OCI^{TM}-F Ultra-Compact Hyperspectral Imager User Manual

Version 1.1

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1.1 Introduction

The **OCI™-F** push-broom hyperspectral cameras (the brand name, OCI, is inspired from "All-seeing Eye") are high-performance, ultra-miniaturized hyperspectral imaging engines, packed with SuperSpeed USB 3.0 interface. They feature dramatic reduction in size and weight and increased data transfer rates. These hyperspectral cameras acquire VIS-NIR hyperspectral data with continuous spectral and spatial coverage. The **OCI™-F** features "true push-broom" fast hyperspectral imaging, simply by using your hand to move the imager or sample. Compactness, simple operation, and intuitive software make the **OCI™-F** imagers very straightforward for applications such as precision agriculture, remote sensing, forensics, and biomedical diagnostics.

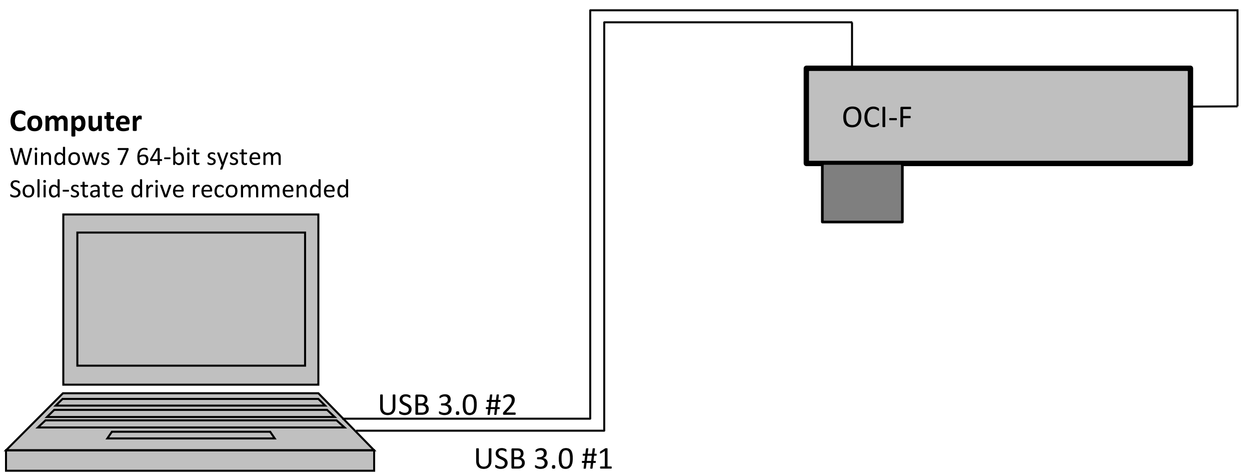
Key Features of OCI™-F

- Full VIS-NIR 400-1000 nm coverage
- Extremely compact and light-weighted
- Scanning with random speed, "true push-broom"
- Real-time image preview
- Innovative design significantly reduces system complexity and enhanced reliability
- Effortless system integration (e.g., less demanding on small UAV system)

OCI™-F hyperspectral camera with a standard f=16 mm (24° FOV) lens, in an ultra-compact package.

1.2 Hardware Set Up

Setup of the OCI-F systems is very simple. The OCI imager is required to be connected to a PC with **two** USB 3.0 cables, which also power and control the imager. An optional highly compact computer may be purchased from BaySpec to make the whole package ready to use, especially in the field or to integration with other systems, e.g., in a UAV system.



An example setup of the OCI™-F imager.

The OCI imager is usually shipped with C-mount lens. Additional C-mount lenses with different FOVs (field of view) can be ordered from BaySpec. For OCI-F system, the standard lens included is a compact, near-infrared (NIR) enhanced lens with 16 mm focal length, covering 24° FOV.

Note: It is recommended to set the lens aperture at f 2.8. For UAV applications, the lens focus should be fixed at ∞.

For customer's convenience, BaySpec also provides an optional compact computer, which runs BaySpec's **SpecGrabber** and **CubeCreator** software to control OCI imager and acquire data, and to process the raw images into hyperspectral data cubes and band images. This computer is balanced between weight, size and performance, extremely easy to use as a desktop or mobile system (with optional battery pack). The computer can connect with external USB mouse/keyboard and HDMI monitor, or be controlled and viewed wirelessly via Wi-Fi hotspot. A licensed VNC server is installed (see A**ppendix A** for the VNC software quick guide).

Compact Computer General Specs	
Dimension	4.5 in x 3.5 in. x 1.1 in.
Weight	1.1 lb.
Power Input	19 V (battery pack optional)
Consumption	Peak 50 W, typical < 10W
CPU	Intel Core i5
Memory	8 G (upgradable)
Storage	400 G (upgradable)
Operating System	Windows 7 Pro
Software	SpecGrabber and CubeCreator
Additional Ports	USB 3.0, HDMI

Note: This computer is configured for OCI imager use only. It is not recommended to use for other purpose (e.g., surfing the Internet). It is not recommended to update its Windows operating system and install unrelated drivers and software.

Note: This computer is configured as a Wi-Fi hotspot for easy use of VNC remote control software (see A**ppendix A** for the VNC software quick guide). The default Wi-Fi hotspot name is "BaySpec-OCI", default password is "BaySpec-OCI".

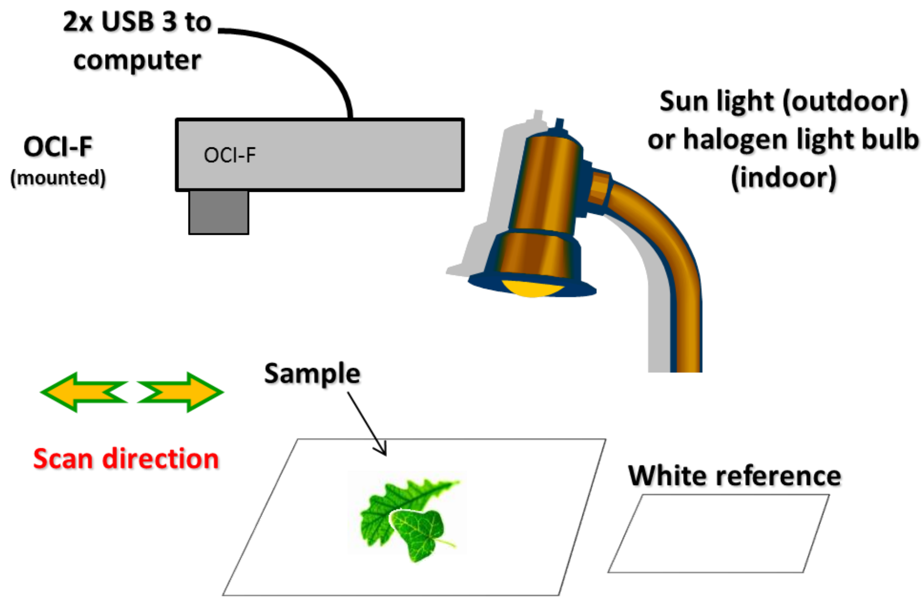
Note: This compact computer is mainly intended for OCI imager data acquisition. For heavy-duty hyperspectral data processing (e.g., > 1000 raw frames, or > 2 GB data set), it is recommended to use a powerful desktop computer.

This setup, consisting of an OCI-F imager, a compact computer, and a battery pack can also be packaged together with BaySpec's ready-to-fly UAV system (UAV costs extra).

1.3 Using the Imager

The following are general steps on how to use the imager:

1. Power on computer. If the compact computer is used, connect external HDMI monitor, keyboard and mouse to access the computer. Alternatively, access the computer wirelessly using VNC (See appendix for VNC guide).
2. Connect the OCI imager to the computer via two USB 3.0 cables.
3. Run SpecGrabber, or set SpecGrabber automatically to run at computer start up.
4. Turn on the illumination for the sample or the white reference (a 95% white reference is provided). Adjust to a proper exposure time in SpecGrabber so for both sensors so that no pixel's intensity shall go over 230 for 8 bit data format or 920 for 10 bit data format to prevent possible saturation. Auto-exposure function can be used. If the exposure time is too long (>5 ms), the user may adjust **Light condition** in SpecGrabber to change the gain of the camera. Check both sensors to prevent pixel saturation.
5. Sample image can be viewed in SpecGrabber's real-time preview window with sensor #2. Adjust the focus on the lens until a sharp image is obtained.
6. Record white reference images with white standard in the field of view. You may need to adjust the distance between the imager and the white standard so that the white standard covers all the field of view of the imager. Adjust exposure time to prevent saturation or under exposure for both sensors before taking white reference.
7. Record dark reference while covering the lens.
8. Start record raw images when the sample or the imager moves to scan. Adjust exposure time to prevent saturation or under exposure for both sensors before recording raw images. Refer to the following SpecGrabber and CubeCreator software guide for acquiring the raw frames and process raw frames into hyperspectral cubes.
9. Power off the OCI imager by turning off the computer, or unplug the USB cables from the computer.


2x USB 3 to computer
OCI-F (mounted)
OCI-F
Sun light (outdoor) or halogen light bulb (indoor)
Sample
Scan direction
White reference

Some general recommendations in imaging setup:

Line scanning: push-broom scanning has to go along with the marked scanning direction. The sample or the camera needs to scan (linearly move) by moving the sample at a relatively constants speed until enough raw frames are captured.

Light source: sun light or halogen light bulbs (~ 50 W) whose spectrum is generally flat (uniform) at 400-1000 nm (common CFL or LED is not recommended because their spectra are not uniform). Illumination should be relatively even on the samples (or the white reference standard). Avoid creating shadows on the samples while recording images. Retake white reference when there is any change in illumination condition. For the application under sun light, an optional spectrometer package has been provided by BaySpec to compensate the light condition change. With this package, the white reference can be recorded only once in the beginning.

Imager alignment and mount: Align the camera so that its optical axis is always perpendicular to the samples. On UAV application, the imager is required to be mounted on a gimbal to keep it perpendicular to the ground. BaySpec provides an optional gimbal package for OCI-F UAV application with extra cost.

2. SpecGrabber User Guide

Note: If a BaySpec computer is provided, the software and drivers have already installed and configured properly for the imager.

BaySpec's SpecGrabber is Microsoft Windows based software to record the hyperspectral images using BaySpec OCI™ hyperspectral imagers. This software is designed for running under **Windows 7 64-bit** system.

The recommend computer configuration is listed below:

OS:	Windows 7 Pro 64-bit
CPU:	Intel® Core™ i3 or higher
RAM:	8 GB or higher
Storage:	Solid-state drive
USB Port:	USB 3.0 SuperSpeed
Display:	1200 × 800 pixels or higher

2.1 Software Installation

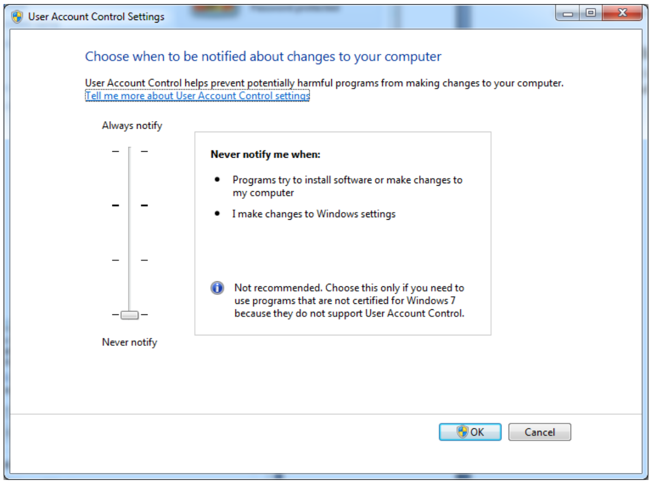
1. Remove any previous version of SpecGrabberUSB3 software
2. Double click the installation file (SpecGrabberUSB3 Installation yyyy_mm_dd.msi) provided by BaySpec to start the installation.
3. Copy the calibration files from the USB flash drive provided by BaySpec under the folder /BaySpec/Calibration files/. The hardware-specific calibration files (OCI-F-Vxxxxxxx.xml) is required to be copied to the program root folder (usually "C:\Program Files\BaySpec, Inc\BaySpec SpecGrabberUSB3). OCI imager would not work properly without correct calibration files.

2.2 Drivers Installation

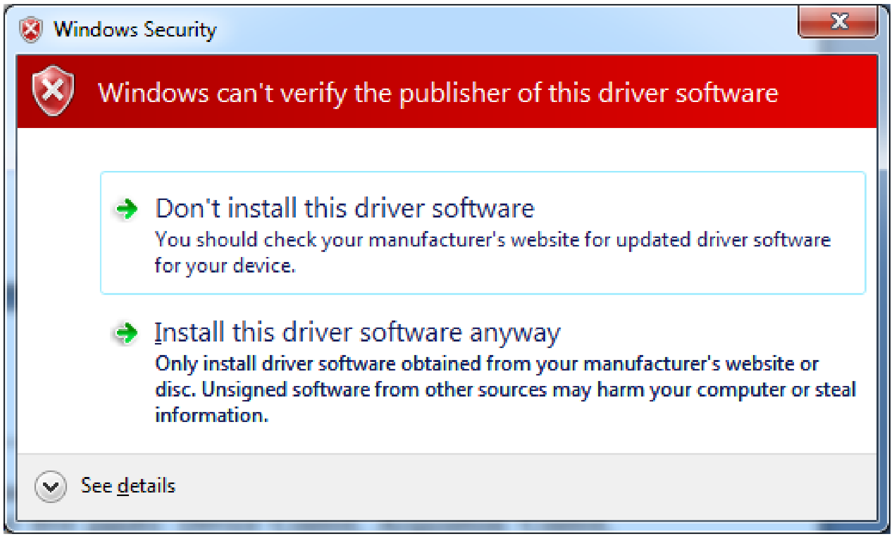
Following these steps to install sensor USB 3.0 driver:

Step 1: Unplug any BaySpec OCI imager.

Step 2: Go to **Control Panel**, click on **User Accounts and Family Safety**. Click on **User Accounts** and then **Change User Account Control settings**. Then drag the horizontal bar to **Never notify**.

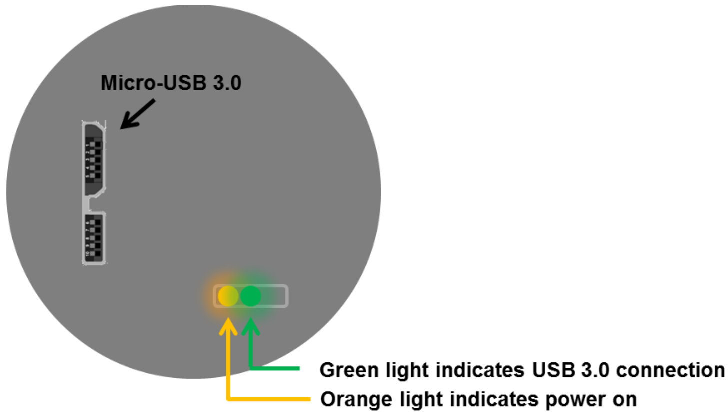


Step 3: Run SpecGrabberUSB3 installer (.msi file) if you have not done so yet. After the installation is completed, locate the driver directory of the SpecGrabber installation. If you used default installation path, it will be at C:\Program Files\BaySpec, Inc\BaySpec SpecGrabberUSB3\Drivers. Double click InstallDriver.bat. If you see the following warning, click on **Install this driver software anyway**.



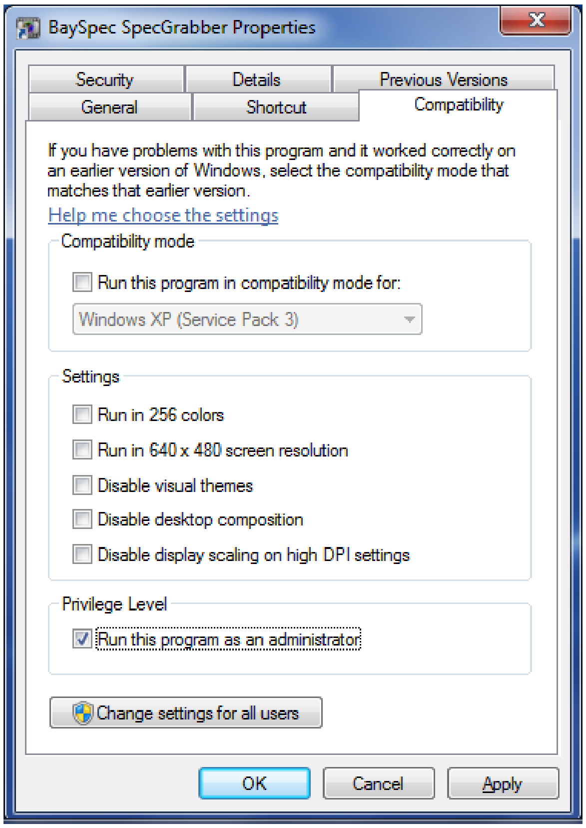
Step 4: Plug Sensor 2 which is close to the lens into a USB3.0 port. If the driver has been installed successfully, you will see a solid green LED on at the top of camera head. If you see the

green LED blinking, the camera has been plugged into a USB2.0 port or driver has not been properly installed.

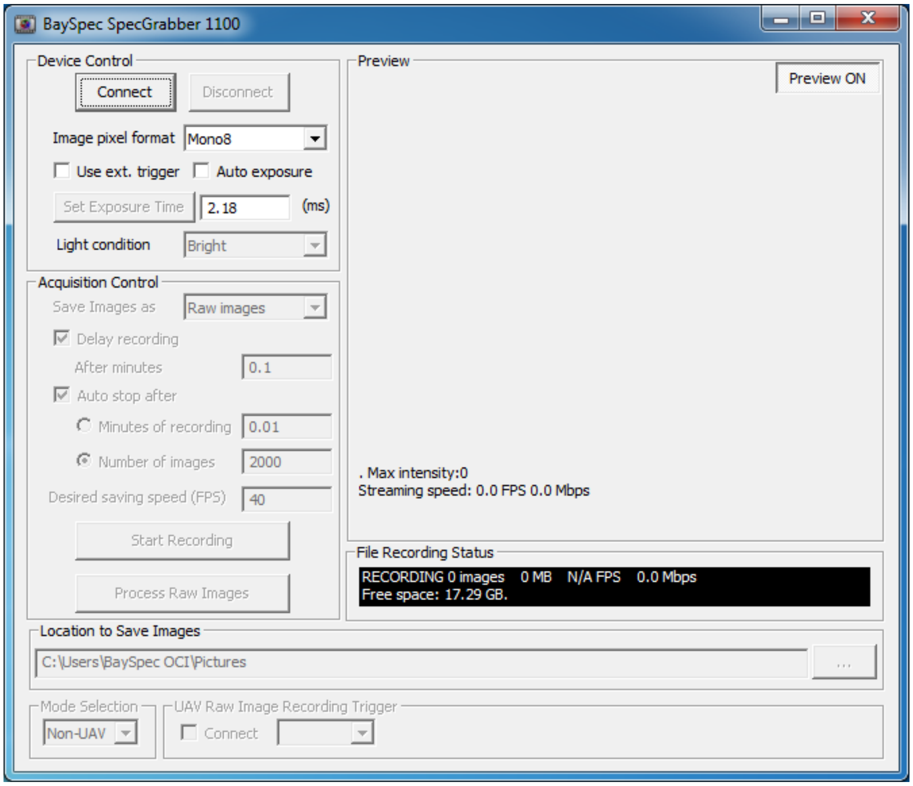


2.3 How to Use SpecGrabber

The SpecGrabber needs to be run as an administrator every time. After installation of SpecGrabber, highlight its shortcut icon on desktop, and right click to bring out property setup window. Click on Compatibility tab and check **Run this program as an administrator**. This will enable the program to save and retrieve parameters from previous run.



