A_PV Impact Assessment by reweighting NNPDF

Ciprian Gal, Hanjie Liu, and Jinlong Zhang

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Inputs

- Pseudo-data:
  - Y. X. Zhao et al.: Eur. Phys. J. A (2017) 53: 55
- PDF replicas:
  - NNPDF2.3 and NNPDFpol1.1
- Methodology
  - Reweighting: NNPDF collaboration, Nucl. Phys. B849 (2011) 112-143

Pseudo-data

- e-p 10x100, 10x250, 15x100, 15x250; Integral luminosity: 500 fb^-1
- Polarization: 80% for electron, 70% for hadron

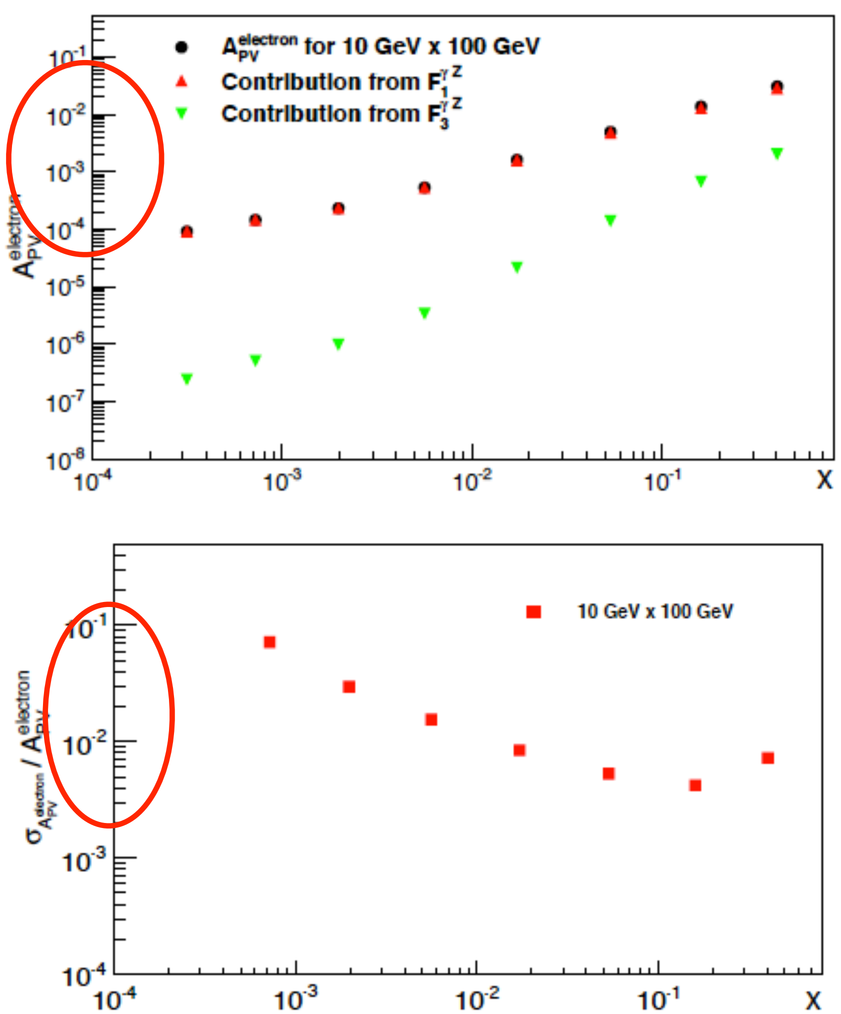


Fig. 2: (Color Online) The predicted relative uncertainty for the measured asymmetry vs. x with 10 GeV longitudinally polarized electron on 100 GeV unpolarized proton. The integrated luminosity of 500 fb^{-1} and electron beam polarization of 80% are assumed.

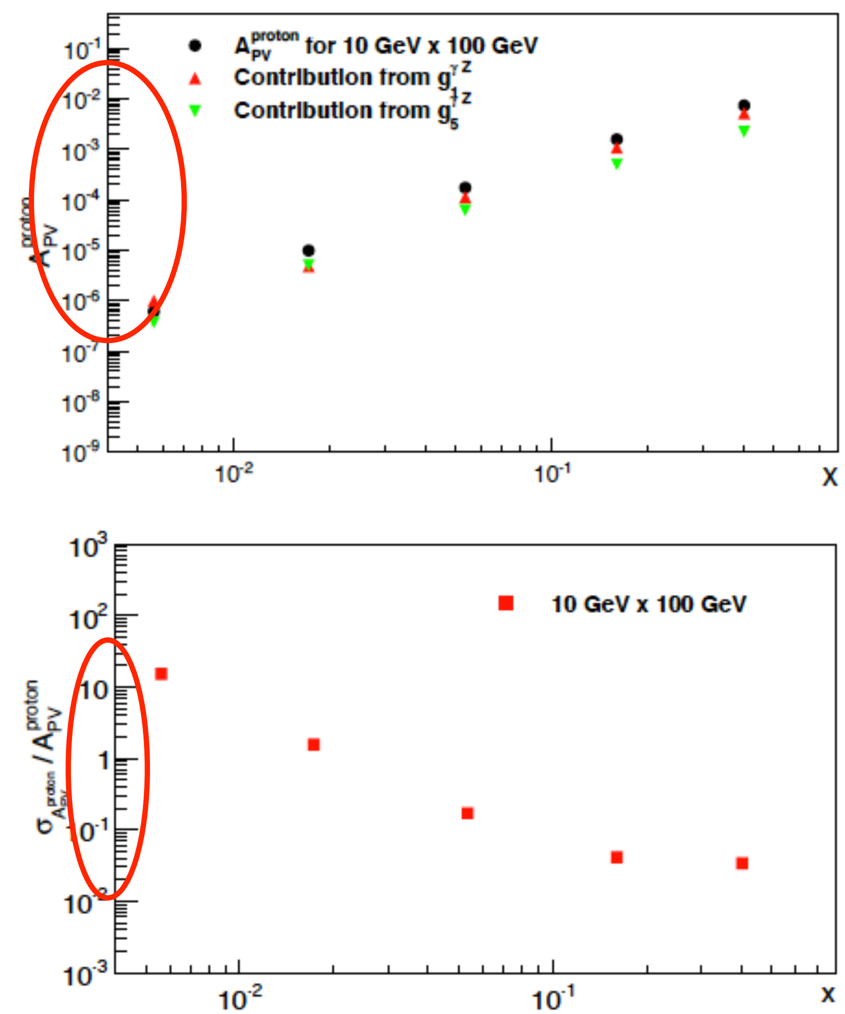


Fig. 4: (Color Online) The predicted relative uncertainty for the measured asymmetry vs. x with 10 GeV unpolarized electron on 100 GeV longitudinally polarized proton. The integrated luminosity of 500 fb^{-1} and proton beam polarization of 70% are assumed.

Eur. Phys. J. A (2017) 53: 55

$\log_{10}(Q^2)$ bin	$\log_{10}(x)$ bin	$\langle Q^2 \rangle$ (GeV^2)	$\langle x \rangle$	y coverage	$\frac{\sigma_{g_1^{\gamma Z}}}{g_1^{\gamma Z}}$	$\langle g_1^{\gamma Z} \rangle$	$\frac{\sigma_{g_5^{\gamma Z}}}{g_5^{\gamma Z}}$	$\langle g_5^{\gamma Z} \rangle$
(0.0, 0.4)	(-4.0, -3.5)	1.5e+00	2.4e-04	(0.32, 0.81)	-1.1e+02	-7.8e+00	8.4e+03	1.0e+00
(0.0, 0.4)	(-3.5, -3.0)	1.8e+00	6.0e-04	(0.10, 0.79)	-4.7e+01	-3.6e+00	2.0e+03	4.5e-01
(0.0, 0.4)	(-3.0, -2.5)	2.0e+00	1.4e-03	(0.10, 0.25)	-3.0e+02	-1.5e+00	4.3e+03	2.0e-01
(0.4, 0.8)	(-4.0, -3.5)	2.5e+00	3.1e-04	(0.79, 0.81)	-1.7e+06	-5.8e+00	1.3e+08	9.2e-01
(0.4, 0.8)	(-3.5, -3.0)	4.0e+00	7.2e-04	(0.25, 0.82)	-5.8e+01	-2.8e+00	2.6e+03	5.9e-01
(0.4, 0.8)	(-3.0, -2.5)	4.5e+00	1.9e-03	(0.10, 0.63)	-4.6e+01	-1.1e+00	5.5e+02	3.9e-01
(0.4, 0.8)	(-2.5, -2.0)	5.2e+00	4.1e-03	(0.10, 0.20)	-6.6e+02	-4.1e-01	1.2e+03	3.7e-01
(0.8, 1.2)	(-3.5, -3.0)	6.9e+00	9.2e-04	(0.63, 0.82)	-1.1e+03	-2.1e+00	4.3e+04	6.4e-01
(0.8, 1.2)	(-3.0, -2.5)	1.0e+01	2.1e-03	(0.20, 0.84)	-3.2e+01	-9.4e-01	4.5e+02	5.8e-01
(0.8, 1.2)	(-2.5, -2.0)	1.1e+01	5.7e-03	(0.10, 0.50)	-6.3e+01	-2.5e-01	9.6e+01	5.4e-01
(0.8, 1.2)	(-2.0, -1.5)	1.4e+01	1.2e-02	(0.10, 0.16)	-5.5e+04	-3.2e-03	4.8e+02	5.9e-01
(1.2, 1.6)	(-3.0, -2.5)	2.0e+01	2.7e-03	(0.50, 0.87)	-1.7e+02	-6.3e-01	1.8e+03	6.8e-01
(1.2, 1.6)	(-2.5, -2.0)	2.7e+01	6.1e-03	(0.16, 0.90)	-2.7e+01	-1.9e-01	6.1e+01	6.9e-01
(1.2, 1.6)	(-2.0, -1.5)	2.9e+01	1.7e-02	(0.10, 0.40)	7.2e+01	6.8e-02	1.8e+01	7.0e-01
(1.2, 1.6)	(-1.5, -1.0)	3.7e+01	3.4e-02	(0.10, 0.13)	1.2e+03	1.6e-01	3.8e+02	7.4e-01
(1.6, 2.0)	(-2.5, -2.0)	6.1e+01	7.9e-03	(0.40, 1.0)	-1.3e+02	-5.5e-02	1.0e+02	8.1e-01
(1.6, 2.0)	(-2.0, -1.5)	7.0e+01	1.9e-02	(0.13, 1.0)	9.3e+00	1.0e-01	8.4e+00	8.0e-01
(1.6, 2.0)	(-1.5, -1.0)	7.5e+01	4.9e-02	(0.10, 0.32)	8.7e+00	1.8e-01	4.5e+00	7.6e-01
(2.0, 2.4)	(-2.0, -1.5)	1.6e+02	2.2e-02	(0.32, 1.0)	6.1e+00	1.5e-01	1.2e+01	8.7e-01
(2.0, 2.4)	(-1.5, -1.0)	1.7e+02	5.8e-02	(0.10, 0.79)	1.1e+00	2.0e-01	1.5e+00	7.8e-01
(2.0, 2.4)	(-1.0, -0.5)	1.9e+02	1.4e-01	(0.10, 0.25)	3.4e+00	1.8e-01	2.1e+00	5.6e-01
(2.4, 2.8)	(-2.0, -1.5)	2.8e+02	2.9e-02	(0.80, 1.0)	1.3e+02	1.9e-01	3.5e+02	8.9e-01
(2.4, 2.8)	(-1.5, -1.0)	4.1e+02	6.3e-02	(0.25, 1.0)	5.7e-01	2.1e-01	1.7e+00	7.9e-01
(2.4, 2.8)	(-1.0, -0.5)	4.4e+02	1.7e-01	(0.10, 0.63)	3.2e-01	1.6e-01	4.5e-01	4.8e-01
(2.4, 2.8)	(-0.5, 0.0)	5.1e+02	3.8e-01	(0.10, 0.20)	4.1e+00	6.0e-02	2.7e+00	1.6e-01
(2.8, 3.2)	(-1.5, -1.0)	7.6e+02	8.5e-02	(0.64, 1.0)	3.1e+00	2.2e-01	1.2e+01	7.2e-01
(2.8, 3.2)	(-1.0, -0.5)	1.1e+03	1.8e-01	(0.20, 1.0)	1.2e-01	1.5e-01	4.2e-01	4.5e-01
(2.8, 3.2)	(-0.5, 0.0)	1.1e+03	4.2e-01	(0.10, 0.49)	3.7e-01	4.7e-02	5.7e-01	1.3e-01
(3.2, 3.6)	(-1.0, -0.5)	2.1e+03	2.5e-01	(0.51, 1.0)	3.2e-01	1.1e-01	1.4e+00	3.0e-01
(3.2, 3.6)	(-0.5, 0.0)	2.7e+03	4.2e-01	(0.20, 1.0)	9.5e-02	4.3e-02	3.7e-01	1.2e-01
(3.6, 4.0)	(-0.5, 0.0)	5.1e+03	5.7e-01	(0.59, 1.0)	4.6e-01	1.3e-02	2.2e+00	3.4e-02

Table 7: Anticipated sensitivities of $g_1^{\gamma Z}$ and $g_5^{\gamma Z}$ functions for individual bins in the (Q^2, x) plane. The projections are for the 10 GeV unpolarized electron beam on the 250 GeV longitudinally polarized proton beam. The first two columns define the $(\log_{10}(Q^2), \log_{10}(x))$ two dimensional bins. The $\langle Q^2 \rangle$ and $\langle x \rangle$ are the $f^2(Q^2)$ weighted (as discussed in Sec. 3) mean values in each bin. The y coverage for the bin is also tabulated. The $\langle g_1^{\gamma Z} \rangle$ and $\langle g_5^{\gamma Z} \rangle$ are the predicted mean values for the structure functions. The $\frac{\sigma_{g_1^{\gamma Z}}}{g_1^{\gamma Z}}$ and $\frac{\sigma_{g_5^{\gamma Z}}}{g_5^{\gamma Z}}$ are the projected relative uncertainties. The cuts mentioned in Sec. 3 are applied to the data.

