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EFFECTS OF VARIATION OF THE LASER PULSE WIDTH ON THE LASER INDUCED PHOTOELECTRONS*

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Abstract. The effects of the variation of the Laser pulse width on the laser induced photoelectrons, from the BNL gun is presented, including the variation in the emittance of the beam, which is crucial to the operation of a Free Electron Laser (FEL). The radio-frequency (RF) electron gun with a photocathode in the end wall of an RF cavity is excited by a laser pulse that is synchronized with the RF, is powered by a conventional type SLAC klystron, and is designed to produce a low emittance beam of 4.65 MeV at the gun exit with the field gradient of 100 MV/m on the Cathode.

I. Introduction

Preliminary measurements for the BNL laser driven radio frequency Gun, indicate a larger value for the laser pulse length (σ_z), (5 Ps or more, a value larger than the design 2ps value). It was also observed [4] that after illuminating the cathode with a pulse of 0.1 mJ/cm² (reached in about 10 Ps), an ("enhanced") emission mode is set during which (after 5 ns of build up time), a large amount of charge is generated and accelerated in the gun for (duration of) 50 ns, after which the gun energy is reduced (lost). The mechanism and damage to the cathode is being investigated. Thus in Section II, Table I, and Figs. (1-6) show variations of the exit beam parameters for (few, due to space limitation) different pulse lengths, as well as different charges.

II. Beam Analysis

The initial specifications used in this analysis are those indicated by the preliminary measurements at ATF [4], e.g. the initial phase of 40°, field gradient of 62 Mv/m on the

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Table 1. Beam exit parameters for BNL Photocathode gun.

Laser Pulse length (σ_z) [Ps]	2	5	5	10
Charge (Q) [nC]	.9	.9	2	.9
Bunch Rms Length (L) [mm]	.963	2.693	2.696	6.614
RMS radius [mm]	3.465	3.042	3.487	2.698
Trans. Emittance [mm-mrad]	14.03	8.71	17.064	11.91
Long. Emittance [mm-mrad]	2.43	30.5	32.65	317.??
Peak current (I) [A]	206	76.8	170.9	32.59
L after mag comp. [mm]	.958	.958	.997	1.56
I after mag. comp. [A]	189	241	517	148
Bunch Ave. Kinetic Energy [MeV]	2.606	2.573	2.573	2.355
RMS Div. [mrad]	25.5	21.3	.265	18.3
Field on cathode [MV/m]	62	62	62	62

cathode (design value is 100 MV/m), and radius of 1.25 mm. Table I gives the variations in the beam parameters at the exit of the Gun.

Figs. 1- a and b, show the effect of wake and bunch self field, and Figs. 1- c and d show the propagation of self field (magnetic component). Fig. 2 - a show $rH_\phi = \text{constant}$ lines for 0.9 nC case. Particles are shown at $Z = 94$ mm (gun exit); Fig. 2-b, show the transverse phase space plot at $Z = 94$ mm, where as Figs. 2 - c and d, show the charge distribution and Current plots (at $Z = 94$ mm), respectively.

Figs. 3 and 4 show the parameters obtained when the laser pulse length is increased from 2 Ps (Figs. 1 and 2), and Figs. 5 and 6 will show the parameters when the pulse length is further increased to 10 Ps. Figs. 3 - show a) constant field lines; b) energy, c) longitudinal emittance; and d) length of the bunch vs Z . Figs. 4 - show a) longitudinal phase space plot; b) Transverse phase space plot of $x - x'$; c) current as function of Z and R ; and d) transverse emittance.

Figs. 5 - show a) constant field lines and position of the particles; b) energy, c) longitudinal emittance; and d) length of the bunch vs Z . Fig. 6 show a) longitudinal phase space plot; b) Transverse phase spec plot of $x - x'$; c) current as functions of Z and R (note the change in the shape as compared to 2 Ps and 5 Ps cases); and d) transverse emittance vs Z . Fig. 7 shows a schematic of the BNL laser driven Photocathode gun.

Summary

We presented an analysis for the BNL RF gun photoelectron beam, illustrating that variation of charge and / or laser pulse length does effect the exit parameters for the beam. Although, Some of the ATF preliminary data [3] showed the emittance of about 4 mm-mrad, (i.e. constant, with no change) when the charge was varied from 0.2 to 2 nC. Although we are still investigating the code used, our other analysis also shows the effects of the variation in charge. As the laser pulse length is increased there obviously are effects including the recent observation (discussed before), and damage to the cathode. Additional information is given in References.

References

- [1] Z. Parsa, *Preliminary emittance measurements and calculations of the laser excited beam from the BNL ATF RF electron gun*, Proc., BNL CAP Meetings, Vol. II, BNL-52292 (1991); Z. Parsa, L. Serafini, (in press); Private Communication, Code ITACA. L. Serafini.
- [2] Z. Parsa and L. Young, this Proc.; A. Fisher et. al. this proc; Z. Parsa and L. Young, Proc. EPAC 1990.
- [3] K. Batchelor, K. McDonald *et al.*, Proc., EPAC, (1988). Z. Parsa, EPAC 1990; and Ref. therein.; Z. Parsa, this conference.
- [4] Z. Parsa, Proc. PF91 Conf., Vancouver, Canada, (Aug. 1991).
- [5] P.G. Strupp, *et al.*, J. Appl. Phys. 69 (6), p. 3472, 1991; N.K. Sherman, Optical Eng., Vol.28, No.10, p. 1114, 1989; R. Fedosejevs, Appl. Phys. B 50, p. 79, 1990; References therein.

Figure Captions

Figure 1. (a and b), show the effect of wake and bunch self field; (c and d) show the propagation of self field (magnetic component).

Figure 2. (a) $rH_\phi = \text{constant}$ lines for 0.9 nC case. Particles are shown at $Z = 94$ mm (gun exit); (b) The transverse phase space plot at $Z = 94$ mm; (c and d) The charge distribution and Current plots (at $Z = 94$ mm), respectively.

Figure 3 The parameters obtained when the laser pulse length is increased from 2 Ps (Fig. 1). 3a) constant field lines; 3b) energy, 3c) longitudinal emittance; and 3d) length of the bunch vs Z .

Figure 4 The parameters obtained when the laser pulse length is increased from 2 Ps (Fig. 2). 4a) longitudinal phase space plot; 4b) Transverse phase space plot of $x - x'$; 4c) current as function of Z and R ; and 4d) transverse emittance.

Figure 5 The parameters when the pulse length is further increased to 10 Ps. 5a) constant field lines and position of the particles; 5b) energy, 5c) longitudinal emittance; and 5d) length of the bunch vs Z .

Figure 6 The parameters when the pulse length is further increased to 10 Ps. 6a) longitudinal phase space plot; 6b) Transverse phase spec plot of $x - x'$; 6c) current as functions of Z and R (note the change in the shape as compared to 2 Ps and 5 Ps cases); and 6d) transverse emittance vs Z .

Figure 7 Schematic of the BNL laser driven Photocathode gun.

Figure 1.

Figure 2.

b

Figure 3

5a

5b

Figure 5

Figure 6

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