SLAC PUB 95-6980 August, 1995

NEXT LINEAR COLLIDER TEST ACCELERATOR INJECTOR UPGRADE

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Introduction:

The Next Linear Collider Test Accelerator (NLCTA) being built at SLAC will integrate the new technologies of X-band Accelerator structures and RF systems for the Next Linear Collider, demonstrate multibunch beam-loading energy compensation and suppression of higher-order deflecting modes, and measure the dark current generated by RF field emission in the accelerator [1]. The current injector being constructed for phase 1 of the NLCTA tests is a simple injector consisting of a gun with a 150 ns long pulse and X-band bunching and accelerating system [2]. While the injector will provide average currents comparable to what is needed for NLC it will not provide the bunch structure since every X-band RF bucket will be filled. The injector upgrade will produce a similar bunch train as planned for NLC mainly a train of bunches 1.4 ns apart with 3 nC in each bunch up to 50 to 60 MeV. The bunching system for the upgrade is more elaborate than the current injector and the plan is to produce a bunch train right at the gun. The difference between the NLCTA injector upgrade and the planned injector for NLC is tha t the NLCTA injector will not have polarized beam and the accelerator sections are X-band rather than S-band. If we are able to produce beams comparable to the NLC requirements with the X-band injector then it should be easier to do with the S-band.

* Work supported by Department of Energy contract DE-AC03-76SF00515

Presented at the 17-th International FEL Conference in NY, NY

Gun Design.

The NLCTA upgrade will have a thermionic gun which produces pulse trains of bunches 1.4 ns apart, 380 ps wide, and 4.8 nC in each bunch for 150 ns at 10 Hz repetition rate. The plan is to use a 714 MHz resonant pulser with a bias to generate the desired bunch train format at the gun. The gun used for the upgrade will have a 35 mm gap between the anode and the cathode to achieve the required 12.6 A of current near the space charge limited flow at 150 KeV. The rms emittance at the gun is about 5 mm-mrad, about a factor of 10 lower than after bunching.

Bunching and Beam Transport System

Figure 1 shows the schematic of the NLCTA injector upgrade. The bunching system consists of two 714 MHz subharmonic bunchers, a two cell S-band traveling wave buncher with $\beta = 0.6$ and 0.7, and the first few cells of the first X-band accelerator section. The S-band buncher requires about 5 MW of power to achieve the 6.7 and 9 MV/m gradients in each of the cells. The two X-band accelerating sections following are identical to and in fact are the same ones used for the first phase of the NLCTA injector. The same solenoid magnets but in slightly different configuration will be used for the upgrade as are being used for the current injector. PARMELA simulation show that at the end of the injector at 56 MeV, 63% of the charge from the gun is captured in 15° of

X-band producing bunches with 3 nC in 3.6 ps at 56 MeV. The energy spread is $\pm$2% and the normalized rms emittance is 40 mm-mrad. Figure 2 shows the beam parameters at the end of the injector as simulated with PARMELA. Table 1 shows the simulation results as compared to the requirements for the NLCTA injector upgrade.

Conclusion

The NLCTA injector upgrade will produce a bunch train similar to that required from the NLC injector. Producing this train in an X-band injector is more difficult than in the S-band and thus we have confidence that the S-band injector planned for NLC will also meet the requirements. Construction of the NLCTA injector upgrade will allow us to study some of the single bunch effects in the X-band accelerator sections that we would not be able to study with the simple injector planned for the first phase.

References

[1] NLC Test Accelerator Conceptual Design Report, SLAC Report-411, August 1993

[2] A. D. Yeremian, R. H. Miller, J. W. Wang, proceeding of LINAC 94 conf., Tsukuba Japan, 1994, p89

Table 1
Electron Beam Requirements and Simulation Results for the NLCTA Injector Upgrade

Parameter	Requirement	Simulation
Total transmission gun to end of injector	____	80%
Capture in 15° X-band (%)	____	63%
Charge in 15° X-band (nC)	2.5	3
μbunch width FWHM (°X-band)	10	5
I_A due to charge in 15° X-band (A)	1.8	2.1
$\varepsilon_{n,rms}$ (m-rad)	$<5 \times 10^{-5}$	4×10^{-5}

Figure Captions

Figure 1. Schematic of the NLCTA injector upgrade.

Figure 2. Electron beam parameters at the end of the NLCTA injector upgrade:

(a) the microbunch pulse shape, (b) the transverse beam distribution,

(c) the longitudinal beam distribution, and (d) the energy spread profile.

Contact author for figures.