

Benchmarking HERAPDF1.0

A M Cooper-Sarkar, Oxford

Sasha Glazov, DESY

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Sasha Glazov et al use MCFM official version

AMCS uses private code from James Stirling- with parameters adjusted to benchmark choices

VERY good agreement (worst case 1% -usually much less)

Results presented are the MCFM ones- cross-check table in extras

Summary of the benchmark cross-sections: standard value of $\alpha_s(M_Z)=0.1176$

14 TeV cross sections

process	σ	exp	model+	model-	para+	para-	$\alpha+$	$\alpha-$
$H(m = 120\text{GeV}), \text{ pb}$	36.79	0.64	0.26	0.50	0.30	1.76	1.04	1.02
$H(m = 180\text{GeV}), \text{ pb}$	16.20	0.31	0.05	0.23	0.16	0.92	0.43	0.42
$H(m = 240\text{GeV}), \text{ pb}$	8.56	0.18	0.03	0.12	0.09	0.55	0.21	0.21
$t\bar{t}, \text{ pb}$	847.12	20.37	5.77	13.06	11.59	65.47	14.26	15.02
$W^-, \text{ nb}$	85.95	0.43	2.27	0.65	1.92	0.42	0.86	0.86
$W^- \times Br_{\ell\ell}, \text{ nb}$	9.280	0.050	0.250	0.070	0.210	0.040	0.093	0.093
$W^+, \text{ nb}$	115.17	0.81	2.91	0.75	2.09	0.59	1.34	1.31
$W^+ \times Br_{\ell\ell}, \text{ nb}$	12.440	0.090	0.310	0.080	0.230	0.060	0.144	0.142
$Z, \text{ nb}$	61.67	0.41	1.74	0.46	1.32	0.27	0.77	0.76
$Z \times Br_{\ell\ell}, \text{ nb}$	2.076	0.014	0.059	0.015	0.045	0.009	0.026	0.026

7 TeV cross sections

process	σ	exp	model+	model-	para+	para-	$\alpha+$	$\alpha-$
$H(m = 120\text{GeV}), \text{ pb}$	10.98	0.23	0.04	0.17	0.12	0.71	0.30	0.30
$H(m = 180\text{GeV}), \text{ pb}$	4.16	0.10	0.02	0.07	0.06	0.32	0.10	0.10
$H(m = 240\text{GeV}), \text{ pb}$	1.93	0.05	0.01	0.04	0.03	0.17	0.04	0.04
$t\bar{t}, \text{ pb}$	144.20	4.10	1.74	3.09	2.47	12.71	0.98	1.24
$W^-, \text{ nb}$	39.72	0.28	0.96	0.27	1.02	0.22	0.36	0.36
$W^- \times Br_{\ell\ell}, \text{ nb}$	4.290	0.030	0.100	0.030	0.110	0.020	0.039	0.039
$W^+, \text{ nb}$	57.03	0.58	1.34	0.43	1.34	0.29	0.64	0.64
$W^+ \times Br_{\ell\ell}, \text{ nb}$	6.160	0.060	0.140	0.050	0.140	0.030	0.069	0.069
$Z, \text{ nb}$	28.81	0.29	0.75	0.20	0.73	0.17	0.35	0.35
$Z \times Br_{\ell\ell}, \text{ nb}$	0.970	0.010	0.025	0.007	0.025	0.006	0.012	0.012

The experimental error is symmetric: the $\alpha+ = 0.1196$, $\alpha- = 0.1156$, use $\alpha+$ as close enough to 0.119 for comparisons

Brief discussion of how to treat HERAPDF1.0 errors

Two files exist on LHAPDF (versions 5.8.1 onwards)

HERAPDF10_EIG.LHgrid and HERAPDF10_VAR.LHgrid

The EIG file has the experimental errors as eigenvectors

Mem=0 is central and mem=1,20 are 10 eigenvectors up and down which can be treated as: $i=1,10 \quad (F(2i)-F(2i-1))/2$ added in quadrature for symmetric errors

The VAR file has model and parametrisation errors

Mem=0 is central, mem=1,8 are model errors ie add in quadrature: $i=1,8 \quad (F(i)-F(0))$ positive and negative deviations separately – this can turn out VERY asymmetric

Mem=9,13 are the parametrisation errors for these we take the envelope i.e. largest deviation: $i=9,13 \quad (F(i)-F(0))$ positive or negative- this can also be VERY asymmetric

Mem=14 is an extra model error for $m_c=1.5$, usually not used since $m_c=1.65$ is one of the standard model errors ($i=6$)

Mem=15,16 are alphas variations 0.1156, 0.1196 respectively- our standard value is 0.1176

All of this information is in the files themselves!

W and Z total cross-sections

PDF set	$\sigma_{W^+} B_{W \rightarrow l\nu}$ (nb)	$\sigma_{W^-} B_{W \rightarrow l\nu}$ (nb)	$\sigma_Z B_{Z \rightarrow ll}$ (nb)
HERAPDF1.0 14 TeV	12.44±0.09 +0.31 -0.08 +0.23-0.06	9.28±0.050 +0.25-0.07 +0.21-0.04	2.076±0.014 +0.059-0.015 +0.045-0.009
$\alpha_S(MZ)$ variation 0.1156–0.1196	±0.14	±0.08	±0.026
HERAPDF1.0 7 TeV	6.16±0.06 +0.14-0.05 +0.14-0.03	4.29±0.03 +0.10-0.03 +0.11-0.02	0.970±0.010 +0.025-0.007 +0.025-0.006
$\alpha_S(MZ)$ variation 0.1156–0.1196	±0.069	±0.039	± 0.012

Experimental errors in red ARE 68%CL

Errors in yellow are model errors

Errors in green are parametrisation errors

Charm mass model error is very asymmetric- increases values by ~2.5% if $m_c=1.65$ rather than $m_c=1.4\text{GeV}$

Tables of W/Z rapidity distributions at 14 TeV in nb

y	$d\sigma/dy(W^+)$	$d\sigma/dy(W^-)$	$d\sigma/dy(Z)$
0.	1.513 $\pm 0.01 \pm 0.05$ ± 0.007	1.394 $\pm 0.01 \pm 0.04$ ± 0.007	0.302 $\pm 0.002 \pm 0.008$ ± 0.002
1.	1.505 $\pm 0.01 \pm 0.05$ ± 0.009	1.34 $\pm 0.01 \pm 0.04$ ± 0.01	0.292 $\pm 0.002 \pm 0.008$ ± 0.002
2.	1.49 $\pm 0.005 \pm 0.04$ ± 0.017	1.19 $\pm 0.01 \pm 0.04$ ± 0.015	0.269 $\pm 0.001 \pm 0.006$ ± 0.004
3.	1.44 $\pm 0.01 \pm 0.04$ ± 0.027	0.925 $\pm 0.015 \pm 0.03$ ± 0.016	0.221 $\pm 0.003 \pm 0.006$ ± 0.004
4.	0.96 $\pm 0.02 \pm 0.07$ ± 0.03	0.394 $\pm 0.025 \pm 0.04$ ± 0.012	0.105 $\pm 0.003 \pm 0.007$ ± 0.004

First error is 68%CL experimental

Model and parametrisation errors are now combined into the second error- and symmetrised

$\alpha_s(M_Z) = 0.1176$ is standard and the variation 0.1156-0.1196 is in blue

Z/W ratio, W asymmetry and W₊/W₋ ratio as functions of rapidity at 14 TeV

y	dσ/dy(Z/W)	dσ/dy(A _W)	dσ/dy(W ₊ /W ₋)
0.	9.91 ±0.01±0.10 ±0.01	0.0348 ±0.002±0.004 ±0.0004	1.0705 ±0.004±0.01 ±0.0005
1.	10.00 ±0.01±0.10 ±0.01	0.0510 ±0.002±0.003 ±0.0005	1.108 ±0.005±0.01 ±0.0005
2.	10.27 ±0.02±0.10 ±0.01	0.1038 ±0.003±0.002 ±0.0004	1.2315 ±0.007±0.01 ±0.0015
3.	10.81 ±0.06±0.16 ±0.05	0.2165 ±0.004±0.01 ±0.0005	1.549 ±0.01±0.03 ±0.001
4.	13.07 ±0.13±0.26 ±0.11	0.4102 ±0.03±0.05 ±0.0004	2.39 ±0.17±0.29 ±0.0005

First error is 68%CI experimental

Model and parametrisation errors are now combined into the second error and symmetrised

$\alpha_s(M_Z)=0.1176$ is standard and the variation 0.1156-0.1196 is in blue

Smaller value of α_s gives larger Z/W ratio

Smaller value of α_s gives larger W-asymm

W/Z rapidity distributions at 7 TeV in nb

y	$d\sigma/dy(W^+)$	$d\sigma/dy(W^-)$	$d\sigma/dy(Z)$
0.	0.866 $\pm 0.005 \pm 0.027$ ± 0.005	0.758 $\pm 0.005 \pm 0.017$ ± 0.005	0.163 $\pm 0.009 \pm 0.0045$ ± 0.001
1.	0.880 $\pm 0.005 \pm 0.026$ ± 0.002	0.725 $\pm 0.005 \pm 0.015$ ± 0.006	0.158 $\pm 0.009 \pm 0.0045$ ± 0.001
2.	0.888 $\pm 0.009 \pm 0.021$ ± 0.012	0.622 $\pm 0.007 \pm 0.015$ ± 0.005	0.143 $\pm 0.0016 \pm 0.0035$ ± 0.002
3.	0.741 $\pm 0.017 \pm 0.035$ ± 0.017	0.362 $\pm 0.017 \pm 0.016$ ± 0.005	0.093 $\pm 0.002 \pm 0.005$ ± 0.0025
4.	0.0779 $\pm 0.007 \pm 0.01$ ± 0.004	0.0245 $\pm 0.0025 \pm 0.0035$ ± 0.002	0.0034 $\pm 0.0008 \pm 0.0005$ ± 0.0035

First error is 68%CL
experimental

Model and
parametrisation errors
are now combined into
the second error and
symmetrised

