Measuring Proton Structure Functions with xFitter

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Review

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Goal of the project:
Use HERA & Fixed Target at N3LO with
xFitter to produce PDF plots and compare
with MSHT and NNPDF

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Use HERA & Fixed Target at N3LO with xFitter to produce PDF plots and compare with MSHT and NNPDF

Previous work:

- Included HERA and Fixed Target in steering.txt
- Produced PDFs for HERA data to use as a baseline
- Attempted fit with HERA + Fixed Target data with a 3.5 GeV^2 Q^2 cut: non-ideal effects present
- Attempted fix with x & Q^2 cut: non-ideal effects remained
- Introduced W2 to the datasets and used to cut at 12.5 GeV^2 along with the Q^2 cut: non-ideal effects further controlled through deviation from MSHT and NNPDF for u and d valence PDFs – hints at tension between the data

N3LO Studies

```
Minimizer: MINUIT
MINUIT:
  Commands: |
    set str 2
    MIGRAD 20000
    HESSE
    call fcn 3

  doErrors: Pumplin
  threads: 20

Parameters:
  Adbar : [ 0.21729894, 0.00596153 ]
  Adv : [ 1.00000000, 0.00000000 ]
  Ag : [ 1.00000000, 0.00000000 ]
  Agp : [ 0.06116521, 0.04085875 ]
  Auv : [ 1.00000000, 0.00000000 ]
  Bdbar : [ -0.07669832, 0.00379618 ]
  Bdv : [ 1.18174075, 0.06832448 ]
  Bg : [ -0.14441817, 0.04632487 ]
  Bgp : [ -0.48321435, 0.04931820 ]
  Buv : [ 0.82332140, 0.01248925 ]
  Cdbar : [ 14.65042635, 2.17686357 ]
  Cdv : [ 5.52795978, 0.32504327 ]
  Cg : [ 3.23168719, 0.25974569 ]
  Cgp : [ 25.00000000, 0.00000000 ]
  Cubar : [ 13.35201436, 1.65139685 ]
  Cuv : [ 2.61122356, 0.08321544 ]
  DATANORM_NMC120 : [ 1.00000000, 0.1000000 ]
  DATANORM_NMC200 : [ 1.00000000, 0.1000000 ]
  DATANORM_NMC280 : [ 1.00000000, 0.1000000 ]
  DATANORM_NMC90 : [ 1.00000000, 0.0000000 ]
  DATANORM_SLAC49a : [ 1.00000000, 0.00000000 ]
  DATANORM_SLAC49b : [ 1.00000000, 0.10000000 ]
  DATANORM_SLAC87 : [ 1.00000000, 0.10000000 ]
  DATANORM_SLAC89b : [ 1.00000000, 0.10000000 ]
  Dubar : [ 3.70239580, 2.47561356 ]
  Duv : [ 0.00000000, 0.00000000 ]
  Euv : [ -1.00048890, 0.06650143 ]
  ZERO : [ 0.00000000, 0.00000000 ]
  fs : [ 0.40000000, 0.00000000 ]
```

```
*
&Cuts

  !-------------------- NC ep  -------------------------

  ! Rule #1: Q2 cuts
   ProcessName(1)     = 'NC e+-p'
   Variable(1)        = 'Q2'
   CutValueMin(1)     = 10.0
   CutValueMax(1)     = 1000000.0

  !--------------------  CC ep  -----------------

   ProcessName(2)     = 'CC e+-p'
   Variable(2)        = 'Q2'
   CutValueMin(2)     = 10.0
   CutValueMax(2)     = 1000000.0


  !------------------- Charm
   ProcessName(3)     = 'NC e+-p charm'
   Variable(3)        = 'Q2'
   CutValueMin(3)     = 10.0
   CutValueMax(3)     = 1000000.0

  !------------------- Beauty
   ProcessName(4)     = 'NC e+-p beauty'
   Variable(4)        = 'Q2'
   CutValueMin(4)     = 10.0
   CutValueMax(4)     = 1000000.0
   ProcessName(5)     = 'muon p'
   Variable(5)        = 'Q2'
   CutValueMin(5)     = 10.0
   CutValueMax(5)     = 1000000.0
   ProcessName(6)     = 'muon p'
   Variable(6)        = 'W2'
   CutValueMin(6)     = 12.5
   CutValueMax(6)     = 100000
   ProcessName(7)     = 'NC e+-p slac'
   Variable(7)        = 'W2'
   CutValueMin(7)     = 12.5
   CutValueMax(7)     = 100000
   ProcessName(8)     = 'NC e+-p slac'
   Variable(8)        = 'Q2'
   CutValueMin(8)     = 10.0
   CutValueMax(8)     = 1000000
```

N3LO Studies

Fits conducted:
All at N3LO

- HERA with Q^2 3.5
- HERA with Q^2 10
- HERA + Fixed Target $Q^2 > 3.5$
- HERA + Fixed Target $Q^2 > 3.5$ $W^2 > 12.5$
- HERA + Fixed Target $Q^2 > 10$ $W^2 > 12.5$

N3LO Studies

Fit	χ^2	ν	χ^2_ν
HERA ($Q^2 > 3.5\ GeV^2$)	1526	1204	1.27
HERA ($Q^2 > 10\ GeV^2$)	1275	1062	1.20
HERA & Fixed Target ($Q^2 > 3.5\ GeV^2$)	3264	2109	1.55
HERA & Fixed Target ($Q^2 > 3.5\ GeV^2\ W^2 > 12.5\ GeV^2$)	2392	1826	1.31
HERA & Fixed Target ($Q^2 > 10\ GeV^2\ W^2 > 12.5\ GeV^2$)	1815	1500	1.21

