We would like to thank the referee for having reviewed this paper and furnishing this report.

We have carefully considered all comments, and we have applied several changes to the original version of the paper to address the issues raised. Detailed responses to all the comments can be found below.

We are available for any further clarifications and/or additional information.

• While it is true that the PROSA 2015 analysis was the first study that demonstrated that the LHCb charm and bottom production data could be added to a PDF fit to constrain the small-x gluon, the authors should mention in the introduction that since then several other groups have considered, either directly or indirectly, the same constraints in other to refine calculations related to the small-x gluon PDF. In particular a combined analysis of the LHCb data at 5, 7, and 13 TeV in the context of the NNPDF3.0 global analysis was presented more than three years ago in [11]. To put the present study in perspective, the discussion of related previous works should be enlarged (rather now it is minimal) and the improvements that are deployed in the present study as compared to those previous works should be specified.

>> Following the suggestion of the referee, the analyses by the NNPDF authors following the original PROSA15 publications are mentioned and cited. The paragraph in the introduction reads:

"The first QCD analysis~\cite{Zenaiev:2015rfa} using forward heavy-flavour production at the LHCb has triggered attention of several PDF groups, which confirmed the significant improvement of the constraints on the gluon distribution by using forward heavy-flavour production measurements obtained with the LHCb experiment. In particular, one group has updated the PDF set NNPDF3.0~\cite{Ball:2014uwa} by including the LHCb charm measurements into the NNPDF3.0 fit using the Bayesian reweighting method and providing the NNPDF3.0+LHCb PDF set~\cite{Gauld:2015yia}. Further LHCb measurements collected at $\sqrt{s}=5$ TeV, 7 TeV and 13 TeV were included in the PDF studies of Refs.~\cite{Gauld:2016kpd,Bertone:2018dse}, where the normalised distributions and cross-section ratios between measurements at different centre-of-mass energies were used, following the suggestion of Ref.\cite{Cacciari:2015fta}, to quantify the impact of the LHCb D-meson measurements on the NNPDF3.0 PDF set. In both analyses~\cite{Gauld:2015yia,Gauld:2016kpd}, the pQCD predictions for charm production in the forward region based on the FONLL approach~\cite{Cacciari:1993mq} were used."

• It is well known that the absolute distributions in pt and rapidity of charm and bottom production cannot be used directly in the PDF fit due to the large scale errors from the NLO scale variations, and that suitable ratios need to be constructed instead. However the choice adopted by the authors, namely to normalise to the 3 < y < 3.5 rapidity bin is not unique. First of all one could consider other rapidity bins, but also one can consider the ratio of cross-sections between different center of mass energies, 13 TeV / 7 TeV and 13 TeV / 5 TeV, for which the experimental information on correlations can be assembled in the same way as for the normalised cross-sections. Given that when constructing these ratios one makes the assumption that scale variations are fully correlated between numerator and denominator (which per se is not obvious) I think it is important to verify the robustness of the fit with alternative ways of including the data. In this respect I would like to request that the authors compare their baseline results with those obtained if the 13 TeV / 7 TeV and 13 TeV / 5 TeV ratios are fitted instead, and in particular to assess which of the two ways to include the LHCb charm and bottom production data is more constraining from the point of view of the PDF fit. One can also do a similar test by normalizing the rapidity distributions to a different reference rapidity bin.

>> Practically the choice of the bin for normalisation is motivated by the fact that all LHCb data sets have a measurement in this bin. Accordingly, we have added the following text in section 2:
“This bin is chosen for normalisation since all relevant LHCb data sets have a measurement in this rapidity range. Choosing a different bin for normalisation would not change the results.”
Furthermore, we have investigated the possibility to consider the ratio of cross-sections between different center of mass energies, but found that such ratios would be affected by larger uncertainties related to the scale variations than the cross sections normalised to a certain interval in rapidity. Therefore we did not use them in our analysis. We have added a new Figure 1 to illustrate scale dependence of absolute cross sections, ratios of cross sections at different center of mass energies, and normalised cross sections.

