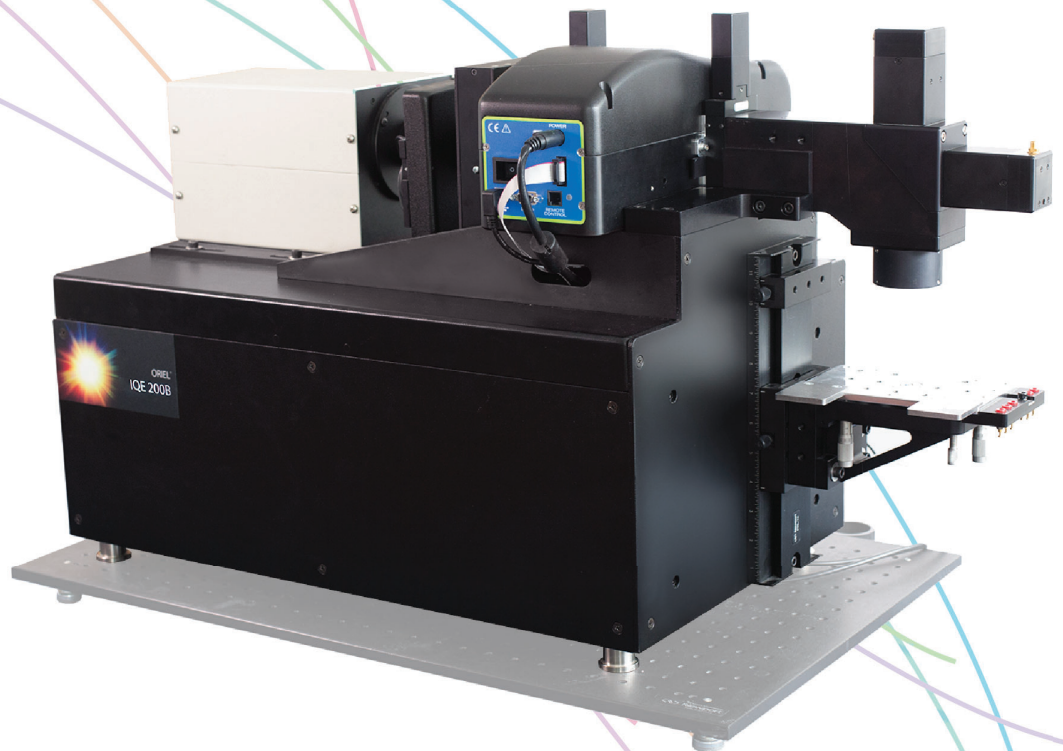


User's Guide

Quantum Efficiency Measurement Solution IQE 200B



Newport Corporation

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Newport Corporation, Irvine and Santa Clara, California and Franklin, Massachusetts; Evry and Beaune-La-Rolande, France; Stahnsdorf, Germany and Wuxi, China have all been certified compliant with ISO 9001 by the British Standards Institution.

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Safety and Warranty Information

- ✓ Details about cautionary symbols
- ✓ Safety markings used on the instrument
- ✓ Information about the warranty
- ✓ Customer service contact information

Safety Information and the Manual

Throughout this manual, you will see the words Caution and Warning indicating potentially dangerous or hazardous situations which, if not avoided, could result in death, serious or minor injury, or damage to the product.

CAUTION

Caution indicates a potentially hazardous situation which can result in minor or moderate injury or damage to the product or equipment.

WARNING

Warning indicates a potentially dangerous situation which can result in serious injury or death.

Safety Symbols

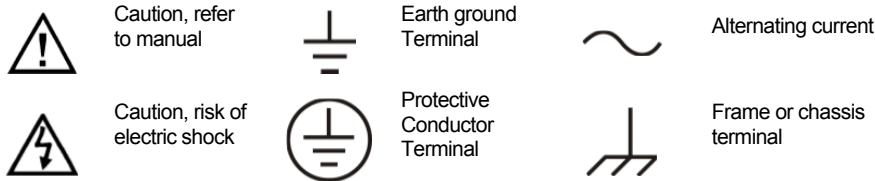
This section describes the safety symbols and classifications.

Technical specifications including electrical ratings and weight are included within the manual. See the Table of Contents to locate the specifications and other product information.

- Indoor use only
- Ordinary Protection: This product is NOT protected against the harmful ingress of moisture.
- IEC Class I Equipment (grounded type)
- Mains supply voltage fluctuations are not to exceed $\pm 10\%$ of the nominal supply voltage.
- Maximum Relative Humidity: $< 85\%$ RH, non-condensing
- Operating temperature range of $18\text{ }^{\circ}\text{C}$ to $28\text{ }^{\circ}\text{C}$
- Storage and transportation temperature of $-40\text{ }^{\circ}\text{C}$ to $70\text{ }^{\circ}\text{C}$
- This equipment is suitable for continuous operation.

Safety Marking Symbols

This section provides a description of the safety marking symbols that may appear on the instrument. These symbols provide information about potentially dangerous situations which can result in death, injury, or damage to the instrument and other components.



Warranty

Oriel Instruments warrants this instrument to be free from defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Oriel Instruments will repair or replace the unit, at the discretion of Oriel Instruments, without charge.

Limitations

This warranty does not apply to fuses, lamps, defects caused by abuse, modifications, or to use of the product for which it was not intended.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability or fitness for any particular purpose. Oriel Instruments shall not be liable for any incidental, special, or consequential damages.

If a problem occurs, please contact Oriel Instruments with the instrument's serial number, and thoroughly describe the nature of the problem.

Returning an Instrument

If an instrument is to be shipped to Oriel Instruments for repair or service, be sure to:

- Obtain a Return Authorization number (RA) from Oriel Instruments Customer Service.
- Attach a tag to the instrument identifying the owner and indicating the required service or repair. Include the instrument serial number from the rear panel of the instrument.
- Attach the anti-static and all other protective caps that were shipped with the instrument.
- Place the instrument in the original packing container with at least 3 inches (7.5 cm) of compressible packaging material. Shipping damage is not covered by this warranty. If the original shipping container is not available, place your instrument in a container with at least 3 inches (7.5 cm) of compressible packaging material on all sides.
- Secure the packing box with fiber reinforced strapping tape or metal bands.
- Send the instrument, to Oriel Instruments. Clearly write the return authorization number on the outside of the box and on the shipping paperwork. Oriel Instruments recommends you insure the shipment.

Repairs are warranted for the remainder of the original warranty or for 90 days, whichever is greater.

Claims for Shipping Damage

When you receive the instrument, inspect it immediately for any damage or shortages on the packing list. If the instrument is damaged, file a claim with the carrier. The factory will supply you with a quotation for estimated costs of repair. You must negotiate and settle with the carrier for the amount of damage.

Comments, Suggestions, and Problems

To ensure that you get the most out of your Oriel product, we ask that you direct any product operation or service related questions or comments to Oriel Instruments Customer Support. You may contact us in whatever way is most convenient:

Phone (406) 586-1244

Fax (406) 586-9405

orielpv.sales@newport.com

Mail to:

Oriel Instruments
31950 East Frontage Road
Bozeman, Montana, U.S.A 59715-8642
www.newport.com/oriel

When you contact us, please have the following information:

- ✓ Model Number
- ✓ Serial Number
- ✓ End-user Name
- ✓ Company
- ✓ Phone
- ✓ Fax
- ✓ Description of the problem

If Oriel Instruments determines that a return to the factory is necessary, you will be issued a Return Authorization (RA) number. Please mark this number on the outside of the shipping box.

The customer or their shipping services are responsible for any shipping damage when returning the instrument to Oriel Instruments; Oriel recommends you insure the shipment. If the original shipping container is not available, place your instrument in a container with at least 3 inches (7.5 cm) of compressible packaging material on all sides.

We look forward to serving you even better in the future!

Chapter 1: Introduction and Specifications

This chapter is an introduction to the IQE-200B Quantum Efficiency Measurement Solution.

- ✓ Safety considerations and unpacking information
- ✓ Product overview
- ✓ Options and accessories
- ✓ Specifications

Safety Considerations



WARNING

If any of the following symptoms exist, or are even suspected, remove the IQE-200B from service. Do not use the IQE-200B until trained service personnel can verify safe operation.

- Visible damage
- Severe transport stress
- Prolonged storage under adverse conditions
- Failure to perform intended measurements or functions

If necessary, return the IQE-200B to Oriel Instruments for service and repair per the section, “Returning and Instrument”, to ensure that safety features are maintained.

Initial Inspection

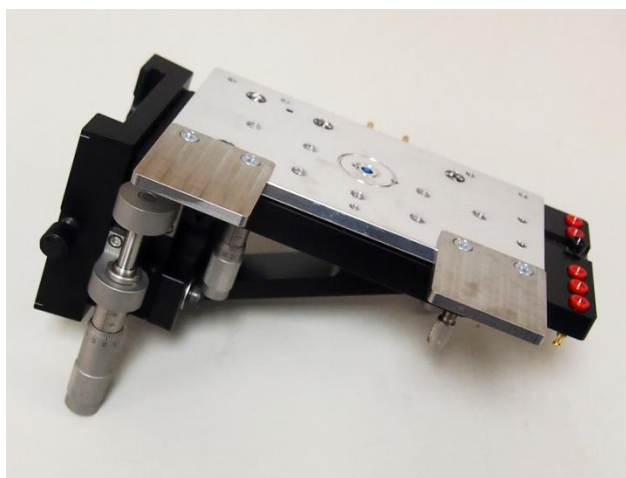
When the IQE-200B is received, verify that the following items were received with the instrument. The IQE-200B ships as four separate packages.

1. IQE-200B Instrument Package
 - a. Primary IQE-200B instrument body (PN: 603401)



IQE-200B Instrument

2. Sample Stage Package
 - a. Sample Stage (PN: 603354)
 - b. Magnetic Probe Plates x2 (PN: 202070)
 - c. #8-32x1/4 inch Screws for Probe Plates x4 (PN: 301173)

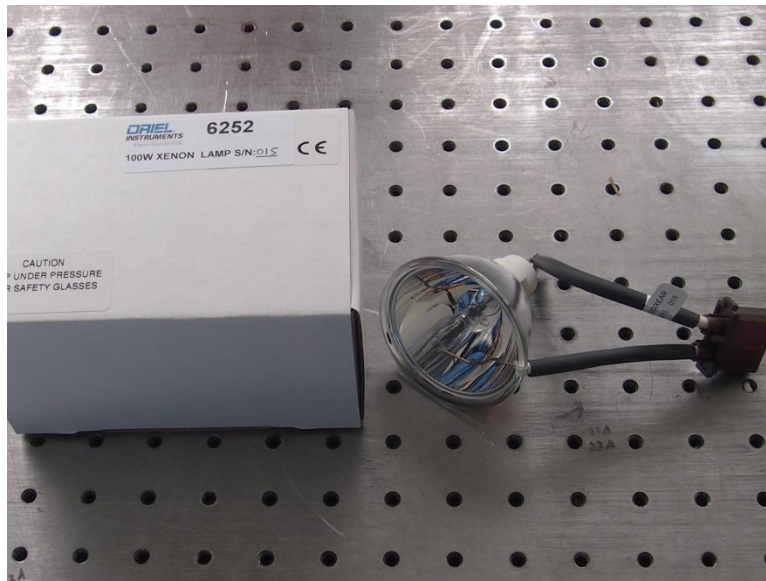


603354 Sample Stage Assembly

3. Accoutrements Package

a. Lamp

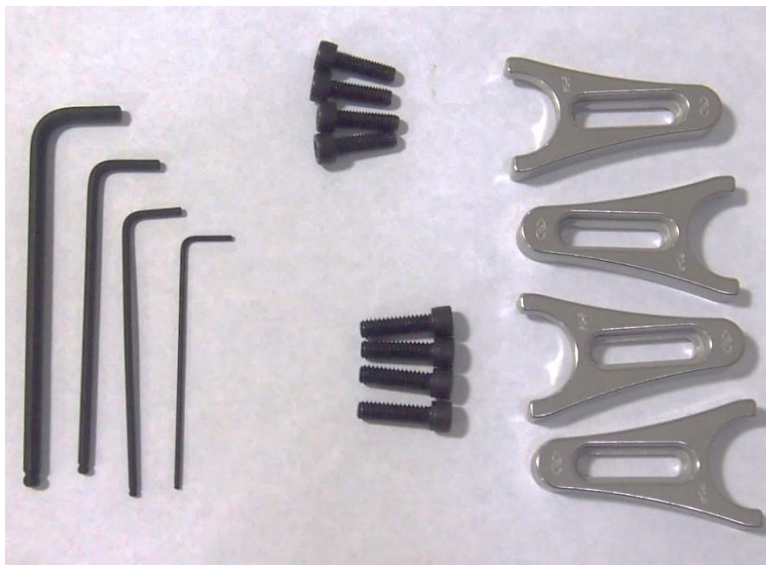
- 100 W Xenon Lamp Assembly (PN: 6252)



6252 Xe Arc Lamp

b. Optical Bench Mounting

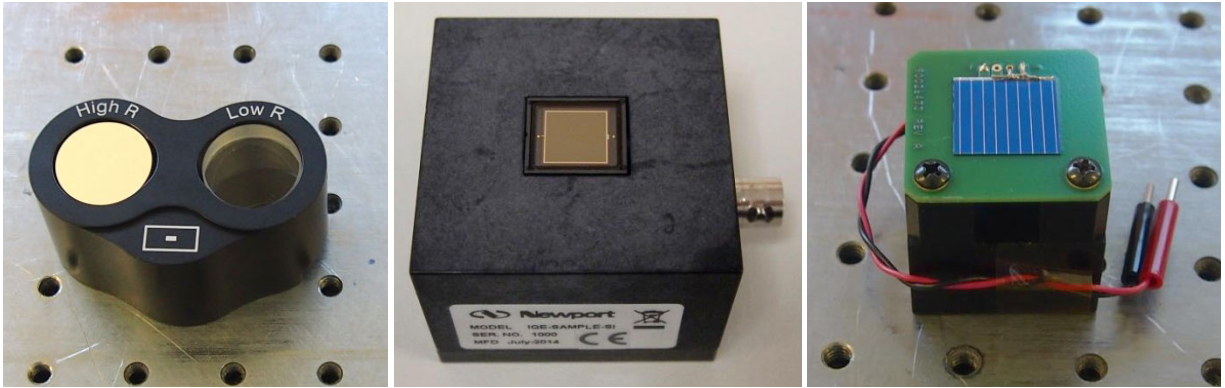
- Mounting Brackets x4 (PN: PS-F)
- 1/4"-20x1" inch Screws x4 (PN: A1JD1432QAZB)
- M6-1.0 x 25 mm Screws x4 (PN: C1JR06025G)
- Hex Ball Drivers, 3/16, 1/8, 3/32, 1/16 (PN: 90-11-044, 90-11-046, 90-11-044, 90-11-042)



Mounting Hardware and Tools

c. Standards

- Hi-Low Reflectance Standard (PN: 603414)
- Calibrated Si Reference Detector (PN: IQE-SAMPLE-SI)
- Silicon QE Test Sample (PN: SAMPLE-QESI)



603414 Specular Reflectance Standard, IQE-SAMPLE-SI Reference Detector, and SAMPLE-QESI Silicon Test Sample Cell

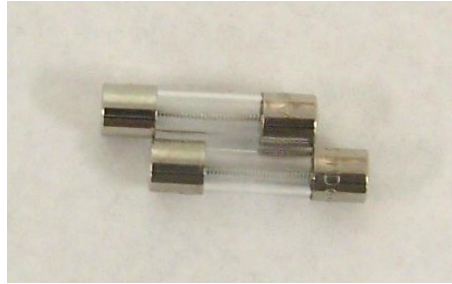
d. Cables

- AC Power Cable (varies by region, not shown)
- USB Cable (PN: 70044)
- BNC Cable, 24 inch x4 (PN: 403230)
- BNC to Clip Lead, 18 inch (PN: 403246)
- BNC to Binding Post Adapter (PN: 403223)



IQE-200B Cable Kit

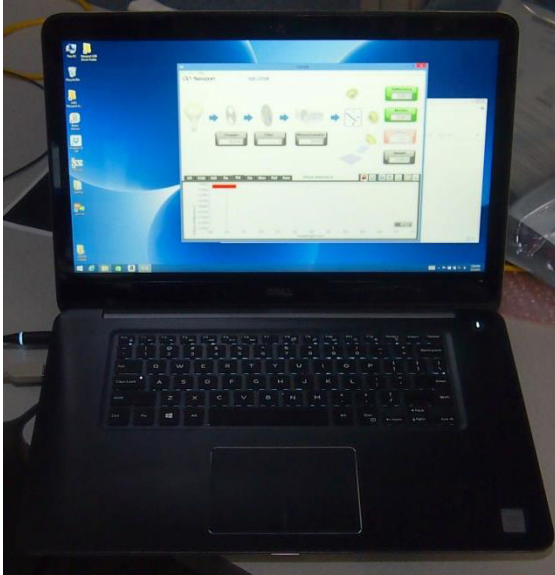
- e. 240VAC Fuses, 1.5A (PN: 15-29-152)



Fuses for 240 V~ Line Voltage

4. Computer Package

- f. Laptop Computer (PN: 800244)
- g. Laptop Power Cable (included with 800244)
- h. USB Thumb Drive – Software, Documents, and Data
 - Manual
 - Certifications
 - Calibration Standards Data
 - QUANTX Software Installers



IQE-200B Control Computer, and USB Drive loaded with Software, Documentation, and Data

Product Overview

The IQE-200B leverages Newport's expertise in optical design, spectroscopy, PV instrumentation, and electronics. These proficiencies have been focused into a complete, sophisticated measurement system for Quantum Efficiency measurement (EQE and IQE).

The IQE-200B empowers researchers to measure Internal Quantum Efficiency (IQE) and quantify External Quantum Efficiency (EQE), also known as Incident Photon to Charge Carrier Efficiency (IPCE), for any photovoltaic device. Employing industry leading, durable components for optical performance, the IQE-200B is assembled, preconfigured, and calibrated at the factory. The product is a turn-key solution which includes all necessary components with integrated light source, monochromator, detectors, electronics, software, and even the computer.

The IQE-200B incorporates a patented detector geometry using a beam splitter, allowing for simultaneous measurement of EQE and the reflective losses to quantify IQE, and a patent pending circuit that protects your cell when being connected and disconnected from building up charges that can potentially damage your PV cell. Unique to this model is an integrated, software-controlled sample voltage bias, adjustable from -10 to +10V. This model also includes a 4-wire sense which broadens the capabilities to include a large range of sample sizes and efficiencies.

A variety of accessory models are available to provide positive sample positioning, temperature control, and electrical probing capabilities.

Features of the IQE-200B

- Complete, turn-key quantum efficiency measurement solution
- Robust, compact design: small footprint of 0.85 x 0.39 m (33.3 x 15.4 in.) to minimize lab space
- Simultaneous IQE, EQE, and spectral response measurements
- Integrated beam chopper with virtual digital lock-in amplifier capable from 4 Hz to 100 Hz
- Integrated monochromator with automated filter selection
- Achromatic optics: maintains spot size throughout the entire spectral range
- Wavelength range: 350 nm to 1100 nm
- User-friendly, icon based software interface for simple calibration and simultaneous spectral response, EQE, IQE and sample reflectivity measurements
- Sturdy sample stage with Z, tip, tilt movement and optical mounting for precise alignment and stability with integrated vacuum chuck and temperature measurement.
- Integrated +/-10 V Voltage bias
- Includes calibrated reflectance standards
- Multiple user selectable gain stages to support a broad range of input signal levels



The IQE-200B Quantum Efficiency Measurement System

Specifications

PERFORMANCE SPECIFICATIONS	
Wavelength Range ¹	350 – 1100 nm
Nominal Spot Size ²	0.8 x 1.0mm +0.1mm, -0.0mm
Nominal Working Distance ³	74mm ± 1mm
Spectral Response Uncertainty	+/- 2.2 % of measured value, 350 – 950 nm +/- 5.5 % of measured value, 950 – 1100 nm
Spectral Response Repeatability ⁴	Better than 0.5%
EQE Uncertainty ⁴	+/- 2.2 % of measured value, 350 – 950 nm +/- 5.5 % of measured value, 950 – 1100 nm
IQE Uncertainty ^{4,6}	+/- 3.7 % of measured value, 350 – 950 nm +/- 6.8 % of measured value, 950 – 1100 nm
Specular Reflectance Uncertainty ⁴	+/- 2.1 % of measured value, 350 – 1100 nm
Specular Reflectance Repeatability ⁴	Better than ≤ 1.0 % of measured value
Spectral Bandwidth (FWHM) ⁵	1 - 40 nm
Wavelength Accuracy	± 0.5 nm
Detector Type	Silicon, large area
Measurement Type	Chopped beam AC measurement with Virtual Lock-In Amplifier
Measurement Voltage Range	+/- 10V
Optical Chopper Frequency	4.0 Hz – 100.0Hz
Chopper Frequency Resolution	0.1 Hz
Sample DC Gain Settings ⁷	10, 100, 1k, 10k, 100k, 1M, 10M
AC Gain Settings	1, 10, 100, 1000
Sample Current Range	10nA – 1.0A
Voltage Bias	- 10 to +10 V @ 0.0 - 0.5 A
ELECTRICAL / MECHANICAL SPECIFICATIONS	
Compliance	CE compliance
Size (H x W x D)	0.85 x 0.40 x .54 m (33.4 x 14.6 x 21.1 in.)
Weight	70.0 lbs (31.8 kg)
Power Requirements	100 - 115 VAC, 3 Amps, 48 – 66 Hz 220 - 240 VAC, 1.5 Amps, 48 – 66 Hz
Temperature	23 ± 5 °C operating; -40 to +70 °C storage
Humidity	< 85 % relative humidity, non-condensing

NOTES

1. Can scan from 300 – 1100 with reduced accuracy and repeatability
2. Over wavelength range of 320 nm to 1100 nm.
3. Working distance measured from bottom of output adapter ring to top of sample.
4. Uncertainty with k=2 confidence. Value is a percent of the measured value.
5. Slit to bandwidth conversion for monochromator as configured is 13.3nm/1.0mm slit width.
6. Excludes diffuse measurement for standard product.
7. DC detector gain setting for Monitor, Reflectance, and Diffuse detectors limited to 10K, 100K, 1M, 10M.

Options and Accessories

Options and accessories available for the IQE-200B Quantum Efficiency Measurement Solution:

DESCRIPTION	MODEL / PART NUMBER
Temperature Controlled Vacuum Chuck	IQE-200B-TC-VAC
Electrical Contact Probe Kit - Magnetic	PVIV-PROBE-KIT
Light Biasing Kit – Delivers white or filtered sample biasing illumination	IQE-LIGHT-BIAS
Vacuum Pump (for sample stage or IQE-200B-TC-VAC)	PVIV-VAC-PUMP PVIV-VAC-PUMP-220
Temperature Controlled Circulating Water Bath (for IQE-200B-TC-VAC)	PVIV-CHILLER
Optical Breadboard, 24 x 36 x 2.3 inches	IG-23-2

Chapter 2:

Assembly and Start-Up Instruction

This chapter describes the assembly process for the IQE-200B system and the start-up procedure.

