CW Injector / IFEL Buncher for a Laser-Driven Linear Collider

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ICFA Mini-Workshop on Novel Concepts for Linear Accelerators and Colliders

DLA Requirements

		"ILC"	Woodpile	PCF Fiber	Grating
E_cms	GeV	1000	1000	1000	1000
Bunch Charge	e	2.0E+10	1.8E+04	3.8E+04	1.0E+04
# bunches/train	#	2820	136	159	375
train repetition rate	MHz	4.0E-06	25	5	10
final bunch length	psec	1.00	1.00	1.00	1.00
design wavelength	micron	230609.58	2.20	1.89	0.80
Invariant Emittances	micron	10/0.04	1e-04/1e-04	1e-04/1e-04	1e-04/1e-04
I. P. Spot Size	nm	554/3.5	0.5/0.5	0.5/0.5	0.5/0.5
Enh Lumi/ top1%	**/cm^2/s**	**2.32E+34**	**2.45E+34**	**2.88E+34**	**2.29E+34**
Beam Power	MW	36.2	4.9	2.4	3.0
Linac Wall-Plug Power	MW	~200	98	48	60
Gradient	MeV/m	30	400	400	830
Total Linac Length	km	47	2.5	2.5	1.2

Parameter Couplings

- Structure characteristics (Z_C, Z_H, β_g) ➔maximum efficiency

$$\eta_{\max} = \frac{Z_C \beta_g}{4 Z_H (1-\beta_g) + Z_C \beta_g}$$

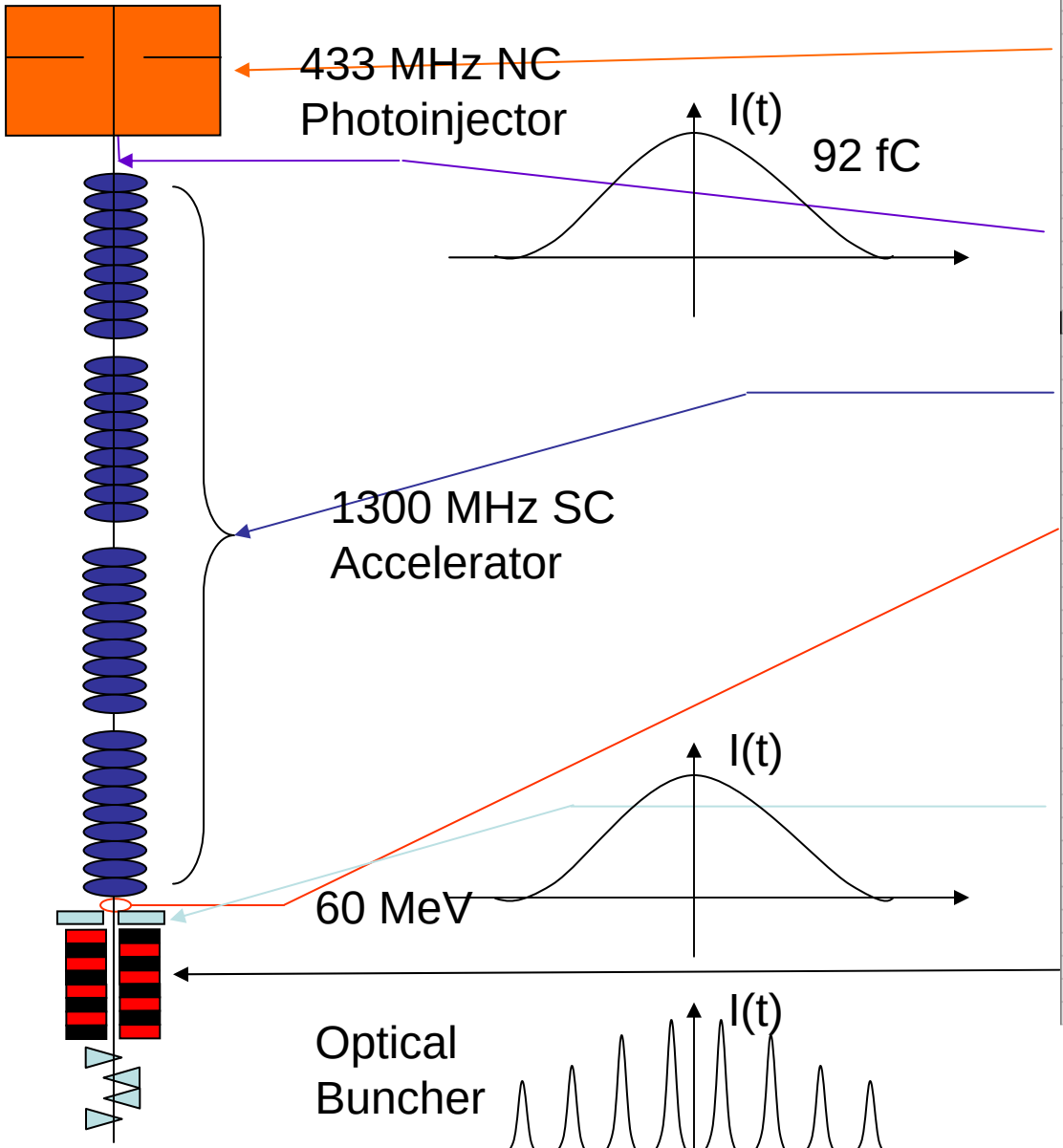
- Maximum Gradient + Efficiency ➔ bunch charge

