

$\Upsilon(nS)$  polarizations versus particle multiplicity in pp collisions at  $\sqrt{s} = 7$  TeV

—Supplemental Material—

The CMS Collaboration<sup>a</sup>

<sup>a</sup>*CERN*

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**Abstract**

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*Email address:*

cms-publication-committee-chair@cern.ch (The CMS  
Collaboration)

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Table 1: Signal yields,  $N$ , and background fractions,  $f_{\text{Bg}}$  (in %), within  $1\sigma$  windows around the nominal  $\Upsilon(nS)$  masses for the considered  $N_{\text{ch}}$  and  $p_{\text{T}}$  ranges.

$p_{\text{T}}$ [GeV]	$N_{\text{ch}}$	$\Upsilon(1S)$		$\Upsilon(2S)$		$\Upsilon(3S)$	
		$N$	$f_{\text{Bg}}$	$N$	$f_{\text{Bg}}$	$N$	$f_{\text{Bg}}$
10–15	0–10	26 900	3	10 200	7	6 500	10
	10–20	51 300	5	18 200	12	10 800	18
	20–30	39 200	7	13 000	18	7 500	26
	30–40	20 100	9	6 300	24	5 200	40
	40–60	11 300	12	3 400	31		
15–35	0–10	10 600	3	4 500	7	3 200	9
	10–20	27 900	4	12 100	9	8 200	12
	20–30	25 700	5	10 900	11	7 200	15
	30–40	15 100	6	6 300	14	3 800	20
	40–60	9 500	7	3 400	17	2 300	24

Table 2:  $\Upsilon$ (nS) polarization parameters in the HX frame. The global uncertainties, independent of state and  $N_{\text{ch}}$  bin, are also indicated.

