Quarkonium production in p-Pb collisions with ALICE

Biswarup Paul
University and INFN Torino (Italy)
On behalf of the ALICE Collaboration

Quark Matter 2018, Venice, Italy
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Outline

- New results on J/ψ, ψ(2S) and ϒ states in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 and 8.16 TeV
- J/ψ results:
  - R_{pPb} vs p_T and Q_{pPb} vs centrality at $\sqrt{s_{NN}}$ = 5.02 TeV at mid-y NEW!!
    [ALICE-PUBLIC-2018-007]
  - R_{pPb} vs p_T and y and Q_{pPb} vs centrality at $\sqrt{s_{NN}}$ = 8.16 TeV at forward-y New publication!!
    [arXiv:1805.04381, ALICE-PUBLIC-2017-007]
  - Multi-differential study of J/ψ Q_{pPb} at forward-y NEW!!
- ψ(2S) results:
  - Q_{pPb} vs centrality at $\sqrt{s_{NN}}$ = 8.16 TeV at forward-y NEW!!
- ϒ results:
  - R_{pPb} vs p_T and y and Q_{pPb} vs centrality at $\sqrt{s_{NN}}$ = 8.16 TeV at forward-y NEW!!
    [ALICE-PUBLIC-2018-008]

p-Pb collisions in ALICE

→ Study pA collisions to understand Cold Nuclear Matter (CNM) effects such as nuclear parton shadowing/color glass condensate, energy loss and comovers absorption

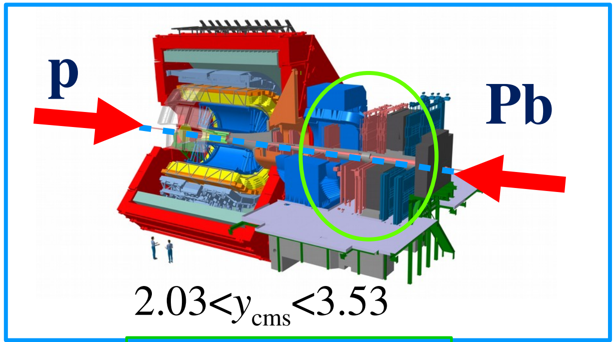
→ No Quark-Gluon Plasma (QGP) is expected in pA collisions. So, the measurement of CNM effects in pA collisions is important to quantify the QGP effects in A-A collisions

→ Quarkonia in ALICE can be measured in two different rapidity intervals:

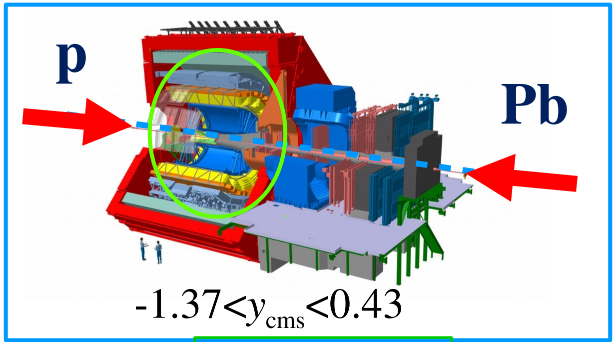
Central Barrel:	$J/\psi \rightarrow e^+e^-$ ($|y| < 0.9$)
Forward muon arm:	$J/\psi \rightarrow \mu^+\mu^-$ ($2.5 < y < 4$)

→ p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ and 8.16 TeV

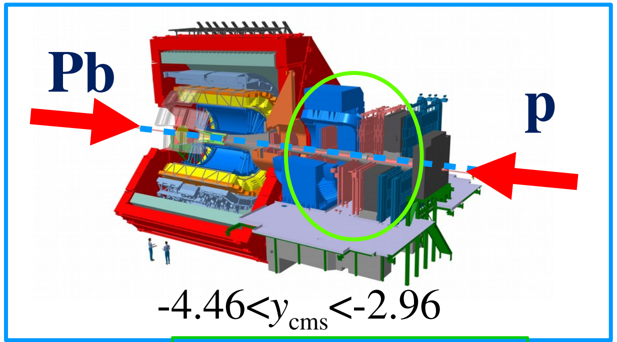
→ ALICE data are collected with two beam configurations: p-Pb and Pb-p, with $\Delta y = +/- 0.465$



Forward rapidity



Mid rapidity



Backward rapidity

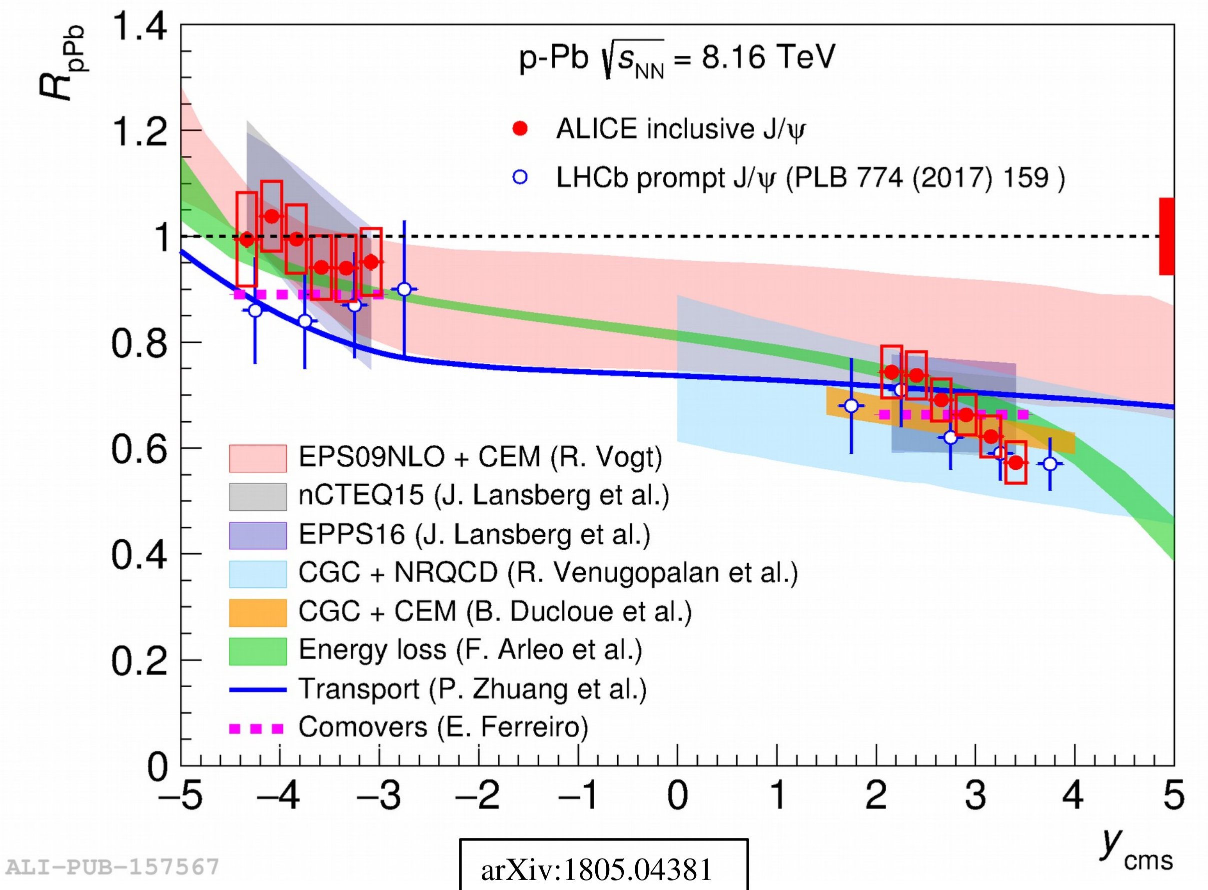
Inclusive J/ψ results in p-Pb collisions

arXiv:1805.04381

ALICE-PUBLIC-2017-007

ALICE-PUBLIC-2018-007

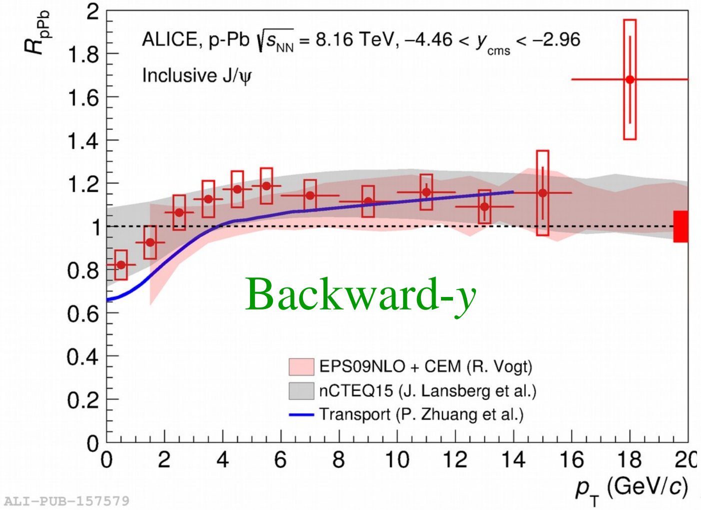
J/ψ R_{pPb} vs y_{cms} at $\sqrt{s_{NN}}$ = 8.16 TeV

