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Nuclear modification factor of D^0 mesons in PbPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

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The transverse momentum (p_T) spectrum of prompt D^0 mesons and their antiparticles has been measured via the hadronic decay channels $D^0 \to K^-\pi^+$ and $\overline{D}^0 \to K^+\pi^-$ in pp and PbPb collisions at a centre-of-mass energy of 5.02 TeV per nucleon pair with the CMS detector at the LHC. The measurement is performed in the D^0 meson p_T range of 2–100 GeV/c and in the rapidity range of $|y| < 1$. The pp (PbPb) dataset used for this analysis corresponds to an integrated luminosity of 27.4 pb^{-1} (530 μb^{-1}). The measured D^0 meson p_T spectrum in pp collisions is well described by perturbative QCD calculations. The nuclear modification factor, comparing D^0 meson yields in PbPb and pp collisions, was extracted for both minimum-bias and the 10% most central PbPb interactions. For central events, the D^0 meson yield in the PbPb collisions is suppressed by a factor of 5–6 compared to the pp reference in the p_T range of 6–10 GeV/c. For D^0 mesons in the high-p_T range of 60–100 GeV/c, a significantly smaller suppression is observed. The results are also compared to theoretical calculations.

1. Introduction

Relativistic heavy ion collisions allow the study of quantum chromodynamics (QCD) at high energy density and temperature. Lattice QCD calculations predict that under such extreme conditions a transition to a strongly interacting and deconfined medium, called the quark-gluon plasma (QGP), occurs [1–3]. Heavy quarks are effective probes to study the properties of the deconfined medium created in heavy ion collisions. These quarks are mostly produced in primary hard QCD scatterings with a production timescale that is shorter than the formation time of the QGP [4]. During their propagation through the medium, heavy quarks lose energy via radiative and collisional interactions with the medium constituents. Quarks are expected to lose less energy than gluons as a consequence of their smaller colour factor. In addition, the so-called “dead-cone effect” is expected to reduce small-angle gluon radiation of heavy quarks when compared to both gluons and light quarks [5–7]. Energy loss can be studied using the nuclear modification factor (R_{AA}), defined as the ratio of the PbPb yield to the pp cross-section scaled by the nuclear overlap function [8]. Precise measurements of the R_{AA} of particles containing both light and heavy quarks can thus provide important tests of QCD predictions at extreme densities and temperatures and in particular allow one to test the expected flavour dependence of the energy loss processes. The comparison to theoretical calculations is fundamental in order to claim any evidence of flavour dependence of the energy loss mechanisms since sizeable discrepancies in the R_{AA} of light and heavy particles can arise as a consequence of the different transverse momentum spectra and fragmentation functions of beauty, charm, and light quarks and gluons.

Evidence of open charm suppression at the CERN LHC was observed by the ALICE Collaboration using the R_{AA} of promptly produced D mesons (D^0, D^+, D^{*+} mesons and their conjugates) at mid-rapidity ($|y| < 0.5$) at a nucleon–nucleon centre-of-mass energy $\sqrt{s_{NN}} = 2.76$ TeV. The measurement was performed as a function of centrality (i.e. the degree of overlap of the two colliding nuclei) and transverse momentum ($1 < p_T < 36$ GeV/c) [9,10]. A maximum suppression by a factor of 5–6 with respect to the pp reference was observed for the 10% most central collisions at p_T of about 10 GeV/c. A suppression by a factor of about 3 was measured at the highest p_T range studied, from 25 to 35 GeV/c. The D meson R_{AA} was found to be consistent with that for all charged particles for p_T from 6 to 36 GeV/c. For lower p_T, the D meson R_{AA} was observed to be slightly higher than the charged-particle R_{AA}, although still compatible within the uncertainties [11,12]. At RHIC, the R_{AA} of D^0 mesons for the 10% most central AuAu collisions at $\sqrt{s_{NN}} = 200$ GeV was measured by the STAR Collaboration in the rapidity range of $|y| < 1$ [13]. A suppression by a factor of 2–3 for

