Charm production at mid-rapidity in ALICE via D meson reconstruction

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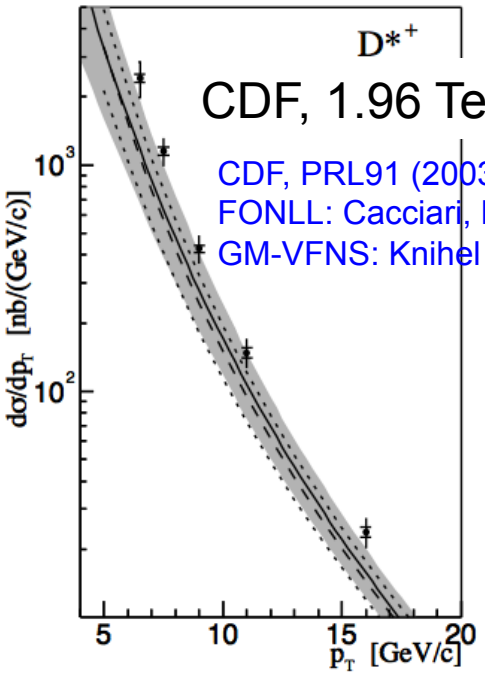
on behalf of the ALICE Collaboration

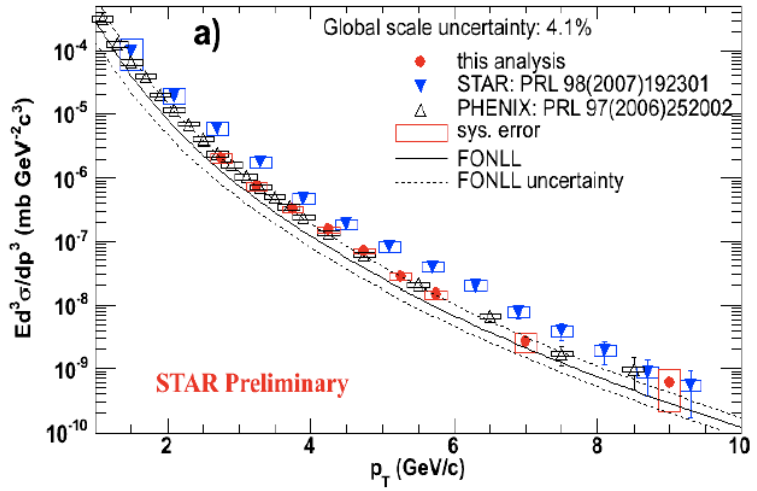
Outline

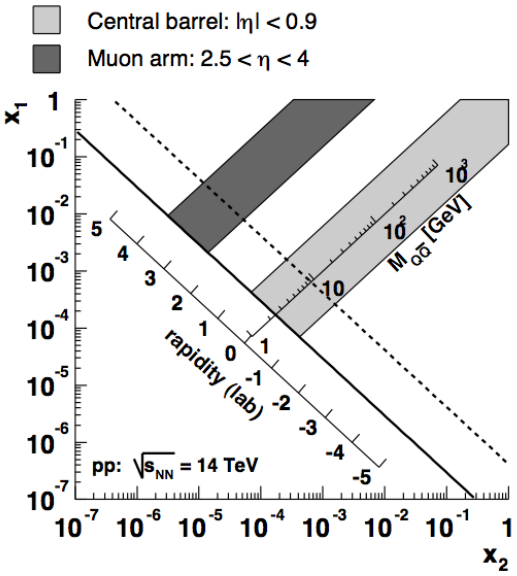
- Introduction
- D meson reconstruction in the ALICE central barrel
  - vertexing
  - particle identification
- D^0 and D^+ production measurement
  - signal selection
  - corrections and systematic errors
- Ongoing analyses: D* and other charm hadrons
- Prospects for Pb-Pb
- Summary

Introduction: charm in pp at LHC

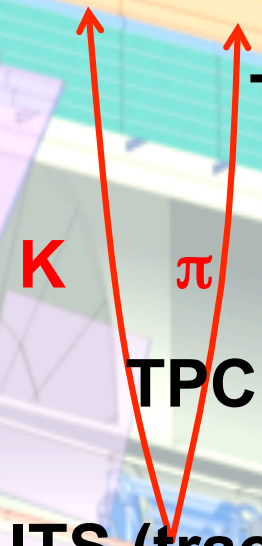
- Important test of pQCD in a new energy domain ($3.5 \times \sqrt{s}_{TEVATRON}$)
  - c production on the upper side of prediction, at Tevatron and RHIC
- Ultimately, ALICE aims at measuring charm production below 1 GeV/c
  - Probe gluon PDF down to $x_{Bjorken} \sim 10^{-4}$
  - Does the factorization approach still hold? Gluon saturation? Non-linear effects in PDF evolution?
- Reference for heavy quark quenching studies in Pb-Pb





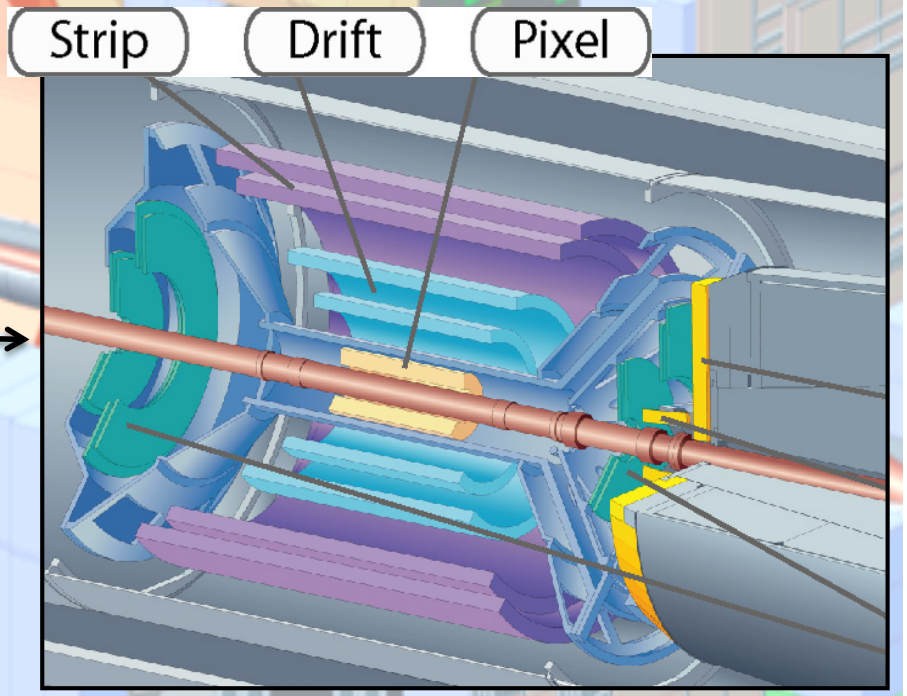


Charm reconstruction in the ALICE barrel, $|\eta|<0.9$



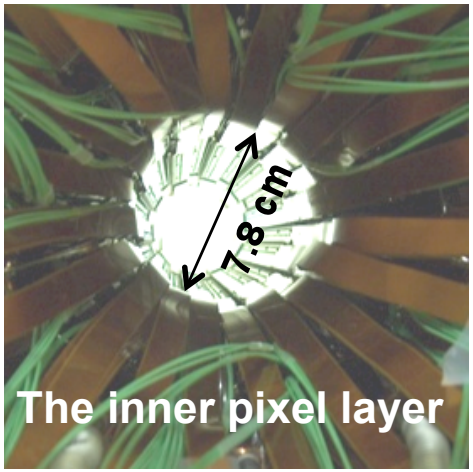
ITS (tracking & vertexing)

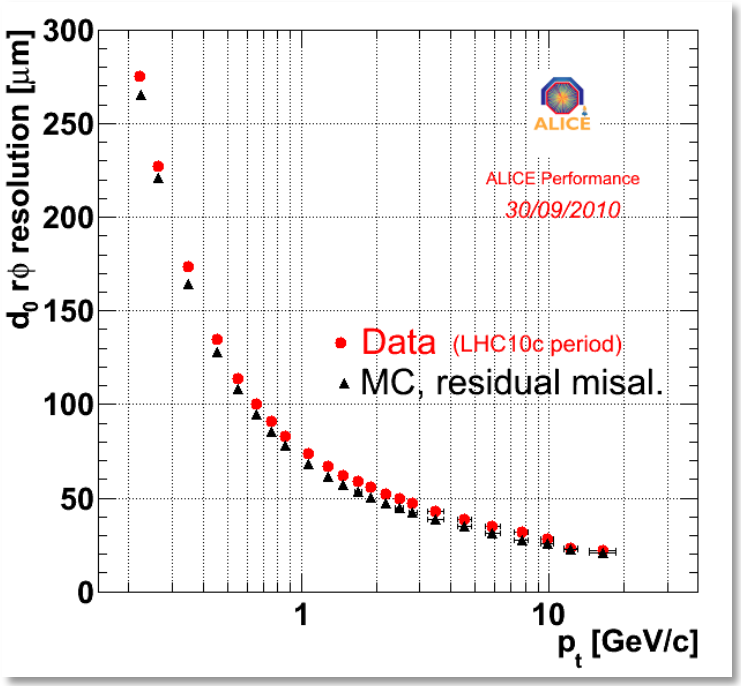
- ✓ $D^0 \rightarrow K\pi$
- $D^+ \rightarrow K\pi\pi$
- $D^* \rightarrow D^0\pi$
- $D_s \rightarrow KK\pi$
- $D^0 \rightarrow K\pi\pi\pi$
- $\Lambda_c \rightarrow \pi Kp$

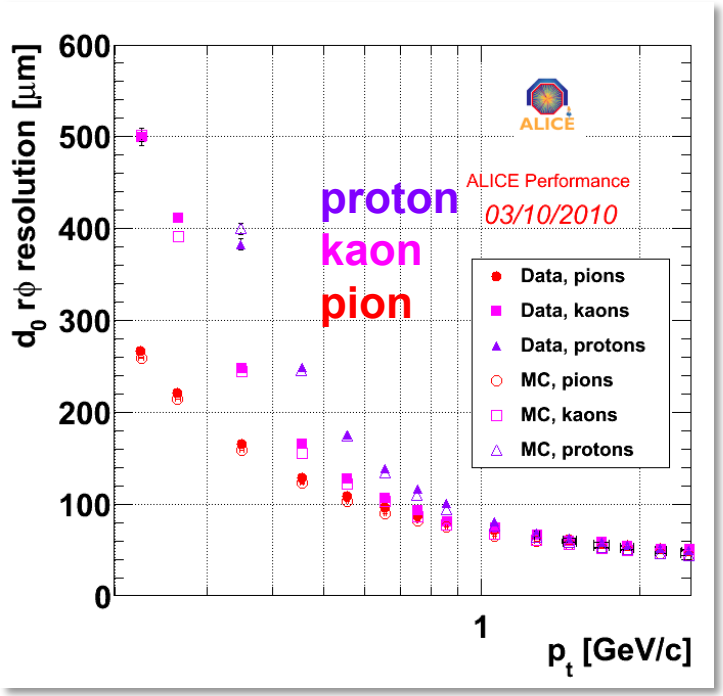


D meson reconstruction in ALICE

- Main selection: displaced-vertex topology
- Tracking and vertexing precision is crucial here
- Inner Tracking System (ITS) was aligned using cosmics and collisions
  - current resolution for pixels: 14 μm (nominal: ≈11 μm)
  - rφ impact parameter resolution of 75 μm at 1 GeV/c
  - particle-mass dependence well understood

