as EB process ->
version 1.5
addition on text ->
version 1.6

Comments as received on draft for paper presentation

Achim Geiser:

Thanks a lot for the great paper draft and the nice results.

I leave simple style comments to others, so please find my significant comments below:

section 4:
The "experimental" uncertainty is now even less experimental than it was before, since the hadron
ization uncertainties are
now also included. In some ZEUS papers we have just called it "fit" uncertainty, but I know that
was not acceptable to H1.
So, my compromise proposal (similar to H1/ZEUS paper arXiv:1804.01019)
line 231: "exp/fit"
line 232:
"where exp/fit denotes the fit uncertainty based on the experimental input uncertainties and the
hadronization uncertainty"
line 234:
"the fit uncertainty"

The EB decided -> experimental
[not the editors wish]

line 251: "The similarity ... no additional tension."
I don't think this is true. Similar chis/dof > 1 indicates similar tension, also in the jet data.
Thus rather:
"The similarity of the chi2/d.o.f. values indicates a similar level of tension for the jet and in
clusive data."
or
"The similarity of the chi2/d.o.f. values indicates that the addition of the jet data does not ch
ange the average level
of tension in the data."
or
"The similarity of the chi2/d.o.f. values indicates that the addition of the jet data does not in
crease the average level
of tension in the data."

The EB decided what to write

line 259: "the negative gluon term" -> "the flexible gluon term"
There is nothing in this term that forces the gluon to become negative, nor can the gluon be prev
ented to become negative
(at low enough scales) even without this term.
A more flexible parametrisation can never bias the result, as long as the fit converges properly.
A more restrictive one can.
Thus "could bias" -> "could significantly alter".
line 266: "the details" -> "these details".
It indicates nothing about potential other variations of the gluon parametrisation.

rephrased

line 278: I would move this difference right to the beginning of the section, since it is a basic
conceptual difference
that is the main asset of this paper w.r.t. the others.
The difference in the treatment of the scale uncertainties in the previous paragraph, although nu
merically more important,
is only a technical difference and should not be highlighted as if it were a conceptual one. Also
, it could be stated that
the 100% scale correlation option is the "traditional" variant.
I am personally convinced the treatement we use use here is better than the traditional one, so I
do *not* propose (and would strongly oppose) changing our default treatment.

done
Structure changed

Section6:
Repeat here (or elsewhere) that the jets were obtained with the kt algorithm and R=1. Remind that
it was established
-> no by EB
(cite arXiv:1003.2923) that at HERA, using the kt or anti-kt algorithms (as used at LHC) is quali
tatively equivalent. <- EB said no

It is in the data section

Figures 9-12:
It is hard to see the comparison on log scale only.
Providing ratio subpanels would be helpful. done - lots of ratios

line 336: "scale uncertainties were not considered for the comparisons to data".
I don't think this is acceptable. The NNLO predictions have significant scale uncertainties (from the jet matrix elements),
and these should be shown (separately). This is different from the potential scale uncertanties of the PDFs that were discussed
in the previous sections, which can indeed not be usefully quantified. see paragraph in new text from Th. Gehrmann

Best regards, Achim (from vacation)

- -

Mandy:
Wrt to Achim's comment on scale uncertainties. He wants them on the data vs theory figures. The question is then exactly what does he want? ie the theory in the figures is for fixed alphas=0.1155 and, so does he want us i) to take that fit with fixed parameters and just alter the scale (as I did in evaluating where to put the \mu cut) and look at the predictions or does he want ii)refits with the new scale (which will not be good if alphas=0.1155 as we have already seen) and predictions from the refit? I think that will show little change just as the PDFs showed little change. I think he must want i). But we have never shown i) in previous work. We need to clarify with him, but I would say there is no hurry.
see special text

Aharon Levy:

Dear Editorial Board members,

Congratulations on completing the HERAPDF2.0 family. Well done!!

Here are some comments to a very well written paper. I tried to read it from the point of view of someone not an expert on the subject.

minor comments:
l. 11, ?.order (NNLO). ✓
l. 34, ?.formalism using the ? ✓
l. 53, ?established [reference]. was removed by EB
l. 91, ?equation (32) ✓
l. 93, ?fit (see?below). analysis ✓
l. 111, ?running electromagnetic? ✓
l. 234, remove one ?the?. ✓
l. 241, Eq. (7). The (7) did not come out in line 231. ✓ fixed

significant(?):
l. 37, remove sentence 'An analysis?.family.' → ensemble
l. 51, remove 'the analysis?at NNLO.' This belongs to the conclusions. → tests rephrased
l. 73, ?several reasons? - are they all listed in this paragraph?
l. 81, In Table I, ?normalised? appears in the data set column and in the caption. Is it obvious what i:
footnote 3, Is it clear why the value of 25 was chosen. All it says is the it should be > 15. added to table capt
l. 203, what is meant by ?technical reasons?? published numbers are not reasonable / tradition
l. 210, when trying to make a point about precision, why use ~ for the uncertainty? removed
Section 3.4 is titled ?hadronisation uncertainties? so is the number given in l. 215 the one that was u:
lines 340, 360 ?ZEUS and H1?Throughout the paper the order is alphabetic, namely H1 and ZEUS. I thought
l. 356, is this last sentence the highlight of the paper? It would be nice to end this with a more significant statement. rephrased

References:
Halina?s name is mispelled in refs [2] and [21].?> Abramowicz.
refs [11] and [12] have the same arXiv number. Change ref [12] to hep-ph/0609285 ✓
ref [17] V. Andreev et al.

Figures:
Fig. 2: a) not good choice of the light blue color (alpha_S free fit). EB wants it that way
Is that the line passing through the blue points?

b) red points connected with a dark line. c) red points connected
with a red line. Why is the x-axis scale of a) different from b)
and c)?
Figs. 3, 4 and 7 the sea label in the figure and the captions are different. done

Best regards,
Aharon

Erich Lohrmann:

Dear Colleagues,
one of the very important results of the paper
is the measurement of alpha_s at NNLO.
It should find its proper place in the title of
the paper and the abstract.

Suggest for title:
'Impact of jet production data at NNLO on the
determination of HERAPDF2.0 parton distributions
and an alpha_s(M_z)'

In the abstract giving alpha_s without the most
important uncertainty is useless. Suggest:
'..is alpha_s(M_Z)=0.1155+-0.0010(exp)+-0.0002(model)
+0.0026/-0.0024 (scale).Scale uncertainties are
discussed in detail...'

fixed in
EB process

Congratulations on an impressive paper.

Best regards,
Erich Lohrmann.

Ewald Paul:

thank you to all who have made possible this nice
finalpaper on HERA PDFs". I have a comment (1) and asuggestion (2).
(1) I think we should not talk about "similarities" in lines 22 and line 354,
since we can talk about consistancies.

done ✓

(2) The lines 50 bto 54 suggest a useful phrasing of the main result:
"The PDFs of previous studies and the new study including jets are
consitent throughout the whole kinematic range."
"The analysis presented here demonstrates concistancy of the jet data
with the inclusive data on NNLO level."
My suggestion: we talk about consistancy instead of simularities and
we improve abstract and summary in the spirit of the nicely summerizing
phrasing in the introduction.

done ✓

Best wishes for the paper,
Ewald

Masahiro Kuze:

Beautiful analysis and paper. Comments are all minor:

L15: does the phrase 'combined PDF and QCD fits' make a rigorous
scientific sense?
Are there different things such as 'PDF fit' and 'QCD fit' and they
are combined?

no rephrased

L111: electro magnetic -> electromagnetic

L126: sorry, I cannot count 10 free parameters - A, B, C for five PDFs make 15?
I guess some readers may think the same, so some explanation is needed. Reordered text to make the constraints clear

L228: (2.0 mu_r, 1.0 mu_r) -> the latter should be mu_f ?

L241: I cannot find Eq. 7.

L321: As discussed 'in' Section 3.3

L333: 'was entered' sounds colloquial. "each jet P_T entered in the cross section (calculation)"

Figure 3,4: the plot shows xS, but the caption says x\Sigma

Figure 6 caption says 0.116 but should be 0.1155

Figure 9, 11: label of the vertical axis (what is plotted) differs from what is said in the caption (I mean the notation) while they match in Figure 10,12. all figures and captions adjusted to be consistent.

L438: at the same time -> At the same time internal now

Notations (I thought Brian is in the EB?):

- s in alpha_s is a label (strong) and not a variable, so should in roman (it seems H1 papers make it in roman and ZEUS papers have it in italics) kept as one name

- T in p_T (as well as T in E_T, L332) is a label (Transverse) and not a variable, so should be in roman

- v in u_v and d_v is a label (valence) and not a variable, ... (ditto) Tradition

- min in Q^2_{min} ... (ditto)

- f in mu_f in Figure 5 caption ... (ditto) + μ_R

Peter Bussey

Line
28 First sentence is a little cumbersome - I suggest to insert "recorded" before "at" and ad
d
a comma after HERA.
Perhaps better: Data from....,ep, have been central.....[1]. Such no
data have been recorded at....at HERA. Then run on to continue with contents of second paragraph.
33 These analyses were based.... [avoid repetition]
34 I think you should not assume familiarity but state the order that these fits were perfor
med (rephrased)
so that the readers know exactly where things stood before this analysis.
36 Define NNLO I think that's there ? ?
.... inclusive DIS data [2]
37 Omit sentence, no need to make excuses. but ad (that is what you ask for)
38 The present analysis has been made possible by the recent provision of jet cross section predictions for ep scattering at NNLO by ~~the NNLOJET authors~~ and their collaborators. [be positive!] they are authors
41 to be constructed from -> to originate from rephrased
42 Can you say something more precise than "treated"? -> , which require .. (that's it) some text was added
46 omit "both" new text
49 All -> The [repetition with "entirely"]
I think I would again say "inclusive DIS"
50 Omit "highly" - it's consistent or it is not. The sentence really needs a phrase of amplification - why should it not be consistent? Why is it a single data set and not two
? added something on "all syst. uncertainties"
51 Omit "very"
53 Reference for this statement. gone
I would omit sentence "It is..." and rephrase a bit.
"With the assumption that it is also valid in hadron-hadron physics, PDF fits EB worked on it

can be made to LHC data. However, they can be biased by any presence of physics
beyond the Standard Model (BSM), including this tacitly in the fitted PDF values and ther
eby
kept EB version
reducing the sensitivity to explicit searches for BSM physics owing to biased background
predictions."
58 Omit final sentence, not needed. EB

