$W^\pm$ and Z^0 Boson Production at Hadron Colliders at NNLO

Johannes Blümlein, DESY

CERN, April 05, 2011

[S. Alekhin, J.B., P. Jimenez-Delgado, S. Moch, E. Reya, Phys.Lett. B697 (2011) 127; 1011.6259]

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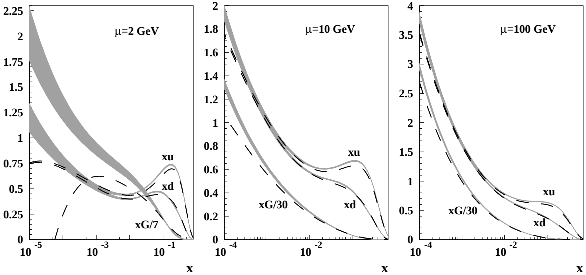
- We compare to all experimental data having ever been measured.
- The study derives realistic theory errors for the use in the present and upcoming measurements at the Tevatron and the LHC.

NNLO Parton Distributions

ABKM09, Phys.Rev. D81 (2010) 014032 vs MSTW08, Eur.Phys.J. C63 (2009) 189

Massless Partons



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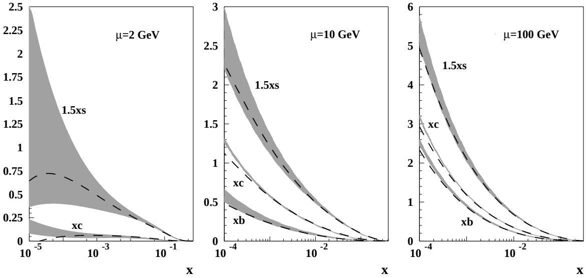
ABKM09, Phys.Rev. D81 (2010) 014032 vs MSTW08, Eur.Phys.J. C63 (2009) 189

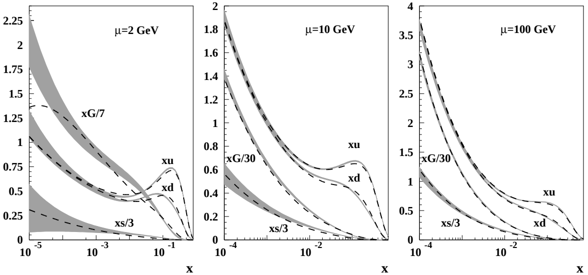
Heavier Quarks



NNLO Parton Distributions

ABKM09, Phys.Rev. D81 (2010) 014032 vs JR, Phys.Rev. D79 (2009) 074023

Massless Partons



$\overline{d} - \overline{u}$

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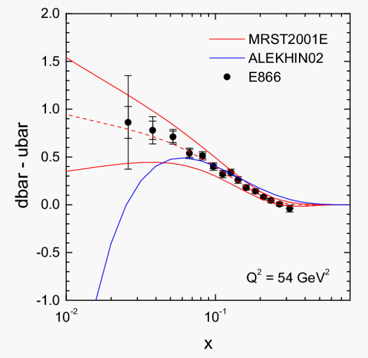
W.J. Stirling, 2004

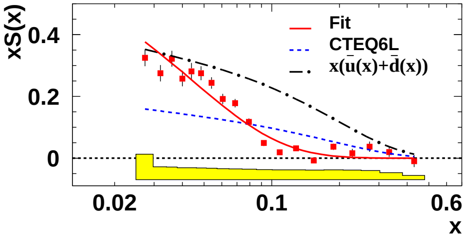
Massless Partons

$\bar{d}(x, Q^2) > \bar{u}(x, Q^2)$ (DY-process)



HERMES Collab., Phys. Lett. B666 (2008) 446

Other Results on the Strange Quark Distribution



Comparison of the current NNLO gluon densities

ABKM09, HERAPDF, JR, MSTW08

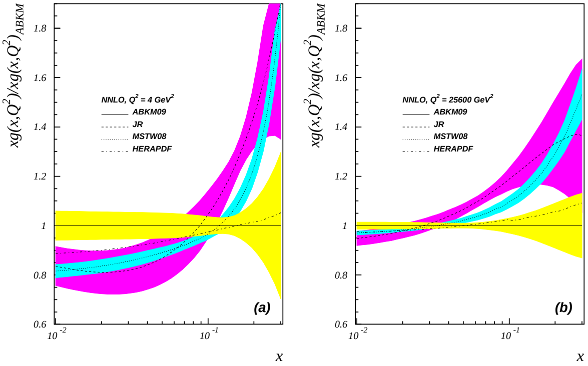
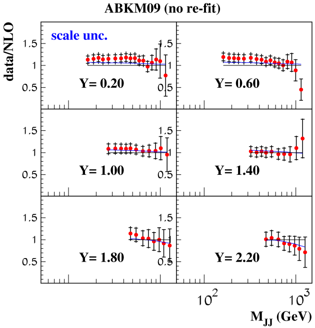
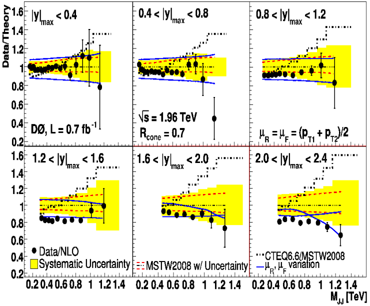


