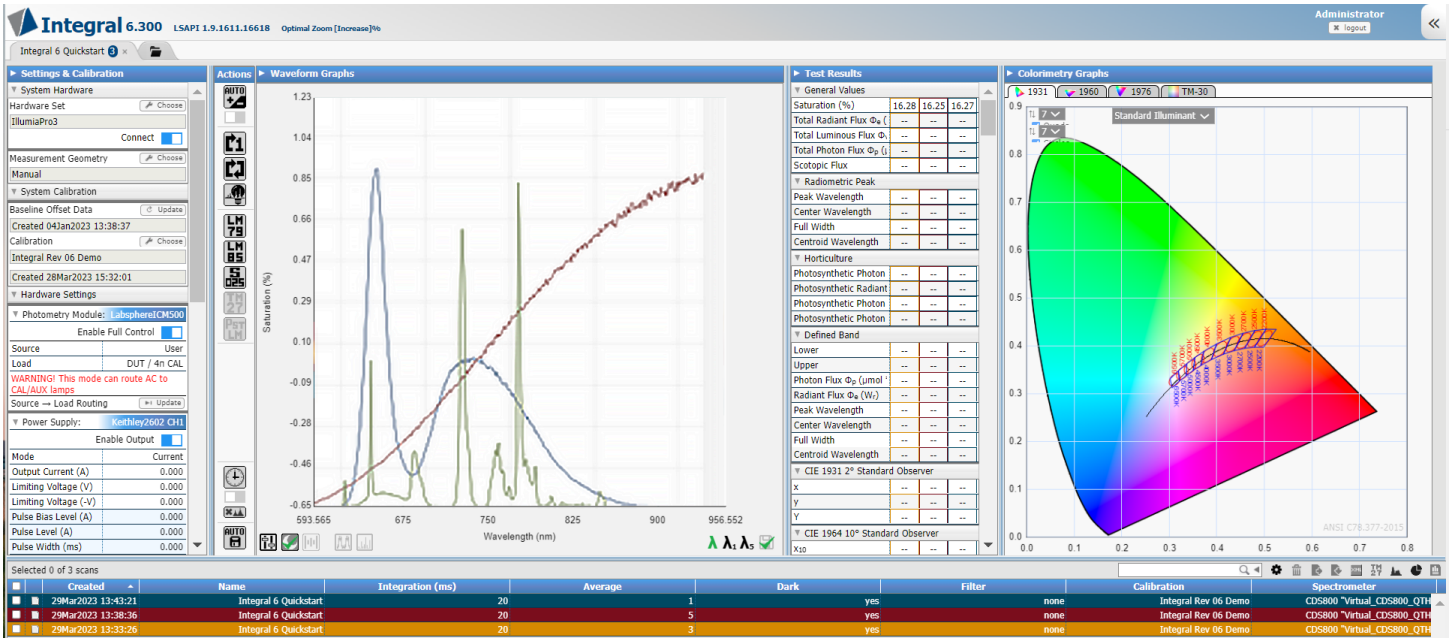
INTEGRAL SOFTWARE

Operation Manual



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Labsphere
advancing the technology of light

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2. DOCUMENT CONVENTIONS

This operator's manual includes the following conventions:

The note icon is used to highlight important configuration information.

The caution icon is used to illustrate environments where an electrical shock hazard exists.

The heat icon indicates situations where hazardous temperatures exist.

The attention icon is used to highlight important configuration information where damage or system conflicts may occur.

Table 1
SOFTWARE COMMAND CONVENTIONS

Convention	Description	Examples
Bold Text	Click commands and Buttons	"Click the **Calibrate Now** button"
→	Menu paths	*File* → *Exit*
"Quoted Italics"	Text from Message Windows	"*Driver successfully communicated…*"
Italics	Text to type into an entry location Or The name of a window or panel	Type, *admin* as the user name. Open the *Create a Calibration* window.

3. INTRODUCTION

This manual covers the operation of the most recent version of the Labsphere software known as "Integral", which is at revision 6.208 as of this publication date. Integral has been designed to be a universal light measurement platform that provides a wide variety of functionality, including the ability to connect to and communicate with a wide variety of Labsphere and 3rd party hardware devices and systems. The hardware devices and systems typically change with each revision of Integral and the supporting software manual. Previous revisions of Integral software and supporting manuals are available from Labsphere for legacy illumia® systems. This manual is not able to cover every hardware configuration that may be used; instead the focus is on the use and understanding of the Integral software itself.

Although the focus of this manual is on the Integral software, there are many references to certain hardware configurations. There are four categories of light measurement systems that will be referenced in these pages:

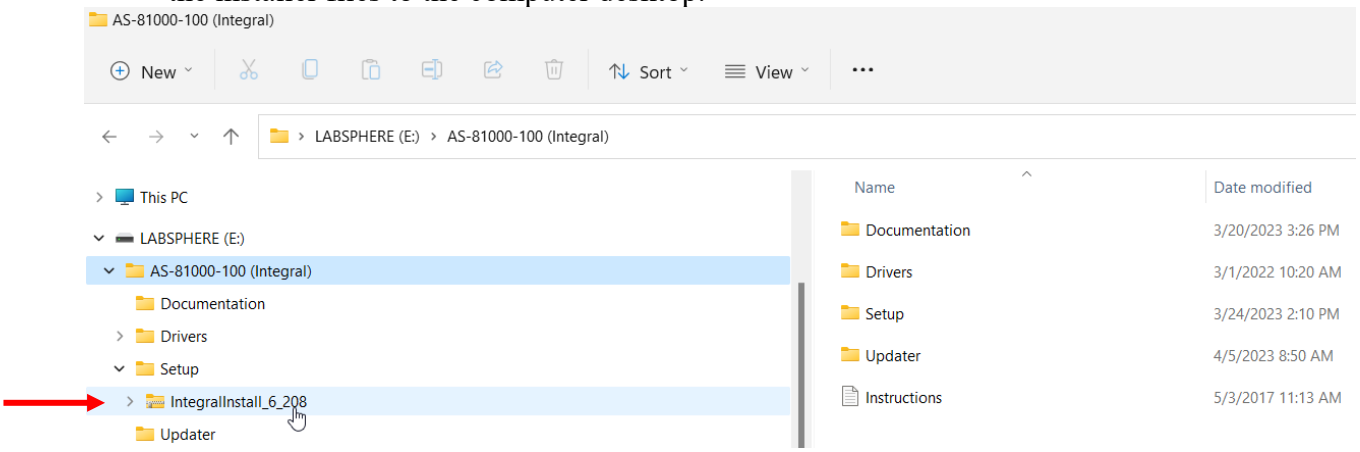
1. illumia®Plus systems with the Labsphere Photometry Module (PM-150)
2. illumia®Plus2 systems with the Labsphere ICM-500 control module
3. illumia®Pro3 systems with the Labsphere ICM-500 control module and Arroyo TEC hardware
4. Light measurement systems with neither the Labsphere PM-150 nor the ICM-500

Additionally, there are Integral "Modules" that may be referenced; such as the "Integral AC Module" and "Integral LM-85 Module." These each have specific documents and manuals regarding their use and will not be covered in detail here.

Full Labsphere systems, such as the illumia®Plus, illumia®Plus2, and illumia®Pro3 systems, come with helpful quickstart guides and complete hardware reference manuals that provide simplified examples for initial setup, configuration, and operation. Please refer to the hardware manual and quickstart guide that came with your system when first setting it up. The following pages provide more detailed information regarding each step and should be used as a complete reference for all aspects of the Integral software platform – from login to report generation.

4. SOFTWARE SETUP

1. Connect the system components as defined in the illumia hardware manual and power on all devices.
2. Insert the Labsphere flash drive into a USB port in the host computer.
3. Navigate down to the compressed "IntegralInstall" folder and right-click on it to extract the installer files to the computer desktop.



4. Right click on the "IntegralInstall64Bit" Windows batch file and select "Run as administrator".
5. The Python 2.7 (beginning) and LSAPI installer (end) run separately. Popup windows will close automatically when they are complete. Choose (D) when prompted for the file (F) or directory (D).
6. Install the Chrome internet browser if it is not on the host computer. 32-bit Chrome is included in the <\Integral Install\Assets\> folder (ChromeSetup32bit.exe).
7. An Integral (URL) shortcut will appear on the desktop. This shortcut will open in the default browser (Integral requires Chrome). Update the Windows default browser if necessary in [System Settings -> Default apps]. Integral can also be manually launched via the Chrome URL=(localhost:5961).

4.1. Using Integral Locally

Integral runs in the Chrome internet browser but does not require connection to the internet to operate. Integral can be run locally by connecting a USB cable from the user's host computer to the Labsphere ICM-500. This configuration does not require a network connection, however, one may be used at any time.

The only difference between running Integral locally versus from any other connected device is that the address of the Integral server is already known.

To run Integral locally, simply open a Chrome browser window (there should be a shortcut for Chrome right on the desktop) and type *localhost:5961* in the address window.

Please note: The ":5961" is a way of addressing a specific "port" on the host. Integral always defaults to port 5961 but this setting may be changed. Please contact Labsphere technical support for assistance changing this number.

4.2. Using Integral Remotely

To use Integral remotely, the remote computer must have the Google Chrome browser installed and be connected to the same network as the host computer. The host computer must be running Integral Services Manager and connected to the same network as the remote computer.

Determine the network name or IP address of the host computer (this may require assistance from a Network Administrator) and then open a Chrome browser window on the remote computer and type "'IP ADDRESS':5961" in the address bar. For example, if the host computer's IP address is 192.168.1.10 then "192.168.1.10:5961" would be typed into the address bar.

Please note: The IP address of the host computer may change. This is controlled by the company/facility network administrator. In some cases, the administrator can assign a "static IP" such that the host computer will always have the same IP address.

4.3. Optimal Viewing Conditions

The Integral user interface includes a large variety of popup screens and limited size menus. The monitor settings of the host Windows computer must be at least 1920 x 1080 resolution, preferably at 100% scale, and in landscape orientation to view all of the user interface components correctly and not cut off important sections of it. If these display settings are modified in Windows to change the size of text, apps, and other items, Integral will notify the user to modify the zoom level in the browser header bar as this directly impacts how Chrome displays Integral.

4.4. Login Procedure

Once the Integral Welcome page (Figure 1) opens from the Chrome browser, the *Username* and *Password* can be entered.

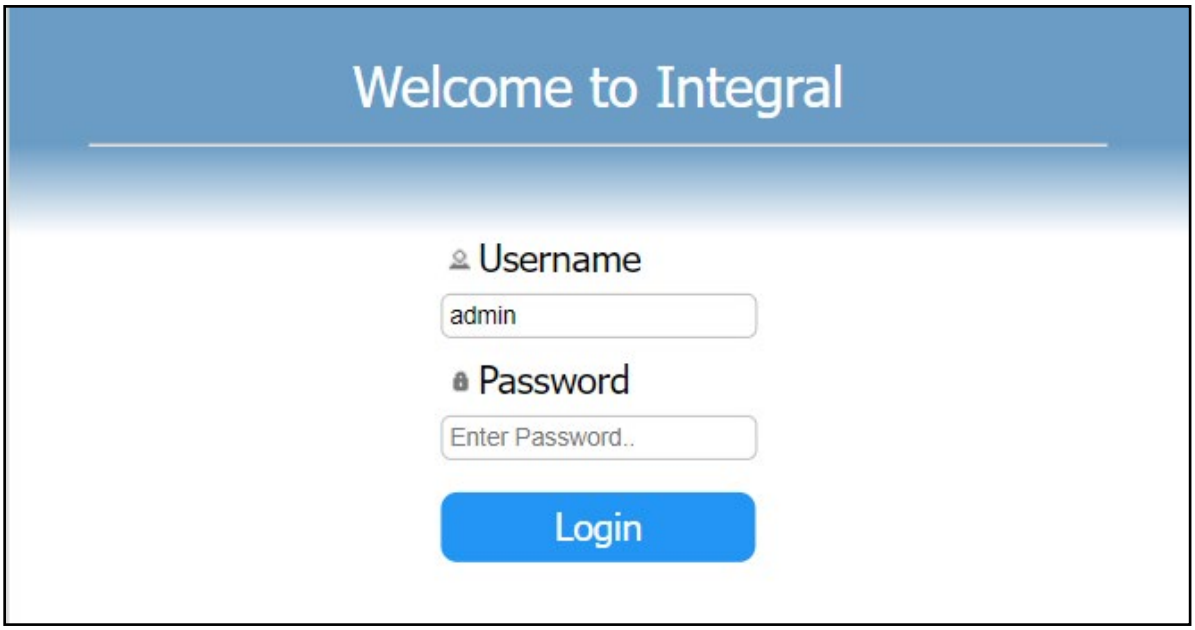


Figure 1: Welcome Screen

Many buttons or other user interface elements will display helpful hints or additional information in a "tip strip" if the mouse cursor is held (hovered) over the user interface element, as shown in Figure 2.

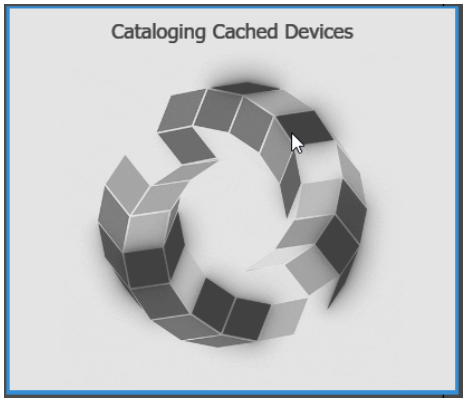
Figure 2: Action Prompt Tip Strip Pop-up

The following is the default login:

1. Type in *admin* as the username.
2. Type in *admin* as the password.

The Integral Administrator may change/add users, passwords, and so on. Please see: Admin Controls.

3. Click the **Log in** button. The "Cataloging Cached Devices" splash screen will briefly appear, followed by the Main Menu home screen:



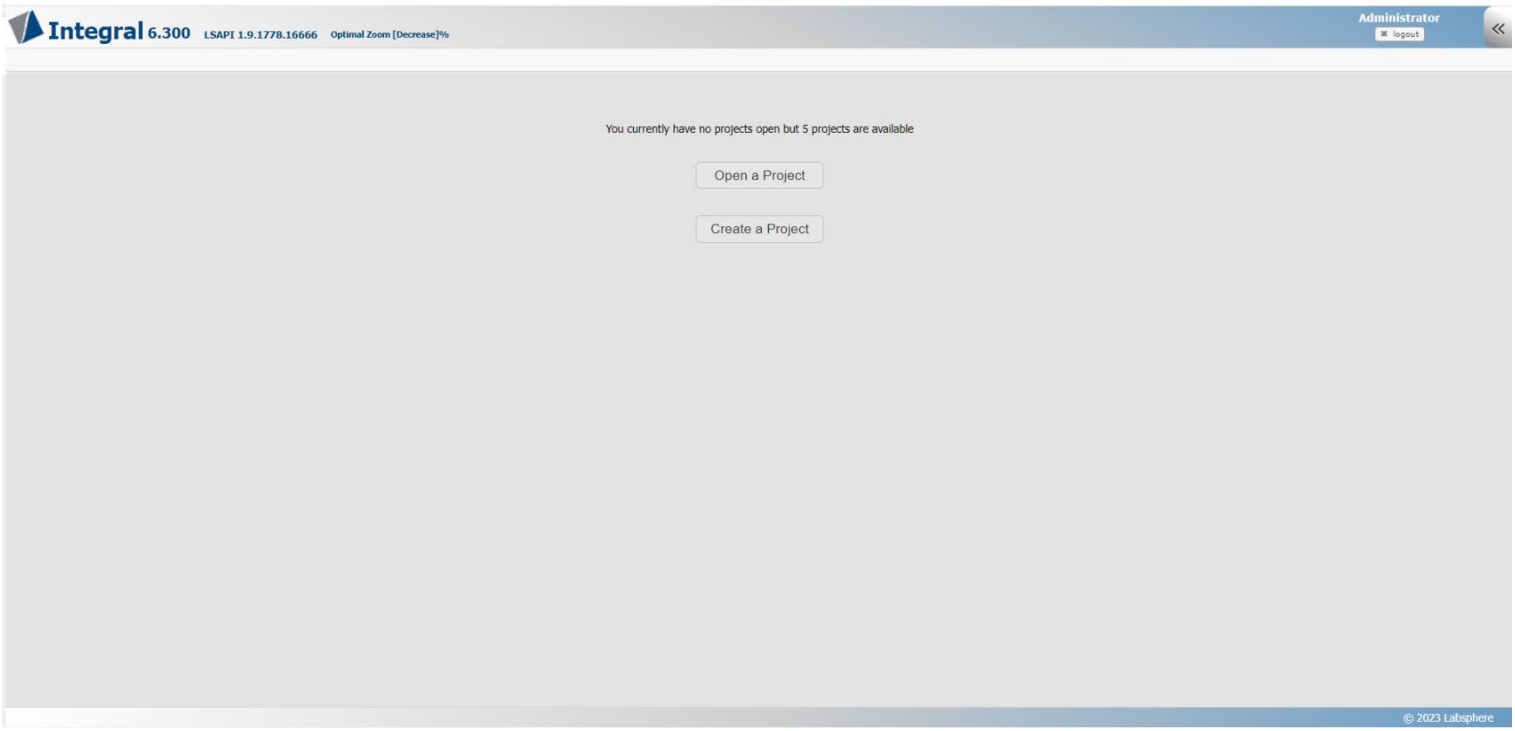


Figure 3: Main Menu Screen

5. PROJECTS

Once logged in, a project may be opened, created, or observed. All measurements in Integral are performed in a project. Projects help organize the user's work and serve as important markers in the database.

5.1 Open a Project

Click the folder icon in the right-side tab at the top of the main screen.

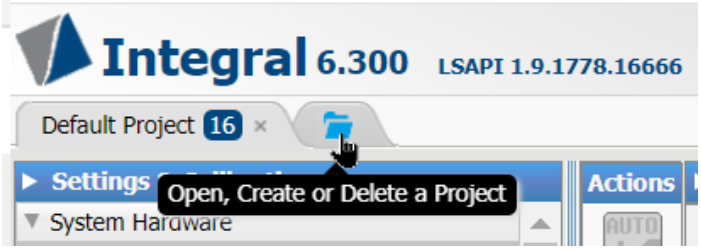


Figure 4: Folder Icon to Open Projects

When the **"Open a Project"** screen appears, choose an existing project from the list in the drop-down box and click the **Open** button.

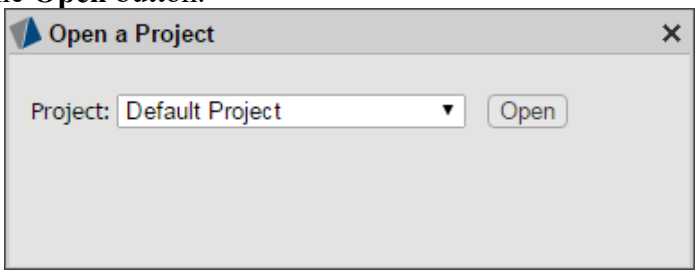


Figure 5: Open a Project Screen

5.2 Create a Project

Click the **Create a Project** button from the main window after login, or from the *Open a Project* Window as described above. The *New Project* screen opens.

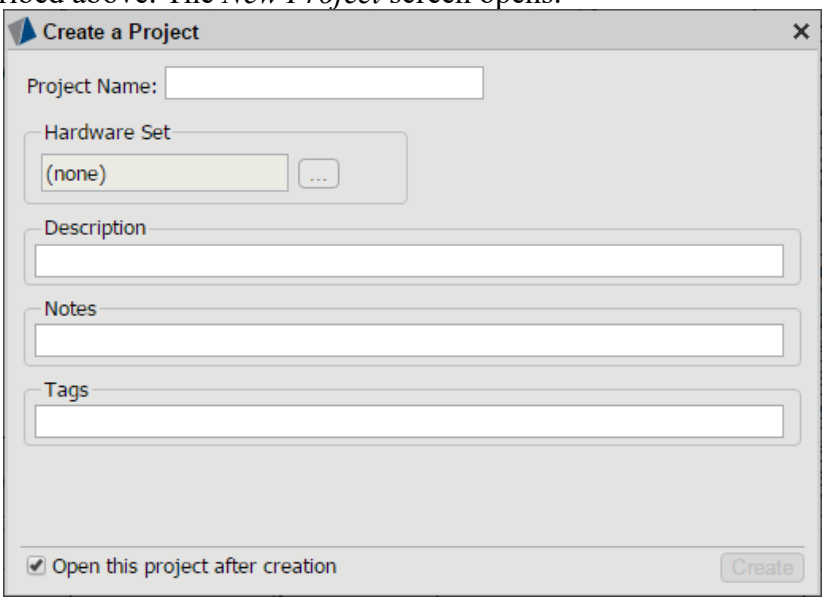


Figure 6: Create a Project Screen

In this screen, a project may be named; which is called “Demo Project” throughout this manual. Every Integral Project must have a unique name. *Project Name* is the only required field in this screen.

The optional fields in this screen are:

Hardware Set – The Set of Hardware used in the Project
Description – User defined description of the Project
Notes – User-supplied notes for the Project
Tags – User-supplied tags that may be used to locate data later

When creating a new project choosing a HW set or Cal is not required. These functions are accessible from the main screen of an open project. Please refer to sections: Hardware Sets and Calibrations.

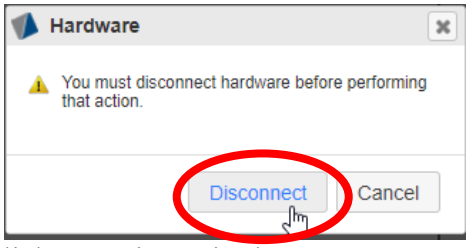
When information has been entered on the *Create a Project* screen, click the **Create** button. The project just created, called “Demo Project” here, will be opened and appear in the Integral main user interface window.

5.3. Closing a Project

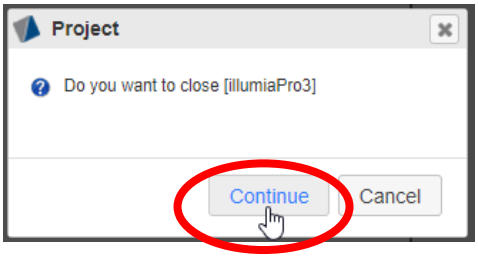
To close an open project:

1. Click the “X” in the project folder tab.

2. If the hardware is connected when doing this, the disconnect hardware warning screen will appear.



3. Click “Disconnect”, then click “Continue” in the next screen.

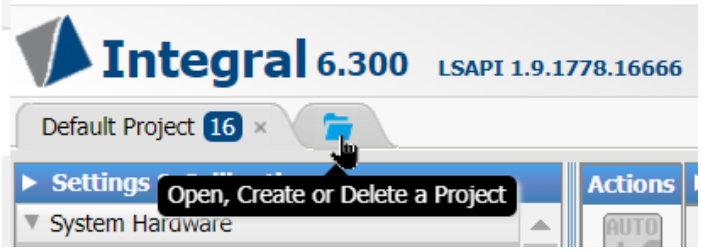


5.4. Deleting a Project

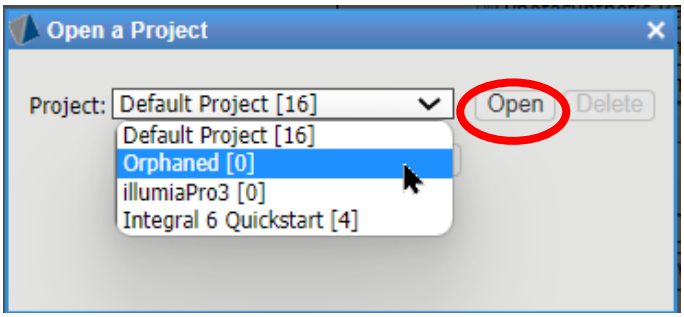
Projects can be completely deleted as necessary to free up memory or to streamline the active project list.

The project to be deleted cannot have any scans associated with it.

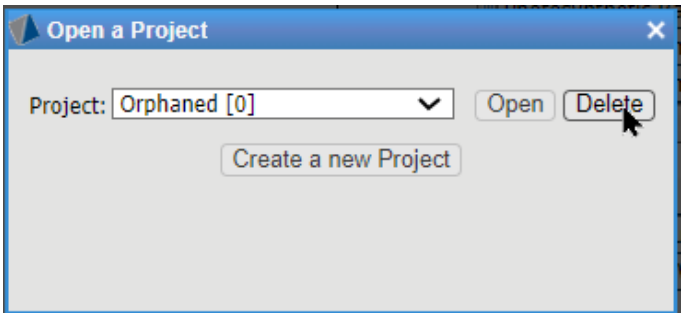
1. Close and disconnect the hardware in the project to be deleted (if open) as shown in the previous section.
2. Click the folder icon in the right-side tab at the top of the main screen.



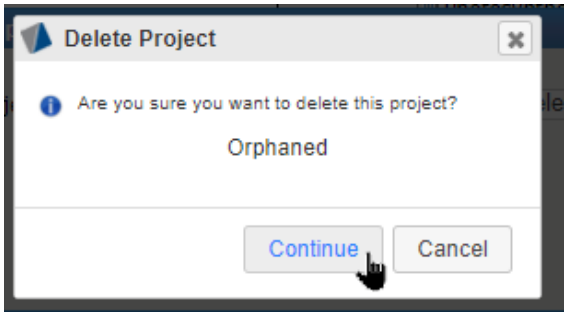
3. When the **"Open a Project"** screen appears, choose the project to be deleted from the list in the drop-down box and click the **Open** button.



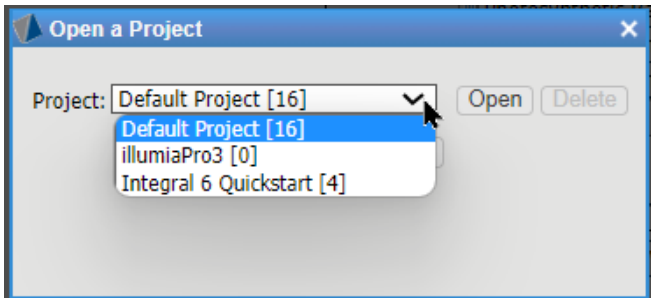
4. The "Delete" button is now active. Note that the project has not been opened.



5. Click the “Delete" button to bring up the confirmation prompt.



6. The **“Open a Project”** screen will reappear with the “Delete” button inactive. Open the project list drop-down menu to witness and confirm that the deleted project is no longer in the list.



7. Click the X in the upper right corner to close the screen.

6. LIGHT MEASUREMENT PROCESS

Performing light measurements with the Integral software follows a series of steps designed to simplify and automate the measurement procedure while allowing the user traceability regarding the measurement equipment and files used in the measurement process. The steps are summarized in the flow chart below with details and options for each step described in the body of this user manual.

The concept of Projects, Hardware Sets, Geometry, and Calibration Sets will be described fully in subsequent sections.

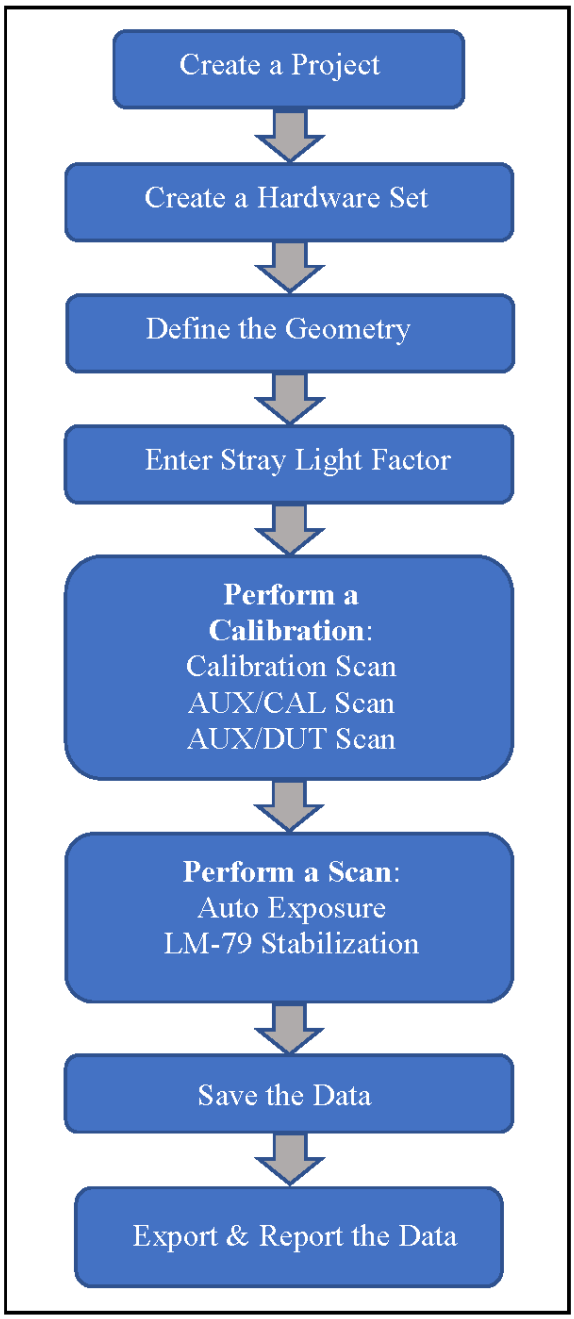


Figure 7: Measurement Flow Chart

6.1. Integrating Sphere Overview

The Labsphere Integral software allows users to accurately measure optical power and color characteristics from a range of light sources. The interior of the integrating sphere provides a diffuse surface that reflects the light in a Lambertian distribution so that the energy is distributed equally on every surface point in the sphere. In theory, this is true, but as soon as the ideal sphere is disrupted by a port, a baffle, or even the device itself, the geometry is no longer a perfect sphere and the measurement needs some sort of compensation to account for these changes.

The Auxiliary lamp accomplishes this by creating a spectrum for the geometry with the calibration lamp in place, and with the device under test (DUT) in place. The ratio of these spectra provides a correction for the relative change in reflectance due to the change in geometry between the calibration and the DUT measurement.

Please refer to Appendix 3: "General Light Measurement Procedures" on page 141 for more information on the measurement procedure. Many more technical guides can also be found on the Labsphere website: http://labsphere.com/support/video-library/

7. INTEGRAL MAIN SCREEN

Once a project is selected, the main Integral window appears as shown below. Details of the functions for each section are included in the following sections of this user manual.

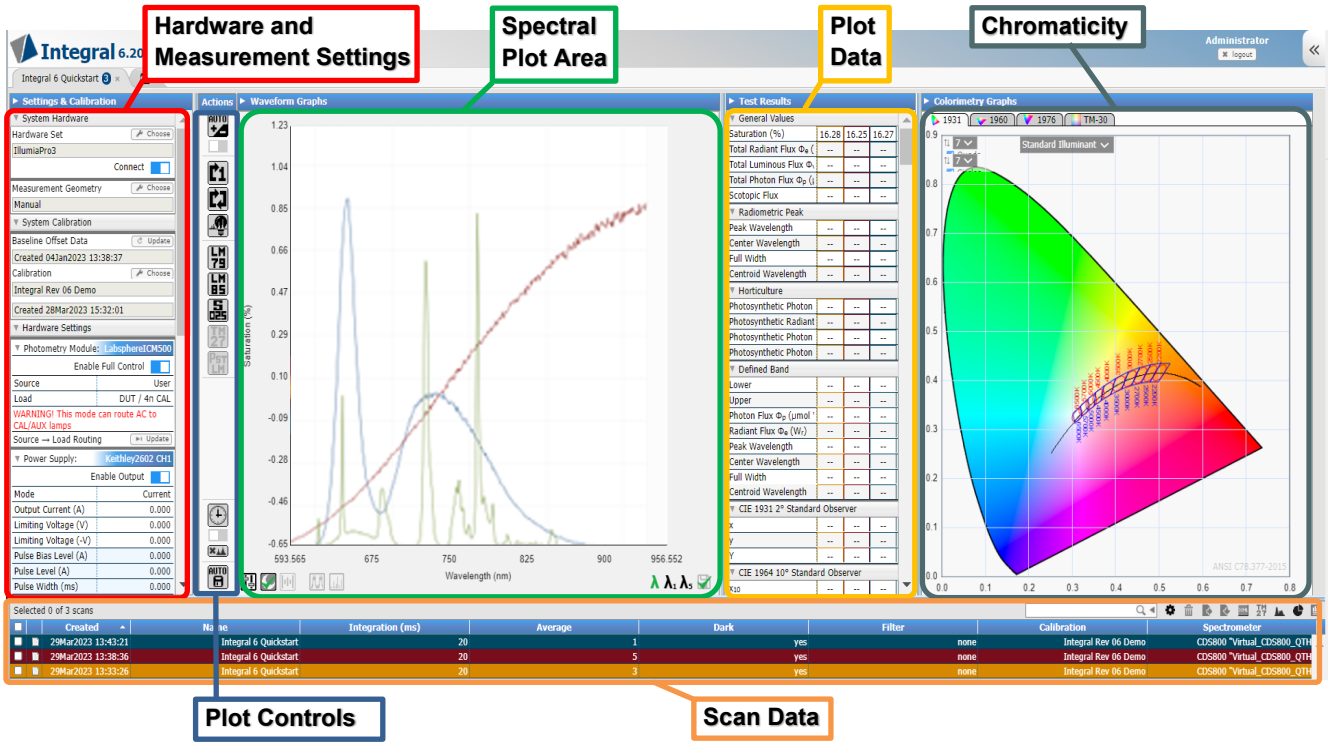


Figure 8: Setting and Calibrations Screen as of revision 6.208— screen contents subject to change with future revisions

Hardware and Measurement Settings

Parameters for controlling the measurements are entered in this section.

Plot Controls

This section contains the performance control buttons used to make and save measurements.

Spectral Plot Area

This section displays visual representations of the measured data in a variety of graphical forms. Display format buttons are positioned below the graph area.

Plot Data

This section displays the test results for calculated values from the latest scan or from selected measurements. The information displayed in this section is read-only.

Chromaticity

This section displays the CIE 1931/1960/1976/TM-30 chromaticity diagrams with multiplier steps and zoom controls in the first three.

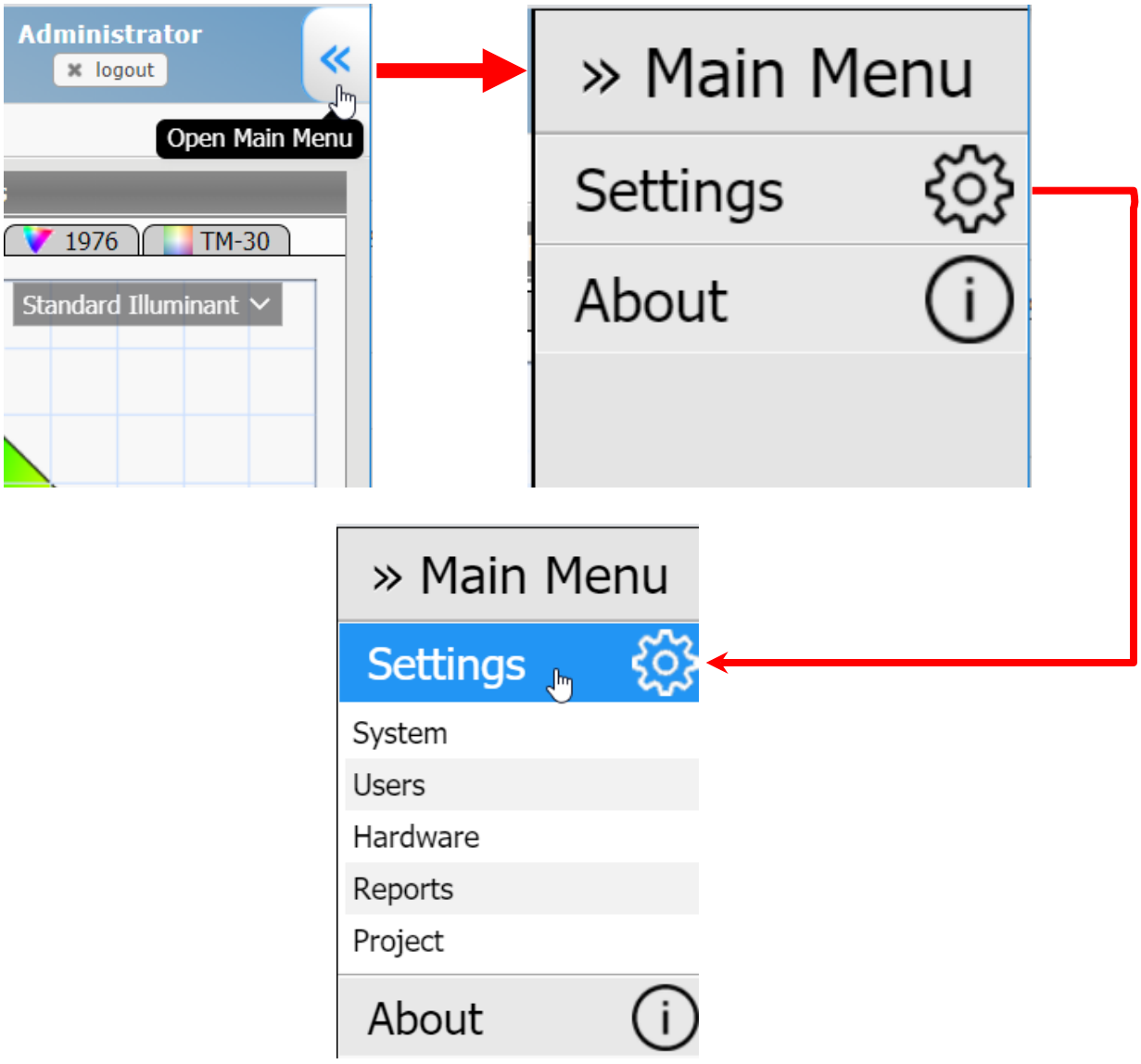
Scan Data

This section displays a running list of the tabulated scan data that has been saved.

7.1. Main Menu

The Main Menu list includes a “Settings” section with five submenus for universal program management and an “About” section that displays the Integral revision level installed and an Update link to the Labsphere software update web page.

Open the Main Menu by clicking on the double arrow icon in the upper right corner of the main screen. Then click on “Settings” to open the settings submenu list:



Refer to section 18 “Main Menu Admin Controls and System Settings” on page 116 for detailed information on each of the Main Menu functions.

7.2. Window Control Tools

The four sectors in the main screen can be opened and closed and scaled to optimize the screen to display the data and parameters that are most relevant for any particular operation.

7.2.1. Min/Max Tool

Each sector in the main screen has a minimize/maximize arrow located in the upper left corner of the window header. Clicking that arrow will minimize the sector, leaving a vertical title strip for reference.

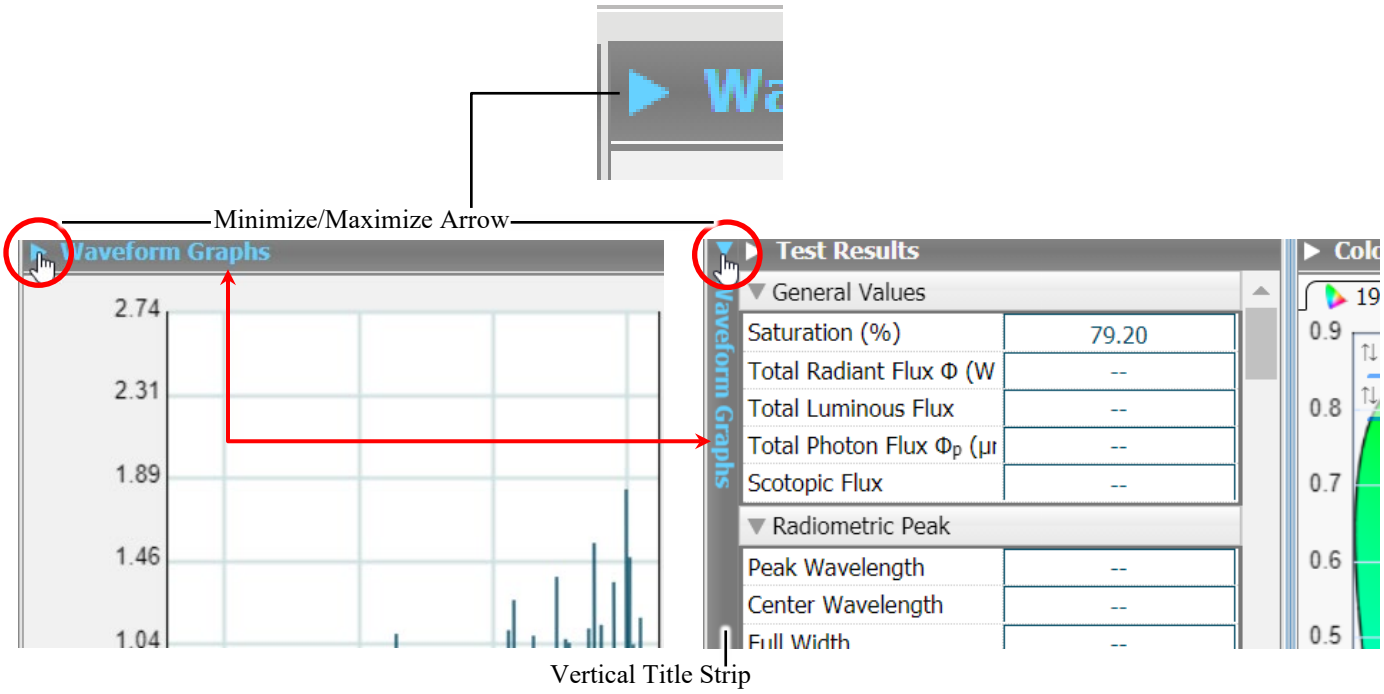


Figure 9: Minimize/Maximize Window Tool

7.2.2. Scaling Tools

The size of each sector in the main screen and the main screen itself can be adjusted the vertical and horizontal scaling tools. Hover the mouse along any of the sector borders and the double arrowhead scaling tool will appear. Click on any vertical border with that scaling tool and drag it either left or right to expand to reduce the width of the sector while simultaneously expanding the width of the neighboring sector. Click on the horizontal border at the bottom of the screen with that scaling tool and drag it either up or down to expand or reduce the horizontal height of all four sectors. This is useful when viewing an extended scan data list at the bottom of the screen.

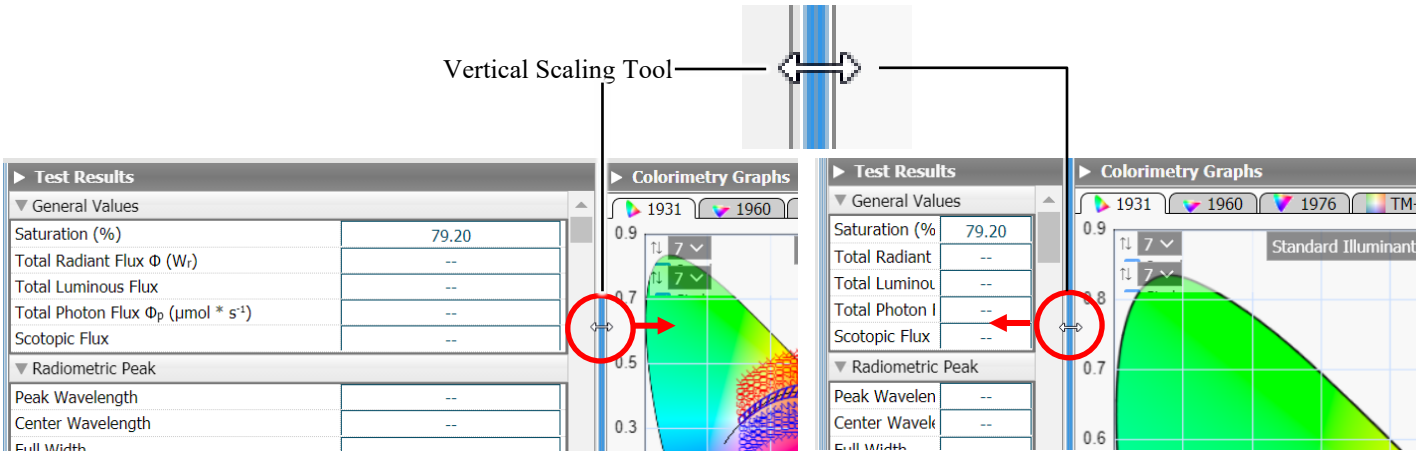


Figure 10: Vertical Scaling Tool — sectors

The width of the data column in the Test Results sector can also be adjusted with its own vertical scaling tool.

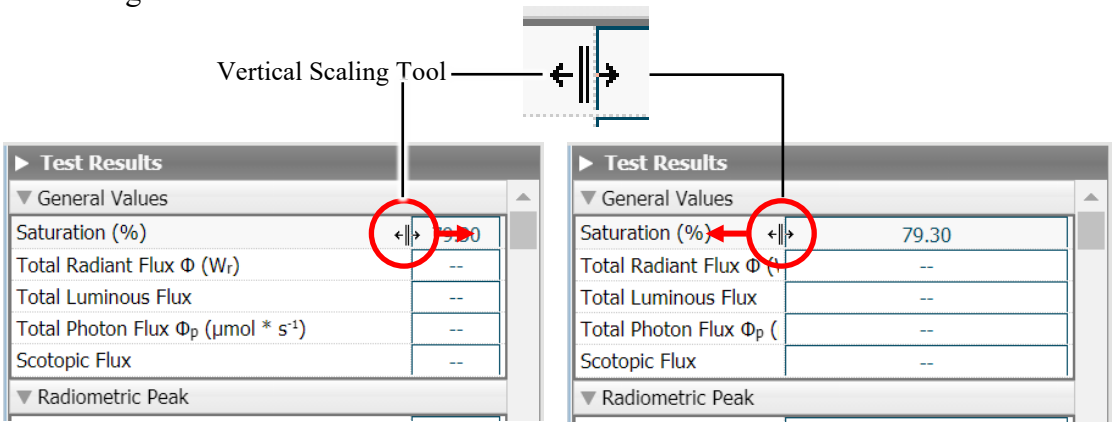


Figure 11: Vertical Scaling Tool — Test Results Column

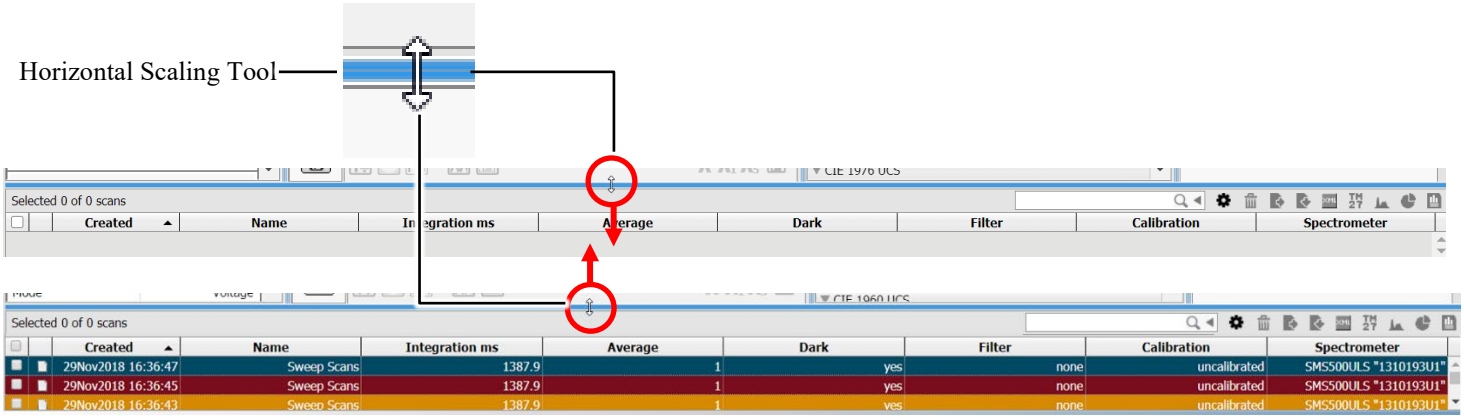


Figure 12: Horizontal Scaling Tool

7.2.3. Zoom-In and Zoom-Out Tools

The waveform and colorimetry graphs that are displayed in the main screen can be zoomed-in and zoomed-out. Left-click and drag over the region to be zoomed-in on (the cursor will change to a magnifying glass), and then release the mouse button. The selected region will expand, and the "curved arrow" zoom icon will appear in the lower left corner of the graph area. A scale factor number will also appear under the zoom icon indicating the number of times the graph region has been expanded. Click and drag again on another region in the graph and that number will increase by one. Click the curved arrow icon to zoom out of each level. The zoom-in tool is a little different between the waveform and colorimetry graphs, but the zoom-out tool is the same for both.

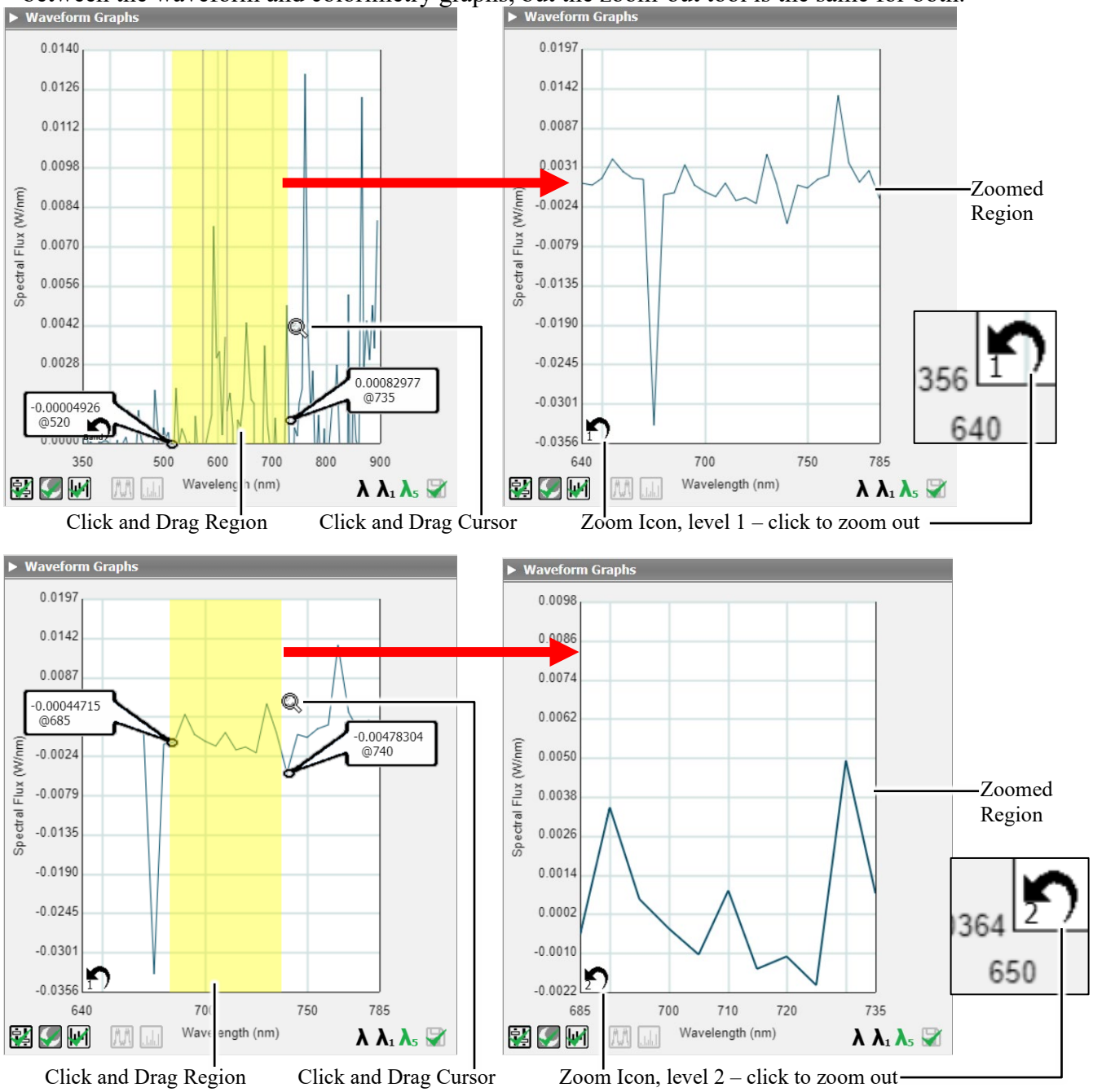


Figure 13: Waveform Graph Zoom Tools — zoom levels 1 and 2 shown

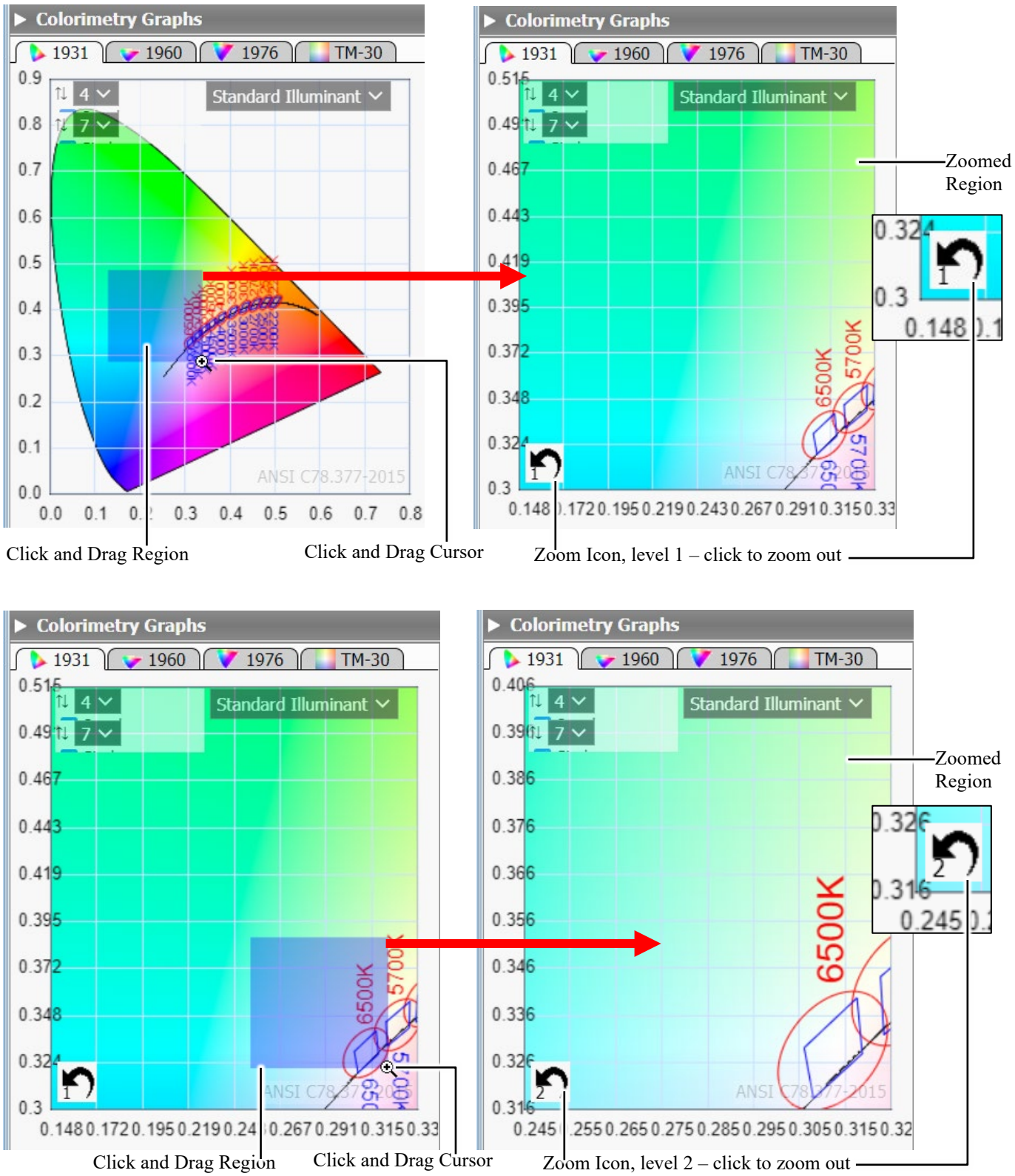


Figure 14: Colorimetry Graph Zoom Tools — zoom levels 1 and 2 shown

7.2.4. Parameter Pencil Cursor

Numerical adjustments made in the hardware control panels in the Settings and Calibration column are done using the parameter pencil cursor. Hovering the mouse over an adjustable parameter value field will cause the pencil cursor to appear. Clicking on the parameter field with the pencil will either open a numerical text entry box or a dropdown list to select from, depending on the parameter being adjusted.

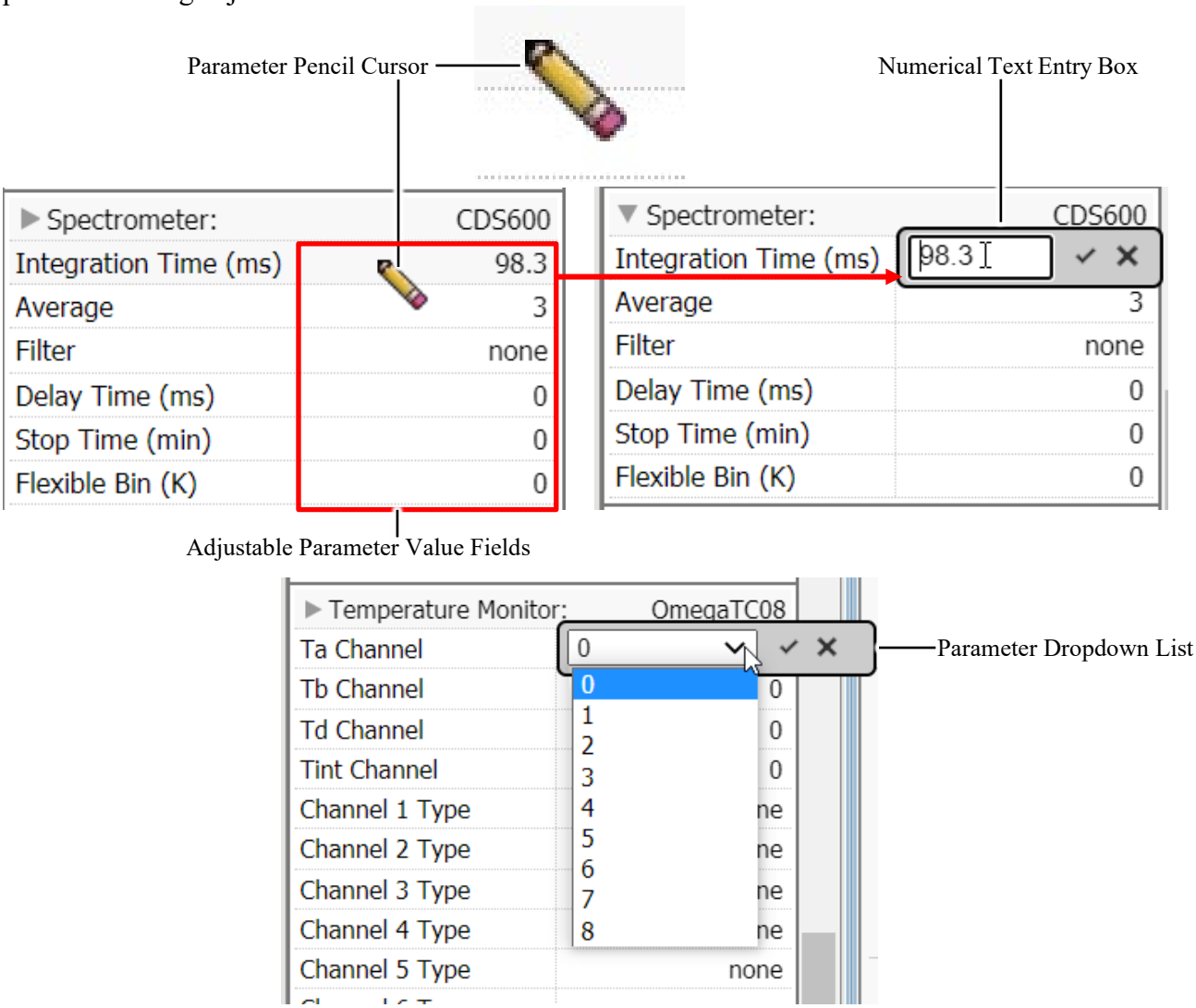
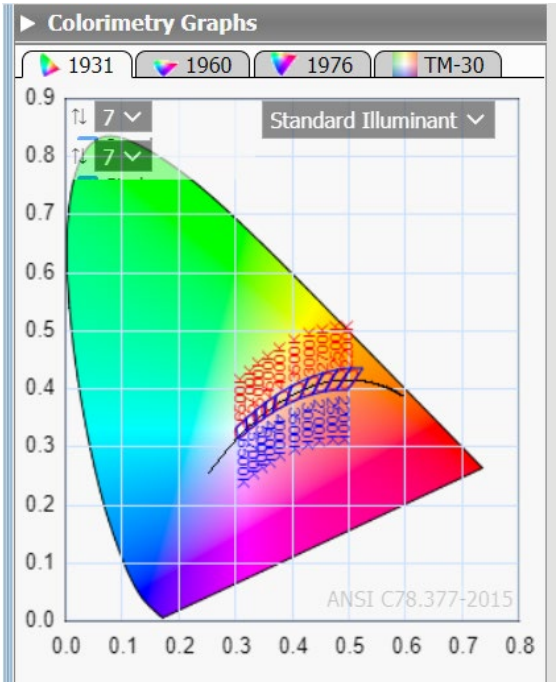


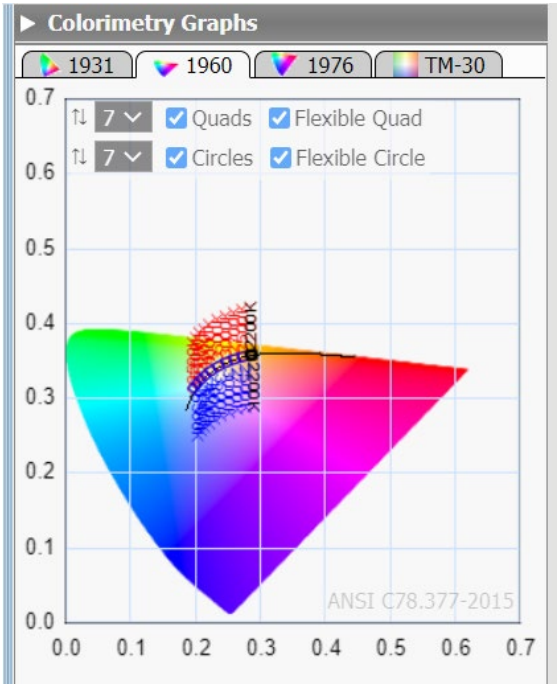
Figure 15: Parameter Pencil Cursor Applications

7.3. Colorimetry Graphs

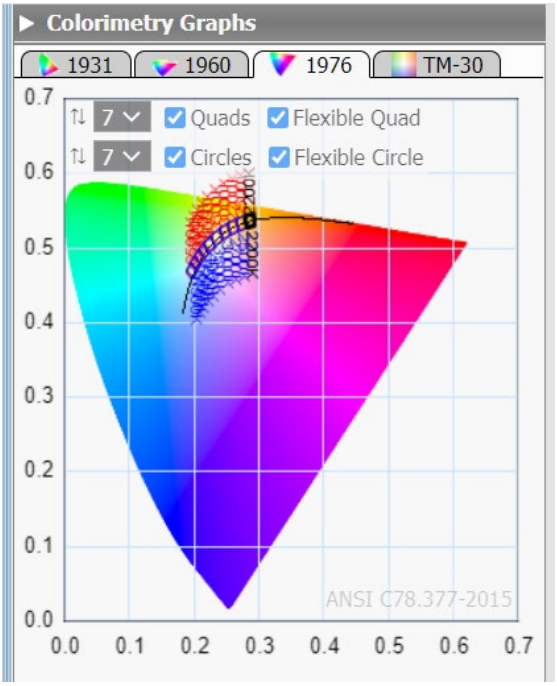
The right side column of the Integral main screen is used to display these industry standard CIE chromaticity diagrams that are relevant to the application:



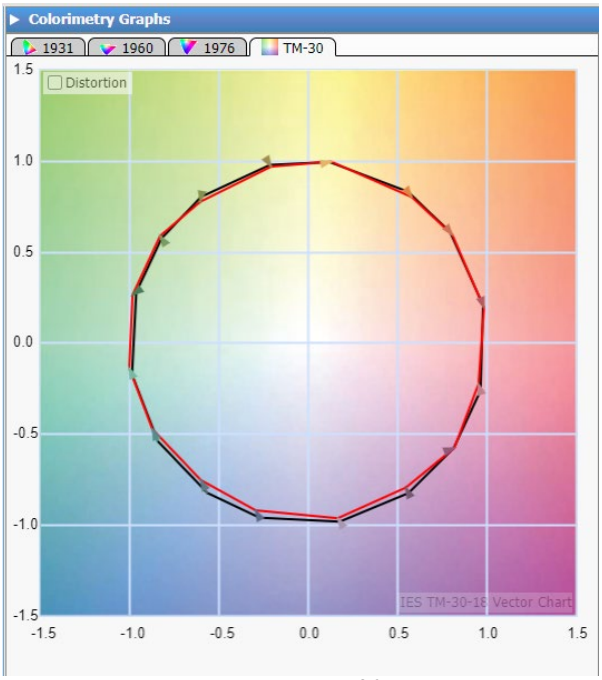
CIE 1931



CIE 1960



CIE 1976



CIE TM-30

Figure 16: Supported Colorimetry Graphs

7.3.1. Size Controls for u′, v′ Circles

The CIE 1976 colorimetry graph contains two dropdown lists that allows the user to control the u′ , v′ circles in the chromaticity diagram. The u′ , v′ circles based on the CIE 1976 color space are then converted to CIE 1960/1931 color spaces. The "1→8" list controls the size of the u′ ,v′ circles (in red), and the "4/7" list selects between the two industry standard rectangular LED bin sizes (in violet).

