

Electron Scattering with Dr. Khakoo

Introduction

This is a document that outlines what to do before, during and after taking data for Dr. Khakoo's Low Energy Electron Scattering experiment. It aims to increase efficiency and productivity. It also aims to explain certain ideas or things in the lab. And the most important advice is to listen and pay attention to everything and anything Dr. Khakoo does or says. And ask any questions you have to him. The lab is to learn.

Formalities

First, some definitions. The experiment is being conducted in a big metal machine that is called a Spectrometer. Check out Figure 1. The data is taken by a nearby computer using a program called LabVIEW. LabVIEW is a sort of program that visualizes code with circuit diagrams. The file type extention is VI. It can control functions, calculate and visually represent how code looks. It also looks like simulating lab with various buttons and switches. The program is already made and set up before the experiment starts and runs almost autonomously. In the issues section, it will outline what to do when a certain error occurs either before, during or after the experiment. Excel is another program that is used to take the data that you received and it will analyze for you. While you are working in the lab, usually you will work with a partner or Dr. Khakoo. Its usually the former but it is possible to run the experiment by yourself, with some exceptions.



Figure 1: The double hemisphere Spectrometer.

Setting Up

This is the section where everything is done before starting a new experiment. What we like to do is purify our molecule that we are going to do research on. To do this, we use Liquid Nitrogen to cool it and then heat it with a heat blower. First, get a sample of your molecule into a glass vial that usually is kept in a vacuum where the 1st ventilator, by the sink. Check out figure 2.



Figure 2: Vial Vacuum Chamber, where the round glass vials are being kept.

Use a pipette to take a small sample into the round glass vials to then attach to the experiment. Usually, this is done by Dr. Khakoo but pay attention to what he does. The next part you will do usually with a partner or Dr. Khakoo, whichever is available. Pour some liquid nitrogen in the appropriate container, as seen in Figure 3, and put it under the vial to cool it down.



Figure 3: The container to cool down the vial.

Then use a heat gun to defrost the vial. This process repeats itself about four times to purify our molecule. When everything is said and done, its time to start tuning everything to start an experiment. Dr. Khakoo is the one who will tune it to a specific energy that will be focused on and to ensure the experiment produces nice data. This includes making sure that there is zero energy loss, because it is Elastic.

Tuning Up

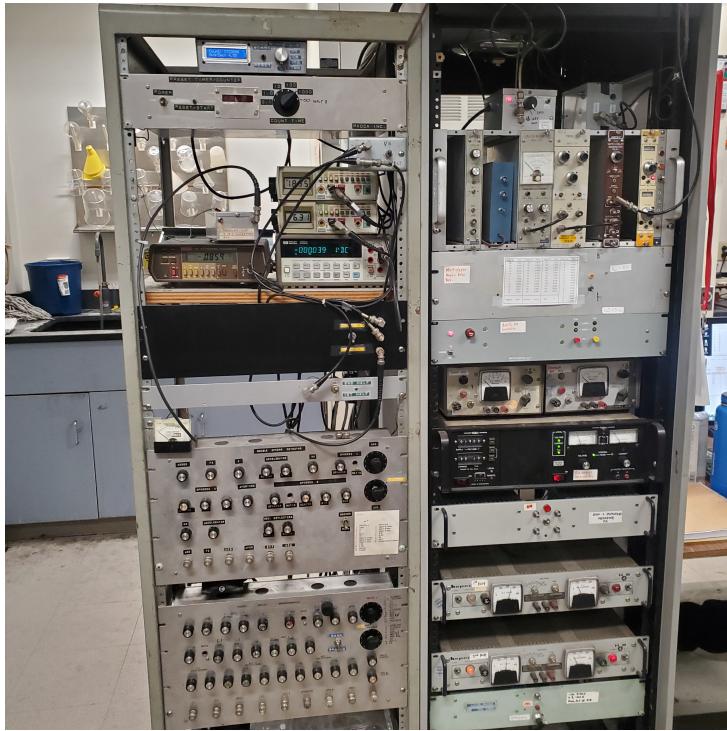


Figure 4: Where all the tuning takes place.