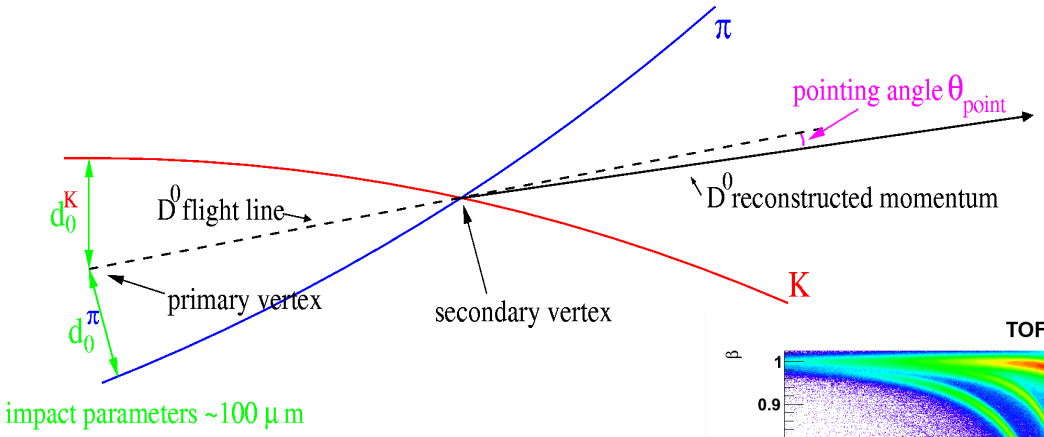


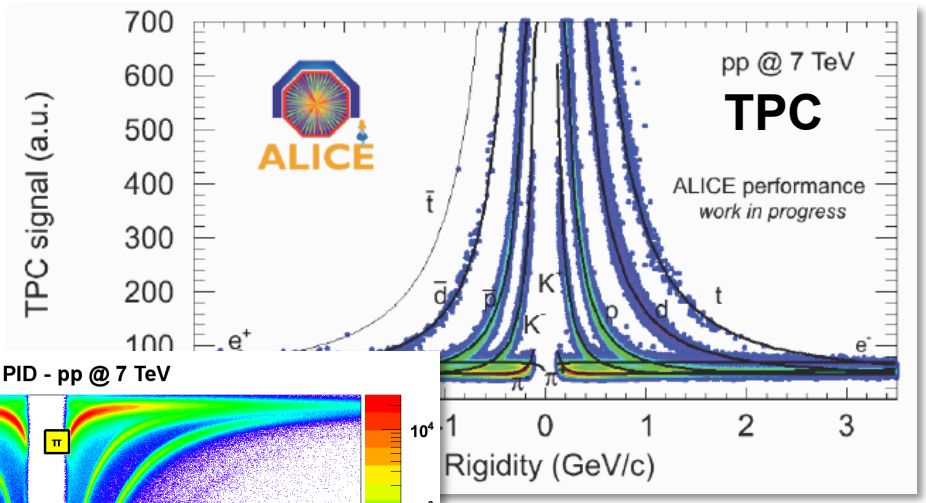


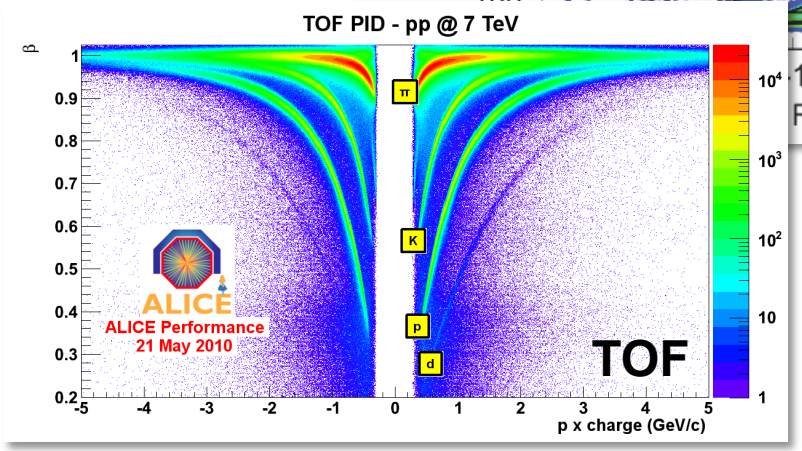


D meson reconstruction in ALICE

- Main selection: displaced-vertex topology
- Example: $D^0 \rightarrow K^-\pi^+$
  - good pointing of reconstructed D momentum to the primary vertex
  - pair of opposite-charge tracks with large impact parameters
- K ID in TPC+TOF helps in rejecting background at low p_t