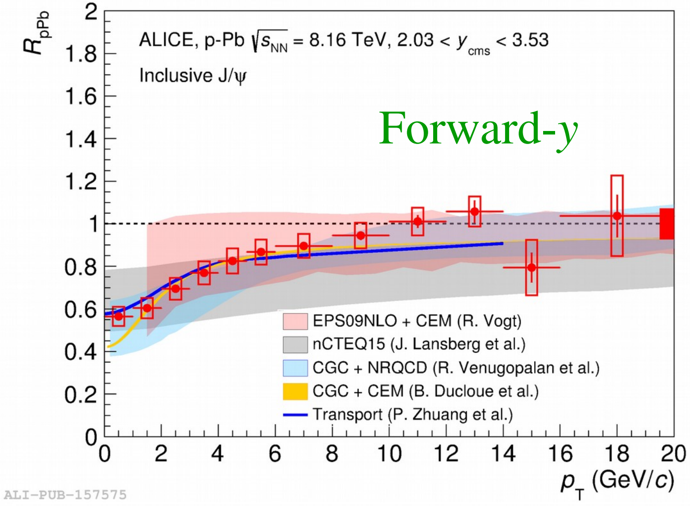


arXiv:1805.04381

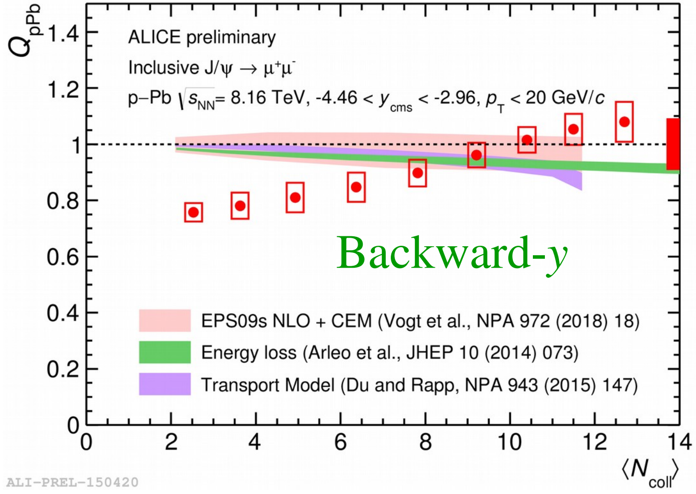
- Stronger suppression is observed at forward rapidity, while R_{pPb} is compatible with unity at backward rapidity
- Results are compatible with LHCb results at the same energy
- Models based on different shadowing implementations, CGC, energy loss, transport models and comovers fairly describe the data.

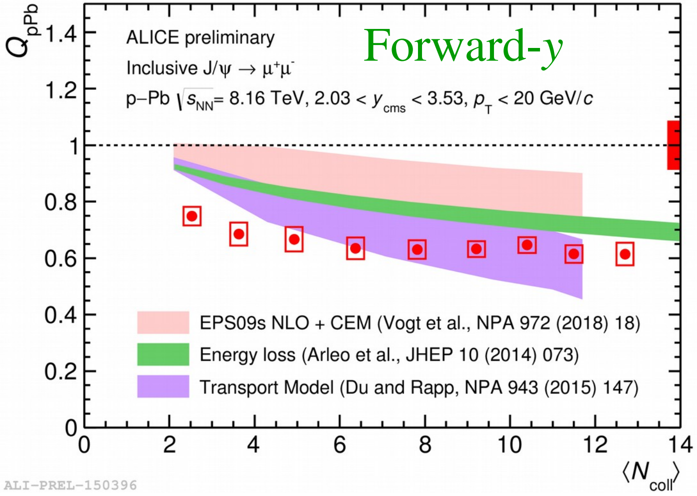
J/ψ R_{pPb} and Q_{pPb} at $\sqrt{s_{NN}}$ = 8.16 TeV compared to models





- R_{pPb} shows a p_T dependence , with an increase from low to high p_T at both forward and backward rapidity



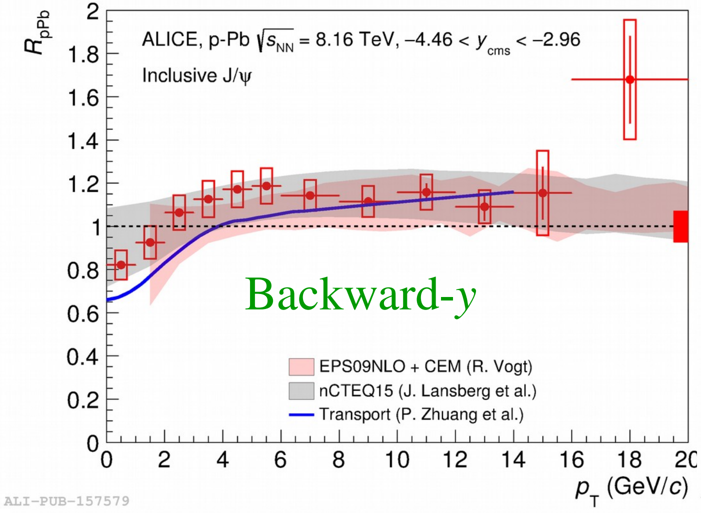


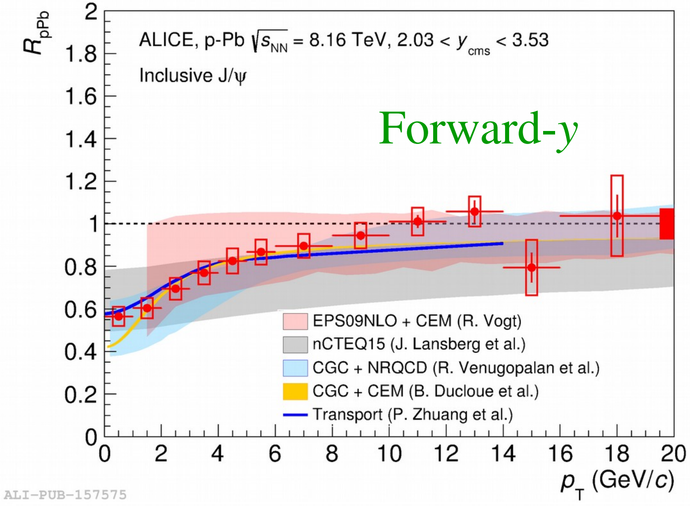
- Q_{pPb} shows a reduction from peripheral to central collisions at forward rapidity, while trend is the opposite at backward rapidity