State	$p_T$ [GeV]	$N_{\text{ch}}$	$\lambda_\theta$	$\lambda_\varphi$	$\lambda_{\theta\varphi}$	$\tilde{\lambda}$
$\Upsilon(1S)$	10–15	0–10	$+0.014^{+0.102}_{-0.110}$	$-0.044^{+0.026}_{-0.029}$	$+0.053^{+0.033}_{-0.036}$	$-0.094^{+0.126}_{-0.138}$
		10–20	$+0.103^{+0.089}_{-0.098}$	$-0.035^{+0.025}_{-0.027}$	$+0.027^{+0.028}_{-0.031}$	$+0.005^{+0.126}_{-0.139}$
		20–30	$+0.187^{+0.102}_{-0.110}$	$-0.041^{+0.026}_{-0.029}$	$+0.035^{+0.033}_{-0.037}$	$+0.066^{+0.128}_{-0.145}$
		30–40	$+0.032^{+0.121}_{-0.132}$	$-0.042^{+0.027}_{-0.031}$	$+0.033^{+0.039}_{-0.044}$	$-0.074^{+0.146}_{-0.159}$
		40–60	$-0.073^{+0.159}_{-0.174}$	$-0.074^{+0.034}_{-0.037}$	$+0.061^{+0.054}_{-0.059}$	$-0.243^{+0.186}_{-0.201}$
$\Upsilon(2S)$	10–15	0–10	$+0.232^{+0.140}_{-0.156}$	$-0.018^{+0.035}_{-0.037}$	$-0.048^{+0.049}_{-0.054}$	$+0.166^{+0.174}_{-0.183}$
		10–20	$+0.214^{+0.126}_{-0.136}$	$-0.047^{+0.032}_{-0.035}$	$-0.055^{+0.042}_{-0.048}$	$+0.075^{+0.158}_{-0.178}$
		20–30	$+0.230^{+0.158}_{-0.171}$	$-0.028^{+0.036}_{-0.040}$	$-0.045^{+0.057}_{-0.061}$	$+0.137^{+0.201}_{-0.222}$
		30–40	$+0.267^{+0.213}_{-0.226}$	$-0.024^{+0.044}_{-0.046}$	$-0.059^{+0.072}_{-0.084}$	$+0.183^{+0.272}_{-0.284}$
		40–60	$+0.317^{+0.289}_{-0.325}$	$-0.061^{+0.055}_{-0.063}$	$+0.023^{+0.103}_{-0.113}$	$+0.128^{+0.345}_{-0.366}$
$\Upsilon(3S)$	10–15	0–10	$+0.074^{+0.169}_{-0.187}$	$-0.028^{+0.038}_{-0.044}$	$-0.044^{+0.061}_{-0.069}$	$-0.002^{+0.205}_{-0.219}$
		10–20	$+0.279^{+0.156}_{-0.173}$	$-0.019^{+0.037}_{-0.040}$	$-0.148^{+0.060}_{-0.064}$	$+0.208^{+0.209}_{-0.223}$
		20–30	$+0.061^{+0.194}_{-0.213}$	$-0.032^{+0.043}_{-0.047}$	$+0.061^{+0.069}_{-0.078}$	$-0.023^{+0.245}_{-0.259}$
		30–60	$+0.672^{+0.285}_{-0.304}$	$+0.051^{+0.061}_{-0.068}$	$-0.196^{+0.108}_{-0.116}$	$+0.798^{+0.435}_{-0.479}$
		global unc.		$\pm 0.085$	$\pm 0.023$	$\pm 0.022$
$\Upsilon(1S)$	15–35	0–10	$-0.002^{+0.102}_{-0.110}$	$-0.054^{+0.029}_{-0.032}$	$+0.020^{+0.038}_{-0.041}$	$-0.142^{+0.128}_{-0.138}$
		10–20	$-0.004^{+0.087}_{-0.094}$	$-0.047^{+0.037}_{-0.041}$	$-0.000^{+0.033}_{-0.038}$	$-0.127^{+0.130}_{-0.142}$
		20–30	$+0.053^{+0.087}_{-0.093}$	$-0.054^{+0.039}_{-0.042}$	$-0.005^{+0.034}_{-0.037}$	$-0.095^{+0.121}_{-0.130}$
		30–40	$+0.036^{+0.097}_{-0.105}$	$-0.026^{+0.033}_{-0.036}$	$-0.000^{+0.037}_{-0.042}$	$-0.037^{+0.128}_{-0.139}$
		40–60	$-0.021^{+0.106}_{-0.112}$	$-0.049^{+0.039}_{-0.044}$	$+0.007^{+0.043}_{-0.046}$	$-0.148^{+0.151}_{-0.164}$
$\Upsilon(2S)$	15–35	0–10	$+0.124^{+0.163}_{-0.168}$	$-0.058^{+0.034}_{-0.039}$	$-0.050^{+0.048}_{-0.054}$	$-0.039^{+0.189}_{-0.190}$
		10–20	$+0.237^{+0.105}_{-0.114}$	$-0.027^{+0.028}_{-0.032}$	$-0.025^{+0.039}_{-0.043}$	$+0.149^{+0.138}_{-0.148}$
		20–30	$+0.205^{+0.104}_{-0.113}$	$-0.086^{+0.030}_{-0.034}$	$+0.052^{+0.038}_{-0.043}$	$-0.040^{+0.141}_{-0.146}$
		30–40	$+0.501^{+0.147}_{-0.153}$	$-0.020^{+0.033}_{-0.037}$	$-0.078^{+0.047}_{-0.053}$	$+0.416^{+0.177}_{-0.184}$
		40–60	$+0.364^{+0.171}_{-0.172}$	$-0.061^{+0.040}_{-0.044}$	$-0.024^{+0.053}_{-0.061}$	$+0.169^{+0.200}_{-0.206}$
$\Upsilon(3S)$	15–35	0–10	$+0.381^{+0.188}_{-0.193}$	$-0.074^{+0.039}_{-0.044}$	$+0.048^{+0.059}_{-0.066}$	$+0.144^{+0.210}_{-0.203}$
		10–20	$+0.244^{+0.121}_{-0.134}$	$-0.029^{+0.033}_{-0.037}$	$-0.035^{+0.041}_{-0.048}$	$+0.151^{+0.169}_{-0.177}$
		20–30	$+0.285^{+0.121}_{-0.132}$	$-0.048^{+0.032}_{-0.036}$	$-0.053^{+0.041}_{-0.048}$	$+0.135^{+0.162}_{-0.165}$
		30–40	$+0.220^{+0.163}_{-0.169}$	$-0.121^{+0.039}_{-0.043}$	$-0.050^{+0.054}_{-0.060}$	$-0.114^{+0.191}_{-0.197}$
		40–60	$+0.278^{+0.218}_{-0.206}$	$-0.072^{+0.048}_{-0.051}$	$-0.143^{+0.068}_{-0.078}$	$+0.057^{+0.246}_{-0.231}$
global unc.		$\pm 0.066$	$\pm 0.019$	$\pm 0.020$	$\pm 0.073$	