Ricostruzione di mesoni D in collisioni pp a 8 TeV con l'esperimento ALICE a LHC

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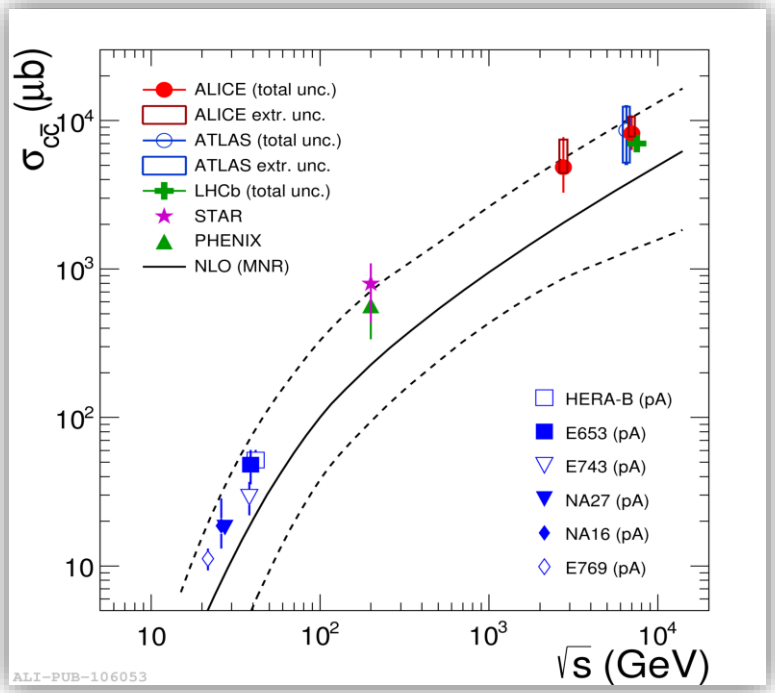
Outline

- Heavy flavour physics in ALICE
- The ALICE detector
- D-meson reconstruction
  - Selection strategy
  - Signal extraction
- Results:
  - p_T differential production cross section for D^+ and D^{*+}
- Conclusions

Heavy-flavour physics in ALICE

Why do we study D mesons?

- LHC as a heavy-flavour factory (charm and beauty):
  - large cross section for $c\bar{c}$ and $b\bar{b}$ production: $\sigma^{c\bar{c}}_{LHC} \approx 100\,\sigma^{c\bar{c}}_{RHIC}$
- Heavy quarks are produced in hard scattering processes in the initial stages of the collision → test of pQCD calculations
- Energy dependence of total charm production cross section in pp well reproduced by NLO pQCD-based calculation over more than 3 orders of magnitude → charm production in pp theoretically under control
- In pp collisions,
  - a reference for Pb-Pb collisions
  - Insight in the production mechanism
  - a test for perturbative QCD in a new energy regime

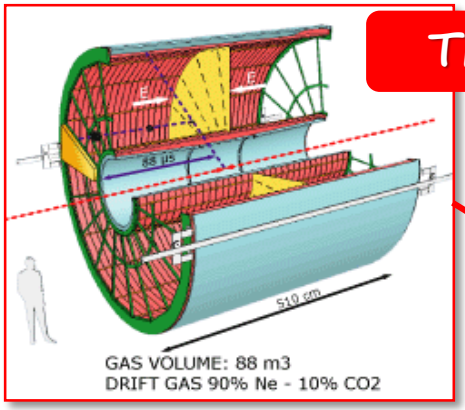


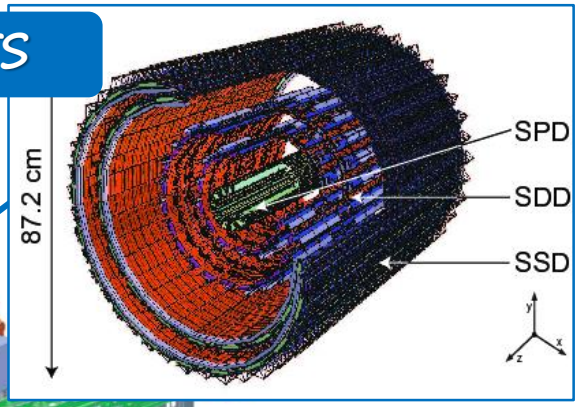
arXiv:1605.07569v1

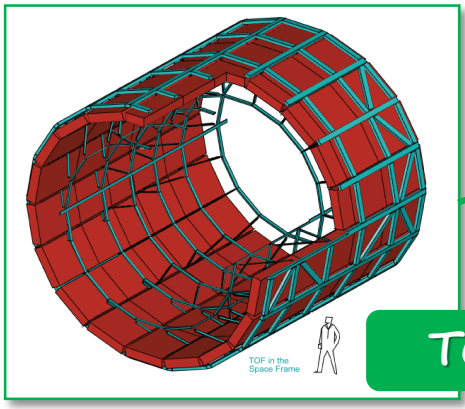
The ALICE detector

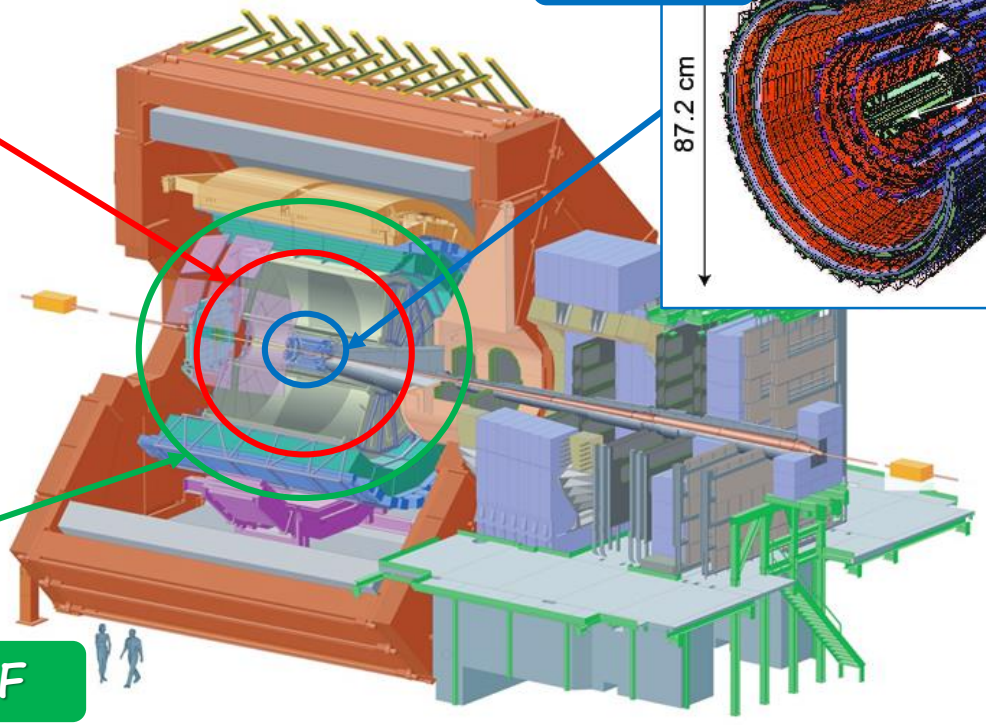
To reconstruct D mesons, we need:

- **Inner Tracking System (ITS)**: precision vertex reconstruction, tracking
- **Time Projection Chamber (TPC)**: tracking, particle identification
- **Time of Flight (TOF)**: particle identification







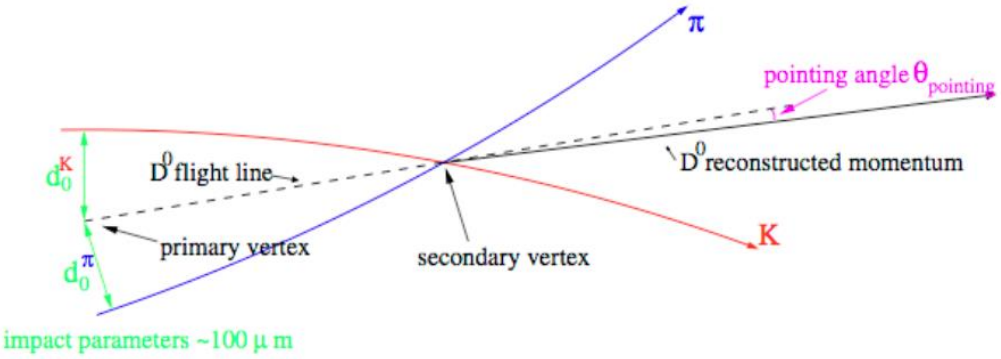


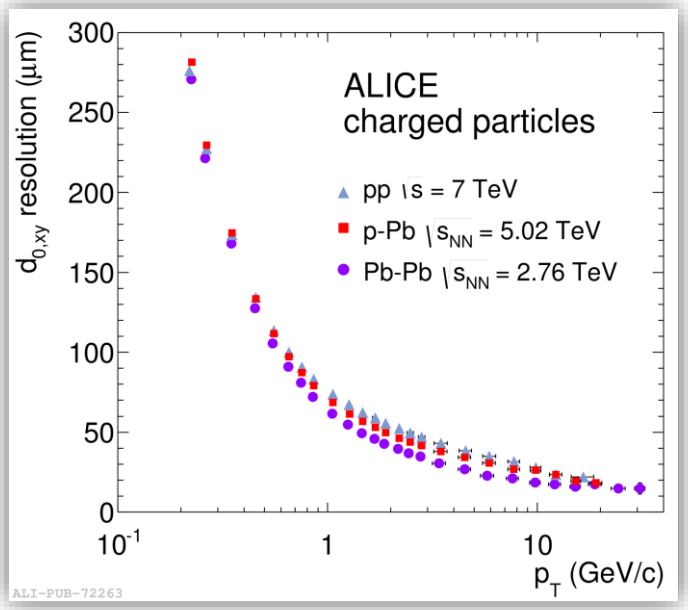
D-meson hadronic decays

Channels studied:

$D^+ \rightarrow K^-\pi^+\pi^+$ [BR (9.13±0.19)%, $c\tau \approx 312$ μm]
$D^{*+} \rightarrow D^0\pi^+$ [BR (67.7±0.5)%] → $K^-\pi^+\pi^+$ [BR (3.93±0.04)%]

- Data sample analysed: pp 2012 data, $\sqrt{s} = 8$ TeV, ~10^8 events
- D^+, D^{*+} and their antiparticles reconstructed in the central rapidity region from their charged hadronic decay channels
- Displaced decay vertex is signature of heavy-flavour hadron decay → tracking and vertexing precision essential for heavy-flavour analysis





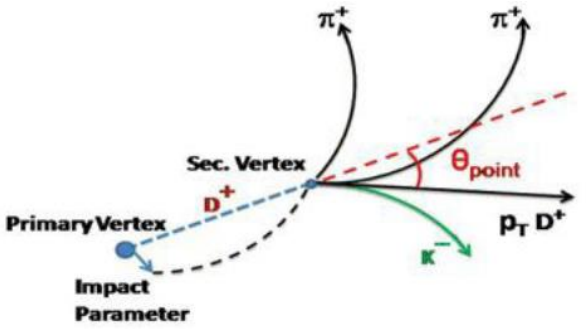
Int. J. Mod. Phys. A 29, 1430044 (2014)

D-meson selection strategy

Same strategy for all D-mesons

- Secondary vertices of D-mesons reconstructed using tracks with:
  - $\eta < |0.8|$
  - $p_T > 0.3$ GeV/c
  - at least 70 associated space points in TPC (out of a maximum of 159)
  - $X^2/ndf < 2$ in the TPC
  - at least one associated hit in either of the two innermost layers in ITS (Silicon Pixel Detector, SPD)

- p_T dependent **kinematic and topological cuts** applied on the final decay products to enhance signal-to-background ratio and maximize significance $\left(signal/\sqrt{signal+background}\right)$. Cuts on:
  - distance of closest approach
  - decay length
  - Pointing angle
  - impact parameter of the decay tracks



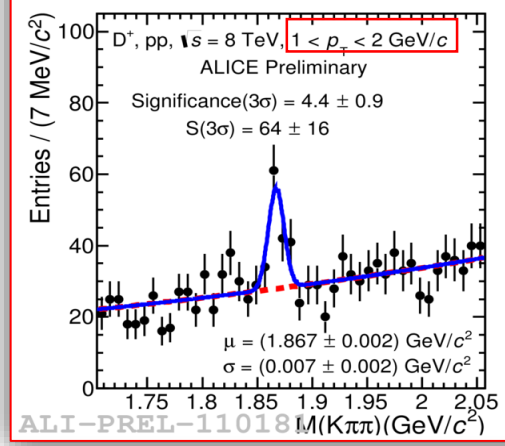
- Additional **background rejection** in the low momentum region through **particle identification** (PID) in TPC and TOF

