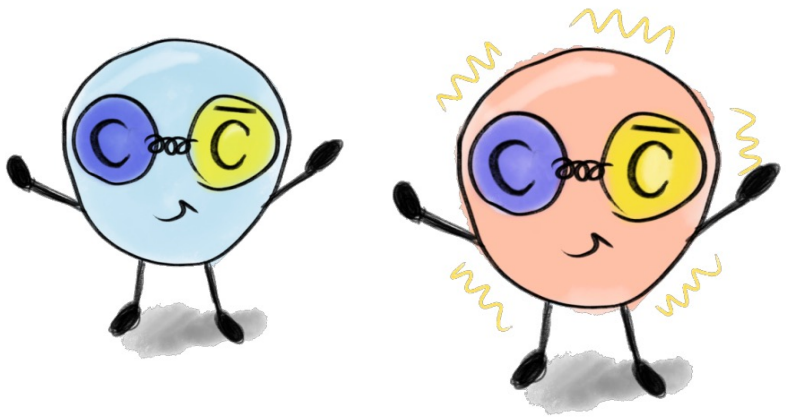
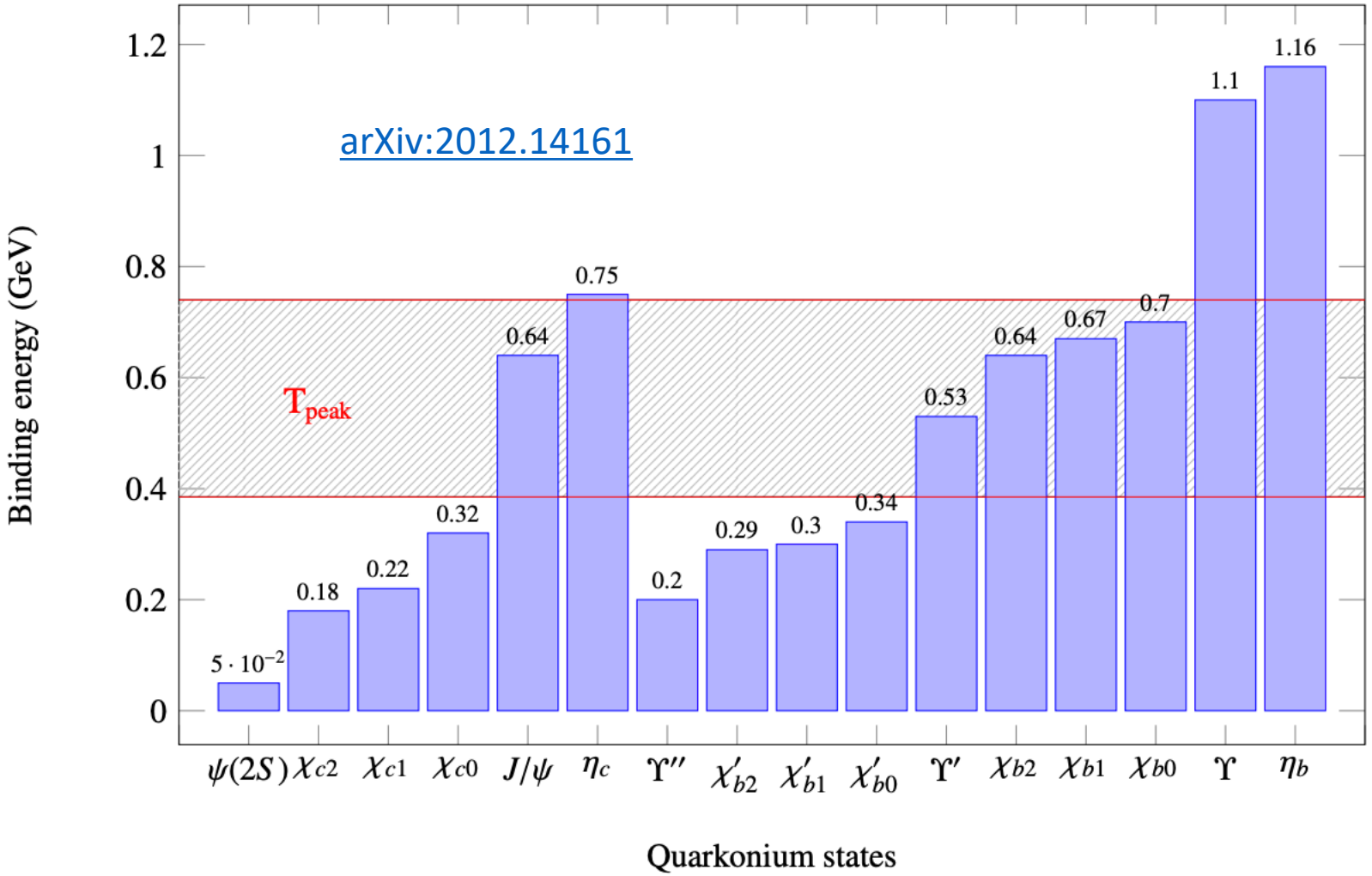
