Recent quarkonium measurements in small systems with the ALICE detector at the LHC

Jhuma Ghosh

On behalf of the ALICE collaboration

Saha Institute of Nuclear Physics, Kolkata, HBNI, India

Outline

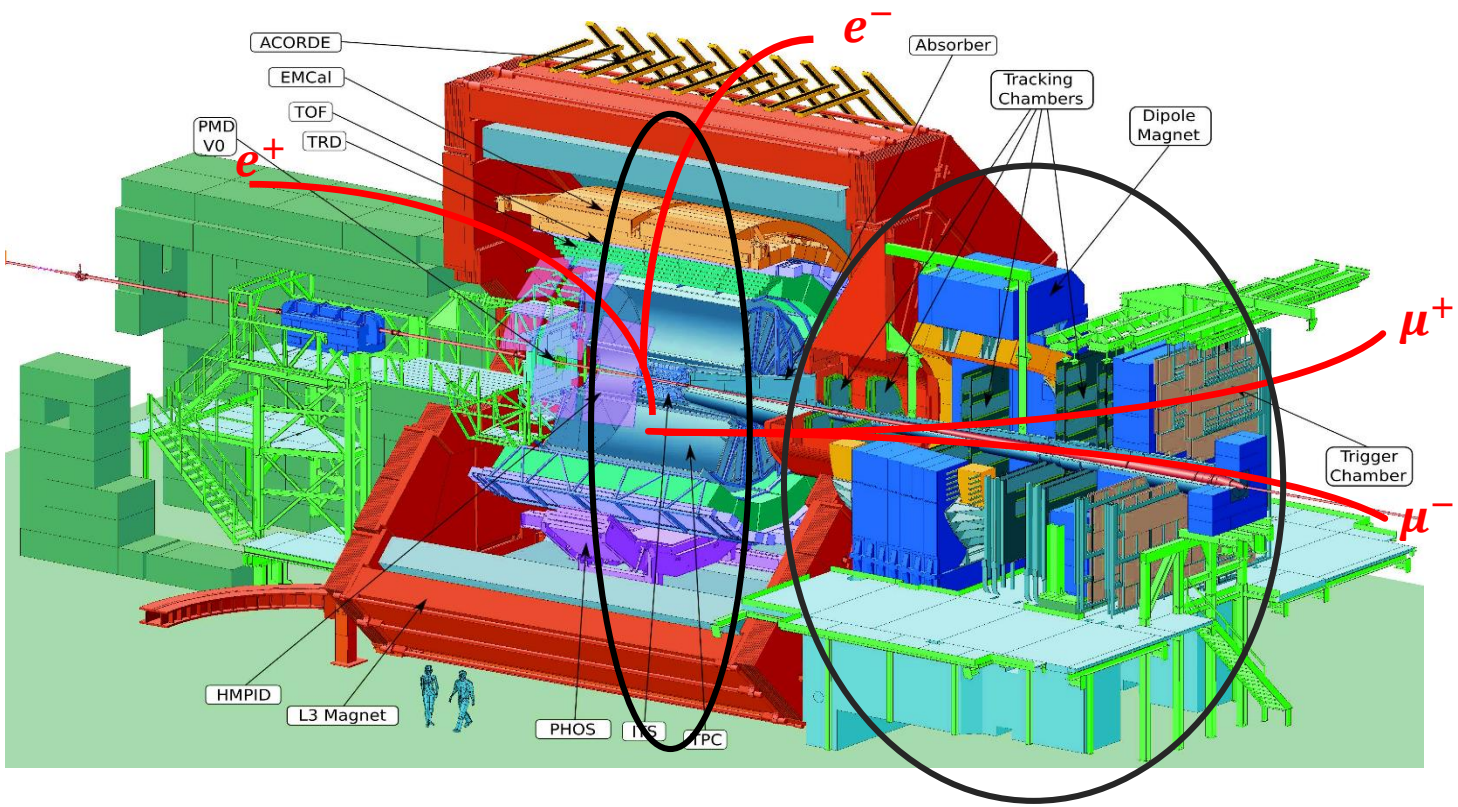
pp

- J/Ψ
  - Cross section in 5.02 TeV pp collisions at mid and forward rapidity New
  - Prompt, non-prompt cross section in 13 TeV pp collisions at mid rapidity New
  - Production vs charged-particle multiplicity in pp collisions at 5.02 and 13 TeV
- Ψ(2S)
  - Cross section in pp collisions 5.02 TeV at forward rapidity New

pPb

- J/Ψ
  - Q_{pPb} and Q_{CP} in p-Pb collisions at 5.02 TeV at mid rapidity New
- ϒ(1S), ϒ(2S)
  - R_{pPb} as a function of p_T and y in p-Pb at 8.16 TeV [arxiv:1910.14405] New publication

A Large Ion Collider Experiment



$|y| < 0.9$ Mid -y

$2.5 < y < 4$ Forward-y

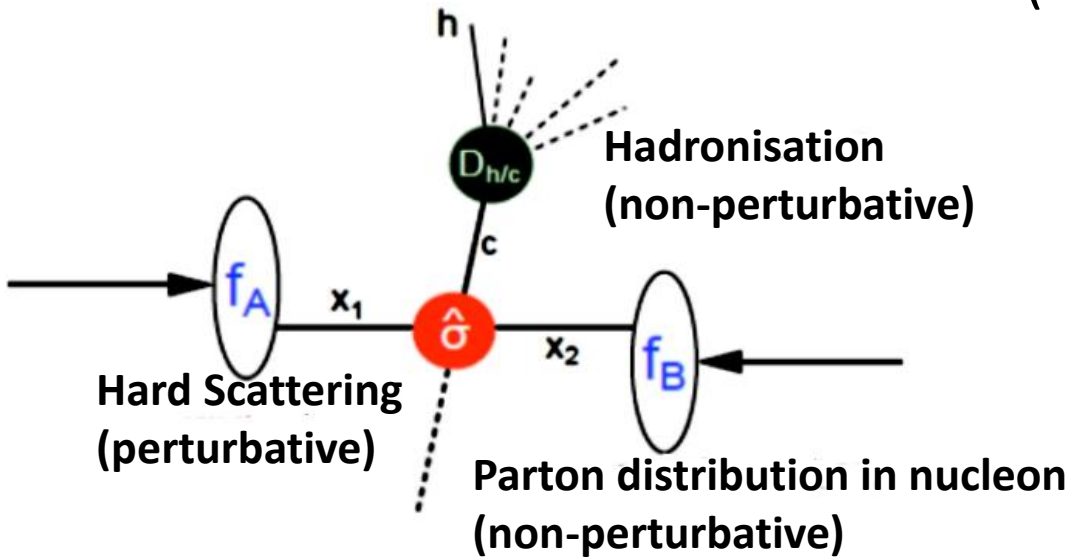
ALICE measures quarkonium via its dielectron (mid-y) and dimuon (forward-y, only inclusive) decay channel down to p_T =0 GeV/c

Quarkonium ($c\bar{c}$ and $b\bar{b}$) productions in pp collisions

Production in initial hard-scattering process (Perturbative)

Two Steps

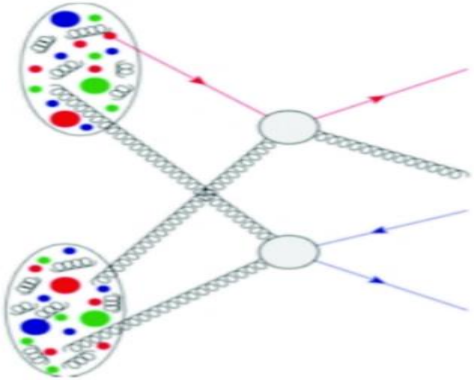
Evolution into colorless bound state (Non-perturbative)



