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Heavy flavours as a probe for the Quark-Gluon Plasma with ALICE at the LHC

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Summary. — ALICE measured D-meson nuclear modification factors in central and semicentral Pb-Pb collisions as well as in p-Pb collisions, and D-meson elliptic flow in semicentral Pb-Pb interactions. The measurements are presented and compared with some of the available theoretical models.

1. – Physics motivation

Heavy flavours are an excellent tool to investigate the properties of the Quark-Gluon Plasma (QGP) created in high-energy nucleus-nucleus collisions. Heavy quarks (charm and beauty) experience the entire evolution of the medium created in heavy-ion collisions interacting with its constituents [1]. In this way, they lose energy and might participate in the collective motion of the system. The momentum distributions of charmed mesons are hence expected to be different in Pb-Pb with respect to pp collisions. We measure such modifications via the nuclear modification factor $R_{\mathrm{AA}} = (\mathrm{d}N_{\mathrm{AA}}/\mathrm{d}p_{\mathrm{T}})/(\langle T_{\mathrm{AA}}\rangle \mathrm{d}\sigma_{\mathrm{pp}}/\mathrm{d}p_T)$, where T_{AA} is the nuclear overlap function, proportional to the number of binary nucleon-nucleon collisions per A-A collision, while $\mathrm{d}N_{\mathrm{AA}}/\mathrm{d}p_{\mathrm{T}}$ and $\mathrm{d}\sigma_{\mathrm{pp}}/\mathrm{d}p_{\mathrm{T}}$ are the p_{T}-differential yield and cross section in A-A and pp collisions, respectively. We can study the colour-charge [2] and quark-mass dependence [3] of parton energy loss as well as possible modifications of hadronization [4] in the presence of the medium. In particular, if hadronization via recombination occurs at low p_{T}, the relative abundance of $\mathrm{D_s}$ mesons with respect to non-strange D mesons should be larger in Pb-Pb than in pp collisions, due to the expected strangeness abundance [5, 6]. Furthermore, it is possible to investigate whether heavy quarks take part in the collective expansion dynamics and thermalize in the medium. This can be done via measurements of the elliptic flow $v_2 = \langle \cos\ 2(\varphi - \psi_{\mathrm{RP}})\rangle$, where φ is the azimuthal angle of each particle and ψ_{RP} is the Reaction Plane angle, determined from the collision impact parameter and the beam direction.

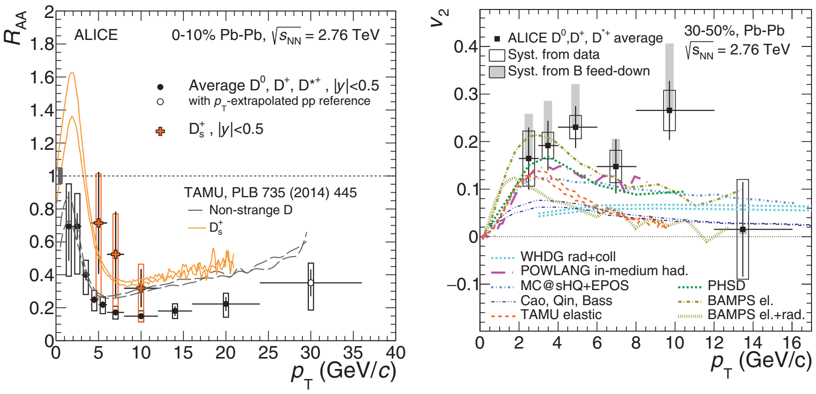

Fig. 1. – Left: R_{AA} of prompt $\mathrm{D_s^+}$ and non-strange D mesons in the 10% most central Pb-Pb collisions as a function of p_{T} compared to predictions of the TAMU model [6,7,9]. Right: Model comparisons for average D-meson v_2 as a function of p_{T} in the 30–50% centrality class [10].

2. – Results

The R_{AA} of prompt D mesons (D^0, D^+, D^{*+}) shows a maximum suppression by a factor of 5–6 in the 10% most central collisions [7]. A reduced suppression is observed when going to more peripheral collisions. In p-Pb collisions, a measurement of the R_{pA} compatible with unity [8] suggests that the large suppression in Pb-Pb collisions at high p_{T} is mainly due to final-state effects, *i.e.* energy loss in the hot and dense medium. In fig. 1 (left), the measured R_{AA} of non-strange D mesons and of $\mathrm{D_s^+}$ in the 10% most central collisions [7,9] are compared to the prediction of the TAMU transport model [6]. The values of the $\mathrm{D_s^+}$-meson R_{AA} are higher than those of non-strange D mesons, although compatible within uncertainties. The model includes recombination of charm quarks with thermally equilibrated strange quarks in the QGP.

The R_{AA} of charged pions and D mesons are compatible within uncertainties in all centrality classes [7]. In models describing the data, other effects in addition to the colour-charge dependence of energy loss, *i.e.* different fragmentation functions and p_{T} shapes, lead to a compensation effect that results in a very similar R_{AA} for D mesons and pions.

The elliptic flow of D mesons was measured in the 30–50% centrality class (fig. 1, right) [10], and a $v_2 > 0$ with a 5.7σ significance was found in the interval $2 < p_{\mathrm{T}} < 6\,\mathrm{GeV}/c$. The models that include substantial elastic interactions with an expanding medium provide a good description of the observed anisotropy. However, they are challenged to simultaneously describe the strong suppression of the high-p_{T} yield of D mesons in central collisions. Reducing the experimental uncertainties on the measurements will help, in the future, to constrain the values of the QGP transport coefficients, otherwise difficult to calculate from QCD principles.

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