

Status report:

5 TeV pp charm combination and total cross section

Achim Geiser, DESY

for the HonexComb charm working group

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M. Mazzilli, J. Metwally, J. Sun, Y. Yang^{*)} ^{*)} = new members

HonexComb meeting, 30. 03. 2021

main objectives:

obtain a **combined measurement of $\sigma_{\text{tot}}(\text{charm})$ and σ_{charm} vs. p_{T} and y** using the existing published measurements of **Alice, CMS and LHCb** at 5 TeV;

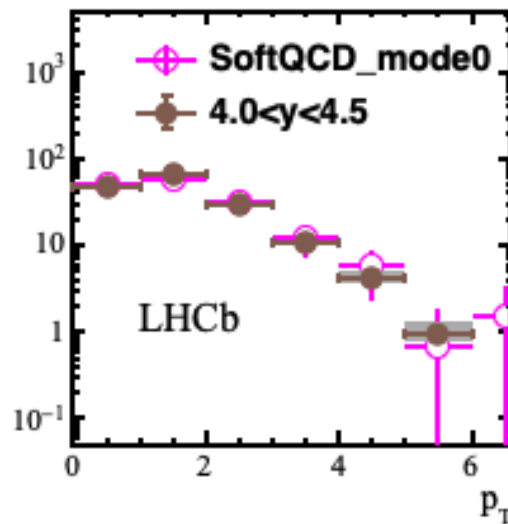
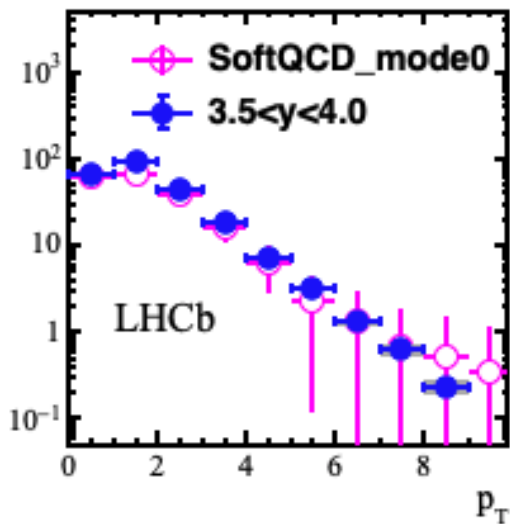
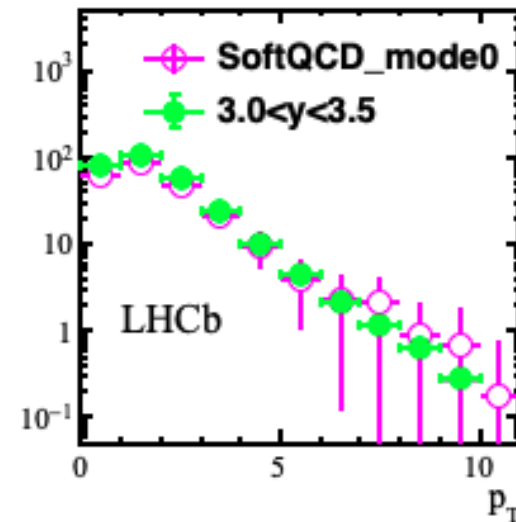
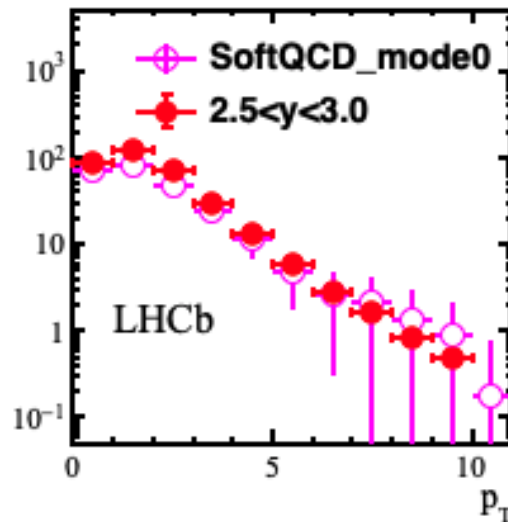
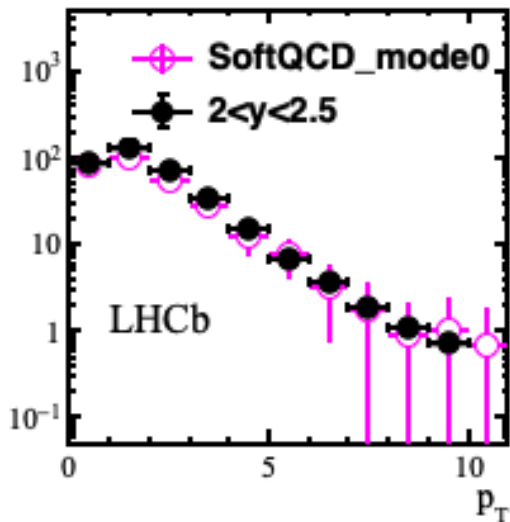
understand **theory**, find “best” description and evaluate/minimize **interpolation/extrapolation uncertainty for total cross section**

