NLCTA-Note #57

April 10, 1996

Subject: NLCTA Gun Tests.
Gun Lot A - Low Current.

Authors: D. Yeremian

Background:

The gun for NLCTA phase 1 labeled **Gun Lot A - low current** was HV processed, a new cathode, EIMAC Y796, was installed and activated with very successful results.

The gun for NLCTA phase 1 operation was received from Boeing in the Summer of 1994. The electrode spacing was modified to operate in the space charge limited mode for 150 kV and 6.6 A, then the gun and ceramic were cleaned, baked, sealed, and pumped for approximately 1 year. The gun was installed on the NLCTA beam line girder 3A without a cathode on February 8, 1996. On February 13 it was vented to dry nitrogen to add some ion gauges and was pumped down again the same day. Girder 3A includes the beam line from the gun up to but not including the first prebuncher. It consists of the gun, the bucking coil, the gun lens, and the first two large solenoids. The beam line components include a gap monitor for current measurement at the gun and a faraday cup installed temporarily at the end. There is a profile monitor and a BPM upstream of the Faraday Cup.

The detailed data discussed in this report is in the NLCTA log book 1, March 6 - , 1996

March 6, 1996 Gun HV processing started.

All the measurements were made using the High Voltage power supply meter for readings. Later power conversion calibrated the supply meter against the Ross high voltage divider. In this report where it is unspecified, the values quoted are the raw values from the HV power supply meter.

Initially we just wanted to put HV across the isolation transformer to make sure it can stand off 160 kV (It is rated at 175 kV)

There was some trouble with the regulation of the power supply beyond 110 kV which was traced to the controller box regulation loop. Controller box regulation was disconnected and the power supply does very well on it's own.

The isolation transformer holds off 160 kV successfully but it seems to draw 50 μA at 160 kV, and 25 μA at 80 kV. When we turn off the power supply it takes about 15 seconds for the voltage to drop as indicated by the power supply meter. It should drop instantaneously if the gun system was drawing that much current. The current on the power supply drops to 0 instantly when turning off the supply. It appears the there is some leakage path in the power supply itself.

We should probably subtract 25 μA per 80 kV from the leakage current as measured by the power supply meter to determine the leakage current in the gun system. Once again unless other wise specified in the data and in this report the leakage current values are quoted as read on the power supply meter.

At 2:35 pm we connected the gun to the HV deck and began processing without a cathode. The processing went very smoothly and by 4:30 pm we were able to sustain 155 kV with a 100 μA leakage current and $\sim 5 \times 10^{-8}$ Torr vacuum.

We turned the gun down to 150 kV to let it run overnight. At about 9:00 pm the power supply went into current limited mode at 200 μA leakage current limit set by us and the voltage dropped to 140 kV. Bill Baumgartner turned the gun off at 9:30 till the next morning.

March 7, 1996

At 9:15 am the vacuum in the gun was less than 10^{-8} Torr. We turned the HV on again and raised it to 157 kV very easily with a leakage current of 100 μA and 2×10^{-8} Torr vacuum. In one hour the problem repeated itself with the power supply limiting at 200 μA. The vacuum actually began to improve as the voltage dropped to 130 kV.

Shut down the HV power supply and make entry. We cannot smell ozone in the air. This is a good sign.

Disconnected the gun from the deck. Dusted the deck and power supply stack with barely damp kemwipe. Swept and wiped the surrounding floor. Set up to run the power supply into the deck system only.

AT 11:45 am we put 155 kV across the deck with 50 μA leakage current still observable on the power supply meter. At about 1:00 pm the same problem surfaced again. The power supply current limited at 200 μA and the voltage is down to 100 kV.

Make another entry for inspection. The isolation transformer under the deck felt cool and looked OK with no externally visible damage. But the Phenolic rod which connects the motor at ground level to the variac on the HV deck for the gun heater power supply voltage adjustment was very hot. Seems that Phenolic is not a very good insulator. Removed the phenolic rod to be replaced with Lucite in the future

Still curious about the ever-present 50 μA leakage current at about 150 kV we disconnected the HV deck and transformer from the power supply and ran the power supply by itself. We still read the 50 μA leakage current on the meter and when you turn of the power supply it still takes about 15 seconds for the voltage to run down while the current disappears instantly.

AT 2:00 pm connected the gun and the HV deck back to the power supply with the phenolic rod missing. Ran the voltage up to 160 kV very easily. At about 3:00 pm the Vacuum was down to $4x10^{-8}$ Torr at 160 kV and 105 μA leakage current. The gun ran for almost the entire weekend at 160 kV.

March 10,1996, Sunday

On March 10 at about 6:00 pm the gun was at 160 kV, with 50 μA leakage current and $5x10^{-9}$ Torr vacuum.

March 11 was devoted to installing a Lucite rode where the phenolic had been, checking magnet polarities, and calibrating the Gun HV power supply with a Ross precision divider.

Jerry Minister took 4 data points at various power supply settings. Here is the data taken by Jerry.

Vref desired (V)	Vref measured (back of supply) (V)	PS meter reading (kV)	SCP panel reading (kV)	Ross div. reading (V) 20kV:1V
7.5	7.44	157.0	164.753	7.499
5.00	4.96	107.0	110.474	4.996
2.5	2.77	57.0	56.030	2.499
1.25	1.237	27.0	28.225	1.250

There is a 7 kV offset on the power supply meter, which is present even when a request of 0 V is made.

There seems to be some cross talk between the controller feedback system and the power supply that introduces instabilities at lower voltages and that is why the SCP panel reading does not have a linear correlation with Vref or the Ross divider.

Power conversion will look into the calibration of the HV power supply, the stabilization of the feedback system, and the excess leakage current in the power supply system.

