QEPVSI-b

Quantum Efficiency Measurement System

User's Manual

ORIEL INSTRUMENTS
A Newport Company

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1 GENERAL INFORMATION

Thank you for your purchase of this quantum efficiency measurement system from Oriel Instruments.

Please carefully read the following important safety precautions prior to unpacking and operating this equipment. In addition, please refer to the complete User's Manual for additional important notes and cautionary statements regarding the use and operation of the system.

Do not attempt to operate the system without reading all the information provided with each of the components.

SYMBOLS AND DEFINITIONS

	**WARNING** Situation has the potential to cause bodily harm or death.
	**CAUTION** Situation has the potential to cause damage to property or equipment.
	**ELECTRICAL SHOCK** Hazard arising from dangerous voltage. Any mishandling could result in irreparable damage to the equipment, and personal injury or death.
	**EUROPEAN UNION CE MARK** The presence of the CE Mark on Newport Corporation equipment means that it has been designed, tested and certified as complying with all applicable European Union (CE) regulations and recommendations.
	This international symbol implies an alternating voltage or current.
Note:	Additional important information the user or operator should consider.

Please read <u>all</u> instructions that were provided prior to operation of the system. If there are any questions, please contact Oriel Instruments or the representative through whom the system was purchased.

GENERAL WARNINGS

- Read all warnings and operating instructions for this system prior to setup and use.
- To prevent damage to the equipment, read the instructions in the equipment manual for proper input voltage.
- This equipment is grounded through the grounding conductor of the power cords.
- Route power cords and other cables so they are not likely to be damaged.
- Disconnect power before cleaning the equipment
- Do not use liquid or aerosol cleaners; use only a damp lint-free cloth.
- Lock out all electrical power sources before servicing the equipment.
- Qualified service personnel should perform safety checks after any service.
- If this equipment is used in a manner not specified in this manual, the protection provided by this equipment may be impaired.
- To prevent damage to equipment when replacing fuses, locate and correct the problem that caused the fuse to blow before re-applying power.
- Do not block ventilation openings.
- Do not position this product in such a manner that would make it difficult to disconnect the power cords.
- Use only the specified replacement parts.
- Follow precautions for static sensitive devices when handling this equipment.
- This product should only be powered as described in the manual.

Do not remove the cover

ELECTRICAL HAZARDS

Make all connections to or from the power supply with the power off.

Do not use the power supply without its cover in place. Lethal voltages are present inside.

FIRE HAZARDS

Lamps are extremely hot during operation, and for several minutes after being shut off. Keep flammable objects away from the lamp and lamp housing.

Newport Research (fan-cooled) Housings are equipped with a condenser lens. The re-focused output of this lens can cause ignition of flammable targets (ex: wooden walls, certain chemicals).

To avoid fire hazard, use only the specified fuses with the correct type number, voltage and current ratings as referenced in the appropriate locations in the service instructions or on the equipment. Only qualified service personnel should replace fuses.

LAMP HANDLING

Read all information and warnings provided with lamp.

The Xenon arc lamp used in this system is filled with rare gas at high pressure, so there is a danger of lamp explosion due to mechanical failure. This is particularly true when the lamp is operating since the internal pressure can reach tens of atmospheres. Thermal strains can cause the lamp to explode under certain conditions.

Never touch any lamp with bare fingers or other contaminates. Skin oil or other substances can burn into the lamp envelope during operation and negatively affect the lamp's performance and lifetime.

Always wear appropriate gloves and impact-resistant goggles when handling any lamp. Avoid any mechanical strain during handling. Do not operate the lamp without all housing panels in place.

Lamps become very hot after only a few minutes of operation (up to 150°C) and remain quite hot for at least 10 to 15 minutes after being turned off.

2 THEORY OF OPERATION

The typical detector calibration compares a detector under test against a 'standard' detector with a known spectral response.

Solar cells are characterized by the QE measurements. The QE measurement is a very important initial measurement determining the efficiency of the cell. As shown in Figure 1, cells made of different materials show different spectral response characteristics, which translate into corresponding QE measurements.

The Sun generates light with a well-defined spectral content, which is illustrated in Figure 1. The measure of how much current a solar cell generates is critically dependent on the convolution of the cell spectral response and the solar spectral distribution.

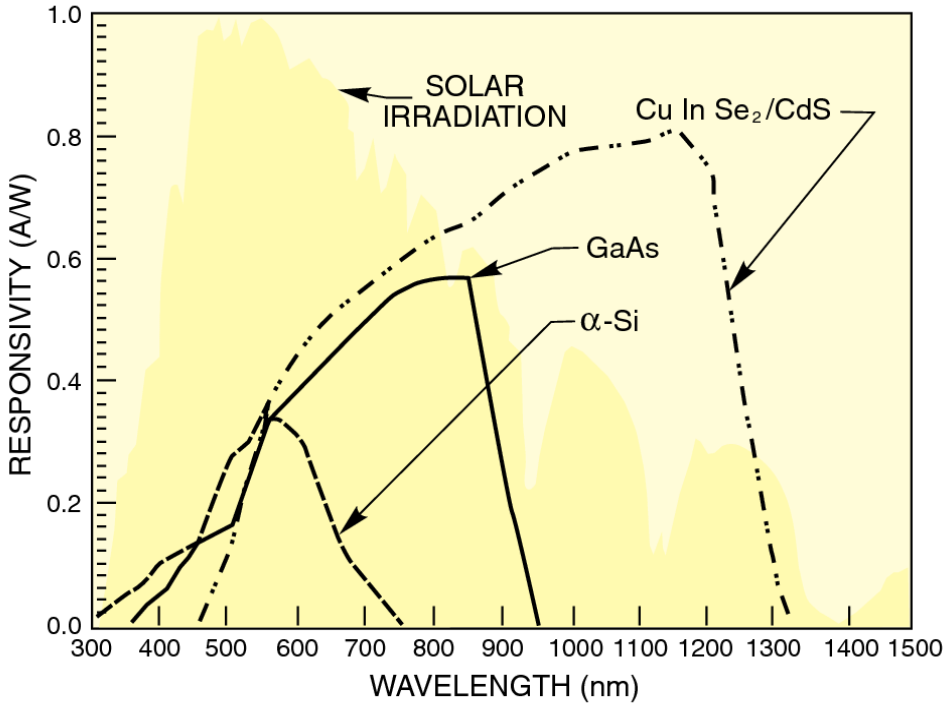


Figure 1: Spectral Responsivity Various Materials

The electronic band structure in a photovoltaic device introduces a wavelength dependent optical absorptivity. A photon with energy larger than the band gap is typically absorbed by the material, while the material is transparent for a photon with energy smaller than the band gap. The absorbed photon energy creates an electron-hole pair, which leads to creation of photocurrent. The spectral response for a photovoltaic device is dependent on this induced photocurrent and on the wavelength of incident light.

According to ASTM 1021-08, the power spectral responsivity, $R_{pa}(\lambda)$, for collected electrons per incident photons may be converted to external quantum efficiency, E$QE(\lambda)$ using the equations below:

$$EQE(\lambda) = \frac{hc}{q} * \frac{Rpa(\lambda)}{\lambda}$$

Equation 1: External Quantum Efficiency (EQE)

where λ is the wavelength, *h* is Planck's constant, *c* the speed of light, and *q* is the electron charge. This can be simplified as:

$$EQE(\lambda) \approx \frac{1240 * Rpa(\lambda)}{\lambda}$$

Equation 2: EQE Simplified

where R_{pa} is the sample's spectral responsivity in Amps/Watt at wavelength λ.

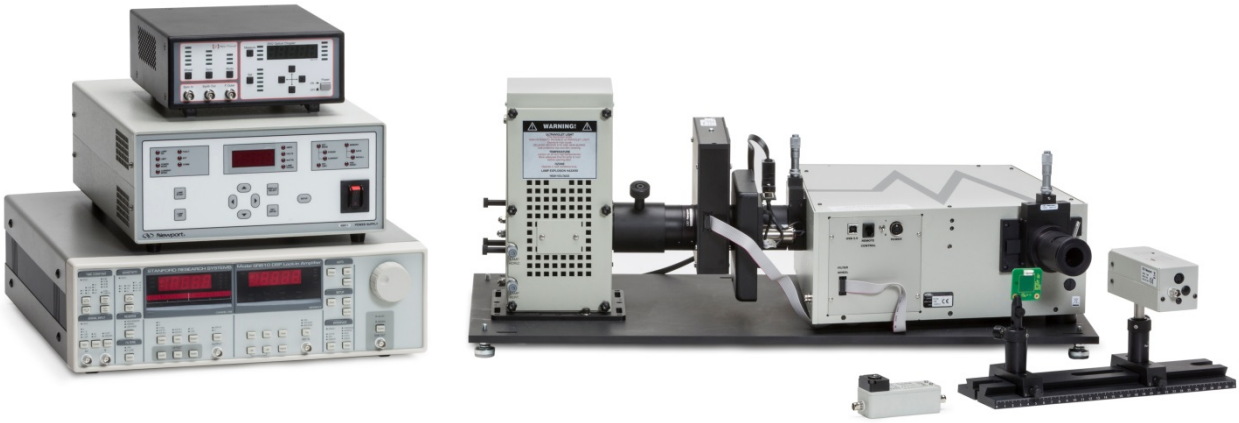


Figure 2: QEPVSI-b System

Note: Breadboard for optical rail is an optional item

ABOUT THE QEPVSI-b

The QEPVSI-b modular system is a cost-effective solution allowing users to measure External Quantum Efficiency (QE or EQE), also known as Incident Photon to Charge Carrier Efficiency (IPCE).

The system utilizes industry-standard Oriel components for the monochromatic light source. The complete system includes the light source, monochromator, reference detector, related electronics

and software. Accessories are available through Newport to provide sample positioning and electrical connections.

Figure 2 illustrates the basic configuration of the QEPVSI-b measurement system. In this configuration, chopped (i.e. modulated) light from a Xenon light source is sent through order sorting filters and into an Oriel Cornerstone™ 260 monochromator to generate a monochromatic light output. The output beam path is focused to a well-defined area. To measure QE, only a portion of the sample needs to be illuminated.

The monochromator scans over a user-selectable wavelength range, with the output focused onto a calibrated silicon reference detector, followed by a test cell resulting in a radiometric measurement. The solar cell under test and calibrated reference detector are connected to an SRS 810 digital lock-in amplifier which isolates the signal from background noise.

Total optical power incident on the detector is compared to the current generated by the cell under test. Instrument control, data collection and calculations are all done through Oriel's TracQ™ Basic software.

CONFIGURATIONS

The QEPVSI-b employs a free-space design with a horizontal beam delivery to a focused spot. The main advantage of the free space setup is its flexibility and the well-defined beam shape. The standard system is designed to measure samples which respond to light in any region between 350 nm and 1100 nm.

3 SYSTEM INSTALLATION

UNPACKING

Your QEPVSI-b pre-aligned system is delivered in custom engineered crate for protection. In addition ancillary instruments are included in the same shipment but packaged separately. Your packages include:

1. One (1) QEPVSI-b pre-aligned system with:
    a. One (1) Oriel Xenon light source
    b. One (1) Cornerstone 260 1/4m USB Monochromator
    c. One (1) Motorized Filter Wheel
    d. One (1) Optical Chopper with Enclosure
    e. Optics, connecting and mounting hardware
    f. Optical grade mounting baseplate
    g. Reference detector/sample cell rail assembly

Additional instruments and cables are delivered in separate packaging. These include:

2. One (1) SRS 810 Lock in Amplifier
3. One (1) Oriel reference detector (Silicon or Germanium as required by the application)
4. One (1) Oriel sample cell with sample holder (Silicon or Germanium)
5. One (1) New Focus chopper controller
6. One (1) Oriel Pre-amplifier for sample amplification
7. One (1) Oriel Lamp power supply (i.e. 69911 for Xenon bulb)
8. Necessary cables and connectors for system configuration including:
    a. One (1) BNC/BNC cable –SRS 810 lock in amplifier to Reference Detector or Current Preamplifier
    b. One (1) BNC/Micro-clip cable – Current Preamplifier to Sample Cell
    c. One (1) BNC/BNC cable – Chopper controller to SRS 810 lock in amplifier
    d. One (1) interconnection cable - Arc lamp power supply to research lamp housing
    e. One (1) 9-pin DSub/Cat 5 cable - Chopper controller to chopper
    f. One (1) 12pin/12pin ribbon cable – Filter wheel to CS260 monochromator
    g. One (1) USB A/B cable – CS260 monochromator to computer
    h. One (1) USB/GPIB-USB-HS cable – computer to SRS810 GPIB port
9. TracQ Basic USB thumb drive

A packing list is included with the system noting all items that were shipped. Remove all items from the shipping containers and verify each item is accounted for by cross-checking the contents against the packing slip.

If any item is missing or damaged, immediately contact Oriel Instruments or the Newport representative from whom the system was purchased.

CHOOSING A LOCATION

Choose an installation location where the power requirements can be met for the system. Be sure power is not applied to the system until the setup has been completed.

The environment should be that of a typical laboratory atmosphere, without excessive humidity and contaminants in the air. Do not allow the ventilation holes on the system's components or its computer to be blocked. Air should be able to circulate freely around the system.

When the system is placed in its final location, check to ensure that none of the pre-assembled items have come loose during shipping. Note that the feet on the mounting plate may be removed so that the assembly can be permanently installed onto an optical table or breadboard, if desired.

ELECTRICAL MAINS SETTING

The SR810 operates from a 100V, 120V, 220V, or 240V nominal AC power source having a line frequency of 50 or 60 Hz. Before connecting the power cord to a power source, verify that the LINE VOLTAGE SELECTOR card, located in the rear panel fuse holder, is set so that the correct AC input voltage value is visible.

Conversion to other AC input voltages requires a change in the fuse holder voltage card position and fuse value. Disconnect the power cord, open the fuse holder cover door, and rotate the fuse-pull level to remove the fuse. Remove the small printed circuit board and select the operating voltage by orienting the printed circuit board so that the desired voltage is visible when pushed firmly into its slot. Rotate the fuse-pull level back into its normal position and insert the correct fuse into the fuse holder.

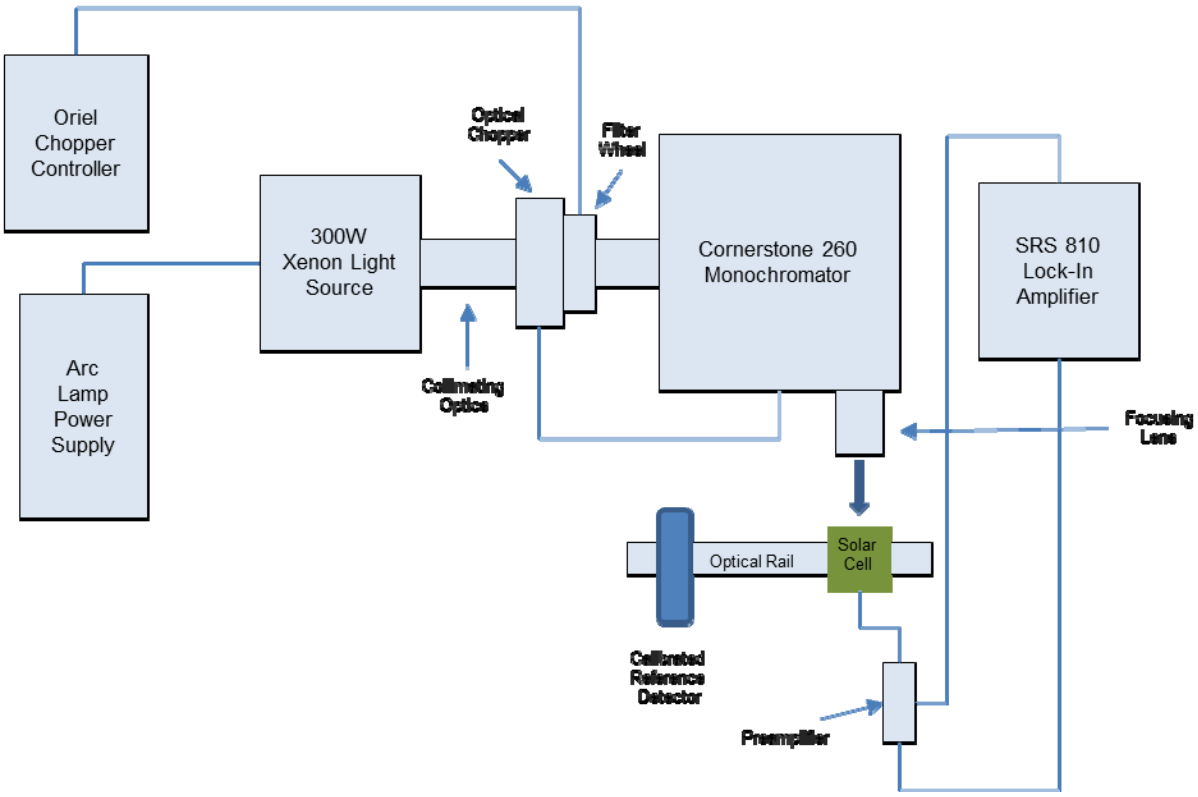


Figure 3: Standard System Block Diagram

4 SYSTEM SETUP

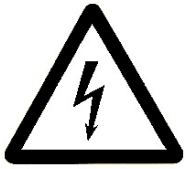
Once the system is positioned in its final location, setting up the system involves the following steps:

1. Installing the lamp
2. Setting up the sample rail
3. Connecting all cables
4. Installing software

After powering up the system, the lamp should be allowed to warm up completely. This warm-up period is necessary to stabilize the lamp's output power. **The lamp warm-up period should be at least 30 minutes prior to making any measurements**.

After the warm-up period, a QE measurement may be performed on the Si test cell included with the system. The data obtained can be compared to the data obtained by Oriel Instruments prior to shipment of the system.

LAMP HANDLING PRECAUTIONS



CAUTION!

When installing the lamp, you MUST:

- Wear eye protection.
- Wear powder-free gloves.
- Make sure the power supply is turned off.

Read all warning labels and literature provided with the lamp. The power supply must be unpowered before installing the lamp. Never touch the glass envelope of any lamp. If it is touched, clean the lamp's envelope with isopropyl alcohol and a clean lint-free tissue.

In order to prevent getting contaminants on the glass envelope, it is advisable to use powder-free latex or nitrile gloves while handling the lamp. Wearing face and eye protection is also strongly advised. Use care when handling the lamp. Do not bend, flex, or otherwise exert any unnecessary force on the lamp. The lamp is under pressure and glass particles can act as projectiles if the lamp is broken.

Unpack the lamp carefully. Set aside the packing material and box, so that they can be used for lamp storage if the system is to be relocated at a later date. Never transport a lamp housing while the lamp installed.

LAMP INSTALLATION

Remove the two socket head cap screws in front of the lamp housing door using the hex wrench provided with the system. Remove the lamp housing door in order to install the lamp.

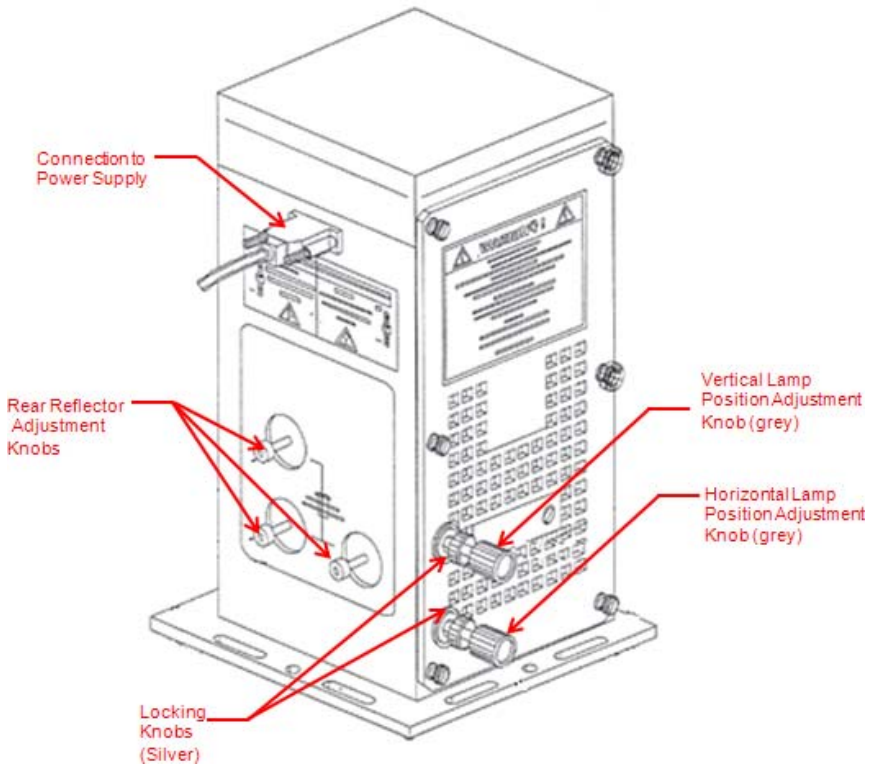


Figure 4: Lamp Housing

To open the research housing, unscrew the six knurled black thumb screws on the side of the housing to remove the access door as shown in above. It may be necessary to back off the knurled lock nuts on the lamp positioning adjustment screws. **Do not turn the grey end caps** as this will move the lamp position. The lamp position and reflector position have been pre-set at the factory.

If the rear reflector or lamp position adjustment knobs are moved, it is possible that the system will require recalibration. However, before performing a recalibration, ensure that one is necessary by running a scan of the test sample provided with the system. If it has not changed, then do not perform a calibration. System calibration should be performed only when absolutely necessary.

XENON LAMP INSTALLATION

Remove the twist tie or cable tie holding the sensor block in place. Loosen the thumbscrew on the lamp mount.

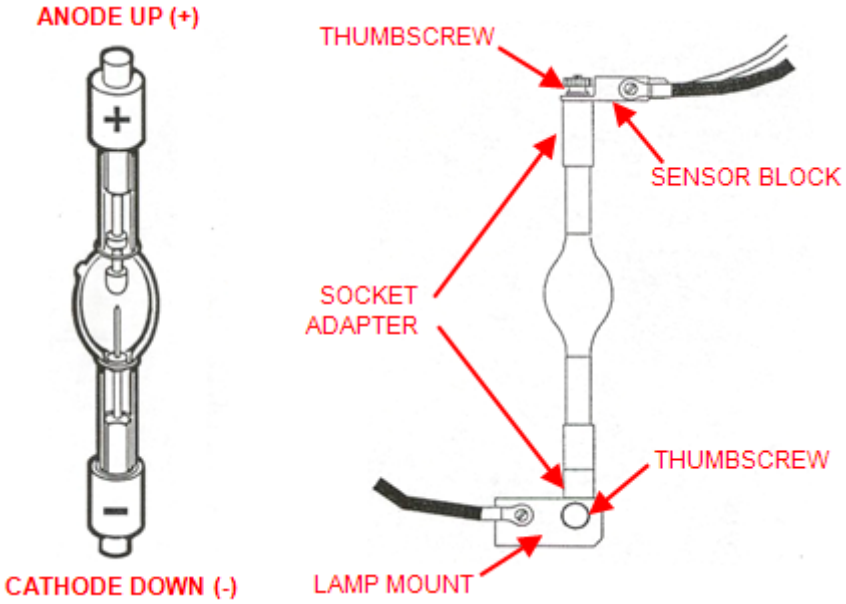


Figure 5: Arc Lamp Orientation

Remove the knurled thumbscrews that come installed on the anode end of the lamp. Place the sensor block onto the threaded post at the anode (+) of the lamp. Secure loosely with the knurled thumbscrew that comes with the lamp.