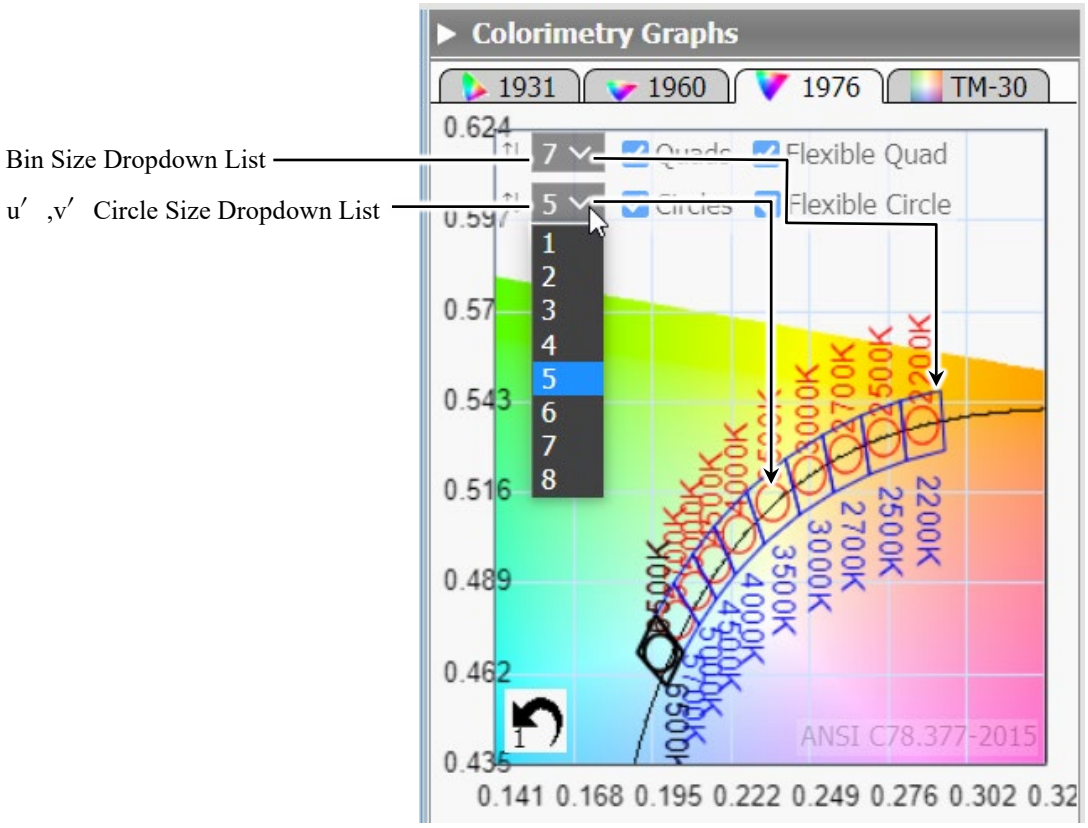


Figure 17: u′ , v′ Circles and Bin Size Dropdown List Controls

7.3.2. Display Controls for u′, v′ Circles

The CIE 1960 and 1976 colorimetry graphs contain four checkboxes that allows the user to toggle sections of the u′ , v′ circle display on and off in the chromaticity diagram. The default setting is for all boxes checked, revealing the full u′ , v′ circle display. The "Circles" and/or the bins (called "Quads") can be selectively turned on and off, as can the flexible Circles and Quads that are shown in black. All four of these elements can also be turned off, revealing only the Planckian locus path.

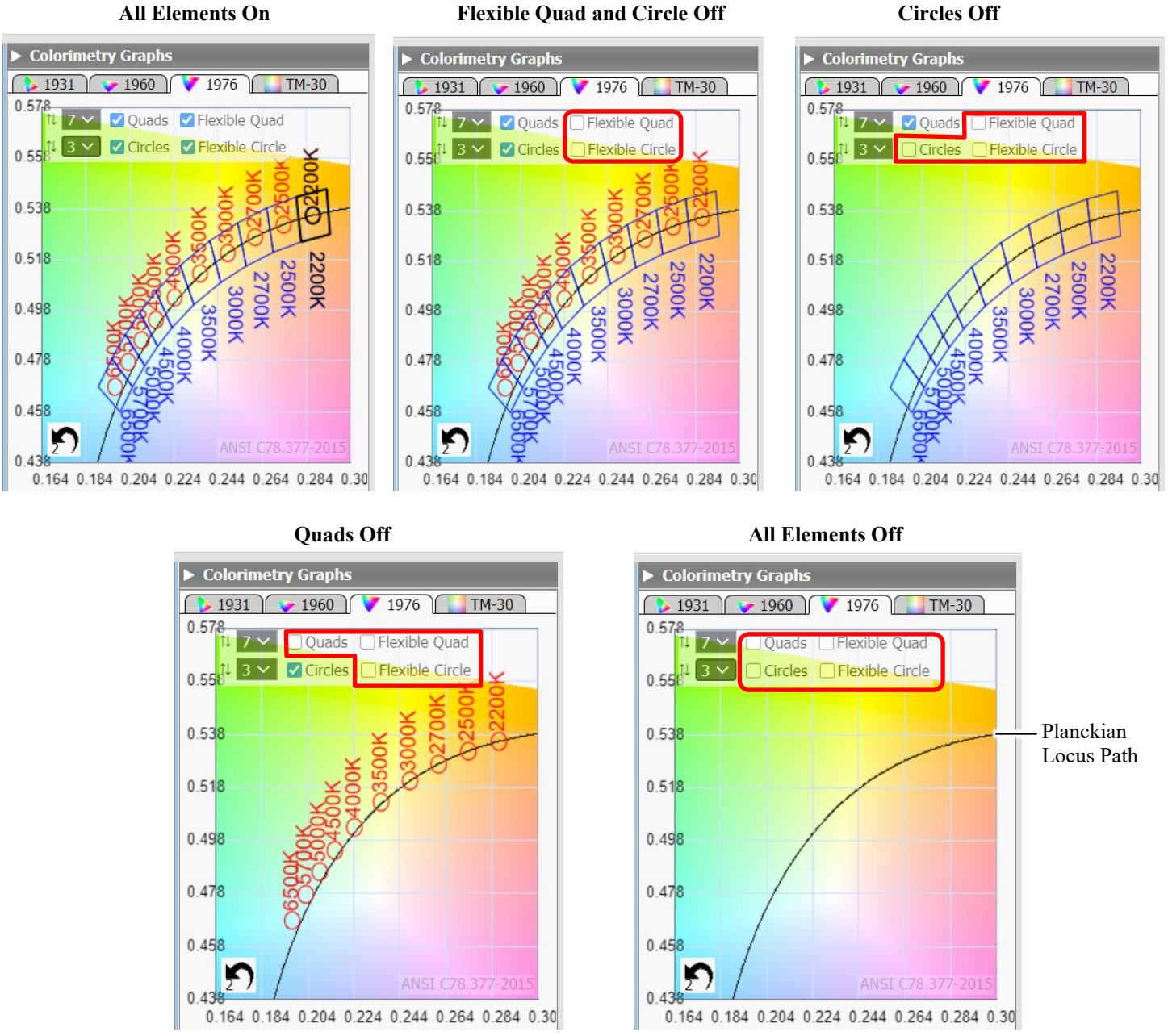


Figure 18: Display Controls for u′ , v′ Circles

7.3.3. Standard Illuminant Selection

The CIE 1931 colorimetry graph contains a dropdown menu that allows the user to select any of the industry standard CIE illuminants that are currently available. Each standard illuminant family designation is followed by its corresponding correlated color temperature (CCT) reference number.

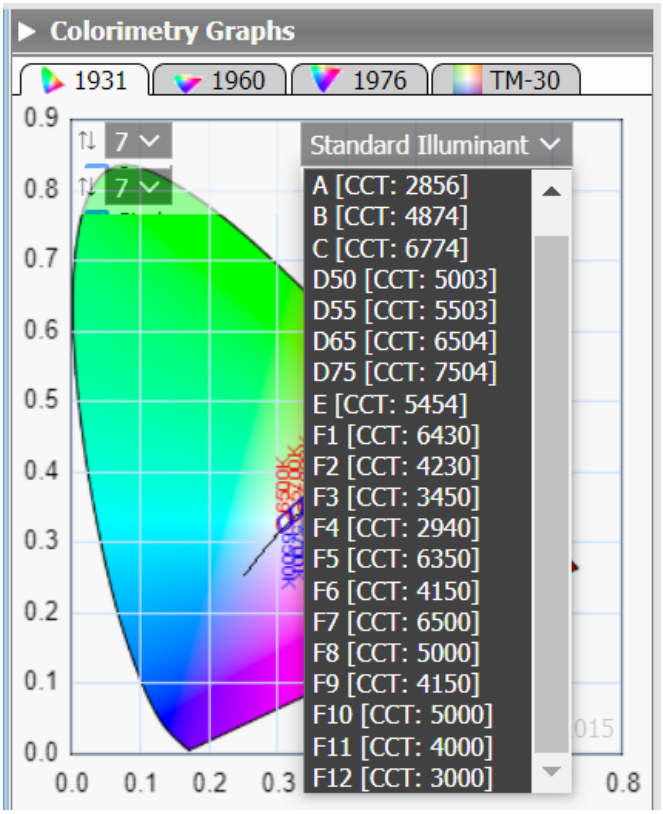


Figure 19: Standard Illuminant Dropdown Menu

8. HARDWARE SETS

Hardware Sets are used to define the specific pieces of hardware used to run tests or create calibrations. By using hardware sets, Integral can always trace measurements or calibrations back to the hardware that was used to create the measurements providing important traceability.

Measurements should not be taken until the spectrometer's stray-light factor has been entered. Refer to section 18.3.4 "Manage Stray Light Factors" on page 122.

A hardware set may be created from the login screen, or at any time from the main screen. Choosing or Creating a Hardware Set is often the first after opening a project. Note that the CDS-30x0 spectrometers require a "wavecal" file to be installed before the device can be cataloged. Refer to section 18.3.3 "Install CDS-30x0 Wavecal File" on page 122 before continuing.

To choose or create a hardware set, start at the top *Settings and Calibrations* section of the main screen and click the **Choose** button:

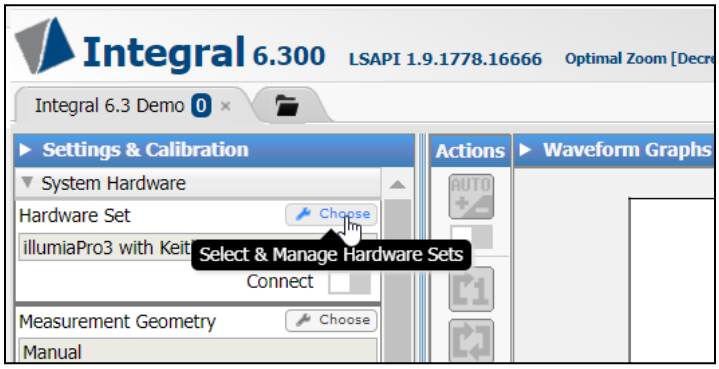


Figure 20: Setting and Calibrations Screen

All available hardware sets are listed in the drop-down box. Highlighting a hardware set will display additional information about that hardware set in the **Details** section of the screen. This screen also provides handy tools related to the hardware (devices) that may be connected to the system. Observe the three Device Catalog buttons: **Refresh** — **Available** — **Supported**

Available Hardware Sets Drop-Down Box

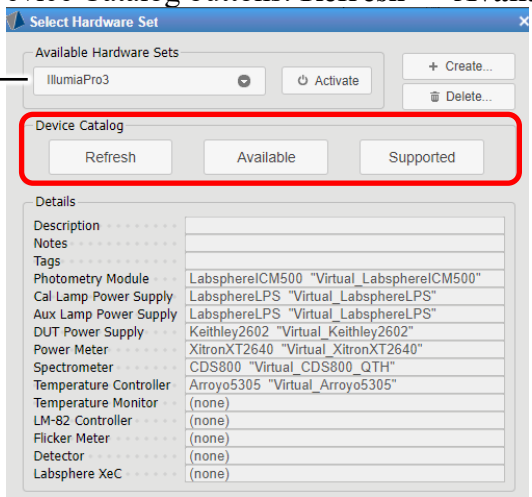


Figure 21: Select Hardware Set Window

Refresh: Instructs Integral to go out and look for any changes to the system. For example, if a device is plugged in, or unplugged, *Refresh* must be clicked before Integral will recognize the change.

Available: Provides a list of the devices currently connected and "available" for use. *Green* represents physical devices while *Blue* represents virtual devices.

Figure 22: Available Pop-up Screen (Current System Hardware)

Supported: This is a list of all the devices Integral *can* support if connected to the system. Labsphere is continuously adding devices to the supported hardware list. Please contact Labsphere for the latest information.

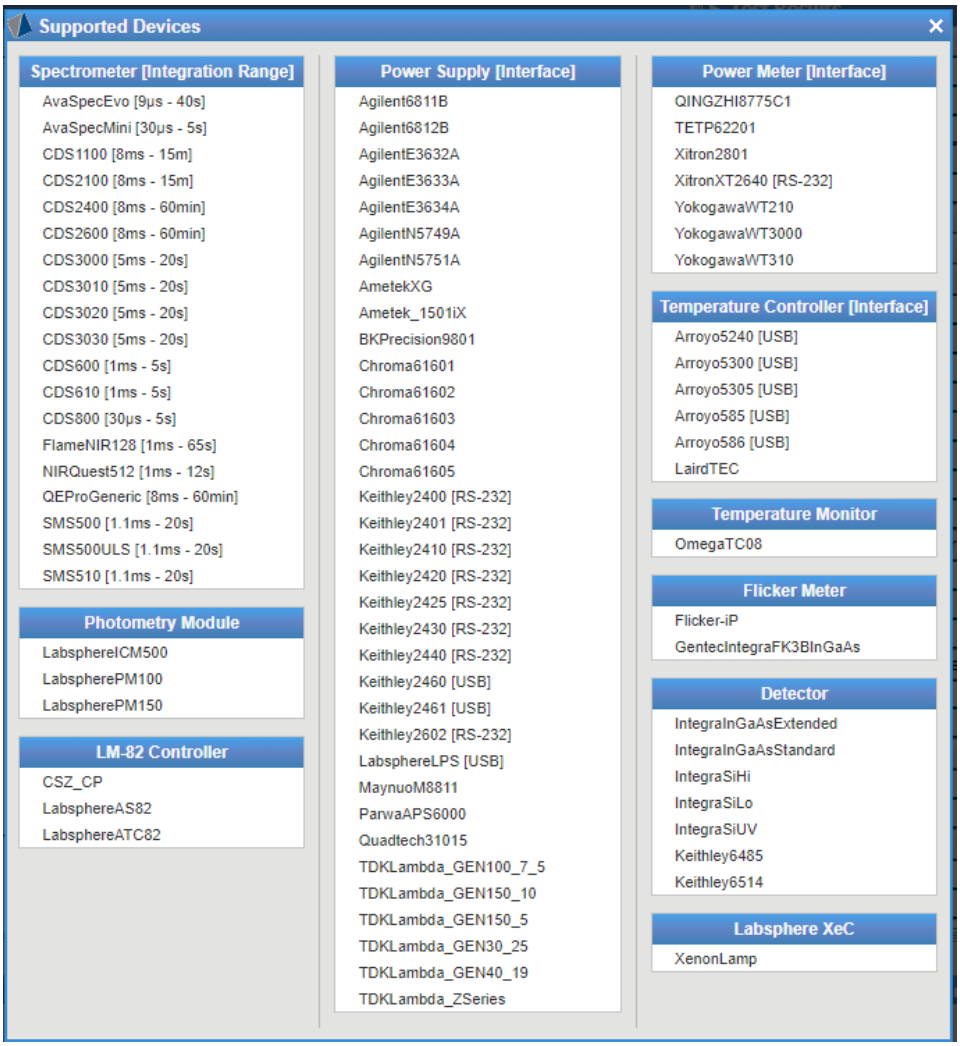
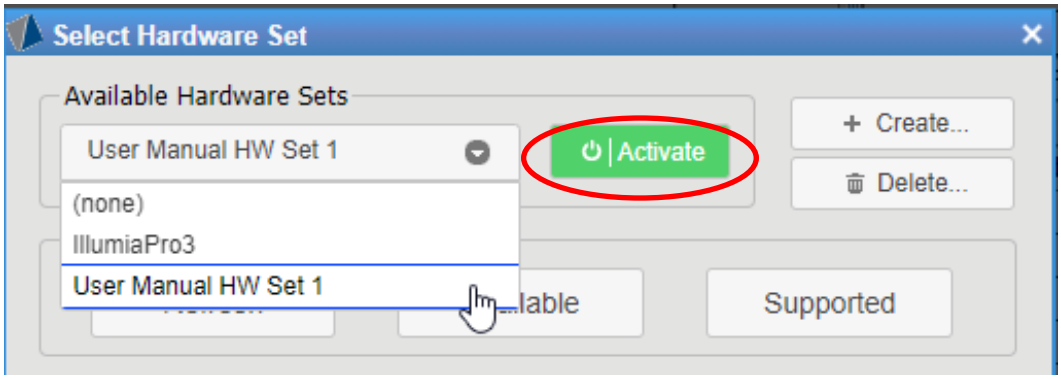


Figure 23: Supported Hardware List (subject to change)

8.1. Choosing an Existing Hardware Set

If an existing hardware set is acceptable for the desired tasks, choose that hardware set from the drop-down menu and click **Activate**.



8.2. Creating a New Hardware Set

To create a new hardware set click Choose from the Hardware set window as described above, and then click the **Create** button. The "Create a Hardware Set" screen appears:

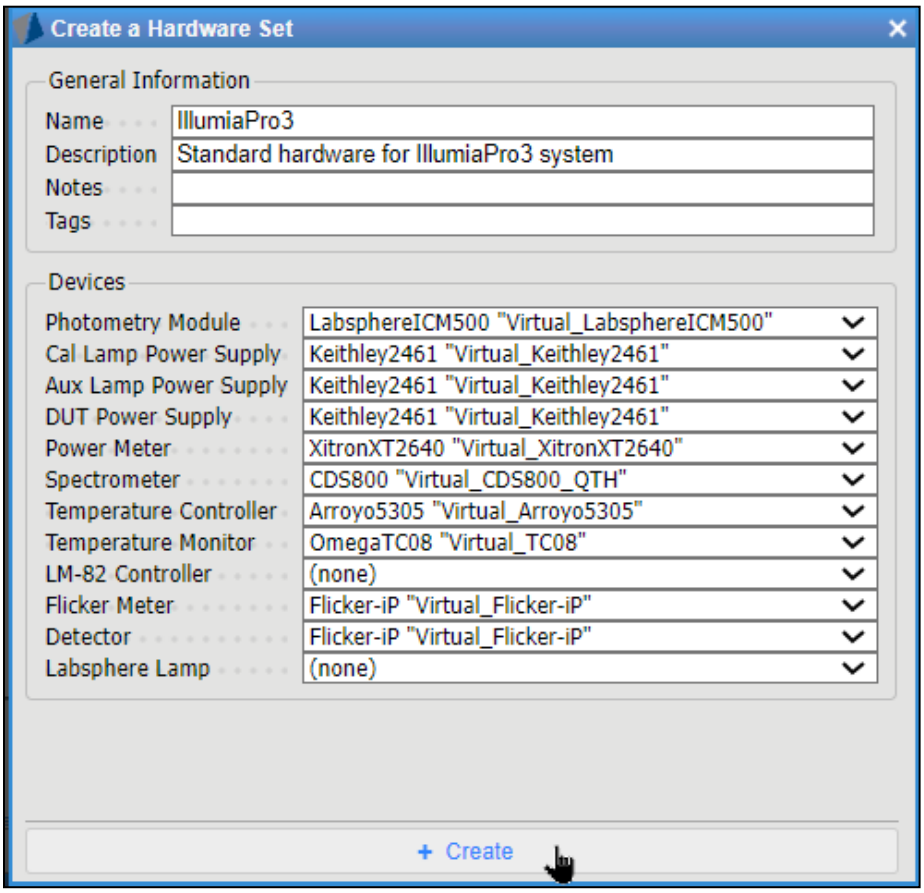


Figure 24: Create a Hardware Set Screen

Make sure to give the new hardware set a unique and descriptive name. The name is required; a description, notes and tags may be added as desired.

In the *Devices* section, select the various devices to be included in the hardware set. Entries are not required for every field. For example, a hardware set may include the devices to run calibration lamps and auxiliary lamps, but a hardware set is not required to include them.

In the special case of the PM-150 several of these device fields will be automatically populated by the Photometry Module.

For more detailed information on the Photometry Module,
refer to the PM-150/100 manual, Labsphere number SX-02990-000.

9. DEFINE THE GEOMETRY

Prior to calibration and measurements, the configuration of the sphere and associated hardware needs to be defined. This will dictate the calibration routine. In the *Settings and Calibration* window, click **Choose** in the *Measurement Geometry* box. This will open the following window with a range of geometry options as described below:

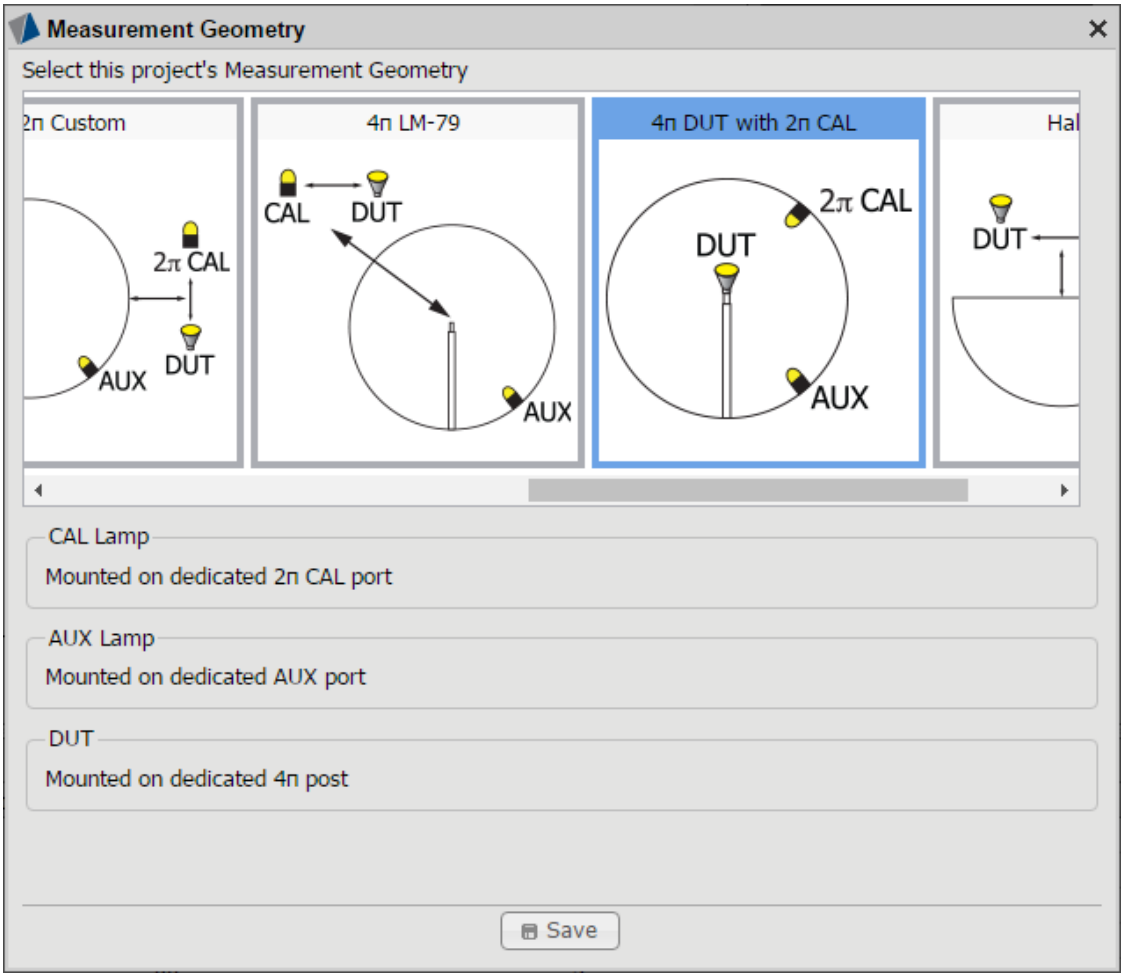


Figure 25: Select Measurement Geometry Screen

Be sure to choose the Measurement Geometry corresponding to the desired test. This will dictate the sequence of events in measurements.

10. CALIBRATIONS

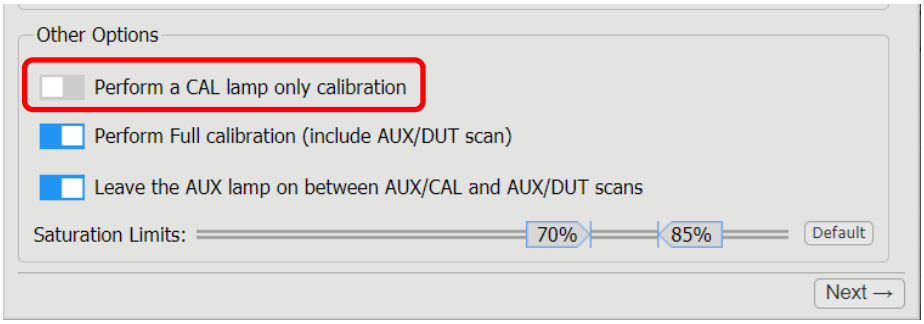
A calibration is required to convert data from the spectrometer into absolute spectral flux values. Spectral flux is often given in units of Watts per nanometer (W/nm), or lumens per nanometer (lm/nm) and describes the optical power contained in a wavelength band.

A calibration may be applied to the data collected from the spectrometer and is applied after other low-level corrections are implemented, such as electrical dark offset, linearity corrections, and in some cases, stray light corrections.

A baseline offset correction should always be performed before starting the calibration process. Refer to section 10.1 “Baseline Offset Correction” on page 40.

A calibration is defined by a set of three scans, or scan set. If the spectrometer includes internal filters, such as the CDS-30X0 family, then a scan is automatically taken for each of the three filter positions that will be used. The internal filters of the CDS-30X0 spectrometers are used to expand the dynamic range of the spectrometer by limiting the amount of light into the spectrometer to allow higher power devices to be measured. The three scans that make a full calibration are:

1) **Calibration Lamp Measurement (CAL Scan)** – This measurement uses a NIST-traceable Calibrated Spectral Flux Standard from Labsphere installed in the Light Measurement system. When the system is set up for calibration, the calibration lamp and the auxiliary lamp are in the integrating sphere. In most cases, all unnecessary fixturing, test lamps, or other apparatus have been removed. By operating the calibration lamp under the prescribed parameters, the performance of the system may be measured and calibrated. For this scan, the calibration lamp is powered on, and the auxiliary lamp is off. The "Perform a CAL lamp only calibration" toggle in "Other Options" can be used to take Radiance/Irradiance measurements.



2) **Auxiliary Lamp with Calibration Configuration (AUX/CAL)** – For this measurement the auxiliary lamp and calibration lamp remain in place as described above with the auxiliary lamp powered on, and the calibration lamp off. Once this measurement is completed, you will have a *base* calibration. The update absorption (AUX/DUT) scan can be performed later to complete a *full* calibration.

3) **Auxiliary Lamp Measurement with DUT (AUX/DUT)** – For this measurement, the DUT is installed in the configuration in which it is to be measured. With the DUT in place, the auxiliary lamp is powered on, and a scan is acquired. (The calibration lamp remains off for this scan.) By comparing the two auxiliary lamp scans, the “self-absorption” of any additional “stuff” in the sphere can be corrected.

Integral uses a “combined” calibration, meaning each scan set includes an Auxiliary scan (even if the Auxiliary scan was effectively skipped).

The calibration procedure for each step listed above requires the steps described in the flow chart below to properly stabilize the lamps for accurate measurements:

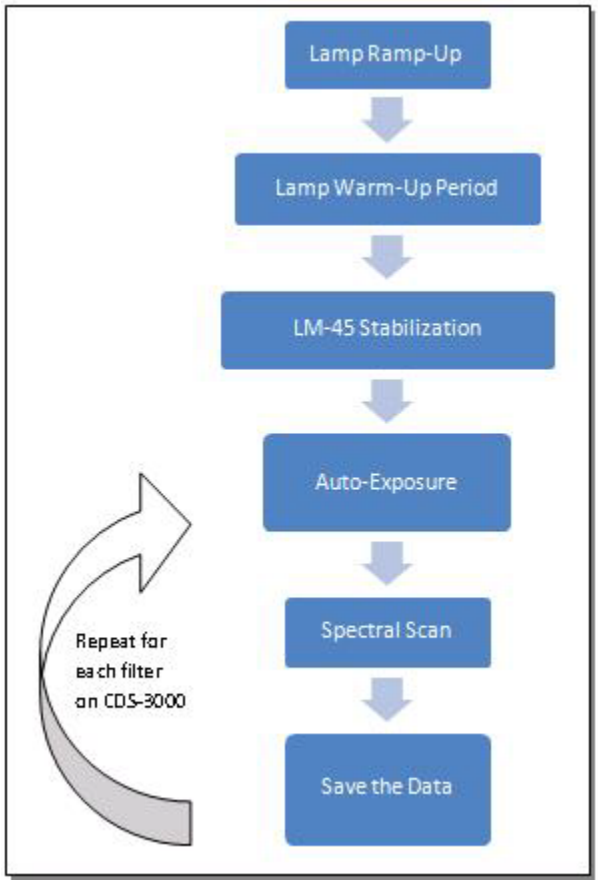


Figure 26: CAL and AUX Lamp Flow Chart

In Integral, a calibration may be *selected* to be used again, a new one may be *created*, or an existing calibration may be *updated* to include a new AUX with DUT scan. To choose, create, or update a calibration, start at the *System Calibration* section and click the **Choose** button:

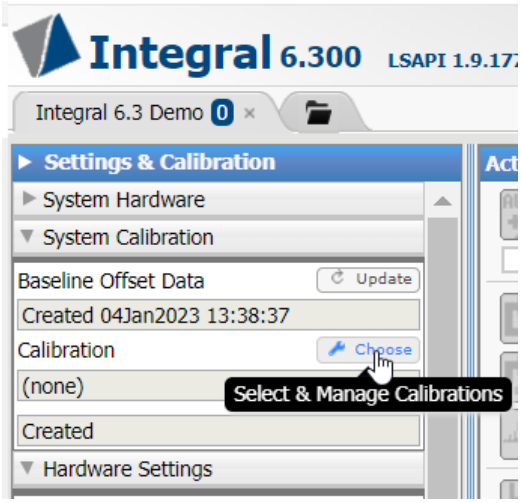


Figure 27: Manage Calibration

The *Manage Calibrations* screen opens. On this screen, the user may choose **Activate**, **Create**, **Update, Delete, or Export**. Note: Details of existing calibration will appear in the window when chosen from the drop-down list.

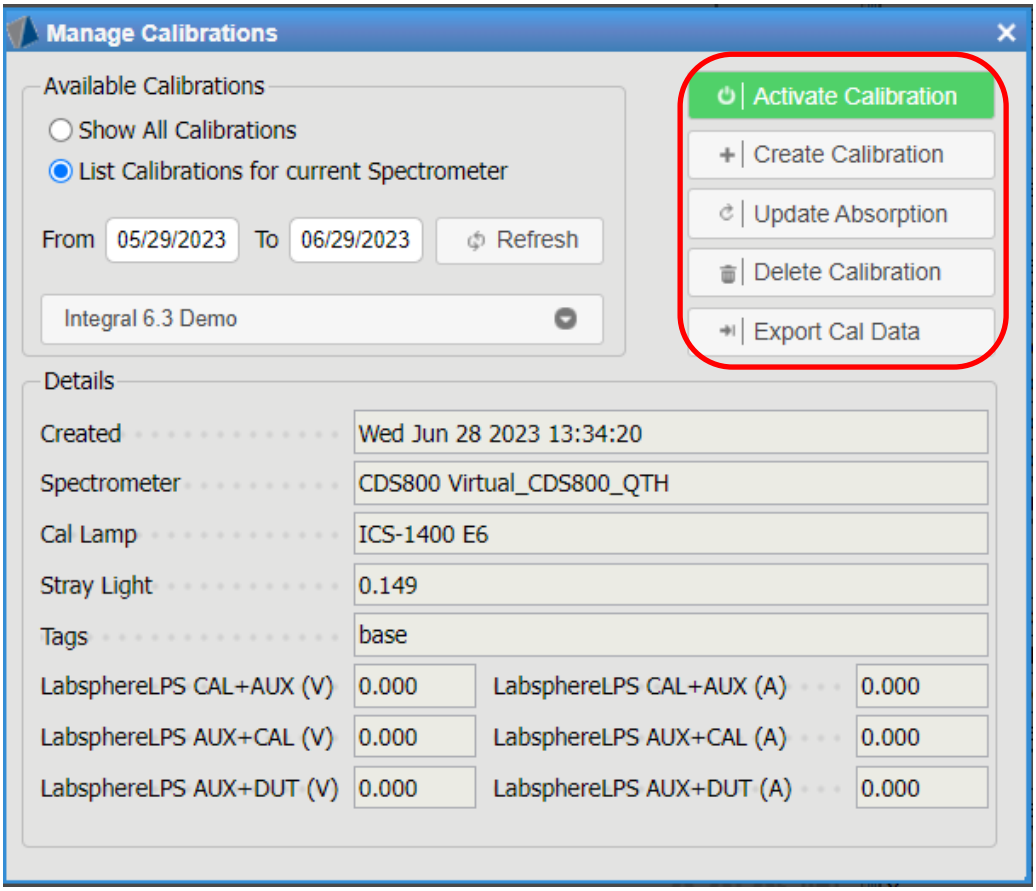


Figure 28: Manage Calibrations Screen

10.1 Baseline Offset Correction

A BOC is a technique that starts by creating an array of measurements that are performed when the equipment is in a “dark state”. For example, BOC data may be acquired when the integrating sphere is closed, and no light source is present in the sphere.

BOC data is an array of measurements performed at various representative integration times. These times are chosen by Labsphere and are picked to cover the entire range of integration times for which a specific spectrometer is capable.

When the system executes the dark offset correction using a shutter-less spectrometer the BOC data array is analyzed, interpolated as needed (to match the actual integration time), and a “virtual” dark signal is determined from those data.

Because dark current is also dependent on sensor temperature an additional correction is required. This correction utilizes a set of sensor pixels that have been permanently (internally) masked. These “dark pixels” are not typically returned in normal measurements but may be evaluated to understand the “scale” of the dark current while the spectrometer is operating. Using data from these dark pixels the BOC function can scale virtual dark offset data as needed.

Given that shutter-less spectrometers must employ this BOC calculation and use pre-determined data, the resulting dark offset correction is inherently less accurate as compared to corrections made with internally shuttered spectrometer.

10.1.1 Maximize BOC Accuracy

One way to maximize the accuracy of a BOC is to take readings for the baseline offset data array just before important measurements and to make sure that these readings are performed when the system is in a normal operating state and is fully temperature stabilized.

One way to ensure stability is to turn on the system and wait for 30-60 minutes. This will allow the electrical components in the spectrometer to thermally stabilize.

Integral can collect new baseline offset data on-demand by clicking the update button as in the image below. On-screen instructions will direct the user to ensure no light is present in the system for the entire time the data are being recorded.

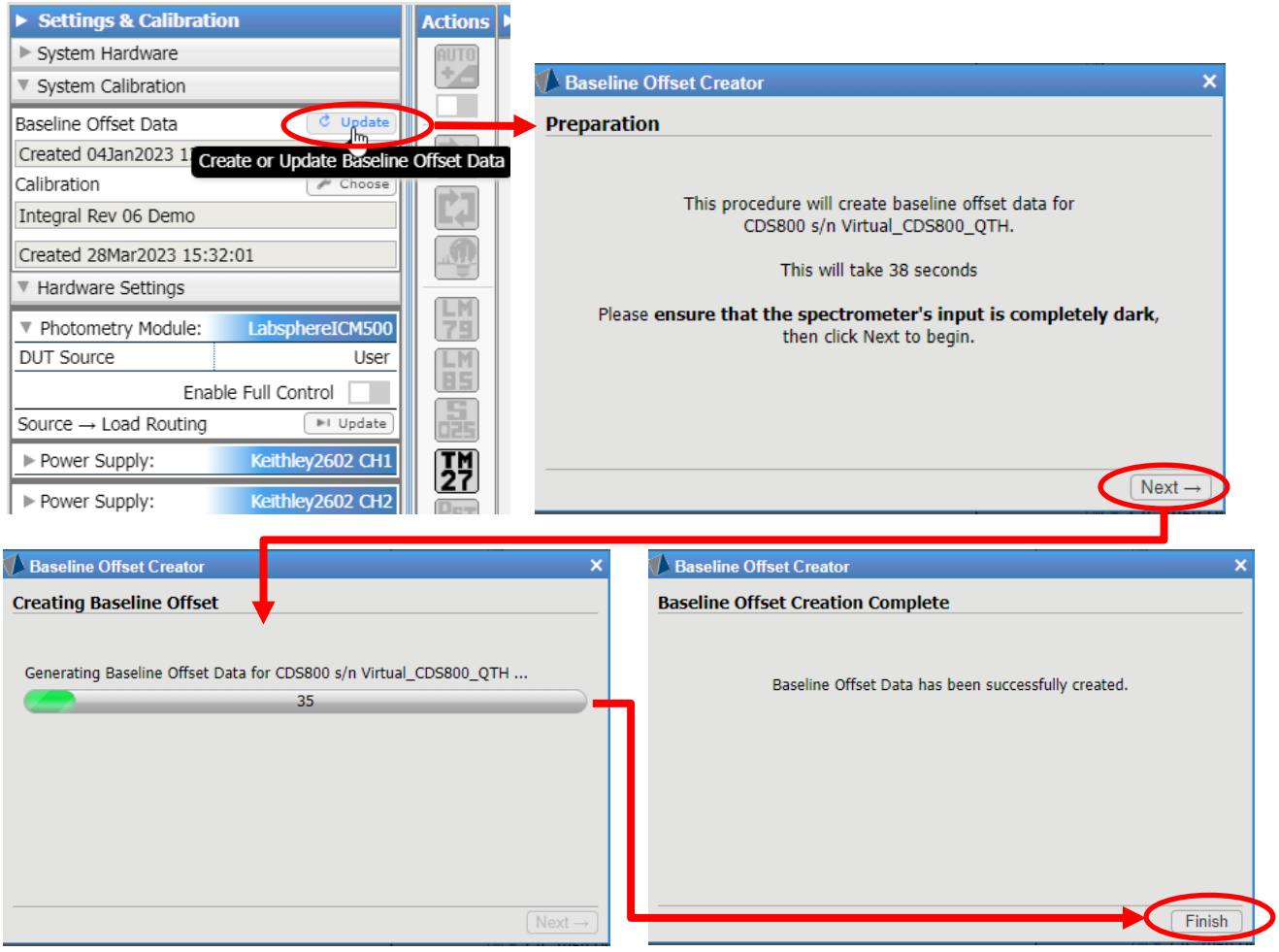


Figure 29: Baseline Offset Correction Data Update

10.2. Activate an Existing Calibration

To activate an existing calibration simply choose the desired calibration from the drop-down list and press **Activate Calibration**.

10.2.1. Date Range

By default, the previous 30 days of calibrations will be available for selection in the drop-down list. If you want to select an older calibration or look at a window of time you can adjust the dates by selecting the **From** or **To** text boxes. Then click the **Refresh** button to repopulate the drop-down list.

10.3. Create a Calibration: Setup

Integral provides a semi-automated calibration wizard to easily and precisely guide the user through the calibration process. To start a new calibration, press **Create New Calibration** from the *Manage Calibration* window. Observe the fields in the *Create a Calibration* window.

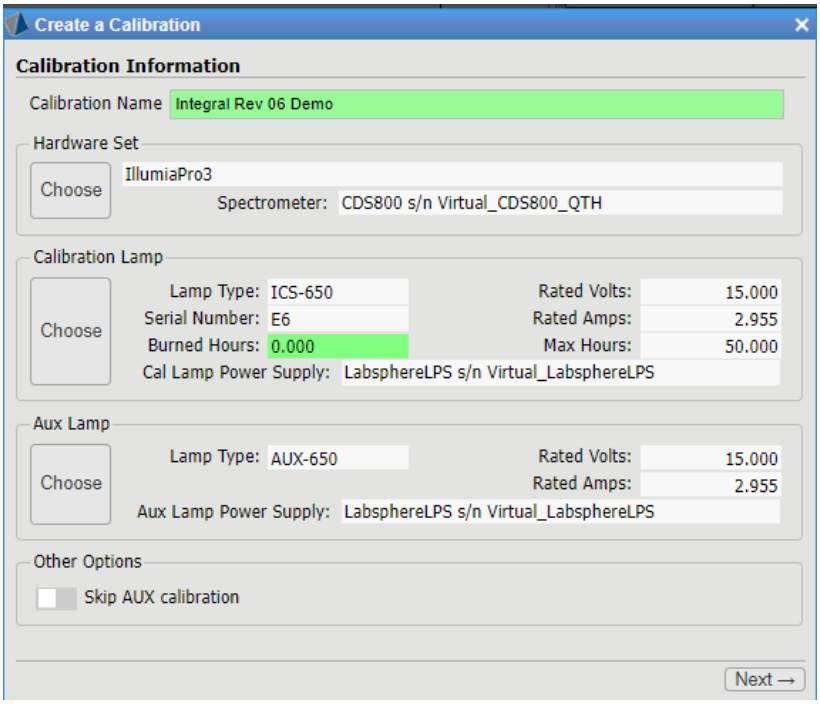


Figure 30: Create a Calibration Screen

Calibration Name

Every calibration must have a unique name. Labsphere recommends including a reference to the DUT for which the calibration is created.

Hardware Set

This indicates the hardware set that will be used to create the calibration. This may be different from the hardware set that is used to run the DUT under standard testing. Calibration hardware may include the PM-150 or ICM-500 photometry modules, if available, or manually-operated power supplies such as a Labsphere LPS or the Keithley 2461. The calibration hardware set is created just as any other hardware set.

Calibration Lamp

It is critical that the calibration lamp used in the calibration is the one selected from the list. All Labsphere calibration lamps have a serial number written on the base of the lamp, or on the socket in the case of internal 2π calibration lamps. Integral must have specific measurement data for the calibration lamp being used. These data are stored in the Integral database. Previously loaded Calibration Lamps are available from the drop-down list in the *Select Calibration Lamp* window.

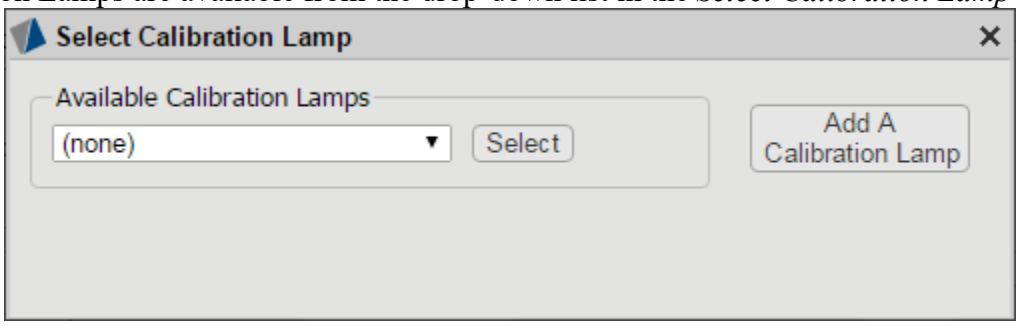


Figure 31: Select a Calibration Lamp Window

10.3.1. Add a Calibration Lamp (file)

Calibration lamps from Labsphere come in a protective case with a Labsphere USB flash drive that includes the NIST-traceable data for the specific calibration lamps provided. These data must be loaded into Integral before performing a calibration. This can be done by either copying the calibration lamp file to the desired location on the host computer, or by leaving the flash drive in the computer and navigating to it when prompted.

To load a new Calibration Lamp file, select **Add a Calibration Lamp** and click the **Select File** button in the *Add a Calibration Lamp* window.

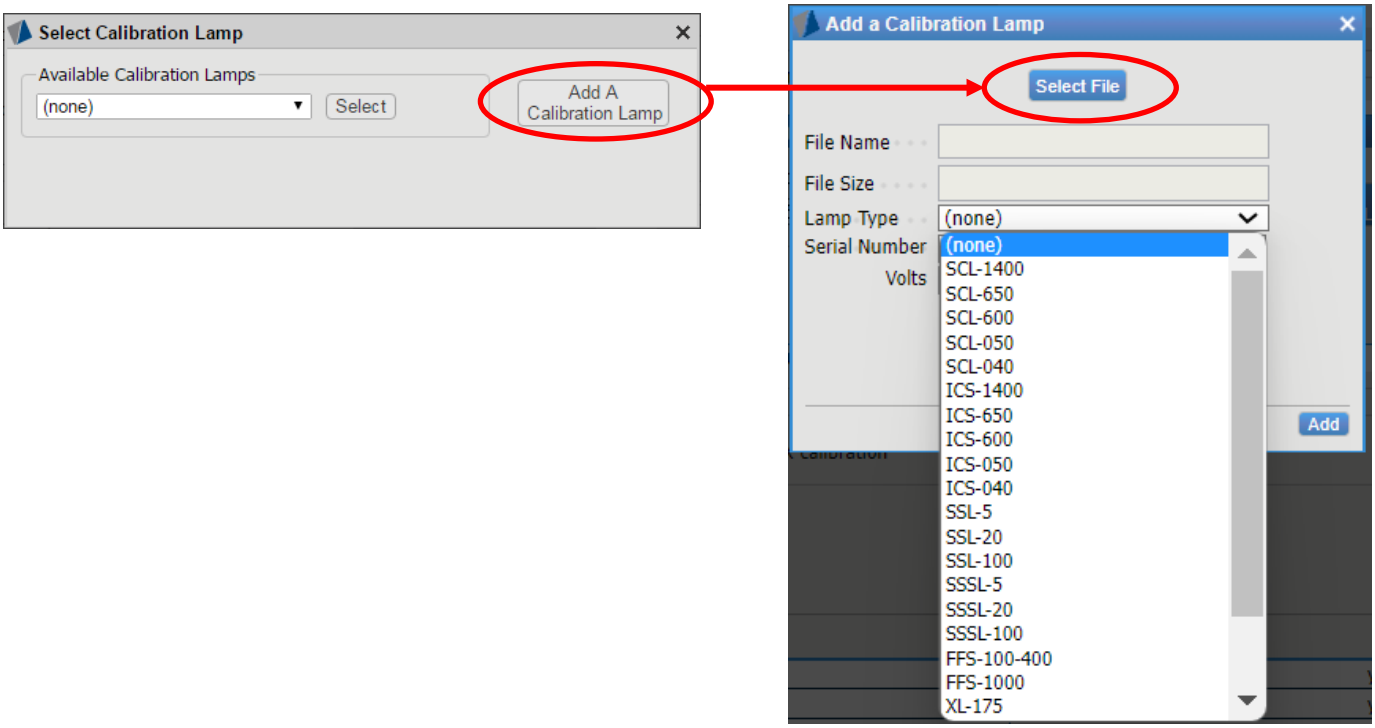


Figure 32: Adding a Calibration Lamp

Integral will launch a File Browser window. It is important to understand that this File Browser Window is provided by whatever device is currently being used and it can only find files on or connected to that device.

Use the File Browser to locate and load the calibration lamp file, either directly from the Labsphere USB flash drive that came with the calibration lamp, or as copied from the flash drive to the user's location on the host computer. The correct file has the form: "LampType SN CalFile.txt." Example: `ICS-650 E6 CalFile.txt."`

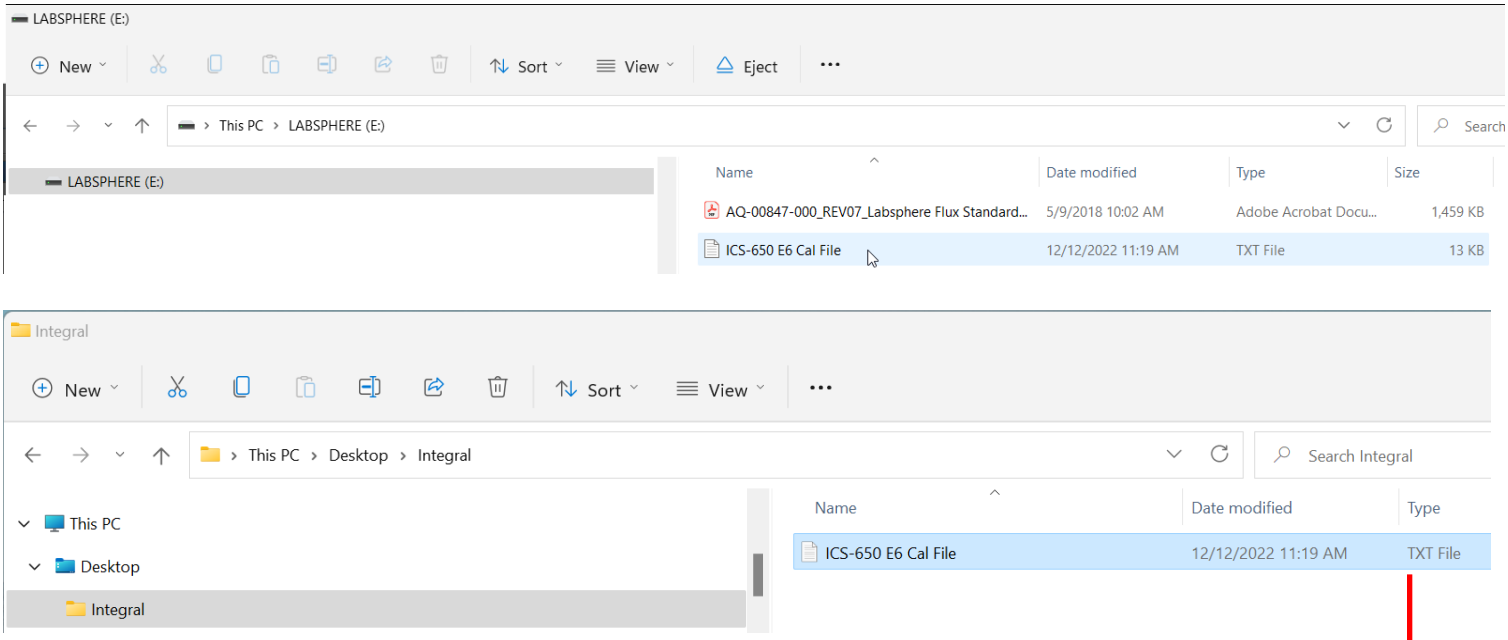
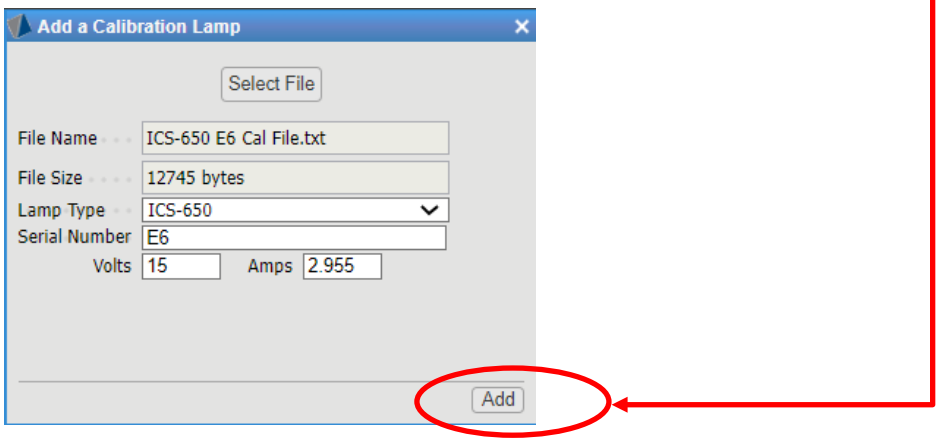


Figure 33: File Browser to Calibration File Locations

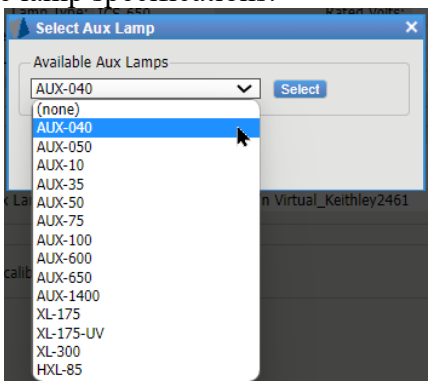
When the correct file is selected, the File Browser window will close and the fields shown in Figure 31: Adding a Calibration Lamp" window will be populated. NOTE: Please review and verify the data in these fields. These data must be correct for Integral to properly utilize the given calibration lamp.

When all settings and fields are verified and correct, click **Add** to install this Calibration Lamp into the Integral database.



10.3.2. Select the Auxiliary Lamp

The correct auxiliary lamp must be selected from the drop-down list so that the current being supplied to the lamp matches the lamp specifications.

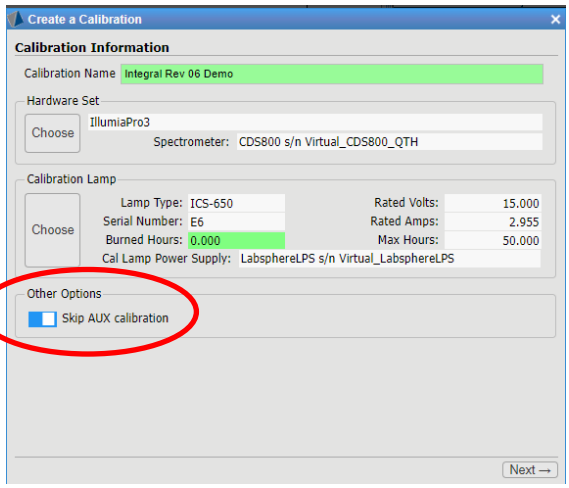


Standard currents for Labsphere auxiliary lamps are shown below and are pre-coded into the Integral software:

LABSPHERE AUXILIARY LAMPS

Lamp	Current	Lamp Power
AUX-040	1.040 A	4 W
AUX-050	1.050 A	5 W
AUX-10	1.670 A	10 W
AUX-35	3.070 A	40 W
AUX-50	4.17 A	50 W
AUX-75	6.250 A	75 W
AUX-100	8.330 A	100 W
AUX-600	2.600 A	33 W
AUX-650	2.955 A	38 W
AUX-1400	2.679 A	75 W
XL-175	16 A	16 W
XL-175-UV	16 A	16 W
XL-300	21 A	21 W
HXL-85	8.5 A	8.5 W

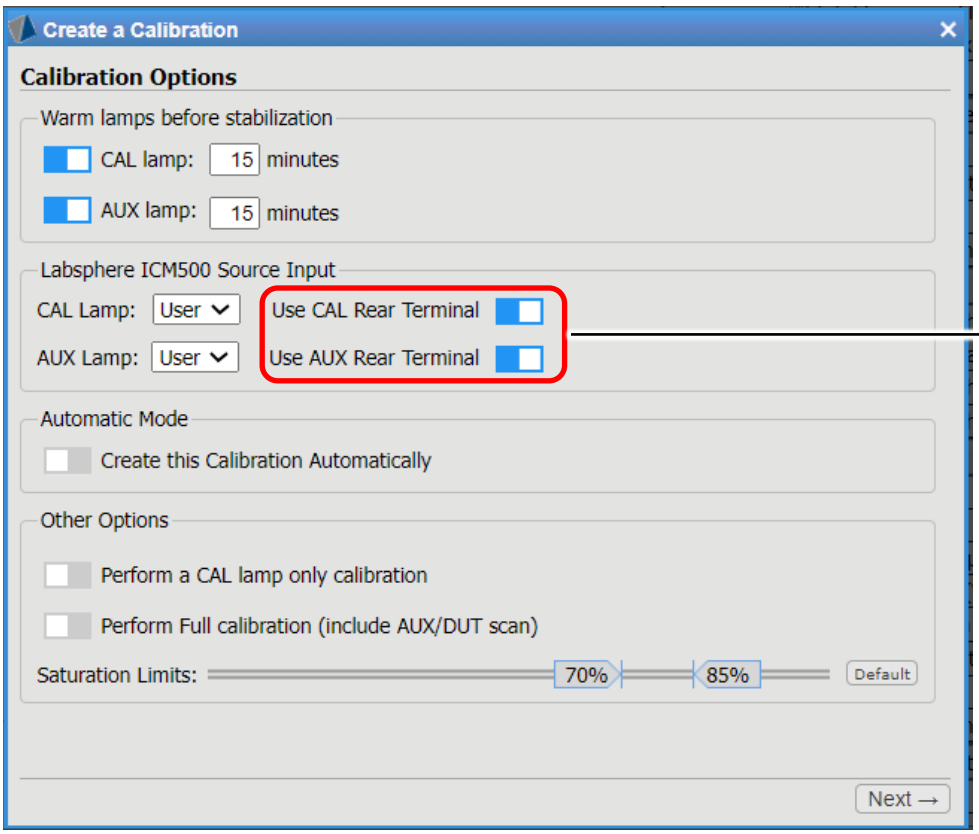
If the DUT is already mounted on the sphere, the auxiliary lamp calibration function can be omitted during the calibration lamp calibration process. To do so, click the “Skip AUX calibration” toggle switch at the bottom of the window.



10.4. Create a Calibration: Start

Update the baseline offset correction. Refer to section 10.1 “Baseline Offset Correction” on page 40.

Once all the basic settings that define a calibration are set, click the **Next** button shown in Figure 29: Create a Calibration Screen. The following window, *Calibration Options*, opens to allow setting of a few additional parameters that will be used during the calibration procedure.



When using a power supply with front terminals like the Keithley 2461, rear/front terminal switches will appear here to direct the source input from the rear to the front terminal. Integral defaults to the rear terminal, however it may be more convenient to use the front terminals in bench-top system configurations.

Figure 34: Calibration Run Settings

Calibration setting parameters include:

- Warm-up Time(s)
  - Prior to a calibration scan being performed (any one of the three described scans) the lamp must undergo the warm-up period, and it must satisfy the LM-45 stability requirement.

Labsphere recommends a 12 to 15-minute warm-up period for the calibration and auxiliary lamps to ensure complete stabilization.

- ICM-500 Source Input
  - Select the source for the CAL and AUX lamps. When using a Labsphere LPS, the input should be changed from "User" (default) to "DC"
- Automatic Mode
  - Only available in specific sphere setups

- Perform a CAL lamp only calibration
  - Turn this on to enable radiance/irradiance scans.
  - While the UI will state the measurement is spectral flux, it can be understood that the units have fundamentally changed with this type of calibration.
- Perform Full Calibration
  - When unchecked, the system will "skip" the last of the scans in the scan set and will NOT perform the AUX with DUT scan
  - The resulting calibration is "completed" automatically by Integral using the AUX with CAL scan for both AUX scans
  - Using such an abbreviated calibration will result in no Auxiliary absorption correction being applied to DUT scans
- Leave AUX Lamp On
  - The AUX Lamp will remain lit after the AUX with CAL scan(s) are complete
  - No warm-up time will be needed between AUX with CAL and AUX with DUT scans

Please remember that the AUX Lamp will remain lit indefinitely after the AUX with CAL scan is complete. Please do not leave the system unattended when using this.

- Saturation Limits
  - These should typically be left at the default values
  - In some cases, a calibration cannot completer with the default limits – in these rare cases the saturation limits may be modified
  - An example of such a case is a CDS-30x0 spectrometer on a system with very bright calibration lamp – on filter "0" it may be near saturation even at very low integration times and the limit may be increased

10.4.1. Calibration Scan

Click **Next**. The *Prepare Calibration Lamp* screen opens with the message that the CAL lamp and AUX lamp that are to be connected to the sphere, and that the CAL lamp is to be connected to its power supply.

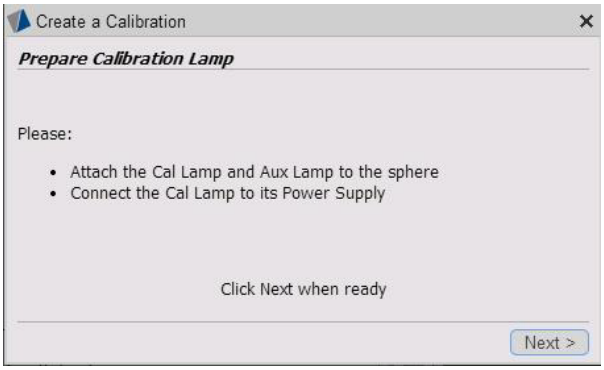


Figure 35: Prepare Calibration Lamp

This screen signifies the start of one of the three scans in the scan set as described previously. It will be similar for each scan, but **please read the message carefully**. The message is there to remind the user to check the system and/or configure it properly for the scan that is about to take place.