$\alpha_s(M_Z) = 0.1176$ is
standard and the
variation 0.1156-0.1196 is
in blue

Z/W ratio, W asymmetry and W₊/W₋ ratio as functions of rapidity at 7 TeV

y	dσ/dy(Z/W)	dσ/dy(A _W)	dσ/dy(W ₊ /W ₋)
0.	10.155 ±0.01±0.10 ±0.005	0.0657 ±0.0029±0.0072 ±0.00001	1.14 ±0.007±0.015 ±0.0005
1.	10.22 ±0.016±0.08 ±0.035	0.0930 ±0.0036±0.0063 ±0.00025	1.200 ±0.007±0.015 ±0.007
2.	10.63 ±0.04±0.08 ±0.03	0.1765 ±0.0028±0.007 ±0.00055	1.4285 ±0.008±0.015 ±0.0015
3.	11.98 ±0.12±0.21 ±0.075	0.347 ±0.024±0.031 ±0.0013	2.055 ±0.13±0.15 ±0.005
4.	30.30 ±4.7±3.0 ±1.55	0.515 ±0.067±0.07 ±0.011	3.119 ±0.6±0.6 ±0.10

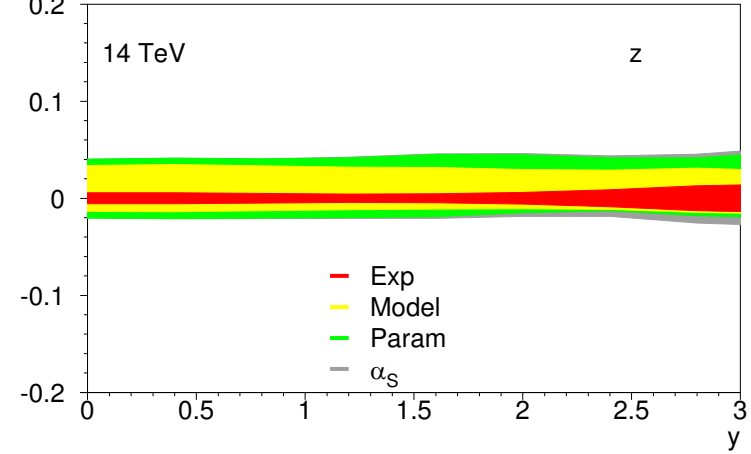
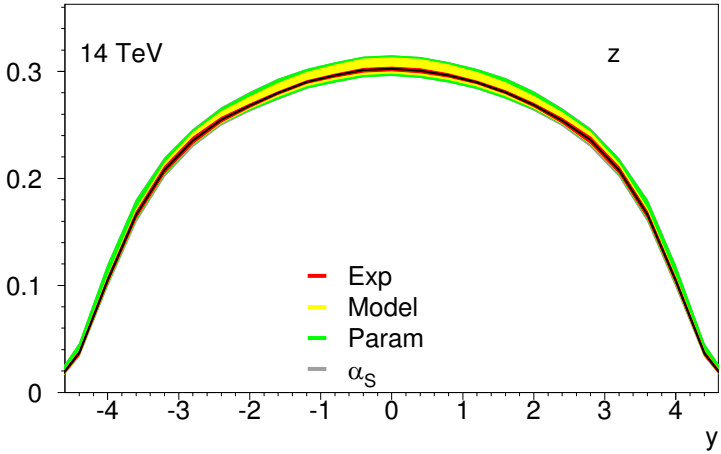
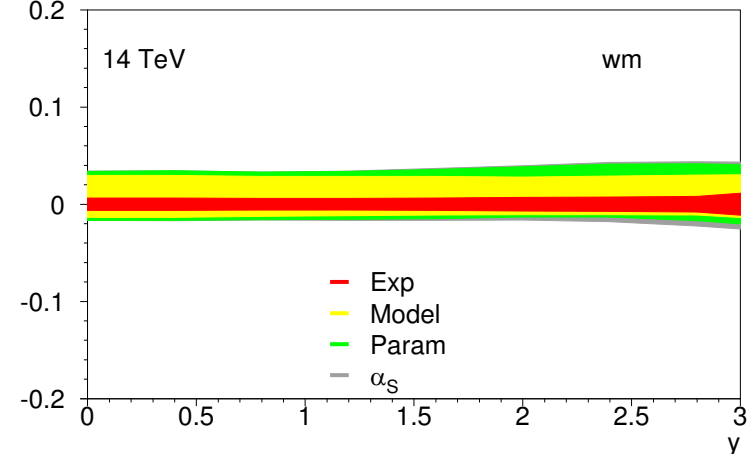
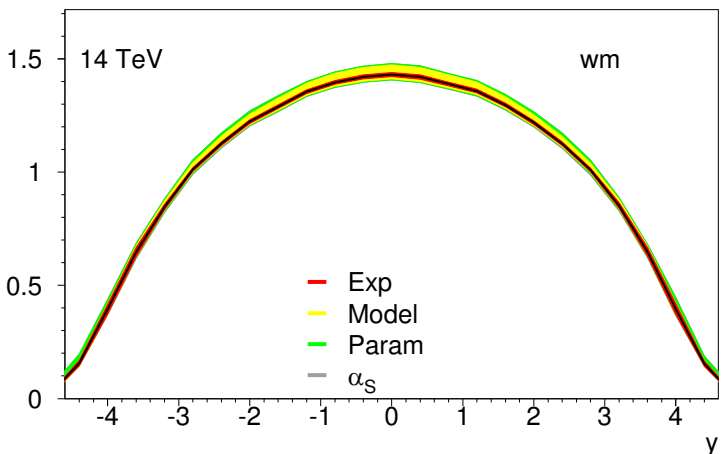
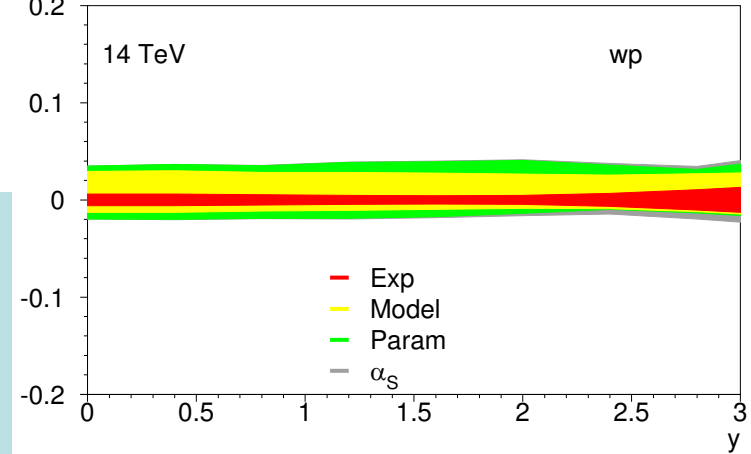
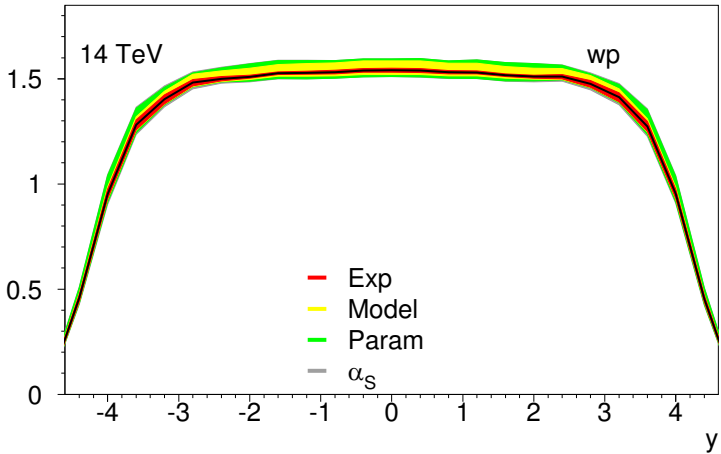
First error is 68%CI experimental

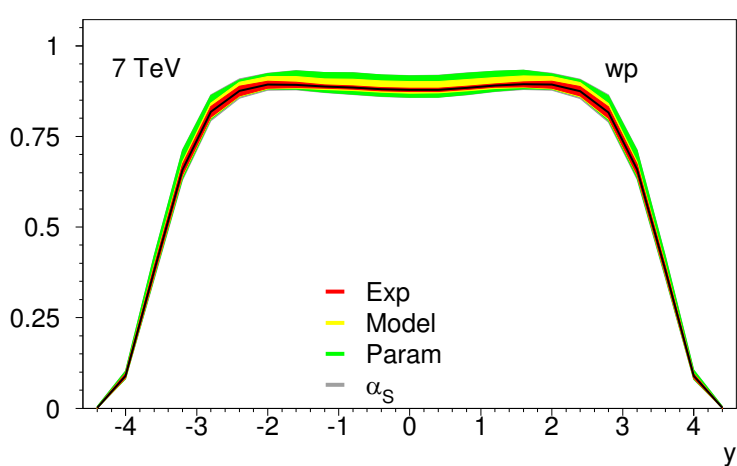
Model and parametrisation errors are now combined into the second errors