$$q_{opt} = \frac{G_o \lambda^2}{2} \frac{1}{c} \frac{1}{Z_H + \frac{1}{4}\left(\frac{\beta_g}{1-\beta_g}\right) Z_C}$$

- Bunch Charge + IP spot size ➔ repetition rate

R. Siemann, *PRST-AB*, **7**, 061303, (2004).

Basic Concept for CW DLA electron source

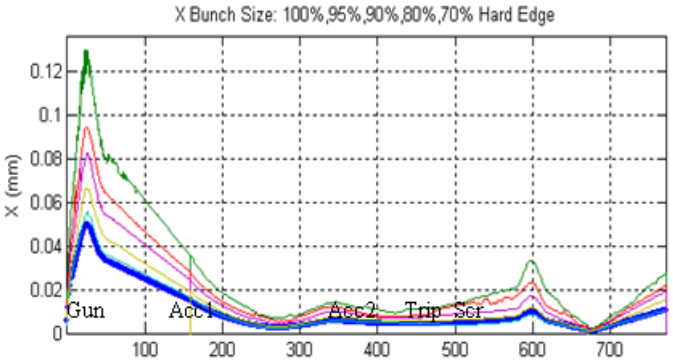


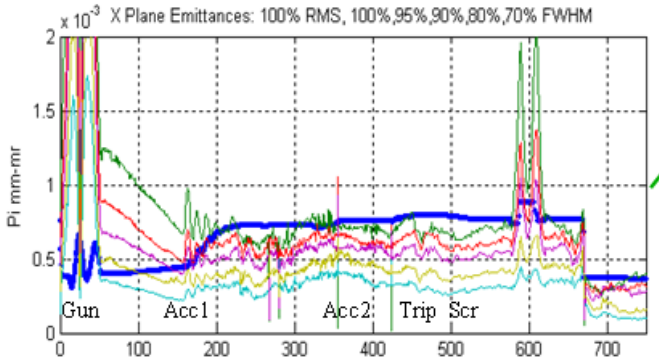
Laser Linear Collider Injector Parameters		
Gun		
Photocathode	CsTe	
Quantum Efficiency	1%	
Structure	1.6 cell room-temperature gun	
Frequency	433 MHz	
Duty Cycle	100%	
Solenoid	20cm x 1 kG, mounted over gun	
Laser Properties		
Laser Pulse Energy (UV)	47 pJ	
Average Laser Power (UV)	20 mW	
Average Laser Power (IR)	0.2 W	10% IR-->UV
Spot Diameter at Cathode	1.1 μm	Flat-top
Laser Pulse Length	20 ps FWHM	Flat-top
Accelerator		
Structures	TESLA 9-cell Niobium Cavity	
Number of Sections	4	
Frequency	1300 MHz	
Accelerating Gradient	18 MeV/m	
Bunch Properties		
Bunch Charge	5.77x10^5 electron per pulse	
Energy at gun exit	7.5 MeV	
Energy at accelerator exit	61.5 MeV	
Bunch Emittances	7.7x10^-4 pi mm-mr	
	7.7x10^-4 pi mm-mr	
	70 pi deg-keV	
Bunch Length	7.7 ps rms	
Energy Spread	92 keV	
Bunch Density (Q/emittance)	0.12 nC/mm-mr	
(LCLS	1.00 nC/mm-mr)	
Optional Collimator		
Aperture	2x2 μm	
Transmitted Fraction:	35%	
Reduced Emittances:	3.6x10^-4 pi mm-mr	
	3.6x10^-4 pi mm-mr	
	70 pi deg-keV	
Optical buncher		
Device	Inverse FEL	
Undulator Period	2.44 cm	

