Rainbow Multispectral Imaging

User Guide

[Revision: 5th May 2023, based on software version 2.3.3]

PHASE**ONE**

IMAGING BEYOND IMAGINATION

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Important General Considerations

Introduction and advice for proper use of a Rainbow MSI System

The Rainbow software is designed to provide for an easy access to the setup and capture of multi-spectral image stacks. The image stacks are captured and may be analyzed according to the methods of **Multiband** imaging or **Narrowband** imaging.

In order to work efficiently and achieve good results from the use of a Rainbow product, it is expected that the user is familiar with the methodology of the system intended for use, be it the Multiband system or the Narrowband system (or both systems):

- Multi-spectral imaging of the **Multiband method** works according to the Charisma guidelines for capture and **visual analysis**, specified on page 60. The Rainbow implementation uses LED light sources to deliver the requested UltraViolet, Visible, or InfraRed light. Charisma Ref: https://www.researchgate.net/publication/267266175_Multispectral_Imaging_in_Reflectance_and_Photo-induced_Luminescence_modes_A_User_Manual

- Multi-spectral imaging of the **Narrowband method** captures and analyzes image stacks comprised of images captured under a wide range of narrowband lights - up to16 narrow bands, ranging from select UV light, throughout Visible light, and into IR light. The Rainbow implementation uses LED-panels to deliver the narrow bands of lighting. In combination with cut-filters on the camera, photo induced luminescence may be captured. The analysis of a Narrowband image stack is often made using statistical methods, chosen for the specific application area. This may include analysis of paintings, analysis of handwritten documents, or analysis for forensic discoveries.

- The Rainbow in-line **Analysis Module** provides an intuitive way for analyzing a multi-spectral stack. Any stack (Multiband or Narrowband) can be analyzed directly in the software with the techniques most often used for image analysis. The functionality of the Analysis Module lets the user form an initial opinion of the image stacks content, useful for making decisions about the content and potentially for further analytical steps to be taken - typically using external software. The three different techniques available within the Rainbow Analysis Module for the analysis of stacks are "Principal Component Analysis" (PCA), "Independent Component Analysis" (ICA), and "Clustering" (K-means).

Please note that a Multiband capture sequence delivers the set of images specified in the Charisma guidelines, *including* false-color images, all *meant to be inspected and analyzed visually*. You may use the Rainbow in-line Analysis Module for further analysis on a Multiband stack if you *exclude/deselect* the false-color images of the desired wavelengths from the Input list (see the step-by-step guide in the workflow chapters on pages 62, 64 and 66).

It is of basic importance that the workflow of capturing multi-spectral stacks is followed, as specified in this User Guide. The steps of: **Project, Recipe, Calibrate, Capture, Browse** and **Export** need to be followed. For example, you *cannot* expect to reach any usable results by simply starting the capturing of images without having completed a proper calibration process.

We wish you all the best with your multi-spectral work,

Phase One
Cultural Heritage Team

Note that content and technical specifications are being reviewed and updated periodically, so please refer to the latest version or contact your Phase One CH partner for advice.

Warnings and advice for proper use of the hardware for the Rainbow MSI System

1. **WARNING:** The illuminator includes ultraviolet LEDs. Whenever this wavelength is activated, it is mandatory that all personnel in the room shall wear personal eye protection with side shields to protect eyes and skin. You must put UV glasses on to prevent damage to your eyes.

2. For the best possible lighting conditions follow this advice:
   a. Please ensure that there is no light pollution from other light sources. In other words, only use the supplied light sources in an otherwise dark room.
   b. Please set up the lights with a 45-degree incident angle at a distance of between 1 to 2 m from the object matter.

3. To make the calibration stages work correctly, please make sure you have available:
   a. One clean sheet of A1 sized flat white paper or cardboard to perfect the Flat Field calibration. We recommend using pearl white photo mounting board, 270g/m2, manufactured by Nordiskt Papper AB of Sweden.
   A background that resembles the intended scene. Please note that a completely dark background can result in issues with poor IR reflectance images (due to IR hot spot issue).

4. Please ensure that the computer will not go into a power saving mode by changing the settings in System Settings. If the computer goes to sleep during long exposure and calibration sequences, the MSI software will not be able to complete the task.

5. Workflow Overview:
   a. Set up the physical position of camera, filter wheel and lights.
   b. Perform the calibration stages: Focus and Alignment, Flat Field Compensation and Exposure Compensation.
   c. Use Live View to position and capture subject matter, repeatedly. This is quick and can be used continuously.
   d. PLEASE NOTE: When changing the physical position of camera, filter wheel or lights: you must perform the calibration stages again, before capturing new subject matter.

6. To make the filter wheel run as quietly as possible, carefully tighten the friction screw at the bottom of the filter wheel. This may seem a little sensitive, but will lead to a smooth and reliable operation.

7. Basic considerations for positioning the camera and the filter wheel:
   a. The iXG/iXH camera is mounted facing down at the top of the rail carrying the camera and filter wheel. With each lens, 72mm or 120mm, the iXG/iXH has a maximum extension for focusing. CAUTION: Please make sure to position the filter wheel outside the camera's maximum extension of 21mm, so that when fully extended, the lens will not foul the filter wheel.
   b. This procedure is recommended:
      i.   Select "Capture" in the MSI software to start Live View.
      ii. Set the Live View focus tool to "Manual mode" and bring the lens to its maximum extension using the arrow-buttons.
      iii. To avoid light falloff (vignetting), now position the filter wheel as close to the lens as possible, using the guide marks on the lens and shroud as seen in the illustration on the right.
      iv. Make sure the shroud is in place to prevent light from entering the gap between the lens and the filter wheel.

8. Sensor cleaning: Please refer to procedure described as an appendix at the end of this document.
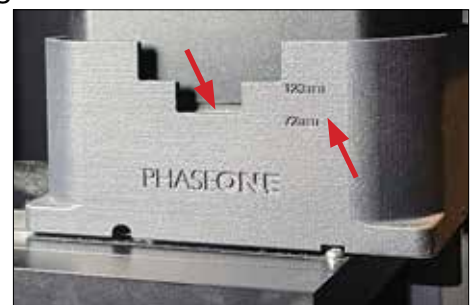
Multiband Imaging

Hardware Setup for Multiband Imaging

Setup of the Multiband Dedo lights

Included equipment:

- 2 x Multiband Dedo DLED7 UV 365nm (ultraviolet) ❶
- 2 x Multiband Dedo DLED7-D visible light (daylight) ❷
- 2 x Multiband Dedo DLED4-BI-IR 860nm/960nm (infrared) ❸
- 2 x Light support rail (for light stand) ❹
- 2 x USB-Switch 4 USB controlled power switch ❺
- 2 x Multiband Dedo DT4-BI power supplies (for IR LED-lights) ❻
- 4 x Multiband Dedo DT7 power supplies ❼

The system consists of six Multiband Dedo LED lights – two DLED7-UV365 (UV - ultraviolet) lights, two DLED7-D visible lights and finally two DLED4-BI-IR (IR - infrared) lights.

Four of the six supplied lights need to have filters mounted. UV-pass filters (dark colored) are mounted in front of the UV LED lights. IR-cut filters (light green) are mounted in front of the VISIBLE LED lights. These filters are stored in a small, folded pouch inside the supplied wheeled bag.

It is important to set up the different LED lights so that the same type (UV, visible and IR respectively) mirror each other's position on both sides of the capture area. The following way is how we recommend that you mount the LED lights on the supplied support rail on the stand with the stands placed on each side of the copy stand:

- Facing the copy stand, mount the two UV lights onto the spigots **closest to** you. The UV lights are identified by a purple color band.
- On the **middle** spigots, mount both of the visible spectrum lights. They are identified by a yellow color band. They should be approx. in line with the iXG/iXH camera.
- Finally, mount the IR lights on the spigots **farthest away from** you. The IR lights are identified by a red color band.

Controlling the light beam angle

Make sure that the light beam is set to be fully flooded on all the lamps instead of set to a spot light. The angle of the light is adjusted by turning the colored ring on the lamp.

Correct light angle – full flood light:

Wrong light angle – spot light:

Connecting the Multiband Dedolight power supplies to the LED lights

The LED lights use different types of power supplies so please be aware of this as you connect them.

The two UV LED lights (purple color band) and the two visible LED lights (yellow color band) need to be connected to the four power supplies labelled **DT7**.

The two IR LED lights (red color band) need to be connected to the two power supplies labelled **DT4-BI**.

Connecting the power for the LED lights

In order for the software to be able to turn the correct LED lights (UV, visible or IR) on and off automatically, the LEDs need to be connected to the two USB controlled power supplies in a specific order.

Each bank of LED lights (UV, visible and IR) should be connected to a USB-Switch power supply in the following order:

- The UV light (purple band) goes in the first socket labelled ❶
- The Visible light (yellow band) goes in the middle socket labelled ❷
- The IR light (red band) goes in the third socket labelled ❸

Each bank of three lights (UV, VIS and IR) should be connected to one USB-switch power supply.

Then connect the USB-Switch power supplies to the power outlet and the USB cables to the supplied USB control hub (see below).

The six power supplies can be secured to the light stands by using the supplied clamps or the integrated wired loops.

Adjust and position the Dedo light heads at approx. 45º to ensure good spread of light over the captured area. WARNING: You must wear protective glasses before you turn the UV lights on!

Setting brightness level and color

You have the ability to set the brightness level on Dedolight power supplies. In addition, the color can be adjusted on the DT4-BI labelled power supplies for the IR LED lights. These are controlled by knobs at the end of the power supplies.

Please ensure to set the brightness to the maximum level with the **Dim**-labeled knobs as well as adjusting the **Color**-labeled knob as shown on the images above. Set the **Dim** knobs all the way up to the max position and set the **Color** knob at a midway position.

Adding additional lights to the 4th socket
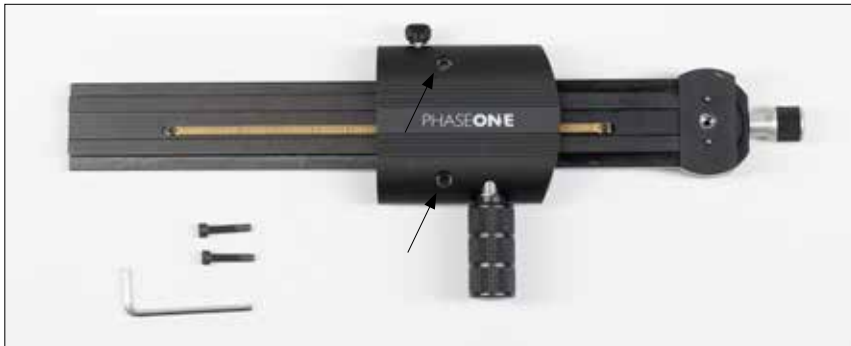
It is possible to add an additional light source of your choice to the 4th (empty) socket of either of the USB controlled power switches, for example, to add a raking light on one side. You can provide your own custom name for the extra light in Settings, and toggle it on and off from there.

The extra light can be added to any Recipe – see the section on working with Recipes below.

Assemble the Filter Wheel and iXG/iXH Camera

The filter wheel is mounted on the supplied rail together with the iXG/iXH camera. Attach it to the Phase One-labeled adjustable mount by using the supplied screws and Allen key:

The iXG/iXH camera attaches to the rail via the quick release mount.

Once the filter wheel and the iXG/iXH camera have been mounted on the rail, the setup should look like this:

Mount the rail with the filter wheel and iXG/iXH Camera on the copy stand.

Next, place the supplied shroud on top of the filter wheel. The purpose of the shroud is to ensure that no light is leaked into the area between the lens and the filter wheel.

Please note that the iXG/iXH Camera has a clear glass filter fitted onto the sensor to be able to record UV and IR light waves outside the visible spectrum. This means that a filter must be used in front of the camera to control what light waves are recorded at different capture stages. This is what the supplied filter wheel accomplishes.

Finally, attach the supplied power supply to the filter wheel and a power outlet and the USB cable from the filter wheel to the supplied USB hub.

WARNING:

THIS ILLUMINATOR INCLUDES ULTRAVIOLET 370 nm (UVA) LEDS

Whenever this wavelength is activated it is mandatory that all personnel in the room shall wear personal eye protection with side shields that as a minimum comply with:

- European Norms EN 170:2002 Personal eye protection - Ultraviolet Filters, Code 2 or 3, Class 2 or 1, shade 2 or 2C, with Category III frames conforming to EN 166:2002 Personal eye protection, or

- International Safety Equipment Association (ISEA) Standard for Occupational and Educational Personal Eye and Face Protection Devices, ANSI/ISEA Z87.1-2015.

Connecting the USB cables

Included equipment:

- 1 x StarTech central USB Hub ❶
- 1 x power supply ❷
- 1 x USB cable ❸

The automation of the system relies on the Rainbow software's ability to control the LED lights, filter wheel and iXG/iXH Camera. This is facilitated by the use of USB connections added to the supplied central USB Hub.

In order to ensure a smooth and reliable operation, it is important to use the supplied USB Hub and to connect the USB cables from the iXG/iXH Camera, Filter Wheel and the lights to a specific USB port on the hub. Please connect the USB cables as follows:

Connect the **Filter Wheel** to port ❶
Connect one **Multiband Cleware USB switch** to port ❷
Connect the 2nd **Multiband Cleware USB switch** to port ❸
Connect the **iXG/iXH Camera** to port ❻

Connect the USB Hub to the power supply and to a USB port on the computer with the Rainbow software installed. Refer to page 14 for the software installation, which will also install the necessary drivers for controlling the Filter Wheel and the LED lights.

Please note connecting the hub to a USB-C port on the computer is recommended for best performance.

The camera can also be connected directly to a free USB port on the computer.

The Filter Wheel and Laptop suitcase

The filter wheel and rail are secured in the foam insert at the top of the MSI case. There is also room for a 17" laptop (not supplied) underneath the foam insert, so please remove it to access the laptop compartment as shown below.
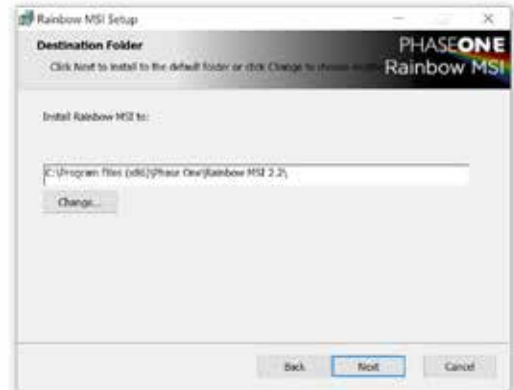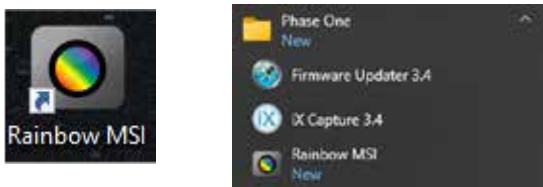
Installation of the Rainbow MSI Software

The Rainbow MSI software comes with an easy-to-use installation file. Just double click on the **Rainbow MSI.msi** file and follow the six steps in the Rainbow MSI Setup Wizard.

You may want to pay attention to the **Destination Folder** path in step three. If you have previous versions of the Rainbow MSI software installed, it is recommended to not overwrite the old version but instead ensure that the software is installed into a new path for the latest version, like \Rainbow MSI 2.3\. This way, you can still use the old version if you encounter any issues with the latest release.

You can change the destination folder by clicking on the **Change…** button.

Once installed, a shortcut will be added to your Windows Desktop. You can also access the software from the Start Menu.

Installation notes

- The software will by default be installed under C: > Program Files (x86) > Phase One > Phase One Rainbow MSI 2.3
- The application data will be installed under C:\Users\<username>\AppData\User\AppData\Local\ Phase One\Rainbow MSI.
  This folder contains the logs and the saved recipes.
- Note that the **AppData** folder and its content are hidden by default on Windows.

Project Folder Structure
The file structure of the project is set up with folder and subfolders as follows:

- **analysis_images** folder
- **calibration** folder
- **calibration_images** folder
  - » **alignment** subfolder
  - » **exposure** subfolder
  - » **flat_field** subfolder
  - » **focus** subfolder
- **previews** folder
- **processed_images** folder
- **raw_images** folder
- **thumbnails** folder

The final files are saved in the **processed_image** folder and you also have the option to access the originally raw captured images, which are stored in the **raw_images** folder.

Rainbow MSI Software Introduction

Getting Started

To launch the Rainbow Multispectral Imaging software, double click on the application icon on the desktop.

The software is designed with five workflow steps, with each step selected by clicking on a tab at the left of the screen named **Project**, **Recipe**, **Calibrate**, **Capture** and **Browse**.


Once you are done with capturing your image project files, you can inspect the finished files by clicking on **Browse**.

Checking that all devices are connected and recognized

Before you start, ensure that all the devices (camera, lights and filter wheel) are properly connected and recognized. You can check this by looking at lower right corner under **Devices** where a solid white dot will indicate that a device is connected and ready to use. If there is an empty circle instead, the device is not properly connected or recognized.
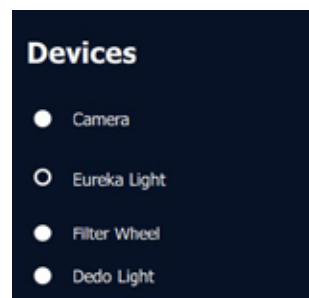
It is possible to expand the device overview by clicking on the Devices box in lower right corner. This will let you inspect the current setup of the Eureka or Dedo Lights and the Filter Wheel in detail. Clicking on a device description will turn that device on and off. Please note that clicking on the 4 – Undefined box will turn on/off both sides even if each side has been defined independently. Click again in the Devices box to close the expanded overview.
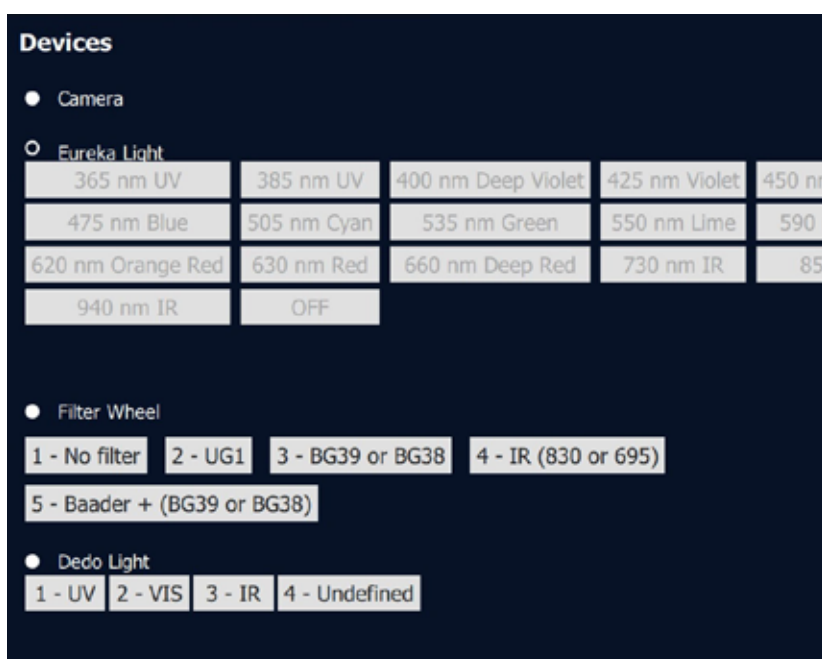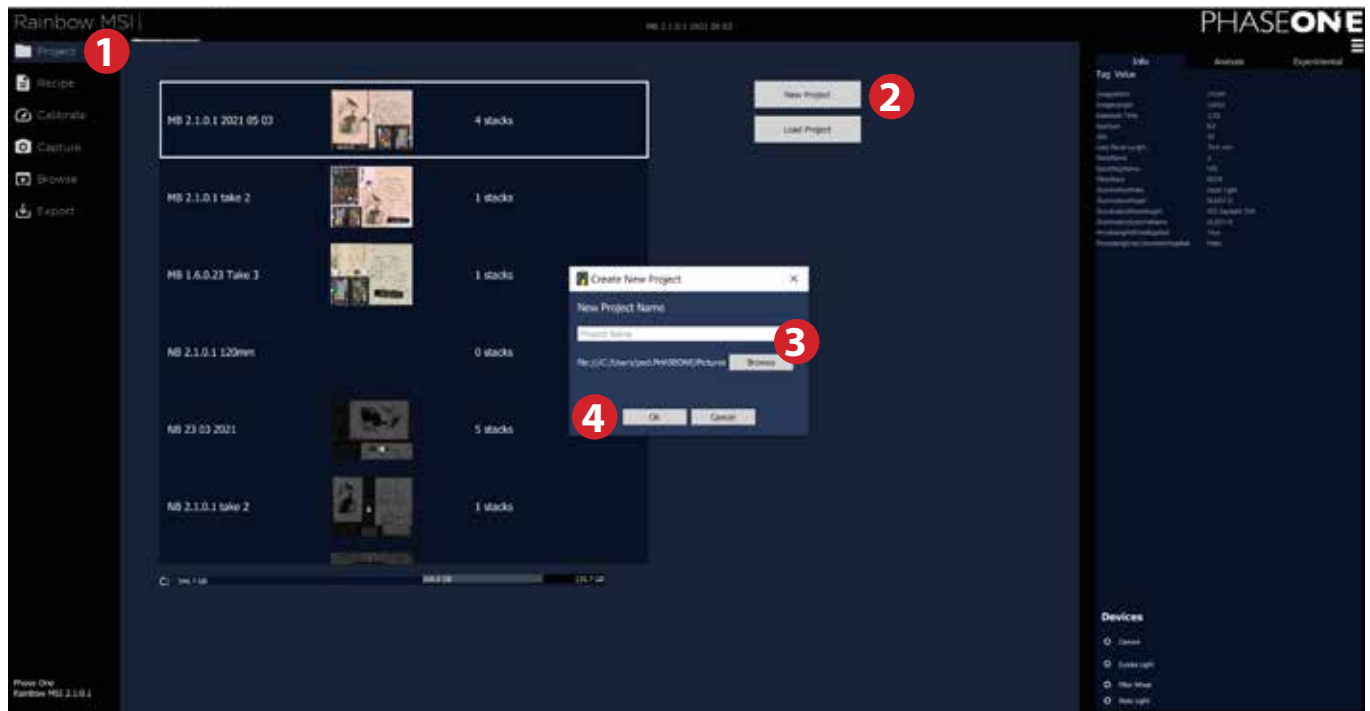

The first step is to create a new project or open an existing one. This is done by clicking on the **Project** tab at the left side of the screen. Please note that if a project was in use when you closed the software last time, it will automatically be reopened when you launch it.
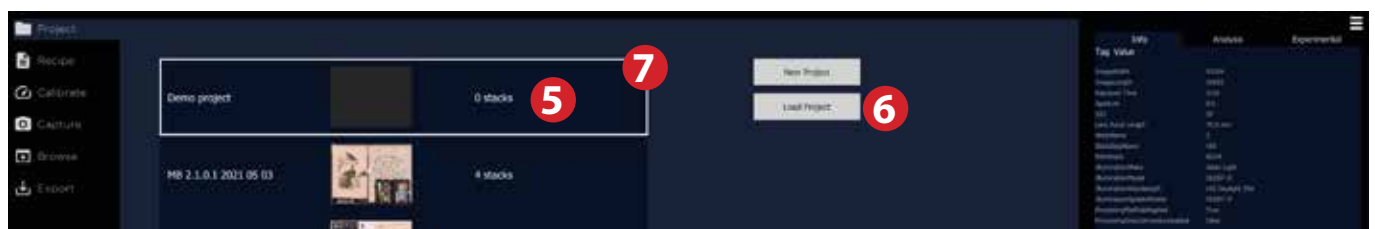
Multiband Imaging Operations
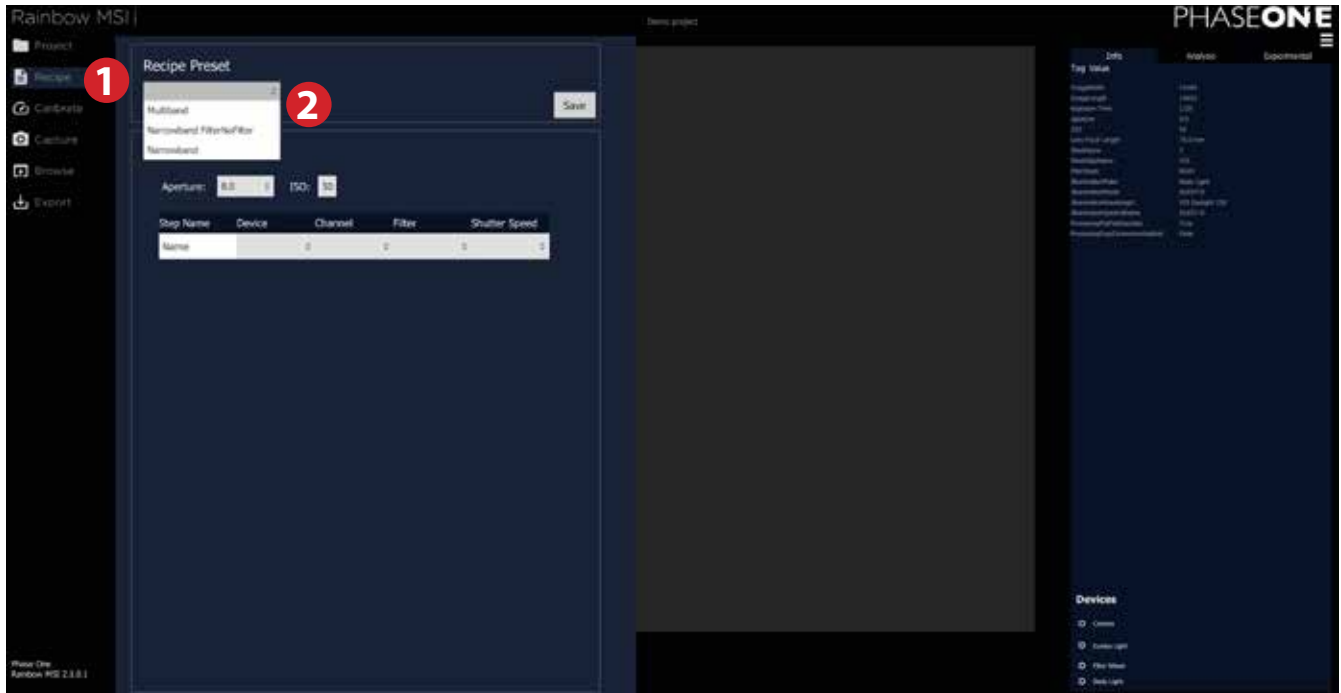
Creating a New Project

1. Click on the **Project** tab.
2. Then click on the button **New Project**.
3. Type a name for the project in the window that appears. Click **Browse** to select the location where to save your project. It is saved in the **Pictures** folder as default.
4. Finally, click **OK** to create the project.

