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

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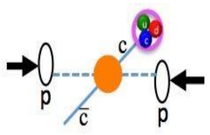
Physics Motivation

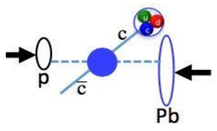
Charm and beauty quarks are produced in hard parton-parton scatterings in hadronic collisions. The production cross section of hadrons containing heavy quarks is measured in pp and p-Pb collisions:

pp collisions provide a sensitive test of pQCD calculations, set constraints on the production mechanisms and serve as a reference for studies in p-Pb and Pb-Pb collisions.



p-Pb collisions allow the study of Cold Nuclear Matter (CNM) effects including:

- modifications of the parton-distribution functions in nuclei (nPDF)
- gluon saturation at low x test Colour-Glass-Condensate predictions,
- k_T -broadening,
- energy loss in the initial and final state



Observable: Nuclear Modification factor (R_{pPb}) defined as:

$$R_{pPb} = \frac{1}{A}\cdot\frac{d^2\sigma_{pPb}/dp_T dy}{d^2\sigma_{pp}/dp_T dy}$$ **where A = 208 is the Pb mass number**

No CNM effects, No final-state effects → R_{pPb} = 1

Experimental Setup

➢The main detectors of ALICE (A Large Ion Collider Experiment) used in this analysis are:

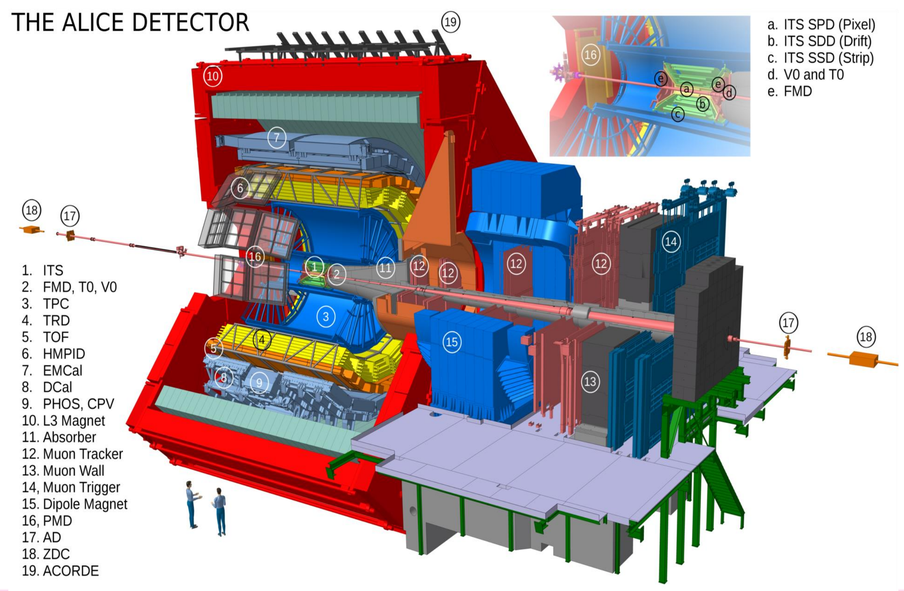
- **Inner Tracking System (ITS)**
- **Time Projection Chamber (TPC)**
- **Time of Flight (TOF)**

Track reconstruction with ITS and TPC in $|\eta| < 0.9$

Particle identification (PID) with TPC and TOF via the measurement of the specific energy loss dE/dx and of the time of flight from the interaction point to the TOF detector

Data sample:

pp , $\sqrt{s}$ =5.02 TeV: L_{int}= (19 ± 1) nb^{-1} (2017)
pp , $\sqrt{s}$ = 8 TeV: L_{int} = (1.9 ± 0.1) nb^{-1} (2012).
pp , $\sqrt{s}$ = 13 TeV: L_{int} = (3.3 ± 0.2) nb^{-1} (2016).
p–Pb , $\sqrt{s_{NN}}$ = 5.02 TeV: L_{int}=(292±10.8)μb^{-1} (2016)



