Measurement of D^0 azimuthal anisotropy in Pb-Pb collisions with the ALICE detector at the LHC

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HEAVY FLAVOURS in ALICE

The main goal of the ALICE experiment is the characterization of the high-density state of strongly interacting matter formed in high-energy heavy-ion collisions. To do so, ALICE studies Pb-Pb as well as p-Pb and pp collisions at the LHC.

Heavy quarks (charm and beauty) are important probes to test the medium formed in Pb-Pb collisions. Being produced in the early stage of the collision, in hard scatterings, heavy quarks can interact with the medium via elastic and inelastic collisions with its constituents (collisional and radiative energy loss).

The azimuthal anisotropy of heavy-flavour hadrons can also bring insights into the degree of thermalization of b and c quarks in the quark-gluon plasma and into the path length dependence of the in medium energy loss.

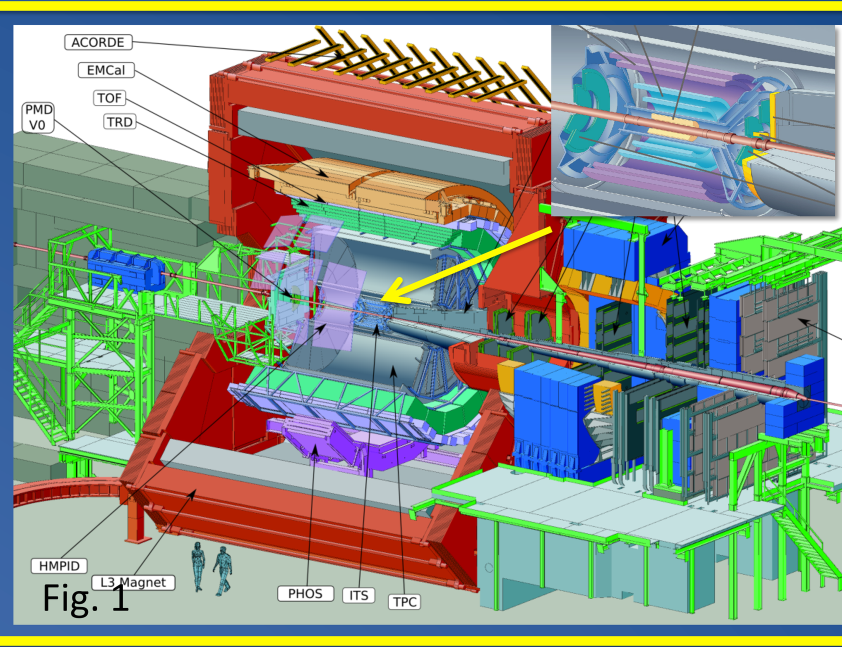


Fig. 1

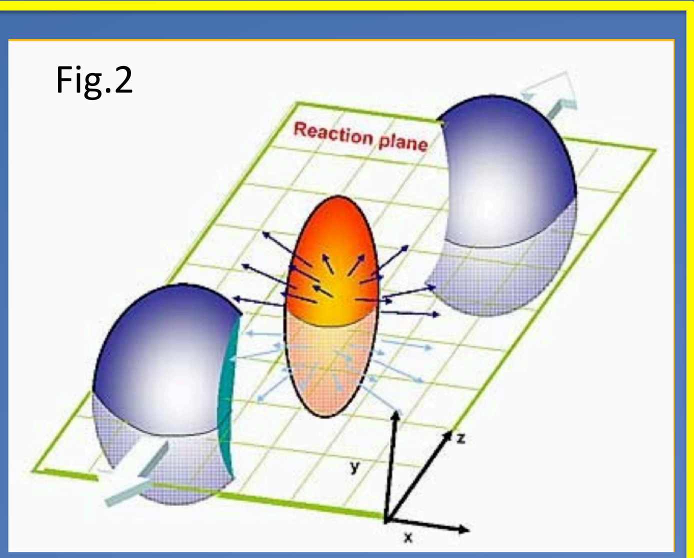
AZIMUTHAL ANISOTROPY

The spatial anisotropy of the overlap region of the colliding nuclei in semi-peripheral heavy-ion collisions is translated into an anisotropy in the momenutm of produced particles.
This momentum anisotropy is due to the different pressure gradients that partons undergo while the medium is expanding in the reaction plane (**In-Plane**) and orthogonal to it (Out-Of-Plane).
Particles azimuthal distribution ($dN/d\phi$), relative to the reaction plane (Ψ_{RP}), can be parametrized by a Fourier expansion:

$$\frac{dN}{d\varphi} \approx \frac{N_0}{2\pi}(1 + v_2 \cos 2(\varphi - \Psi_{RP}))$$

where v_2 is the elliptic flow coefficient.