5. It will note that it currently contains zero stacks since no captures have been done yet.
6. If you instead want to open and continue on a previous project, just locate the project and click on it. If the project is not visible in the project tab, click on the **Load Project** button, then browse to its location on the computer, double-click to open the Project Folder and then click "Select Folder". Please note this can take a few seconds when loading Projects with large amounts of data.
7. If you need to delete a project, hover the mouse over the project frame and click on the cross icon. **Please note when you delete a project in this way, all images associated with that project are deleted from the computer hard drive.**

Selecting a Capture Recipe

1. Click on the **Recipe** tab at the left side of the screen.
2. Select a Recipe from the **Recipe Preset** drop-down menu at the top. The software comes with both **Multiband** (Dedo lights) and **Narrowband** (Eureka lights) presets so ensure you select **Multiband** which fits with the Dedo light setup.
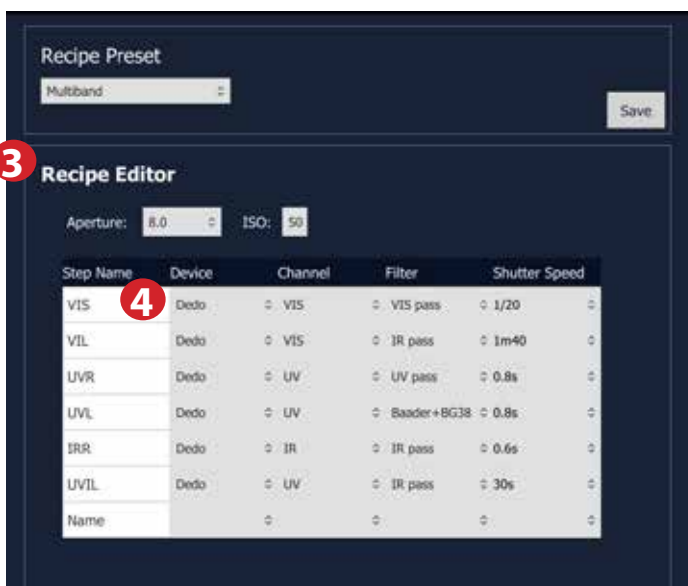
3. Once a Recipe Preset is selected, the **Recipe Editor** will show a predefined list of capture sequences that is set up with different lights (visible, UV and IR) and filter combinations:
4. In the example above, the Recipe will go through six capture combinations noted under **Step Name**. The different combinations of lights and filters are as follows:
   VIS = Visible light with visible light pass filter.
   VIL = Visible light with IR pass filter.
   UVR = UV light with UV pass filter.
   UVL = UV light with Baader+BG39 filter.
   UVIL = UV light with IR pass filter.
   IRR = IR light with IR pass filter.

If you do not use a Preset, you will have to create these combinations of lights and filters yourself (Please see **Creating your own Recipe** below).
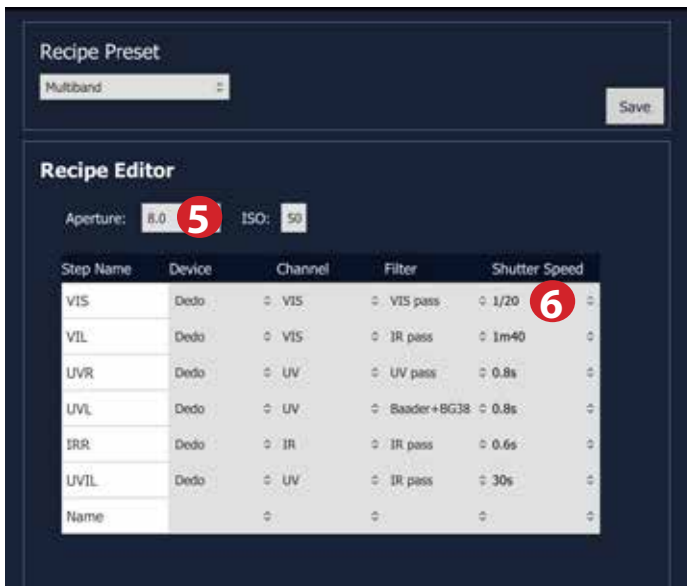
5. In the **Recipe Editor**, ensure that the lens aperture is set according to the selected recipe by click-ing on the **Aperture** drop-down menu.
6. You can adjust the exposure time by clicking in the **Shutter Speed** row to modify these. This step is important to remember if you change the aperture in order to keep the exposure constant.
7. You can add and remove steps from a Recipe. To add a light connected to the 4th socket in the USB controlled power socket, select Dedo as the Device and then select the light from the drop-down menu according to the name you originally saved for that light. Note that the choice is side-specific.

Important note about Aperture, ISO and Shutter Speed

In the Recipe Editor you have access to the three parameters of the capture: Aperture, ISO and Shutter Speed. Please note that the Exposure Compensation is automatically calculated in the calibration process setting the exposure gain and the white balance for best possible exposure. This is done assuming that Aperture and ISO is kept constant as specified in the Recipe.

Should you want to work at, for example, a higher ISO you will need to start in the Recipe Editor by setting the new ISO and manually adjust Shutter Speeds up or down in 1/3 steps. Then, re-do the calibration process, which will calculate a new Exposure Compensation.

Creating your own Recipe
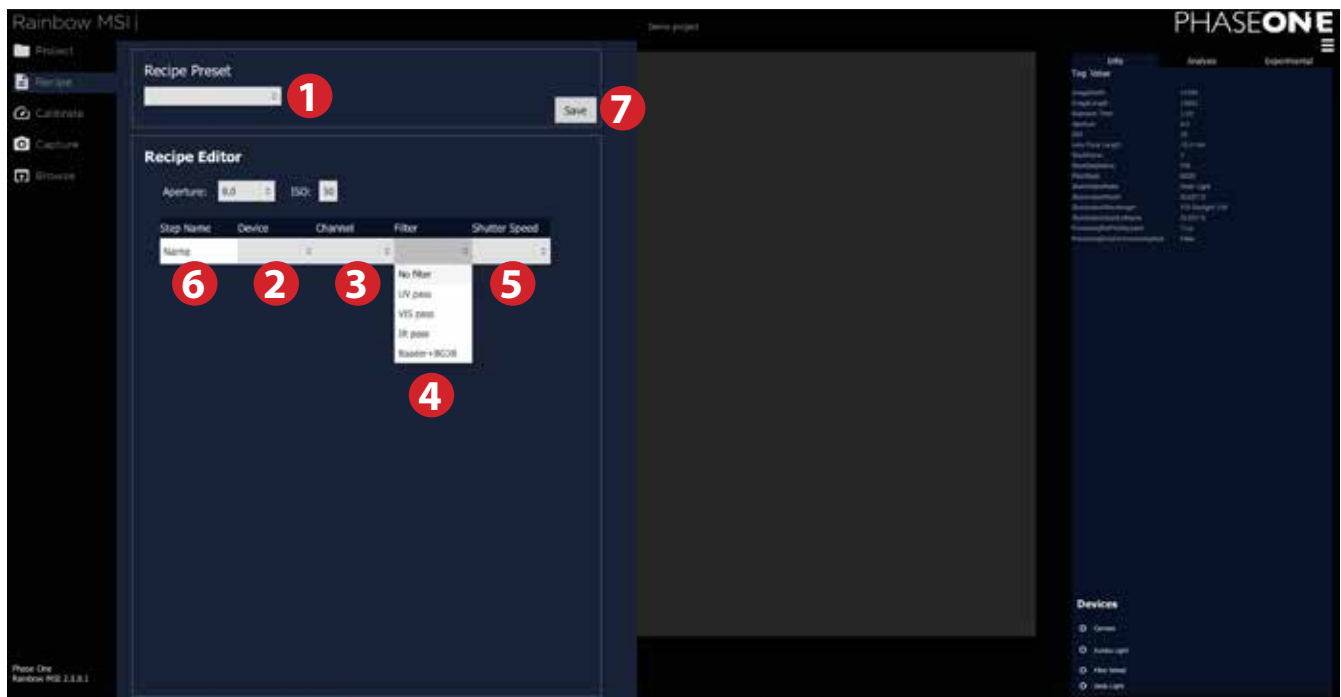
1. Make sure that you haven't selected a built-in recipe from the **Recipe Preset** drop-down menu to get a clean slate to work with.
2. You now have to set up a sequence of captures with each their light, filter and shutter speed. Select the **Multiband Dedo** light type from the **Device** drop-down menu.
3. Select the light type (UV, IR, Visible or 4th socket light) from the **Channel** drop-down menu.
4. Choose the needed filter combination from the **Filter** drop-down menu.
5. Finally, you also need to select the required exposure time from the **Shutter Speed** drop-down menu.
6. You can name each of the individual captures in the sequence in the **Step Name** field to keep things organized.
7. The recipe will be saved automatically in the background as you start to work with the project. If you want to reuse the created recipe in another project later on, then please remember to save it to disk by clicking on **Save**.

You can delete a created row in the Recipe by hovering the mouse over it and clicking on the cross icon.

Calibration Process

A very important part of the Multi Spectral Imaging workflow is to do a **Focus and Alignment** calibration as well as calibrations for **Flat Field Compensation** and **Exposure Compensation**. This is needed to ensure a satisfactory capture and final image quality. The calibration processes are automated and will only require that you change a target for each step. These steps will be explained on the following pages.

It is important to point out that the resulting calibration is **only** valid for the setup of the lights and the distance from camera to the subject that you were using during the calibration process.

If you move the lights or change the camera distance substantially, it is essential to redo the calibration process – otherwise the captured and processed images will not be a of a satisfactory quality. You can, however, reuse the current calibration if the distance from camera to subject is not changed substantially. This means that for example pages from a book can still be captured without issues with the current calibration.

Please note that the user interface might look like the application is frozen while the calibration processes are going on. This is normal behavior.

Please note that no calibrations are carried out for any light connected to the 4th socket in the USB controlled power socket.

Expected calibration times

The time to complete a calibration depends on the number of steps in the recipe and the selected shutter speeds. The calibration times for a standard **Multiband** Recipe Preset are as follows:

- Focus and Alignment Calibration – approximately 3 min. 20 sec.
- Flat Field Compensation – approximately 1 min. 40 sec.
- Exposure Compensation/White Balance – approximately 8 min. 10sec.

General Calibration Settings

You can change the general calibration settings by clicking on the settings icon in the upper right side of the software.
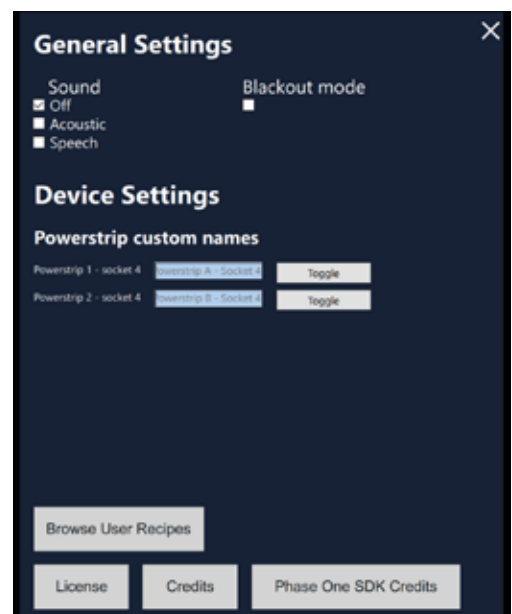
Audible feedback

It is possible to choose whether you want an audible feedback to sound from the computer when a calibration process is completed. Here you can either choose a sound (**Acoustic**) or a voice (**Speech**) to indicate that the process has ended, or to turn the audible feedback off entirely (**Off**).

The audible feedback is available so that if the screen is turned off during the calibration process you can tell when the process is done.

Blackout Mode
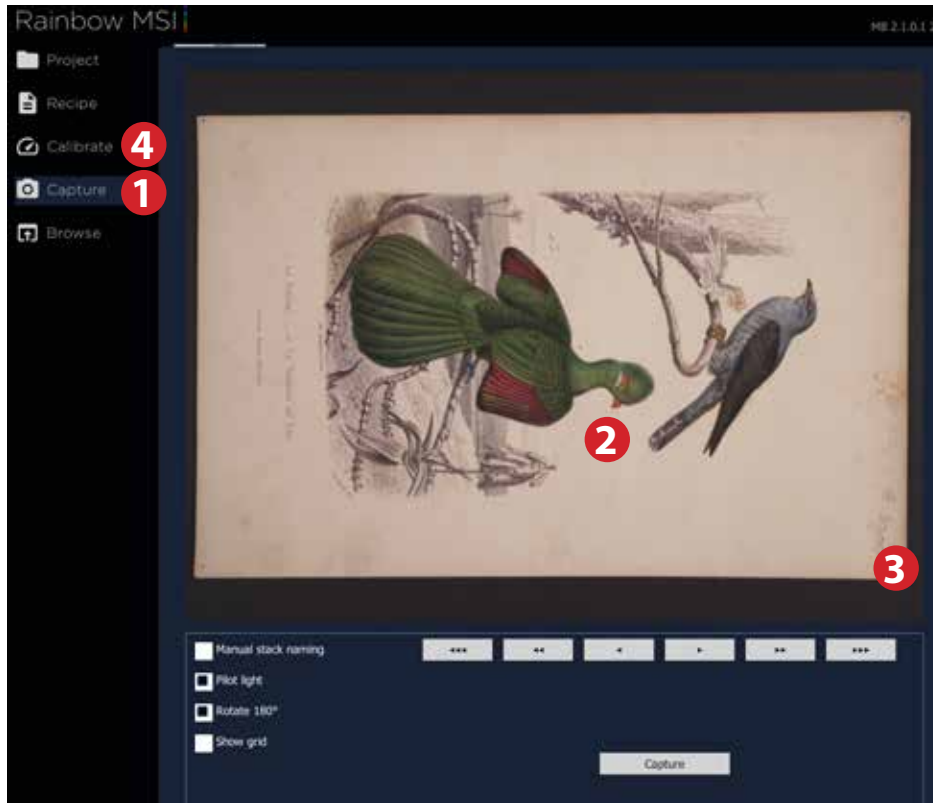
If you want the computer screen to turn off during the calibration process to ensure complete darkness, please enable **Blackout mode**.

> **WARNING:** From this stage on, you **must** wear UV protective glasses to prevent damage to your eyes!

Adjusting camera distance before calibration

It is important to set the working distance between the camera and the subject matter before you start the calibration process. If you change the camera distance during the capture process, the calibration steps will have to be redone. Follow these steps to get the desired framing of the subject matter correct:
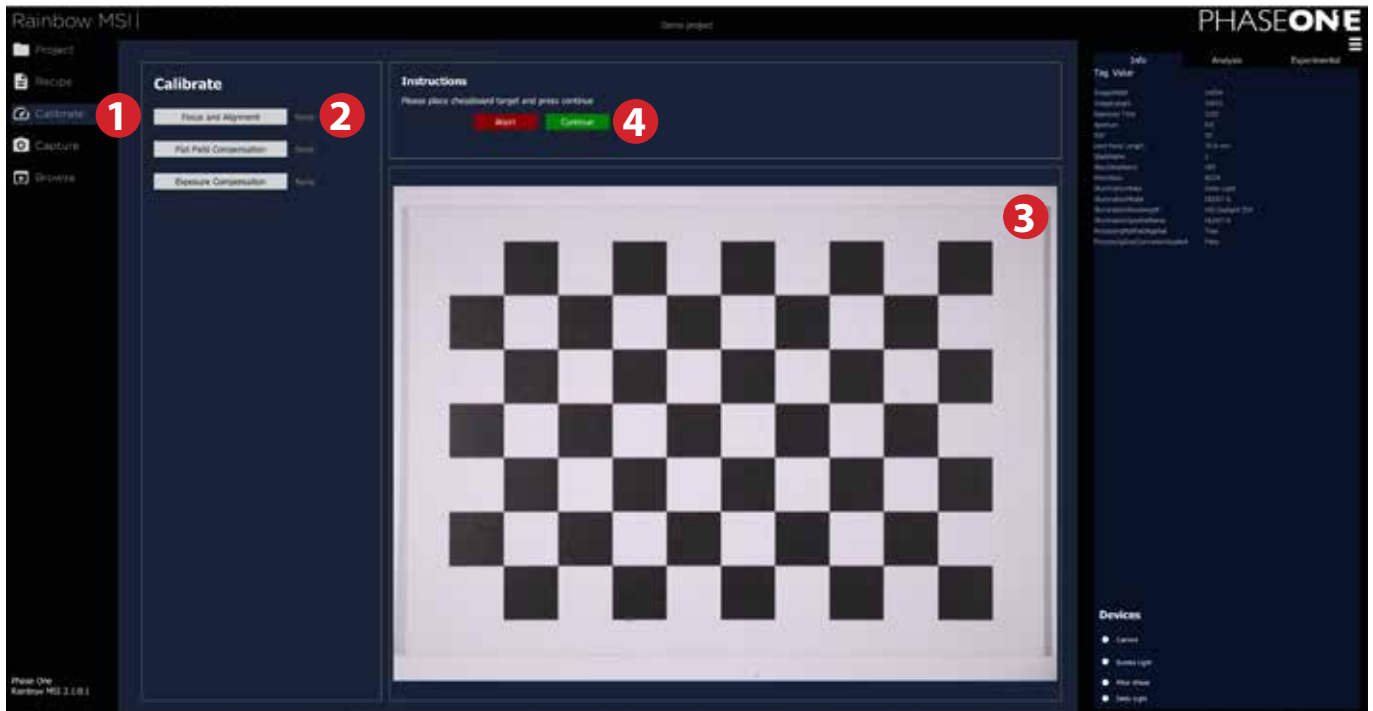

1. Click on the **Capture** tab to open Live View.
2. Place the subject matter inside the frame. Then click on the subject for the camera to focus on it. The Live View feed will show you the same frame as the final capture.
3. Change the distance of the camera on the copy stand to zoom in or out depending on whether you need a tighter framing or a wider framing. Keep an eye on the border of the subject matter.
4. Once you are satisfied with the framing of the subject matter, click on the **Calibrate** tab and continue on to the next chapter.

Important note: In order to get the best results from the following calibration step, please make sure to position the lights such that the initial light coverage is as smooth as possible. If you place the lights, and especially the IR light, close to the repro table top and focused at the same point, you may be forcing a severe light fall off that makes it difficult to get the calibration steps consistent between the three reflection images *IR-reflected, VIS-reflected*, and *UV-reflected* for Multiband.
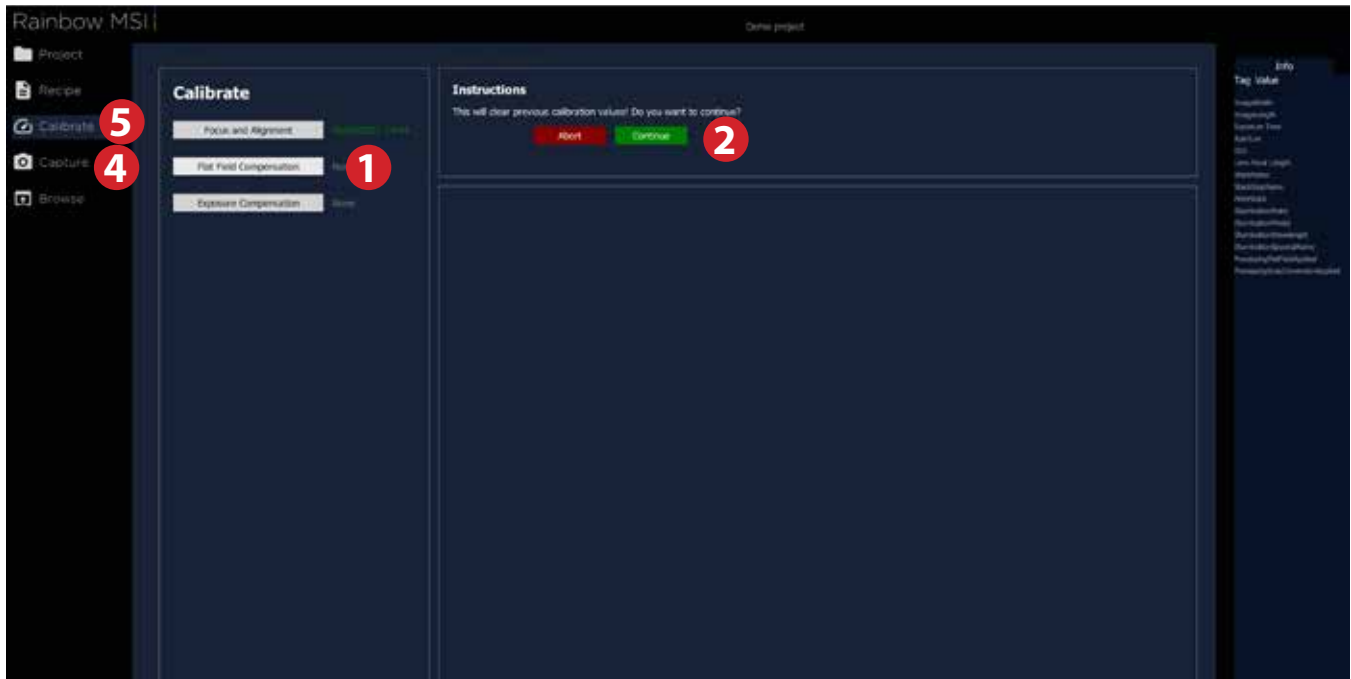
Focus and Alignment Calibration

It is important to make the **Focus and Alignment Calibration** since the correct focus plane will change slightly depending on the used light wave (UV, visible light and IR) which means that the system will need to refocus for each light band. Technically, the system will obtain a correct focus for the visible light (**Multiband**) and make a scaling and alignment calibration based on the detection of the corners together with precalculated offsets for the other light waves.

