



High  
Luminosity  
LHC



# Update of HL-LHC parameters due to new bunch length

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# HL-LHC current table

(link)

Parameter	Nominal LHC (design)	HL-LHC 25ns (standard)	HL-LHC 25ns (BCMS) <sup>9</sup>	HL-LHC 8b+4e <sup>12</sup>
Beam energy in collision [TeV]	7	7	7	7
$N_b$	1.15E+11	2.2E+11	2.2E+11	2.3E+11
$n_b$	2808	2748	2604	1968
Number of collisions in IP1 and IP5 <sup>1</sup>	2808	<a href="#">2736</a>	<a href="#">2592</a>	1960
$N_{tot}$	3.2E+14	6.0E+14	5.7E+14	4.5E+14
beam current [A]	0.58	1.09	1.03	0.82
x-ing angle [ $\mu$ rad]	285	590	590	554 <sup>10</sup>
beam separation [ $\sigma$ ] <sup>11</sup>	9.4	12.5	12.5	12.5 <sup>10</sup>
$\beta^*$ [m]	0.55	0.15	0.15	0.15
$\epsilon_n$ [ $\mu$ m]	3.75	2.50	2.50	2.20
$\epsilon_L$ [eVs]	2.50	2.50	2.50	2.50
r.m.s. energy spread	1.13E-04	1.13E-04	1.13E-04	1.13E-04
r.m.s. bunch length [m]	7.55E-02	7.55E-02	7.55E-02	7.55E-02
IBS horizontal [h]	80 -> 106	18.5	18.5	13.1
IBS longitudinal [h]	61 -> 60	20.4	20.4	17.6
Piwinski parameter	0.65	3.14	3.14	3.14
Total loss factor R0 without crab-cavity	0.836	0.305	0.305	0.304
Total loss factor R1 with crab-cavity <sup>13</sup>	(0.981)	0.829	0.829	0.828
beam-beam / IP without Crab Cavity	3.1E-03	3.3E-03	3.3E-03	3.9E-03
beam-beam / IP with Crab cavity <sup>13</sup>	3.8E-03	1.1E-02	1.1E-02	1.3E-02
Peak Luminosity without crab-cavity [ $\text{cm}^{-2} \text{s}^{-1}$ ]	1.00E+34	7.18E+34	6.80E+34	6.38E+34
Virtual Luminosity with crab-cavity: $L_{peak} * R1 / R0$	(1.18E+34)	19.54E+34	18.52E+34	17.40E+34
Events / crossing without levelling and without crab-cavity	27	198	198	246
Levelled Luminosity [ $\text{cm}^{-2} \text{s}^{-1}$ ]	-	5.00E+34 <sup>5</sup>	5.00E+34	3.63E+34
Events / crossing (with leveling and crab-cavities for	27	138	146	140
Peak line density of pile up event [event/mm] (max over	0.21	1.25	1.31	1.28
Leveling time [h] (assuming no emittance growth) <sup>8, 13</sup>	-	8.3	7.6	9.5

# What changed?

In CERN-ACC-NOTE-2015-0009 the bunch length and the energy spread are updated according to the latest HL-LHC optics  $\gamma_t=53.73$  and assuming  $\epsilon_L=2.5$  eVs.

Implications in the rest of the parameters follow.

# Parameter table I

	US2a	8b+4e
E [TeV]	7	7
$N_b$ [ $10^{11}$ ]	2.2	2.3
$n_{bunches}$	2748	1968
IP1&5 colls	2736	1960
$N_{tot}$ [ $10^{14}$ ]	6.0	4.5
beam current [A]	1.09	0.82
x-sing angle [ $\mu rad$ ]	590	554
beam separation [ $\sigma$ ]	12.5	12.5
$\beta^*$ [m]	0.15	0.15
$\epsilon_n$ [ $\mu m$ ]	2.5	2.2
$\epsilon_L$ [eVs]	2.5	2.5
E spread [ $10^{-4}$ ]	1.08	1.08
bunch length [cm]	8.1	8.1
IBS horizontal [h]	18.8	13.6
IBS longitudinal [h]	20.6	16.9
Piwinski parameter	3.4	3.4

## Parameter table II

	US2a	8b+4e
Loss factor no CC	0.285	0.285
Loss factor with CC	0.800	0.800
beam-beam no CC [ $10^{-3}$ ]	3.0	3.6
beam-beam with CC [ $10^{-2}$ ]	1.1	1.3
Peak Lumi without CC [ $cm^{-2}s^{-1}10^{34}$ ]	6.73	5.99
Virtual lumi with CC [ $cm^{-2}s^{-1}10^{35}$ ]	1.88	1.68
Pile-up without lev CC	186	231
Leveled lumi [ $cm^{-2}s^{-1}10^{34}$ ]	5	3.63
Pile-up with lev CC	138	140
Peak pile-up density	1.19	1.2
Leveling time [h]	8.5	9.5
Number of collisions IP2/IP8	2452/2524	1163/1868
$N_b$ at injection [ $10^{11}$ ]	2.3	2.4
$n_b$ per injection	288	224
$N_{tot}$ per injection [ $10^{13}$ ]	6.6	5.4
Emittance at injection [ $\mu m$ ]	2	1.7

# Outlook

New parameters to come for the new cross sections:  
 $\sigma_{inel}=81$  mbar and  $\sigma_{tot}=111$  mbar