Carefully place the lamp into the lamp mount with the cathode side down. This is the end of the lamp where a brass socket adapter has already been installed at the factory. Rotate the lamp so that the protrusion on the envelope and the starter wire (if provided with the lamp) are facing towards the back of the lamp housing. The back of the lamp housing is where the baffle covers the fan, directly opposite of the door opening. After the lamp has been oriented correctly, be sure to tighten the thumbscrew on the lamp mount and tighten the thumbscrew at the top of the Lamp.

Replace the door of the lamp housing, making sure to engage the safety interlock tabs. Replace the nuts holding the door in place. Under no circumstances should the interlock tabs be removed or the interlock circumvented or defeated. Note that the lamp housing cannot be operated without its door being secured in place. If the door is not secured in place, an iLOC error will appear on the power supply display.

Replace the access cover on the lamp housing and mounting screws.

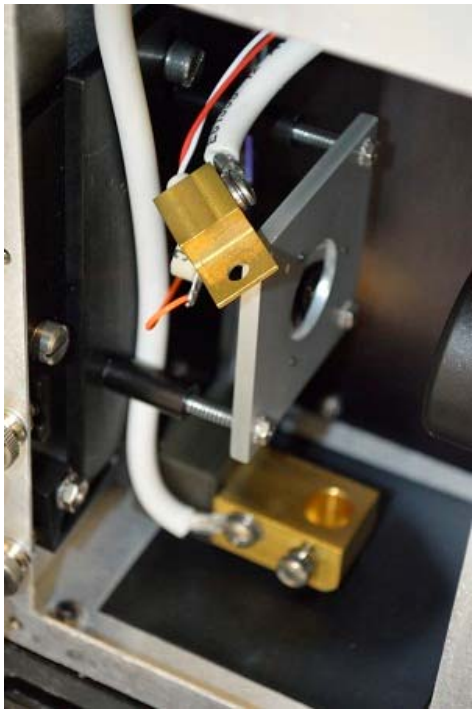


Figure 6: Preparing for Lamp Installation

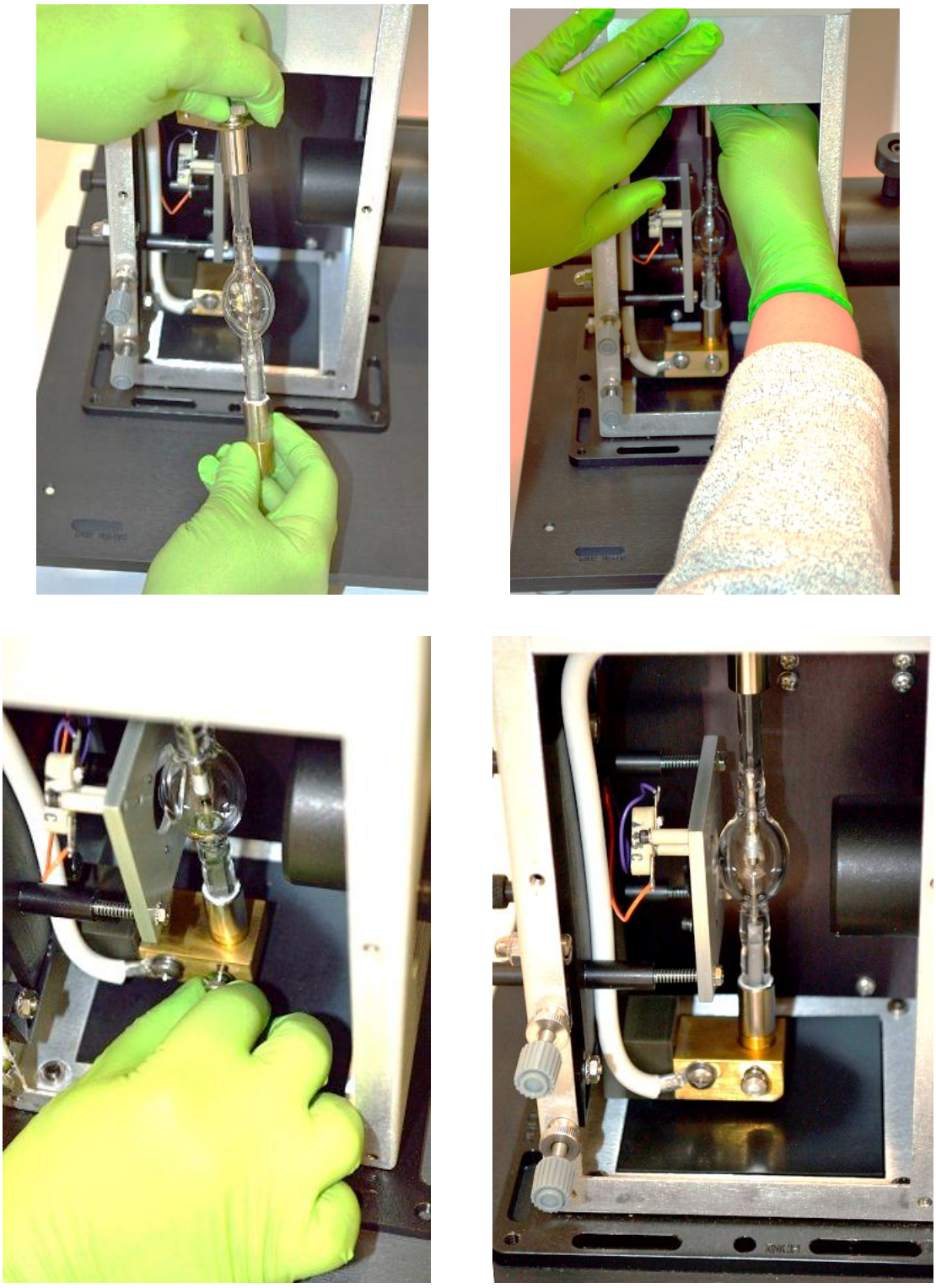


Figure 7: Installing the Lamp

SAMPLE RAIL INITIAL SETUP

A lens assembly is provided with a 32mm focal length lens installed. The lens assembly must be connected to the output of the monochromator in order to illuminate the reference detector and sample with a focused spot of light. Remove the protective cap from the monochromator output and the mating end of the focusing assembly. Install the lens assembly using the hex wrench provided with the system. Leave the second protective cap on the end of the lens assembly when the system is not in use.

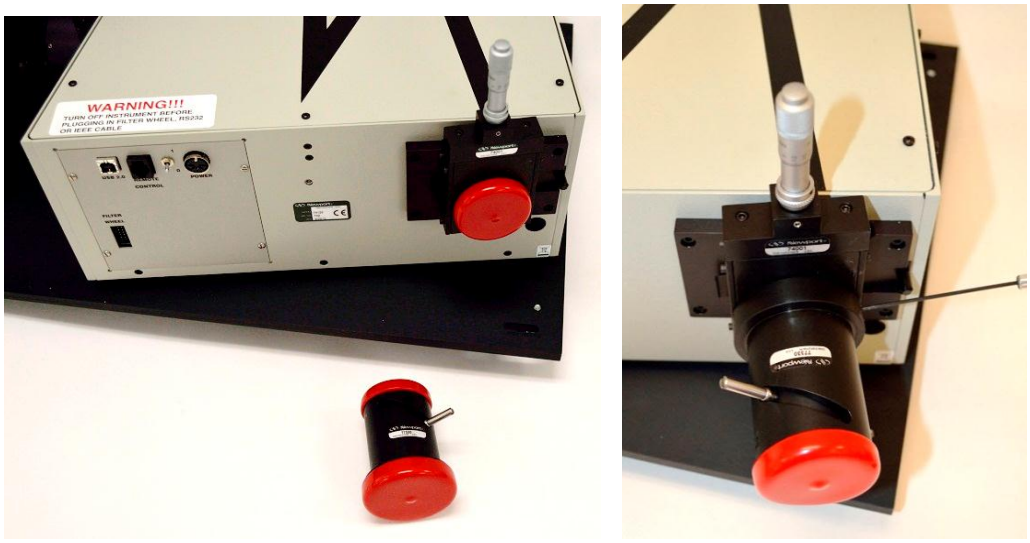


Figure 8: Focusing Lens Assembly Connection

Assemble the optical rail as shown below. The rail may be permanently mounted to an optical table or breadboard, if desired. The rail must be located so that the light is focused onto the active area of the reference detector and sample, as each is slid into position in front of the detector. Verify the location of the rail after the system is powered up and a visual alignment can be performed.

Figure 9: Optical Rail Assembly

CABLE CONNECTIONS

Note: Do not switch any device to “on” prior to making and verifying all connecting are properly made. Instrument damage may result.

Light Source Connections

Power cables may be connected to the instruments. However, connections to the electrical mains should be done after all other cables have been installed and it is verified that the monochromator, power supply and lock-in amplifiers are in the OFF position.

Connect the 70050 cable between the lamp housing and the power supply. Verify the power supply’s switch on its front panel is in the OFF position. Connect the power cord to the power supply.

Figure 10: Power Supply Connections

NOTE: it is important that these connections be tightened completely, to prevent arcing and damage to the system. Damage due to poor electrical connections is not covered under warranty.

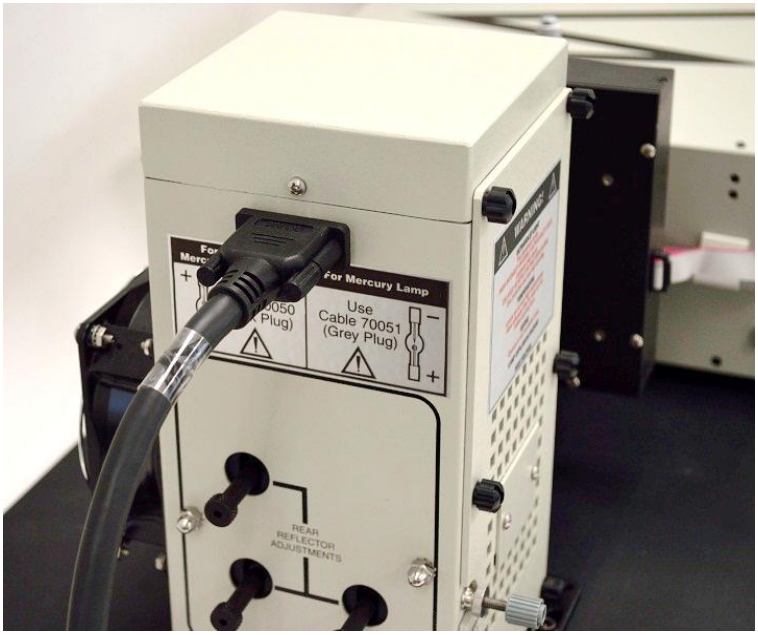


Figure 11: Lamp Housing Cable Connection

The ribbon cable connecting the monochromator to the filter wheel assembly is installed prior to shipment. Connect the power adapter and USB cable to the monochromator. Verify the monochromator's power switch is in the OFF (O) position. Insert the power cord into the power adapter.

Do not connect the USB cable to the computer until the TracQ Basic software is installed.

Filter Wheel Connection

Ensure the 12 pin ribbon cable connecting the monochromator to the filter wheel assembly *is installed before turning on the monochromator*

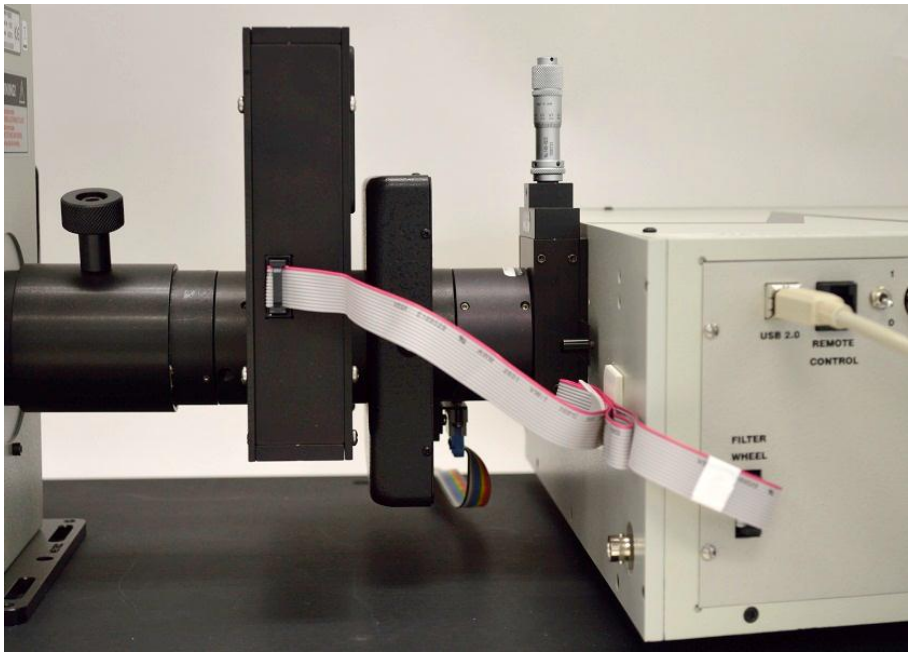


Figure 12: Filter Wheel to Monochromator Connection

Chopper Controller to Chopper Wheel Connection

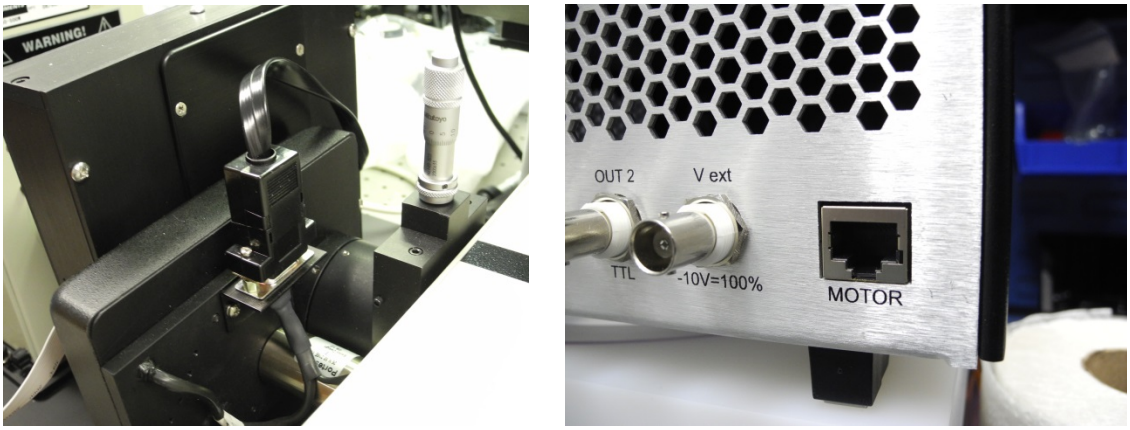


Figure 13: Chopper Controller (CAT 5) to Chopper wheel Connection (9-pin DSub)

Monochromator Connection

Important note: Do not connect the USB cable to the computer until the TracQ Basic software is installed.

Verify the monochromator's power switch is in the OFF (O) position. Connect the power adapter and USB cable to the monochromator. Insert the power cord into the power adapter.

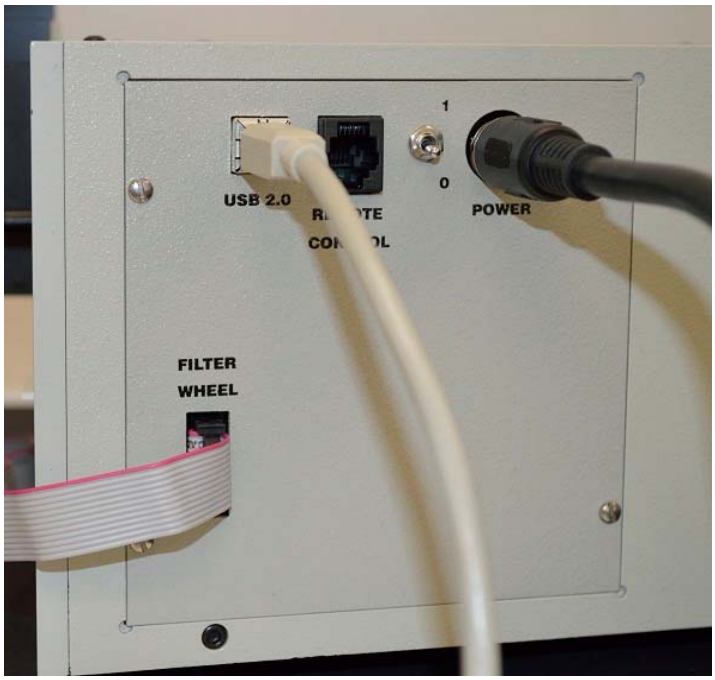


Figure 14: Monochromator Connections - USB to Computer and Power Adapter Input

Reference Detector Connections

Power is delivered to the reference detector from the SRS810 lock-in amplifier using a coiled cable with a Hirose 5-pin round connector on one end and a 9-pin DSub connector on the opposite end. The supplied cable reduces the ±20V output from the SRS810 "Preamp" output on the back panel to +-15V input to the reference detector as shown in Figure 15.

Figure 15: Power to the Reference Detector from the Preamp output of the SRS810.

A BNC/BNC cable is used to connect the signal output from the Reference detector to the input of the SRS810 front panel “A/I” in the “System Input” region as shown in Figure 16.

Figure 16: Reference Detector Connection to the SRS 810

Sample Detector Connections

Connect the mini clips to the connector on the back of the sample provided with the system. The Red lead attaches to the left most pin on the back of the PCB and the Black lead attaches to the rightmost pin as shown in Figure 17. This sample was tested and the factor and its quantum efficiency are included on the USB thumb drive to compare the QEPVSI-B system performance upon arrival. Note that the sample holder appearance may vary from the photograph shown below. Connect the BNC end of the cable to the input of the current preamplifier as shown.

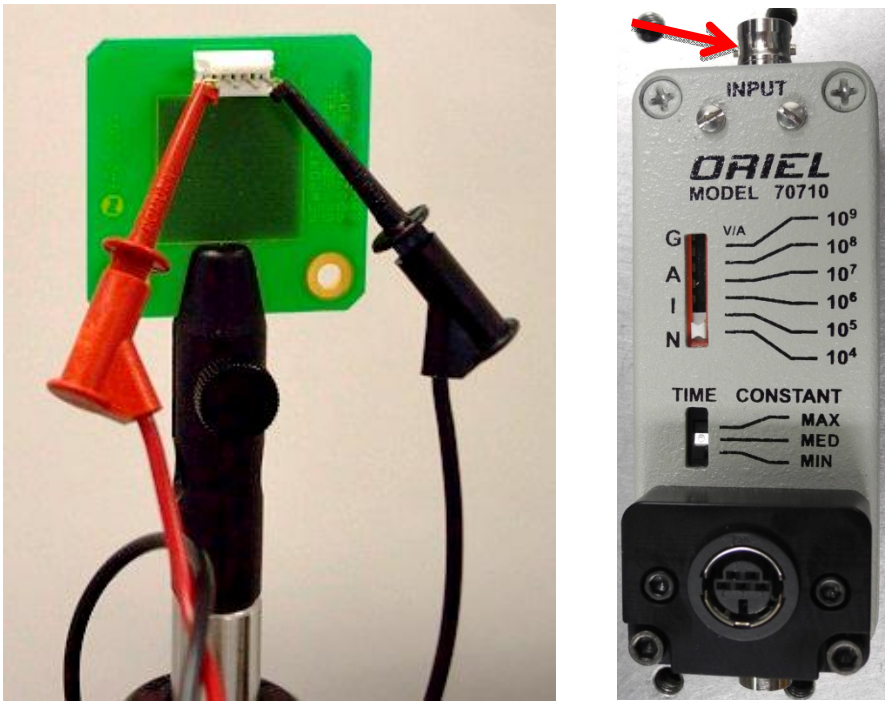


Figure 17: Sample Cell Connections to Current Preamplifier

Note: both the power cable and BNC signal cable will be removed from the Reference Detector and connected to the power and BNC signal on this current preamplifier when it is time to measure the sample cell.

Refer to the user's manual for the lock-in amplifier if it is necessary to change the setting

Chopper to Lock in Amplifier Connection

Connect the front panel "synth-out" on the New Focus Chopper Controller to the "ref-in" port on the front panel of the SRS 810 Lock-in amplifier as shown in Figures 21. .

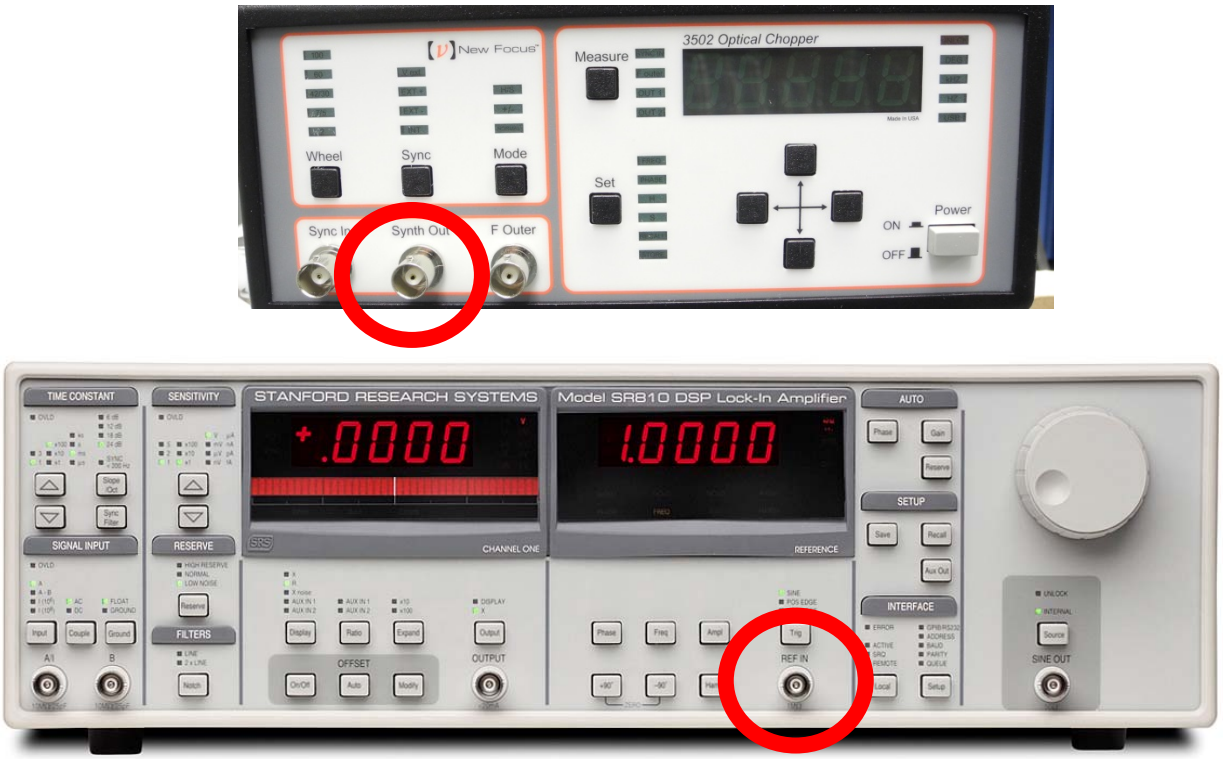


Figure 18: Chopper Synth Output to SRS 810 Ref Input

Connect the USB/GPIB cable between the computer and the SRS GPIB connector after installing the TracQ Basic software.