Figure 2: Comparison of the NNLO gluon distributions at $Q^2 = 4$ GeV^2 and $Q^2 = (160$ GeV$)^2$ for the ratios $xg(x,Q^2)/xg(x,Q^2)_{\rm ABKM}$ for ABKM09 (full line), (dashed line), MSTW08 (dotted line), and HERAPDF(dash-dotted line, without error band).

Combined NNLO & NLO fit including jet data

Run II D0 dijet data in the ABKM fit





D0 Collaboration PLB 693, 531 (2010)

The NLO ABKM09 ***predictions*** compared with the D0 Run II dijet data:

- Mixed scheme: 3-flavor PDFs for the DIS and 5-flavor PDFs for jets
- FastNLO tool allows to employ the NLO corrections.
- $\mu_r = \mu_F = M_{JJ}$

Kluge, Rabberitz, Wobbisch [hep-ph 0609285]

Impact of the data on ABKM PDFs is marginal

ABKM describes jet data better than the fits based on the Run II data??

The strong coupling constant

$\alpha_s(M_Z^2)$ from NNLO DIS analyses

	$\alpha_s(M_Z^2)$	
BBG	$0.1134 \ {+0.0019 \atop -0.0021}$	valence analysis, NNLO
GRS	0.112	valence analysis, NNLO
ABKM	0.1135 ± 0.0014	HQ: FFNS $N_f = 3$
ABKM	0.1129 ± 0.0014	HQ: BSMN-approach
JR	0.1124 ± 0.0020	dynamical approach
JR	0.1158 ± 0.0035	standard fit
MSTW	0.1171 ± 0.0014	
ABM	0.1147 ± 0.0012	FFNS, incl. combined H1/ZEUS data
Gehrmann et al.	$0.1153 \pm 0.0017 \pm 0.0023$	e^+e^- thrust
Abbate et al.	$0.1135 \pm 0.0011 \pm 0.0006$	e^+e^- thrust
BBG	$0.1141 \ {+0.0020 \atop -0.0022}$	valence analysis, $\mathrm{N^3LO}$
world average	0.1184 ± 0.0007	

$$\Delta_{\rm TH}\alpha_s = \alpha_s(\mathrm{N^3LO}) - \alpha_s(\mathrm{NNLO}) + \Delta_{\rm HQ} = +0.0009 \pm 0.0006_{\rm HQ}$$

$W^\pm$ and Z^0 $pp(\bar{p})$-cross sections

Tree (LO) :

Contributing Processes

$$
\begin{aligned}
(u_v + \bar{u}) \otimes \bar{d}' + c \otimes \bar{s}' &\rightarrow W^+ \\
(d'_v + \bar{d}') \otimes \bar{u} + \bar{c} \otimes s' &\rightarrow W^- \\
(u_v + \bar{u}) \otimes \bar{u} + (d_v + \bar{d}) \otimes \bar{d} + s \otimes \bar{s} + c \otimes \bar{c} + b \otimes \bar{b} &\rightarrow Z^0
\end{aligned}
$$

$$
\begin{aligned}
C_V = & \sum_i q_i \otimes \bar{q}_i{}' + a_s \left[C_1^{q\bar{q}} \sum_i q_i \otimes \bar{q}_i{}' + C_1^{gq} G \otimes \sum_i (q_i + \bar{q}_i) \right] \\
& + a_s^2 \left[C_2^{q\bar{q}} \sum_i q_i \otimes \bar{q}'_i + C_2^{qq} \sum_i q_i \otimes q'_i + C_2^{\bar{q}\bar{q}} \sum_i \bar{q}_i \otimes \bar{q}'_i \right. \\
& \left. + C_2^{gq} G \otimes \sum_i (q_i + \bar{q}_i) + C_2^{gg} G \otimes G \right] + O(a_s^3)
\end{aligned}
$$

