Υ production in p–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 8.16$ TeV with ALICE at the LHC

Wadut Shaikh

Saha Institute of Nuclear Physics, Kolkata
On behalf of the ALICE Collaboration

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Outline

1. Physics Motivation
2. Upsilon(1S) R_{pA} vs rapidity and p_{T}
3. Upsilon(1S) Q_{pA} vs centrality
4. Conclusion

Quarkonia ($q\bar{q}$), i.e. charmonium ($c\bar{c}$) and bottomonium ($b\bar{b}$), are an important probe to study the properties of the Quark-Gluon Plasma (QGP) created in heavy-ion collisions at LHC energies. Various effects influence the production of quarkonia.

Suppression or Enhancement of $q\bar{q} \Rightarrow$ **QGP**

Suppression: dissociation via color screening

Enhancement: recombination of $q\bar{q}$

Note

For Υ less/no (re)generation, due to the small number of produced b quarks

▲ A sequential suppression of bottomonium states has been observed ordered by their binding energy in the presence of deconfined color medium.

Other effects not related to QGP may also influence the production of quarkonia.

Cold nuclear matter effects:

- Shadowing and anti-shadowing

$\Rightarrow$ modification of the PDF in nucleus with respect to free nucleons.

- Energy loss

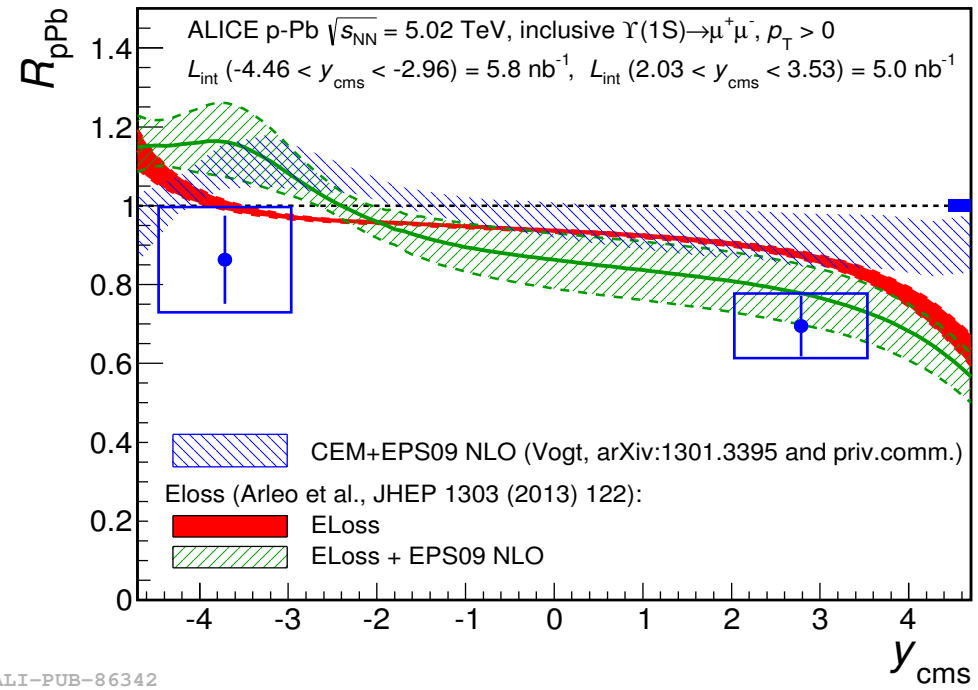
$\Rightarrow$ gluon radiation induced by multiple parton scattering in the nucleus

- Final-state effects

$\Rightarrow$ interaction with the hadronic medium

▼ For more quantitative conclusions on sequential suppression in Υ, a precise assessment of these effects is also needed.These effects are studied in p–Pb collisions where QGP is not expected to be formed.

Upsilon in p-Pb 5.02 TeV



▶ Υ(1S) production measurement in p–Pb at $\sqrt{s_{\rm NN}} = 5.02$ TeV shows a suppression at forward rapidity and no significant suppression at backward rapidity

(Phys. Lett., B740:105-117, 2015)

$\Rightarrow$ The large statistics collected in p-Pb collisions at $\sqrt{s_{\rm NN}} = 8.16$ TeV allows us to study Υ production as a function of centrality, $p_{\rm T}$ and rapidity.

