Abstract We have carried out a wide study of shadowing and antishadowing effects on $J/\psi$ production in $dAu$ collisions at $\sqrt{s_{NN}} = 200$ GeV. We have studied the effects of three different gluon nPDF sets, using the exact kinematics for a $2 \to 2$ process, namely $g + g \to J/\psi + g$ as expected from LO pQCD. We have computed the rapidity dependence of $R_{CP}$ and $R_{dAu}$ for the different centrality classes of the PHENIX data. For mid rapidities, we have also computed the transverse-momentum dependence of the nuclear modification factor, which cannot be predicted with the usual $2 \to 1$ simplified kinematics. All these observables have been compared to the PHENIX data in $dAu$ collisions.

1 Introduction

At high temperature and densities, QCD predicts the existence of a deconfined state of matter, the Quark-Gluon Plasma (QGP) which is expected to be produced in relativistic nucleus-nucleus ($AB$) collisions. For 30 years, charmonium production in hadron collisions has been a major subject of investigations, on both experimental and theoretical sides. $J/\psi$ production should indeed be sensitive to the QGP formation, by a process analogous to Debye screening of electromagnetic field in a plasma [1]. A significant suppression of the $J/\psi$ yield was observed at SPS energy by the NA50 experiment [2,3], and at RHIC by the PHENIX experiment in AuAu [4] and CuCu [5] collisions at $\sqrt{s_{NN}} = 200$ GeV. In 2010 and 2011, data have been taken at the LHC in PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, where the $J/\psi$ has also been found to be suppressed [6–8].
However, the interpretation of the results obtained in $AB$ collisions relies on a good understanding and a proper subtraction of the cold nuclear matter (CNM) effects which are known to already impact the $J/\psi$ production in proton (deuteron)–nucleus ($pA$ or $dA$) collisions, where the deconfinement cannot be reached. Experiments on $dAu$ collisions at RHIC [9,10] have indeed revealed that CNM effects play an essential role at $\sqrt{s_{NN}} = 200$ GeV in the production of $J/\psi$ as well as of $\Upsilon$ (see e.g. [11]). In particular, the shadowing of the initial parton distributions due to the nuclear environment and the nuclear absorption resulting from the breakup of the $c\bar{c}$ pair by its multiple scattering with the remnants of the incident nuclei have a significant impact.

Previous studies [12–14] have also shown that the $J/\psi$ partonic-production mechanism affects the way to compute the nuclear shadowing and thus its expected impact on the $J/\psi$ production. Most studies on the $J/\psi$ production in hadronic collisions assume that the $c\bar{c}$ pair is produced by a $2 \to 1$ partonic process where both initial particles are two gluons carrying some intrinsic transverse momentum $k_T$. The sum of the gluon intrinsic $k_T$ is transferred to the $c\bar{c}$ pair, thus to the $J/\psi$ since the soft hadronisation process does not significantly alter the kinematics. This is supported by the picture of the Colour Evaporation Model (CEM) at LO (see [15] and references therein) or of the Colour-Octet (CO) mechanism at $\alpha_s^2$ [16]. In such approaches, the transverse momentum $p_T$ of the $J/\psi$ comes entirely from the intrinsic $k_T$ of the initial gluons. We will refer to this production mechanism as to the intrinsic scheme.

However, this is not sufficient to describe the $p_T$ spectrum of quarkonia in hadron collisions. Recent theoretical works incorporating QCD corrections or $s$-channel cut contributions have emphasised [17–24] that the colour-singlet (CS) mediated contributions are sufficient to describe the experimental data for hadroproduction of both charmonium and bottomonium systems without the need of CO contributions. For instance, as illustrated by Fig 1, the yield predicted by the LO CSM [25] reproduces correctly the PHENIX, CDF and ALICE measurements without resorting to any colour-octet mechanism nor parameter fitting. Furthermore, recent works [26–29] focusing on production at $e^+e^-$ colliders have posed stringent constraints on the size of CO contributions, which are the precise ones supporting a $2 \to 1$ hadroproduction mechanism at low $p_T$ [15].