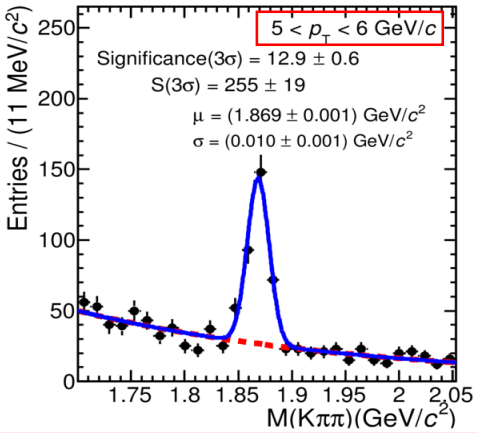
- Signal extracted from fits to the **invariant mass distributions**

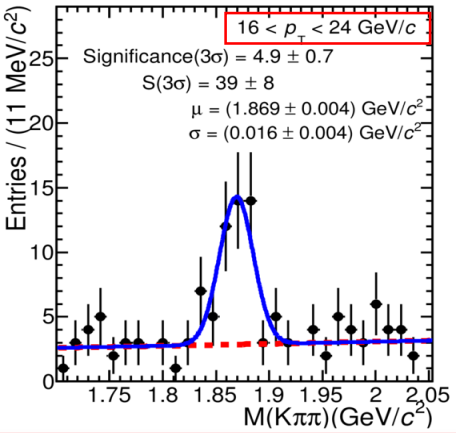
D-meson reconstruction

Examples of signal extracted in different p_T bins

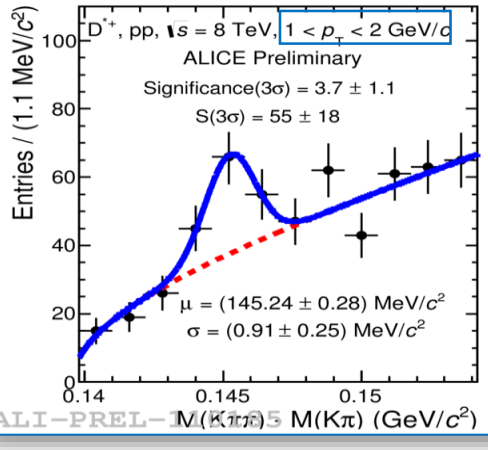
D^+

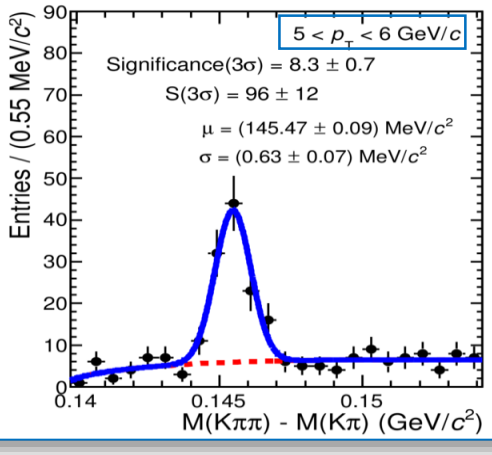


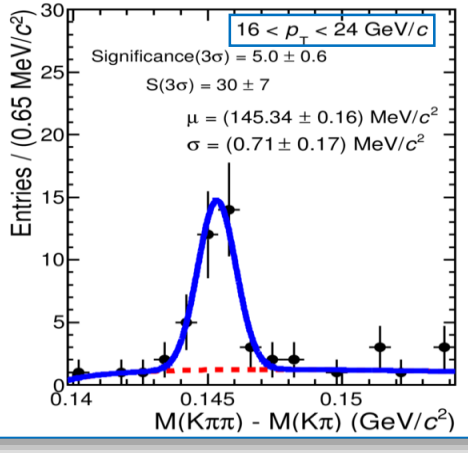




D^{*+}







Feed-down subtraction

The D-meson production cross-sections $d\sigma/dp_T$ contain the contribution prompt ($c\to D$) and feed-down from B-decays ($b\to B\to D$)

Acceptance x efficiency from Monte Carlo for feed-down D mesons

$$f_{\text{prompt}} = 1 - (N^{\text{D feed-down raw}} / N^{\text{D raw}}) =$$

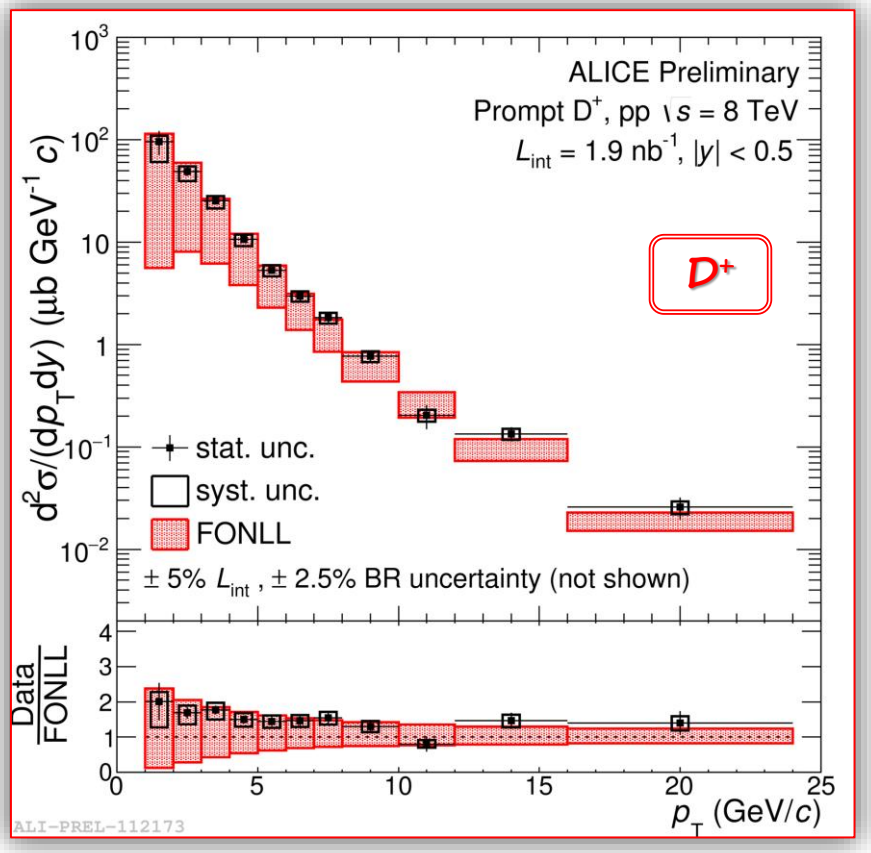
$$= 1 - \left(\frac{\mathrm{d}^2\sigma}{\mathrm{d}y\,\mathrm{d}p_T}\right)^{\text{FONLL}}_{\text{feed-down}} \cdot \frac{(\text{Acc} \times \varepsilon)_{\text{feed-down}} \cdot \Delta y\,\Delta p_T \cdot \text{BR} \cdot L_{\text{int}}}{N^{\text{D raw}}/2}$$

