Inclusive ψ(2S) suppression in p-Pb collisions at $\sqrt{s_{NN}}$ = 8.16 TeV with ALICE at the LHC

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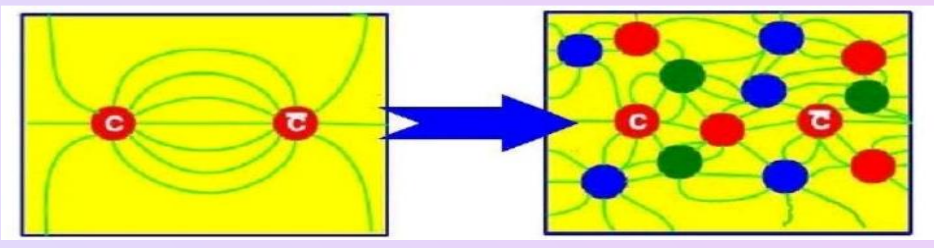
Physics Goal



At high energy density (~ 1GeV/fm^3) nuclear matter undergoes a phase transition from a confined state to a state of deconfined quarks and gluons, called Quark-Gluon Plasma (QGP). Such a state is produced in high energy heavy-ion collisions.

Charmonium is a bound state of charm (c) and anti-charm ($\bar{c}$) quarks. The $c\bar{c}$ pair dissociates into free quarks in the presence of the QGP due to the Debye screening of the binding potential by the large number of surrounding color charges. Therefore, charmonium is a useful probe of the properties of the QGP. Quarkonium production can be modified also by

Cold Nuclear Matter (CNM) effects like:

- ❖ energy loss ← Sufficient to explain J/ψ suppression
- ❖ shadowing or anti-shadowing (nuclear modification of the Parton Distribution Function (nPDF))
- ❖ Comovers absorption ← Needed to explain ψ(2S) suppression

Such effects can be investigated in p-Pb collisions.

The precise assessment of CNM effects in p-Pb collisions is important to correctly quantify the QGP effects in Pb-Pb collisions.

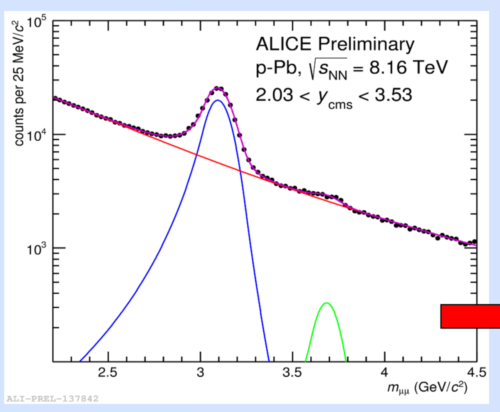
Analysis

Nuclear modification factor (R_{pPb})

$$R_{pPb}^{J/\psi} = \frac{N_{J/\psi}^{corr}}{< T_{pPb} > N_{MB}.BR.\sigma_{J/\psi}^{pp}}$$

$$R_{pPb}^{\psi(2S)} = R_{pPb}^{J/\psi} * \frac{\sigma_{pPb}^{\psi(2S)}}{\sigma_{pPb}^{J/\psi}} * \frac{\sigma_{pp}^{J/\psi}}{\sigma_{pp}^{\psi(2S)}}$$

where, $N^{corr}_{J/\psi}$ is $N_{J/\psi}/A\times\varepsilon$, N_{MB} is the number of minimum bias events, T_{pPb} is the thickness function.

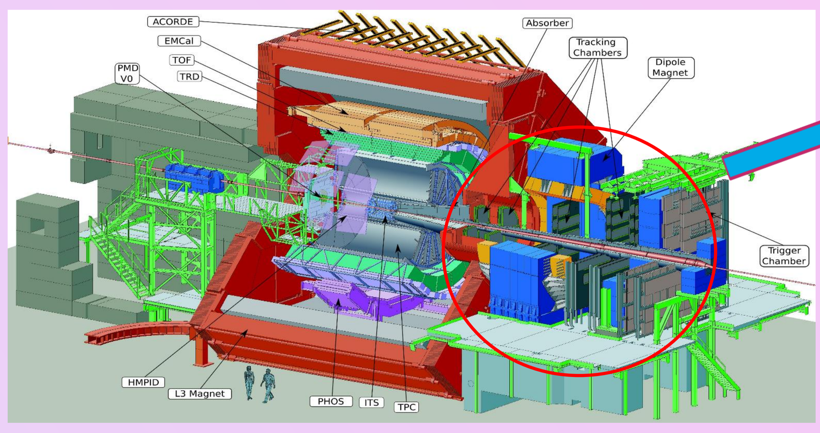


$N_{\psi(2S)}$ obtained by fitting the invariant mass spectra with signals and background shapes

