ZEUS-EW QCD analysis

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What is ZEUS-EW

- ZEUS-EW based on experience and studies of Volodymyr&Co for electroweak fits using all available HERA data
- Data samples used in ZEUS-EW
  - HERAI: separate data samples (input to data combination) → to preserve correlations between H1 and ZEUS for HERAI and between H1 data for HERAI and HERAII
  - HERAII
    - ZEUS polarised e±p data (8 samples for CC & NC)
    - H1 upolarised e±p data (4 samples for CC & NC)
    - Properly treated correlations
- QCD correction $O(\alpha_s)$ applied (not done for HERAPDF2.0)
- Parameterisation
  - 13 parameters for QCD fit + 4 free couplings
- All other settings as for HERAPDF2.0

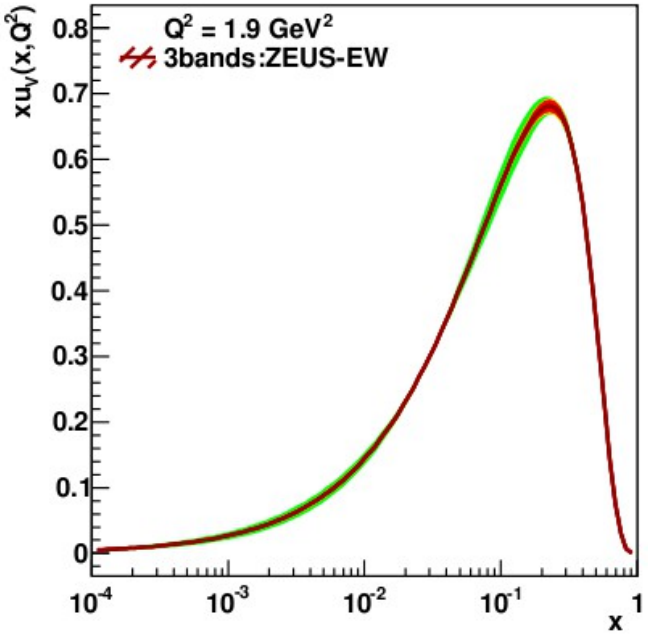
ZEUS-EW: fit results

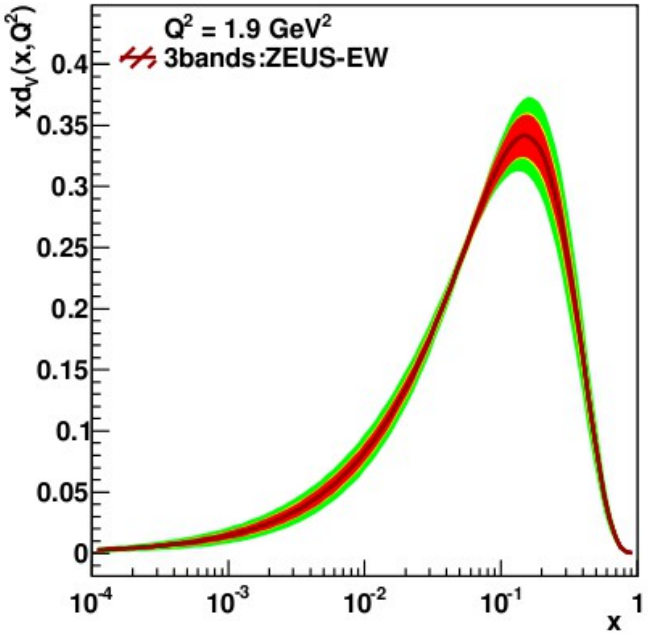
- Fit results
  - Shown for HERAII data sets, the rest in backup
  - Reasonable chi2s

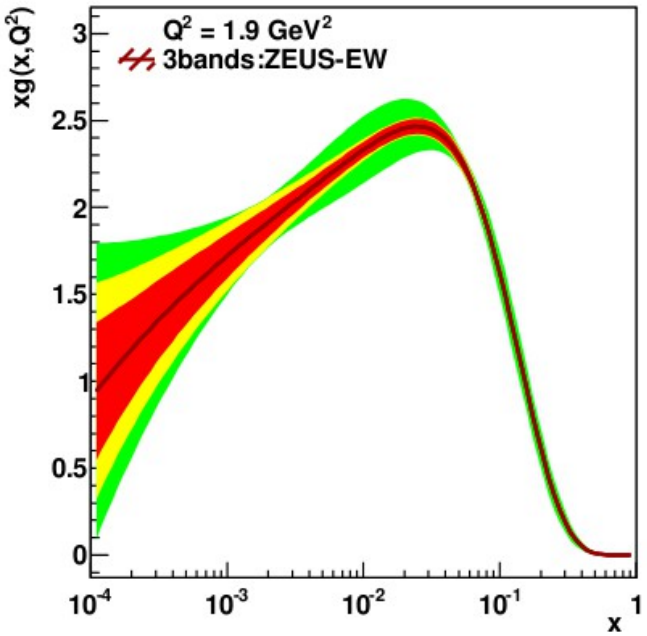
After minimisation		3273.26	2925	1.119

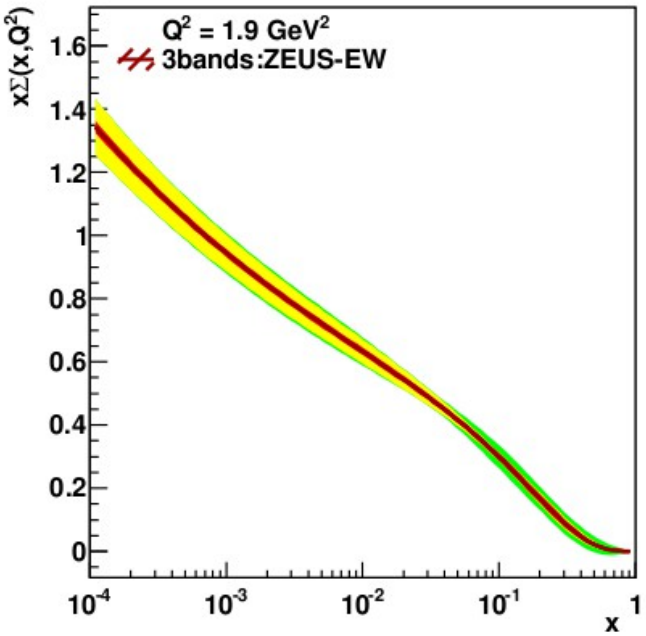
Partial chi2s				
Dataset	1	60.02(-1.01)	37	ZEUS inclusive CC e-p LH HERA-II data
Dataset	2	38.90(-0.59)	34	ZEUS inclusive CC e-p RH HERA-II data
Dataset	3	21.22(+2.90)	35	ZEUS inclusive CC e+p LH HERA-II data
Dataset	4	55.14(+1.35)	35	ZEUS inclusive CC e+p RH HERA-II data
Dataset	5	123.97(+2.05)	90	ZEUS inclusive NC e-p LH HERA-II data
Dataset	6	106.47(+2.26)	90	ZEUS inclusive NC e-p RH HERA-II data
Dataset	7	113.45(+3.72)	90	ZEUS inclusive NC e+p LH HERA-II data
Dataset	8	136.34(+2.97)	90	ZEUS inclusive NC e+p RH HERA-II data
Dataset	9	39.03(+2.67)	29	h1H2-ccemP0.dat
Dataset	10	46.07(+3.36)	29	h1H2-ccepP0.dat
Dataset	11	185.73(+5.82)	151	h1H2-ncemP0.dat
Dataset	12	150.56(+5.77)	150	h1H2-ncepP0.dat