SpecGrabber GUI consists of five panels: Device Control, Acquisition Control, Preview, Status, and Location to Save Images. The GUI elements and their functionalities are described below.



BaySpec's SpecGrabber Interface

2.3.1 Device Control

Under **Device Control** panel, there are two buttons, **Connect** and **Disconnect**.

- When clicking on the **Connect** button, the program will try to search and connect two sensors. If successful, the status panel will show message “Camera connected”. Otherwise it will show message on why it fails. Usually this process will take couple of seconds.
- When the camera is connected, check the checkbox **Enable preview** under the preview panel will display what the camera sees (current raw frame).

Enabling preview may reduce frame streaming speed in high-speed imaging.

- Click on **Disconnect** button will disconnect the camera.
- The dropdown list **Image pixel format** will enable the user to select the raw image pixel format. Two data formats are available for sensors 1, **Mono10** and **Mono8**. Sensor 2 will only have one data format, **Mono8**. When Mono8 is selected, the image will be saved as 8 bits per pixel. When Mono10 is selected, the image will be saved as 16 bits per pixel, but only the last 10 bits contain the valid data. This selection will only be enabled before the **Connect** button being pressed.
- Checking the checkbox **Use external trigger** (for selected models) will enable the camera’s streaming speed to be controlled by external trigger. The frequency of the external trigger has to be lower than the maximum streaming speed of the camera.
- The user may use this feature combined with **Delay recording** to achieve interface free automation of image recording.
- The user can change the exposure time of the camera by editing the exposure time in the unit of millisecond and then pressing the button **Set Exposure Time**.
- If checkbox **Auto exposure** is checked, pressing the button **Set Exposure Time** will enable the program to get and set the optimized exposure time, which will enable the camera reach 90% of saturation intensity (about 230 for Mono8 and 922 for Mono10), under current light condition. Pixel saturation should be avoided during the image recording. On the other hand, under exposure should also be avoided because it prevent the imager to use the full dynamic range of the sensor.
- Camera gain is controlled by dropdown list **Light condition**. There are four options: Very bright, Bright, Dim, and Very dim. For example, if the light source is very bright and the user would like to have a little longer exposure time, the selection of Very bright will set the lowest value of gain for the camera. However, please note: if the user sets the exposure time too high (>5 ms), the camera may not be able to get the desired streaming and saving frame rate.

- The **light condition** setup has to be consistent for white reference, dark background, and raw image recording. For example, if the user recorded white reference and dark background under **Bright** condition, raw image recording has to be recorded under this condition as well.

2.3.2 Acquisition Control

Acquisition Control is to control how the images will be saved. Also it is used to generate the predefined file systems which are ready to be processed by other BaySpec hyperspectral image processing software.

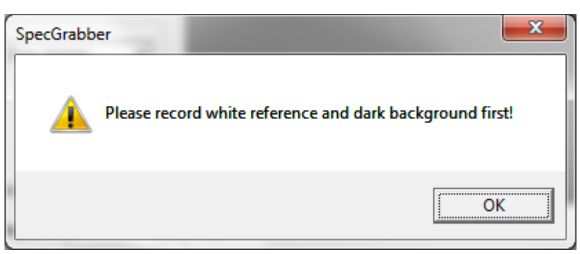
The name of a file system created by SpecGrabber contains information on the conditions the image files when they were recorded. For example, a folder name of 14-38-11RES1280_EXP0021_GAN0010_BIT08_2EXP0001_GAN0010_RES1280_BIT08 indicates this set of image data was recorded at 2:38:11 in the afternoon, the width of the images of sensor 1 is 1280 pixels, the exposure time is 2.1 milliseconds, and the images are saved at a format of 8 bits per pixel. Also it indicates the second sensor width is 1280 pixels and the images are saved as 8 bit per pixel. All the information will be used by other BaySpec hyperspectral image processing software.

Do not rename the folder generated by SpecGrabber. For organizing purpose, user can move the whole folder under other named folders.

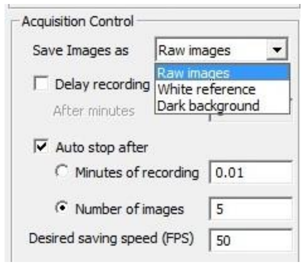
Within each folder, there are usually 3 sub folders for each sensor, WhiteRef, Dark, and RawImages. WhiteRef and Dark contain the averaged white reference and dark background image, which will be used to calculate the reflectance of each hyperspectral image saved in the folder of RawImages. A copy of sensor calibration file in xml format is also saved under this directory.

When the user clicks the button **Start Recording**, SpecGrabber will create a file system under the folder selected by **Location to Save Images** and start to save images captured by the camera into the sub file folders.

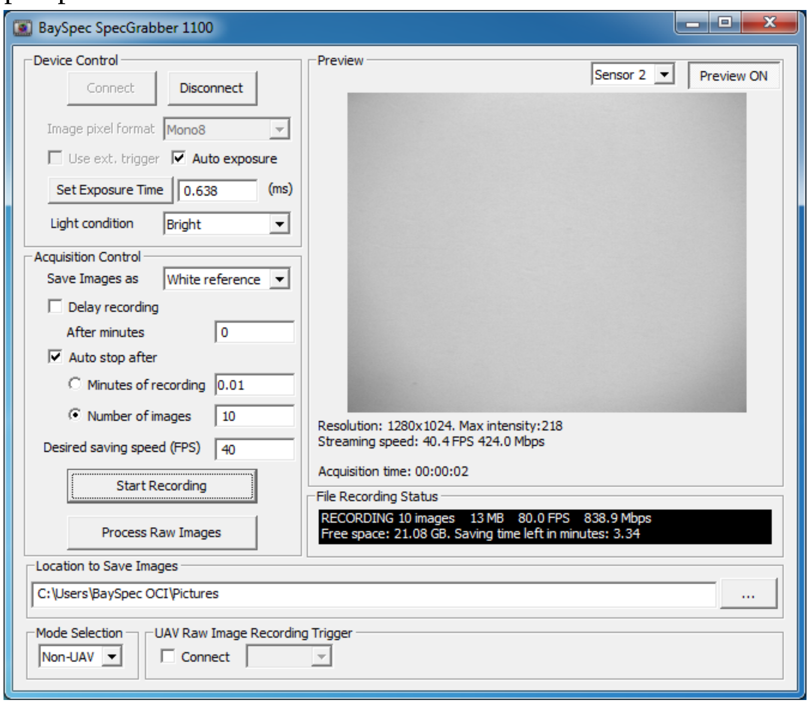
Every time when SpecGabber starts to record raw images, it looks for the white and dark reference. If the program fails to locate the white reference or dark background, the following message will appear.



The user can start record white reference or dark background by slecting the **White reference** or **Dark background** from the dropdown list of **Save Images as.**



It is always a good practice to record white reference and dark background before recording raw images with hyperspectral information.



The user can start and stop recording by clicking **Start recording/Stop recording** button. However, the start and stop recording can also be controled by the program in a pre-defined fasion. For example, if **Delay recording** is checked, after input a waiting time in the unit of minutes. Clicking on **Starting recording** will prompt a count down clock. At the end of waiting time, the image saving starts.

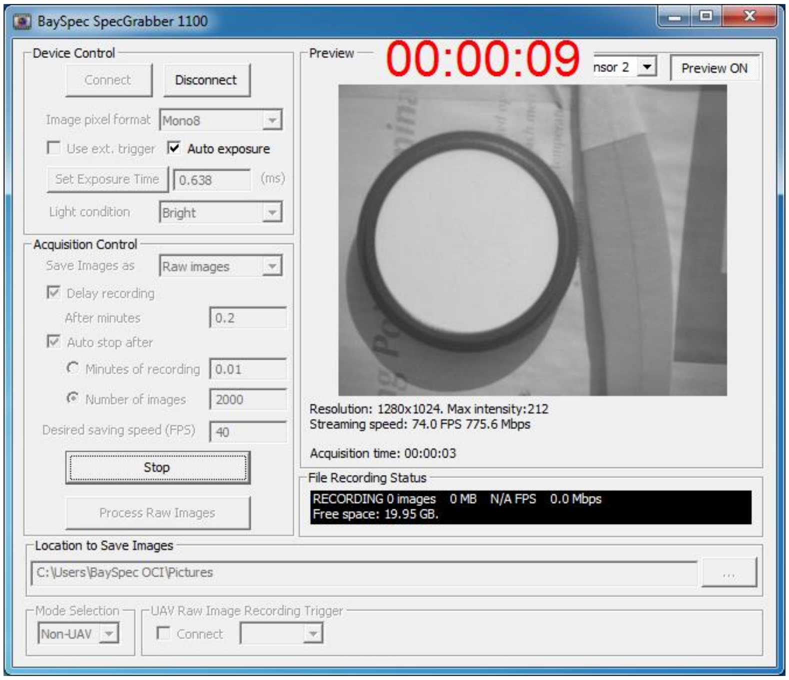


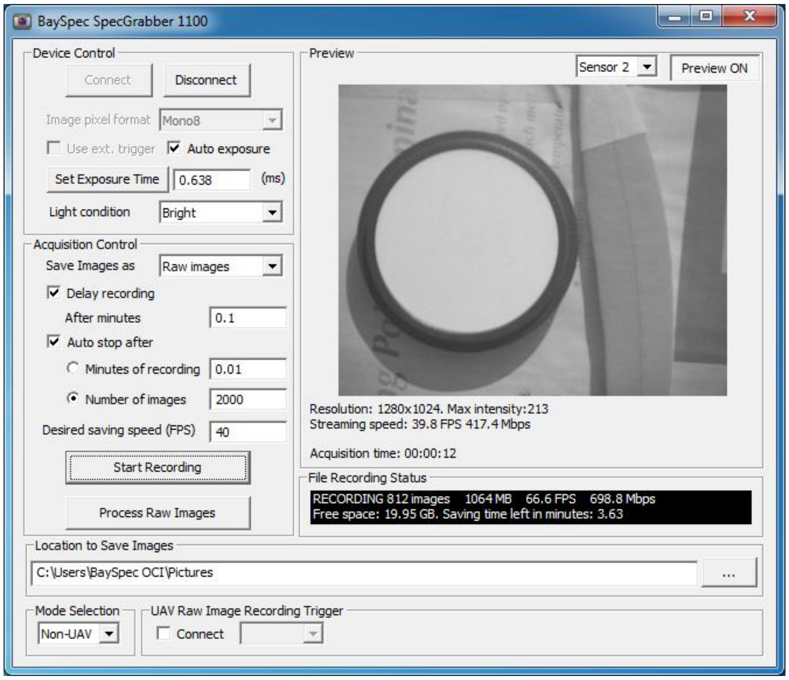
Image recording can be automatically stopped by checking the checkbox of **Auto stop after**. There are two options on how the automatic stop is initiated. The first one is to define Minutes of recording. The second one is to define the number of images to be recorded.

The user can also control the image saving speed by defining **Desired saving speed** in the unit of frames per second (FPS). If the user wants to get the maximum saving speed, just sets this value to be high, for example, 50 frames per second. For OCI-F, **Desired saving speed** can only be set for sensor 1. The saving speed of sensor 2 will be set automaticaly to be the same as sensor 2.

Once a file system is created and raw images are recorded, clicking **Process Raw Images** will start BaySpec CubeCreator program. The user can process/view the raw images and the hyperspectral cube files over there (see CubeCreator section).

2.3.3 Preview

Once enabled, preview panel provides real-time image streaming feed and the streaming information is displayed at **Status** panel. The user can use mouse wheel to zoom in or zoom out the preview image. This would be helpful when focusing the lens and viewing the sample.



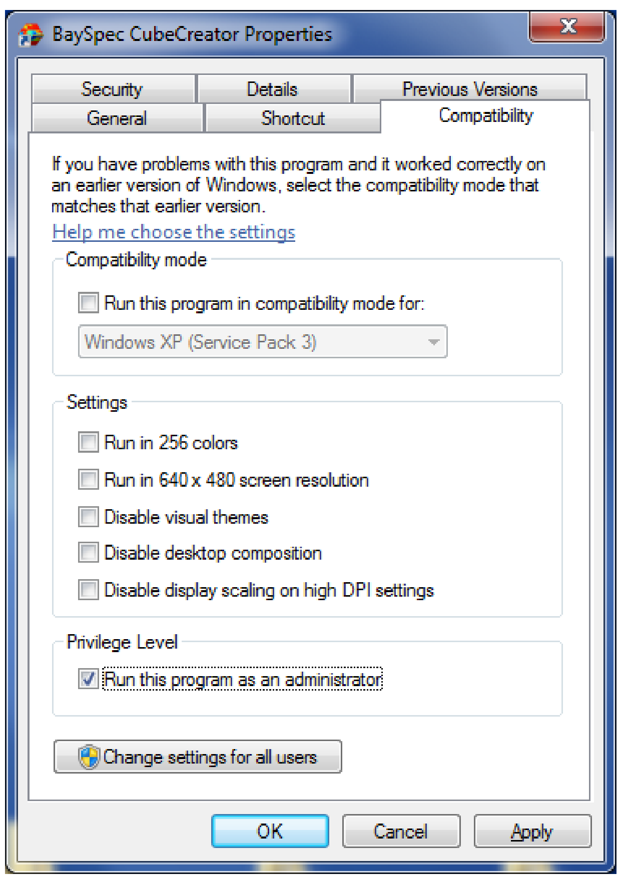
3. CubeCreator User Guide

3.1 Set up

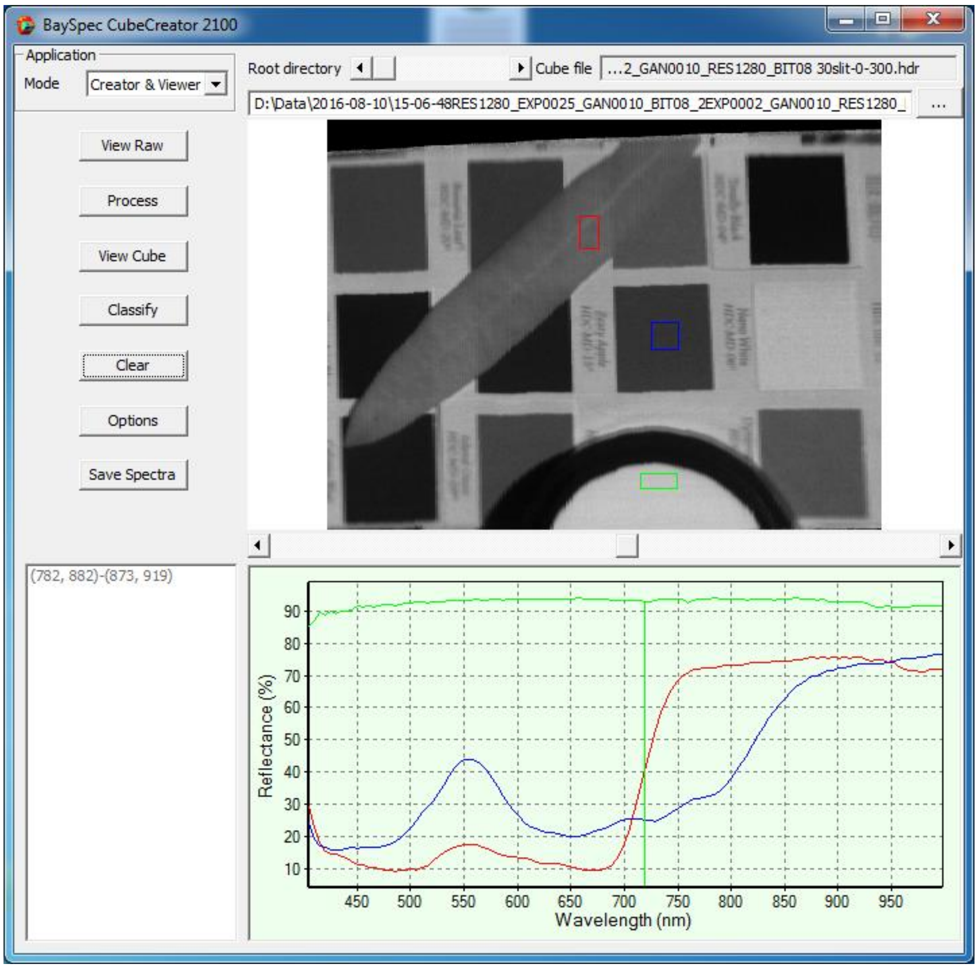
Note: If a BaySpec computer is provided, the software is already installed and configured properly for the imager.

BaySpec's CubeCreator is Microsoft Windows based software to process raw images recorded by BaySpec hyperspectral imagers into hyperspectral cubes. It allows the user to display and check the white reference, dark background and raw images. Also the user can use it to view the hyperspectral cubes and band images. This software is designed for running under Windows 8, 7, Vista, and XP operation system.

The software is recommended to be run as an administrator every time. After installation of CubeCreator, highlight its shortcut icon on desktop, and right click to bring out property setup window. Click on Compatibility tab and check Run this program as an administrator. This will enable the program to save and retrieve its parameters from previous run.



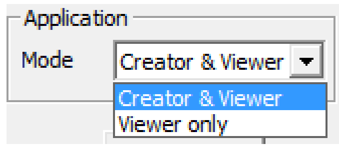
Note: for heavy-duty hyperspectral data processing (e.g., > 1000 raw frames, or > 2 GB data set), it is recommended to use a powerful desktop computer.



The GUI elements and their functionalities are described in sections below.

3.2 Application Mode

CubeCreator is designed to work under 2 modes:



Creator & Viewer

Under this mode, the program will allow the user to view the recorded raw images, process the raw images to create hyperspectral cube files, display the spectra from the cube files, and perform classification calculation from the spectrum data.

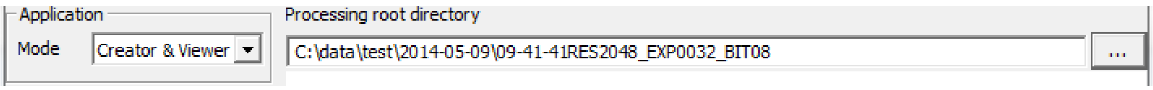
Viewer Only

Under this mode, the program will work as a hyperspectral cube file viewer only. All the functionalities associated with hyperspectral cube file creation will be disabled.

