



# VM200

---

## Operating Manual

REV 1.0  
7/22/2014



# Table of Contents

|                                    |            |
|------------------------------------|------------|
| Table of Figures                   | 2          |
| System Overview                    | 3          |
| Packing List                       | 4          |
| Setup                              | 5          |
| Operating In Monochromator Mode    | 6, 7       |
| Operating In Spectrometer Mode     | 8          |
| Obtaining Spectra                  | 9, 10      |
| Mounting and Operating with a Lamp | 10         |
| Calibration                        | 11         |
| Focusing                           | 12, 13     |
| Add-on Options                     | 14         |
| Appendix                           | 15, 16, 17 |
| NIST Calibration                   | 18, 19     |

## Table of Figures

|  |    |
|--|----|
| <a href="#">FIGURE 1: CUTAWAY VIEW OF VM200</a> .....                              | 3  |
| <a href="#">FIGURE 2: MOTOR DRIVE CONTROLLER BOX</a> .....                         | 6  |
| <a href="#">FIGURE 3: DETECTOR CONNECTIONS</a> .....                               | 6  |
| <a href="#">FIGURE 4: PHOTODIODE INDICATOR LIGHTS &amp; ZERO BUTTON</a> .....      | 7  |
| <a href="#">FIGURE 5: SLIT WIDTH ADJUSTMENT MICROMETER</a> .....                   | 7  |
| <a href="#">FIGURE 6: CCD USB PORT</a> .....                                       | 8  |
| <a href="#">FIGURE 7: CCD INDICATOR LIGHTS &amp; ZERO BUTTON</a> .....             | 8  |
| <a href="#">FIGURE 8: SLIT WIDTH ADJUSTMENT MICROMETER</a> .....                   | 9  |
| <a href="#">FIGURE 9: EXAMPLE OF CCD SIGNAL LEVEL NON-LINEAR EFFECT</a> .....      | 9  |
| <a href="#">FIGURE 10: EXIT SLIT FOCUSING COLLAR AND FASTENING SET-SCREW</a> ..... | 12 |
| <a href="#">FIGURE 11: CCD FOCUSING COLLAR AND FASTENING SET-SCREW</a> .....       | 13 |
| <a href="#">FIGURE 12: GRATING EFFICIENCY CURVE</a> .....                          | 15 |
| <a href="#">FIGURE 13: TYPICAL RESPONSE CURVE OF THE AXUV PHOTODIODE</a> .....     | 16 |
| <a href="#">FIGURE 14: TYPICAL RESPONSE CURVE OF THE HAMAMATSU S9840 CCD</a> ..... | 17 |
| <a href="#">FIGURE 15: NIST STANDARD CALIBRATION CURVE</a> .....                   | 18 |
| <a href="#">FIGURE 16: NIST CALIBRATION MEASUREMENTS</a> .....                     | 18 |
| <a href="#">FIGURE 17: NIST TRACEABLE QUANTUM EFFICIENCY CHART</a> .....           | 19 |

## System Overview

The Resonance Ltd. monochromator/spectrometer is designed for laboratory applications yet is rugged enough for field use. The system is hermetically sealed and can be used in the vacuum ultraviolet region (wavelengths below 190 nm) with a nitrogen or helium purge, or by connecting to a vacuum system either through the slits or through a 2.75" Conflat® style flange on its base. The compact size of the unit results in a small internal volume (only 2 liters), allowing for a rapid pumping time.