- same 5 TeV pp charm data as shown in earlier presentations (ALICE, CMS, LHCb):
single widest coverage by measurements, of interest as reference for 5 TeV Heavy Ion data
- **progress with data-theory comparison** (PYTHIA and FONLL) (others in preparation)
- **summary and outlook, paper plans**

LHCb D^0 data vs. PYTHIA 8 CR0

5 TeV pp D^0

mode 0 Work in progress



J. Sun
M. Mazilli

Comparison of LHCb data with PYTHIA, using QCD colour reconnection model mode 0.

LHCb: Eur. Phys. J. C79 (2019) 388
Data described reasonably.

mode 2 see backup

Prompt D^0 double differential cross section integrate \rightarrow total charm cross sections

D^0

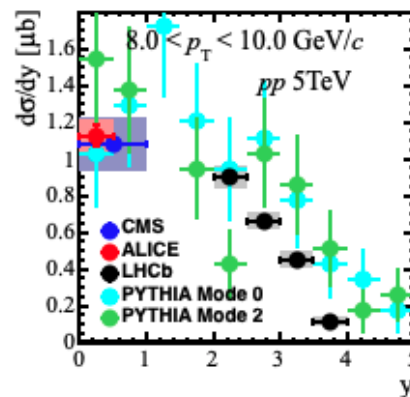
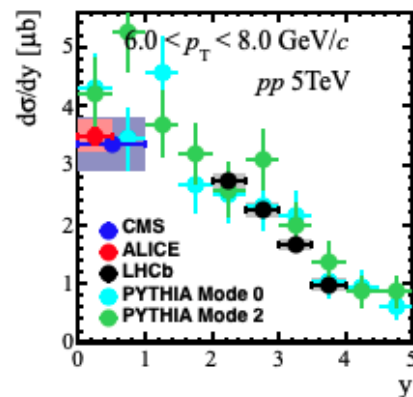
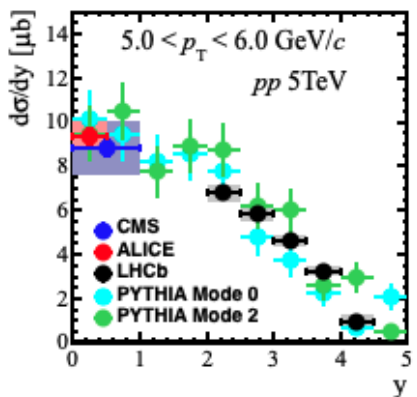
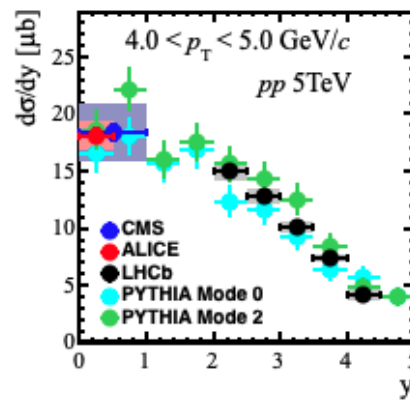
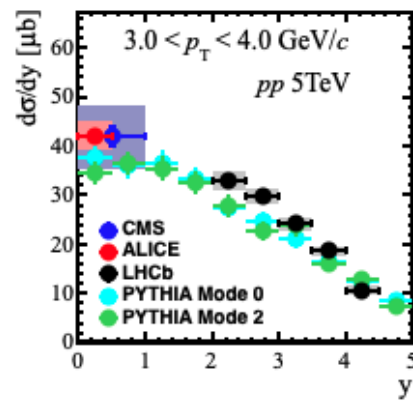
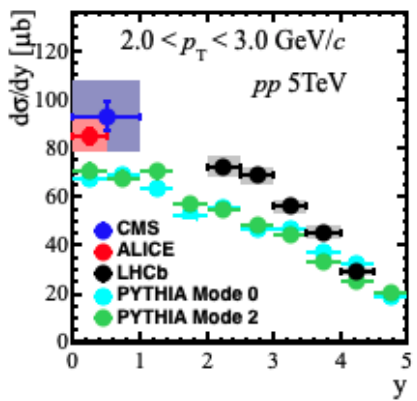
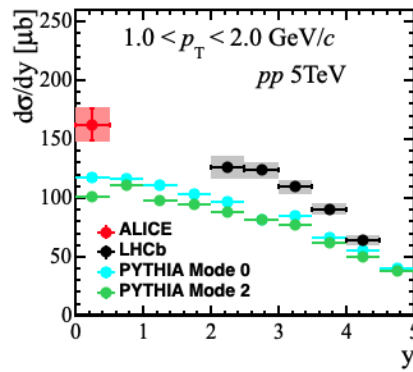
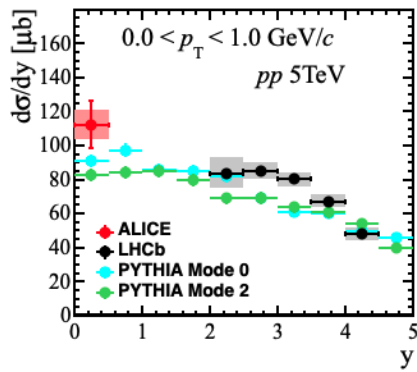
5 TeV pp

