AA

pA

pp

Overview on hidden heavy flavour results

Roberta Arnaldi
INFN Torino (Italy)

The 18th International Conference on
Strangeness in Quark Matter (SQM 2019)
10-15 June 2019, Bari (Italy)

Outlook

AA
pA
pp

Overview of most recent results on several quarkonium states

$\Upsilon(1S)$ $\Upsilon(2S)$ $\Upsilon(3S)$ J/ψ $\psi(2S)$

(almost to scale ☺)

in different colliding systems:

pp
vacuum reference + pp physics

pA
cold/(hot?) nuclear matter effects

AA
hot matter effects

Outlook

Overview of most recent results on several quarkonium states

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in different colliding systems:

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hot matter effects

Outlook

AA

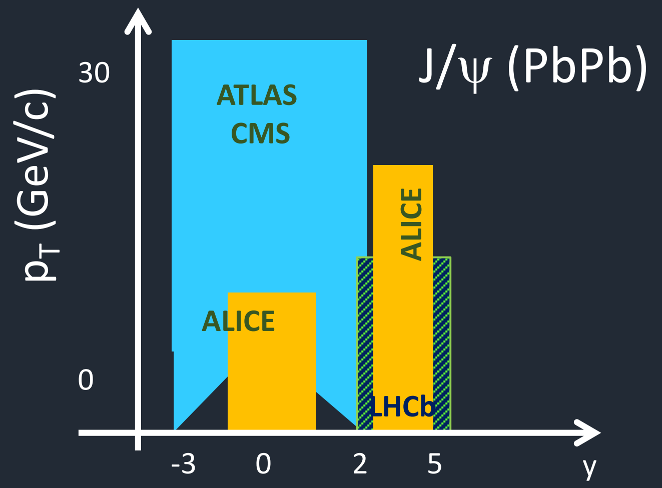
pA

pp

RHIC:
various collision systems are explored, scanning in energy

Exp.	System	$\sqrt{s_{NN}}$ (TeV)
PHENIX STAR	AuAu, CuCu, CuAu, UU	0.039 – 0.2
	p-A, d-Au, p-Al, ^{3}He-Au	0.2
	pp	0.2-0.5

LHC:
results are complementary, due to different kinematic coverages



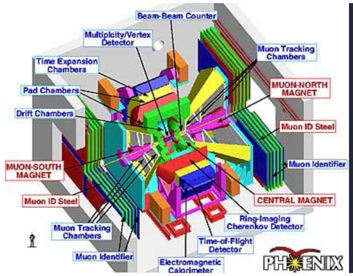
Exp.	System	$\sqrt{s_{NN}}$ (TeV)
ALICE ATLAS CMS LHCb	PbPb, XeXe	2.76, 5.02, 5.44
	pPb	5.02, 8.16
	pp	2.76, 5, 7, 8, 13

AA

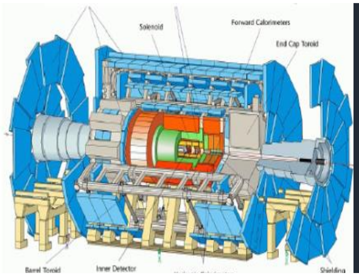
pA

pp

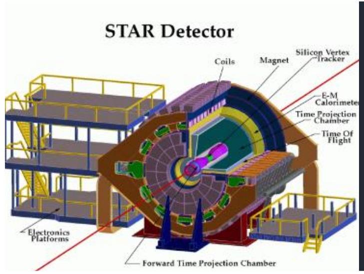
Credits



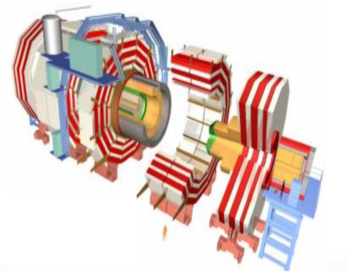
PHENIX
Marzia Rosati Mon 14.30



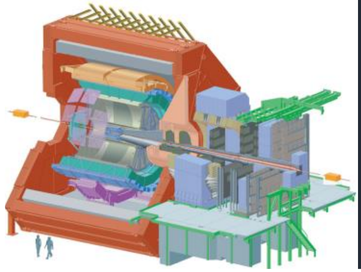
ATLAS
Martin Spousta Mon 15.30



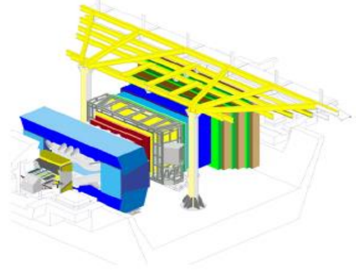
STAR
Guanna Xie Mon 15.30
Te-Chuan Huang Thu 14.00



CMS
Ruslan Chistov Mon 17.00
Daniele Fasanella Tue 17.10
Xiao Wang Thu 16.30,
P. Pujahari Tue 11.00



ALICE
Andrea Rossi Mon 16.30
Minjung Kim Thu 14.40
Wadut Shaikh Thu 15.20



LHCb
Shanzhen Chen Mon 17.00
Hengne Li Thu 14.20

(main focus of my talk will be on the newest results presented in this conference)

New quarkonium results

AA
pA
pp

pp
- production cross sections
- production vs. event activity
- production in jets

pA
- R_{pA} studies for ground and excited states production
- J/ψ elliptic flow

AA
- multi-differential R_{AA} measurements
- new observables as
  - polarization
  - ϒ elliptic flow

All the new RHIC and LHC measurements:

- extend the kinematic coverage reached so far
- have an improved precision

→ pp, pA and AA results represent a challenge for theory comparison

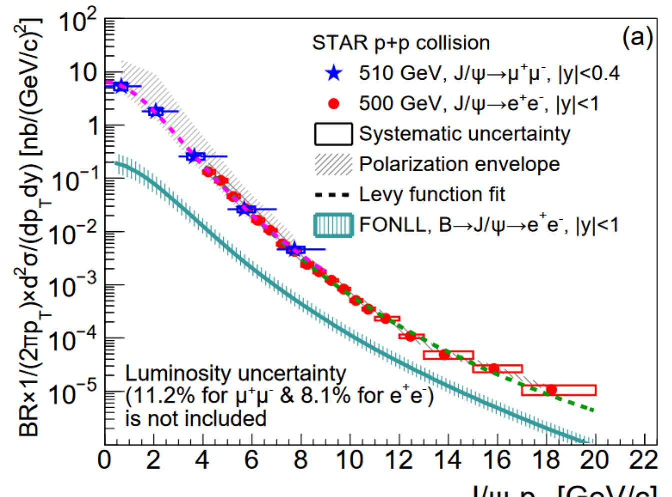
pp collisions

pp

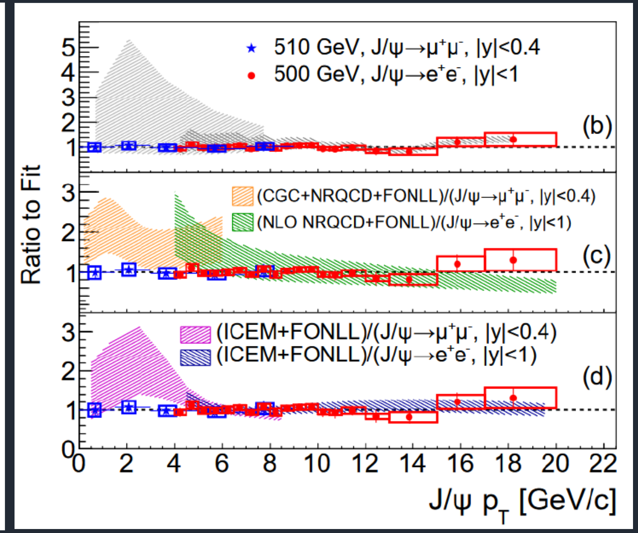
STAR, pp@200 - 500/510GeV

J/ψ precision measurement extending the p_T coverage up to 20GeV/c

→ agreement with iCEM, NRQCD, CGC+NRQCD models (+FONNL) within uncertainties



STAR, arXiv:1905.06075

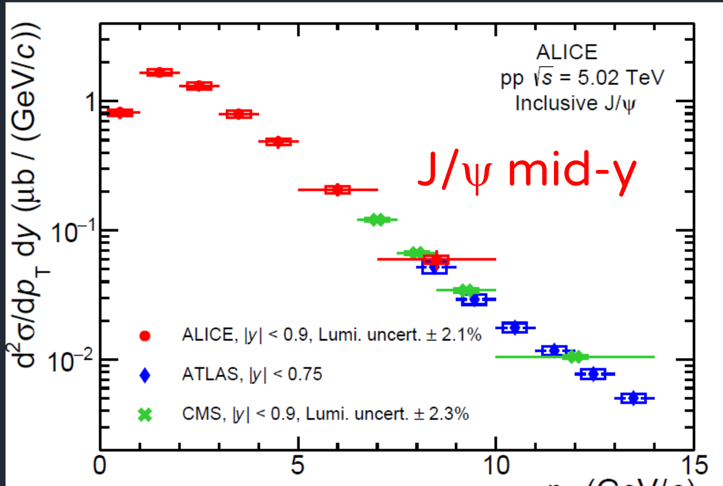


ALICE pp@5, 13TeV

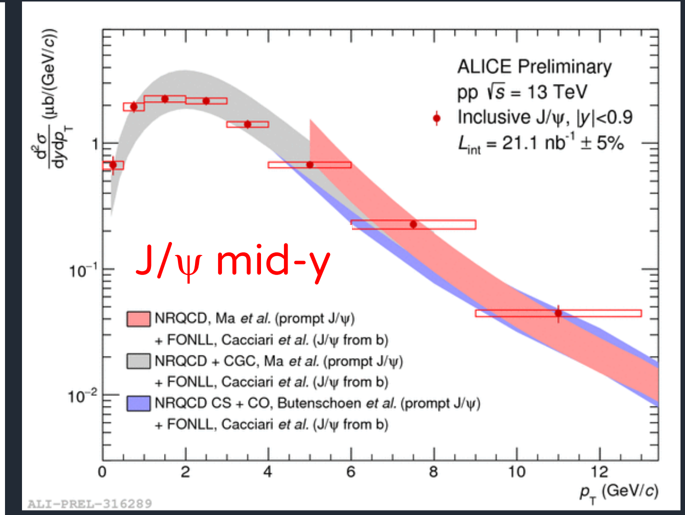
improved quarkonium cross sections with Run2 data

→ larger luminosity wrt Run1

→ increase pp reference precision for R_{AA}



ALICE arXiv:1905.07211



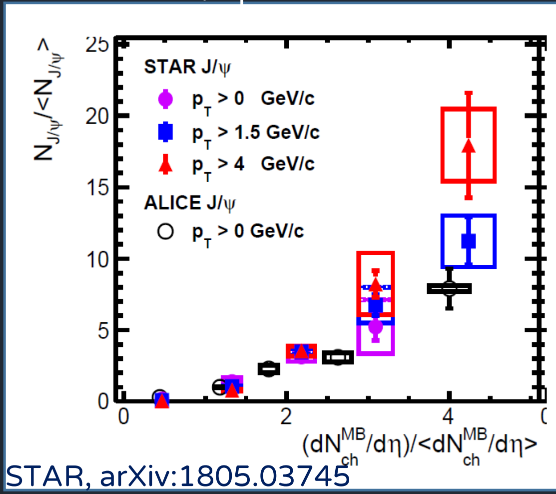
→ improved references for pA and AA studies

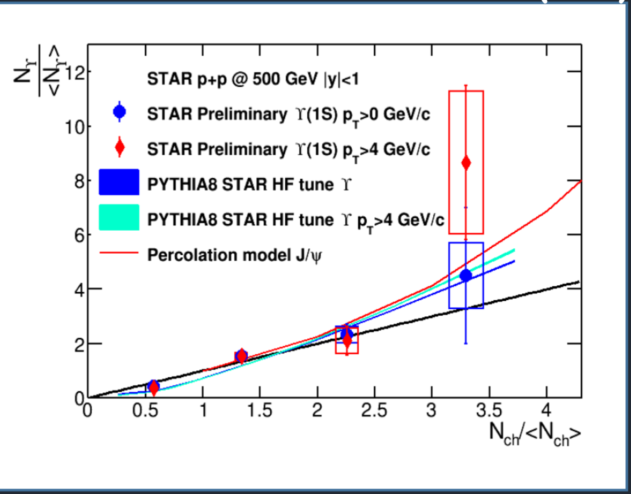
Onia production vs ev. activity

pp

STAR J/ψ

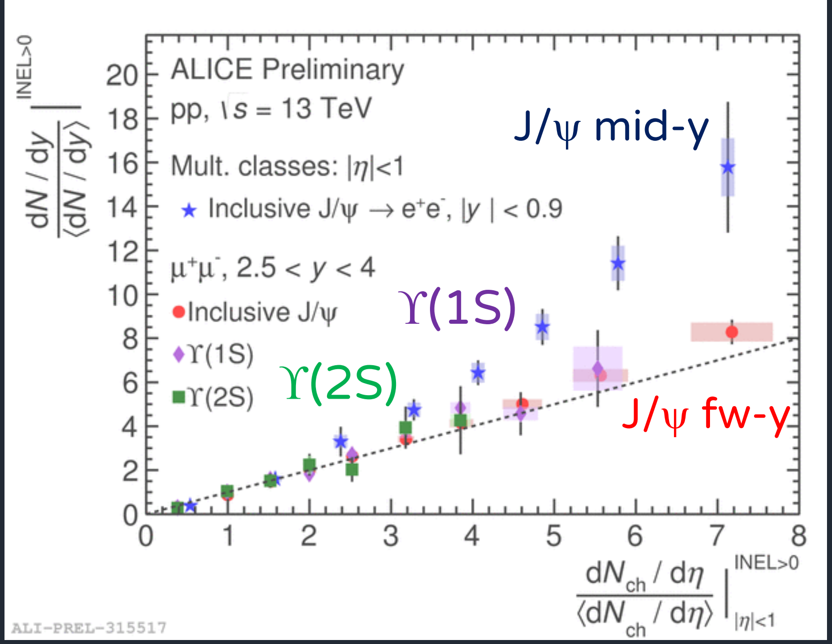
STAR ϒ(1S)





STAR, arXiv:1805.03745

ALICE



Study role of MPI in quarkonium production

Increase of J/ψ and ϒ yields with event activity observed at RHIC and LHC

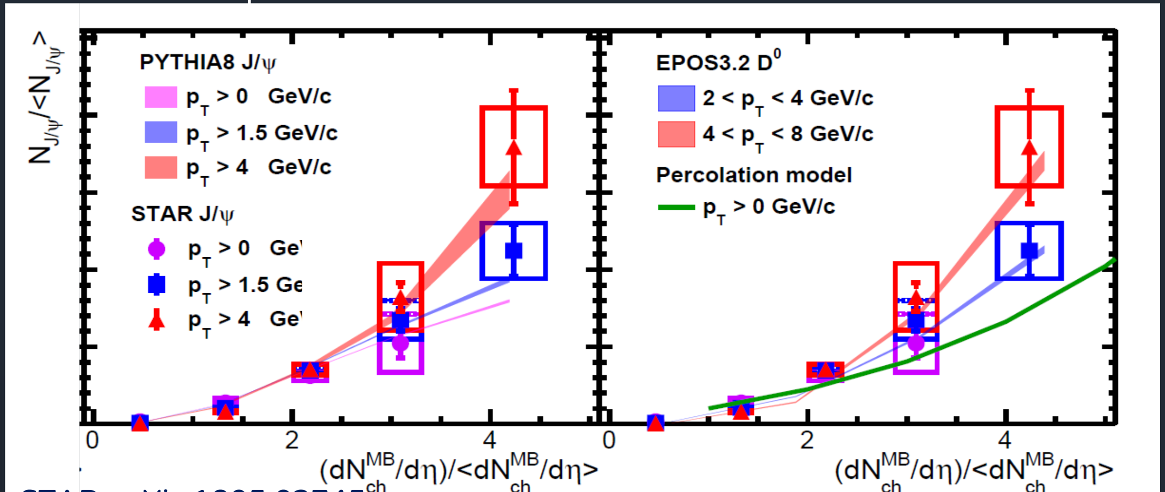
→ Increase is:

- weakly dependent on energy
- stronger for high p_T
- stronger than linear when no rapidity gap is present between quarkonium and multiplicity measurement
- independent on quarkonium state

Onia production vs ev. activity

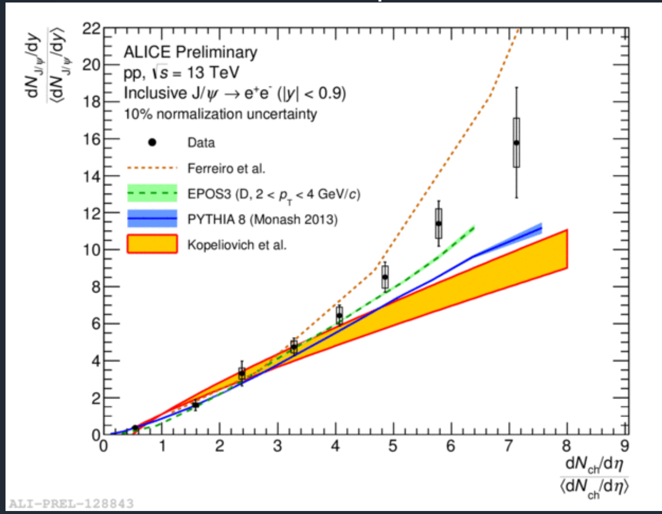
pp

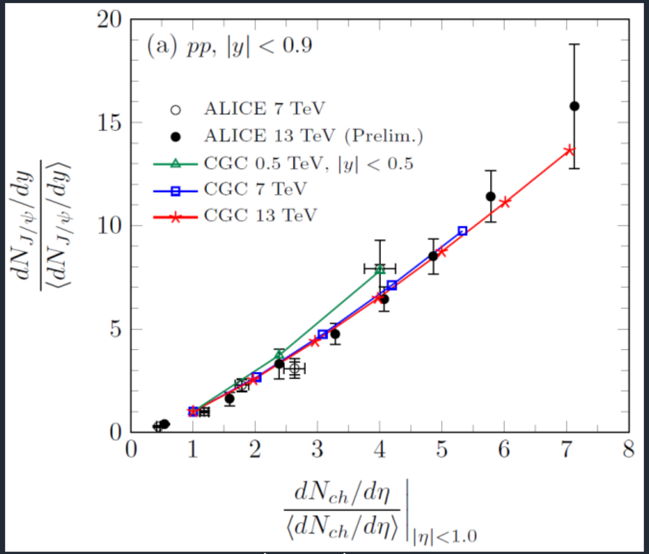
STAR J/ψ



STAR, arXiv:1805.03745

ALICE J/ψ





Ma et al, PRD98 (2018) 074025

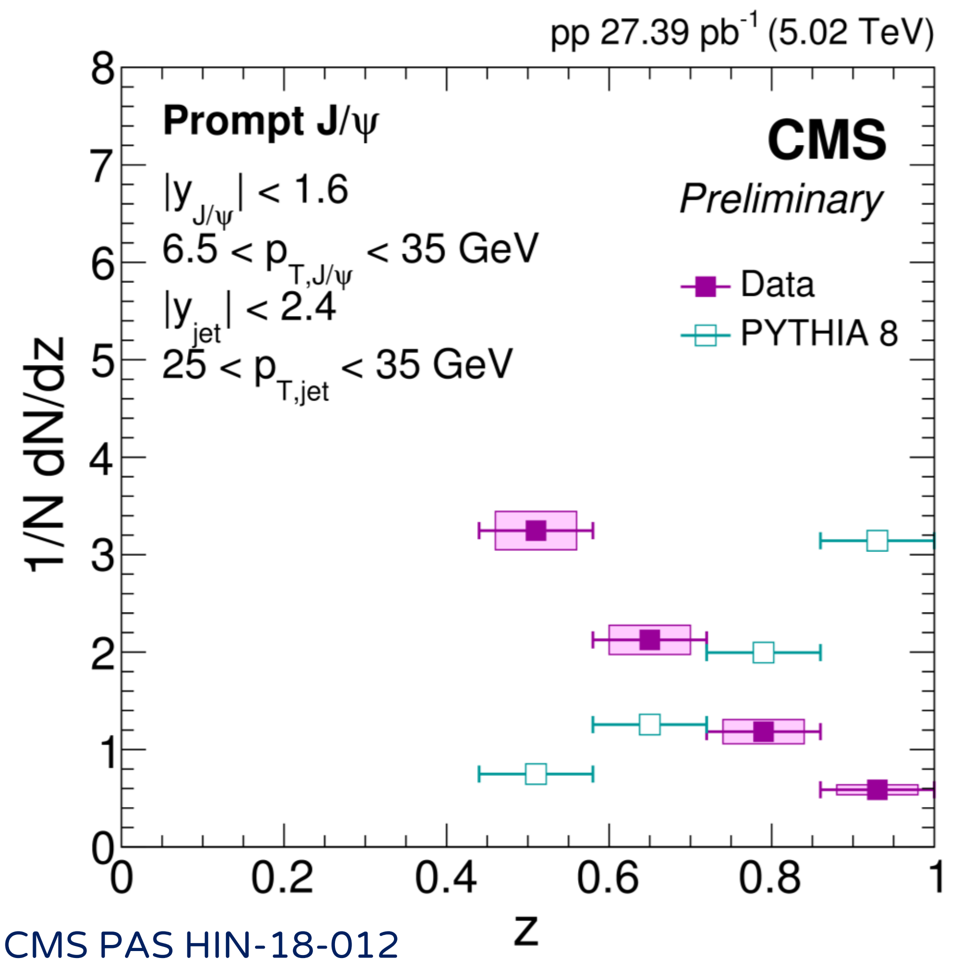
Study role of MPI in quarkonium production

Most predictions, based on different underlying processes, are in qualitative agreement with data

- EPOS3 and PYTHIA: include MPI
- Kopeliovich: high multiplicities reached via contribution of higher Fock states
- Percolation: mimic MPI via interactions of colour sources with finite spatial extension
- CGC saturation effects

J/ψ production in jets

pp



CMS PAS HIN-18-012

Prompt J/ψ production is studied in jets through the self-normalized z distribution

$$z = \frac{p_T^{J/\psi}}{p_T^{jet}}$$

Prompt J/ψ carry a small fraction of jet momentum
→ their production is accompanied by a large jet activity, much larger than the one predicted by PYTHIA8

Result is consistent with similar observation from LHCb in pp@13TeV (PRL118(2017)19,2001)

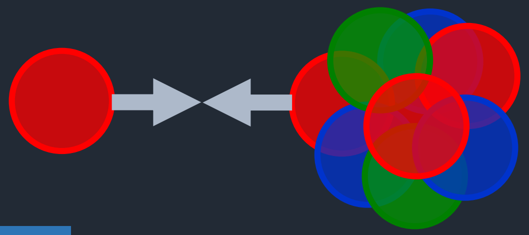
Cold Matter effects

pA

Quarkonium production is affected by effects related to cold nuclear matter (CNM):

- nuclear parton shadowing/gluon saturation
- energy loss
- $c\bar{c}$ break-up in nuclear matter

addressed via pA collisions, to investigate

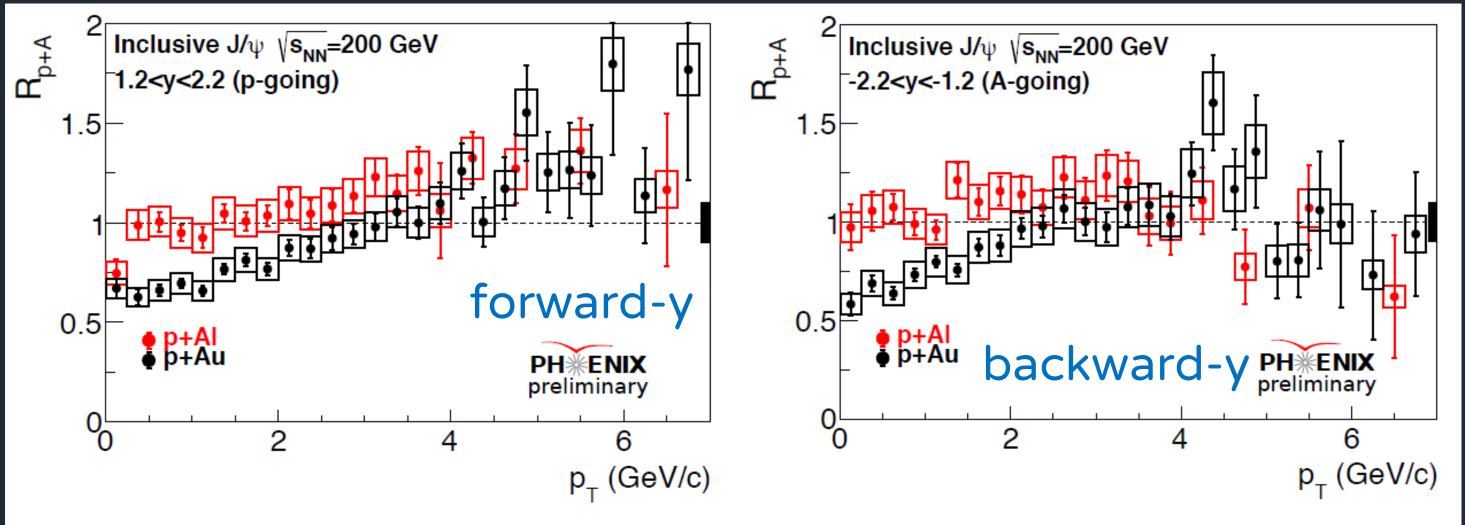


- role of the various CNM contributions, whose importance depends on kinematic and energy of the collisions
- size of CNM effects, fundamental to interpret quarkonium AA results
- presence of possible hot matter effects

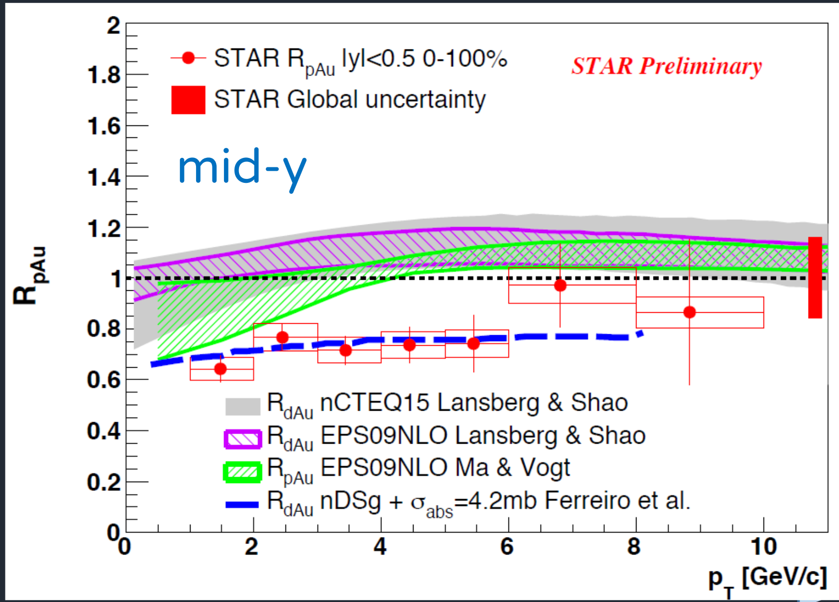
J/ψ in pA collisions at RHIC

pA

J/ψ production in small systems now studied, also multi-differentially, in p-Al, p-Au, d-Au, ^{3}He-Au



- limited CNM effects in p-Al data
- similar R_{pA} increase vs p_T in p-Au, d-Au, ^{3}He-Au. No forward vs backward-y difference?
- shadowing models predict R_{pA} slightly higher than unity (at mid-y)
- additional contribution on top of shadowing, as the cc break up in medium?