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p_T larger than 3 GeV/c was seen. This suggests that a significant energy loss of charm quarks in the hot medium also occurs at RHIC energies. A first indication of a sizeable difference in the R_{AA} of B and D mesons was observed when comparing the ALICE D meson R_{AA} with the nonprompt J/ψ meson (i.e. from b-hadron decays) R_{AA} measurement performed by the CMS Collaboration in PbPb collisions at the same energy and collision centrality [14]. The R_{AA} of nonprompt J/ψ mesons in the p_T range 6.5–30 GeV/c was indeed found to be significantly larger than the R_{AA} of D mesons in the 8–16 GeV/c p_T region for central events. The D^0 p_T range was chosen to give a similar median p_T value to that of the parent b hadrons decaying to J/ψ particles [9]. Several measurements were also performed to address the relevance of cold nuclear matter effects for the suppression observed for heavy-flavour particles. Indeed, these phenomena can affect the yield of such particles, independently of the presence of a deconfined partonic medium. For instance, modifications of the parton distribution functions (PDFs) in the nucleus with respect to nucleon PDFs [15–17] could change the production rate of heavy-flavour particles. To evaluate the relevance of these effects, the production of prompt D mesons was measured in pPb collisions at mid-rapidity at 5.02 TeV by the ALICE Collaboration [18]. The nuclear modification factor in pPb collisions (R_{pA}) was found to be consistent within the 15–20% uncertainties with unity for p_T from 2 to 24 GeV/c. This suggests that the suppression of D mesons observed in PbPb collisions cannot be explained in terms of initial-state effects but is mostly due to strong final-state effects induced by the QGP. A similar conclusion was obtained from the study of the R_{pA} of B mesons in pPb collisions at 5.02 TeV, where values consistent with unity within the uncertainties were found for p_T from 10 to 60 GeV/c [19].

In this Letter, the production of prompt D^0 mesons in PbPb collisions at 5.02 TeV is measured for the first time up to a p_T of 100 GeV/c, allowing one to study the properties of the in-medium energy loss in a new kinematic regime. The D^0 meson and its antiparticle are reconstructed in the central rapidity region ($|y| < 1$) of the CMS detector via the hadronic decay channels $D^0 \to K^-\pi^+$ and $\overline{D}^0 \to K^+\pi^-$. The production cross section and yields in pp and PbPb collisions, respectively, and the R_{AA} of prompt D^0 mesons are presented as a function of their p_T. The R_{AA} is reported for two centrality intervals: in the inclusive sample (0–100%), and in one corresponding to the most overlapping 10% of the collisions.

2. The CMS detector

The central feature of the CMS apparatus is a superconducting solenoid of 6 m internal diameter, providing a magnetic field of 3.8 T. Within the solenoid volume are a silicon tracker which measures charged particles within the pseudorapidity range $|\eta| < 2.5$, a lead tungstate crystal electromagnetic calorimeter (ECAL), and a brass and scintillator hadron calorimeter (HCAL). The ECAL consists of more than 75 000 lead tungstate crystals, and is partitioned into a barrel region ($|\eta| < 1.48$) and two endcaps extending out to $|\eta| = 3.0$. The HCAL consists of sampling calorimeters composed of brass and scintillator plates, covering $|\eta| < 3.0$. Iron hadron forward (HF) calorimeters, with quartz fibres read out by photomultipliers, extend the calorimeter coverage out to $|\eta| = 5.2$. A detailed description of the CMS experiment can be found in Ref. [20].

3. Event selection and Monte Carlo samples

The pp (PbPb) dataset used for this analysis corresponds to an integrated luminosity of 27.4 pb^{-1} (530 μb^{-1}). The D^0 meson production is measured from p_T of 2 up to 20 GeV/c using large samples of minimum-bias (MB) events (≈2.5 billion pp events and ≈300 million PbPb events). Minimum-bias events were selected online using the information from the HF calorimeters and the beam pickup monitors. For measuring the D^0 meson production above 20 GeV/c, dedicated high-level trigger (HLT) algorithms were designed to identify online events with a D^0 candidate. Since events with a high-p_T D^0 meson are expected to leave large energy deposits in HCAL, HLT algorithms were run on events preselected by jet triggers in the level-1 (L1) calorimeter trigger system. In PbPb collisions, the D^0 triggers with p_T threshold below 40 GeV/c were run on events passing the L1 MB trigger selection. While the MB and lower-threshold triggers had to be prescaled because of the high instantaneous luminosity of the LHC, the highest threshold trigger used in the analysis ($p_T > 60\,(50)$ GeV/c for PbPb (pp) data taken) was always unprescaled. The efficiency of the HLT algorithms was evaluated in data, and modelled by a linear function of D^0 p_T. The efficiency was found to be about 100 (90)% in pp (PbPb) collisions for events passing the corresponding L1 selection.