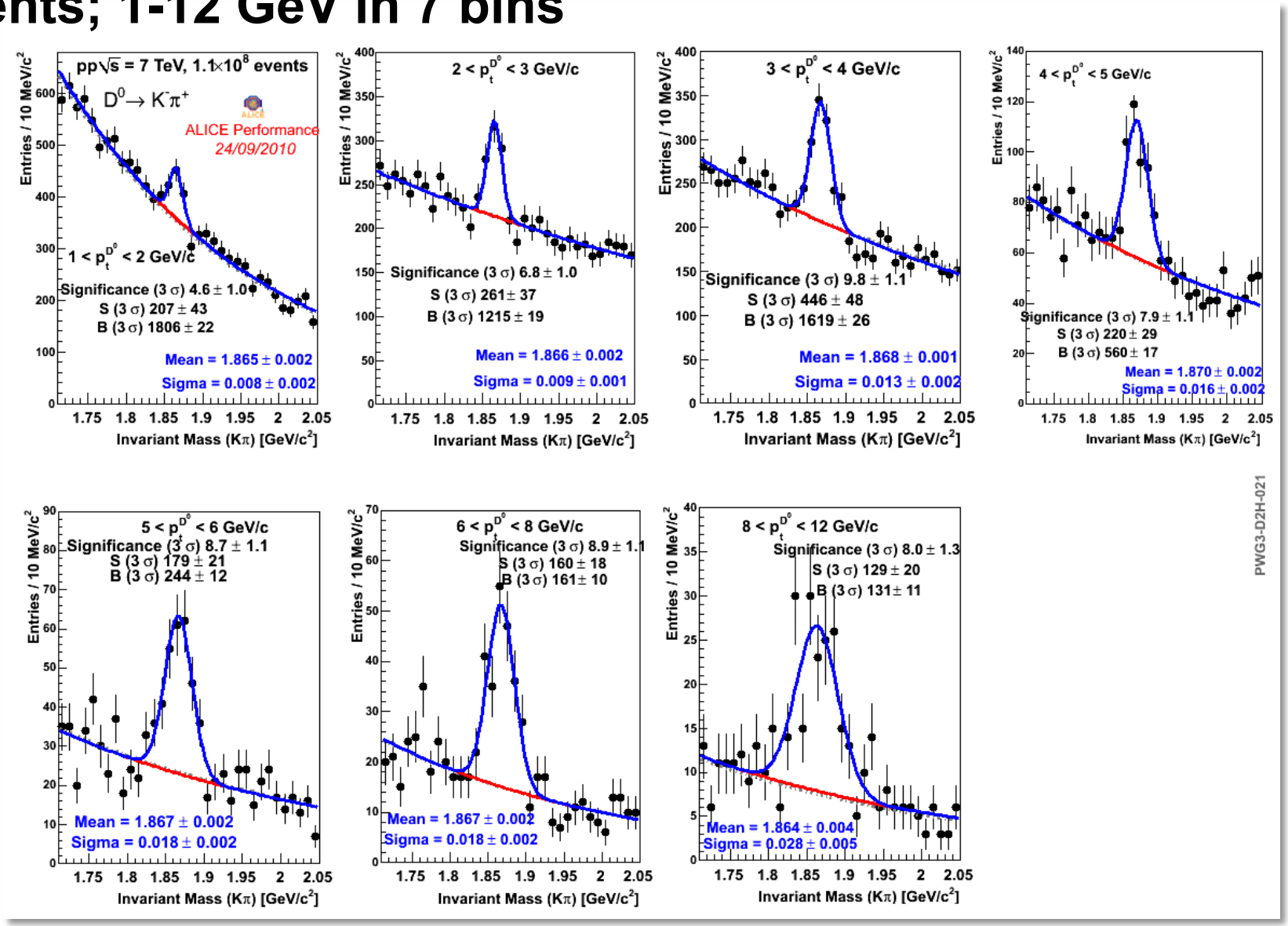






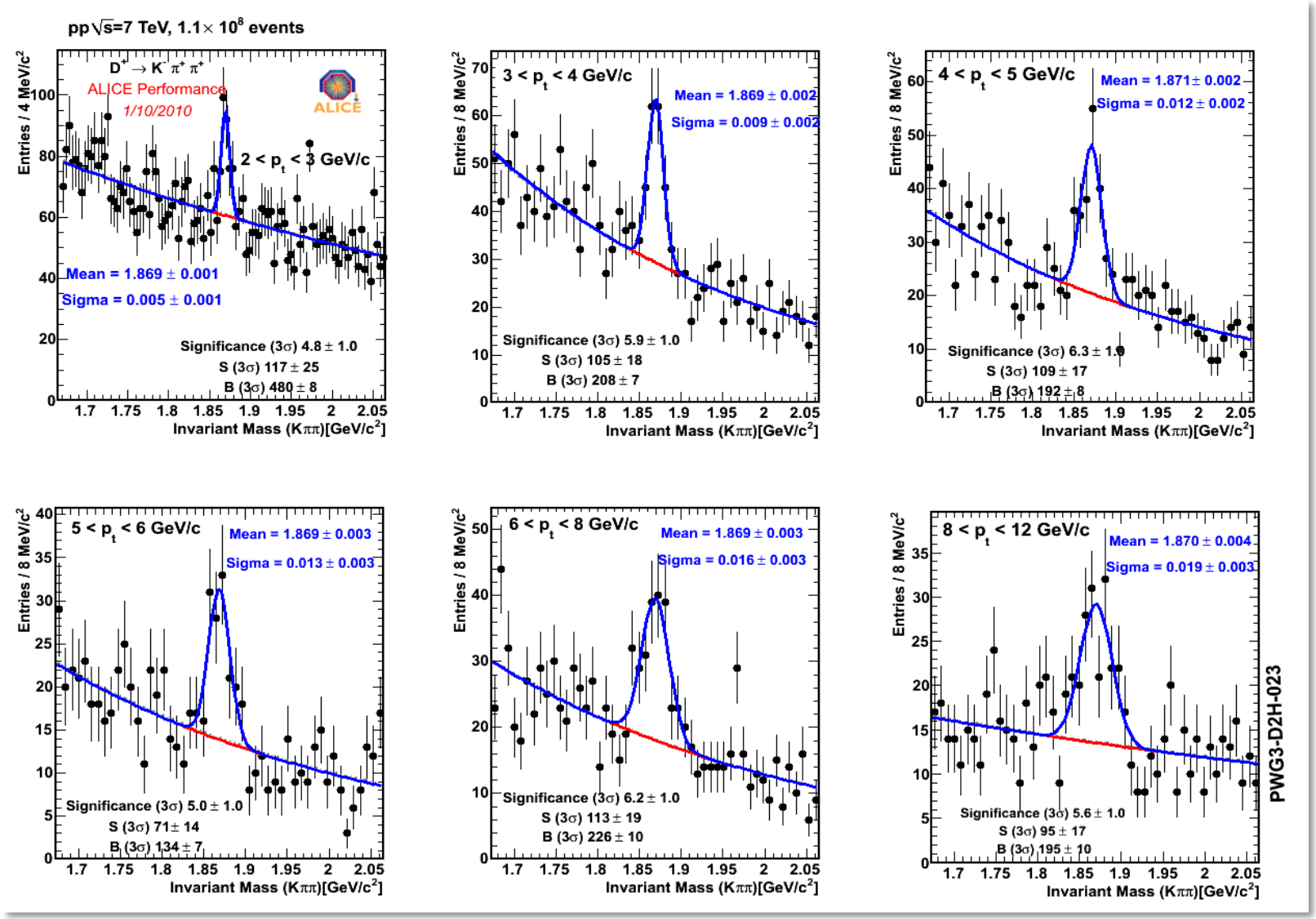
Signals: $D^0 \rightarrow K^-\pi^+$

10^8 events; 1-12 GeV in 7 bins



Signals: $D^+ \rightarrow K^-\pi^+\pi^+$

10^8 events; 2-12 GeV in 6 bins

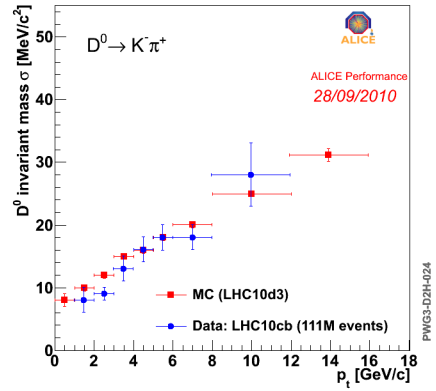


D mesons: from signals to cross sections

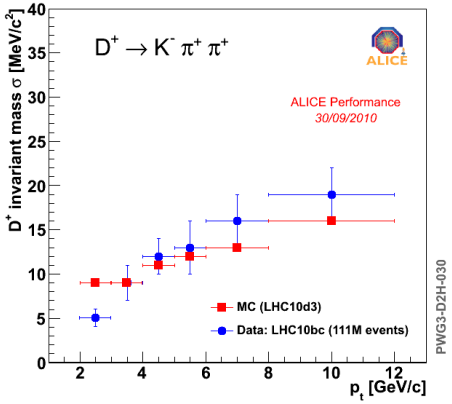
- Corrections: 1) efficiency 2) feed-down B→D
  - then, normalization to cross section, using σ_{MB} from VdM scan
- But first: data-MC comparisons
  - detector response well described in MC

D^0:

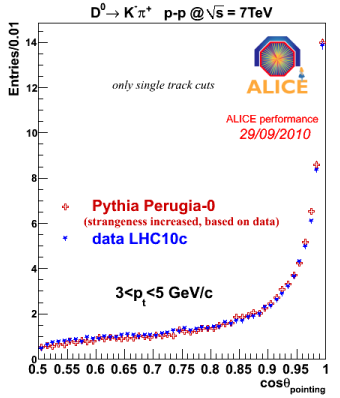
mass resolution

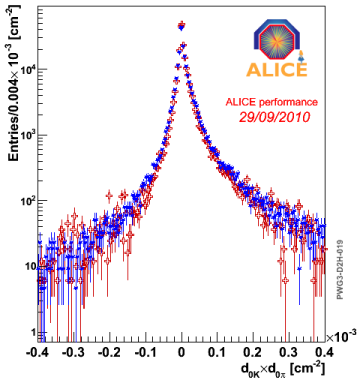


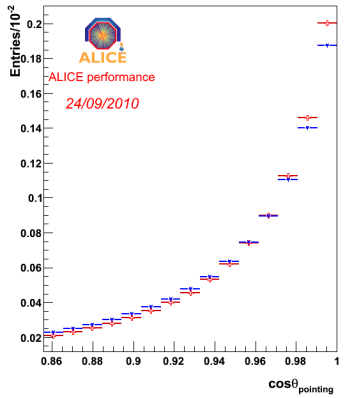
D^+:

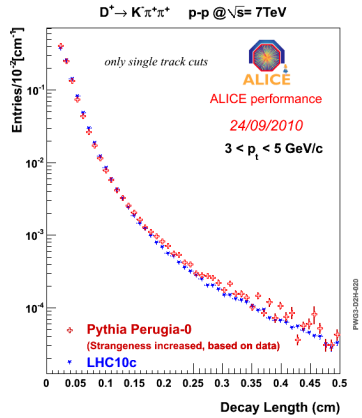


cut variables



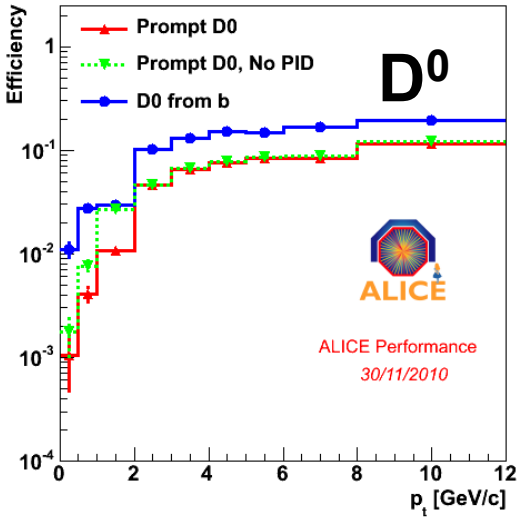


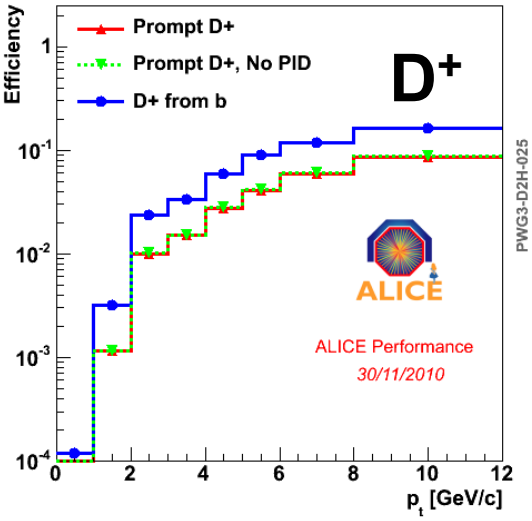




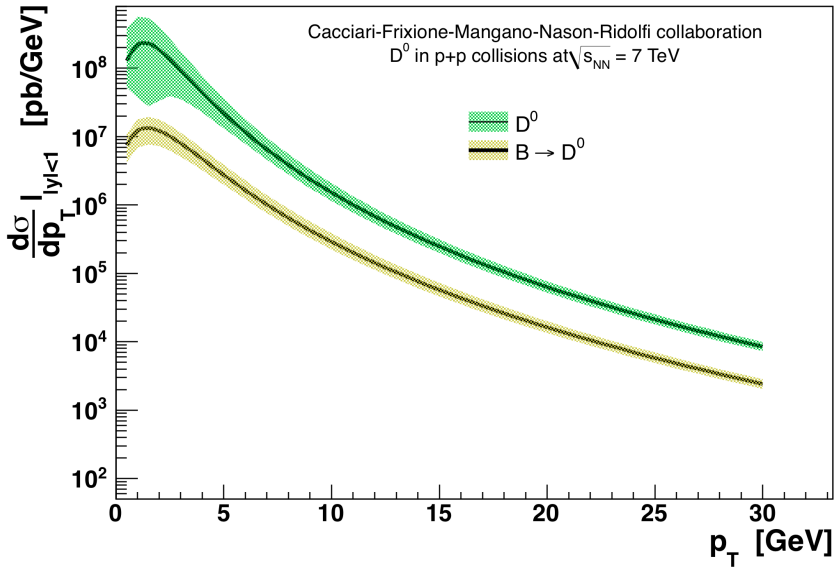
D mesons: from signals to cross sections

- Corrections: 1) efficiency
  - 1% → 10% from low to high p_t
  - factor 1.5 larger for B feed-down D mesons



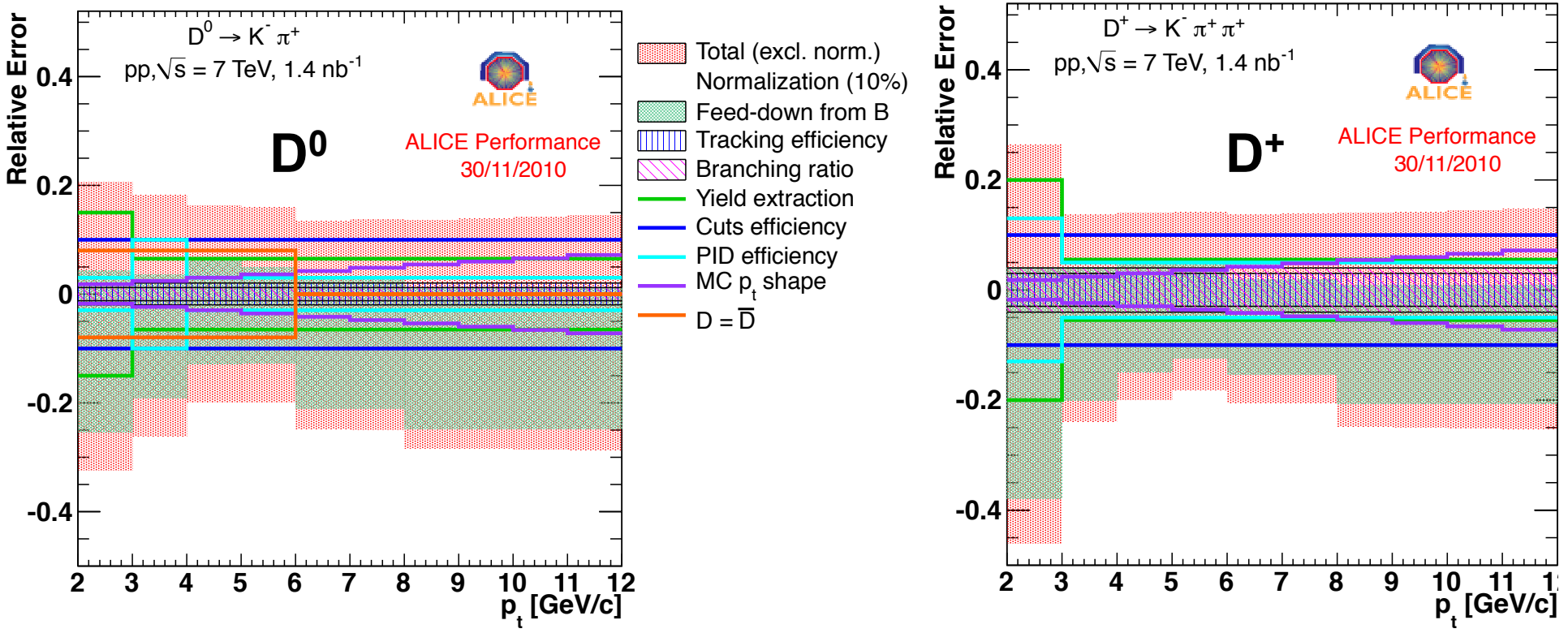


- Corrections: 2) feed-down B→D: ~10-15%
  - for now, subtract using FONLL B→D predictions
    - FONLL describes well B production at Tev and LHC
  - with full 2010 statistics will be corrected based on data (D displacement to vertex, à la CDF)