▷ Integrated luminosity: 8.4$\pm$0.2 nb^{-1} (p–Pb), 12.8$\pm$0.3 nb^{-1} (Pb–p)

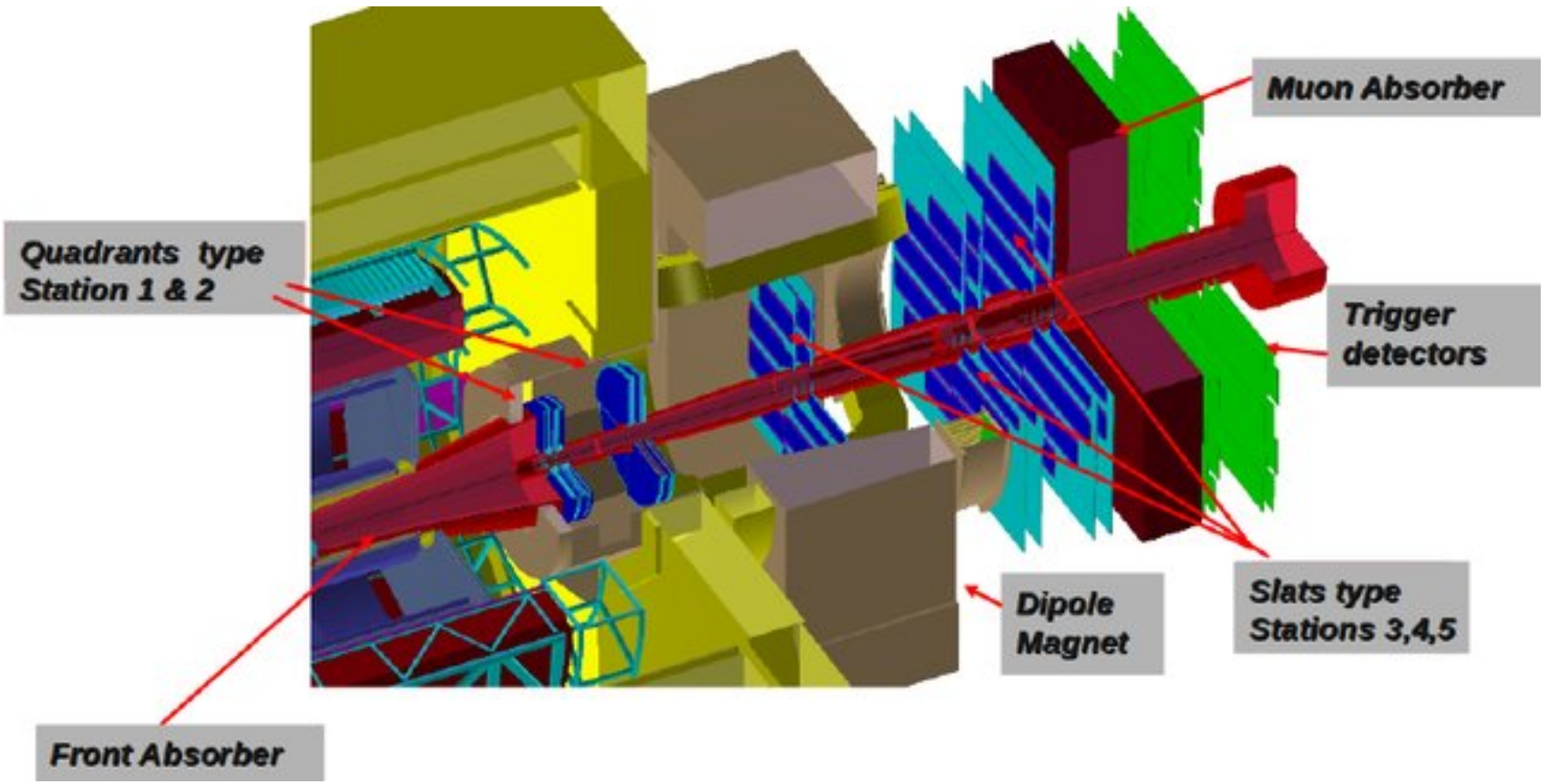
New at 8.16 TeV !