• I find a bit surprising that the authors do not compare their results with those of the other publicly available PDF fits that include the LHCb charm data at 5, 7, and 13 TeV, in particular the NNPDF3.0+LHCb and the NNPDF3.1sx+LHCb sets. This comparison should be added to the revised version of the paper, to assess whether or not the resulting small-x gluons (and their associated uncertainties) agree in the various cases. In this respect the comparison with the sets that constrain both small-x resummation and the LHCb data is particularly important since the shift between the fixed-order and resummed calculation is expected to be included within the theory error band of the PROSA fit determined by means of the scale variation method.

>> We have added Fig. 5 where we compare PROSA 2019 FFNS, PROSA 2019 VFNS with NNPDF3.1 and the results from Ref. [12], though we stick to comparing NLO variants of all fits as we do not attempt to discuss small-x resummation in our paper.

• In the assumptions in their PDF fit the authors take the strangeness ratio fs = 0.4, inconsistent with the ATLAS measurements of W,Z production at 7 TeV. While I don't expect any big change in the small- x gluon PDF, I still think that it would be important to assess the robustness of the fit if fs=1.0, in line with the ATLAS preferred value, is used.

>> We think that the referee might confuse fs = sbar/(dbar+dbar) with rs = sbar/dbar. The ATLAS value of fs would be 0.5, not 1.0, and thus it is within our model variation fs = 0.4 +- 0.1. Furthermore, the CMS results on extraction of strangeness in the proton using W+c measurements at 7 and 13 TeV (performed with contributions of the authors of the present paper) are in perfect agreement with the neutrino-data result on fs=0.3 and is also within the variation used in the model uncertainty estimate.

• I am not sure if the comparisons in Fig. 1 tell us more in the absence of PDF uncertainties, since we cannot tell how significant is the change in central values. Also the sharp turnover at edge of the kinematic region at small-x seems to be artificial, and probably would disappear with small adjustments in the parametrisation?

>> In Fig. 1 (now Fig. 2) the uncertainties of our nominal parametrisation [BG 4p] are displayed which allows one to see whether we could have a parametrisation bias or not by comparing to central results of the fits using different parametrisations. For this comparison, only uncertainties on the BG 4p are relevant. Remarkably, the sharp turnover which is observed for two of the parametrisation forms could be constrained only by data covering the very low x region.

• Concerning the main results of the PDF fit, I would like to see a discussion of the separate impact of the ALICE data, since this is to the best my knowledge the first time that these measurements have been added to a PDF fit. So I propose to start from a HERA+LHCb baseline and then add the ALICE data, to see what is then the corresponding reduction at the level of PDF uncertainties.

>> We found that ALICE data are well described in the fit, but do not provide significant additional constraints on the PDFs once the LHCb data are included. It is a non-trivial self-consistency check of the fitting procedure, and we have added the following sentence in section 5:
“It turns out that once the LHCb data are included in the fit, the inclusion of ALICE data provide no significant additional constraints on the PDFs, but since the ALICE data cover the central range of y, the consistent description of these data serves as a non-trivial self-consistency check of the fit using normalised cross sections.”

• In Table 1 for some of the D0 datasets such as the 5 TeV and 13 TeV ones one seems to achieve a non-optimal chi2 description. The authors should discuss what are the possible reasons for this poor agreement. Is this related to some specific region in pt and rapidity? And here I understand that the chi2 contains only the experimental errors but that theory uncertainties are not part of the definition right?

>> Indeed the chi2 contains only the experimental errors but not theoretical ones. Those non-optimal chi2 values are present for most precise LHCb D0 measurements (LHCb 5 TeV D0, LHCb 13 TeV D0). They are not related to any specific regions in pt and rapidity. Perhaps, for these precise data sets theoretical uncertainties of a few percent would play a noticeable role if included in the chi2 expression. We have added the following text in section 5:
“...illustrating a satisfactory agreement among all the data sets (note that the χ^2 expression does not include theoretical uncertainties, but we account for them in the evaluation of the theory uncertainties associated to the PDFs).”

