



Heavy-flavor production in LHC p-p interactions using the ALICE detector

by

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On behalf of the ALICE Collaboration



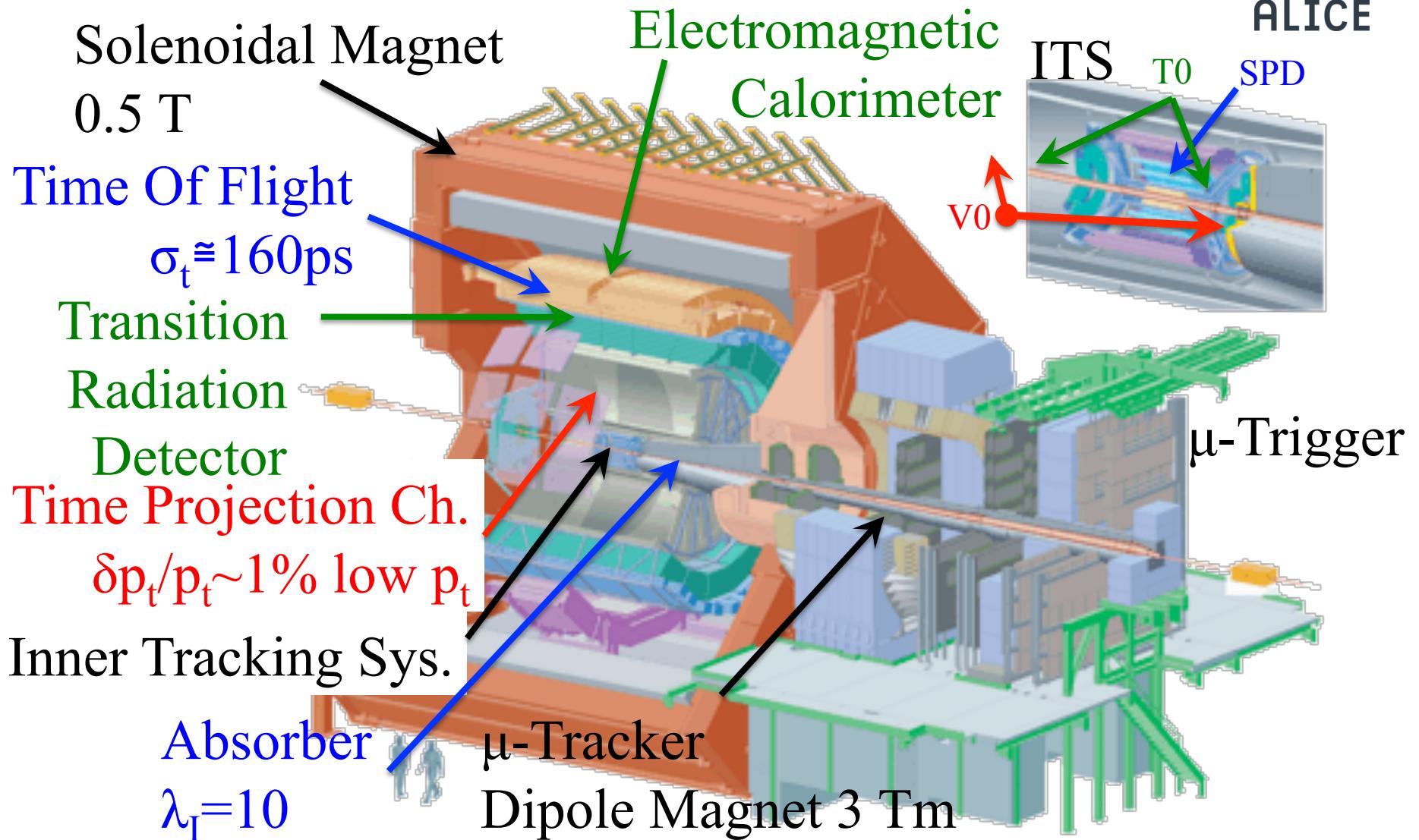
Outline

- ALICE Detector
- Data and Selections
- Acceptance
- Results
 - Central D0, D+, D*+, Ds+ at $\sqrt{s}=7$ & 2.76 TeV
 - Central electrons from semileptonic HF decays at $\sqrt{s}=7$ TeV
 - Forward muons from semileptonic HF decays at $\sqrt{s}=7$ & 2.76 TeV
- Conclusion

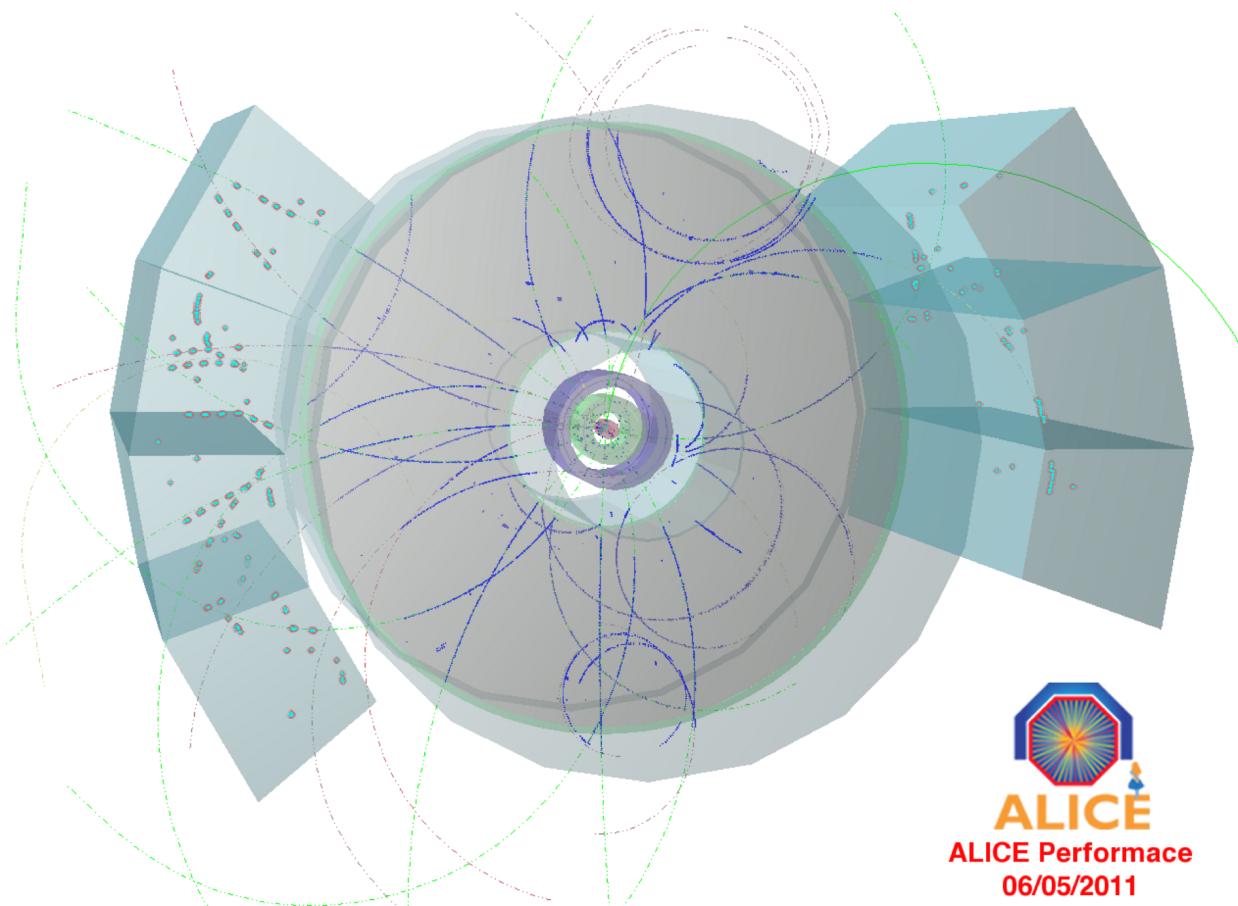
The ALICE Detector



ALICE



Proton-Proton Collision Event Display



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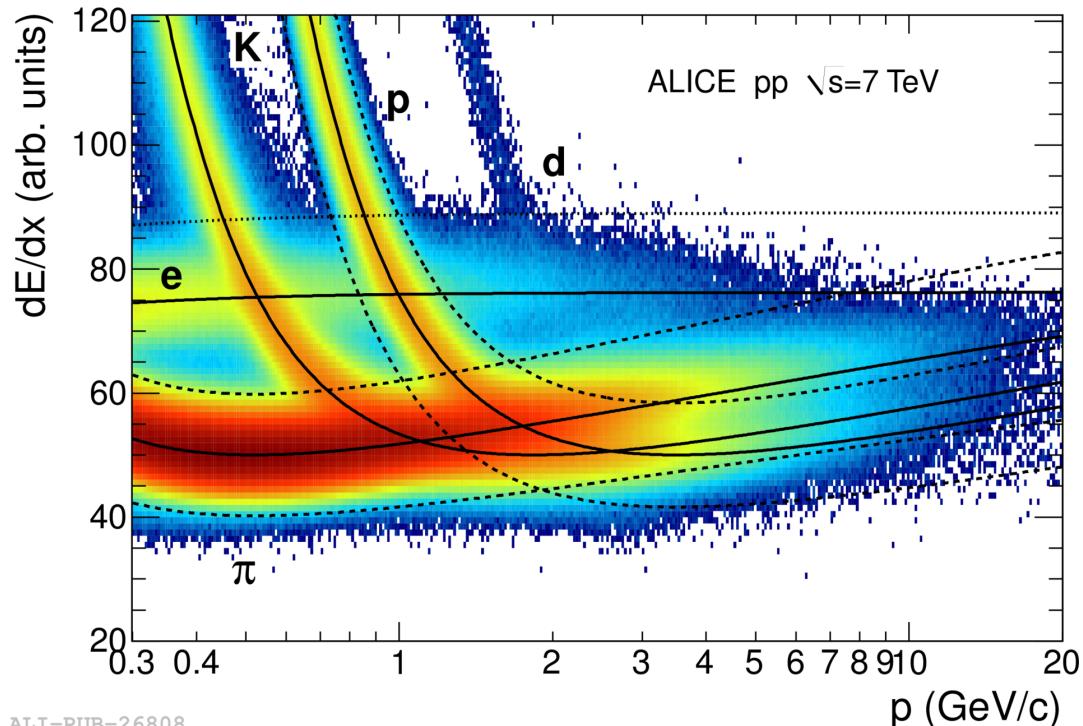
4

Central Tracking and PID



160ps resolution ALICE

K. Aamodt et al., Phys. Lett. B 704 (2011) 444, doi:10.1016/j.physletb2011.09.054



“Good” ITS 1 measurement in Inner SPD

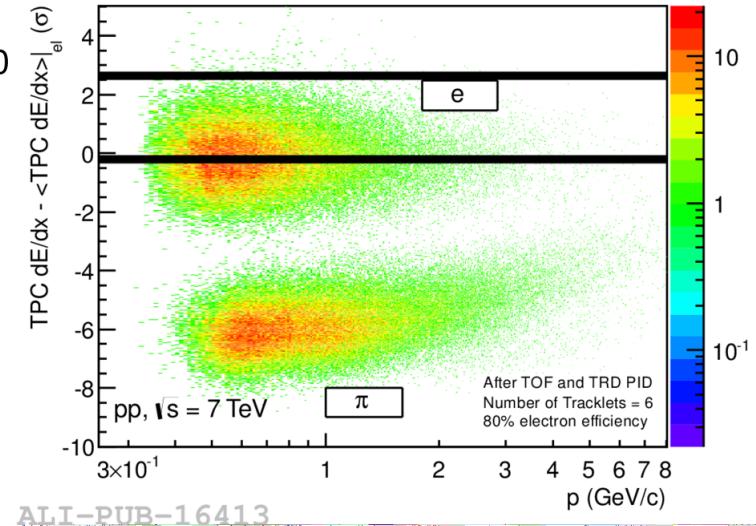
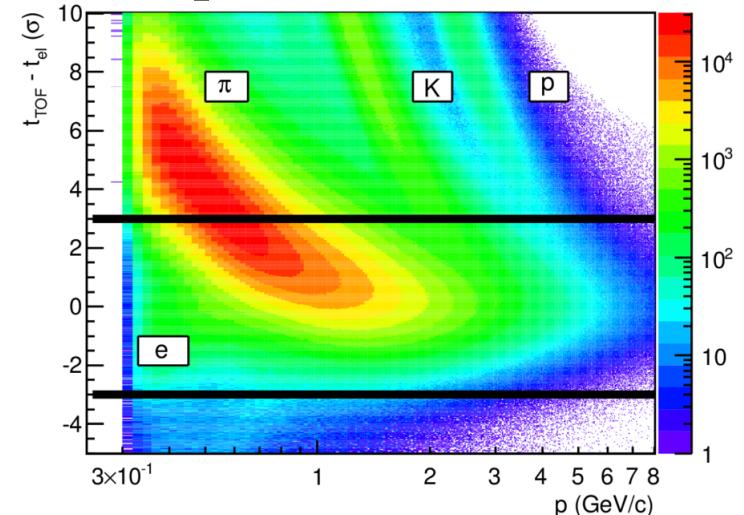
layers or 1 measurement in layer 5

SSD. (p_t between 80-200 MeV/c)

“Good” TPC track 70/159 measurements
minimum & $\chi^2/ndf < 2$.

“Good” TOF timing requires T0 signal.
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Trigger and D meson data selection

Min Bias Trigger central

- SPD – 1 or 2 hits $|\eta| < 1.95$
- or V0 – one or both sides
 $2.8 < \eta < 5.1$ & $-3.7 < \eta < -1.7$
- and Timing such that Beam-Beam crossing

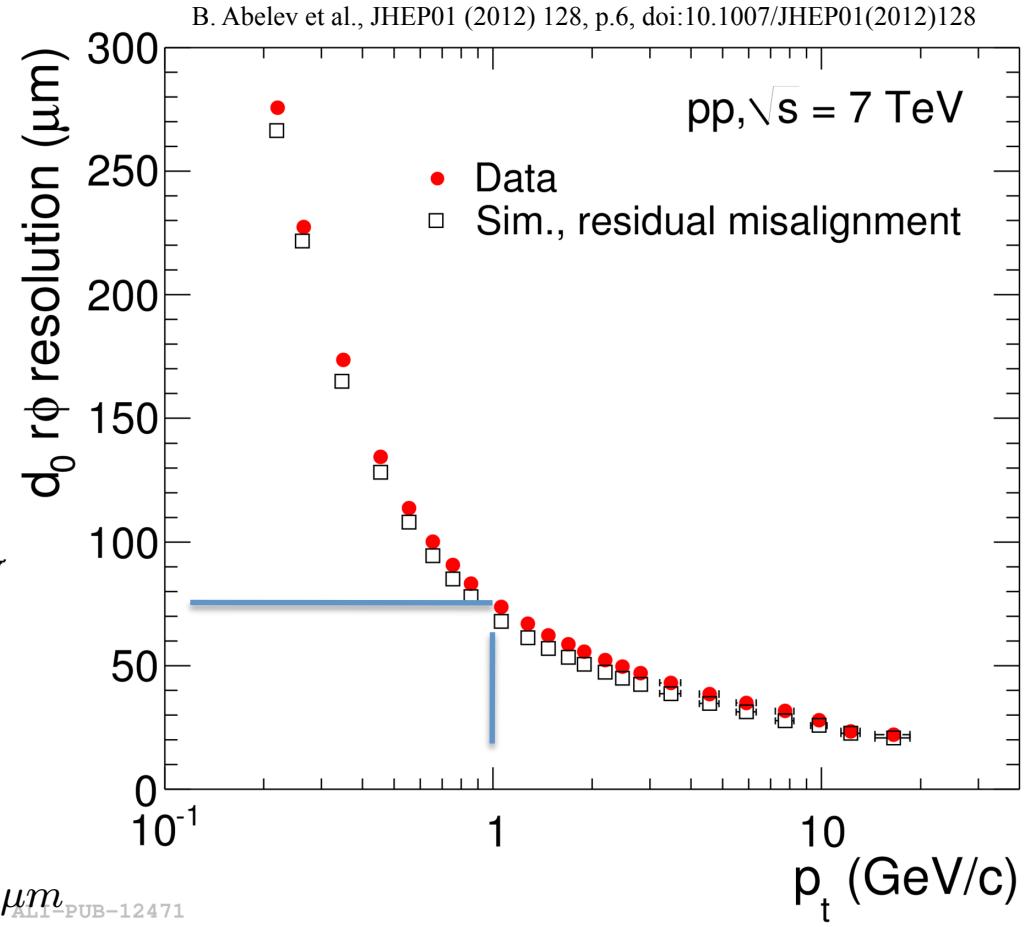
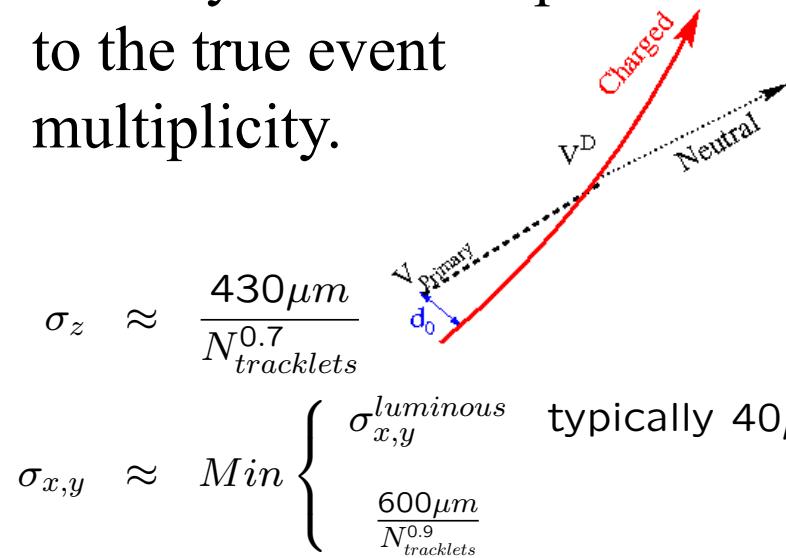
$$\sigma_{\text{MB}}(7 \text{ TeV}) = 62.5 \pm 2.2 \text{ (total) mb}$$

$$\sigma_{\text{MB}}(2.76 \text{ TeV}) = 54.8 \pm 1.7 \text{ (total) mb}$$

- 7 TeV
2010 data, $L_{\text{int}} = 5 \text{ nb}^{-1}$
 D_s^+ 2010 data, $L_{\text{int}} = 4.8 \text{ nb}^{-1}$
- 2.76 TeV
2011 data, $L_{\text{int}} = 1.35 \text{ nb}^{-1}$
- Reconstructed $|y| < 0.5$
 D^+, D^{*+} $1 < p_t < 24 \text{ GeV/c}$ 7TeV
 D^+, D^{*+} $2 < p_t < 12 \text{ GeV/c}$ 2.76TeV
 D^0 $1 < p_t < 16 \text{ GeV/c}$ 7TeV
 D^0 $1 < p_t < 12 \text{ GeV/c}$ 2.76TeV
 D_s^+ $2 < p_t < 12 \text{ GeV/c}$ 7 TeV

Vertex Resolution

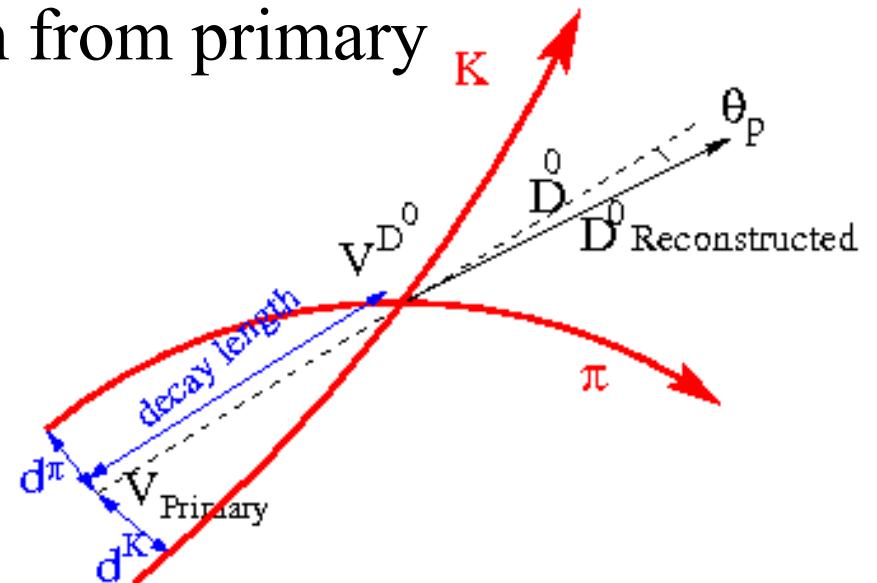
Vertex first reconstructed using SPD Tracklets.
 Tracklet are matched signals in the inner and outer layers of the SPD that point to the Primary vertex. Proportional to the true event multiplicity.



