ENERGY ANALYZER

INTRODUCTION:

Measuring the energy distribution of the beam is a form of longitudinal phase-space mapping. It is useful for being able to assess dispersive or chromatic effects on the beam.

OBJECTIVE:

In this experiment we will intercept the beam with a high-resolution, retarding-potential energy analyzer (EA). We will first attempt manual data collection through a scope to understand how it works. Later we will run and automated energy scan and process the results to obtain average beam energy and energy spread as a function of time as well as the energy distribution in the middle of the pulse.

BACKGROUND:

- Lecture on Energy Analyzer by Rami Kishek.
- Y. Cui, Y. Zou, A. Valfells, M. Walter, I. Haber, R.A. Kishek, S. Bernal, M. Reiser, and P.G. O'Shea, *"Design and Operation of a Retarding Field Energy Analyzer with Variable Focusing for Space-Charge Dominated Electron Beams,"* Review of Scientific Instruments **75(8)**, 2736 (2004).

EQUIPMENT:

(see Experimental Station Data Sheet)

PROCEDURE:

1. Familiarize with the equipment: LSE station, solenoid controls, energy analyzer controls and circuit, etc.
2. Record Bias Voltage
3. [Assistance Required] Open Gate Valve.
4. Turn on gun High Voltage to 5 kV, using the top power supply in the blue rack.
5. Turn on solenoid power supplies and set the currents of S1, S2 to the default values. The S1 power supply is the white lambda and the S2 supply is the middle Kepco supply.
6. With the mesh potential off, connect the EA collector signal to the scope.
7. Turn the scope on and see if you can detect the signal. Record.
8. Set the battery to obtain a potential difference of 110 V between the mesh and the cylinder.

9. The bottom supply in the blue rack is the energy analyzer supply. With **help**, set the switch in the rear of the supply to local, and turn the supply on and set it to 5060 V. How does the collector signal change?
10. Adjust the cylinder/mesh potential difference using the battery. Does that affect the signal much?
11. Adjust the current of the solenoids to increase the current density going through the EA pinhole (do this with the mesh HV off). Turn the mesh HV back on to 5060 eV. Do you see any change and why? Go back to original settings.

Manual Energy Analyzer Scan:

12. Scan the mesh potential from 5040 to 5080 V in steps of 2 V. Record the EA signals (both as a function of time and at a particular time value). What do you estimate the mean beam energy and the energy spread to be?
13. Plot the energy profiles as a function of time on the same graph to show the effect of the mesh potential on the beam distribution.

Automated Energy Analyzer Scan:

14. Turn down the supply to zero and turn it off. Reset the switch to remote in the rear of the supply.
15. Use the software to scan the mesh potential from 5030 to 5090 V in steps of 0.5 V. CAUTION: The “start” and “end” settings refer to the increments above the 5000 eV beam energy.
16. [Assistance Required] Turn off HV supplies. Close Gate Valve.

ANALYSIS / QUESTIONS:

1. Process the data to obtain the average beam energy and energy spread as a function of time.
2. Focus on one point in the middle of the pulse (say 60 ns downstream), and plot the collector signal as well as the energy distribution (derivative of collector signal).
3. Why is the beam energy different at the head and tail of the pulse?
4. What do you expect to happen if the energy analyzer is further away from the gun?
5. What do you expect to see if the beam current is higher?
6. Comment on the possible sources of energy spread.