D meson analysis pp collisions at 8 TeV

Daan Leermakers on behalf of the 8 TeV crew

May 10, 2016

Contents

For D^{*+} and D^{+} mesons the corrected differential cross section was measured, in this presentation the analysis will be summarized by looking at the following steps:

- Invariant mass distributions
- Efficiencies and acceptance
- The cross section
- Estimation of systematic uncertainties

The D^{0} meson analysis is not included and will be included at a later stage. For D^{*+} and D^{+} an analysis note is being written and an ARC is formed.

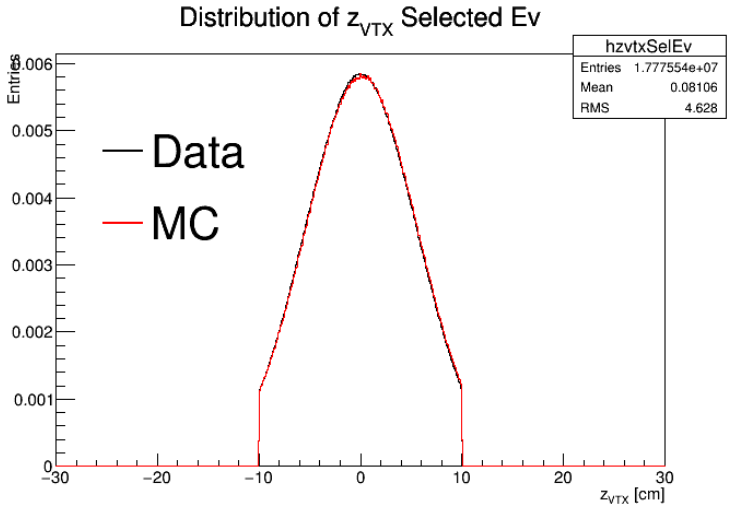
Data set

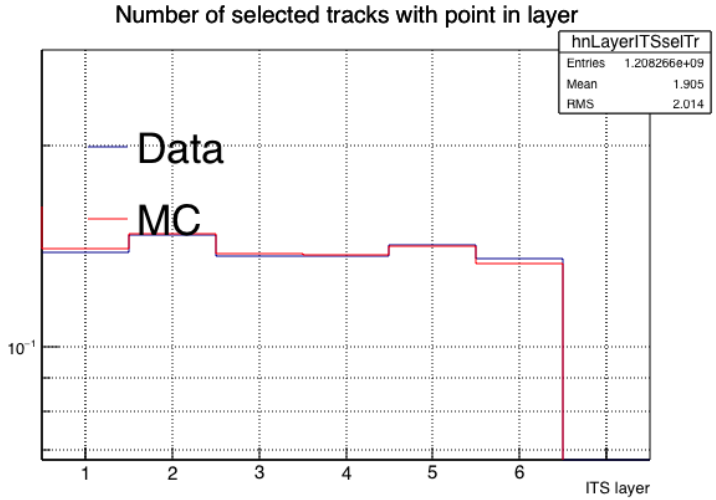
period	INT7 (M)
LHC12a	14.97
LHC12b	11.74
LHC12c	16.23
LHC12d	15.22
LHC12e	0.69
LHC12f	2.45
LHC12g	5.36
LHC12h	33.39
LHC12i	2.83
Total	102.88

Table: Number of events in millions for the 2012 pp data sample

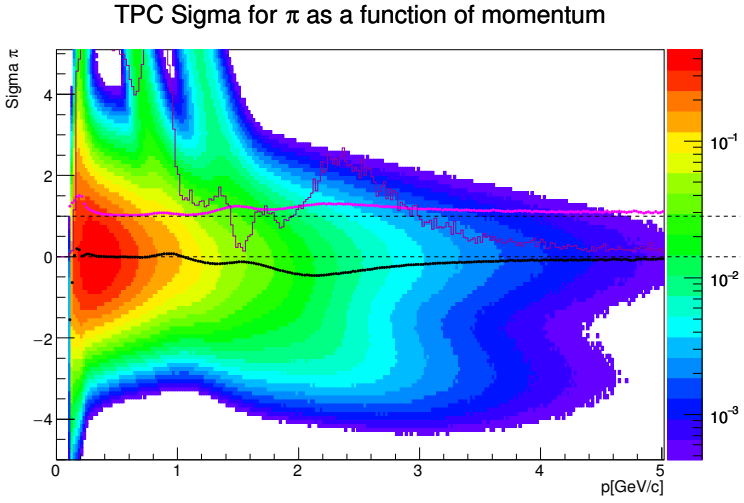
- LHC12a-LHC12i pass 2 used
- $\sim$100 million events analysed
- Monte carlo simulation LHC15l2a2 used for efficiency corrections.
- Pythia production heavy flavour enriched. HF quarks forced to decay in the hadronic channels.
- 19.5 million MC events analysed

Quality assurance

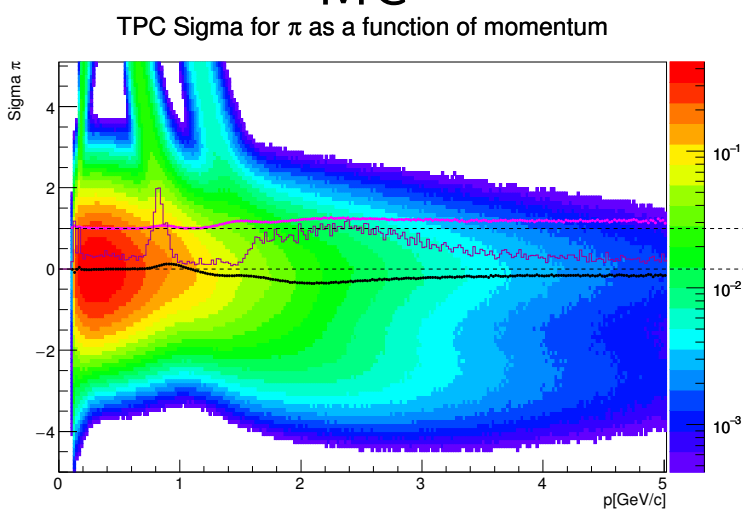




data



MC



- QA checks performed on data and MC. A few example plots are shown.

Invariant mass method

- The hadronic decays $\mathrm{D}^{*+} \rightarrow \mathrm{D}^0\ \pi^+ \rightarrow \mathrm{K}^{\pm}\ \pi^{\mp}\ \pi^+$ and $D^+ \rightarrow K^-\pi^+\pi^+$ as well as their charge conjugates have been reconstructed.
- The invariant mass spectra of (D^{*+} - D^0) and D^+ are fitted with a background function plus a Gaussian.

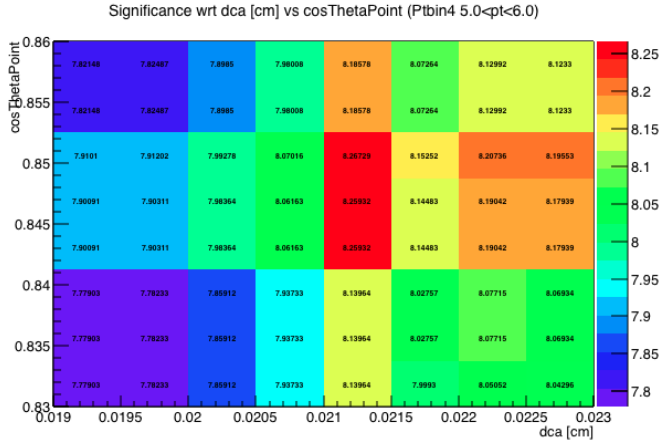
  e.g. D^{*+} background function:

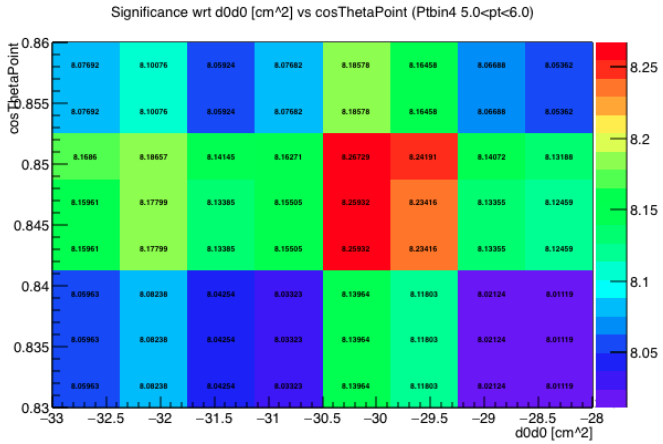
$$f_{background} = a\sqrt{x - m_\pi}e^{b(x-m_\pi)}. \quad (1)$$

- Reconstruction has been successful in 11 p_{T} bins from 1 to 24 GeV/c for both mesons.
- Selection cuts are used to maximize the significance of the fits.

Cut optimization

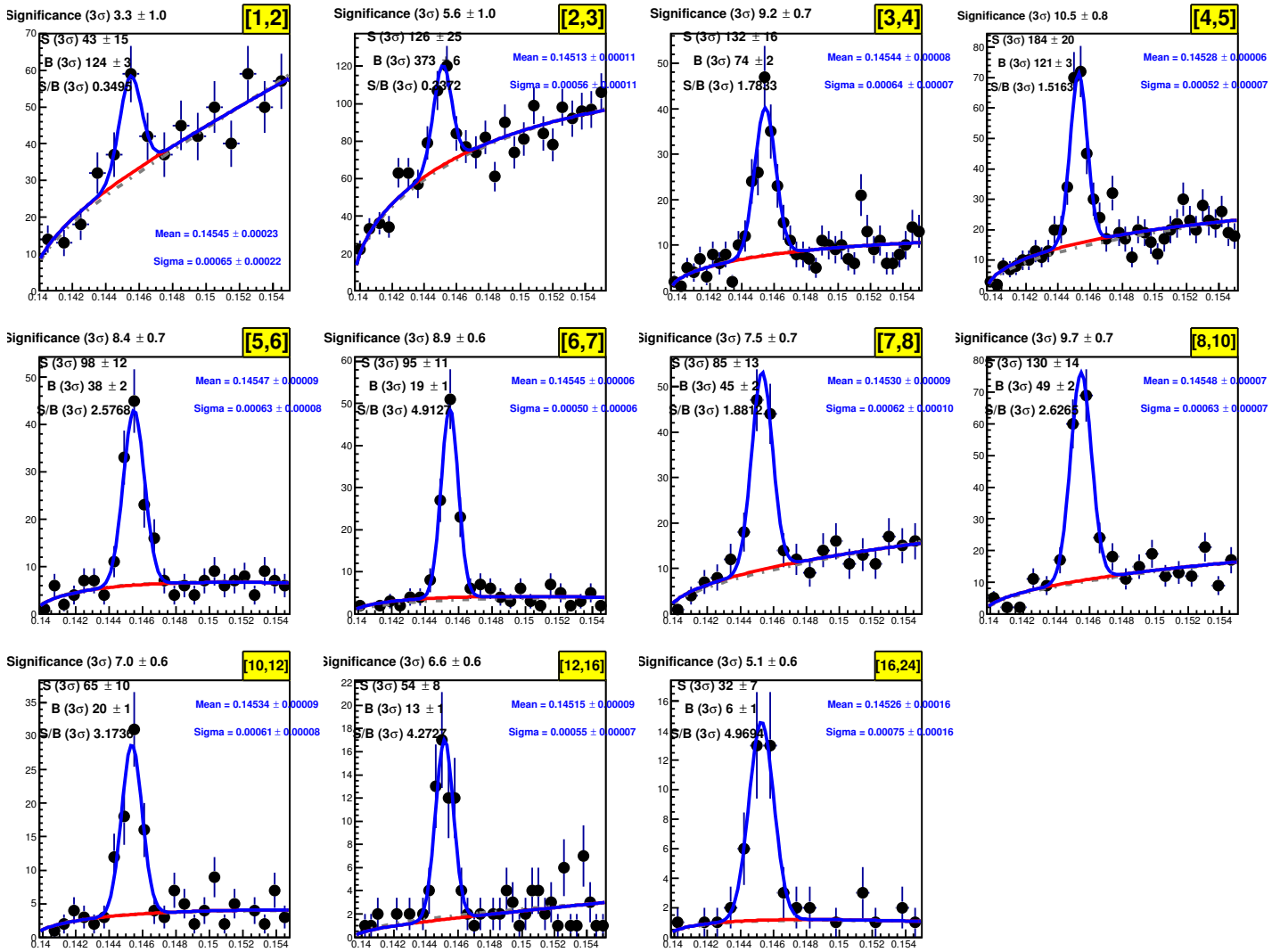
- For the D^{*+} analysis, three cuts have been varied with respect to the 7 TeV pp cuts.
  - Distance of closest approach to the primary vertex
  - The product of the impact parameters $d^0_K \times d^0_\pi$
  - The cosine of the pointing angle between the reconstructed D^0 momentum and the D^0 flight line
- Optimization with respect to the significance is done by using a cut optimization macro which fits the invariant mass spectra for a variety of cuts in a user specified range.



