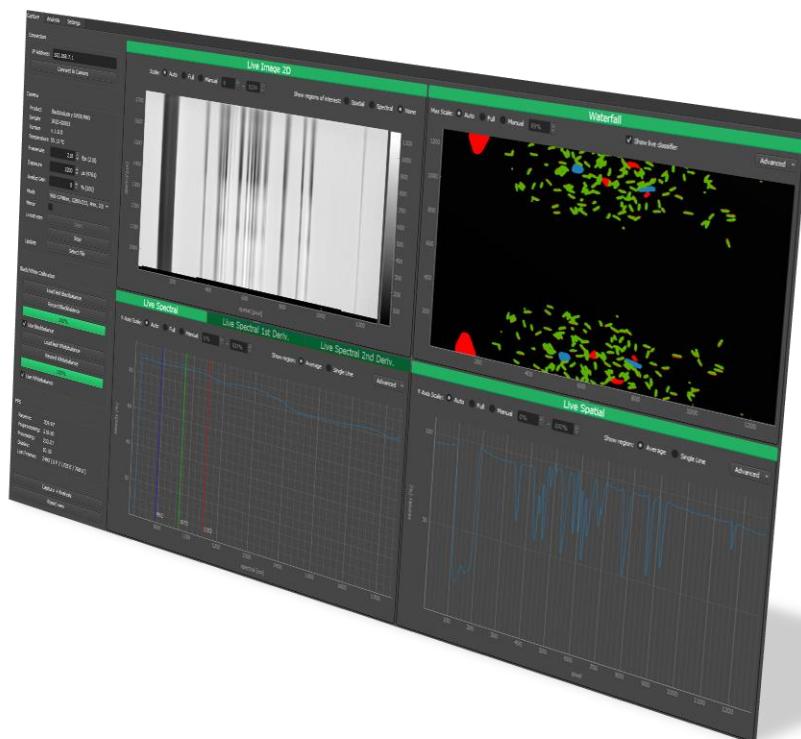




# User Manual

HAIP BlackStudio Software

Version 0.2.35 and later



## 1 INTRODUCTION

Dear Customer,

We would like to thank you for the purchase of a HAIP Solutions GmbH product and wish you successful, insightful and at the same time pleasant work.

HAIP BlackStudio is a recording software for hyperspectral images that enables the acquisition of real-time spectral data. The software is dedicated to the series of BlackIndustry cameras for industrial in-line applications.

Additionally, feel free to check out the tutorial of the BlackStudio software on our YouTube channel:

[YouTube Tutorial BlackStudio.](#)

### 1.1 ABOUT THE USER MANUAL

Please read this User Manual carefully before first use and study the warnings and safety instructions. Keep the instructions! This allows you to find and look up important clues later.

We hope that the User Manual answers all your questions. If this is not the case or if you would like to report a service or warranty claim, please contact our support team via our website:

[www.haip-solutions.com](http://www.haip-solutions.com)

Or contact us directly:

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## 1.2 ABOUT HAIP SOLUTIONS

HAIP Solutions GmbH is a driver of innovation in the field of hyperspectral camera solutions. It was founded in October 2019 and is based in Hanover.

We develop, produce, and distribute high-quality and user-oriented hyperspectral systems for applications in the fields of agriculture & forestry, food industry and recycling. With our application-oriented product solutions, we provide competent and flexible support for both commercial and research applications.

In addition to stationary hyperspectral imaging systems, our products also include solutions for mobile applications, such as handheld or UAV-based.

## 1.3 WARRANTY

HAIP Solutions GmbH warrants to the original purchaser that HAIP BlackStudio is free from malfunctions within the scope of the statutory warranty from the date of purchase or installation. During this warranty period, if any defects or malfunctions arise, we will provide prompt technical support and assistance to rectify the issue. This also includes updates or patches to address any known issues or vulnerabilities. If a solution cannot be achieved within a reasonable time frame, we will either replace the software or refund the purchase price at our discretion. This warranty does not cover issues arising from improper use, unauthorized modifications, or third-party software conflicts.

## 1.4 DISCLAIMER AND PERFORMANCE CHARACTERISTICS OF THE SYSTEM

HAIP Solutions GmbH can neither guarantee nor check the performance characteristics of the software and rejects any warranty and liability claims if products of HAIP Solutions GmbH have been misused, neglected, or damaged. Furthermore, this applies if the products have been damaged by external influences or have not been used in accordance with the enclosed instructions for use; if accessories that are not recommended by HAIP Solutions GmbH have been used, or if repair work has been carried out by service personnel not authorized by HAIP Solutions. The performance of the system may vary depending on several factors, including but not limited to hardware and network infrastructure used, the complexity and size of data being processed and external factors such as internet connectivity and server availability. We do not guarantee that the system will be free from bugs, errors, or vulnerabilities. We will make continuous efforts to address any reported issues and provide updates as necessary.



## 1.5 PATENTS/REGISTERED TRADEMARKS/COPYRIGHT

This operating manual is the property of HAIP Solutions GmbH. A complete or partial duplication of the instructions as well as the transfer to third parties are not permitted without the express written consent of HAIP Solutions GmbH.

HAIP Solutions GmbH makes every effort to ensure the accuracy of the information in the operating instructions. This document is subject to change without notice.

## 1.6 WARNINGS

The HAIP BlackStudio software may only be operated by qualified personnel and not without prior instruction by an employee of HAIP Solutions GmbH or by personnel expressly authorized by HAIP Solutions GmbH.

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## 2 HAIP BLACKSTUDIO SOFTWARE – OVERVIEW

The **HAIP BlackStudio** software is a data acquisition, processing and analysis software designed for the hyperspectral cameras of the **HAIP BlackIndustry** series.

The software is divided into five different main tabs:

- **Capture Tab** to perform and overview the data acquisition (chapter 3)
- **Analysis Tab** to process and analyze the acquired data (chapter 4)
- **Database Tab** for permanently managing and storing data (chapter 5)
- **Settings Tab** to select basic settings (chapter 6)
- **Manuals Tab** for looking up the User Manual and Quick Start Guide.

The following chapters introduce the individual tabs and explain their scope and functions.

## 3 BLACKSTUDIO – CAPTURE TAB

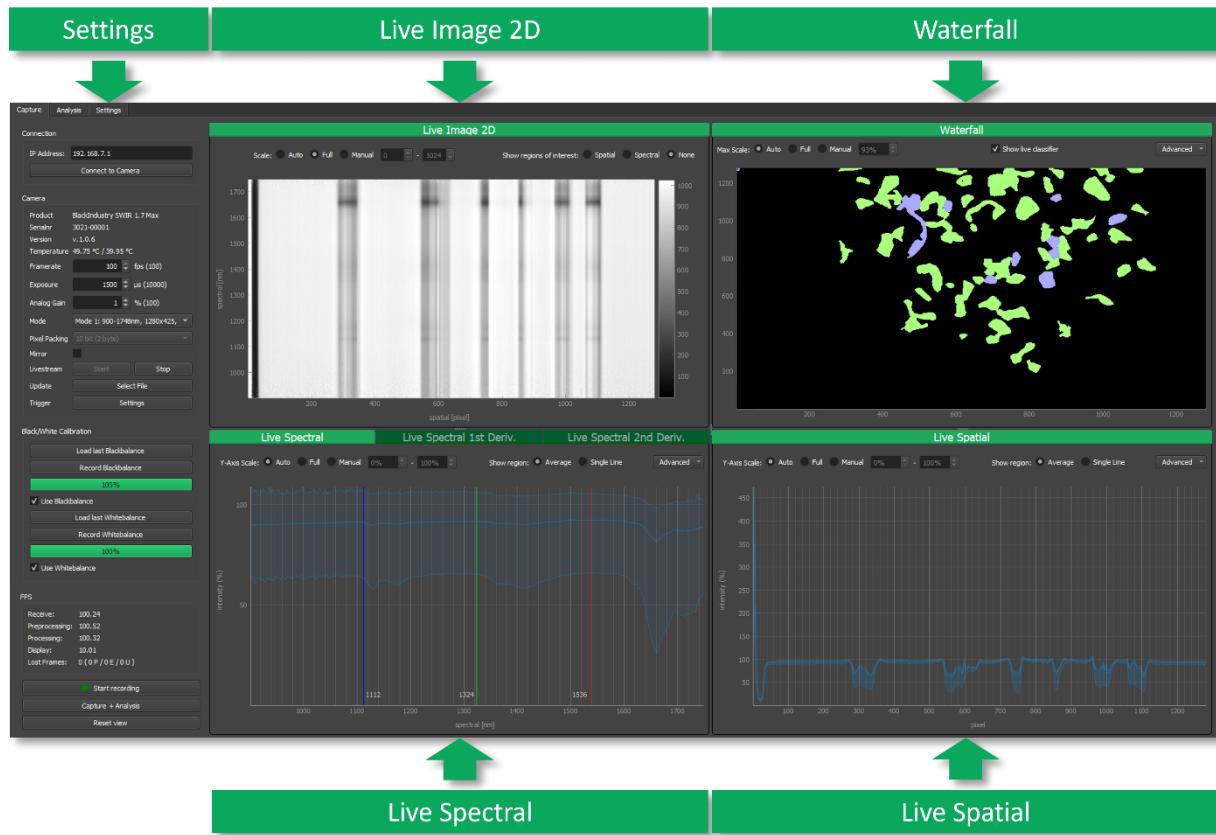
In the **Capture tab** of the HAIP BlackStudio software, all settings for successful data acquisition can be adjusted. Additionally, information about the currently captured hyperspectral data is displayed via the four **livestream windows**:

- **Live Image 2D**
- **Waterfall**
- **Live Spectral**
- **Live Spatial**

### 3.1 CAPTURE TAB – OVERVIEW

The **Capture tab** consists of four livestream windows and a settings section on the left-hand side.