$\alpha_s(M_Z)=0.1176$ is standard and the variation 0.1156-0.1196 is in blue

Smaller value of α_s gives larger Z/W ratio

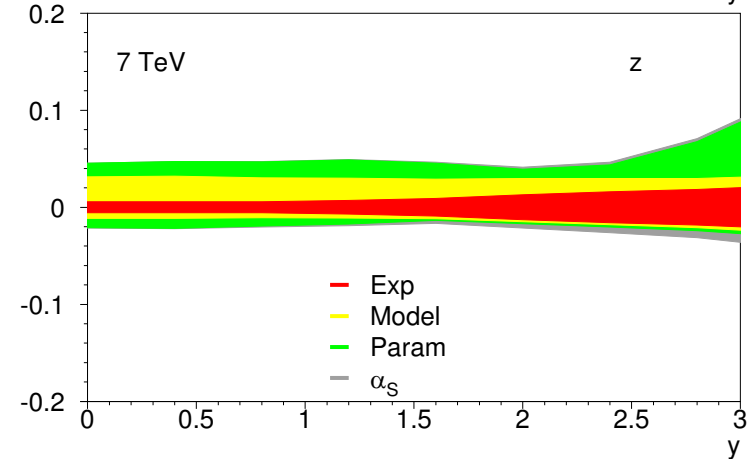
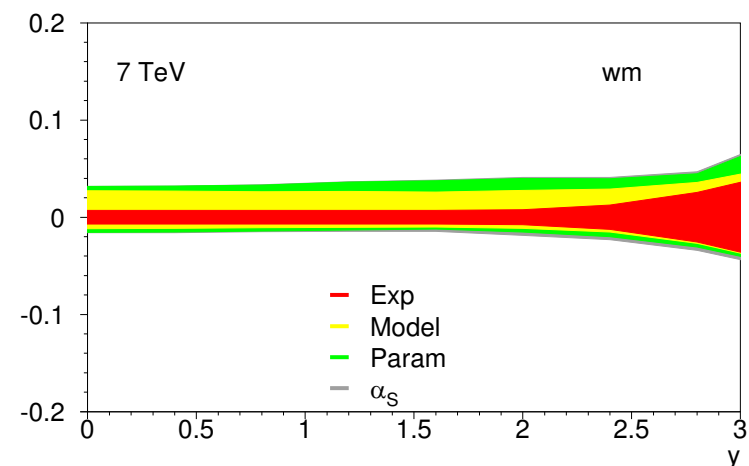
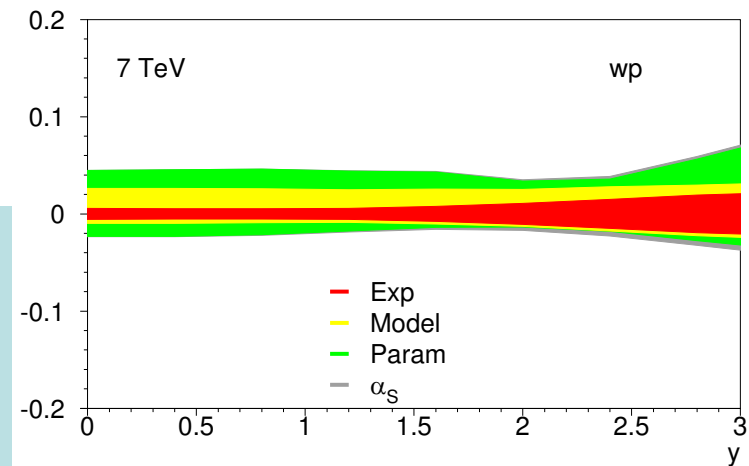
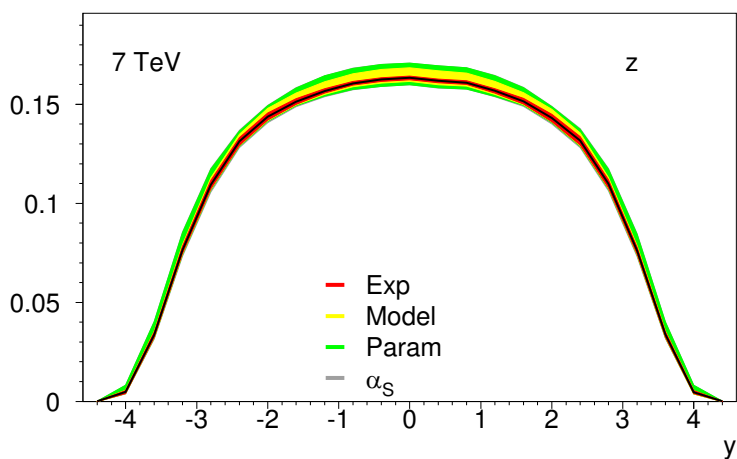
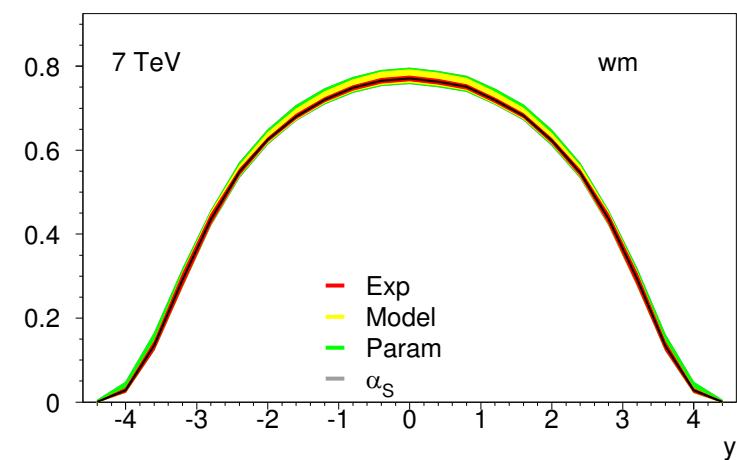
W+ W- Z rapidity distributions AND error bands
14 TeV





W+ W- Z rapidity distributions AND error bands

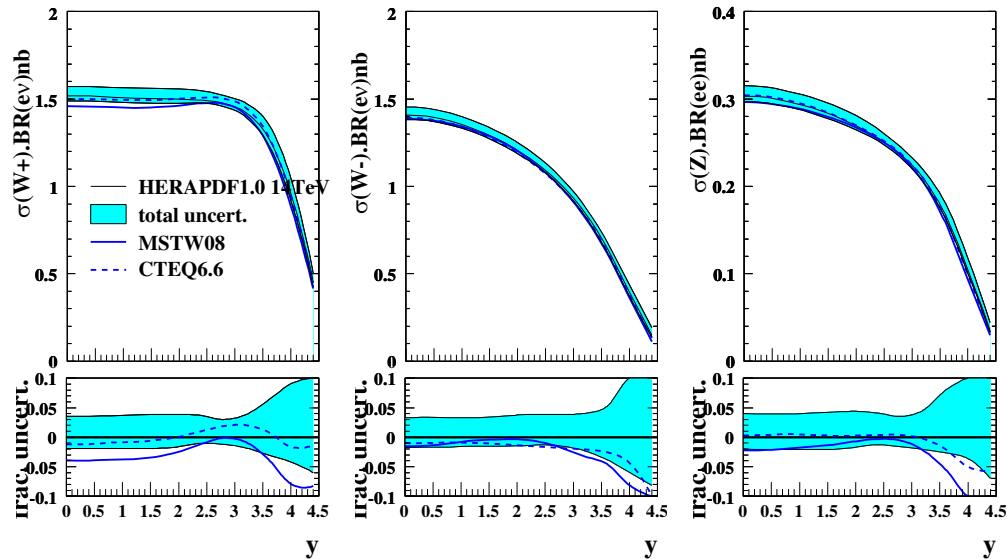
7 TeV



W and Z total cross-sections compared with MSTW08 and CTEQ66:
ratio of PDF/HERAPDF1.0

PDF set	$\sigma_{W^+} B_{W \rightarrow l\nu}$ (nb)	$\sigma_{W^-} B_{W \rightarrow l\nu}$ (nb)	$\sigma_Z B_{Z \rightarrow ll}$ (nb)
CTEQ66/HERAPDF1.0 14TeV	1.001	0.983	0.999
MSTW08/HERAPDF1.0 14TeV	0.969	0.980	0.978
CTEQ66/HERAPDF1.0 7TeV	0.982	0.958	0.975
MSTW08/HERAPDF1.0 7TeV	0.966	0.976	0.973

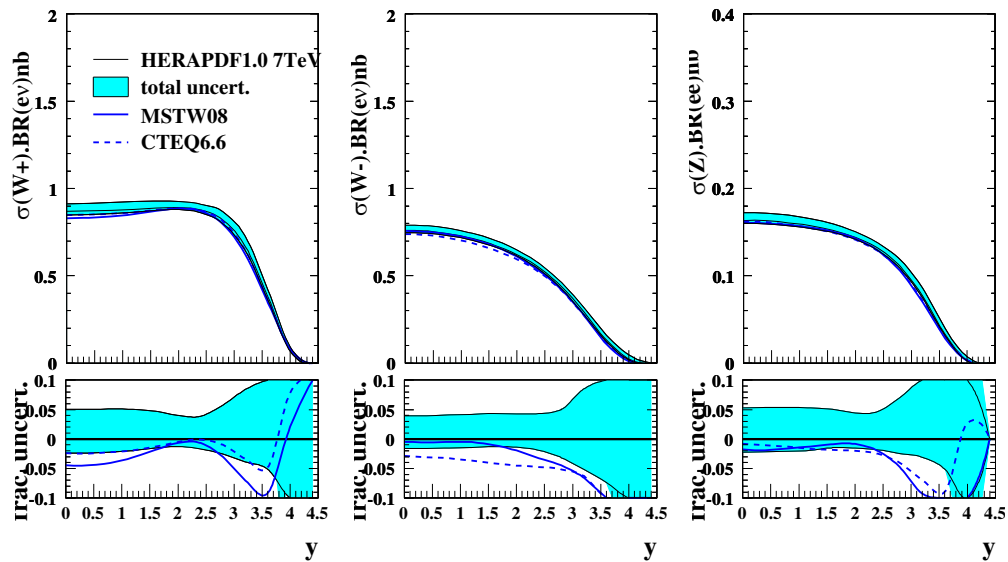
Differences all within ~3%



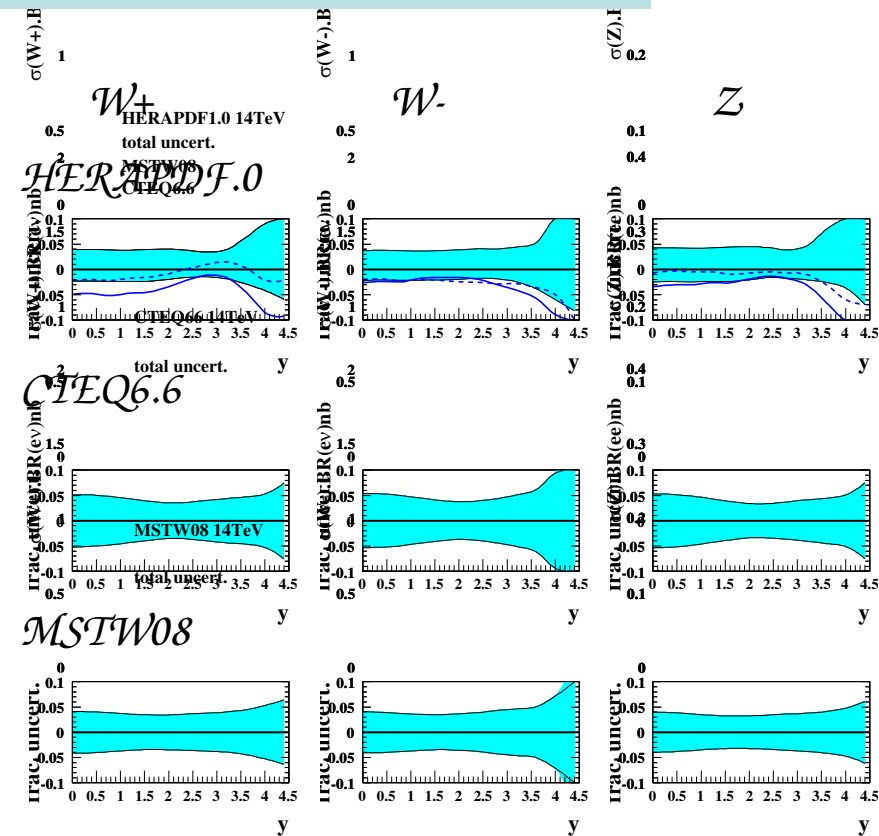
Compare HERAPDF1.0
and CTEQ66 MSTW08
central values