If using the PM-150 in a 2π calibration configuration, then both the CAL and AUX lamps are already installed, the wiring is correct, and the system can automatically power the standards at the correct times. In this configuration the calibration process is more automated, making it easier for the user.

If **not** using a PM-150, then these messages are **especially important** because it may be required to install the different lamp standards, move wiring, and ensure the correct power supplies are being used at the correct times. These screens and the messages therein should help guide the process.

Click **Next**. The *Calibration Lamp Scan* screen opens, showing that the CAL lamp power is ramping up.

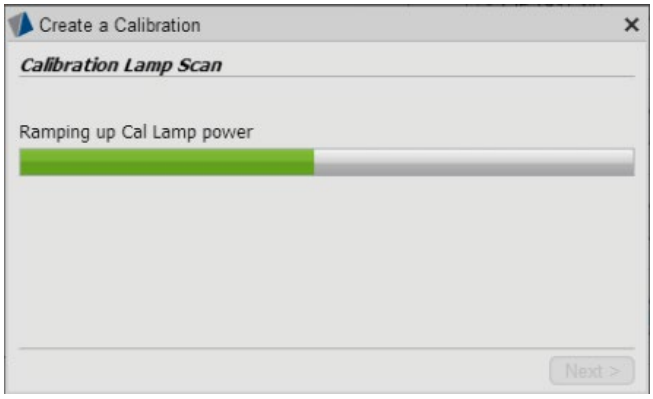


Figure 36: Ramping Up CAL Lamp

Click **Next**. The next screen opens, showing that the CAL lamp is warming up:

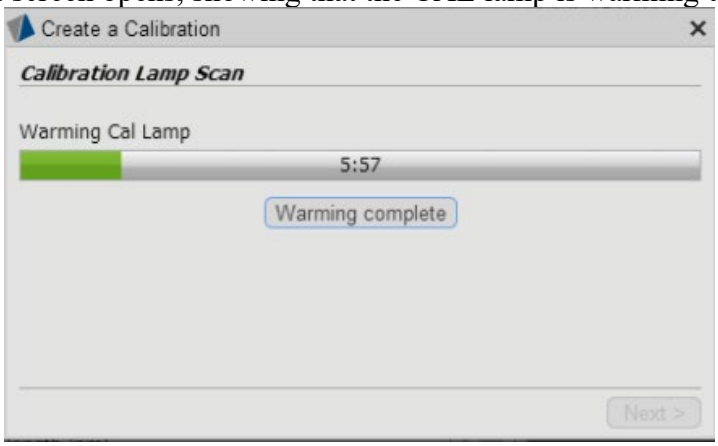


Figure 37: Warming CAL Lamp Screen

After the warm-up period, the next screen will appear and show the CAL lamp stabilization:

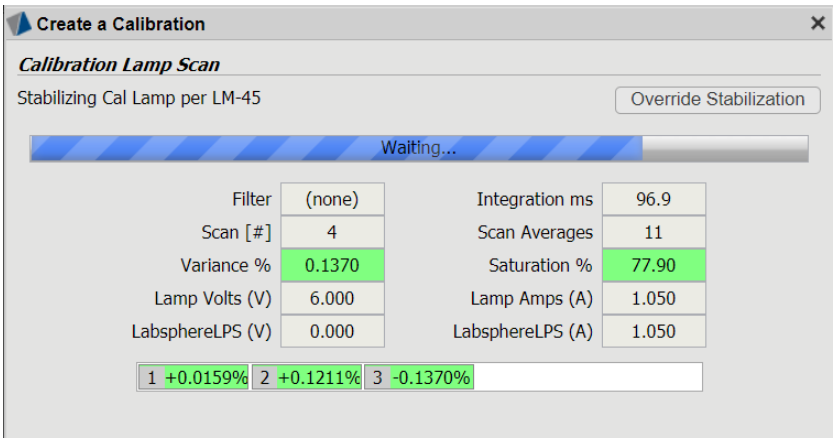


Figure 38: Stabilize CAL Lamp Screen

At this point, Integral performs an auto-exposure to determine the appropriate integration time for the spectrometer. Once this is calculated, the lamp undergoes the stabilization per LM-45. This procedure measures the lamp at 15 second intervals over a 1-minute period resulting in 5 measurements of the light output. The percent difference is calculated between the maximum and minimum values for following five consecutive measurements. The window shown in Figure 37 indicates the pertinent information during stabilization;

Filter position (if applicable) – filter 0, 1, or 2 for the CDS-30x0
Scan Count (1 to 5) – the number of scans taken during the LM-45 procedure
Variance – the % difference from Maximum reading to Minimum reading
Lamp Volts (V) – the calibration lamp's voltage rating
Labsphere LPS (V) – the lamp power supply voltage
Integration, ms – the spectrometer integration time
Scan Averages – the number of averages for the calibration (fixed at 3)
Saturation – maximum % aaturation of the spectrometer pixels.
Lamp Amps (A) - the calibration lamp's current rating
Labsphere LPS (A) - the lamp power supply current

If the difference in scan values is less than 0.25%, then the lamp is stable, and a scan will be performed as shown below:

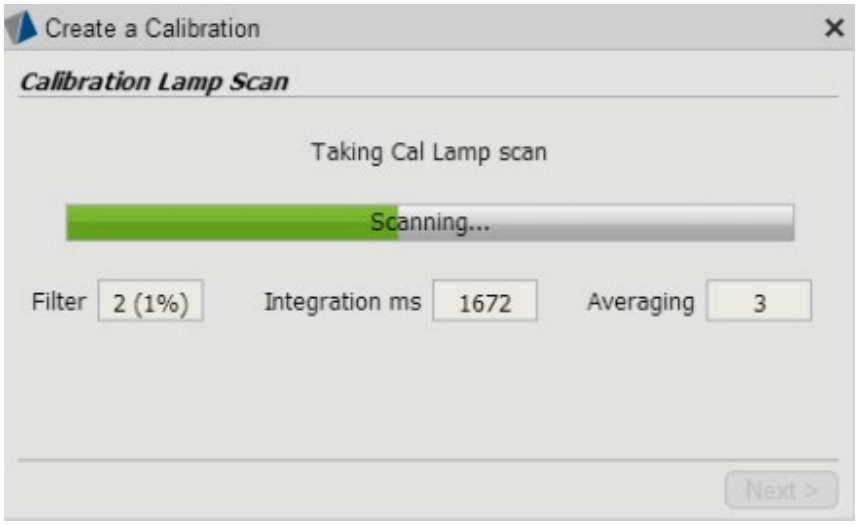


Figure 39: Taking Calibration after Stabilization

This process will repeat for each filter in the CDS-30X0 spectrometer. Upon completion of the calibration scan, a message will appear indicating that the calibration was successful:

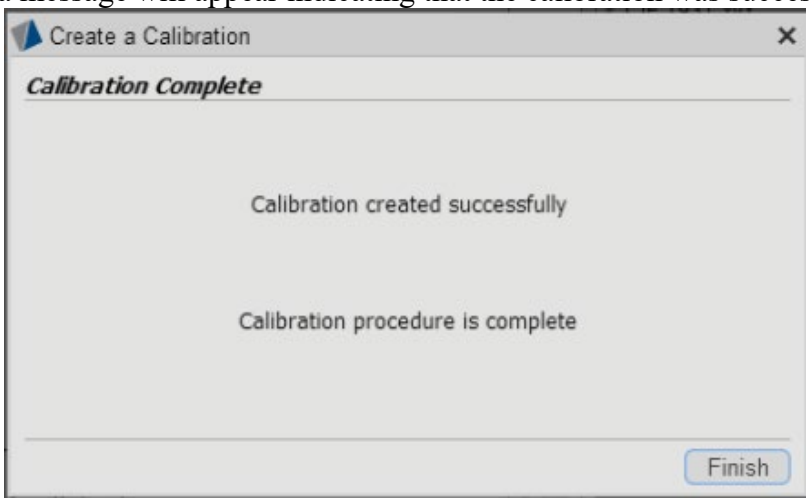


Figure 40: Calibration Created Successfully Screen

10.4.2. AUX/CAL Scan

Following the Calibration scan, the system will guide the user through a similar process for the Auxiliary Lamp Scan with the CAL lamp in place. If the PM-150 is being used, this step will be automatic. For any other set up, the user will need to follow the instructions provided by the wizard to ensure proper connections between the power supply and lamps.

10.4.3. AUX/DUT Scan

Following the AUX/CAL scan, the system will guide the user through a similar process for the Auxiliary Lamp Scan with DUT in place. The user must first install the DUT before starting this final scan in the calibration scan set. Even if the DUT is not available at the time of performing a calibration it is recommended that this final scan be completed as described (simply run a scan without the DUT).

10.5. Update a Calibration

The **Update** option for a calibration copies the calibration lamp scan, and the AUX/CAL scan from an existing calibration and replaces the third scan in the set with a new AUX/DUT measurement. This allows the user to use a scan from the calibration lamp and apply it to multiple DUTs without going through the first two steps in the calibration process.

Care must be taken when performing AUX/DUT scans after the initial Calibration and AUX/Cal scans are taken. If the auxiliary lamp does not go through the proper stabilization period, the difference in the auxiliary light output will skew the correction for the new DUT. For the most accurate measurements it is recommended that the aux lamp be warmed up for the full period and the stabilization routine performed on the AUX lamp.

It should also be noted that measuring DUTs of similar geometry with the same AUX/DUT scan, may result in skewed results. Depending on the size of the DUT, and the size of the sphere, the influence may vary. It is very important that if a single AUX/DUT file is being used for multiple measurements of similar DUTs, that all geometry is duplicated in the sphere as closely as possible between measurements. This includes the placement of the power/sense wires as well as any orientation of the devices.

At this point, the calibration wizard will guide the user through the final AUX/DUT calibration process as before.

The Update Absorption function will not run if the hardware set that was used with the chosen calibration has been deleted.

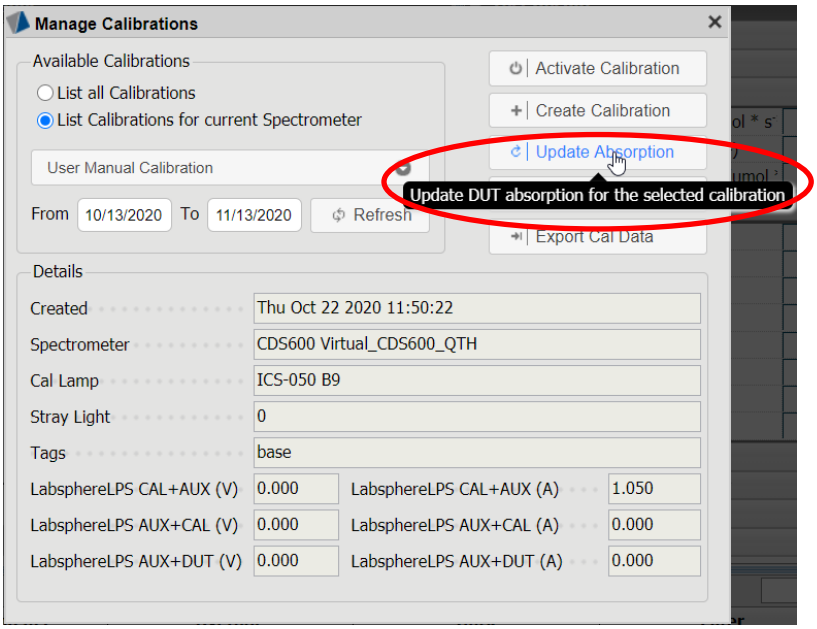


Figure 41: Update Absorption

10.6. Delete Calibration

By selecting a calibration, you can delete it via the **Delete Calibration** button. All scans previously saved with this calibration will still function the same, however the calibration will no longer be available in the user interface.

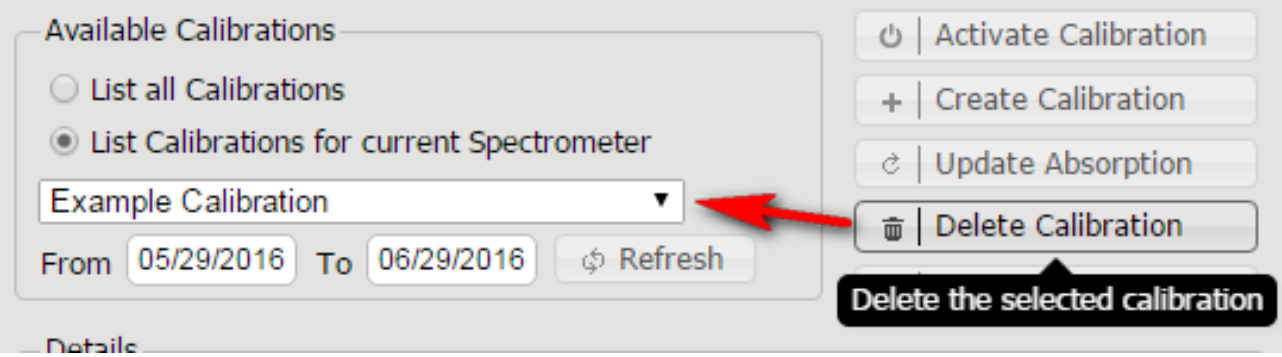


Figure 42: Delete Calibration

10.7. Export Calibration

Selecting a calibration will give you the option of exporting your calibration information.

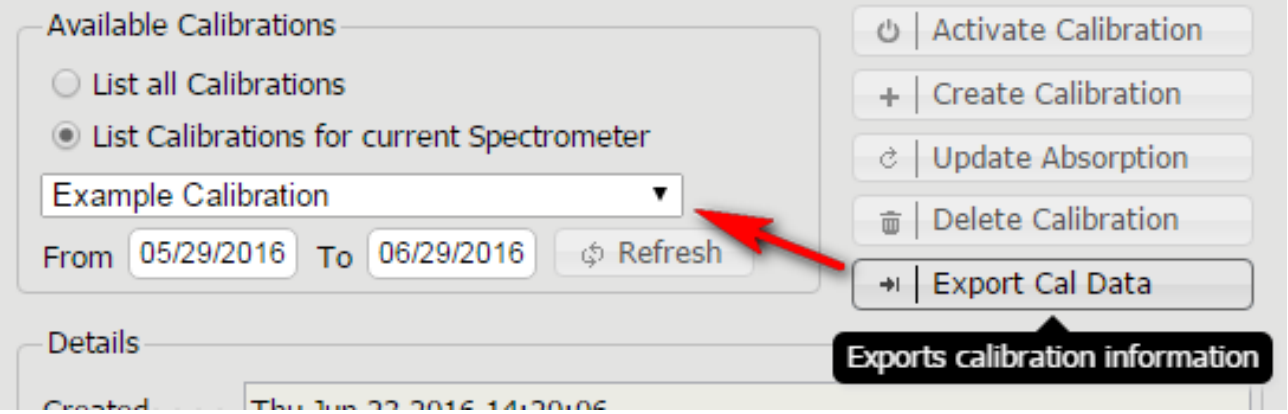


Figure 43: Export Calibration

The calibration export will generate a .csv that includes all calibration information. This data includes the calibration name, timestamp, lamp type, lamp serial number, spectrometer type, spectrometer serial number, spectrometer wavelength, calibration lamp counts, AUX with calibration counts, AUX with DUT counts, and the calibration lamp FLUX.

	A	B	C	D	E
1	Integral Calibration Data	API==1.6.177.0			
2	CalName=delete_this_2	Timestamp=1466706006	CalLampType=ICS-050	CalLampSN=B9	
3	SpectrometerType=CDS2100	SpectrometerSN=Virtual_CDS2100_QTH			
4	Scan	CalLamp	AuxWithCal	AuxWithDut	CalLampFlux
5	Filter	none	none	none	
6	IntTimeMs	97	97	97	
7	Saturation	0.7814	0.7779	0.7779	
8	Timestamp	1466705990	1466706002	1466706002	
9	Wavelength	counts	counts	counts	W/nm
10	302.015	-2.49E-03	-2.41E-03	-2.41E-03	0
11	302.805	-3.22E-03	-2.32E-03	-2.32E-03	0
12	303.595	-1.78E-03	-2.43E-03	-2.43E-03	0
13	304.385	-1.95E-03	-2.33E-03	-2.33E-03	0
14	305.175	-2.07E-03	-2.36E-03	-2.36E-03	0
15	305.965	-1.44E-03	-2.58E-03	-2.58E-03	0
16	306.755	-1.86E-03	-1.87E-03	-1.87E-03	0
17	307.545	-1.60E-03	-1.51E-03	-1.51E-03	0
18	308.335	-2.34E-03	-1.53E-03	-1.53E-03	0

Figure 44: Export Example

10.8. Dark Correction

All photo-sensitive sensors have some inherent “dark current” that creates a real, measurable, signal even when no light is hitting the sensor. Each pixel on a sensor array may have a different dark current. “Dark” readings change based on sensor integration time and is also related to the temperature of the sensor. Generally speaking, dark readings increase with the temperature of the sensor.

In order to get an accurate measurement during real measurements (of a DUT for example) the dark current must be understood and subtracted from the spectrometer’s signal before other analysis can be performed (lumens, color, etc.). Some spectrometers have an internal (mechanical)` shutter while others do not.

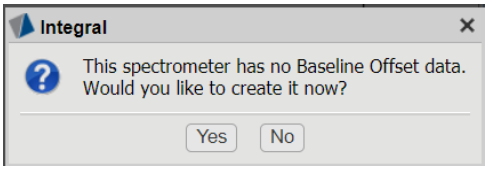
10.8.1. Spectrometers with a Shutter

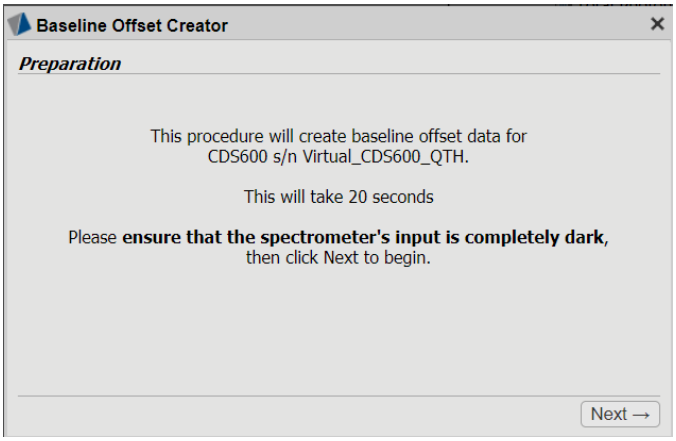
When a spectrometer has an internal shutter, this shutter may be programmatically closed, and a measurement performed with no light reaching the sensor. This measurement is used to understand and offset the dark current across the sensor. Typically, this measurement is performed periodically (not every measurement) and whenever the integration time of the spectrometer changes.

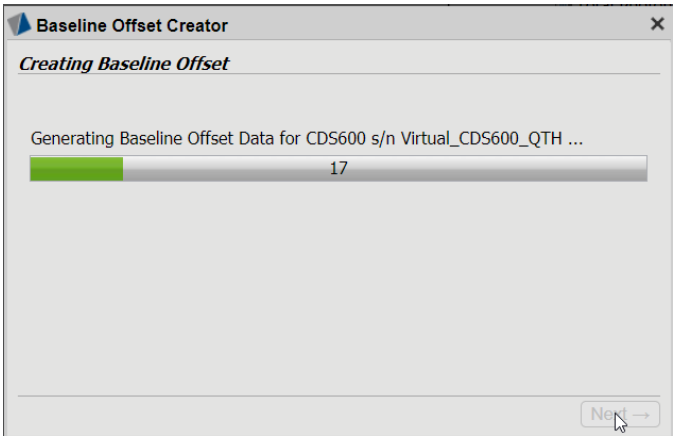
10.8.2. Spectrometers without a Shutter

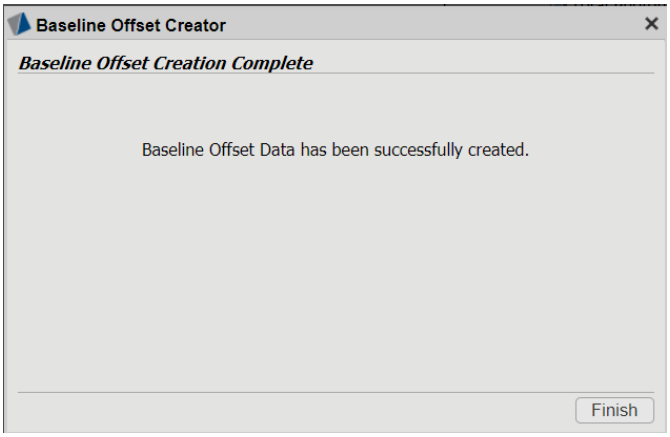
For the "shutter-less" spectrometers the dark offset correction becomes more involved. For these spectrometers, Labsphere employs a technique called "Baseline Offset Correction" (BOC). When choosing a shutter-less spectrometer, Integral will query the user to create baseline offset data automatically before adding the spectrometer to the hardware set with the following prompt screens:

The spectrometer needs to be fully blocked from light during this process.









11. HARDWARE SETTINGS (SPECTROMETER, POWER SUPPLY, ETC.)

Prior to taking any measurements, the spectrometer and other (optional) devices such as DUT power supply need to be configured. These settings are found in the **Hardware Settings** section of the user interface.

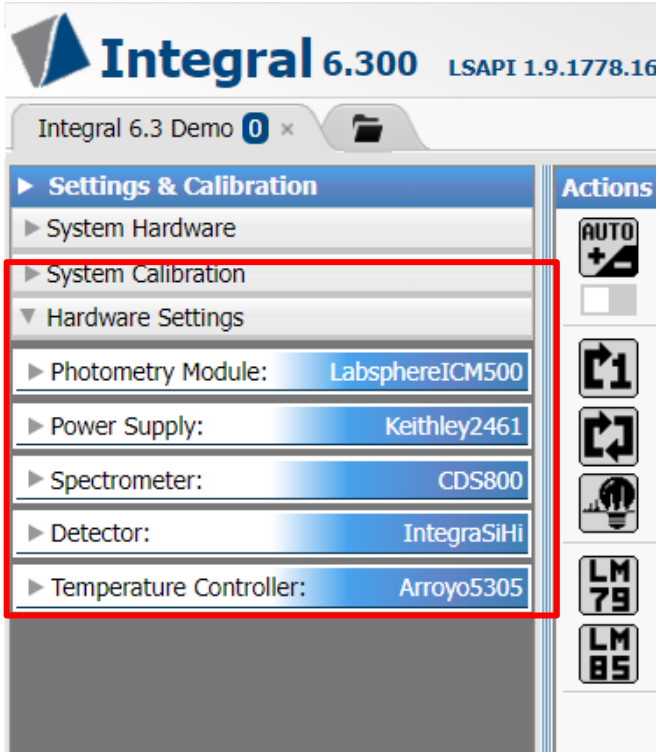
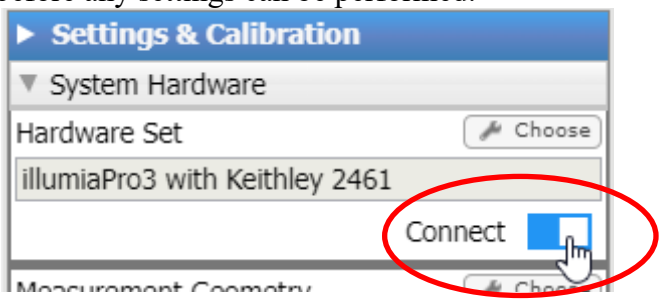


Figure 45: Hardware Settings Area (list will vary with available hardware)

A hardware set must be connected with the "Connect" toggle switch before any settings can be performed.



The specific user interface elements that appear in this area are determined by which hardware devices are connected. Please remember to scroll down to find all the settings available.

11.1 Photometry Module Controls — PM-150/100

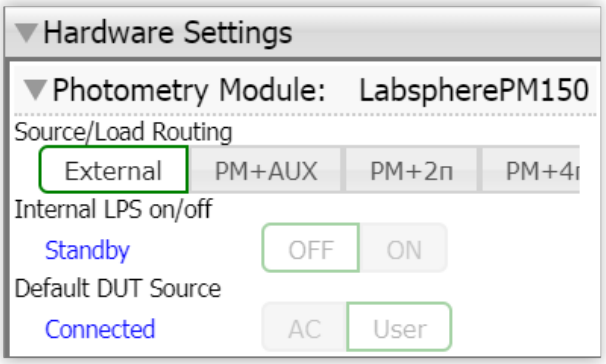


Figure 46: PM-150 Photometry Module Controls

The PM-150 Photometry Module controls are broken into three sections, [Source/Load Routing] which defaults to External routing (AC or User) once you connect to the PM-150. [Internal LPS on/off] which controls the on/off power for the PM-150 when using PM+AUX / PM+2π / PM+4π. [Default DUT Source] available only when using a DUT power supply, this dictates the External routing.

11.2 Photometry Module Controls — ICM-500

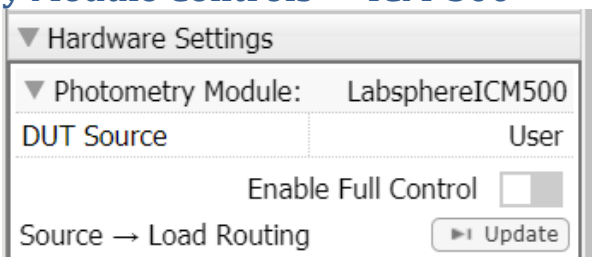
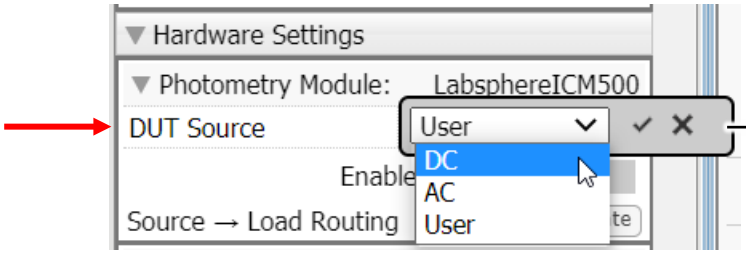
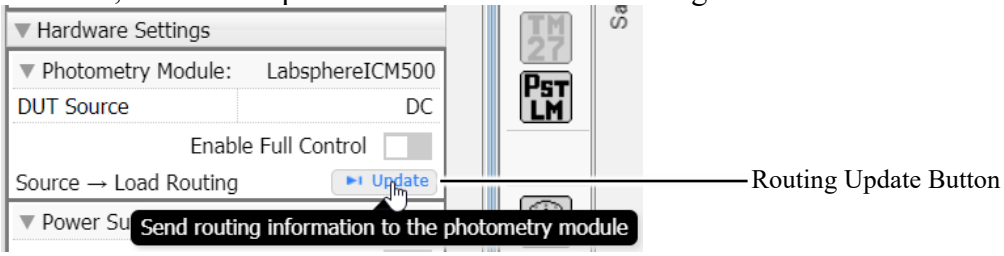


Figure 47: ICM-500 Control Panel — standard mode

NOTE: illumia®Plus2 users must select the ICM-500 as the photometry module. In the ICM-500's standard mode, the "DUT Source" determines the load type which can be set to "User, AC, or DC" in the dropdown list.



Once the DUT source is selected, click the "Update" button to send that routing information to the ICM-500.



11.2.1 ICM-500 Full Control Mode

Click the "Enable Full Control" toggle switch to open the lamp selection routing parameter called "Load". Note the red warning text. Refer to section 11.2.2 "ICM-500 Lamp Warning Text" on page 58.

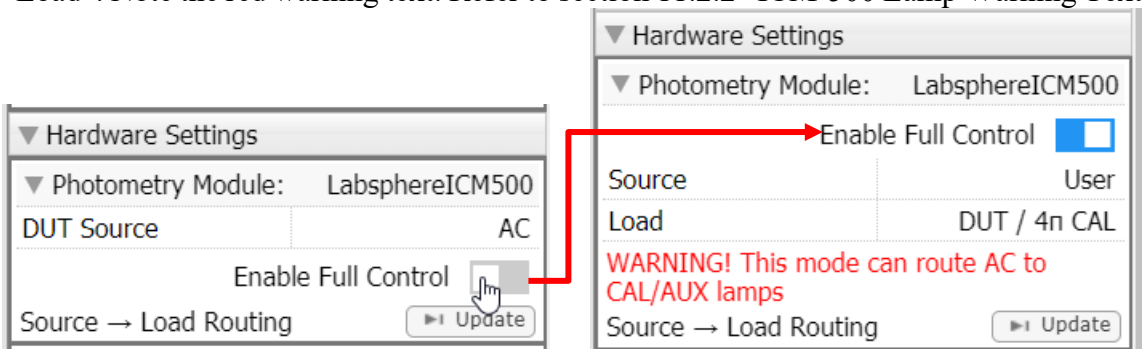
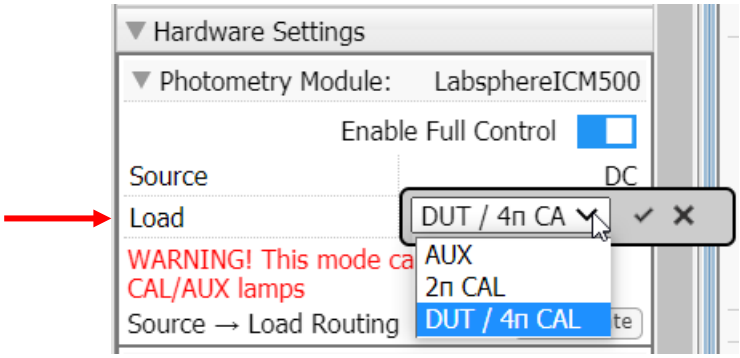
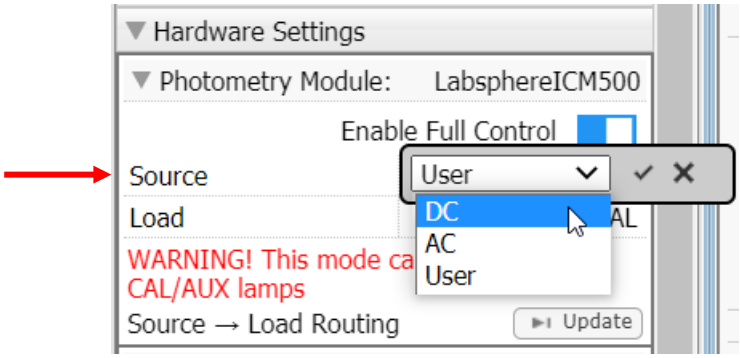


Figure 48:ICM-500 Control Panel — full control mode

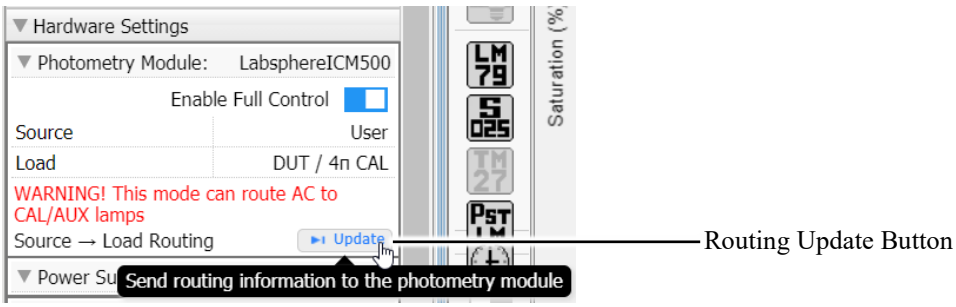
Click the "Load" parameter to open the lamp selection dropdown list. This list will be populated with the lamps selected in the current hardware set.



The "DUT Source" parameter changes to "Source" with the same "User, AC, or DC" dropdown list as used in standard mode.



Once the Source and lamp are selected, click the "Update" button to send that routing information to the ICM-500.



11.2.2 ICM-500 Lamp Warning Text

> WARNING! This mode can route AC to CAL/AUX lamps

When full control is enabled in the ICM-500, the LPS power supply will now be able get power if the ICM-500 is routing power to it. Therefore, any time that full control mode is enabled, the Photometry Module control panel automatically issues this warning to the user to remind them that they could possibly send AC power to the DC lamps in the system if settings in the lamp power supply are incorrect.

This warning is displayed because Integral does not control the lamp power supplies or other peripheral hardware directly. In illumia®Plus2 systems, Integral's hardware control is limited to the routing configurations of the ICM-500 that indirectly affect the hardware peripherals. It is up to the user to set up and configure the lamp power supplies and other peripheral hardware independently using the software or control panels of each device.

When this lamp power routing warning message is encountered, Integral may display the error code "E-680". This is not actually a software error and needs to be cleared externally. In the case of the Labsphere LPS power supplies, press the "Info" button on the front panel to clear the error.

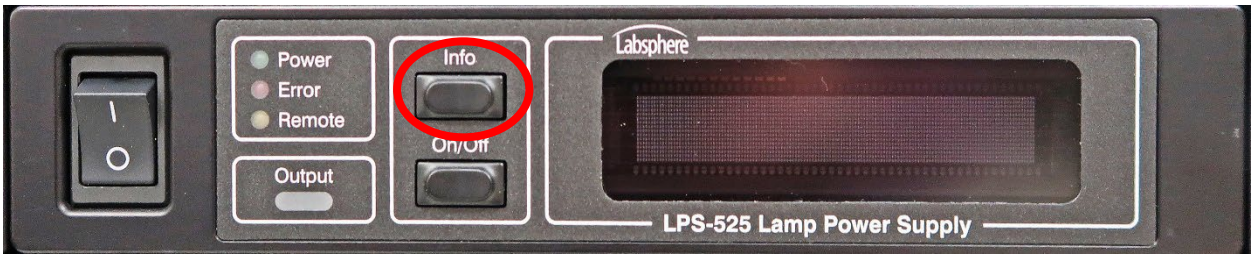
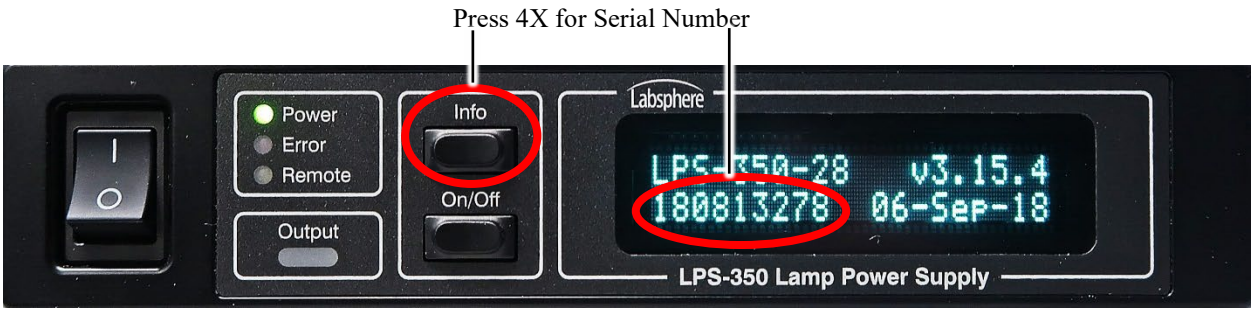


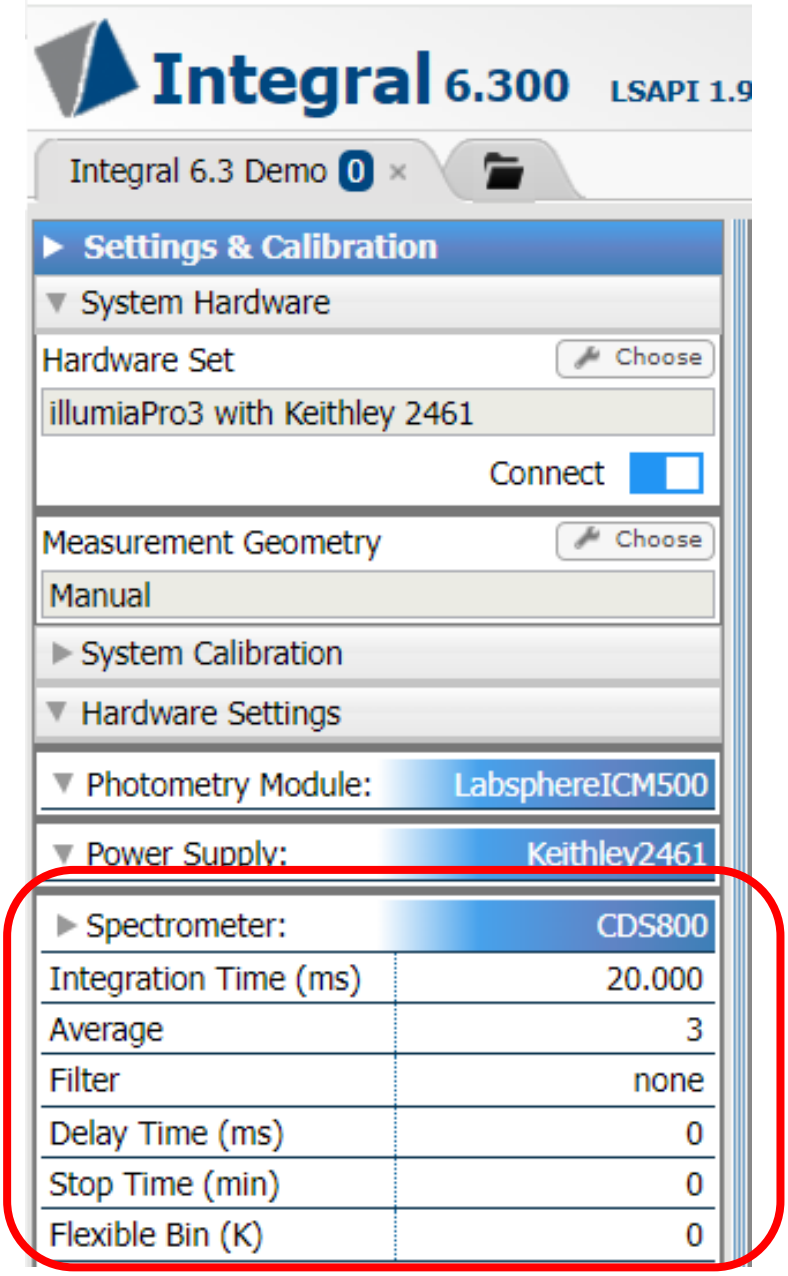
Figure 49: Info Button on LPS Power Supplies — press it to clear E-680 error codes

11.2.3. Labsphere LPS Power Supply Serial Number

It is important to identify the power supply when selecting from multiple LPS power supplies in software. Press the "Info" button four times to display the model number, serial number, and firmware date and revision of the instrument.



11.3 Spectrometer Controls



The checkbox *Take Dark Scans with DUT Scans* should generally be used. This setting will force the system to take a new "dark scan" whenever the integration time changes to ensure a recent and valid dark correction can be performed. For spectrometers that have internal shutters such as the CDS-30x0 this will force a scan with the shutter closed. For spectrometers without an internal shutter (such as the CDS-600), the system will use a calculation based on the Baseline Offset Correction data.

Integration Time – How long the spectrometer "integrates" the light hitting its sensor. This can be set manually, or the user may click the **Auto-exposure** button to have Integral calculate the best integration time.

Averages – The number of scans that are averaged for the final data set. This is useful for reducing noise in spectral results.

Filter – This is only available for spectrometers with integrated filters such as the CDS-30x0 family. This may be set manually or can be determined from the auto-exposure feature.

Delay Time – The time to wait between scans when operating in "continuous scan" mode. This delay time is what dictates the reporting interval for all the measurement instruments. The auto-save limit is 8000 scans. Longer delay times are suggested for long-term tests.

Stop Time – The amount of time the spectrometer will scan before it stops. There is a hard limit of 96 hours maximum for this function.

Flexible Bin – Based on the ANSI C78.377-2015 specification, you can define a set Flexible Bin (K) between 2200 and 6500 per 100 (K) increments. If you would rather have Integral auto define the flexible bin, set the value to 0 (default).

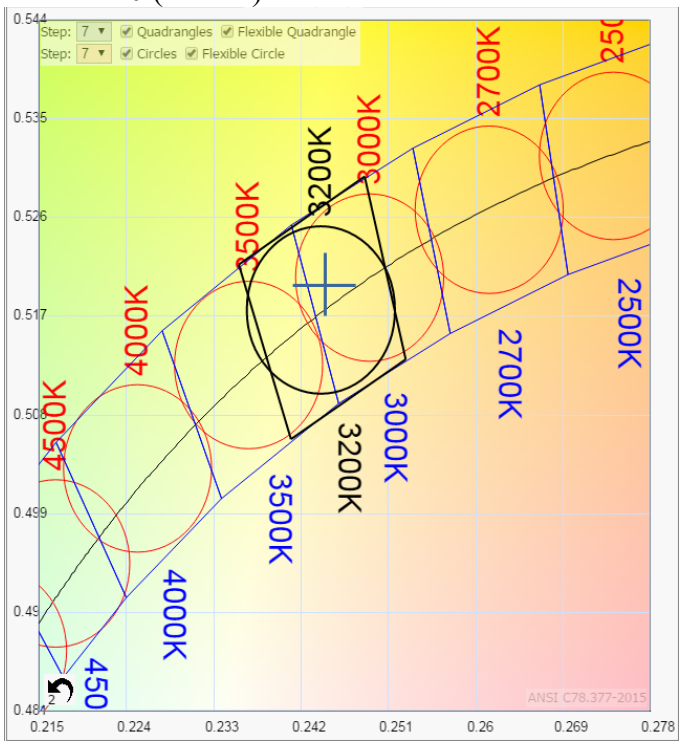


Figure 50: Flexible Binning

11.4 Power Supply Controls

For the AC Module, and other supported DUT power supplies, the user needs to set the Mode (voltage/current control), Voltage, Current, and Frequency (for AC sources). Once set, click **Enable Output** to send power to the DUT.

Power Supply:	Chroma61605
Enable Output	
Mode	Voltage
Output Voltage (V)	0.000
Limiting Current (A)	0.000
Frequency (Hz)	60.000

11.4.1. Remote Sensing

The Labsphere LPS is capable of remote sensing with the appropriate cabling connected to the REMOTE socket on the rear panel.

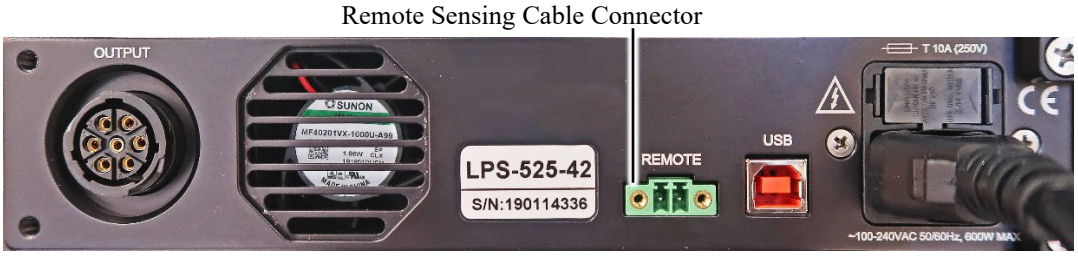


Figure 51: Labsphere LPS Power Supply — rear panel

Enable this function in Integral by toggling the "Remote Sense" switch to the ON position.

Power Supply:	LabsphereLPS
Enable Output	
Mode	Current
Output Current (A)	2.000
Limiting Voltage (V)	15.000
Remote Sense	

Remote Sense Switch ON

11.5 Temperature Controller Functions

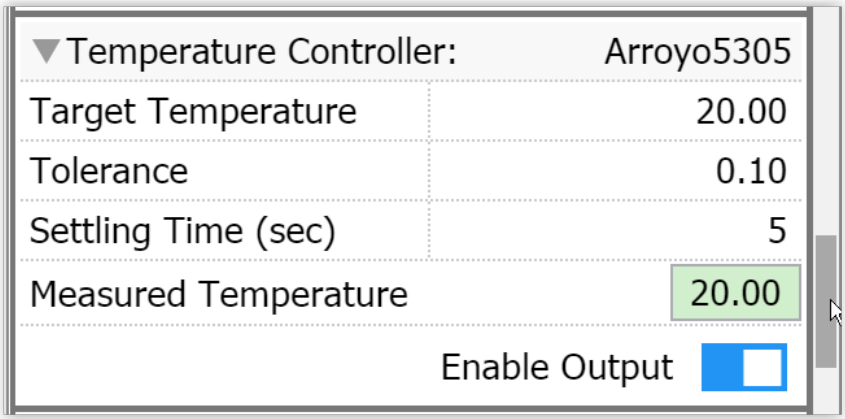
Here you will be able to set the temperature of the TEC you are connected to. Do this by clicking the number next to **Target Temperature**, then setting its value.

The **Tolerance** setting is the range of degrees that the temperature needs to be within before it will stabilize and proceed. This will ensure that the temperature stays where it needs to be.

The **Settling Time** value is the estimated time necessary to correct and reset the TEC. TEC controllers tend to over-shoot the target temperature. The **Settling Time** value can be used with the **Tolerance** value to prevent this. Five or more seconds has proven useful in practice.

The **Measured Temperature** color is based on the Tolerance.

Once set, click **Enable Output** and the TEC will begin adjusting the temperature. As the temperature changes, Integral will measure it every 5 seconds showing a color to indicate if the TEC is stable. The colors displayed will range from red (unstable) to green (stable).



11.6 Performing Scans

Scans are initiated by clicking the icons to the left of the Waveform Graphs window and are described on the next page.

NOTE: Taking a scan also instructs the system to check other devices that may be measuring things like DUT voltage, current, power, temperatures, etc.

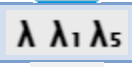
Icon	Function	Description
	Single Scan	Performs a single scan.
	Continuous Scan	Performs continuous scans per the *Scan Interval (ms)* set in the *Spectrometer settings*.
	Save Scan	The scan displayed and the calculated values are saved to the data base
	Auto Save	Scans acquired under single or continuous mode are automatically saved when acquired. There is an 8,000 scan limit for Auto Save.
	Apply Calibration	Applies the selected Calibration set to the data. Data is displayed as W/nm.
	Import TM-27 SPDX file	Upload any scan that will perform LSAPI colorimetry calculations, from Integral & scans generated in other software. Refer to section 16 “TM-27” on page 108.
	Apply Dark Correction	Applies a dark correction to the data to help correct spectral data and reduce noise.
	Auto-Exposure	Performs an auto exposure: refer to section 11.7 on page 64.
	Auto-Exposure Lock Switch	Locks in auto-exposure function for every scan; refer to section 11.7 on page 64.
	LM-85 Stabilization	Performs an LM-85 stabilization: refer to section 11.11 “LM-85 DUT Stabilization on page 69.
	LM-79 Stabilization	Performs an LM-79 stabilization: refer to section 11.8 on page 65.
	CIE S 025 Stabilization	Performs the S 025 stabilization: refer to section 11.9 on page 67.
	Change Resolution	Change the resolution of scans with three options ranging from pixelspace, to 1 nanometer, and 5 nanometers.
	Manually Define Band	Provides manual definition of upper and lower wavelengths.
	Perform a PstLM Scan	Performs a scan for short-term flicker severity: refer to section 12.6.4 on page 93.
	Display Flicker Waveform	Functions as an on/off toggle for the Flicker Waveform graph
	Display Fast-Fourier Transform	Functions as an on/off toggle for the Fast-Fourier Transform graph
	Perform Sweeping Scans	Performs sweeping scans as defined in the Sweep Settings parameter menu: refer to Figure 69: Sweep Settings Parameter Menu” on page 97.
	Clear Scan Data	Click to clear the waveform graph and any cached temporal data.
	Spectral Photon Flux Toggle Switch	Turns the Spectral Photon Flux function on and off: refer to [Main Menu] -> [Settings] -> [Project]
	Visible Spectrum Overlay Toggle Switch	Turns the Visible Spectrum Overlay function on and off which changes the display of the Spectral Power Distribution (SPD) graph: refer to [Main Menu] -> [Settings] -> [Project]

Figure 52: Scans and Action Icons in Integral

11.7 Auto-Exposure

In order to achieve accurate measurements, it is important that the spectrometer operating in a range that best utilizes the dynamic range of its internal sensor. The auto-exposure feature runs the spectrometer through a range of integration times to achieve maximum saturation of 70-85%, which is optimal for most spectrometers.

Please ensure the DUT is powered on or that there is some light coming into the spectrometer. Otherwise, auto exposure may create an error because it may not be able to achieve the goal of 70-85% saturation on a completely dark system.
To perform an auto exposure routine, click the 

button.

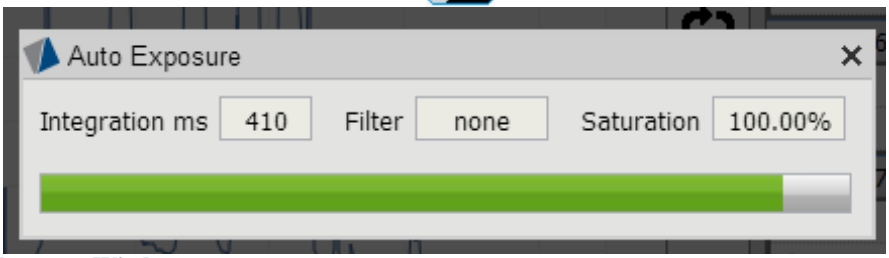


Figure 53: Auto Exposure Window

Set the lock switch below the 

button to the ON position to require an auto exposure routine before every scan. The auto exposure button will then change to having a green checkmark over it, indicating that the auto exposure function is always on.

11.8 LM-79 Stabilization

The IESNA-LM-79 standard describes a stabilization routine intended to produce a stable condition from which to perform LED measurements thus providing a uniform baseline for data comparisons. The LM-79 Stabilization routine compares two values of flux and power (current and voltage) at intervals at least 10 minutes apart. When the variance of these values is within 0.5%, the lamp is declared stable.

11.8.1 LM-79 Version Selection

Integral supports two versions of the LM-79 standard:

- LM-79-08
- LM-79-19

The minimum time to complete the routine is 20 minutes for LM-79-19 and 30 minutes for LM-79-08, with the addition of any stabilization time necessary for either version. To choose the LM-79 version:

1. Go to "Main Menu/Settings/Project"
2. Click on the LM-79 Version dropdown menu to select between the two versions.

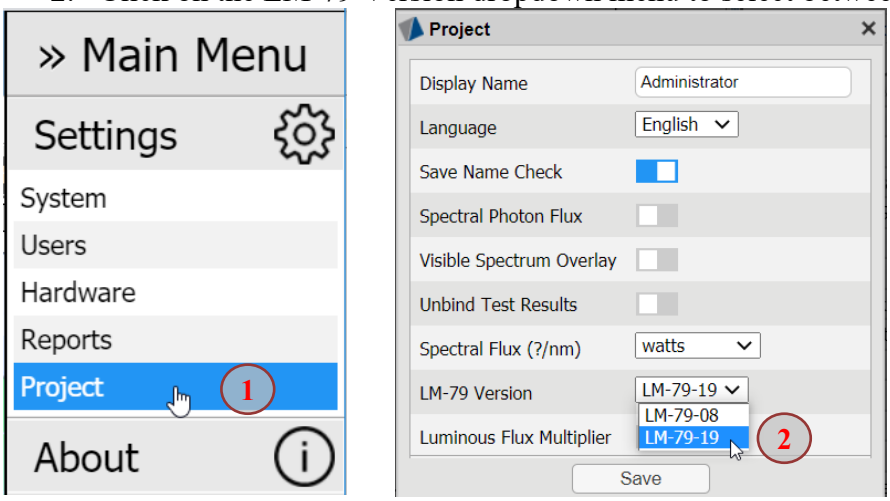


Figure 54: LM-79 Version Selection

11.8.2 LM-79 Stabilization Procedure

Integral automates the LM-79 Stabilization routine by measuring the DUT at 1 to 5-minute intervals and then compares three data points that are at least 10 minutes apart. Data is displayed in a table indicating Flux, Voltage, Current, and Power at each time interval. To perform the LM-79 stabilization, complete the following steps:

1. Power on the DUT.
2. Have a calibration applied; this can be done by clicking on , the icon next to the spectral plot.
3. Click the LM 79 button and choose the source for the electrical measurements.
4. Save each individual scan (optional).
5. Define a warm-up time (optional). This time lets the bulb reach photometric and electrical stabilization with temperature equilibrium.
6. Stabilization time typically ranges from 30 minutes for small luminaires, to 120 minutes for large luminaires. Warm-up time is calculated into this.

7. Data may be exported to a .csv file when the routine is successfully completed.
8. An “official” LM-79 scan may be performed after the stabilization routine is complete. This will be indicated by a checkmark on the LM-79 icon. 
9. This scan should be saved to the database and an LM-79 report can be created using those data.

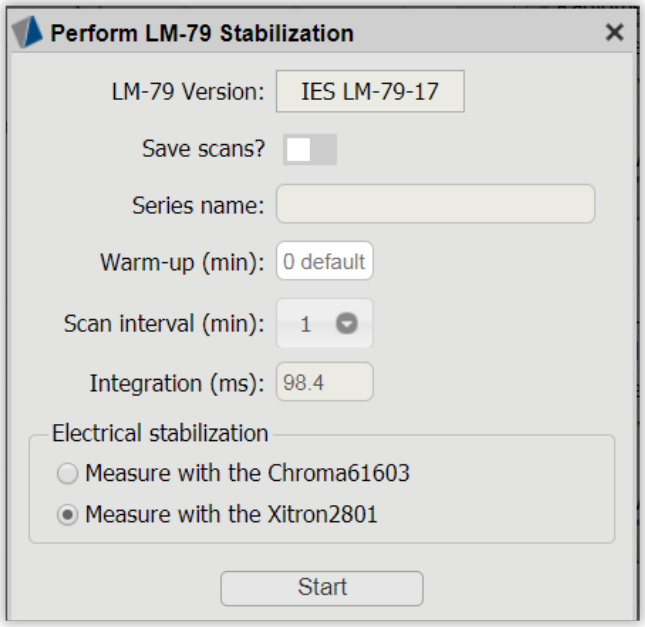


Figure 55: Starting the LM-79 Stabilization Routine

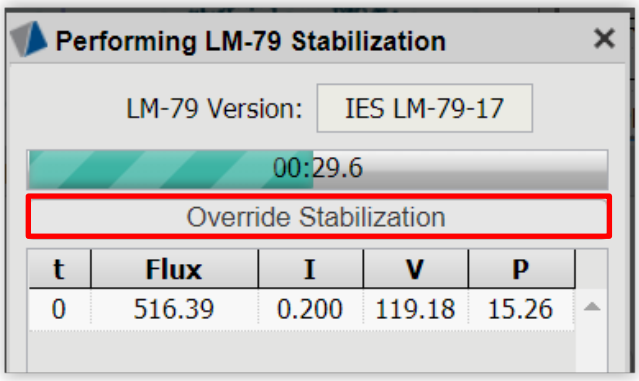


Figure 56: Override LM-79 Stabilization (optional: export data)

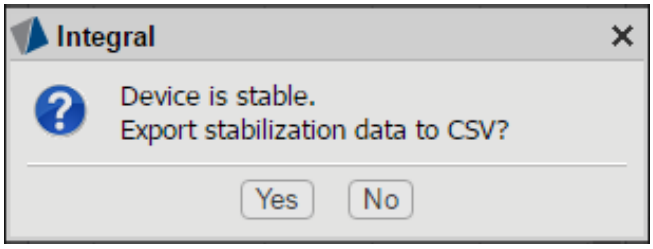


Figure 57: Export LM-79 Data

11.9 CIE S 025 Stabilization

S 025 is a test method for LED lamps, LED Luminaires and LED Modules. This standard provides requirements to perform reproducible photometric and colorimetric measurements.

To complete the S 025 stabilization routine the DUT shall be operated for at least 30 minutes. It will be considered stable if the relative difference of maximum and minimum readings of light output and electrical power observed over the last 15 minutes is less than 0.5% of the minimum reading. If the DUT is pre-burned, it does not need to be operated for 30 minutes, and it is considered stable if the readings of the last 15 minutes meet the previous requirement.

To begin the S 025 stabilization routine, click the button in the Actions section  . Should the DUT exhibit large fluctuations and stabilization conditions are not achieved, within 45 minutes of operation for LED lamps or 150 minutes for LED luminaires the observed fluctuations can be reported via the “Override Stabilization” button.

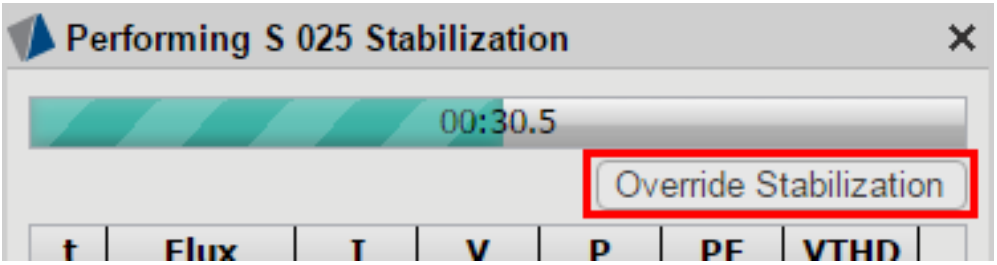


Figure 58: Override S 025 Stabilization (optional: export data)

11.10 LM-82 Sequence

Integral uses the IES LM-82-12 approved method for the characterization of LED light engines and LED lamps for electrical and photometric properties as a function of temperature. To run an LM-82 Sequence click the Run Sequence button in the LM-82 Controller:

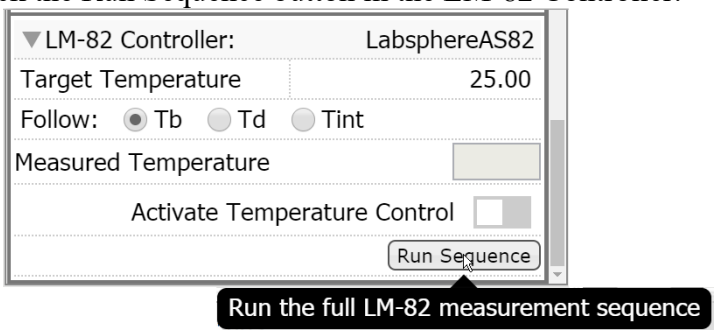


Figure 59: Run the full LM-82 measurement sequence

11.10.1 Controller

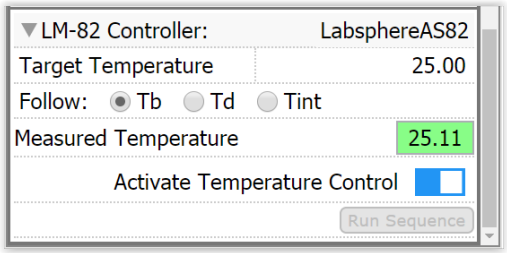
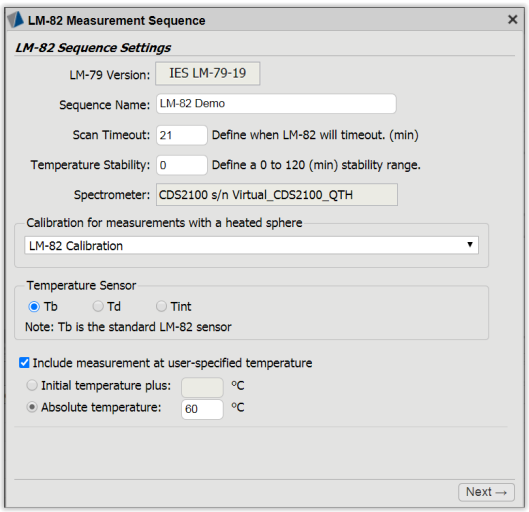


Figure 60: LM-82 Controller by Target Temperature

The LM-82 Controller allows you to set the target temperature between 15 and 70 degrees independent of running an LM-82 sequence. Once the active button is checked it will start measuring the current temperature by what it's following (Tb default) in five second intervals.

11.10.2 Measurement Sequence Settings

To run the LM-82 you will need to set up the sequence information.

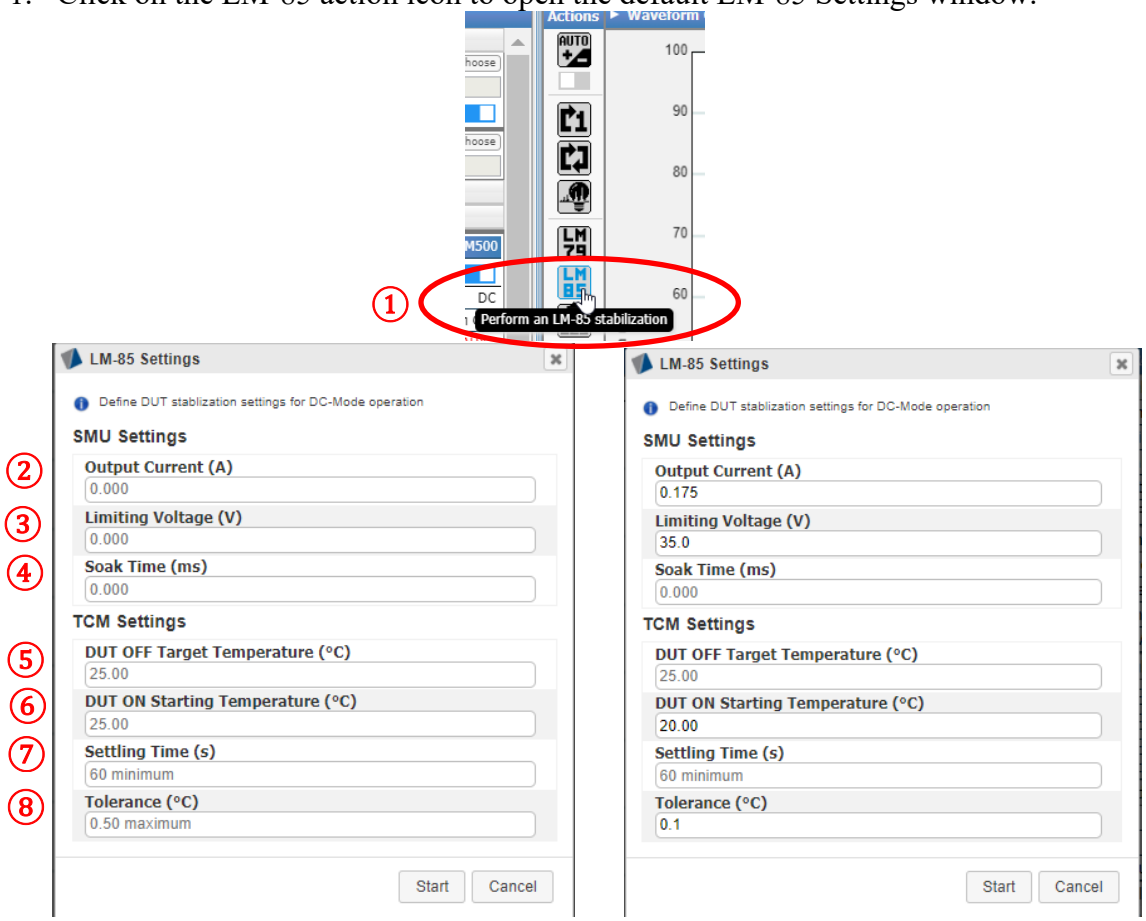


1. **Sequence Name**: Choose a name for the sequence.
2. **Scan Timeout** (optional): This option allows you to control when the LM-82 scan will skip the step it is currently on, should it fail to stabilize. Before you can override the LM-79, stabilization must run twenty readings, so choose an integer greater than twenty.
3. **Temperature Stability** (optional): Define how many readings (0 to 120 min.) the LM-82 temperature should be stable for before moving onto the next step (0 default).
4. **Calibration for measurements with a heated sphere**: Select a calibration to run the LM-82 sequence.
5. **Temperature Sensor**: LM-82 guidelines recommend using Tb although you can test Td and Tint as well.
6. **User Specified Temperature** (optional): This option allows control of the initial Tb/Td/Tint plus -15 to 40 °C. Absolute temperature allows for 15 to 70 °C.