Parton densities with total uncertainty



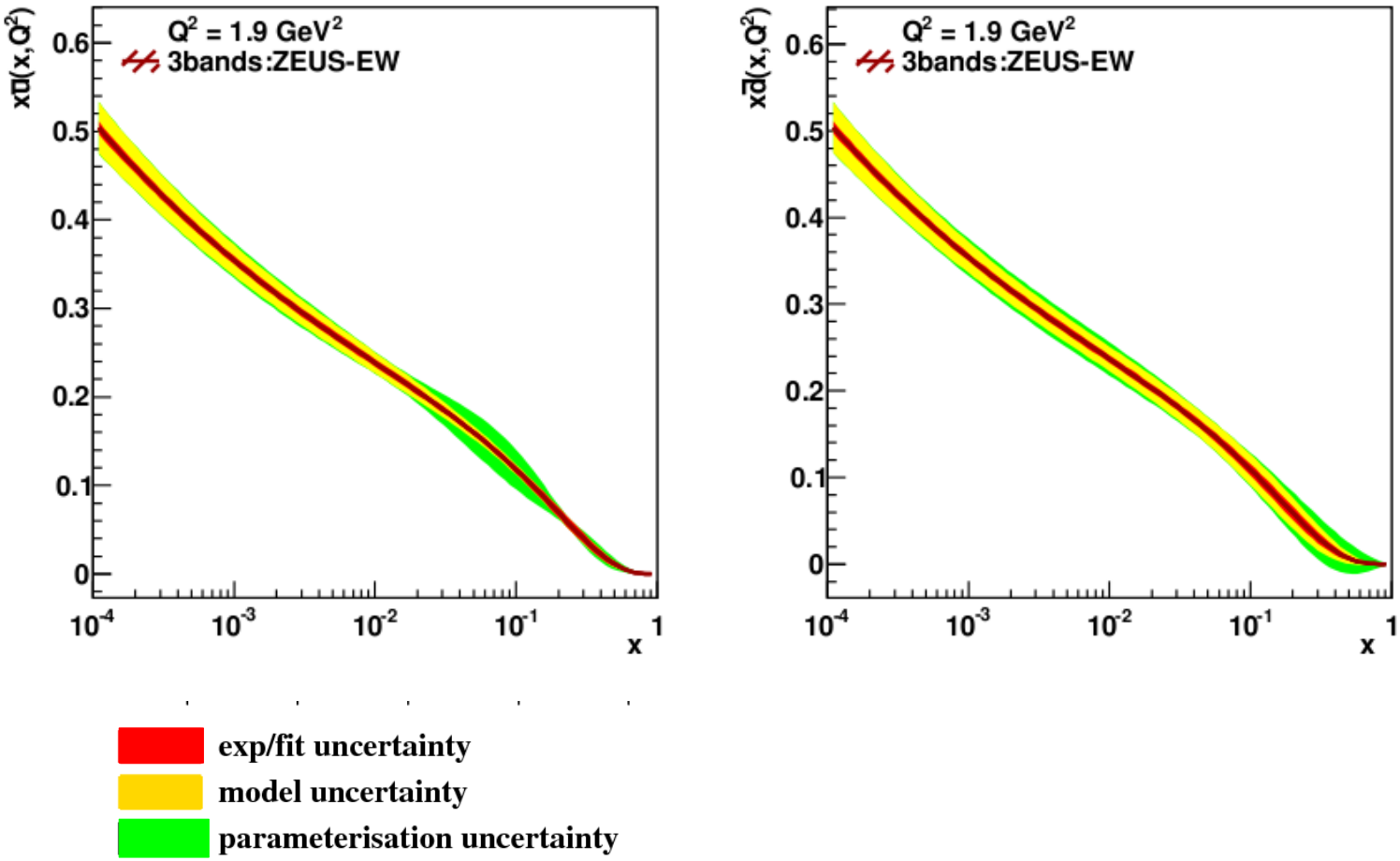






exp/fit uncertainty
model uncertainty
parameterisation uncertainty

Parton densities with total uncertainty

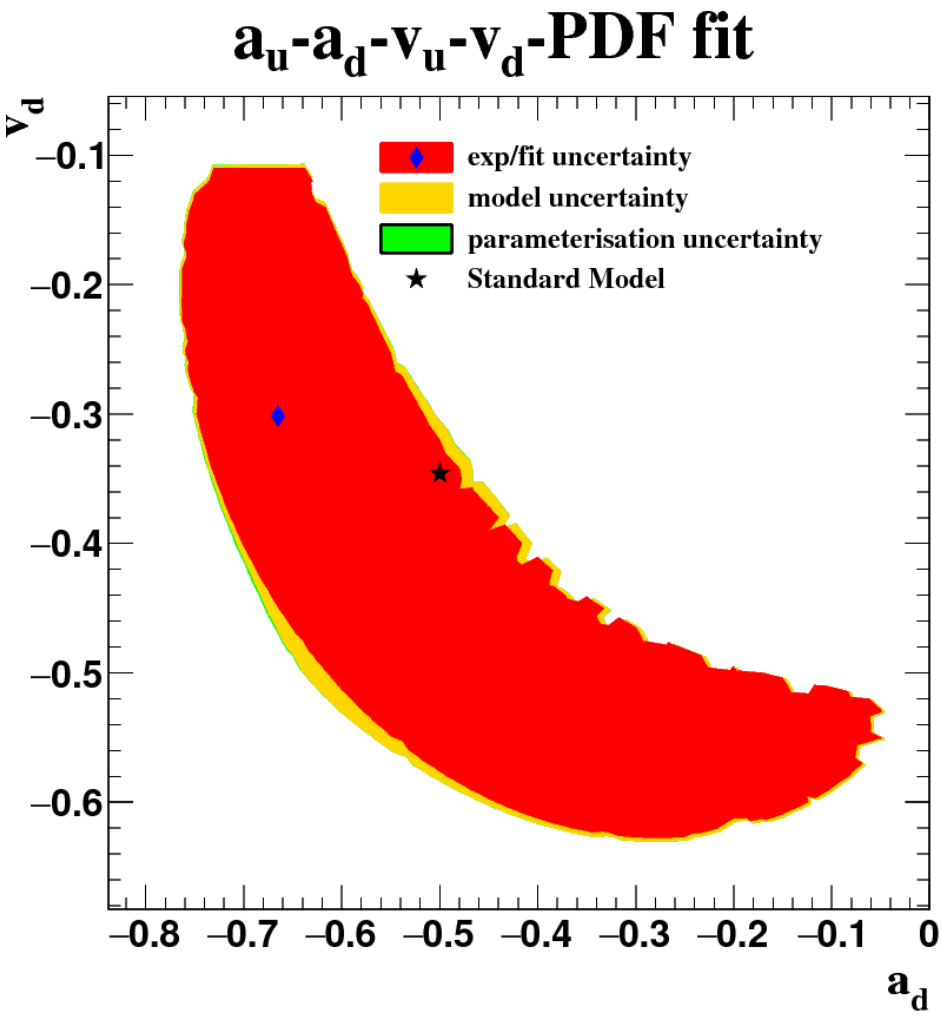


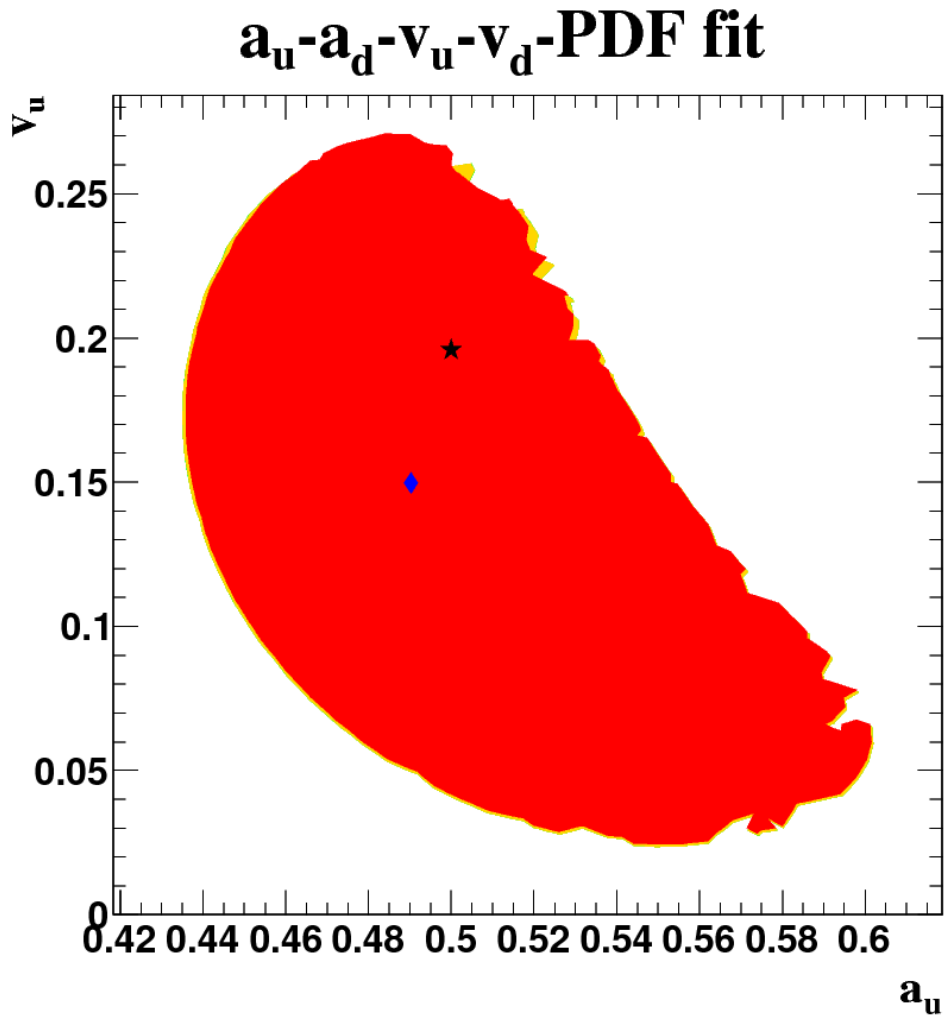
ZEUS-EW: couplings

- Total uncertainty estimated on the results (includes experimental, model and parametrisation uncertainties → backup)

Au = 0.490	**+0.065**	**-0.042**	**(total)**	**SM: 0.5**
	+0.062	-0.039	(exp)	
	+0.021	-0.016	(mod)	
	+0.003	-0.008	(par)	
Ad = -0.665	**+0.245**	**-0.107**	**(total)**	**SM: -0.5**
	+0.238	-0.098	(exp)	
	+0.059	-0.037	(mod)	
	+0.009	-0.020	(par)	
Vu = 0.150	**+0.245**	**-0.107**	**(total)**	**SM: 0.196**
	+0.085	-0.089	(exp)	
	+0.014	-0.021	(mod)	
	+0.003	-0.003	(par)	
Vd = -0.301	**+0.236**	**-0.238**	**(total)**	**SM: -0.346**
	+0.232	-0.229	(exp)	
	+0.042	-0.064	(mod)	
	+0.011	-0.005	(par)	

