D-meson v_2 measurement in Pb-Pb collisions at 5.02 TeV with ALICE

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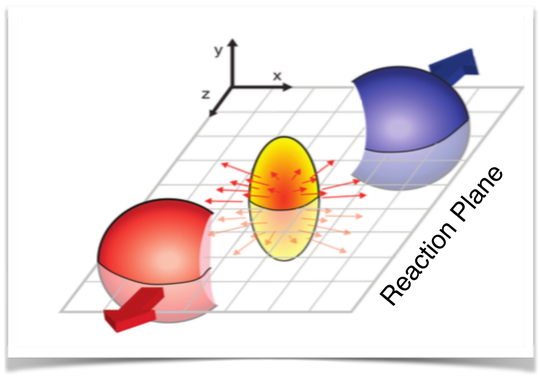
Physics motivations

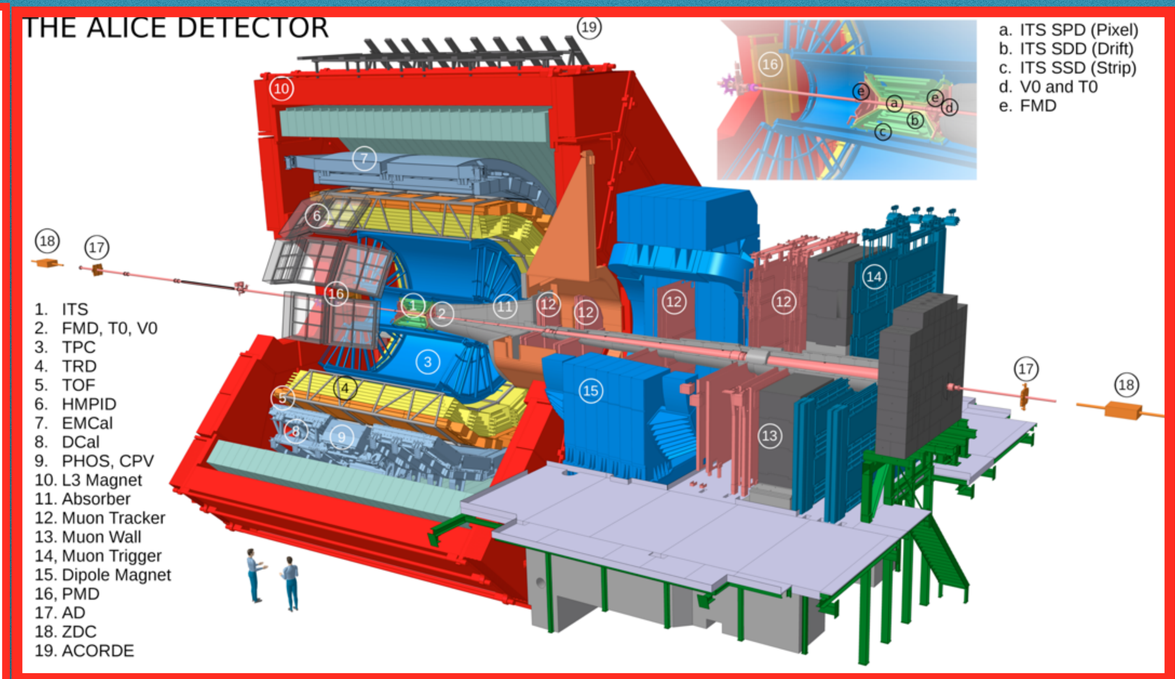


In non-central heavy-ion collisions the overlap region features a geometric anisotropy. Multiple interactions during the expansion of the system convert it into an azimuthally anisotropic distribution in momentum space of the produced particles:

$$\frac{dN}{d\varphi} = \frac{N_0}{2\pi} + \frac{N_0}{\pi}\sum_n^{\infty} v_n \cos(n(\varphi - \psi_n))$$

ψ_n: n-th order symmetry plane; ***v*₂: elliptic flow** parameter.

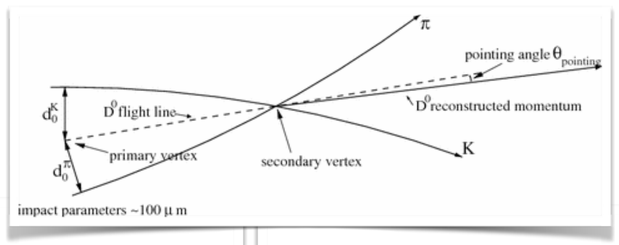
The measurement of open charm v_2 helps in **understanding the transport properties of the Quark Gluon Plasma (QGP)** encoded in the spatial diffusion coefficient D_s [1].