J/ψ in pA collisions at LHC

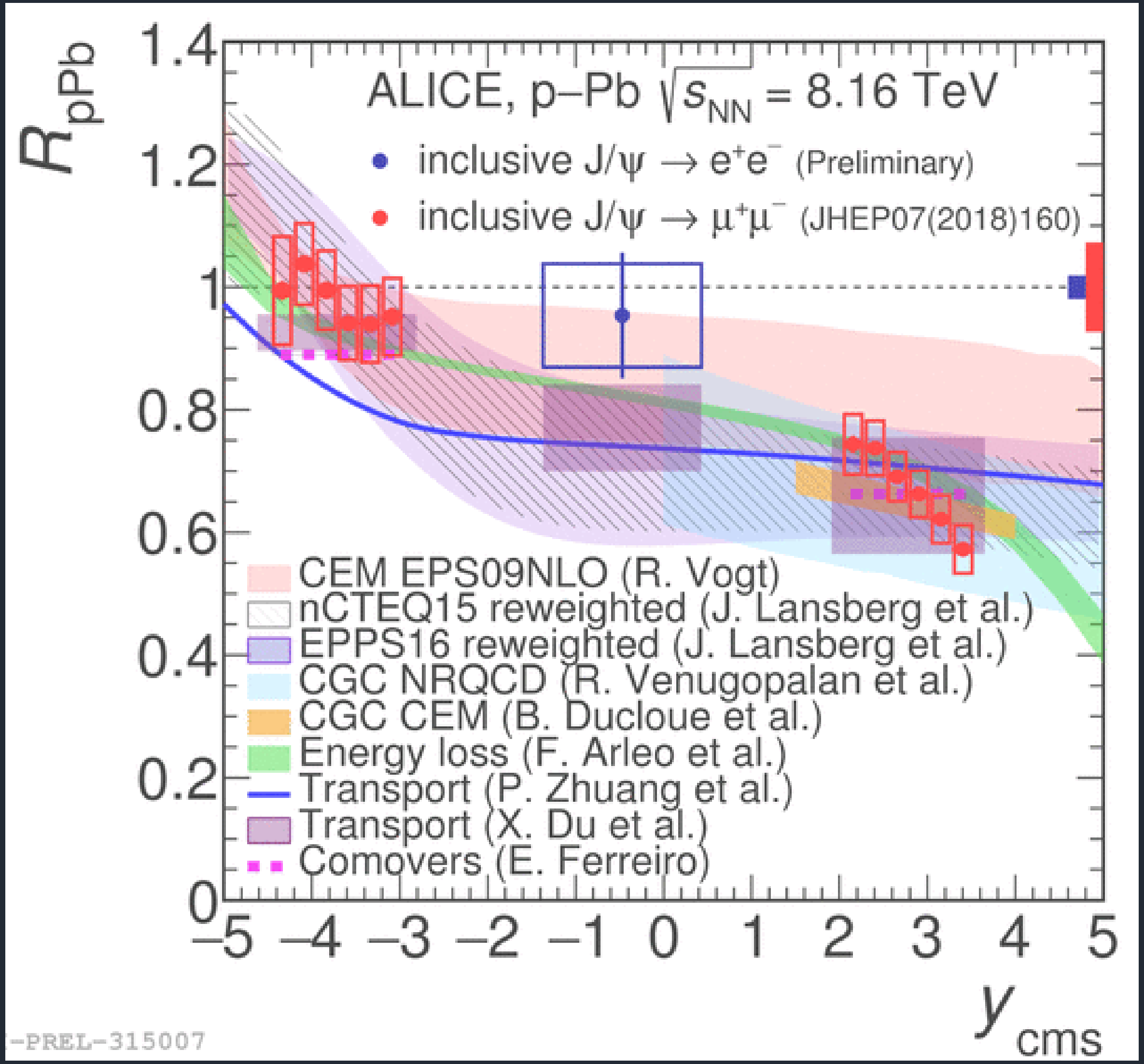
pA

CNM effects affect J/ψ production mainly at forward-y and low p_T

→ consistent results between experiments in similar kinematic range (LHCb, PLB774 (2017) 159)

fair agreement between data and models based on shadowing, CGC, energy loss

→ size of uncertainties (mainly shadowing) still limits a more quantitative comparison

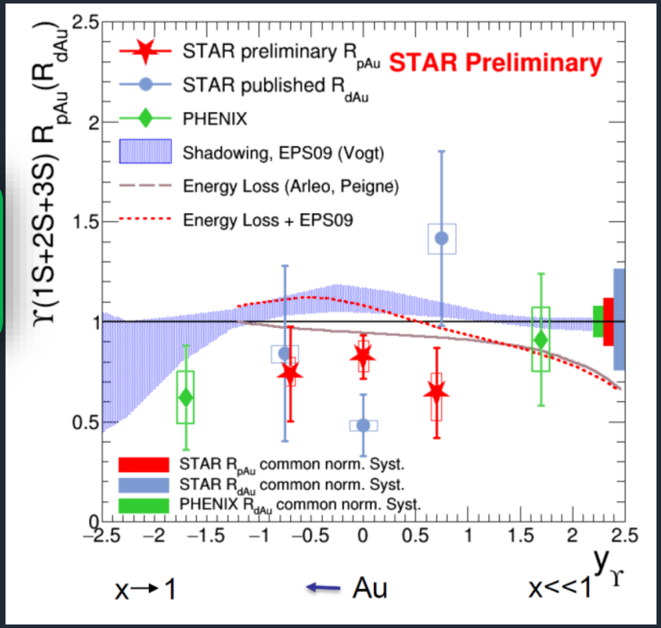


p-going direction: 2.3 10^{-5}<x<1.5 10^{-4}
Pb-going direction: 1.5 10^{-2}<x<10^{-1}

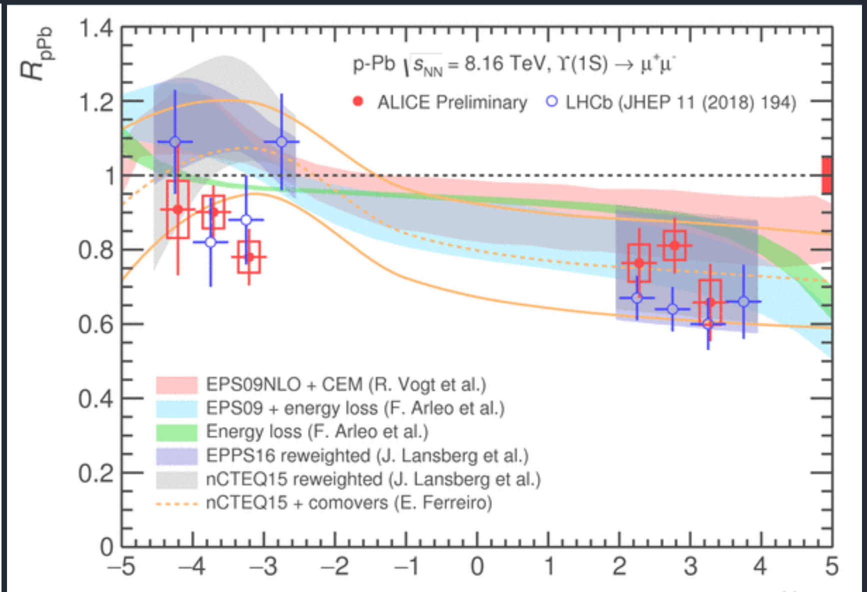
ϒ in pA collisions

pA

STAR

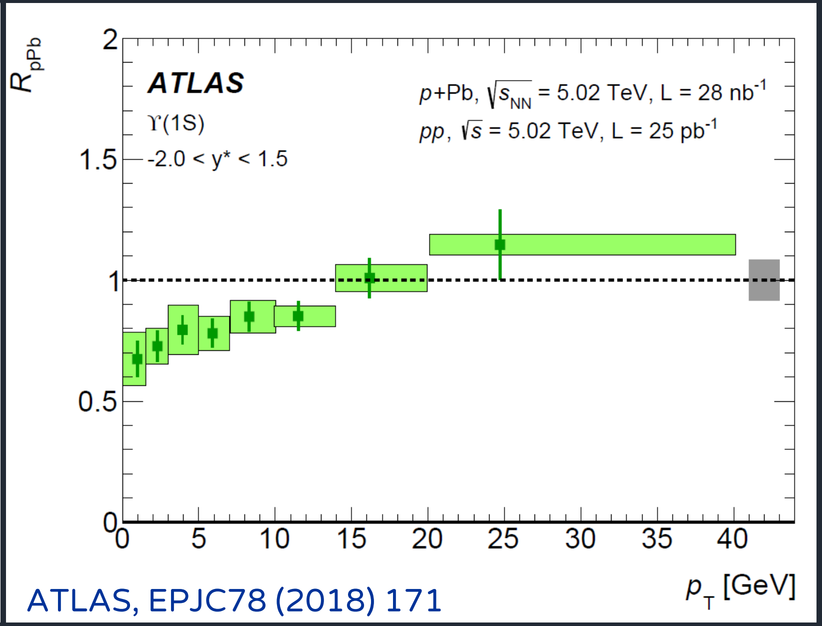


ALICE, LHCb



ALICE-PUBLIC-2018-008

ATLAS



ATLAS, EPJC78 (2018) 171

RHIC:

Improved precision in p-Au, but a precise comparison with models is still difficult

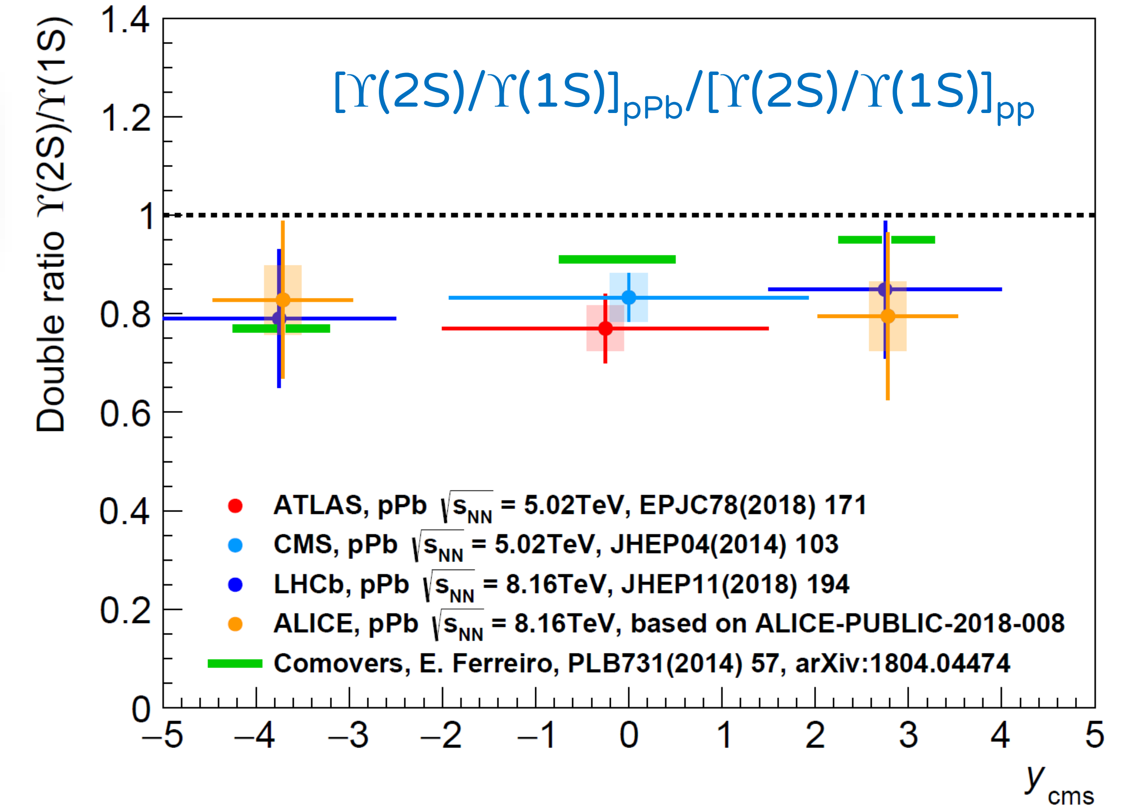
LHC:

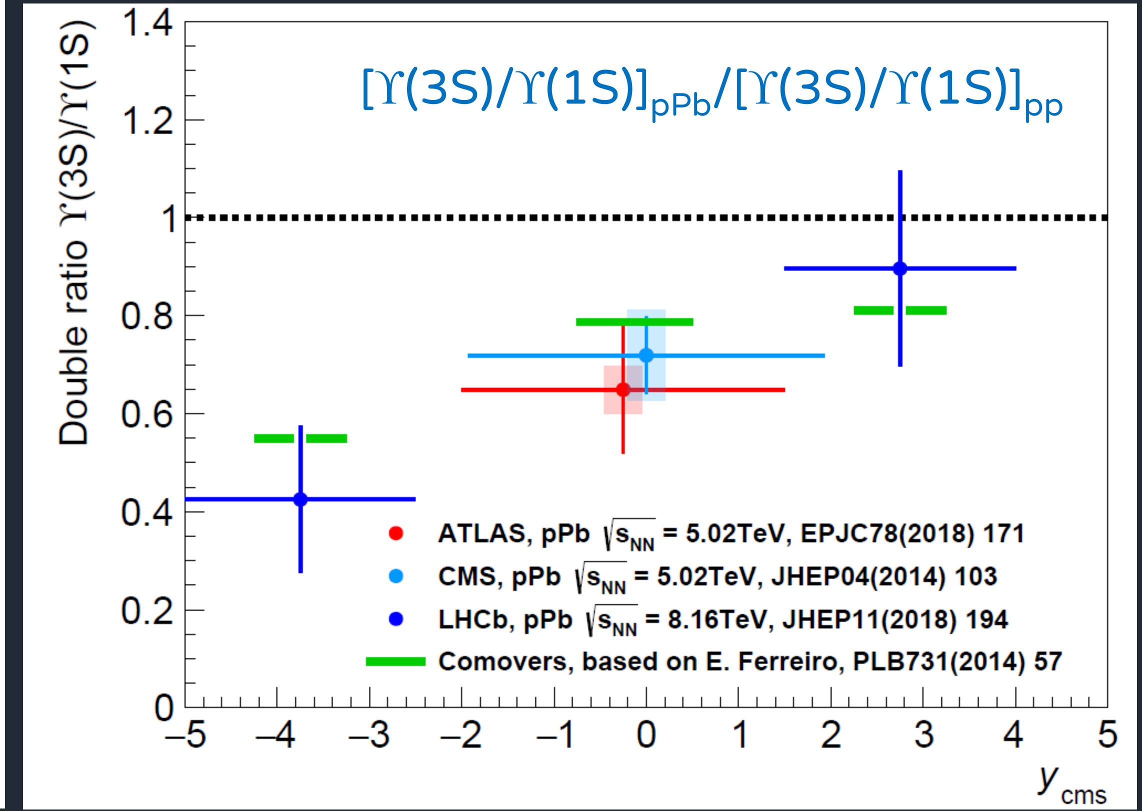
- suppression stronger at forward-y and low p_T
- shadowing and energy loss models fairly describe data at forward-y and mid-y, but slightly overestimate backward-y R_{pA}?

Excited bottomonium states

pA

Excited Υ states show a stronger suppression than Υ(1S) in pPb wrt pp

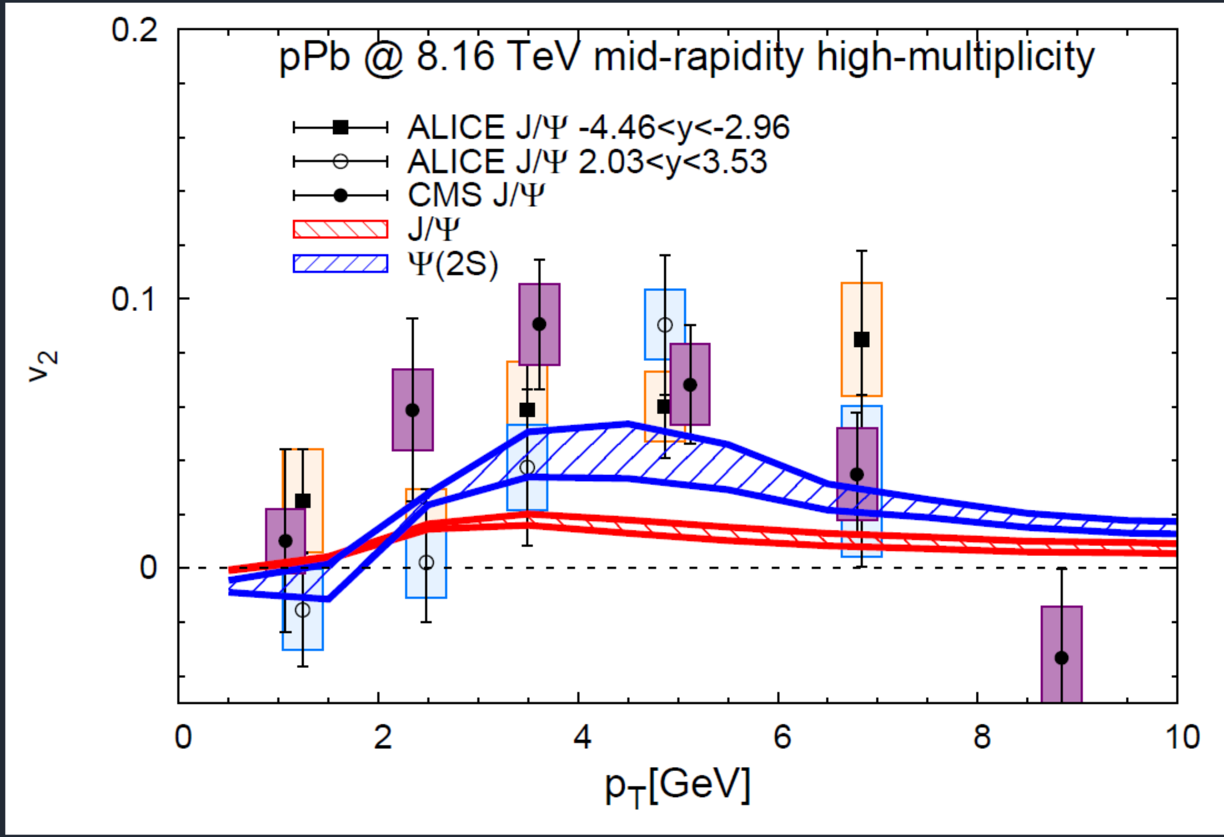




Final state effects might be needed to explain the observations, as for charmonium

J/ψ elliptic flow in pA

pA



ALICE, PLB 780 (2018) 7
CMS, PAS HIN-18-010
Rapp et al, JHEP03(2019)015

a significant non-zero v_2 is observed in high-multiplicity p-Pb

- size of v_2 similar to the one measured in PbPb
- however, common v_2 interpretation for PbPb, based on regeneration or path lengths effects doesn't work in pPb
- models where the v_2 originates from final state effects (dissociation/regeration) in the fireball underestimate the data

[E. Chapon, Friday 12.00]

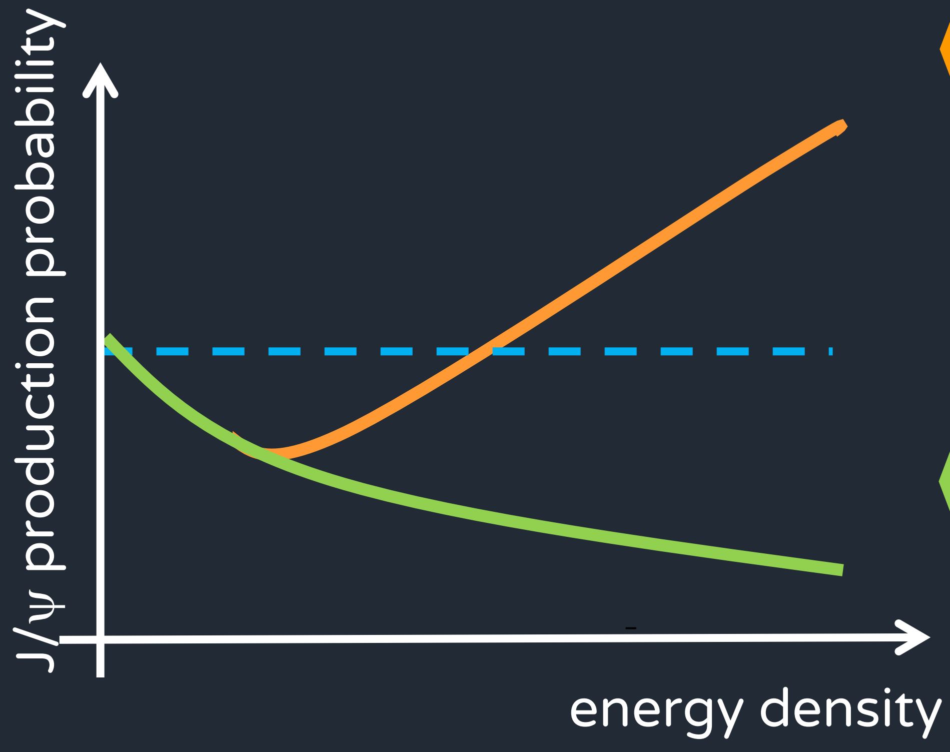
Hot Matter effects

AA

the original idea:

quarkonium production suppressed via color screening in QGP

(T.Matsui,H.Satz, PLB178 (1986) 416)



Recombination

$q\bar{q}$ abundance increases with collision energy

Central AA coll	$N_{c\bar{c}}$ per ev.	$N_{b\bar{b}}$ per ev.
RHIC, 200GeV	~10	-
LHC, 5.02 TeV	~115	~3

→ (re)combination at hadronization or in QGP enhances charmonium production

→ small contribution for bottomonium (also at LHC)

P. Braun-Muzinger,J.Stachel, PLB490(2000)196, R.Thews et al,PRC63:054905(2001)

Sequential melting

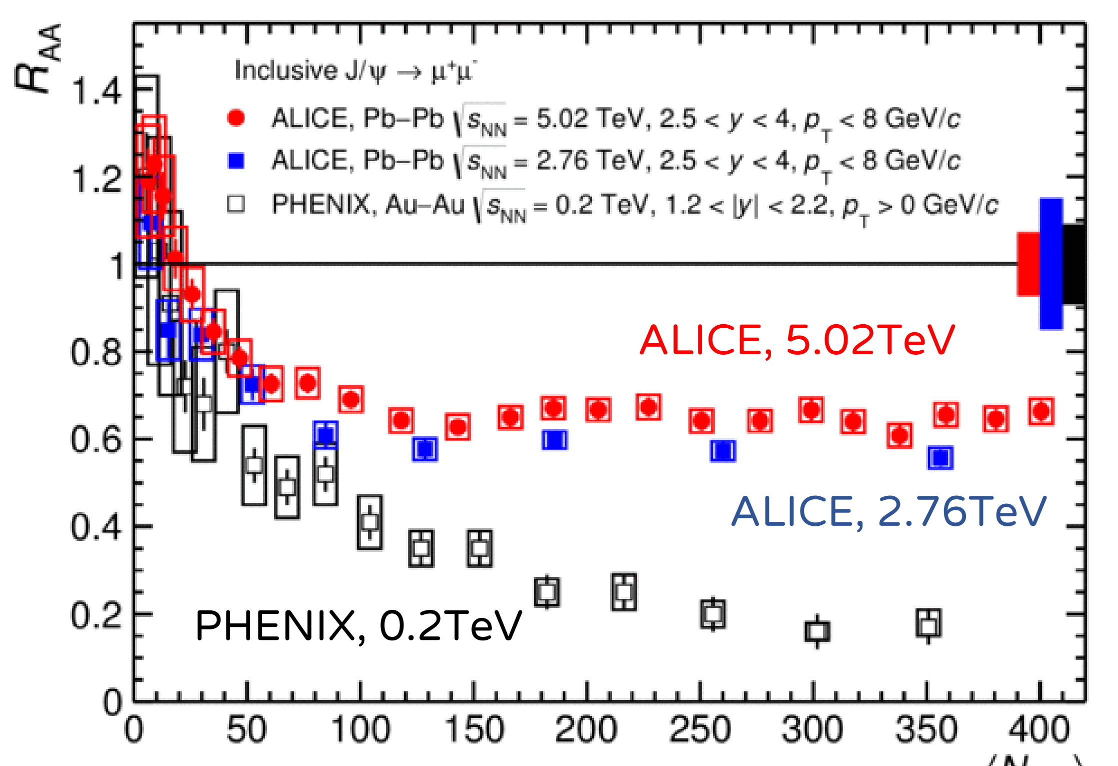
differences in quarkonium binding energies lead to a sequential melting with increasing temperature