For the offline analysis, events have to pass a set of selection criteria designed to reject events from background processes (beam-gas collisions and beam scraping events) as described in Ref. [21]. In order to select hadronic collisions, both pp and PbPb events are required to have at least one reconstructed primary interaction vertex with a distance from the centre of the nominal interaction region of less than 15 cm along the beam axis. In addition, in PbPb collisions the shapes of the clusters in the pixel detector have to be compatible with those expected from particles produced by a PbPb collision [22]. The PbPb collision events are also required to have at least three towers in each of the HF detectors with energy deposits of more than 3 GeV per tower. The combined efficiency for this event selection, and the remaining nonhadronic contamination, is $(99 \pm 2)\%$. Selection efficiencies higher than 100% are possible, reflecting the possible presence of ultraperipheral (nonhadronic) collisions in the selected event sample. The collision centrality is determined from the total transverse energy deposition in both the HF calorimeters. Collision centrality bins are given in percentage ranges of the total inelastic hadronic cross section, with the 0–10% bin corresponding to the 10% of collisions having the largest overlap of the two nuclei.

Several Monte Carlo (MC) simulated event samples are used to evaluate background components, signal efficiencies, and detector acceptance corrections. The events produced include both prompt and nonprompt (from b hadron decays) D^0 meson events. Proton–proton collisions are generated with PYTHIA 8 v212 [23] tune CUETP8M1 [24] and propagated through the CMS detector using the GEANT4 package [25]. The D^0 mesons are decayed with EVTGEN 1.3.0 [26], and final-state photon radiation in the D^0 decays is simulated with PHOTOS 2.0 [27]. For the PbPb MC samples, each PYTHIA 8 event is embedded into a PbPb collision event generated with HYDJET 1.8 [28], which is tuned to reproduce global event properties such as the charged-hadron p_T spectrum and particle multiplicity.

4. Signal extraction

The D^0 candidates are reconstructed by combining pairs of oppositely charged particle tracks with an invariant mass within 0.2 GeV/c^2 of the world-average D^0 mass [29]. Each track is required to have $p_T > 1$ GeV/c in order to reduce the combinatorial background. For high-p_T D^0 mesons (above 20 GeV/c) in PbPb data, the single track cut is raised to $p_T > 8.5$ GeV/c to account for the selection ($p_T > 8$ GeV/c) performed at the HLT. All tracks are also required to be within $|\eta| < 1.5$. For each pair of selected tracks, two D^0 candidates are created by assuming that one of the particles has the mass of the pion while the other has the mass of the kaon, and vice-versa. The D^0 mesons are required to be within