1. Click on the **Calibrate** tab at the top left of the screen.
2. Click on the **Focus and Alignment** button to start Liveview.
3. Place the supplied checkerboard focus target on the copy stand. IMPORTANT: the whole checkerboard MUST be placed visibly inside the imaging area for the calibration to deliver correct results.
4. Click on the green **Continue** button to start the **Focus and Alignment** calibration process.

Flat Field Compensation

The **Flat Field Compensation** process will ensure light uniformity on the images by calculating the light falloff and applying a correction. This will be done for each light/filter combination to ensure maximum image quality.
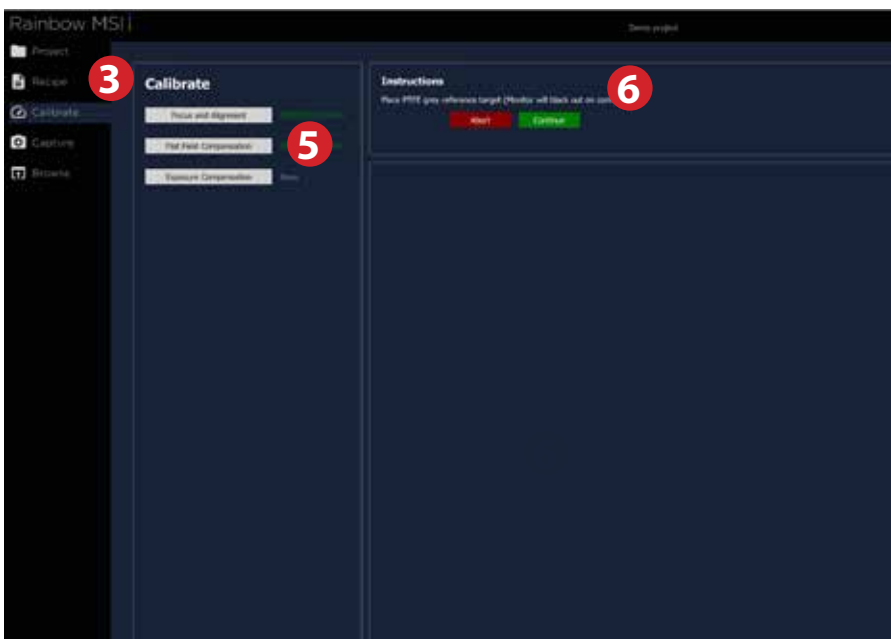

1. Click on the **Flat Field Compensation ❶** button.
2. Then click on the green **Continue ❷** button.
3. Place a large white piece of paper or similar that **covers the entire image area** on the copy stand. Ensure that it is kept as flat as possible. Refer to the General Considerations section.
4. You can check whether the white paper is indeed covering the entire image frame by entering Live View. This is done by clicking on the **Capture ❹** tab.
5. Once confirmed, select the **Calibrate ❺** tab again.
6. Make sure that all normal lights are turned off in the room so that it is completely dark.
7. Click on the green **Continue ❷** button to start the calibration process.
8. The computer screen will now turn off to ensure complete darkness if blackout option is selected in settings. The process will take approximately 1:40 minutes for a standard Multiband recipe. The screen will turn back on when the process is complete.

Exposure Compensation and White Balance

It is necessary to perform an exposure calibration to get useful results with properly exposed captures. This process will also adjust the white balance automatically. Please note no calibration is run for VIL and UVIL images
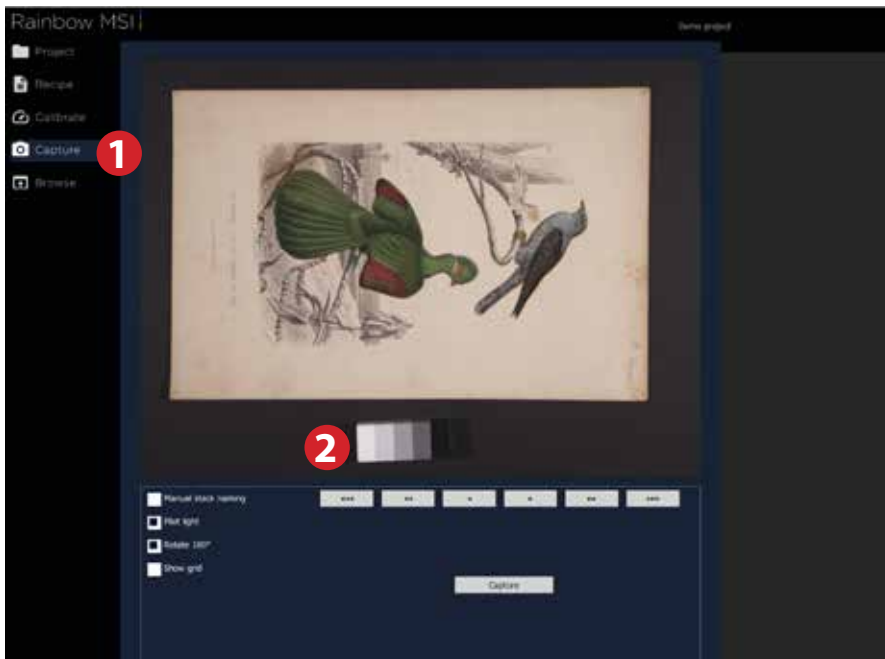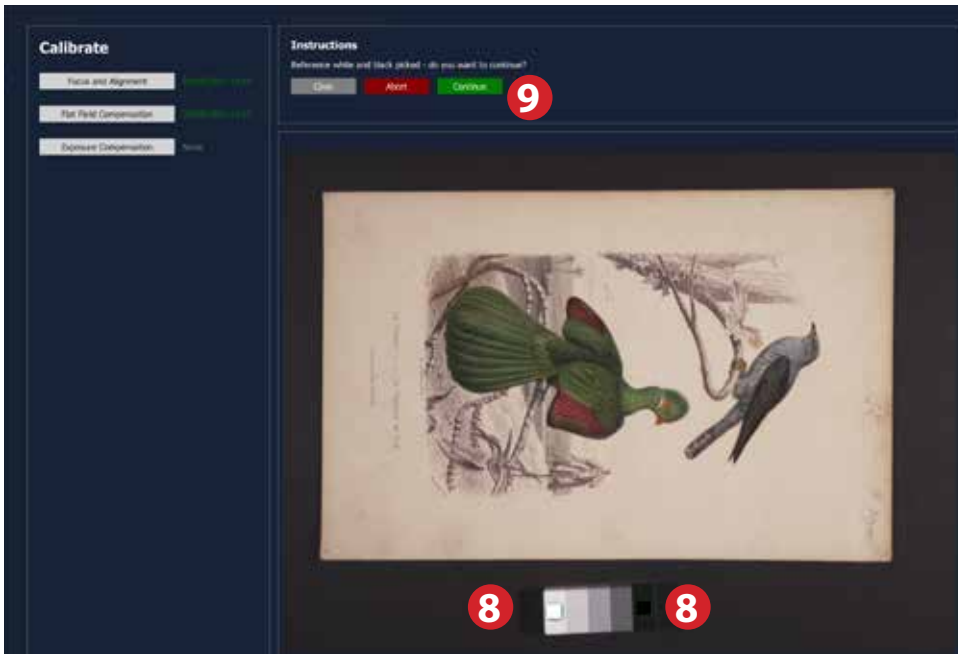

1. Click on the **Capture** tab to open Live View.
2. Place the subject matter inside the frame and the PTFE-target next to it.
   Please do not move the PTFE target until all images have been reviewed (see Reviewing the Captures for IR flare mitigation).

3. Click on the **Calibrate** tab.
4. To automatically re-run the calibration for over- or under-exposed images, put a check in the Automatic Re-run box. Note that a degree of under-exposure is allowed, so use a manual compensation to maximise the data captured.
5. Click on the **Exposure Compensation** button.
6. Then click on the green **Continue** button. Verify that the PTFE-target is in place and click on the green **Continue** button again to start the calibration process.

7. The computer screen will now turn off to ensure complete darkness if the blackout option has been selected in settings and the camera will make a capture sequence corresponding to the selected recipe.
8. The screen will turn back on and a preview will be displayed in the viewer.
9. You will now be asked to select the white and the black part of the PTFE. First select the white part, then the black.

10. Click on the green **Continue** button once you're done.

11. The software will report as the adjustments are being made so that you can follow the progress: The process will take approximately 8 min. 10 sec. for a standard Multiband recipe.
12. If the Automatic Re-run box is checked, any over- or overly under-exposed images will be recalibrated automatically by the software.
Please do not move the PTFE exposure calibration target during the calibration process.

Handling failed Exposure Calibration

If the **Automatic Re-run** Calibration box is not checked, the Exposure Calibration might fail due to one or more steps being either underexposed 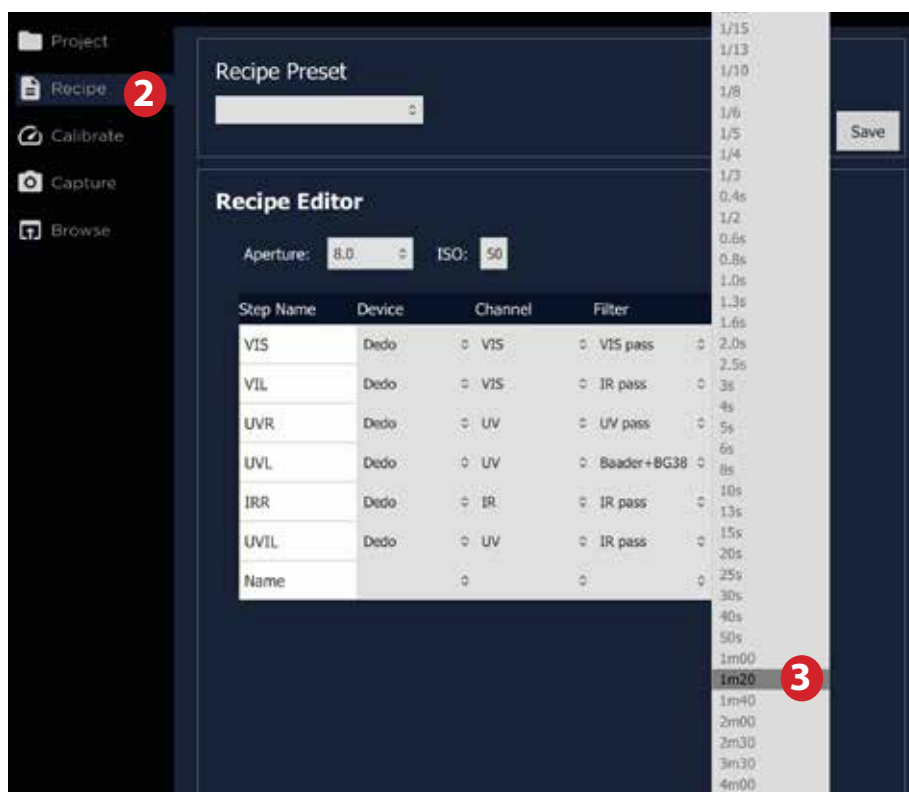or overexposed. You will have the option to click Re-run at this stage to automatically re-calibrate for these steps, or you can re-run the steps manually. If you do not select Re-run, an error message will tell you what recommended shutter speed you should use instead.

1. In the example above, it is recommended to try again with a shutter speed of 1m20s. Note the recommended shutter speed before moving to the next step.

2. Open the **Recipe** tab and change the shutter speed ❸ according to the recommendations in the error warning.

4. Once you have changed the shutter speed, click on the **Calibrate** tab. Then click on **Exposure Compensation** ❺ and finally redo the calibration by clicking on **Approve** ❻. The software will then only recalibrate the adjusted steps.

Reuse Recipe/Calibration

This functionality is used for copying the Recipe and Calibrations from an existing Project to a new Project.
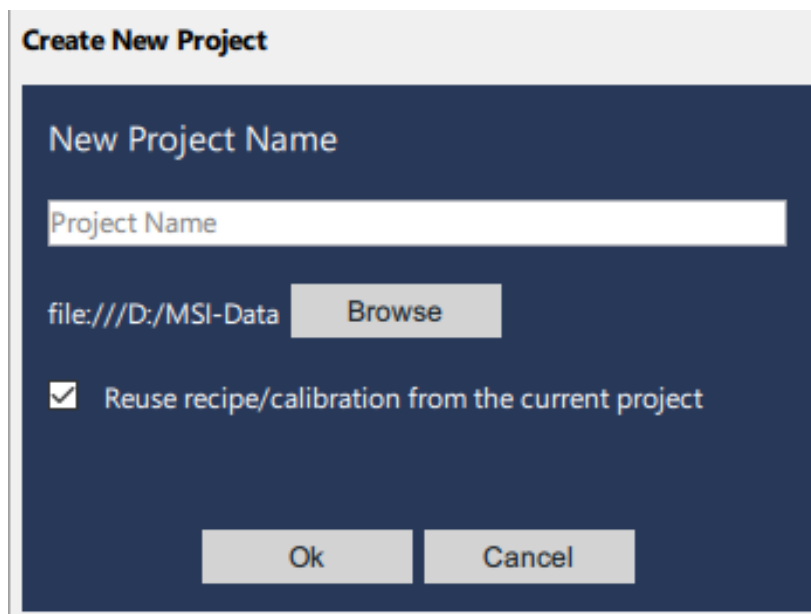
When reusing recipe and calibrations please make sure that the physical system setup has not changed since the original calibration. If, for instance, the camera distance or light source distance/angles have changed – the calibration will not yield good results.

Recipe settings are closely associated with a set of calibrations and hence both the recipe and calibrations need to be reused in order to ensure a correct match.

There are two options for reusing recipe/calibration from a previous project.

Option 1.

In the "Create New Project" dialog box is a checkbox with the text "Reuse recipe/calibration from the current project". Put a tick in the box if you want to reuse the recipe and calibrations from the previous Project.

This checkbox is only presented if there are calibrations present in the previously loaded project.
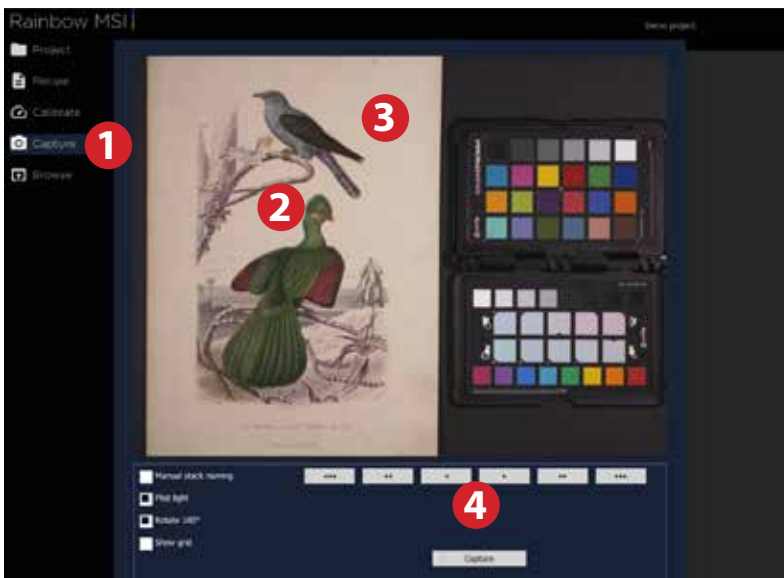
Option 2.

In each of the Recipe and Calibration boxes is a button with the text "Load Recipe/Calibration from previous Project".

This button is only presented if there are calibrations present in the previously loaded project.

Please note that pressing this button will overwrite all existing recipe and calibrations that might be present in the current project.
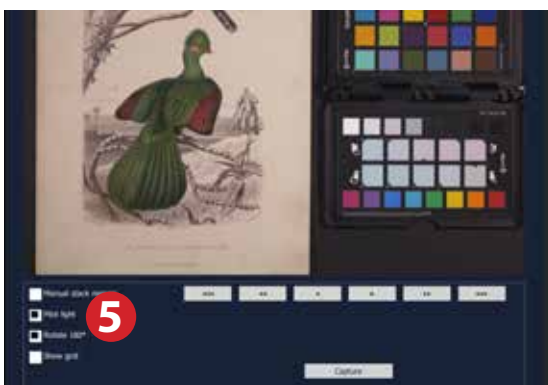
Using Live View, Focus and Capturing

Under the **Capture** tab it is possible to use Live View, autofocus and manual focus as well as execute the Recipe (the capture sequence) that you have set up previously in the Recipe section.
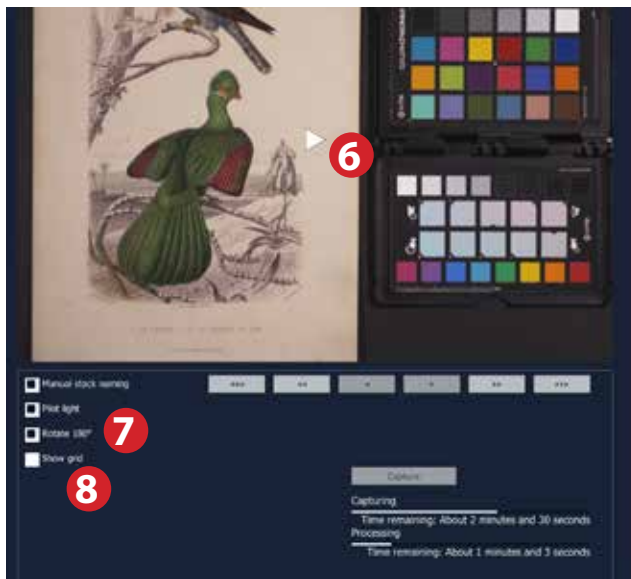

1. Select the **Capture** tab or use the keyboard shortcut *Spacebar* to check for specific details in the subject by using the Live View feed.
2. You can autofocus on any part of the subject by clicking once in the Live View image. The software will autofocus in the center of the live view image if you use the keyboard shortcut *F*.
3. If you double click in the Live View window, you will zoom into 100% on the subject. Double click-ing again will return to the full screen Live View feed. It is also possible to use the scroll wheel on a mouse to zoom in and out.
4. You can use the six focus nudge buttons under the Live View window to adjust the focus manually. The outer triple-arrow buttons are used for large steps, the double-arrow buttons for fine adjust-ments, while the inner single-arrow buttons provide ultra-fine adjustment. The focus nudging buttons are always enabled, except when capturing.
   Please note that the subject might be thicker (closer to the camera) than the initial focus obtained during the Focus Calibration step that was done on a thin focus target paper. For this reason, you might need to refocus before doing a capture.

5. **Pilot light** will turn on the Dedo VIS light. This will help when you want to use manual focus, for instance. Once a capture starts, the light will be turned off, and then turned on automatically again once the capture is finished. The global keyboard shortcut for toggling the pilot light on and off is *P*.

6. The Live View feed will automatically pause after a certain time without any activity. Should that happen, just click on the play icon on the Live View feed to activate it again.
7. It is possible to rotate the image 180 degrees. This option can come in handy if the image is captured upside-down as a result of the camera being mounted on a stand. If you want the display and image capture on the iXG/iXH camera to follow the rotation of the Live View, you first need to set this manually on the camera by selecting Menu > Image Orientation > 180°.
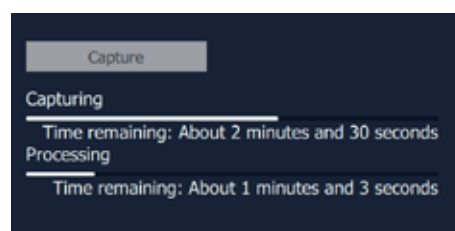8. You can display a grid with the **Show Grid** option as an aide to align the subject when in Live View.

9. You have the option to either let the software name the images within a stack, or name them manually with the **Manual stack naming** option. It is set to **Automatic** as default. If you select **Manual**, you will be prompted to enter a name and optionally Dublin Core Title, Creator, Description and Identifier for the captured stack of images.
10. Once you are done and ready, click on the **Capture** button to execute the chosen Recipe. The capture and processing progress will then be indicated by two progress bars:

The keyboard shortcut for starting a capture with the **Capture** tab open is *Spacebar*.

Cancel Capture Sequence

After a capture sequence has been initiated, it is possible to cancel the capture sequence.

Once a capture sequence has been started, a cancel button appears next to the capture button.

This could be useful if a long sequence has been triggered and the user notices that the subject matter has been wrongly positioned or something is missing from the scene.

Please be aware that this will cancel the ongoing capture sequence entirely and delete all folders and files that might have already been produced by the given capture sequence.

Pressing the cancel button will break the capture as soon as possible – please note that this might take some time, depending on the current exposure time, since ongoing actions need to be stopped and all system components, both software and hardware, need to be reset to their original state.

It is recommended to let the cancel operation complete before interacting further with the software.

Reviewing the captures

Once a capture sequence is completed, the image stack is saved and can be reviewed from within the software. This is how the Browser and Viewer part of the user interface works:

1. Each capture sequence will be displayed in a horizontal Browser row.
2. Once you select a capture sequence ❶, the image stack will be displayed in a vertical Browser row. You can scroll up and down if there are many images in the stack.
3. If you click on an image in the stack, it will be displayed in the Viewer ❹.
4. If you double-click on the image in the Viewer or use the scroll wheel, you will zoom into 100% on the subject. Double clicking again or using the scroll wheel will return back to the full screen view.
5. If you right click on an image in the Viewer, you have the option to display a readout of the RGB values in that individual image at the point selected, or to re-do the IR exposure calibration (Multi-band only). Displaying the values can be a useful way to check for IR flare.

In certain circumstances, the exposure in the IR and IRFC images can be incorrect due to IR flare in the image. This can be seen if the exposure values in the PTFE target differ greatly to the other images in the stack, and sometimes the PTFE target will have a tint in the IRFC image. In such a case, the resulting stack will not adhere to the CHARISMA guidelines.

To solve this issue, select Re-do IR Calibration from the right click drop-down menu. The IR flare will be mitigated in the image stack and the updated images should adhere to the CHARISMA guidelines. **Note that it is important that the PTFE target has not been moved from where it was placed for the original calibration.**

The new calibration will only apply to the selected image stack, so the next image stack captured will revert to the original stored calibration.