@ 1 GeV/c $\rightarrow 75\mu m$



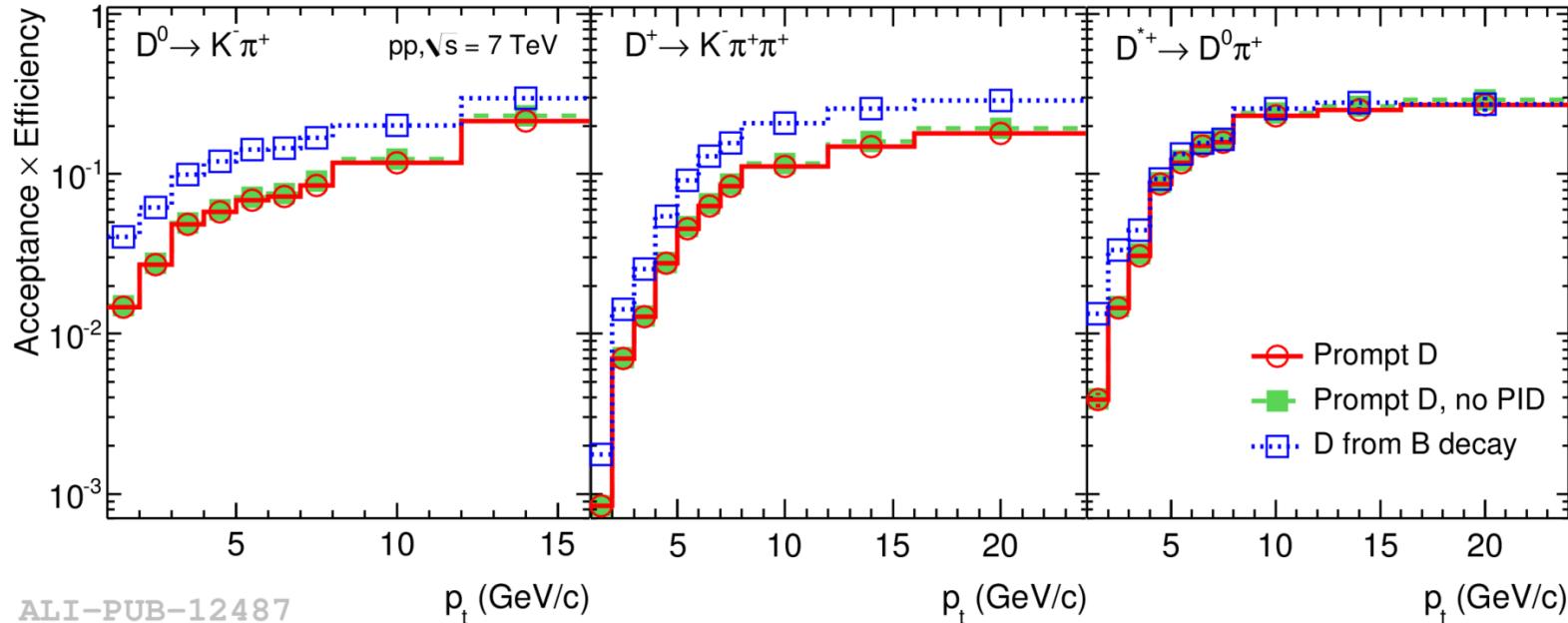
- $d^K \times d^\pi < (120 \text{ }\mu\text{m})^2$
- $K \& \pi p_t > 0.4 \text{ GeV}/c$ for $1 < p_t^{D^0} < 2 \text{ GeV}/c$
- $K \& \pi p_t > 0.7 \text{ GeV}/c$ for $p_t^{D^0} > 2 \text{ GeV}/c$
- Decay Length ($r\varphi$) $> 100 \mu\text{m}$ from primary
- $\cos(\theta_p) > 0.8$



D^0 , D^+ , & D^{*+} Efficiencies



B. Abelev et al., JHEP01 (2012) 128, p.11, doi:10.1007/JHEP01(2012)128



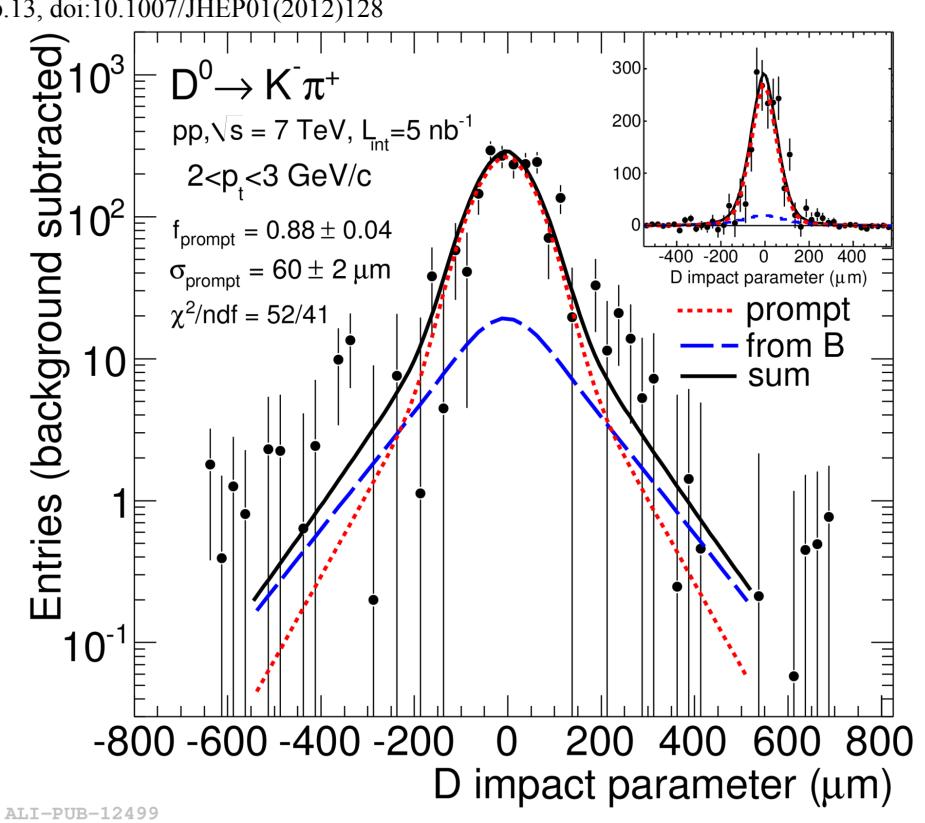
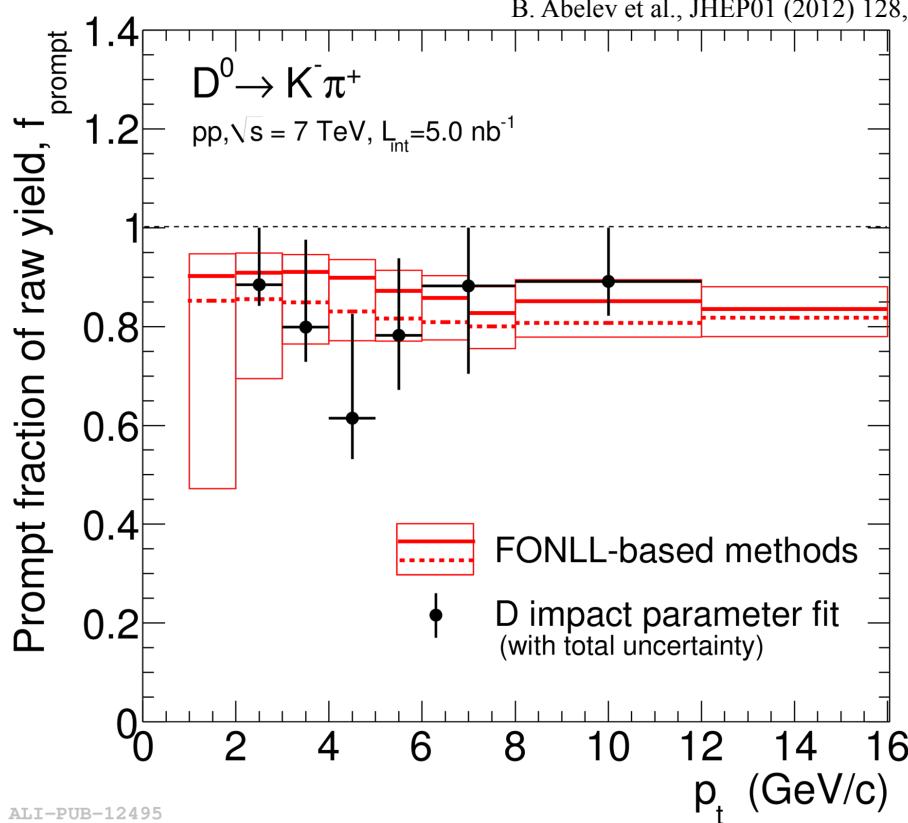
ALICE-PUB-12487

$$\frac{d\sigma^D}{dp_t} = \frac{1}{2\Delta y \Delta p_t} \frac{f_{prompt}(p_t) N_{raw}^D(p_t) \Big|_{|y| < y_{fid}}}{(A \times \epsilon)_{prompt}(p_t) BR(D \rightarrow X) L_{int}}$$

f_{prompt} corrects for $B \rightarrow D$ decays based on a FONLL pQCD calculation

MC's used include PYTHIA 6.4.21 with Perugia-0 tune
and EvtGen passed through Geant 3 and a full ALICE
simulation matched to the run conditions.

Prompt Fraction



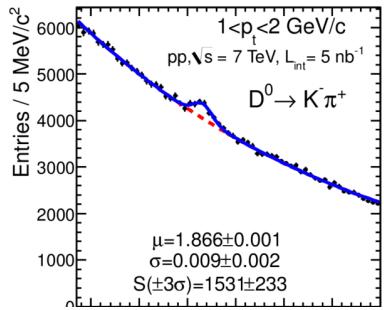
ALI-PUB-12495

ALI-PUB-12499

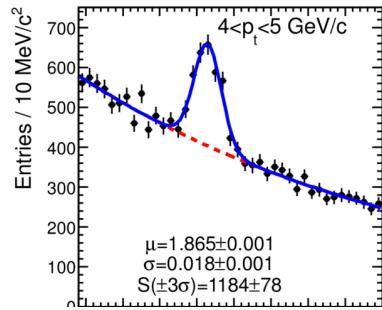


D meson mass 7 TeV

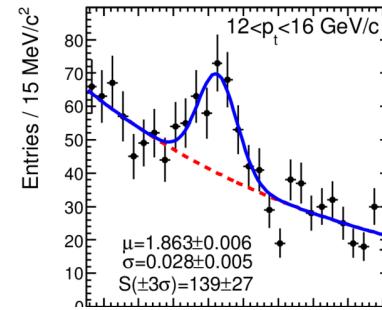
$1 < p_t < 2 \text{ GeV}/c$



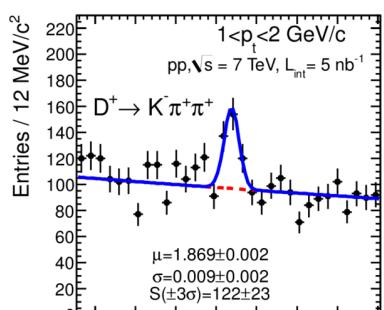
$4 < p_t < 6 \text{ GeV}/c$



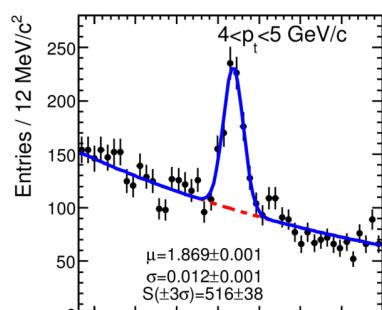
$12 < p_t < 16 \text{ GeV}/c$



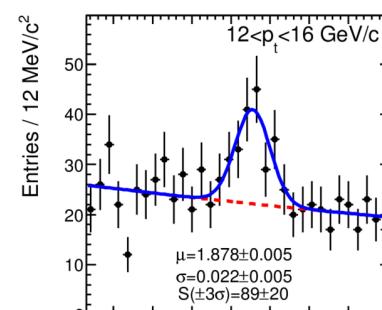
$1 < p_t < 2 \text{ GeV}/c$



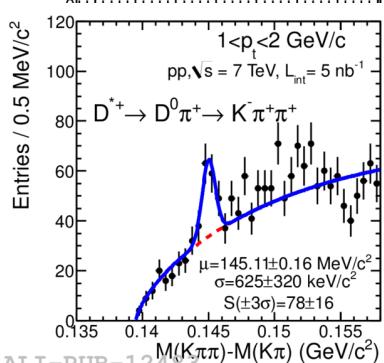
$4 < p_t < 5 \text{ GeV}/c$



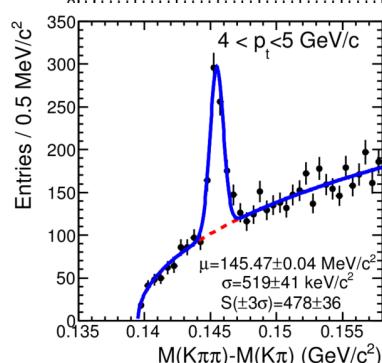
$12 < p_t < 16 \text{ GeV}/c$



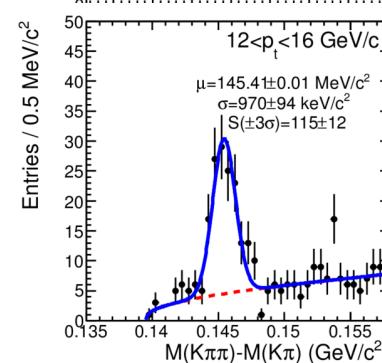
$1 < p_t < 2 \text{ GeV}/c$



$4 < p_t < 5 \text{ GeV}/c$



$12 < p_t < 16 \text{ GeV}/c$



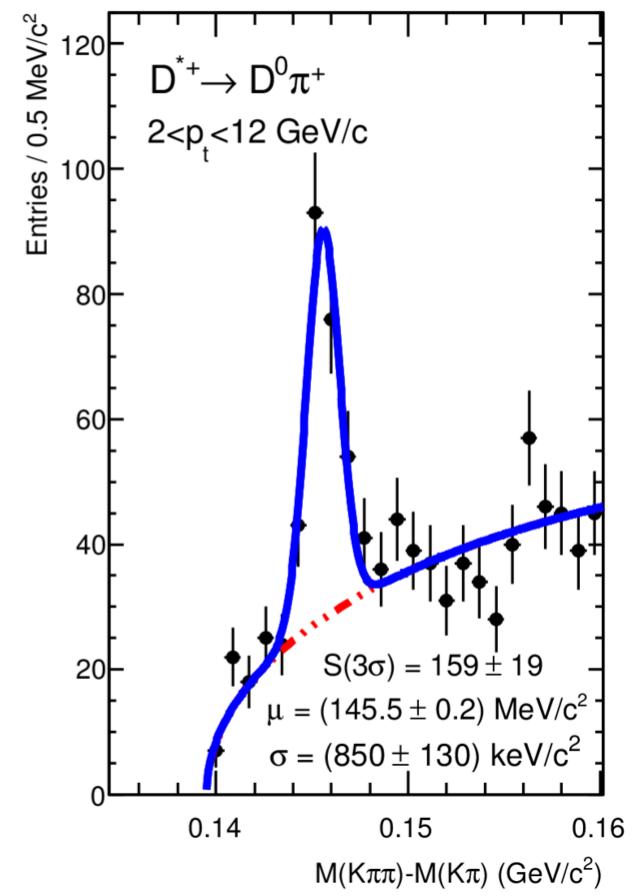
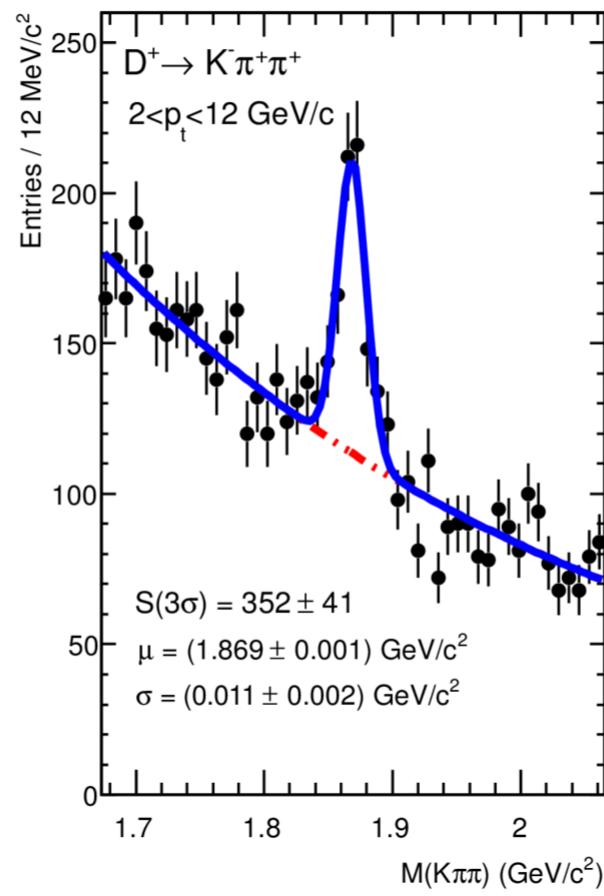
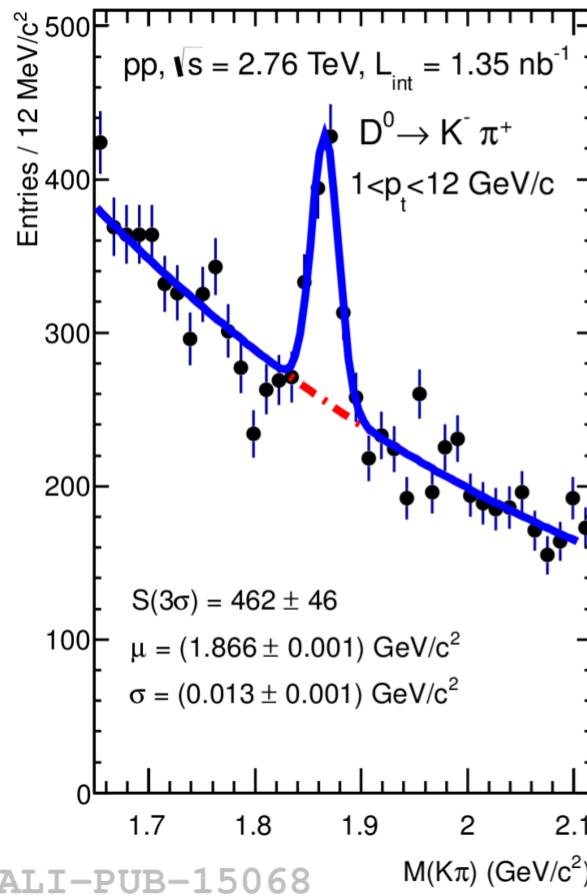
ALI-PUB-12483

