Excited quarkonia states in pp and p-Pb collisions

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Quarkonia As Tools 2020

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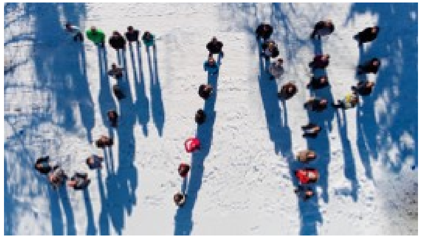
Istituto Nazionale di Fisica Nucleare



Physics motivation

- Quarkonium production:

  pp collisions:

  → Reference process to understand the pA and A-A collisions

  → Useful to investigate production mechanisms (CEM, NRQCD ...)

  p-Pb collisions:

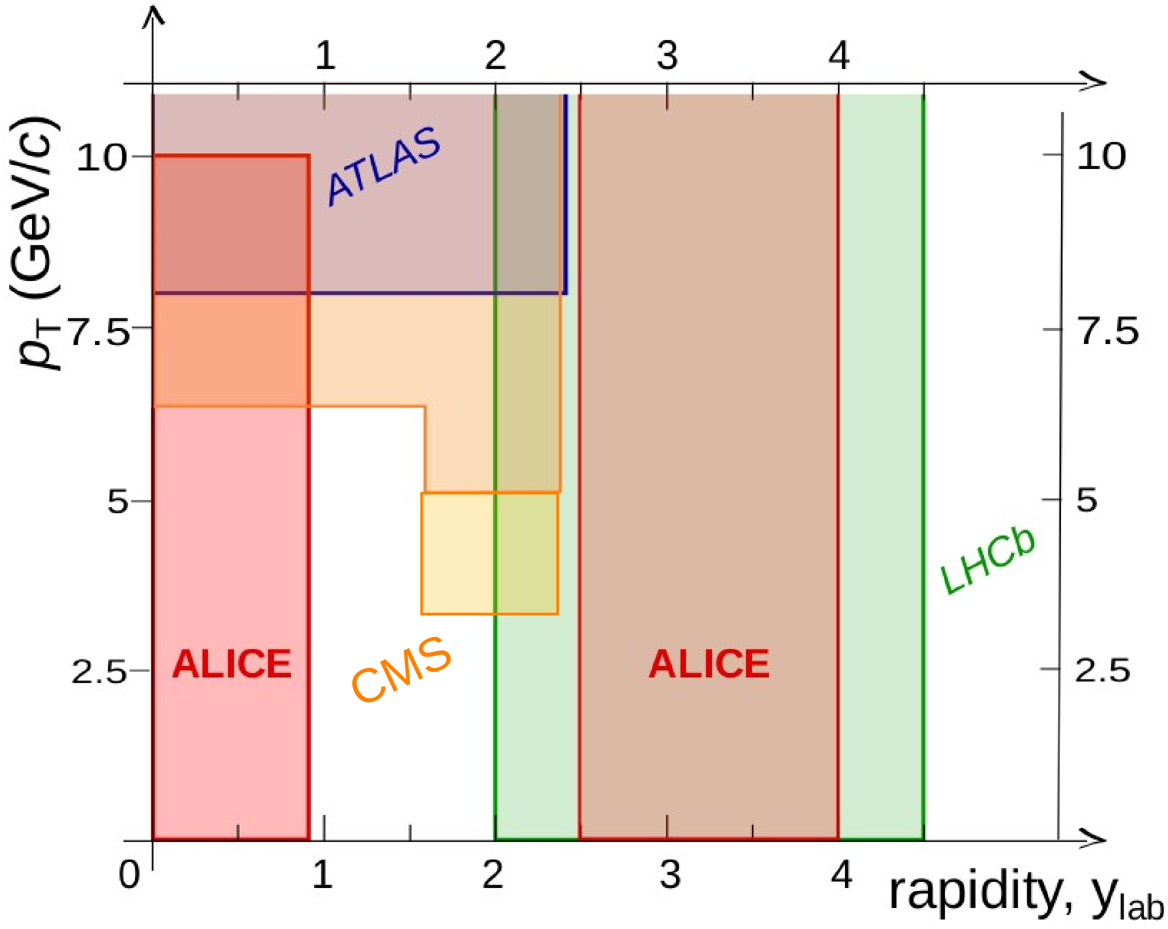
  Cold nuclear matter (CNM) effects:

  → Initial state effects: Gluon shadowing, gluon saturation

  → Coherent parton energy loss

  → Final state effects: comovers absorption ..

