

Measurement of the $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ cross sections in pp collisions at
 $\sqrt{s} = 7 \text{ TeV}$

—Supplemental Material—

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Abstract

Supplemental material

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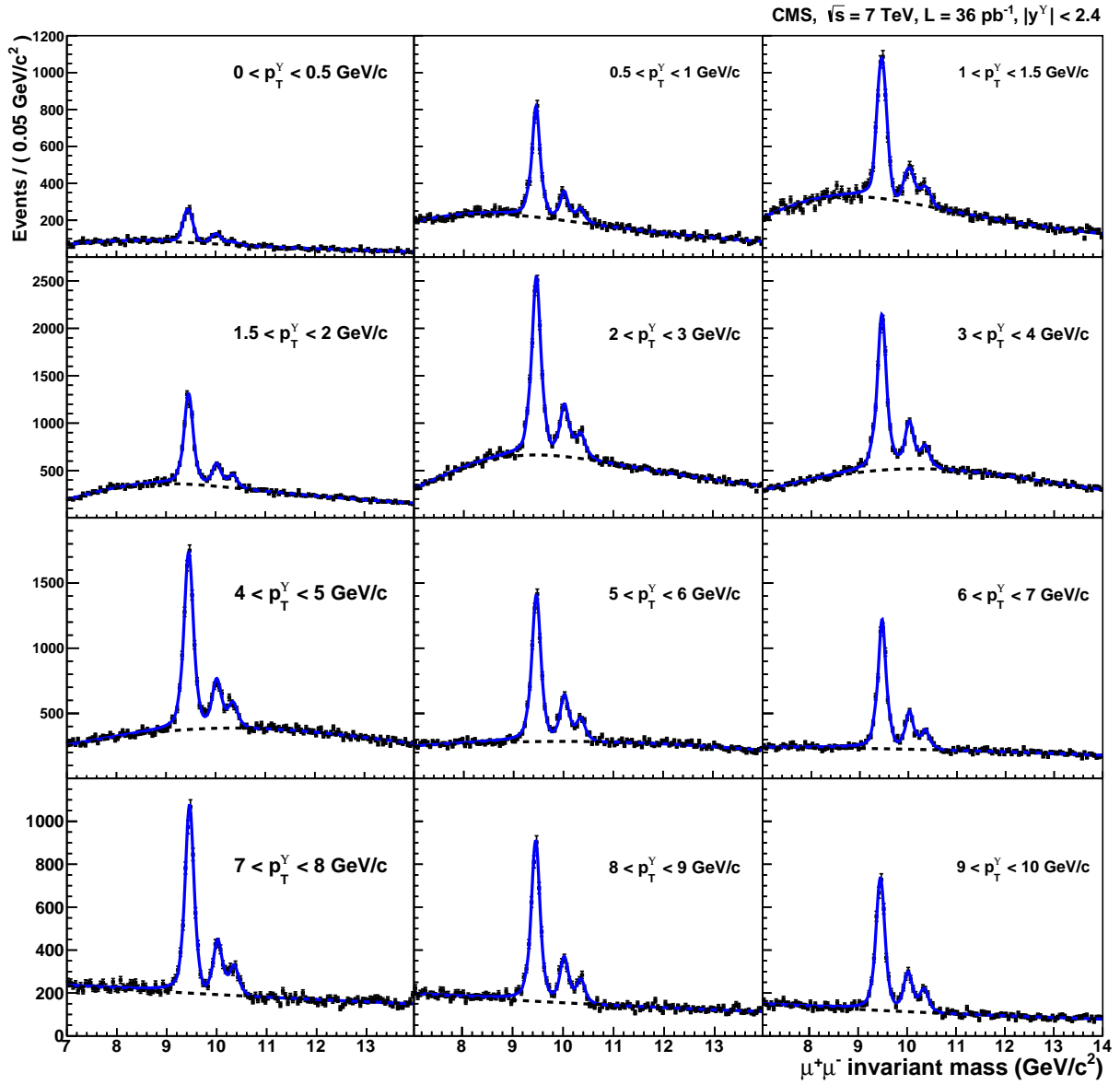


Figure 1: Fit to the dimuon invariant-mass distribution in the specified p_T regions for $|y| < 2.4$, before accounting for acceptance and efficiency. The solid line shows the result of the fit described in the text, with the dashed line representing the background component.

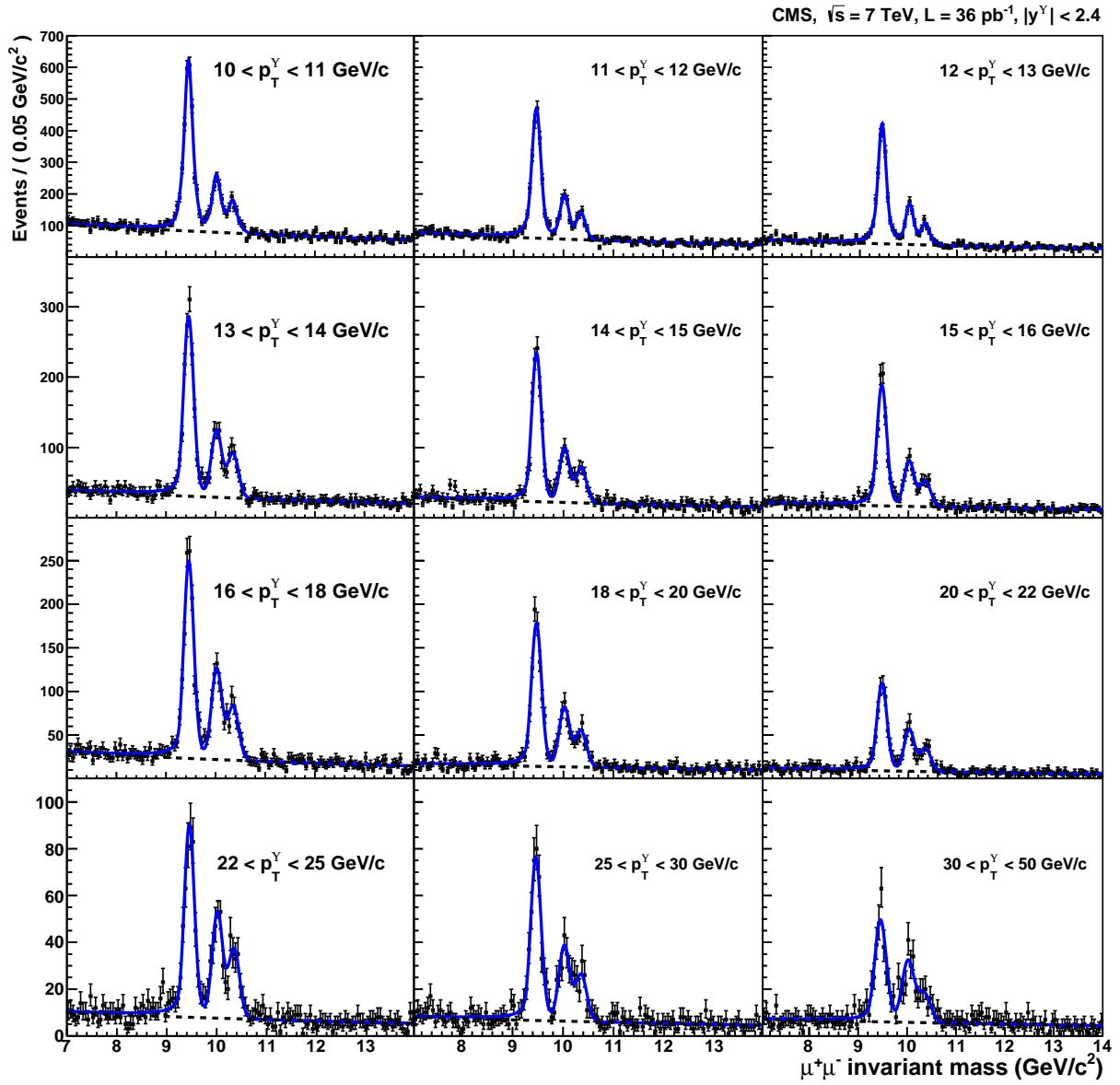


Figure 2: Fit to the dimuon invariant-mass distribution in the specified p_T regions for $|y| < 2.4$, before accounting for acceptance and efficiency. The solid line shows the result of the fit described in the text, with the dashed line representing the background component.

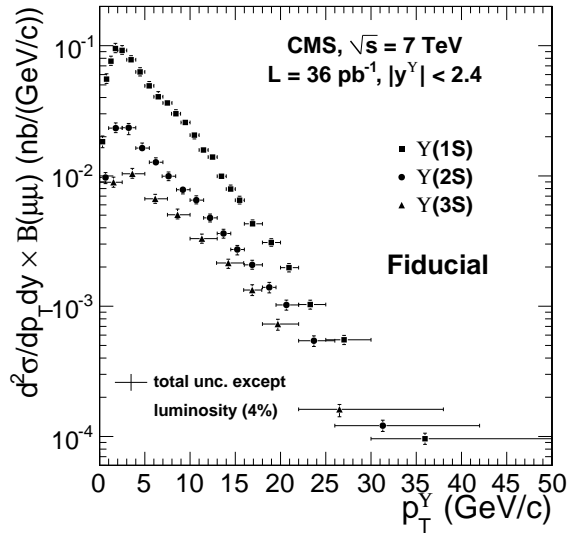


Figure 3: Measured $\Upsilon(nS)$ differential fiducial cross sections as a function of p_T^Υ in the rapidity range $|y^\Upsilon| < 2.4$. The error bars indicate the total uncertainties, except for the 4% uncertainty in the integrated luminosity.