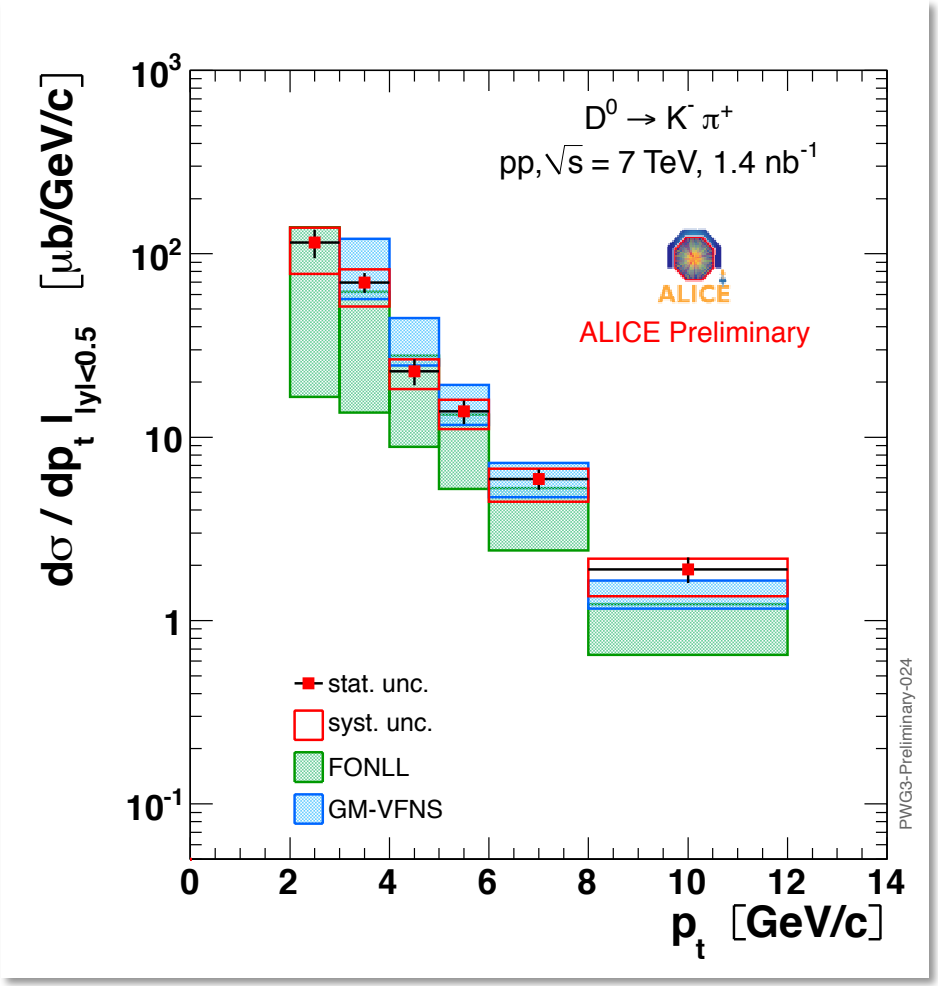


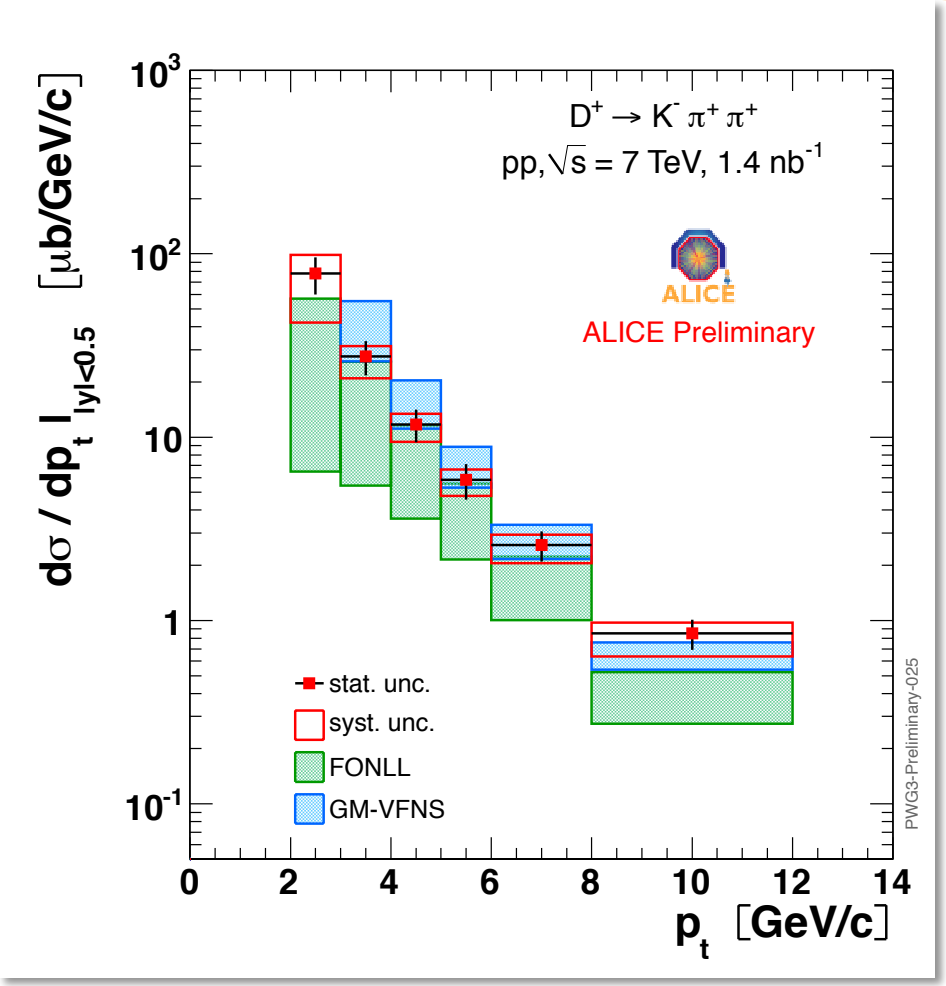
Systematic Uncertainties

- Total systematic 20-40% p_t-dep. + 10% on σ_{MB} (VdM scan)
- Main systematic error: B feed-down from FONLL + ALICE-MC
  - conservative estimate of error
    - FONLL uncertainty (small for B) +
    - two methods considered (subtr. of D from B, fraction of prompt D)
  - to be reduced using data-driven method with full 2010 statistics



D^0 and D^+ $d\sigma/dp_t$, $|y|<0.5$, pp 7 TeV



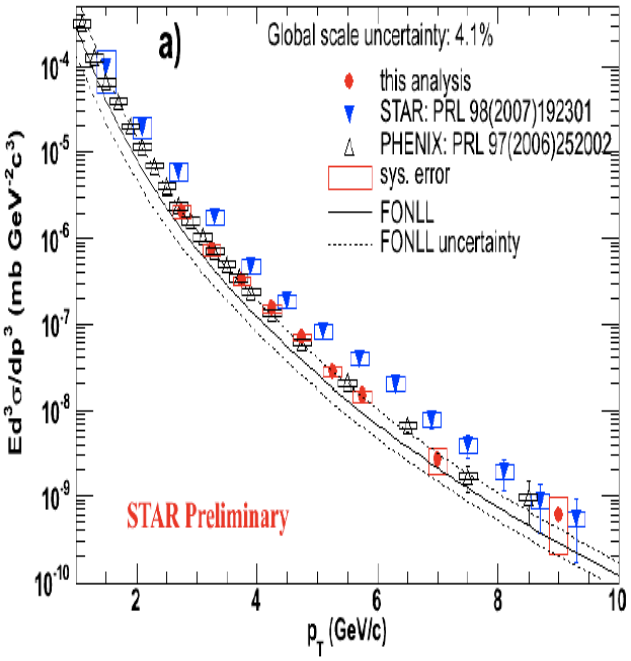


- $2 < p_t < 10$ GeV/c, with 1.4 nb^{-1} (~20% of 2010 statistics)
- y acceptance is p_t-dep ($\Delta y \sim 0.5 \rightarrow 0.8$): data scaled to $|y|<0.5$
- pQCD predictions (FONLL and GM-VFNS) compatible with our data

