

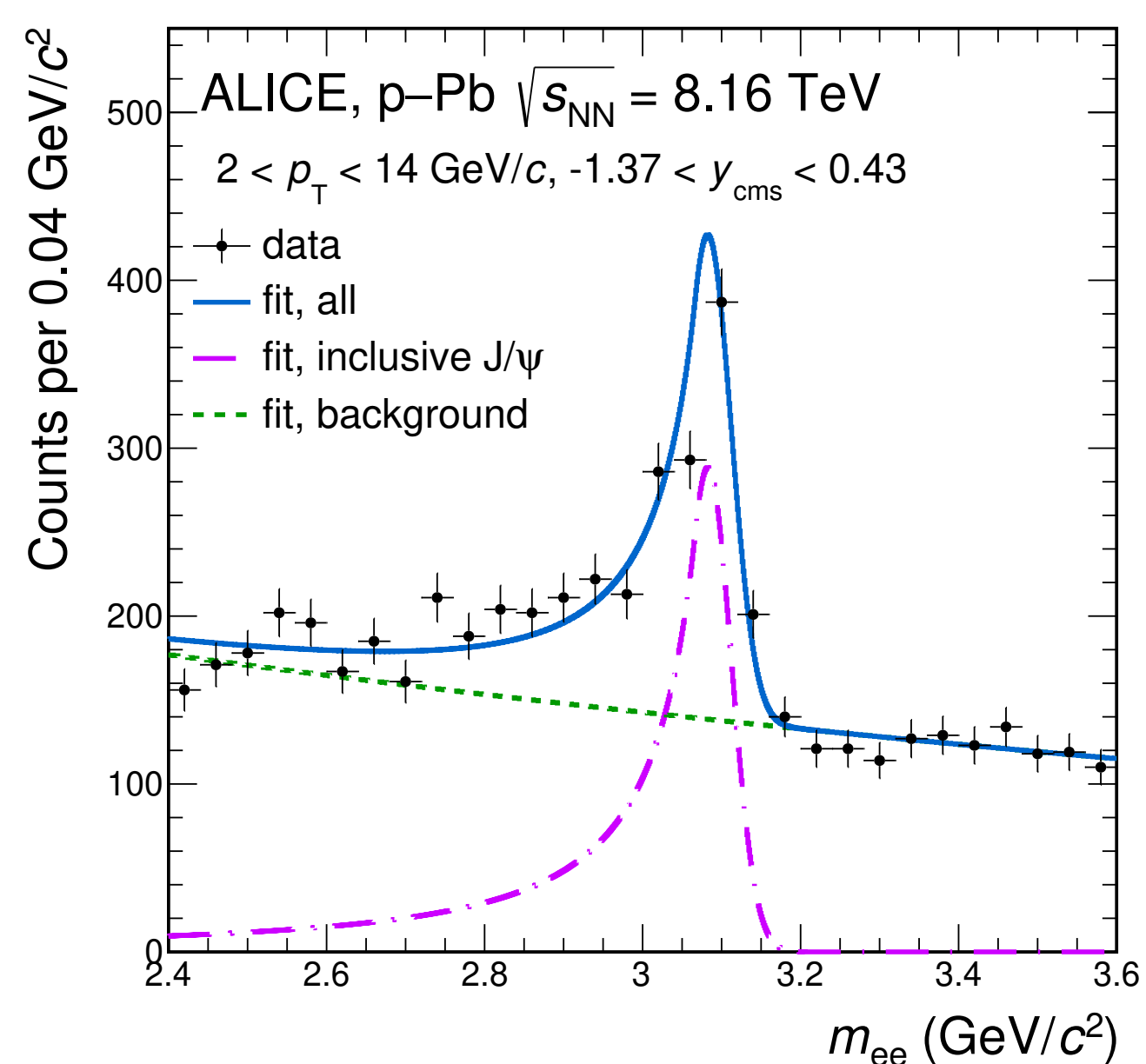
Introduction

Quarkonium production in small systems:

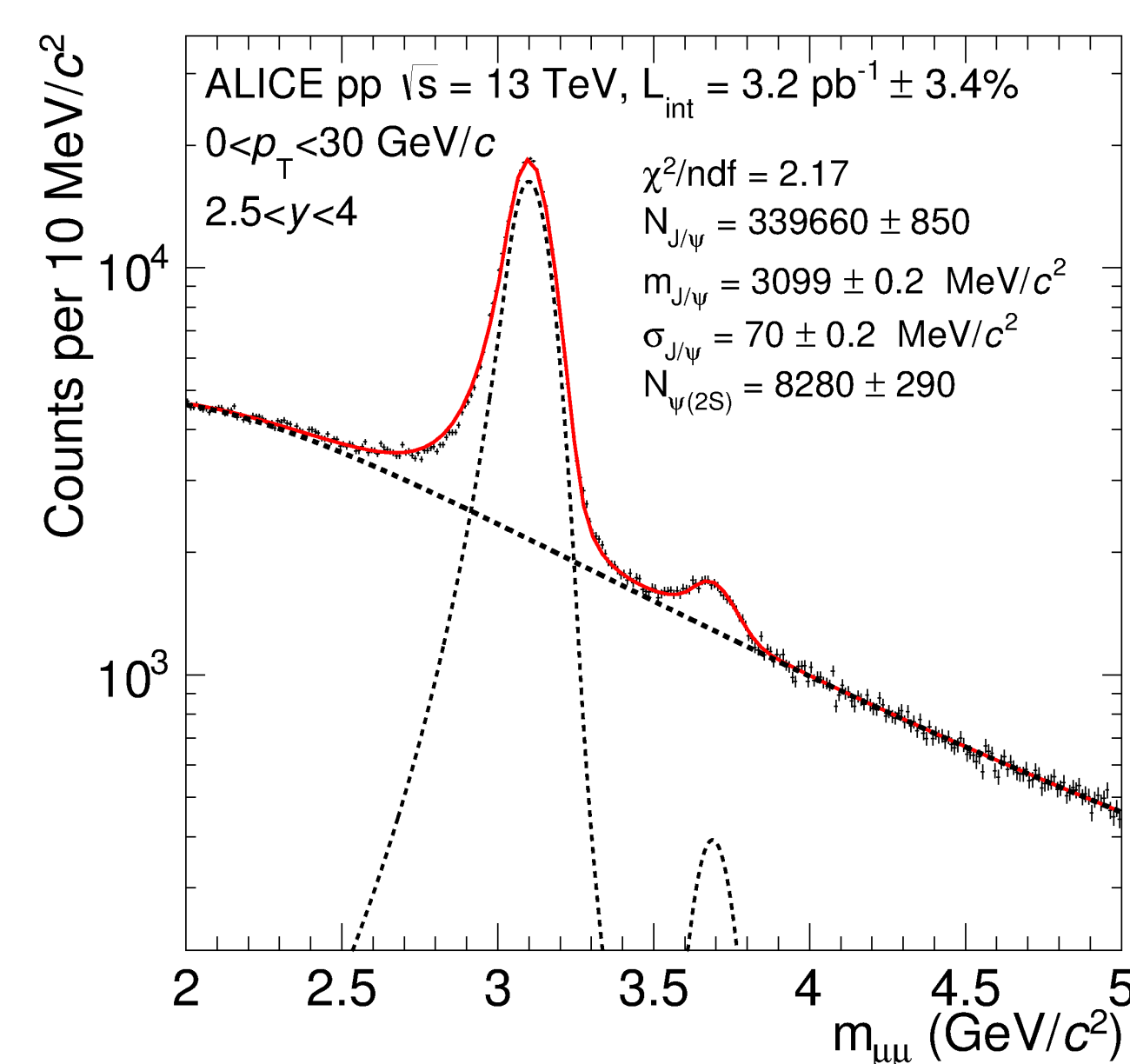
- Collective-like behaviour observed in high multiplicity events:
→ Does J/ψ exhibit flow in pp collisions?
- J/ψ as a function of charged particle multiplicity: investigate relation between hard (J/ψ) and soft (multiplicity) event components
- Quarkonium production mechanisms are not fully understood
 - Tests perturbative (heavy quark production in initial hard scattering) and non-perturbative (binding into quarkonia) QCD regimes
- Reference for the quarkonium production in Pb–Pb collisions (J/ψ suppression, (re)generation and flow) and p–Pb collisions (Cold Nuclear Matter effects)

Quarkonium signal extraction

Midrapidity:¹ ($J/\psi \rightarrow e^+e^-$)