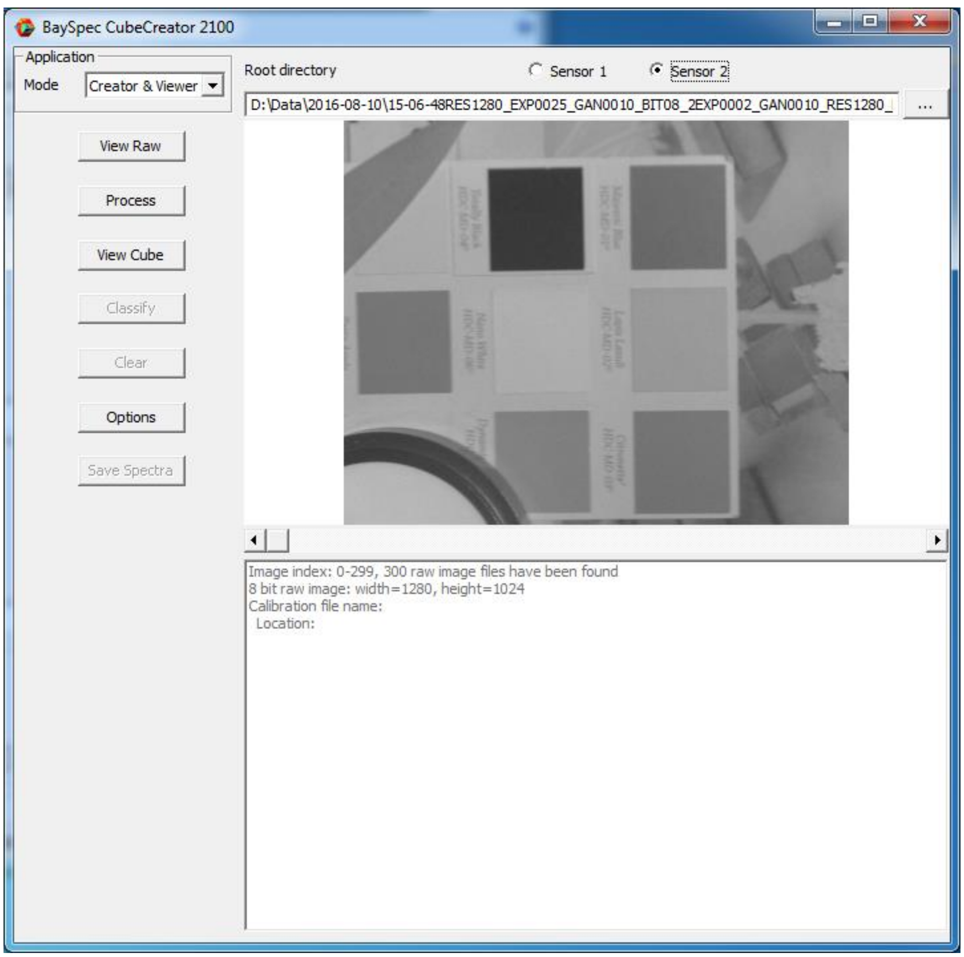
CubeCreator is capable to take 16 bit images as input. But all the output files will be displayed and saved in 8 bit format.

3.3 View Raw Frames

In order to view raw images, the user has to click the top right button  to locate the root directory of a file system recorded by BaySpec hyperspectral imagers.



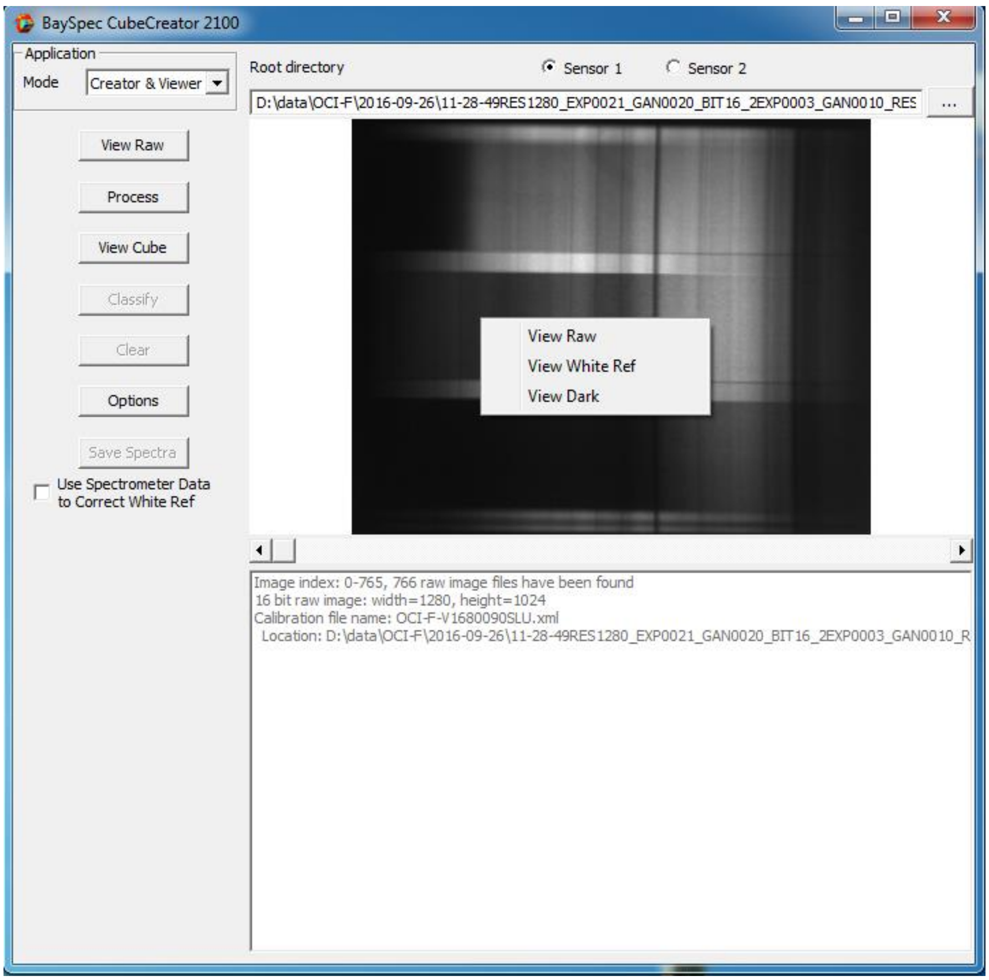
The name of a file system created by BaySpec hyperspectral imagers contains information on the conditions the image files when they were recorded. All the information will be used by the program later in the processing procedure. Therefore the user is not supposed to change the folder names.



Within each data set, there are usually 6 sub folders, WhiteRef, Dark, and RawImages for sensor 1, and WhiteRef_FS2, Dark_FS2, and RawImages_FS2 for sensor 2. WhiteRef and Dark contain the averaged white reference and dark background image, which will be used to calculate the reflectance of each hyperspectral image saved in the folder of RawImages. A copy of camera calibration file in *.xml format is also saved under the data set directory.

Once clicked the folder selection button or clicked the **View Raw** button on the left, raw images saved in the file system will be displayed at top and the information about the file system will be displayed at bottom on right side. If there is more than one raw image in the file system, the user can use the scroll bar to display the other images.

Right click on any raw image will bring out a popup menu for user to display and check the quality of white reference and dark background images.

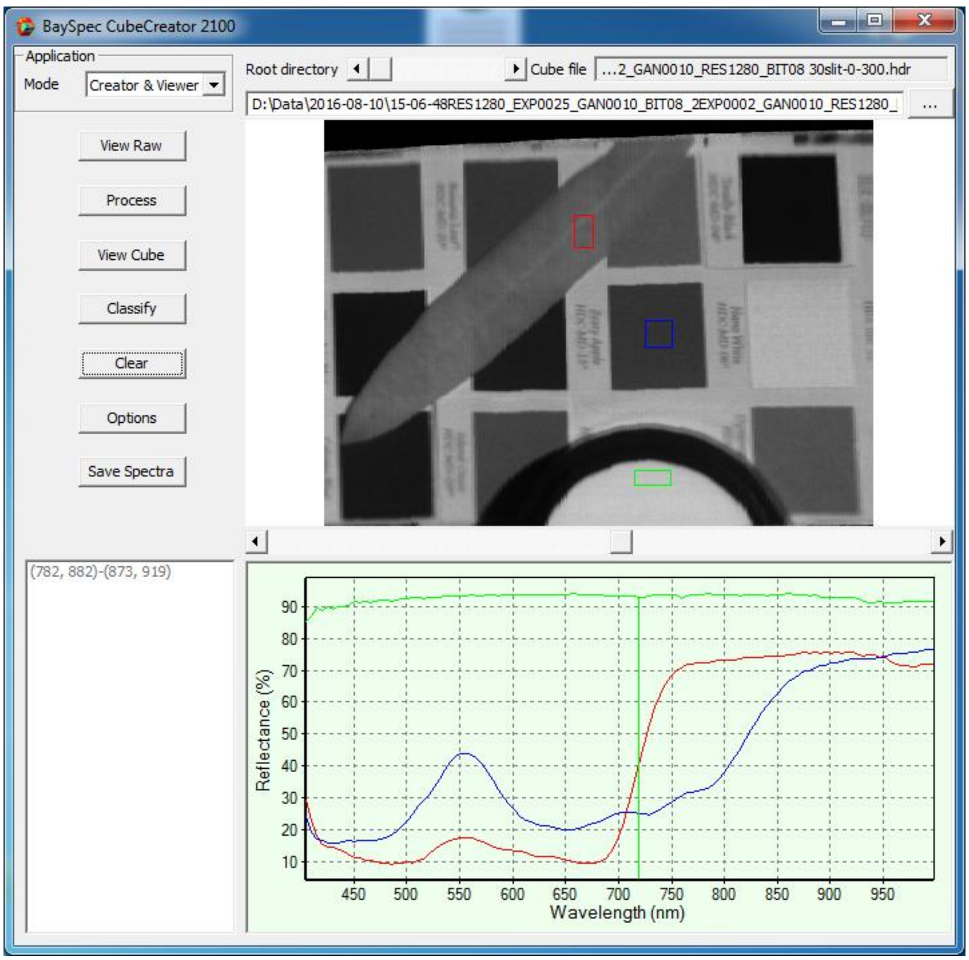


3.4 Process Raw Frames into Hyperspectral Cube

Clicking the **Process** button will start to process the raw images into hyperspectral cube file, and display the results of band images at different wavelength bands. If the file system had been processed before, a message would show up and ask the user to confirm whether the user wants to reprocess to overwrite previously processed cube. Answering No will prevent the program to process the images and display only the existing hyperspectral cube file.

The user may use horizontal scroll bar to view band images at different wavelengths, or use mouse to create a rectangle ROI (region of interest) area on the data cube to display the spectrum averaged from the pixels in the ROI. A total number of 8 ROIs can be viewed together.

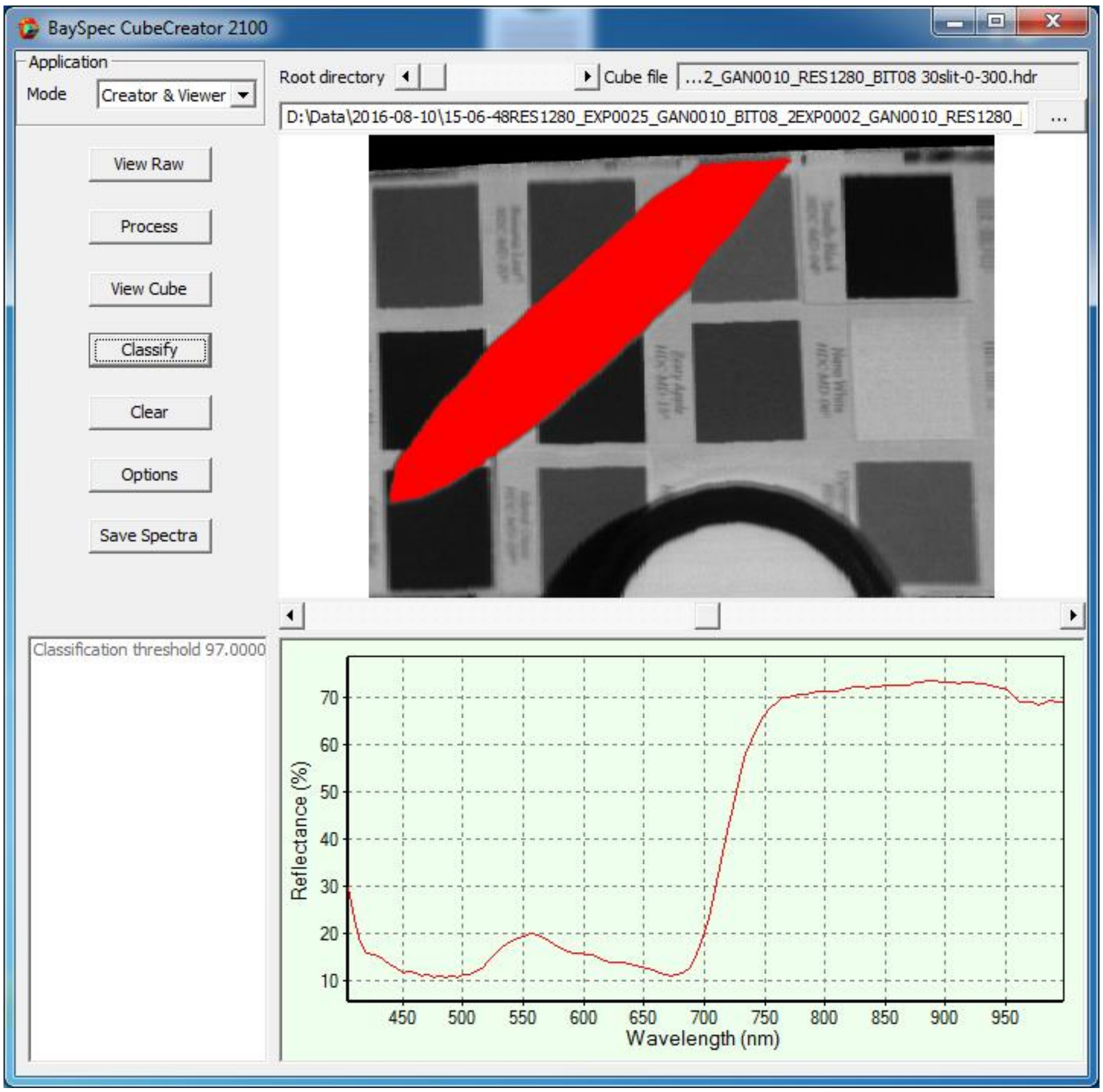
Clicking on the **Clear** button will clear the selection of the areas and clear the spectra diagram also. Clicking on the **Save Spectra** button will prompt dialog box for the user to save the spectra data in .csv format (ASCII format).



3.5 Hyperspectral Cube Classification

CubeCreator provides basic hyperspectral data classification (image segmentation) functions, which can group pixels with similar spectra based on Pearson linear correlation algorithm, when the correlation value is larger than the classification threshold defined in **Options**.

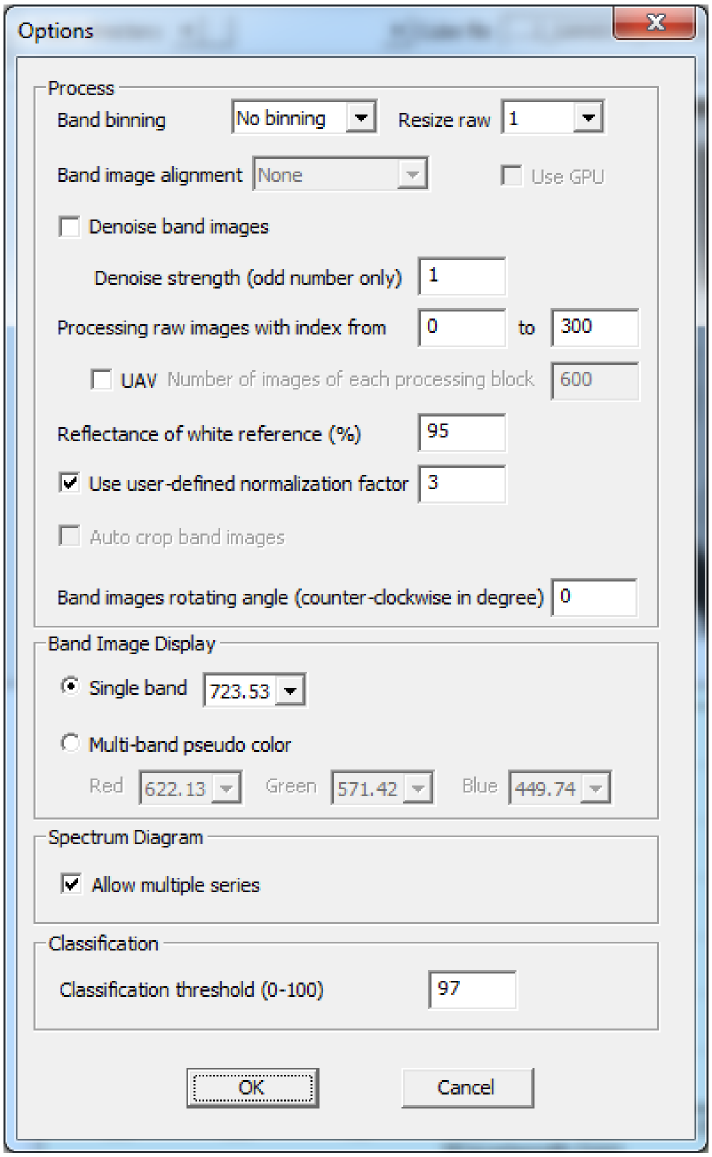
Once the ROIs are defined, clicking the **Classify** button will start classification process in which all the pixels whose spectra are similar to the selected ROI spectral are labeled as the same color. This provides a quick method to segment hyperspectral image based on the material (i.e., spectral characteristics).



A simple spectral classification result

3.6 Options

The **Options** button in CubeCreator will bring a separate dialog window consisting of 4 panels:



3.6.1 Process

The process panel contains all the parameters associated with raw image processing.

Band binning displays the options to bin neighbor bands. For fast processing speed and reduced cube data size, user can select 2 to 1 or 4 to 1 band binning to have the data down-sampled.

Resize raw provides options to select the size of final band images. Using smaller ratio will shorten the image processing time and reduce cube file size, with lower spatial resolution.

Band image alignment defines the method to align the final band images before creation of hyperspectral cube file. There are 2 options, **None** and **Regular**. None indicates no alignment will be applied. Regular indicates that a normal image registration method is used. The users may try each option to see which one provides the best band image registrations.

The checkbox **Use GPU** will enable CubeCreator to take advantage of the GPU resource of the computer to speed up image processing and provide a better alignment of the band images. **Use GPU** is always checked for OCI-F**.**

The checkbox **Denoise band images** allows the user to decide whether denoise method will be applied to the band images. If the checked, the user may define the **Denoise strength** which is defined as an odd number starting from 1. The larger value of this number will create smother images with lowered spatial information.

Processing raw images with index from to allows the user to select the range of raw images. If the user has recorded large amount of images, it is recommended to divide them into groups and process separately so a few bad raw images will not affect the whole data cube.

The checkbox **UAV** will enable the user to define the **Number of images for each processing block**. The program will break all the selected raw images into continuous processing blocks with 50% overlapping. It will be convenient for large amount of raw images to be processed automatically. The final results will be a large amount of small hyperspectral cube files which can be further stitched together to a single large cube file through BaySpec CubeStitcher software.

Reflectance of white reference defines the reflectance value of the white reference images saved in the WhiteRef directory. BaySpec provides a small 95% white reference board in the OCI wavelength range. The 95% white reference is measured against NIST traceable white reference targets.