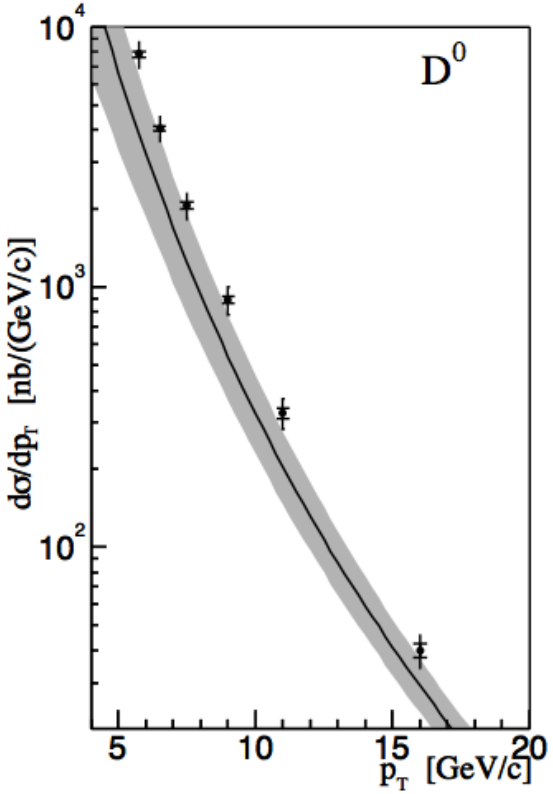
Charm at y~0 from 0.2 to 7 TeV

- Similar trend over ×35 in √s: charm on the high side of the predictions

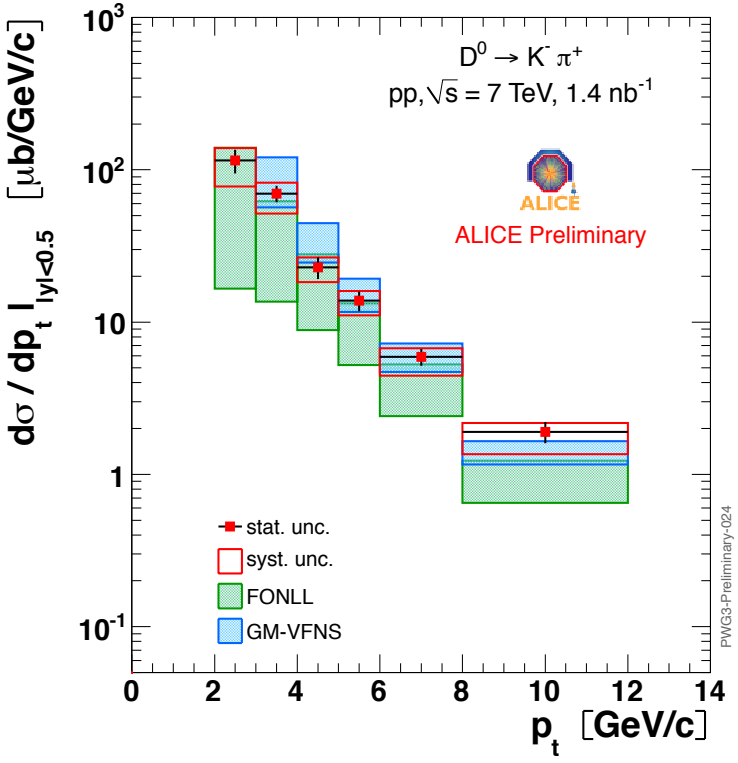
RHIC 0.2 TeV



Tevatron 1.96 TeV



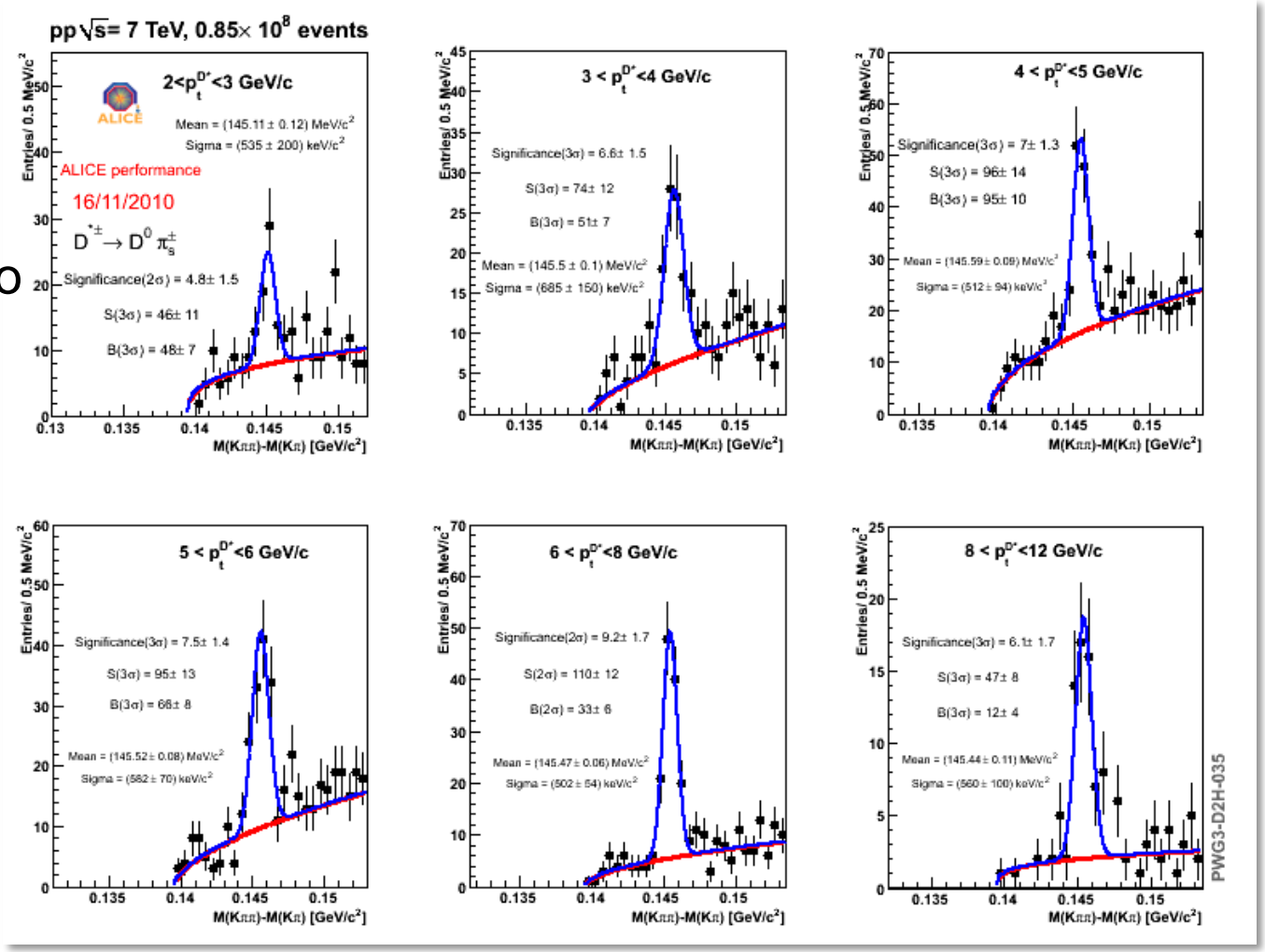
LHC 7 TeV



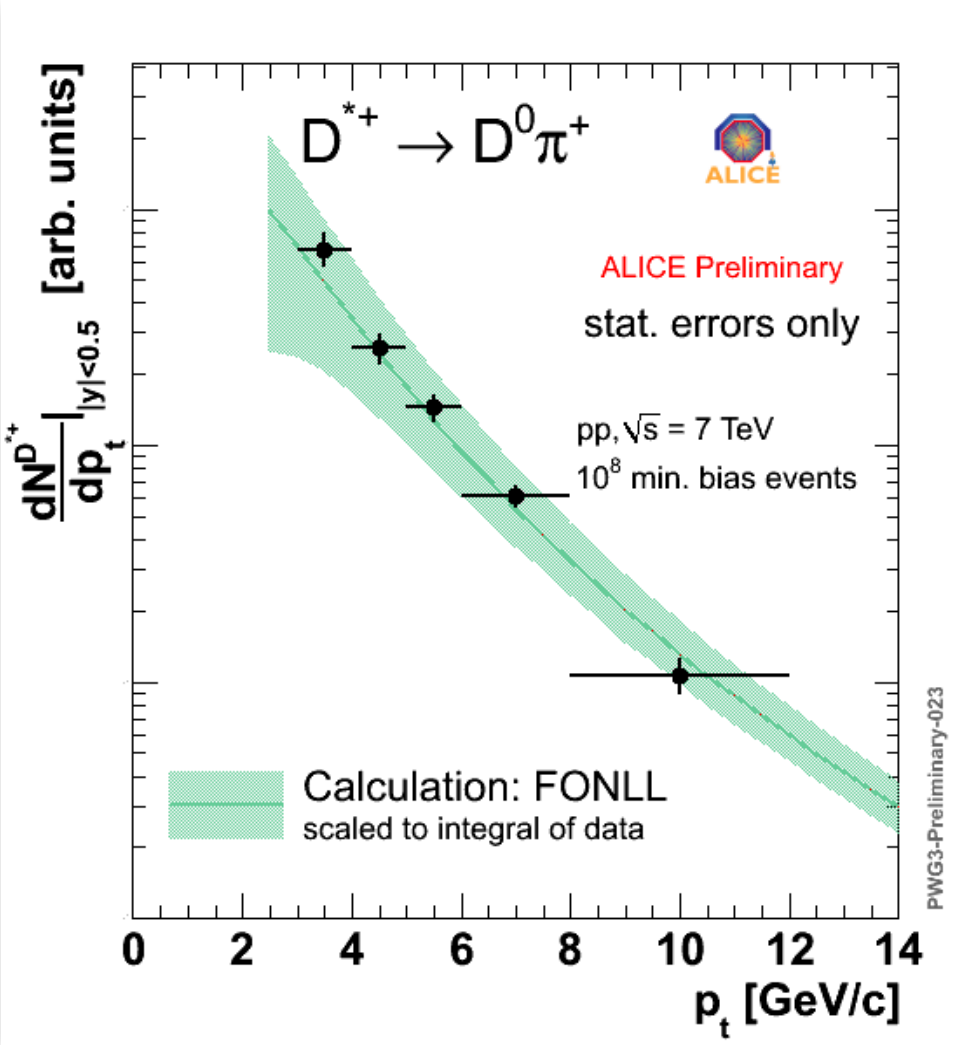
Coming soon: D^{*+}

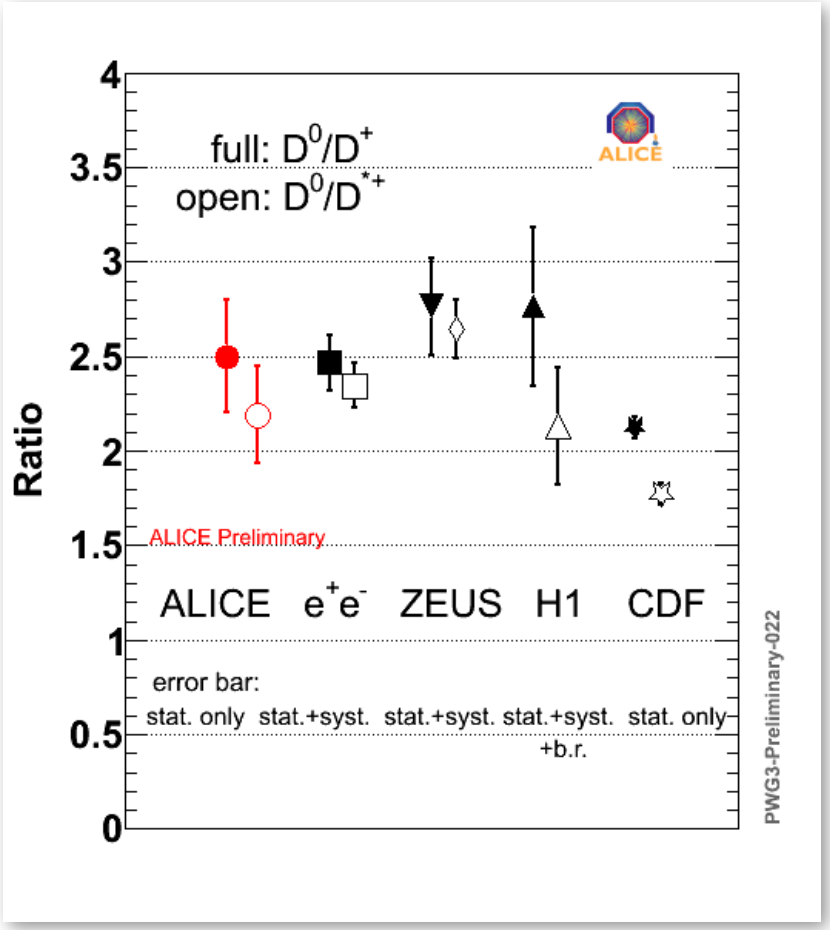
$D^{*+} \rightarrow D^0\pi^+$
2-12 GeV/c

- Soft pion reconstruction down to 100 MeV/c using ITS as standalone tracker
- Evaluation of systematics ongoing



D^{*+} dN/dp_t and D ratios



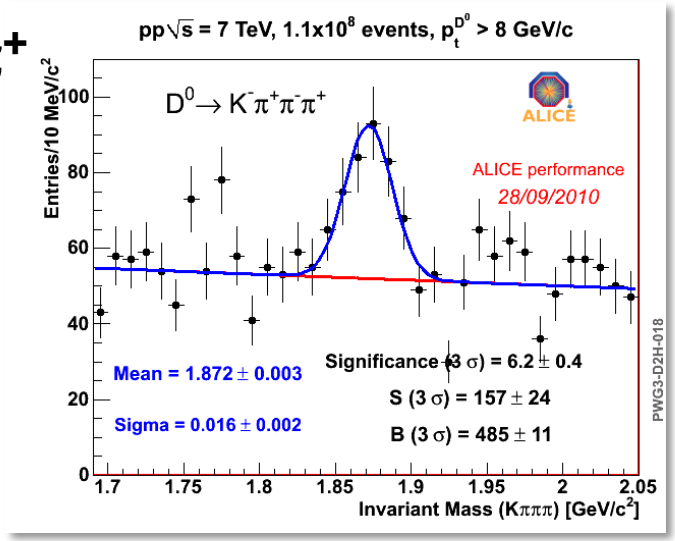


- Only statistical errors
- Shape compares well with pQCD (FONLL)

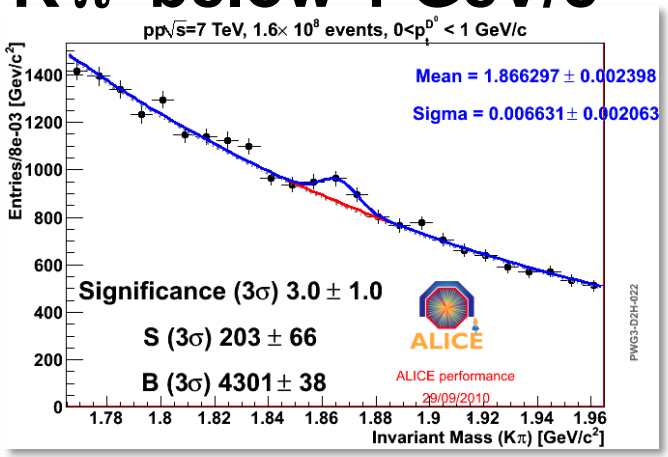
ee, H1, ZEUS: JHEP07 (2007) 074
CDF: PRL 91 (2003) 241804

