SLAC MEMORANDUM

DATE: **May 27, 2005**

TO: **Sayed Rokni, Radiation Safety Officer**

FROM: **Eric R. Colby, E-163 Spokesman**

SUBJECT: **Installation of New Electron Source at the NLCTA**

With this memo I am formally seeking the Radiation Physics Department's evaluation and subsequent approval to install a new RF-powered photoemission electron source at the NLCTA. We would like to install and commission this gun in the May-June 2005 timeframe. This request to install and operate the gun represents a significant step beyond the scope of the currently progressing NLCTA Restart Plan.

Synopsis

The NLCTA presently has a thermionic gun electron source that produces a pulse train of 2 Amperes[1] at 160 kV[2] with a pulse duration of up to 120 nsec[1]. We will remove this gun, and replace it with an s-band 1.6 cell rf gun. The remainder of the NLCTA will be unchanged (we will seek separate approval for installing the extraction beamline into the E-163 experimental hall in 4-6 months). The new gun can produce beams of significantly greater energy (up to 7 MeV, vs. 160 keV for the old gun), but at significantly reduced average beam current (up to 10 nA vs. 2.4 μA, averaged over 1 second), resulting in significantly reduced beam powers at all downstream locations (see Table 1).

The beam current, energy, and power produced by each electron source are compared in Table 1. The new gun, even in the worst-case failure scenario, will produce significantly less beam power than the old gun at all locations except right out of the gun itself.

Table 1. Comparison of beam parameters for the old (thermionic) and new (photoemission) NLCTA guns

Maximum Values	**Thermionic Gun**	**RF Gun**	
		Nominal case	**Worst case failure**
Charge per bunch	175 pC	1 nC	Varies significantly
Bunches per beam pulse	1371	1	>1000
Total charge per beam pulse	240 nC	1 nC	2.3 μC
Beam pulse repetition rate	10 Hz	10 Hz	10 Hz
Average beam current	2.4 μA	10 nA	23 μA (ave)
Beam Energy	160 keV	7 MeV	7 MeV (max) 4 MeV (ave)
Average beam power	0.38 W	0.07 W	92 W
Beam transmission to chicane	50%	100%	0.5%[3]
Beam energy at chicane	60 MeV	67 MeV	64 MeV (ave)
Beam power at Chicane	71.3 W	0.67 W	7.4 W
Beam transmission to spectrometer	100%	100%	20%
Beam power assuming E=500 MeV	594 W	5 W	11.5 W
Beam power assuming E=1.17 GeV	1390 W	11.7 W	27 W

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[1] D. Yeremian, *et al*, "NLCTA Injector Experimental Results", in Proc. IEEE Part. Accel. Conf., Vacouver, B.C., p.2852-4, (1997).

[2] D. Yeremian, NLCTA-Note #57, (1996).

[3] E. Colby, "Explosive Electron Emission Loss Calculations for E-163", memo sent to Heinz Vincke, (2004).

As shown in Table 1, even the worst-case failure mode (the so-called explosive electron emission[4] (EEE) mode) results in significantly less beam power than for long-pulse operation of the thermionic gun at all locations except right out of the gun. The EEE-produced beam has very large emittances and energy spread and is rapidly lost in the first few meters of transport. It is worth noting that explosive emission is very damaging to the electron source (it results from the formation of a plasma on the cathode surface when too high a laser intensity is used; this plasma erodes the surface of the cathode), and will be actively avoided during operation.

The new gun will be integrated into the PPS system in a manner similar to the old gun. The high voltage charging supply for the modulator is powered through two redundant contactors which will be connected to the NLCTA PPS system. The high voltage supply will only be powered when the NLCTA enclosure is in No Access and all beam stoppers have been removed. Without rf, the gun cannot produce an electron beam or x-rays. [The laser hazard associated with the gun is handled by a separate Laser Safety System]. No changes to the present NLCTA shielding or BSOIC placement will be necessary to install the new gun.

It is expected that the gun will operate for 50-60 hours per week during the commissioning, then at least 1-2 weeks per month (40-50 hrs/week) thereafter, with usage depending on the evolving ILC and E-163 programs, and on the introduction of other experiments and users.

7 MeV Spectrometer Beamline

A 72° vertical bend dipole and short spur beamline will be installed immediately downstream of the gun, as shown in Figure 1. This spectrometer will direct the full photocurrent (10 nA/0.07W) at a 72 degree angle upwards towards the roof of the NLCTA. The beam will be fully stopped in a Faraday Cup made of 0.75" thick steel, backed by additional steel shielding as RP deems necessary.