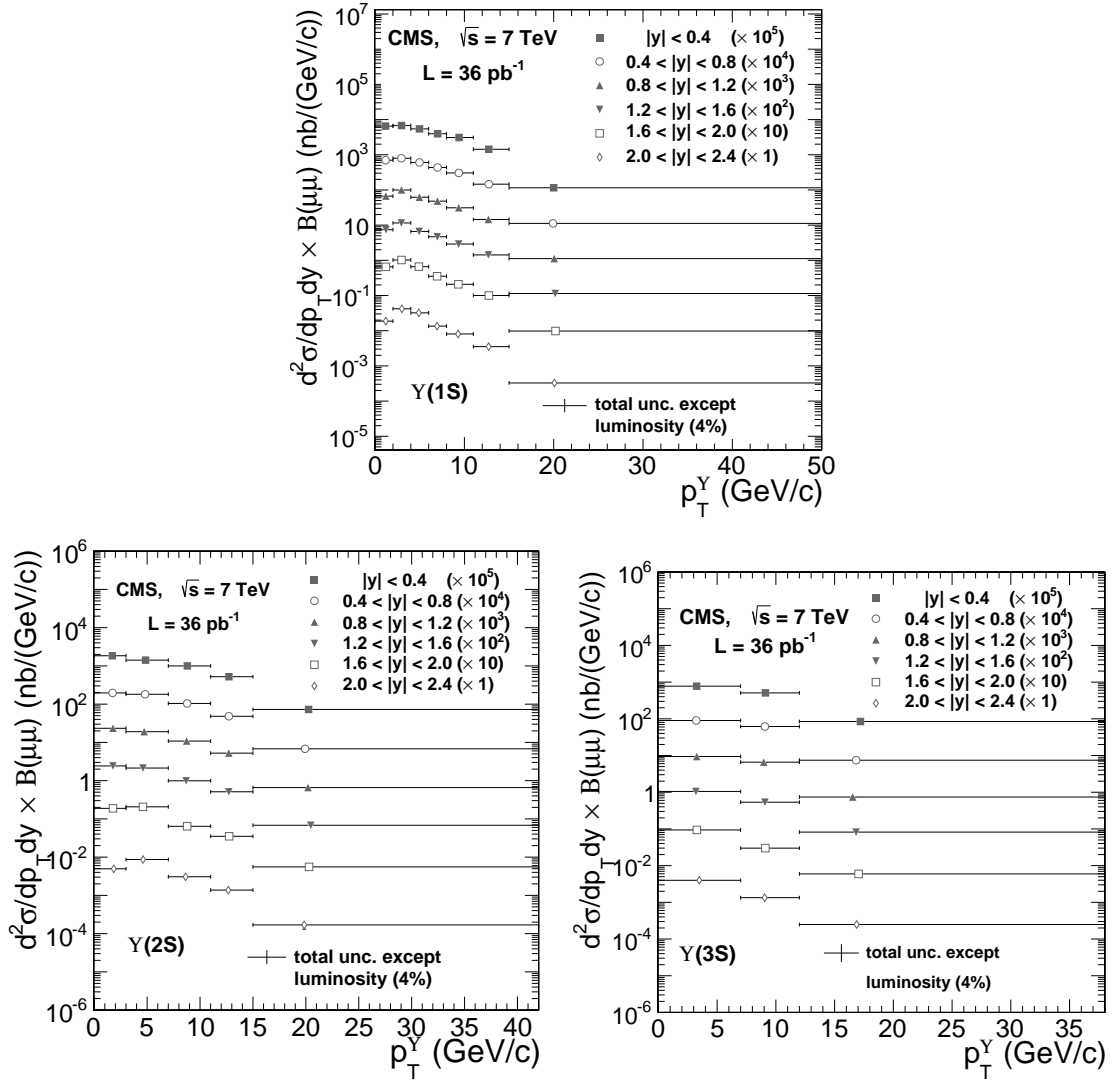


Figure 4: The $\Upsilon(nS)$ differential fiducial cross sections as a function of p_T^Y in six rapidity ranges, scaled for clarity by the factors shown in the figures.

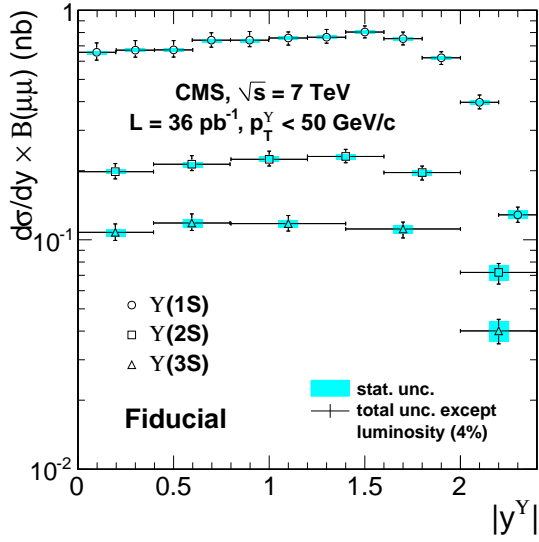


Figure 5: Differential fiducial cross sections of the $\Upsilon(nS)$ as a function of rapidity. The regions show the statistical uncertainties and the error bars show the total uncertainties, except for the 4% uncertainty in the integrated luminosity.

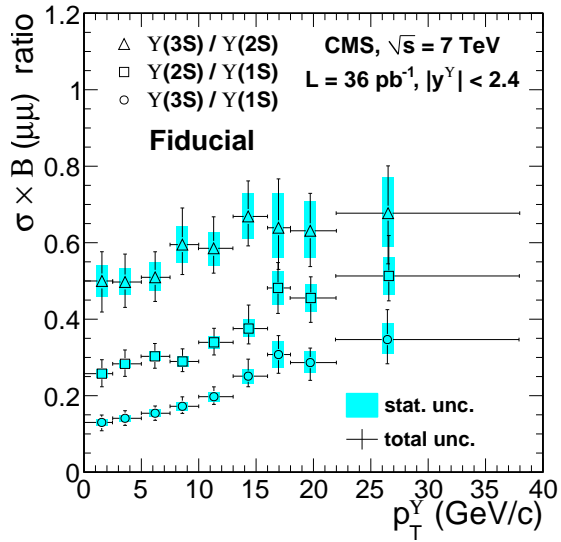


Figure 6: Ratios of the differential fiducial cross sections for the $\Upsilon(nS)$ as a function of p_T^Υ in the rapidity range $|y^\Upsilon| < 2.4$.

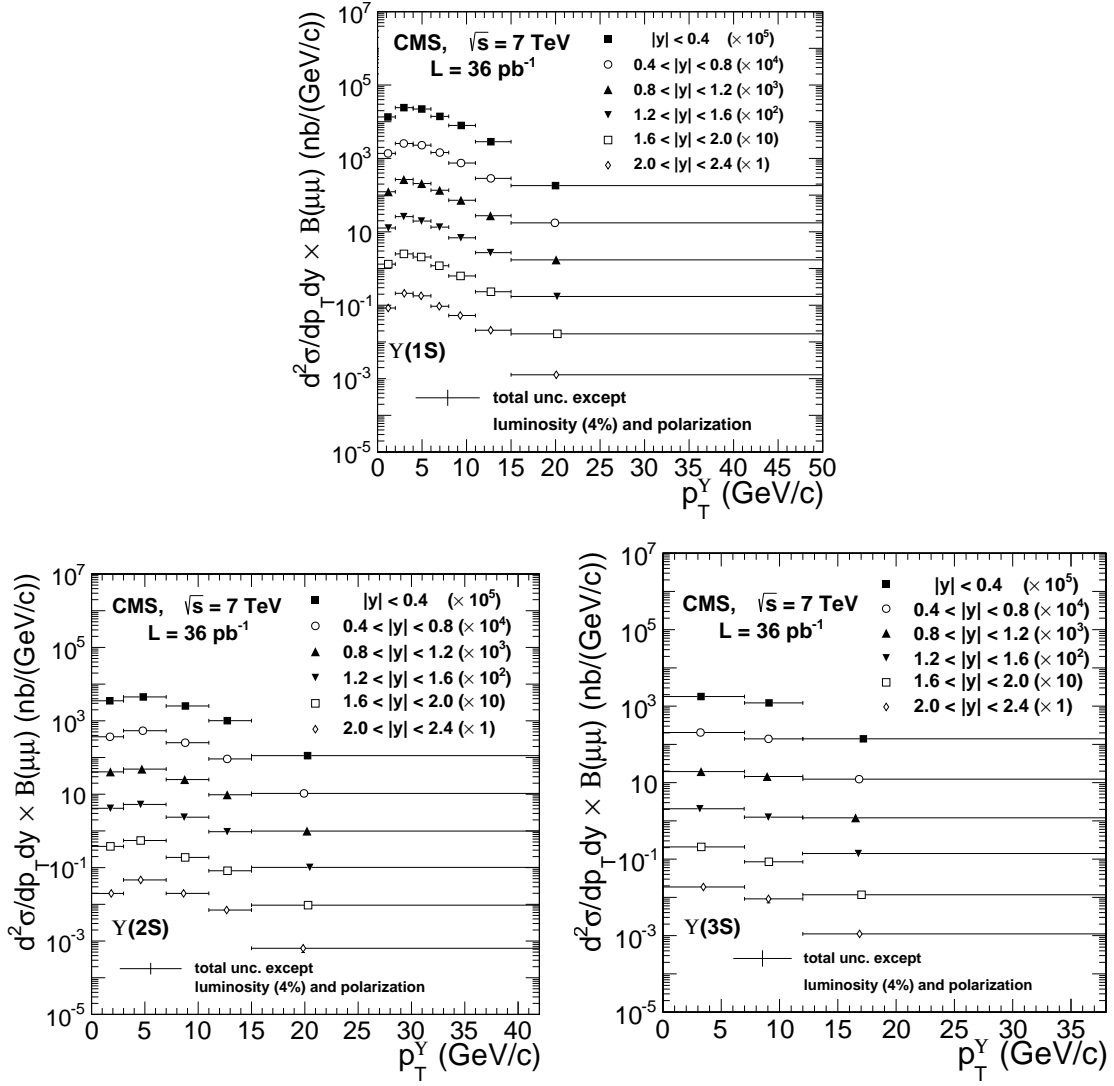


Figure 7: Differential production cross sections of the $\Upsilon(nS)$ as a function of p_T^Υ in six rapidity regions. The measurements have been multiplied by the factors shown in the figure for clarity.

