Charmonium production as a function of charged-particle multiplicity in p-Pb collisions with ALICE at the LHC

Theraa TORK
IJCLab, IN2P3-CNRS

High multiplicity events in small systems

Unexpected behaviors, point to the creation of QGP, where observed in small systems:

- Elliptic flow of charged particles: long-range angular correlation.
  JHEP 10.1007/09(2010).

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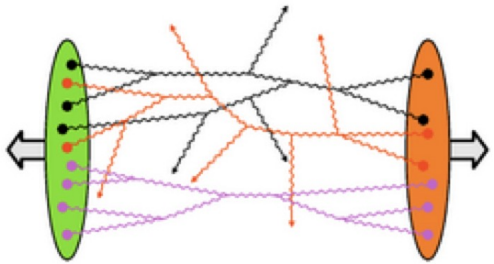

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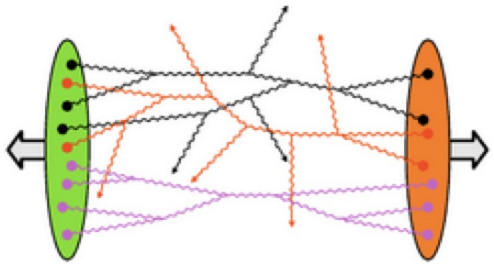

Our main motivation is to study MPIs in small systems

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Charmonium production as a function of charged-particle multiplicity with the ALICE experiment.

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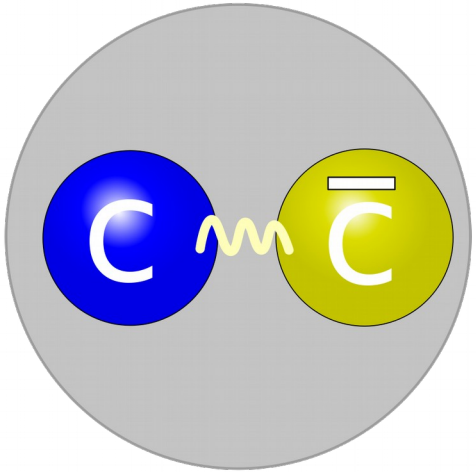
- c-quarks are created during the perturbative QCD.
  Due to their heavy mass ~ 1.5 GeV.

- The bound state is formed during non perturbative QCD.
  Binding energy is few MeV.



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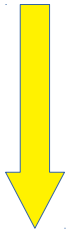

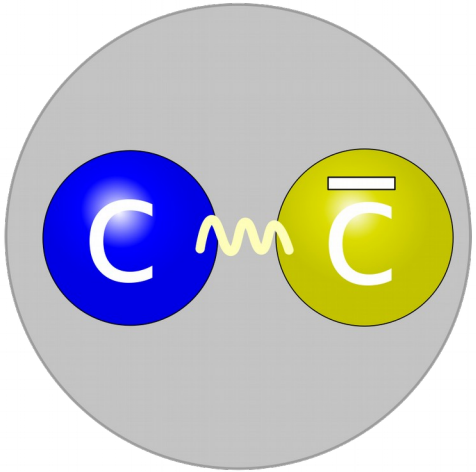

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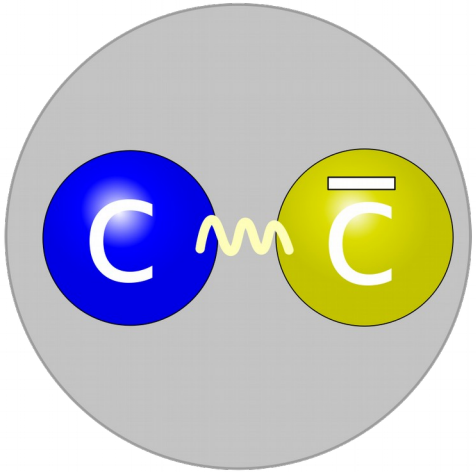
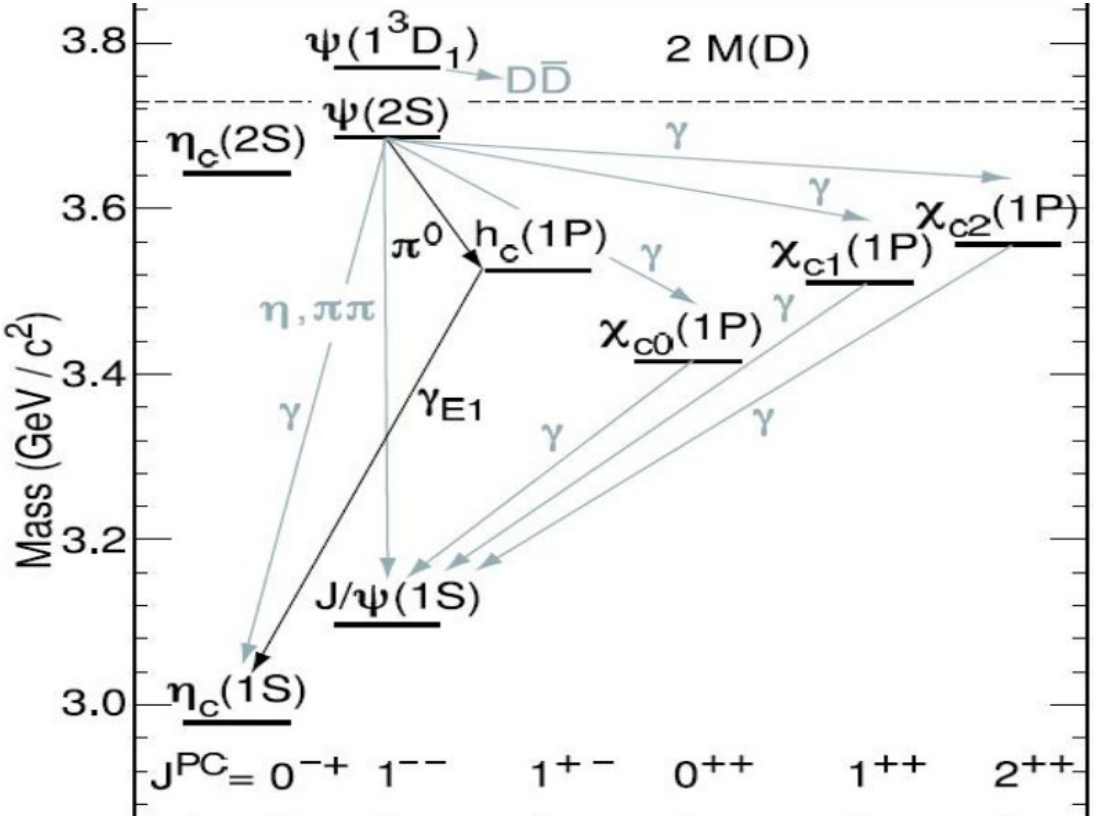


Provide an excellent tool to test perturbative and non perturbative QCD processes.