Fig.2

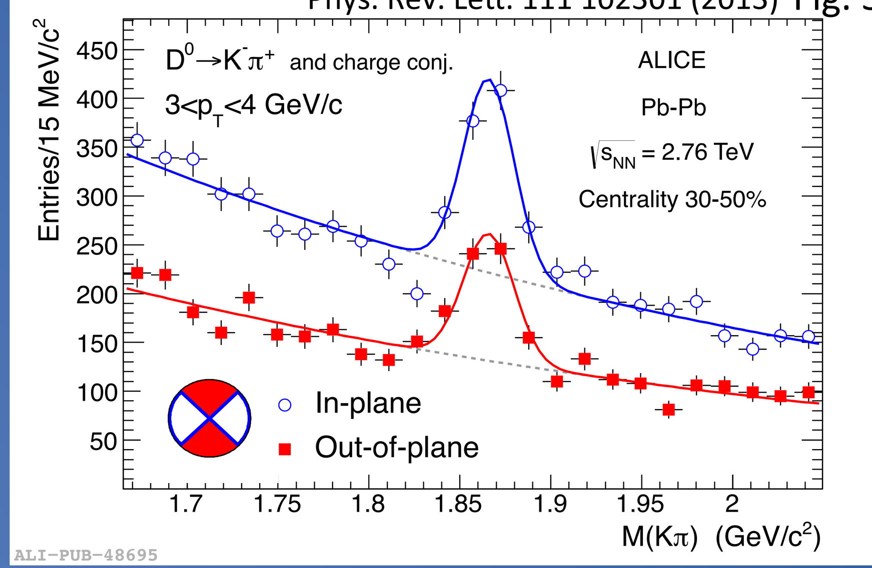


The reaction plane was estimated using Time Projection Chamber tracks in the region $0 < \eta < 0.8$.

D^0 RECONSTRUCTION

D^0 mesons are reconstructed from the $D^0 \rightarrow K^-\pi^+$ decay. D^0 candidates are built from pair of opposite sign tracks, forming a decay vertex displaced from the interaction one. The selection exploits the $c\tau$~150 µm of D^0 meson and the good impact parameter resolution obtained with the Silicon Pixel Detector.
Kaon identification is also used to reduce the combinatorial background.

Phys. Rev. Lett. 111 102301 (2013) Fig. 3



The D^0 azimuthal anisotropy analysis is based on the event plane method where an asymmetry in D^0 yields is evaluated in the two wide azimuthal angle regions, relative to the reaction plane (**In-Plane** and Out-Of-Plane, Fig. 3).