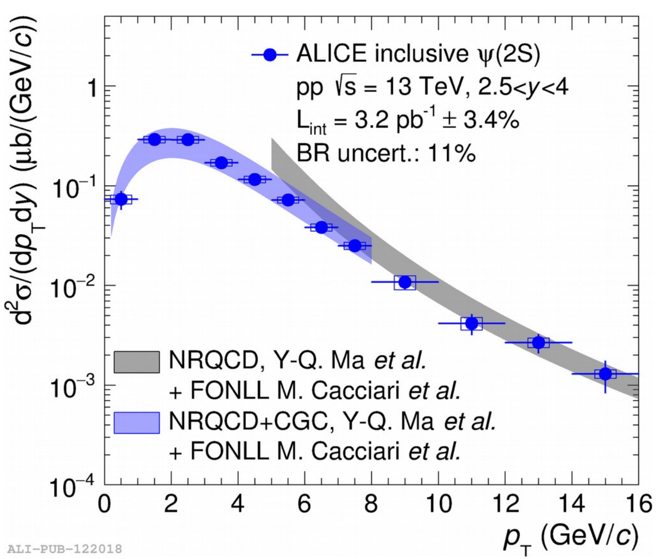
LHC experiments

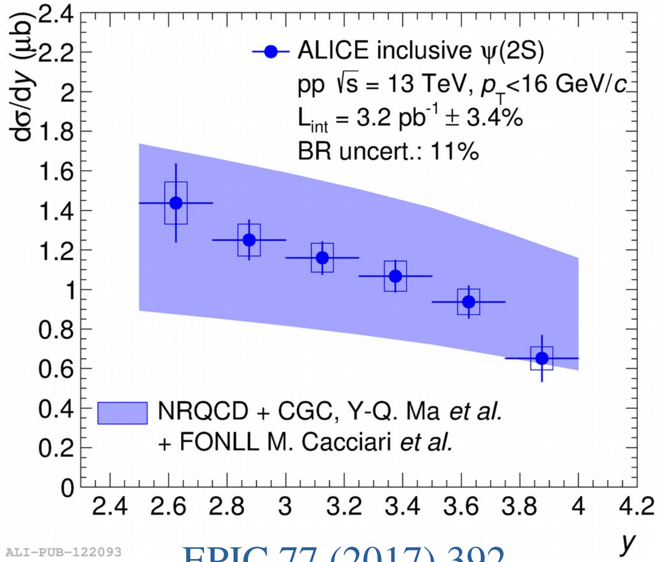


arXiv:1609.01135

- Acceptance of J/ψ measurements by the four LHC experiments as a function of p_T and rapidity
- For the mid rapidity detectors (as the ALICE central barrel, ATLAS and CMS) only one half of the acceptance is shown
- For ϒ family, all experiments have acceptance down to zero p_T