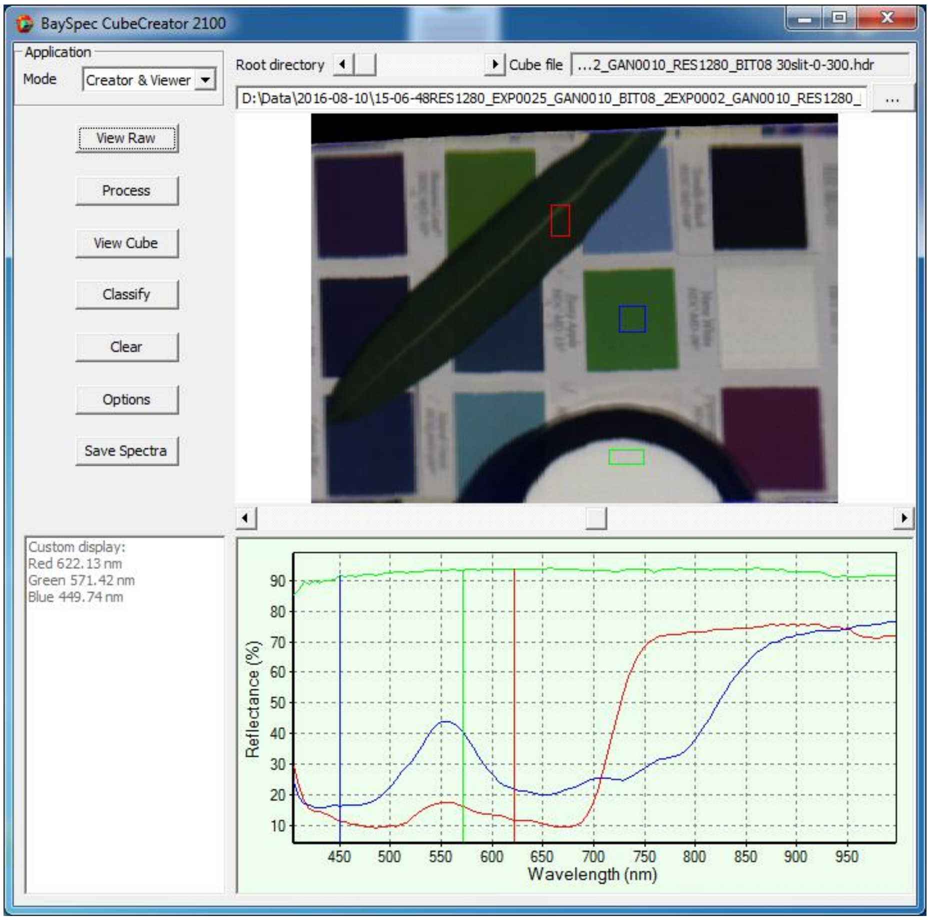
The checkbox **Use user-defined normalization factor** allows the user to select whether the user-defined normalization factor will be used. If the user wants to increase the intensity (brightness) of the band images, the user may check this checkbox and set the value to be greater than 1. It is for band image viewing only and won't affect the actual spectrum.

The checkbox **Auto crop band images** allows the user to select whether the black boundaries of the final band images to be cut out after processing and alignment. The checkbox **Auto crop band images** is disabled for OCI-F.

Band image rotating angle defines the rotating angle for the final hyperspectral cube file. It is defined as counter clockwise in degree. Negative value is also acceptable.

3.6.2 Band Image Display

Band Image Display has two options: Single band and Multi-band pseudo color. When Single band is selected, the user may choose which band of wavelength to display from the dropdown list, or browsing the band images by scrolling the horizontal bar. When Multi-band pseudo color is selected, the user may select three bands of wavelengths for pseudo-RGB channels and it will display a pseudo-color image based on user's selection.



3.6.3 Spectrum Diagram

When the checkbox **Allow multiple series** is selected, the spectrum diagram screen will allow multiple ROI selections (up to 8). Otherwise, only the most current spectrum will be displayed.

3.6.4 Classification

Classification threshold defines the threshold for classification process. In the process, a pixel's spectrum is compared with reference spectrum from selected ROI. If the calculated correlation ratio is greater than this threshold, the pixel will be marked as the same color as the reference.

Appendix A VNC® Remote Control Software

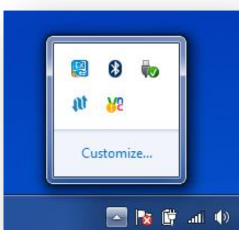
Note: If a BaySpec compact computer is provided, it is already configured as a Wi-Fi hotspot for easy use of VNC remote control software. The default Wi-Fi hotspot name is “BaySpec-OCI”, default password is “BaySpec-OCI”, and default VNC connection address is 192.168.173.1 (this IP address may change. Please refer to VNC server’s information).

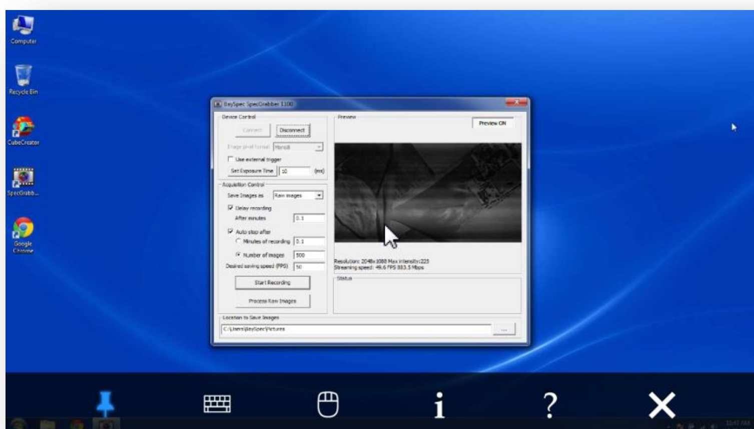
A licensed copy of VNC® server is installed on the OCI compact computer provided. User can download VNC viewer for computers and devices that need be connected to the OCI computer.

https://www.realvnc.com/

VNC enables user to remotely access and control computers from another computer or mobile devices. This will offer great convenience to view and control the OCI computer wirelessly by anther device (e.g., PCs, tablets, Android and iOS smartphones) when the OCI computer running VNC server and the device running VNC viewer are in the same Wi-Fi network.

VNC server information can be found at Windows’ notification area.





Remotely control the OCI imager using an iPhone through VNC Viewer

More help documents on VNC remote control can be found at the link below.

https://www.realvnc.com/support/documentation.html

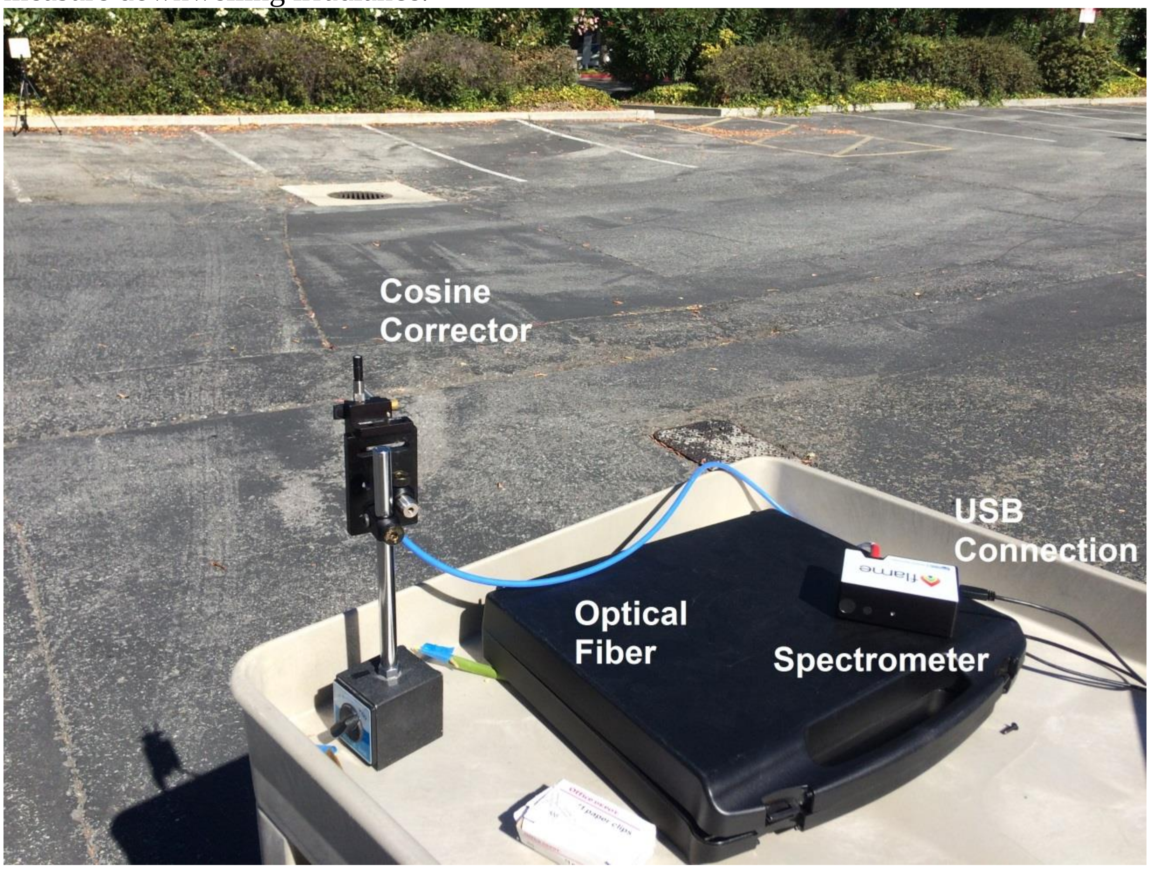
Appendix B Irradiance Measurement and White Reference Correction

B1. Software Installation

1. Install the software under the Spectrometer folder from the flash drive provided by BaySpec.
2. Apply the product key.
3. Copy the irradiance calibration file "yyyy_mm_dd_OOIIrrad.cal" in Spectrometer folder into the root folder of software installation which is "C:\Program Files\Ocean Optics\OceanView\ by default.

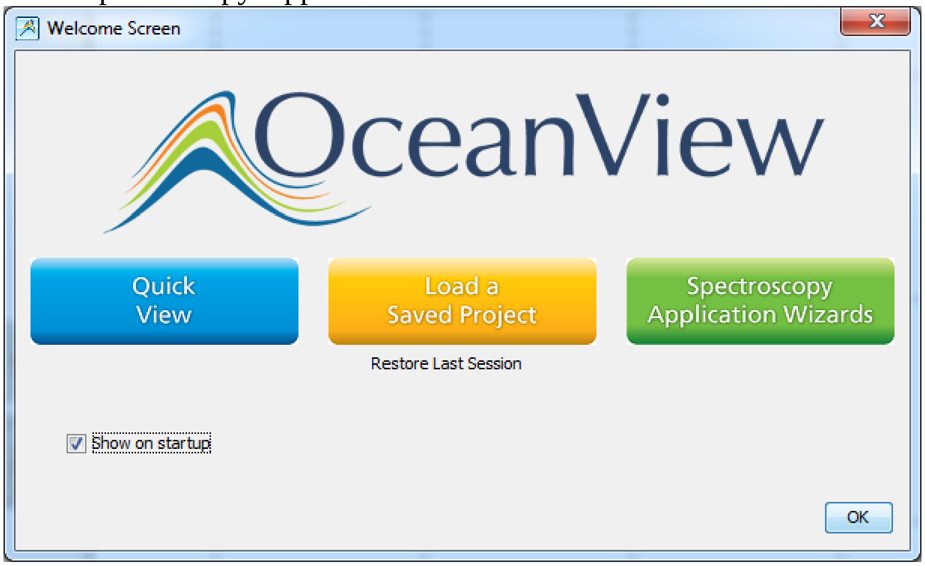
B2. Spectrometer Setup

Irradiance measurement and white reference correction package includes a spectrometer, a cosine corrector, and an optical fiber connector. The spectrometer has been calibrated for absolute irradiance measurement together with the cosine corrector and the optical fiber. Please don't remove those components from the spectrometer. The cosine corrector has to be setup to measure downwelling irradiance.

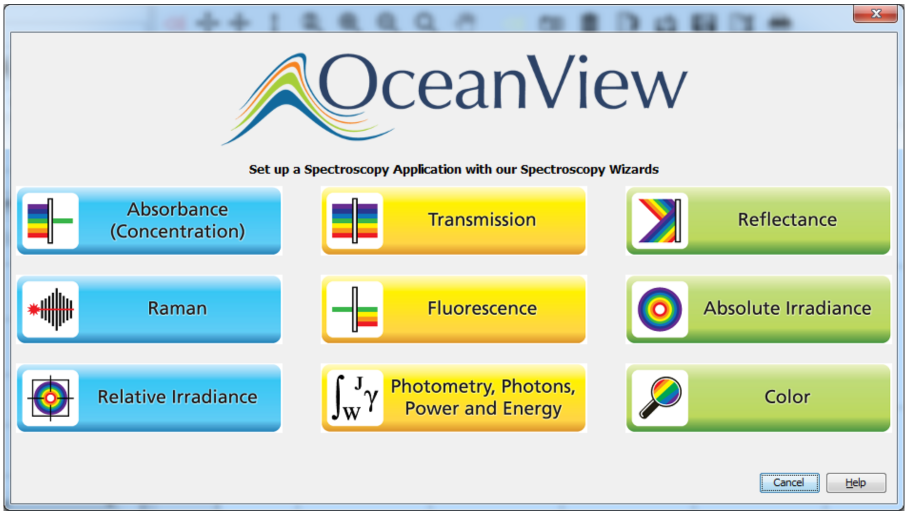


B3. Irradiance Measurement

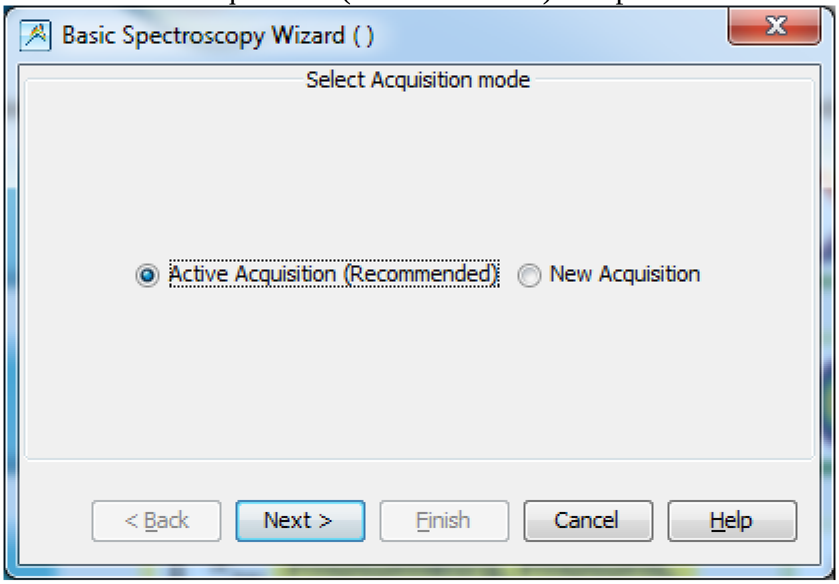
1. Connect the USB connector out of spectrometer to a USB port where the spectrometer software has been installed.
2. Start OceanView software
3. Click Spectroscopy Application Wizard on Welcome Screen



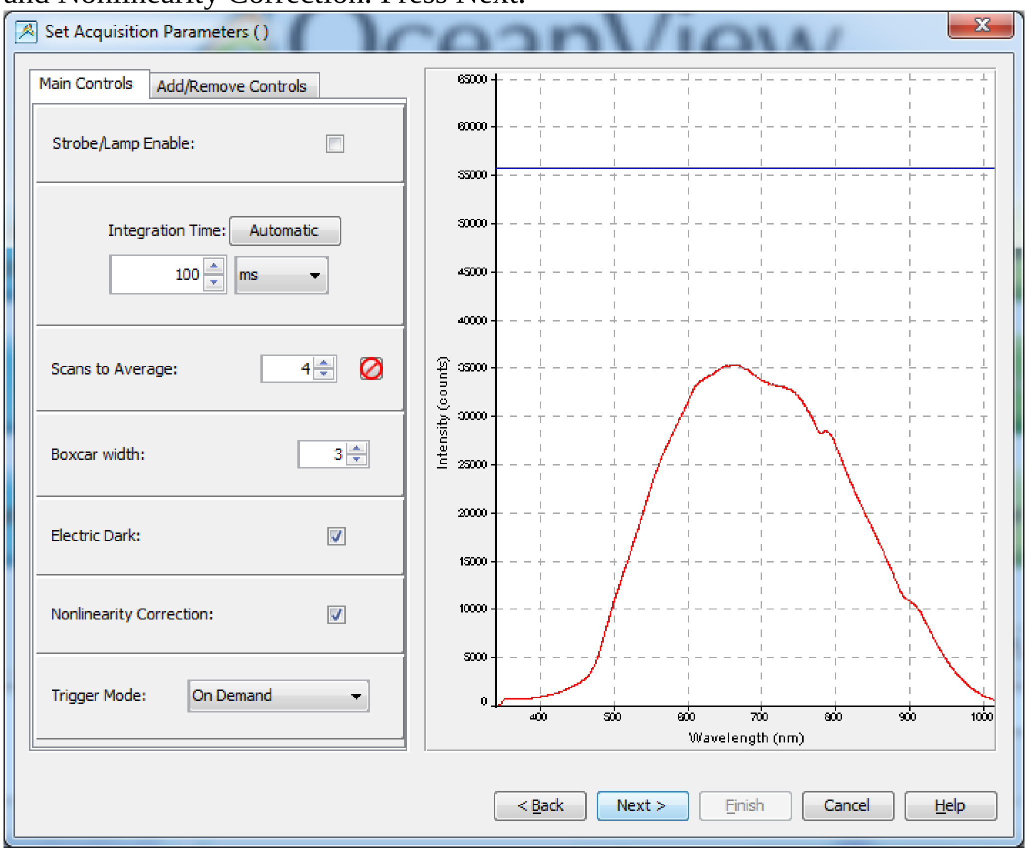
4. Select Absolute Irradiance



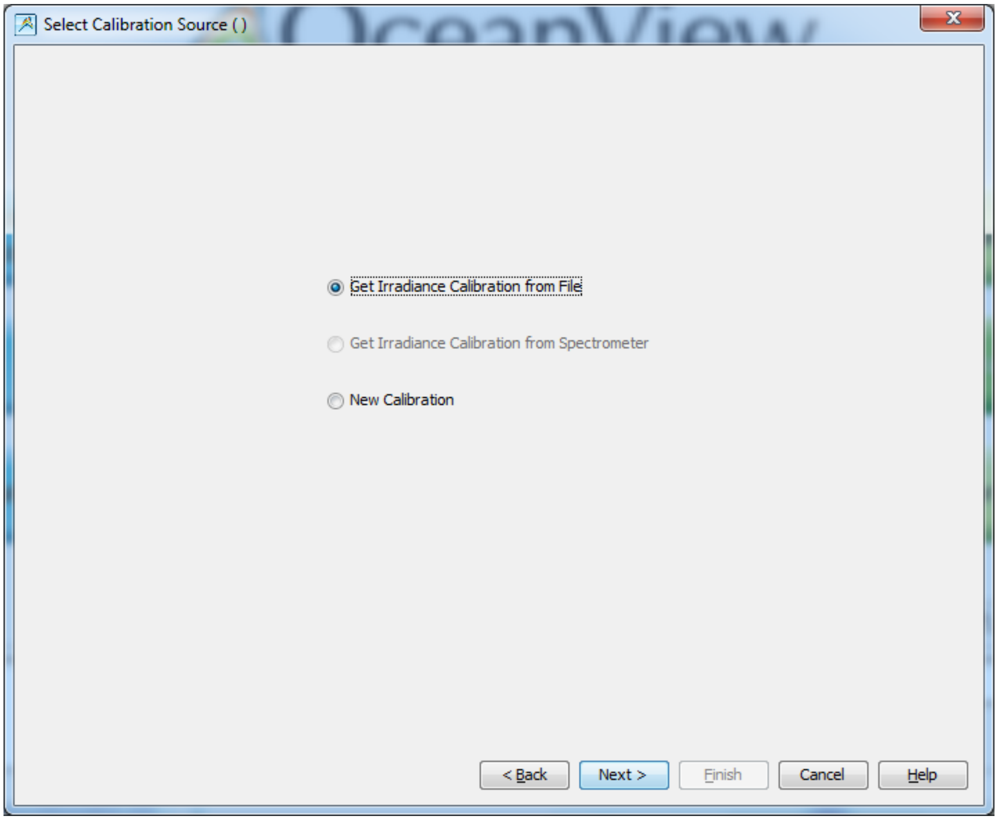
5. Select Active Acquisition (Recommended) and press Next button