Notice how the name of each capture sequence file mirrors what was entered in the **Step Name** of the **Recipe**.

File handling

Rename Stack

You can rename a stack of images by right-clicking on the master stack thumbnail and selecting **Rename stack**. After renaming, press Enter.

Reprocess Stack

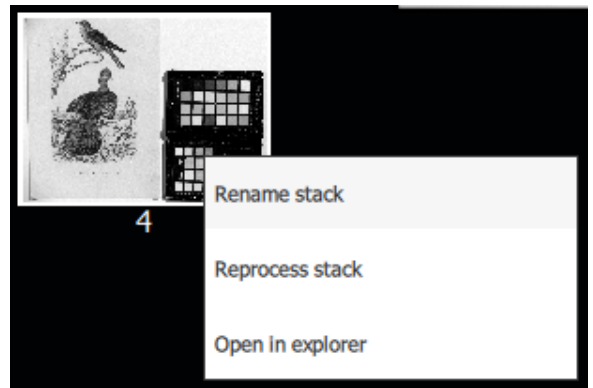You can reprocess a stack of images by right-clicking on the master stack thumbnail and selecting **Reprocess stack**.

Open in Explorer

It is possible to open a stack of images by right-clicking on the master stack thumbnail and selecting **Open in explorer.**

Delete

You can delete a stack of images by hovering the mouse over the master stack thumbnail and clicking on the cross icon.

Opening the finished files
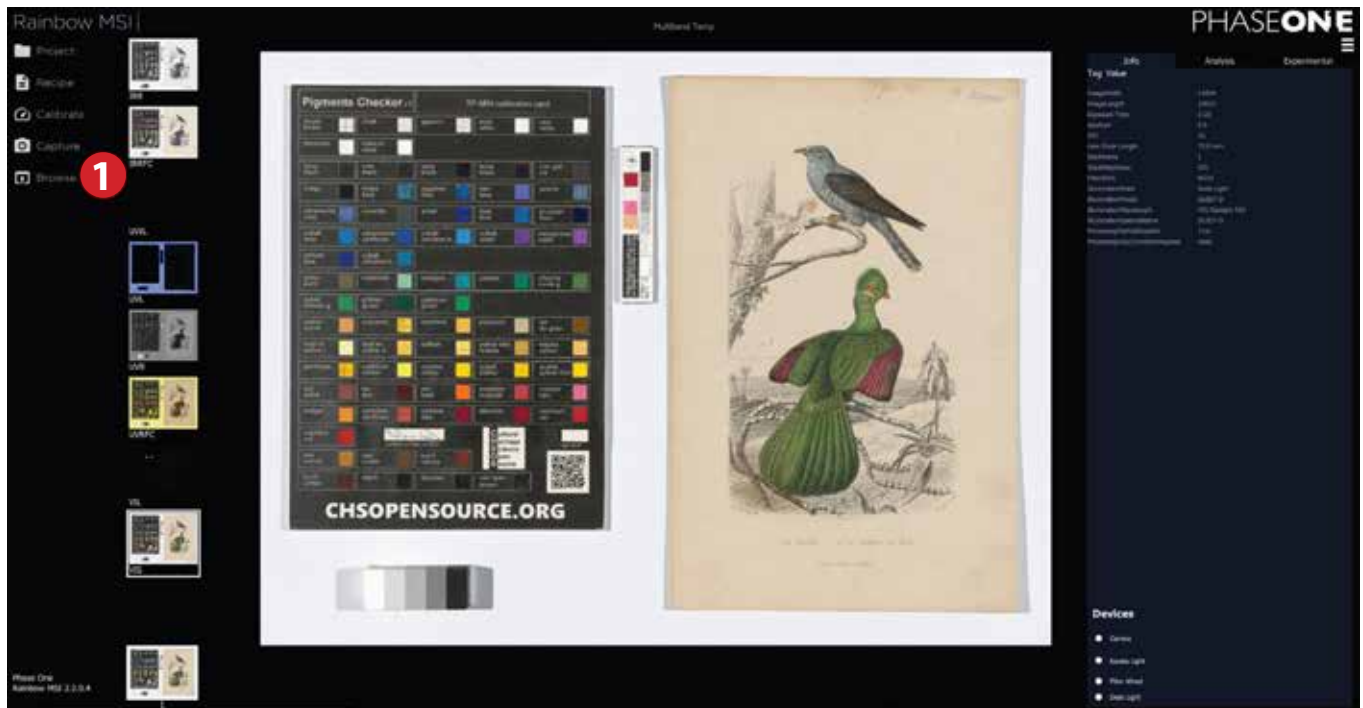
1. Once you are done with the capturing process, click on the **Browse** tab.
2. The software will now open the folder with all the processed images, ready for you to inspect.

The processed files are saved as 16-bit uncompressed TIFFs.
Further analysis can be carried out on the images if required – see **Analysis Module for Multispectral Stacks**.

Narrowband Imaging

Hardware Setup for Narrowband Imaging

Light setup – Narrowband Eureka LED panels

Included equipment:

- 2 x Narrowband Eureka multi-LED light panels.
- 2 x Eureka power supplies
- 2 x USB A-A cables

Setup of the Narrowband Eureka multi-LED light panels

Mount the two Narrowband Eureka multi-LED light panels on light stands and place them on each side of the copy stand so they are mirrored in position and have the same light angle. Ideally, they should be set up at a 45º angle to achieve a good spread of light over the capture area.

Connect the two supplied Narrowband Eureka power supplies to the lights and a power outlet using the correct adapter for your country/region. Finally, connect the two USB cables to the supplied USB control hub (see later in the guide).

Assemble the Filter Wheel and iXG/iXH Camera

The filter wheel is mounted on the supplied rail together with the iXG/iXH camera. Attach it to the Phase One-labeled adjustable mount by using the supplied screws and Allen key:

The iXG/iXH camera attaches to the rail via the quick release mount.

Once the filter wheel and the iXG/iXH camera have been mounted on the rail, the setup should look like this:

Mount the rail with the filter wheel and iXG/iXH Camera on the copy stand.

Next, place the supplied shroud on top of the filter wheel. The purpose of the shroud is to ensure that no light is leaked into the area between the lens and the filter wheel.

Please note that the iXG/iXH Camera has a clear glass filter fitted onto the sensor to be able to record UV and IR light waves outside the visible spectrum. This means that a filter must be used in front of the camera to control what light waves are recorded at different capture stages. This is what the supplied filter wheel accomplishes.

Finally, attach the supplied power supply to the filter wheel and a power outlet and the USB cable from the filter wheel to the supplied USB hub.
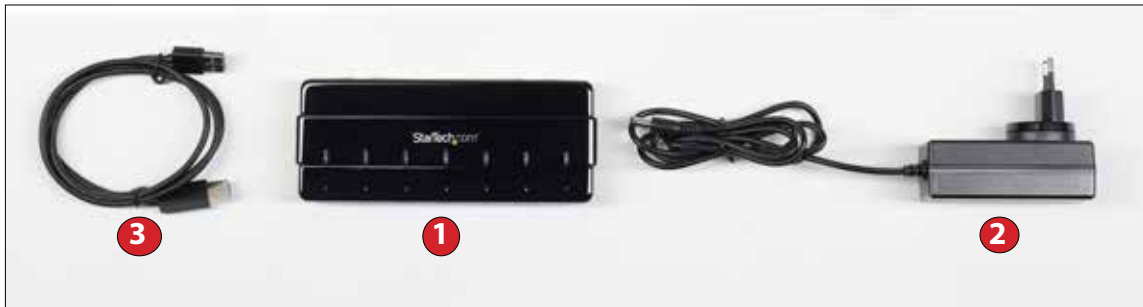

WARNING:

THIS ILLUMINATOR INCLUDES ULTRAVIOLET 370 nm (UVA) LEDS

Whenever this wavelength is activated it is mandatory that all personnel in the room shall wear personal eye protection with side shields that as a minimum comply with:

- European Norms EN 170:2002 Personal eye protection - Ultraviolet Filters, Code 2 or 3, Class 2 or 1, shade 2 or 2C, with Category III frames conforming to EN 166:2002 Personal eye protection, or

- International Safety Equipment Association (ISEA) Standard for Occupational and Educational Personal Eye and Face Protection Devices, ANSI/ISEA Z87.1-2015.

Connecting the USB cables

Included equipment:

- 1 x StarTech central USB Hub ❶
- 1 x power supply ❷
- 1 x USB cable ❸

The automation of the system relies on the Rainbow software's ability to control the LED lights, filter wheel and iXG/iXH Camera. This is facilitated by the use of USB connections added to the supplied central USB Hub.

In order to ensure a smooth and reliable operation, it is important to use the supplied USB Hub and to connect the USB cables from the iXG/iXH Camera, Filter Wheel and the lights to a specific USB port on the hub. Please connect the USB cables as follows:

Connect the **Filter Wheel** to port ❶
Connect one **Narrowband Eureka** light to port ❹
Connect the 2nd **Narrowband Eureka** light to port ❺
Connect the **iXG/iXH Camera** to port ❻

Connect the USB Hub to the power supply and to a USB port on the computer with the Rainbow software installed. Refer to page 42 for the software installation, which will also install the necessary drivers for controlling the Filter Wheel and the LED lights.

Please note connecting the hub to a USB-C port on the computer is recommended for best performance.

The camera can also be connected directly to a free USB port on the computer.

The Filter Wheel and Laptop suitcase

The filter wheel and rail are secured in the foam insert at the top of the MSI case. There is also room for a 17" laptop (not supplied) underneath the foam insert, so please remove it to access the laptop compartment as shown below.
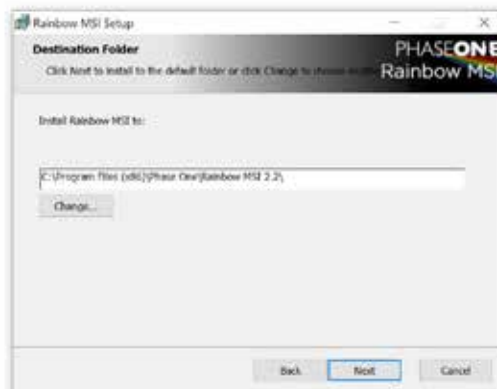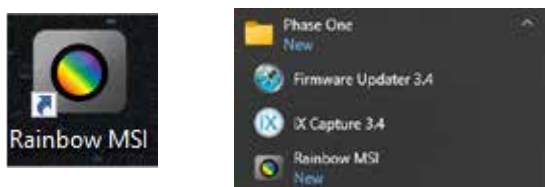
Installation of the Rainbow MSI Software

The Rainbow MSI software comes with an easy-to-use installation file. Just double click on the **Rainbow MSI.msi** file and follow the six steps in the Rainbow MSI Setup Wizard.

You may want to pay attention to the **Destination Folder** path in step three. If you have previous versions of the Rainbow MSI software installed, it is recommended to not overwrite the old version but instead ensure that the software is installed into a new path for the latest version, like \Rainbow MSI 2.3\. This way, you can still use the old version if you encounter any issues with the latest release.

You can change the destination folder by clicking on the **Change…** button.

Once installed, a shortcut will be added to your Windows Desktop. You can also access the software from the Start Menu.

Installation notes

- The software will by default be installed under C:\Program Files (x86)\Phase One\Phase One Rainbow MSI 2.3
- The application data will be installed under C:\Users\<username>\AppData\User\AppData\Local\ Phase One\Rainbow MSI.
  This folder contains the logs and the saved recipes.
- Note that the **AppData** folder and its content are hidden by default on Windows.

Project Folder Structure
The file structure of the project is set up with folder and subfolders as follows:

- **analysis_images** folder
- **calibration** folder
- **calibration_images** folder
  - » **alignment** subfolder
  - » **exposure** subfolder
  - » **flat_field** subfolder
  - » **focus** subfolder
- **previews** folder
- **processed_images** folder
- **raw_images** folder
- **thumbnails** folder

The final files are saved in the **processed_image** folder and you also have the option to access the originally raw captured images, which are stored in the **raw_images** folder.

Rainbow MSI Software Introduction

Getting Started

To launch the Rainbow Multispectral Imaging software, double click on the application icon on the desktop.

The software is designed with six workflow steps, with each step selected by clicking on a tab at the left of the screen named **Project**, **Recipe**, **Calibrate**, **Capture**, **Browse** and **Export**.


Once you are done with capturing your image project files, you can inspect the finished files by clicking on **Browse**.
Running a **Narrowband** session also gives you the option to **Export** to **Paleo Toolbox** (covered later in the user guide).

Checking that devices are online and working

Before you start, ensure that all the devices (camera, lights and filter wheel) are properly connected and recognized. You can check this by looking at lower right corner under **Devices** where a solid white dot will indicate that a device is connected and ready to use. If there is an empty circle instead, the device is not properly connected or recognized.
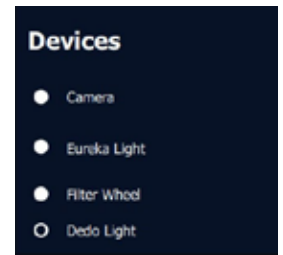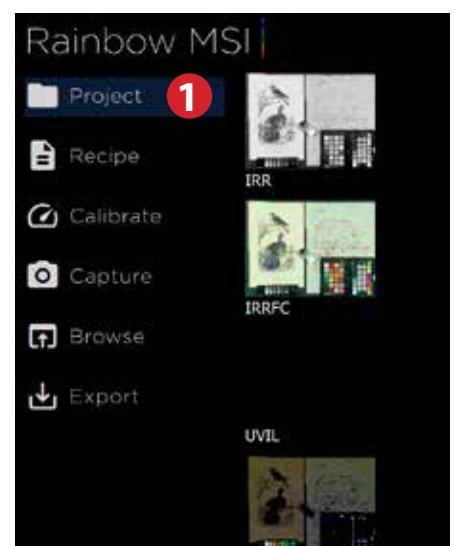
It is possible to expand the device overview by clicking on the **Devices** box in lower right corner. This will let you inspect the current setup of the Eureka or Dedo Lights and the Filter Wheel in detail. Clicking on a device description will turn that device on and off.

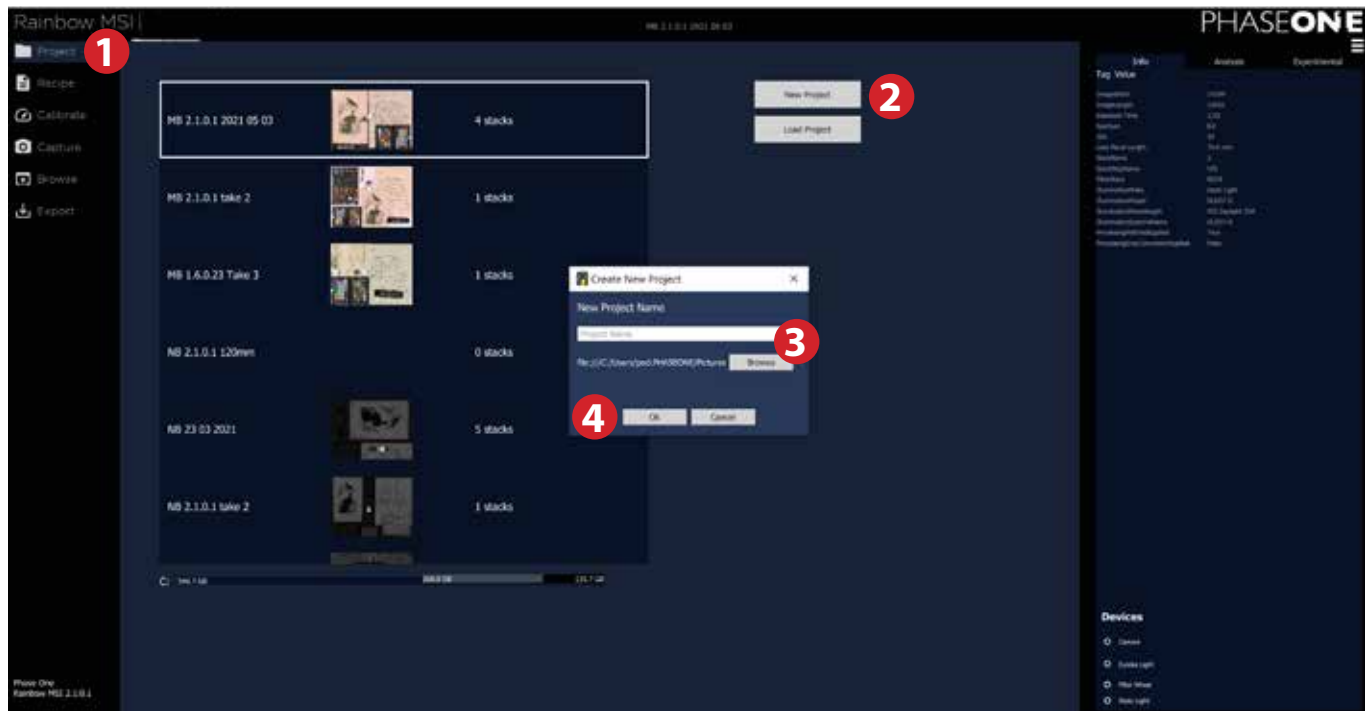Click again in the **Devices** box to close the expanded overview.

The first step is to create a new project or open an existing one. This is done by clicking on the **Project** tab at the left side of the screen. Please note that if a project was in use when you closed the software last time, it will automatically be reopened when you launch it.
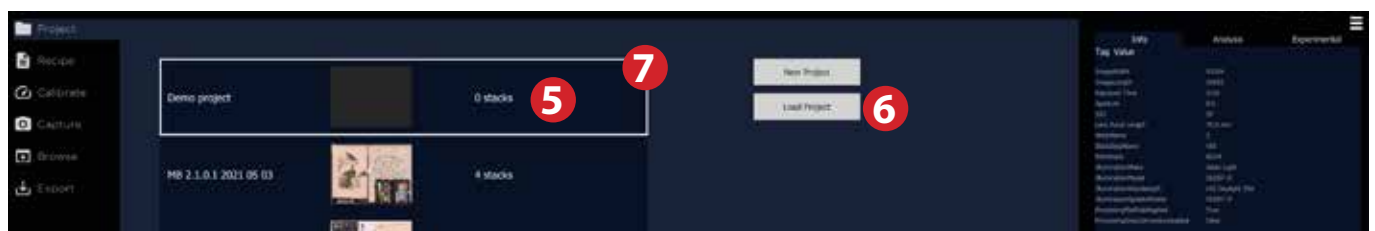
Narrowband Imaging Operations
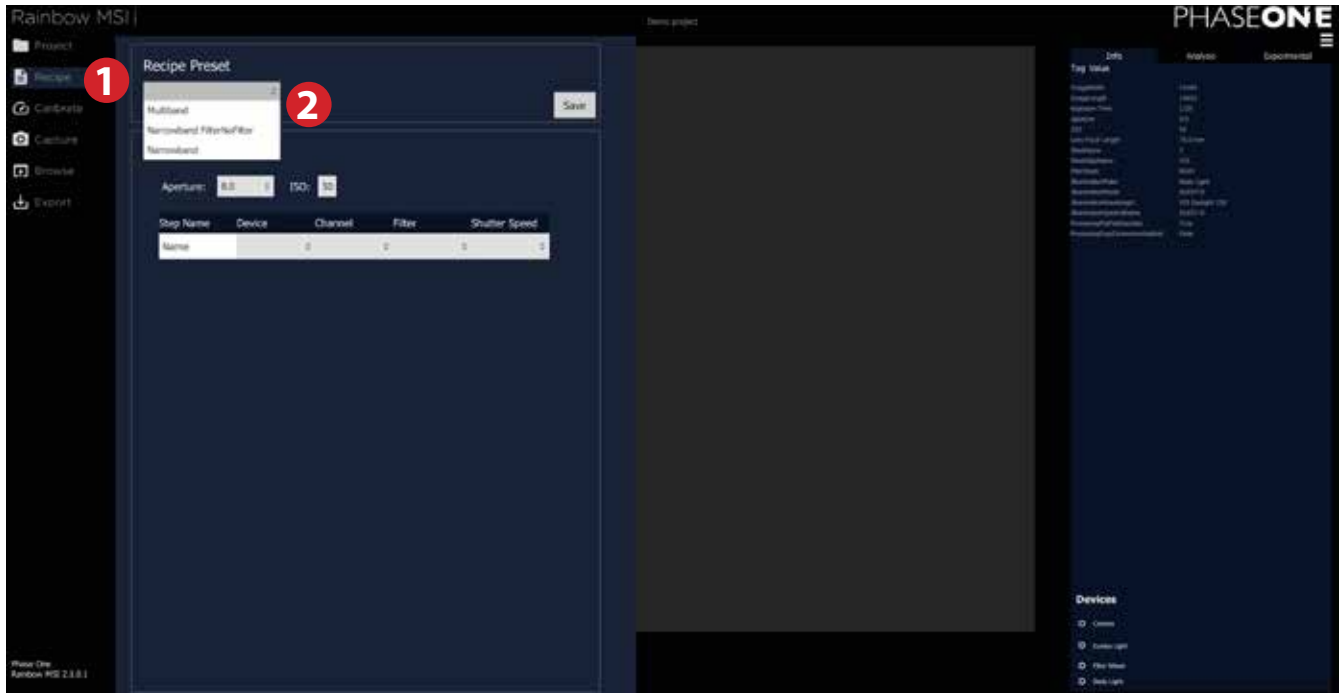
Creating a New Project

1. Click on the **Project** tab.
2. Then click on the button **New Project**.
3. Type a name for the project in the window that appears. Click **Browse** to select the location where to save your project. It is saved in the **Pictures** folder as default.
4. Finally, click **OK** to create the project.

5. It will note that it currently contains zero stacks since no captures have been done yet.
6. If you instead want to open and continue on a previous project, just locate the project and click on it. If the project is not visible in the project tab, click on the **Load Project** button, then browse to its location on the computer, double-click to open the Project Folder and then click "Select Folder". Please note this can take a few seconds when loading Projects with large amounts of data.
7. If you need to delete a project, hover the mouse over the project frame and click on the cross icon. **Please note when you delete a project in this way, all images associated with that project are deleted from the computer hard drive.**

Selecting a Capture Recipe

1. Click on the **Recipe** tab at the left side of the screen.
2. Select a Recipe from the **Recipe Preset** drop-down menu at the top. Ensure that you select **Narrowband** that fits with your Eureka light setup.
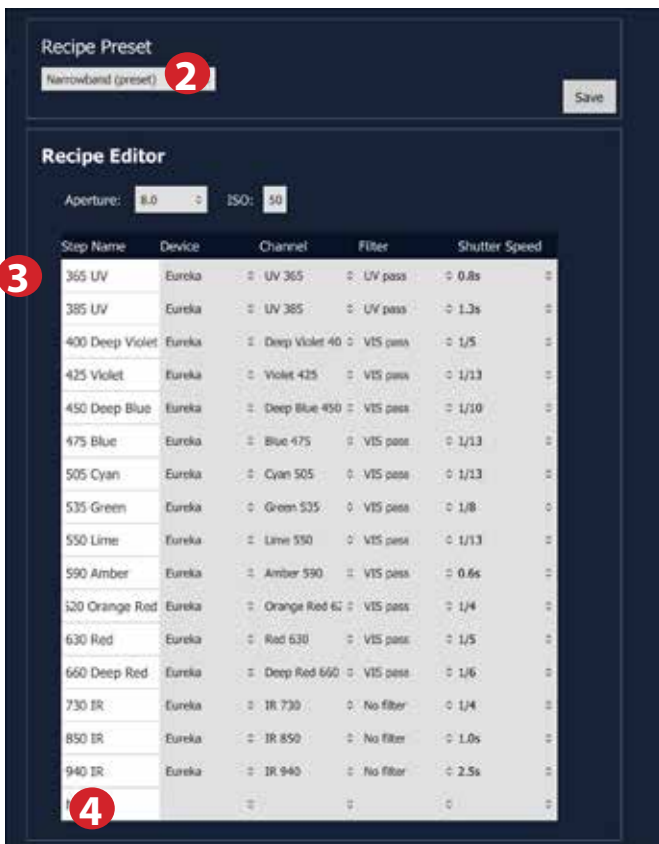
3. Once a Recipe Preset is selected, the **Recipe Editor** will show a predefined list of capture sequences that is set up with different lights (visible, UV and IR) and filter combinations.
4. In the example above, the Recipe will go through 16 capture combinations noted under **Step Name**. The **Channel** column notes the colors where **UV** = UV light and **IR** = IR light. The **Filter**

column controls the used filter where **UV** = UV pass filter and **VIS** = Visible light pass filter.
If you do not use a Preset, you will have to create these combinations of lights and filters yourself
(Please see **Creating your own Recipe** below).