IQE-200B Installation

Tools Required:

- #1 Phillips Screw Driver (not included)
- 1/16" Allen Wrench (PN: 90-11-042, included)
- 3/16" Allen Wrench (PN: 90-11-044, included)
- 9/64" Allen Wrench (not included)

STEP 1: ATTACH THE IQE-200B TO THE OPTICAL BENCH BREADBOARD

Parts needed to complete this step:

- 1 – Primary IQE-200B instrument body (PN: 603401)
- 4 – Optical bench mounting brackets (PN: PS-F)
- b) 4 – 1/4"-20x1" (PN: A1JD1432QAZB) or M6-1.0 x 25mm screws (PN: C1JR06025G)

Tools needed to complete this step:

- 9/64" Allen Wrench (not included)

Procedure:

- Place the IQE-200B onto the optical bench surface in an easily-accessible location
- Locate two holes nearest any two supporting feet on the base of the IQE-200B
- Repeat for both mounting brackets:
 - Place the semi-circular end of the mounting bracket around the supporting foot.
 - Rotate the mounting bracket such that a hole in the optical bench aligns inside the slit on the mounting bracket.
 - Using the 9/64" Allen Wrench, tighten one 1/4"-20 screw (or M6-1.0mm screw) into the hole through the slot in the mounting bracket.



Mounting Bracket Assembled

STEP 2: ATTACH SAMPLE STAGE

Parts needed to complete this step:

- 1 – Sample Stage (PN: 603354)

Procedure:

- Locate slide rail on IQE-200B on the right side of the instrument



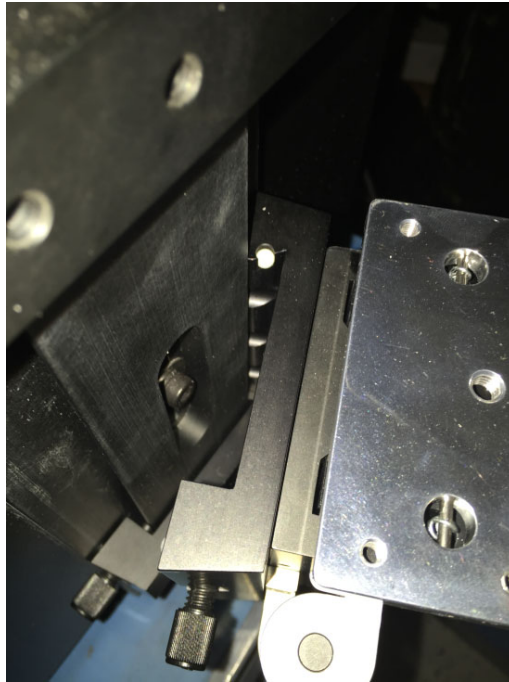
Sample Stage Slide Rail

- Unscrew thumb screw on left side of sample stage until only a few threads are holding the screw into the stage (or until the end of the screw is flush with the bottom of the V-groove on the inside of the stage mount).



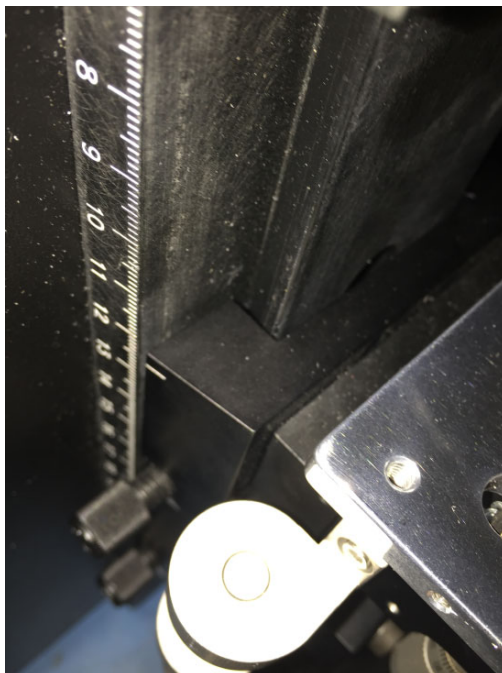
Location of Knurled Knob on Sample Stage

- With sample stage in the right hand, place right side of stage into right side of slide rail.



Right Side of Sample Stage Aligned

- Pivot the sample stage to align the left side of the sample stage to the left side of the slide rail. Using the left hand, tighten the thumb screw to secure the stage.



Left Side of Sample Stage Aligned

STEP 3: INSTALL LAMP

Parts needed to complete this step:

- 100 W Xenon Lamp Assembly (P/N 6252)

Tools needed to complete this step:

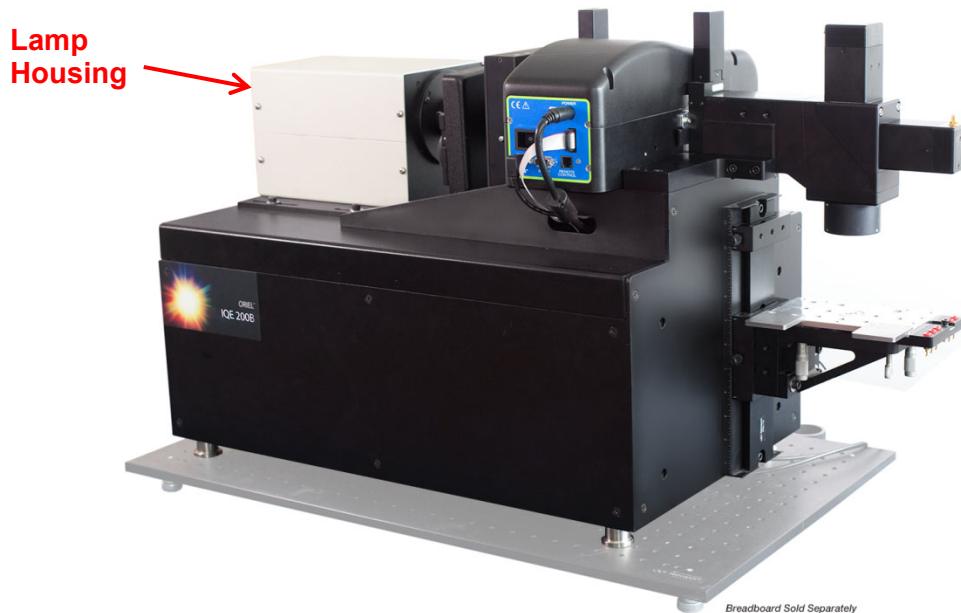
- #1 Phillips Screwdriver (not included)
- Gloves (not included), to prevent oils from contaminating the lamp

WARNING

- Before beginning this step, ensure that the main power supply is disconnected.
- When working with any lamp, handle carefully, and do not touch the bulb with bare fingers.

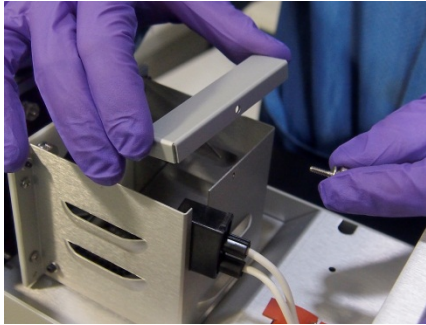
PROCEDURE

- Locate the lamp housing on the IQE-200B.



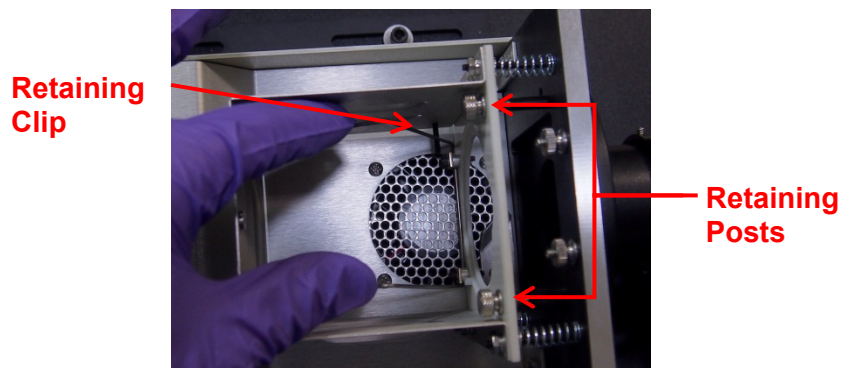
Location of Lamp Housing on the IQE-200B

- Using the Phillips screwdriver, remove the screws from the left and right sides of the top cover of the lamp housing (4).
- Remove the lamp housing cover.
- Remove the lamp cage connector retention cover by removing the thumbscrew and set aside.



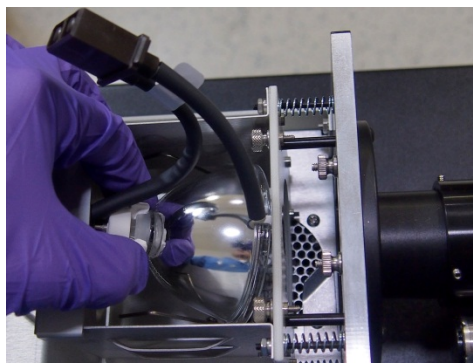
Lamp Cage Retention Cover and Thumbscrew

- Gently squeeze together the handles of the lamp retaining clip to disengage from the grooved retaining posts, and let it pivot back to its open position.



Lamp Retaining Clip and Posts

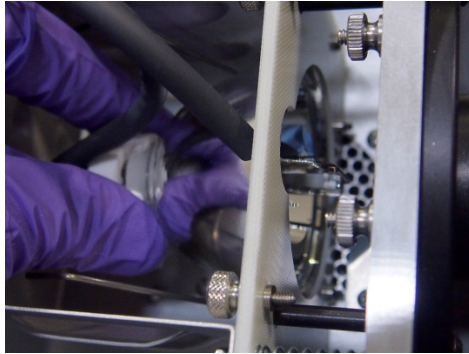
- Remove the new lamp from its packaging. Grasp it by the ceramic base with the Anode wire oriented upward for best maneuvering.



Lamp Handling, Insertion, and Removal

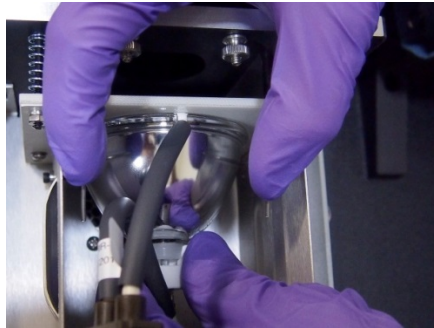
- Gently lower the lamp into the lamp cage. Rotate it slightly and tilt it back so that the anode lead wire clears the lamp seating plate.
- Guide the reflector rim into the recessed lamp seat, using the two white pegs as rests for guiding the lamp into place.

- Make sure the Anode wire is centered within the cutout at the top of the lamp seating plate.



Lamp Seating

- Engage the lamp retaining clips, one at a time, over the back side of the reflector rim on either side within the grooved retaining post above them.



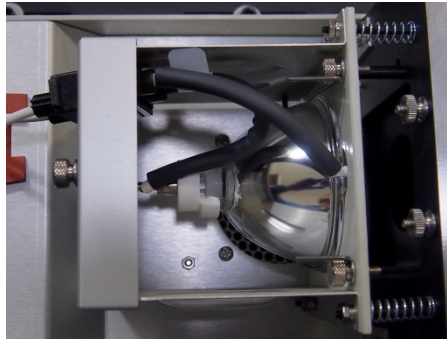
Lamp Held While Retaining Clip Engaged

- Slide the power supply connector into the cutout in the rear of the lamp cage while connecting it to the lamp connector.
 - Be careful not to stress the wires at the lamp ends.
 - Note that the connector is keyed for proper polarity.



Lamp Connector Engagement

- Replace the lamp cage connector retention cover and secure the thumbscrew.
- Replace the top cover, sliding it straight down.
- Replace the four (4) Phillips head screws in the top cover, tightening securely.



Properly Mounted Lamp

STEP 4: CONNECT CABLES

Parts needed to complete this step:

- Power Cable (Region-specific)
- USB Cable
- Laptop Computer
- Laptop Power Cable
- 240VAC Fuses, 1.5A (PN: 15-29-152)
- BNC Cables, 24 inch x3 (PN: 403230)

Tools needed to complete this step:

- Allen Wrench 1/8" (PN: 90-11-046 included)

PROCEDURE



Never connect or disconnect system cables when the IQE-200B is powered. This may result in permanent damage to the system. Sample cables should only be connected or disconnected when the sample circuit is in the *disabled* state (see Sample Control Screen in Chapter 4).

Monochromator Connections

- Ensure the monochromator cables are connected
 - Both the power and USB cables protruding from the IQE-200B body should be connected to the correspondingly labeled connectors on the side of the monochromator.



Monochromator Cable Connections

Lamp Power Connection

- Ensure the lamp power cable is connected.



Lamp Power Switch and Connector

Rear Panel Connections



Before beginning this step, inspect power cables to ensure the correct terminals exist for the region in which the IQE-200B is being installed.

Ensure the properly rated fuse is installed for the given line voltage.



Rear Panel of IQE-200B

- Ensure the detector cables are connected
 - Connect a 24" BNC cable between the BNC connector on the reflectance (top) detector and the reflectance BNC connector on the rear panel, labeled "A" in the figure above.
 - Connect a 24" BNC cable between the BNC connector on the monitor (side) detector and the monitor BNC connector on the rear panel, labeled "B" in the figure above.

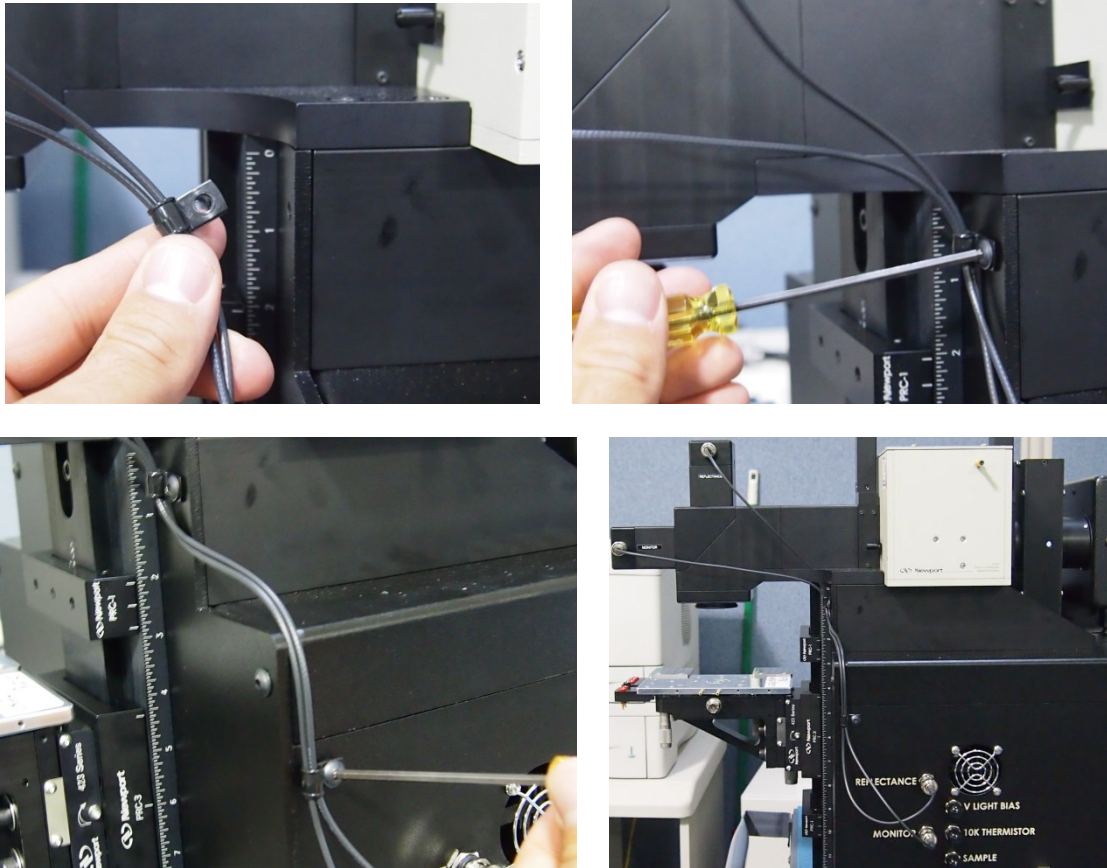


Detector BNC Connections



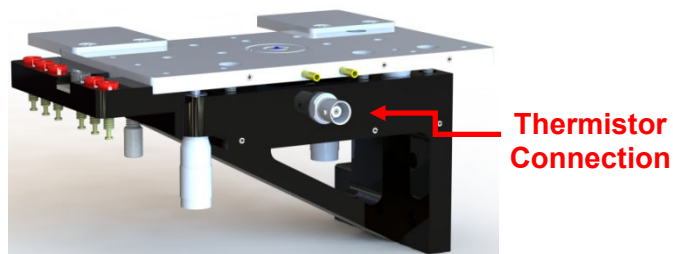
Connecting the Detector Cables

- The monitor and reflectance cables may be secured to the IQE-200B chassis using the included size Allen wrench through the existing cable loops.



Securing the Detector Cables to the Chassis

- Connect the Thermistor Cable
 - Connect a 24" BNC cable between the rear panel marked "10K Thermistor" and the back of the sample stage located on the right side of the instrument.



IQE-200B Sample Stage Thermistor Connection

- Connect the USB Cable
 - Connect the corresponding end of the USB Cable to the USB connector on the rear panel.
 - Connect the other end of the USB Cable to an available USB port on the Laptop Computer.
- Connect the Laptop Power Cable between the Laptop Computer power supply and a live outlet.

- Connect the IQE-200B Power Cable
 - While pressing the tab, remove the fuse holder from the power entry module on the rear panel of the IQE-200B.
 - Ensure that the correct fuses are installed based on the table next to the power entry module. The product arrives with fuses rated for line voltages 100-120V~. Included with the shipment are fuses properly rated for line voltage 220-240V~
 - Connect the corresponding end of the Power Cable to the power connector on the rear panel of the IQE-200B, labeled “D”.
 - Connect the other end of the power cable into a live outlet.

IQE-200B Start-Up

This start-up sequence should be followed each time the IQE-200B is powered from a cold state.



The instrument must be powered on and connected via USB before launching the software. The software expects the hardware to be enumerated and the drivers loaded at startup. Starting the software prior to hardware enumeration will result in loss of full software control and possibly erratic operation. To correct this, shut down the software and restart the software only when the hardware is powered on and USB has been enumerated.

STEP 1: POWER ON THE IQE-200B



UV radiation emitted from this product. Minimize exposure to eyes and skin. Use appropriate shielding.

PROCEDURE

- Switch the main IQE-200B system power switch on the rear panel to the “on” position.
- Listen for the chopper wheel to begin rotating. *To avoid heating of the chopper wheel, it must be spinning before turning on the lamp.*
- Power on the lamp by switching the lamp power switch to the “on” (I) position. The light on the switch will illuminate, indicating that the lamp housing has power.
 - The lamp power switch is on the rear panel of the lamp housing.
 - Allow the lamp to warm up for approximately 30 minutes for optimal stability.



Lamp Power Switch

- Power on the monochromator by switching its power switch to the “1” position.
 - The monochromator power switch is located on the side of the monochromator.
 - When powered on, the monochromator will begin a audible start-up sequence. The monochromator may already have this switch in the on position when received. It is acceptable to leave this switch on when shutting off or turning on the instrument from the main power switch.



Monochromator Power Switch

STEP 2: POWER ON THE LAPTOP COMPUTER AND START THE SOFTWARE



Before beginning this step, ensure that the previous procedure, “IQE-200B Installation”, has been completed in its entirety.

PROCEDURE

- Power on the laptop computer.
- Start the QUANTX software by double-clicking on the QUANTX Software Icon.
 - The QUANTX software will launch and initiate operation.



QUANTX Software Icon

 **WARNING**

Before your first measurements with your new IQE-200B system, please refer to Appendix A for a procedure to check that the wavelength output by the monochromator is correctly calibrated.

IQE-200B Shut-Down

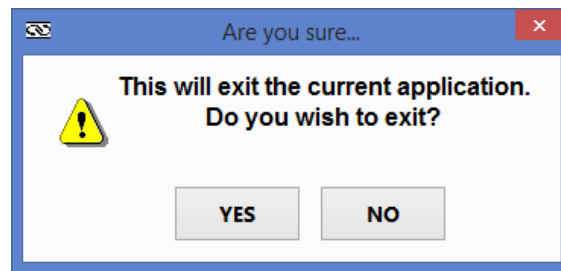
This procedure describes the correct, safe way to shut down the IQE-200B.

STEP 1: STOP THE QUANTX SOFTWARE

The software must be closed before powering off the system. Powering off or disconnecting the USB cable from the system while the software is running will result in an error state within the software.

PROCEDURE

- Click the “X” in the upper right hand corner of the software interface to close the software.
- When prompted for confirmation to exit the application, select “Yes”.



Software Exit Prompt

STEP 2: POWER OFF THE LAMP

 **WARNING**

Always power off the lamp before the main system power.

PROCEDURE

- Switch the lamp power switch to the “O” (off) position.
- The lamp cooling fans will continue to blow, bringing the temperature of the lamp down to a safe level before stopping.
- Do not continue the shut-down procedure until the fans have stopped.

STEP 3: POWER OFF SYSTEM AND DISCONNECT CABLES



As noted above, do not proceed to this step until the lamp cooling fans have stopped.

PROCEDURE

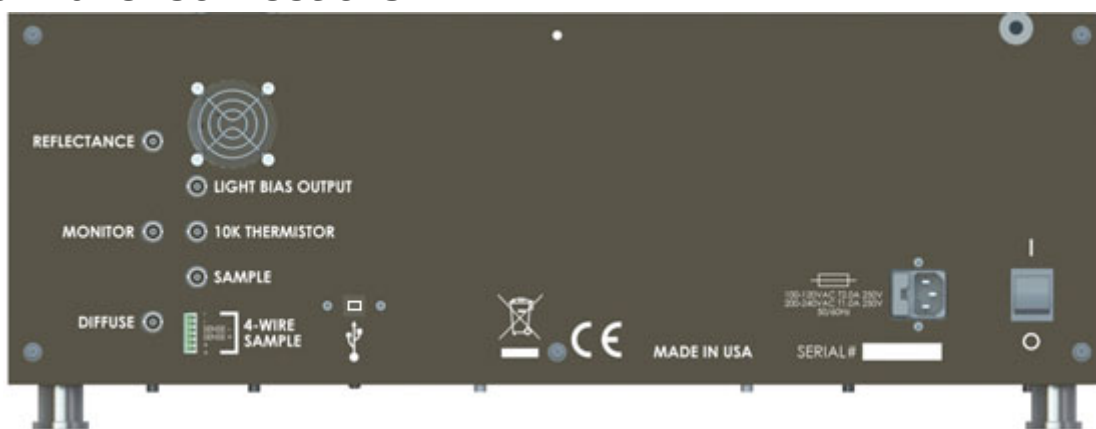
- Switch the mains power switch on the back of the IQE-200B main chassis to the “off” (O) position.
- The USB and AC power cables may now be removed from the system.

