Quarkonia as probes of initial and final states in small systems with ALICE

Graduiertenkolleg 2149 Research Training Group

ALICE

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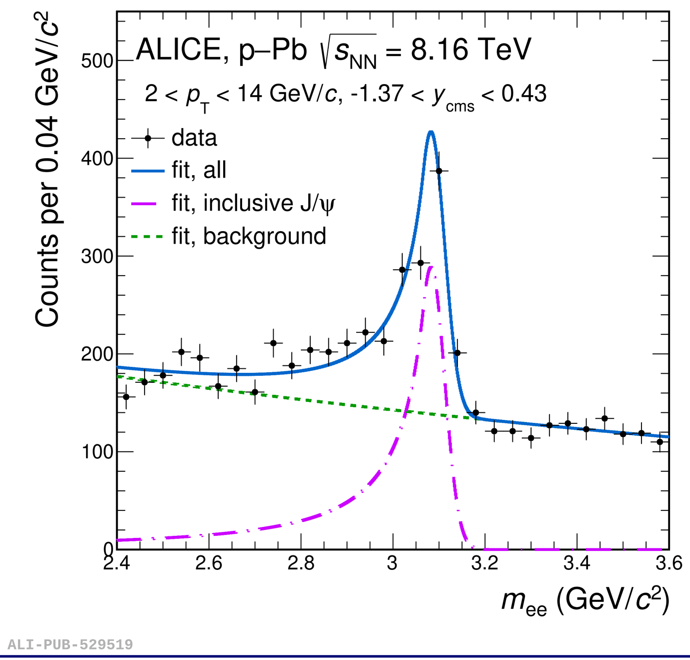
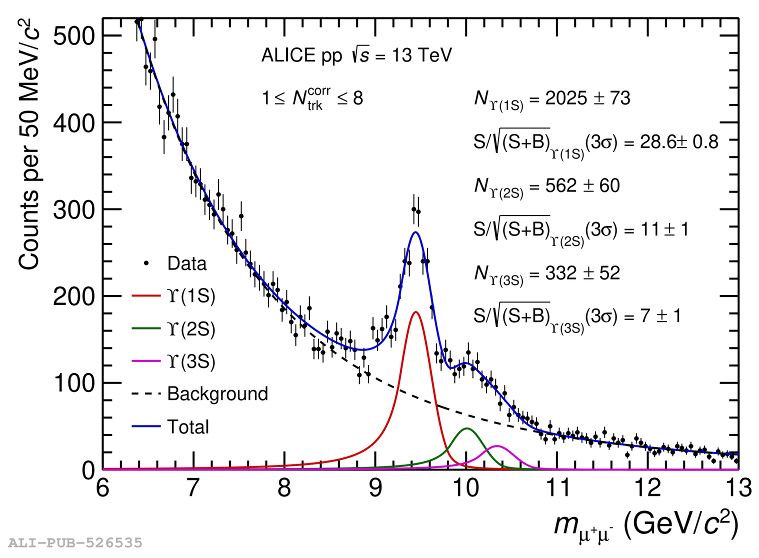
Motivations