B. Abelev et al., JHEP01 (2012) 128, p.8, doi:10.1007/JHEP01(2012)128

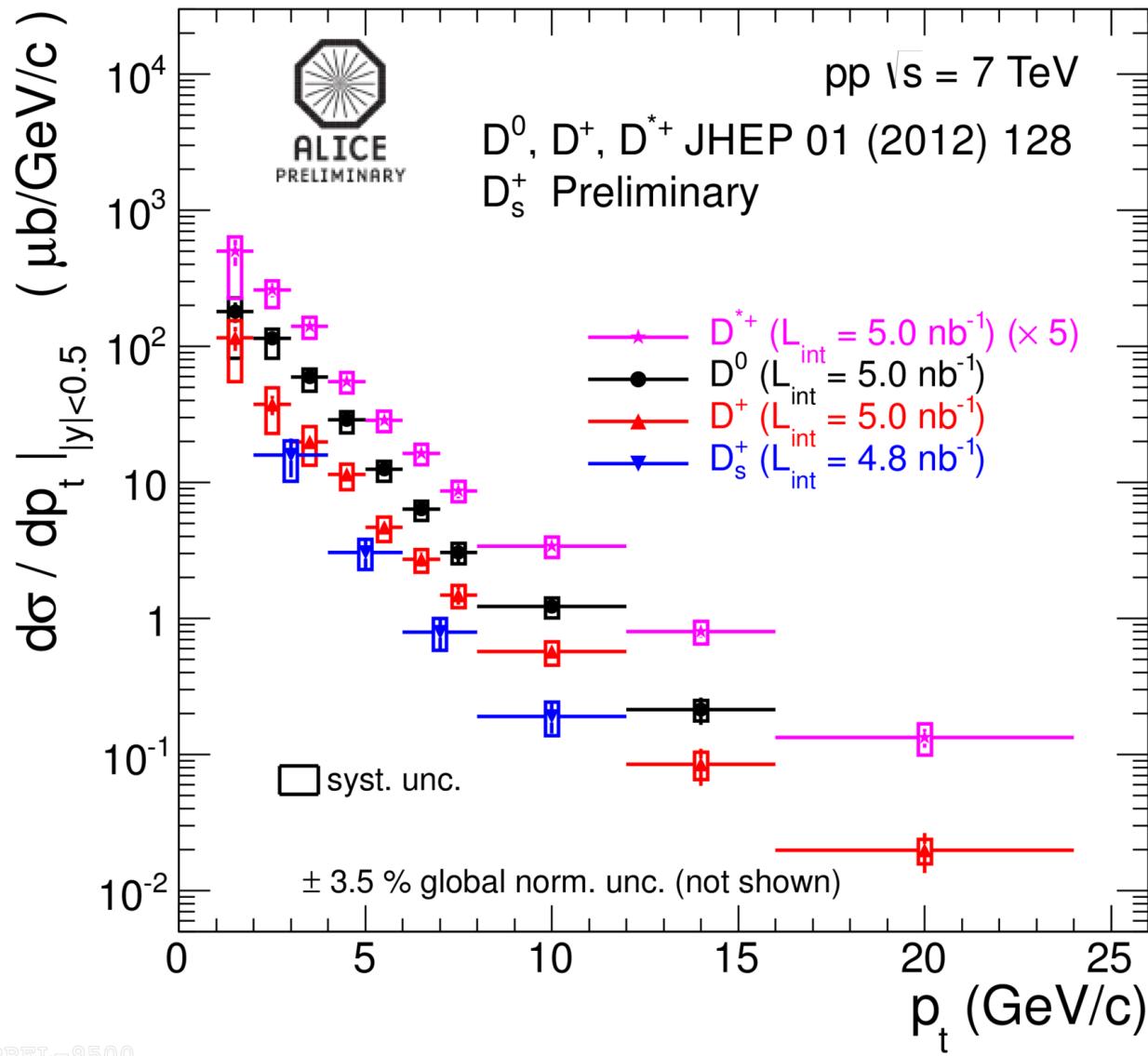


D meson Mass 2.76 TeV

B. Abelev et al., arXiv:1205.4007v1 [hep-ex] 17 May 2012, p.6



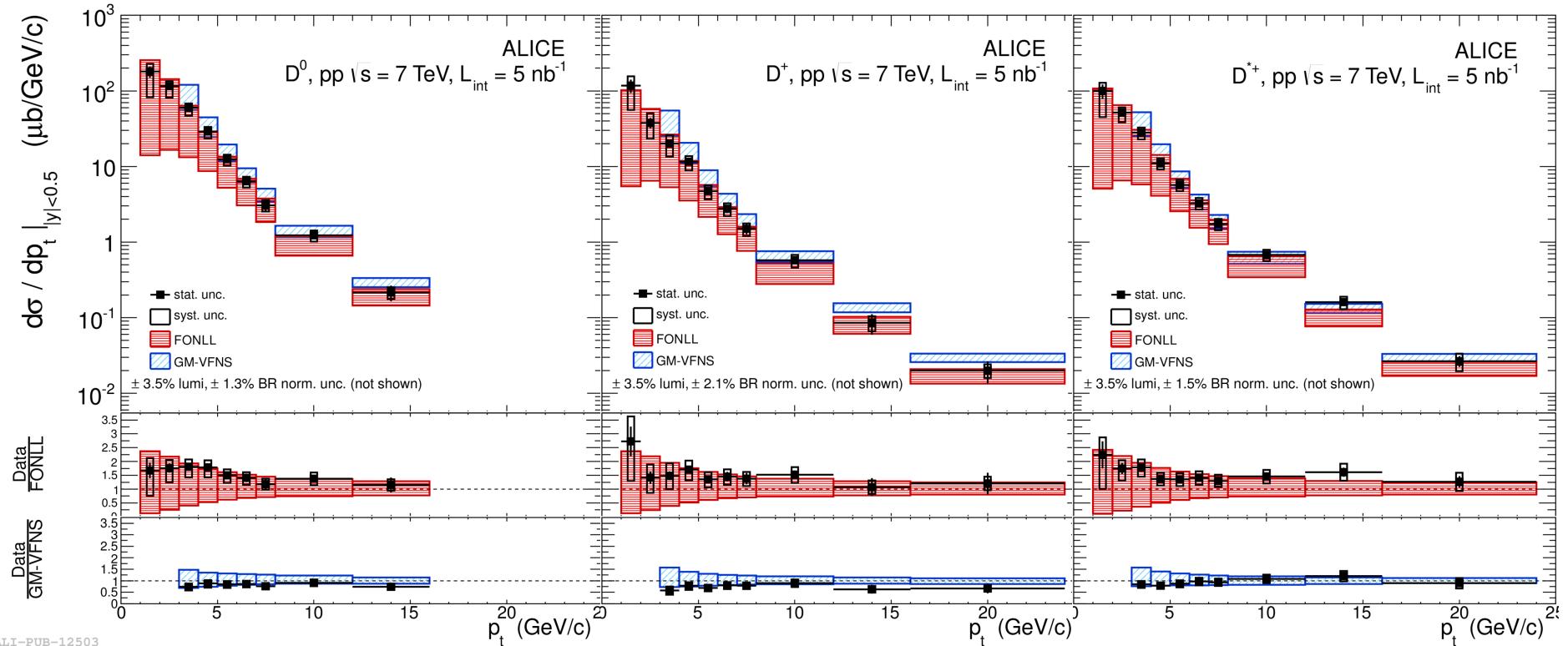
D Meson p_t Cross sections



D^0, D^+, D^{*+} Compared Theory 7 TeV



B. Abelev et al., JHEP01 (2012) 128, p.16, doi:10.1007/JHEP01(2012)128



ALI-PUB-12503

M. Cacciari, M. Greco, P. Nason, JHEP 05 (1998) 007

M. Cacciari, S. Frixione, P. Nason, JHEP 05 (2001) 006

M. Cacciari, S. Frixione, N. Houdeau, M.L. Mangano, P. Nason, G. Ridolf, CERN-PH-TH/2011-227

B.A. Kniehl et al., AIP Conf. Proc. 792:867-870 (2005), arXiv:hep-ph/0507068

B.A. Kniehl et al., Eur. Phys. J C41 199, 199 (2005)

B. A. Kniehl et al., DESY 12-013, MZ-TH/12-07, LPSC 12019, arXiv: 1202.0439 (2012)

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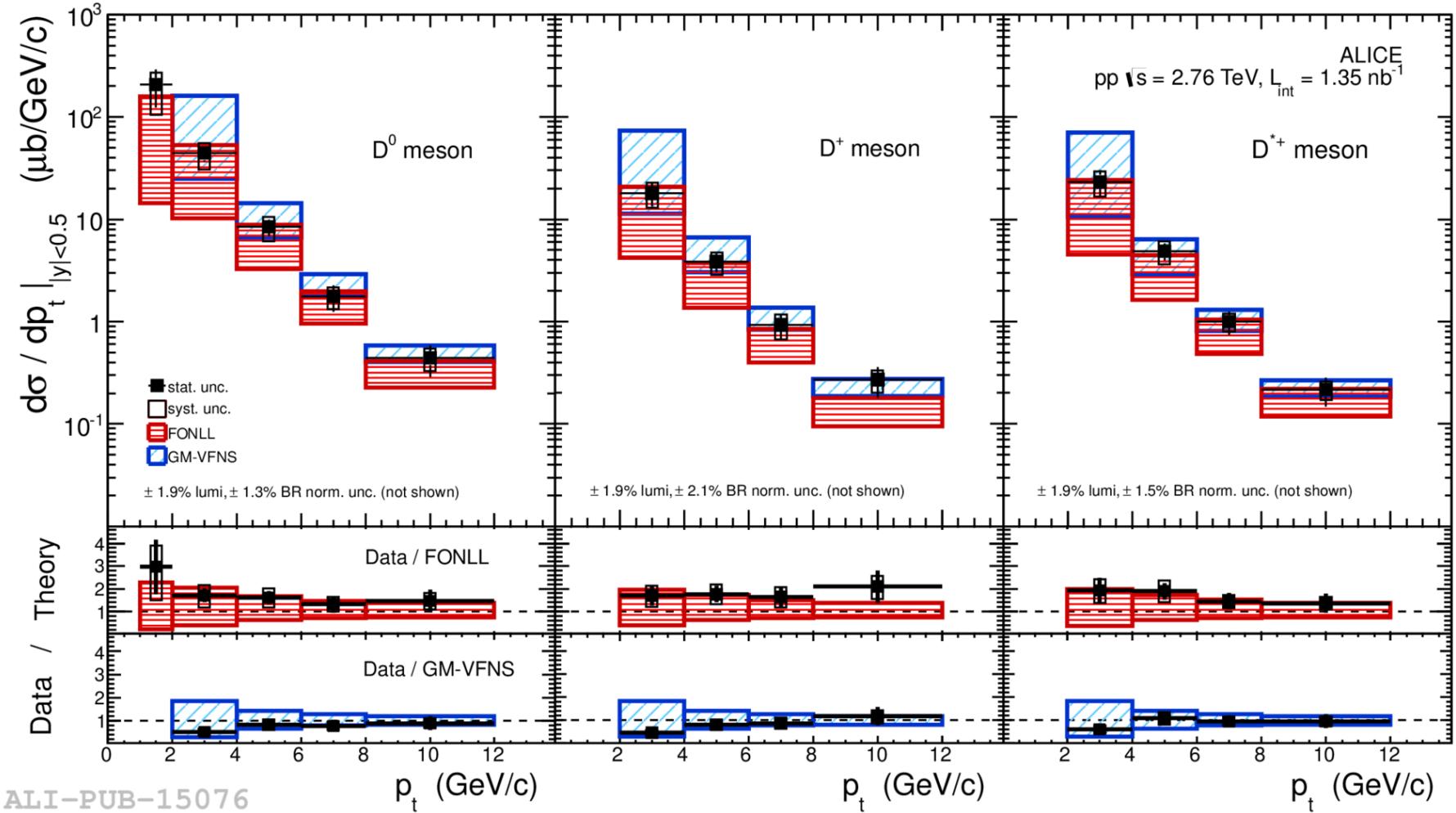
14

D^0, D^+, D^{*+} Compared Theory

2.76 TeV



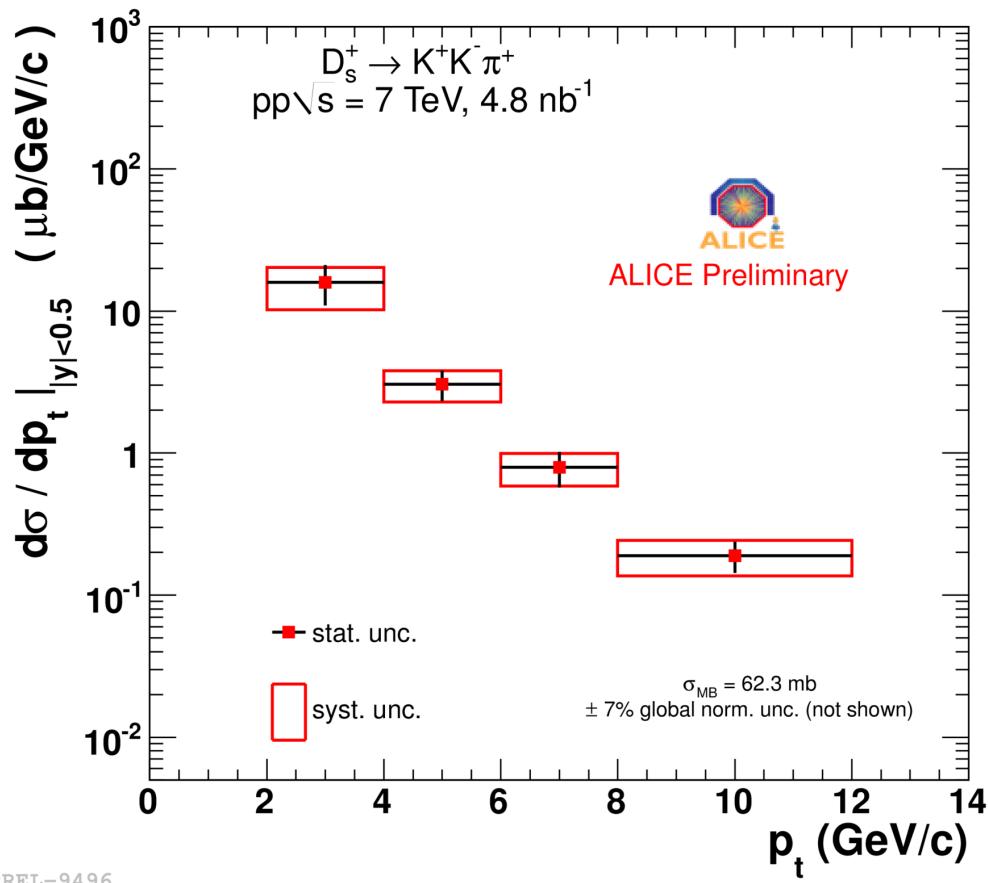
B. Abelev et al., arXiv:1205.4007v1 [hep-ex] 17 May 2012, p.9



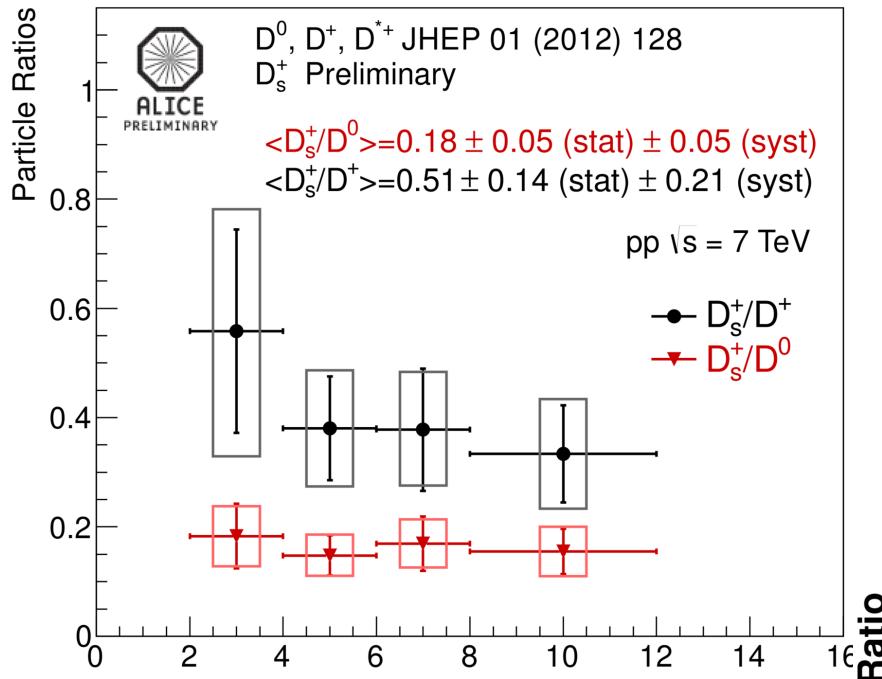
In Both energy regimes, the FONLL pQCD & GM-VFNS predictions agree with our data.



