# Measurements of $D^0$ meson production in pp collisions with ALICE at the LHC

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## Motivation

### Heavy quarks: charm and beauty

- ◊ Large masses: ~1.3 GeV/$c^2$ (charm) and ~ 4.5 GeV/$c^2$ (beauty).
- ◊ Produced in hard scattering processes between partons in the initial stages of the hadronic collisions.
- ◊ They are efficient probes of the strongly interacting matter formed in high-energy heavy-ion collisions.

### Theoretical approach at high energies

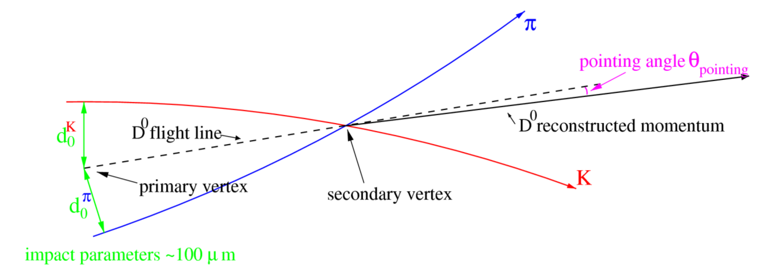
- ◊ Heavy-flavour production calculable with perturbative QCD techniques.
- ◊ Cross section factorized in terms of partonic hard-scattering cross section, **PDFs** of the incoming hadrons and non-perturbative **fragmentation functions** of the heavy quark to a given hadron species.
- ◊ The state of the art are calculations with NLO plus Next-to-Leading Log (FONLL,[1] GM-VFNS[2]) based on collinear factorization, and LO calculations in the $k_T$-factorization approach.[3]

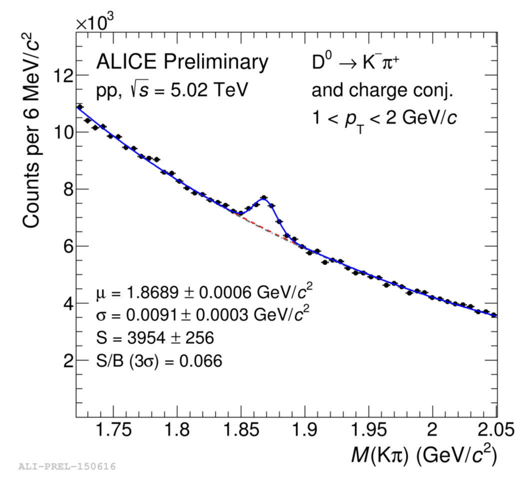
### $D^0$-meson cross section in pp collisions

- ◊ Provides a test of pQCD calculations.
- ◊ A probe to investigate gluons PDFs since **cross section ratios** at different energies and rapidities are **less sensitive to the perturbative scale uncertainties**.[4]
- ◊ A reference for the study of effects induced by the hot medium created in nucleus-nucleus collisions and Cold Nuclear Matter effects in proton-nucleus collisions.