Analysis Strategy

$D^+ \rightarrow K^- \pi^+ \pi^+$ Reconstruction

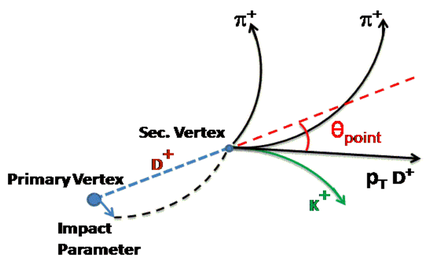
D^+ mesons ($c\tau \approx 312$ μm [1]) are measured exploiting their displaced vertex topology in the central rapidity region via hadronic decays $D^+ \rightarrow K^- \pi^+ \pi^+$ (Branching Ratio , BR = 9.46 ± 0.24 %)

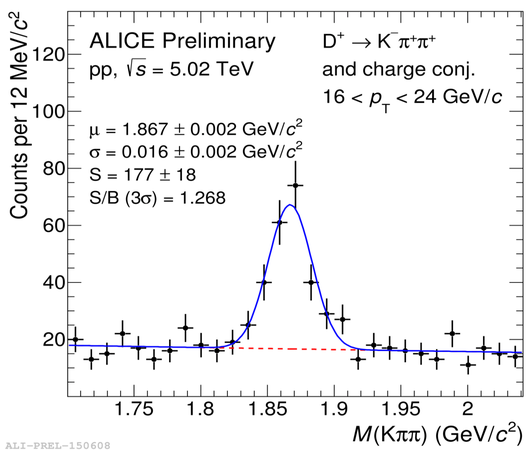
✓Build triplets of tracks with proper combination of charges.

✓Selection criteria based on distance between primary and decay vertices and pointing of the reconstructed D^+-meson momentum to the primary vertex.

✓Particle identification of pions and kaons with TPC and TOF to reduce the background at low p_T.

✓D^+ yield is extracted by fitting the invariant mass distribution with a Gaussian function for the signal and an exponential function to model the background.





Corrections

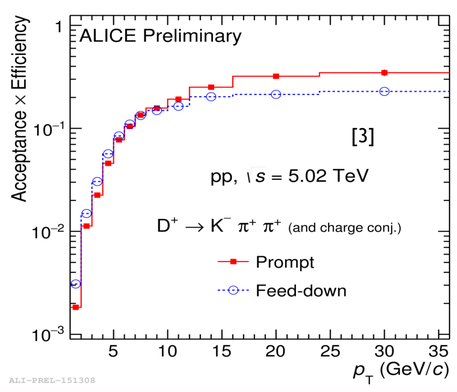
Raw yield corrected for the acceptance of the detector and for the **reconstruction and selection efficiency** which are obtained from Monte Carlo simulations

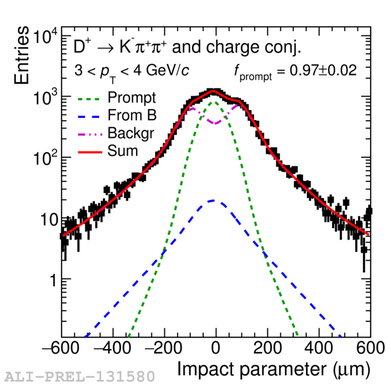
B-feed-down correction: D^+ mesons coming from B decays are subtracted by computing the fraction of prompt D^+, f_{prompt}, according to the formula:

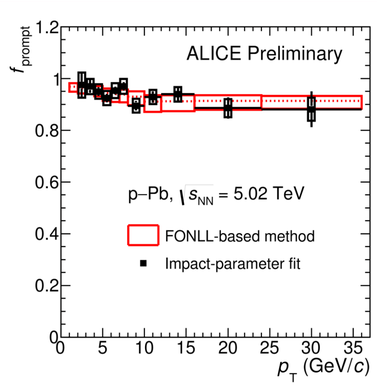
$$f_{prompt} = 1 - \frac{N^{D\pm}_{feeddown}}{N^{D\pm}_{raw}} = 1 - A.\left(\frac{d^2\sigma}{dp_T dy}\right)_{feeddown}.\ R^{feeddown}_{pPb}\ \frac{(Acc\times\epsilon)_{feeddown}.\ c_{\Delta y}\ \Delta p_T.BR.L_{int}}{N^{D\pm}_{raw}/2}$$

where A=1 and R_{pPb} = 1 in pp collisions, $c_{\Delta y}$ is the rapidity acceptance correction factor