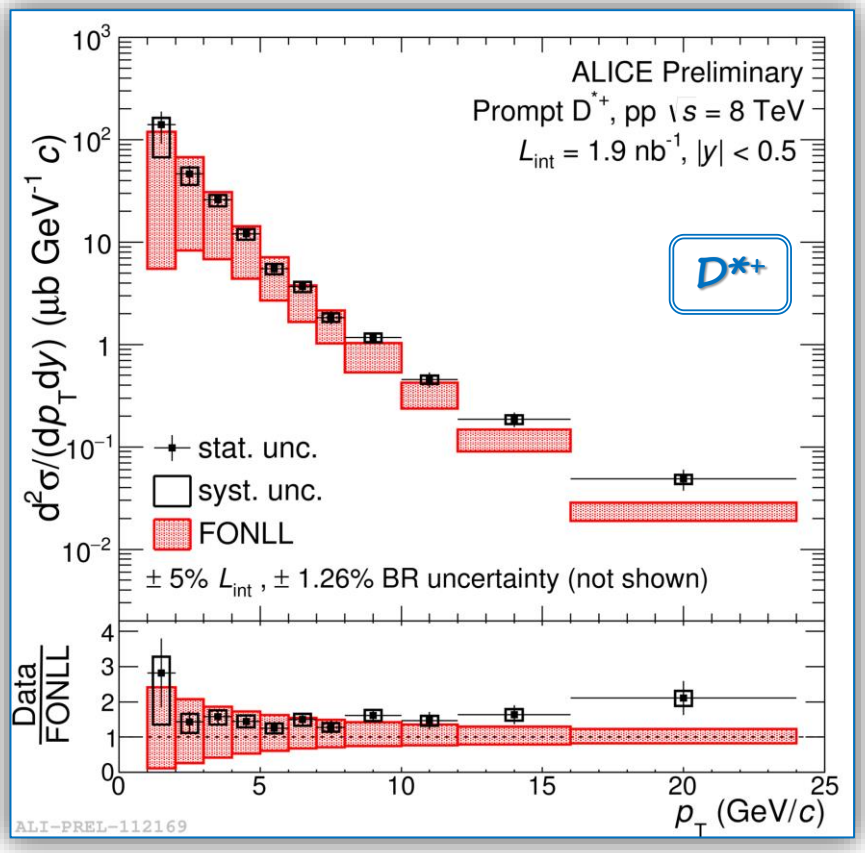
Beauty production cross section from FONLL + EvtGen B→D decay kinematics

N^{Draw} contains both particles and antiparticles, while FONLL does not

D-meson cross section

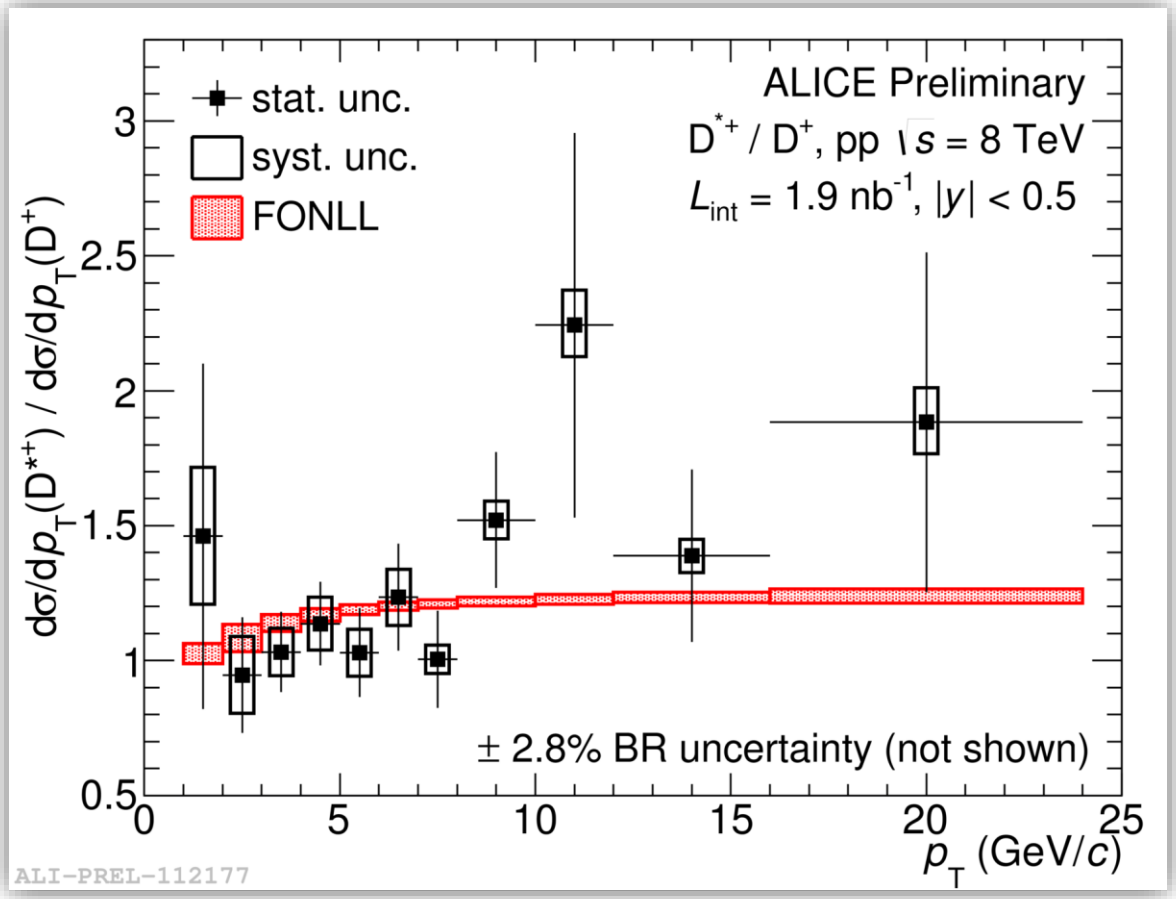
p_T differential production cross section for prompt charmed D mesons