14 TeV

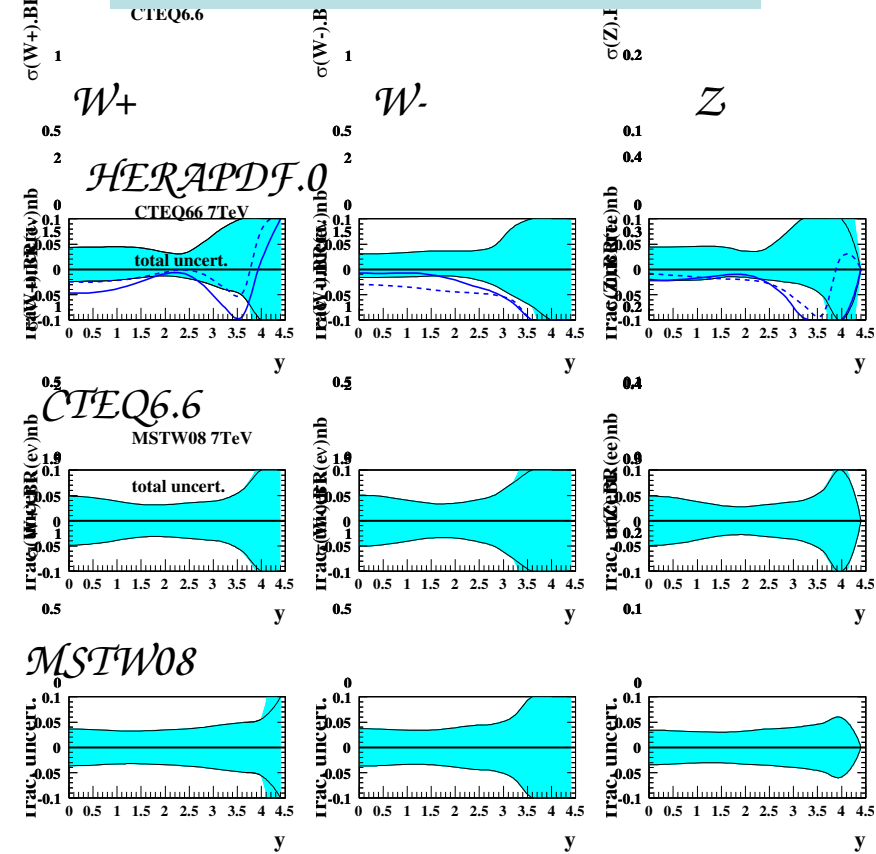
7 TeV



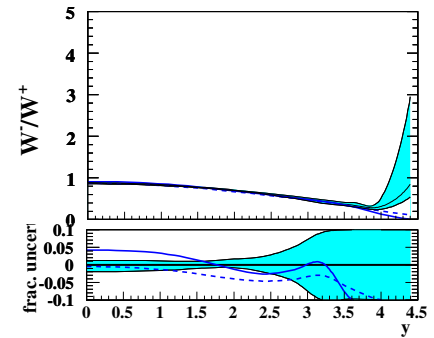
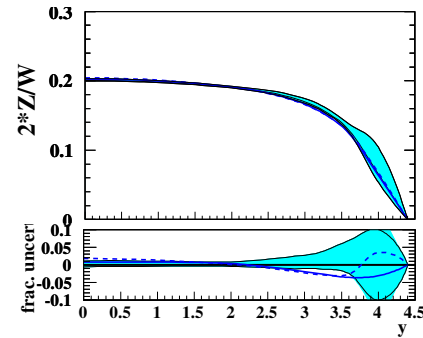
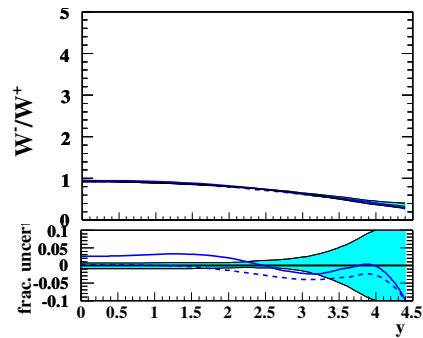
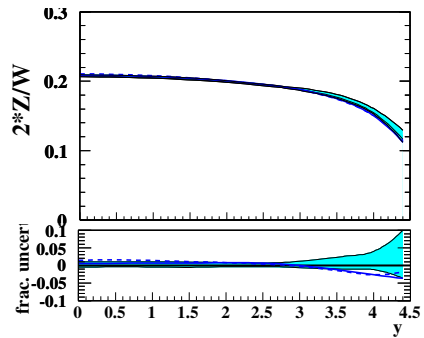
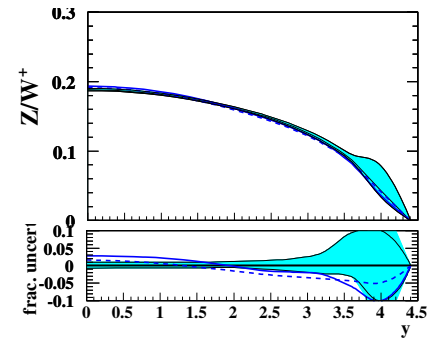
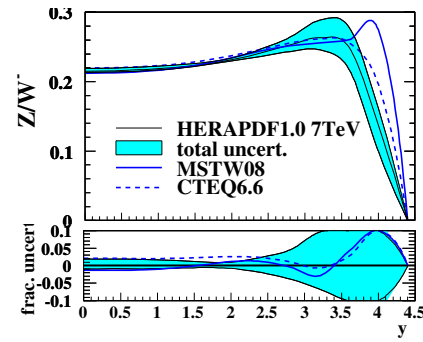
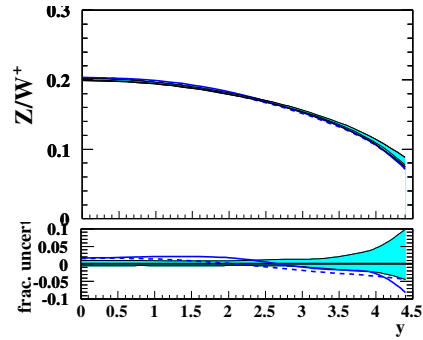
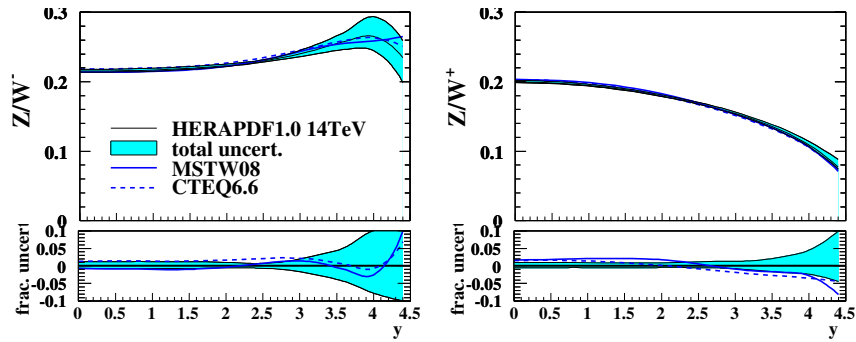
Compare also TOTAL error bands at 14 TeV



Compare also TOTAL error bands at 7 TeV



These CTEQ and MSTW error bands are at 90%CL
 The HERAPDF1.0 band includes model and parametrization errors