J. Sun
M. Mazilli

Work in progress

comparison of data
with PYTHIA
using two different QCD
colour reconnection(CR)
models
(mode 0 and mode 2, see
backup)

ALICE: JHEP 06 (2017) 147
CMS: PLB 782 (2018) 474
LHCb: EPJ C79 (2019) 388

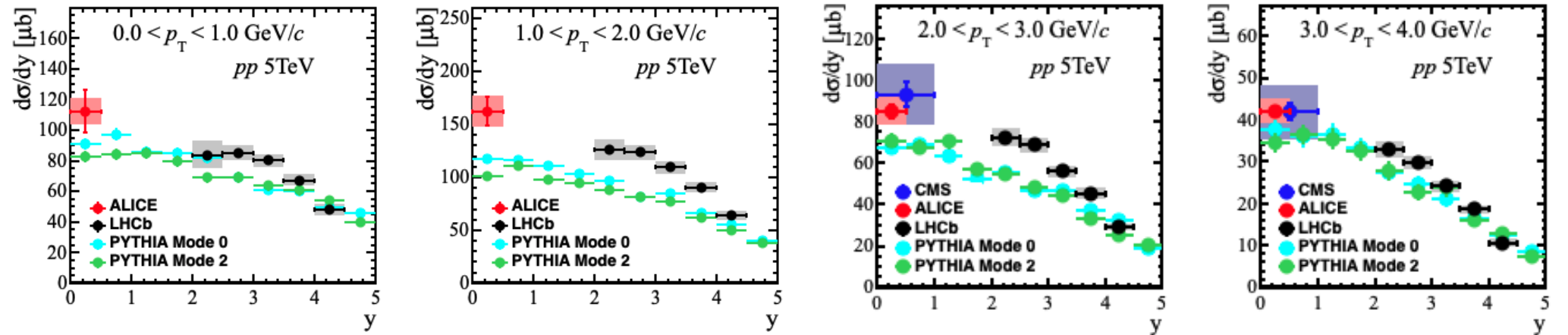


Prompt D^0 double differential cross section low p_T part

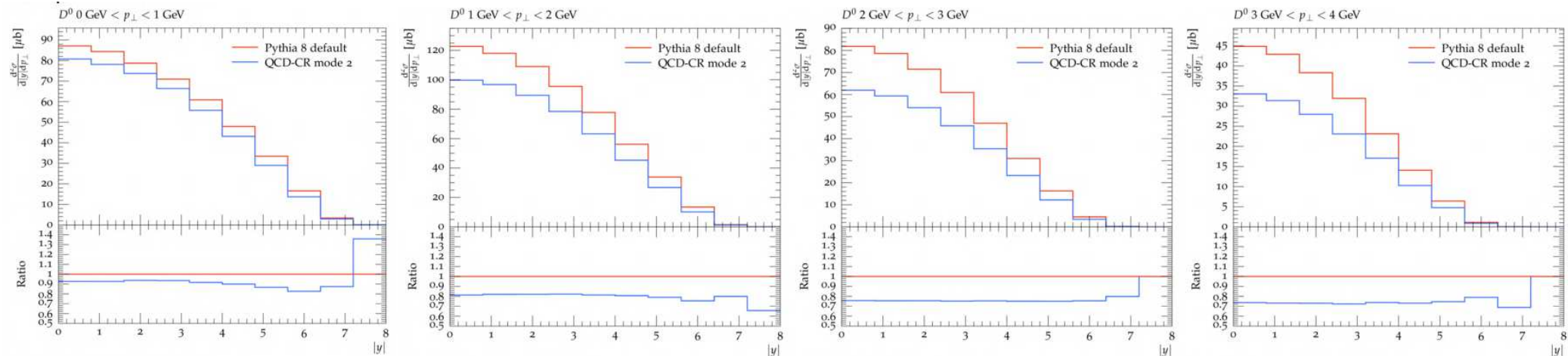
