Measurements of D^{*+}-meson production in Pb–Pb and pp collisions with ALICE at the LHC

Annelies Veen for the ALICE collaboration
Utrecht University, The Netherlands
Universiteit Utrecht

2015 KOBE JAPAN

Physics motivation

Heavy quarks, charm and beauty, are primarily produced in hard scattering processes in the early stages of the collision. They are considered as excellent probes to study the Quark-Gluon Plasma (QGP) produced in high-energy heavy-ion (A–A) collisions.

- Energy loss in the medium via gluon radiation and elastic collisions.
  - Dependent on path length, colour charge and parton mass.
- Quantification of the effect via the nuclear modification factor ($R_{\rm AA}$).

$$R_{\rm AA} = \frac{1}{\langle T_{\rm AA}\rangle} \cdot \frac{{\rm d}N_{\rm AA}/{\rm d}p_{\rm T}}{{\rm d}\sigma_{\rm pp}/{\rm d}p_{\rm T}}, \quad (1)$$

$\langle T_{\rm AA}\rangle$ is the average nuclear overlap function (Glauber model).

- pp collisions represent the needed reference for A–A collisions and a powerful tool to test NLO pQCD calculations.

$R_{\rm AA}$ vs $p_{\rm T}$

- D^{*+}-meson acceptance and efficiency correction are obtained via Monte Carlo simulations. Feed-down (from B) correction based upon FONLL calculations [2].
- The Pb–Pb $p_{\rm T}$-differential yield ${\rm d}N/{\rm d}p_{\rm T}|_{|y|<0.5}$ is compared with the pp yield scaled by $\langle T_{\rm AA}\rangle$ as shown in Fig. 1 [2].
- The D^{*+} $R_{\rm AA}$ in the 30-50% centrality class is shown in Fig. 2.

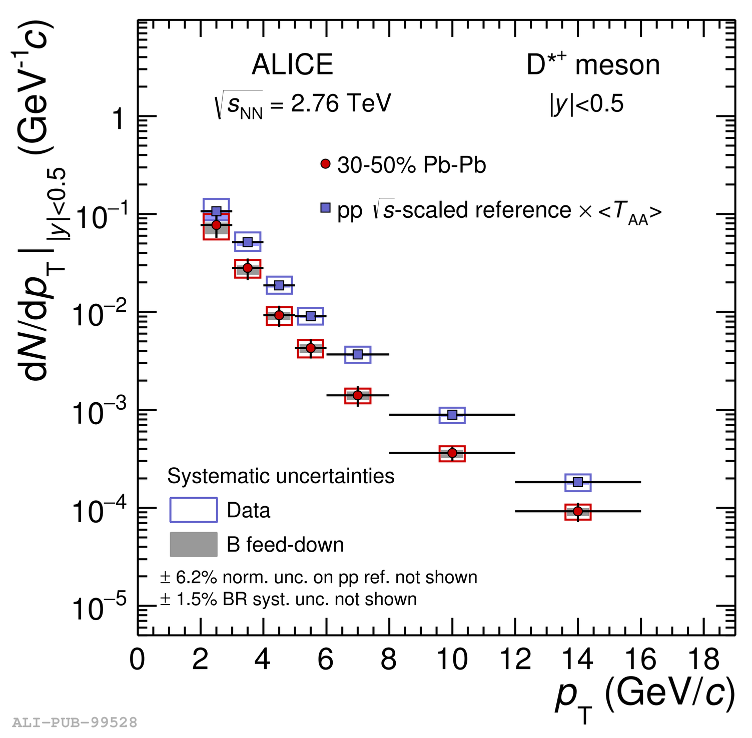


Figure 1: ${\rm d}N/{\rm d}p_{\rm T}$ of D^{*+} mesons in Pb–Pb collisions at 2.76 TeV for the 30-50% centrality class. The rescaled pp reference is also shown [7].

