Update on work towards HERAPDF*.*Jets at NNLO

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- Recap of Iris' plan
- Not all sets fitted at NLO CAN be fitted at NNLO due to lack of predictions, lack of grids or lack of reliability thereof
- However, I think we now have sufficient NNLO grids to proceed
- Choose the cuts to be made at NLO- then move to NNLO
- This can be done with the Oxford code, but xFitter lacks an NNLO jets implementation

What was Iris's plan for HERAPDF3.0Jets at NNLO?

1) keep ALL settings as for HERAPDF2.0
throw the heavy flavour data out for the fit
--> HERAPDF2.5NLO-Jets-only
compare HERAPDF2.0Jets to HERAPDF2.5NLOJets-only
message: it makes no difference

2) produce the exactly same fit in NNLO --> HERAPDF2.5NNLO-Jets-only
MAJOR MESSAGE:
What does NNLO do?
How does alphas_s change?
Is the scale uncertainty less?

3) add new jet data and produce [with everything else still as HERAPDF2.0]
HERAPDF3.0NLO-Jets-only
HERAPDF3.0NNLO-Jets-only
==> Message: what do low Q^2 jets do.

4)-- do new mass parameter scans with new HF data and produce
HERAPDF3.5NLO-Jets-only
HERAPDF3.5NNLO-Jets-only
==> message: mass parameters are insignificant at this level

5)-- add the HF data to the fit and produce
HERAPDF3.5NLO-Jets
HERAPDF3.5NNLO-Jets
==> message: using the HF data explicitly doesn't do anything,
but everything is consistent…….FULL PLAN in back-up

But her plan cannot be executed EXACTLY as it is BECAUSE
2) produce the exactly same fit in NNLO --> HERAPDF2.5NNLO-Jets-only
CANNOT be done

The HERAPDF2.0Jets contains
ZEUS di-jets = 22 19.
DIS JETzeus96/97 = 30 27.4
H1 HERA1 highq2 =24 14.1
H1 HERA1 lowq2 = 22 15.99
H1 2013 inclusive= 24 21.4
H1 2013 dijets = 24 43.1
H1 2013 trijets = 16 18.6

- Firstly **trijets are not available at NNLO** we HAVE to cut them out
- Secondly there have to be **more stringent cuts on the low Q2 jets at NNLO**, we have to cut ~6 more data points (and the new HERA2 H1 2016 lowQ2 jets also need cuts)
- Thirdly the NNLO is available for ZEUS inclusive jets now **But** for DIS JETzeus98/00 not DIS JETzeus96/97. **NOTE there was a reason for the choice of zeus96/97 inclusive for the Jet fits—there is no overlap with dijets. If we use 98/00 instead then there is a 20% overlap.**
- Fourthly not All the ZEUS dijets points can be predicted accurately at NNLO

So we have to make these changes at stage 1’ and then go to stage 2 etc.

We have progress on this

Let's enumerate what we have to do…

1. The first step is to reconstruct HERAPDF2.0Jets job exactly as it was, with the older jet data sets and the older charm combination at NLO—and be sure it is the same as it was

2. The next step is to remove the older charm—and compare those two jobs

3. The next step is to remove the first ETbin for every Q2 bin of the ZEUS dijets (the bin with average ET less or equal 12.0) and compare again. The reason is that we have been told that NNLO calculations are unstable for this bin—but I will have more to say later

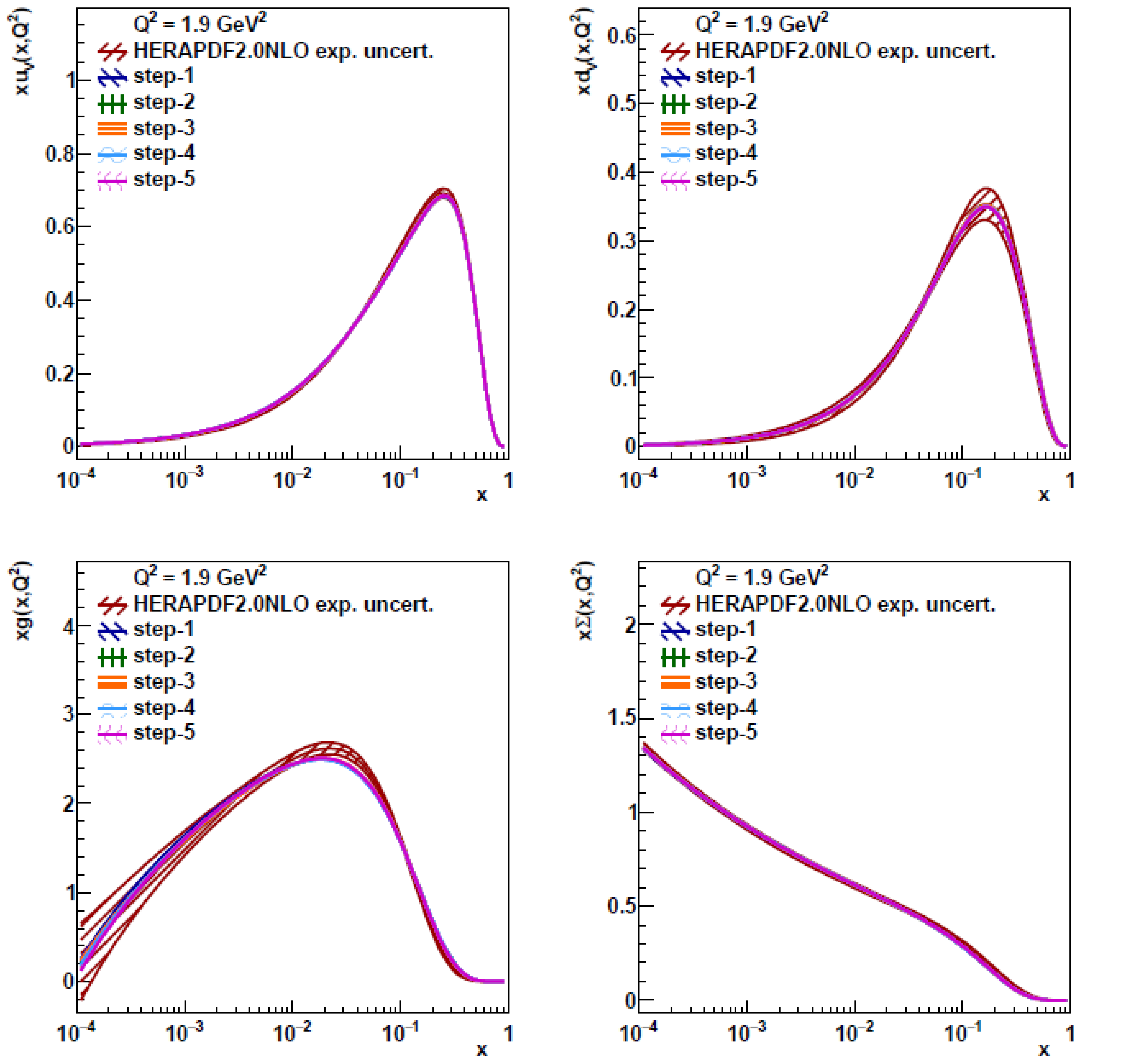
4. The next step is to SWAP ZEUS inclusive 96/97 for 98/00 and compare again

5. The next step is to remove trijets—that is H1 2013 high Q2 trijets, which are the only trijets in the old HERAPDF2.0Jets fit—and compare.

6. The next step is to remove a few more data points from the H1 lowQ2 2009 jets for future comparison with NNLO. There are three different criteria for doing this:i) on could increase the kfactor requirement to kfactor < 2.2 (we already require kfactor <2.5); ii) one could require μ = sqrt(ptave^2+Q^2) > 13.5, this ONLY AFFECTS the lowq2 jets; iii) one could cut on the size of the scale variations considering both NLO and NNLO
These decisions also affect the newer H1 2016 low Q2 Jet data sets which we will add later.