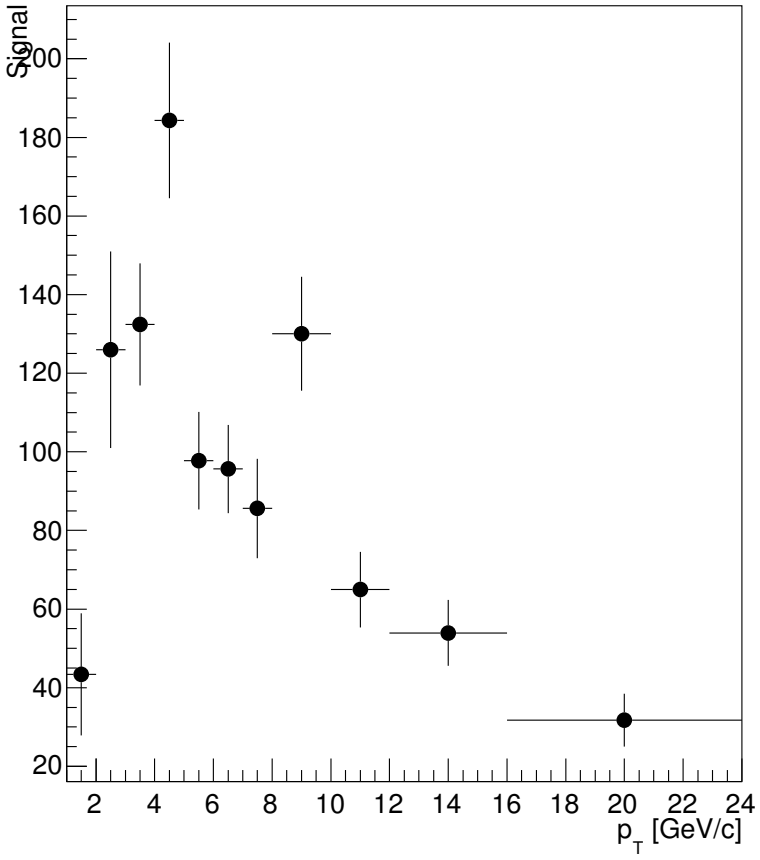


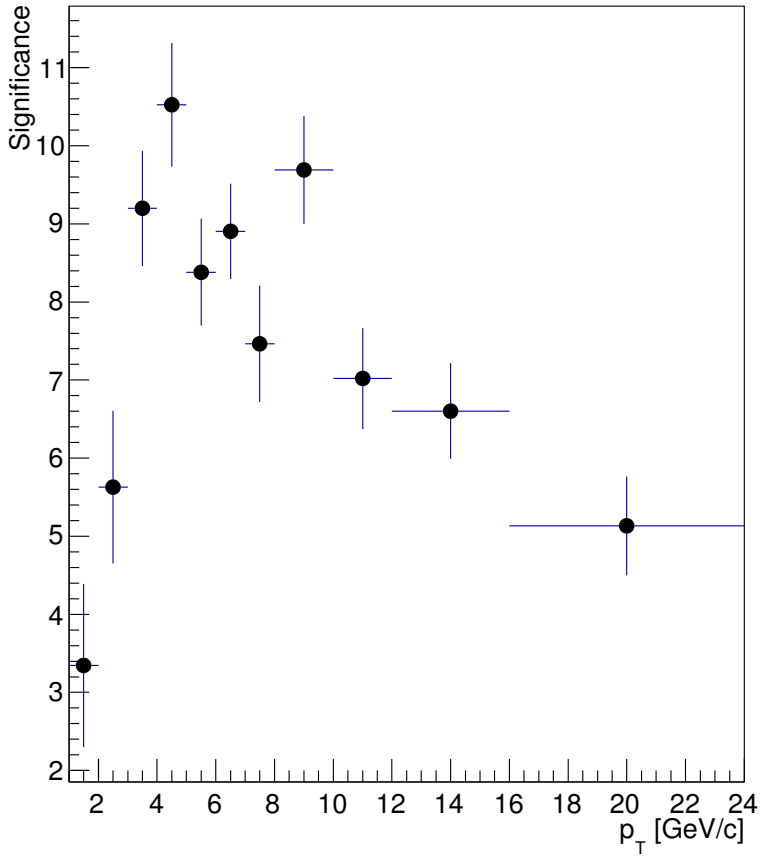
Invariant mass spectra D^{*+}

- A clear signal is obtained in 11 p_{T} bins.
- Almost no cuts are applied above 7 GeV/c