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- Improvement when applying a higher Q^2 cut
- Jump when introducing new data, non-ideal region + tension between the data
- HERA + Fixed Target with both Q^2 10 and W^2 close to HERA Q^2 10 baseline

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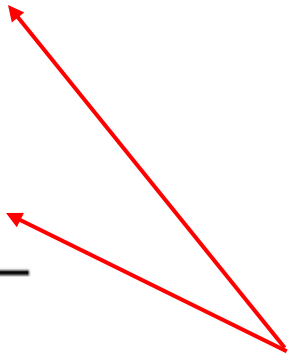
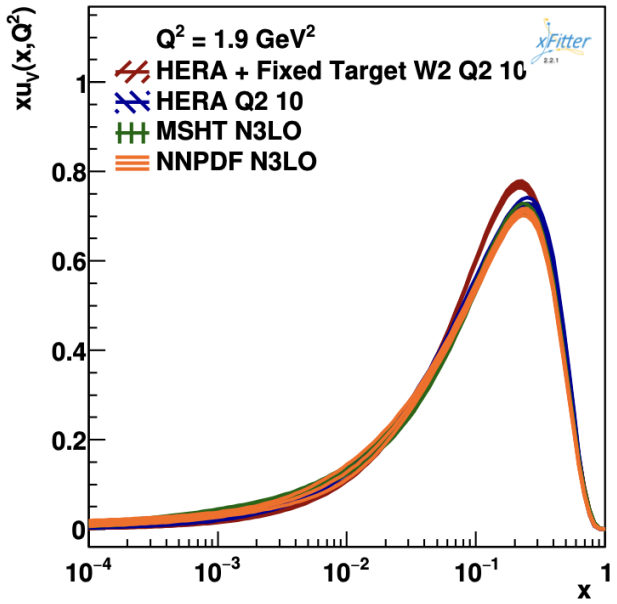
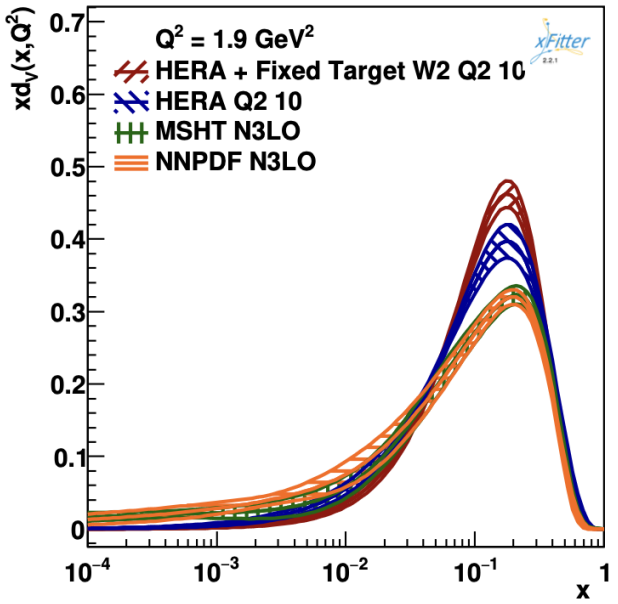


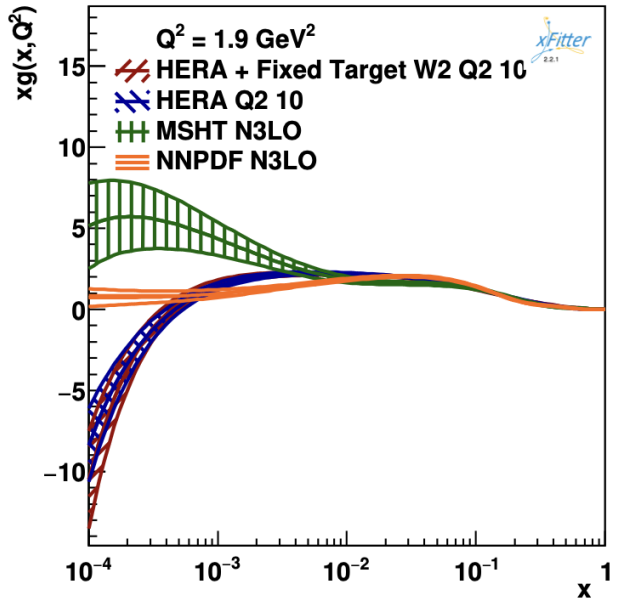
- Improvement when applying a higher Q^2 cut
- Jump when introducing new data, non-ideal region + tension between the data
- HERA + Fixed Target with both Q^2 10 and W2 close to HERA Q^2 10 baseline