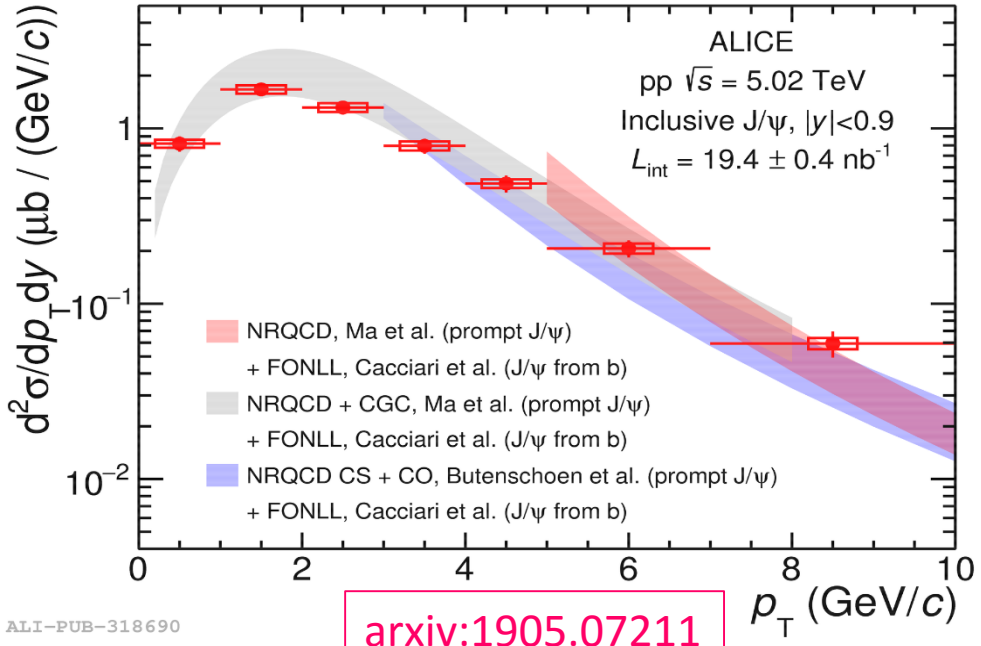
Production cross section provides test ground for several theoretical models

Multiplicity dependent measurements

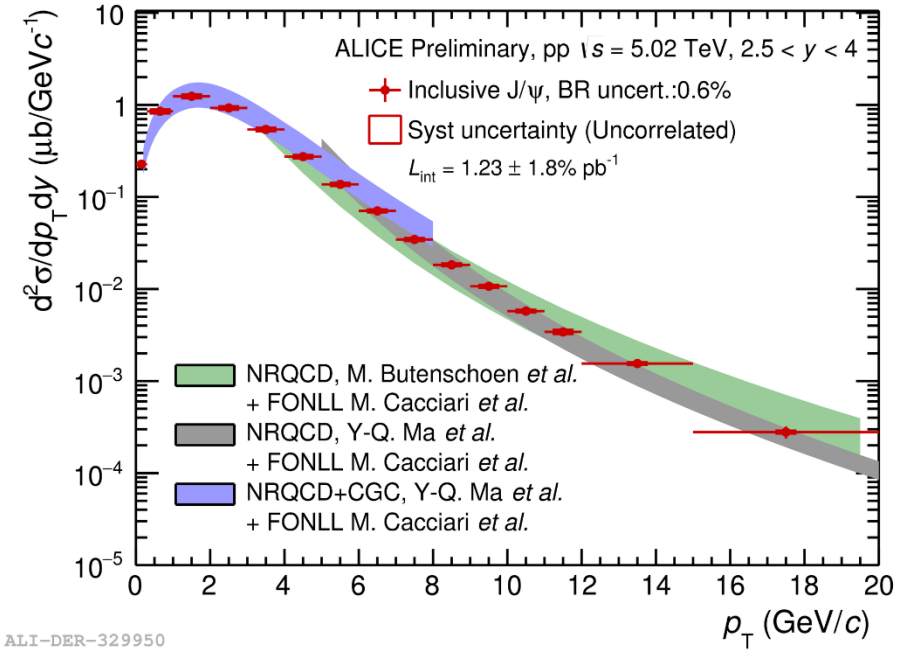
- ❑ Interplay between soft and hard mechanisms of particle production
- ❑ Study the role on Multiple Parton Interactions (MPI)



