Update on technical aspects in the fits

WORK IN PROGRESS

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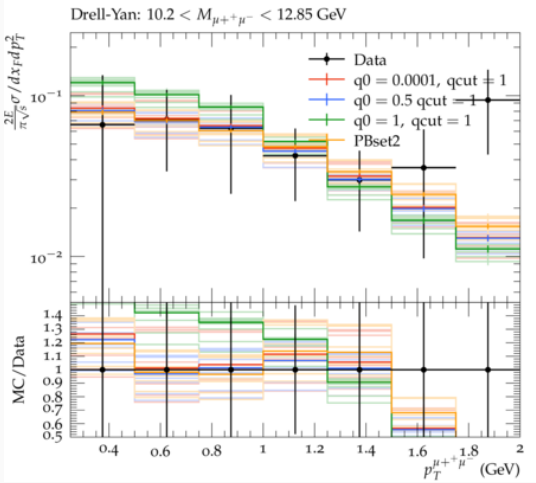
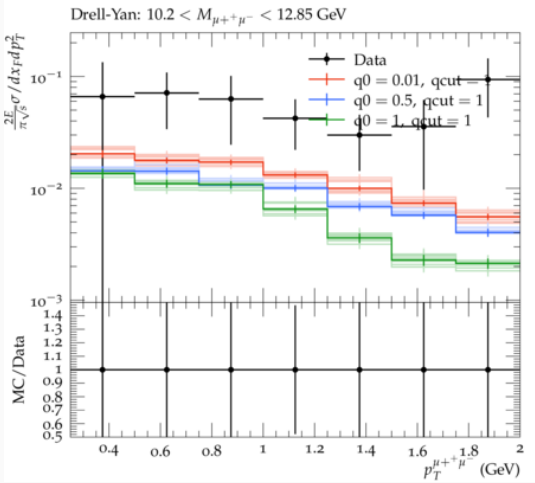
Reminder: result discussed during the last meeting



5 param gluon



3 param gluon

With 3 param gluon last mass windows of the NUSEA measurement not described (for any q0)
Ideas from the meeting:
large mass window $\Leftrightarrow$ large x $\longrightarrow$ large x not well constrained by HERA data

What has happened later:

- initial parameters in the fit procedure responsible for the bad description of the data!
  Sara used different minuit.in and she could describe the data well with 3 param gluon

Today: I will show you our studies on minuit.in in xFitter

Minuit.in and tolerance

Minuit.in

I study the following issues:

- Do the final parameters from the fit (parsout_0 file) depend on the initial parameters? (minuit.in.txt file)
- Does the result change depending on which tolerance I use?

I repeat this study for QCDnum and PB mode, with 3 and 5 parameter gluon (all at NLO)

Here the tolerance has default value (0.1)!
migrad 1000000 = migrad 1000000 0.1
However, what we were using up to now was:
migrad 1000000 3000

How does it impact our studies?

example of minuit.in.txt:

```
set title
new  14p HERAPDF
parameters
    2   'Bg'    -0.015     0.008425
    3   'Cg'     9.11     0.147543
    7   'Aprig'     1.048     0.065600
    8   'Bprig'    -0.167     0.021452
    9   'Cprig'    25.000000     0.000000
   12   'Buv'     0.714     0.006087
   13   'Cuv'     4.84     0.043079
   15   'Euv'    13.4     0.426948
   22   'Bdv'     0.806     0.012319
   23   'Cdv'     4.08     0.120159
   33   'CUbar'     8.06     0.181346
   34   'DUbar'    11.9     0.730286
   41   'ADbar'     0.176     0.001972
   42   'BDbar'    -0.172     0.003790
   43   'CDbar'     4.88     0.281947

*call fcn 3
migrad 1000000
*hesse
set print 3

return
```