Digal,Petrecki,Satz PRD 64(2001) 0940150

Charmonium in AA

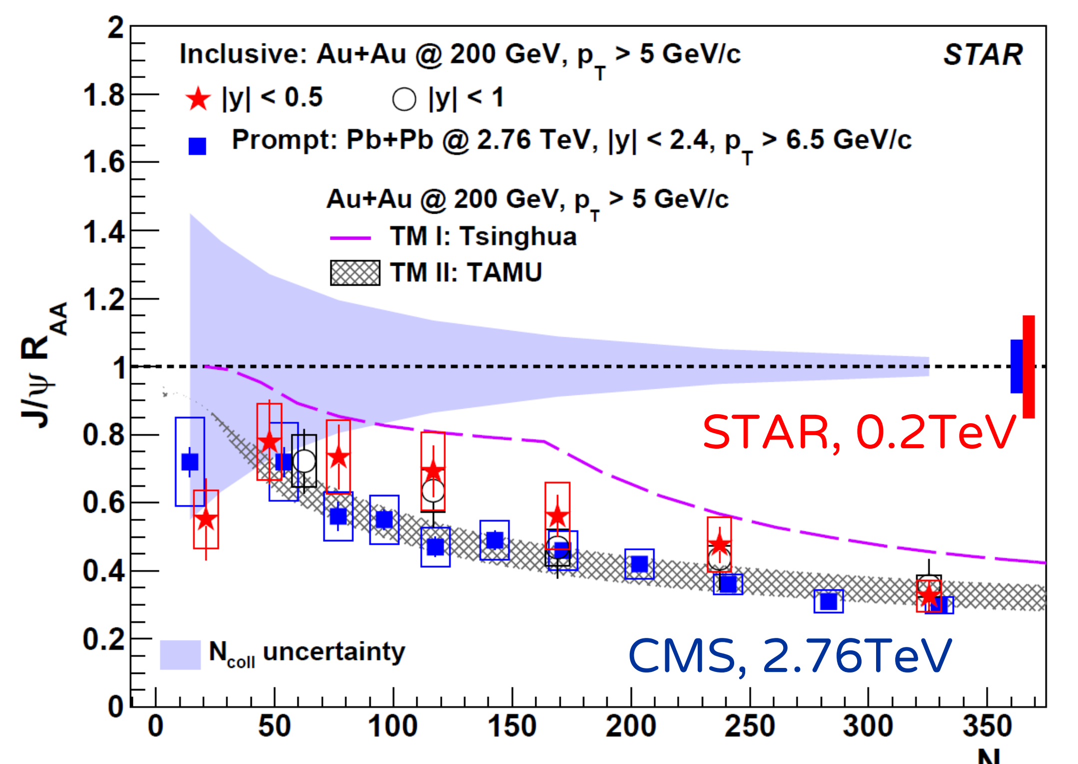
AA

Low p_T J/ψ



ALICE, PLB766 (2017) 212

High p_T J/ψ



STAR, arXiv:1905.13669, CMS, EPJC77 (2017) 252

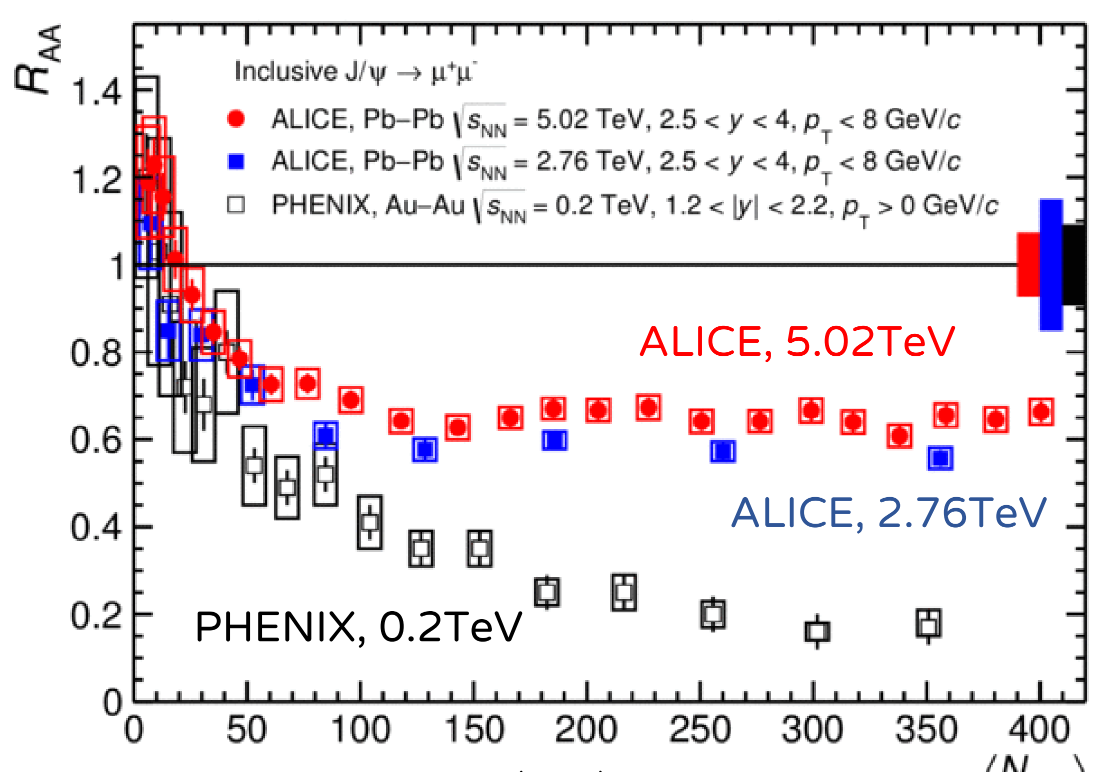
stronger suppression at RHIC in central events, in spite of the larger LHC energy densities

suppression increases towards central events, being of similar size at RHIC and LHC energies

Charmonium in AA

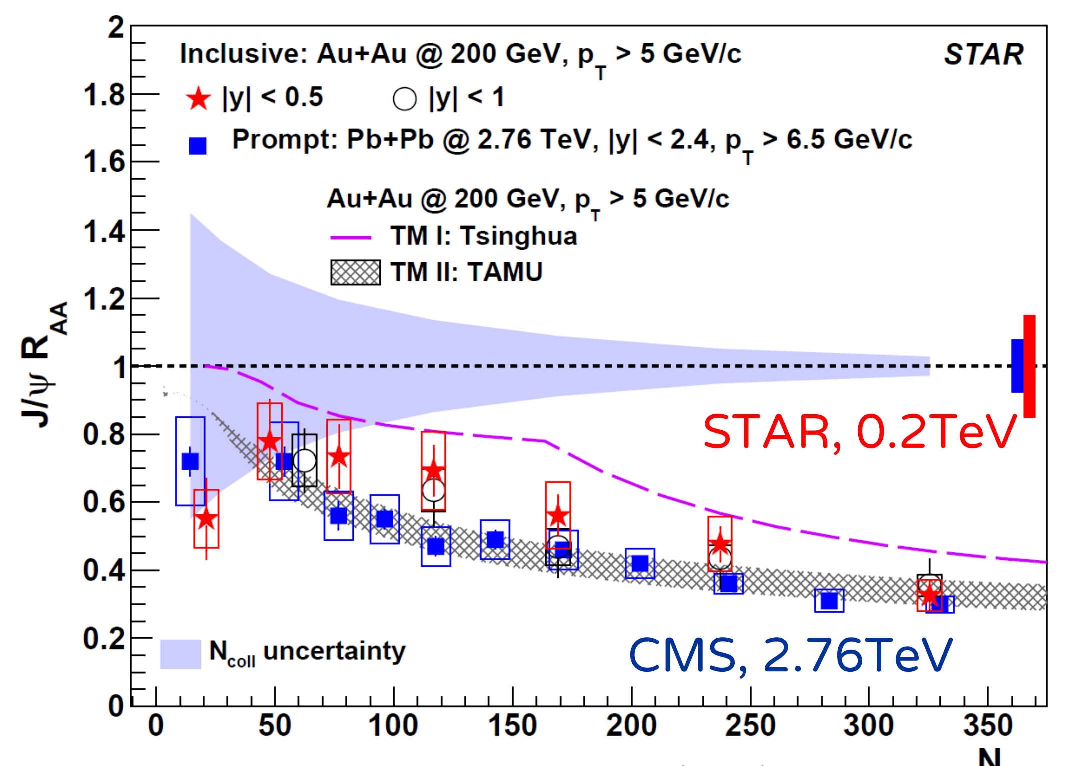
AA

Low p_T J/ψ



ALICE, PLB766 (2017) 212

High p_T J/ψ

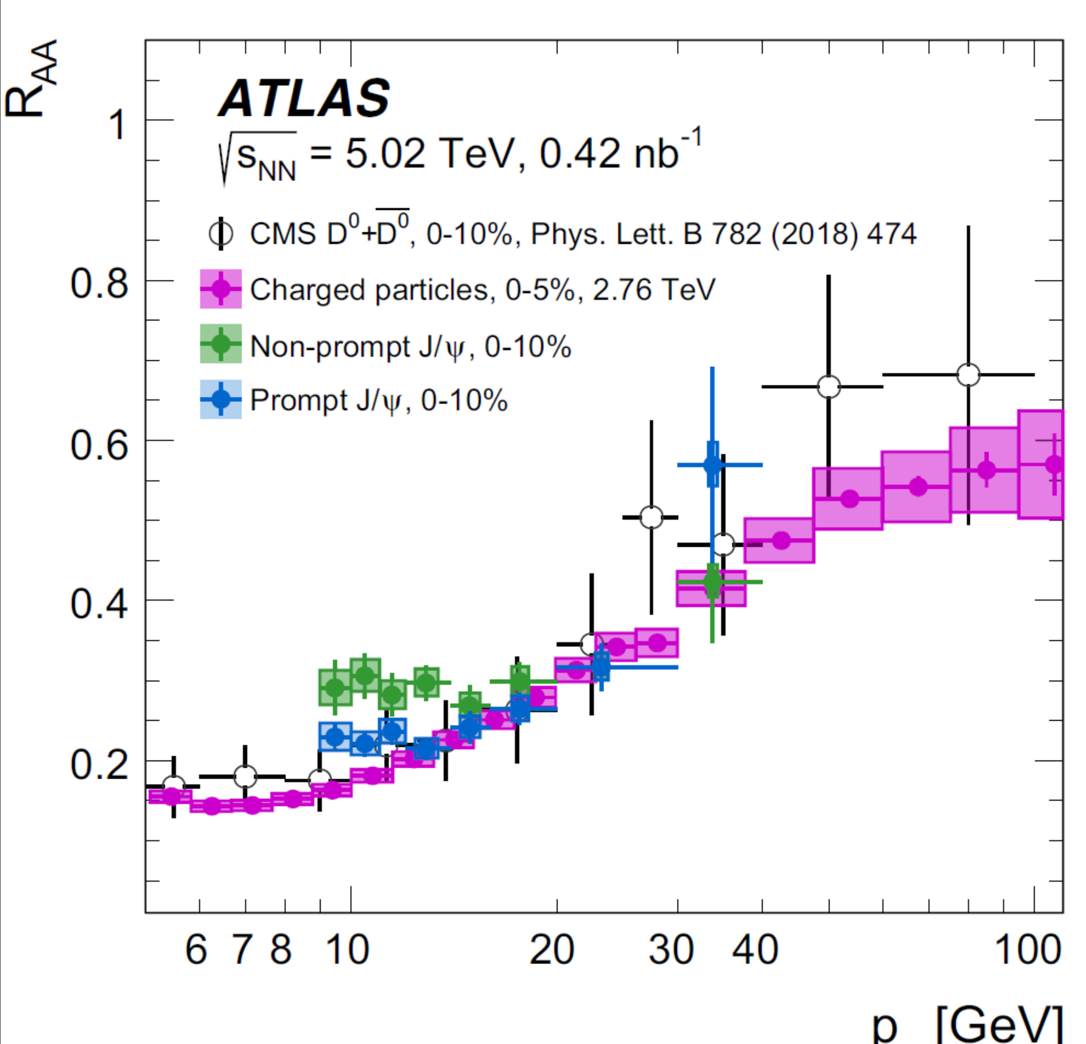


STAR, arXiv:1905.13669, CMS, EPJC77 (2017) 252

Models with suppression + regeneration mechanisms, with regeneration at play in the low p_T region and at high energy, fairly describe the data

Very high p_T J/ψ

AA



ATLAS, EPJC78(2018) 762

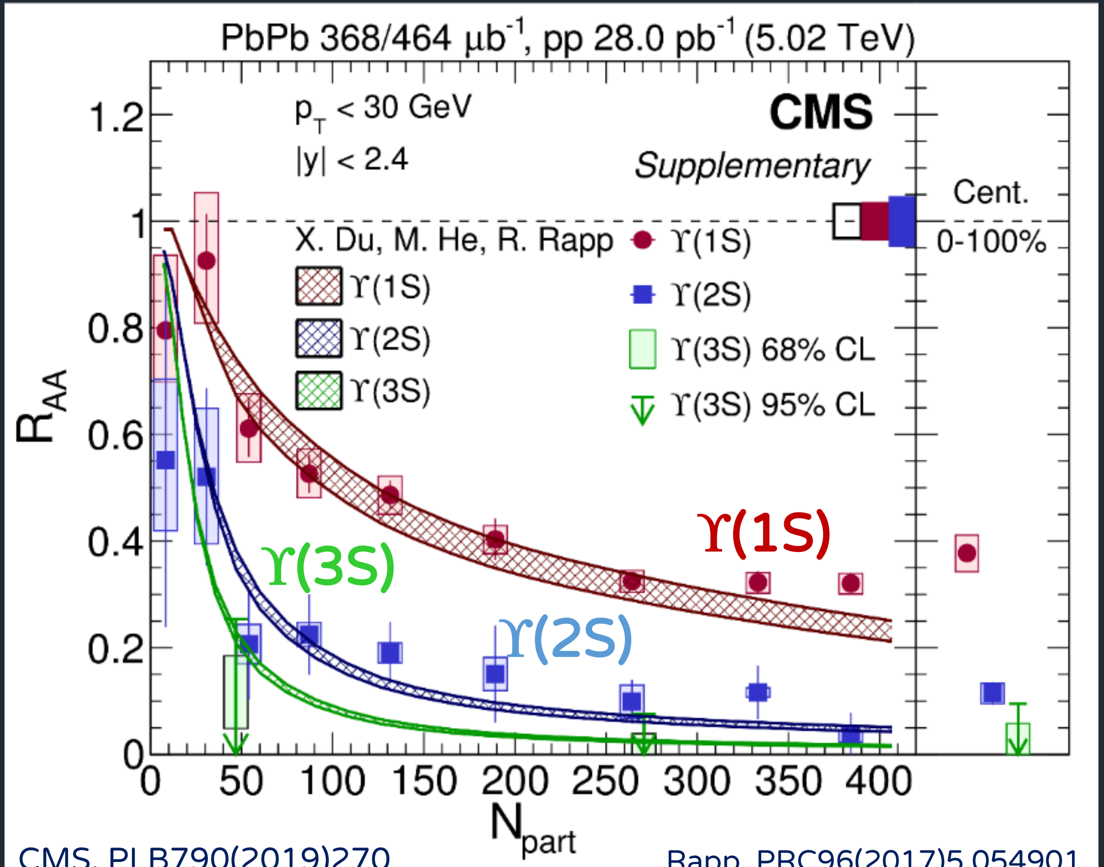
Indication of a high p_T rise, as for charged hadrons or D mesons

→ weak regeneration expected, parton energy-loss at play?

AA

Bottomonium in AA

Three ϒ states with different sensitivity to the medium → limited recombination and no B feed-down (but large feed down from excited states) → interesting for sequential suppression studies



CMS, PLB790(2019)270

Rapp, PRC96(2017)5,054901

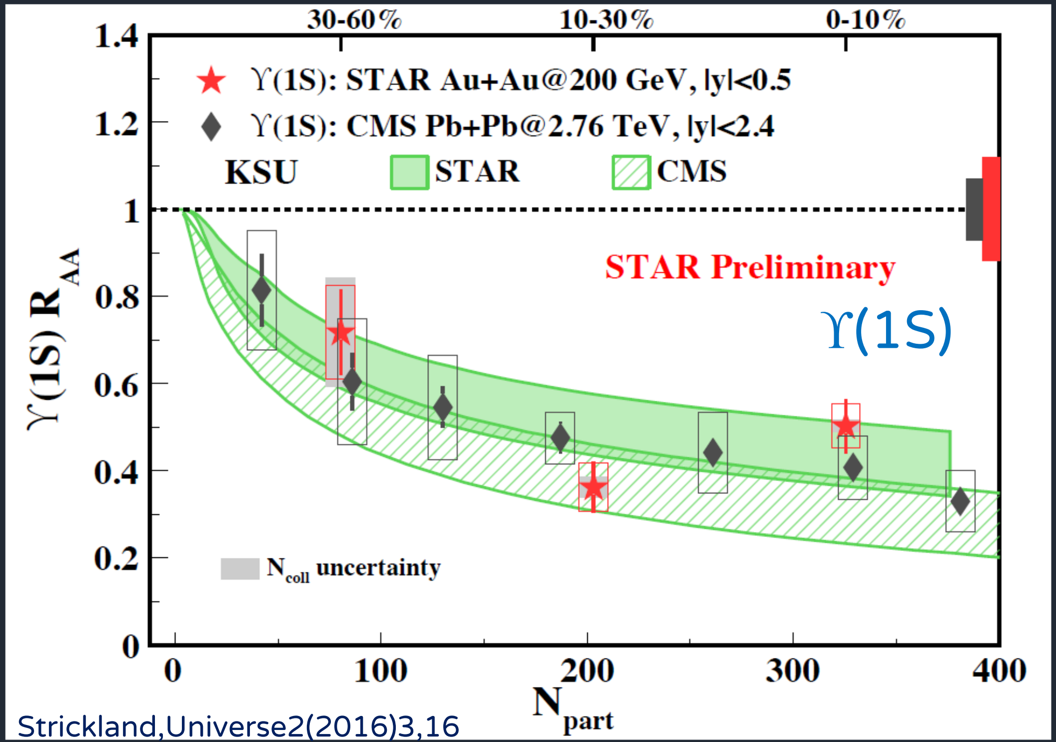
Strong centrality suppression for all ϒ(nS) (factor ~2 for ϒ(1S), ~9 for ϒ(2S))

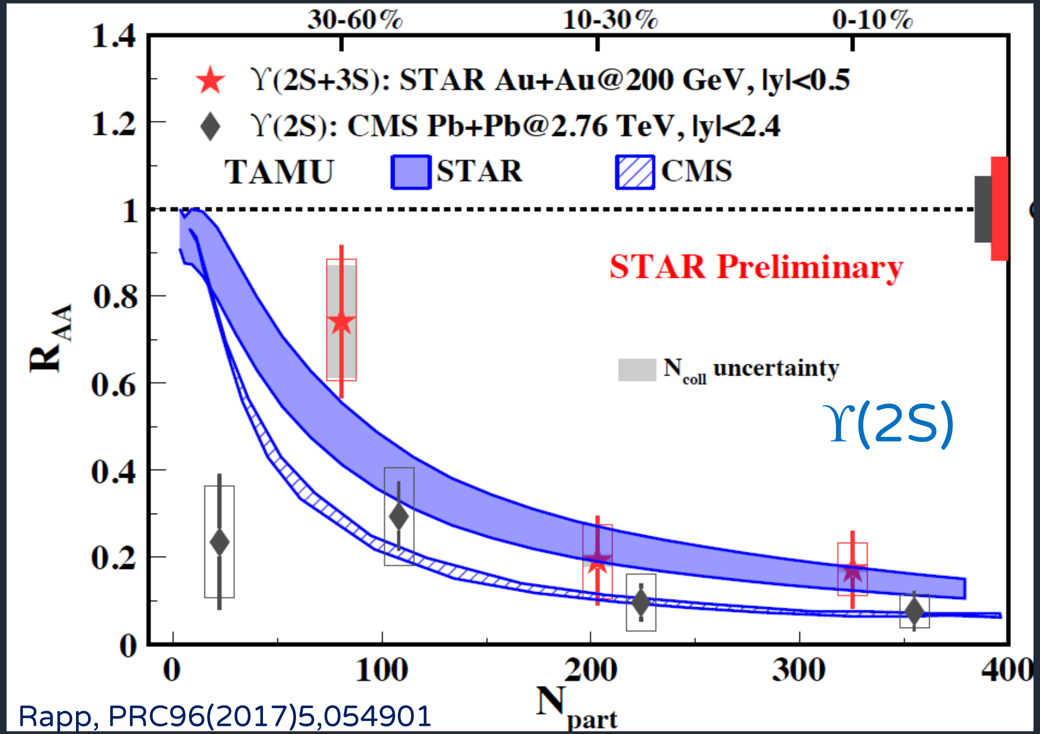
- lower R_{AA} values for excited states compatible with sequential suppression
- suppression of directly produced ϒ(1S)? Feed down contribution ~ 30%
- models (almost all including suppression and regeneration) fairly describe the data

CMS, PLB 790 (2019) 270

Bottomonium in AA

AA



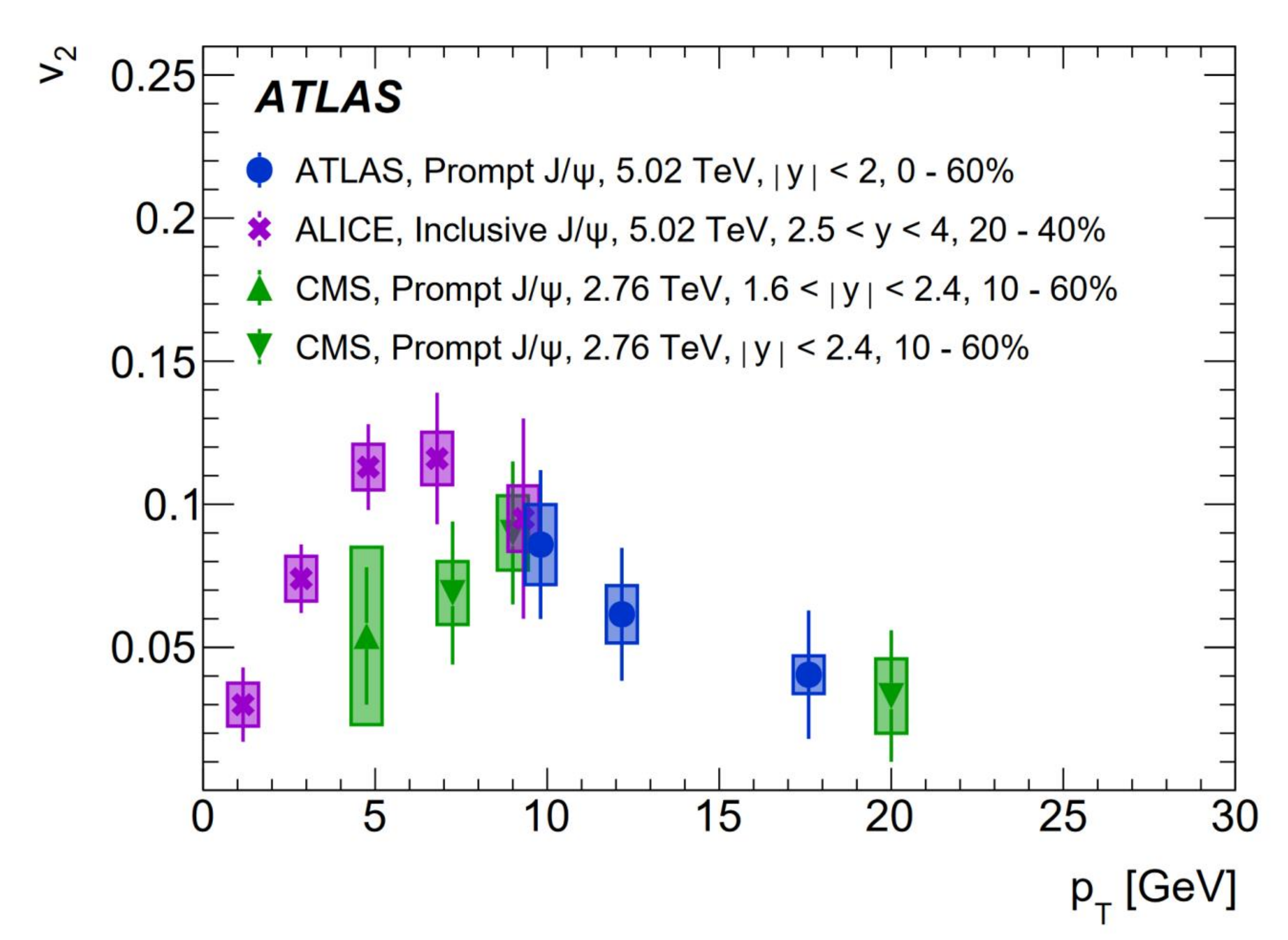


- Similar Υ(1S) suppression, within uncertainties, at RHIC and LHC → might imply weak or no suppression of direct Υ(1S) at LHC
- Excited states suppression is stronger at LHC

Models describing LHC results also describe RHIC ones

J/ψ elliptic flow

AA



ALICE, PRL 119 (2017) 242301, arXiv:1811.12727
ATLAS, EPJC 78 (2018) 784
CMS, EPJC 77 (2017) 252

J/ψ from recombination should inherit the thermalized charm flow

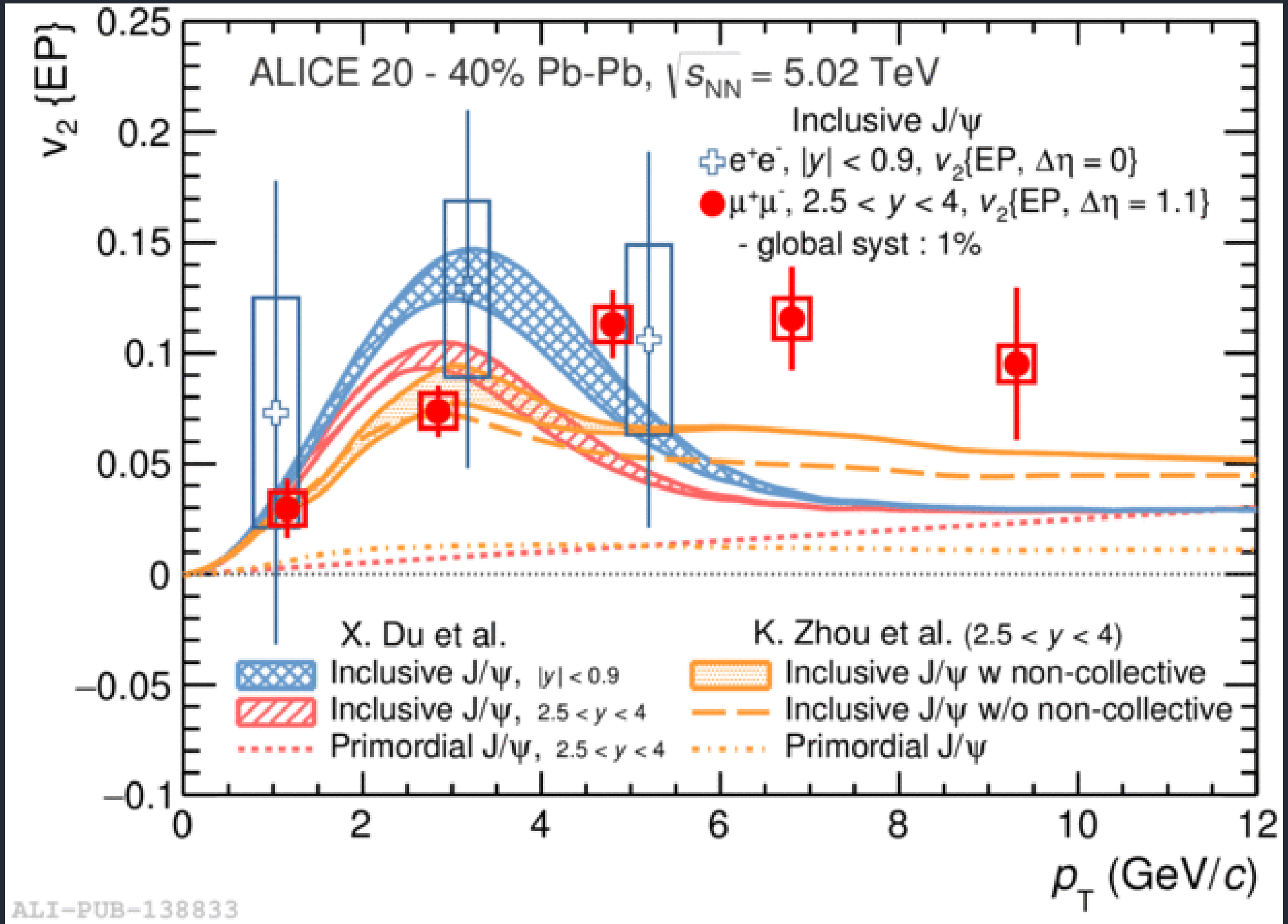
J/ψ v_2 measurement over a broad p_T range

low p_T:
evidence for non-zero flow
(ALICE, 7σ effect in 4<p_T<6 GeV/*c*)

high p_T:
$v_2 \neq 0$ (ATLAS and CMS)