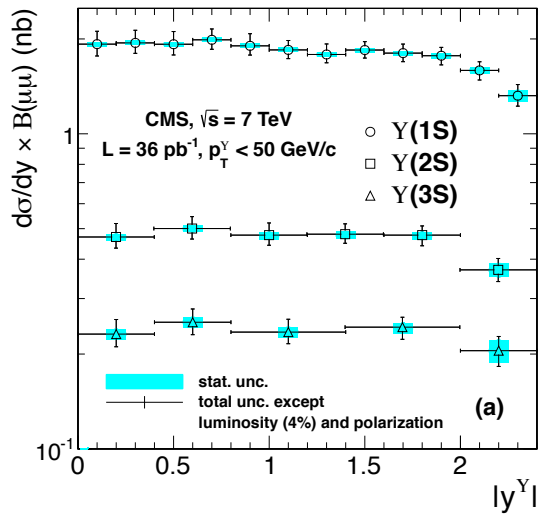


Figure 8: Acceptance-corrected differential production cross sections as a function of rapidity. The bands represent the statistical uncertainty and the error bars represent the total uncertainty, except for those from the $\Upsilon(nS)$ polarization and the integrated luminosity.

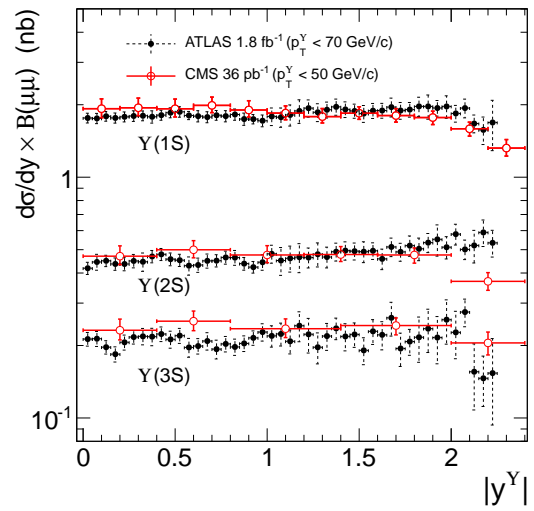
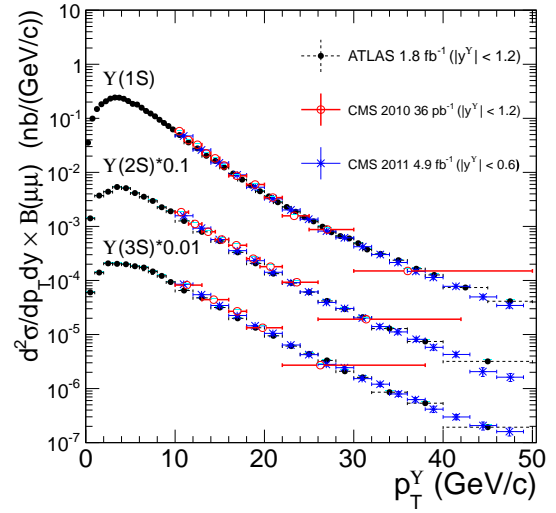


Figure 9: Comparison of the $\Upsilon(nS)$ acceptance-corrected differential cross section results to the ATLAS results, as a function of p_T^Y (left) and y^Y (right).

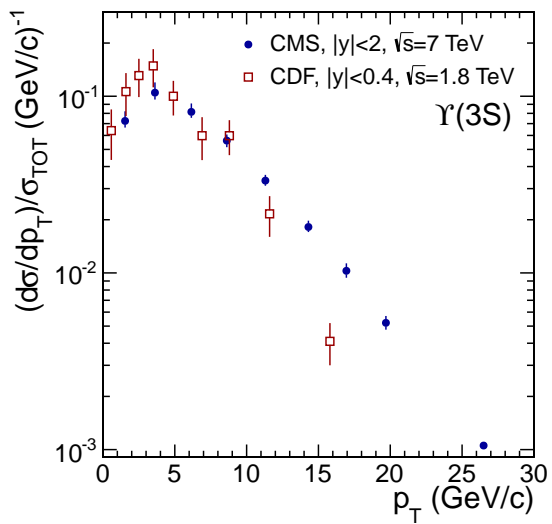
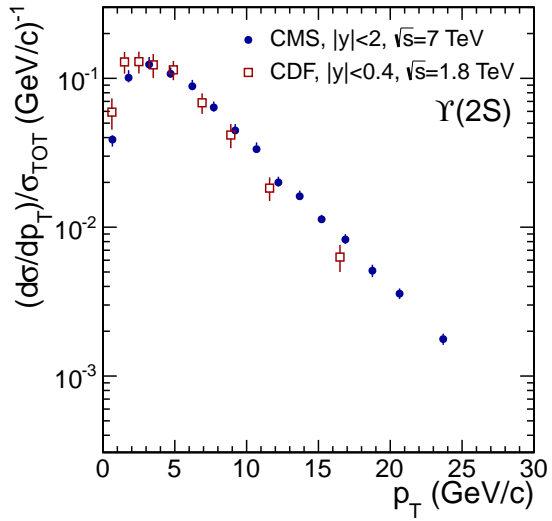
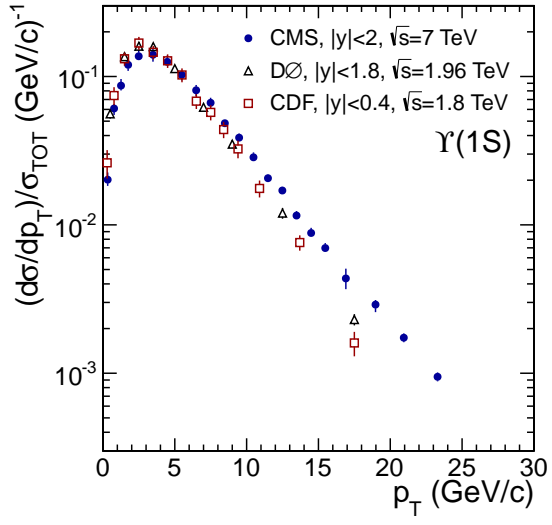


Figure 10: Comparison of acceptance-corrected differential cross section results, normalized by $\sigma_{TOT} = \sum(d\sigma/dp_T)\Delta p_T$, to the CDF and DØ results, as a function of p_T , for $\Upsilon(1S)$ (top), $\Upsilon(2S)$ (left), $\Upsilon(3S)$ (right).

Table 1: The product of the fiducial $\Upsilon(1S)$ production cross sections, σ , integrated and differential in p_T^Υ , and the dimuon branching fraction, \mathcal{B} , integrated over the rapidity range $|y^\Upsilon| < 2.4$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

$ y^\Upsilon < 2.4$				
$\Upsilon(1S)$				
p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
0–0.5	0.0440	5.4	8 (8)	11 (11)
0.5–1	0.133	3.1	8 (8)	10 (10)
1–1.5	0.182	2.5	8 (8)	9 (9)
1.5–2	0.228	2.4	8 (8)	10 (9)
2–3	0.442	1.6	8 (7)	9 (8)
3–4	0.374	1.8	6 (6)	8 (7)
4–5	0.302	1.8	7 (7)	8 (8)
5–6	0.236	2.0	7 (6)	8 (7)
6–7	0.195	2.0	8 (7)	9 (9)
7–8	0.174	2.1	5 (5)	7 (6)
8–9	0.144	2.3	6 (5)	7 (7)
9–10	0.1235	2.4	5 (4)	7 (6)
10–11	0.0988	2.5	6 (5)	8 (7)
11–12	0.0759	2.8	4 (4)	7 (6)
12–13	0.0670	2.9	4 (4)	7 (6)
13–14	0.0477	3.3	5 (4)	7 (7)
14–15	0.0381	3.6	5 (5)	7 (7)
15–16	0.0312	4.0	5 (4)	8 (7)
16–18	0.0412	3.5	5 (5)	7 (7)
18–20	0.0296	4.0	5 (4)	7 (7)
20–22	0.0187	5.1	4 (4)	8 (8)
22–25	0.0148	5.8	4 (4)	8 (8)
25–30	0.0133	6.1	4 (4)	8 (8)
30–50	0.00923	7.8	6 (6)	11 (10)
0–50	3.06	0.6	6 (6)	8 (7)

Table 2: The product of the fiducial $\Upsilon(2S)$ production cross sections, σ , integrated and differential in p_T^Υ , and the dimuon branching fraction, \mathcal{B} , integrated over the rapidity range $|y^\Upsilon| < 2.4$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

$ y^\Upsilon < 2.4$				
$\Upsilon(2S)$				
p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
0–1	0.0467	6.3	7 (8)	10 (11)
1–2.5	0.168	3.4	8 (8)	10 (10)
2.5–4	0.169	3.1	8 (11)	9 (12)
4–5.5	0.118	3.3	8 (7)	10 (9)
5.5–7	0.0917	3.6	6 (5)	8 (8)
7–8.5	0.0716	3.4	7 (7)	9 (9)
8.5–10	0.0564	4.0	5 (5)	8 (8)
10–11.5	0.0470	4.1	6 (5)	8 (8)
11.5–13	0.0343	4.6	4 (4)	7 (8)
13–14.5	0.0260	5.2	5 (5)	8 (8)
14.5–16	0.0196	5.7	4 (6)	8 (9)
16–18	0.0198	5.5	6 (5)	9 (8)
18–19.5	0.01005	7.5	4 (5)	9 (10)
19.5–22	0.0123	6.8	5 (5)	9 (9)
22–26	0.0104	7.4	4 (5)	9 (10)
26–42	0.00930	8.0	5 (5)	10 (10)
0–42	0.910	1.2	6 (5)	7 (7)