62 coherent? Above it was "consistent". I'd stick with that but say what it means. added something on systematics
67 ... squared in the DIS process,
This sentence has "published" three times! Omit "which were...[27]" as it is just
background information here and makes the sentence cumbersome. rephrased
71 Omit ", however, only" [Basically, the reader just needs the facts.]
Since the reader may now be a little confused as to what "new" means, I would repeat
the reference or else mention the present analysis. rephrased
73 Say:... were excluded in order to ensure convergence of the perturbative series [EXPLAIN

THIS!] and to ensure that the NNLO scale uncertainties were no greater tha 10%.....
I think the rest of the text here is too chatty and you need to stick to the basic points
.
Well, these are the facts deemed important..,
76 b
78 "bin" is jargon, should we say "interval" ? [passim]
78-9,82 had to be excluded -> were excluded [passim, too chatty]
80 were judged to be -> were [avoid subjectivity] – but it was subjective ☺

89 The present analysis was performed in the same way as the previous [more concise]
90 Does this mean "cros-section data with Q^2 > 3.5 GeV^2"? If so, say it like that;
if not, make the meaning clearer?
91 I think you should repeat the crucial chisq definition here. no – by EB decision – it takes pages!
92 State what you mean by evolution and mention DGLAP (again).
97 Can you reference the second program?? no – sorry
100 As explained in the next section? Better say that.
103 ... was made possible by the.... [sounds more forceful!]. Repeat the reference.
116 results no

119 Could just say "For the gluon PDF, an additional term..." ~~Aft as before~~
123 I think this sentence would be better at the start of the section. section rearranged.
132-137 I think these lines should go before the sentence starting line 125.
However it becomes a little unclear at what point the addition of new parameters reordered
stopped. If this means when all the parameters in 132-137 were used, and this was
optimal, then I'd say "... could not be improved by inclusion of further terms".
(which are not included in 132-137, I suppose.)
139 equal, Bubar=Bdbar, resulting in a single...

153 How did you assign the variations that were used?
177 etc fixed points?
182 Clarify or omit sentence. tried to clarify

204 Omit "It was checked that"

211 is differentd -> differs
215 Somehow this paragraph seems to be left hanging. was reordered !
224 ... uncertainties", which....
226 This source of uncertainty [suddenly "uncertainty" become singular.]
234 omit "so-called" but remind reader what this chisq means.
240 ... uncertainty, which dominates the uncertainties.
241 Eq. 7 doesn't seem to be there. is there
245 Omit the vague word "significantly" ? EB called it significant
249-252 Consider moving this paragraph up a bit, near to where the chisq is first discussed in th no
is
does not work
section.
256 Well there can be no doubt about the minima! I would simply say that the positions of
minimum chisquared are in close agreement, indicating that any anomalies at low Q^2 are
small.
258 This is hardly surprising since inclusive DIS is dominated by a QED vertex. It would be
as well to remind the reader of this, perhaps at the start of the section where you
correctly say that jets are essential. Does fig 2c add anything to the paper? – EB wants it
271 analyses
277 which is similar to the cut used here.
278 ... that both the H1 and...were performed gone
286 Consider just calling it "NNLO PDF evaluation" – no: it shows results and not the evaluation
297 I'd rearrange: it becomes questionable to quantify the theory uncertainties.. was rewritten
(CTG provides this text)
(for which IA is grateful)

302 Not sure what "map out" means. rewritten
333 entered -> used rewritten
337, 358 Omit very no (see ratio plots)
340 For completeness add "DIS" into the sentence.
342 ... have been used...
343 called -> denoted as gone
345 Maybe: ... with alphaS allowed to vary freely.. gone
347 This result for...
350 for -> with rephrased

Fig 7, 8. You might consider replacing the green by light blue to assist the colour-blind.
(I add that this does not include me) However if you had no complaints before, perhaps this is not so important. tradition - has always been like this

Comment: A first reaction is why not include the PDF set with floating alphaS and uncertainties associated with this method. I can understand a rationale: a future user might want to use yet an other value of alphaS, perhaps with an uncertainty, and hopefully will be able to extract the desired i nformation from the two sets you have provided. It might be good to make this explicit. well no, we did it last time and nobody wants it. — the community has not gone this direction

---

Robert Klanner

Comments to: ?Impact of jet production data on the next-to-next-to-leading order5 determination of HERA
Paper Draft v0.5 ? July 27, 2020

The paper is very well written, contains highly relevant results and is very complete.

My comments refer to minor formal issues

l.24 ?agree very well? For me ?very well? is a very subjective judgement; they either agree, possibly s
line24: within uncertainties

l.271 both analysis -> both analyses
line 8: left it as was

l.262 ?+/-0.009(exp)? The spacing between the number and the opening parenthesis appears to be inconsis
tried to find last omissions

References

[17] Is ?H. Collaboration? correct? fixed

[29] F. Aaron et al., [H1 and ZEUS Collaboration], -> F. Aaron et al. [H1 and ZEUS Collaboration]
, -> remove ?,? for consistency. cannot manage

Table 2 : Central Value -> Central value

Fig. 8 : I would have expected that delta(xg)/xg is centered at 0 and not at 1. What am I missing? I pr

Fig.11 The variable <pT>_2 denote -> The variable <pT>_2 denotes

l. 438 NNLO. at the -> NNLO. At the

l.439 as the NNLO fit since the H1 -> as the NNLO fit, since the H1

Footnote p.25: I also agree with the inclusion of the appendix; I understand that this footnote w ill be removed. yes, certainly. → moved to internal by EB

l.469 Additional Material -> Additional material; Alpha Scan -> Alpha scan

Footnote p.27: I support the inclusion of the material in the paper. EB eliminated it - sorry

Caption Fig. 16, 17: old procedure -> procedure of Ref. [] internal extra material - no [] needed

In several of the captions (e.g. Fig. 15) both ?gluon PDFs? and ?gluon distributions? are used. In my o
okay gluon PDFs everywhere

Again, my congratulations to the authors for this excellent paper. Thank you.

Greetings,
Robert

H1

Joerg Gayler

```
Comments to v0.5 July 27

 Thank you very much for these efforts for final words of the two collaborations.

 Significant: I list here all questions that are not just wording only.
==============

  General: I miss a bit a general outline of the fit procedure.
      We determine alpha_s and PDFs. In the introduction one learns that we determine
      both simultaneously. Then in 3.1 to 3.4 nothing is said on alpha_s. Then
      alpha_s is determined fitting also pdfs, but discussed only in context
      of scaling violations. And then alpha_s is unexpectedly fixed to determine pdfs
      which one had assumed to have been already determined together with alpha_s.
      To understand the paper more easily, I would like to have some guidance early on.

      Comparisons with other results in section 4.1 is a bit meager, showing only the
      level of consistency, if data are treated similarly. But the difference of the
      Results or the agreement is of interest in first place. The paper could also compare
      the result to other important analyses in different reactions. What is the
      relevance of the result on alpha_s?

  Comments in detail:

 3.1 Choice ..
----------------
 127 "extra parameters .. one at a time": Is there some arbitrariness in which
     sequence the further parameters were chosen? Is the actual choice of parameters
     depending on the sequence?

 3.2. Model ..
----------------
 What is done with alpha_s in these PDF fits?

 Or the other way round, one wonders whether these variations lead only to uncertainties
 on the PDFs and not on alpha_s. In the introduction it is said, that fitted together.

 153 what determined the variation of mu^2_f0?

 3.3
-----
 175 Here in 3.3 alpha_s is mentioned. But what in 3.2? I already asked there.

 191  but mu_f0 = sqrt(1.6) = 1.26 < 1.37. One could check and state what happens then.

 4
----
 228   I guess (2,0 mu_r, 1,0 mu_F)

 4.1
-----
 269-277   The reader ist not so much interested whether data agree, if treated the
    same way, but at least as much whether the results are very different or not if
    different assumptions are used. So the main results as they were presented should be
    compared as well.

 282  Again the main focus seems to be on trying to do the same.

 5
-----
  305 if mentioned, what was then actually done, which scale variations assumed, as for
      the alpha_s fit?

  318-320 "The reduction in model and parameterisation uncertainty ... mostly due to
     the necessity to change the estimation procedure." What does this mean?
     Understandable? Further discussion is rather technical. I would expect some words
     on the actual observations, like that the largest effect is seen at large x.
     Is it really significant as it appears to be?


 Minor:
```

Handwritten annotations (in margin, beside the respective items):

- General, first paragraph: EB → rephrasing
- General, second paragraph: eliminated by EB
- 127: no
- 3.2: rephrased for clarity
- 153: tradition – it's now listed
- 175: is independent
- 191: more text added
- 228: ✓
- 269-277: followed EB decisions
- 282: cannot compare apples to pears
- 305: is now in text
- 318-320: text reworked to clarify more figures provided

=========
Abstract
----
24 "Predictions": a bit much, as fitted to these data. Suggest: calculated cross sections
we always used "predictions" (left it for consistency)

Data
----
73 "excluded for several reasons, including..."Sounds as if there would be more reasons than explained. May be "for several reasons: to ensure ..." ✓

3.2
-----
153 "was added to the parameterization uncertainty". But there is nothing yet to add on. ✓ The reader thinks to have missed something.
(model + parameterisation is one entity)
modified text.