In Figure 4, you can see the various electronics that make our experiment work. On the left side, this is where the detector and electron gun is tuned. The various knobs have names which are analogous to its position on its respective device. The top left most side has a small counter where you can see if there is any count, that is, to check if scattering is taking place. Below that are multi-meters that measure current, pressure and energy. The left most brown is where we measure the current of the filament and also a Faraday cup switch. More on this later. The stacked identical multi-meters measure the pressure of the chamber and the angle at which the detector using volts rather than degrees. The table for converting and knowing where you are is a white paper on the right side of this cabinet. To control the detector, its the same side and these are the red and yellow buttons. Red goes counter-clockwise and yellow goes clockwise. Back to the stack of multi-meters, the bottom white one with a green text display is where we can measure energy loss and set our energy. At the bottom right, there are knobs which change a part of either the detector or the gun. As mentioned previously, Dr. Khakoo will mainly take the role of using these knobs, do not touch them unless given the OK.

During all this, typically we will measure a resonance, find a contact potential, and make sure we get a good number of counts. To get a good number, there is a VI file named “Manual Gas Chopper” on the desktop to have the computer check for “Gas On” or “Gas Off.” Dr. Khakoo will call out which one is necessary and calling it back to confirm is to make sure it is properly chopping. If the counts look good, the next part is to find the resonance experimentally and compare it to a well known value of 19.366 eV that is on the spectrometer tank.

Computers

Open up the “Acquire EELS V5.vi” file either on the desktop or through LabView and set it up. An example of how it looks is in Figure 5. In the MCS Settings tab, change Stop Voltage to 2.5 and

the number of points to 400. Then uncheck the box to chop the gas beam and click on the button “Do not set angles.” Make sure the button is on for this scenario. Make sure to change the name of the molecule to Helium and put 0 for the energy and number of cycles. On the Total Sweeps tab, make sure to click the “Hold at Start” button and make sure it is off. Then click the right arrow below the “File, Edit, View...” panel to run the program. If done well, the program will start counting and you’ll look for a resonance. As Dr. Khakoo says, “look for the white space” and a slight dip in the counts chart. Use cursors provided by the program as the button “Cursors On.” The button should be on and two lines will appear on the graph. Move them wherever necessary and look at where it is using the Cursors menu near the same button. Bin2 is typically what you will use to see where it is. On the left most of the program, there should be a current bin indicator, pause when it hits the same number using the pause now button.

Once you find the number, Dr. Khakoo will tell you and write it down on a notebook on a desk nearby as $E_{res} = neV$ where n is the energy number. Next is to find the contact potential, which is the potential from the filament to properly get the energy for the electrons. And as another note, a Filament is a piece of metal that gets really hot and shoots off electrons. This is found by doing $E_{res} - E_{act} = \Delta E$ where the first term is the experimentally found, 2nd term is the well known value of 19.366 eV and delta E is the contact potential. Now he will adjust the energy based off this number by $E_{want} - \Delta E = E_{use}$. For example, if I am doing 10 eV and the contact potential is 1.056 eV, then $10eV - 1.056eV = 8.944eV$ which is the energy that will be actually used in the experiment.



Figure 5: The labview program is shown here as a screenshot.

Now comes the data taking. When you take data, you use the LabVIEW program “Aquire EELS V5.vi” and need to change the MCS settings in the tab of the same name. Change the stop voltage to 0.4, number of points to 100, chop the gas beam, change the name of molecule if needed to, change the energy if needed to, change the number of cycles to 2 and Dr. Khakoo will give you

a zero angle measured in volts. Then make sure the “Do not set angles” button is off and click the little folder button carefully. Whichever experiment you are doing depends on which notepad you will use that is in the Data folder. You can find this folder in the Favorites section of the file dialog window. On the Total Sweeps tab, make sure the “Hold at Start” button is on, cursors are optional to have on and the boxes labeled as “Signal+Background,” “Background,” and “True Signal” are all checked on. Now you are ready to start taking data, run the program and a dialog box that will show you angle will come up. Once it found the angle, a smaller dialog box will say “Found Angle” and click OK to start recording data.