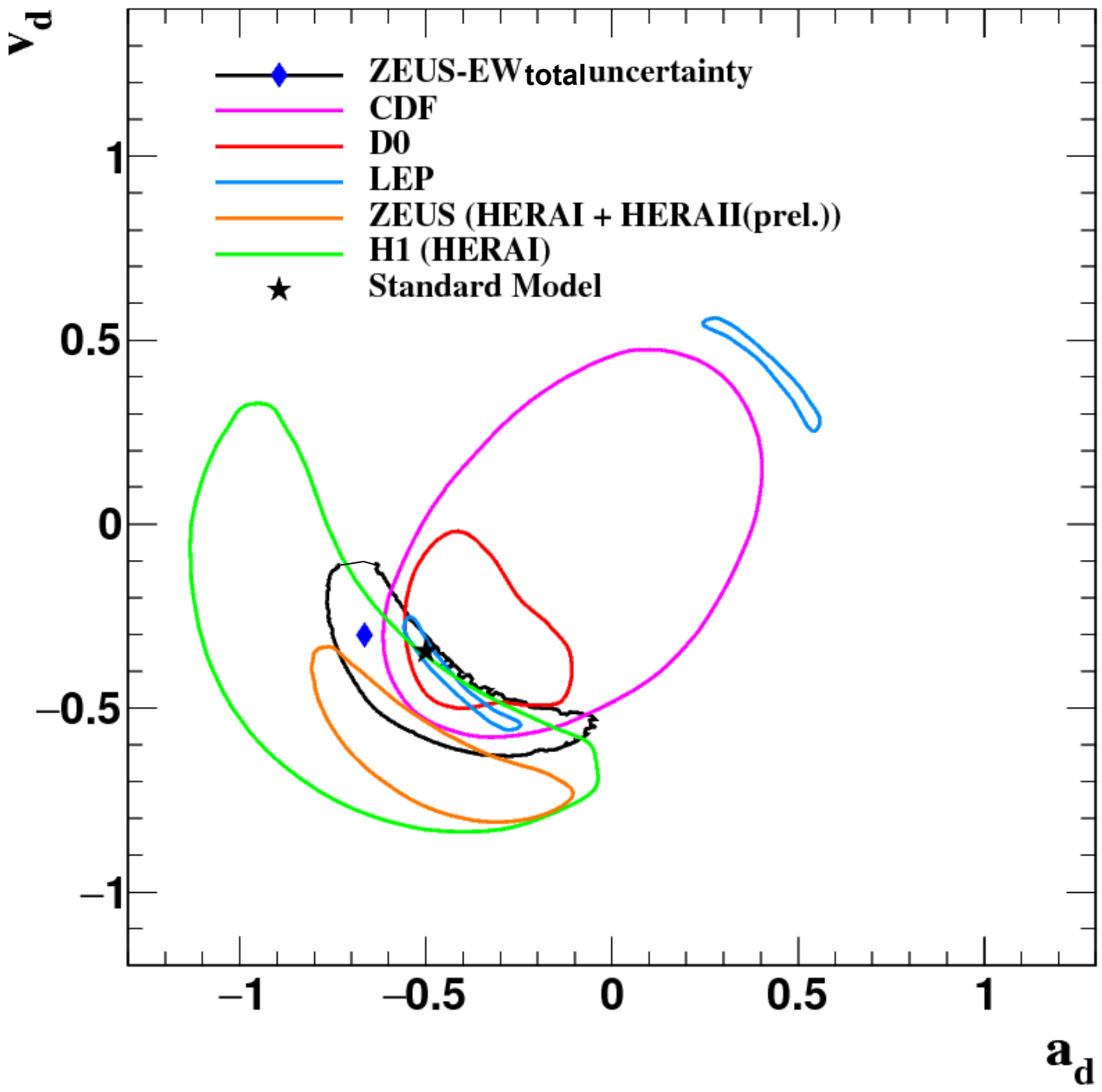
Breakup of uncertainties



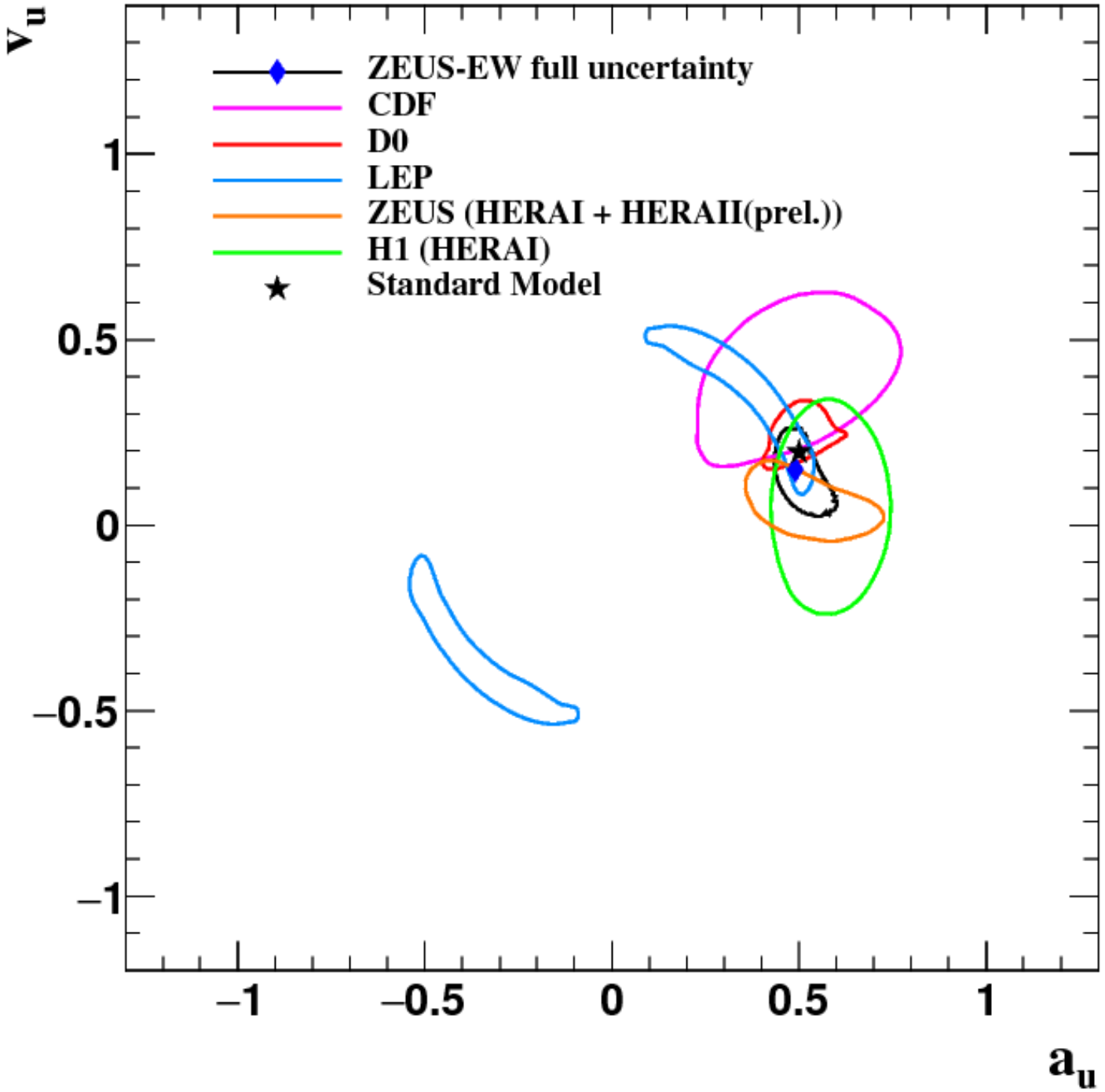


- Parameterisation uncertainty of adding DUbar to fit not included yet

a_u-a_d-v_u-v_d-PDF fit



a_u-a_d-v_u-v_d-PDF fit

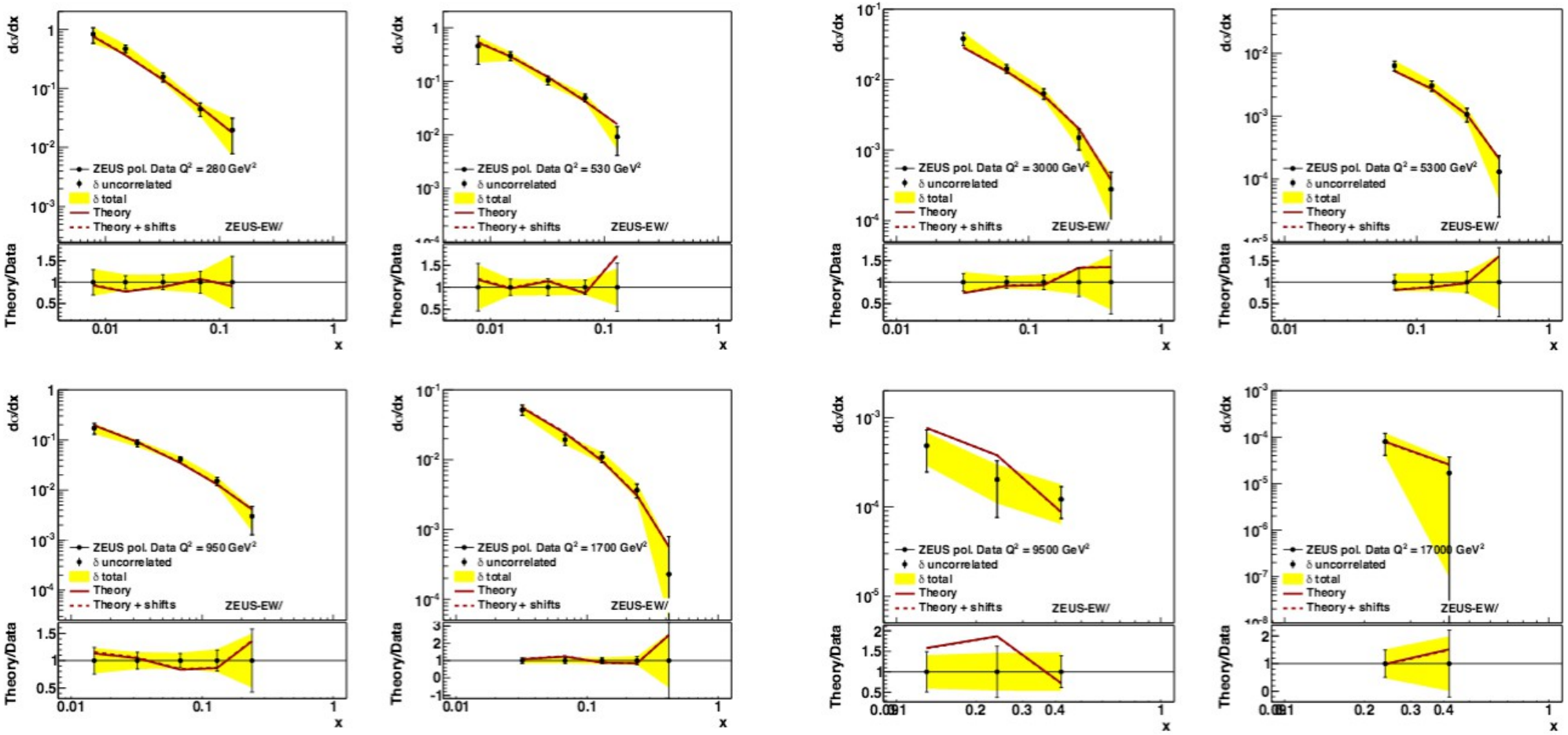


World results (full uncertainties)

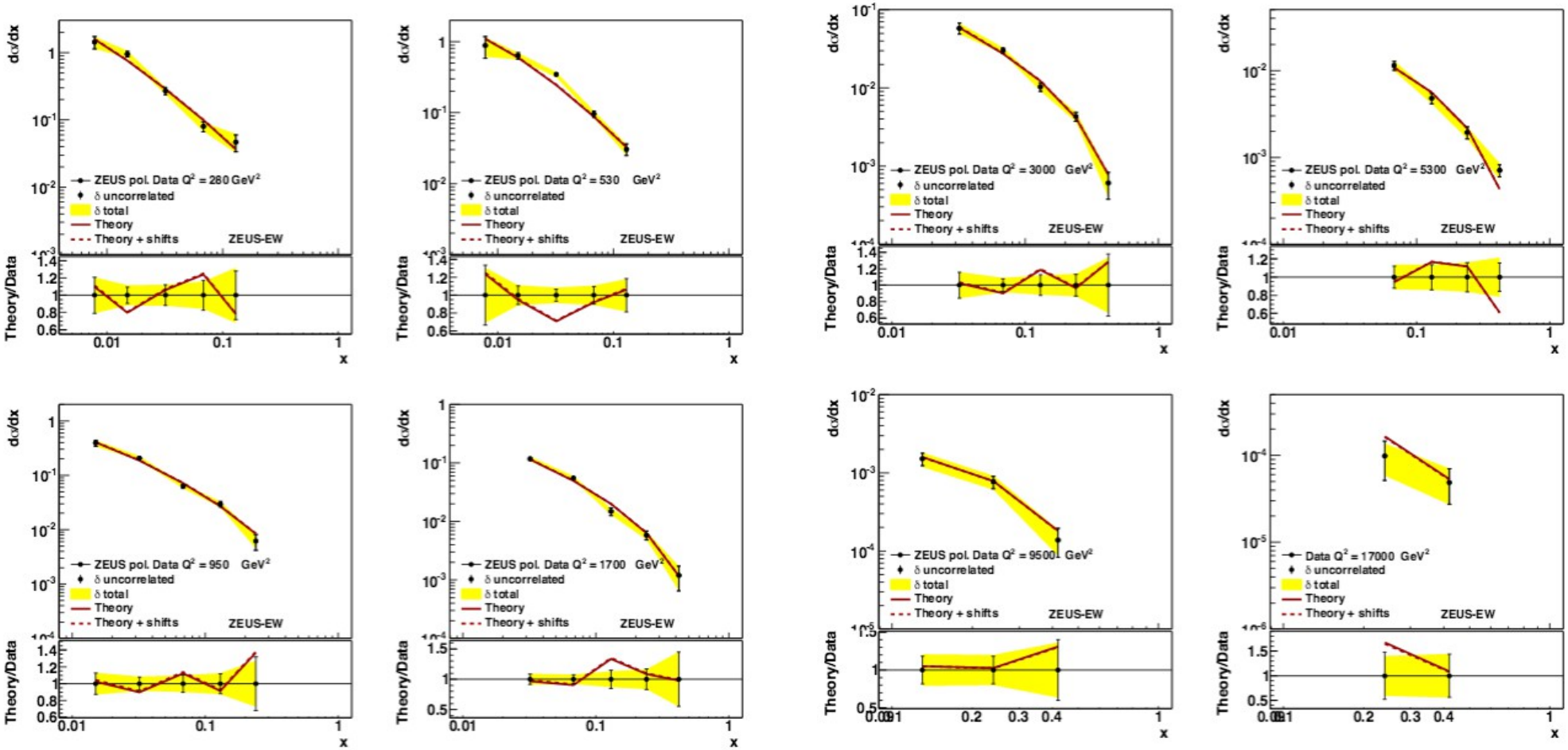
	a_u	a_d	v_u	v_d
LEP	$0.47^{+0.05}_{-0.33}$	$-0.52^{+0.05}_{-0.03}$	$0.24^{+0.28}_{-0.11}$	$-0.33^{+0.05}_{-0.07}$
D0	0.50±0.11	-0.50±0.17	0.20±0.11	0.35±0.25
CDF	$0.44^{+0.22}_{-0.19}$	$-0.02^{+0.36}_{-0.54}$	$0.40^{+0.17}_{-0.20}$	$-0.23^{+0.64}_{-0.30}$
H1: HERA1 (publ.)	0.56±0.10	-0.77±-0.37	0.05±0.19	-0.50±0.37
ZEUS: HERA1+2 (prel.)	0.51±0.20	-0.54±0.37	0.05±0.10	-0.64±0.24
ZEUS-EW	$\mathbf{0.49}^{+0.065}_{-0.042}$	$\mathbf{-0.67}^{+0.245}_{-0.107}$	$\mathbf{0.15}^{+0.086}_{-0.092}$	$\mathbf{-0.30}^{+0.236}_{-0.238}$
SM	0.5	-0.5	0.196	-0.346

- Current full uncertainties are compatible with ones from other experiments
  - Note precision on a_u and v_u.