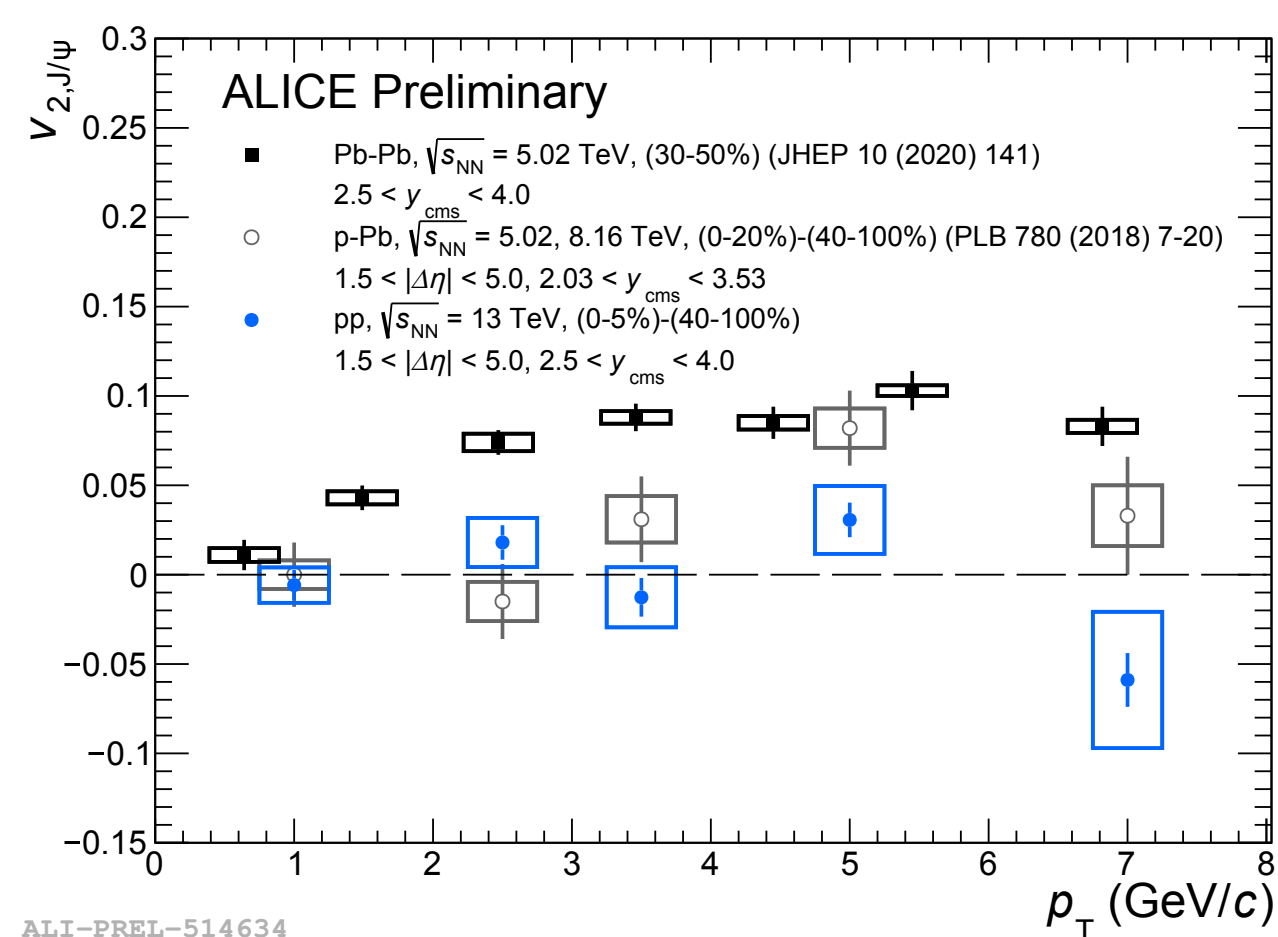


Forward rapidity:² ($J/\psi, \psi(2S)$ and $\Upsilon(nS) \rightarrow \mu^+\mu^-$)