R. Hamberg, W.L. van Neerven, T. Matsuura, Nucl.Phys. B359 (1991) 343

$W^{\pm}$ and Z^0 $p\overline{p}$-cross sections

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$\sqrt{s}$ (TeV)		0.546	0.630	1.8	1.96
ABM10	$W^{\pm}$	5.632 ± 0.092	7.045 ± 0.111	24.441 ± 0.235	26.740 ± 0.259
$\alpha_s = 0.1147 \pm 0.0012$	Z^0	1.761 ± 0.022	2.187 ± 0.028	7.181 ± 0.068	7.846 ± 0.075
ABKM09	$W^{\pm}$	5.804 ± 0.075	7.222 ± 0.091	23.88 ± 0.243	26.09 ± 0.265
$\alpha_s = 0.1135 \pm 0.0014$	Z^0	1.806 ± 0.020	2.234 ± 0.024	7.056 ± 0.068	7.691 ± 0.075
JR	$W^{\pm}$	5.983 ± 0.148	7.346 ± 0.159	23.069 ± 0.238	25.157 ± 0.251
$\alpha_s = 0.1124 \pm 0.0020$		(5.358 ± 0.152)	(6.637 ± 0.167)	(22.121 ± 0.274)	(24.181 ± 0.296)
	Z^0	1.837 ± 0.029	2.268 ± 0.034	6.975 ± 0.071	7.586 ± 0.076
		(1.648 ± 0.028)	(2.047 ± 0.033)	(6.667 ± 0.080)	(7.272 ± 0.087)
MSTW08	$W^{\pm}$	5.469 ± 0.151	6.802 ± 0.176	23.14 ± 0.394	25.35 ± 0.422
$\alpha_s = 0.1171 \pm 0.014$	Z^0	1.654 ± 0.047	2.056 ± 0.056	6.773 ± 0.126	7.406 ± 0.134
HERAPDF	$W^{\pm}$	6.121	7.519	24.51	26.80
$\alpha_s = 0.1145$	Z^0	1.853	2.296	7.319	7.978

Table 1: NNLO predictions for the production cross sections $\sigma(p\overline{p} \to V + X)$ $[nb]$, with $V = W^{\pm}, Z^0$. The abbreviation $W^{\pm}$ refers to the sum $W^+ + W^-$. Notice that for $p\overline{p}$ collisions the W^+ and W^- cross sections are equal. The errors refer to the $\pm 1\sigma$ pdf uncertainties. The NNLO values of α_s refer to $\alpha_s = \alpha_s(M_Z^2)$. To allow for a comparison with the corrections up to NLO the corresponding cross sections for the JR distributions are also listed as an example in parentheses.

$W^{\pm}$ and Z^0 *pp*-cross sections

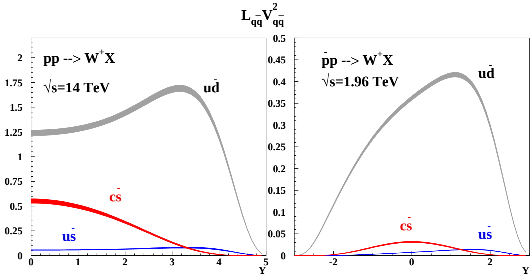
$\sqrt{s}$ (TeV)		0.5	7	10	14
ABM10	W^+	1.236 ± 0.057	59.86 ± 0.838	85.58 ± 1.267	118.4 ± 1.891
	W^-	0.363 ± 0.092	40.28 ± 0.535	60.28 ± 0.852	86.58 ± 1.331
	$W^{\pm}$	1.600 ± 0.070	100.1 ± 1.315	145.9 ± 2.065	205.0 ± 3.186
	Z^0	0.305 ± 0.015	29.01 ± 0.391	42.77 ± 0.633	60.69 ± 0.963
ABKM09	W^+	1.160 ± 0.046	58.86 ± 0.903	85.14 ± 1.427	119.4 ± 2.072
	W^-	0.348 ± 0.014	39.43 ± 0.614	59.56 ± 0.993	86.53 ± 1.525
	$W^{\pm}$	1.509 ± 0.058	98.27 ± 1.527	144.7 ± 2.436	205.9 ± 3.658
	Z^0	0.287 ± 0.012	28.42 ± 0.457	42.28 ± 0.743	60.70 ± 0.115
JR	W^+	1.138 ± 0.061	54.57 ± 1.10	78.43 ± 1.98	109.31 ± 3.13
		(1.245 ± 0.065)	(52.96 ± 0.99)	(76.60 ± 1.74)	(107.58 ± 2.95)
	W^-	0.387 ± 0.028	37.15 ± 0.79	55.54 ± 1.44	80.02 ± 2.31
		(0.427 ± 0.030)	(36.39 ± 0.72)	(54.67 ± 1.26)	(79.16 ± 2.12)
	$W^{\pm}$	1.525 ± 0.052	91.72 ± 1.82	133.99 ± 3.35	189.29 ± 5.41
		(1.672 ± 0.053)	(89.36 ± 1.57)	(131.23 ± 2.87)	(186.74 ± 4.95)
	Z^0	0.300 ± 0.011	27.24 ± 0.50	40.39 ± 0.95	57.85 ± 1.56
		(0.336 ± 0.012)	(26.57 ± 0.43)	(39.57 ± 0.81)	(57.00 ± 1.42)
MSTW08	W^+	1.221 ± 0.0421	56.80 ± 0.971	81.83 ± 1.405	114.0 ± 1.945
	W^-	0.416 ± 0.017	39.63 ± 0.678	59.45 ± 1.008	85.63 ± 1.484
	$W^{\pm}$	1.637 ± 0.052	96.41 ± 1.607	141.3 ± 2.372	199.6 ± 3.379
	Z^0	0.319 ± 0.011	27.89 ± 0.481	41.34 ± 0.705	58.99 ± 1.012
HERAPDF	W^+	1.219	59.37	85.37	119.0
	W^-	0.414	40.82	61.06	87.94
	$W^{\pm}$	1.633	100.2	146.4	206.9
	Z^0	0.322	29.08	42.95	61.22

