LCLS Physics Requirements Document # 1.3-002	Linac	Revision 2

L1-Linac Requirements

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Brief Summary: This specification summarizes physics requirements for the first linac section in the LCLS (L1-Linac).

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LCLS L1-Linac Requirements

The L1-linac (L1) is composed of the three existing SLAC linac sections 21-1b, 21-1c, and 21-1d, as shown in Figure 1 below. The requirements of this linac section are to accelerate a single 1-nC, 1-mm long electron bunch, at a repetition rate of 120 Hz, from 135 MeV to 250 MeV with the existing S-band (2.856 GHz) RF. This must be accomplished at an off-crest RF phase (−25° with respect to accelerating crest) in order to energy-chirp the bunch in preparation for bunch compression in the BC1 chicane, just beyond L1. In addition, the transverse slice-emittance of the electron bunch must be well preserved to a level of <4% growth in both planes.

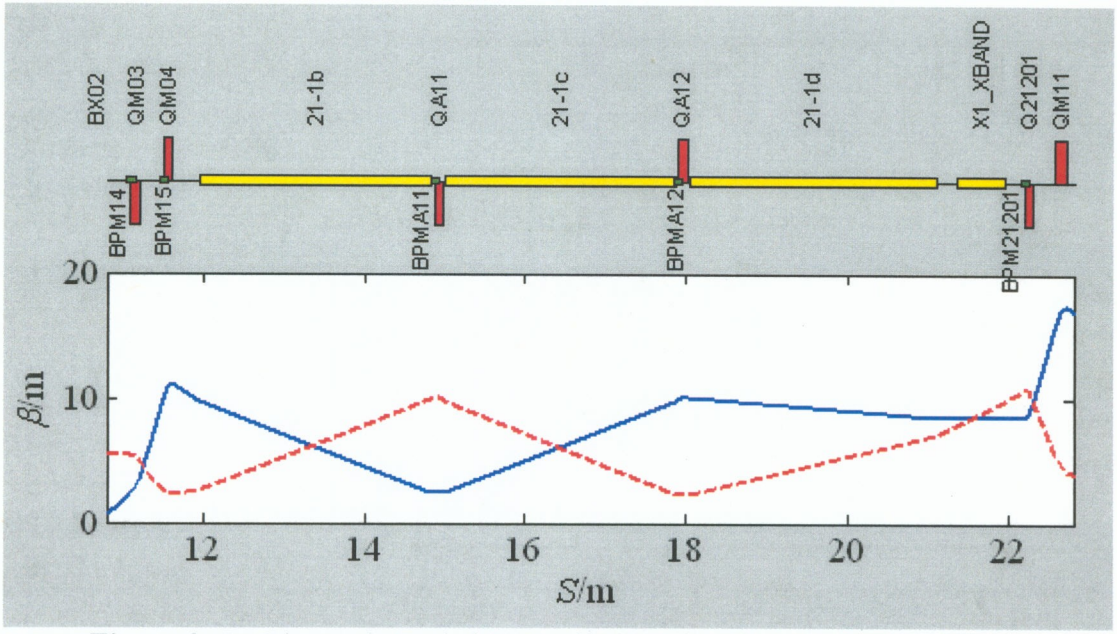

Figure 1: L1-Linac schematic layout with beta functions and device names.

The low energy beam in the L1-Linac requires more frequent focusing stations than provided by the existing linac in sector-21 and thus two new quadrupole magnets must be added after the 21-1b and the 21-1c sections. New beam position monitors (BPMs) and x and y steering corrector magnets (not shown) are also required very near these new quadrupoles in order to control the trajectory to within 250 μm.

In order to allow more linear bunch compression, a short (60 cm) X-band (11.424 GHz) RF section is included just after the three L1 S-band sections. This section operates with a decelerating voltage of 19 MV (at crest), but phased near the negative RF crest (phase of −160°). Therefore, the S-band RF sections must accelerate up to 268 MeV, where after the X-band decelerates down to 250 MeV. Both the S-band and the X-band contribute to the linear energy-chirp of 1.6% rms prior to the BC1 chicane.

The S-band RF must be stable to 0.1-deg rms with its one klystron. The RF amplitude must be stable to 0.1% rms, while the X-band RF must be stable to 0.5-deg-X rms with its one klystron and its RF amplitude must be stable to 0.25% rms

Table 1 lists some of the main parameters of the L1-Linac.

Table 1: L1-Linac parameters (1 nC, 120 Hz).

Parameter Description	**Symbol**	**Value**	**Unit**
Initial to final electron energy	E	135 to 250	MeV
Bunch length (rms)	σ_z	830	μm
Active length of system	L	8.8	m
Relative energy spread of e^- bunch (rms)	σ_E/E	0.1 to 1.6	%
RF phase of S-band sections	φ_s	−25	S-deg
RF phase of X-band sections	φ_x	−160	X-deg
S-band voltage at crest (not incl. ~15% overhead)	ΔV_s	147	MV
S-band mean phase stability (rms)	$\Delta\varphi_s$	0.1	deg-S
S-band mean amplitude stability (rms)	$\Delta V_s/V_{s0}$	0.1	%
X-band voltage at crest (not incl. ~15% overhead)	ΔV_x	19	MV
X-band mean phase stability (rms)	$\Delta\varphi_x$	0.5	deg-X
X-band mean amplitude stability (rms)	$\Delta V_x/V_{x0}$	0.25	%