- The livestream windows, indicated by the green title bar, can be freely arranged by drag & drop or resized using the mouse curser.
- Open the individual windows to full screen by double clicking on the dedicated green title bar.
- Via the **Reset View** button, the default arrangement of the windows can be regained.



### 3.2 CAPTURE TAB - LIVE IMAGE 2D WINDOW

- Displays currently recorded pixel line (Spatial x Spectral).

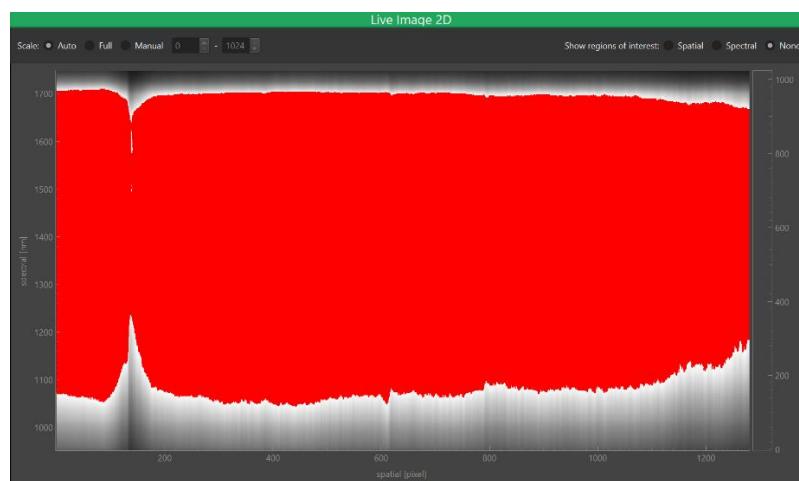
#### Settings:

- **Scale:** Adjust the intensity scale [Auto adjustment | Full stretch | Manual selection].
- **Show regions of interest:** Show and adjust regions of interests (ROIs) [Spectral | Spatial | None]: The intensity information of the current recording is obtained from these ROIs (see **Live Spectral & Live Spatial**).
  - Left Double click to open a new ROI
  - Right-click to delete a ROI
  - Adjust the ROI width by sliding the region markers
  - Click on a ROI and hold to move an entire ROI
  - Note that several ROIs can be defined at the same time (see screenshot below).

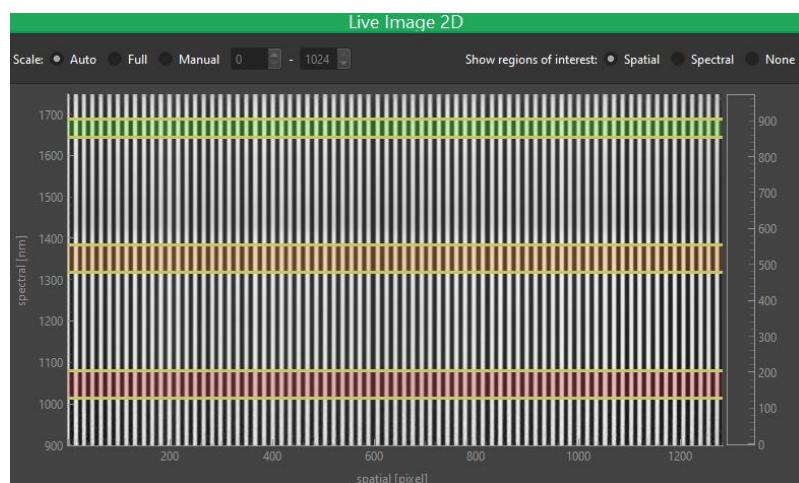
### Live Image 2D View with active Livestream:



**Live Image 2D View** with active Livestream but showing oversaturation: Adjust Exposure and Analog Gain settings to achieve an adequate illumination level and to eliminate oversaturation (for 10-bit Pixel Packing, oversaturation indicated in red).



### Live Image 2D View with several spatial ROIs:



### 3.3 CAPTURE TAB - WATERFALL WINDOW

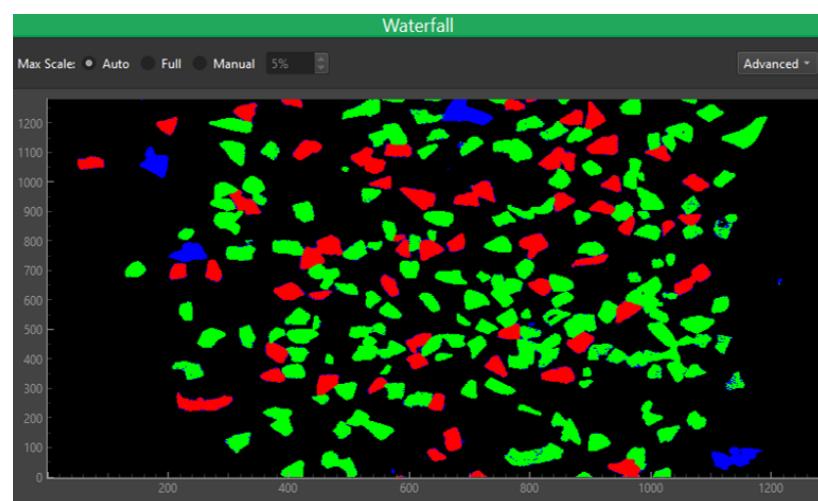
- All recorded pixel lines are displayed consecutively. The latest line is added at the top of the screen (Spatial x Spatial).

#### Settings:

- **Max Scale:** Adjust the intensity scale of the displayed data [Auto adjustment | Full stretch | Manual selection].
- **Advanced:** **Enable live classifier** for live classification as soon as a classifier has been trained.
  - The live classifier enables the live classification of the recorded objects after a preliminary image classification.
  - This function is still available but is **deprecated**. It is recommended to use the new **On-Camera Classifier** tool (see chapter 8.5).
- By moving the red, green and blue sliders in the **Live Spectral View**, the color scheme in the **Waterfall window** can be changed.



#### Classified Waterfall window via on-camera classifier:



### 3.4 CAPTURE TAB - LIVE SPECTRAL WINDOW

- Displays the spectral intensity for each camera wavelength (Spectral x Intensity).

#### Settings:

- By moving the red, green and blue sliders, the color scheme in the Waterfall window can be changed.
- **Y-Axis scale:** Auto | Full | Manual (identical to Live 2D View).
- **Show region:**
  - **Average:** Average value of the intensity of the spectral ROI. Values from several ROIs are color-coded.
  - **Single Line:** Intensity values of the single middle line of a spectral ROI. Values from several ROIs are color-coded.
- **Advanced:**
  - **Use mono slider:** one greyscale slider for the color scheme of the Waterfall window.
  - **Show Min/Max:** Displays intensity value range from min to max.
  - **Export .png:** export current view as \*.png file.
  - **Export .csv:** export currently recorded intensity values of a pixel line .
- **Live Spectral 1<sup>st</sup> Derivation & 2<sup>nd</sup> Derivation:** Display the first/second derivation of spectral intensity (spectral x intensity).
  - **Savitzky-Golay:** Perform Savitzky-Golay Smoothing.
  - **Export .png:** export current view as \*.png file.
  - **Export .csv:** export currently recorded intensity values of a pixel line.



### 3.5 CAPTURE TAB - LIVE SPATIAL WINDOW

- Displays the spectral intensity for each pixel line (Spatial x Intensity).