J/ψ elliptic flow

AA



ALICE, PRL 119 (2017) 242301, arXiv:1811.12727
ATLAS, EPJC 78 (2018) 784
CMS, EPJC 77 (2017) 252

J/ψ from recombination should inherit the thermalized charm flow

J/ψ v_2 measurement over a broad p_T range

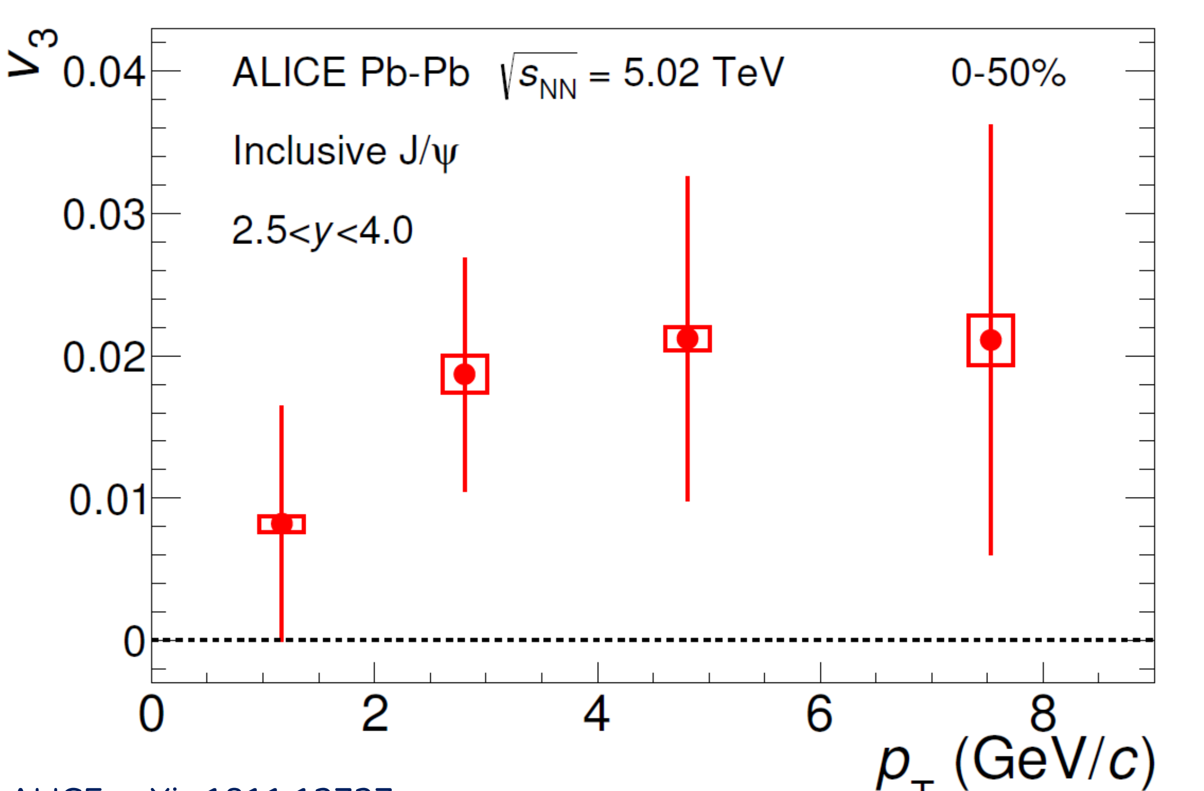
Comparison to models:

low p_T:
v_2 reproduced including a strong J/ψ regeneration component

high p_T:
energy loss path-length dependence plays a role, but v_2 still underestimated

AA

J/ψ triangular flow



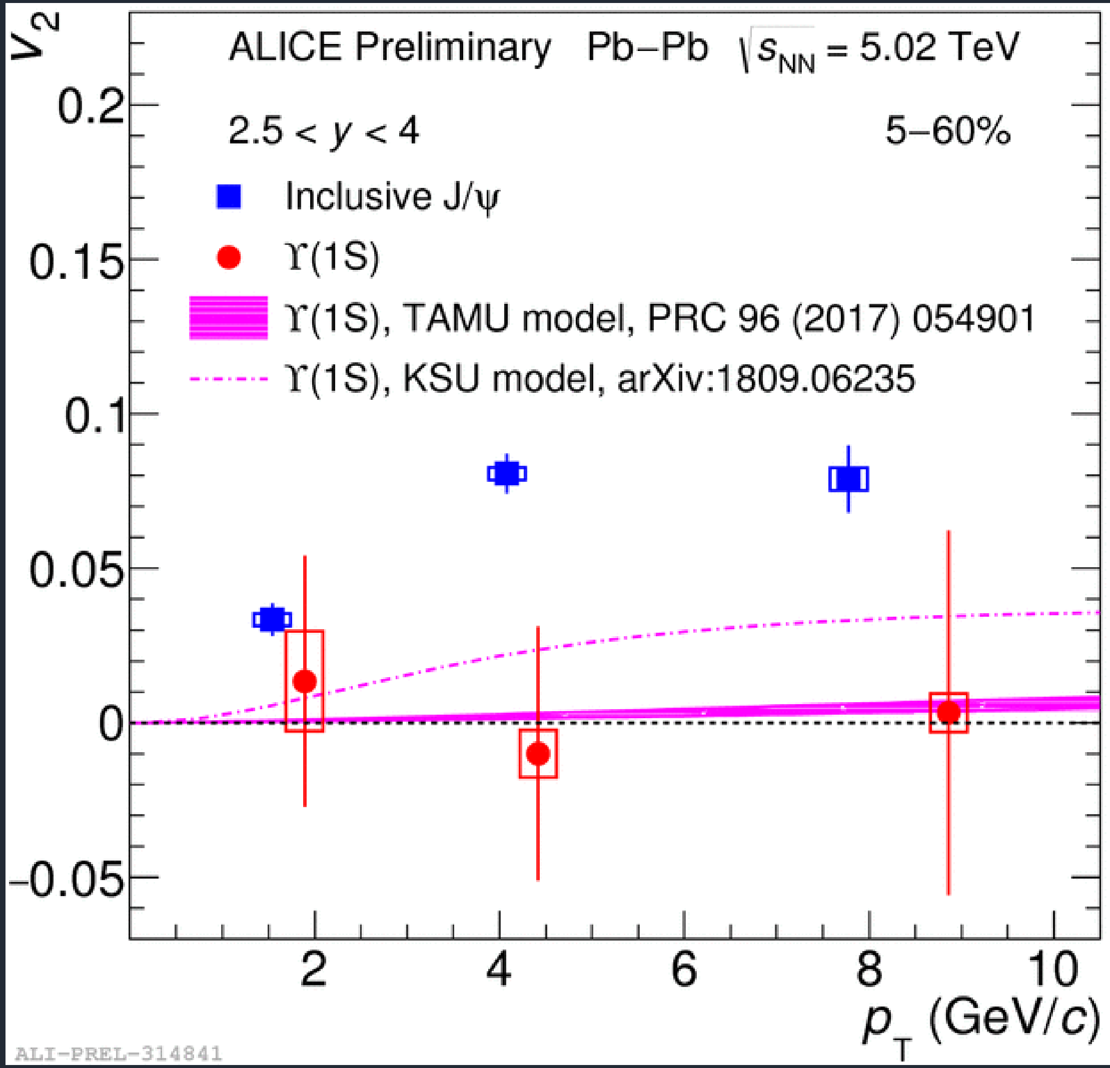
ALICE, arXiv:1811.12727

First measurement of inclusive J/ψ v_3

3.7σ significance for a positive v_3 over the full p_T range

Υ(1S) elliptic flow

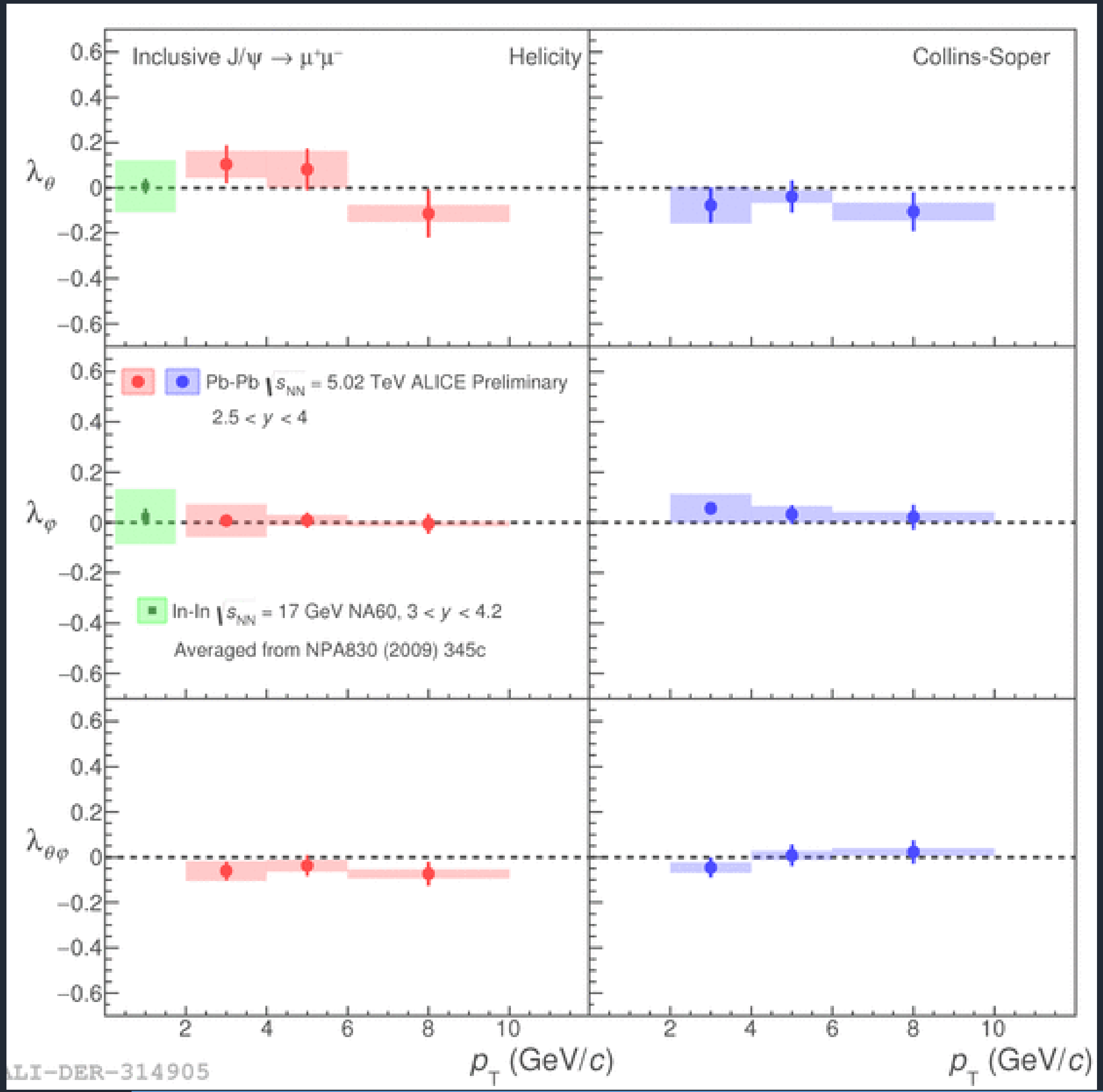
AA



First measurement of Υ(1S) elliptic flow in AA, based on 2015+2018 samples

- Υ(1S) v_2 is consistent with zero over the full p_T range, in 5-60% centrality
- v_2 is compatible with the small values predicted by theory models including (TAMU) or not (KSU) a regeneration contribution
- J/ψ v_2 is 2.6σ higher than the Υ(1S) one in $2<p_T<5$ GeV/c
  → hint for a different production mechanisms in PbPb?

J/ψ polarization



First J/ψ polarization measurement in PbPb collisions

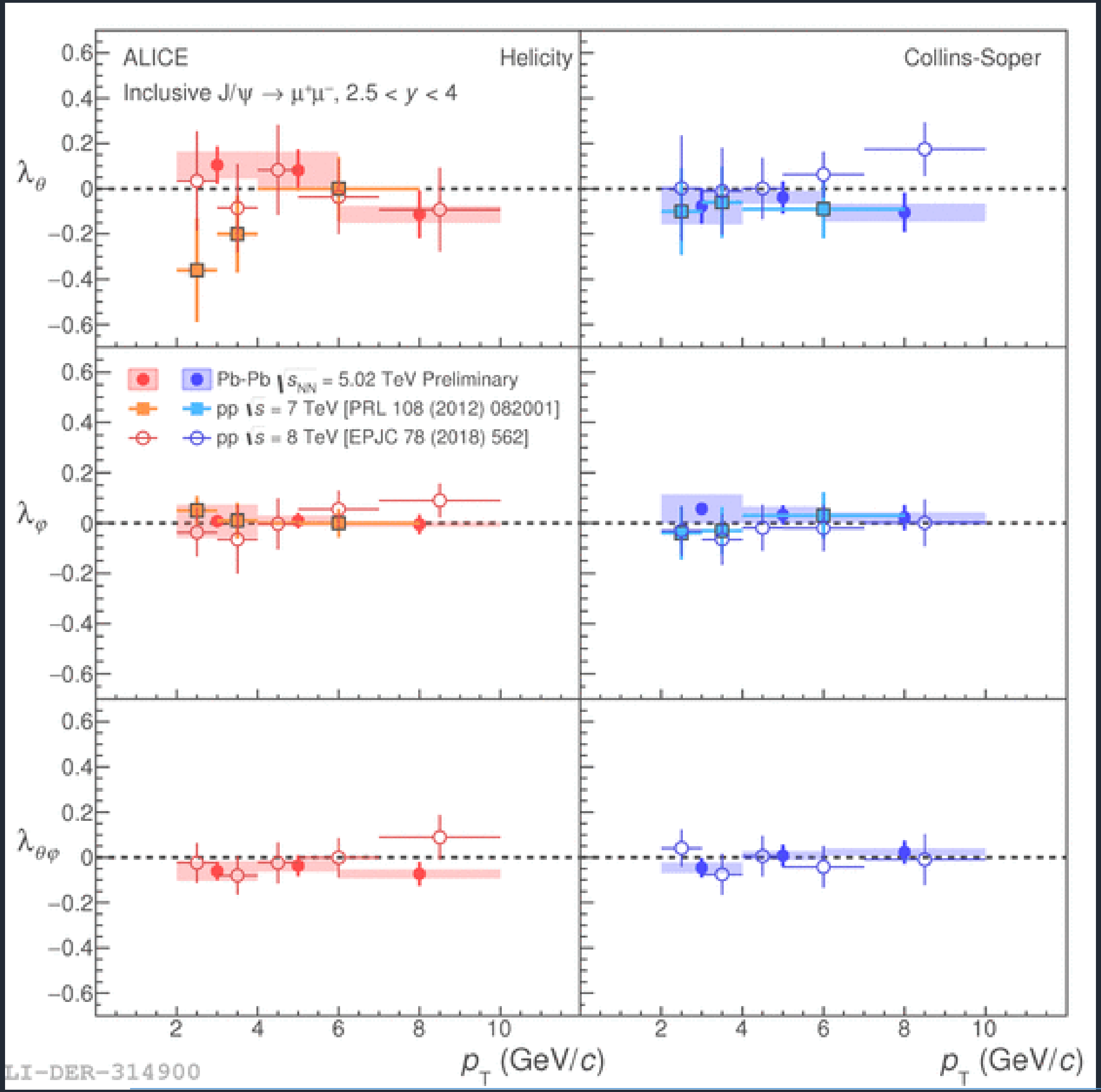
Polarization parameters are evaluated from the angular distribution of decay muons in the quarkonium rest frame:

$$W(\cos\theta,\varphi) \propto \frac{1}{3+\lambda_\theta}\left(1 + \lambda_\theta \cos^2\theta + \lambda_\varphi \sin^2\theta \cos 2\varphi + \lambda_{\theta\varphi} \sin 2\theta \cos\varphi\right)$$

- All J/ψ polarization parameters are consistent with zero
- Result compatible with a first measurement at SPS energies (NA60, InIn@$\sqrt{s_{NN}}$ = 17GeV)

J/ψ polarization

AA



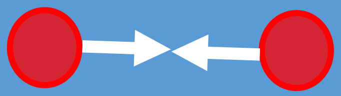
First J/ψ polarization measurement in PbPb collisions

- All polarization parameters are consistent with zero
- Result compatible with a first measurement at SPS energies (NA60, InIn@$\sqrt{s_{NN}}$ = 17GeV)
- Weak or no polarization in PbPb, as already in pp collisions
- Theory guidance needed!

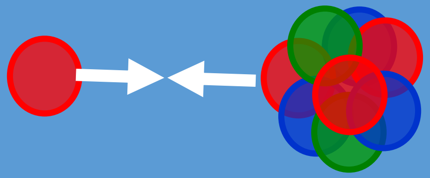
AA
pA
pp

Conclusions

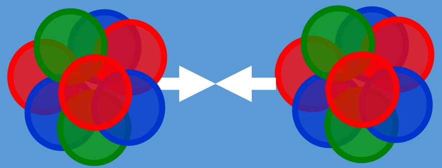
In all collisions systems results are reaching a high-precision level and new observables are becoming accessible



pp: several aspects of quarkonium production are now extensively studied over a very broad kinematic range



pA: ground states production can be explained via "standard" CNM effects, while final state effects are needed for the excited states

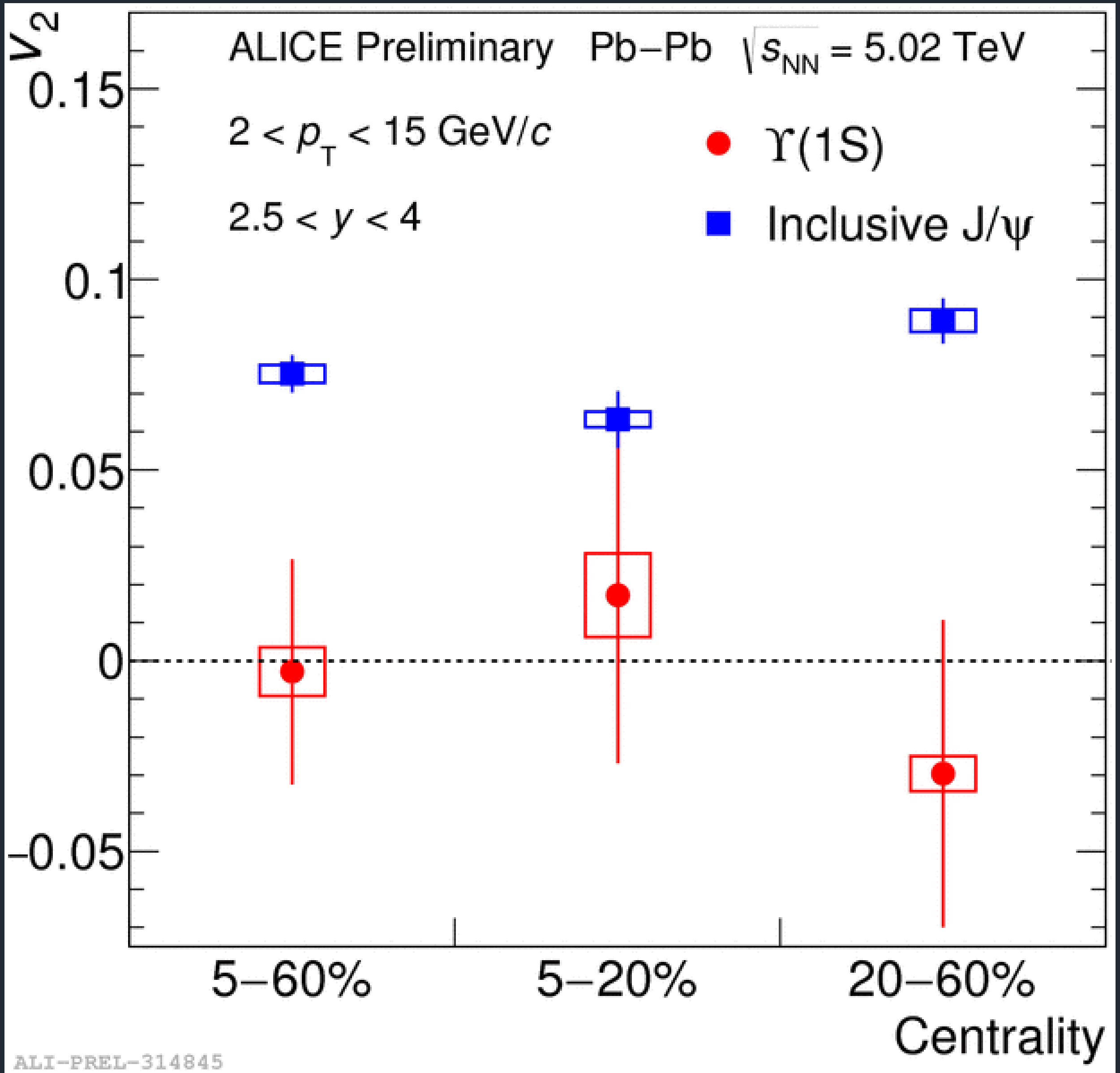


AA: quarkonium R_{AA} and elliptic flow measurements are interpreted in terms of suppression and recombination

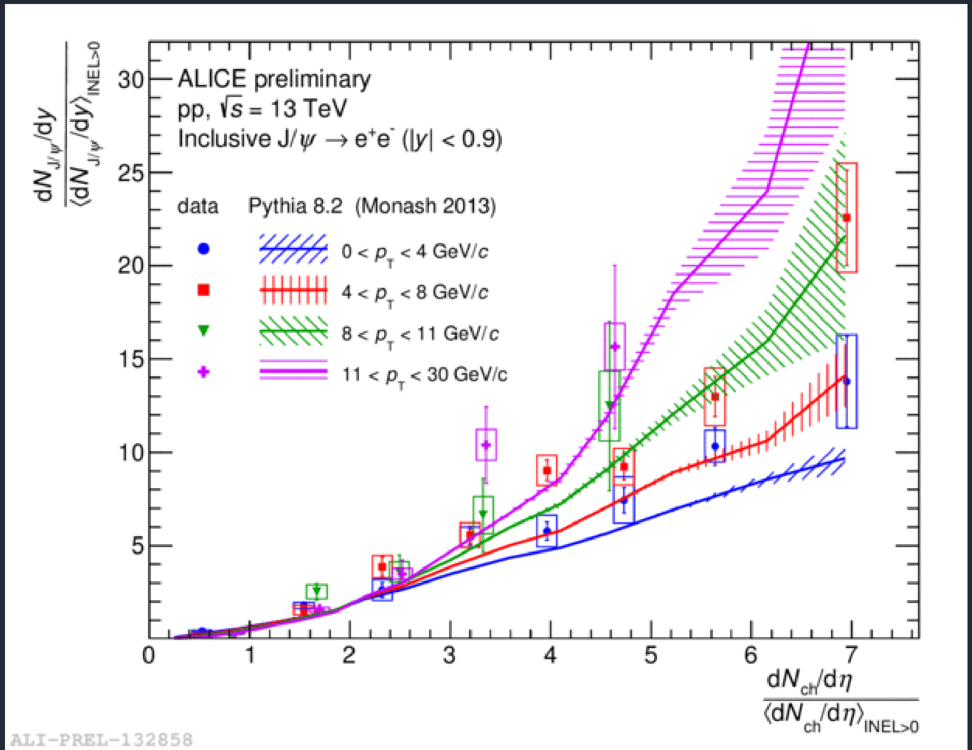
These results, spanning over several orders of magnitude in $\sqrt{s}$, will improve even further the path towards a consistent picture of all quarkonium states

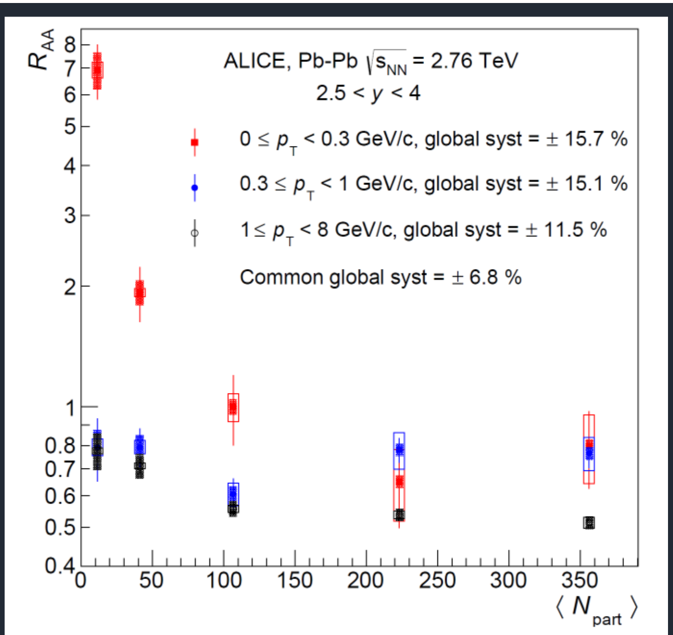
Thanks!