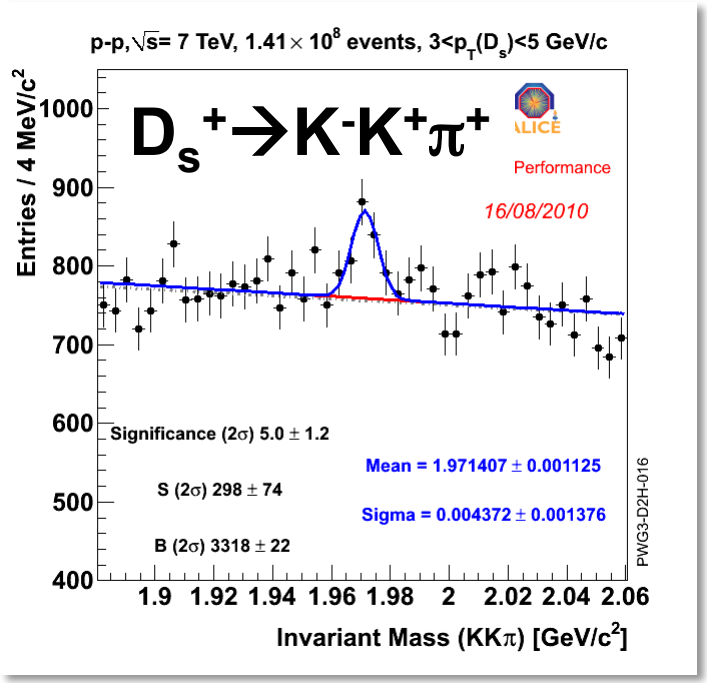
Other ongoing analyses:

$D^0 \rightarrow K^-\pi^+\pi^+\pi^+$



$D^0 \rightarrow K^-\pi^+$ below 1 GeV/c

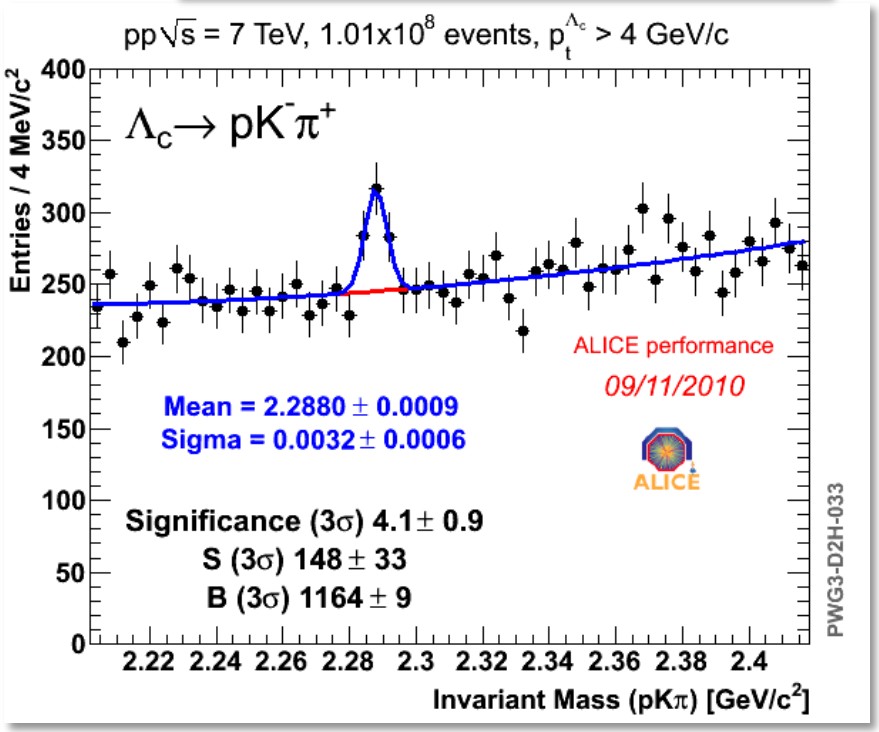




$\Lambda_c^+ \rightarrow pK^-\pi^+$

($c\tau$ = 60 μm)

π/K/p ID crucial here!



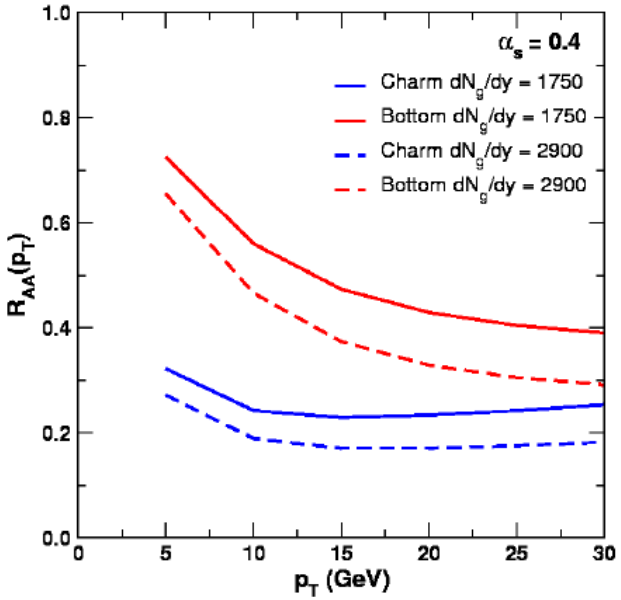
Prospects for Pb-Pb

- NLO predictions (**charm** & **beauty**)
  - ~ factor 2 uncertainty from NLO and shadowing (Pb-Pb)

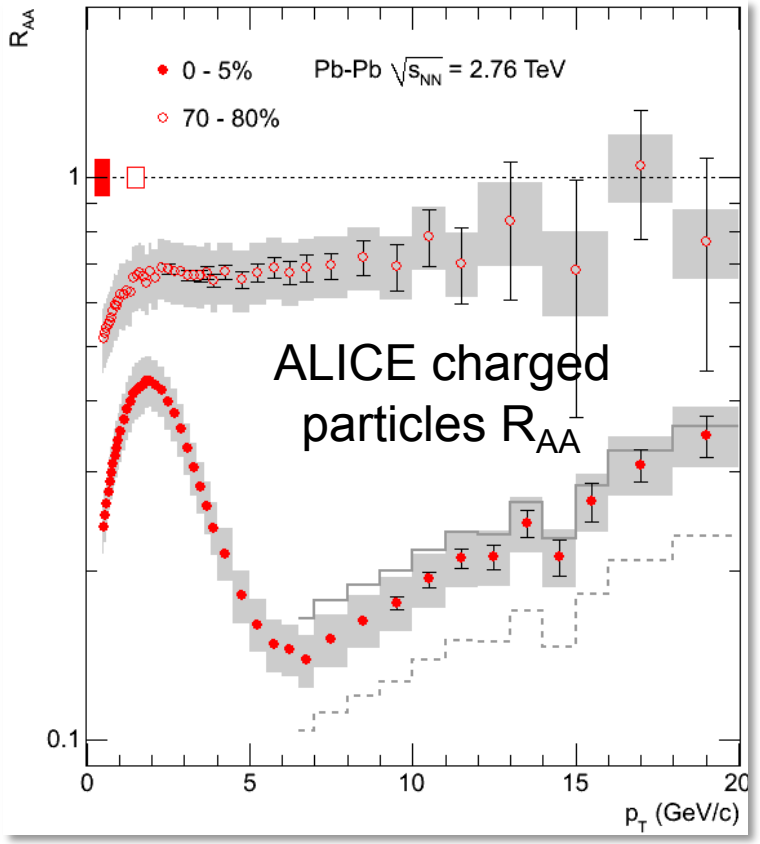
MNR code: Mangano, Nason, Ridolfi, NPB373 (1992) 295.
EKS98, EPS08: Eskola et al., EPJC9 (1999) 61; JHEP07 (2008) 102

system : $\sqrt{s_{NN}}$:	Pb-Pb (0-5%) 5.5 TeV	**Pb-Pb (0-5%) 2.76 TeV**
$N_{tot}^{Q\bar{Q}}$	90 / 3.7	**56 / 2**

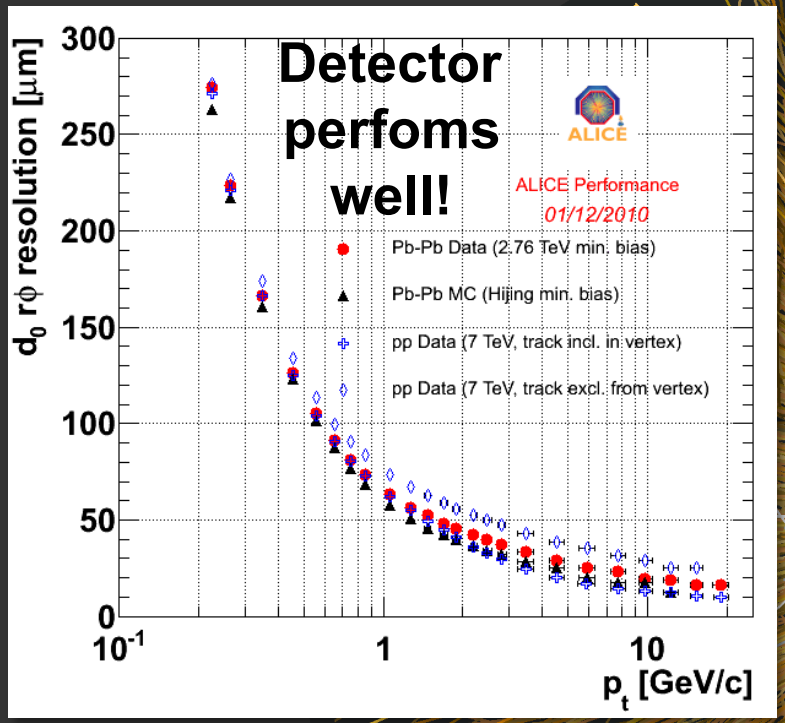
- Energy loss based predictions: factor 5 suppression for D mesons (R_{AA}~0.2)



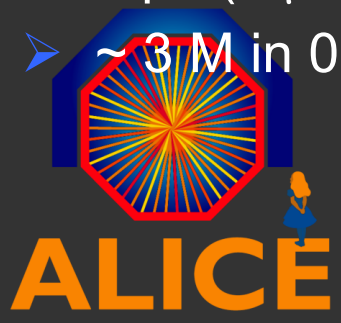
Wicks, Gyulassy, "Last Call for LHC Predictions" workshop