Gas and Pressures

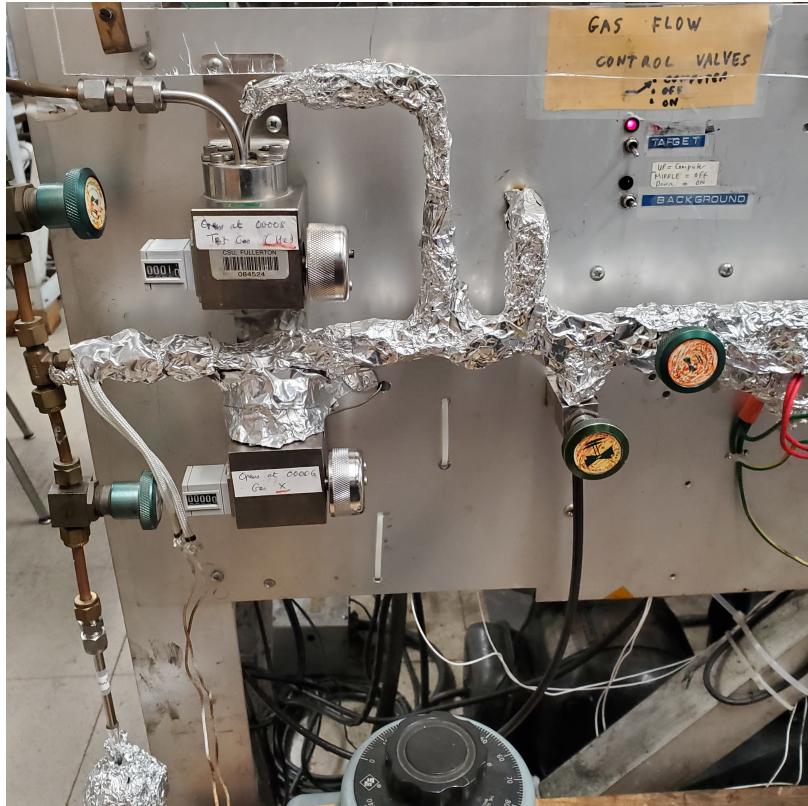


Figure 6: The valves used for increasing or decreasing the pressure of the gases

Before we can take any real data, we need to put our gas in the tank. In Figure 6, you can see the on the lower left corner where the glass vial of our molecule will be. Towards the right, two boxes with knobs are shown with labels. The top is for Helium and the bottom is of the other gas molecule. The dials work that dialing it towards you is opening it and away from you is closing it. You will see there is a number counter that will change on your actions. When the dial is below 0, it is completely closed. Although the label will indicate when it starts to open. As a good measure, when shutting down, put that dial to zero. Towards the right are two switches. During the experiment, they should be kept to what is shown in Figure 6. Anything not mentioned should be considered something you do not touch unless noted by Dr. Khakoo. As for the dials, use them gently and slowly. If you increase the pressure too much, the machine will shut itself off. Put in the gas slowly and let the gauge reach a nice equilibrium. We typically run the gases around 1.0×10^{-6} to 2.0×10^{-6} torr. And the typical vacuum pressure is 1.5×10^{-7} torr.

