LCLS Parameters – March 2017

Typical measured LCLS parameters with hard and soft x-rays. The values are general guidelines. Many parameters vary according to the exact energy, pulse length and band-with. Stability values (at bottom) are taken over a few minutes.

General SASE Parameters

Photon Beam Parameters	Symbol	Hard x-rays	Soft x-rays	Short Pulse soft	Short Pulse hard	Unit
Fundamental wavelength	λ_r	6.2-0.97	44.3-6.2	44.3-6.2	6.2-0.97	Å
Photon Energy	$\hbar\omega$	2000-12800	280-2000	280-2000	2000-12800	eV
Final linac e- energy	γmc^2	6.7-16.9	2.5-6.7	2.5-6.7	6.7-16.9	GeV
FEL 3-D gain length	L_G	1.5-5.4	1.0 – 2.6	0.6 – 1.6	1.0 – 2.9	m
Photons per pulse	$N\gamma$	0.57 – 16	10 – 55	1.1 – 11	0.17 – 2.6	10^{12}
Pulse Energy	U	5	4	0.51	0.5	mJ
Peak brightness	B_{pk}	0.083 – 1.4	0.0033 – 0.14	0.0054 – 0.21	0.14 – 1.5	10^{33} §
Average brightness (120Hz)	$\langle B \rangle$	1 – 19	0.051 – 2.8	0.0084 – 0.22	0.14 – 1.5	10^{21} §
SASE bandwidth (FWHM)	$\Delta\omega/\omega$	0.1-0.4	0.1-0.8	0.2 – 1.2	0.2 – 0.6	%
Final pulse duration (FWHM)	$\Delta\tau_f$	50-250	70-400	6.7 – 20	5.0 - 10	fs
Electron Beam Parameters						
Bunch Charge	Q	0.15 – 0.25	0.15 – 0.25	0.02	0.02	nC
Total Energy Spread	$\sigma E/E$	10^{-3}	10^{-3}	10^{-3}	10^{-3}	1
Inject. bunch length (rms)	σ_{z0}	650	650	230	230	μm
Undul. bunch length (rms)	σ_{zf}	4.3 – 22	6.1 – 35	0.6 – 1.7	0.4 – 0.9	μm
Final peak current	I_{pk}	1.0 – 3.0	0.63 – 2.1	1.0 – 3.0	2.0 – 4.0	kA
Proj. Emittance (injector)	$\gamma\varepsilon_{x,y}$	0.45	0.45	0.2	0.2	μm
Slice Emittance (injector)	$\gamma\varepsilon^{s}_{x,y}$	0.37 – 0.47	0.37 – 0.47	0.17	0.17	μm
Proj. Emittance (Undulator)	$\gamma\varepsilon^{u}_{x,y}$	0.5-1.6	0.5-1.6	0.3-1.0	0.3-1.0	μm
Single Bunch Rep. Rate	F	120	120	120	120	Hz
UV laser energy on cath.	u_l	15	15	~2	~2	μJ
UV laser beam diam. on cath.	$2R$	1.2	1.2	0.6	0.6	mm
e- energy stability (rms)	$\Delta E/E$	0.02	0.07	0.1	?	%
e- x,y stability (rms)	x/σ_x	15,10	25,20	?,?	?,?	%
e- timing stability (rms)	Δt	50-100	50-100	?	?	fs
Peak current stability (rms)	$\Delta I/I$	10	6	8	?	%
Charge Stability (rms)	$\Delta Q/Q$	2.5	2.5	?	?	%
FEL pulse energy stability	$\Delta N/N$	<10	<10	<15	?	%

§Brightness units are photons/sec/mm²/mrad²/0.1%-BW

Seeded x-ray beam parameters

Mode	Energy Range	Bandwidth	Pulse Energy	Pulse Length
HXRSS	> 4.5 keV	0.35-1.5 eV	~ 1 mJ	Up to 40 fs
SXRSS	0.4-1.2 keV	~ 100 meV @ 400 eV ~ 150 meV @ 530 eV ~ 200 meV @ 800 eV	< 50 – 100 μJ @ 20 fs Up to ~ 0.5 mJ with pedestal	20 – 120 fs