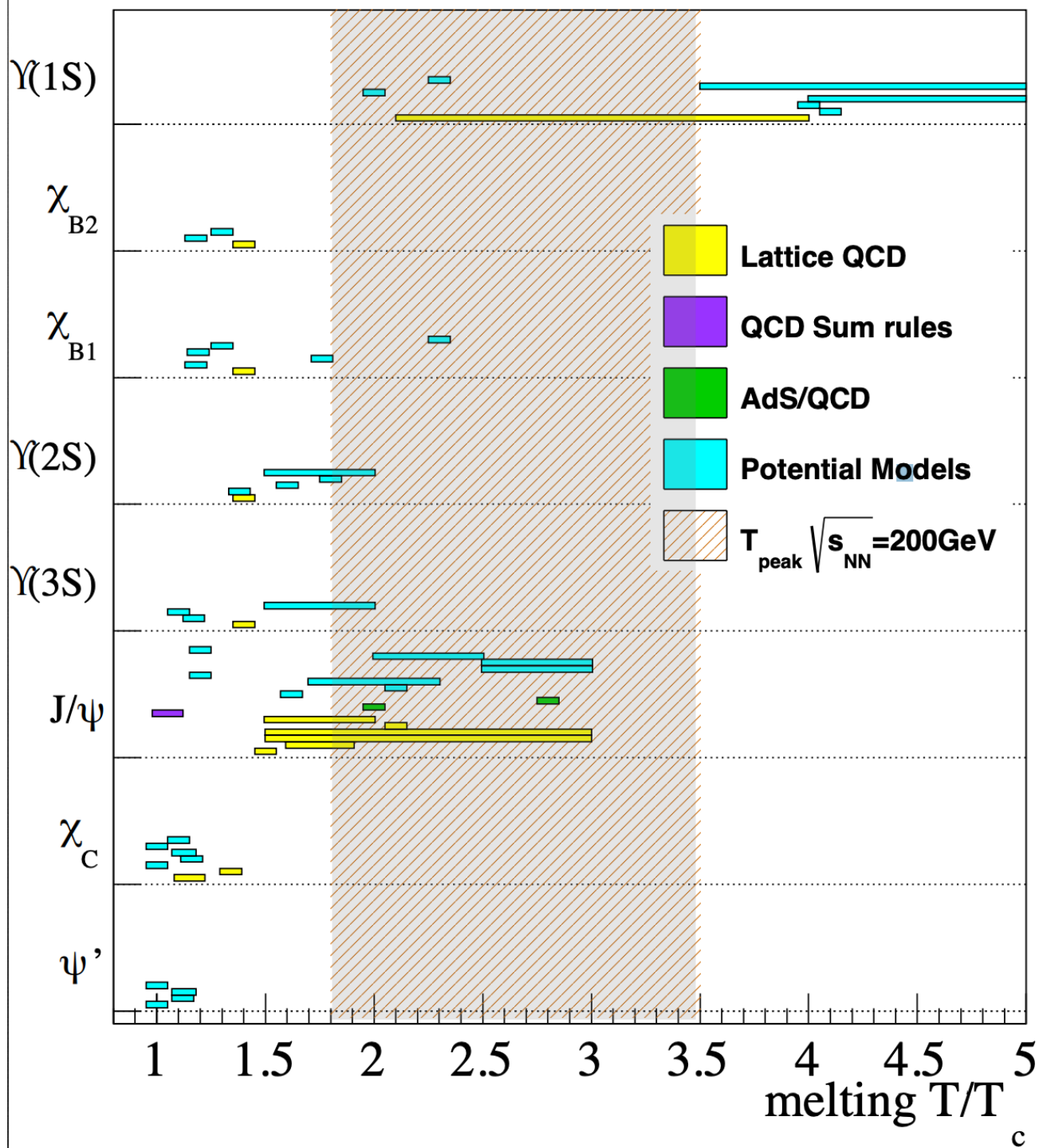
QUARKONIA AS TOOLS FOR MEDIUM CHARACTERIZATION