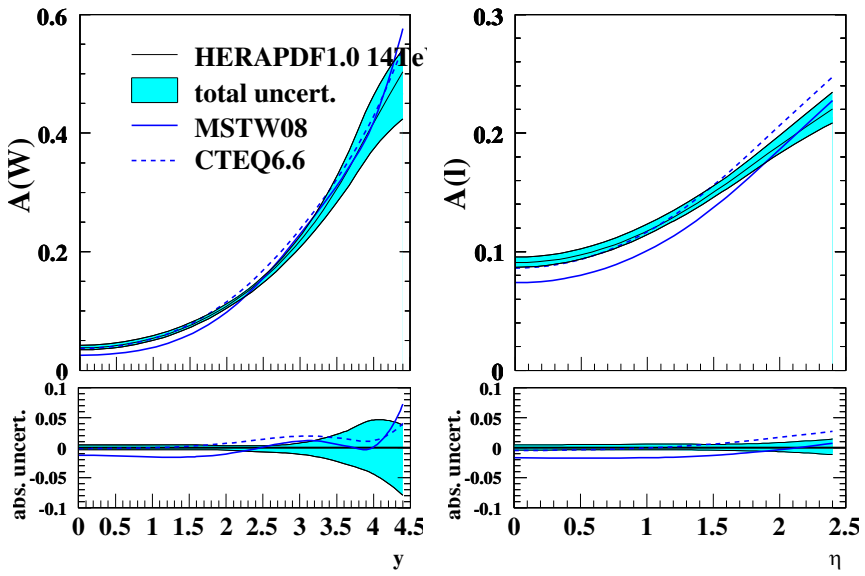
14 TeV

7 TeV

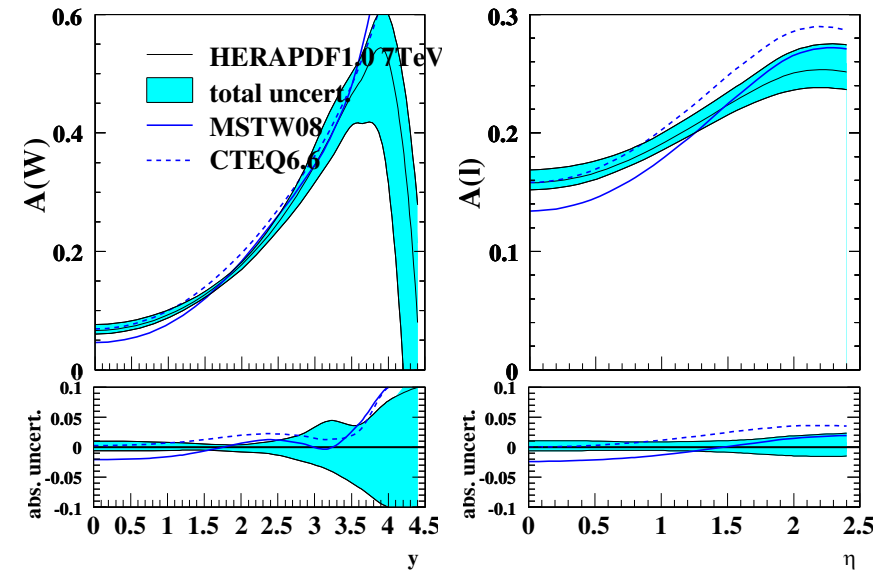
Plots of ratios:

$2*Z/W$, Z/W_+ , Z/W_- , W_-/W_+

Compare HERAPDF1.0 and CTEQ66 MSTW08 central values for ratios

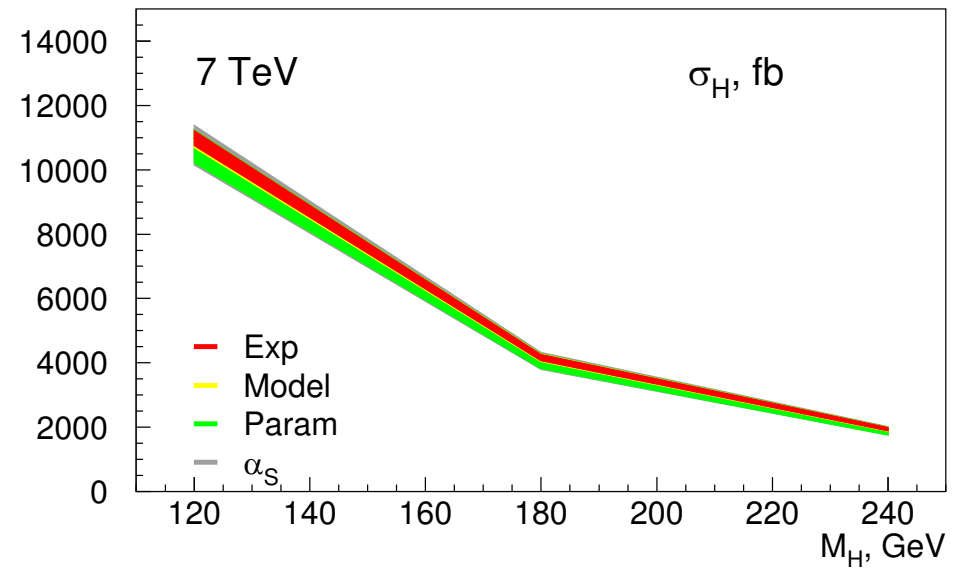
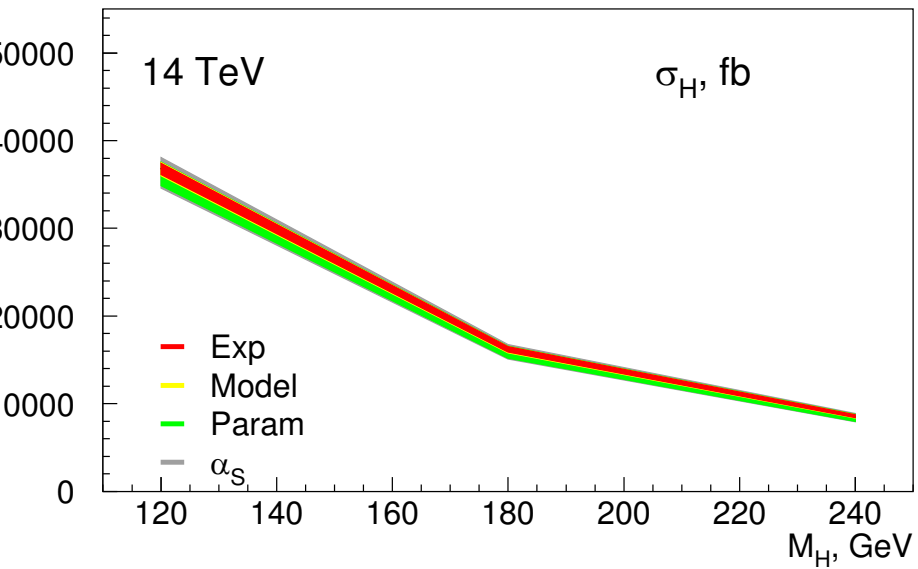


14 TeV

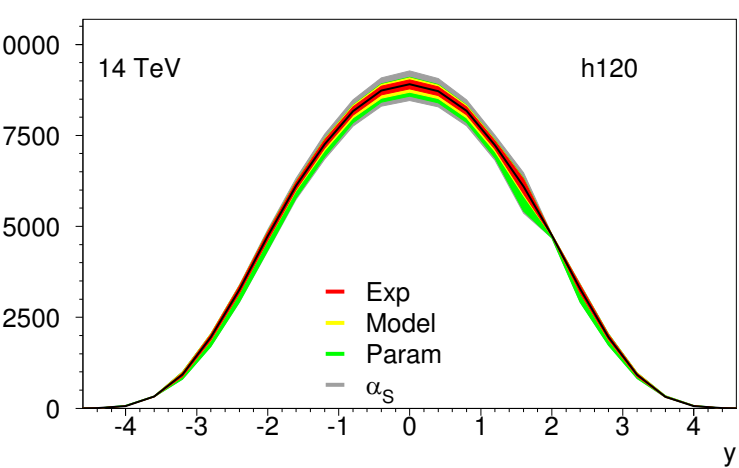


7 TeV

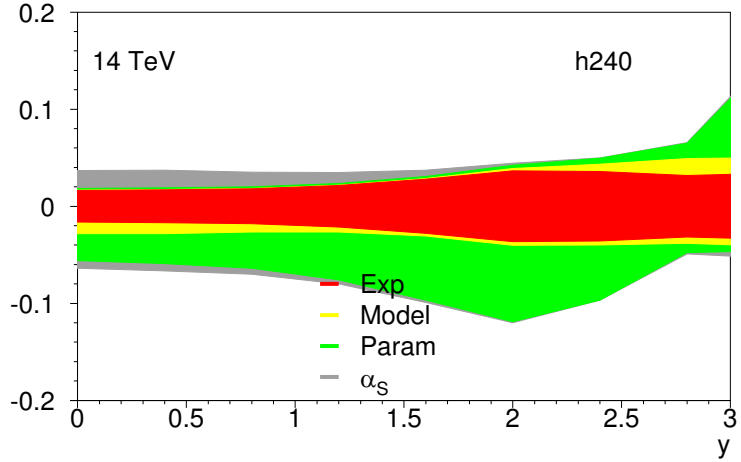
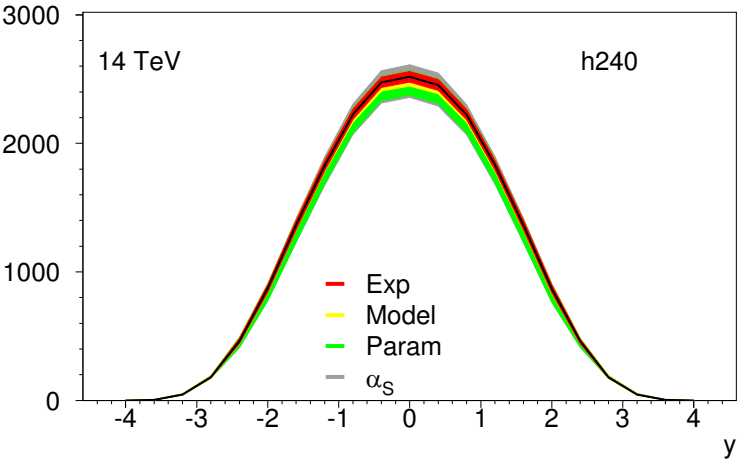
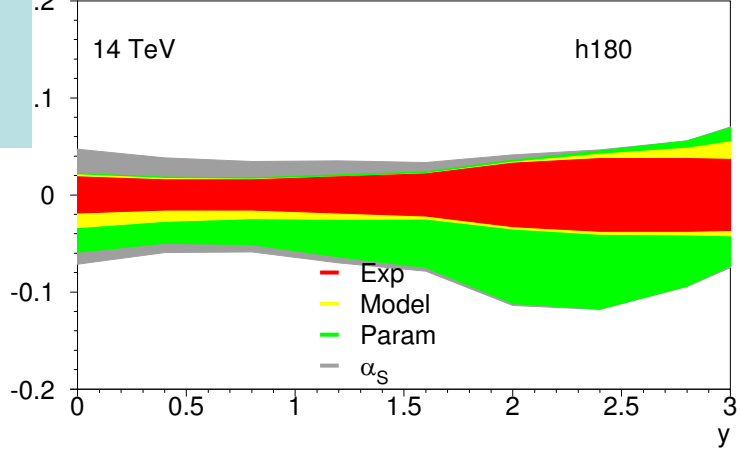
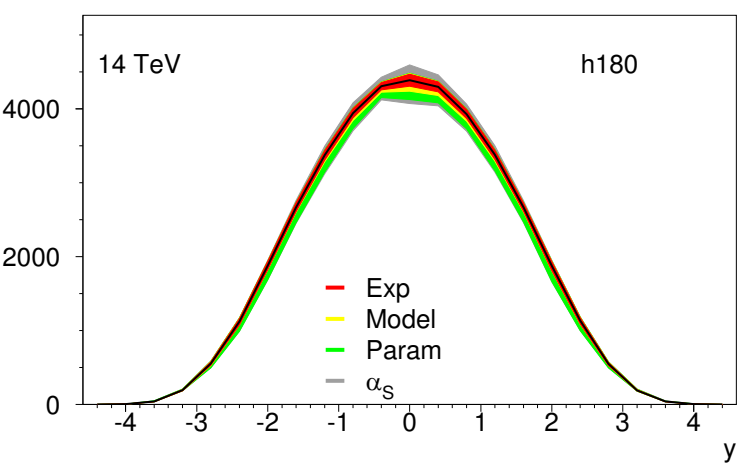
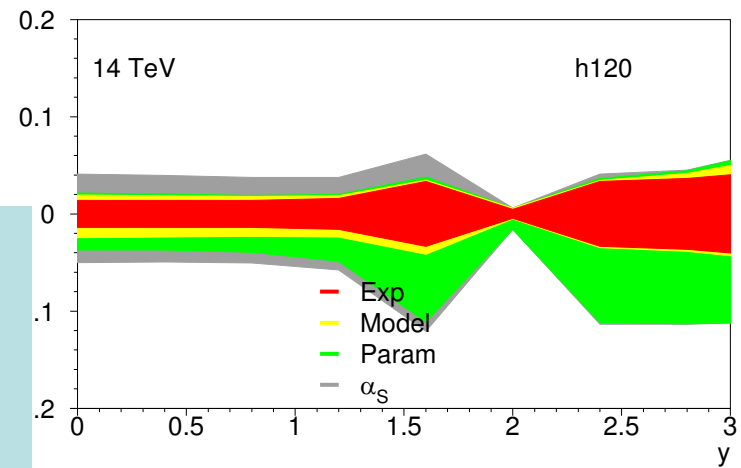
Plots of Asymmetries:
Compare HERAPDF1.0 and CTEQ66 MSTW08 central values for W and lepton asymmetries