Figure 19: IEEE 488-2 GPIB Port for Computer Control Connection

As a final check, verify all connections including the front and back panel connections the SRS lock-in amplifier as shown in Figures 21 and 22.

Lamp Ignition

The power supply has been factory configured for proper operation with the QE system. No adjustments to the settings are required.

To start the lamp, first switch on the power supply using the switch located on its front panel. There is no output until the Lamp Start button on the front panel of the power supply. A Xenon lamp will go to full power immediately after it has been ignited. The lamp must be allowed to fully warm up and stabilize prior to data acquisition.

By pressing the Display/Select button, one can observe the current, voltage, watts or lamp hours on the display. A red LED in the display area indicates which parameter is being shown. The average lifetime is 900 hours for the Xenon lamp provided with the system. Periodically check the lamp hours so that a replacement lamp may be ordered before the original lamp fails.

The lamp housing is cooled by its own fan. The fan speed is regulated by the electronics built into the lamp housing. An additional safety shutoff switch is also present to turn off the lamp in case of overheating.

When one is finished with using the system, use the Lamp Off button to turn off the lamp. While the power switch is left on, the lamp housing fan will switch to high speed to cool the lamp. This cooling process takes approximately 20 minutes. After this time has elapsed, the fan shuts off.

Note: Excessive ignition places stress on the lamp, wears away the arc lamp electrodes and will reduce lamp life. Always allow the lamp to cool off completely before re-igniting it. If there are any difficulties igniting the lamp, refer to the troubleshooting section of this manual for possible causes of lamp ignition failure and power supply error messages.

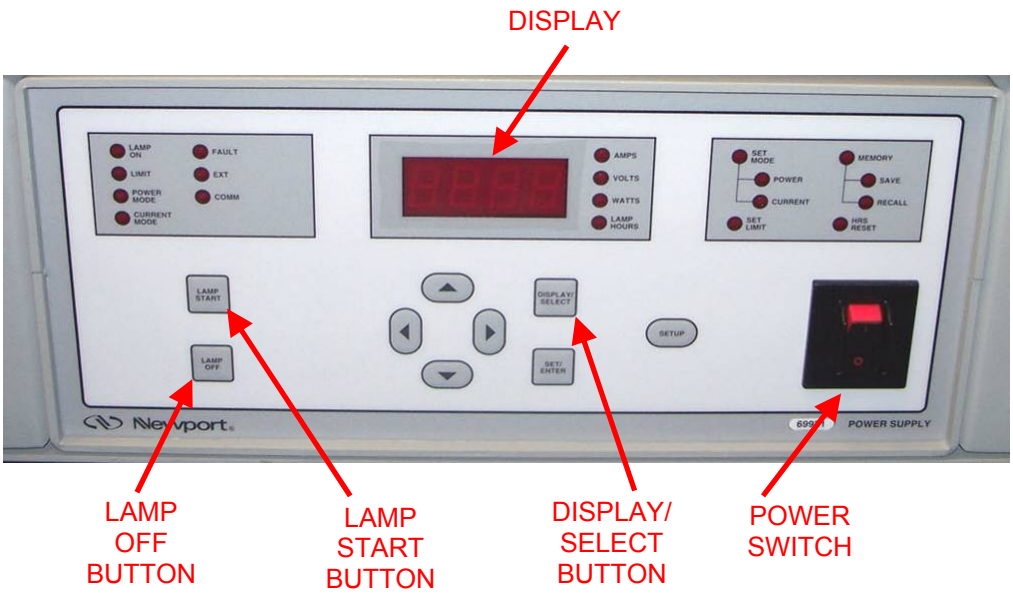


Figure 20: Power Supply Front Panel

Power on all Instruments

Please turn on the instruments as follows and adjust settings as described. Please allow the lamp to come to equilibrium after approximately 30 minutes before making measurements with the system.

- Set lamp to desired power output by pressing the “Set Enter” button for 3 seconds and adjusting the power setting (i.e. To 300W) using the arrow keypad.
    - Press “enter” to set lamp power value
    - Press lamp start to turn on lamp. Verify lamp comes on.
- Turn on CS260 monochromator by setting the small switch to “1” next to the AC power input. The monochromator will initialize itself.
- Turn on the SRS 810 using the rocker switch on the pack panel. The SRS810 will initialize itself.
- Turn on New Focus chopper controller using the power button on the front panel
    - Set wheel to “2”
    - Set sync to “int”
    - Set mode to “normal”
    - Measure can be left on any setting
    - Set Freq to 30Hz. Verify the chopper frequency by reading the “Freq” on the front panel of the SRS810

5 SYSTEM START UP

- ✓ Turn on lamp to 300W and let warm up for 30 minutes.
- ✓ Turn on chopper controller and adjust to the following settings:
  - o Wheel to “2”
  - o Sync to “int”
  - o Mode to ‘normal’
  - o Measure can be set to anything
  - o Set to “freq” and adjust frequency to 30 Hz
  - o Verify BNC cable connects from “Synth” to “REF IN” input on the SRS810 front panel. PHOTO
- ✓ Turn on SRS810 lock-in amplifier and adjust to the following settings:
  - o Time Constant – software will set this with your input
  - o Signal input to “A”
  - o Reserve to “low noise”
  - o Filters to “2x line”
  - o Display to “X”
  - o Press the Freq button to display frequency – should match the chopper controller reading
  - o Under Auto press the “phase” button.
  - o Under Interface cycle through the menu with the “select” button and check that the GPIB port is set to “2”
  - o Under Output press the Select button to turn OFF “internal” to the SRS locks to the chopper frequency PHOTO
- ✓ Turn on Reference Detector by plugging in the power cable from the SRS810.
  - o Set gain on Reference detector to “10^4”
  - o Select time to “min”
  - o Verify BNC cable connects the output of the Reference Detector to input on SRS810 labeled “A/1” PHOTO
- ✓ Turn on Computer and allow to boot up
  - o Verify GPIB-HS-USB adapter is connected from back panel of SRS810 to a USB port on the computer
  - o Verify USB cable is connected from the CS260 monochromator to a USB port on the computer

6 SETTING UP TRACQ™ ACQUISITION SOFTWARE

- ✓ Launch TracQ Basic 6.5
- ✓ Verify TracQ is in communciation to both the Monochrometer and the SRS810 by noticing green indicators by these instrument labels.
    - o If you have a red indicator on the monochromator, from the pull down menu choose Monochromator →Select Monochromator Library Path… and browse the model number of your monochromator, such as *74125USB* folder.
        - ▪ Click on the Current Folder button
    - o If you have a red indicator on the Detection Instrument, from the pull down menu choose Detection Instr. →Select Detector Library Path… and browse the model number of your lock-in amplifier such as *SR810* folder.
        - ▪ Click on the Current Folder button
        - ▪ You may also check the GPIB port the software is pointing to. From the menu, select Detection Instr. → Setup Communications and verify the GPIB address is set to *2*

Setup Parameters for the Monochromator:

- ✓ From the menu, select Monochromator →Setup Parameters…
    - o Verify your settings match the factory defaults. These can be changed in the future if desired. Click on *Ok* when finished
    - o From the menu, select Monochromator → Wavelength Units… to set the units you wish your data to be reported in…
    - o From the menu, select Monochromator → Gratings… to verify the gratings match the following change over wavelength parameters.
    - o From the menu, select Monochromator → Filters… to verify the filters match the following change over wavelengths
    - o From the menu, select Monochromator → Port… to verify the output port is set to *AUTO*. Select Ok to exit menu.

Set up SRS810 Lock-in Amplifier

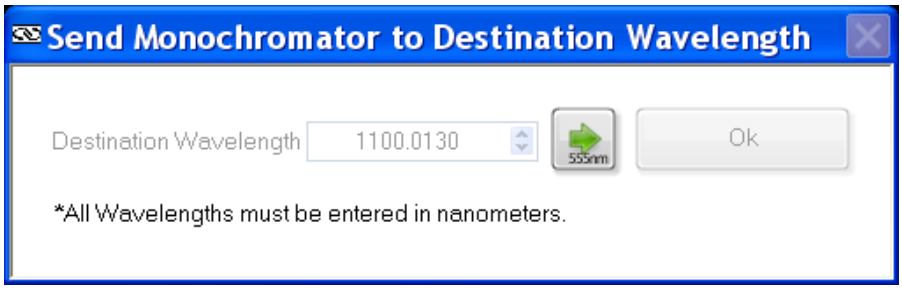
- o From the menu, select Detector Instr. → Setup Parameters… to verify the filters match the following change over wavelengths
- o Verify the SRS810 control panel matches the following settings. Note that the *Frequency* is a read-only value and cannot be changed.

Now you are ready to make some measurements on your samples!

7 MEASURING A PV CELL

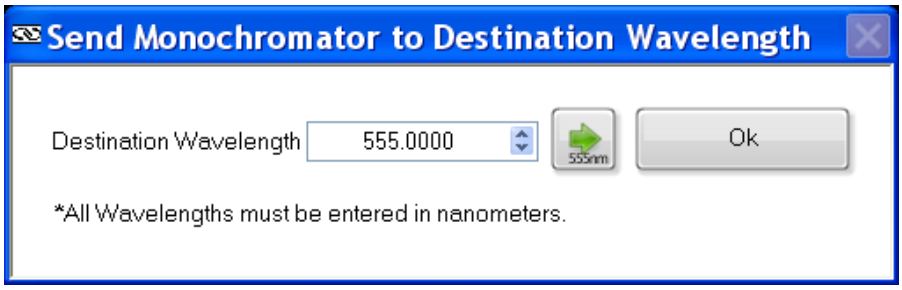
Initial Sample Alignment and Setup

Click on the  button on the TracQ front panel to set the monochromator wavelength to something you can see, like 555nm (green). There is nothing special about 555nm, it is just easy to see and easy to remember. The following pop up comes up the first time:

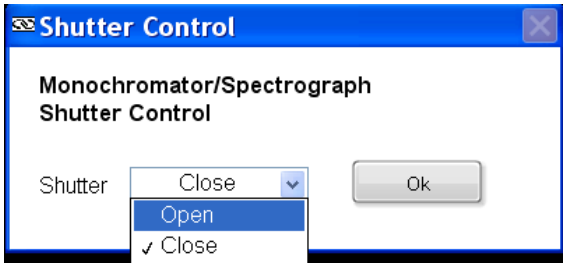


Note that the destination wavelength is greyed out and cannot be adjusted the first time the wavelength is set per use of TracQ.

Please press the green arrow  to automatically send the wavelength to 555nm. You will hear the monochromator shift to this wavelength and, when complete, returns you to the destination wavelength window. Select Ok to exit the window.

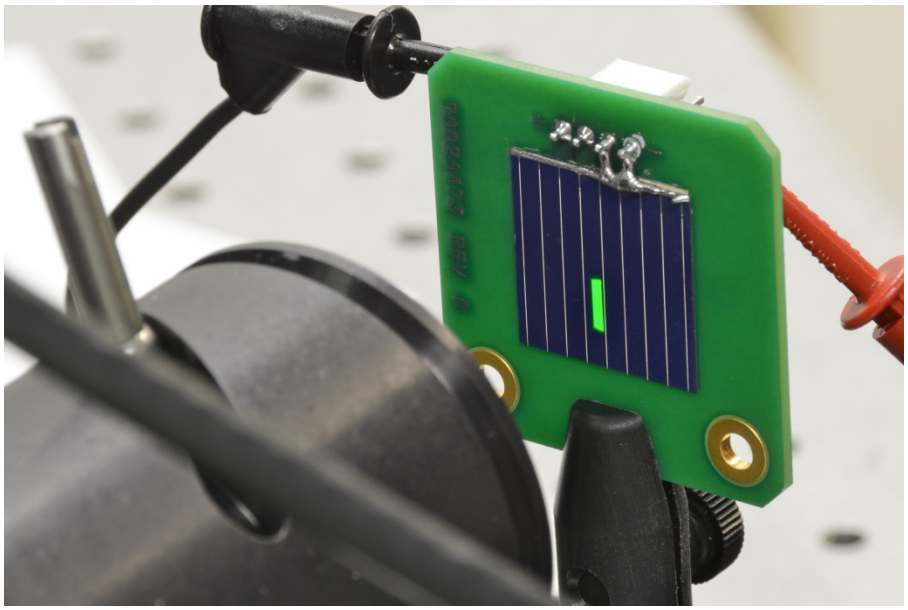


You should now be able to see a green rectangle of light exiting the monochromator. If you cannot see this, verify the shutter is open on the monochromator. From the menu, select Monochromator → Shutter…

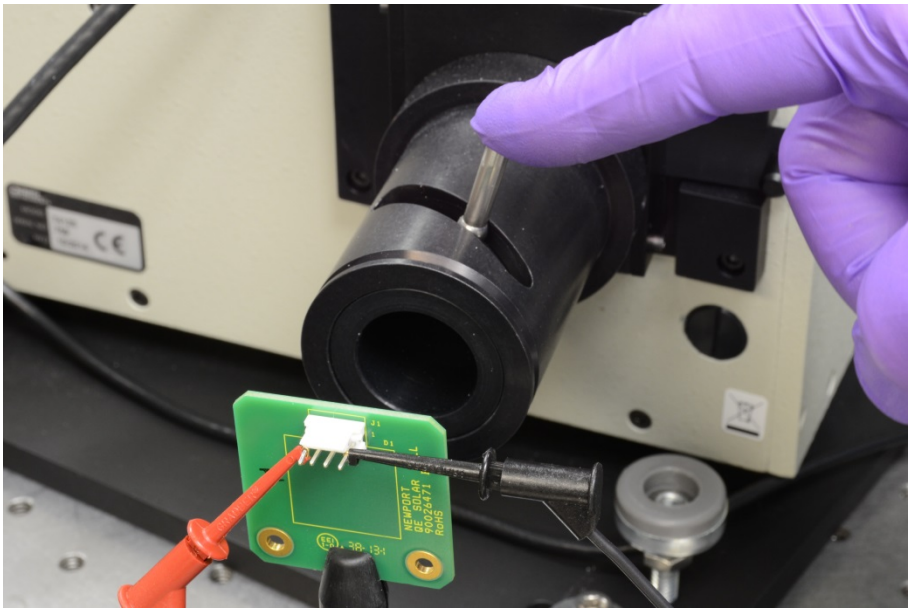


Place your sample (sample cell shown) centered on the beam at approximately 40mm from the output of the monochromator.

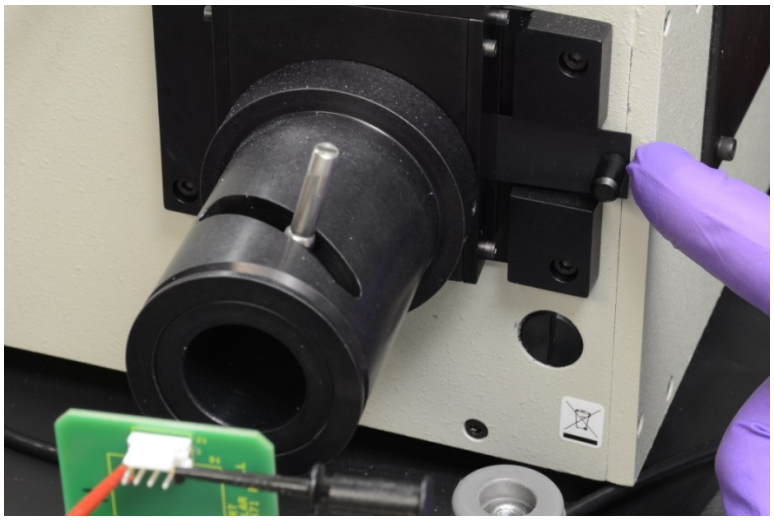
Adjust the distance between sample surface and monochromator output tube to bring the edges of the beam into a sharp rectangle on the surface of the sample.



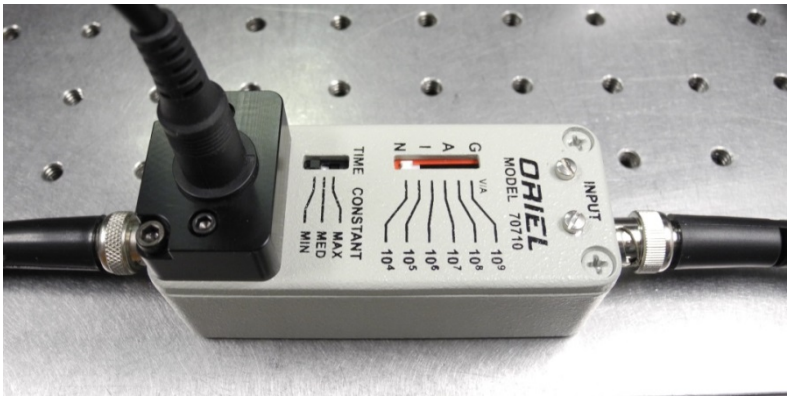
Adjust the output lens position to make a small adjustment of the beam size with the goal of squeezing the beam entirely within the electrodes on the cell. The distance of the cell from the monochromator output will have to be re-adjusted to bring the beam back into sharp focus after the output lens has been adjusted.



Adjust the vertical size of the beam using the horizontal slider on the output slit. The sample position will not need to be adjusted after changing the slit height.



Connect the *input* from the signal preamplifier to the sample using supplied clips or probes with a BNC connector on the opposite end. Set the GAIN to 10^4 and the Time Constant to MIN as shown. Note that the power cable from the Preamp output from the SRS is connected to the front 5-pin Hirose Power input on the amplifier.



Connect the power to the preamplifier and the *output* BNC to port *A/I* on the SRS810 using a BNC/BNC cable.

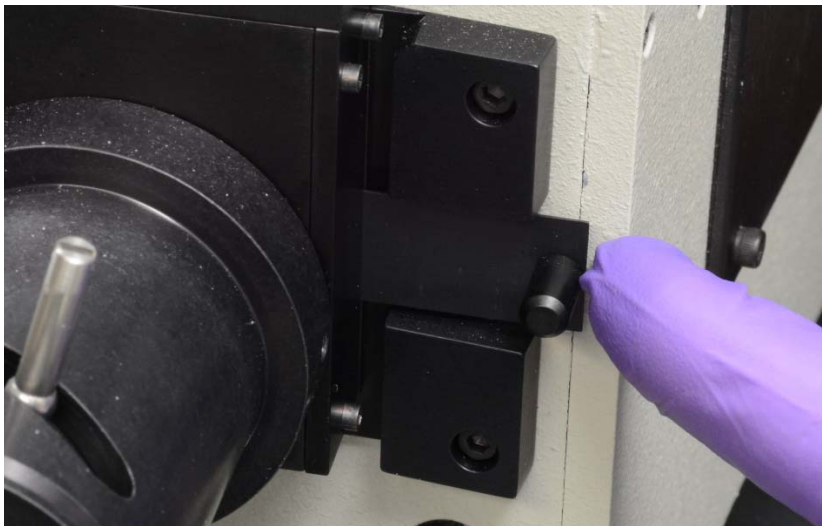
Press the Auto Phase to allow the SRS810 to lock to the phase difference between the chopper sync signal and the pulse light signal from the sample cell. The auto phase can be pushed a few times to verify the lock-in phase is consistent.

Set the sensitivity on the SRS810 to 1x1 Volt.

As a general rule, the voltage measured from output on the sample cell should be <0.2V in order to keep from saturating the 1Vmax signal on the lock-in amplifier during a wavelength scan from large emission peaks produced by the Xe lamp

If the measured value exceeds this level, there two ways to reduce the intensity of the light on the sample to keep it from saturating the lock-in amplifier

Reduce the beam height on the sample, thereby the beam intensity, by reducing the height by reducing the vertical slit on the horizontal slider setting.