Charmonia


3.8
3.6
3.4
3.2
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Mass (GeV / c²)
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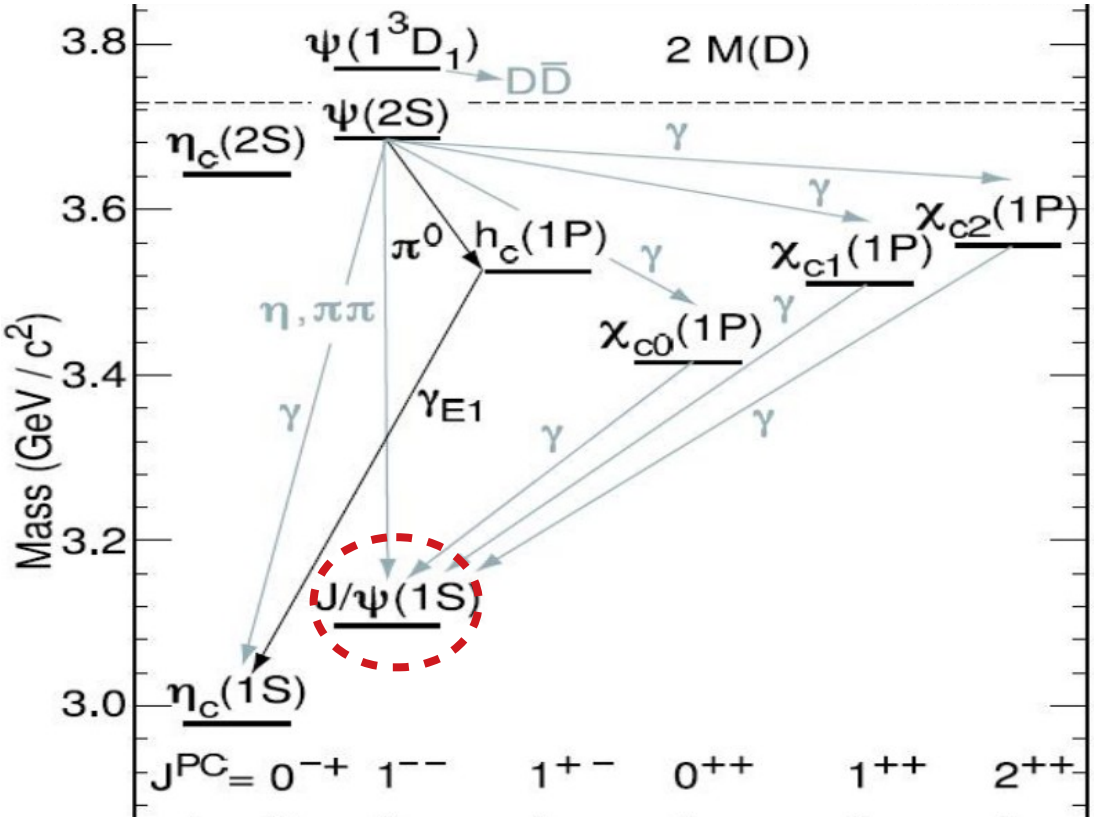
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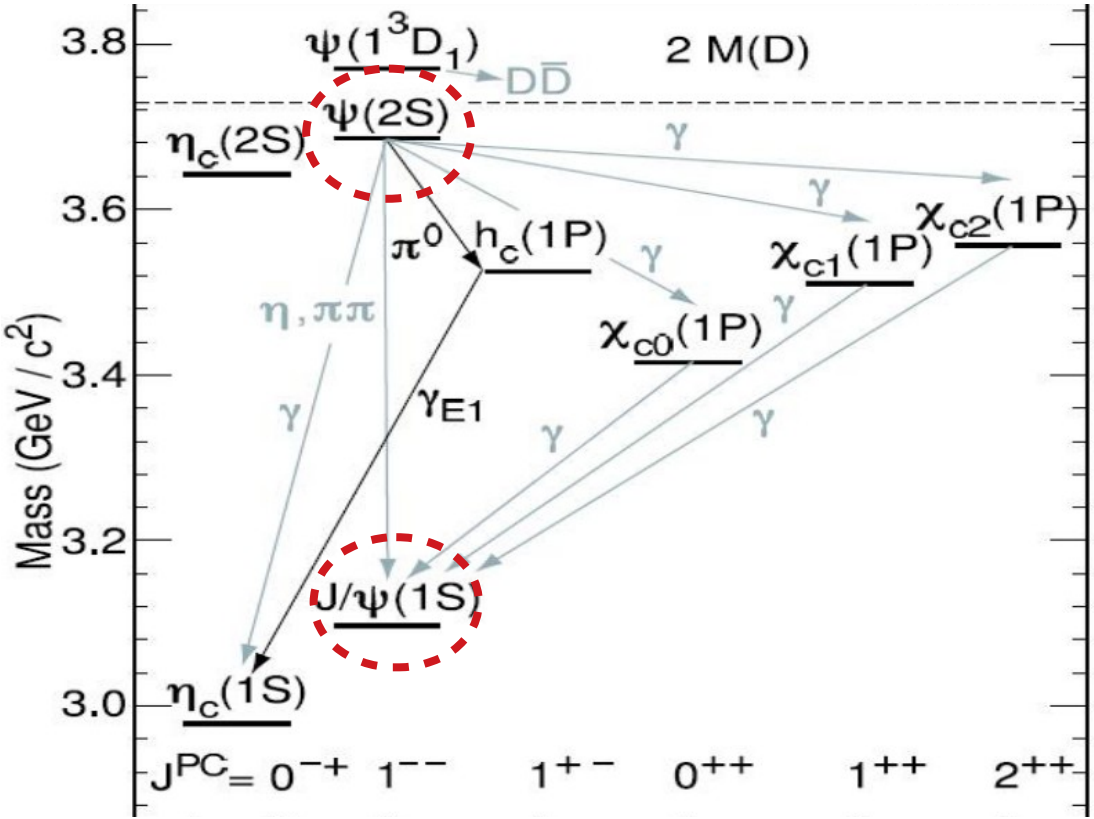
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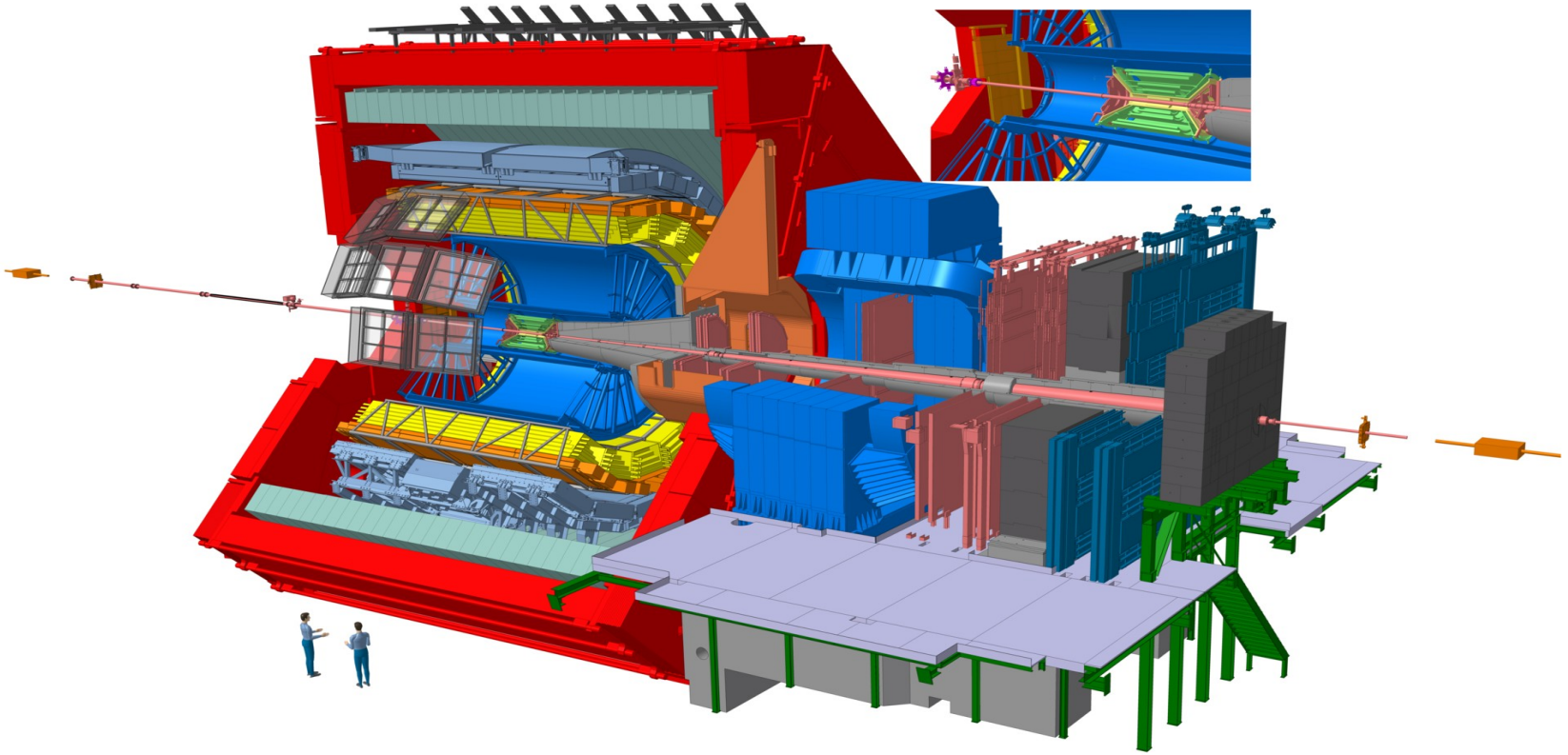
ALICE detector