Tamar Zakareishvili's quarkonia

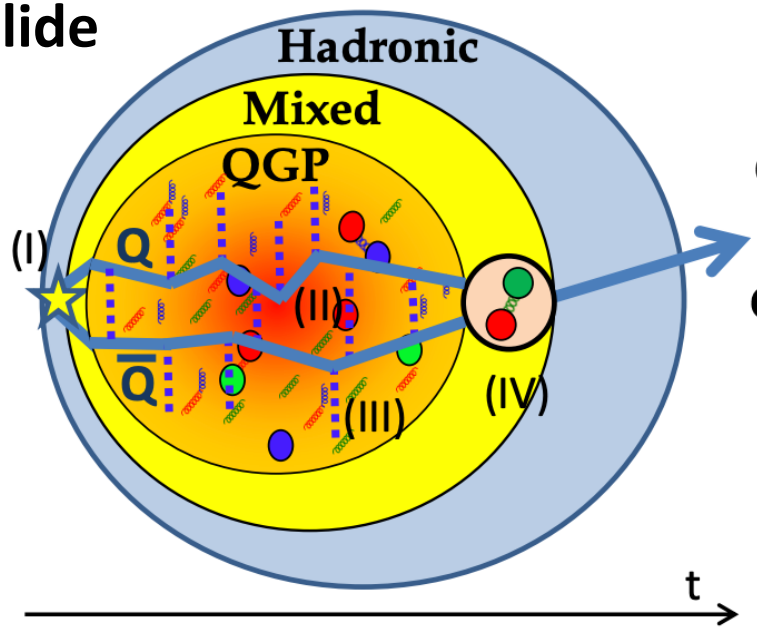


What Quarkonia can tell about QGP temperature ?


Υ(1S)
χB2
χB1
Υ(2S)
Υ(3S)
J/ψ
χC
ψ'
Lattice QCD
QCD Sum rules
AdS/QCD
Potential Models
Tpeak √sNN=200GeV
1
1.5
2
2.5
3
3.5
4
4.5
5
melting T/Tc

The full scheme

Paul Gossiaux's slide



Quarkonium
?
Open mesons

Strictly speaking, only resolved at the end of the evolution

Beware of quantum coherences during the whole evolution !

Especially at early time…

In practice, what counts is the so-called decoherence time, not the "Heisenberg time"

Complicated QFT problem (also due to the evolving nature of the QGP that mixes several scales)… only started to be addressed at face value recently

How to proceed ?

