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

Annelies Veen for the ALICE Collaboration

Utrecht University & Nikhef, The Netherlands

1. Physics motivation

Heavy quarks (**charm** and **beauty**) are produced in hard scattering processes in the initial stages of the collision. This makes them a valuable probe of the **Quark-Gluon Plasma** created in Pb-Pb collisions.

Measurements of open heavy-flavour production in p–Pb collisions allow the study of cold nuclear matter (**CNM**) effects.

Effects relevant for heavy flavours include:

- shadowing,
- gluon saturation,
- k_{T} broadening,
- initial- and final- state energy loss,
- possible hot-medium like effects.

Studies of heavy flavours in pp collisions provide:

- a reference for p–Pb an Pb–Pb collisions, and
- an excellent test of NLO pQCD calculations.

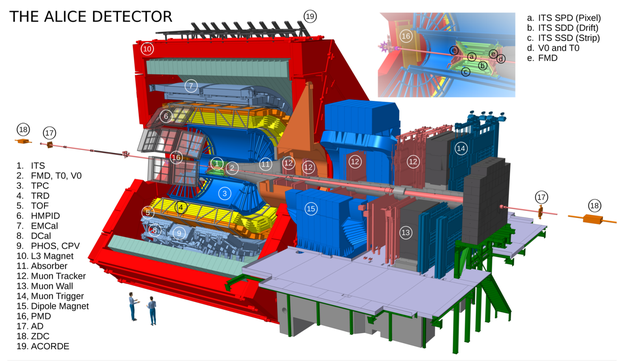
Quantification of the effect of cold nuclear matter effects is done via the nuclear modification factor (R_{pPb}):

$$R_{\mathrm{pPb}} = \frac{1}{A} \cdot \frac{\mathrm{d}^2\sigma_{\mathrm{pPb}}/\mathrm{d}p_{\mathrm{T}}\mathrm{d}y}{\mathrm{d}^2\sigma_{\mathrm{pp}}/\mathrm{d}p_{\mathrm{T}}\mathrm{d}y}, \quad (1)$$

where $A = 208$ is the Pb mass number.

2. Reconstruction & Analysis method

- Reconstruction in the hadronic decay channel: $\mathrm{D}^{*+} \to \mathrm{D}^0\pi^+ \to \mathrm{K}^-\pi^+\pi^+$. Branching fractions of 67.7 ± 0.5 % ($\mathrm{D}^{*+} \to \mathrm{D}^0\pi^+$) and 3.93 ± 0.04% ($\mathrm{D}^0 \to \mathrm{K}^-\pi^+$) [1].
- The analysis is based on:
  - precise tracking information via the Inner Tracking System (ITS) and Time Projection Chamber (TPC),
  - reconstruction of the D^0 decay vertex, to select vertices showing a displayed topology, which is subsequently combined with a "soft" pion,
  - particle identification from the TPC via specific energy loss and Time-Of-Flight (TOF).



- D^{*+}-meson raw yield extracted via fit to the invariant mass difference $M(\mathrm{K}^-\pi^+\pi^+) - M(\mathrm{K}^-\pi^+)$ [2].
- Acceptance and selection-efficiency correction from Monte Carlo simulations [2].

3. Data samples

- pp @ $\sqrt{s} = 7$ TeV: 2010 data sample $L_{\mathrm{int}} = (6 \pm 0.2)$ nb^{-1} [2].
- pp @ $\sqrt{s} = 8$ TeV: 2012 data sample $L_{\mathrm{int}} = (1.9 \pm 0.1)$ nb^{-1}.
- pp @ $\sqrt{s} = 13$ TeV: 2016 data sample $L_{\mathrm{int}} = (3.3 \pm 0.2)$ nb^{-1}.
- p–Pb @ $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV: 2016 LHC run 2 data sample L_{int}=$(292 \pm 10.8)\mu$b^{-1} [3].

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

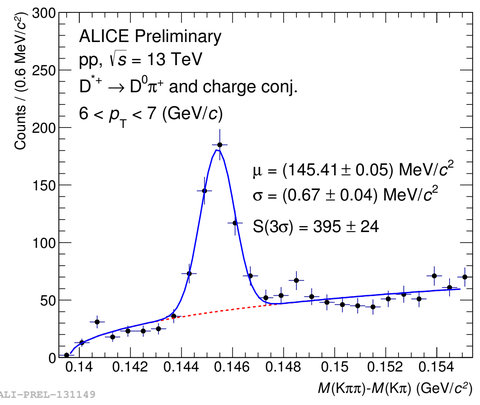


Figure 1: Invariant mass difference for D^{*+} candidates with $6 < p_{\mathrm{T}} < 7$ GeV/c.