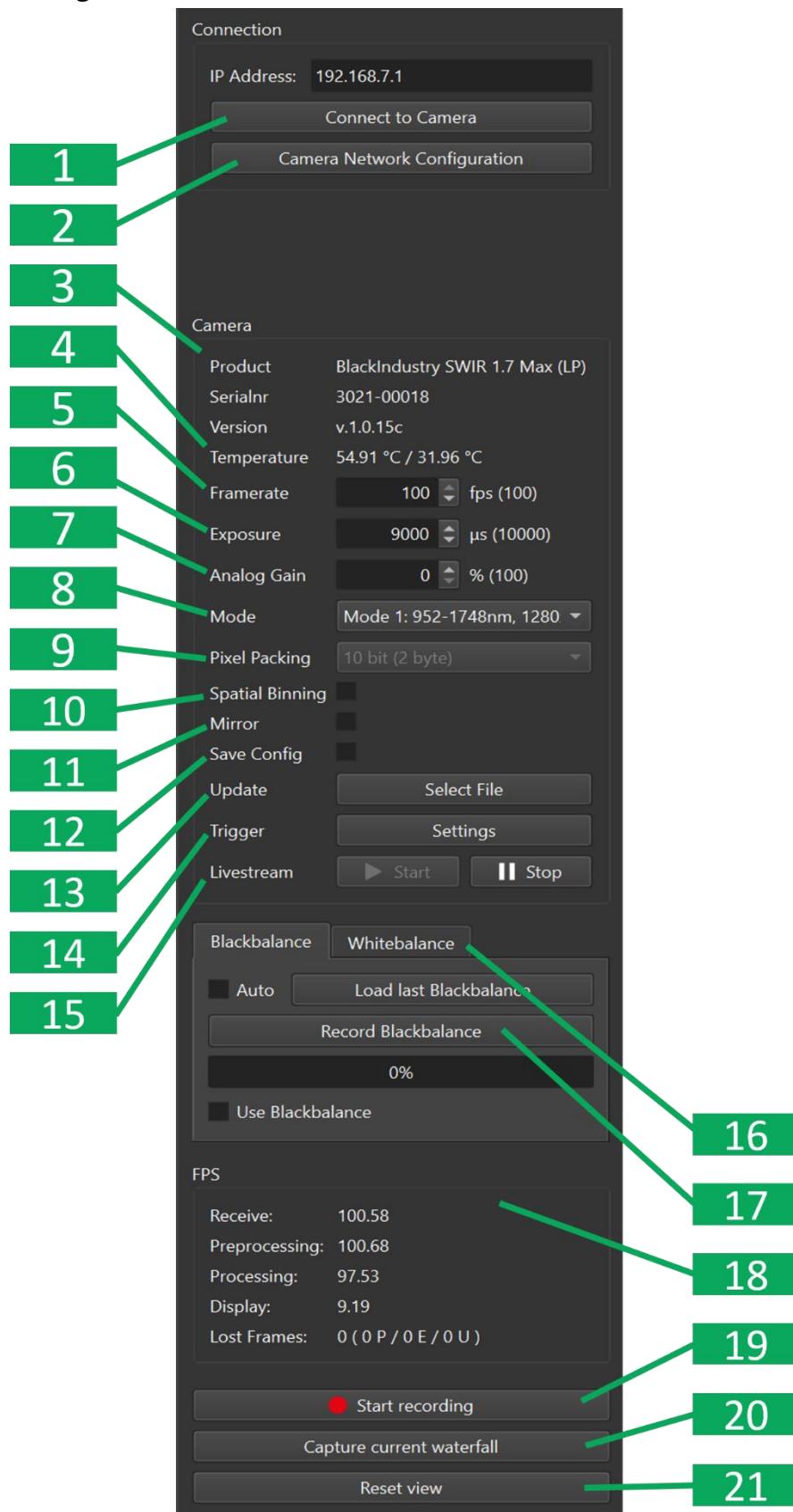
#### Settings:

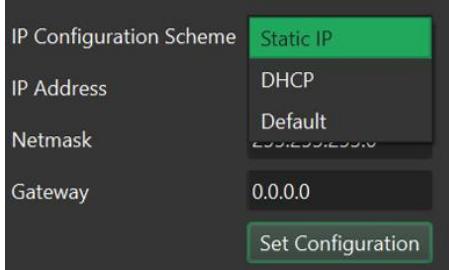
- **Y-Axis scale:** Auto | Full | Manual (identical to Live 2D View).
- **Show region:**
  - **Average:** Average value of the intensity of the spatial ROI. Values from several ROIs are color-coded.
  - **Single Line:** Intensity values of the single middle line of a spatial ROI. Values from several ROIs are color-coded.
- **Advanced:**
  - **Show Min/Max:** Display value range from min to max.
  - **Export .png:** export current view as image file.
  - **Export .csv:** export currently recorded intensity values of a pixel line.



### 3.6 CAPTURE TAB - SETTINGS

The **Settings** section is displayed on the left side of the **Capture tab**. Detailed information about each setting can be found in the table below.



No.	Setting	Description
1	<b>Connect to Camera</b>	Enter the IP-address of the camera (default 192.168.7.1) and press <b>Connect to Camera</b> .
2	<b>Camera Network Configuration</b>	Change the network configuration according to your needs. <b>Caution:</b> this is a permanent change to the camera. 
3	<b>Camera Information</b>	Once the camera is connected, the following camera information is displayed: <ul style="list-style-type: none"> <li><b>Product</b></li> <li><b>Serial Number</b></li> <li><b>Version</b> (Firmware version)</li> </ul>
4	<b>Temperature</b>	Displayed when livestream starts. Sensor temperature on the left and internal control temperature on the right side. A recording with the camera may only be started once a specific temperature has been reached.
5	<b>Framerate (in fps)</b>	Select the frame rate for line scan data acquisition (maximum varies according to readout mode).
6	<b>Exposure (in µs)</b>	The longer the exposure time, the more photons are received by detector, resulting in increased pixel intensity and a “brighter” image (maximum depends on camera mode).
7	<b>Analog Gain (in %)</b>	Increases sensitivity of the sensor (value is multiplier) (maximum 100 %).
8	<b>Mode</b>	Select a preferred (binning) readout mode that is available for the connected camera model (exemplary modes for BlackIndustry SWIR 1.7): <div style="background-color: #00AEEF; color: white; padding: 2px 0;"><b>Mode 0: 952-1748nm, 1280x200, 4nm, 197FPS</b></div> <div style="background-color: #333; color: white; padding: 2px 0;"><b>Mode 1: 952-1748nm, 1280x399, 2nm, 100FPS</b></div> <div style="background-color: #333; color: white; padding: 2px 0;"><b>Mode 2: 952-1748nm, 1280xROI, MULTI-ROI, 1330FPS</b></div> <div style="background-color: #333; color: white; padding: 2px 0;"><b>Mode 3: 952-1748nm, 1280xROI, CALIBRATED-MULTI-ROI, 1330FPS</b></div>
9	<b>Pixel Packing</b>	Select a preferred data size ( <b>8-bit / 10-bit</b> ). The 10-bit data can be packed for the transmission process ( <b>5/4</b> )

		or <b>3/2</b> ) to utilize the Ethernet line efficiently. Alternatively select <b>Classified Color Mode</b> .
10	<b>Spatial Binning</b>	Data from the BlackIndustry SWIR 1.7 Max camera is binned to 640 pixels when activated.
11	<b>Mirror</b>	Depending on the mounting direction of the camera, it is possible to mirror the waterfall and live image by activating the checkbox (Important: Black/White Calibration needs to be renewed after activation).
12	<b>Save Config</b>	Activate the checkbox to save the settings. The settings are automatically reloaded when the camera is rebooted.
13	<b>Update</b>	Once a new camera firmware version is available, it can be updated via the <b>Select File</b> button. <ul style="list-style-type: none"> <li>• The connected camera must be rebooted for the update to be applied.</li> <li>• All updates must be carried out one after the other and no version number may be skipped.</li> <li>• A previous version can no longer be accessed.</li> </ul>
14	<b>Trigger</b>	If the connected camera supports external trigger functionality, two trigger modes may be selected: <ul style="list-style-type: none"> <li>• <b>Frame Start</b></li> <li>• <b>Frame Burst Start</b></li> </ul> For more information see chapter 7.2.
15	<b>Livestream</b>	<b>Start:</b> Livestream will be displayed on all four windows and the current temperature of the sensor will be automatically received. <b>Stop:</b> stops the livestream of the connected camera.
16	<b>Black Balance</b>	Close the camera lens with the lens cap. Start the recording via <b>Record Blackbalance</b> . Afterwards, the calibration will be automatically applied, unless disabled (Important: Balance will not be saved when closing the software, but you can load the Blackbalance from the previous session by clicking <b>Load last Blackbalance</b> if it fits your selected mode) (Further information in chapter 7.1). <b>Attention: As soon as a new frame rate has been set, a new BlackBalance must always be recorded.</b>
17	<b>White Balance</b>	Record a Whitebalance by scanning a dedicated white reference target which is suitable for your application. Start the recording via <b>Record Whitebalance</b> .