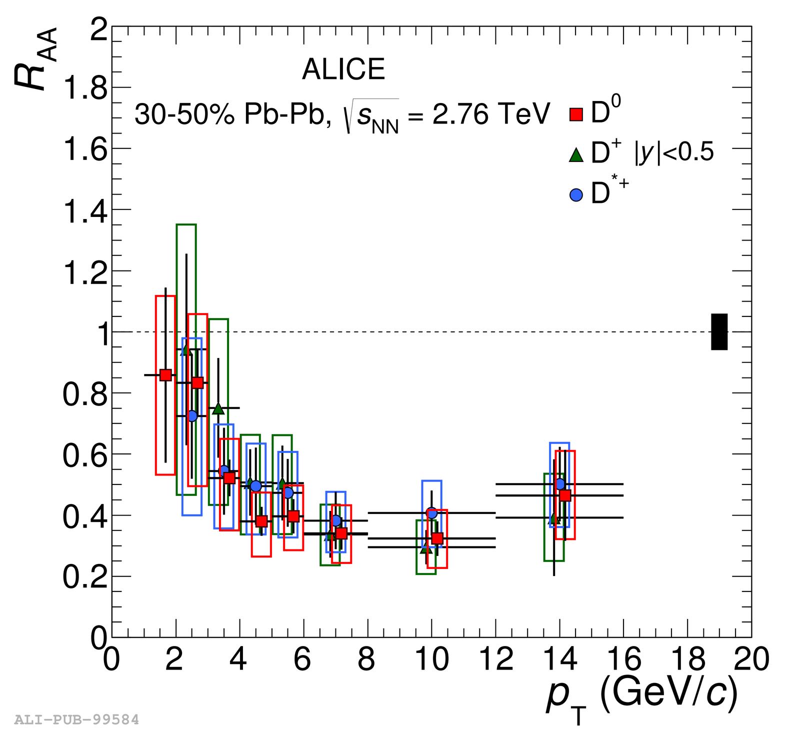


Figure 2: $R_{\rm AA}$ of D^{*+}, D^0 and D$^+$ mesons in Pb–Pb collisions at 2.76 TeV for the 30-50% centrality class. The D^0 symbols are at the centre of the bin and the D^{*+} and D$^+$ are shifted for visibility [7].

- A suppresion of the D^{*+} yield is observed for $p_{\rm T} > 3$ GeV/c.

