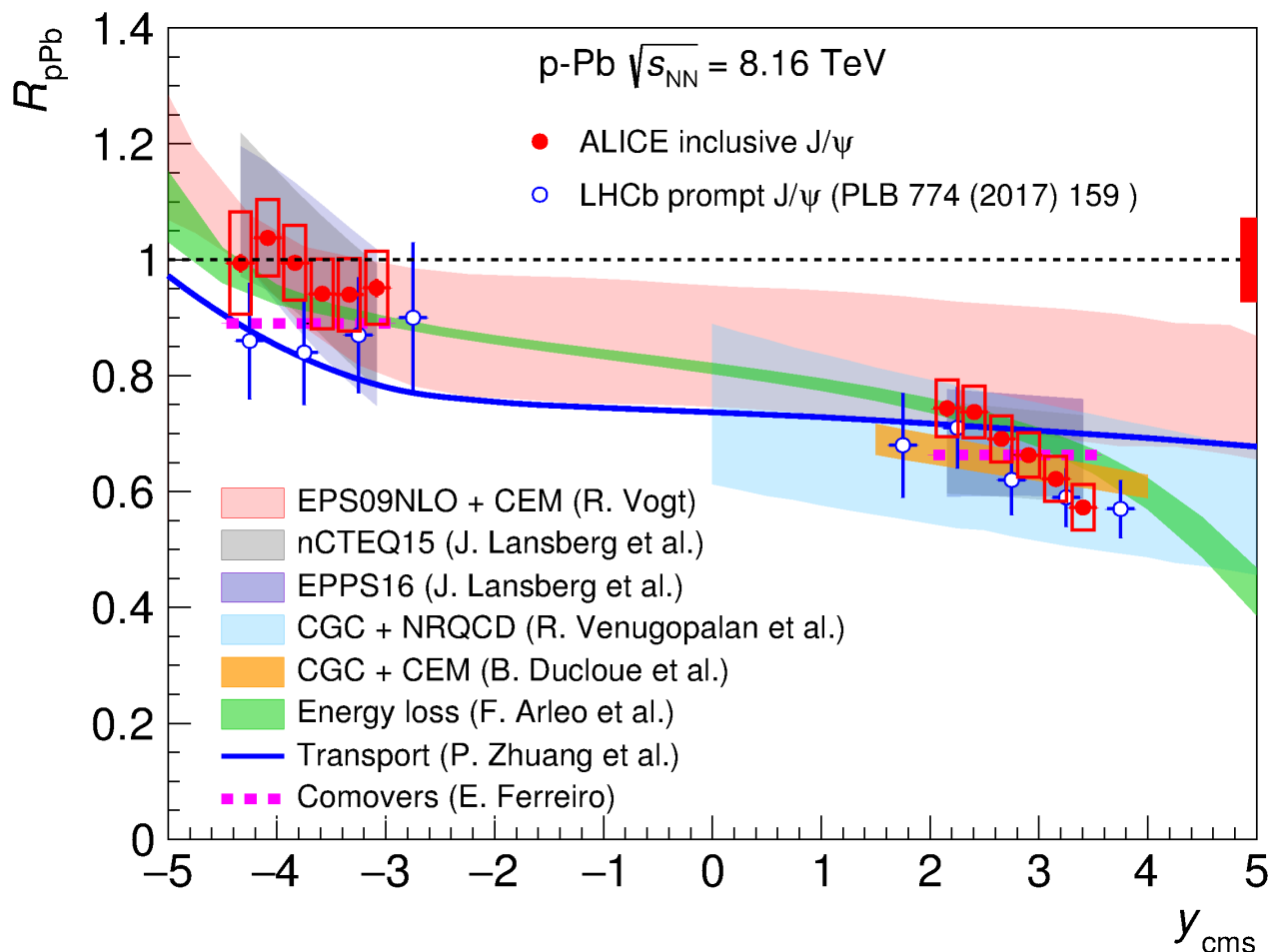


Rapp, Du, [arXiv:1704.07923](https://arxiv.org/abs/1704.07923)

J/ψ production in p–Pb collisions

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$$7 \cdot 10^{-3} \lesssim x \lesssim 3 \cdot 10^{-2}$$

$$10^{-5} \lesssim x \lesssim 5 \cdot 10^{-5}$$

$$R_{pPb} = \frac{dN_{pPb}/dp_T dy}{\langle N_{coll}^{pPb} \rangle \cdot dN_{pp}/dp_T dy}$$

$$\langle N_{coll}^{pPb} \rangle \simeq 7$$

Shadowing describes data
(shadowing uncert. are large)

Color Glass Condensate also
successful

ALICE, [JHEP 07 \(2018\) 160](#)