		Afterwards, the calibration will be automatically applied, unless disabled (Important: Balance will not be saved when closing the software, but you can load the Whitebalance from the previous session by clicking <b>Load last Whitebalance</b> if it fits your selected mode) (Further information in chapter 7.1).
18	<b>FPS Information</b>	Information on <b>FPS</b> (frames per second) during livestreaming. The FPS values of <b>Receive</b> , <b>Preprocessing</b> and <b>Processing</b> should correspond to the selected <b>framerate</b> . The FPS value of <b>Display</b> should always be approx. 10 Hz. <b>Lost Frames</b> indicates problems either during the Processing on device (P), the Ethernet Bandwidth (E) or the User-Software (U). The ideal is to have a value of 0. When the <b>Lost Frames</b> value is above 0, please check your setup (also Pixel Packing settings) or contact the support team of HAIP Solutions GmbH.
19	<b>Start/Stop Recording</b>	<b>Start Recording:</b> the software starts recording the lines that are acquired by the camera. <b>Stop Recording:</b> the software stops the recording and directs automatically to the <b>Analysis Tab</b> . (More information in chapter 4).
20	<b>Capture current Waterfall</b>	All lines, currently displayed in the <b>Waterfall window</b> , are captured. The resulting image will be automatically displayed in the <b>Analysis Tab</b> .
21	<b>Reset view</b>	Resets arrangement of Livestream windows.

## 4 BLACKSTUDIO - ANALYSIS TAB

In the **Analysis tab** of the BlackStudio software, previously captured hyperspectral data can be displayed in a two-dimensional view and subsequently analyzed. Moreover, a pixel-based classifier can be trained and executed based on spectral data.

The structure and functionalities of the Analysis Tab are presented below.

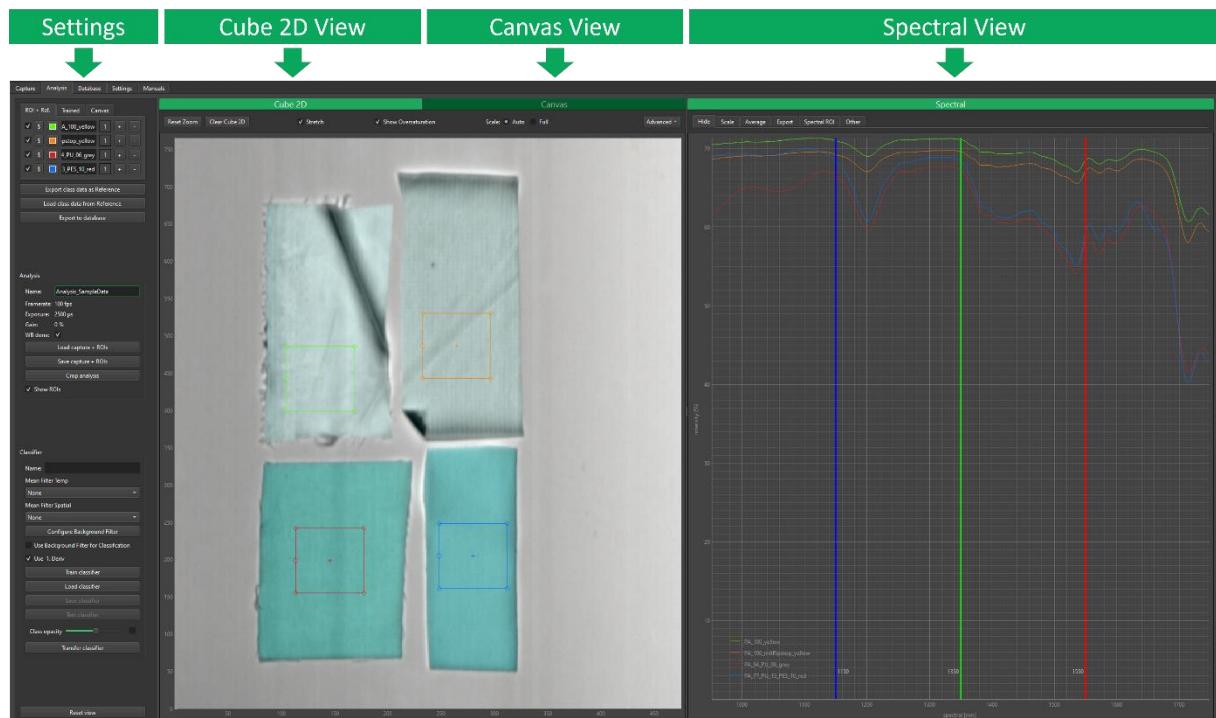
### 4.1 ANALYSIS TAB – OVERVIEW

The **Analysis tab** consists of four sections, which are explained in detail in the following subchapters:

- The **Settings Section**
- The **Cube 2D View**
- The **Canvas View**
- The **Spectral View**

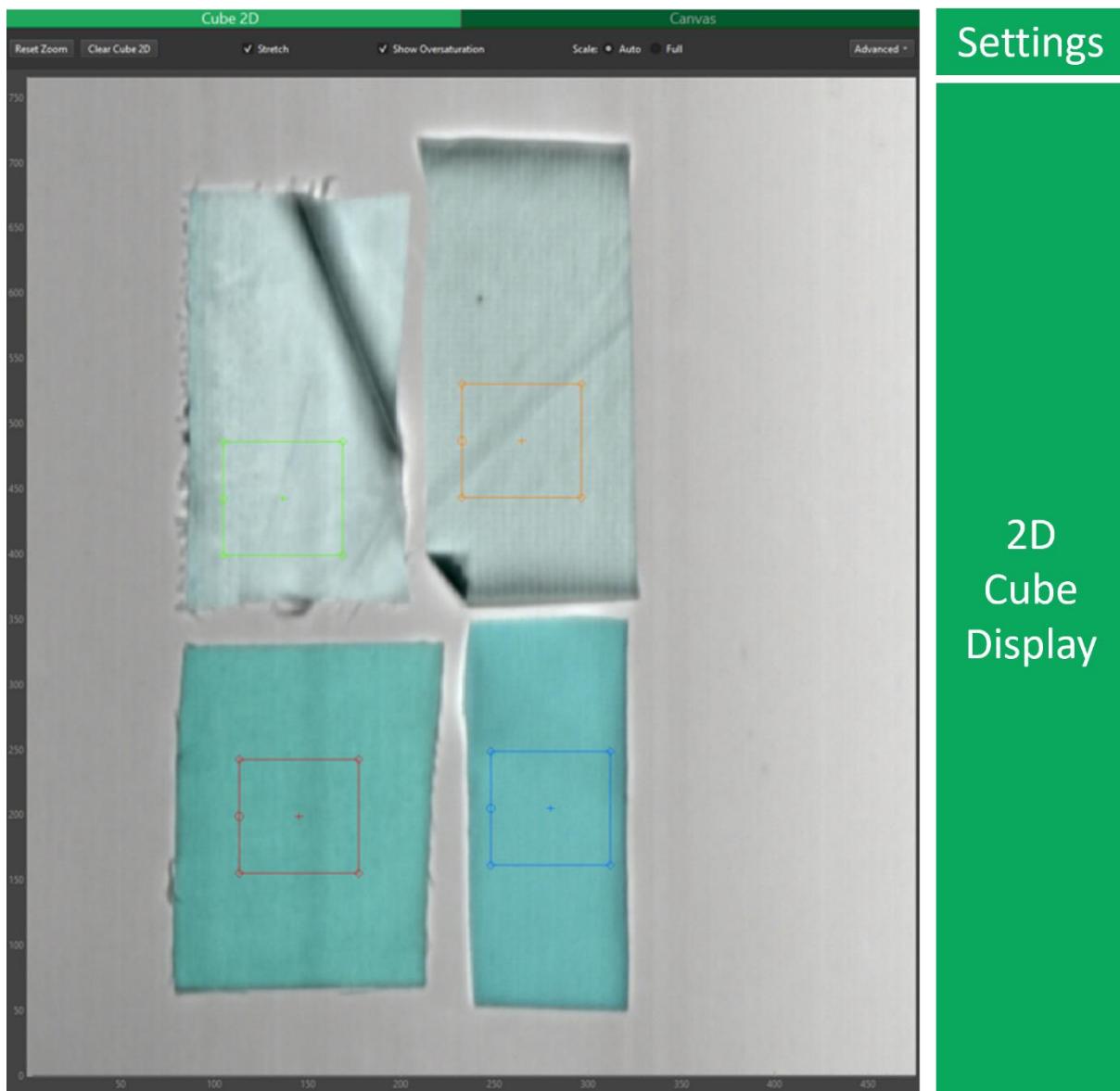
Identical to the Capture Tab, the three sections can be displayed variably:

- The three view windows, indicated by the green title bar, can be freely arranged by drag & drop or resized using the mouse pointer.
- Open the individual windows to full screen by double clicking on the dedicated green title bar.
- Via the **Reset View** button, the default arrangement of the windows can be regained.