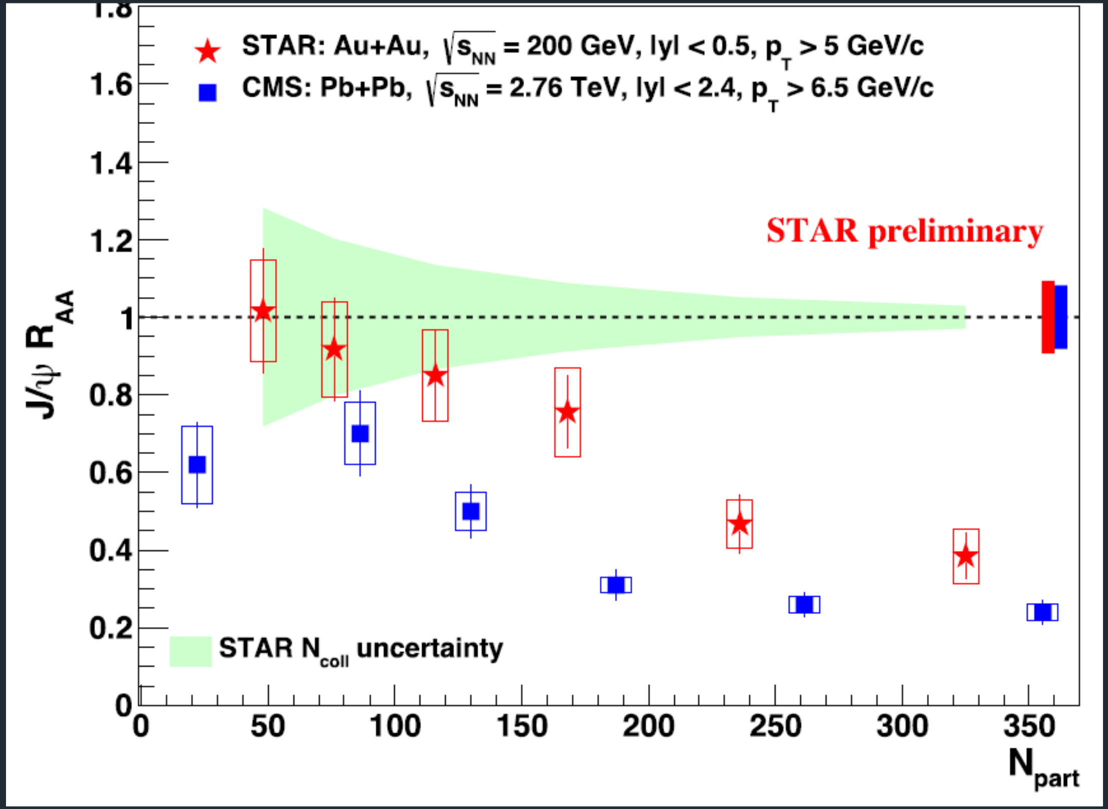
Backup Slides



ALICE Preliminary Pb–Pb $\sqrt{s_{NN}}$ = 5.02 TeV
2 < p_T < 15 GeV/c
2.5 < y < 4
ϒ(1S)
Inclusive J/ψ
v_2
0.15
0.1
0.05
0
−0.05
5−60%
5−20%
20−60%
Centrality
ALI-PREL-314845


ALICE preliminary
pp, √s = 13 TeV
Inclusive J/ψ → e⁺e⁻ (|y| < 0.9)
data
Pythia 8.2 (Monash 2013)
0 < p_T < 4 GeV/c
4 < p_T < 8 GeV/c
8 < p_T < 11 GeV/c
11 < p_T < 30 GeV/c
dN_J/ψ/dy / ⟨dN_J/ψ/dy⟩_INEL>0
dN_ch/dη / ⟨dN_ch/dη⟩_INEL>0
ALI-PREL-132858

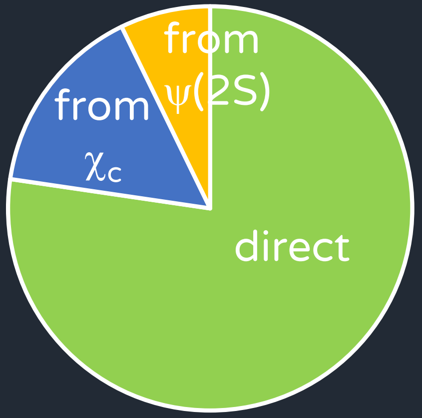

ALICE, Pb-Pb √s_NN = 2.76 TeV
2.5 < y < 4
0 ≤ p_T < 0.3 GeV/c, global syst = ± 15.7 %
0.3 ≤ p_T < 1 GeV/c, global syst = ± 15.1 %
1≤ p_T < 8 GeV/c, global syst = ± 11.5 %
Common global syst = ± 6.8 %
R_AA
⟨ N_part ⟩


STAR: Au+Au, √s_NN = 200 GeV, |y| < 0.5, p_T > 5 GeV/c
CMS: Pb+Pb, √s_NN = 2.76 TeV, |y| < 2.4, p_T > 6.5 GeV/c
STAR preliminary
STAR N_coll uncertainty
J/ψ R_AA
N_part

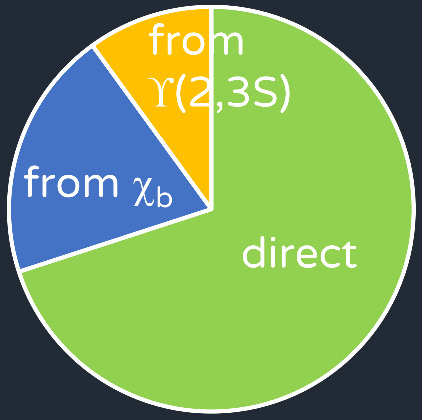
Quarkonium sequential melting

state	J/ψ	χ_c	$\psi(2S)$	$\Upsilon(1S)$	$\Upsilon(2S)$	$\Upsilon(3S)$
Mass(GeV)	3.10	3.51	3.69	9.46	10.0	10.36
ΔE (GeV)	0.64	0.22	0.05	1.10	0.54	0.20
r_o(fm)	0.50	0.72	0.90	0.28	0.56	0.78

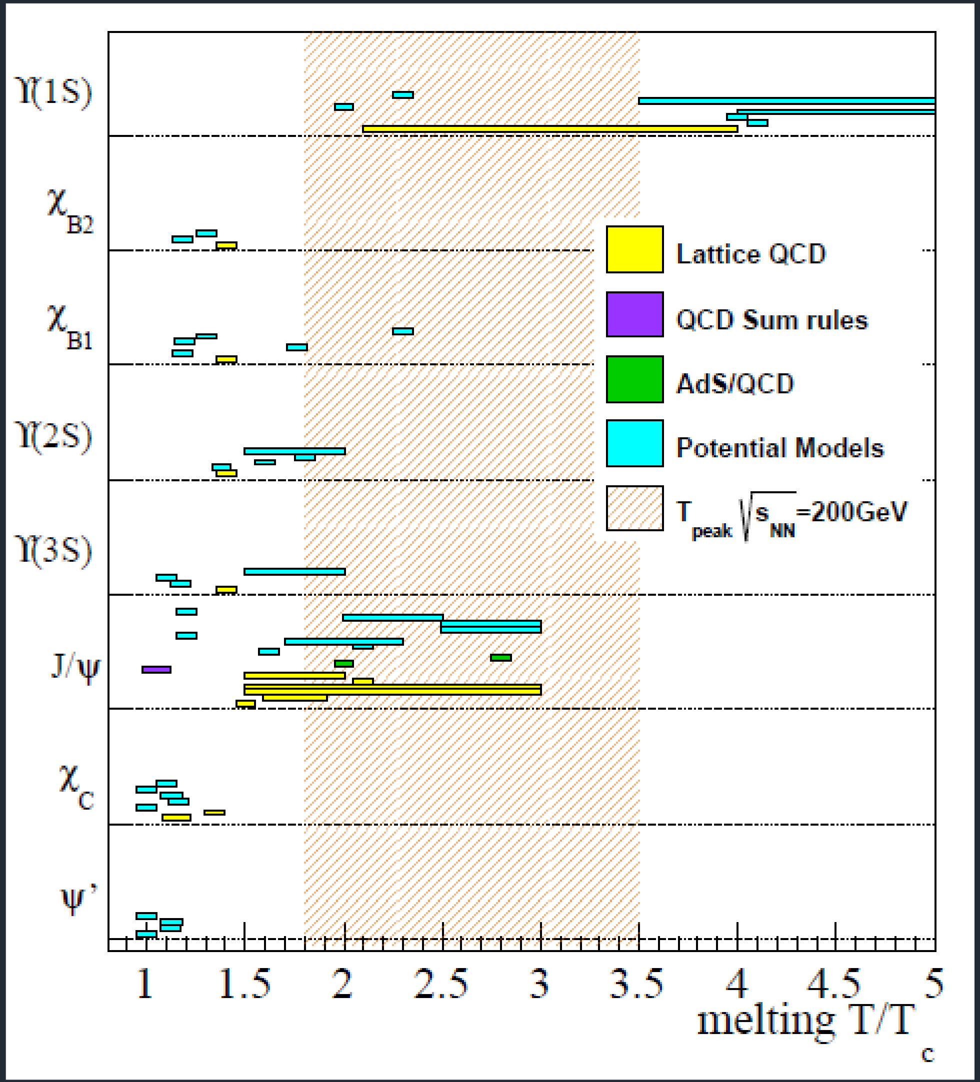
(Digal,Petrecki,Satz PRD 64(2001) 0940150)



Low p_T J/ψ



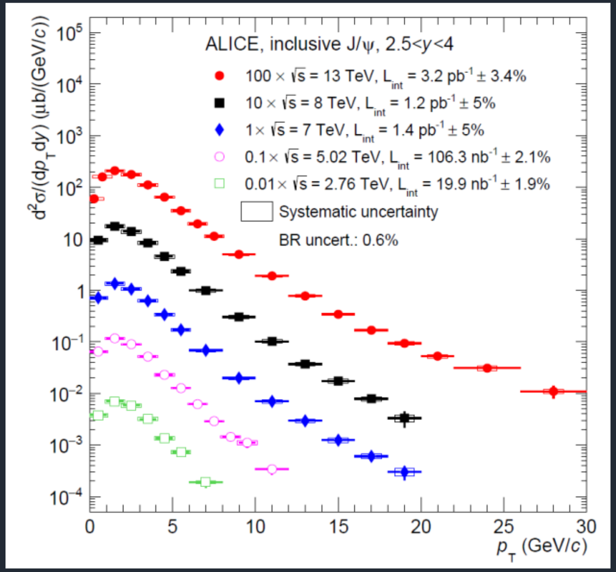
Low p_T $\Upsilon(1S)$

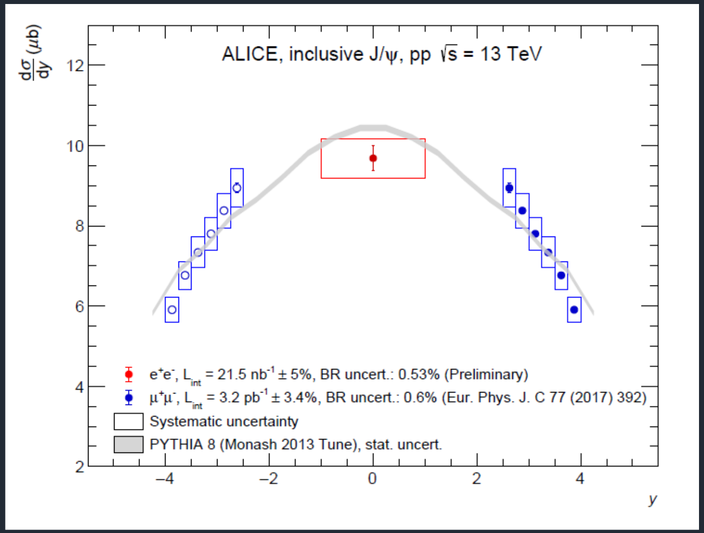


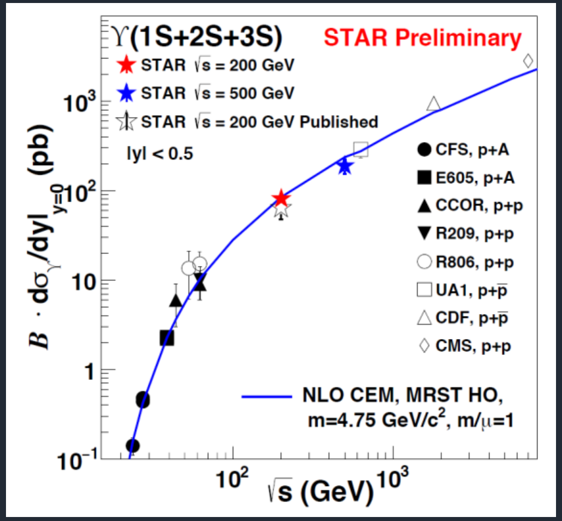
PHENIX, Phys.Rev C91, 024913

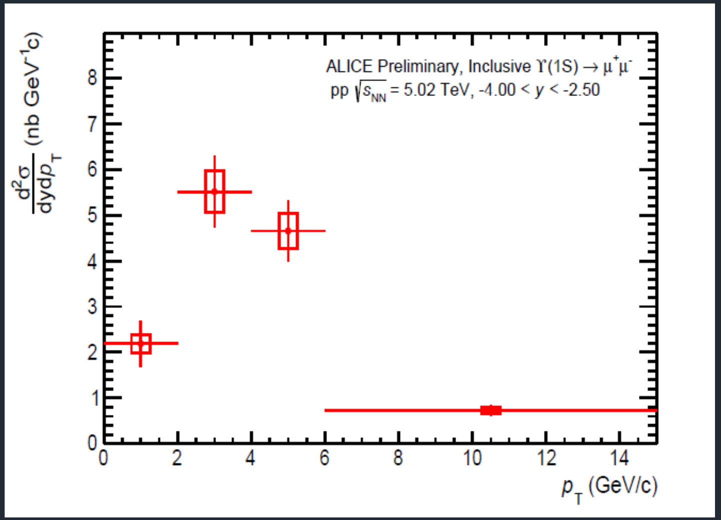
Quarkonium production

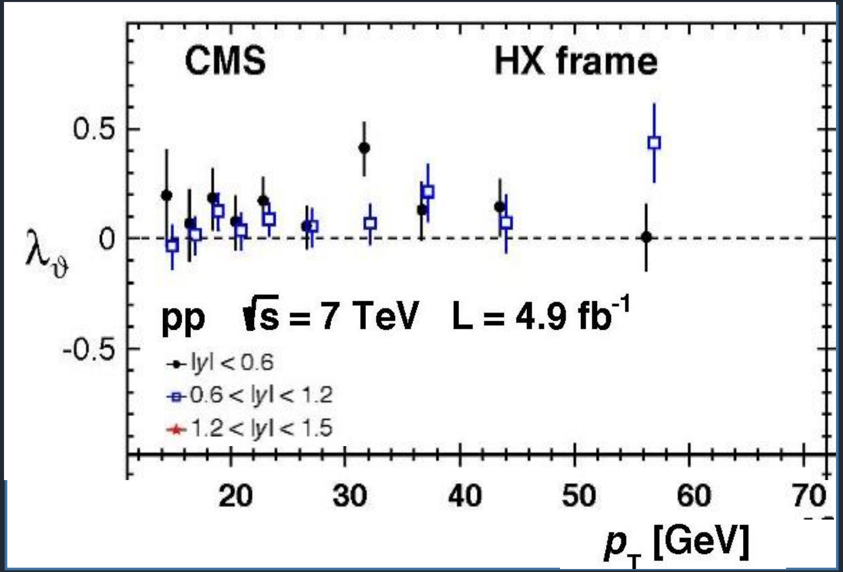
pp

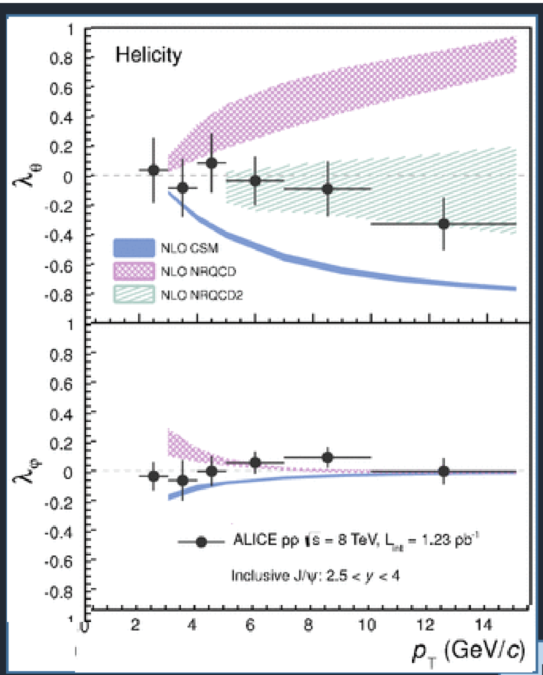








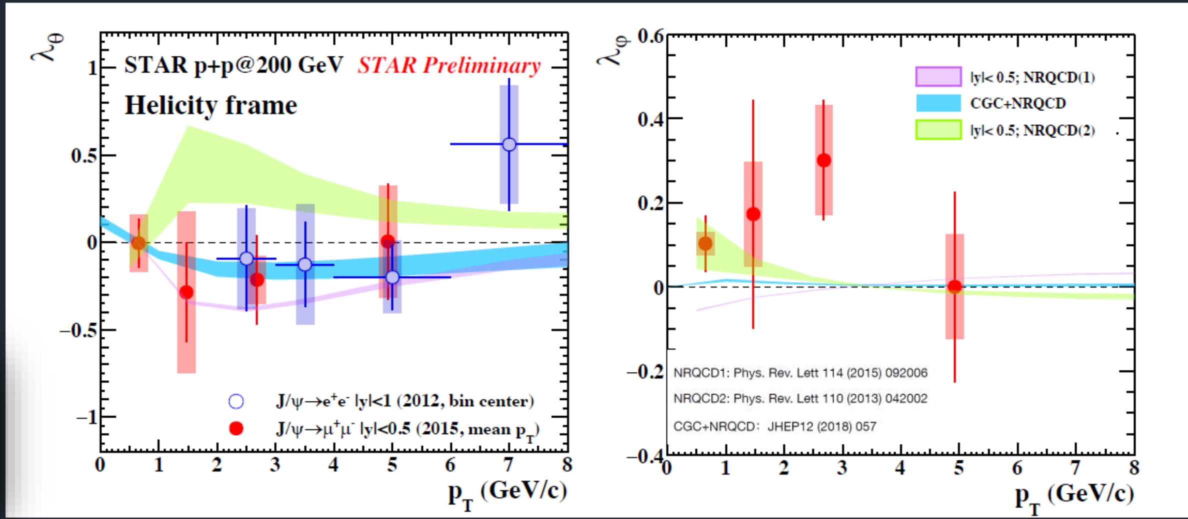




Quarkonium polarization

pp

STAR

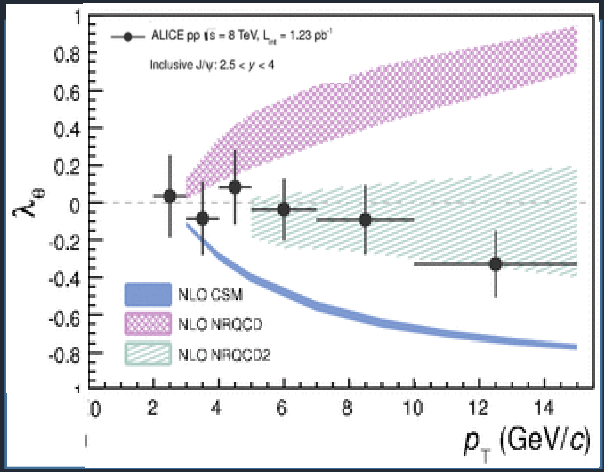


Polarization parameters are evaluated from the angular distribution of decay muons in the quarkonium rest frame:

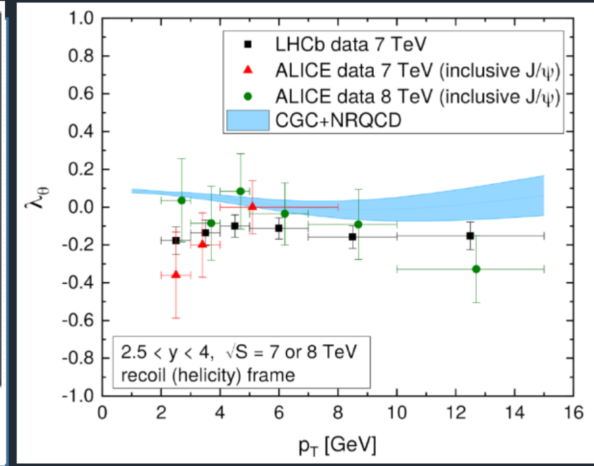
$$W(\cos\theta,\varphi) \propto \frac{1}{3+\lambda_\theta}\left(1+\lambda_\theta\cos^2\theta+\lambda_\varphi\sin^2\theta\cos 2\varphi+\lambda_{\theta\varphi}\sin 2\theta\cos\varphi\right)$$

no significant J/ψ polarization from RHIC to LHC energies, up to p_T = 70 GeV/c (CMS, PLB727(2013)381)

ALICE, LHCb



ALICE, Eur. Phys. J. C 78 (2018) 562



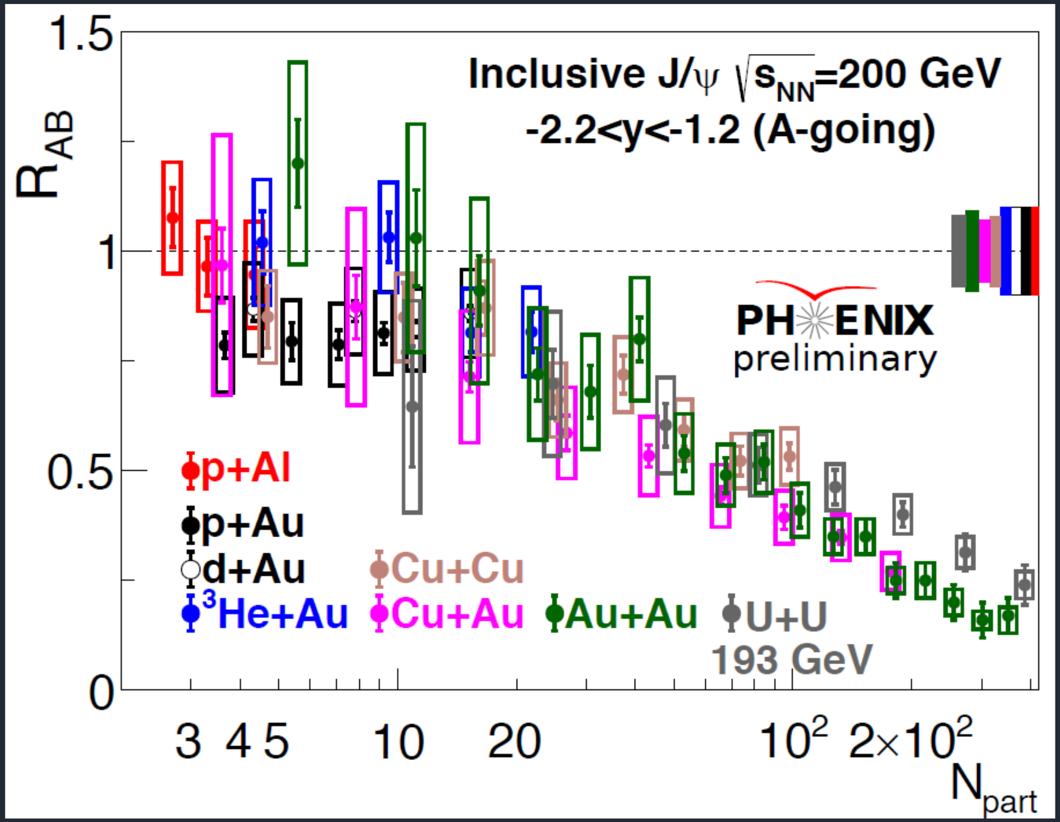
Ma et al, JHEP1812 (2018)057

still some tension, between data and theory models, in the description of all polarization parameters

→ agreement improves with CGC+NRQCD calculation

AA: J/ψ R_{AA} in various systems

➡ Further constraints to the models may also come from comparison of different systems



RHIC: many different AA collisions investigated

- smooth suppression pattern from pA to AA
- R_{AA}<1 already in pA → CNM effects

