Measurement of D^0 nuclear modification factor and elliptic flow in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE

Stefano Trogolo on behalf of the **ALICE Collaboration**
Università degli Studi di Padova - INFN Padova

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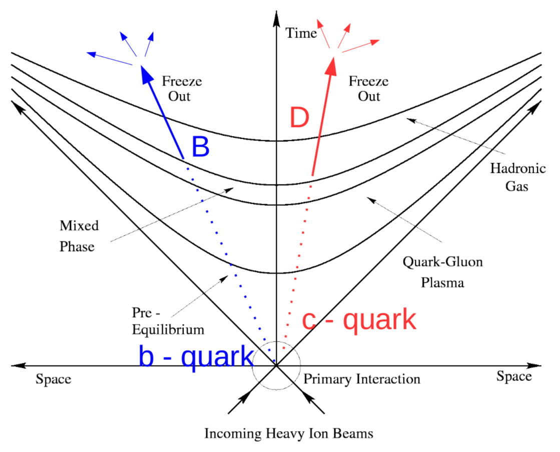
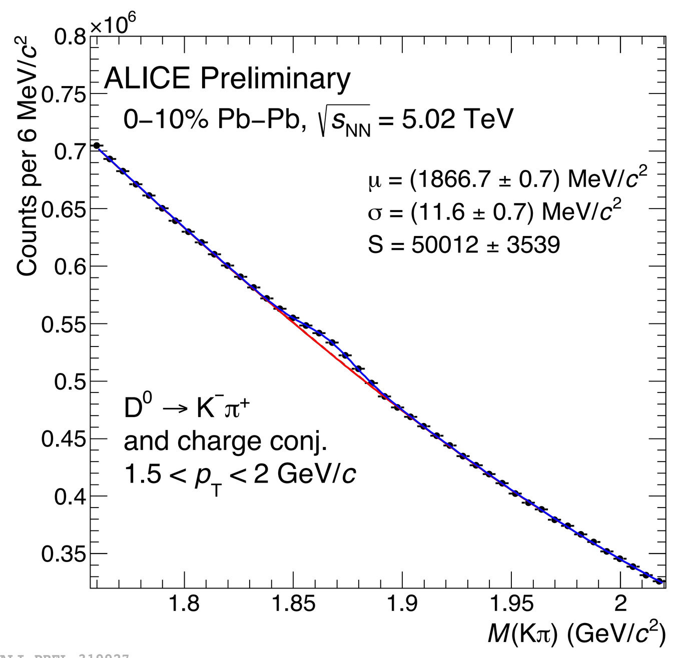
Heavy flavours in the Quark-Gluon Plasma

- Heavy flavours (i.e. c and b quarks) are mainly produced in hard-scattering process on short time scale in the early stage of the collision
- They probe the full evolution of the QGP created in ultra-relativistic heavy ion collisions, interacting with its constituent



D^0 reconstruction

- Reconstruction of decay vertices displaced ~100 microns from primary vertex combining pairs of tracks with proper charge sign
- Particle identification (PID) of decay tracks and geometrical selection of displaced decay-vertex topology
- Efficiency correction with Monte Carlo simulations using HIJING [1] events enriched with PYTHIA [2] $c\bar{c}$ and $b\bar{b}$ pairs
- Beauty feed-down subtraction based on FONLL [3] calculations



