ψ(2S) production as a function of charged-particle multiplicity in pp and p—Pb collisions with ALICE at the LHC

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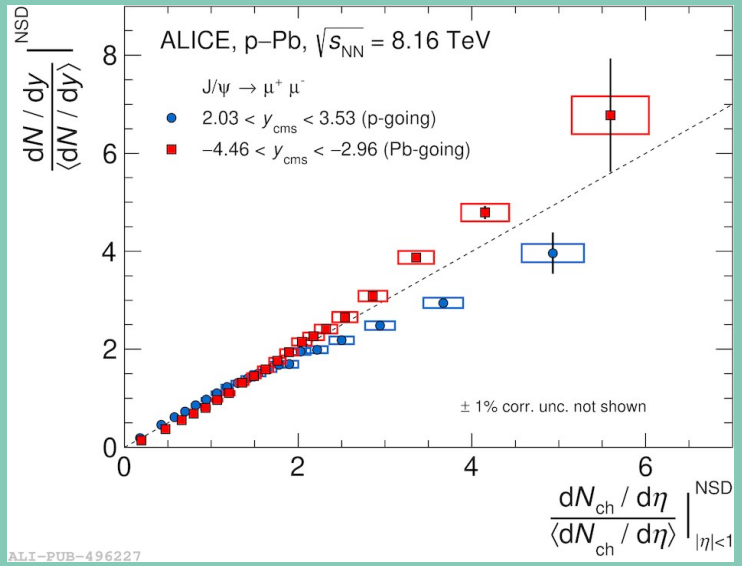
J/ψ yields, measured at forward rapidity, increase with increasing charged-particle multiplicity, measured at mid rapidity, in pp and p—Pb collisions at the LHC. A weaker than linear increase is observed at forward rapidity in p—Pb.



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arXiv:2112.09433

Possible scenarios

Multiparton interaction ?

Multiple parton interactions (MPI) affect particle production. (1)

Initial state effects?

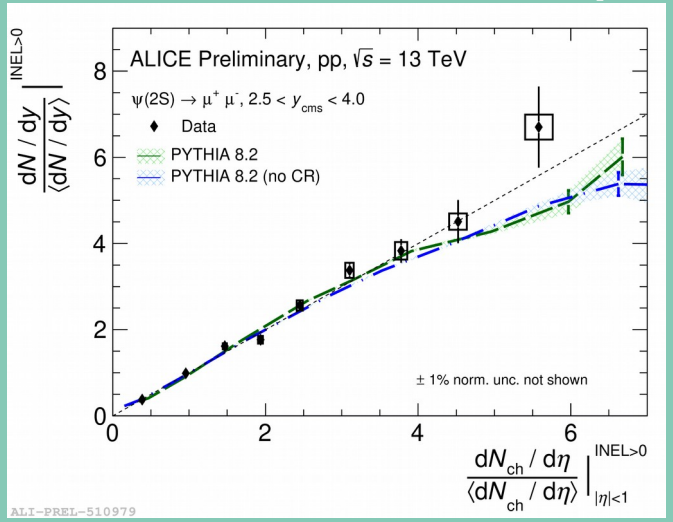
Initial-state effects, such as the modification of PDFs in nuclei, influence particle production. (2)

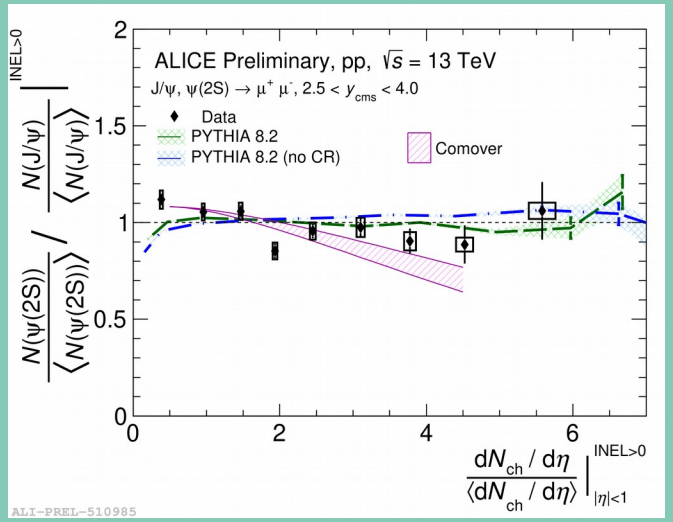
Final state effects?