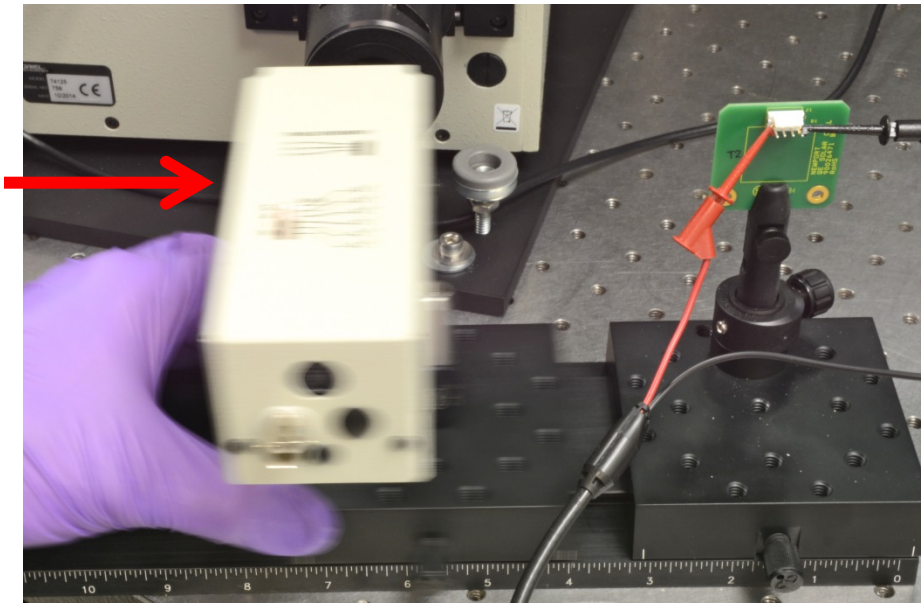
Reduce the front and back slit on the monochromator. Reducing the slits will reduce intensity and the bandwidth of the incident beam on the sample according to the following chart:

Slit A = B setting (um)	Spectral Bandwidth (nm)
100	
200	
300	
400	
500	
600	
700	
800	

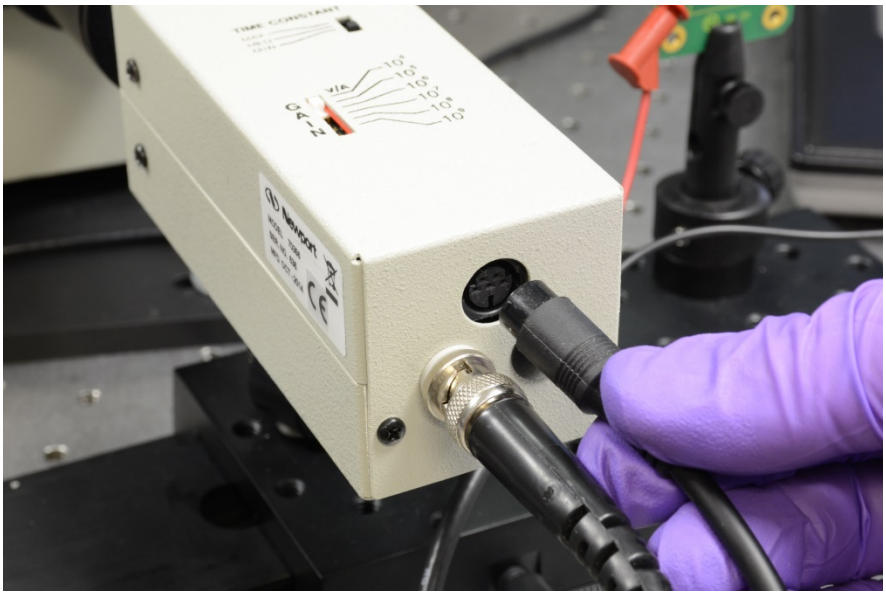
Be sure to match the slit settings in order to achieve optical bandwidth resolution.

Please do not change the beam focus to reduce power. This will reduce the spot size on the diffraction grating in the monochromator reducing the bandwidth resolution an unknown amount.

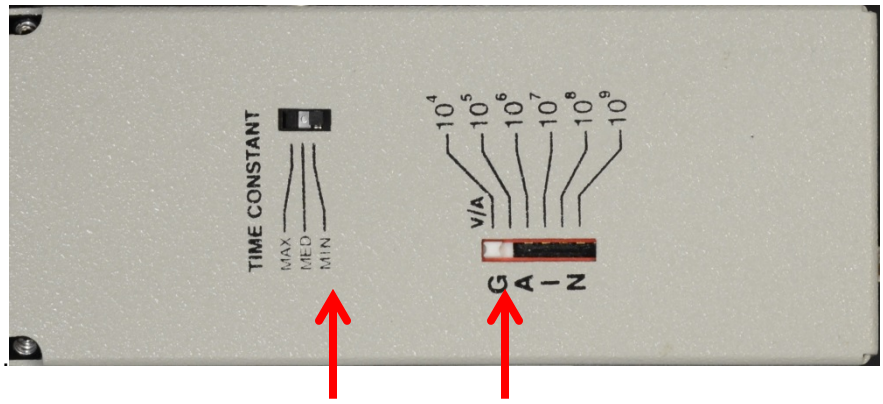
Now that the sample cell is set up appropriately, replace it with the supplied calibrated reference detector.



Move the power cable and BNC cable from the sample amplifier to the back panel of the reference detector.

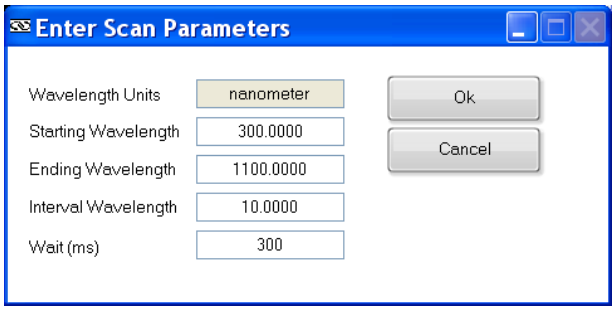


Set the GAIN to 10^4 and Time Constant to Min on the top of the reference detector.



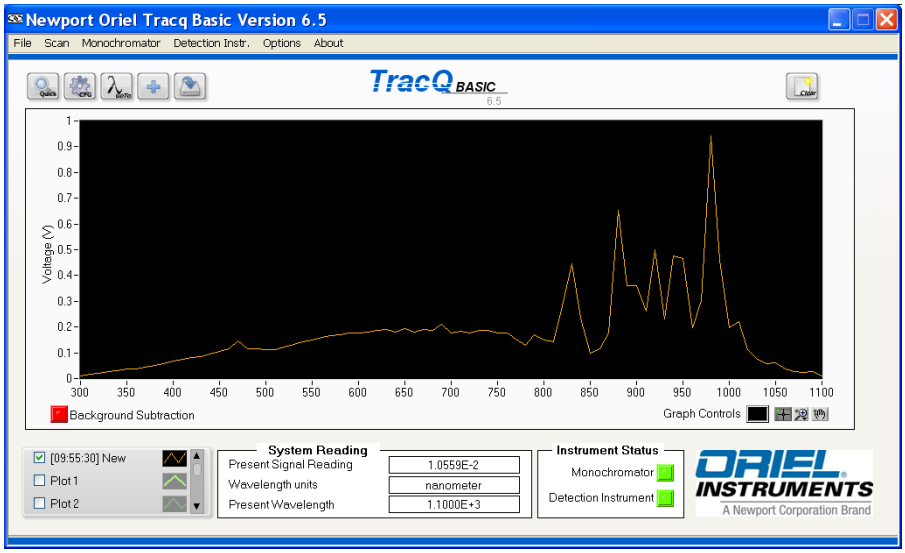
Make a First Reference Scan – ref1:

From the TracQ menu, select Scan →Enter Scan Parameters and adjust the scan parameters to the following settings. Click on *Ok* when finished.

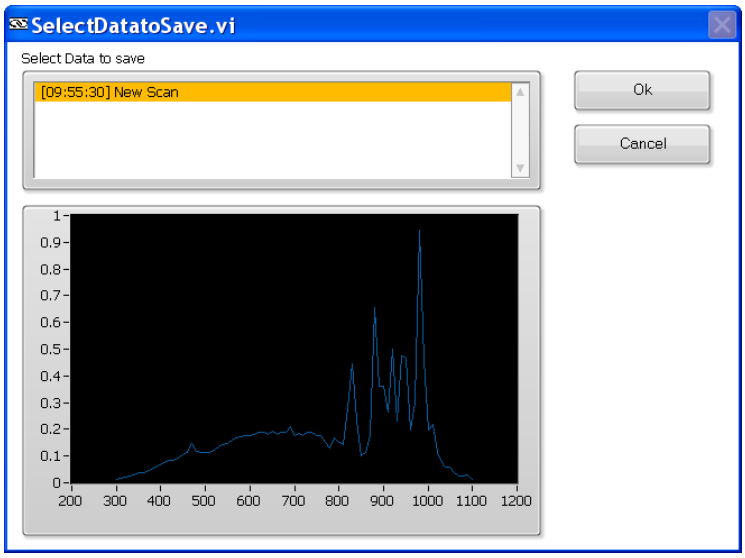


Click on 

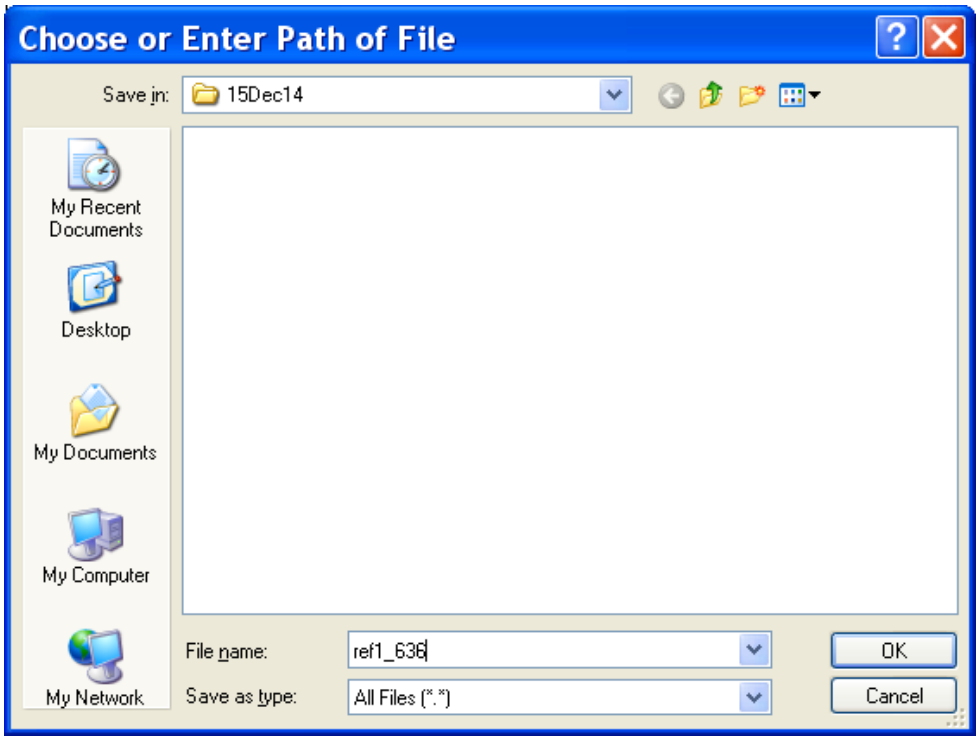
to perform a wavelength scan on the reference detector. The monochromator will automatically reset to the start wavelength and step through each interval wavelength, recording the detector signal from the lock-in amplifier at each step, until the ending wavelength is reached.



After the scan is complete, click on  to save the data. A pop up window will appear that allows you to choose the scan you wish to save, in this case, there is only one. Highlight the New Scan and click on *Ok*.

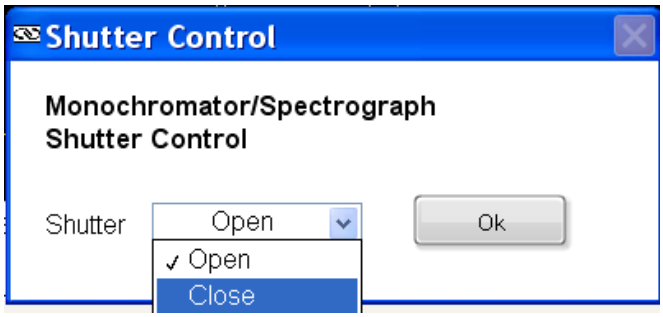


Save file as ***ref1_636***. The number 636 happens to be the last 3 numbers of the serial number of the reference detector.

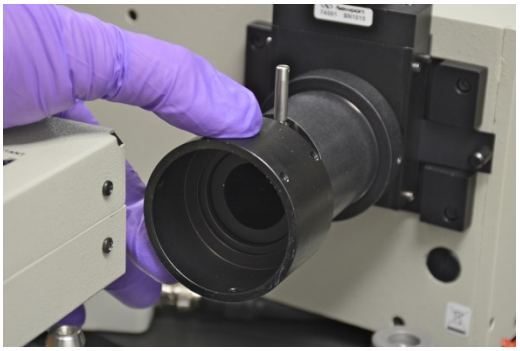


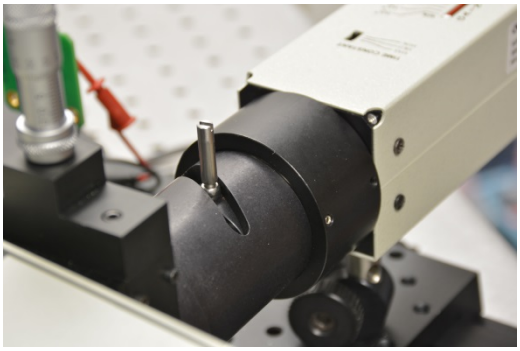
Make a Background Noise Scan – background:

Close the shutter on the monochromator by clicking on Monochromator → Shutter… Select *Close* from the pull down menu on the popup menu. You should hear the shutter physically close on the monochromator and the signal drop to 0000 on the SRS810. Click on *Ok* when done.



NOTE: For optimal data collection, it is helpful to minimize all light entering the detector for this and all subsequent scans. The lock-in amplifier naturally filters out modulated light above the chopping frequency (i.e. 30Hz), but low frequency, CW light or impulses like room lights being switched off/on can affect the data during a wavelength scan. Installing a Newport 71310 sleeve on to the output of the monochromator can help significantly in reducing unwanted light entering the reference detector and your samples.





Press the *Auto Gain* button on the SRS810 to automatically reset the instrument to increase the sensitivity to read the signal from the Reference Detector with no incident light.

After Auto Gain is complete, manually adjust the sensitivity +- one step from the front panel (i.e. from 2 x 10 uV to 1 x 10uV). This does two things:

- Takes the instrument out of auto gain mode so it doesn't change during a wavelength scan
- Keeps the signal from saturating *during* a wavelength scan.

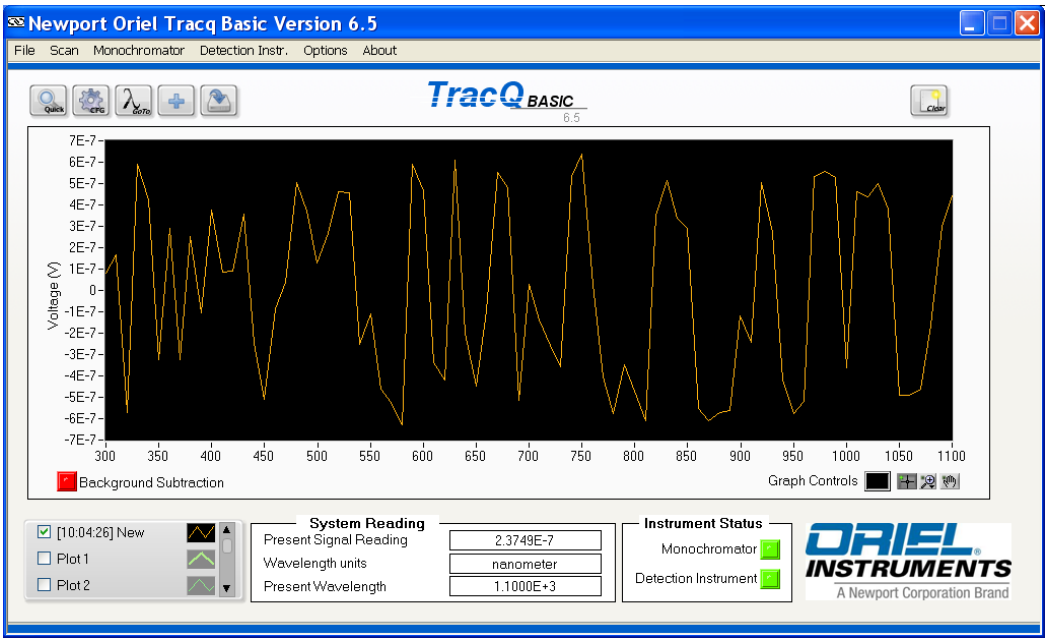
You know the sensitivity is too high when the red OVLD symbol appears on the display of the SRS. Reduce the sensitivity as needed to take the signal out of overload.

Click on 

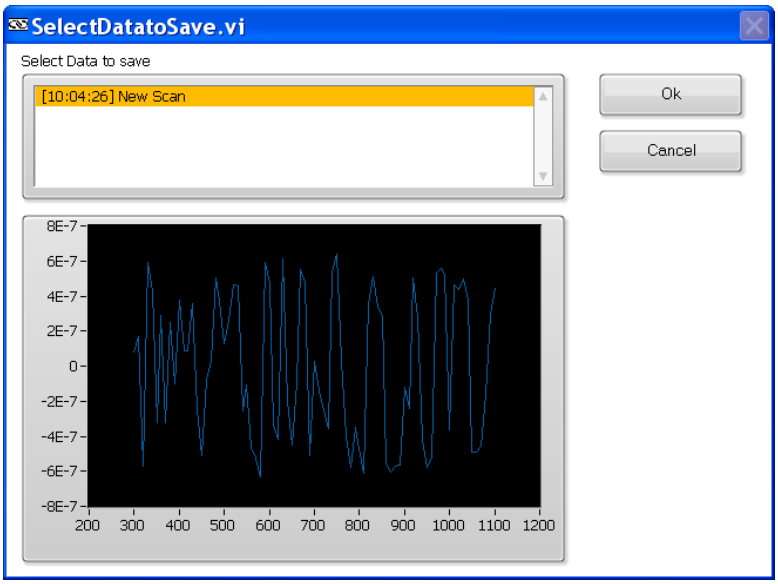
to clear the ref1_636 data from the screen. Clearing the screen will enable the auto scale feature of the plot to adjust to the much smaller signal of the background scan.

Click on 

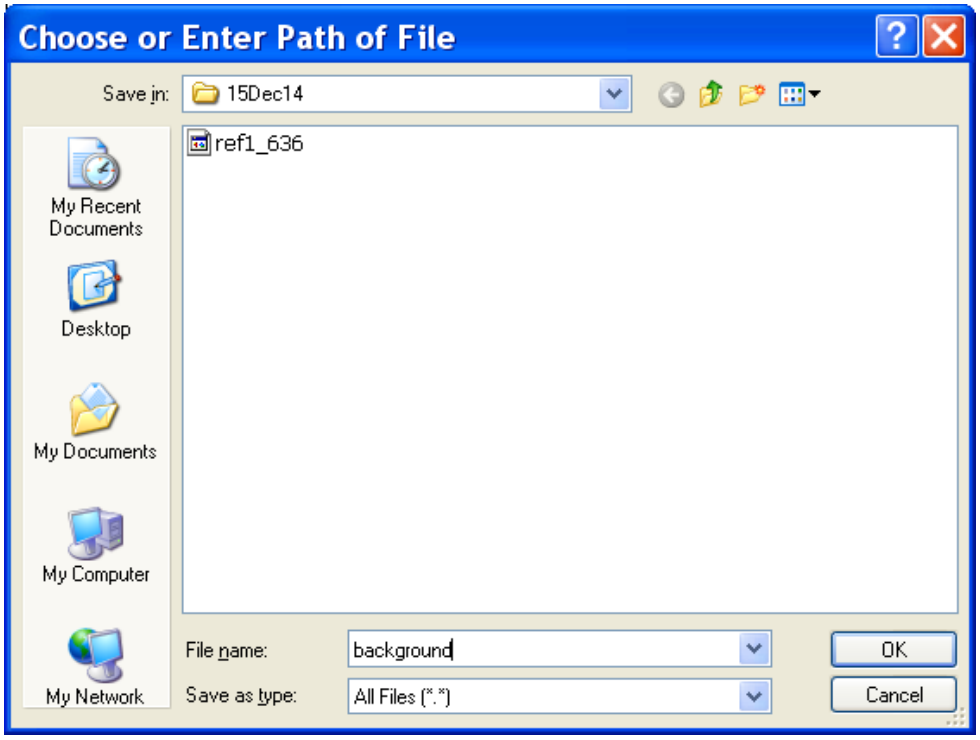
to perform a wavelength scan on the reference detector with no light to measure the background signal of the system.



After the scan is complete, click on  to save the data. Highlight the New Scan and click on *Ok*.

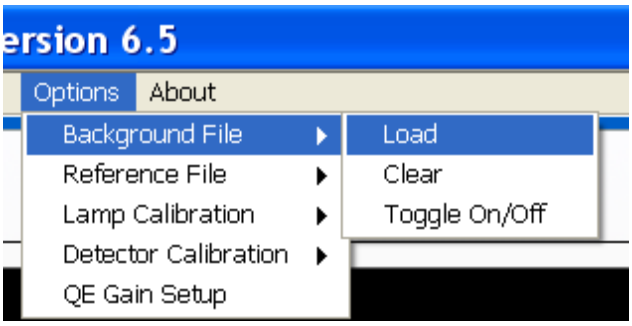


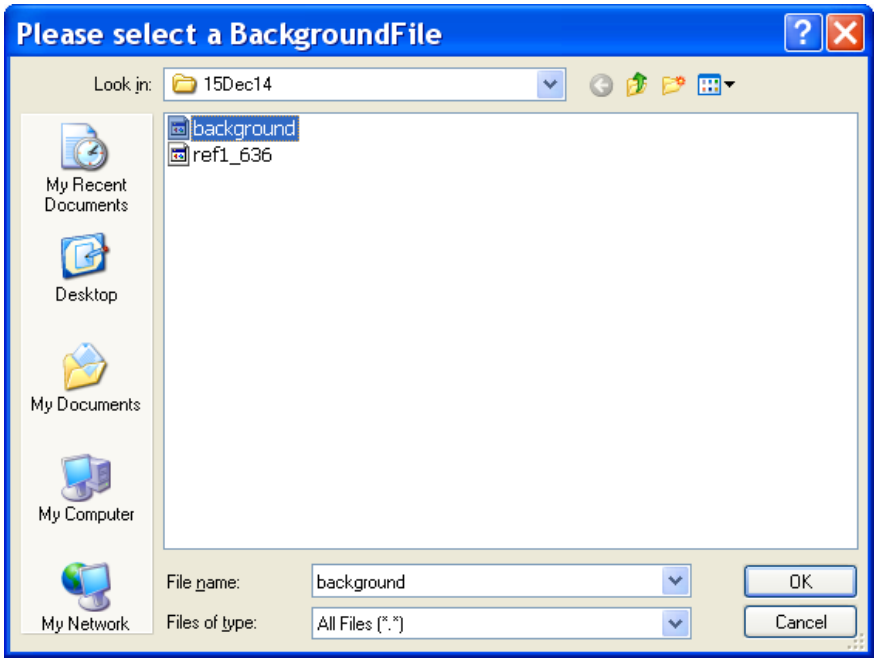
Save the file as ***background.***



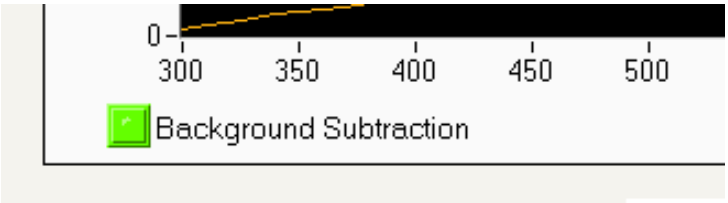
Make a Second Reference Scan – background: ref2

Now the background noise of the reference detector can be subtracted from all future wavelength scans performed with the reference detector. To subtract the background, select "Options → Load" and browse to the file you just named "background". Click on *OK* when finished.