ALICE detectors

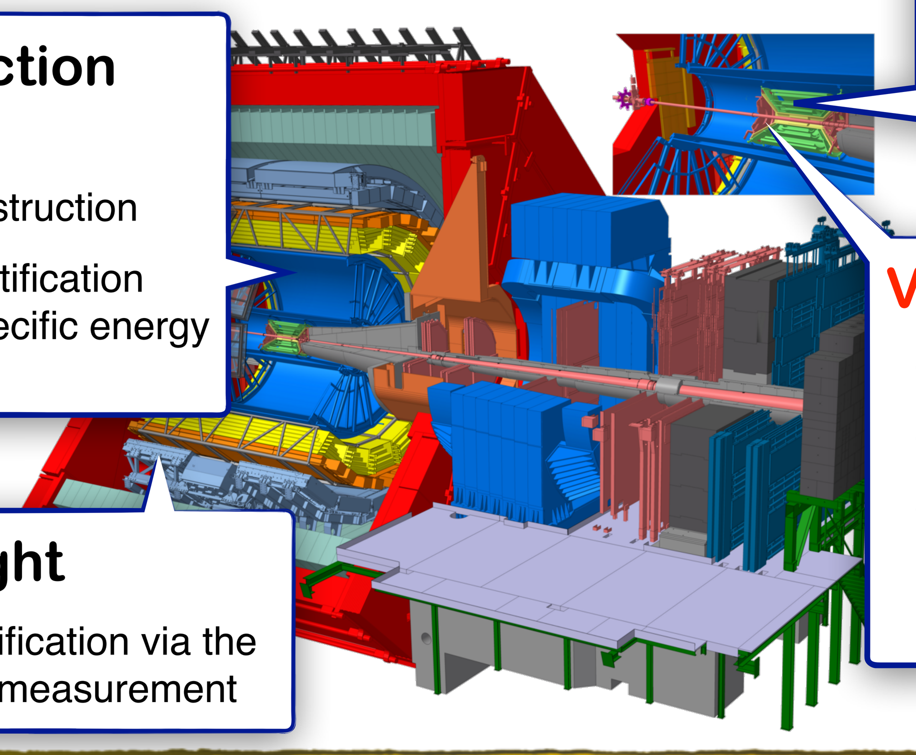
- Data sample used for the analysis
  → Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV collected in 2018
  → $\mathcal{L}_{int} \approx$ 114 μb^{-1} (0-10%) and $\mathcal{L}_{int} \approx$ 49 μb^{-1} (30-50%)
- Main detectors used for D-mesons analyses

Inner Tracking System
- Track reconstruction
- Reconstruction of primary and secondary (decay) vertices

Time Projection Chamber
- Track reconstruction
- Particle identification (PID) via specific energy loss

V0 detectors
- Trigger
- Centrality
- Event Plane determination (estimator of Reaction Plane)