Muon Spectrometer

$J/\psi, \psi(2S) \rightarrow \mu^-\mu^+$

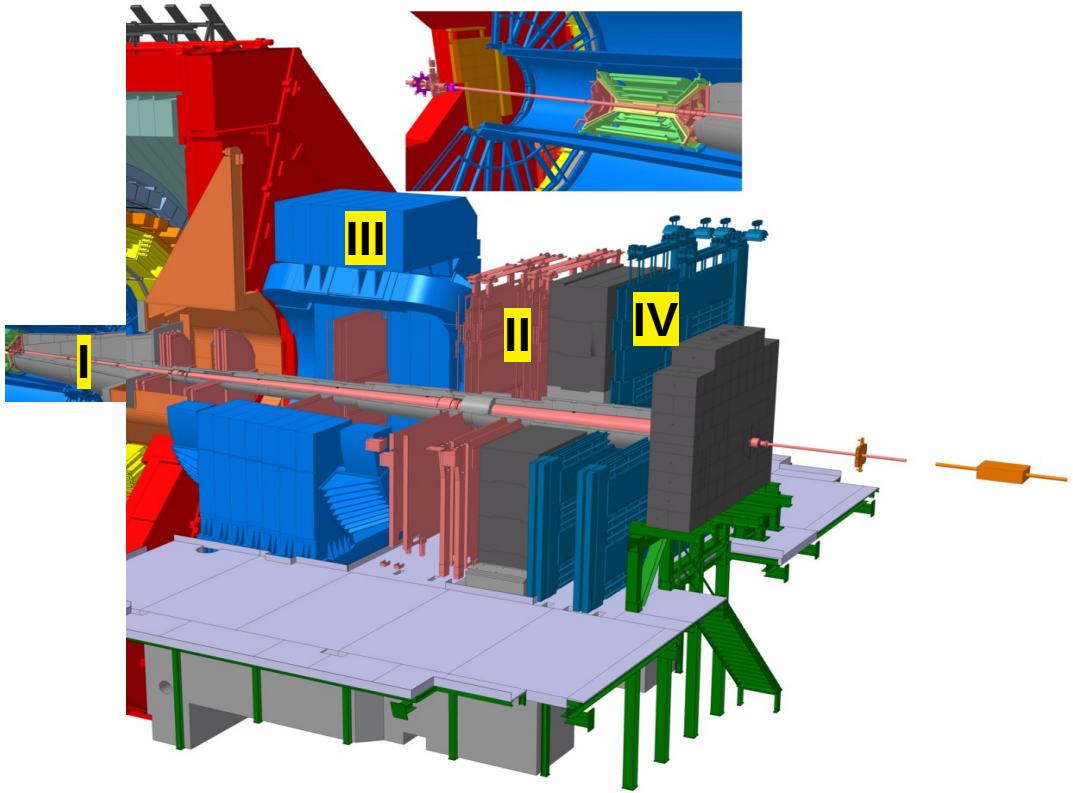
$2.5 < y_{lab} < 4.0$

I. Front absorber.

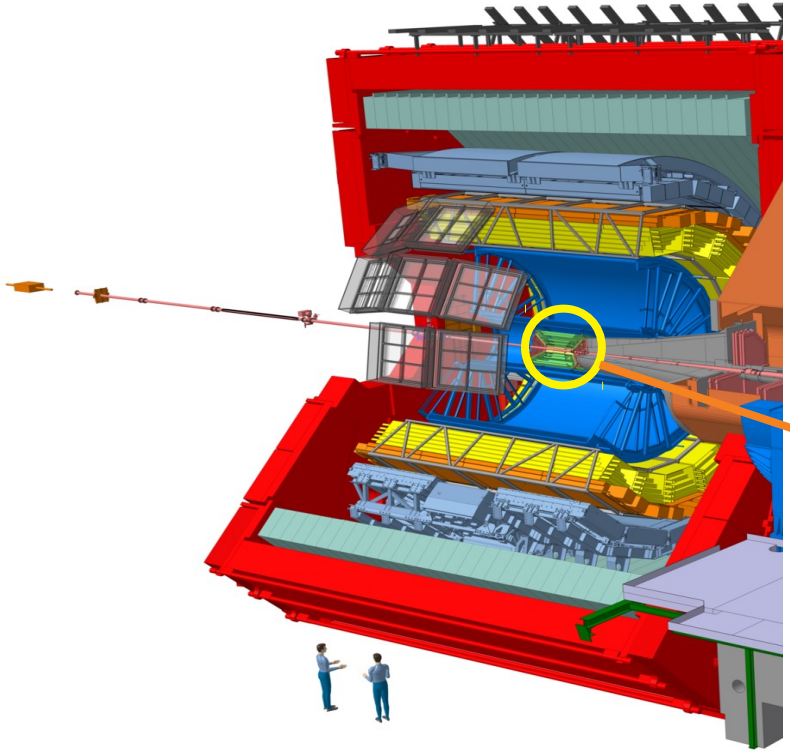
II. Muon tracking chambers.