ψ(2S) production in pp collisions





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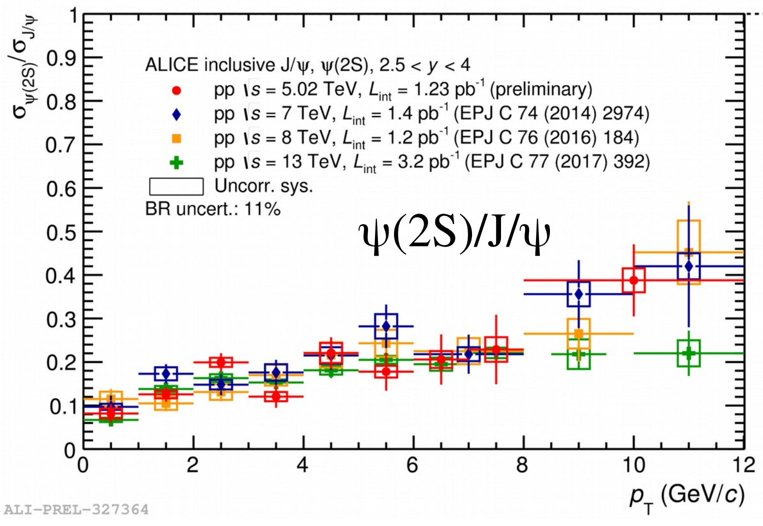
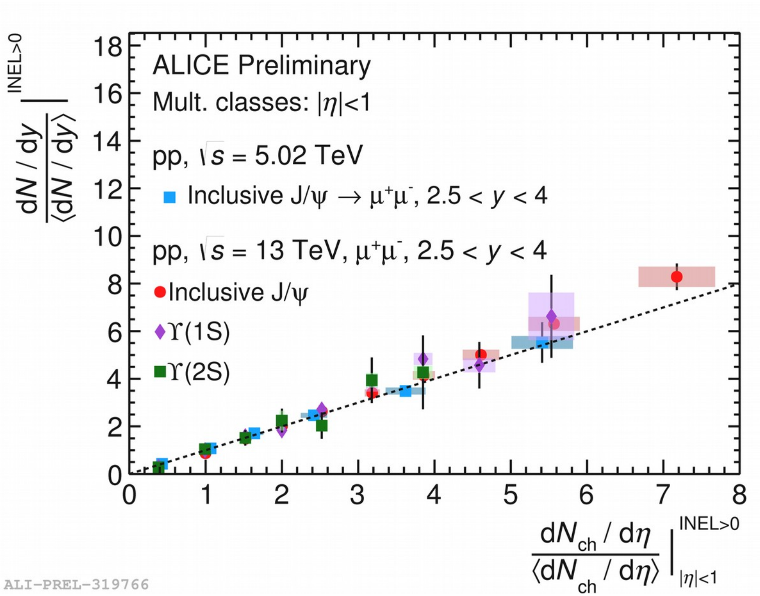
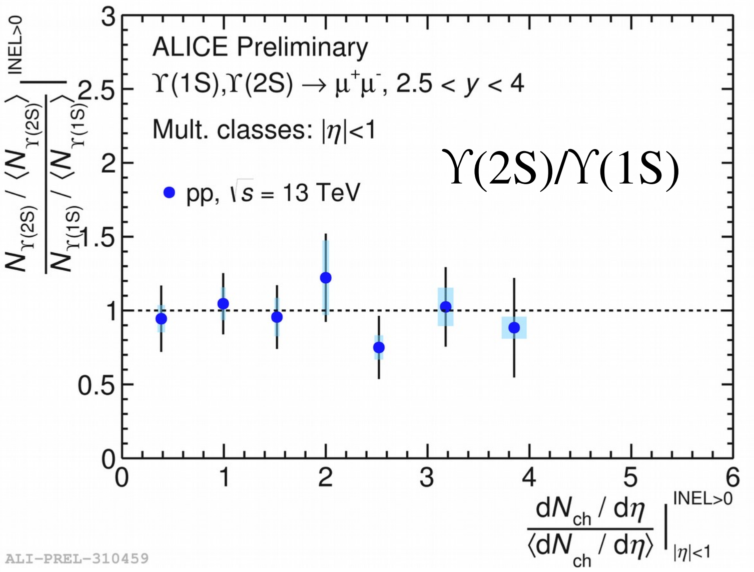


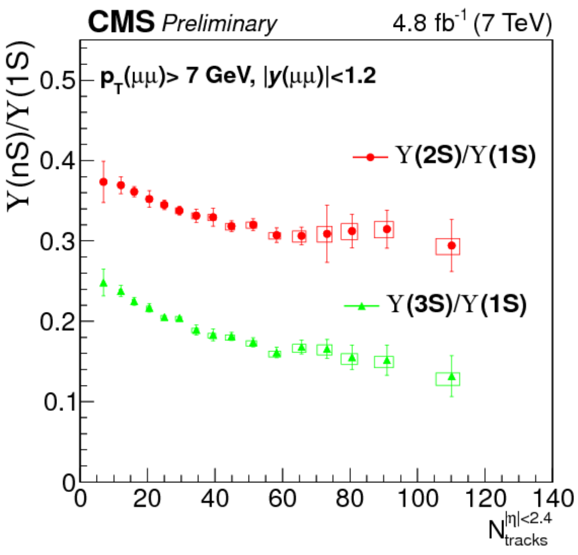
- CGC+NRQCD [Phys. Rev. Lett. 113 (2014) 192301] for prompt ψ(2S) at low p_T
- FONLL for ψ(2S) from B decay