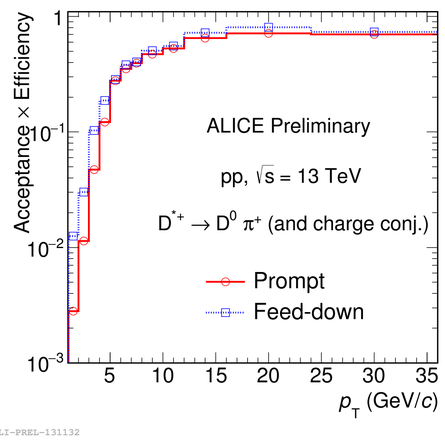


Figure 2: The acceptance × efficiency for D^{*+} mesons.

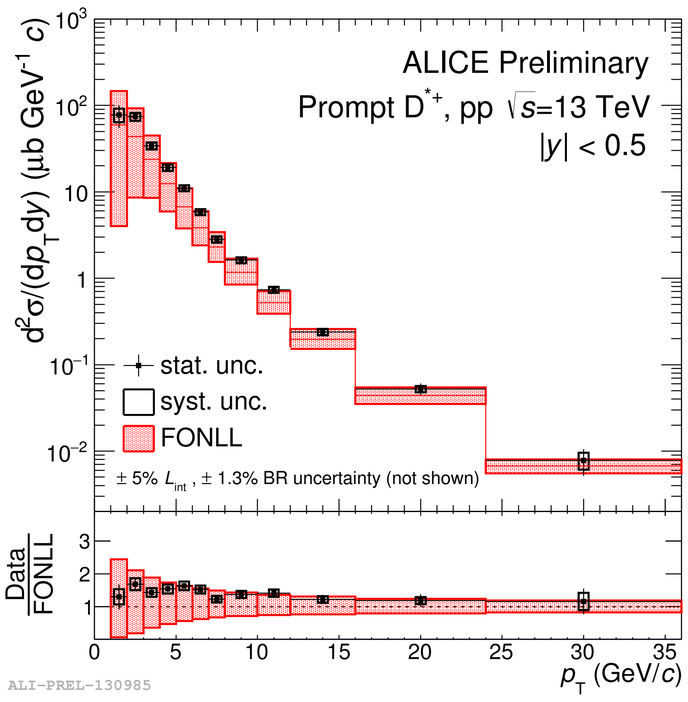


Figure 3: D^{*+} production cross section compared to FONLL pQCD calculations.

- The D^{*+} production cross-section at 13 TeV is measured in $1 < p_{\mathrm{T}} < 36$ GeV/c.
- The data are in the upper edge of the FONLL uncertainty band.

5. Cross section vs Collision energy

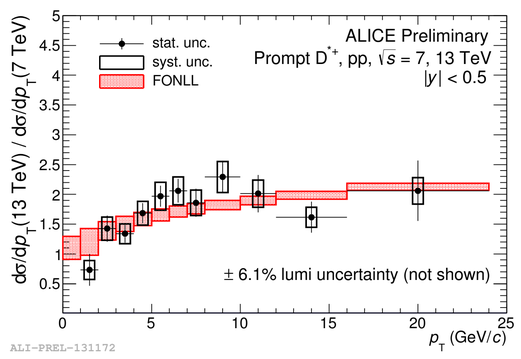


Figure 4: Ratio of the D^{*+} p_{T}-differential cross sections at 13 TeV and 7 TeV [2].

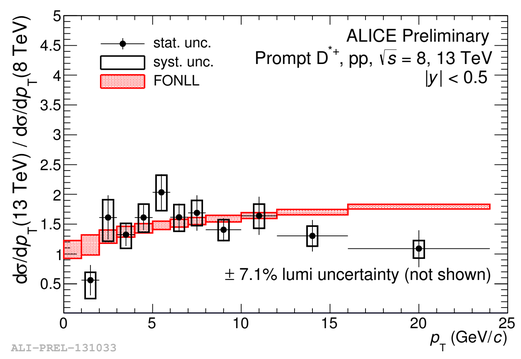


Figure 5: Ratio of the D^{*+} p_{T}-differential cross sections at 13 TeV and 8 TeV.