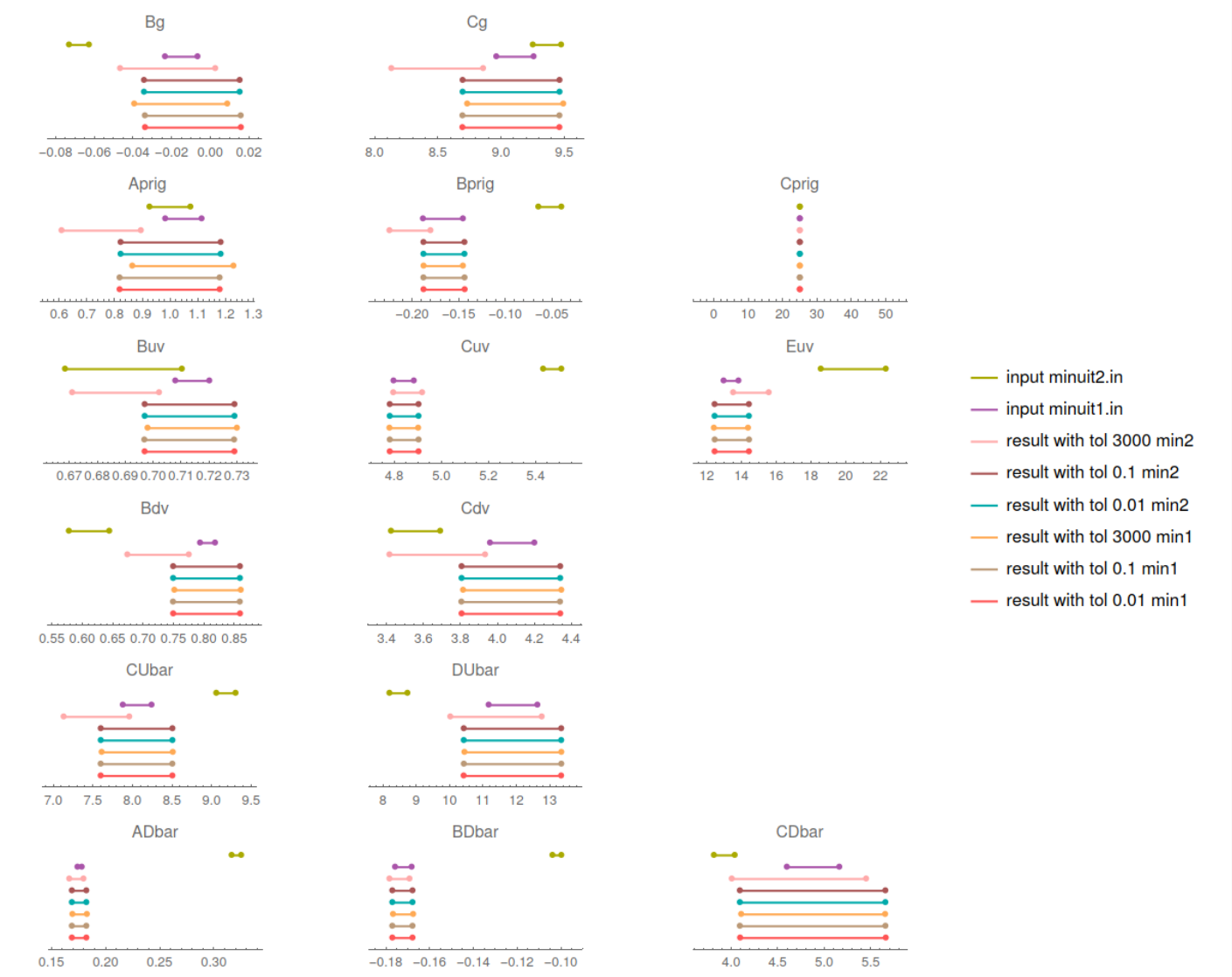
Check 1: QCDnum mode, 3 param gluon

Both minuit.in 1 and minuit.in 2 far away from final results.

Results obtained with minuit 1 and minuit2 very different, I don't know which are correct (I dont know "the true" in this scenario)

Smaller tolerance doesn't improve the situation

Check 2: QCDnum mode, 5 param gluon



tolerance 0.01 and 0.1 for herapdf and minuit2 very similar, tolerance 3000 minuit1 very slightly different for Bg, Cg, Aprig,..

tolerance 3000 minuit2 more different but still within uncertainty.

Important: minuit.in 1 = HERAPDF2.0 so very close to true

→ I think it's safer to use smaller tolerance! With minuit.in far away from true and big tolerance I can eventually end up with wrong parameters

QCDnum mode: summary

For 3 param gluon, the final result depends on the input we give. Tolerance doesn't matter

Sasha Glazov confirms our observation:

"I think we had an issue with two gluon solutions in the past when fitting HERA-only data. "
"There are two disjoint minima, with a similar chi2, and minuit is stuck in one of them if initial parameters are close to it. It is a common problem for highly non-linear problems. If you update to master, you can try ceres minimizer which should handle it better. "