Taking Data

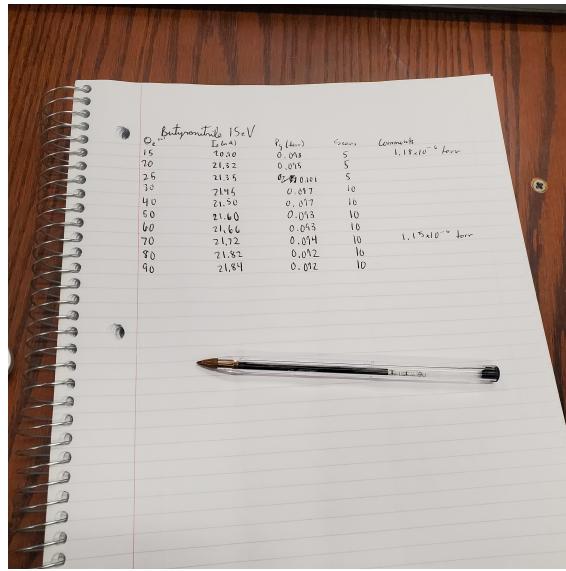


Figure 7: The notebook showing what to write down and the set up

In Figure 7, this is chart you will write down. Typically, the angles depend on what notepad you use. The amount of scans is also included in this notepad file. At the top the order goes

| $\theta_e (^\circ)$ | $I_e (nA)$ | $P_g (\text{torr})$ | Scans | Comments |
|---------------------|------------|---------------------|-------|----------|
|---------------------|------------|---------------------|-------|----------|

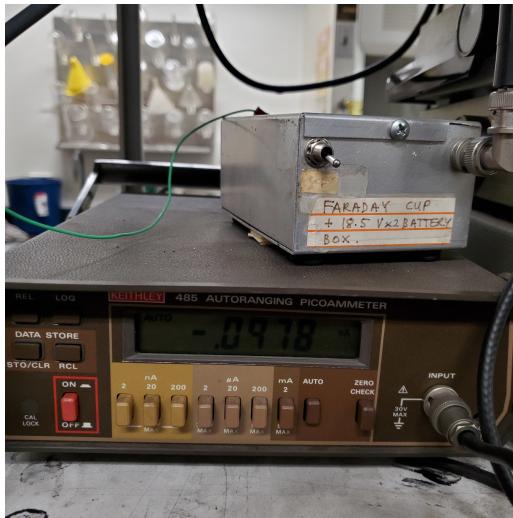
The comments tab is usually for writing down the chamber pressure given by the gauge that is on Figure 8.



Figure 8: Ion Gauge for the Chamber Pressure

When the new angle is being found by the program, you need to manually get the current by moving the Faraday flag lightly until you feel a stop. Slide towards the left to place the flag in front. Slide towards the right to place it back. Slide/Rotate gently. Go the Faraday cup box and switch it up and keep it down for the duration of the experiment. While the switch is up, look at the multi-meter below and record whichever value you see first or feel satisfied with. This should not take more than a second realistically. This also helps to carry on the experiment quicker because it can take hours for a single Energy to finish. When you get a value, switch it back down and

remember to put back the Faraday flag or you will ruin the data. And make sure to remember the value as you will write it down in the Lab notebook. There is a red line on the slider, make sure it is at the default location as shown in Figure 9 when taking data.



(a) The Multi-meter and Faraday Cup switch box



(b) The Flag slider under the Spectrometer, red line indicates where the flag is

Figure 9: The 1st is by the tuning cabinet and the 2nd is under the spectrometer by the computer.

You will repeat this process for all the angles and cycles of a particular energy you are doing. When you are looking at the program, make sure to write the pressure of what the gas is at. I would wait until a scan is done so it can update. While you are doing this, you will have to make an excel file either from a template or one that is provided.