Data/theory comparison: CC e^+p LH



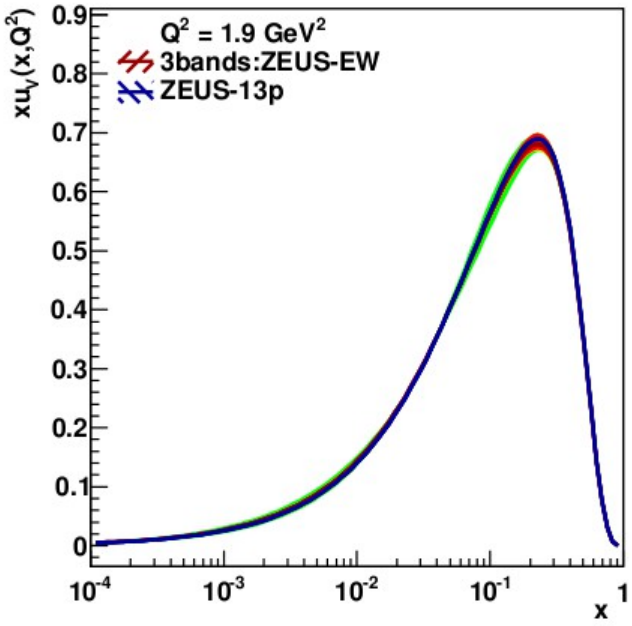
Data/theory comparison: CC e^+p RH

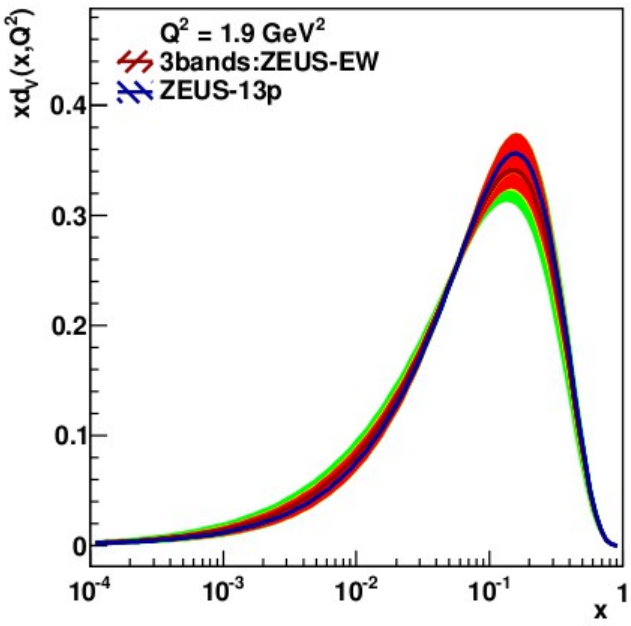


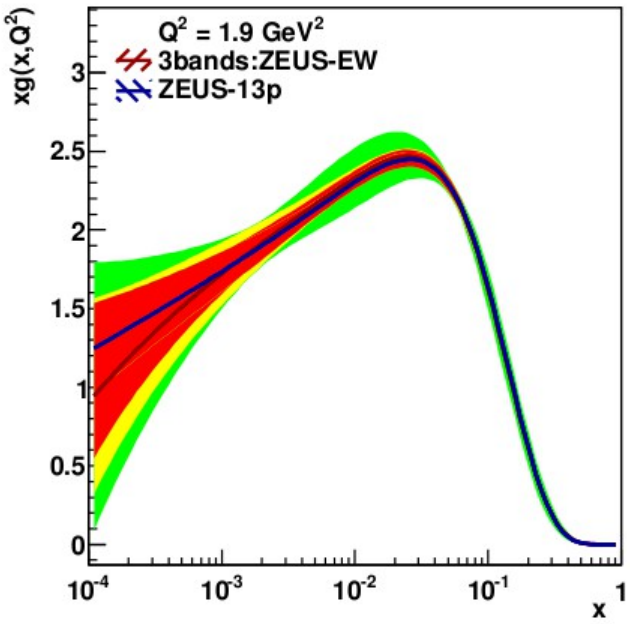
Cross checks

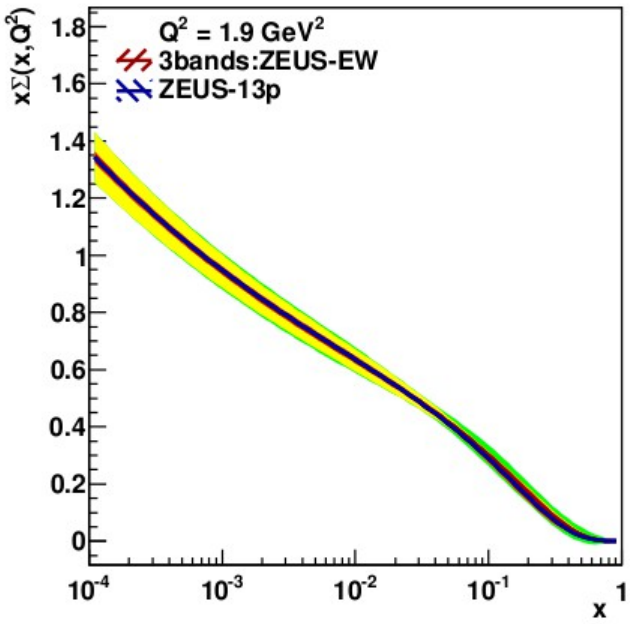
- Make ZEUS-13p fit with couplings set to SM values
- Compare with ZEUS-EW

Comparison to ZEUS-13p





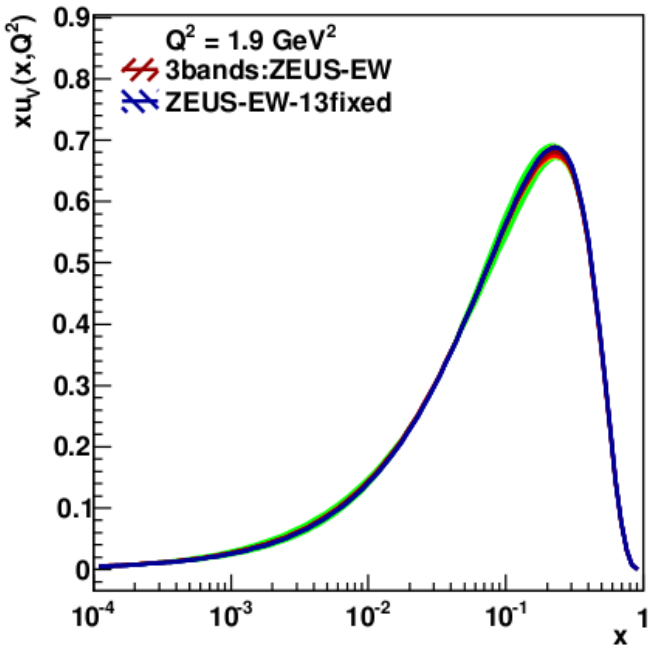


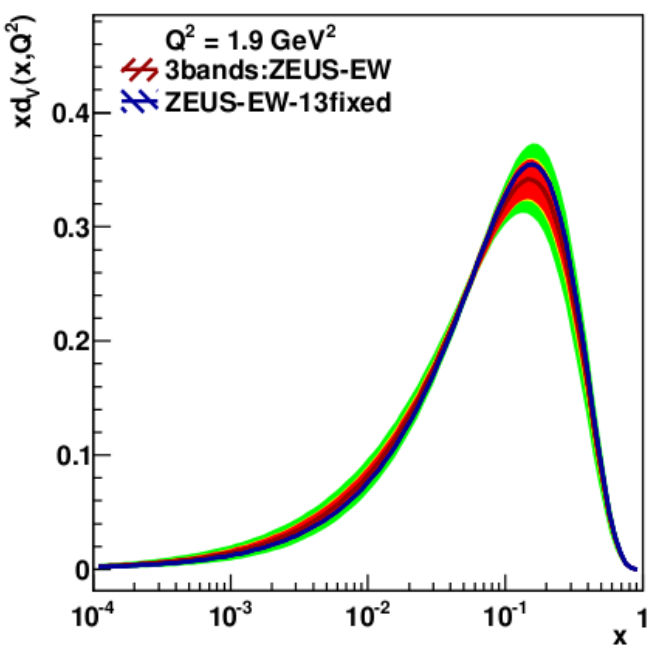


Cross checks

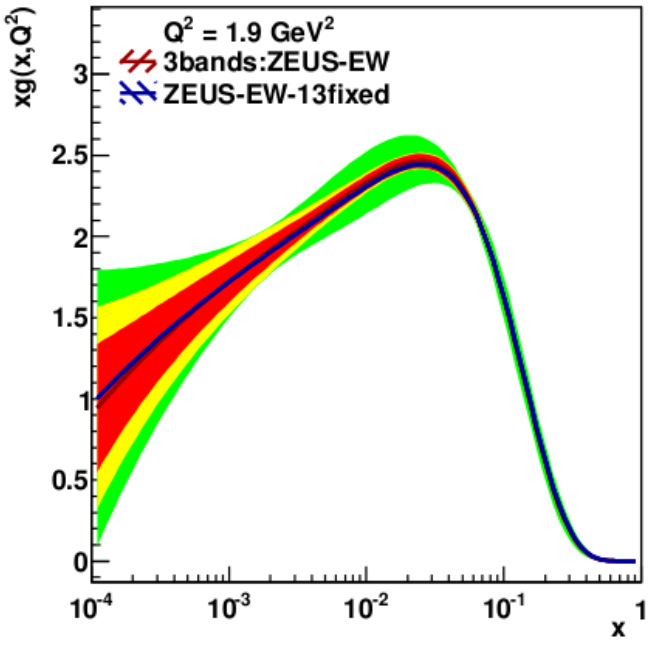
- Check if QCD is decoupled from EW
  - Make ZEUS-13p fit with couplings set to SM values
  - Fix 13 parameters from QCD fit
  - Fit only 4 couplings: ZEUS-EW-13fixed
  - Compare with ZEUS-EW

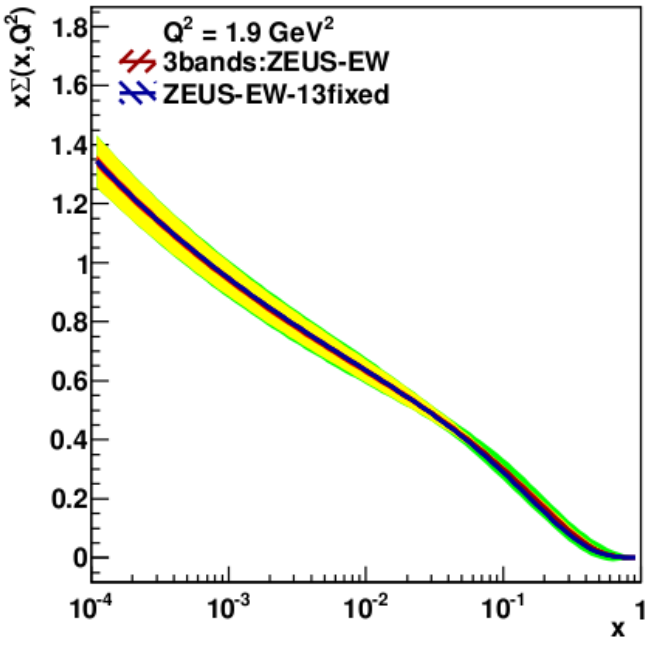
Comparison to ZEUS-EW-13fixed





exp/fit uncertainty
model uncertainty
parameterisation uncertainty





- PDFs agree very well

ZEUS-EW-13fixed: couplings

- ZEUS-EW → experimental uncertainty only

```
Au =  0.490  +0.062 -0.039        SM:  0.5
Ad = -0.665  +0.238 -0.098        SM: -0.5
Vu =  0.150  +0.085 -0.089        SM:  0.196
Vd = -0.301  +0.232 -0.229        SM: -0.346
```