III. Dipole magnet 3T.m.

IV. Muon trigger chambers.

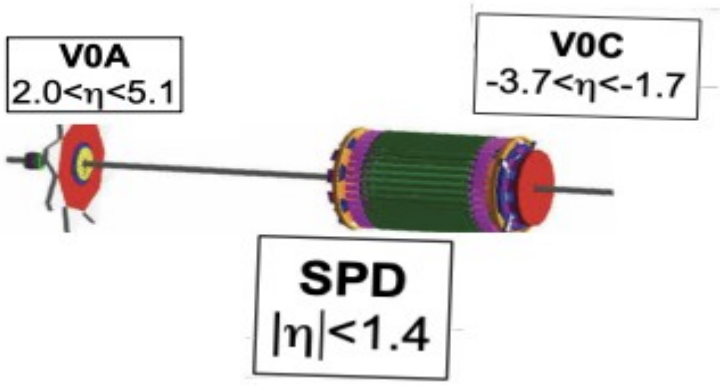


Central barrel



Measure charged-particle multipicity

- V0 scintillators.
- Silicon pixel detector (SPD)

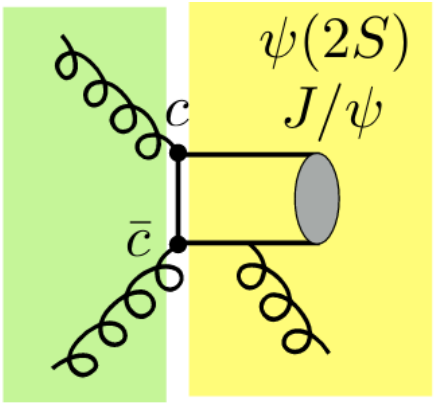


Charmonia production in p-Pb collisions

Cold nuclear matter effects

Nuclear environment effects

- **Initial state effects**



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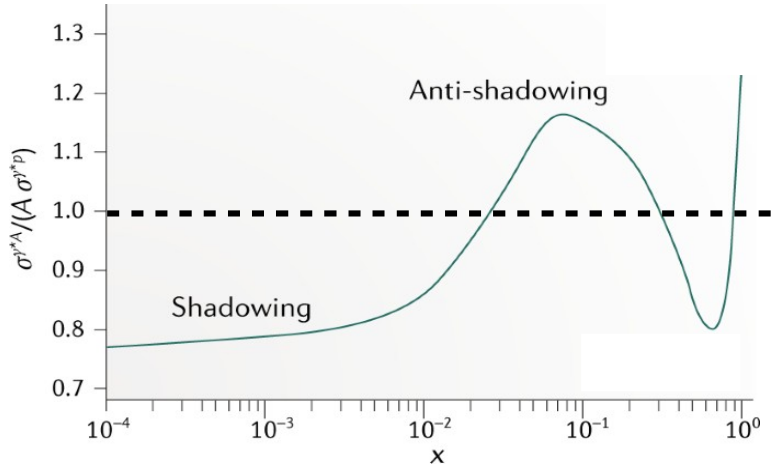

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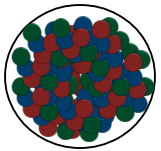

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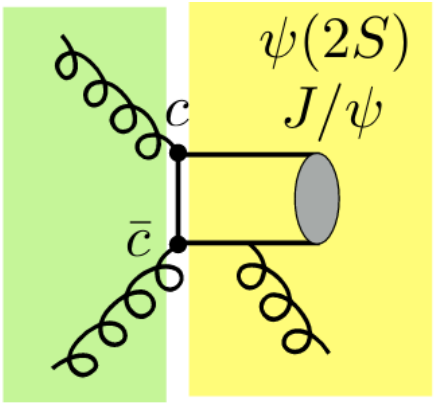

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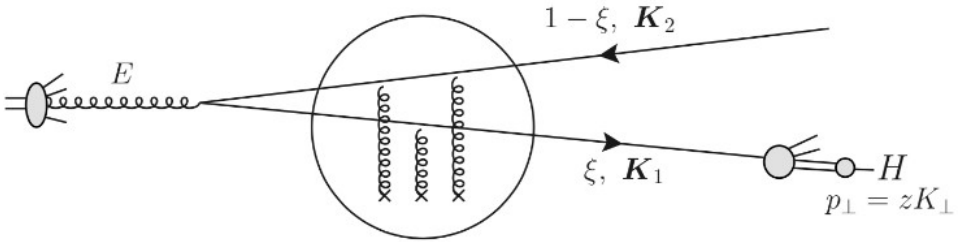

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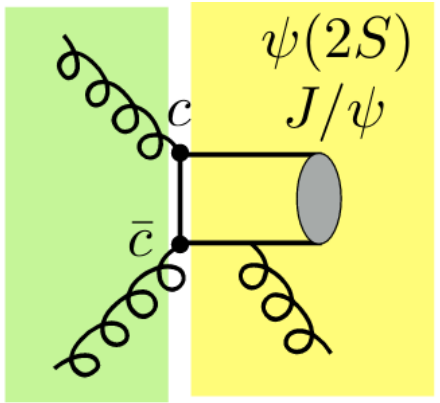

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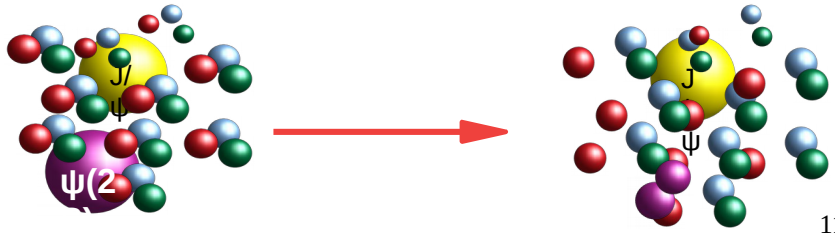
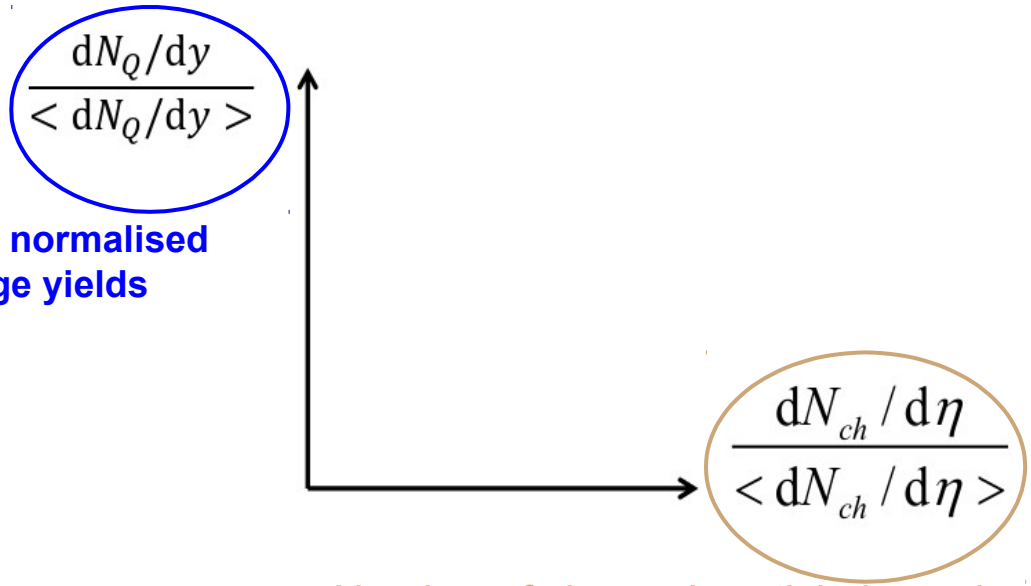
- **Final state effects**
  - Interaction with comoving particles.