## 4.2 ANALYSIS TAB – CUBE 2D VIEW

The screenshot below shows the Cube 2D View within the Analysis tab with an exemplary loaded hyperspectral data cube.



### Settings:

- **Reset Zoom:**
  - You can zoom in and out as required in the **Cube 2D View**. The full extent can be restored by pressing **Reset Zoom**.
- **Clear Cube 2D:**
  - Clears the **Cube 2D View** including hyperspectral cube and ROI markers.
  - A warning will appear before deletion: "Clearing Cube 2D View will reset all ROI markers saved on the Cube2D image and deletes the image! Make sure to save your ROIs and image beforehand."

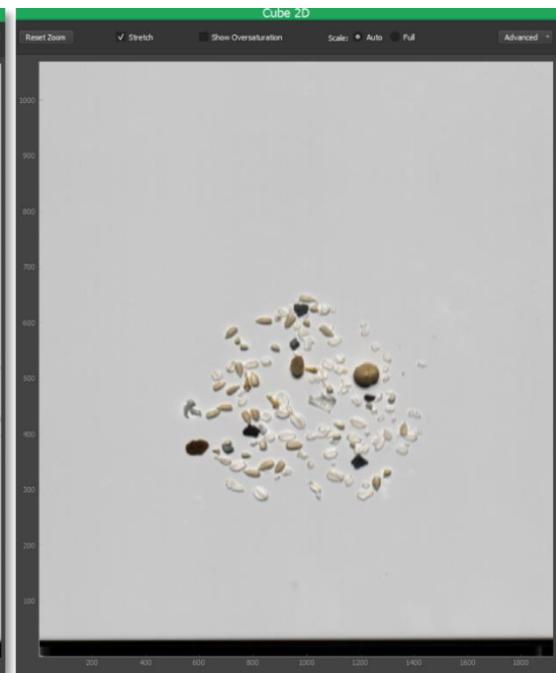
- **Stretch:**

- Activated by default.
- When activated: The scale of the hyperspectral cube is adapted to the size of the 2D Cube display.
- When deactivated: the hyperspectral cube is displayed in its original extent. This extent depends on several settings, such as the **Framerate** and the speed of the conveyer belt.
- To examine the entire data cube, you can scroll around (up/down/left/right).

**Stretch deactivated**



**Stretch activated**



- **Show Oversaturation:**

- Activated by default.
- When activated: Oversaturated pixels are displayed in red in the **Cube 2D View**. Oversaturated pixels will not be included in the mean spectra of ROI markers. When deactivated: Oversaturated pixels will not be highlighted. The oversaturated pixels will be included in the calculation of mean spectra of ROI markers.

- **Scale:**

- **Auto:** The intensity is scaled automatically. The automatic scale aligns the highest measured intensity to the maximum gray scale.
- **Full:** The full scale varies depending on the radiometric resolution of the camera.

- **Advanced:**

- **Export .png:** Export the currently displayed **Cube 2D View** as \*.png file.

## Cube 2D View:

- **Color scheme:**
  - The color scheme in the **Cube 2D View** can be manipulated by the three sliders in red, green and blue in the **Spectral View**.
- **Zoom:**
  - The **Cube 2 D View** can be zoomed in and out by scrolling. The aspect ratio of the pixels remains unchanged.
  - Holding the right mouse button and moving the cursor to the right causes the pixels to be enlarged in X direction.
  - Holding the right mouse button and moving the cursor upwards causes the pixels to be enlarged in Y direction.
  - To reset a zoom, please press **Reset Zoom**.

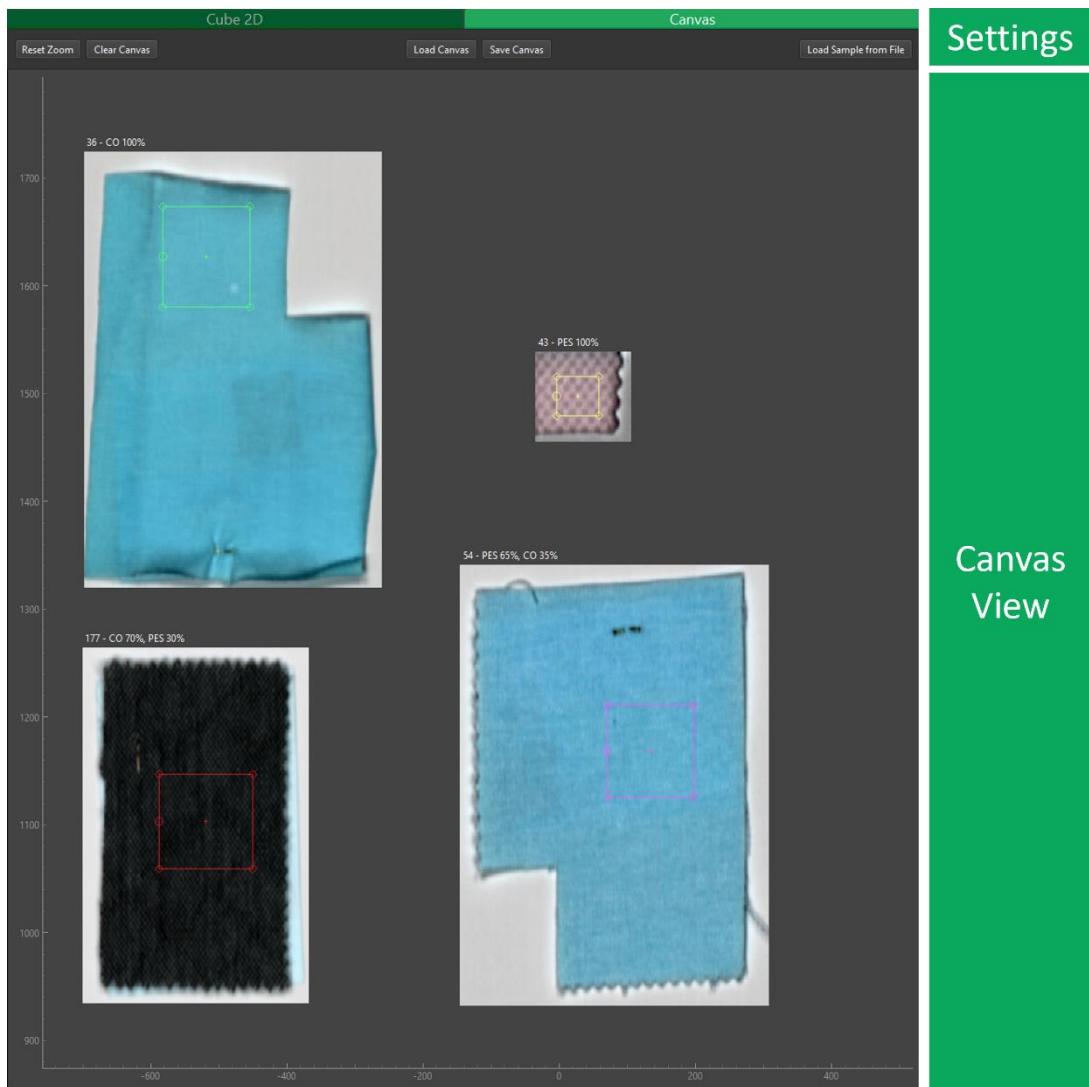
## 4.3 ANALYSIS TAB – CANVAS VIEW

The **Canvas View** enables the visualization, analysis and classification of image snippets that are stored in the **Database**. The **Load into Canvas** button in the **Database tab** can be used to load any snippets from the database into the canvas view. All snippets and the associated ROIs can be freely arranged in **Canvas View**. Snippets and ROI markers can be moved together or separately. New ROI markers can also be created. Please note that only snippets which cover the same wavelength range can be simultaneously loaded into the **Canvas View**!