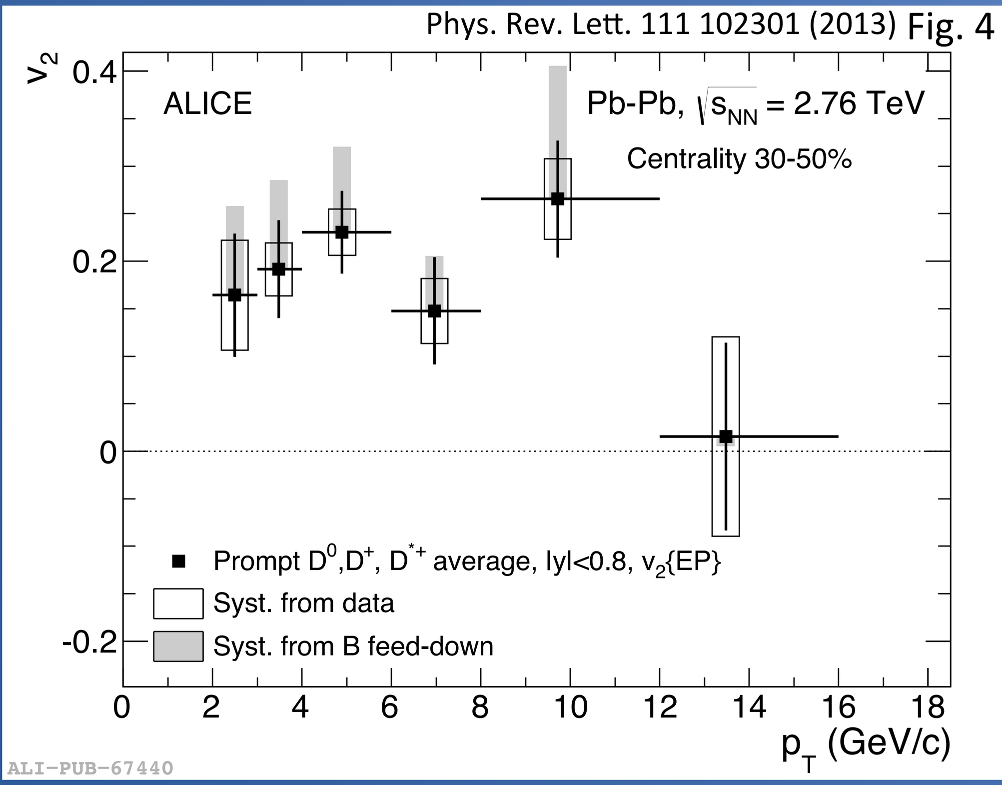
RESULTS

D^0 v_2 has been measured as a function of p_T in the 30-50% centrality class in the range $2 < p_T < 16$ GeV/c: data show a non-zero v_2 in $2 < p_T < 6$ GeV/c (5.7σ effect, Fig. 4). The measurement has been done also in 0-10%, and 10-30% centrality classes: a lower effect is expected to occur because of the smaller anisotropy of the overlap region of the two nuclei. The D^0 v_2 for the three centrality classes show similar magnitude as charged particle v_2, that is dominated by light flavour hadrons (Fig. 5).

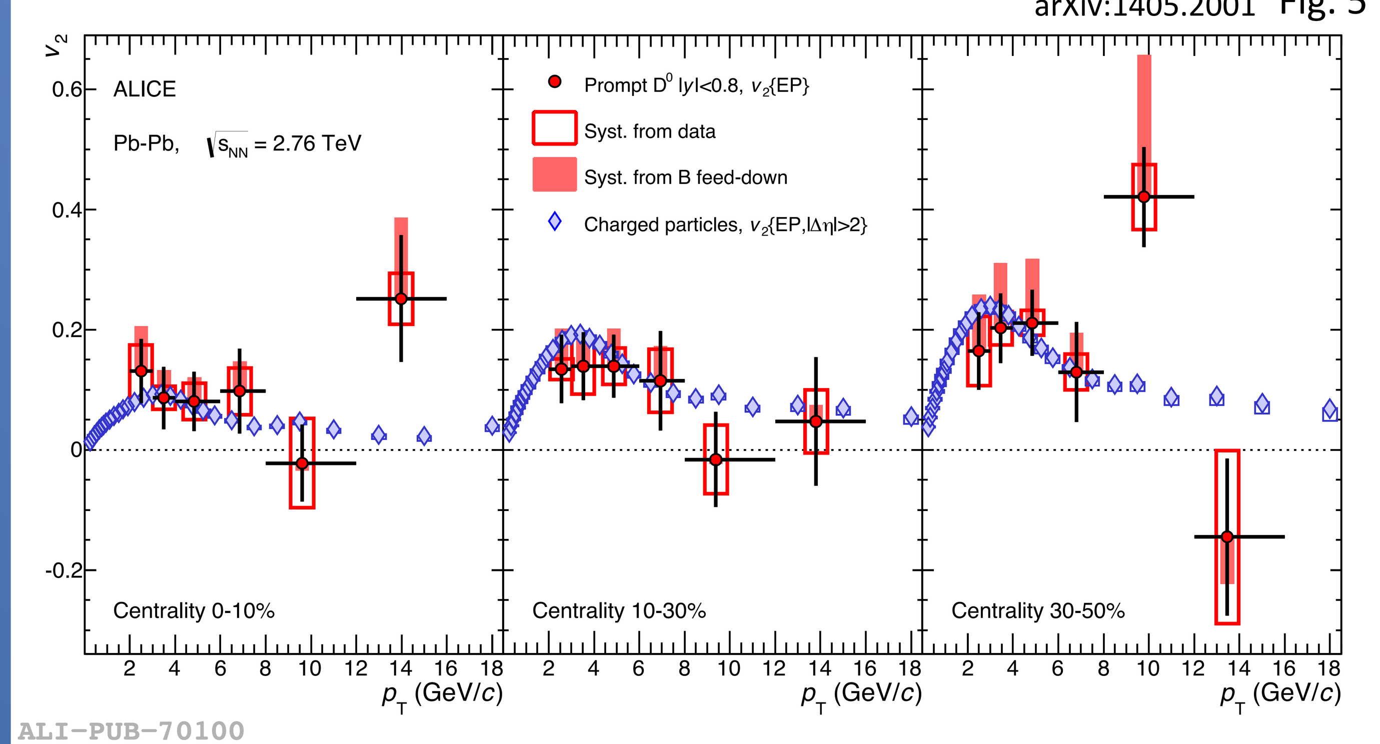
The nuclear modification factor of D^0 mesons in the 30-50% centrality class is shown in Fig. 6 for the In-Plane and Out-Of-Plane directions with respect to the event plane:
- **a large suppression for $p_T > 4$ GeV/c is observed in both directions with respect to the event plane.**
- **a stronger suppression is observed in the Out-Of-Plane azimuthal region.**

