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D meson nuclear modification factor in Pb-Pb collisions with the ALICE detector

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Summary. — Open heavy-flavour hadrons are a powerful tool to investigate the properties of the high-density medium created in heavy-ion collisions at high energies as they come from the hadronization of heavy quarks. The latter are created in the early stage of the interaction and experience the whole collision history. Heavy-quark in-medium energy loss can be investigated by comparing the heavy-flavour production cross sections in p-p and nucleus-nucleus collisions. D mesons are identified from their hadronic decays which are reconstructed with ALICE in the central rapidity region using the tracking and PID detectors. We report on the measurements of D^+, D^0, D^{*+} and D_s^+ production as a function of transverse momentum (p_T) in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76\,\text{TeV}$, which allow one to calculate the nuclear modification factor. The latter is expected to be sensitive to the in-medium energy loss of charm quarks.

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Theory predicts that, while traversing the QGP fireball produced in heavy-ion collisions, quarks and gluons lose part of their energy via elastic collisions with the other medium constituents and gluon radiation. A mass dependence of the energy loss is expected: $\langle \Delta E \rangle_b \ll \langle \Delta E \rangle_c \ll \langle \Delta E \rangle_{u,d,gluons}$. This in-medium energy loss can be studied by comparing p_T spectra of the produced particles in AA and pp collisions, where no medium is produced, by means of the nuclear modification factor

$$R_{AA}(p_T) = \frac{1}{\langle N_{coll} \rangle} \frac{dN_{AA}/dp_T}{dN_{pp}/dp_T},$$

where $\langle N_{coll} \rangle$ is the average number of binary collisions that occur in a single nucleus-nucleus collision, N_{AA} and N_{pp} are the measured particle yields in AA and pp collisions respectively. $R_{AA} \neq 1$ indicates that medium effects are present.

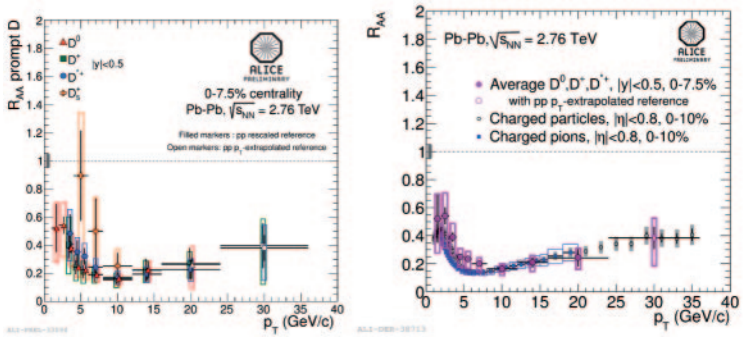

Fig. 1. – Left panel: D^0, D^+, D^{*+} and D_s^+ R_{AA} as a function of p_T. Right panel: average D meson R_{AA} as a function of p_T compared to charged hadrons R_{AA}.

The analysis presented is based on the reconstruction of D mesons in the following hadronic decay channels $D^0 \to K^-\pi^+$, $D^+ \to K^-\pi^+\pi^+$, $D^{*+} \to D^0\pi^+$ and $D_s^+ \to \phi\pi^+ \to K^+K^-\pi^+$ in the central barrel of the ALICE apparatus ($|\eta| < 0.9$). D meson candidates are formed by combining pairs and triplets of tracks within each event. Topological cuts are applied to reduce the combinatorial background, in particular separation between the primary and secondary vertices and small pointing angle (angle between the reconstructed momentum and the D meson flight line). These selections require excellent tracking and vertexing performance, provided by the Inner Tracking System (ITS) and Time Projection Chamber (TPC). A further background rejection is obtained applying a PID selection on the decay tracks by combining information from the TPC and the Time of Flight detectors. The 2011 Pb-Pb data sample allowed the ALICE Collaboration to calculate R_{AA} for D^0, D^+, D^{*+} and D_s^+ (fig. 1, left). The R_{AA} values of D^0, D^+ and D^{*+} are compatible within uncertaintes. Their average is shown together with charged particles R_{AA} (fig. 1 right). Figure 2 shows D meson R_{AA} (data coming from the 2010 data sample [1]) as a function of centrality compared to non-prompt J/ψ from B hadron decays (CMS preliminary data [2]). Note that D meson and J/ψ are measured in a different p_T and rapidity range. In fig. 2D meson R_{AA} is plotted together with predictions coming from several theoretical models. From these results we can see that

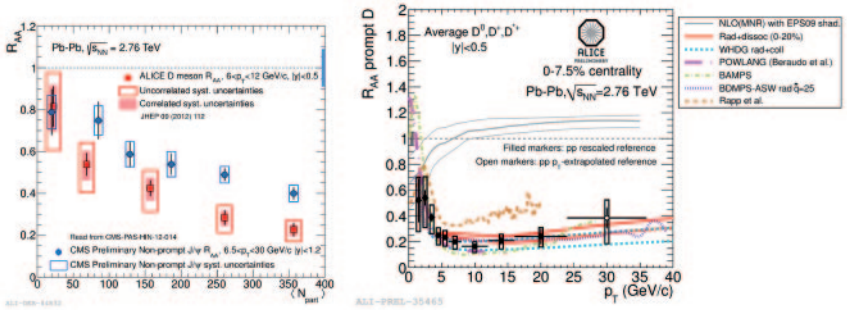

Fig. 2. – Upper panel: average D meson R_{AA} as a function of centrality compared to non-prompt J/ψ R_{AA}. Lower panel: average D meson R_{AA} as a function of p_T compared to models.

while higher statistics is needed for conclusions on D_s^+ R_{AA}, which could be enhanced at low/intermediate p_T due to hadronization via coalescence with strange quarks, D^0, D^+ and D^{*+} show a similar suppression as that of charged hadrons, indicating that charm quarks are strongly affected by the medium, more than b quarks, as the comparison with non-prompt J/ψ suggests. Comparisons with theoretical models indicate that modification of the PDFs in the nuclei alone cannot explain the results and this indicates that the observed suppression is a final state effect due to the presence of the medium.

REFERENCES

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