Measurement of D-meson production and azimuthal anisotropy in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE

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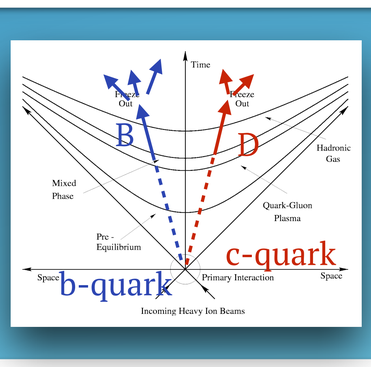
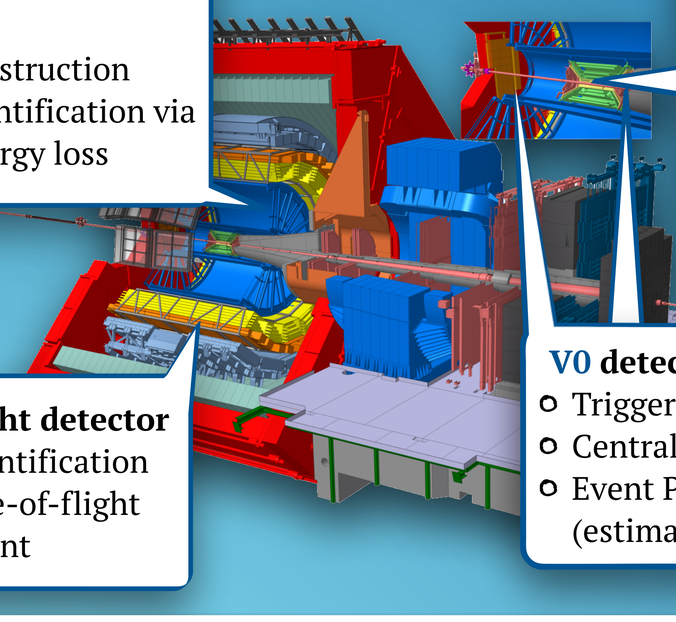
Heavy flavours in the QGP

- Heavy flavours (i.e. c and b quarks) are mainly produced in hard-scattering processes on short time scales
- They experience the full evolution of the Quark-Gluon Plasma (QGP) created in ultra-relativistic heavy ion collisions, interacting with its constituents



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



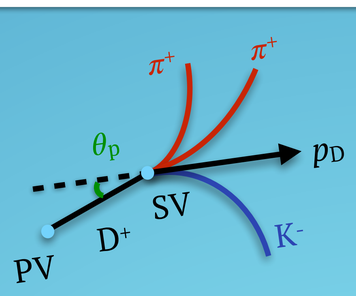
Inner Tracking System
- Track reconstruction
- Reconstruction of primary and decay vertices

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

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

D-meson reconstruction

$$\mathrm{D^0} \rightarrow \mathrm{K^-}\pi^+ (\mathrm{BR} = 3.93\%)$$
$$\mathrm{D^+} \rightarrow \mathrm{K^-}\pi^+\pi^+ (\mathrm{BR} = 9.46\%)$$
$$\mathrm{D^{*+}} \rightarrow \mathrm{D^0}(\rightarrow \mathrm{K^-}\pi^+)\pi^+ (\mathrm{BR} = 67.7\% \text{ x } 3.93\%)$$
$$\mathrm{D_s^+} \rightarrow \phi(\rightarrow \mathrm{K^+K^-})\pi^+ (\mathrm{BR} = 2.27\%)$$

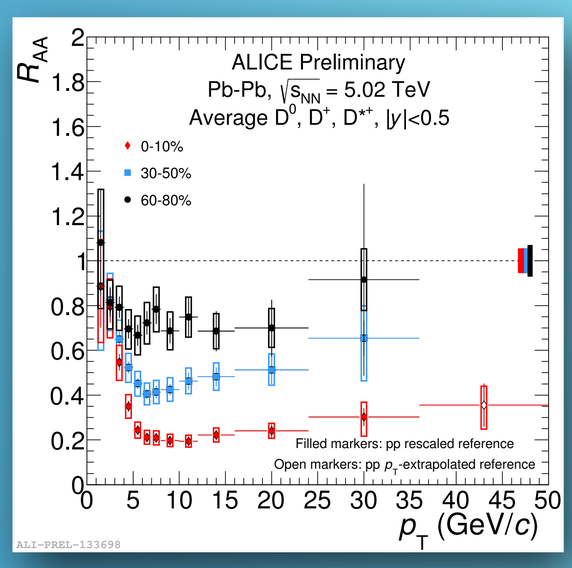


- Reconstruction of decay vertices displaced few hundred microns from primary vertex combining pairs/triplets of tracks with proper charge sign
- Particle identification (PID) of decay tracks and geometrical selection of displaced decay-vertex topology
- Efficiency correction with Monte Carlo simulations 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