## Analysis Strategy

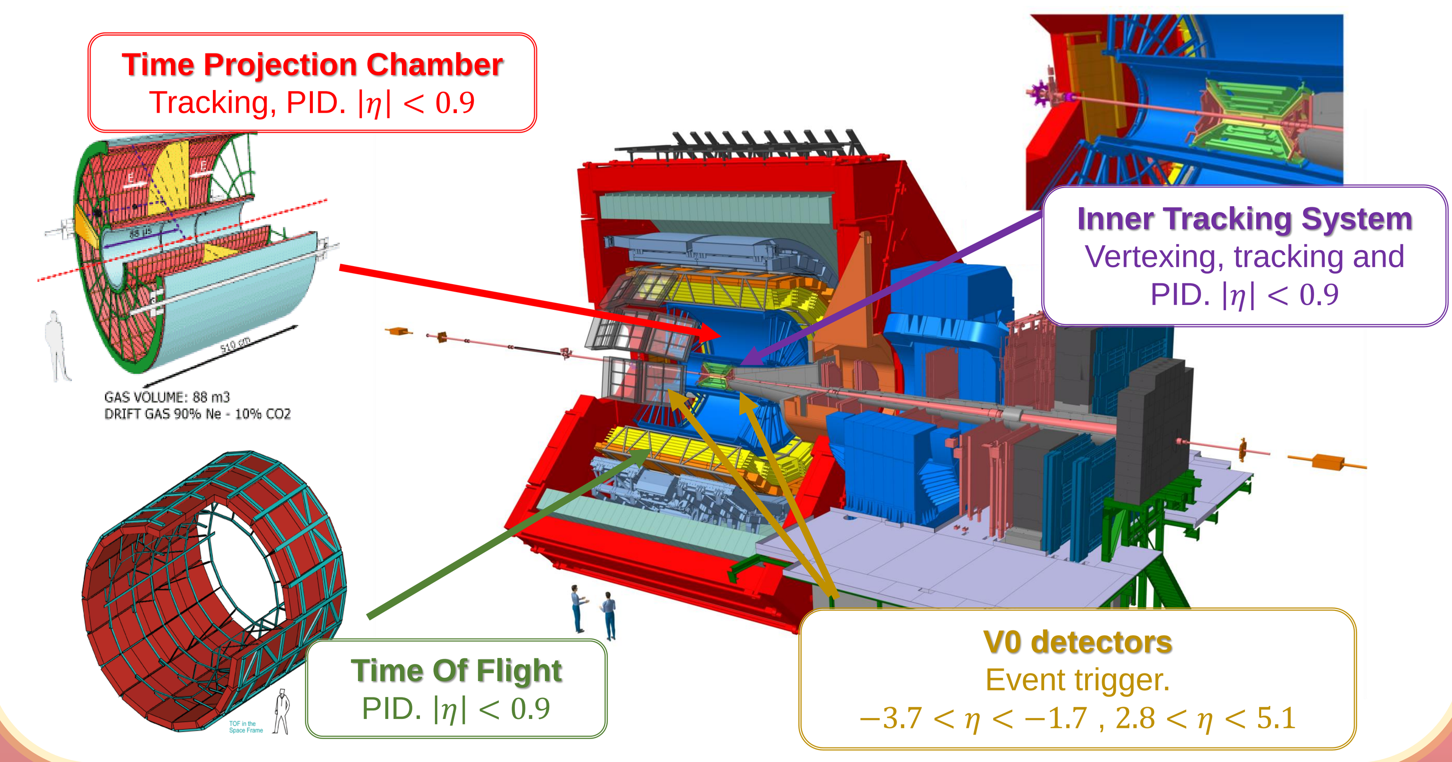
- ◊ $D^0$ reconstructed via the **decay channel $D^0 \rightarrow K^-\pi^+$** (and charge conjugated), BR=3.93 ± 0.04 %.[5]
- ◊ Typical signal signature: presence of a displaced **secondary vertex** ($c\tau$ = 123 μm).
- ◊ **Particle identification** (TOF and TPC) and **topological cuts** to reduce the combinatorial background.
- ◊ $D^0$–meson raw yields extracted from fit to **invariant mass** spectra: Gaussian (signal) + exponential (background) functions.
- ◊ Efficiency × Acceptance evaluated using Monte Carlo simulations performed with PYTHIA6 (Perugia-2011 tune).
- ◊ **Feed-down $D^0$** mesons (i.e. from decay of beauty hadrons) subtraction based on pQCD calculations (FONLL).[1]
- ◊ An analysis **w/o decay-vertex reconstruction** is also performed: the shape of the combinatorial background invariant mass distribution is studied with dedicated techniques ("track rotation, event mixing, like sign, side-band fit").
  - ✓ Compatible results with the standard approach in the common $p_T$ interval.
  - ✓ Better precision for $p_T$ < 1 GeV/$c$.




Invariant mass distribution for $D^0$ candidates, at $\sqrt{s}$ = 5 TeV.

