# Measurement of D$^{*+}$-meson production in small systems with ALICE at the LHC


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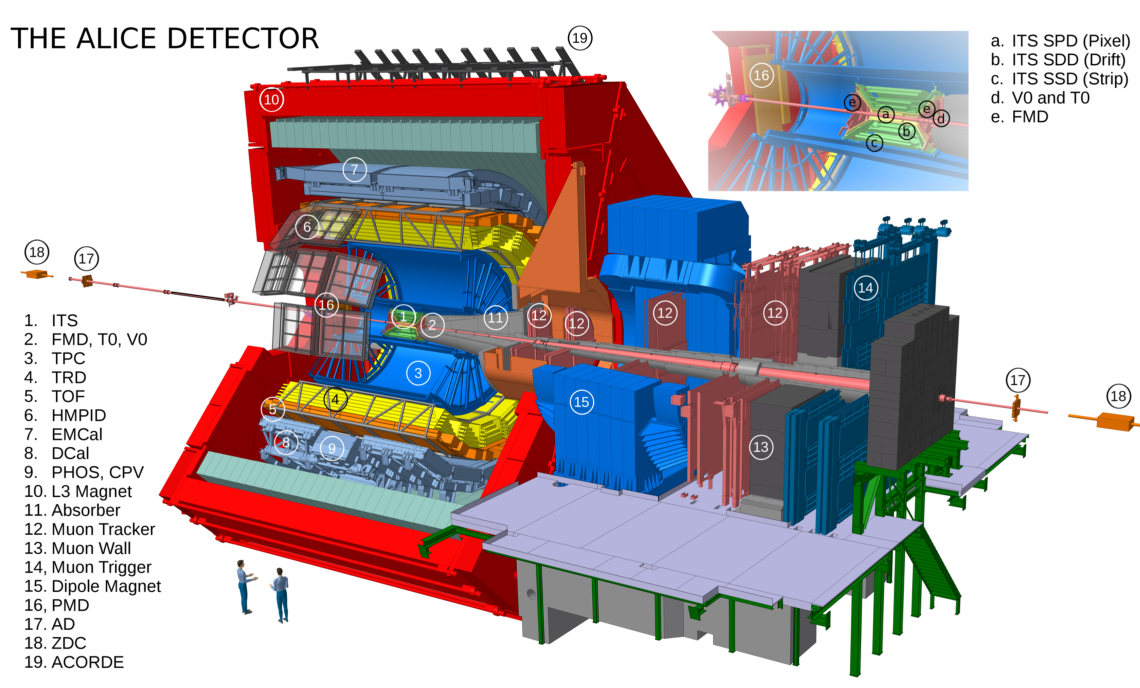
## 1. Physics motivation

- **Charm** and **beauty** quarks are valuable probes to study the properties of the **Quark-Gluon Plasma** created in ultra-relativistic **Pb–Pb** collisions.
- **Measurements in p–Pb** collisions are crucial to investigate Cold Nuclear Matter (**CNM**) effects and distinguish them from hot nuclear matter effects present in Pb-Pb collisions. Relevant **CNM** effects include: shadowing, gluon saturation, $k_T$-broadening, initial- and final- state energy loss as well as possible hot-medium like effects.
- **Measurements** of heavy flavours in **pp collisions** provide:
  - an excellent **test of pQCD calculations**,
  - a **reference** for measurements in p–Pb and Pb–Pb collisions.
- The **nuclear modification factor**, $R_{pPb}$, is used to quantify CNM effects: $R_{pPb} = \frac{1}{A} \cdot \frac{d^2\sigma_{pPb}/dp_T dy}{d^2\sigma_{pp}/dp_T dy}$, where $A = 208$ is the Pb mass number.

## 2. D$^{*+}$ Reconstruction in ALICE

- D$^{*+}$ reconstruction at central rapidity via the hadronic decay channel: $D^{*+} \to D^0\pi^+ \to K^-\pi^+\pi^+$.
  B.R. of 67.7 ± 0.5 % ($D^{*+} \to D^0\pi^+$) and 3.93 ± 0.04% ($D^0 \to K^-\pi^+$) [1].