A single grating is used to maximize throughput in the vacuum ultraviolet region and to minimize scattered light. The standard grating is a 45mm square f/4.2 concave holographic grating with an aluminum/MgF2 overcoat. The reflective properties of this or any grating can be severely damaged by mechanical contact with any solid, liquid or vapor. **Never blow on the surface of the grating or onto the slit openings.**

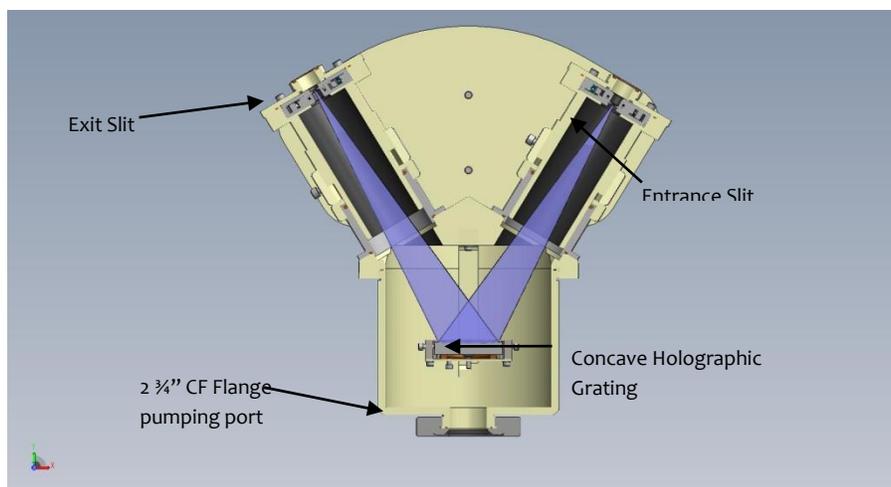


Figure 1: Cutaway view of VM200

## Packing List

Below is a list of all the components shipped with the VM200. If you find any of these items to be missing, please contact Resonance Ltd. to arrange to have it delivered.

| Item                               | Quantity |
|------------------------------------|----------|
| VM200 Monochromator                | 1        |
| Motor Drive Electronics Box        | 1        |
| EUV Si Diode                       | 1        |
| CCD Array                          | 1        |
| 18 VDC Power Supply                | 1        |
| 5 VDC Power Supply                 | 1        |
| Software Disc                      | 1        |
| Lab Jack                           | 1        |
| USB Cable                          | 1        |
| BNC Cable                          | 1        |
| 2 3/4" Viton Gasket                | 1        |
| 2 3/4" Copper Gasket               | 1        |
| 018 Viton O-rings                  | 3        |
| 1/4 - 28 x 1: SS Socket Head Bolts | 6        |

## Setup

The VM200 is supplied with either an exit slit, to allow use of the system as a monochromator, or a CCD for spectrometer operation or both.

In monochromator mode, a detector can be mounted at the exit slit either by a 2 ¾" CF flange or a 1"-20 thread with a shoulder to hold and compress the o-ring (if vacuum operation is required). In spectrometer mode, the CCD module is mounted in the place of the exit slit using 4 4-40 x 1 ½" stainless steel socket head cap screws.

The VM200 spectrometer can be fixed in any orientation and attached to a VUV light source that attaches to a CF flange or a 1"-20 thread with a shoulder to hold and compress the o-ring for vacuum operation. If purged operation is desired, an adaptor flange can be used to allow purge gas to enter the spectrometer through the flange at the bottom of the spectrometer and exit the entrance slit. Vacuum or purged operation is necessary only when observing wavelengths less than 190 nm. Keep in mind that the VUV properties can be easily damaged by organic contaminants therefore use only oil-free purge gas.

For mounting to a purge system, light source, or detector a standard CF flange that screws directly onto the 1"-20 at the base has been supplied (see Figure 1). If a CF flange is not compatible with the system, any counter-bored flange design (NW, ASA, etc.) with a female 1"-20 tpi thread adaptor with a shoulder to hold and compress the o-ring can be used. Since the design of the interface to a lamp will depend on the lamp design, we have supplied one 2.75" CF type flange, which screws directly onto the 1"-20 flange to allow maximum adaptability.

