James Franck and Gustav Hertz first performed this experiment in 1913, and were awarded the 1925 Nobel Prize "for their discovery of the laws governing the impact of an electron upon an atom." Electrons were emitted from a high temperature cathode and accelerated (due to a higher potential grid) through a mercury vapor and onto a measuring electrode. Franck and Hertz found distinct dips in the measured current whenever the relative potential between the cathode and grid reached an integer multiple of 4.9 V, providing the first electrical measurement of energy quantization in atoms. An energy of 4.9 eV corresponds to a known ultraviolet emission line in the mercury spectrum (λ=254 nm) and a later iteration of the experiment confirmed the emission of this ultraviolet light for accelerating potential exceeding 4.9 V. Therefore, electrons accelerated at voltages exceeding 4.9 V have sufficient energy to undergo an inelastic collision with a mercury atom. The loss of kinetic energy leads to a lower speed and therefore a lower current. Electrons accelerated at voltages exceeding 9.8 V can undergo two inelastic collisions, etc.

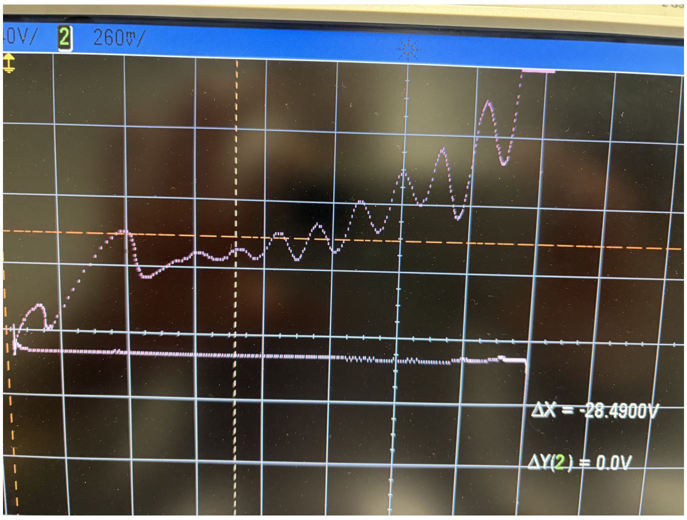
First, connect the Franck-Hertz tube, the operating unit, and the oscilloscope as shown on page 2 of the equipment manual and turn everything on.

Then turn the thermostat and allow the heater to reach a temperature of 180-190°C. Don't turn the thermostat knob that high right away; instead start with the thermostat at 150° and then slowly turn it up in small steps so that it equilibrates gently without overshooting. Once the temperature is steady, take the data. You should clearly see the dips in the Franck-Hertz signal. Play with the reverse bias, accelerating voltage, heater, and amplitude knobs until you can capture a scan with as many clear equally-spaced dips as possible (at least 6). Take a photo of the oscilloscope. A good scan is shown below.

Roughly, speaking

- The reverse bias knob shifts your signal left or right (to higher or lower voltages).
- The heater knob controls how many electrons are emitted from the cathode. It is suggested to set it between 4 and 7 V.
- The amplitude knob determines the amplification of the signal. You want to be able to make out the smaller dips, but also not saturate the signal at higher accelerating voltage.
- The accelerating voltage knob determines the maximum difference through which the electrons are accelerated. A higher value may give more dips, but

may also lead to a saturated signal.



Use the oscilloscope cursor to locate the position (in accelerating voltage) of the dips.

Turn off the heater and let the chamber cool below 100°C. Take a photo of this 'cold curve'. It should saturate at pretty low accelerating voltages: without any mercury to absorb them the electron current is very large.

Once you have the positions of the dips, determine the energy of the transition and uncertainty. Do this by making a plot with the dip positions as the y-axis and successive integers (i.e. 1 through 6) as the x-axis values. The slope of this line is the spacing between dips. Determine this value with an uncertainty. Report your measured value for the transition both as an energy and as a wavelength (each with the uncertainty). How does this compare to the accepted value of 254 nm?

Turn it:

- Picture of the signal both hot and cold.
- Graph of dip position vs. number, with well labeled axes, fit to a line and showing a least-squares fit.
- The slope of that line, with an uncertainty and given with units.
- The wavelength corresponding to that energy, with an uncertainty and units.