- FONLL pQCD-based calculations [Cacciari et al., JHEP 1210 (2012) 137] fully compatible with data
- FONLL predictions on average lower than the measured cross section

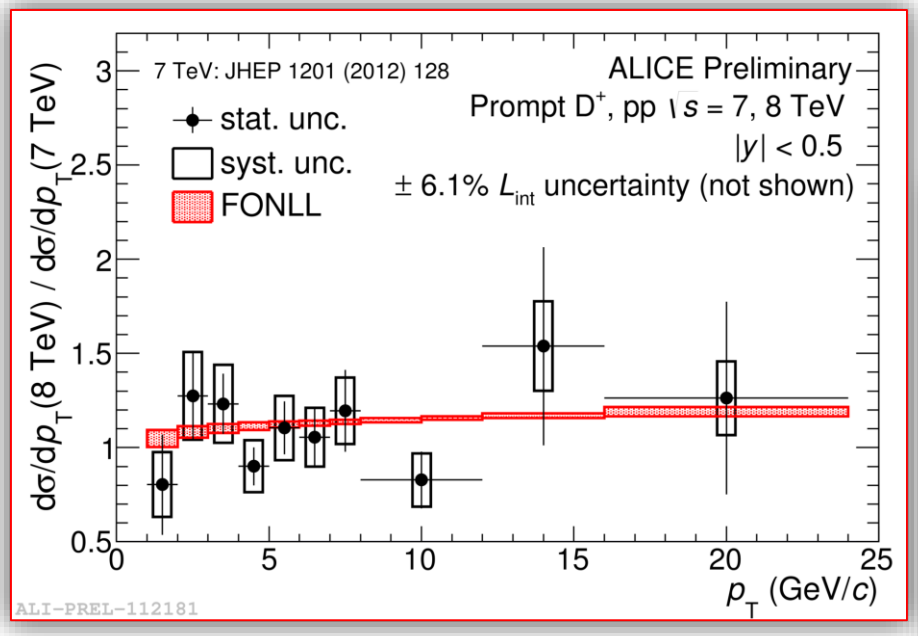
D^{*+}/D^{+} cross section ratio @ 8 TeV



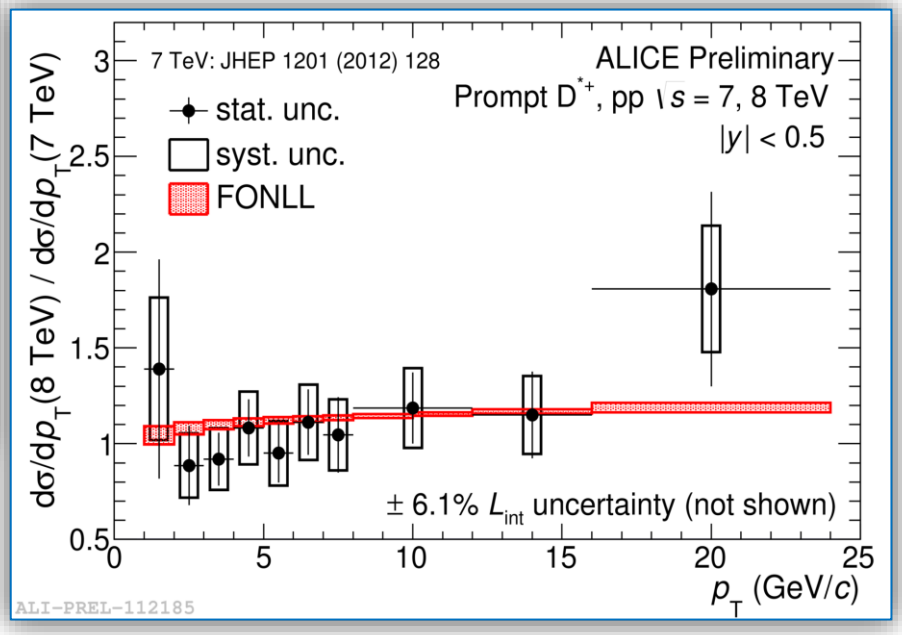
- D^{*+} and D^{+} compared to each other and with FONLL predictions
- The ratio of the production cross section is compatible with the predicted ratio by FONLL

Comparison to 7 TeV results

ALICE 2010 data, pp collisions at $\sqrt{s}$ = 7 TeV
JHEP 1201 (2012) 128



D+



D*+

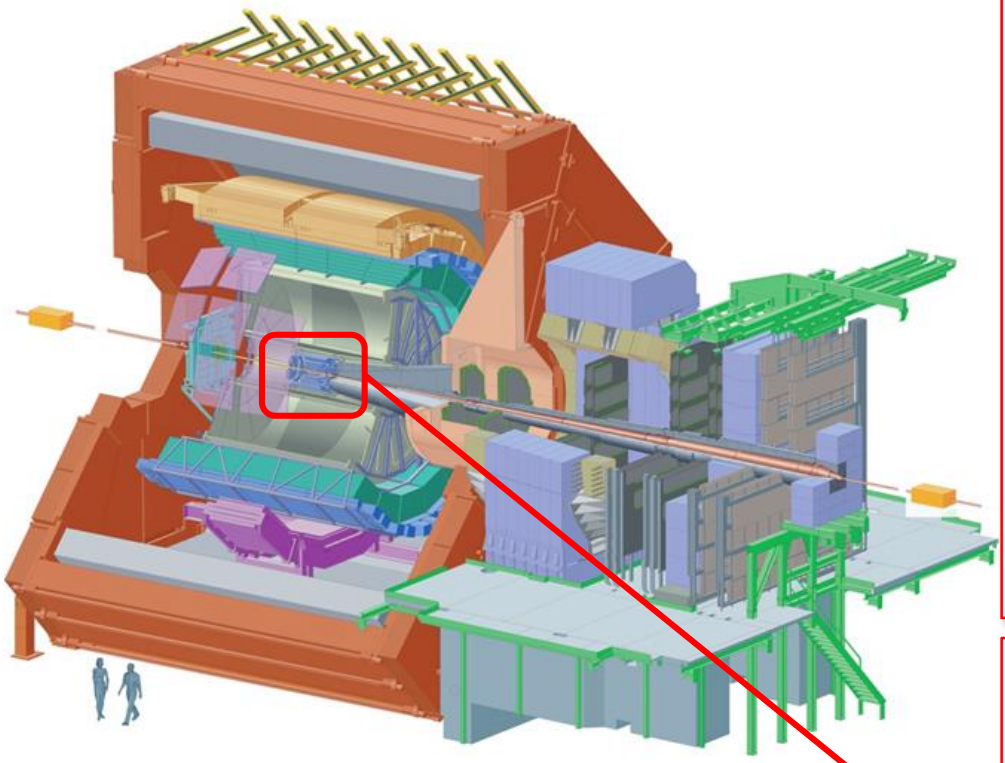
Within the statistical fluctuations, the 8 TeV and 7 TeV results are fully compatible