Analysis method

➡**D mesons are reconstructed in the central rapidity region from the hadronic decay channels** [2]:

- $D^0 \to K^-\pi^+$ (BR = 3.93 ± 0.04%, $c\tau \approx 123$ μm)
- $D^+ \to K^-\pi^+\pi^+$ (BR = 9.46 ± 0.24%, $c\tau \approx 312$ μm)
- $D^{*+} \to D^0\pi^+$ (BR = 67.7 ± 0.5%) with D^0 decaying as $D^0 \to K^-+\pi^+$
- $D_s^+ \to \phi\pi^+ \to K^-K^+\pi^+$ (BR = 2.27 ± 0.08%, $c\tau \approx 149.9$ μm)



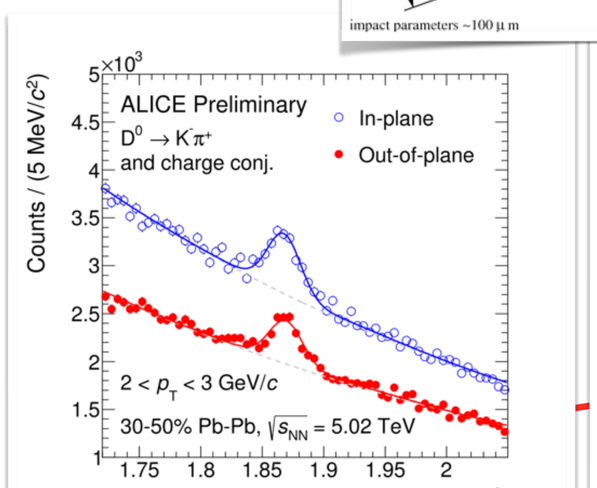
- The D^0, D^+, D_s^+-meson decay vertex are reconstructed and signal candidates are identified selecting vertices with displaced topology. The combinatorial background is suppressed by applying topological selections and particle identification with TPC and TOF.

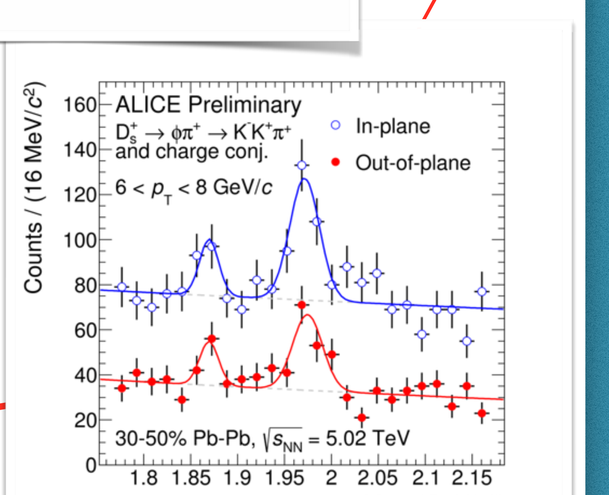
  Pairs of D^0 and pion candidates are built to measure the D^{*+} decay signal.

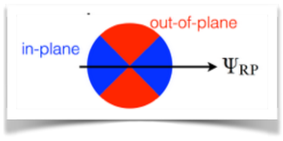
➡ **The elliptic flow parameter v_2 is calculated with the Event-Plane method** [3]

- The reaction plane angle of the collision is estimated by measuring the event plane angle ψ_2 with the V0 detector
- The resolution on the event plane R_2 is estimated with the three sub-event method (using the V0 detector and the positive and negative η regions of the TPC).

➡ **D-meson yields evaluated independently in the in-plane and out-of-plane azimuthal quadrants.**