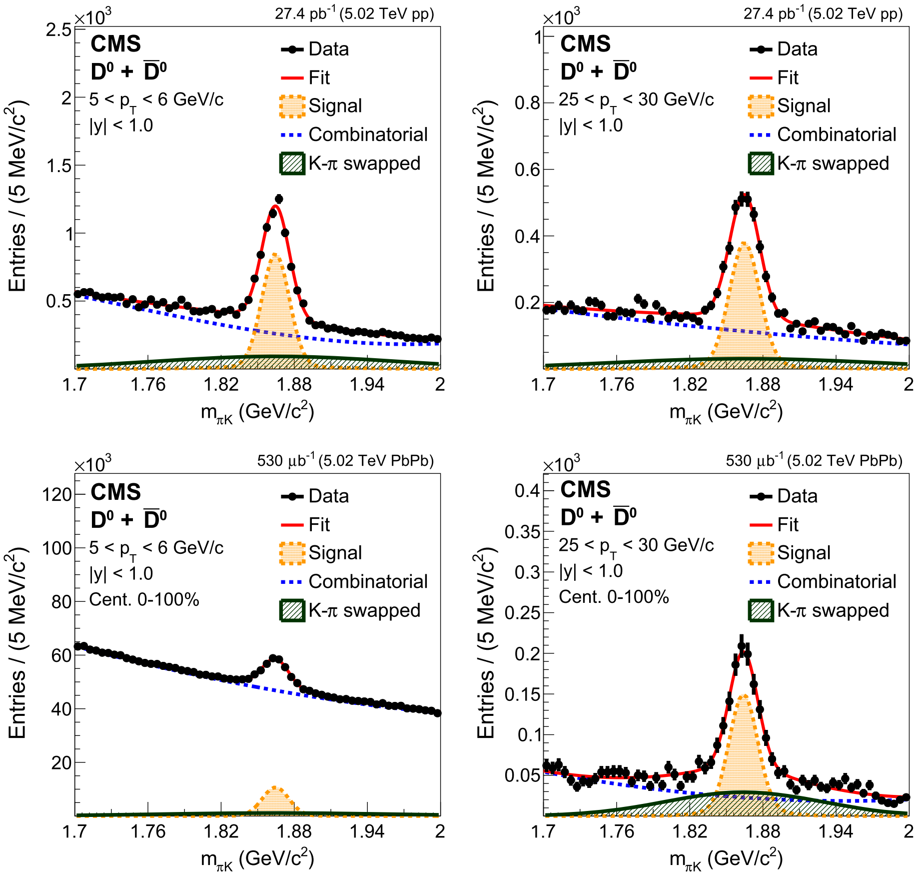

Fig. 1. Examples of D^0 candidate invariant mass distributions in pp (top) and PbPb (bottom) collisions at 5.02 TeV . (For interpretation of the colours in the figure(s), the reader is referred to the web version of this article.)

$|y| < 1$, optimised in conjunction to the track pseudorapidity selection to give the best signal to background ratio over the whole range of D^0 p_T studied. In order to further reduce the combinatorial background, the D^0 candidates are selected based on three topological criteria: on the three-dimensional (3D) decay length L_{xyz} normalised to its uncertainty (required to be larger than 4–6), on the pointing angle θ_p (defined as the angle between the total momentum vector of the tracks and the vector connecting the primary and the secondary vertices and required to be smaller than 0.12), and on the χ^2 probability, divided by the number of degrees of freedom, of the D^0 vertex fit (required to be larger than 0.025–0.05). The selection is optimised in each p_T bin using a multivariate technique [30] in order to maximise the statistical significance of the D^0 meson signals.

The D^0 meson yields in each p_T interval are extracted with a binned maximum-likelihood fit to the invariant mass distributions in the range $1.7 < m_{\pi K} < 2.0\,\text{GeV}/c^2$. Several examples of D^0 candidate invariant mass distributions are shown in Fig. 1 for pp (top) and PbPb (bottom) collisions. The combinatorial background, originating from random pairs of tracks not produced by a D^0 meson decay, is modelled by a third-order polynomial. The signal shape was found to be best modelled over the entire p_T range measured by two Gaussian functions with the same mean but different widths. An additional Gaussian function is used to describe the invariant mass shape of D^0 candidates with incorrect mass assignment from the exchange of the pion and kaon designations. The widths of the Gaussian functions that describe the D^0 signal shape and the shape of the D^0 candidates with swapped mass assignment are free parameters in the fit. Also, the ratio between the yields of the signal and of the D^0 candidates with swapped mass assignments is fixed to the value extracted from simulation.

The D^0 p_T-differential cross section in each p_T interval in pp collisions is defined as:

$$\left.\frac{d\sigma_{pp}}{dp_T}\right|_{|y|<1} = \frac{1}{2}\frac{1}{\Delta p_T}\frac{1}{\mathcal{B}\,\mathcal{L}}\left.\frac{f_{\text{prompt}}\,N_{pp}}{(\alpha\,\epsilon)_{\text{prompt}}\,\beta_{\text{prescale}}\,\epsilon_{\text{trigger}}}\right|_{|y|<1}, \quad (1)$$

where Δp_T is the width of the p_T interval, $\mathcal{B}$ is the branching fraction of the decay chain, $\mathcal{L}$ is the integrated luminosity, $(\alpha\,\epsilon)_{\text{prompt}}$ represents the correction for acceptance and efficiency and N_{pp} is the yield of D^0 and $\bar{D}^0$ mesons extracted in each p_T interval. In both pp and PbPb cases, the value of α_{prompt} ranges from about 0.3 at 2–3 GeV/c to about 100% at 60–100 GeV/c. The value of ϵ_{prompt} ranges for PbPb (pp) from about 0.02 (0.03) at 2–3 GeV/c to about 0.4 (0.6) at 60–100 GeV/c. The factor 1/2 accounts for the fact that the cross section is given for the average of particles and antiparticles. The raw yields N_{pp} are corrected in order to account for the average prescale factor β_{prescale} and the efficiency $\epsilon_{\text{trigger}}$ of the trigger that was used to select events in that specific p_T interval. The factor f_{prompt} is the fraction of D^0 mesons that comes directly from c quark fragmentation and is measured using control samples in data by exploiting the difference in the distributions of a quantity found by multiplying the 3D D^0 decay length L_{xyz} by the sine of the pointing angle $\sin(\theta_p)$ of prompt and nonprompt D^0 mesons. In particular, the value of f_{prompt} (typically in the range 0.8–0.9) is measured in each p_T interval by fitting the distribution of $L_{xyz}\sin(\theta_p)$ using the prompt and nonprompt shapes obtained from MC simulation.

