OBSERVATIONS OF SECONDARY EMISSION CHAMBER DEGRADATION FROM VERY HIGH INTENSITY PROTON BEAMS AT THE AGS *

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1 INTRODUCTION

Degradation of Secondary Emission Chamber (SEC) efficiencies has been seen in the past.[1] As a result, instruments in use today are built to minimize any such effects. With beam intensities as high as 6×10^{13} *protons per pulse* incident on these devices we are again observing significant degradation in SEC efficiencies. In this report we will present observations of these effects and methods we have developed to cope with them.

2 DISCUSSION

The AGS uses SEC's to monitor beam intensity of the slow extracted beam and at experimenter targets. Beam currents for these beams vary from less than $\frac{1}{2}$ μamp to over 2 μamp. Typically beam is 1.2 to 1.6 seconds in length with intensities of 15×10^{12} (on target SEC's) to over 60×10^{12} (just after extraction point), protons per 3.2 to 3.6 sec pulse rate.

Each SEC contains 5 successive parallel 1 mil silver plated aluminum plates. Three of the plates (#1,#3, & #5) are connected to a high voltage power supply and typically operate at 750 volts. A small titanium sputter ion pump (8L/sec) located on top of the SEC box keeps each SEC at a vacuum of 10^{-9} to 10^{-8} torr. Two of the plates (#2 & #4) are summed and the output goes into an I/F module which is adjusted to count 6500 counts per sec for 524 nA.

The principles behind how SEC's work have been described completely as long ago as the mid-1960's. [1][2] In general the foil surfaces can be considered as electron emitters. The emission is independent of foil thickness, being a surface phenomena. For the most part low energy electrons are collected, although for high energy proton beams, other effects, such as Rutherford scattering contribute to the signal. The SEC efficiency is defined to be

$$\rho_c = \frac{number\ of\ emitted\ electrons}{number\ of\ incident\ charged\ particles} \times 100\%$$

This is a function of foil material, surface conditions, chamber pressure, properties of incident particles, and incident angle of the incident particles. For thin low mass foils, the efficiency is a linear function of the energy lost by the incident proton beam.[2]

$$\rho = k \cdot \frac{dE}{dx}$$

For 24 GeV/c protons on aluminum, $\frac{dE}{dx}$ is about 1.8 MeV g^{-1} cm^2. [6] Typical efficiencies are of the order of 2.2 % per emitting surface. [2] The degree of degradation we have observed is or the order of 20 to 30 %, which implies the efficiency, or number of emitted electrons, has decreased by at least the same amount.

In order to study this phenomena, we installed an X-Y movable table at one of the target stations in the AGS Slow Extracted Beam Lines. The SEC was located about three feet in front of the target. It was driven remotely and the position control was calibrated. We monitored the change in SEC counts versus total intensity on target, from a 90 degree target monitor telescope. We then would move the table and compare the efficiency from a fresh area of the SEC surfaces to the normal operating position. Since the beam was targeted for an experiments use, the position of the beam on the SEC was fairly stable over the period of the run, although some changes were made in order to satisfy the experimenter needs.

The total beam that was put on target was more than 2×10^{19} protons at an energy of about 25.2 GeV/c.

We also did a very simple modeling exercise, to provide a picture of what the surface efficiency may look like. In this exercise a two dimensional gaussian beam was scanned accross a two dimensional gaussian "efficiency hole" each of the same widths. This simulated the moving of the table with the beam position held constant.

3 RESULTS

Figure 1 shows the efficiency versus horizontal position of the table, for the clean, new SEC and after it had been irradiated by 4×10^{19} integrated proton flux on the SEC.

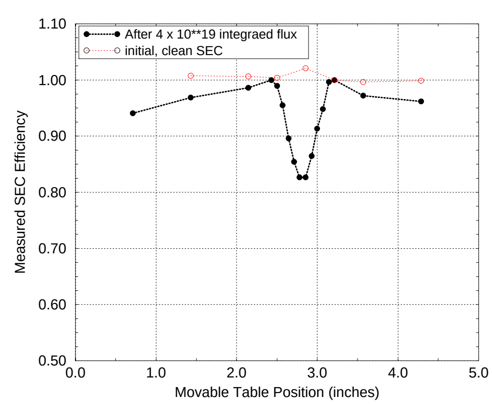

Figure 1: Horizontal Scan of SEC Efficiency.

Figure 2 shows the efficiency versus vertical position of the table, for the clean, new SEC and after it had been ir-

* Work performed under the auspices of the U.S. Dept. of Energy

radiated by 4×10^{19} integrated proton flux on the SEC. In Figure 3 the efficiency is shown degrading over time. This data is from a different SEC located just after the extraction channel in the AGS. This SEC shows efficiency dropping by about 0.2 to 0.3 % for every 10^{18} protons/cm^2, in which the total flux to this device was a little over 10^{20} protons/cm^2. The degradation of the SEC on the table after an integrated flux of 4×10^{19} corresponds to about 18 %. This means there was about a 0.4 % drop in efficiency for every 10^{18} protons/cm^2. We have done simple simulations of these scans of the SEC. From these, which simply moved a 2-dimensional Gaussian beam over a 2-dimensional Gaussian hole, we find the degradation at the core of the beam is significantly greater. A measured response of 75 % corresponds to the central part of the degradation being at a response of more like 40 %.

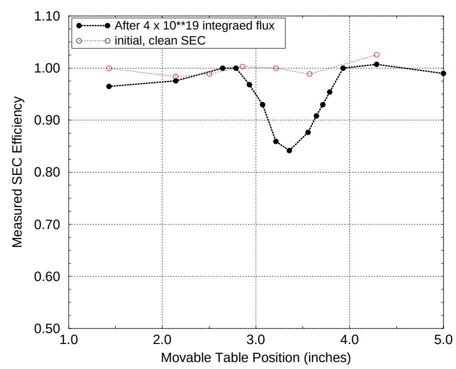

Figure 2: Vertical Scan of SEC Efficiency.

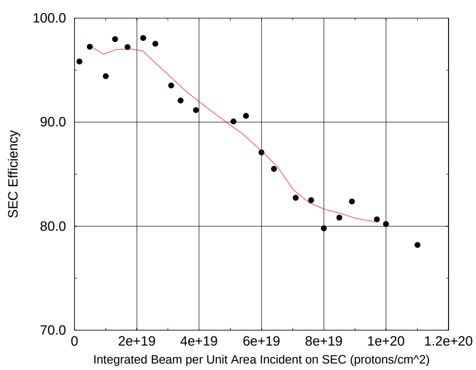

Figure 3: SEC Efficiency vs integrated incident beam flux.

4 CONCLUSIONS

With the AGS now reaching intensities of 6×10^{13} protons per AGS period, we are again seeing the effects of deteriorated SEC efficiency. Yamin and Repeta reported in 1979 that the newly designed SEC could expect to see a 1% change in efficiency for 10^{18} incident protons/cm^2. [7] What we have observed are rates of deterioration of 0.2 to 0.5 % per 10^{18} protons/cm^2. [3] [4] [5]

We do not think it is pratical to try to make a better SEC. The methods used to keep the surfaces clean are very good. We find, since only a small portion of the SEC surface is being hit with beam, that it is better to understand the degradation and have a movable SEC, which can be placed to a fresh location periodically. This extends the life of the SEC, provides us with reliable intensity monitoring, and allows us to preserve the methods we use to build these devices (which makes them more cost effective).

5 REFERENCES

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