11.11. LM-85 DUT Stabilization

As per Section 6 of ANSI/IES LM-85-20 the approved method for the DC mode operation for the optical and electrical measurements of LED packages and arrays. The stabilization routine takes between 20 and 30 minutes depending on the user's TCM settings. Once completed, the LM-85 stabilization finds the closest forward voltage (Vf) with the DUT ON Target Temperature when compared to the baseline forward voltage (Vf0) of the DUT OFF Target Temperature. At that point, the user can turn on the DUT in DC mode, measure the device in DC mode and get the same results as measuring a single short pulse or multiple short pulses.

1. Click on the LM-85 action icon to open the default LM-85 Settings window.



2. **Output Current (A):** Enter the driving current for the DUT.
3. **Limiting Voltage (V):** Enter the limiting voltage that is expected.
4. **Soak Time (ms):** Enter the soak time amount if the DUT requires this parameter.
5. **DUT OFF Target Temperature (°C)**: Enter the target temperature that the stabilization will be based on.
6. **DUT ON Target Temperature (°C)**: To speed up the routine, enter the target temperature that the DUT is expected to stabilize nearby. If this is unknown, enter the same value as DUT OFF and the routine will calculate it.
7. **Settling Time (s)**: As defined by LM-85 must be at least 60 seconds. This value can be increased to accommodate larger devices under test.
8. **Tolerance (°C)**: LM-85 defines +/- 0.5 tolerance as the maximum accepted window. The Arroyo 5305 TEC controller takes some time to stabilize at the desired target temperature. This setting defines that window at which the settling time will begin counting.

11.12 Temperature Monitor Channel Status and Assignment

Integral provides up to eight channels of temperature monitoring in the illumia® systems. There are eight generic and four specific ("T") thermocouple selections, all of which are assignable to accommodate various temperature monitoring functions. Scroll down in the Test Results column to view the "Temperature Monitor" test results panel below. The data fields will be blank as shown until channels are assigned and scans are taken.

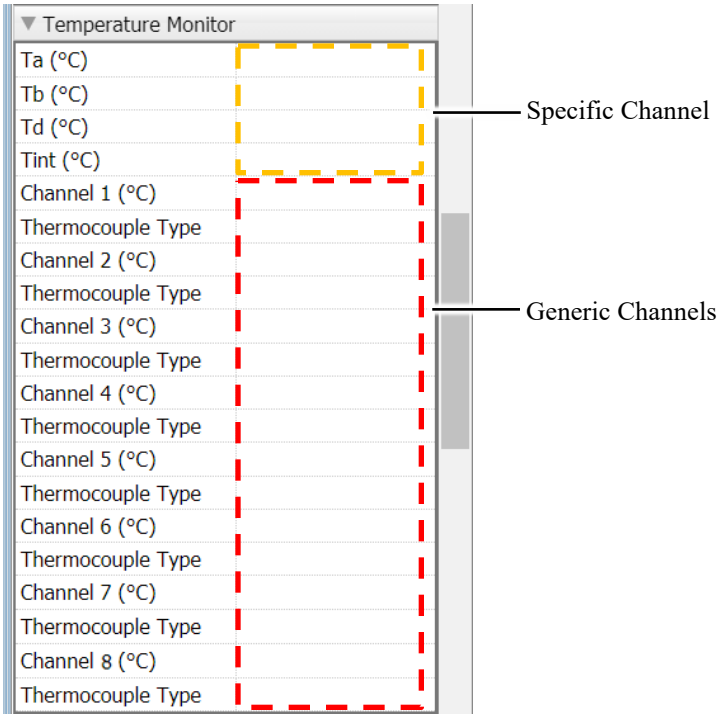


Figure 61: Temperature Monitor Test Results Panel — no assignments made

11.12.1. Thermocouple Types and Functions

The eight generic thermocouple selections are identified by their predetermined channel number and the thermocouple "Type" letter that the user assigns to it. Integral supports these eight industry standard thermocouple types below:

Thermocouple Type	Temperature Range (°C)				
	Short Term Use	Continuous Use	Class 1 Tolerance	Class 2 Tolerance	Class 3 Tolerance
Type E	- 40 to +900	0 to +800	-40 to +800	-40 to +900	-200 to +40
Type J	- 180 to +800	0 to +750	-40 to +750	-40 to +750	N/A
Type K	- 180 to +1300	0 to +1100	-40 to +1000	-40 to +1200	-200 to +40
Type N	- 270 to +1300	0 to +1100	-40 to +1000	-40 to +1200	-200 to +40
Type R	-50 to +1700	0 to +1600	0 to +1600	0 to +1600	N/A
Type S	- 50 to +1750	0 to +1600	0 to +1600	0 to +1600	N/A
Type T	- 250 to +400	- 185 to +300	-40 to +350	-40 to +350	-200 to +40
Type B	0 to +1820	+200 to +1700	N/A	+600 to +1700	+600 to +1700

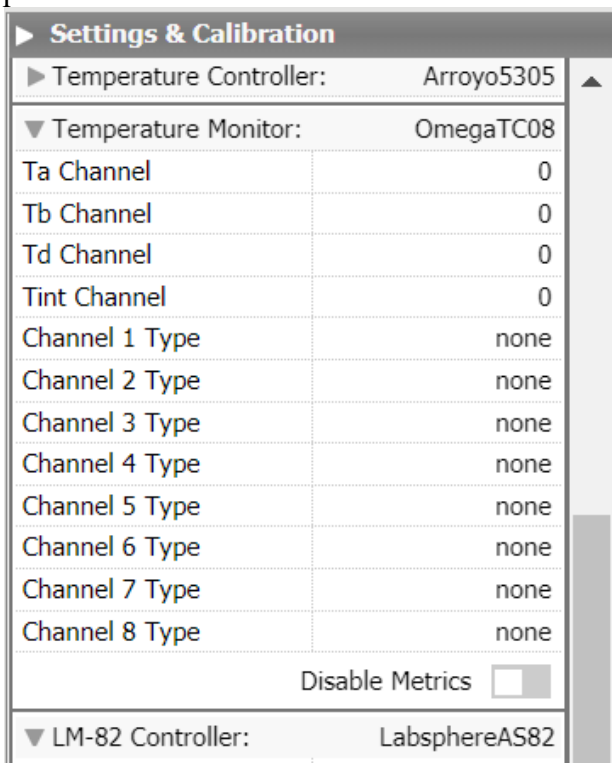
Figure 62: Standard Thermocouple Types by Letter

The four specific (“T”) thermocouple selections are identified by their predetermined function and must be assigned to one of the eight channels to be implemented. These channels are optional and normally used in LM-82 illumia®Plus systems.

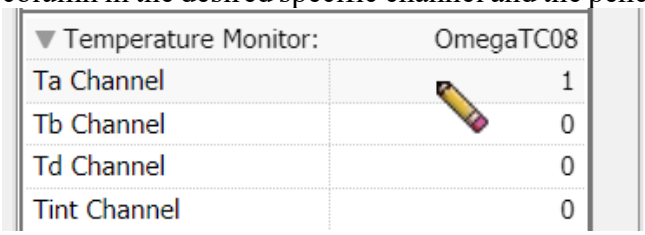
Thermocouple Designation	Function
Ta	Measure the ambient temperature
Tb	Measure the temperature at the base of a lamp
Td	Measure the temperature at the driver section of a lamp
Tint	Measure the sphere’s internal temperature

11.12.2. Thermocouple Assignments

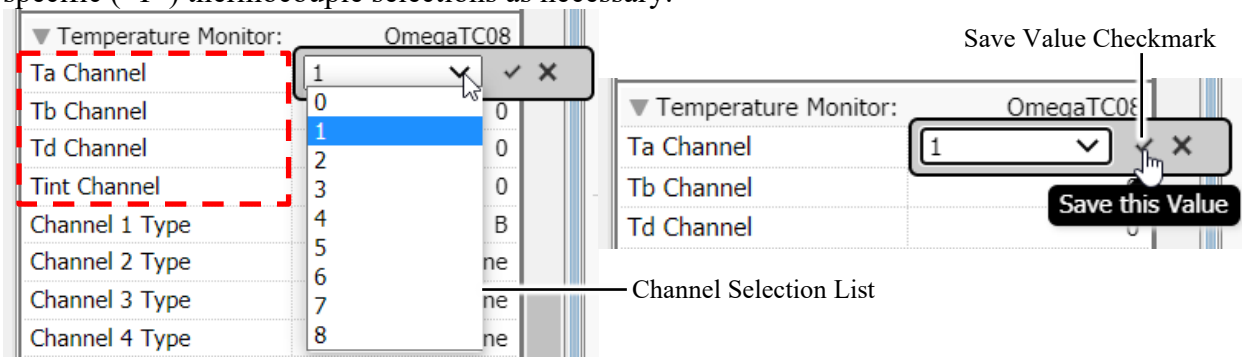
1. Scroll down in the “Settings & Calibration” column to the “Temperature Monitor” control panel. It lists the same twelve thermocouple selections that are in the “Temperature Monitor” test results panel.



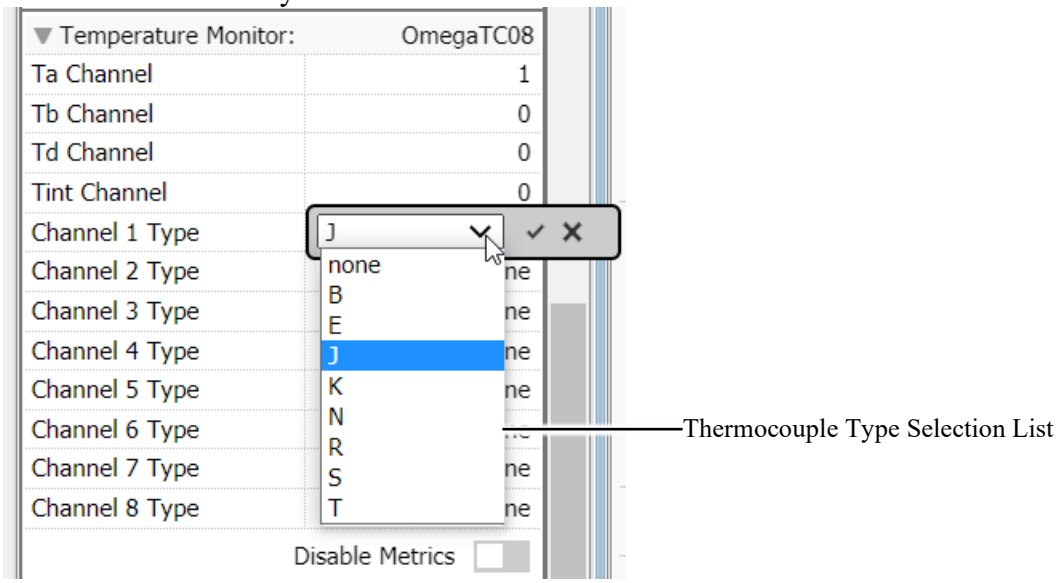
2. Hover over the data column in the desired specific channel and the pencil cursor will appear.



3. Click on the data field with the pencil cursor and select the desired thermocouple channel from the dropdown menu. Save the value by clicking the checkmark. Repeat for the other specific ("T") thermocouple selections as necessary.



4. Hover over the data column in the desired generic selection and click on it to open the thermocouple "Type" dropdown list. Refer to Figure 62: Standard Thermocouple Types by Letter" on page 70. Select the desired thermocouple type from the dropdown menu and save the value by clicking the checkmark. Repeat for the other generic thermocouple selections as necessary.



5. When the channel assignments have been made, click the “Perform Single Scan” button and observe the new temperature values in the Temperature Monitor table. Unassigned channels will display a double dash “- -". Unavailable channel numbers will display “NaN”.

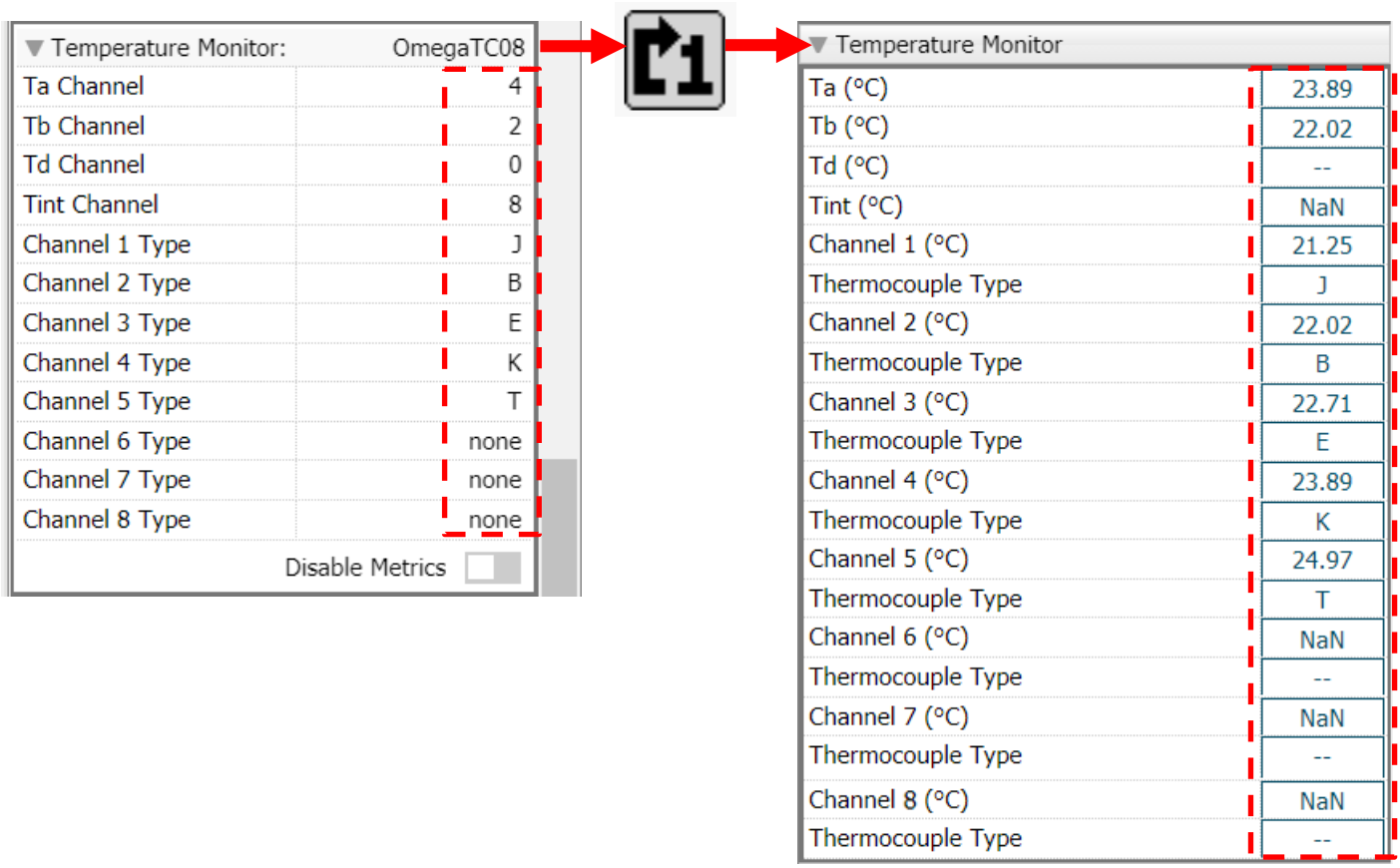


Figure 63: Temperature Monitor Test Results Panel — with assignments made

12 DISPLAYING DATA

Data from saved scans may be displayed in the result viewers by simply clicking on a record in the database viewer on the bottom of the screen. Multiple records may be selected by holding the *shift* or *control* keys. Data associated with scans is color-coded as shown in the database viewer.

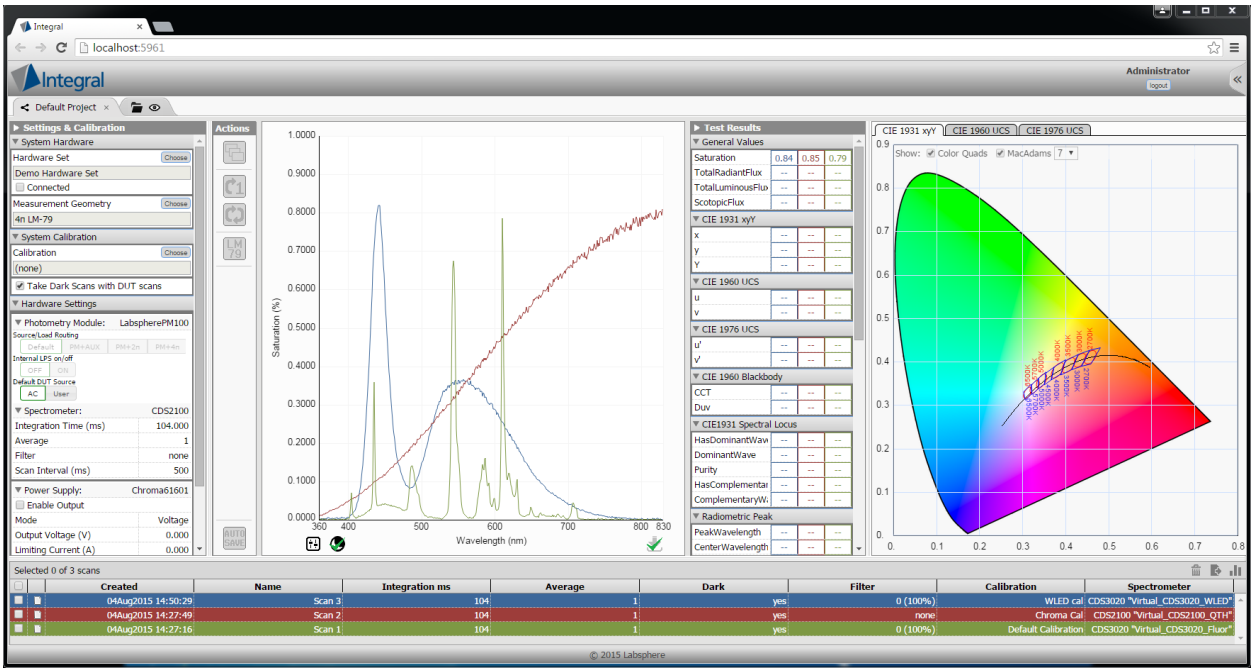


Figure 64: Viewing Multiple Scans

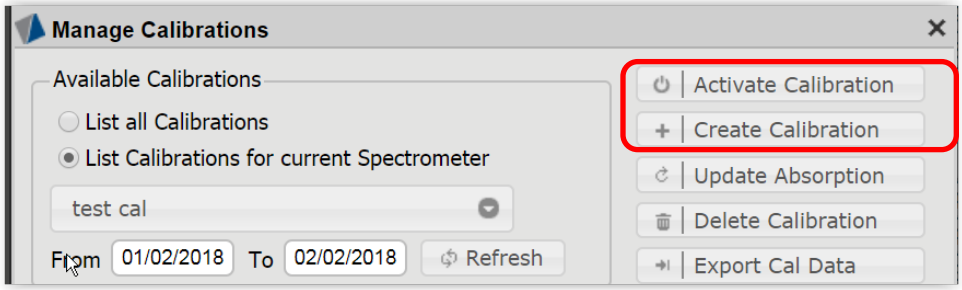
Scans are selected for view by clicking anywhere on the record line. This will highlight the record with a color (used to correlate record to viewed data).

Scans are selected for export/report using the checkbox at the start of each record line.

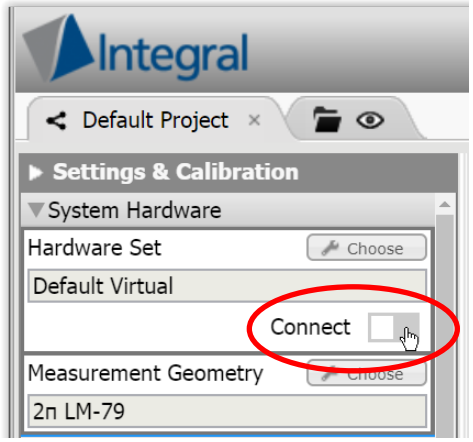
12.1 Banded Data

Data from scans may be displayed in upper and lower bands that are selected by the operator.

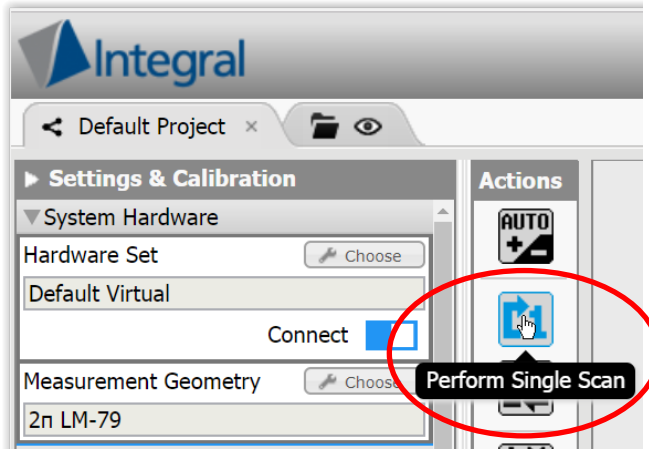
1. Create a calibration and then activate it. Refer to section 10.2 “Activate an Existing Calibration” on page 42.



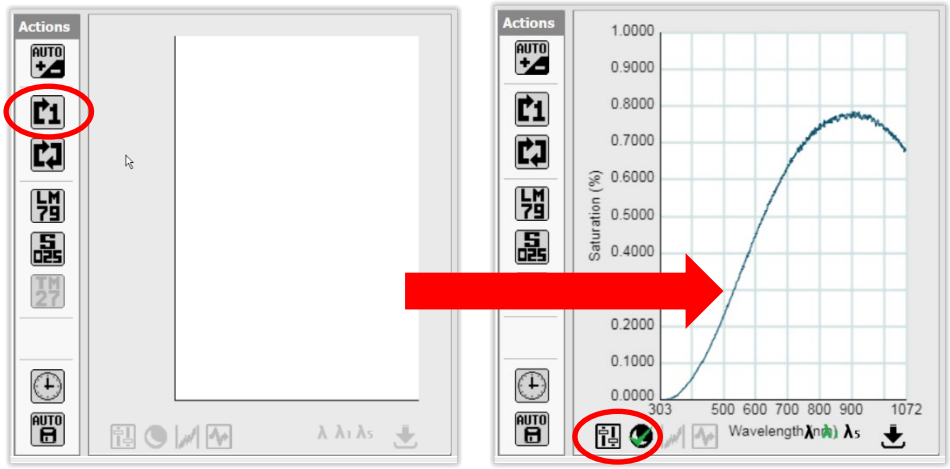
2. Click the “Connect” switch to connect to the hardware set.



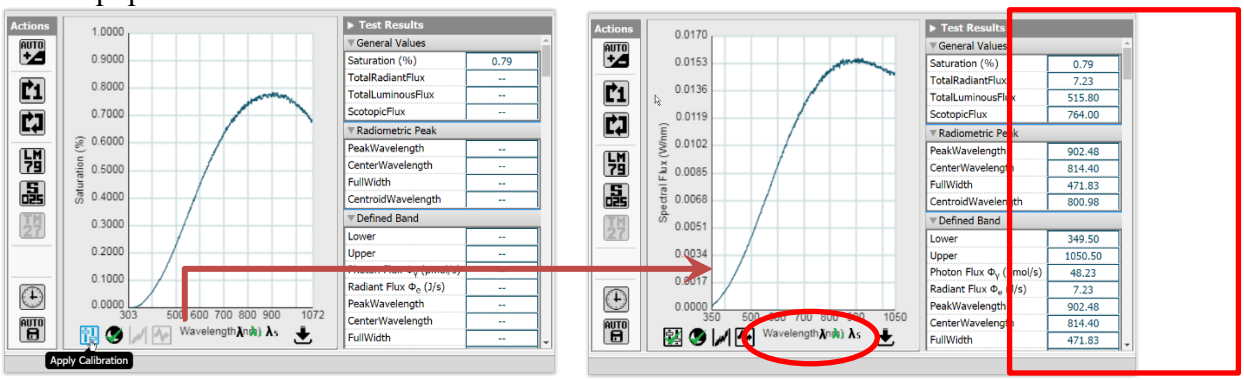
3. Take a scan by clicking one of the scan options in the “Actions” column.



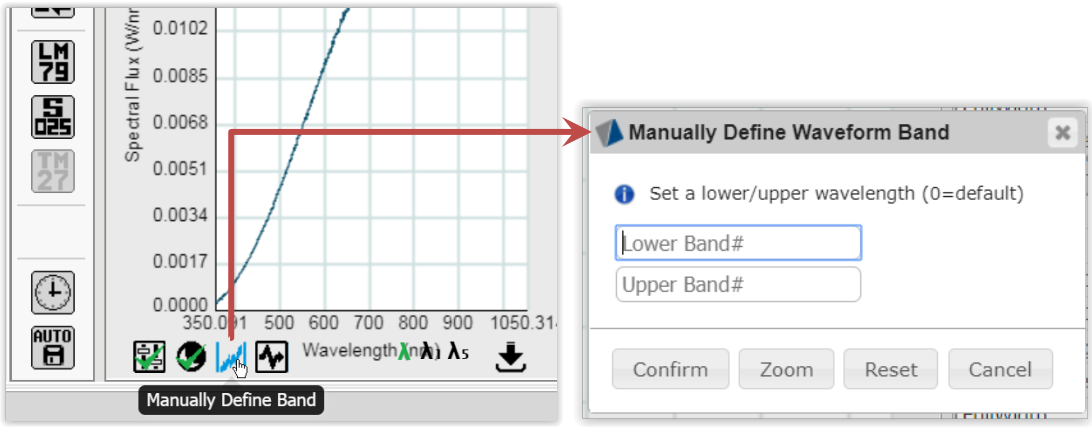
4. The Wavelength graph appears, and the Calibration and Dark Correction icon buttons are now selectable.



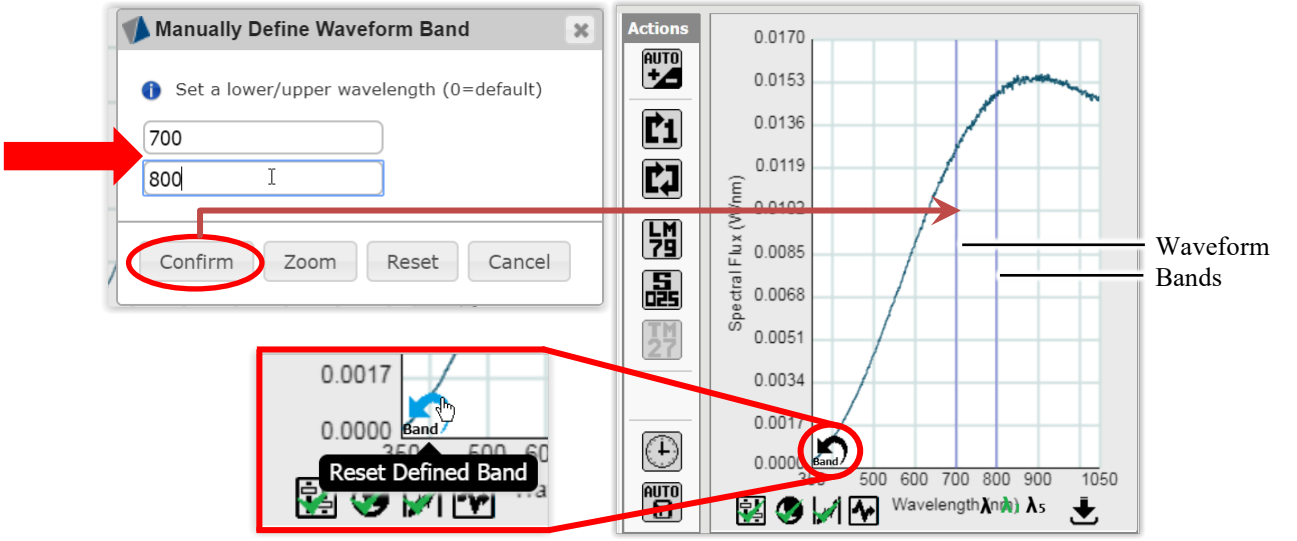
5. Click the "Apply Calibration" icon button. The Wavelength graph changes, band data and integrated flux icons are selectable, and the Test Results parameter windows are now populated.



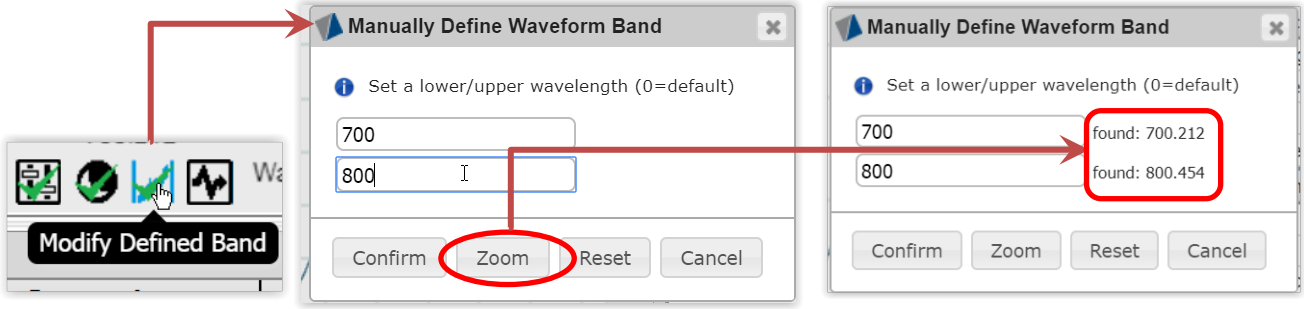
6. The resulting wavelength graph resolution is in pixel-space which requires exact waveform band designation. Click the "Manually Define Band" icon which will bring up the upper/lower wavelength entry window.



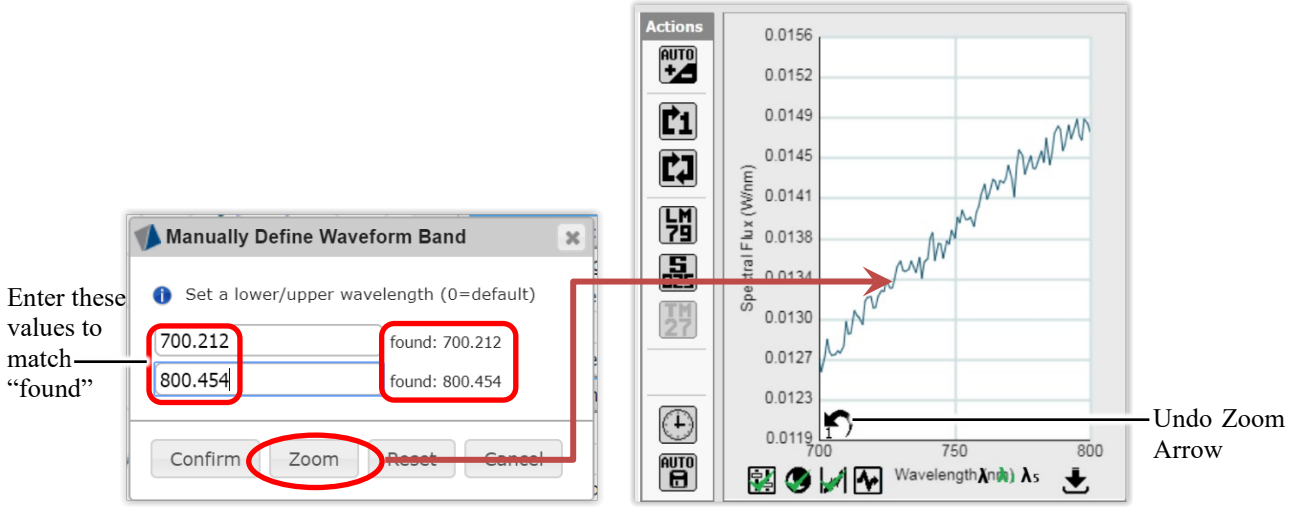
7. Enter the desired lower and upper waveform bands to be evaluated and click “Confirm”. The upper and lower waveform bands will display on the graph and the Reset Defined Band arrow will appear.



8. Click the “Modify Defined Band” button to bring up the “Manually Define Waveform Band” window again. This time click the “Zoom” button and Integral will find the closest waveforms to those that were manually entered previously.



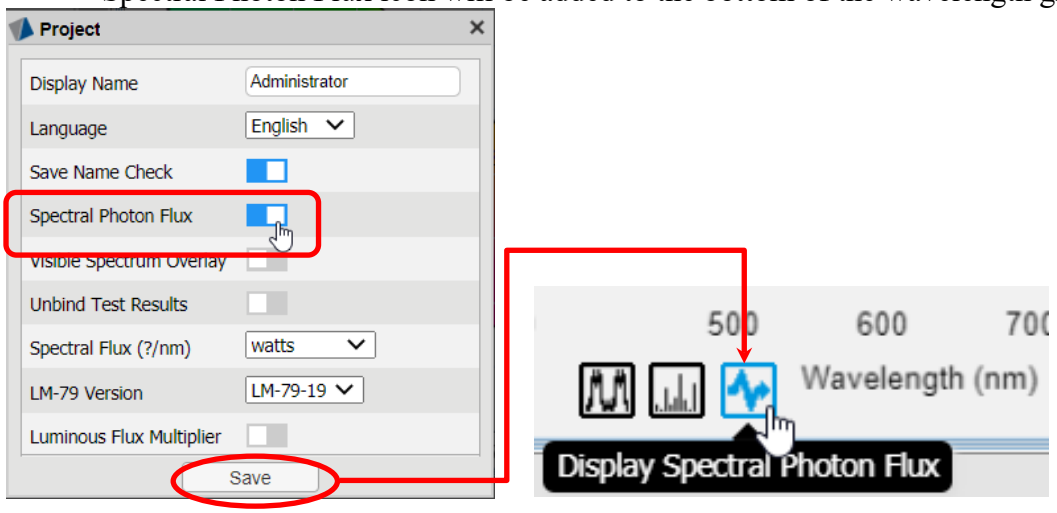
9. Enter the exact “found” waveform values into the lower and upper wavelength fields and click “Zoom” again to display the actual waveform as defined. Click the “Undo Zoom” arrow to back out.



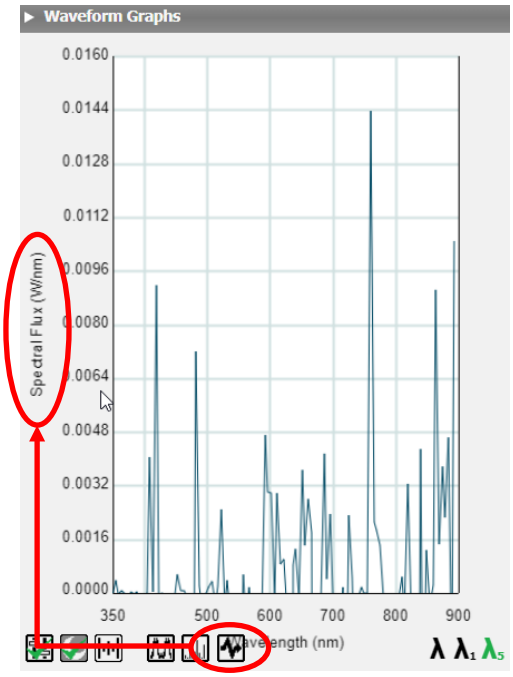
12.2 Horticulture Parameters

Parameters used in horticulture applications can be displayed over the selected waveform band.

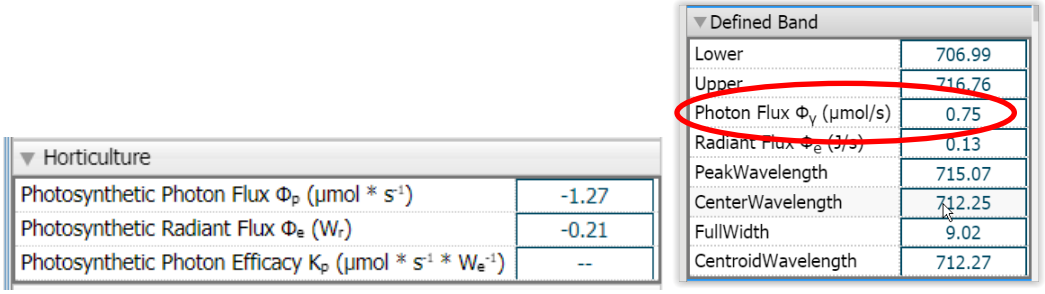
1. Switch on the Spectral Photon Flux function in the Project menu and click "Save". The Spectral Photon Flux icon will be added to the bottom of the wavelength graphs screen.



2. Click the "Spectral Photon Flux" icon to enable that function in the wavelength display.



3. Scroll down the Test Results column to display the "Horticulture" parameters window. The Photon Flux parameter in the Defined Band window is also relevant to horticulture use.



12.3 TM-30 Reporting

Integral 2.0 (and greater) supports the IES TM-30 standard; a new system of related light measurements and graphics that are used together to evaluate and communicate a light source's color rendering properties. Go to the Integral main screen and click on the "TM-30" tab at the far right to bring up the TM-30 default vector chart below. Scroll down the Test Results column to display the TM-30 parameters (partial display shown below).

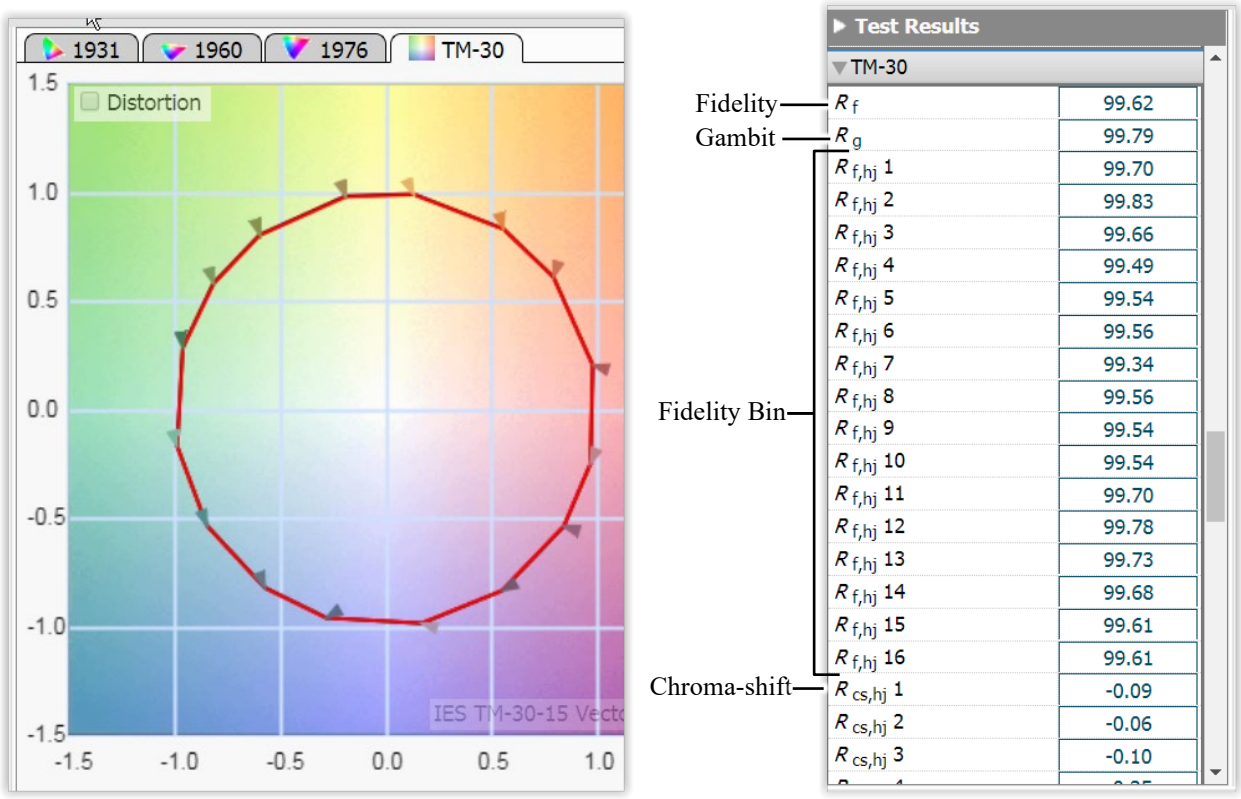


Figure 65: TM-30 Default Vector Chart and Test Results Parameters.

12.3.1 TM-30 Bins

There are 99 counts in a TM-30 scan. Integral organizes the counts into "bins" in different quadrants (Fidelity Bin shown above).

12.3.2 TM-30 Comparative Display Vector

Click and drag over any arrowhead area to zoom in and view the variation of the user's scan compared to the TM-30 standard. The resulting vector arrow represents the variation.

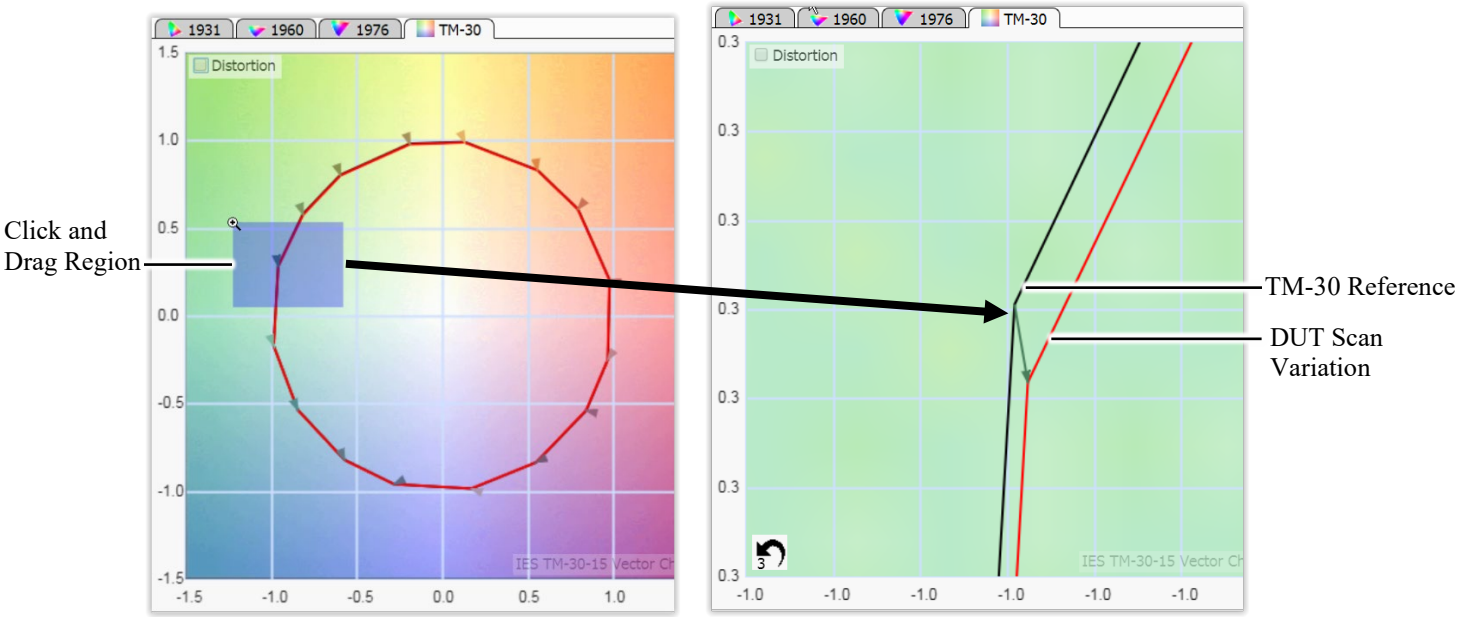


Figure 66: TM-30 Comparative Display Vector

12.3.3 TM-30 Color Distortion Display

Click the "Distortion" button to isolate the color information:

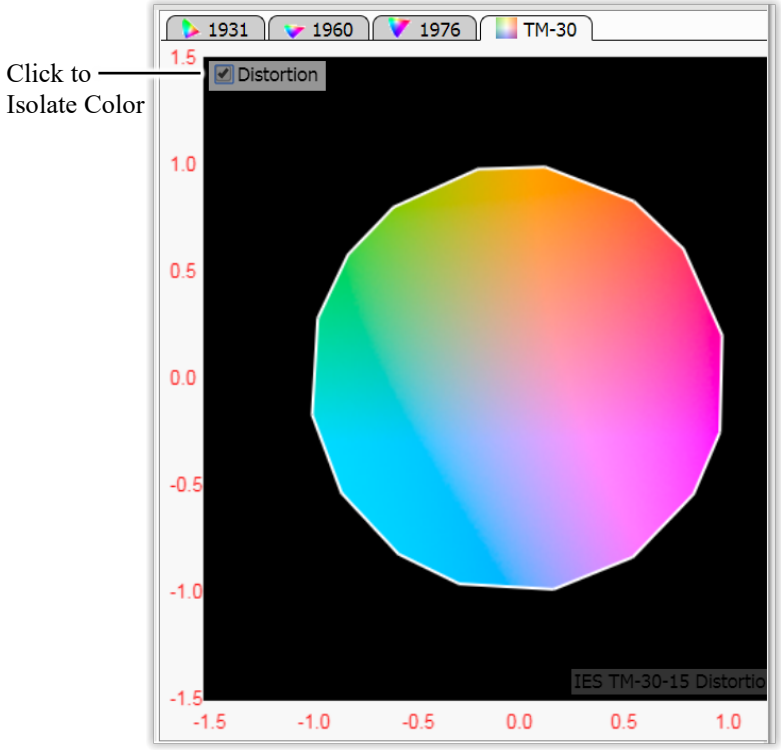
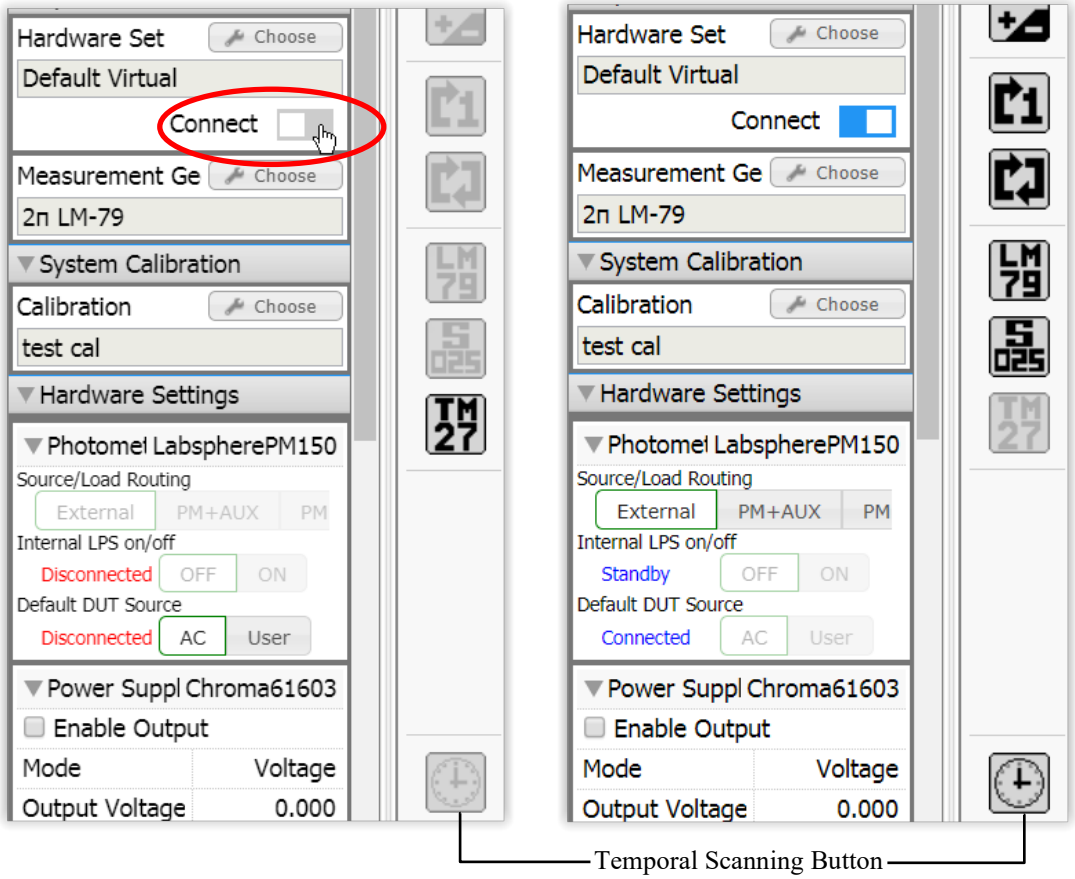


Figure 67: TM-30 Color Distortion Display

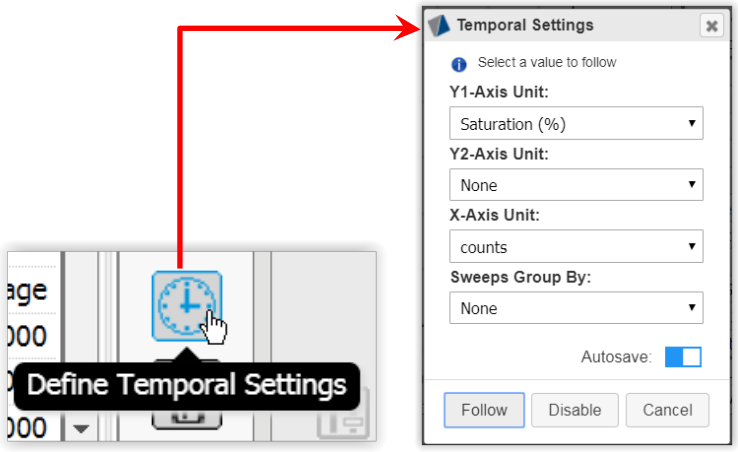
12.4 Temporal Scanning and Plotting

This feature enables the user to plot and record any measured value against time for better understanding of lamp, luminaire and fixture, and output sensitivity over elapsed time of operation. Live or saved data scans can be compared. Every value listed in the Test Results column can be assigned to the Y-axis and plotted over a choice of five different time intervals on the X-axis.

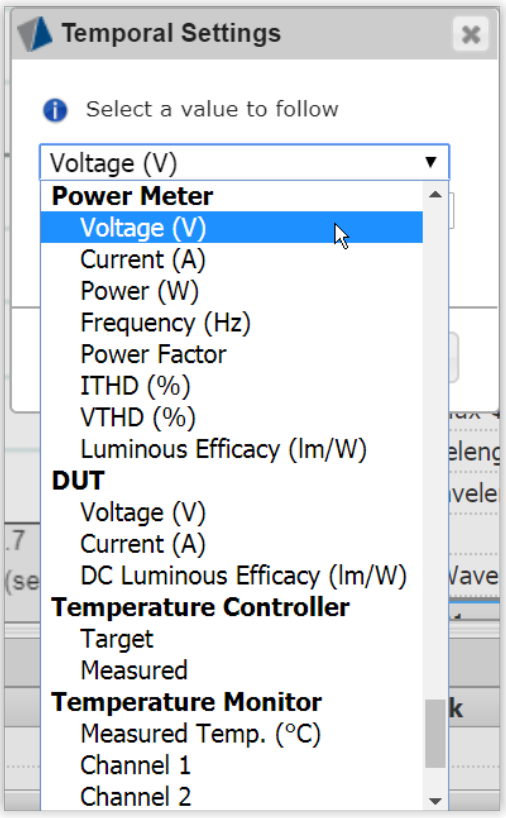
1. Connect to the desired hardware set to activate the Temporal Settings button from its grey-out state.

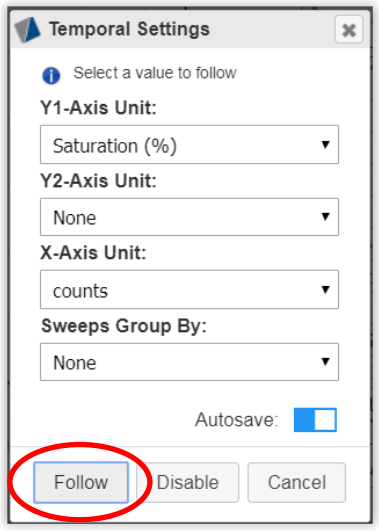


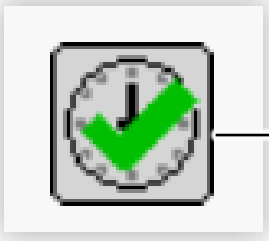
2. Hover over the Temporal icon to identify its function. Click on the icon to open the "Temporal Settings" control panel.



3. Using the dropdown menus, select the test values for the Y1-axis and Y2-axis, and the time interval for the X-axis. Click "Follow" when done. The Temporal icon will be marked with a green check-mark, indicating that the function is now active.

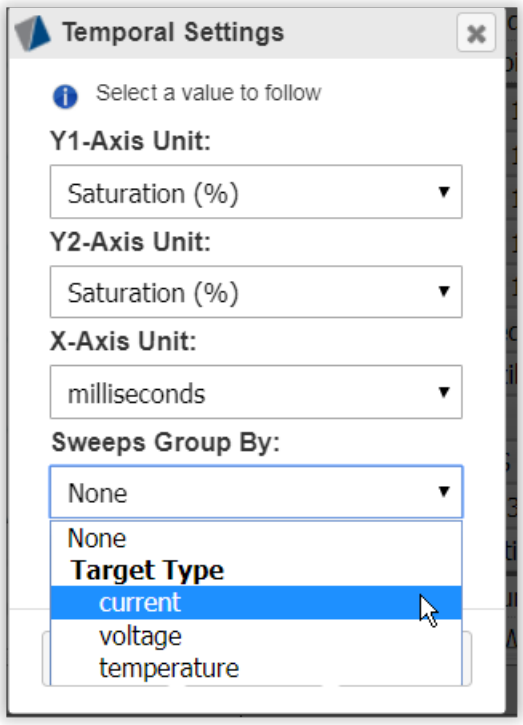




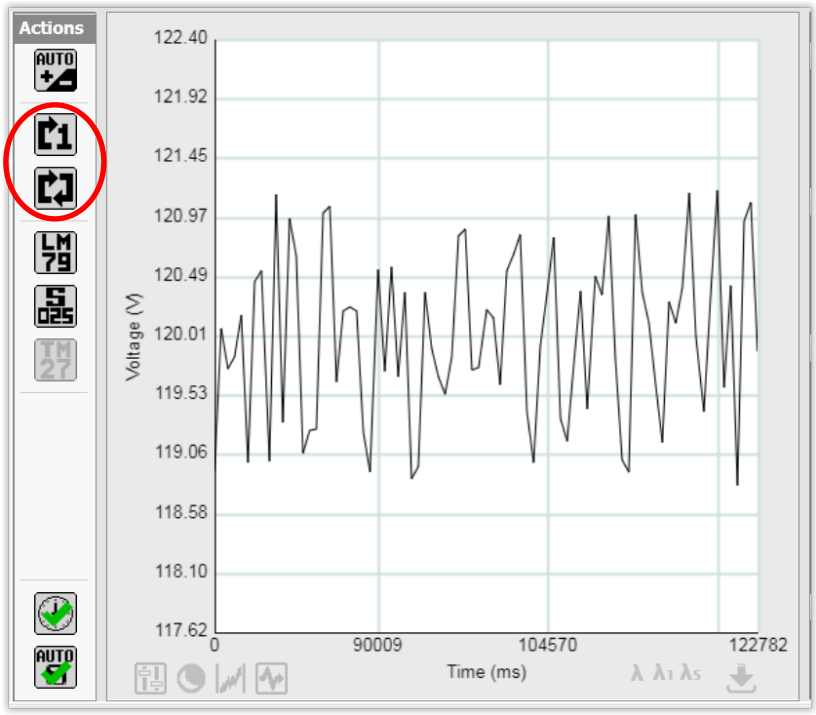


Temporal Function Active

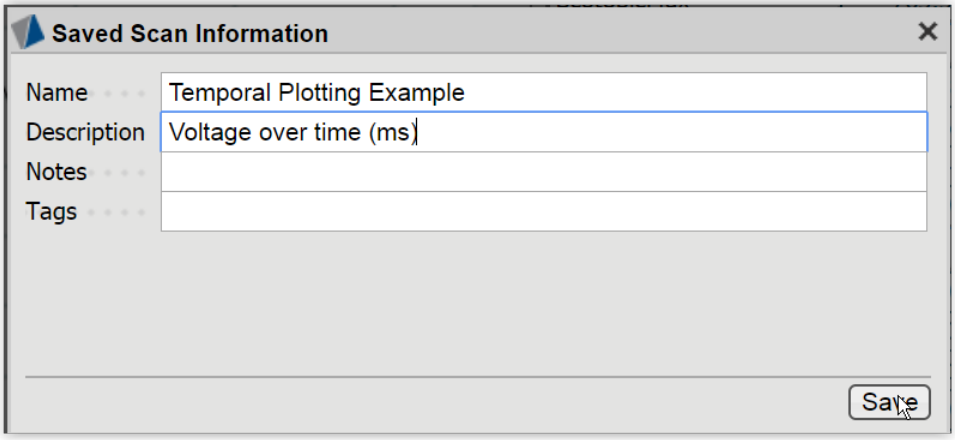
4. Temporal Settings for LIVT Sweeps include a grouping function. Click the “Sweeps Group By” dropdown menu to review the options.



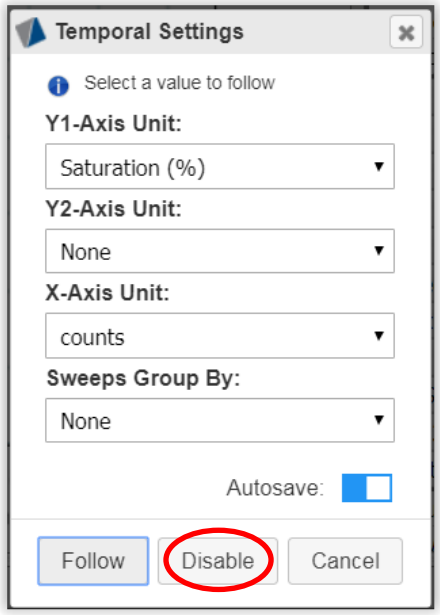
5. Click the single or continuous scan buttons to populate the graph.



6. Manually or Auto-Save the scan.

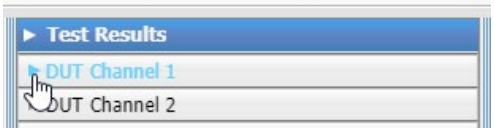


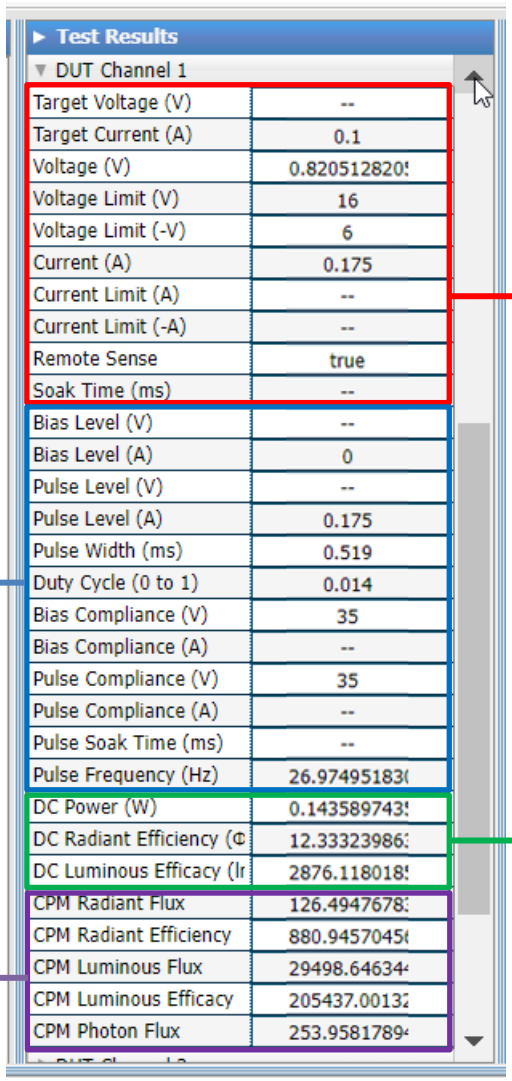
7. Click the "Disable" button to stop the Temporal scanning function.



12.5. DUT Channel Test Results Metrics

Scroll down the Test Results column to display the “DUT Channel 1” or “DUT Channel 2” parameter list headings. Click the arrow to exdpand the column. Note that the list of metrics are the same for each channel.





Depending on the power supply Mode (Current/Voltage), the saved scan will reflect different values. For example, when in Current Mode the resulting saved scan will show the Target Current along with other project settings if Remote Sense is being used. The measured Current and Voltage will be pulled from the power supply. Additionally, when in Current Mode the project setting for Voltage Limit (V) and Reverse Bias Voltage Limit (-V) will be recorded.

Pulse Frequency will be automatically calculated when the appropriate values (Pulse Width and Duty Cycle) are being used in the project.

For DC related measurements Integral automatically calculates the DC Power, DC Radiant Efficiency, and DC Luminous Efficacy when the appropriate values (Total Radiant Flux / Total Luminous Flux) exist.

For Continuous Pulse Mode (CPM) Integral automatically calculates the related CPM metrics when the appropriate values (Total Radiant Flux / Total Luminous Flux / Total Photon Flux) exist.

12.6 Flicker-iP Scanning and Plotting

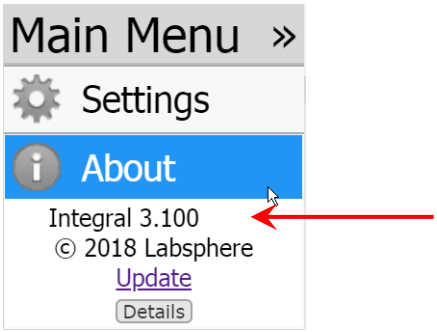
The illumiaPlus system provides the means to scan and plot the results of a phenomenon known as flicker; the rapid fluctuations in a lamp's power supply voltage. This occurs when a voltage drop is generated over the source impedance of the grid by the changing load current of an equipment or facility. These fluctuations in time generate flicker. This can result in visible changes in brightness of a lamp that can affect sensitive electronics and create disturbances in photosensitive humans.