Cross checked with a data-driven method that exploits the different shapes of the transverse-plane impact parameter distributions of prompt and feed-down D^+ mesons

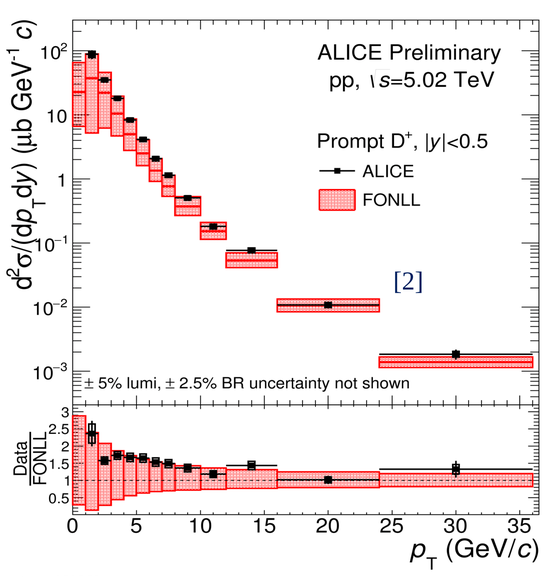


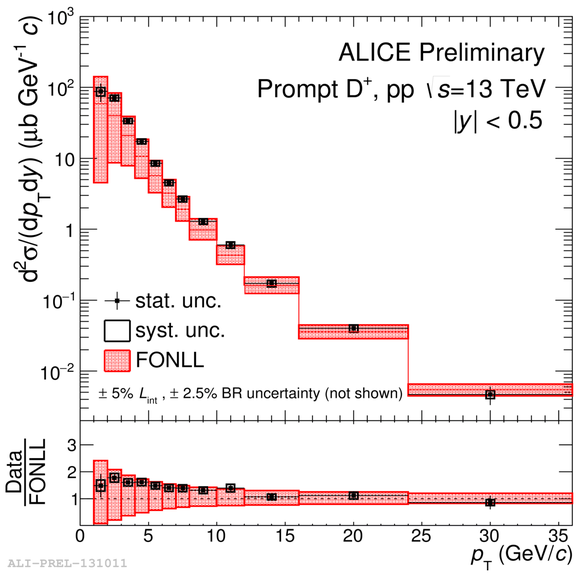


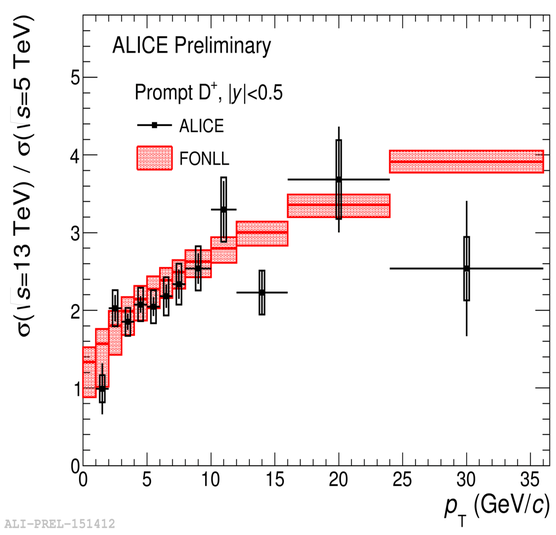


Results

pp collisions







p_T differential production cross section in pp collisions at $\sqrt{s}$ = 5.02 and 13 TeV

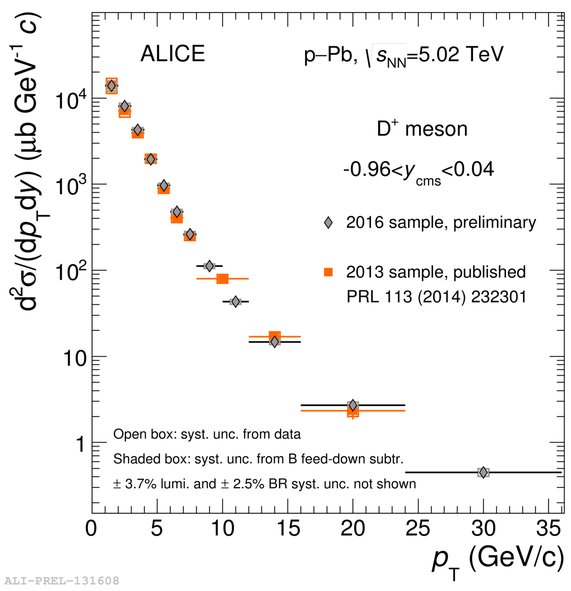
✓ Described by pQCD-based calculations within uncertainties

