Livio Bianchi
on behalf of the ALICE Collaboration

J/ψ production measurements
in pp and PbPb collisions
in the ALICE experiment at the LHC
Motivations for $J/\psi$ studies

The ALICE experiment and its performance in detecting quarkonia

Results in pp collisions at 7 TeV and 2.76 TeV

Results in PbPb collisions at 2.76 TeV

Conclusions
Motivations for $J/\psi$ in pp

Need to understand production mechanism. Several models:

- **CEM**: phenomenological;
- **CSM LO**: bad x-sect. reproduction (ruled out in the ‘90s);
- **COM**: good x-sect. reprod. for all quarkonia, bad polarization prediction;
- **CSM NLO**: x-sect. better than LO, better polar. prediction

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J.P. Lansberg - arXiv:1003.4319

Livio Bianchi
EPS HEP 2011
Grenoble - 21/07/11
Motivations for $J/\psi$ in pp & HI collisions

Quarkonium suppression proposed as a probe of deconfinement. Observed suppression in central collisions at SPS and RICH (above cold nuclear matter effects)

Many issues as:

- Suppression at PHENIX not larger than at SPS (regeneration? Interesting to study at higher energies)
- PHENIX finds larger suppression at forward rapidity → interesting to study the forward region at LHC
ALICE detector and performance
The ALICE experiment

ALICE studies $J/\psi$ production down to $p_T=0$ both at mid-rapidity ($|y|<0.9$) in the di-electron channel and at forward rapidity ($2.5<y<4$) in the di-muon channel.

**Inner Tracking System (ITS), 6 layers:**
- 2 pixel layers (SPD)
- 2 drift layers (SDD)
- 2 strip layers (SSD)

**Time Projection Chamber (TPC):**
main tracking detector, used for PID via specific energy loss

**V0:** scintillator arrays at forward and backward rapidities – used for MB trigger (with SPD) and for centrality determination

**Muon Spectrometer:**
- Front absorber
- 5 tracking stations
- Dipole magnet
- Iron wall
- 2 trigger stations
**J/ψ→μ⁺μ⁻ and →e⁺e⁻ in ALICE (pp)**

ALICE took data in pp runs at 7 (arXiv:1105.0380) and 2.76 TeV. Integrated luminosity corresponding to the results that will be shown:

<table>
<thead>
<tr>
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<th>J/ψ→μ⁺μ⁻</th>
<th>J/ψ→e⁺e⁻</th>
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<tbody>
<tr>
<td>√s = 7 TeV</td>
<td>15.6 nb⁻¹</td>
<td>3.9 nb⁻¹</td>
</tr>
<tr>
<td>√s = 2.76 TeV</td>
<td>20.2 nb⁻¹</td>
<td>1.1 nb⁻¹</td>
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2 peculiarities of ALICE:
1. In the Forward spectrometer the acceptance is slowly dependent on \( p_T \) and, as in the e⁺e⁻ channel, goes down to \( p_T = 0 \)
2. In central barrel PID performed with the TPC (in the future also TRD and EMCAL): ±3σ inclusion cut for electrons, ±3.5σ(3σ) exclusion cuts for pions (protons).
Data were taken at 2.76 TeV in both channels - total luminosity of 2.7 μb⁻¹

To estimate centrality: V0 amplitude fitted with glauker model

Four centrality classes chosen for muons:
[0,10]% [10,20]% [20,40]% [40,80]%

Only two for electrons:
[0,40]% [40,80]%
Results: pp collisions at 7 TeV & 2.76 TeV
pp at $\sqrt{s}=7\text{TeV} \& 2.76\text{TeV}$: cross-section

Integrated inclusive $J/\psi$ production cross sections:

$\sigma(2.5<y<4) = 6.31\pm 0.25{\text{(stat)}} \pm 0.8{\text{(syst)}} + 0.95(\lambda_{\text{CS}}=+1)-1.96(\lambda_{\text{CS}}=-1) \ \mu b$

$\sigma(|y|<0.9) = 10.7\pm 1.2{\text{(stat)}} \pm 1.7{\text{(syst)}} + 1.6(\lambda_{\text{HE}}=+1)-2.3(\lambda_{\text{HE}}=-1) \ \mu b$

$\sigma(2.5<y<4) = 3.46\pm 0.13{\text{(stat)}} \pm 0.32{\text{(syst)}} \pm 0.28{\text{(lumi)}} + 0.55(\lambda_{\text{CS}}=+1)-1.11(\lambda_{\text{CS}}=-1) \ \mu b$