As a consequence, $J/\psi$ production at low and mid $p_T$ likely proceeds via a $2 \to 2$ process, which we refer to as the extrinsic scheme, such as $g + g \to J/\psi + g$, instead of a $2 \to 1$ process. The former $2 \to 2$ kinematics is then the most appropriate to derive CNM effects at RHIC, and to provide predictions at LHC energy [30,31]. One could also go further and consider more than two particles in the final state, as expected from the real-emission contributions at NLO and NNLO [17–21]. It is clear from the yield polarisation [32] that these contributions start to dominate for $p_T$ above $1 - 2m_c$. The effect of more partons in the final state is to increase the difference between the results obtained in both schemes. However the implementation of NLO and NNLO codes in a Glauber model with an inhomogeneous shadowing is not yet available.

In this work, we present our results for the rapidity and transverse-momentum dependence of the nuclear modification factors, $R_{dAu}$ and $R_{CP}$ obtained using the extrinsic scheme for different collision centralities. We compare them with the new PHENIX data [10].

![Fig. 1](image-url) $d\sigma_{\text{direct}}/dy|_{y=0} \times \text{Br}$ from $gg$ fusion in $pp$ collisions for $\sqrt{s}$ from 200 GeV up to 14 TeV compared to the PHENIX [33], CDF [34] and ALICE data [35,36]
2 Our Approach

In order to describe $J/\psi$ production in nuclear collisions, our Monte Carlo framework [12, 13] is based on the probabilistic Glauber model. The nucleon-nucleon inelastic cross section at $\sqrt{s_{NN}} = 200$ GeV is taken to be $\sigma_{NN} = 42$ mb and the maximum nucleon density to be $\rho_0 = 0.17$ nucleons/fm$^3$. We also need to implement the partonic process for the $c\bar{c}$ production model that allows us to describe the $pp$ data and the CNM effects.

For a given $J/\psi$ momentum (thus for fixed rapidity $y$ and $p_T$), the processes discussed above, i.e. the intrinsic $g + g \rightarrow c\bar{c}$ and the extrinsic $g + g \rightarrow J/\psi + g$, will proceed on the average from initial gluons with different Bjorken-$x$. Therefore, they will be affected by different shadowing corrections.

In the intrinsic scheme, the measurement of the $J/\psi$ momentum in $pp$ collisions completely fixes the longitudinal momentum fraction of the initial partons:

$$x_{1,2} = \frac{m_T}{\sqrt{s_{NN}}} \exp(\pm y) \equiv x_{1,2}^0(y, p_T),$$

with $m_T = \sqrt{M^2 + p_T^2}$, $M$ being the $J/\psi$ mass.

In the extrinsic scheme, the knowledge of the $y$ and $p_T$ spectra is enough to fix $x_1$ and $x_2$. Actually, the presence of a final-state gluon introduces further degrees of freedom in the kinematics, allowing several $(x_1, x_2)$ for a given set $(y, p_T)$. The four-momentum conservation explicitly results in a more complex expression of $x_2$ as a function of $(x_1, y, p_T)$:

$$x_2 = \frac{x_1 m_T \sqrt{s_{NN}} e^{-y} - M^2}{\sqrt{s_{NN}}(\sqrt{s_{NN}} x_1 - m_T e^y)}.$$  \hspace{1cm} (2)

Equivalently, a similar expression can be written for $x_1$ as a function of $(x_2, y, p_T)$. Models are then mandatory to compute the proper weighting of each kinematically allowed $(x_1, x_2)$. This weight is simply the differential cross section at the partonic level times the gluon PDFs, i.e. $g(x_1, \mu_F)g(x_2, \mu_F) d\sigma_{gg \rightarrow J/\psi + g}/dy dp_T dx_1dx_2$. In the present implementation of our code, we are able to use the partonic differential cross section computed from any theoretical approach. In this work, we shall use the Colour-Singlet Model (CSM) at LO at LHC energy, which was shown to be compatible (see Fig. 1) [22, 25] with the magnitude of the $p_T$-integrated cross-section as given by the PHENIX $pp$ data [33], the CDF $p\bar{p}$ data [34] and the recent LHC $pp$ data at $\sqrt{s_{NN}} = 7$ TeV [36] and $\sqrt{s_{NN}} = 2.76$ TeV [35].