- Υ(1S) $R_{\rm pPb}$ as a function of centrality and $p_{\rm T}$
- Integrated Υ(2S) $R_{\rm pPb}$

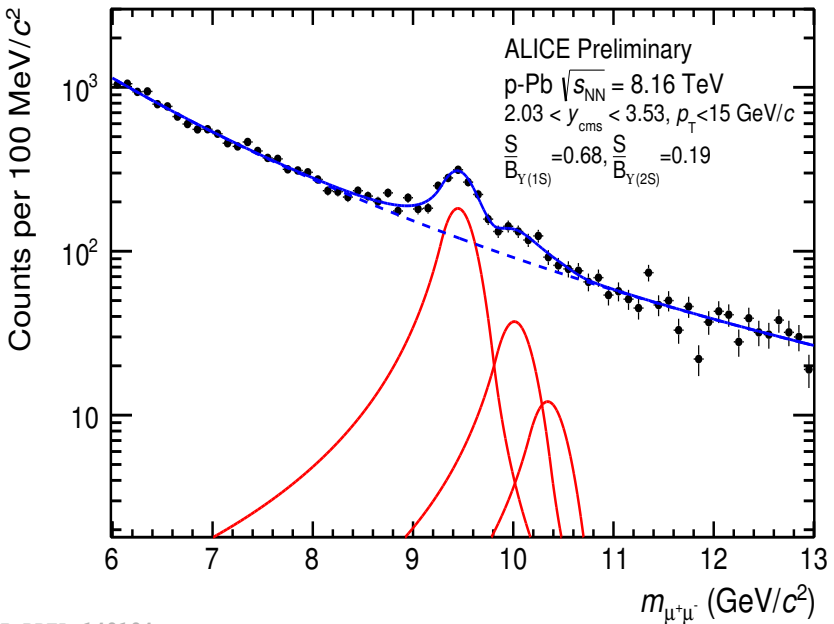
ALICE

Υ is measured via dimuon decay channel with the ALICE Muon Spectrometer down to zero transverse momentum and pseudorapidity range -4 $< \eta_{\rm lab} <$ -2.5.

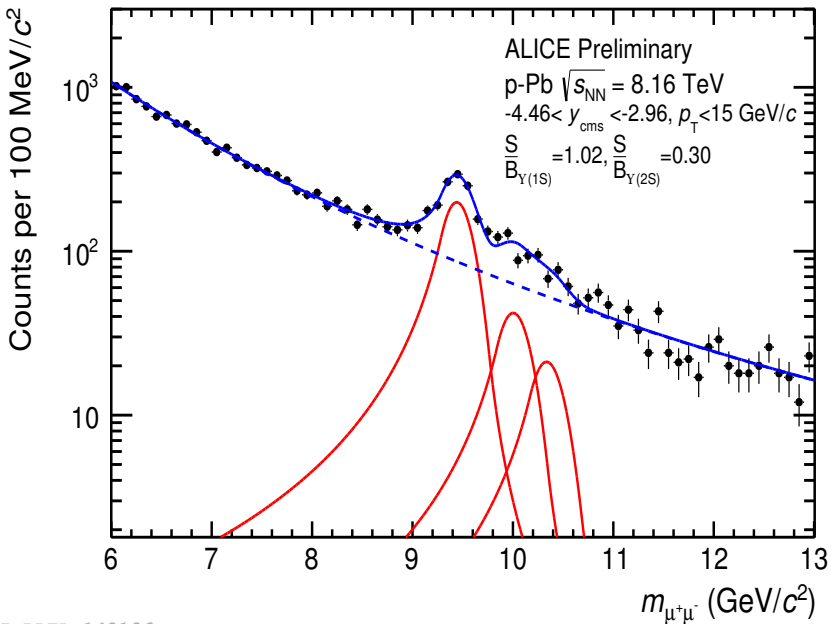
- p–Pb: forward ($2.03 < y_{\rm cms} < 3.53$)
- Pb–p: backward ($-4.46 < y_{\rm cms} < -2.96$)