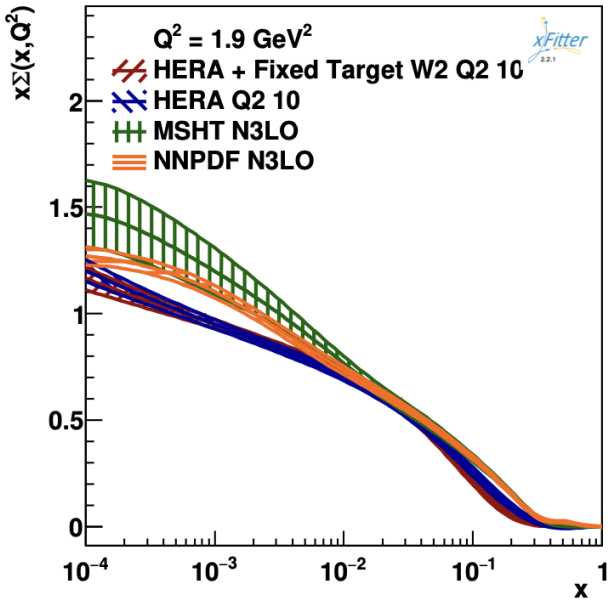
N3LO Studies

- Divergence for u and d valence
- Inconclusive for gluon PDF

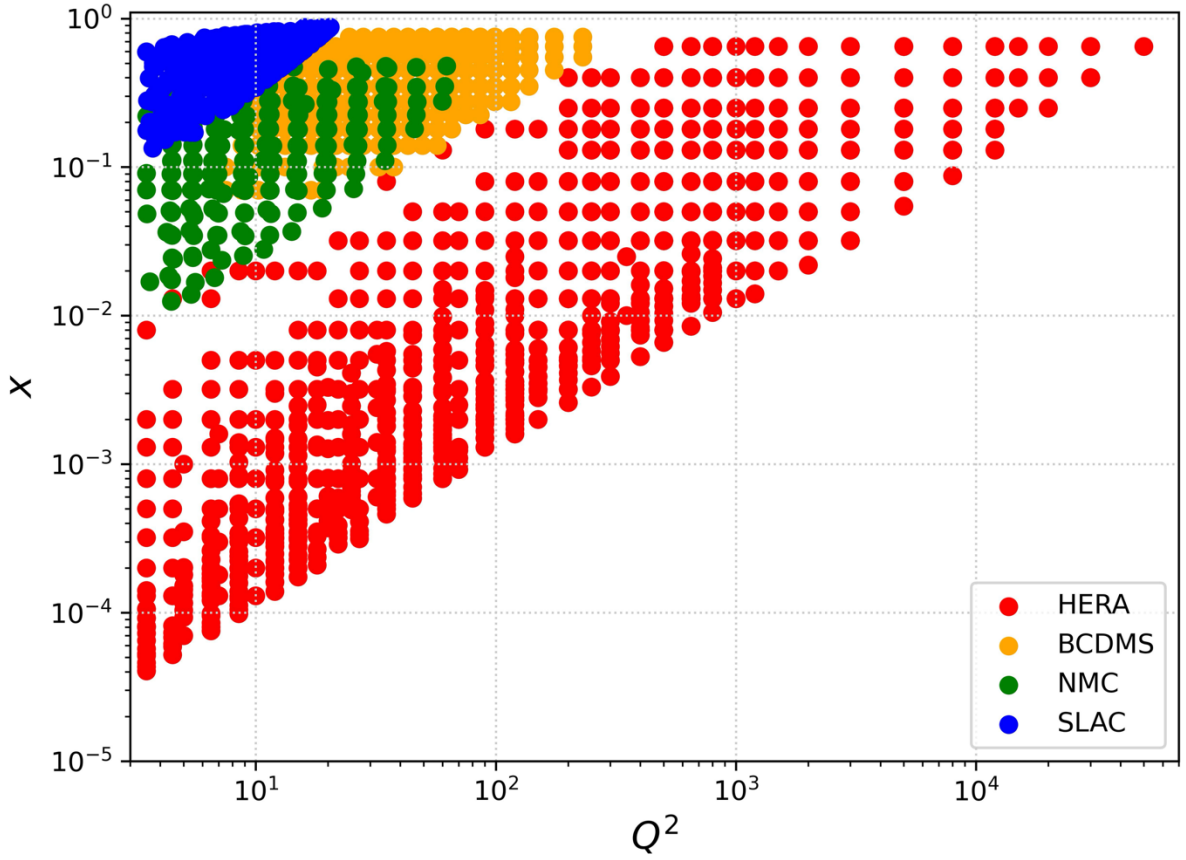


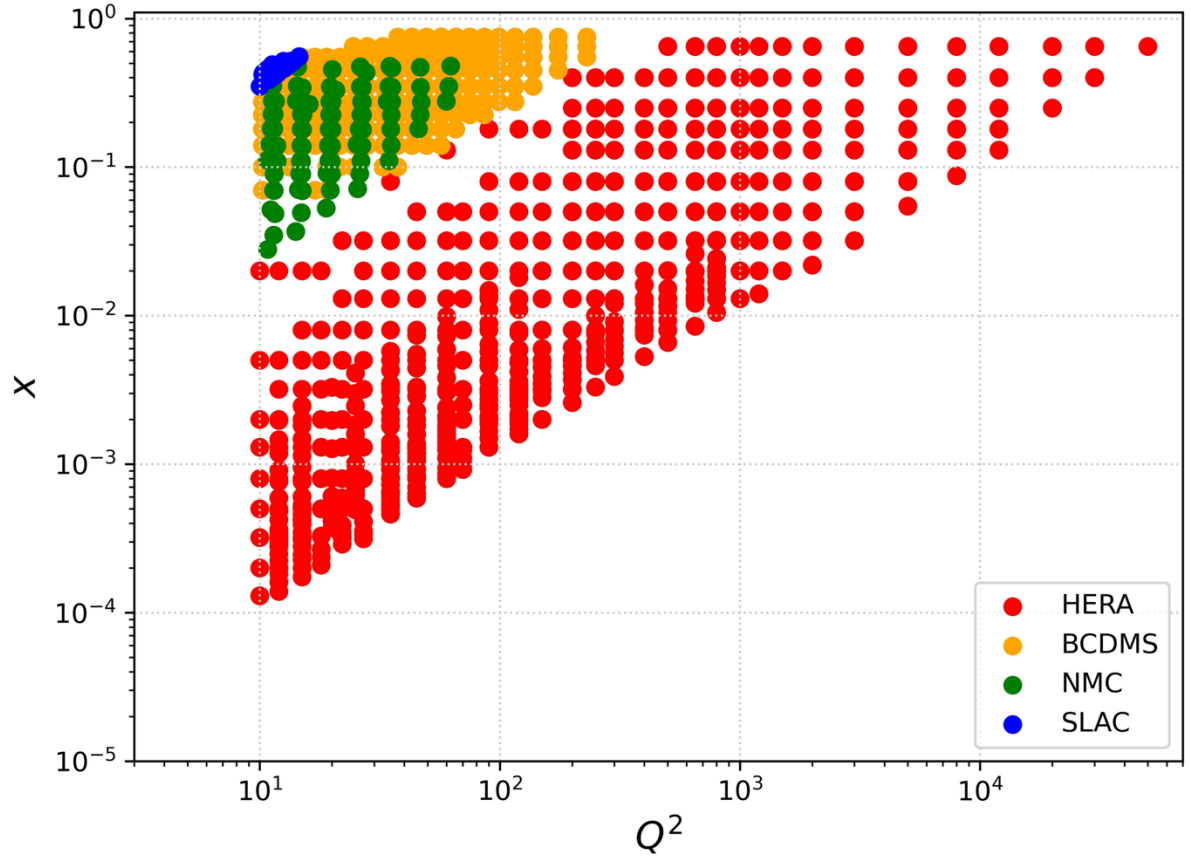






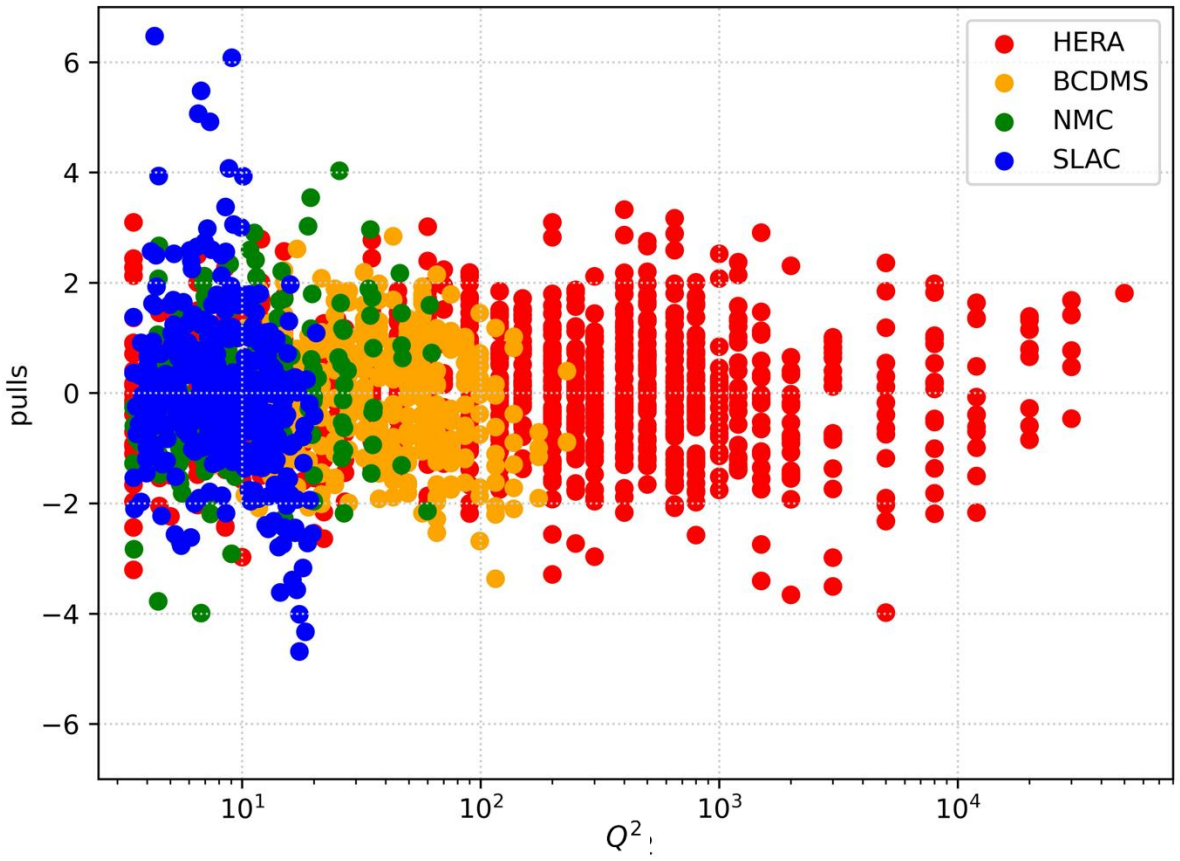
N3LO Studies: Q2 3.5 v all cuts

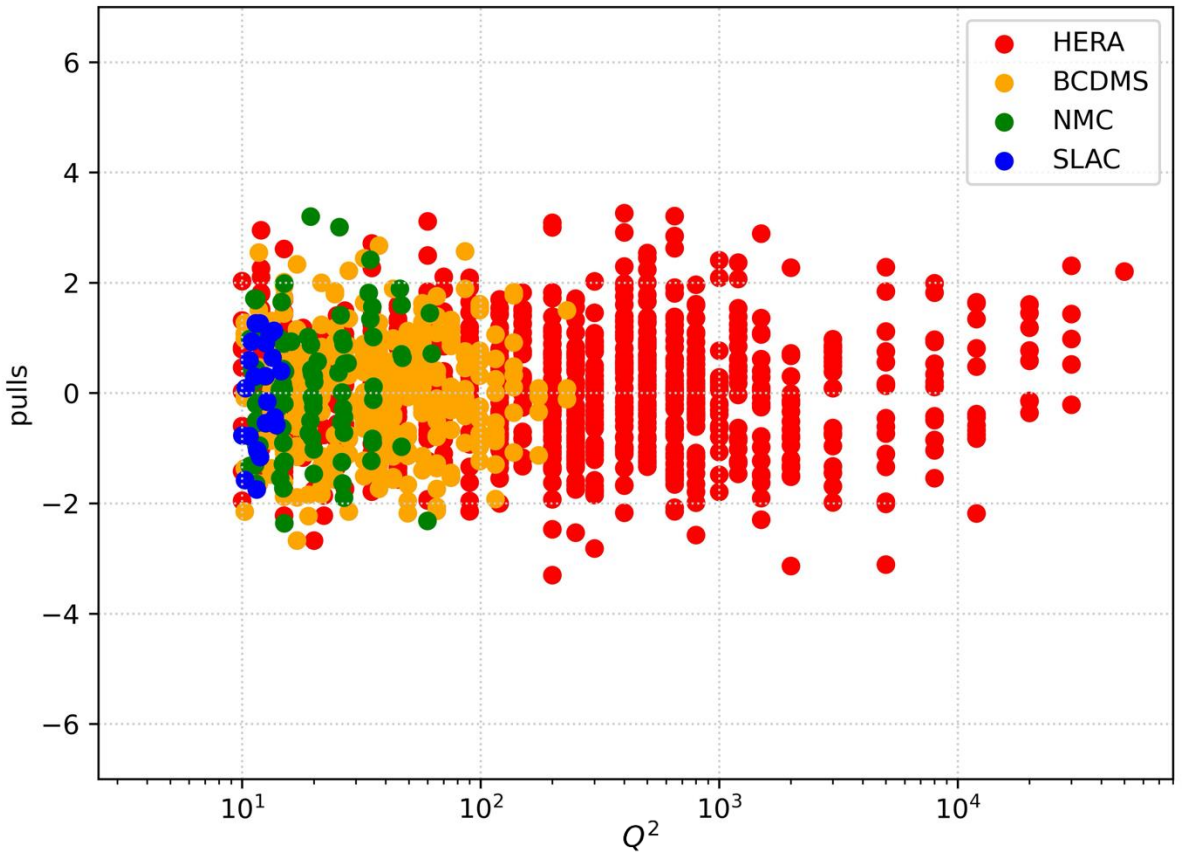




Kinematic coverage before and after all the cuts

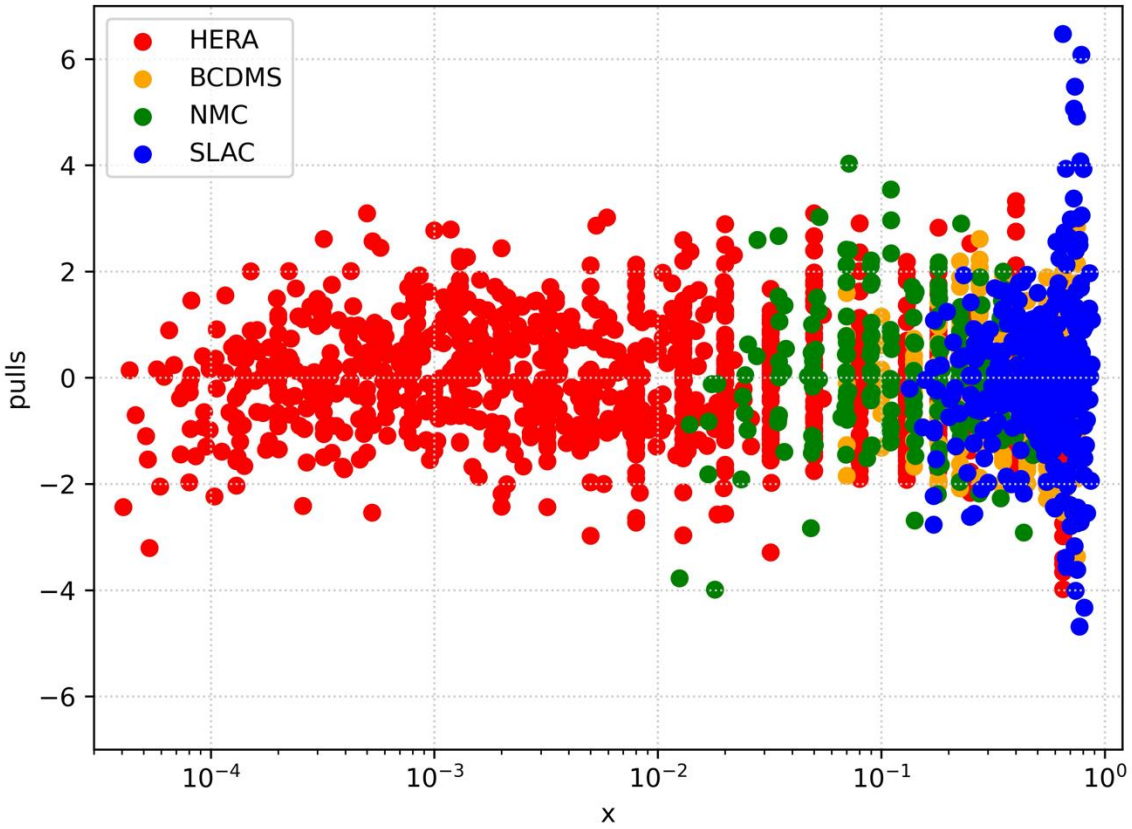
N3LO Studies