Table 3: The product of the fiducial $\Upsilon(3S)$ production cross sections, σ , integrated and differential in p_T^Υ , and the dimuon branching fraction, \mathcal{B} , integrated over the rapidity range $|y^\Upsilon| < 2.4$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

$ y^\Upsilon < 2.4$				
$\Upsilon(3S)$				
p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
0–2.5	0.107	5.3	7 (7)	10 (10)
2.5–5	0.125	4.5	8 (8)	10 (10)
5–7.5	0.0801	4.7	6 (6)	9 (8)
7.5–10	0.0604	4.8	9 (8)	11 (10)
10–13	0.0476	4.5	6 (7)	8 (9)
13–16	0.0308	5.1	5 (6)	8 (9)
16–18	0.0127	7.5	6 (5)	10 (10)
18–22	0.0140	6.9	7 (7)	11 (11)
22–38	0.0124	7.4	9 (9)	12 (12)
0–38	0.490	2.0	6 (6)	8 (7)

Table 4: The product of the fiducial $\Upsilon(\text{nS})$ production cross sections, σ , integrated and differential in p_T^Υ , and the respective dimuon branching fraction, \mathcal{B} , integrated over the rapidity range $|y^\Upsilon| < 0.4$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature (Σ_{sys}), and the total uncertainty ($\Delta\sigma$; including stat., Σ_{sys} , and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

$ y^\Upsilon < 0.4$					
	p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
$\Upsilon(1\text{S})$	0–2	0.104	3.5	14 (13)	15 (14)
	2–4	0.108	3.1	10 (11)	11 (12)
	4–6	0.0870	2.9	10 (9)	11 (11)
	6–8	0.0632	3.3	14 (14)	15 (15)
	8–11	0.0741	2.9	7 (7)	8 (8)
	11–15	0.0458	3.3	5 (5)	7 (7)
	15–50	0.0323	3.7	4 (5)	7 (7)
$\Upsilon(2\text{S})$	0–3	0.0442	7.0	12 (11)	15 (14)
	3–7	0.0453	4.9	11 (11)	12 (12)
	7–11	0.0320	5.3	8 (7)	10 (10)
	11–15	0.0167	6.1	5 (5)	9 (9)
	15–42	0.0157	5.7	4 (5)	8 (9)
$\Upsilon(3\text{S})$	0–7	0.0434	6.5	14 (12)	16 (15)
	7–12	0.0203	7.5	10 (9)	13 (13)
	12–38	0.0176	5.9	5 (5)	9 (9)

Table 5: The product of the fiducial $\Upsilon(\text{nS})$ production cross sections, σ , integrated and differential in p_T^Υ , and the respective dimuon branching fraction, \mathcal{B} , integrated over the rapidity range $0.4 < |y^\Upsilon| < 0.8$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature (Σ_{sys}), and the total uncertainty ($\Delta\sigma$; including stat., Σ_{sys} , and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

$0.4 < y^\Upsilon < 0.8$					
	p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
$\Upsilon(1\text{S})$	0–2	0.112	3.3	12 (12)	13 (13)
	2–4	0.127	3.0	9 (9)	10 (11)
	4–6	0.0967	2.8	8 (8)	9 (9)
	6–8	0.0695	3.3	12 (12)	13 (13)
	8–11	0.0731	2.9	6 (5)	8 (7)
	11–15	0.0467	3.3	6 (6)	8 (8)
	15–50	0.0314	0.8	4 (4)	6 (6)
$\Upsilon(2\text{S})$	0–3	0.0472	7.2	12 (11)	14 (14)
	3–7	0.0580	4.5	8 (8)	10 (10)
	7–11	0.0334	5.2	7 (5)	10 (8)
	11–15	0.0154	6.6	5 (6)	9 (10)
	15–42	0.0147	5.9	4 (5)	8 (8)
$\Upsilon(3\text{S})$	0–7	0.0504	6.8	13 (11)	15 (13)
	7–12	0.0247	6.8	7 (7)	11 (10)
	12–38	0.0155	6.5	5 (5)	9 (9)

Table 6: The product of the fiducial $\Upsilon(\text{nS})$ production cross sections, σ , integrated and differential in p_T^Υ , and the respective dimuon branching fraction, \mathcal{B} , integrated over the rapidity range $0.8 < |y^\Upsilon| < 1.2$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

0.8 < y $^\Upsilon$ < 1.2					
	p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
$\Upsilon(1S)$	0–2	0.107	3.7	9 (9)	11 (10)
	2–4	0.160	2.7	9 (9)	10 (10)
	4–6	0.0995	2.9	7 (6)	8 (8)
	6–8	0.0770	3.1	12 (12)	13 (13)
	8–11	0.0746	2.9	5 (8)	7 (9)
	11–15	0.0464	3.4	6 (6)	8 (8)
	15–50	0.0313	3.8	5 (6)	7 (8)
$\Upsilon(2S)$	0–3	0.0561	6.1	11 (10)	13 (12)
	3–7	0.0610	5.0	8 (8)	10 (10)
	7–11	0.0347	5.3	14 (14)	15 (15)
	11–15	0.0168	6.2	6 (7)	9 (10)
	15–42	0.0142	6.2	6 (7)	10 (10)
$\Upsilon(3S)$	0–7	0.0526	7.7	17 (17)	19 (19)
	7–12	0.0264	6.9	11 (14)	14 (17)
	12–38	0.0154	6.8	10 (10)	13 (13)

Table 7: The product of the fiducial $\Upsilon(\text{nS})$ production cross sections, σ , integrated and differential in p_T^Υ , and the respective dimuon branching fraction, \mathcal{B} , integrated over the rapidity range $1.2 < |y^\Upsilon| < 1.6$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

1.2 < y $^\Upsilon$ < 1.6					
	p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
$\Upsilon(1S)$	0–2	0.119	3.5	6 (12)	8 (13)
	2–4	0.184	2.4	7 (6)	8 (8)
	4–6	0.1059	2.8	6 (5)	8 (7)
	6–8	0.0747	3.0	5 (6)	7 (7)
	8–11	0.0697	3.0	5 (5)	7 (7)
	11–15	0.0456	3.3	6 (6)	8 (8)
	15–50	0.0319	3.8	7 (8)	9 (10)
$\Upsilon(2S)$	0–3	0.0582	6.2	6 (6)	10 (9)
	3–7	0.0684	4.5	7 (6)	9 (8)
	7–11	0.0317	5.5	5 (6)	9 (9)
	11–15	0.0164	6.5	5 (5)	9 (9)
	15–42	0.0147	6.4	8 (9)	11 (12)
$\Upsilon(3S)$	0–7	0.0589	6.9	6 (5)	10 (10)
	7–12	0.0214	7.7	9 (9)	13 (12)
	12–38	0.0171	6.7	8 (8)	11 (11)

Table 8: The product of the fiducial $\Upsilon(\text{nS})$ production cross sections, σ , integrated and differential in p_{T}^{Υ} , and the respective dimuon branching fraction, \mathcal{B} , integrated over the rapidity range $1.6 < |y^{\Upsilon}| < 2.0$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

1.6 < $ y^{\Upsilon} $ < 2.0					
	$p_{\text{T}} \text{ (GeV}/c)$	$\sigma \cdot \mathcal{B} \text{ (nb)}$	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
$\Upsilon(1\text{S})$	0–2	0.105	3.1	9 (8)	10 (9)
	2–4	0.164	2.5	6 (5)	8 (7)
	4–6	0.1058	2.7	5 (4)	7 (6)
	6–8	0.0564	3.2	4 (4)	6 (6)
	8–11	0.0500	3.4	6 (6)	8 (8)
	11–15	0.0321	4.1	5 (5)	8 (8)
	15–50	0.0274	4.4	6 (6)	8 (8)
$\Upsilon(2\text{S})$	0–3	0.0452	6.2	8 (8)	11 (11)
	3–7	0.0661	4.3	7 (7)	9 (9)
	7–11	0.0205	7.0	10 (10)	13 (13)
	11–15	0.0112	8.3	5 (5)	11 (11)
	15–42	0.0120	8.1	6 (5)	11 (11)
$\Upsilon(3\text{S})$	0–7	0.0525	7.2	9 (9)	12 (12)
	7–12	0.0120	10.6	15 (15)	19 (19)
	12–38	0.0124	8.8	6 (6)	11 (12)

Table 9: The product of the fiducial $\Upsilon(\text{nS})$ production cross sections, σ , integrated and differential in p_{T}^{Υ} , and the respective dimuon branching fraction, \mathcal{B} , integrated over the rapidity range $2.0 < |y^{\Upsilon}| < 2.4$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

2.0 < $ y^{\Upsilon} $ < 2.4					
	$p_{\text{T}} \text{ (GeV}/c)$	$\sigma \cdot \mathcal{B} \text{ (nb)}$	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
$\Upsilon(1\text{S})$	0–2	0.0299	5.3	9 (9)	11 (11)
	2–4	0.0671	2.8	7 (5)	8 (7)
	4–6	0.0515	3.7	12 (12)	13 (13)
	6–8	0.0216	5.6	6 (7)	9 (10)
	8–11	0.0194	5.8	6 (6)	9 (9)
	11–15	0.0113	7.2	9 (8)	12 (12)
	15–50	0.0092	9.1	13 (12)	16 (16)
$\Upsilon(2\text{S})$	0–3	0.0119	13.2	11 (10)	18 (17)
	3–7	0.0278	7.6	9 (8)	12 (12)
	7–11	0.0098	10.9	9 (8)	14 (14)
	11–15	0.00440	14.7	8 (7)	17 (17)
	15–42	0.00365	20.4	10 (9)	23 (23)
$\Upsilon(3\text{S})$	0–7	0.0223	11.2	10 (9)	16 (15)
	7–12	0.0054	19.3	7 (7)	21 (21)
	12–38	0.00518	15.8	8 (8)	18 (18)