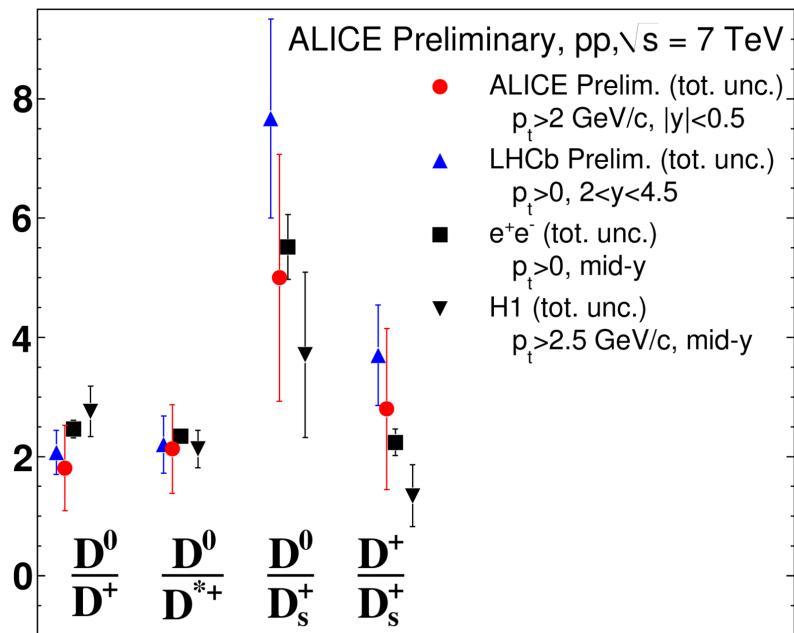
D_s^+ Meson preliminary results



Ratios



ALI-PREL-9484

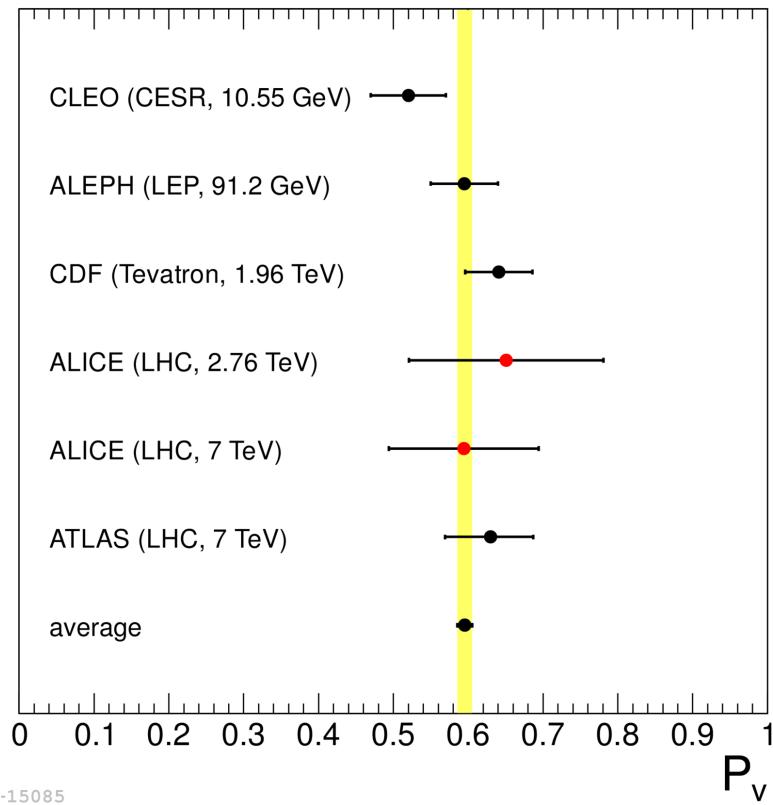


ALI-PREL-9458



Vector/Pseudo-Scalar Ratio

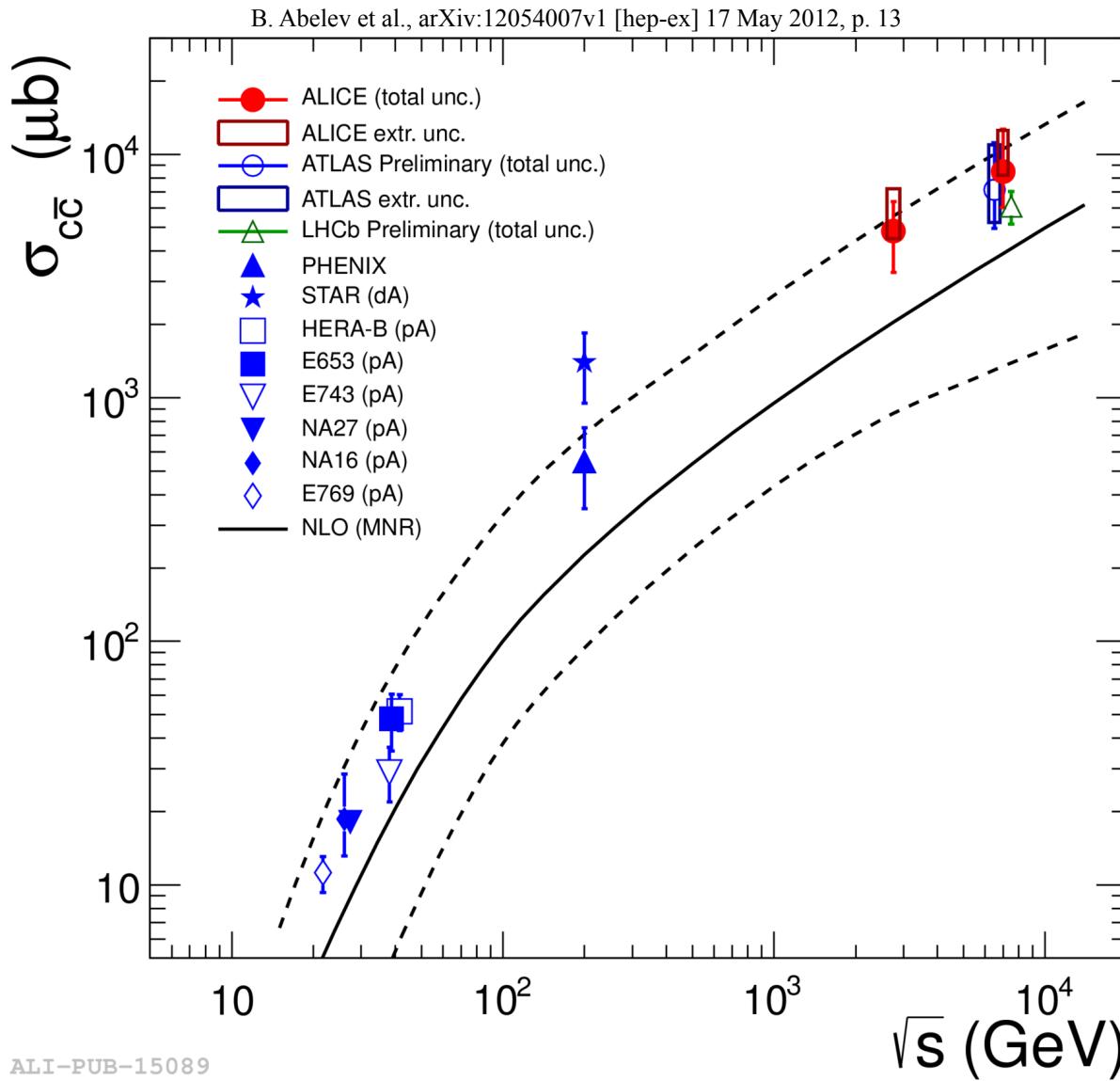
B. Abelev et al., arXiv:1205.4007v1 [hep-ex] 17 May 2012, p. 13



$$\begin{aligned}
 P_V(c\bar{d}) &= \frac{\text{Vector D's}}{\text{Pseudo-scalar D's}} \\
 &= \frac{\sigma_{tot}(D^{*+})}{\sigma_{tot}(D^+) + \sigma_{tot}(D^{*+}) BR_{D^{*+} \rightarrow D^0 \pi^+}}
 \end{aligned}$$

$$P_V = 0.60 \pm 0.01$$

Total Charm Production cross section



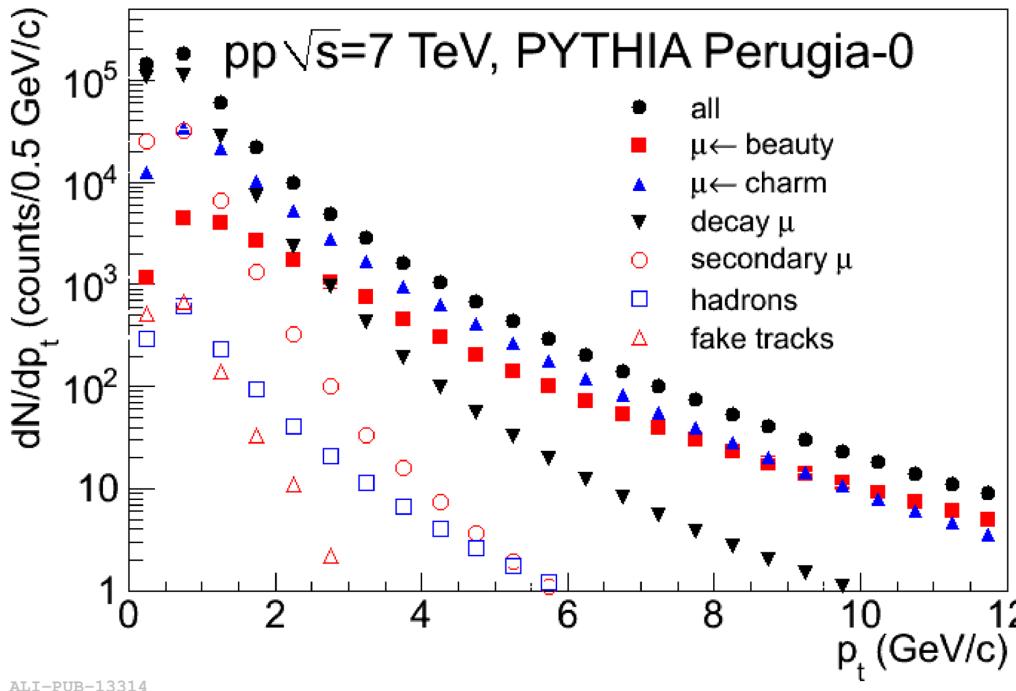
p-A & d-A scaled by a
Glauber calculation of the
number of Binary Collisions.

NLO (MNR) by M.
Mangano, P. Nason, G.
Ridolfi, Nucl. Phys. B 373
(1992).

Energy Dependence
described by a pQCD
calculations.



HF via Muon decay

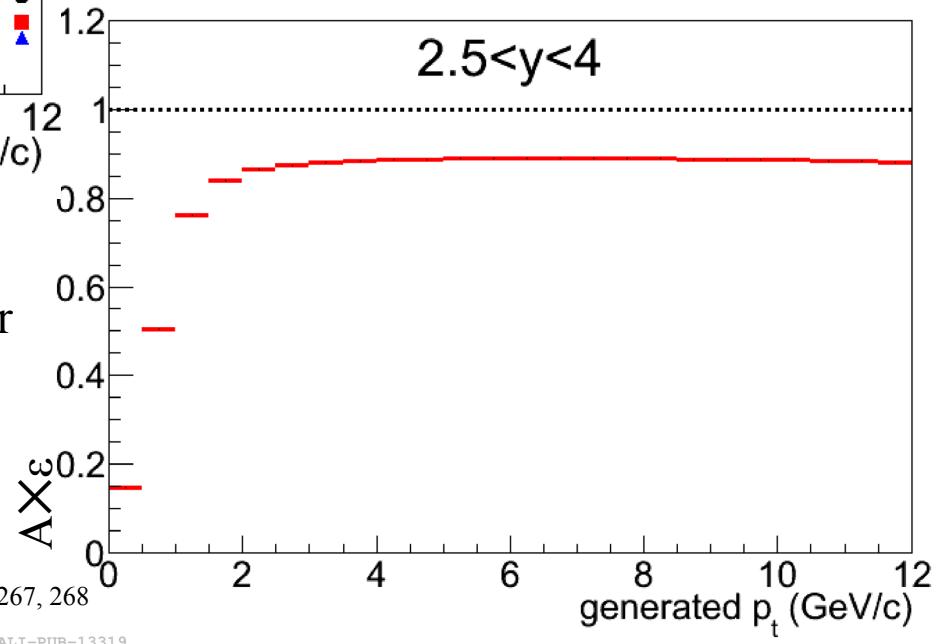


ALI-PUB-13314

μ -MB Trigger

MB Trigger + 1 μ in Muon Trigger Chamber

$L_{int}=16.5 \text{ nb}^{-1} 7 \text{ TeV}$
 $L_{int}=19 \text{ nb}^{-1} 2.76 \text{ TeV}$
 $2 < p_t < 12 \text{ GeV}/c 7 \text{ TeV}$
 $2 < p_t < 10 \text{ GeV}/c 2.76 \text{ TeV}$
 $-4. < y < -2.5$



B. Abelev et al., Phys. Let. B 708 (2012), doi:10.1016/j.physletb.2012.01.063, p 267, 268

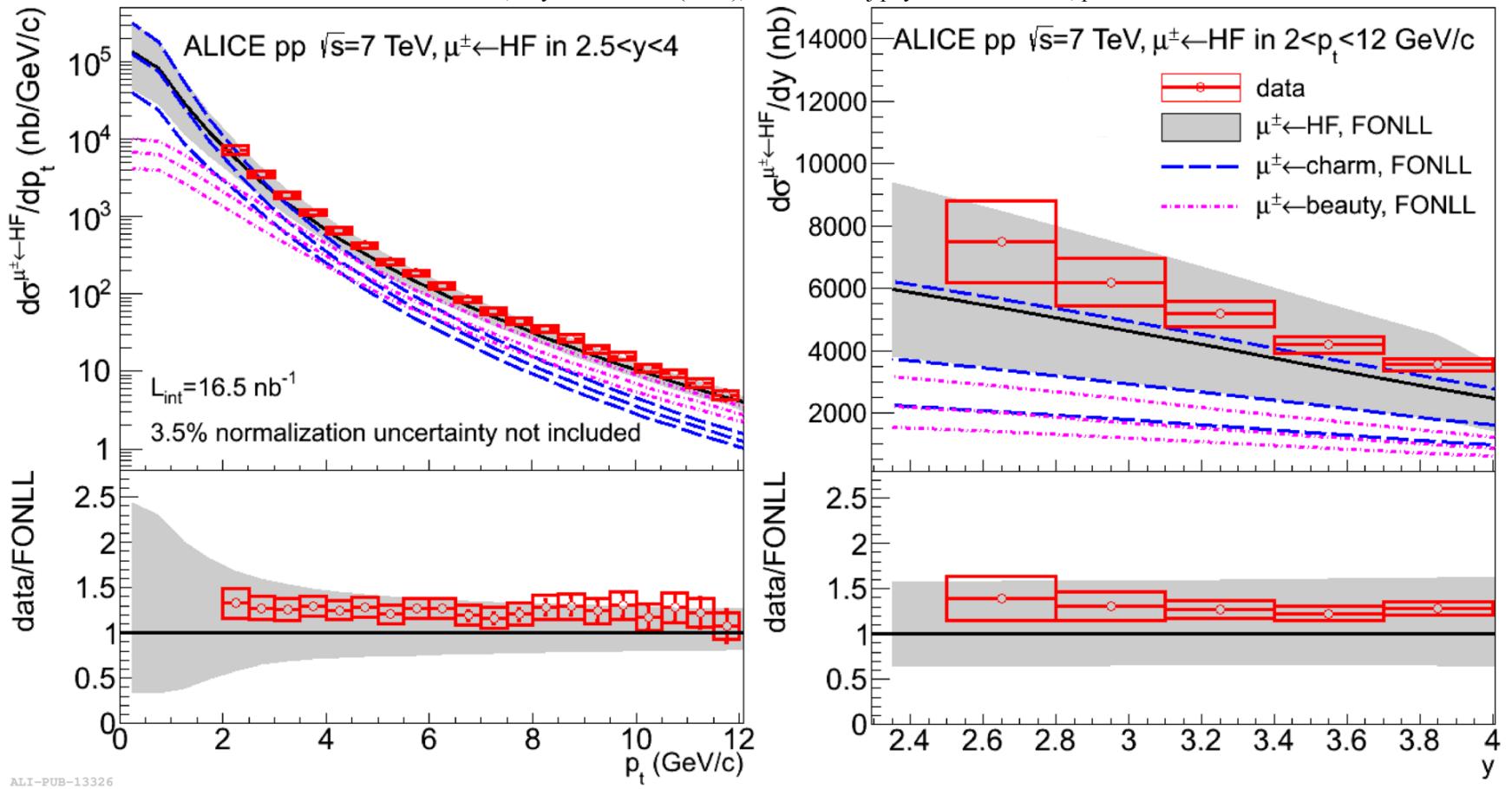
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From Muon Decays 7TeV