Chapter 3:

Description of Components

This chapter is a general description of the components that make up the IQE-200B Quantum Efficiency Measurement Solution.

Back Panel Connections



IQE-200B Back Panel Connections

The back panel of the instrument is laid out to make connection to the stage, sample, and system detectors easy and straight forward.

Reflectance – Connect the top most detector, marked REFLECTANCE, on the output optics assembly to the REFLECTANCE port.

Monitor – Connect the outer most detector, marked MONITOR, on the output optics assembly to the MONITOR port.

Diffuse – This port is provided for future upgrades to the system. Nothing is connected to this port at this time.

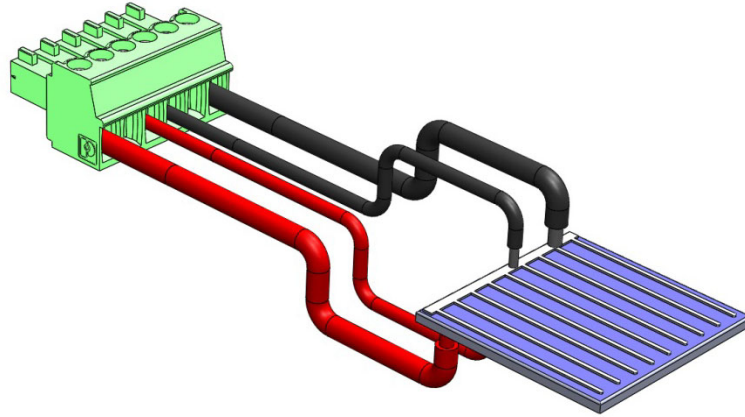
Light Bias Output– This provides a 0 – 5V DC signal to be used with the light bias accessory (Model IQE-LIGHT-BIAS). This feature is not currently active at this time.

10K Thermistor – This provides a 100 μ A signal to be connected to a 10K thermistor. The resistance of the thermistor is measured and converted to degrees Celsius. The temperature is displayed on the Sample screen in the software.

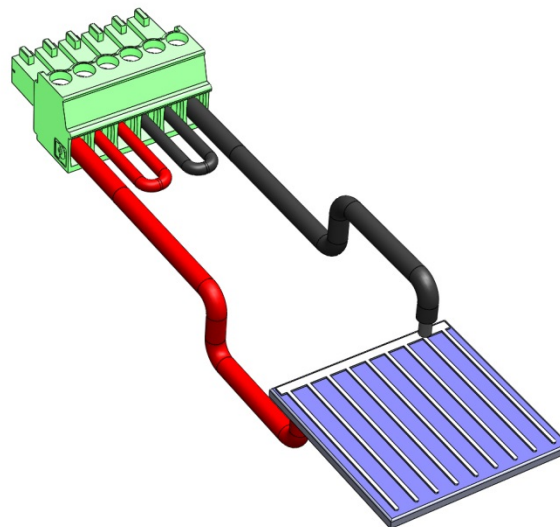
Sample – The sample under test can be connected to either the BNC Sample port or the 4-Wire Sample terminal block. The connection selected must also be set in the software on the Sample page



4-Wire Sample – connecting the Sample to the 4-Wire terminal input will provide 4-wire voltage measurement of the sample. This is necessary if you are interested in knowing the true value across your sample cell without the added voltage drop of the anode/cathode leads to the voltage sense circuit in the IQE system. This is important, for instance, with small PV cells that generate a small open circuit voltage across its anode/cathode.



4-wire connection from the back panel terminal input to PV cell. The \pm sense wires measure the true voltage drop at the cell and exclude the additional voltage drop of anode/cathode wires.



4-wire connector configured as a **2-wire connection** by jumping the \pm sense wires to the + anode and the – cathode wires. This configuration is common for larger PV cells that generate a large open circuit voltage across the anode/cathode.

USB – Connect the computer to the USB port prior to turning on the instrument.

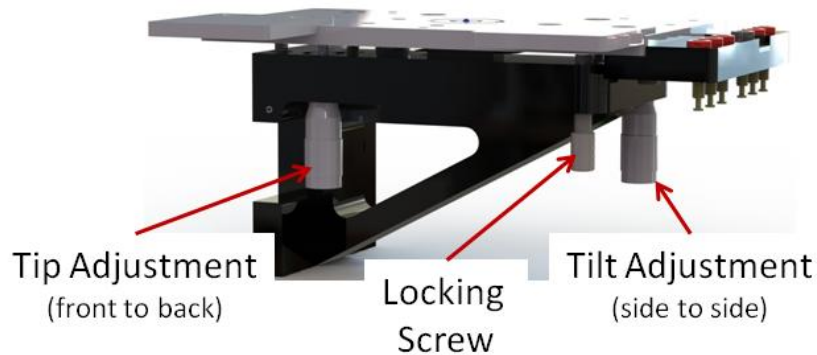
IEC Power Connection and Fuse Holder – The IQE input A/C power works over the range of 100-120V and 220-240 VAC. Refer to the rear panel for the correct rating of fuse for each range.

On / Off Switch – The instrument main power switch is on the back of the unit. The lamp can be turned off independently via a switch on the lamp housing. It is good practice to turn off the lamp and let the fan cool the lamp for several minutes before turning off the main power to the instrument. The monochromator has an independent switch on the front of the unit. The Main power switch must be on for the light source or the monochromator to come on. It is **not necessary** to turn off the monochromator before turning off the Main switch.

Tip-Tilt Stage

The IQE-200B comes with a Tip-Tilt stage to aid the user in correctly placing and connecting to the sample. The installation of the stage is described in the assembly Instructions.

The Tip-Tilt stage can be adjusted $\pm 2.5^\circ$ from front to back and side to side. This is useful when the sample does not sit flat on the stage. The stage can then be adjusted to put the surface of the sample at a normal incidence to the light path.

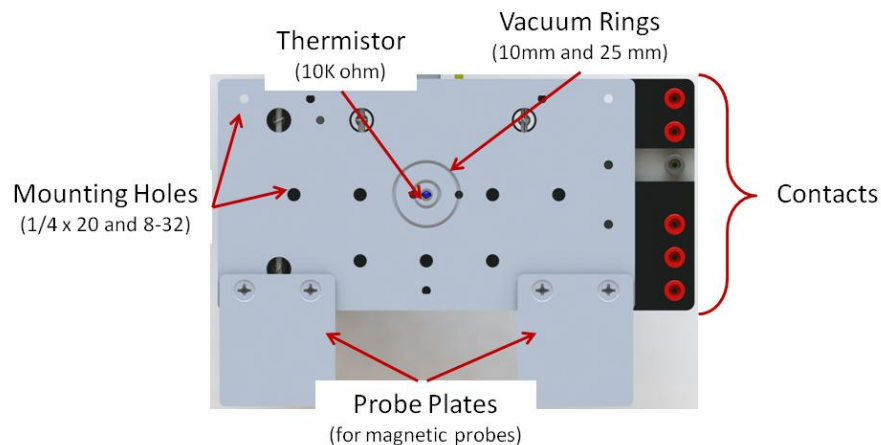


603354 IQE-200B Sample Stage Adjustments

Tip Adjustment – Raises and lowers the front of the stage.

Tilt Adjustment – Raises and lowers the right side of the stage.

Locking Screw – Used to prevent movement of the platform under heavy loads such as water cooled plates resting on the stage.

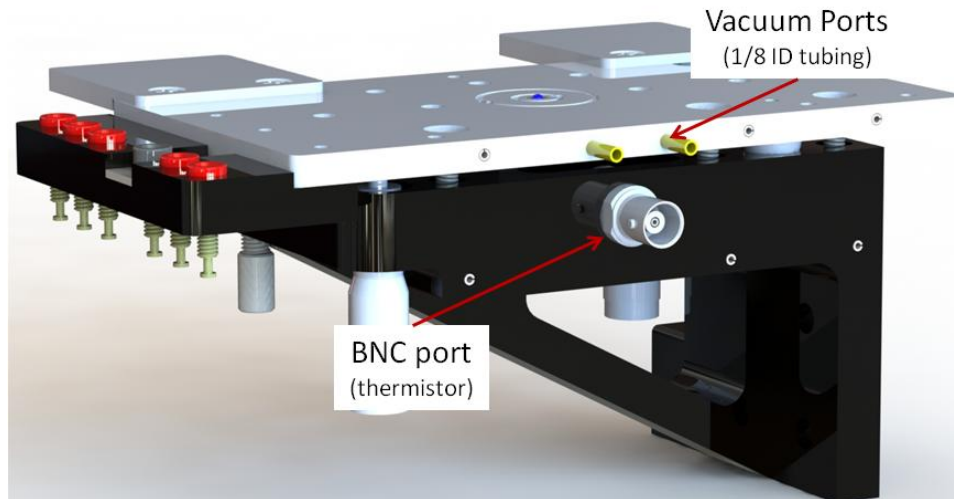


603354 IQE-200B Sample Stage Sample Interface Features

Mounting Holes – The platform has multiple tapped holes in the surface to allow the user to mount whatever is desired. The holes are 1/4"-20 and 8-32 tapped holes. Use of metric screws in the platform will damage the threads.

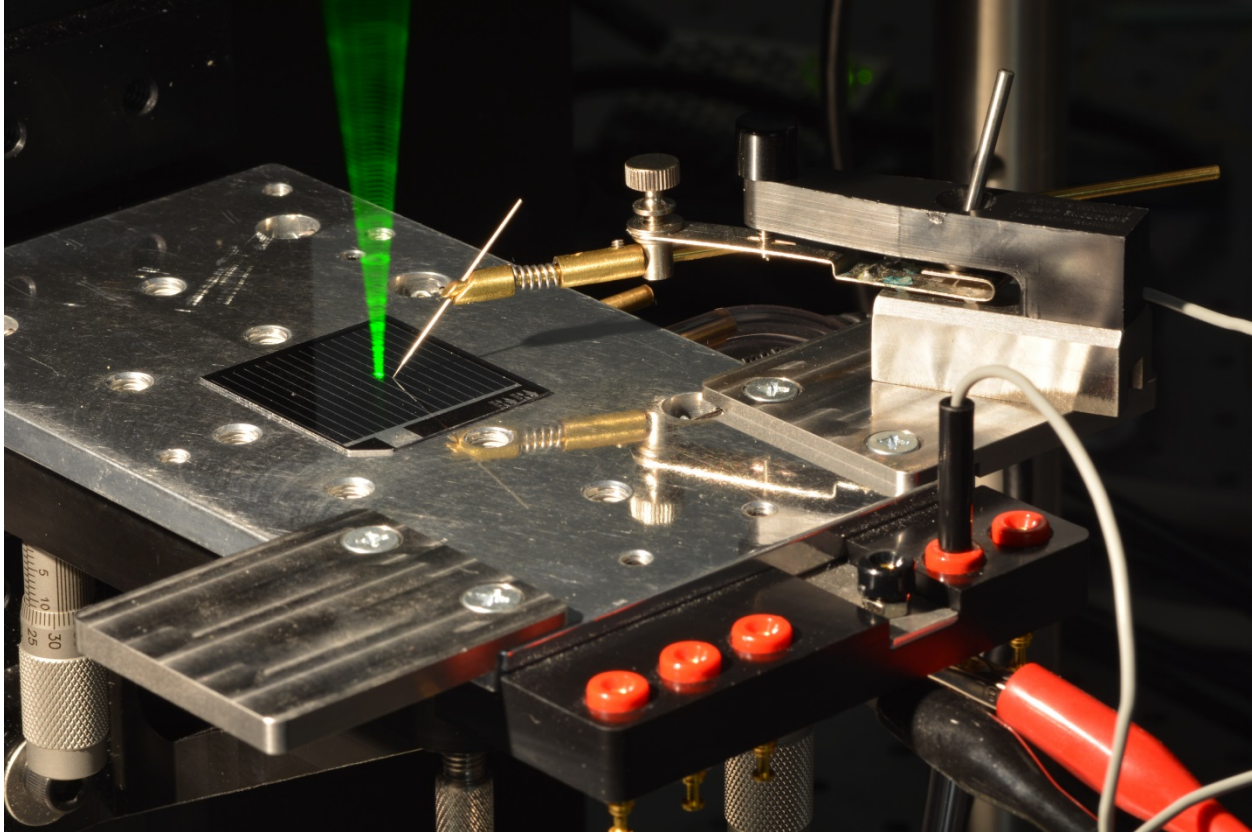
Thermistor – A 10K thermistor is located in the center of the platform. The thermistor is on a spring bias to aid in contacting with the sample. The Thermistor is wired to the BNC port on the back side of the platform.

Vacuum sample hold-down – Two vacuum rings are provided at 10mm and 25mm diameters to hold down thin samples directly to the sample stage. Each ring are connected to a 1/8" vacuum port on the back of the stage to. The instrument ships with vacuum tubing to connect to a standard vacuum pump



Contact Points – There are 6 contact jacks mounted on the platform. The jacks are isolated from each other and from the instrument ground. The black contact is tied to the polished, sample stage plate for easy connection to samples with a common back side connection.

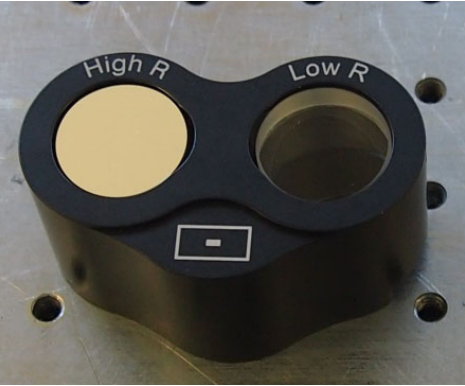
Probe Plates – The system ships with two probe plates. These are intended for use with magnetic base probes. The plates can be screwed to any of the four corners on the platform.



Steel probe plates can attach to any corner of the stage plate to support magnetic probes. The backside contact of this PV sample is in electrical contact with the polished surface of the stage which is shorted to the black mini-banana jack. A second connection is made through the probe contacting a bus bar next to the beam position.

Reflectance Standard

The IQE-200B ships with a calibrated reflectance standard designed to provide reliable and repeatable measurements when used with the IQE-200B.

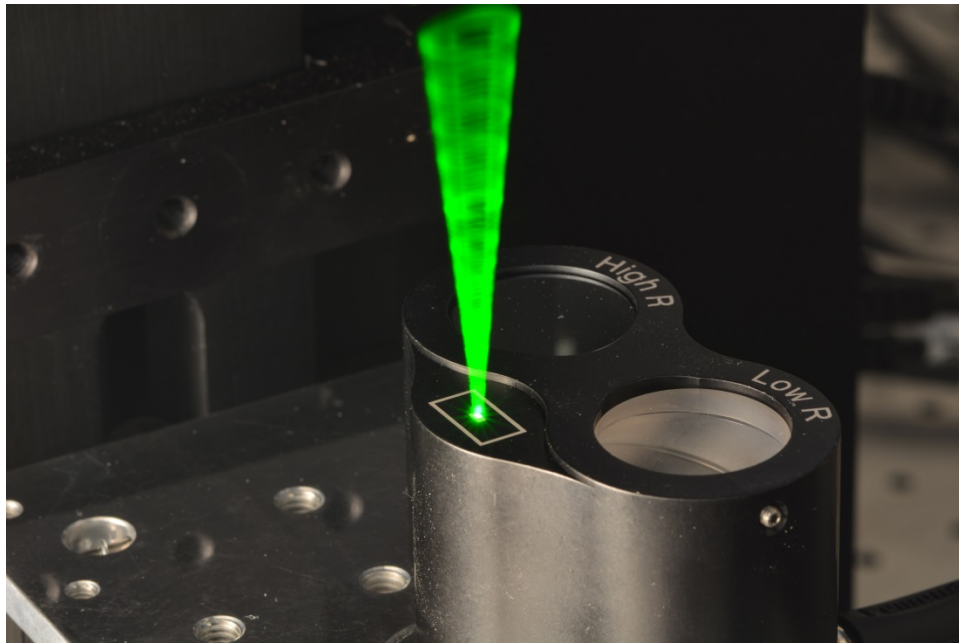


603414 IQE-200B Specular Reflectance Standard

The housing contains both a high and low reflectance standard. The calibration files for the standard are included on the computer that ships with the system. The machined recess in the top of the holder lies at the same height as the surface of the reflectors to give you a scattering surface to see the beam and adjust the sample stage height until the focal plane is reached.

The standard includes a focusing point on the front face to aid in setting the proper working height of the stage.

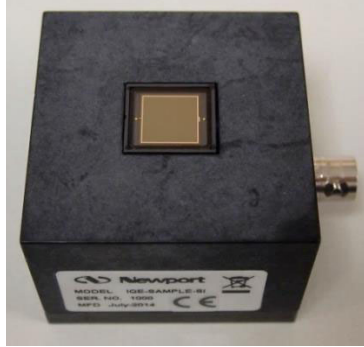
1. First place the standard on the stage with the focusing point (small rectangle) in the light path.
2. Turn the lamp on, and with the lamp sufficiently warmed up, select a wavelength that is visible such as 555nm.
3. Adjust the vertical position of the sample stage by loosening the thumb screw, slide stage up or down along rail and lock the stage into place with the thumb screw. Fine vertical adjustments can be made using the micrometer next to the thumb screw until the beam size is minimized and approximately the same size as the spot etched on the face of the reflection standard holder.



The high and low reflectance standard surfaces are the same height as the target etched on the holder. The calibrated reference detector and the test sample also match the height of the focal plane so little or no vertical stage adjustment is necessary between calibrations and testing.

Calibrated Reference Detector

The IQE-200B ships with a calibrated reference detector (IQE_Sample Si_XXX) designed to provide reliable and repeatable calibration for the IQE-200B.



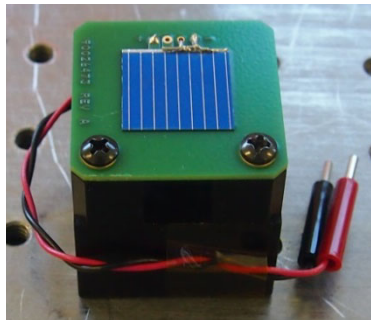
IQE-Sample_Si_XXX Calibrated Reference Detector.

This detector cube contains a 10x10mm silicon photodetector whose spectral response was measured at Newport against a known calibrated reference detector calibrated at NRC following 17025 certification standards. The spectral response file is preloaded on the laptop and USB flash drive that accompanies the IQE-200B. Please take great care of the detector by keeping the cover on unless it is in use, not dropping it or touching/contaminating the detector area. This may cause the detector to perform differently from its calibration and will reduce the accuracy of the IQE measurements. Newport offers a recalibration service in the event you would like to have the detector recalibrated.

The housing contains a standard BNC port to connect a BNC cable to from the back panel of the IQE system labeled “Sample”. The height of the calibrated reference detector matches the height of the optical surfaces in the supplied reflectance standard to make monitor and reflectance detector calibration at the focal plane of the output beam without having to move the height of the sample stage.

Test Sample

The instrument ships with a Test Sample which is a silicon based PV cell. A final test is run at the factory using this sample. The results of this scan are saved on the included USB flash drive. These can be used to compare the results from your scan to the factory set up.



SAMPLE-QESI IQE-200B Test Sample

Note that this cell is not intended for use to verify system performance specifications. Newport recommends using calibrated reference cell model 91150V for this purpose. This reference cell is accredited to the ISO/IEC 17025 standard by our PV Calibration and Test Lab. Please contact a Newport sales engineer for more information.

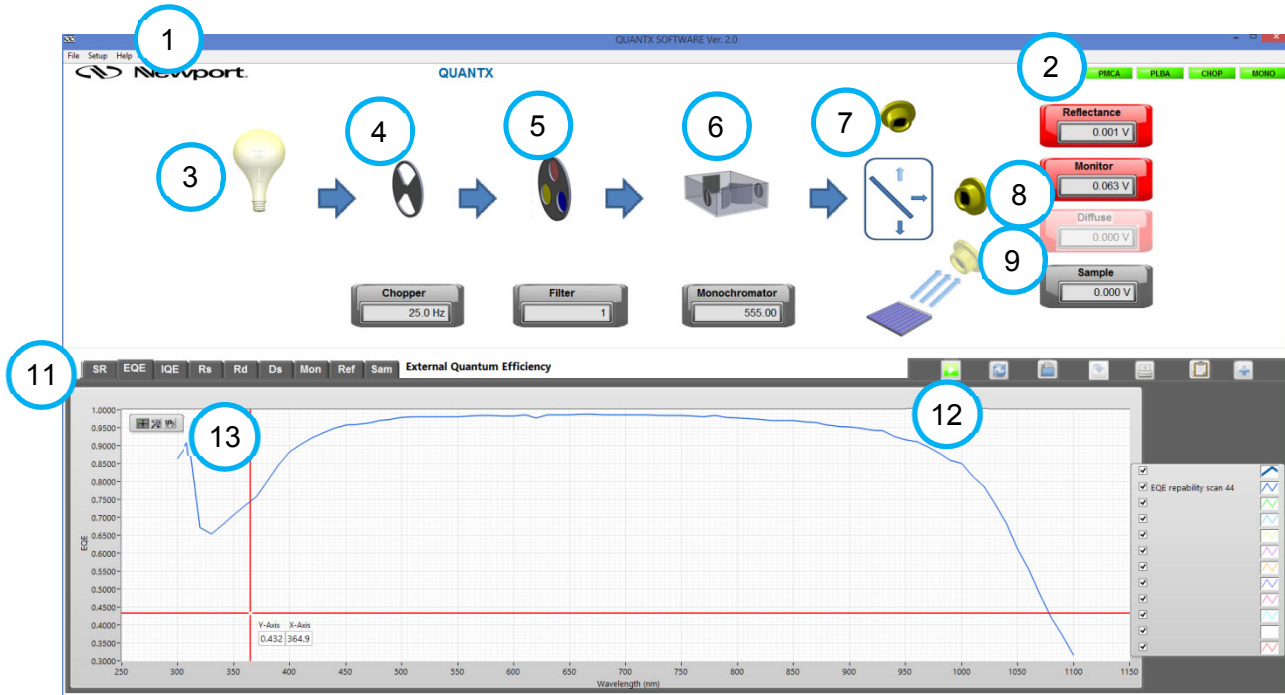
Chapter 4: QUANTX Software

The IQE-200B system includes a software application to operate the system. The software is icon based to make the operation straightforward for a wide audience of users. The computer that ships with the system comes with the software pre-installed. To launch the software double click on the desktop icon.



Main Screen

When the software is launched it opens the main control screen shown below:





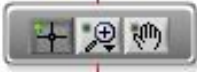


A description of the controls on the main screen are described in the following chart. More details on how to use each function is presented in this chapter and Chapter 5.

Item	Icon	Name	Description
1		Pull down menu	Provides a quick navigation and information for the application.

