

# Beam Parameters and Lattices for CDR 0.4

## Nominal Beam Parameters

The nominal operating range for the NLC is illustrated in Table 1 where we have listed the IP beam parameters for 500 GeV and 1 TeV center-of-mass. For the 500 GeV case, the main linacs consist of 11 DLDS sectors each and have active lengths of roughly 4280 meters while, in the 1 TeV case, the main linacs consist of 22 DLDS sectors each and have active lengths of roughly 8570 meters.

The parameter operating range for each linac configuration is defined by the three parameter sets A, B, and C. The specifications on the collider subsystems are such that the subsystems will meet the most difficult requirements across the parameter range.

**Table 1 NLC IP parameters for 500 GeV and 1 TeV in the center-of-mass**

	500 GeV			1 TeV		
	A	B	C	A	B	C
CMS Energy (GeV)	510	500	482	1022	1000	964
<b>Luminosity (<math>10^{33}</math>)</b>	<b>5.3</b>	<b>5.4</b>	<b>5.5</b>	<b>10.6</b>	<b>10.8</b>	<b>11</b>
Repetition Rate (Hz)	120	120	120	120	120	120
<b>Bunch Charge (<math>10^{10}</math>)</b>	<b>0.7</b>	<b>0.82</b>	<b>1</b>	<b>0.7</b>	<b>0.82</b>	<b>1</b>
Bunches/RF Pulse	95	95	95	95	95	95
Bunch Separation (ns)	2.8	2.8	2.8	2.8	2.8	2.8
<b>Eff. Gradient (MV/m)</b>	<b>58.7</b>	<b>57.3</b>	<b>55.2</b>	<b>58.7</b>	<b>57.3</b>	<b>55.2</b>
Injected $\gamma\epsilon_x / \gamma\epsilon_y$ ( $10^{-8}$ )	300 / 3	300 / 3	300 / 3	300 / 3	300 / 3	300 / 3
$\gamma\epsilon_x$ at IP ( $10^{-8}$ m-rad)	400	450	500	400	450	500
<b><math>\gamma\epsilon_y</math> at IP (<math>10^{-8}</math> m-rad)</b>	<b>6.5</b>	<b>8.5</b>	<b>12</b>	<b>6.5</b>	<b>8.5</b>	<b>12</b>
$\beta_x / \beta_y$ at IP (mm)	12 / 0.12	12 / 0.12	13 / 0.15	12 / 0.12	12 / 0.15	13 / 0.15
<b><math>s_x / s_y</math> at IP (nm)</b>	<b>310 / 4.0</b>	<b>330 / 4.6</b>	<b>365 / 6.2</b>	<b>220 / 2.8</b>	<b>235 / 3.2</b>	<b>260 / 4.4</b>
$\sigma_z$ at IP (um)	90	120	140	90	120	140
Yave	0.11	0.09	0.08	0.32	0.25	0.23
Pinch Enhancement	1.46	1.35	1.39	1.46	1.35	1.39
Beamstrahlung $\delta B$ (%)	3.2	3	3	8.3	8.1	8.4
Photons per e+/e-	0.86	0.96	1.05	1.12	1.25	1.38
Active linac length (km)		4.3			8.6	
AC Power for rf (MW)		100			200	

At each of the nominal operating configurations, the linac must be able to deliver beams with XX% (50%?) of the nominal energy. This specifies the operating range for the beam delivery systems and the linac optics.

Finally, the NLC must be able to deliver highly polarized electrons to the IP; this requires spin rotator components upstream and downstream of the damping rings. In addition, the capability to accelerate polarized positrons must be maintained in the positron source; this sets certain geometric constraints on the layout of the positron side.

## Emittance and Jitter Budgets

Preliminary emittance and jitter budgets are listed in Tables 2 and 3 respectively. These budgets will have to be redistributed for CDR 0.4 however they provide a guide for the present. Tolerances to attain these budgets will be specified in the future.