Reweighting NNPDF replicas

NNPDF collaboration, Nucl. Phys. B849 (2011) 112-143

- Assess impact of new (pseudo-)data by commonly used reweighting methods
  - Observables replicas from PDF replicas
  - Pseudo-data central value smeared
- Challenge: only limited number of replicas available

$$\mathcal{P}(f|y)\mathcal{D}f = \frac{\mathcal{P}(y|f)}{\mathcal{P}(y)}\mathcal{P}(f)\mathcal{D}(f)$$

y: EIC (pseudo-) data
f: PDFs

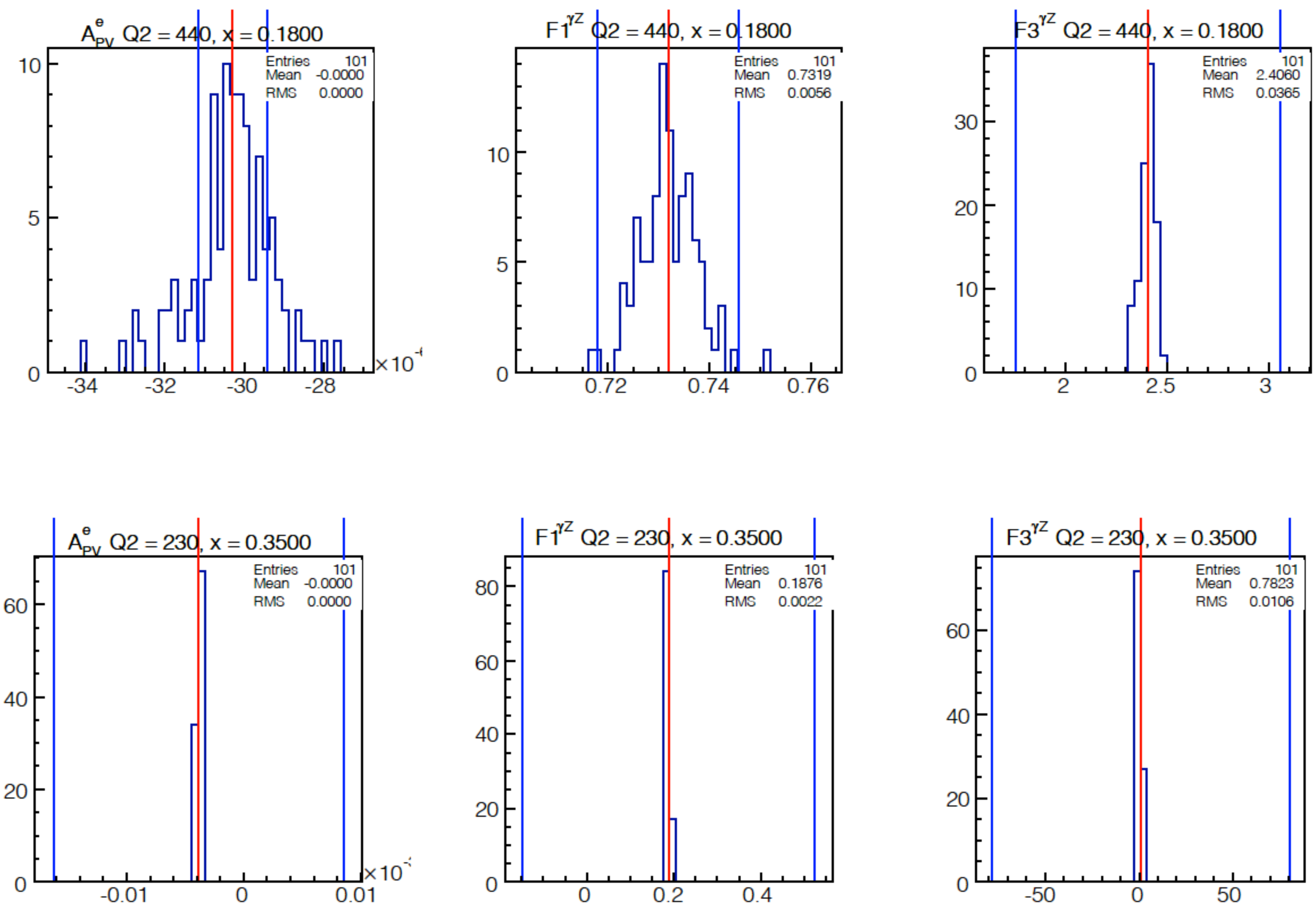
$$\omega_k = \mathcal{N}_\chi (\chi^2_k)^{(n-1)/2} e^{-\frac{1}{2}\chi^2_k}$$

$$\mathcal{N}_\chi = \frac{1}{N}\sum_{k=1}^{N} (\chi^2_k)^{(n-1)/2} e^{-\frac{1}{2}\chi^2_k}$$

χ^2_k: between pseudo-data and prediction from PDFs

$$\chi^2(y, f) = \sum_{i,j=1}^{n} (y_i - y_i[f])\sigma^{-1}_{ij}(y_j - y_j[f]).$$

A^{e}_{PV}: Impactful vs non-impactful bins



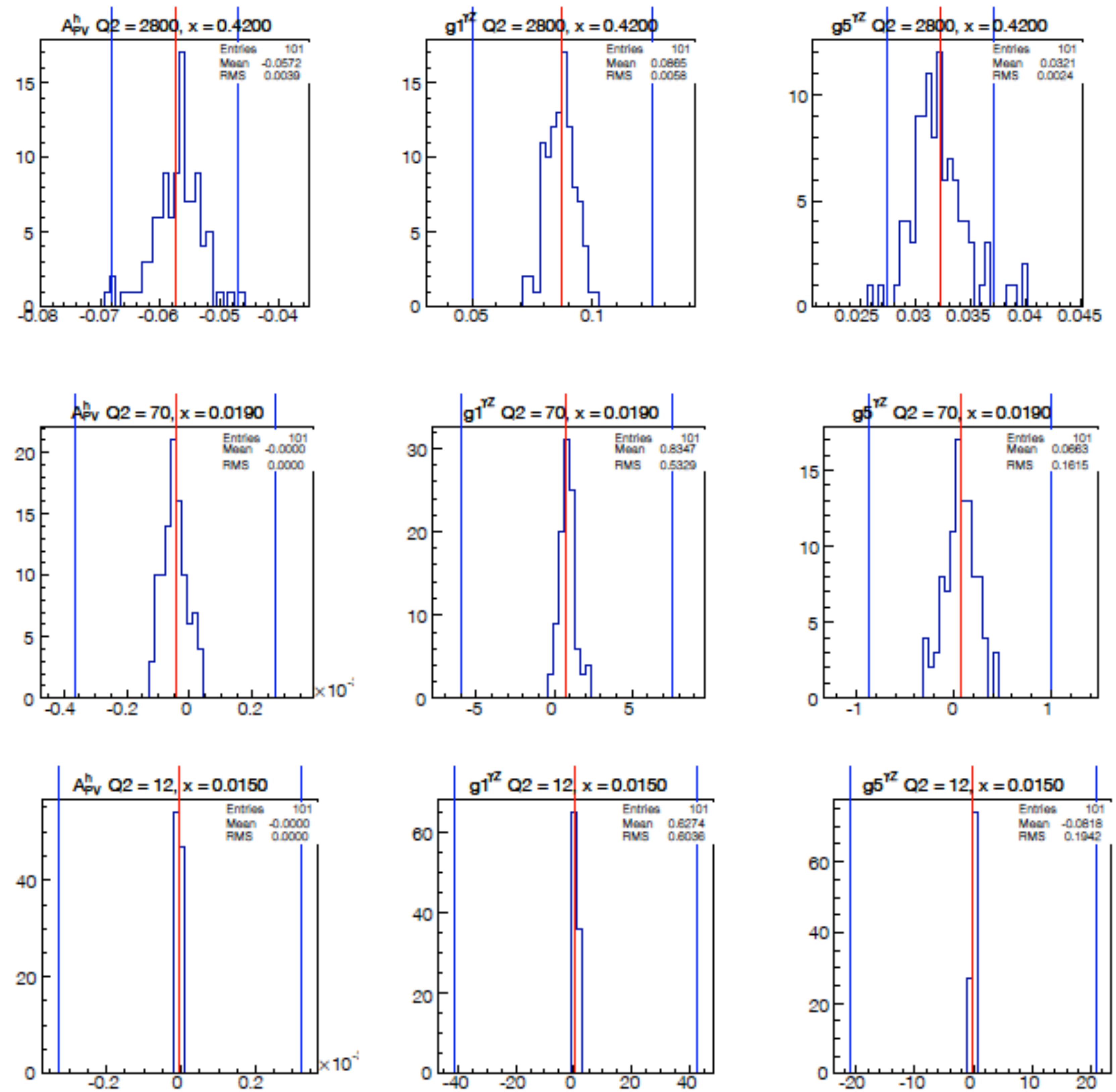
Red line: central value; blue lines: uncertainties from Yuxiang's table