5 TeV pp D^0

J. Sun, M. Mazilli

Work in progress



C. Bierlich



top:

SoftQCD with colour reconnection (CR) mode 0 slightly closer to data than CR mode 2

bottom:

PYTHIA default model (no CR) compared to QCD CR mode 2 model (tune checks ongoing)

30.03.2021

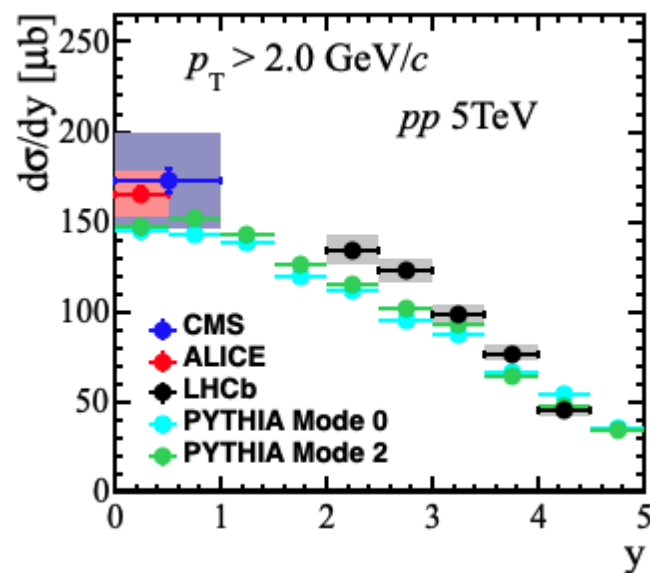
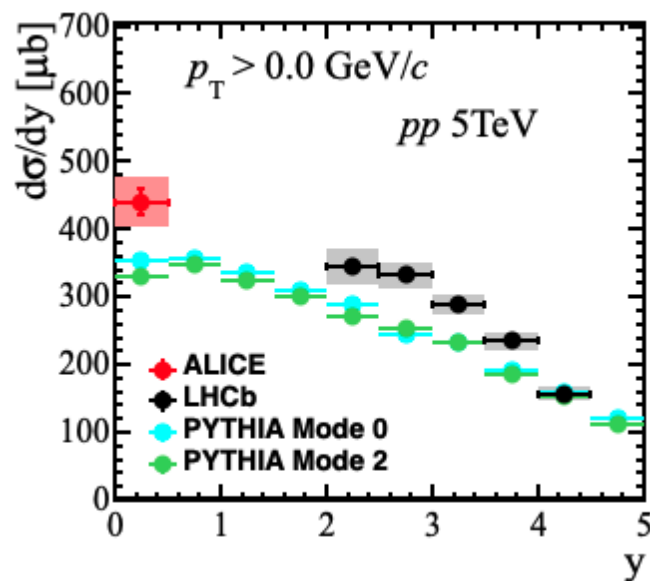
A. Geiser, HonexComb meeting