1) Initial state
2) (Screened) interaction between both HQ
3) Interactions with surrounding QGP partons
4) Projection on the final quarkonia

First incomplete QM treatments dating back to Blaizot & Ollitrault, Thews, Cugnon and Gossiaux; early 90's

Lets make our live easier :

- **Turn off initial state effects :** quarkonia states ratios with other QQ states and open heavy flavor

- **Turn off regeneration :** go to environments with small QQ in the system
  - Low energy for charmonia (RHIC, SMOG)
  - Bottomonia

Feed-down to Υ(nS) from measurements in pp collisions

- Using S-wave differential cross-section measurements from ATLAS or CMS in pp at √s = 7 TeV + LHCb P-wave to S-wave ratio measurements

ATLAS [PRD 87 (2013) 052004] *CMS [PLB 727 (2013) 101]* *CMS [PLB 749 (2015) 14]* *LHCb [EPJC 74 (2014) 3092]*

- Extract feed-down fraction from fits to S-wave and P-wave diff. cross-section and PDG branching ratios

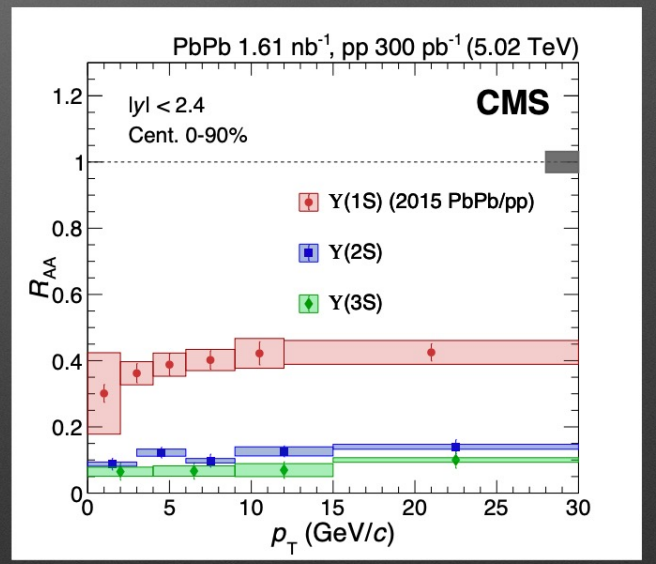
Υ(1S) feed-down fraction at $< p_T >_{\Upsilon(1S)}$ ~ 5.8 GeV

ATLAS + LHCb: 1S	
State	$\langle p_T \rangle$ feed-down fraction
$\Upsilon(1S)$	0.763 ± 0.010
$\Upsilon(2S)$	0.0625 ± 0.0019
$\chi_b(1P)$	0.127 ± 0.009
$\Upsilon(3S)$	0.00786 ± 0.00018
$\chi_b(2P)$	0.039 ± 0.004

direct

feed-down

Boyd et al. [PRD 108 (2023) 094024]