A_{PV}^{h}: Impactful vs non-impactful bins

Best only few

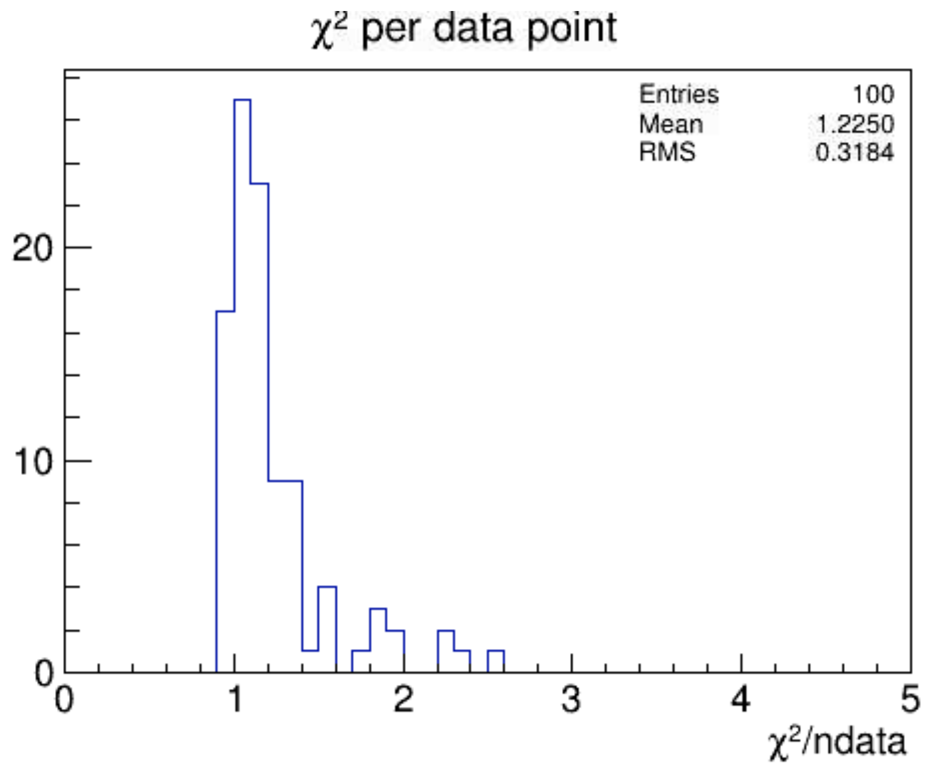
Normal

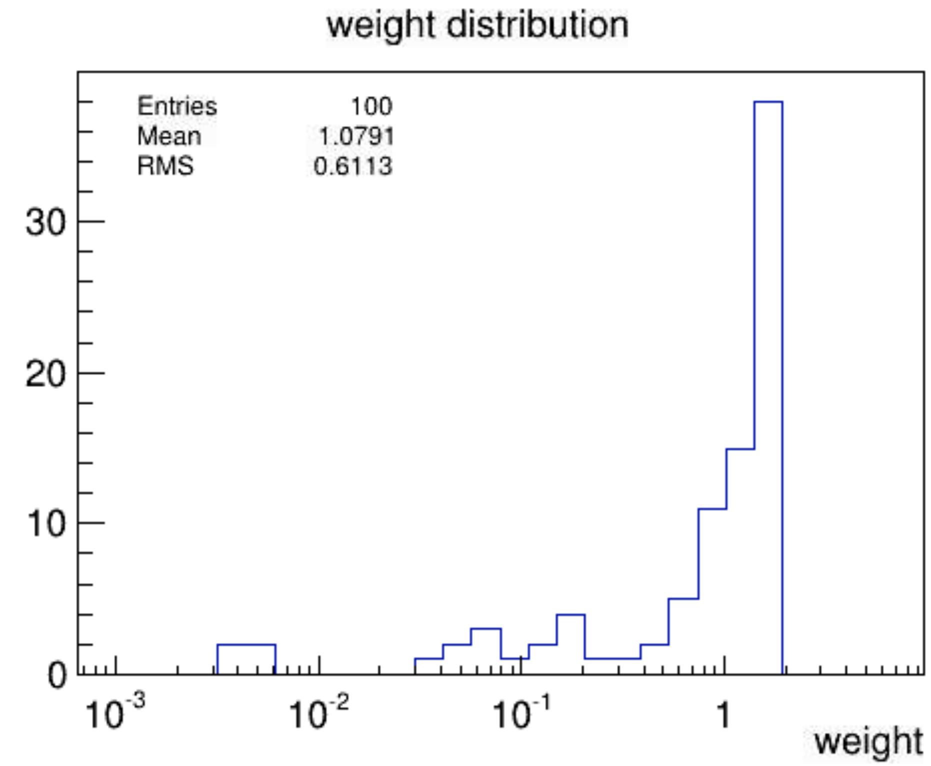
Useless but a lot



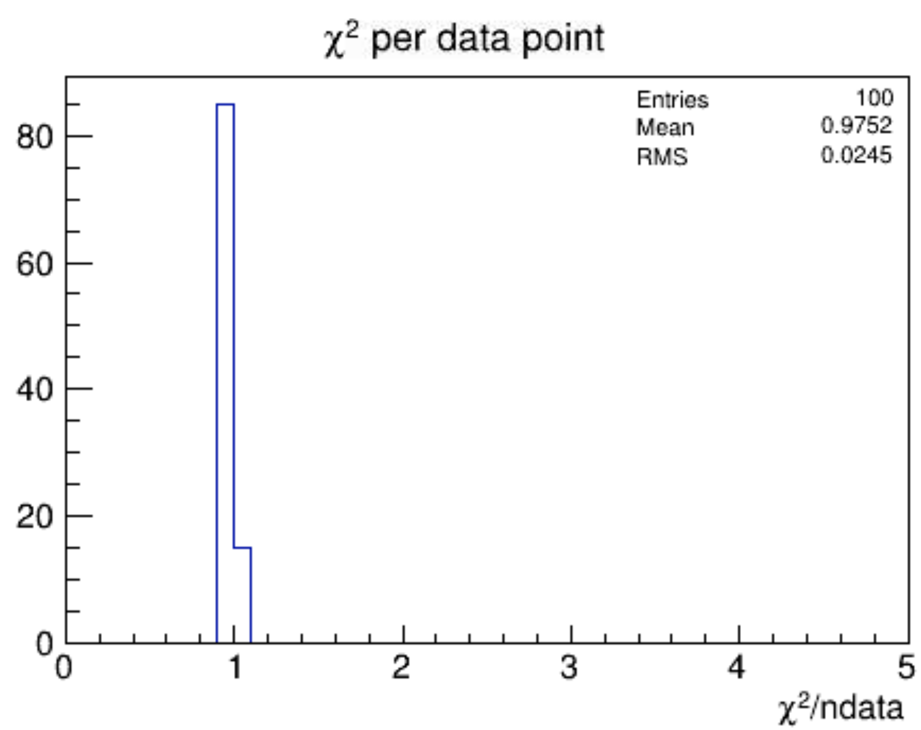
Chi2 and weights

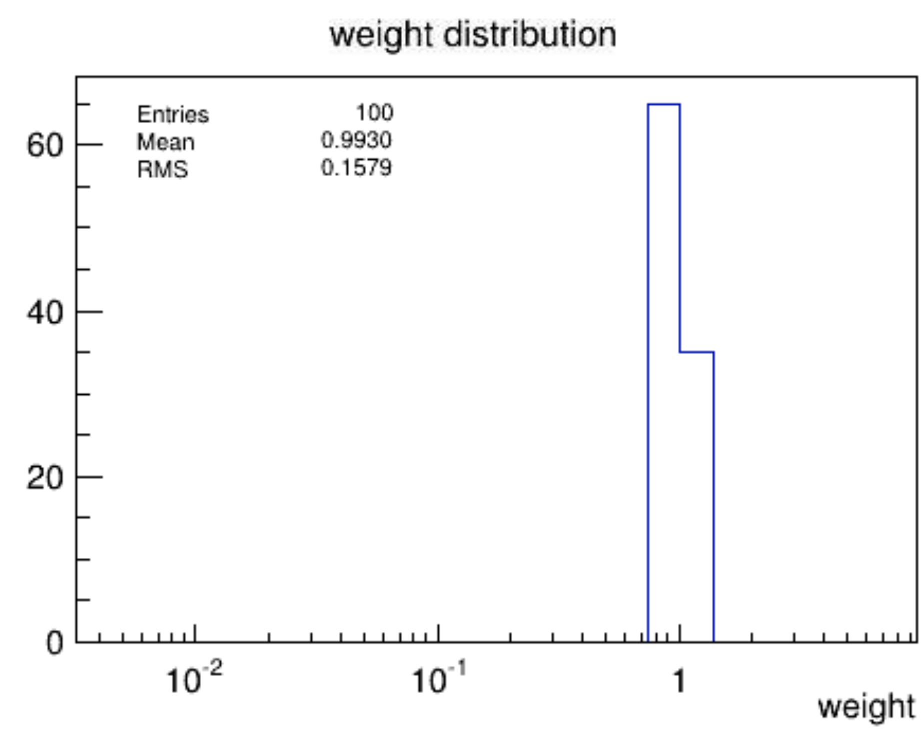
A^{e}_{PV}



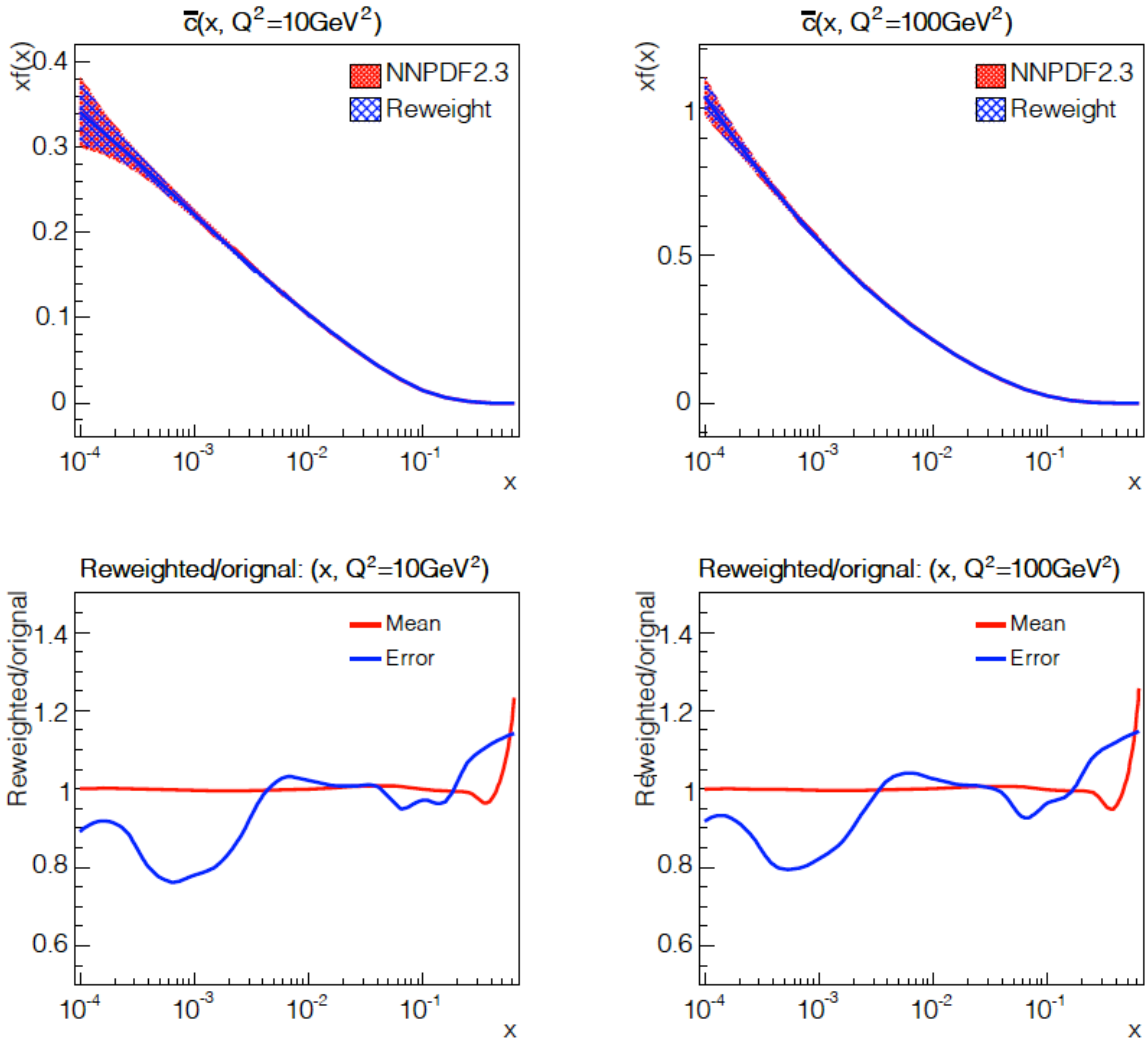


A^{h}_{PV}

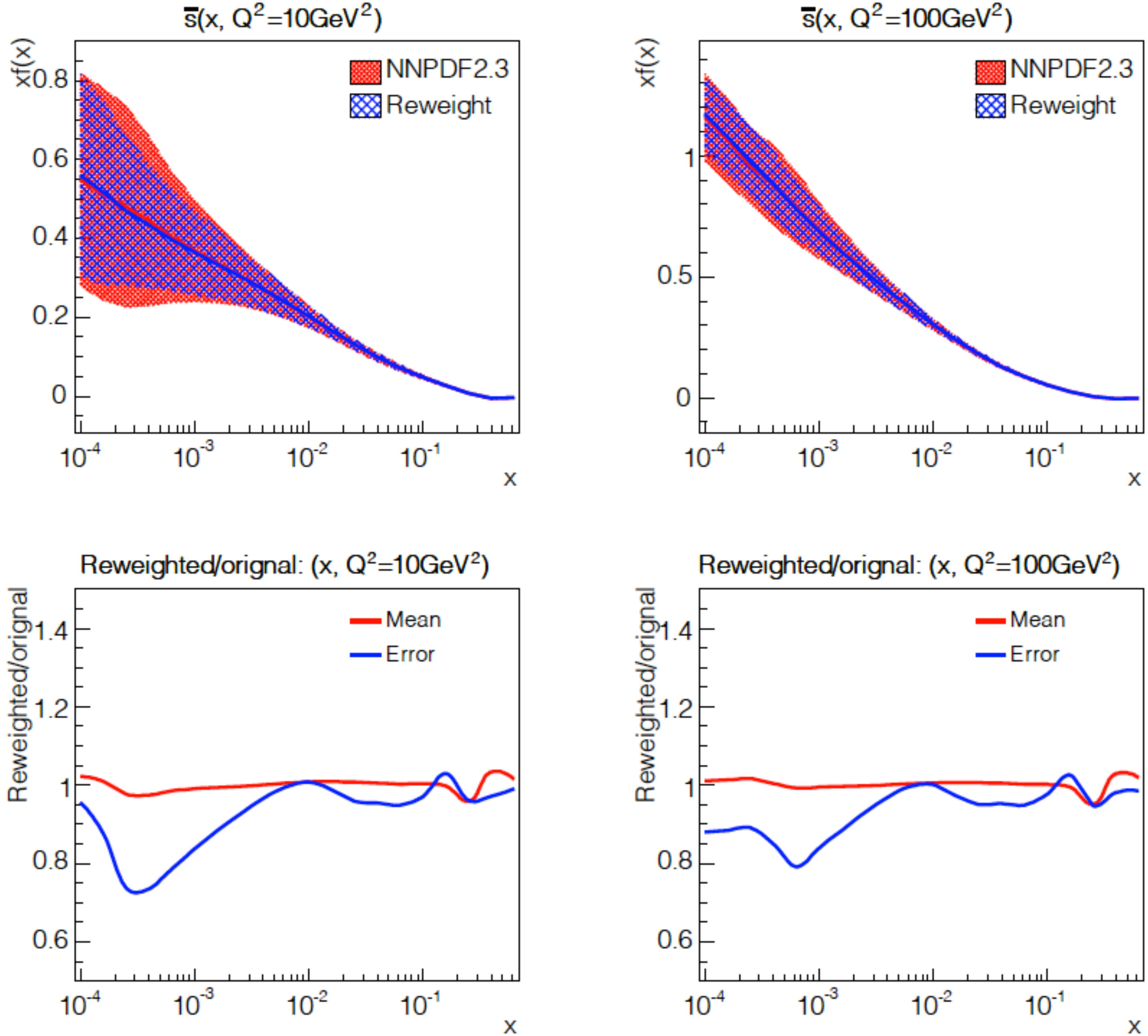




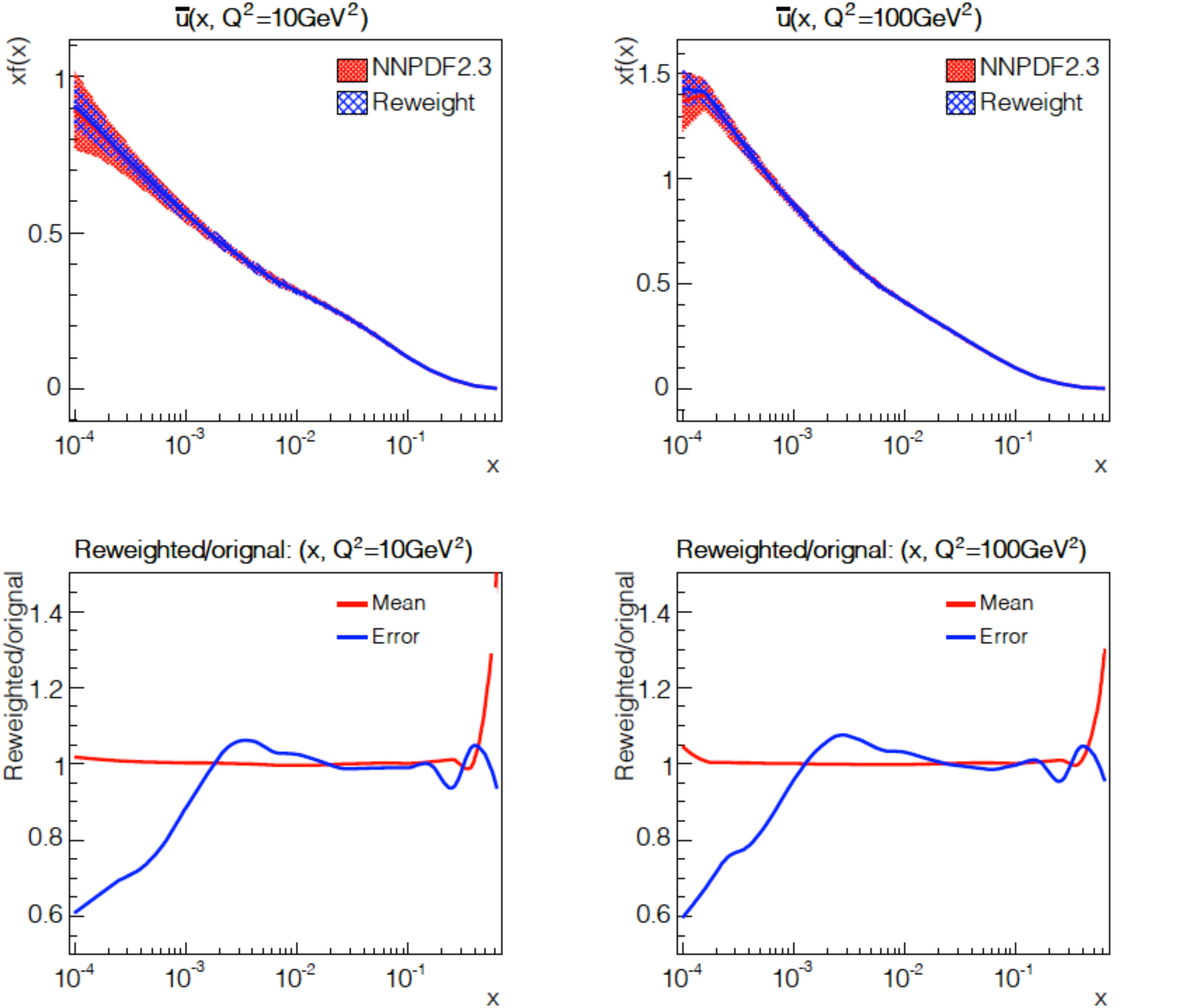