To obtain the yield of $J/\psi$ in $pA$ and $A$ collisions, a shadowing-correction factor has to be applied to the $J/\psi$ yield obtained from the simple superposition of the equivalent number of $pp$ collisions. This shadowing factor can be expressed in terms of the ratios $R_i^A$ of the nuclear Parton Distribution Functions (nPDF) in a nucleon belonging to a nucleus $A$ to the PDF in the free nucleon:

$$R_i^A(x, Q^2) = \frac{f_i^A(x, Q^2)}{A_i^\text{nucleon}(x, Q^2)}, \hspace{0.5cm} i = q, \bar{q}, g.$$  \hspace{1cm} (3)

The numerical parametrisation of $R_i^A(x, Q^2)$ is given for all parton flavours. Since quarkonia are essentially produced through gluon fusion at RHIC [15], we restrict our study to gluon shadowing. Several shadowing parametrisations are available. Here we will consider three of them: EKS98 [37], EPS08 [38] and nDSg at LO [39]. Recently, a new parametrisation with fit uncertainties, EPS09 [40], has been made available. Yet, in the case of gluons, the region spanned by this parametrisation is approximately bounded by both the nDS and EPS08 values. The central curve of EPS09 is also very close to EKS98. We consider sufficient to use only EKS98, EPS08 and nDSg. The spatial dependence of the shadowing has been included with a shadowing proportional to the local density [41–43].

The second CNM effect that we take into account concerns the nuclear absorption. In the framework of the probabilistic Glauber model, this effect is usually parametrised by introducing an effective absorption cross section $\sigma_{\text{abs}}$. It reflects the break-up of correlated $c\bar{c}$ pairs due to inelastic scattering with the remaining nucleons from the incident cold nucleus. Here we choose four values of the effective absorption cross section ($\sigma_{\text{abs}} = 0, 2.8, 4.2, 6$ mb) following our previous works [13,14].
3 Results

3.1 Rapidity and Transverse-Momentum Dependence of $R_{dAu}$

We first present our results for the nuclear modification factor $R_{dAu}$ which characterises the $J/\psi$ suppression in $dAu$ collisions. It is the ratio obtained by normalising the $J/\psi$ yield in $dAu$ collisions to the $J/\psi$ yield in $pp$ collisions at the same energy times the average number of binary inelastic nucleon-nucleon collisions $N_{coll}$:
Fig. 4 Idem as the Fig. 3 for EPS08

Fig. 5 Idem as the Fig. 3 for nDSg

\[ R_{dAu} = \frac{dN_{J/\psi}^{dAu}}{dN_{J/\psi}^{pp}} \frac{dN_{J/\psi}}{dN_{coll}} \]  

(4)

In Fig. 2, we show \( R_{dAu} \) vs \( y \) obtained for different shadowing parametrisations, EKS98, EPS08 and nDSg. We focus only on the extrinsic scheme. Our curves are compared to the PHENIX data [10]. The lower panels in each of Fig. 2a–c refer to central collisions (centrality class 0–20%, i.e. the 20% most central collisions) and the upper panels to peripheral collisions (centrality class 60–88%). Our previous study [14], based on older PHENIX data [9] suggested that the effective absorption cross section which reproduced the most accurately
the data was $\sigma_{abs} \approx 3$–$4$ mb. Among the four different values $\sigma_{abs} = 0, 2.8, 4.2$ and 6 mb, which we have been considered here, the best match seems to be between 2.8 and 4.2 mb. The agreement is good for the most central collisions. For peripheral ones, none of the gluon nPDFs which we used is able to accommodate with the most backward data. We also note that the precision of the data does not allow to distinguish between the different shadowing parametrisations. These results show similar features to those Ref. [10], where $\sigma_{abs}$ is taken to be 4 mb. This was expected since EPS09 shadowing is approximately bounded by EPS08 and nDSg and its central curve is close to EKS98.

We now turn to the discussion of the transverse-momentum dependence of $R_{dAu}$ in the mid-rapidity region. Once more, we would like to emphasize that it can only be predicted if one works in the extrinsic scheme. Our results for different centrality classes for EKS98 are shown on Fig. 3, for EPS08 on Fig. 4 and for nDSg on Fig. 5. $R_{dAu}$ is found to increase with $p_T$. This is due to the increase of $x_2$ for increasing $p_T$ which follows from Eq. 2. This effect is more pronounced for the EPS08 than for EKS98 and nDSg due to its stronger antishadowing. Note that the centrality dependence induced by the anti-shadowing—via its strength dependence on the local nuclear density—is increasingly compensated by that of the break-up probability for increasing $\sigma_{abs}$. For central collisions, the production point can be well inside the gold nucleus where the anti-shadowing is expected to be stronger but where the break-up probability is also larger.