Table 2: NNLO predictions for the production cross sections $\sigma(pp \to V + X)$ $[nb]$, with $V = W^{\pm}, Z^0$. The abbreviation $W^{\pm}$ denotes the sum $W^+ + W^-$. The errors refer to the $\pm 1\sigma$ pdf uncertainties. To allow for a comparison with the corrections up to NLO we also listed the corresponding cross sections for the JR distributions as an example in parentheses .

$W^{\pm}$ and Z^0 $p\bar{p}$-cross sections

The knowledge of the strange and charm quark distributions is important at LHC.

The cross sections at NLO and NNLO differ by 1 to 1.5 $\sigma_{\rm PDF}$.



$W^{\pm}$ and Z^0 production cross sections

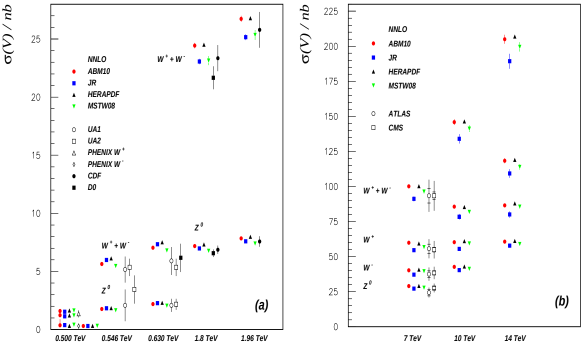
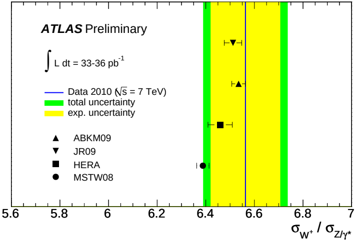


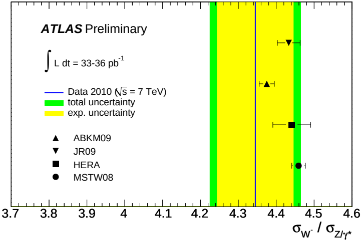
Figure 1: Comparison of different NNLO predictions for the inclusive W^+, W^-, $W^{\pm}$, and Z^0 boson production cross sections in $p\overline{p}$ annihilation and pp scattering ($\sqrt{S} = 0.5$ TeV) based on the pdfs of recent NNLO analyses, ABM,ABKM,JR,HERAPDF,MSTW08,MSTW10, and the corresponding experimental data by UA1,UA2,PHENIX,CDF,CDF1,D0,ATLAS,CMS. Left panel (a): the lower energy region corresponds to $p\overline{p}$ collisions, except at 0.5 TeV, which refers to pp scattering. For the latter case the predictions refer to (from above) $W^+ + W^-$, W^+, W^- and the ones for Z^0 are given to the right of the ones for W^-. Right panel (b): LHC energies (pp collisions); the inner error bars refer to $(\sigma^2_{\rm stat} + \sigma^2_{\rm syst})^{1/2}$ and the total error is obtained by adding the luminosity error in quadrature.