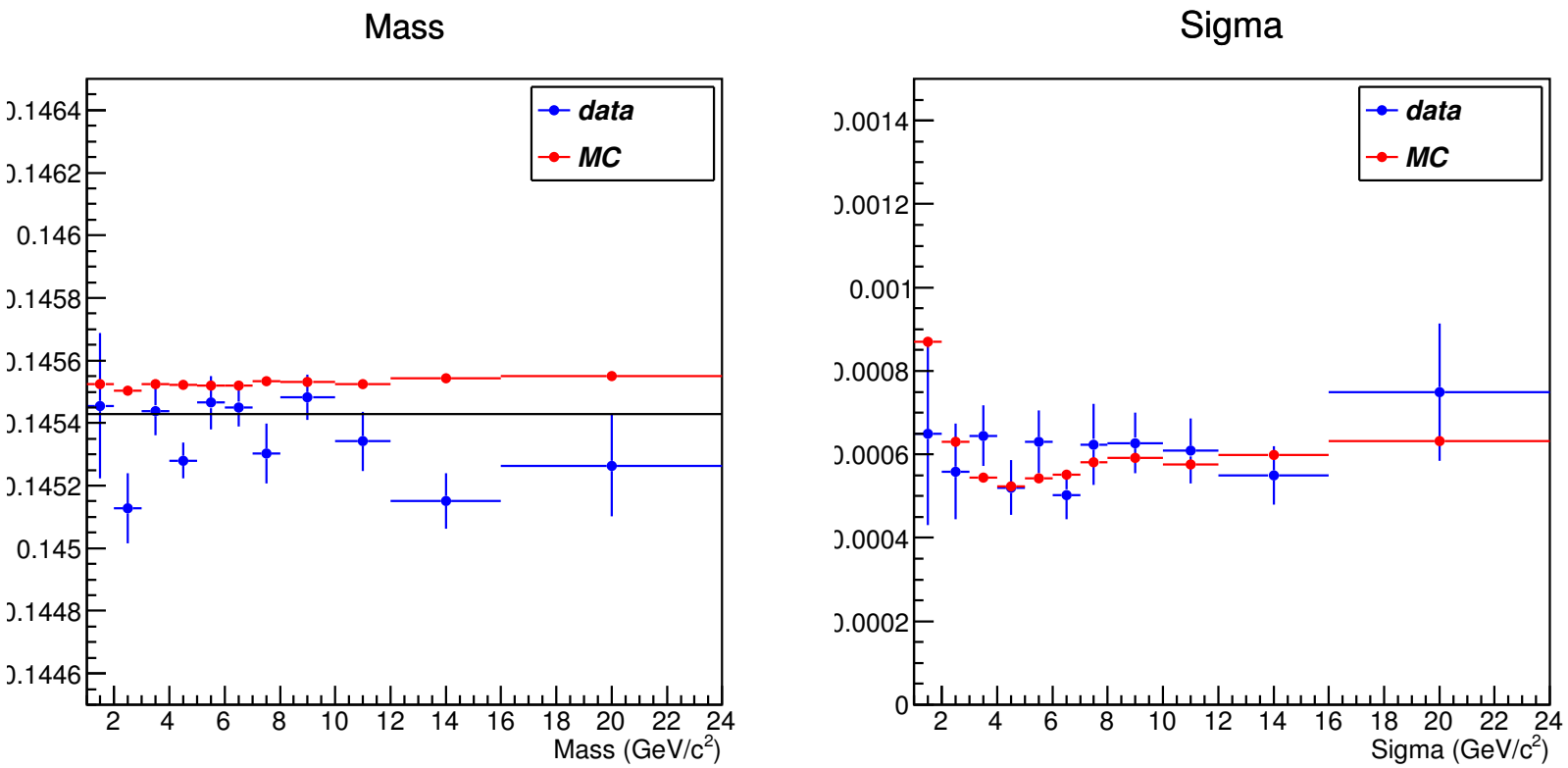
Raw yield and significance





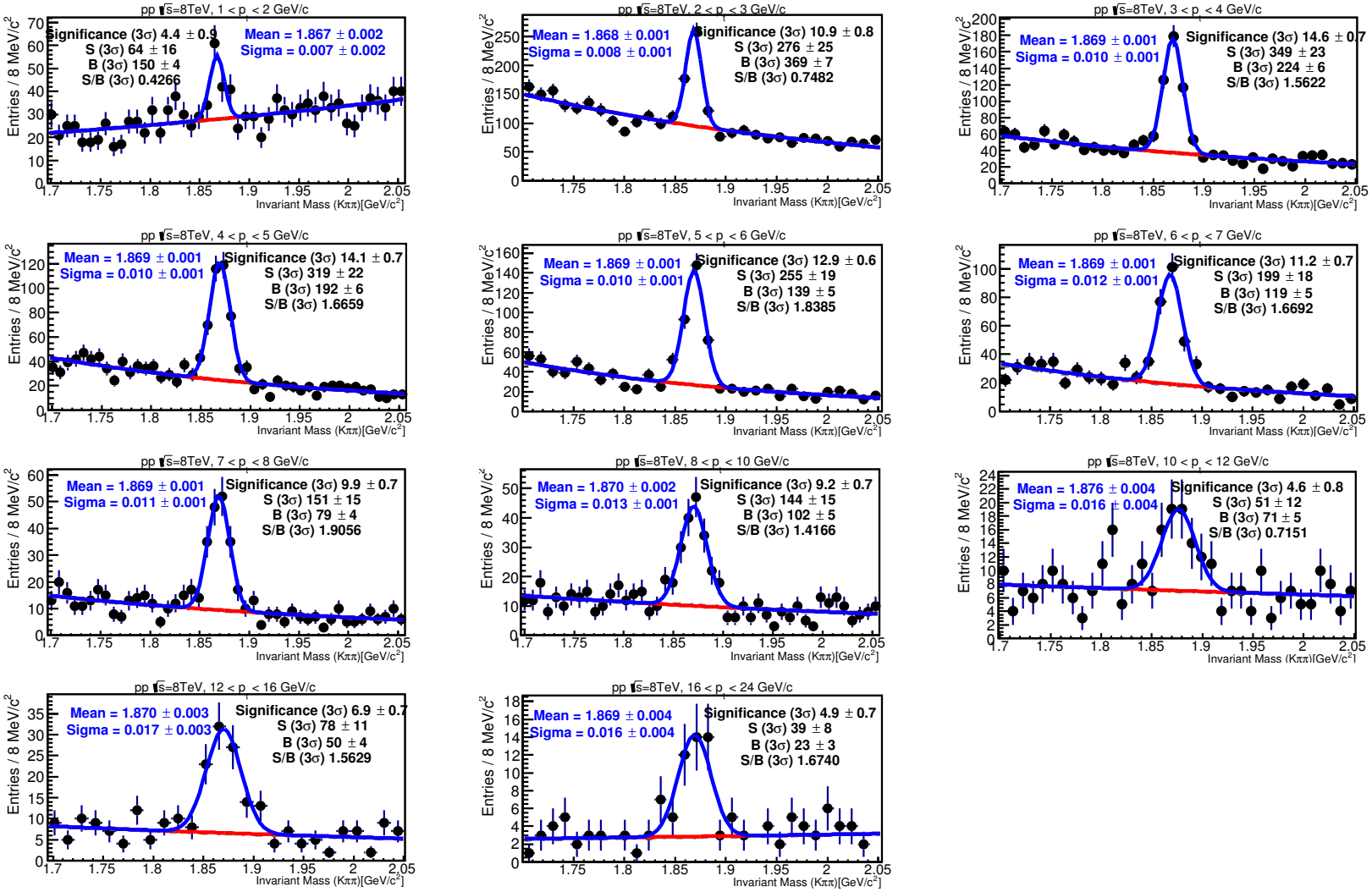
- Raw yield will be corrected with the efficiency $\times$ acceptance to obtain the actual number of D^{*+} mesons
- The significance is above five in all bins except at 1-2 GeV/c

Mean and width



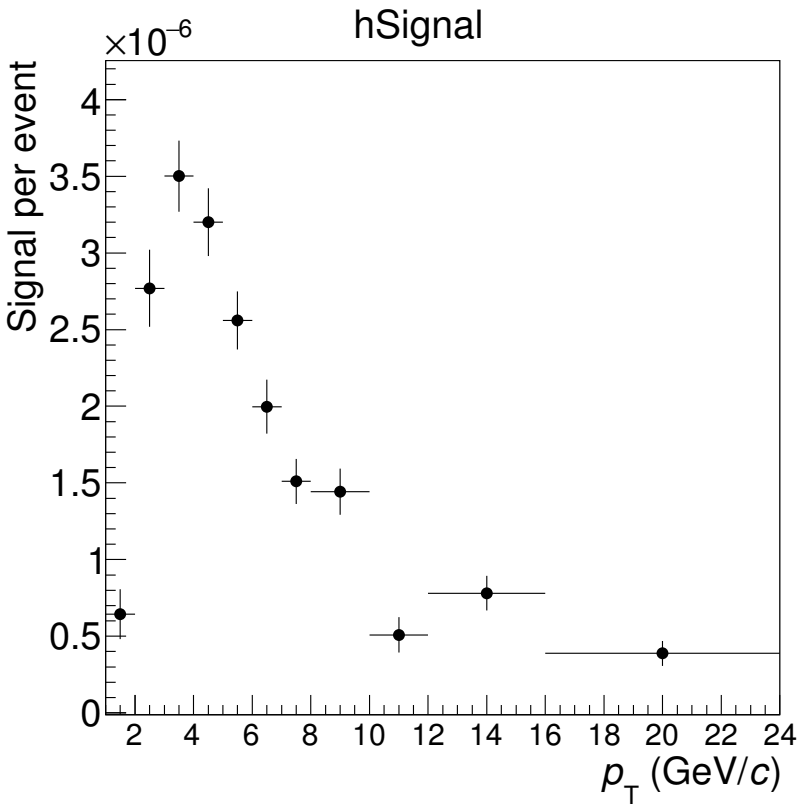
- The mass obtained from data is slightly below the PDG value for the D^{*+} - D^{0} mass while the MC is above
- The width of the distributions agree within statistical errors.

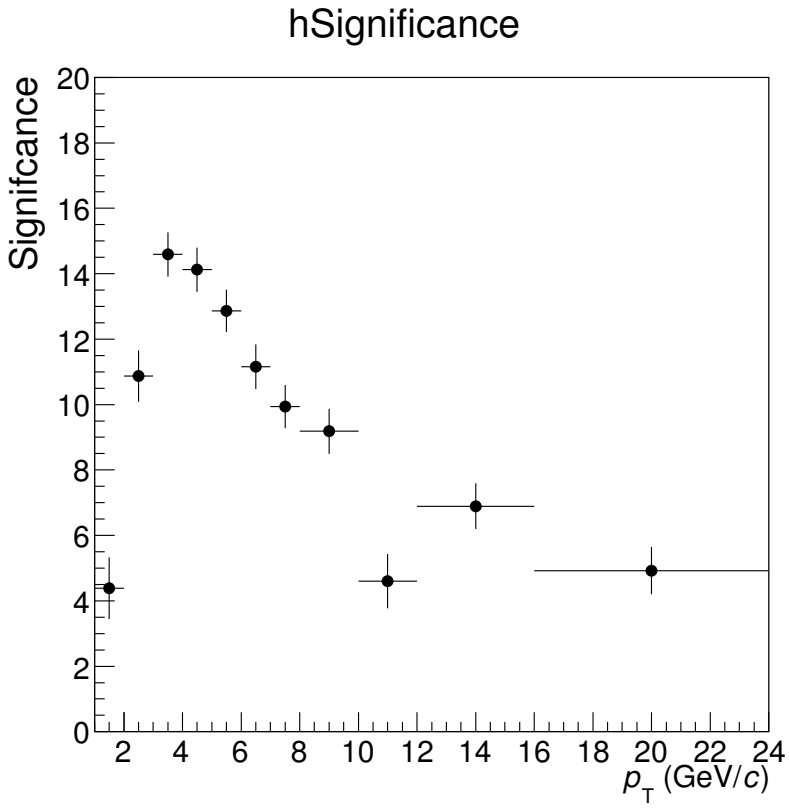
Invariant mass spectra D^+



- A clear signal is obtained in all 11 p_{T} bins.

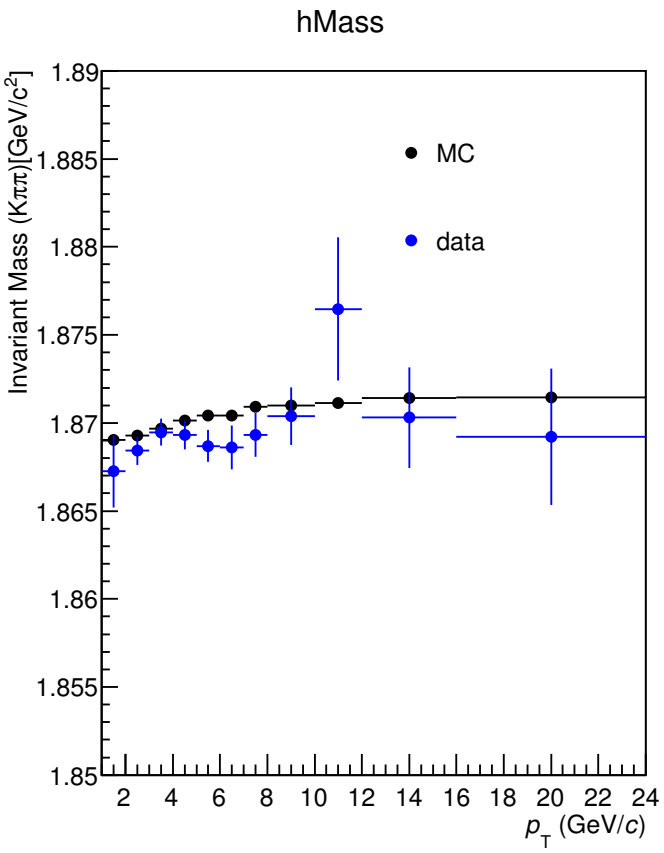
Raw yield and significance

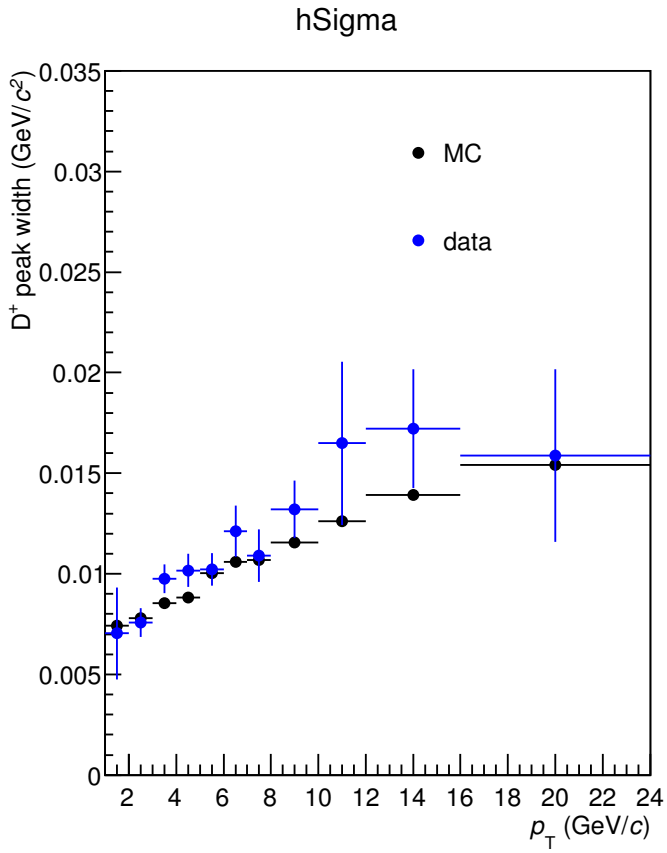




- Raw yield per event will be correct for efficiencies in cross section calculations.
- A good significance ($>$4.4) is obtained in all p_{T} bins.