Unpolarized PDFs



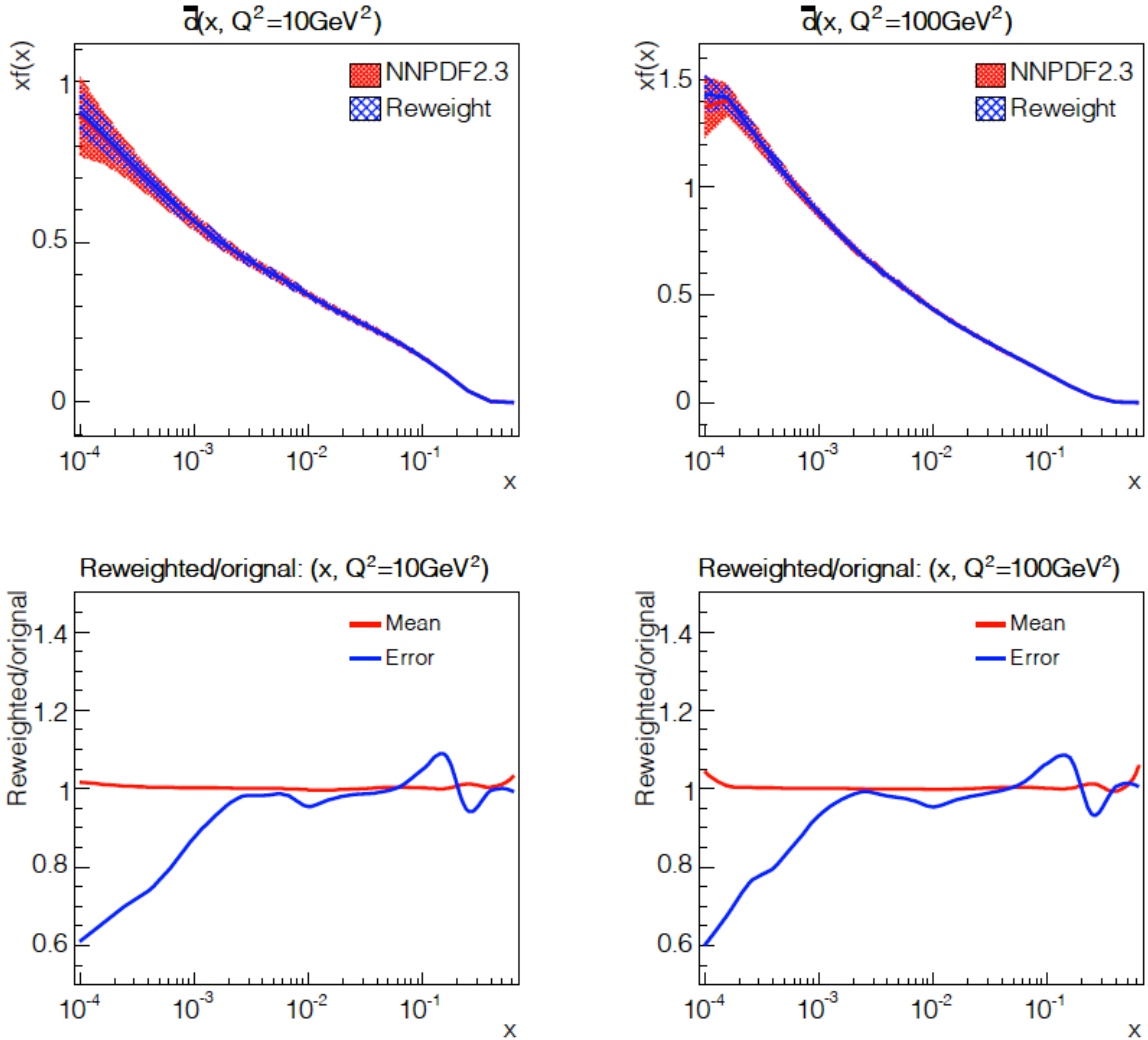
c̄(x, Q²=10GeV²)
xf(x)
NNPDF2.3
Reweight
0.4
0.3
0.2
0.1
0
10⁻⁴
10⁻³
10⁻²
10⁻¹
x
c̄(x, Q²=100GeV²)
xf(x)
NNPDF2.3
Reweight
1
0.5
0
10⁻⁴
10⁻³
10⁻²
10⁻¹
x
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal
Mean
Error
1.4
1.2
1
0.8
0.6
10⁻⁴
10⁻³
10⁻²
10⁻¹
x
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error
1.4
1.2
1
0.8
0.6
10⁻⁴
10⁻³
10⁻²
10⁻¹
x