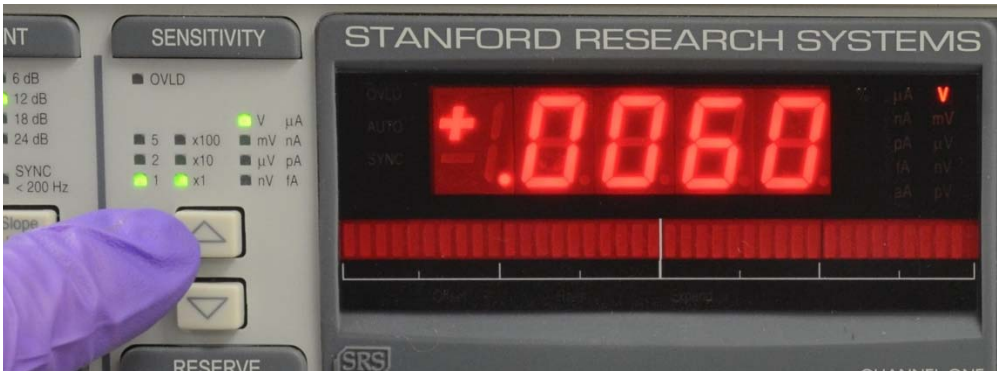




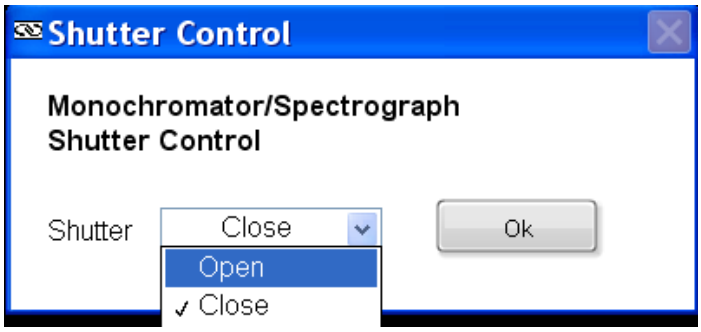
Notice that *Background Subtraction* is now highlighted green indicating that the present scan has the background data subtracted from the measured detector signal.



Adjust the *Sensitivity* of the SRS810 to 1x1V.

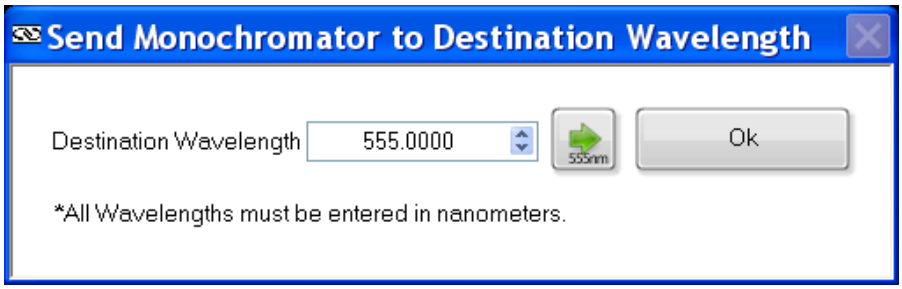


Open the shutter on the monochromator by clicking on Monochromator → Shutter… Select *Open* from the pull down menu on the popup menu. You should hear the shutter physically open on the monochromator and the signal increase on the SRS810. Click on *Ok* when done.



Click on the 

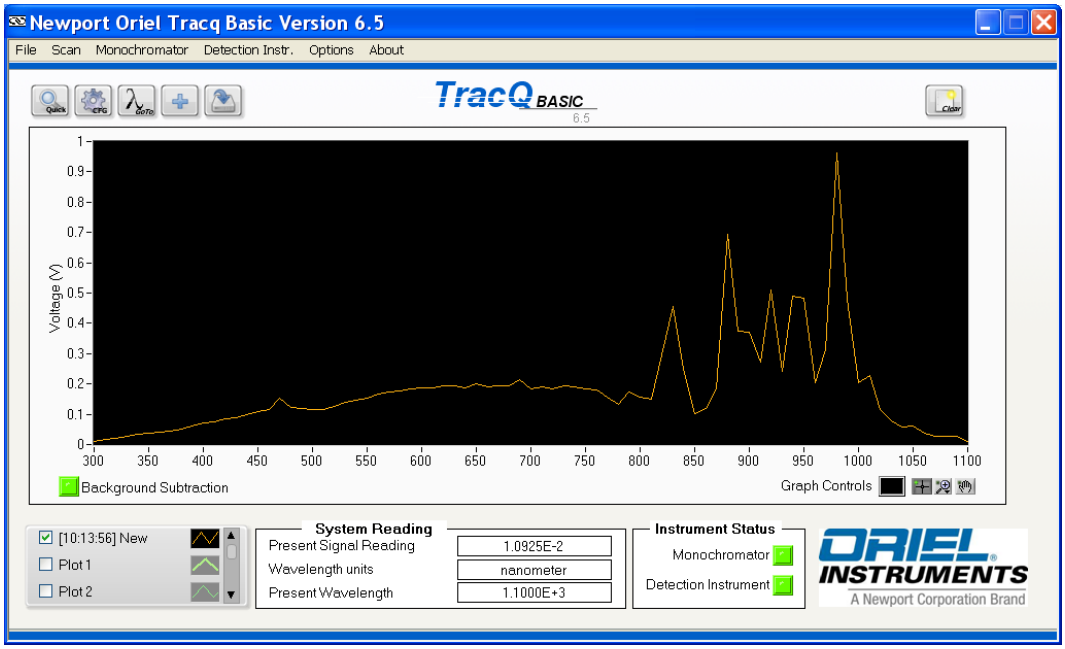
button on the TracQ front panel to set the monochromator wavelength to 555nm (green). When following pop up comes up, set the wavelength to 555nm and click on *Ok*



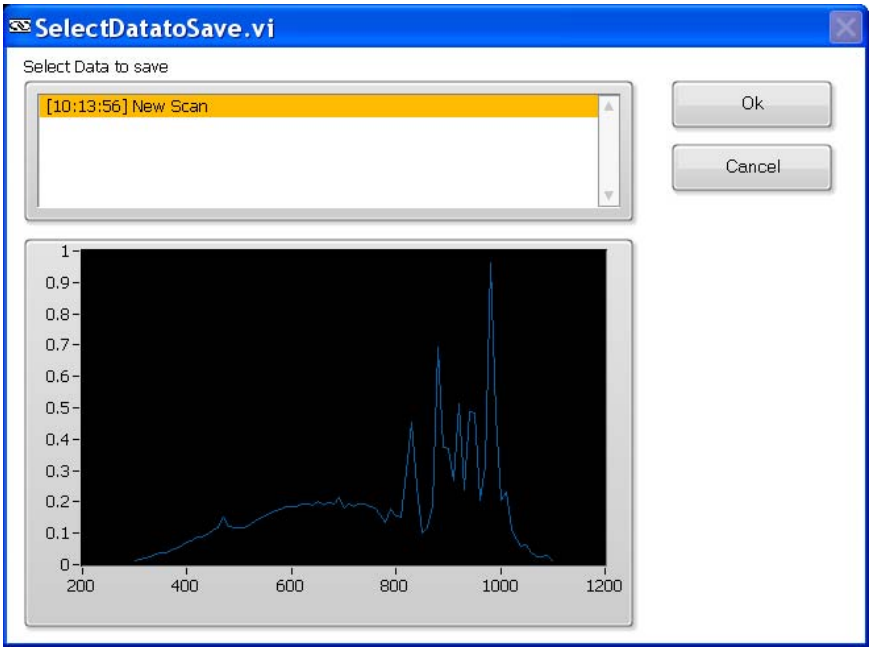
Verify the detector signal from the SRS810 is **<0.2V** to keep it from saturating during the wavelength scan.

Click on  to clear the background data from the screen.

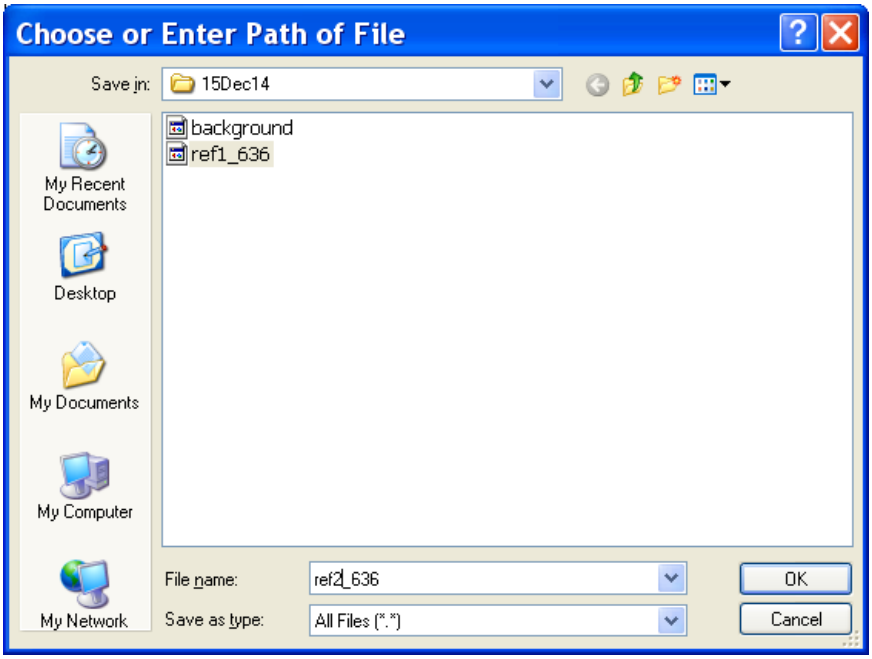
Click on  to perform a wavelength scan on the reference detector a second time with background subtraction on.



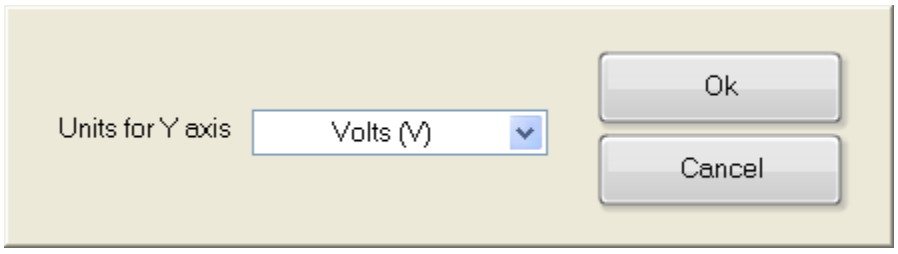
After the scan is complete, click on  to save the data. Highlight the New Scan and click on *Ok*.



Save the file as ***ref2_636***.

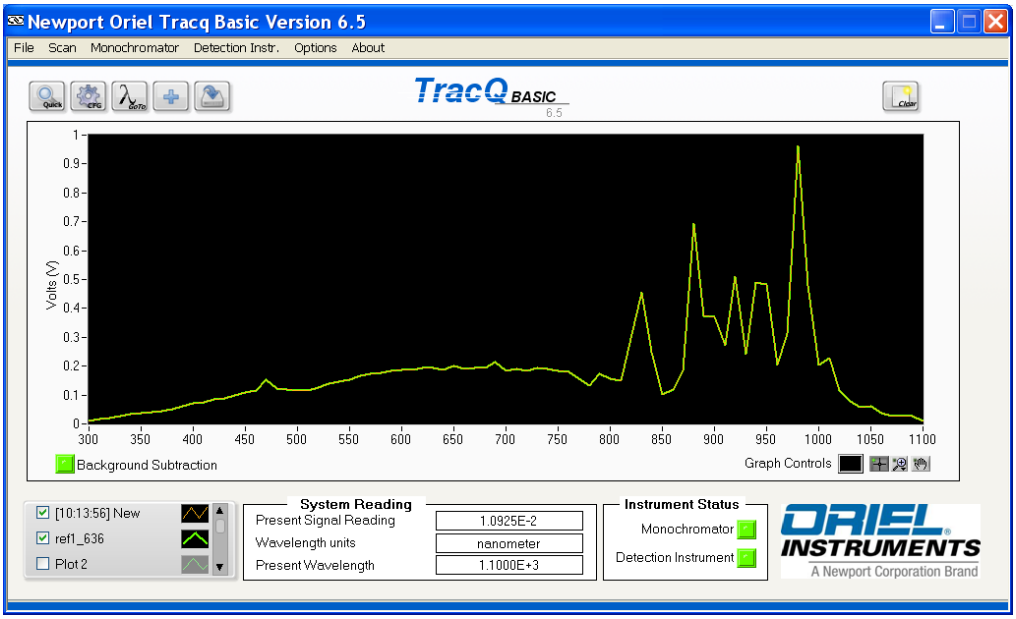


Load the first reference scan you made to compare the two reference scans to see if they are identical. From the menu on the TracQ front panel, select Options → Load… and the following popup is displayed.



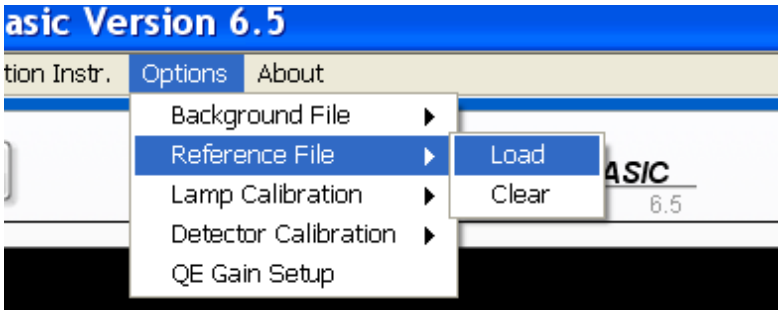
Choose *Volts (V)* from the pull down menu to display the ref1_636 scan as voltage vs wavelength to overlap the current ref2_636 scan for direct comparison.

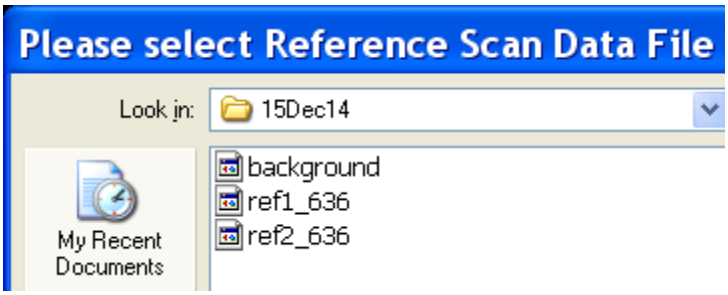
Browse to ref1_636, highlight the file name and click on *OK* to load the file. In the case shown below, both ref1 and ref2 scans overlapped almost perfectly giving the appearance of a single scan.



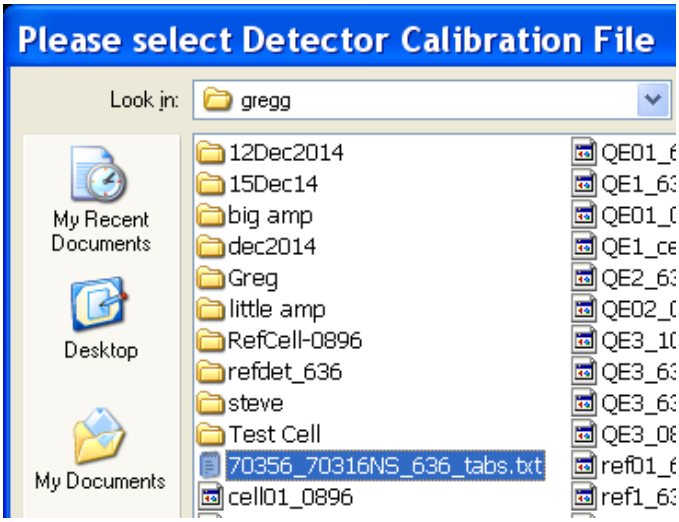
If the reference scans are identical, then background noise is low and bulb is warmed up. This is a good sign the system is stable and ready to make accurate measurements of you samples.

If you are satisfied, *load* the second reference file that TracQ will use to calculate a quantum efficiency measurement by selecting “Options” on the front panel to TracQ and select Reference file → Load → “ref2_636”





You can also load the calibration file for your specific Reference Detector by Detector Calibration → Load → "70356_70316N_636_tabs.txt". This calibration file for *your specific reference detector* is included on your USB jump drive. You can copy this txt file to your data folder for more convenient loading when needed. Your file name will differ from the one listed here based on the serial number of your detector.

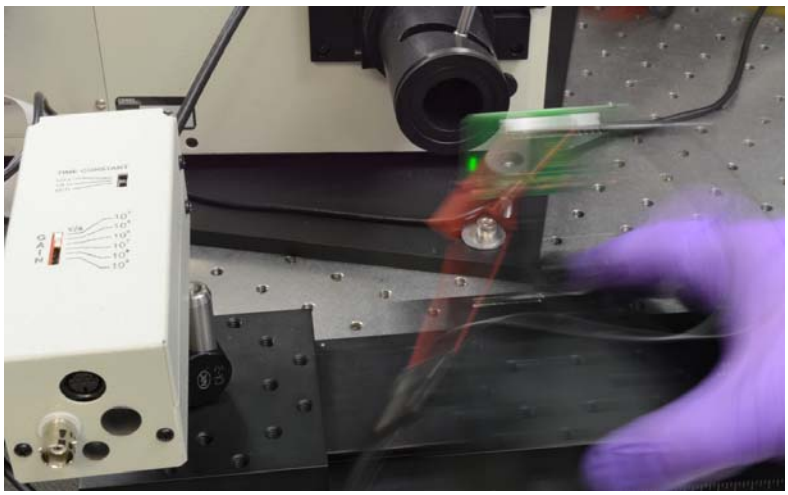


Now you have calibrated your QEPVSI-b for following wavelength scans of your solar samples or filter transmission.

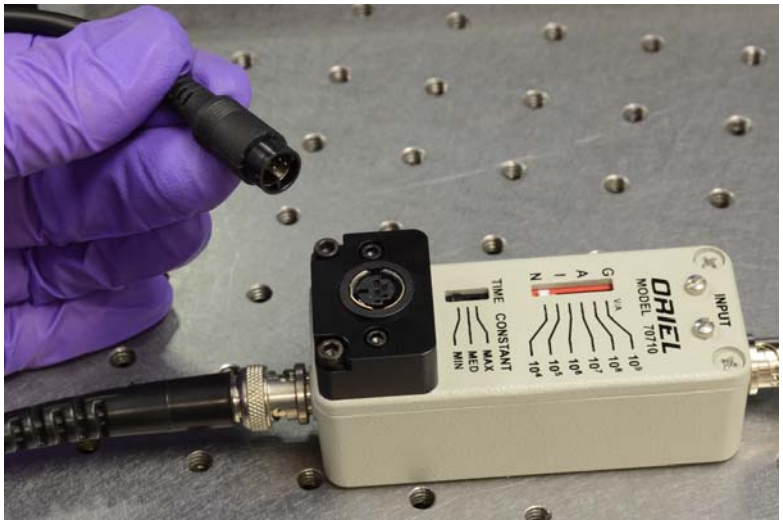
It is very important at this point that you resist modifying the QE_PV_SI instrument in any way from its current configuration before completing your test scans. For instance, do not turn off/on the lamp; adjust the collimation of the lamp, the input/output slits on the monochromator, the output lens position and the horizontal slider that controls beam height. If changes are made or you return to your system after a long period of time (many hours) in which the lab environment has changed, please repeat these calibration steps.

Align Sample and Set Up for QE Scans

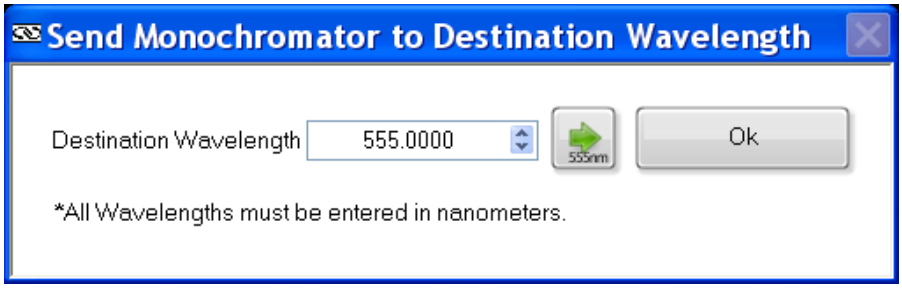
Slide the reference detector over and replace it with your sample that you originally aligned to the output beam of the monochromator.



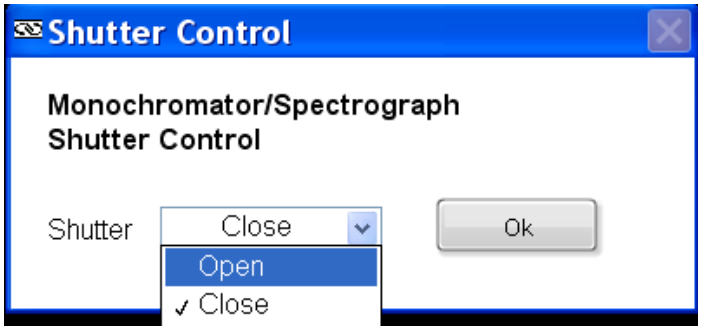
Move the power cable and BNC cable from the reference detector back to the sample amplifier. Verify the GAIN = 10^4 and Time Constant = MIN.



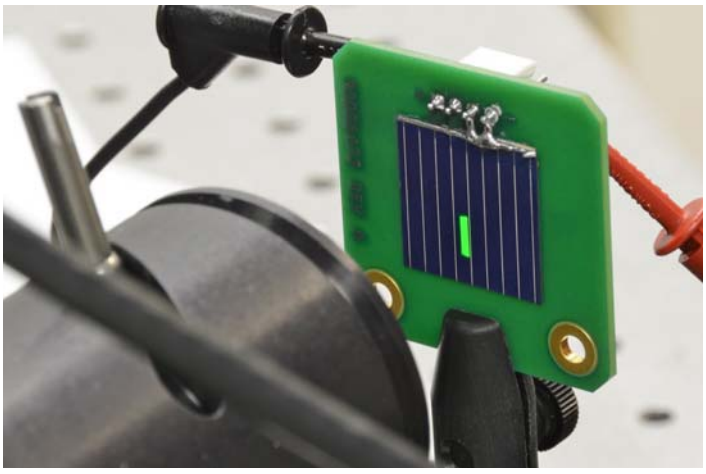
Click on the  button on the TracQ front panel to return the monochromator wavelength to 555nm (green) so you can align the beam on the sample. When following pop up comes up, set the wavelength to 555nm and click on *Ok.*



If you do not see the beam after resetting the wavelength to 555nm, the shutter may be closed. Open the shutter by selecting Monochromator → Shutter… and select *Open.*



Carefully position the sample so the beam falls completely between the bus bars on the sample for maximum sample cell output.