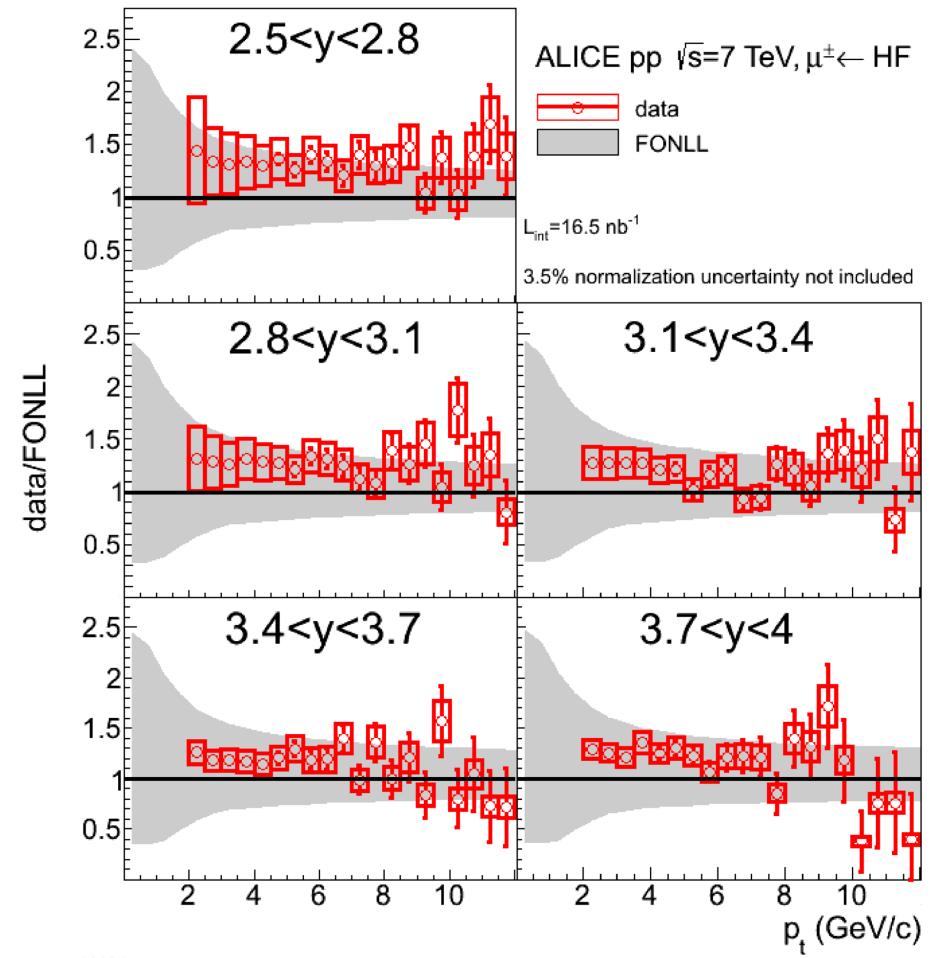
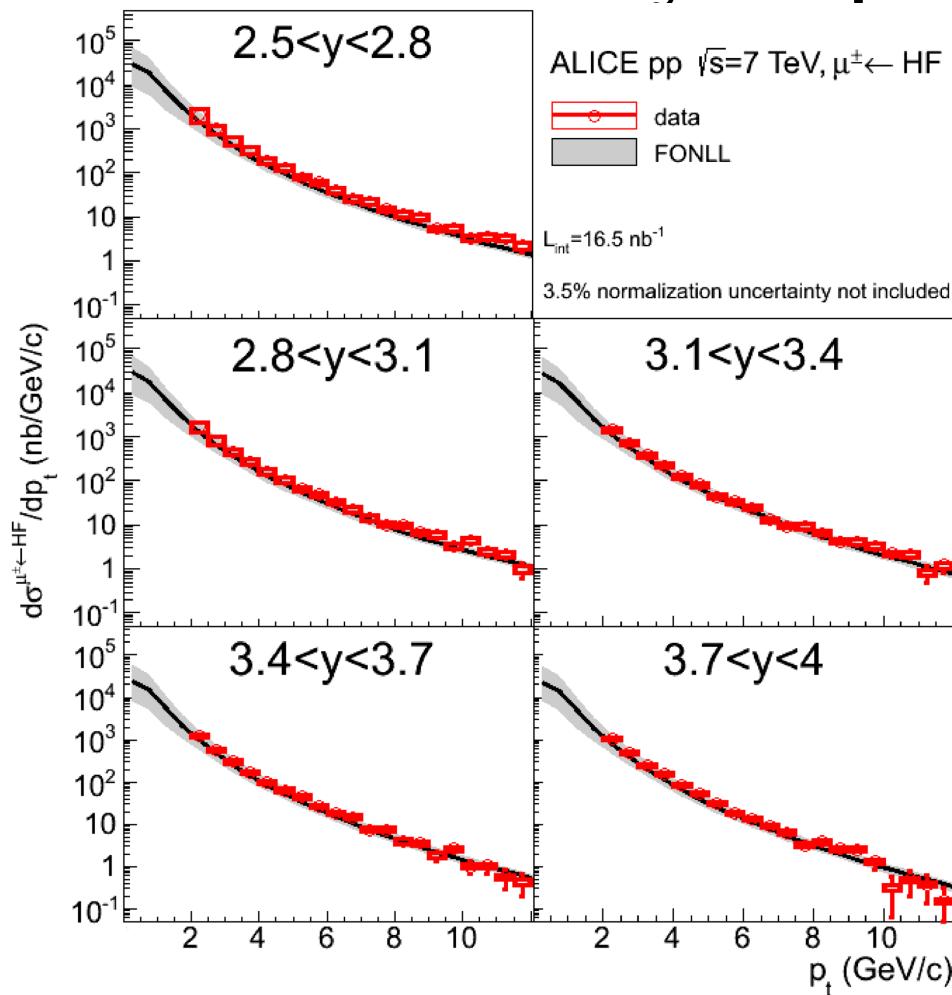
B. Abelev et al., Phys. Let. B 708 (2012), doi:10.1016/j.physletb.2012.01.063, p 269



ALI-PUB-13326



By Rapidity bins



ALI-PUB-13330

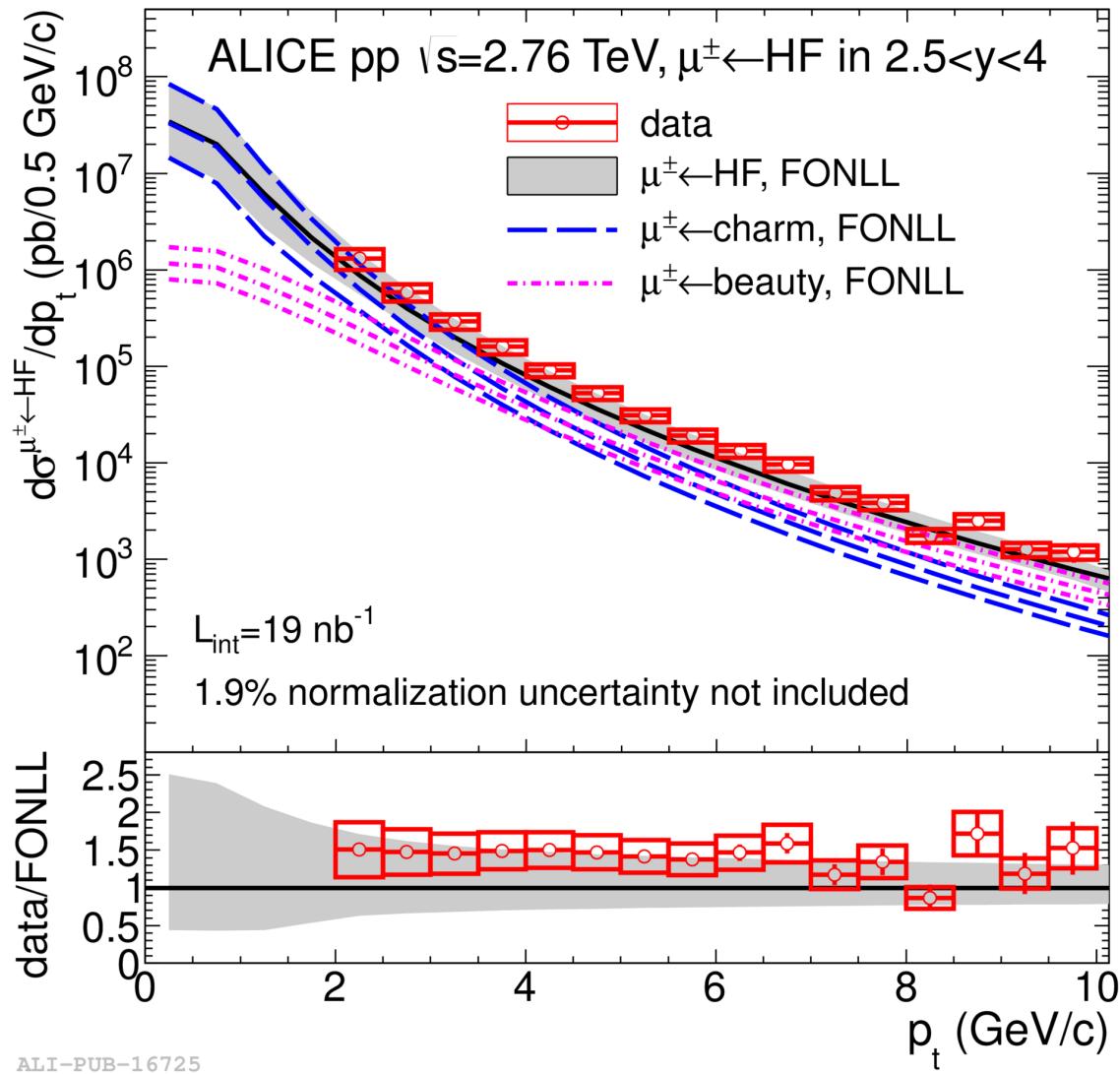
ALI-PUB-13334

B. Abelev et al., Phys. Let. B 708 (2012), doi:10.1016/j.physletb.2012.01.063, p 2670

Muon decay 2.76 TeV



B. Abelev et al., arXiv:1205.6443v1 [hep-ex] 29 May 2012, p. 5



ALI-PUB-16725

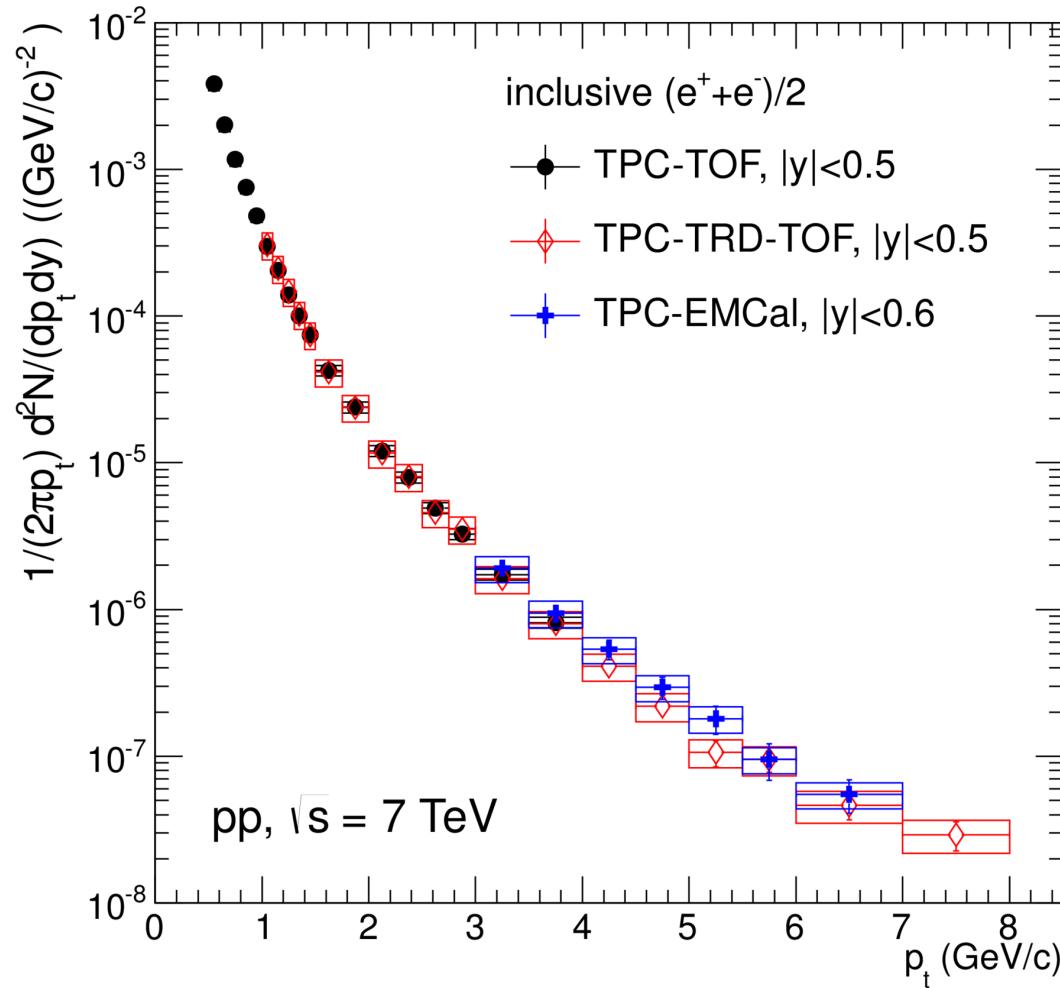
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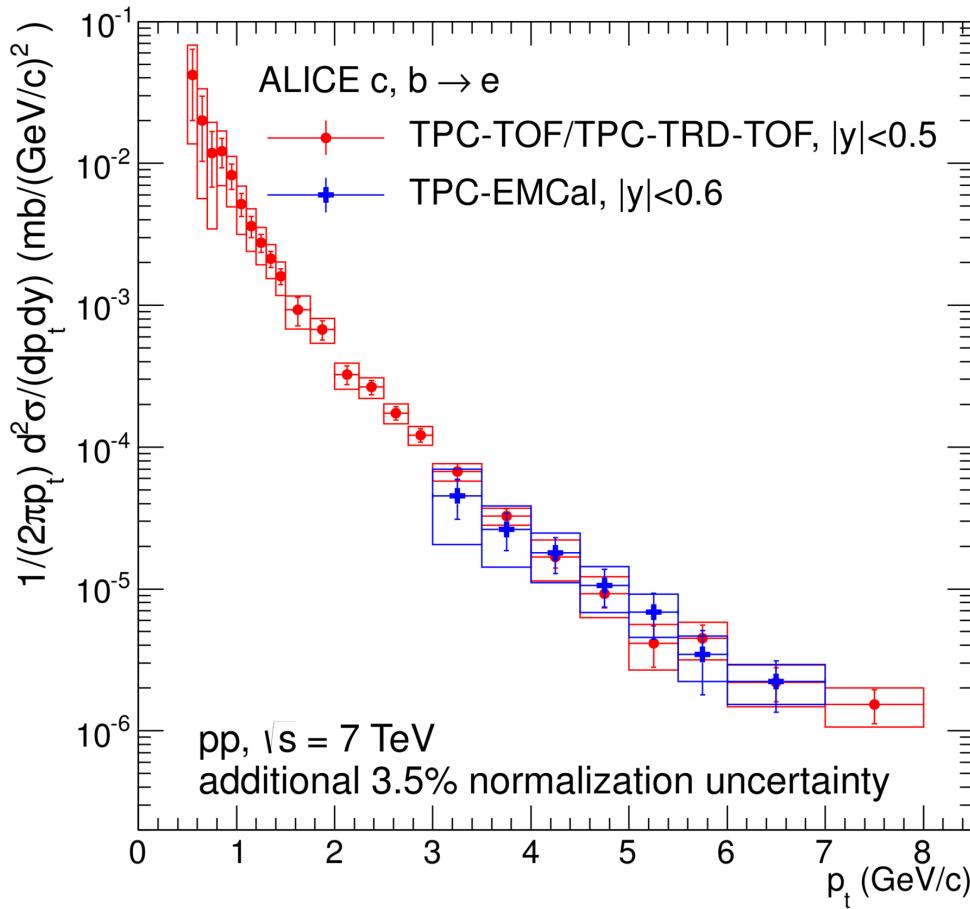
Inclusive Electron production





Inclusive e^\pm production

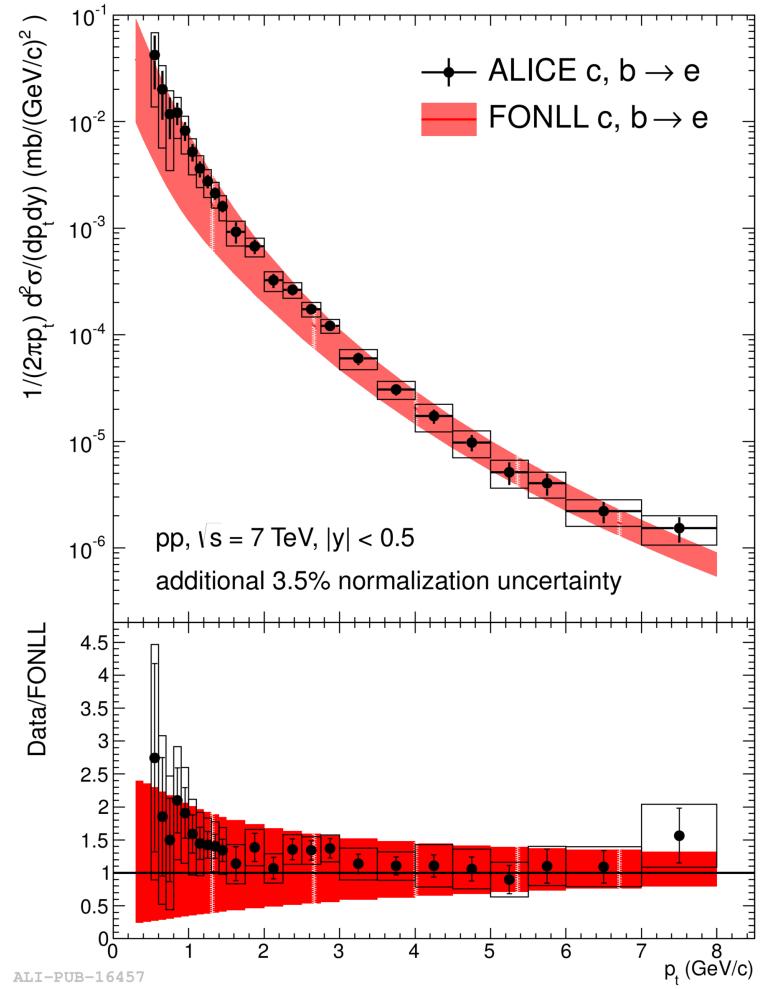
B. Abelev et al., arXiv:1205.5423v1 [hep-ex] 24 May 2012, p. 22



ALI-PUB-16453

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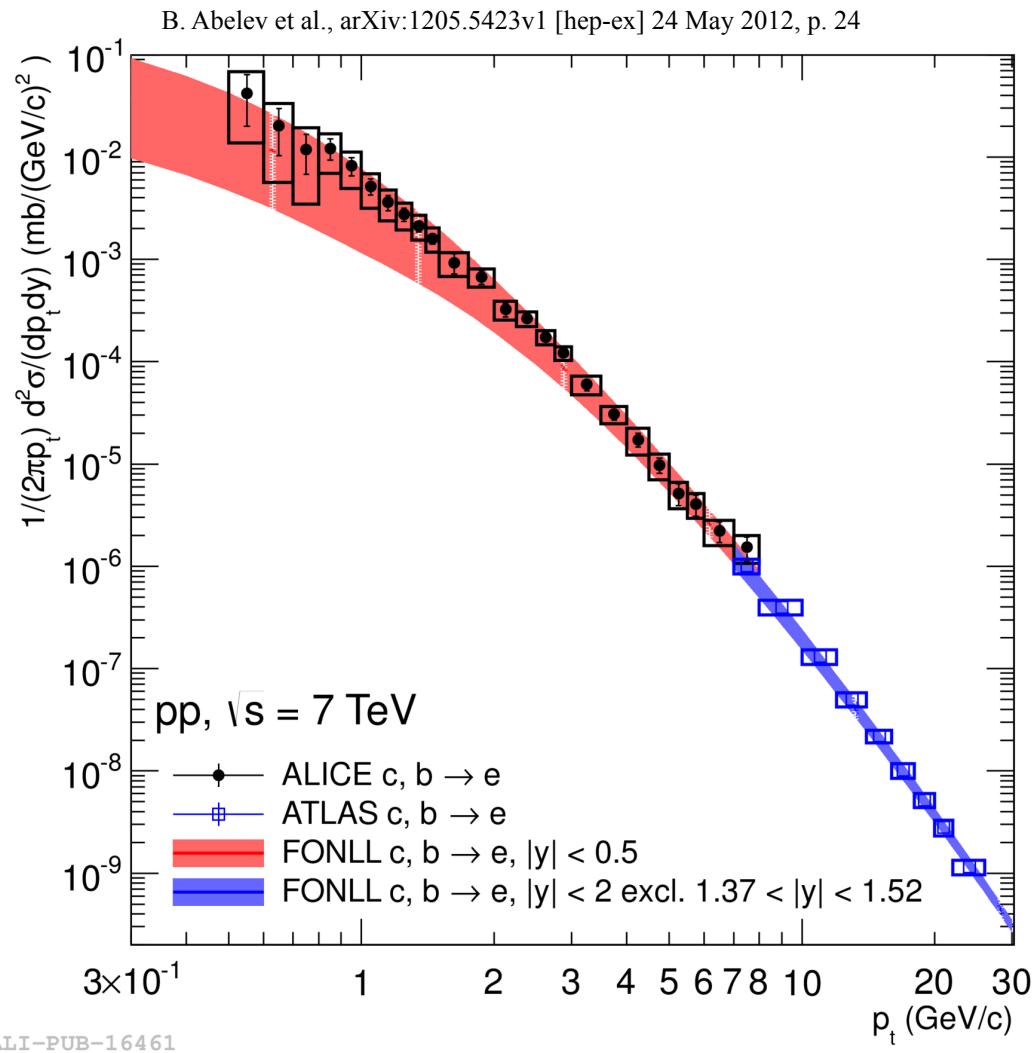
B. Abelev et al., arXiv:1205.5423v1 [hep-ex] 24 May 2012, p. 23



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Inclusive e^\pm production





Conclusion

- p_t dependent cross sections for D^0 , D^+ , D^{*+} , & D_s^+ (not 2.76 TeV)
 - ✧ p_t from 1 up to 24 GeV/c & $|y|<0.5$ at 7 and 2.76 TeV
- p_t dependent cross sections for Heavy Flavors via e & μ decay.
 - ✧ e: p_t from 0.5 up to 8 GeV/c & $|y|<0.5$ at 7 TeV
 - ✧ μ : P_t from 2 up to 12 GeV/c & $-4<|y|<-2.5$ at 7 TeV
- Well described by FONLL-pQCD and GM-VFNS calculations
- Particle ratios also presented.