Polarized Beam Parameters

Standard LCLS configurations deliver linearly polarized x-ray beams. Upon request, circularly polarized beams with adjustable helicity can be provided. The parameters for polarized beams are summarized in the following table:

Parameter	Value	Unit
Energy range	500 – 1200	eV
Pulse Energy	200	μJ
Polarization	99	% circularly

Dual Bunch & Dual Energy Parameters

Multi-color Pulse Mode Table

SOFT X-RAYS

Technique	Pulse Separation	Min Pulse Duration	Energy Separation	Max Energy/Pulse	Mode	Setup Time	Comments
Fresh Slice							Modes with the dechirper + orbit control.
Two SASE Pulses	~-15 to +850 fs	~5-8 fs	+/-2.5%	200 - 500 uJ (20 fs duraton)	SASE		Probe intensity is higher if the max delay req'd is 35 fs. Pump pulse intensity is higher if the min delay req'd is +15 fs or more (no zero delay).
Linear SASE + Polarization Controlled SASE	~-15 - +850 fs	~5-8 fs	+/-2.5%	300 uJ	SASE		Only pump polarization can be controlled. See also comments re: Fresh-slice, Two SASE Pulses.
One Pulse Self-Seeded, One SASE	0 - 50 fs	~15-20 fs	+/-2.5%	100 uJ seeded, 200 uJ SASE	SASE SEEDED		Only probe polarization can be controlled. See also comments re: Fresh-slice, Two SASE Pulses. Requires longer setup.
Three SASE Pulses	0 - 900 fs (1st to 2nd), 0 - 50 fs (2nd to 3rd)	~5-8 fs	2.5% range for all	100 uJ	SASE		Second pulse has lowest intensity, weak if E > 700 eV.
Split Undulator SASE	0 - 50 fs	40 fs	+/-2.0%	30 uJ	SASE		Minimally invasive, easy to maintain.
Double Slotted Foil	15 - 70 fs	~ 10 fs	+/-1.5%	100-300 uJ	SASE		Minimally invasive, easy to maintain. Delay and energy separation are not independent, minor tuning needed between changes.
Two bucket (ns spacing)	350 ps increments, +/- 120 ns	40 fs	+/-2%	0.5-2 mJ (100 fs duration SASE)	SASE SEEDED		Under development
Twin Bunches (fs spacing)	-	-	-	-	-		Intensity performance comparable to Fresh-slice. Max time separation shorter and tuning more invasive. Recommend Fresh Slice going forward.

HARD X-RAYS

Technique	Pulse Separation	Min Pulse Duration	Energy Separation	Max Energy/Pulse	Mode		Comments
Twin Bunches							Requires long setup (laser stacker/injector tune).
Two SASE Pulses	0 - 125 fs	~ 10 fs	0.2-3%	2 mJ (30 fs duration)	SASE		1st/probe pulse always higher photon energy
Twin bunches + V slotted foil	+/- 50 fs	~5-10 fs	~3%	50 uJ	SASE		
Twin bunches + HXR Self-Seeding	0-100 fs	~ 10 fs	~1 %	150 uJ per pulse	SEEDED		Both colors or a single color can be seeded. Requires longer setup time (hours).
Double Slotted Foil	7-20 fs	~ 10 fs	+/-1.5%	100-300 uJ	SASE		Minimally invasive, faster setup than twin bunches. Delay/energy separation not independent, minor tuning needed between changes.
Two bucket (ns spacing)	350 ps increments, +/- 120 ns	20 fs	~ 2%	1-2 mJ (40 fs duration SASE)	SASE SEEDED		Under development
Fresh Slice / Split Undulator	-	-	-	-	-		Do not apply for hard X-rays (insufficient FEL gain length).

For detailed information and trade-off decisions, contact the Instrument Scientist!