Hardware Instructions

Operation:

Laser

-Turn on water, verify that the pressure is 5.5 GPM for the laser.
-Turn on main power disconnect (No.3 208V).
-Wait ten minutes for laser power supply to warm up.
-Turn on air purge.
-Turn the current knob counter-clockwise to turn the current down as low as possible (bad for laser to start with a high current).
-Press the "ON" button and laser will start in 10 or 15 seconds.
-Check to make sure that the "auto fill enable" button is lit.
-Adjust to desired current (30 Amps or so).
-Measure laser power with the thermopile (use multimeter on DCV setting while the optical chopper is off) and adjust rear mirrors to maximize power.

Instruments

-Set up the lab jack and the liquid nitrogen dewar on the red marks on the optical table.
-Set up the heat gun and point it towards the side of the dewar closest to the monochromator, use the cool setting. This gets rid of condensation on the outside of the dewar.
-Fill the detector with liquid nitrogen (use the holder that is attached to the optical table), wait ten minutes and then refill the detector with liquid nitrogen.
-Verify that the red marks on 0-1000V knob on the detector power supply are aligned, which is the -250VDC bias that the detector requires.
-Turn on the optical chopper, the lock in amplifier and the detector power supply.
-Move the monochromator to a position where there is a strong signal, 925 meV works well for most samples. See the software operating instructions if necessary.
-Adjust the XYZ translator to move the lens, adjust the mirrors and try turning the sample in the dewar to maximize the signal on the lock in amplifier.
-To see the beam with the protective goggles on, align the mirrors and place the laser beam onto the sample, place a white piece of paper or infrared sensor in front of the beam. One can also use a very low current (<20Amps) to align the mirrors without the goggles.

Shutdown:

-Close the shutter on the laser.
-Press the off button on the laser power supply.
-Turn off the cooling water and the main power disconnect.
-Turn off the optical chopper, the detector power supply and the lock in amplifier
-Turn off the air purge and write in the laser logbook.

Description of entire setup:

The computer runs two separate programs simultaneously to control the monochromator and the lock in amplifier. Each is controlled by a serial cable (RS-232). The lock in amplifier is connected to port 1 and the monochromator to port 2. The lock in amplifier detects the signal from the germanium detector. The detector is cooled with liquid nitrogen, and powered by the model 823 North coast bias supply. It receives a bias of –250volts from a BNC output on this supply which is connected to the "HV" BNC connection on the detector. The knob that controls the HV output on the supply is to be set at 778. There is a red mark to indicate this spot and the –250 V can be checked with a multimeter. There is also an odd shaped connector on this supply that connects to the detector's label "POWER". It is +-12V on some of the pins, the exact configuration can be found in the manual.

The detector is "coupled" to the monohromator by a custom-made aluminum flange. There is felt in the inside of the flange to prevent light from entering the detector during an experiment. The flange is held to the monochromator by 4 "6-32" set screws. There is also a holder attached to the optical table to place the detector into while filling it with liquid nitrogen.

The lens is position on an XYZ translator approximately (from the closest part of the lens to the monochromator: 3", from the farthest part of the lens to the monochromator: 5" {the lens is 2" thick}). The center of the monochromator is 12.5" above the optical table. The sample should be placed 9"away from the monochromator.

The optical chopper is set at a frequency of 400HZ or so.

Troubleshooting:

Diffusion Pump:

-A loud popping noise occurs (the shutting the throttle valve) when the liquid nitrogen trap is not filled and one attempts to evacuate the chamber with the high vacuum pump.

Laser:

-If the laser will not start, the upper right corner of the power supply should display a two-digit number. This an error code that tells what the problem is. The manual has a list of what these codes mean. One problem we had was that the remote control connector in the back of the power supply was not plugged in, so we could not start the laser.

-If the laser starts but does not emit light, the mirrors are probably severely out of adjustment.

-If the laser cover is off or loose the laser will not start.

Weak, noisy or unusual signals:

-Make sure that the surface of the sample is clean from vacuum grease and other dirt. Acetone cleans the surface very well.

-Make sure the dewar is clean. If it is dirty on the inside there will be more bubbles in the liquid nitrogen. It is also cleaned very well with acetone.

-Increasing the time constant on the lock in amplifier will decrease the noise in the signal, but will also decrease the resolution unless the time between data points is adjusted (SCAN RATE).