J/Ψ cross section in pp $\sqrt{s}$ = 5.02 TeV at mid and forward-y

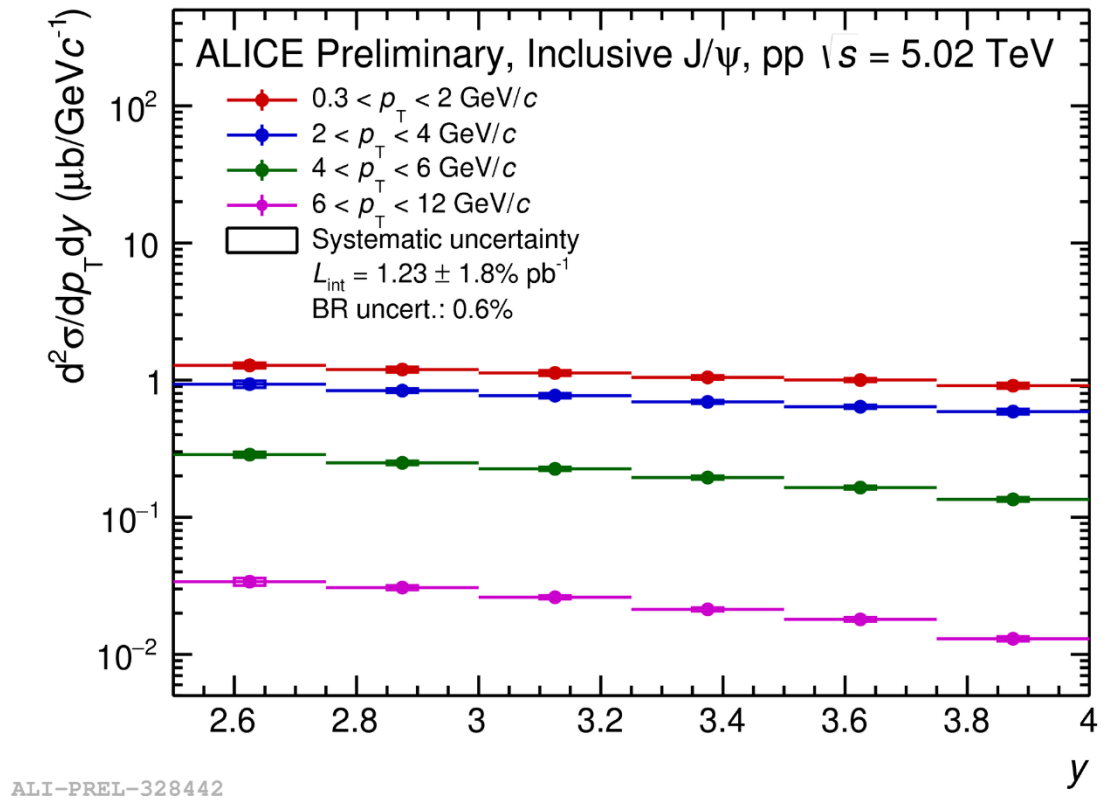


arxiv:1905.07211



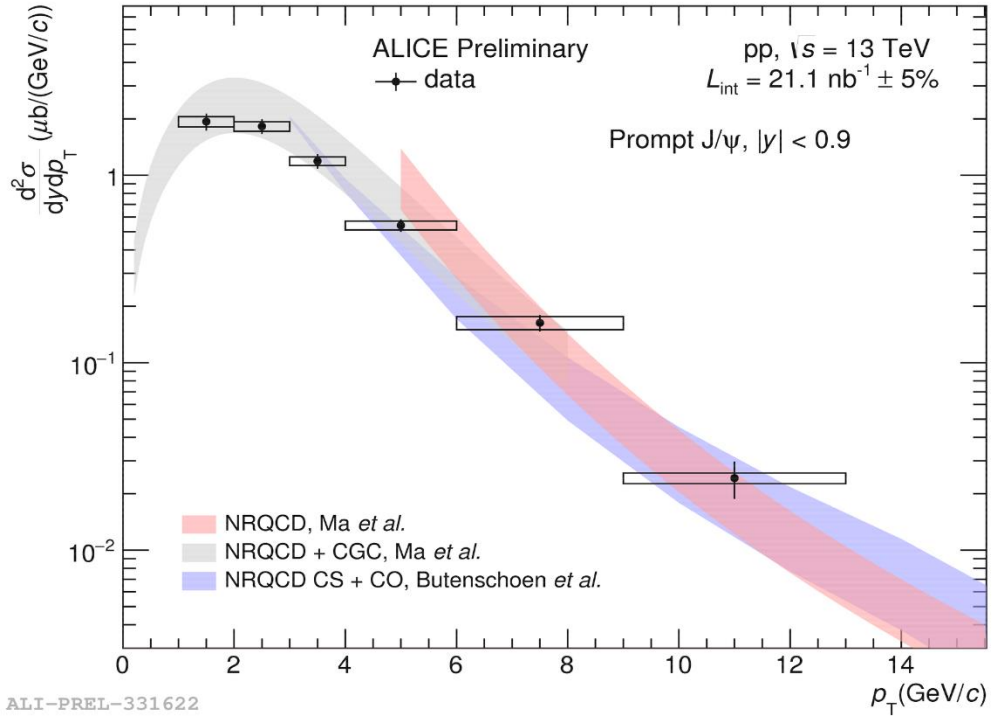
- Inclusive (=prompt and non-prompt) measurement
- p_T reach up to 20 GeV/c at forward rapidity, to be used as pp reference for R_{AA} analysis in Pb-Pb collisions
- J/Ψ cross section for p_T < 8 GeV/c is well described by NRQCD+CGC model
- NRQCD+FONLL (for non-prompt contribution) describes the data throughout the whole p_T range at forward rapidity.

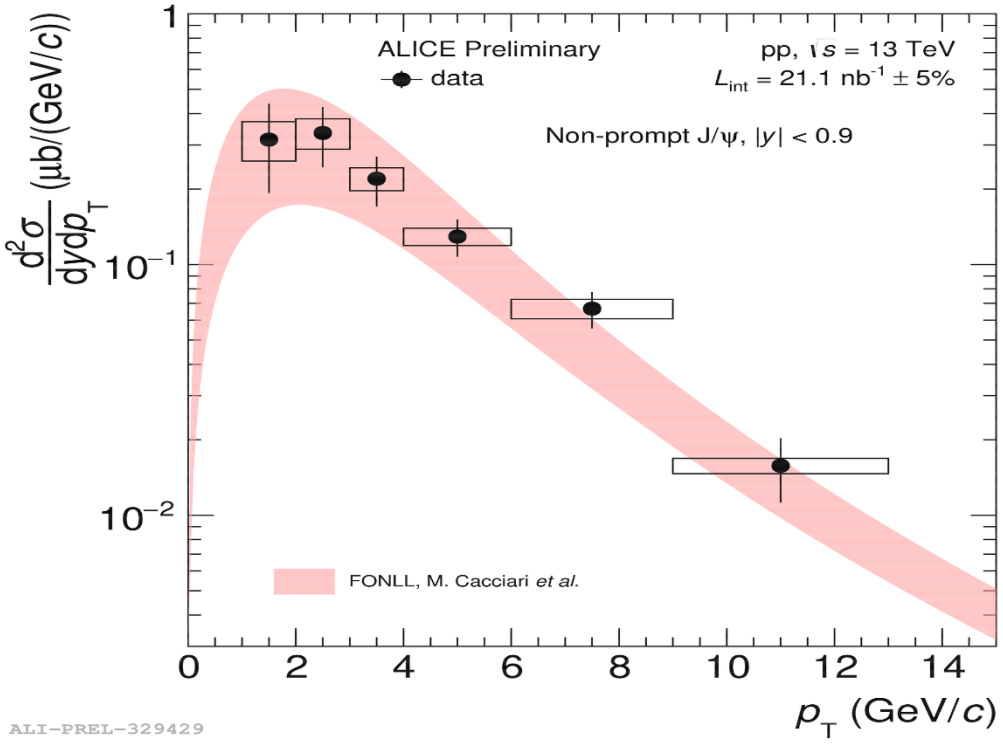
Multi-differential J/Ψ cross section in pp $\sqrt{s}$ = 5.02 TeV at forward-y



- Multi-differential cross section results in p_T and y bins show the change in slope going from high to low p_T
- Serves as a reference for R_{AA} analysis in Pb-Pb collisions

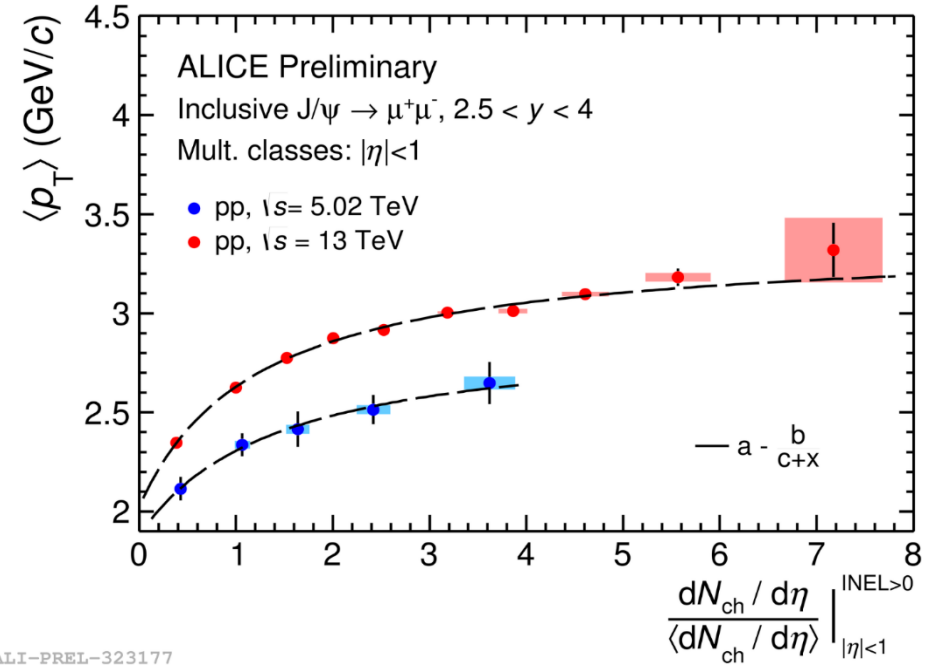
Prompt/non-prompt J/Ψ cross section in pp $\sqrt{s}$ = 13 TeV at mid-y