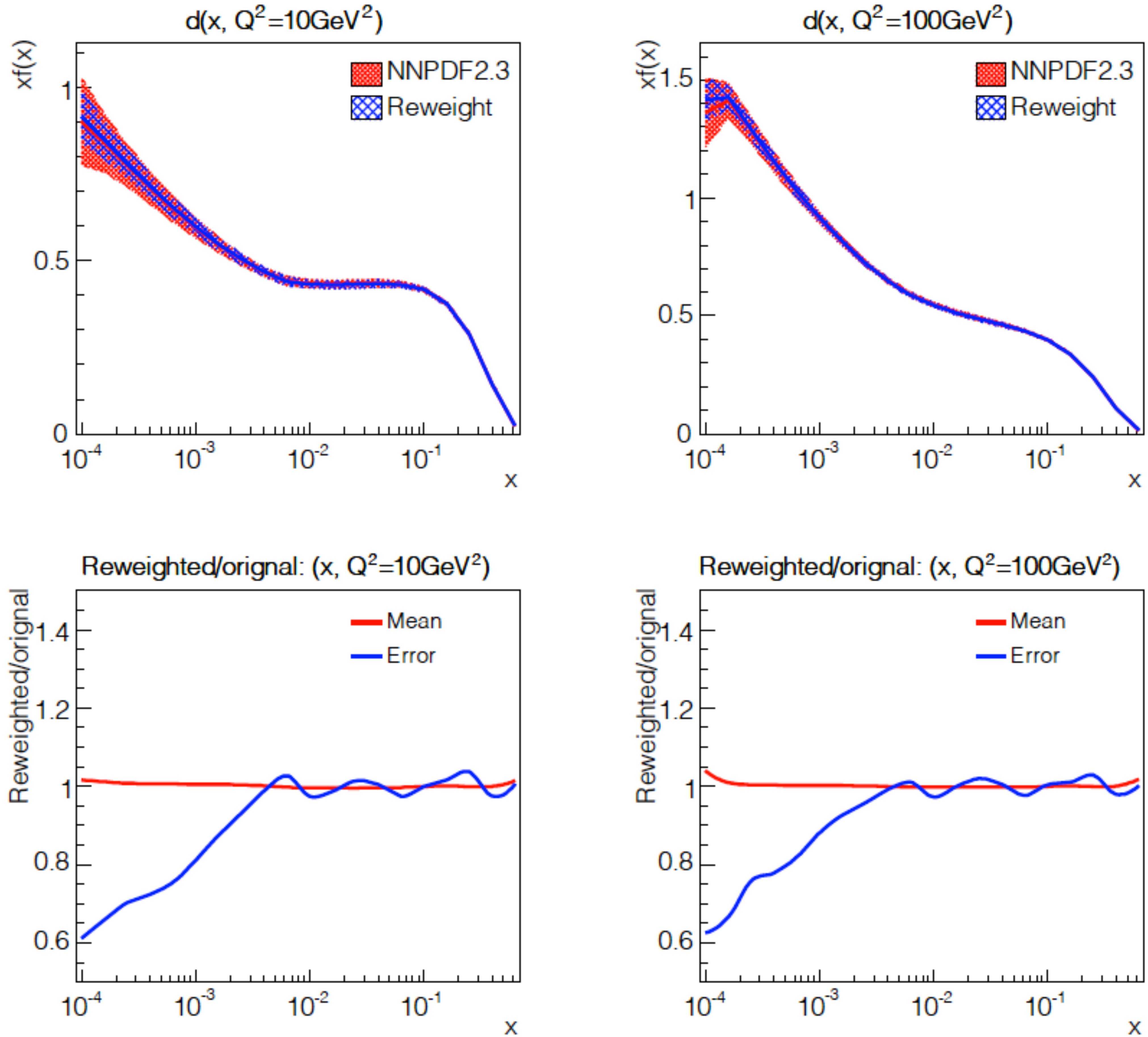
s̄(x, Q²=10GeV²)
s̄(x, Q²=100GeV²)
xf(x)
NNPDF2.3
Reweight
x
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error

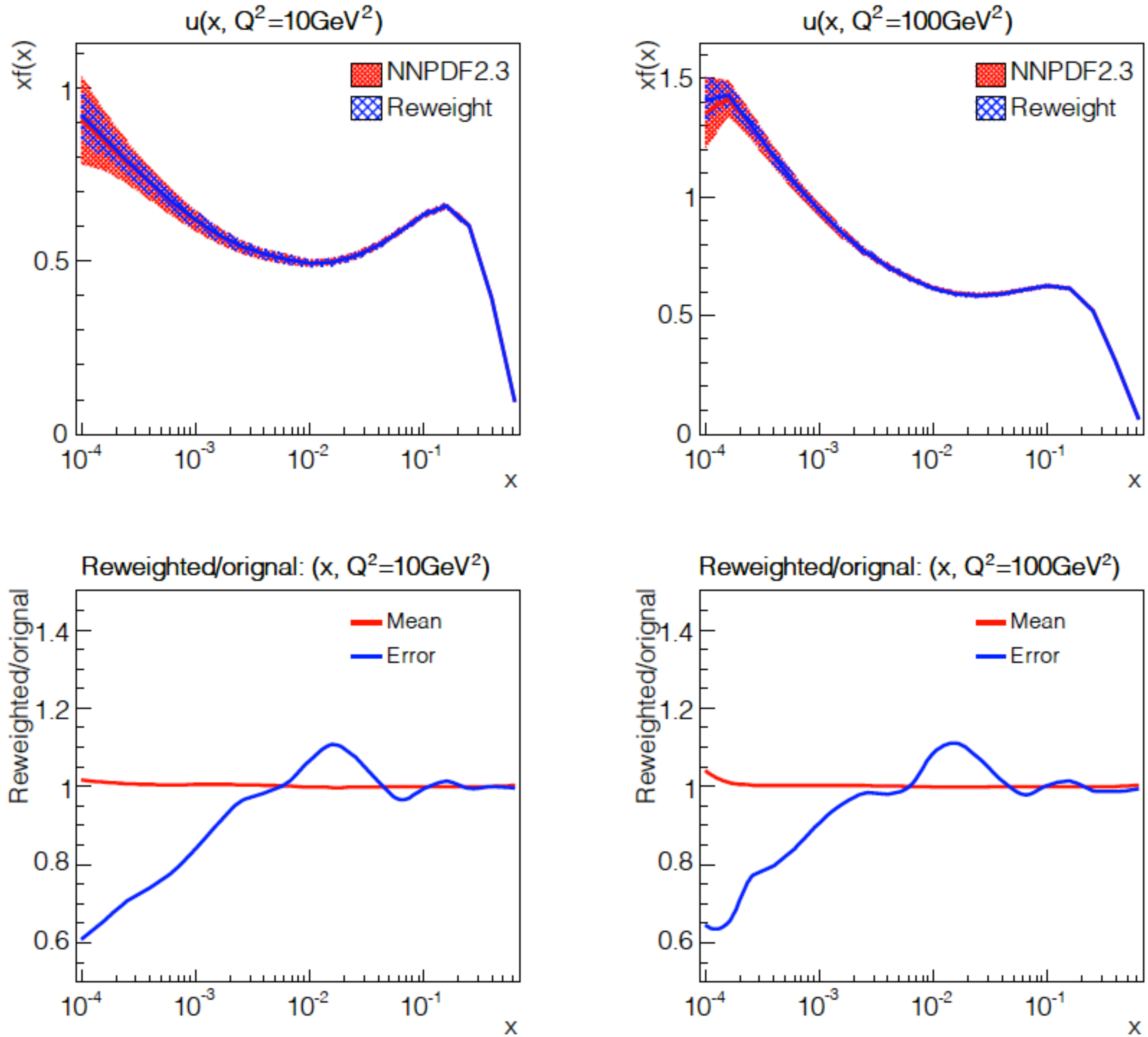


$\bar{u}(x, Q^2=10GeV^2)$
xf(x)
NNPDF2.3
Reweight
x
$\bar{u}(x, Q^2=100GeV^2)$
xf(x)
NNPDF2.3
Reweight
x
Reweighted/orignal: $(x, Q^2=10GeV^2)$
Reweighted/orignal
Mean
Error
x
Reweighted/orignal: $(x, Q^2=100GeV^2)$
Reweighted/orignal
Mean
Error
x

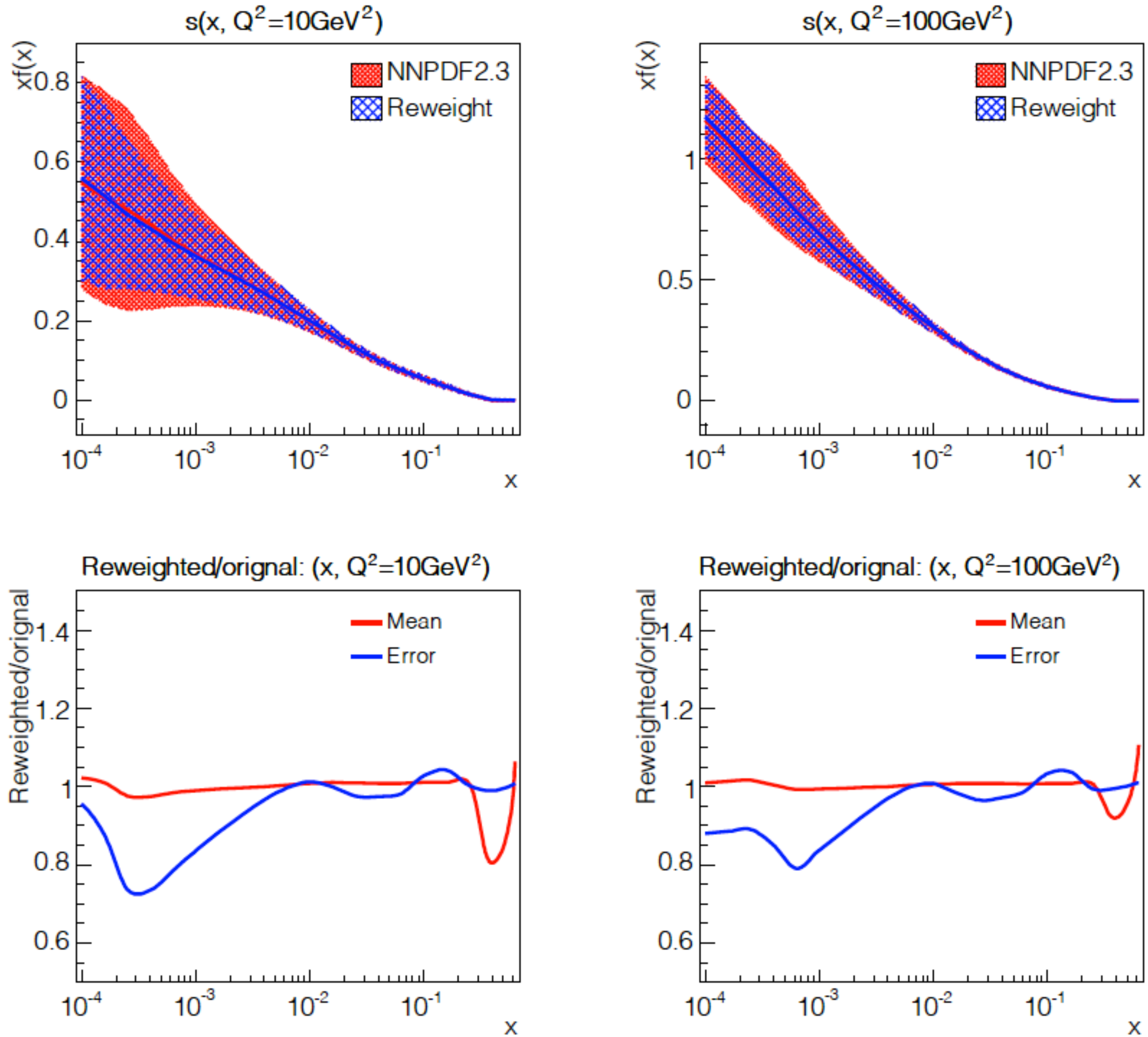


d̄(x, Q²=10GeV²)
xf(x)
NNPDF2.3
Reweight
x
d̄(x, Q²=100GeV²)
xf(x)
NNPDF2.3
Reweight
x
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal
Mean
Error
x
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error
x