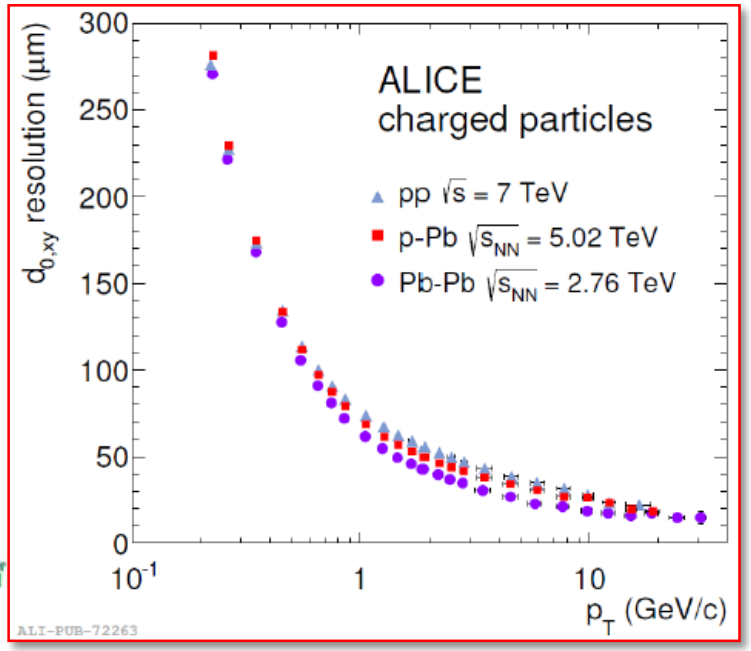
Conclusions

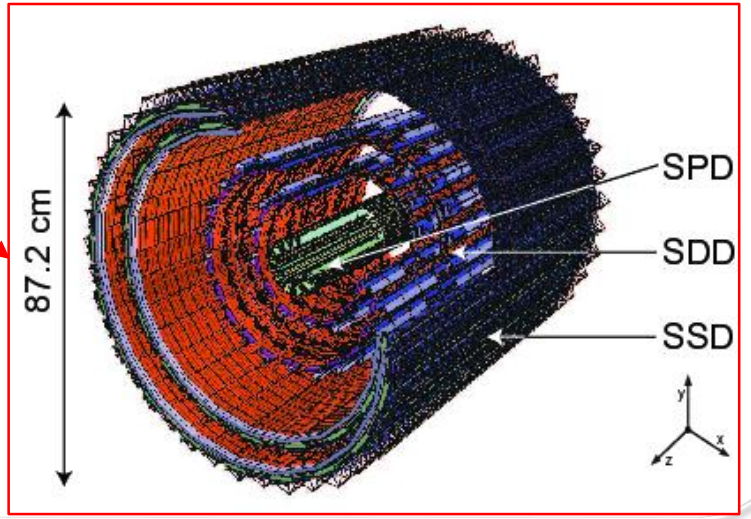
- The production cross section of D^{*+} and D^{+} was measured by ALICE in pp collisions at 8 TeV in the transverse momentum range $1 < p_T < 24$ GeV/c
- The results of D^{+} and D^{*+} mesons are consistent
- D-meson p_T-differential production cross sections are well described by pQCD calculations: agreement within uncertainties with the FONLL calculations
- The cross section evolution with the center-of-mass energy, as shown by the comparison of the 8 TeV results with the 7 TeV published cross sections, is well predicted by FONLL calculations
- The analysis of the $D^{0} \rightarrow K^{-}\pi^{+}$ channel is ongoing: stay tuned for the results!