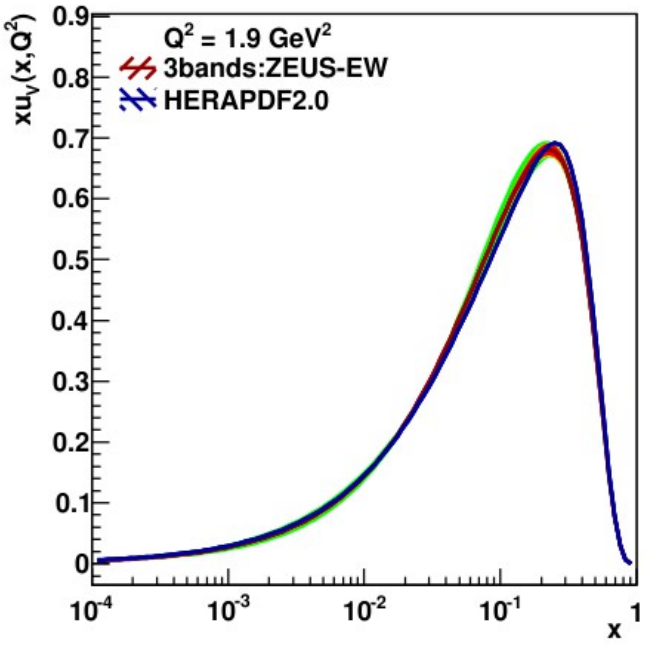
- ZEUS-EW-13fixed → symmetric experimental uncertainty only

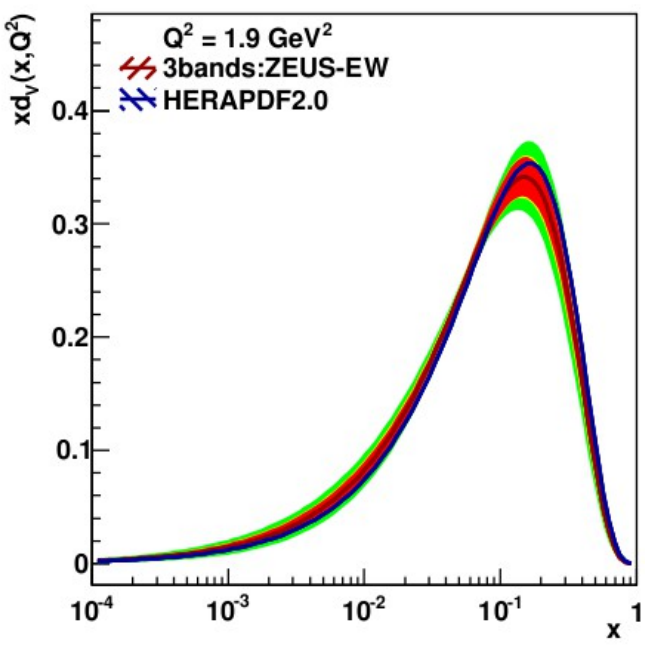
```
Au =  0.477  +/- 0.035
Ad = -0.668  +/- 0.124
Vu =  0.150  +/- 0.083
Vd = -0.299  +/- 0.228
```

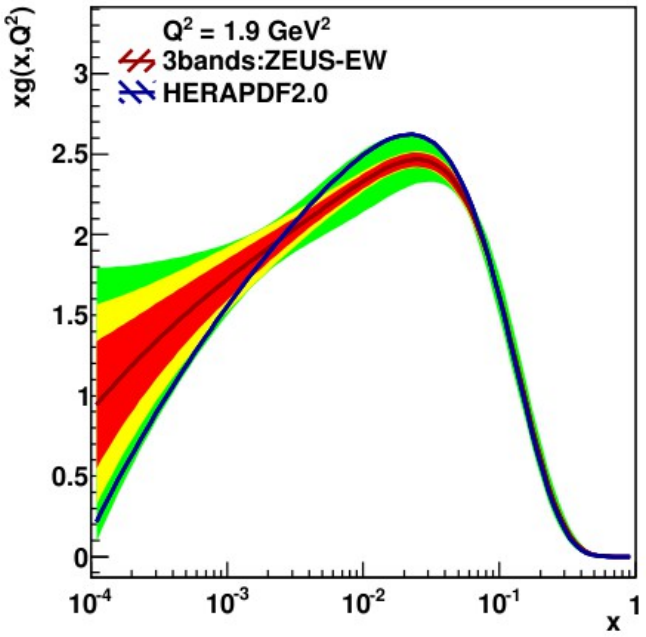
- Fitted couplings agree very well within experimental uncertainties

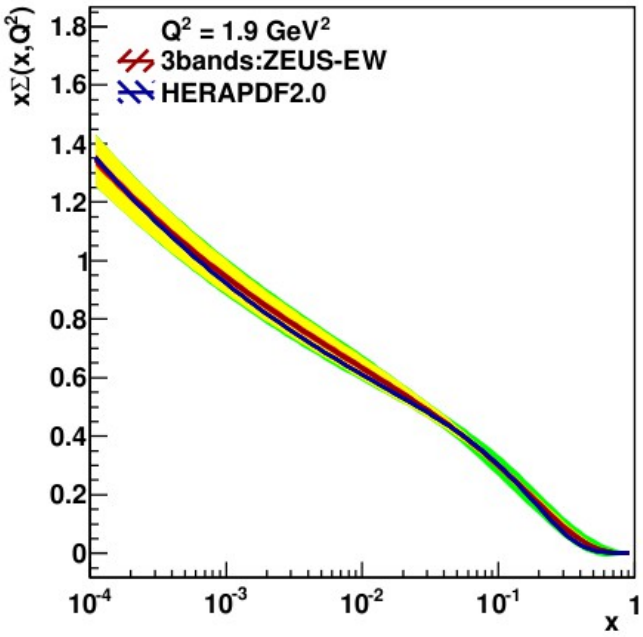
Comparison to HERAPDF2.0

Comparison to HERAPDF2.0





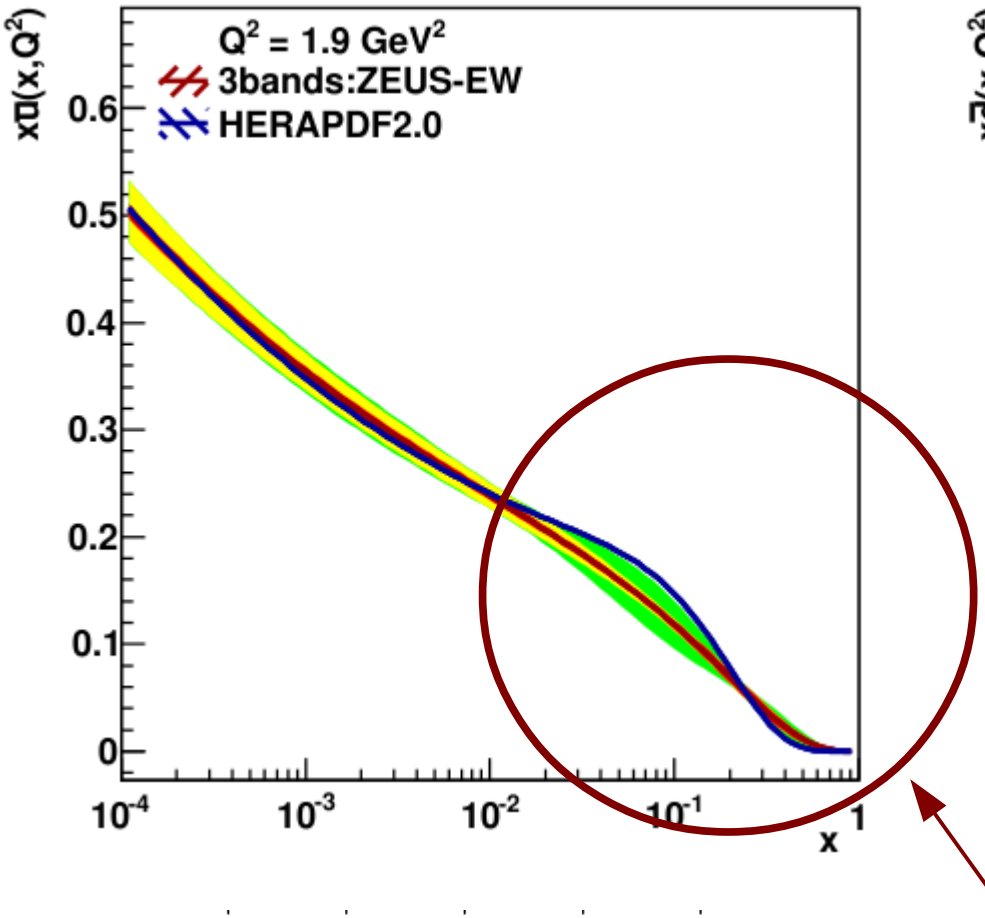


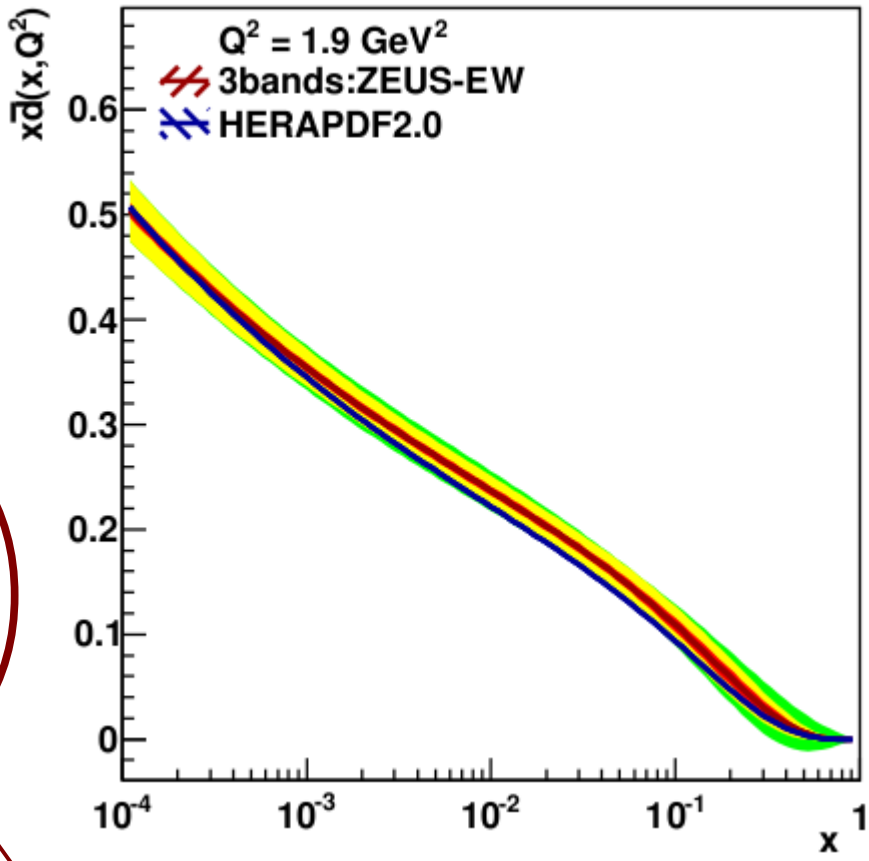


exp/fit uncertainty
model uncertainty
parameterisation uncertainty

- Most important issue – number of parameters in QCD fit

Comparison to HERAPDF2.0





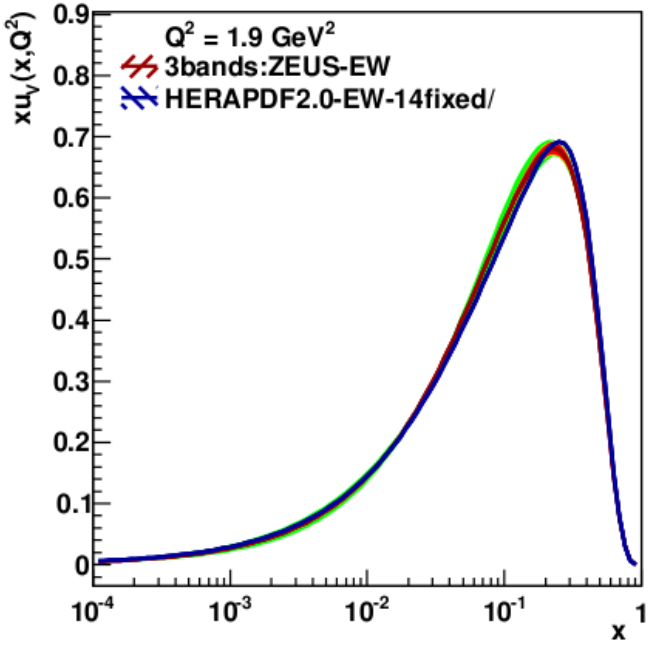
exp/fit uncertainty
model uncertainty
parameterisation uncertainty