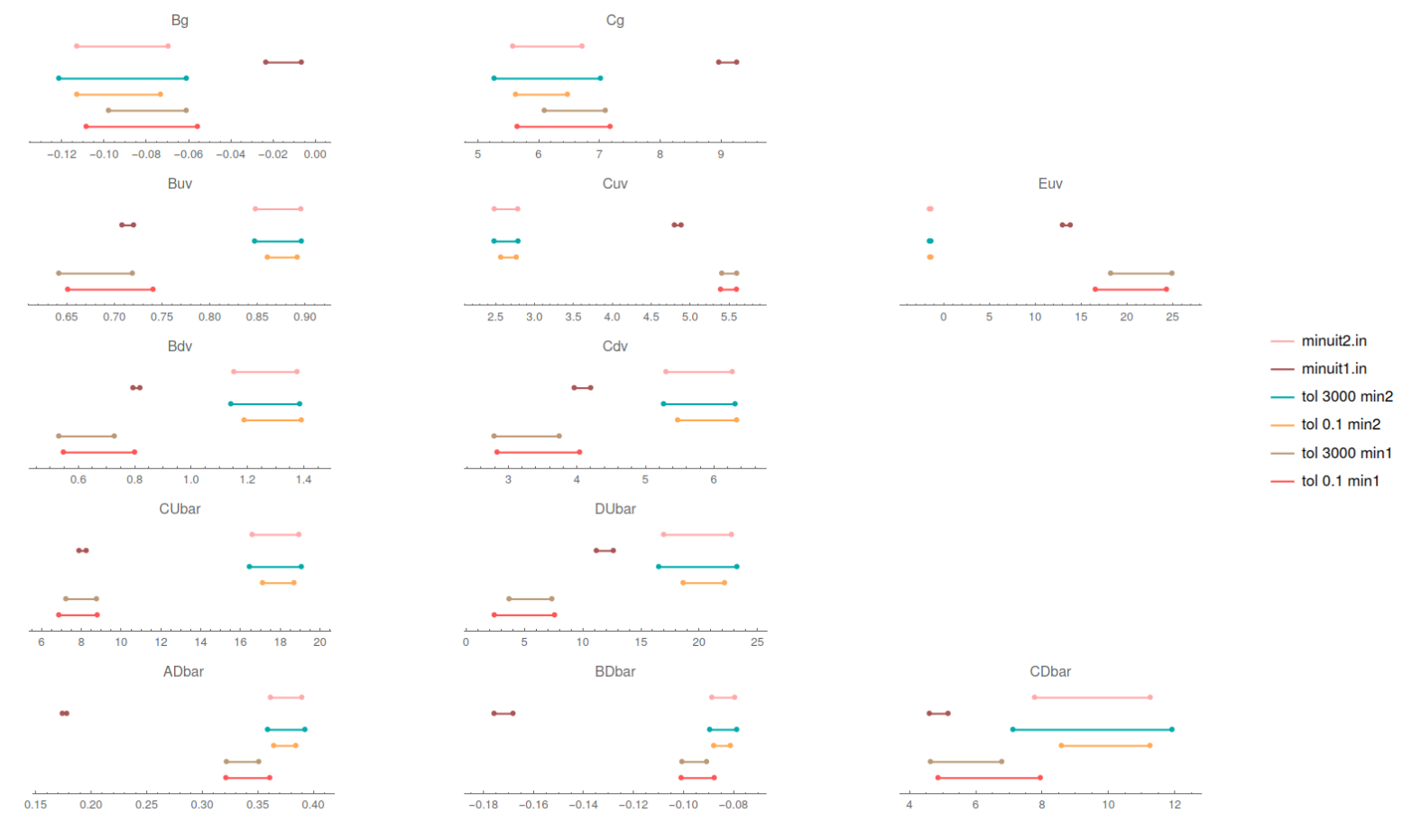
5 param gluon free from such problem but better to use small tolerance

I also asked Sasha about the tolerance parameter:

Ola: "I know that one can call migrad by doing:
migrad $\longrightarrow$ fit is performed (default number of calls 2000).
migrad 20000 $\longrightarrow$ fit is performed up to 20000 calls, then terminates.
But I know that sometimes also third column is specified:
migrad 20000 1000
What does the third parameter means exactly? Is it ok to set it to such a high value or it should be much smaller? "

Sasha: "For fortran minuit commands, you can check the manual, e.g. https://root.cern.ch/download/minuit.pdf
I see two parameters used for migrad for the first time. The second parameter, according to the manual, is the tolerance. It should be small, indeed. See page 20 of the manual."