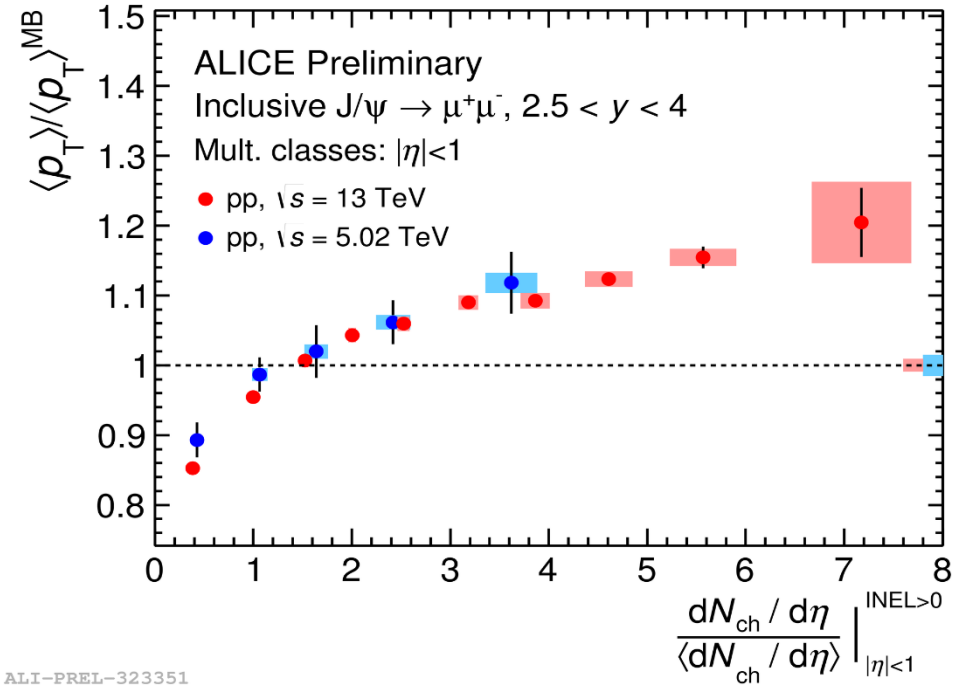




- Theoretical models compared to the data
- NRQCD (+CGC at low p_T describe well the prompt J/Ψ measurements
- FONLL describe well the non-prompt J/Ψ cross section

J/Ψ production vs multiplicity in pp $\sqrt{s}$ = 5.02 and 13 TeV

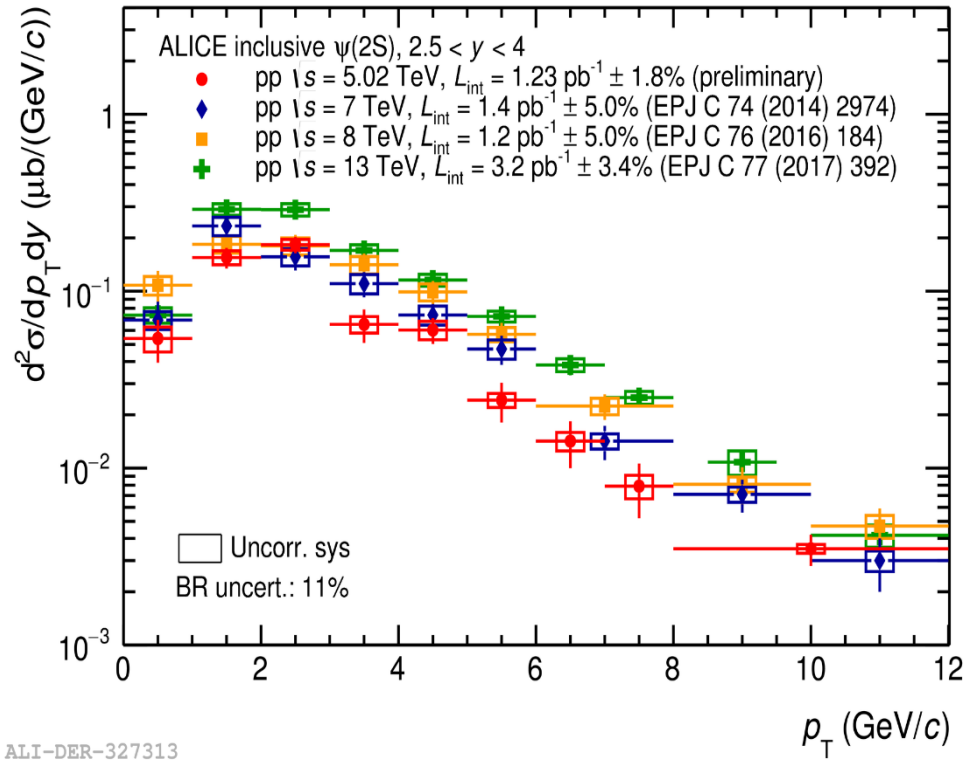


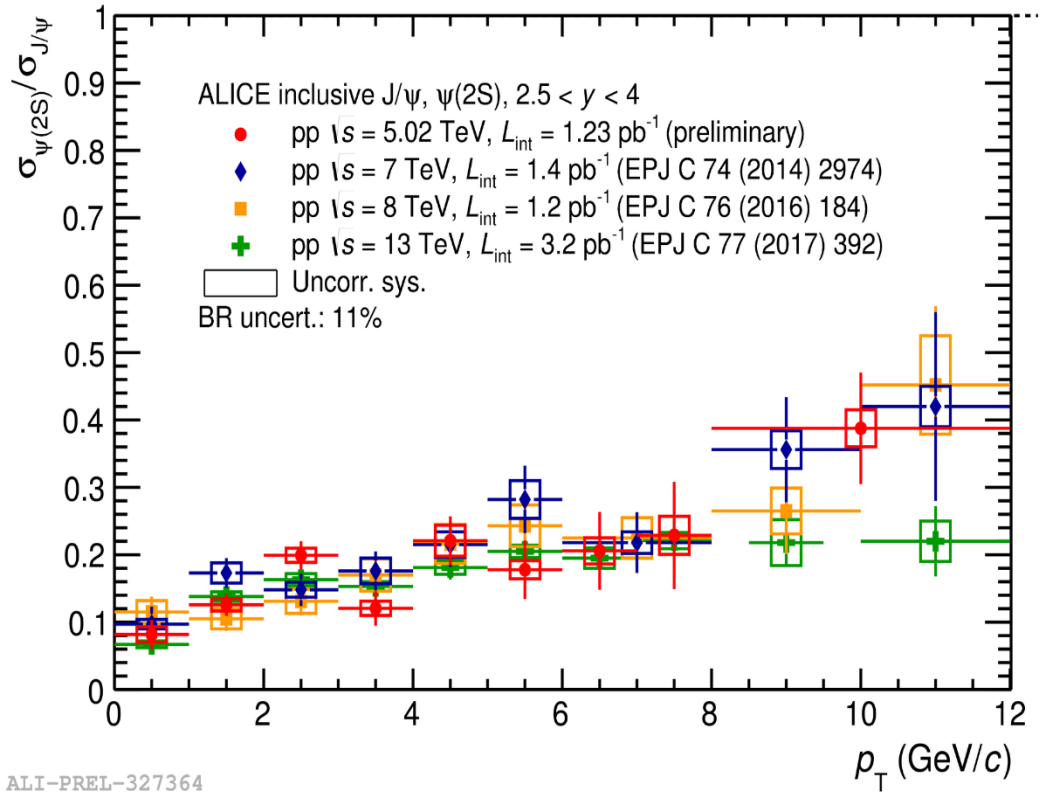


- An increase of $\langle p_T \rangle$ of J/ψ is observed in low multiplicity region, and a saturation towards high multiplicity for both collision energies.
- Relative $\langle p_T \rangle$ is independent of centre-of-mass energy