- The evolution of the D^{*+}-meson p_{T}-differential cross section from 7 and 8 TeV to 13 TeV is described, within uncertainties, by FONLL calculations.

6. p–Pb results

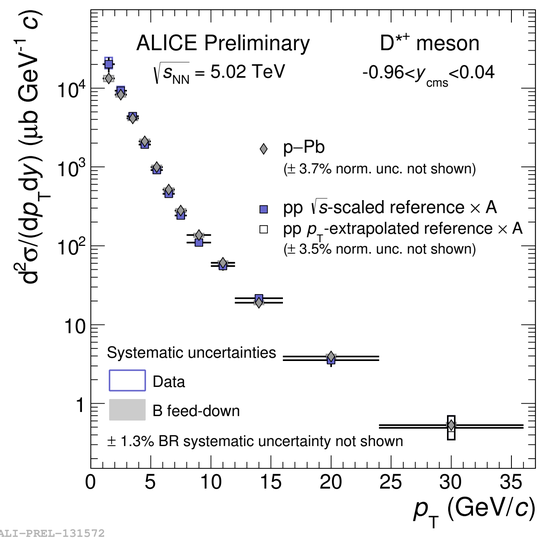


Figure 6: p_{T}-differential production cross-section of D^{*+} mesons in p–Pb collisions at 5.02 TeV obtained with run-2 data [3].

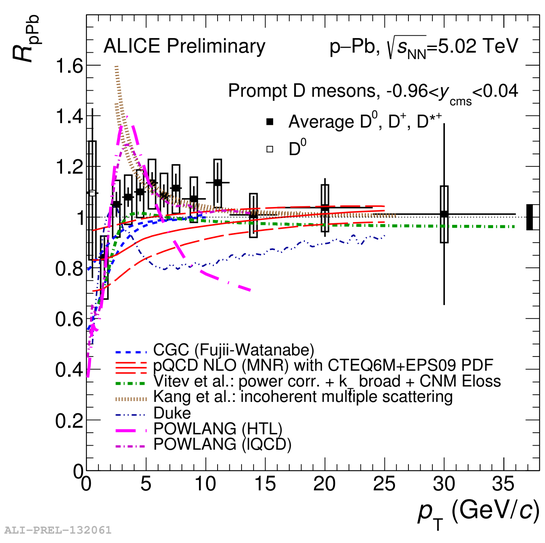


Figure 7: The average of the R_{pPb} of D^{*+}, D^0 and D^+ mesons in p–Pb collisions at 5.02 TeV obtained with run-2 data [3].

- The larger-size data sample of p-Pb collisions collected in 2016 (x6 gain w.r.t. 2013 sample) allowed us to:
  - reduce the cross-section uncertainties by a factor of ~ 2,
  - extend the p_{T} range of the measurements to 36 GeV/c.
- The pp reference is obtained by multiplying by A the cross section measured at 7 TeV after extrapolating it in p_{T} up to 36 GeV/c and scaling it in energy to 5.02 TeV.
- The R_{pPb} results are compatible with unity. The precision does not allow us to distinguish between scenarios with only CNM effects and those including hot-medium effect. The data disfavours a suppression larger than 15 % at high p_{T}.
- The R_{pPb} uncertainty is dominated by that of the pp reference. This measurement will benefit from the new pp sample at $\sqrt{s} = 5$ TeV which will be collected at the end of 2017.

References

[1] C. Patrignani *et al.* (Particle Data Group), *The review of particle physics*, Chin. Phys. C, **40**, 100001 (2016).

[2] Acharya, Shreyasi *et al.* [ALICE Collaboration], *"Measurement of D-meson production at mid-rapidity in pp collisions at* $\sqrt{s} = 7$ *TeV,"* arXiv:**1702.00766** [hep-ex]

[3] [ALICE Collaboration], *"Measurement of prompt* D^0, D^+, D^{*+} *and* $\mathrm{D}_{\mathrm{s}}^+$ *production in p-Pb collisions at* $\sqrt{(s_{\mathrm{NN}})} = 5.02$ *TeV,"* ALICE-PUBLIC-2017-008