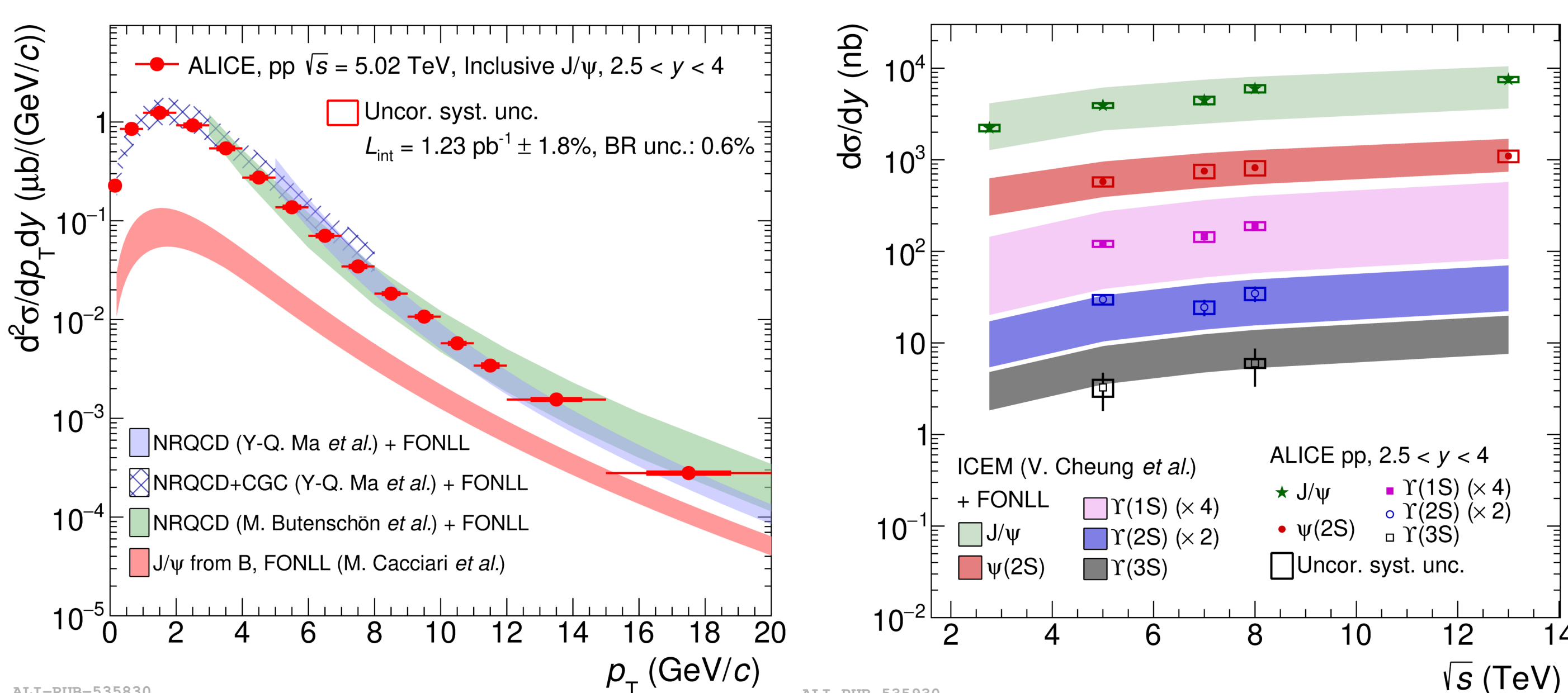
- Quarkonia yields are extracted by fit to (binned) invariant mass spectrum
- Non-prompt fraction is extracted at midrapidity by simultaneous fit of the invariant mass and pseudoproper decay length distribution

J/ψ elliptic flow at forward rapidity in pp at 13 TeV



- Motivation:** Collective-like behaviour has been observed in high-multiplicity ("central") pp collisions
- Results:** J/ψ v_2 in high-multiplicity pp collisions at 13 TeV is compatible with zero
⇒ J/ψ does not seem to exhibit flow

