national accelerator laboratory

TM-385
2420.000

NOTE ON THE PROPERTIES OF THE LARGE ION CHAMBER AND SECONDARY EMISSION MONITOR LOCATED IN NEUHALL

L. N. Hand

Cornell University

August 21, 1972

Information is given about the large ion chamber (LIC) and SEM now located in Neuhall.

$$\frac{Q_{LIC}}{Q_{BEAM}} = 13.3 \pm .7$$ (up to 10^7 p/burst on fast spill)

$$\frac{Q_{SEM}}{Q_{BEAM}} = 0.274 \pm .010$$ (any beam intensity)

HV (both) = -800 volts

The purpose of this note is to describe the characteristics of the large ion chamber (LIC) and secondary emission monitor (SEM) which have been placed in the proton beam just upstream of DX1 in Neuhall. These monitors have been loaned to NAL by the Laboratory of Nuclear Studies at Cornell.

Physical Description

LIC: Two HV planes of thin foil surround one foil signal plane. Only the output labeled "thin" works and has been calibrated. The cable ground must be isolated from the ion chamber ground to prevent ground loops. A special connector has been provided for this. HV connections are MHV, signal and ground are BNC.

SEM: 6 HV foils and 5 thin copper signal foils provide 10 gaps for collecting the electrons. Great care must be taken to avoid breaking the Kovar seals for the signal and HV leads. Dirt or fingerprints on the seal for the signal lead will cause leakage current. The outside windows are stainless steel and have been permanently welded on. They would be hard to break but it could be done with a sharp point and would ruin the SEM. Care should be exercized when working near the exposed HV. A 1 meg resistor should be installed in series at the supply, but this has not been done. The signal cable should be a male type C connector at the SEM end.

Gas Filling

LIC: For NAL use the ion chamber was filled to 1.8 psi (using crude meter on chamber) of commercial grade hydrogen gas. The temperature at the time of filling was estimated to be 80°F.

SEM: The SEM has been under vacuum continuously since its initial operation at Cornell in 1967. It is unlikely that the vacuum rose above a few microns in transporting it. A Vacion pump is permanently installed on the SEM and should be left on at all times. If the pump is off for more than 10 minutes, it may be necessary to restart it with a diffusion pump. A typical Vacion current is 200 μA for a vacuum $<10^{-6}$ mm Hg.

Signal Cables

Two RG 8/u single shielded cables were pulled for the signals. These were previously tested for leakage and found to be mostly satisfactory, although with increased care better results could be obtained. They are about 150 feet long and have rf connectors at the integrator ends. If they are moved or bent, charge leaks out of the dielectric and it is necessary to wait ~ one hour (worst case) before things settle down. These cables should not be run through a patch panel or mistreated or they will become useless.

Calibration Procedure

The calibration of both monitors was done using 100 Mev electrons at the linac located at the U. S. Naval Postgraduate

School in Monterey, California with the help of Professor E. Dally and co-workers. 100 Mev electrons were used because the monitor calibration should depend only on the particle velocity which then is the same as for 200 GeV protons. The primary standard for beam intensity was a Faraday cup, with an absolute precision of <±2%. Carey Model 410 vibrating reed electrometers were used along with 1% precision capacitors. The machine gave a nominal 2 μsec pulse at a rep. rate of 60 cps.

SEM Calibration

$$\frac{Q_{SEM}}{Q_{BEAM}} = 0.274 \pm .010 \qquad \text{(HV = -400 volts)}$$

Calibration intensity: 2×10^7 electrons/pulse to 1.4 x 10" electrons/pulse. 17 ratios were determined. No systematic variation was observed. The lowest ratio was 0.266, the highest 0.292. The calibration took about 2 hours. The beam spot was 1.2 cm in diameter and was not moved during the calibration.

Ion Chamber Calibration (Electrons)

Two gas mixtures were used:

(a) commercial grade He

(b) ultra-pure H_2

In both cases the chamber was evacuated to less than 50 microns vacuum and then filled to +2 psi on the meter. We estimate this meter is accurate to ±5% of the absolute pressure (~16.7 psi at 70° F.) A range of beam currents was used from 10^6 to over 10^{10} electrons/pulse.

The results are as shown in the table below:

Gas	HV	Q_{IC}/Q_{BEAM}	Saturation Intensity
He	- 500 v	19.1 ± .1 (relative error)	$<5\times10^8$
	-1000 v	19.7 ± .1	$<10^9$
H_2	- 800 v	13.7 ± .1	$<10^9$

Calibration for NAL H_2 Filling

Assuming dE/dx in the NAL commercial grade H_2 is the same as for one pure USN H_2 (the saturation may be somewhat lower due to impurities in the gas), we get (correcting for temperature and pressure differences):

$$\frac{Q_{LIC}}{Q_{BEAM}} = \frac{(293°K)}{(298°K)} \times \frac{16.5}{16.7 \text{ psi}} \times 13.7$$

$$= 0.97 \times 13.7$$

Large ion chamber calibration $\frac{Q_{LIC}}{Q_{BEAM}} = 13.3 \pm .7$

The error is largely from uncertainties in the filling of the chamber.

Saturation Characteristics

Figure 1 shows the saturation behavior of the ion chamber filled with He gas at -1000 and -500 volts. The hydrogen data is not shown, but resembles the -500 v curve for He. If we take $I_{SAT} = 5 \times 10^8$ electrons/pulse/1.2 cm diameter beam, we can easily calculate the saturation at NAL with a 2 mm diameter spot.