### Settings:

- **Reset Zoom:**
  - You can zoom in and out as required in the **Canvas View**. The full extent can be restored by pressing **Reset Zoom**.
- **Clear Canvas:**
  - Clears the Canvas View including hyperspectral cube and ROIs
  - A warning will appear before deletion: "Clearing Canvas view will reset all ROI markers saved on the Canvas! Make sure to save your ROIs beforehand."
- **Load Canvas:**
  - Load a previously stored full **Canvas View** including all the snippets it contains.
- **Save Canvas:**
  - Save the currently displayed **Canvas View**, including its contained data (\*.hcr & \*.img).

- **Load Sample from File:**
  - Load a previously created data cube into the canvas view. Accordingly, this does not have to be stored in the database beforehand.

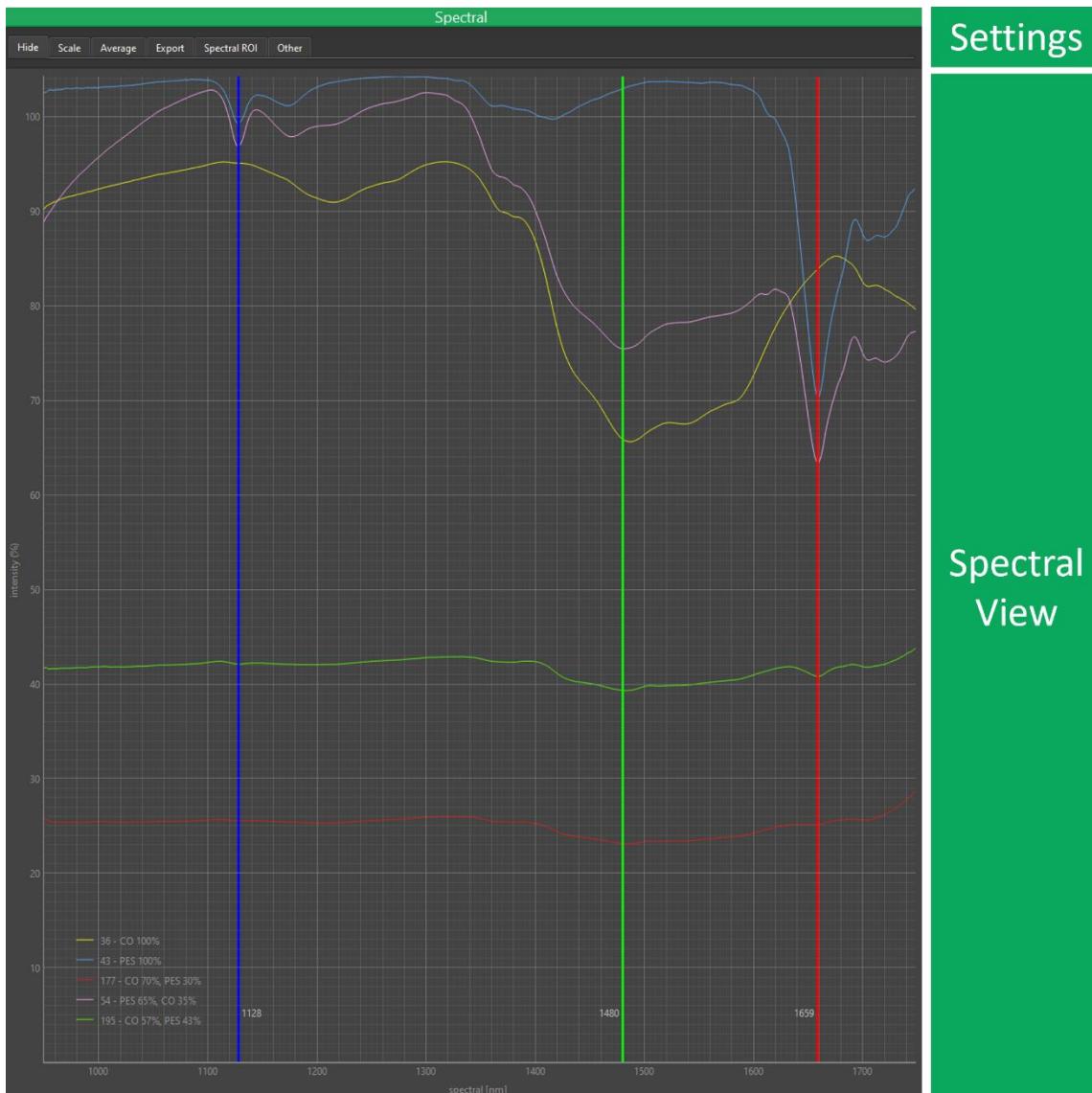


#### 4.4 ANALYSIS TAB - SPECTRAL VIEW

In the **Spectral View**, the spectral intensity curves of pre-defined ROI-classes are displayed.

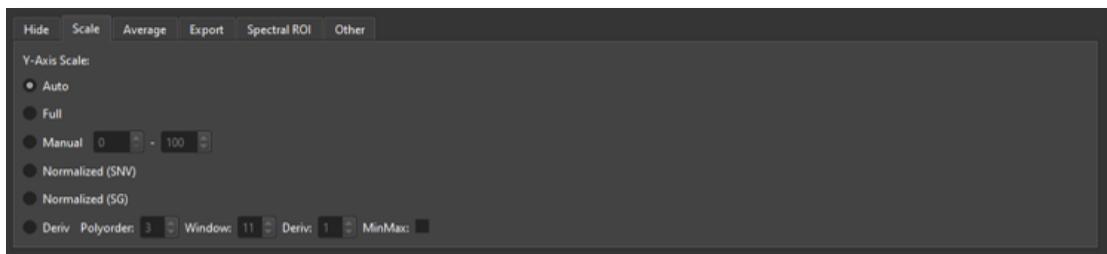
- All spectral curves of all ROIs are displayed, from the **Cube 2D View** as well as from the **Canvas View**. In the settings bar in the **ROI + Ref. window**, the spectral curves of existing ROIs can be displayed or hidden by setting a check mark. For more information on ROI + Ref. window, see chapter 4.5.1.
- By sliding the red, green and blue slider, adjust the color presentation of the currently opened **Cube 2D View** or **Canvas View**.

- By scrolling or holding the right mouse button and moving the mouse pointer in the **Spectral View**, it is possible to zoom in the X direction so that a desired wavelength range is enlarged.



### Settings:

- **Scale:**



Adjust the **Y-axis scale** according to your needs. The intensity level on the Y-axis varies depending on which samples are currently loaded. If the data is already white referenced, the intensity level is given in percentage %, otherwise in the absolute values in digital numbers (DN).

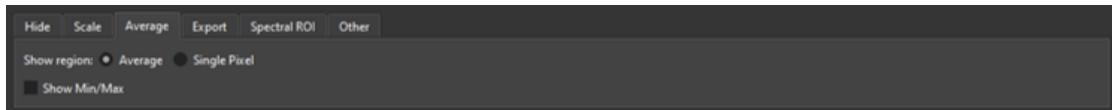
- **Auto:** Automatic adjustment to intensity levels of currently selected ROIs
- **Full:** Full stretch (either % or DN)
- **Manual:** Manual selection of the Y-axis range to be displayed (0–100 % or 0 – max. DN)
- **Normalized (SNV):** SNV (Standard Normal Variate) is calculated by subtracting each spectrum by its own mean and dividing it by its own standard deviation. Therefore, after SNV, each spectrum will have a mean of 0 and a standard deviation of 1.
- **Normalized (SG):** Normalization based on (Stokman and Gevers) Norm us-

$$R_{SG}(\lambda) = \frac{R(\lambda)}{\sum_{i=1}^N R(\lambda_i)} - \min_{j \in [1, N]} \frac{R(\lambda_j)}{\sum_{i=1}^N R(\lambda_i)}$$

ing this formular:

- **Deriv:** Displays the intensity spectra in the first, second or third **derivative**. Possibility of selecting the polyorder and the window. Savitky Golay smoothing is always applied. If the zero derivative is set, the original data is smoothed accordingly. Min-Max normalization by activating **MinMax** checkbox.

- **Average:**



- **Show region – Average:** Provides the intensity values of the entire selected ROI-class as average.
- **Show region – Single Pixel:** Provides the intensity values of the selected ROI-class from the center pixel of the respective ROI (center pixel is marked in ROI).
- **Show Min/Max:** Activate the checkbox to display the value range of the entire ROI from minimum to maximum.

- **Export:**



- **Export .png:** Export the displayed Spectral View as an image (\*.png).
- **Export .csv:** Export the intensity values of the displayed spectral curves in \*.csv file format.