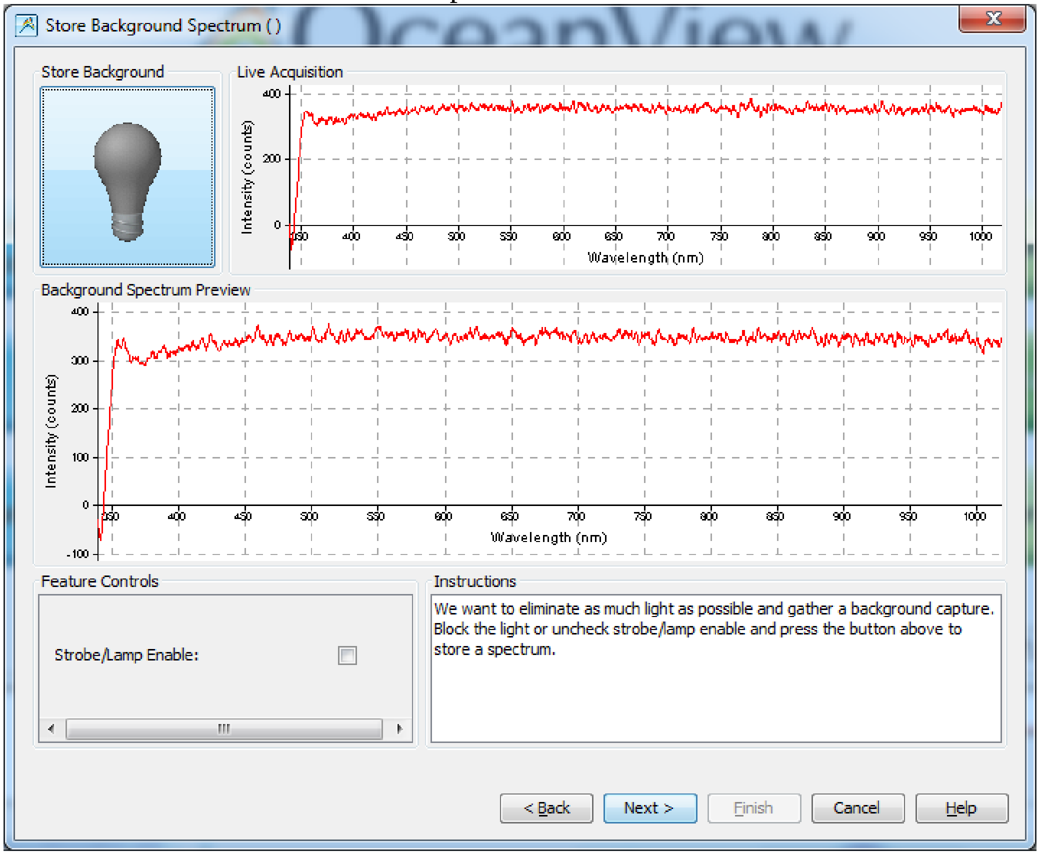
6. Set the value of Scans to Average to 4 and Boxcar width to 3. Check both Electric Dark and Nonlinearity Correction. Press Next.



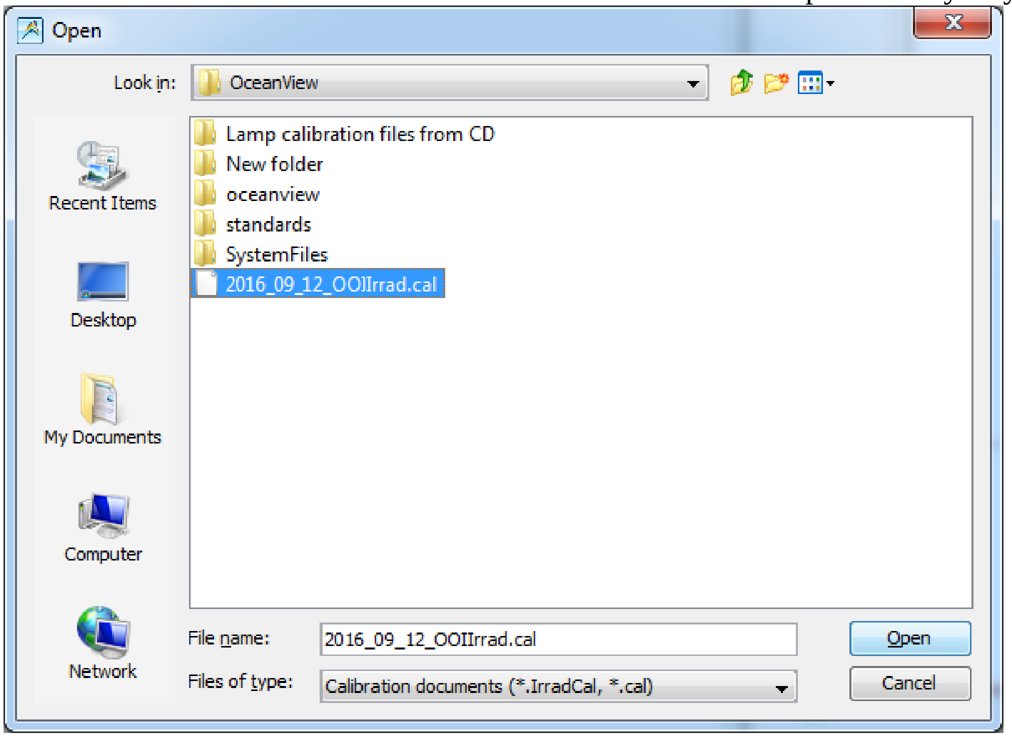
7. Select Get Irradiance Calibration from File. Press Next



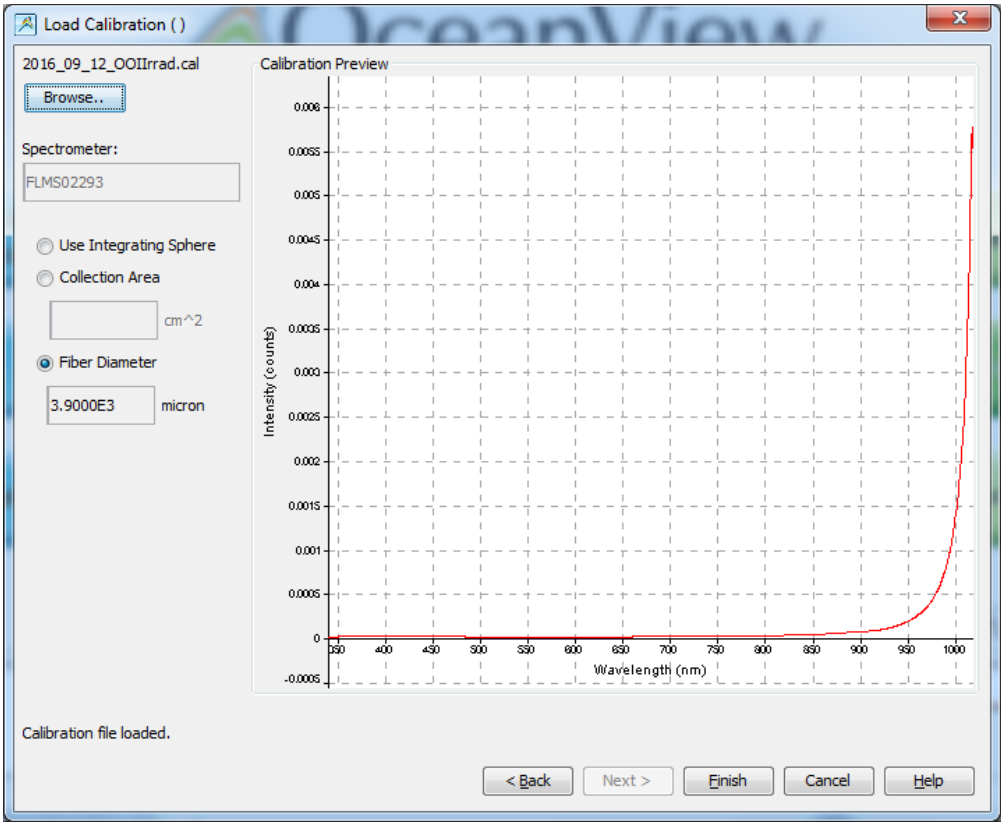
8. Cover the cosine corrector head totally and click on the light bulb icon. Dark background information will be stored for the spectrometer. Press Next



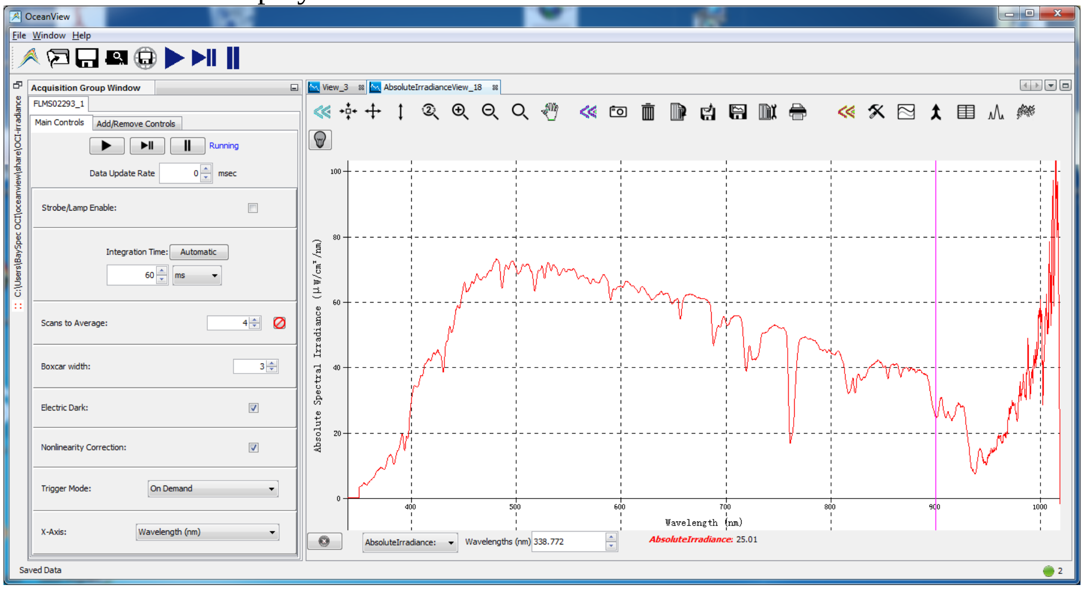
9. Click the Brows button and load the irradiance calibration file provided by BaySpec.



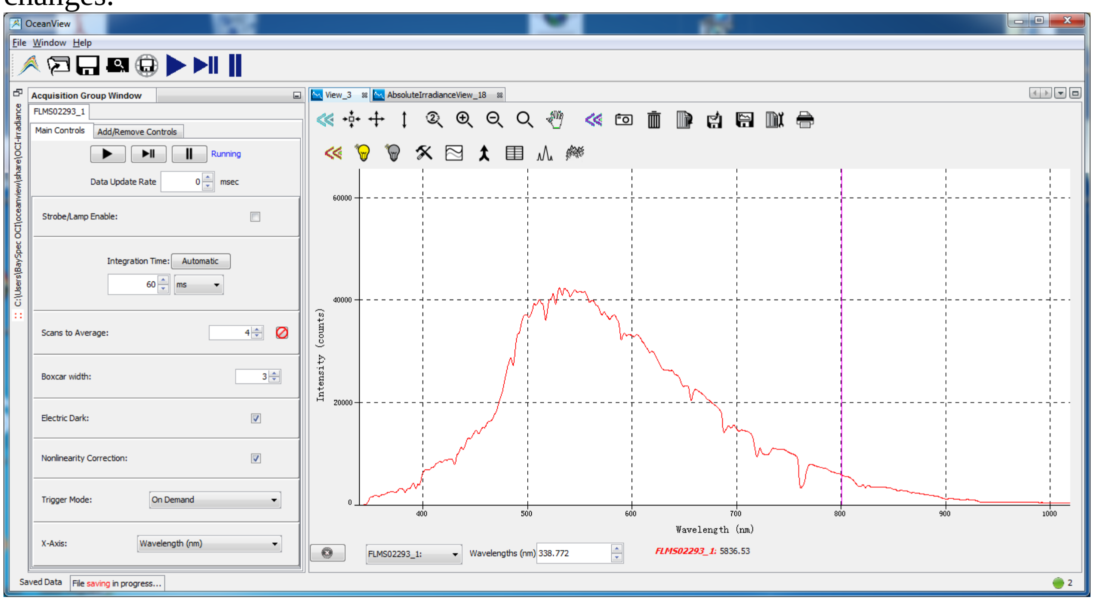
10. Click Finish.



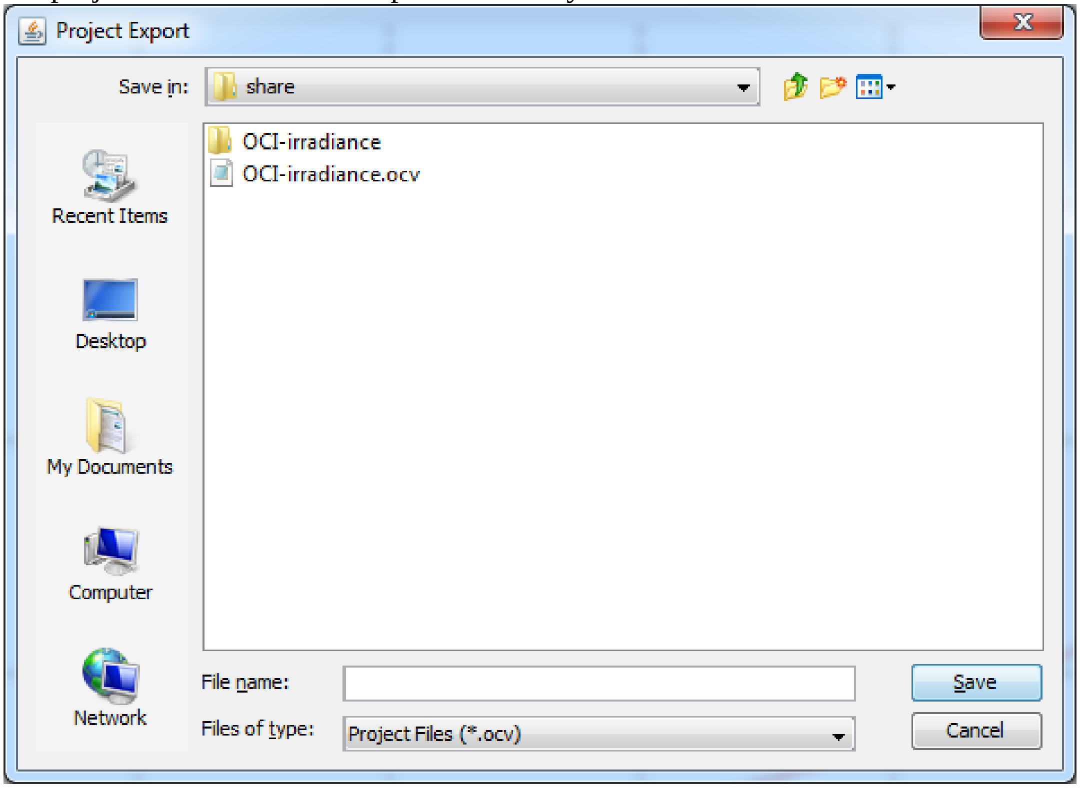
11. You will see the display of absolute irradiance measurement.



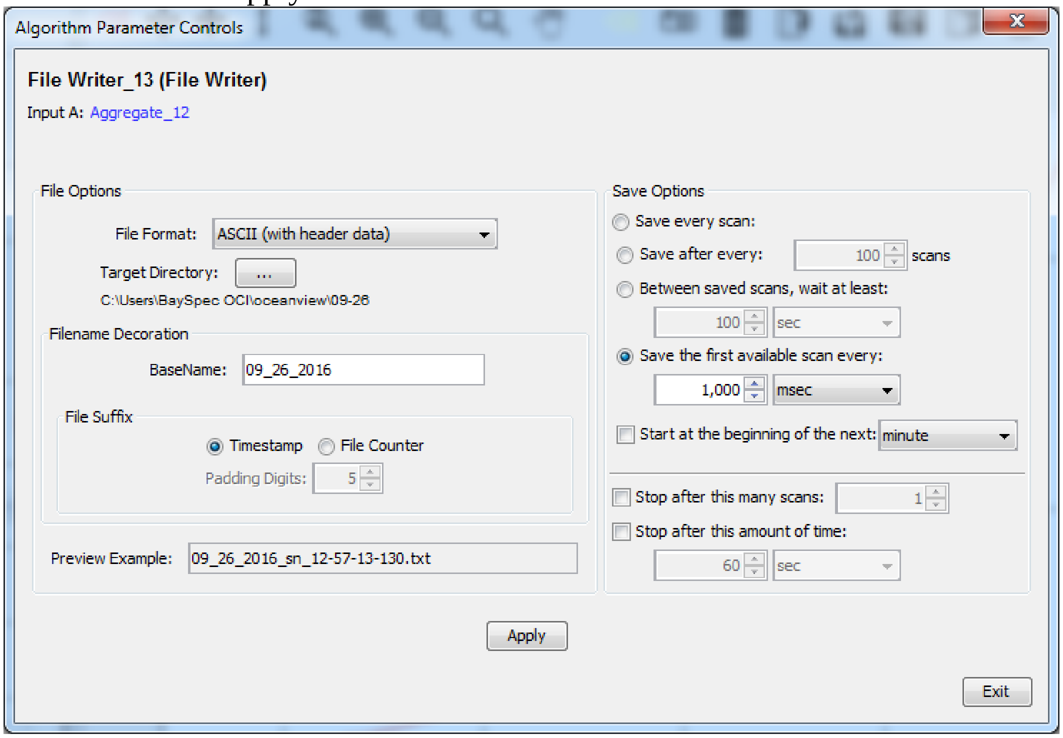
12. Switch to View_3 by clicking on the tab. Change the value of the Integration Time to make sure intensity counts will not reach saturation (65535) even if light condition changes.