Mean and width

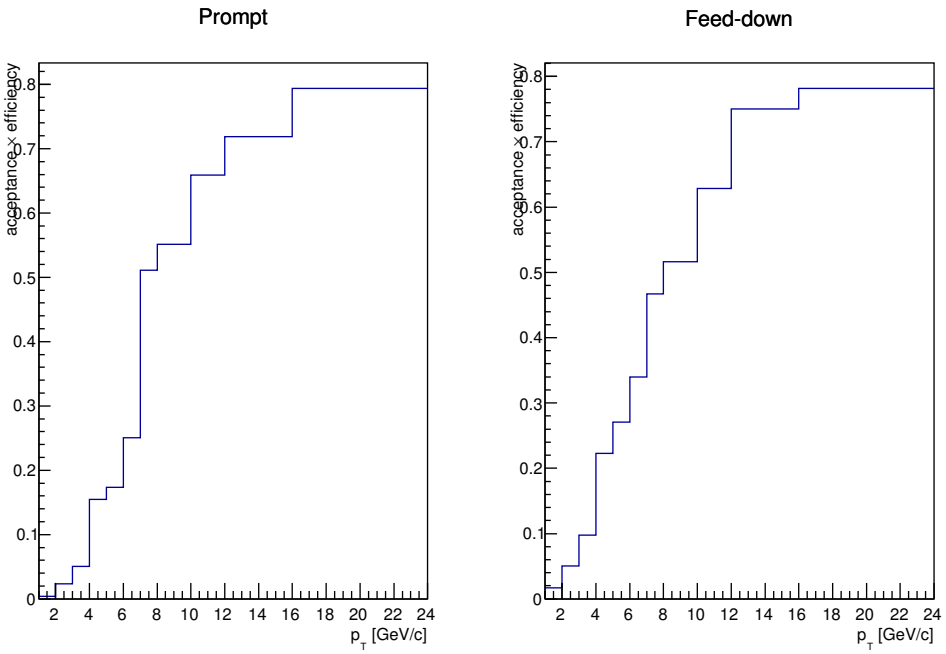




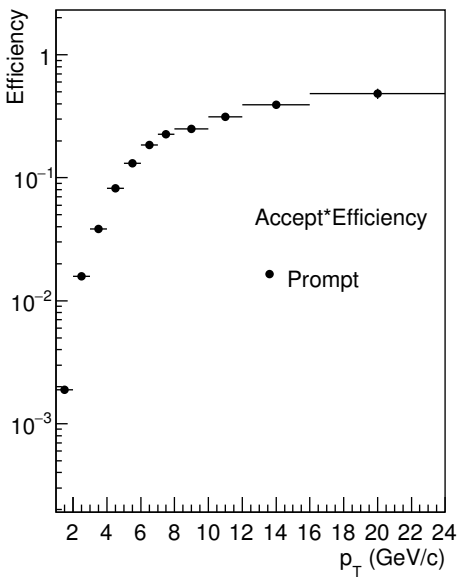
- The mass obtained from data agrees nicely with the MC mass considering the statistical error.
- The shape of the widths is very similar for data and MC. The absolute value is slightly higher for data.

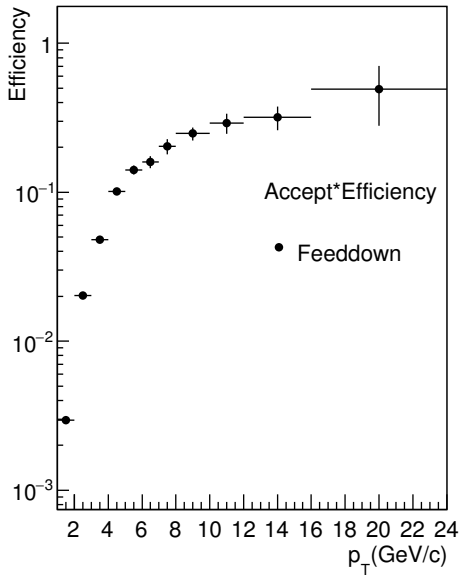
Efficiencies and acceptance

D^{*+}



D^{+}





- Prompt efficiencies $\times$ acceptance will be used to scale the yield, feed-down corrections are applied to obtain the prompt cross section.

Corrected differential cross section

The corrected differential cross section is computed for e.g. D^{*+} using:

$$\left.\frac{d\sigma^{\mathrm{D}^{*+}}}{dp_{\mathrm{T}}}\right|_{|y|<0.5} = \frac{1}{2}\frac{1}{\Delta y \Delta p_{\mathrm{T}}}\frac{f_{prompt}(p_{\mathrm{T}}) \cdot N^{\mathrm{D}^{*+},raw}(p_{\mathrm{T}})|_{|y|<y_{fid}}}{(Acc \times \epsilon)_{prompt}(p_{\mathrm{T}}) \cdot BR \cdot L_{int}} \quad (2)$$

- Factor $\frac{1}{2}$ to correct for taking into account charge conjugate decays
- Cross section is computed per rapidity slice. $|y|<0.5$ so $\Delta y = 1.0$
- Branching ratio BR $= 0.026$
- Integrated luminosity $L_{int} = \frac{56\times10^9}{103\times10^6}$[1] [pb]

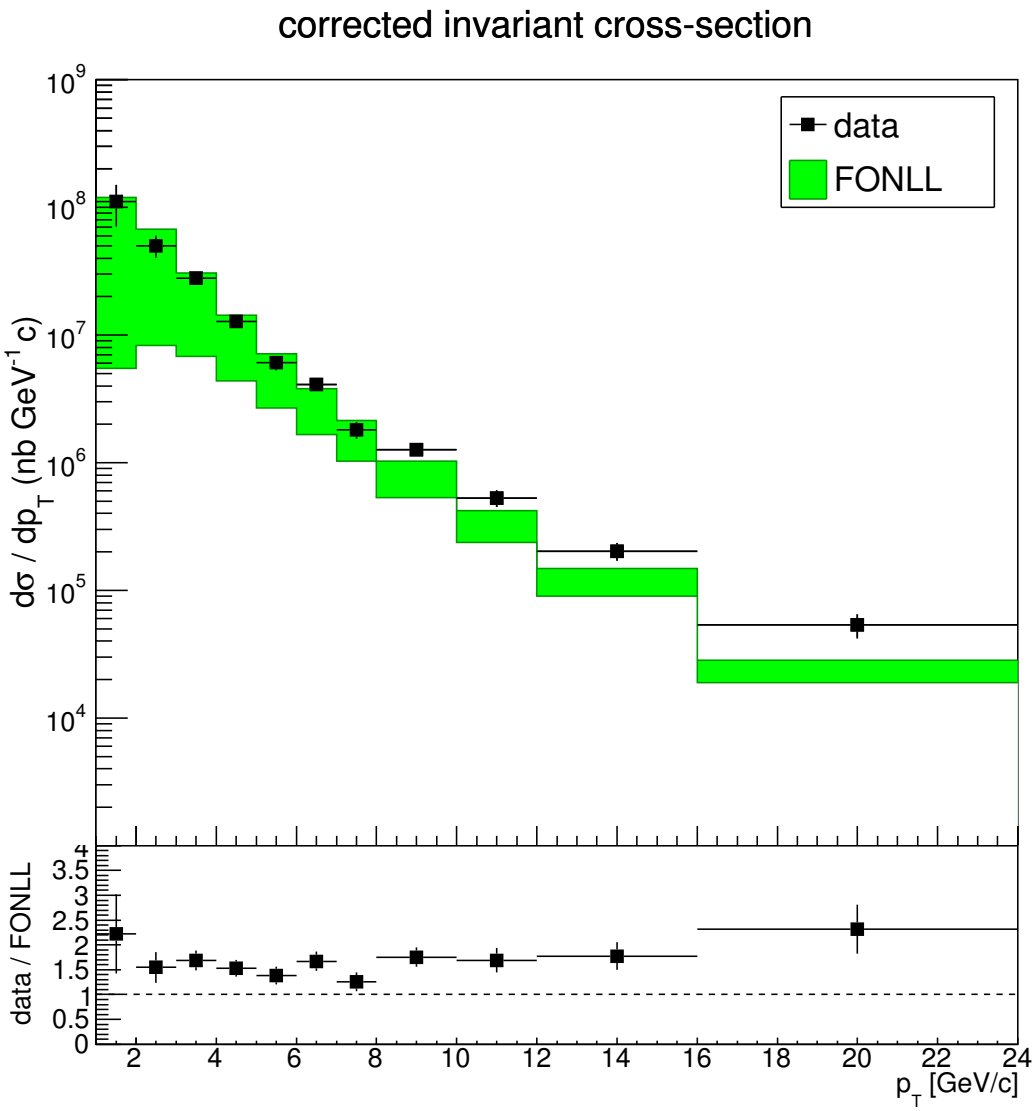
[1] Train runs 1468 to 1477

Feed-down correction

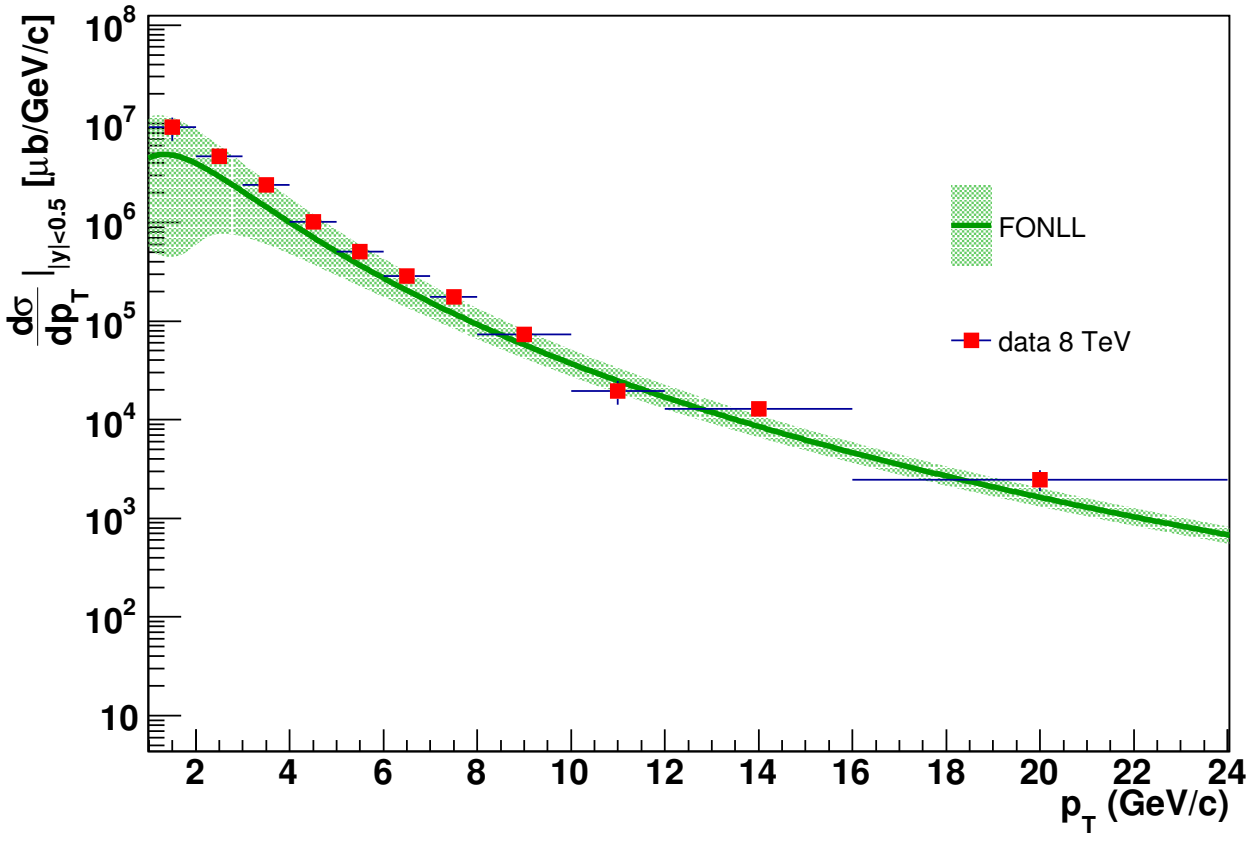
- We have two ways of calculating the feed down correction. Nb which is based on FONLL predictions for beauty and fc which is also based on FONLL but uses the ratio charm to beauty.
- For this analysis Nb is used to compute the central value since FONLL describes charm better than beauty.
- A convolution of fc and Nb is taken as a systematic on f_{prompt}.