2		Component Status Bar	Indicates system component connectivity (Green = communicating, Red = disconnected)
3		Lamp	Represents Xenon white light source. Icon has no functionality.
4		Optical Chopper Control	Modulates the white light from the lamp at a set frequency for lock in detection. Min frequency = 4Hz Max frequency = 100Hz
5		Filter Wheel Control	Contains order-sorting optical filters that automatically synchronize with the monochromator to provide monochromatic output. Filter 1 → 2 @ 610nm Filter 2 → 3 @ 1030nm
6		Monochromator Settings	Set the start, stop, and step wavelength of the measurement scan.
7		Reflectance Detector	Settings for measurement and calibration for specular reflectance detector.
8		Monitor Detector	Settings for measurement and calibration for monitor detector.
9		Diffuse Detector	Settings for measurement and calibration for diffuse reflectance detector – not yet enabled.
10		Sample	Settings for measurement for calibrated reference detector and PV samples.
11		SR	Spectral Response of the PV sample, measured in Amps per Watt (A/W) over the wavelength range of the

			scan.
		EQE	External Quantum Efficiency of the PV sample measured in x100% over the wavelength range of the scan.
		IQE	Internal Quantum Efficiency of the PV sample measured in x100% over the wavelength range of the scan.
		Rs	Specular Reflectance off the surface of the PV sample measured in x100% over the wavelength range of the scan.
		Rd	Diffuse Reflectance off the surface of the PV sample measured in x100% over the wavelength range of the scan. Not enabled.
		Ds	Diffuse (V) Lock in voltage proportional to the current from the diffuse detector. Not enabled.
		Mon	Monitor (V) Lock in voltage proportional to the current from the monitor detector.
		Ref	Reflectance (V) Lock in voltage proportional to the current from the reflectance detector.
		Sam	Sample (V) Lock in voltage proportional to the current from the sample.
12		Start Stop Scan	Turns red during scan. Click to stop scan with the option to save data up to stopped wavelength.
		Clear Graphs	Clears all graphs from main screen. Graphs automatically clear when a new scan is started.
		Load Scan Data	Load a single, previous measurement saved in the "LOGS" folder.

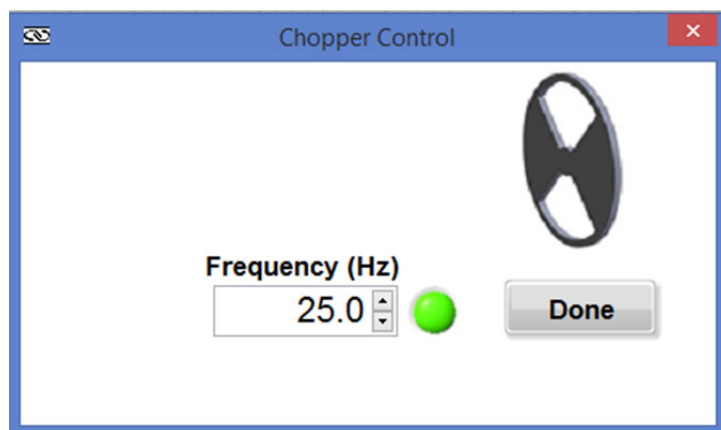
		Save all Graph Data	Saves current measurement (RS, EQE, IQE, SR, Mon, Ref Sam) as a time-stamped, tab-delimited text file in the LOGS folder.
		Print Visible Graph	Sends to current, visible graph on main screen to local printer.
		Jsc Calculator	Enables floating pop up window with short circuit current density Jsc values calculated from current scan at various conditions including AM0, AM1.5, AM1.5D+C.
		Expand / Compress Graph	Enlarges graph to full screen of application to see graph detail. Click on – to reduce graph to original size.
13		Graph Manipulation Tools	Zoom in using boundary, zoom in using region, pan graph, zoom out to full scale. Double left click on graph to zoom back out..

Chopper Control

Click on Chopper Wheel Icon to set frequency of the optical chopper.



An optical chopper is used to amplitude modulate the white light from the Xe lamp at a 50% duty cycle using a 2-hole chopper blade. This generates an AC signal from the system detectors and PV sample that can be combined in the lock in amplifier to output low noise measurements and filter out background/room lights with frequencies greater than the chopper frequency. Slow chopping frequencies can result in a longer scan time, but may be necessary for PV cells with slow response time.



Chopper Control Window - Indicator turns green when chopper rotation is locked to desired frequency.

Function	Sets the chopping frequency of the system	The indicator light turns bright green when the chopper has locked to the input frequency.
Range	4Hz to 100Hz	Use lower chopping frequencies when measuring PV cells with slow response times.
Increment/decrement	± 0.1 Hz and settable to 0.1Hz	Use arrows to increase/decrease chopper speed or enter desired value. Press enter to set chopper frequency to new value.
Default	25 Hz	

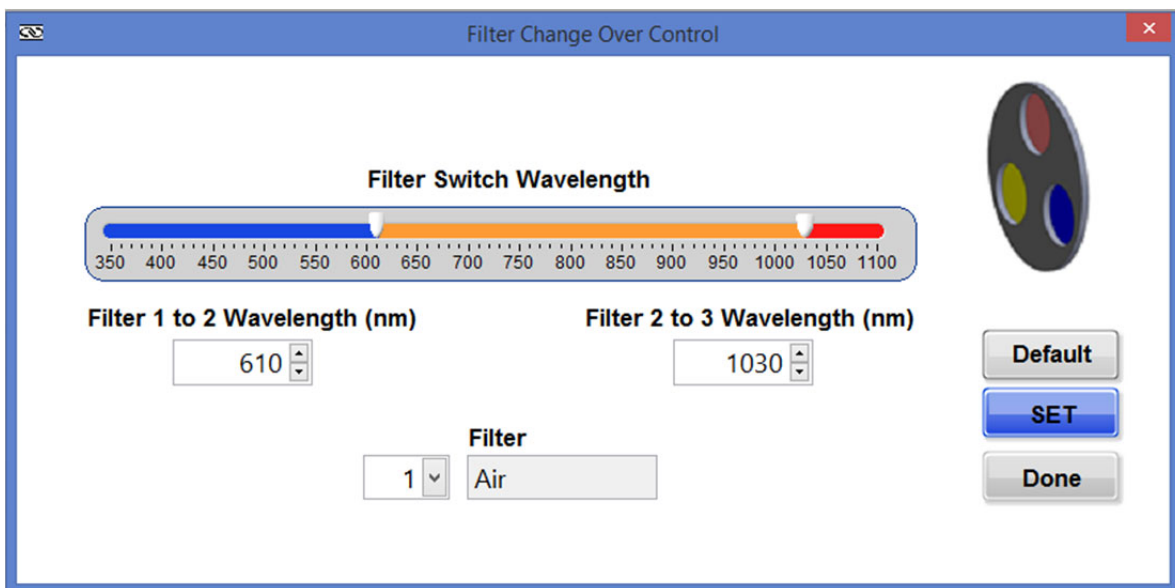
Filter Wheel Control

Click on Filter Wheel Icon to set switch over wavelengths to order-sorting filters.



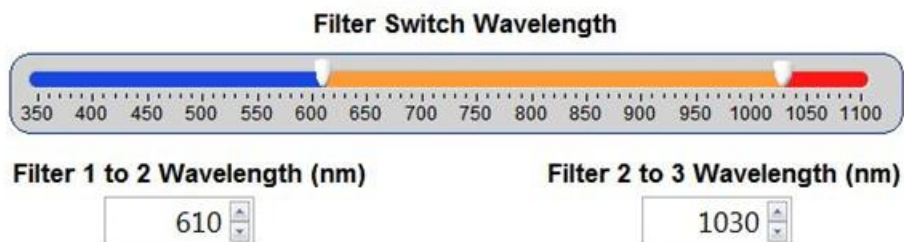
A filter wheel containing order-sorting optical filters is synchronized with the monochromator to eliminate unwanted light from passing through the monochromator. For instance, when set to 800nm, the monochromator will also pass $800/2 = 400\text{nm}$ light through unless the lower wavelength light is filtered out. The filters switch into place automatically as the monochromator tunes past the switch-over wavelength. The default settings will work for most measurements. You may want to move the switch over wavelength $\pm 10\text{nm}$ if a feature of interest in your scan lies near one of default switch-over wavelengths.

Filter Settings Window



Filter Settings Window

The switch-over wavelength can be adjusted using a) slider, b) increment/decrement arrows or c) entering desired number. Hit enter key to for selection to take effect.



Adjust filter using slider or input boxes

IMPORTANT: Be sure to click on the “SET” button after changing the wavelength values or returning to the Default values for the changes to take effect.



Save the new wavelength settings by clicking on the SET button

Manual Filter Select

You have the option to rotate the filter manually if desired. Click on the down arrow and select the filter number you want. The filter wheel will rotate immediately after you make your selection as indicated by an audible motor sound. The IQE-200B is fitted with a standard 5-position filter wheel of which only 3 positions are being used with the additional two positions reserved for wavelength expansion. Therefore the wheel will take longer to switch from position 3 to position 1 because it only rotates one direction. This is normal.

Manual filter adjust can be helpful when determining if the filter switch-over wavelength is affecting a feature in your scan. For instance, tune the wavelength of the monochromator to the peak of the feature of interest and switch filter manually while monitoring the current output of your PV sample using a separate current meter.



Manual Filter Selection

Note that the manual setting is only temporary and the instrument will revert to automatic filter control when the filter settings window is closed.

Function	Sets the switch-over wavelength for the order sorting filters	Adjust either switch over wavelength by $\pm 1\text{nm}$ to $\pm 10\text{nm}$ to move off the wavelength corresponding to a feature of interest in your scan
Range	Filter 1 \rightarrow 2: 350 to Filter 2 \rightarrow 3 Filter 2 \rightarrow 3: Filter 1 \rightarrow 2 to 1100nm	Recommend 610nm \pm 10nm for 1 \rightarrow 2 Recommend 1030nm \pm 10nm for 2 \rightarrow 3
Increment/ decrement	1nm	Use arrows to increase/decrease filter switch-over wavelength. Press enter to set chopper frequency to new value.
Default	Filter 1 \rightarrow 2 610nm Filter 2 \rightarrow 3 1030nm	Can click on the "Default" button to reset switch-over wavelength to these values
Filters	1 = air 2 = 10CGA-590 3 = 10CGA-1000	No filter in position 1 Cut on filter at 590nm Cut on filter at 1000nm

Monochromator Control

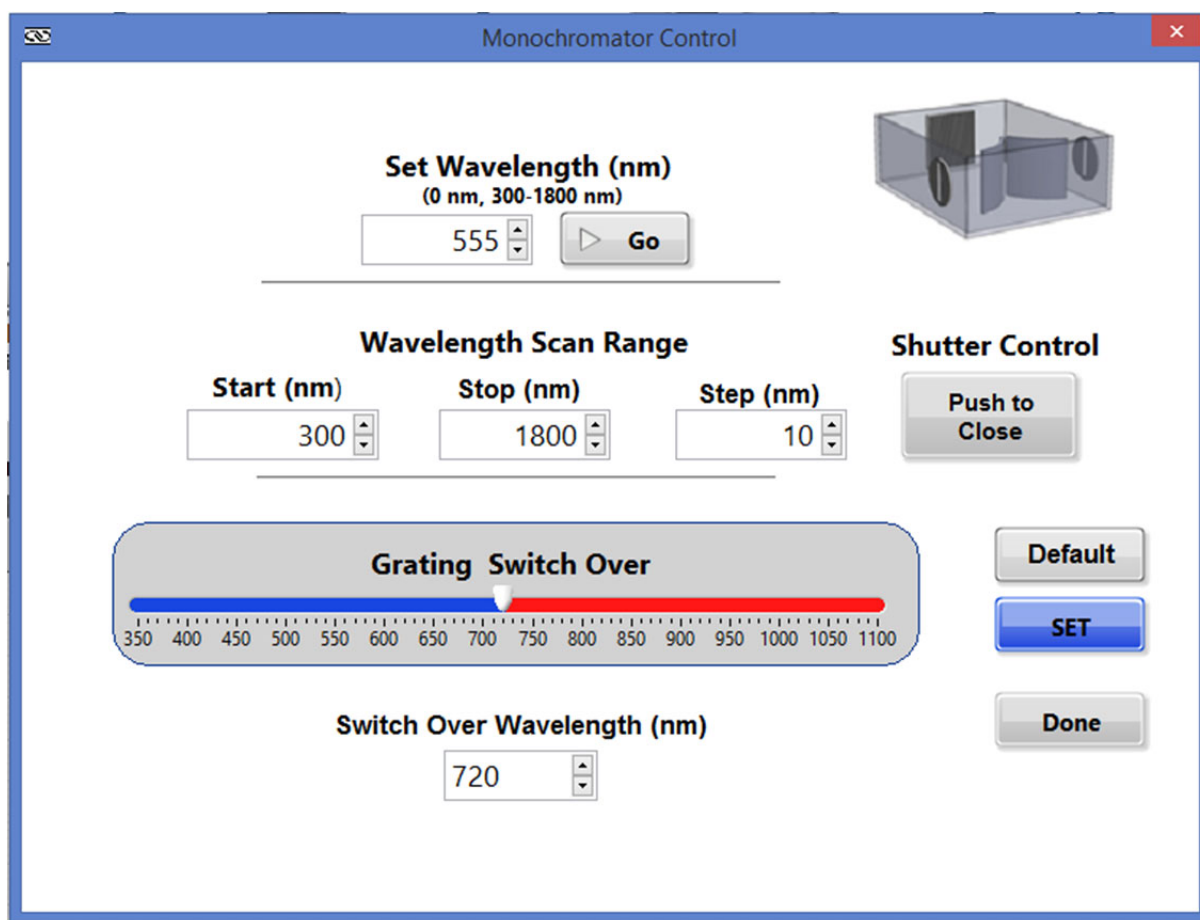
Click Monochromator Icon to manually set wavelength, set scan start, stop, and step size wavelengths, and set the grating switch over wavelength.



A 1/8m Oriel Monochromator (CS130B) is used to filter out a narrow bandwidth of the incident white light source and tune its center wavelength across a desired range of interest. The full width at half maximum (FWHM) bandwidth is set by the entrance / exit slit width. The monochromator uses two, 600 lines/mm ruled diffraction gratings, one blazed at 350nm for the visible range and the other at 1000nm for the near infrared range

The input/exit slit on the IQE-200B has been factory set at 750 μm for a 10nm FWHM bandwidth and protected from accidentally bumping the micrometers by protective covers.

Monochromator Settings Window



Set Wavelength

The current wavelength of the monochromator can be set manually using Set Wavelength in the monochromator settings window. This is useful to setting the output to a visible wavelength to align the beam on to the PV sample. The input can be entered manually or by using increment/decrement arrows. Click on the “Go” button for the setting to take place. After a moment, the actual wavelength of the monochromator is shown. *NOTE: The actual wavelength of the monochromator will rarely exactly match the set wavelength due to mechanical limitations of the monochromator drive. This is normal.*

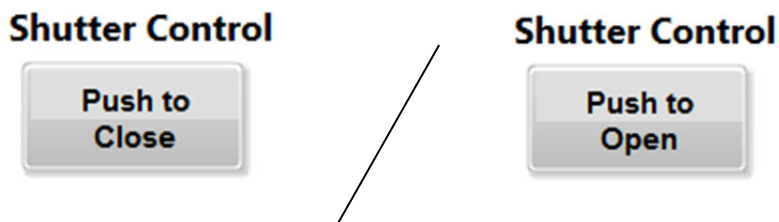
Set Wavelength (nm)

555.06

Function	Sets the center wavelength of the monochromator manually	Set to visible wavelength such as 555nm to aid in beam alignment on to the sample.
Range	350 – 1100nm	
Increment/decrement	1nm	Use arrows to increase/decrease wavelength. Press enter to set wavelength to new value.
Default	555nm	For beam alignment

Shutter Control

The monochromator includes an integrated shutter to control the illumination of the sample. When scanning a sample, the shutter is always opened but returns to the state, open or closed, that the shutter was in prior to starting the scan. The button indicates the action the shutter will take once selected.




Monochromator Scan Control

The start/stop/step wavelengths of the scan are set using the Wavelength Scan Range in the monochromator settings window. One strategy is to select a narrow range to do a test scan over for quick feedback to verify the detector and sample signals are not saturated (ie ~ 10V). Once you are satisfied with the narrow scan results, you can increase to the full wavelength range confident the results will be accurate. **IMPORTANT:** Click on the “SET” button for these settings to take effect!

Wavelength Scan Range

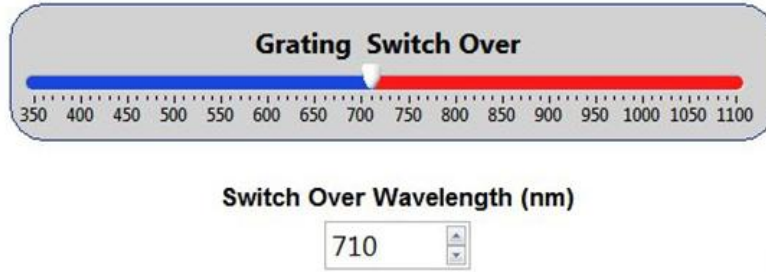
Start (nm)	Stop (nm)	Step (nm)
350	450	10

Function	Sets the start, stop and step wavelength scan of the monochromator	Set to visible wavelength such as 555nm to aid in beam alignment on to the sample.
Range	Start = 300 nm to stop wavelength Stop = start wavelength to 1100nm Step = 1nm and up	Step wavelength = 10nm typical, 40nm max as per ASTM E1021-06 standard and 13 steps across full scan
Increment/decrement	1nm	Use arrows to increase/decrease wavelength. Press enter to set wavelength to new value.
Default	Start = 350nm Stop = 1100nm Step = 10nm	300-330nm = EQE accuracy <25% 340nm = EQE accuracy < ± 7% 350nm + = EQE accuracy <±3%
NOTE		Press “SET” button for wavelength values to take place

Monochromator Grating Control

The CS130B monochromator contains two, 600 lines/mm ruled diffraction gratings blazed at 350nm for the visible range and 1000nm for the near infrared range (extended range not yet available). The grating switch over control allows you to select the wavelength the monochromator switches from grating #1 to grating #2 for higher efficiency. Grating #1 has high enough efficiency through the entire scan range from 300-1100nm so not switch is needed during this wavelength range. As a result, the switch over wavelength is set to a default of 1110nm so no switch takes place. Grating #2 will be used in the extended range version of the

IQE-200B to scan from 1100 to 1800nm.



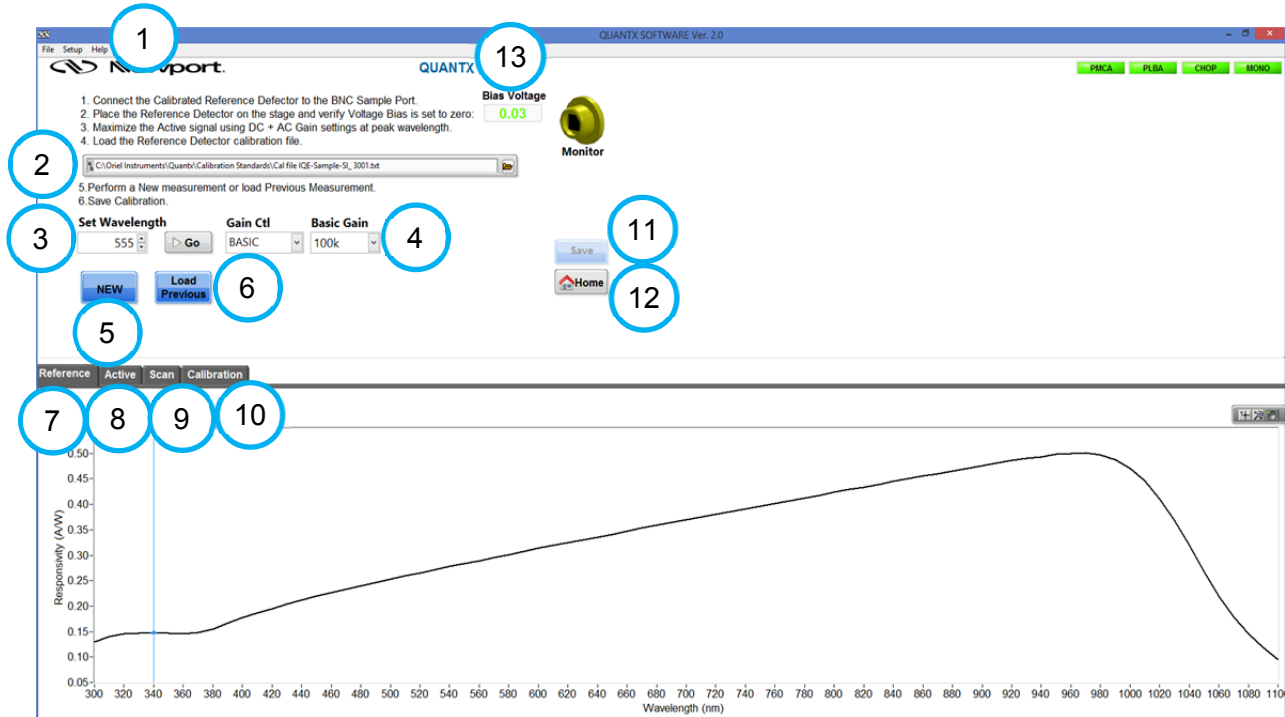
Adjust grating switch-over wavelength using slider or input box. Typically no switch-over is needed during up through 1100nm so the switch over wavelength is default is 1110nm.

Function	Sets the switch-over wavelength for the diffraction gratings	Grating #1 is efficient enough to scan the full range up to 1100nm so no switch over is needed. .
Range	350 – 1100nm	Typical = 1110nm (no switch-over)
Increment/ decrement	1nm	Use arrows to increase/decrease wavelength. Press enter to set wavelength to new value.
Default	1110nm	Set to $\lambda > 1100\text{nm}$ so no switch occurs

Monitor Calibration Controls



Click on the Monitor Detector icon to visit the monitor settings screen



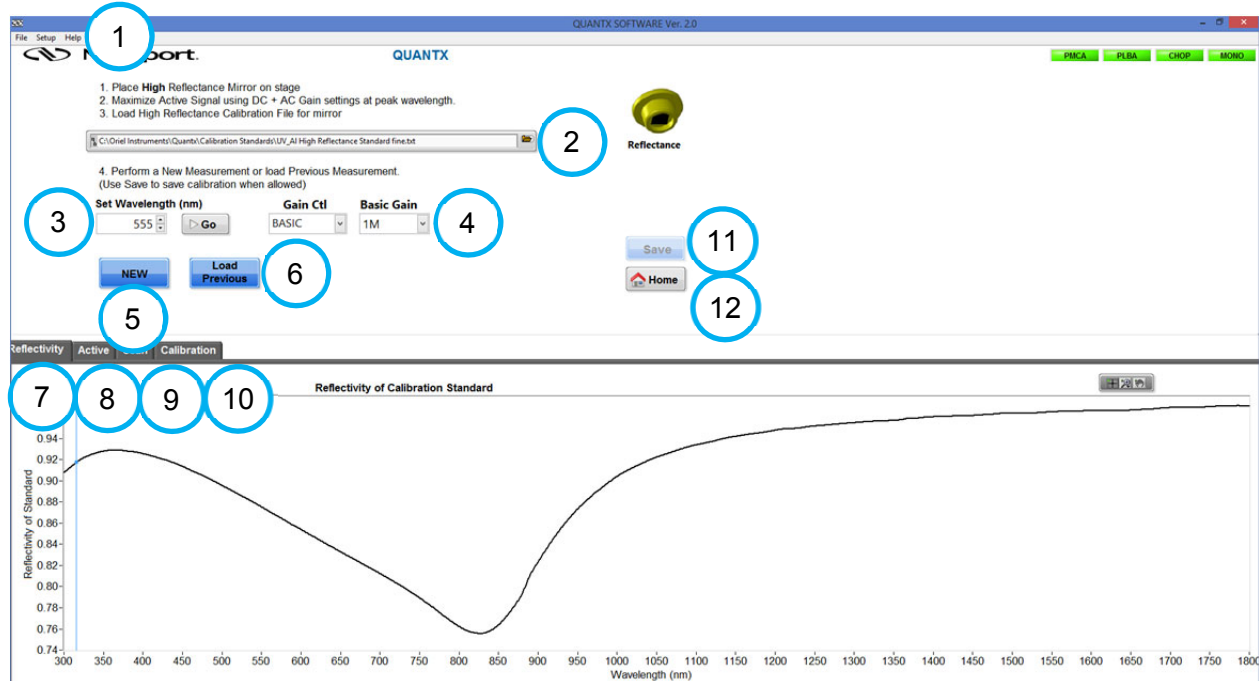
The monitor detector screen guides the user through the steps needed to define the relationship between the monitor detector signal and the spectral response of the calibrated reference detector. More specifically, the signal from the monitor detector directly correlates to the optical power at the sample at each wavelength step. Once calibrated, measured signals from the PV samples and reflectance detectors are divided by the monitor detector signal to make the measurements independent of lamp intensity fluctuations. The monitor calibration is needed to calculate spectral response (SR) and external quantum efficiency (EQE) of the sample.