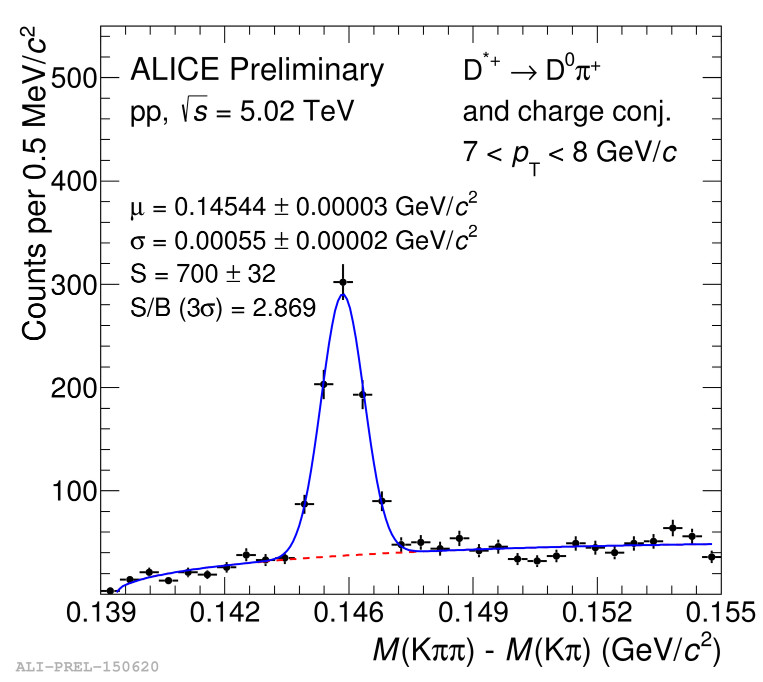

Analysis based on:

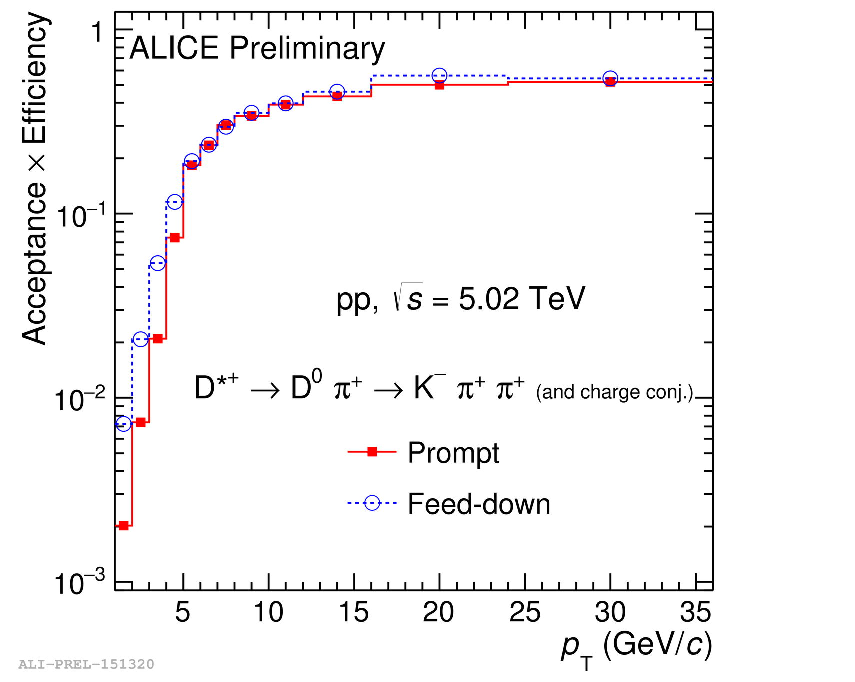
- **Tracking information** via ① **I**nner **T**racking **S**ystem and ③ **T**ime **P**rojection **C**hamber
- **Selection of D$^0$ decay vertices** displaced from the interaction vertex.
  - combination with pion tracks (down to very low $p_T$)
- **Particle identification** via the **TPC** and ⑤ **T**ime-**O**f-**F**light to reduce combinatorial background.