Corrected differential cross section D^{*+}

- Corrected differential cross section obtained
- Comparisson with pQCD calculations FONLL at 8 TeV.
- As expected FONLL underestimates the charm quark production

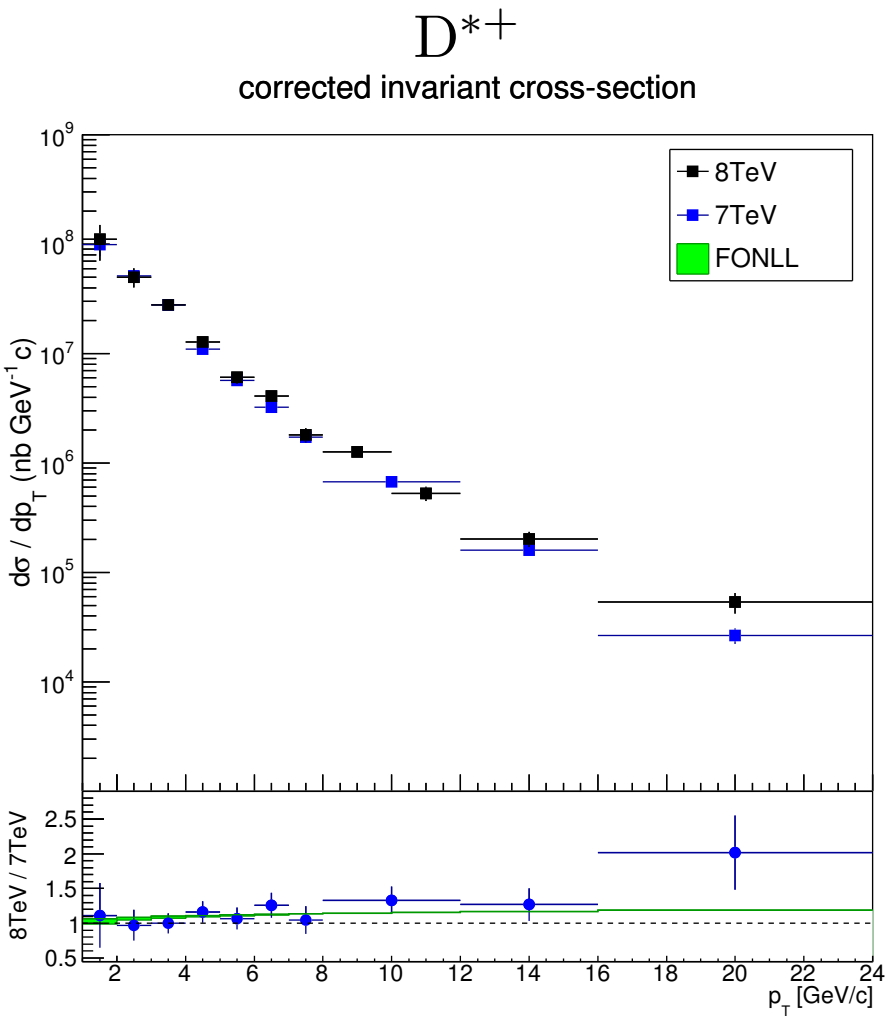


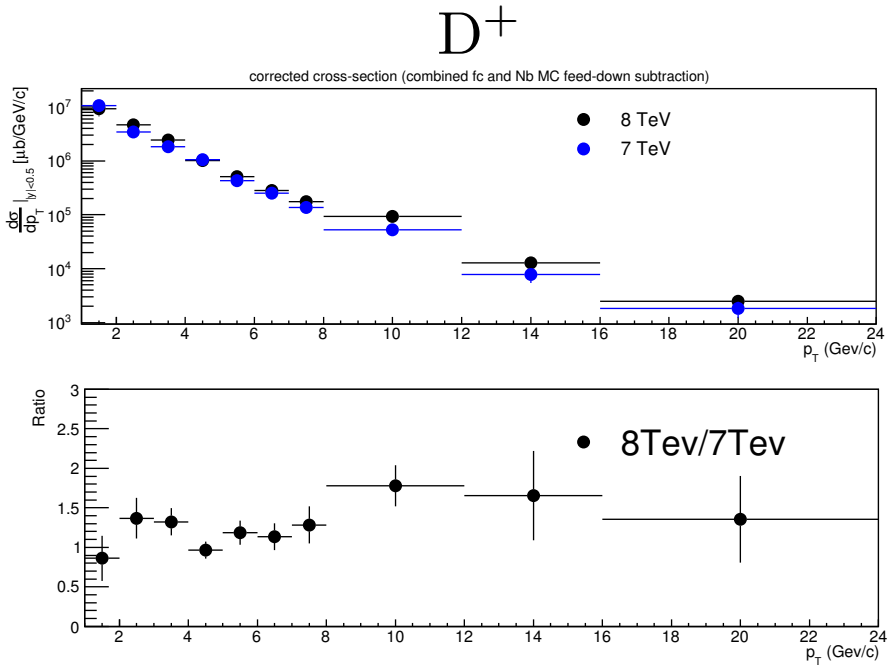
Corrected differential cross section D^+



- Corrected differential cross section obtained in same p_{T} range.
- FONLL underestimates the charm production, consistent with D^{*+} result.

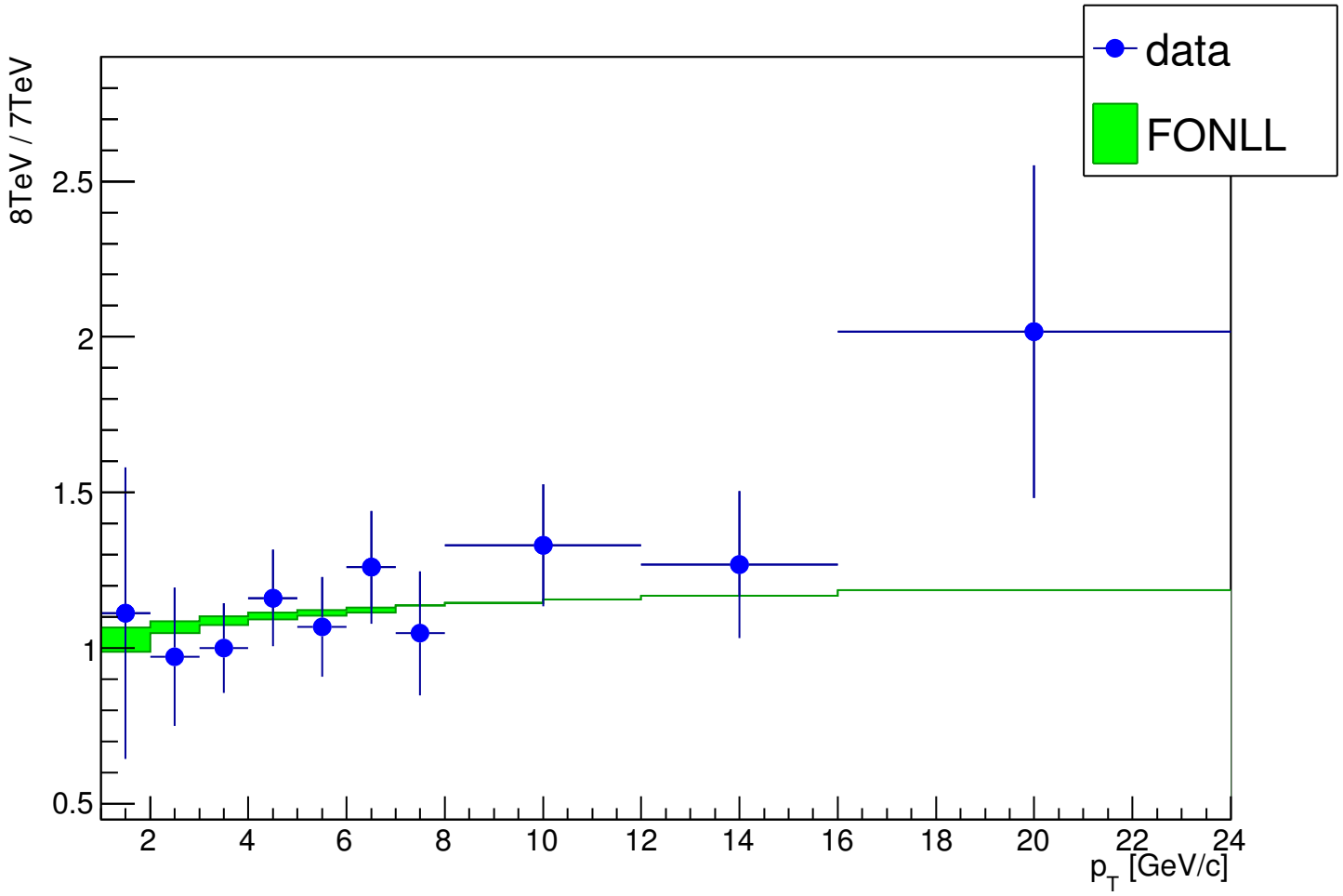
Comparison 7 TeV pp





- 8 TeV cross section above 7 TeV for both mesons.

Ratio 8/7 TeV D^{*+}



- Excellent agreement between data and theory predictions.

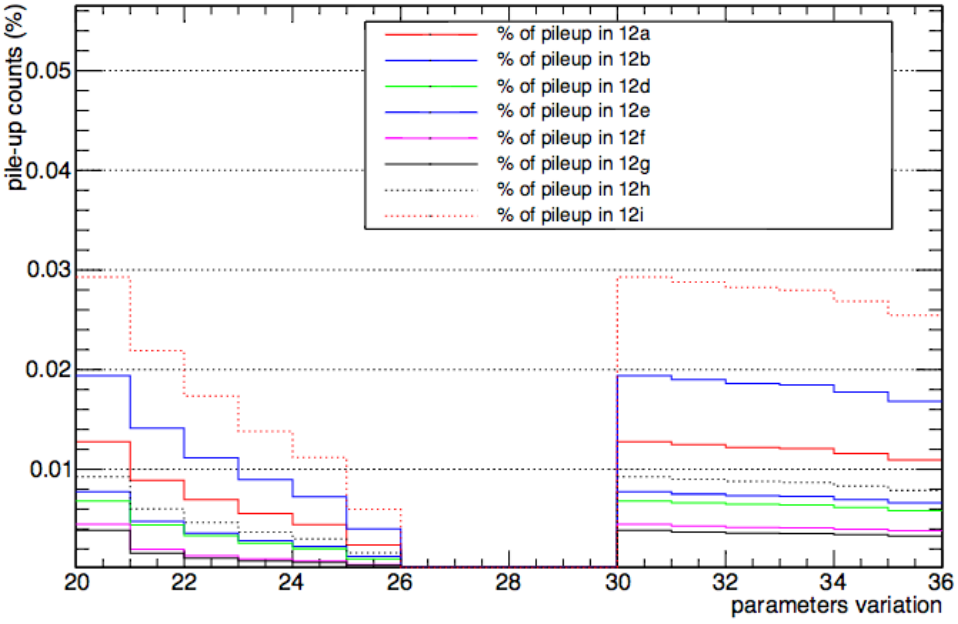
Systematic uncertainties

To estimate the uncertainty induced by the method used to obtain the cross section the following sources of systematic uncertainty are considered:

- Tracking efficiency
- Pile up
- Raw yield extraction
- PID
- Cut variation
- MC p_{T} shape

Note: The systematic uncertainty estimation is ongoing.