**Note: if while mounting the threads bind, do not force any further. The piece may be loosened by applying a small amount of isopropyl alcohol to the bottom of the thread. After capillary action has drawn the liquid up into the thread the piece may be unscrewed.**

## Operating in Monochromator Mode

1. Plug the motor cable into the motor drive controller box



Figure 2: Motor Drive Controller Box

2. Plug in the driver box power supply
3. Plug in the USB cable
4. Plug in the LabJack USB cable
5. Connect the detector BNC cable from the detector signal output to the LabJack
6. Plug in the detector power supply



Figure 3: Detector Connections

## Operating in Monochromator Mode (continued)

7. Start the Program
8. Make sure the 'Stepper' and 'Photodiode' indicator lights both turn green
9. Click on the 'Zero' button



Figure 4: Photodiode Indicator Lights & Zero Button

1. You are now ready to obtain spectra

### Performing a Scan

1. Set the slits to the desired width for the ideal signal vs. resolution.

**Note:** There is backlash in the micrometer dial, so it is best to completely close the slits (to approximately 10 micron below zero) and then open them to the desired width, otherwise the set slit width may not match the actual width.



Figure 5: Slit Width Adjustment Micrometer

2. Enter the desired starting wavelength for the scan in the  Scan Minimum box
3. Enter the desired ending wavelength for the scan in the  Scan Maximum box
4. Set the scan speed/step resolution by moving the sliding bar to the desired step increment  

5. Click on the  button

## Operating in Spectrometer Mode

1. Repeat steps 1-3 from monochromator mode
2. Plug in the CCD USB cable



Figure 6: CCD USB Port

3. Start the program
4. Make sure the 'Stepper' and 'CCD' indicator lights both turn green
5. Click on the 'Zero' button

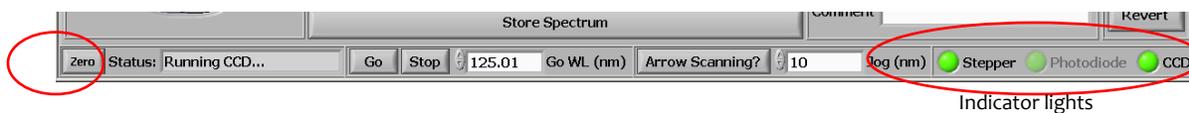


Figure 7: CCD Indicator Lights & Zero Button

6. You are now ready to obtain spectra

## Obtaining Spectra

1. Set the entrance slit to the desired width for the ideal signal vs. resolution.

**Note: There is backlash in the micrometer dial, so it is best to completely close the slits (to approximately 10 micron below zero) and then open them to the desired width, otherwise the set slit width may not match the actual width.**



Figure 8: Slit Width Adjustment Micrometer

2. Set the integration time and the number of averages to the desired levels.

**(Note: at higher signal levels [ $>2000$  counts] the CCD begins to respond non-linearly, resulting in the appearance of loss of resolution and a rounded peak, therefore it is idea to adjust the integration time to keep the signal to a reasonable level).**

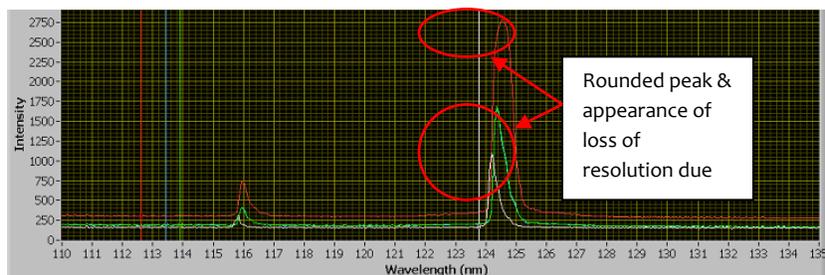


Figure 9: Example of CCD signal level non-linear effect

3. Enter the desired center wavelength in the   box at the bottom of the screen and click the  button

## Obtaining Spectra (continued)

4. If it appears that the actual center wavelength does not match the wavelength entered, there is a CCD center offset function in the settings tab ( **CCD Centre Offset**) that allows the user to compensate for this. Due to some non-linear effects within the system, this offset may need to be adjusted based on the center wavelength setting.
5. To remove the dark spectrum from the measured signal, turn off the light source and click on  to store it to memory and on  to subtract it from the displayed signal.
6. Turn the light source back on
7. Click on the  button to save the spectrum to memory to allow it to be recalled at a later point during the test run