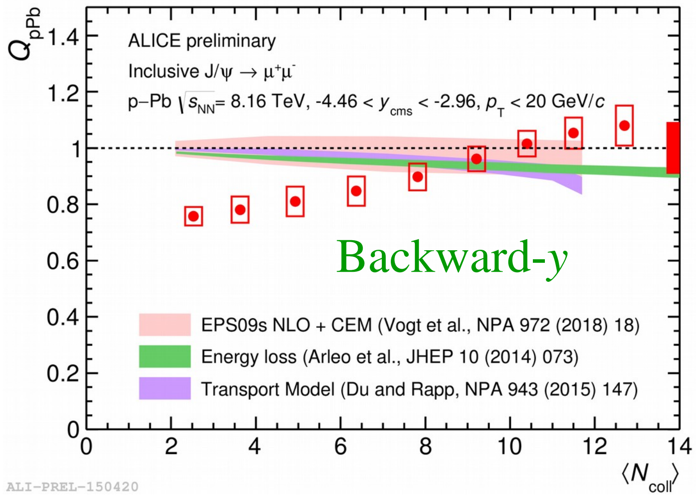
arXiv:1805.04381

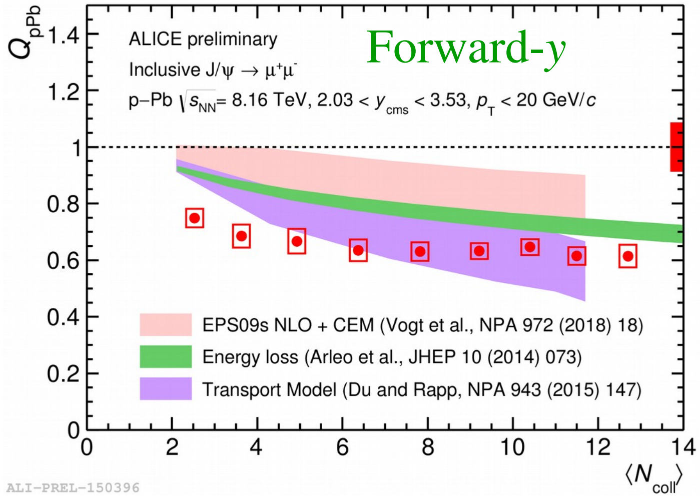
ALICE-PUBLIC-2017-007

J/ψ R_{pPb} and Q_{pPb} at $\sqrt{s_{NN}}$ = 8.16 TeV compared to models









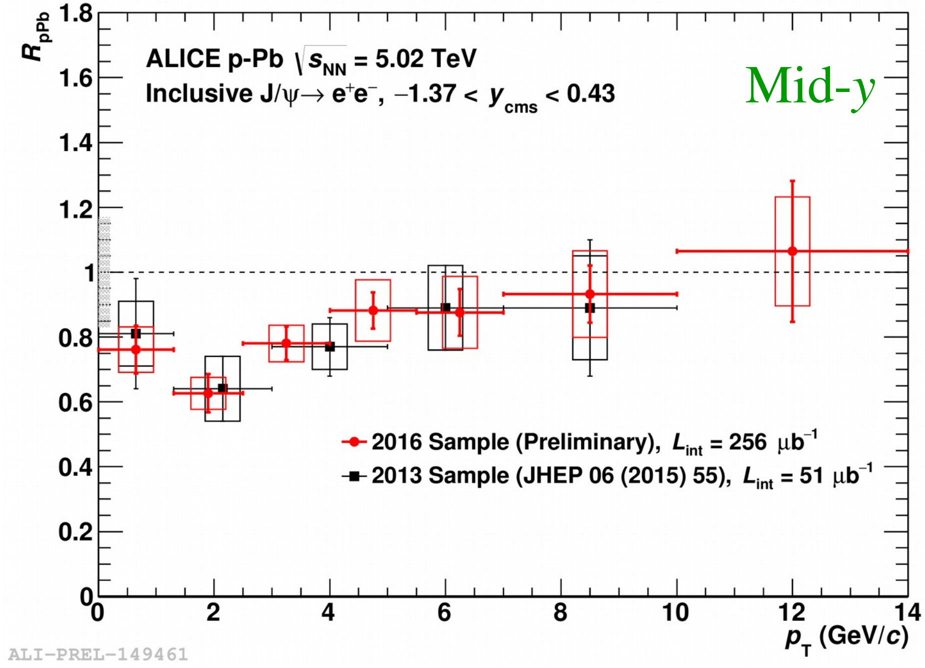
- More precise results with smaller uncertainties are able to constrain the theoretical predictions
- The models fail to describe simultaneously all aspects of J/ψ suppression (rapidity, p_T and centrality)

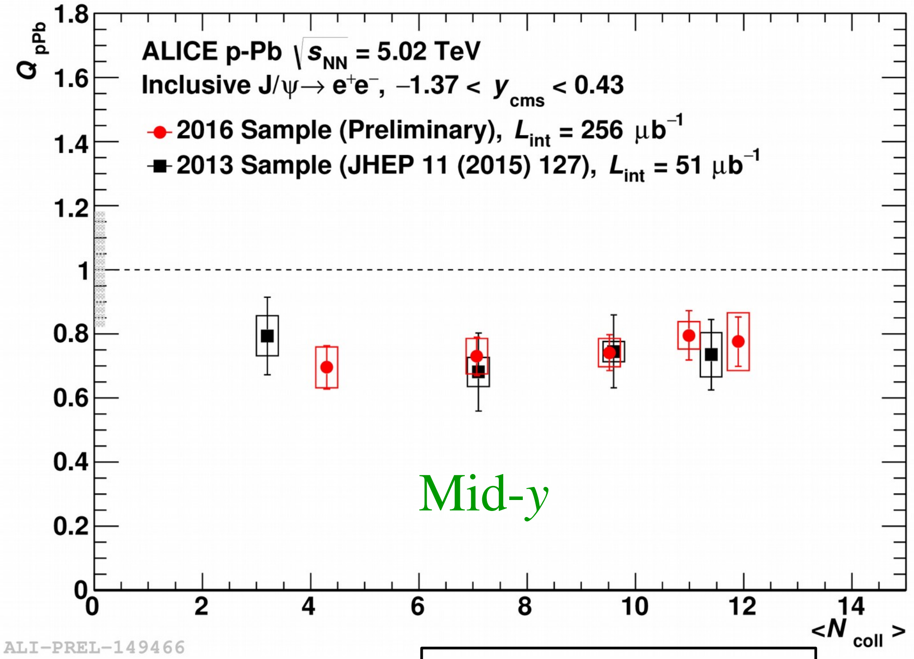
arXiv:1805.04381

ALICE-PUBLIC-2017-007

NEW!!

J/ψ R_{pPb} and Q_{pPb} at $\sqrt{s_{NN}}$ = 5.02 TeV (mid-y)



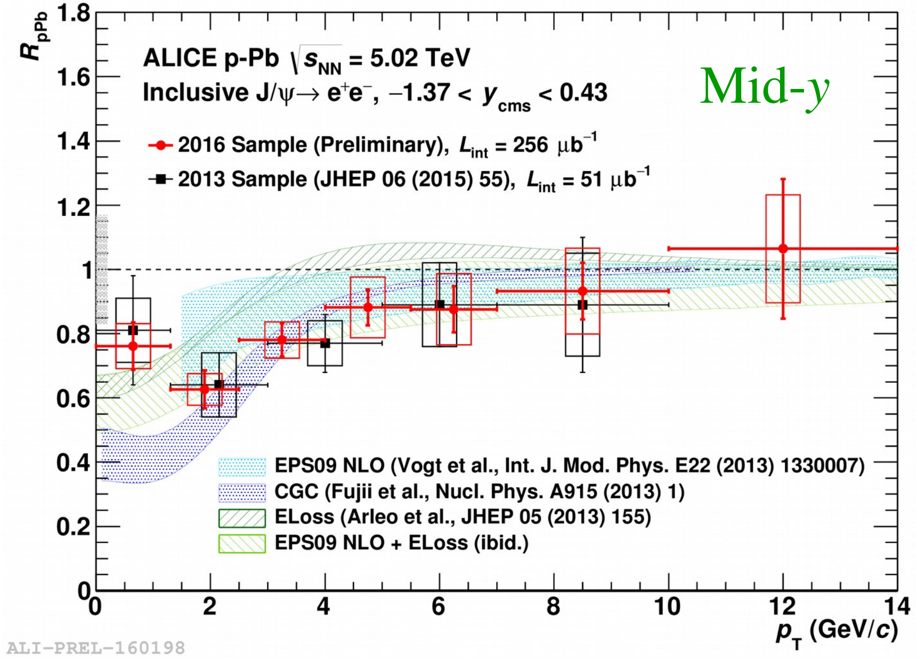


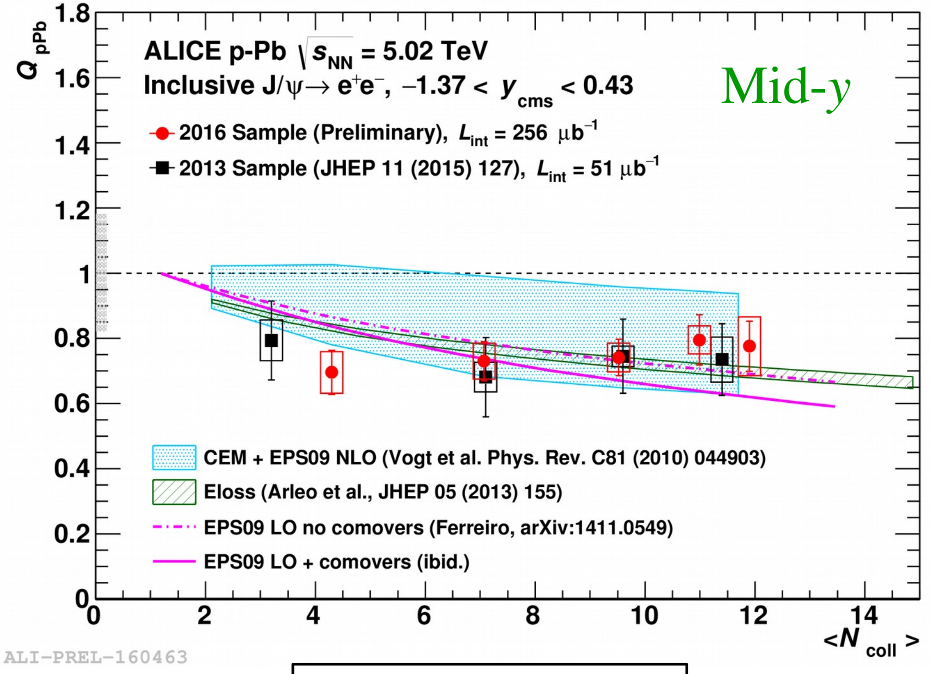
ALICE-PUBLIC-2018-007

- Run2 analysis with increased luminosity (L_{int}(2016) = 256 μb^{-1}, L_{int}(2013) = 51 μb^{-1}) shows increased precision
- R_{pPb} increases with p_T
- No centrality dependence of Q_{pPb} is observed

NEW!!