Table 10: The product of the fiducial $\Upsilon(nS)$ production cross sections, σ , integrated and differential in $|\eta^\Upsilon|$, and the respective dimuon branching fraction, \mathcal{B} , integrated over the p_T range $p_T^\Upsilon < 50 \text{ GeV}/c$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature (Σ_{sys}), and the total uncertainty ($\Delta\sigma$; including stat., Σ_{sys} , and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

$p_T^\Upsilon < 50 \text{ GeV}/c$					
	$ \eta $	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
$\Upsilon(1S)$	0–0.2	0.262	1.7	9(9)	10(10)
	0.2–0.4	0.268	1.7	9(9)	10(10)
	0.4–0.6	0.269	1.7	9(9)	10(10)
	0.6–0.8	0.295	1.7	7(6)	8(8)
	0.8–1.0	0.295	1.7	8(8)	9(9)
	1.0–1.2	0.303	1.8	6(6)	7(7)
	1.2–1.4	0.305	1.7	7(7)	8(8)
	1.4–1.6	0.322	1.7	5(4)	7(6)
	1.6–1.8	0.301	1.7	6(5)	7(7)
	1.8–2	0.248	1.9	6(5)	7(7)
	2–2.2	0.159	2.3	7(5)	8(7)
	2.2–2.4	0.0514	4.3	6(5)	9(7)
	0–2.4	3.08	0.5	6(6)	8(7)
$\Upsilon(2S)$	0–0.4	0.158	2.4	8(7)	9(9)
	0.4–0.8	0.170	2.6	8(7)	9(9)
	0.8–1.2	0.179	2.8	7(7)	9(9)
	1.2–1.6	0.185	2.7	6(5)	8(7)
	1.6–2	0.157	2.9	6(6)	8(7)
	2–2.4	0.0577	7.6	7(6)	11(11)
	0–2.4	0.907	1.2	6(5)	7(7)
$\Upsilon(3S)$	0–0.4	0.0858	3.7	8(8)	10(10)
	0.4–0.8	0.0946	4.0	8(7)	10(9)
	0.8–1.4	0.141	3.8	7(7)	9(9)
	1.4–2	0.134	4.0	7(7)	9(9)
	2–2.4	0.0321	10.3	7(5)	13(12)
0–2.4	0.487	2.0	6(6)	8(7)	

Table 11: The ratio of $\Upsilon(3S)/\Upsilon(1S)$ fiducial cross sections, and its p_T dependence, integrated over the rapidity range $|\eta^\Upsilon| < 2.4$, with statistical and systematic uncertainties combined in quadrature. The numbers in parentheses are negative variations.

p_T (GeV/c)	$\Upsilon(3S)/\Upsilon(1S)$
0–2	0.129 ± 0.009 (0.008) ± 0.017 (0.020)
2–5	0.141 ± 0.008 (0.008) ± 0.018 (0.016)
5–8	0.154 ± 0.009 (0.009) ± 0.016 (0.016)
8–10	0.172 ± 0.011 (0.011) ± 0.022 (0.014)
10–13	0.197 ± 0.012 (0.012) ± 0.022 (0.016)
13–16	0.251 ± 0.019 (0.018) ± 0.037 (0.021)
16–18	0.308 ± 0.035 (0.033) ± 0.031 (0.037)
18–22	0.287 ± 0.029 (0.027) ± 0.023 (0.037)
22–38	0.345 ± 0.042 (0.038) ± 0.055 (0.051)
0–38	0.158 ± 0.004 (0.004) ± 0.016 (0.016)

Table 12: The ratio of $\Upsilon(2S)/\Upsilon(1S)$ fiducial cross sections, and its p_T dependence, integrated over the rapidity range $|y^\Upsilon| < 2.4$, with statistical and systematic uncertainties combined in quadrature. The numbers in parentheses are negative variations.

p_T (GeV/c)	$\Upsilon(2S)/\Upsilon(1S)$
0–2	0.258 ± 0.011 (0.011) ± 0.034 (0.032)
2–5	0.283 ± 0.010 (0.010) ± 0.035 (0.031)
5–8	0.302 ± 0.012 (0.012) ± 0.031 (0.028)
8–10	0.289 ± 0.014 (0.013) ± 0.030 (0.022)
10–13	0.339 ± 0.016 (0.016) ± 0.032 (0.029)
13–16	0.376 ± 0.023 (0.022) ± 0.053 (0.034)
16–18	0.481 ± 0.045 (0.042) ± 0.046 (0.053)
18–22	0.454 ± 0.037 (0.035) ± 0.040 (0.053)
22–38	0.511 ± 0.051 (0.047) ± 0.083 (0.046)
0–38	0.296 ± 0.005 (0.005) ± 0.031 (0.029)

Table 13: The ratio of $\Upsilon(3S)/\Upsilon(2S)$ fiducial cross sections, and its p_T dependence, integrated over the rapidity range $|y^\Upsilon| < 2.4$, with statistical and systematic uncertainties combined in quadrature. The numbers in parentheses are negative variations.

p_T (GeV/c)	$\Upsilon(3S)/\Upsilon(2S)$
0–2	0.500 ± 0.043 (0.040) ± 0.062 (0.072)
2–5	0.497 ± 0.036 (0.034) ± 0.063 (0.057)
5–8	0.510 ± 0.039 (0.037) ± 0.053 (0.051)
8–10	0.595 ± 0.049 (0.046) ± 0.079 (0.062)
10–13	0.581 ± 0.046 (0.043) ± 0.067 (0.049)
13–16	0.669 ± 0.061 (0.057) ± 0.066 (0.054)
16–18	0.639 ± 0.089 (0.079) ± 0.083 (0.077)
18–22	0.631 ± 0.077 (0.070) ± 0.057 (0.065)
22–38	0.675 ± 0.096 (0.085) ± 0.068 (0.101)
0–38	0.534 ± 0.017 (0.016) ± 0.054 (0.051)

Table 14: The product of the $\Upsilon(1S)$ acceptance-corrected production cross sections, σ , integrated and differential in p_T^Υ , and the dimuon branching fraction, \mathcal{B} , measured for four polarization scenarios, in the helicity frame (HX) and Collins-Soper (CS) frame, each for $\lambda_\theta = 1$ and $\lambda_\theta = -1$, integrated over the rapidity range $|y^\Upsilon| < 2.4$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature (Σ_{sys}), and the total uncertainty ($\Delta\sigma$; including stat., Σ_{sys} , and the uncertainty in the integrated luminosity) are in percent. For the four polarization scenarios the fractional change to the central value of the cross section relative to the unpolarized value is given in percent. The numbers in parentheses are negative variations.

$ y^\Upsilon < 2.4$									
$\Upsilon(1S)$									
p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$	HX		CS		
					$\lambda_\theta = 1$	$\lambda_\theta = -1$	$\lambda_\theta = 1$	$\lambda_\theta = -1$	
0–0.5	0.0859	5.4	8 (7)	11 (10)	+19	–24	+21	–26	
0.5–1	0.263	3.3	8 (7)	9 (9)	+22	–24	+23	–25	
1–1.5	0.374	2.6	8 (8)	9 (9)	+23	–22	+26	–24	
1.5–2	0.505	2.4	9 (8)	10 (9)	+16	–27	+19	–29	
2–3	1.16	1.6	8 (10)	9 (11)	+20	–25	+26	–27	
3–4	1.21	2.1	7 (6)	9 (8)	+20	–26	+21	–26	
4–5	1.084	2.1	7 (6)	8 (8)	+21	–25	+21	–24	
5–6	0.879	1.9	7 (9)	8 (10)	+19	–25	+16	–23	
6–7	0.680	2.6	6 (6)	8 (7)	+18	–24	+13	–23	
7–8	0.556	2.0	6 (5)	7 (7)	+20	–22	+12	–13	
8–9	0.419	2.2	5 (5)	7 (7)	+19	–22	+9	–9	
9–10	0.331	2.3	5 (4)	7 (6)	+19	–21	+7	–4	
10–11	0.238	2.5	5 (4)	7 (6)	+17	–20	+4	–1	
11–12	0.179	2.9	5 (4)	7 (6)	+18	–19	+6	+0	
12–13	0.145	2.9	5 (4)	7 (7)	+16	–20	+2	+2	
13–14	0.0990	3.2	4 (5)	7 (7)	+14	–21	–0	+3	
14–15	0.0750	3.6	5 (5)	8 (7)	+15	–20	–1	+5	
15–16	0.0595	3.8	5 (5)	7 (7)	+13	–19	–1	+5	
16–18	0.0732	3.4	5 (5)	7 (7)	+12	–20	–3	+6	
18–20	0.0500	3.8	5 (4)	7 (7)	+13	–18	–2	+7	
20–22	0.0302	5.1	5 (4)	8 (8)	+11	–18	–3	+6	
22–25	0.0237	5.6	5 (4)	8 (8)	+9	–18	–3	+4	
25–30	0.0205	6.0	5 (4)	9 (8)	+10	–16	–1	+4	
30–50	0.0123	7.4	6 (6)	10 (10)	+5	–17	–7	+3	
0–50	8.55	0.6	7 (6)	8 (7)	+19	–24	+16	–19	

Table 15: The product of the $\Upsilon(2S)$ acceptance-corrected production cross sections, σ , integrated and differential in p_T^Υ , and the dimuon branching fraction, \mathcal{B} , measured for four polarization scenarios, in the helicity frame (HX) and Collins–Soper (CS) frame, each for $\lambda_\theta = 1$ and $\lambda_\theta = -1$, integrated over the rapidity range $|y^\Upsilon| < 2.4$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature (Σ_{sys}), and the total uncertainty ($\Delta\sigma$; including stat., Σ_{sys} , and the uncertainty in the integrated luminosity) are in percent. For the four polarization scenarios the fractional change to the central value of the cross section relative to the unpolarized value is given in percent. The numbers in parentheses are negative variations.