Fast $I_{SAT} = \frac{(.2)}{(1.2)} \times 5\times10^8$ protons/burst

Spill $I_{SAT}^{FAST\ SPILL} = 1.4 \times 10^7$ protons/burst

<u>This means that the LIC is not useful on fast spill at normal intensities</u>.

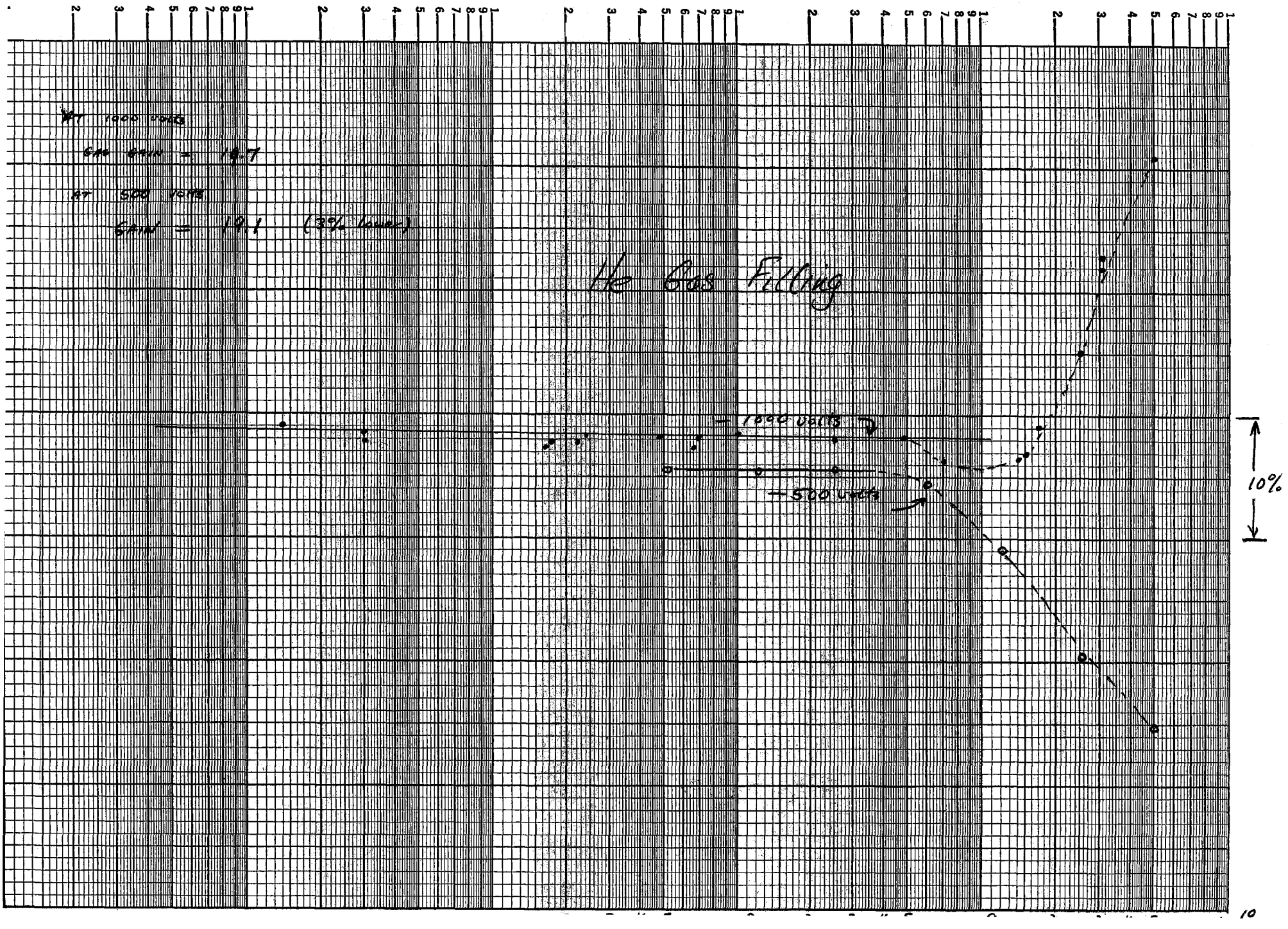
To estimate the behavior with slow spill is difficult since a detailed theory of the recombination and collection of positive ions is necessary. We will make two calculations, one optimistic and one pessimistic. The optimistic calculation assumes that 20 μsec is sufficient to clear the chamber and the pessimistic that 1 msec is needed. Under the optimistic calculation, a nominal 100 msec spill (5000 main ring traverses, each with 12 booster pulses) will give:

$$I_{SAT}^{SLOW\ SPILL} < 0.8 \times 10^{12}\ \text{p/burst} \quad \text{(optimistic)}$$

$$I_{SAT}^{SLOW\ SPILL} < 1.4 \times 10^{9}\ \text{p/burst} \quad \text{(pessimistic)}$$

There is such a large range here that this number should be empirically determined using the SEM as a primary monitor. Note it will depend on the operating conditions of the main ring and extraction duty factor.

ION CHAMBER


AT 1000 VOLTS
GAIN = 19.7
AT 500 VOLTS
GAIN = 19.1 (3% LOSS)
He Gas Filling
1000 VOLTS
500 VOLTS
10%