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Measurement of D meson azimuthal anisotropy in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76\,\text{TeV}$ with ALICE

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Summary. — The azimuthal anisotropy of prompt D^0, D^+ and D^{*+} mesons has been measured with the ALICE detector in Pb-Pb semi-central collisions at the energy $\sqrt{s_{\rm NN}} = 2.76\,\text{TeV}$. The anisotropy is quantified in terms of the second Fourier coefficient v_2 and of the nuclear modification factor $R_{\rm AA}$ as a function of the estimated reaction plane direction. v_2 is found to be significantly larger than zero and $R_{\rm AA}$ indicates a stronger suppression in the direction orthogonal to the reaction plane compared to the parallel direction.

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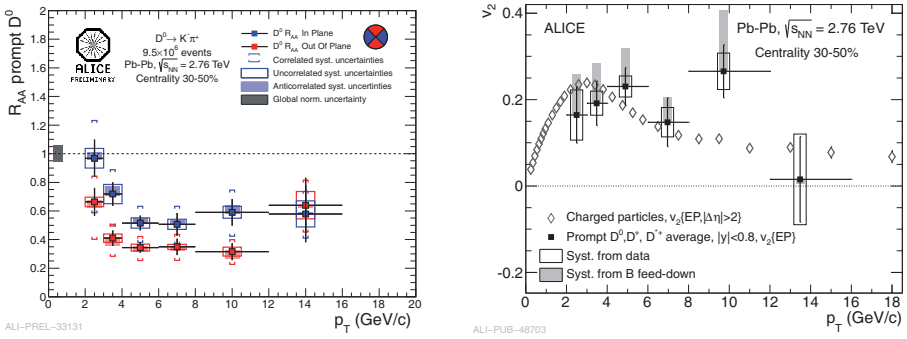
ALICE is the LHC experiment dedicated to the study of heavy-ion collisions at ultra-relativistic energies. Pb-Pb collisions are used to explore the properties and dynamics of strongly interacting matter at extremely high temperature and energy density. The ALICE apparatus consists of a central barrel, that includes detectors for track and vertex reconstruction and particle identification, a forward muon spectrometer and a set of small detectors in the forward regions for trigger and event characterization [1].

Because of their large mass ($m_c \sim 1.5\,\text{GeV}$ and $m_b \sim 4.5\,\text{GeV}$), charm and beauty quarks are produced predominantly before a strongly interacting medium is formed. Thus final state heavy-flavour hadrons originate from heavy quarks that experienced all the stages of the system evolution. By measuring the modification of the momentum distributions of D mesons produced in Pb-Pb collisions with respect to a pp reference, it is possible to study the energy loss mechanisms of c quarks in the medium. The energy loss results in a suppression of the particle yield in Pb-Pb at large momenta, which is usually quantified in terms of the nuclear modification factor $R_{\rm AA}(p_{\rm T}) = \frac{{\rm d}N_{\rm AA}/{\rm d}p_{\rm T}}{\langle N_{\rm coll}\rangle {\rm d}N_{\rm pp}/{\rm d}p_{\rm T}}$, defined as the ratio of the $p_{\rm T}$ spectrum in Pb-Pb collisions to the one in pp collisions, scaled by the number of binary collisions. On the other hand, D meson azimuthal anisotropy carries information on the possible thermalization of heavy quarks in the medium and on the degree to which they take part in the collective expansion.



(a) (b)

Fig. 1. – (a) D^0 R_{AA} in-plane and out-of-plane in the 30–50% centrality class. (b) Average of D^0, D^+ and D^{*+} v_2 as a function of p_T compared to charged-particle v_2 in the 30–50% centrality class [4, 5].

In non-central heavy-ion collisions, the nuclear overlap region is anisotropic in spatial coordinates. During the expansion of the system, the pressure gradients generated by interactions among quarks and gluons transform the initial spatial anisotropy into a momentum anisotropy of produced particles. The azimuthal distribution of final state particles can be parametrized by a Fourier expansion with respect to the reaction plane, defined as the plane spanned by the vector of the impact parameter and perpendicular to the beam direction. The azimuthal anisotropy is dominated by the second Fourier coefficient v_2, commonly denoted elliptic flow.

The open charm mesons D^0, D^+ and D^{*+} were reconstructed in the central rapidity region from their hadronic decay channels. The selection of the D meson candidates was based on the reconstruction of displaced secondary vertices. Topological cuts and particle identification were applied to reduce the background. The D meson signal was measured in two azimuthal regions with respect to the event plane for 9.5×10^6 events in the 30–50% centrality class [2]. The event plane is an experimental estimate of the reaction plane of the collision and it is defined using reconstructed tracks [3]. The D^0 nuclear modification factor R_{AA}, shown in fig. 1(a), indicates a suppression that is larger in the out-of-plane direction than in the in-plane one. A positive elliptic flow coefficient v_2 is observed, with 5.7σ significance in $2 < p_T < 6\,\mathrm{GeV}/c$ (fig. 1(b)) [4]. The measured D meson v_2, obtained as the average of D^0, D^+ and D^{*+} v_2, is comparable in magnitude to that of charged particles (fig. 1(b)), which is dominated by light flavour hadrons [5].

The observed non-zero v_2 and the different in-plane and out-of-plane suppression indicate that the in-medium interactions transfer to quarks as heavy as $\sim 1.5\,\mathrm{GeV}$ information on the azimuthal anisotropy of the system. The measured D meson v_2 of the same magnitude of the charged hadrons v_2, could be an indication of the fact that also charm quarks take part in the collective expansion of the medium.

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