Pileup studies



number	20	21	22	23	24	25
cutz (cutc fixed 3)	0.6	0.8	1	1.1	1.5	2

number	30	31	32	33	34	35
cutc (cutz fixed 0.6 cm)	3	4	5	6	7	10

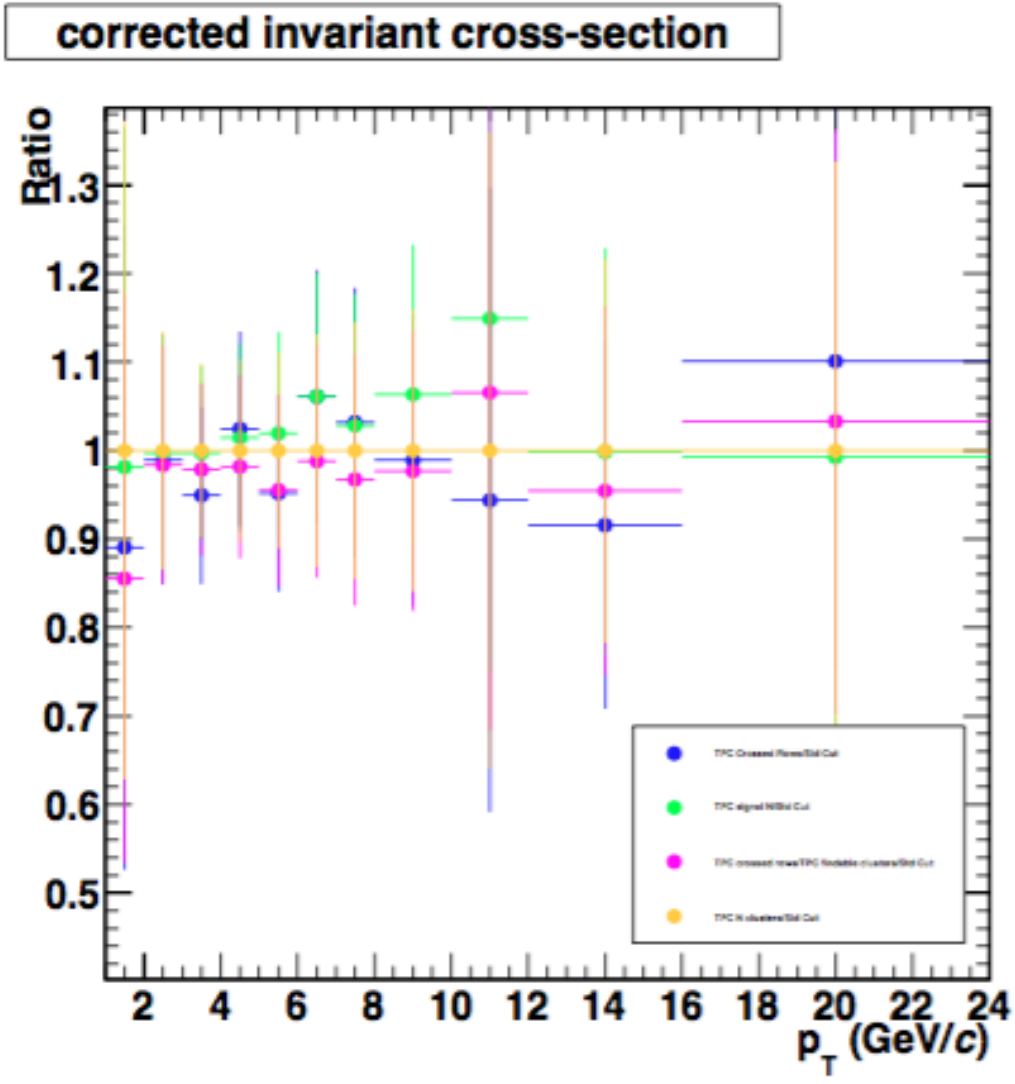
- The number of candidate tracklets as well as the size of the region were varied while keeping the other fixed.
- The pileup is below 3% for all periods, The highest contribution comes from the high luminosity period LHC12i.

https://indico.cern.ch/event/525343/

Systematic uncertainty on tracking

- Standard track section cuts are compared with the standard cuts plus the following constrains for the TPC:
  - crossed rows $>$ 120 - $(5/p_{\mathrm{T}})$
  - # clusters$>$0.5 * crossed rows
  - signal N$>$0.5 * crossed rows
  - $\frac{\text{crossed rows}}{\text{findable clusters}} > 0.9$
- The spread of the corrected yields is below 5% but probably the cuts are not effective enough

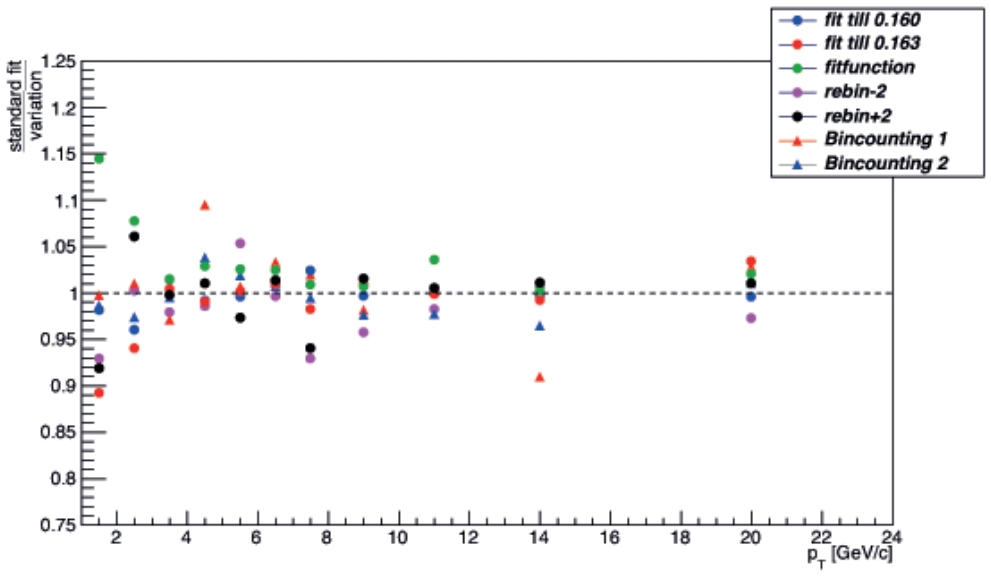
  Additional checks ongoing.