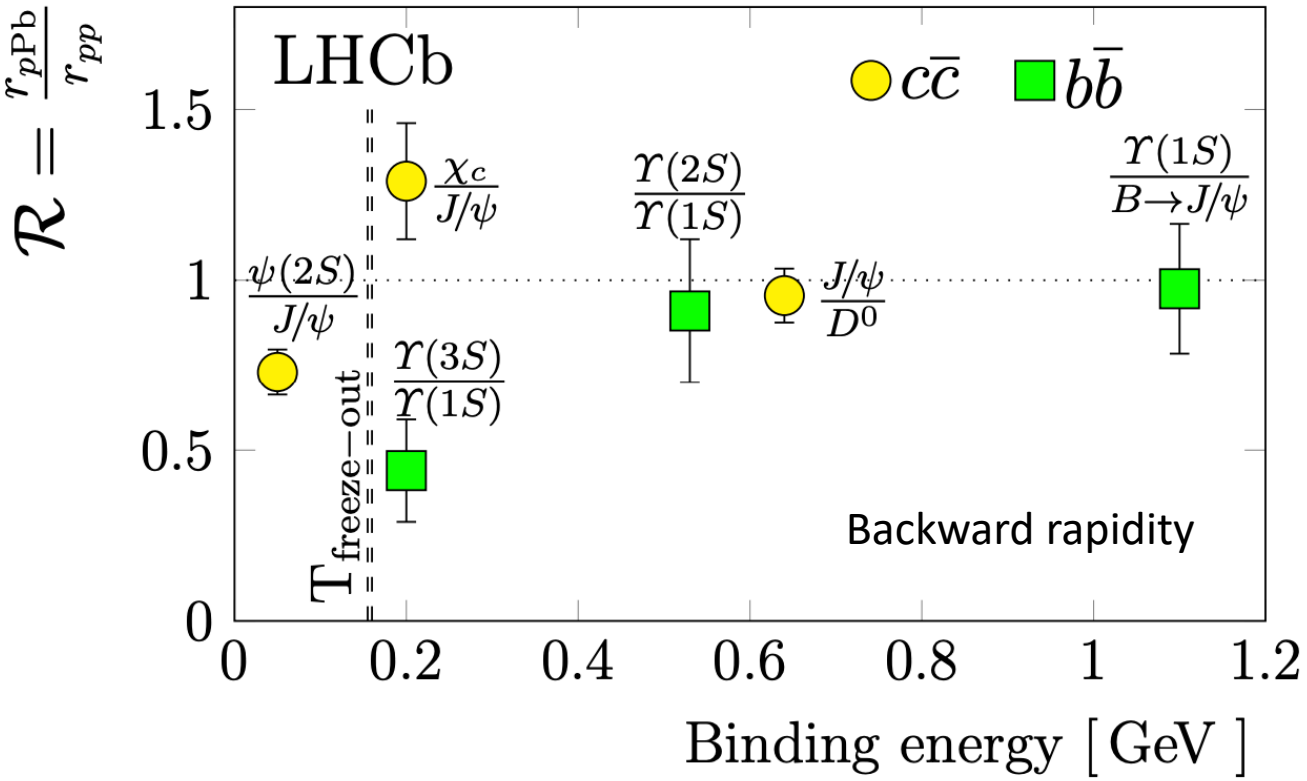


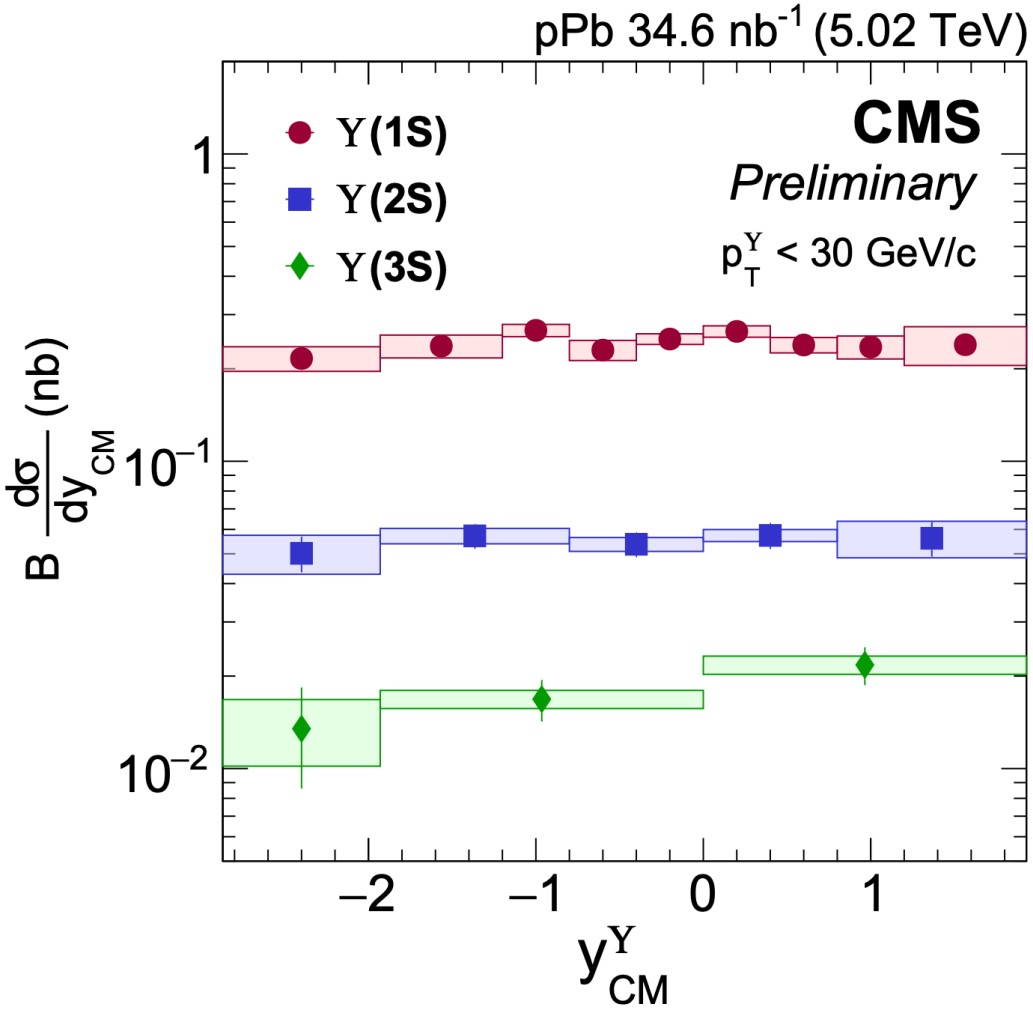
CMS [arXiv : 2303.17026]