integrate/sum double differential -> single differential

5 TeV pp

D^0

Work in progress



J. Sun
M. Mazilli

Use this to interpolate/extrapolate to total cross sections

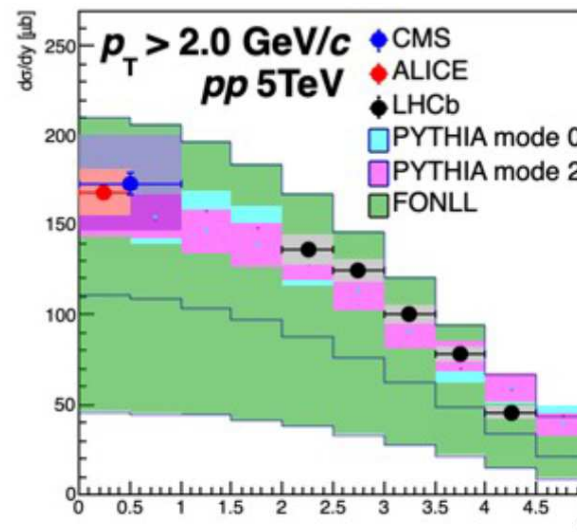
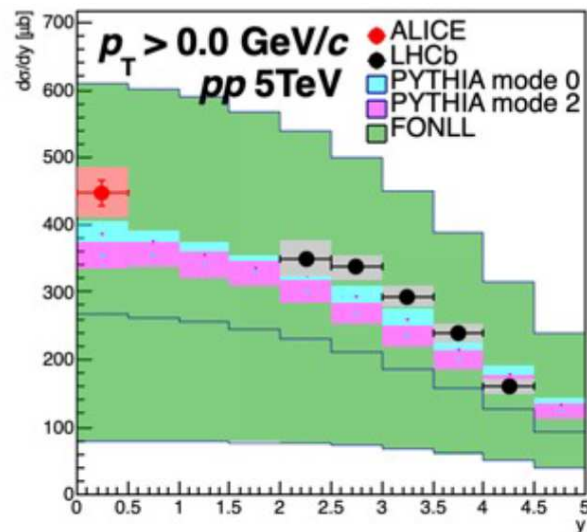
prompt D meson differential cross section integrate, inter-/extrapolate -> total charm cross section

5 TeV pp D^0

Work in progress

Comparison with data including FONLL predictions for D^0

J. Metwally
J. Sun
M. Mazilli



FONLL settings:
PDF: CTEQ 6.6 +unc.
mc: 1.5 +/- 0.2 GeV
fact. scale: *2/*0.5
ren. scale: *2/*0.5

fragmentation tuned
to LEP data

FONLL: NLO + NLL QCD prediction, absolute prediction with uncertainties, no tuning
<http://www.lpthe.jussieu.fr/~cacciari/fonll/fonllform.html> and references therein

PYHTIA: LO + LL prediction, tuned to (other) data, no a priori uncertainties (stat only)