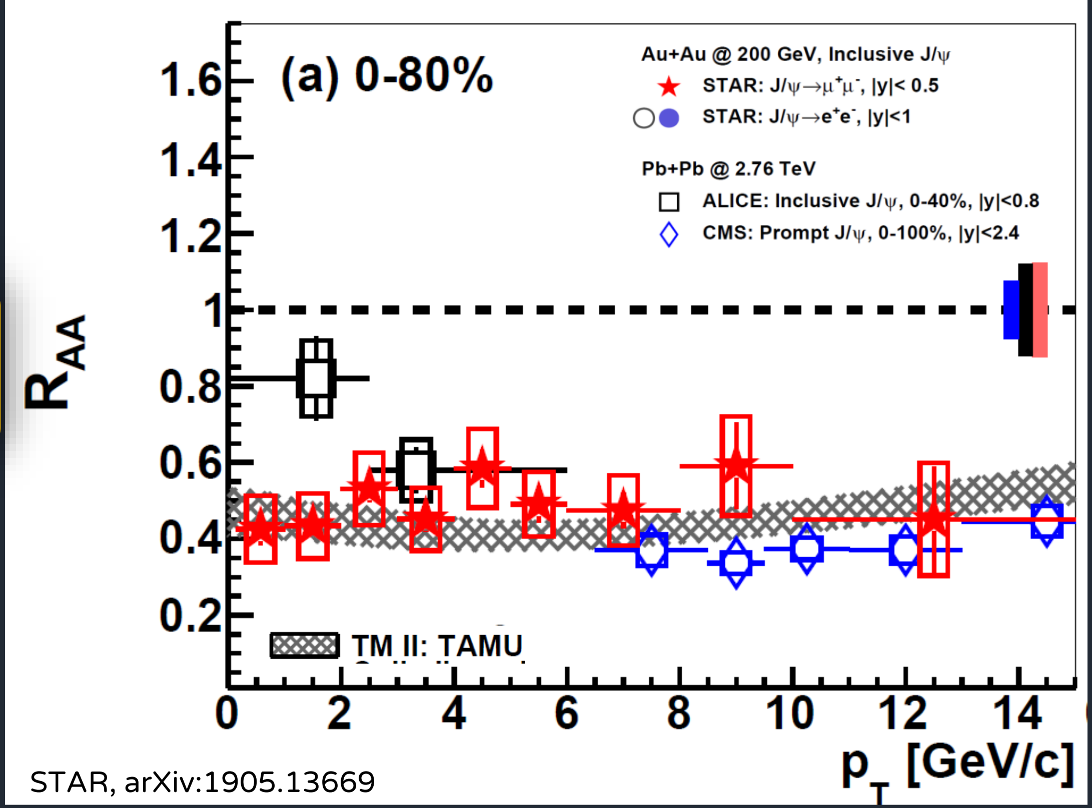
⬇

precise pA measurements needed to quantitatively interpret AA results

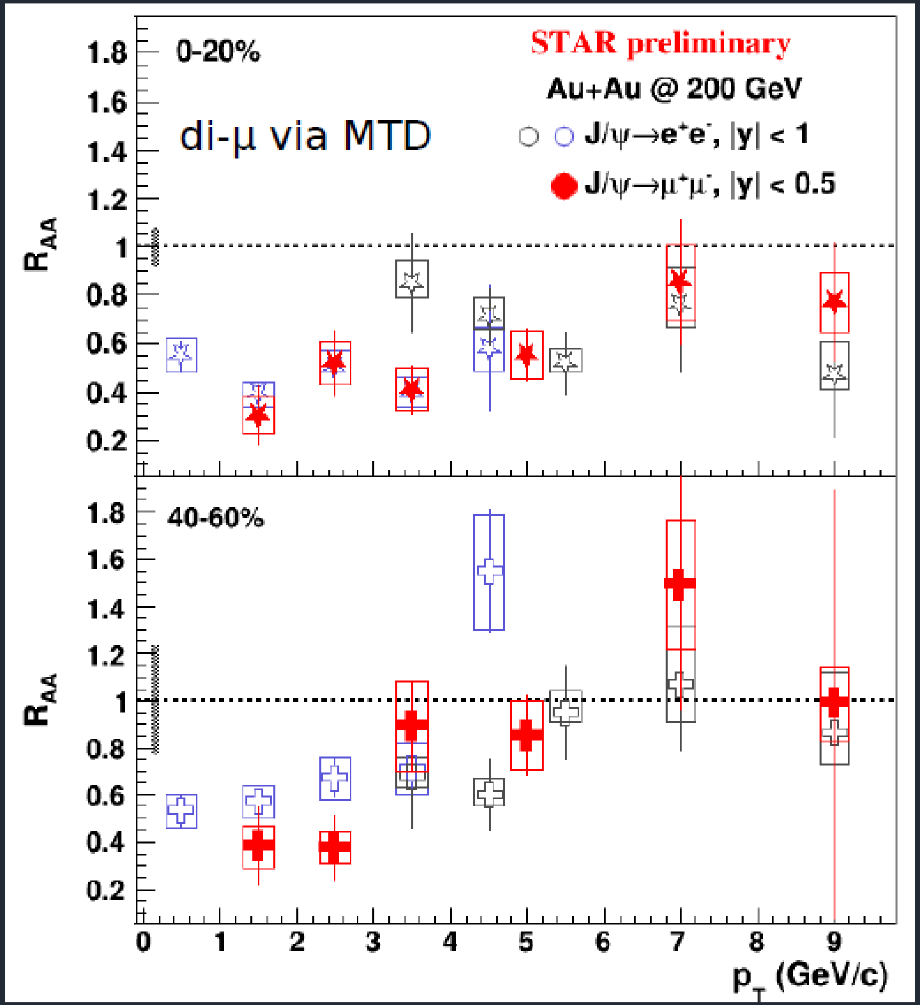
Charmonium in AA

AA
pA
pp

New data



Old data

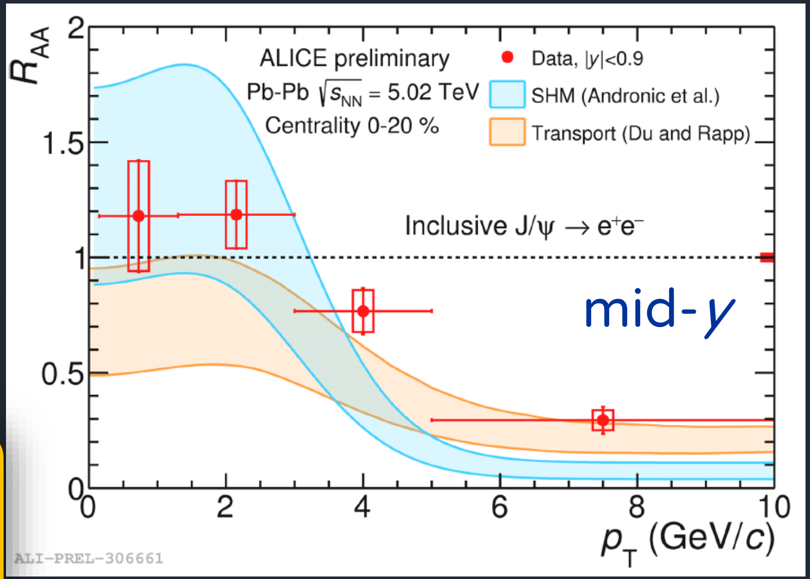


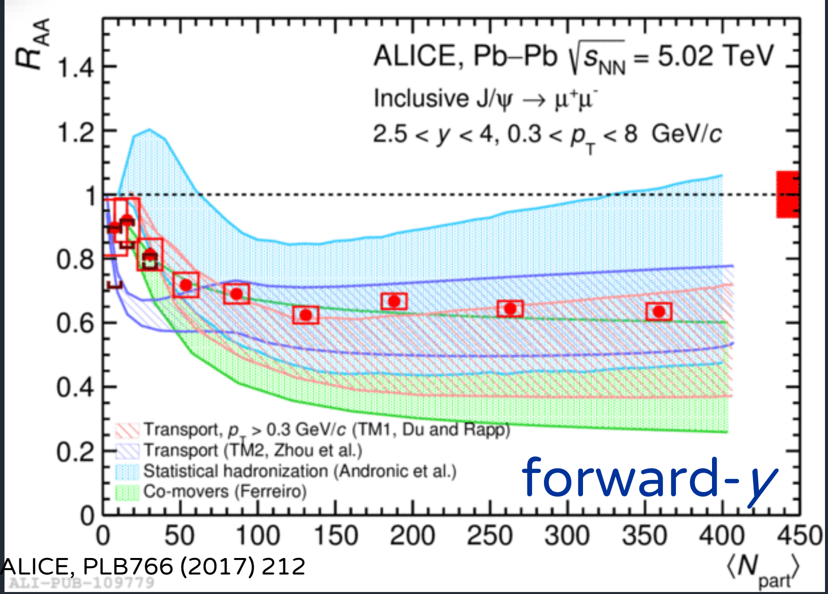
Rise at very low p_T at LHC energies

→ suppression + regeneration mechanisms at play at p_T<2GeV/c

Flat RAA up to high pT values for RHIC

Charmonium in AA





ALICE, PLB766 (2017) 212

Transport models: based on thermal rate eq. with continuous J/ψ dissociation and regeneration in QGP and hadronic phase

X. Zhao, R. Rapp NPA 859 (2011) 114, K. Zhou et al, PRC 89 (2011) 05491

Statistical hadronization: J/ψ produced at chemical freeze-out according to their statistical weight

A. Andronic et al., NPA 904-905 (2013) 535

Comover model: J/ψ dissociated via interactions with partons - hadrons + regeneration contribution

E. Ferreiro, PLB749 (2015) 98, PLB731 (2014) 57

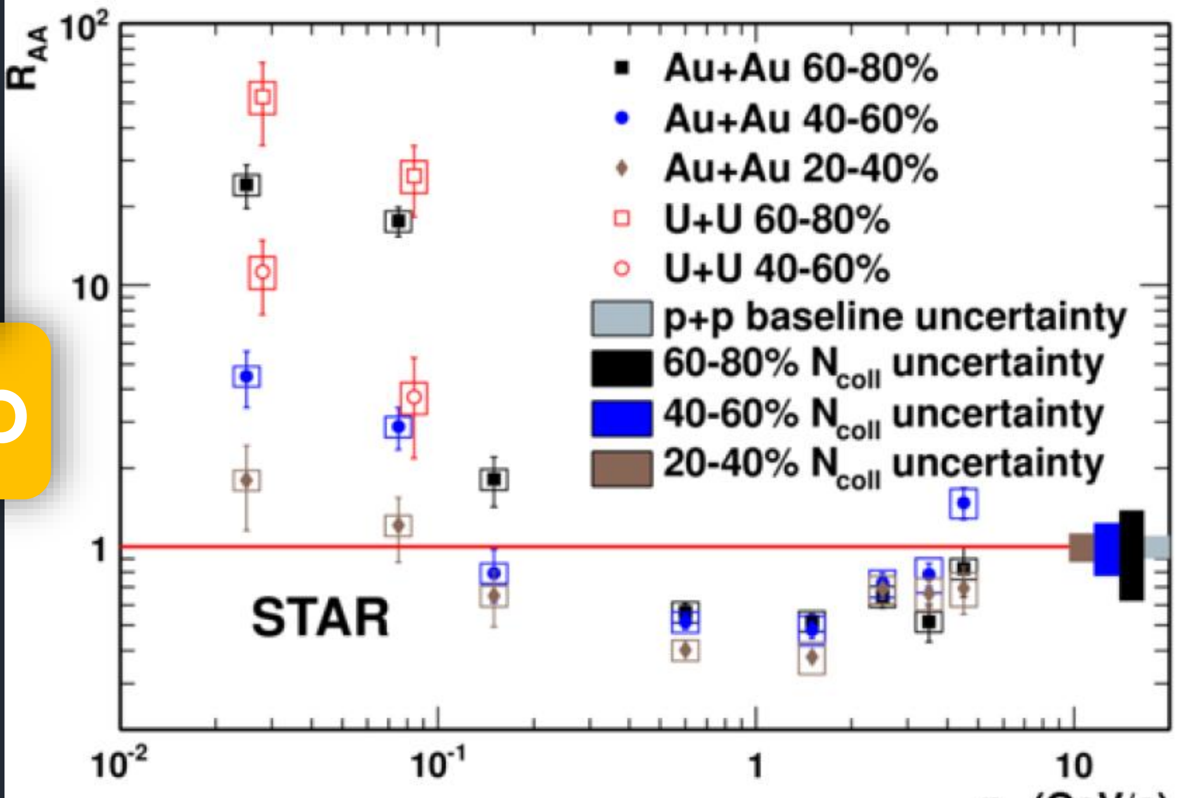
All models fairly describe the data

↓

but large uncertainties associated to charm cross section and shadowing (data precision better than the theory one)

Very low p_T J/ψ

AA
pA
pp

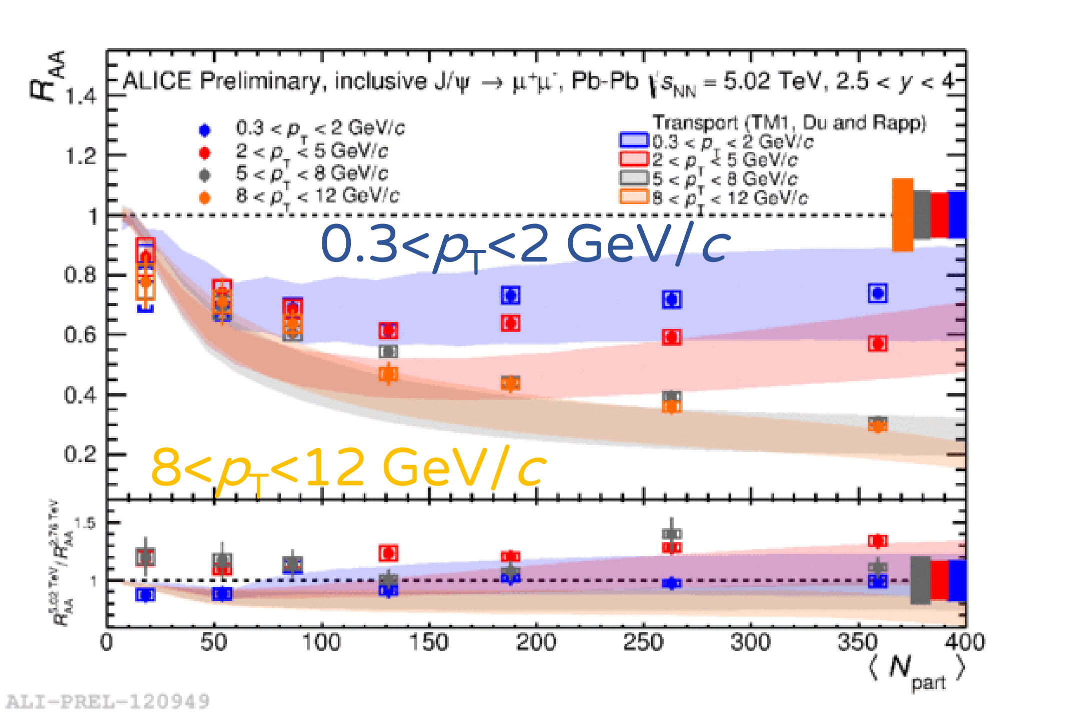


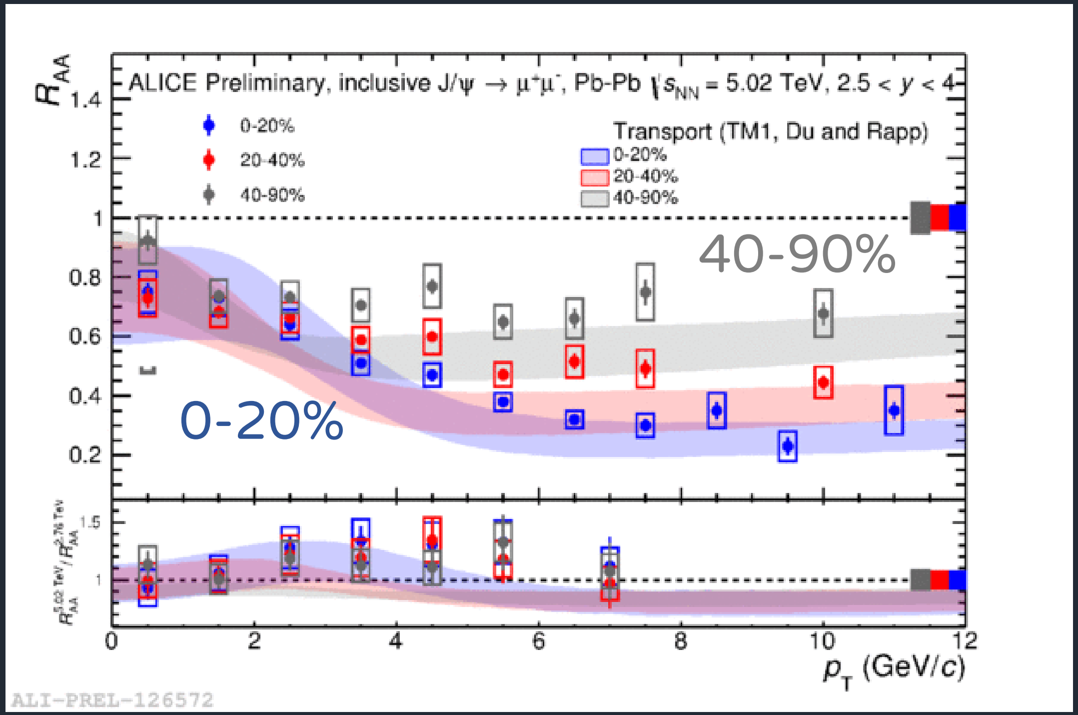
STAR, arXiv:1904.11658

Large enhancement observed at low p_T (<0.2 GeV/c) in the J/ψ R_{AA}, in both Au-Au and U-U peripheral collisions

- effect similar to the one observed by ALICE for p_T<0.3GeV/c (PRL116 (2016) 222301)
- cannot be described by hadronic production (color screening, regeneration, CNM effects)
- excess possibly due to coherent photon-nucleus interactions (b<2R)

Multi-differential J/ψ R_{AA}





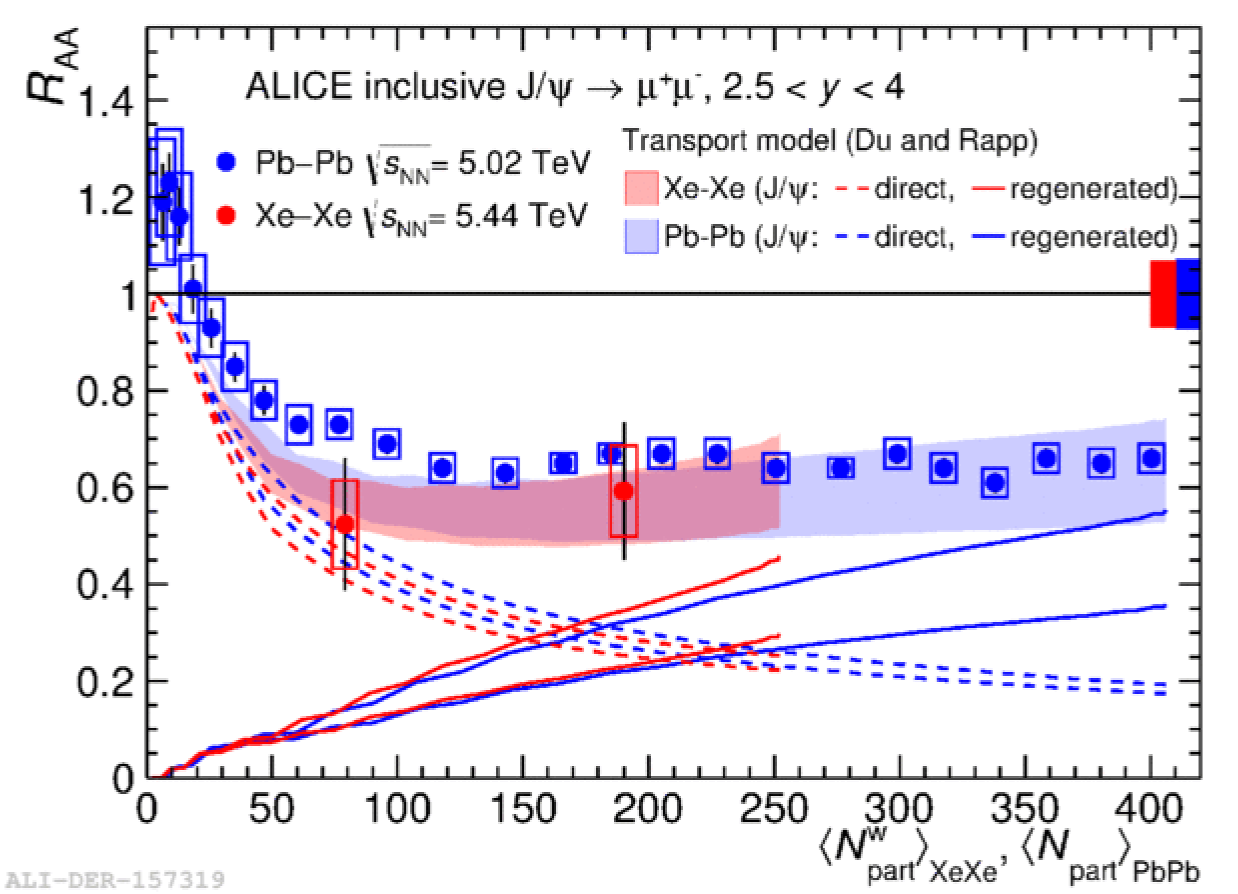
Zhao et al., NPA 859 (2011) 114

➡ R_{AA} vs p_T for different centrality bins (and vice-versa) at $\sqrt{s_{NN}}$=5.02 TeV

Striking features observed in ALICE results
- → no R_{AA} centrality dependence in $0.3<p_T<2$ GeV/*c*
- → ~70% suppression for central events at p_T~10 GeV/*c* (as for CMS and ATLAS)

J/ψ R_{AA} in Xe-Xe collisions

- Further constraints to the models may also come from comparison of different systems

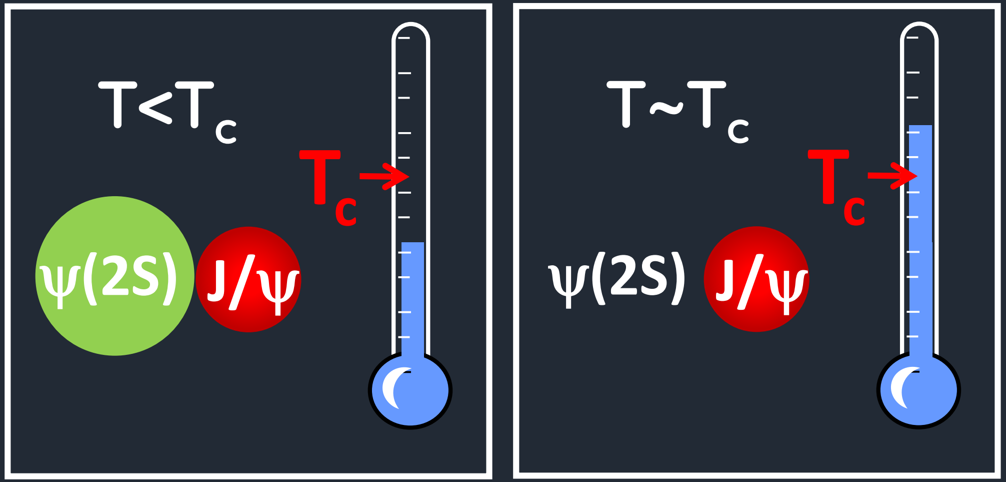


ALICE, arXiv:1805.04383

- **LHC:** few hours XeXe run in 2017
  - Similar R_{AA} in Xe-Xe and Pb-Pb (A_{Xe} = 129, A_{Pb} = 208)
  - In TAMU transport model, for a given N_{part}
    - central collisions: the higher N_{coll} and $\sqrt{s_{NN}}$ lead to a slightly larger regeneration in XeXe
    - peripheral/semi-central collisions: the larger nuclear overlap in XeXe induces a stronger suppression
- Unfortunately, not all systems at RHIC and LHC have yet enough precision to allow detailed comparisons

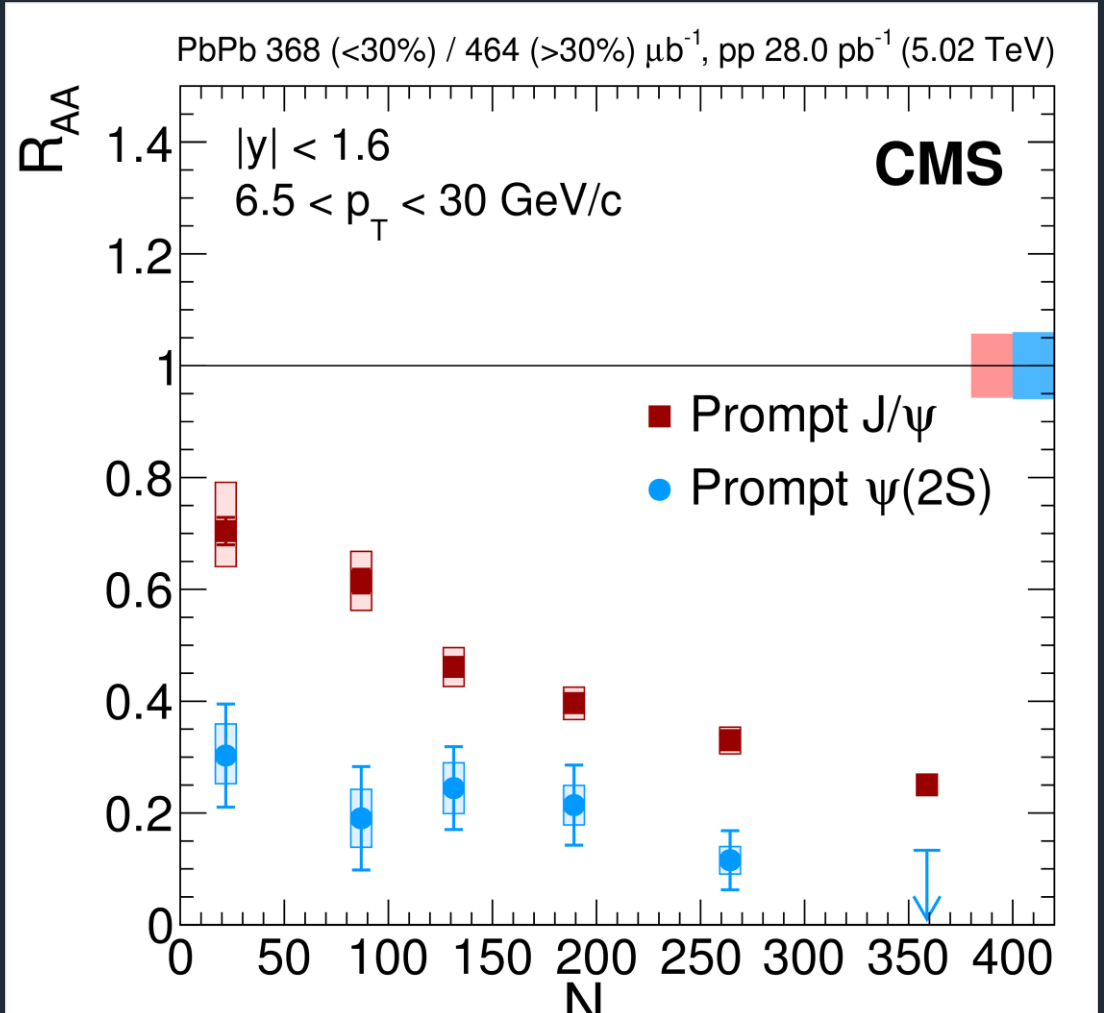
ψ(2S) in AA

ψ(2s) is a loosely bound state (binding energy: ψ(2s)~60 MeV, J/ψ ~640MeV)



ψ(2S) suppression stronger than the J/ψ at high p_T, as expected in a sequential suppression scenario