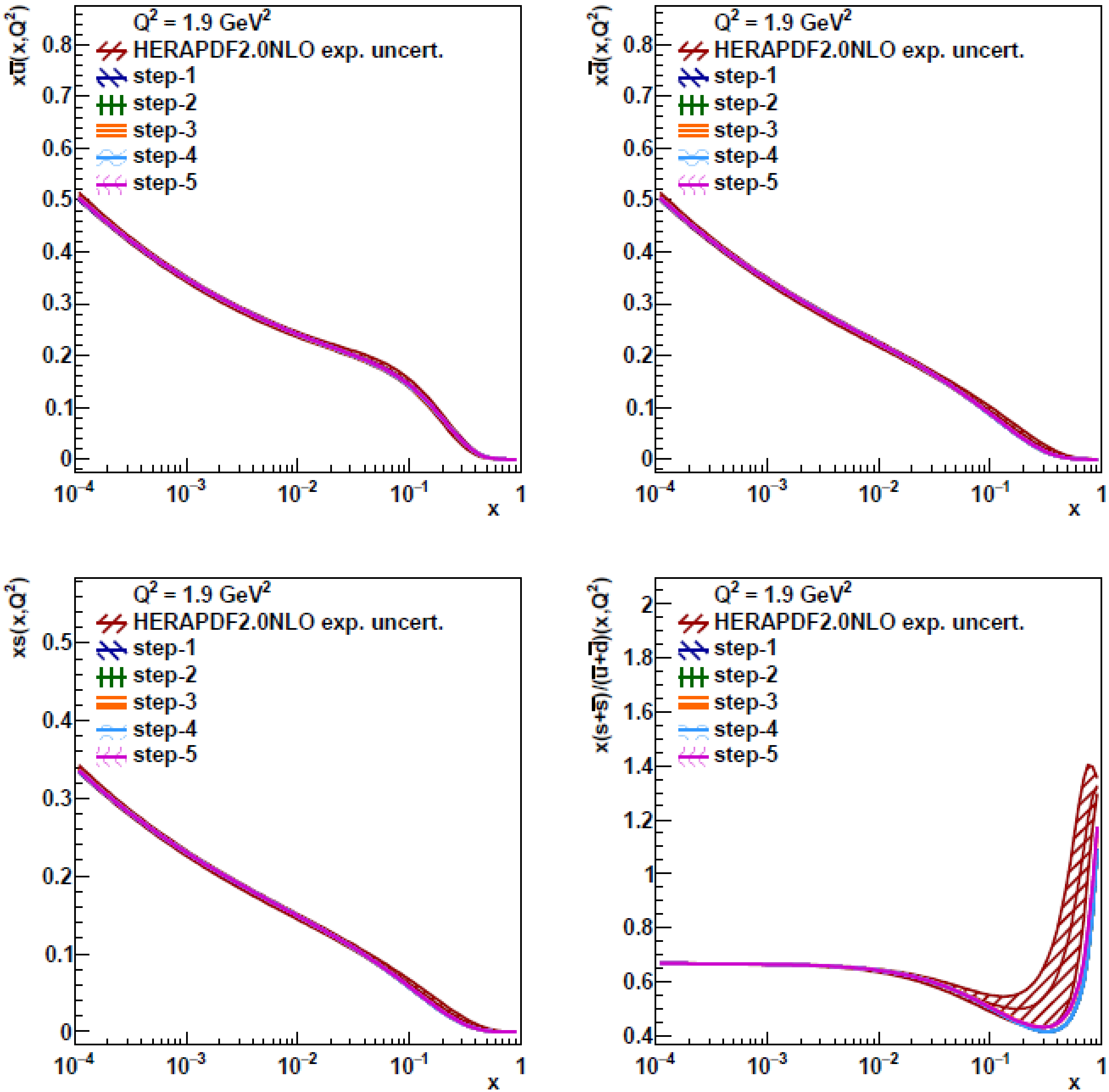
One has to make a decision on which cuts to use at stage 6….and then go to NNLO..

Steps 1-5



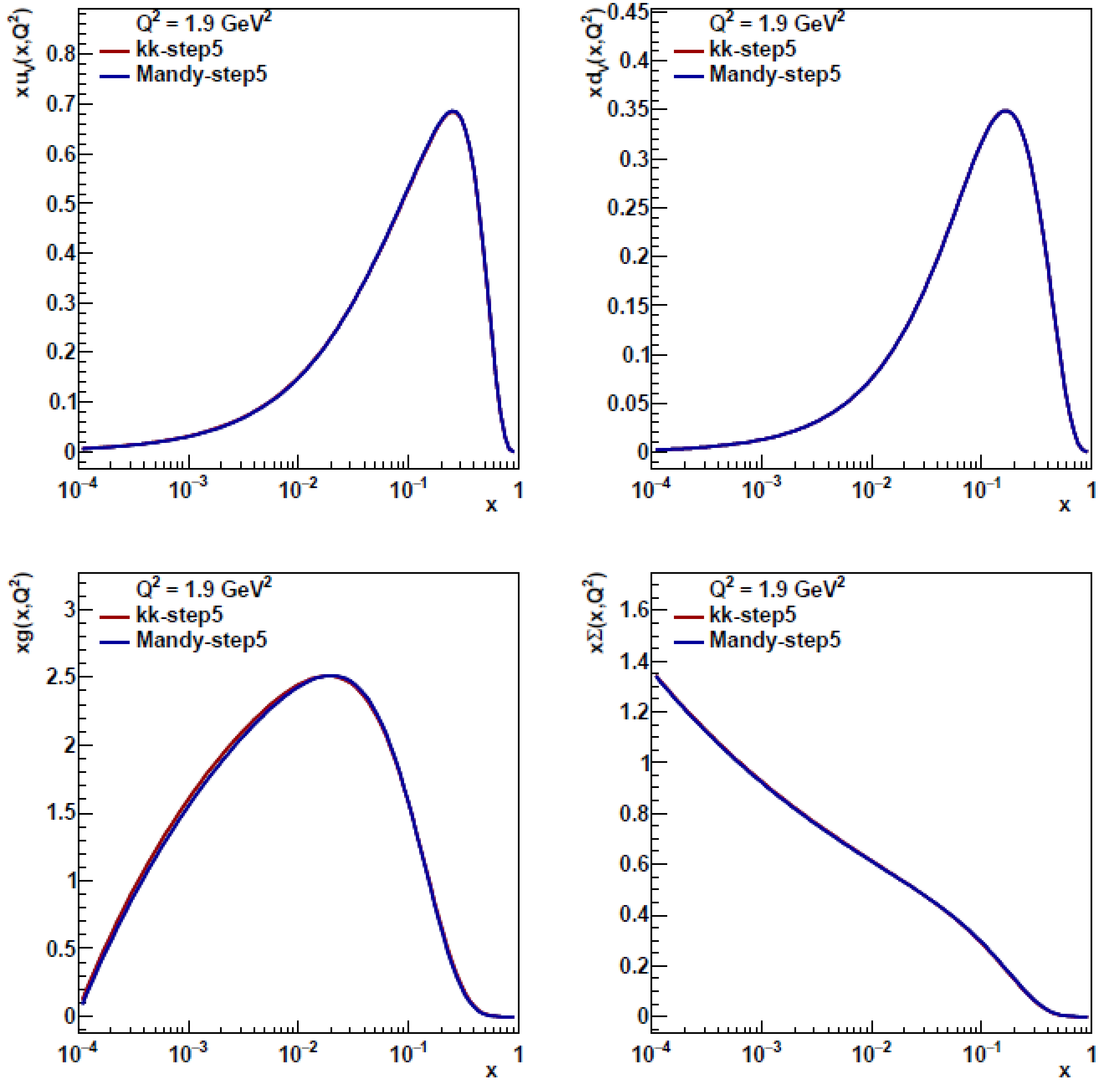
Q^2 = 1.9 GeV^2
HERAPDF2.0NLO exp. uncert.
step-1
step-2
step-3
step-4
step-5
$xu_v(x,Q^2)$
$xd_v(x,Q^2)$
$xg(x,Q^2)$
$x\Sigma(x,Q^2)$
x