Item	Description of Monitor Screen
1	Pull down file menu provides a quick navigation and information for the application
2	Load Spectral Response of calibrated reference detector
3	Set wavelength / display present wavelength of the output beam. Temporarily set output wavelength to optimize monitor detector settings
4	<p>Gain settings for monitor detector signal gain. Recommended setting: Basic 100k</p> <p>The QuantX software provides two options for gain settings, Basic and Advanced. Basic gain settings allow for a single gain factor to be selected, while the underlying constituent gains are set automatically. Advanced gain settings yield access to independent selection of DC and AC gain, as well as the signal coupling.</p> <p>The signal is processed through two gain stages. The first, DC, boosts the entire signal including the component from any light bias. The second stage is the AC stage, which removes the constant component from light biasing. The overall gain in AC coupling is the product of these two gains, while in DC coupling it is the DC gain alone.</p> <p>Increase gain until amplitude of Active signal (8) increases to approximately 1Vpp for optical signal to noise ratio.</p> <p>DC Gain = 10K, 100K, 1M, 10M AC Gain = 1, 10, 100, 1000 Coupling = AC (centered about 0) or DC (starts at 0)</p>
5	NEW - Starts a new scan and stop the scan before it reaches the stop wavelength, if desired
6	Load Previous - option to quickly load the last calibration of the calibrated reference detector if the IQE system has not changed since its last calibration
7	Reference (A/W) – graph of the spectral response of the calibrated reference detector as a function of wavelength (nm)
8	Active (Volts) – graph of the chopped optical signal as function of time used to optimize gain
9	Scan (Volts) – raw, lockin signal recorded by the monitor detector as a function of wavelength(nm)
10	Calibration – effective spectral response of the monitor detector correlating the detector signal to the optical power at the sample at each wavelength step. <i>Calibration data cannot be graphed until the scan is complete.</i>
11	Save – Enabled when scan is completed or stopped manually. Saves calibration file for monitor detector by overwriting last calibration file.
12	Home – Exits calibration screen and returns to home IQE screen. Selecting home before saving the calibration file will void the monitor detector calibration.
13	Bias Voltage – Read out of the bias voltage on the calibrated reference detector. This should be zero (or very near 0) as indicated by the green text for an accurate calibration. If the bias voltage is not zero (red), visit the sample screen and zero the bias voltage before calibration.

Reflectance Measurement Controls



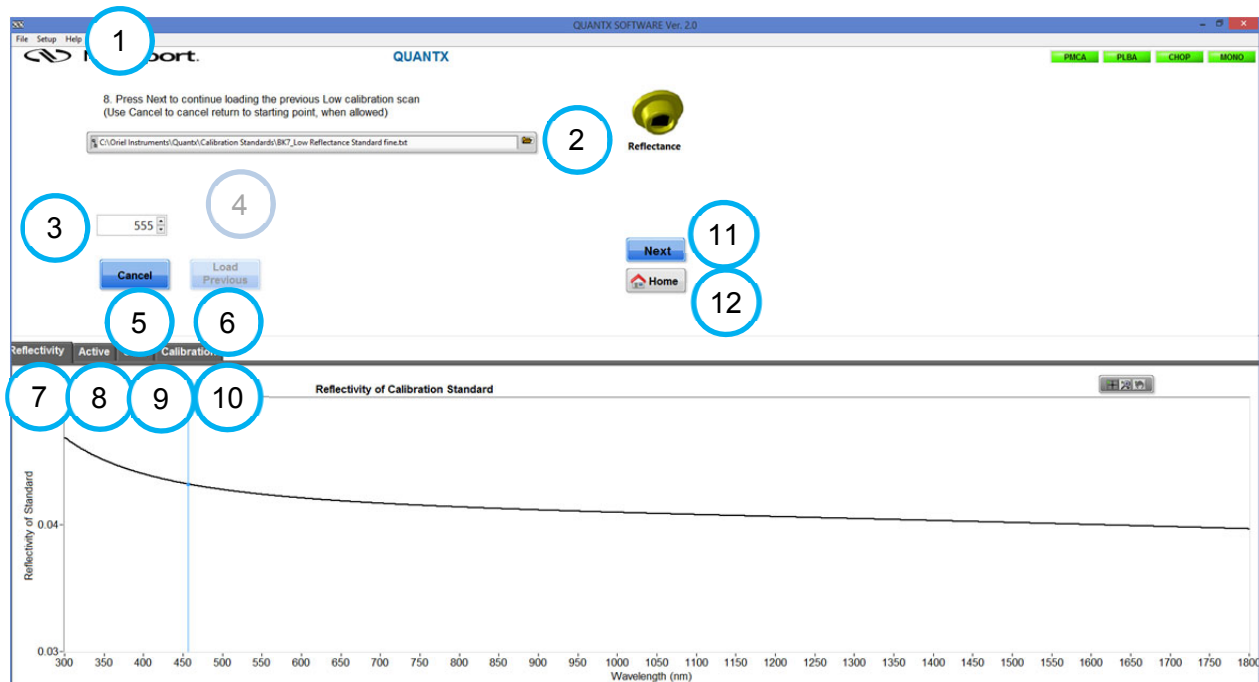
Click on the Reflectance Detector icon to visit the reflectance settings screen



The reflectance detector screen guides the user through the steps needed to define the relationship between the reflectance detector signal and the specular reflectivity of the sample. In the first screen, the detector measures the reflectivity off a known, *high reflection* standard as a function of wavelength. Following this measurement, a second screen guides the user through a similar measurement off a known, low reflection standard. The specular reflectivity of an unknown PV sample will fall between these two extremes and can be uniquely determined. The sample reflectivity is needed to calculate the IQE from the EQE of the sample. The reflectance detector signal is divided by the monitor detector signal to make the measurements independent of lamp intensity fluctuations.

Item	Description of First Reflection Screen
1	Pull down file menu provides a quick navigation and information for the application
2	High reflectance file for high reflectance standard
3	Set wavelength / display present wavelength of the output beam. Temporarily set output wavelength to optimize reflectance detector settings
4	<p>Gain settings for reflectance detector signal gain. Increase gain until amplitude of Active signal (8) increases to approximately 1-2Vpp for optical signal to noise ratio.</p> <p>The QUANTX software provides two options for gain settings, Basic and Advanced. Basic gain settings allow for a single gain factor to be selected, while the underlying constituent gains are set automatically. Advanced gain settings yield access to independent selection of DC and AC gain, as well as the signal coupling.</p> <p>The signal is processed through two gain stages. The first, DC, boosts the entire signal including the component from any light bias. The second stage is the AC stage, which removes the constant component from light biasing. The overall gain in AC coupling is the product of these two gains, while in DC coupling it is the DC gain alone.</p> <p>DC Gain = 10K, 100K, 1M, 10M AC Gain = 1, 10, 100, 1000 Coupling = AC (centered about 0) or DC (starts at 0)</p>
5	NEW - Starts a new scan and stop the scan before it reaches the stop wavelength, if desired
6	Load Previous - option to quickly load the last calibration of the high reflectance detector if the IQE system has not changed since its last calibration
7	Reflectivity (x100%) – graph of the reflectivity of the high reflectance standard as a function of wavelength (nm)
8	Active (Volts) – graph of the chopped optical signal as function of time used to optimize gain values and tip/tilt of the sample stage
9	Scan (Volts) – raw, lockin signal recorded by the reflectance detector using the high reflectance standard as a target as a function of wavelength (nm).
10	Calibration – slope “m” and intercept “n” for relating the reflectance detector signal to sample reflectivity. <i>This cannot be graphed on this screen yet until the low reflectance standard has completed.</i>
11	Save – Enabled when scan is completed or stopped manually. Saves calibration file for high reflectance sample by overwriting last calibration file. Calibration must be saved to continue to the low reflectance calibration step.
12	Home – Exits calibration screen and returns to home IQE screen. Selecting home on this screen will void the reflectance detector calibration.

To advance to the second reflectance calibration screen, a reflectance file should automatically load (2), select New (5) or Load Previous (6), and Save (11) the results. The second calibration will replace the first screen.



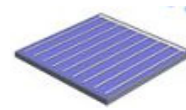
Item	Description of Second Reflection Screen
1	Pull down file menu provides a quick navigation and information for the application
2	Low reflectance file for high reflectance standard
3	Display present wavelength of the output beam.
4	<i>Note that the ability to adjust the detector is intentionally removed from this screen in order to match the gain values set in the first screen</i>
5	NEW - Starts a new scan and stop the scan before it reaches the stop wavelength, if desired
6	Load Previous - option to quickly load the last calibration of the low reflectance detector if the IQE system has not changed since its last calibration
7	Reflectivity (x100%) – graph of the reflectivity of the low reflectance standard as a function of wavelength (nm)
8	Active (Volts) – graph of the chopped optical signal as function of time
9	Scan (Volts) – raw, lockin signal recorded by the reflectance detector using the low reflectance standard as a target as a function of wavelength (nm).
10	Calibration – slope “m” and intercept “n” for relating the reflectance detector signal to sample reflectivity.
11	Save – Enabled when scan is completed or stopped manually. Saves calibration file for low reflectance sample by overwriting last calibration file. Calibration must be saved to complete the calibration
12	Home – Exits calibration screen and returns to home IQE screen.

Diffuse Measurement Controls

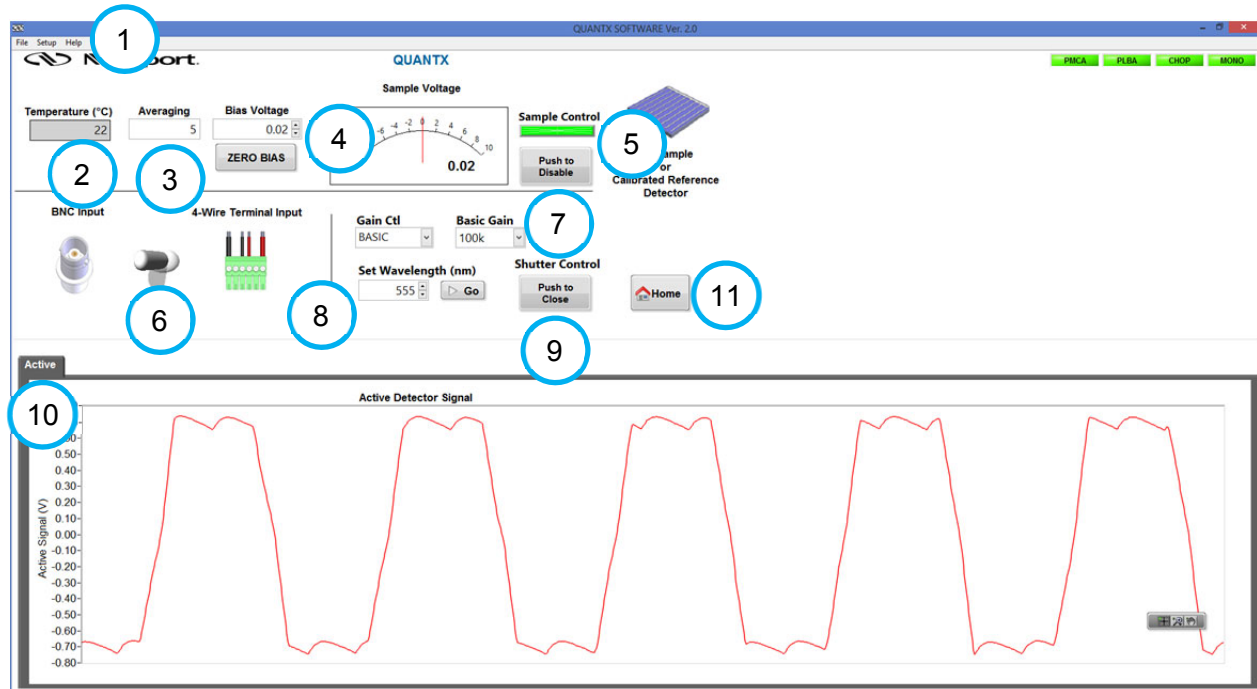
This is a place holder for future support of diffuse measurements.



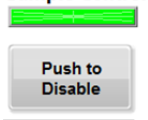

Sample Measurement Controls



Click on Sample icon to enter the sample screen and adjust the **voltage bias**



The sample screen contains settings needed to measure the reference detector during calibration and your PV samples. It includes voltage bias control for your sample, sample connection to the IQE system, trans-impedance gain, and an enable/disable switch to safely connect the electrical output of your sample to the detection circuit. The details of these features are outlined in the chart below

Item	Description of Sample Screen
1	Pull down file menu provides a quick navigation and information for the application
2	<p>Temperature - spring loaded 10K thermistor is located on the surface of the sample stage to measure the approximate temperature of the sample. The resistance of the thermistor is converted to degree Celsius using the Steinhart-Hart equation with the generalized coefficients:</p> $C1 = 1.125 \times 10^{-3}$ $C2 = 2.347 \times 10^{-4}$ $C3 = 0.855 \times 10^{-7}$
3	<p>Averaging – sets the number of detector/sample measurements the IQE instrument makes <i>at each wavelength step</i> during a scan and averages each detector/sample measurement.</p> <p>1 = quick scan to get a rough estimate of sample performance (8'30" for default scan) 10 = good calibration and high accuracy scan (10'50" for default scan) 40 = excellent calibration and ultra-high accuracy scan (18'30" for default scan)</p>
4	<p>Bias Voltage - sets a bias voltage on the sample from 0 - ±10V up to a current of 0.5A. The actual voltage across sample is displayed on the analog meter for quick reference, and displayed digitally on the lower right hand corner for recording purposes. The voltage can be set to zero quickly by clicking on the "ZERO BIAS" button.</p> <p>Note: The sample needs to be enabled (5) for an accurate bias voltage readout</p>
5	<p>Enable Sample – switches the sample connection from the safety circuit to the detector circuit in the instrument. DO NOT CONNECT/DISCONNECT YOUR SAMPLE TO THE IQE INSTRUMENT WHEN THE SAMPLE CIRCUIT IS ENABLED! Doing so may damage the sample.</p> <p>When the status bar is lit, this indicates that the sample circuit is enabled. The button indicates the action the circuit will take once selected.</p> <p>Sample Control</p>  <p>When the status is not lit, this indicates that the safety circuit is enabled. The button indicates the action the circuit will take once selected.</p> <p>Sample Control</p> 
6	<p>Input – switch must correlate to the input the sample is connected to make measurements. The BNC is convenient for the calibrated reference cell. The 4-wire allows ± sense wires to run to the cell contacts for a true 4-wire measurement. Both inputs default to the safety circuit so it is safe to connect the sample to either input unless it is enabled (5). Do not connect a cell that can exceed the input limit = ±10V @ 0.5A.</p>
7	<p>Gain settings for sample signal gain. Increase gain until amplitude of Active signal (9) increases to approximately 1-2Vpp for optical signal to noise ratio.</p> <p>DC Gain = 100, 1000, 1K, 10K, 100K, 1M, 10M AC Gain = 1, 10, 100, 1000 Coupling = AC (centered about 0) or DC (starts at 0)</p> <p>Note: AC gain disabled when Coupling = DC</p>
8	<p>Set wavelength / display present wavelength of the output beam. Temporarily set output wavelength to optimize sample settings</p>
9	<p>Shutter Control – same functionality of the shutter as in the Monochromator Control icon</p>

10	Active (Volts) – graph of the chopped optical signal as function of time. Sample must be Enabled for the chopped signal to be accurate.
11	Home – Exits sample screen and returns to home IQE screen. You can leave the sample screen with the sample either Enabled or Disabled.





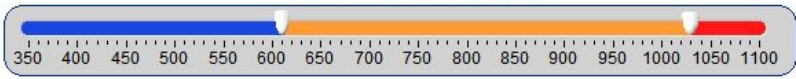

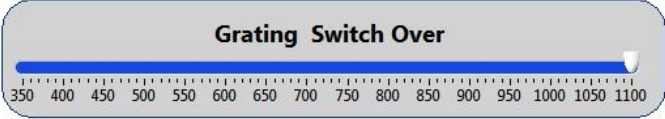
Chapter 5:

Calibration and Measurement

This section describes how to calibrate the monitor and reflectance detector built into the IQE-200B using the supplied calibrated reference detector and reflectance standards to achieve accurate measurements. These procedures assume the IQE-200B is set up and running and the IQE-200B software application has just been launched and is in control of the system. Please configure the system and follow the calibration steps listed below to familiarize yourself with the calibration process. Once understood, the system settings can be tailored to fit your specific measurement.

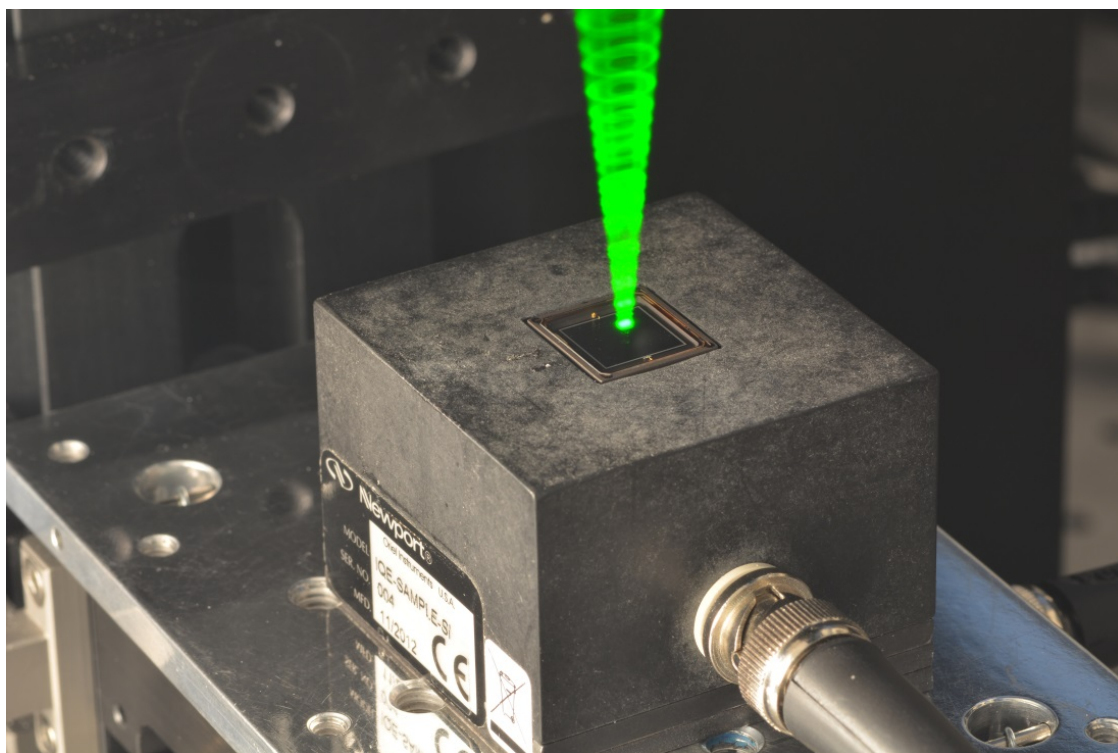
System Configuration

Set up the IQE-200B system according the following default configuration in preparation for calibration scans

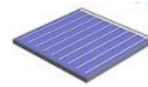
System Setting	Description						
	Frequency (Hz) <input type="text" value="25.0"/>						
							
	Filter Switch Wavelength  Filter 1 to 2 Wavelength (nm) <input type="text" value="610"/> Filter 2 to 3 Wavelength (nm) <input type="text" value="1030"/>						
	Set Wavelength (nm) <input type="text" value="555.04"/> <input type="button" value="Go"/> <hr/> Wavelength Scan Range <table style="width: 100%; border: none;"> <tr> <td style="text-align: center;">Start (nm)</td> <td style="text-align: center;">Stop (nm)</td> <td style="text-align: center;">Step (nm)</td> </tr> <tr> <td style="text-align: center;"><input type="text" value="350"/></td> <td style="text-align: center;"><input type="text" value="1100"/></td> <td style="text-align: center;"><input type="text" value="10"/></td> </tr> </table> <hr/> Grating Switch Over  Switch Over Wavelength (nm) <input type="text" value="1110"/>	Start (nm)	Stop (nm)	Step (nm)	<input type="text" value="350"/>	<input type="text" value="1100"/>	<input type="text" value="10"/>
Start (nm)	Stop (nm)	Step (nm)					
<input type="text" value="350"/>	<input type="text" value="1100"/>	<input type="text" value="10"/>					

Monitor Detector Calibration


1. Place detector on sample plate at the focal plane of beam. It is not important to level the sample stage using the tip/tilt adjustments to calibrate the spectral response. Visual inspection of level is adequate. Connect to sample port with BNC. Make sure it is clean and free of dust

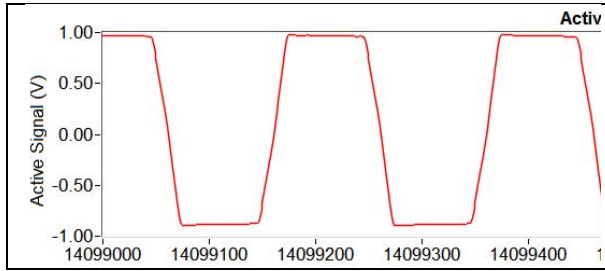


Calibrated reference detector approximately centered under the output beam at 555nm.