## The ALICE detector



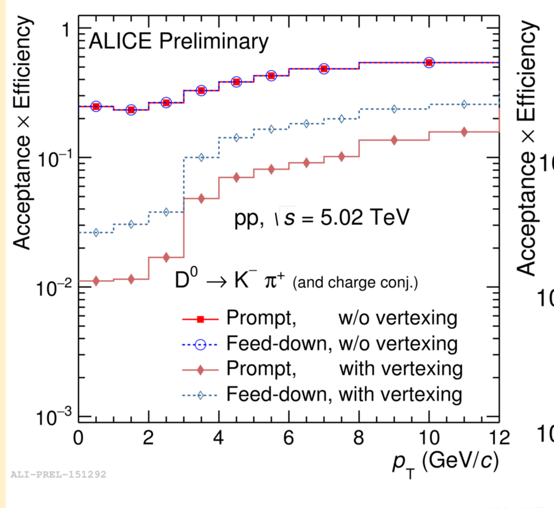

## Data samples

- ◊ pp, $\sqrt{s}$ = 5.02 TeV: $L_{int}$= 19 nb$^{-1}$ (2017).
- ◊ pp, $\sqrt{s}$ = 7 TeV: $L_{int}$ =(6.0±0.2)nb$^{-1}$ (2010).
- ◊ 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).

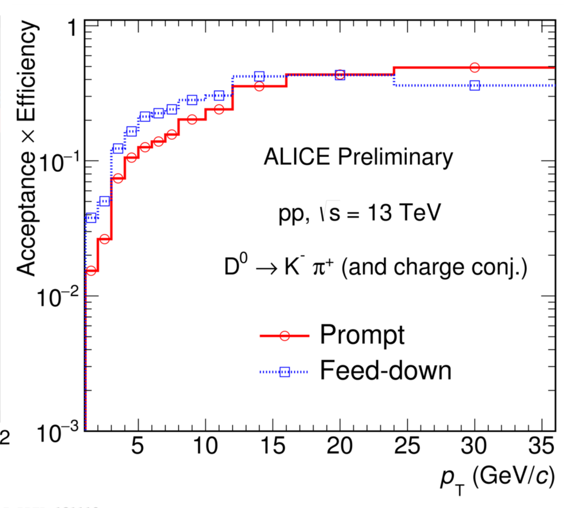
## RESULTS

**Acceptance × Efficiency** in pp collisions for prompt and feed-down $D^0$ mesons. In the left panel the efficiency for the analysis without decay vertex reconstruction is also shown.