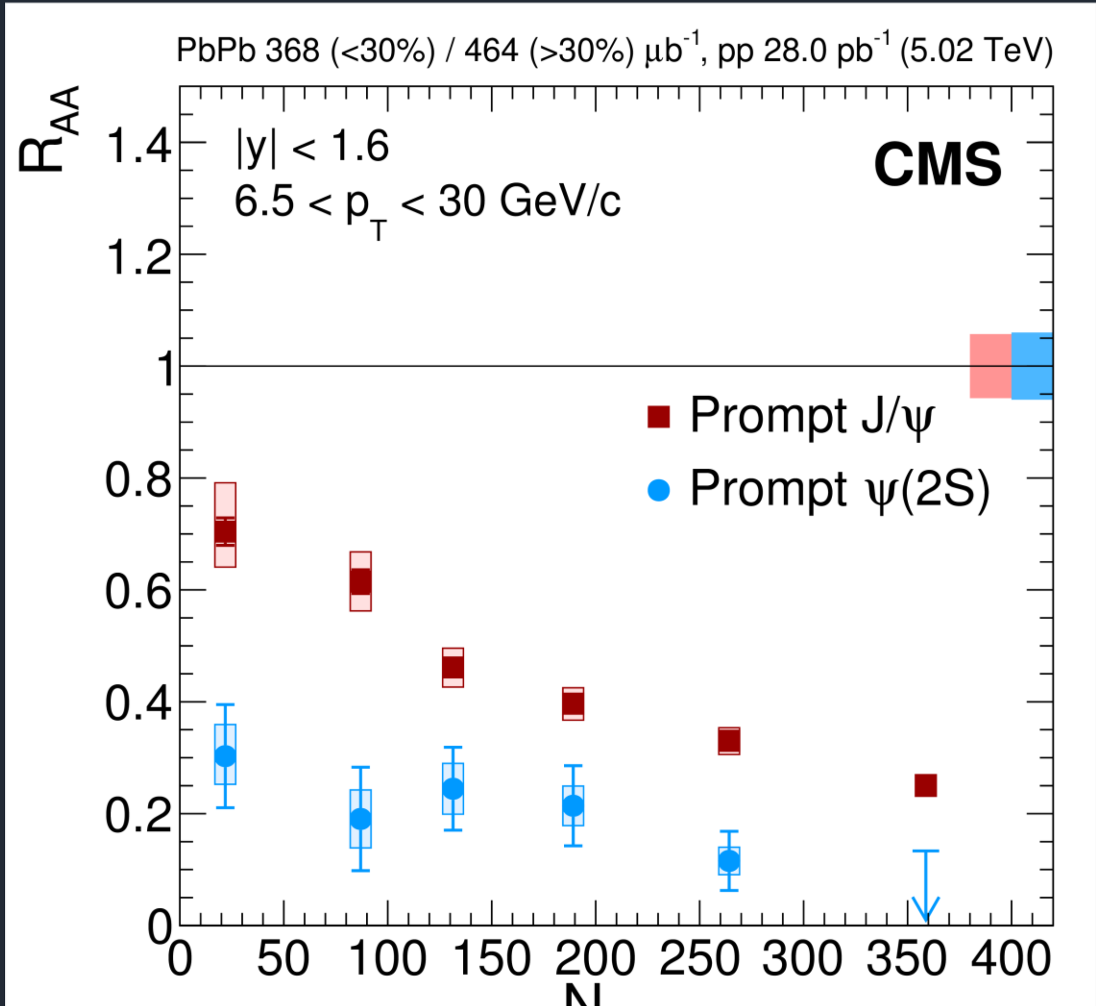
High p_T



CMS, EPJC 78 (2018) 509

ψ(2S) in PbPb

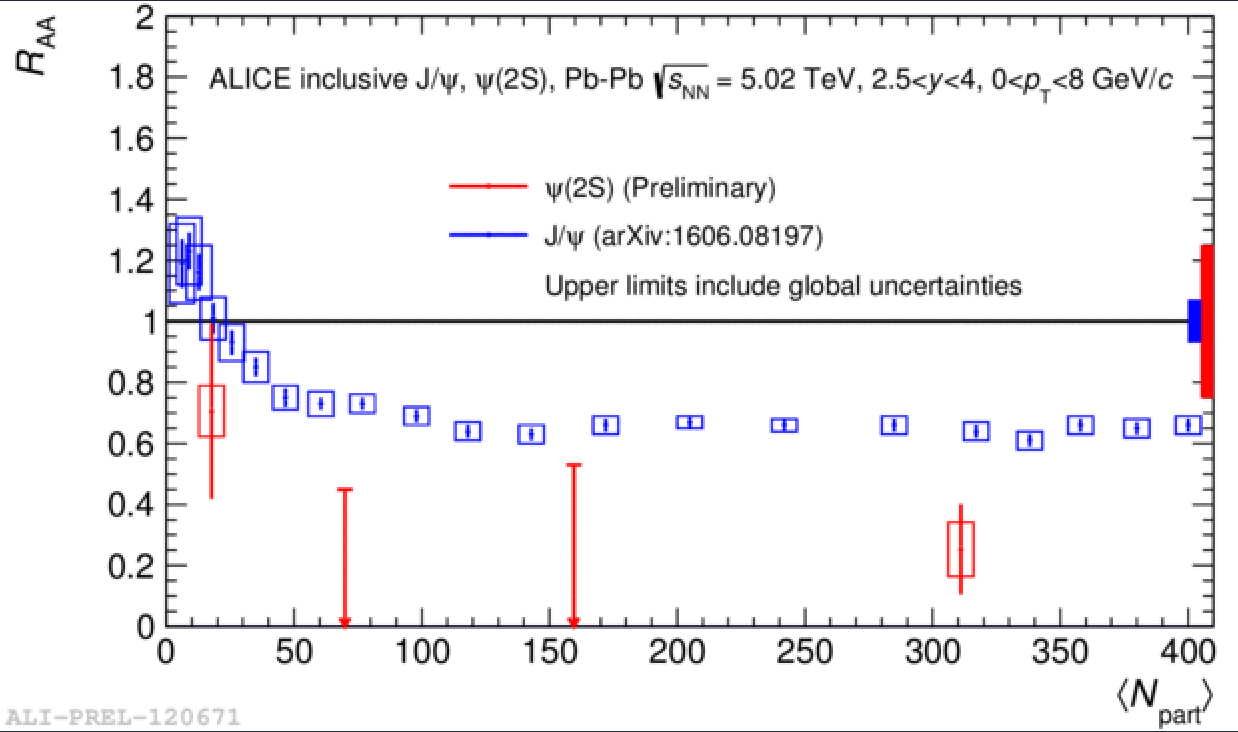
High p_T



CMS, arXiv:1712.08959

- Stronger ψ(2S) suppression wrt J/ψ over all centralities, both at high and low p_T

Low p_T



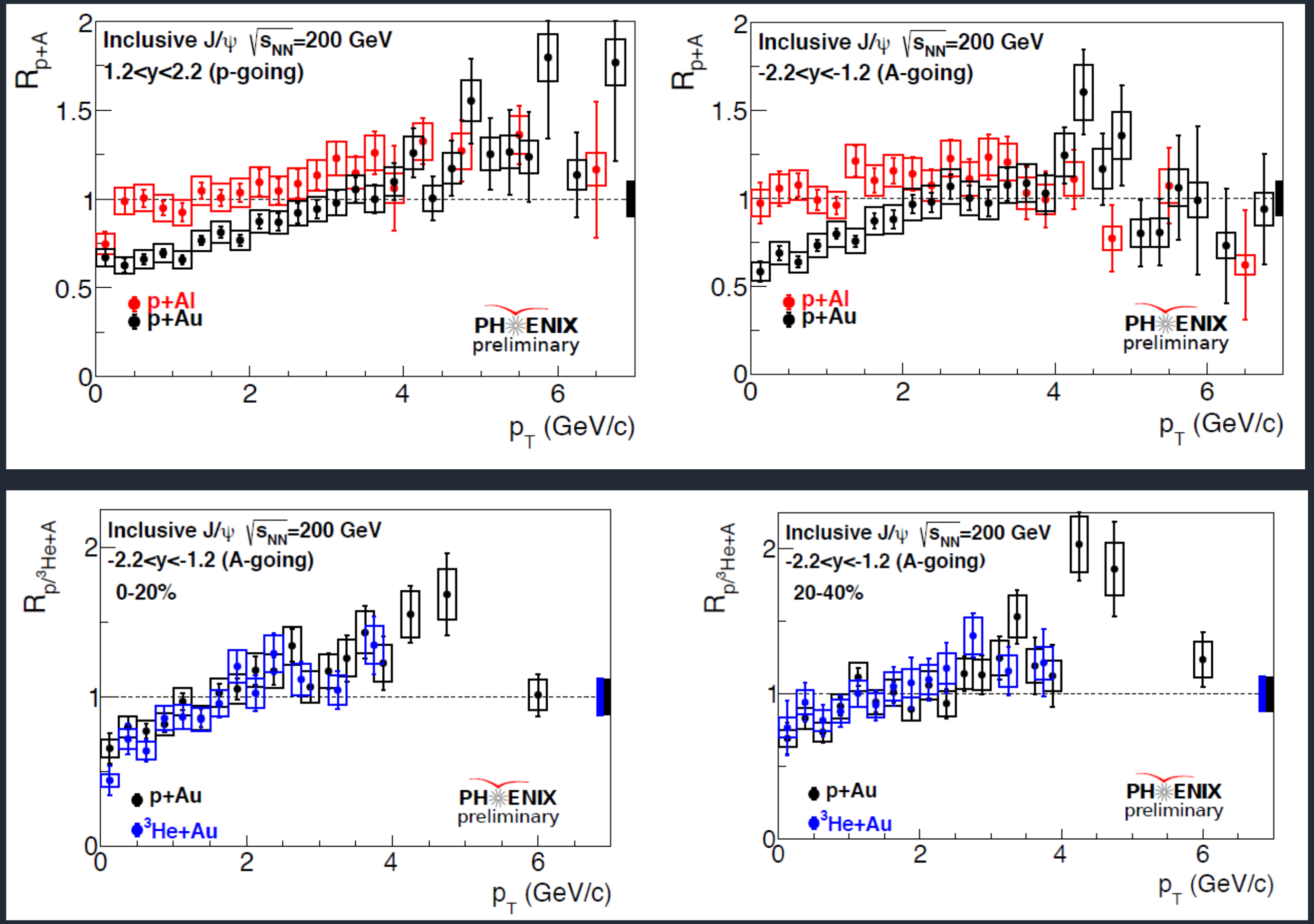
J/ψ in pA collisions at RHIC

pA

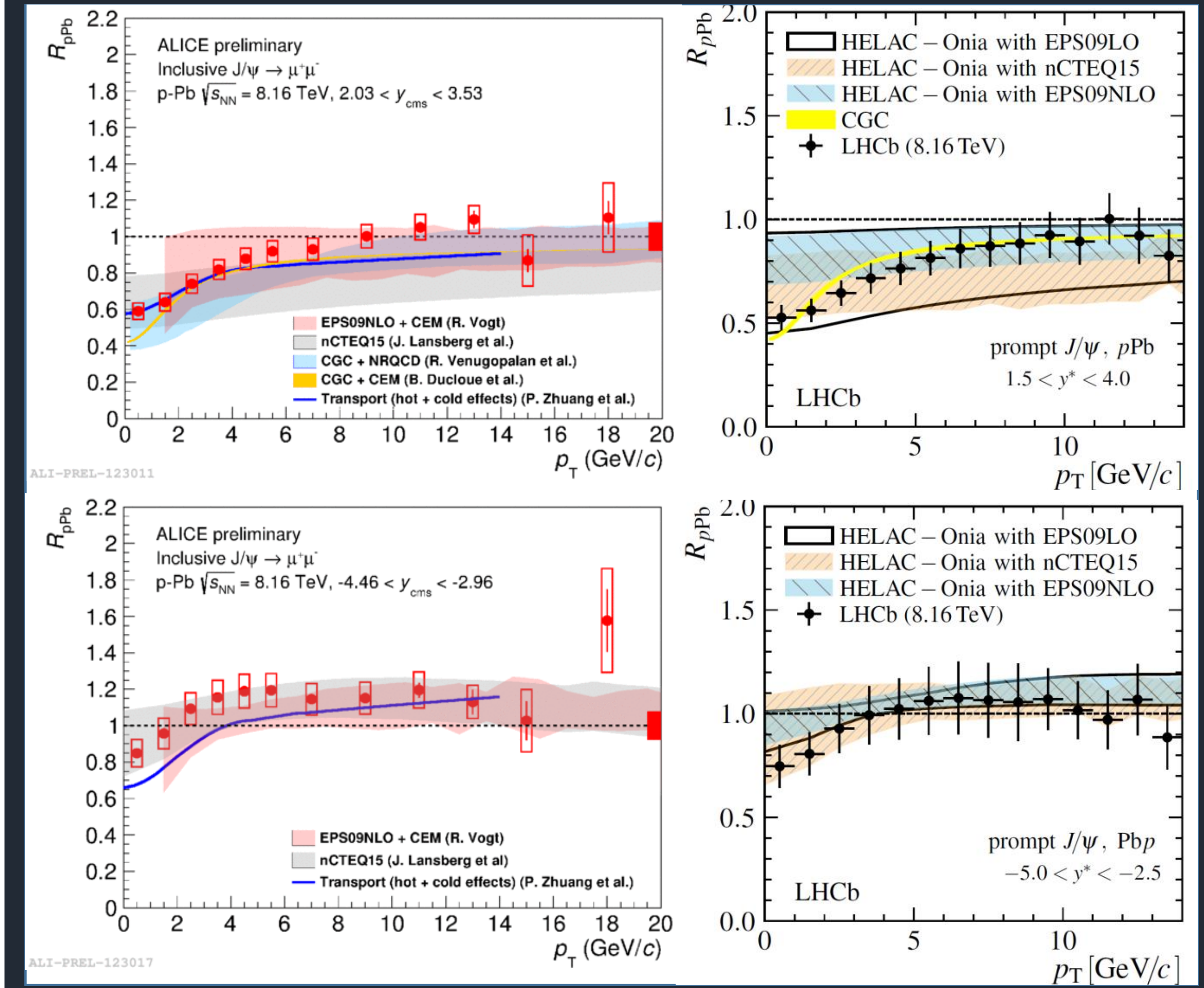
pp

J/ψ production in small systems now studied, also multi-differentially, in p-Al, p-Au, d-Au, ^{3}He-Au

- limited CNM effects in p-Al data
- similar R_{pA} increase vs p_T in p-Au, d-Au, ^{3}He-Au



p_T dependence of J/ψ R_{pA}



- Slightly different y coverage in ALICE and LHCb, but rather similar p_T dependences
- Shadowing and energy loss models describe R_{pA} vs p_T

J/ψ: pA vs AA

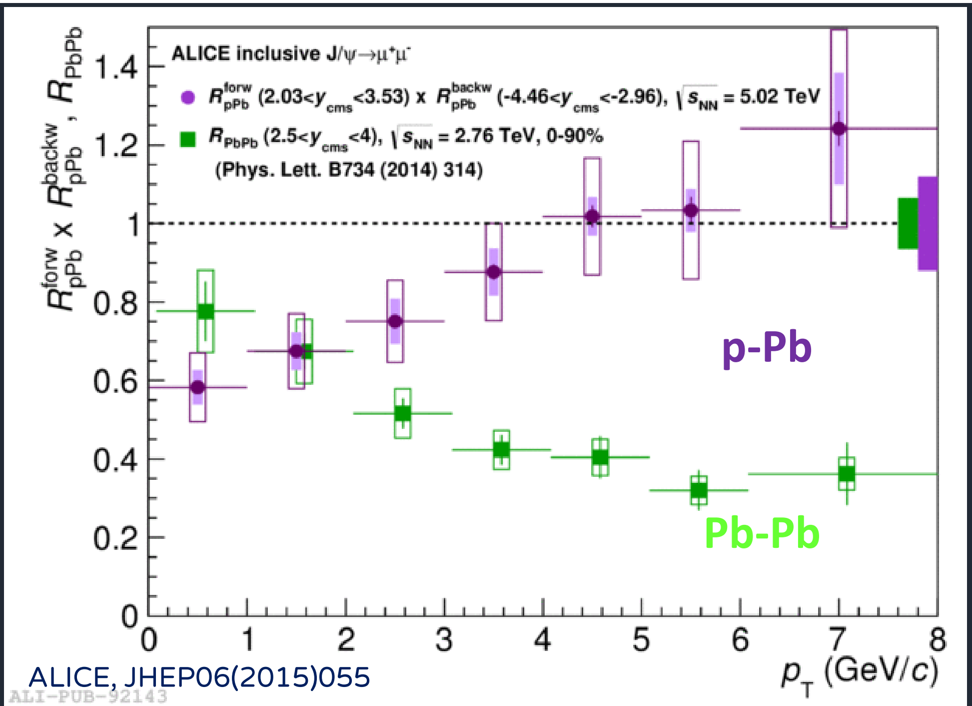
Can the suppression in AA be due to CNM effects?

⬇

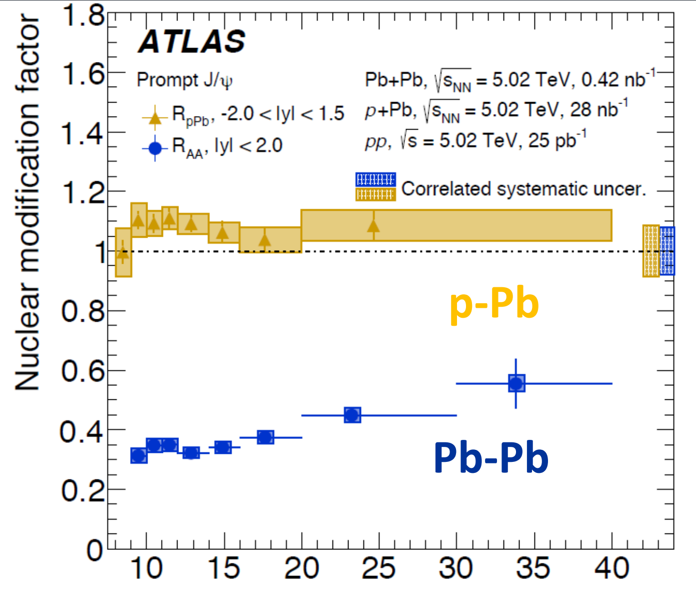
assume $R_{AA} = R_{pA} \times R_{Ap}$ (as for shadowing dominance)

⬇

comparison of pA and AA results indicates that CNM effects cannot account for the observed R_{AA} at high p_T



ALICE, JHEP06(2015)055

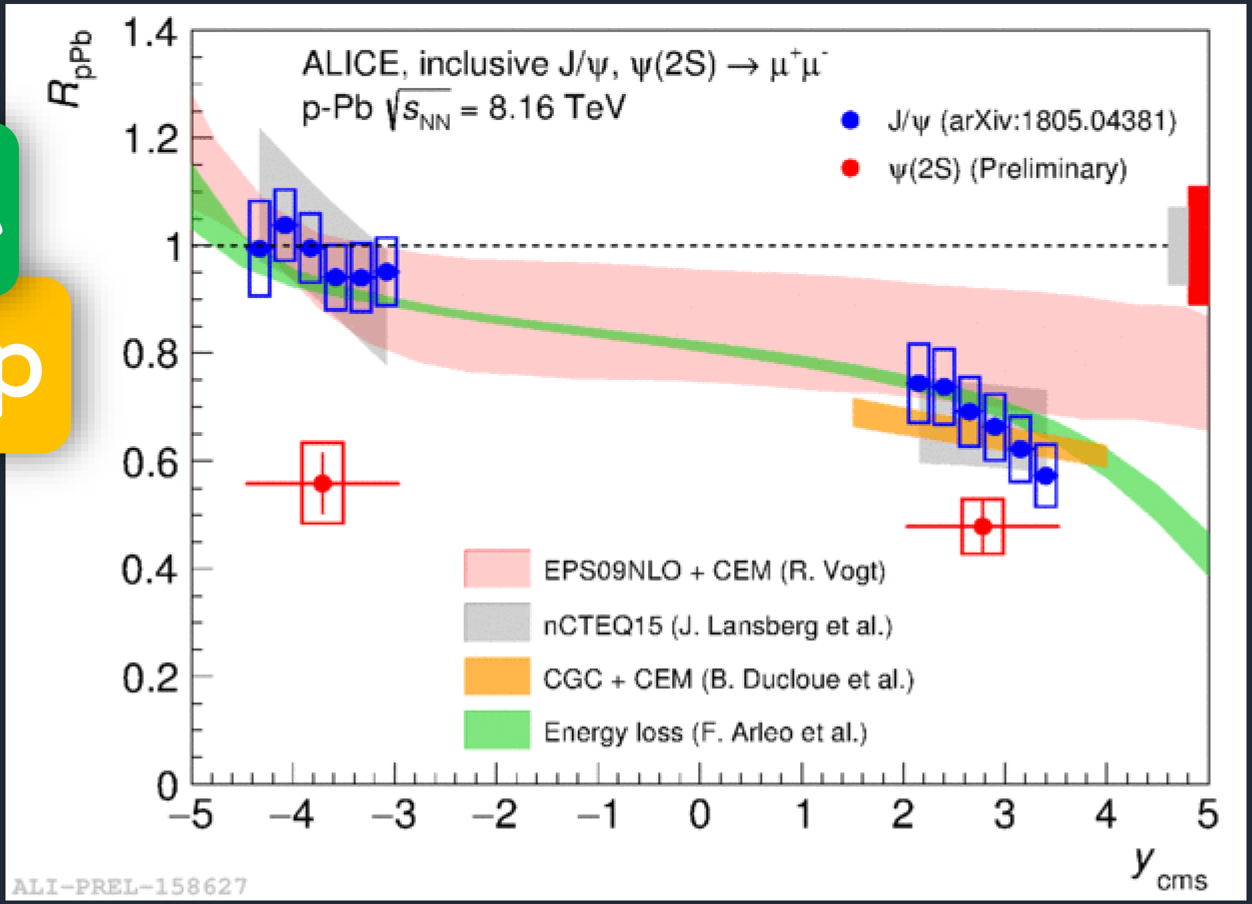


ATLAS, EPJC78(2018)762
ATLAS, EPJC78(2018)171

Excited charmonium states

pA

pp



ψ(2S) suppression is stronger than the J/ψ one, in particular at backward-y and at low p_T, both at RHIC and LHC

At LHC and RHIC energies

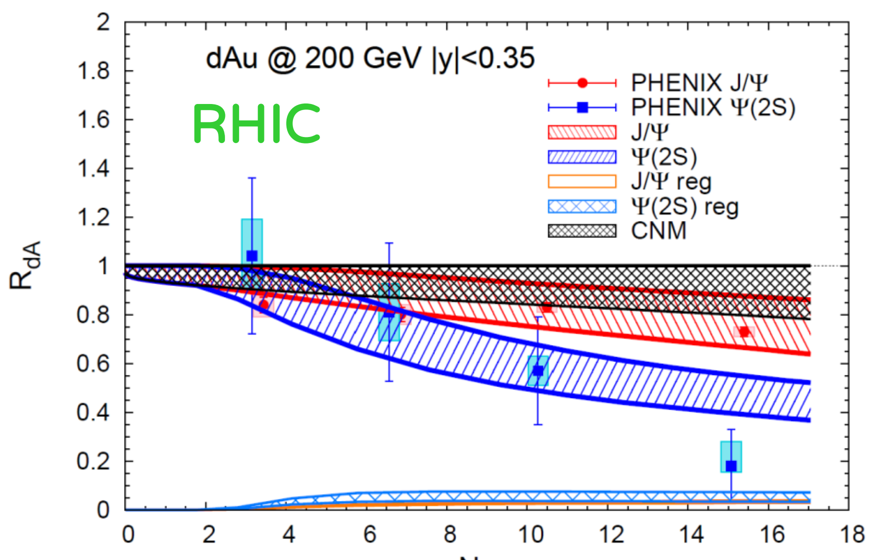
formation time > crossing time

same effects expected for J/ψ and ψ(2S)