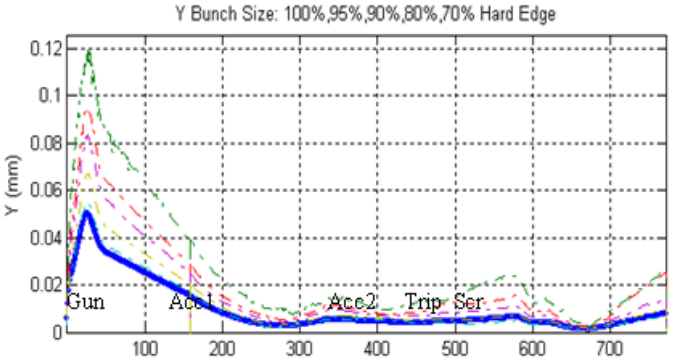
For 2 μm bunch spacing

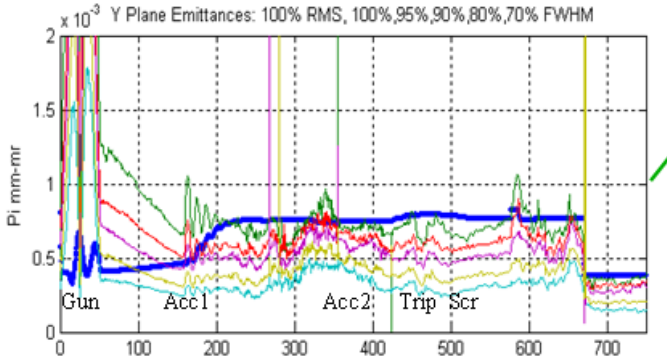
Injector Simulations

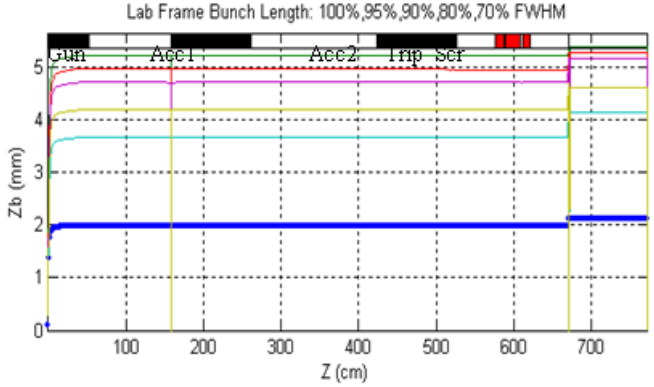
PARMELA, UCLA/FNAL Version

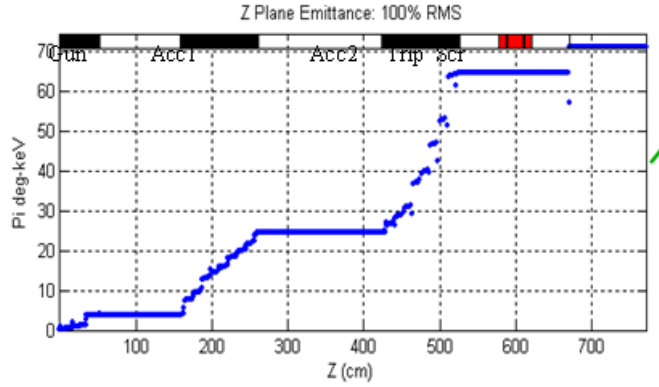












Thermal Emittance Contribution:

$$\varepsilon \approx \frac{R}{2\sqrt{3}}\sqrt{\frac{2E_{kin}}{m_o c^2}}$$

2.3×10^{-10}m-rad for Cs_2Td (E_{kin}0.55 eV) and R=0.5 μm

Envelopes (left) and emittances (right) for the 60 MeV injector.