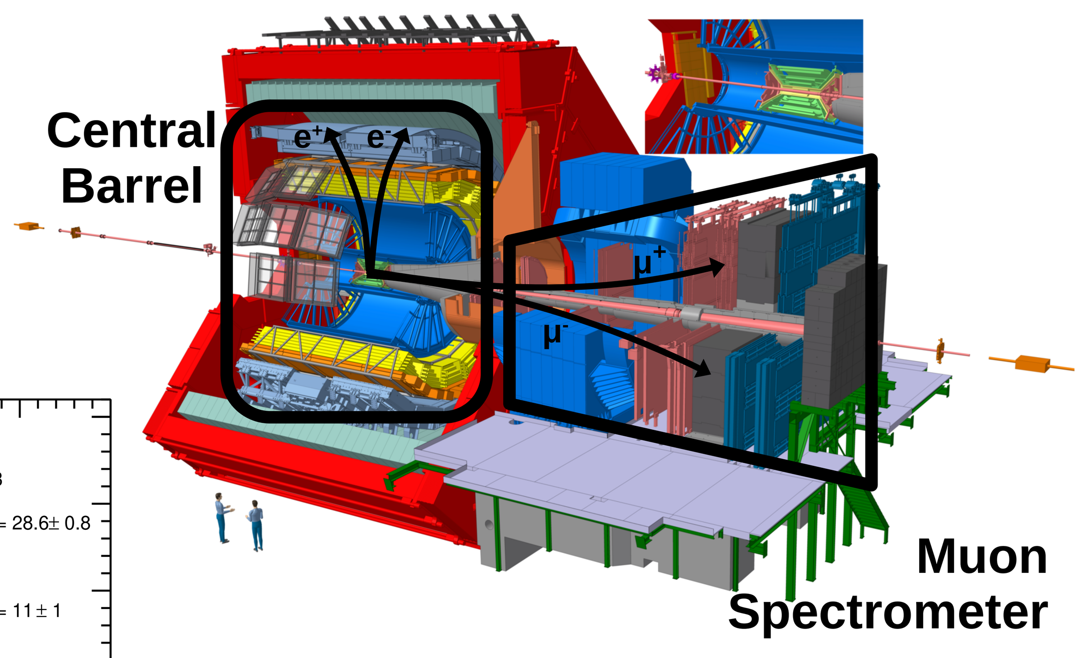
- Collective-like features seen in small systems (pp, p–Pb) at high charged-particle multiplicity density
- Quarkonium production sensitive to hard component of particle production, especially for:
  - Initial states effects inside the colliding protons/Pb (Multiple Partonic Interactions, Color Glass Condensate, Cold Nuclear Matter effects...)
  - Final states effects (modifications in a medium or high string density environment)
- Charged-particle multiplicity sensitive to its soft component → correlating quarkonium and multiplicity to study differences and interplay between hard and soft components

Quarkonium measurements in ALICE (Run 1 & 2) [1]

- $J/\psi \to e^+e^-$ at midrapidity ($|y_{lab}| < 0.9$) in central barrel (left, [2])
- J/ψ, $\psi(2S)$, $\Upsilon(nS) \to \mu^+\mu^-$ at forward rapidity ($2.5 < y_{lab} < 4$) in muon spectrometer (right, [3])







- Prompt and non-prompt components extracted at midrapidity from 2D likelihood fit, considering mass and pseudo-proper decay time

J/ψ pair production at forward rapidity in pp at 13 TeV [4]

- Gives insight into Double Parton Scattering, as well as J/ψ production mechanisms
- Results compatible with previous LHCb measurement [5]:

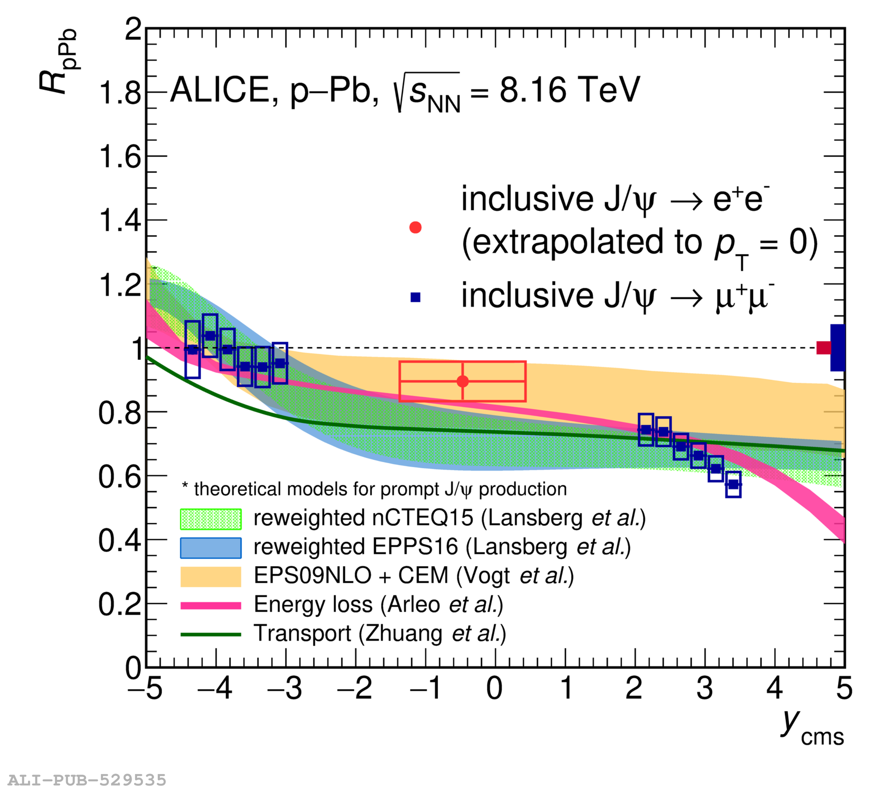
$$\sigma(J/\psi J/\psi) = 10.3 \pm 2.3\ \text{(stat.)} \pm 1.3\ \text{(syst.)}\ \text{nb}$$