3.3
----
165 parameterS ✓

178 As I understand, it is more clear to say: "one of the mass-parameter values. ... was used ...
rewrote for clarity

182 Is it obvious, the the M_b plot demonstrates the power of the method? Is it, because we get a parabola?
removed

241 where is equation 7? fixed

4.
---
264 multiplied into the .. gluon term. Is this just a factor (1 + Dx)? Is this a clear wording at least for natives?
rephrased

4.1

278-280 Reads strange: first it is said that H1 and NNLOJet analyses were done using fixed PDFs. Next sentence a simultaneous fit of alpha_s and PDFs.
Components were redone by E

5
----
321. IN section 3.3 ✓

References

Ref. 2
Was there some agreement on the sequence: "ZEUS and H1"? Why not alphabetical?
Because its fun to watch how important it is to be first (at least for H1 people) editors need some fun too

Ref 36 (2019) ---> (2017) ✓

All the best, Joerg

Karla Cantún

Dear Editor~~s~~, just one

Thank you for sharing the draft.
In general, I enjoyed reading it.
I just have a couple of minor comments:

Reference [2] is cited twice on lines 35 and 36, which looks repetitive. two different parts of paper

Equation 7 is referenced on line 241, but I could not find it in the text. [fixed] fixed

Cheers,

Karla Cantún

Comments to the draft v.05-July 27, 2020

Impact of jet production on the NNLO determination of HERAPDF2.0 parton distributions
Dieter Haidt, August 24, 2020

The present analysis of the H1 and ZEUS data from HERA based on the inclusive processes as well a
s jet production within NNLO of pQCD is a major achievement and constitutes an essential part of
HERA?s legacy. Some of the authors remember the very first steps performed by MARK at SLAC and Gargamel
The emphasis of the present analysis is to study the impact of data on jet production when added
to the previous analyses of the inclusive data alone. Apart from increasing the statistics the u
nique value of jet production comes from the direct dependence of the gluon (lines 217-231). I
suggest therefore devote the first chapter to discussing the improvement in the pdf parameters an
d their correlations determining the phenomenological parton distribution functions. The crux of
all analyses is the limited knowledge of the gluon distribution function obtained from the triang
ular phasespace in (x,Q2). The jetdata provide a genuine new insight. Within the same framework :
compare the parameter fit using the inclusive data alone with the new fit in this paper of inclu
sive data + jetdata. Illustrate it with two figures and make it quantitative with tables of the
bestvalues and their correlations in both cases. Comments on the improved gluon distribution are
welcome.
Thanks to Katarzyna I had a chance to study the correlation table of the combined data. I had ant
icipated strong correlations the gluon and the seaquark parameters and also between alpha_s and t
he gluon parameters, but to my surprise there are only rather moderate correlations with all pdf
parameters. Perhaps the comparison with the correlation table using the inclusive data alone wil
l elucidate my prejudice.
Line 139 : The momentum sumrule is an integral in x from 0 to 1. Given the conditions of our anal
ysis the application of the momentum sumrule is useless and only introduces a bias. The reason is
that an integration is required over the full range in x for all Q2. The behavior of the pdf at
low x is unknown. Due to the triangular shape of the phase space the constraint for increasing Q2
is getting more and more uncertain, since there are no measurements for low x, while the paramet
ric x -dependence merely reflects the evolved information from the low Q2-region. Therefore, drop
the momentum sumrule.
The heavy flavor contribution is included through pQCD evolution from massless quarks. A remark w
ould be in order, why we did not use our own direct measurements. Is it because of missing NNLO p
redictions ?
It is of particular interest to illustrate the impact of the systematic sources on the value of a
lpha_s. A figure showing the variation of alpha_s with the scale parameters would be revealing, s
ince the uncertainty of the bestfit is dominated by the scale uncertainties. The parametric depen
dence should be done for fixed pdf, otherwise the effect may be compensated partially by adjustin
g the (many) pdf parameters. The point will be whether the value of alpha_s is significantly shi
fted when varying the scale parameters. If it turns out that the central value of alpha_s is lit
tle dependent on the scale uncertainties, then we have a strong argument that our determination i
n the spacelike region differs from the one in the timelike region, which is also affected by sca
le uncertainties.
The determination of the parton distribution functions and alpha_s are linked. The key to the und
erstanding of our paper is largely related to the chisquare function and the way it is exploited
. I suggest to devote a detailed presentation, technicalities may be deferred to an Appendix.
a. How is the chi2-function defined ?

Please see decisions of EB. There were also personal discussions.

chi2(p) = Term with matrix(yi,f,C) + Term with constraints

we refer to the HERAPDF $\boxed{2.0}$ paper the standard

yi = measurements
xi = kinematic variables
f = prediction depending upon kinematics and free parameters
C = correlation matrix containing the uncertainties
p = alpha_s + pdf-parameters + systematic parameters

b. How are the systematic uncertainties implemented ? and in particular the splitting ?
c. Is the fit performed simultaneously for all free parameters ? Or in terms of fixed values
for alpha_s ? Is the ?so-called? chisquare scan a sequence of ch2-fits with fixed values of alpha_s in
d. The chi2/dof is quoted as 1.2. Does this indicate an underestimation of some uncertainties
, perhaps the scale uncertainties ? If so, would it be possible to repeat the fit with enlarged u
ncertainties to see the effect on the bestvalue of alpha_s ?
e. Is the meaning of chi2 the same everywhere in the text ?
f. Is the gluon distribution function dominating value and size of alpha_s among the pdfs ? H
ow big are the shifts in alpha_s caused by the systematics in the pdfs and the scales ? Shifts a
re linear effects. It may be justified to average over some of them.
g. The determination of alpha_s is dominated by the systematic theory error of +-0.0024 comp
ared to the experimental error +-0.001. One may ask whether the treatment of the systematics has
an important effect on the central fit value of alpha_s (see point f)
Line 284 : why is the scale uncertainty almost equal to this analysis (and not bigger) ? it is what it is
Figure 2a : I don?t understand. Are all parameters except for alpha_s free ~~?~~ yes also the scales ? Note my
Figures 3-7 : Why is the green band for medium x broad for uv and not for dv ? The figures for d

Scale uncertainties are not considered for PDFs - see new text

its the result - it is what it is because of Duv (is in text) all this is not new since the HERAPDF2.0 publication.

αs is a fixed value, PDFs are fitted, uncertainties are compared.
→ we provide PDFs for two values of α including all uncertainties.

ifferent alpha_s do not mean very much, since the pdfs are part of the fit.
Figure 8 : I don?t understand. What remains constant and what is part of the fit ? What do you conclude
Line 344 : are we quoting the fit values and correlations for the two values of alpha_s assumed.
Line 347 : A careful discussion should be given qualifying ?compatible?. Note my remarks above.
I suggest a much extended conclusion. I have - for my own sake - tried to highlight what we have achieved., since the present paper is perhaps the last word and therefore a legacy of HERA inviting some remarks on the overall increase in knowledge as well as some critical remarks on further improvements left to future studies. We may comment on the performance of the collider HERA, the experimental achievements of H1 and ZEUS with detailed publications and a final comparison with QCD (for the first time) at NNLO. The confrontation of experiment and theory provides a consistent picture. EB: This is a paper explicitely on one subject. Legacy plots were provided 2015

see EB decisions

The basic question is to what extent we have tested QCD. Our concern is perturbative QCD, which reduces the question to stating in which (x,Q2)-region pQCD is valid. This implies to worry about two frontiers (a) the transition in Q2 from the nonperturbative to perturbative regime and (b) the transition from moderate x-values to very low x-values. The first question is addressed by considering various starting scales in Q2, thus getting safe against higher twists. The other question, though important, may remain disregarded, since it concerns only the small tip in the phase space region at low Q2 and low x. Given the assumption that in the selected phase space region pQCD be valid the data are used to determine the parton distribution function, which are the necessary input to predict the observables. Since pQCD is applied at order NNLO (which is an achievement in itself), there is an intrinsic purely theoretical uncertainty coming from the truncation of the perturbative series. We address this uncertainty by varying the scales involved. Our conclusion about the impact of these systematic uncertainties will be decisive in judging the difference of our determination in the spacelike regime of alpha_s and the existing one in the timelike regime. In any case here is a task for future work in theory. The EB considers QCD [pQCD] as standard
The determination of the parton distributions is of value in itself and represents an important achievement, although there are still several weak aspects : the a priori assumption of the shapes , specific assumptions regarding the flavours , in particular the unknown s sbar-quark contribution and the role of the gluon. It should be emphasized that all in all the present knowledge is remarkable.
The experimental information is shared between the determination of the parton distribution functions and the confrontation with pQCD. Is is possible to make an educated guess what fraction of the experimental information is actually available for testing pQCD ? The observation that the correlations between the pdf parameters and alpha_s are weak, is perhaps a strong argument in favour of real test of pQCD.
Our analysis demonstrates a consistent picture and complements the efforts in the timelike region .

EB: This paper is written within the framework of pQCD which is considered a proven theory. Others might want to conduct more tests. It is beyond the scope of this paper.

Jan und Nelly Olson

Dear members of the Editorial Board for the paper
"Impact of Jet Production Data on the Next-to-Next-to-Leading Order Determination of HERAPDF2.0 Parton Distributions"

We have now read through the draft 0.5 from 27.07.2020 of this paper and are quite happy, the paper is already close to completion in the current form. From our side there are no objections to the content.
We understand that this is a paper for the specialists and that therefore the introduction and physics background presentation is rudimentary, with the body of the paper concentrating on the technical
details and problems of the fitting procedure. The occasional use of technical jargon is also acceptable, when seen from this aspect.

Nevertheless, a couple of remarks can be made:

Line 35 describes this paper as the "completion" of the HERAPDF2.0 family. We think that this is too strong a word, since we see that there are possibilities for still further steps; explicitly we think of future NNLO calculations for heavy quark data involvement in the fitting. Thus, inclusive + jets + heavy quarks for the PDFNNLO fitting.

There will be no further analyses. The team will not consider it.

The heavy quarks enter also as Vector Meson Production, accessible to QCD calculations. In this connection we like to mention the paper arXiv:1908.08398 by C.A.Flett et al., "How to include exclusive J/psi production data in global pdf analyses".

We believe that inclusion of such HERA data will improve the uncertainty situation at low x for the gluon PDF, once the corresponding NLO/NNLO

H1 and ZEUS specialist after long discussions concluded that adding heavy quarks should not be done.

calculations are available.