Steps 1-5

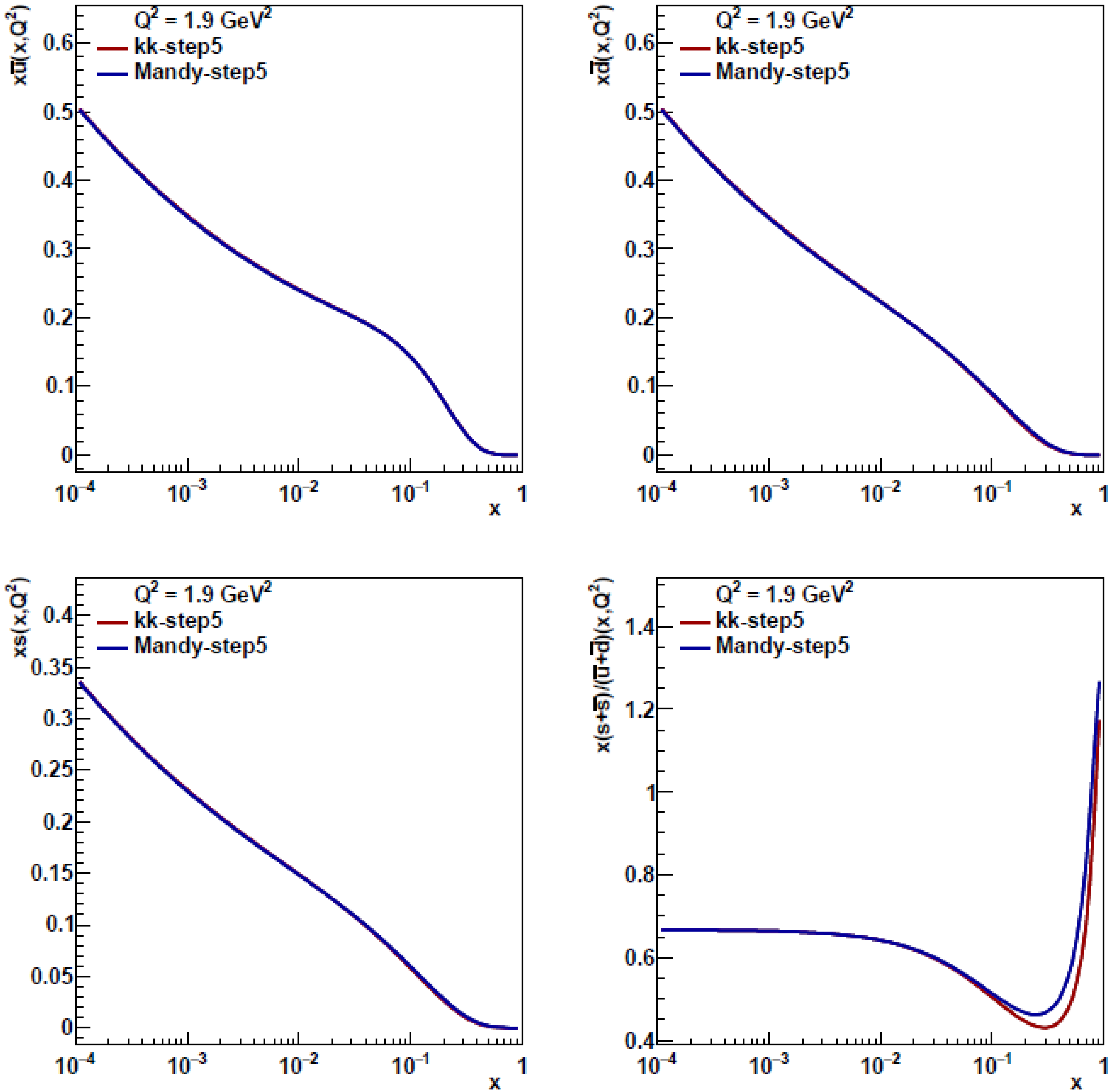


Q² = 1.9 GeV²
HERAPDF2.0NLO exp. uncert.
step-1
step-2
step-3
step-4
step-5
xū(x,Q²)
xd̄(x,Q²)
xs(x,Q²)
x(s+s̄)/(ū+d̄)(x,Q²)
x
10⁻⁴
10⁻³
10⁻²
10⁻¹
1

Compare Mandy (Oxford code) and Katarzyna (xFitter) at step 5
(all other steps also the same)

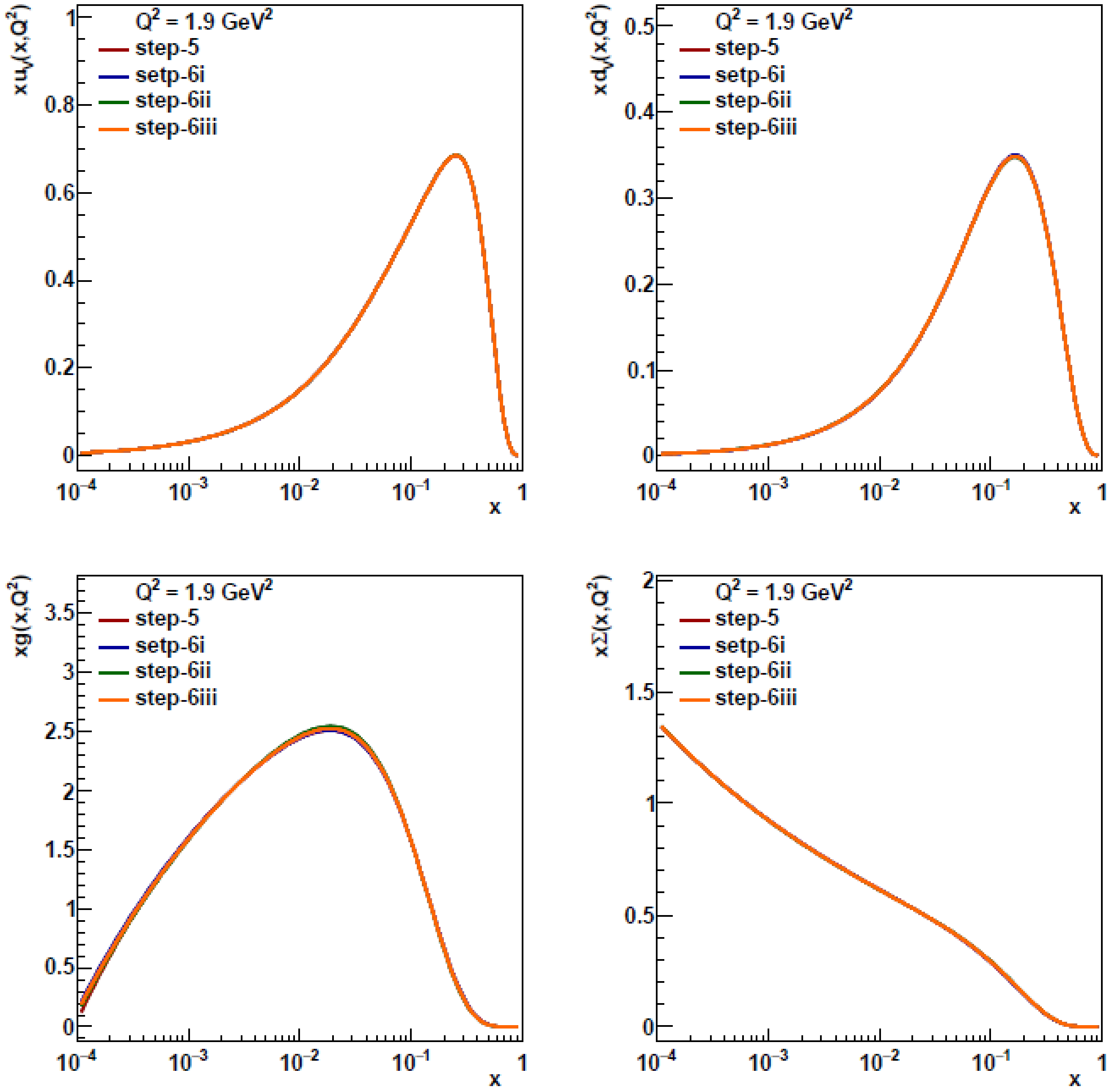


Compare Mandy (Oxford code) and Katarzyna (xFitter) at step 5
(all other steps also the same)



Now steps 5 to 6.i,ii,iii— we will talk about these varying cuts—

What I want you to note is that it makes little difference



Now steps 5 to 6.i,ii,iii— we will talk about these varying cuts—

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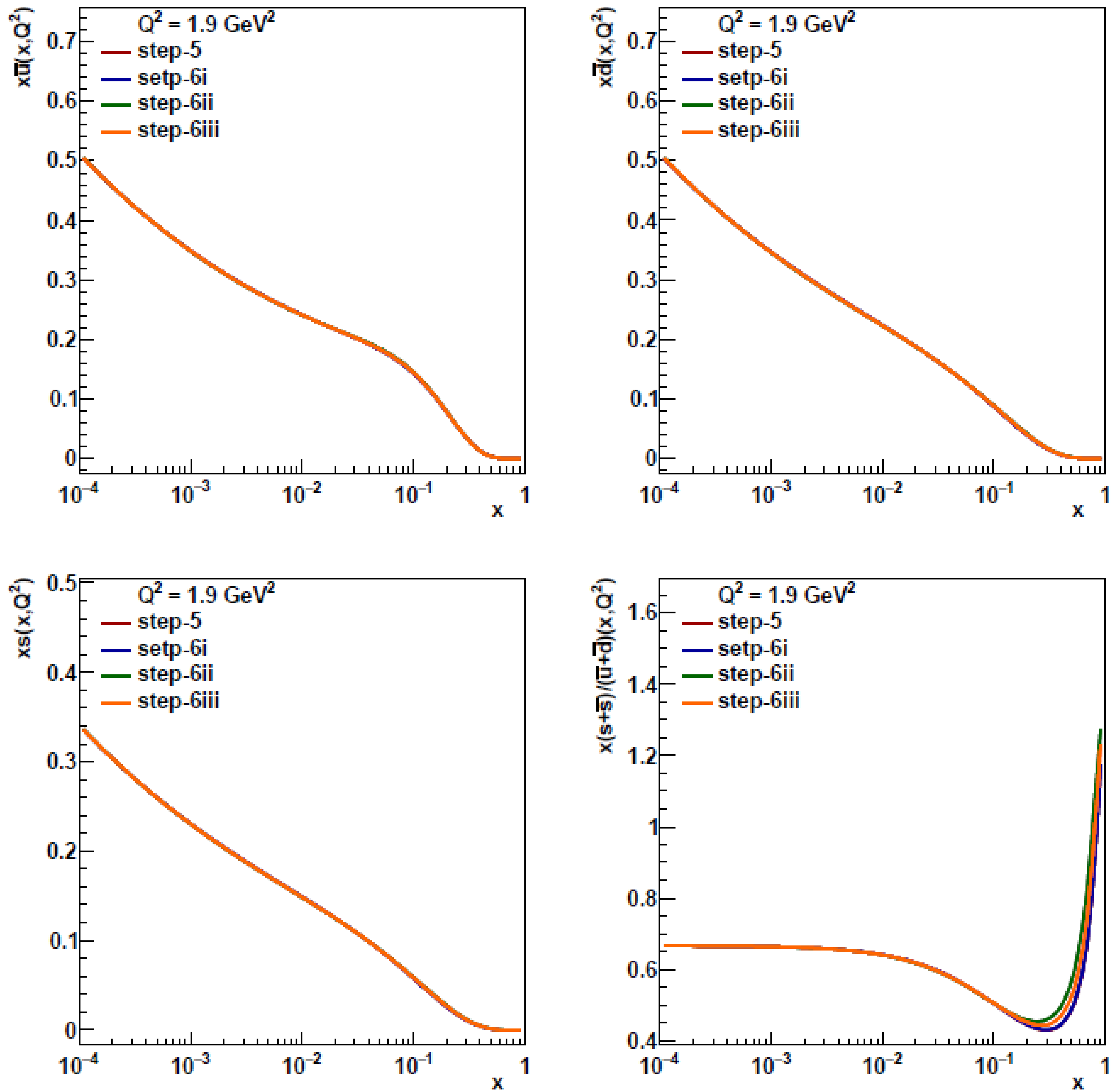


Now let's talk about the extra cuts being made at stage 6 for the move to NNLO
I have investigated these cuts not just in terms of

i)the size of NLO to LO k-factors, as was done already for NLO

but also in terms of a kinematic cut ii)$\mu = \sqrt{(ptave^2 + Q^2)} > 13.5$ is required

AND finally in terms of the iii) size of scale variations at NLO and NNLO

What I have done is take the parameters of the HERAPDF2.0 Q2>3.5 fit and fix them and then look at renormalisation and factorisation scale changes of a factor of two up and down on **ALL** the jet data sets.