5. In the **Recipe Editor**, ensure that the lens aperture is set according to the selected recipe by click-
ing on the **Aperture** drop-down menu.
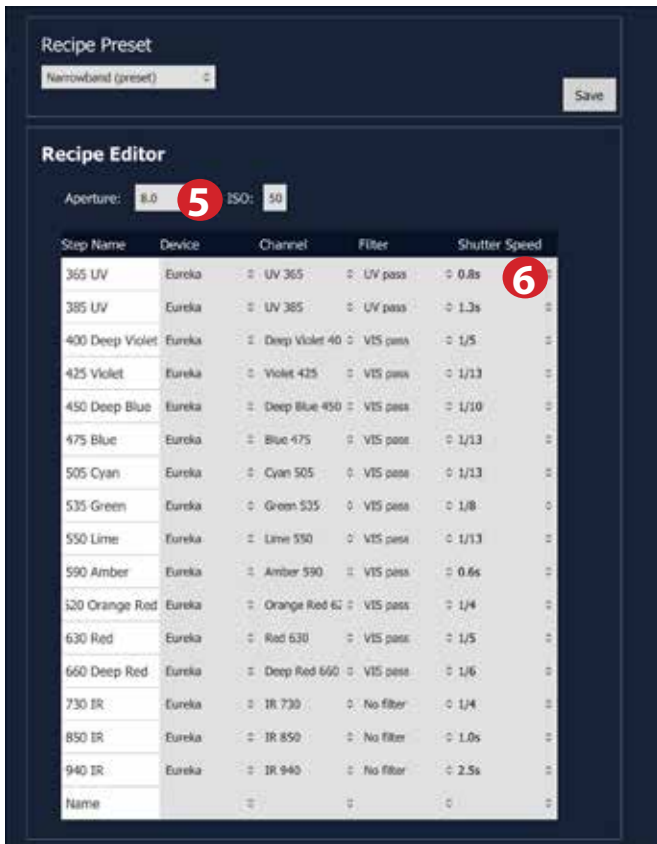
6. You can adjust the exposure time by clicking in the **Shutter Speed** row to modify these. This step
is important to remember if you change the aperture in order to keep the exposure constant.

Important note about Aperture, ISO and Shutter Speed

In the Recipe Editor you have access to the three parameters of the capture: Aperture, ISO and Shutter
Speed. Please note that the Exposure Compensation is automatically calculated in the calibration
process setting the exposure gain and the white balance for best possible exposure. This is done
assuming that Aperture and ISO is kept constant as specified in the Recipe.

Should you want to work at, for example, a higher ISO you will need to start in the Recipe Editor by
setting the new ISO and manually adjust Shutter Speeds up or down in 1/3 steps. Then, re-do the
calibration process, which will calculate a new Exposure Compensation.

If using an iXG or iXH Achromatic camera, the base ISO is 200.
If using an RGB iXG or iXH camera, the base ISO is 50.

Creating your own Recipe
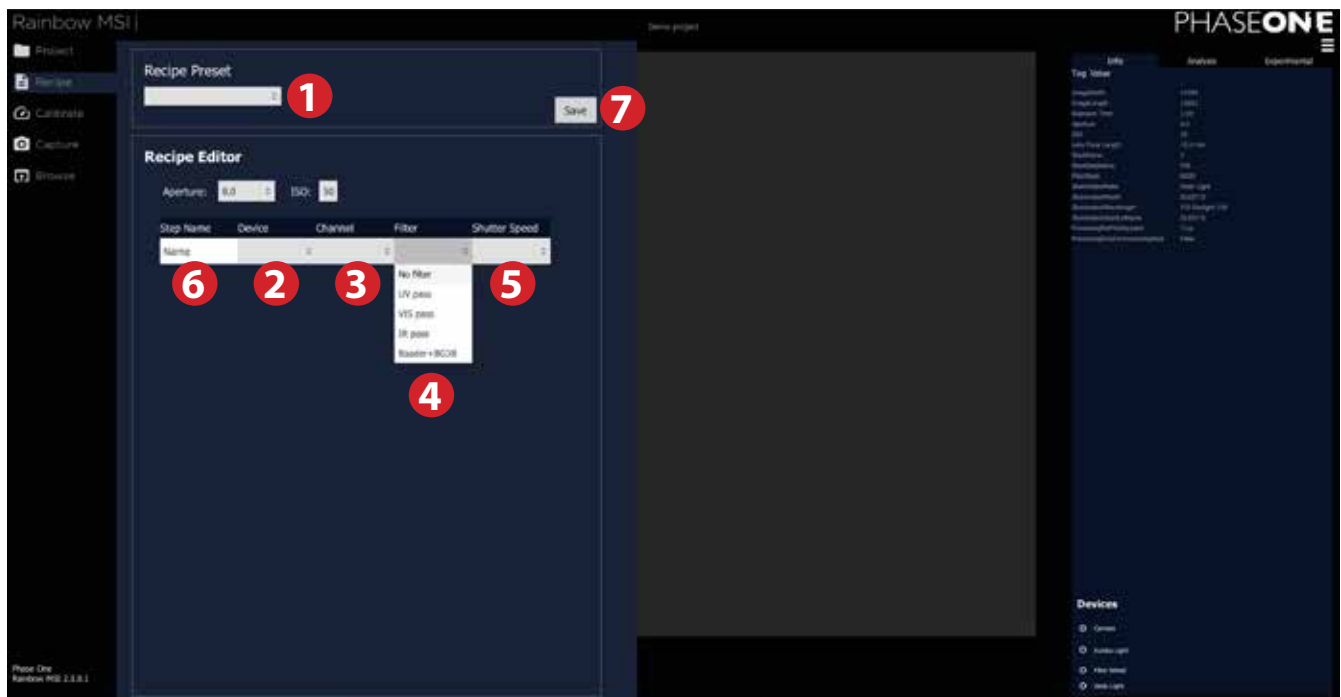
1. Make sure that you haven't selected a built-in recipe from the **Recipe Preset** drop-down menu to get a clean slate to work with.
2. You now have to set up a sequence of captures with each their light, filter and shutter speed. Select the **Eureka** light type from the **Device** drop-down menu for **Narrowband**.
3. Select the light type (UV, IR or Visible light) from the **Channel** drop-down menu.
4. Choose the needed filter combination from the **Filter** drop-down menu.
5. Finally, you also need to select the required exposure time from the **Shutter Speed** drop-down menu.
6. You can name each of the individual captures in the sequence in the **Step Name** field to keep things organized.
7. The recipe will be saved automatically in the background as you start to work with the project. If you want to reuse the created recipe in another project later on, then please remember to save it to disk by clicking on **Save**.

You can delete a created row in the Recipe by hovering the mouse over it and clicking on the cross icon.

Calibration Process

A very important part of the Multi Spectral Imaging workflow is to do a **Focus and Alignment** calibration as well as calibrations for **Flat Field Compensation** and **Exposure Compensation**. This is needed to ensure a satisfactory capture and final image quality. The calibration processes are automated and will only require that you change a target for each step. These steps will be explained on the following pages.

It is important to point out that the resulting calibration is **only** valid for the setup of the lights and the distance from camera to the subject that you were using during the calibration process.

If you move the lights or change the camera distance substantially, it is essential to redo the calibration process – otherwise the captured and processed images will not be a of a satisfactory quality. You can, however, reuse the current calibration if the distance from camera to subject is not changed substantially. This means that for example pages from a book can still be captured without issues with the current calibration.

Please note that the user interface might look like the application is frozen while the calibration processes are going on. This is normal behavior.

Expected calibration times
The time to complete a calibration depends on the number of steps in the recipe and the selected shutter speeds. The calibration times for a **16-step Narrowband** Recipe Preset are as follows:

- Focus and Alignment Calibration – approximately : 6 min. 50 sec.
- Flat Field Compensation – approximately 6 min. 30 sec.
- Exposure Compensation/White Balance – approximately 6 min.

General Calibration Settings
You can change the general calibration settings by clicking on the settings icon in the upper right side of the software.
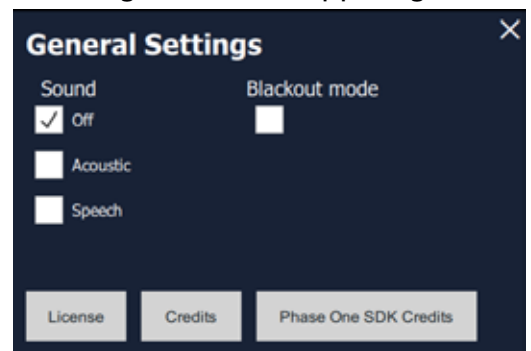
Audible feedback
It is possible to choose whether you want an audible feedback to sound from the computer when a calibration process is completed. Here you can either choose a sound (**Acoustic**) or a voice (**Speech**) to indicate that the process has ended, or to turn the audible feedback off entirely (**Off**).

The audible feedback is available so that if the screen is turned off during the calibration process you can tell when the process is done.

Blackout Mode
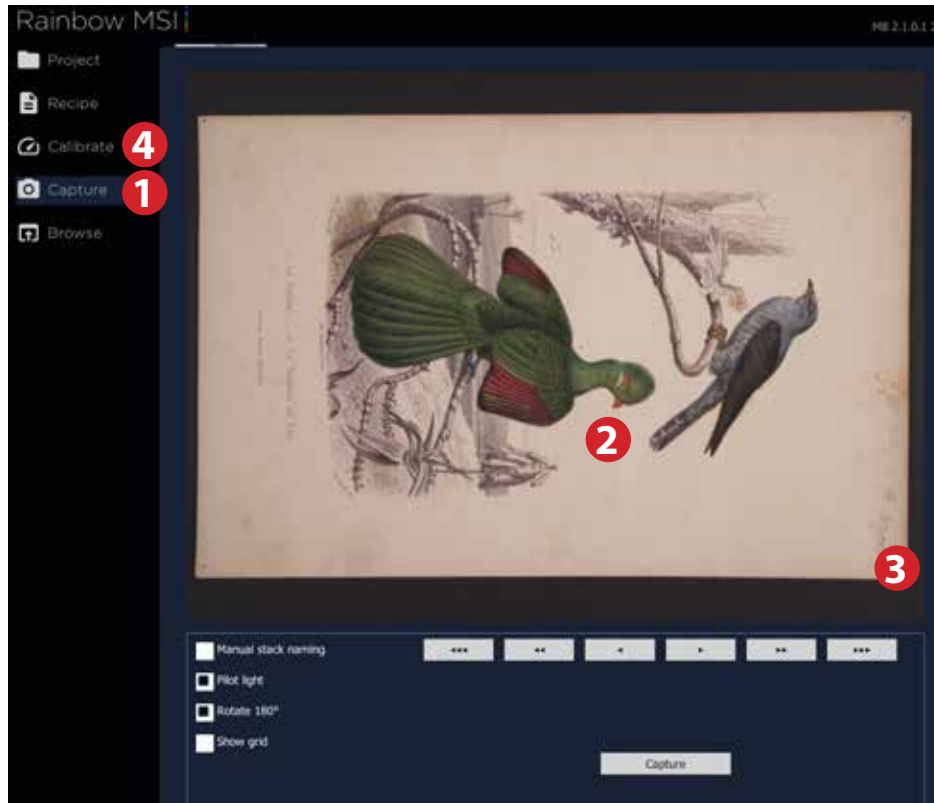If you want the computer screen to turn off during the calibration process to ensure complete darkness, please enable **Blackout mode**.

> **WARNING:** From this stage on, you **must** wear protective UV glasses to prevent damage to your eyes!

Adjusting camera distance before calibration

It is important to set the working distance between the camera and the subject matter before you start the calibration process. If you change the camera distance during the capture process, the calibration steps will have to be redone. Follow these steps to get the desired framing of the subject matter correct:
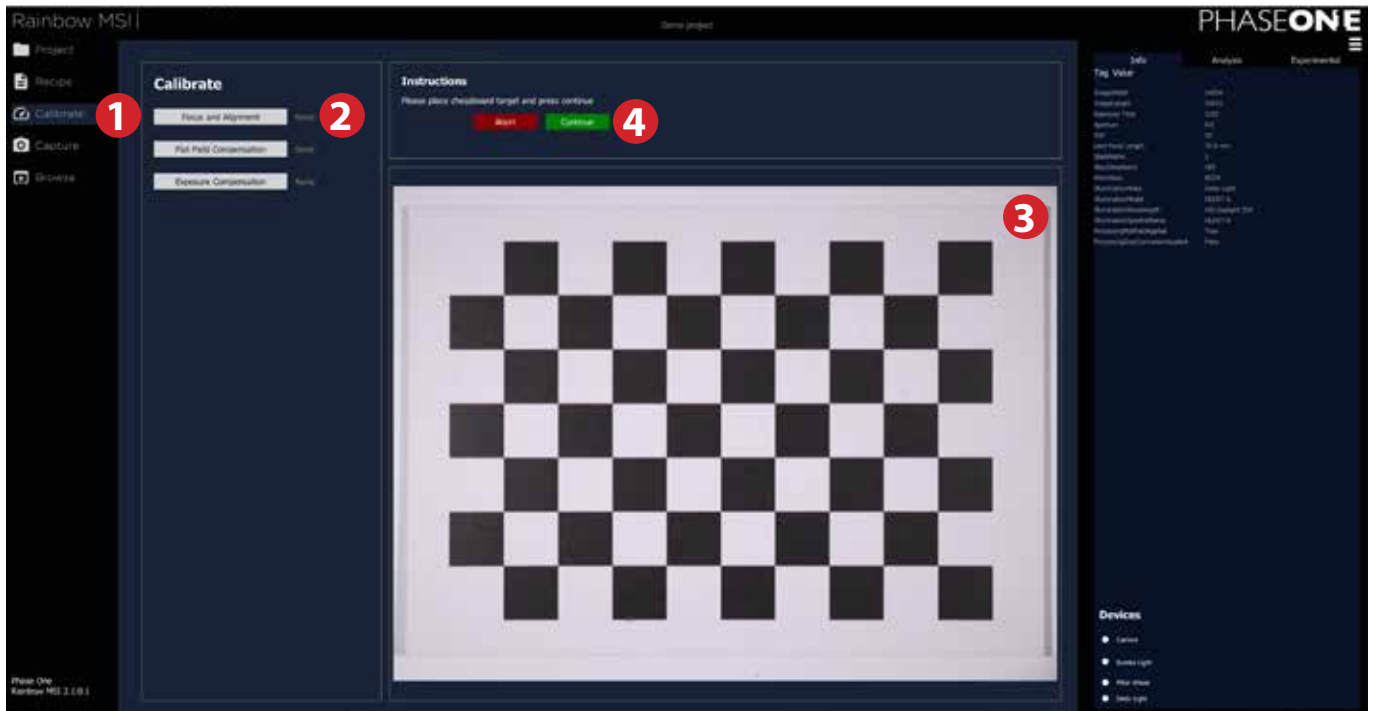

1. Click on the **Capture** tab to open Live View.
2. Place the subject matter inside the frame. Then click on the subject for the camera to focus on it. The Live View feed will show you the same frame as the final capture.
3. Change the distance of the camera on the copy stand to zoom in or out depending on whether you need a tighter framing or a wider framing. Keep an eye on the border of the subject matter.
4. Once you are satisfied with the framing of the subject matter, click on the **Calibrate** tab and continue on to the next chapter.

Important note: In order to get the best results from the following calibration step, please make sure to position the lights such that the initial light coverage is as smooth as possible. If you place the lights, and especially the IR light, close to the repro table top and focused at the same point, you may be forcing a severe light fall off that makes it difficult to get the calibration steps consistent between the 16 reflected channels for **Narrowband** (2 UV, 11 visible and 3 IR).
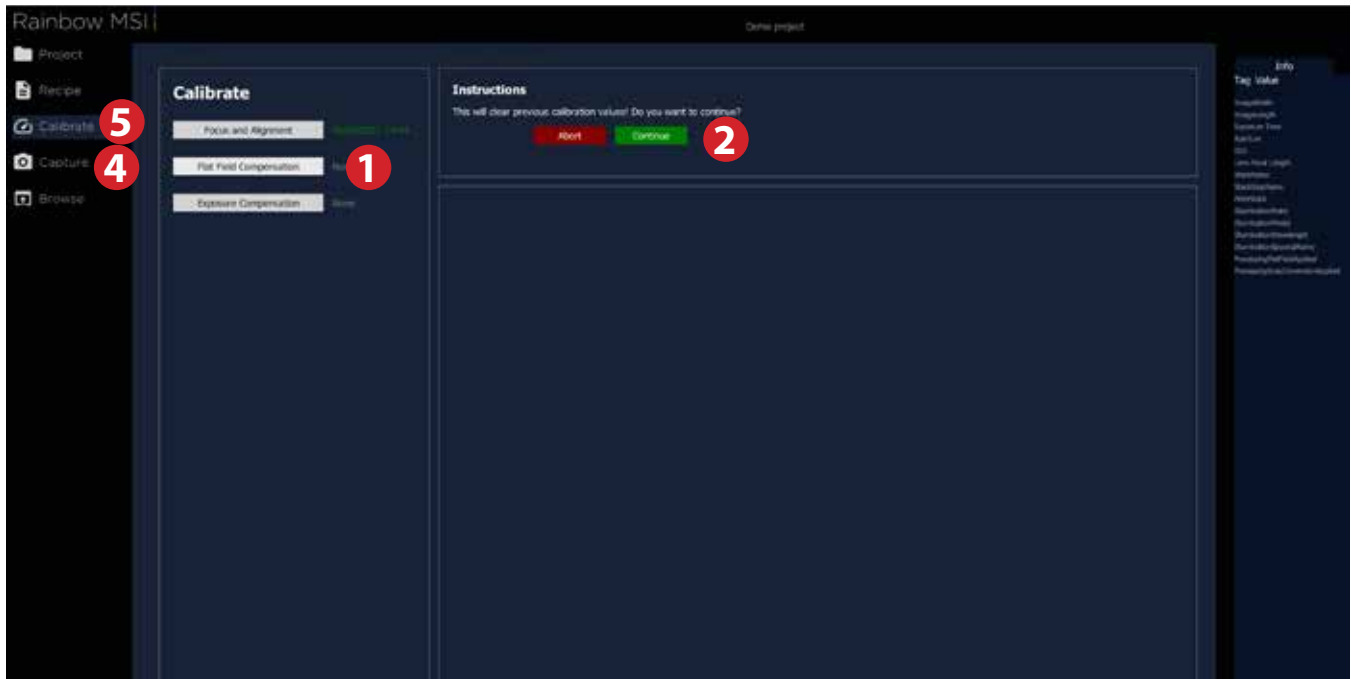
Focus and Alignment Calibration

It is important to make the **Focus and Alignment Calibration** since the correct focus plane will change slightly depending on the used light wave (UV, visible light and IR) which means that the system will need to refocus for each light band. Technically, the system will obtain a correct focus for the 550 Lime light with Narrowband and make a scaling and alignment calibration based on the detection of the corners together with precalculated offsets for the other light waves.

1. Click on the **Calibrate** tab at the top left of the screen.
2. Click on the **Focus and Alignment** button to start Liveview.
3. Place the supplied checkerboard focus target on the copy stand. IMPORTANT: the whole checkerboard MUST be placed visibly inside the imaging area for the calibration to deliver correct results.
4. Click on the green **Continue** button to start the **Focus and Alignment** calibration process.

Flat Field Compensation

The **Flat Field Compensation** process will ensure light uniformity on the images by calculating the light falloff and applying a correction. This will be done for each light/filter combination to ensure maximum image quality.
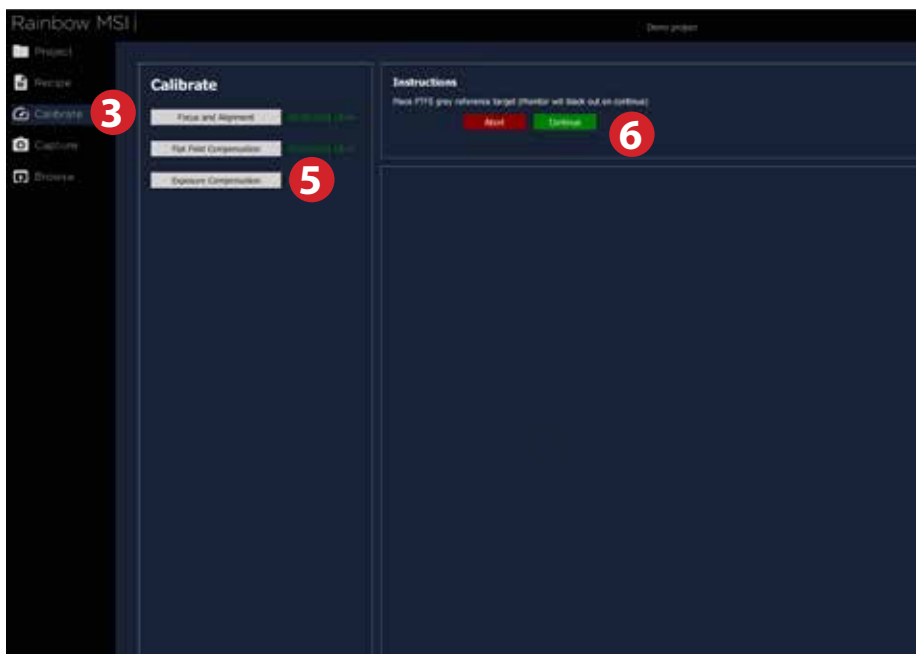

1. Click on the **Flat Field Compensation** ❶ button.
2. Then click on the green **Continue** ❷ button.
3. Place a large white piece of paper or similar that **covers the entire image area** on the copy stand. Ensure that it is kept as flat as possible. Refer to the General Considerations section.
4. You can check whether the white paper is indeed covering the entire image frame by entering Live View. This is done by clicking on the **Capture** ❹ tab.
5. Once confirmed, select the **Calibrate** ❺ tab again.
6. Make sure that all normal lights are turned off in the room so that it is completely dark.
7. Click on the green **Continue** ❷ button to start the calibration process.
8. The computer screen will now turn off to ensure complete darkness if blackout option is selected in settings. The process will take approximately 6 min. 30 sec. for a 16-step **Narrowband** recipe. The screen will turn back on when the process is complete.