Thus, we would not too strongly stress that the current paper is final, as far as HERAPDFs go. Hopefully there is much more to come! — NOT from the analyses involved so far

Another comment:
Chapter 2 describes in detail how several data points were exempted from the analysis, for various technical reasons. In the final results, one would like to see the predictions of the fitted PDFs for these points, which were NOT included in the fitting procedure. The paper makes the statement that there is good agreement between the fits and the fitted data, which naively is no surprise and only confirms that the inclusive and the jet data are compatible. However, the reader gets curious and wonders about the agreement (or possible disagreement) in the immediate neighborhood of the fitting phase space, the neighborhood which is given by the left out data poi nts.

EB decided against this as the calculation are not valid for these points.
Please also see documents on EB decisions.

It remains to be said that the paper is very well written, the English is excellent and there are almost no typos. Congratulations! Thank you!

Our detailed remarks follow below.

Our best wishes for a speedy and smooth publication!

Nelly and Jan

We lost a year due to a lack of new grids. Thanks anyhow.

There are 8 footnotes, which all (except footnotes 7,8) need a small correction:
"word \footnote{...}" --> "word\footnote{...}"
in order not to "fly free in the air".

matter of taste ... anyhow, done in text but: \, for variables

In footnote 3 the final period "." is missing (line 122) ✓

We understand that footnotes 7,8 will not appear in the final paper.
of course

line 33 "milestone for" --> "milestone in" ✓

line 43 "charm and bottom masses" --> "charm- and bottom-quark masses" ✓
(cf. line 105) ✓

line 74 "and that the NNLO..." -->
"and limiting the NNLO scale uncertainties from becoming too large" rephrased

line 75 "to the ~24%" --> "to ~24%" ✓

line 90 "for Q2 starting" --> "for Q2 values starting" rephrased

line 244 "hope substantially to reduce" -->
"hope to substantially reduce" rephrased

line 253 "data with relatively low Q2" -->
"data with relatively low Q2 values" OR
"data at relatively low Q2" ✓

line 287 "fit where" --> "fit in which" rephrased

line 297 "on them" "on PDFs" rephrased

line 321 "discussed Section" --> "discussed in Section" ✓

line 334 "the the" --> "the" ✓

Ref.[12] The given arXiv number, 1801.06415, is wrong and a repetition from ref.[11].
The correct arXiv number is [hep-ph/0609285] ✓
========> done

```
Ref.[13]    The arXiv number 1208.3641  refers to a writeup by
             D.Britzger, K.Rabbertz, F.Stober and M.Wobisch, from DIS2012
             with title "New features in version 2 of the fastNLO project"
            We believe that this is the correct reference, since it goes
            together with Ref.[12]. Thus, you have got the authors wrong
            here!
  =======> done
```

✓

```
Ref.[29]    "et al.,"  -->  "et al."
  ===> I did not manage to convince bibtex
```

Sorry

```
Refs [9,10,12,15,33]    ", and"  -->  " and"
  ===> I did not manage to convince bibtex
```

Sorry

Stefan Schmidt

Dear authors, dear editor,

congratulations for finishing up this draft. Here are a few comments.

All the best,
Stefan

Thanks

Paper structure and changes to figures/analysis
===
Section 4 and 5/6 should be swapped. First we determine PDFs with fixed
alpha_s and compare to jets data. The free-alpha_s fits should come
after that (same order as in the summary).

no
EB decision

**
As already said in the paper presentation, I would prefer very much to
have figure 8 or 15 with the same alpha_s for both PDFs. Using different
alpha_s blurs the message of the figure. People will possibly try to relate the uncertainty diffe
rences to the alpha_s choice rather than focus on the message of uncertainty improvements through
 the new data.

see EB decisions on figures

minor textual comments
======================
line 38: a typo "Yhis" -> "This" ✓

line 85: maybe explain what is meant by "complete NNLO"
   (something like this
    ... consistently including both massive and light flavoured jets...)

rephrased in EB
process

line 116: missing reference ✓
    ... improved ... fits, confirming earlier findings [36].

nice to have grids before they
are released, isn't it.
serves vanity well.

line 188: perhaps explain this problem a bit more in detail?
    ... such that a non-vanishing charm contribution can be generated
      perturbatively for any scale above the M_c threshold. no

---

** Mark Sutton on comment by Stefan

Hi, on the note of differing alpha_s for the plots, I would disagree strongly - for the main comp
arison,
we should compare the deafult results from the earlier fit, with the default result from the new
fit.

If it is felt necessary to address this point about the differing alphas values from the fits in
this way,
one could include additional plots comparing the fits, but using the same alphas value, as auxill
iary
plots, or in an appendix.

In this case, it would be open to discussion whether the alphas value used should be that from th
e
older fit, or from the newer fit - one could easily argue, that the older fit should be presented

with
the newer alphas value from the new fit, and indeed, since the new fit in some sense supercedes the older fit, and so might be expected to be in some sense "better", then this might be the more reasonable suggestion.

In either case, using a value that was not the result from the fit itself might be expected to ar tifically
inflate the errors, which may be another reason to disfavour doing this, but in that case, probab ly
better to artificially inflate the errors of the older fit.

However, clearly showing the results of a fit which included some parameter, but with the PDF the n
evaluated with a different value for that parameter, which was not the value of the parameter tha t
resulted from the fit would be reasonably meaningless, since that would not actually be the resul t
of the fit at all. So if the fits themselves favour particular alphas values, then showing the r esults of one
of the fits with respect to a different alphas value would be highly misleading.

If one wanted a comparison with the same alphas value, then both fits would need to be explicitly performed with the same value of alphas from the outset, but this would be a completely different comparison from comparing uncertainties from fits where the alphas was included as fit parameter, even if alphas itself was then later chosen to be the same for the evaluation of the PDFs since t he
alphas and gluon are strongly correlated.

see EB decisions on figures

Cheers
Mark

Mandy:
Just a note of clarification to Stefan and Mark's comments.
We do have new fits with both alpha-s=0.118 and 0.1155 both fixed alpha_s fits.
The alpha_s =0.1155 is our preferred value from the free alphas fit but we
are showing the uncertainties for the fixed alphas fits. We can provide these
uncertainty comparisons for both values for the new fit and indeed Katarzyna
has some plots ready to show next week.
We cannot so easily go back and use the value alpha_s=0.1155 for the old fit
as this means re-running fits, we had never used this precise value in the past.

EB decisions

Stephan during PP:
wants the comparison of the gluon uncertainties for same alpha_s=0.118
Jets NNLO
NNLO
is in pap10/new_figures:newFigure8-ssComment.pdf
Katarzyna
I've made the plot that Stefan requested
(the uncertainty comparison with the same alpha_s).
Please have a look.
Things do look similar to the present comparison,
just slightly worse (as we've expected).

see EB decisions on plots

Zhiqing Zhang

Dear editors and all,

Thank for providing the paper draft. I have only one major comment.

My understanding based on the discussions during the meetings is that the main focus of the paper is on the HERAPDF2.0 NNLO jet PDF set and the result of alpha_s is a byproduct and should be de-emphasized. The current version of the paper draft does not reflect this.

Indeed, if we would take this alpha_s result more seriously, one should provide/clarify its corre lation with the previous results based on the similar data sets. Otherwise it won?t be easy for others

Cheers,
Zhiqing

EB decided on paper
H1 does not have a monopoly on α_s

Comments on V0.5 - Max Klein -- came in after deadline and was not dicussed in 2020 EB
some of it was discussed 2021

Dear Friends

many thanks for this paper, another culmination of decades of work on PDFs.

I am sorry that this comes late but had told Matthew I may have difficulties to comment on the sh
ort deadline set.

It is very important to see that jets and inclusive DIS are compatible, and the small DIS alphas value remains a puzzle. We saw that in 2000 when he had made a huge effort to extract the couplin
g, by reducing the PDF influence with a minimalistic parameterisation and when we studied for ver
y long how to use BCDMS which now isn't so important owing to our jet data [that paper has been t
he most cited by H1 hep-ex/0012053] .

I find the name HERAPDF2.0Jets NNLO rather 'barock' not nice. I understand the history and the de
sire to provide all details with the name, but are they all needed? what about HERAjets and HERAi
ncl, these names will be used in PDF context only anyhow.Did we have a version 1.0 for/with jets,
not sure; the order in QCD could be provided in text and captions as is done already (fig 2 e.g.
) This could also be done, for example, in fig 3.
I expect you do not change this, cna live with that, but wanted to state it. This is only an H1+ZEUS paper, because the analysers wanted to keep the name HERAPDF

Figures:

2b,c it would be more instructive if you chose the same y scale, say 0-15
for both plots. to use 0-50 makes c) even more shallow than it is wrt b)

Fig 3: you plot xf(x,Q^2) which was fitted using Q2 as the factorisation scale.
It is in my view better to write Q2=10 GeV2, even if previously we did it like this,
while before that time we wrote Q2=.. Q2 is used is in many areas and
DIS papers before and after.

more important: a really nice plot and result!

caption: delete at the value muf= 10 (sounds like that has sth to do with alphas)
and it is in the plot. (here and elsewhere).

Please see documentation on EB decisions for Figures as in paper ✓

Fig 4: delete: the PDG ✓ value and muf=10.. stays (PDG may change and is not important here)

Fig 6 caption: .116 --> ✓ .1155

Fig. 7 dashed --> ✓ dotted

this gives the impression as if nothing happened through jets, but it did
- by fixing alphas to 0.1155 instead of 0.118, so we know better.