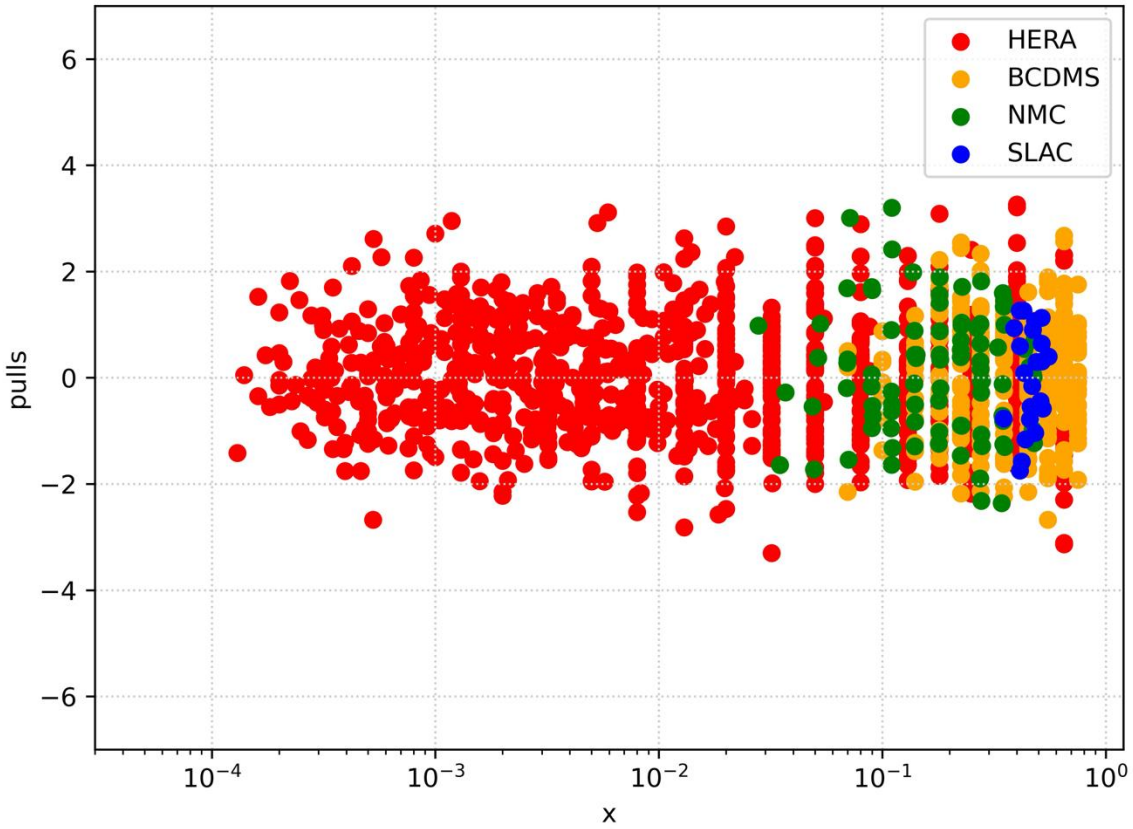




Pulls before(only Q^2 3.5 cut) and after all the cuts as a function of Q^2

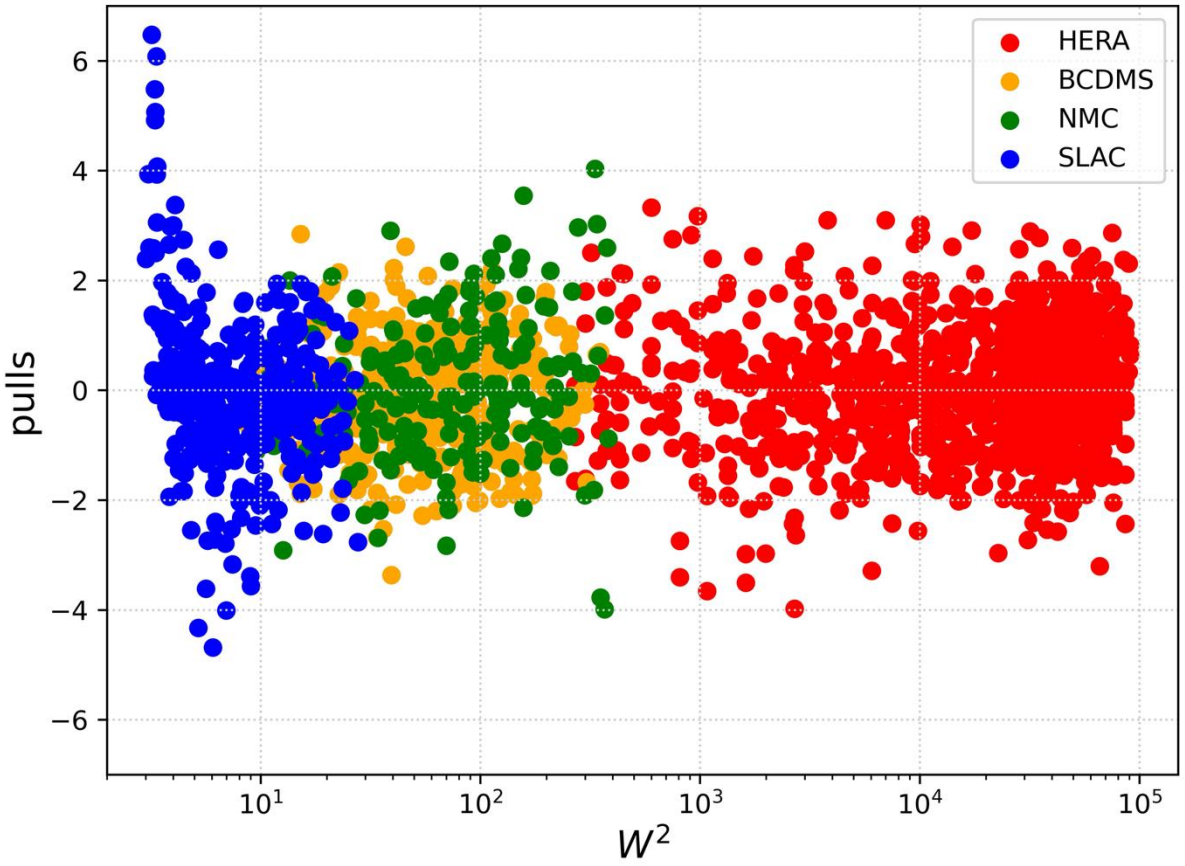
N3LO Studies

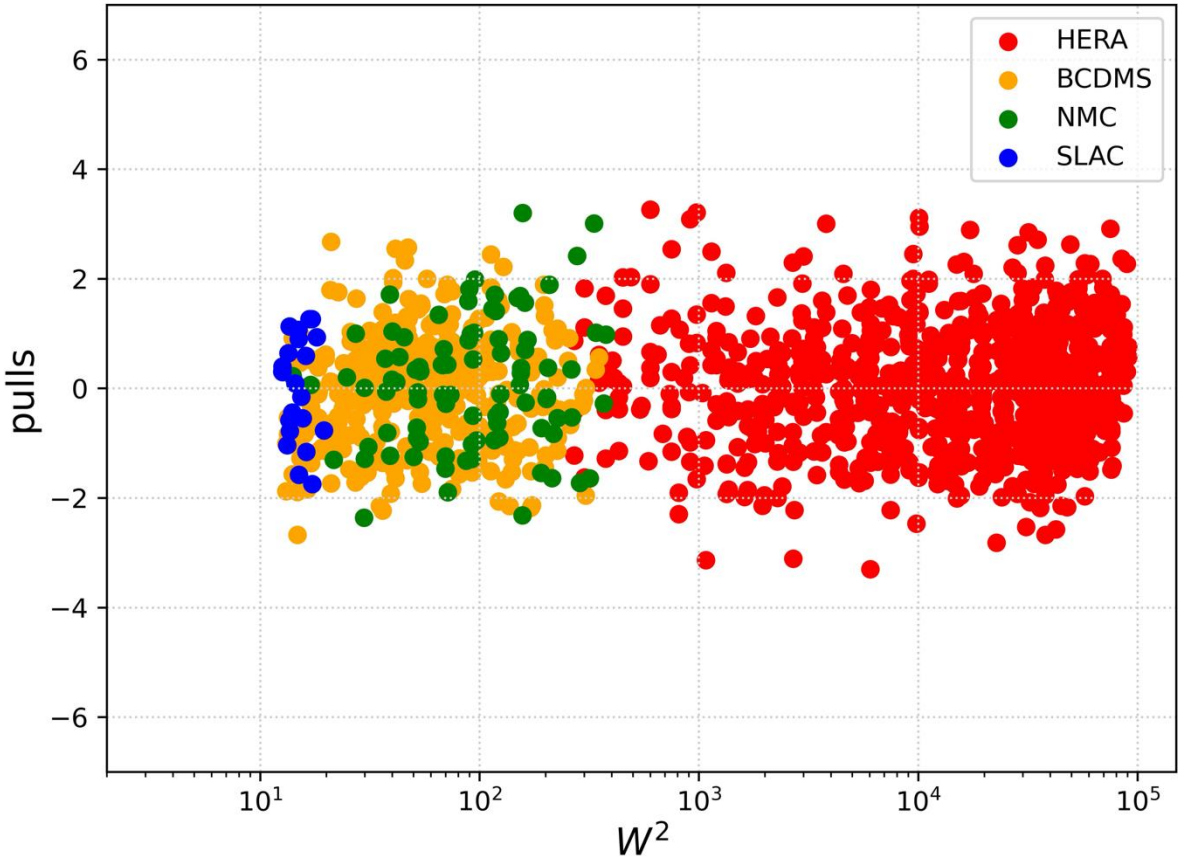




Pulls before(only Q^2 3.5 cut) and after all the cuts as a function of Bjorken x

N3LO Studies





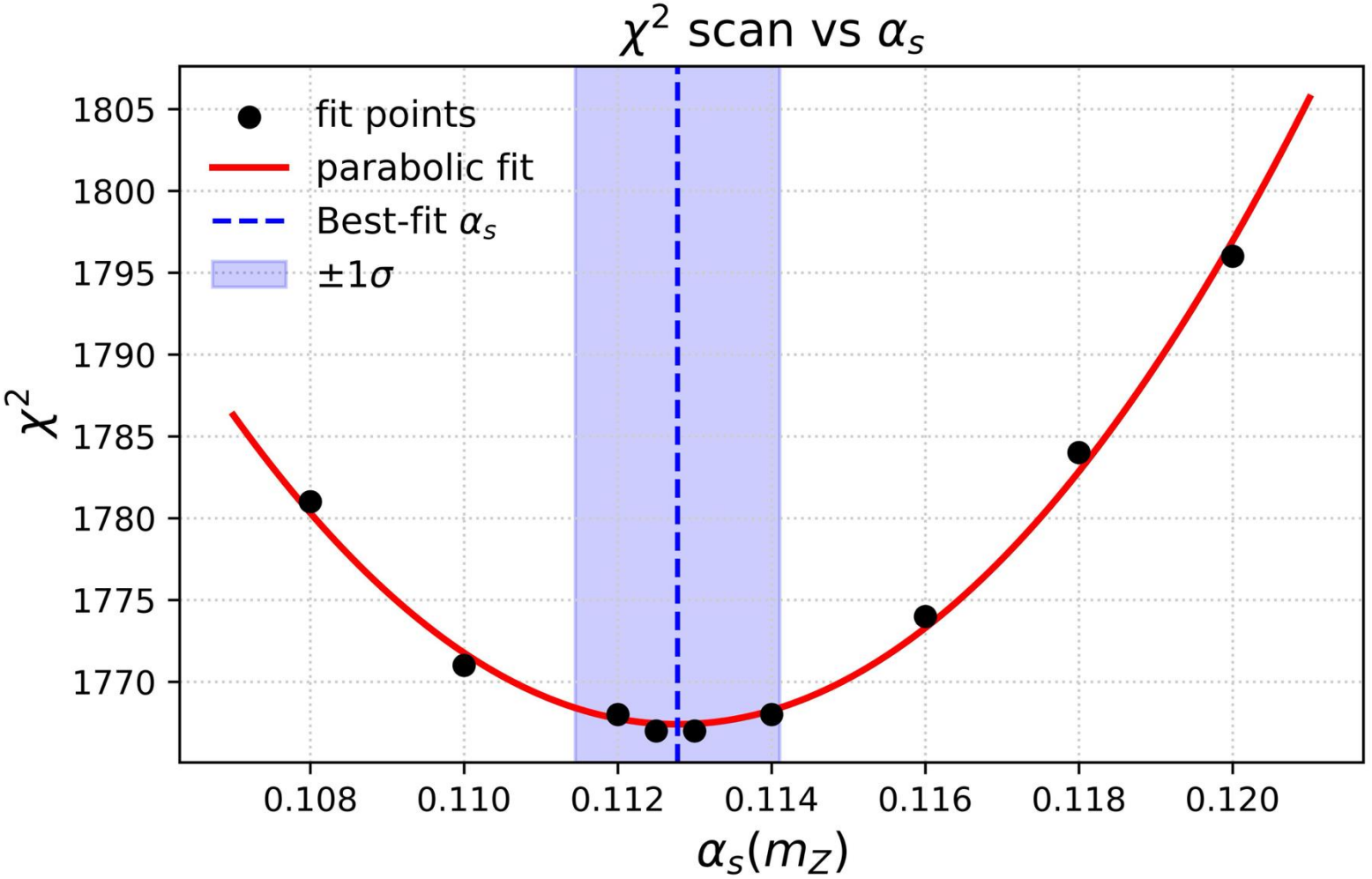
Pulls before(only Q^2 3.5 cut) and after all the cuts as a function of W^2