Exposure Compensation and White Balance

It is necessary to perform an exposure calibration to get useful results with properly exposed captures. This process will also adjust the white balance automatically.
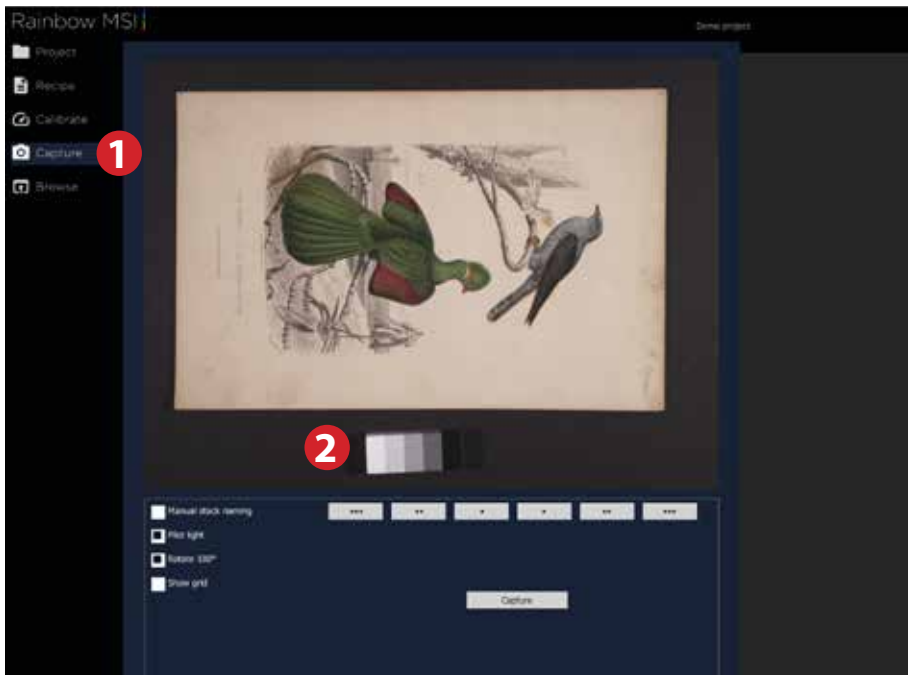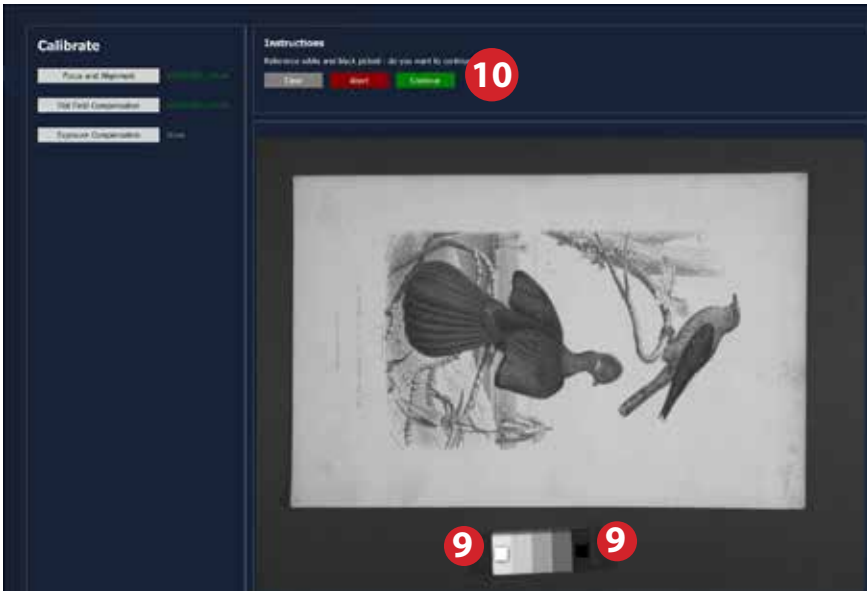

1. Click on the **Capture** tab to open Live View.
2. Place the subject matter inside the frame and the PTFE-target next to it.
   Please do not move the PTFE target until all images have been reviewed.

3. Click on the **Calibrate** tab.
4. To automatically re-run the calibration for over- or under-exposed images, put a check in the **Automatic Re-run** box. Note that a degree of under-exposure is allowed, so use a manual compensation to maximise the data captured.
5. Click on the **Exposure Compensation** button.
6. Then click on the green **Continue** button. Verify that the PTFE-target is in place and click on the green **Continue** button again to start the calibration process.

7. The computer screen will now turn off to ensure complete darkness if the blackout option has been selected in settings and the camera will make a capture sequence corresponding to the selected recipe.
8. The screen will turn back on and a preview will be displayed in the viewer.
9. You will now be asked to select the white and the black part of the PTFE. First select the white part, then the black.

10. Click on the green **Continue** button once you're done.
11. The software will report as the adjustments are being made so that you can follow the progress:

12. If the Automatic Re-run box is checked, any over- or overly under-exposed images will be recalibrated automatically by the software.
    Please do not move the PTFE exposure calibration target during the calibration process.

The process will take approximately 6 min. for a **16-step Narrowband** recipe.

Handling failed Exposure Calibration

If the **Automatic Re-run** Calibration box is not checked, the Exposure Calibration might fail due to one or more steps being either underexposed or overexposed. You will have the option to click **Re-run** at this stage to automatically re-calibrate for these steps, or you can re-run the steps manually. If you do not select Re-run, an error message will tell you what recommended shutter speed you should use instead.

Please do not move the PTFE exposure calibration target during the calibration process.
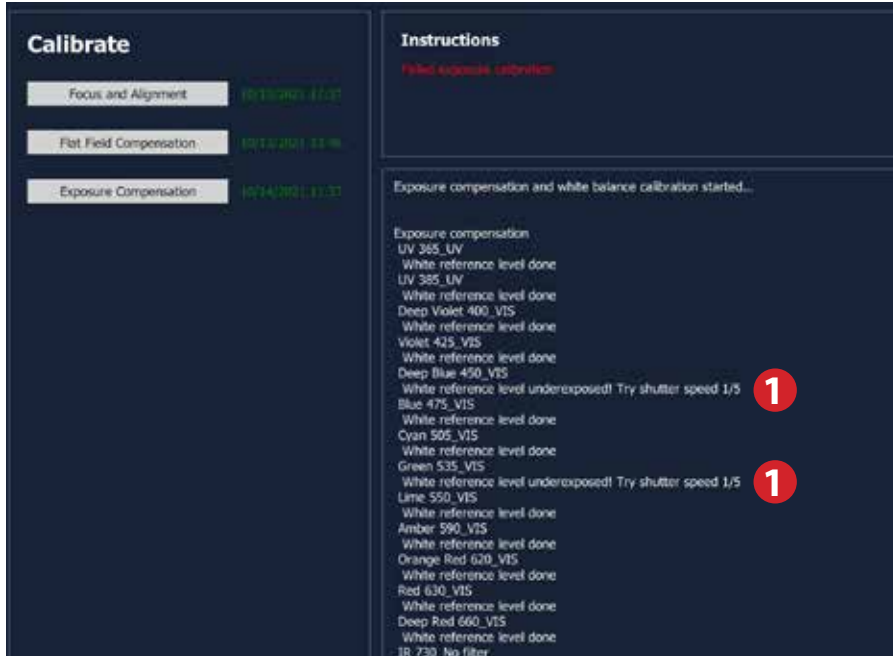
1. In the example above, it is recommended to try again with a shutter speed of 1/5s. Note the recommended shutter speed before moving to the next step.
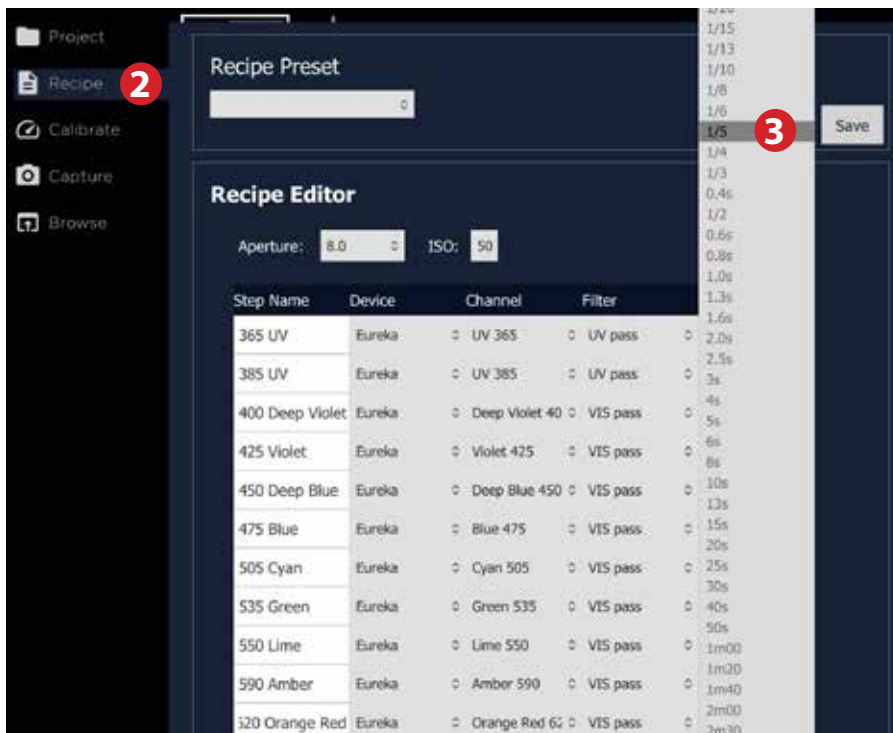
2. Open the **Recipe** tab and change the shutter speed ❸ according to the recommendations in the error warning.
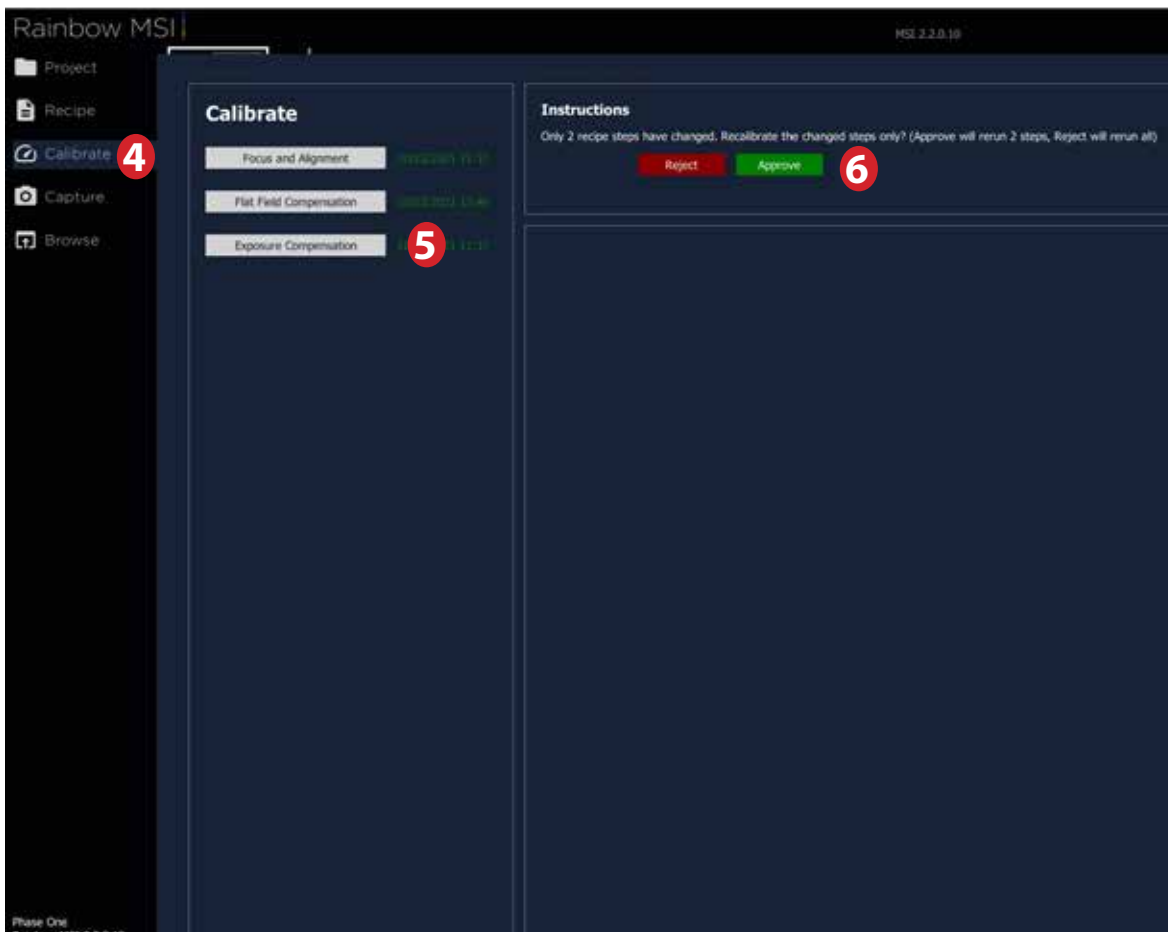
4. Once you have changed the shutter speed, click on the **Calibrate** tab. Then click on **Exposure Compensation 5** and finally redo the calibration by clicking on **Approve 6**. The software will then only recalibrate the adjusted steps.

Reuse Recipe/Calibration

This functionality is used for copying the Recipe and Calibrations from an existing Project to a new Project.

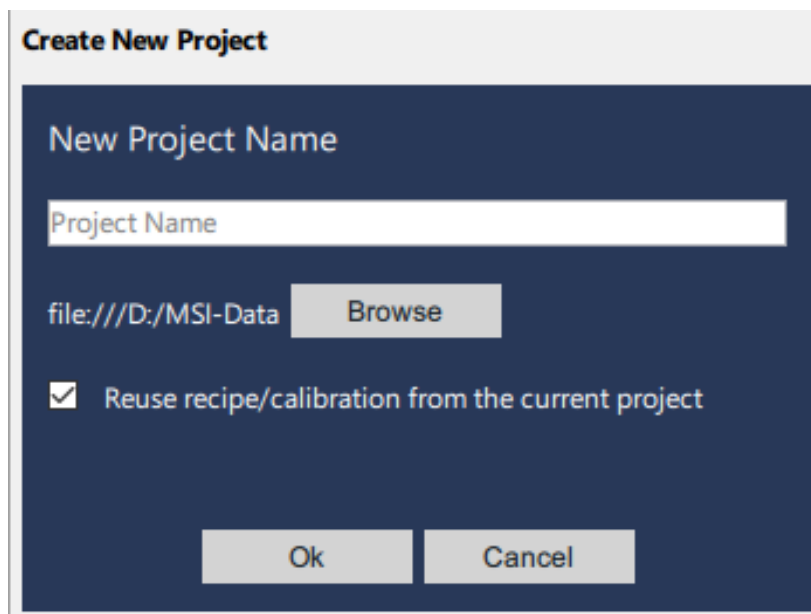When reusing recipe and calibrations please make sure that the physical system setup has not changed since the original calibration. If, for instance, the camera distance or light source distance/angles have changed – the calibration will not yield good results.

Recipe settings are closely associated with a set of calibrations and hence both the recipe and calibrations need to be reused in order to ensure a correct match.

There are two options for reusing recipe/calibration from a previous project.

Option 1.

In the "Create New Project" dialog box is a checkbox with the text "Reuse recipe/calibration from the current project". Put a tick in the box if you want to reuse the recipe and calibrations from the previous Project.

This checkbox is only presented if there are calibrations present in the previously loaded project.
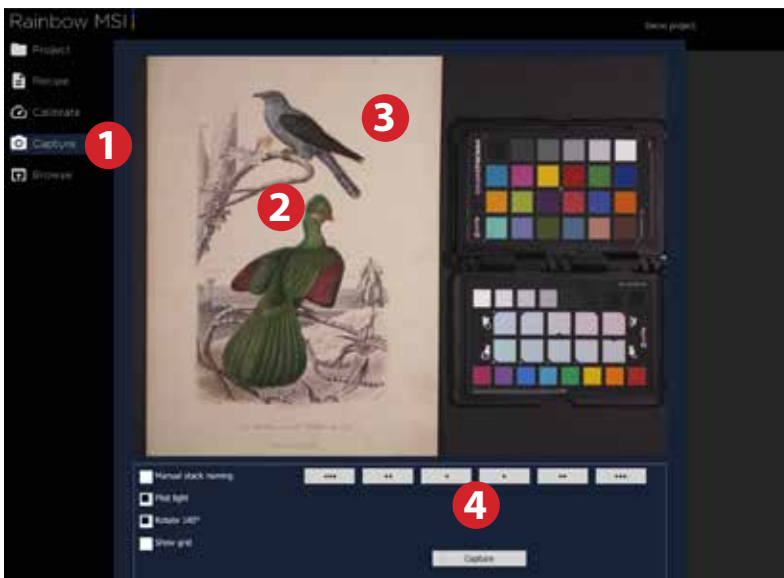
Option 2.

In each of the Recipe and Calibration boxes is a button with the text "Load Recipe/Calibration from previous Project".

This button is only presented if there are calibrations present in the previously loaded project.

Please note that pressing this button will overwrite all existing recipe and calibrations that might be present in the current project.
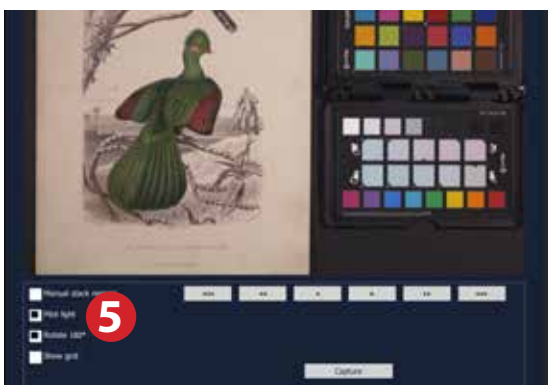
Using Live View, Focus and Capturing

Under the **Capture** tab it is possible to use Live View, autofocus and manual focus as well as execute the Recipe (the capture sequence) that you have set up previously in the Recipe section.
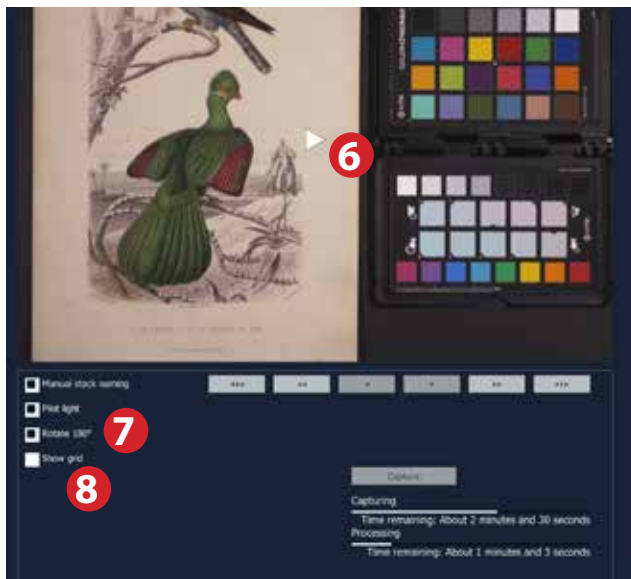

1. Select the **Capture** tab or use the keyboard shortcut *Spacebar* to check for specific details in the subject by using the Live View feed.
2. You can autofocus on any part of the subject by clicking once in the Live View image. The software will autofocus in the center of the live view image if you use the keyboard shortcut *F*.
3. If you double click in the Live View window, you will zoom into 100% on the subject. Double clicking again will return to the full screen Live View feed. It is also possible to use the scroll wheel on a mouse to zoom in and out.
4. You can use the six focus nudge buttons under the Live View window to adjust the focus manually. The outer triple-arrow buttons are used for large steps, the double-arrow buttons for fine adjustments, while the inner single-arrow buttons provide ultra-fine adjustment. The focus nudging buttons are always enabled, except when capturing.
    Please note that the subject might be thicker (closer to the camera) than the initial focus obtained during the Focus Calibration step that was done on a thin focus target paper. For this reason, you might need to refocus before doing a capture.

5. **Pilot light** will turn on the Eureka Lime light. This will help when you want to use manual focus, for instance. Once a capture starts, the light will be turned off, and then turned on automatically again once the capture is finished. The global keyboard shortcut for toggling the pilot light on and off is *P*.

6. The Live View feed will automatically pause after a certain time without any activity. Should that happen, just click on the play icon on the Live View feed to activate it again.

7. It is possible to rotate the image 180 degrees. This option can come in handy if the image is captured upside-down as a result of the camera being mounted on a stand. If you want the display and image capture on the iXG/iXH camera to follow the rotation of the Live View, you first need to set this manually on the camera by selecting Menu > Image Orientation > 180°.
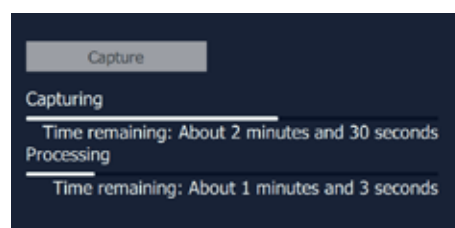
8. You can display a grid with the **Show Grid** option as an aide to align the subject when in Live View.

9. You have the option to either let the software name the images within a stack, or name them manually with the **Manual stack naming** option. It is set to **Automatic** as default. If you select **Manual**, you will be prompted to enter a name and optionally Dublin Core Title, Creator, Description and Identifier for the captured stack of images.

10. Once you are done and ready, click on the **Capture** button to execute the chosen Recipe. The capture and processing progress will then be indicated by two progress bars:

The keyboard shortcut for starting a capture with the **Capture** tab open is *Spacebar*.

Cancel Capture Sequence

After a capture sequence has been initiated, it is possible to cancel the capture sequence.

Once a capture sequence has been started, a cancel button appears next to the capture button.

This could be useful if a long sequence has been triggered and the user notices that the subject matter has been wrongly positioned or something is missing from the scene.

Please be aware that this will cancel the ongoing capture sequence entirely and delete all folders and files that might have already been produced by the given capture sequence.

Pressing the cancel button will break the capture as soon as possible – please note that this might take some time, depending on the current exposure time, since ongoing actions need to be stopped and all system components, both software and hardware, need to be reset to their original state.

It is recommended to let the cancel operation complete before interacting further with the software.

Reviewing the captures

Once a capture sequence is completed, the image stack is saved and can be reviewed from within the software. This is how the Browser and Viewer part of the user interface works:

1. Each capture sequence will be displayed in a horizontal Browser row.
2. Once you select a capture sequence ❶, the image stack will be displayed in a vertical Browser row. You can scroll up and down if there are many images in the stack.
3. If you click on an image in the stack, it will be displayed in the Viewer ❹.
4. If you double-click on the image in the Viewer or use the scroll wheel, you will zoom into 100% on the subject. Double clicking again or using the scroll wheel will return back to the full screen view.
5. If you right click on an image in the Viewer, you will display a readout of the RGB values in that individual image at the point selected when an RGB camera is used; or a single value when an Achromatic camera is used.

Notice how the name of each capture sequence file mirrors what was entered in the **Step Name** of the **Recipe**.

File handling

Rename Stack
You can rename a stack of images by right-clicking on the master stack thumbnail and selecting **Rename stack**. After renaming, press Enter.