Dimuon invariant spectrum



p–Pb



Pb–p

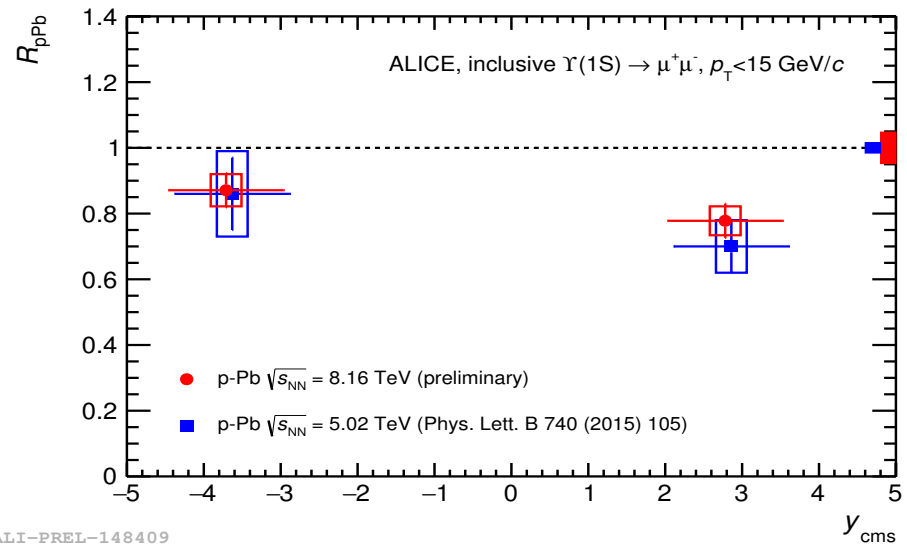
♦ For differential study, we have divided the sample in 3 rapidity, 5 p_{T} and 4 centrality bins.

Nuclear modification factors ($R_{\rm pA}$)

$$R_{\rm pPb} = \frac{N_{\Upsilon(1S)}}{\langle T_{\rm pPb} \rangle \,.\, N_{\rm MB} \,.\, (A \times \varepsilon) \,.\, BR_{\Upsilon(1S)\to\mu^+\mu^-} \,.\, \sigma^{\rm pp}_{\Upsilon(1S)}}$$

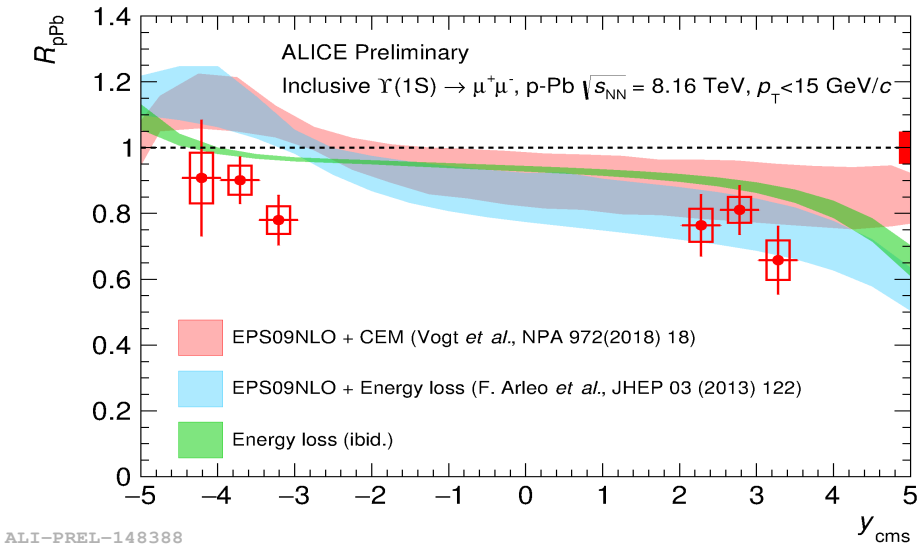
The y and $p_{\rm T}$ integrated $R_{\rm pA}$ of Υ(1S) at 8.16 TeV:

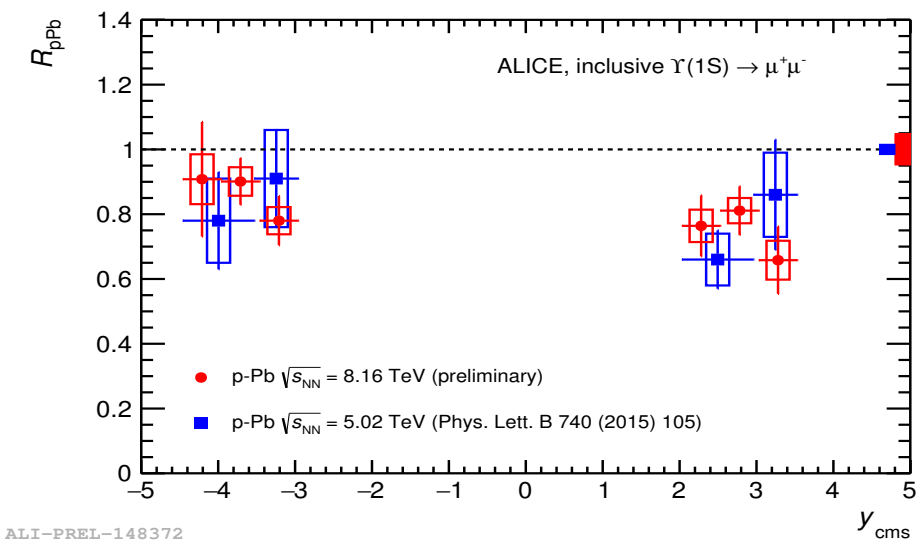
$R_{\rm pA}$ =0.778 $\pm$ 0.052(stat) $\pm$ 0.045(syst) $\pm$ 0.034(global)
$R_{\rm Ap}$ =0.871 $\pm$ 0.052(stat) $\pm$ 0.050(syst) $\pm$ 0.038(global)