$$\frac{1}{2}\frac{\sigma(J/\psi)^2}{\sigma(J/\psi J/\psi)} = 6.2 \pm 1.4\ \text{(stat.)} \pm 1.1\ \text{(syst.)}\ \text{mb}$$

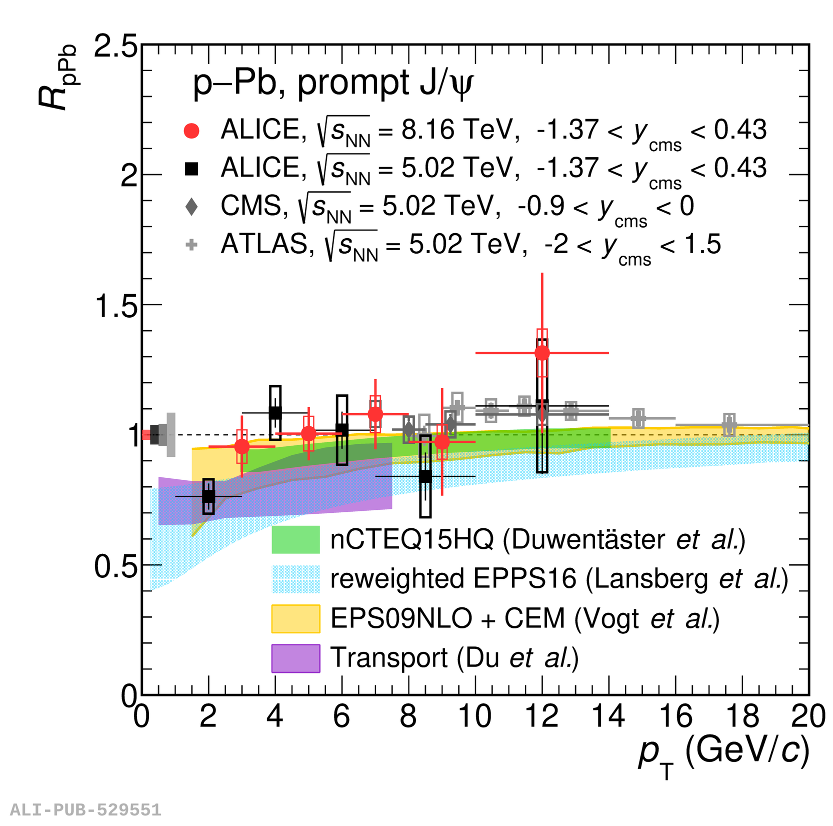
J/ψ production at midrapidity in p–Pb at 8.16 TeV [2]