Our results are also compared to the most recent PHENIX data [44] which suffer from rather large experimental uncertainties for increasing $p_T$. The agreement with the data is reasonable. In addition to the plot of $R_{dAu}$ vs $p_T$ in the mid rapidity region of PHENIX, we show in the appendix our predictions for backward and forward rapidities to be compared to forthcoming data.

### 3.2 Rapidity Dependence of $R_{CP}$

In this section, we will discuss the rapidity dependence of $R_{CP}$ which give specific information on the centrality dependence of the CNM. This quantity has the advantage to be a ratio in which many of the systematic uncertainties of the data cancel. It is the ratio between central and the peripheral $R_{dAu}$,

$$R_{CP} = \frac{\frac{dN^{(0-20\%)}_{J/\psi}}{dy}}{\frac{dN^{(0-20\%)}_{\text{coll}}}{dy}} \bigg/ \frac{\frac{dN^{(60-88\%)}_{J/\psi}}{dy}}{\frac{dN^{(60-88\%)}_{\text{coll}}}{dy}} \bigg) \quad (5)$$

Figure 6 presents our results for $R_{CP}$ versus $y$ for three gluon nPDFs (EKS98, EPS08, nDSg) and the same four values of $\sigma_{abs}$ as above. We have already discussed the corresponding preliminary data from PHENIX in [14], from which we performed fits of the effective break-up cross section. We had shown at that time that a constant value of $\sigma_{abs}$ was acceptable when the EPS08 nPDF was chosen. As we obtained in our complete fit [14] taking into account all types of experimental errors [14], the comparison with the published PHENIX data shown on Fig. 6 suggests a $\sigma_{abs}$ smaller than what would be expected from the comparison with $R_{dAu}$ presented in the previous section. Our curve for EPS08 seems to better reproduce the most forward points,
while it slightly misses two of the three mid-$y$ points. A strong shadowing seems in any case needed to account for these data (Figs. 8, 9, 10, 11).

4 Conclusions

We have evaluated the rapidity, the centrality and the transverse-momentum dependence of Cold Nuclear Matter effects—essentially the shadowing—on $J/\psi$ production versus rapidity and transverse momentum in $dAu$ collisions at $\sigma_{NN} = 200$ GeV and compared our predictions with the latest PHENIX data. We have used our probabilistic Glauber Monte–Carlo framework, JIN, which allows us to encode $2 \to 2$ partonic mechanisms for $J/\psi$ production. In particular, we have used the CSM at LO which is now recognised to correctly account for the bulk of the $J/\psi$ cross section in $pp$ at RHIC.

We have used three gluon nPDFs (EKS98, EPS08 and nDSg) and considered a reasonable range of effective absorption cross sections, $\sigma_{abs} = 0, 2.8, 4.2, 6$ mb. Our results, compared to the most recent PHENIX data [10] are in agreement with our previous study [14] where $\sigma_{abs} \approx 3–4$ mb was suggested from the comparison with $R_{dAu}$ and $\sigma_{abs} \approx 2–3$ mb from the comparison with $R_{CP}$. This difference may have some physical meaning but the uncertainties both in the knowledge of gluon (anti-)shadowing and in the experimental data preclude drawing any strong conclusions. Finally, we reassess that EPS08 with a strength proportional to the local nuclear density combined with a $2 \to 2$ partonic process is found to reproduce fairly well the most forward $R_{CP}$ data.

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A Appendix: $R_{dAu}$ vs $p_T$ for Different Rapidity and Centrality Classes

In addition to the plot of $R_{dAu}$ vs $p_T$ in the mid rapidity region of PHENIX, we show in this appendix our prediction for backward and forward rapidities (Figs. 8, 9, 10, 11).

![Appendix](image-url)

**Fig. 7** $J/\psi$ nuclear modification factor in $dAu$ at $\sqrt{s_{NN}} = 200$ GeV versus $p_T$ integrated on the centrality, for four effective absorption cross sections using (a) EKS98, (b) EPS08, (c) nDSg in the three rapidity regions covered by PHENIX.
Fig. 8  Idem as the Fig. 7 for the centrality class 0–20%

Fig. 9  Idem as the Fig. 7 for the centrality class 20–40%

Fig. 10  Idem as the Fig. 7 for the centrality class 40–60%
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Fig. 11 Idem as the Fig. 7 for the centrality class 60–88%