The Flicker-iP scanning and plotting functions requires the Flicker Test Accessory hardware and Integral Version 3.1 or greater software upgrade to the illumiaPlus system; order number AA-01510-000. Contact Labsphere Customer Service for purchasing information. Refer to the Labsphere Flicker Detector Quickstart Guide, manual number SX-03400-000, for hardware and software installation information.

12.6.1 Flicker Actuation

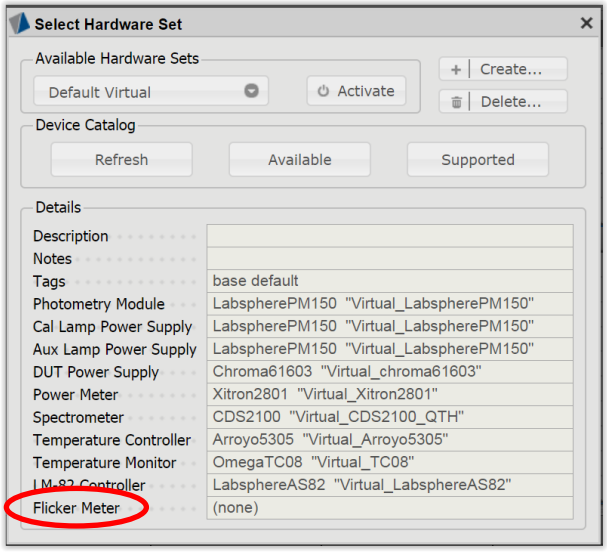
After the Flicker Test Accessory hardware and software upgrade has been made to the illumiaPlus system, the new Flicker hardware must be actuated to use it. This is done by creating a hardware set that includes the Flicker-iP hardware detector or connecting to an existing hardware set that includes it:

1. Ensure that the Flicker Test Accessory hardware and software upgrade has been made and that the Integral software is at version 3.100 or higher in the "About" screen.

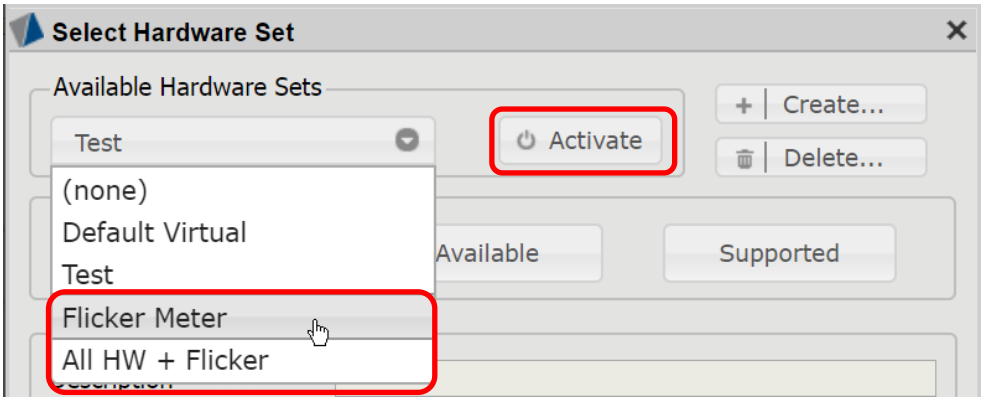


2. Go to the "Actions" column and ensure that the new PstLM button has been added. Refer to section 12.6.4 "PstLM Scan" on page 93.

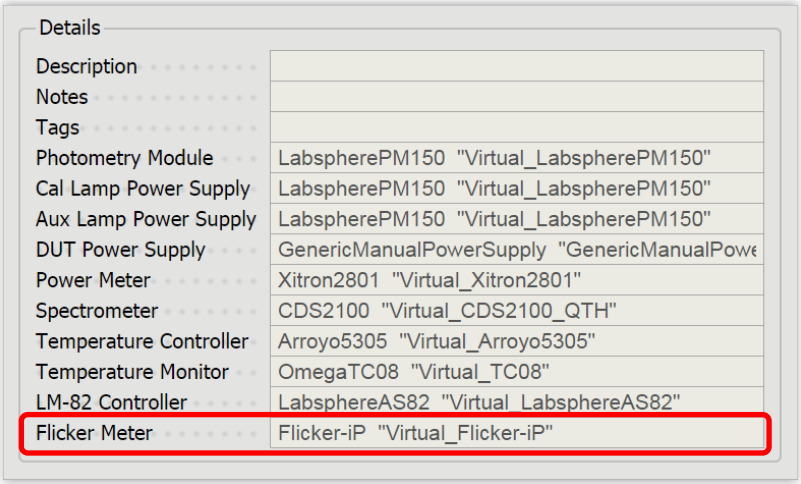
3. Go to the System Hardware menu and click “Choose” to open the “Select Hardware Set” screen. Ensure that the text “Flicker Meter” appears at the bottom of the list in the “Details” panel.



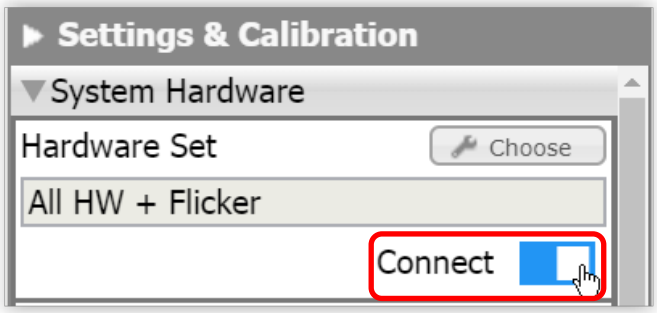
4. Click on the “Available Hardware Sets” drop-down menu and select either “Flicker Meter” to customize a new hardware set, or select “All HW + Flicker” to add the Flicker function to the Default hardware set.



The Flicker Meter hardware description will appear in the resulting “Details” list.



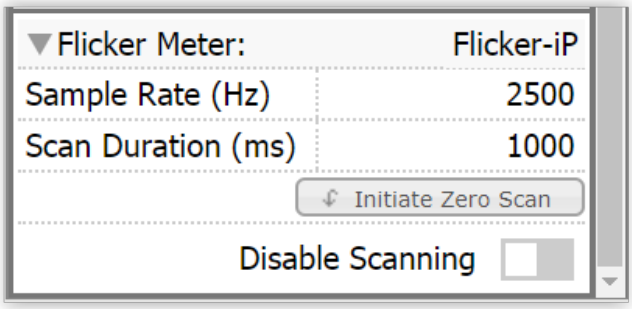
5. Click the “Activate” button and note the addition of Flicker to the resulting “System Hardware list. Click the “Connect” switch to connect the Flicker hardware to the IllumiaPlus Plus system.

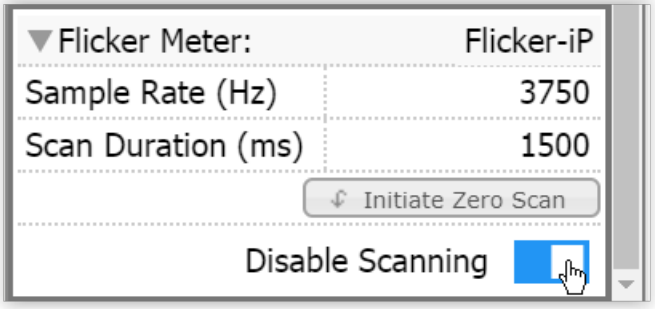


12.6.2 Flicker Operation

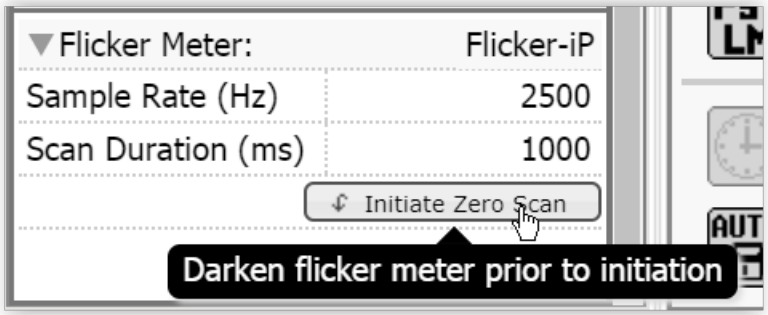
1. Scroll down through the Hardware Settings list to the Flicker Meter line and open its control panel.

NOTE: *Once the Flicker hardware has been activated, it will scan for flicker analysis and generate flicker data in every illumiaPlus light measurement function. This may not be necessary or wanted in certain situations, in which case, click the "Disable Scanning" button at the bottom-right of the Flicker Meter panel.*

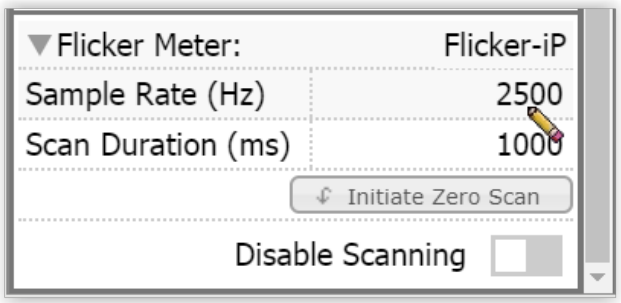


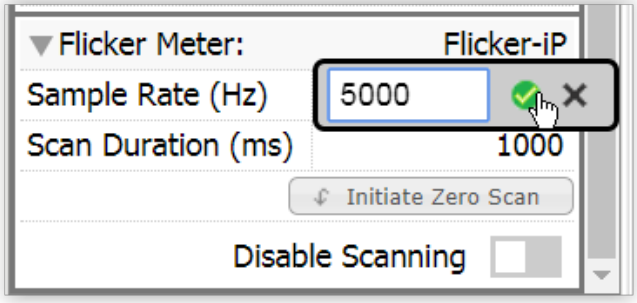


2. Click the "Initiate Zero Scanning" button to darken the flicker meter prior to initiation if necessary.

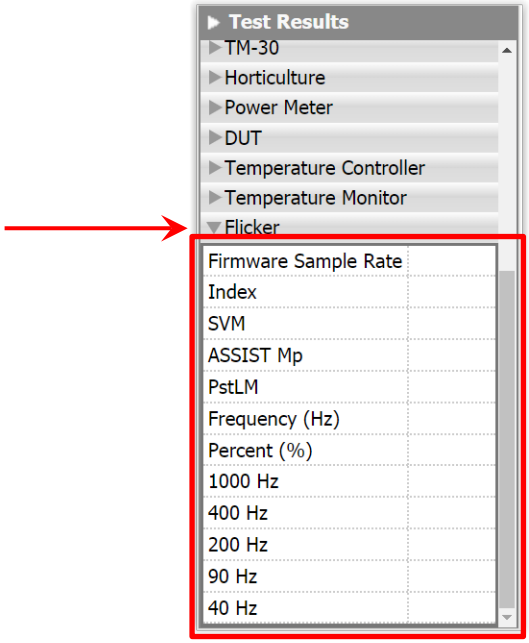


3. Enter the desired sample rate and scan duration with the pencil tool and click the green check marks to save the values.

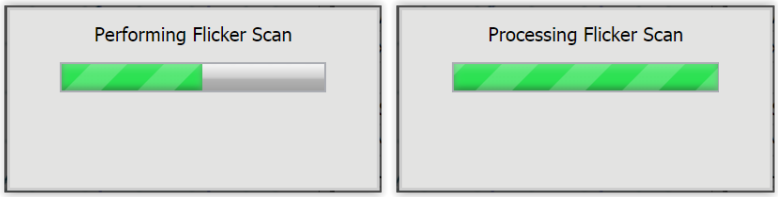




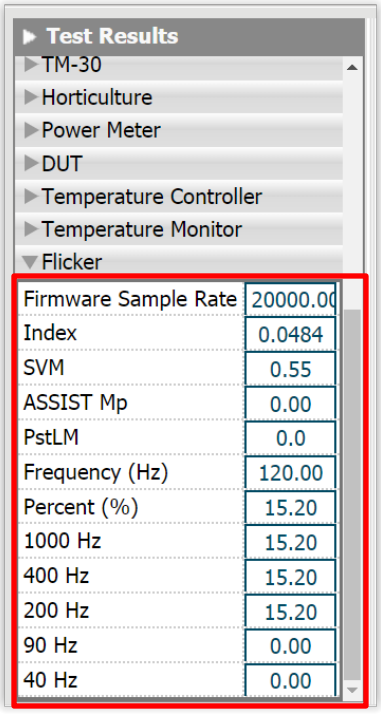
4. Scroll down through the Test Results list to the Flicker line and open its parameter value screen.



5. Execute a single or continuous scan action command. The following Flicker progress windows will briefly appear:



6. Once the scan is complete, the Flicker parameter value screen will display the results:



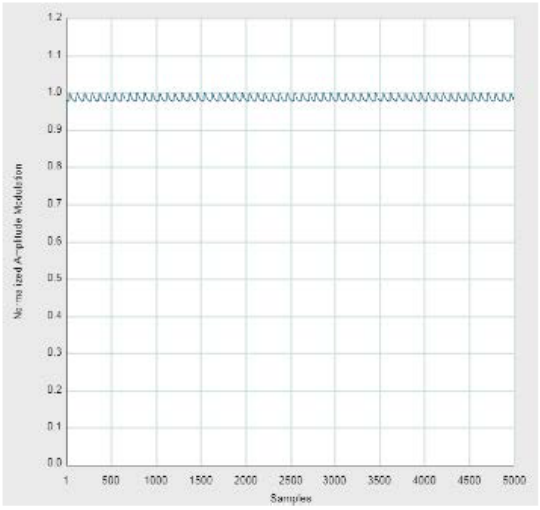
7. A Flicker Measurement Report will display the data in more detail. Refer to section 17 “Reporting” on page 111 for information on generating data reports.

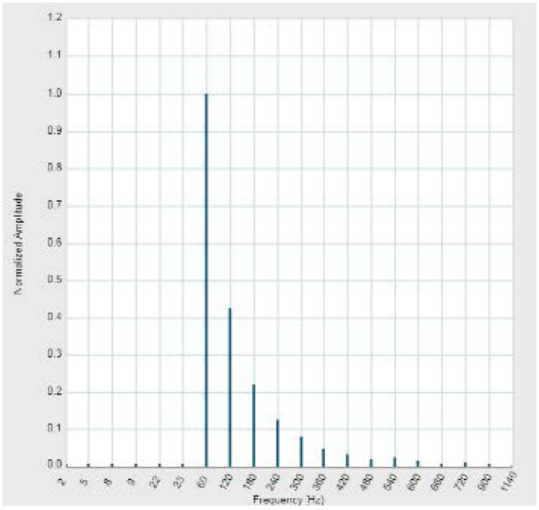
Flicker Measurement Report

Generated by Labsphere's Integral™ Light Measurement Platform

Date		**Equipment**	Flicker-iP with Virtual CDS2100
Lab	Labsphere test lab	**Scan Duration (ms)**	1000
Operator	Marc Southard	**Sample Rate (Hz)**	5000
Entity	Labsphere, Marc Southard, 231 Shaker Street, North Sutton, New Hampshire 03260 603.927.4266 msouthard@labsphere.com		
Manufacturer	Labsphere internal test on a standard 15.6" laptop monitor.		
Orientation	Directly mounted to monitor.		
Dimmer	None, Dell, LCD Monitor		
Source	IPS Display, Samsung, SDC4C48		
Ballast/Driver	Driver, Samsung, Dell Latitude E5550		

Flicker Waveform **Fast-Fourier Transform**





Test Results					Amplitude Modulation					
Flicker Index	**Percent Flicker**	**SVM**	**ASSIST Mp**	**Freq.**	**Cut-off Frequency**	1000 Hz	400 Hz	200 Hz	90 Hz	40 Hz
0.00	1.18	0.04	0.03	60.00	**100% output**	1.20	1.23	1.27	1.03	0.04

12.6.3 Firmware Sample Rate

The requested flicker sample rate is entered in the Flicker Meter and displayed in the Firmware Sample Rate window after scanning. These two numbers will not be the same but actually represent the same value. In the example below, the flicker sample rate has been entered as 2500 Hz and the Firmware Sample Rate window reports it as 20000.00 Hz.

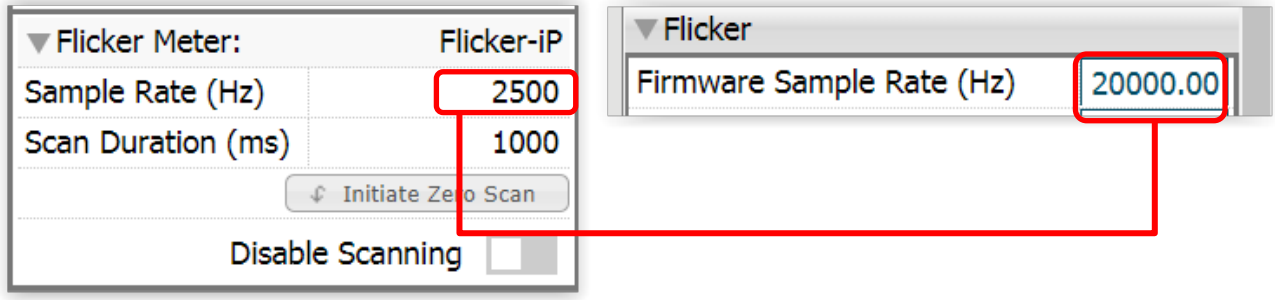


Figure 68: Flicker Meter Sample Rate vs Firmware Sample Rate

This difference in numbers comes from the anti-aliasing function that the Flicker-iP detector applies to *average* the transient signal samples. Therefore, the higher sample rate shown in the Firmware Sample Rate window represents the *pre-averaging* sample rate performed by the Flicker-iP detector, and the lower sample rate shown in the Flicker Meter window represents the *post-averaging*, anti-aliased sample data.

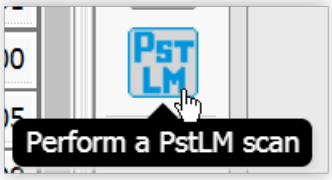
JA.10 Compliance Note

Flicker-iP will select the maximum internal Firmware Sample Rate of 20000.00 when either an effective sample rate of 5000 or 2500 is requested in the Flicker Meter window. Note that entering random sample rate values in the Flicker Meter window may yield non-linear results in the Firmware Sample Rate window.

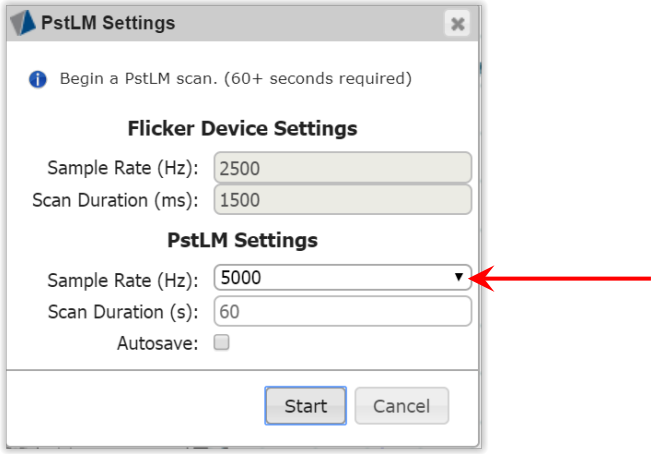
12.6.4 PstLM Scan

One of the parameters in the Flicker parameter value screen is PstLM. Acquiring the data for this parameter requires a separate PstLM scan function, which is the light measurement of the *short-term flicker severity* index, known as "Pst". Pst is a statistical quantification of the instantaneous flicker sensation. Refer to section 12.7.6 "PstLM" on page 95 for more information.

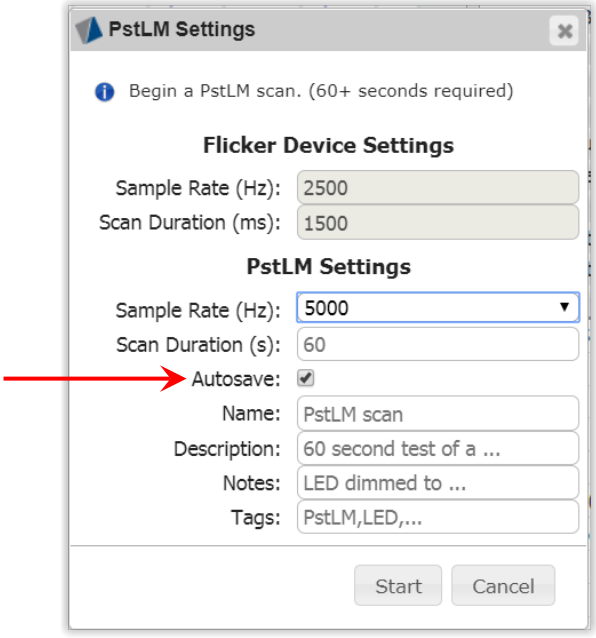
1. Go to the Actions column and click the "PstLM" button. This will bring up the PstLM Settings control panel.



2. Set the Pst sample rate from the Sample Rate drop-down menu. Note that the Flicker device settings are entered in the Flicker Meter control panel defined in step 3 of section 12.6.2 "Flicker Operation" on page 89.



3. Check the "Autosave" box to display more information on the PstLM scan.



12.7 Temporal Lighting Artifacts (TLA) Metrics for Flicker

A TLA is a change in the visual perception of a human observer in the fluctuation of the luminance or spectral distribution over time that is caused by a light stimulus in a particular environment. The following are TLA metrics for the evaluation of flicker that are performed by Integral:

12.7.1 Percent Flicker

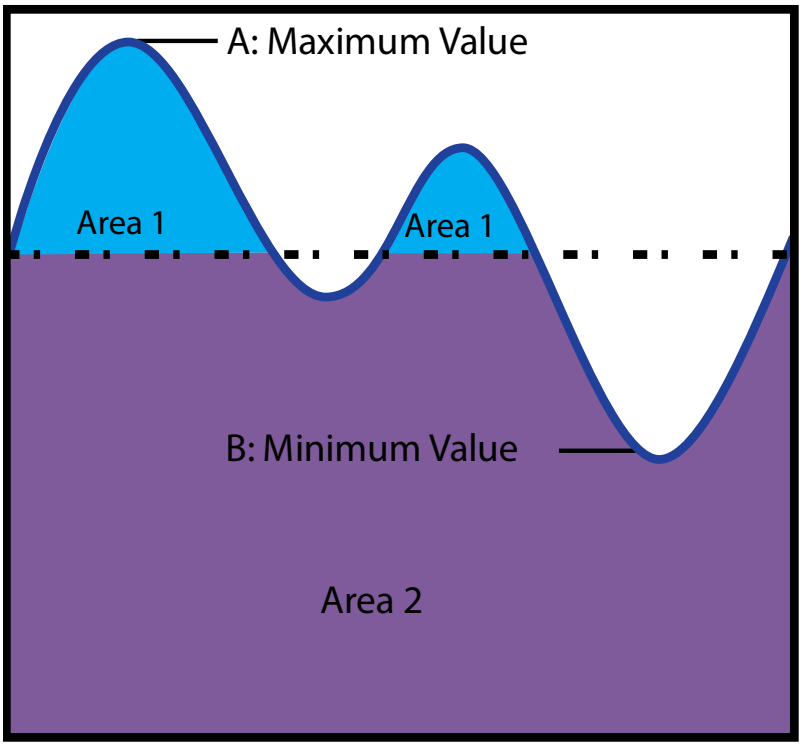
- 0-100% scale
- Accounts for average, peak to peak amplitude
- Percent Flicker = $100\% \times \frac{A - B}{A + B}$

12.7.2 Flicker Index

- 0 – 1.0 scale
- Accounts for average, peak to peak amplitude, shape duty cycle
- Flicker Index = $\frac{\text{Area 1}}{\text{Area 1} + \text{Area 2}}$

12.7.3 Flicker Frequency

- 1 / periods of cycles



12.7.4 SVM

SVM stands for “stroboscopic visibility measure”. The function of this metric is to evaluate the stroboscopic effect (also known as the “wagon-wheel” effect) that happens when moving objects are combined with light modulation within the 80 Hz to 2,000 Hz frequency range. In order to calculate the SVM value, a signal of at least 1 second must be entered into the Flicker meter’s “Scan Duration” parameter window. Refer to step 3 in section 12.6.2 “Flicker Operation” on page 89.

For more information on the SVM metric, go to “NEMA 77-2017 (Temporal Light Artifacts) and CIE TN 006:2016 (Visual aspects of time-modulated lighting systems).

12.7.5 ASSIST Mp

ASSIST Mp is a *perceptual modulation* metric as defined by the Alliance for Solid-State Illumination Systems and Technologies (ASSIST) of the Lighting Research Center. This metric provides a method of quantifying the human response to flicker and accurately predict human flicker perception for any lamp, light output waveform, and frequency. The accuracy of this metric depends on the frequency of modulation to be low enough to be seen directly (typically less than 80 Hz). The interaction of the light source with moving objects (creating a stroboscopic effect) must be avoided to prevent any indirect perception,

Refer to "Recommended metric for assessing the direct perception of light source" Vol 11, Issue 3, Jan 2015; A. Bierman, RPI Lighting Research Center.

12.7.6 PstLM

PstLM is the light measurement function and metric to determine the short-term flicker severity (Pst). This metric is the assessment of changes in luminance caused by the ballast/light source combination with standardized (constant) supply voltage. In short-term flicker, a distinction is made between flicker caused by the power supply voltage and flicker caused by the light source in connection with the ballast.

Refer to IEC/TR 61547-1: 2015 and IEC 60050- 161:1990, 161-08-18.

13 TRIGGER FUNCTIONS

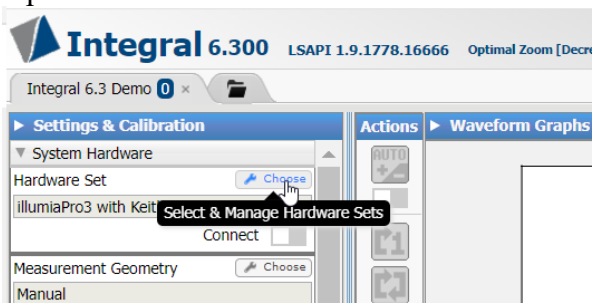
13.1 Lumens Current Voltage Temperature (LIVT) Sweeps and Pulse

Integral can perform LIVT sweeps and pulse of the lumens amount, temperature, current, and voltage.

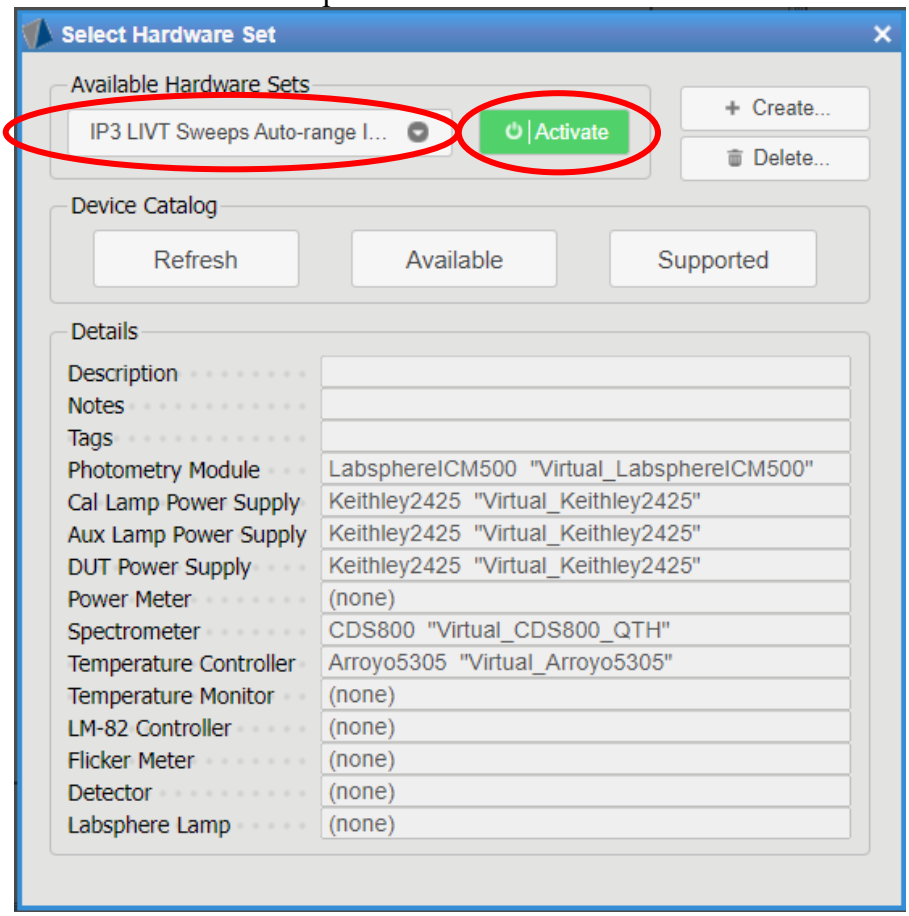
A supported Keithley power supply is required to run this process.

Triggered scans do not use scan averaging.

1. Open the Settings & Calibration window and drop down the System Hardware window and click "Choose" to open the Select Hardware Set window.



2. Choose or create a sweeps hardware set like the one below and click the Activate button:



3. Click the "Perform Sweeping Scans" icon to open the Sweep Settings menus (Standard and Pulse) shown in Figure 69 and Figure 70.

In the Standard column, choose current or voltage in the Power Supply Mode drop-down. Enter the sweep setting parameters as required. Note that the screen shot on the right is an example of typical parameter settings using a Keithley 2425 DUT power supply and an Arroyo 53054 TEC in the hardware set with a 150mA LED as the DUT.

① The "**Soak Time**" setting is how long the LED is on before taking the scan.

② The "**Tolerance"** setting is the range of degrees that the temperature needs to be within before it will stabilize and proceed. This will ensure that the temperature stays where it needs to be.

③ The "**Settling Time"** setting is the estimated time necessary to correct the TEC controller's over-shoot of the target temperature.

④ The **"Nonlinearity Factor"** value represents the amount of the nonlinear compensation algorithm that is applied to the standard sweep scan; with 0.0 = off and 1.0 = fully applied.

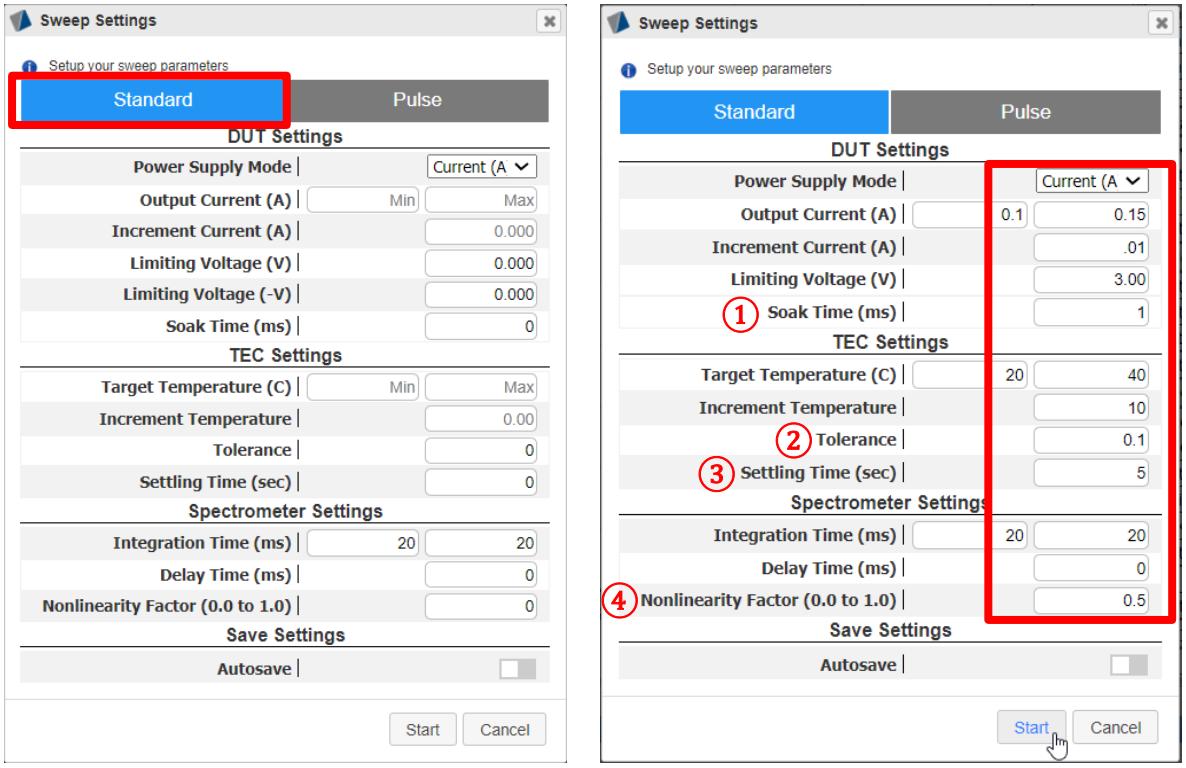


Figure 69: Sweep Settings Parameter Menu — Standard Column

In the Pulse column, enter the comparable sweep setting parameters as required for the pulse mode measurements of the DUT.

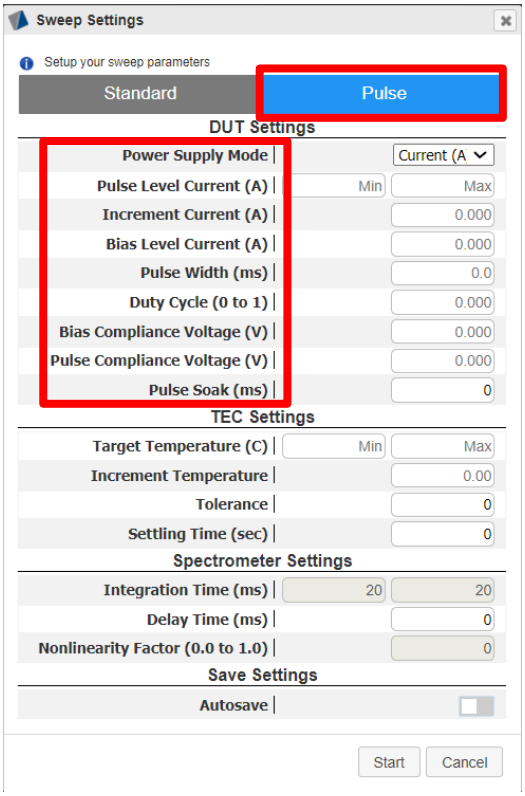
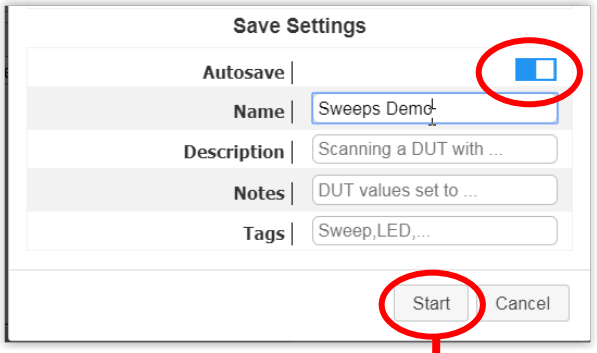
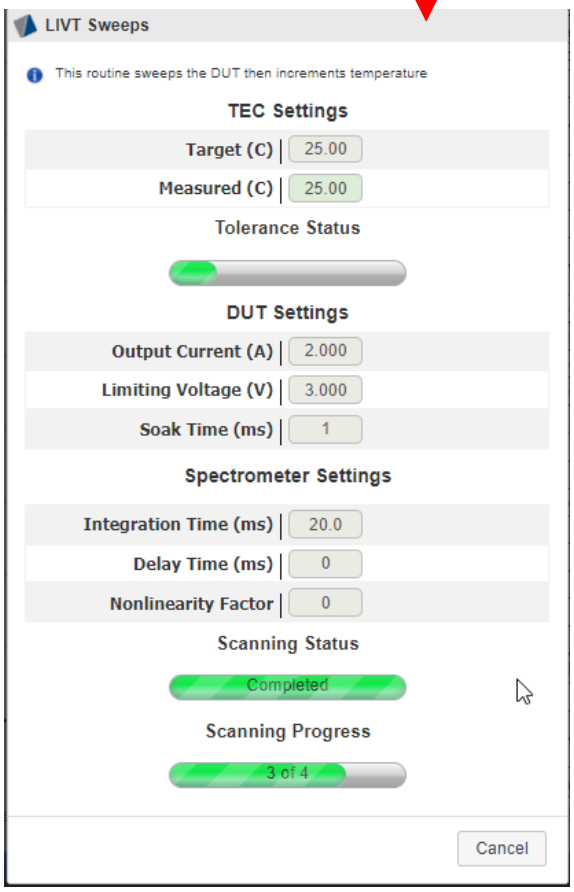


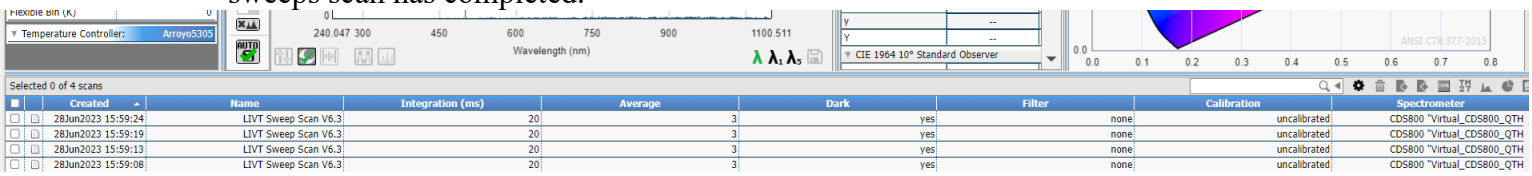
Figure 70: Sweep Settings Parameter Menu — Pulse Column

4. Click the Autosave toggle switch to extend the Sweep Settings window down. Enter the file name of the sweeps scan and any other relevant information, and then click “Start”. The “LIVT Sweeps” progress screen (similar to below) will appear.



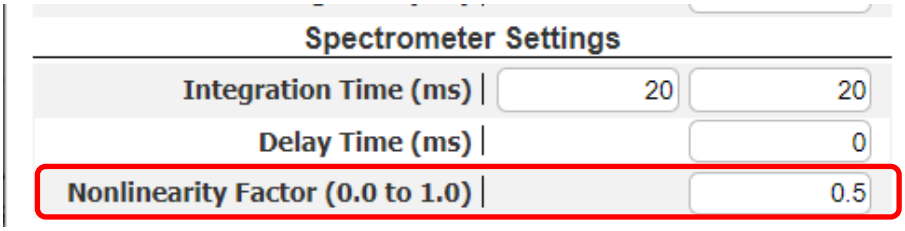


The scan table at the bottom of the main screen will populate with similar data after the sweeps scan has completed.



13.2. Nonlinearity Factor in LIVT Sweep Scans

The nonlinearity factor can be applied to LIVT sweep scans to optimize the resulting data to represent how the LED responds under actual operating conditions. This includes controlling the noise floor under low power conditions and determining the saturation levels under normal and high-power conditions, and for other operating conditions in between.



The value entered in this line represents a *percentage* of the nonlinearity compensation that will be applied to the scan, with "0.0" not applying the factor and "1.0" fully applying it. It is recommended to use a trial, iterative process at first, in order to determine what nonlinearity factor values work best for the LED operating conditions that are anticipated. A comparative example of applying the nonlinearity factor in LIVT sweeps on an OSRAM OSLON® LED is shown below. Graphic examples of applying the factor to this LED and a Bridgelux_BXRE-27S1001-B-7X LED are shown in the next two sections.

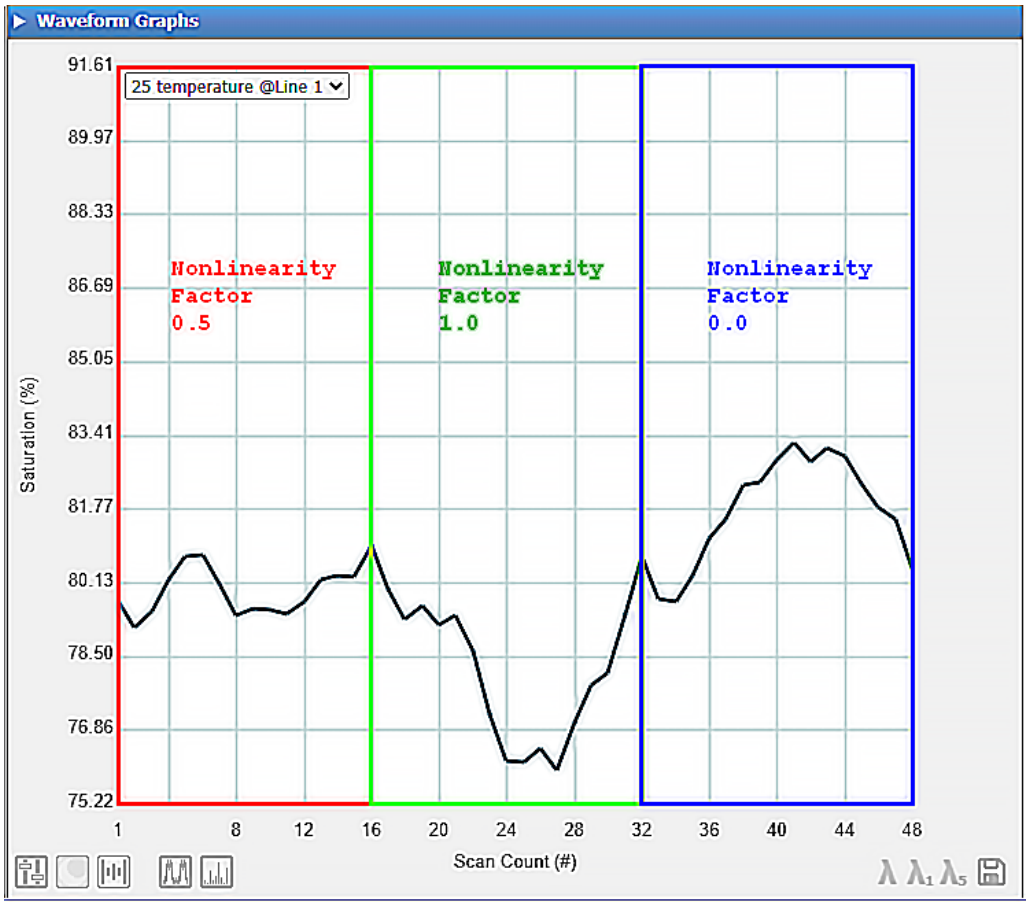


Figure 71: Minimum to Nominal Nonlinearity Comparison

13.2.1. Nonlinearity Examples — OSRAM OSLON® LED

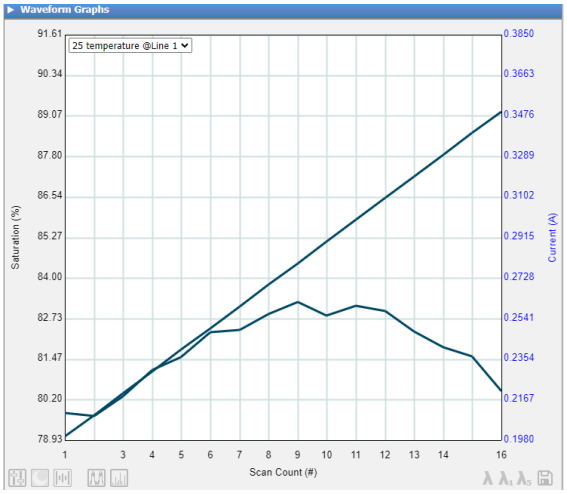


Figure 73: Minimum to Nominal Nonlinearity — 0.0 factor

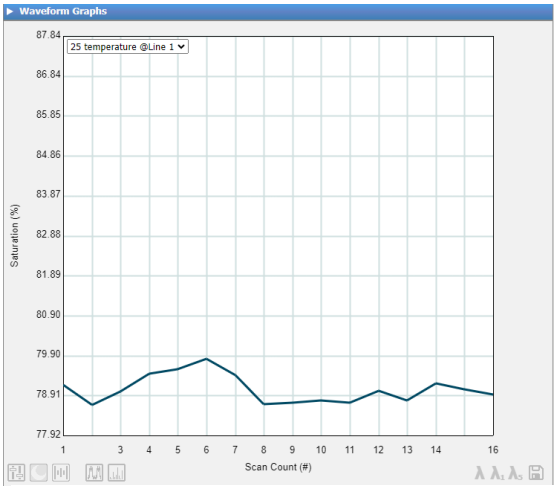


Figure 72: Minimum to Nominal Nonlinearity — 0.4 factor

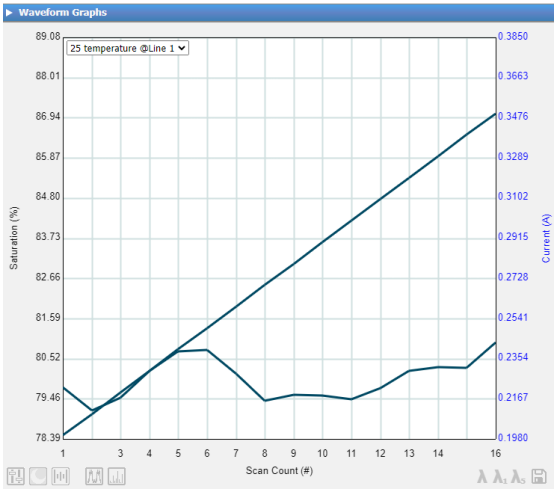


Figure 75: Minimum to Nominal Nonlinearity — 0.5 factor

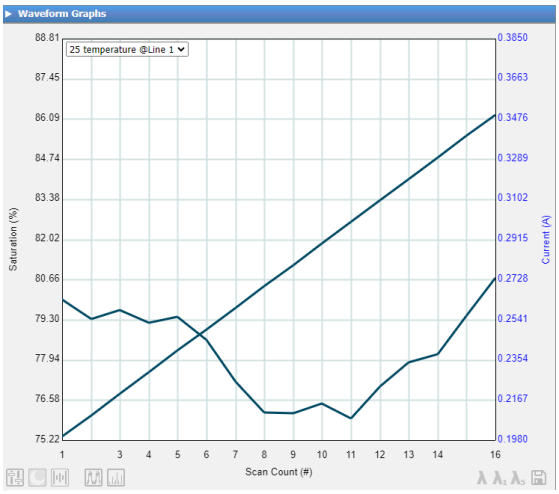


Figure 74: Minimum to Nominal Nonlinearity — 1.0 factor

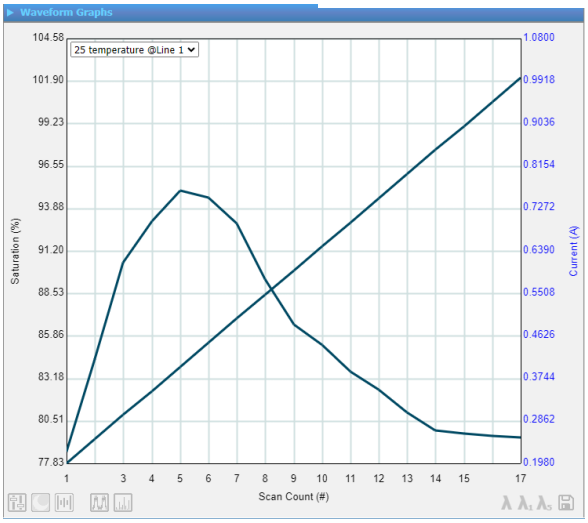


Figure 76: Minimum to Maximum Nonlinearity — 1.0 factor

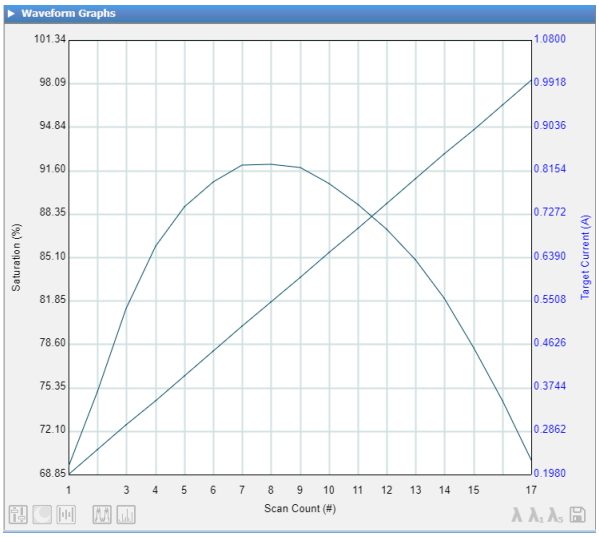


Figure 78: Minimum to Maximum — 70% saturation

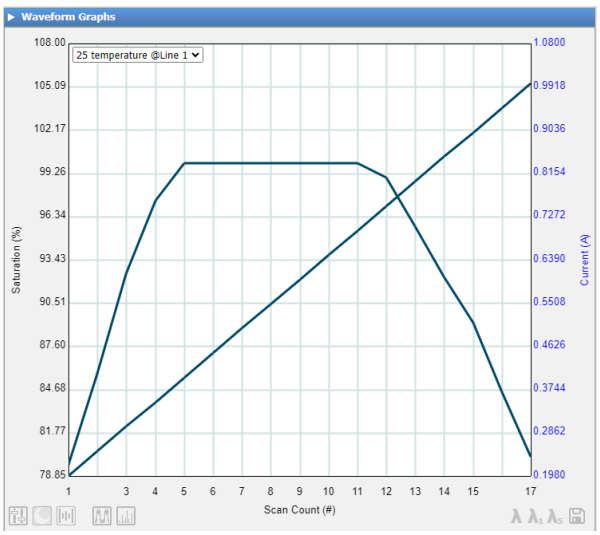


Figure 77: Minimum to Maximum — 80% saturation

13.2.2. Nonlinearity Examples — Bridgelux_BXRE-27S1001-B-7X

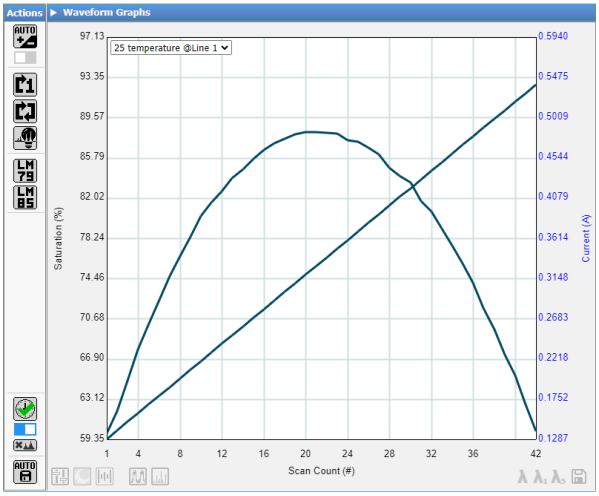


Figure 80: Minimum to Maximum — 60% saturation

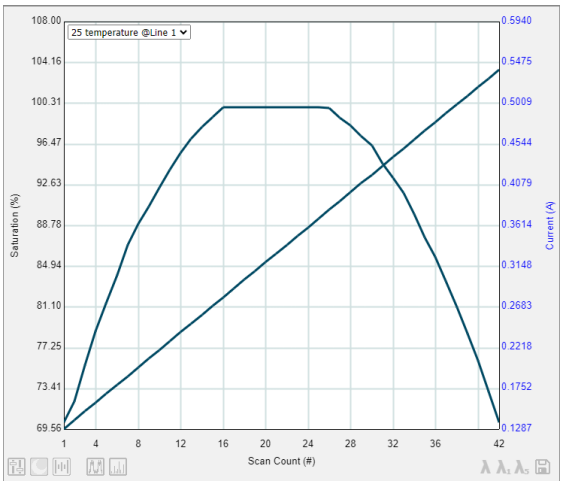


Figure 79: Minimum to Maximum — 70% saturation

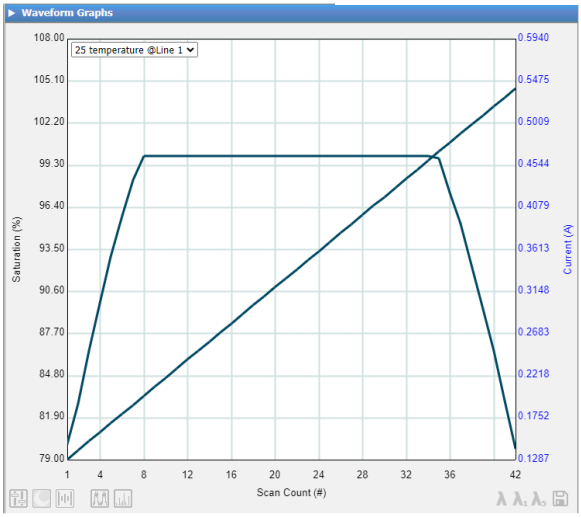
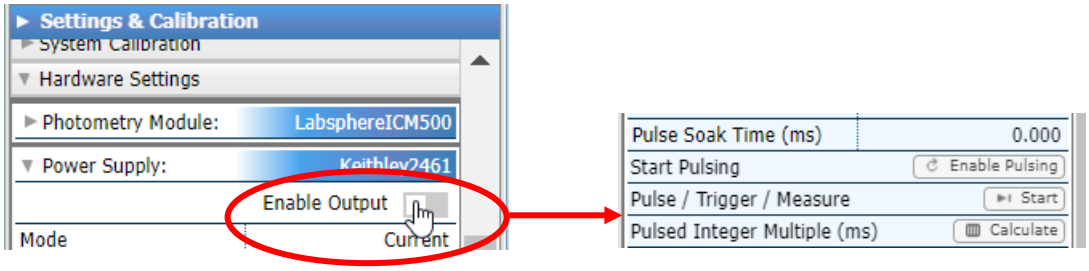


Figure 81: Minimum to Maximum — 80% saturation

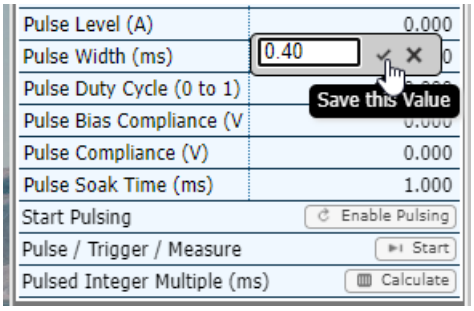
13.3. Integer Multiple Calculator

Integral is capable of taking an accurate spectrometer scan of pulsed measurements without starting or stopping the scan during a pulse. In order to do this, use the Integer Multiple Calculator to ensure the integration time used will start and stop at the same place during a pulsed sequence.

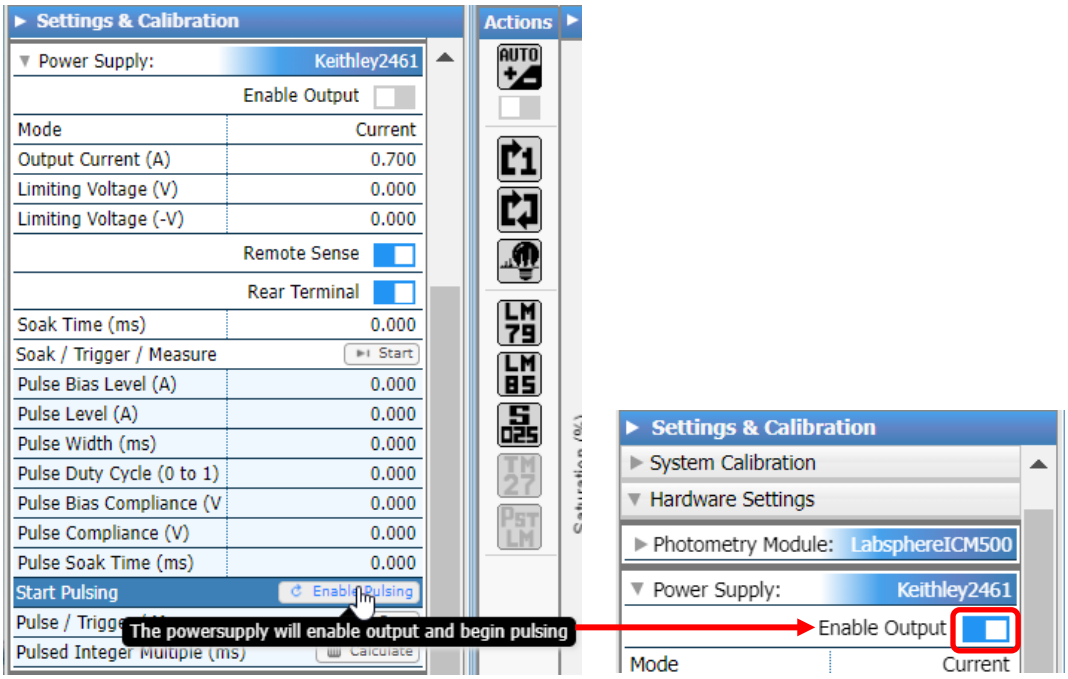
1. Disable the power supply output to access the pulse control buttons.



2. Set the pulse width (ms) to the desired value that is at least 0.4 or higher.

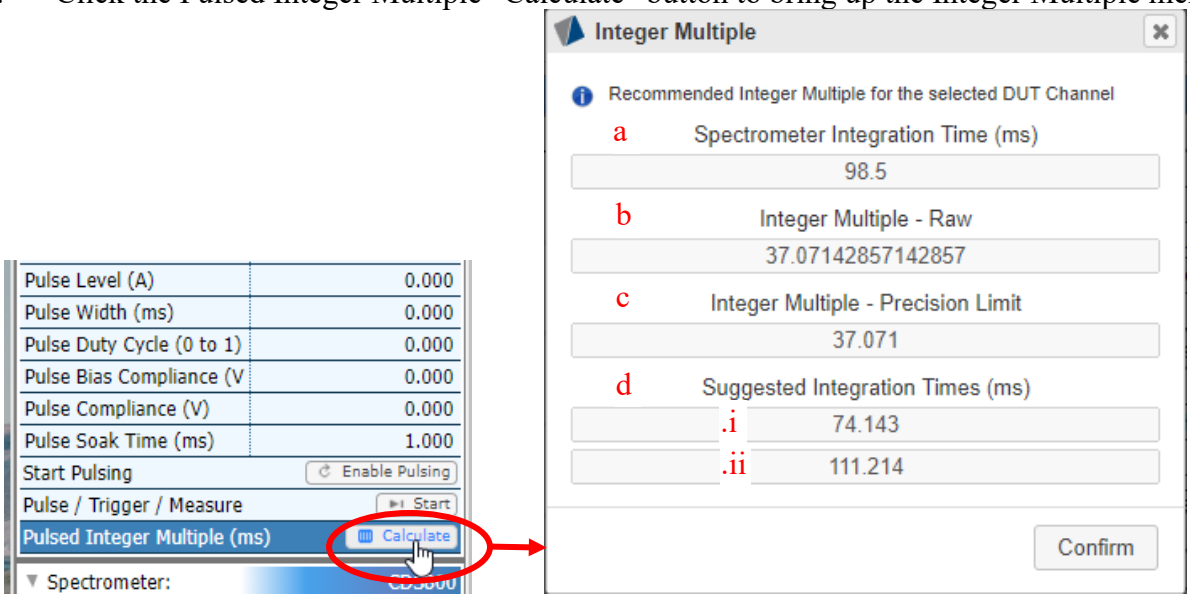


3. Turn the DUT on in pulse mode by clicking the Start Pulsing button. This will toggle the "Enable Output" switch back on as the two are tied together.



4. Perform an autoexposure to ensure the spectrometer reaches ~80% saturation. Refer to section 11.7 “Auto-Exposure” on 64.

5. Click the Pulsed Integer Multiple “Calculate” button to bring up the Integer Multiple menu.



a. **Spectrometer Integration Time:** shows what the auto exposure calculated to hit ~80% saturation.
b. **Integer Multiple - Raw:** The minimum calculated integration time without any rounding applied.
c. **Integer Multiple - Precision Limit:** The limit rounded to the nearest microsecond.
d. **Suggested Integration Time:** The calculator displays the closest calculated Integer Multiple Integration Time for the specified integration time.
   i. Suggested Integration Time *below* the Spectrometer Integration Time (e.g. 74.143)
   ii. Suggested Integration Time *above* the Spectrometer Integration Time (e.g. 111.214)

13.4 Power Supply Remote Trigger Function

The Keithley 2400 series power supplies have a hardware trigger (TRIG) button on the front panel that can be activated remotely in Integral using the Keithley Power Supply control panel.

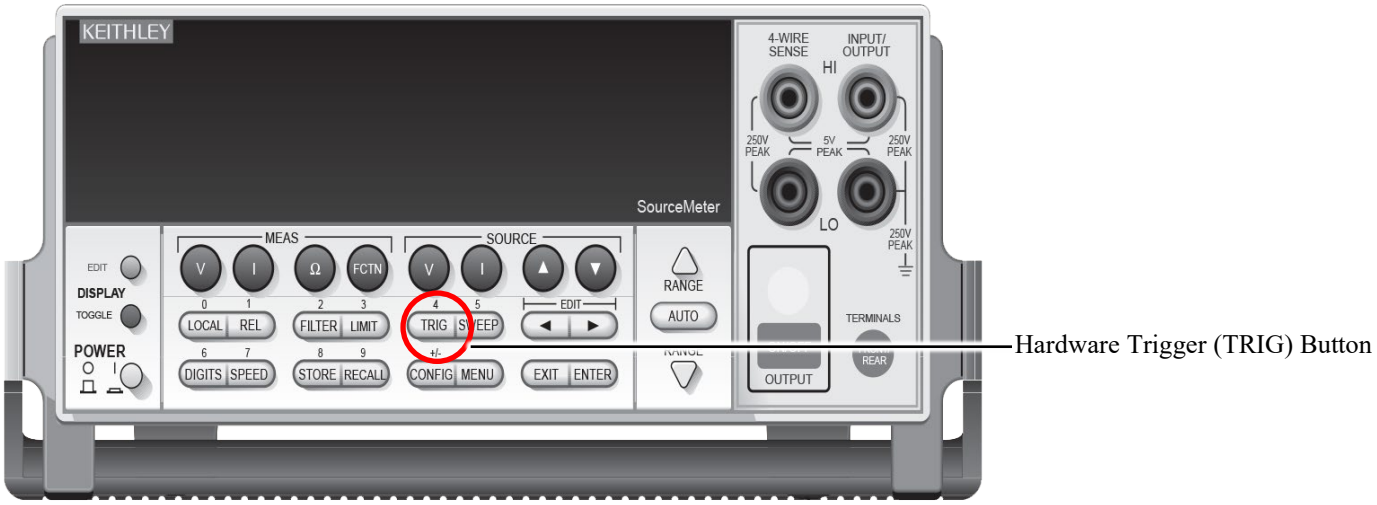
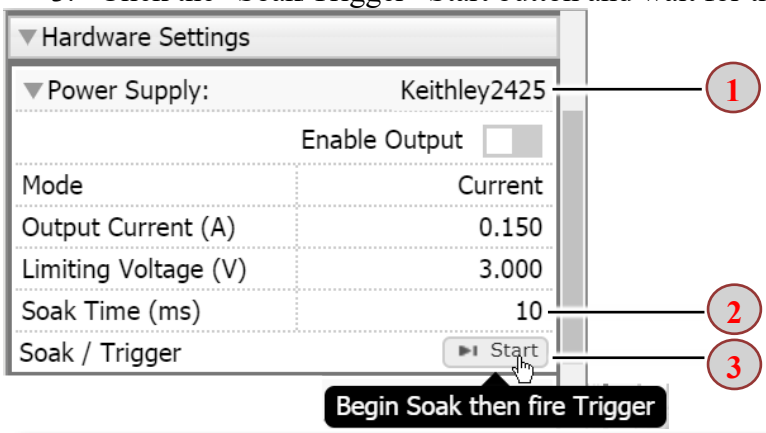
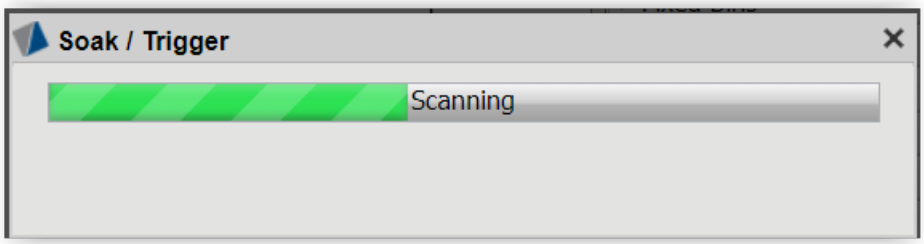


Figure 82: Keithley 2400 Series Front Panel

1. Bring up the Keithley Power Supply control panel on Hardware Settings.
2. Enter the "Soak Time (ms)". Refer to Step 3 on page 97.
3. Click the "Soak/Trigger" Start button and wait for the scanning progress to finish.