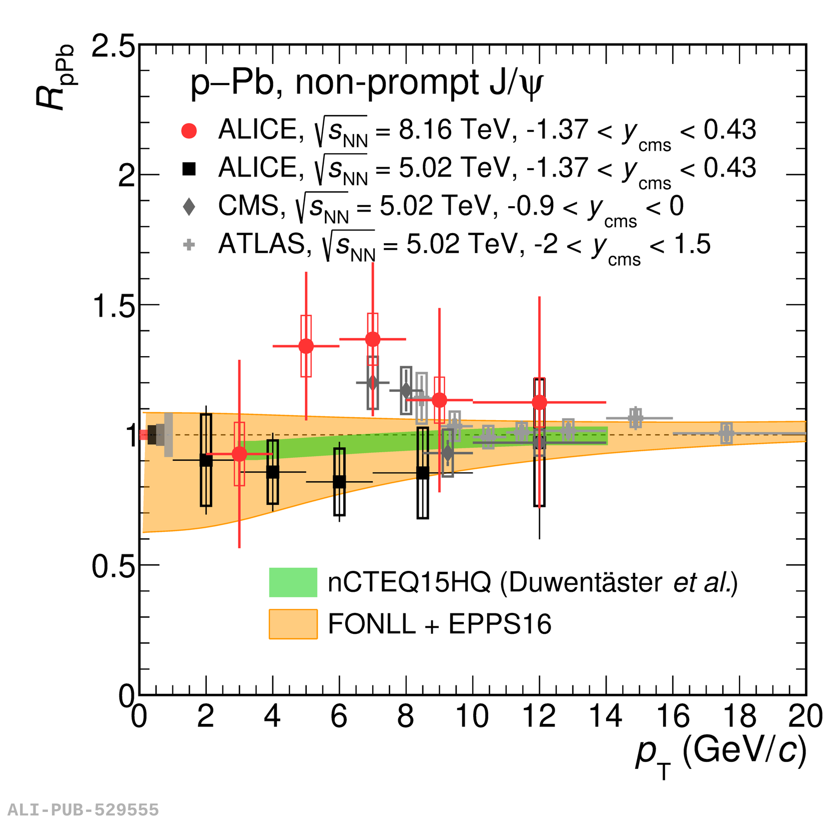
- Nuclear modification factor R_{pA} used to quantify Cold Nuclear Matter effects (parton shadowing, gluon saturation...):

$$R_{pA} = \frac{d^2\sigma^{pA}_{J/\psi}/dy\,dp_T}{A \times d^2\sigma^{pp}_{J/\psi}/dy\,dp_T}$$



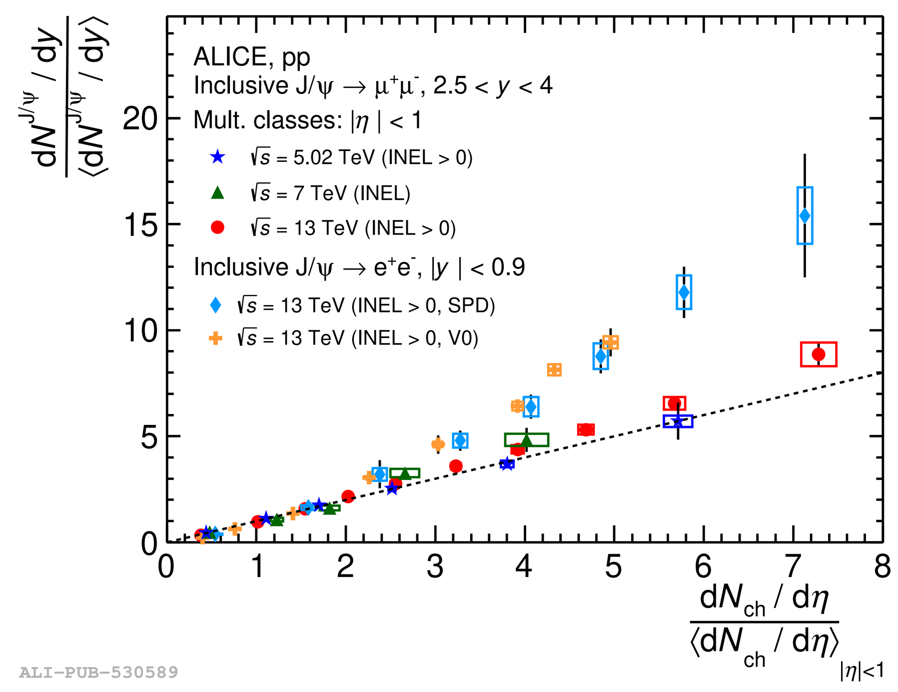
- **Rapidity-dependent inclusive J/ψ R_{pPb}:**
  - R_{pPb} smaller at forward rapidity (p-going) due to gluon shadowing inside Pb nuclei
  - All models except energy loss model [6] include nuclear shadowing from different nuclear Parton Distribution Functions [7,8]
  - Energy loss [6] and transport model [9] include final-state effects
  - Trend well described by all models
- **Prompt and non-prompt p_T-differential J/ψ R_{pPb}:**
  - R_{pPb} consistent with unity, but with a small drop at low p_T for prompt J/ψ, well described by all models within uncertainties