**Table 2 Emittance budgets for 500 GeV and 1 TeV cms**

	500 GeV			1 TeV		
	A	B	C	A	B	C
$g_{e_x}/g_{e_y}$ from DR [ $10^{-8}$ m-rad]	300 / 3			300 / 3		
$\Delta\varepsilon_x/\Delta\varepsilon_y$ to 10 GeV [%]	5 / 15	15 / 40	20 / 70	5 / 15	15 / 40	20 / 70
$\Delta\varepsilon_x/\Delta\varepsilon_y$ in linac [%]	15 / 60	20 / 100	25 / 150	15 / 60	20 / 100	25 / 150
$\Delta\varepsilon_x/\Delta\varepsilon_y$ in BD [%]	10 / 40	15 / 40	20 / 70	10 / 40	15 / 40	20 / 70
$D_{e_x}/D_{e_y}$ at IP [ $10^{-8}$ m-rad]	400 / 6.5	450 / 8.5	500 / 12	400 / 6.5	450 / 8.5	500 / 12

**Table 3 Jitter budgets for 500 GeV and 1 TeV cms**

	500 GeV			1 TeV		
	DX / $s_x$	DY / $s_y$	DE / E	DX / $s_x$	DY / $s_y$	DE / E
From DR	0.1	0.1	0	0.1	0.1	0
From injector	0.1	0.2	0.001	0.1	0.2	0.001
From linac	0.1	0.375	0.002	0.1	0.375	0.002
From BD	0.1	0.25	0	0.1	0.25	0
From FD	0.1	0.25	0	0.1	0.25	0
<b>At IP</b>	<b>0.22</b>	<b>0.56</b>	<b>0.0022</b>	<b>0.22</b>	<b>0.56</b>	<b>0.0022</b>

## High Luminosity and 1.5 TeV Operation

The NLC is being design with significant margins in the operating parameters. These margins should allow for faster collider commissioning. In addition, they allow for the possibility of higher luminosity operation after the commissioning period is completed. Parameters for high luminosity operation are listed in Table 4 for the 500 GeV and the 1

TeV linac configurations. The primary requirements for the high luminosity operation are:

- Operation with a 1.4 ns bunch spacing instead of the nominal 2.8 ns spacing
- Operation with roughly 50% higher beam powers
- Generation and operation with significantly smaller beam emittances

**Table 4 NLC IP parameters for high luminosity at 500 GeV and 1 TeV cms**

	500 GeV	1 TeV
CMS Energy (GeV)	446	888
<b>Luminosity (<math>10^{33}</math>)</b>	<b>20</b>	<b>34</b>
Repetition Rate (Hz)	120	120
<b>Bunch Charge (<math>10^{10}</math>)</b>	<b>0.75</b>	<b>0.75</b>
Bunches/RF Pulse	190	190
Bunch Separation (ns)	1.4	1.4
<b>Eff. Gradient (MV/m)</b>	<b>50.2</b>	<b>50.2</b>
Injected $\gamma\epsilon_x / \gamma\epsilon_y$ ( $10^{-8}$ )	300 / 2	300 / 2
$\gamma\epsilon_x$ at IP ( $10^{-8}$ m-rad)	360	360
<b><math>\gamma\epsilon_y</math> at IP (<math>10^{-8}</math> m-rad)</b>	<b>3.5</b>	<b>3.5</b>
$\beta_x / \beta_y$ at IP (mm)	8 / 0.10	10 / 0.12
<b><math>s_x / s_y</math> at IP (nm)</b>	<b>260 / 2.8</b>	<b>220 / 2.2</b>
$\sigma_z$ at IP (um)	110	110
Yave	0.10	0.26
Pinch Enhancement	1.43	1.49
Beamstrahlung $\delta B$ (%)	4	8.8
Photons per e+/e-	1.13	1.33

These requirements have some impact on the injector systems, the radiation levels along the collider, and the requirements on the beam dumps. They also have some impact on the machine protection system for the collider.