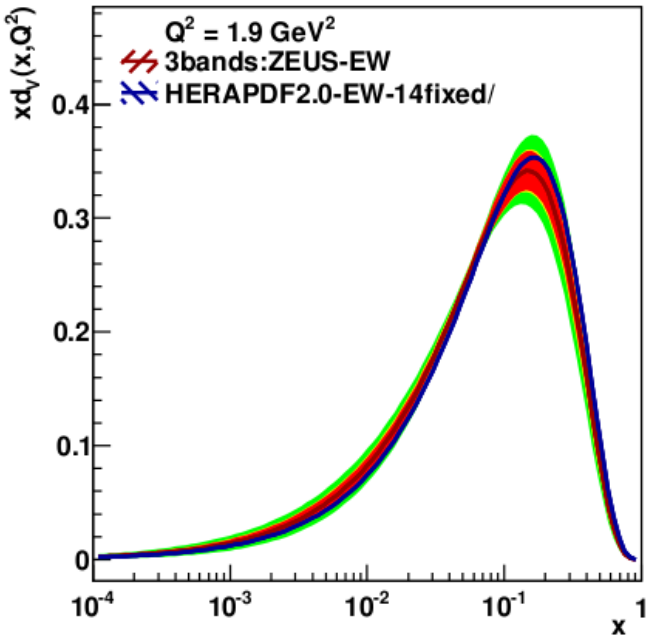
- Most important issue – number of parameters in QCD fit

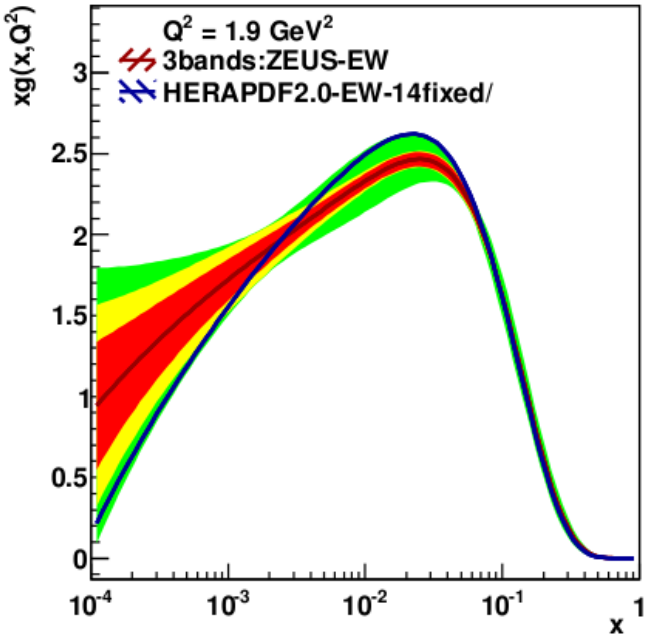
Comparison to HERAPDF2.0

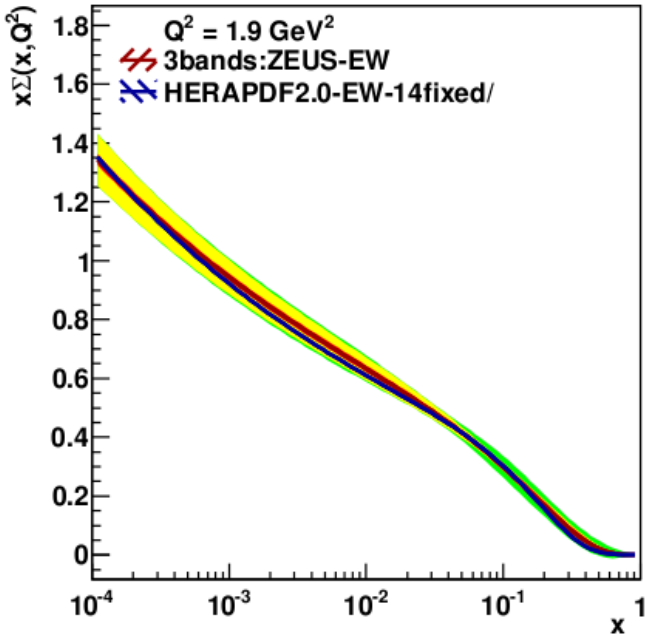
- Fix 14 parameters to HERAPDF2.0 values
  - Fit only 4 couplings: HERAPDF2.0-EW-14fixed
  - Compare with ZEUS-EW

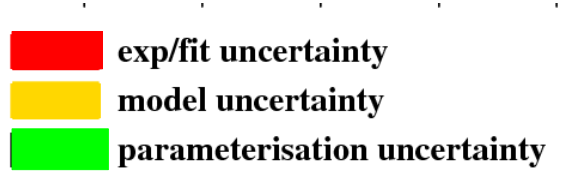
Comparison to HERAPDF2.0-EW-14fixed



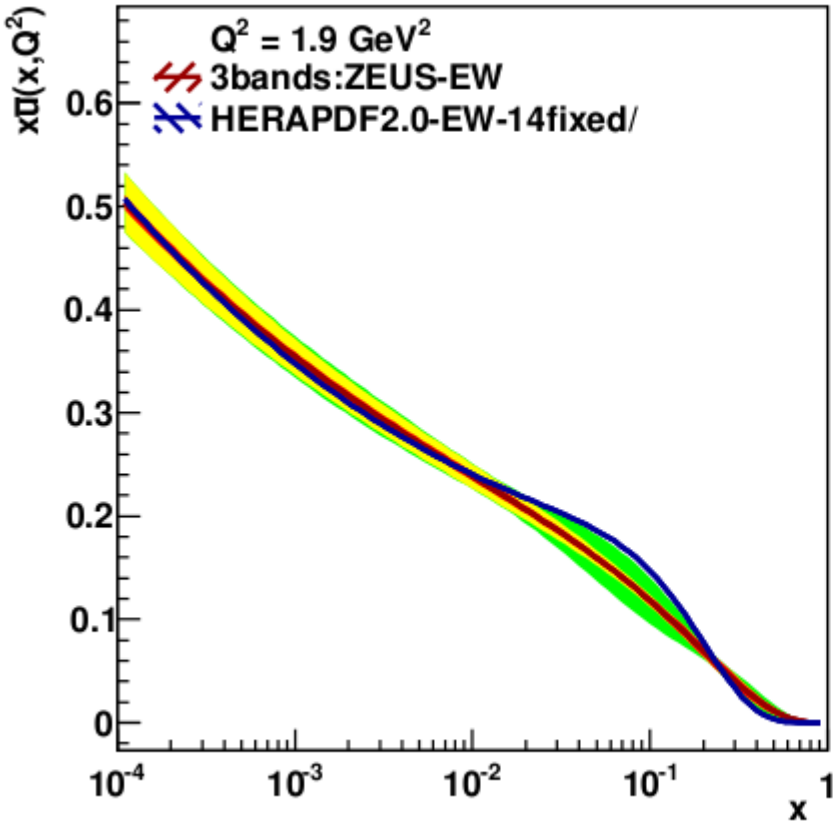


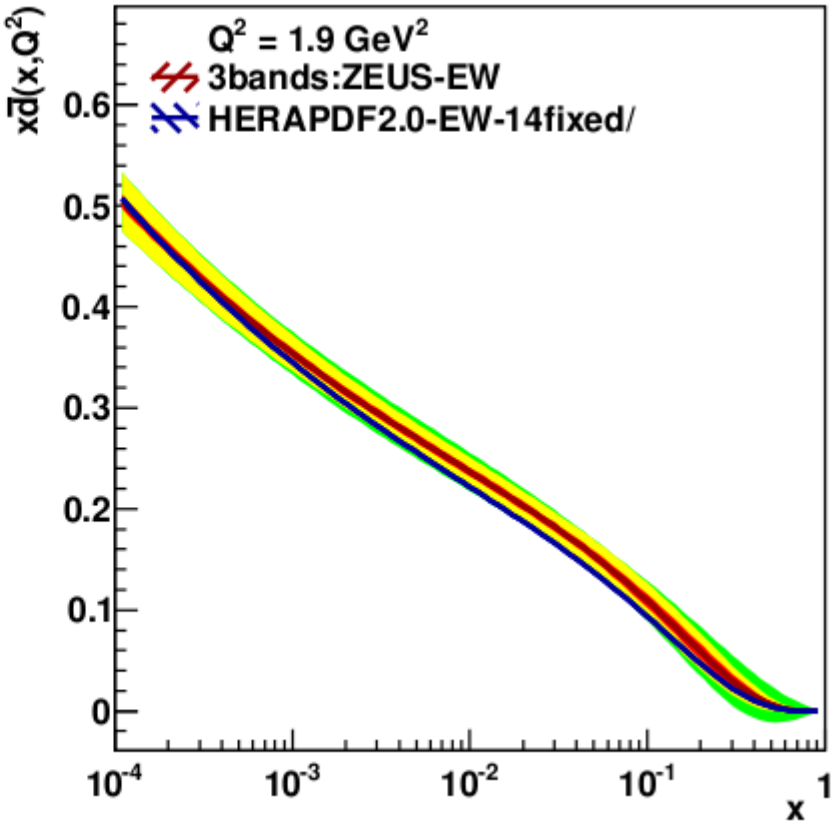






Comparison to HERAPDF2.0-EW-14fixed





exp/fit uncertainty
model uncertainty
parameterisation uncertainty

- Similar effect for 14 parameters seen as for HERAPDF2.0

ZEUS-EW-14fixed: couplings

- ZEUS-EW → experimental uncertainty only

```
Au =  0.490  +0.062 -0.039        SM:  0.5
Ad = -0.665  +0.238 -0.098        SM: -0.5
Vu =  0.150  +0.085 -0.089        SM:  0.196
Vd = -0.301  +0.232 -0.229        SM: -0.346
```