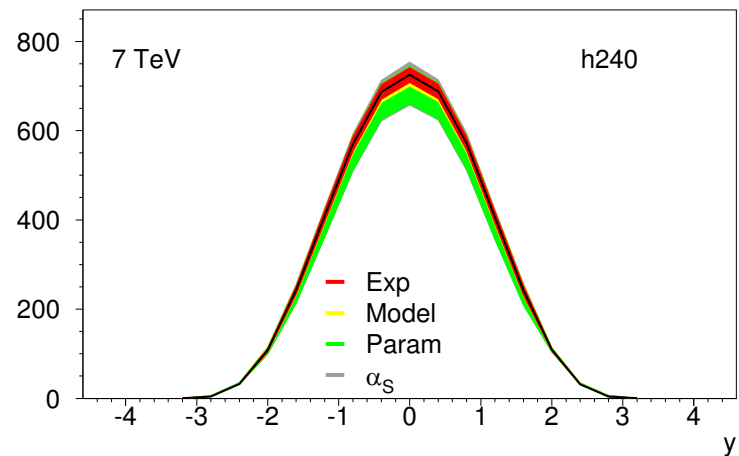
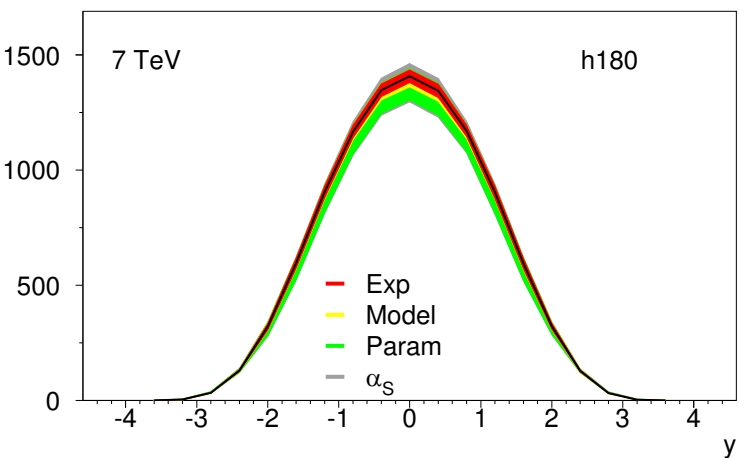
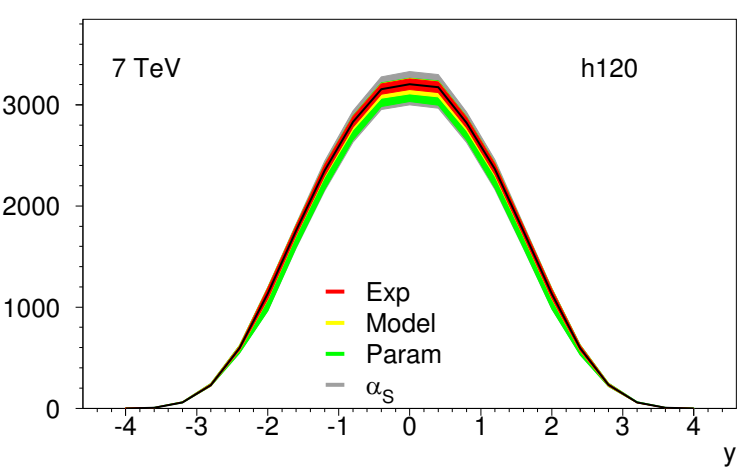


Higgs cross sections as a function of mass (fb)

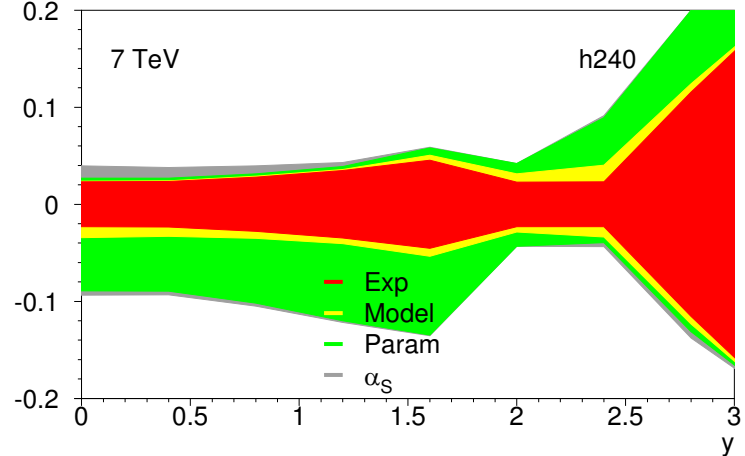
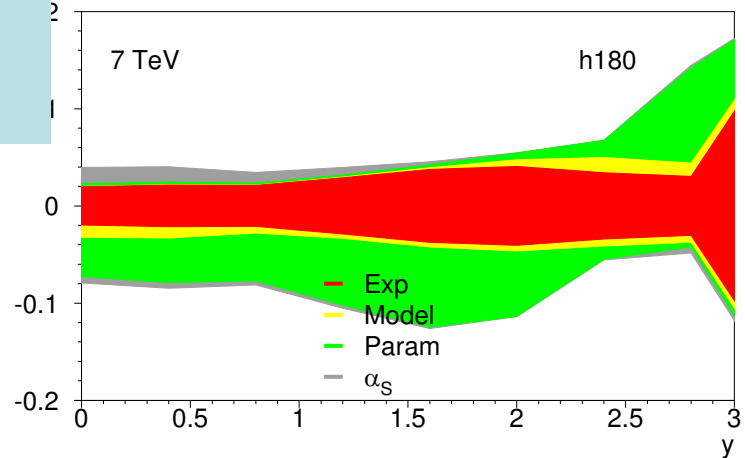
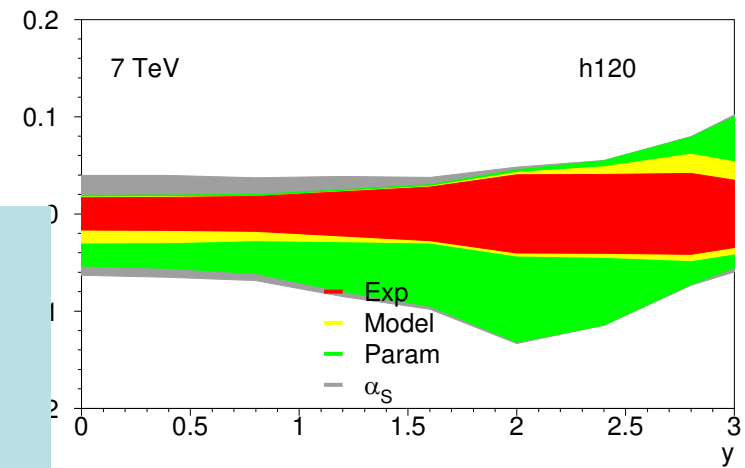