### $\sqrt{s}$ = 5.02 TeV

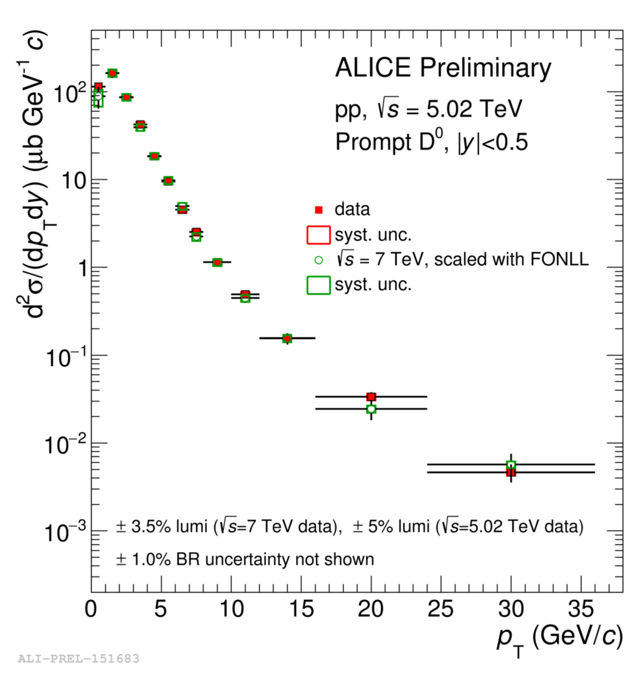



### $\sqrt{s}$ = 13 TeV



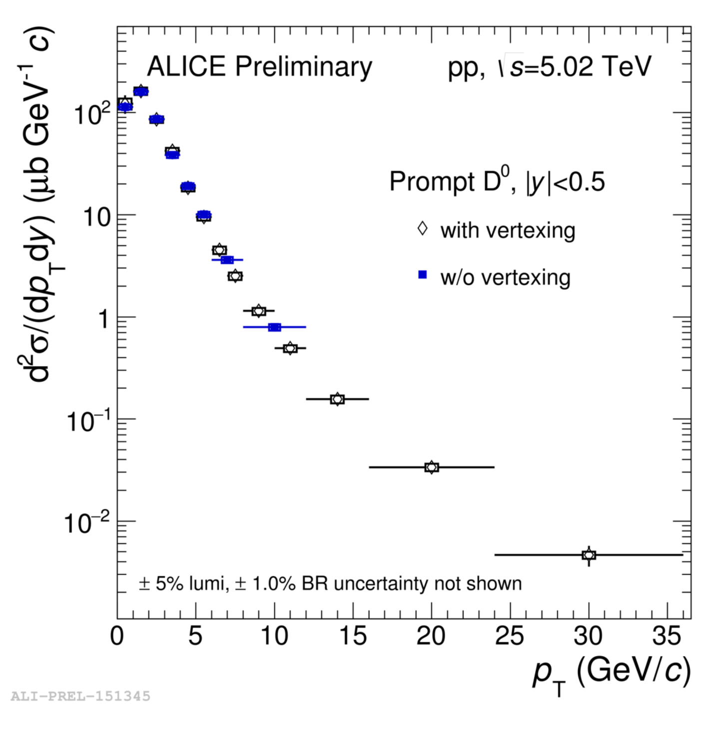

- ◊ Increasing trend as a function of $p_T$.
- ◊ Acc × Eff generally larger for feed-down D mesons due to the larger displacement from the primary vertex with respect to the prompt $D^0$.
- ◊ Significantly **higher efficiency**, identical for prompt and feed-down $D^0$-mesons, for the analysis w/o decay-vertex reconstruction.

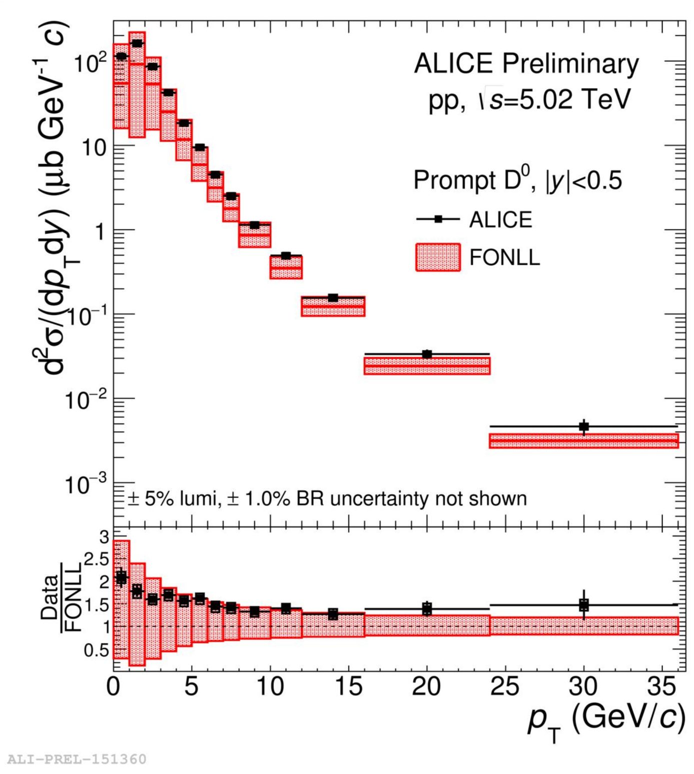
$p_T$-differential cross section in pp collisions at $\sqrt{s}$ = 5.02 TeV compared to the pQCD-based energy scaling of the 7 TeV cross section to 5 TeV.