Excel and Analyzing Data

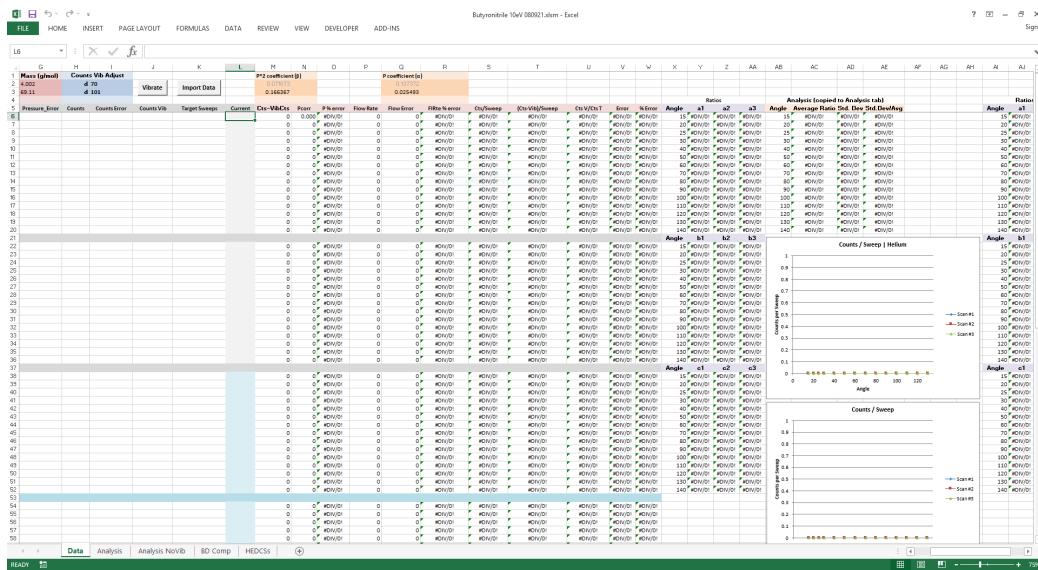


Figure 10: An example of a blank excel file waiting for current values

This section will not be written out in completion since there is another guide already made in the lab for you. This guide was made by Dr. Sakaamini and there is a hard copy in the lab by the computer. But a quick run down is the 1st half is done at the beginning of an experiment while the 2nd half is done at a new energy level for the experiment. And also made by Dr. Sakaamini are the excel files that streamline the analyzing data section. Your job is to simply make sure the files are right and write in the current values that you wrote down. As redundant as this sounds, having a hard copy of all the data is nice. Note on the excel file, the molecules are color coded. Gray is for Helium and Blue is for your molecule. The guide in the lab goes more in depth on how to use the excel file, what do with it and more. When you are done with an energy, save all the files and upload it to the Dropbox folder. Let Dr. Khakoo see any data that you did in the Lab and discuss how it went.