[POSTER] J/Ψ production as a function of charged-particle multiplicity in pp collisions at √s = 13 TeV at forward rapidity with ALICE at the LHC (Presenter: Thakur, Dhananjaya)

Ψ(2S) cross section in pp $\sqrt{s}$ = 5.02 TeV at forward rapidity





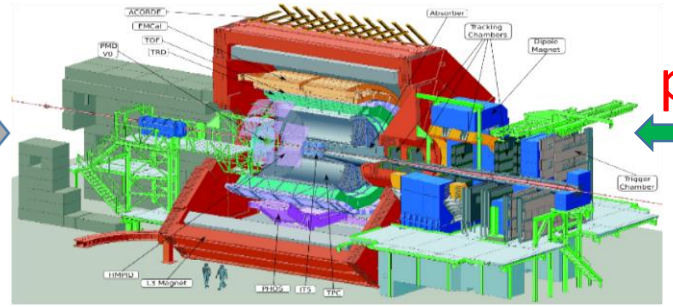
No change in shape or magnitude of the Ψ(2S) to J/Ψ ratio as a function of p_T with collision energies

p-Pb collisions in ALICE

- Why?
  - ✓ To understand cold nuclear matter (CNM) effects such as nuclear parton shadowing, energy loss, comovers absorption
  - ✓ To precisely quantify the role of Quark Gluon Plasma (QGP) in Pb-Pb collisions, disentangling the presence of CNM effects
- Convention: $y > 0$, when muon arm is in the p-going direction
- A rapidity shift of $\Delta y = -0.465$ with two beam configurations

