Charmonium production in p-Pb collisions
with ALICE at the LHC

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Charmonium studies in p-Pb collisions in ALICE.

→ Run-1 results in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

→ Run-2 results in p-Pb collisions at $\sqrt{s_{NN}} = 8.16$ TeV

The results are available in:
CERN-ALICE-PUBLIC-2017-001 and CERN-ALICE-PUBLIC-2017-007
Physics motivation

- On top of the hot matter mechanisms in AA collisions, other effects, related to cold nuclear matter (CNM), might affect quarkonium production:
  - Nuclear parton shadowing/color glass condensate
  - Energy loss
  - $c\bar{c}$ break-up in nuclear matter

- CNM are investigated in pA collisions, addressing:
  - Role of the various contributions, whose importance depends on kinematic and energy of the collisions.
  - Size of CNM effects to disentangle hot and cold nuclear matter effects in AA collisions to interpret quarkonium AA results.
Quarkonium in ALICE can be measured in two ways:

**Central Barrel:** \( J/\psi \rightarrow e^+e^- \)  
(\( |y| < 0.9 \))

Electrons tracked using ITS and TPC  
Particle identification: TPC (+TOF)

**Forward muon arm:** \( J/\psi \rightarrow \mu^+\mu^- \)  
(\( 2.5 < y < 4 \))

Muons identified and tracked in the muon spectrometer

- Acceptance coverage in both \( y \) regions down to zero \( p_T \)
- The ALICE results presented in this talk refer to inclusive \( J/\psi \).
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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**  
  \( 2.03 < y_{\text{cms}} < 3.53 \)

- **Mid rapidity**  
  \( -1.37 < y_{\text{cms}} < 0.43 \)

- **Backward rapidity**  
  \( -4.46 < y_{\text{cms}} < -2.96 \)
J/ψ $R_{pPb}$ vs $y_{cms}$ and $p_T$ at $\sqrt{s_{NN}} = 5.02$ TeV

- Clear J/ψ suppression at forward rapidity, and compatible with unity at backward rapidity.
- The $R_{pPb}$ increases with $p_T$ at forward and mid rapidity and shows a weaker $p_T$ dependence at backward rapidity.
- The suppression behavior of J/ψ is compatible with CNM based on shadowing and/or energy loss models.
$\psi(2S)$ suppression is stronger than the $J/\psi$ one.

Theoretical predictions (based on shadowing and energy loss) can not describe the stronger $\psi(2S)$ suppression.

This strong $\psi(2S)$ suppression is possibly due to final-state effects.
At forward rapidity, the $J/\psi$ and $\psi(2S)$ $Q_{pPb}$ show a similar decreasing pattern.

At backward rapidity, $Q_{pPb}$ behavior are different, with the $\psi(2S)$ significantly more suppressed for largest centrality.

$\psi(2S)$ behaviour can be interpreted if models include final-state effect.
$J/\psi$ $R_{pPb}$ vs $y_{cms}$ and $p_T$ at $\sqrt{s_{NN}} = 8.16$ TeV

- Clear $J/\psi$ suppression at forward rapidity, and compatible with unity at backward rapidity.
- Compatible $R_{pPb}$ at $\sqrt{s_{NN}} = 5.02$ and 8.16 TeV even if $x_F$ coverage is slightly different.
- $p_T$ coverage extended up to 20 GeV/$c$ in Run-2.
- $R_{pPb}$ increases with $p_T$ at forward rapidity and shows a weaker dependence at backward rapidity.
- In Run-2 we have increased the precision on the results.
**J/ψ R_{pPb} compared to models at $\sqrt{s_{NN}} = 8.16$ TeV**

- Good agreement between data and models based on shadowing and/or energy loss, as at $\sqrt{s_{NN}} = 5.02$ TeV.

- Theoretical uncertainties still limit a more quantitative comparison.
Higher luminosity collected at $\sqrt{s_{NN}} = 8.16$ TeV allows a finer binning with respect to $\sqrt{s_{NN}} = 5.02$ TeV.

$Q_{pPb}$ decreases with $N_{\text{coll}}$ at forward rapidity while an opposite trend is observed in backward rapidity.

Similar pattern at both energies, slightly lower values at $\sqrt{s_{NN}} = 8.16$ TeV but compatible within the uncertainties.
Charmonium production has been measured in p-Pb collisions at \( \sqrt{s_{NN}} = 5.02 \) and 8.16 TeV.

\( J/\psi \) shows a suppression with a strong kinematic dependence, with a similar pattern at the two centre-of-mass energies.

Theoretical models based on shadowing and/or energy loss are in fair agreement with data.

New \( J/\psi \) results in p-Pb collisions at \( \sqrt{s_{NN}} = 8.16 \) TeV are shown as a function of centrality. They confirm, at both forward and backward rapidity, the trend observed at \( \sqrt{s_{NN}} = 5.02 \) TeV, with an increased precision.

\( \psi(2S) \) shows a stronger suppression than \( J/\psi \), possibly due to final-state effects.
Thank you
p-Pb collisions at $\sqrt{s_{NN}} = 8.16$ TeV

→ Results from 2016 data set, based on dimuon triggered events

→ $J/\psi$ yield extracted fitting the opposite sign dimuon invariant mass spectrum.
→ Signal is extracted with a extended Crystal Ball function or a pseudo-Gaussian function. Background: phenomenological fits of the invariant mass spectrum.
→ Results obtained with different techniques are combined to extract $<N_{J/\psi}>$ and to evaluate systematic uncertainties.
$J/\psi$ $Q_{pPb}$ vs centrality at $\sqrt{s_{NN}} = 8.16$ TeV

ALICE
Inclusive $J/\psi \rightarrow \mu^{+}\mu^{-}$, $2.03 < y_{\text{cms}} < 3.53$

- $p$--Pb $\sqrt{s_{NN}} = 8.16$ TeV (preliminary)
- $p$--Pb $\sqrt{s_{NN}} = 5.02$ TeV (JHEP 11 (2015) 127)

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