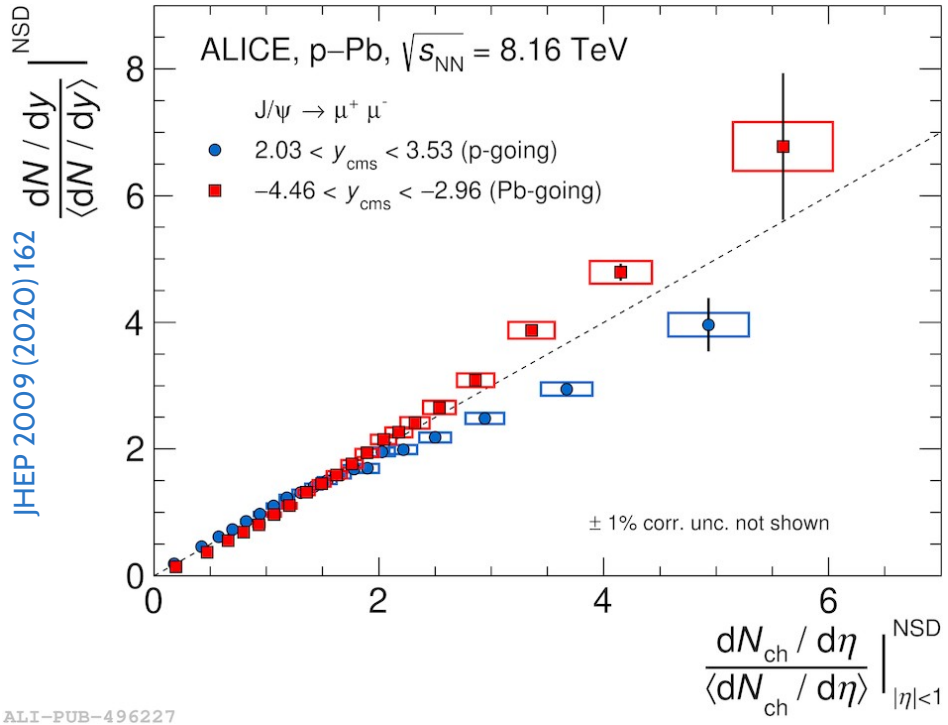
Particle production vs multiplicity



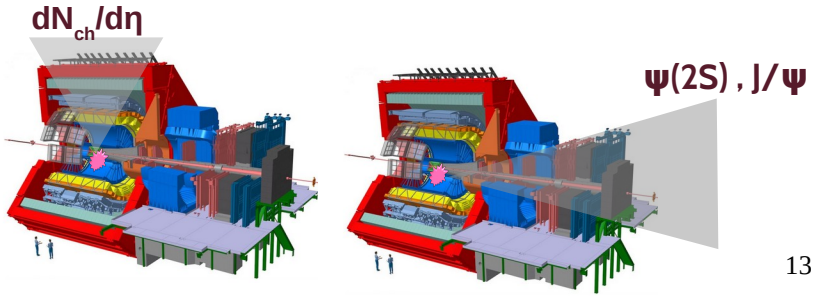
yields of charmonia normalised to the their average yields

Number of charged-particle in each rapidity normalised to the average number of charged particles

Multiplicity dependence of J/ψ production



- J/ψ yields increase with $dN_{ch} / d\eta$ in both rapidity regions.
- Faster (Slower) than linear increase observed at backward (forward) rapidity.
- The different behavior likely due to different Bjorken-*x* regions probed.



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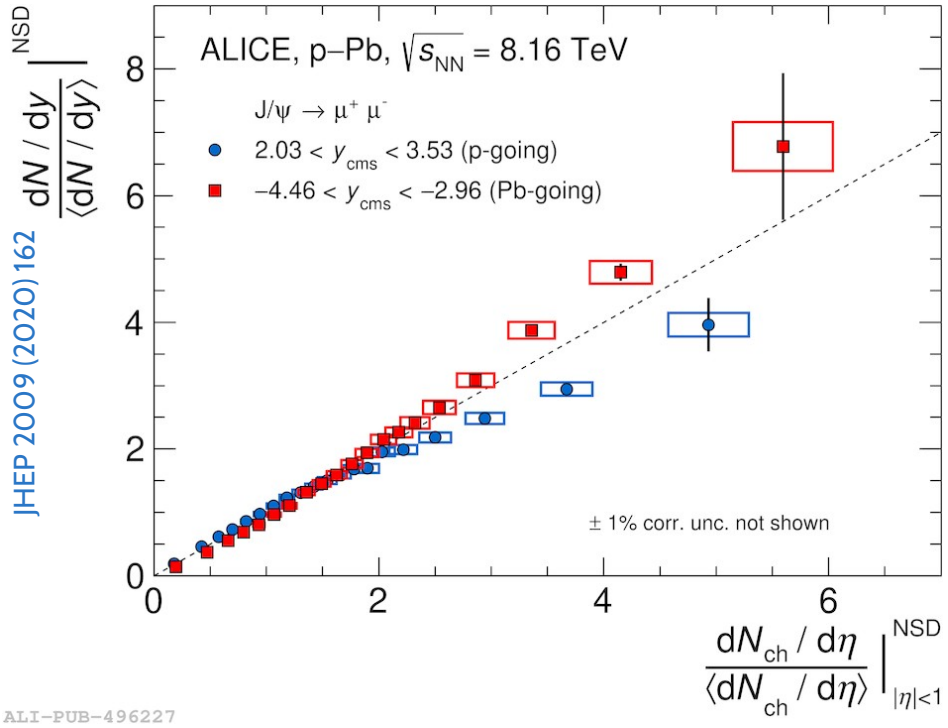

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ALI-PUB-496227

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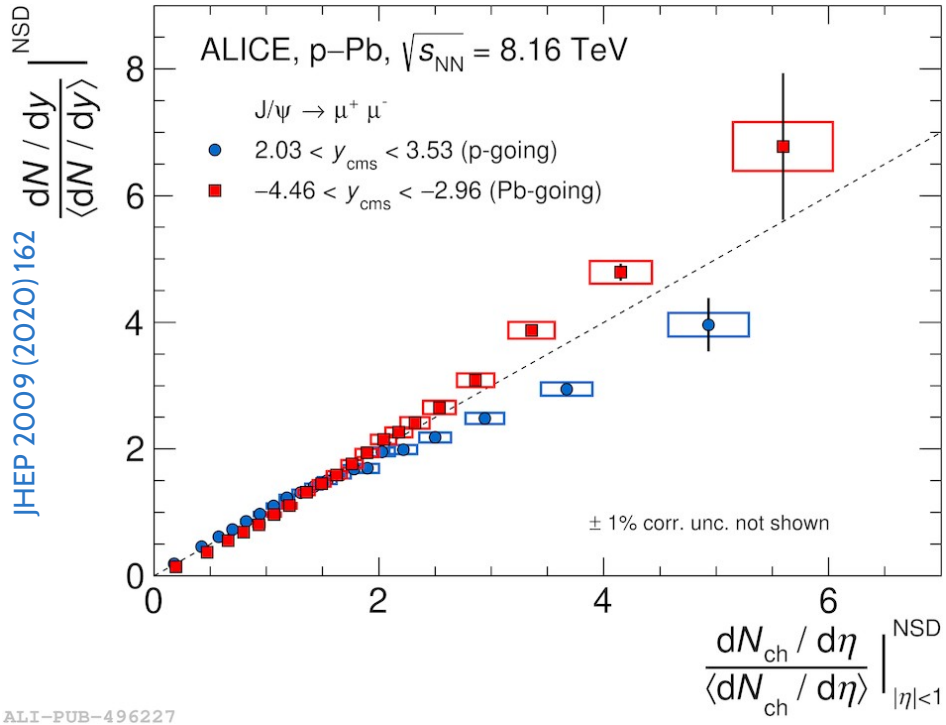