- a particular question regards the gluon at large x. refering to an email
by Mandy and Katarzyna from 14.8., they said :
it does seem that the jets make the high-x gluon a bit softer (as well as reducing uncertainty)

text and figures were added

the plot then attached compared xg inclusive with xg with jets. but the scale was chosen such t
hat the blue line ran out at x=0.5. I propose to make and include a plot log xg (from 10-4 to sth
like 20) as function of linear x (0-1) with these two gluons. then we would see a real differenc
e. the large x behaviour of xg is very important and hard to get in inclusive DIS due to the vale
nce (non-singlet) dominance. Such a plot was discussed

Fig 8 not sure I like this: it shows 4 times that jets have no influence on the
gluon uncertainty (very little) - is that the message? text was added

Fig 9/10: if the cross section is indeed for a wide bin, then you do not plot
dsigma/dpt but some delta sigma/delta pt. It would be much better to
apply a bin center correction (probably in Q2 and pt) and then indeed
plot a differential cross section. or it needs a different notation I think. data are shown as published

Fig 11 caption: this is not a 'differential cross section' cf the remark above. or?

you have a jet x setion d2sigma/dptdQ2 what is exactly the cross section y axis corrected

```
you normalise this to, what is sigma_NC?
and then what is the unit of sigma/sigma_NC?

you write only datafitted are shown, how does the fit describe the other data?

why do do you show this ratio?
```

This is H1's way of publishing. The analysers of this paper cannot change it whatever they think about it.

```
I think one should also include a plot with the inclusive data and how they are described.
after all: that is a fit to both inclusive and jets. in the inclusive we had two puzzles: how we
describe the lowest x data and how we reproduce the FL turnover. A kind of final, overall fit, I
think, cannot be presented without illustrating the quality of the description of the NC data al
so.

your fig 2 indicates that the low q2 puzzle may have been gone??,
at least alphas is stable with q2min. since the alphas for q2 >3.5
is the same as for q2 >10, two questions: how does the uncertainty
reduce with lower q2 (one only sees this a bit in fig 2) and why
do you still limit the data to q2 >10 instead of 3.5 as we did
previously, do you have reasons to do that other than inclusive history?
after all, one of the indications of new lox physics was the chi2 variation
with q2min and one is interested to know whether including jets affects this
and how (maybe that is discussed and i overlooked it, sorry in this case)
```

That was always the case. The 'problem' is χ^2 and it extends to x 100 GeV²

```
Appendix A
------------

just reading this, it is not clear why that is here presented. IF you want to do an alphas discus
sion in earnest, then all the points here listed need to be really discussed/evaluated. My impres
sion is that this 1 page list of subtleties is better either left out or indeed seriously discuss
ed, but that could lead to 10 pages and change the paper (and its schedule).
```

All this was demanded by H1 and later pushed to internal material by the EB

```
Text

I am unable to comment on the text in detail for lack of time. I understand the EB meets tomorrow
. Thus a few quick observations only, I will be glad to read a next version more carefully/thorou
ghly.

132 i would not talk about a family here, maybe set is better
```

used otherwise → ensemble the editor would still prefer "family"

```
133 were based but still are, no? MSbar
```

✓

```
135 represents the completion --> complements
    [never they this is the end]
```

It is the end

Nobody involved will go for another paper, neither the analysers nor the editor.

```
137/38 delete An -- family.
    138 when --> since
```

no rephrased

```
150 delete highly or indicate why they are not consistent
    [what is meant here H1-ZEUS or/and inclusive+jets?]
    then say that because of the consistency we can use a straightforward chi2=1 criterion to def
ine the experimental uncertainties
```

added why rephrased trivial published!

```
151 I do not understand the statement that jet and inclusive data are consistent at NLO (or NNLO)
. if we want to say they can be consistently described in NNLO QCD then this belongs to the concl
usion, not the introduction.
```

rephrased → text

```
one expects at the end of the intro a guide about the paper structure and not the LHC philosophy
which I would put to the intro beginning.
```

paper is too short for that

```
typo: the the line 234

1236 if the minimum would not have been the fit result, one would worry,
     so why do you write this?
```

so that you don't worry.

```
1269 i do not understand the 'impossible comparison' logics: even if the scales were treated diff
erently (which is anyhow more art than science) shouldn't one be able to compare the results, unc
ertainties etc?
```

EB decisions eliminated comparisons between apples and pears

```
i notice that then indeed you compare all (284/5) which is good
==========================================================================
```

red: EB process

blue: before reading

DESY-20-xxx

following H1prelim-19-041, ZEUS-prel-19-001

General remarks: many too long centences, split them, it is not easy to follow description of the fit procedure i

Some rephrasing, but it's written for literates

Impact of jet production data on the next-to-next-to-leading order determination of HERAPDF2.0 parton distributions

? Measurement of HERAPDF2.0 parton distributions and \alpha_s(Mz) at NNLO with HERA jet production data.

EB decision

Paper Draft v0.5 – July 27, 2020

Author list

Abstract

NAME

collaborations

The HERAPDF2.0 family of parton distribution functions (PDFs) was introduced in 2015. The final stage is to analyse the HERA data on inclusive deep inelastic ep scattering and jet cross sections as published by H1 and ZEUS experiments at next-to-next-to-leading order (NNLO). In the fit to obtain the PDFs of HERAPDF2.0Jets ~~NNLO~~ at NNLO with jet data, cross-section predictions made available by NNLOJET authors and their collaborators are compared to these data. ~~Published~~ HERA data on heavy-quark production were used to determine optimal values of for charm and beauty the mass parameters ~~for the charm and beauty quarks.~~ Combined PDF and QCD fits were performed ~~both~~ with the strong coupling constant, $\alpha_s(M_Z^2)$, either free or fixed. The result of the fit with $\alpha_s(M_Z^2)$ as a free parameter is $\alpha_s(M_Z^2) = 0.1155 \pm 0.0010$ (exp) ± 0.0002 (model ~~+ parameterisation~~) +0.0026/-0.0024 (scale). Scale uncertainties are discussed in detail. Sets of parton density functions from fits with fixed $\alpha_s(M_Z^2) = 0.1155$, the value preferred by HERAPDF2.0Jets NNLO, ~~and~~ or with $\alpha_s(M_Z^2) = 0.118$, the value used for the published HERAPDF2.0 at NNLO analysis, based on inclusive data only, are presented and compared to each other. The PDFs of HERAPDF2.0Jets at NNLO for fixed $\alpha_s(M_Z^2) = 0.118$ are also compared to the PDFs of HERAPDF2.0 at NNLO. The ~~similarity~~ consistency of the PDFs ~~demonstrates~~ corresponds to the consistency of inclusive and jet-production cross-section data. ~~Predictions~~ Calculations based on HERAPDF2.0Jets at NNLO agree ~~very well~~ with the measured cross sections for jet-production data used in the fits. within ? uncertainties

? what was combined? Combined PDF and QCD fit was?

rephrased

Both PDF and QCD fits were ?...and combined

What is similarity?

→ dictionary

Name

1 Introduction

recorded

Data from deep inelastic scattering (DIS) of electrons [1] on protons, ep, at centre-of-mass energies of up to $\sqrt{s} \approx 320$ GeV collected at HERA, have been central to the exploration of proton structure and quark–gluon dynamics as described by perturbative Quantum Chromo Dynamics (pQCD) [1].

The combination of H1 and ZEUS data on inclusive ep scattering and the subsequent pQCD analysis, ~~introducing~~ which introduced the family of parton density functions (PDFs) known as HERAPDF2.0, was a milestone for the exploitation [2] of the HERA data. The HERAPDF analyses were based on pQCD fits to the HERA DIS data in the DGLAP [3–7] formalism ~~in the~~ based on $\overline{\text{MS}}$ scheme [8].

rephrased

~~The~~ This work ~~presented here represents the completion~~ completes of the HERAPDF2.0 family [2] with an analysis at NNLO based on HERA inclusive [2] and jet-production data published separately by the H1 and ZEUS ZEUS and H1 collaborations. teaser for AA ~~An analysis of jet data at NNLO was not possible at the time of the introduction of the HERAPDF2.0 family~~. This analysis became possible when the NNLOJET authors and their collaborators [9–17] provided jet cross section predictions for ep scattering at NNLO. rephrased The present analysis became possible with the jet cross section calculations for ep scattering at NNLO from NNLO authors and their collaborators [9-17]

The treatment of jets at NNLO assumes them to be ~~constructed~~ produced by / originate from massless partons. However, the inclusive data were ~~treated~~ analysed within the RTOPT [18–20] Variable Flavour Number Scheme (VFNS), which requires values of the parameters for the charm and bottom masses, M_c and M_b, as input. These parameters were optimised using cross sections for charm and bottom production, which were published as combined data by the H1 and ZEUS collaborations [21]. ?

rephrased at ETB level

The strong coupling constant $\alpha_s(M_Z^2)$ was determined by fitting ~~both~~ the PDF parameters and $\alpha_s(M_Z^2)$ simultaneously. This avoids biases in the determination of $\alpha_s(M_Z^2)$ that could be introduced by fits of $\alpha_s(M_Z^2)$ with fixed PDF parameters [22]. ?

All results presented here are based ~~entirely~~ only on HERA ~~data, i.e.~~ DIS? inclusive and jet-production data. The HERA inclusive data ~~represent~~ is are a single~~, highly~~ consistent data set. Furthermore, the jet data have been found earlier to be ~~very~~ consistent with the inclusive data at NLO [2]; The the analysis presented here also demonstrates found consistency between the jet and inclusive data at NNLO level at NNLO. In addition, DIS is the only process for which the factorisation theorem is fully established. [...] It is only a standard assumption that it is also valid for hadron-hadron interaction processes. However, even if this assumption is valid, PDF fits to LHC data would be biased by contributions from any physics effects any physics Beyond the Standard Model (BSM) ~~whose effects have~~ so far escaped detection, thereby reducing the sensitivity ~~of~~ to searches for BSM due to biased background predictions. Thus, the HERAPDF2.0 family of PDFs provide a benchmark to which PDFs including data from LHC colliders may be compared. ~~This could reveal BSM effects or the need for an extension of the QCD analyses for some processes.~~

rephrased

rephrased in ETB process

2 Data

rephrased

Data taken by the H1 and ZEUS collaborations from 1993 to 2007 were combined to form a ~~coherent~~ consistent set of inclusive ~~HERA ep DIS~~ cross sections of DIS ep scattering at HERA, [2], which was used as input to the determinations of all previous ~~members~~ PDF sets of the HERAPDF2.0 family. The HERAPDF2.0Jets analysis at NLO used selected inclusive jet and dijet production data [23–27] from ~~ZEUS and H1~~ H1 and ZEUS, which

[1] From here on, the word "electron" refers to both electrons and positrons, unless otherwise stated.