$W^\pm$ and Z^0 production cross sections

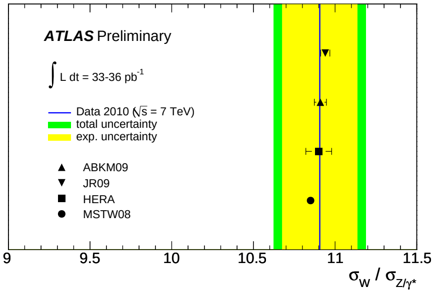
Recent measurements of $W^\pm$ and Z-production cross sections at ATLAS

ATLAS-CONF-2011-041





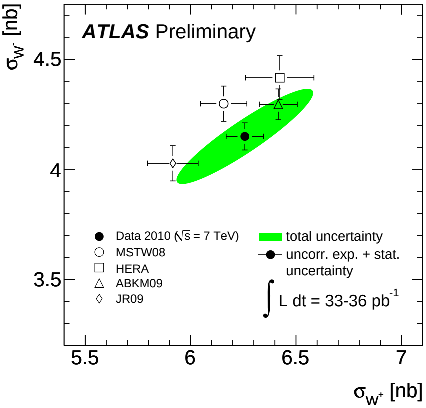
$[W^+ + W^-]$ and Z-production cross sections at ATLAS
ATLAS-CONF-2011-041



However, the flavor contributions to $\sigma(W^+)$ and $\sigma(W^-)$ are different.

$W^\pm$ and Z^0 production cross sections

Correlation between the W^+ and W^- and cross sections



$W^\pm$ and Z^0 production cross sections

ATLAS-CONF-2011-041, CMS PAS EWK-10-005

$$
\begin{aligned}
ATLAS : \sigma(W^+) &= 6.257 \pm 0.017 \pm 0.152 \pm 0.188 \pm 0.213 nb \\
CMS : \sigma(W^+) &= 6.04 \pm 0.02 \pm 0.06 \pm 0.08 \pm 0.24 nb \\
ATLAS : \sigma(W^-) &= 4.149 \pm 0.014 \pm 0.102 \pm 0.124 \pm 0.141 nb \\
CMS : \sigma(W^-) &= 4.26 \pm 0.01 \pm 0.04 \pm 0.07 \pm 0.17 nb \\
ATLAS : \sigma(Z^0) &= 0.945 \pm 0.006 \pm 0.011 \pm 0.038 \pm 0.032 nb \\
CMS : \sigma(Z^0) &= 0.975 \pm 0.007 \pm 0.007 \pm 0.018 \pm 0.039 nb
\end{aligned}
$$

Theory prediction (CMS) :

$$
\begin{aligned}
W^+ &: \quad 6.15 \pm 0.29_{\rm TH} \; nb \; (CMS), \quad \Delta_{\rm TH} = 0.500 \; nb \; (ATLAS) \\
W^- &: \quad 4.29 \pm 0.23_{\rm TH} \; nb \; (CMS), \quad \Delta_{\rm TH} = 0.390 \; nb \; (ATLAS) \\
Z^0 &: \quad 0.97 \pm 0.04_{\rm TH} \; nb \; (CMS), \quad \Delta_{\rm TH} = 0.085 \; nb \; (ATLAS)
\end{aligned}
$$

(*NNLO*)

W^+ vs W^- production cross sections

ATLAS-CONF-2011-041, CMS PAS EWK-10-005

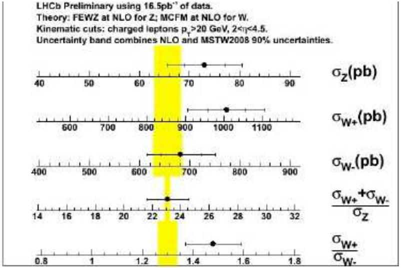
$$\sigma(W^+)/\sigma(W^-)$$

$$\begin{aligned} ATLAS: &\quad 1.511 \pm 0.057 \\ CMS: &\quad 1.421 \pm 0.034 \\ \underline{Theory:} & \\ ABKM: &\quad 1.497 \pm 0.032 \\ JR: &\quad 1.469 \pm 0.042 \\ HERA: &\quad 1.452 \pm 0.049 \\ MSTW: &\quad 1.433 \pm 0.037 \end{aligned}$$

$W^{\pm}$ and Z^0 production cross sections: LHCb

Correlation between the W^+ and W^- and cross sections

(T. Shears)



Predictions for the H^0 production cross sections at LHC

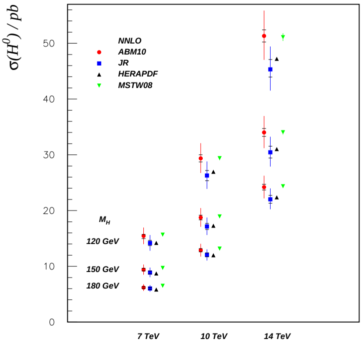


Figure 3: Predictions of the inclusive Higgs–boson production cross sections at NNLO for different energies at the LHC for the parton distributions ABM10, JR, HERAPDF, MSTW08. For the ABM10 and JR distributions the scale variation errors corresponding to the range $M_H/2 \le \mu_F = \mu_R \le 2M_H$ are included. The inner error bars refer to the pdf–errors only.