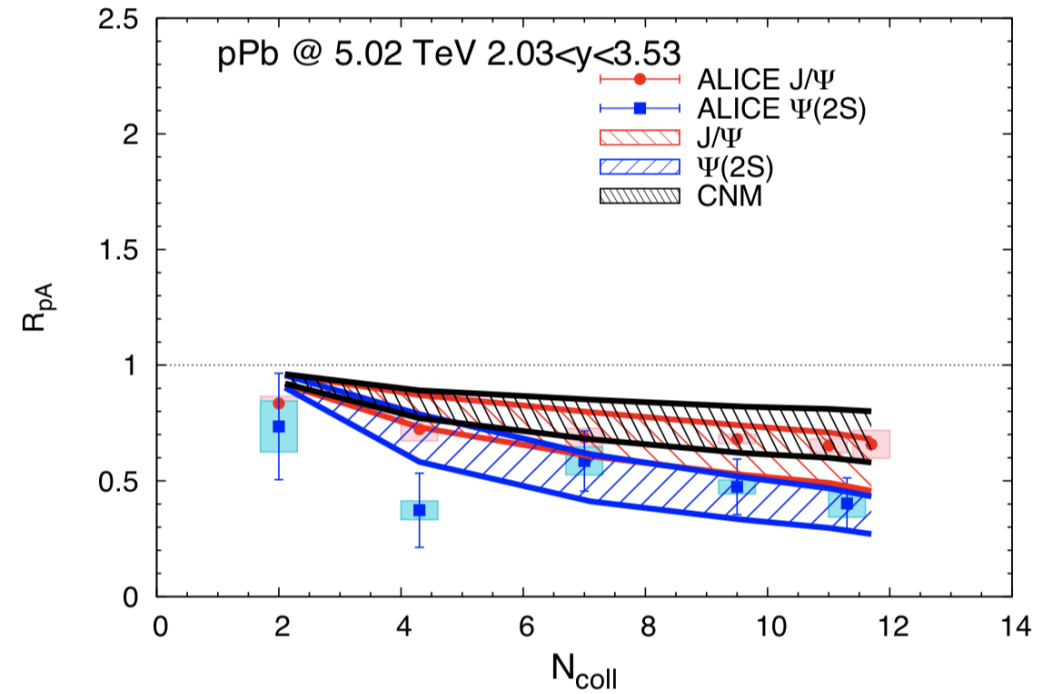
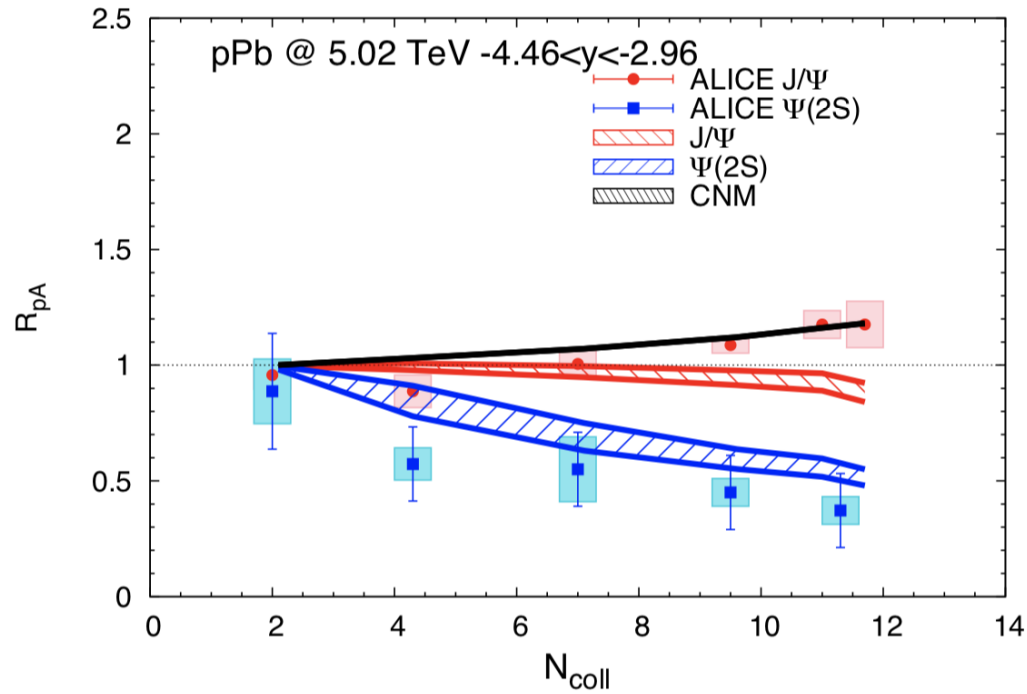
LHCb, [PLB 774 \(2017\) 159](#)

Seen also with Run 1 data (5.02 TeV): ALICE, [JHEP 02 \(2014\) 073](#), [06 \(2015\) 55](#)

J/ψ and $\psi(2S)$ production in p-Pb collisions

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Du, Rapp, [JHEP 1903 \(2019\) 015](#)