**(Note: Memory is cleared once the program is closed)**

## Mounting and Operating with a Lamp

Any of the several Resonance VUV lamps may be screwed directly onto the 1"-20 thread at the spectrometers entrance slit to bring the as close to the slit as possible. For other light sources, a 2 3/4" CF adapter flange with 1/4"-28 threaded holes has been provided to allow easy coupling to the system. When mounting to the 1"20 thread, carefully remove the CF flange (if applicable) from the entrance slit and attach the lamp ensuring the o-ring is compressed. NOTE: if high vacuum is unattainable, check that the front o-ring or gasket is fully compressed and has not been pinched.

## Calibration

It is possible that occasionally the wavelength scale may need recalibration. To do this, 3 known wavelengths are required, ideally with two of them near the far ends of the wavelength scale.

1. With the light source on, scan across the spectrum
2. Note the locations of the known wavelengths by either setting the plot cursors on the peaks or noting separately the wavelength of the peak as accurately as possible
3. Go to the 'Settings' tab
4. If the wavelengths were recorded using the plot cursors:
  - a. Enter the three known wavelengths into the  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$  boxes in the 'Spectrometer Wavelength Calibration' section
  - b. In the 'Grab Cursor' drop-down box, select the first plot cursor
  - c. Click on the 'Grab' button next to the according known wavelength. The step location of the plot cursor should appear in the 'Step @' box next to the button.
  - d. Repeat this process with for the other two wavelengths
  - e. Click on the 'Calculate' button
  - f. A notice box should appear indicating that the coefficients have been changed and the system needs to be re-zeroed. Click 'OK'
  - g. If no mistakes have been made and you are confident of new coefficients, click the 'Save Settings' button and then zero the monochromator
5. If the wavelengths were recorded separately:
  - a. In the 'Conversions' section, convert the three recorded wavelengths to step number
  - b. Enter the three known wavelengths into the  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$  boxes in the 'Spectrometer Wavelength Calibration' section
  - c. Manually enter the obtained step number for each of the wavelengths
  - d. Click on the 'Calculate' button
  - e. A notice box should appear indicating that the coefficients have been changed and the system needs to be re-zeroed. Click 'OK'
  - f. If no mistakes have been made and you are confident of new coefficients, click the 'Save Settings' button and then zero the monochromator
6. Perform another scan to ensure the wavelength scale is now accurate. Repeat the process if necessary

## Focusing

If for some reason you suspect that VM200 may need to be refocused, this can be done using either the detector for in monochromator mode, or the CCD in spectrometer mode. Focusing is done much quicker and simpler with the CCD, however instructions for performing this task in either mode are provided.

### Monochromator Mode

1. Select a light source with a known sharp line and connect it to the monochromator
2. Set the slits to as narrow as possible while still obtaining a decent signal
3. Scan across the line.
4. On the exit slit arm, loosen the set screw that fastens the collar into place



Figure 10: Exit slit focusing collar and fastening set-screw

5. Rotate the collar counter-clockwise from the top and then push the slit down until the two collars make contact. Do this far enough to go beyond the suspected focal distance
6. Take a spectral scan of the selected line
7. Note whether or not the line has become any narrower and the signal has increased. If it has, continue to lower the slit.
8. If it appears that the signal has come out of focus, rotate the collar in the opposite direction a set amount and take another scan
9. Continue to repeat step 8 until you have scanned past the focal point and the line begins to broaden and have a lower peak signal.
10. Begin rotating the collar in smaller increments in the opposite direction and scanning at each interval until again you have just passed the focal position.

## Focusing (continued)

11. Repeat step 10, with smaller adjustment changes each time you change directions, until you are finally confident to have settled at the focal point.
12. Retighten the set screw to ensure the focus is held.