The nominal scales are $\mu_R = \sqrt{(ptave^2 + Q^2)}/2$ and $\mu_F = Q^2$ but this hardly matters it is the changes that we are looking at.

I have done this at both NLO and NNLO and compared. With one exception NNLO scale variations are always less than NLO variations

Firstly let's track back to step 3

where 6 of the data points for the ZEUS-dijets were removed since I was told the NNLO predictions were unstable

There are 22 data points differential in ET and Q2 .

The data points are distributed as 4/4/4/4/3/3 in increasing Q2..and within each group they are ordered in ET.

All information is in back-up but I will report here percentage changes under scale variation for NLO and NNLO—for the largest change, which is μ_R up by factor of two.

Changes are given fractionally so 0.044 means 4.4%

NLO Mur=2

0.044,0.079,0.064,0.03/ 0.019,0.069,0.055,0.026 /

0.0018, 0.056,0.044,0.019/ 0.008,0.04,0.036,0.014/

0.00,0.036,0.016/0.01,0.04,0.022

NNLO Mur=2

0.073,0.05,0.026,0.23/ 0.044,0.027,0.026,0.01/

0.007,0.002,0.03,0.002/0.014,0.028,0.005,0.002/

0.016,0.007,0.012/0.013/0.023,0.017

There is a worrying tendency for the scale variation to be larger at NNLO than at NLO for the first Et bin of each Q2 group. These are the same bins we were asked to cut -on grounds of unreliability- and this seems like a good reason why.

For ALL other bins the scale variation is less at NNLO

Secondly let's consider the old H1 low Q2 inclusive jets data set h109-162.

There are 28 data points grouped as 7 groups of 4, where the 7 groups are of increasing Q2 and the 4 points within each groups are of increasing ET

The scale variations can be large both at NLO (46%) and at NNLO(28%), but are **always** smaller at NNLO. I discuss the large size at NLO as a basis for cuts.

I will present the largest changes- which are for μ_R down by factor of two

NLO Mur=1/2

0.46*,0.31*,0.24,0.17/0.46*,0.29*,0.22,0.17/0.40*,0.27,0.22,0.16/**
0.36*,0.25,0.21,0.15/0.32**,0.24**,0.20,0.14/ 0.27**,0.21,0.18,0.13 /**
0.20,0.18,0.15, 0.12**

NNLO Mur=1/2

0.28*,0.13*,0.096,0.065 /0.26*,0.13*,0.087, 0.068 /0.23*,0.12,0.086,0.066 /**
0.21*,0.11,0.08, 0.06 /0.19**,0.11**,0.08, 0.06 /0.16**,0.10, 0. 077, 0.056 /**
0.12, 0.09,0.068,0.055/**

Ratio NLO/NNLO

1.64*,2.38*,2.5,2.83/ 1.77*,2.23*,2.52,2.5/ 1.74*, 2.25, 2.56, 2.42/**
1.71*, 2.27, 2.625, 2.27/1.68**,2.18**,2.5, 2.33/ 1.69**,2.1,2.33,2.32/**
1.66, 2.0, 2.21, 2.18/**

The * indicates points that we have always cut even at NLO using a k-factor criterion
The ** indicates the extra cut from using a kinematic cut μ > 13.5GeV
This cuts NLO scale variations >~24% and NNLO scale variations > ~10%

The **stands for those points that were already cut at NLO because their NLO/LO k-factors are >2.5. This was points 1,2,5,6,9,13.

If we increase this k factor requirement to cutting NLO/LO k-factor >2.2
we would cut **1,2,3,5,6,7,9,10,13,14,17.** This is **step 6.i**

If instead we put a cut on μ = sqrt(ptave^2+Q^2) > 13.5,
We would cut **1,2,5,6,9,10,13,14,17,18,21,25.** This is **step 6.ii**

Or we could chose to cut on large scale variations if we said the NLO scale variation should be less than 24% (and a cut NNLO scale variations of less than 11% gives the same points)
We would cut **1,2,3,5,6,9,10,13,14,17,18,21** This is **step 6.iii**
All of these give very similar results as you have seen

I am of the strong opinion that a kinematic cut is the simplest

The only other jet data set which is affected by ANY of these suggested cuts is the new H1 lowQ2 2016 inclusive and dijets which has similar large scale variations at NLO. These come as 48 data points in 8 groups (increasing in Q2) of 6 points (increasing in ET)

I had already suggested the cut μ = sqrt(ptave^2+Q^2) > 13.5 for these data, but one could equally well cut on the size of scale variation—it would hit much the same points just as it does for the older low Q2 data.

H1_lowq2_2016 standard Q^2+pt2/2=mur,Q^2=muf

NLO Mur=1/2

0.47*,0.35*,0.25,0.20,0.15,0.09/ 0.44*,0.33*,0.24,0.18,0.14,0.087/ 0.40*,0.31*,0.23,0.18,0.13,0.08/ 0.36*,0.29*,0.22,0.17,0.13,0.077/ 0.32*,0.26*,0.21,0.17,0.12,0.073 /0.28*,0.24*,0.19,0.15,0.11,0.067/0.23*,0.21*,0.17,0.15,0.11,0.06/ 0.18*,0.18*,0.16,0.14,0.10,0.055

NNLO Mur=1/2

0.31*,0.19*,0.11,0.077,0.052,0.024/ 0.29*,0.18*,0.11,0.076,0.051,0.022/ 0.26*,0.17*,0.09,0.075,0.050,0.026/ 0.24*,0.16*,0.10,0.07,0.05,0.023/ 0.22*,0.14*,0.10,0.075,0.044,0.025 /0.18*,0.13*,0.09,0.07,0.043,0.022/ 0.14*,0.11*,0.094,0.068,0.043,0.022/ 0.13*,0.10*,0.087,0.063,0.047,0.023

Ratio NLO/NNLO

1.51*,1.84*,2.26,2.6,2.88,3.75/ 1.51*,1.83*,2.18,2.36,2.74, 3.95 /1.54*,1.82*,2.55,2.4,2.6,3.08/ 1.5*,1.81*,2.2,2.42,2.6,3.5/ 1.45*, 1.85*,2.1,2.27,2.72,2.92/ 1.55*,1,85*, 2.1,2.14,2.56,3.05/ 1.64*,1.91*,1.81,2.2,2.56,2.72/ 1.38*,1.8*,1.84,2.22,2.12,2.39

The * indicates points cut by the kinematic cut

NOW we can proceed to stage 2—but ONLY with Oxford code

2) produce the exactly same fit in NNLO --> HERAPDF2.5NNLO-Jets-only

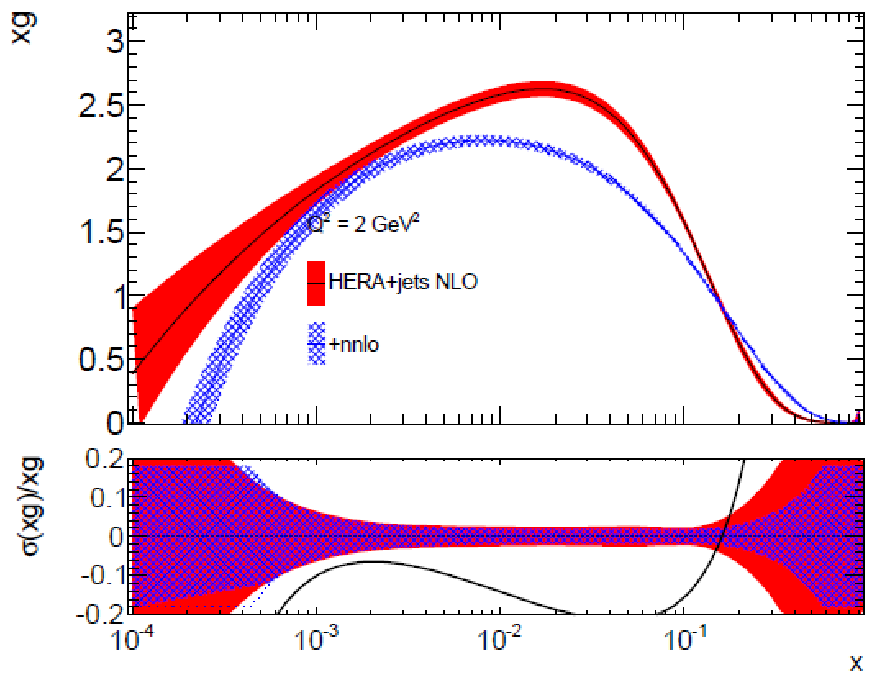
MAJOR MESSAGE:

What does NNLO do?—see below, it gives you a harder high-x gluon, it also did this without the jets

How does $\alpha_s(M_Z)$ change?- first check $\alpha_s(M_Z)$ with the stage 1 data for NLO—$\alpha_s(M_Z)$ = 0.1179±0.001, rather than 0.1183±0.0009 as published, with scale variation ±0.0034 rather than +0.0037/-0.0030 as published.