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Monte Carlo Simulations

MC's used include PYTHIA 6.4.21 with Perugia-0 tune and EvtGen passed through Geant 3 and a full ALICE simulation matched to the run conditions.



Other Decay Channels

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

$|y| < 0.4 + 0.3 * (p_t/5)$ for $0 < p_t < 5 \text{ GeV}/c$

$|y| < 0.8$ for $p_t > 5 \text{ GeV}/c$

$\sum d_0^2 < (750 \text{ } \mu\text{m})^2$

$dca(r\varphi) > 300 \mu\text{m}$ from primary

$\cos(\theta^*) > 0.95$

- $D^{*+}(2010) \rightarrow D^0 \pi^+$

$p_t^{D^0} \rightarrow K\pi > 0.2 \text{ GeV}/c$

$p_t^\pi > 0.08 \text{ GeV}/c$

soft π 's allow 4 layer ITS only tracks

- $D_s^+ \rightarrow \varphi \pi^+ \rightarrow K^- K^+ \pi^+$

$|\eta| < 0.8$ for $p_t > 0.4 \text{ GeV}/c$

$|y|$ like D^+ but quadratic fit.

ϕ reconstructed

$dca(r\varphi) > 350 \mu\text{m}$ from primary

$\cos(\theta^*) > 0.94$ at low p_t

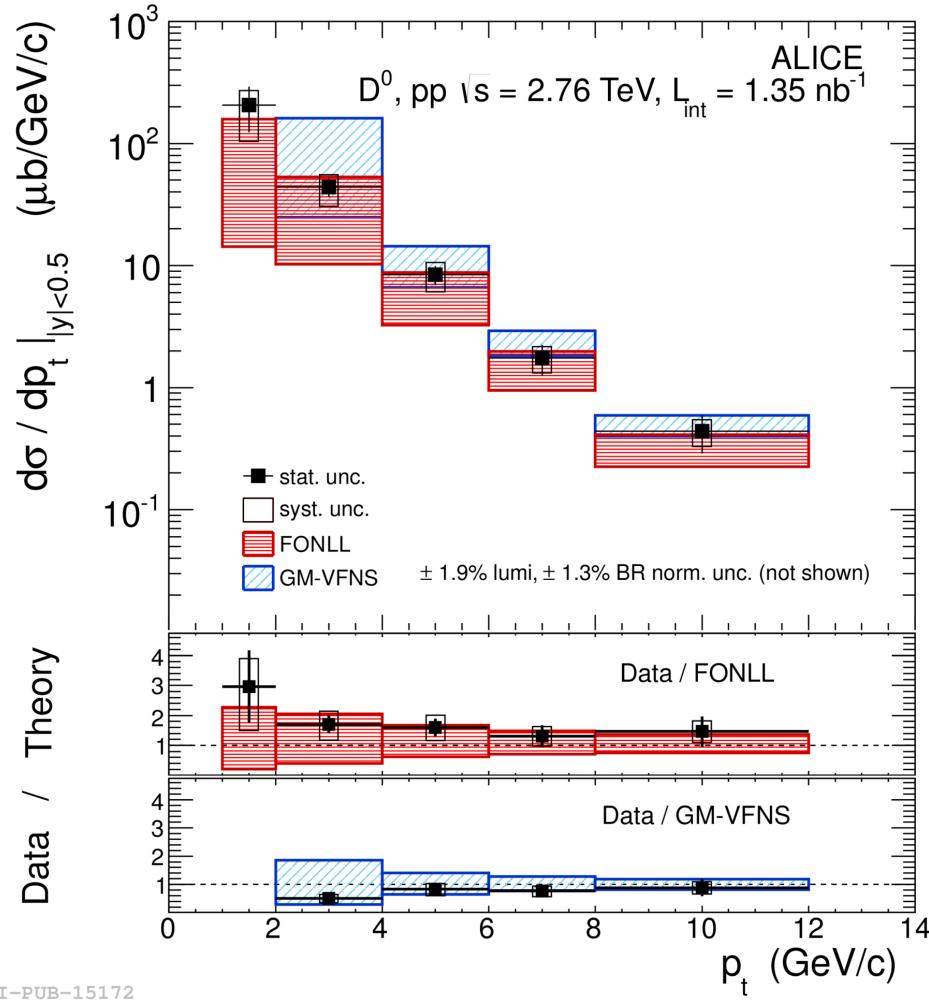
$\cos(\theta_{\pi, D_s^+}) < 0.95$ at low p_t

$\cos 3(\theta_{K\pi}) < 0.1$ at low p_t

At Least 2 ITS (1 must be in SPD)

D0 production 2.76

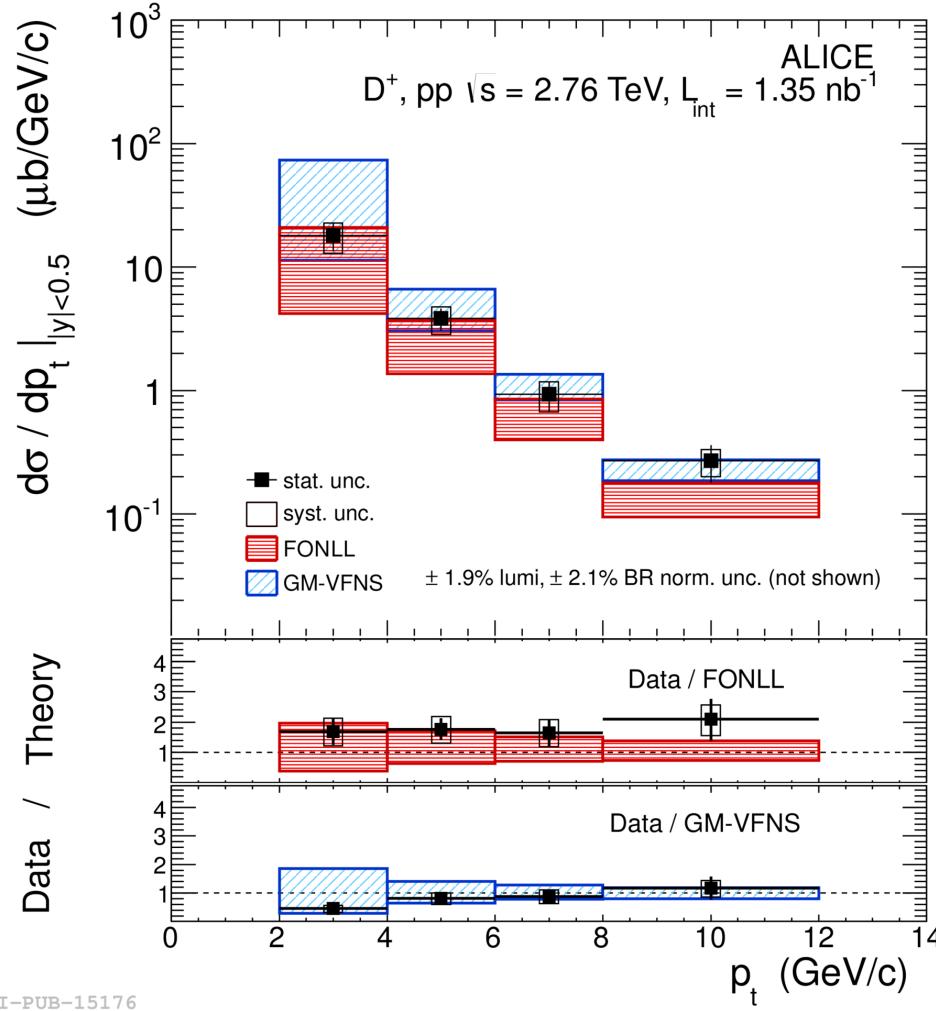
B. Abelev et al., arXiv:12054007v1 [hep-ex] 17 May 2012, p. 9



ALI-PUB-15172

D+ Production 2.76

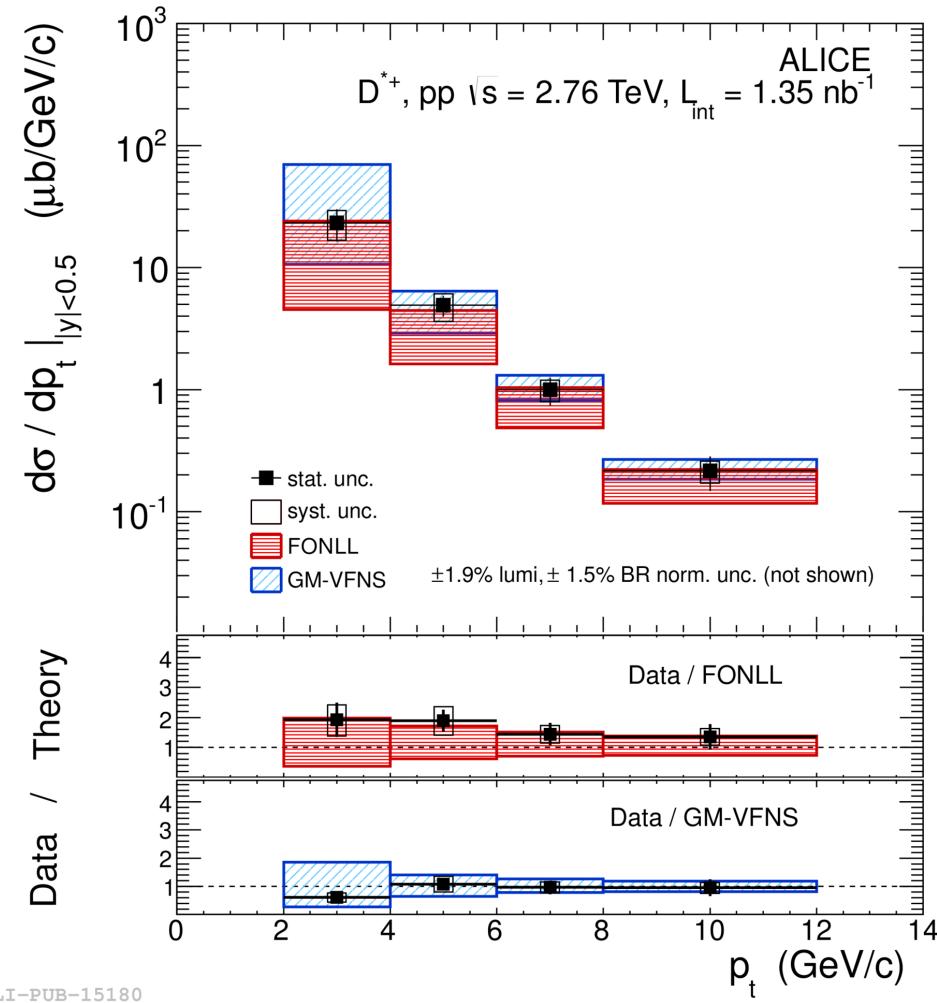
B. Abelev et al., arXiv:12054007v1 [hep-ex] 17 May 2012, p. 9





D^*+ production 2.76

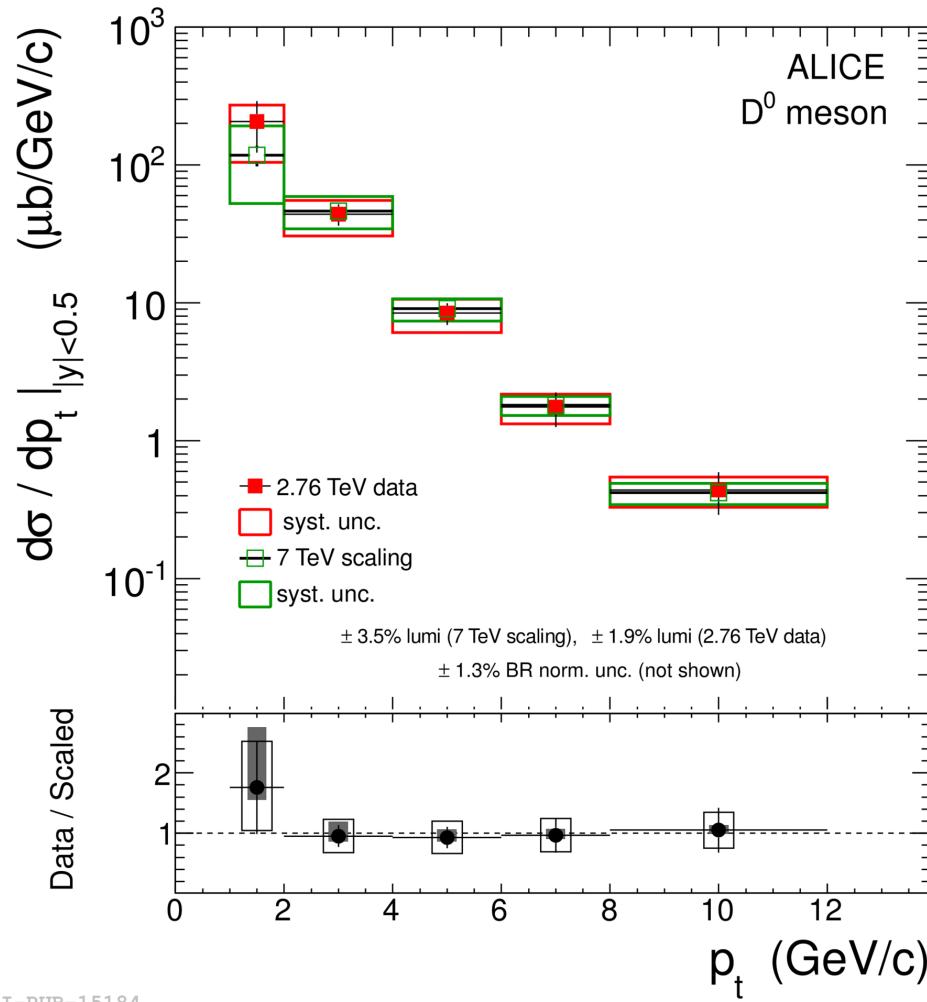
B. Abelev et al., arXiv:12054007v1 [hep-ex] 17 May 2012, p. 9