For example, in the comovers model, charmonia can be dissociated by interactions with the final state comoving particles.(3)

(1) P. Bartalini, arXiv:1111.0469.
(2) R. Vogt, Phys. Rev. C 71, 054902, JHEP10(2014)073
(3) E.G.Ferreiro, Phys. Lett. B 749 (2015) 98–103

Self-normalized yields of ψ(2S) and ψ(2S)-over-J/ψ vs. multiplicity in pp collisions





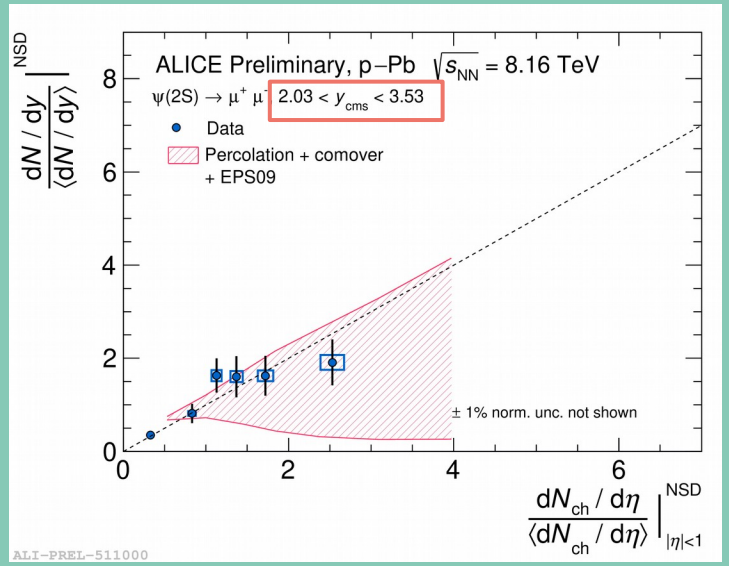
- Self-normalized ψ(2S) yields increase with self-normalized charged-particle multiplicity.
- PYTHIA 8[(1)] calculations (including MPI) describe the results. No significant influence of the color-reconnection scenario observed in the simulations.
- At large multiplicity, PYTHIA 8 starts to deviate from linear behaviour vs. multiplicity, which is not seen in data.

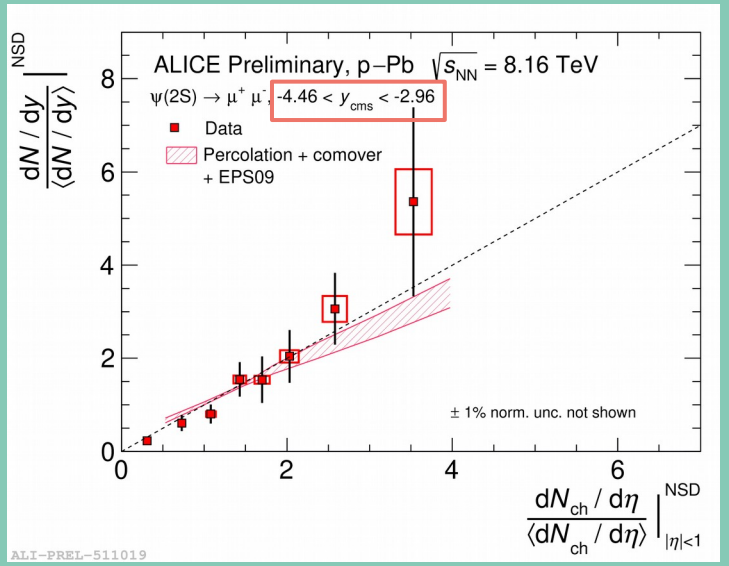
- Self-normalized yields of ψ(2S)-over-J/ψ : similar behaviour of J/ψ and ψ(2S) self-normalized yields with charged-particle multiplicity.
- Flat ratio described by PYTHIA 8 calculations.
- In the comover model[(2)], charmonia can be dissociated by interacting with the comoving final-state particles. A stronger effect is expected for Ψ(2S) due to its lower binding energy. The comover calculation is compatible with data within uncertainties.