Time-Of-Flight
- Particle identification via the time-of-flight measurement

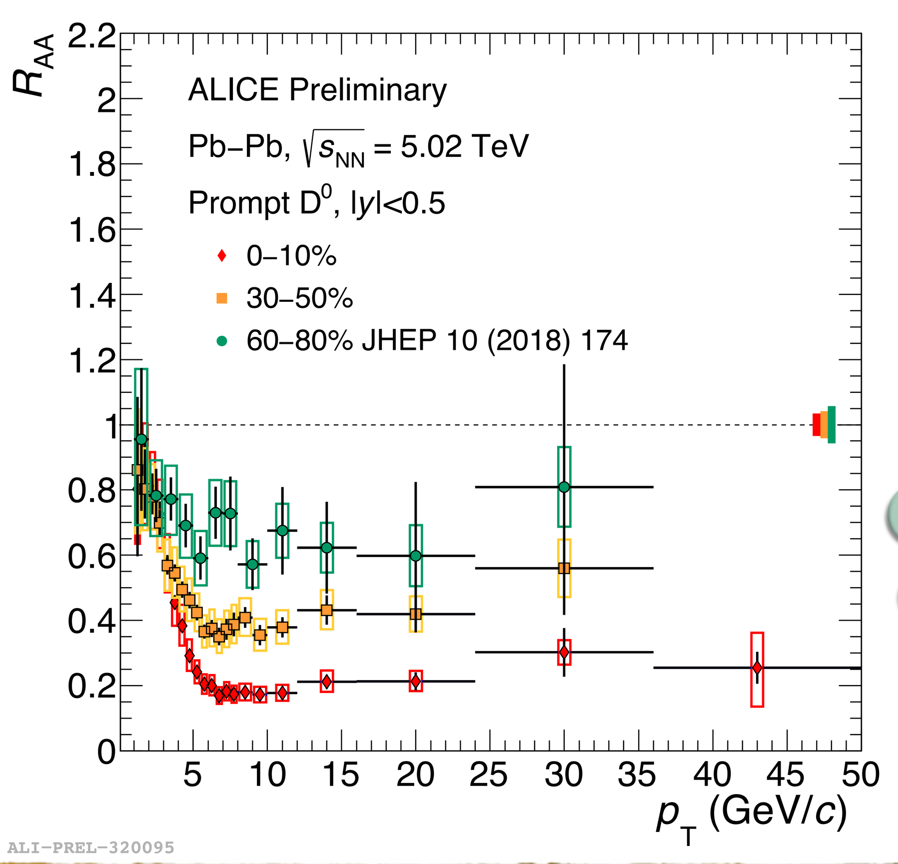


Nuclear modification factor

$$R_{AA} = \frac{1}{\langle T_{AA}\rangle}\frac{dN_{AA}/dp_T}{d\sigma_{pp}/dp_T}$$

- $\langle T_{AA}\rangle$ is the average nuclear overlap function, proportional to the number of binary nucleon-nucleon collisions
- $d\sigma_{pp}/dp_T$ is the D^0 cross-section measured in pp collisions at $\sqrt{s}$ = 5 TeV