The D^0 p_T-differential production yield in each p_T interval in PbPb collisions is defined as:

$$\frac{1}{T_\mathrm{AA}}\frac{\mathrm{d}N_\mathrm{PbPb}}{\mathrm{d}p_\mathrm{T}}\bigg|_{|y|<1} = \frac{1}{T_\mathrm{AA}}\frac{1}{2}\frac{1}{\Delta p_\mathrm{T}}\frac{1}{\mathcal{B}\,N_\mathrm{MB}}\,\frac{f_\mathrm{prompt}\,N_\mathrm{PbPb}}{(\alpha\,\epsilon)_\mathrm{prompt}\,\beta_\mathrm{prescale}\,\epsilon_\mathrm{trigger}}\bigg|_{|y|<1}, \qquad (2)$$

where N_MB is the number of MB events used for the analysis and T_AA is the nuclear overlap function [8], which is equal to the number of nucleon–nucleon (NN) binary collisions divided by the NN cross section and can be interpreted as the NN-equivalent integrated luminosity per heavy ion collision. The values of T_AA are $5.61\,\mathrm{mb}^{-1}$ for inclusive PbPb collisions and $23.2\,\mathrm{mb}^{-1}$ for central events [21]. The other terms were defined analogously to Eq. (1).

5. Systematic uncertainties

The yields are affected by several sources of systematic uncertainties arising from the signal extraction, acceptance and efficiency corrections, branching fraction, and integrated luminosity determination. The uncertainty in the raw yield extraction (1.6–8.2% for pp and 1.3–17.5% for PbPb data, with the highest value at low-p_T, which is the region with the smallest signal to background ratio) is evaluated by repeating the fit procedure using different background fit functions and by forcing the widths of the Gaussian functions that describe the signal to be equal to the values extracted in simulations to account for possible differences in the signal resolution in data and in MC. In the background variation study, an exponential plus a second-order polynomial function was considered instead of the first order polynomial one, which is used as default. The final uncertainty in the raw yield extraction is defined as the sum in quadrature of the relative differences of the signal variation and the maximum of all the background variations.

The systematic uncertainty due to the selection of the D^0 meson candidates (0.5–3.6% for pp and 2.7–8.1% for PbPb data, with the highest value at low-p_T) is estimated by considering the differences between MC and data in the reduction of the D^0 yields obtained by applying each of the D^0 selection variables described in Sec. 4. The study was performed by varying one selection at a time, in a range that allowed a robust signal extraction procedure and by considering the maximum relative discrepancy in the yield reduction between data and MC. The total uncertainty was the quadratic sum of the maximum relative discrepancy obtained by varying each of the three selection variables separately.

The uncertainty due to the D^0 trigger efficiency (1% for pp and 2% for PbPb data) is evaluated as the statistical uncertainty in the zeroth-order coefficient of the linear function used to describe the plateau of the efficiency distribution. The systematic uncertainty in the hadron tracking efficiency (4.0% for pp and 6.0–6.5% for PbPb data) is estimated from a comparison of two- and four-body D^0 meson decays in data and simulated samples [31].

To evaluate the systematic uncertainty in the prompt D^0 meson fraction, the width of the $L_\mathrm{xyz}\sin(\theta_\mathrm{p})$ MC prompt and nonprompt templates are varied in a range that covers the observed differences between the data and MC values. The systematic uncertainty (10% for both pp and PbPb data) was obtained in each p_T bin as the difference between the f_prompt value extracted from the variation that gives the best χ^2 fit to data and the nominal f_prompt value. To evaluate this uncertainty for the R_AA measurement, the widths of the template distributions are varied simultaneously in pp and PbPb. The systematic uncertainty on the f_prompt correction was evaluated as the spread of the ratios of f_prompt in PbPb and pp to account for partial cancellations of the systematic effects in the two analyses.

The uncertainty related to the simulated p_T shape (smaller than 0.5% for both pp and PbPb data) is evaluated by reweighting the simulated D^0 meson p_T distribution according to the p_T shape obtained from a fixed-order plus next-to-leading logarithmic (FONLL) prediction [32].

The systematic uncertainty in the cross section measurement is computed as the sum in quadrature of the different contributions mentioned above. The global uncertainty in the pp measurement (2.5%) is the sum in quadrature of the systematic uncertainty in the integrated luminosity (2.3% [33]) and in the branching fraction $\mathcal{B}$ (1.0% [29]). The global uncertainty in the PbPb measurement (+3.6%, −4.1% for the centrality range 0–100% and +2.9%, −3.7% for 0–10%) is the sum in quadrature of the uncertainties in the MB selection efficiency (2%), in the branching fraction (1.0%) and in the T_AA (+2.8%, −3.4% for the centrality range 0–100% and +1.9%, −3.0% for 0–10%). For the R_AA results, no cancellation of uncertainties is assumed between the pp and PbPb results.