2. Click on Sample icon to enter the sample screen and adjust the following settings

Sample Setting	Description
<p>Temperature (°C)</p> <p>21.4</p>	<p>Reading should be close to room temperature in degrees C. Verify BNC cable is connected from sample stage BNC to Temperature BNC on back panel.</p>
<p>Averaging</p> <p>10</p>	<p>1 = minimum average. Scan time = 8' 30" good for quick scan test 5 = low average for calibration. Scan time = 9' 31" 10 = recommended for calibration. Scan time = 10' 50" 40 = high accuracy calibration. Scan time = 18' 30"</p>
<p>Bias Voltage</p> <p>0.01</p> <p>ZERO BIAS</p>	<p>Set Bias Voltage = 0 for calibration using a) enter "0" in bias voltage text box b) click on "zero bias"</p>
<p>BNC Input 4-Wire Terminal Input</p> 	<p>Verify input selection switch points to the BNC input port. Verify BNC cable is connected from Calibrated Sample Cell to BNC input on back panel.</p>
<p>Set Wavelength (nm)</p> <p>555.04</p> <p>Go</p>	<p>If you can't see the output, verify wavelength is set to a visible value such as 555nm. Center beam on to detector surface.</p>
<p>Sample Control</p> <p>Push to Enable</p> <p>Sample Control</p> <p>Push to Disable</p>	<p>Enable Sample (calibrated reference detector) and verify chopped signal is being plotted on the Active graph at the bottom of the Sample Screen.</p>
<p>DC Gain AC Gain Coupling</p> <p>100k 1 AC</p>	<p>Adjust gain settings to: DC Gain = 100K AC Gain = 1 Coupling = AC</p> <p>NOTE: If the gain is too high, signal will saturate at the Xe emission peaks and require you to reduce the gain and rescan. The noise floor is $\sim 10^{-4}$ below signal for high dynamic range of the signal. Note that DC coupling turns off the AC gain factor.</p> <p>DC gain = lower noise good for slower chopping frequencies. AC gain = higher chopping frequencies with less concern to noise.</p>


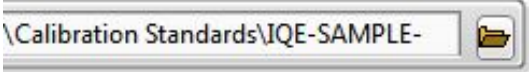
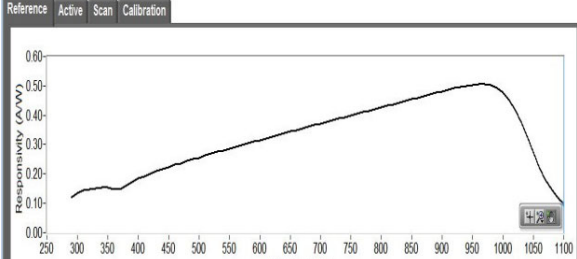
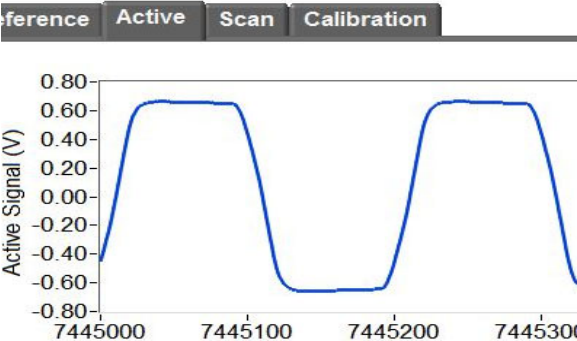
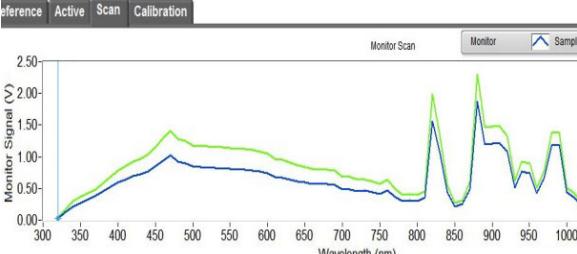



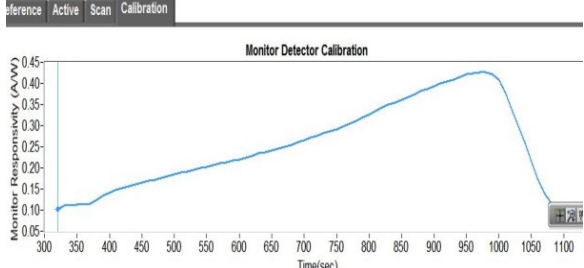



Active signal should have square tops/bottoms with amplitude of 1-2 Vpp.

Note if the chopped signal has wavy or non-flat tops/bottoms you may need to shield the detector from room lights by placing the supplied 1.5" tube on top of the detector.



3. Click on the Monitor Detector icon to enter the monitor calibration screen

Monitor Setting	Description
<p>Bias Voltage</p> <p>0.00</p>  <p>Monitor</p>	<p>Check the bias voltage = 0 (green). If bias voltage is $\neq 0$ (red) then return to sample screen and zero the bias voltage.</p>
	<p>Load the calibrated reference detector calibration. The calibration file should be titled "SAMPLE-IQE-Si_xxxx"</p>
	<p>Check the calibration curve for the calibrated reference detector is what you expect under the "Reference" tab in the graph area at the bottom of the screen</p>
<p>Set Wavelength (nm)</p> <p>555.04</p> <p>Go</p>	<p>Verify wavelength is tuned to a visible value such as 555nm to and check beam is centered on calibrated reference detector.</p>
<p>DC Gain 100k</p> <p>AC Gain 1</p> <p>Coupling AC</p>	<p>Adjust gain settings to:</p> <p>DC Gain = 100K</p> <p>AC Gain = 1</p> <p>Coupling = AC</p>
<p>Reference Active Scan Calibration</p> 	<p>Click on the "Active" tab to view the chopped signal. Verify the amplitude of the signal is approximately 1 Vpp to keep the signal from saturating at wavelengths associated with the Xe emission peaks.</p>
<p>NEW</p>	<p>Click on the "NEW" button to begin calibration.</p>
<p>Reference Active Scan Calibration</p> 	<p>View the raw detector signal (lockin-voltage) as the wavelength scans by selecting the "Scan" tab in the graph area.</p> <p>Monitor = Blue Curve</p> <p>Reference Detector = Green Curve</p> <p>NOTE: If signals exceed 10V at Xe emission peaks, reduce gain on appropriate detector and repeat scan.</p>

	Click on "Save" when scan is complete
<p style="text-align: center;">Are you sure you want to save the calibration? Doing so will overwrite previous calibration.</p> <p style="text-align: center;"> <input type="button" value="Yes"/> <input type="button" value="No"/> </p>	Click on "Yes" at the prompt to overwrite last calibration with the new monitor calibration.
	Check calibration on "Calibration" tab. It should look similar to the calibrated reference scan with slightly lower values.
	NOTE: If the monitor detector was recently calibrated you can "load previous" to load the last calibration file made as an alternative to making a new scan. This will reset the gain values for the monitor and sample to their last settings as well. Save calibration after loading file. Use this feature to save time calibrating system if is unchanged from last use. See table below for suggestions when to use this feature.
	Click on "Home" to return to main screen.
	Verify monitor detector is calibrated as indicated by a green border surround the detector value on the main screen. NOTE: The system does not check the accuracy of the calibration. The green border only indicates the process of calibration and saving the file was successful.

Important! Do not modify the Monitor gain settings from this point. Doing so will require you to repeat this calibration!

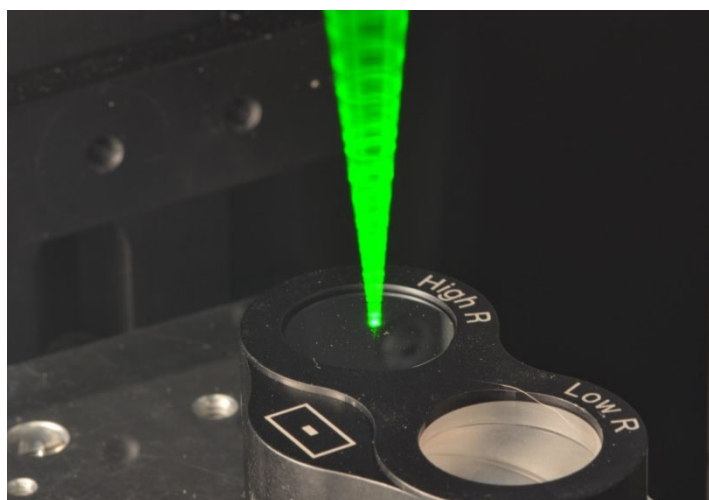
With just the monitor detector calibrated, only the SR, EQE will be calculated during a sample scan. The Mon, Ref and Sam raw signals will also be plotted and saved in the LOG file along with SR and EQE. Remove the calibrated reference detector from the sample stage to prepare for reflectance detector calibration.

The chart below suggests the conditions you can use the "Load Previous Calibration" feature to save time recalibrating the system if it is unchanged from the last time it was calibrated. If there is ever a question, please perform a new calibration.

Condition of System	Load Previous Calibration
Lamp installed or replaced	X
Lamp turned off / on	X
Slit width adjusted	X
Monitor and Reflection Gains the same	✓
Monitor or Reflection Gains changed	X
Chopper frequency changed	✓
PV Sample Gains changed	✓
Test different PV samples	✓
Bias voltage applied to sample	✓
Room temperature changed > ±3C	X
Sample Temperature (only) changed	✓
Sample averaging changed	✓
Input switched from BNC to 4-Wire Terminal	✓
Start / Stop wavelength changed (within calibrated wavelength range)	✓
Step wavelength changed ($\Delta\lambda > 1\text{nm}$)	✓
Calibrated with supplied Reference Detector	✓
Calibrated with different Reference Detector	X
Calibrated with supplied Reflectance Standards	✓
Calibrated with different Reflectance Standards	X
Sample stage moved so sample is out of focal plane	X
Sample stage moved so sample is returned to focal plane	✓

Reflectance Detector Calibration


1. Place reflection standards on sample plate at the focal plane of beam. The holder was made the same thickness as the calibrated reference detector so no adjustment should be necessary for stage height. Make sure the high and low reflection surfaces are clean and free of dust. Center the **High R** reflector under the output beam of the IQE-200B



Center the high reflective sample under the output beam at 555nm.

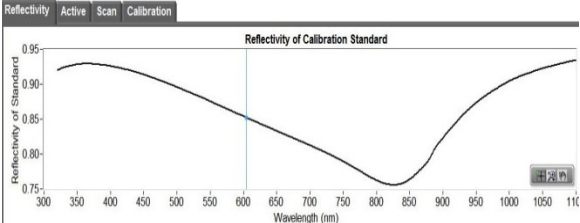
- Click on the Monitor icon to enter the monitor calibration screen and verify the following gain settings for the monitor, which is needed for the reflectance calibration


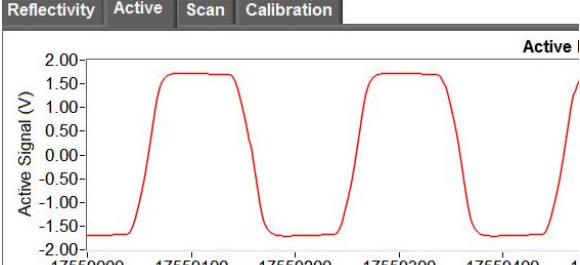
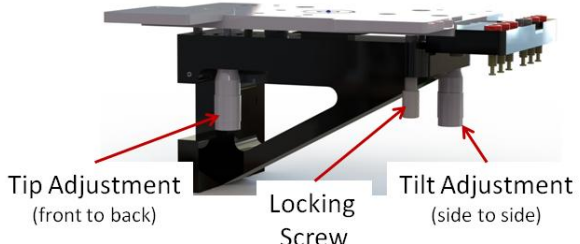

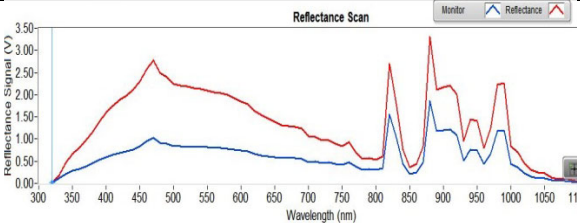
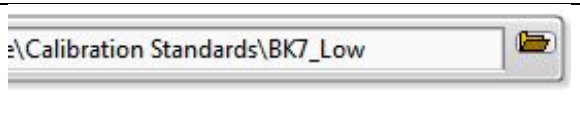
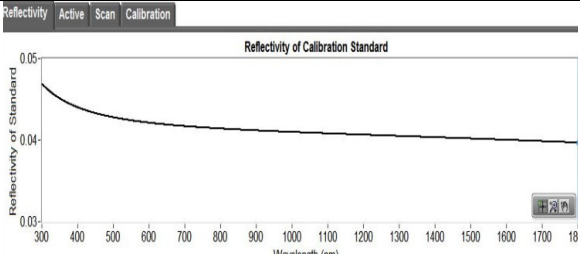


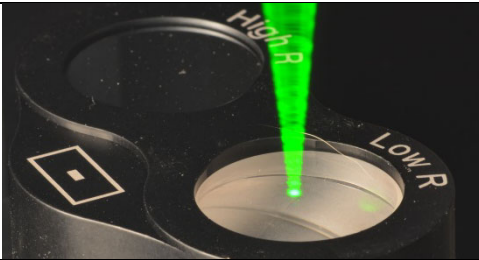
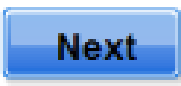
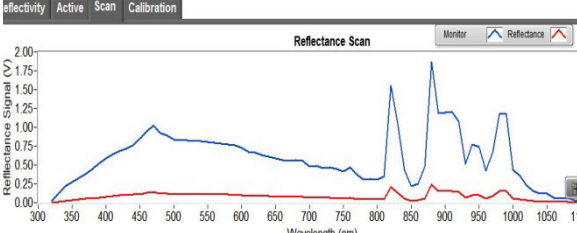

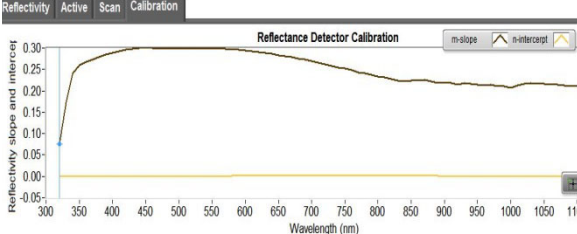
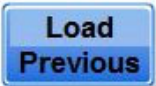

Monitor Setting	Description
<p>Bias Voltage</p> <p>0.00</p>  <p>Monitor</p>	<p>Check the bias voltage = 0 (green). If bias voltage is \neq 0 (red) then return to sample screen and zero the bias voltage.</p>
<p>Set Wavelength (nm)</p> <p>555.04</p> <p>Go</p>	<p>Verify wavelength is tuned to a visible value such as 555nm to and check beam is centered on High Reflectance standard.</p>
<p>Gain Ctl</p> <p>BASIC</p> <p>Basic Gain</p> <p>100k</p>	<p>Adjust gain settings to:</p> <p>Mode: Basic Gain: 100k</p>
<p>Home</p>	<p>Click on "Home" to return to main screen.</p>


- Click on the Reflectance Detector icon to enter the reflectance calibration screen.



Reflectance Setting	Description
<p>Calibration Standards</p>	<p>The reflectance file for the high reflectance standard should load automatically. The calibration file should be titled "UV_AI_High_Standard_fine"</p>
	<p>Check the calibration curve for the High R standard is what you expect under the "Reflectivity" tab in the graph area at the bottom of the screen</p>
<p>Set Wavelength (nm)</p> <p>555.04</p> <p>Go</p>	<p>Verify wavelength is tuned to a visible value such as 555nm</p>
<p>Gain Ctl</p> <p>BASIC</p> <p>Basic Gain</p> <p>1M</p>	<p>Adjust gain settings to:</p> <p>Mode: Basic Gain: 1M</p>

	<p>Center the beam on High R standard.</p>
	<p>Click on the “Active” tab to view the chopped signal. Verify the amplitude of the signal is approximately 2-3 Vpp to keep the signal from saturating at wavelengths associated with the Xe emission peaks.</p> <p>Note if the chopped signal has wavy or non-flat tops/bottoms you may need to shield the detector from room lights by placing the supplied 1.5” tube on top of the detector.</p>
	<p>Adjust the tip/tilt on the sample stage to optimize the amplitude of the active reflected signal. This insures the maximum reflectivity is measured.</p> <p>Note: to turn off auto scale of amplitude during tip/tilt optimization, right click on the values of the vertical axis and deselect “autoscale”</p>
	<p>Click on the “NEW” button to begin calibration of the High R.</p>
	<p>View the raw detector signal (lockin-voltage) as the wavelength scans by selecting the “Scan” tab in the graph area.</p> <p>Monitor = Blue Curve Reflectance = Red Curve High R</p> <p>NOTE: If signals exceed 10V at Xe emission peaks, reduce gain on appropriate detector and repeat scan.</p>
	<p>After the high reflectance scan completes, the Low Reflectance screen will appear. The reflectance file for the low reflectance standard should load automatically. The calibration file should be titled “BK7_Low Reflectance Standard DECIMAL”.</p>
	<p>Check the calibration curve for the Low R standard is what you expect under the “Reflectivity” tab in the graph area at the bottom of the screen</p> <p>Note: No gain values are offered on this screen because the high and low reflective standards must be calibrated at the same gain values</p>

	<p>Center the beam on the Low R standard.</p> <p>It is not usually necessary to maximize the tip/tilt of the reflective signal from the Low R standard because the reflective standard holder guarantees the window surface is parallel with the High R standard, which was optimized. Due to the low signal, it can be difficult to optimize this reflection.</p>
	<p>Click on the “NEXT” button to begin calibration of the Low R.</p>
	<p>After the low reflectance scan completes, you will be returned to the first screen. View the raw detector signal (lockin-voltage) as the wavelength scans by selecting the “Scan” tab in the graph area.</p> <p>Monitor = Blue Curve Reflectance = Red Curve Low R</p>
	<p>Click on “Save” when scan is complete</p>
<p style="text-align: center;">Are you sure you want to save the calibration? Doing so will overwrite previous calibration.</p> <p style="text-align: center;"> <input type="button" value="Yes"/> <input type="button" value="No"/> </p>	<p>Click on “Yes” at the prompt to overwrite last calibration with the new reflectance calibration.</p>
	<p>Check calibration on “Calibration” tab. The calibration contains a slope “m” and intercept “n” for each step in wavelength and should approximately have the following average values:</p> <p>m = 0.25 n = 0.001</p>
	<p>NOTE: If the reflectance detector was recently calibrated you can “load previous” to load the last calibration file made as an alternative to making new calibration scans. This will reset the gain values for the reflectance and monitor to their last settings as well. Save calibration after loading both the high and low reflectance calibrations. Use this feature to save time calibrating system if is unchanged from last use. See table above for suggestions when to use this feature.</p>
	<p>Click on “Home” to return to main screen.</p>
	<p>Verify Reflectance detector is calibrated as indicated by a green border surround the detector value on the main screen.</p>

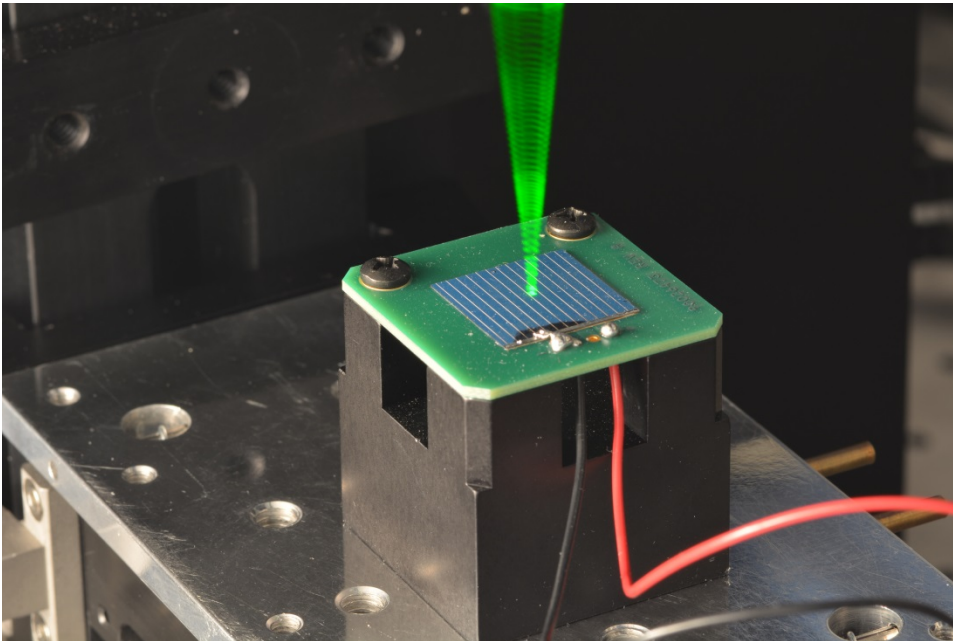
	<p style="text-align: center;">Reflectance</p> <p style="text-align: center;">0.869 V</p>	<p>NOTE: The system does not check the accuracy of the calibration. The green border only indicates the process of calibration and saving the file was successful.</p>
-----------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Important! Do not modify the Reflectance gain settings from this point. Doing so will require you to repeat this calibration!

With just the reflectance detector calibrated, only the reflectance Rs will be calculated during a sample scan. The Mon, Ref and Sam raw signals will also be plotted and saved in the LOG file along with Rs. Remove the reflectance standards from the sample stage to prepare for PV sample measurement.

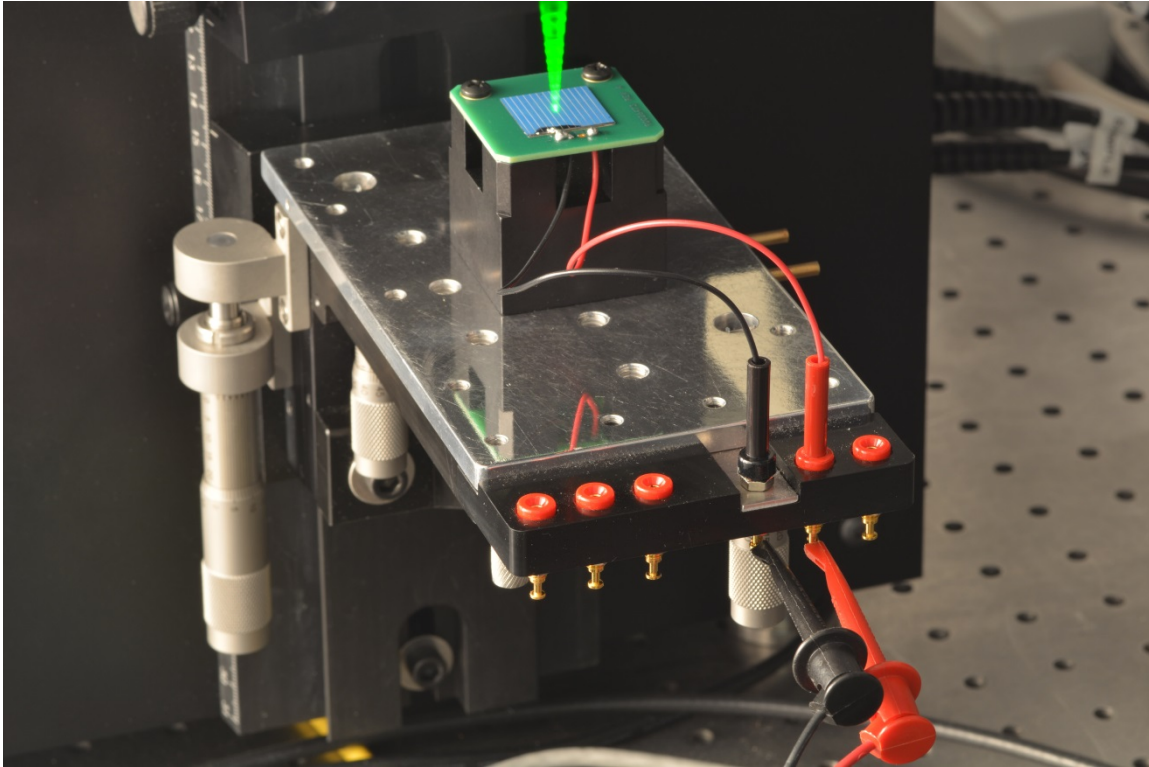
Measurement of Sample PV Cell

1. Place the PV test sample (SAMPE-QESI) supplied with the IQE-200B system on the sample stage at focal plane of the beam. The holder was made the same thickness as the calibrated reference standard so no adjustment should be necessary for stage height. Make sure the surface of the cell is clean and free of dust.