Quarkonium production at forward rapidity in pp at 5 TeV

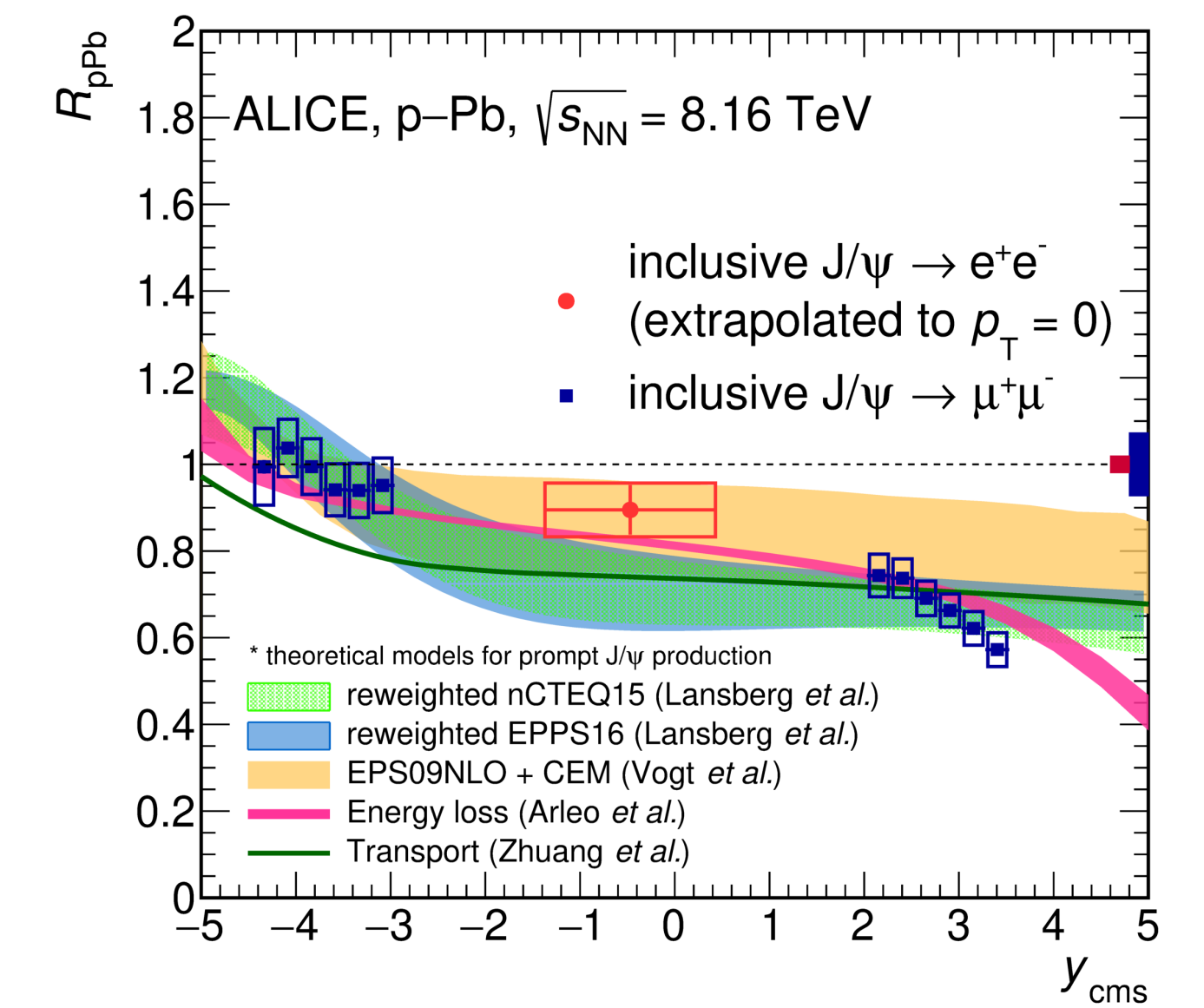


- y and p_T differential and energy dependent charmonium (bottomonium) cross sections², as well as the $\psi(2S)$ to J/ψ ratios, overall well described by NRQCD based^{3,4,5} and/or ICEM⁶ models, across different collision energies
- Ratios of charmonium cross sections** at different collision energies only partly described by the same models
- Relatively large model uncertainties for y differential and p_T differential $\Upsilon(1S)$ cross sections (not shown)