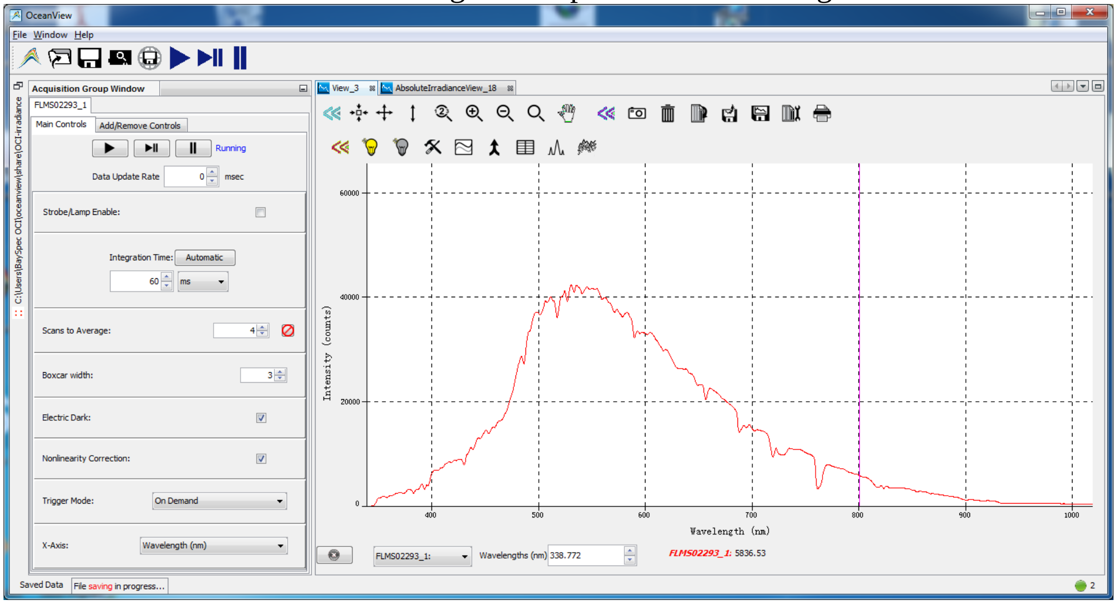
13. Save the project file for later use. Next time when starting OceanView, you can just load the project file and all the setup will be ready.



14. Click on the icon called Configure Graph Saving on the top of right panel. Create a saving folder using the button Target Directory. Provide a base name based on the date using the format "mm_dd_yyyy". This is a very important step because it provides the correct time stamps for later processing. On Save Options, select Save the first available scan every 1000 msec. Make sure the checkbox "Stop after this many scans" is unchecked. Press Apply and then Exit.



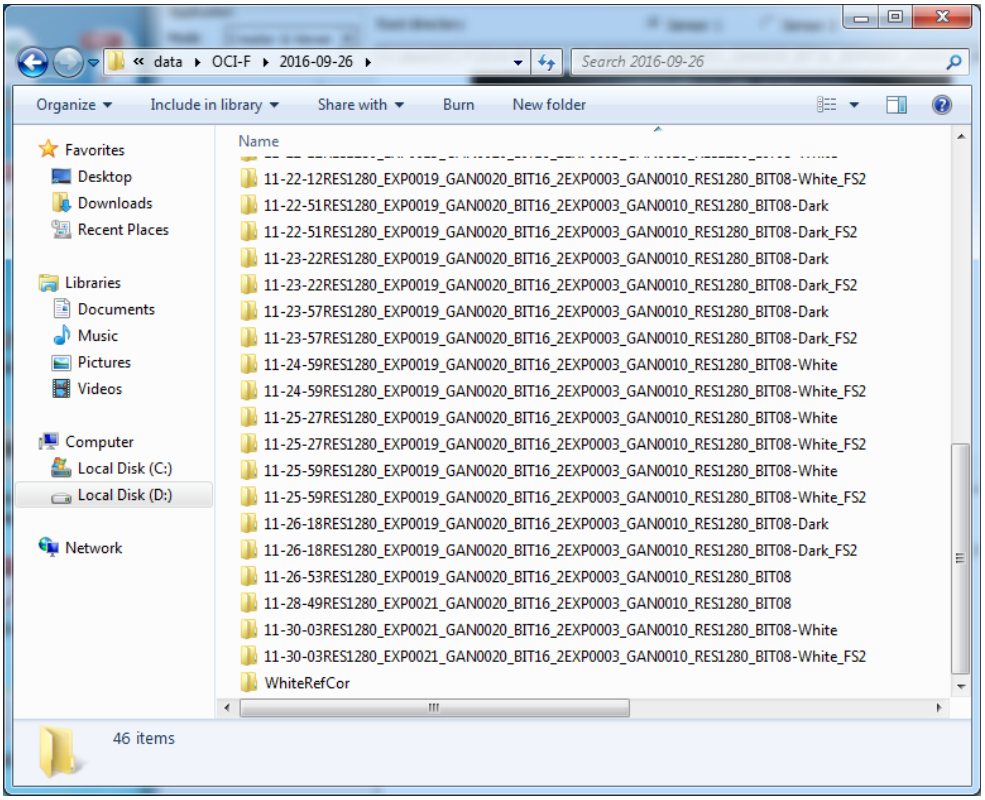
15. Click on the icon Save Graph to Files. A status of file saving in progress will be shown on the left bottom. Click the icon again will pause the file saving.



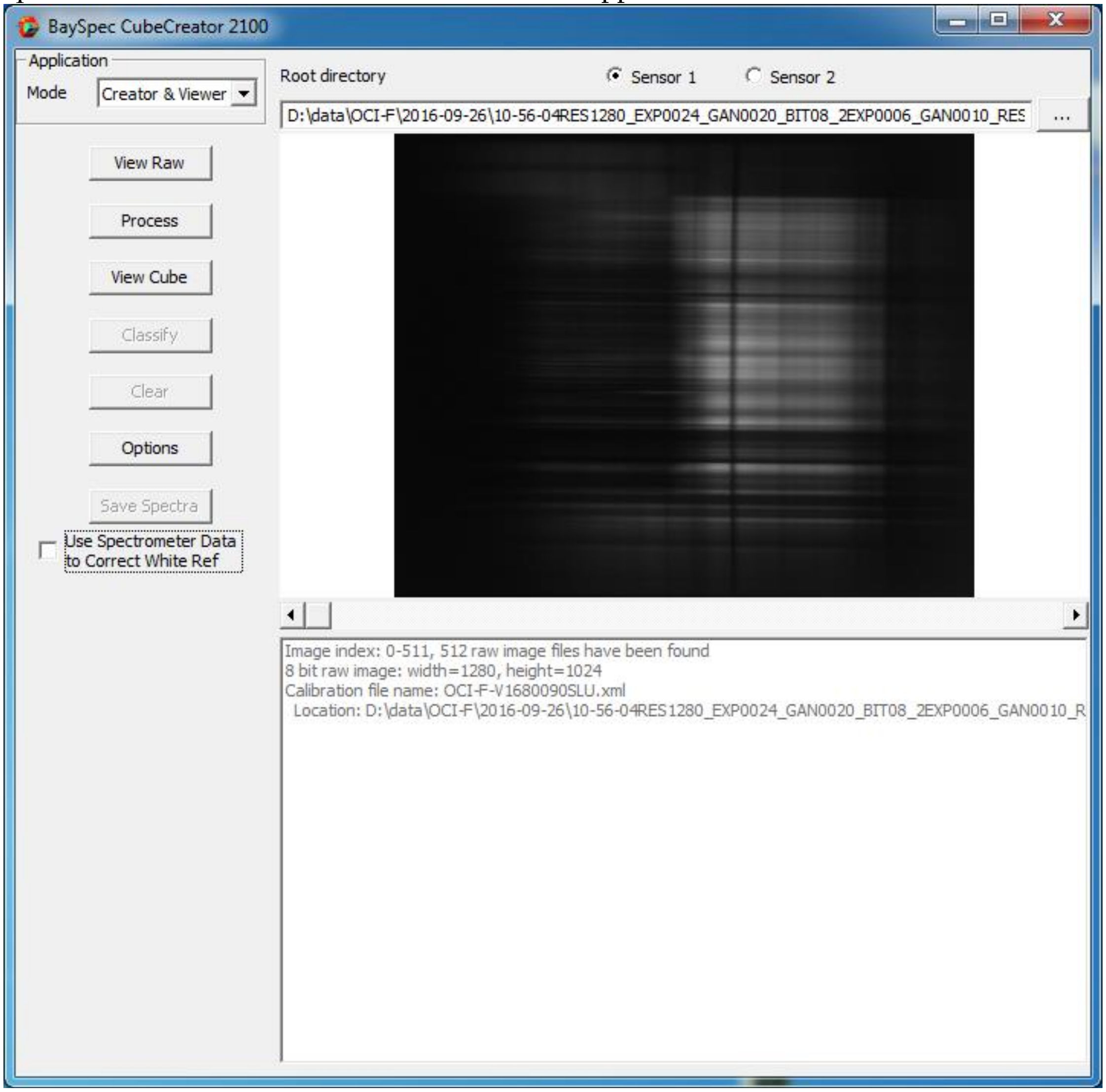
B4. Work with CubeCreator

Spectrometer file saving should start before any image recording by SpecGrabber and end after. In this way the time stamps of irradiance measurement will cover the whole range of OCI image recording.

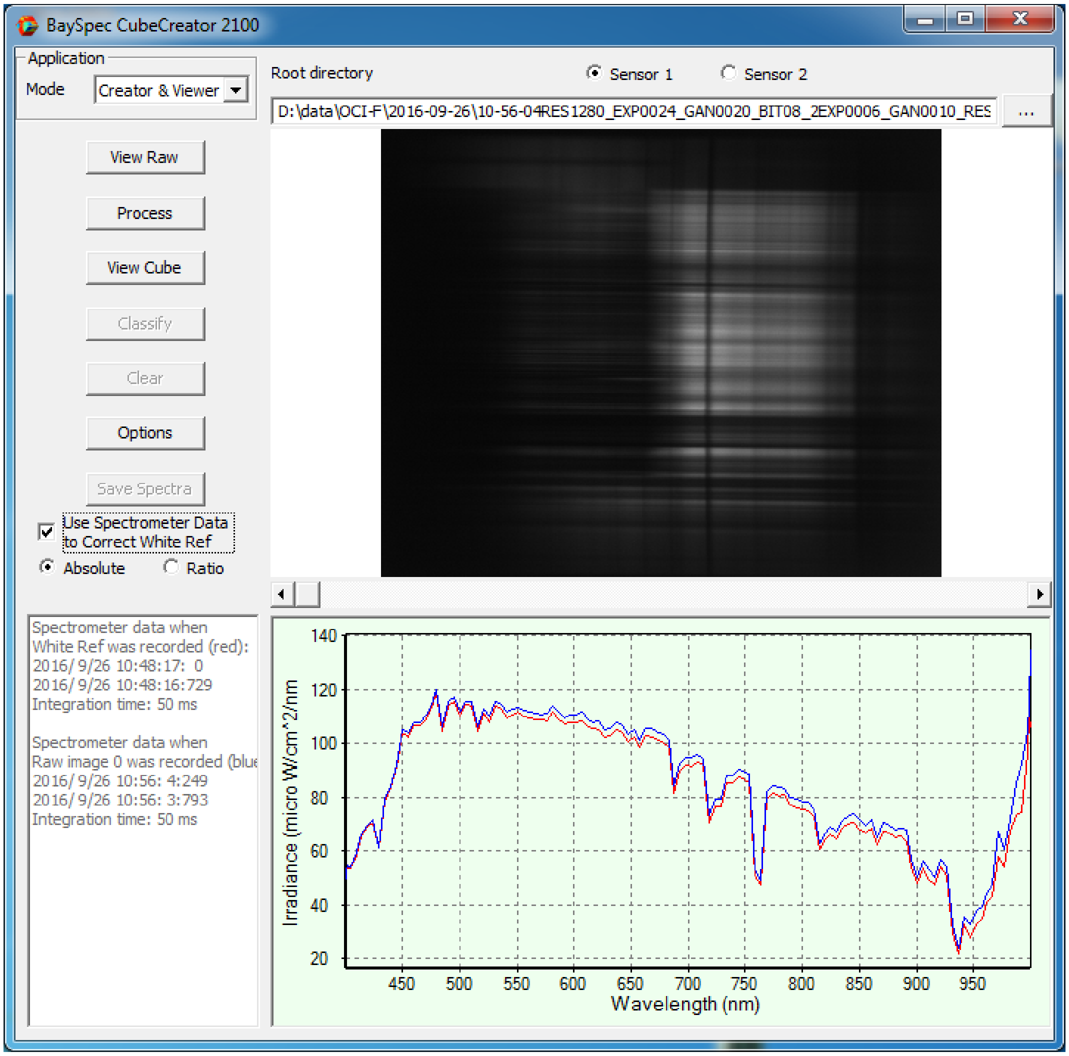
Rename the folder containing all the irradiance measurement to “WhiteRefCor” and copy the folder to the upper level of individual dataset folder. The following screen is an example of the folder structure.



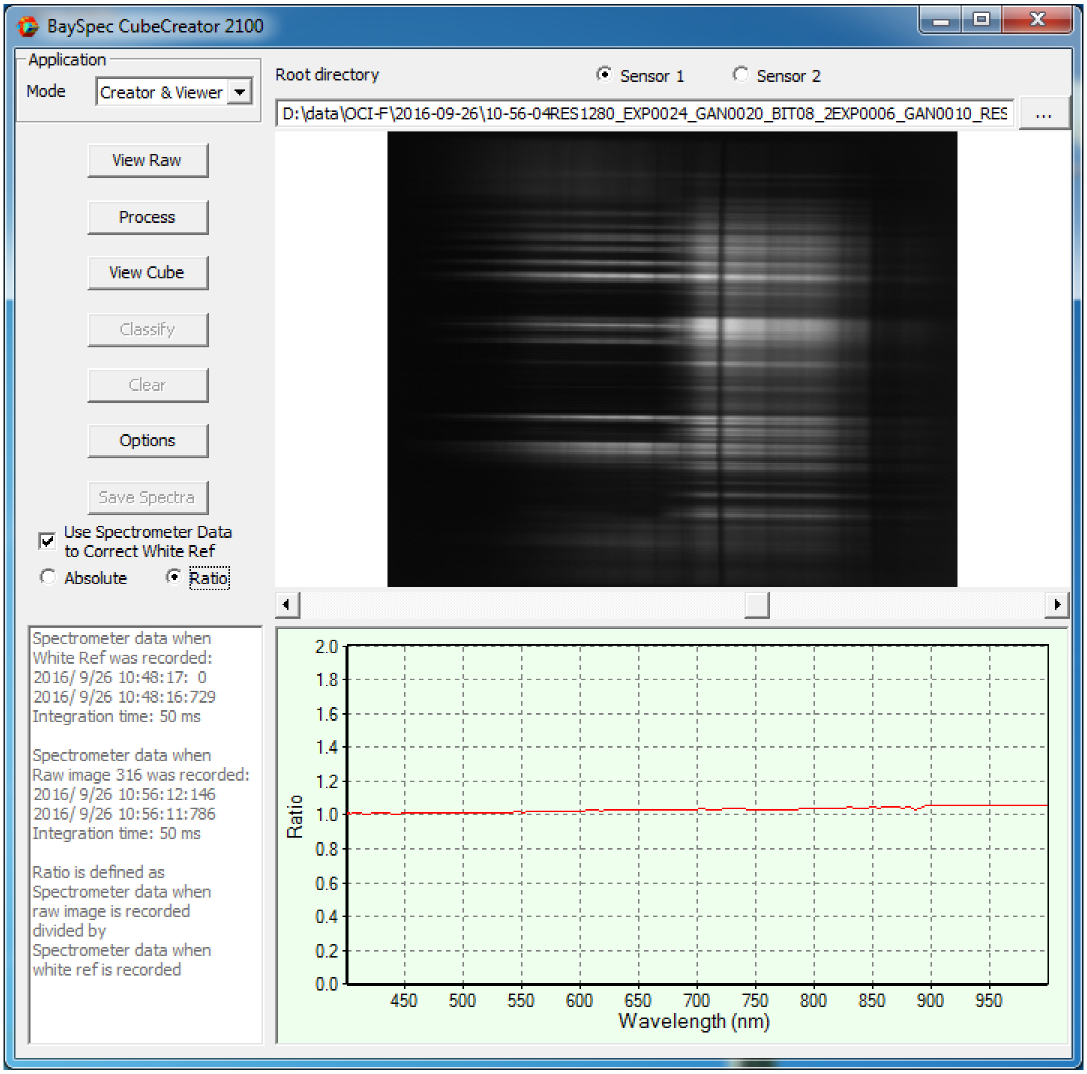
Start CubeCreator. If the program detects the existence of WhiteRefCor folder, a checkbox "Use Spectrometer Data to Correct White Ref" will appear.



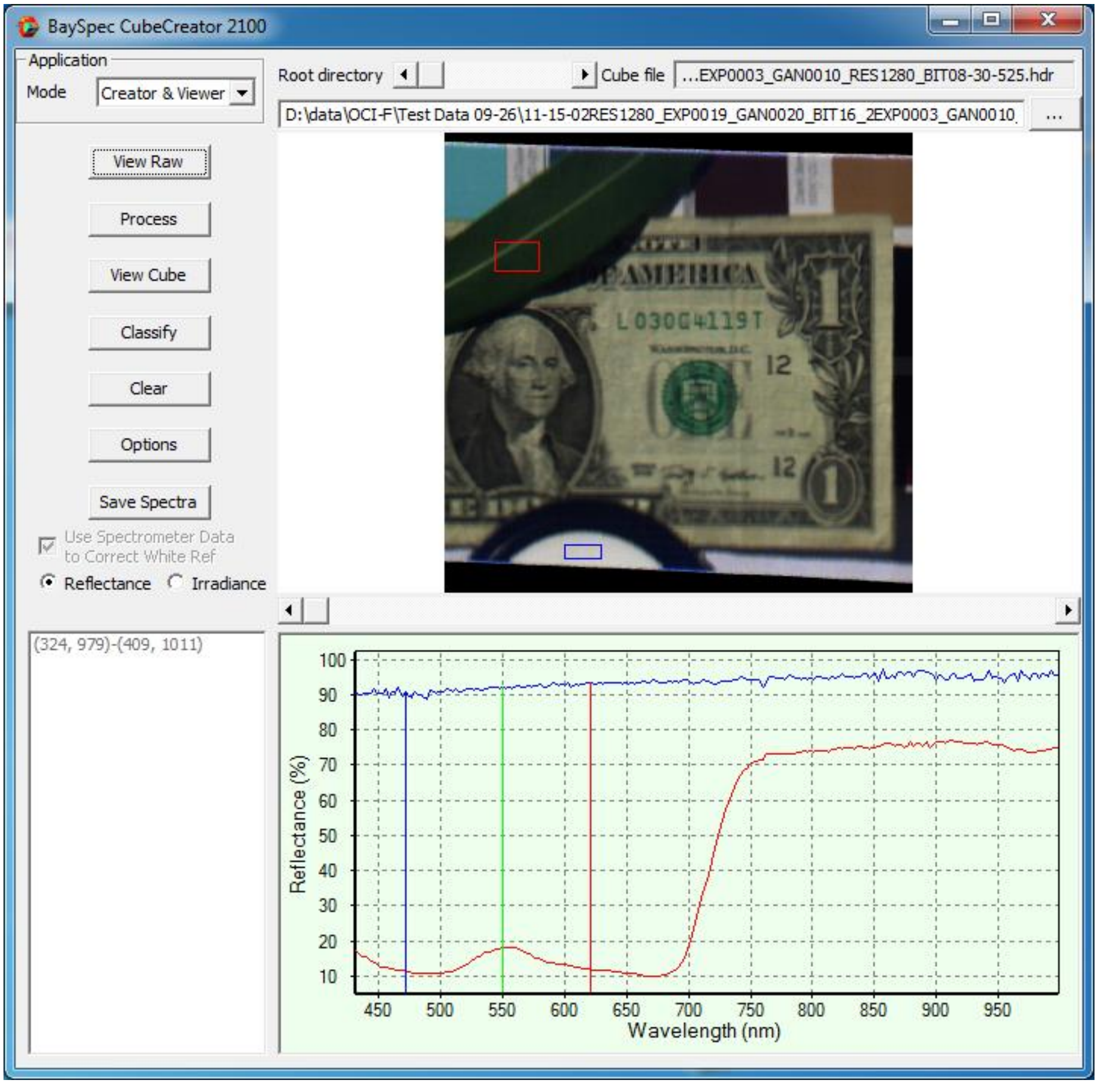
Check the checkbox. If the time stamps of irradiance measurement don't match the time stamps of the white reference and raw images, an error message will appear. Otherwise, the spectrometer data when the white reference was recorded and spectrometer data when raw image was recorded will be plotted. Selecting the option of Absolute will show absolute irradiance results.