J/ψ R_{pPb} and Q_{pPb} compared to theory at $\sqrt{s_{NN}}$ = 5.02 TeV(mid-y)



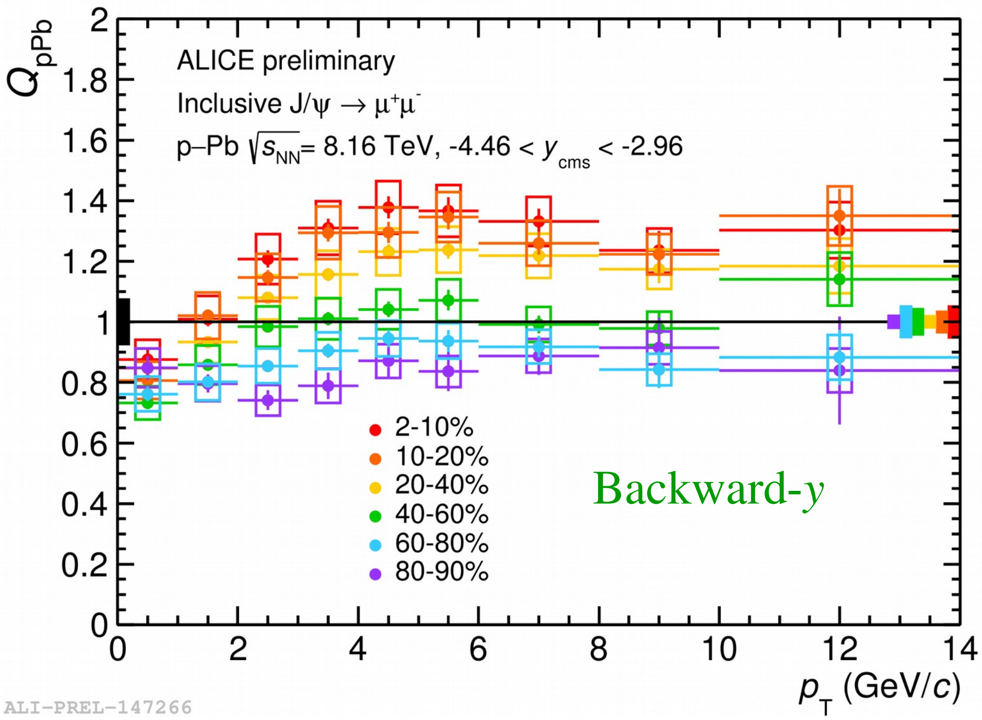


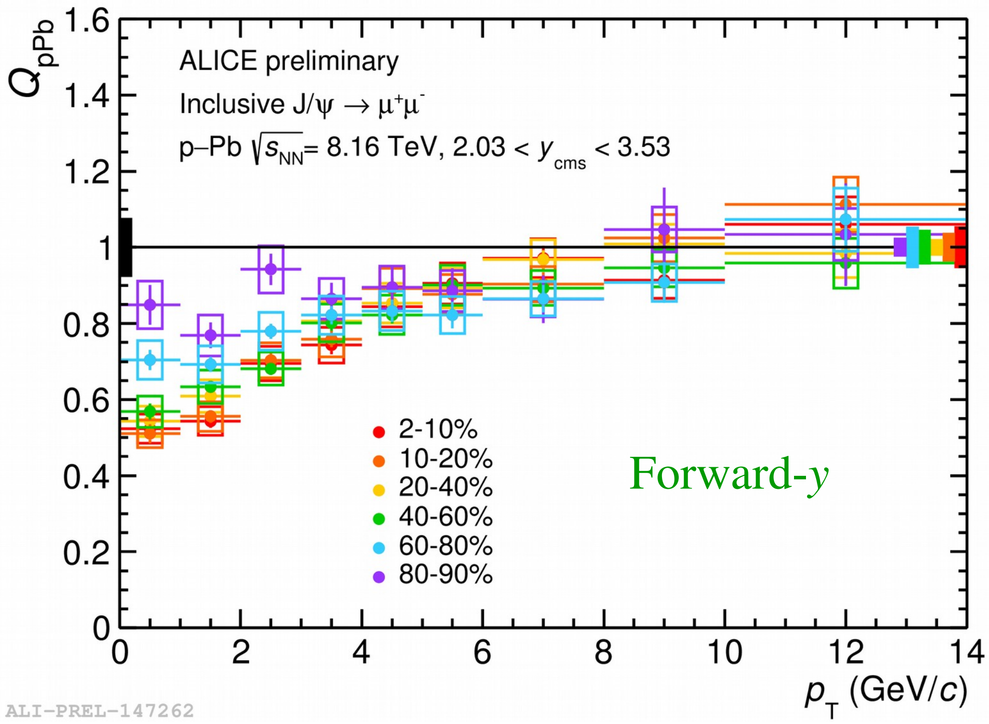
ALICE-PUBLIC-2018-007

- Theoretical models based on shadowing and/or energy loss, CGC and comovers are in fair agreement with the data

NEW!!

Multi-differential study of J/ψ Q_{pPb} at $\sqrt{s_{NN}}$ = 8.16 TeV

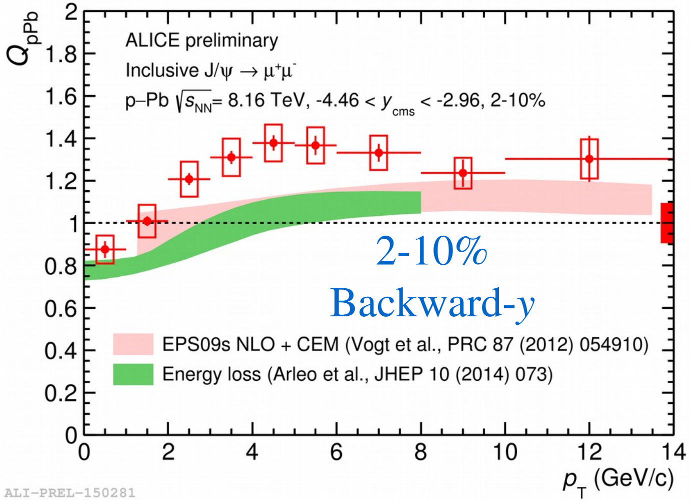


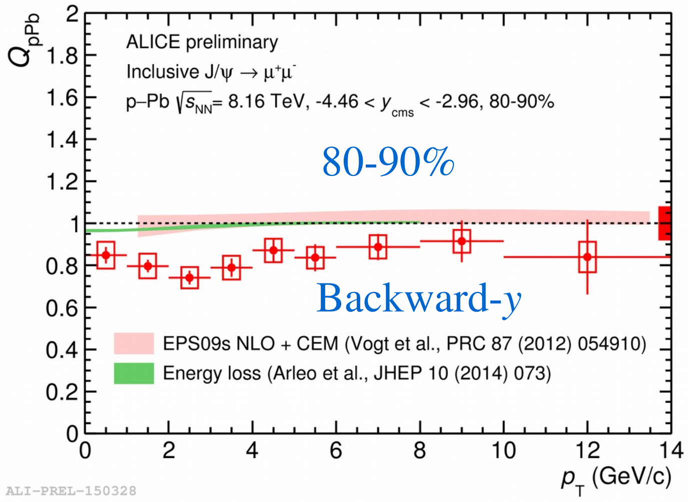


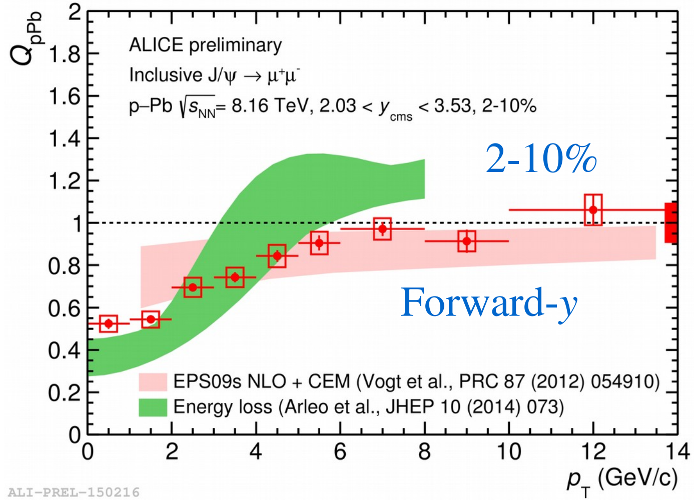
- Clear evolution of Q_{pPb} vs p_T in different centrality classes
- At backward rapidity, enhancement in most central collisions for $p_T > 3$ GeV/c
- At forward rapidity, stronger suppression at low p_T in most central collisions and Q_{pPb} is compatible with unity for $p_T > 7$ GeV/c within uncertainties for all centrality intervals

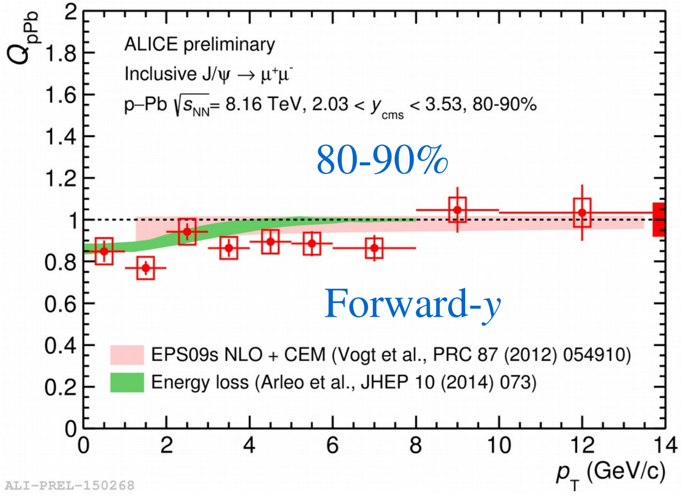
NEW!!