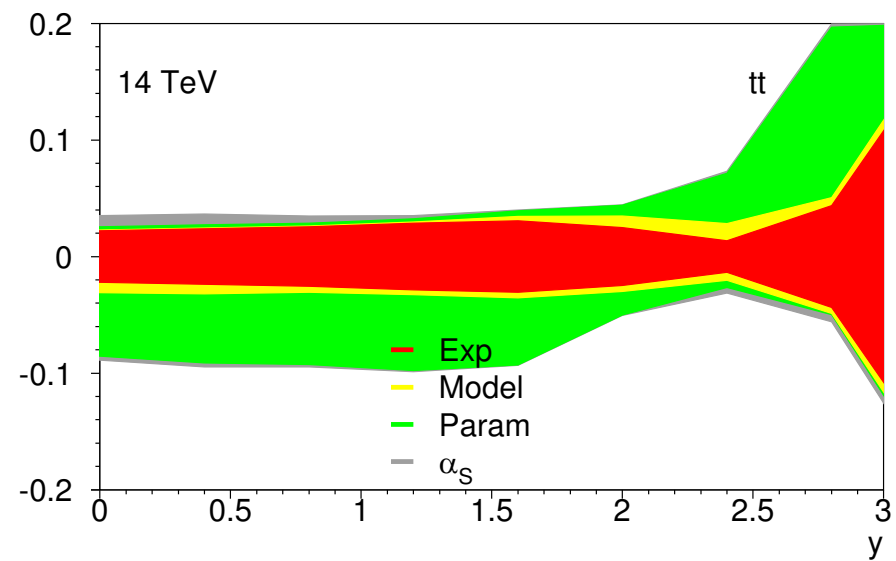
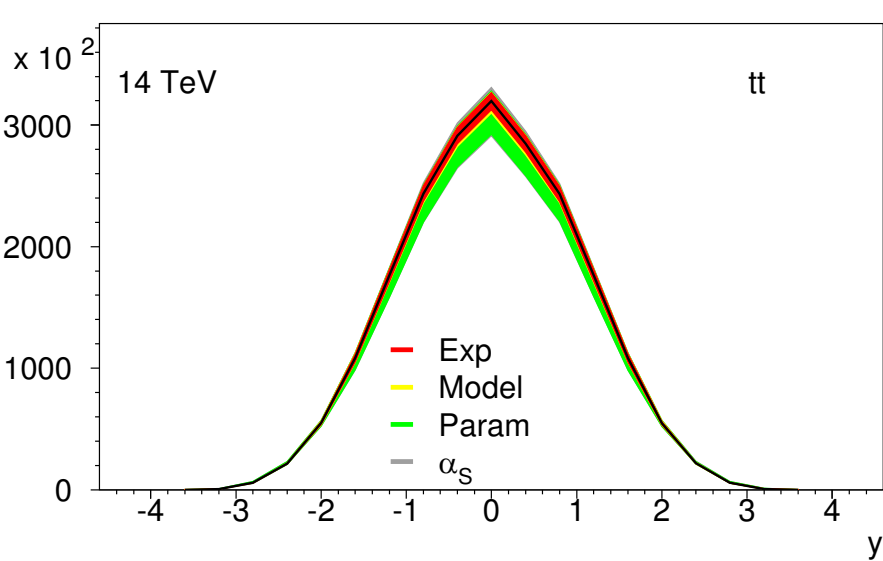
Higgs rapidity distributions AND error bands for MH=120,180,240 GeV At 14 TeV



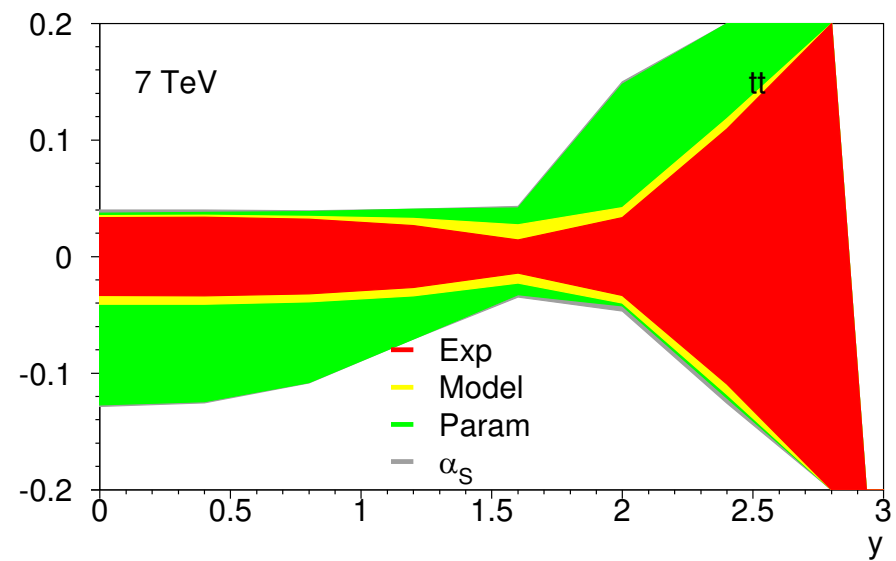
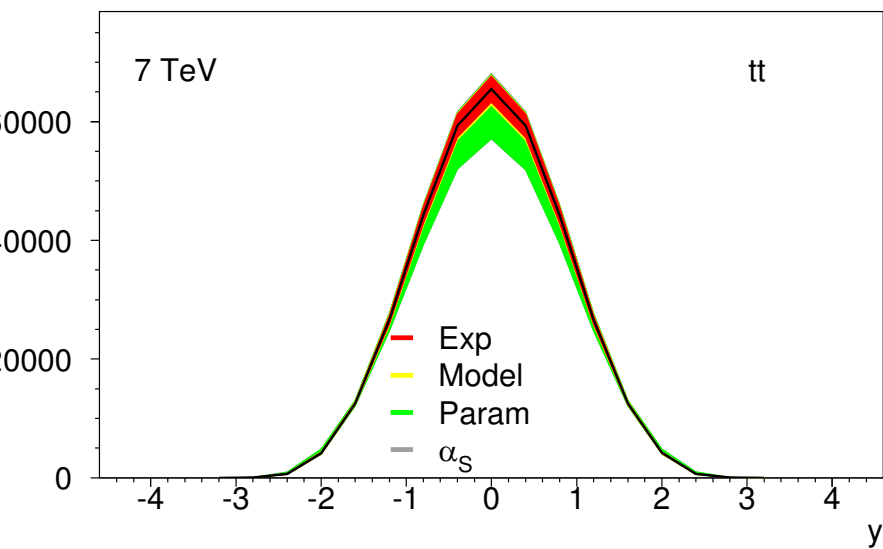


Higgs rapidity distributions AND error bands for MH=120,180,240 GeV At 7 TeV





t-tbar rapidity distributions AND error bands
at 14 TeV and 7 TeV



extras

W Z cross-sections HERAPDF1.0

PDF set	$\sigma_{W^+} B_{W \rightarrow l\nu}$ (nb)	$\sigma_{W^-} B_{W \rightarrow l\nu}$ (nb)	$\sigma_Z B_{Z \rightarrow ll}$ (nb)
HERAPDF1.0 14 TeV Mandy	12.34±0.08 +0.31 -0.08 +0.21-0.06	9.18±0.045 +0.24-0.08 +0.20-0.04	2.072±0.012 +0.05-0.015 +0.04-0.01
Sasha	12.44±0.09 +0.31 -0.08 +0.23-0.06	9.28±0.050 +0.25-0.07 +0.21-0.04	2.076±0.014 +0.059-0.015 +0.045-0.009
$\alpha_S(M_Z)$ variation 0.1156–0.1196	± 0.12	± 0.07	± 0.02
	± 0.14	± 0.08	± 0.026
HERAPDF1.0 7 TeV Mandy	6.13±0.06 +0.14-0.04 +0.13-0.03	4.26±0.03 +0.10-0.03 +0.11-0.02	0.971±0.012 +0.024-0.005 +0.023-0.004
Sasha	6.16±0.06 +0.14-0.05 +0.14-0.03	4.29±0.03 +0.10-0.03 +0.11-0.02	0.970±0.010 +0.025-0.007 +0.025-0.006
$\alpha_S(M_Z)$ variation 0.1156–0.1196	± 0.06	± 0.03	± 0.01
	± 0.069	± 0.039	± 0.012