D0 7 compared to 2.76

B. Abelev et al., arXiv:12054007v1 [hep-ex] 17 May 2012, p. 10

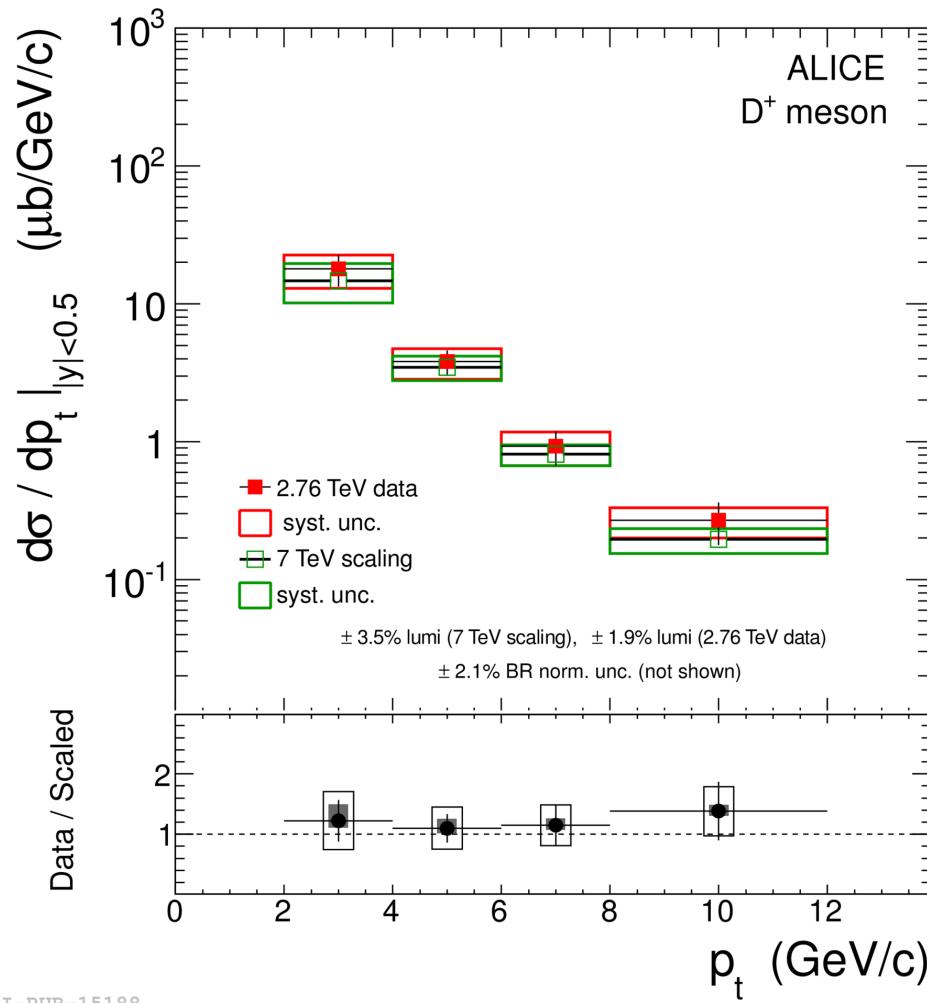


ALI-PUB-15184



D+ comparison 7 to 2.76

B. Abelev et al., arXiv:12054007v1 [hep-ex] 17 May 2012, p. 10

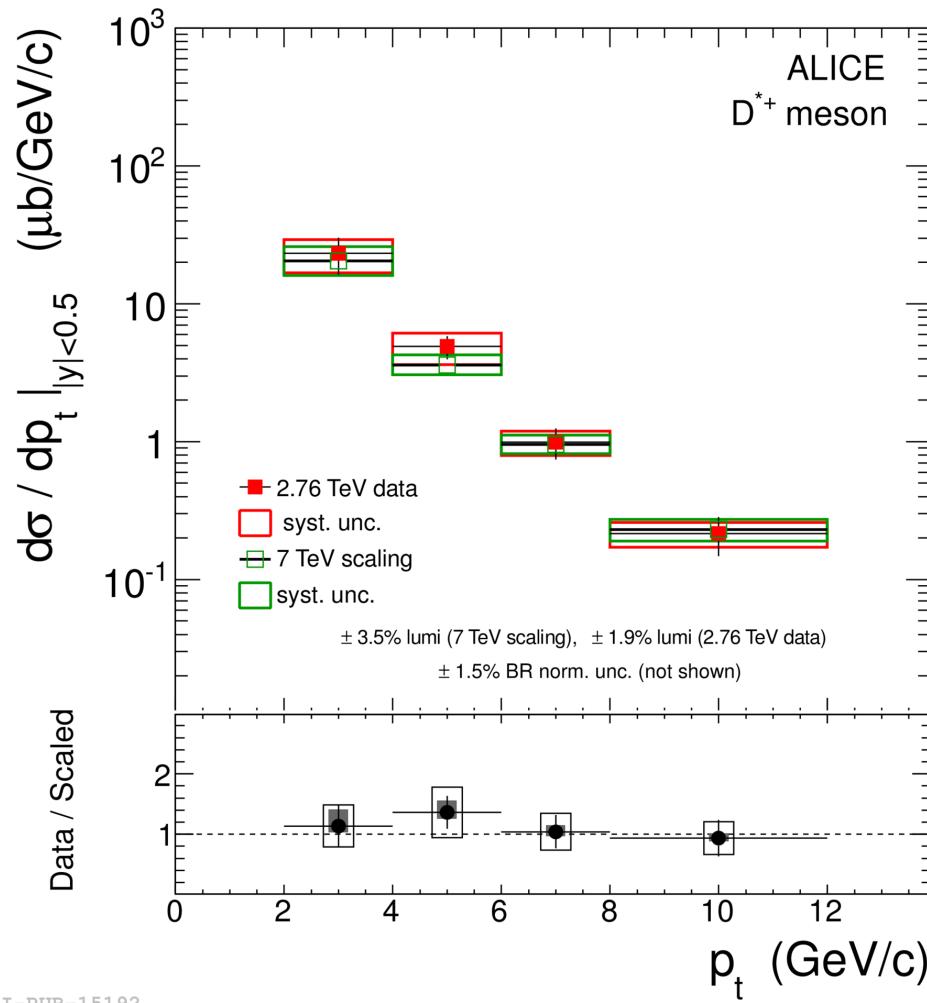


ALI-PUB-15188



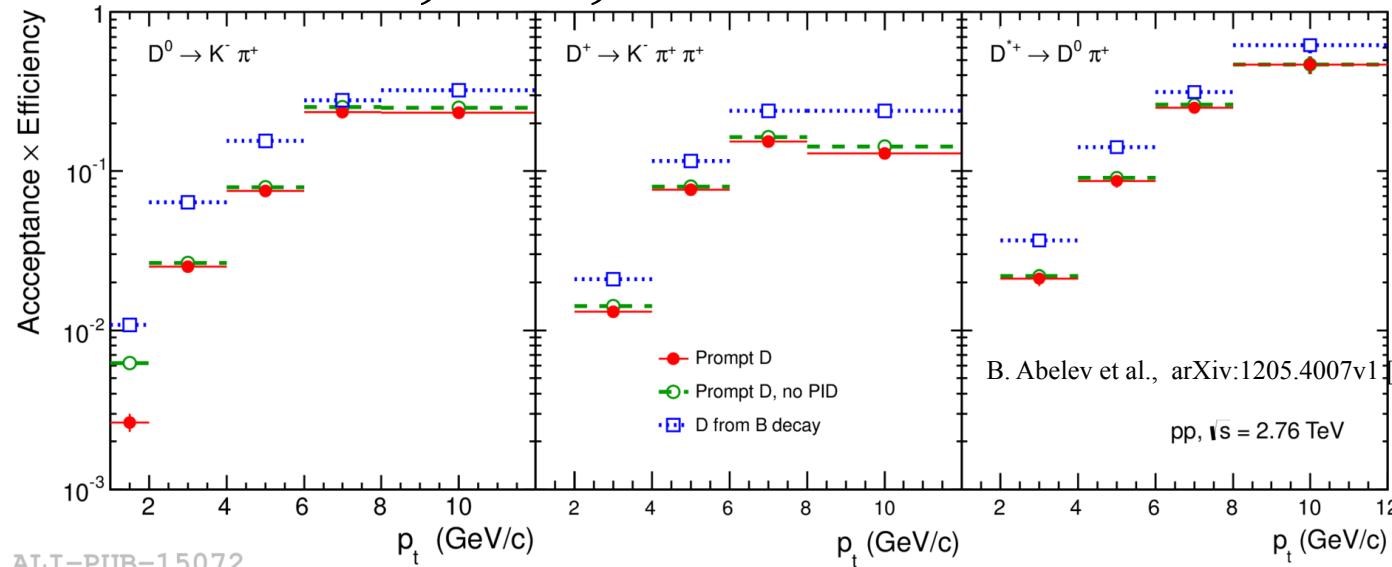
D^{*}+ comparison 7 and 2.76

B. Abelev et al., arXiv:12054007v1 [hep-ex] 17 May 2012, p. 10



ALI-PUB-15192

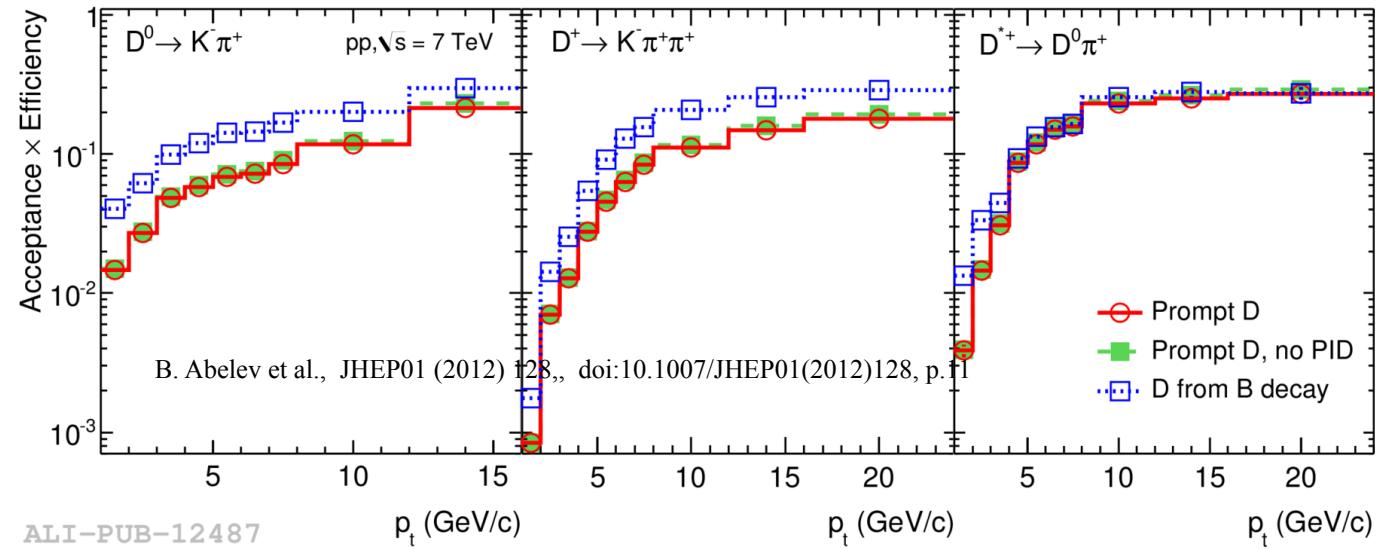
D^0 , D^+ , & D^{*+} Efficiencies



ALI-PUB-15072

$$\frac{d\sigma^D}{dp_t} = \frac{1}{2\Delta y \Delta p_t (A \times \epsilon)_{prompt}(p_t) BR(D \rightarrow X) L_{int}} f_{prompt}(p_t) N_{raw}^D(p_t) \Big|_{|y| < y_{fid}}$$

f_{prompt} corrects
for $B \rightarrow D$ decays
based on a
FONLL pQCD
calculation



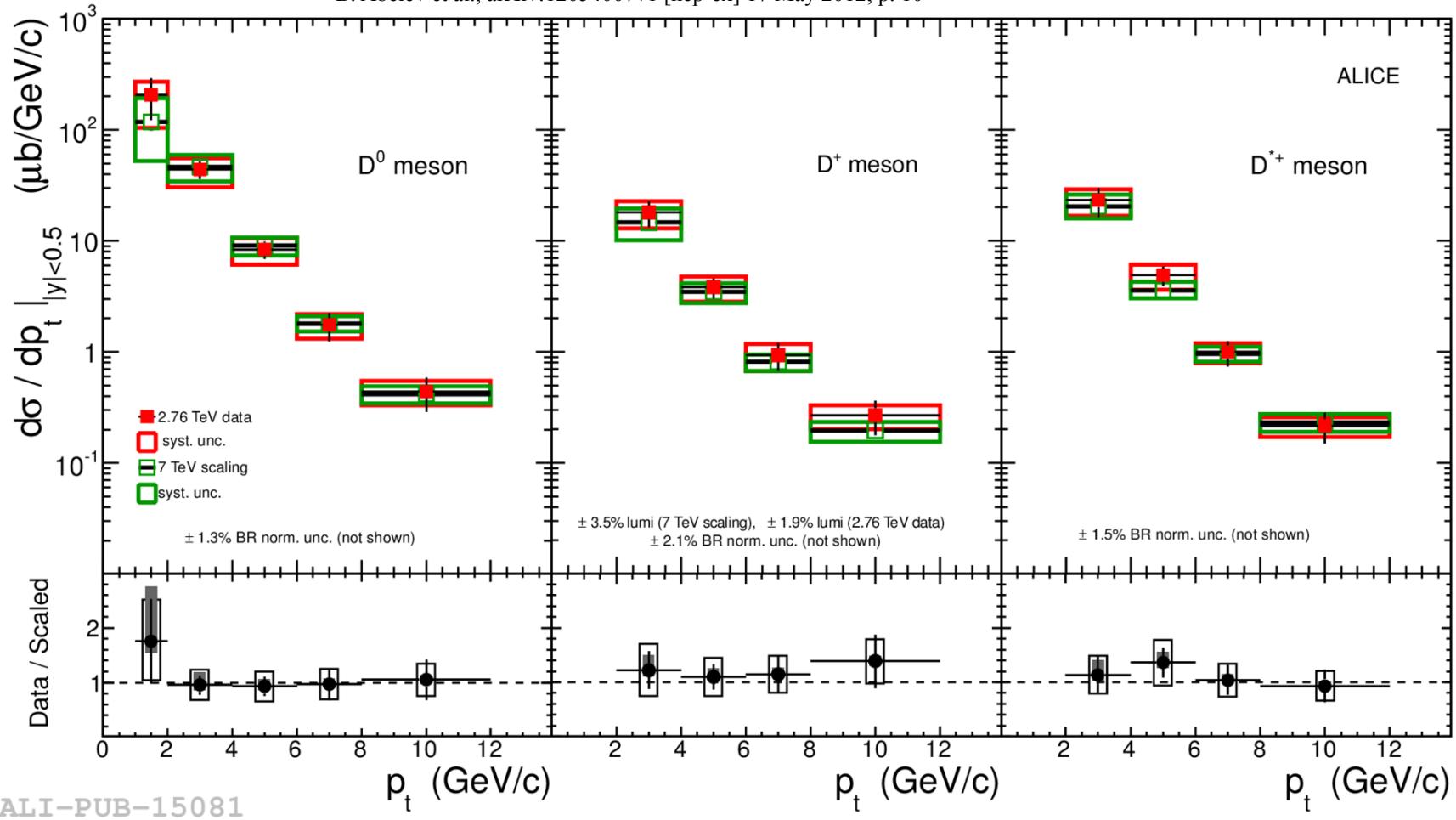
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ALI-PUB-12487

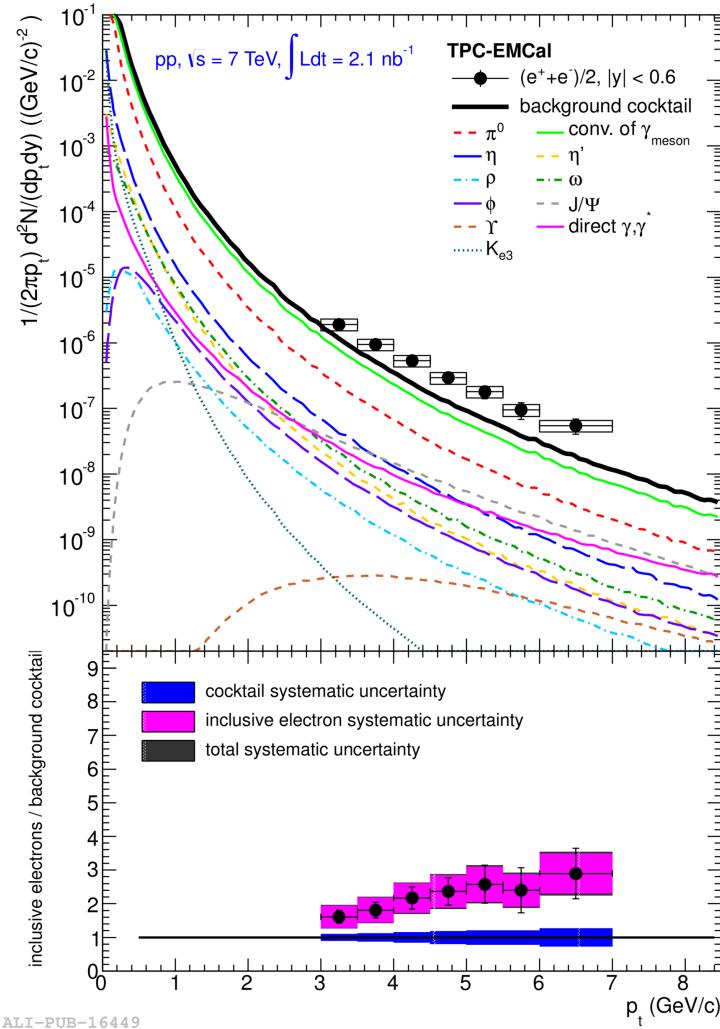
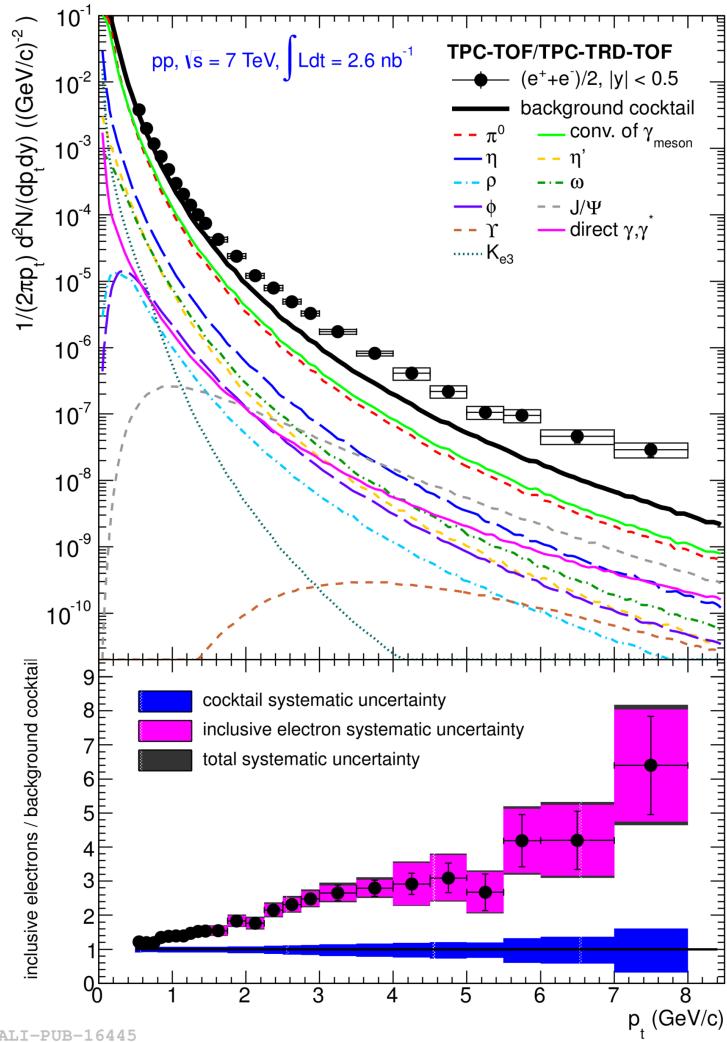