$$R_{AA}(p_T, y) = \frac{1}{\langle T_{AA} \rangle} \frac{d^2N_{AA}/dp_T dy}{d\sigma/dp_T dy}$$

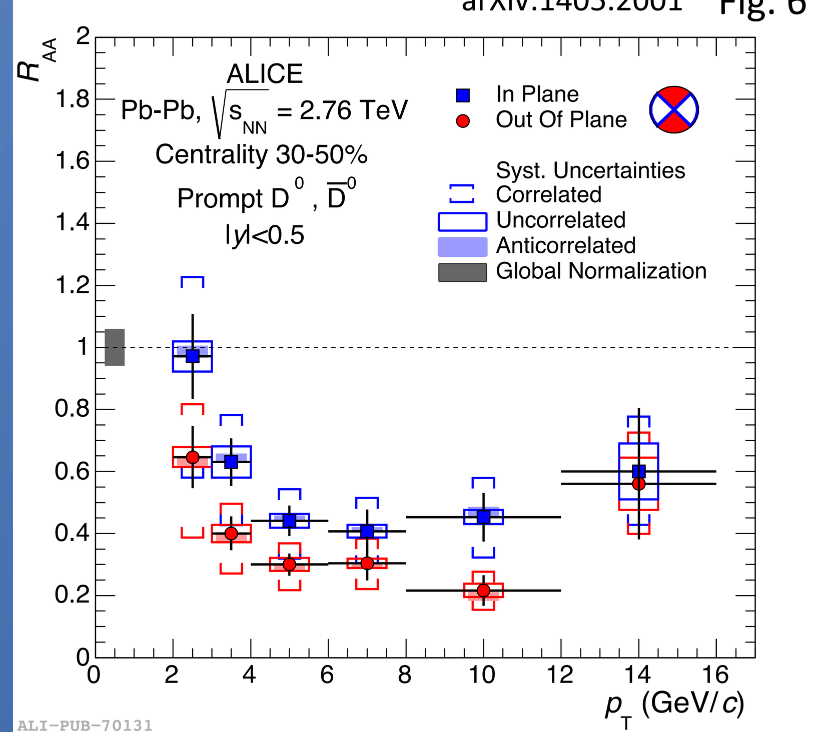
Phys. Rev. Lett. 111 102301 (2013) Fig. 4



arXiv:1405.2001 Fig. 5



arXiv:1405.2001 Fig. 6



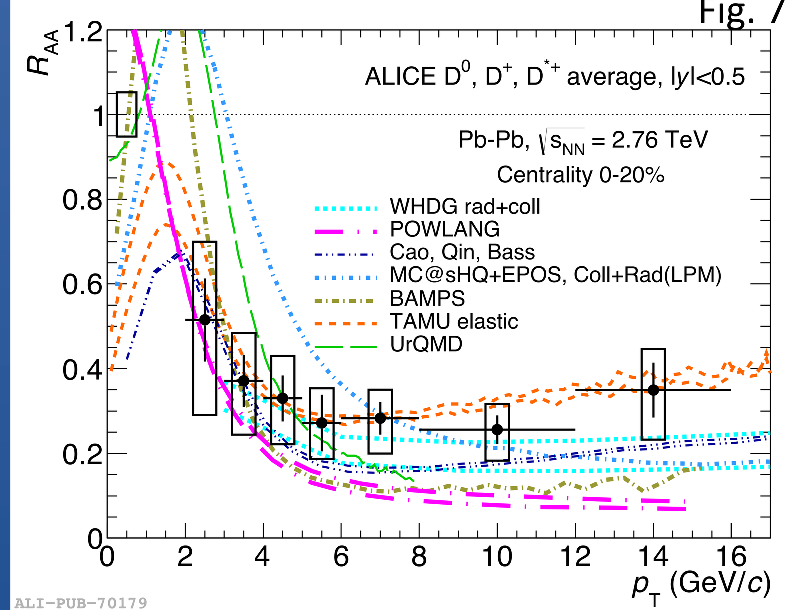
During the collective expansion, charm quarks interact with the medium constituents that transfer information on the azimuthal anisotropy of the system.