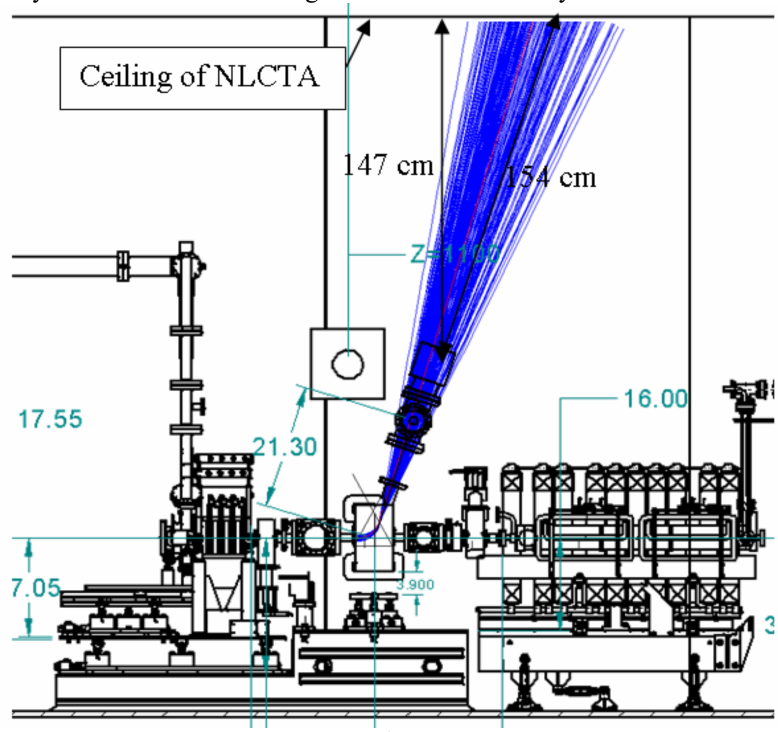

FIGURE 1. Elevation view of photo gun, showing 72° spectrometer and energy analysis beamline. Rays are 200 representative particles showing the EEE beam trajectory in the absence of any materials (e.g. spectrometer iron, dump, flanges, vacuum chamber, etc.)

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[4] E. Colby, "Explosive Electron Emission Loss Calculations for E-163", memo sent to Heinz Vincke, (2004).

In the worst-case scenario, the bend dipole is on when the EEE beam is produced (23 µA/92W). Since the EEE beam has a large energy spread, it is lost in a broad fan covering 64°-78° (99% of particles), shown in Figure 2 (left). Working downstream from the bend center of the spectrometer, the outgoing fan is shielded by the following items:

1. Spectrometer yoke: 1.5" thick, covering 77° to 127° above the beam axis
2. Spectrometer chamber exit flanges, 1.5" thick, covering 60° to 69.5° and 74.5° to 84°
3. Faraday cup beam dump, 0.75" thick, covering 69.5° to 74.5°
4. Spectrometer chamber wall, 0.25" thick, covering 51° to 10°
5. Beam tube presents significant material in the remaining angles

Figure 2 (right) shows that 7 MeV electrons range out in iron within 5 mm, meaning that the spectrometer vacuum chamber wall (6.35 mm) already presents sufficient material to stop the electrons.

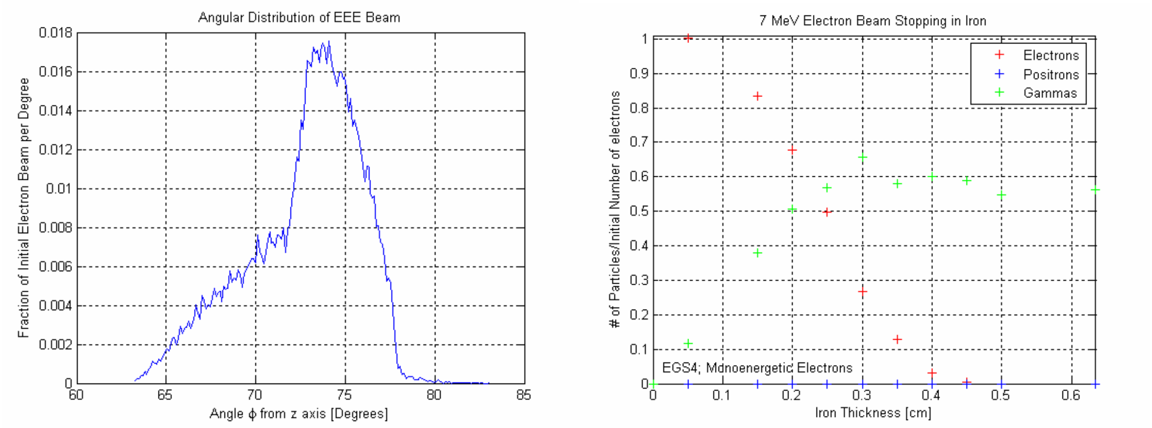

FIGURE 2: Angular distribution (left) of EEE beam at nominal spectrometer bend field, and range out of monoenergetic 7 MeV electrons (right) in elemental iron, from EGS4.

Request

I ask that Radiation Physics review our request to install the RF Gun at the NLCTA and work with us to establish and follow the proper approval procedure.