To calculate **Axε of J/ψ** and **ψ(2S)** a MC is produced using as input p_T and y distributions tuned on the data.

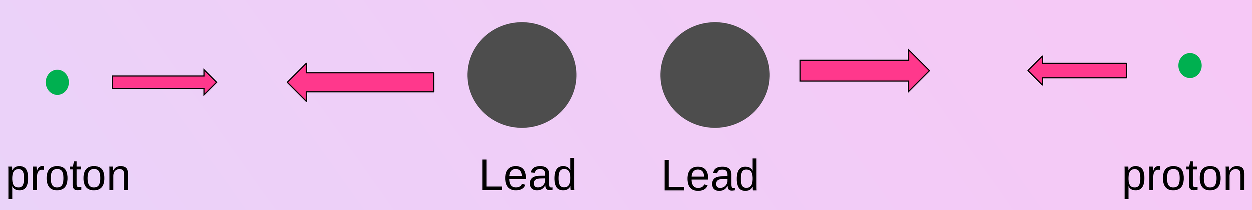
pp reference is obtained from the study of ψ(2S) cross sections in pp collisions at $\sqrt{s}$ = 7 TeV.

ALICE Detector



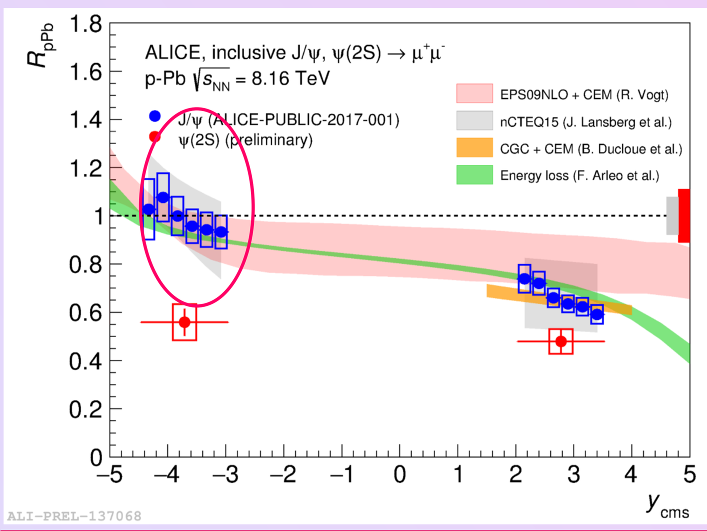
Muon Spectrometer
$c\bar{c} \rightarrow \mu^+\mu^-$
$-4 < y < -2.5$

p-Pb ($2.03 < y_{cms} < 3.53$) Pb-p ($-4.46 < y_{cms} < -2.96$)



Data have been collected at two centre of mass energies: $\sqrt{s_{NN}}$ = 5.02 TeV, 8.16 TeV.

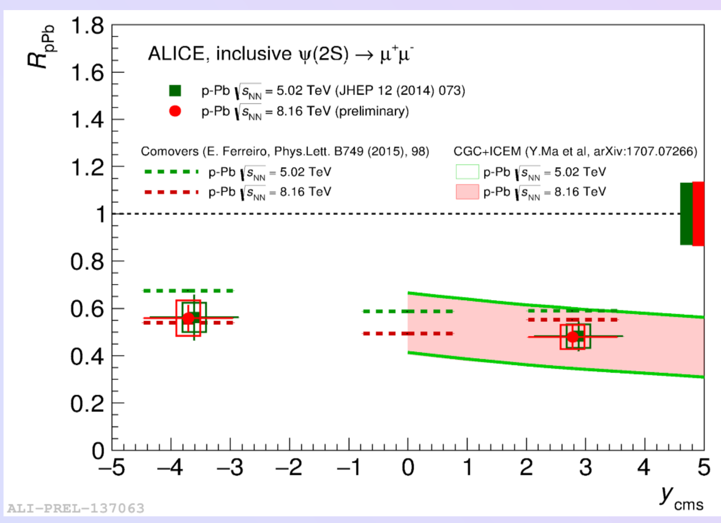
R_{pPb} of ψ(2S) vs y compared to R_{pPb} of J/ψ and CNM models