$R_{\rm AA}$ vs $\langle N_{\rm part}\rangle$

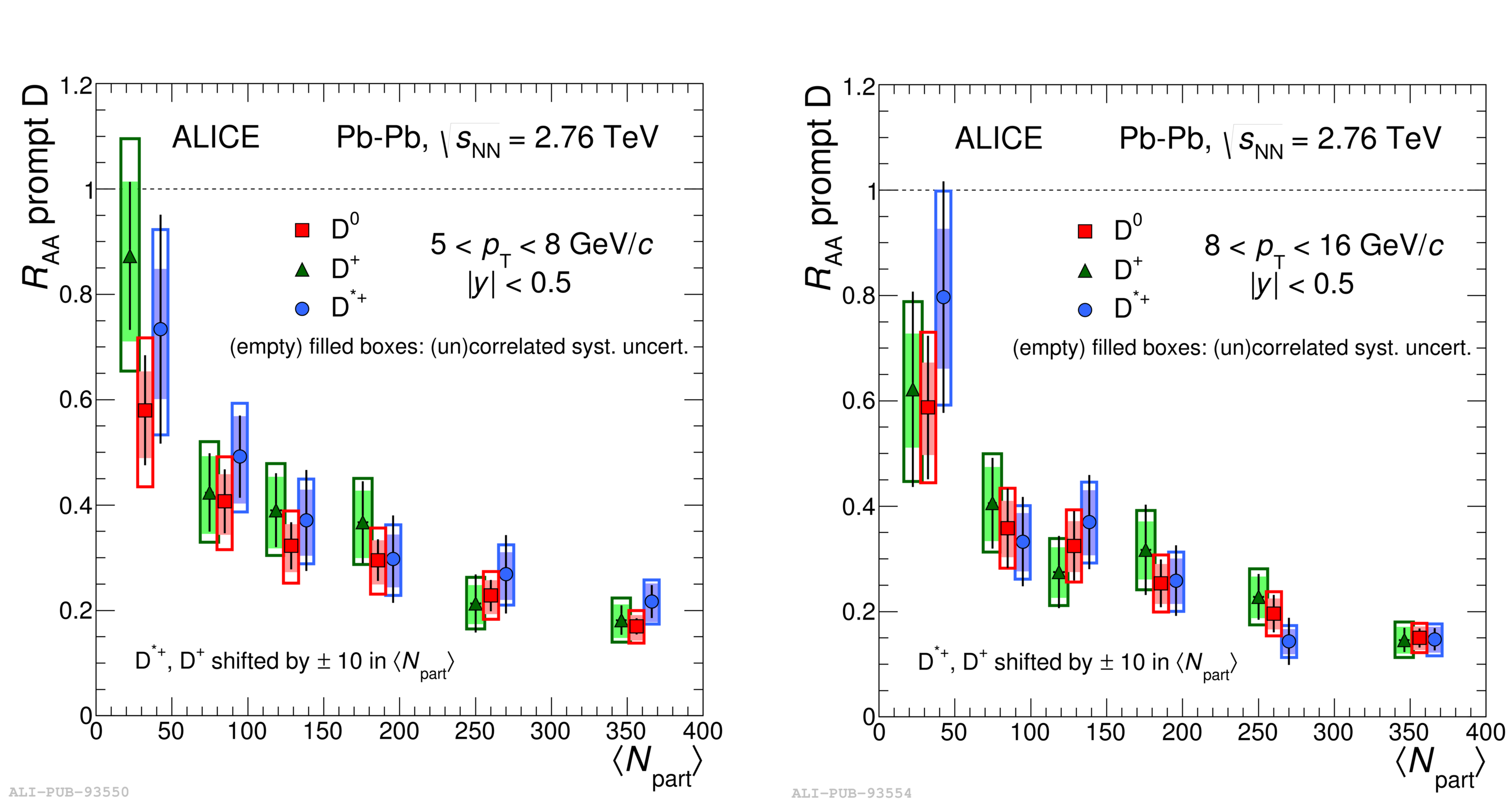


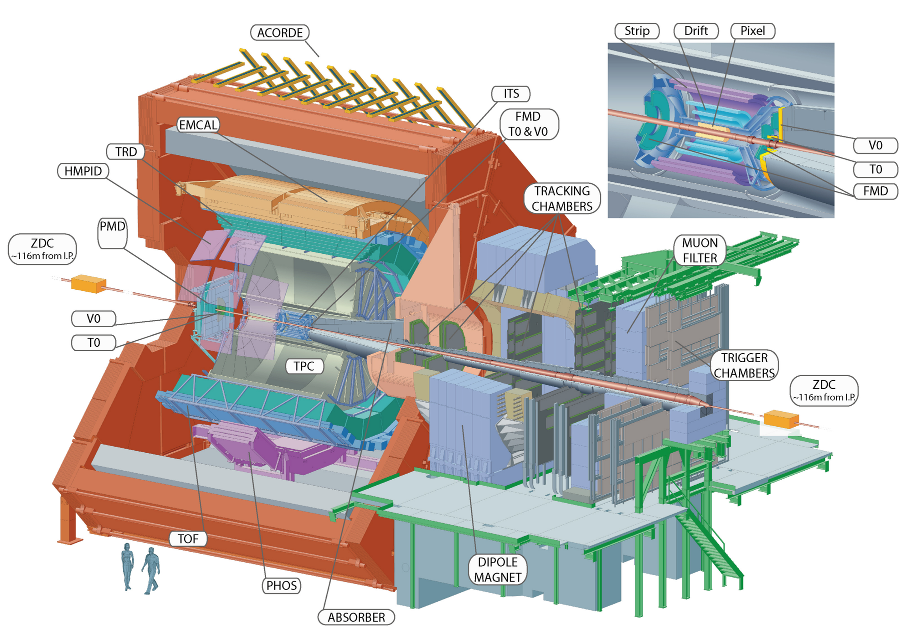
Figure 3: $R_{\rm AA}$ as a function of $\langle N_{\rm part}\rangle$ of D^0, D$^+$ and D^{*+} in $p_{\rm T}$ bins from 5 to 8 GeV/c (left) and from 8 to 16 GeV/c (right). The correlated systematic uncertainties are visualised via the filled boxes, the uncorrelated systematic uncertainties via the open boxes and the statistical uncertainties via the bars [2].