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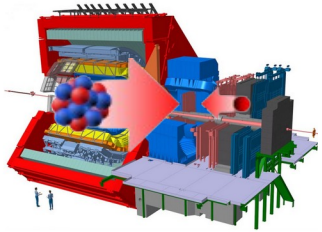

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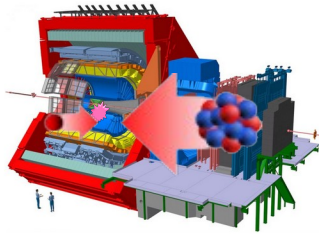

J/ψ vs multiplicity in p-Pb collisions

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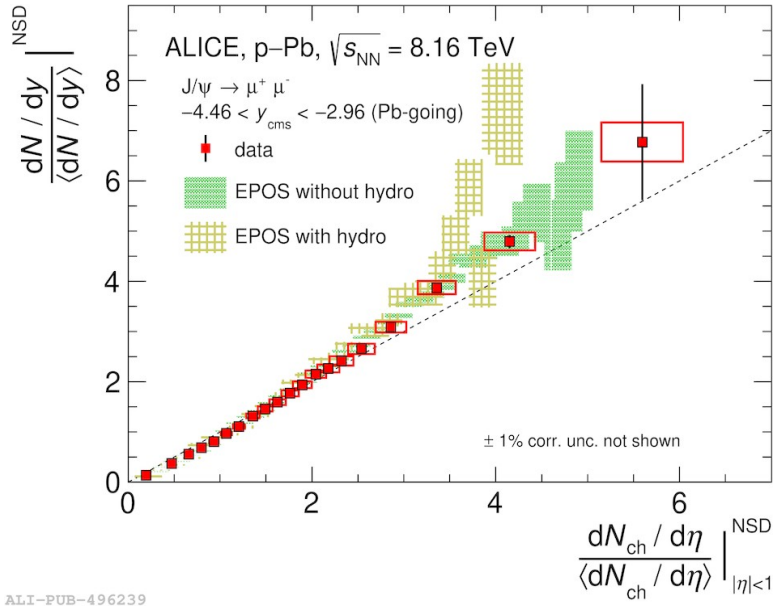

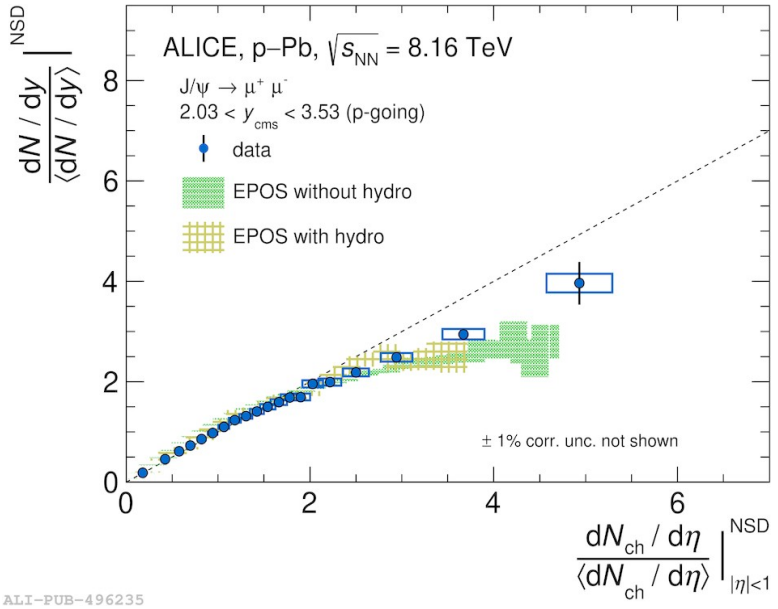

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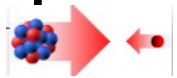
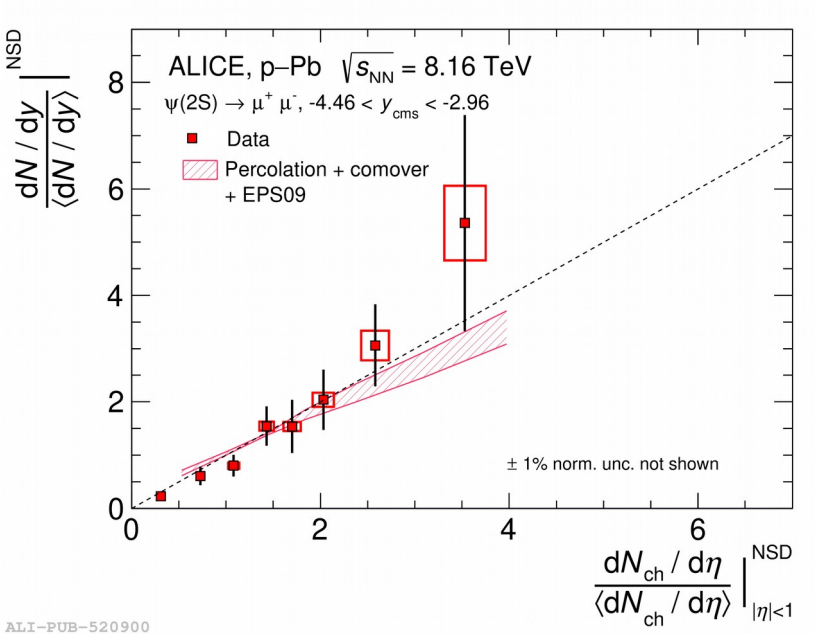
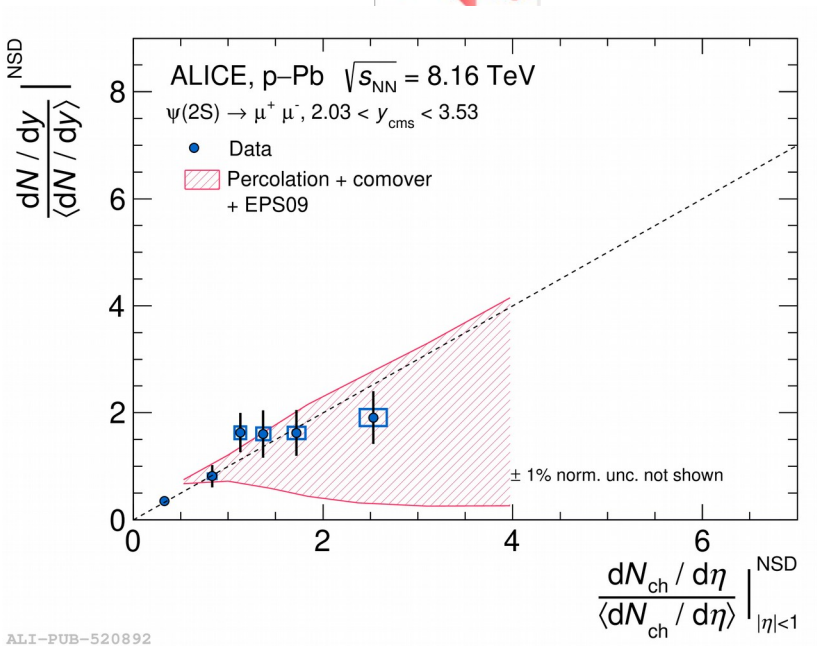
EPOS describes the behavior of J/ψ vs multiplicity in both rapidity regions.