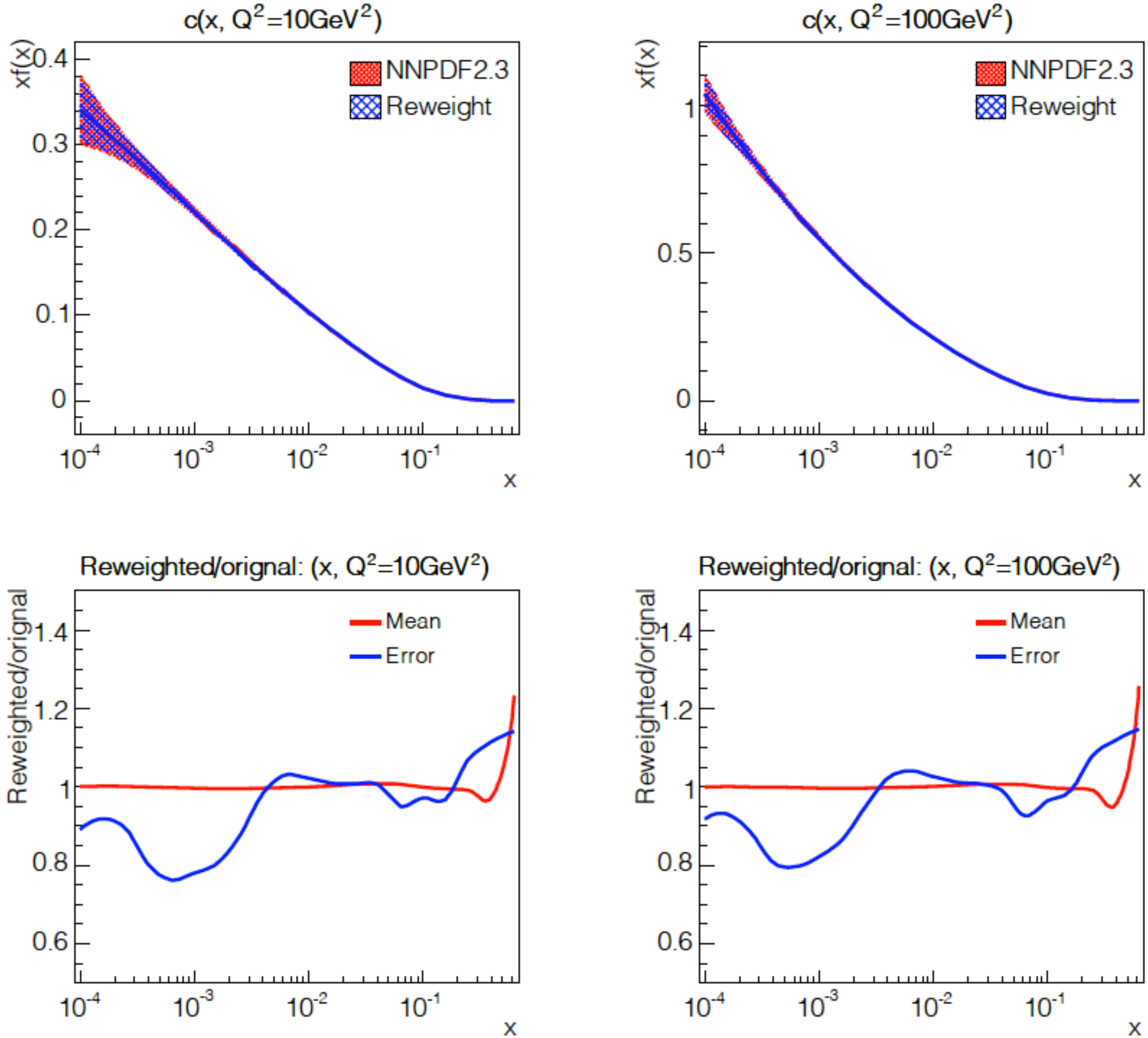

d(x, Q²=10GeV²)
xf(x)
NNPDF2.3
Reweight
x
d(x, Q²=100GeV²)
xf(x)
NNPDF2.3
Reweight
x
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal
Mean
Error
x
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error
x



u(x, Q²=10GeV²)
xf(x)
NNPDF2.3
Reweight
u(x, Q²=100GeV²)
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal
Mean
Error
Reweighted/orignal: (x, Q²=100GeV²)
x

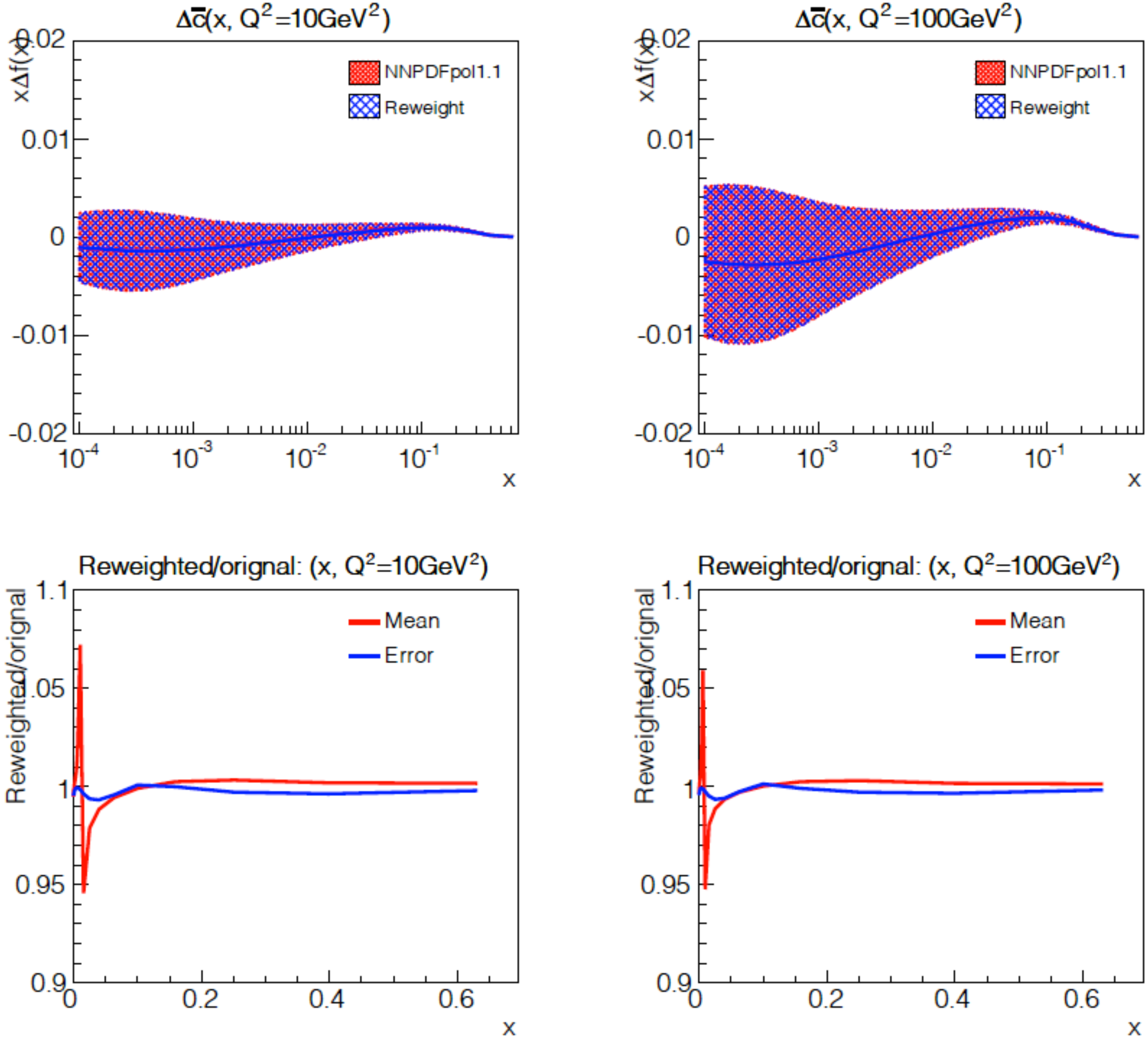


s(x, Q²=10GeV²)
s(x, Q²=100GeV²)
xf(x)
NNPDF2.3
Reweight
0.8
0.6
0.4
0.2
0
1
0.5
10⁻⁴
10⁻³
10⁻²
10⁻¹
x
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error
1.4
1.2
1
0.8
0.6

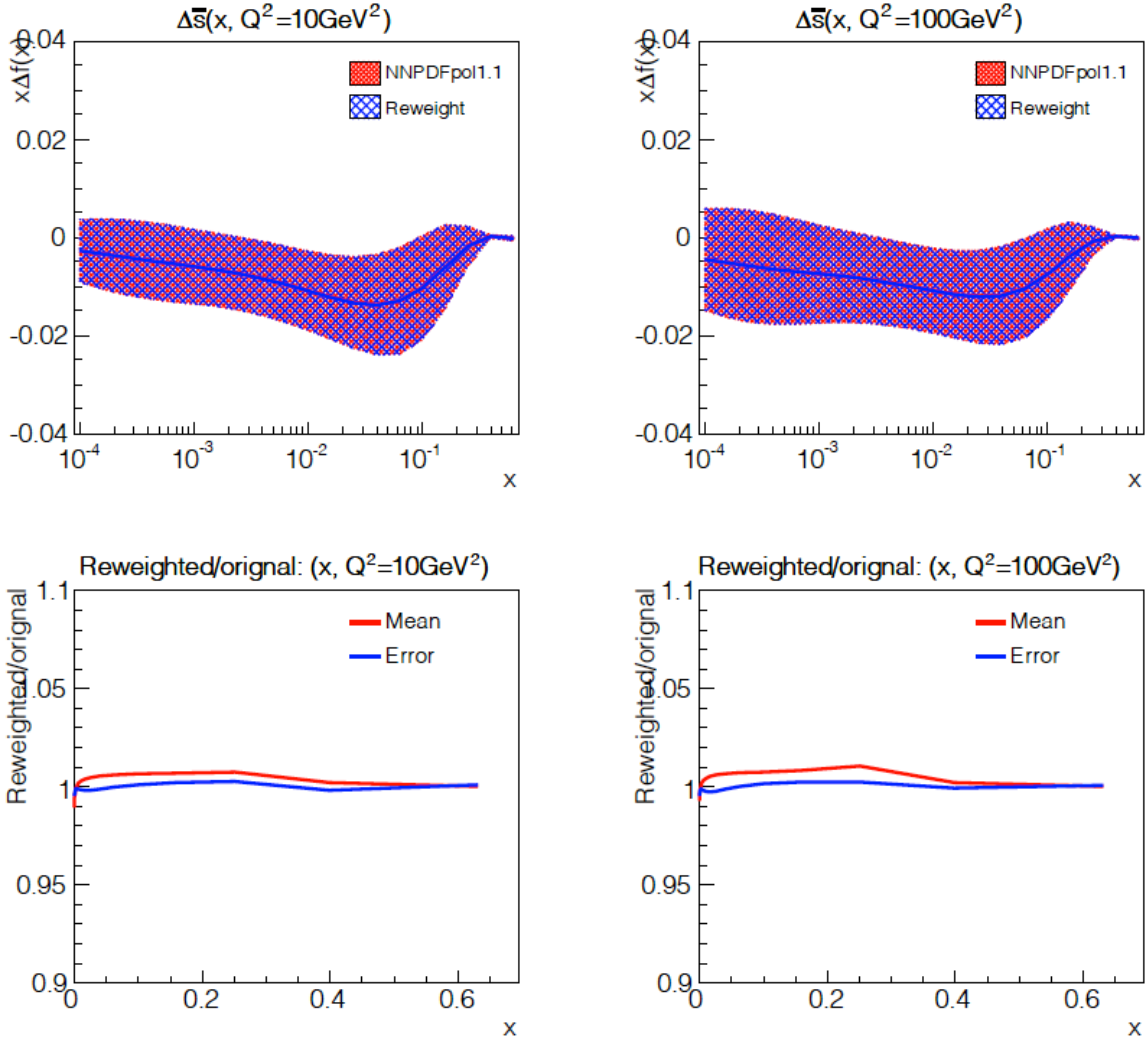


c(x, Q^2=10GeV^2)
c(x, Q^2=100GeV^2)
xf(x)
NNPDF2.3
Reweight
x
Reweighted/orignal: (x, Q^2=10GeV^2)
Reweighted/orignal: (x, Q^2=100GeV^2)
Reweighted/orignal
Mean
Error