N3LO Studies

```
   1   'Adbar'     0.201695     0.019505
   2   'Adv'     1.000000     0.000000
   3   'Ag'     1.000000     0.000000
   4   'Agp'     0.268080     0.054220
   5   'Auv'     1.000000     0.000000
   6   'Bdbar'    -0.083942     0.015456
   7   'Bdv'     1.262349     0.089677
   8   'Bg'    -0.604440     0.142530
   9   'Bgp'    -0.661974     0.106610
  10   'Buv'     0.848171     0.018483
  11   'Cdbar'    11.809276     2.608634
  12   'Cdv'     5.795115     0.410763
  13   'Cg'     2.106909     0.901820
  14   'Cgp'    25.000000     0.000000
  15   'Cubar'    15.854858     1.599993
  16   'Cuv'     2.625505     0.097792
  17   'DATANORM_NMC120'     0.980215     0.024592
  18   'DATANORM_NMC200'     1.036062     0.017896
  19   'DATANORM_NMC280'     1.027923     0.017569
  20   'DATANORM_NMC90'     1.000000     0.000000
  21   'DATANORM_SLAC49a'     1.000000     0.000000
  22   'DATANORM_SLAC49b'     1.005428     0.020390
  23   'DATANORM_SLAC87'     1.016096     0.016047
  24   'DATANORM_SLAC89b'     1.010350     0.019097
  25   'Dubar'    10.896419     3.634229
  26   'Duv'     0.000000     0.000000
  27   'Euv'    -1.036714     0.074116
  28   'ZERO'     0.000000     0.000000
  29   'fs'     0.400000     0.000000
output/parsout_1 (END)
```

Parsout_1

N3LO Studies



$$\alpha_0 \qquad \sigma$$

$$\alpha_s = 0.113 \pm 0.001$$

~5σ away from the PDG value

Fixed target datasets have pulls that decrease the strong coupling

$$\chi^2 = \frac{(\alpha_s - \alpha_0)^2}{\sigma^2} + c$$

Next Steps

- Testing new datafiles with W2 cut and pushing to the git
- Modifying the initial parametrisation to allow more flexibility in the fit
- Performing scans over more parameters to get uncertainties for the strong coupling