$\sigma(|y|<0.9) = 6.44\pm 1.42{\text{(stat)}} \pm 0.88{\text{(syst)}} \pm 0.52{\text{(syst)}} + 0.64(\lambda_{\text{HE}}=+1)-1.42(\lambda_{\text{HE}}=-1) \ \mu b$

At forward rapidity the $d^2\sigma/dydp_T$ was extracted at both the energies → well reproduced by NRQCD calculations at NLO

Comparison at 7 TeV with other LHC experiments: fair agreement both at forward rapidity (with LHCb) and at mid rapidity, where ALICE is complementary to ATLAS and CMS
J/ψ yield as a function of the charged particle multiplicity studied at central and forward rapidities.

Linear increase observed

The J/ψ yield exhibits a weaker increase with dN_{ch}/dη than the high p_T muons (>80% of which are coming from heavy flavors). Different mechanisms can explain this observation such as kinematical effects, modification of the p_T distribution, modification of the bottom to charm ratio, etc..

STILL WORK FOR THE INTERPRETATION
Results: PbPb collisions at 2.76 TeV
$R_{AA}$ VS centrality

$R_{AA}^i$ calculated only in the forward region:

$$R_{AA}^i = \frac{Y_{J/\psi}^i}{\langle T_{AA}^i \rangle \cdot \sigma_{J/\psi}^{inclus}(2.76 \text{ TeV})}$$

Raw yields were corrected for acc$\times$eff:

$$Y_{J/\psi}^i = \frac{N_{J/\psi}^i}{B.R. \cdot Acc \times Eff \cdot N_{MB}^i}$$

- $p_T$ and $y$ inputs taken from interpolation based on real data (F. Bossu et al., arXiv:1103.2394)
- less than 2% dependence of tracking efficiency on the centrality

Normalization to the inclusive cross-section measured in pp at 2.76 TeV

Systematics dominated by signal extraction (up to 19% in the most central bin) and by the uncertainty on the pp inclusive cross-section measurement (13%)
The inclusive $J/\psi$ $R_{AA}$ integrated over all the centralities is measured to be:

$$R_{AA}^{0\text{-}80\%} = 0.49 \pm 0.03\text{(stat)} \pm 0.11\text{(syst)}$$

The dependence of $R_{AA}$ on centrality not strong.

note that the most peripheral class includes semi-central events!!

The comparison with the results obtained by PHENIX at forward rapidity (1.2<|y|<2.2) shows less suppression at LHC then at RHIC: hint for regeneration?

Better agreement with PHENIX data at mid-rapidity, but not at very high $N_{\text{part}}$
R_{AA} VS centrality: results (II)

We can compare the $R_{AA}$ to pure shadowing predictions
K.J.Eskola et al., JHEP 0904:065, 2009

Uncertainties on the shadowing predictions are very high: need of pA data at LHC for addressing cold nuclear matter issues
R_{CP} computed in both forward and central rapidity regions: allows to compare with ATLAS result.

Ratio normalized to the 40-80% bin

Error bars: statistical uncertainties
Empty boxes: centrality dependent systematic uncertainties

The R_{CP} extracted in ALICE at forward rapidity is not in agreement with the one extracted by ATLAS at mid-rapidity, especially in central collisions

Higher suppression at higher \( p_T \)? Or at central rapidities? Or both?

The mid-rapidity result in ALICE has too large errors to allow a comparison
Conclusions

ALICE has been studying inclusive $J/\psi$ production in a large rapidity region extending from -0.9 to 4 and down to $p_T=0$

The inclusive production cross-sections in pp collisions at 7 TeV and at 2.76 TeV, as well as the $p_T$ and $y$ differential cross sections, are in nice agreement with what found by the other LHC experiments both at forward rapidity and at mid-rapidity.

The measured $d^2\sigma/dp_Tdy$ is in good agreement with NRQCD NLO predictions at both the energies.

The inclusive $J/\psi$ yield shows a linear increase as a function of $dN_{ch}/d\eta$.

In PbPb at 2.76 TeV the $R_{AA}$ factor was measured at forward rapidity as a function of the centrality.

Comparison with the PHENIX → less suppression at LHC with respect to RICH in central collisions. The interpretation of this result will be simpler when pA data at the same energy will be taken.

The $R_{CP}$ was also measured. The factor is larger with respect to what ATLAS measures at mid-rapidity, possibly reflecting some kinematical dependence of the factor itself.

Thank you