References

1. Matsui, T., Satz, H.: J/ψ suppression by Quark–Gluon plasma formation. Phys. Lett. B 178, 416 (1986)
2. Abreu, M.C., et al.: NA50 Collaboration: Evidence for deconfinement of quarks and gluons from the J/ψ suppression pattern measured in Pb Pb collisions at the CERN-SPS. Phys. Lett. B 477, 28 (2000)
3. Alessandro, B.: NA50 Collaboration: A new measurement of J/ψ suppression in Pb–Pb collisions at 158 GeV per nucleon. Eur. Phys. J. C 39, 335 (2005)
4. Adare, A.: PHENIX Collaboration: J/ψ production vs centrality, transverse momentum, and rapidity in Au + Au collisions at \( \sqrt{s_{NN}} = 200 \) GeV. Phys. Rev. Lett. 98, 232301 (2007)
5. Adare, A.: PHENIX Collaboration: J/ψ production in \( \sqrt{s_{NN}} = 200 \) GeV Cu + Cu collisions. Phys. Rev. Lett. 101, 122301 (2008)
6. Pillot, P.: ALICE Collaboration: J/ψ production at forward rapidity in Pb–Pb collisions at \( \sqrt{s_{NN}} = 2.76 \) TeV, measured with the ALICE detector. J. Phys. G 38, 124111 (2011)
7. Silvestre, C.: CMS Collaboration: Quarkonia measurements by the CMS experiment in pp and PbPb collisions. J. Phys. G 38, 124033 (2011)
8. Aad, G., et al.: Atlas Collaboration: Measurement of the centrality dependence of J/ψ yields and observation of Z production in lead–lead collisions with the ATLAS detector at the LHC. Phys. Lett. B 697, 294 (2011)
9. Adare, A., et al.: PHENIX Collaboration: Cold nuclear matter effects on J/ψ yields as a function of rapidity and nuclear geometry in deuteron–gold collisions at \( \sqrt{s_{NN}} = 200 \) GeV. Phys. Rev. Lett. 107, 142301 (2011)
10. Ferreiro, E.G., Fleuret, F., Lansberg, J.P., Matagne, N., Rakotozafindrabe, A.: Gluon EMC effect and fractional energy loss in Upsilon production in dAu collisions at RHIC. arXiv:1110.5047 [hep-ph]
11. Ferreiro, E.G., Fleuret, F., Rakotozafindrabe, A.: Transverse momentum dependence of J/ψ shadowing effects. Eur. Phys. J. C 61, 859–864 (2009)
12. Ferreiro, E.G., Fleuret, F., Rakotozafindrabe, A.: Centrality, rapidity and transverse-momentum dependence of cold nuclear matter effects on J/ψ production in dAu, CuCu and AuAu collisions at \( \sqrt{s_{NN}} = 200 \) GeV. Phys. Rev. C 81, 064911 (2010)
13. Lansberg, J.P.: J/ψ, ψ′ and Υ production at hadron colliders: a review. Int. J. Mod. Phys. A 21, 3857 (2006)
14. Che, P.L., Leibovich, A.K.: Color-octet quarkonia production II. Phys. Rev. D 53, 6203 (1996)
15. Campbell, J.M., Maltoni, F., Tramontano, F.: QCD corrections to J/ψ and Upsilon production at hadron colliders. Phys. Rev. Lett. 98, 252002 (2007)
16. Gong, B., Wang, J.X.: Next-to-leading-order QCD corrections to J/ψ polarization at Tevatron and Large-Hadron-Collider energies. Phys. Rev. Lett. 100, 232001 (2008)
17. Artoisenet, P., Campbell, J.M., Lansberg, J.P., Maltoni, F., Tramontano, F.: \( n \) production at Fermilab Tevatron and LHC energies. Phys. Rev. Lett. 101, 152001 (2008)
18. Lansberg, J.P.: On the mechanisms of heavy-quarkonium hadroproduction. Eur. Phys. J. C 61, 693 (2009)
19. Lansberg, J.P.: J/ψ production at \( \sqrt{s} = 1.96 \) and 7 TeV: color-singlet model, NNLO* and polarisation. J. Phys. G 38, 124110 (2011)
20. Brodsky, S.J., Lansberg, J.P.: Heavy-quarkonium production in high energy proton–proton collisions at RHIC. Phys. Rev. D 81, 051502 (2010)