14. EXPORTING DATA

Data from scans saved in the database can be quickly exported to the user in .CSV format. Exports include all the data associated with each scan including calculated values such as CRI/CQS/TM-30 and CCT as well as any electrical or temperature measurements that may have been performed.

To export one or more scans, select the desired scan(s) using the check box next to each record in the table displayed at the bottom of the user interface. Alternatively, there are keyboard shortcuts for selecting scans. The CTRL key allows you to select multiple scans singularly. The SHIFT key allows you to select multiple scans from your last selected scan (anchor point) to the desired scan endpoint.

Exported data files (*.CSV) may be opened directly in Microsoft Excel for viewing, copying, pasting, graphing, etc.

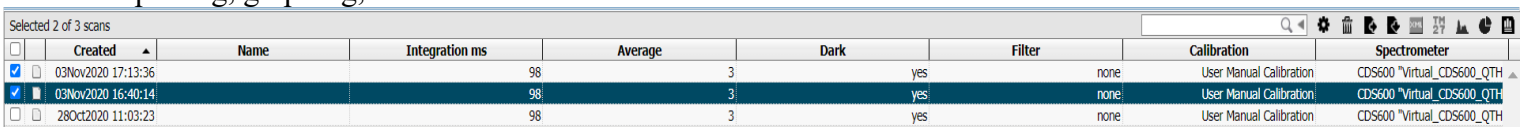
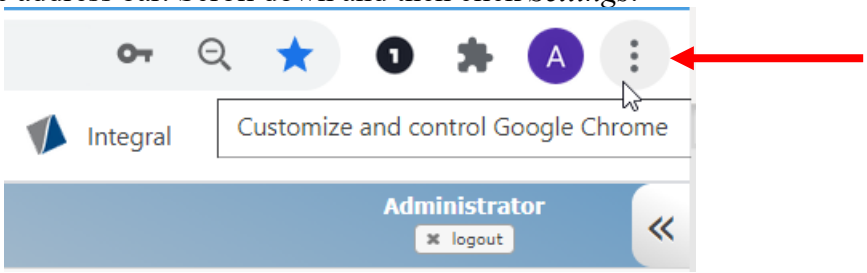


Figure 83: Selecting Scans from the Database

Click the *Export selected scans*  or *transpose*  icon. Data will be bundled into a *.CSV file and delivered to the Chrome browser.

The Chrome browser will automatically save files to the *Downloads* directory. The file download setting for Chrome may be modified to save to a different location or to create a "save as" dialog with every download. Integral has no control over these settings.

To change the file storage location in the Chrome browser, click on the Chrome customize icon on the right end of the address bar. Scroll down and then click *Settings*.



At the bottom of the options page click *"Advanced"* to expand your settings. In the *Downloads* section you can set the download location, or check *Ask where to save each file before downloading*:

Figure 84: Download Storage Location in the Chrome Browser

15. EXPORTING GRAPHS

After displaying a saved scan, you will be able to view it via different chromaticity graphing options. Every chart has different options, and zooming capabilities. Depending on your preference you may want to modify the chart for your own needs before exporting. By clicking the **Export displayed graph** button Integral will copy your currently displayed graph (excluding the overlaid options) and export a .PNG file to your download folder.

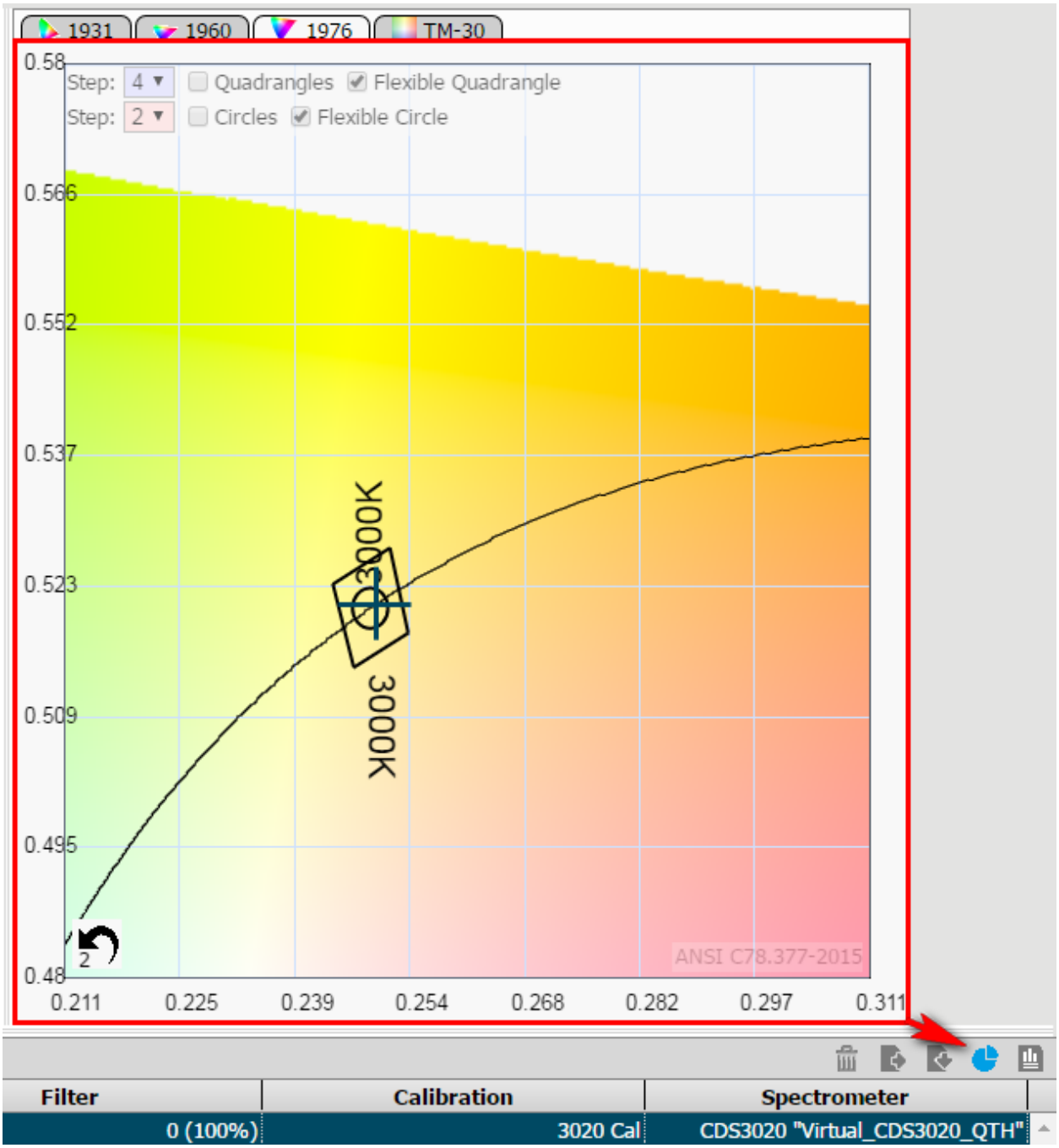


Figure 85: Exporting the Displayed Graph

16. TM-27

IES TM-27-14 *Standard Format for the Electronic Transfer of Spectral Data*

16.1 Export SPDX

By selecting a single saved scan, you will be able to export data in the SPDX standardized format. Checking a single scan and selecting the **TM-27** button generates an XML file with the extension of [**.spdx**]. A 1nm SPDX file is compatible with the IES TM-30 advanced calculation tool. Once the file is generated it can be located in your default Chrome Download location.

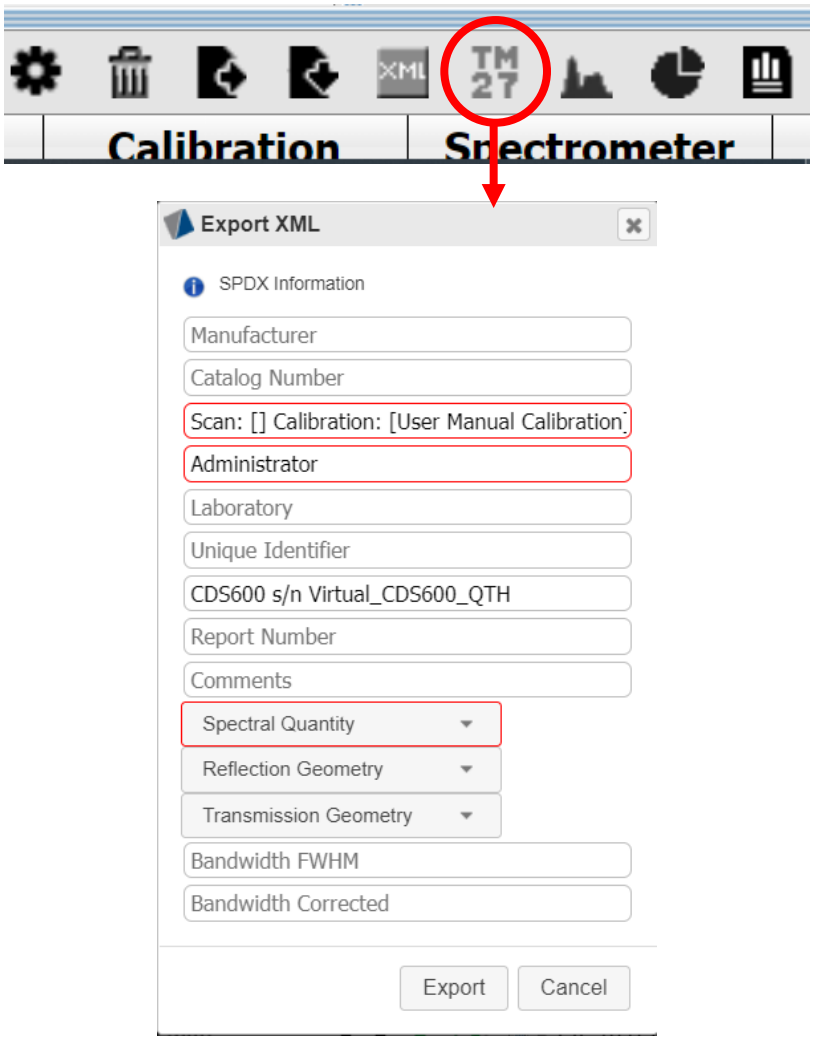


Figure 86: Export TM-27 — required fields circled in red

When defining data for the TM-27 export, there are a few fields which are required. Of these, Description/File Creator and Spectral Quantity must be defined. When inputting a Spectral Quantity, you will be prompted to also define Reflection Geometry for “reflectance” or Transmission Geometry for “transmittance”.

IES TM-27 **Table 3: Spectral Quantity Element Attributes**

“flux”	Radiant flux
“absorptance”	Absorptance
“transmittance	Transmittance
“reflectance”	Reflectance
“intensity”	Radiant intensity
“irradiance”	Irradiance
“radiance”	Radiance
“exitance”	Radiant Exitance
“R-Factor”	Reflectance factor
“T-Factor”	Transmittance factor
“relative”	Relative spectral power distribution
“other”	User-specified in Comments

IES TM-27 **Table 4: Reflection Geometry Element Attributes**

“di:8”	Diffuse / eight-degree, specular component included
“de:8”	Diffuse / eight-degree, specular component excluded
“8:di”	Eight-degree / diffuse, specular component included
“8:de”	Eight-degree / diffuse, specular component excluded
“d:d”	Diffuse / diffuse
“d:0”	Alternative diffuse
“45a:0”	Forty-five degree annular / normal
“45c:0”	Forty-five degree circumferential / normal
“0:45a”	Normal / forty-five degree annular
“45x:0”	Forty-five degree directional / normal
“0:45x”	Normal / forty-five degree directional
“other”	User-specified in Comments

IES TM-27 **Table 5: Transmission Geometry Element Attributes**

“0:0”	Normal / normal
“di:0”	Diffuse / normal, regular component included
“de:0”	Diffuse / normal, regular component excluded
“0:di”	Normal / diffuse, regular component included
“0:de”	Normal / diffuse, regular component excluded
“d:d”	Diffuse / diffuse
“other”	User-specified in Comments

16.2 Import SPDX

Integral can import any file that uses the TM-27 SPDX XML layout. Once a file is selected click "Load" and Integral will process this information similar to a calibrated scan.

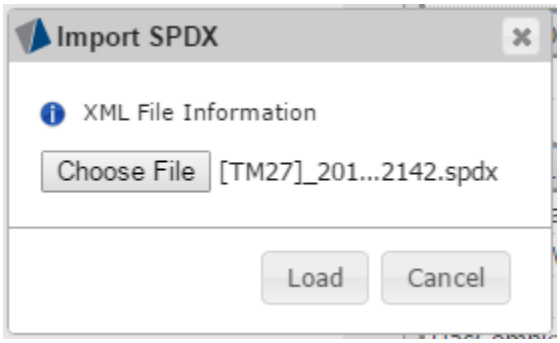


Figure 87: Choose an SPDX/XML to Import

Note: For a spectrum set the Spectral Quantity to "flux"; otherwise select "other" for any other type of scan data being imported (Integral *TM-27 export* sets this automatically). Refer to a TM-27 SPDX file to view all settings used by Integral when uploading a file created with other software.

17. REPORTING

Reporting is similar to Exporting but provides more advanced features for formatting data, adding graphics, and producing a polished, professional report.

To upload a new report template please see: Reports.

17.1 Creating and Generating a Report

Once a report definition is loaded into Integral it is available for use for "Creating" a report. Reports are created from the main window by selecting desired scans using the check boxes ☑ in the database view and clicking the **Generate a Report** button on the right. Choose the template (loaded earlier) to use for this report and click **Select**.

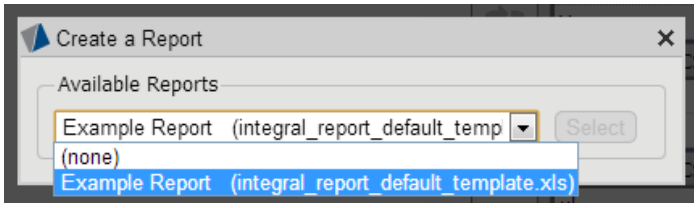


Figure 88: Choose a Report Template

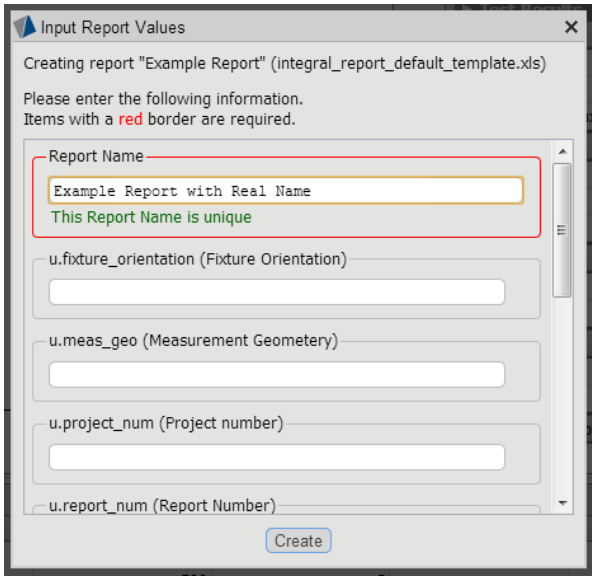


Figure 89: Input Report Values (User Data)

The Input Report Values dialog handles all the information that the report can include, based on the report template loaded earlier, which are not "standard" Integral data. For example, a report template calls for "u.something" which is a user tag and not standard measurement data. The Input Report Values dialog asks the user to fill in the field for u.something. This dialog also includes a way to choose any images that were not set earlier.

Further, there are some required fields. The first required field is the "Report Name." Report Name is not necessarily part of the report template but is required for Integral. All reports must have a unique name. This name is used in the Integral reports database and allows previously-created reports to be re-generated at any time.

Other data fields are defined by the report template and may or may not be required. Required fields are highlighted in red. Once all required fields have data a user may click **Create**. A report will be created and may be sent to the user, if desired. The user does not need to generate a copy of the report at this time as report generation can happen any time in the future through the manage report section of the Main Menu. If the user asks for a copy of the report, that file will be created and sent to the browser.

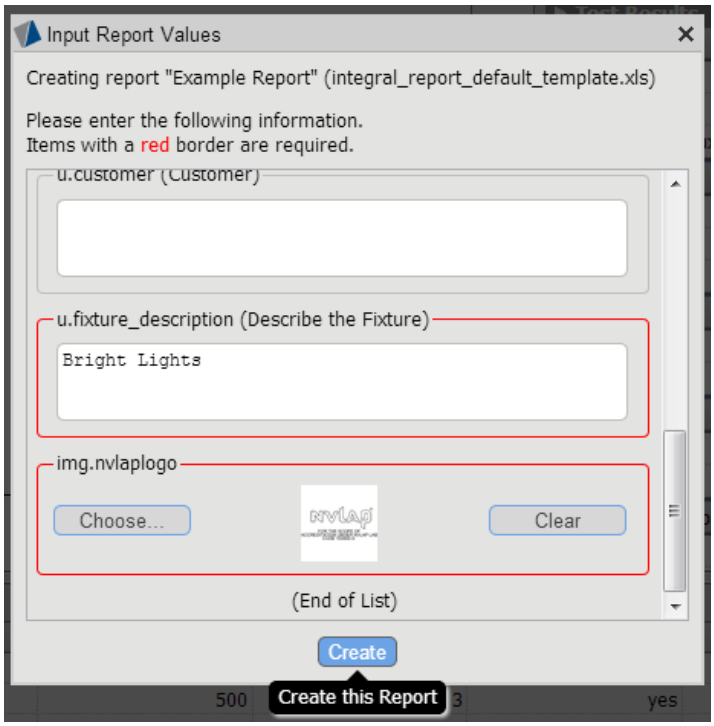


Figure 90: User Data and Inputs

A report will be created and may be sent to the user, if desired. The user does not need to generate a copy of the report at this time as report generation can happen any time in the future through the manage report section of the Main Menu. If the user asks for a copy of the report, that file will be created and sent to the browser.

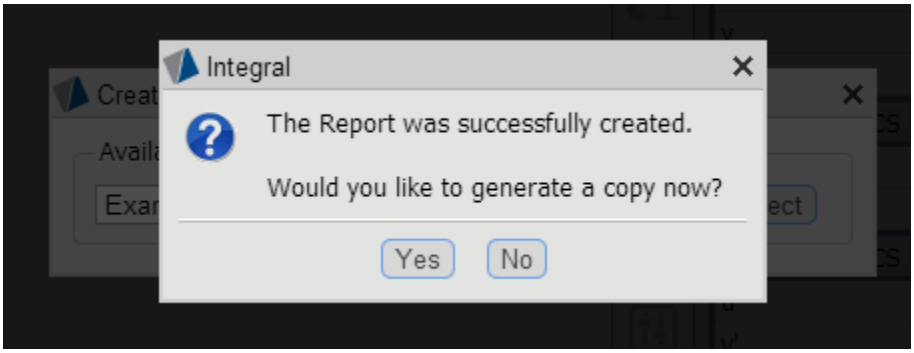


Figure 91: Getting a Copy of the Report

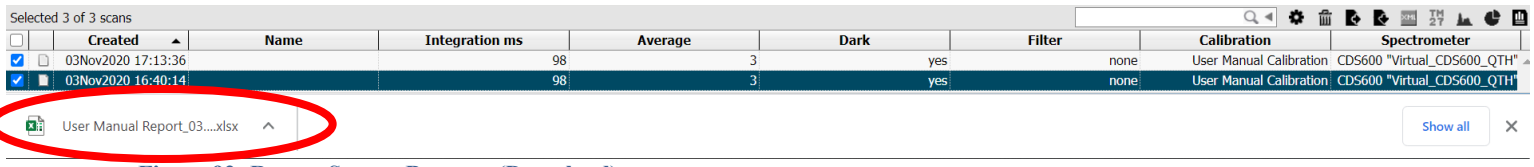


Figure 92: Report Sent to Browser (Download)

The report.xlsx file may be opened in Excel or compatible program. Note: Google "Sheets" can open .xlsx files and may be used online in Google Docs and as a "Chrome App." However, please note that Integral reports are formatted for best viewing in Excel.

Please also note that the report Template may specify more than one worksheet in the resulting Report workbook.

See "APPENDIX 3: CREATING AND WORKING WITH REPORT TEMPLATES" for more information on creating and modifying report templates.

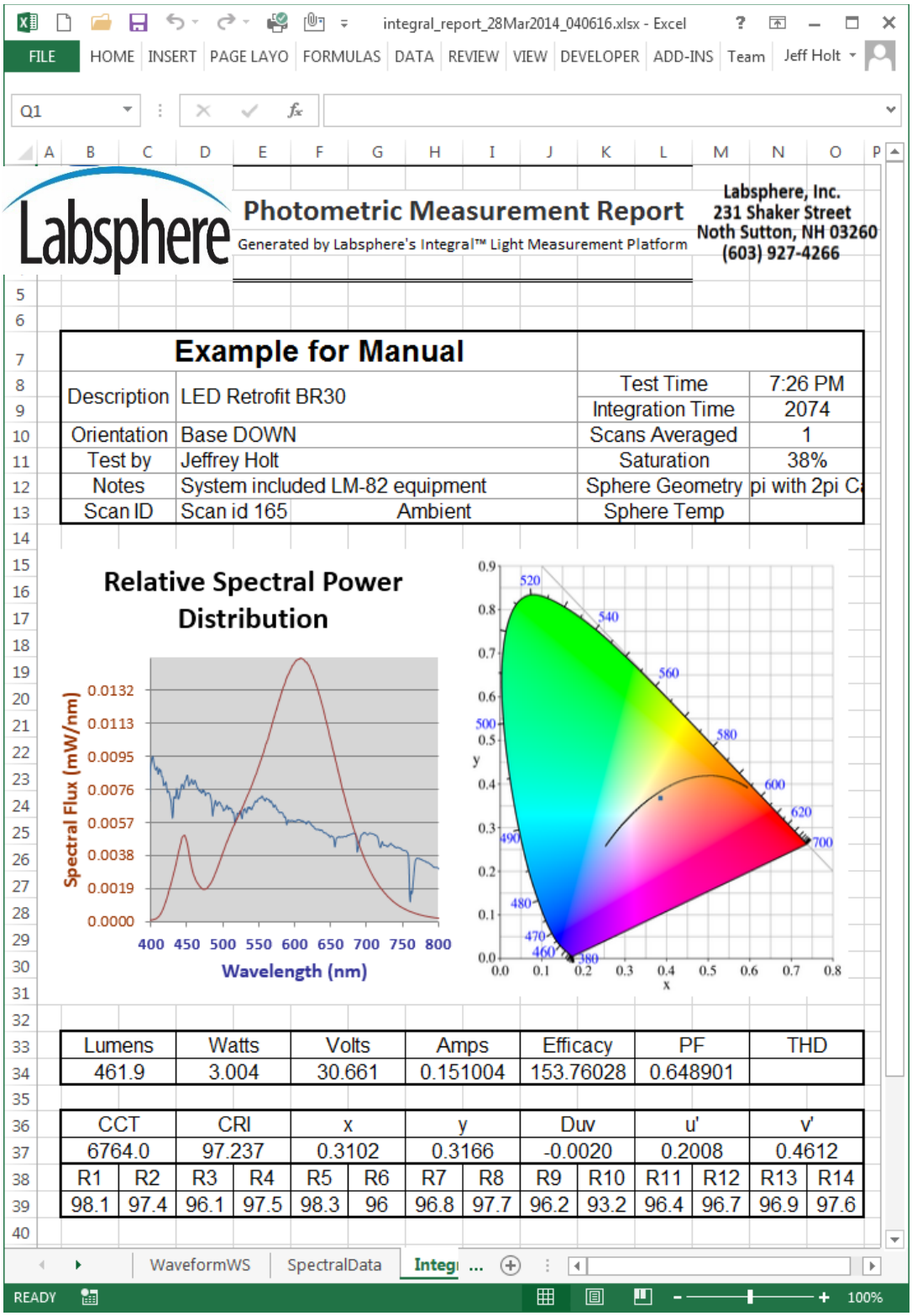


Figure 93: Sheet One of Report

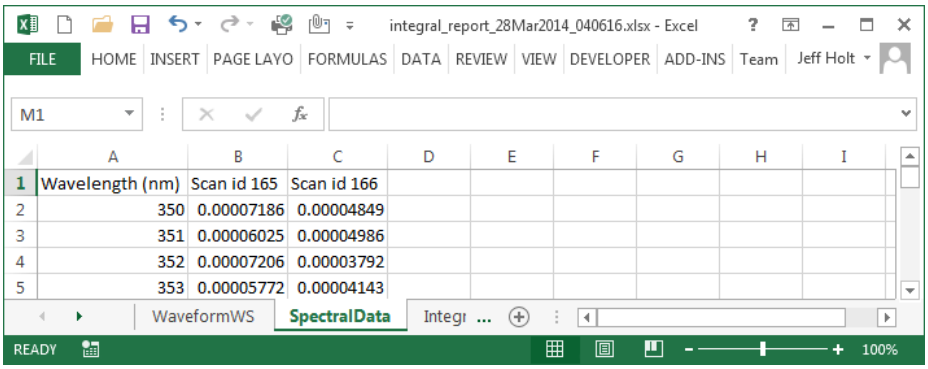


Figure 94: Sheet Two of Report

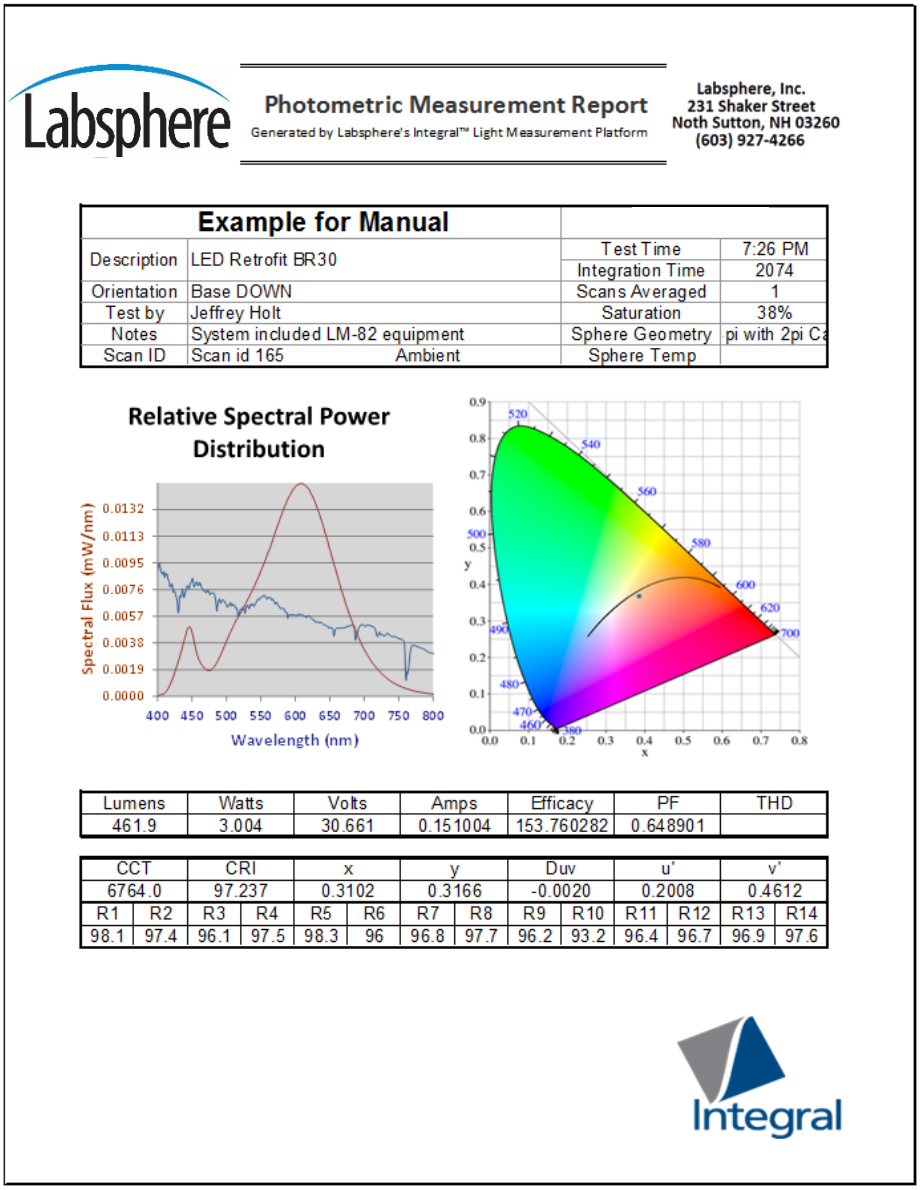


Figure 95: Printed Report

18. MAIN MENU ADMIN CONTROLS AND SYSTEM SETTINGS

Admin controls and system settings are listed in the Main Menu under "Settings". Click the double arrow icon in the upper right section of the main screen to expand the Main Menu window.

18.1 System Settings

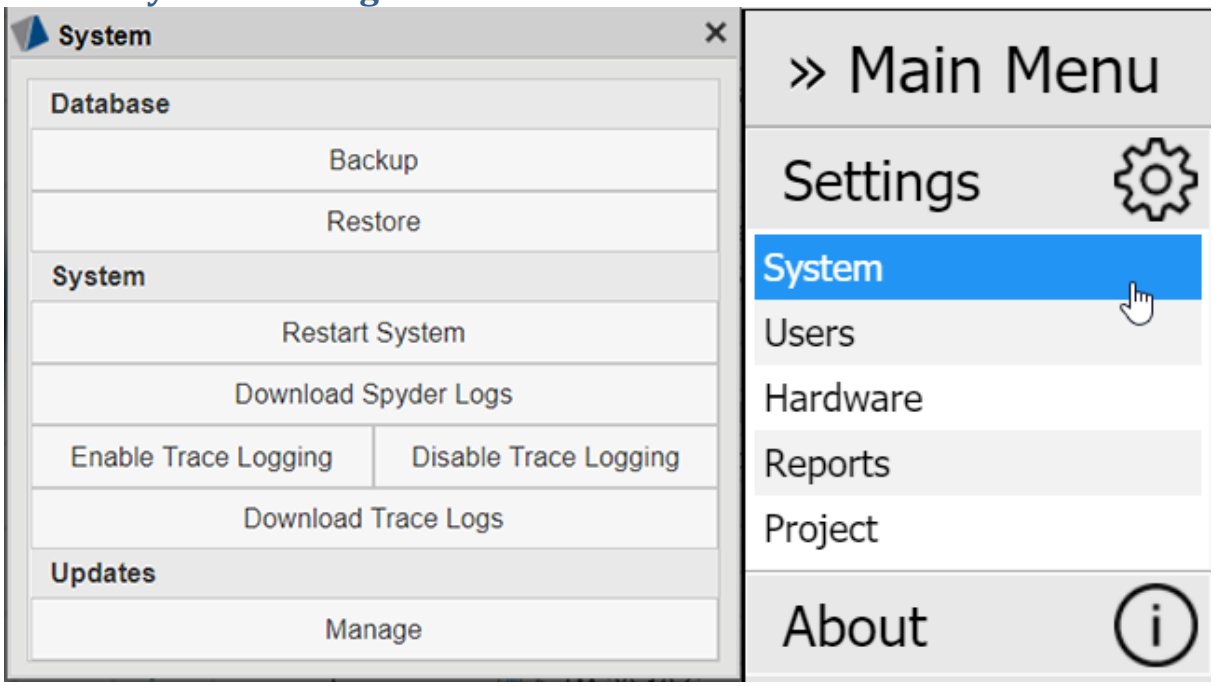


Figure 96: System Settings

18.1.1 Backup and Restore the Integral database

- Backup packages the database and sends it to the Chrome browser; similar to file exports and reports
  - Save this file locally, to a USB stick, or to a network location
- Restore will take a previously saved database and re-install it to be the current database
  - Remember that Integral launches a File Browser on the device currently being used – the saved database file must be visible from that device

18.1.2 Restart the System

- In rare instances it may be necessary to restart the Integral server remotely
  - Click **Restart System** and Integral will do the rest

18.1.3 Manage Updates

The Integral platform is continuously expanding. Occasionally Labsphere will provide customers with active support plans an "Integral Update" file. This file may be sent via email or located on the Labsphere server or Internet location.

The Integral update file name with look like this: "I-1.001.iup."

Click the **Manage** button to install and activate a new version of Integral.

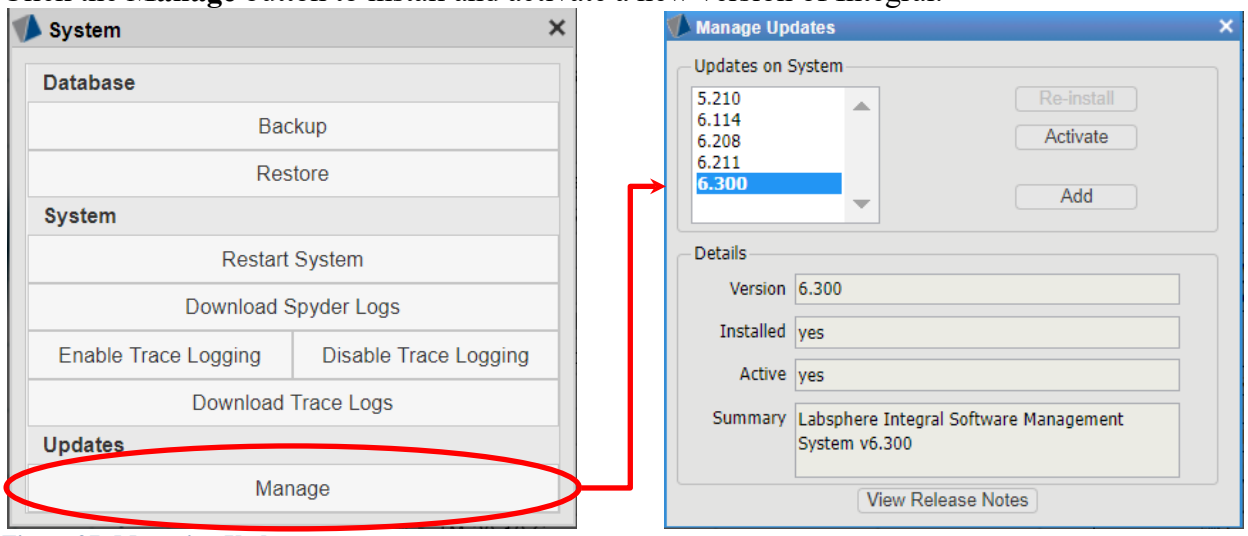


Figure 97: Managing Updates

Clicking **Add** will provide a window with two choices: "Search Removable Media" and "Upload an Update." If the update file is on a USB drive, plug this drive into the host computer and click the **Search Removable Media**.

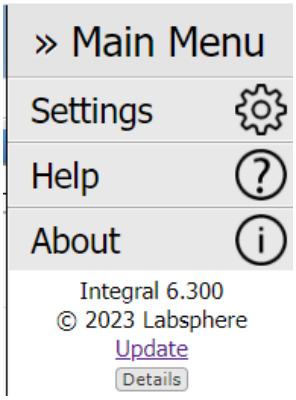
If the file is already downloaded somewhere click **Upload an Update** to open a File Browser. Then navigate to the update file and upload it.

Once loaded, the new version will appear in the list as in Figure 85: Managing Updates. Click the desired version (like the highest number) and click **Install**.

Next, **Activate** the new version. Activating will migrate the current versions database into the new version (no data will be lost) and restart the Integral server using the new version.

18.1.4 Downloading Updates

Integral includes a link to the Labsphere Customer Support web page. Go to: *Main Menu* → *About* and click "Update".



The Labsphere Customer Support web page will then open in Chrome. Enter your contact information, type "Integral update request" in the "How may we help you" field and click "Send".

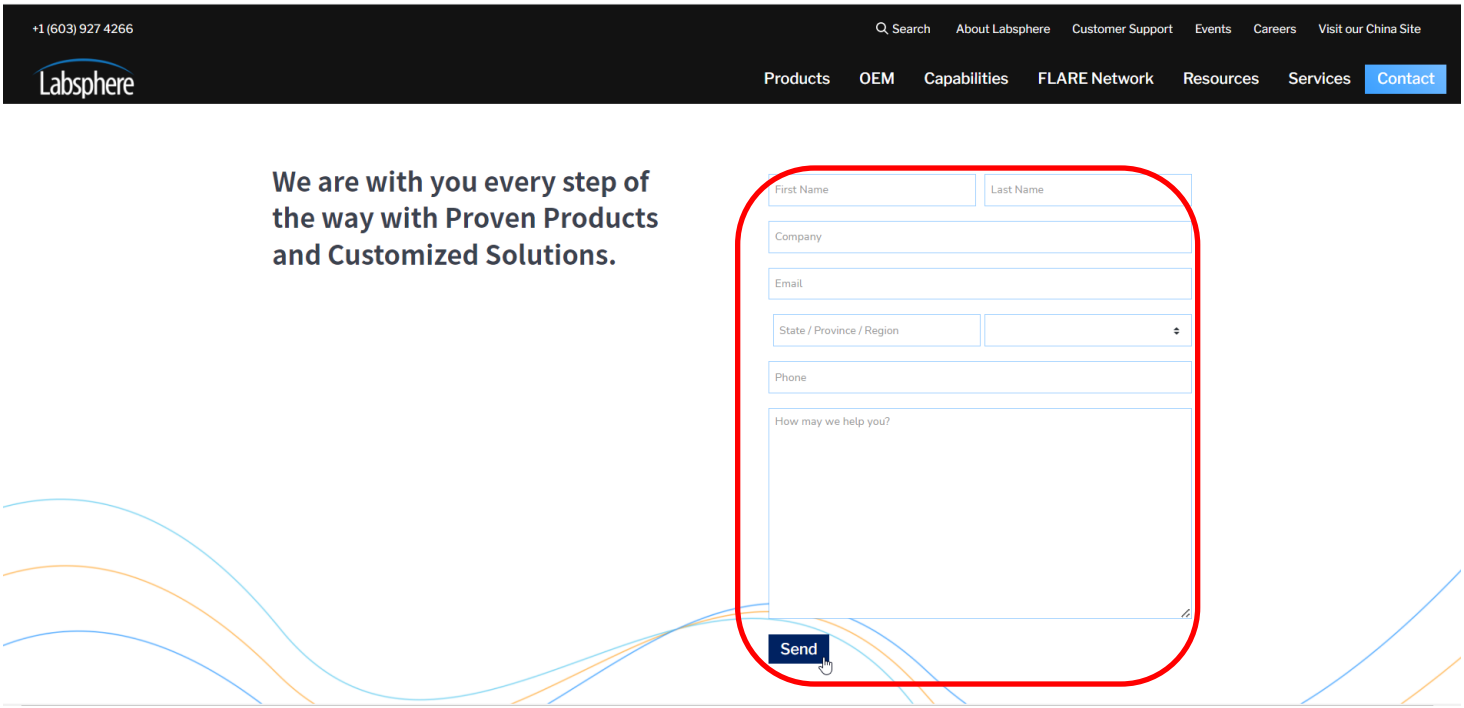


Figure 98: Labsphere Contact Page for Integral Update Request

18.2 User Settings and Controls

18.2.1 Changing Integral User Names, Passwords, and Permissions

Use the Main Menu "flyout" control in the upper right of the user interface. Select **Users** to bring up the *Manage Users* window. Select a user and click **Edit** and set the desired new settings. Click **Save** when complete.

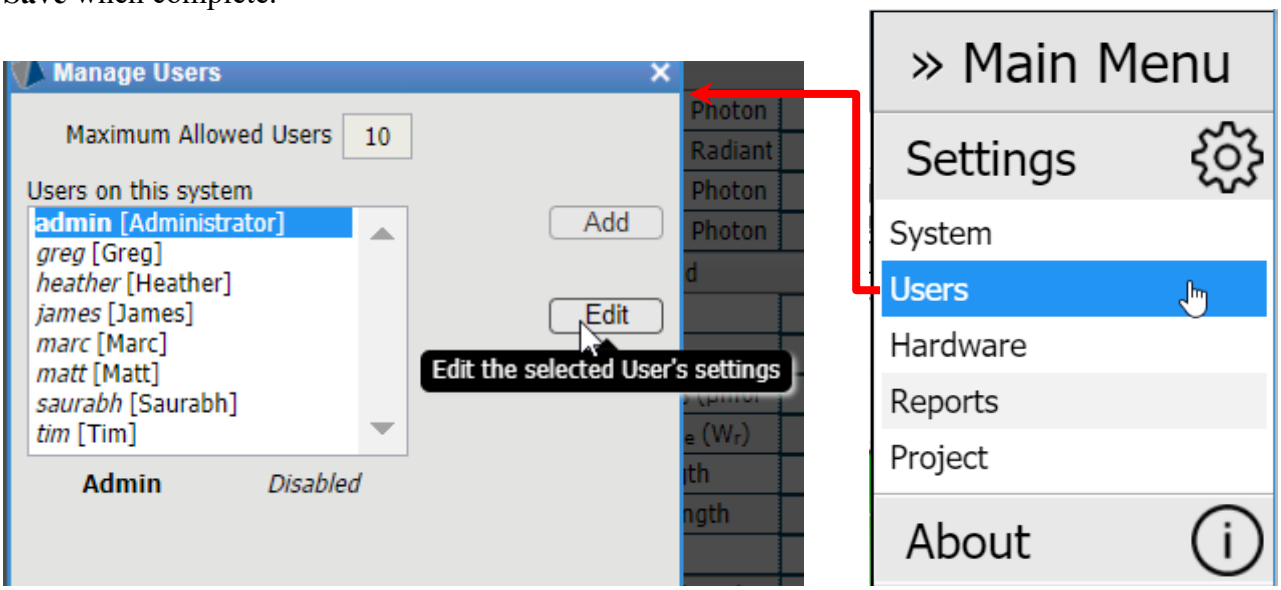


Figure 99: Manage Users

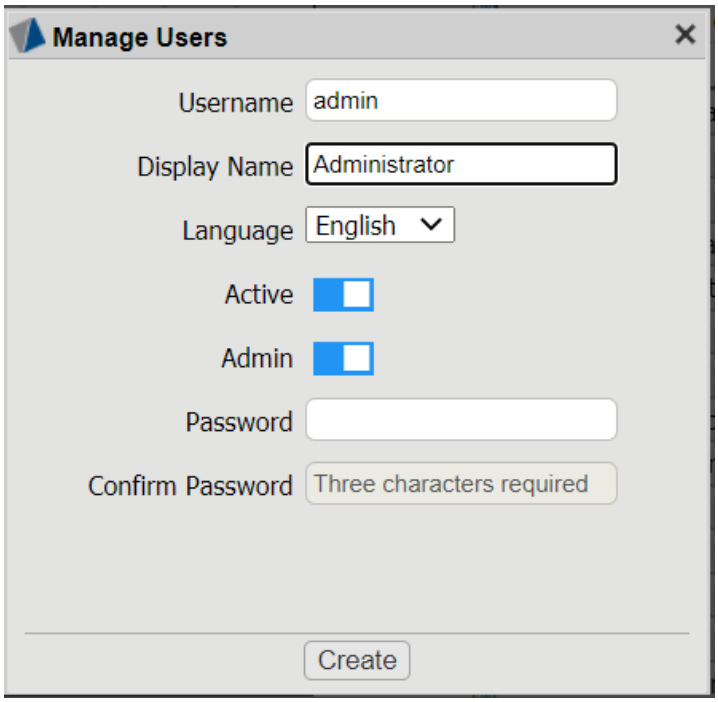


Figure 100: Edit User

18.3 Hardware

Most “standard” hardware functions are handled in the main user interface. However, there are special cases where a user needs to use the functions in the “Hardware” menu here.

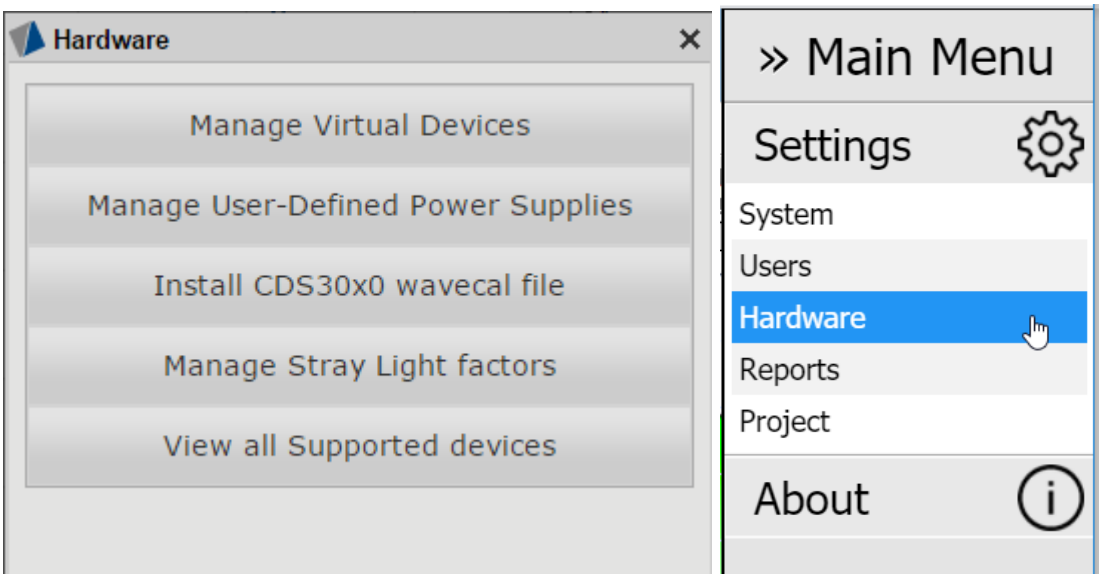


Figure 101: Hardware Settings in Menu

18.3.1 Install Virtual Devices

A user may install "Virtual" devices such as virtual spectrometers, power supplies, temperature controllers, etc. These virtual devices can be added to hardware sets and "connected" to. They will imitate real devices and return spectral data, for example. This can be useful in debug or demonstration purposes.

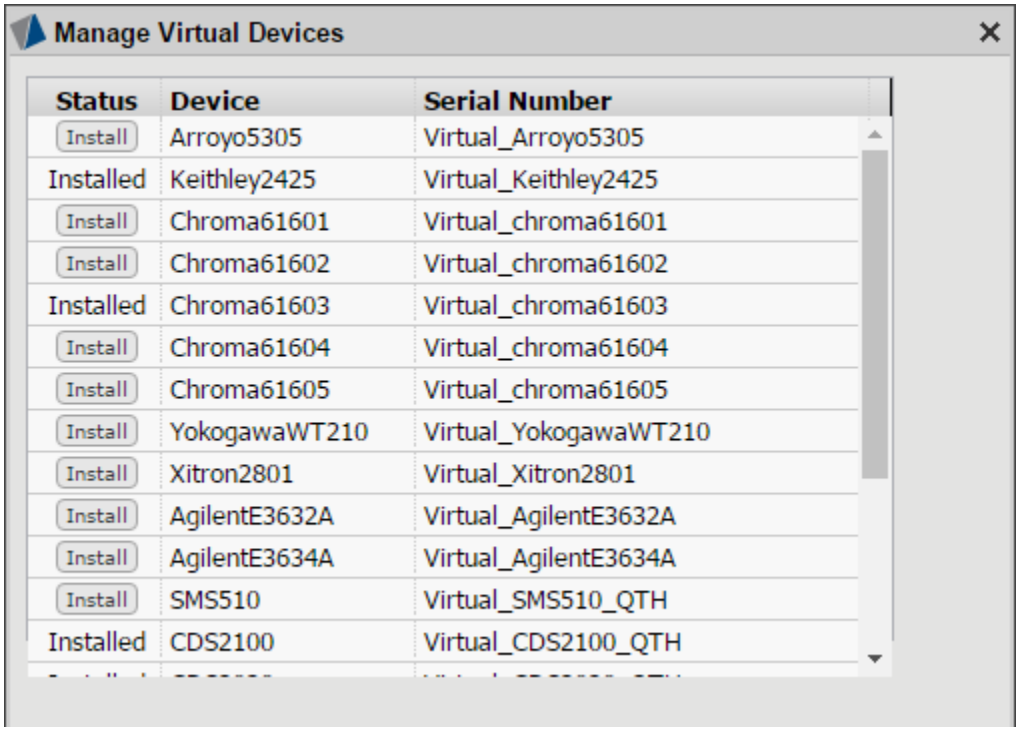


Figure 102: Managing Virtual Devices

18.3.2 Manage User-Defined Power Supplies

"User-Defined Power Supplies" are placeholder devices. A user-defined power supply is one that exists in real-life but cannot be connected to Integral (not supported or does not have a communication interface).

By creating user-defined power supplies in Integral these devices can be added and tracked in the database as part of hardware sets but do not otherwise show up in the controls and settings (Integral cannot control these devices).

18.3.3 Install CDS-30x0 Wavecal File

The CDS-30x0 family of spectrometers cannot operate without an individually-created "wavecal" file. This file may be obtained from Labsphere is shipped with any CDS-30x0 spectrometer. Locate the file in the *Main Menu → Settings → Hardware → Install CDS30x0 wavecal file*.

Figure 103: Install CDS30x0 wavecal file

To install a wavecal file simply click the button and navigate to the wavecal file using a standard File Browser. Note that the file will need to be visible to the device currently being used to operate Integral. A USB drive with the wavecal file may be needed to install in Integral.

If the wavecal file cannot be located, go to **https://www.labsphere.com/support/** and request to have it sent to you. Provide the model and serial number (located on the device) in your message.

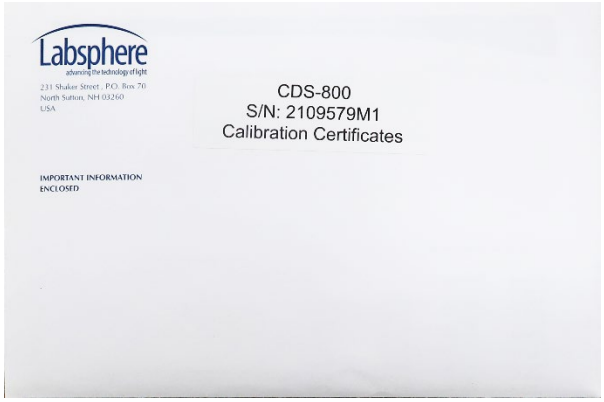
18.3.4 Manage Stray Light Factors

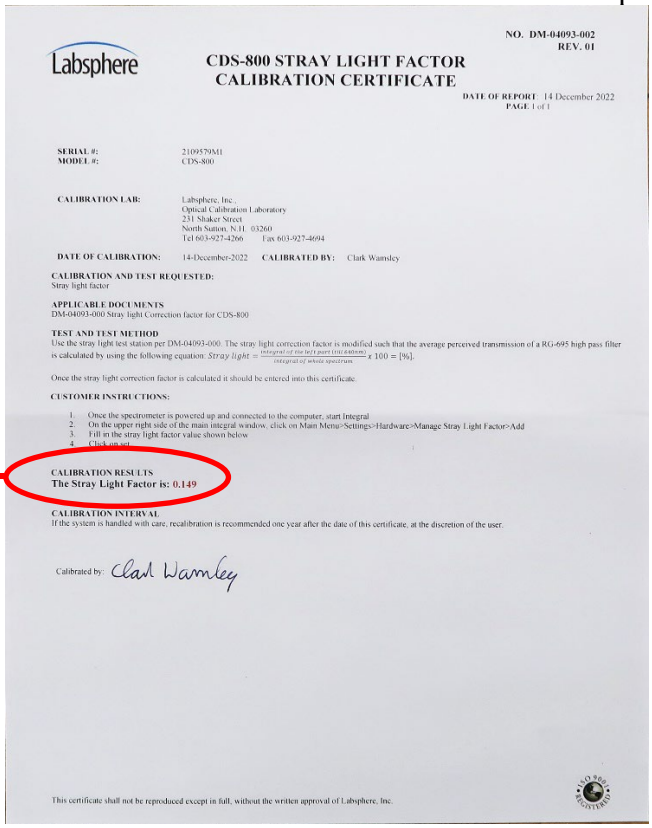
Labsphere spectrometers can include correction for "stray light". Stray light is light that is "misplaced" inside the spectrometer (for example some "red" light ends up in "blue" pixel bins). Labsphere can characterize an individual spectrometer to correct for these errors. Note: the CDS-30x0 family of spectrometer handles stay light correction internally and do not need an additional correction factor applied.

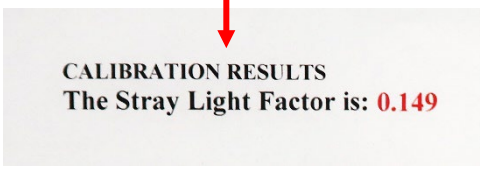
Spectrometer that include stray light correction factors are:

- CDS-600
- CDS-610
- CDS-800
- CDS-1100
- CDS-2100
- CDS-2600

The stray light correction factor is included with the spectrometer when shipped from the Labsphere factory and is on the spectrometer's calibration certificate inside the certificate envelope.



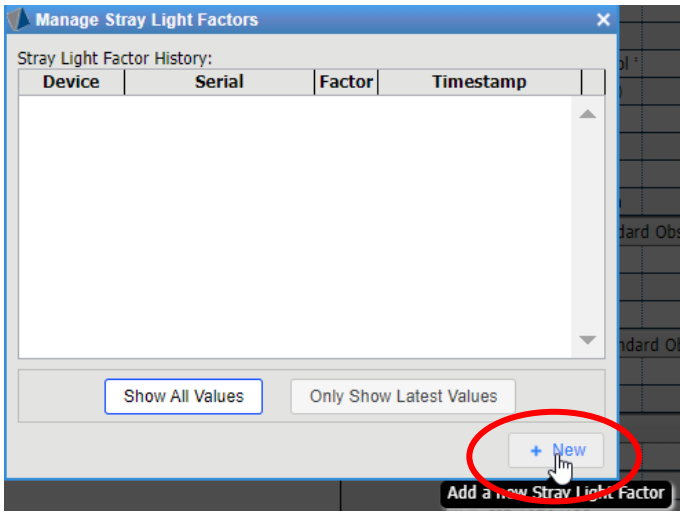




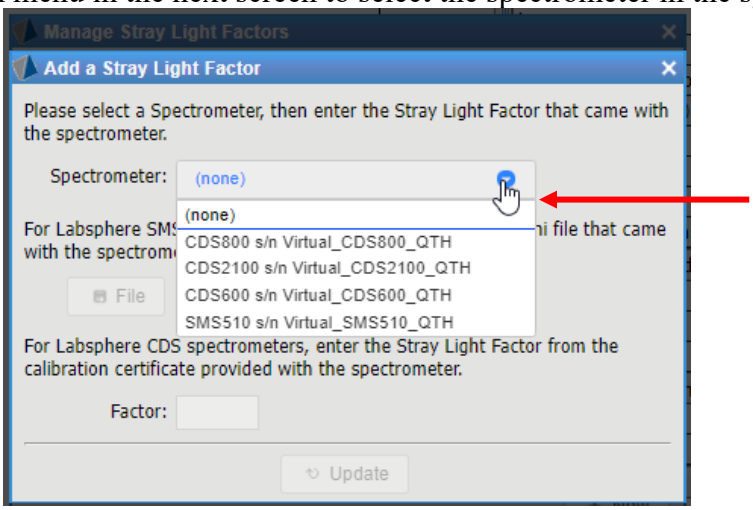
This factor must be set in the Integral user interface by clicking on the "Manage Stray Light Factors" button and following the steps provided.

1. Go to *Main Menu* → *Settings* → *Hardware* and click on "Manage Stray Light Factors".

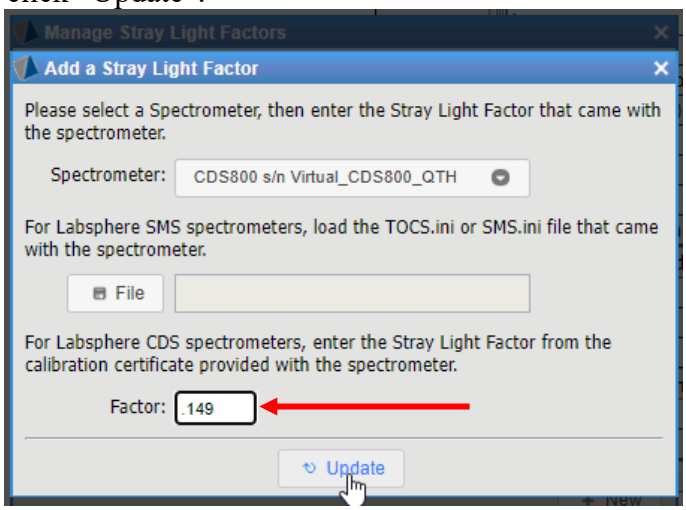
2. Click “+New” in the next screen.



3. Use the dropdown menu in the next screen to select the spectrometer in the system.

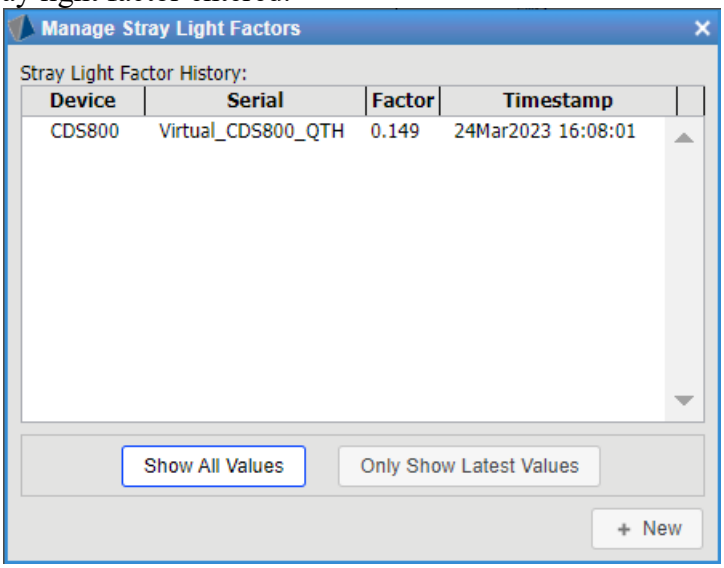


4. Locate the stray light factor on the spectrometer’s calibration certificate, type it into the “Factor” field and click “Update”.



5. The next screen will ask to calibrate the spectrometer. Click “Confirm” if needed.

6. The Manage Stray Light Factors screen will appear again with the selected spectrometer device and its stray light factor entered.



If the TOCS.ini of SMS.ini file cannot be located but the stray light factor is known, it may be added directly into the “Factor” field without specifying a file. The stray light factor must be a number between 0 and 1.

18.4 Reports

There are two ways to get scan and associated measurement data from Integral; "Exports" and "Reports." Exports are a "data dump" where all measurement data associated with selected scans are provided in an unformatted .csv file. Reports provide control over what data are gathered, where those data are presented, how the page is formatted, included images, and simple charts.

It is important to remember that whenever a user asks for data, the Integral system gathers the information from the Integral database (generally stored on the Cube), packages this data, and sends the data to the user's browser window. The browser receives the data as it would any other file download.

By default, Chrome is configured to put downloads into the user's download folder/location. Chrome's settings may be adjusted to default to a different download location or generate a "Save As" dialog with every download.

Please note that Integral does not have control over these settings – Integral simply sends the file and Chrome must decide what to do with it.

Reports in Integral are based on Microsoft Excel workbooks. One or more "Template" workbooks may be loaded into Integral and used to generate "Report" workbooks. The templates are used to define the data, look, and format of reports.

Please note that a user does not need Microsoft Excel to use these features and that the Cube does not have Excel installed by default. Integral and the Cube can use and create Excel-formatted files even if it cannot open them in Excel!

18.4.1 Locate Previously Installed Report Template(s)

Default templates can be located in the folder "C:\Integral\<version>\server\excel".

The default template files include:

ANSI_C78_377_2015_Template.xls
Labsphere_LM_82_Template.xls
Labsphere_Standard_LM79_Template.xls
Labsphere_Standard_Template_multi_shift_down.xls
Labsphere_Standard_Template_multi_shift_right.xls
Labsphere_Import_Chart_LM79_Template.xls

18.4.2 Upload or Update a Report Template

Some default report templates are included with Integral. Please note that creating a template can be a little tricky and is covered in Appendix 4: "Creating and Working with Report Templates" on page 143.

Templates may be uploaded as a new report definition or, if already installed, existing report definitions may be updated with minor changes (report templates may take some iterations to perfect, use "Update" when making these iterative changes).

To upload a report template to Integral, go to *Main Menu* → *Reports* → *Add a Definition*. To **Update** a report definition, highlight the desired report: *Main Menu* → *Reports* → *Update*.

Updates to a report definition cannot be "undone". Only use update when an existing definition needs minor changes.