T. Sjöstrand et al., Comp. Phys. Comm. 191 (2015) 159 [arXiv:1410.3012]

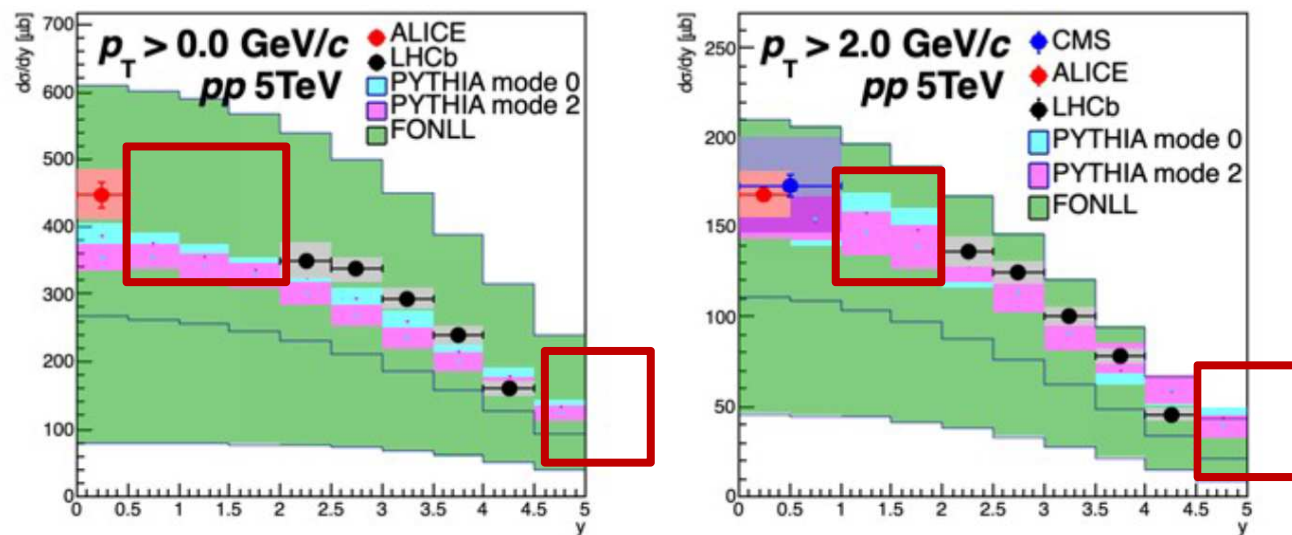
J.R. Christiansen and P.Z. Skands, JHEP 1508 (2015) 003 [arXiv:1505.01681]

prompt D meson differential cross section integrate, inter-/extrapolate -> total charm cross section

5 TeV pp D^0

Work in progress

Comparison with data including FONLL predictions for D^0



FONLL settings:
PDF: CTEQ 6.6 +unc.
mc: $1.5 \pm 0.2 \text{ GeV}$
fact. scale: $*2/*0.5$
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fragmentation tuned
to LEP data

FONLL: NLO + NLL QCD prediction, absolute prediction with uncertainties, no tuning

PYHTIA: LO + LL prediction, tuned to (other) data, no a priori uncertainties (stat only)

Find settings which describe data best

Find shape which describes data best

Interpolate/extrapolate to total cross section

Summary, conclusions and outlook

Project for combined treatment of published 5 TeV pp charm data from Alice, CMS and LHCb is making good progress

New person power is strengthening the team

Comparisons with MC models and QCD theory predictions are ongoing

Next:

- Extrapolate to total cross section, with determination of uncertainty**
- Publish paper on findings from data/theory comparisons, and total cross section**

-> reference for future pp and heavy ion measurements

Backup

Colour reconnection models

<https://cds.cern.ch/record/2262253/files/ATL-PHYS-PUB-2017-008.pdf>

Three CR models have been considered.

Colour reconnection enhances e.g. Λ_c production

- MPI based CR model (CR0): In this model, the probability for coloured partons with transverse momentum p_T from MPI to reconnect is calculated according to:

$$P_{\text{rec}}(p_T) = \frac{(R_{\text{rec}} \cdot p_{T0})^2}{R_{\text{rec}} \cdot p_{T0} + p_T^2} \quad \text{CR mode 0} \quad (1)$$

where R_{rec} is the `ColourReconnection:range` and p_{T0} is the `MultipartonInteractions:pT0Ref` parameter in Table 1. For each MPI system that undergoes a reconnection, partons from lower p_T MPI systems are added to the dipoles defined by the higher p_T MPI system, in a way that minimizes the total string length.

- QCD based model (CR1):

This model evolved from the MPI based model. The main difference with respect to CR0 and CR2 (described next) is the more complete treatment of the QCD multiplet structure and in particular that reconnections of dipoles can produce structures of three (anti-)colour indices (junctions), thereby enhancing the production of baryons. As in the CR2 model, in this model only reconnections which lower the string length are performed.