6. Results

The p_T-differential production cross section in pp collisions measured in the interval $|y| < 1$ is presented in the left panel of Fig. 2. The result is compared to the prediction of FONLL and a general-mass variable flavour number scheme (GM-VFNS) [34–36] calculation. The CMS measurement lies close to the upper bound of the FONLL prediction and the lower bound of the GM-VFNS calculation. The D^0 p_T-differential production yields divided by the nuclear overlap functions T_AA in PbPb collisions in the 0–100% and 0–10% centrality ranges are presented in the right panel of Fig. 2 and compared to the same pp cross section shown in the left panel.

The nuclear modification factor, R_AA is computed as:

$$R_\mathrm{AA} = \frac{1}{T_\mathrm{AA}}\frac{\mathrm{d}N_\mathrm{PbPb}}{\mathrm{d}p_\mathrm{T}}\bigg/\frac{\mathrm{d}\sigma_\mathrm{pp}}{\mathrm{d}p_\mathrm{T}}\,. \qquad (3)$$

The R_AA in the centrality range 0–100% is shown in the left panel of Fig. 3 as a function of p_T. The R_AA shows a suppression of a factor 3 to 4 at p_T of 6–8 GeV/c. At higher p_T, the suppression factor decreases to a value of about 1.3 in the p_T range 60–100 GeV/c. The R_AA for the centrality range 0–10% is presented in the right panel of Fig. 3. The D^0 R_AA in central events shows a hint of stronger suppression if compared to the inclusive R_AA result for $p_\mathrm{T} > 5$ GeV/c. In this comparison, the large overlap between the two results has to be considered. Indeed, roughly 40% of the D^0 candidates used in the measurement in the centrality range 0–100% are also included in the 0–10% result.

The results are also compared to calculations of four types of models: (a) two perturbative QCD-based models that include both collisional and radiative energy loss, (M. Djordjevic [37] and CUJET 3.0 [38–40]) and one that includes radiative energy loss only (I. Vitev [41,42]), (b) a transport model based on a Langevin equation that includes collisional energy loss and heavy-quark diffusion in the medium (S. Cao et al. [43,44]), (c) a microscopic off-shell transport model based on a Boltzmann approach that includes collisional energy loss only (PHSD [45,46]), and (d) a model based on the anti-de Sitter/conformal field theory (AdS/CFT) correspondence, that includes thermal fluctuations in the energy loss for heavy quarks in a strongly coupled plasma [47]. The AdS/CFT calculation is provided for two settings of the diffusion coefficient D of the heavy quark propagation through the medium: dependent on, and independent of the quark momentum. For D^0 meson $p_\mathrm{T} > 40$ GeV/c, the perturbative QCD-based models describe the suppression in both centrality ranges within the uncertainties, although the trend suggested by these predictions is typically lower than that in the experimental data. The model based