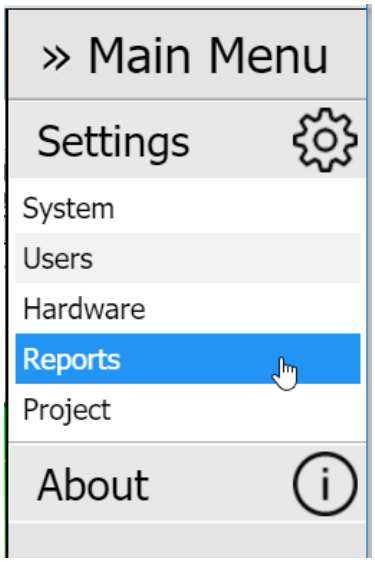


Figure 104: Manage Reports Location

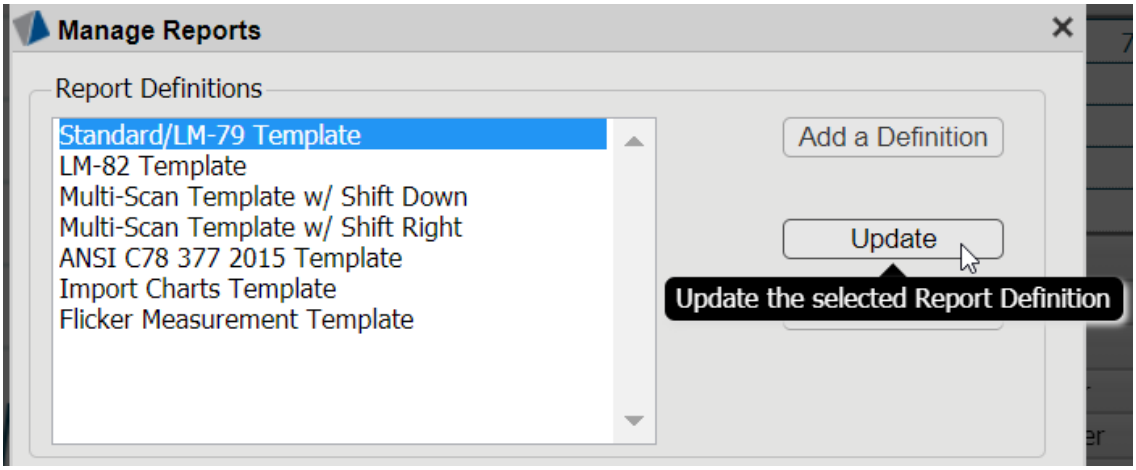


Figure 105: Update Report Definition (Template)

Provide a Name and description for the new report definition. These fields are required. Use the **File** button to open a file browser and locate the template to use.

Please note that the file browser is looking for files on the device being used to operate Integral.

Please note that the report template must have the file extension ".xls." Integral cannot use ".xlsx" at this time. The user may need to open the report template in Excel and save an "Excel 97-2003 Workbook" in order to get the proper extension on the template.

When the correct file is selected, click **Add** to import it into Integral.

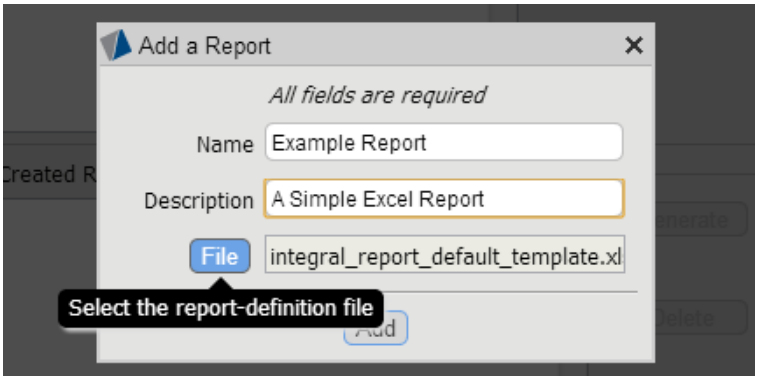


Figure 106: Name and Select an .xls Template

18.4.3 Define User Tags

Integral will look through the template file provided and determine if the template includes "tags" Integral has not defined to this point. For example: the report template may define a cell or piece of data tagged "Customer_ID." If Integral does not know what a "Customer_ID" is, then the user must define this new tag. Once a tag is defined Integral remembers this tag for next time. Different templates may use the same tags. Integral will use the same definition for all tags with the same name.

Note: Additional details regarding tags are provided in the section: Tag List.

When a report is generated from a definition all user tags in that definition are used to define editable fields in the report create dialog. For example: there may be a field for "Customer ID" which allows the user generating the report to enter "ACME Lights" which will then appear in the report (as defined in the template).

When a report template is uploaded to Integral, all unknown user tags will display in a dialog. The user must define each before the template will finish installing. To define a user tag, simply click on the tag and select "Define." A dialog will appear with fields for tag descriptions and data length.

Please note that the length refers to the maximum allowable characters that may be entered in the field defined by the tag and is also use to size the field presented in the report generator dialog. Length should be long enough but not too long.

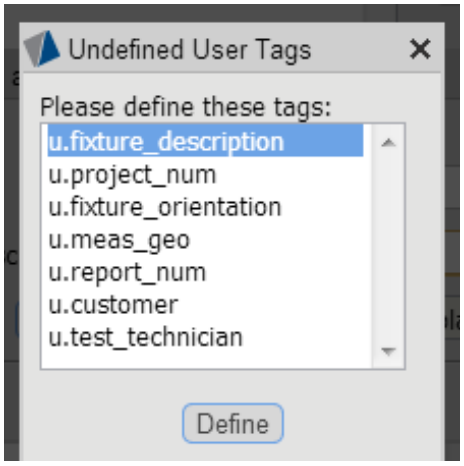


Figure 107: Define New User Tags

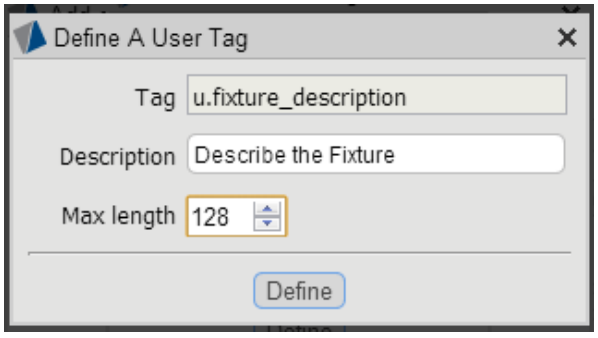


Figure 108: Tag Description and Field Length

Once all the Undefined User Tags are defined (or were defined earlier and are already in the Tag database), Integral will ask the user to specify the user fields that are required to have *some* data entered by a user when the report is generated. For example, when uploading the report template, the user makes the "Test_Technician" field required. Now, every report that is created using that new report definition requires the user to enter at least *some* text in the field for "Test Technician." Required fields are specified for every report definition entered into Integral. "Test Technician" may be required in one report but not another.

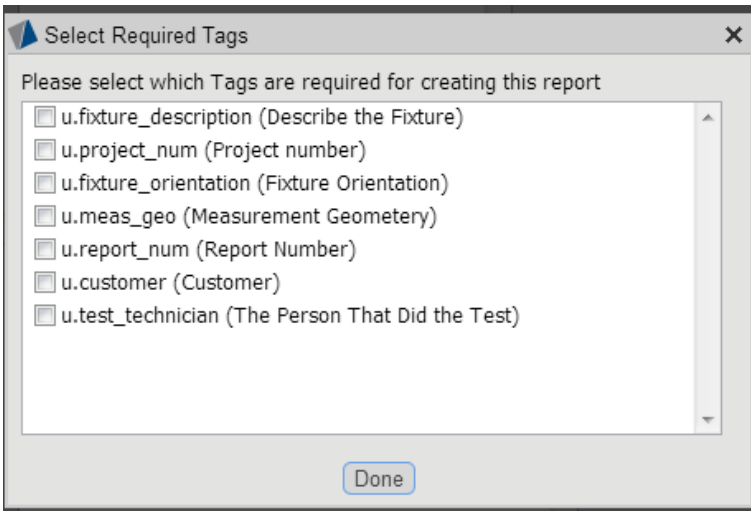


Figure 109: Define Required Fields (Check Box)

18.4.4 Define Images

Images are defined in the template using Image Tags. Image Tags are slightly different from User Tags in that images are always unique to a specific report definition. In this way, different report definitions may have the same image tags but can use different images. Images are also different in that they can be chosen by the person installing the report definition or by the person using that definition to create some report later.

During install, Integral looks at the report template and finds all the image tags. For each image the user must decide whether to "Choose Image Now" or "Choose Image at Report Creation". "Choose Image Now" brings up an image viewer/upload dialog.

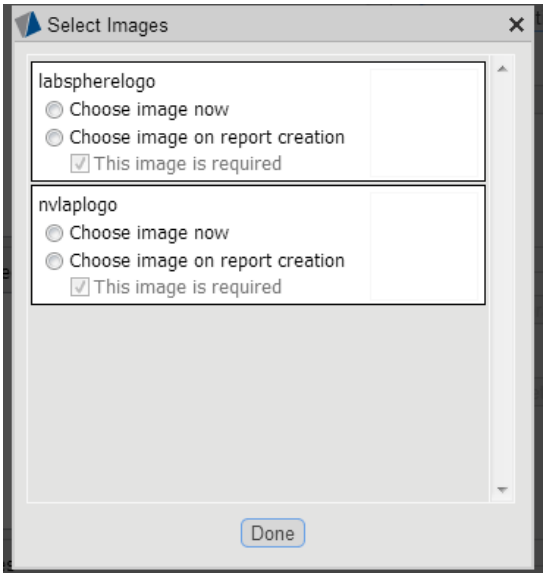


Figure 110: Define Images

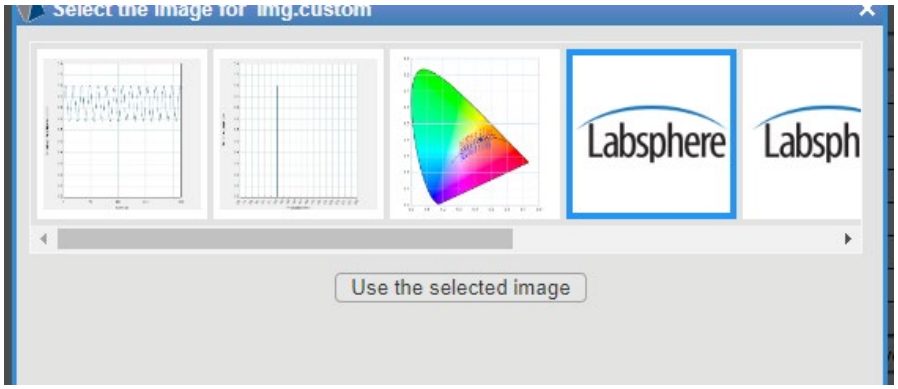


Figure 111: Adding and Selecting Images

Images that are already in the image database will appear in the view. If a new image is needed, select **Add** to bring up a file browser. Support image types include: .png, .jpg, and .bmp. Once an image is loaded into the image database a thumbnail will be in the scrollable list. Select the desired image and click "Use the Selected Image."

Once all tags and images are defined, the report template is fully loaded into Integral and will appear in the available Report Definitions List.

18.4.5 Tag List

The "View All Tags" button brings up a window with all the tags known to Integral. Some tags are "standard" Integral tags that define data that are included with "normal" measurements. An example of a standard tag is "i.m.Cx," which is "CIE 1931 'x' color space coordinate." Note that the tag format suggests "Integral.Measurement.Cx." Other tags in the view are "User Tags" which have the format "u.something" and "Image Tags" in the format "img.something." These "non-standard" tag where defined when a new template was uploaded. All report tags may be downloaded as a .csv file for reference or use in creating or modifying templates.

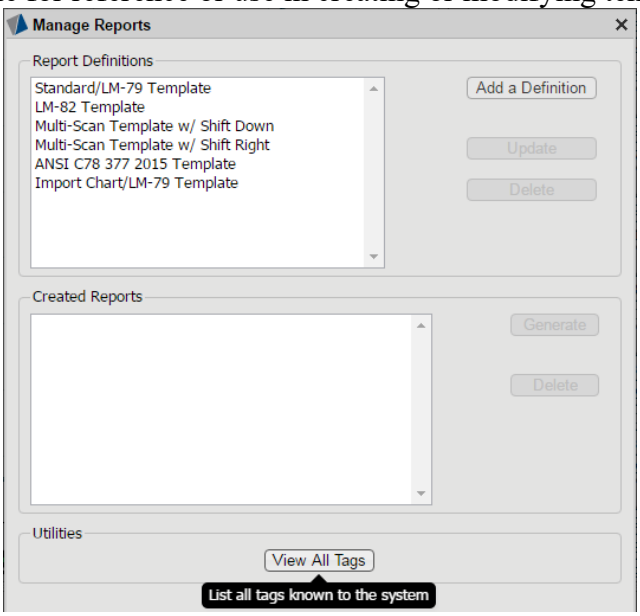


Figure 112: View Tag List

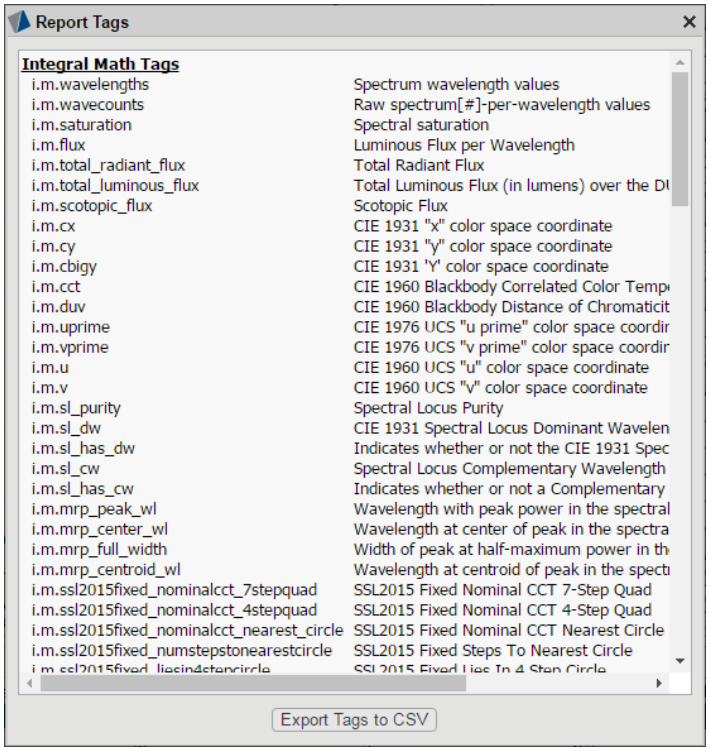
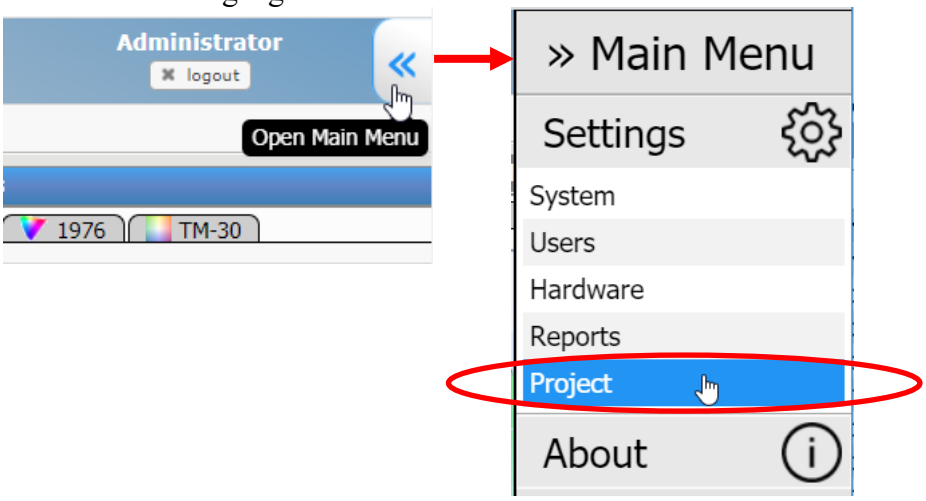


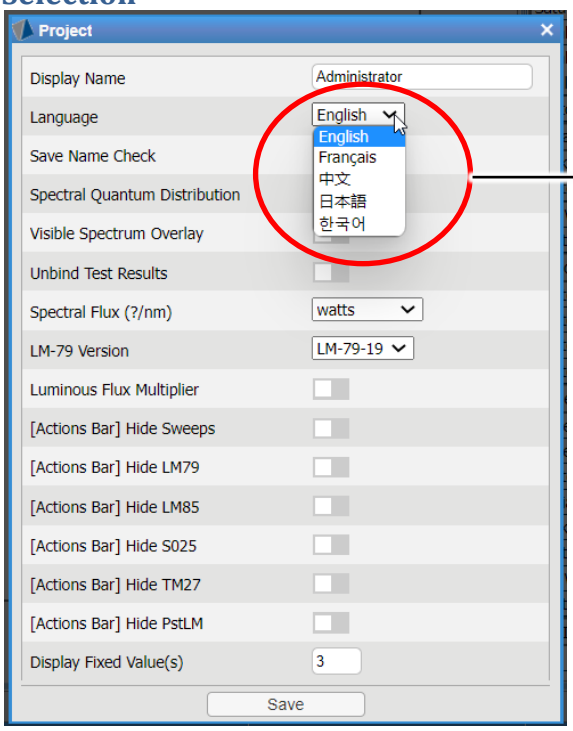
Figure 113: View or Export Tag List

18.5 Project Settings

The Project menu allows the user to select system preferences including their desired display name and what language to use in the user interface.



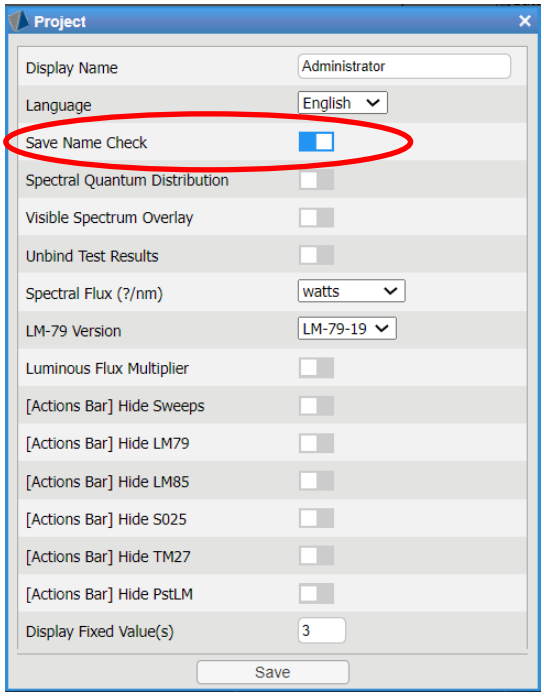
18.5.1 Language Selection



Language Selection Dropdown List

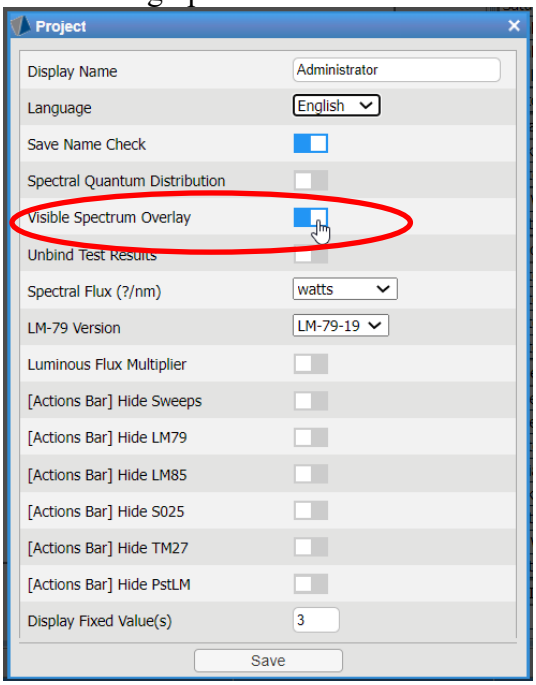
18.5.2 Check for Duplicate Save Names

Toggle on the “Save Name Check” switch (default position) to prevent naming and saving a new file with an existing name.



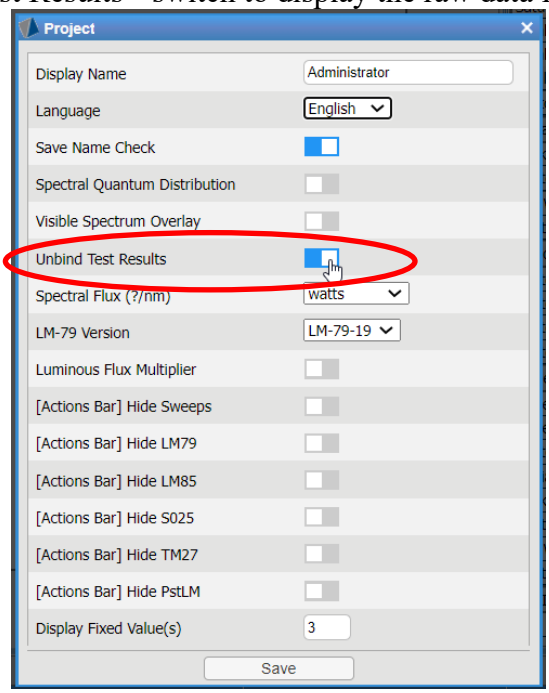
18.5.3. Visible Spectrum Overlay

Toggle on the "Visible Spectrum Overlay" switch to add color to the visible spectrum on the Spectral Power Distribution waveform graph.



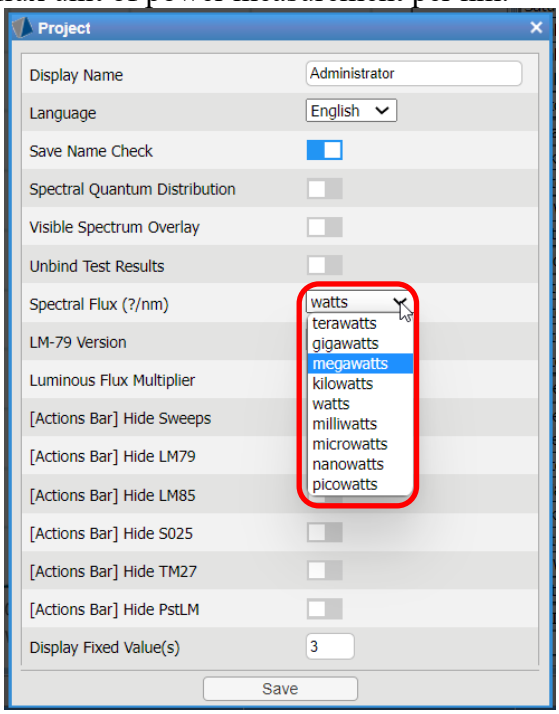
18.5.4. Unbind Test Results

Toggle on the " Unbind Test Results " switch to display the raw data for test results.



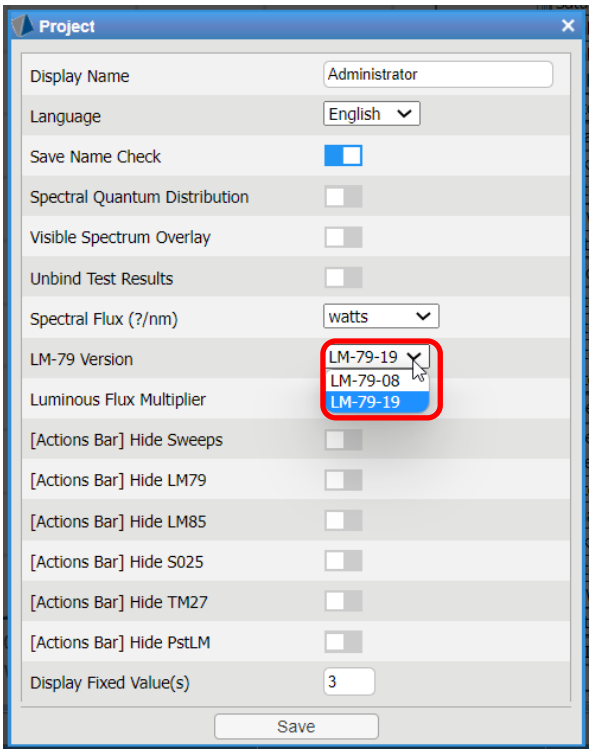
18.5.5. Spectral Flux

Select the default spectral flux unit of power measurement per nm.



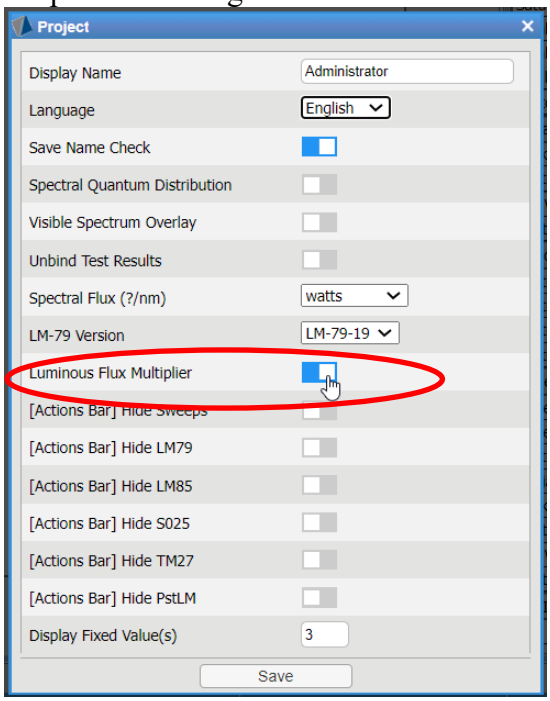
18.5.6. LM-79 Version

Use the dropdown menu to select the default version of LM-79 to be used in Integral.



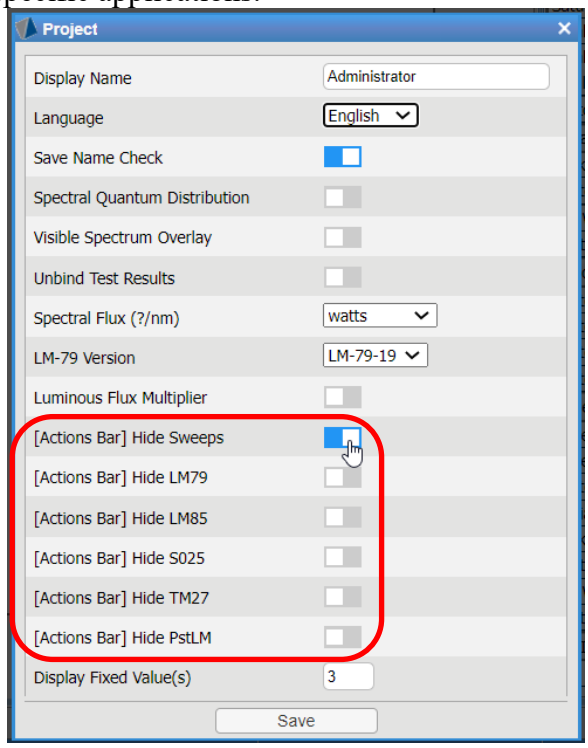
18.5.7. Luminous Flux Multiplier

Toggle on the " Luminous Flux Multiplier " switch to add an optional field to the spectrometer settings which enables the comparison of a light source between two different spheres.



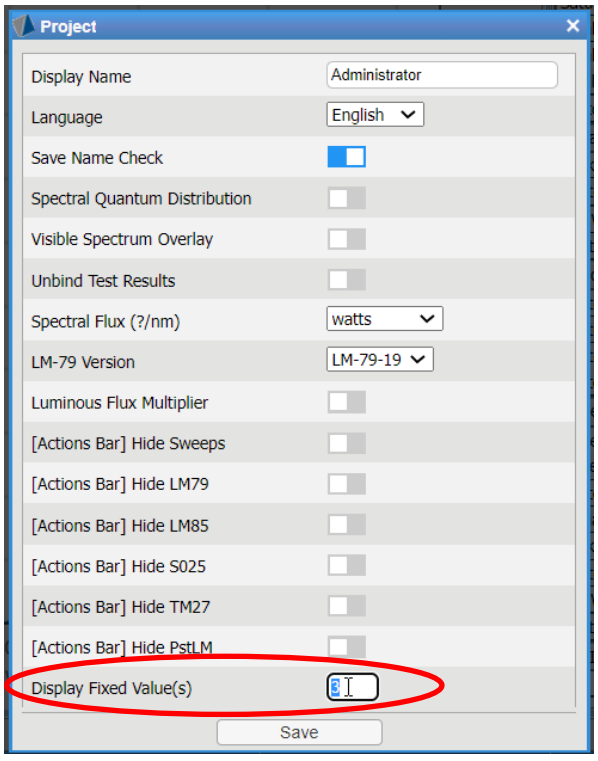
18.5.8. Hide Action Bar Icons

Toggle off the non-essential, specialized command icons from the Action Bar for a cleaner user interface customized for specific applications.



18.5.9. Display Fixed Values

Enter a number from 1 to 8 for the default number of decimal places to be displayed in most of the hardware setting sections.



APPENDIX 1: NOTES ON ILLUMIA®PLUS2 AND ILLUMIA®PRO3 SYSTEMS

Labsphere began production of the illumia®Plus2 systems in April 2020 and the illumia®Pro3 systems in March 2023. These next generation illumia platforms take a more open-ended and adaptable "à la carte" approach by allowing the user to integrate and control a much wider variety of Labsphere and 3rd party hardware components into their Integral-based light measurement systems. This was accomplished by changing the Photometry Module from a pre-defined, stand-alone hardware unit with an onboard computer running Integral, into a series of external à la carte hardware components with the user's computer running Integral. This approach provides the user with many more options in choosing the most appropriate electronic support peripherals from 3rd parties and Labsphere, including our new series of lamp power supplies available in various power ranges.

The component selection and routing functions that are a part the Photometry Module have been replaced with the new Labsphere ICM-500 control module that functions as the center hub of illumia®Plus2 and illumia®Pro3 systems. Therefore illumia®Plus2 and illumia®Pro3 users should bypass instructions regarding the Photometry Module in this manual and seek out those that employ the ICM-500 instead. This should start with the selection of the ICM-500 as the photometry module when creating the hardware set. Refer to section 8.2 "Creating a New Hardware Set" on page 35. Note that Labsphere offers upgrade kits to first generation illumia®Plus users to easily convert their system to an illumia®Plus2. Please contact your Labsphere sales engineer for details.

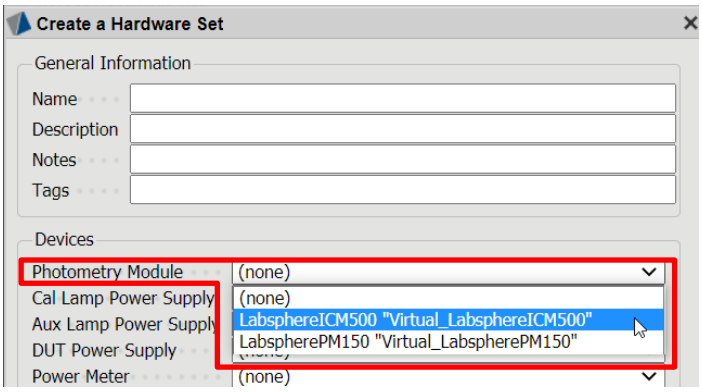


Figure 114: ICM-500 Selection — required for all illumia®Plus2 systems

Figure 115: ICM-500 Control Module

APPENDIX 2: LIGHT MEASUREMENT LAMP AND POWER SUPPLY GUIDE

Lamp Type	Lamp Part #	Power Supply	Supply Part #	Voltage	Current
AUX-35	AS-02639-000	LPS-100-0307	AS-02600-301		3.07
AUX-50	AS-02737-050	LPS-150-0416	AS-02656-416		4.17
AUX-75	AS-02576-OPT	LPS-100-0625	AS-02600-625		6.25
AUX-100	AS-02737-000	LPS-100-0833	AS-02600-833		8.33
ICS-050					
ICS-XXX					
ICS-XXX					
SCL-050	AS-02528-001	LPS-100-0105	AS-02600-105		1.05
SCL-600	AS-01335-000	LPS-100-0260	AS-02600-260		2.6
SCL-1400	AS-01342-000	LPS-150-0268	AS-02656-268		2.68
CSFS-050	AS-02528-000	LPS-100-0105	AS-02600-105		1.05
CSFS-1400	AS-01343-000	LPS-150-0268	AS-02656-268		2.68
CSFS-600	AS-01336-000	LPS-100-0260	AS-02600-260		2.6
FFS-100-1000	AS-02768-200	LPS-100-0833	AS-02600-833		8.33
FFS-100-400	AS-02768-100	LPS-150-0416	AS-02656-416		4.17

Power Supply	**Output Power, W**	**Current, A**	**Part #**	**Lamps**
LPS-100-0042	5	4.2	AS-02600-042	IHLS-100-05
LPS-100-0105	4.4	1.05	AS-02600-105	SCL-050, CSFS-050
LPS-100-0167	10	1.67	AS-02600-167	IHLS-100-10, EHLS-100-20D
LPS-100-0260	32	2.6	AS-02600-260	CL-600, SCL-600, CLFS-600, CSFS-600
LPS-100-0278	30	2.78	AS-02600-278	LPS-100-30D
LPS-100-0307	40	3.07	AS-02600-307	EHLS-100-35R, IHLS-100-35R, AUX-35
LPS-100-0625	75	6.25	AS-02600-625	EHLS-100-75R, IHLS-100-75, EHLS-100-75D, AUX-75
LPS-100-0676	45	6.76	AS-02600-676	150W Direct Mounts
LPS-100-0833	100	8.33	AS-02600-833	EHLS-100-100R, IHLS-100-100, AUX-100, FFS-100-1000
LPS-150-0635	150	6.35	AS-02656-635	IHLS-DM-150
LPS-150-0685	120	6.85	AS-02656-685	EHLS-100-120
LPS-150-0660	120	6.6	AS-02656-660	KI-120
LPS-150-0268	75	2.68	AS-02656-268	CL-1400, SCL-1400, CLFS-1400, CSFS-1400
LPS-150-0625	200	6.25	AS-02656-625	EHLS-100-150R
LPS-150-0416	50	4.16	AS-02656-416	FFS-100-400, AUX-50

APPENDIX 3: GENERAL LIGHT MEASUREMENT PROCEDURES

In general, when using a calibration lamp in a 4π configuration, light measurement involves 4 primary steps as outlined in Figure 6:

1. Install Calibration Lamp and make a measurement. (Reference Scan)
2. Turn off Calibration Lamp, turn on Auxiliary Lamp and make a measurement. (Auxiliary Reference Scan)
3. Remove Calibration Lamp, install Device Under Test (DUT), leave Auxiliary Lamp on and make a measurement. (Auxiliary DUT Scan)
4. Turn off Auxiliary Lamp, Turn on DUT, and make a measurement.

If an internal 2π calibration lamp is used, it may remain in the sphere at all times. Note that, in some instances and other industry literature, the calibration lamp is referred to as the *Reference Standard*. With the four scans described above, the user may apply the auxiliary correction to arrive at a corrected spectral flux measurement for the DUT. The auxiliary correction scans are used to compensate for the absorption and reflection differences between the calibration geometry and DUT geometry in the sphere:

$$\Phi_{DUT}(\lambda) = \Phi_{Ref}(\lambda)\frac{y_{DUT}(\lambda)}{y_{Ref}(\lambda)}\frac{y_{AUX-Ref}(\lambda)}{y_{AUX-DUT}(\lambda)}$$

Where,

$\Phi_{DUT}(\lambda) =$	Spectral Radiant Flux of DUT.
$\Phi_{Ref}(\lambda) =$	Spectral Radiant Flux of Reference Standard (Cal file from Labsphere).
$y_{DUT}(\lambda) =$	Spectral Scan of DUT.
$y_{Ref}(\lambda) =$	Spectral Scan of Reference Standard (Cal Lamp).
$y_{AUX-DUT}(\lambda) =$	Spectral Scan of Auxiliary lamp with DUT in place.
$y_{AUX-REF}(\lambda) =$	Spectral Scan of Auxiliary Lamp with Reference Standard in place.

This process is automatically executed when auxiliary correction is selected. The user may also elect to process the spectral flux measurement of the DUT without applying the auxiliary correction. This measurement provides an indication of the magnitude of the correction and can aid in determining the influence of the DUT geometry on the measurement.

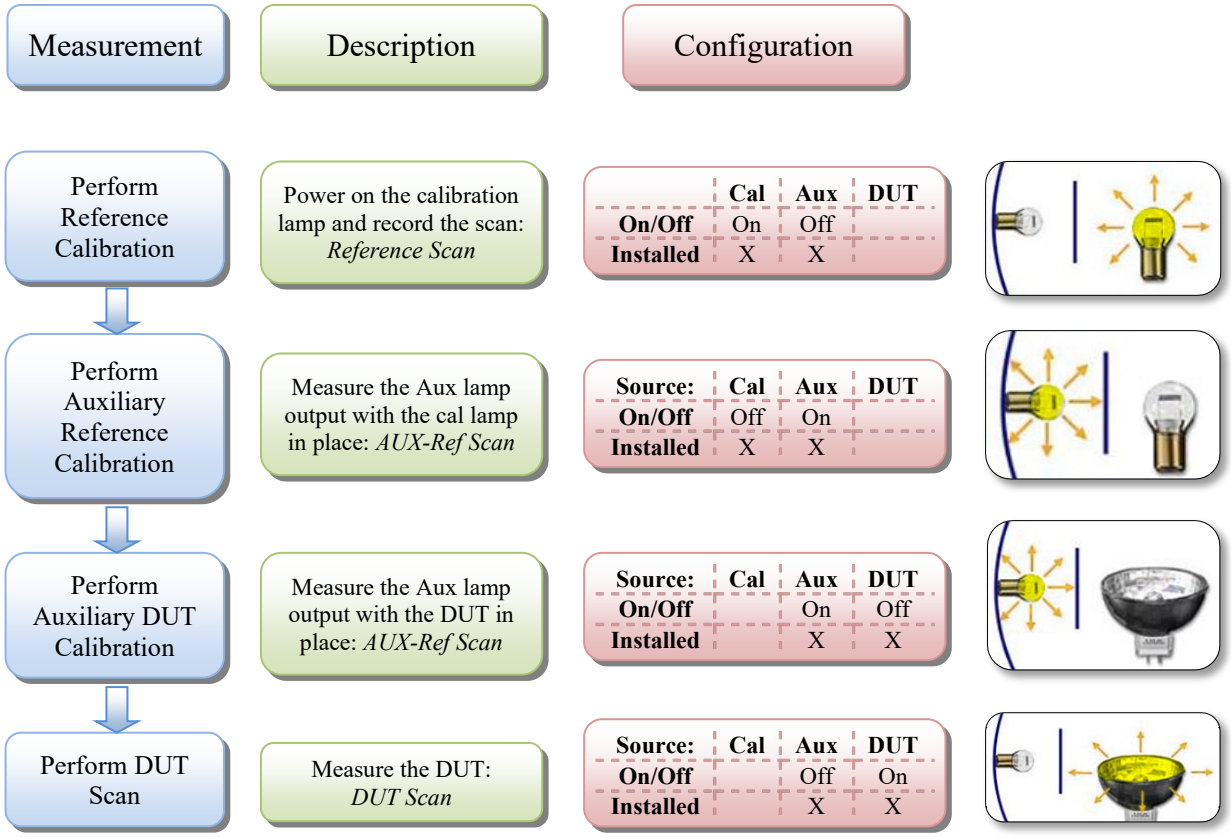


Figure 116: Light Measurement Flow Chart

APPENDIX 4: CREATING AND WORKING WITH REPORT TEMPLATES

Working with report templates can seem a little abstract. Report templates are a "map" that Integral uses to define what information to gather, where to put that data, and how the finished page should look. This means that the report template will not look exactly like the finished report. Some formatting and other settings will be the same but some data fields and tables expand based on the number of scans selected when the report is generated. Data and data location are defined by textual tags, as will be shown.

Further, images such as logos and things like graphs and charts are defined by textual tags and thus do not appear as images or charts in the template. This means that these elements may shift when the report is generated and could also obscure other fields and data.

Working with report templates is an iterative process. A template will need to be created or modified, loaded, and tested to ensure it "behaves" as intended.

The Integral reporting tool and working with templates may take some time to master – this is a result of the tool being designed to be as flexible and universal as possible. Users should start by understanding generating reports from existing templates (17.1 Creating and Generating a Report) and looking at the default template shipped with Integral.

Template Basics

For illustration, this guide will utilize the default template, shown in part below. Users will notice that the template is a mixture of "normal" text and "tagged" fields.

Note: Templates must be an ".xls" file. Use the "save as" function in Excel to choose the file extension (.xls is also known as "Excel 97-2003 Workbook" format). Finished reports are returned as an ".xlsx" file.

Normal Text

"Normal" text is transferred from template to final report "as-is" and will not be modified during the process. If the template has a cell with text "Hello World" the final report will also contain "Hello World."

%% Tagged Text %%

"Tagged" text utilizes Integral's special notation which designates cells and data that will be dynamically generated. Tagged text is fully enclosed by "%%" (which is unlikely to occur outside of the Integral template notation). The enclosed data (text) is part of a special command and parameter language that Integral uses to make decisions when generating a report.

Tags and how Integral interprets these data are explained in detail below. This special Integral Report "language" will expand as the reporting functions and features expands in future versions of Integral.

Cell Formatting

The example template has various text and cell formatting shown. This formatting is carried over directly to the resulting report. For example: borders, font, style, color, etc. specified for specific cell are used in correlating cells in the final report. This formatting can include information such as how many decimal places are used, in what way a date is shown, even language. To see this information right-click a cell in Excel and choose "Format Cells." The Format Cells dialog shows these settings.

Formatting specified by Excel in the template is also used for "tagged" cells; if the tagged cell is **bold** then data that is shown in that cell in the final report will also be **bold**.

Please note that the tagged cells are usually displayed in the template as simple text but these cells can still have other format options selected. For example: %%i.s.scan_dt%% tells Integral to put the scan date-time in that cell. The cell displays as simple text in the template but may still have "Date" with specific display settings for month/day/year (or day/month/year, etc.) selected in that cell's format setting. These settings will be used by Excel in the final report.

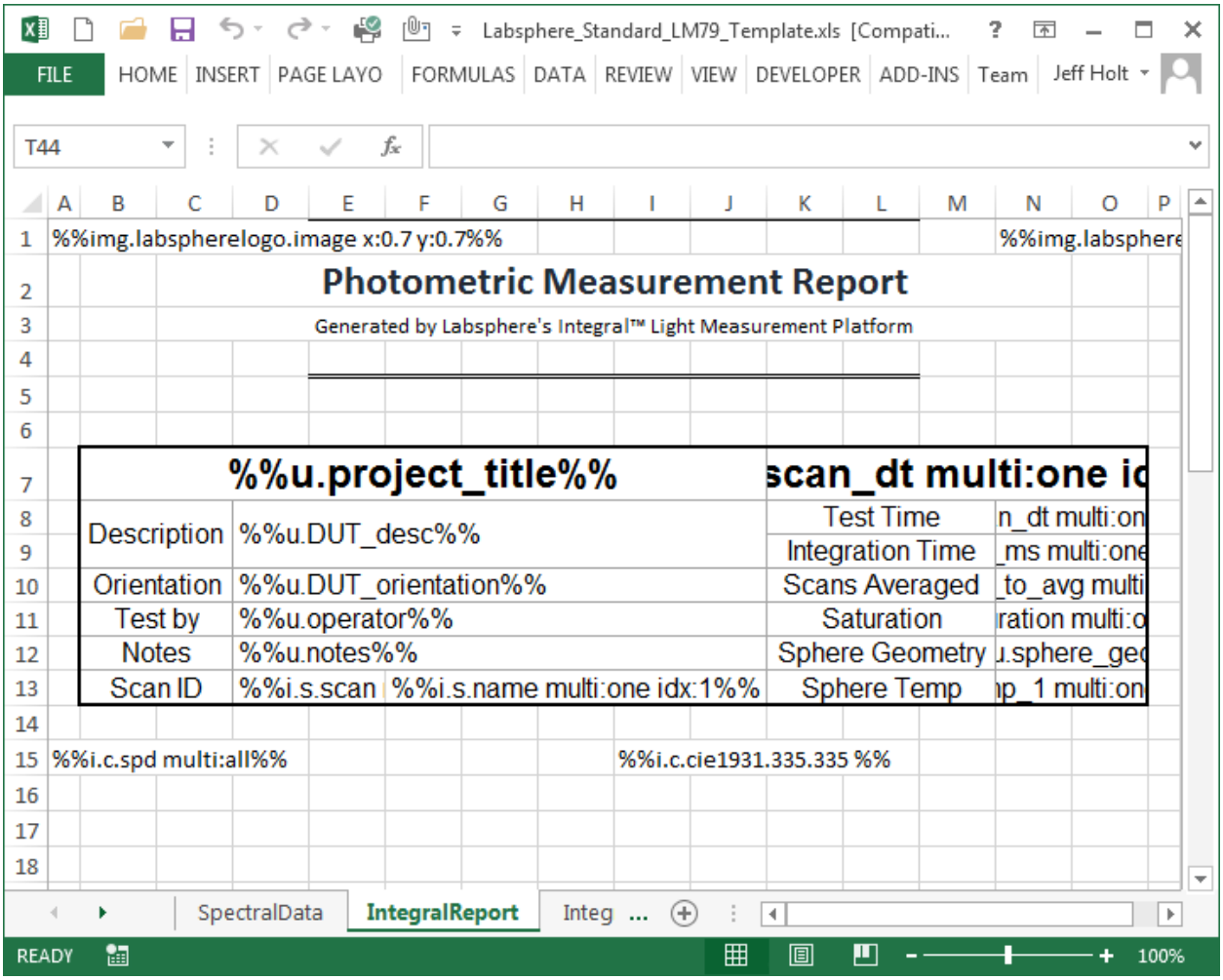


Figure 117: Integral Default Template Example

Multiple Worksheets

The Integral Report tool supports multiple worksheets. Any worksheets that are created in the template will be carried over to the finished report using the name and order of the sheets from the template.

Tagged Cells for Dynamic Data

Tagged cell data is not carried over to the final report. Rather, tagged cells are treated as commands or rules for the Integral Report generator. The Report generator uses the data bounded by tags to make decisions on what data is used for that cell and if any other cell behavior or modification is required.

The tag dictionary is available for view or download from the Main Menu of the Integral user interface. Navigate to *Main Menu* → *Settings* → *Reports* → *View All Tags*. This list may be exported to the browser as a .csv file. Note that the tag dictionary will update and grow as new tags are added including user-defined tags in new templates.

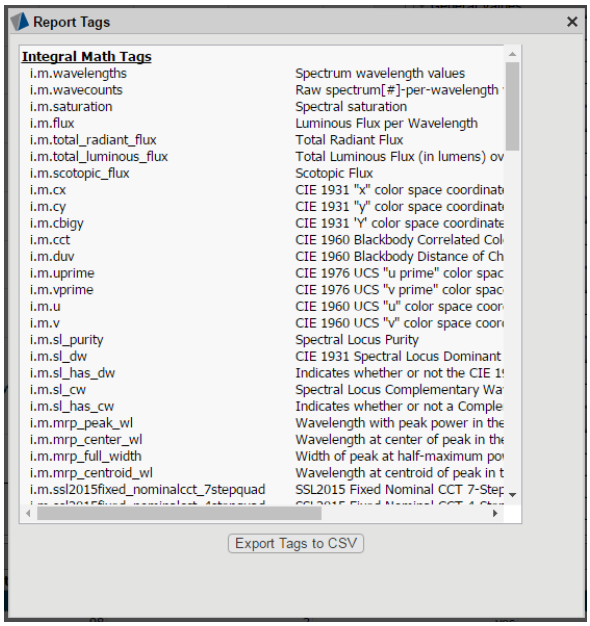


Figure 118: Integral Report Tag Dictionary

Name-Spaced Data Families

Integral employs a "name-spacing" scheme for different data "families". A family is simply a category of data or functionality. For example "i.s.something" is "Integral." "Scan".something. "u.something" is a generic "User".something (generally User data is unknown to integral before the report is created).

Tag Name-Spaces

Cell and data behavior may be further defined by various "modifiers." These modifiers are an extension of the special Integral report language. Not all modifier can be used with all cells and data types.

Tag Data Modifiers

Two very important modifiers are "multi" and "shift." As an example, a cell can read: "%%i.s.scan multi:all shift:down%%." Taking this apart we see that the cell calls for "Integral Scan" (the database scan ID) and "Multi-scan All" (use all the scans sent to the report) with the behavior of "shift records down" (put the scan ID from each scan as a column starting here).

Special Tags and Special Behavior Notes

When working with reports using multiple scans data are often specified to "shift" down or to the right. For example, when shifting "down" each scan data point is placed directly below the last of that same type; effectively putting data in columns. Similarly, when shifting right data are put in rows.

When data from multiple scans are put into a finished report using the multi:all shift:direction modifiers the reporting tool must insert additional cells into the report. These new cells are not directly represented in the template – they are added dynamically to accommodate the number of scans that were sent to the report. Because the number of scans sent to a report is only known at generation time (not when creating the template) the template must be designed to accommodate these shifting data.

Reports templates that will be used to report multiple scans must be carefully planned because adding cells at report generation time will force all the data below (when shifting down) or to the right (when shifting right) to move.

Generally, as in the example above, a whole series of data points will move together, shifting whole blocks of data down or right.

There may be situations that require cells to shift *without* adding data – effectively adding blank cells. This may be required to keep other cells that do include text or other data the correct relative location, even when various scans are added in various places. Use the special tag "xl.blank" to keep relative positions consistent. For example: "%%xl.blank multi:all shift:down%%" will add blank cells down for every scans are sent to the report.

Side-by-Side Reporting Example

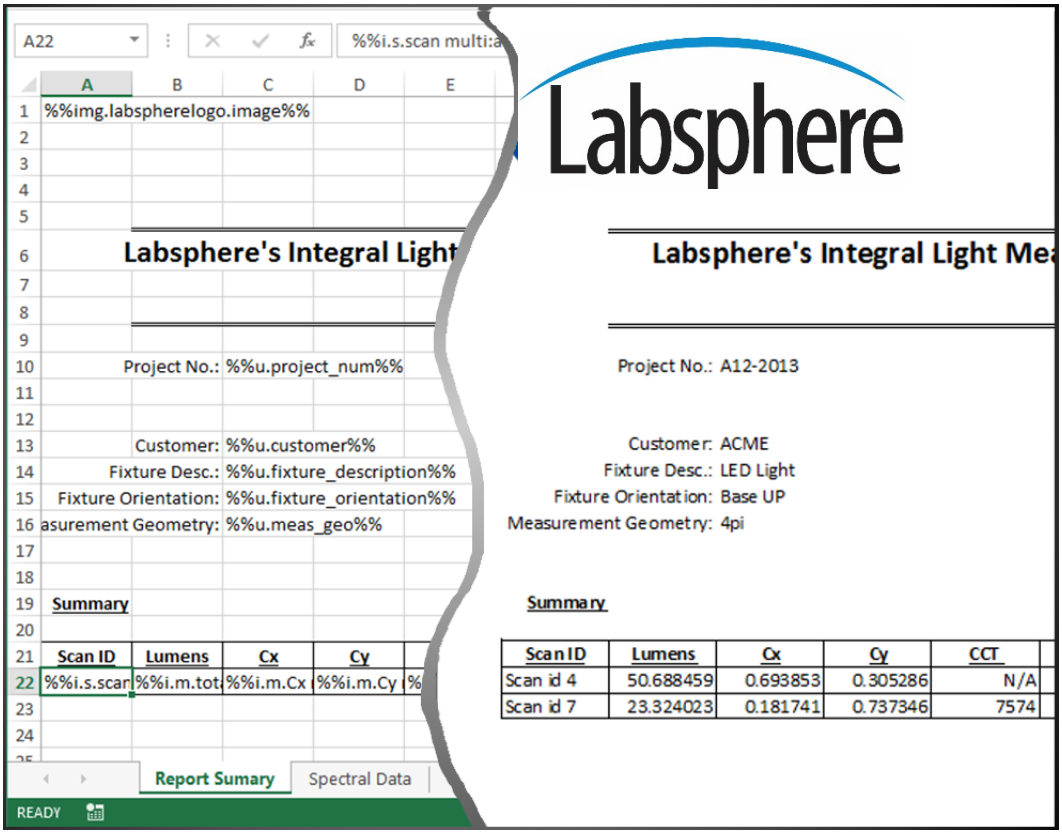


Figure 119: Custom Template and Report (Printed to PDF)

Reports are returned to the user as an .xlsx file. This file is sent to the browser by Integral and can then be opened in Excel and modified or printed as desired.

Note: Chrome will automatically save files to the *Downloads* directory. The file download setting for Chrome may be modified to save to a different location or to create a "save as" dialog with every download. Integral has no control over these settings.

Charts and Graphs in Reports

One powerful tool provided is the ability to add specific Charts and Graphs into a generated report. There are two types of charts provided: Spectral Power Distribution (SPD) and Chromaticity Diagram CIE1931. Currently there are few user-settable controls for the default CIE1931 chart.

Default CIE1931

To add a CIE1931 chart to a report use the tag:

%%i.c.cie1931.335.335 %%

This suggests "Integral Chart CIE1931 with Length 335pixels and Height 335 pixels.

Custom Graphs

By using the **Export displayed graph** button Integral auto-formats your graph into the 335x335 pixel area used for the chart import template. You can add any graph to a report using the *Import Chart Template (Labsphere_Import_Chart_Template.xls)* report.

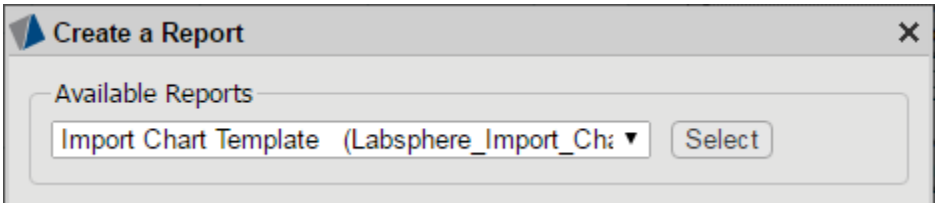


Figure 120: Select the Import Chart Template

When creating, upload your exported graph into the report. Do this by selecting an image from the browser download folder. Default location: "C:\Users\%username%\Downloads"
see: *Exporting Graphs*.

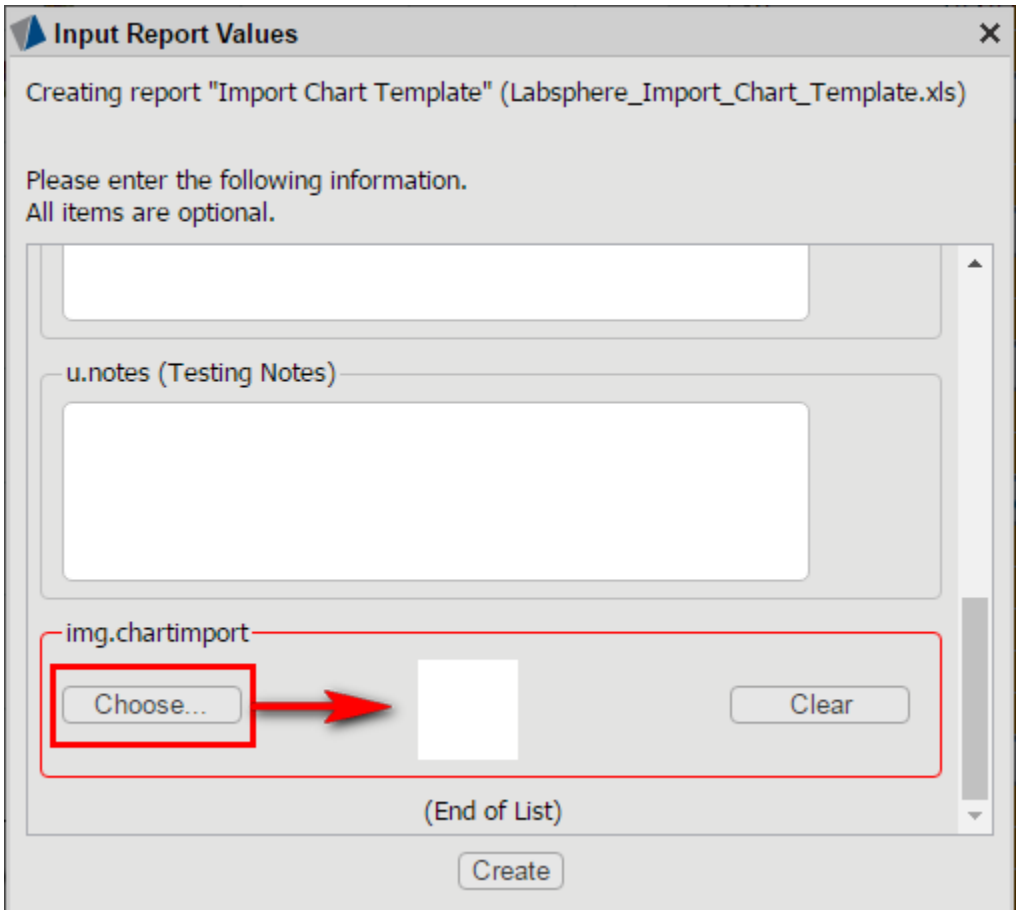


Figure 121: Import a Chart

Spectral Power Distribution (SPD)

To add an SPD graph to a report, use the tag:

%%i.c.spd multi:all%%

This suggests “Integral Chart SPD with Multiple Scan Traces, All Traces.

Additional control over behavior and appearance of SPD graphs are in a new, special worksheet that is part of the template but is not included in the finished report. This special worksheet must have the name “IntegralDefs” to be recognized and used but the report generator. Use the provided default report template as an example and further information regarding the use and behavior of IntegralDefs. The default report as the original .xls may be found as described in section: Locate Previously Installed Report Template(s).

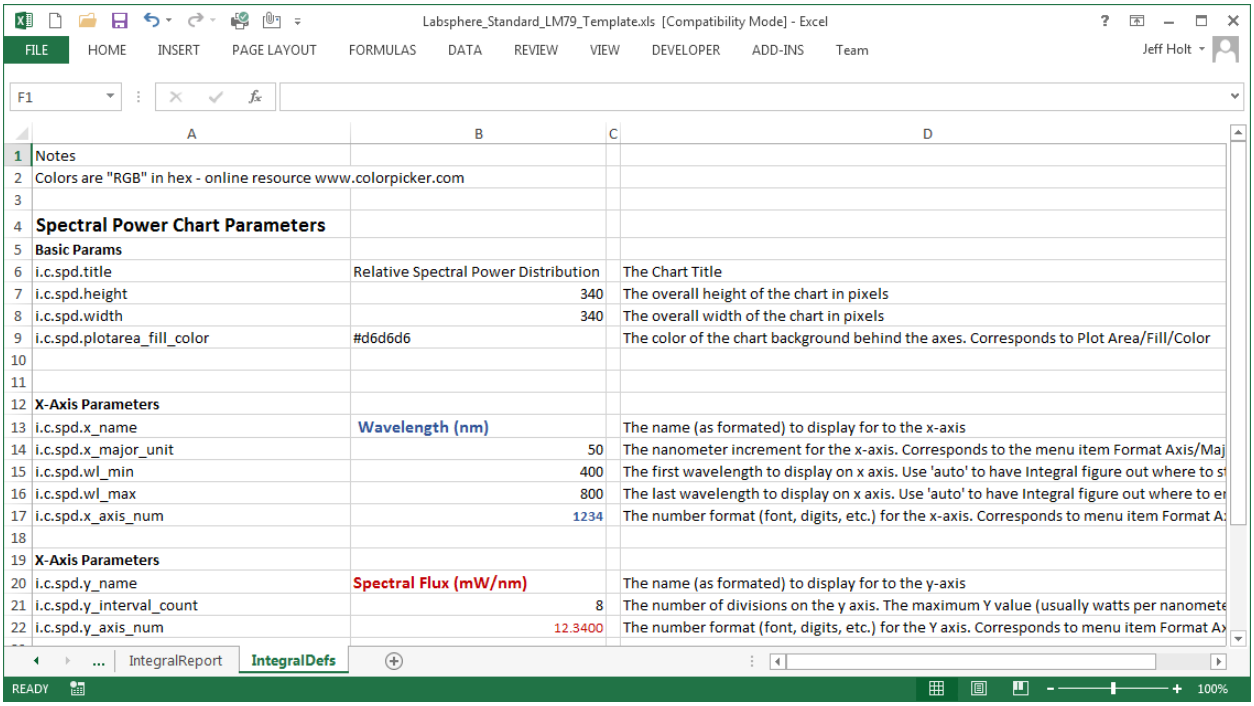


Figure 122: Integral Chart Definition Worksheet in Template

Report Examples

Labsphere

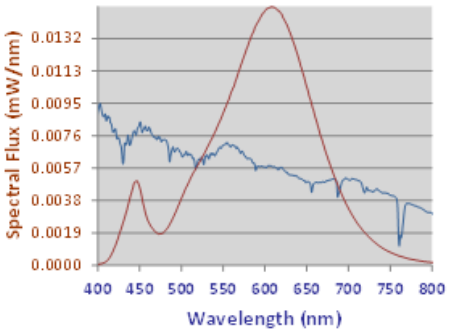
Photometric Measurement Report

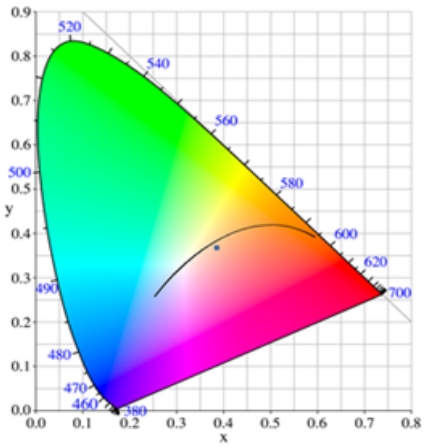
Generated by Labsphere's Integral™ Light Measurement Platform

Labsphere, Inc.
231 Shaker Street
Noth Sutton, NH 03260
(603) 927-4266

Example for Manual			
Description	LED Retrofit BR30	Test Time	7:26 PM
		Integration Time	2074
Orientation	Base DOWN	Scans Averaged	1
Test by	Jeffrey Holt	Saturation	38%
Notes	System included LM-82 equipment	Sphere Geometry	pi with 2pi Ca
Scan ID	Scan id 165 Ambient	Sphere Temp	

Relative Spectral Power Distribution



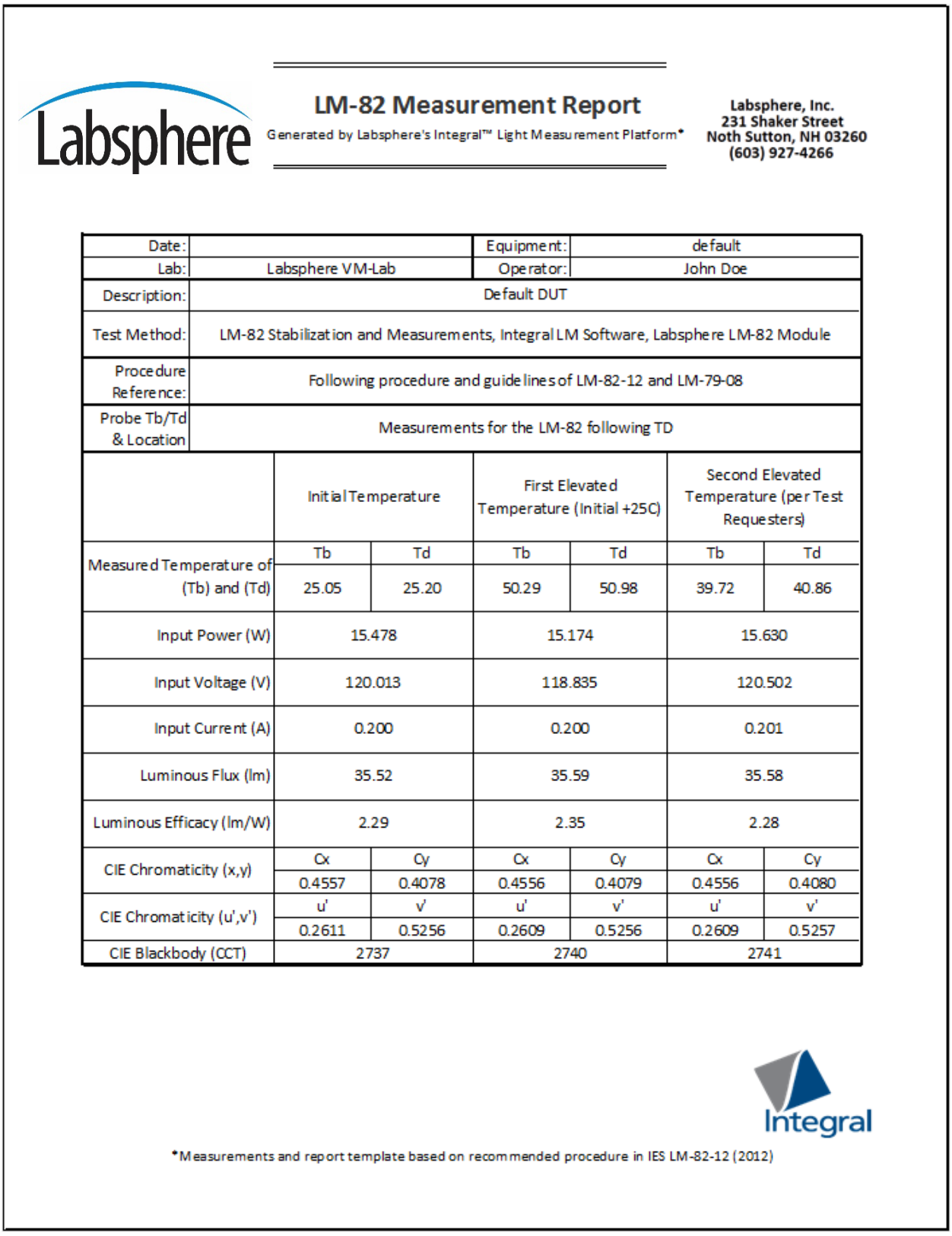


Lumens	Watts	Volts	Amps	Efficacy	PF	THD
461.9	3.004	30.661	0.151004	153.760282	0.648901	

CCT		CRI		x		y		Duv		u'		v'	
6764.0		97.237		0.3102		0.3166		-0.0020		0.2008		0.4612	
R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
98.1	97.4	96.1	97.5	98.3	96	96.8	97.7	96.2	93.2	96.4	96.7	96.9	97.6

Integral

Figure 123: Labsphere's General Report Including LM-79 Data



LM-82 Measurement Report

Generated by Labsphere's Integral™ Light Measurement Platform*

Labsphere, Inc.
231 Shaker Street
Noth Sutton, NH 03260
(603) 927-4266

Date:		Equipment:	default
Lab:	Labsphere VM-Lab	Operator:	John Doe
Description:	Default DUT		
Test Method:	LM-82 Stabilization and Measurements, Integral LM Software, Labsphere LM-82 Module		
Procedure Reference:	Following procedure and guidelines of LM-82-12 and LM-79-08		
Probe Tb/Td & Location	Measurements for the LM-82 following TD		

	Initial Temperature		First Elevated Temperature (Initial +25C)		Second Elevated Temperature (per Test Requesters)	
Measured Temperature of (Tb) and (Td)	Tb	Td	Tb	Td	Tb	Td
	25.05	25.20	50.29	50.98	39.72	40.86
Input Power (W)	15.478		15.174		15.630	
Input Voltage (V)	120.013		118.835		120.502	
Input Current (A)	0.200		0.200		0.201	
Luminous Flux (lm)	35.52		35.59		35.58	
Luminous Efficacy (lm/W)	2.29		2.35		2.28	
CIE Chromaticity (x,y)	Cx	Cy	Cx	Cy	Cx	Cy
	0.4557	0.4078	0.4556	0.4079	0.4556	0.4080
CIE Chromaticity (u',v')	u'	v'	u'	v'	u'	v'
	0.2611	0.5256	0.2609	0.5256	0.2609	0.5257
CIE Blackbody (CCT)	2737		2740		2741	

*Measurements and report template based on recommended procedure in IES LM-82-12 (2012)

Figure 124: Labsphere's LM-82 Report (Requires the LM-82 Module)

APPENDIX 5: RECOMMENDED PRACTICE FOR VALIDATING ILLUMIA PLUS CALIBRATION

1. INTRODUCTION

This document was created specifically to provide a means for validating the calibration of an illumia Plus integrating sphere spectroradiometer between recalibrations.