Then running at NNLO is still going but it looks like $\alpha_s(M_{Z)}$ will be significantly lower

Is the scale uncertainty less?—I believe I have already demonstrated this



It probably makes more sense to work hard on alphas at the end stage of the fit

That would also be the time to re-do parametrisation scan

In between we compare 'apples to apples'

Conclusion

All is ready to go ahead with an NNLO HERAPDF Jets fit, with main focus on the PDF

BUT

1. ZEUS expresses some unhappiness that the inclusive jet data set for which we now have grids is 98/00 rather than 96/97
2. Does everyone accept the choice of the kinematic cut $\mu > 13.5$GeV on data?
3. Are people happy with the plan?
4. MOST importantly WILL THERE BE an XFITTER NNLO Jets implementation?
5. And if not do we go ahead with Oxford code only?

Backup

1) keep ALL settings as for HERAPDF2.0 but throw the heavy flavour data out for the fit

--> HERAPDF2.5NLO-Jets-only

compare HERAPDF2.0Jets to HERAPDF2.5Jets-only

message: it makes no difference

2) produce the exactly same fit in NNLO --> HERAPDF2.5NNLO-Jets-only

MAJOR MESSAGE:

What does NNLO do?

How does alphas_s change? Is the scale uncertainty less?

3) add new jet data and produce [with everything else still as HERAPDF2.0]

HERAPDF3.0NLO-Jets-only

HERAPDF3.0NNLO-Jets-only

==> Message: what do low Q^2 jets do.

4)-- do new mass parameter scans with new HF data and produce

HERAPDF3.5NLO-Jets-only

HERAPDF3.5NNLO-Jets-only

==> message: mass parameters are insignificant at this level

5)-- add the HF data to the fit and produce

HERAPDF3.5NLO-Jets

HERAPDF3.5NNLO-Jets

==> message: using the HF data explicitly doesn't do anything,but everything is consistent…….

The addition of other data added will have to be discussed not as much in detail as the stuff before.

HERAPDF3.0NLO-Jets-only

HERAPDF3.0NNLO-Jets-only

-- should have full error analysis

The rest could be treated with exp. unc. only
and called consistent.

Record scale variations:NLO H1_lowq2_old standard Q^2+pt2/2=mur,Q^2=muf

110.04402773309909 13.183465292828803 2.7201138602981181 9.8954486253619245E-002 73.818790329912289
8.9420845871682975 1.8359072873333806 6.6497001231540662E-002 46.196952876583936 5.7634117383366652
1.1856471391906231 4.2889153916746407E-002 29.537110645863802 3.8393297736250047 0.79643372241136945
2.8907063054001890E-002 18.196879700217433 2.5039983276696289 0.52787708100555408 1.9310366579762244E-002
10.966647506420323 1.6202668647926650 0.34967309649022116 1.2946751855922239E-002 4.0910236807056446
0.69866618678682657 0.16070663427692738 6.1596595006755258E-003

Mur=2~0.23*,0.19*,0.17,0.13/~0.22*,0.18*,0.16,0.12/0.21*,0.18,0.15,0.12/0.19*,0.17**,0.14,0.11/0.18**,0.16**,0.14,0.11/0.16**,0.15,0.13,0.11/0.13**,0.13,0.12,0.10 *bins excluded on kfac, **bins excluded on scalemu—probably should have been!!**

84.220286597226661 10.656562442231168 2.2747225732510357 8.6211896532670237E-002 57.329699638560150
7.2933246915016410 1.5461122546518071 5.8235508507399412E-002 36.520262622728659 4.7500543334078325
1.0063787252347653 3.7777950194596330E-002 23.764031380170824 3.1966661965945042 0.68108353543210487
2.5597865841874581E-002 14.918957478032079 2.1076467022179881 0.45494926348007719 1.7192796037336599E-002
9.1748611581152169 1.3799063955179902 0.30386573486210999 1.1593192874949877E-002 3.5385939273458034
0.60799425836229015 0.14181561427439937 5.5738800605532090E-003

Mur=1/2~0.46*,0.31*,0.24,0.17/0.46*,0.29*,0.22,0.17/0.40*,0.27,0.22,0.16/0.36*,0.25**,0.21,0.15/0.32**,0.24**,0.20,0.14/ 0.27**,0.21,0.18,0.13 /0.20**,0.18,0.15, 0.12**

161.68730048098587 17.226609515633932 3.3786184411433284 0.11643563007348690 106.15729976400223
11.547741280497608 2.2600161797957936 7.7705470131070598E-002 64.636097534752466 7.3386605534915912
1.4447184174548875 4.9730217043805036E-002 40.155376570561543 4.8199856198789259 0.96093604175721536
3.3275637633374593E-002 23.960625761288451 3.0956805172697672 0.63029710403571781 2.2062868264778806E-002
13.944435691331369 1.9694921515131147 0.41284192674864312 1.4674478385342898E-002 4.9094409381254156
0.82350981722169436 0.18573542505112714 6.8788042721480468E-003

Muf=2

125.80139137396846 13.604727992882719 2.6485963024421837 9.2212600998487049E-002 82.028141923629363
9.1240736744432098 1.7832591302726766 6.2254813807149992E-002 50.058571747344594 5.8240426175449054
1.1498635865027673 4.0341302799161267E-002 31.413671002225204 3.8538688011103459 0.77192568811958739
2.7295996388252555E-002 19.109218641866622 2.5054852887132562 0.51238873322345357 1.8320908543354879E-002
11.408389588822482 1.6189556610492135 0.34026529391587279 1.2345881701320784E-002 4.2105087389089997
0.69759073158250662 0.15709659772823381 5.9210717804558102E-003

Muf=1/2

79.085536961747025 11.783815340704054 2.7350860152962411 0.10889011031633833 57.759104287921396
8.2856731018051804 1.8685818278329644 7.2688013249052663E-002 38.390676186127621 5.4682381853062667
1.2131992367586186 4.6487740148820872E-002 25.554060236765235 3.6971811384594115 0.81659028947556445
3.1097678418924034E-002 16.270268389754897 2.4419585354923030 0.54237970392765067 2.0648643466896686E-002
10.081781369184126 1.5970569289103702 0.35989821694709845 1.3773578282295829E-002 3.8810511425215144
0.69676045019646715 0.16550669593745931 6.5016680932497364E-003

NNLO H1 lowq2 old less scale variation than at NLO but still large

h1 lowq2 old 321	1661.3441527177624	166.54092923810774	30.906798487694960	12.094249992598415
h1 lowq2 old 322	1565.8509118935835	166.84292891042094	30.822371584262338	12.490598604693481
h1 lowq2 old 323	1541.2124668286756	175.02528263283060	33.296905520232961	13.583904710517269
h1 lowq2 old 324	938.90453990186279	113.93603280051484	22.302277475292069	9.2033744498174581
h1 lowq2 old 325	1120.2654299771309	147.56883196295686	29.603066818796126	12.544978291082611
h1 lowq2 old 326	655.08670580417720	93.443071495210873	19.662321050285605	8.4321739790522976
h1 lowq2 old 327	1401.0734335779105	237.52881590403084	53.771983664732240	24.531716148018372

Mur=2~0.17*

h1 lowq2 old 321	1374.2933374094696	146.32426622799710	27.819901330869122	11.173845612499269
h1 lowq2 old 322	1308.5945154564163	146.83907160881373	27.929628101737347	11.533169097930942
h1 lowq2 old 323	1302.0990235212648	154.76772822743226	30.215816447264153	12.578574703578555
h1 lowq2 old 324	803.03495108673383	101.42167680853356	20.317159366071674	8.5589730861849187
h1 lowq2 old 325	968.99133847529697	131.81594042249091	27.051189317594162	11.667573986076931
h1 lowq2 old 326	573.78766834773387	84.200741140235294	18.027135465782724	7.8796821742657990
h1 lowq2 old 327	1255.6660985481606	216.38486711884798	49.752652173643526	23.003934943298177