### Spectrometer Mode

1. Select a light source with a known sharp line and connect it to the monochromator
2. Set the slits to as narrow as possible while still obtaining a decent signal
3. Scan so that the line is centered in the CCD
4. On the CCD arm, loosen the set screw that fastens the collar into place



Figure 11: CCD focusing collar and fastening set-screw

5. Rotate the collar counter-clockwise from the top and then push the slit down until the two collars make contact. Do this far enough to go beyond the suspected focal distance
6. Note whether or not the line has become any narrower and the signal has increased. If it has, continue to lower the slit.
7. If it appears that the signal has come out of focus, rotate the collar in the opposite direction a set amount and continue until you have gone beyond the focal point and the line begins to broaden and have a lower peak signal.
8. Begin rotating the collar in smaller increments in the opposite direction and monitoring the line at each interval until again you have just passed the focal position.
9. Repeat step 10, with smaller adjustment changes each time you change directions, until you are finally confident to have settled at the focal point.
10. Retighten the set screw to ensure the focus is held.

## Add-on Options

- Adjustable Slit Assemblies
- Motorized Scanning
- Software Control
- Adaptor Flange for Purged Operation
- RF Light Source
- Pumping Station
- CCD Array
- EUV/VUV/UV/Vis Detector

## Appendix

The VM200 monochromator (Vacuum Monochromator 200mm focal length) contains a concave holographic grating with AlMgF2 coating. This grating has the following specifications:

### Monochromator

|                             |                            |
|-----------------------------|----------------------------|
| Model                       | VM200                      |
| No. of Lines/mm             | 1200 l/mm                  |
| Diameter                    | 40 x 45mm                  |
| Coating                     | AlMgF2                     |
| Spectral Range of Operation | 100 – 400nm                |
| Radius of Curvature         | 200mm                      |
| Body Seal Types             | Viton O-rings              |
| Body Mating Flanges         | 2 3/4" Conflat type x 2    |
| Ultimate Pressure           | <1 x 10 <sup>-6</sup> mbar |

### Wavelength Drive

|                          |                         |
|--------------------------|-------------------------|
| Type                     | 10 turn dial/lead screw |
| Backlash                 | 0.5nm (vacuum)          |
| Step Size                | 0.4 – 15 Angstroms      |
| Standard Scanning Speeds | 0.4 – 15 nm/sec         |
| Accuracy                 | ± 0.3nm                 |

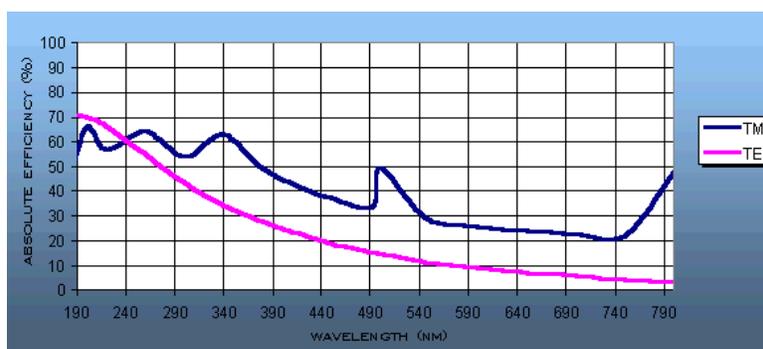


Figure 12: Grating efficiency curve

# Appendix

## Photodiode Detector

The XUVSi-D-L-EUV contains an absolute UV silicon photodiode with a low noise, high gain amplifier.

|                              |                                |
|------------------------------|--------------------------------|
| Type                         | Absolute UV Silicon Photodiode |
| Photodiode Model             | AXUV100G                       |
| Photodiode Sensitivity Range | 1 – 1000nm                     |
| Photodiode Size              | 10 x 10mm                      |
| Internal Gain                | 1 x 10 <sup>9</sup> A/V        |
| A to D Type                  | LabJack                        |
| A to D Bit Resolution        | 12 Bit                         |
| Differential Gains           | 1, 2, 4, 5, 8, 10, 20          |