COMPARISON WITH MODELS

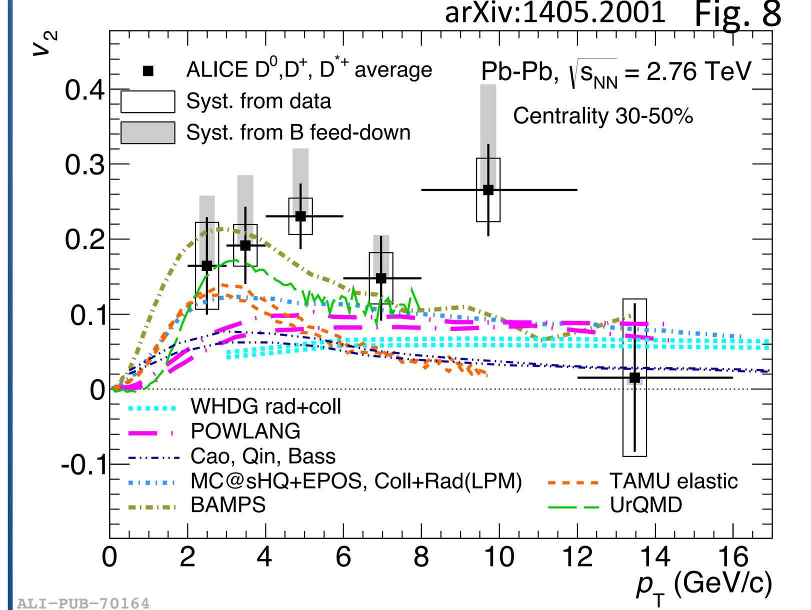
	HQ production	Medium Modeling	Heavy quarks interactions	Hadronization
WHDG (AIP Conf Proc. 1441 (2012) 889	FONLL, no shadowing	Glauber model collision geometry, no hydro evolution	radiative + collisional energy loss	fragmentation
POWLANG (J. Phys. G 38 (2011) 124144)	POWEG (NLO) + EPS09 shadowing	2+1d expanding medium with viscos hydro evolution	HQ transport (Langevin) + collisional energy loss	fragmentation
Cao, Quin, Bass (Phys Rev C 88 (2013) 044907)	LO pQCD + EPS09 shadowing	2+1d expanding medium with viscous hydro evolution	HQ transport (Langevin) + quasi elastic scattering + radiative energy loss	recombination + fragmentation
MC@sHQ+EPOS2 (Phys Rev C 89 (2014) 014905)	FONLL, no shadowing	3+1d fluid dynamical expansion (EPOS)	HQ transport (Boltzmann) + radiative + collisional energy loss.	recombination + fragmentation
BAMPS (Phys Lett B 717 (2012) 430)	MC@NLO, no shadowing	3+1d fully dynamic parton transport model	HQ transport (Boltzmann) + collisional energy loss	fragmentation
TAMU elastic (arXiv:1401.3817)	FONLL + EPS09 shadowing	transport + 3+1d ideal hydro evolution	HQ transport (Langevin) + collisional energy loss + diffusion in hadronic phase	recombination + fragmentation
UrQMD (arXiv:1211.6912)	PYTHIA, no shadowing	3+1d ideal hydro evolution	HQ transport (Langevin) + collisional energy loss	recombination + fragmentation

A number of model calculations are available for the heavy flavour azimuthal anisotropy and the nuclear modification factor (Figs. 7-8). Simultaneous comparison of different observable is important to constrain the description of the energy loss in the theoretical models.

Fig. 7



arXiv:1405.2001 Fig. 8



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