Mur=1/2 ~0.28*,0.13*,0.096,0.065 /0.26*,0.13*,0.087, 0.068 /0.23*,0.12,0.086,0.066 / 0.21*,0.11**,0.08, 0.06 /0.19**,0.11**,0.08, 0.06 /0.16**,0.10, 0. 077, 0.056 / 0.12**, 0.09,0.068,0.055/**

h1 lowq2 old 321	2126.8835635673390	187.72725794423064	33.890489671297019	12.885445662248584
h1 lowq2 old 322	1969.8969868312597	188.04458620823237	33.466614138517293	13.350638127261856
h1 lowq2 old 323	1902.4127556376695	196.36710276498474	36.171589474965991	14.481094618030305
h1 lowq2 old 324	1134.8474469256244	126.74483528898965	24.135148204189694	9.7587095486407698
h1 lowq2 old 325	1330.0366377987352	163.88886368720316	31.971106982127093	13.336401853474303
h1 lowq2 old 326	762.75079884436968	102.71701422112261	21.193429373299011	8.9149030265021665
h1 lowq2 old 327	1576.1818056920088	258.93549472885343	57.474110243921785	25.924767338175442

Muf=2

h1 lowq2 old 321	1710.4585825302454	167.39672923298545	30.782512315415016	11.980670071901931
h1 lowq2 old 322	1611.7002517360322	167.64903748860738	30.715137223751309	12.372179300886307
h1 lowq2 old 323	1584.4340123396348	175.90498816197157	33.190666576995639	13.466069212799292
h1 lowq2 old 324	963.86279993156052	114.58627132079681	22.247643527875432	9.1284330625327268
h1 lowq2 old 325	1147.7970053149234	148.32296468190754	29.530601118748102	12.439176299802096
h1 lowq2 old 326	670.40733902842510	93.939707971459200	19.607799208041417	8.3661491938504806
h1 lowq2 old 327	1427.1156952290910	238.52366599365939	53.651728850497449	24.341264816848060

Muf=1/2

h1 lowq2 old 321	1550.1316302030848	165.78984995302383	31.200225454466189	12.283217211527852
h1 lowq2 old 322	1463.9548319817800	166.14233947392864	31.094654748669871	12.684332847689241
h1 lowq2 old 323	1446.2991995068887	174.23541191193704	33.570092435060289	13.779270896416165
h1 lowq2 old 324	884.94058235237765	113.33464320433133	22.459809671628069	9.3289379729897330
h1 lowq2 old 325	1062.4640315750014	146.90608706010906	29.807192654214550	12.718937559302528
h1 lowq2 old 326	624.54748708257432	93.016587218628246	19.802205267534266	8.5420309019577356

Record scale variations:NLO ZEUSdijets standard Q^2+pt2/2=mur,Q^2=muf

5.4636528755629277	1.4922675038612769	0.28289986043128779	2.2639837257985903E-002
3.1601573786169705	1.0481134673530017	0.22706141238735442	1.9552125960306706E-002
1.6304329160991613	0.62590275230039505	0.16398414445318019	1.5999019582659001E-002
0.74320288788491162	0.32193126292757990	0.10064368167620950	1.1810810816813006E-002
0.34318325907235508	0.11426275554263407	1.0830688669453926E-002	9.5475776111740435E-002
3.4545743853044132E-002	3.8825400107203589E-003		

Mur=2* ~0.044,0.079,0.064,0.03/ 0.019,0.069,0.055,0.026 / 0.0018, 0.056,0.044,0.019/ 0.008,0.04,0.036,0.014/ 0.00,0.036,0.016/0.01,0.04,0.022/

5.2209740685785322	1.3770212139168427	0.26488192570903973	2.1896518844782643E-002
3.1063253783518108	0.98163557790578737	0.21513169493697096	1.9055357350764735E-002
1.6334723794992163	0.59323978941603606	0.15702771787775330	1.5692206814571869E-002
0.74893389220143536	0.30837911606117635	9.7066906344606546E-002	1.1641815899812316E-002
0.34346510641629335	0.11031217636510740	1.0653170669186685E-002	9.4509572333483088E-002
3.3235217435849104E-002	3.7952292531716679E-003		

Mur=1/2 ~0.018,0.08,0.07,0.01/ 0.026,0.06,0.04, 0.00/ 0.056, 0.04,0.028, 0.01/ 0.059,0.03, 0.018,0.017 /0.039,0.019, 0.008/ 0.015, 0.028, 0.005/

5.5624189967868585	1.6162620049129208	0.30035425045754172	2.2925337735037309E-002
3.0764752717663439	1.1111543507683863	0.23692610252174731	1.9569278216111097E-002
1.5438045948407026	0.65280229151150027	0.16856857303055231	1.5868600773272221E-002
0.70137937749497870	0.33119751891586063	0.10254219123301124	1.1643918421196282E-002
0.33000554472718863	0.11654235690574526	1.0743058772392726E-002	9.4041723673555344E-002
3.5542575901097773E-002	3.9026445177190883E-003		

Muf=2 <1%~0.013

5.5066355992066285	1.4714745546854167	0.27598119824146738	2.2048491642073297E-002
3.1970074345810064	1.0382801285469117	0.22298730097963623	1.9187901276538074E-002
1.6539919763038371	0.62167788152845727	0.16181440440008205	1.5786912919732766E-002
0.75307616414315648	0.32016457156509903	9.9625923229752153E-002	1.1711596427429066E-002
0.34628077023537940	0.11359501392119362	1.0775863298435844E-002	9.6011393741803328E-002
3.4289731994963865E-002	3.8664056105374494E-003		

Muf=1/2 <1%~0.024

5.4472858735920946	1.5278735316625314	0.29364526235015426	2.3571603292228880E-002
3.1437726039100062	1.0669273986726655	0.23345902761676848	2.0129745712125217E-002
1.6181164863826403	0.63455444517262782	0.16732363820024507	1.6320902424044201E-002
0.73718494845760896	0.32546721561157471	0.10222390439342711	1.1970007755096270E-002
0.34146005749874908	0.11556088146511176	1.0947277540425390E-002	9.5485031689389002E-002

NNLO yes a decrease in variation from the second bin of each group onward

zeusdijets 371 6.7553109024137186 1.7647024664777069 0.33040248398344130 2.8157209295354268E-002
zeusdijets 372 3.7391499809305144 1.2554406375246399 0.26895124637603540 2.3312680065432419E-002
zeusdijets 373 1.7127524563399361 0.73157010873998041 0.20210296137709308 1.8759138812508805E-002
zeusdijets 374 0.86315427938007294 0.39214903120139266 0.11267514815037322 1.3956895230871133E-002
zeusdijets 375 0.37159066986101963 0.12648596744317192 1.2044192972683897E-002
zeusdijets 376 9.9426745250127221E-002 3.3875711661415363E-002 3.9301368574226146E-003

MUR=2~0.073,0.05,0.026,0.23/ 0.044,0.027,0.026,0.01/ 0.007,0.002,0.03,0.002/0.014,0.028,0.005,0.002/0.016,0.007,0.012/ 0.013/0.023,0.017

zeusdijets 371 6.2907603391131595 1.6787300775315239 0.32186408240068176 2.7450195763634326E-002
zeusdijets 372 3.5781877642957052 1.2009102122543445 0.26248222296483081 2.3101297271943627E-002
zeusdijets 373 1.7248645226886303 0.71209108160838597 0.19636056234110366 1.8724563922875130E-002
zeusdijets 374 0.85169301942010056 0.38125276449103196 0.11320198676706036 1.3919844553436315E-002
zeusdijets 375 0.37740724508687901 0.12744412538036462 1.2190249236108803E-002
zeusdijets 376 0.10071751110634800 3.4749787865989382E-002 4.0023196166098316E-003

MUR=1/2~0.11,0.045,0.009,0.024/ 0.079,0.019, 0.014, 0.004/ 0.0005, 0.02, 0.028, 0.005 /0.035,0.028,0.024,0.0/ 0.019, 0.029,0.027,0.026 /0.22, 0.062, 0.04

zeusdijets 371 7.5106655733360288 1.8426544650957732 0.33357075943227171 2.8937424412519851E-002
zeusdijets 372 4.0335247307216724 1.3107201409036788 0.27286392463500780 2.3400469916049722E-002
zeusdijets 373 1.7117350435166807 0.74642138412651893 0.20793949836218772 1.8672718127171084E-002
zeusdijets 374 0.89358199008371841 0.40324630665553207 0.10990955985018334 1.3951197303581745E-002
zeusdijets 375 0.36426358122480196 0.12292728351514541 1.1734063425215043E-002
zeusdijets 376 9.7251523018692082E-002 3.1912021840697545E-002 3.7835993910251510E-003

MUF=2 ~0.1% ~0.0044

zeusdijets 371 6.7477064686796551 1.7574911150338766 0.32933686998412648 2.7809041240921373E-002
zeusdijets 372 3.7316829661772082 1.2500565869468425 0.26763967812893247 2.3177083791063997E-002
zeusdijets 373 1.7213578743928566 0.72992475188964745 0.20061604508211750 1.8654762882894513E-002
zeusdijets 374 0.85794416529581952 0.39034209459654651 0.11246963629822879 1.3883148310273527E-002
zeusdijets 375 0.37190157705848614 0.12654098571149439 1.2027994495233075E-002
zeusdijets 376 9.9751854001734377E-002 3.4137376353930202E-002 3.9508721345017043E-003