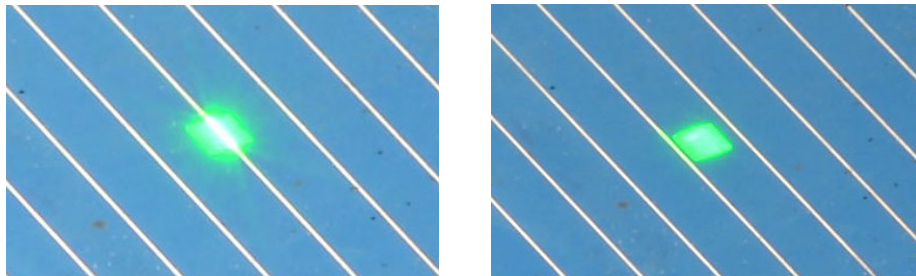
Center the sample cell under the output beam at 555nm.

2. Connect the red and black mini-banana jacks of the PV test cell to the mini-banana sockets on the stage as shown. The sockets are convenient for connecting cables to the sample without pulling the sample out of alignment. Connect the mini-clips of the mini-clip to BNC cable to the jacks on the bottom of the stage as shown. Note that in AC coupling mode, the polarity of the cable connections does not matter. The BNC end connects to the “sample” port of the back panel of the IQE-200B. NOTE: the sample could also be connected to the 4-wire terminal port and configured for two-wire operation. See Chapter 3 for details.



Attach the mini-clips of the BNC cable to the jacks in **reverse polarity** when operating in DC coupling mode.

3. **Important!** Center the beam **between the bus bars** on the sample cell. If the beam overlaps a bus bar, the SR and EQE response will be too low and the reflectivity R_s will be too high.

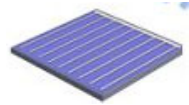


If the beam overlaps the bus bars on the sample cell (left) the measurements of the cell will be inaccurate. Move the sample cell over until the beam lies **between** the bus bars (right).




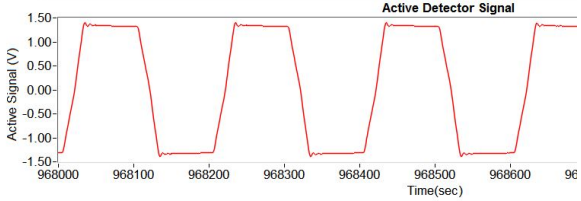
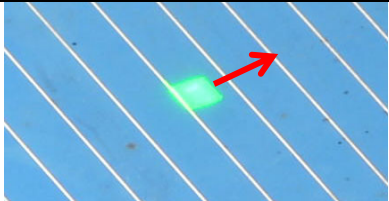
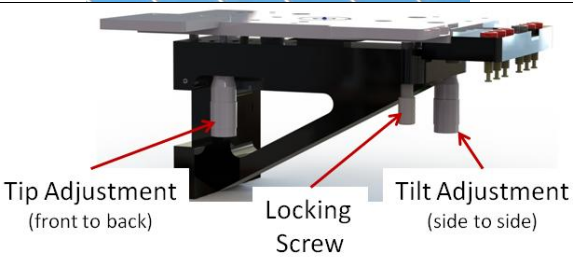

4. Click on the monochromator icon to adjust the scan range for the sample.

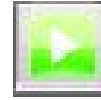
Monochromator Setting			Setting
Wavelength Scan Range			Scan range cannot exceed calibration scan range, but may be less Start ≥ λCal start Stop ≤ λCal stop Step = or ≠ ΔλCal
Start (nm) <input type="text" value="350"/>	Stop (nm) <input type="text" value="1100"/>	Step (nm) <input type="text" value="10"/>	



5. Click on Sample icon to enter the sample screen and adjust the following settings





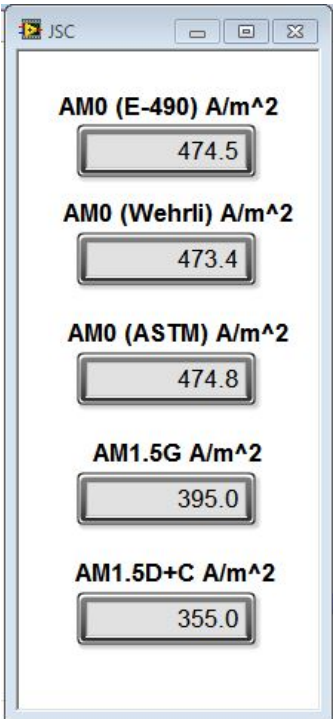
Sample Setting	Description
<p style="text-align: center;">Temperature (°C)</p> <p style="text-align: center;"><input type="text" value="21.4"/></p>	Reading should be close to room temperature in degrees C. Verify BNC cable is connected from sample stage BNC to Temperature BNC on back panel.
<p style="text-align: center;">Averaging</p> <p style="text-align: center;"><input type="text" value="5"/></p>	1 = minimum average. Scan time = 8' 30" good for quick scan test 5 = low average for calibration. Scan time = 9' 31" 10 = recommended for calibration. Scan time = 10' 50" 40 = high accuracy calibration. Scan time = 18' 30"
<p style="text-align: center;">Bias Voltage</p> <p style="text-align: center;"><input type="text" value="0.01"/></p> <p style="text-align: center;">ZERO BIAS</p>	Set Bias Voltage = 0 for this PV sample measurement using a) enter "0" in bias voltage text box b) click on "zero bias"
<p>BNC Input 4-Wire Terminal Input</p> 	Verify input selection switch points to the BNC input port. Verify BNC cable is connected from Calibrated Sample Cell to BNC input on back panel.
<p style="text-align: center;">Set Wavelength (nm)</p> <p style="text-align: center;"><input type="text" value="555.04"/> Go</p>	If you can't see the output, verify wavelength is set to a visible value such as 555nm. Center beam on to detector surface.
<p>Sample Control Sample Control</p> <p style="text-align: center;"><input checked="" type="checkbox"/> <input checked="" type="checkbox"/></p> <p style="text-align: center;">Push to Enable Push to Disable</p>	Enable Sample (calibrated reference detector) and verify chopped signal is being plotted on the Active graph at the bottom of the Sample Screen.
<p>Gain Ctl Basic Gain</p> <p style="text-align: center;"><input type="text" value="BASIC"/> <input type="text" value="100k"/></p>	Adjust gain settings to: Mode: Basic Gain: 100k NOTE: Changing the gain values on the sample (only) will not void the system calibration! This allows you to increase/decrease gain based on your sample. ⁷

	<p>DC gain = lower noise good for slower chopping frequencies.</p> <p>AC gain = higher chopping frequencies with less concern to noise.</p>
 <p>Active Detector Signal</p> <p>Active Signal (V)</p> <p>Time(sec)</p>	<p>Active signal should have square tops/bottoms with amplitude of 1-2 Vpp.</p> <p>Note if the chopped signal has wavy or non-flat tops/bottoms you may need to shield the detector from room lights by placing the supplied 1.5" tube on top of the detector.</p>
	<p>Translate the PV sample so the beam <i>lies between</i> the bus bars. The bus bars will reduce the accuracy by</p> <ol style="list-style-type: none"> Lowering efficiency of PV sample because the bars do not contribute to the photocurrent Increase specular reflection greater than the overall reflection of the PV sample.
 <p>Tip Adjustment (front to back)</p> <p>Locking Screw</p> <p>Tilt Adjustment (side to side)</p>	<p>Adjust the tip/tilt on the sample stage to optimize the amplitude of the active reflected signal if necessary.</p> <p>NOTE: This step is <i>not necessary</i> on this sample because the surface has low specular reflectivity. You may, however, notice a change in signal amplitude when adjusting tilt because the beam position translates on/off a bus bar during the tilt motion.</p>
	<p>Click on "Home" to return to main screen.</p>



6. Click “scan” button on main screen to begin measuring your sample

Sample Setting	Description
	<p>SR = Spectral Response (A/W)</p>
	<p>EQE = External Quantum Efficiency (x100 %)</p>
	<p>IQE = Internal Quantum Efficiency (x100 %)</p>
	<p>Rs = Specular Reflectance (x100 %)</p>
	<p>Mon = Raw Monitor Signal (Volts, lockin value)</p>
	<p>Ref = Raw Reflectance Signal (Volts, lockin value)</p>
	<p>Sam = Raw Sample Signal (Volts, lockin value)</p>

		Expand / Compress graph area to see details
		Save all graph data when scan is complete. This creates a LOG file containing all detector and sample measurements in tab-delimited text format.
		Print visible graph. Prints the graph you are currently viewing to your default printer if connected.
	 	<p>Jsc = Short Circuit Current Density values calculated from recent scan at various conditions including:</p> <p>AM0 = E-490 with no atmosphere AM0 = Wehrli with no atmosphere AM0 = ASTM with no atmosphere AM1.5G = 48.2° from zenith, 1.5atmospheres AM1.5D+C = Direct + Circumsolar 1.5 atmospheres</p>

- View the measurement LOG file by browsing to Oriel Instruments/LOGS and locating the most recent log file by date.

```

2018-10-11_0902 - Notepad
File Edit Format View Help
User: Andy
Text Name: Detector EQE scan
Notes: Detector 1903 EQE scan
Time: 10/11/2018 9:02:24 AM
X coordinate: 0.000000
Y coordinate: 0.000000
Temperature: 21.007287
Bias Voltage: -0.322067

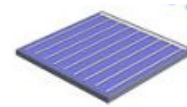
Integrated Jsc(mA/cm^2):
AM0(E490): 312.9
AM0(Mer113): 312.1
AM0(ASTM): 313.0
AM1.5G: 361.1
AM1.5bC: 235.8

CHI-Diffuse CHI-Monitor CHI-Reflectance CHI-Sample
DC Gain: 100000.000000 100000.000000 100000.000000 100000.000000
AC Gain: 1.000000 10.000000 10.000000 10.000000
Zero Offset: 0.000000 0.000005 0.000006 0.000020

wavelength CHI-Diffuse CHI-Monitor CHI-Reflectance CHI-Sample SR EQE IQE RS RD
349.984000 NaN 2.295792E-1 2.267029E-1 3.066236E-1 0.159867 0.566413 1.003366 0.435487 NaN
359.971000 NaN 2.615046E-1 2.819003E-1 3.389930E-1 0.149592 0.515308 0.958477 0.457847 NaN
370.031000 NaN 2.989403E-1 3.356703E-1 3.789783E-1 0.147574 0.494531 0.928153 0.467188 NaN
380.011000 NaN 3.522044E-1 3.866044E-1 4.437229E-1 0.158467 0.517087 0.936876 0.448072 NaN
390.007000 NaN 4.135259E-1 4.391509E-1 5.200252E-1 0.171380 0.546919 0.947019 0.424608 NaN
400.037000 NaN 4.693763E-1 4.884230E-1 6.037288E-1 0.182391 0.565359 0.954942 0.407966 NaN
410.006000 NaN 5.032271E-1 5.145336E-1 6.543623E-1 0.192343 0.581713 0.963230 0.396081 NaN
419.971000 NaN 5.392677E-1 5.434797E-1 7.001459E-1 0.200205 0.591360 0.964004 0.387968 NaN
430.009000 NaN 5.559595E-1 5.557955E-1 7.404309E-1 0.207293 0.597762 0.964416 0.380183 NaN
439.966000 NaN 5.859208E-1 5.799486E-1 7.876656E-1 0.212545 0.606646 0.970227 0.374739 NaN
449.997000 NaN 6.445497E-1 6.349353E-1 8.749774E-1 0.222265 0.613668 0.972365 0.370125 NaN
460.022000 NaN 7.249177E-1 7.073824E-1 9.951070E-1 0.229301 0.618085 0.974982 0.366055 NaN
469.968000 NaN 8.181266E-1 7.938421E-1 1.130112E+0 0.236228 0.623261 0.979706 0.363829 NaN
479.985000 NaN 9.297744E-1 8.949353E-1 1.280408E+0 0.241588 0.628202 0.984431 0.361582 NaN
489.997000 NaN 6.932912E-1 6.636526E-1 9.702451E-1 0.249206 0.630648 0.985444 0.360036 NaN
500.006000 NaN 6.584223E-1 6.196149E-1 9.145991E-1 0.252005 0.631900 0.987235 0.358917 NaN
510.009000 NaN 6.147436E-1 5.974818E-1 8.588172E-1 0.251230 0.633136 0.989189 0.357923 NaN
520.008000 NaN 6.223793E-1 5.883662E-1 8.790605E-1 0.267204 0.637170 0.991485 0.357358 NaN
530.002000 NaN 6.154424E-1 5.813396E-1 8.724550E-1 0.273189 0.639156 0.994371 0.357226 NaN
539.991000 NaN 6.147436E-1 5.826394E-1 8.746474E-1 0.279179 0.641009 0.997200 0.357181 NaN
549.975000 NaN 6.123541E-1 5.817805E-1 8.815592E-1 0.285157 0.642930 1.001024 0.357728 NaN
559.010000 NaN 6.036881E-1 5.745508E-1 8.724393E-1 0.291188 0.644740 1.004765 0.358318 NaN
570.004000 NaN 5.959257E-1 5.669712E-1 8.618347E-1 0.297170 0.646470 1.008965 0.359274 NaN
579.972000 NaN 5.879806E-1 5.610159E-1 8.527883E-1 0.302170 0.646049 1.009930 0.360303 NaN
590.012000 NaN 5.767308E-1 5.508564E-1 8.365879E-1 0.308176 0.647678 1.014285 0.361443 NaN
599.960000 NaN 5.474571E-1 5.220084E-1 7.933438E-1 0.314120 0.649216 1.019422 0.363553 NaN
609.997000 NaN 5.236353E-1 4.957561E-1 7.513306E-1 0.320202 0.650906 1.024510 0.364666 NaN
620.019000 NaN 5.003370E-1 4.746174E-1 7.242944E-1 0.325211 0.650402 1.029200 0.366664 NaN
630.035000 NaN 4.919345E-1 4.690918E-1 7.243329E-1 0.331211 0.651870 1.032481 0.368454 NaN

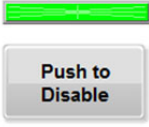

```

This file contains all the data collected from the wavelength scan of your sample. It can be directly imported into Excel, Origin etc. for your data manipulation

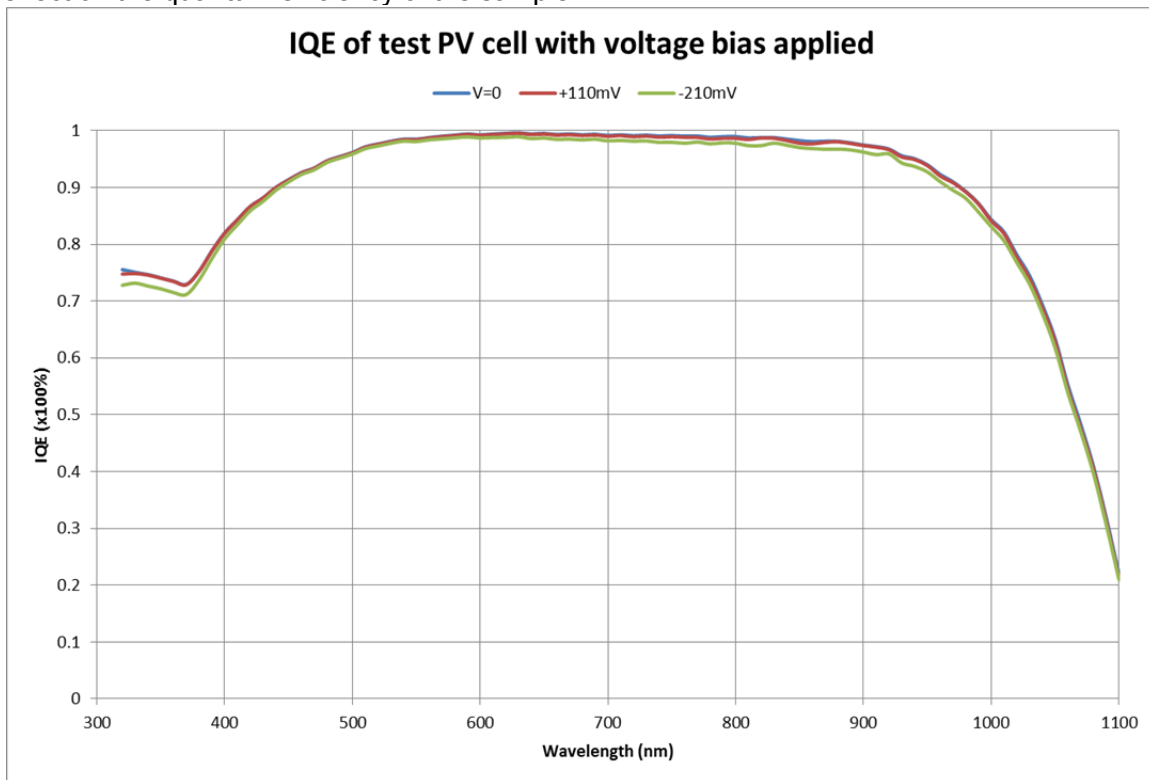


- Click on Sample icon to enter the sample screen and adjust the **voltage bias**

Sample Setting	Description
<p>Bias Voltage</p> <p>0.11</p> <p>ZERO BIAS</p>	Set Bias Voltage = +0.110V (+110mV) for the next PV sample measurement by typing in the value in the input box
<p>Sample Control</p> <p>Push to Enable</p>	Enable Sample to verify a bias is being added across the anode/cathode of the PV sample when it is electrically connected to the circuit.
<p>Sample Voltage</p> <p>0.15</p>	Sample voltage increases to the set value after the sample is enabled = 0.11V. The true voltage drop across the sample (0.15V) is slightly different because a) extra voltage drop in 2-wire configuration and b) digitization/linearity of DAQ used to step voltage has ~ ± 20mV error which is noticeable at this low bias voltage.

<p style="text-align: center;">Sample Control</p> 	<p>Disable the sample in preparation for a new scan with bias voltage applied. This is done automatically at the beginning of a new scan in case you forget</p>
	<p>Click on "Home" to return to main screen.</p>

- Repeat scan process outlined in step 6, this time with a voltage bias applied to the sample. A comparison of IQE scans with voltage biases (+110mV and -210mV) is shown in comparison to no bias voltage applied to the sample. Notice that, for this sample, the bias voltage has very little effect on the quantum efficiency of the sample.



- To see an earlier measurement, "load" the previous log file to see what the IQE values were for zero voltage bias. There is no way to overlap the two plots in the same graph at this time – please look for this feature in the next revision of the IQE-200B application.

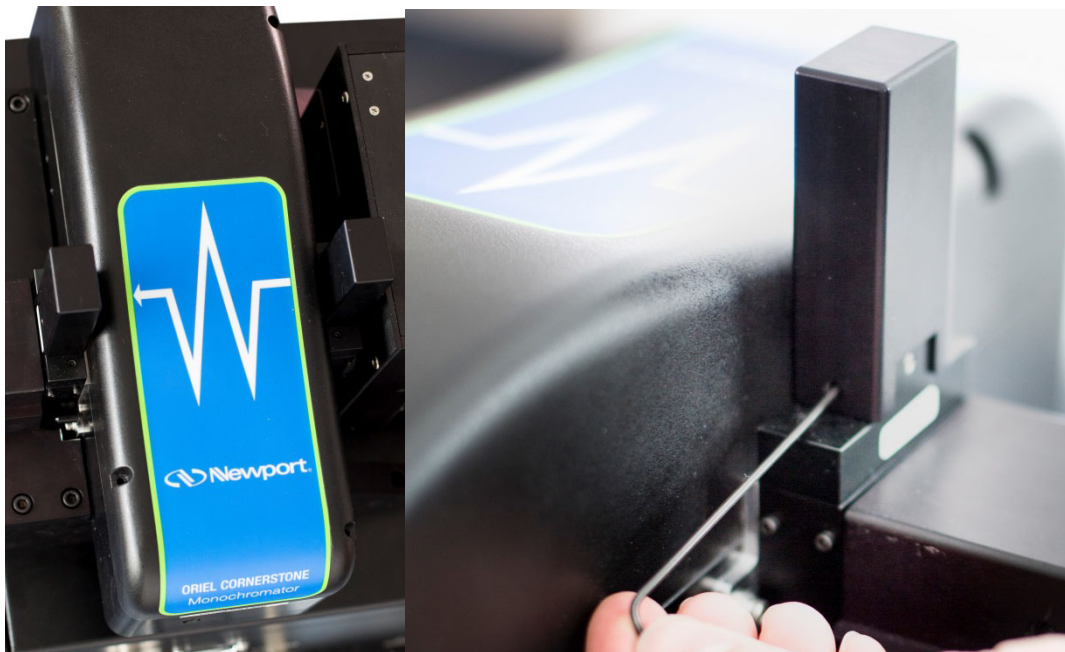
Appendix A:

IQE-200B System Wavelength Check

This appendix describes a procedure for checking the calibration of the wavelength output by the system. It ensures that the wavelength of light output by the system matches that which is reported by the software. This should be done before your first measurements when the system is first received. It is also recommended whenever the IQE-200B system is moved significantly, e.g. from one lab or building to another.

PROCEDURE

1. Power on the IQE-200B system according to the Start-Up procedure in Chapter 2. The lamp should be allowed to warm up for about 30 minutes to stabilize.
2. Remove the monochromator slit adjustment covers.