Multi-differential J/ψ Q_{pPb} compared to theoretical models



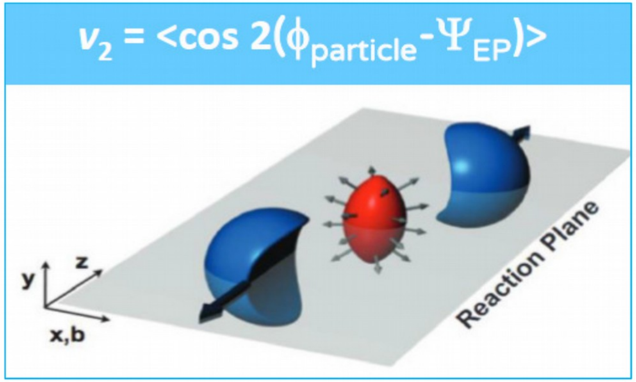




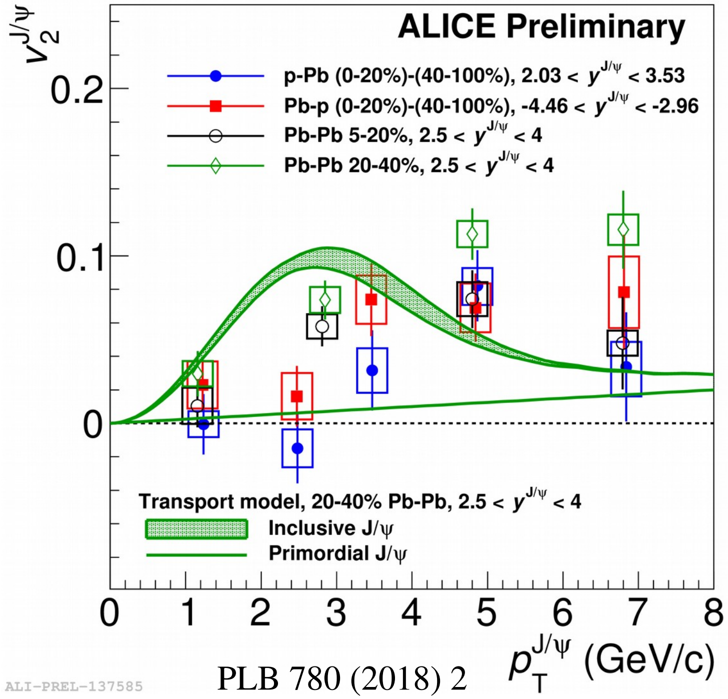


- In central collisions:
  - shadowing predicts a weaker p_T dependence w.r.t. the one observed in data
  - energy loss predicts an increase of Q_{pPb} with a different steepness than the measured one
- In peripheral collisions:
  both theory models show no p_T dependence, consistent with the Q_{pPb} measurement, within uncertainties

Azimuthal anisotropy (v_2) of J/ψ



- In a strongly-interacting medium, pressure gradients convert any initial spatial anisotropy into a momentum anisotropy
- Anisotropy is quantified by the 2nd order coefficient v_2 of the Fourier expansion of the particle azimuthal distribution
- In Pb-Pb collisions, non-zero J/ψ v_2 suggests charm quark participation to the collective expansion of the system



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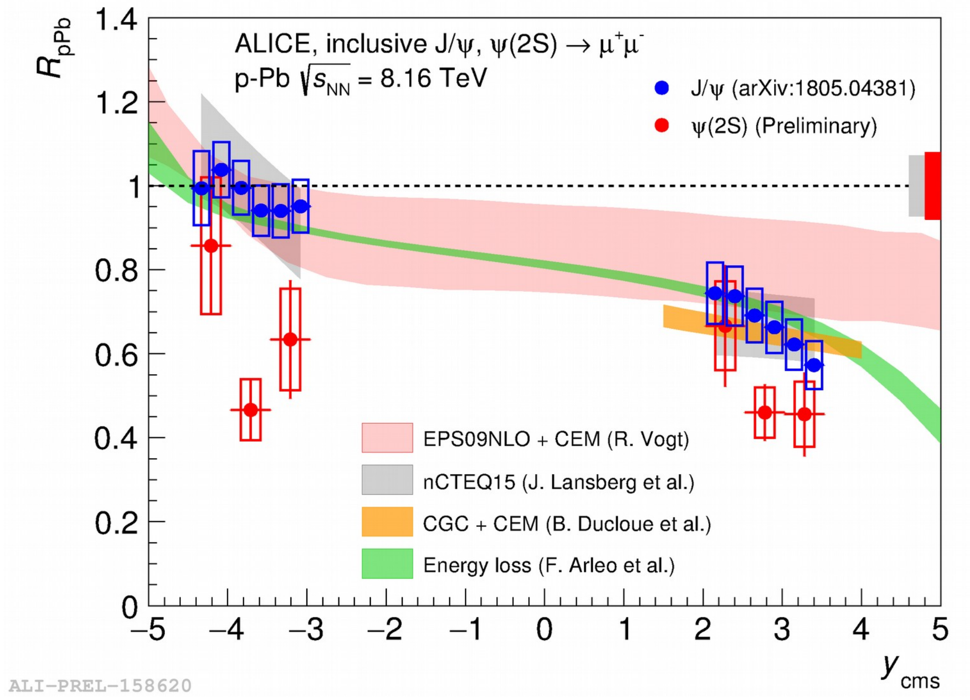
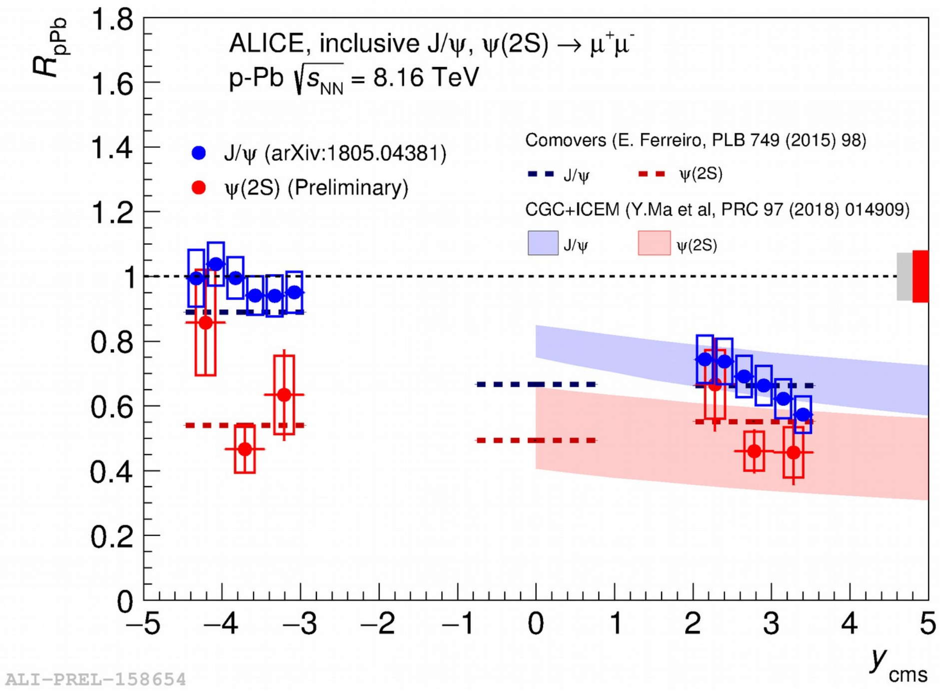
- Observation of non-zero v_2 in p-Pb for $p_T > 3$ GeV/c!
- Total significance (forward + backward, 5.02+8.16 TeV, $3 < p_T < 6$ GeV/c) ~ 5σ
- Values are similar as the ones obtained in Pb-Pb
- Common mechanism?