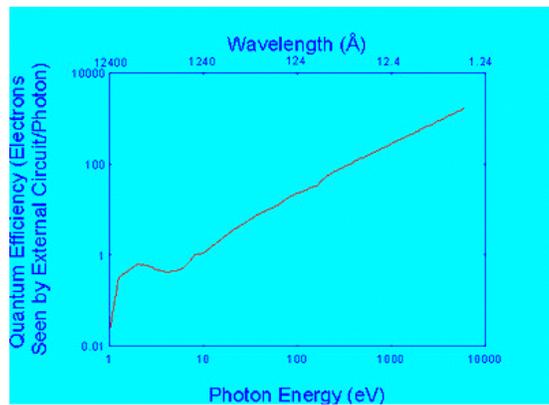


Figure 13: Typical response curve of the AXUV photodiode (go to <http://www.ird-inc.com/text/axuvopeprin.txt> for complete data table)

## Appendix

### CCD

Resonance Ltd. uses a Hamamatsu CCD array modified to allow detection of EUV/VUV radiation.

|                             |                           |
|-----------------------------|---------------------------|
| Type                        | Linear CCD, 2048 elements |
| Height/Width of Active Area | 0.2 x 28mm                |
| Model                       | S9840 (Hamamatsu)         |
| Number of Active Pixels     | 2048                      |
| Pixel Size                  | 14 x 14 $\mu\text{m}$     |

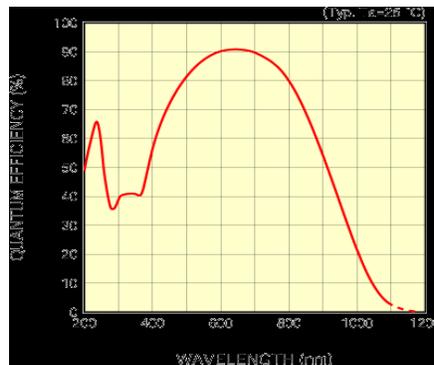


Figure 14: Typical response curve of the Hamamatsu S9840 CCD

### Adjustable Slits

Resonance Ltd. uses ThorLabs Adjustable slits modified to be compatible with vacuum operations.

|                     |                      |
|---------------------|----------------------|
| Slit Height         | 1mm                  |
| Slit Width Range    | 0 – 6mm              |
| Blade Parallelism   | <25 $\mu\text{m}$    |
| Slit Width Accuracy | $\pm 50 \mu\text{m}$ |