$-4.46 < y_{cms} < -2.96$

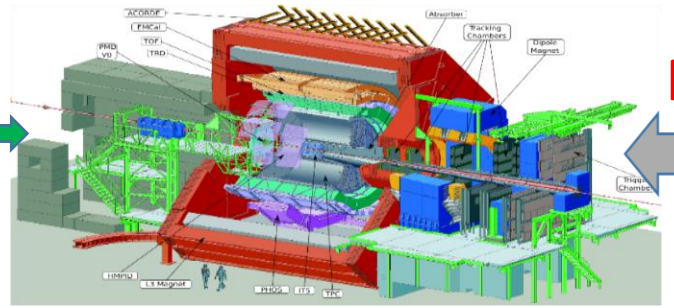
Pb → ← p



Backward-y

$-1.37 < y_{cms} < 0.43$

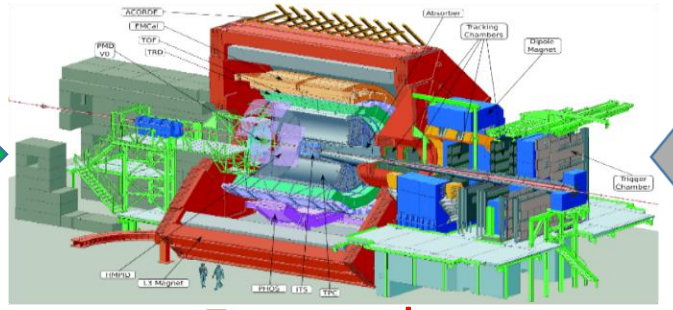
p → ← Pb



Mid-y

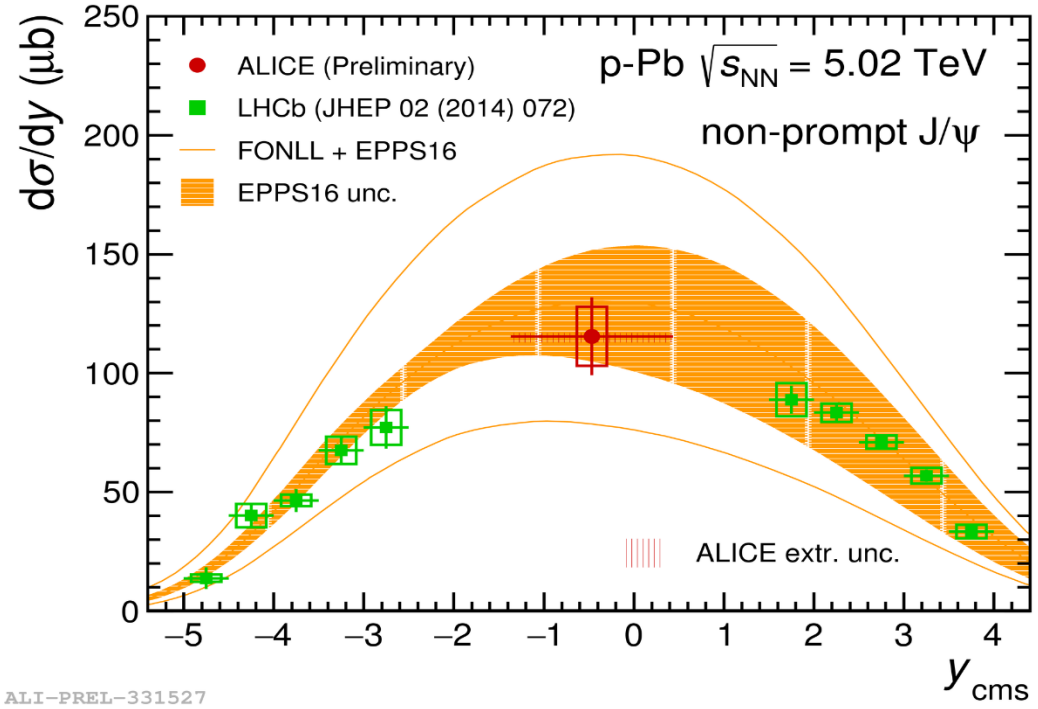
$2.03 < y_{cms} < 3.53$

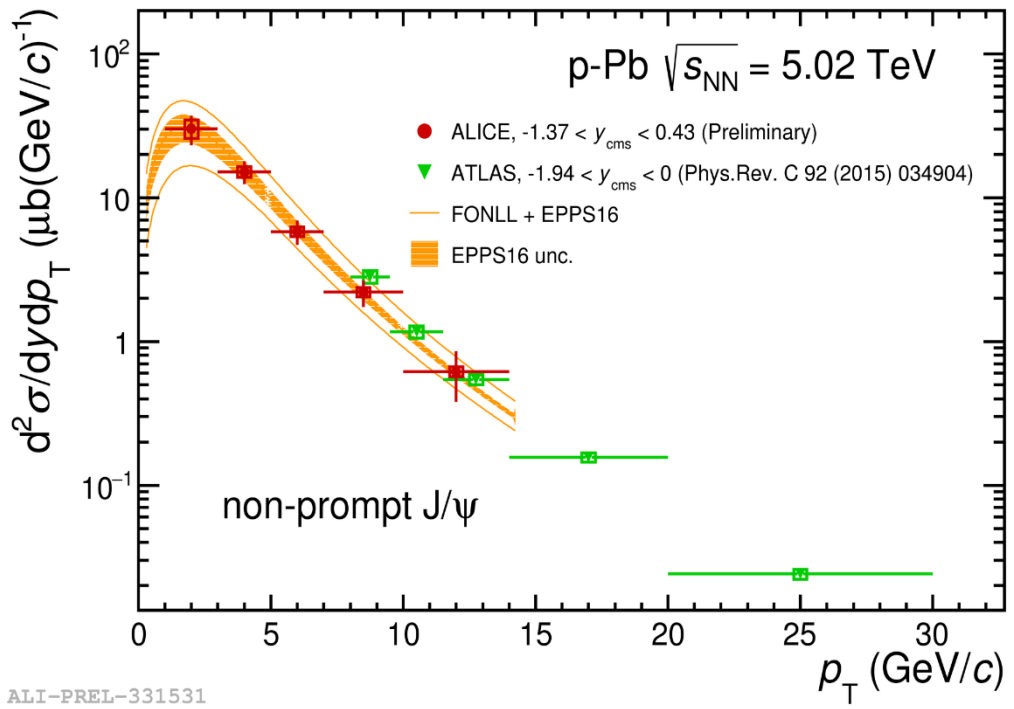
p → ← Pb



Forward-y

Non-prompt J/ψ cross section in p-Pb $\sqrt{s_{NN}}$ = 5.02 TeV at mid-y

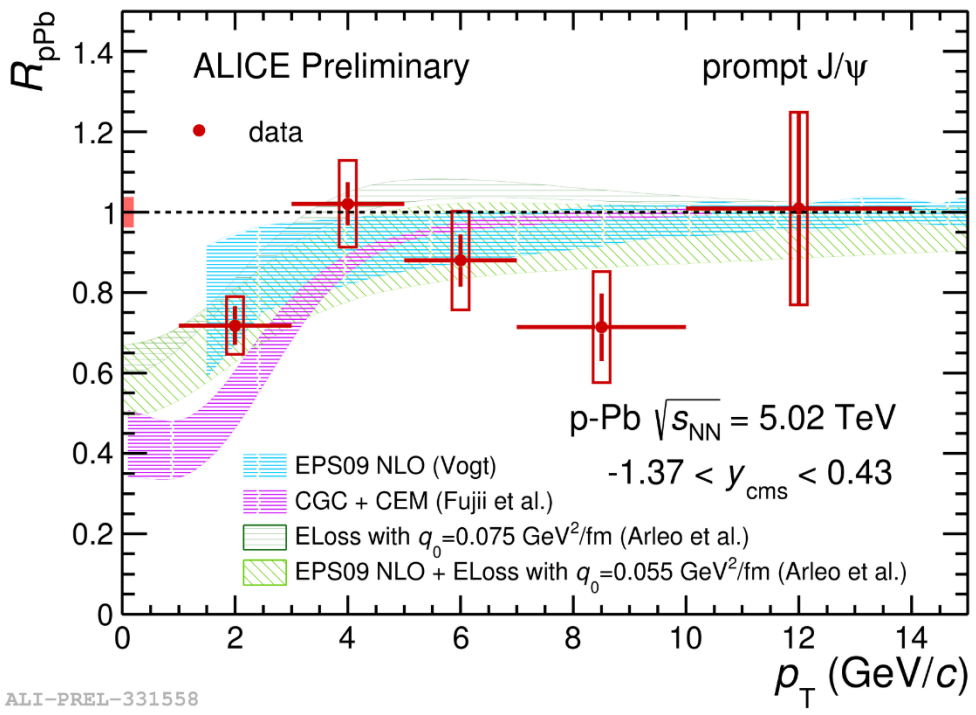


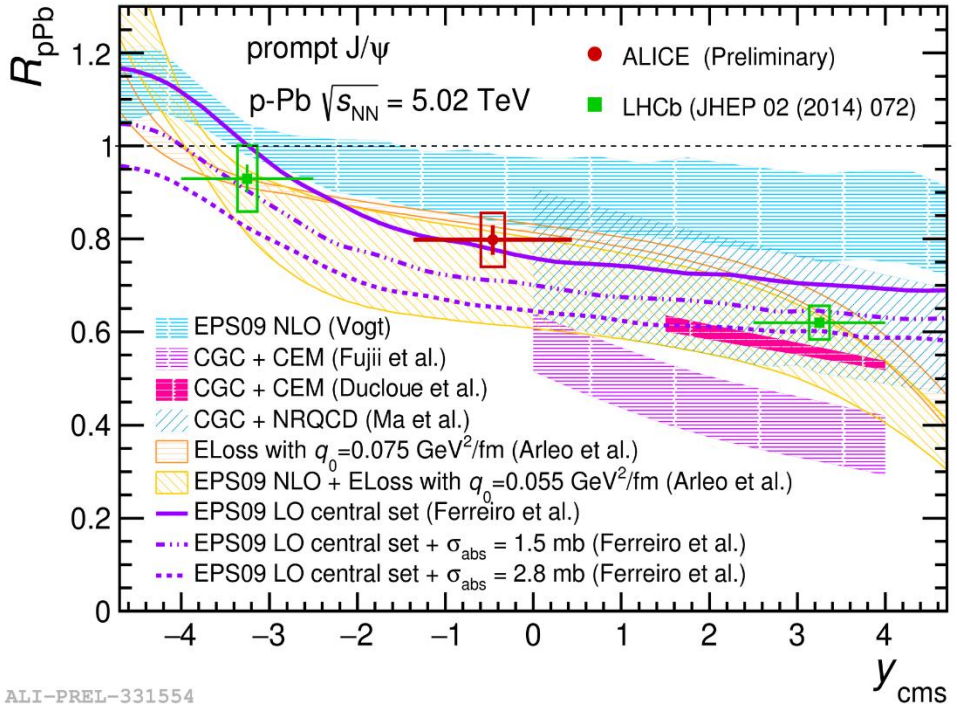


- Complementary results between two experiments
- Comparison with EPPS16 and FONLL. The total theoretical uncertainties on the production cross section, dominated by those of the b-quark mass and the QCD factorisation and renormalisation scales, are larger than the experimental uncertainties at low p_T, preventing to draw conclusions on the presence of nuclear effects for this observable.

Prompt J/Ψ R_{pPb} in p-Pb $\sqrt{s_{NN}}$ = 5.02 TeV (p_T > 1 GeV/c)