Backup slides

The ALICE detector - ITS



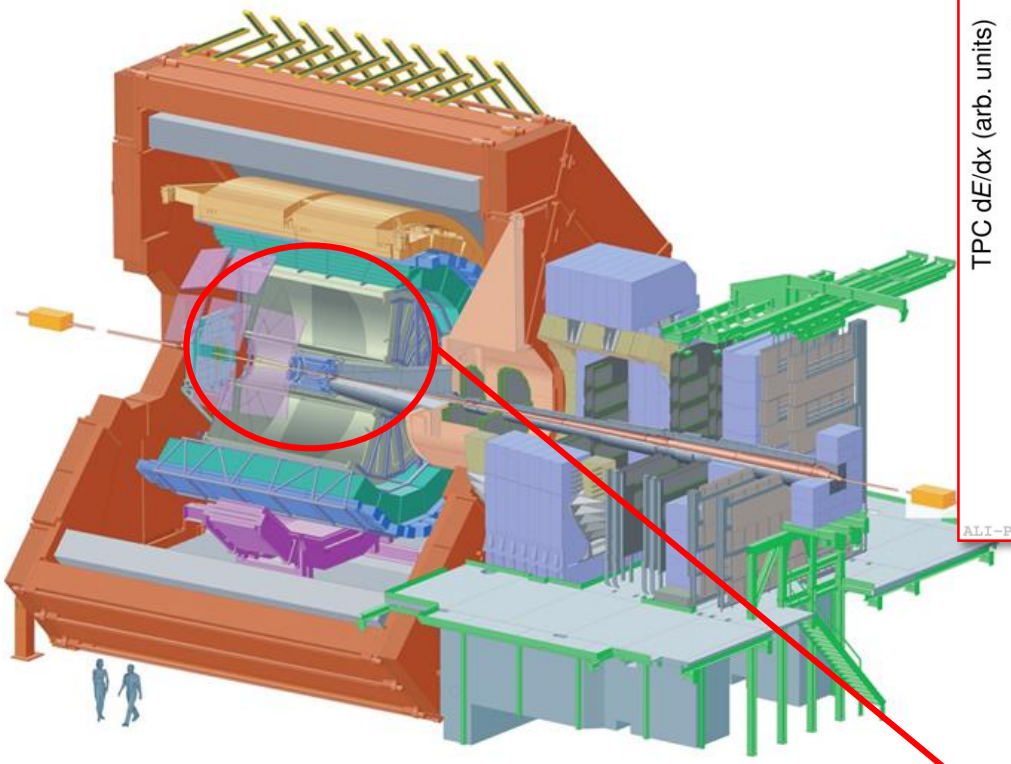


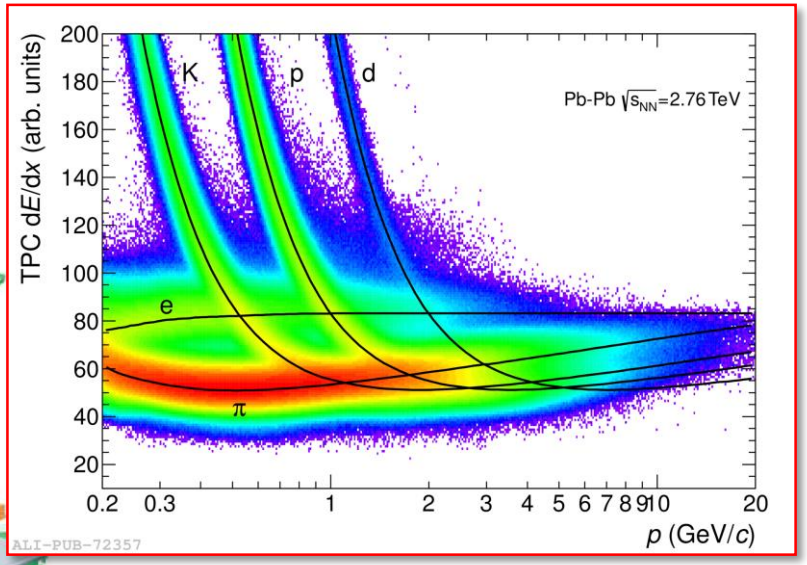


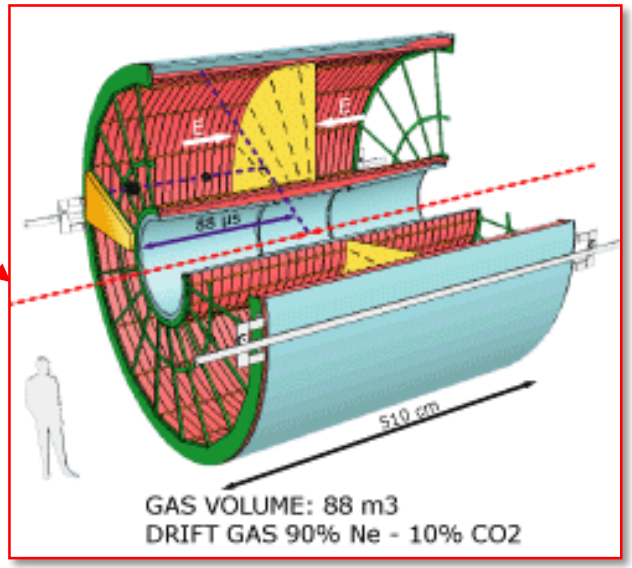
Inner Tracking System

- ✓ Vertex reconstruction
- ✓ Tracking

The ALICE detector - TPC



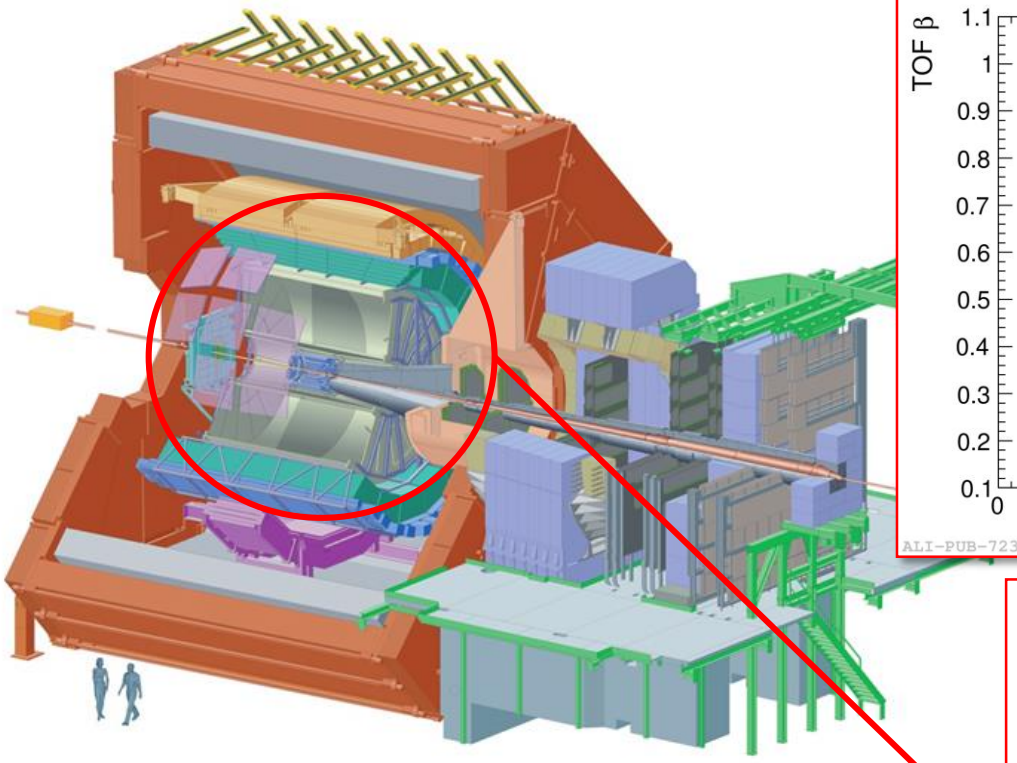


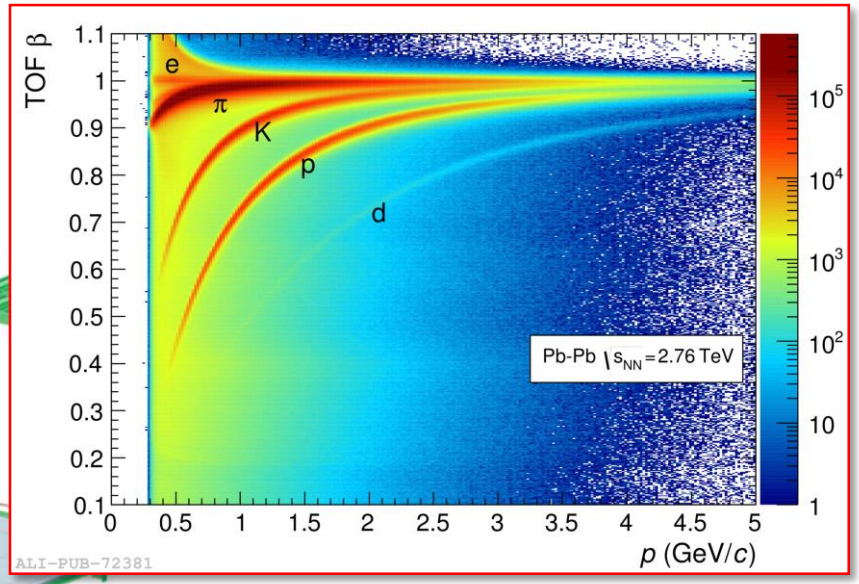


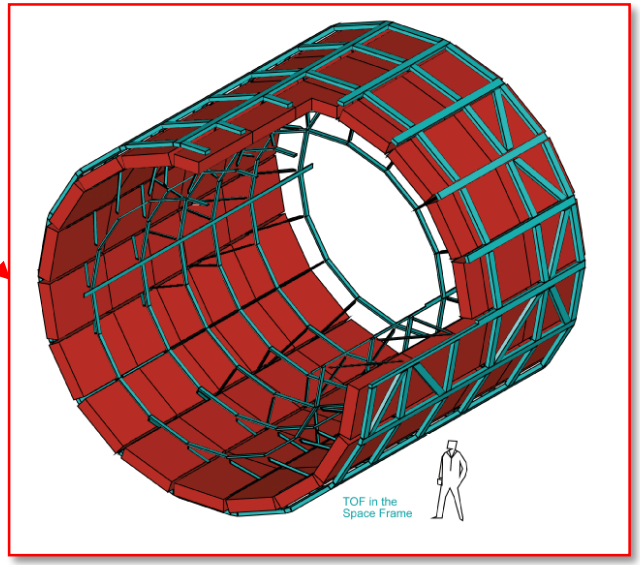
Time Projection Chamber

- ✓ Tracking
- ✓ Particle identification

The ALICE detector - TOF







Time Of Flight

✓ Particle identification

Efficiency correction

- Prompt D-meson production yields obtained by correcting the raw yields for the **acceptance x efficiency**
- Correction factor determined both for prompt D-mesons and for the feed-down from B-meson decays
- B decays are more displaced from the primary vertex ($c\tau$ 500 μm): feed-down D-mesons more efficiently selected by topological cuts
- Efficiencies were computed using Monte Carlo simulations, configured to reproduce:
  - the hadronic decays channels of interest for the analysis