- Indication of Υ(1S) suppression observed both at forward and backward rapidities
- The significance of the suppression is about 2.8σ and 1.7σ in p–Pb and Pb–p, respectively
- $R_{\rm pPb}$ is compatible at both energies

Υ(1S) R_{pPb} as function of y with model prediction

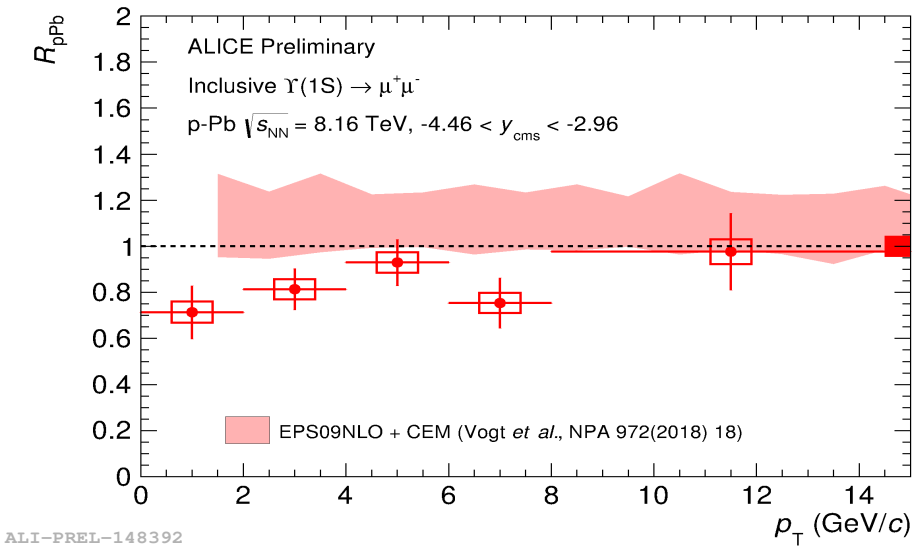


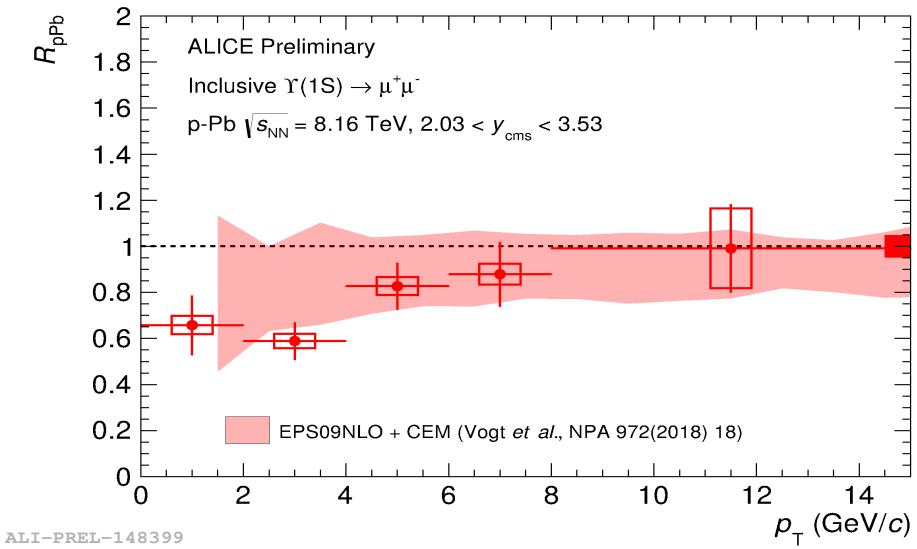


$\Rightarrow$ The shadowing calculation and energy loss describe the rapidity dependent results at forward rapidity within uncertainties while they overestimate the data at backward rapidity