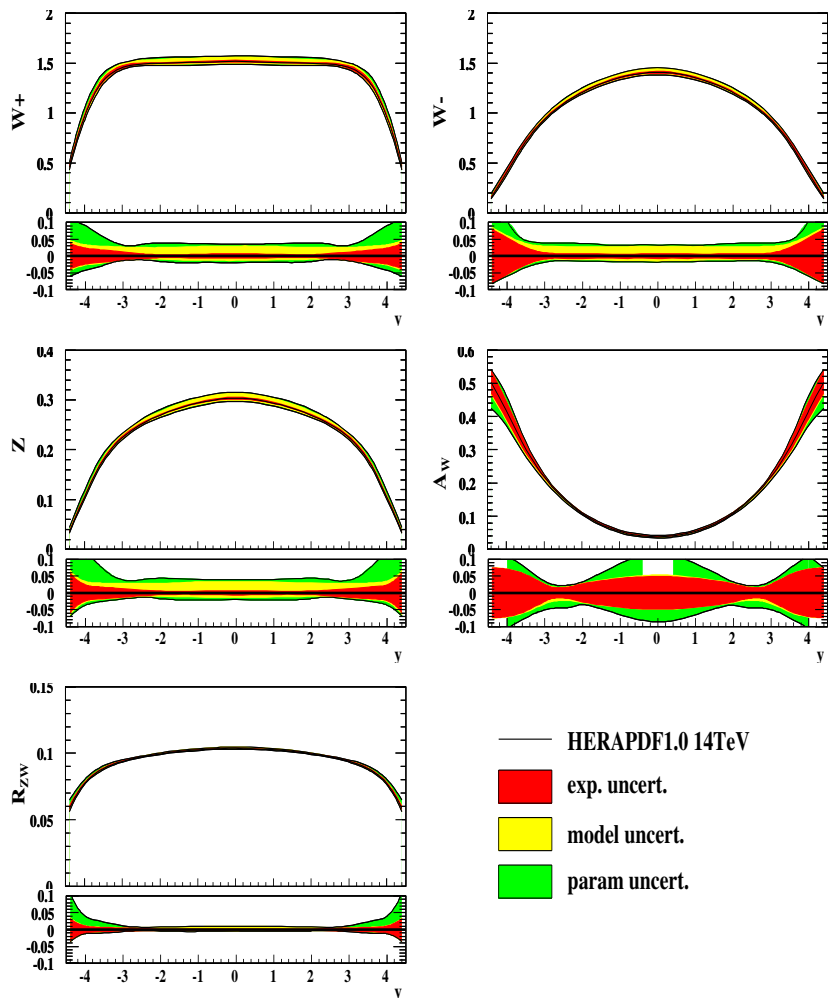
Experimental errors in red ARE 68%CL

Errors in yellow are model errors

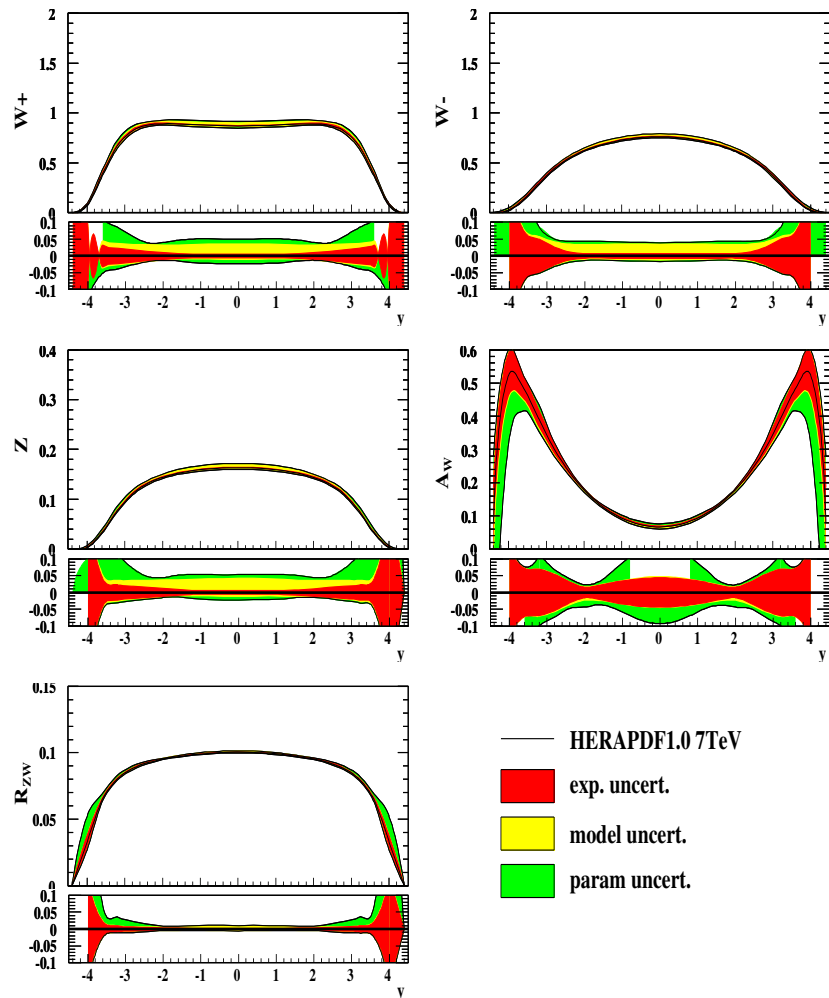
Errors in green are parametrisation errors

Charm mass model error is very asymmetric increases values by ~2.5% if $m_c=1.65$ rather than $m_c=1.4\text{GeV}$

W and Z rapidity distributions



W and Z rapidity distributions



14 TeV



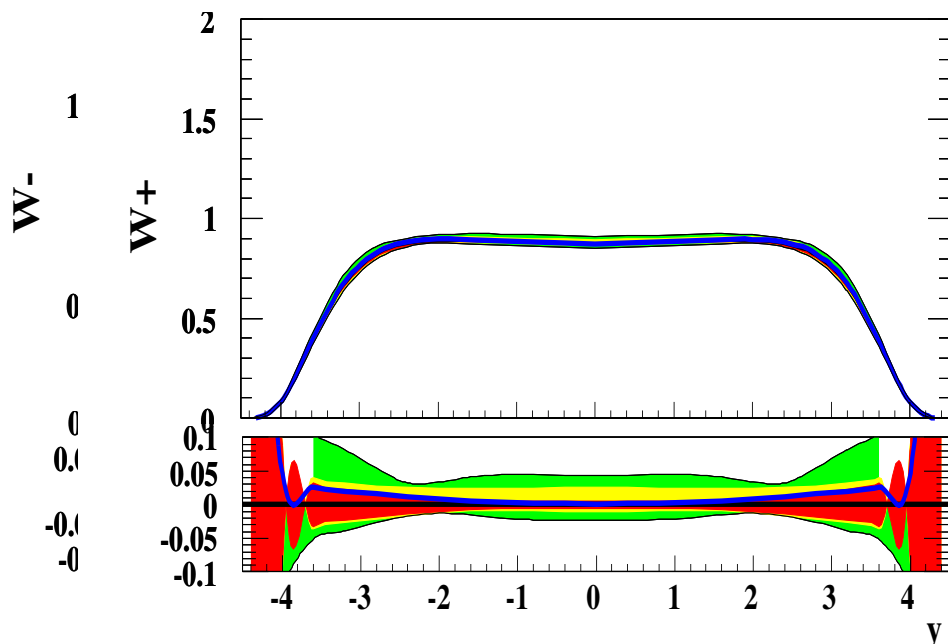
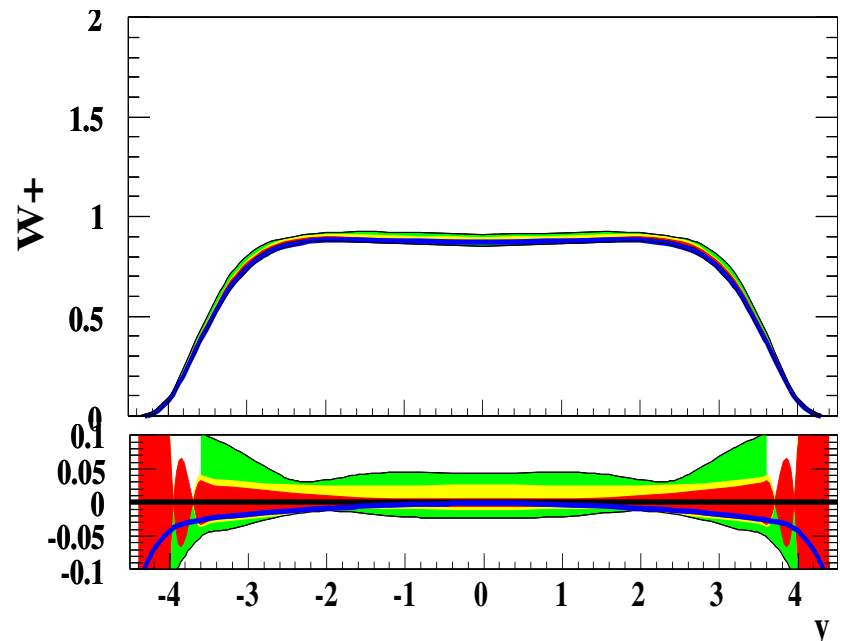
7 TeV

$\alpha_s(M_Z)=0.1156$ in blue

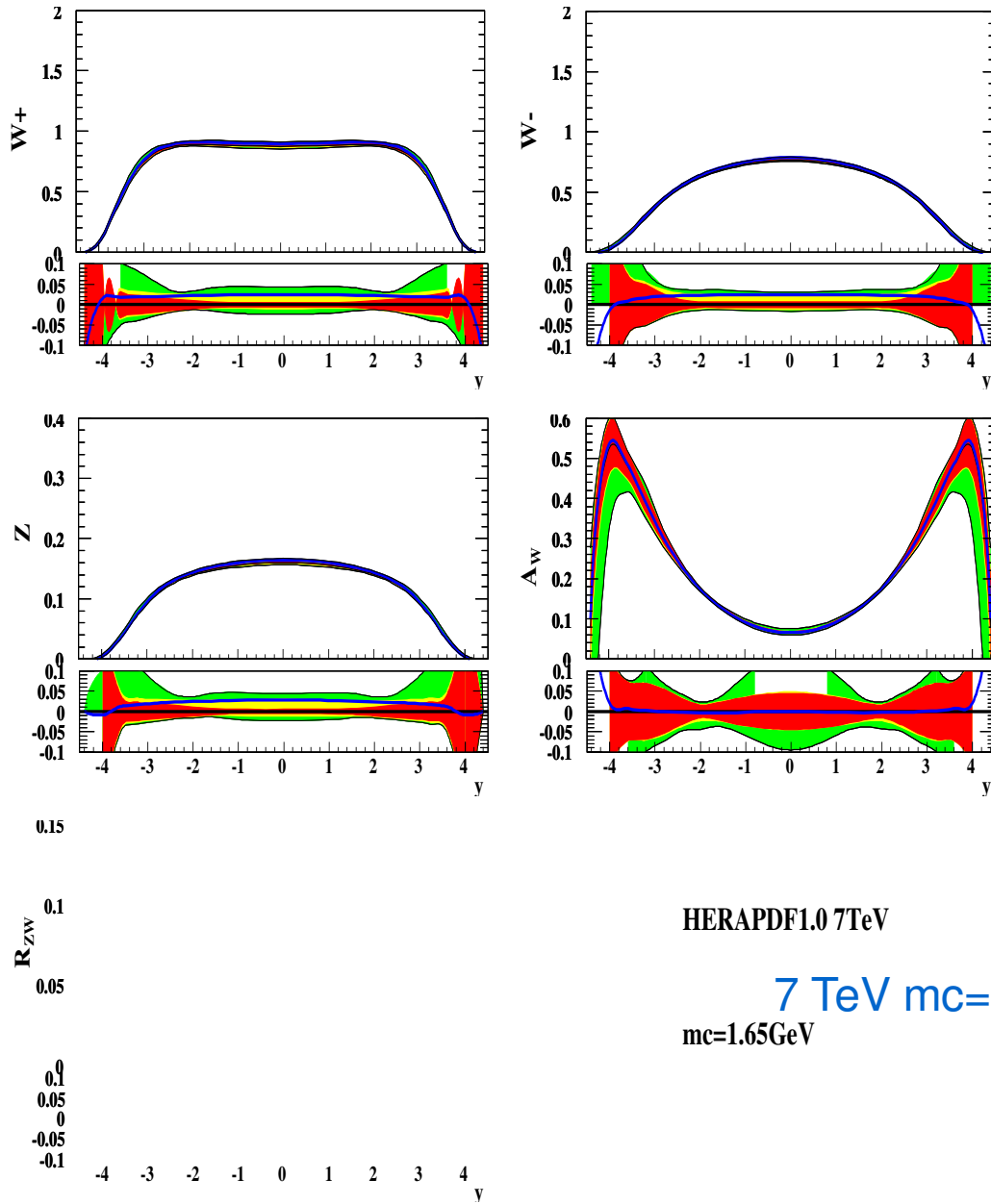
W and Z rapidity distributions

$\alpha_s(M_Z)=0.1196$ in blue

W and Z rapidity



W and Z rapidity distributions



HERAPDF1.0 7TeV

7 TeV $mc=1.65$ in blue
 $mc=1.65$ GeV