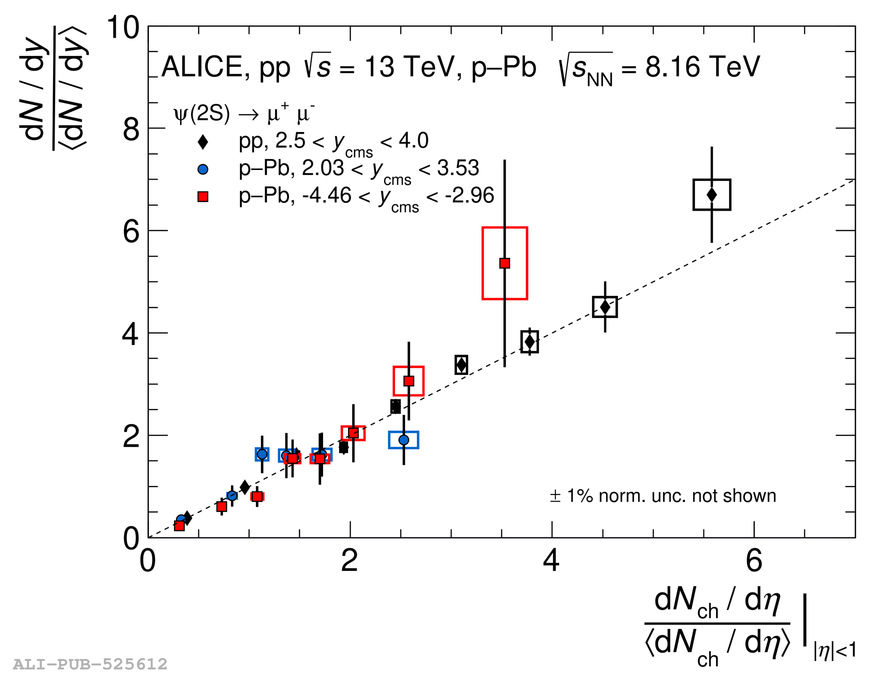


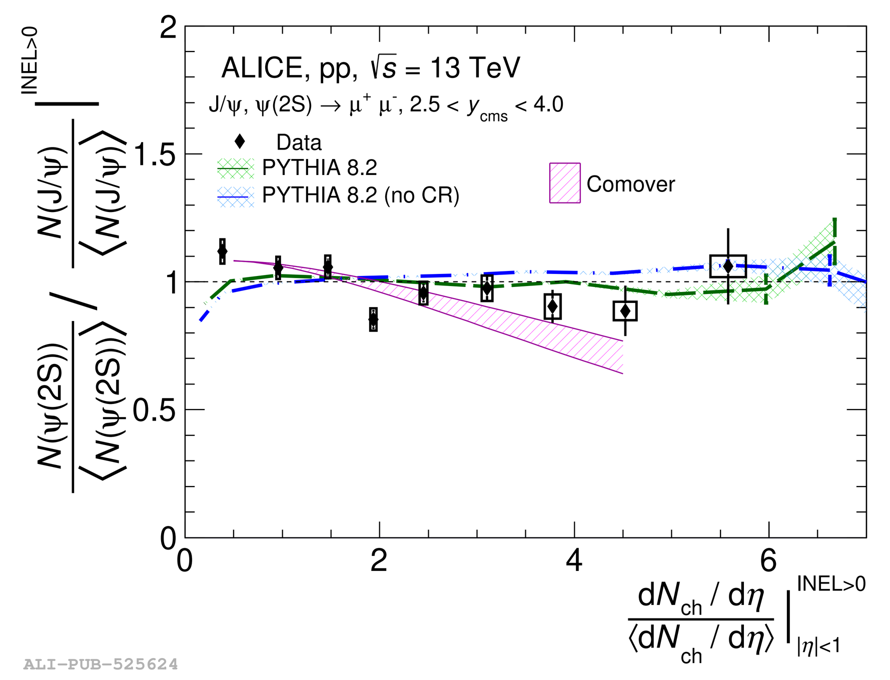
Multiplicity-dependent quarkonium production in pp and p–Pb