  - the multiplicity distributions observed in data
  - the conditions of the luminous region
  - the ALICE subsystems, in terms of active electronic channels, calibration, time evolution during the data taking

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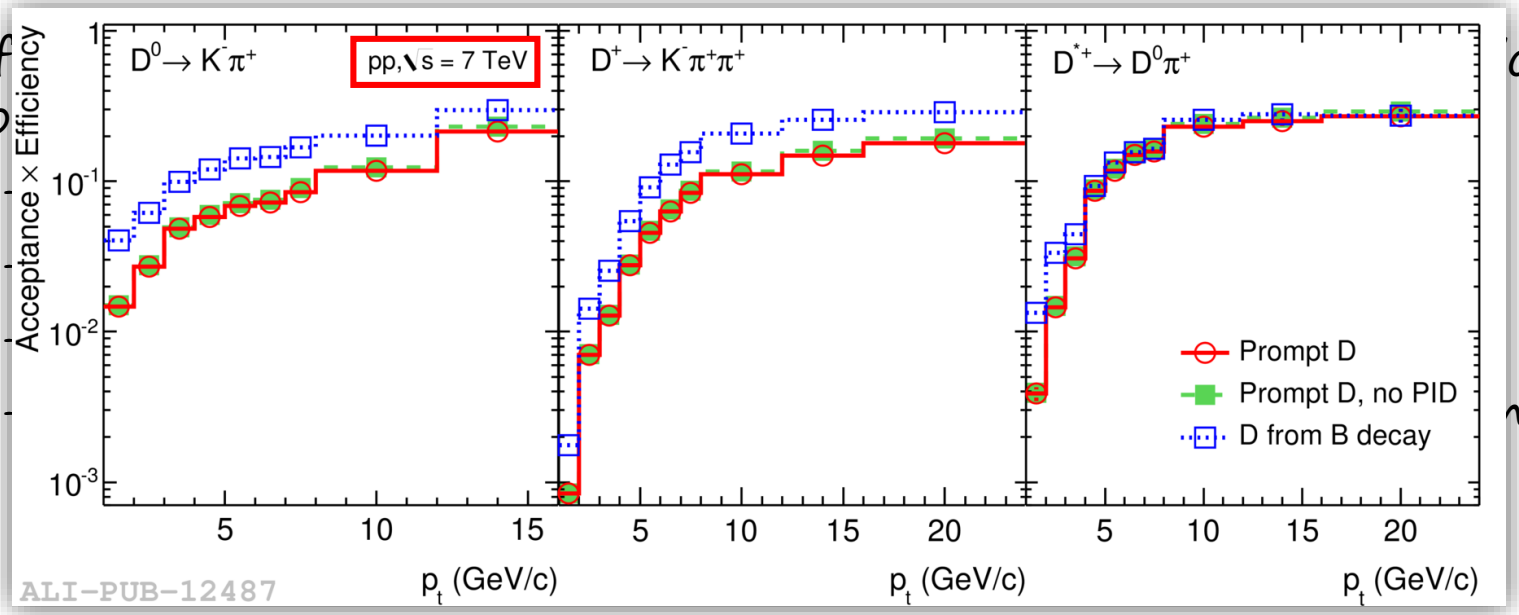
- Ef ons, co nels,



CERN-PH-EP2011-181 – arXiv:1111.1553v2

Systematic uncertainties

Sources of systematic uncertainties investigated in this analysis:

- Raw yield extraction from the invariant mass distributions
- Particle identification (PID) strategy
- Cut variation (topological selection criteria)
- p_T shape of the generated D in the MC
- Tracking efficiency
- Feed-down subtraction

p_T	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-10	10-12	12-16	16-24
Raw Yield extraction	8	6	3	3	3	3	3	2	2	2	2
PID	0	0	0	0	0	0	0	0	0	0	0
Cut Variation	10	10	5	5	5	5	1	1	1	1	1
p_T shape	2	2	1	1	0	0	0	0	0	0	0
Tracking	9	9	9	9	9	9	9	9	9	9	9
feed-down above	4	3	3	2	3	2	2	1	2	2	1
feed-down below	50	17	11	7	6	6	3	5	5	6	8

Systematic uncertainty evaluated for the D^{*+} meson