Reprocess Stack
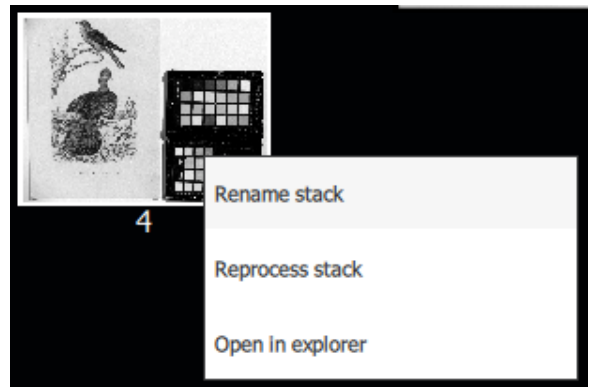You can reprocess a stack of images by right-clicking on the master stack thumbnail and selecting **Reprocess stack**.

Open in Explorer
It is possible to open a stack of images by right-clicking on the master stack thumbnail and selecting **Open in explorer.**

Delete
You can delete a stack of images by hovering the mouse over the master stack thumbnail and clicking on the cross icon.

The Spectral Readout Tool (Narrowband only)

The Readout Tool is found under the Readout tab in the right pane of the software. Please note the Readout Tool can only be used with a full (16 image) narrowband reflectance image stack using filters for the UV and visible bands. For the UV365 and UV385 captures, use the UG1 visible block filter; for the 11 visible bands from 400nm to 660nm, use the BG38 UV/IR cut filter; for the IR bands from 730nm to 940nm, no filter is required. Luminescence images are not supported with the Readout Tool.
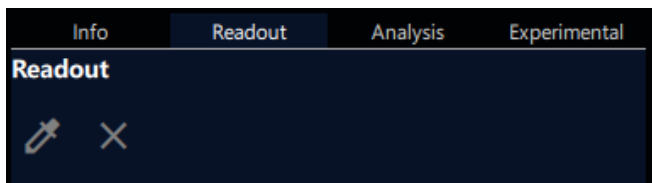
The Readout Tool is activated by pressing the 'eyedropper' button/icon. Once the eyedropper is selected, the software will load the 16 narrowband channels and 'live readout' is enabled. The color of the readout will adapt based on a pre-calibrated narrowband to RGB conversion.

Hovering the mouse in the image viewer will change the display of the graph to show the current 'live readout' at that point on the image.
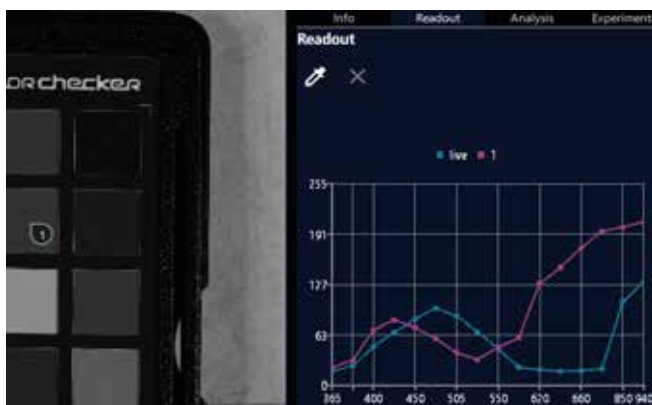
Left clicking on the image will place a readout marker on the image, fixed at that point.
A readout marker can be moved by clicking and dragging it with the left mouse button. The graph will update once the mouse button is released. Up to 9 readout markers can be placed on the image.
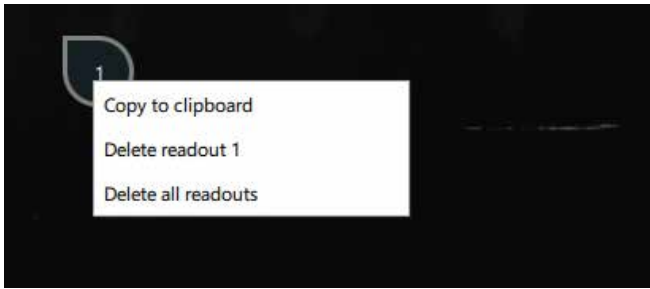
Right clicking on a readout marker will present three options:
- copy to clipboard
- delete that single readout marker
- delete all readout markers.

To distinguish between the line series in a chart, hovering the mouse over a readout marker will highlight the relevant series in the graph.
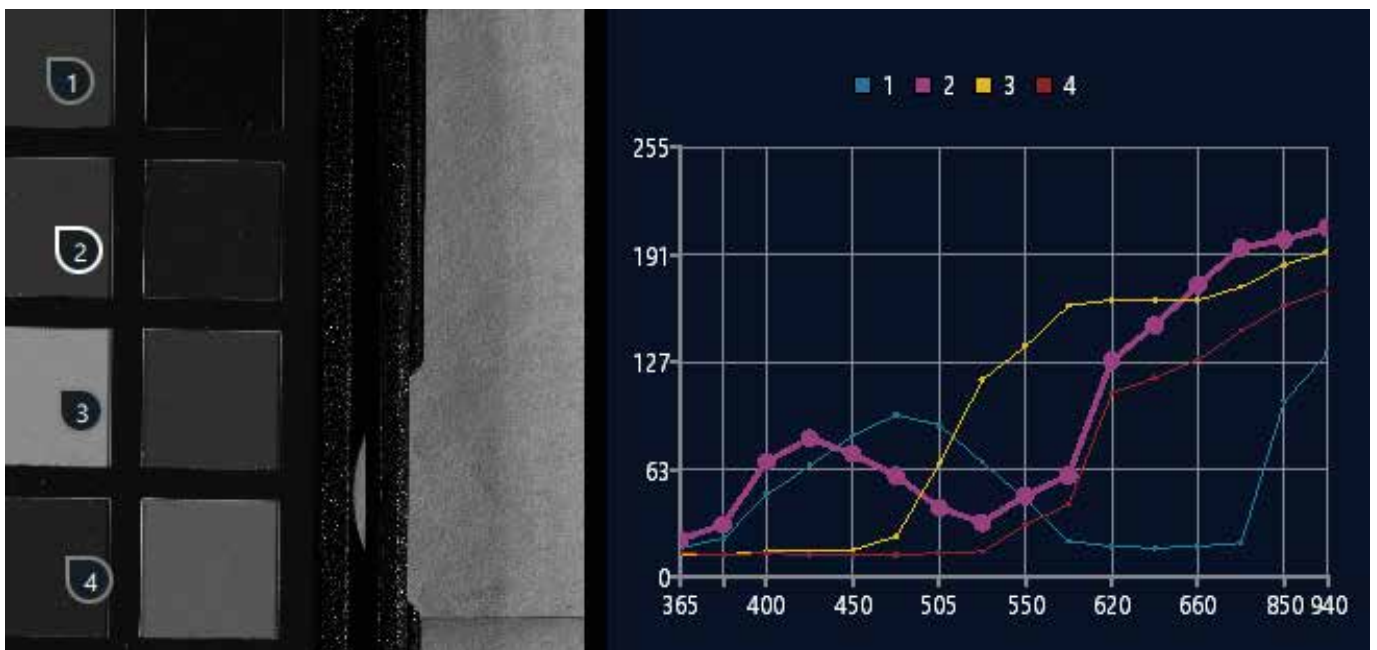
Readout markers and vectors are stored continuously and will be available when changing the image stack or project, and when re-launching the application.

Opening the finished files

1. Once you are done with the capturing process, click on the **Browse** tab.
2. The software will now open the folder with all the processed images, ready for you to inspect.

The processed files are saved as 16-bit uncompressed TIFFs.

Export to Paleo (Narrowband only)

When you have been capturing with **Narrowband** where **Eureka** lights is part of the recipe, you have to option to export the project to Paleo, including file naming for direct transfer into Paleo Toolbox.

1. Click on the **Export** button. This will give you the option to name the scene to be exported as well as which stacks to include.
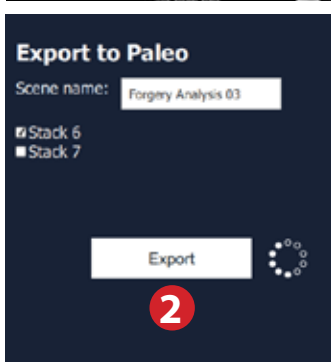
2. Click on **Export**,when ready.

Analysis Module for Multi-spectral Stacks

The Basic Analysis Module provides an intuitive way to analyze any multi-spectral stack. With this module any stack (**Multiband** or **Narrowband**) can be analyzed directly in the software with some of the techniques most often used for image analysis. This feature lets you form an initial opinion about further analytical steps to be taken, typically in external software.
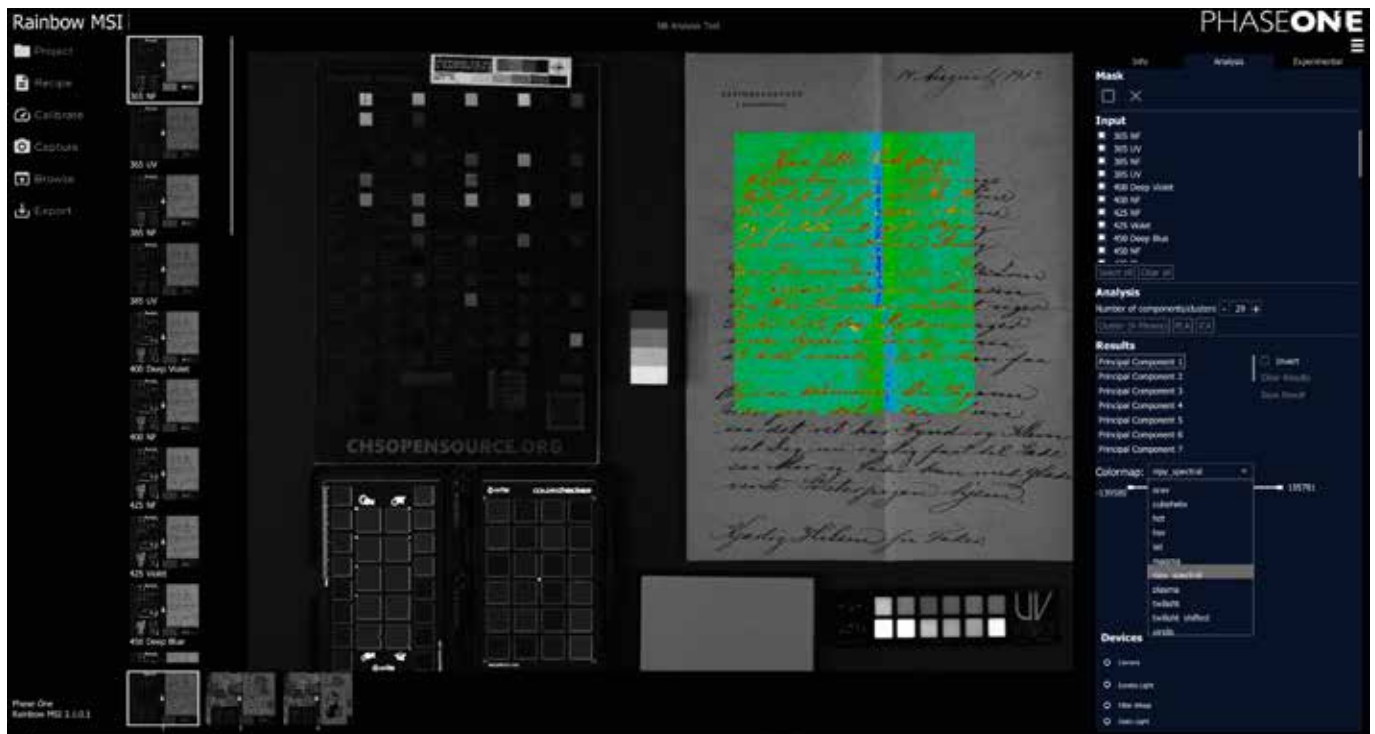
Please note that **Multiband** capture and export delivers the set of images specified in the **Charisma** guidelines, *including* false-color images. These images can be inspected and analyzed visually.

You can use Analysis Module for further analysis on a Multiband stack if you *exclude* the false-color images of the desired wavelengths from the **Input** list (Step 5 in the step-by-step guides on the following pages). Just make sure that these are deselected in the list.

Special knowledge of the mathematics and statistics methods forming the kernel of these analysis is not required. Imagine the input stack as a cube with all the images layered and aligned, each captured with its specific wavelength. Looking through the stack from above in Rainbow MSI, each pixel position points through the layers to a set of values representing reflectance or luminescence response at the wavelengths captured. To speed up processing performance dramatically, the analysis methods are optimized to work on a randomized subset of the input values. This allows for complex analysis operations to be made quickly on vast amounts of data, a process that would otherwise be impossible.

There are three different techniques available for the analysis of stacks in Rainbow MSI version 2.3 which will be covered on the following pages.

Principal Component Analysis (PCA) introduction

This analysis method is used for statistically reducing the dimensions in diverse signal/image processing and machine learning applications to the "principal components", hereby providing a good insight and overview of the data.
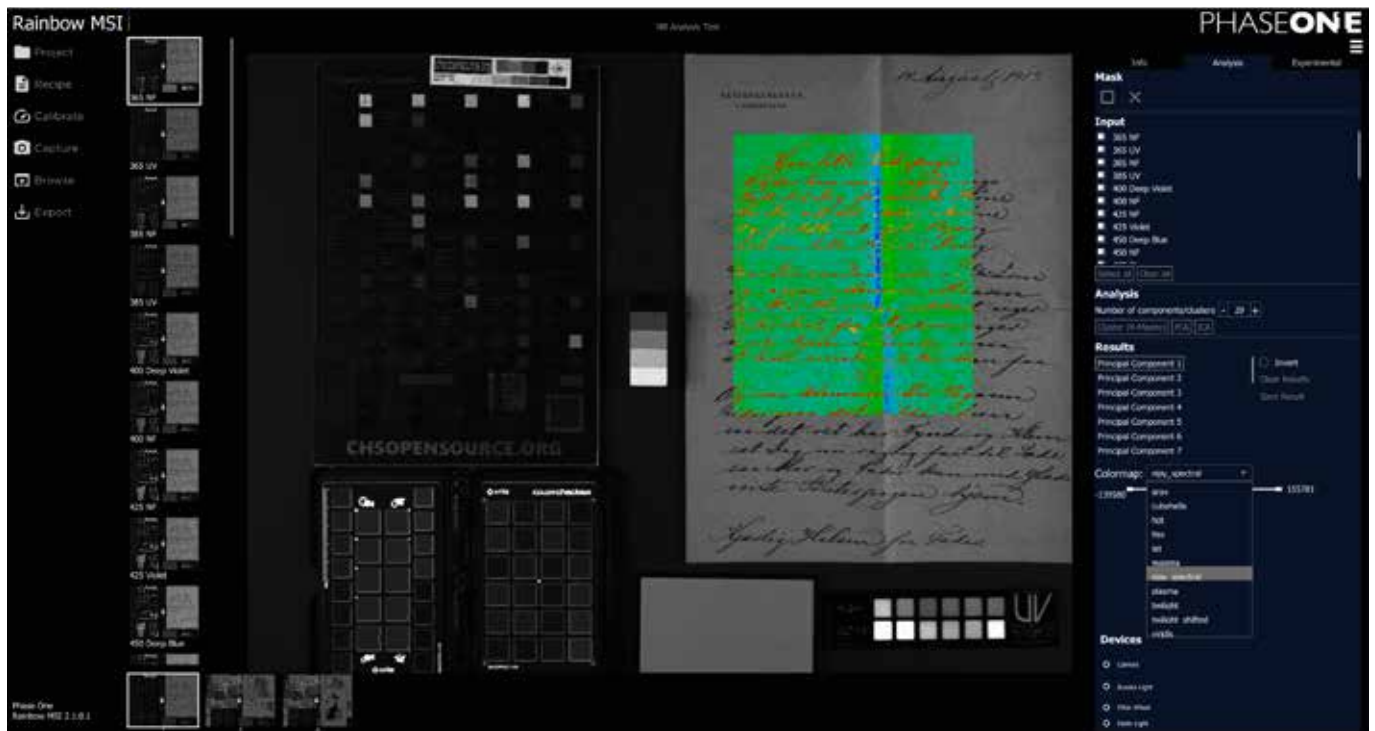

The main objective of PCA is to obtain a set of characteristics (principal components) that best summarize the large amount of data in the input stack. The first Principal Component contains the most well-defined characteristics drawn from all the different input data. Using PCA with multispectral imaging, the Principal Components are calculated with information from across all the spectral bands captured, ultraviolet, visible, and infrared.

The internal high-resolution representation of the pixel values provides for an option to define and control the most desired range as the basis for the image analysis on the screen, using sliders. When interacting with these sliders it becomes intuitively apparent that certain materials show up concentrated in given ranges, and this interactive method can be used for isolating materials of interest.

The PCA analysis tool includes an option for selecting a colormap, that translates grayscale values to various color gradients, which serve to accentuate certain parts of the displayed image.

More info is available here: wikipedia.org/wiki/Principal_component_analysis

Using Principal Component Analysis (PCA)
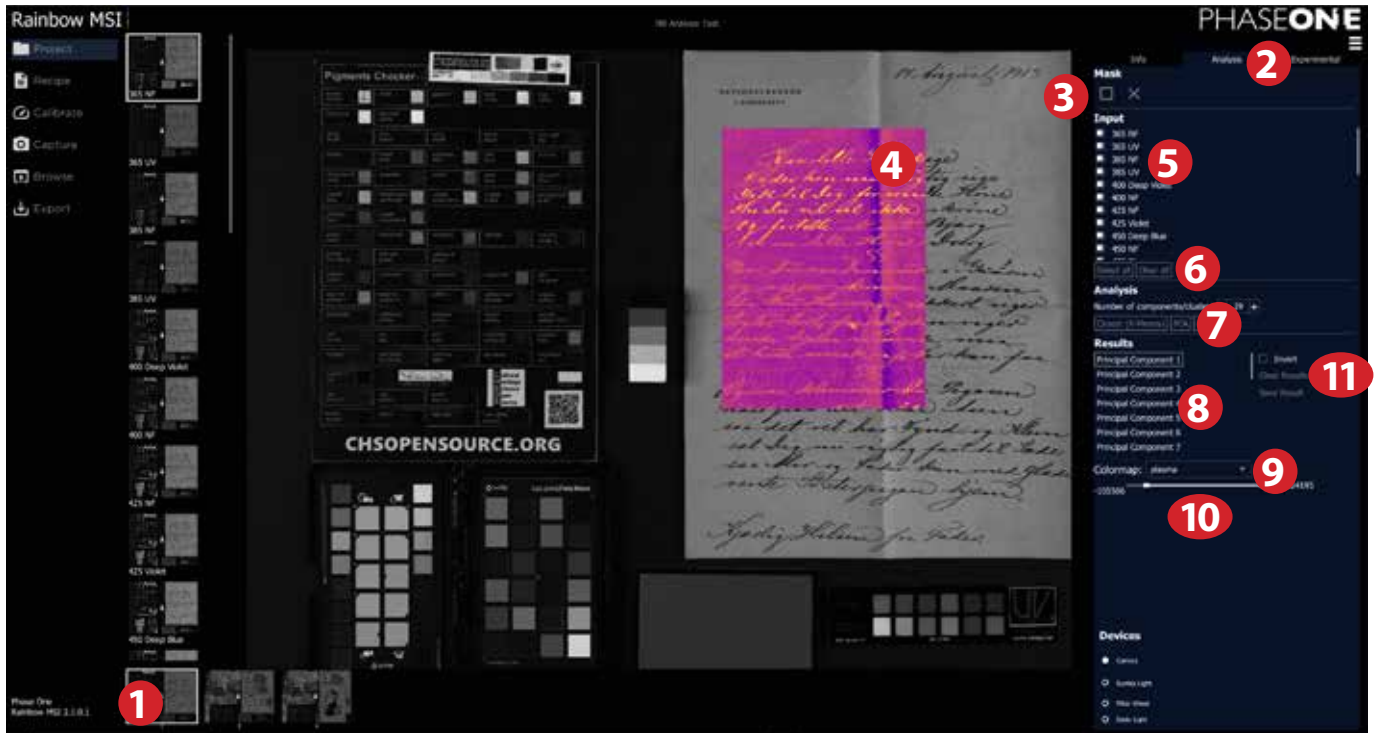
1) Select the stack that you want to analyze. Please note that you will be able to analyze all the images within that stack regardless of which part of the sequence you are currently viewing.

2) Ensure that you have selected the **Analysis** tab to get access to the feature.

3) You can either choose to analyze the entire image or a part of it. If you want to analyze a specific area, click on the **Mask** icon and draw an area on the subject ❹ with your mouse. If you want to delete the mask area again, click on the cross next to the **Mask** icon ❸.

5) From the **Input** list, select the captures from the stack that you want to include in the analysis. Click on the check box next to each capture to include them. If you want to include all the captures, click on **Select All** ❻. You can also deselect all in one go by clicking on **Clear all** ❻.

7) You are now ready to start the analysis by choosing the method. Click on **PCA**.

8) The software will then do the calculations and list the different components or clusters in the **Results** list. Click on one of these in the list to show the analysis directly on the subject ❹.

9) You can change the color interpretation of the component or cluster analysis from **Colormap** drop-down menu. Some will show the result more distinctly than others.

10) If the visual result of the analysis is still difficult to evaluate, you can move the end points of the slider to optimize the visual contrast and get a more clear interpretation.

Please note that if you create a new analysis by clicking on **Cluster (K-Means)**, **PCA** or **ICA** ❼ those will be added to the bottom of the **Results** list ❽. If you instead want to start all over on a clean state, click on **Clear Results** ⑪ first, then start the new analysis.

The step of exporting the analysis for external use will be covered later in this guide.

Independent Component Analysis (ICA)

As the name states - this analysis method seeks to find independent components in the input data. In complex data analysis this is used for what is called "signal separation". When imaging a historic document one can think of multiple signals or layers which are mixed: the paper, watermark(s), inks, mold, stains, hair, dust, etc.

The more distinct input images or channels the analysis method is set to work with, the more output signals/channels can be generated. It is useful to think about how many different signals/materials you think that your current subject matter contains and set the number of components accordingly. Try incrementing the number in subsequent runs and find the "sweet spot". Sometimes the results can come as a surprise, and quite different from what you initially thought.

More info is available here: wikipedia.org/wiki/Independent_component_analysis

Using Independent Component Analysis (ICA)

1) Select the stack that you want to analyze. Please note that you will be able to analyze all the images within that stack regardless of which part of the sequence you currently are viewing.

2) Ensure that you have selected the **Analysis** tab to get access to the feature.

3) You can either choose to analyze the entire image or a part of it. If you want to analyze a specific area, click on the **Mask** icon and draw an area on the subject ❹ with your mouse. If you want to delete the mask area again, click on the cross next to the **Mask** icon ❸.

5) From the **Input** list, select the captures from the stack that you want to include in the analysis. Click on the check box next to each capture to include them. If you want to include all the captures, click on **Select All** ❻. You can also deselect all in one go by clicking on **Clear all** ❻.

7) You are now ready to start the analysis by choosing the method. Click on **ICA**.

8) The software will then do the calculations and list the different components or clusters in the **Results** list. Click on one of these in the list to show the analysis directly on the subject ❹.

9) You can change the color interpretation of the component or cluster analysis from **Colormap** drop-down menu. Some will show the result more distinctly than others.

Please note that if you create a new analysis by clicking on **Cluster (K-Means)**, **PCA** or **ICA** ❼ those will be added to the bottom of the **Results** list ❽. If you instead want to start all over on a clean state, click on **Clear Results** ❿ first, then start the new analysis.

The step of exporting the analysis for external use will be covered later in this guide.