This process assumes the user has some basic experience using Labsphere illumia®Plus systems with Integral software

2. CALIBRATIONS

A calibration is required to convert data from the spectrometer into absolute spectral flux values. Spectral flux is often given in units of Watts per nanometer (W/nm) and describes the optical power contained in a wavelength band.

A calibration may be applied to the data collected from the spectrometer and is applied after other low-level corrections are implemented, such as electrical dark offset, linearity corrections, and in some cases, stray light corrections.

The three scans in a scan set are:

4) **Calibration Lamp Measurement (CAL Scan)** – This measurement uses a NVLAP Accredited Calibrated Total Spectral Flux Standard from Labsphere installed in the integrating sphere spectroradiometer in the orientation described in the lamp's calibration certificate. When the system is set up for calibration, the calibration lamp and the auxiliary lamp are in the integrating sphere. In most cases, all unnecessary fixturing, test lamps, or other apparatus have been removed. By operating the calibration lamp under the prescribed parameters, the performance of the system may be measured and calibrated. For this scan, the calibration lamp is powered on, and the auxiliary lamp is off.

5) **Auxiliary Lamp with Calibration Configuration (AUX/CAL)** – For this measurement the auxiliary lamp and calibration lamp remain in place as described above with the auxiliary lamp powered on, and the calibration lamp off.

6) **Auxiliary Lamp Measurement with DUT (AUX/DUT)** – For this measurement, the DUT is installed in the configuration in which it is to be measured. With the DUT in place, the auxiliary lamp is powered on, and a scan is acquired. (The calibration lamp remains off for this scan.) By comparing the two auxiliary lamp scans, the "self-absorption" of any additional "stuff" in the sphere can be corrected.

The calibration procedure for each step listed above requires the steps described in the flow chart below to properly stabilize the lamps for accurate measurements:

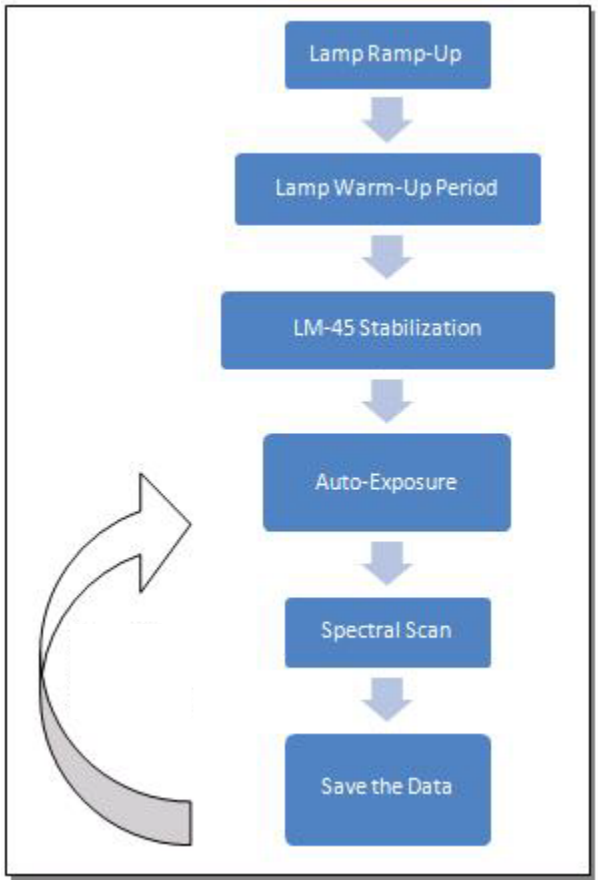


Figure 125: CAL and AUX Lamp Flow Chart

In Integral, a calibration may be *selected* to be used again, a new one may be *created*, or an existing calibration may be *updated* to include a new AUX with DUT scan. Start at the *System Calibration* section and click the **Choose** button:

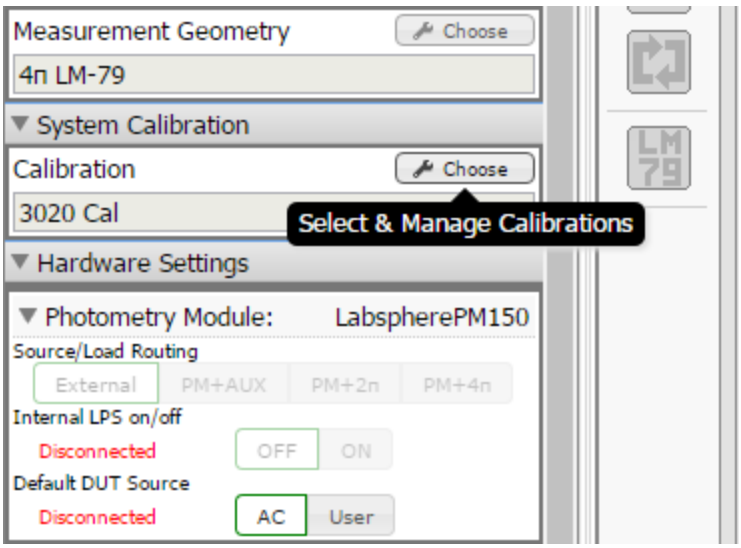


Figure 126: Manage Calibration

The *Manage Calibrations* screen opens:

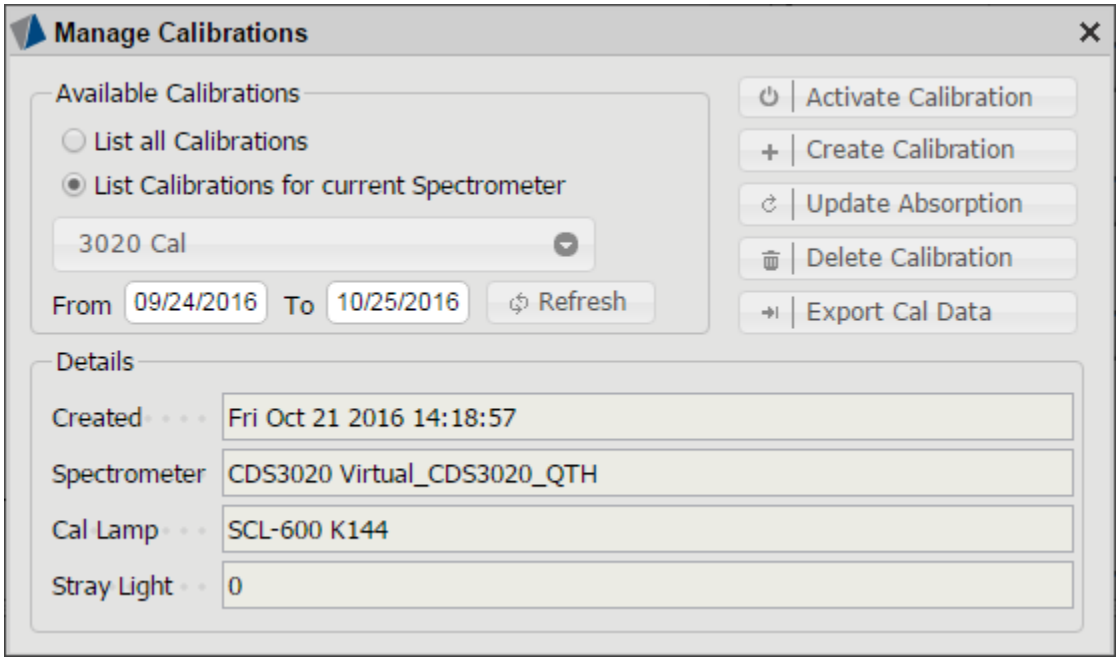


Figure 127: Manage Calibrations Screen

On this screen, the user may choose **Activate**, **Create**, **Update, Delete, or Export**. For this exercise we will choose Create Calibration

2.1 Create a Calibration: Setup

Integral provides a semi-automated calibration wizard to easily and precisely guide the user through the calibration process.

To start a new Calibration, press **Create New Calibration** from the *Manage Calibration* window. Observe the fields in the *Create a Calibration* window.

For this example, we will use SCL-1400-E154 to calibrate the integrating sphere spectroradiometer.

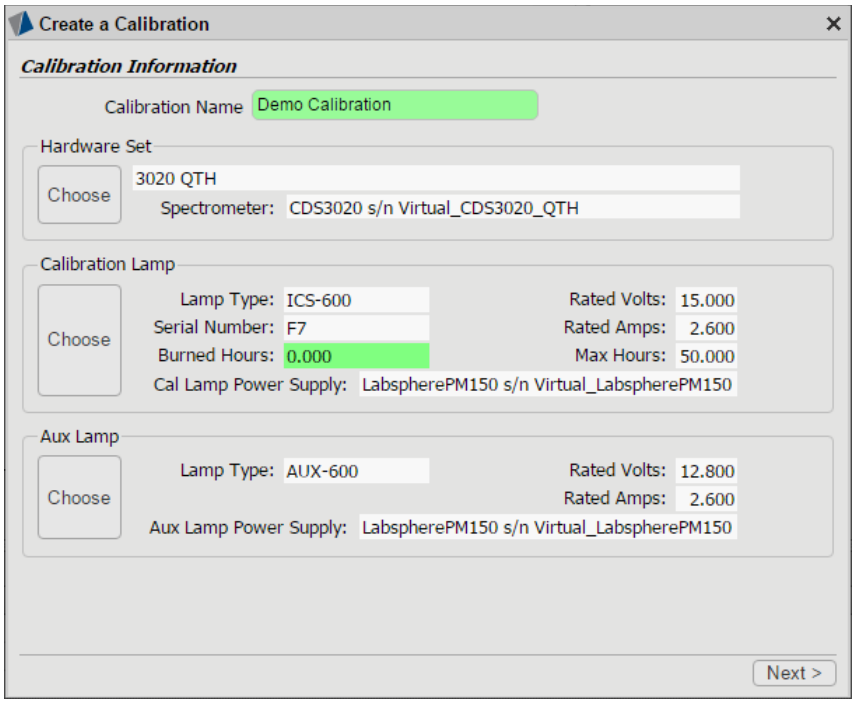


Figure 128: Create a Calibration Screen

Calibration Name

Every calibration must have a unique name. Labsphere recommends including a reference to the DUT for which the calibration is created.

Hardware Set

This indicates the hardware set that will be used to create the calibration.

Calibration Lamp

It is critical that the calibration lamp used in the calibration is the one selected from the list. All Labsphere calibration lamps have a serial number written on the base of the lamp. Integral must have specific measurement data for the calibration lamp being used. These data are stored in the Integral database. Previously loaded Calibration Lamps are available from the drop-down list in the *Select Calibration Lamp* window.

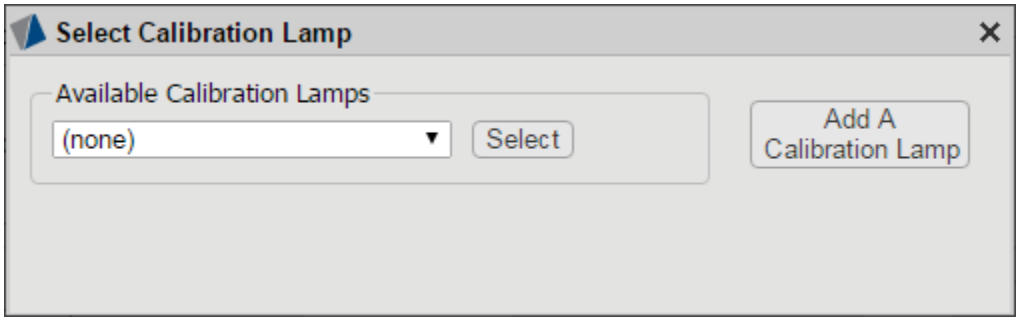


Figure 129: Select a Calibration Lamp Window

2.1.1 Select the Auxiliary Lamp

The correct auxiliary lamp must be selected from the drop-down list so that the current being supplied to the lamp matches the lamp specifications. Standard currents for Labsphere auxiliary lamps are shown below and are pre-coded into the Integral software. For this exercise select the AUX lamp on your systems (AUX-75).

Table 2
LABSPHERE AUXILIARY LAMPS

Lamp	Current	Lamp Power
AUX-35	2.639 A	35 W
AUX-50	4.16 A	50 W
AUX-75	2.576 A	75 W
AUX-100	2.737 A	100 W

2.2 Create a Calibration: Start

Once all the basic settings that define a calibration are set, click the **Next** button shown in Figure 29: Create a Calibration Screen.

The following window, *Calibration Options*, opens to allow setting of a few additional parameters that will be used during the calibration procedure.

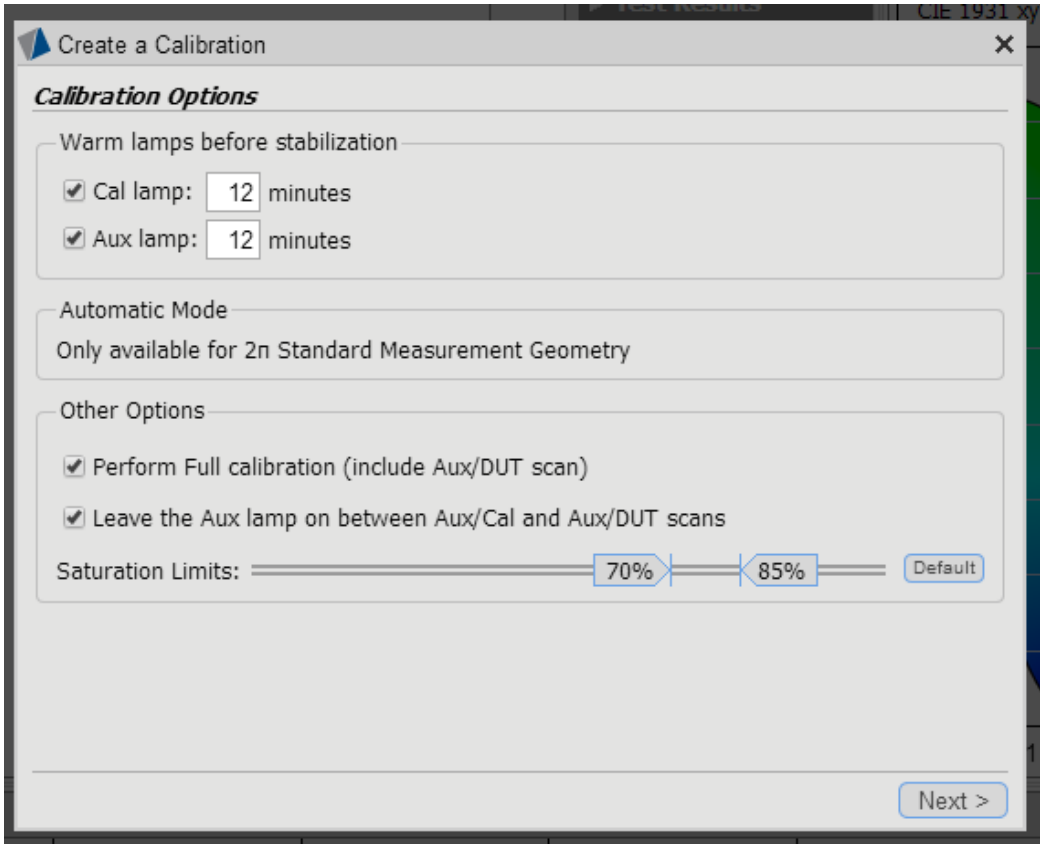


Figure 130: Calibration Run Settings

Calibration setting parameters include:

- Warm-up Time(s)
  - Prior to a calibration scan being performed (any one of the three described scans) the lamp must undergo the warm-up period, and it must satisfy the LM-45 stability requirement. Labsphere recommends a 15 to 20-minute warm-up period for the calibration and auxiliary lamps to ensure complete stabilization.

- "Automatic Mode"
  - Only available in specific sphere setups
- Perform Full Calibration
  - When unchecked, the system will "skip" the last of the scans in the scan set and will NOT perform the AUX with DUT scan
    - The resulting calibration is "completed" automatically by Integral using the AUX with CAL scan for both AUX scans
    - Using such an abbreviated calibration will result in no Auxiliary absorption correction being applied to DUT scans
- Leave AUX Lamp On
  - The AUX Lamp will remain lit after the AUX with CAL scan(s) are complete
  - No warm-up time will be needed between AUX with CAL and AUX with DUT scans

- Saturation Limits
  - These should typically be left at the default values
  - In some cases, a calibration cannot completer with the default limits – in these rare cases the saturation limits may be modified

2.2.1 Calibration Scan

Click **Next**. The *Prepare Calibration Lamp* screen opens with the message that the CAL lamp and AUX lamp are to be connected to the sphere, and that the CAL lamp is to be connected to its power supply.

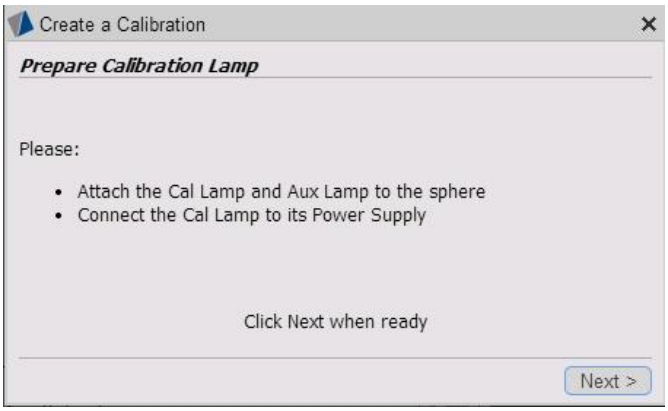


Figure 131: Prepare calibration Lamp

Click **Next**. The *Calibration Lamp Scan* screen opens, showing that the CAL lamp power is ramping up.

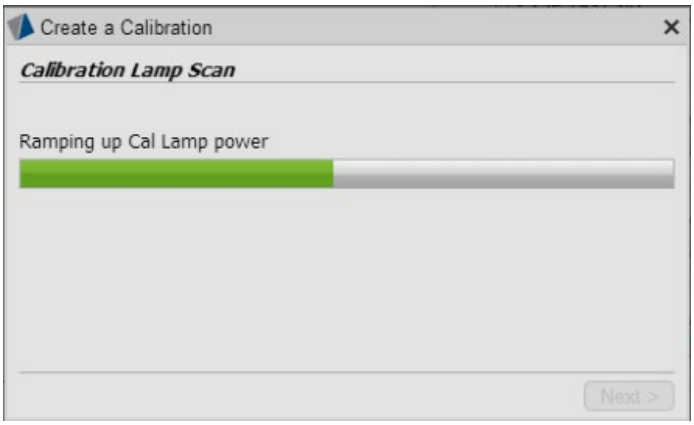


Figure 132: Ramping Up CAL Lamp

Click **Next**. The next screen opens, showing that the CAL lamp is warming up:

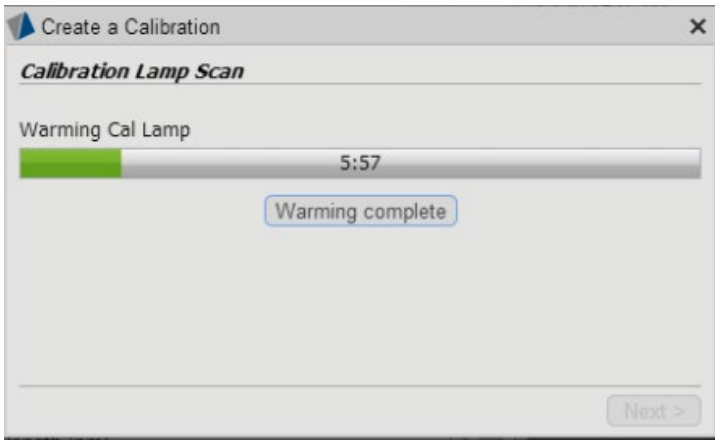


Figure 133: Warming CAL Lamp Screen

After the warm-up period, the next screen will appear and show the CAL lamp stabilization:

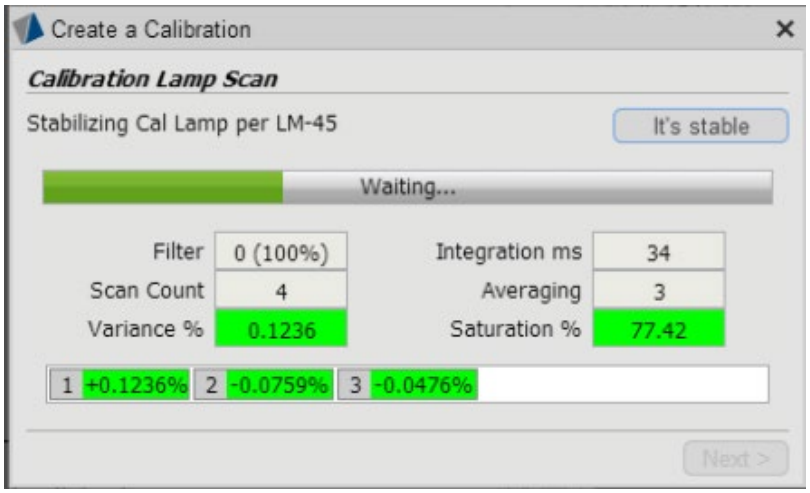


Figure 134: Stabilize CAL Lamp Screen

At this point, Integral performs an auto-exposure to determine the appropriate integration time for the spectrometer. Once this is calculated, the lamp undergoes the stabilization per LM-45. This procedure measures the lamp at 15 second intervals over a 1-minute period resulting in 5 measurements of the light output. The percent difference is calculated between the maximum and minimum values for following five consecutive measurements. The window shown in Figure 37 indicates the pertinent information during stabilization;

Scan Count (1 to 5) – the number of scans taken during the LM-45 procedure.
Variance – Is the % difference from Maximum reading to Minimum reading
Integration, ms – Spectrometer integration time
Averaging – Number of averages for the calibration (fixed at 3)
Saturation – maximum % Saturation of the spectrometer pixels.
Scan values (%) – scan value relative to the five previous scans

If the difference in scan values is less than 0.25%, then the lamp is stable and a scan will be performed as shown below:

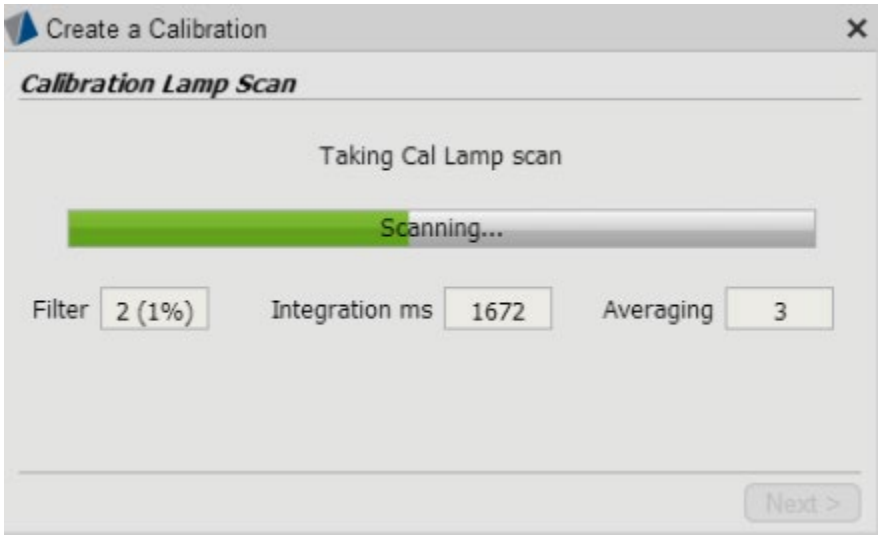


Figure 135: Taking Calibration after Stabilization

Upon completion of the calibration scan, a message will appear indicating that the calibration was successful:

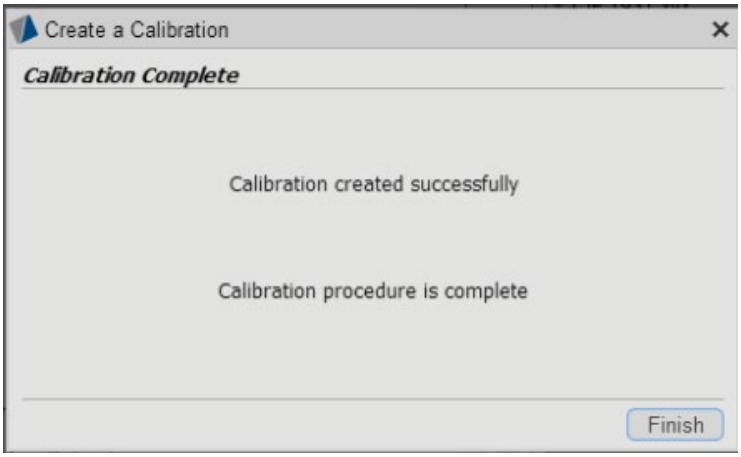


Figure 136: Calibration Created Successfully Screen

2.2.2 AUX/CAL Scan

Following the Calibration scan, the system will guide the user through a similar process for the Auxiliary Lamp Scan with the CAL lamp in place. If the PM-150 is being used, this step will be automatic. For any other set up, the user will need to follow the instructions provided by the wizard to ensure proper connections between the power supply and lamps.

2.2.3 AUX/DUT Scan

Following the AUX/CAL scan, the system will guide the user through a similar process for the Auxiliary Lamp Scan with DUT in place.

For this exercise the leave the standard lamp mounted in the sphere in the 4π position. This will be the configuration for checking the stability of the integrating sphere spectrometer spectral responsivity.

3. MEASUREMENTS TO VALIDATE THE INTEGRATING SPHERE RESPONSE

At this point you have established a calibration configuration to test the calibration. The system is set up with the SCL-1400 in the sphere in the 4π position and the auxiliary lamp on its port located on the equator. SCL-1400 will be used to validate the integrating sphere spectroradiometer calibration periodically. The Photometry Module will be used to control the SCL-1400 for the stability test. The Photometry Module controls are broken into three sections. [Source/Load Routing] which defaults to External routing (AC or User) once you connect to the PM-150. [Internal LPS on/off] which controls the on/off power for the PM-150 when using PM+AUX / PM+2π / PM+4π. For this test select PM+4π, and Internal LPS on/off.

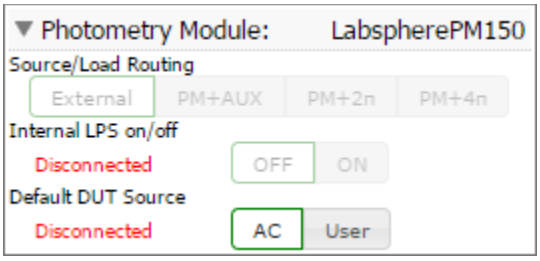


Figure 14: Photometry Module Controls

We will use SCL-1400-F154 in this example, since Labsphere provides a measurement uncertainty using SCL-1400-F154 as the standard and data.

Mount the SCL-1400-F154 in the sphere with the base up as described in the calibration certificate. Choose "LPS on" and allow a second SCL-1400-F154 to warm up for 15 to 20 minutes. Scans are initiated by clicking the icons to the right of the Spectral Display window and are described below. Select Auto-Exposure. Select Auto Save. Select Single Scan to take a scan of SCL-1400-F154.

Icon	Function	Description
	Single Scan	Performs a single scan.
	Continuous Scan	Performs continuous scans per the *Scan Interval (ms)* set in the *Spectrometer settings*.
	Save Scan	The scan displayed and the calculated values are saved to the data base
AUTO	Auto Save	Scans acquired under single or continuous mode are automatically saved when acquired.
	Apply Calibration	Applies the selected Calibration set to the data. Data is displayed as W/nm.
	Apply Dark Correction	Applies a dark correction to the data to help correct spectral data and reduce noise.
AUTO	Auto-Exposure	Performs an auto exposure.
LM 79	LM-79 Stabilization	Performs an LM-79 stabilization.
λ λ1 λ5	Change resolution	Change the resolution of scans with three options ranging from pixelspace, to 1 nanometer, and 5 nanometer.

Export this scan and data. Data from scans saved in the database are exported in .CSV format. Exports include all the data associated with each scan including calculated values such as lumens which will be the reference to check the stability of the calibration.

To export one or more scans, select the desired scan(s) using the check box next to each record in the table displayed at the bottom of the user interface. Exported data files (*.CSV) may be opened directly in Microsoft Excel for viewing, and analysis.

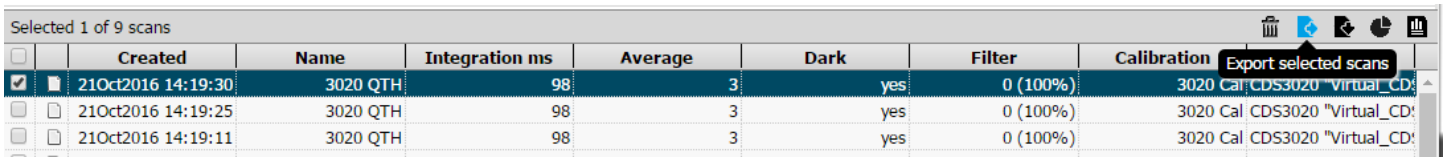


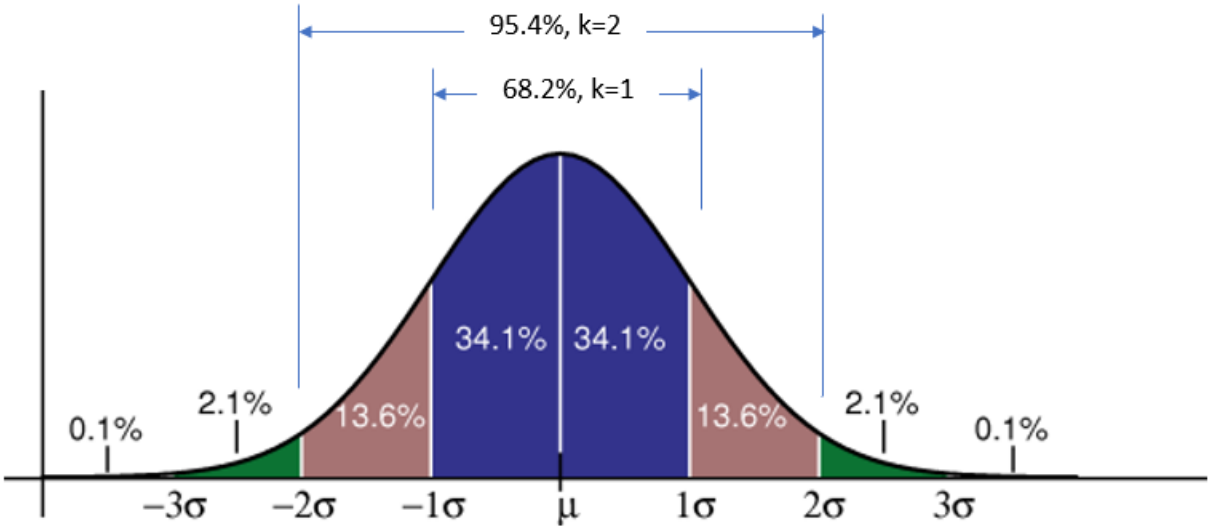
Figure 137: Selecting Scans from the Database

Click the *Export selected scans*  or *transpose*  icon. Data will be bundled into a *.CSV file and delivered to the Chrome browser. The Chrome browser will automatically save files to the *Downloads* directory. The file download setting for Chrome may be modified to save to a different location or to create a “save as” dialog with every download. Integral has no control over these settings.

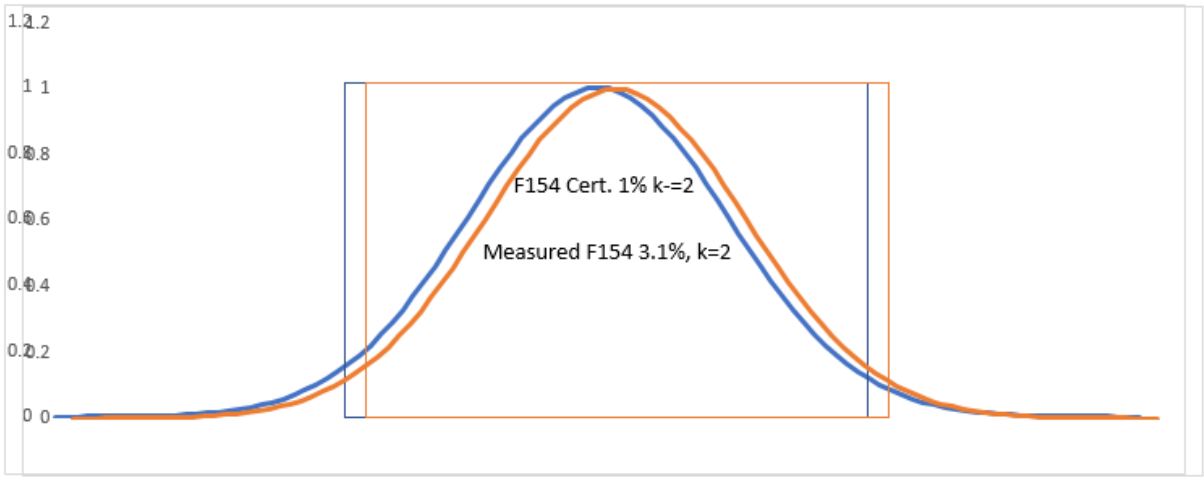
4. VALIDATING THE SPHERE SPECTRORADIOMETER RESPONSE

Use this scan to validate the integrating sphere spectroradiometer lumen responsivity calibration.

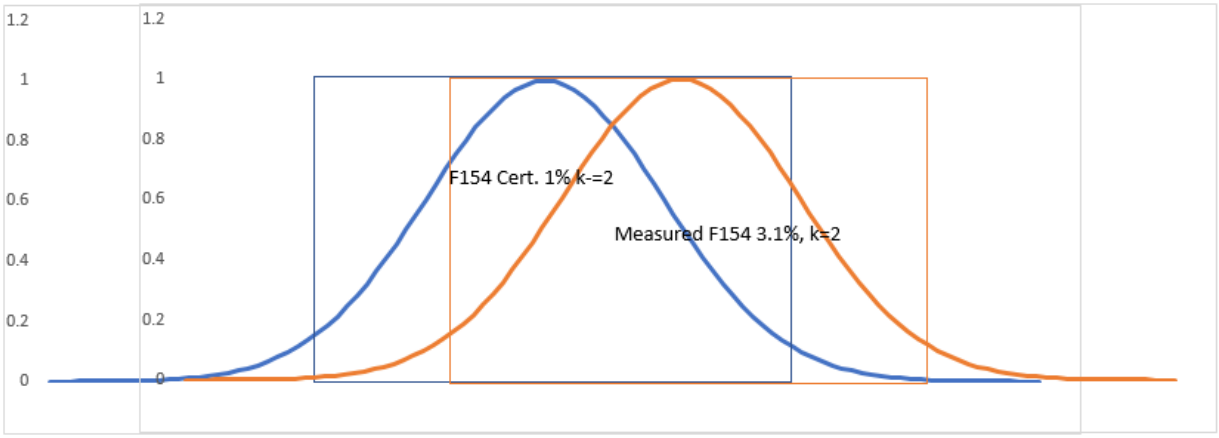
To compare performance the measure lumens bounded by the expanded uncertainty k=2 for SCL-1400-F154 shall be with the within the certified values and bounded uncertainty in the calibration certificate provided by Labsphere with the artifact. Below are three examples passing this criterion and one that fails. It is recommended that this be done with at least two validation calibration reference lamps



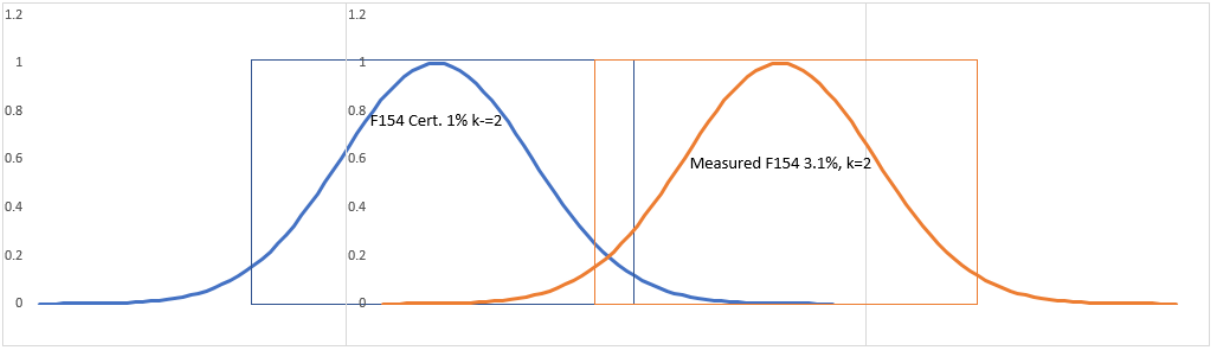
Example of k=2, 95.4% confidence level. 1% for lumens certified. And, 3.1 % when measured in the illumia®Plus system based on uncertainty analysis with data provided for the lamp measured in illumia®Plus integrating sphere spectroradiometer.



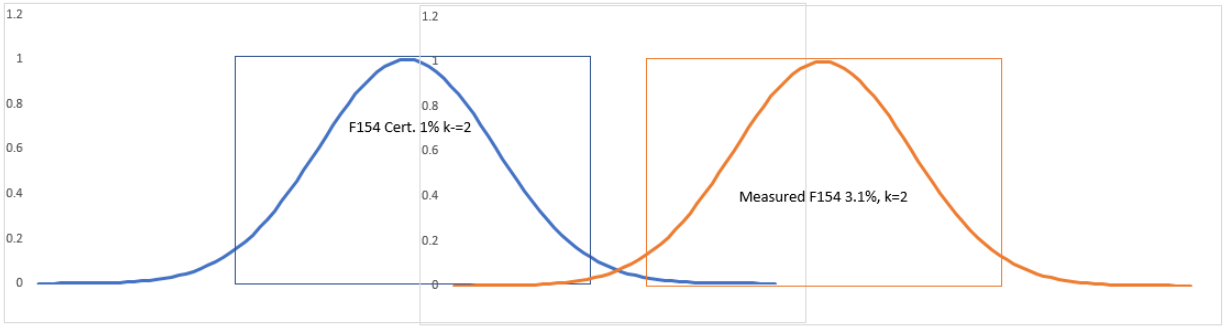
In this example the Blue represents certified lumens of F154 +/-1% and measured lumens uncertainty 3.1% (Orange). The overlap difference is almost not negligible, this validation passes.



In this example the overlap is closer, this validation passes. About 1.3% difference.



In this example. the difference is about 3.2% difference. The overlap is small but theoretically this validation passes too at less than 4.1% difference.



The last plot is an example an invalid calibration check. The uncertainty of the lamps does not overlap with the uncertainty of the measurement. In this case additional measurements with other standard lamps will indicate if the sphere calibration is bad or calibration lamps has drifted, or the lamp used to validate the calibration has drifted.

APPENDIX 6: TROUBLESHOOTING

Chrome Troubleshooting

For most issues relating to Chrome, proceed through these steps from 1 to 4.

Chrome Advanced Settings

Many of these steps require access to Chrome advanced settings. This is accessed under the browser settings located on the upper right section of the browser:

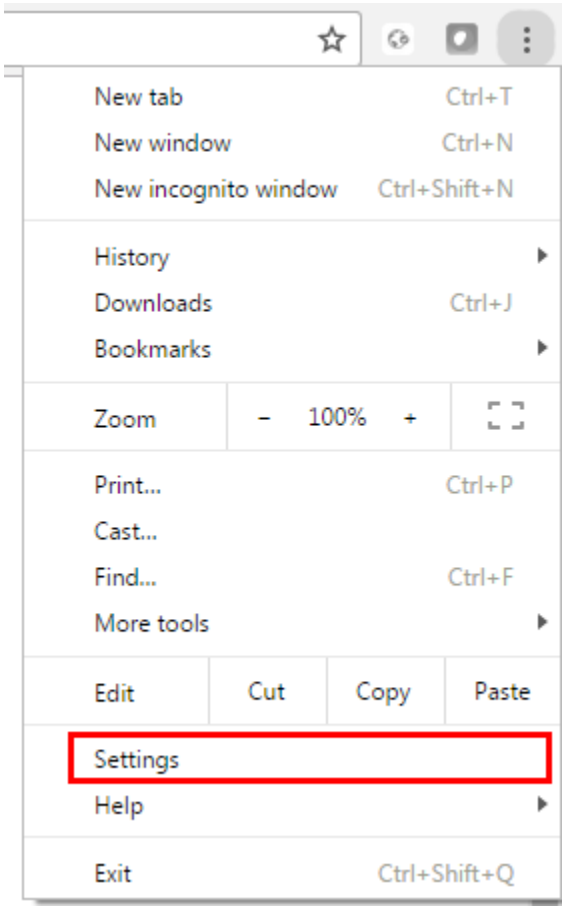


Figure 138: Chrome Settings

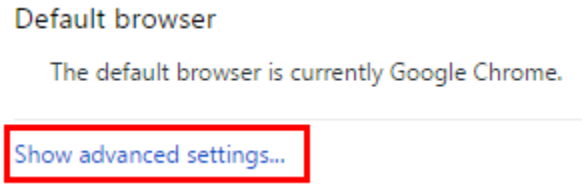


Figure 139: Chrome Advanced Settings

1. Refreshing Cached Images and JavaScript files

Following an update, it may be necessary to update the cached JavaScript files for Integral. To do this you can hit the keyboard shortcut **<CTRL+F5>** when connected to Integral. This will force the browser to get the newest version of all JavaScript files it had previously saved. You can also do this manually via Chrome settings:

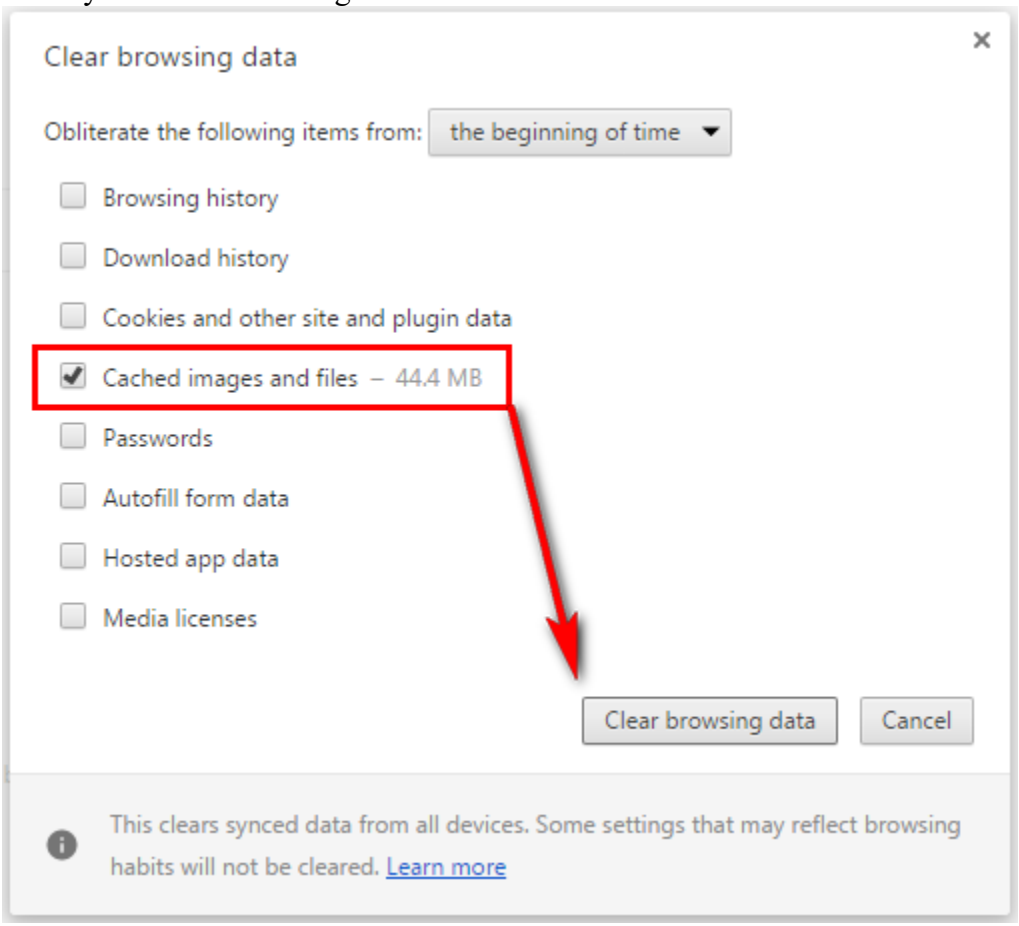


Figure 140: Clear Chrome Cached Images & Files

2. Missing Variables/Values or User Interface Elements

If information in the user interface is not showing up correctly or behaving as it normally does, it is likely that the Chrome profile being used has been corrupted in some way. Delete and then restore your Chrome profile to reset it.

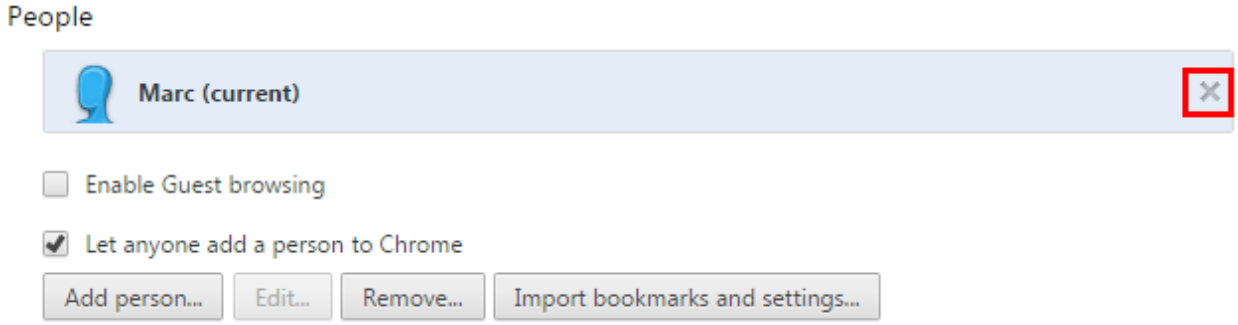


Figure 141: Reset your Chrome Profile

Once this is done you can log back in to restore your profile

3. Clear Browsing Data

Some settings unrelated to cached files or profile settings can be saved to browsing data. That is why we recommended deleting this extra data to eliminate any problems it can cause.

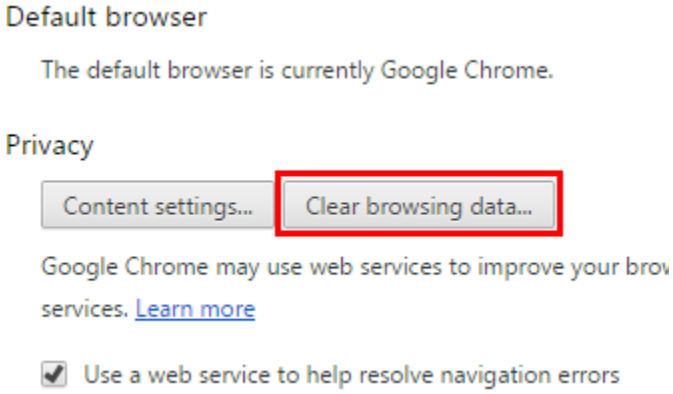


Figure 142: Clear Browsing Data

4. Resetting the Chrome Browser

There may be custom data/plugins that could interfere with the Integral user interface. This could be carry over from older versions of Chrome. Whatever the case may be, you can reset the Chrome Browser to restore all default settings. At the bottom of Chrome settings under *advanced settings* there is a **Reset settings** button.

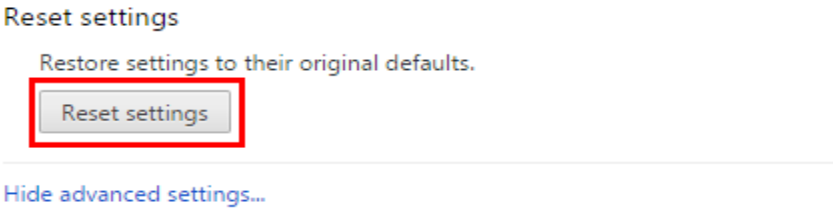


Figure 143: Reset your Chrome settings

Integral Troubleshooting

Integral Server Not Starting After Upgrading to 1.6+

Beginning with Integral 1.6 the software started using the Microsoft Visual C++ Redistributable for Visual Studio 2015 (x86). Be sure to install this software package before using the newest versions of the software. You can confirm that this package is installed via *Control Panel → All Control Panel Items → Programs and Features*.

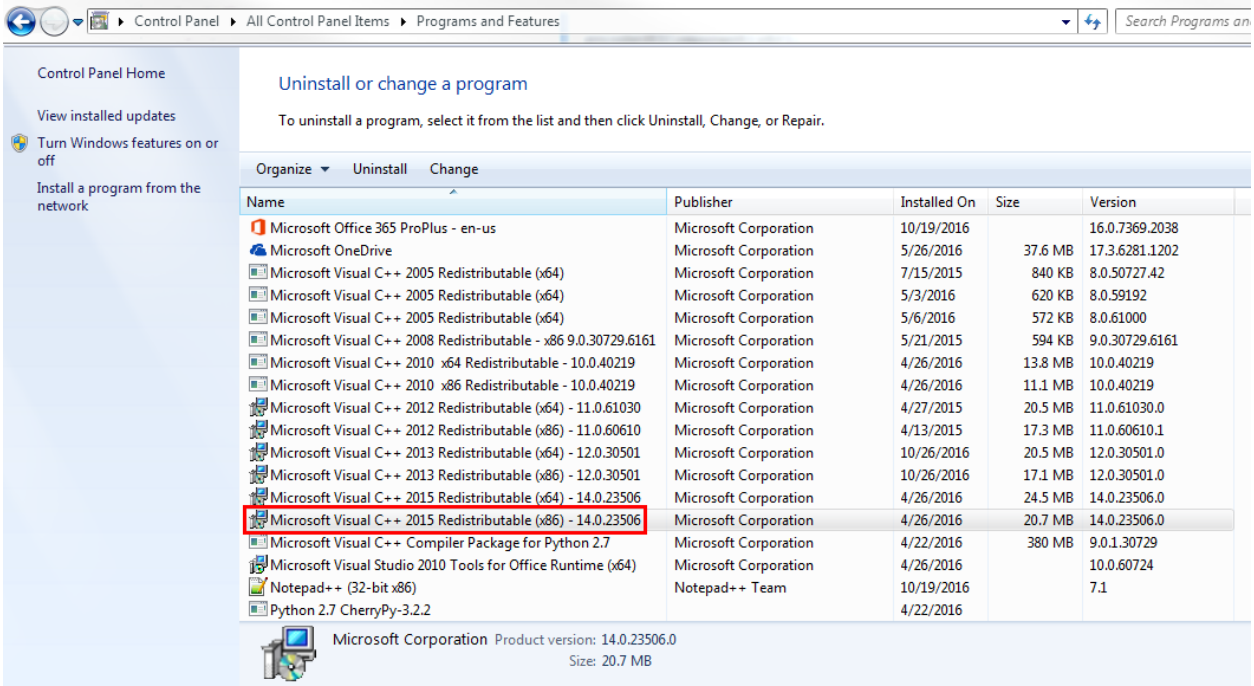


Figure 144: Microsoft Visual C++ 2015 Redistributable (x86)

Starting the Integral Server

If Integral did not start, the server can be started manually. Do this by clicking the **Start Integral Server** option after right clicking the Integral Service Manager located in the taskbar.

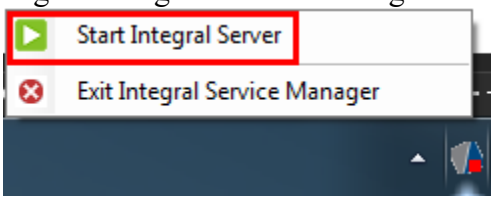


Figure 145: Integral Server Start

Integral Update Activation

After clicking the activate button Integral should restart on the version that has been activated.

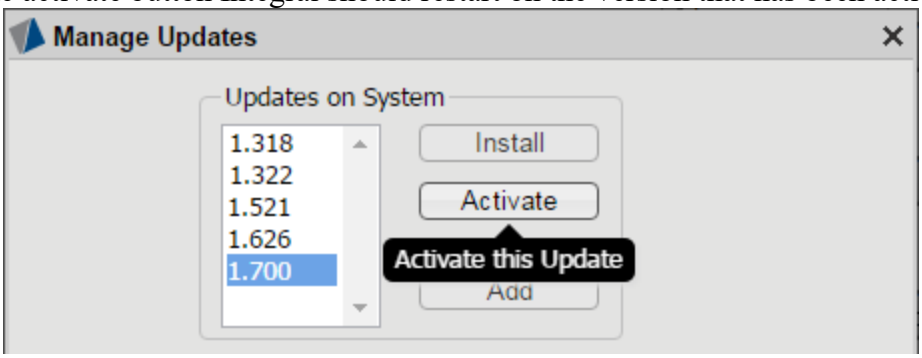


Figure 146: Integral Activate Update

If this error occurs it can be fixed via: Control Panel / System / Advanced / Environment Variables / System Variables / Path / Edit.

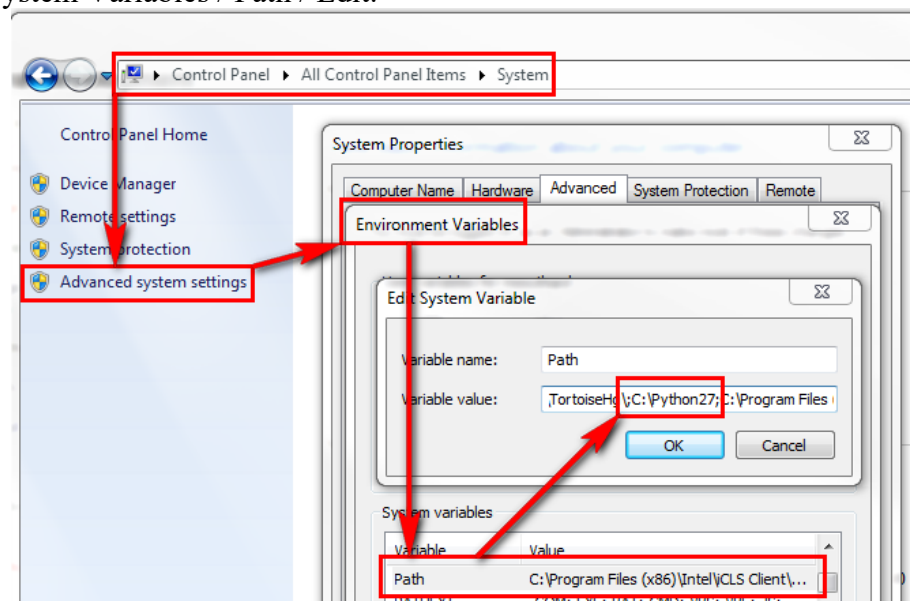


Figure 147: Python27 System Variable Setup Procedure

The Python27 path should read "C:\Python27". If it isn't strictly that value, please modify/add that path as shown above.

Next, if this action was not captured, clicking **Restart Integral Server** via the Integral Service Manager (located in the taskbar) will manually restart the server into the new version.

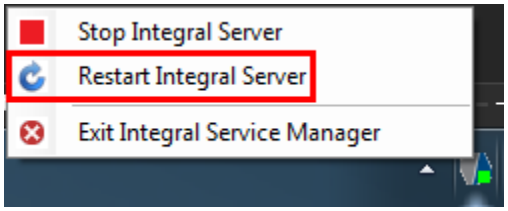


Figure 148: Integral Server Restart

Launch the Integral Service Manager

To launch the Integral Service Manager manually, locate the associated executable in the folder: "C:\Integral\<version>\tools\bin\IntegralSvcMgr.exe"

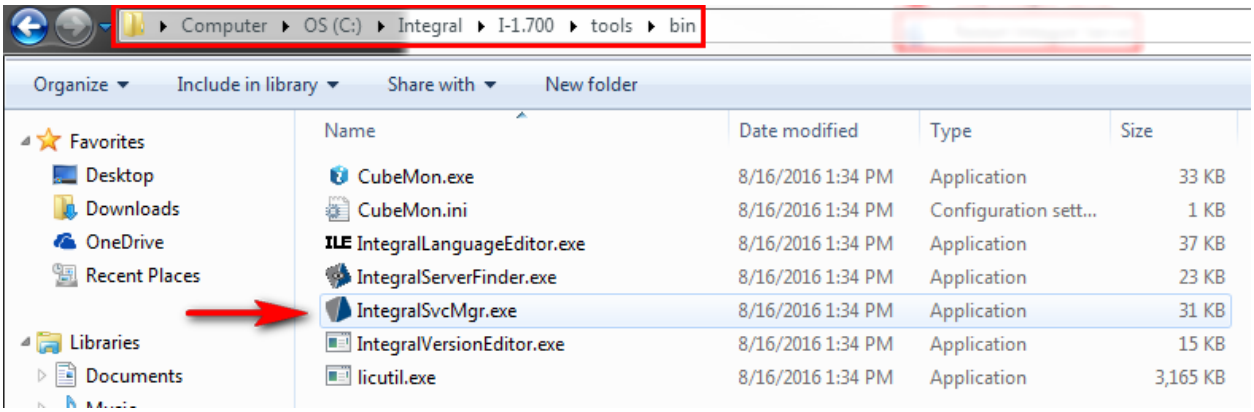


Figure 149: Integral Service Manager Executable

After doing so you can create a shortcut wherever you would like to make it more easily accessible.

Device Connect Failure

When trying to connect to a hardware set, a device may fail to connect. Be sure to check that all devices are connected properly, then manually refresh your device catalog. This will force Integral to look for any changes in your hardware.

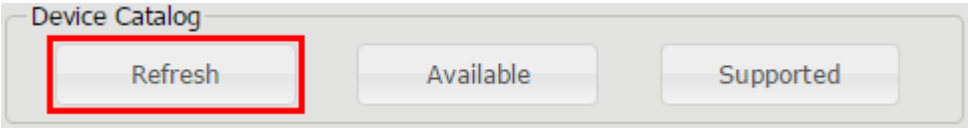


Figure 150: Refresh Device Catalog

Spectrometer Drivers

Spectrometer drivers (by default) are in the directory "C:\Labsphere\SpectrometerDrivers2"**.**

APPENDIX 7: KEITHLEY 246X NI-VISA HARDWARE DRIVER

The Keithley 246X SourceMeter series in some custom IllumiaPro2 systems requires a separate NI-VISA hardware driver to be installed in order to have it recognized by Integral.

NI-VISA is an NI instrument driver that is an implementation of the Virtual Instrument Software Architecture (VISA) I/O standard. VISA is a standard for configuring, programming, and troubleshooting instrumentation systems comprising GPIB, VXI, PXI, serial (RS232/RS485), Ethernet/LXI, and/or USB interfaces.

Navigate the system's host computer to this location to download and install the NI-VISA hardware driver:

https://www.ni.com/en-us/support/downloads/drivers/download.ni-visa.html#442805

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