In addition, possible parameters for 1.5 TeV operation are listed in Table 5; these parameters should be treated as highly preliminary however they are important to keep in mind so that we do not unthinkingly limit the future capability of the collider during the initial design. The high gradient column assumes that the active linac length is the same as for the 1 TeV case but twice the rf power is delivered to the accelerator structures. The additional length case, assumes that the 1 TeV linac length is increased by 50%, i.e. 11 DLDS sectors are added. Both cases are based on the ‘case C’ parameters but, for the high gradient parameters, the bunch charge is increased by 40% to maintain the same beam loading.

Finally, the maximum beam powers for different operating modes are listed in Table 6.

**Table 5 NLC IP parameters for two possible modes of operation at 1.5 TeV cms**

	<b>High Gradient</b>	<b>Additional Length</b>
CMS Energy (GeV)	1406	1478
<b>Luminosity (<math>10^{33}</math>)</b>	<b>12</b>	<b>10</b>
Repetition Rate (Hz)	60	90
<b>Bunch Charge (<math>10^{10}</math>)</b>	<b>1.4</b>	<b>1.0</b>
Bunches/RF Pulse	95	95
Bunch Separation (ns)	2.8	2.8
<b>Eff. Gradient (MV/m)</b>	<b>80.2</b>	<b>57.3</b>
Injected $\gamma_{\epsilon_x} / \gamma_{\epsilon_y}$ ( $10^{-8}$ )	300 / 3	300 / 3
$\gamma_{\epsilon_x}$ at IP ( $10^{-8}$ m-rad)	450	450
<b><math>g_{\epsilon_y}</math> at IP (<math>10^{-8}</math> m-rad)</b>	<b>14</b>	<b>10</b>
$\beta_x / \beta_y$ at IP (mm)	15 / 0.2	13 / 0.2
<b><math>s_x / s_y</math> at IP (nm)</b>	<b>220 / 4.5</b>	<b>200 / 3.7</b>
$\sigma_z$ at IP ( $\mu\text{m}$ )	145	145
Yave	0.6	0.4
Pinch Enhancement	1.6	1.5
Beamstrahlung $\delta B$ (%)	22	14
Photons per e+/e-	2.1	1.6
Active linac length (km)	8.6	12.8
AC Power for X-band rf (MW)	200	225

**Table 6 Maximum beam parameters**

<b>Energy</b>	<b>Rep. Rate</b>	<b>Max. Charge</b>	<b># Bunches</b>	<b>Max. Power<sup>(a)</sup></b>
500 GeV	120 Hz	0.82e10	95	8.5 MW
482 GeV <sup>(b)</sup>	120 Hz	1.0e10	95	10 MW
450 GeV <sup>(c)</sup>	120 Hz	0.75e10	190	14 MW
750 GeV <sup>(d)</sup>	90 Hz	1.0e10	95	12 MW
750 GeV <sup>(d)</sup>	60 Hz	1.4e10	95	11 MW

(a) Includes 10% overhead above maximum values

(b) Assumes larger beam loading with higher charge

(c) Assumes larger beam loading with higher charge and 1.4 ns bunch spacing

(d) Two possible upgrade scenarios to 1.5 TeV cms

## Lattices and Documentation

The current lattices for CDR 0.4 are located in the Accelerator Physics region of the NLC web site. As of the beginning of March, the decks are not all at the CDR 0.4 standard however the current status, parts counts, decks, and plots can all be found under CDR\_0.4 at: [http://www-project.slac.stanford.edu/lc/local/AccelPhysics/nlc\\_lattices\\_index.htm](http://www-project.slac.stanford.edu/lc/local/AccelPhysics/nlc_lattices_index.htm) where the beamline names are defined in: <http://www-project.slac.stanford.edu/lc/local/AccelPhysics/Lattices/Documentation/names.html>. The beamline parts counts are based on direct counts of components in the lattices—unless otherwise noted in the ‘status’ section, these should contain all of the beamline components including magnets, rf cavities, and diagnostic and correction elements as defined in: <http://www-project.slac.stanford.edu/lc/local/AccelPhysics/Lattices/Documentation/names.html>.