- Only conjecturing the melting of the excited states feeding down Υ(1S) is not enough
  - cold nuclear matter (CNM) effects ? direct Υ(1S) melting ?

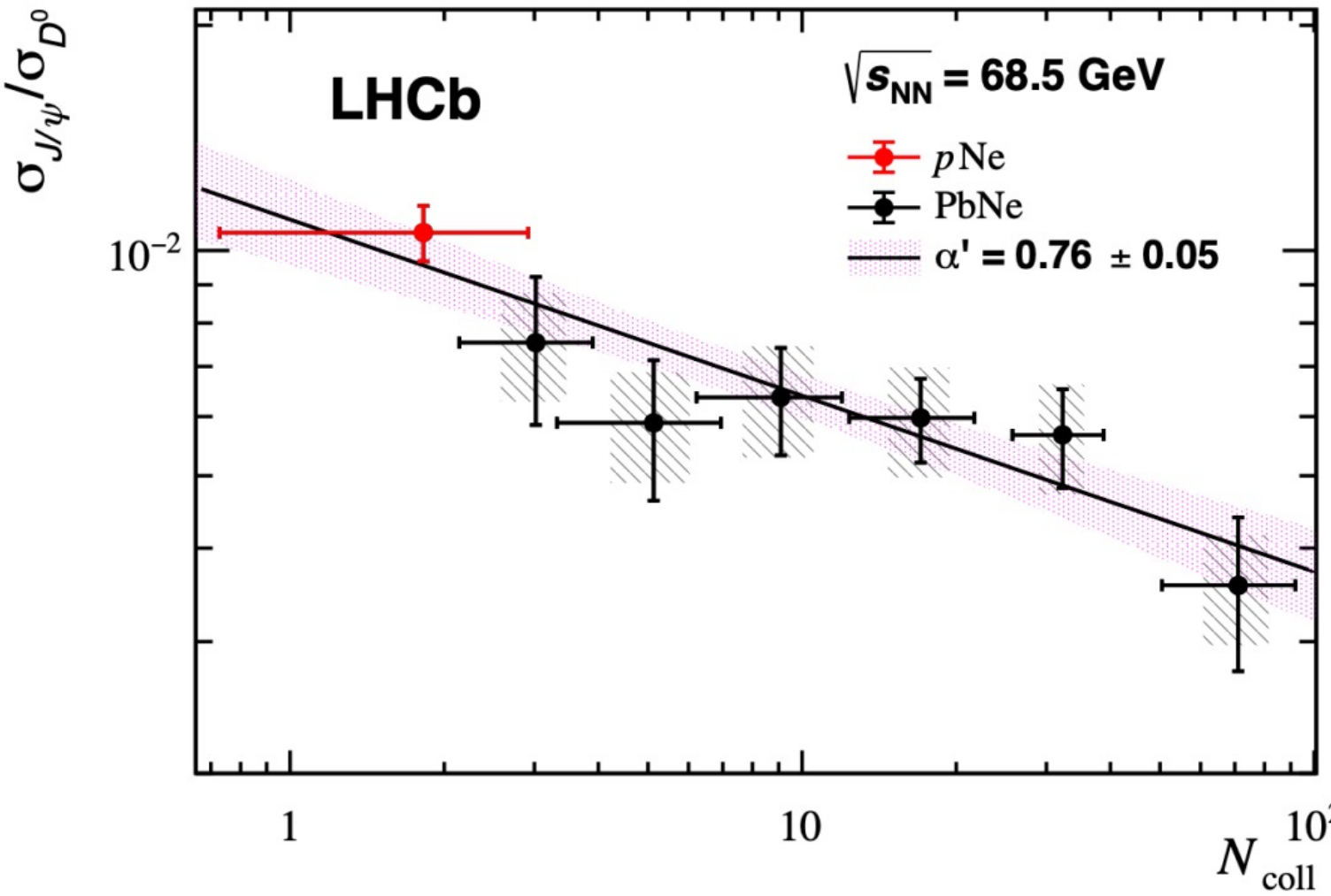
What about Υ(1S)/B-meson vs. Npart ??