### Data Samples

- pp @ $\sqrt{s} = 5$ TeV: $L_{int} = (19 \pm 1)$ nb$^{-1}$ (2017).
- pp @ $\sqrt{s} = 7$ TeV: $L_{int} = (5^{\pm 0.3}_{\pm 0.15})$ nb$^{-1}$ (2010) [2].
- pp @ $\sqrt{s} = 8$ TeV: $L_{int} = (1.9 \pm 0.1)$ nb$^{-1}$ (2012).
- pp @ $\sqrt{s} = 13$ TeV: $L_{int} = (3.3 \pm 0.2)$ nb$^{-1}$ (2016).
- p–Pb @ $\sqrt{s_{NN}} = 5.02$ TeV: $L_{int}$= (292±10.8) $\mu$b$^{-1}$ (2016) [3].

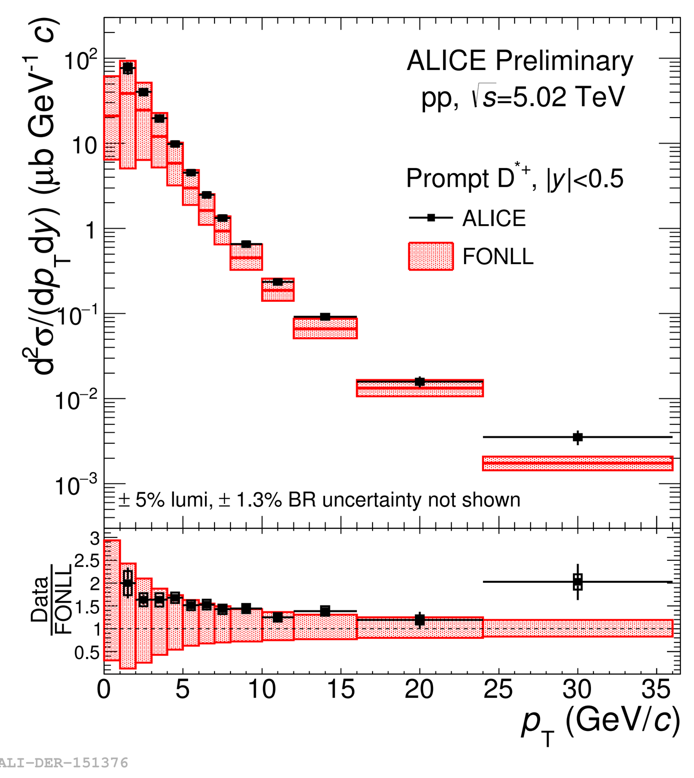
## 3. Analysis Method:

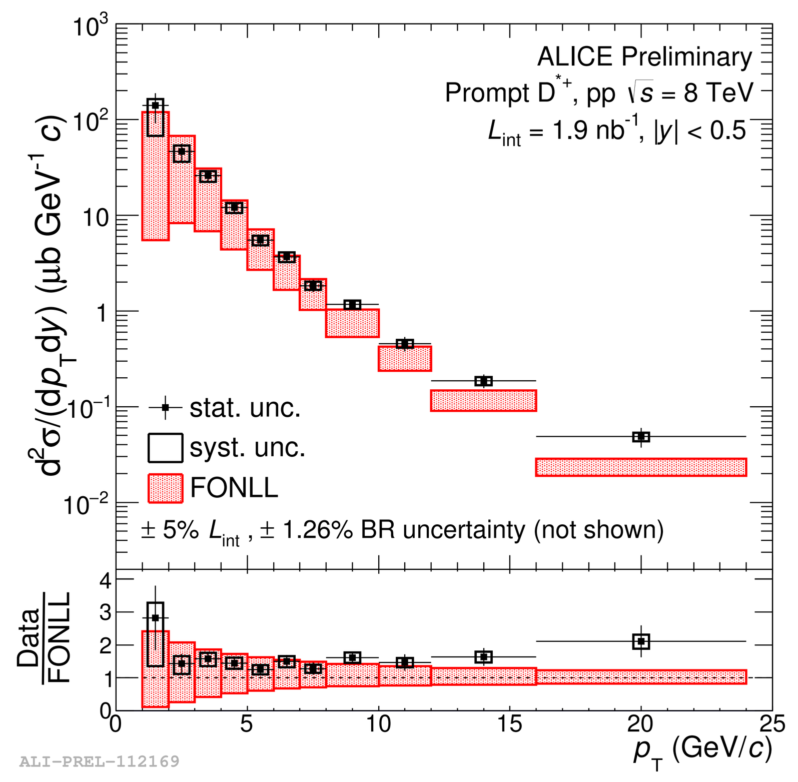


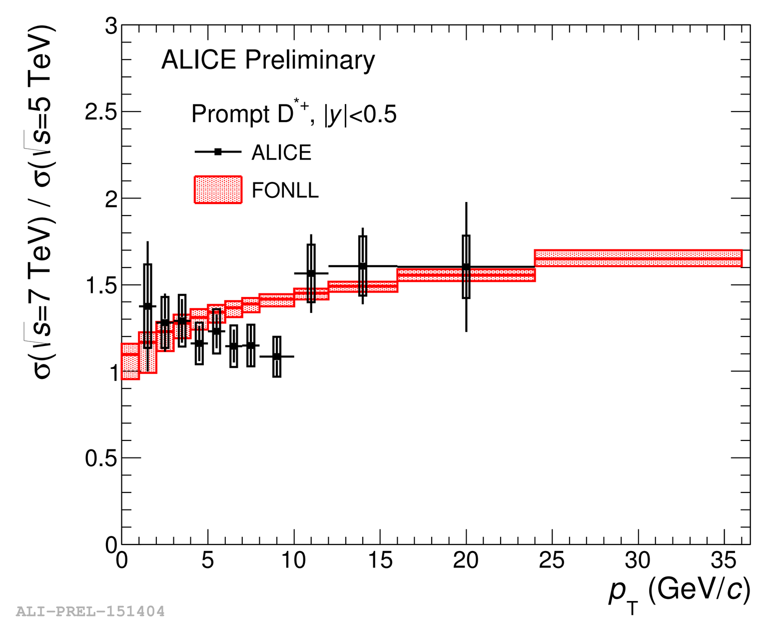



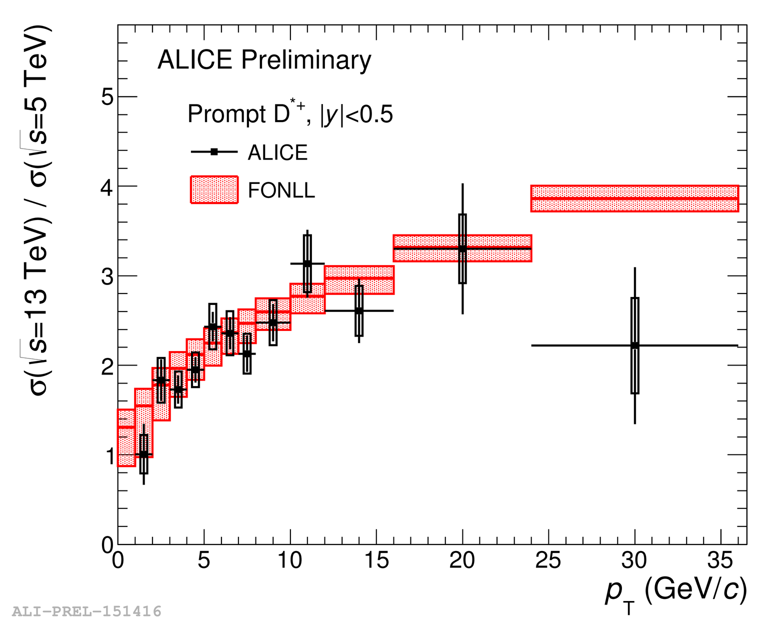

- D$^{*+}$-meson raw yield extracted via fit to the invariant mass difference $M(K^-\pi^+\pi^+) - M(K^-\pi^+)$ distributions [2].
- Acceptance and selection efficiency correction from Monte Carlo simulations [2] and feed-down (D meson from beauty-hadron decays) correction based on FONLL calculations.