(1) TorbjörnSjöstrand et.al, Comput. Phys. Commun. 191488 (2015) 159–177

(2) E.G.Ferreiro, Phys. Lett. B 749 (2015) 98–103

Self-normalized ψ(2S) yields vs multiplicity in p—Pb collisions





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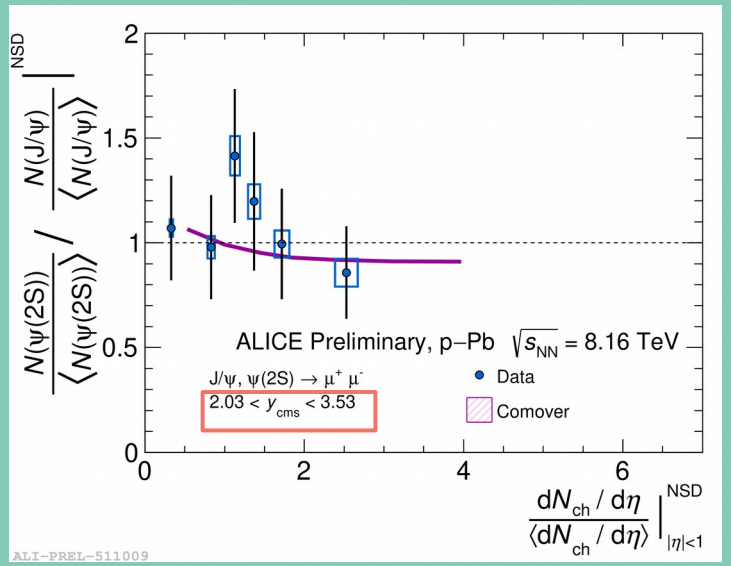
- Self-normalized ψ(2S) yields increase with self-normalized charged-particle multiplicity in both rapidity ranges for p—Pb collisions.
- Percolation[1] + comover[2] + EPS09[3] calculation is compatible with both measurements
  - In the percolation model, the strings, that are formed in each parton interaction, have non-negligible transverse size and can interact.
  - EPS09 nPDF uncertainties are large at forward rapidity(low-x).

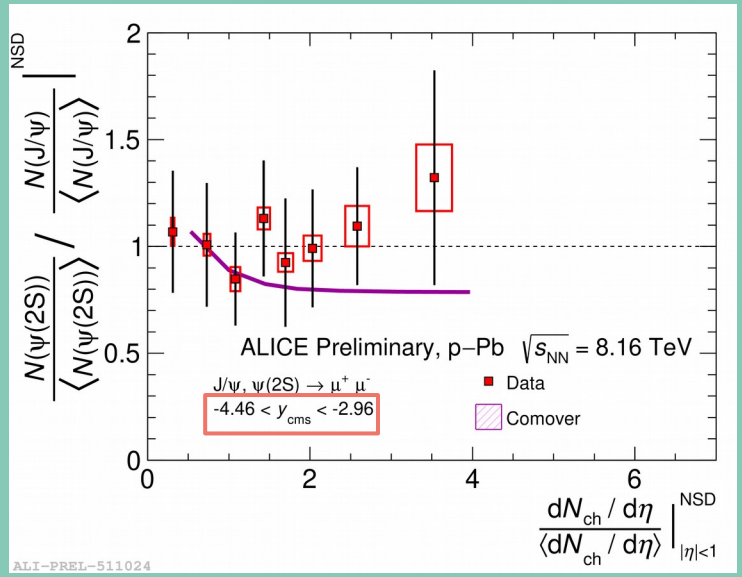
(1) N. Armesto et al, Phys. Rev. Lett. 77 (1996) 3736–3738