What to do in the Lab

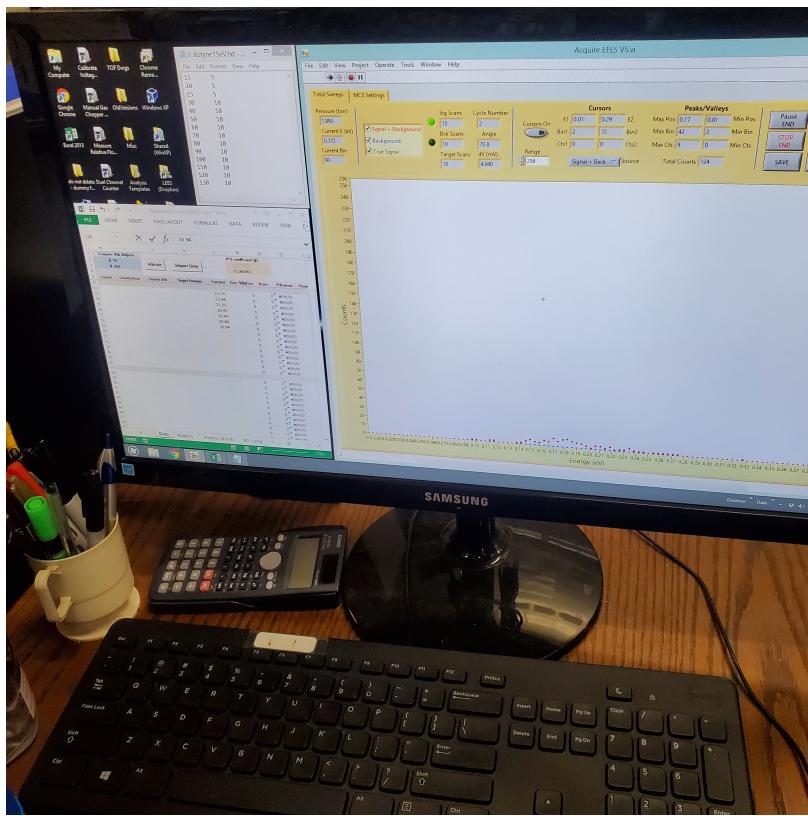


Figure 11: How the data process looks

After sometime of working in the lab, you'll find yourself adopting a good routine. And you'll find yourself with some time. If those scans are 10 or 15, you'll know what I mean. Dr. Khakoo may mention this and I will mention it now, you can do something else while you wait for the data taking to happen. For example, I am writing this while I'm in the lab. You can do homework, read a book, read some articles, bring a laptop, or something productive. Remember, you are still taking data so pay close attention as well. And while you are waiting, you can make sure the current values are in and if you finish one cycle of a molecule, remember to import the data. Take frequent peaks or as much as you need to while performing another task. The scans of 5 are pretty quick so it is recommended to just wait it out. If you need to leave the lab, ask a partner to watch the experiment for you, pause the program or ask Dr. Khakoo. Try to not leave for an extended

period amount of time away from the lab when the computer is taking data.

Help and Errors

This section will talk about every error that is happened in the course of the lab to troubleshoot easier. These will be out of order because they will be written down as I remember them and as new problems arise.

Too much gas, greater than 2.0×10^{-6}

Unless done by Dr. Khakoo, you need to decrease the amount of gas. Adjust the dial slowly and wait until the needle is stable and the number on the red LED screen number stabilizes.

Low counts

You have either a low current or low pressure. Pause the program with the “Pause NOW” and check both. Adjust as needed to.

No counts

You might have left the Faraday flag on, repeat that angle and the rest of the experiment.

Only managed to get one cycle of data, not two

You need to go to MCS settings for the Labview program and put 1 cycle instead. Finish that cycle and import the first data file and adjust the 2nd. The excel file containing the data needs to be changed by making the cycle number 2 instead of 1.

Data does not import

You need to make sure all the angles are in agreement. Often times, different energies will call for different angles. Check the data file of the excel sheet for the particular molecule and see if there is anything extra that is not needed and adjust as needed to. For example, if you repeated the 2nd cycle and the 1st data sheet has the first angle at the 2nd cycle but you already repeated it, you need to delete all of the data associated with it.

Data imported but the graphs don't have anything

You need to make sure all the current values are correct. Sometimes an extra period can affect all the data.

I copy and pasted the data but it messed up all the graphs

When you copy and paste data, you need to paste as special and put values. All those cells are used by the equations in the excel sheet and move with it. Try to undo what you did or make another excel sheet.

When I imported the data, the some angles did not show up

That is because the data file that you imported has the wrong angles that were not detected by the master excel file. You need to change either or, whichever has less. Rule of thumb is changing multiple angles on the master excel file is easier than all the angles on the data excel file sheet.

Stepper Motor got stuck

You can use the Move Stepper.vi file on the desktop to put it at the angle you need to and restart the Data Labview program. It will read it is already there and move on. Adjust any data that you get based off of this restart.

The current dropped by more than 10 percent

You can use the red knob on the electron gun side on the tuning cabinet. If it cannot go any higher, ask Dr. Khakoo.

The flag feels strange and I don't get any current value

It is currently being shorted by the gun because it is rubbing against it. The flag fell, contact Dr. Khakoo.

The background is much higher than the signal

Contact Dr. Khakoo immediately.

The graph is looking strange, not as expected

The gas beam is probably not centered. Contact Dr. Khakoo.

If any question that you have is not here, always contact Dr. Khakoo.

Author's Notes

I wrote this whole paper out for myself generally but I thought it was a cool project to do. If anyone can use this document, that would be great! Most of what is covered here will be taught during the lab. If anything, this is to cover your bases, fill any gaps or a nice refresher. When you do it yourself, it will become second nature. I even showed Dr. Khakoo and felt it was unnecessary but it was cool to do. And it also shows you what to expect and how the lab process works.