$\Rightarrow$ Υ(1S) R_{pPb} measurements at $\sqrt{s_{\mathrm{NN}}} = 8.16$ TeV are compatible with those at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV

$\Upsilon(1S)$ $R_{\rm pPb}$ as function of $p_{\rm T}$ with model prediction





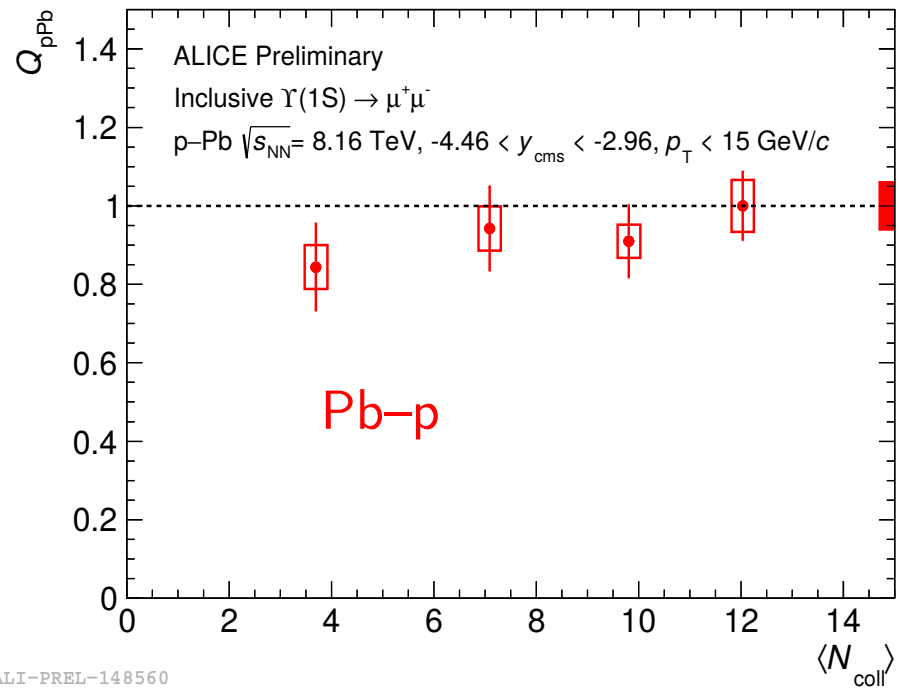
⇒Stronger $\Upsilon(1S)$ suppression observed at low $p_{\rm T}$ both at forward and backward rapidities

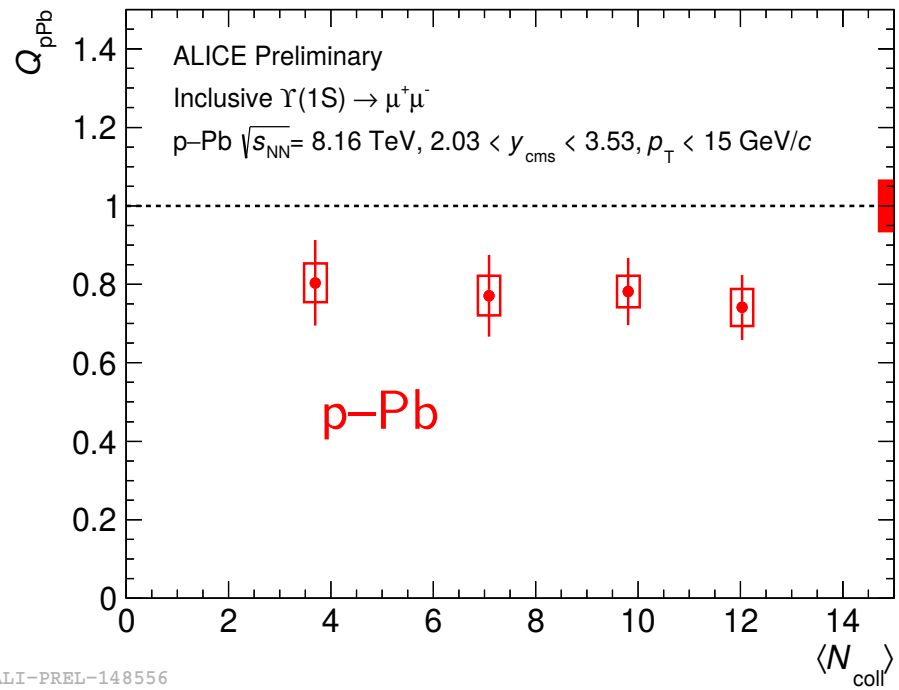
⇒ Shadowing calculation describes the $p_{\rm T}$-dependent results at forward rapidity within uncertainties while they overestimate the data at backward rapidity