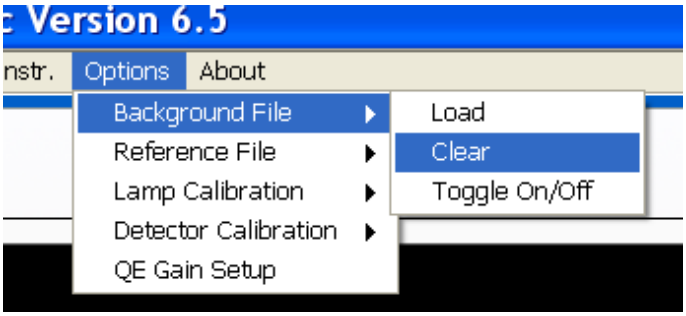


Press the Auto Phase to allow the SRS810 to lock to the phase difference between the chopper sync signal and the pulse light signal from the sample cell. The auto phase can be pushed a few times to verify the lock-in phase is consistent. The phase will likely be different from what it was previously when using the reference detector. This is normal.

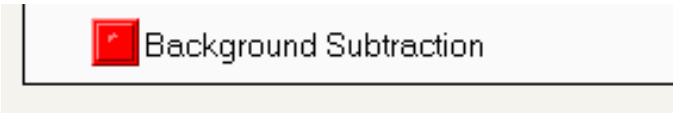
Verify the detector signal from the SRS810 is **<0.2V** to keep it from saturating during the wavelength scan. The reading should approximately match what it was during initial alignment.

Make a Background Scan of your Sample: Background_sample

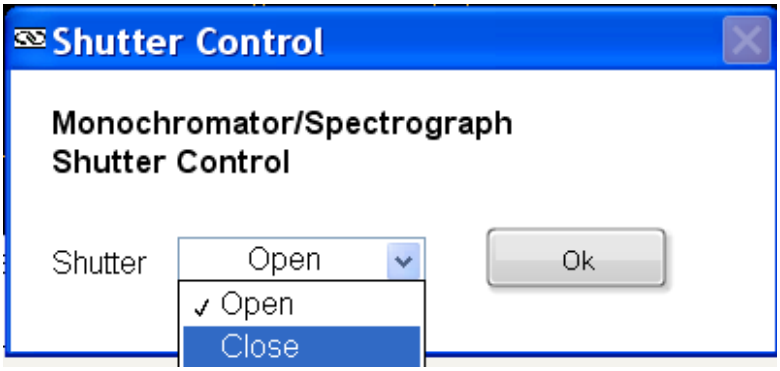
Now that you have verified the alignment and settings of your sample, you can make a background noise scan based on the sample amplifier. First we must remove the background file made by the reference detector. Select "Options → Background File → Clear" to clear the background subtraction.



Verify Background Subtraction is off by noticing the green indicator has become read.



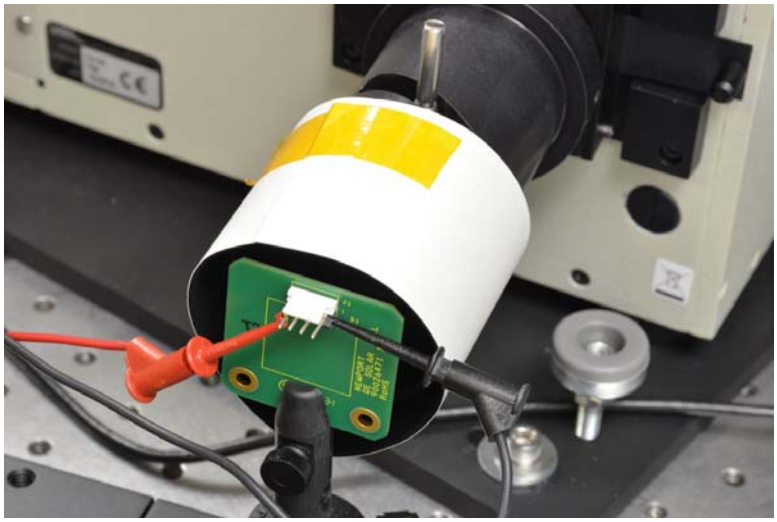
Close the shutter on the monochromator by clicking on Monochromator → Shutter… Select *Close* from the pull down menu on the popup menu. Click on *Ok* when done.



Press the *Auto Gain* button on the SRS810 to automatically reset the instrument to increase the sensitivity to read the signal from the sample cell with no incident light.

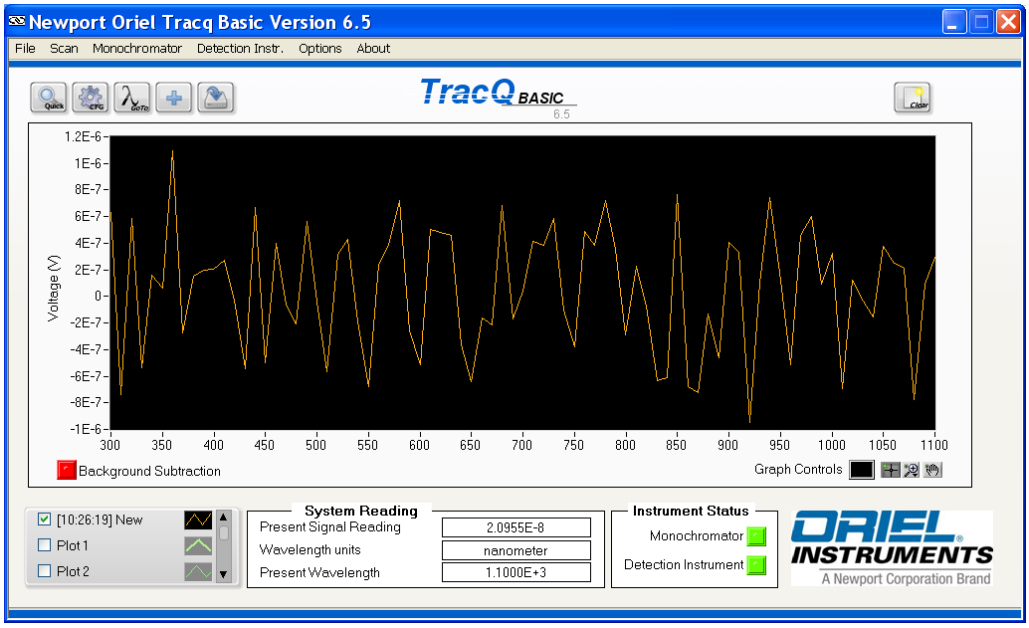
After Auto Gain is complete, manually adjust the sensitivity +- one step manually from the front panel (i.e. From 2 x 10 uV to 5 x 10uV).

Minimize light entering the sample cell by covering the sample from room lights and equipment lights. For instance, it can help to wrap a 50 x 200mm piece of black felt round the output sleeve of the monochromator. You can monitor the signal on the SRS810 to verify the signal on the detector is as low as possible.

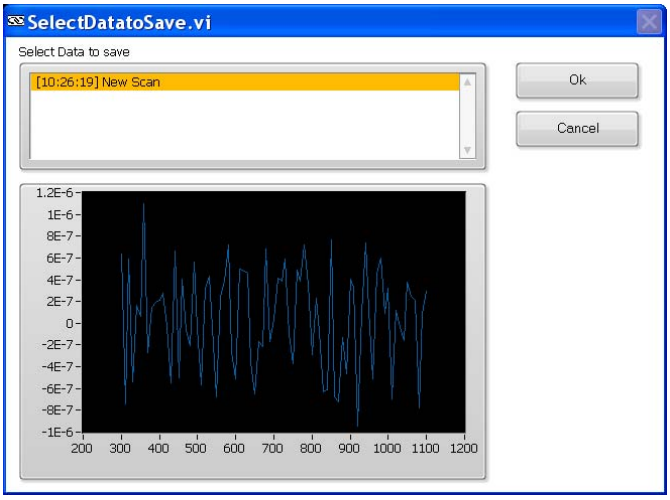


Click on  to clear the ref2_636 data from the screen

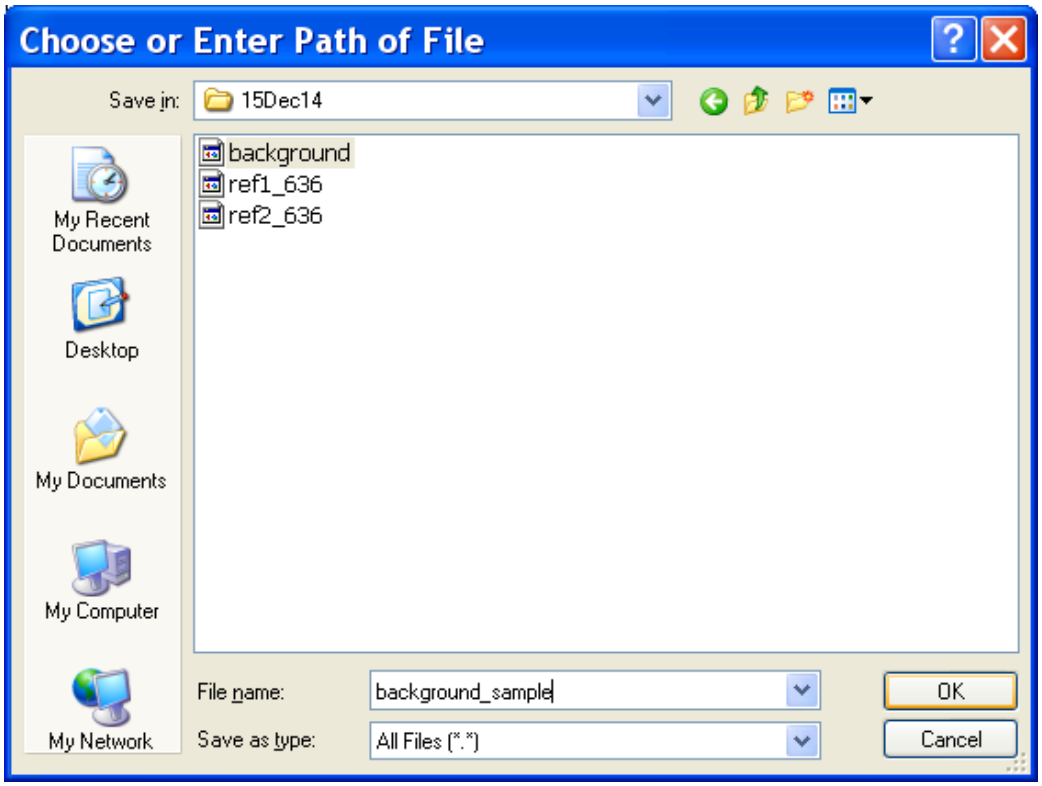
Click on  to perform a wavelength scan on the reference detector with no light to measure the background signal of the system.



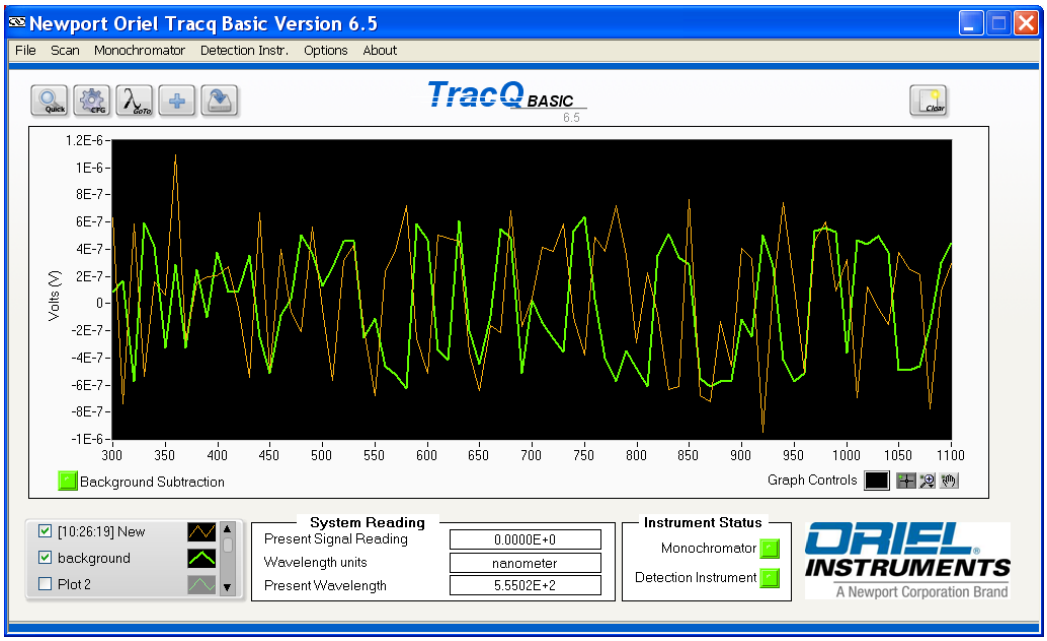
After the scan is complete, click on  to save the data. Highlight the New Scan and click on *Ok*.



Save the file as ***background_sample.***

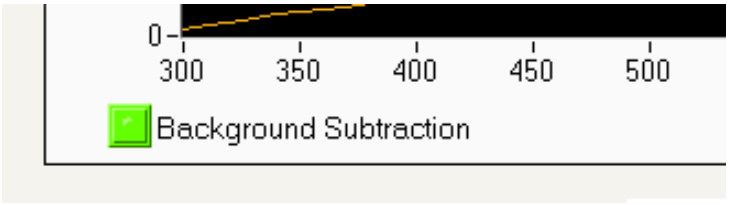


You can load the **background** file in to your graph to verify the noise between the sample amplifier and the reference cell are similar by clicking on  and browsing to the file “background” in your data folder.



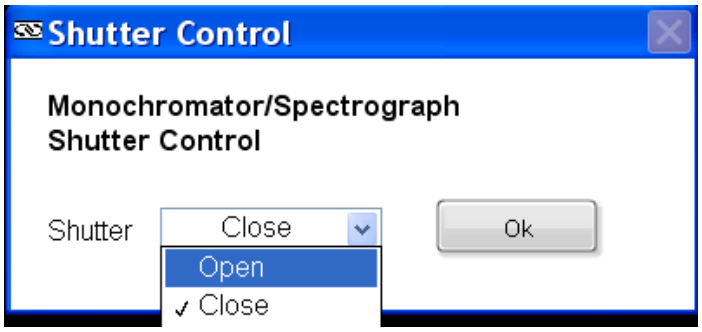
Now the background noise of sample amplifier can be subtracted from all future wavelength scans performed with your sample cell. To subtract the background, select “Options → Load” and browse to the file you just named “background_sample”. Click on *OK* when finished.

Verify the background subtraction is active.

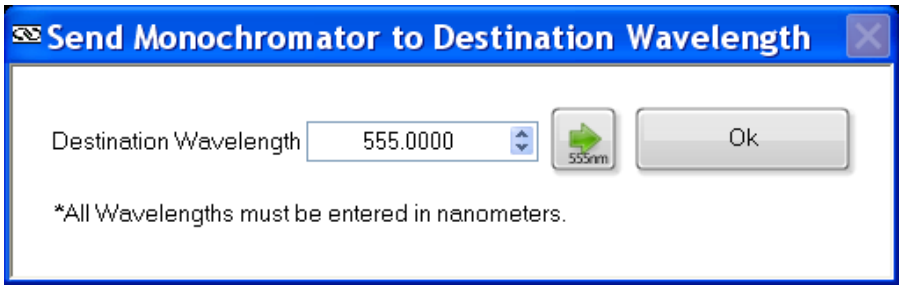


Make Wavelength Scan of your Sample: sample01

To make a wavelength scan of your sample, first open the shutter on the monochromator by clicking on Monochromator → Shutter… Select *Open* from the pull down menu on the popup menu. Click on *Ok* when done.



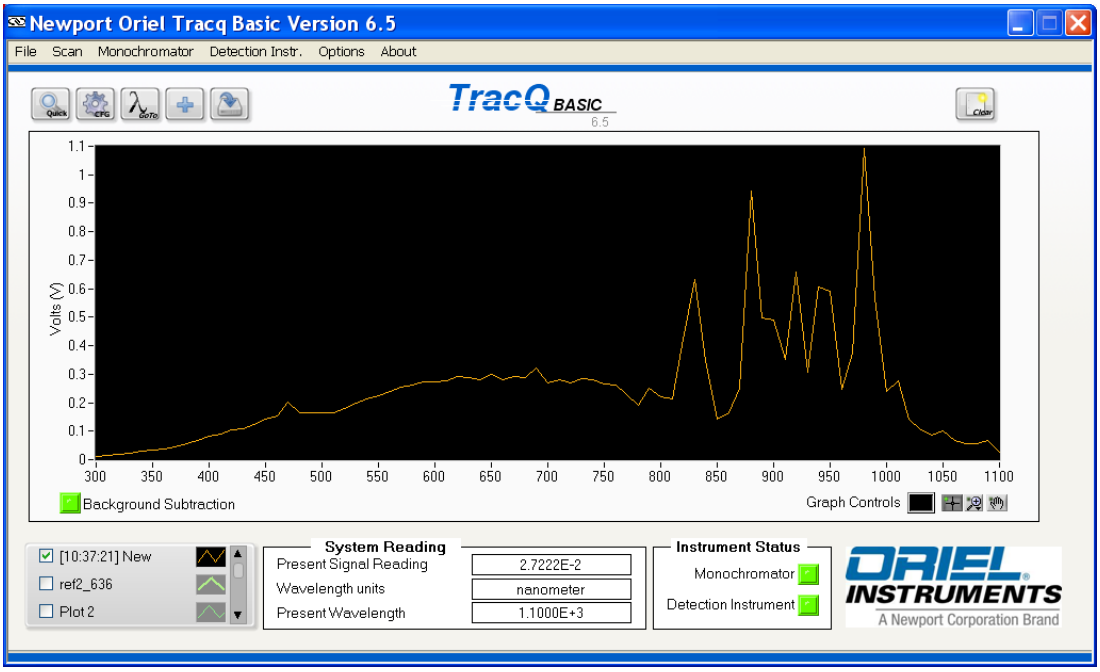
Click on the  button on the TracQ front panel to set the monochromator wavelength to 555nm (green). When following pop up comes up, set the wavelength to 555nm and click on *O.*



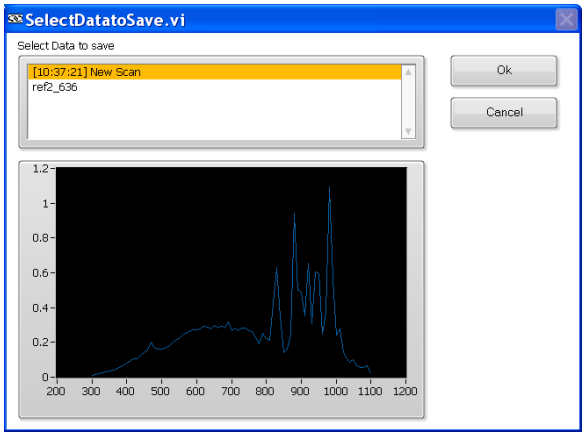
Verify the detector signal from the SRS810 is **<0.2V** to keep it from saturating during the wavelength scan.

Click on  to clear the background data from the screen.

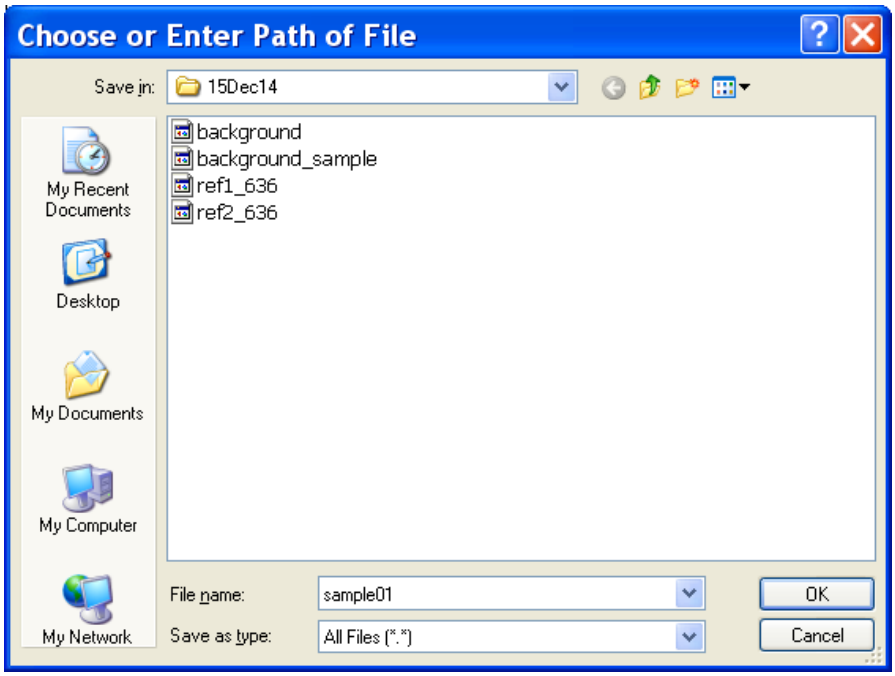
Click on  to perform a wavelength scan on the reference detector a second time with background subtraction on.

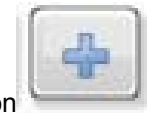


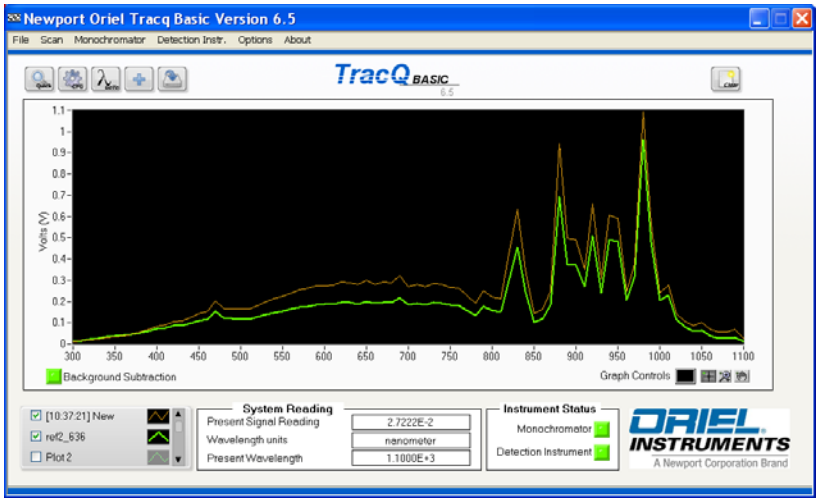
After the scan is complete, click on  to save the data. Highlight the New Scan and click on *Ok*.