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Conclusions

- The LHC standard candles seem to challenge our present knowledge on the u and d quark distributions, after 35 years of their measurement.

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- Already the current precision requires NNLO determinations of the pdfs.
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- $W^{\pm}$ and Z^0 boson production at LHC is currently predicted with an accuracy of 10%, mainly due to the present differences in the sea quark densities.
- It is remarkable, that the present NNLO predictions are very well compatible with the measured cross section ratios.

Conclusions

- An important measurement to constrain the $\overline{d} - \overline{u}$ distribution is possible using the Drell-Yan data sufficiently below the Z-resonance at the LHC.

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- Future NNLO corrections for $ep \to 2\mathrm{jets}$ will help to constrain the gluon distribution and α_s better from the HERA data.
- Detailed comparisons should be carried out at NNLO for the different pdf-fits w.r.t. the treatment of the various theoretical aspects and data-treatment (e.g. systematic errors), to improve the predictions further.

Back-up Slides

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H^0 $p\bar{p}$-production cross section at Tevatron

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M_H (GeV)	ABM10	ABKM09	JR	MSTW08	HERAPDF
100	1.438 ± 0.066	1.380 ± 0.076	1.593 ± 0.091	1.682 ± 0.046	1.417
110	1.051 ± 0.052	1.022 ± 0.061	1.209 ± 0.078	1.265 ± 0.038	1.055
115	0.904 ± 0.047	0.885 ± 0.055	1.060 ± 0.072	1.104 ± 0.034	0.917
120	0.781 ± 0.042	0.770 ± 0.050	0.933 ± 0.067	0.968 ± 0.031	0.800
125	0.677 ± 0.038	0.672 ± 0.045	0.823 ± 0.062	0.851 ± 0.029	0.700
130	0.588 ± 0.034	0.589 ± 0.041	0.729 ± 0.058	0.752 ± 0.026	0.615
135	0.513 ± 0.031	0.518 ± 0.037	0.647 ± 0.054	0.666 ± 0.024	0.541
140	0.449 ± 0.028	0.456 ± 0.034	0.576 ± 0.050	0.591 ± 0.022	0.479
145	0.394 ± 0.025	0.403 ± 0.031	0.514 ± 0.047	0.527 ± 0.020	0.424
150	0.347 ± 0.023	0.358 ± 0.028	0.461 ± 0.044	0.471 ± 0.018	0.377
155	0.306 ± 0.020	0.318 ± 0.026	0.413 ± 0.041	0.421 ± 0.017	0.336
160	0.271 ± 0.019	0.283 ± 0.024	0.371 ± 0.039	0.378 ± 0.016	0.300
165	0.240 ± 0.017	0.253 ± 0.022	0.335 ± 0.036	0.341 ± 0.014	0.269
170	0.213 ± 0.015	0.226 ± 0.020	0.302 ± 0.034	0.307 ± 0.013	0.241
175	0.190 ± 0.014	0.203 ± 0.019	0.274 ± 0.032	0.278 ± 0.012	0.217
180	0.169 ± 0.013	0.182 ± 0.017	0.248 ± 0.030	0.251 ± 0.012	0.195
185	0.151 ± 0.012	0.164 ± 0.016	0.225 ± 0.028	0.228 ± 0.011	0.176
190	0.136 ± 0.011	0.148 ± 0.015	0.205 ± 0.027	0.207 ± 0.010	0.159
200	0.109 ± 0.009	0.121 ± 0.013	0.170 ± 0.024	0.172 ± 0.009	0.131

Table 3: NNLO predictions for the production cross sections $\sigma(p\bar{p} \to H^0 + X)$ $[pb]$ at $\sqrt{S} = 1.96$ TeV. The errors refer to the $\pm 1\sigma$ pdf uncertainties.