23. Lansberg, J.P., Cudell, J.R., Kalinovsky, Yu.L.: New contributions to heavy quarkonium production. Phys. Lett. B 633, 301 (2006)
24. Haberzettl, H., Lansberg, J.P.: Possible solution of the $J/\psi$ production puzzle. Phys. Rev. Lett. 100, 032006 (2008)
25. Lansberg, J.P.: Total $J/\psi$ and Upsilon production cross section at the LHC: theory vs. experiment. PoS ICHEP 2010, 206 (2010)
26. He, Z.G., Fan, Y., Chao, K.T.: Relativistic correction to $e^+e^- \rightarrow J/\psi + gg$ at B factories and constraint on color-octet matrix elements. Phys. Rev. D 81, 054036 (2010)
27. Zhang, Y.J., Ma, Y.Q., Wang, K., Chao, K.T.: QCD radiative correction to color-octet $J/\psi$ inclusive production at B factories. Phys. Rev. Lett. 102, 162002 (2009)
28. Ma, Y.Q., Zhang, Y.J., Chao, K.T.: QCD correction to $e^+e^- \rightarrow J/\psi gg$ at B factories. Phys. Rev. Lett. 102, 162003 (2009)
29. Gong, B., Wang, J.X.: Next-to-leading-order QCD corrections to $e^+e^- \rightarrow J/\psi gg$ at the B factories. Phys. Rev. Lett. 102, 162003 (2009)
30. Ferreiro, E.G., Fleuret, F., Lansberg, J.P., Matagne, N., Rakotozafindrabe, A.: Cold nuclear matter effects on extrinsic $J/\psi$ production at $\sqrt{s_{NN}} = 2.76$ TeV at the LHC. Nucl. Phys. A 855, 327 (2011)
31. Ferreiro, E.G., Fleuret, F., Lansberg, J.P., Matagne, N., Rakotozafindrabe, A.: Cold nuclear matter effects on extrinsic $p_T$ at $\sqrt{s_{NN}} = 5.5$ TeV at the LHC. Nucl. Phys. A 862-863CF, 297 (2011). arXiv:1101.5295 [hep-ph]
32. Lansberg, J.P.: QCD corrections to $J/\psi$ polarisation in $pp$ collisions at RHIC. Phys. Lett. B 695, 149 (2011)
33. Adare, A., et al.: $J/\psi$ production vs transverse momentum and rapidity in $p+p$ collisions at $\sqrt{s} = 200$ GeV. Phys. Rev. Lett. 98, 232002 (2007)
34. Acosta, D., et al.: CDF Collaboration: Measurement of the $J/\psi$ meson and $b-$hadron production cross sections in $p\bar{p}$ collisions at $\sqrt{s} = 1600$ GeV. Phys. Rev. D 71, 032001 (2005)
35. Arnaldi, R.: Measurement of $J/\psi$ production in $pp$ collisions at $\sqrt{s} = 2.76$ and 7 TeV with ALICE. J. Phys. G 38, 124106 (2011)
36. Aamodt, K.: ALICE Collaboration: Rapidity and transverse momentum dependence of inclusive $J/\psi$ production in pp collisions at $\sqrt{s} = 7$ TeV. Phys. Lett. B 704, 442 (2011)
37. Eskola, K.J., Kolhinen, V.J., Salgado, C.A.: The scale dependent nuclear effects in parton distributions for practical applications. Eur. Phys. J. C 9, 61 (1999)
38. Eskola, K.J., Paukkunen, H., Salgado, C.A.: An improved global analysis of nuclear parton distribution functions including RHIC data. JHEP 0807, 102 (2008)
39. de Florian, D., Sassot, R.: Nuclear parton distributions at next to leading order. Phys. Rev. D 69, 074028 (2004)
40. Eskola, K.J., Paukkunen, H., Salgado, C.A.: EPS09—a new generation of NLO and LO nuclear parton distribution functions. JHEP 0904, 065 (2009)
41. Klein, S.R., Vogt, R.: Inhomogeneous shadowing effects on $J/\psi$ production in $dA$ collisions. Phys. Rev. Lett. 91, 142301 (2003)
42. Vogt, R.: Shadowing and absorption effects on $J/\psi$ production in $dA$ collisions. Phys. Rev. C 71, 054902 (2005)
43. Bedjidian, M., et al.: Hard probes in heavy ion collisions at the LHC: heavy flavour physics. CERN-2004-009-C, hep-ph/0311048
44. da Silva, C.L.: Heavy Flavor and Quarkonia measured in PEHNIX. Talk given at “Quark Matter 2011”. Annecy, France (2011)