Clustering (K-means)

In the context of image analysis, Cluster analysis or clustering is the task of grouping a set of pixel-ob-servations in such a way, that the properties of pixel-observations in the same group (called a cluster) are more similar (in some sense) to each other than to those in other groups (clusters). Clustering is a main task of exploratory data analysis, and a common technique for statistical data analysis, used in many fields, including image analysis, pattern recognition, and bioinformatics. K-means clustering groups the pixel-observations into "k" number of clusters, in which each observation belongs to the cluster with the nearest mean (cluster centers or cluster centroid), serving as a model of the cluster.
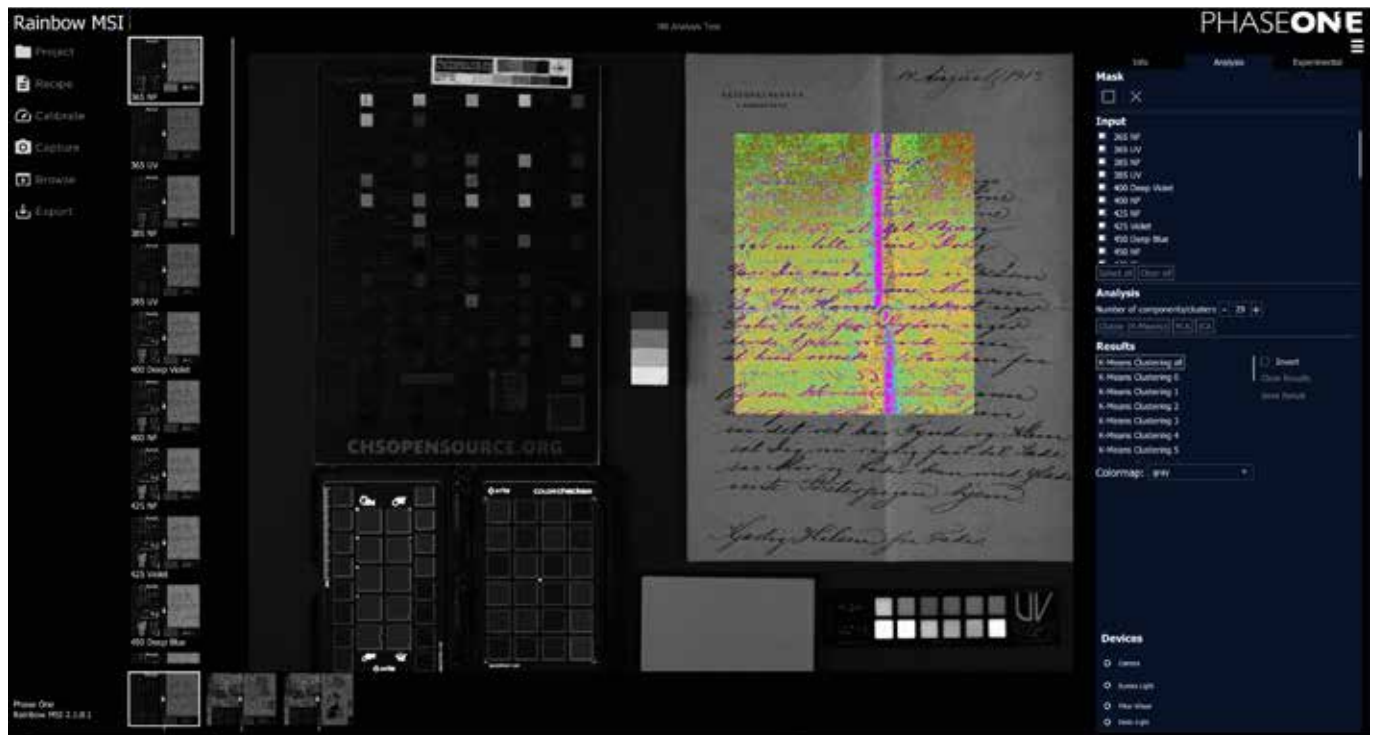
Cluster analysis as such is not an automatic task, but an iterative process of knowledge discovery or interactive multi-objective optimization that involves trial and error. It is often necessary to modify model parameters, like the number of clusters, until the result achieves the desired properties of the analysis.

The correct choice of k is often ambiguous, but intuitively the optimal choice of k will strike a balance between maximum compression of the data using a single cluster, and maximum accuracy by assign-ing each data point to its own cluster.

More info is available here: wikipedia.org/wiki/K-means_clustering

Using Clustering (K-means)

1) Select the stack that you want to analyze. Please note that you will be able to analyze all the images within that stack regardless of which part of the sequence you currently are viewing.

2) Ensure that you have selected the **Analysis** tab to get access to the feature.

3) You can either choose to analyze the entire image or a part of it. If you want to analyze a specific area, click on the **Mask** icon and draw an area on the subject ❹ with your mouse. If you want to delete the mask area again, click on the cross next to the **Mask** icon ❸.

5) From the **Input** list, select the captures from the stack that you want to include in the analysis. Click on the check box next to each capture to include them. If you want to include all the captures, click on **Select All** ❻. You can also deselect all in one go by clicking on **Clear all** ❻.

7) You are now ready to start the analysis by choosing the method. Click on **Cluster (K-Means)**.

8) The software will then do the calculations and list the different components or clusters in the **Results** list. Click on one of these in the list to show the analysis directly on the subject ❹.

9) You can change the color interpretation of the component or cluster analysis from **Colormap** drop-down menu. Some will show the result more distinctly than others.

Please note that if you create a new analysis by clicking on **Cluster (K-Means)**, **PCA** or **ICA** ❼ those will be added to the bottom of the **Results** list ❽. If you instead want to start all over on a clean state, click on **Clear Results** ❿ first, then start the new analysis.

The step of exporting the analysis for external use will be covered later in this guide.

Save and Load Analysis Settings

You can save a set of Analysis Settings for subsequent use on further image stacks.
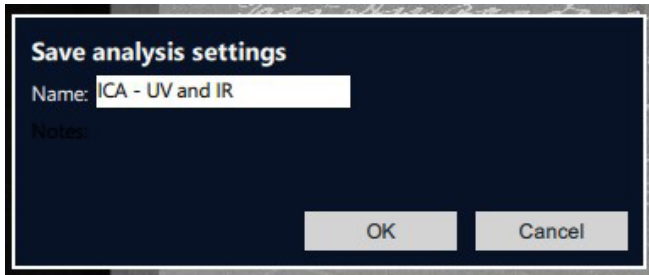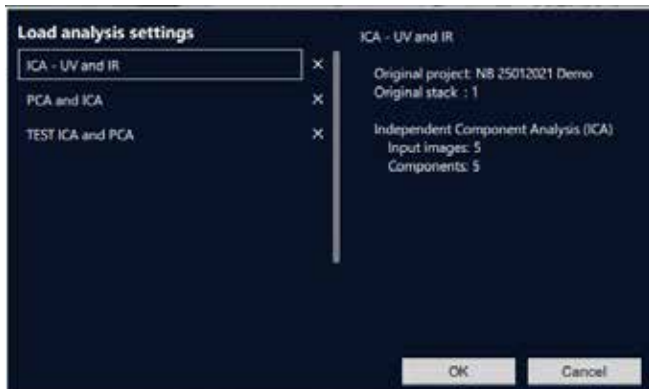

Save a set of Analysis Settings by clicking on the Save Settings button. You will be prompted to name the settings before clicking **Save**.

Please note there is currently no warning if a name is duplicated. If a name is duplicated, the original stored Settings will be over-written with the new Settings, so please take care when selecting a name for a new set of stored Settings.

Settings are saved in User\AppData\Local\Phase One\Rainbow MSI\recipes\analysis_settings

All components of the Analysis Settings are stored, including which images from the stack are selected for the analysis, the analysis run, the color map selected, if any, whether the selection was inverted, and for PCA only, the selection of values included with the slider.

To load a stored set of Analysis Settings, click on the **Load Settings** button.

Select the Settings you want to use. A pop-up will show the Settings that have been used.

You can delete individual lines from these Settings by clicking on the 'x' at the end of each line.

To use the same Region of Interest as the original Analysis, check the **Re-use original Region of Interest** box, otherwise the Analysis will be made with the current selected Region of Interest.

Exporting the Analysis Results

1) Once you are satisfied with an analysis, select the component or cluster in the **Results** list that you want to export. You can only select and save one at a time.

2) Click on the **Save Result** button. The TIFF file is then saved in the Project Folder within the subfolder "Analysis_Images".

3) If you want to verify the saved result, click on the **Browse** tab, find the "Analysis_Images" folder for your project and open the image in an external software.

Please note that in addition to the TIFF files, Rainbow MSI will also save a json-file in the "Analysis_Images" folder with metadata information specifying the analysis-method, region-of-interest, etc.

The saved TIFF files are named automatically using the method name, component/cluster number and an additional "edit" designator. The "edit" designator makes it possible to save multiple different edits of a single analysis result to cover different colormaps and value ranges.

Many popular platforms and software environments offer tools for statistical analysis of multi-variate recordings or captures. They include ImageJ + Paleo Toolbox, MATLAB and more.

Metadata handling within Rainbow MSI

Metadata content and implementation within Rainbow MSI

The metadata of each image captured with Rainbow MSI are all stored (embedded) in the raw file and in the processed TIFF files. The Metadata types of EXIF, IPTC, XMP are used to contain the following elements:

- EXIF data describing the camera system:
    - » EXIF in TIFF IFD (Image File Directory)
- Project, Object:
    - » Within the Dublin Core namespace of XMP
- Capture Software:
    - » Within the Rainbow Namespace of XMP
- Illumination:
    - » Within the Rainbow Namespace of the XMP
- Filter and filter setup:
    - » Within the Rainbow Namespace of the XMP

The metadata can be inspected using a standard metadata viewer "ExifTool". Here follows an example.
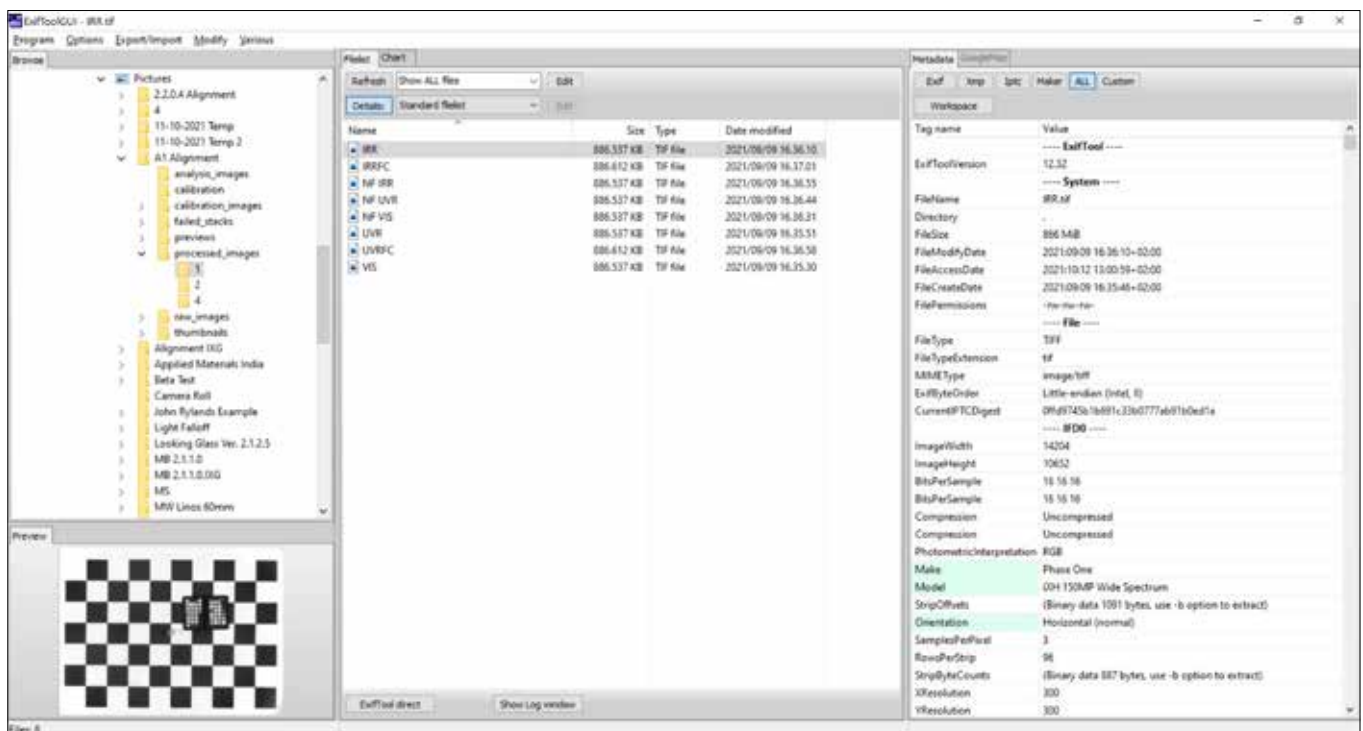
Typical uses of the metadata include:

    i. Extracting/copying relevant metadata from the image files to a central database from which selections, filtering and sorting can be performed.

    ii. On-line Viewer with capabilities to search, select and sort images of a specific kind.

Example of metadata in the Phase One Rainbow MSI namespace:

Troubleshooting

1 **Before launching the Rainbow application: Please make sure that all devices are connected and powered ON.**

In general, never disconnect or connect any device while the Rainbow software is running. In case you have connected a device with the Rainbow software ON, the device may not be detected by the application. To resolve the issue: close and restart the application.

2 **Verifying that the system is ready for use**

Before you start working, please ensure that all the devices (camera, lights and filter wheel) are properly connected, powered and recognized.

The **Devices window** in lower right corner shows all active USB connections.
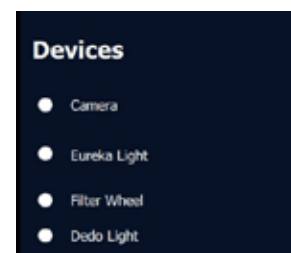
To check that the devices are correctly powered and ready for use, please check the expanded **Devices detail window** by clicking on the **Devices** window. This will let you inspect the current status of the Eureka Lights, the Filter Wheel and the Dedo Lights in detail. Click again in the **Devices detail window** to close the expanded overview. To check that the camera is ready, click the **Capture Tab** in upper left corner, which displays what the camera is "seeing" in live view mode.

3 **Adjusting ISO or Aperture after an initial completed calibration.**

In the **Recipe Editor** you have access to the three parameters of the capture: Aperture, ISO and Shutter Speed. Please note that the Exposure Compensation is automatically calculated in the calibration process setting the exposure gain and the white balance for best possible exposure. *This is done assuming that Aperture and ISO is kept constant as specified in the Recipe.*

Should you want to work at, for example, a different ISO or a different Aperture you will need to start in the Recipe Editor by setting the new ISO or Aperture values. Then adjust all Shutter Speeds up or down in 1/3 steps. Hereafter, re-do the Flat Field calibration and the Exposure Calibration process.

Process completion feedback
Audio: In the top right menu, under General Settings, it is possible to choose whether you want

audible feedback from the computer when a calibration process is completed. You can choose a sound (**Acoustic**) or a voice (**Speech**) to indicate that the process has ended, or to turn the audible feedback off entirely (**Off**).

The audible feedback is available to signal when a step in the process is done.

Pilot light: In the Capture Tab click the **Pilot Light** button to turn on the Pilot light when the process is done. The keyboard shortcut "P" turns the Pilot light function ON / OFF.

4 Why does the Focus and Alignment calibration stops when working with 120mm?

The camera position may be outside the focusing range of the camera. Please enter the **Capture** tab and check if the camera is able to focus – either in manual or autofocus mode.

5 Why does the Focus and Alignment calibration not finish correctly?

Please make sure that the checkerboard target is correctly aligned, almost parallel to the image frame.

6 Why does the Camera not enter Live View?

a. Please make sure that other applications on the computer are not exercising the camera (for example Capture One).
b. Contact to the camera may be lost. Please turn the camera OFF and ON and restart the Rainbow application.

7 Where do I find the files from the captured stack?

Select the image stack you wish to find, and then click the **Browse** tab for Explorer window.

8 Where do I find the image metadata?

The metadata is embedded in the image files – both the raw and the processed TIFF files. Please check the User Guide for details on the metadata content and structure.

9 How long does it take to calibrate?

The time to complete a calibration depends on the number of steps in the recipe and the selected shutter speeds. The duration of a calibration run for a full Recipe Preset are approximately as follows (if your setup requires long exposure times the calibration duration increase accordingly).

Narrowband Calibration (16 recipe steps)
- Focus and Alignment: 6min 50sec.
- Flat Field Compensation: 6min 30sec.
- Exposure Compensation: 6min.

Multiband Calibration Standard recipe.
- Focus and Alignment: 3min 20sec.
- Flat Field Compensation: 1min 40sec.
- Exposure Compensation: 8min 10sec

Project Folder Structure

The file structure of the project is set up with folder and subfolders as follows:

- **analysis_images** folder
- **calibration** folder
- **calibration_images** folder
    - » **alignment** subfolder
    - » **exposure** subfolder
    - » **flat_field** subfolder
    - » **focus** subfolder
- **previews** folder
- **processed_images** folder
- **raw_images** folder
- **thumbnails** folder

You can concentrate fully on the final files in the **processed_image** folder, but you also have the option to inspect the originally raw captured images in the **raw_images** folder.

Metadata Structure

The included Metadata contains a basic structure of:
- Project, Object: Dublin Core in XMP
- EXIF data describing the camera system: EXIF in XMP
- Capture Software: Rainbow Namespace in XMP
- Illumination: Rainbow Namespace in XMP
- Filter and filter setup: Rainbow Namespace in XMP

The included metadata will be added to the TIFF header of the image files and all metadata in the TIFF file are available as XMP. Please use an XMP enabled software like EXIF tool to access and read all metadata.

Example: Metadata displayed in UI on monitor for each Rainbow image:

Example: EXIF metadata as seen by an XMP enabled EXIF tool

Versioning

This edition of the MSI User Guide is based on software version 2.3.2

Notice of Liability

The information in this guide is provided "as is". Content and technical specifications are being reviewed and updated periodically, so please refer to the latest version or contact your Phase One CH partner for advice.

Appendix

Assemble the Filter Wheel

Included equipment :
- 1 x Filter Wheel
- 1 x Filter carousel
- 1 x UG1 Visible block Filter
- 1 x BG38 UV/IR Cut Filter
- 1 x BG39 UV/IR Cut Filter
- 1 x Baader UV/IR Cut/L Filter
- 1 x RG830nm IR Pass Filter
- 1 x Power supply
- 1 x USB cable
- 1 x Mounting Rail (for filter wheel and iXG/iXH Camera)

Service the Filter Wheel

The supplied motorized 2-inch filter wheel comes with a 5-position carousel that includes four filters. The filters have been assembled in the filter carousel before packaging to ensure that they are installed in the correct order.

Warning: Do not touch the filter wheel while it is turned on. If you have to adjust it, you must first switch it off by disconnecting the USB cable. Then reconnect the USB once you are done.

In case you need to exchange a filter, they need to be assembled in the following order in the carousel:
❶ No filter
❷ UG1 Visible block filter
❸ BG38 UV/IR Cut filter
❹ RG830 IR Pass filter
❺ Baader UV/IR Cut/L filter and BG39 UV/IR cut filter

One of the wheel positions uses no filter as this is used to focus and use Live View etc. with the iXG/iXH Camera.

The carousel has been inserted into the filter wheel to protect it during transport and it is thus ready to use. You can remove (and re-insert) the filter carousel by first loosening the friction screw at the bottom of the filter wheel, and then loosening the knob at the top corner of the filter wheel and opening the cover. The carousel can then be slid in or out, but be careful not to touch or damage the filters while doing so. After reinserting the filter carousel, first tighten the knob at the top corner of the filter wheel, and lastly tighten the friction screw at the bottom of the filter wheel.

Recommended PC configuration

Processor: Intel i7 processor or later, with multiple cores and 8MB or greater cache
Memory: Minimum 32GB GB RAM (Increasing to 64GB will give improved performance, especially for analysis-heavy projects)
Storage: 1TB SSD hard disk or larger
Graphics card: A high quality graphics card with powerful GPU performance is recommended for optimum performance
Operating System: Windows 10
Minimum 2 free USB ports

Cleaning the sensor on the camera

Phase One iXG/iXH Camera

Sensor Cleaning Procedure

Ver. 1.2

Phase One 2014-2018 90040957

Introduction

This procedure shows how to clean the sensor on iXG/iXH camera.

The procedure is done in four steps:

1. Removing the lens
2. Cleaning the camera interior and sensor module
3. Reassembling the camera body
4. Mounting the lens

Required tools

Before you start, make sure that you have the following:

•   A clean, dry place to perform the service

•   Hex #2.5mm screwdriver

•   Torque handle set to 70cNm

•   2.5mm x 100mm Hex head bit

•   Phase One cleaning kit

Dismounting a Lens from the iXG/iXH Camera

Lenses on the iXG/iXH series of cameras are easily dismounted.

NOTE: Ensure that you only dismount lenses in a clean environment. Place the detached lens on a soft cloth on the table to avoid scratching the lens.

To dismount the lens:

- Release the lens' locking levers.

- Remove the lens by pulling it gently away from the camera.

NOTE: If no lens is being mounted, ensure that the camera is stored in a way that protects it from dust, moisture and other damage. When the iXG/iXH camera is mounted facing down, always make sure (double check) that the lens is well secured by having the lens locking levers engaged.

- Cover the front of the camera to prevent damage to the sensor.

- With a 2.5mm hex screwdriver, release the four camera module screws and lift the entire camera body, place it on a clean surface.

Note: Make sure that the sensor module is well protected.

Release Screws and Lift
Camera body

Cleaning the Camera's Sensor

- Locate the small plastic wiper and identify the size that fits your sensor size.

- Fold one cloth and fold this over the wiper so that you have two layers of cloth.

- Apply 2-3 drops of Eclipse fluid to the edge of the folded cloth.

- In one move, swipe the surface of the sensor in one direction from start to finish.

- Inspect the sensor and check to see if it is clean by holding it near a light. And/or with a magnifying glass

If necessary, move the cloth layer one centimeter on the wiper and repeat the process. Never swipe twice with the same area of the cloth.

Reassembling the Camera Body in Place

- Realign the camera body into place.

- Tighten the captive screws with a torque of 70cNm.

Mounting a Lens

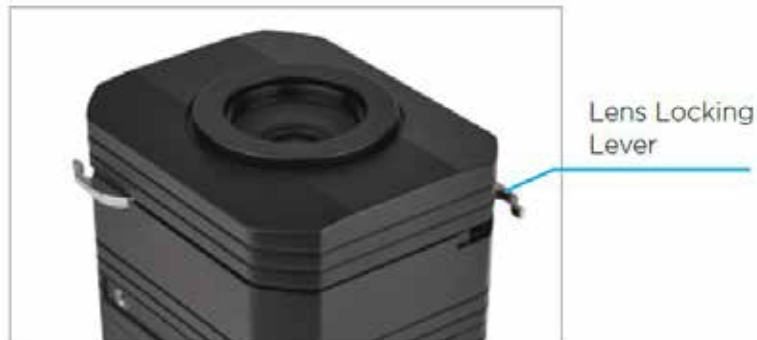**NOTE**: Before mounting or dismounting a lens, ensure that the power cable is not attached to the camera.

- Place the Lens over the iXG/iXH camera body and guide it into position against the camera body using the two large positioning pins.

- Close the Lens locking levers.

Note: The Lens is a-symmetrical, and can only be fitted in ONE position.

- Replace the lens, take and inspect image. We recommend photographing a uniform grey or white paper or an image that is diffused by holding an opaque filter in from of the lens

- Repeat the above steps as necessary until the sensor is clean