• I find quite interesting that the authors perform a fit both in the FFN and in the VFN scheme, since this comparison was absent in the PROSA15 paper. However I find that the discussion could be enlarged, and in particular I would recommend that the corresponding chi2 values of the VFNS fit are added to Table 1. The reason is that this way one can see the relative differences at the chi2 level in the two schemes, both for the HERA datasets and for the heavy quark cross-section datasets. In particular it is worth discussing in which scheme is the HERA data better described.

>> We found a very similar quality of the description of fitted data (both from HERA and LHC) in the VFNS and FFNS fits, as stated in section 5.1 of the paper. Actually there is a notable discussion of this in the HERAPDF combination papers (inclusive and charm/beauty), where it was also found that the descriptions are similar. To recall, we have added these citation when discussing the fit quality in section 5.1:
“... (consistent with the observations in Refs. [8,16]).”

• In the comparisons in Fig 3, is the total PDF error band defined in exactly the same way in the PROSA15 and the PROSA19 fits? By comparing the two error bands it seems to me that the uncertainties in the two fits are not very different. This is at odds with other findings, for example those of Ref. [11]. I would be grateful if the authors could comment on this point. Also from Fig. 3, is my understanding correct that the total PDF error band is essentially dominated by the theoretical (scale?) uncertainties?

>> We found that the gluon PDF uncertainties in the new PROSA2019 PDF fit are significantly reduced compared to the PROSA2015 fit, as can be seen from Fig. 3 (left), especially for x < 10^-5. To discuss this further in the text, we have added the following sentence in section 5:
"This improvement is attributed mainly to the presence of the new LHCb data in the fit which extends the coverage to lower values of x."
The total PDF error band is not exactly the same in the PROSA2015 and PROSA2019 fits, as described in section 4 of this paper and section 5 of Eur.Phys.J. C75 (2015) 396, because the increased amount of fitted data required a more flexible PDF parametrisation.

• A final remark concerning the prompt neutrino fluxes concern the statement that nuclear PDF uncertainties can be neglected. I am not sure I agree with this statement, since given the large uncertainties affecting nPDFs at small-x it might be that these become comparable or larger than the PDF uncertainties in the calculation of the prompt neutrino flux. An interesting method to investigate this point would be to redo the calculation using for example EPPS16 or nNNPDF1.0 as input PDFs rather than the PROSA19 PDFs, and then compare with the total uncertainties in the PROSA19 calculation of the prompt cross-section. However I would not insist too much in this test, since it would be a bit beyond the scope of this paper.

>> Ref. [A. Bhattacharya et al., JHEP 11, 167 (2016), arXiv:1607.00193] has studied the impact of the nuclear corrections and used various power law extrapolations to estimate the effect of the nuclear corrections for the lighter nuclei.

For example, they "have included nuclear effects on the prompt neutrino flux, which reduces the flux by 20%-30% for energies between E = 10^5 − 10^8 GeV ..." and they also note that nuclear effects on the total charm cross section are smaller than those on the prompt neutrino flux ("between 4% and 13% at 10^5 − 10^8 GeV").

While this is certainly an important source of uncertainties, the nuclear uncertainties are in line with what we have presented in the current calculations. The predictions using nuclear PDFs and those using proton PDFs have at present overlapping uncertainty bands.

As there is significant activity on nPDFs at present, these issues may be worth revisiting in a future study, and we've included an additional statement in the text to reflect this progressing situation:

“With the prospect of new facilities such as the LHeC and EIC on the horizon, improved analyses of the nuclear PDFs are emerging, and these issues may warrant reexamination in the near future.” (the last sentence in the Summary)

Additionally we note that not all nuclear PDFs available at present can be used for a computation of prompt neutrino fluxes in our framework. In particular, we performed a preliminary investigation of the very recently released nNNPDF1.0, but this yields negative differential cross-sections in particular regions of phase space. Some of these issues were already discussed for the case of proton PDFs, in the appendix of Ref. 1705.10386. Due to these complications, this topic requires further study beyond the scope of the current work; as these topics are under active investigation, we have no doubt that these issues will be resolved in the near future.