Comparison 7 & 2.76 TeV

B. Abelev et al., arXiv:12054007v1 [hep-ex] 17 May 2012, p. 10



Electronic D decays



ALI-PUB-16445

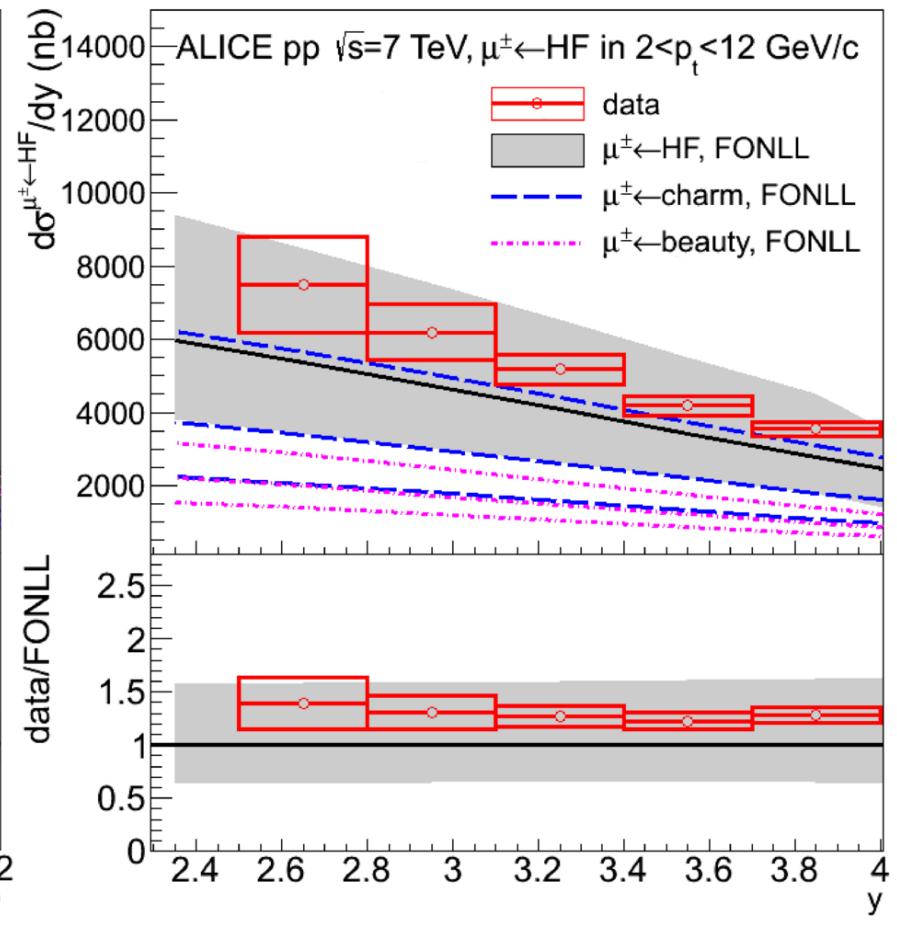
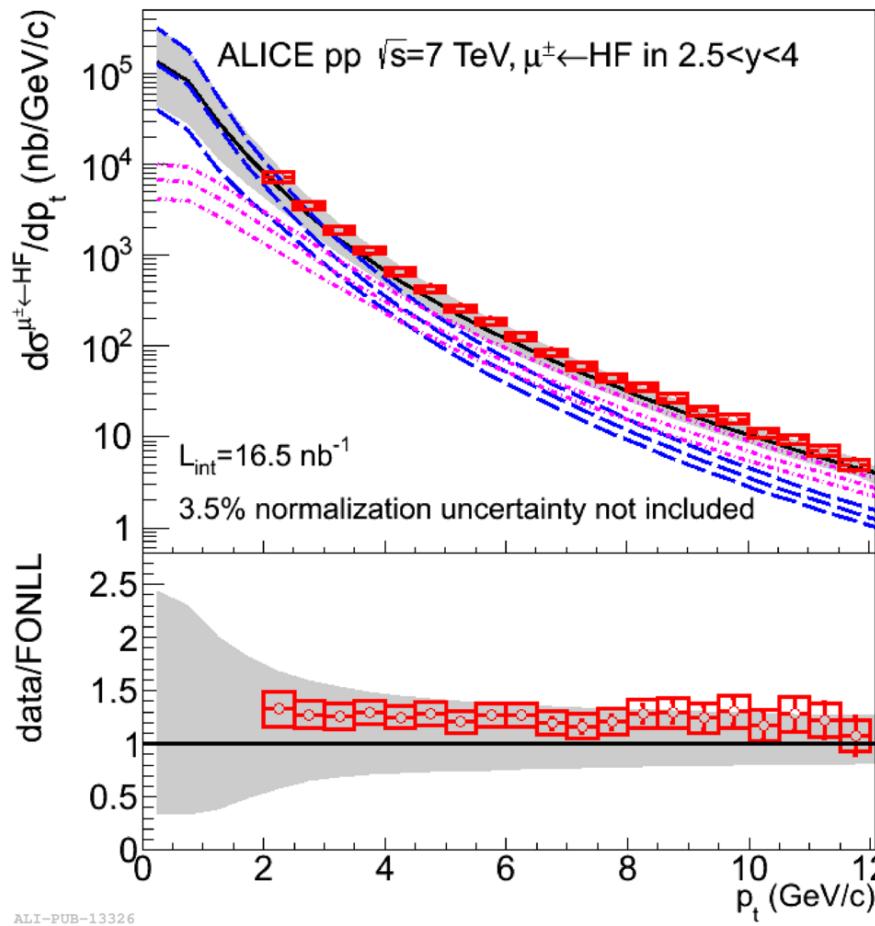
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Compared to FONLL pQCD

B. Abelev et al., Phys. Let. B 708 (2012), doi:10.1016/j.Physletb.2012.01.063,, p. 269





Data Samples and Selections used

System	$ \eta < 0.9$	$-2.5 < \eta < -4$	$ \eta < 0.9$	$-2.5 < \eta < -4$
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p-p \sqrt{s}	2.76 TeV	2.76 TeV	7.0 TeV	7.0 TeV
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Year	2011	2011	2010	2010
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$\langle A \times \epsilon \rangle$	0.139 [e $^\pm$]	0.346 [μ^\pm]	0.098 [e $^\pm$]	0.329 [μ^\pm]
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$$R^{\ell^+ \ell^-} = \frac{N_{MB}^\mu}{N_{\mu-MB}^\mu} \Big|_{\ell=\mu} \quad 1.0 \qquad \qquad 0.0326 \pm 0.0002 \quad 1.0 \qquad \qquad 0.0326 \pm 0.0002$$

$$\sigma_{J/\Psi} = \frac{N^{\ell^+ \ell^-}}{(A \times \epsilon)^{\ell^+ \ell^-} BR(J/\Psi \rightarrow \ell^+ \ell^-)} \times \frac{\sigma_{MB}}{N_{MB}} \times R^{\ell^+ \ell^-}$$



Cristal Ball Function

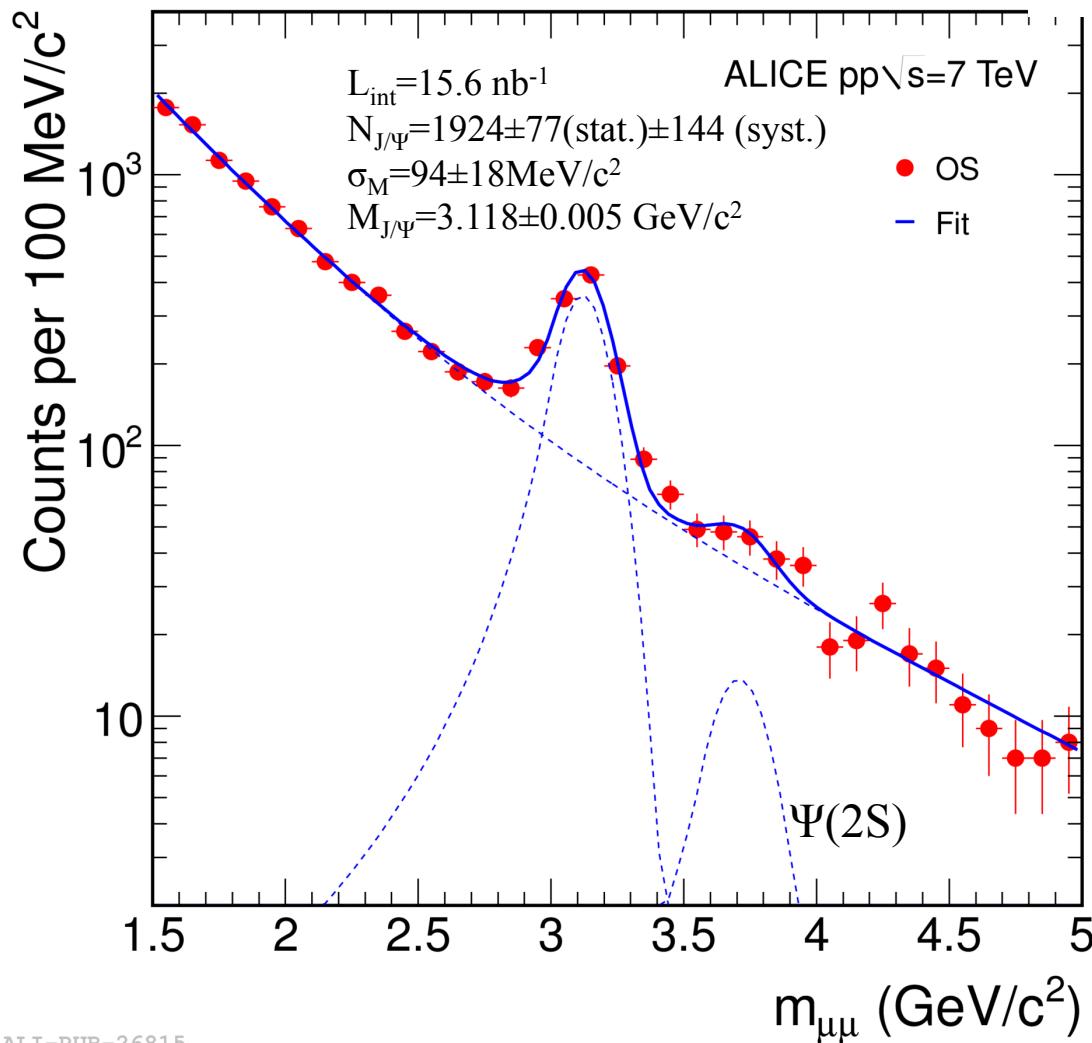
$$\frac{dL}{dM_{\mu\mu}}(M_{\mu\mu}; \alpha, M, \sigma, n) = N \begin{cases} e^{-\frac{(M_{\mu\mu}-M)^2}{2\sigma^2}} & \frac{M_{\mu\mu}-M}{\sigma} > -\alpha \\ \left(\frac{n}{|\alpha|}\right)^n e^{-\frac{|\alpha|^2}{2}} \left(\frac{n}{|\alpha|} - |\alpha| - \frac{M_{\mu\mu}-M}{\sigma}\right)^{-n} & \frac{M_{\mu\mu}-M}{\sigma} \leq -\alpha \end{cases}$$

J/ Ψ Production 7 TeV



$$\sigma = 6.31 \pm 0.25 \pm 0.76 + 0.95 - 1.96 \mu\text{b}$$

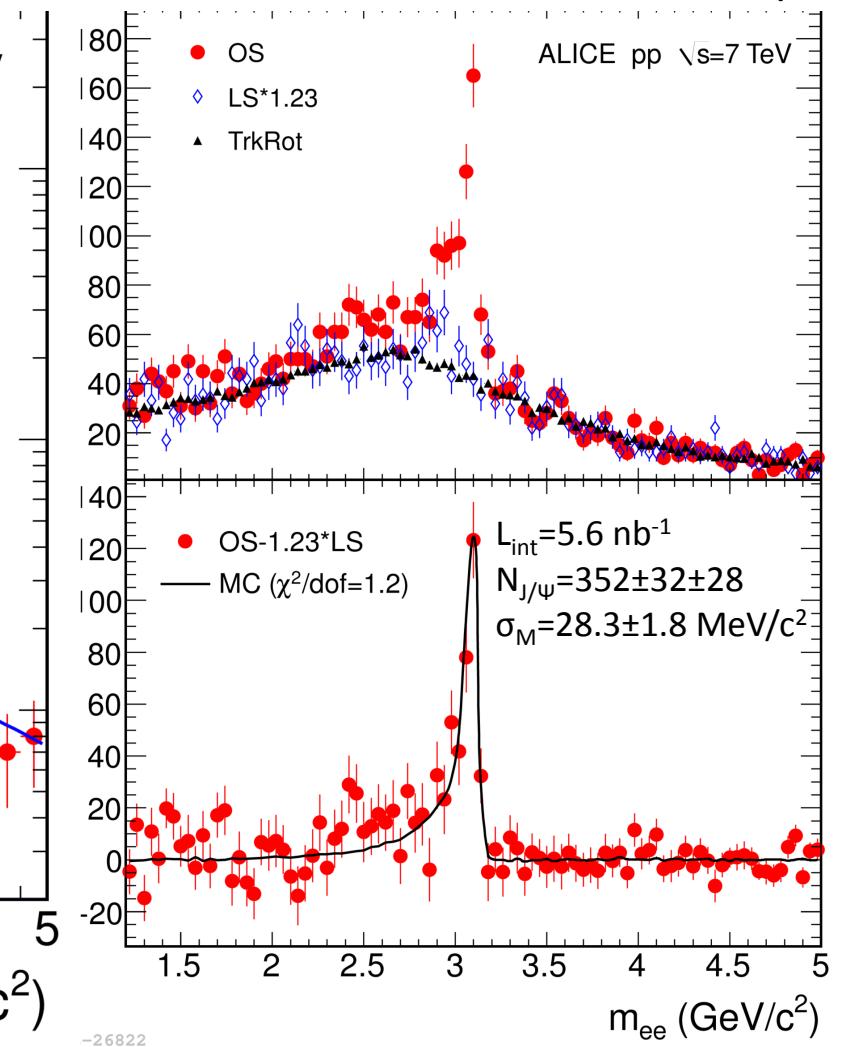
$$\sigma = 10.7 \pm 1.0 \pm 1.6 \pm 1.6 + 1.6 - 2.3 \mu\text{b}$$



ALICE-PUB-26815

K. Aamodt et al., Phys. Let. B 704 (2012) doi:10.1016/j.physletb2011.09.054, p. 444,445

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J/ Ψ Production 2.76 TeV



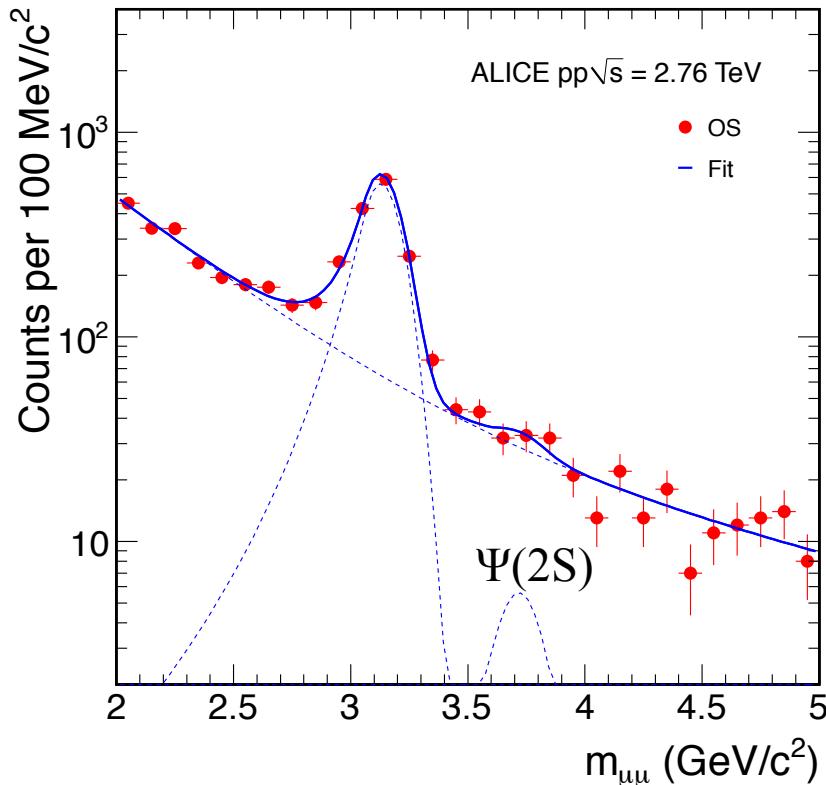
$$\sigma = 3.34 \pm 1.24 \pm 0.13 + 0.28 - 0.53 \text{ } \mu\text{b}$$

$$L_{\text{int}} = 19.9 \text{ nb}^{-1}$$

$$N_{J/\Psi} = 1364 \pm 53$$

$$w_{J/\Psi} = 0.083 \pm 0.004 \text{ GeV}/c^2$$

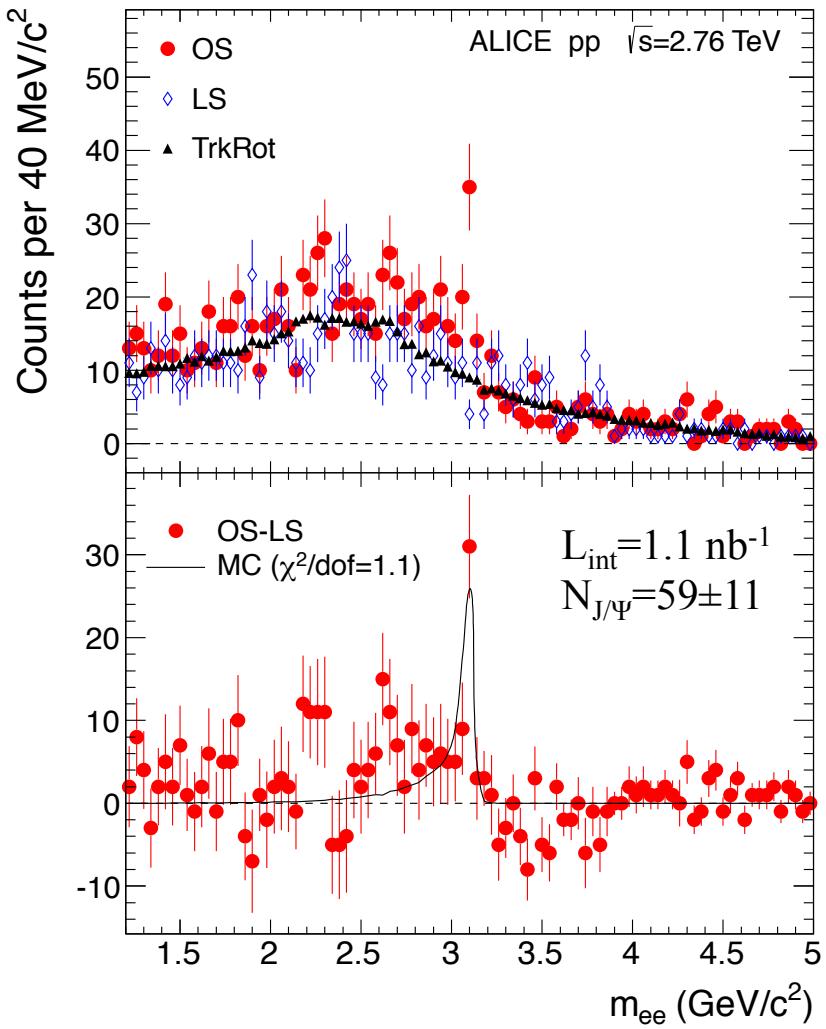
$$M_{J/\Psi} = 3.129 \pm 0.004 \text{ GeV}/c^2$$



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B. Abelev et al., arXiv:1203.3641v1 [hep-ex] 16 Mar 2012, p. 5

$$\sigma = 6.71 \pm 1.24 \pm 1.22 + 1.01 - 1.41 \text{ } \mu\text{b}$$



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