arXiv:2311.01562





Bottomonia is a VERY SLOW object



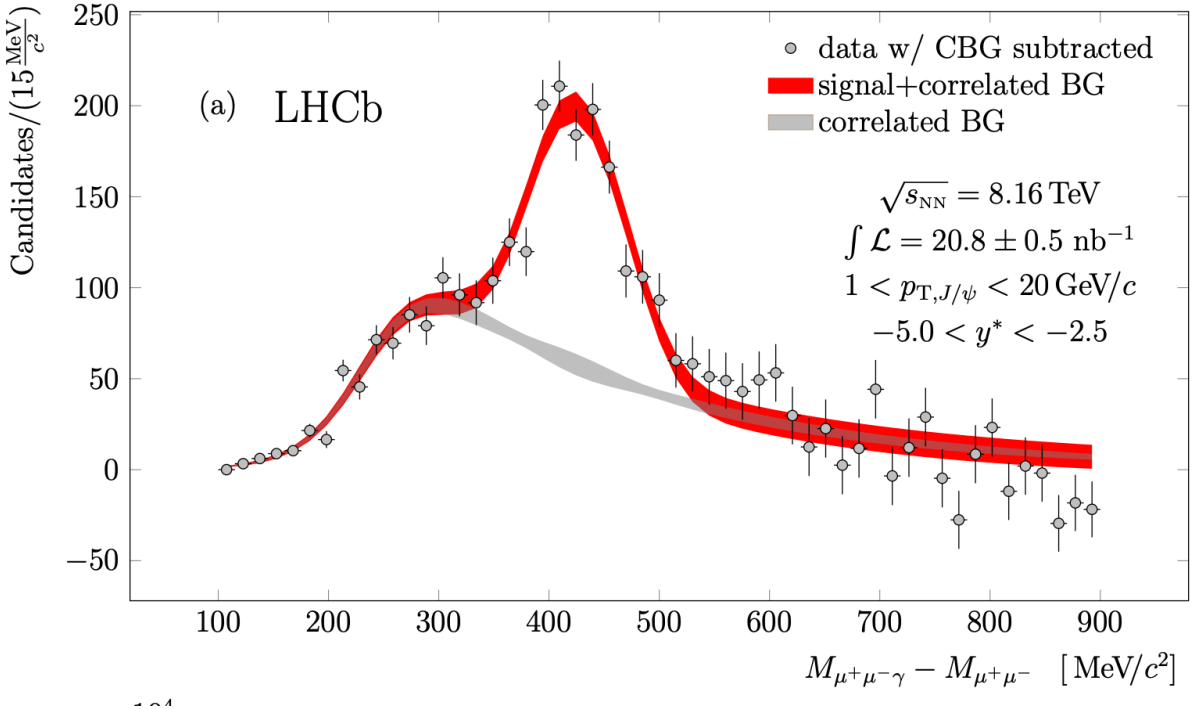
Absorption in hadrons (comovers)