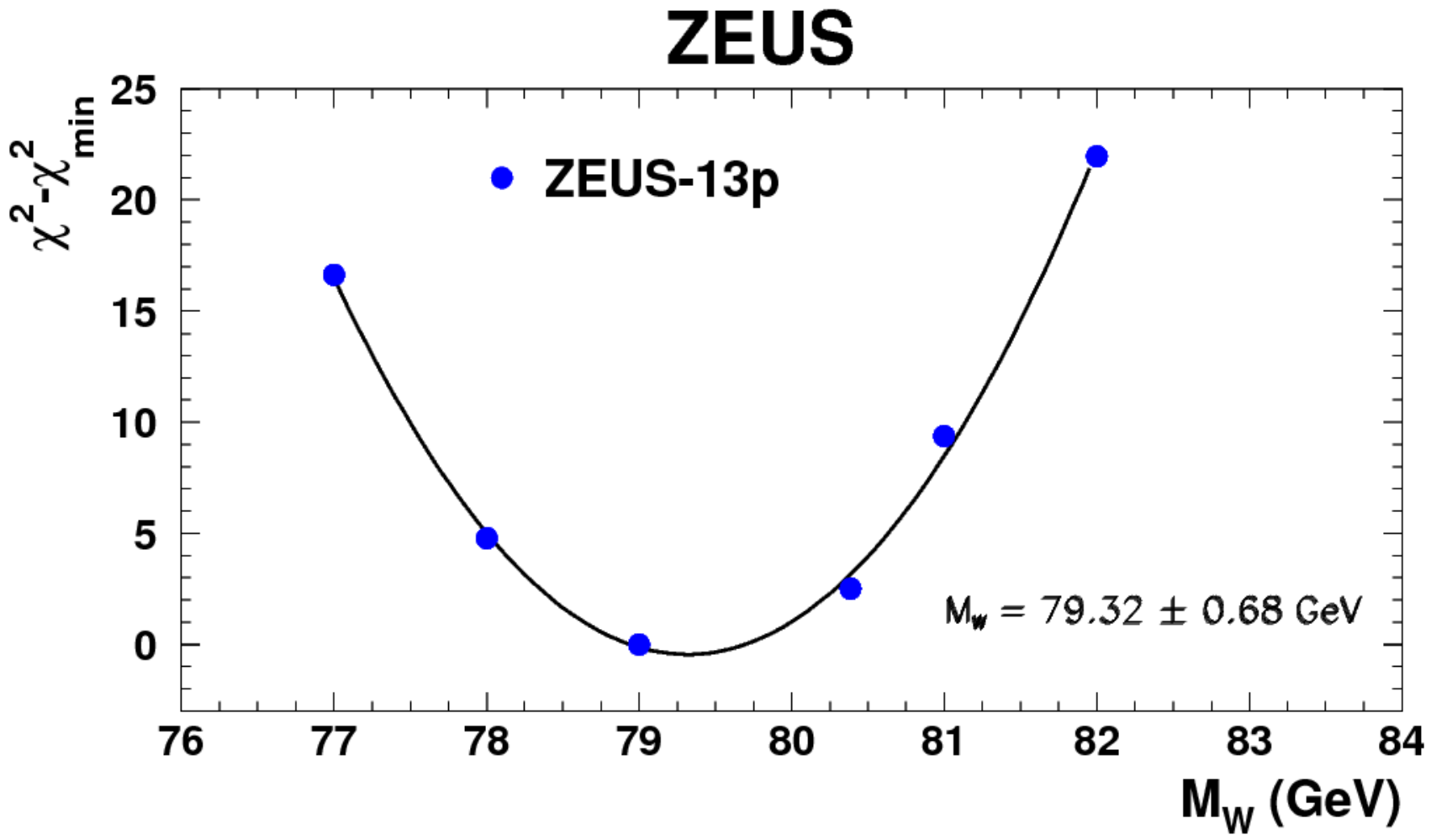
- ZEUS-EW-13fixed → symmetric experimental uncertainty only

```
Au =  0.473  +/- 0.033
Ad = -0.694  +/- 0.109
Vu =  0.153  +/- 0.080
Vd = -0.278  +/- 0.225
```

- Fitted couplings agree very well within experimental uncertainties

Fit of W mass M_W

Fitted M_W



- M_W = 79.32 ± 0.68 GeV (exp. uncertainty, rest will be added)
- PDG14: M_W = 80.385 ± 0.015 GeV (consistent but far less precise)

Outlook

- Analysis well advanced
  - Most results almost final
  - Small adjustments to correlations of systematic uncertainties have to be mage → final data sets
- Plans to publish as ZEUS Collaboration material presented in this talk, maybe with some small additions
- Paper draft almost ready
- We plan to start editorial procedure in november

Backup

```
After minimisation    3273.26  2925     1.119

  Partial chi2s
Dataset    1     60.02( -1.01)    37  ZEUS inclusive CC e-p LH HERA-II data
Dataset    2     38.90( -0.59)    34  ZEUS inclusive CC e-p RH HERA-II data
Dataset    3     21.22( +2.90)    35  ZEUS inclusive CC e+p LH HERA-II data
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Dataset    7    113.45( +3.72)    90  ZEUS inclusive NC e+p LH HERA-II data
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Dataset    9     39.03( +2.67)    29  h1H2-ccemP0.dat
Dataset   10     46.07( +3.36)    29  h1H2-ccepP0.dat
Dataset   11    185.73( +5.82)   151  h1H2-ncemP0.dat
Dataset   12    150.56( +5.77)   150  h1H2-ncepP0.dat
Dataset   13     45.81( +2.05)    23  h1H2fl-lowQ2.dat
Dataset   14     17.47( +0.32)    29  h1H2fl-medQ2.dat
Dataset   17     21.01( +0.35)    25  h1_ccep.dat
Dataset   18     29.73( +0.11)    28  h1_ccep00.dat
Dataset   19     18.94( -0.39)    29  z_zcceps2.dat
Dataset   20     17.32( +0.84)    28  h1_ccem.dat
Dataset   21     22.52( +0.58)    26  z_zccems2.dat
Dataset   22    111.14( +4.19)   126  h1_cnem.dat
Dataset   23      6.51( +0.68)    13  h1_cnemfl.dat
Dataset   24     46.63( +0.73)    92  z_zncems2.dat
Dataset   25      3.98( +0.34)     8  h1_95-00lo.dat
Dataset   26     55.77( +1.16)    50  h1_95-00hi.dat
Dataset   27     11.39( +0.35)    15  h1_969700lo.dat
Dataset   28     97.79( -1.28)    84  h1_969700hi.dat
Dataset   29     90.44( +1.42)   130  h1_cnep.dat
Dataset   30    141.00( +2.06)   147  h1_cnep00.dat
Dataset   31    181.48( +2.98)   162  z_zncephs2.dat
Dataset   32     94.44( -0.61)    75  z_zncepls2.dat
Dataset   33     77.08( +1.13)    90  z_zncep00s2.dat
Dataset   34     32.18( +0.87)    30  z_zccep00s2.dat
Dataset   35     55.29( +0.43)    25  z_svx95.dat
Dataset   36    106.39( -4.11)    79  ZEUS_FL_LER_nominal
Dataset   37     84.05( +3.07)    84  ZEUS_FL_LER_satellite
Dataset   38     69.77( -0.04)    79  ZEUS_FL_HER_nominal
Dataset   39     81.85( -0.04)    85  ZEUS_FL_HER_satellite
Dataset   40     58.30( +1.56)    66  h1H2-460.dat
Dataset   41    116.01( -1.84)    98  h1hq2fl-Ep460-P0.dat
Dataset   42     98.73( +1.50)    85  h1H2-575.dat
Dataset   43     89.24( +0.03)   118  h1hq2fl-Ep575-P0.dat
Dataset   44     65.27( -2.09)    76  ZEUS_FL_MER_nominal
Dataset   45     77.35( -0.86)    77  ZEUS_FL_MER_satellite

 Correlated Chi2    124.70136760059260
 Log penalty Chi2    46.756976800099608
 Systematic shifts          169
```
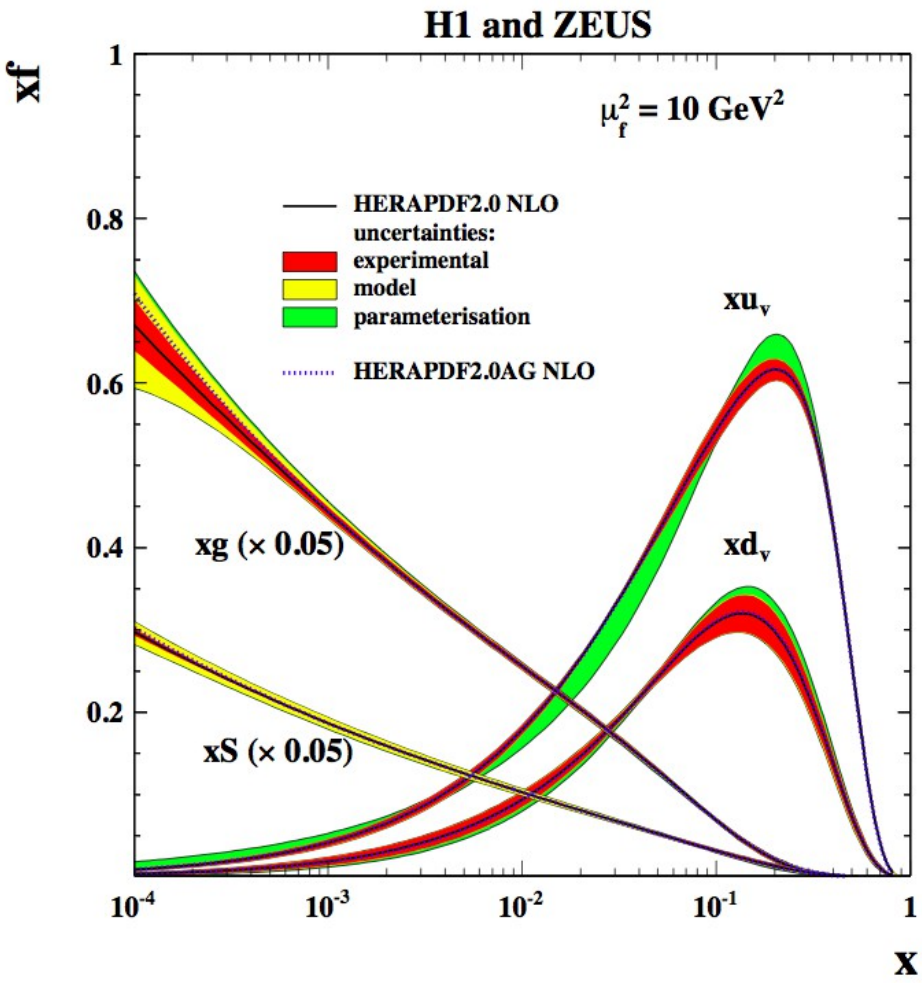

Color decomposition of uncertainties

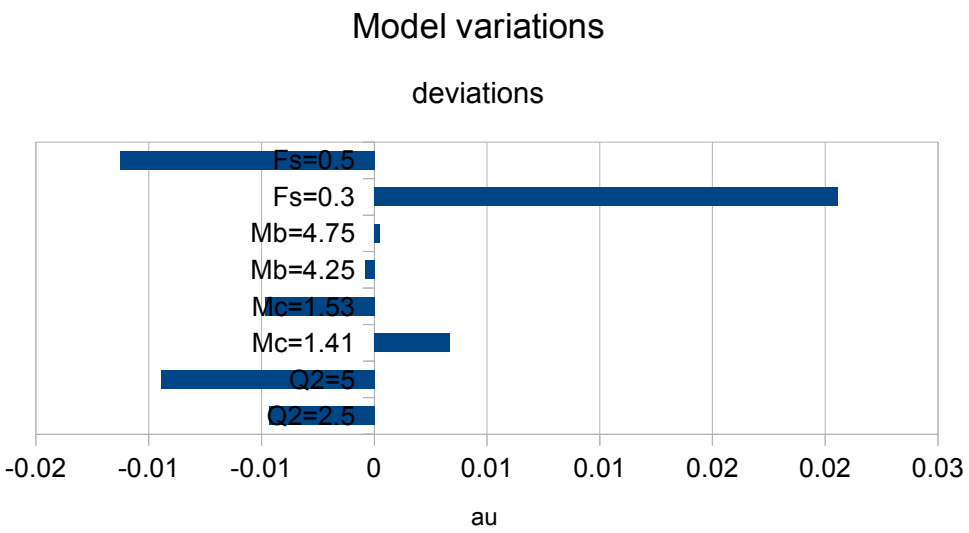


- Experimental uncertainties:
  - Hessian method
  - Conventional $\Delta\chi^2 = 1$ => 68% CL