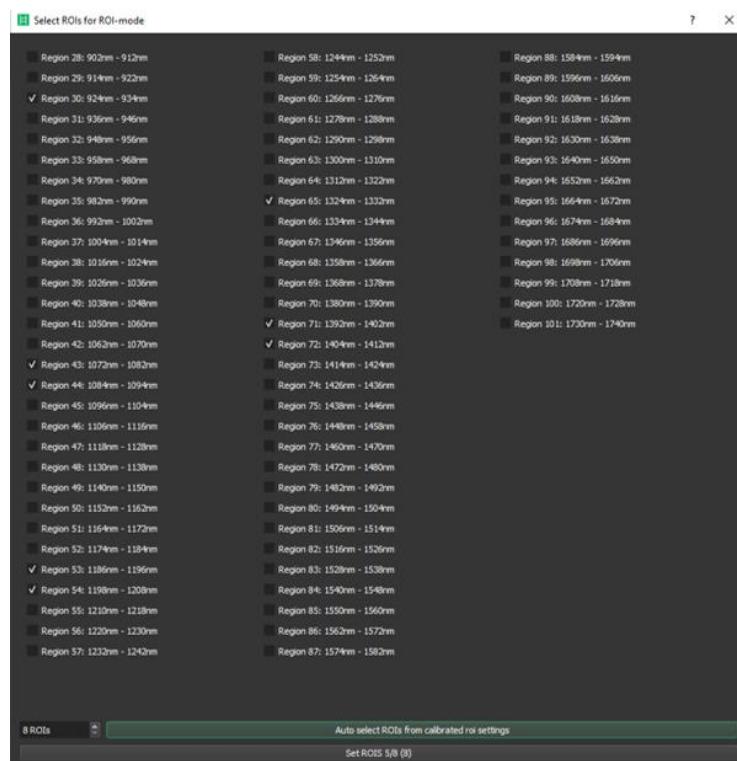
- **Spectral ROI:**

Please note that this function is only available for cameras from the BlackIndustry SWIR series! More information on Spectral ROIs can be found in chapter 7.3. This chapter only describes the basic settings.

In order to use the **Multiple-ROI functionality** (Readout Mode of camera, see chapter 7.3), the desired **Spectral ROIs** have to be defined first. This is done via the **Spectral ROI tab** in the Spectral View:

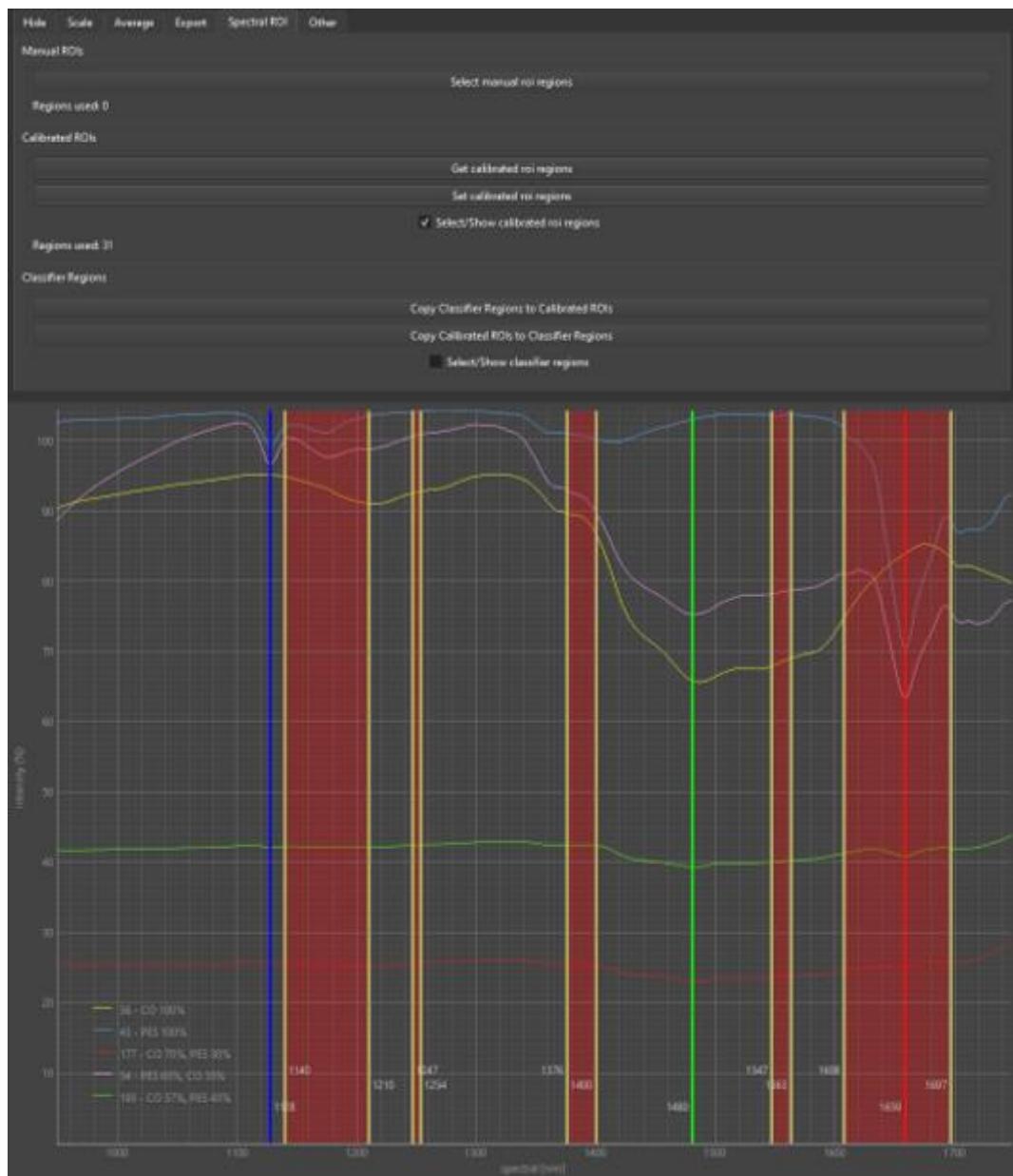
- **Manual ROIs:**

- Option to manually select spectral ROIs for **Mode 2 (Uncalibrated) MULTI-ROI**. Any region of the camera can be selected by clicking on it. If several consecutive regions are selected, one single ROI is created from the sensor regions.
- **Note:** This function is intended for experts.
- A maximum of 8 ROIs can be created in total. The number of regions selected does not matter.
- To confirm the selected regions and transfer them to the camera, press the **Set ROIs X/8** button.
- Alternatively, you may use the **Auto select ROIs from calibrated ROI settings** button to copy calibrated ROIs, that were previously set on the camera, to the manual selection. The program attempts to automatically find the matching regions of your camera (please note that spectral ROIs must first be selected and set via the **Calibrated ROIs** section).

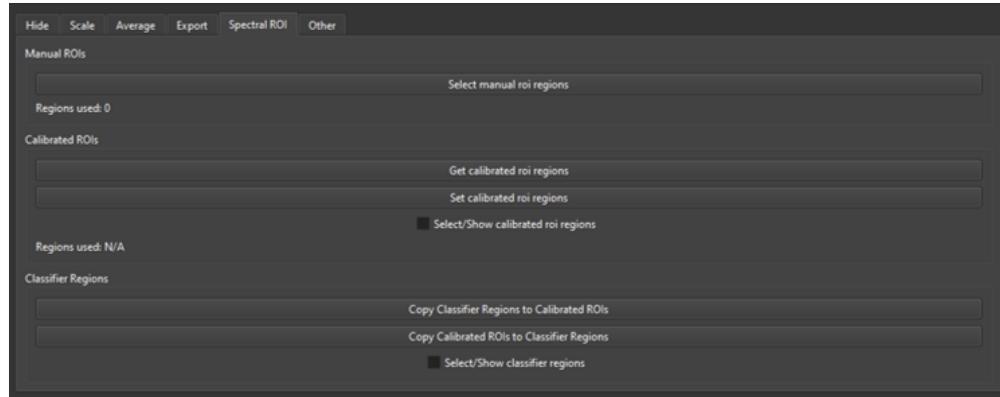


- **Calibrated ROIs:**

- Calibrated spectral ROIs can be selected and shown by activating the checkbox **Select>Show calibrated ROI regions**.
- By double-clicking in the **Spectral View**, spectral ROIs can be created, displayed as red bars. The size of the ROIs can be changed by dragging the sliders. Right-click to delete a region. A maximum of 8 ROIs can be created. The number of selected sensor regions within the ROIs is indicated under **Regions used**.
- Press **Set calibrated ROI regions** to transfer the ROIs to the camera. The Spectral ROIs are stored on the camera until new ROIs are set. Even rebooting the camera does not delete the Spectral ROIs
- To access the spectral ROIs stored on the camera, press the **Get calibrated ROI regions** button.