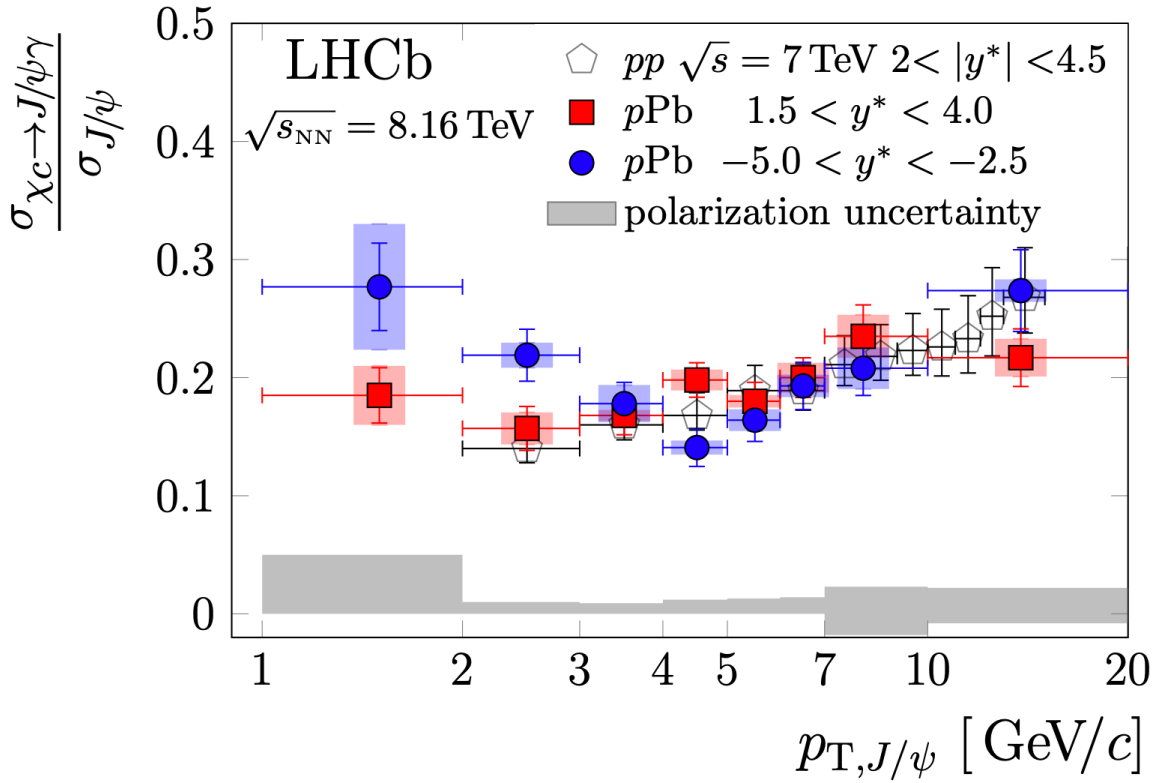
Color screening

No Initial-state effects

(Minimum) No regeneration

Is that a exponential slope ???





χ_c has a binding energy close to the freeze-out temperature.