J/ψ production at midrapidity in p–Pb at 8.16 TeV

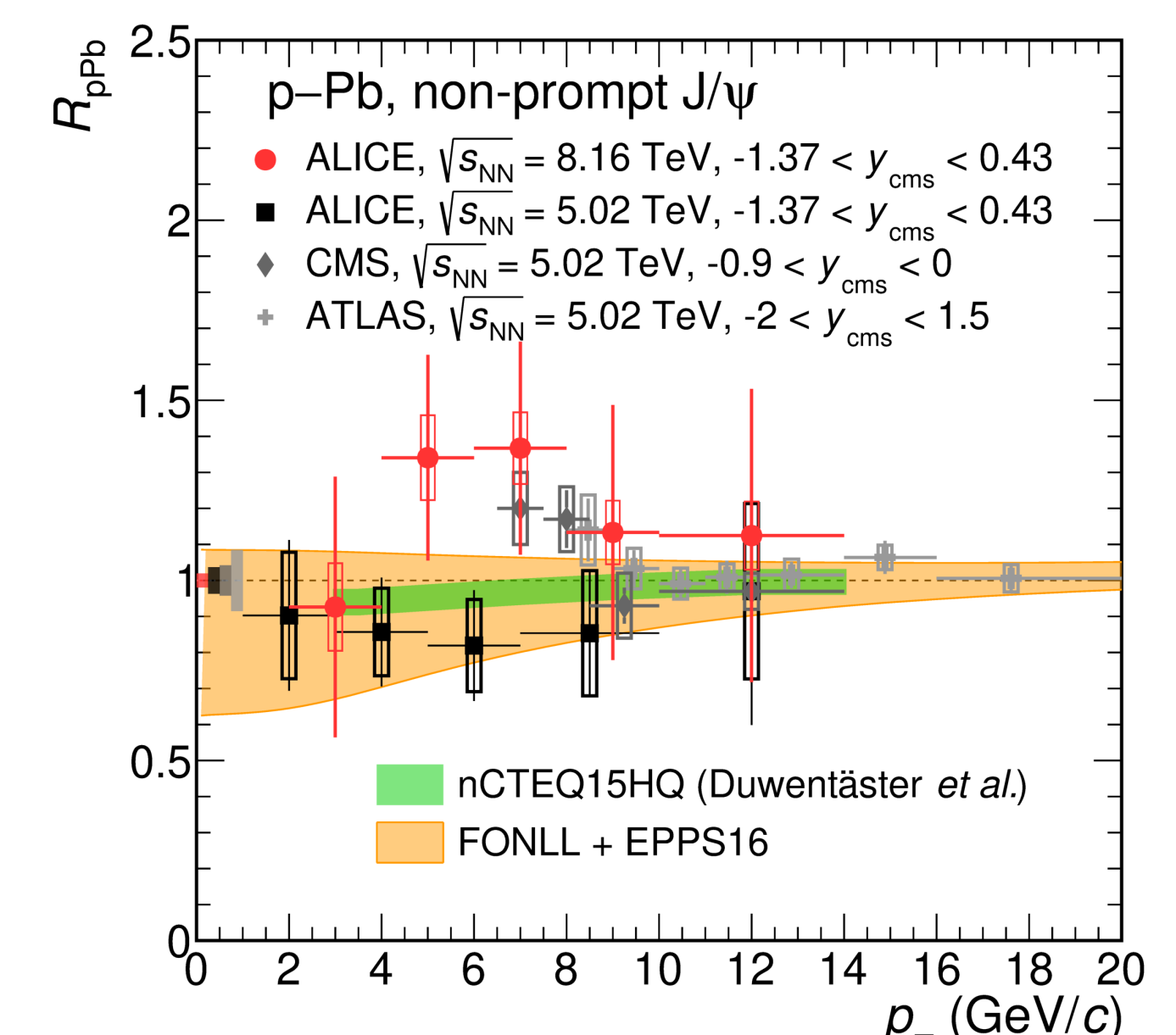
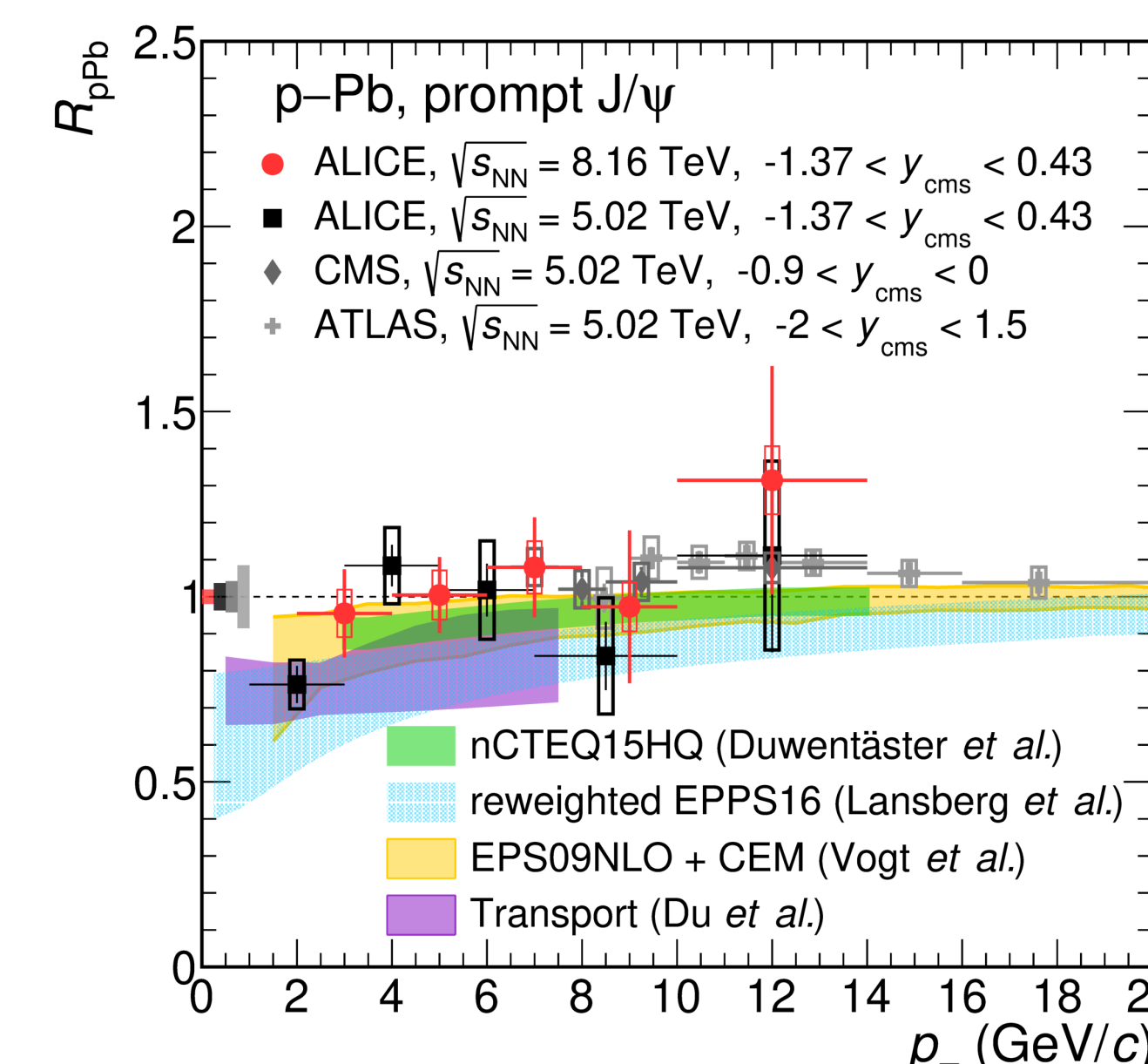