Inclusive ψ(2S) results in p-Pb collisions

ψ(2S) R_{pPb} vs y_{cms} at $\sqrt{s_{\mathrm{NN}}}$ = 8.16 TeV

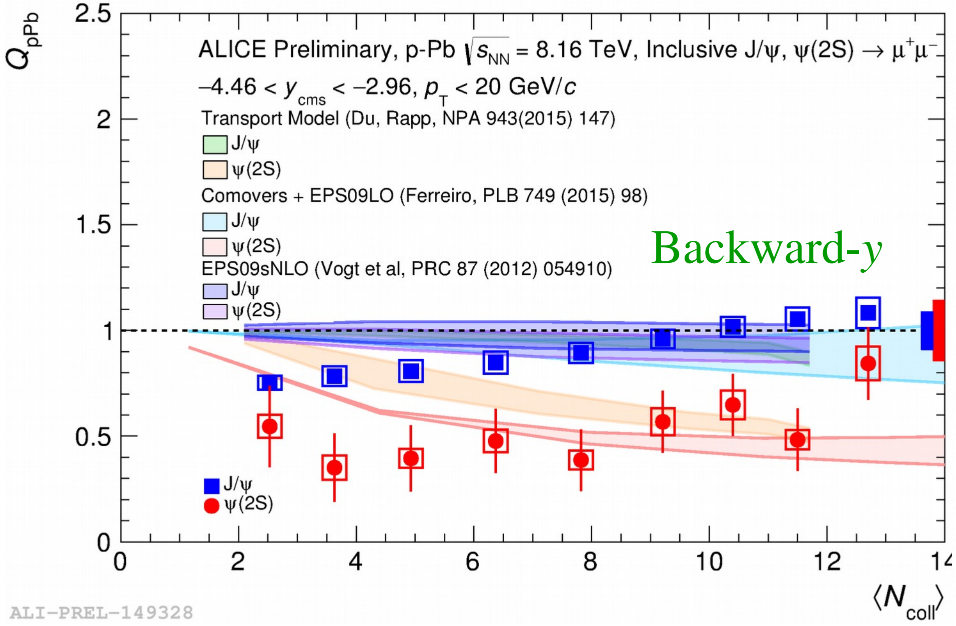


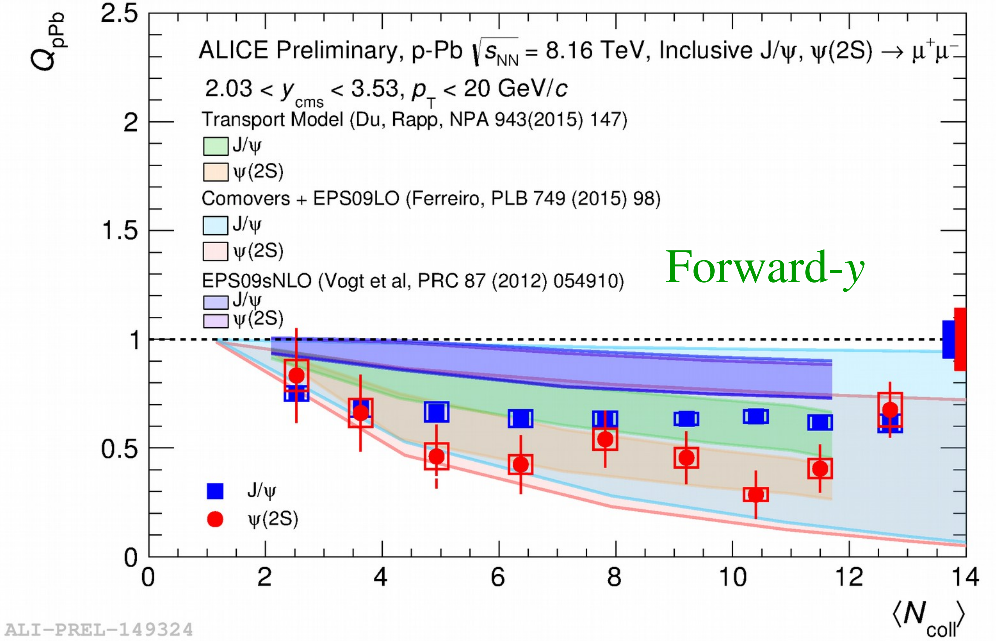


- ψ(2S) suppression is stronger than the J/ψ, especially at backward rapidity
- Theoretical predictions based on shadowing and energy loss can not describe the stronger ψ(2S) suppression
- Model including final-state effects reproduce ψ(2S) behaviour also at backward rapidity

NEW!!

ψ(2S) Q_{pPb} vs centrality at $\sqrt{s_{NN}}$ = 8.16 TeV





- The ψ(2S) suppression is stronger than J/ψ, especially at backward rapidity
- At forward rapidity the Q_{pPb} of ψ(2S) follows the same trend as J/ψ while at backward rapidity trend is different
- At backward rapidity, final-state effects needed to explain the ψ(2S) behaviour. Some discrepancies between the data and the model in the peripheral region

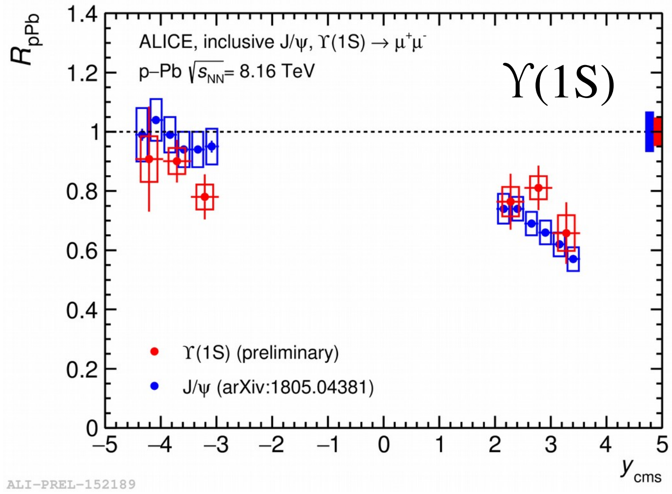
NEW!!

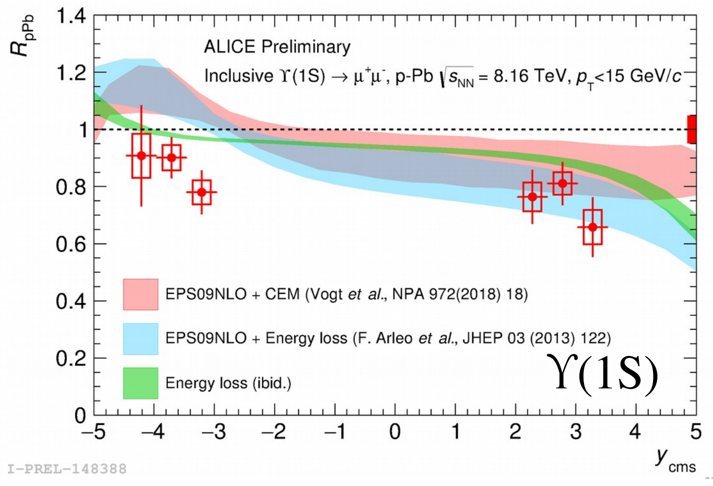
Inclusive $\Upsilon(1S)$ and $\Upsilon(2S)$ results in p-Pb collisions

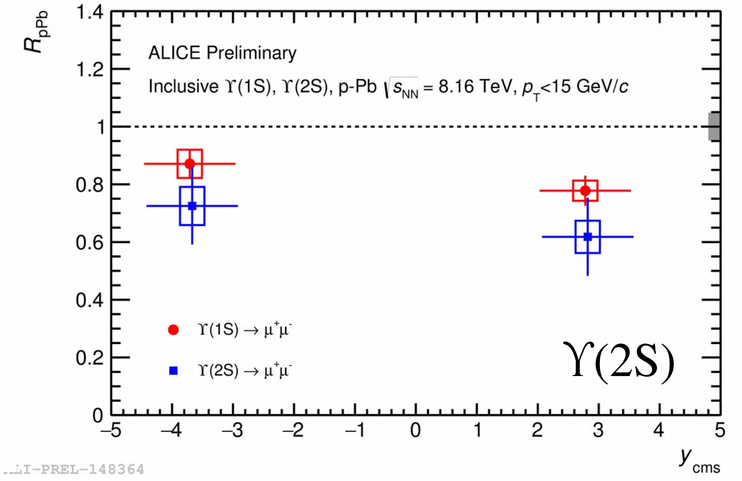
ALICE-PUBLIC-2018-008

NEW!!

Υ(1S) and Υ(2S) R_{pPb} vs y_{cms} at $\sqrt{s_{NN}}$ = 8.16 TeV





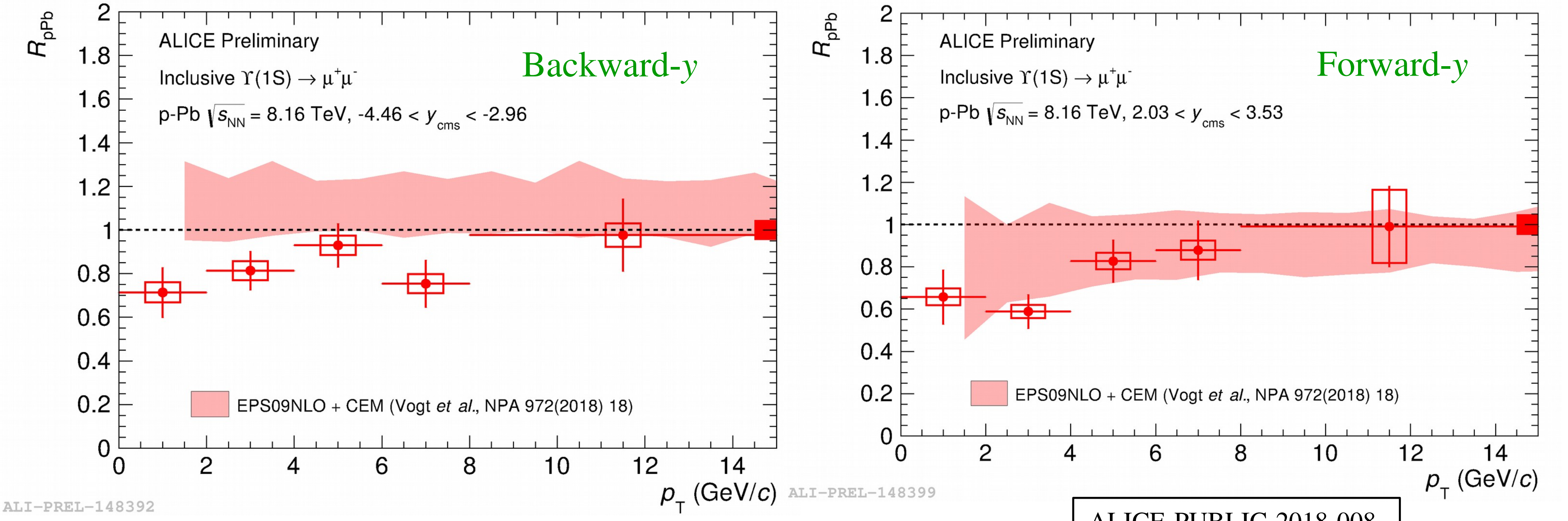


ALICE-PUBLIC-2018-008

- Similar Υ(1S) suppression at forward and backward rapidity
- Υ(1S) and J/ψ R_{pPb} agree within ~ 1σ both at forward and backward rapidity
- Theoretical predictions based on shadowing and energy loss describe the forward rapidity results but slightly overestimate the backward rapidity results
- Υ(2S) suppression is consistent with Υ(1S) but a small hint of being more suppressed (as observed by CMS and ATLAS at mid-y)
- Larger statistics at $\sqrt{s_{NN}}$ = 8.16 TeV allows us to measure Υ(1S) R_{pPb} in rapidity, p_T and centrality bins

NEW!!