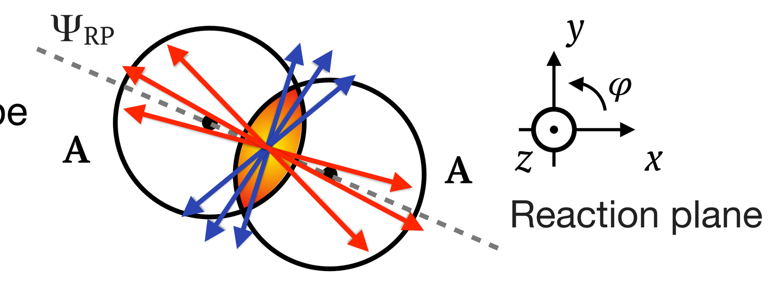
- It provides information about the of energy loss in the QGP which can occur via:
  - inelastic process (gluon radiation) [4]
  - elastic scatterings (collisional process) [5]



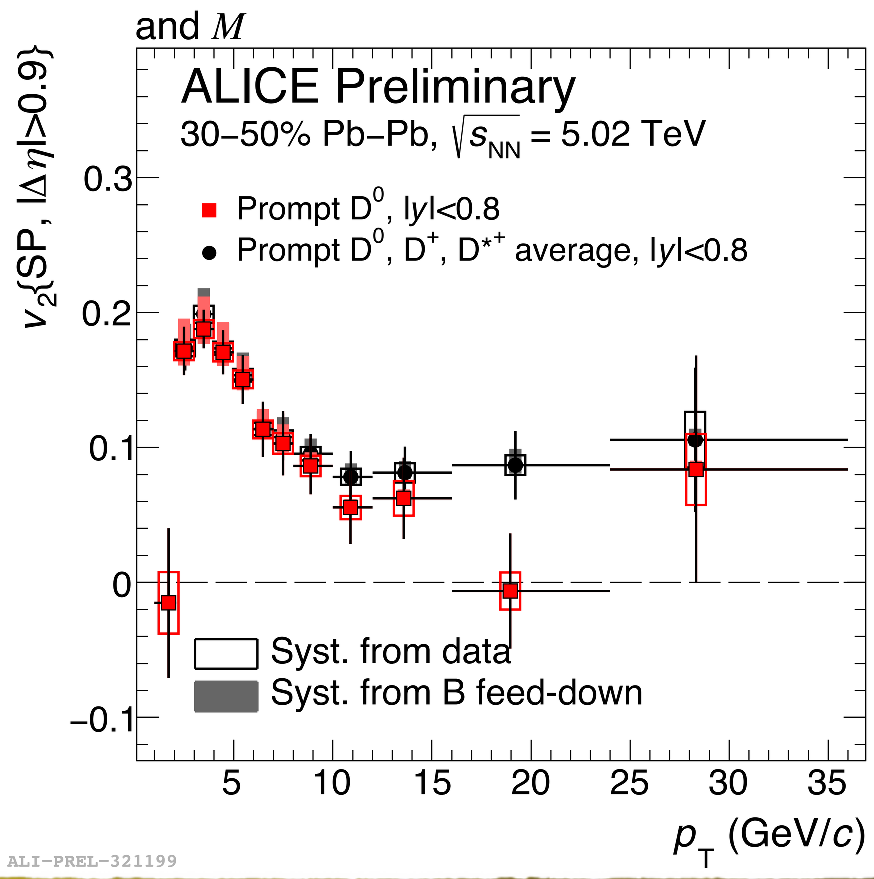
- Prompt D^0 R_{AA} in Pb-Pb collisions in three different centrality classes
- R_{AA} (60-80%) > R_{AA} (30-50%) > R_{AA} (0-10%) → suppression factor up to a factor 5 observed in the 10% most central Pb-Pb collisions for p_T > 5 GeV/c