In addition .....in lower Q^2 events and six new high Q^2 points at low pT were added as input to NNLO analysis. Here Q^2 is ....transfer in DIS process squared and pT is the transverse energy of a jet. These new high Q^2 data complete high Q^2 data set of H1 [27].

rephrased

were again used for the present analysis at NNLO. In addition, new data [28], ~~published by~~ from / by the H1 collaboration on jet production in lower Q^2 events, where Q^2 is the four-momentum-transfer squared, together with six new high-Q^2 points at low p_T, where p_T is the transverse energy of the jet, which were published by H1 in the same publication to complete the previously published high-Q^2 data set [27], were added as input to the NNLO analysis. A summary on the data of jet production used is provided in Table 1.

rephrased

The new? treatment of inclusive jet and dijet production at NNLO was~~, however, only~~ applicable to a slightly reduced phase space as compared to HERAPDF2.0Jets NLO analysis. All data points with $\mu = \sqrt{\langle p_T^2 \rangle + Q^2} \leq 13.5$ GeV had to be excluded ~~for several reasons, including~~ to ensure ensuring convergence of the perturbative which? series and that the NNLO scale uncertainties ~~did not become too large; the scale uncertainties~~ to ensure were ~~held at~~ below $\approx 10\,\%$~~,~~ in NNLO calculations ~~in comparison~~ Just compare to to the $\approx 24\,\%$ at NLO. This requirement also ensures that μ is significantly larger than the b-quark mass, which is necessary because the jets are assumed to be built from massless partons ~~in the calculation of the NNLO predictions~~. In addition, for each Q^2 bin, the six? data points with the lowest $\langle p_T \rangle$ had to be excluded from the ZEUS dijet data set because the available NNLO predictions for these points were judged to be incomplete considering the kinematic cuts [2]. The resulting reduction of data points is detailed in Table 1. In addition, the trijet data [27] which were used as input to HERAPDF2.0Jets NLO ~~had to be~~ were excluded as no NNLO treatment was available. due to missing NNLO calcuations

difficult? to understand

rephrased

Let "The resulting ...in table 1" be the last centence in the paragraph.

The inclusive charm data [29], ~~which were~~ included in the analysis at NLO [2] were not explicitly used in the PDF fits of the this analysis ~~presented here~~, since complete? what is it? NNLO predictions were not available. Heavy quark data [21] were only used to optimise the charm and beauty mass parameter values ~~for charm~~, M_c, and ~~beauty,~~ M_b, which ~~are needed~~ serve as input to the adopted RTOPT [20] NNLO approach to ~~the~~ fit~~ting~~ ~~of~~ the inclusive data.

rephrased

3 QCD Analysis

present performed rephrased manner No

The ~~analysis presented here~~ present analysis was ~~done along~~ performed the same ~~lines~~ manner as all previous HERAPDF2.0 analyses [2]. ~~Only~~ cross sections for Q^2 grater than ~~starting~~ at $Q^2_{min} = 3.5\,\mathrm{GeV}^2$ were used in the analysis. The χ^2 definition was taken from equation 32 of the previous paper [2]. please, remind us the definition NO The value of the starting scale for the DGLAP evolution? ~~evolution~~ was taken as $\mu^2_{f0} = 1.9\ \mathrm{GeV}^2$. The parameterisation which one? and choice of free parameters also followed the prescription for the HERAPDF2.0Jets NLO fit, see Section 3.1 below.

has none (as you well know)

All fits were performed using the programme QCDNUM [30] within the xFitter framework, formerly HERAFitter, framework [31] and were cross-checked with an independent programme, name of the program? which was already used as a second programme in the HERAPDF2.0 analysis. The results obtained using the two programmes, as previously for all HERAPDF2.0 fits [2], were in excellent agreement, i.e. well within fit uncertainties. All numbers presented here were obtained using xFitter.

The light-quark coefficient functions were calculated in QCDNUM. The heavy-quark coefficient functions were calculated in the general-mass variable-flavour-number scheme RTOPT [18], with recent modifications [19,20].

[2]Due to the kinematic cuts used in selecting the dijet data, the LO prediction for the cross sections is zero. Thus, the NNLO term is only the second non-zero term.

The analysis presented here became possible due to the newly available treatment of jet production at NNLO, [1] using the zero-mass scheme. This is expected to be a reasonable approximation when the relevant QCD scales are significantly above the charm- and beauty-quark masses. The jet data were included in the fits at full NNLO using predictions for the jet cross sections calculated using NNLOJET [9–11], which was interfaced to the fast interpolation grid codes, fastNLO [12–14] and APPLgrid [15,16] using the APPLfast framework [17], in order to achieve the required speed for the convolutions needed in an iterative PDF fit. The NNLO jet predictions were provided in the massless scheme and were corrected for hadronisation and Z^0 exchange before they were used in the fits. A running electro magnetic electromagnetic α as implemented in the 2012 version of the programme EPRC [32] was used in the treatment of the jet cross sections.

The choice of scales for the jet data had to be adjusted for the NNLO analysis. At NLO, the factorisation scale was chosen as for the inclusive data, i.e. $\mu_{\mathrm{f}}^2 = Q^2$, while the renormalisation scale was linked to the transverse momenta, p_T, of the jets as $\mu_{\mathrm{r}}^2 = (Q^2 + p_T^2)/2$. For the NNLO analysis, $\mu_{\mathrm{f}}^2 = \mu_{\mathrm{r}}^2 = Q^2 + p_T^2$ was used. This ~~resulted in an~~ to improved χ^2 for the fits. Scale variations were also considered and are discussed in Sections 4 and 5.

3.1 Choice of PDF parameterisation and model parameters

PDFs were parameterised as ~~a~~ functions of x at the input scale by the generic form

$$xf(x) = Ax^B(1-x)^C(1+Dx+Ex^2). \tag{1}$$

The PDF of the gluon had ~~was an exception, for which~~ replaced an additional term of the form $A_g' x^{B_g'}(1-x)^{C_g'}$ ~~was~~ subtracted [3]

The parameterised PDFs xf(x) are the gluon distribution xg, the valence-quark distributions xu_v, xd_v, and the u-type and d-type anti-quark distributions $x\bar{U}$, $x\bar{D}$, where $x\bar{U} = x\bar{u}$ and $x\bar{D} = x\bar{d}+x\bar{s}$ at the chosen starting scale. The parameterisation for the central fit was determined by initially fixing the D, E and A_g' parameters to zero. This resulted in 10 15 ? free parameters. due to constrains described below ? The extra parameters were introduced one at a time until the χ^2 of the fit could not be further improved. This is also called the χ^2 saturation method. This resulted in a 14 parameter fit which satisfied the criteria that all PDFs and all predicted calculated cross sections were positive throughout the kinematic region probed by the data entering the fit. The suitability of the parameterisation was, thus, also verified for the selection of jet data.

all HERAPDF papers used „predicted" for this step

see lines 138 – 146

Text was reordered

The final parameterisation was

$$\begin{aligned}
xg(x) &= A_g x^{B_g}(1-x)^{C_g} - A_g' x^{B_g'}(1-x)^{C_g'}, && (2)\\
xu_v(x) &= A_{u_v} x^{B_{u_v}}(1-x)^{C_{u_v}}\left(1+E_{u_v}x^2\right), && (3)\\
xd_v(x) &= A_{d_v} x^{B_{d_v}}(1-x)^{C_{d_v}}, && (4)\\
x\bar{U}(x) &= A_{\bar{U}} x^{B_{\bar{U}}}(1-x)^{C_{\bar{U}}}\left(1+D_{\bar{U}}x\right), && (5)\\
x\bar{D}(x) &= A_{\bar{D}} x^{B_{\bar{D}}}(1-x)^{C_{\bar{D}}}. && (6)
\end{aligned}$$

[3] The parameter $C_g' = 25$ was fixed since the fit is not sensitive to this value, provided it is high enough ($C_g' > 15$) ensuring that the term does not contribute at large x.

The normalisation parameters, A_g, A_{u_v}, A_{d_v}, were constrained by the quark-number and momentum sum rules. The B parameters, $B_{\bar{U}}$ and $B_{\bar{D}}$, were set equal, $B_{\bar{U}} = B_{\bar{D}}$, such that there was a single B parameter for the sea distributions.

The strange-quark distribution was expressed as an x-independent fraction, f_s, of the d-type sea, $x\bar{s} = f_s x\bar{D}$ at Q_0^2. The central value $f_s = 0.4$ was chosen to be a compromise between the determination of a suppressed strange sea from neutrino-induced di-muon production [33,34] and the determination of an unsuppressed strange sea from the ATLAS collaboration [35]. The further constraint $A_{\bar{U}} = A_{\bar{D}}(1-f_s)$, together with the requirement $B_{\bar{U}} = B_{\bar{D}}$, ensured that $x\bar{u} \to x\bar{d}$ as $x \to 0$.

3.2 Model and parameterisation uncertainties

Model and parameterisation uncertainties on the PDFs resulting from the central fit were evaluated by varying the input assumptions. The central values of the model parameters and their variations are summarised in Table 2. The uncertainties on the PDFs obtained from variations of M_c, M_b, f_s, Q^2_{min} were added in quadrature, separately for positive and negative uncertainties, and represent the model uncertainty.

The uncertainty obtained from the variation of μ^2_{f0} was added to the parameterisation uncertainty. A variation of the number of terms in the polynomial $(1 + Dx + Ex^2)$ was considered for each of the parton distributions listed in Eqs. 2–6. For this, all 15-parameter fits which have one more non-zero free D or E parameter were considered as possible variants and the resulting PDFs compared to the PDF from the 14-parameter central fit. The only significant change in the PDFs was observed for the addition of a D_{u_v} parameter. The uncertainties on the central fits from the parameterisation variations were stored as an envelope representing the maximal deviation at each x value.

The total uncertainties on the PDFs were obtained by adding experimental (fit), model and parameterisation uncertainties in quadrature.