-If the signal is negative try pushing the autophase button on the lock in amplifier.

Software Operating Instructions

The program is designed to start at an energy controlled by the user and increase in energy at any rate and magnitude the user wishes. It shows the signal strength graphically and digitally in real time until the user wishes to stop the scan or the energy has increased to the end energy, which is also controlled by the user. When this happens the data is displayed in a separate graph that plots energy in meV on the X-axis and signal strength in mV on the Y-axis. If the user wishes to save the data, the raw data (energy and the corresponding signal strength) in an excel file, along with the parameters of the monochromator and the lock in amplifier and the miscellaneous notes that the user has entered. The resolution on the monochromator is angstroms.

The objects that are in white are notes for future use. They are not required to run the program and do not effect it in any way. They are stored with the raw data when the user chooses the save option. The orange objects are controls and are required to run the program. The other objects are displays of various kinds.

Detailed operation of a standard scan across a range of energies:

1. Open Monochromator controller and Lock in Amplifier controller.

2. Run the Lock in amplifier program first (push the white button on the upper left hand corner of the screen) and make sure that the reference input indicator changes to Locked. Adjust the controls as desired.

3. Run the monochromator program (push the black button on the upper left hand corner of the screen) and select the GOTO option and press the GO button (a screen should popup). Note that the Lock in amplifier program does not change it's display value while the monochromator is running, this is normal.

4. Enter an energy that you believe will have a strong signal from the detector and press GO. 945 meV seems to work fine with the liquid nitrogen dewar. You can get a stronger signal from the Si substrate at 1095meV at very low temperatures with the compressed liquid helium dewar. Then press the exit button.

5. Adjust the lens position with the XYZ translator and the mirrors while watching the front screen on the lock in amplifier (the physical piece of equipment) to maximize the signal. Push the autophase button on the lock in amplifier controller when you start to get a signal.

6. Now select the BEGIN option on the front panel of the Monochromator controller. Enter the START and END ENERGIES that you want to scan through. Enter the SCAN RATE that you wish to scan at. If you are scanning at very low temperatures and resolution is important then the general rule of thumb (according to Professor Lyon) is that this rate should be 5-6 times the time constant. So if the time constant on the lock in amplifier is 1s then the scan rate should be 5000ms at least. However a rate of 350ms seems to work fine for 77K

measurements, but do not enter a value below 350ms or the plot becomes digitized.

7. Press the go button and the countdown to scan indicator should start to countdown. Once it reaches zero, there should be data registering in the graph below and the current energy should be increasing or decreasing. If you wish to stop the scan, press the red stop button. The scan cannot be stopped while the countdown to scan is taking place.

8. The bottom graph takes the data in real time and plots only the signal strength in mV. The graph to the right gives a finished plot of signal strength vs energy after the scan has completed or the stop button is pushed.

9. To save the data, enter the sample number, temperature taken at, file name, slit size and laser current or laser power and select the save command and press go. The data should now be saved in the PL measurement program folder as a file "sample number-filename.xls". This is an excel file that saves all the parameters of both the monochromator, the lock in amplifier and the data from the scan (energy in meV and signal strength in mV).

Changing units:
The default units are nanometers. To change the units, select the UNITS option and press GO. Select the desired unit from the screen that pops up, press go and then press exit when finished. Always be sure to select the SIZE option, press GO, then press the GO button on the pop up screen. If you don't, the scan will count from the START ENERGY to 0 (there is a bug in the program that I haven't had the time to find, but this alleviates the problem).

Changing the distance between data points:
The program is defaulted to increase in energy by 1 nm at a time set by the SCAN RATE, which is an adjustable variable. However by selecting the SIZE command, you can change the distance between measurements (10nm for example) or can scan in a decreasing fashion from a high energy to low energy if you wish. To do this, select the SIZE option, press GO, and then choose the desired distance between data points and whether you scan from a low energy to a high energy. Press GO to apply the change and then press EXIT when finished. There is no specific reason for counting down or up that I know of, it was a feature that was built in for debugging purposes.

Changing the default values:
While the program is not running change the value by selecting the cursor from the tools palette and then type in the new value. Right click on the new value and select data operations, and then "make current value default".

Note about unused display variables:

Above the graph on the right are some variables that are not important to us or should never be changed. Make sure that the baud rate is 9600, the COM is port 2 and that the time delay is 6000. Be aware that the serial number is also located here. The other items located here are not used in the normal operation of the program.

