LCLS Engineering Specification Document # 1.2-100	Injector	Revision 0

Design Specifications for the 120 Hz Gun

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Brief Summary: This document gives the specifications for the LCLS injector 120- Hz RF gun. The gun is based upon the BNL/UCLA/SLAC prototype gun with additional cooling for higher average power and a cathode load lock.

Keywords: RF gun, 120 Hz, cathode load lock

Key WBS#'s: 1.2.4

120 Hz Gun Design Approach

The basic beam requirements from the RF gun are a normalized emittance of 1 micron, a peak current of 100 amperes and energy of 5 to 6 MeV. Given current technology, this beam quality can only be attained using an RF photocathode gun. The gun architecture chosen for LCLS is the 1.6 cell, s-band gun. The LCLS prototype was developed in a collaboration of BNL, UCLA and SLAC has been in operation at the SLAC Gun Test Facility (GTF) since 1998. This gun is shown in Figure 1.

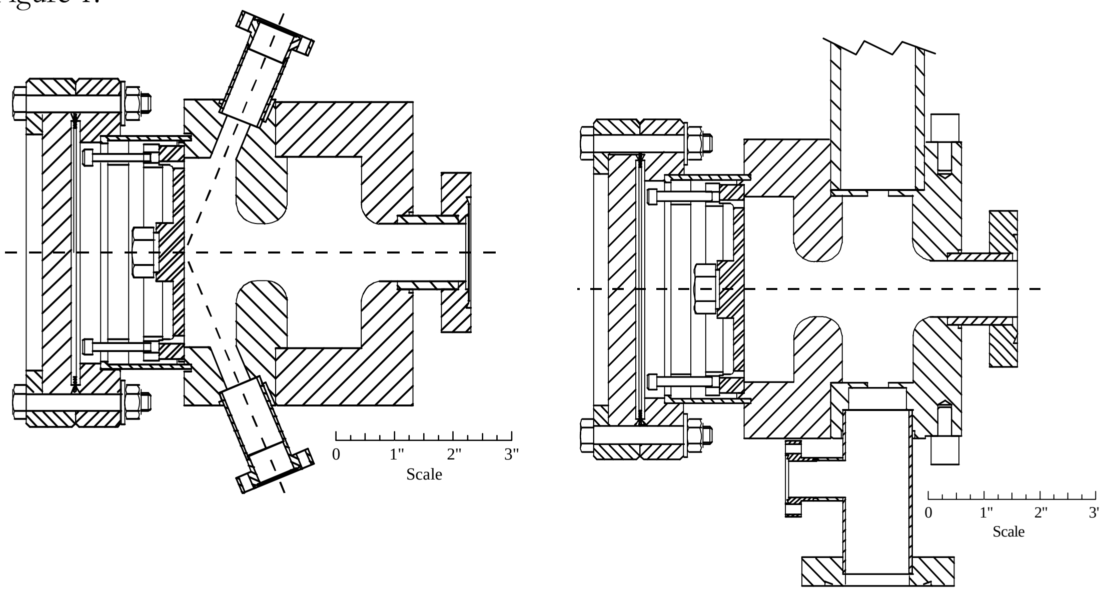

Figure 1 The LCLS/GTF prototype rf gun showing a single rf feed and grazing incidence laser ports.

120 Hz Gun Requirements

The LCLS nominal requirements are 120 MV/m on axis field and 120 Hz repetition rate. However, it is desirable to operate the gun at higher field gradients since the beam brightness improves as the field is increased. The maximum field that has been reached in the prototype gun before rf breakdown occurs is 140 MV/m. Thus the 140 MV/m, 120 Hz case, with 4 kW average power dissipation is the design goal for the LCLS gun.

Maximum Field	R = 10 Hz	R = 50 Hz	R = 120 Hz
E_c = 100 MV/m	0.17 kW	0.85 kW [1]	2.03 kW
E_c = 120 MV/m	0.25 kW		2.94 kW
E_c = 140 MV/m	0.33 kW		4.00 kW

Table 1. Average power dissipation as a function of repetition rate and peak field.

The specifications for the LCLS gun are shown in Table 2. The frequency is determined by the SLAC klystron frequency. All mechanical dimensions and tolerances are chosen to achieve this frequency and a balance field profile in the two cells. The requirement for the maximum frequency shift from 0 to full power to be < 100 kHz is primarily due to the width of the π mode resonance (see Table 2). With larger frequency deviations the field on axis is reduced for a constant klystron power and a substantial phase shift is also encountered due to the standing wave. The variation of phase with resonant frequency is proportional to the filling time of the cavity. A 100 kHz frequency shift would produce an 18 degree phase shift for a 500 ns filling time. Larger frequency deviations would be increasingly difficult to control with feedback. This phase shift also determines the temperature stability requirement of 0.07 ˚C corresponding to 1 degree of gun phase fluctuation. The mode separation must be maintained at a minimum of 3.5 MHz for the desired field profile shown in Figure 2 in order to reduce the mode beating effects to tolerable levels. The rf coupling coefficient should be between 1.6 and 2 to reduce the filling time so that transient effects are not important with short klystron pulses of approximately 2.5 μs.

The complete thermal analysis and additional specifications for the 120 Hz gun are given in Reference [2].

Parameter	Value	units
f_π	2856.0	MHz
$f_{\pi\ 0power} - f_{\pi\ highpower}$	< 100	kHz
$f_\pi - f_0$	> 3.5	MHz
τ	450-550	ns
$\beta = Q_0/Q_E$	1.6-2	
RF Coupling holes	2	
RF coupling hole maximum area	1.91	cm^2
Q_0	>11500	
E_{max} on axis	140	MV/m
$(E-E_{nom})/E_{nom}$ along the axis	2	%
Maximum von Mises stress	3-5	ksi
Gun Temperature Stability	0.07	˚C

Table 2. The LCLS gun electrical and mechanical specifications.

[1] F. Sakai, X. Wang, H. Kotaki, K. Nakajima, T. Watanabe, K. Kinoshita, S. Kondo, M. Kando, H. Dewa, T. Ueda, K. Yoshii, M. Uesaka, A. Ogata, H. Naanishi, M. Washio, A. Endo, I. Ben-Zvi, J. Skaritka and M. Woodle, BNL Report 65003, (1997).

[2] "Design Considerations for the LCLS RF Gun", R. Boyce, D.H. Dowell, J. Hodgson, J.F. Schmerge, N. Yu, LCLS-TN-04-4