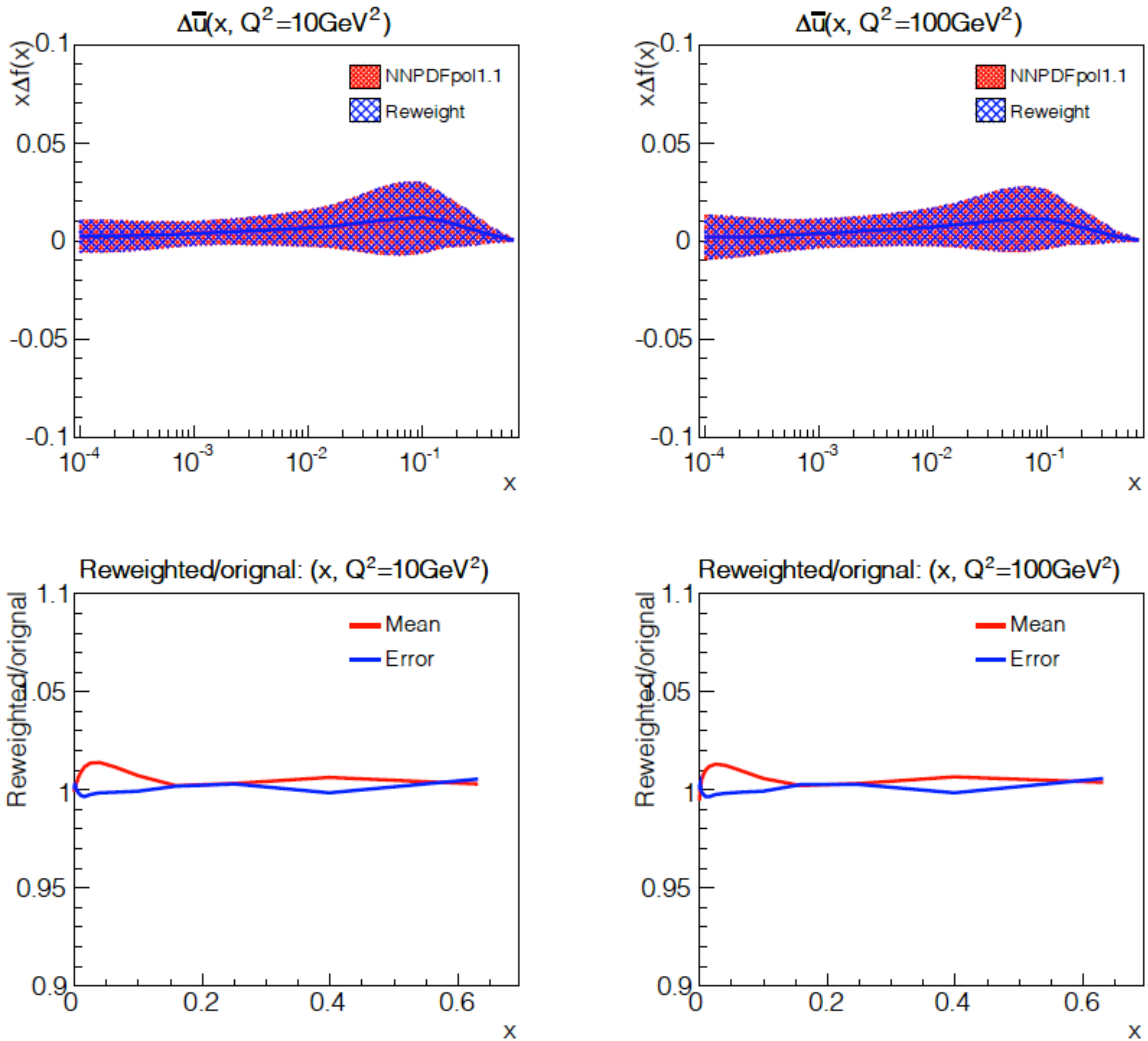
Polarized PDFs



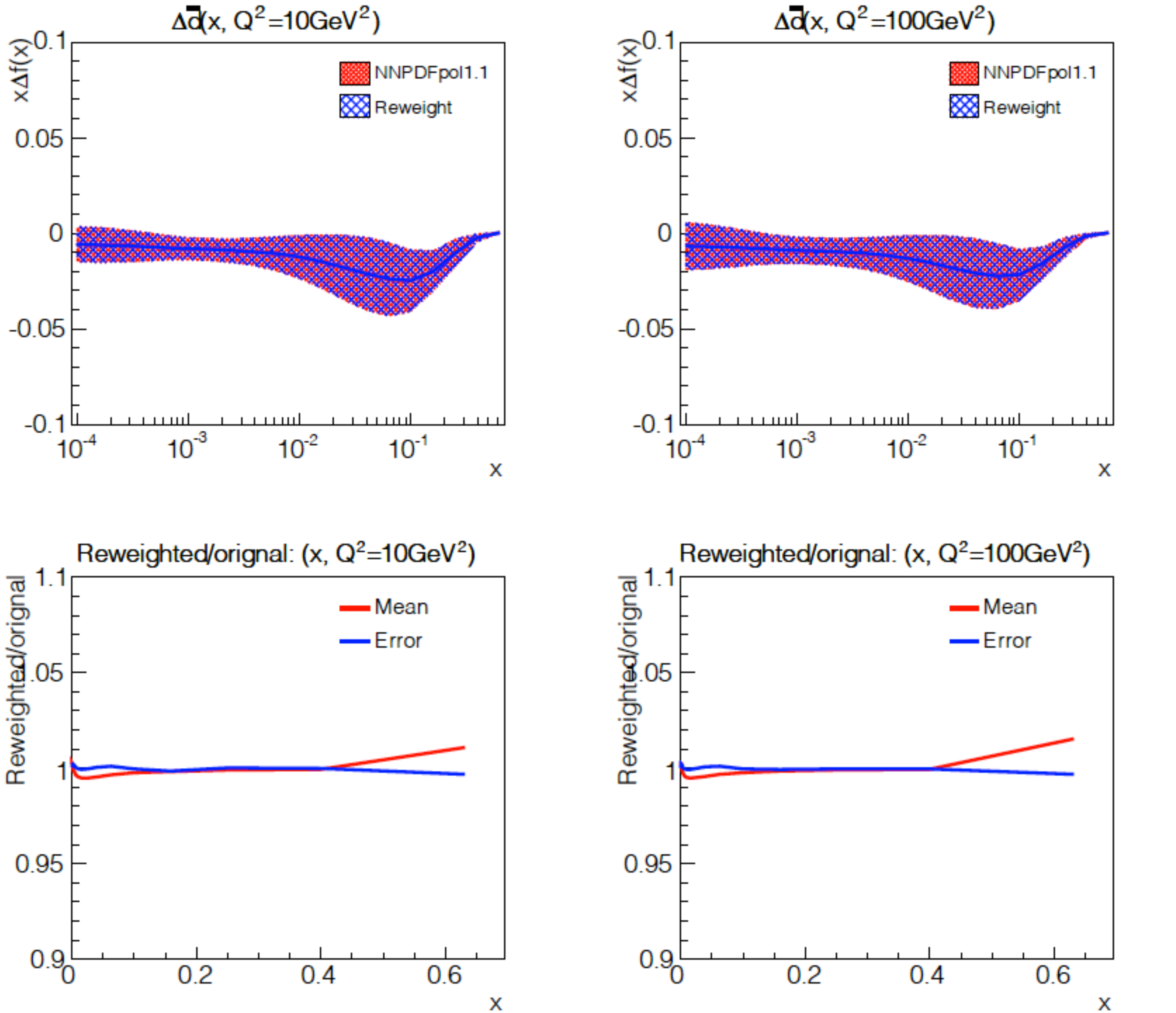
$\Delta\bar{c}(x, Q^2=10GeV^2)$
$x\Delta f(x)$
NNPDFpol1.1
Reweight
0.02
0.01
0
-0.01
-0.02
10^{-4}
10^{-3}
10^{-2}
10^{-1}
x
$\Delta\bar{c}(x, Q^2=100GeV^2)$
$x\Delta f(x)$
NNPDFpol1.1
Reweight
0.02
0.01
0
-0.01
-0.02
10^{-4}
10^{-3}
10^{-2}
10^{-1}
x
Reweighted/orignal: $(x, Q^2=10GeV^2)$
Reweighted/orignal
Mean
Error
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6
x
Reweighted/orignal: $(x, Q^2=100GeV^2)$
Reweighted/orignal
Mean
Error
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6
x



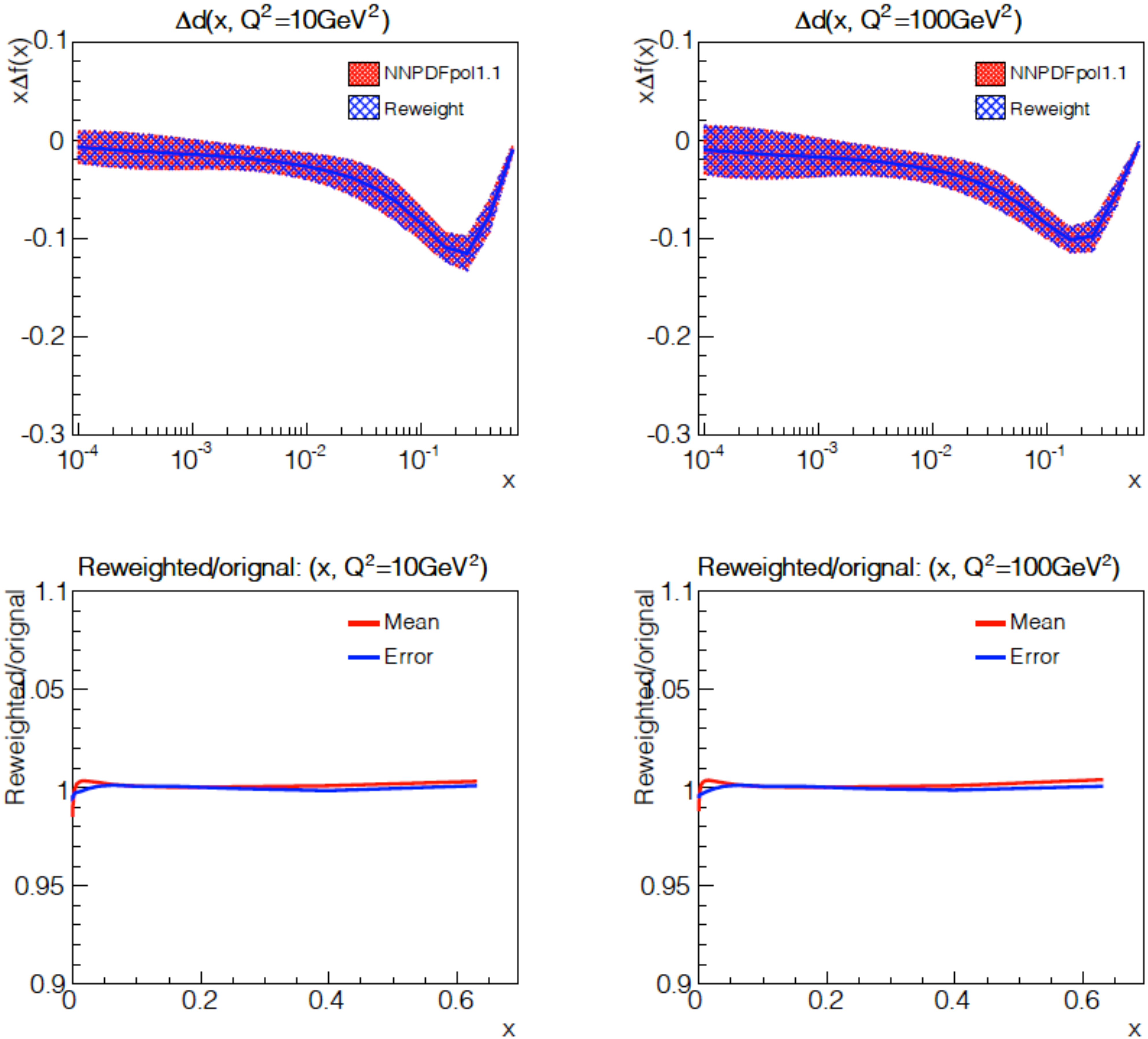
Δs̄(x, Q²=10GeV²)
xΔf(x)
NNPDFpol1.1
Reweight
0.04
0.02
0
-0.02
-0.04
10⁻⁴
10⁻³
10⁻²
10⁻¹
x
Δs̄(x, Q²=100GeV²)
xΔf(x)
NNPDFpol1.1
Reweight
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal
Mean
Error
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6
x
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error