Complements observations by other LHC experiments

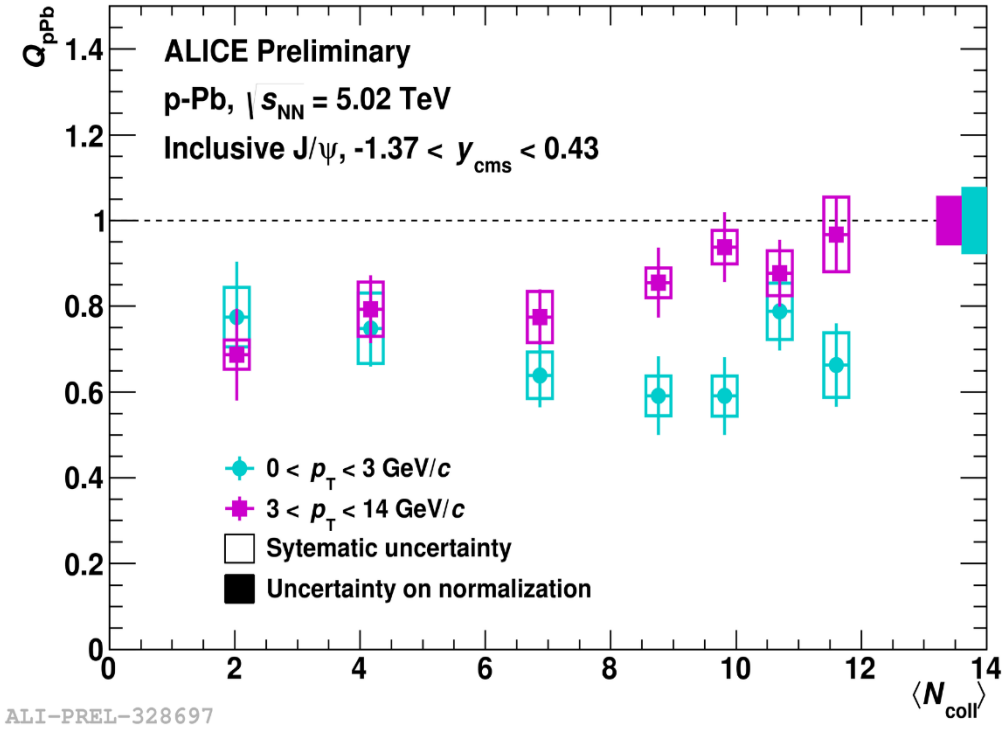




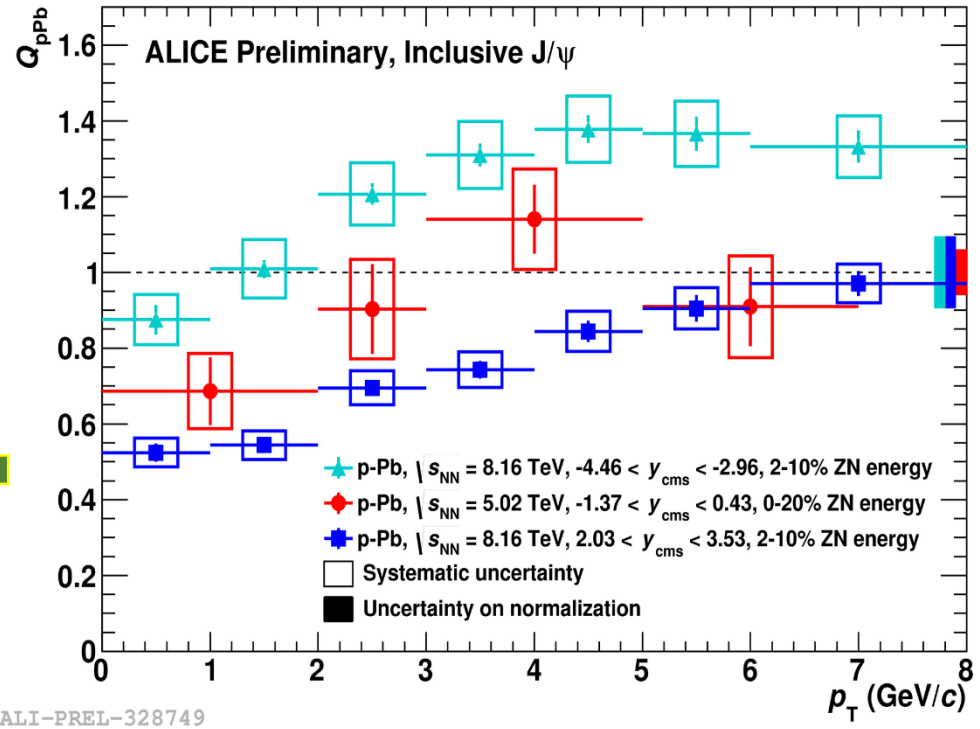
Prompt J/Ψ suppression is observed at p_T < 3 GeV/c, while it approaches to unity at high p_T

The data closely matches with the theory within uncertainties

Q_{pPb} of J/ψ in p-Pb $\sqrt{s_{NN}}$ = 5.02 TeV at mid-y



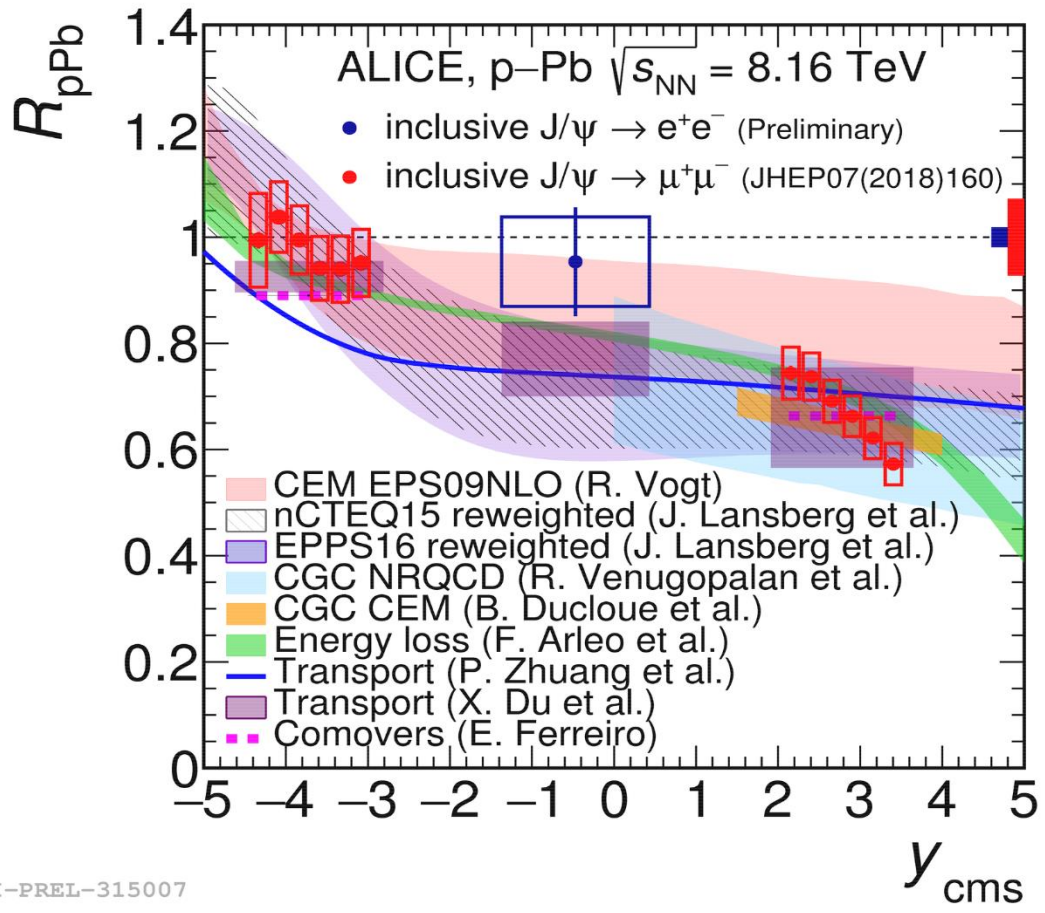
Increase of J/ψ Q_{pPb} is seen at intermediate p_T for higher $\langle N_{coll} \rangle$