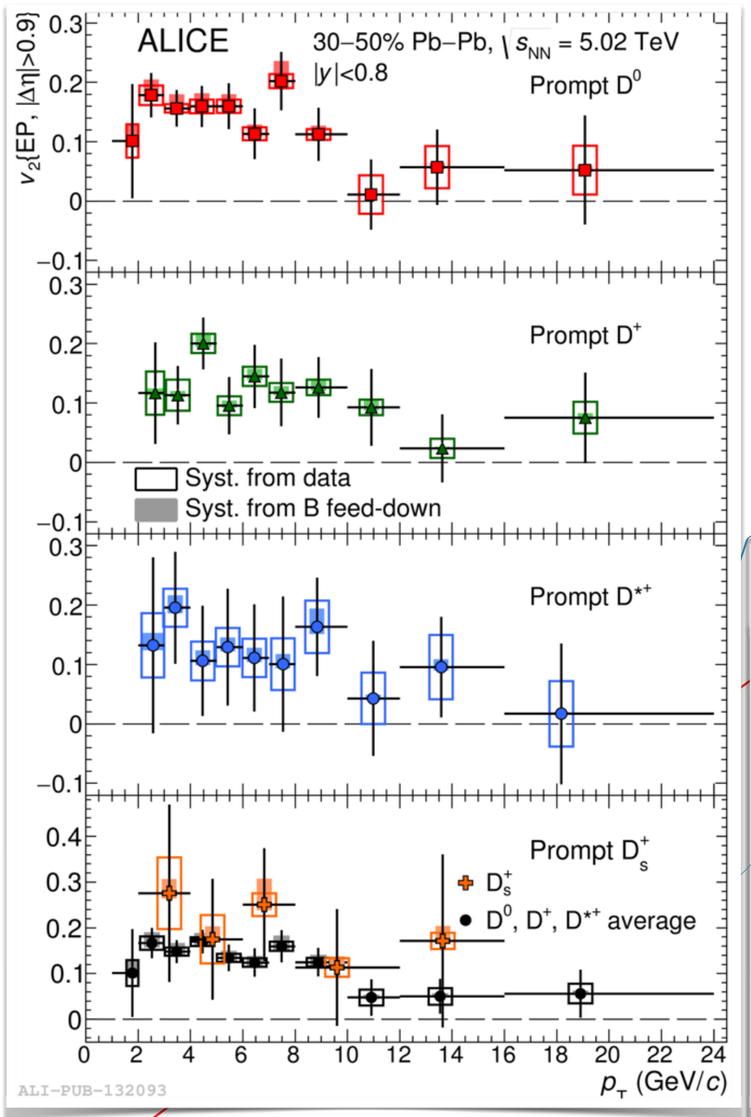




$$v_2 = \frac{1}{R_2}\frac{\pi}{4}\frac{N_{\text{in-plane}} - N_{\text{out-of-plane}}}{N_{\text{in-plane}} + N_{\text{out-of-plane}}}$$

Results

➡The measured v_2 distributions of D^0, D^+ and D^{*+}-mesons are compatible with each other within uncertainties in the 30-50% centrality class.

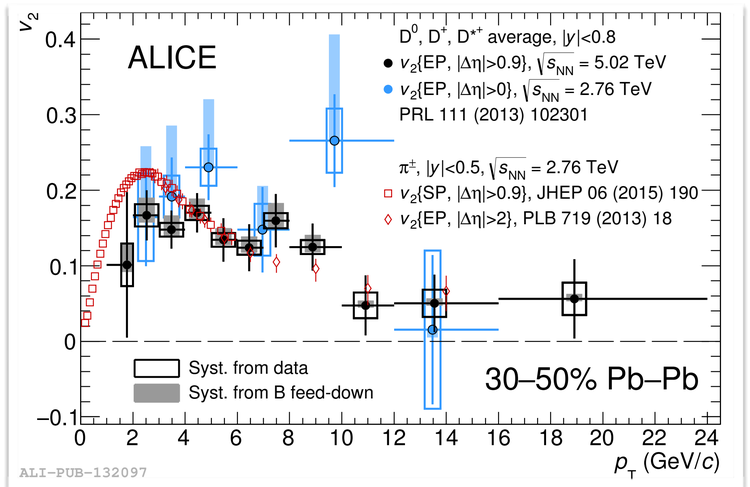


➡Non-strange D-meson average v_2 larger than 0 in $2 < p_T < 10$ GeV/c in the 30-50% centrality class.

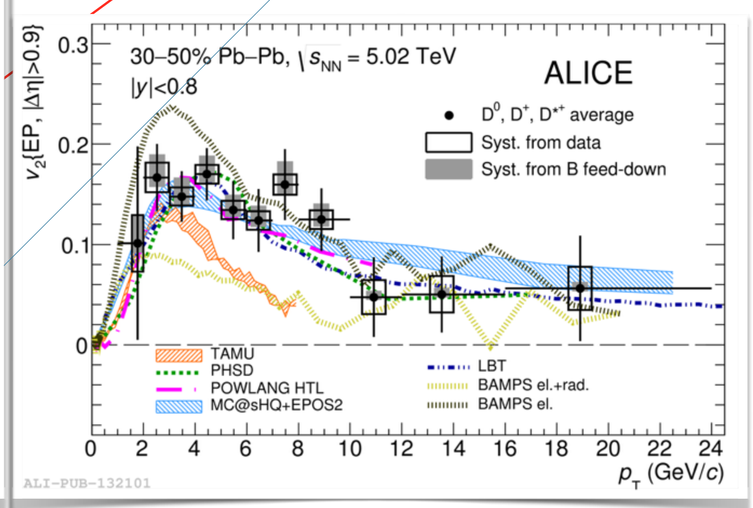
➡D-meson v_2 is comparable in magnitude to that of $\pi^{\pm}$ for $4 < p_T < 10$ GeV/c.

Charm quarks participate in the collective expansion of the medium.

➡D_s^+-meson v_2 in 30-50% centrality class is compatible with that of non-strange D mesons and positive with a significance of 2.6σ in $2 < p_T < 8$ GeV/c [4].



The comparison to model calculations set constraints to the medium parameters.



- All theoretical calculations include a hydrodynamical QGP expansion and all models except BAMPS include hadronization via quark recombination in addition to fragmentation.
- BAMPS-el [5], POWLANG [6], TAMU [7] include only collisional parton energy loss.
- BAMPS-el+rad [5], LBT [8], MC@sHQ [9], PHSD [10] include also parton energy loss via gluon radiation.

➡Model calculations that provide a fair description of the measurement (LBT, MC@sHQ, PHSD, POWLANG) use values of the heavy quark **spatial diffusion coefficient in the range $2\pi\, T\, D_s \sim 1.5\text{-}7$ at the critical temperature $T_c \sim 155$ MeV.**

➡**Thermalization time for charm quarks is $\tau_c = (m_c/T)\, D_s \sim 3\text{-}14$ fm/c** with $T = T_c$ and $m_c = 1.5$ GeV/c^2 [4].

References:
[1] G. D. Moore and D. Teaney, PRC71 064904 (2005)
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