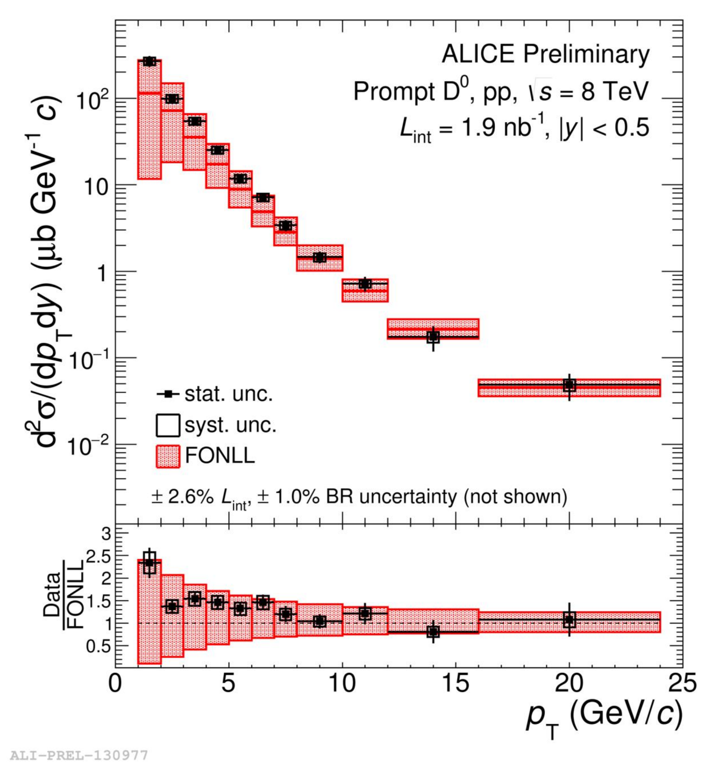

$D^0$-meson **$p_T$-differential cross section** in pp collisions at $\sqrt{s}$ = 5.02 TeV, $\sqrt{s}$ = 8 TeV and $\sqrt{s}$ = 13 TeV in different $p_T$ ranges. The comparison with FONLL[1] perturbative QCD calculations is shown. The value in 0 < $p_T$ < 1 GeV/c at $\sqrt{s}$ = 5.02 TeV is from the analysis without decay vertex.