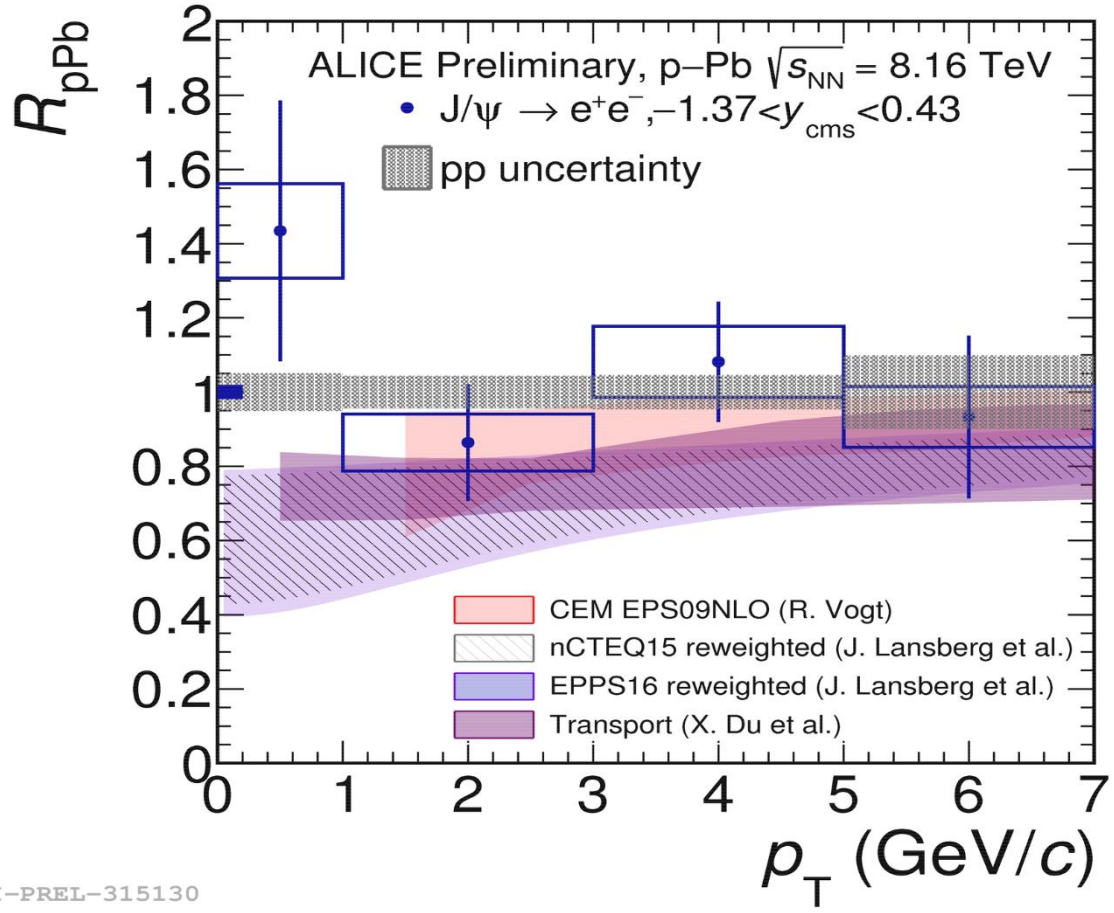


Evolution of the trend of Q_{pPb} vs p_T with rapidity

[POSTER] J/Ψ production at mid-rapidity in p-Pb collisions with the ALICE detector (Presenter: Hayashi, Shinichi)

J/ψ cross section in p-Pb $\sqrt{s_{NN}}$ = 8.16 TeV at mid-*y*

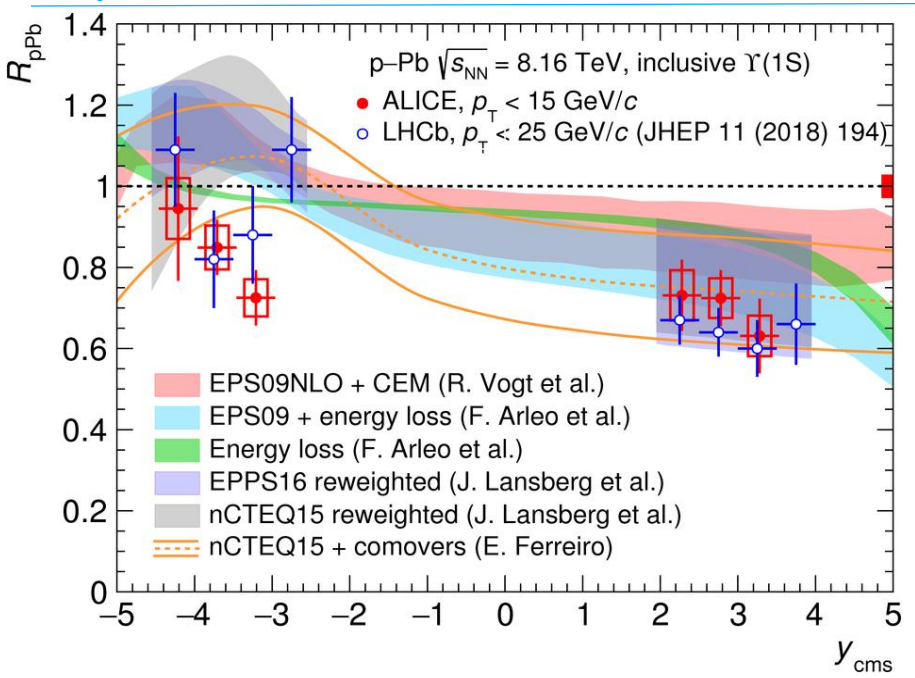




- Data compared with several models and forward-*y* measurement
- R_{pPb} vs *y* matches with CEM prediction, but it is underestimated by other models

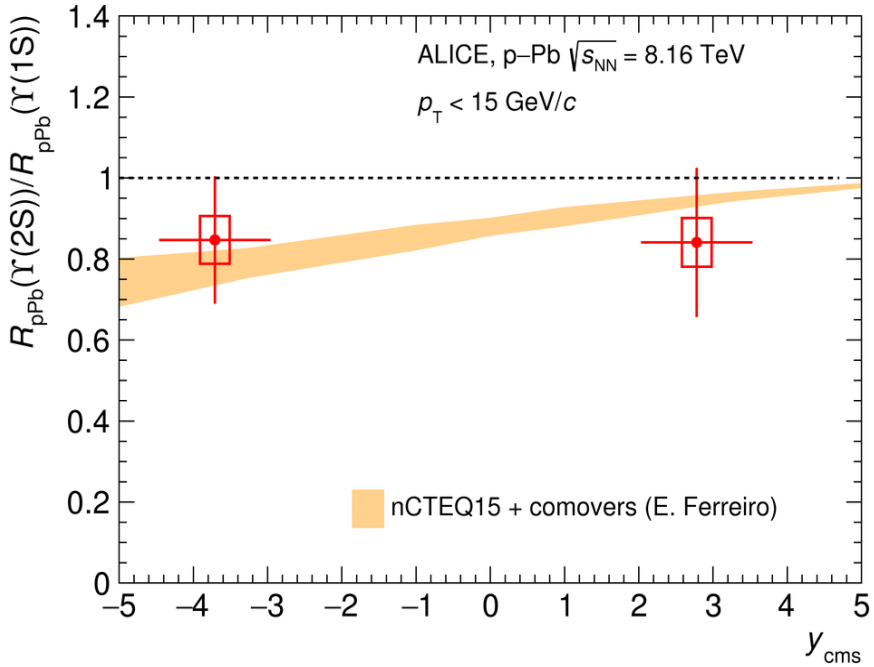
R_{pPb} of ϒ(1S) in p-Pb $\sqrt{s_{NN}}$ = 8.16 TeV at forward-y

arxiv:1910.14405



The shadowing calculations describe fairly well the y_{cms} dependence of the at forward-y, while they slightly overestimate the results at backward-y

In this ratio, the shadowing contribution and other theoretical uncertainties cancel out. So, the shape of the theoretical curve is driven by the interactions with the comoving particles, which affect mostly ϒ(2S) at backward-y



Conclusion

pp

- J/Ψ
  - $\langle p_T \rangle$ shows saturation towards high multiplicity
  - Cross section in pp collisions at 5.02 and 13 TeV compared to several models
- Ψ(2S)
  - Cross section ratio of two resonance states at 5.02 TeV

p-Pb

- J/Ψ
  - (Non)prompt cross section described well by models
  - Increase of J/ψ Q_{pPb} is seen at intermediate p_T for higher $\langle N_{\mathrm{coll}} \rangle$
- ϒ(1S), ϒ(2S)
  - R_{pPb} is slightly overestimated by models at backward-*y*, whereas it is well described at forward-*y*