Q_{pA} vs centrality

$$Q^{i}_{\mathrm{pPb}} = \frac{N^{i}_{\Upsilon(1S)}}{\langle T^{i}_{\mathrm{pPb}} \rangle \cdot N^{i}_{\mathrm{MB}} \cdot (A \times \varepsilon) \cdot BR_{\Upsilon(1S)\to\mu^{+}\mu^{-}} \cdot \sigma^{\mathrm{pp}}_{\Upsilon(1S)}}$$

Fist look at Q_{pA} of Υ(1S):

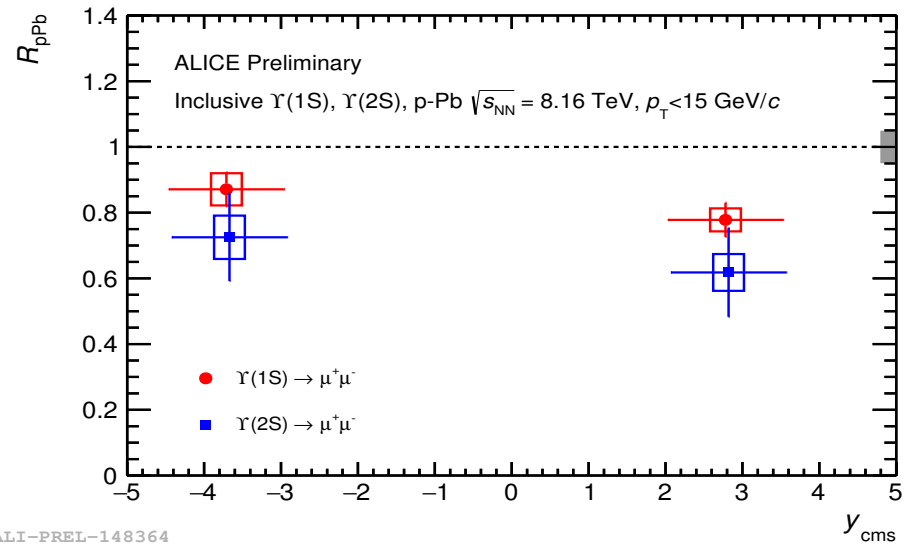




- at forward and backward rapidity, no strong centrality dependence of Q_{pA} within uncertainties.

Integrated R_{pA} of Υ(2S)

- The Υ(2S) is limited by the statistics and therefore p_{T} and y integrated result is presented.



- The two resonances show similar suppression, slightly larger for Υ(2S).
- LHCb(JHEP 11 (2018) 194), CMS(JHEP 04 (2014) 103) and ATLAS(Eur. Phys. J. C 78 (2018) 171) also observed more Υ(2S) suppression compared to the Υ(1S).

Conclusions

- Suppression of the $\Upsilon(1S)$ yields in p–Pb collisions is observed at both forward and backward rapidities w.r.t binary-scaled pp collisions at the same center-of-mass energy of 8.16 TeV
- The R_{pPb} values are similar at forward and backward rapidities with a hint for a stronger suppression at low p_{T}
- At both rapidity intervals there is no evidence for a centrality dependence of the $\Upsilon(1S)$ Q_{pPb}
- The results obtained at $\sqrt{s_{\mathrm{NN}}} = 8.16$ TeV are compatible with those measured by ALICE in p–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV during the LHC Run I
- Models based on nuclear shadowing and coherent parton energy loss fairly describe the data at forward rapidity, while they tend to overestimate the R_{pPb} at backward rapidity
- $\Upsilon(2S)$ R_{pPb} shows a similar suppression in the two investigated rapidity ranges. Shows with a hint of slightly larger suppression for $\Upsilon(2S)$ over $\Upsilon(1S)$

THANK YOU