(2) E.G.Ferreiro, Phys. Lett. B 749 (2015) 98–103

(3) K.J. Eskola et al, JHEP 04 (2009) 065

Self-normalized yields of ψ(2S)-over-J/ψ yields vs multiplicity in p—Pb





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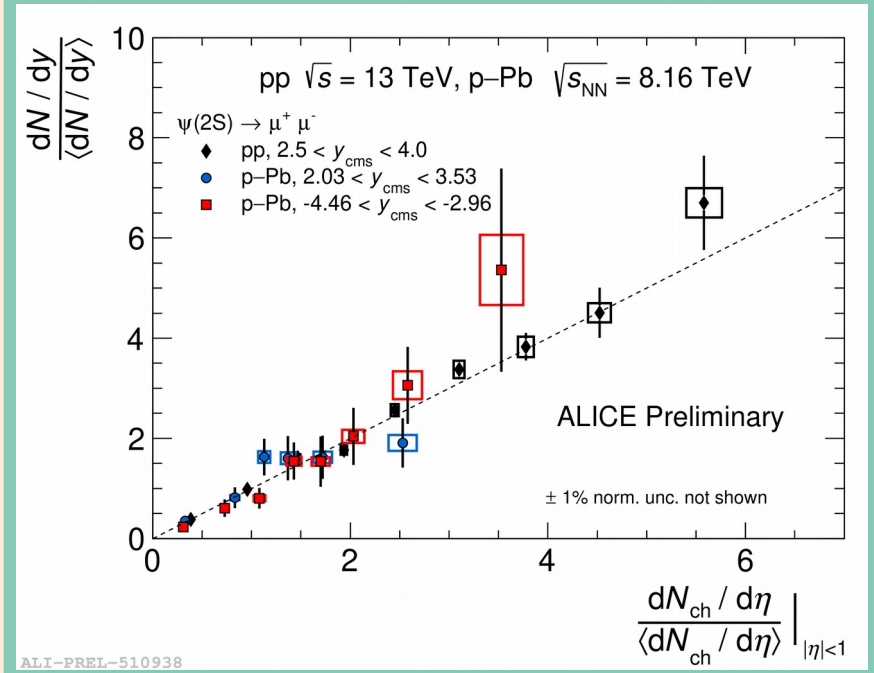
- ψ(2S)-over-J/ψ self-normalized yields: similar behaviour of J/ψ and ψ(2S) self-normalized yields with charged-particle multiplicity.
- Similar trend of the ratios vs. charged-particle multiplicity at forward and backward rapidity for p—Pb collisions.
- Ratios are consistent, within their large experimental uncertainties, with the comover calculation, which takes into account final state effects. A small influence of the rapidity interval is expected in the comover model for the ratio in p—Pb collisions.

Conclusion

- Normalized ψ(2S) yields increase as a function of charged-particle multiplicity in pp and p—Pb collisions. Similar increasing behaviour with charged-particle multiplicity is found for J/ψ.
- PYTHIA 8 simulations, which consider MPIs, describe the pp results.
- Percolation + comover + EPS09 calculation, which considers final-state effects, reproduces ψ(2S) yields in p—Pb collisions in both rapidity regions. However, the theoretical uncertainties at forward rapidity are large.
- Comover model estimates are consistent with the ψ(2S)-over-J/ψ ratios in p—Pb collisions within the large experimental uncertainties.
- In pp collisions, the comovers model is compatible with data within theoretical and experimental uncertainties.
- More precise measurements and predictions are needed to disentangle among the different effects at play.