Variation	Standard Value	Lower Limit	Upper Limit
Q^2_{min} [GeV^2]	3.5	2.5	5.0
Q^2_{min} [GeV^2] HiQ2	10.0	7.5	12.5
M_c(NLO) [GeV]	1.47	1.41	1.53
M_c (NNLO) [GeV]	1.43	1.37	1.49
M_b [GeV]	4.5	4.25	4.75
f_s	0.4	0.3	0.5
μ_{f_0} [GeV]	1.9	1.6	2.2

Adding D and E parameters to each PDF

- Parametrisation uncertainties
  - largest deviation
- Model uncertainties
  - all variations added in quadrature


Model variations
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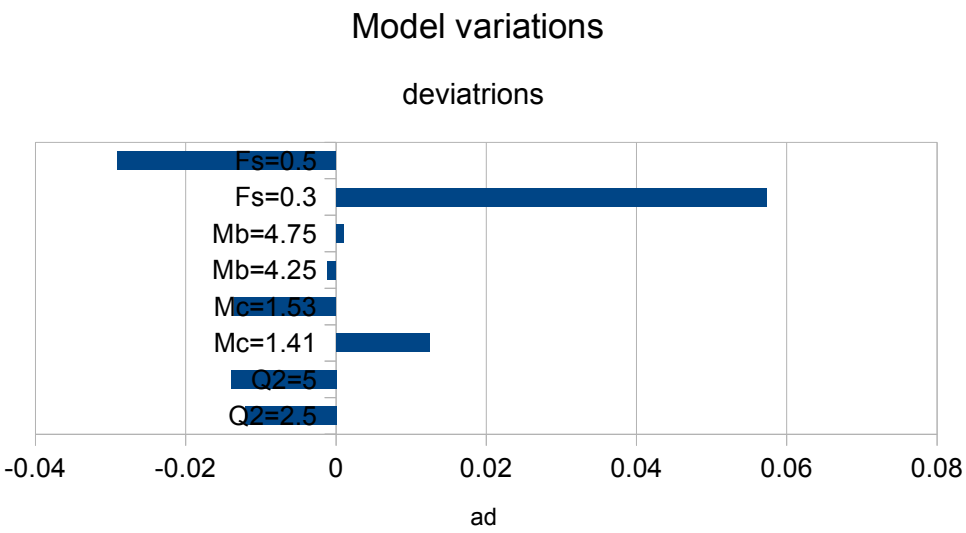
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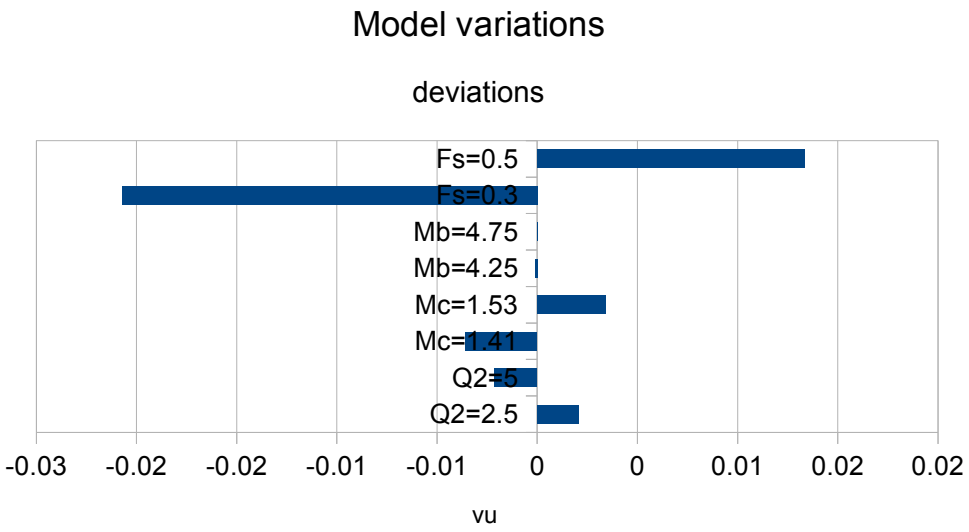
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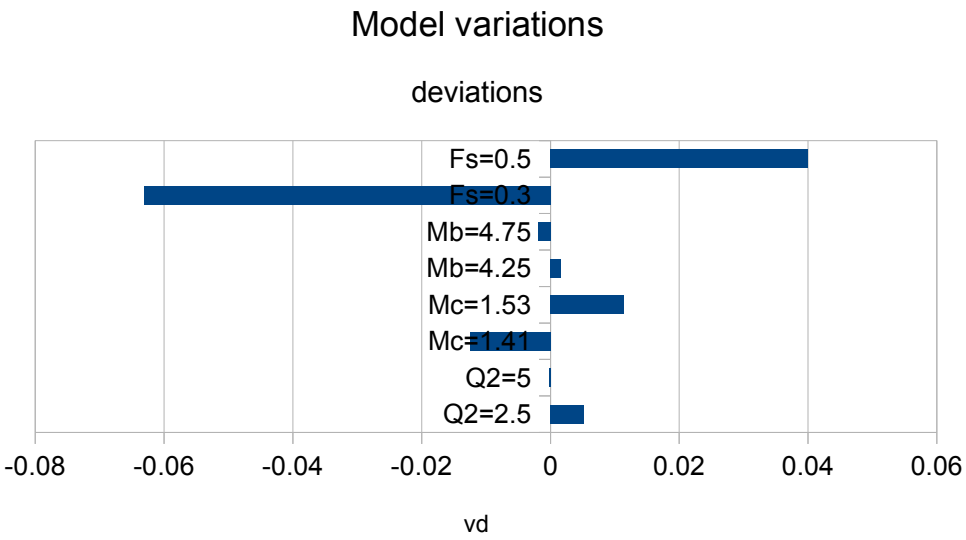
Model variations
deviations
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Mb=4.75
Mb=4.25
Mc=1.53
Mc=1.41
Q2=5
Q2=2.5
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-0.02
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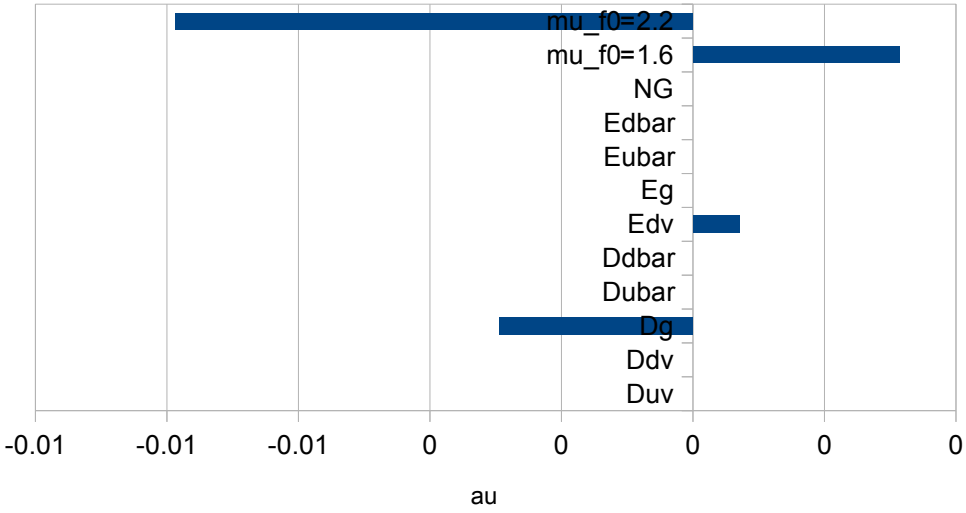
0.04
0.06
vd

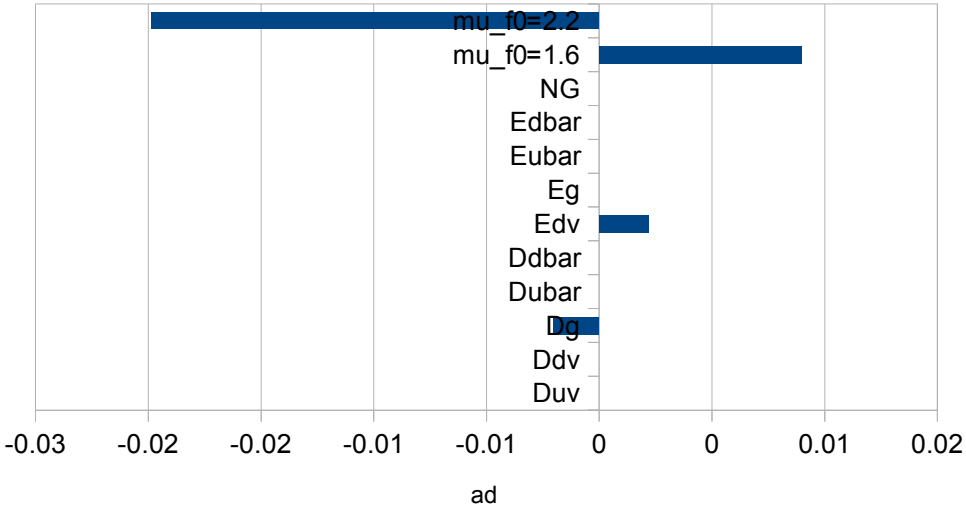
Parameterisation variations

deviations



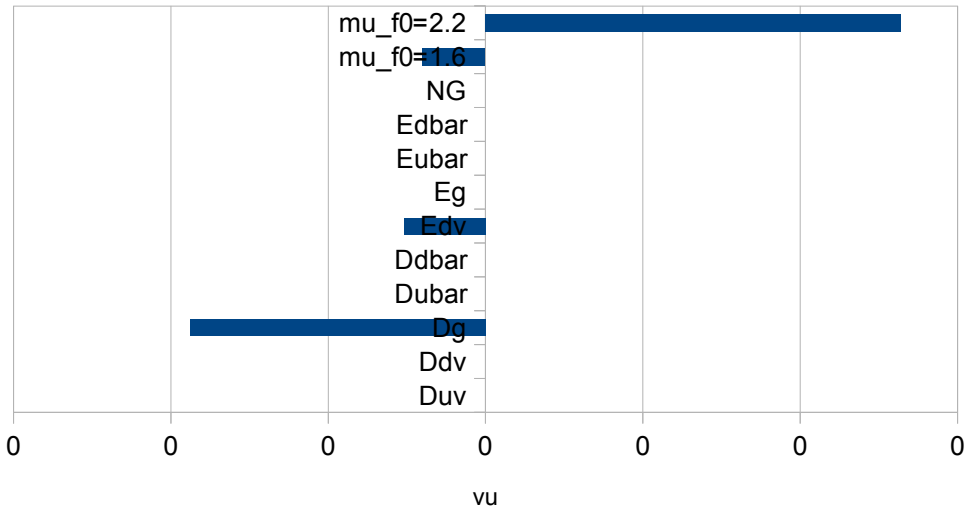
Parameterisation variations

deviations



Parameterisation variations

deviations



Parameterisation variations

deviations