$ y^\Upsilon < 2.4$ $\Upsilon(2S)$									
p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$	HX		CS		
					$\lambda_\theta = 1$	$\lambda_\theta = -1$	$\lambda_\theta = 1$	$\lambda_\theta = -1$	
0–1	0.0829	5.9	9 (8)	11 (11)	+18	–23	+19	–24	
1–2.5	0.331	3.3	11 (10)	12 (11)	+14	–23	+18	–25	
2.5–4	0.409	3.1	9 (8)	10 (9)	+22	–24	+21	–26	
4–5.5	0.362	3.3	8 (7)	9 (9)	+18	–22	+16	–24	
5.5–7	0.286	3.6	7 (6)	9 (8)	+17	–23	+15	–20	
7–8.5	0.212	3.9	7 (7)	9 (9)	+21	–20	+15	–12	
8.5–10	0.146	4.0	6 (6)	9 (8)	+20	–18	+11	–5	
10–11.5	0.1123	4.1	6 (6)	9 (8)	+19	–18	+8	–0	
11.5–13	0.0765	4.6	5 (5)	8 (8)	+17	–18	+6	+1	
13–14.5	0.0519	5.1	5 (5)	8 (8)	+14	–20	+0	+3	
14.5–16	0.0376	5.7	5 (7)	9 (10)	+14	–19	+1	+3	
16–18	0.0373	5.3	6 (5)	9 (8)	+13	–18	+1	+3	
18–19.5	0.0159	7.4	5 (4)	10 (9)	+13	–18	–3	+9	
19.5–22	0.0204	6.6	5 (5)	9 (9)	+11	–16	–1	+5	
22–26	0.0158	7.2	5 (4)	10 (9)	+11	–16	–3	+7	
26–42	0.0126	7.7	6 (5)	10 (10)	+10	–15	–4	+9	
0–42	2.21	1.2	7 (6)	8 (7)	+14	–24	+13	–20	

Table 16: The product of the $\Upsilon(3S)$ acceptance-corrected production cross sections, σ , integrated and differential in p_T^Υ , and the dimuon branching fraction, \mathcal{B} , measured for four polarization scenarios, in the helicity frame (HX) and Collins–Soper (CS) frame, each for $\lambda_\theta = 1$ and $\lambda_\theta = -1$, integrated over the rapidity range $|y^\Upsilon| < 2.4$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature (Σ_{sys}), and the total uncertainty ($\Delta\sigma$; including stat., Σ_{sys} , and the uncertainty in the integrated luminosity) are in percent. For the four polarization scenarios the fractional change to the central value of the cross section relative to the unpolarized value is given in percent. The numbers in parentheses are negative variations.

$ y^\Upsilon < 2.4$ $\Upsilon(3S)$									
p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$	HX		CS		
					$\lambda_\theta = 1$	$\lambda_\theta = -1$	$\lambda_\theta = 1$	$\lambda_\theta = -1$	
0–2.5	0.203	5.3	8 (8)	11 (10)	+17	–21	+20	–25	
2.5–5	0.287	4.5	10 (11)	12 (12)	+17	–22	+20	–25	
5–7.5	0.227	4.6	9 (8)	11 (10)	+16	–22	+20	–22	
7.5–10	0.157	4.8	11 (10)	12 (12)	+23	–16	+16	–5	
10–13	0.113	4.3	7 (5)	9 (8)	+20	–15	+12	–1	
13–16	0.0617	5.0	5 (5)	8 (8)	+14	–17	+4	+1	
16–18	0.0227	7.4	6 (5)	10 (10)	+12	–18	–1	+4	
18–22	0.0229	7.0	7 (6)	10 (10)	+12	–17	–1	+6	
22–38	0.0185	7.6	13 (13)	15 (15)	+10	–15	–0	+6	
0–38	1.11	2.0	9 (8)	10 (9)	+16	–21	+14	–17	

Table 17: The product of the $\Upsilon(nS)$ acceptance-corrected production cross sections, σ , integrated and differential in p_T^Υ , and the respective dimuon branching fraction, \mathcal{B} , measured for four polarization scenarios, in the helicity frame (HX) and Collins–Soper (CS) frame, each for $\lambda_\theta = 1$ and $\lambda_\theta = -1$, integrated over the rapidity range $|y^\Upsilon| < 0.4$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. For the four polarization scenarios the fractional change to the central value of the cross section relative to the unpolarized value is given in percent. The numbers in parentheses are negative variations.

$ y^\Upsilon < 0.4$									
	$p_T(\text{GeV}/c)$	$\sigma \cdot \mathcal{B}(\text{nb})$	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$	HX		CS	
						$\lambda_\theta = 1$	$\lambda_\theta = -1$	$\lambda_\theta = 1$	$\lambda_\theta = -1$
$\Upsilon(1S)$	0–2	0.216	3.4	14 (13)	15 (14)	+10	–16	+21	–27
	2–4	0.387	3.2	11 (10)	12 (12)	+15	–22	+20	–26
	4–6	0.355	3.0	10 (10)	11 (11)	+21	–27	+16	–22
	6–8	0.224	3.2	9 (9)	10 (10)	+17	–30	+3	–17
	8–11	0.190	2.9	7 (7)	8 (8)	+22	–27	–0	+1
	11–15	0.0914	3.3	5 (5)	7 (7)	+20	–25	–4	+10
	15–50	0.0509	3.7	4 (4)	7 (7)	+17	–22	–5	+13
$\Upsilon(2S)$	0–3	0.084	6.6	16 (15)	18 (17)	+22	–13	+20	–25
	3–7	0.143	4.9	13 (16)	15 (17)	+27	–16	+15	–19
	7–11	0.0813	5.3	9 (8)	11 (11)	+21	–26	+2	–3
	11–15	0.0323	6.1	6 (5)	9 (9)	+20	–25	–4	+9
	15–42	0.0243	5.7	5 (4)	8 (8)	+16	–21	–5	+12
$\Upsilon(3S)$	0–7	0.100	6.5	15 (14)	17 (16)	+12	–16	+16	–22
	7–12	0.0487	7.5	11 (11)	14 (14)	+20	–25	+2	–3
	12–38	0.0291	5.9	5 (5)	9 (9)	+17	–23	–5	+11

Table 18: The product of the $\Upsilon(nS)$ acceptance-corrected production cross sections, σ , integrated and differential in p_T^Υ , and the respective dimuon branching fraction, \mathcal{B} , measured for four polarization scenarios, in the helicity frame (HX) and Collins–Soper (CS) frame, each for $\lambda_\theta = 1$ and $\lambda_\theta = -1$, integrated over the rapidity range $0.4 < |y^\Upsilon| < 0.8$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. For the four polarization scenarios the fractional change to the central value of the cross section relative to the unpolarized value is given in percent. The numbers in parentheses are negative variations.

$0.4 < y^\Upsilon < 0.8$									
	$p_T(\text{GeV}/c)$	$\sigma \cdot \mathcal{B}(\text{nb})$	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$	HX		CS	
						$\lambda_\theta = 1$	$\lambda_\theta = -1$	$\lambda_\theta = 1$	$\lambda_\theta = -1$
$\Upsilon(1S)$	0–2	0.220	4.5	13 (12)	14 (13)	+20	–25	+21	–26
	2–4	0.409	3.0	10 (9)	11 (10)	+21	–25	+22	–25
	4–6	0.367	2.9	8 (8)	9 (9)	+20	–25	+16	–21
	6–8	0.231	3.3	7 (6)	9 (8)	+13	–27	+2	–15
	8–11	0.180	2.9	6 (5)	8 (7)	+19	–23	–0	+2
	11–15	0.0915	3.3	6 (6)	8 (8)	+18	–23	–4	+10
	15–50	0.0492	3.8	4 (4)	7 (7)	+15	–20	–5	+13
$\Upsilon(2S)$	0–3	0.088	7.3	14 (13)	16 (15)	+18	–23	+19	–24
	3–7	0.172	4.5	10 (9)	11 (11)	+17	–23	+15	–20
	7–11	0.0811	5.2	6 (6)	9 (9)	+17	–23	+1	–2
	11–15	0.0293	6.6	5 (5)	9 (9)	+17	–22	–4	+9
	15–42	0.0227	5.9	4 (4)	8 (8)	+15	–20	–5	+12
$\Upsilon(3S)$	0–7	0.115	6.7	14 (13)	16 (15)	+16	–22	+16	–21
	7–12	0.0558	6.8	7 (6)	11 (10)	+16	–22	+1	–2
	12–38	0.0257	6.5	5 (5)	9 (9)	+15	–21	–4	+10

Table 19: The product of the $\Upsilon(\text{nS})$ acceptance-corrected production cross sections, σ , integrated and differential in p_T^Y , and the respective dimuon branching fraction, \mathcal{B} , measured for four polarization scenarios, in the helicity frame (HX) and Collins–Soper (CS) frame, each for $\lambda_\theta = 1$ and $\lambda_\theta = -1$, integrated over the rapidity range $0.8 < |y^Y| < 1.2$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. For the four polarization scenarios the fractional change to the central value of the cross section relative to the unpolarized value is given in percent. The numbers in parentheses are negative variations.