Save the scan as **sample01** with the index at the end to help you keep track of subsequent scans performed no the sample.

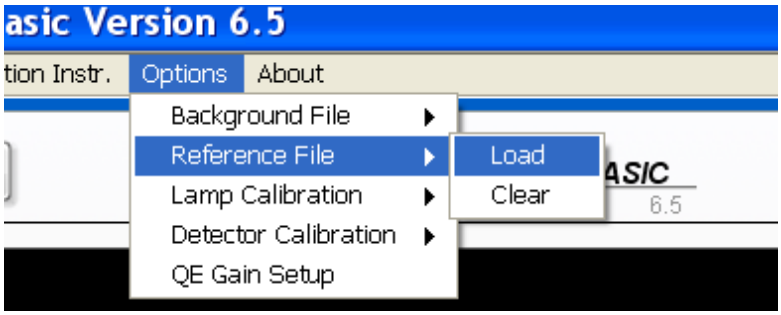


If interested, load ref2_636 to see the difference in the wavelength scans between you sample and reference detector by clicking on  , selecting *volt (V)* from the pull down menu on the popup window and browsing to the file “ref2_636” in your data folder. It is common for the sample cell (brown curve) to have a slightly higher response than the reference detector (green curve) as shown.



Make QE Scan of your Sample: QEsample01

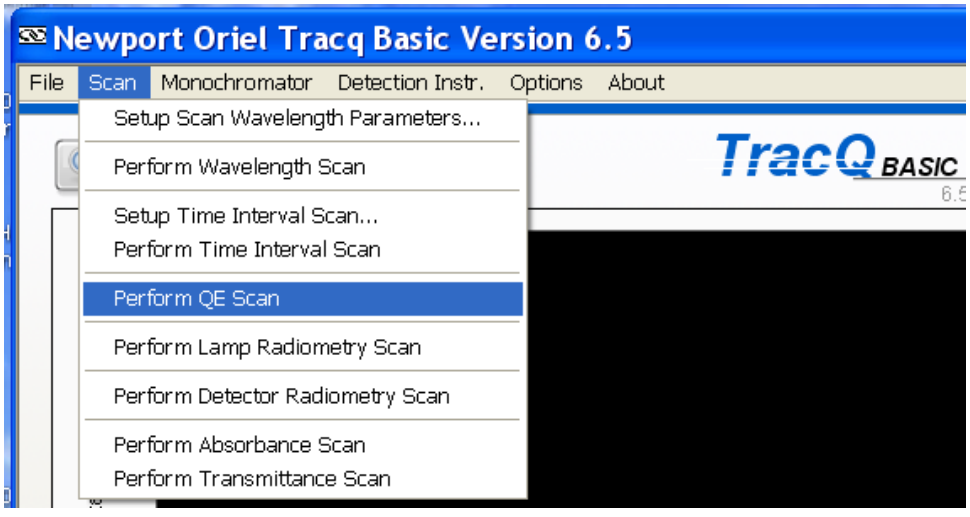
Before making a QE scan, make sure all the proper files are loaded that TracQ needs to calculate the quantum efficiency of your sample by selecting “Options” on the front panel to TracQ and load the following files…



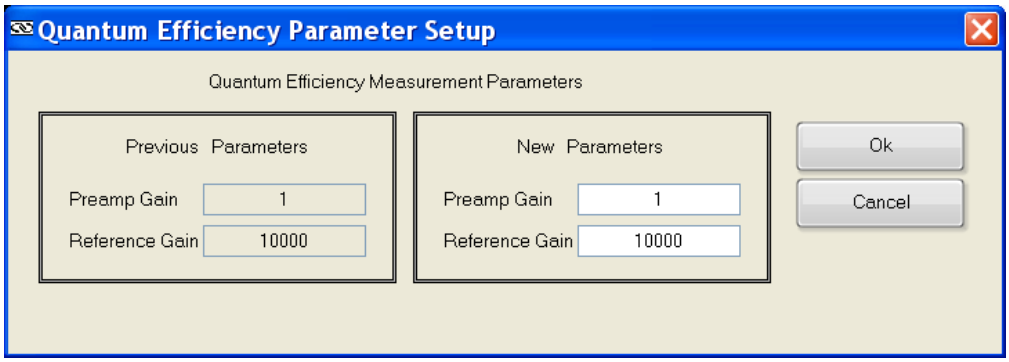
Options → Background File → Load → “background_sample”
Options → Reference File → Load → “ref2_636”
Options → Detector Calibration → Load → “70356_70316N_636_tabs.txt”

Click on  to clear the sample data from the screen.

From the menu on the front panel of the TracQ, select Scan → Perform QE Scan

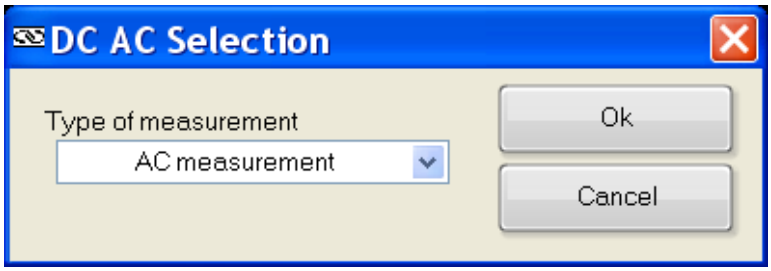


A popup window will appear that will accept the gain settings on the sample amplifier. The Preamp Gain is always = 1 when using the SRS810 as the power source for the amplifier. The Reference Gain should match the GAIN setting switch on top of the sample amplifier (i.e. 10^4)



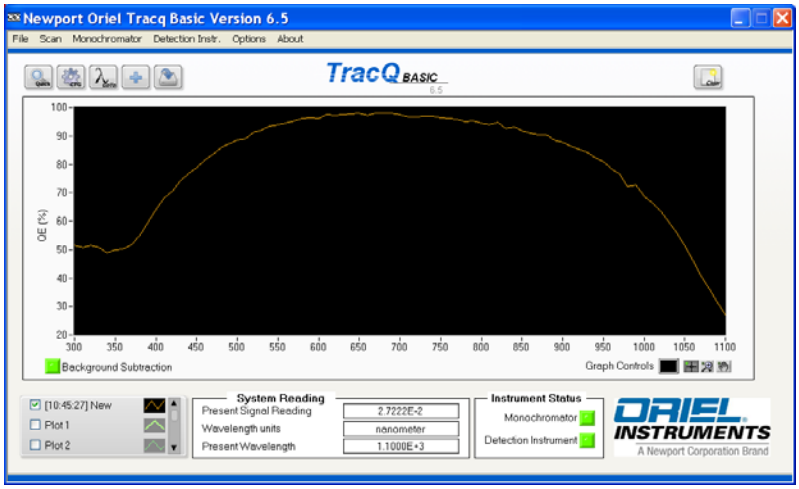
Click *Ok* when finished.

A second popup window will appear. Please select *AC measurement* from the pull down menu and click *Ok* when finished.

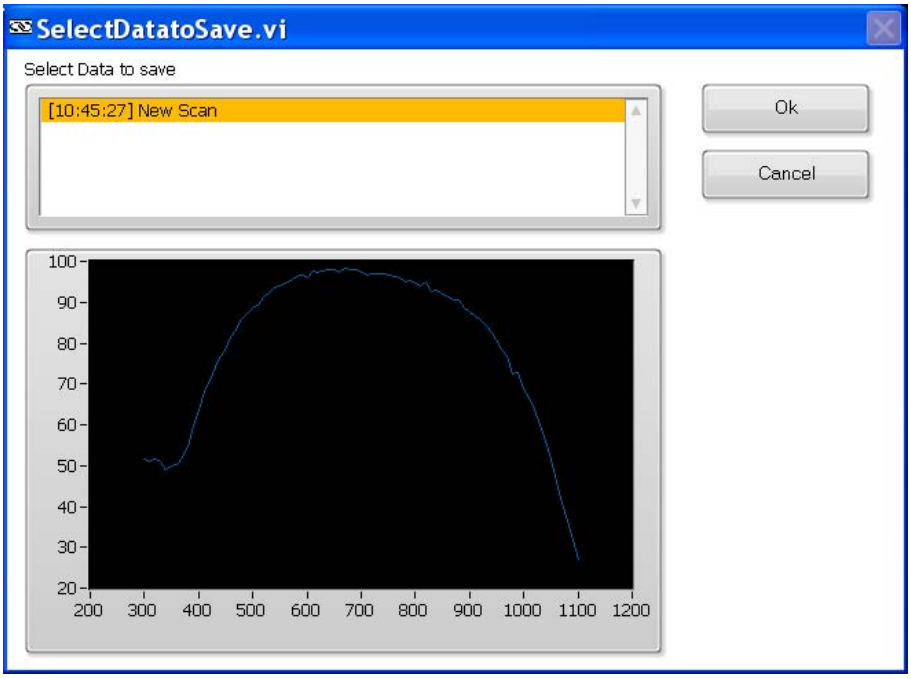


The QE scan will automatically begin. You can abort the scan at any time during the scan by clicking on the  button.

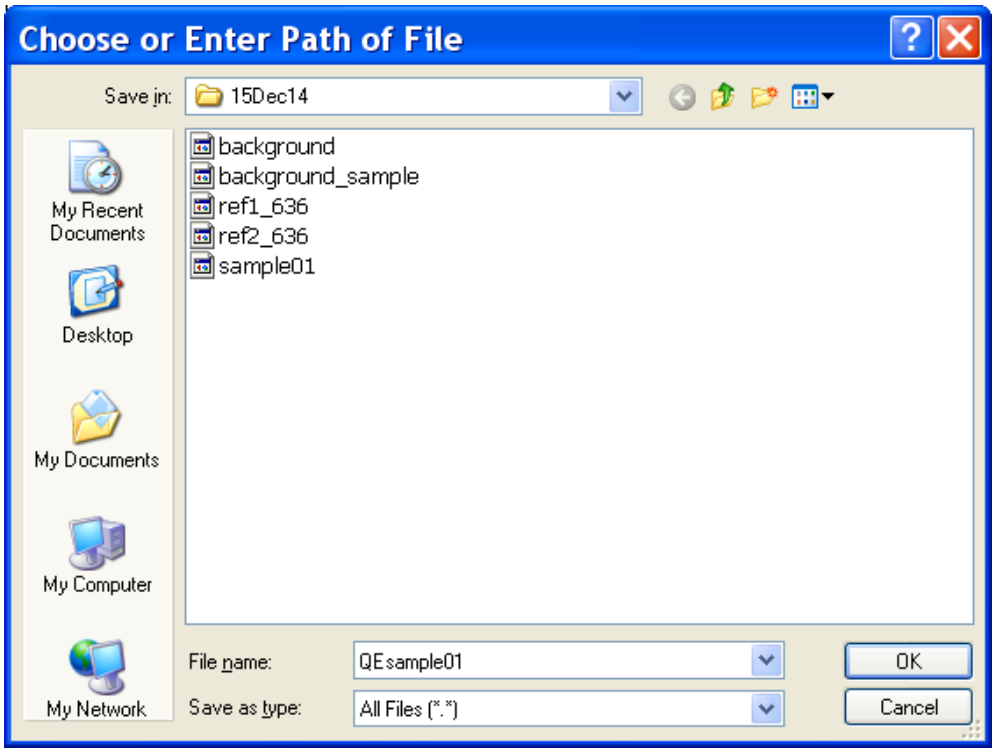
Your QE scan should look similar to the following, peaking around 95%.



After the scan is complete, click on  to save the data. Highlight the New Scan and click on *Ok*.



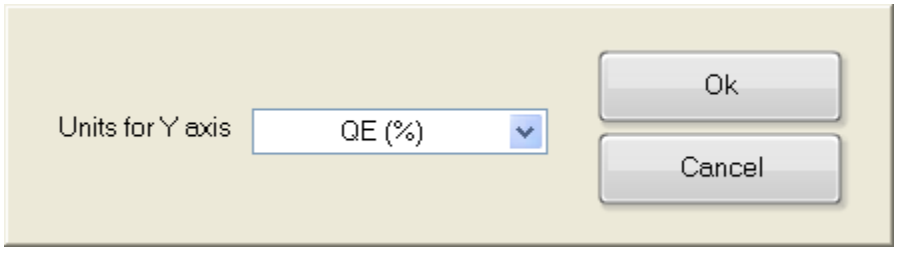
Save the scan as **QEsample01.**



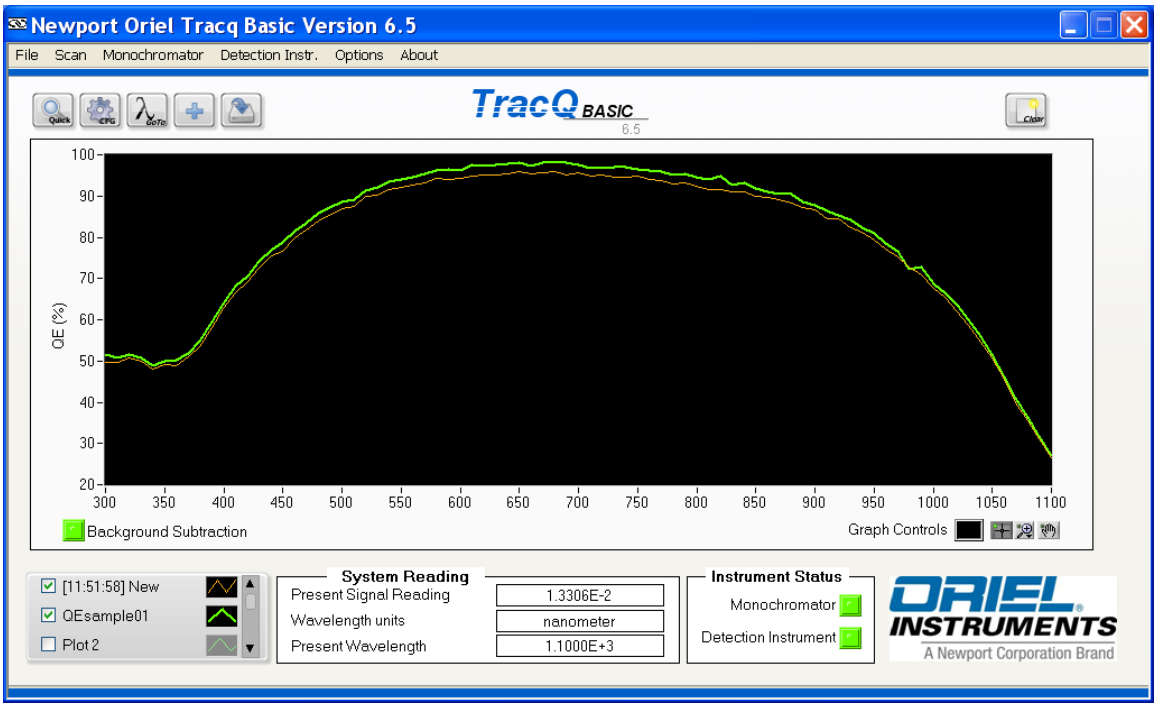
You can load the QE scan of your sample made at the factory to compare to your scan and help verify your QE-PV-Si system is performing properly. Click on  and the following popup window appears.

Select *QE%* from the pull down window and click *Ok* when finished.

Browse to the file “QEsample_factory” file on your USB jump drive to load the factory scan.



Your QE scan of your sample cell (brown curve) should be nearly identical to the factory QE scan of your sample (green curve). Slight differences may arise from exact placement of the beam on the sample and, especially, if part of the beam overlaps a bus bar on the sample surface.



Once you have verified a successful sample scan, you are ready to measure other samples or filters as desired.

8 MAINTENANCE

LAMP REPLACEMENT

The *average* life of the standard arc lamp is 900 hours. Note that the lifetime of the lamp can be affected by the manner in which it is used. Frequent ignitions, contamination of the lamp envelope and an excessively hot operating environment may all lead to reduced lamp life.

To avoid system down time, consider purchasing a replacement lamp as the lamp nears the end of its useful life.

300W Xe Lamp , Ozone Free Part Number 6258

The hours of use should be regularly monitored on the lamp's power supply, then reset when the lamp is replaced. To check the lamp hours on the power supply, press the Display/Select button until the Lamp Hours LED is illuminated.

Always wear powder-free gloves and eye protection when handling a lamp and read all precautions that came with the replacement lamp. The QE system should be powered off. During lamp replacement, it is an ideal time to inspect the lamp housing for signs of wear. Refer to the next section for more information.

When an arc lamp is to be replaced, remove the old lamp and unscrew the brass socket adapter from the bottom terminal. On the replacement lamp, remove the thumb screw on the bottom terminal and screw on the brass socket adapter. Refer to the lamp installation section of this manual for more information.

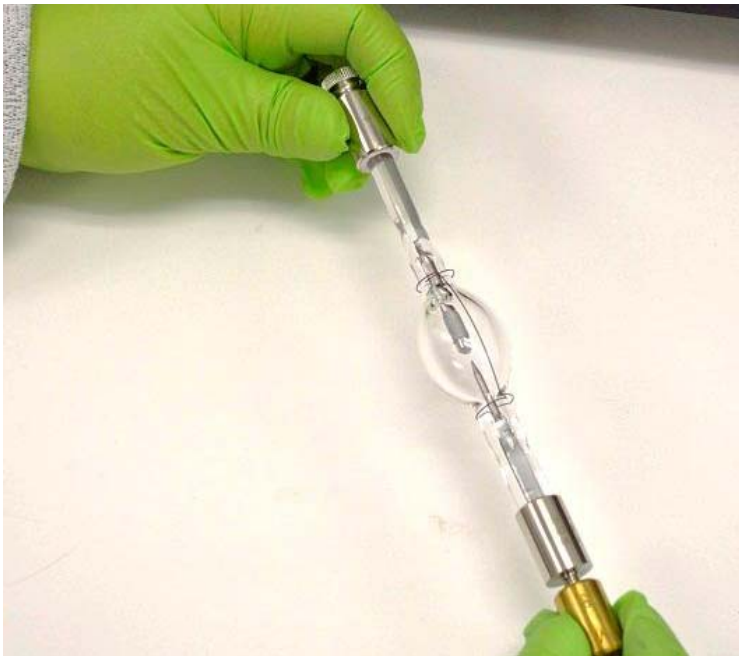


Figure 21: Preparing Replacement Lamp

As soon as the replacement lamp is installed, reset the lamp hours. To reset the lamp hours on the power supply, the lamp must be off and the power supply turned on.

1. Press the Setup button.
2. Press the Display/Select button until Hrs Reset LED is blinking.
3. Press and hold the Set/Enter button until the display goes blank.
4. Press Setup.

CLEANING

Clean the exterior of the system using a clean, dry cloth. Ensure that the ventilation holes are not blocked with dust. Vacuum the openings, if necessary.

When not in use, cover the focusing lens assembly.

9 TROUBLESHOOTING

POWER SUPPLY ERROR MESSAGES

The power supply will display an error messages to indicate various reasons as to why a lamp cannot be ignited. Only one message can be displayed at one time.

Message	Error	Possible Causes
iLOC	Interlock Error	• Lamp housing door not closed. • Black lamp cable not in place. • Overheating
LP	Lamp Housing or Lamp Failure	• Lamp reached end of life. • Replacement lamp installed upside down. • Lamp construction defect. • Excessive humidity / condensation on igniter. • Igniter component failure. • Arcing due to insulation wear.
PS	Power Supply Failure	• Contact for service

If an iLOC error is displayed, check that the door is secured in place. If necessary, loosen the door screws, push the door upward and re-tighten the screws. Ensure the black cable going to the left side of the lamp housing is secure. If all items are in place, contact for service.

There are no user serviceable parts inside of the power supply. Do not open and attempt to troubleshoot this unit. Contact Oriel Instruments or the representative from whom this system was purchased for service.

For more information on the LP error message, refer to the section in this manual on lamp ignition difficulties.

DIFFICULTY IGNITING ARC LAMP

When the Lamp On button is pushed on the power supply, up to five ignition attempts are made. If the arc lamp does not ignite, an LP error will appear on the power supply display. Ignition failure can be due to a number of causes.

The system is designed to operate in a typical laboratory atmosphere. Excessive humidity or condensation on the igniter will cause an LP error. A clicking noise is heard when ignitions are attempted. If the clicking noise is absent, there may be a problem with a component on the igniter itself.

If a replacement lamp is installed upside down, it will likely ignite. However, the lifespan of the lamp is greatly reduced. If the lamp's electrode has a ball formed on the end, this indicates that the lamp was used incorrectly. This situation is not covered under warranty.

Discoloration of the terminals of the lamp – particularly the top one – can indicate overheating. Normally the fan on the lamp housing begins to operate a few minutes after the lamp is ignited. The fan speed is regulated so that the lamp is maintained at its optimal temperature.

If the lamp envelope is completely black inside, it may indicate that the seal at one of the terminal end caps has broken. This could be due to rough handling, a lamp defect or a failure when overheated.

Some arc lamps are shipped with a wire around its envelope. This "starter wire" assists with lamp ignition. Do not remove this wire.

LAMP CARE AND HANDLING

Do not allow any contaminants or fingerprints to get onto the lamp envelope. Always wear powder-free gloves. Clean the lamp with isopropyl alcohol and dry completely before using. If contaminants are not removed, it may lead to darkening of the lamp envelope, reduced light output, overheating and premature failure.

LAMP HOUSING THERMOSTAT

The lamp housing is equipped with a shut-off switch which will activate when the lamp housing becomes too hot. The lamp will be shut off and an iLOC error will appear on the power supply display. When the lamp housing temperature returns to normal, the iLOC error will disappear. The lamp housing will require servicing before the lamp is ignited again. Note that overheating will reduce the lamp's life.