- No dependence of ψ(2S)/J/ψ ratio on $\sqrt{s}$
- No change in shape of the ψ(2S)/J/ψ as a function of p_T

Multiplicity dependence of quarkonia in pp collisions





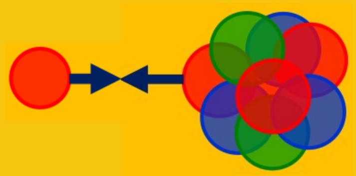


CMS PAS BPH-14-009

- Underlying physics:
- Multi-parton interaction (MPI)
- Interplay between hard and soft QCD process

- Linear increase of quarkonia yield with multiplicity at ALICE (forward-y)
- No strong energy and quarkonia states dependence observed at ALICE
- ϒ(2S)/ϒ(1S) has no multiplicity dependence at ALICE (forward-y) while decreasing trend at CMS (mid-y)

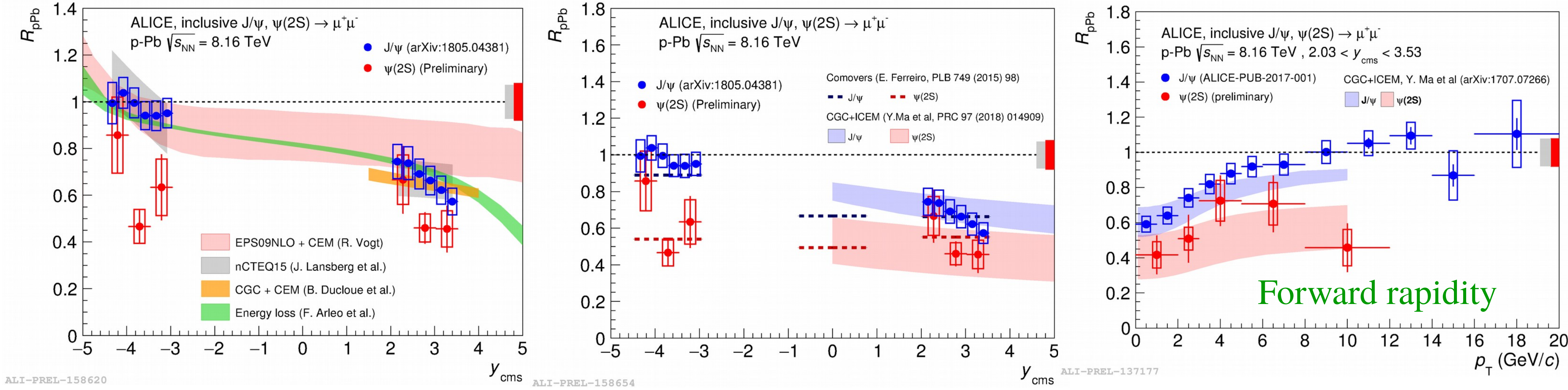
p-Pb



cold nuclear matter effects:

shadowing/CGC, energy loss...

Nuclear modification factor of ψ(2S) at $\sqrt{s_{NN}}$ = 8.16 TeV



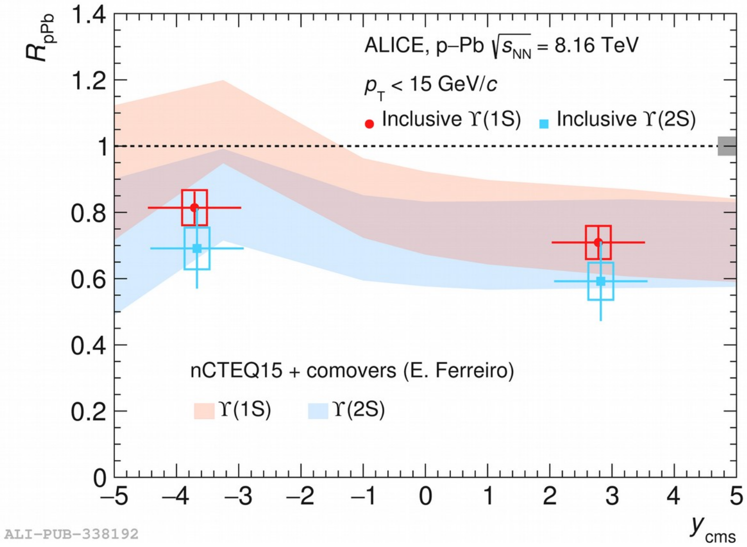
- ψ(2S) suppression is stronger than the J/ψ one, especially at backward rapidity