Multiplicity dependence of ψ(2S) production







arXiv:2204.10253

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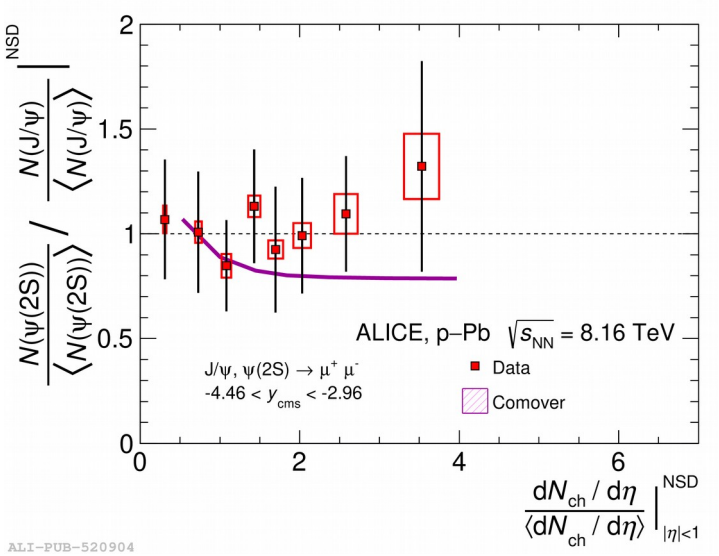
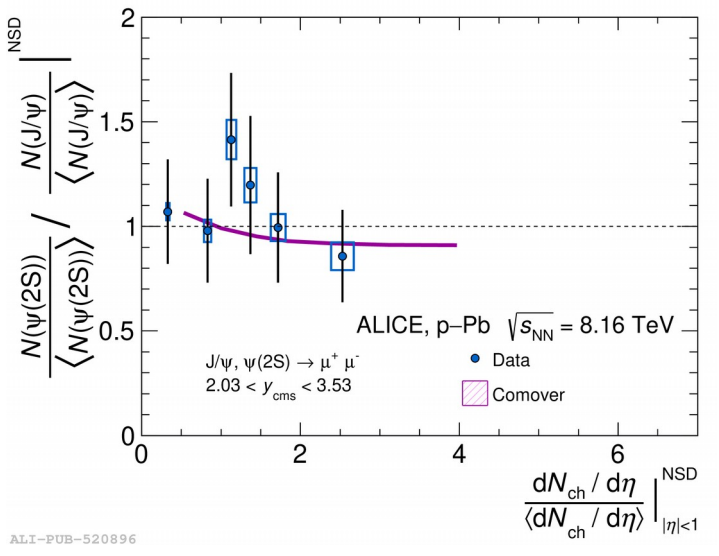
- The ψ(2S) yield increases with increasing $dN_{ch}/d\eta$ in p–Pb collisions.
- Percolation+ comovers+EPS09 calculation predicts the trend of the measurements
  - Large uncertainty at forward rapidity due to EPS09 nPDF uncertainty.

Multiplicity dependence of ψ(2S)-over-J/ψ production





- Similar behavior of J/ψ and ψ(2S) vs $dN_{ch}/d\eta$ in p-Pb.
- Similar trend of the ψ(2S)-to-J/ψ ratio vs multiplicity in both rapidity regions.
- The comovers calculation describes the data within statistical and systematic uncertainties.

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Comparison to pp collisions at 13 TeV

Multiplicity dependence of ψ(2S) production

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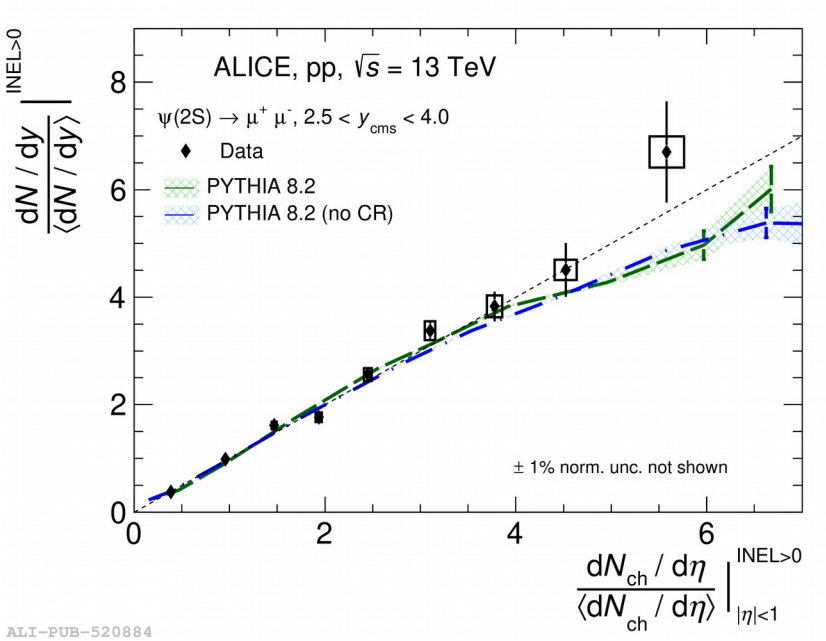
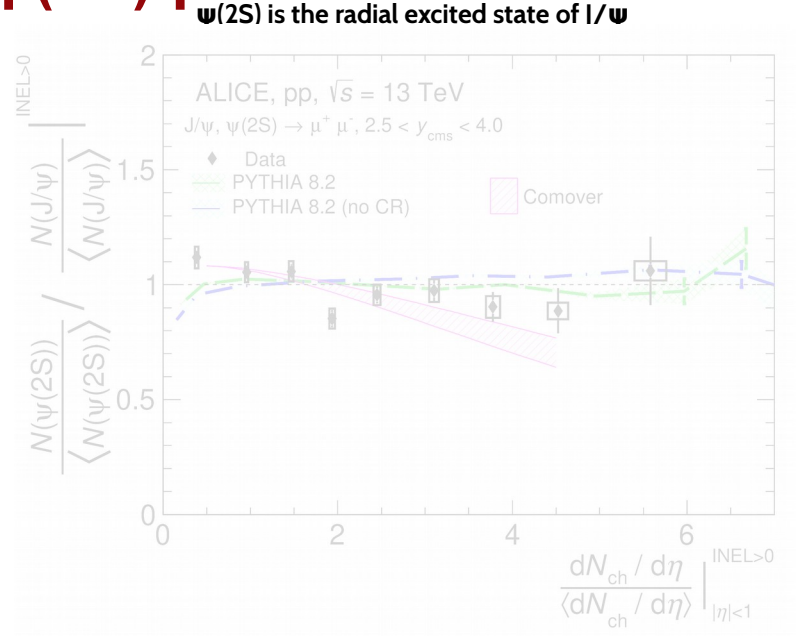
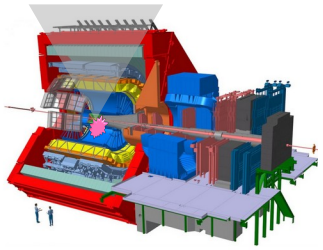


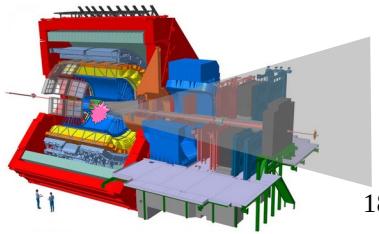
ψ(2S) is the radial excited state of J/ψ



- ψ(2S) yields increase linearly with $dN_{ch}/d\eta$.
- PYTHIA 8.2 predicts the trend of the measurements at the probed multiplicities.