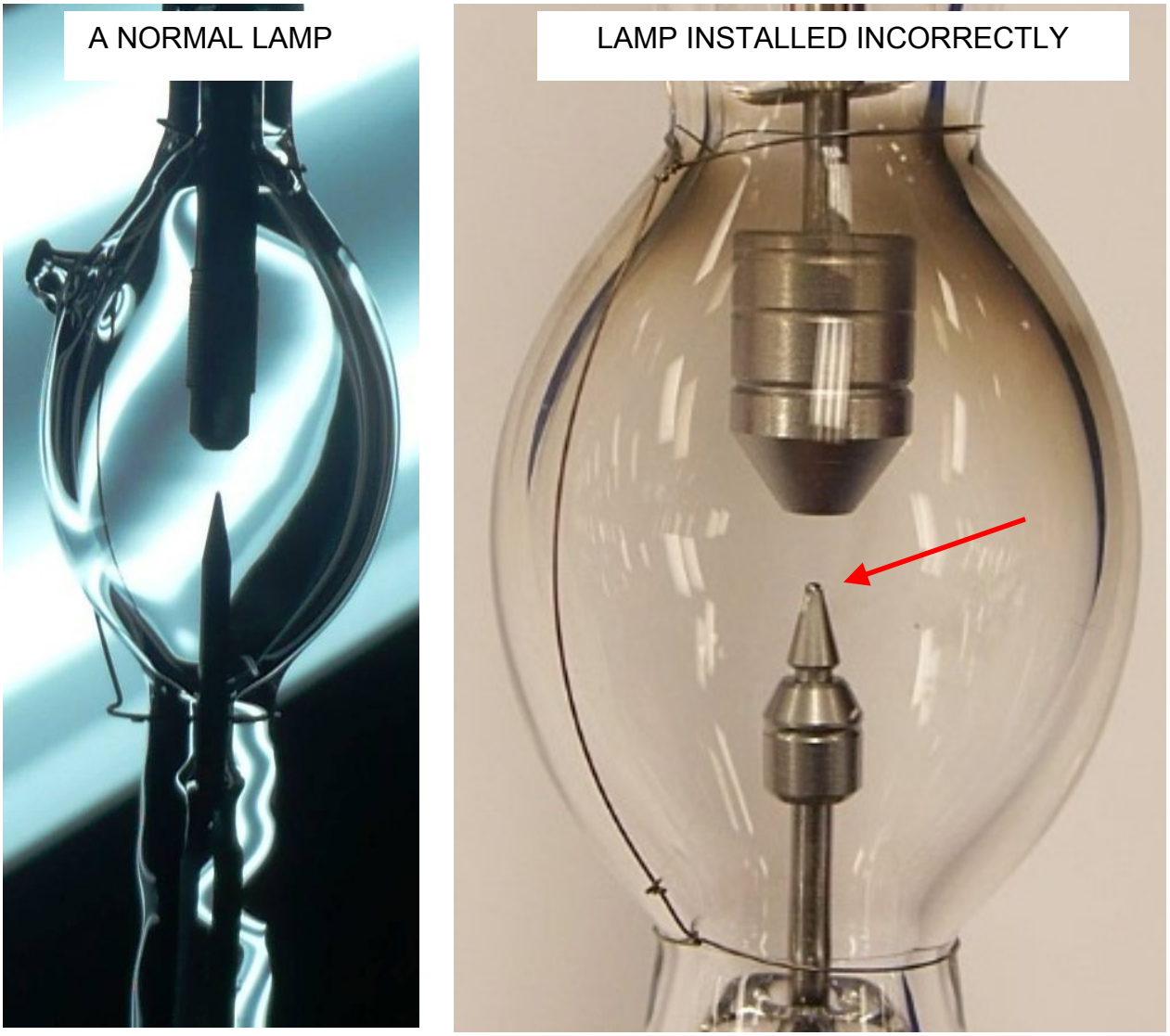


Figure 22: Arc Lamp Installed Backwards

10 SPECIFICATIONS

GENERAL

Lamp Type	300W Xenon
Weight	50 lbs (23 kg), not including packing material or power supply
Dimensions, Mounting Plate	15.5” x 30” x 3/8” (394 x 762 x 10 mm)

MONOCHROMATOR

Communication Interface	USB, Optional 74009 Hand Controller accessory
Wavelength Accuracy	0.50 nm
Stray Light	0.03%
Ruled Diffraction Gratings	1200 lines/mm, quantity 2 installed (models 74163 and 74164)
Power Requirements (for DC Adapter)	100 to 240 VAC, 47 to 63 Hz

FILTER WHEEL

Communication Interface	Controlled via monochromator
Speed	<2 seconds per position
Filters	Qty (3) order sorting filters installed, cut-on wavelengths at 335 nm, 590 nm, 1000 nm

LAMP POWER SUPPLY

Input Voltage	95 to 264 VAC
Input Frequency	50 to 60 Hz
Input Current, Maximum	8 A
Line Regulation	0.01%
Light Ripple	<0.5% rms
Weight	20 lbs (9 kg), not including packing material
Dimensions	16.0” x 12.0” x 5.7” (406 x 25 x 145 mm)

SOFTWARE

Operating System	Microsoft Windows 7 (32-bit or 64-bit) Microsoft Windows XP, Service Pack 3
Processor	2 GHz minimum
RAM	1 GB minimum
Hard Drive Space	800 MB
Peripherals	CD-ROM, USB port

LOCK-IN AMPLIFIER

SIGNAL CHANNEL	
Voltage Inputs	Single-ended (A) or differential (A-B)
Current Input	10^6 or 10^8 Volts/Amp
Full Scale Sensitivity	2 nV to 1 V in a 1-2-5-10 sequence (expand off). Input Impedance Voltage: 10 MΩ+25 pF, AC or DC coupled Current: 1 kΩ to virtual ground
Gain Accuracy	±1% from 20°C to 30°C (notch filters off), ±0.2% typical
Input Noise	6 nV/√Hz at 1 kHz (typical)
Signal Filters	60 (50) Hz and 120(100) Hz notch filters (Q=4)
CMRR	100 dB at 10 kHz (DC Coupled), decreasing by 6 dB/octave above 10 kHz
Dynamic Reserve	Greater than 100 dB (with no signal filters)
Harmonic Distortion	-80 dB

REFERENCE CHANNEL	
Frequency Range	1 mHz to 102 kHz
Reference Input	TTL (rising or falling edge) or Sine; Sine input is 1 MΩ, AC coupled (>1 Hz); 400 mV pk-pk minimum signal
Phase Resolution	0.01°
Absolute Phase Error	<1°
Relative Phase Error	<0.01°
Phase Noise	External synthesized reference: 0.005° rms at 1 kHz, 100 ms, 12 dB/oct. Internal reference: crystal synthesized, <0.0001° rms at 1 kHz
Phase Drift	<0.01°/°C below 10 kHz <0.1°/°C to 100 kHz
Harmonic Detect	Detect at Nxf where N<19999 and Nxf<102 kHz.
Acquisition Time	(2 cycles + 5 ms) or 40 ms, whichever is greater
DEMODULATOR	
Zero Stability	Digital display has no zero drift on all dynamic reserves
Analog outputs:	<5 ppm/°C for all dynamic reserves
Time Constants	10 µs to 30 s (reference > 200 Hz). 6, 12, 18, 24 dB/oct rolloff Up to 30000 s (reference < 200 Hz). 6, 12, 18, 24 dB/oct rolloff Synchronous filtering available below 200 Hz
Harmonic Rejection	-80 dB

INTERNAL OSCILLATOR	
Frequency	1 mHz to 102 kHz
Frequency Accuracy	25 ppm + 30 µHz
Frequency Resolution	4 1/2 digits or 0.1 mHz, whichever is greater
Distortion	f<10 kHz, below -80 dBc. f>10 kHz, below -70 dBc.1 Vrms amplitude
Output Impedance	50 Ω
Amplitude	4 mVrms to 5 Vrms (into a high impedance load) with 2 mV resolution (2 mVrms to 2.5 Vrms into 50 Ω load); Amplitude Accuracy 1%
Amplitude Stability	50 ppm/°C
Outputs	Sine output on front panel. TTL sync output on rear panel. When using an external reference, both outputs are phase locked to the external reference

DISPLAYS	
Channel 1	4 1/2 digit LED display with 40 segment LED bar graph X, R, X Noise, Aux Input 1 or 2. The display can also be any of these quantities divided by Aux Input 1 or 2. (Y and q are available over the interface only)
Offset	X, Y and R may be offset up to ±105% of full scale. (Y via interface only)
Expand	X, Y and R may be expanded by 10 or 100. (Y via interface only)
Reference	4 1/2 digit LED display; display and modify reference frequency or phase, sine output amplitude, harmonic detect, offset percentage (X or R), or Aux Outputs 1-4.
Data Buffer	8k points from Channel 1 display may be stored internally. The internal data sample rate ranges from 512 Hz down to 1 point every 16 seconds. Samples can also be externally triggered. The data buffer is accessible only over the computer interface.

INPUTS AND OUTPUTS	
Channel 1 Output	Output proportional to Channel 1 display, or X Output Voltage: ±10 V full scale. 10 mA max output current
X and Y Outputs	Rear panel outputs of cosine (X) and sine (Y) components Output Voltage: ±10 V full scale. 10 mA max output current
Aux. Outputs	4 BNC Digital to Analog outputs ±10.5 V full scale, 1 mV resolution. 10 mA max output current
Aux. Inputs	4 BNC Analog to Digital inputs Differential inputs with 1 MΩ input impedance on both shield and center Conductor; ±10.5 V full scale, 1 mV resolution
Trigger Input	TTL trigger input triggers stored data samples
Monitor Output	Analog output of signal amplifiers (before the demodulator)

GENERAL	
Interfaces	IEEE-488 and RS-232 interfaces standard. All instrument functions can be controlled through the IEEE-488 and RS-232 interfaces.
Preamp Power	Power connector for SR550 and SR552 preamplifiers
Power	40 Watts, 100/120/220/240 VAC, 50/60 Hz
Dimensions	17"W x 5.25"H x 19.5"D
Weight	30 lbs.

11 APPENDIX I – SYSTEM RESOLUTION

LIGHT SPOT SIZE ADJUSTMENT

Micrometer-driven adjustable slits are mounted at the input and output ports of the Cornerstone 260 monochromator. The micrometers are used to adjust the width and height of the apertures. They have been set at Oriel Instruments so that the reference detector and sample which is provided are not over-filled.

Note: the reference detector scan and sample scan must be completed using the same slit width in order to obtain accurate QE data.

The slit is adjustable from completely closed to 3 mm wide. Use a 10x multiplier to convert the micrometer reading to the slit opening size in µm. For example, turning the micrometer handle from 0 to 1 adjusts the slit from completely closed to 10 µm wide.

The completely closed position is when the zero on the body of the micrometer lines up with the zero on the turning portion, as shown in Figure 24. One complete revolution equals 50 on the micrometer (500 µm).

A change in the slit width will alter the resolution of the monochromator. Refer to Section 0 for more information.

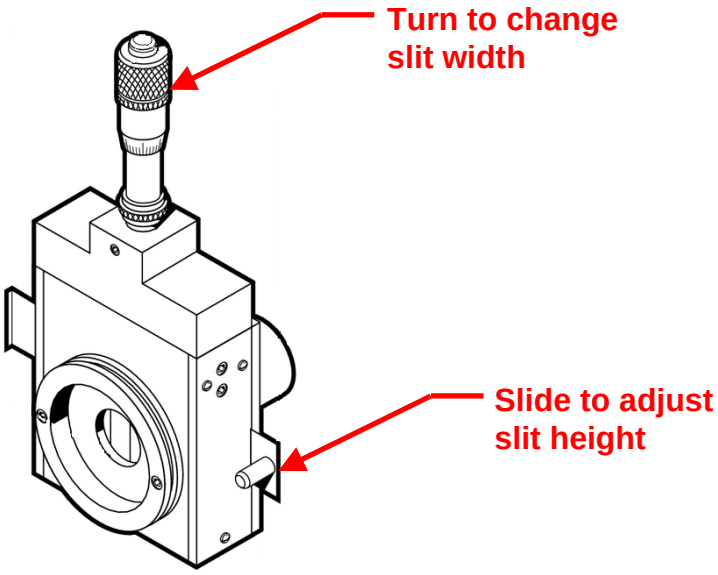


Figure 23: Micrometer Driven Slit

MONOCHROMATOR RESOLUTION

The QEPVSI-B ships out with the input and output slits set to 750 microns and a minimum slit height. The input and output slits should be set to same width and height. The slit width, along with the grating dispersion, determines the resolution of the monochromator.

Use the following formula to determine the effect of monochromator input slit width on the resolution of the instrument.

Slit Width (mm) x Reciprocal Dispersion (nm/mm) = Resolution at Blaze Wavelength

Grating	Wavelength Range	Reciprocal Dispersion	Blaze Wavelength
#1	300 nm to 500 nm	3.2 nm/mm	350 nm
#2	500 nm to 1100 nm	3.1 nm/mm	750 nm

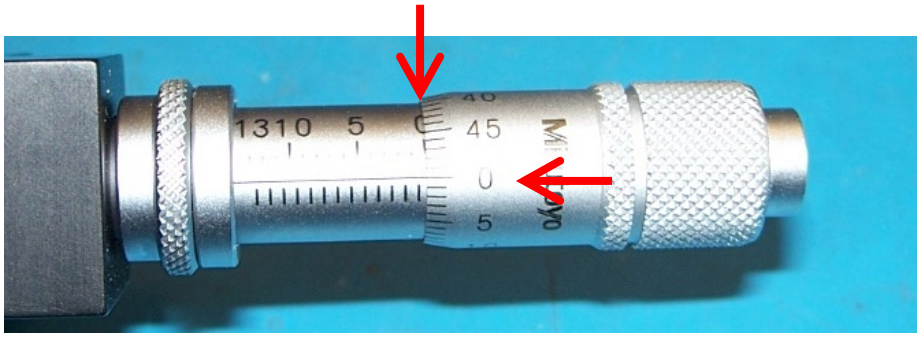


Figure 24: Micrometer Reading in Closed Position

12 APPENDIX II – OPTIONAL CABLES AND ADAPTERS

Oriel Instruments recognizes that many possibilities exist in how a sample can be electrically connected, so a number of cables and adapters are offered. These may be used with the basic sample platform, temperature controlled vacuum chuck, probes or with an end user's own fixtures.

For more information or to purchase any of these items, contact Oriel Instruments or regional sales representative.

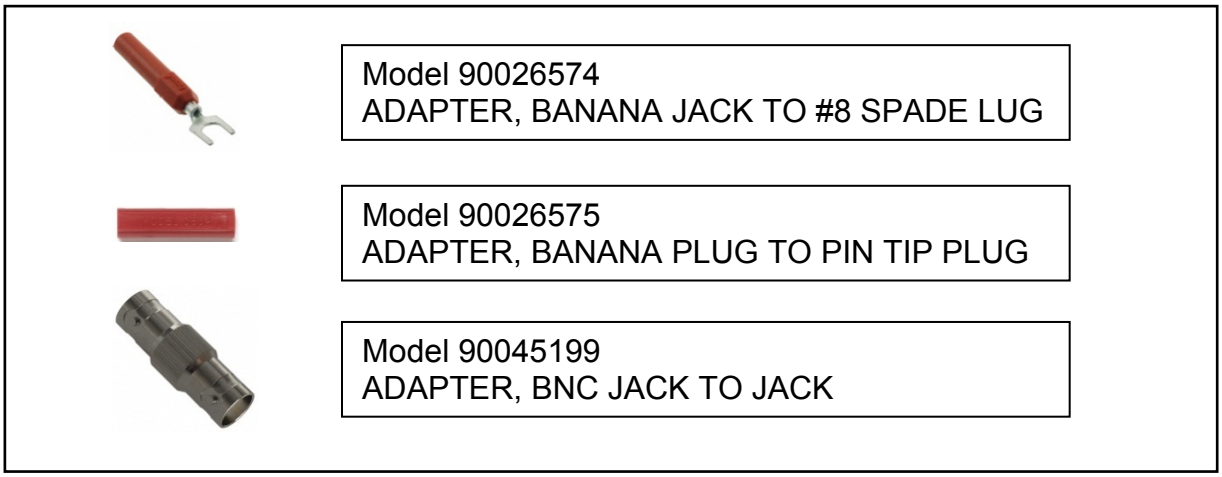


Figure 25: Connection Adapter Options

70017
CABLE, BNC M-M LOW NOISE (1M)

90009203
CABLE, BNC MALE TO DOUBLE BANANA PLUG

90015781
CABLE, BNC MALE TO MICROGRABBER CLIPS
(Quantity 1 included with system)

90023571
CABLE, BNC MALE TO MINI-ALLIGATOR CLIPS (4FT)

90034502
CABLE, BNC MALE TO FEMALE (1M)

90034566
CABLE, BNC MALE TO PIN TIP (5FT)

Figure 26: Cable Options

13 EU DECLARATION OF CONFORMITY

EC DECLARATION OF CONFORMITY

Manufacturer's name:	Newport Corporation
Manufacturer's address:	150 Long Beach Boulevard Stratford, CT 06615 USA
Declares that the product:	
Product Name:	ORIEL®QUANTUM EFFICIENCY MEASUREMENT KIT
Model Numbers:	QE-PV-SI
Type of equipment:	Electrical equipment for measurement, control and laboratory use in industrial locations
conforms to the following Product Specifications:	
Safety:	EN 61010-1:2010
EMC:	EN 61326-1:2006 +cor:2008 +cor:2010
complies with the following Directives:	2004/108/EC EMC Directive 2006/95/EC Low Voltage Directive
and accordingly, carries the CE mark **CE mark affixed:**	Beaune; May 20, 2011

Domenic Assalone
Site Manager, Oriel Products Division
150 Long Beach Boulevard
Stratford, CT 06615 USA

Bruno Rety
Authorized to compile technical documentation
Group Director, PPT Instrument and Motion Europe
Micro-Controle Division of Newport Corporation
Zone Industrielle
45340 Beaune la Rolande, France

14 WARRANTY AND SERVICE

CONTACTING ORIEL INSTRUMENTS

Oriel Instruments belongs to Newport Corporation's family of brands. Thanks to a steadfast commitment to quality, innovation, hard work and customer care, Newport is trusted the world over as the complete source for all photonics and laser technology and equipment.

Founded in 1969, Newport is a pioneering single-source solutions provider of laser and photonics components to the leaders in scientific research, life and health sciences, photovoltaics, microelectronics, industrial manufacturing and homeland security markets.

Newport Corporation proudly serves customers across Canada, Europe, Asia and the United States through 9 international subsidiaries and 24 sales offices worldwide. Every year, the Newport Resource catalog is hailed as the premier sourcebook for those in need of advanced technology products and services. It is available by mail request or through Newport's website. The website is where one will find product updates, interactive demonstrations, specification charts and more.

To obtain information regarding sales, technical support or factory service, United States and Canadian customers should contact Oriel Instruments directly.

Oriel Instruments
31950 East Frontage Road
Bozeman, MT 59715 USA

Telephone: 800-459-9459 (toll-free in United States)

Fax: 406-586-9405

Sales: oriel.sales@newport.com
Technical assistance: oriel.tech@newport.com

Customers outside of the United States must contact their regional representative for all sales, technical support and service inquiries. A list of worldwide representatives can be found on Oriel's website: http://www.newport.com/oriel.

REQUEST FOR ASSISTANCE / SERVICE

Please have the following information available when requesting assistance or service:

- Contact information for the owner of the product
- Instrument model number (located on the product label)
- Product serial number and date of manufacture (located on the product label)
- Description of the problem

To help Oriel's Technical Support Representatives diagnose the problem, please note the following:

- Is the system used for manufacturing or research and development?
- What was the state of the system right before the problem?
- Had this problem occurred before? If so, when and how frequently?
- Can the system continue to operate with this problem, or is it non-operational?
- Were there any differences in the application or environment before the problem occurred?

REPAIR SERVICE

This section contains information regarding factory service for this product. The user should not attempt any maintenance or service of the system beyond the procedures outlined in this manual. This product contains no user serviceable parts other than what is noted in this manual. Any problem that cannot be resolved should be referred to Oriel Instruments.

If the instrument needs to be returned for service, a Return Material Authorization (RMA) number must be obtained prior to shipment to Oriel Instruments. This RMA number must appear on both the shipping container and the package documents.

Return the product to Oriel Instruments, freight prepaid, clearly marked with the RMA number and it will either be repaired or replaced it at Oriel's discretion.

Oriel is not responsible for damage occurring in transit. The Owner of the product bears all risk of loss or damage to the returned Products until delivery at Oriel's facility. Oriel is not responsible for product damage once it has left the facility after repair or replacement has been completed.

Oriel is not obligated to accept products returned without an RMA number. Any return shipment received by Oriel without an RMA number may be reshipped by Newport, freight collect, to the Owner of the product.

NON-WARRANTY REPAIR

For Products returned for repair that are not covered under warranty, Newport's standard repair charges shall be applicable in addition to all shipping expenses. Unless otherwise stated in Newport's repair quote, any such out-of-warranty repairs are warranted for ninety (90) days from date of shipment of the repaired Product.

Oriel will charge an evaluation fee to examine the product and determine the most appropriate course of action. Payment information must be obtained prior to having an RMA number assigned. Customers may use a valid credit card, and those who have an existing account with Newport Corporation may use a purchase order.

When the evaluation had been completed, the owner of the product will be contacted and notified of the final cost to repair or replace the item. If the decision is made to not proceed with the repair, only the evaluation fee will be billed. If authorization to perform the repair or provide a replacement is obtained, the evaluation fee will be applied to the final cost. A revised purchase order must be submitted for the final cost. If paying by credit card, written authorization must be provided that will allow the full repair cost to be charged to the card.

WARRANTY REPAIR

If there are any defects in material or workmanship or a failure to meet specifications, notify Oriel Instruments promptly, prior to the expiration of the warranty.

Except as otherwise expressly stated in Oriel's quote or in the current operating manual or other written guarantee for any of the Products, Oriel warrants that, for the period of time set forth below with respect to each Product or component type (the "Warranty Period"), the Products sold hereunder will be free from defects in material and workmanship, and will conform to the applicable specifications, under normal use and service when correctly installed and maintained. Oriel shall repair or replace, at Oriel's sole option, any defective or nonconforming Product or part thereof which is returned at Buyer's expense to Oriel facility, provided, that Buyer notifies Oriel in writing promptly after discovery of the defect or nonconformity and within the Warranty Period. Products may only be returned by Buyer when accompanied by a return material authorization number ("RMA number") issued by Oriel, with freight prepaid by Buyer. Oriel shall not be responsible for any damage occurring in transit or obligated to accept Products returned for warranty repair without an RMA number. Buyer bears all risk of loss or damage to the Products until delivery at Oriel's facility. Oriel shall pay for shipment back to Buyer for Products repaired under warranty.

WARRANTY PERIOD

All Products (except consumables such as lamps, filters, etc.) described here are warranted for a period of twelve (12) months from the date of shipment or 3000 hours of operation, whichever comes first.

Lamps, gratings, optical filters and other consumables / spare parts (whether sold as separate Products or constituting components of other Products) are warranted for a period of ninety (90) days from the date of shipment.

WARRANTY EXCLUSIONS

The above warranty does not apply to Products which are (a) repaired, modified or altered by any party other than Oriel; (b) used in conjunction with equipment not provided or authorized by Oriel; (c) subjected to unusual physical, thermal, or electrical stress, improper installation, misuse, abuse, accident or negligence in use, storage, transportation or handling, alteration, or tampering, or (d) considered a consumable item or an item requiring repair or replacement due to normal wear and tear.

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Persons receiving goods for demonstrations or temporary use or in any manner in which title is not transferred from Newport shall assume full responsibility for any and all damage while in their care, custody and control. If damage occurs, unrelated to the proper and warranted use and performance of the goods, recipient of the goods accepts full responsibility for restoring the goods to their original condition upon delivery, and for assuming all costs and charges.

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Model: QEPVSI-b