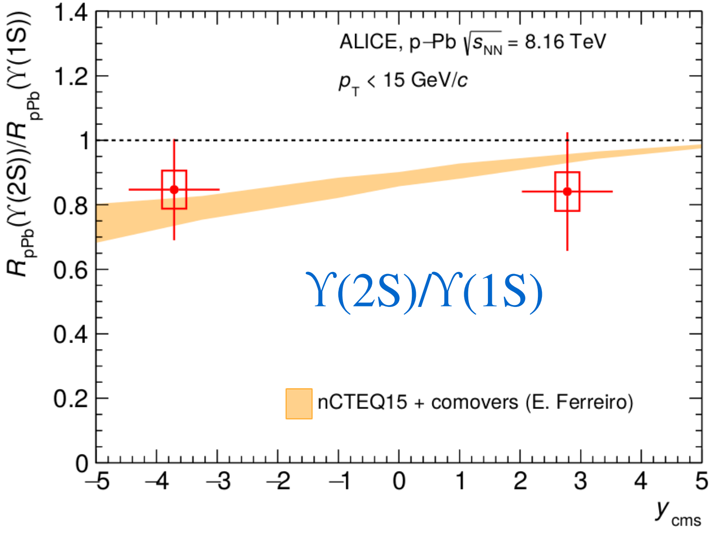
$$R_{pPb}^{J/\psi} = \frac{Y_{pPb}^{J/\psi}}{\langle T_{pPb} \rangle \ \sigma_{pp}^{J/\psi}}$$

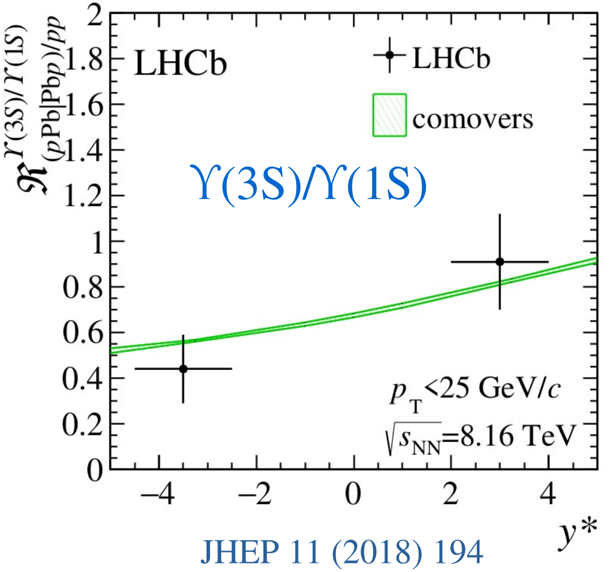
- No strong y and p_T dependence of ψ(2S) R_{pPb}

- Theoretical predictions based on shadowing and energy loss can not describe the stronger ψ(2S) suppression
- Models including final-state effects reproduce ψ(2S) behaviour at both forward and backward rapidity

Υ(nS) R_{pPb} vs y_{cms} at $\sqrt{s_{NN}}$ = 8.16 TeV







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ALICE-PUBLIC-2018-008, arXiv:1910.14405

- Υ(1S) and Υ(2S) R_{pPb} agree within 0.8σ both at forward and backward rapidity
- The shadowing contribution and most of the theory uncertainties cancel out in the ratio
- The shape of the theoretical calculation is, hence, mainly driven by the interactions with the comoving particles, which affect mostly the Υ(2S) and Υ(3S) in the backward rapidity region

Conclusions

→ CGC + NRQCD describes the low p_T region of charmonium cross section
[Our phenomenology paper: Comparison of NRQCD+FONLL calculation with charmonium results in pp collisions from ALICE, ATLAS, CMS and LHCb: J. Phys. G: Nucl. Part. Phys. 42 (2015) 065101]