0.8 < y ^Y < 1.2									
	$p_T(\text{ GeV}/c)$	$\sigma \cdot \mathcal{B}(\text{ nb})$	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$	HX		CS	
						$\lambda_\theta = 1$	$\lambda_\theta = -1$	$\lambda_\theta = 1$	$\lambda_\theta = -1$
$\Upsilon(1S)$	0–2	0.198	3.7	11 (9)	12 (10)	+20	–25	+20	–24
	2–4	0.426	2.7	9 (9)	10 (10)	+20	–26	+19	–25
	4–6	0.331	2.9	7 (6)	8 (8)	+17	–25	+13	–21
	6–8	0.217	3.4	7 (7)	9 (8)	+22	–18	+12	–7
	8–11	0.174	2.9	5 (5)	7 (7)	+15	–21	–1	+2
	11–15	0.0879	3.4	6 (5)	8 (8)	+15	–21	–4	+9
	15–50	0.0482	3.8	5 (5)	8 (8)	+13	–19	–5	+12
$\Upsilon(2S)$	0–3	0.098	6.2	14 (13)	15 (15)	+18	–23	+17	–23
	3–7	0.155	5.3	11 (8)	13 (10)	+19	–22	+16	–19
	7–11	0.0803	5.3	8 (7)	10 (10)	+14	–20	+1	–2
	11–15	0.0309	6.2	6 (6)	10 (9)	+14	–20	–4	+9
	15–42	0.0214	6.2	6 (6)	10 (9)	+13	–18	–5	+11
$\Upsilon(3S)$	0–7	0.109	7.7	15 (14)	17 (17)	+16	–22	+14	–20
	7–12	0.0579	6.9	9 (9)	12 (12)	+13	–19	+2	–3
	12–38	0.0250	6.8	6 (6)	10 (10)	+13	–19	–4	+10

Table 20: The product of the $\Upsilon(\text{nS})$ acceptance-corrected production cross sections, σ , integrated and differential in p_T^Y , and the respective dimuon branching fraction, \mathcal{B} , measured for four polarization scenarios, in the helicity frame (HX) and Collins–Soper (CS) frame, each for $\lambda_\theta = 1$ and $\lambda_\theta = -1$, integrated over the rapidity range $1.2 < |y^Y| < 1.6$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. For the four polarization scenarios the fractional change to the central value of the cross section relative to the unpolarized value is given in percent. The numbers in parentheses are negative variations.

1.2 < y ^Y < 1.6									
	$p_T(\text{ GeV}/c)$	$\sigma \cdot \mathcal{B}(\text{ nb})$	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$	HX		CS	
						$\lambda_\theta = 1$	$\lambda_\theta = -1$	$\lambda_\theta = 1$	$\lambda_\theta = -1$
$\Upsilon(1S)$	0–2	0.203	3.5	10 (8)	11 (9)	+19	–23	+21	–22
	2–4	0.416	2.4	7 (6)	8 (7)	+20	–26	+18	–25
	4–6	0.315	2.8	6 (5)	8 (7)	+20	–24	+17	–21
	6–8	0.215	3.0	5 (6)	7 (7)	+17	–22	+11	–15
	8–11	0.165	3.0	5 (5)	7 (7)	+13	–19	+2	–4
	11–15	0.0868	3.3	5 (5)	7 (7)	+13	–19	–3	+6
	15–50	0.0485	3.8	4 (4)	7 (7)	+12	–18	–5	+11
$\Upsilon(2S)$	0–3	0.099	6.2	11 (11)	13 (13)	+18	–24	+18	–23
	3–7	0.161	4.5	7 (6)	9 (9)	+18	–23	+17	–22
	7–11	0.0758	5.5	7 (6)	10 (9)	+14	–19	+6	–9
	11–15	0.0305	6.5	5 (5)	9 (9)	+12	–18	–2	+5
	15–42	0.0219	6.4	5 (4)	9 (9)	+11	–17	–4	+10
$\Upsilon(3S)$	0–7	0.113	6.8	7 (7)	11 (10)	+17	–23	+16	–22
	7–12	0.0480	7.7	10 (10)	13 (13)	+13	–18	+5	–8
	12–38	0.0276	6.7	8 (7)	11 (11)	+11	–17	–3	+7

Table 21: The product of the $\Upsilon(\text{nS})$ acceptance-corrected production cross sections, σ , integrated and differential in p_T^Υ , and the respective dimuon branching fraction, \mathcal{B} , measured for four polarization scenarios, in the helicity frame (HX) and Collins–Soper (CS) frame, each for $\lambda_\theta = 1$ and $\lambda_\theta = -1$, integrated over the rapidity range $1.6 < |y^\Upsilon| < 2.0$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. For the four polarization scenarios the fractional change to the central value of the cross section relative to the unpolarized value is given in percent. The numbers in parentheses are negative variations.

1.6 < y $^\Upsilon$ < 2.0									
	p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$	HX		CS	
						$\lambda_\theta = 1$	$\lambda_\theta = -1$	$\lambda_\theta = 1$	$\lambda_\theta = -1$
$\Upsilon(1S)$	0–2	0.211	3.1	7 (6)	9 (8)	+22	–26	+23	–27
	2–4	0.401	2.5	6 (4)	7 (6)	+22	–26	+24	–27
	4–6	0.330	2.6	5 (4)	7 (6)	+20	–25	+23	–27
	6–8	0.191	3.2	4 (4)	7 (6)	+18	–22	+20	–24
	8–11	0.151	3.4	5 (4)	7 (7)	+15	–20	+15	–19
	11–15	0.0746	4.1	5 (5)	8 (7)	+10	–16	+5	–9
	15–50	0.0465	4.4	6 (6)	9 (8)	+9	–14	–1	+3
$\Upsilon(2S)$	0–3	0.091	6.8	8 (8)	11 (11)	+21	–25	+22	–27
	3–7	0.175	4.4	7 (6)	9 (9)	+19	–24	+23	–27
	7–11	0.0608	7.0	7 (6)	10 (10)	+14	–20	+17	–22
	11–15	0.0263	8.3	5 (5)	11 (10)	+10	–15	+7	–11
	15–42	0.0205	8.1	6 (5)	11 (11)	+8	–13	–0	+1
$\Upsilon(3S)$	0–7	0.117	7.2	9 (9)	13 (12)	+19	–23	+23	–26
	7–12	0.0341	10.6	18 (18)	22 (21)	+13	–19	+16	–21
	12–38	0.0243	8.8	6 (6)	11 (11)	+8	–13	+4	–6

Table 22: The product of the $\Upsilon(\text{nS})$ acceptance-corrected production cross sections, σ , integrated and differential in p_{T}^{Υ} , and the respective dimuon branching fraction, \mathcal{B} , measured for four polarization scenarios, in the helicity frame (HX) and Collins–Soper (CS) frame, each for $\lambda_{\theta} = 1$ and $\lambda_{\theta} = -1$, integrated over the rapidity range $2.0 < |y^{\Upsilon}| < 2.4$. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{sys.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{sys.}}$, and the uncertainty in the integrated luminosity) are in percent. For the four polarization scenarios the fractional change to the central value of the cross section relative to the unpolarized value is given in percent. The numbers in parentheses are negative variations.

2.0 < y $^{\Upsilon}$ < 2.4									
	$p_{\text{T}}(\text{GeV}/c)$	$\sigma \cdot \mathcal{B}(\text{nb})$	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{sys.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$	HX		CS	
						$\lambda_{\theta} = 1$	$\lambda_{\theta} = -1$	$\lambda_{\theta} = 1$	$\lambda_{\theta} = -1$
$\Upsilon(1\text{S})$	0–2	0.135	5.3	8 (7)	11 (9)	+30	–31	+32	–31
	2–4	0.338	2.8	7 (6)	9 (8)	+23	–28	+30	–32
	4–6	0.289	4.1	8 (6)	10 (9)	+27	–21	+38	–28
	6–8	0.150	5.8	7 (6)	10 (9)	+23	–21	+34	–29
	8–11	0.126	5.8	7 (5)	10 (9)	+18	–20	+31	–29
	11–15	0.0667	7.2	8 (7)	12 (11)	+14	–18	+28	–29
	15–50	0.0356	9.1	9 (9)	14 (13)	+6	–13	+18	–24
$\Upsilon(2\text{S})$	0–3	0.0475	13.2	9 (8)	16 (16)	+27	–30	+30	–32
	3–7	0.148	7.5	7 (5)	11 (10)	+20	–25	+31	–32
	7–11	0.0636	10.9	8 (7)	14 (13)	+16	–22	+29	–31
	11–15	0.0224	14.7	9 (8)	18 (17)	+12	–18	+26	–29
	15–42	0.0137	20.4	11 (11)	24 (23)	+9	–14	+20	–24
$\Upsilon(3\text{S})$	0–7	0.105	11.2	8 (6)	14 (13)	+22	–28	+30	–32
	7–12	0.0366	19.3	11 (9)	22 (22)	+14	–20	+29	–31
	12–38	0.0231	15.8	9 (8)	19 (18)	+9	–14	+24	–27

Table 23: The product of the Υ (nS) acceptance-corrected production cross sections, σ , integrated and differential in p_T^Υ , and the respective dimuon branching fraction, \mathcal{B} , measured for four polarization scenarios, in the helicity frame (HX) and Collins–Soper (CS) frame, each for $\lambda_\theta = 1$ and $\lambda_\theta = -1$, integrated over the p_T range $p_T^\Upsilon < 50$ GeV/c. The statistical uncertainty (stat.), the sum of the systematic uncertainties in quadrature ($\Sigma_{\text{syst.}}$), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{syst.}}$, and the uncertainty in the integrated luminosity) are in percent. For the four polarization scenarios the fractional change to the central value of the cross section relative to the unpolarized value is given in percent. The numbers in parentheses are negative variations.