MUF=1/2~0.05%~0.0084

zeusdijets 371 6.7524814827694835 1.7795464010166111 0.33311551381727439 2.8725415418396526E-002
zeusdijets 372 3.7442904657094118 1.2654689659801586 0.27141783243820922 2.3531544463186154E-002
zeusdijets 373 1.7049704949830164 0.73576819630756052 0.20425655522177510 1.8874115196362454E-002
zeusdijets 374 0.87093964931546186 0.39517483261951630 0.11305161114857583 1.4023693542581102E-002
zeusdijets 375 0.37169735957114974 0.12664079127999012 1.2070547088024925E-002
zeusdijets 376 9.9291115691093251E-002 3.3708845858661539E-002 3.9265241712961117E-003

ZEUS dijets summary

NLO
Mur=1/2 ~0.018,0.08,0.07,0.01/ 0.026,0.06,0.04, 0.00/ 0.056, 0.04,0.028, 0.01/ 0.059,0.03, 0.018,0.017 /0.039,0.019, 0.008/ 0.015, 0.028, 0.005/
NNLO
MUR=1/2~0.11,0.045,0.009,0.024/ 0.079,0.019, 0.014, 0.004/ 0.0005, 0.02, 0.028,0.005 /0.035,0.028,0.024,0.0/ 0.019, 0.029,0.027 /0.022, 0.062, 0.04/

NLO USE this for right and wrong ways illustartion
Mur=2* ~0.044,0.079,0.064,0.03/ 0.019,0.069,0.055,0.026 / 0.0018, 0.056,0.044,0.019/ 0.008,0.04,0.036,0.014/
0.00,0.036,0.016/0.01,0.04,0.022
NNLO
MUR=2~0.073,0.05,0.026,0.23/ 0.044,0.027,0.026,0.01/
0.007,0.002,0.03,0.002/0.014,0.028,0.005,0.002/0.016,0.007,0.012/
0.013/0.023,0.017

Record scale variations:NLO H1_lowq2_2016 standard Q^2+pt2/2=mur,Q^2=muf

1242.1095672957736 416.88186148349752 92.593892833205047 15.636085608735891 2.5383003946692466
0.44964985201741559 939.45681905998197 328.01301311740019 74.754112635791316 12.812223907026455
2.1016389669950035 0.37502107583752753 965.21657942905006 352.31129082229450 82.938178435337178
14.487977704260620 2.4032636587674934 0.43133881574892458 702.45903299359190 270.48530666660253
66.181590088721066 11.818916621628496 1.9853544988336986 0.36014946834071138 582.91519250916906
236.44355969438334 60.395813970076858 11.046609564438173 1.8815099421286481 0.34421852601779207
523.61595861372655 225.31498926708119 60.632578170415584 11.427050945935072 1.9790526001178499
0.36566086982544782 440.33666533015474 202.84427998464437 58.309906479723765 11.425420226171676
2.0187363614317668 0.37810348958471790 277.91891504607986 137.22966669417897 42.241540801844359
8.6545559837797672 1.5651595240245813 0.29717934028225634

Mur=2~0.23,0.20,0.17,0.12,0.11,0.08 /0.21,0.19…

955.60835161970601 335.11916073052782 77.166596434885363 13.453987228929831 2.2526919115802371
0.41370034978470460 733.17257231798442 265.82486989709321 62.652708493822594 11.071829327148579
1.8715204134126657 0.34605240612927324 765.68298558863466 288.23435447890370 69.958539752612324
12.578000126939807 2.1480282531643282 0.39937672740274510 567.41437811561502 223.68133975753815
56.224138001111186 10.312969849886407 1.7816014692018260 0.33447204917979440 479.12188298648294
197.70459917563269 51.682163478147473 9.6877315079078965 1.6947932031609441 0.32069881993711236
438.71445088897752 190.78713449565245 52.316745433028032 10.078164837327341 1.7901001428133223
0.34183027715066855 376.87645493864756 174.32529275115209 50.807345032062017 10.143270716409264
1.8350533373173756 0.35480705971559834 242.65962655533741 119.64660167401765 37.176444499967303
7.7348061746207639 1.4296212365241037 0.27992341914690694

Mur=1/2~0.47*,0.35*,0.25,0.20,0.15,0.09/0.44*,0.33*,0.24,0.18,0.140.087/0.40*,0.31*,0..23,0.18,0.13,0..08/0.36*,0.29*,0.22,0.17,0.13,0.077/0.32*,0.26*,0..21,0.17,0.12,0.073 /0.28*,0.24*,0.19,0.15,0.11,0.067/0.23*,0.21*,0.17,0.15,0.11,0.06/ 0.18*,0.18*,0.016,0.014,0.10,0.055/

1830.4097953386804 561.36883438554253 115.90644317022985 18.704196798872491 2.9118164919458343
0.49113715007821340 1355.3451008006325 436.19585984956888 92.864421859806953 15.238675389067822
2.3997902657926922 0.40791672798448408 1357.5818888247968 461.52499840819479 102.13292272738872
17.125165058248449 2.7303844063662610 0.46689110355061236 958.08634399136542 348.20925263504159
80.695049182266629 13.874540368897561 2.2432026633380726 0.38813835961748344 770.41402959096888
298.87272211328315 72.892724260904899 12.878779964512104 2.1147535421506158 0.36925398469184945
668.29283700863505 278.86029019189084 72.322508030306054 13.218607818106536 2.2114368618929996
0.39032106699704244 540.59322434708997 244.84182330784978 68.597028713785747 13.095754422025772
2.2400564967013890 0.40135394671747615 328.98944363895549 161.66671359001600 48.989430019851866
9.8268202489911687 1.7248698037733250 0.31369503905125512

NNLO H1 lowq2 2016 less scale variation than at NLO

1679.9078843739710	533.40096536138515	113.54285990229077	19.113316194499010	3.1178411454997104
0.52607741009263431	1246.7098556019669	413.83450288704000	91.155580493828296	15.621670629137533
2.5697779077388869	0.43585490622523321	1249.6479681000685	441.32128077191334	99.713626777623958
17.537640984789224	2.9268785700797504	0.50659507998612086	897.54578429974606	330.86432584206995
78.915657456041416	14.189813672952656	2.3969056748037096	0.42071573136054774	731.92905879600312
283.69902518926864	71.967413061643455	13.234911664214428	2.2516628527106222	0.40222410708871076
632.70375833998867	266.49762071573338	70.905346855755823	13.618426513141571	2.3633966436505962
0.42619770528487960	513.75890119504049	236.18263337485911	68.317796025171717	13.551191788365919
2.4083432319565019	0.43762747628922904	323.34776354743047	156.01324360251644	48.961201029869748
10.137483000523247	1.8704645503130777	0.34324148321704434		

Mur=2

1373.8759382999563	455.83718405313851	100.79628251911592	17.449396418868037	2.9158850944080714
0.50572442192127876	1031.6467438334855	355.84981136561998	81.144569312867247	14.284824520210012
2.4073753071970914	0.41998352435332448	1048.5671822488193	381.42741564035833	89.253836933106655
16.084132484083597	2.7474108009898193	0.48732406810259565	761.31778337555579	288.93274090219063
70.926936715027836	13.055926185021477	2.2564112055831065	0.40533238286694523	628.11602636082785
250.08278738171433	64.797520391147700	12.195696357590034	2.1267051719403440	0.38775372867621338
553.44947172448587	236.88256643000284	64.348780306672296	12.583648041263659	2.2349675198088130
0.41166196294994906	458.01540880317094	211.99645662662923	62.127435576479478	12.556869103678917
2.2806743419820821	0.42367671951806218	290.77433423927499	141.72589494244744	44.799756028430920
9.4420737696816026	1.7712479690320271	0.33275484871104472		

Mur=1/2~0.31*,0.19*,0.11,0.077,0.052,0.024/0.29*,0.18*,0.11,0.076,0.051,0.022/0.26*,0.17*,0.19,0.075,0.050,0.026/0.24*,0.16*,0.10,0.07,0.05,0.023/
0.22*,0.14*,0.10,0.075,0.044,0.025/0.18*,0.13*,0.09,0.07,0.043,0.022/0.14*,0.11*,0.094,0.068,0.043,0.022//0.13*,0.10*,0.087,0.063,0.047,0.023

2210.0318201248765	635.95008167982280	126.27876372493144	20.615007309562198	3.2824893174201648
0.53867832113169778	1612.1593743558042	489.07484786854201	101.20302709523304	16.839622465597913
2.7025761038148719	0.44515896765601892	1576.0614322378105	518.32502341500594	109.95862935741856
18.852497598906613	3.0731626423008152	0.51981601774182640	1111.9152719188546	382.24324961231963
86.737760378109343	15.208619043593623	2.5094118066767708	0.43128984143949961	889.54761099544680
323.20950368384115	79.212457839272759	14.188822489697303	2.3485572293204973	0.41260966161143720
743.54747720322462	300.24016251141211	77.290343802977233	14.576883402468100	2.4657090433652020
0.43649814906438766	585.07885965683897	262.84863728737969	74.665353463285157	14.487427231313315
2.5132986765868268	0.44742035735216418	364.57356676518782	170.94316305429291	53.243987464488491
10.781620216057041	1.9576453652350587	0.35079377042481008		