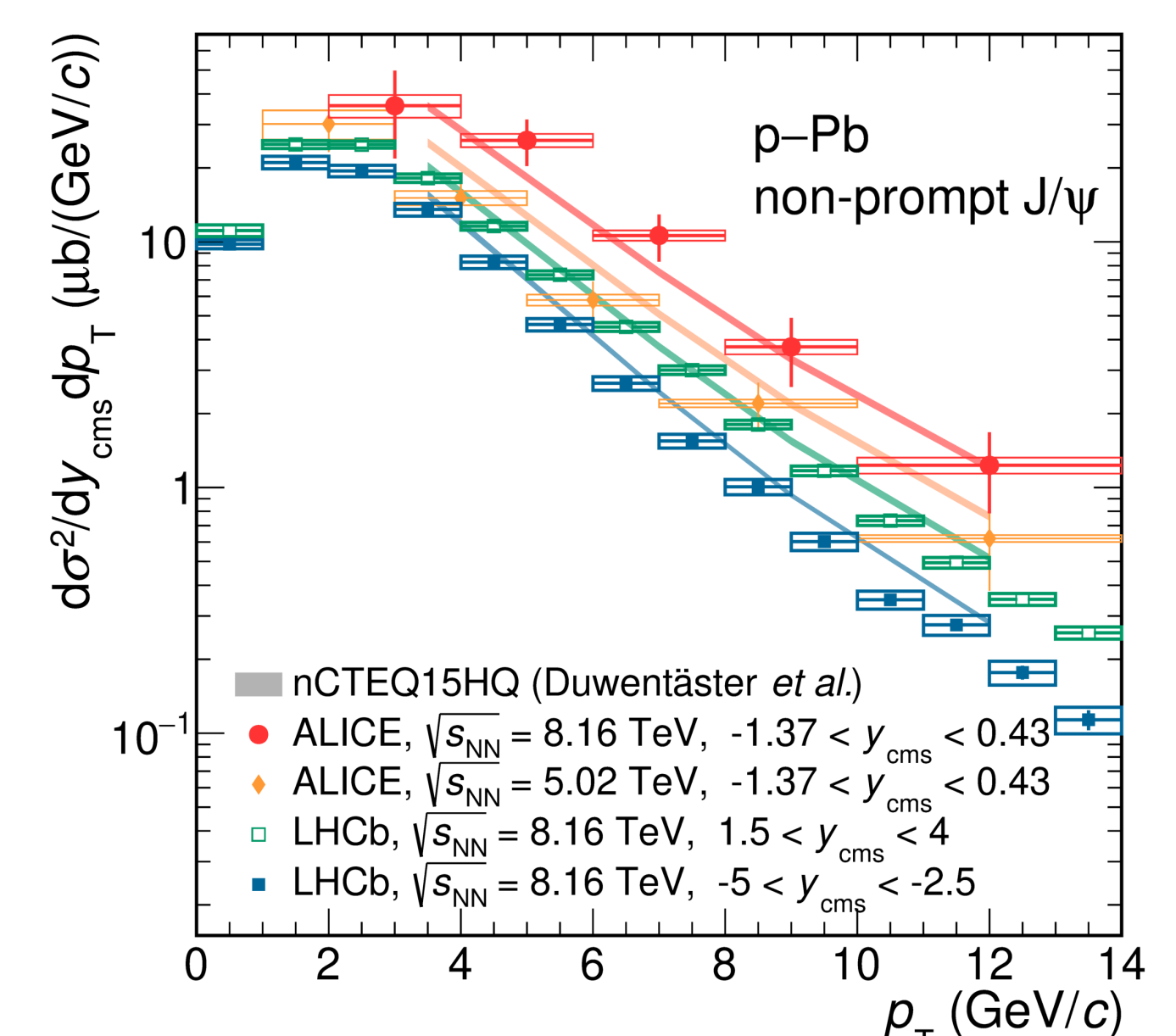
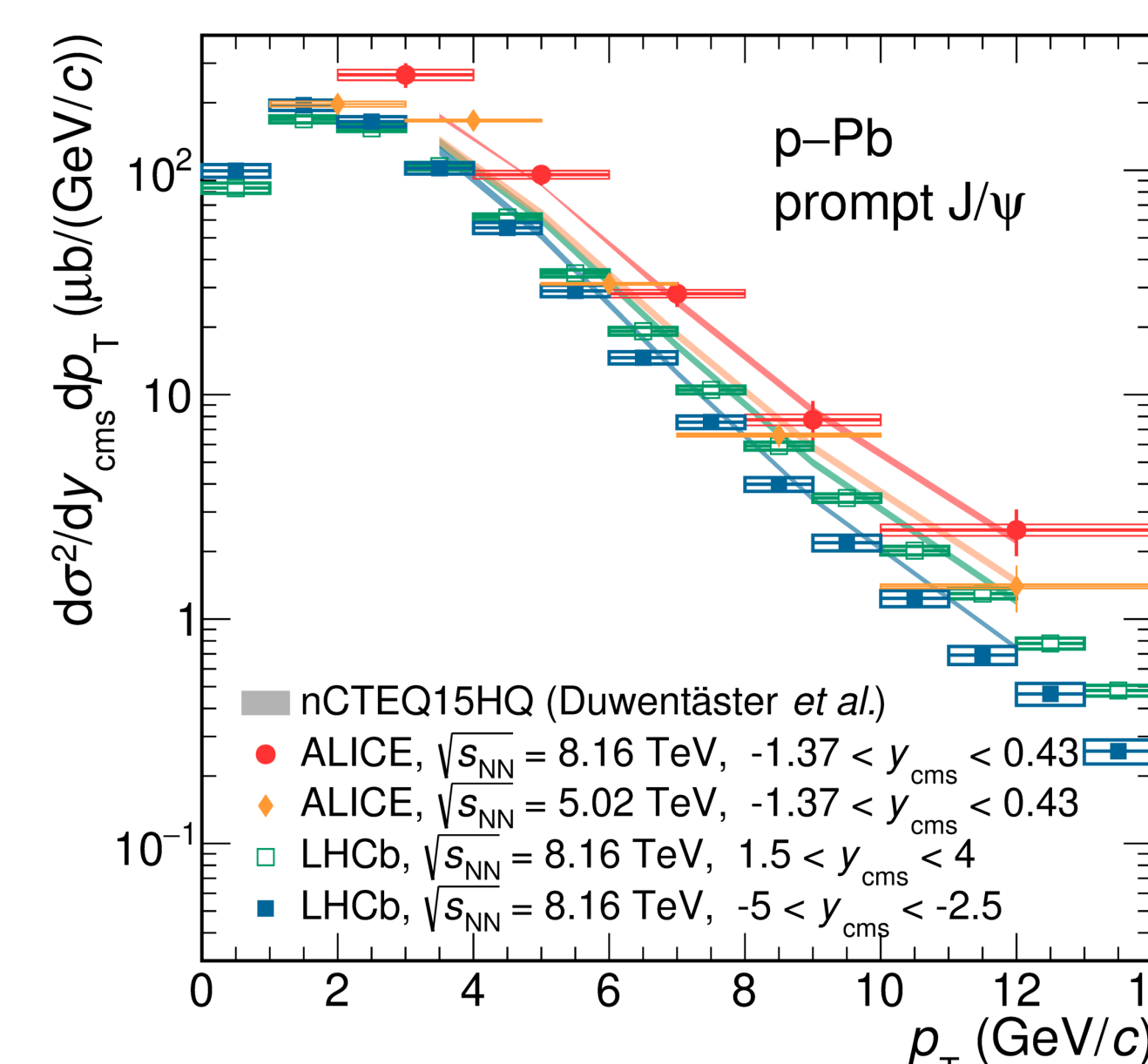
Inclusive J/ψ production:¹