→ The quarkonium production increases linearly as a function of multiplicity in different rapidity region

→ ψ(2S) shows a stronger suppression than J/ψ, final-state effects needed to explain the ψ(2S) behaviour

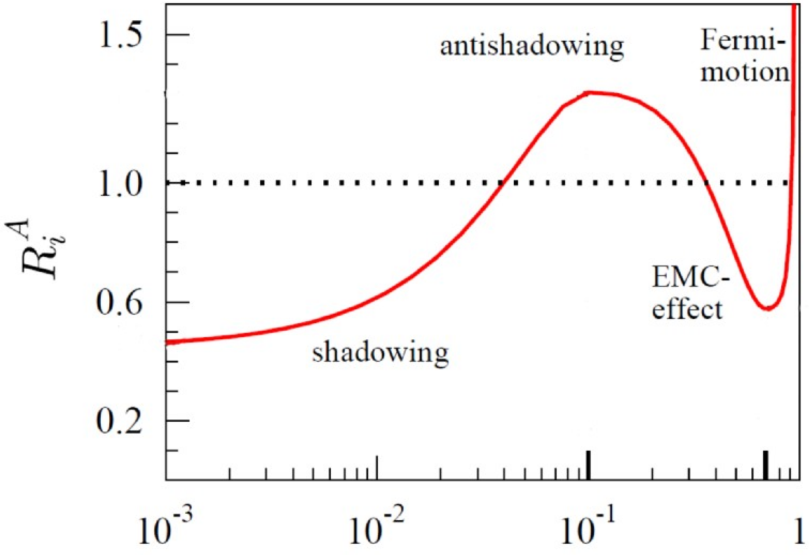
→ Similar ϒ(1S) and ϒ(2S) suppression at backward and forward-*y*

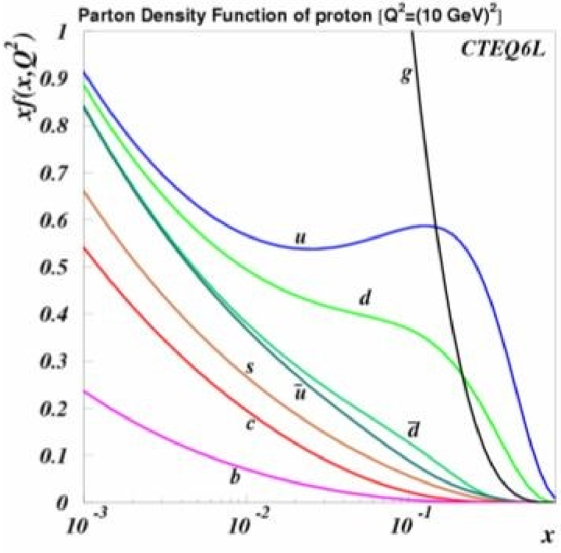
→ Model based on shadowing and comover interaction describe the ϒ(2S) result