Steps 1-5 from
Katarzyna

Dataset	HERAPDF2.0NLO exp. uncert.	step-1	step-2	step-3	step-4	step-5
Charm cross section H1-ZEUS combined	41 / 47	41 / 47	-	-	-	-
ZEUS inclusive jet 98-00 data	-	-	-	-	27 / 30	27 / 30
ZEUS inclusive dijet 98-00/04-07 data	19 / 22	17 / 22	17 / 22	15 / 16	15 / 16	15 / 16
H1 inclusive jet 99-00 data	13 / 24	12 / 24	12 / 24	12 / 24	12 / 24	12 / 24
H1 low Q2 inclusive jet 99-00 data	24 / 22	22 / 22	22 / 22	22 / 22	21 / 22	22 / 22
ZEUS inclusive jet 96-97 data	26 / 30	26 / 30	26 / 30	26 / 30	-	-
HERA1+2 CCep	43 / 39	44 / 39	44 / 39	44 / 39	44 / 39	44 / 39
HERA1+2 CCem	54 / 42	54 / 42	54 / 42	54 / 42	54 / 42	54 / 42
HERA1+2 NCem	221 / 159	224 / 159	223 / 159	223 / 159	224 / 159	223 / 159
HERA1+2 NCep 820	68 / 70	69 / 70	69 / 70	69 / 70	69 / 70	68 / 70
HERA1+2 NCep 920	442 / 377	449 / 377	450 / 377	449 / 377	450 / 377	448 / 377
HERA1+2 NCep 460	217 / 204	218 / 204	218 / 204	218 / 204	218 / 204	218 / 204
HERA1+2 NCep 575	220 / 254	221 / 254	221 / 254	221 / 254	221 / 254	221 / 254
H1 normalised inclusive jets with unfolding	0 / 24	0 / 24	0 / 24	0 / 24	0 / 24	0 / 24
H1 normalised dijets with unfolding	0 / 24	0 / 24	0 / 24	0 / 24	0 / 24	0 / 24
H1 normalised trijets with unfolding	0 / 16	0 / 16	0 / 16	0 / 16	0 / 16	-
Correlated χ^2	101	98	89	89	89	89
Log penalty χ^2	+1.3	-6.77	-7.81	-7.00	-8.93	-7.31
Total χ^2 / dof	1574 / 1354	1571 / 1340	1522 / 1293	1520 / 1287	1519 / 1287	1498 / 1271
χ^2 p-value	0.00	0.00	0.00	0.00	0.00	0.00

Steps 1-5 from
Katarzyna

Parameter	HERAPDF2.0NLO exp. uncert.	step-1	step-2	step-3	step-4	step-5
'Bg'	-	0.00 ± 0.22	0.02 ± 0.17	0.02 ± 0.19	0.02 ± 0.15	-0.006 ± 0.025
'Cg'	-	7.45 ± 0.84	7.56 ± 0.79	7.69 ± 0.84	7.47 ± 0.79	7.56 ± 0.25
'Aprig'	-	0.36 ± 0.86	0.31 ± 0.65	0.35 ± 0.77	0.27 ± 0.53	0.412 ± 0.099
'Bprig'	-	-0.242 ± 0.093	-0.25 ± 0.11	-0.233 ± 0.100	-0.26 ± 0.11	-0.239 ± 0.018
'Cprig'	-	25.00	25.00	25.00	25.00	25.00
'Buv'	-	0.687 ± 0.036	0.692 ± 0.034	0.694 ± 0.035	0.688 ± 0.034	0.690 ± 0.012
'Cuv'	-	4.866 ± 0.086	4.861 ± 0.083	4.860 ± 0.084	4.867 ± 0.083	4.866 ± 0.051
'Euv'	-	14.9 ± 2.4	14.5 ± 2.2	14.4 ± 2.2	14.8 ± 2.2	14.75 ± 0.78
'Bdv'	-	0.789 ± 0.095	0.799 ± 0.094	0.799 ± 0.094	0.791 ± 0.094	0.790 ± 0.040
'Cdv'	-	3.98 ± 0.41	4.03 ± 0.40	4.02 ± 0.40	3.98 ± 0.40	3.98 ± 0.21
'CUbar'	-	7.52 ± 0.79	7.53 ± 0.80	7.58 ± 0.81	7.53 ± 0.79	7.60 ± 0.31
'DUbar'	-	9.5 ± 2.6	9.4 ± 2.5	9.6 ± 2.6	9.5 ± 2.5	9.81 ± 0.97
'ADbar'	-	0.184 ± 0.011	0.183 ± 0.010	0.183 ± 0.011	0.184 ± 0.010	0.1831 ± 0.0057
'BDbar'	-	-0.1659 ± 0.0073	-0.1669 ± 0.0065	-0.1674 ± 0.0068	-0.1663 ± 0.0065	-0.1670 ± 0.0038
'CDbar'	-	6.0 ± 1.5	6.0 ± 1.5	5.9 ± 1.5	6.0 ± 1.5	5.83 ± 0.62
'alphas'	-	0.1180	0.1180	0.1180	0.1180	0.1180
'fs'	-	0.4000	0.4000	0.4000	0.4000	0.4000

Compare Mandy and Katarzyna at step 5
(all other steps also the same)

Reminder this is as good as it ever gets —in fact better than most

Dataset	kk-step5	Mandy-step5
ZEUS inclusive jet 98-00 data	27 / 30	27 / 30
ZEUS inclusive dijet 98-00/04-07 data	15 / 16	16 / 16
H1 inclusive jet 99-00 data	12 / 24	12 / 24
H1 low Q2 inclusive jet 99-00 data	22 / 22	22 / 22
HERA1+2 CCep	44 / 39	44 / 39
HERA1+2 CCem	54 / 42	54 / 42
HERA1+2 NCem	223 / 159	224 / 159
HERA1+2 NCep 820	68 / 70	69 / 70
HERA1+2 NCep 920	448 / 377	449 / 377
HERA1+2 NCep 460	218 / 204	220 / 204
HERA1+2 NCep 575	221 / 254	221 / 254
H1 normalised inclusive jets with unfolding	0 / 24	0 / 24
H1 normalised dijets with unfolding	0 / 24	0 / 24
Correlated χ^2	89	91
Log penalty χ^2	-7.31	-8.82
Total χ^2 / dof	1498 / 1271	1503 / 1271
χ^2 p-value	0.00	0.00

Compare Mandy and Katarzyna at step 5
(all other steps also the same)

Reminder this is as good as it ever

Parameter	kk-step5	Mandy-step5
'Bg'	-0.006 ± 0.025	-0.014 ± 0.025
'Cg'	7.56 ± 0.25	7.89 ± 0.25
'Aprig'	0.412 ± 0.099	0.566 ± 0.099
'Bprig'	-0.239 ± 0.018	-0.2 ± 1.0
'Cprig'	25.00	25.00
'Buv'	0.690 ± 0.012	0.70 ± 0.12
'Cuv'	4.866 ± 0.051	4.8 ± 1.1
'Euv'	14.75 ± 0.78	14.01 ± 0.78
'Bdv'	0.790 ± 0.040	0.8 ± 1.0
'Cdv'	3.98 ± 0.21	3.96 ± 0.21
'CUbar'	7.60 ± 0.31	7.65 ± 0.31
'DUbar'	9.81 ± 0.97	10.10 ± 0.97
'ADbar'	0.1831 ± 0.0057	0.2 ± 1.0
'BDbar'	-0.1670 ± 0.0038	-0.17 ± 0.10
'CDbar'	5.83 ± 0.62	5.48 ± 0.62
'alphas'	0.1180	0.1180
'fs'	0.4000	0.4000

Now steps 5 to 6.i,ii,iii— we will talk about these varying cuts—
What I want you to note is that it makes little difference

Dataset	step-5	setp-6i	step-6ii	step-6iii
ZEUS inclusive jet 98-00 data	27 / 30	27 / 30	28 / 30	27 / 30
ZEUS inclusive dijet 98-00/04-07 data	15 / 16	15 / 16	16 / 16	16 / 16
H1 inclusive jet 99-00 data	12 / 24	12 / 24	12 / 24	12 / 24
H1 low Q2 inclusive jet 99-00 data	22 / 22	20 / 17	13 / 16	18 / 16
HERA1+2 CCep	44 / 39	44 / 39	43 / 39	44 / 39
HERA1+2 CCem	54 / 42	54 / 42	54 / 42	54 / 42
HERA1+2 NCem	223 / 159	223 / 159	223 / 159	223 / 159
HERA1+2 NCep 820	68 / 70	69 / 70	68 / 70	68 / 70
HERA1+2 NCep 920	448 / 377	449 / 377	445 / 377	447 / 377
HERA1+2 NCep 460	218 / 204	218 / 204	218 / 204	218 / 204
HERA1+2 NCep 575	221 / 254	221 / 254	220 / 254	221 / 254
H1 normalised inclusive jets with unfolding	0 / 24	0 / 24	0 / 24	0 / 24
H1 normalised dijets with unfolding	0 / 24	0 / 24	0 / 24	0 / 24
Correlated χ^2	89	89	90	89
Log penalty χ^2	-7.31	-6.41	-4.82	-6.04
Total χ^2 / dof	1498 / 1271	1497 / 1266	1488 / 1265	1494 / 1265
χ^2 p-value	0.00	0.00	0.00	0.00