H^0 pp-production at LHC $\sqrt{S} = 7$ TeV

M_H (GeV)	ABM10	ABKM09	JR	MSTW08	HERAPDF
100	22.82 ± 0.53	21.18 ± 0.60	20.48 ± 0.70	22.95 ± 0.31	20.90
110	18.65 ± 0.44	17.30 ± 0.49	16.92 ± 0.56	18.84 ± 0.26	17.12
115	16.95 ± 0.40	15.72 ± 0.45	15.46 ± 0.50	17.16 ± 0.23	15.58
120	15.45 ± 0.37	14.34 ± 0.41	14.17 ± 0.45	15.69 ± 0.22	14.22
125	14.14 ± 0.35	13.12 ± 0.38	13.03 ± 0.41	14.39 ± 0.20	13.03
130	12.96 ± 0.32	12.03 ± 0.35	12.01 ± 0.37	13.23 ± 0.19	11.97
135	11.92 ± 0.29	11.07 ± 0.33	11.10 ± 0.34	12.20 ± 0.17	11.02
140	10.99 ± 0.27	10.21 ± 0.31	10.29 ± 0.32	11.28 ± 0.16	10.18
145	10.15 ± 0.26	9.44 ± 0.29	9.55 ± 0.29	10.45 ± 0.15	9.42
150	9.40 ± 0.24	8.75 ± 0.27	8.89 ± 0.27	9.71 ± 0.14	8.74
155	8.73 ± 0.23	8.13 ± 0.25	8.30 ± 0.25	9.04 ± 0.14	8.13
160	8.12 ± 0.21	7.56 ± 0.24	7.75 ± 0.24	8.43 ± 0.13	7.57
165	7.56 ± 0.20	7.05 ± 0.23	7.26 ± 0.23	7.88 ± 0.12	7.07
170	7.06 ± 0.19	6.59 ± 0.21	6.82 ± 0.21	7.38 ± 0.12	6.62
175	6.60 ± 0.18	6.17 ± 0.20	6.41 ± 0.20	6.92 ± 0.11	6.20
180	6.19 ± 0.17	5.79 ± 0.19	6.04 ± 0.19	6.51 ± 0.11	5.83
185	5.80 ± 0.16	5.43 ± 0.18	5.70 ± 0.18	6.13 ± 0.10	5.48
190	5.46 ± 0.15	5.11 ± 0.17	5.39 ± 0.18	5.78 ± 0.10	5.16
200	4.84 ± 0.14	4.55 ± 0.16	4.83 ± 0.16	5.16 ± 0.09	4.60
220	3.88 ± 0.12	3.67 ± 0.14	3.96 ± 0.14	4.20 ± 0.08	3.73
240	3.18 ± 0.10	3.02 ± 0.12	3.32 ± 0.13	3.49 ± 0.07	3.09
260	2.66 ± 0.09	2.55 ± 0.10	2.84 ± 0.12	2.96 ± 0.06	2.61
280	2.28 ± 0.08	2.19 ± 0.09	2.48 ± 0.11	2.58 ± 0.06	2.26
300	2.00 ± 0.08	1.94 ± 0.09	2.23 ± 0.11	2.29 ± 0.06	2.00

Table 4: NNLO predictions for the production cross sections $\sigma(pp \to H^0 + X)$ $[pb]$ at LHC for $\sqrt{S} =$ 7 TeV. The errors refer to the $\pm 1\sigma$ pdf uncertainties.

H^0 *pp*-production at LHC $\sqrt{S} = 8$ TeV

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M_H (GeV)	ABM10	ABKM09	JR	MSTW08	HERAPDF
100	28.81 ± 0.65	26.81 ± 0.74	25.66 ± 0.91	28.85 ± 0.38	26.38
110	23.71 ± 0.54	22.04 ± 0.61	21.31 ± 0.72	23.83 ± 0.32	21.74
115	21.62 ± 0.49	20.09 ± 0.56	19.53 ± 0.65	21.77 ± 0.29	19.85
120	19.78 ± 0.46	18.38 ± 0.51	17.95 ± 0.59	19.96 ± 0.27	18.18
125	18.15 ± 0.42	16.86 ± 0.48	16.55 ± 0.53	18.35 ± 0.25	16.70
130	16.70 ± 0.39	15.52 ± 0.44	15.29 ± 0.49	16.93 ± 0.23	15.39
135	15.41 ± 0.36	14.32 ± 0.40	14.17 ± 0.44	15.65 ± 0.21	14.21
140	14.25 ± 0.34	13.24 ± 0.38	13.16 ± 0.41	14.51 ± 0.20	13.16
145	13.21 ± 0.32	12.28 ± 0.36	12.26 ± 0.37	13.48 ± 0.19	12.22
150	12.27 ± 0.30	11.41 ± 0.33	11.44 ± 0.35	12.55 ± 0.18	11.37
155	11.42 ± 0.28	10.63 ± 0.31	10.69 ± 0.32	11.71 ± 0.17	10.60
160	10.66 ± 0.26	9.92 ± 0.29	10.02 ± 0.30	10.96 ± 0.16	9.90
165	9.96 ± 0.25	9.28 ± 0.27	9.41 ± 0.28	10.27 ± 0.15	9.27
170	9.33 ± 0.23	8.69 ± 0.26	8.85 ± 0.27	9.64 ± 0.14	8.69
175	8.75 ± 0.22	8.15 ± 0.25	8.34 ± 0.25	9.06 ± 0.14	8.17
180	8.22 ± 0.21	7.67 ± 0.24	7.88 ± 0.24	8.54 ± 0.13	7.69
185	7.73 ± 0.20	7.22 ± 0.23	7.45 ± 0.23	8.06 ± 0.12	7.25
190	7.29 ± 0.19	6.81 ± 0.21	7.06 ± 0.22	7.62 ± 0.12	6.85
200	6.51 ± 0.18	6.09 ± 0.20	6.36 ± 0.20	6.84 ± 0.11	6.14
220	5.28 ± 0.15	4.96 ± 0.17	5.26 ± 0.17	5.61 ± 0.10	5.02
240	4.37 ± 0.13	4.13 ± 0.15	4.44 ± 0.15	4.70 ± 0.09	4.19
260	3.70 ± 0.12	3.51 ± 0.13	3.83 ± 0.14	4.03 ± 0.08	3.58
280	3.20 ± 0.10	3.05 ± 0.12	3.38 ± 0.14	3.53 ± 0.07	3.13
300	2.83 ± 0.10	2.72 ± 0.11	3.05 ± 0.13	3.17 ± 0.07	2.79