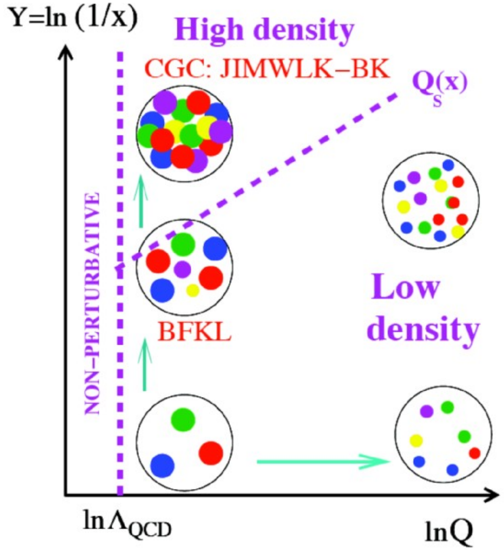
Thank you

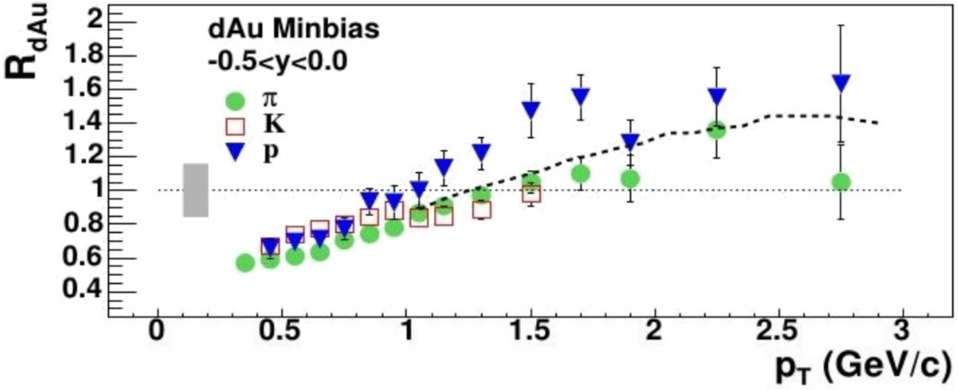
CNM

$$R_i^A(x,Q^2) = \frac{f_i^A(x,Q^2)}{f_i(x,Q^2)},$$

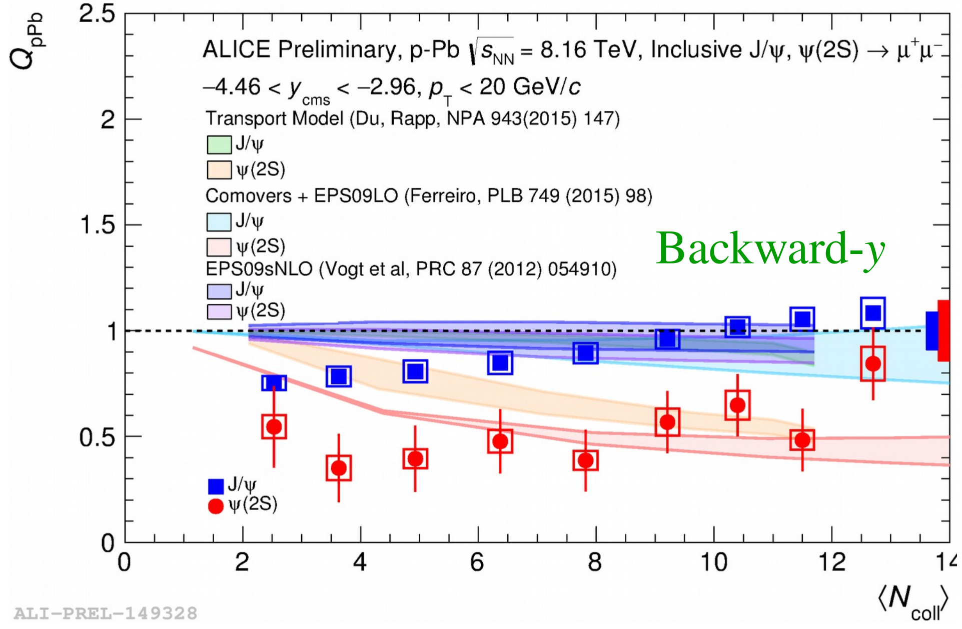


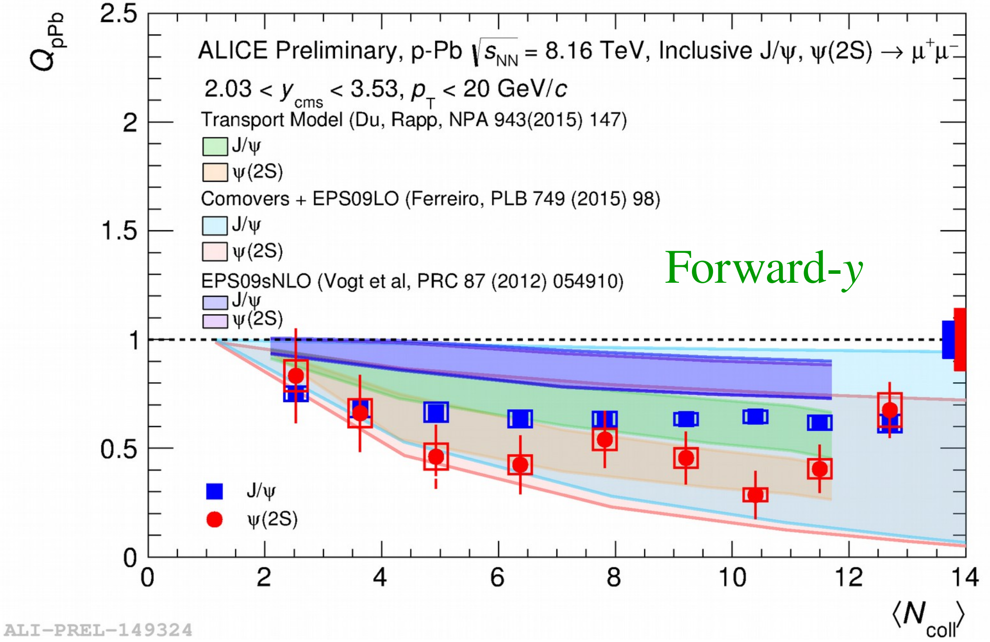






$\psi(2S)$ Q_{pPb} vs centrality at $\sqrt{s_{NN}}$ = 8.16 TeV

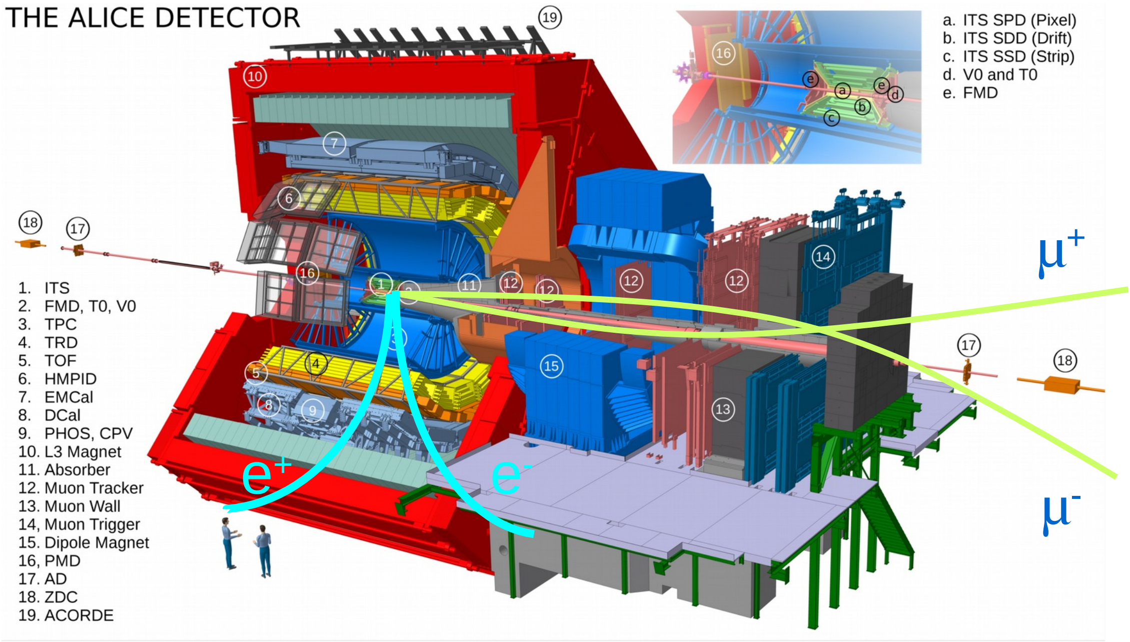




- The $\psi(2S)$ suppression is stronger than J/ψ one, especially at backward rapidity
- At forward rapidity the Q_{pPb} of $\psi(2S)$ follows the same trend as J/ψ while at backward rapidity trend is different
- At backward rapidity, final-state effects needed to explain the $\psi(2S)$ behaviour. Some discrepancies between the data and the model in the peripheral region

A Large Ion Collider Experiment

→ Quarkonia in ALICE are measured in two rapidity ranges:



Central barrel:

$J/\psi \rightarrow e^+e^-$ ($|y| < 0.9$)

Electrons tracked using ITS and TPC
Particle identification: TPC (+TOF)

Forward muon arm:

$J/\psi \rightarrow \mu^+\mu^-$ ($2.5 < y < 4$)

Muons identified and tracked in the muon spectrometer

→ Acceptance coverage in both y regions is down to zero p_T

ψ(2S) and ϒ(nS) in pp collisions at $\sqrt{s}$ = 13 TeV