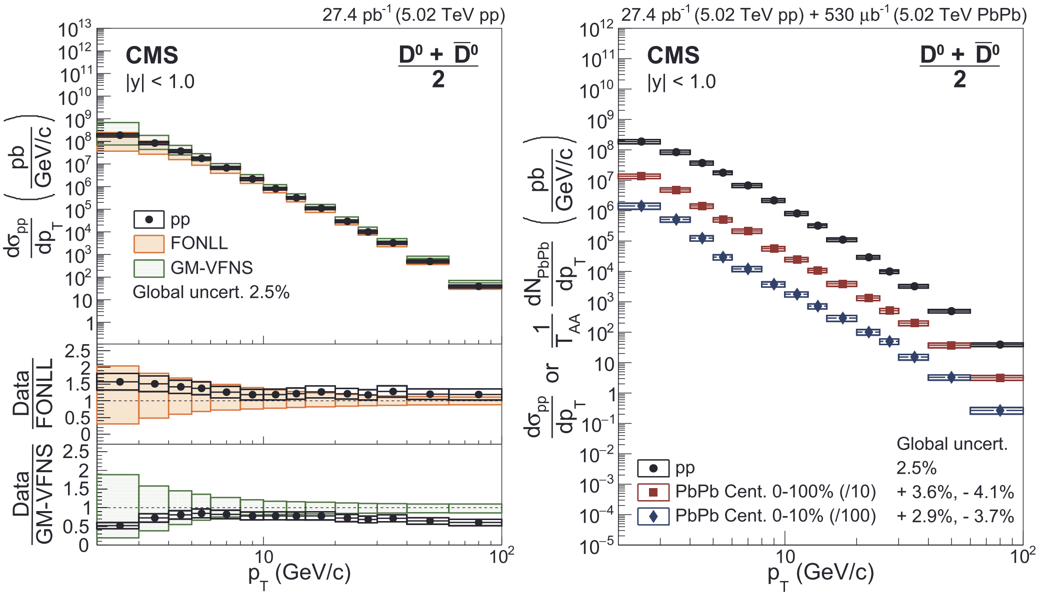

Fig. 2. (left) The p_T-differential production cross section of D^0 mesons in pp collisions at $\sqrt{s} = 5.02$ TeV. The vertical bars (boxes) correspond to statistical (systematic) uncertainties. The global systematic uncertainty, listed in the legend and not included in the point-to-point uncertainties, comprises the uncertainties in the integrated luminosity measurement and the D^0 meson $\mathcal{B}$. Results are compared to FONLL [32] and GM-VFNS [34–36] calculations. (right) The p_T-differential production yields of D^0 mesons divided by the nuclear overlap functions T_{AA} for PbPb collisions in the 0–100% (red) and 0–10% (blue) centrality ranges compared to the same pp cross sections shown in the left panel (black).

on a Langevin approach describes the measurement well in the centrality range 0–100%, while it predicts slightly too much suppression for central events. The AdS/CFT calculations describe well both the 0–100% and the 0–10% measurements. In the intermediate p_T region ($10 < p_T < 40$ GeV/c), all the theoretical calculations describe well the R_{AA} results in both centrality intervals. For $p_T < 10$ GeV/c, the PHSD prediction that includes shadowing can reproduce the measurement in the 0–100% centrality region accurately, while the Langevin calculation predicts significantly more suppression than seen in data for both centrality ranges. In the same low-p_T region, the AdS/CFT calculation lies at the lower limit of the experimental uncertainties for both 0–10% and 0–100% measurements.

The D^0 R_{AA} measured in the centrality range 0–100% is compared in the top panel of Fig. 4 to the CMS measurements of the R_{AA} of charged particles [21], $B^{\pm}$ mesons [48] and nonprompt J/ψ meson [49] performed at the same energy and in the same centrality range. The systematic uncertainties between the R_{AA} measurement of the D^0 mesons, and of the light and beauty particles, are almost completely uncorrelated. The only common contribution comes from the systematic uncertainty of one track (4%), which is however negligible when compared to the total uncertainties. The D^0 meson R_{AA} values are consistent with those of charged particles for $p_T > 4$ GeV/c. For lower p_T, a somewhat smaller suppression for D^0 mesons is observed. The R_{AA} of the $B^{\pm}$ mesons, measured in the p_T range 7–50 GeV/c and the rapidity range of $|y| < 2.4$, is also consistent with the D^0 meson measurement within the experimental uncertainties. The R_{AA} of nonprompt J/ψ, which was found to have almost no rapidity dependence [49], is shown here measured in the p_T ranges 6.5–50 GeV/c in $|y| < 2.4$, and 3–6.5 GeV/c in $1.8 < |y| < 2.4$. Its R_{AA} is found to be higher than the D^0 meson R_{AA} in almost the entire p_T range. The D^0 meson R_{AA} in the centrality range 0–10% is compared in Fig. 4 to the charged-particle R_{AA}. As observed for 0–100% PbPb events, the two results are consistent within uncertainties for $p_T > 4$ GeV/c and a somewhat smaller suppression for charmed mesons is observed at lower p_T.

7. Summary

In this Letter, the transverse momentum (p_T) spectra of prompt D^0 mesons in pp and PbPb collisions and the D^0 meson nuclear modification factor (R_{AA}) in the central rapidity region ($|y| < 1$) at $\sqrt{s_{NN}} = 5.02$ TeV from CMS are presented. The R_{AA} of prompt D^0 mesons is measured as a function of their p_T from 2 to 100 GeV/c in two centrality ranges, inclusive and 10% most central. The D^0 meson yield is found to be strongly suppressed in PbPb collisions when compared to the measured pp reference data scaled by the number of binary nucleon–nucleon collisions. These measurements are consistent with the R_{AA} of charged hadrons in both centrality intervals for $p_T > 4$ GeV/c. A hint of a smaller suppression of D^0 R_{AA} with respect to charged particle R_{AA} is observed for $p_T < 4$ GeV/c. The D^0 R_{AA} was found to be compatible with the $B^{\pm}$ R_{AA} in the intermediate p_T region and significantly lower than the nonprompt J/ψ meson R_{AA} for $p_T < 10$ GeV/c. Comparisons to different theoretical models show that the general trend of the R_{AA} is qualitatively reproduced at high p_T. Comparisons to different theoretical models show that the general trend of the R_{AA} is qualitatively reproduced at high p_T, while quantitative agreement for all centrality and p_T selections is yet to be attained.