✓ The data points lie on the upper edge of the theoretical uncertainty band as already observed in pp collisions at $\sqrt{s}$ = 7 TeV [4] and 2.76 TeV [5]

The ratio of the cross sections at different energies can help to constrain gluon parton distribution functions at low x used in pQCD calculations

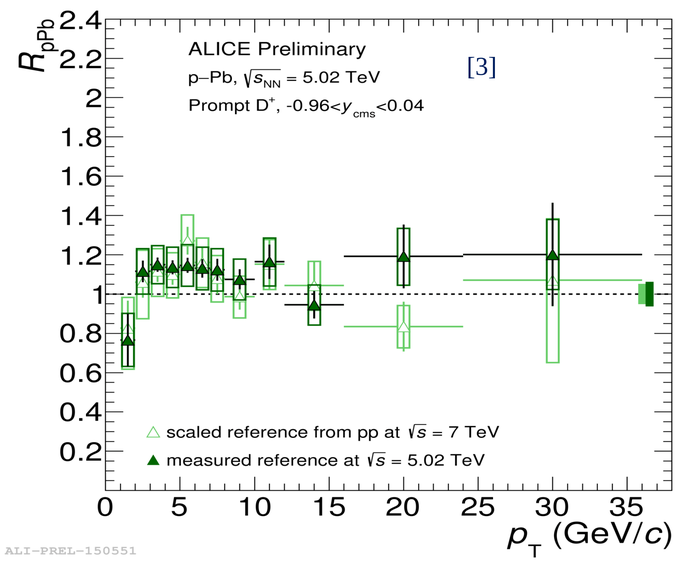
✓ The ratio of the p_T differential cross section at $\sqrt{s}$ = 13 and 5.02 TeV is compatible with FONLL calculations within uncertainties

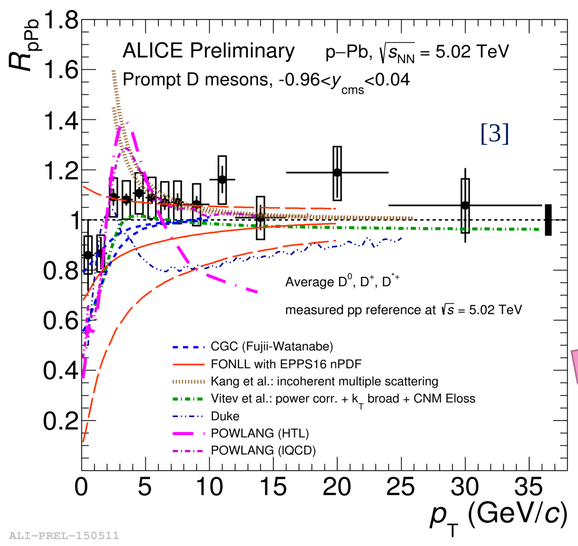
p-Pb collisions



✓ Factor 2 improvement in statistical precision and extended p_T reach w.r.t Run-1

✓ p_T-differential cross section for D^+ mesons from Run-1 [6] is compatible with Run-2 measurements





✓ D^+ R_{pPb} consistent with unity

✓ R_{pPb} obtained with pp reference by scaling the measurement at $\sqrt{s}$ = 7 TeV is in agreement with the R_{pPb} obtained with pp reference measured at $\sqrt{s}$ = 5.02 TeV

✓ Models including CNM effects and medium effects describe experimental results

✓ Data disfavour a suppression larger than 10-15% for 5 < p_T < 12 GeV/c

References

[1] [Particle Data Group], Chin. Phys. C, 40, (2016) 100001
[2] [ALICE Collaboration], ALICE-PUBLIC-2018-006
[3] [ALICE Collaboration], ALICE-PUBLIC-2017-008
[4] [ALICE Collaboration], JHEP 1207 (2012) 191
[5] [ALICE Collaboration], JHEP 1201 (2012) 128
[6] [ALICE Collaboration], PRL 113 (2014) 232301