Preliminary judgment indicates that we should subtract 7 kV from the HV reading and 50 μA from the leakage current so after the weekend processing the gun parameters were as follows: **153 kV, < 1 μA, 5×10^{-9} Torr.**

March 12, 1996 Cathode Installation

The cathode was installed by Ron Koontz and John Eichner. Vacuum department was present to vent and pump down the system. The gun was vented to dry Nitrogen for less than 2.5 hrs for the purpose of installing the cathode.

The cathode installed is an EIMAC Y796 Ser # DWG049J (2 cm^2)

The cathode checks before installation show that the impedance between the heater and the cathode is 0.2 Ω at room temperature and the Grid to cathode is open. It seams to be a good cathode.

After the installation the gun quickly pumped down to $4x10^{-6}$ Torr at which time the 20 l/sec ion pump near the Faraday cup was struck and quickly after that the 8 l/sec pump at the gun was struck.

March 15, 1996 Cathode Activation.

The Vacuum in the gun is already down to $5x10^{-9}$ Torr.

The goal here is to heat the cathode gradually, to evaporate the surface layer contamination, and check the cathode emission characteristics.

We connected the heater power supply across the cathode heater by connecting the + terminal to the heater side and the - terminal on the cathode side. The grid was grounded and the curve tracer was connected accross the cathode and the grid. We set up a small fan in the back of the gun to cool the seal and prevent venting due to the conduction of the heat from the cathode heater to the seals. Later we realized that it is better to connect the + terminal of the heater to the cathode side to slow down the breakdown of the heater resistance due to electrolysis and thus we switched the terminals on the cathode heater. Figure 1 shows the final electrical schematic.

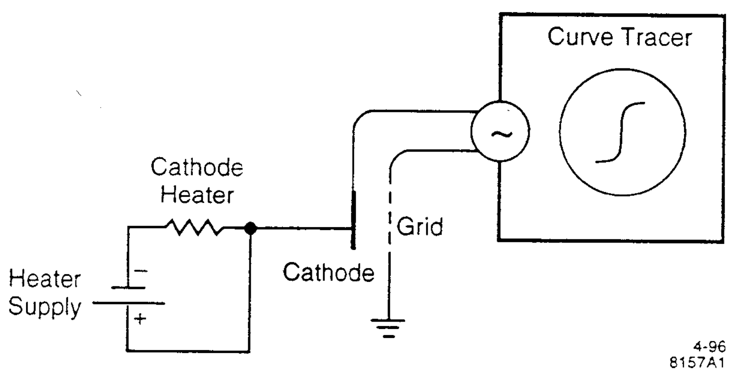
Originally we started the activation with the - terminal of the heater power supply on the cathode side of the heater and with 15 V from the curve tracer between the cathode and the grid. We increased the heater power supply voltage gradually while pumping on the gun and not allowing the vacuum to rise above $7x10^{-6}$ Torr.

At heater power of 5v,6A, emission started (20μA, @ 15V).
In 10 min. w/ heater at 8V,7.6A the emission was 400 mA @ 7V.

Suddenly the heater began to short and current went up while the voltage came down on the heater supply. We reduced the power on the heater supply and raised it again and in a few minutes the problem reoccurred.

Ron switched the polarity on the heater power supply leads and the problem seemed to disappear. With a heater power of 6A, 5.5 V (33W) the cathode emission was 440 mA @7 V. And this condition was stable for at least 20 minutes when we terminated the activation.

Cathode heater power of 33 W corresponds to 950° C [1]. In this same reference we can see that for the same type of cathode used at the SLC injector the heater resistance was nearly twice the resistance of the cathode installed in the NLCTA gun (1.7 Ω instead of the 0.9 Ω). Ron has also contacted the manufacturer regarding the problem of the heater shorting when the cathode side is connected to the negative terminal. According to the manufacturer the cathode side is supposed to be connected to the positive terminal to minimize electrolysis effects which cause the drop in heater resistance but this problem is typically not supposed to surface until later in the cathode life even if the negative terminal is connected to the cathode. It is possible that this cathode will have a shorter lifetime than a typical cathode, and we have to be careful to connect the positive terminal to the cathode side of the heater. The typical thermionic cathodes last a little more than one year of continuous operation.



Summary:

The Gun for NLCTA is ready for operation and is in very good shape. It is possible that the cathode life time may be less than one year. This is not particularly alarming since we have 2 more cathodes available for NLCTA, and the accelerator department has about 6 thermionic cathodes which probably will not be useful to them since the polarized source gun is performing so well.

The Gun Characteristics are as follows:

Processed to 153 kV with < 1 μA leakage current and 5x10-9 Torr pressure (after applying the preliminary power supply calibrations and anomalies).

The cathode emission is very good with 440 mA @7 V at 950° C

The cathode heater resistance is about 0.9 Ω at 950° C (half the expected value)

The power conversion department still has to resolve the power supply regulation and calibration problems in the computer. They also need to make sure that all the solenoids can be activated from the computer. As soon as they do these tasks we will try to check the polarities of the magnets again.

The controls department has already replaced the phenolic rod with lucite for the heater power supply control on the HV deck. They are ready to install and check out the pulser but I believe they are waiting for the Accelerator Readiness Review (ARR) committee approval to do this task.

The controls departments has also connected the gun gap monitor and the Faraday cup signals to the computer. Some odds and ends remain on making the profile monitor camera operational which should be ready very shortly.

Reference:

1. R. F. Koontz, "CID Thermionic Gun System", SLAC-PUB-2824, October, 1981

Acknowledgments:

Many people were instrumental in these experiments - Bill Baumgartner, Mike Browne, John Eichner, Robert Fuller, Ron Koontz, Val Nesterov, Jerry Minister, Mike Robertson, Bill Roster and Juwen Wang.