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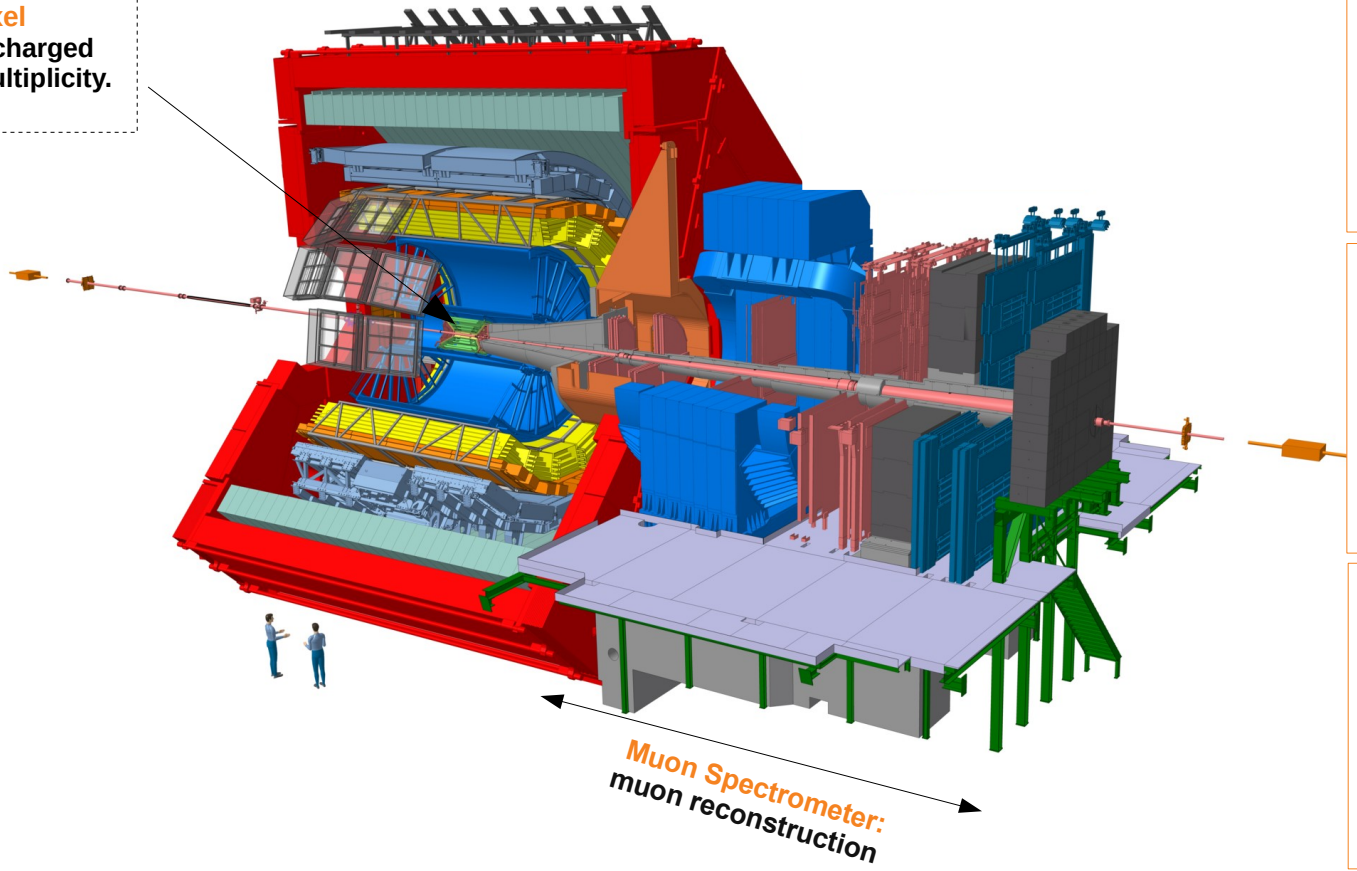
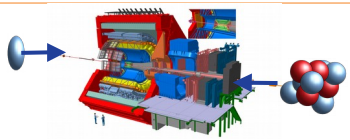
Thank you !

Backup slide

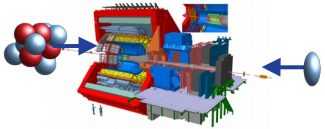
ALICE detector and data sample

Silicon pixel detector: charged particle multiplicity.

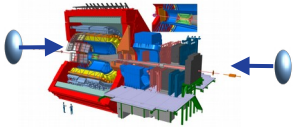




p—Pb at $\sqrt{s_{NN}}$ = 8.16 TeV
(p-going direction)
$2.03 < y_{cms} < 3.53$
$X_{pb} \sim 10^{-2}$



p—Pb at $\sqrt{s_{NN}}$ = 8.16 TeV
(Pb-going direction)
$-4.46 < y_{cms} < -2.96$
$X_{pb} \sim 10^{-5}$



pp at $\sqrt{s}$ = 13 TeV

$2.5 < y_{cms} < 4.0$