- y -dependent R_{pPb} :
 - Overall trend described by all models
 - R_{pPb} at midrapidity tends to be above or at upper limits of model predictions
 - Transport model (including final-state effects) underestimates R_{pPb} at backward and midrapidity
- J/ψ cross section (extrapolated to $p_T = 0$):
 $1409 \pm 89(\text{stat.}) \pm 84(\text{syst.}) \mu\text{b}$



Prompt and non-prompt J/ψ production:

- The measured cross section and R_{pPb} well described by calculations based on nCTEQ15HQ nPDFs⁷
- R_{pPb} of prompt J/ψ described by CEM based calculations⁸ and transport model⁹ in applicability range at low p_T
- FONLL+EPPS16 predictions¹⁰ for R_{pPb} of non-prompt J/ψ agree with data within uncertainties, which get larger for smaller p_T
- R_{pPb} compatible with unity within uncertainties ($p_T > 2 \text{ GeV}/c$)



Summary

J/ψ production at midrapidity in p–Pb at 8.16 TeV:

- p_T -integrated nuclear modification factor of J/ψ in p–Pb collisions lies between forward and backward rapidity, as predicted qualitatively by models
- J/ψ shows moderate cold nuclear matter effects in the studied p_T and rapidity range

Quarkonium at forward rapidity in pp:

- J/ψ does not seem to exhibit flow (in contrast to p–Pb and Pb–Pb collisions)
- y and p_T differential quarkonium cross sections, $\psi(2S)$ to J/ψ ratios overall well described by NRQCD based or ICEM models
- Outlook:**
Differential measurements of the $\Upsilon(nS)$ states in pp at 13 TeV in preparation

References

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- [10] FONLL+EPPS16 (Eskola, Paakkinen, Paukkunen, Salgado), Eur. Phys. J. C 77 (2017) 163