- The suppression increases from peripheral (60-80%) [6] to central (0-10%) Pb-Pb collisions
- Similar behavior observed for other non-strange D mesons

Azimuthal anisotropy



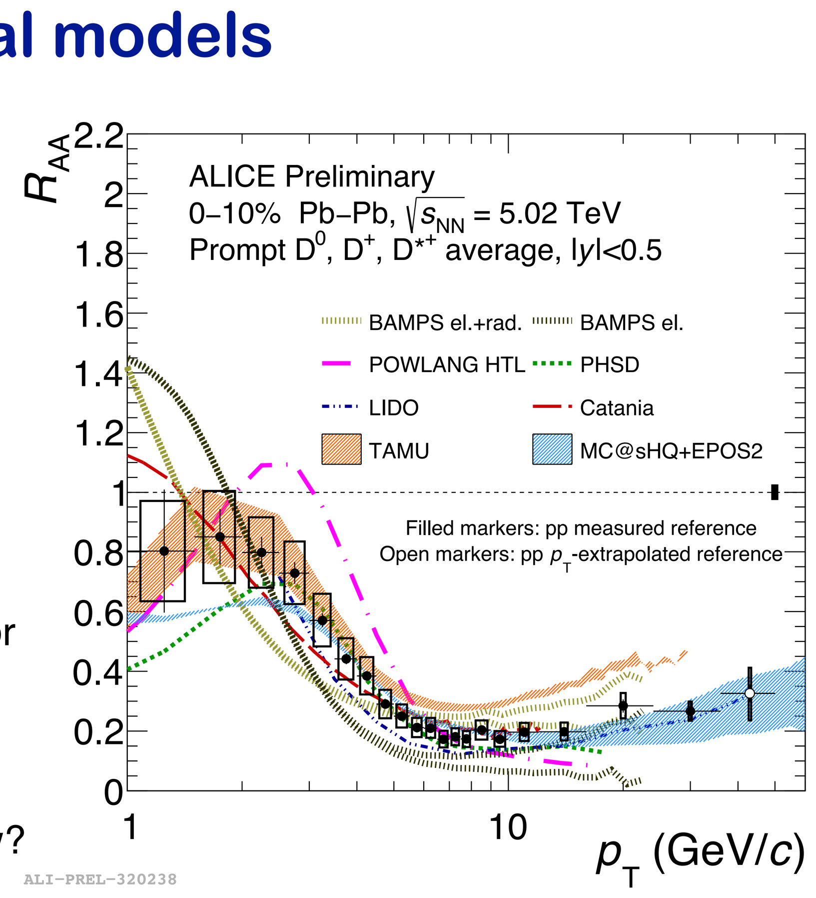
- The azimuthal distribution of particle momenta can be written in terms of Fourier expansion
  → $v_2 = \langle\cos[2(\varphi - \Psi_2)]\rangle$ second-order coefficient
- Scalar product method adopted
  - based on the measurements of the *Q-vectors*
    $$Q_{2,x} = \sum_{i=1}^{N} w_i\cos(2\varphi_i) \qquad Q_{2,y} = \sum_{i=1}^{N} w_i\sin(2\varphi_i)$$
  - v_2 is evaluated for in bins of invariant mass
    $$v_2(M) = \frac{1}{R_2}\langle u_D \cdot Q_2^A / M^A\rangle(M)$$
  - v_2 of the signal via a simultaneous fit of $v_2(M)$ and M
    $$v_2(M) = v_2^S\frac{S(M)}{S(M)+B(M)} + v_2^B\frac{B(M)}{S(M)+B(M)}$$