Prospects for Pb-Pb



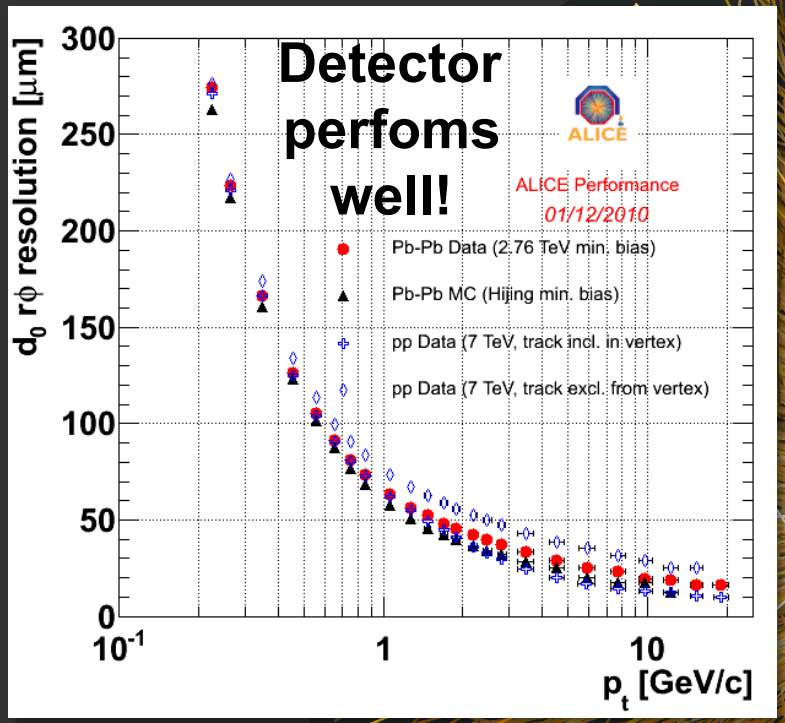
- Since Nov 7:
  - ~ 30 M Pb-Pb inelastic events on tape (4 μm^{-1})
  - ~ 3 M in 0-10% most central

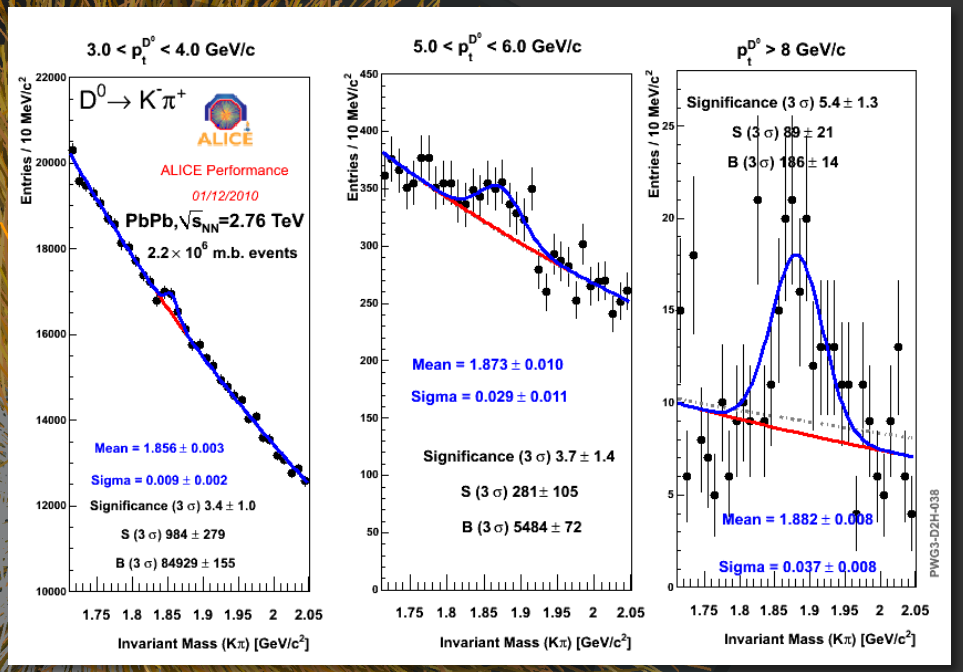


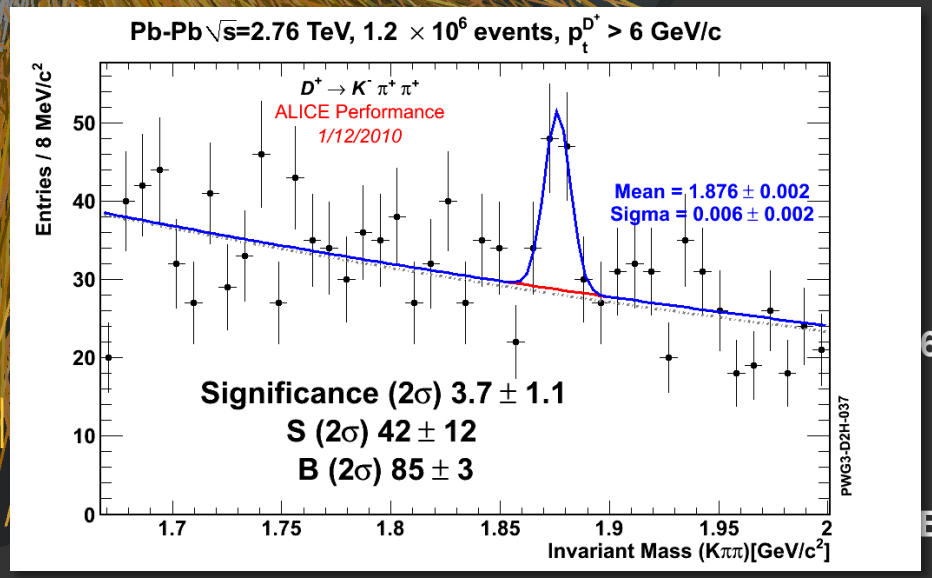
Pb+Pb @ sqrt(s) = 2.76 ATeV

2010-11-08 11:29:52
Fill : 1482
Run : 137124
Event : 0x0000000042B1B693

Prospects for Pb-Pb







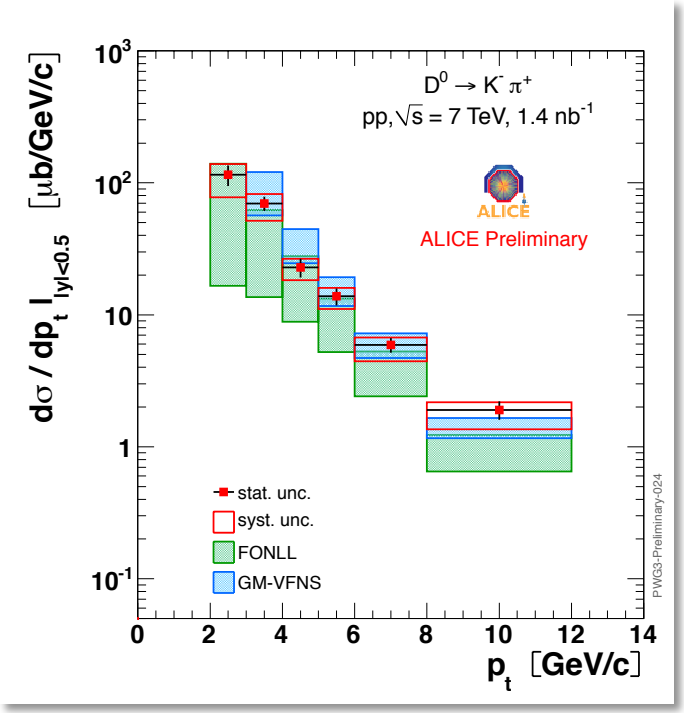
- Since Nov 7:
  - ~ 30 M Pb-Pb inelastic events on tape (4 μm^{-1})
  - ~ 3 M in 0-10% most central

6 ATeV

B1B693

Summary

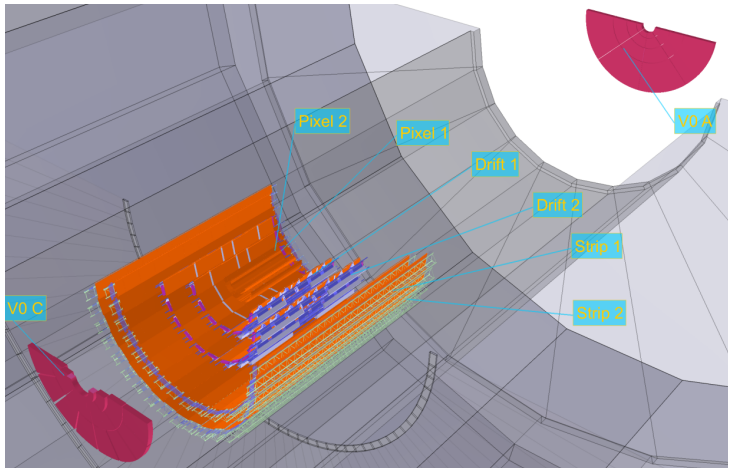
- First D meson cross sections at mid-rapidity at LHC
  - measured in 2-10 GeV/c
  - pQCD predictions agree with data
- Ongoing:
  - increase statistics
  - extend to lower and higher p_t
  - will allow to reduce systematics
  - B-feed-down from data
- Coming soon: D*+
  - promising also: other D^0 channel, D_s, Λ_c