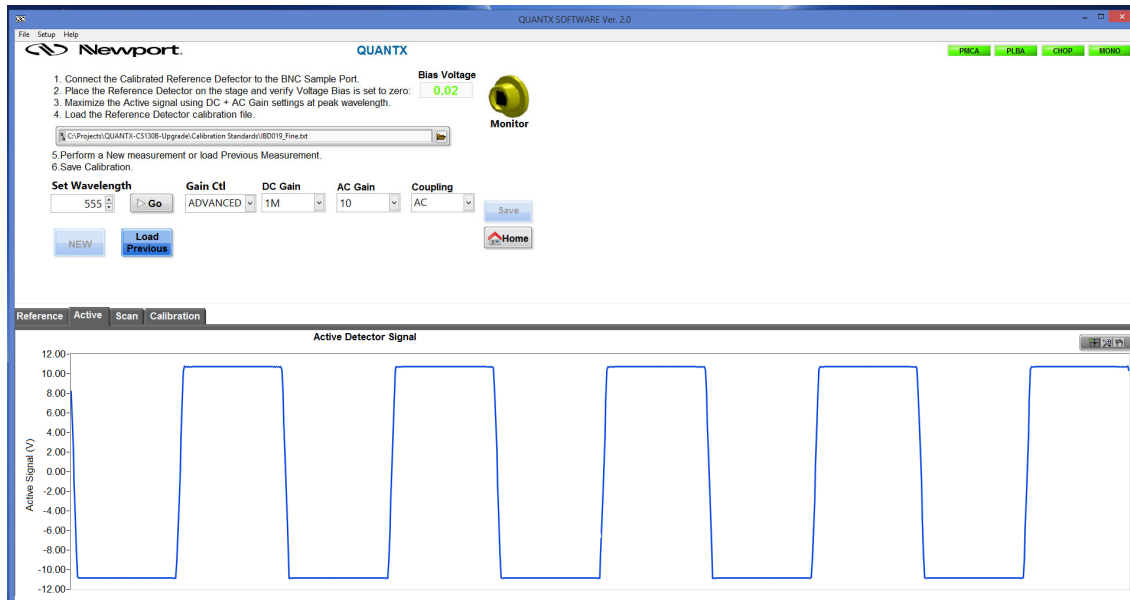




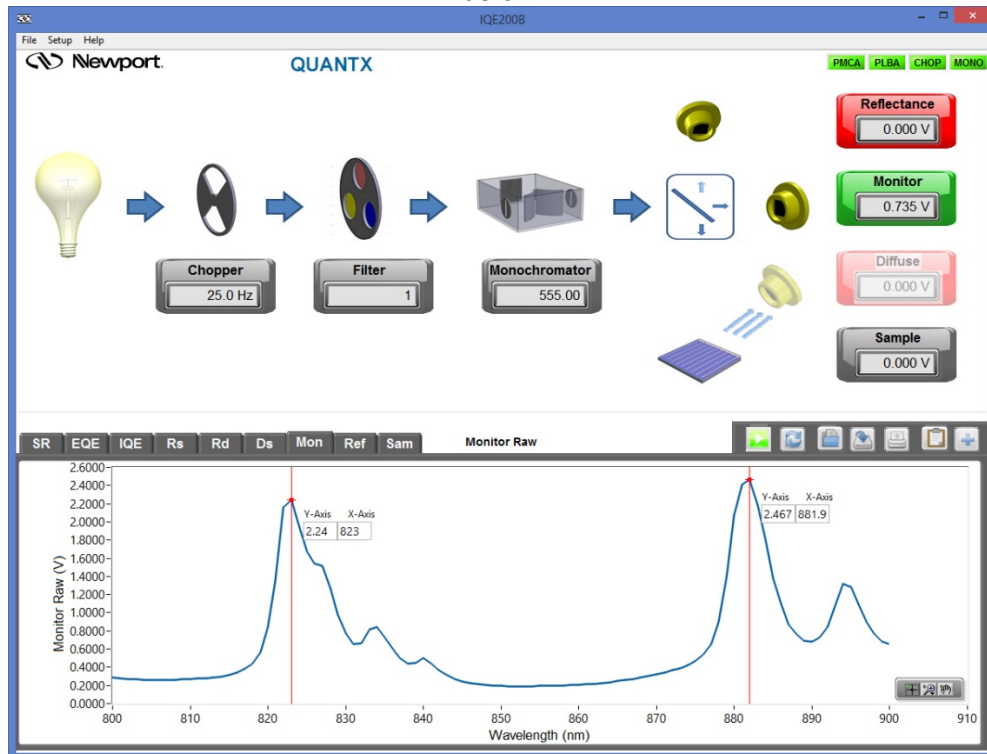
3. Adjust the slit width to 75 μm . This is 7.5 on the micrometer scale.



- In the Monitor detector screen, select Advanced under Gain Ctl (Control) to set the monitor gain settings to 1M DC Gain, 10 AC Gain, and AC Coupling, as shown below.



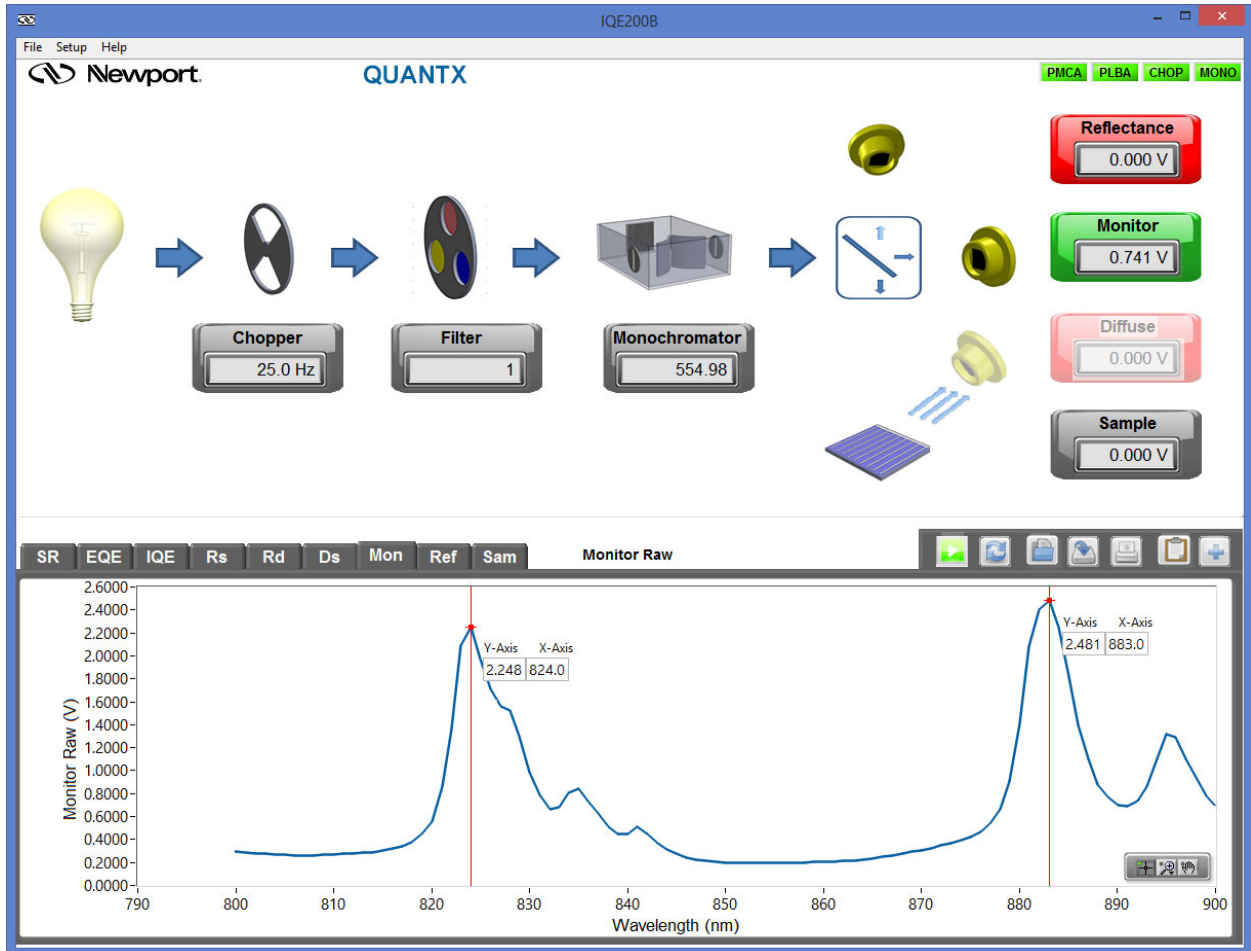
- In the Monochromator screen, set the scan parameters to start at 800nm, stop at 900nm with 1nm steps.
- Click the start scan button to run the scan.
- When the scan is complete, check for the two tallest peaks in this scan range. They are strong Xenon emission lines and should be located at 823nm and 882nm as shown below.



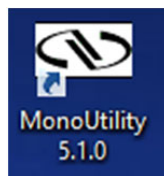
8. If the two tallest peaks are at these locations, within $\pm 1\text{nm}$, then the wavelength is in calibration. Reduce the Monitor detector gain to Gain Ctl Basic and Basic Gain 100k. Then return the monochromator input and output slits to $750\mu\text{m}$ (75 on the micrometer scale, or 1.5 full clock-wise revolutions from zero).
9. If the peaks are not within this tolerance, then they must be corrected using the procedure below.

WAVELENGTH CORRECTION PROCEDURE

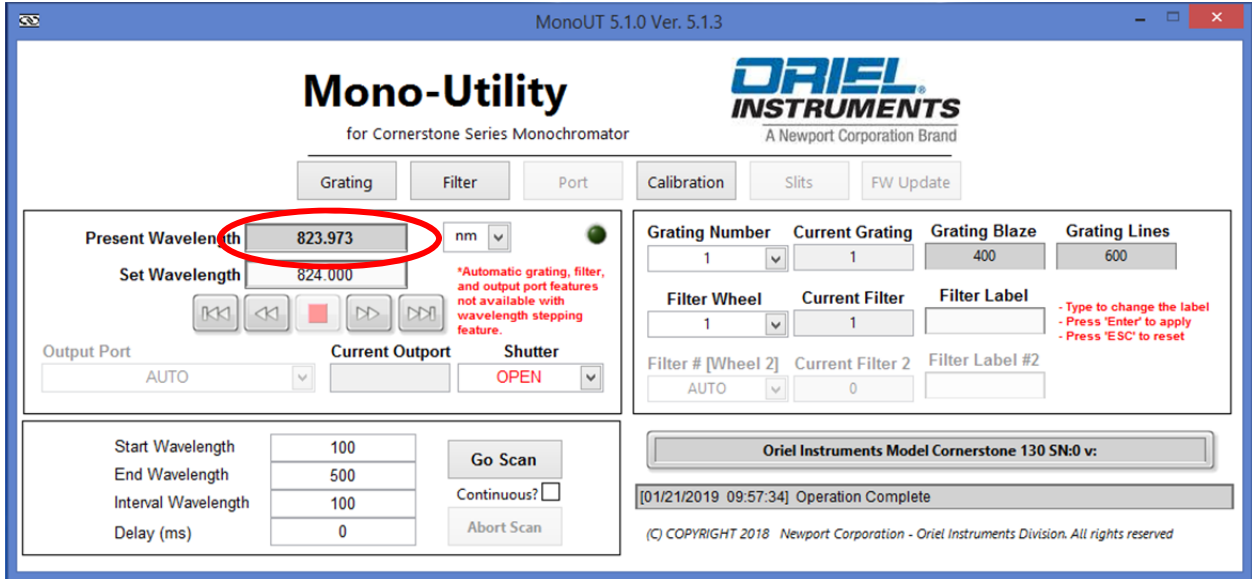
1. In the scan below, the two peaks are off of their ideal value by +1 nm. This indicates that the monochromator calibration is slightly off. The peaks should be at 823nm and 882nm, but they are actually at 824nm and 883nm.



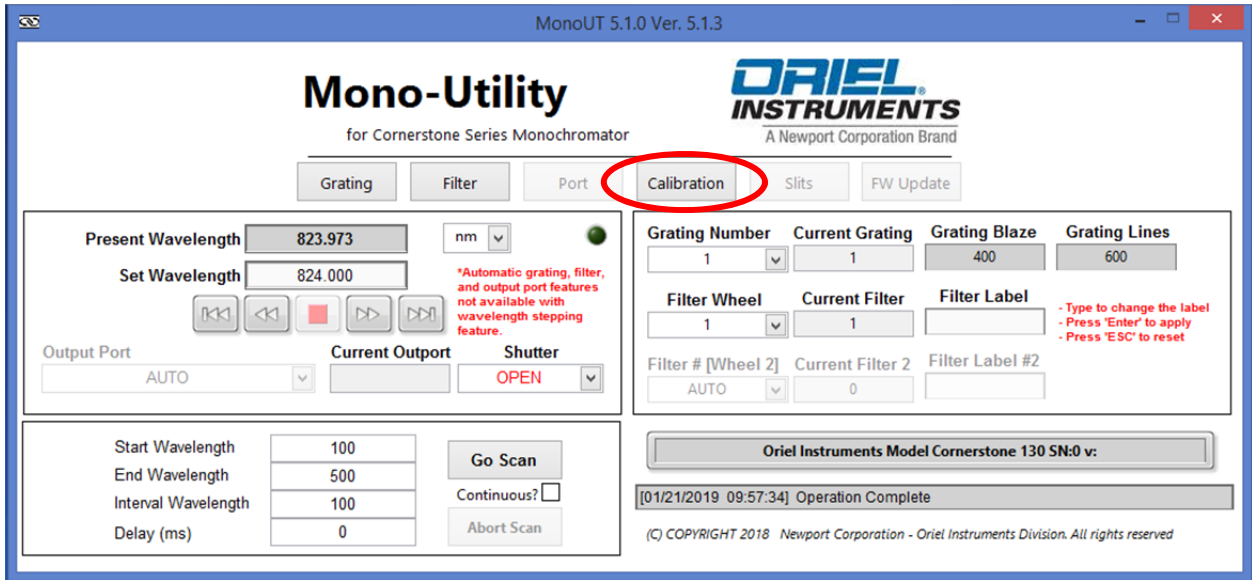
2. Close the QuantX application and open the Monochromator Utility application on the desktop.



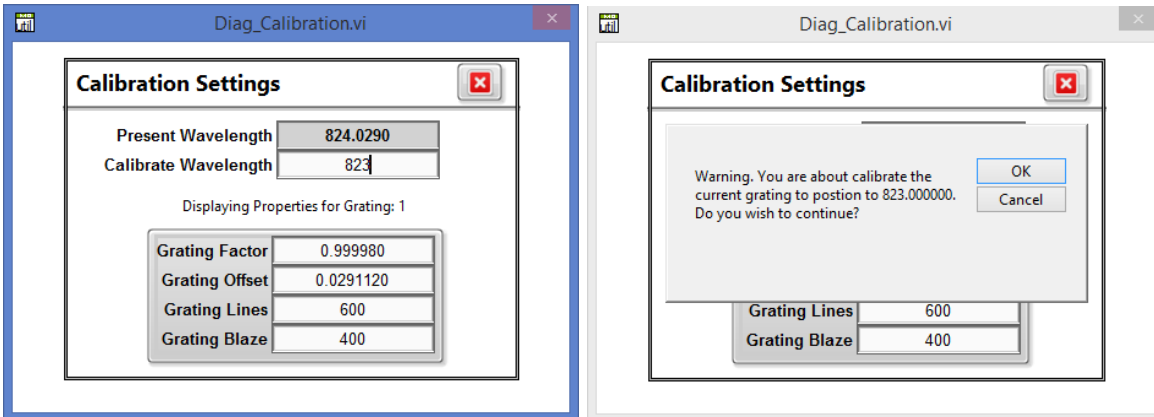
- The Cornerstone 130B should be automatically detected and the program should initialize.
- We will use the peak found at 824nm to correct the wavelength calibration of the monochromator.
- Input "824" into the "Set Wavelength" field of the monochromator utility and press <Enter> to send the monochromator to that wavelength.



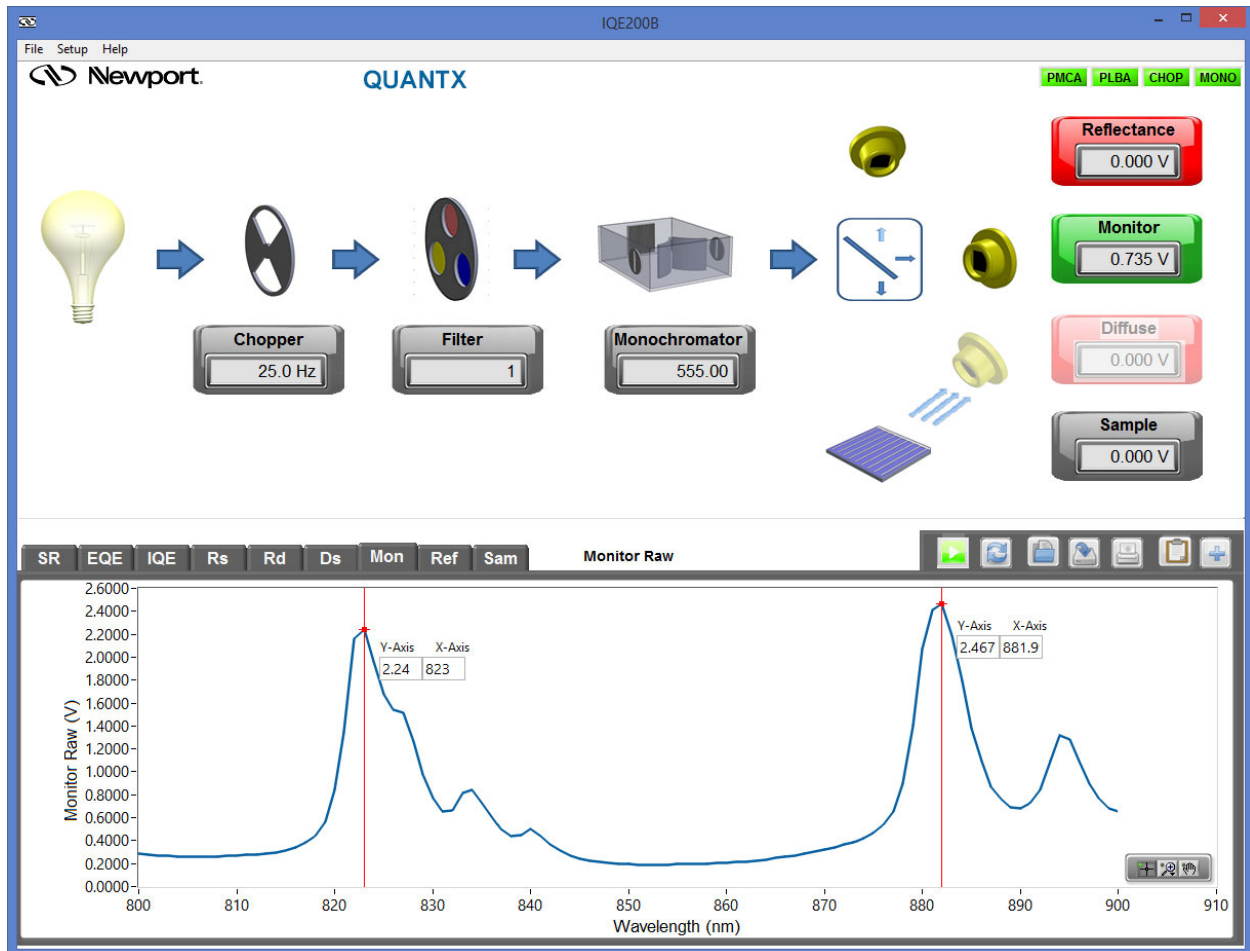
6. Next, click the “Calibration” button.



7. Since the peak found at 824nm should actually be at 823nm, input this into the “Calibrate Wavelength” field of the Calibration Settings popup window and press <Enter>. Press “OK” in the warning message box that appears.



- Close the Monochromator Utility application and repeat the wavelength check procedure above. The peaks should now appear at the correct locations.



- If the monochromator cannot be recalibrated such that the Xenon emission lines appear in the correct location, or if the wavelength is off by a large amount on initial receipt of the instrument (>10nm), please contact Oriel support for assistance.

Appendix B:

IQE-200B Monochromator Resolution

This appendix describes monochromator resolution.

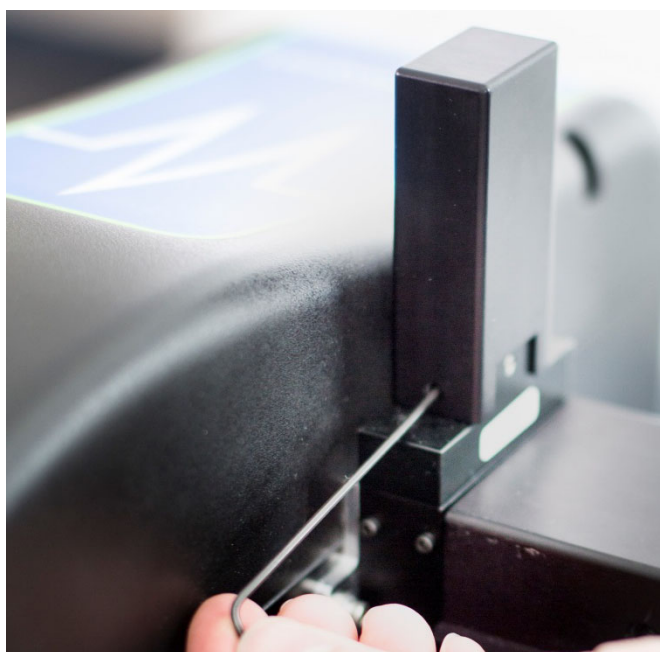
The slit width settings for various bandwidths follow the dispersion relationship:
 $\Delta\text{wavelength}/\Delta\text{slit width} = 13.3\text{nm/mm}$

Slit Width	FWHM Bandwidth	Notes
75 μm	~1nm	Minimum wavelength step for IQE-200B, expect low power
750 μm	~10nm	Typical wavelength bandwidth and wavelength step
3.0mm	~40nm	Maximum bandwidth recommended by ASTM E1021-06

It is recommended to match the FWHM bandwidth with the wavelength step size $\Delta\lambda$ for best resolution and maximum output power of the IQE-200B. Recommended settings are listed in the following chart:

Slit width	Notes
FWHM < $\Delta\lambda$	Accuracy good, low power
FWHM = $\Delta\lambda$	Recommended for high accuracy and optimal power
FWHM > $\Delta\lambda$	Not recommended, accuracy compromised,

To change the slit spacing, first remove both micrometer covers using a 2/56" ball end driver as shown.



Remove protective cover on exit slit micrometer using a 2/56" ball driver

Unscrew the micrometer on the entrance slit CCW until it passes 0mm on the scale indicating the slit is fully closed. You can watch the output of the IQE-200B vanish (if set to a visible wavelength like 555nm) as the slit closes. It will not harm the slit to turn the micrometer beyond zero. Turn in the micrometer CW back to zero and continue until the desired slit spacing is reached. Install the cover for this micrometer to prevent accidentally bumping it. Repeat for the entrance slit adjustment.



Exit slit adjusted to $0.50 + 0.25 = 0.75\text{mm} = 750\mu\text{m}$

If the slit widths have been adjusted such that the FWHM bandwidth (monochromator step size) is less than 10nm, please note that the calibration files loaded in the software may need to be changed. In the Calibration Standards folder there should be a set of reference standard calibration files for the three (3) standards included with your system that end with '_fine'. These files contain calibration data points at 1nm intervals over the applicable wavelength range for each standard. To ensure the highest wavelength accuracy, we recommend using these files for any calibration.