- The centrality classes are determined via a fit to the V0 signal distribution based on the Glauber model. $\langle N_{\rm part}\rangle$ is defined as the average number of nucleons participating in the collisions in each centrality class, obtained from the Glauber model calculation in each class [2,6].

- Results: a centrality-dependent suppression pattern of the $R_{\rm AA}$ is observed for all three mesons. The suppression reaches a factor of 5-6 in the highest $p_{\rm T}$ interval for the 0-10% centrality class [2].

Reconstruction & raw yield extraction

- Reconstruction in the hadronic decay channel: D$^{*+} \rightarrow$ D$^0\pi^+ \rightarrow$ K$^-\pi^+\pi^+$. Branching fractions of 67.7 ± 0.5 % and 3.88 ± 0.05%, respectively [1].
- The analysis strategy is based on:
  - a precise tracking (Inner Tracking System (ITS), combined with Time Projection Chamber (TPC)),
  - reconstruction of the D^0 decay secondary vertex (ITS) and then combined with a soft pion,
  - particle identification (TPC via specific energy loss and Time-Of-Flight (TOF)).
  - Pb–Pb: determination of the centrality of the collision (V0).



- An invariant mass analysis on the mass difference $M({\rm K}^-\pi^+\pi^+) - M({\rm K}^-\pi^+)$ is done in order to extract the raw yield [2].

Data samples

- Pb–Pb @ $\sqrt{s_{\rm NN}} = 2.76$ TeV:
  - 2011 data-sample : $L_{\rm int} = 21.3 \pm 0.7\ \mu{\rm b}^{-1}$ for the 0-10% centrality class and $L_{\rm int} = 5.8 \pm 0.2\ \mu{\rm b}^{-1}$ for the 10-50% centrality class.
  - 2010 data sample: $L_{\rm int} = 2.2 \pm 0.1\ \mu{\rm b}^{-1}$ for the 50-80% centrality class.
- pp @ $\sqrt{s} = 7$ TeV: 2010 data sample ($L_{\rm int} = 5^{\pm 0.3}_{\pm 0.15}$ nb^{-1}) [4].
- pp @ $\sqrt{s} = 13$ TeV: 48 × 10^6 events collected in 2015 from LHC run II.

Proton-proton collisions at $\sqrt{s} = 13$ TeV

- First prospects for the current ongoing pp collisions at 13 TeV are shown.
- The distribution of the mass difference after selection cuts is shown in Fig. 4.