- Will serve as a reference for Pb-Pb studies

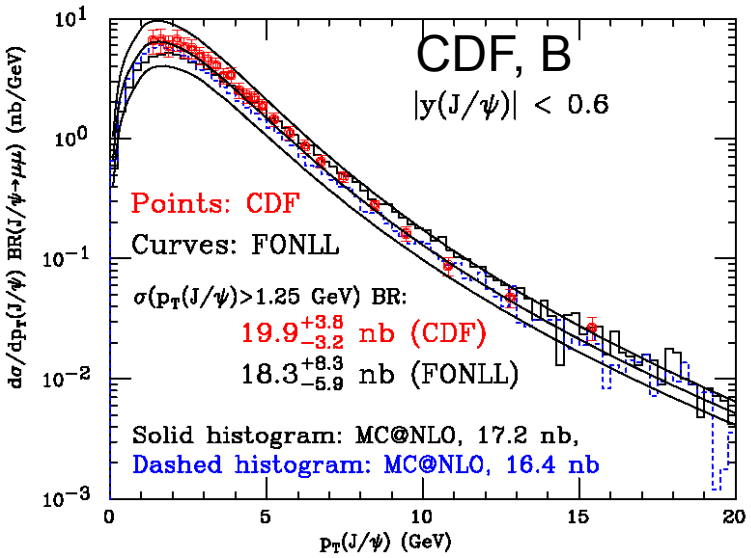
EXTRA SLIDES

Trigger & Data sample, pp 7 TeV



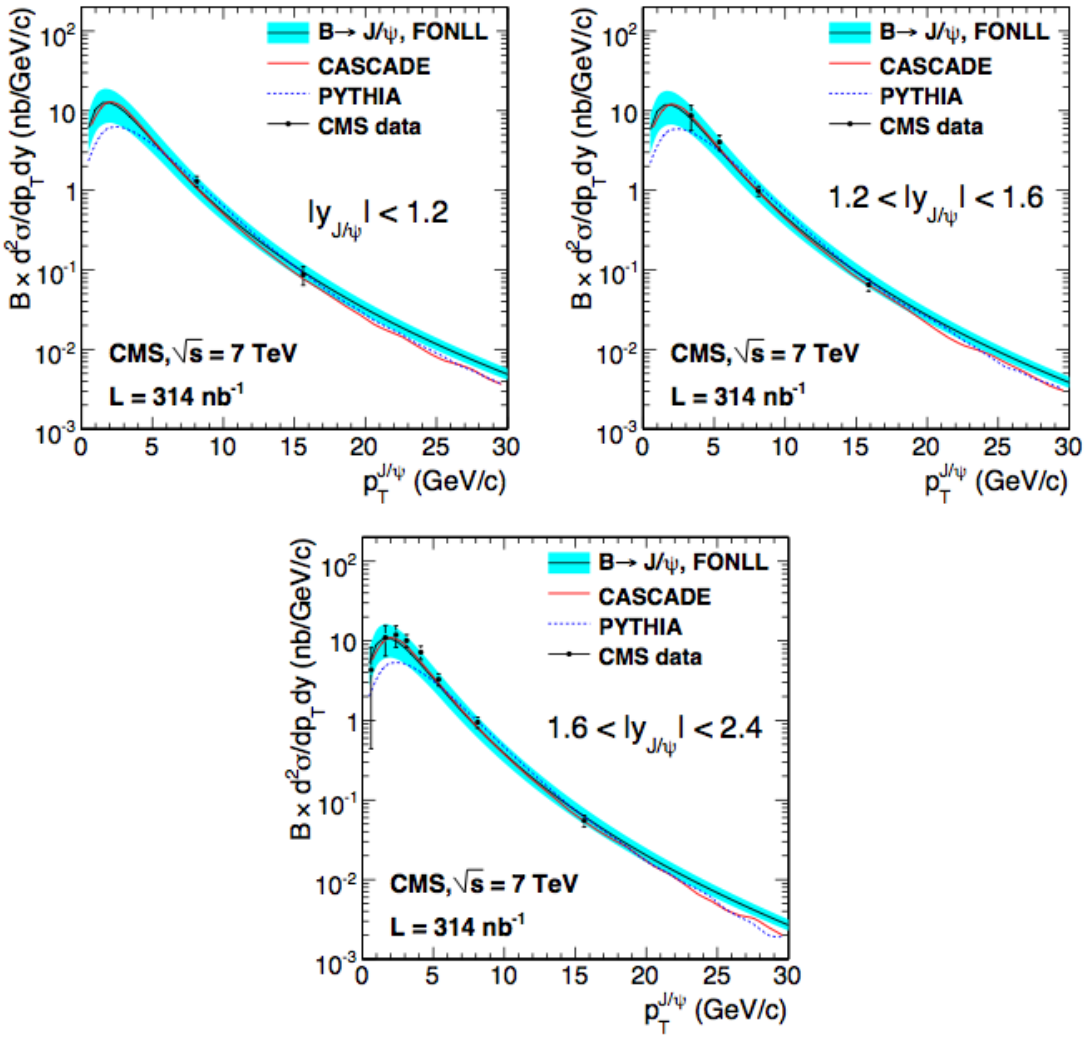
- **"Minimum bias"**, based on interaction trigger:
  - **SPD or V0-A or V0-C**
    - at least one charged particle in 8 η units
    - ~95% of σ_{inel}
  - read out all ALICE
- **single-muon** trigger:
  - forward muon in coincidence with Min Bias
  - read out MUON, SPD, V0, FMD, ZDC
- Both activated in coincidence with the BPTX beam pickups
- Since March 31st 2010, collected
  - ~8.5×10^8 minimum bias triggers
  - ~1.3×10^8 muon triggers
- Results presented today based on ~10^8 minimum bias triggers

FONLL vs. data, beauty production 2-7 TeV

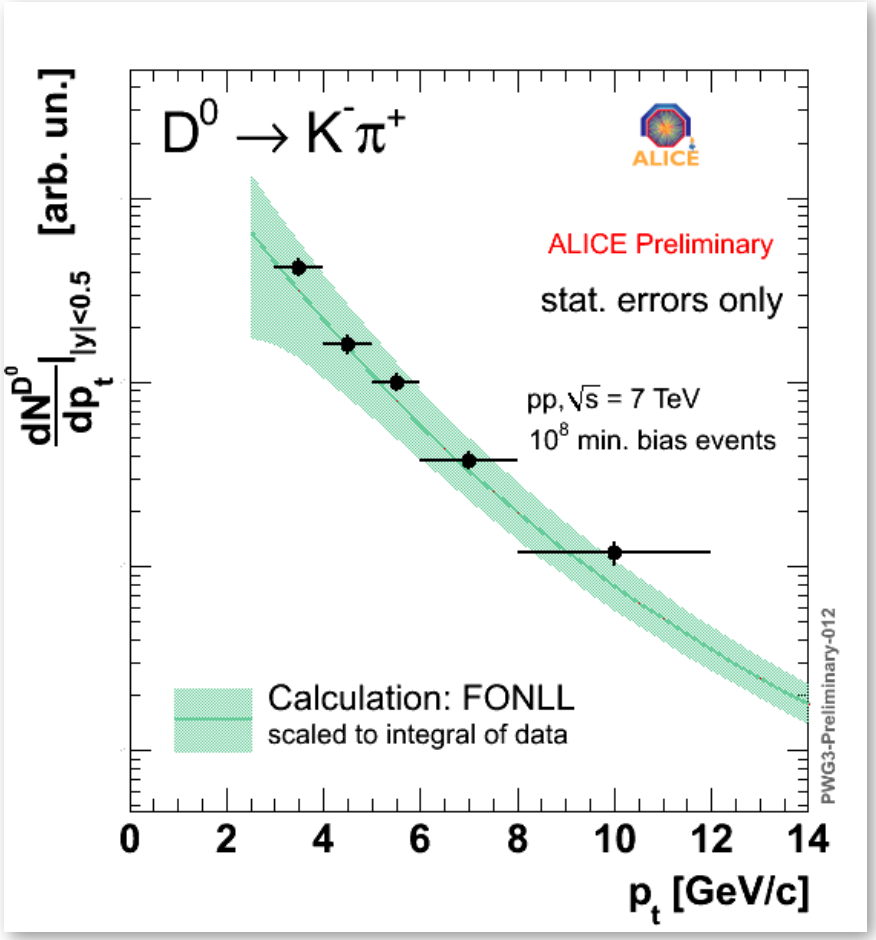


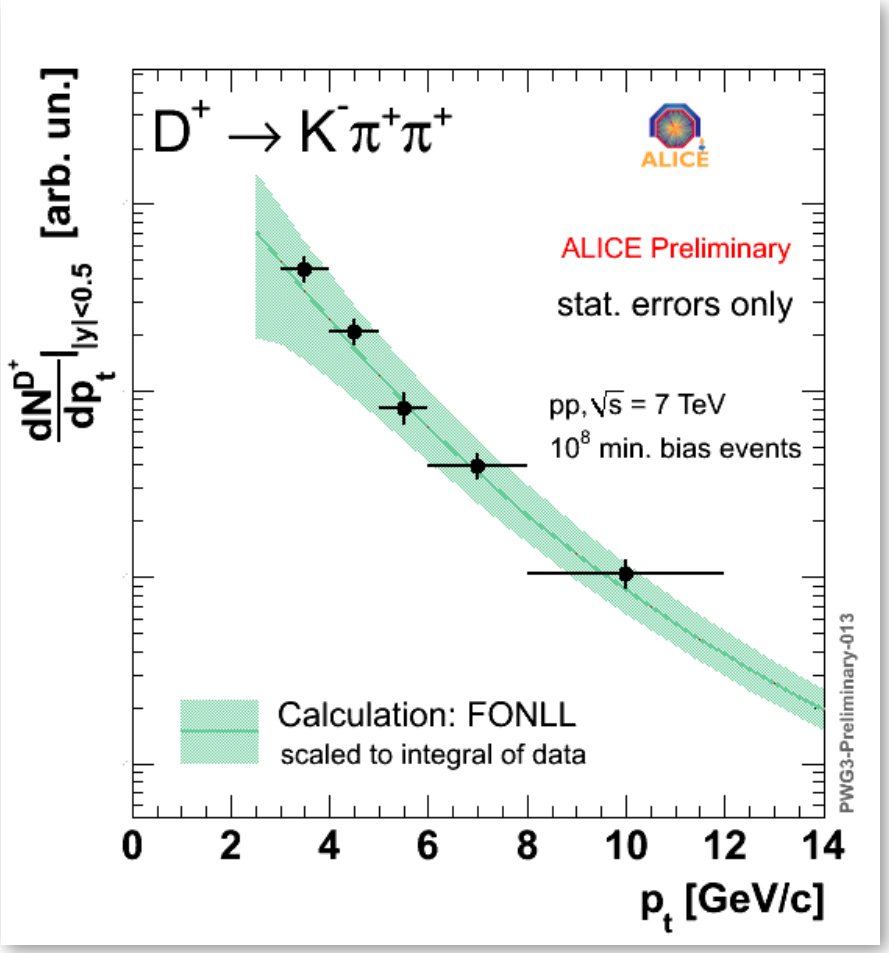
FONLL, MC@NLO:
Cacciari, Frixione, Mangano, Nason and Ridolfi, JHEP0407 (2004) 033

CMS, arXiv:1011.4193



D^0 and D^+ dN/dp_t





- Only statistical errors
- Shape compares well with pQCD (FONLL)

D mesons: from signals to cross sections

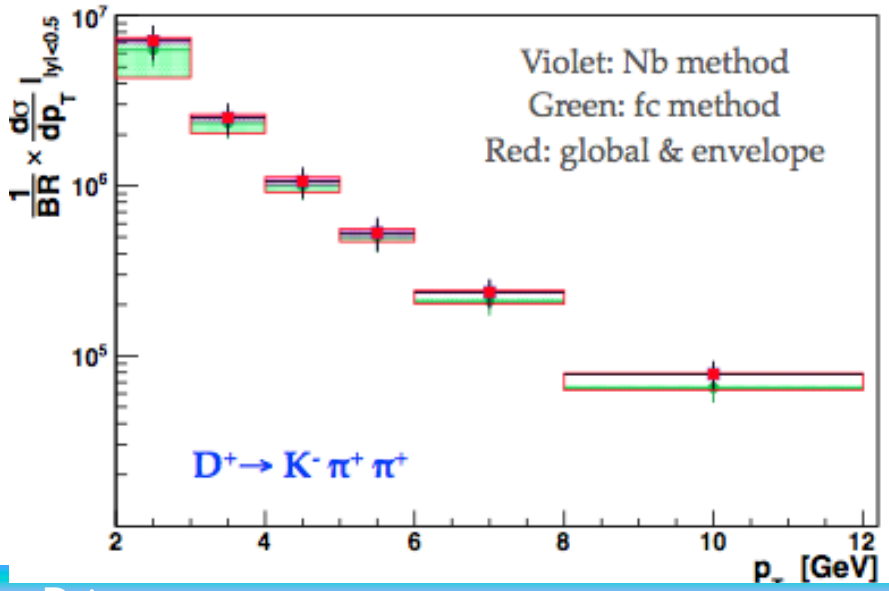
$$\left.\frac{d\sigma}{dp_t}\right|_{|y|<0.5} = \frac{1}{2}\cdot\frac{1}{\Delta y(p_t)}\cdot\frac{1}{B.R.}\cdot\frac{1}{\varepsilon_c}\cdot f_c(p_t)\cdot\frac{N^D_{raw}(p_t)\big|_{|y|<\Delta y(p_t)}}{\Delta p_t}\frac{(\sigma^{CINT1B}/\sigma^{V0AND})}{N_{CINT1B}}\sigma^{V0AND}$$

- Corrections: feed-down B→D: ~10-15%
  - main method ("Nb-subtraction"): FONLL input is only the DfromB cross section

$$f_c(p_t)\cdot N^D_{raw}(p_t)\big|_{|y|<\Delta y(p_t)} = N^D_{raw}(p_t)\big|_{|y|<\Delta y(p_t)} - N^{DfromB}_{FONLL}(p_t)\big|_{|y|<\Delta y(p_t)}$$

where: $$N^{DfromB}_{FONLL}(p_t)\big|_{|y|<\Delta y(p_t)} = \sigma^{DfromB}_{FONLL}(pt)\cdot\varepsilon_{DfromB}\cdot\Delta y\Delta p_t\cdot 2\cdot BR\cdot L_{\text{int}}$$

  - second method ("prompt fraction fc"): FONLL input is the ratio of prompt to total D meson cross sections
  - use the total envelope of the error bands (from FONLL) of two methods as a systematic error



Pb-Pb: expected performance