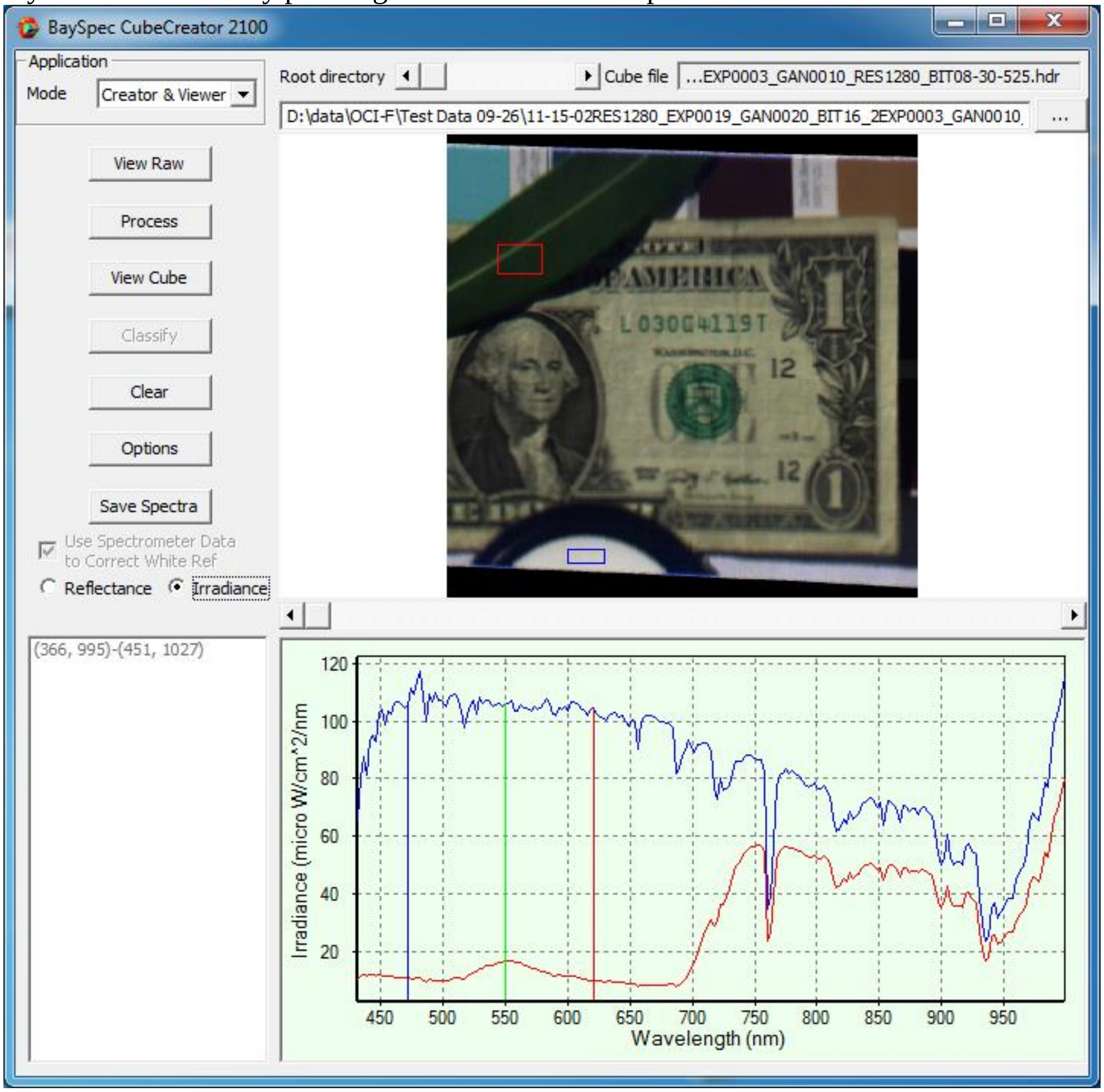
Selecting the option of Ratio will show the ratio of irradiance values. These ratios will be used to correct the intensity of white reference during data processing if the check box of "Use Spectrometer Data to Correct White Ref" is checked.



After processing, the use may select to display the reflectance or the irradiance results of ORI.



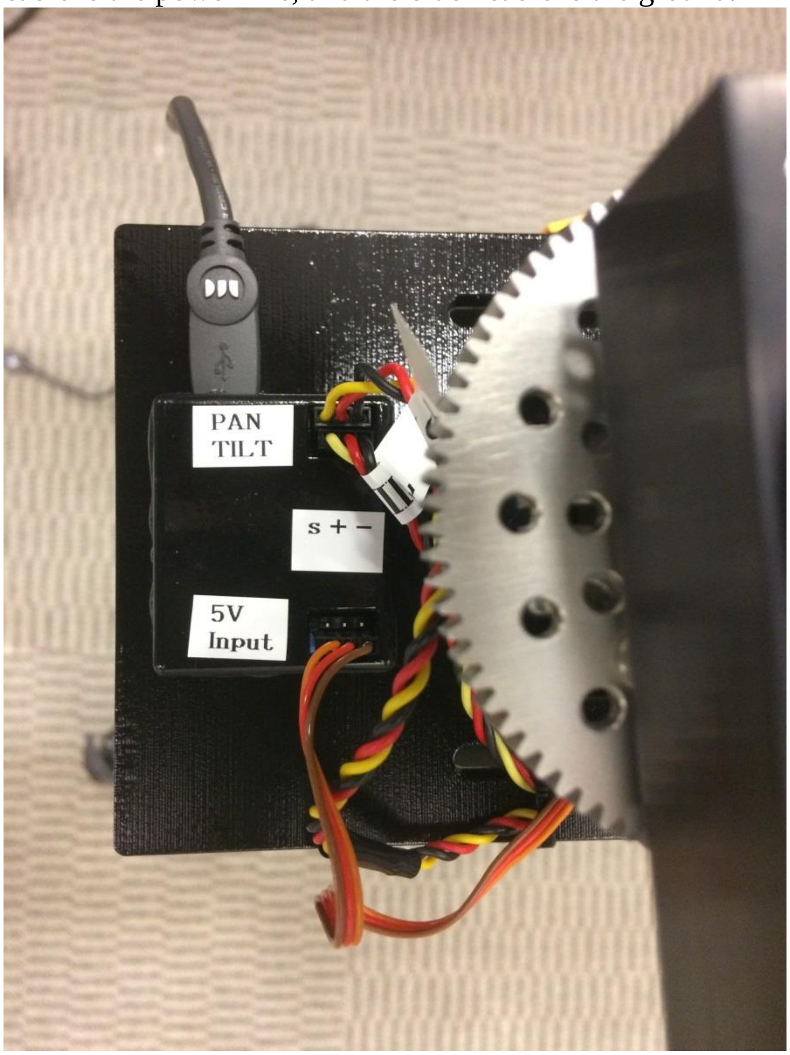
Please note that the irradiance values of band images are the calculated results assuming the ambient light condition is maintaining as that when the white reference was recorded. The user may save the results by pressing the button of Save Spectra.

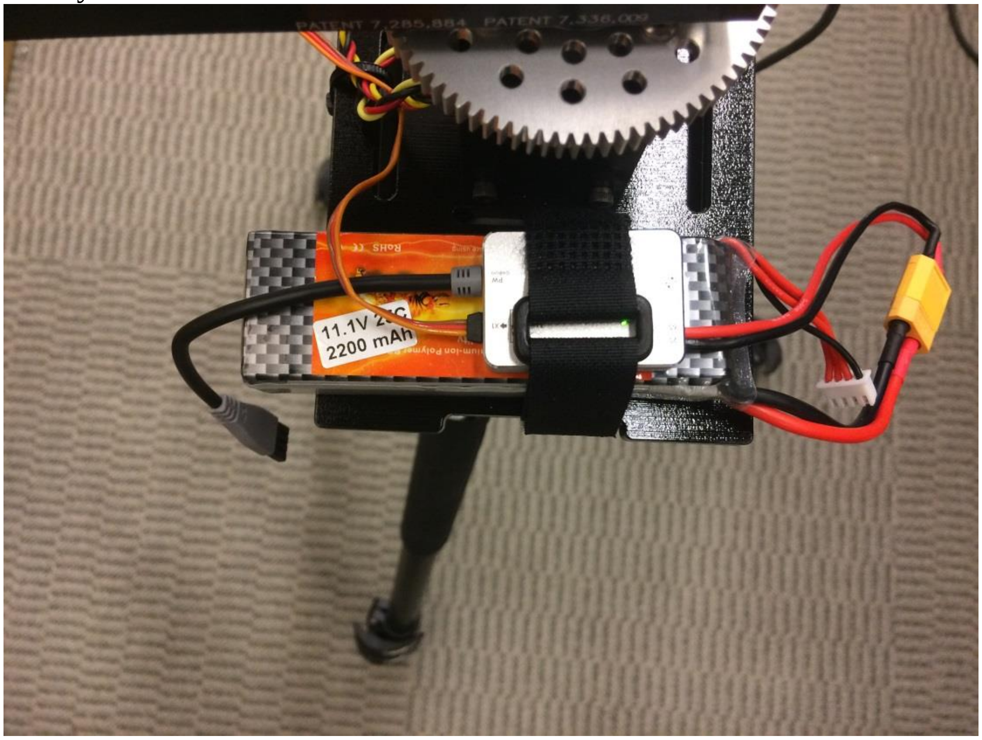


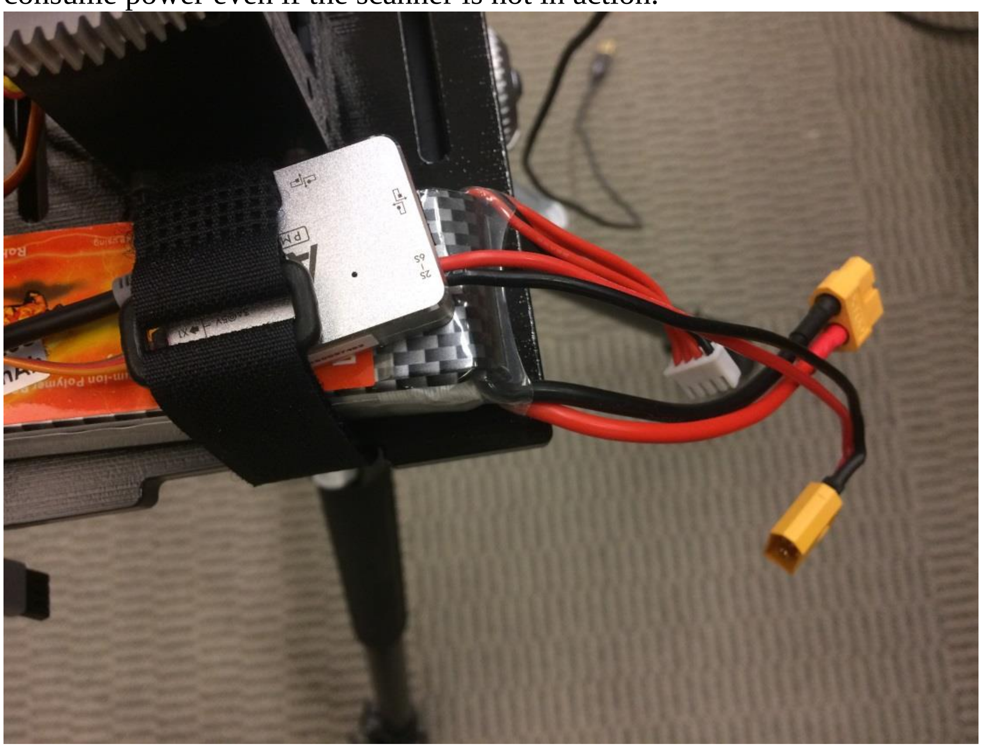
Appendix C Using Tripod Scanner

C1. Scanner Setup

1. Connecting Servos to the controller. Please note the yellow cable is the signal line, red cable is the power line, and the black cable is the ground.

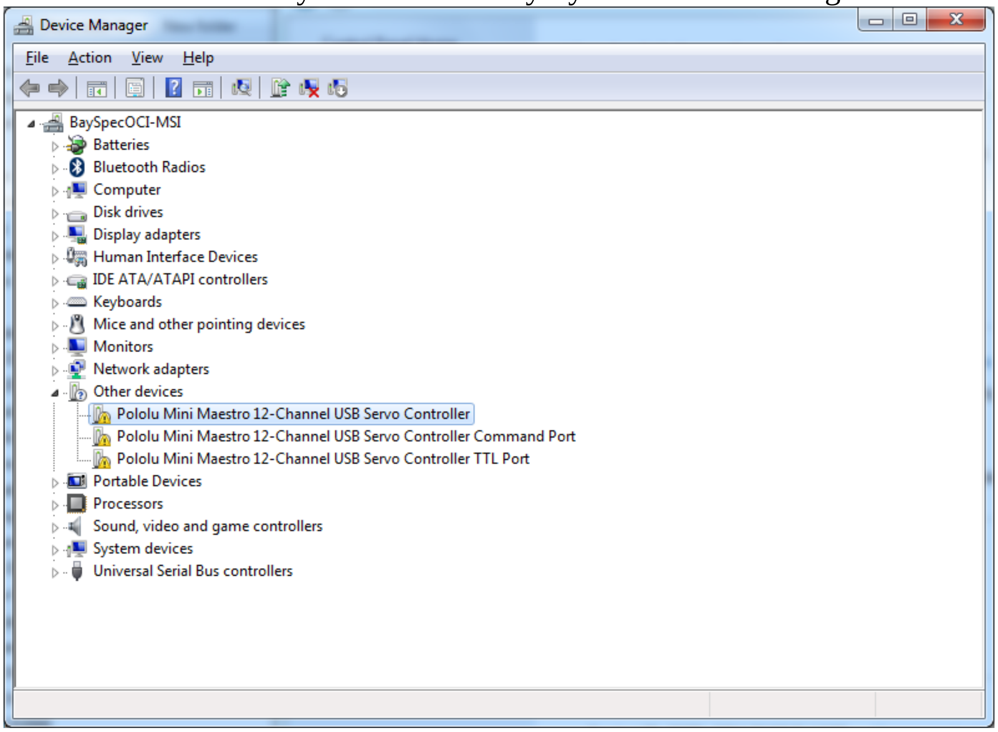


2. The controller is power by 5V DC from a DJI power module which converts 3S-6S Lipo battery to 5V.


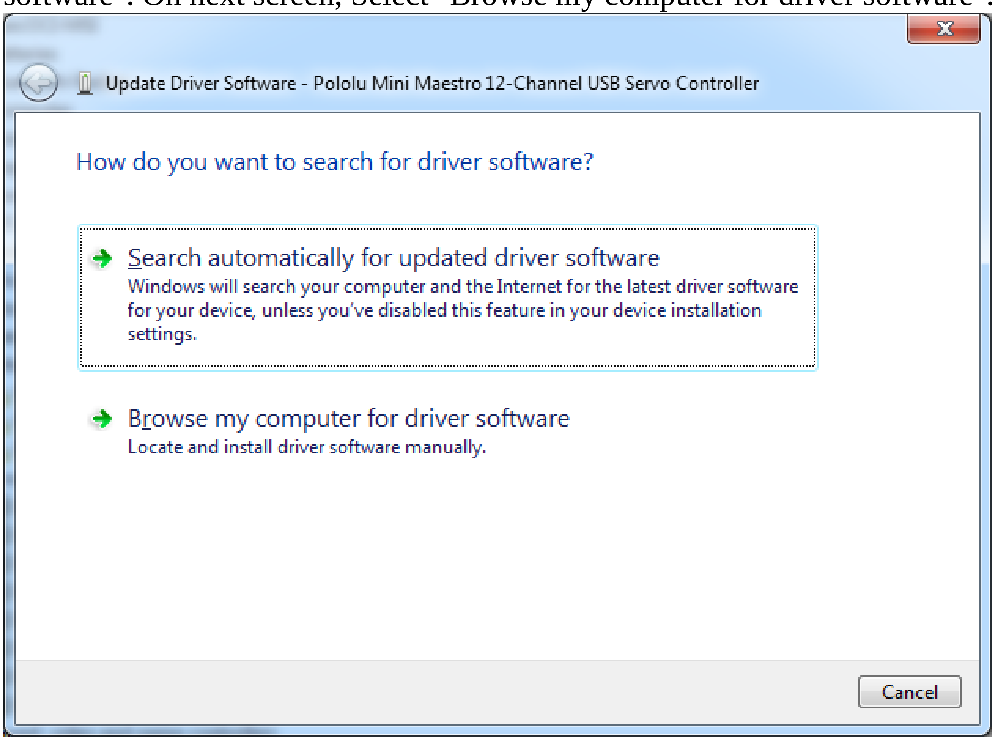
Disconnect the Lipo battery from the power module when the use of scanner is done. Otherwise it will drain the battery because the power module and scanner controller consume power even if the scanner is not in action.