- Data shows larger suppression of ψ(2S) compared to J/ψ at backward rapidity.
- J/ψ and ψ(2S) results are compared with shadowing and energy loss models.

• Shown models correspond to the J/ψ, but the effects included in the models are largely independent on the specific resonance, so the same behaviour is expected for ψ(2S).
• Shadowing and energy loss cannot explain ψ(2S) suppression, especially at backward rapidity.

R_{pPb} vs y compared to final state effects models



Two models are compared to the data :
1. "CGC + ICEM, Y. Ma et al.": soft color exchanges between $c\bar{c}$ hadronizing pair and comoving partons

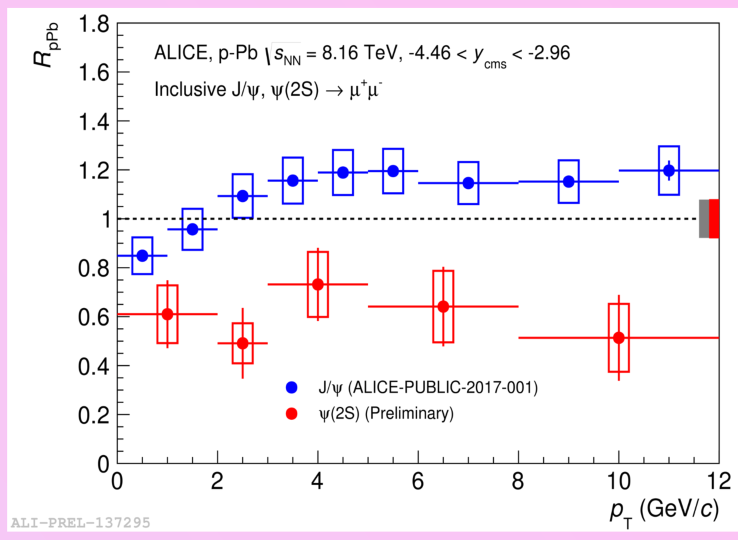
2. "COMOVERS, E. Ferreiro": final-state interactions with the comoving medium

✓Models including final-state effects reproduce the ψ(2S) suppression at both forward and backward rapidity, and at both energies.

References

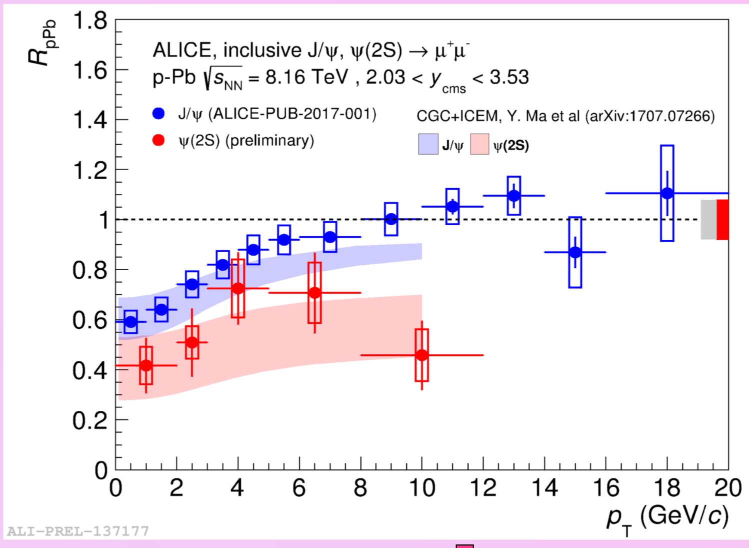
1) E. Ferreiro Phys.Lett.B749 (2015), 98
2) Y. Ma. Et al. arxiv:1707.07266
3) "Suppression of ψ(2S) production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV", JHEP 12(2014)073
4) "Centrality dependence of ψ(2S) in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV", JHEP 06(2016)50