- **Forward [10] and midrapidity [11] J/ψ production as a function of charged-particle multiplicity in pp collisions:**
  - Multiplicity (measured at midrapidity) and quarkonium yields normalized to their average values
  - Forward rapidity: increase close to linear
  - Midrapidity: increase stronger than linear

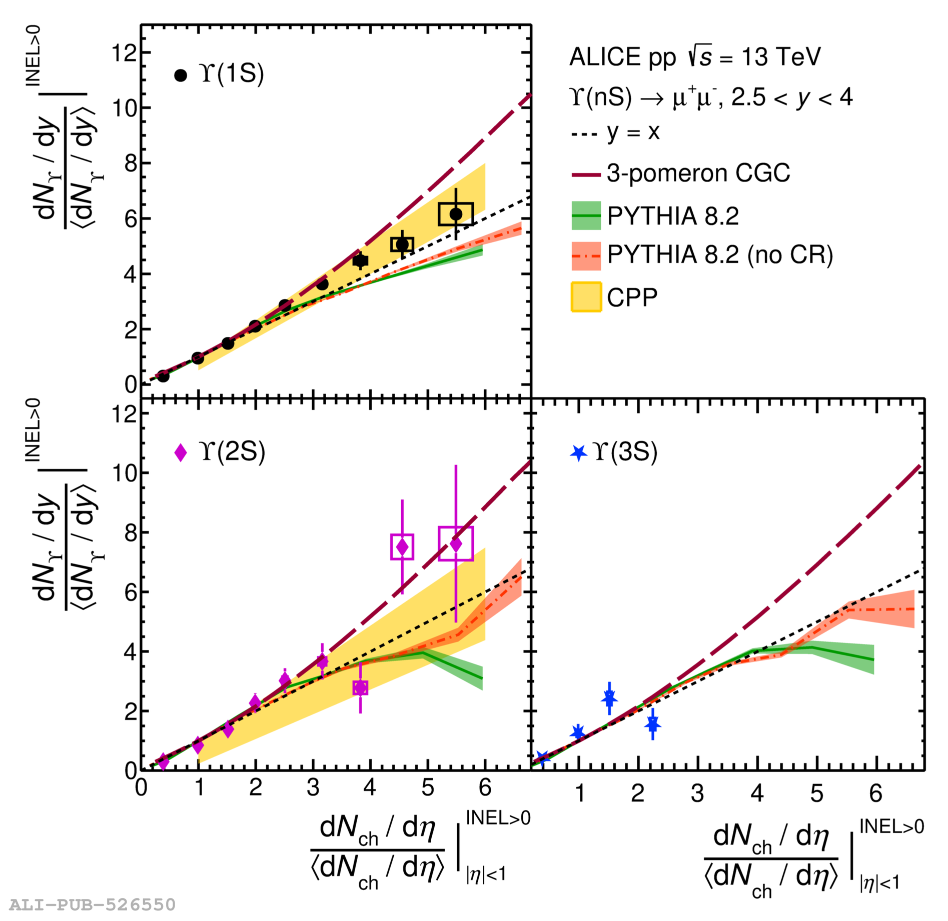


- **ψ(2S) production as a function of charged-particle multiplicity in pp collisions at 13 TeV and p–Pb collisions at 8.16 TeV [12]:**
  - Increase close to linear in both pp and p–Pb collisions (left)
  - Excited states less bound → more sensitive to final-state effects such as dissociation in medium
  - ψ(2S)-to-J/ψ ratio in pp (right) shows no strong evidence for suppression within uncertainties, but is still compatible with little suppression (as implemented in comover model [13])





- **Υ(nS) (n=1,2,3) production as a function of charged-particle multiplicity in pp collisions at 13 TeV [3]:**
  - Trends close to linear increase, well reproduced by models [14–16]
  - Measurement precision does not yet allow conclusions on additional dissociation for less bound states



Summary

- J/ψ pair production in pp collisions gives insight on Double Parton Scattering → cross-section measured at forward rapidity compatible with previous LHCb measurements
- p–Pb collisions gives insight into Cold Nuclear Matter effects → J/ψ nuclear modification factor, consistent with unity, well reproduced by calculations using nPDF
- Self-normalized quarkonium yields at forward rapidity as a function of self-normalized midrapidity multiplicity show almost linear trends in pp and p–Pb collisions , the increase is stronger than linear at midrapidity

References

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