# NIST Calibration

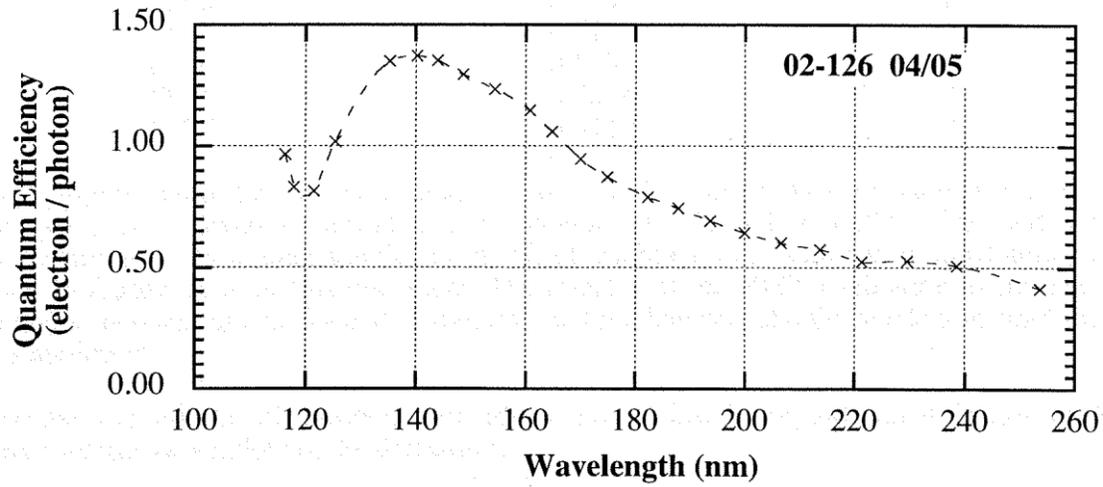


Figure 13: NIST Standard Calibration Curve

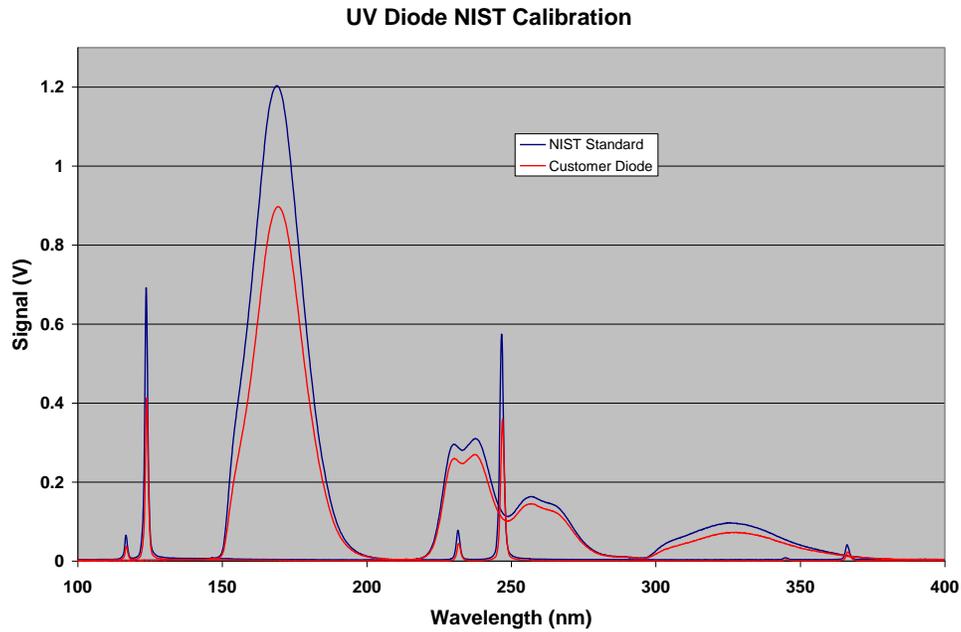


Figure 14: NIST Calibration Measurements

# NIST Calibration (continued)

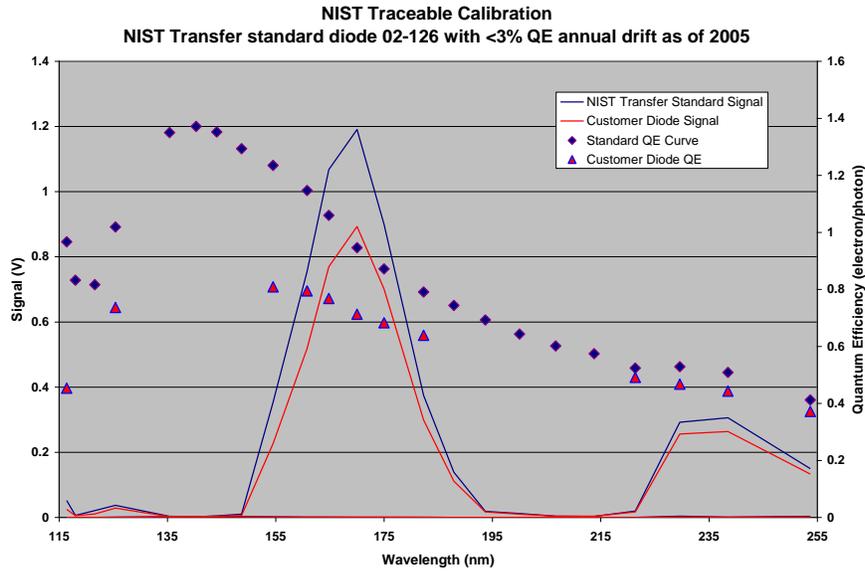


Figure 15: NIST Traceable Quantum Efficiency Chart