$p_T^\Upsilon < 50$ GeV/c									
	y	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{syst.}}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$	HX		CS	
						$\lambda_\theta = 1$	$\lambda_\theta = -1$	$\lambda_\theta = 1$	$\lambda_\theta = -1$
$\Upsilon(1S)$	0–0.2	0.770	1.7	10 (9)	11 (10)	+27	–16	+22	–9
	0.2–0.4	0.777	1.7	9 (9)	10 (10)	+19	–25	+12	–16
	0.4–0.6	0.770	1.7	9 (9)	10 (10)	+20	–18	+13	–15
	0.6–0.8	0.795	1.7	8 (8)	9 (9)	+20	–24	+13	–15
	0.8–1.0	0.761	1.7	9 (8)	10 (9)	+18	–24	+12	–15
	1.0–1.2	0.738	1.8	6 (5)	7 (7)	+18	–24	+11	–16
	1.2–1.4	0.714	1.7	7 (7)	8 (8)	+18	–23	+12	–16
	1.4–1.6	0.738	1.7	5 (4)	7 (6)	+18	–23	+14	–18
	1.6–1.8	0.721	1.7	6 (5)	7 (7)	+19	–23	+18	–21
	1.8–2	0.708	1.9	6 (5)	7 (6)	+20	–24	+23	–26
	2–2.2	0.636	2.3	6 (5)	8 (7)	+20	–24	+28	–30
	2.2–2.4	0.528	4.2	7 (5)	9 (8)	+22	–26	+32	–32
0–2.4	8.66	0.6	7 (6)	8 (7)	+19	–24	+16	–19	
$\Upsilon(2S)$	0–0.4	0.376	2.5	10 (9)	11 (11)	+16	–21	+10	–13
	0.4–0.8	0.400	2.5	9 (8)	10 (9)	+17	–23	+10	–13
	0.8–1.2	0.380	2.8	9 (8)	10 (9)	+16	–22	+10	–13
	1.2–1.6	0.382	2.7	7 (6)	8 (8)	+16	–22	+12	–16
	1.6–2	0.380	2.9	7 (6)	8 (8)	+17	–22	+19	–23
	2–2.4	0.295	5.1	7 (5)	9 (8)	+19	–24	+29	–31
	0–2.4	2.21	1.3	8 (7)	9 (8)	+26	–16	+23	–12
$\Upsilon(3S)$	0–0.4	0.185	3.9	11 (10)	12 (12)	+15	–20	+9	–11
	0.4–0.8	0.202	3.9	10 (9)	11 (11)	+16	–22	+9	–11
	0.8–1.4	0.282	3.8	9 (9)	11 (10)	+15	–21	+8	–11
	1.4–2	0.290	4.0	7 (7)	9 (9)	+16	–21	+16	–20
	2–2.4	0.164	8.3	7 (6)	12 (11)	+18	–23	+29	–31
	0–2.4	1.12	2.1	8 (7)	10 (8)	+16	–21	+14	–17

Table 24: The ratio of $\Upsilon(3S)/\Upsilon(1S)$ acceptance-corrected cross sections, and its p_T dependence, integrated over the rapidity range $|y^\Upsilon| < 2.4$, for the unpolarized scenario, with statistical and systematic uncertainties. The numbers in parentheses are negative variations.

p_T (GeV/c)	$\Upsilon(3S)/\Upsilon(1S)$
0–2	0.108 ± 0.007 (0.007) ± 0.015 (0.015)
2–5	0.101 ± 0.006 (0.006) ± 0.015 (0.012)
5–8	0.122 ± 0.007 (0.007) ± 0.016 (0.014)
8–10	0.154 ± 0.010 (0.009) ± 0.022 (0.017)
10–13	0.197 ± 0.012 (0.011) ± 0.020 (0.015)
13–16	0.258 ± 0.019 (0.018) ± 0.021 (0.019)
16–18	0.305 ± 0.034 (0.032) ± 0.027 (0.026)
18–22	0.283 ± 0.030 (0.028) ± 0.022 (0.027)
22–38	0.323 ± 0.039 (0.036) ± 0.050 (0.089)
0–38	0.129 ± 0.003 (0.003) ± 0.018 (0.015)

Table 25: The ratio of $\Upsilon(2S)/\Upsilon(1S)$ acceptance-corrected cross sections, and its p_T dependence, integrated over the rapidity range $|y^\Upsilon| < 2.4$, for the unpolarized scenario, with statistical and systematic uncertainties. The numbers in parentheses are negative variations.

p_T (GeV/c)	$\Upsilon(2S)/\Upsilon(1S)$
0–2	0.221 ± 0.010 (0.009) ± 0.030 (0.024)
2–5	0.230 ± 0.008 (0.008) ± 0.028 (0.030)
5–8	0.266 ± 0.011 (0.010) ± 0.033 (0.025)
8–10	0.270 ± 0.012 (0.012) ± 0.034 (0.029)
10–13	0.330 ± 0.016 (0.015) ± 0.029 (0.028)
13–16	0.372 ± 0.023 (0.022) ± 0.025 (0.028)
16–18	0.502 ± 0.046 (0.043) ± 0.040 (0.041)
18–22	0.449 ± 0.039 (0.036) ± 0.032 (0.048)
22–38	0.466 ± 0.047 (0.044) ± 0.074 (0.121)
0–38	0.264 ± 0.005 (0.005) ± 0.032 (0.028)

Table 26: The ratio of $\Upsilon(3S)/\Upsilon(2S)$ acceptance-corrected cross sections, and its p_T dependence, integrated over the rapidity range $|y^\Upsilon| < 2.4$, for the unpolarized scenario, with statistical and systematic uncertainties. The numbers in parentheses are negative variations.

p_T (GeV/c)	$\Upsilon(3S)/\Upsilon(2S)$
0–2	0.490 ± 0.042 (0.040) ± 0.067 (0.070)
2–5	0.440 ± 0.032 (0.030) ± 0.082 (0.057)
5–8	0.459 ± 0.035 (0.033) ± 0.054 (0.053)
8–10	0.569 ± 0.047 (0.044) ± 0.078 (0.063)
10–13	0.597 ± 0.046 (0.043) ± 0.062 (0.044)
13–16	0.693 ± 0.063 (0.059) ± 0.060 (0.047)
16–18	0.607 ± 0.082 (0.074) ± 0.058 (0.051)
18–22	0.630 ± 0.079 (0.071) ± 0.060 (0.044)
22–38	0.69 ± 0.10 (0.09) ± 0.15 (0.14)
0–38	0.490 ± 0.015 (0.015) ± 0.069 (0.058)

Table 27: The product of the $\Upsilon(nS)$ acceptance-corrected production cross sections, σ , integrated and differential in p_T^Υ , and the respective dimuon branching fraction, \mathcal{B} , integrated over the rapidity range $|y^\Upsilon| < 1.2$ and the p_T^Υ range from 10 to 50 GeV/c. The cross sections assume the $\Upsilon(nS)$ are unpolarized. The statistical uncertainty (stat.), the sum in quadrature of the systematic uncertainties excluding the contribution from the polarization uncertainty ($\Sigma_{\text{syst.}}$), the systematic uncertainties from the polarization (syst.(pol)), and the total uncertainty ($\Delta\sigma$; including stat., $\Sigma_{\text{syst.}}$, syst.(pol), and the uncertainty in the integrated luminosity) are in percent. The numbers in parentheses are negative variations.

		$ y^\Upsilon < 1.2$				
	p_T (GeV/c)	$\sigma \cdot \mathcal{B}$ (nb)	$\frac{\text{stat.}}{\sigma}$	$\frac{\Sigma_{\text{syst.}}}{\sigma}$	$\frac{\text{syst.(pol.)}}{\sigma}$	$\frac{\Delta\sigma}{\sigma}$
$\Upsilon(1S)$	10–11	0.139	2.8	8 (7)	5 (1)	10 (9)
	11–12	0.0949	3.4	5 (4)	4 (1)	8 (7)
	12–13	0.0779	3.6	6 (5)	3 (1)	8 (8)
	13–14	0.0540	4.1	5 (4)	3 (1)	8 (7)
	14–15	0.0436	4.4	5 (5)	3 (1)	9 (8)
	15–16	0.0322	5.0	5 (5)	3 (1)	9 (8)
	16–18	0.0415	4.2	5 (4)	2 (2)	8 (8)
	18–20	0.0286	4.9	5 (4)	2 (2)	8 (8)
	20–22	0.0164	6.4	4 (4)	2 (2)	9 (9)
	22–25	0.0113	7.6	5 (4)	2 (2)	10 (10)
	25–30	0.0105	7.8	4 (4)	1 (2)	10 (10)
	30–50	0.00720	9.4	5 (5)	3 (2)	12 (12)
	10–50	0.558	1.3	6 (5)	4 (2)	8 (7)
$\Upsilon(2S)$	10–11.5	0.0661	4.9	8 (8)	9 (3)	13 (10)
	11.5–13	0.0400	5.7	6 (6)	8 (4)	12 (10)
	13–14.5	0.0287	6.3	6 (5)	8 (4)	12 (10)
	14.5–16	0.0206	6.9	6 (6)	7 (4)	12 (11)
	16–18	0.0215	6.4	9 (9)	6 (3)	13 (12)
	18–19.5	0.0091	9.5	6 (5)	5 (3)	13 (12)
	19.5–22	0.0108	8.5	7 (7)	6 (4)	13 (12)
	22–26	0.0089	9.3	9 (8)	7 (4)	15 (14)
	26–42	0.00737	9.7	6 (6)	6 (4)	14 (13)
	10–42	0.213	2.4	5 (5)	7 (3)	10 (8)
$\Upsilon(3S)$	10–13	0.0591	5.2	7 (6)	5 (3)	11 (10)
	13–16	0.0318	6.3	6 (5)	8 (4)	12 (10)
	16–18	0.0129	9.1	10 (10)	9 (5)	17 (15)
	18–22	0.0128	8.4	7 (7)	8 (4)	14 (12)
	22–38	0.0104	8.9	6 (6)	6 (4)	13 (12)
	10–38	0.127	3.2	7 (5)	7 (3)	11 (8)