Changing parameters on the lock in amplifier:
Simply select the parameter that you want (while the monochromator's program is not running).

Compressed Helium Dewar Operation

Operation:

Mount Sample
-Vent the vacuum space by opening the green valve on the dewar if it is under vacuum.
-Remove the clamp that holds the shroud on and lift off the shroud.
-Remove the four screws at the bottom and lift off the radiation shield.
-Mount the sample with vacuum grease and use the sample holder to kep the sample in place. (if you don't use the sample holder the sample will fall off, and it also improves the thermal contact).
-Replace the radiation shield and the shroud and reclamp the shroud.
-Be sure to replace the radiation shield so that the laser will have the largest opening to go through.
-It is also a good idea to turn the shroud at an angle of 20 degrees toward the laser.

Diffusion Pump Operation
-Press green button.
-Turn MP dial to position 2.
-Fill liquid nitrogen trap.
-Wait for the "<10^-2" light on the leak detector cabinet to light.
-Wait 10 minutes to allow the diffusion pump to heat up.
-Verify that the green valve near the cold head is open.
-Rough pump the system by turning the MP valve to position 1.
-When the pressure is less than 5 X 10^-2 torr, turn the MP valve back to position 2 and quickly open the throttle valve (larger of the two valves). A green light on the leak detector should indicate that the valve is open.
-Wait until the system reaches a suitable low pressure. (the leak detector is not working properly).
-Close green valve on cold head to isolate cold head from diffusion pump.
-Turn off the diffusion pump by closing the throttle valve and then turning the MP valve to the middle position, and then push the red stop button.

Cryogenics
-Switch on Lakeshore 331 temperature controller (switch is in rear of instrument).
-Adjust setpoint (button 6) to desired temperature. (if desired temp is above 8K, make sure that the heater is turned on).
-Check rear pressure gauge to verify correct pressure 250PSI, there is a mark on the gauge as an indicator.
-Turn on cooling water to 7GPM (1.5 GPM for the cryogenic compressor and 5.5 GPM for the laser).
-Turn on 8200 Compressor to begin cooldown.

Laser
-Turn on water, verify that the pressure is 7 GPM for both instruments (1.5 GPM for the cryogenic compressor and 5.5 GPM for the laser).

-Turn on main power disconnect (No. 3 208V).
-Wait ten minutes for laser power supply to warm up.
-Turn on air purge.
-Turn the current knob counter-clockwise to turn the current down as low as possible (bad for laser to start with a high current).
-Press the "ON" button and laser will start in 10 or 15 seconds.
-Check to make sure that the "auto fill enable" button is lit.
-Adjust to desired current (30 Amps or so).
-Measure laser power with the thermopile and adjust rear mirrors to maximize power.
-Write in laser log.

Instruments
-Fill the detector with liquid nitrogen, wait ten minutes and then refill the detector with liquid nitrogen.
-Verify that the red marks on 0-1000V knob on the detector power supply are aligned, which is the -250VDC bias that the detector requires.
-Turn on the optical chopper, the lock in amplifier and the detector power supply.
-Move the monochromator to a position where there is a strong signal, 945meV works well for most samples, but 1100meV can give an even stronger signal at low temperatures.
-Adjust the XYZ translator to move the lens and adjust the mirrors to maximize the signal on the lock in amplifier.

You should be ready to take data now.

Shutdown:

-Close the shutter on the laser.
-Turn off the 8200 compressor and the lakeshore 331 temperature controller.
-Press the off button on the laser power supply.
-Turn off the cooling water and the main power disconnect.
-Turn off the optical chopper, the detector power supply and the lock in amplifier
-Turn off the air purge and write in the laser logbook.

Mirror Adjustment for Laser

If the laser does not lase, the mirrors are misaligned. To realign the mirrors use the fine adjustment knobs. Keep track of the original position of the knobs, because the probability that the mirrors are severely misaligned is small. If the fine adjustment knobs do not align the mirror, gently grab the mirror assembly (it is a large, round knob that extends out of the laser and says Spectra Physics on it) and try to move it into a position that lases. Then adjust the mirrors to this position. If this still doesn't work try the method suggested ion page 4-10 of the manual. Basically it consists of rocking the mirror assembly (spectra physics knob) in a vertically direction, while adjusting the coarse horizontal direction.