$\Upsilon(1S)$ R_{pPb} vs p_T at $\sqrt{s_{NN}}$ = 8.16 TeV

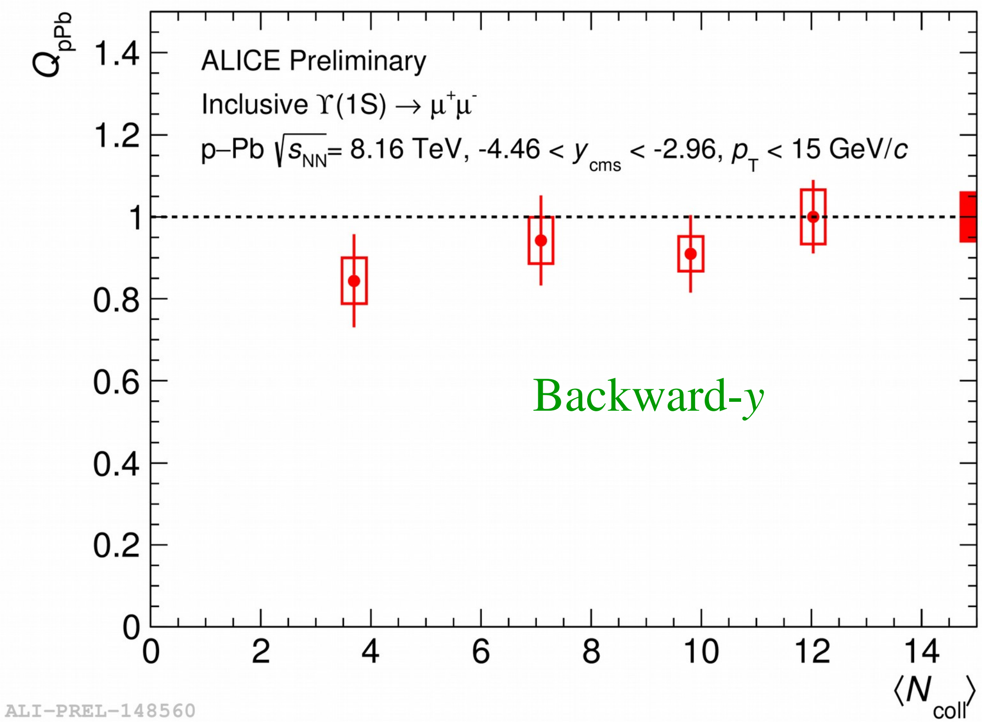


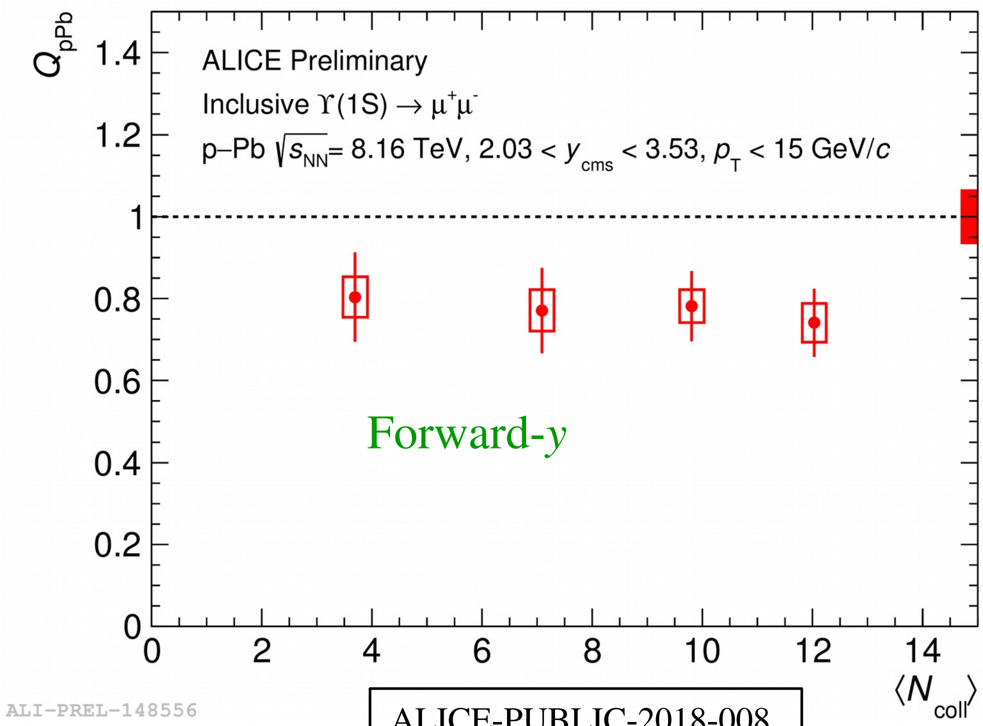
ALICE-PUBLIC-2018-008

- A similar behaviour at both forward and backward rapidity with a hint of a stronger suppression at low p_T
- Theoretical predictions based on shadowing describe the forward rapidity results but slightly overestimate the backward rapidity results

NEW!!

$\Upsilon(1S)$ Q_{pPb} vs centrality at $\sqrt{s_{NN}}$ = 8.16 TeV





ALICE-PUBLIC-2018-008

- Almost no centrality dependence of Q_{pPb} both at forward and backward rapidity
- A hint for a stronger suppression at forward rapidity

Conclusions

→ Quarkonium production has been measured in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 and 8.16 TeV
→ Run2 results increased significantly the precision of the measurements
→ Models face difficulties in describing consistently all results

J/ψ:
→ J/ψ shows a stronger suppression at forward-*y* than at backward-*y*, where R_{pPb} is compatible with unity
→ Theoretical models based on CNM effects qualitatively describe J/ψ results

ψ(2S):
→ ψ(2S) shows a stronger suppression than J/ψ, final-state effects needed to explain the ψ(2S) behaviour

ϒ:
→ Similar ϒ(1S) and ϒ(2S) suppression at backward and forward-*y*
→ Shadowing and energy loss models describe ϒ(1S) behaviour at forward-*y* results while they overestimate backward-*y* results

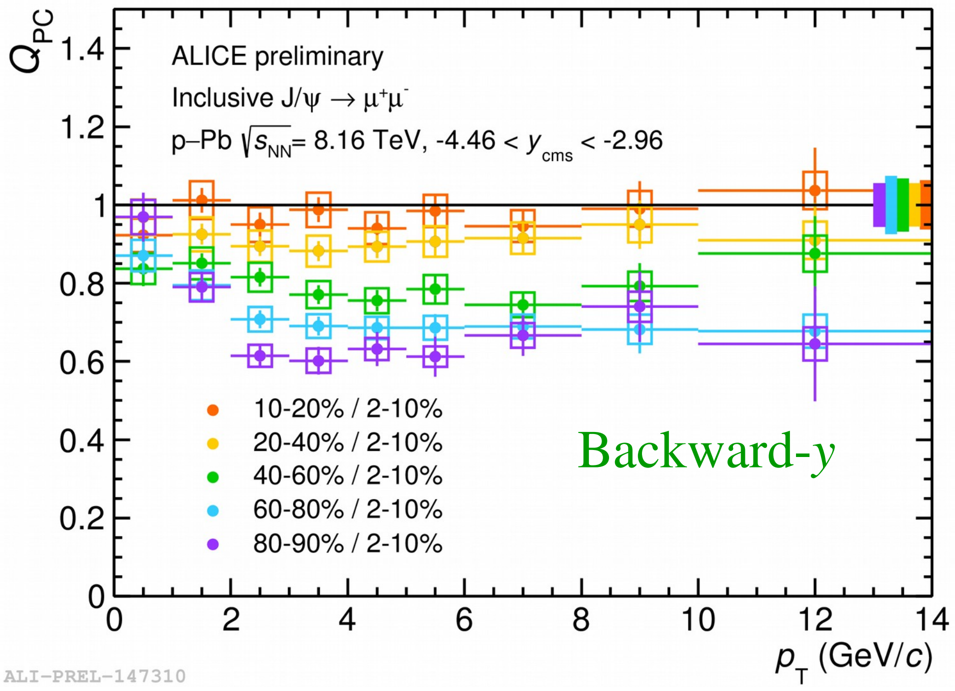
Posters:

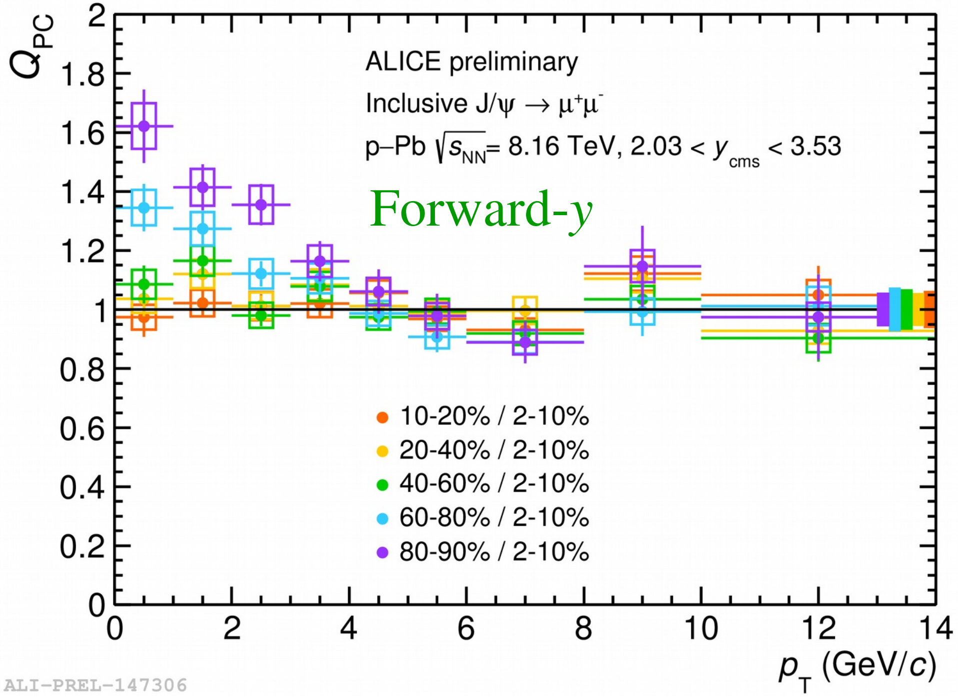
- J/ψ production at mid-rapidity in p-Pb collisions with the ALICE detector (Shinichi Hayashi)
- Inclusive ψ(2S) suppression in p-Pb collisions with ALICE at the LHC (Jhuma Ghosh)
- Upsilon production in p-Pb collisions with ALICE at the LHC (Wadut Shaikh)

Thank you

NEW!!

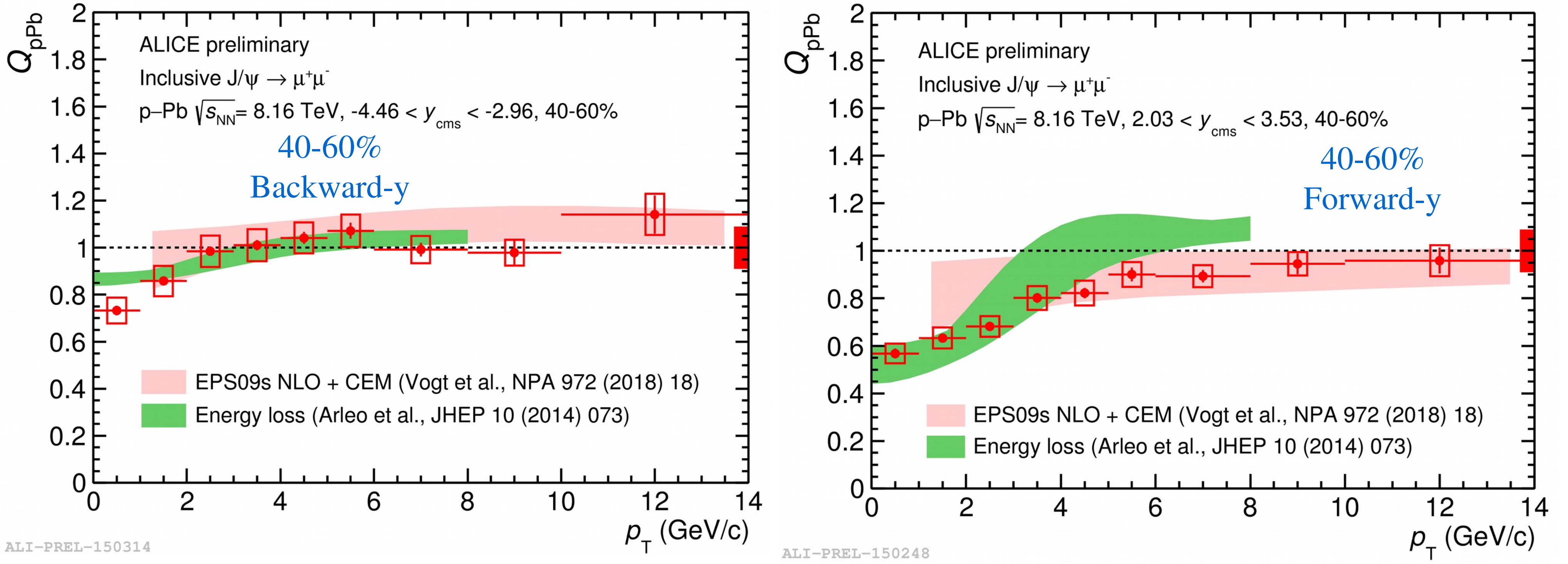
J/ψ Q_{PC} at $\sqrt{s_{NN}}$ = 8.16 TeV





NEW!!

Multi-differential J/ψ Q_{pPb} compared to theoretical models



Azimuthal anisotropy (v_2) of J/ψ

Low multiplicity

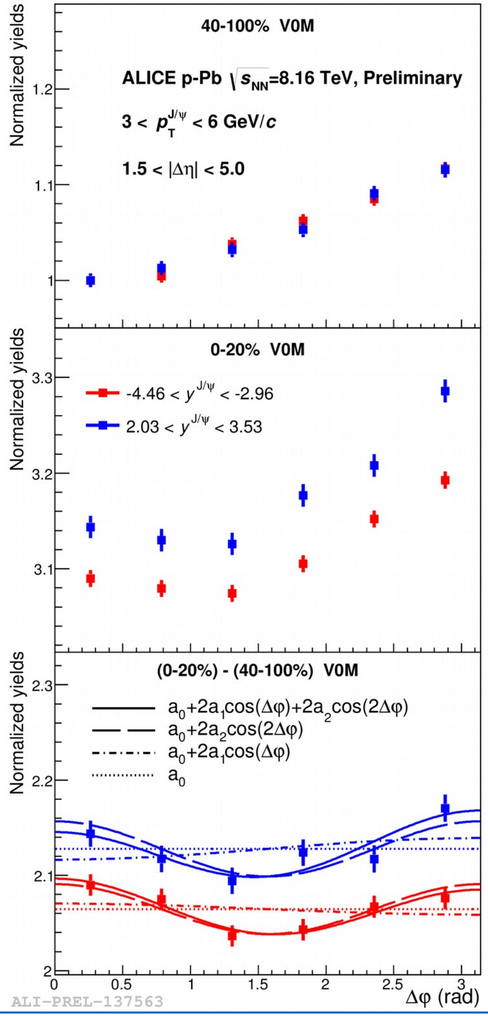
Clear away-side correlation presumably due to recoil jet

High multiplicity

Additional enhancement at both near and away sides

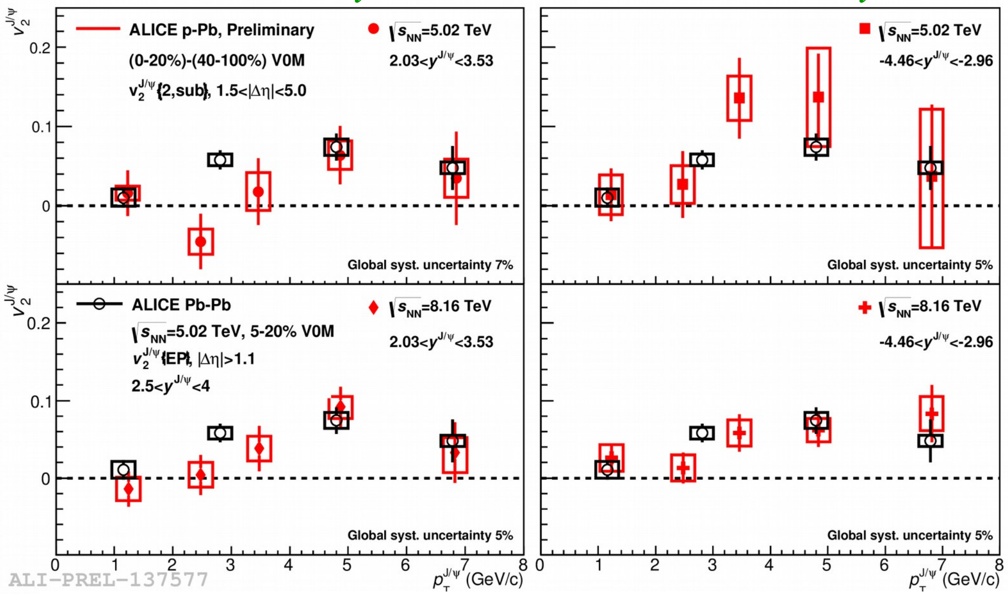
Low multiplicity
–
High multiplicity

Jet correlations eliminated via subtraction



Forward-y

Backward-y



- $p_T < 3$ GeV/c → v_2 compatible with 0
  In line with expectation of no recombination
- $3 < p_T < 6$ GeV/c → $v_2 > 0$
  Total (forward+backward,5.02+8.16 TeV) significance about 5σ
  Values comparable to the measurements in central Pb-Pb collisions