Table 5: NNLO predictions for the production cross sections $\sigma(pp \to H^0 + X)$ $[pb]$ at LHC for $\sqrt{S} = 8$ TeV. The errors refer to the $\pm 1\sigma$ pdf uncertainties.

H^0 pp-production at LHC $\sqrt{S} = 14$ TeV

M_H (GeV)	ABM10	ABKM09	JR	MSTW08	HERAPDF
100	71.16 ± 1.53	67.27 ± 1.78	62.24 ± 2.62	70.73 ± 0.98	65.54
110	60.05 ± 1.27	56.60 ± 1.48	52.77 ± 2.11	59.73 ± 0.81	55.28
115	55.42 ± 1.17	52.17 ± 1.36	48.82 ± 1.92	55.16 ± 0.73	51.01
120	51.32 ± 1.10	48.25 ± 1.24	45.32 ± 1.74	51.10 ± 0.69	47.23
125	47.63 ± 1.00	44.73 ± 1.16	42.16 ± 1.59	47.46 ± 0.62	43.83
130	44.33 ± 0.94	41.59 ± 1.08	39.32 ± 1.45	44.19 ± 0.57	40.80
135	41.36 ± 0.87	38.77 ± 1.00	36.77 ± 1.33	41.26 ± 0.53	38.07
140	38.67 ± 0.81	36.22 ± 0.93	34.45 ± 1.23	38.60 ± 0.49	35.60
145	36.23 ± 0.77	33.92 ± 0.87	32.36 ± 1.13	36.21 ± 0.46	33.37
150	34.02 ± 0.71	31.83 ± 0.81	30.46 ± 1.04	34.03 ± 0.43	31.34
155	32.00 ± 0.67	29.93 ± 0.77	28.72 ± 0.97	32.04 ± 0.40	29.49
160	30.16 ± 0.64	28.20 ± 0.72	27.14 ± 0.90	30.22 ± 0.38	27.81
165	28.48 ± 0.62	26.62 ± 0.68	25.70 ± 0.83	28.58 ± 0.36	26.28
170	26.93 ± 0.57	25.16 ± 0.65	24.37 ± 0.78	27.05 ± 0.34	24.87
175	25.52 ± 0.54	23.83 ± 0.61	23.15 ± 0.73	25.65 ± 0.32	23.58
180	24.21 ± 0.52	22.61 ± 0.58	22.03 ± 0.69	24.37 ± 0.31	22.39
185	23.00 ± 0.49	21.48 ± 0.56	20.99 ± 0.64	23.18 ± 0.29	21.30
190	21.90 ± 0.47	20.44 ± 0.53	20.04 ± 0.61	22.09 ± 0.28	20.29
200	19.91 ± 0.43	18.59 ± 0.49	18.33 ± 0.55	20.14 ± 0.26	18.49
220	16.75 ± 0.37	15.64 ± 0.41	15.59 ± 0.45	17.03 ± 0.22	15.62
240	14.38 ± 0.33	13.44 ± 0.36	13.54 ± 0.38	14.70 ± 0.19	13.46
260	12.60 ± 0.29	11.79 ± 0.33	12.01 ± 0.34	12.96 ± 0.18	11.85
280	11.27 ± 0.27	10.56 ± 0.30	10.86 ± 0.30	11.66 ± 0.17	10.64
300	10.32 ± 0.25	9.69 ± 0.28	10.07 ± 0.29	10.75 ± 0.16	9.80

Table 6: NNLO predictions for the production cross sections $\sigma(pp \to H^0 + X)$ $[pb]$ at LHC for $\sqrt{S} =$ 14 TeV. The errors refer to the $\pm 1\sigma$ pdf uncertainties.