PB mode, 3 param gluon



Situation the same as for QCDnum: different result depending on the input parameter

PB mode, 5 param gluon

Situation more complicated:

Two different minuits with tolerance 0.1 give the same result. Two different minuits with tolerance 3000 give the same result (except DUbar) but big tension between them and big uncertainty

Result for tolerance 0.1 and 3000 different

But: xFitter experts do not support big tolerance value

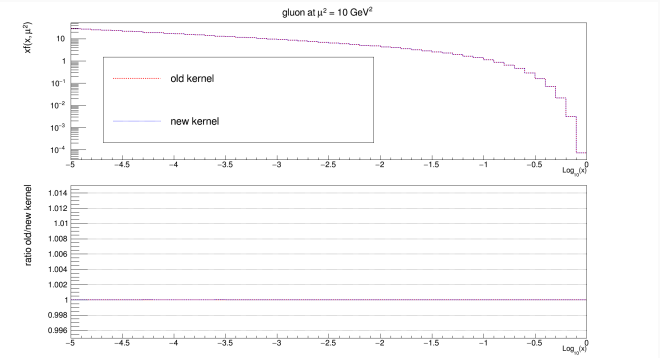
PB mode: summary

we should use 5 param gluon, with small tolerance

Some problems solved with small tolerance

kernel dependence problem

Reminder: two kernels which differ just by seed for random nbs, give very different fit results when tolerance 3000!



old kernel

```
 2 'Bg' -0.067923 0.005156
3 'Cg' 9.363115 0.112018
7 'Aprig' 0.999437 0.073797
8 'Bprig' -0.052239 0.012360
9 'Cprig' 25.000000 0.000000
12 'Buv' 0.689355 0.020920
13 'Cuv' 5.470044 0.038616
15 'Euv' 20.430294 1.869749
22 'Bdv' 0.611178 0.033188
23 'Cdv' 3.556943 0.133209
33 'CUbar' 9.181064 0.121697
34 'DUbar' 8.462828 0.269704
41 'ADbar' 0.320833 0.004417
42 'BDbar' -0.101811 0.002031
43 'CDbar' 3.925651 0.112063
```

new kernel

```
 2 'Bg' -0.092683 0.019205
3 'Cg' 8.398716 0.498291
7 'Aprig' 1.227128 0.457516
8 'Bprig' -0.039711 0.054122
9 'Cprig' 25.000000 0.000000
12 'Buv' 0.717442 0.015334
13 'Cuv' 5.434586 0.064772
15 'Euv' 18.048658 1.167315
22 'Bdv' 0.664193 0.046942
23 'Cdv' 3.496595 0.265049
33 'CUbar' 7.779089 0.397091
34 'DUbar' 4.900976 0.795625
41 'ADbar' 0.336976 0.009648
42 'BDbar' -0.096411 0.003547
43 'CDbar' 5.397514 0.463001
```

Even though kernels so similar, the fit parameters are different

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the same kernels, fit with tolerance=1: (0.1 still not converged)

old kernel:

2	'Bg'	-0.194012	0.004004
3	'Cg'	7.371147	0.089024
7	'Aprig'	0.721496	0.025256
8	'Bprig'	-0.241942	0.005770
9	'Cprig'	25.000000	0.000000
12	'Buv'	0.735965	0.003519
13	'Cuv'	5.433125	0.132659
15	'Euv'	17.118255	0.533930
22	'Bdv'	0.720212	0.012939
23	'Cdv'	3.686008	0.112824
33	'CUbar'	7.834472	0.506493
34	'DUbar'	4.555165	0.360508
41	'ADbar'	0.342262	0.004171
42	'BDbar'	-0.094913	0.002059
43	'CDbar'	6.173654	0.176100

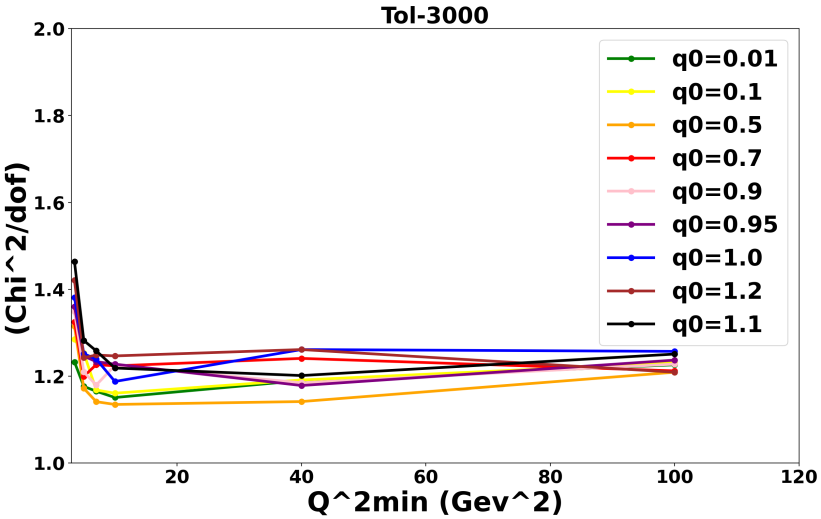
new kernel:

2	'Bg'	-0.195946	0.008406
3	'Cg'	7.543790	0.184414
7	'Aprig'	0.793964	0.052103
8	'Bprig'	-0.238265	0.011896
9	'Cprig'	25.000000	0.000000
12	'Buv'	0.739070	0.006215
13	'Cuv'	5.428415	0.013184
15	'Euv'	16.881593	0.504560
22	'Bdv'	0.721550	0.017539
23	'Cdv'	3.695395	0.272185
33	'CUbar'	7.879347	0.050672
34	'DUbar'	4.630354	0.371145
41	'ADbar'	0.341586	0.004618
42	'BDbar'	-0.095280	0.000825
43	'CDbar'	6.102591	0.439279

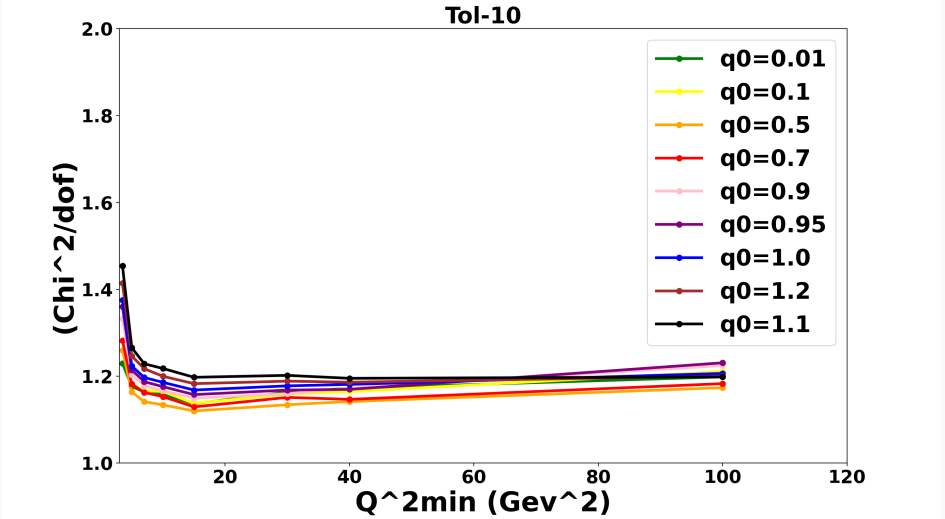
The fit parameters the same within uncertainty

Problems 1: fluctuations in the χ^2 vs $Q^2_{\min}$ plot

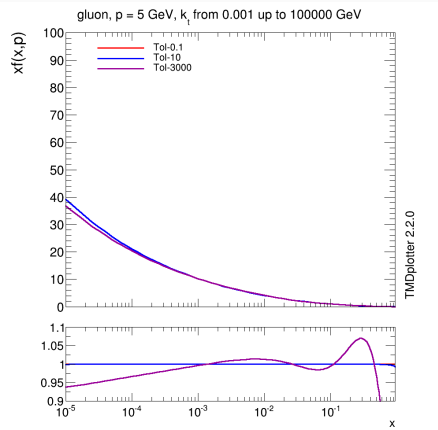
tolerance 3000:

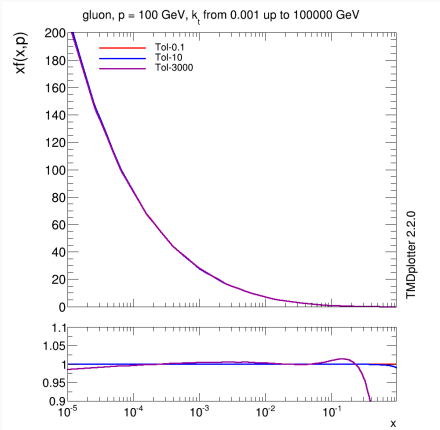


tolerance 10:



With small tolerance problem with fluctuations solved





Seems like there is no difference between results obtained with tolerance 0.1 and 10 but tolerance 3000 can give very different results.

Problems/Issues to keep in mind

- jobs with small tolerance run longer and often fail
- even for a quick tests it is however important to run with smaller tolerance, big tolerance can bias the results
- sometimes the following strategy needed: start with big tolerance, obtain converged job, rerun with the parameters from converged job and smaller tolerance again etc, repeat until the default (?) tolerance is reached
- sometimes this is not enough, and the width of the "step" has to be increased but then one needs to rerun it again with smaller width

Appendix