C2. Driver Installation

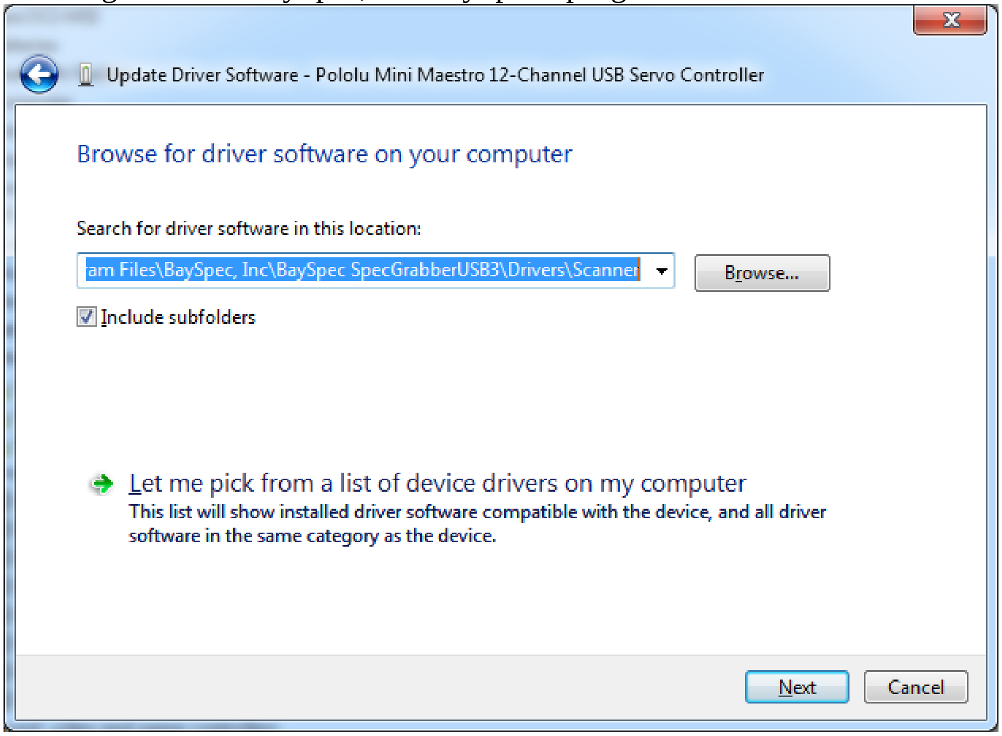
1. Connect the USB connector to a computer USB port.
2. Go to /Control Panel/System and Security/System/Device Manager



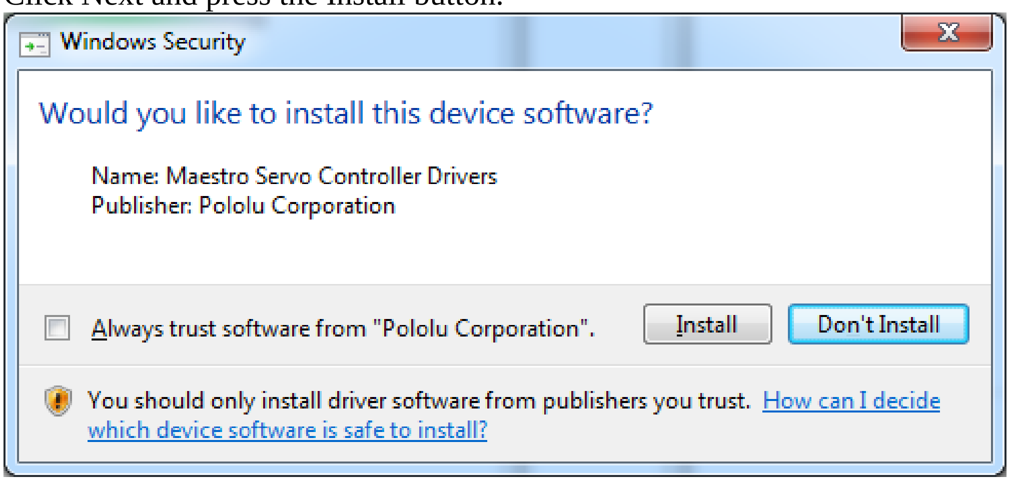
3. Highlight the first unknown device of "Pololu" and right click to select "Update Driver software". On next screen, Select "Browse my computer for driver software".



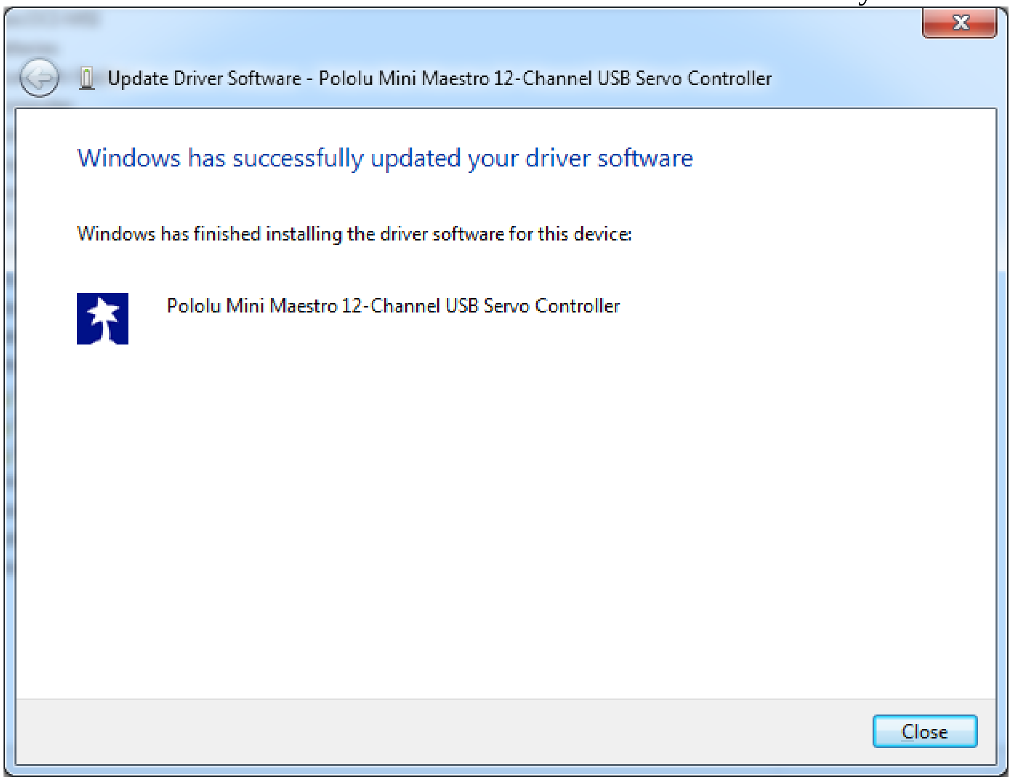
4. Select the folder where the Scanner drivers files have been stored, which is at "C:\Program Files\BaySpec, Inc\BaySpec SpecgrabberUSB3\Drivers\Scanner" by default.



5. Click Next and press the Install button.



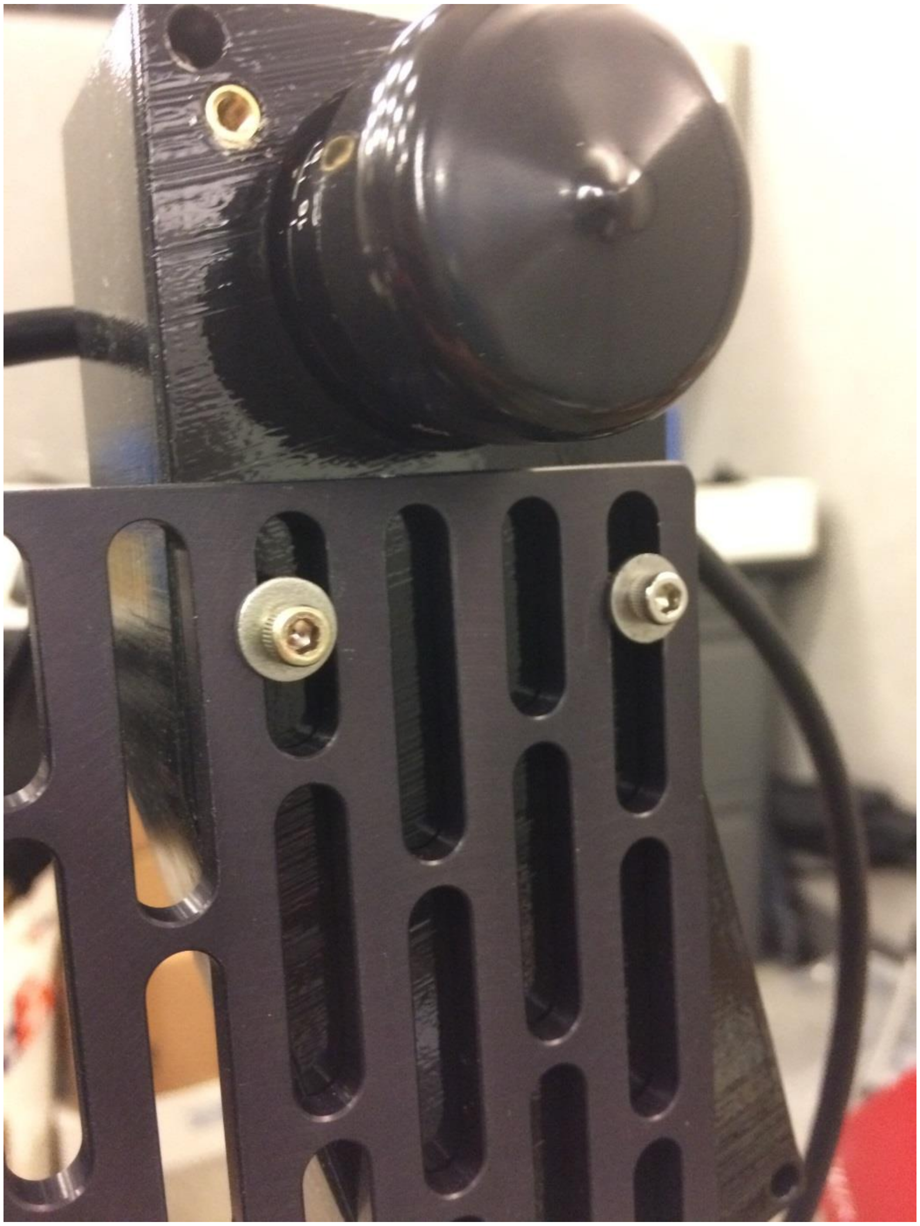
6. The final screen will show the driver has been installed successfully.



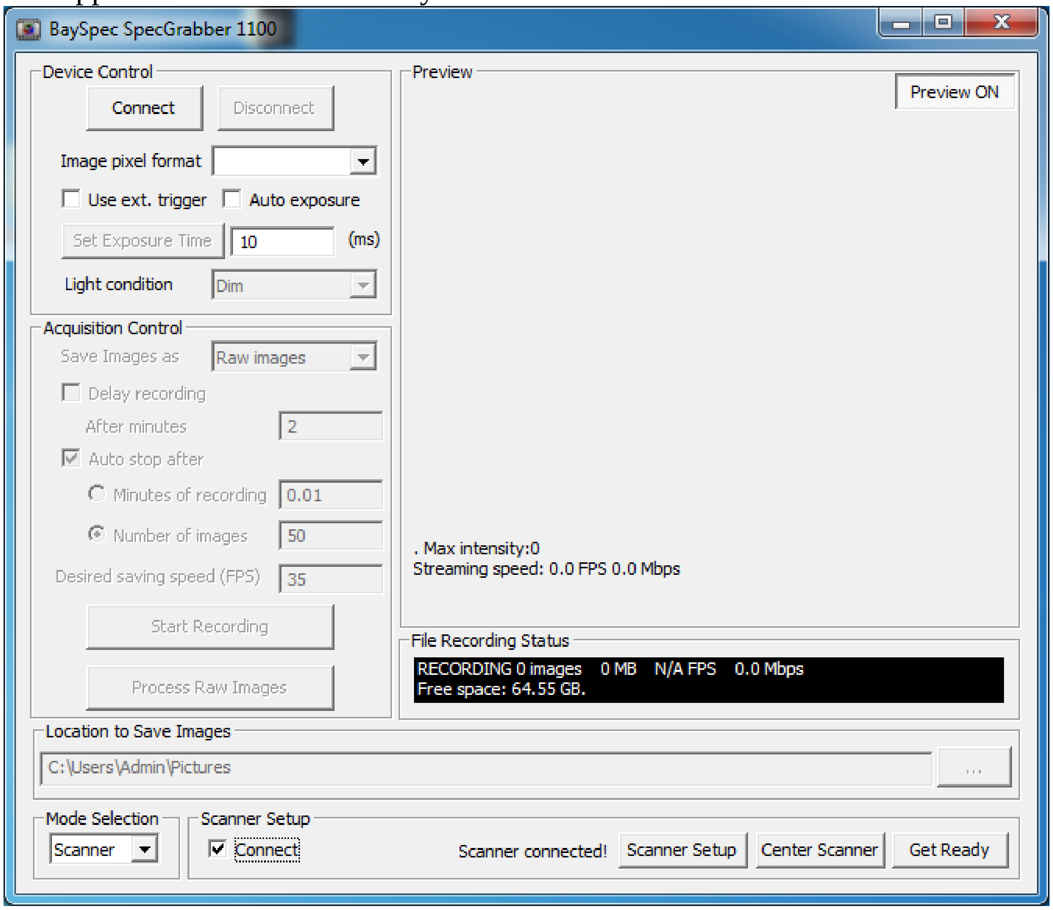
7. Repeat the same steps for the other two unknown devices.

C3. Using Scanner with SpecGrabber

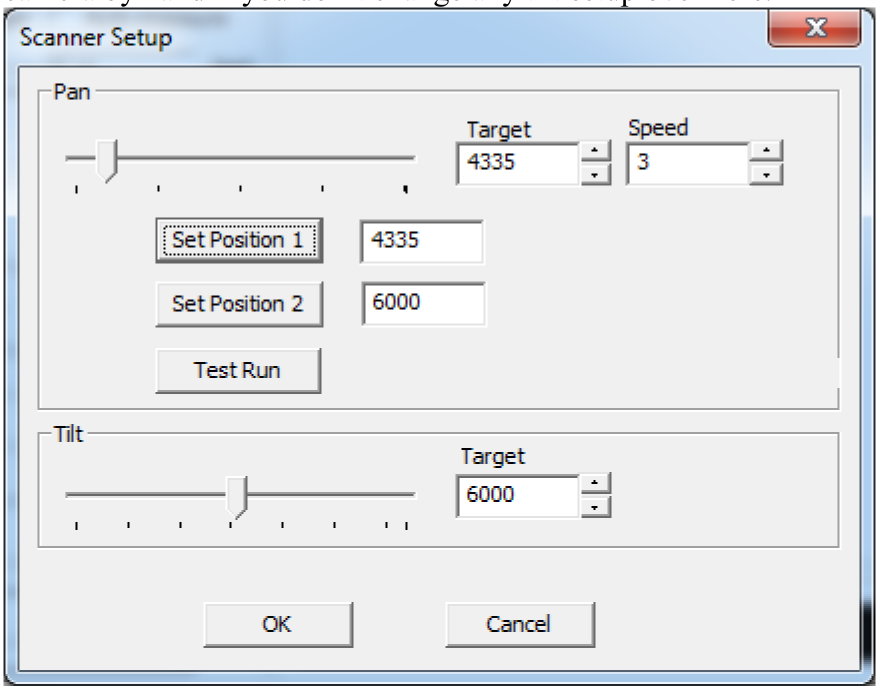
1. Mount OCI-F camera with scanner



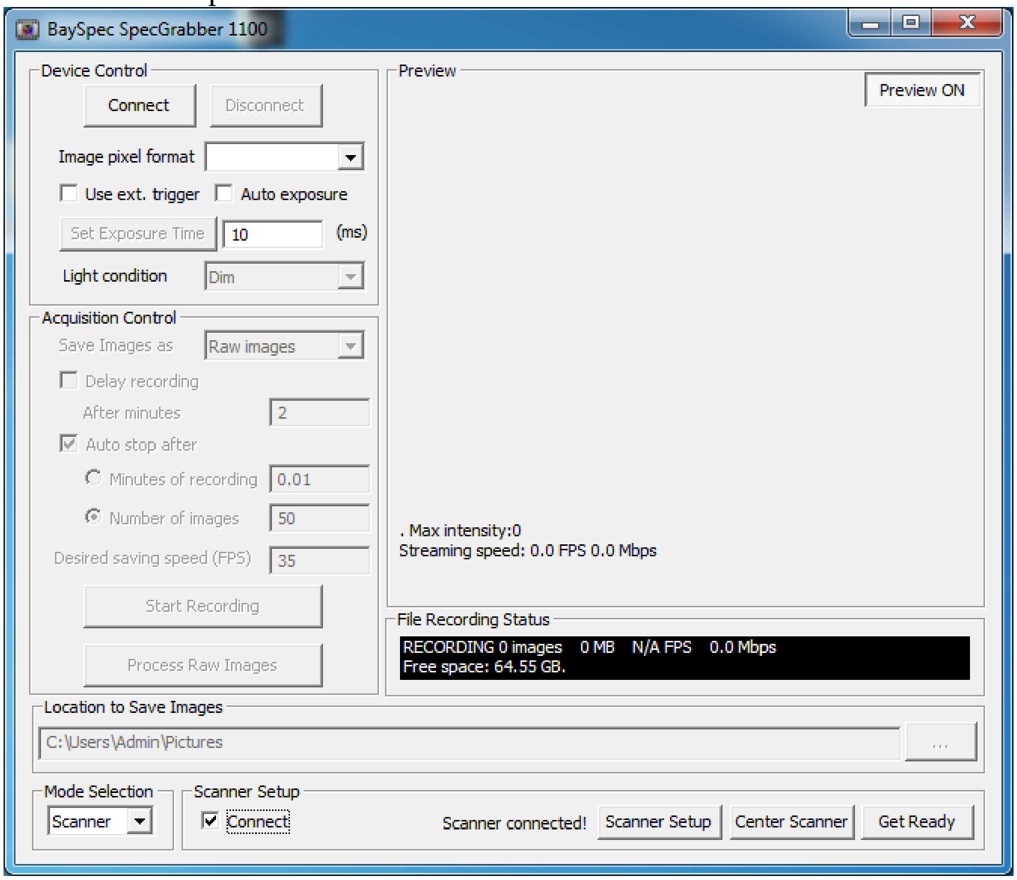
2. Connect OCI-F and the scanner to the computer. Start SpecGrabber. Select Scanner from Mode Selection and check the checkbox of Connect. A message of Scanner connected will appear if the scanner is ready.



3. Click on the button Scanner Setup. In the Pan panel, set the camera to the starting and end position by the button “Set Position 1” and “Set Position 2”. You my do a test run by pressing the button “Test Run”. Also you may change the rotation speed of pan by decreasing or increasing the number of Speed. Number 1 will be the slowest speed. Unless necessary, don’t touch the setup of Tilt panel. You may adjust the tilting angle of camera by hand if you don’t change any tilt setup over here.



4. Press OK and go back the main screen. You may press the button “Center Scanner” to point the camera to the center of starting and end position. This is convenient when you need to record the image of white reference. After that you can press the button of “Get Ready” to set the camera to either starting or end position. Uncheck the Auto stop under Acquisition Control panel. By clicking Start Recording under Save Image as “Raw image” mode, SpecGrabber will start recording raw images and stop recording when the scanner reaches the end position.



5. The following is a setup to recording white reference.

6. Scanner in action.

7. Hyperspectral results using scanner