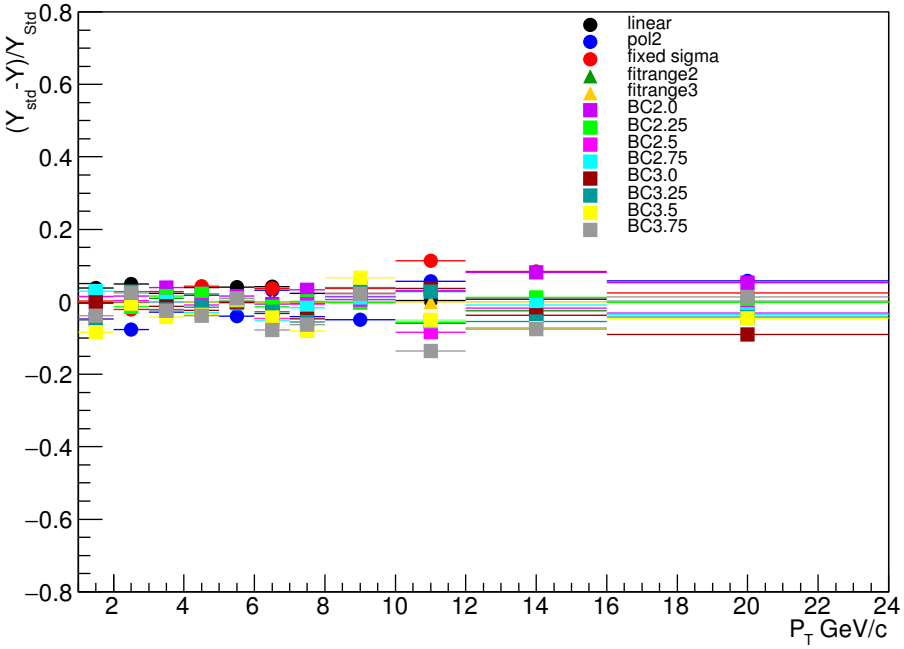
https://indico.cern.ch/event/525344/

Systematic error yield extraction

D^{*+}

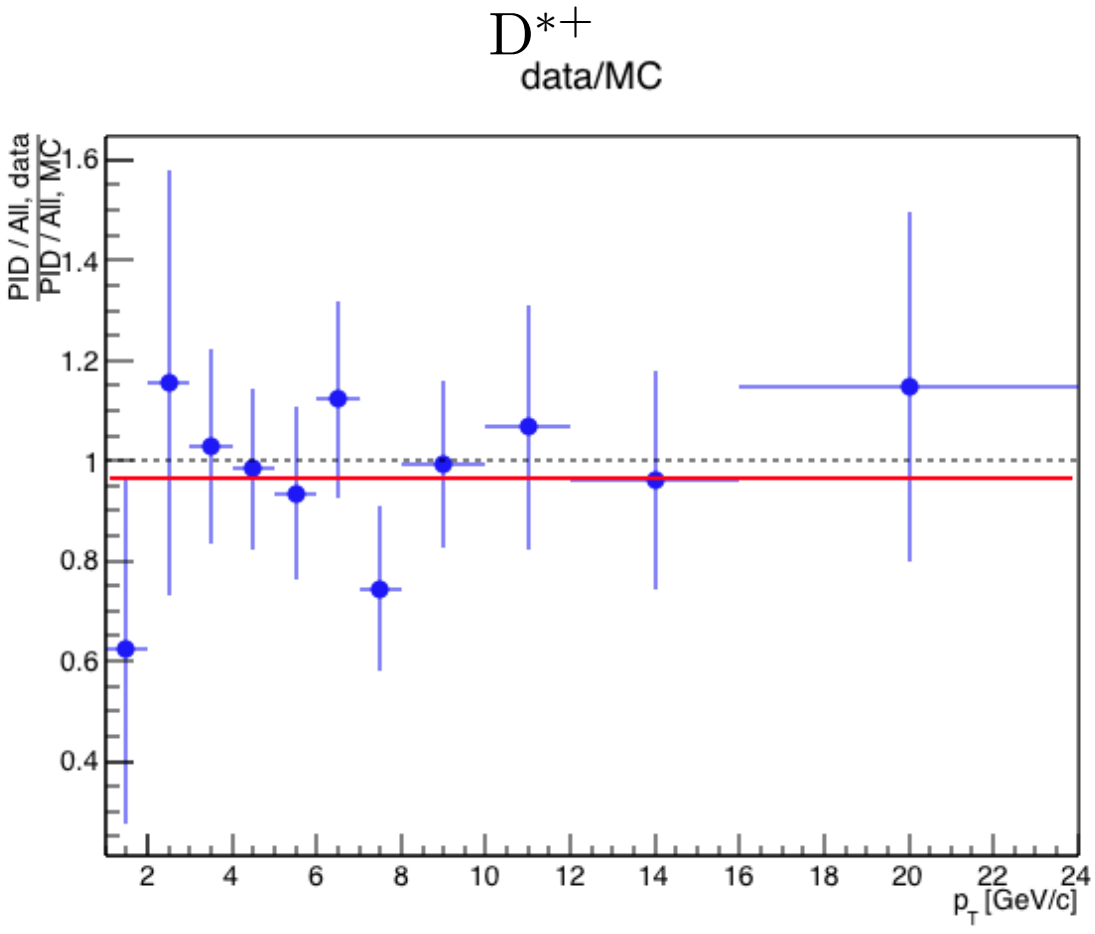


D^{+}



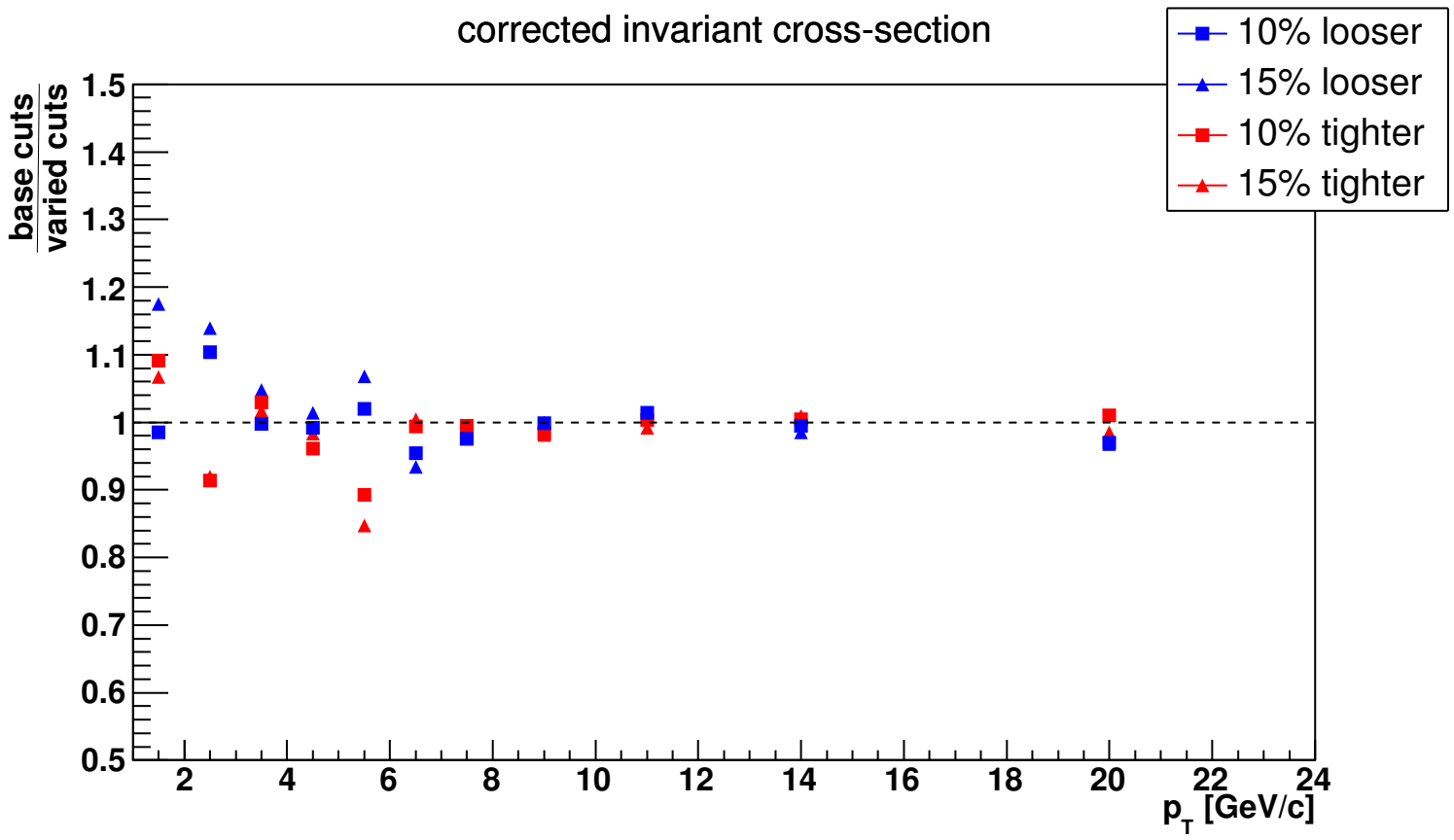
- With few exceptions the systematic is around 5%.

Systematics PID



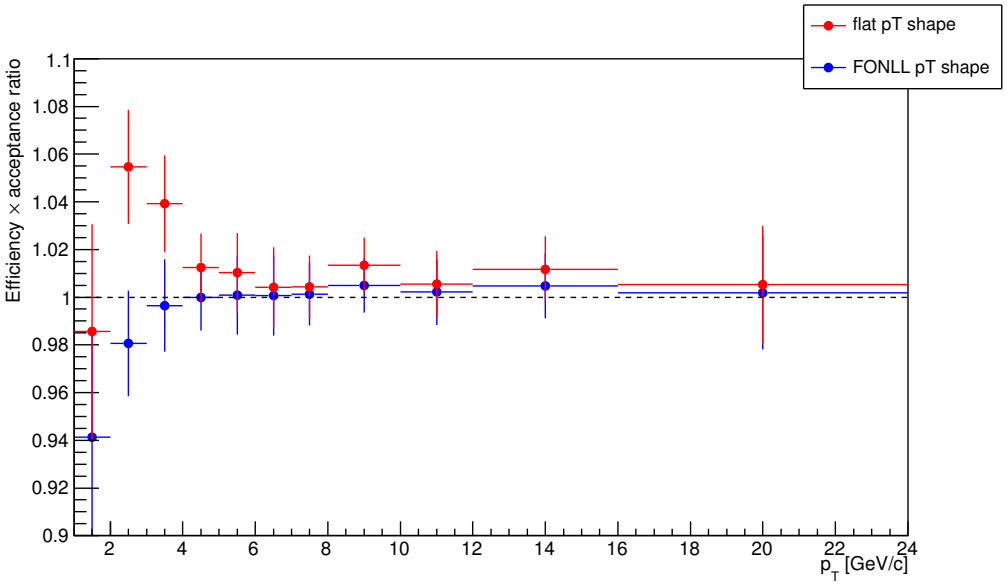
- The analysis can be performed both with and without PID.
- The systematic due to PID is only a few percent.

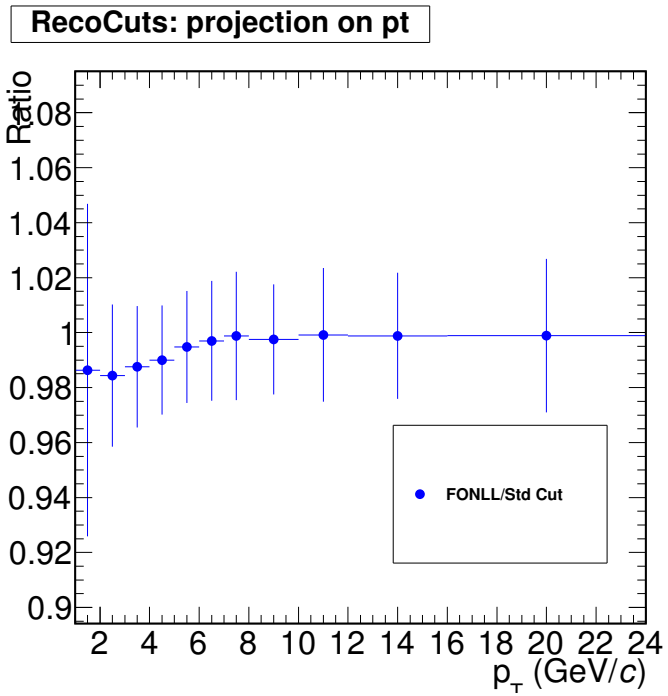
Cut variation



- Two sets of looser and two sets of tighter cuts have been tested. Systematic evaluated from the ratio of the corrected cross section.

MC p_T shape





- In general the assumed p_{T} shape for the MC is generated by Pythia. Assuming a flat p_{T} distribution and one generated by FONLL indicates the effect of this assumption.
- Since the flat p_{T} shape is not realistic the FONLL p_{T} shape is used to estimate the error. We see that the error less than 1% above 5 GeV/c and only a few percent below.

Analysis note

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

May 10, 2016

D-meson reconstruction in pp collisions at $\sqrt{s} = 8$ TeV with the ALICE detector

D. Leermakers, R. Bala, A. Sharma

Abstract

The analysis of D^{*+} and D^{+} production in p-pcollisions at $\sqrt{s} = 8$ TeV at the LHC is described. The D-mesons are reconstructed in the hadronic channels $D^{*+} \rightarrow D^{0}\pi^{+} \rightarrow K^{-}\pi^{+}\pi^{+}$ and $D^{+} \rightarrow K^{-}\pi^{+}\pi^{+}$ using the invariant mass analysis strategy. Minimum bias events from data periods LHC12a till LHC12i are considered. The D^{*+} and D^{+} mesons are successfully reconstructed in the p_T range 1-24 GeV/c. The detector efficiency is obtained from the Monte Carlo dataset LHC15l2a which is quality assured. Ultimately the cross sections are calculated.