R_{pPb} vs p_T and centrality compared to R_{pPb} of J/ψ and final state effects models

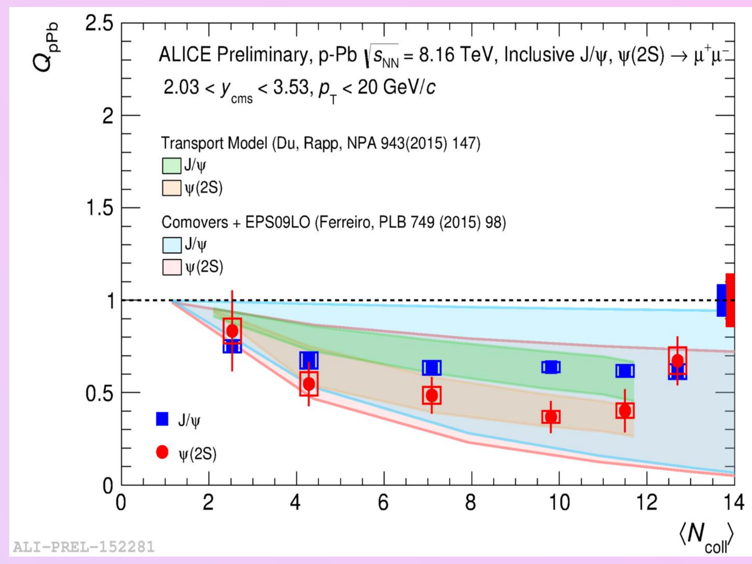


- A larger suppression of ψ(2S) compared to J/ψ is also observed as a function of p_T.

The R_{pPb} vs p_T at forward rapidity is compared with a CGC model.

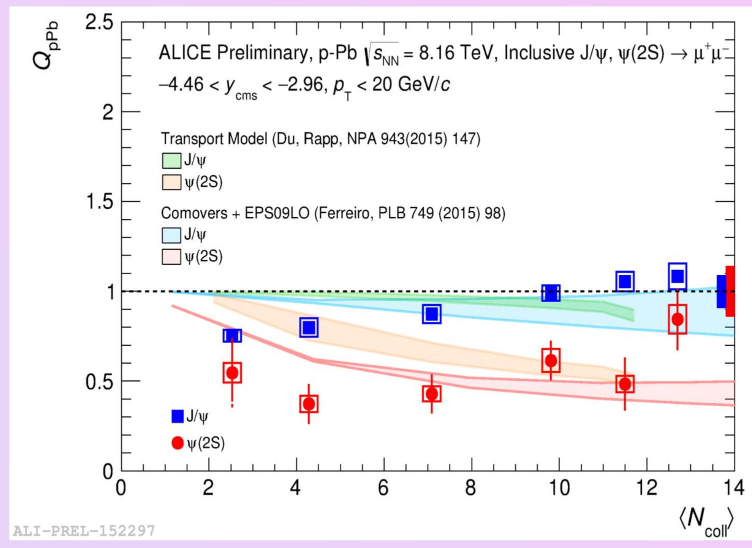


The ψ(2S) is more suppressed than the J/ψ as a function of p_T.



- The ψ(2S) suppression is found to follow the same trend as the J/ψ at forward rapidity.

At backward rapidity, stronger ψ(2S) suppression compared to the J/ψ, is also visible as a function of centrality



Outlook

✓Strong suppression of ψ(2S) in p-Pb collisions at $\sqrt{s_{NN}}$ = 8.16 TeV at backward rapidity, different from J/ψ

✓Energy loss and shadowing are not able to describe this behaviour.

✓Models including final-state effects reproduce the ψ(2S) behaviour at backward rapidity at both $\sqrt{s_{NN}}$ = 5.02 and 8.16 TeV.

✓Transport model describe well both J/ψ and ψ(2S) data.

✓The ψ(2S) suppression shows a similar trend compared to J/ψ as a function of centrality at forward rapidity.