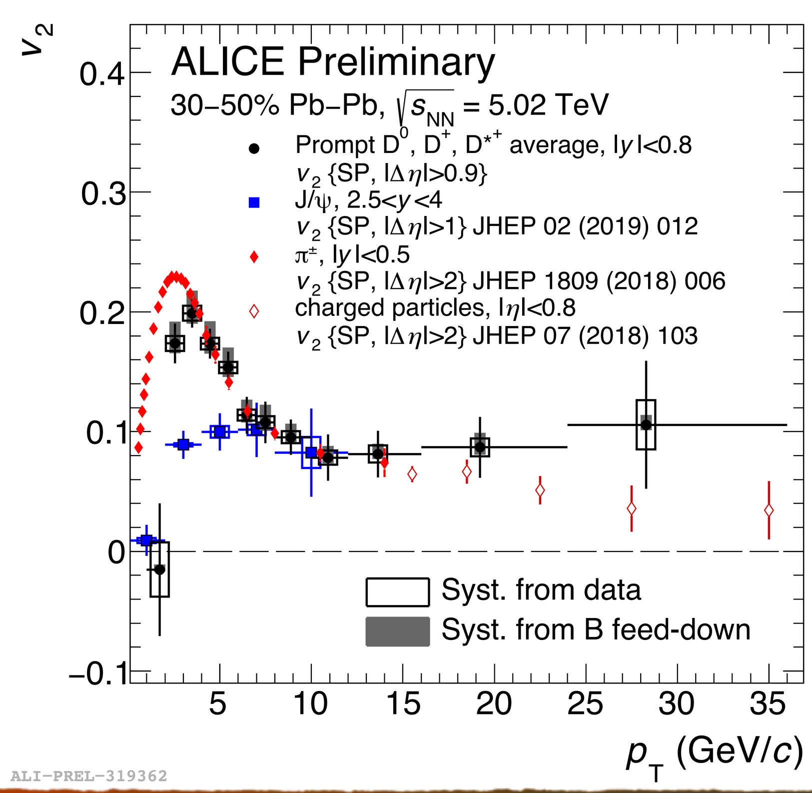


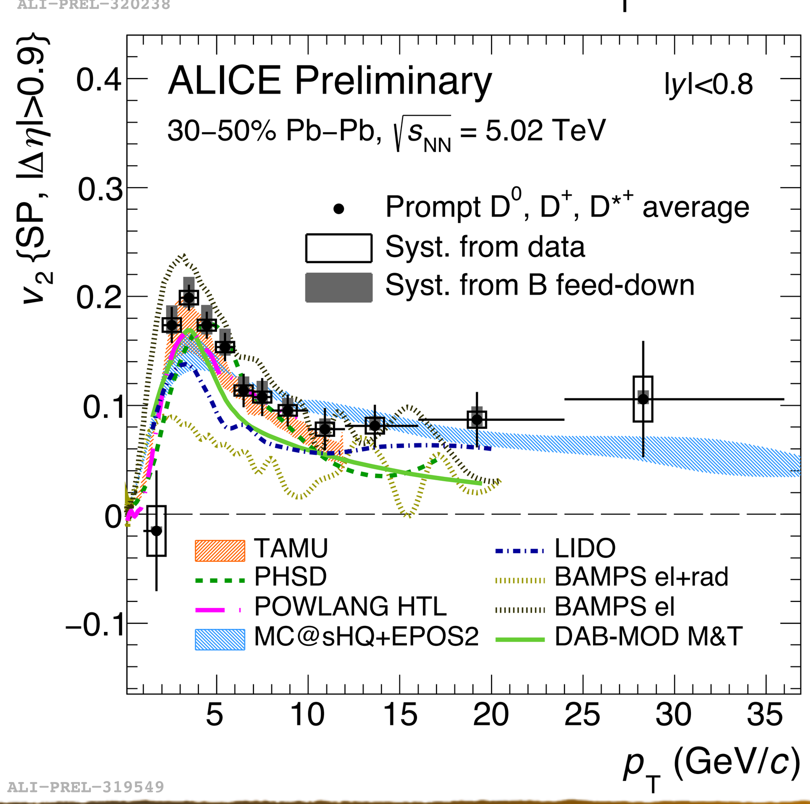
- V0C detector (–3.7 < η < –1.7) used to estimate the Reaction Plane
- Prompt D^0 v_2 in Pb-Pb collisions larger than 0 in 2 < p_T < 16 GeV/c
- Average prompt non-strange D-meson v_2 shows the same trend of the prompt D^0 v_2
- A non-zero v_2 indicates that the charm quarks participate to the collective expansion of the medium

Comparison with theoretical models

- Heavy-quark transport in medium with realistic evolution can fairly describe the data for p_T < 10 GeV/c [7-12]
  → interplay of collisional energy loss, radial flow, hadronisation via recombination
- Models based on pQCD [13-15] provide a good description of the data for p_T >10 GeV/c → radiative energy loss dominant effect
- Heavy-quark spatial-diffusion coefficient in the range of $2\pi T D_s(T)$ ≈ 1.5 - 7 at T≈ 155 MeV [16] for models describing the v_2
- Hint of $v_2(J/\Psi) < v_2(D) < v_2(\pi^{\pm})$ for p_T < 4 GeV/c
  → how light quarks contribute to open charm flow?