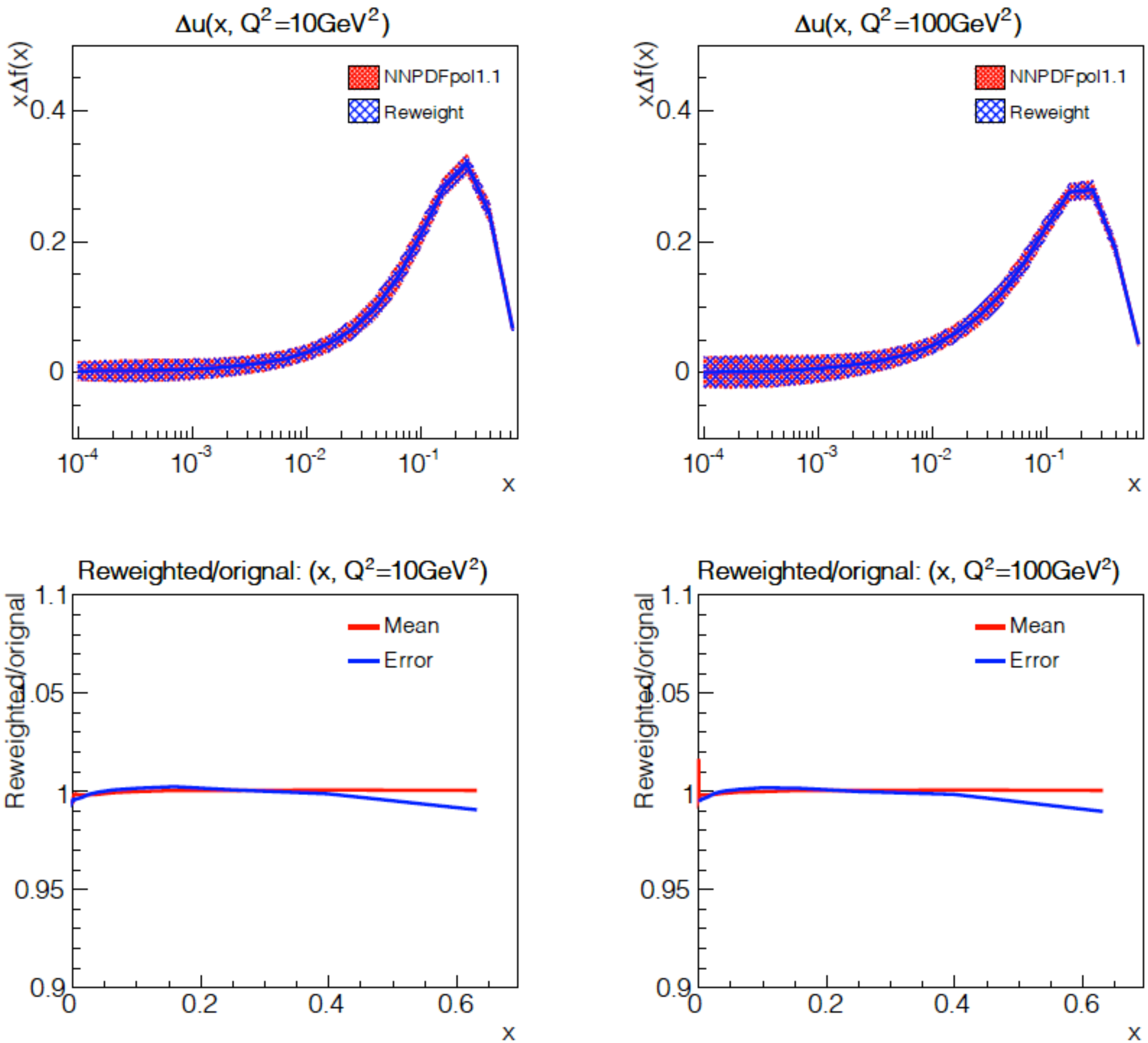
$\Delta\bar{u}(x, Q^2=10GeV^2)$
NNPDFpol1.1
Reweight
$x\Delta f(x)$
0.1
0.05
0
-0.05
-0.1
10^{-4}
10^{-3}
10^{-2}
10^{-1}
x
$\Delta\bar{u}(x, Q^2=100GeV^2)$
NNPDFpol1.1
Reweight
$x\Delta f(x)$
0.1
0.05
0
-0.05
-0.1
10^{-4}
10^{-3}
10^{-2}
10^{-1}
x
Reweighted/orignal: (x, Q^2=10GeV^2)
Mean
Error
Reweighted/orignal
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6
x
Reweighted/orignal: (x, Q^2=100GeV^2)
Mean
Error
Reweighted/orignal
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6
x



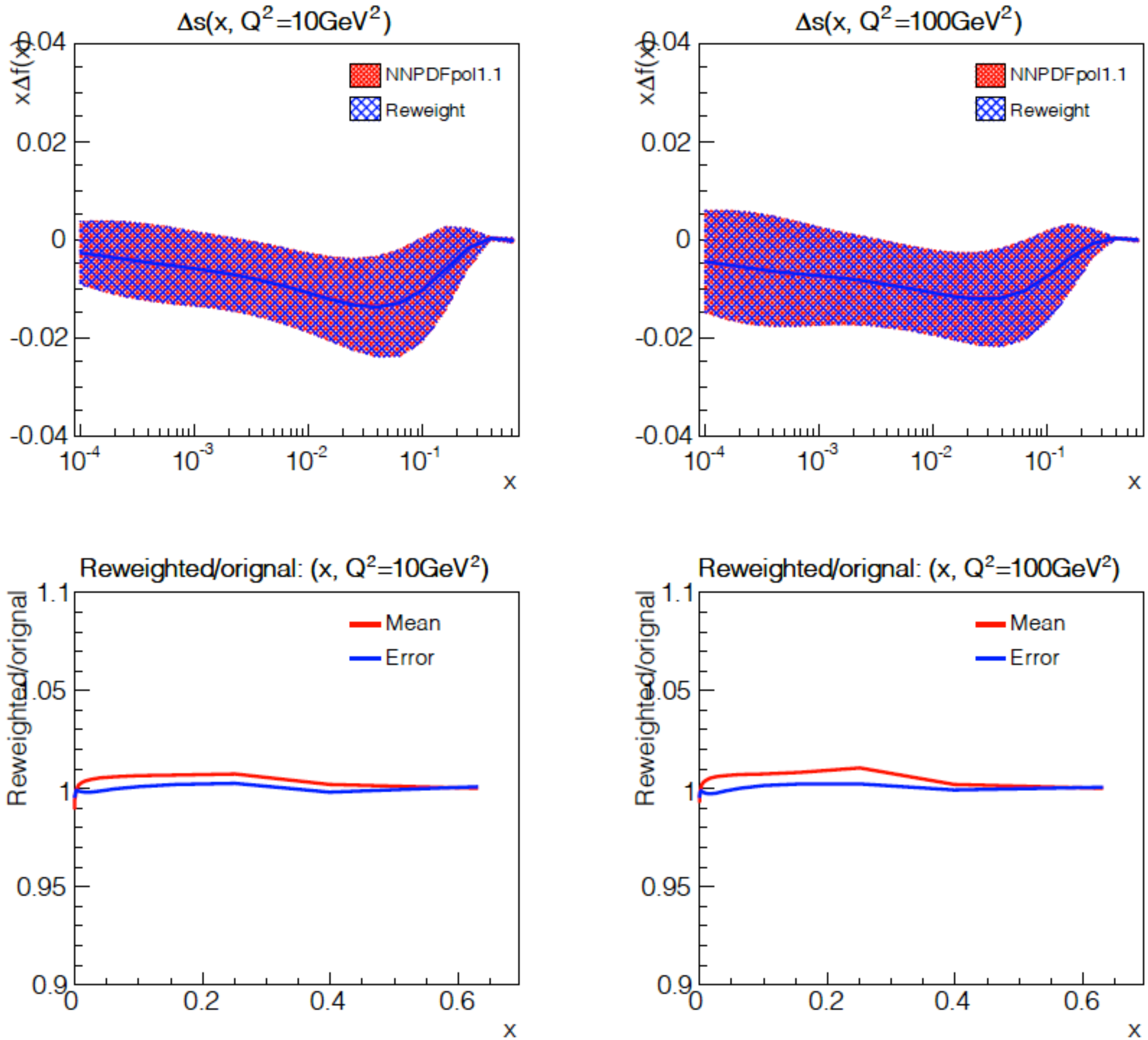
Δd̄(x, Q²=10GeV²)
Δd̄(x, Q²=100GeV²)
xΔf(x)
NNPDFpol1.1
Reweight
0.1
0.05
0
-0.05
-0.1
10⁻⁴
10⁻³
10⁻²
10⁻¹
x
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6



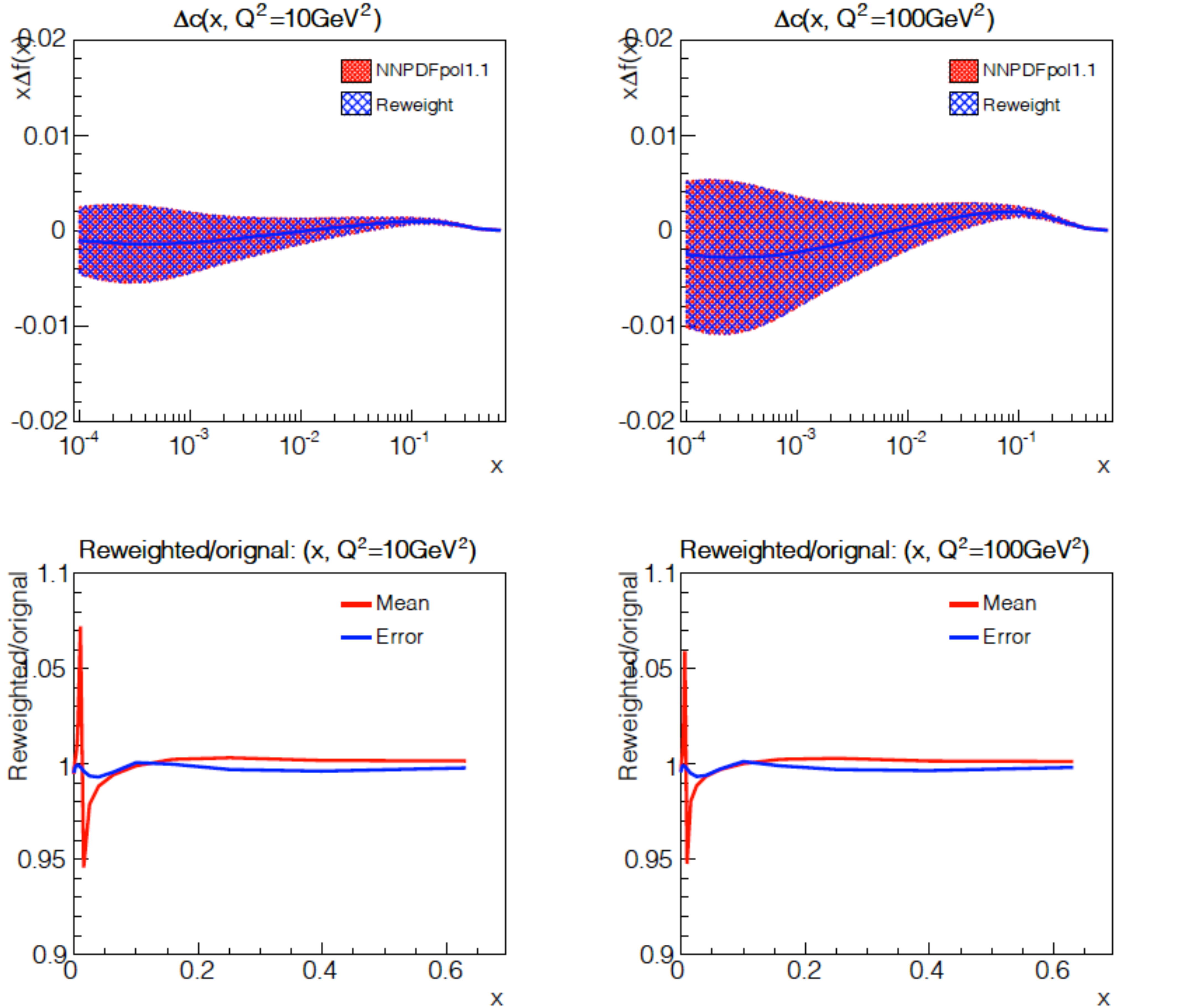
Δd(x, Q²=10GeV²)
Δd(x, Q²=100GeV²)
xΔf(x)
NNPDFpol1.1
Reweight
0.1
0
-0.1
-0.2
-0.3
10⁻⁴
10⁻³
10⁻²
10⁻¹
x
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6



Δu(x, Q²=10GeV²)
Δu(x, Q²=100GeV²)
xΔf(x)
NNPDFpol1.1
Reweight
0.4
0.2
0
10⁻⁴
10⁻³
10⁻²
10⁻¹
x
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6



Δs(x, Q²=10GeV²)
Δs(x, Q²=100GeV²)
xΔf(x)
NNPDFpol1.1
Reweight
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error
x



Δc(x, Q²=10GeV²)
Δc(x, Q²=100GeV²)
xΔf(x)
NNPDFpol1.1
Reweight
0.02
0.01
0
-0.01
-0.02
10⁻⁴
10⁻³
10⁻²
10⁻¹
x
Reweighted/orignal: (x, Q²=10GeV²)
Reweighted/orignal: (x, Q²=100GeV²)
Reweighted/orignal
Mean
Error
1.1
1.05
1
0.95
0.9
0
0.2
0.4
0.6

Summary

- Impact assessment for EIC pseudo-data from Yuxiang Zhao et al.'s paper. Parameters are different from YR baseline.

- Unpolarized PDF: ~30% improvement at lower x range (~10^-3), from NNPDF2.3, by including A^{e}_{PV} at EIC

- Polarized PDF: no visible improvement by including A^{h}_{PV} at EIC