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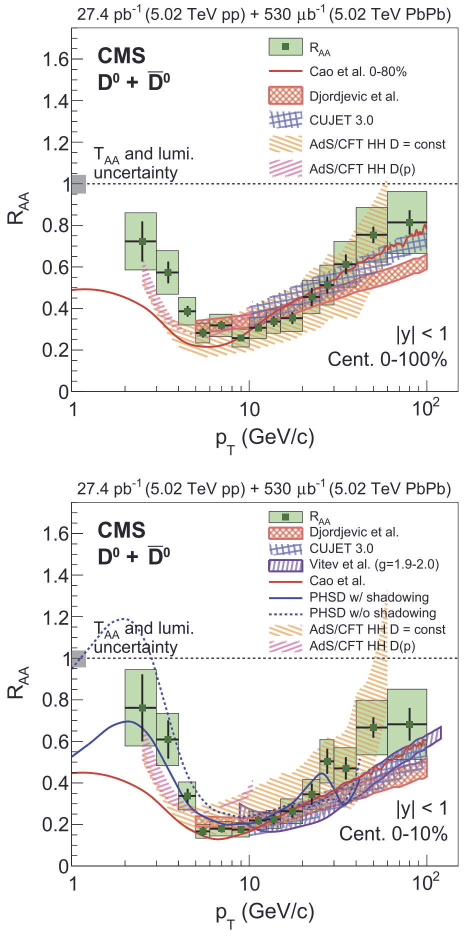

Fig. 3. R_{AA} as a function of p_T in the centrality range 0–100% (top) and 0–10% (bottom). The vertical bars (boxes) correspond to statistical (systematic) uncertainties. The global systematic uncertainty, represented as a grey box at $R_{AA} = 1$, comprises the uncertainties in the integrated luminosity measurement and T_{AA} value. The D^0 R_{AA} values are also compared to calculations from various theoretical models [37–47].

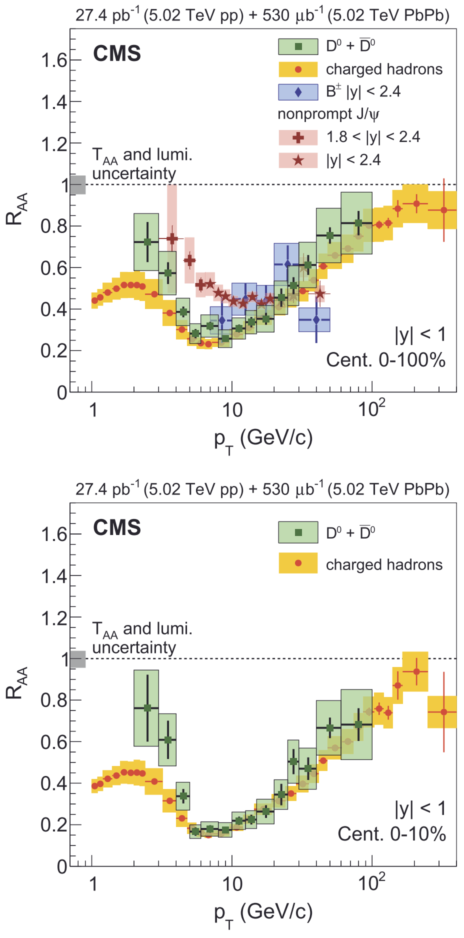

Fig. 4. (top) Nuclear modification factor R_{AA} as a function of p_T in the centrality range 0–100% (green squares) compared to the R_{AA} of charged particles (red circles) [21], $B^{\pm}$ mesons (blue triangles) [48] and nonprompt J/ψ meson (purple crosses and stars) [49] in the same centrality range at 5.02 TeV. (bottom) Nuclear modification factor R_{AA} as a function of p_T in the centrality range 0–10% (green squares) compared to the R_{AA} of charged particles (red circles) [21] in the same centrality range.

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