## 4. Production cross sections in pp collisions at various energies and ratios between different energies



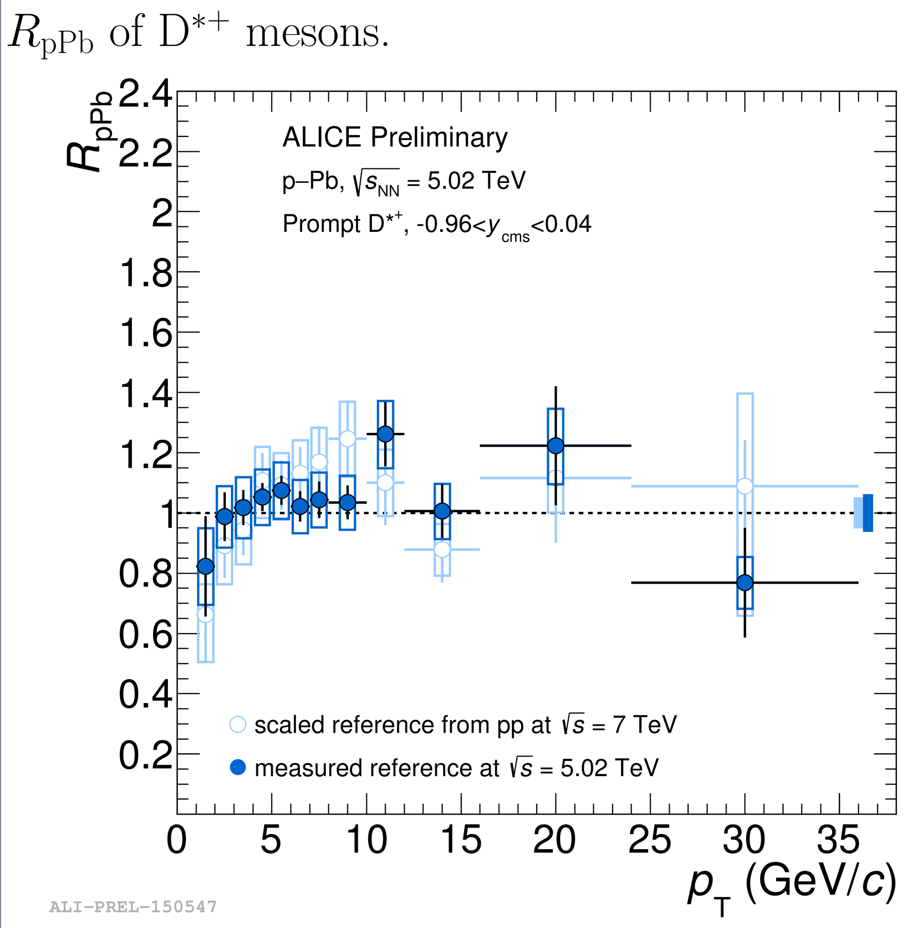



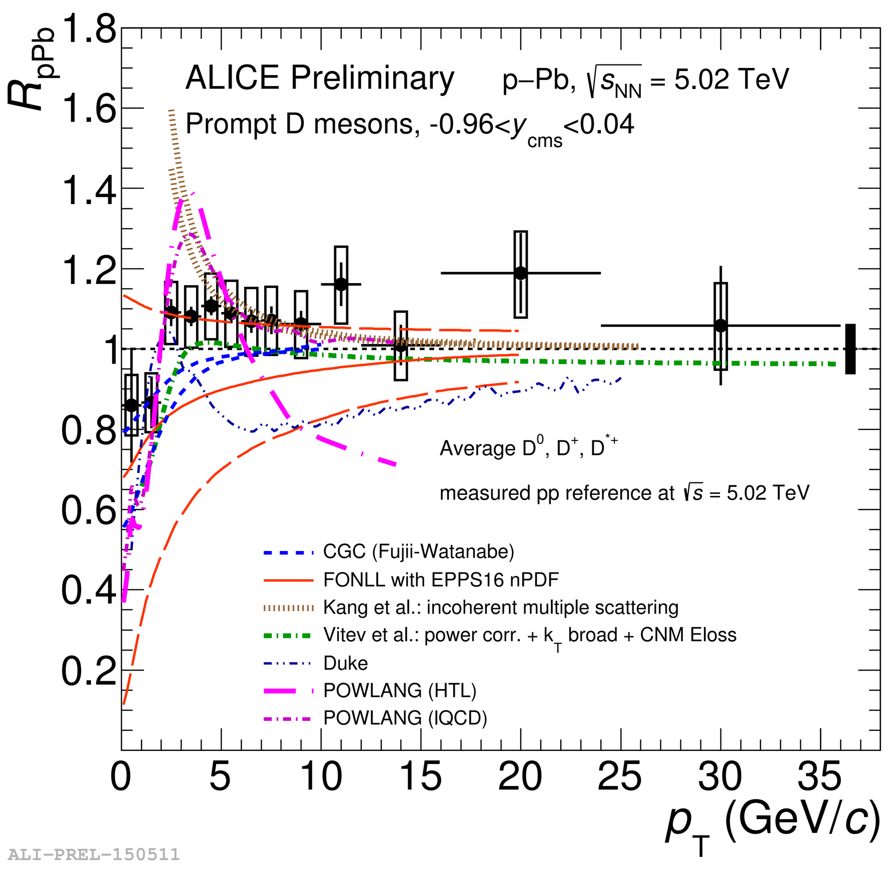

- The D$^{*+}$ production cross sections at $\sqrt{s} = 5$ TeV and 8 TeV are measured in $1 < p_T < 36$ GeV/$c$ and $1 < p_T < 24$ GeV/$c$.
- The ratio of the cross sections at different energies can help to constrain the gluon PDF used in pQCD calculations.
- The ratio D$^{*+}$ $p_T$-differential cross sections at 7 / 5 TeV (left) and 13 / 5 TeV are compatible, within uncertainties, with FONLL calculations.
- **D$^{*+}$ cross section measured in pp collisions at $\sqrt{s}$ = 5,8,7 and 13 TeV are consistent with FONLL pQCD calculations. The central points are closer to the upper edge of the theoretical uncertainty band.**

## 5. p–Pb results

$R_{pPb}$ of D$^{*+}$ mesons.




Average $R_{pPb}$ of D$^{*+}$, D$^0$ and D$^+$ mesons.




- The larger data p-Pb sample collected during the LHC run 2 allows:
  1) extension of the cross section measurement up to $p_T = 36$ GeV/$c$
  2) reduction of the uncertainties on the measurement by a factor ∼ 2 w.r.t. Run 1 results.
  3) improved precision on the $R_{pPb}$ using the measured cross section in pp collisions at 5.02 TeV.
- **The $R_{pPb}$ is consistent with unity within uncertainties.**
  - **The current precision of the model calculations and of the measurement does not allow us to conclusively distinguish scenarios with only CNM effects and those including also hot-medium effects in p-Pb collisions.**
  - **The data disfavour a suppression larger than 15 % at high $p_T$.**


## References

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

[2] [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 D$^+_s$ production in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV,"* ALICE-PUBLIC-2017-008

[4] [ALICE Collaboration], *"Measurement of D$^0$, D$^+$, D$^{*+}$ and D$^+_s$ production in pp collisions at $\sqrt{s} = 5.02$ TeV with ALICE,"* ALICE-PUBLIC-2018-006