Conclusion and outlook

Conclusion

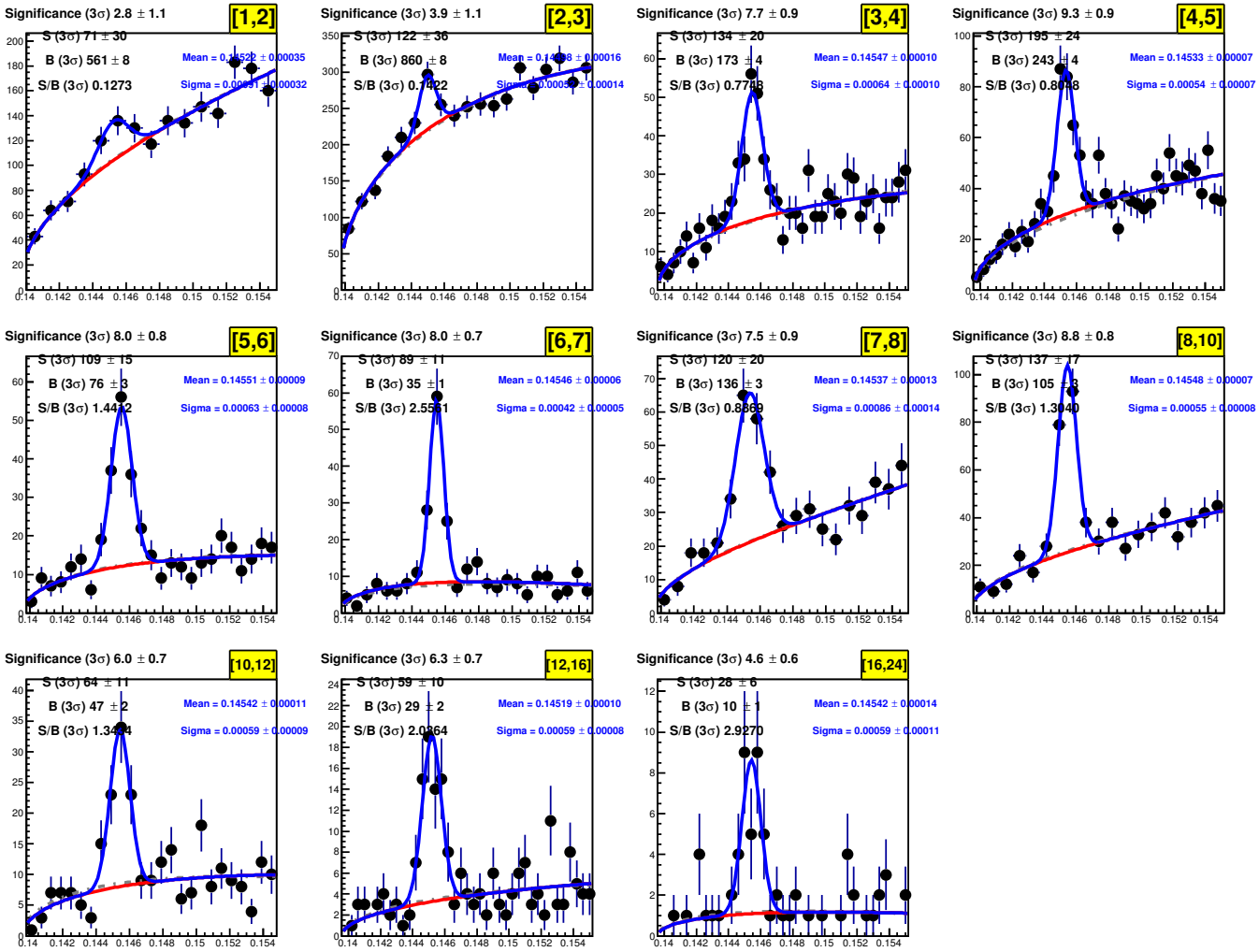
- Corrected differential cross section for 8 TeV pp collisions is obtained from 1 to 24 GeV/c for both D^{*+} and D^{+} mesons.
- As expected it is higher than the FONLL prediction as well as the 7 TeV result.
- Systematic error estimation ongoing.
- Analysis note almost ready.

Outlook

- Aim for preliminary request by the end of May
- Optimizing some more challenging p_{T} bins.
- Finalizing the systematic error estimations.

Backup

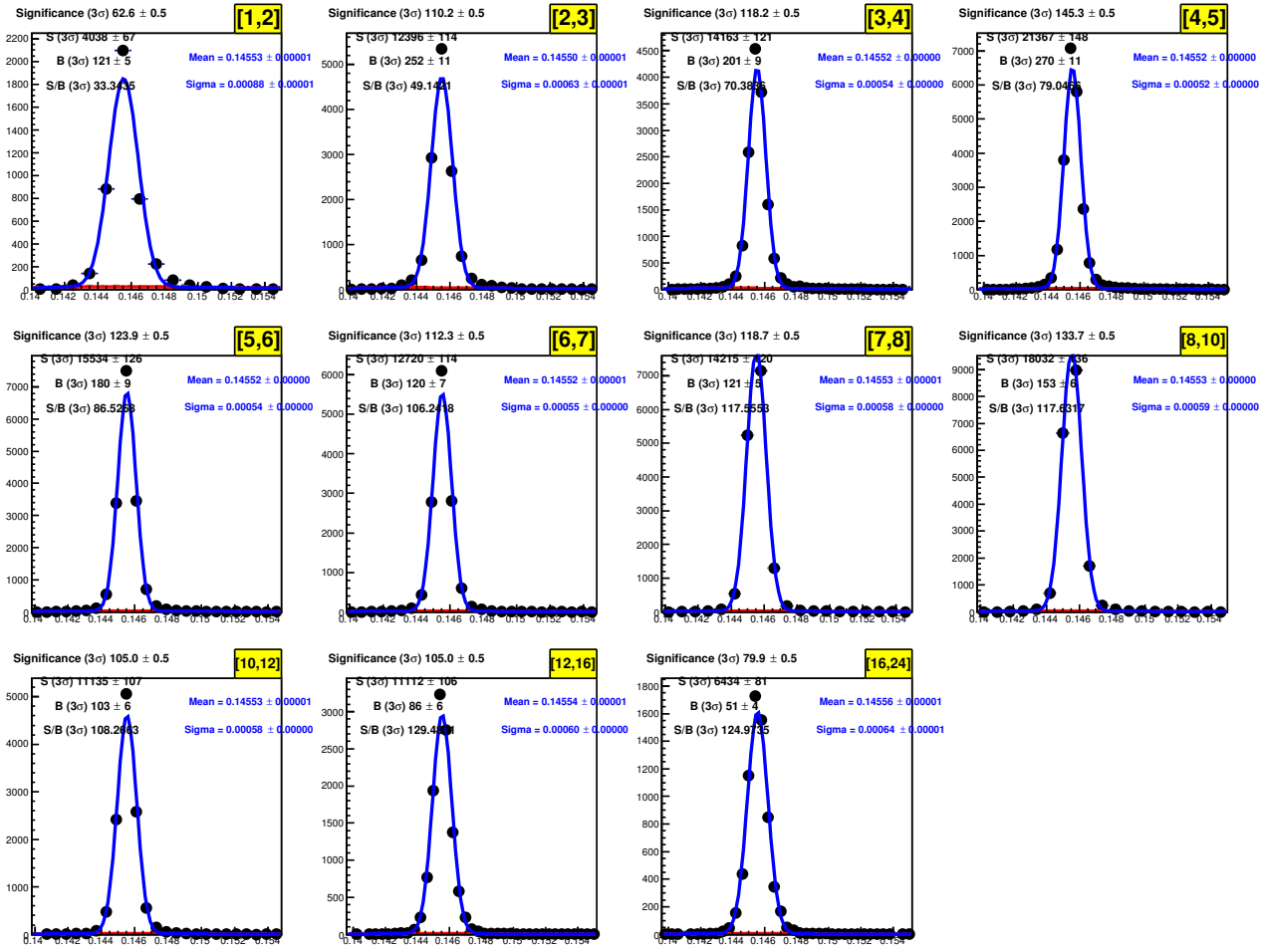
Mass spectra without PID D^{*+}



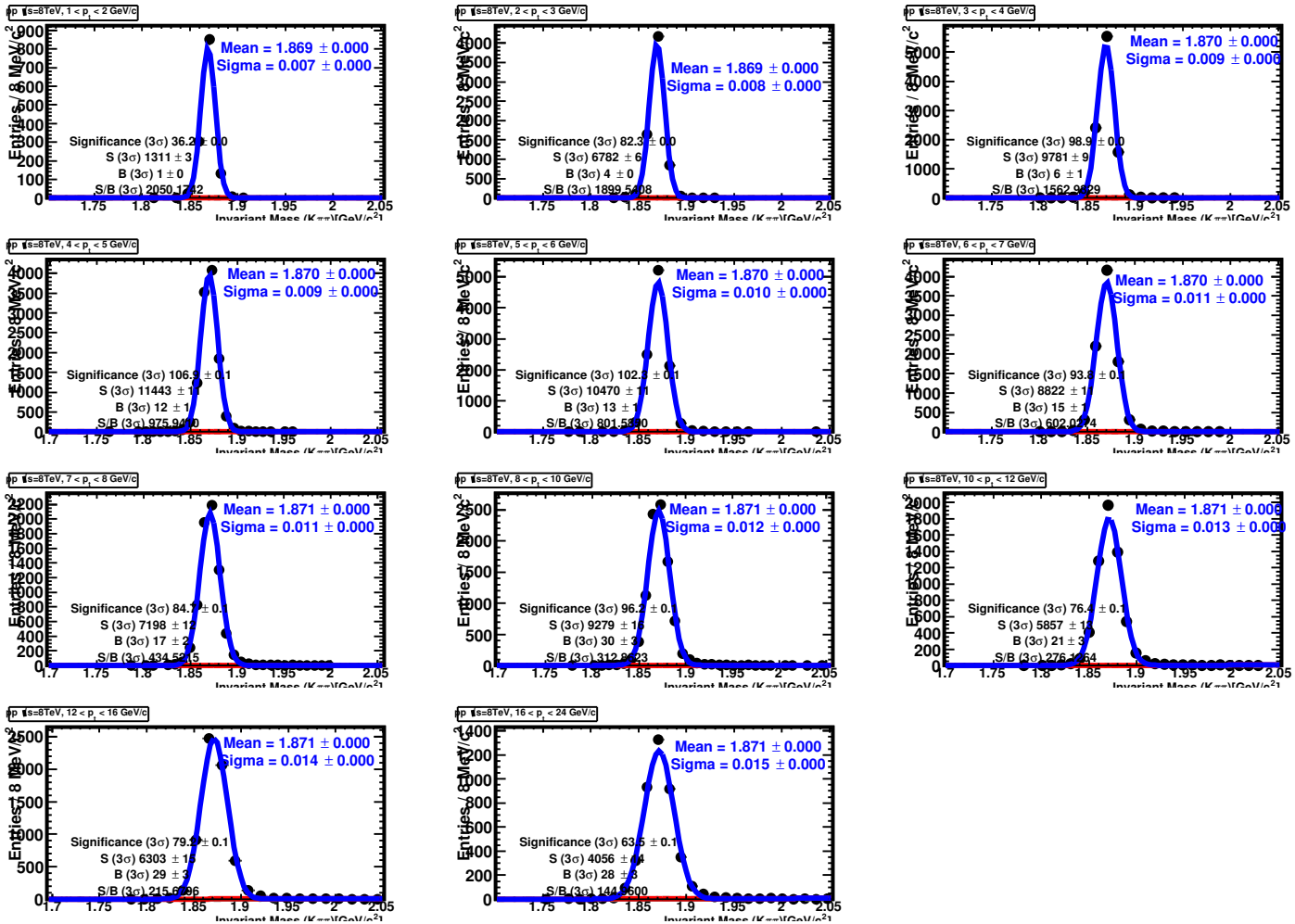
- All bins have a decent fit without PID.
- PID mainly influences low p_T bins.

Invariant mass spectra MC production D^{*+}

- For mean and width comparison MC mass spectra are fitted
- Charm and beauty forcing as well as hadronic decay forcing allow for very nice fits



Invariant mass spectra MC production D^+



- For mean and width comparison MC mass spectra are fitted.