Nuclear modification factor

$$R_{\mathrm{AA}} = \frac{1}{\langle T_{\mathrm{AA}} \rangle} \frac{\mathrm{d}N_{\mathrm{AA}}/\mathrm{d}p_{\mathrm{T}}}{\mathrm{d}\sigma_{\mathrm{pp}}/\mathrm{d}p_{\mathrm{T}}}$$

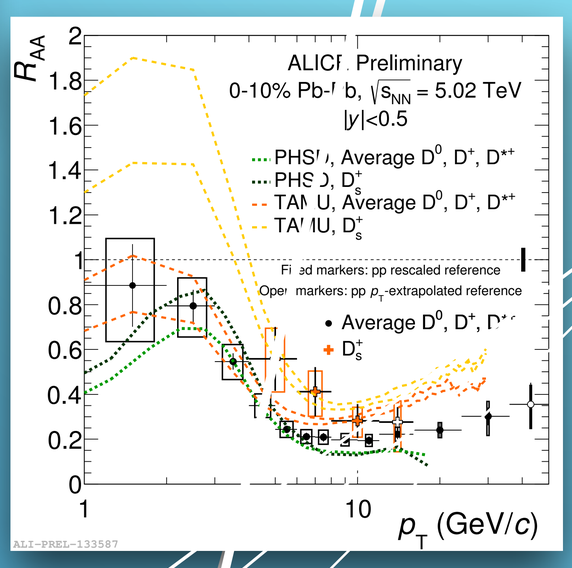
- $\langle T_{\mathrm{AA}} \rangle$ is the average nuclear overlap function, proportional to the number of binary nucleon-nucleon collisions
- It provides information about the mechanism of energy loss in the QGP

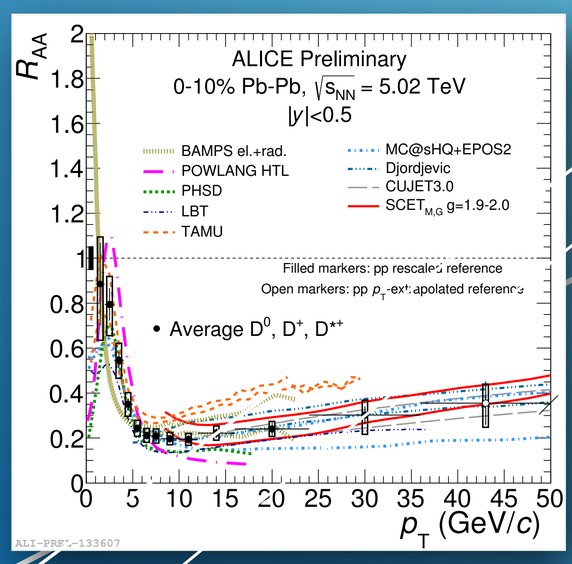


- Large suppression up to a factor 5 observed in the 10% most central Pb-Pb collisions for $p_{\mathrm{T}} > 4$ GeV/c [4]

- The suppression decreases from central (0-10%) to peripheral (60-80%) collisions [4]

- The comparison between $\mathrm{D_s^+}$ and non-strange D mesons allows to study the modification of the hadronisation mechanism
- Hint of smaller $\mathrm{D_s^+}$-meson suppression w.r.t. non-strange D mesons [4]
  - → expected in case of hadronisation via coalescence due to the enhanced production of s quarks in the QGP



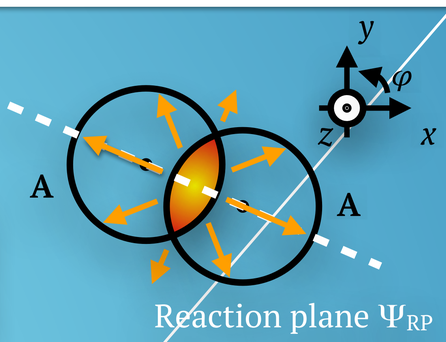


- Models based on heavy-quark transport can fairly reproduce the data for p_{T}<10 GeV/c [6-12]
  - → interplay of collisional energy loss, radial flow, hadronisation via recombination
- Models based on pQCD provide a good description of the data for p_{T}>10 GeV/c [13-15]
  - ▶ radiative energy loss dominant effect

Azimuthal anisotropy

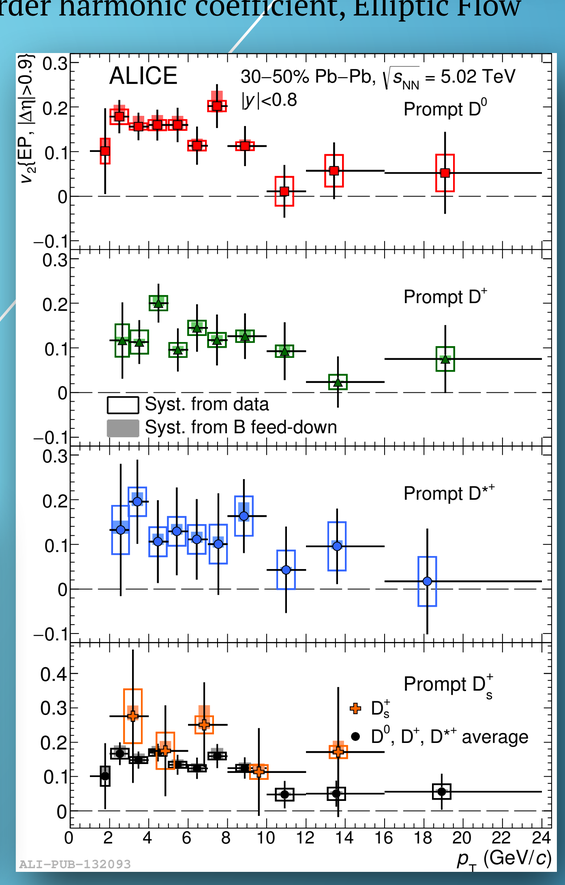
- The azimuthal distribution of particle momenta can be written in terms of Fourier expansion