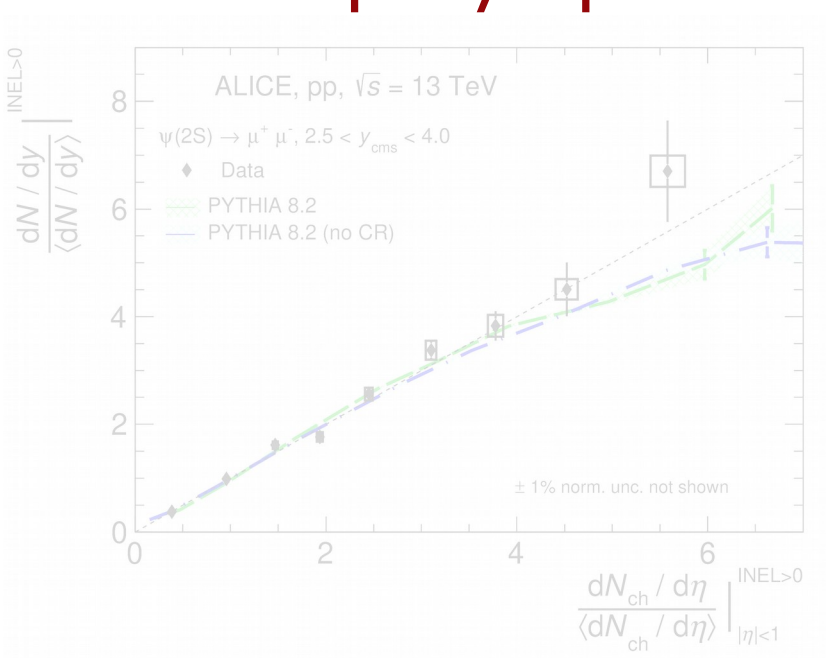
$dN_{ch}/d\eta$



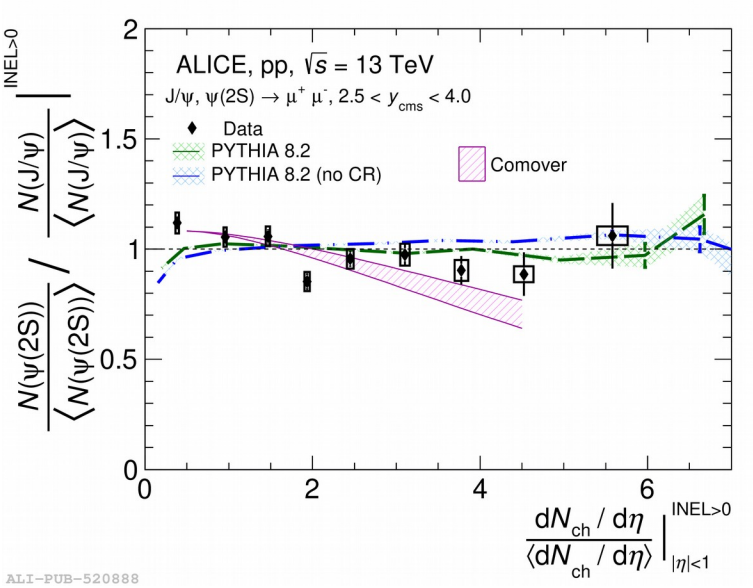


ψ(2S)

Multiplicity dependence of ψ(2S) production

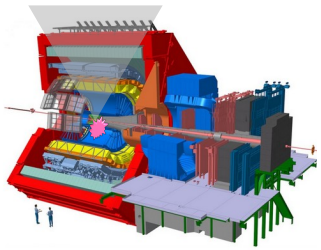


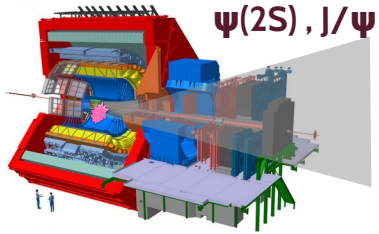
ψ(2S) is the radial excited state of J/ψ



arXiv:2204.10253

$dN_{ch}/d\eta$





- Similar behavior for J/ψ and ψ(2S) vs multiplicity.
- Measurements are compatible with available models within uncertainties:
  - Comovers: predicts a stronger suppression of ψ(2S) at high multiplicity.
  - PYTHIA 8.2 : suggests a flat ψ(2S)-to- J/ψ ratio.

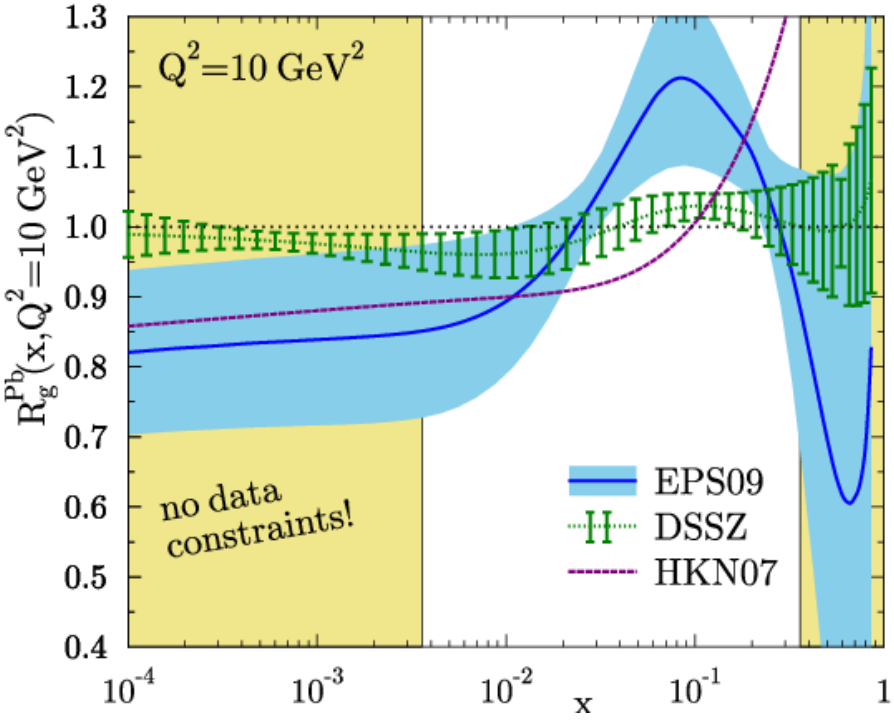
Conclusion

- J/ψ yield at forward and backward rapidity as a function of charged-particle multiplicity is described by EPOS calculation, that includes both initial and final state effects.
- ψ(2S) measurements at large rapidities are not conclusive due to limited statistics.
- More stringent tests of the models are needed to disentangle initial and final-state effects.

LHC RUN 3 will bring constraints to MPI modeling thanks to higher statistics expected for data.

Thank you !

Nuclear PDF


Q^2=10 GeV^2
no data constraints!
EPS09
DSSZ
HKN07
$R_g^{Pb}(x,Q^2=10\ GeV^2)$
x
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1