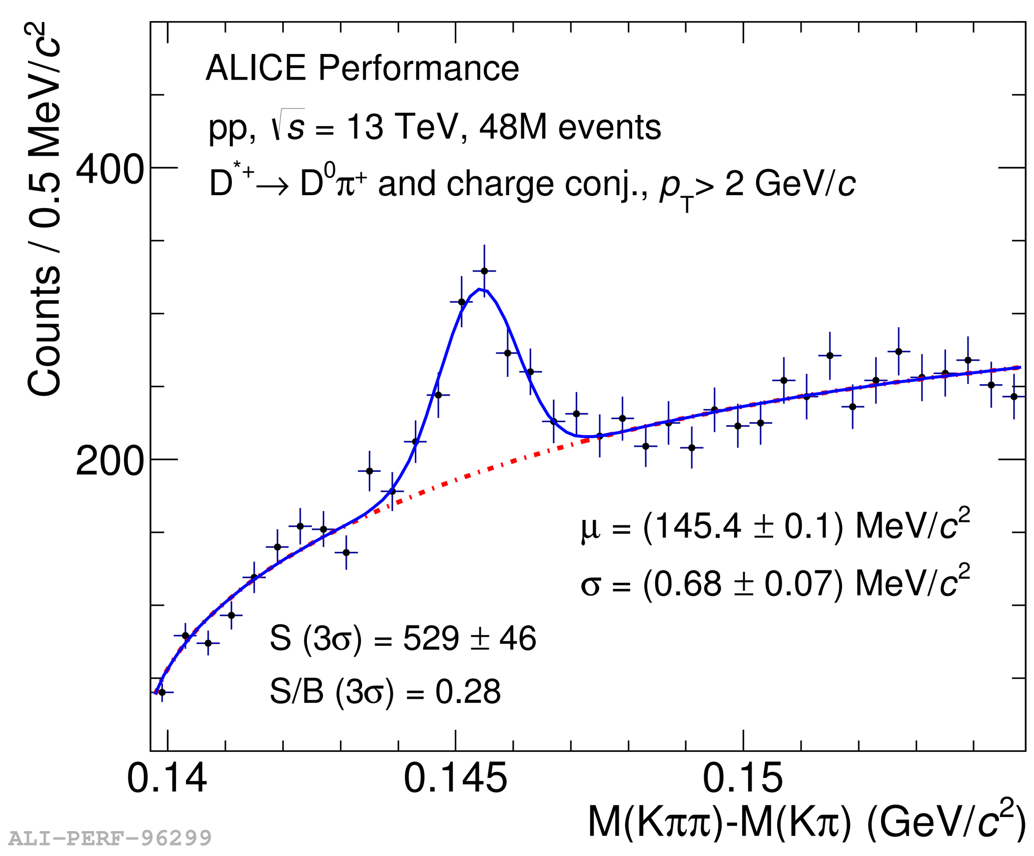


Figure 4: The invariant mass difference $M({\rm K}^-\pi^+\pi^+) - M({\rm K}^-\pi^+)$ for the D^{*+} candidates and their charge conjugates for D^{*+} mesons with $p_{\rm T} > 2$ GeV/c. The blue curve is the fit function of a combined signal and background function, while the red dashed line represents the background fit function.

- A signal peak is found at the mass difference corresponding to the D^{*+} meson.
- Improvement is expected via an increase of statistics.

References

[1] K.A. Olive et al (Particle Data Group), *The review of particle physics*, Chin. Phys. C **38** (2014) 090001 .

[2] J. Adam *et al.* [ALICE Collaboration], *"Centrality dependence of high-$p_{\rm T}$ D meson suppression in Pb-Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV,"* arXiv:**1506.06604** [nucl-ex].

[3] B. Abelev *et al.* [ALICE Collaboration], *"Suppression of high transverse momentum D mesons in central Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV,"* JHEP **1209** (2012) 112.

[4] B. Abelev *et al.* [ALICE Collaboration], *"Measurement of charm production at central rapidity in proton-proton collisions at $\sqrt{s} = 7$ TeV,"* JHEP **1201** (2012) 128.

[5] R. Averbeck, N. Bastid, Z. Conesa del Valle, P. Crochet, A. Dainese and X. Zhang, *"Reference Heavy Flavour Cross Sections in pp Collisions at $\sqrt{s} = 2.76$ TeV, using a pQCD-Driven $\sqrt{s}$ – Scaling of ALICE Measurements at $\sqrt{s} = 7$ TeV,"* arXiv:**1107.3243** [hep-ph].

[6] B. Abelev *et al.* [ALICE Collaboration], *"Centrality determination of Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV with ALICE,"* Phys.Rev.C **88** no. **4**, (2013) 044909.

[7] J. Adam *et al.* [ALICE Collaboration], *"Transverse momentum dependence of D-meson production in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV,"* arXiv:**1509.06888** [nucl-ex]