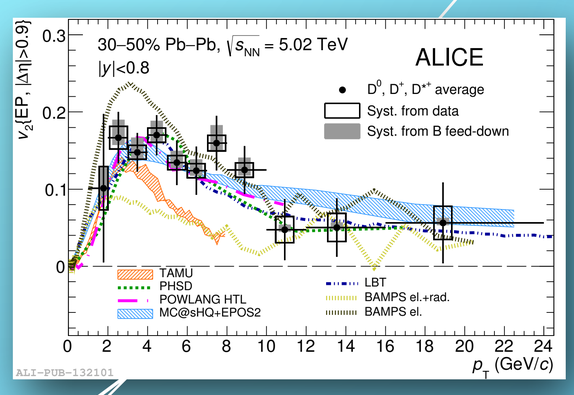
$$E\frac{\mathrm{d}^3N}{\mathrm{d}^3p} = \frac{1}{2\pi}\frac{\mathrm{d}^2N}{p_{\mathrm{T}}\mathrm{d}p_{\mathrm{T}}\mathrm{d}y}\left\{1 + \sum_{n=1}^{\infty} v_n \cos[n(\varphi - \Psi_{\mathrm{RP}})]\right\}$$



→ $v_2 = \langle \cos[2(\varphi - \Psi_{\mathrm{RP}})] \rangle$ second-order harmonic coefficient, Elliptic Flow

- Non-strange D-meson v_2 larger than 0 in 2 < p_{T} < 10 GeV/c indicates the participation of the charm quark in the collective expansion of the medium
- $\mathrm{D_s^+}$-meson v_2 compatible with that of non-strange D mesons and positive with a significance of 2.6σ in 2 < p_{T} < 8 GeV/c [5]





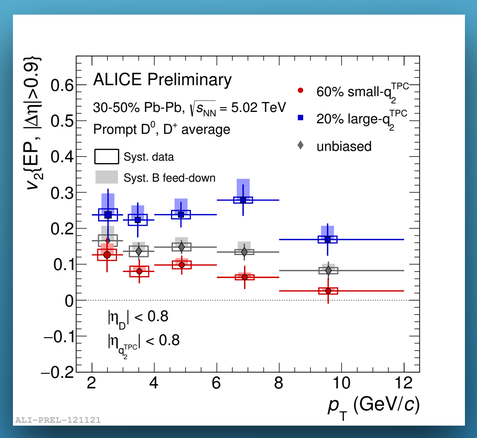
- The comparison to model calculations can constrain medium parameters
  - ▶ Calculations that describe the data use heavy-quark spatial diffusion coefficient in the range of $2\pi TD_{\mathrm{s}}(T) \approx 1.5$–$7$ at $T = T_{\mathrm{c}} \approx 155$ MeV [5]

Diffusion coefficient D_{s}

$$D_{\mathrm{s}} = \frac{\eta}{(e+p)}$$

where η is the shear viscosity and $(e+p)$ the enthalpy [17]

- The Event-shape engineering (ESE) technique applied to the D-meson v_2 provides additional information about the coupling of the c quark and the bulk of light quarks in the underlying medium
- Events with same centrality are classified in different eccentricity classes, according to the magnitude of the second-order harmonic reduced flow vector q_2 [16]



- Larger D-meson v_2 measured in events with large average elliptic flow (large-q_2) and smaller for events with small average elliptic flow (small-q_2)
- Non-flow contaminations and auto-correlations between q_2 and D mesons could slightly enlarge the effect (q_2 and D mesons measured in the same pseudorapidity range)

References

[1] PRD 44 (1991) 3501
[2] JHEP 0605 (2006) 026
[3] JHEP 9805 (1998) 007
[4] ALICE-PUBLIC-2017-003
[5] arXiv:1707.01005
[6] TAMU: PLB 735, 445-450 (2014)
[7] PHSD: PRC 92, 014910 (2015)
[8] POWLANG: EPJC 75, 121 (2015)
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[10] BAMPS: JPG 42, 115106 (2015)
[11] Xu,Cao,Bass: PRC 88, 044907 (2013)
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[15] Djordevic: PRC 92, 024918 (2015)
[16] PRC 66, 034904 (2002)
[17] PRC 71, 064904 (2005)