- Gluon-move model (CR2):

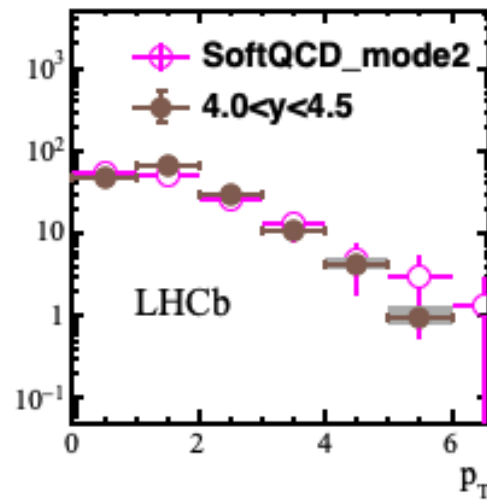
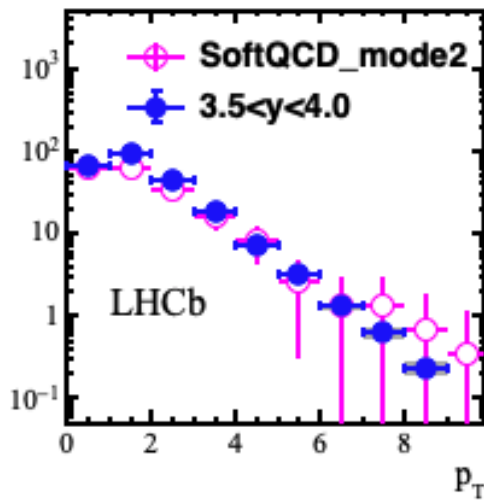
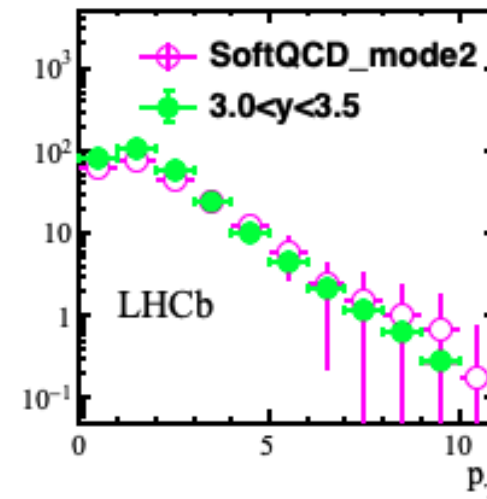
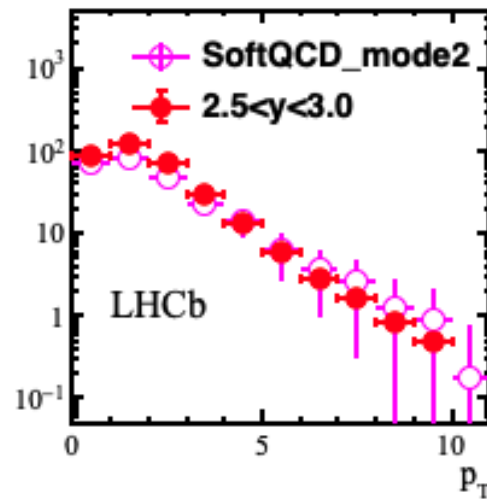
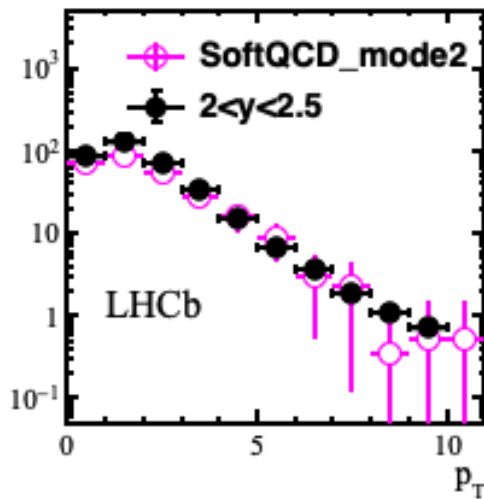
CR mode 2

In the gluon move model (CR2), reconnections are performed in the same way as in the CR0 model. The main differences with the default model are that in the CR2 model only gluons are considered for reconnection. For each gluon all the reconnections to all MPI systems are considered (not only the ones for softer MPIs), therefore in principle the colour flow from the hard interaction can be affected more significantly than in the default model.

LHCb D^0 data vs. PYTHIA 8 CR2

5 TeV D^0

mode 2 Work in progress



Comparison of LHCb data with PYTHIA, using QCD colour reconnection model mode 2.

Data described reasonably.