3.3 Optimisation of M_c and M_b

see above

The charm- and beauty-mass parameters M_c and M_b were needed as input to the RTOPT scheme used to calculate cross sections ~~predictions~~ for the inclusive data. The optimal values of these parameter were re-evaluated, since new combined HERA data became available [21], superseding the previously published combination of charm data [29] and the data published separately by H1 and ZEUS on beauty production. The optimisation was done through fits to the inclusive HERA data together with the new combined heavy-flavour data [21] by ? NO with varying choices of the parameter values. The values resulting in the lowest χ^2 values of the fit were chosen used in NO ~~for the jet analysis~~. Their one standard deviation uncertainties were determined by fitting the χ^2 values with a quadratic function and finding the mass-parameter values corresponding to $\Delta\chi^2 = 1$ values. This is the same procedure as used for HERAPDF2.0 NNLO [2], where the older data on charm and beauty data were used.

The fits for the optimisation were performed using the fixed value of $\alpha_s = 0.1155$ [4]. As a first iteration, M_c was varied with fixed $M_b = 4.5$ GeV and M_b was varied with fixed $M_c = 1.43$ GeV, i.e. the mass-parameter values used for HERAPDF2.0 NNLO were used as fix-points. In every iteration, the mass-parameter values as obtained in the previous iteration were used as new fix-points. The iteration was ended once values stable to around 0.1 % for M_c and M_b were observed. The final χ^2 scans are shown in Fig. 1. The minimum in χ^2 is observed for a value of M_c close to the technical limit, see below, of the fitting procedure. The minimum in χ^2 for M_b demonstrates the power of the method. The resulting values are $M_c = 1.41 \pm 0.04$ GeV and $M_b = 4.20 \pm 0.10$ GeV, quite close to the values of HERAPDF2.0 NNLO, with slightly reduced uncertainties.

The part of the model uncertainty concerning the heavy-flavour mass parameters would nominally have involved varying the value of M_c to the minimum and maximum of its one standard-deviation uncertainty. However, for M_c, the downward variation created a conflict with μ_{f0}, which has to be less than M_c in the RTOPT scheme, such that charm can be generated perturbatively. Thus, only an upward variation of M_c was considered and the resulting uncertainty on the PDFs was symmetrised. In addition, the requirement ~~condition~~ $\mu_{f0} < M_c$ created a conflict with the variation of μ^2_{f0}. The normal procedure would have included an upward variation of μ^2_{f0} to 2.2 GeV^2 but μ_{f0} would have become larger than the upper end of the uncertainty interval of M_c [5]. Thus, μ^2_{f0} was only varied downwards to 1.6 GeV^2, and the resulting uncertainty on the PDFs was again symmetrised. The suitability of the chosen central parameterisation was re-verified for the new settings for M_c and M_b using the χ^2 saturation method as described in Section 3.1.

Since predictions at NNLO for the jet data were only available in the zero-mass scheme, and results for the treatment of the inclusive data in different VFNS and FFNS schemes were consistent [2], no other heavy-flavour schemes were investigated.

3.4 Hadronisation uncertainties

For the jet-data analysis, it was also necessary to consider hadronisation and the effect of the uncertainties on hadronisation corrections. The uncertainties on the hadronisation corrections, which were supplied in the original publications, were reviewed for this analysis. The H1 uncertainties were used as published, while for technical reasons, those for the ZEUS data were increased to the maximum value quoted in the publications, 2 %. It was checked that this change made no significant difference to any of the results presented below.

The uncertainties on the hadronisation corrections were included as input to the HERAPDF2.0 Jets NNLO fits. They were treated as systematic uncertainties correlated between all data sets. Thus, their contribution became part of the overall experimental, i.e. fit, uncertainties. For fits with fixed $\alpha_s(M_Z^2)$, their contribution was negligible. For fits with free $\alpha_s(M_Z^2)$, their contribution to the experimental uncertainty on $\alpha_s(M_Z^2)$ was $\sim \pm 0.0006$. compare to L215 ?

The current procedure is differs ~~different~~ from the procedure employed for the HERAPDF2.0Jets NLO fit. In the HERAPDF2.0Jets NLO analysis, hadronisation uncertainties were applied using the offset method, i.e. performing separate fits with the hadronisation corrections set to

rephrased in EB process

[4] A cross-check was performed with the fixed value of $\alpha_s = 0.118$ and no significant difference in the resulting M_c and M_b values were observed.

[5] In previous HERAPDF analyses, the uncertainty on M_c was large enough to accommodate the upward μ^2_{f0} variation.

their maximal and minimal values. ~~This resulted in a~~ So then ? hadronisation uncertainty on $\alpha_s(M_Z^2)$ of was ± 0.0012 [2]. compare to L205 Conclusion ? Algorithm used in this work leads to smaller values of hadronisation uncertainties

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4 Determination of the strong coupling constant

Jet-production data are essential for the determination of the strong coupling constant, $\alpha_s(M_Z^2)$. In pQCD fits to inclusive DIS data alone, the gluon PDF is determined via the DGLAP equations, using the observed scaling violations. This results in a strong correlation between the shape of the gluon distribution and the value of $\alpha_s(M_Z^2)$. Data on jet and dijet production cross-sections provide an independent constraint on the gluon distribution and are also directly sensitive to $\alpha_s(M_Z^2)$. Thus, such data are essential for an accurate simultaneous determination of $\alpha_s(M_Z^2)$ and the gluon distribution.

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When determining $\alpha_s(M_Z^2)$, it is necessary to consider so-called "scale uncertainties". They These represent the uncertainty ies due to the influence of higher orders in the perturbation extension. This uncertainty ies was were evaluated by varying the renormalisation and factorisation scales by a factor of two, both separately and simultaneously[6], ~~and selecting~~ the maximal positive and negative deviations of the result were considered as the "de facto" scale uncertainty ies. These were observed for $(2.0\mu_r, 1.0\mu_f)$ mu_f ? and $(0.5\mu_r, 1.0\mu_f)$, respectively. its a selection, not a consideration

The HERAPDF2.0Jets NNLO fit with free $\alpha_s(M_Z^2)$ results in

$$\alpha_s(M_Z^2) = 0.1155 \pm 0.0010\,(\text{exp}) \;\pm 0.0002\,(\text{model} + \text{parameterisation}) \; {}^{+0.0026}_{-0.0024}\,(\text{scale}) \;, \quad (7) \; ?$$

where "exp" denotes the experimental uncertainty, which was taken as the fit uncertainty, including the contribution from hadronisation uncertainties. The value of $\alpha_s(M_Z^2)$ and the size of the experimental uncertainty were confirmed by the the result of a ~~so-called~~ χ^2 scan in $\alpha_s(M_Z^2)$, rephrased which is (short description) and is shown in Fig. 2a). Numerous fits with varying $\alpha_s(M_Z^2)$ were performed and the clear minimum observed in χ^2 coincides with the above value of $\alpha_s(M_Z^2)$ ~~determined with the fit~~ this — points nowhere. The width of the minimum in χ^2 confirms the fit uncertainty. The combined model and parameterisation uncertainty shown in Fig. 2a) was determined by performing similar scans, for which the values of the model parameters and the parameterisation were varied as described in Section 3.1.

Figure 2a) also shows the scale uncertainty~~; it~~, which dominates the uncertainties. This scale uncertainty as listed in Eq. 7 was evaluated under the assumption of 50 % correlated and 50 % uncorrelated uncertainties between bins ? and data sets. This allows for a direct comparison to the NLO result from HERAPDF2.0Jets NLO, which also used this procedure. A strong motivation to determine $\alpha_s(M_Z^2)$ at NNLO was the hope substantially to reduce scale uncertainties and, indeed, the NNLO scale uncertainty of $(+0.0026, -0.0024)$ is ~~significantly~~ no lower than the $(+0.0037, -0.0030)$ previously observed in the HERAPDF2.0Jets NLO analysis. Any further comparisons of the NLO and the NNLO results and their uncertainties require special considerations, some of which are discussed in Appendix A.

put tis paragraph after L223 ? Does not work – tried it

The HERAPDF2.0Jets NNLO fit with free $\alpha_s(M_Z^2)$ was based on 1349 data points and had a χ^2/d.o.f. = 1594/1334 = 1.195. This can be compared to the χ^2/d.o.f. = 1363/1131 = 1.205

[6]This procedure is often called 9-point variation, where the nine variations are $(0.5\mu_r, 0.5\mu_f)$, $(0.5\mu_r, 1.0\mu_f)$, $(0.5\mu_r, 2.0\mu_f)$, $(1.0\mu_r, 0.5\mu_f)$, $(1.0\mu_r, 1.0\mu_f)$, $(1.0\mu_r, 2.0\mu_f)$, $(2.0\mu_r, 0.5\mu_f)$, $(2.0\mu_r, 1.0\mu_f)$, $(2.0\mu_r, 2.0\mu_f)$.

for HERAPDF2.0 NNLO based on inclusive data only [2]. The similarity of the χ^2/d.o.f. values indicates that the data on jet production do not introduce any additional tension.

The question whether data with relatively low Q^2 bias the determination of $\alpha_s(M_Z^2)$ arose within the context of the HERAPDF2.0 analysis [2]. Figure 2b) shows the result of $\alpha_s(M_Z^2)$ scans with Q^2_{min} for the inclusive data set to 3.5 GeV^2, 10 GeV^2 and 20 GeV^2. Clear minima are visible which coincide within uncertainties. Figure 2c) shows the result of similar scans with only the inclusive data used as input [2]. The inclusive data alone cannot sufficiently constrain $\alpha_s(M_Z^2)$.

It has also been suggested that the use of the A'_g term, also called "the negative gluon term", in the gluon parameterisation could bias the determination of $\alpha_s(M_Z^2)$. Thus a cross-check was made with the alternative gluon parameterisation, worth to show this parameterisation AG [2], for which this term is absent. A value of $\alpha_s(M_Z^2) = 0.1152 \pm 0.0009$(exp) was obtained, in agreement with the result for the standard parameterisation. A further cross-check was made by removing the A'_g term, but, in addition, adding a $(1 + D_g x)$ term multiplied into the main gluon term. The resulting value was $\alpha_s(M_Z^2) = 0.1151 \pm 0.0009$(exp) with a value of D_g consistent with zero. These results demonstrate that the present $\alpha_s(M_Z^2)$ determination is not sensitive to the details of the gluon parameterisation.