### $\sqrt{s}$ = 5.02 TeV

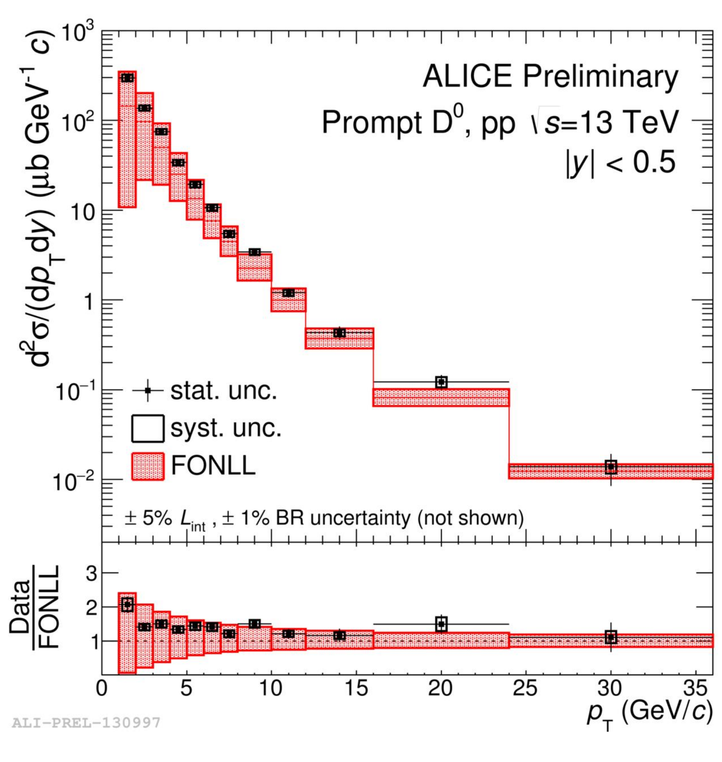



### $\sqrt{s}$ = 8 TeV



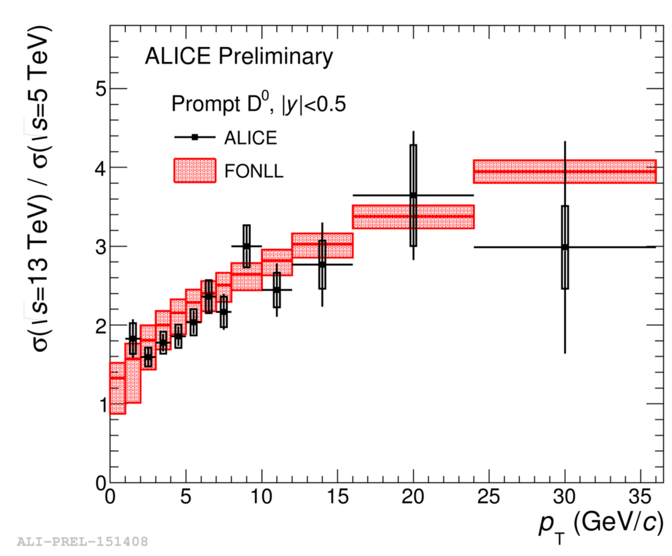

### $\sqrt{s}$ = 13 TeV



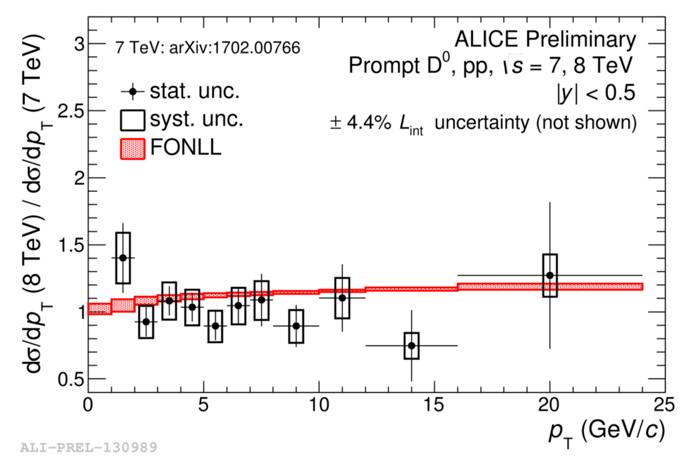

- ◊ The top-left panel shows that the cross sections measured with and without reconstruction of the decay vertex are compatible.
- ◊ The experimental results lie on the upper part of the theoretical uncertainty band.

**Ratios of $p_T$-differential cross section** at different energies. FONLL[1] calculations are shown in red.

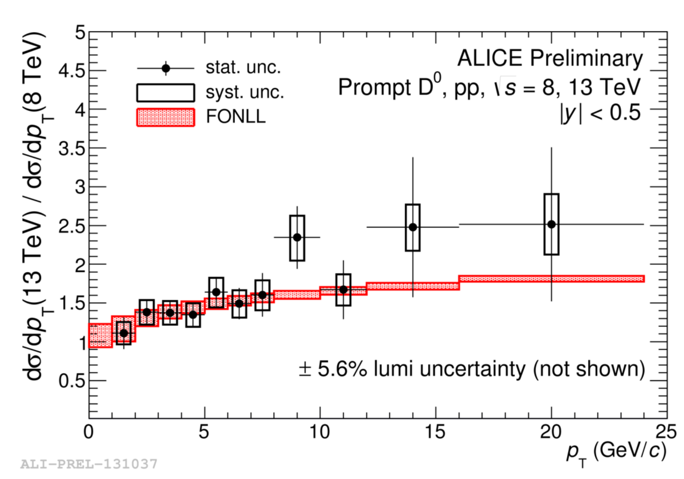
### $\sqrt{s}$ = 13 TeV / $\sqrt{s}$ = 5.02 TeV




### $\sqrt{s}$ = 8 TeV / $\sqrt{s}$ = 7 TeV




### $\sqrt{s}$ = 13 TeV / $\sqrt{s}$ = 8 TeV




- ◊ **Good agreement** with pQCD calculations.

[1] M. Cacciari et al, JHEP 10 (2012) 137
[2] B. A. Kniehl et al, EPJ C72 (2012) 2082
[3] R. Maciula et al, Phys. Rev. D87 no. 9 (2013) 094022
[4] M. Cacciari et al, EPJ C75 (2015) 12
[5] C. Patrignani et al., Chin. Phys. C 40, (2016) 100001