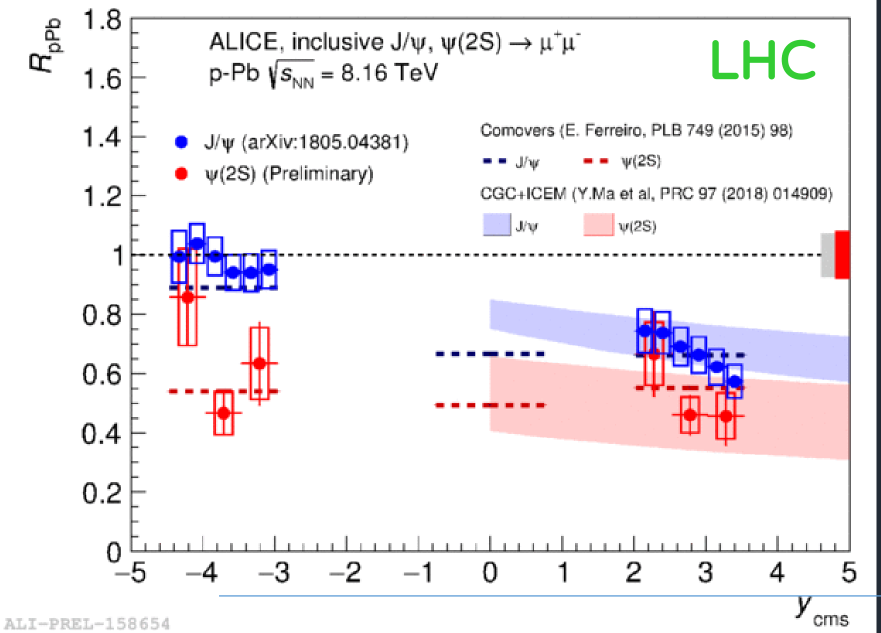
Excited charmonium states

pA

pp



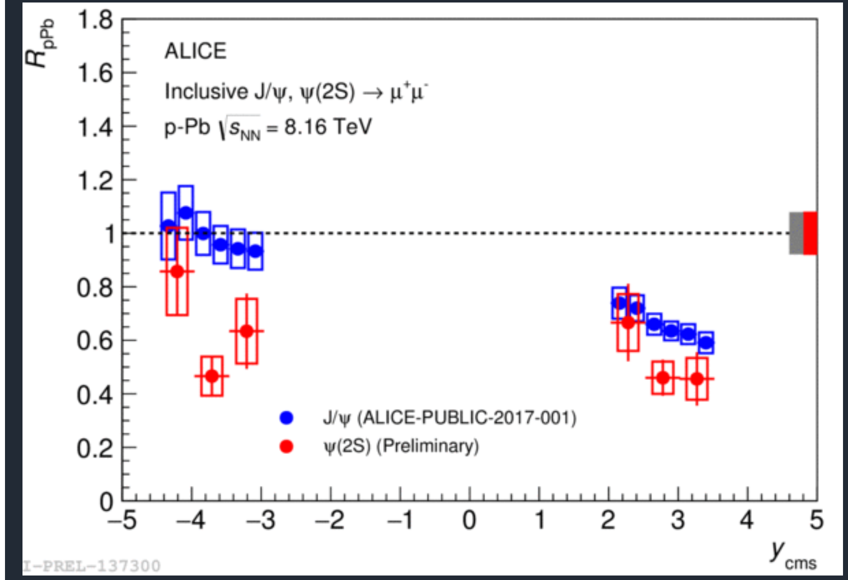
Rapp et al, JHEP03(2019)015

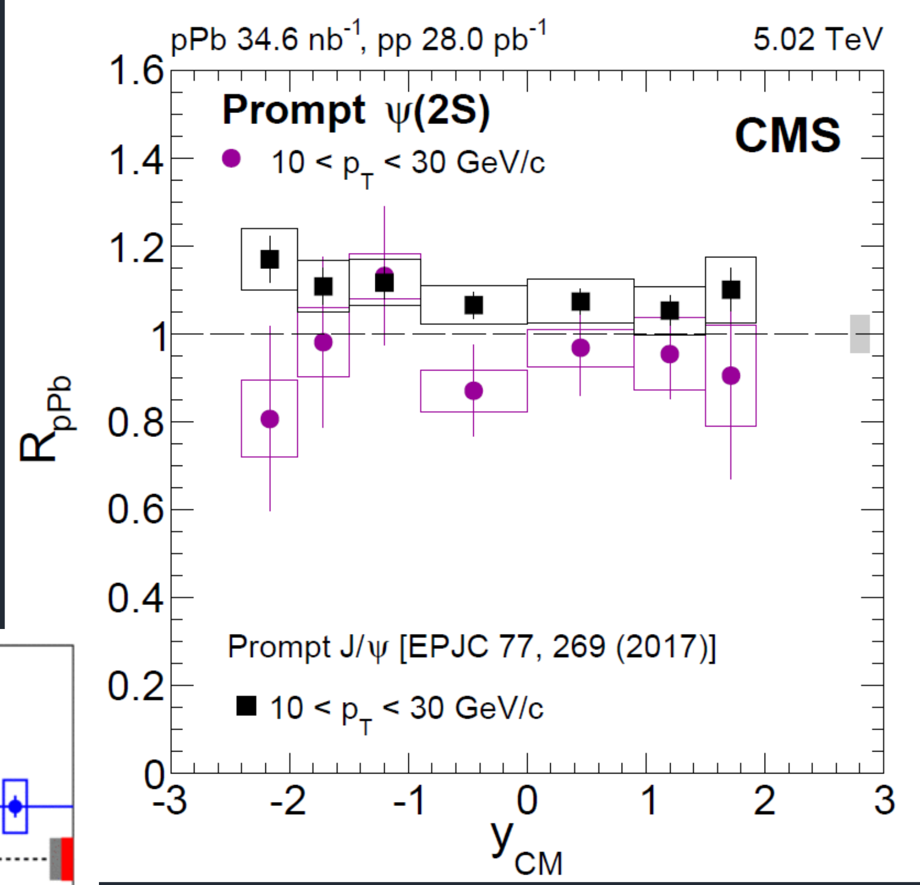


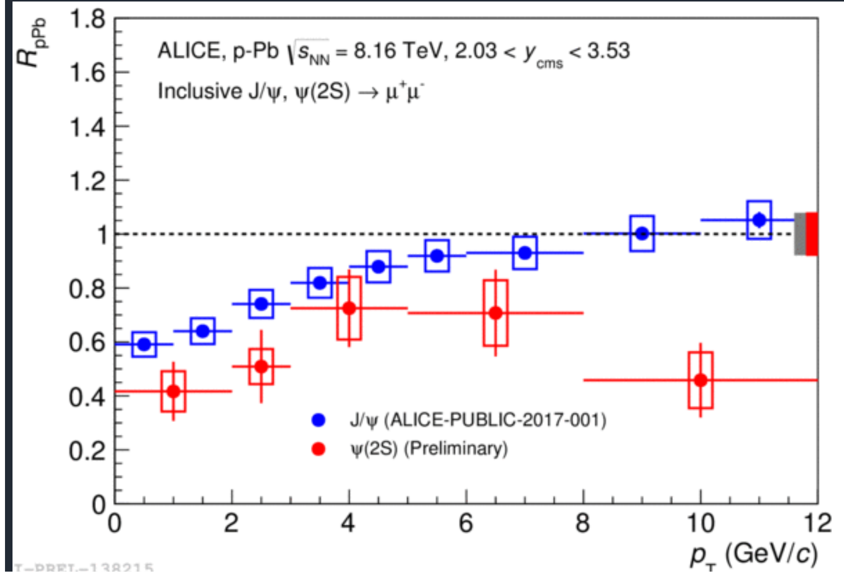
additional final state effects needed to describe the data both at RHIC and LHC energies

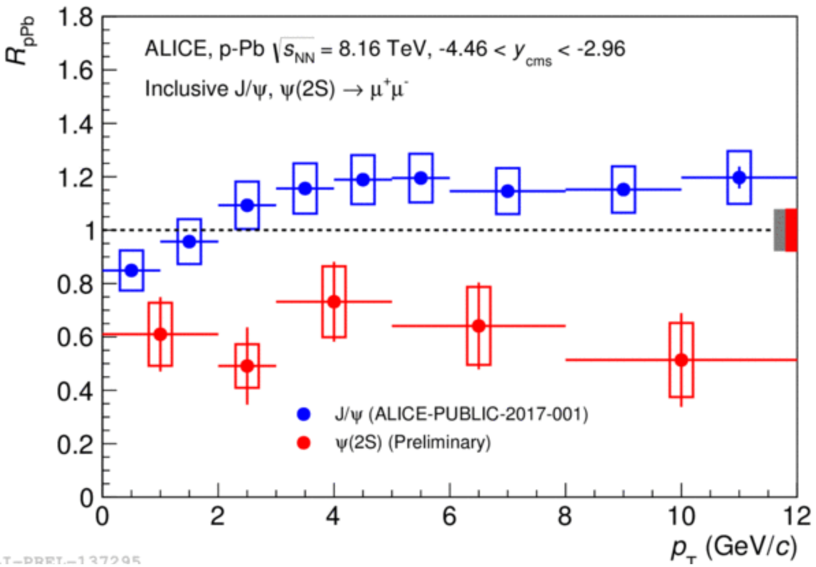
- soft color exchanges between hadronizing $c\bar{c}$ and comoving partons (Ma, Venugopalan)
- "classical" comover model, with break-up σ tuned on low energy data (Ferreiro)
- regeneration and dissociation in the QGP and hadronic phase (Rapp, Zhuang)

J/ψ and ψ(2S) comparison in pA







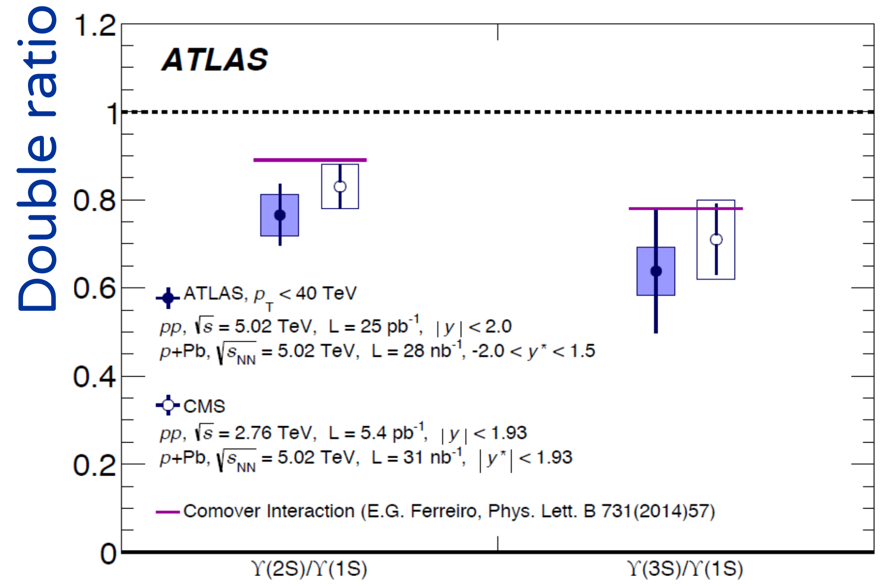


Excited bottomonium states

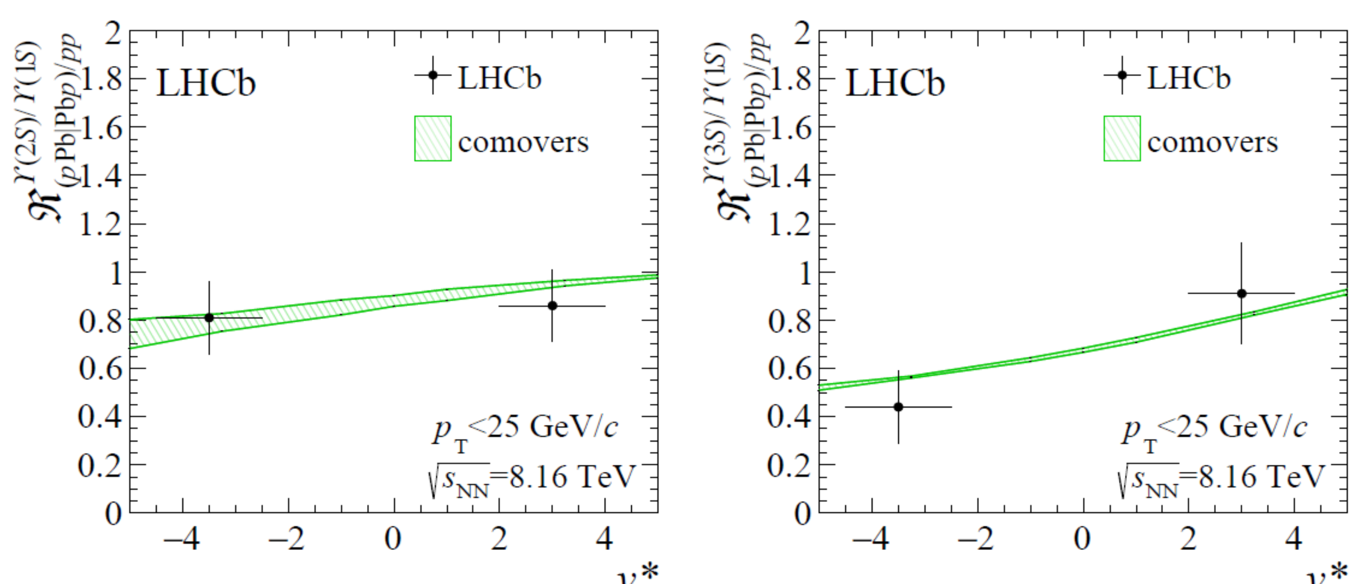
pA

pp

Also the excited Υ states show a stronger suppression than $\Upsilon(1S)$ in pPb wrt pp



ATLAS, EPJC78(2018)171, CMS, JHEP04(2014)103



LHCb, JHEP11(2018)194

Final state effects might be needed to explain the observations, as for charmonium

Strong suppression for $\Upsilon(3S)$ wrt $\Upsilon(1S)$ at backward-y, consistent with comovers model

Bottomonia in AA

Three states characterized by very different binding energies:

Υ(1S): Eb~1100 MeV
Υ(2S): Eb~500 MeV
Υ(3S): Eb~200 MeV

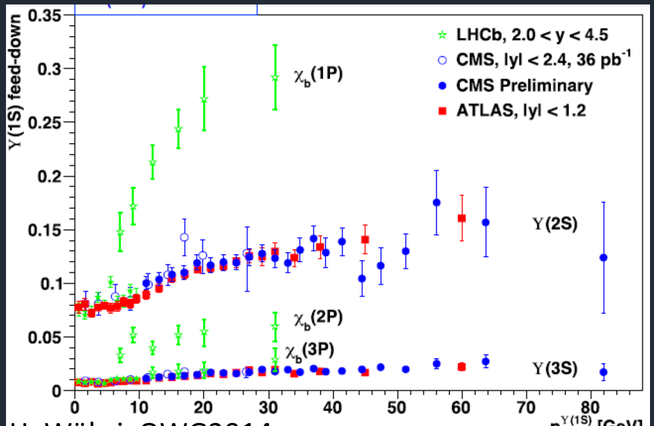
Υ(3S) Υ(2S) Υ(1S) → Sensitive in very different ways to the medium

With respect to charmonium:

- Limited recombination effects → interesting for sequential suppression studies
- More robust theoretical calculations, due to higher b quark mass
- No B hadron feed-down → simpler interpretation?

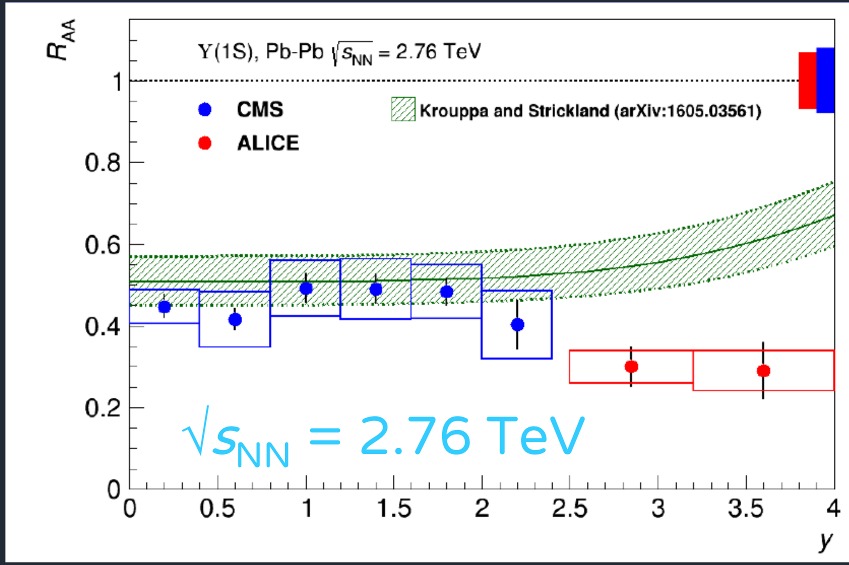
Some drawbacks

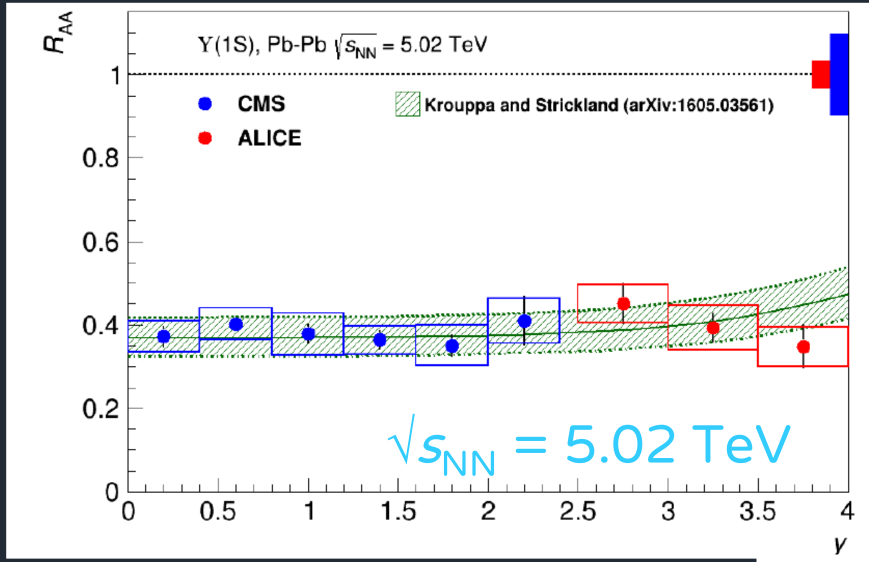
- Lower production cross sections
- Non negligible feed-down contributions from higher states



H. Wöhri, QWG2014

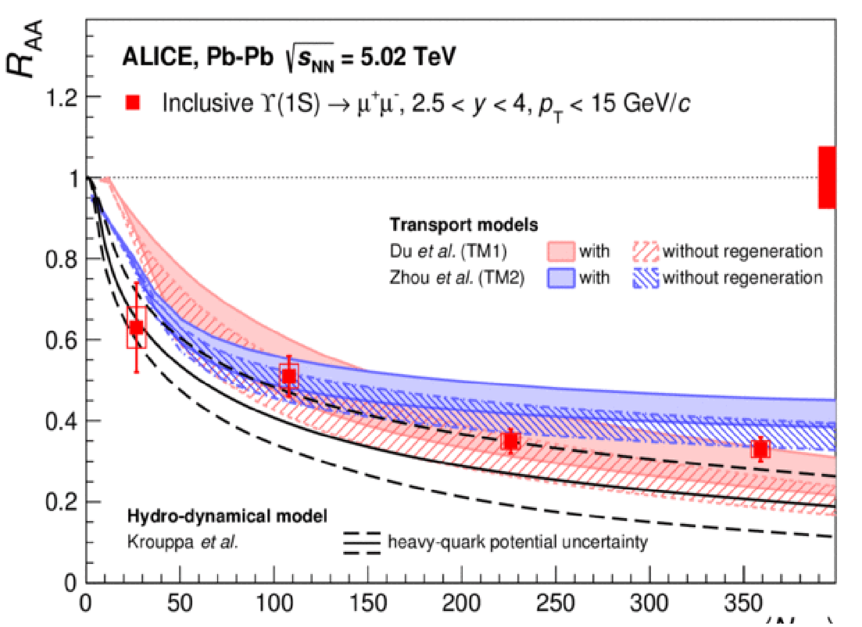
Υ(1S) in ALICE: theory comparison





CMS-PAS-HIN16-023
CMS arXiv:1611.01510

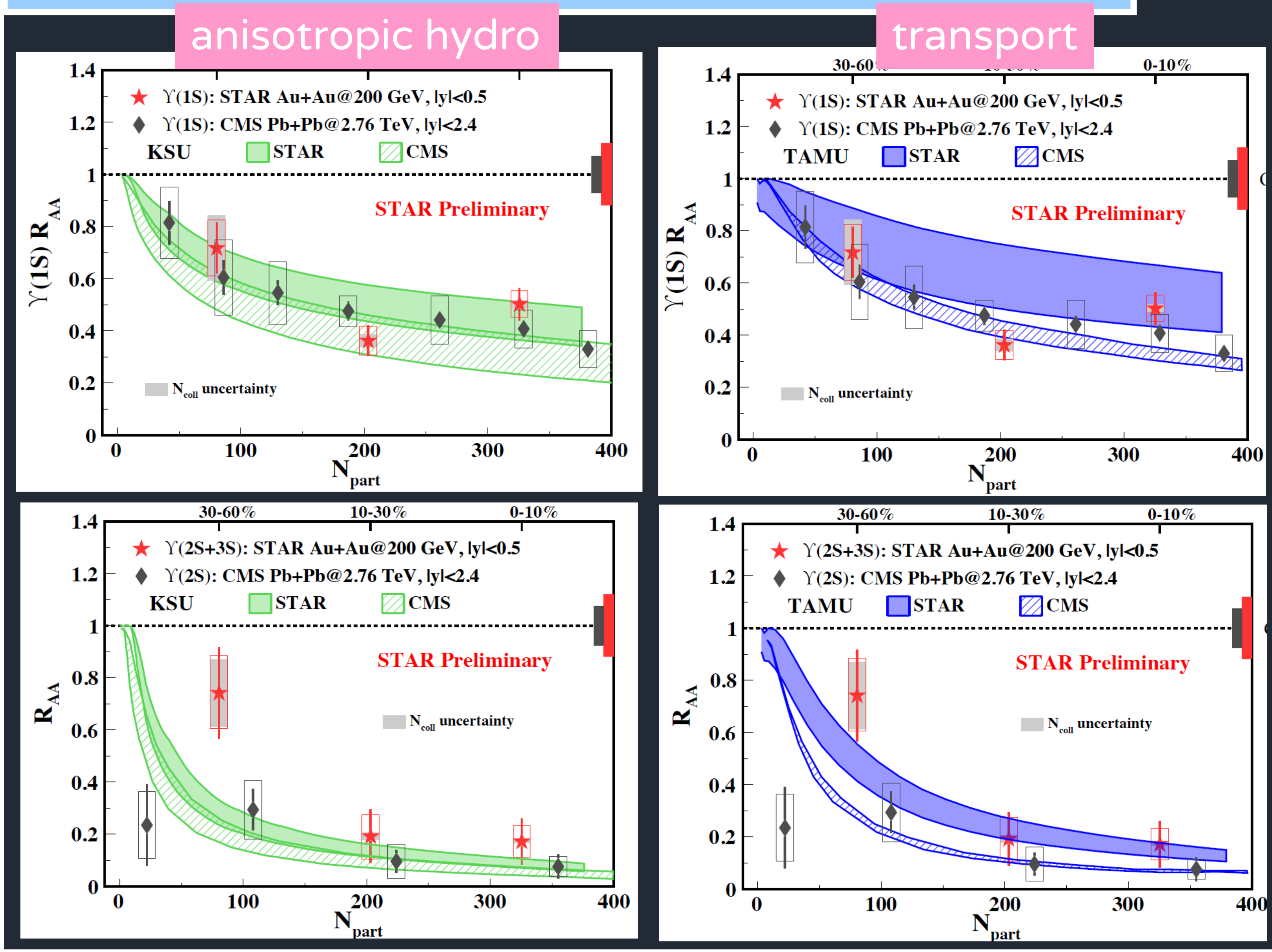
E. Scomparin, QM17



- Suppression increases with y at $\sqrt{s_{NN}}$ = 2.76TeV
- Suppression is constant at $\sqrt{s_{NN}}$ = 5.02TeV

- Some tension in the R_{AA} evolution vs *y* with energy, but still large uncertainties

Bottomonium at RHIC



- Similar Υ(1S) suppression, within uncertainties, at RHIC and LHC
- Excited states suppression is stronger at LHC

→ √s-dependence of feed down and CNM effects need to be precisely quantified

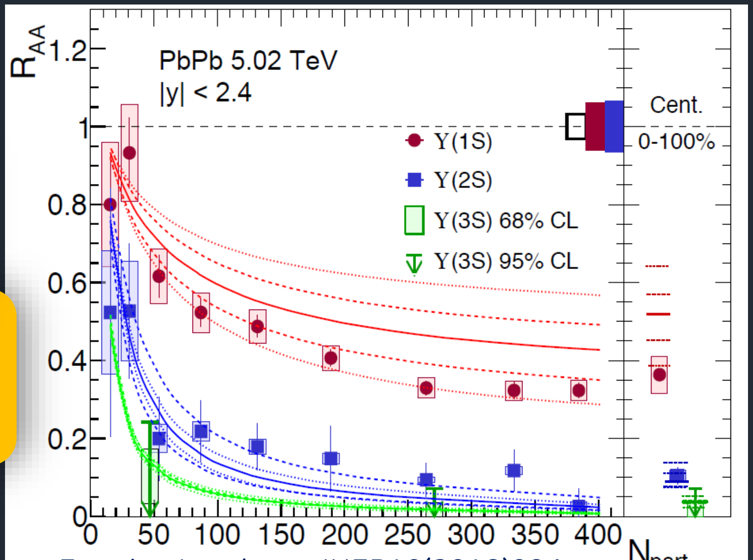
➡ Models describing LHC results also describe RHIC ones

T (RHIC) ~ 440 MeV
T (LHC) ~ 630 MeV
(M. Strickland, arXiv:1807.07452)

Bottomonium in AA

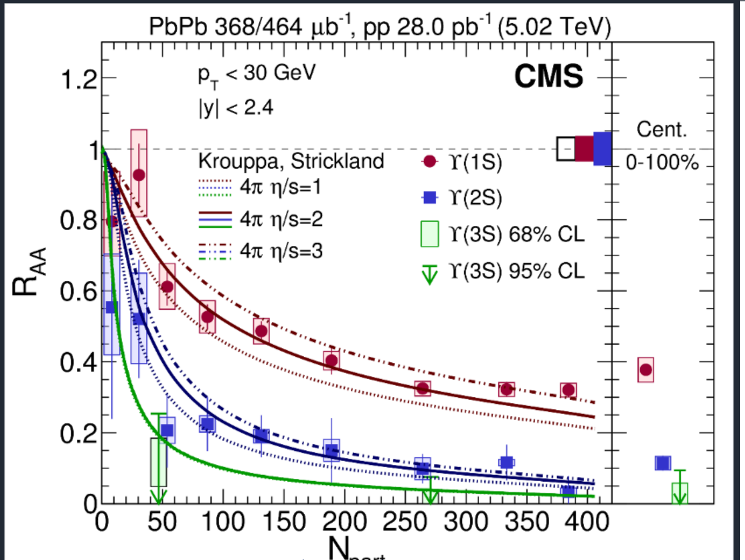
AA
pA
pp

comovers



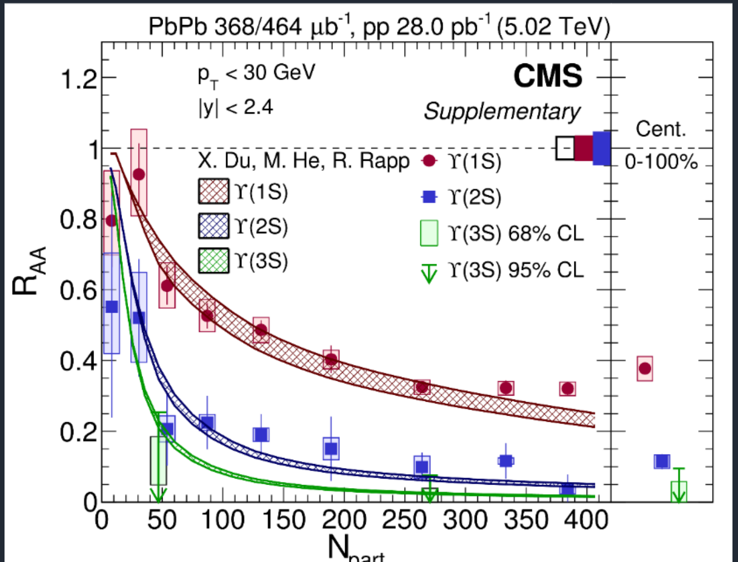
Ferreiro, Lansberg, JHEP10(2018)094

anisotropic hydro



Strickland,Universe2(2016)3,16

transport



Rapp, PRC96(2017)5,054901

All models agree with data within uncertainties

- regeneration now included in most of the models, but contribution is small
- comparison to models might help in determining the initial QGP T

$\sqrt{s_{NN}}$ = 5.02TeV → T~630 MeV (Kroupa-Strickland) T~550-800 MeV (Du, He, Rapp)