4.1 Comparison to previous determinations

The result presented here cannot be directly compared to an H1 result [36] and a result published by the NNLOJET authors and their collaborators [37] because even though some of the same jet data sets were used by both analysis, the scale uncertainties were treated differently. whose ? NNLO authors Their assumption on the correlation of scale uncertainties was that they are 100 % correlated between ? bins and data sets. In order to facilitate a comparison, the current analysis was modified to make the same assumption. This case we obtained resulted in a scale uncertainty of $^{+0.0036}_{-0.0034}$(scale). ~~This uncertainty, obtained~~ for data with $\mu > 13.5$ GeV, These values can be compared to the uncertainties of ± 0.0042 published by H1 and ± 0.0036 published by NNLOJET group NNLOjet, both obtained for data with $\mu > 2M_b$, which is ~~a~~ quite similar to the cut., used here.

all changed in EB pross

It should be noted that both these H1 [36] and the NNLOJet [37] analyses were done using fixed PDFs for fits of $\alpha_s(M_Z^2)$. The H1 collaboration provided also one simultanous fit of $\alpha_s(M_Z^2)$ and PDFs, [?] based on H1 inclusive and jet data only, and for ? with $Q^2_{min} = 10$ GeV^2. For comparison, the analysis presented here was modified to limit the data by setting $Q^2_{min} = 10$ GeV^2. Again, the H1 analysis assumed that scale uncertainties were fully correlated and, thus, this was also done for this modification of the current analysis. The value of $\alpha_s(M_Z^2)$ published by H1 is $\alpha_s(M_Z^2) = 0.1142 \pm 0.0011(exp)\pm 0.0003$(model/parameterisation)$\pm 0.0026$(scale) while the current modified analysis resulted in $\alpha_s(M_Z^2) = 0.1154 \pm 0.0009(exp)\pm 0.0002$(model/parameterisation)$\pm 0.0025$(scale).

5 The PDFs of HERAPDF2.0Jets NNLO

Rephrased

A value for $\alpha_s(M_Z^2)$ was fixed at 0.1155, as determined by the fit where it was a free parameter, and ~~was~~ used for the determination of the PDFs in HERAPDF2.0Jets NNLO. The value listed in

rephrased

PDG12 [38], 0.118~~, which was also~~ (the value determined in the HERAPDF2.0Jets NLO analysis), was used for the original HERAPDF2.0 analyses at NNLO based on inclusive data only. The PDFs of HERAPDF2.0Jets NNLO are shown for fixed $\alpha_s(M_Z^2) = 0.1155$ in Fig. 3 and fixed $\alpha_s(M_Z^2) = 0.118$ in Fig. 4, together with their uncertainties, at the scale $\mu_f^2 = 10\,\text{GeV}^2$. The uncertainties shown include experimental, i.e. fit, uncertainties, and model and parameterisation uncertainties as defined in Section 3.2. Details on the two sets of PDFs as released are listed in Appendix B.

Scale uncertainties on PDFs derived with a fixed $\alpha_s(M_Z^2)$ were not considered. When PDFs are determined for a fixed value of $\alpha_s(M_Z^2)$, a quantification of theory uncertainties on them through a variation of the renormalisation and factorisation scales in the fit becomes questionable. Even after the compensation of explicit scale-dependent terms in the NLO and NNLO coefficients, a variation of the renormalisation scale effectively amounts, in its numerical effect, to a modfication of the value of $\alpha_s(M_Z^2)$. Fixing the value of $\alpha_s(M_Z^2)$ externally amounts to forcing the fit away from a local minimum, where a variation of the scales could map out the putative uncertainty from missing higher orders. Therefore, scale variations were not used as a proxy for uncertainties on the PDF extraction due to missing higher orders. Nevertheless, a cross-check with scale variations was made and the difference in the resulting PDFs was found to be negligible compared to the other uncertainties presented in Fig. 3.

do not understand

(Cannot help it) Anyhow — TG rephrased his text to make it easier.

A comparison between the PDFs obtained for $\alpha_s(M_Z^2) = 0.1155$ and $\alpha_s(M_Z^2) = 0.118$ is provided in Figs. 5 and 6 for the scales $10\,\text{GeV}^2$ and M_W^2, respectively. Here, only total uncertainties are shown. At the lower scale, a significant difference is observed between the gluon distributions; the distribution for $\alpha_s(M_Z^2) = 0.1155$ is above the distribution for $\alpha_s(M_Z^2) = 0.118$ for x less than $\approx 10^{-2}$. This correlation between the value of $\alpha_s(M_Z^2)$ and the shape of the gluon PDF is as expected from QCD evolution. At the scale of M_W^2, the differences become negligible in the visible range of x due to QCD evolution.

New text at the beginning makes it clear, there are two sets of PDFs

.118

A comparison between the PDFs obtained with alpha_s ? by HERAPDF2.0Jets NNLO with $\alpha_s(M_Z^2) = 0.118$ and the PDFs of HERAPDF2.0 NNLO, based on inclusive data only, is provided in Fig. 7. These two sets of PDFs do not show any significant differences in the central values. However, there is a significant reduction of the uncertainties on the gluon PDF NNLOjet ? fit as shown in Fig. 8 at the scale of $\mu_f = 10$ GeV^2. The reduction in model and parameterisation uncertainty for $x < 10^{-3}$ is mostly due to the necessity to change the estimation procedure compared to that used for HERAPDF2.0 NNLO. The change in the ranges in which M_c and M_b were varied contributed negligibly to the change in uncertainties, except for the following effect. As discussed in Section 3.3, in this analysis it was necessary ~~in this analysis~~ to symmetrise the downward variation of μ_{f0}^2 rather than allowing both upward and downward variations. This had the positive effect of removing a ? slight double-counting of error sources that could not be avoided in the original HERAPDF2.0 NNLO procedure. The reduction in the model and parameterisation uncertainties for $x < 10^{-3}$ is mostly due to this effect, whereas the reduction in model and parameterisation uncertainties for $x > 10^{-3}$ is due to the influence of the jet data.

0.1155 in fig.8

However, you can allways only compare PDFs with same α_s.

rephrased in EB process

6 Comparisons of predictions to jet data

Comparisons of the predictions based on HERAPDF2.0Jets NNLO with fixed $\alpha_s(M_Z^2) = 0.1155$ to the data on jet production used as input to the fits are shown in Figs. 9, 10, 11 and 12.

All predictions were computed using the assumption of massless jets, i.e. the transverse energy, E_T, and the transverse momentum of a jet, p_T, were assumed to be equivalent. For the inclusive jet analyses, each jet p_T was entered separately. For dijet analyses, the average of the transverse momenta, $\langle p_T \rangle$ was used. In these cases, $\langle p_T \rangle$ was also used to set the the factorisation and renormalisation scales to $\mu_f^2 = \mu_r^2 = Q^2 + \langle p_T \rangle^2$ for calculating cross section calculations predictions. as above Scale uncertainties were not considered for the comparisons to data. The predictions based on the PDFs of HERAPDF2.0Jets NNLO clearly fit the data used as input ~~very~~ See remarks well, showing that the NNLO QCD predictions for both inclusive data and jet data are highly compatible.

7 Summary

was fun to see H1 react

The HERA data set on inclusive ep scattering as published by the H1 and ZEUS ZEUS and H1 collaborations [2], together with selected data on jet production, published separately by the two collaborations, were used as input to a pQCD analysis at NNLO. The resulting two PDF sets are denoted as ~~called~~ HERAPDF2.0Jets NNLO; they have fixed values of $\alpha_s(M_Z^2)$ of 0.1155 and 0.118. This completes the HERAPDF2.0 family of parton distribution functions.

An analysis with ~~free~~ $\alpha_s(M_Z^2)$ ~~was performed for which~~ rephrased ~~$\alpha_s(M_Z^2)$~~ and the PDFs ~~were~~ fitted simultaneously was performed. ~~This resulted in~~ a value of $\alpha_s(M_Z^2)$ why?? $= 0.1155 \pm 0.0010\,(\text{exp}) \pm 0.0002\,(\text{model/}$ $/\text{parameterisation})\ ^{+0.0026}_{-0.0024}\,(\text{scale})$ was obtained. This result on $\alpha_s(M_Z^2)$ is compatible with the world average [39] and it is competitive in comparison with other determinations at NNLO. The scale uncertainties were calculated with the assumption of 50 % correlated and 50 % uncorrelated uncertainties between ?? bins and data sets. They would increase to $\pm^{+0.0036}_{-0.0034}$ for the assumption of fully correlated uncertainties.

Comparisons between the PDFs of HERAPDF2.0Jets NNLO obtained for the two values of $\alpha_s(M_Z^2)$ of 0.1155 and 0.118 were shown, as well as comparisons to HERAPDF2.0 NNLO, for which jet data were not used as input to the fit. All these PDFs are very similar, showing the consistency of the data. On balance, the inclusion of the jet data has two consequences: i) a lower value of $\alpha_s(M_Z^2)$ is favoured; ii) the uncertainty on the gluon PDF is reduced. The predictions from HERAPDF2.0Jets NNLO were compared to the jet production data used as input. The predictions describe the data ~~very~~ well. they do.

8 Acknowledgements

We are grateful to the HERA machine group whose outstanding efforts have made the H1 and ZEUS ZEUS and H1 experiments possible. We appreciate the contributions to the construction, maintenance and operation of the H1 and ZEUS detectors of many people who are not listed as authors. We thank our funding agencies for financial support, the DESY technical staff for continuous assistance and the DESY directorate for their support and for the hospitality they extended to the non-DESY members of the collaborations. We would like to give credit to all partners contributing to the EGI computing infrastructure for their support. We acknowledge the support of the IPPP Associateship program for this project.