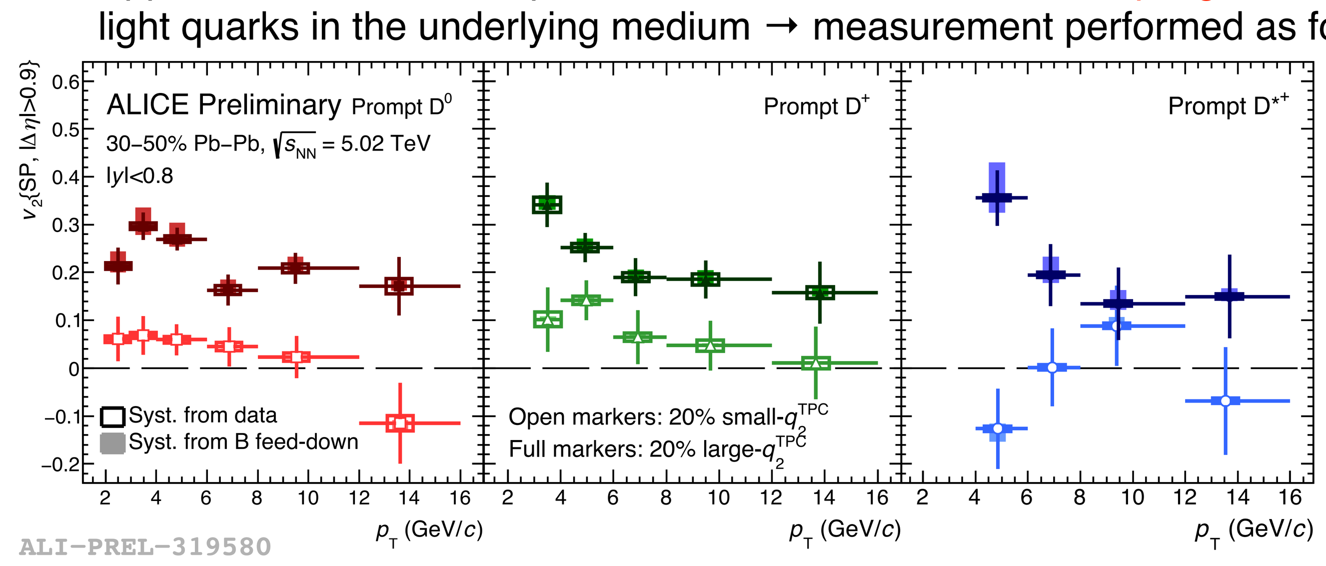






Event-shape engineering

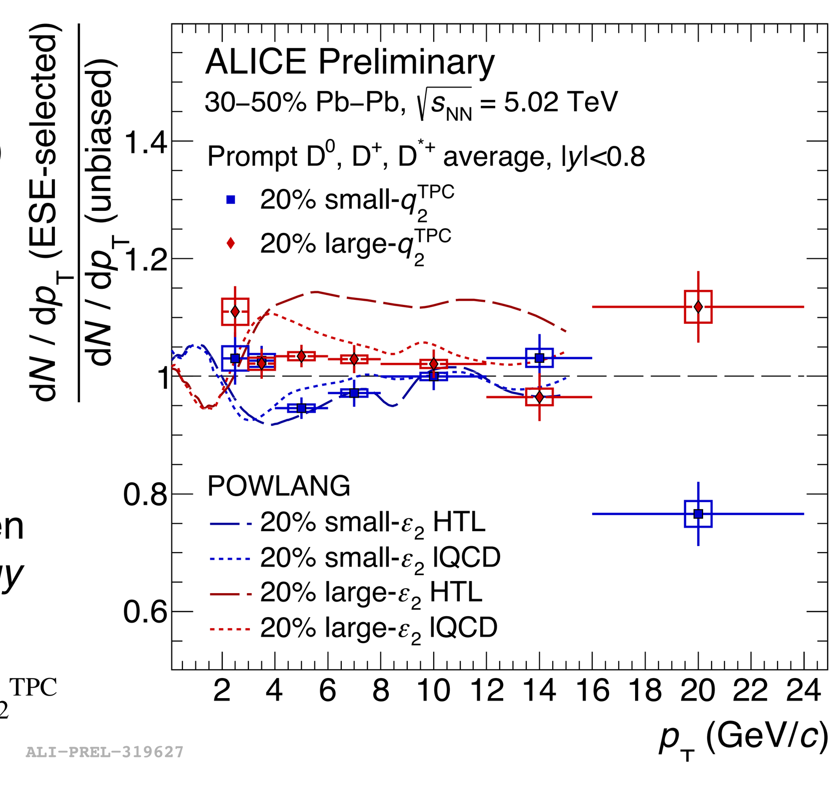
- Event-shape engineering (ESE) technique [17] based on the observation of event-by-event v_n at fixed centrality → linear correlation between final state v_n and initial state eccentricity ε_n
- Applied to the D meson, provides information about the coupling of the *c* quark and the bulk of light quarks in the underlying medium → measurement performed as for the unbiased v_2



- Events in the same centrality class are classified according to the magnitude of the 2nd harmonic reduced flow vector [18]

$$q_2 = |\vec{Q}_2|/\sqrt{M}$$

- Larger D^0 v_2 measured in events with large average elliptic flow (large-q_2^{TPC}) and smaller for events with small average elliptic flow (small-q_2^{TPC})
  → similar result also for D^+ and D^{*+}
- Non-flow contaminations could slightly enlarge the effect → q_2 and D-meson v_2 measured in the same η range
- Ratio of p_T-differential yields in ESE and unbiased samples → investigate a possible interplay between *azimuthal anisotropy* and the *radial flow* and *energy loss*
- Hint of hierarchy for p_T < 8 GeV/c between small-q_2^{TPC} and large-q_2^{TPC}



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