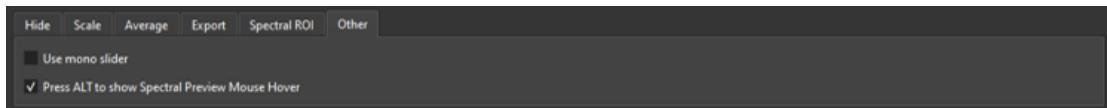
- **Classifier Regions:**



Select up to 8 spectral regions to be considered for training a classifier. The spectral information of the unselected areas is therefore not considered in the classifier. Further information on the classifier can be found in chapter 8.4.

- Activate the checkbox **Select/Show classifier regions** to select classifier regions by double-clicking in the **Spectral View** and dragging the sliders to the desired extent. Right-click to delete a region. By default, the entire wavelength range is considered. For each new classifier, a new decision can therefore be made regarding which spectral regions are of interest.
- Once the suitable spectral regions for an ideal classification have been identified, they can be transferred to the calibrated spectral ROIs via **Copy Classifier Regions to Calibrated ROIs**. This enables the use of the ideal spectral sensor regions in calibrated ROI mode. To transfer and save these sensor regions on the camera, press **Set calibrated ROI regions**.
- Conversely, the calibrated sensor ROIs that have already been created can also be transferred to the classifier regions via **Copy Calibrated ROIs to Classifier Regions**.

- **Other:**



- **Use mono slider:** Activate checkbox to change the color coding of the **Cube 2D View** or **Canvas View** to grayscale. Move the slider to select the desired wavelength to be displayed.
- **Press ALT to show Spectral Preview Mouse Hover:** Activate the checkbox and press the ALT key on the keyboard. If the cursor is now moved over the

samples in the **Cube 2D View** or in the **Canvas View**, a preview of an intensity curve of the corresponding pixel is displayed in the **Spectral View**.

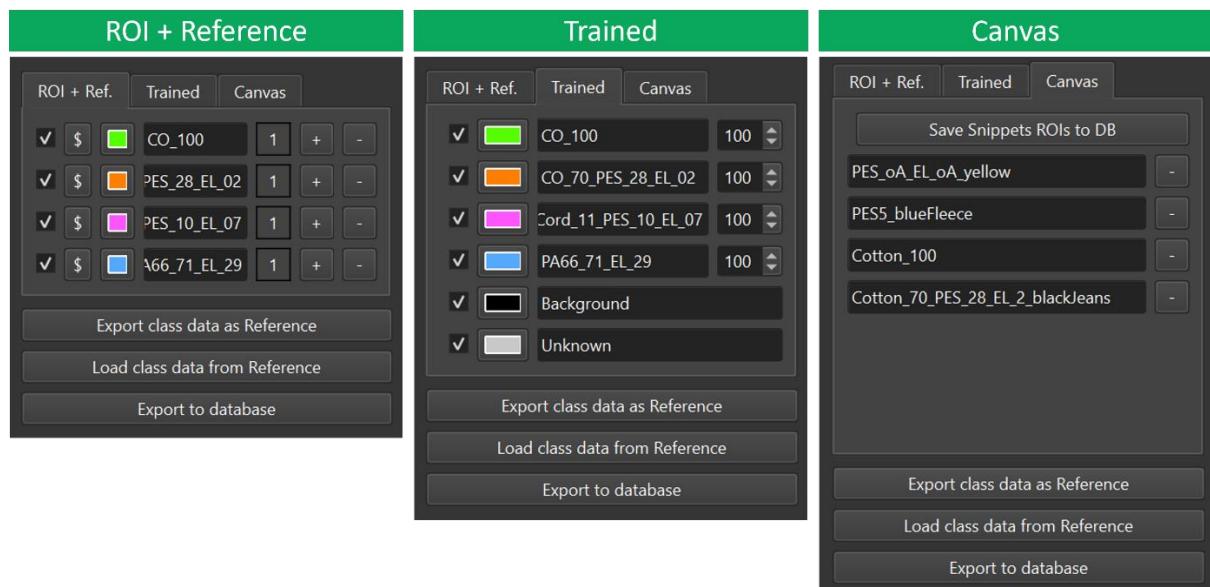
## 4.5 ANALYSIS TAB – SETTINGS SECTION

The **settings section** in the **Analysis Tab** is divided into three sub-categories:

- The **Data and ROI** panel
- The **Analysis** panel
- The **Classifier** panel

### 4.5.1 SETTINGS SECTION – DATA AND ROI

The **Data and ROI** segment in the upper third of the settings section provides information on which ROIs are currently displayed in the **Cube 2D View** and in the **Canvas View**. You can switch between three tabs:



#### 1. ROI + Reference:

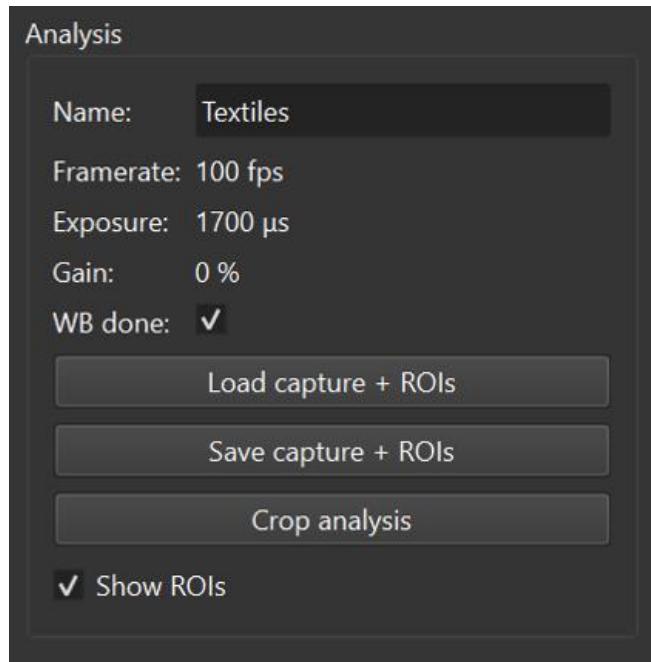
All newly created or imported ROIs are displayed in the **ROI + References (Ref.)** section.

- Assign a color and a meaningful name to each ROI.
- The \$ button can be used to select predefined classes including coloring if required (The classes can be customized according to requirements under /config/sample-table.csv in the program directory). Alternatively, previously created materials from the database can also be assigned.
- Add additional ROIs of the same class or delete them using the + and - symbol.

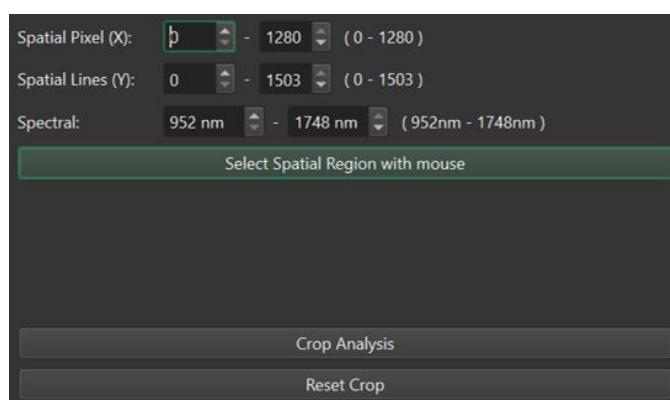
- d) The current number of ROIs displayed for each class is indicated by the number next to it. If you add reference data to the ROI, the background gets colored green. (More information see **Export / Load class data as reference**).
2. **Trained:**
- When a classifier was trained based on ROIs, these ROIs are displayed in the **Trained tab** with color coding and name.
- a) The background is displayed in black by default and unknown, unclassifiable areas are gray by default.
  - b) The number behind each trained ROI indicates the **threshold** for the 'Unknown' class (default 100). If the value is reduced, pixels that are closest to the class but further away than the set threshold are classified as Unknown. The threshold is specified in a Euclidean distance, but in a transformed space, so it has no real equivalent.
3. **Canvas:**
- This tab lists all ROIs and snippets that can be found in the canvas view. By pressing the - button behind it, the ROIs can be removed together with the snippets.
- a) **Save Snippets ROIs to DB:** New ROIs can be created in the **Canvas View** and existing ones can be changed. If the changes are to be saved in the database, press the button. If the snippets are then reloaded from the database, they are displayed as they were when the button was pressed.
4. **Export class data as Reference:**
- When clicked, the displayed ROIs from the **ROI + Ref.** tab are saved as \*.hpr file in a desired storage location. For advanced management of reference data, you might want to use the database.
5. **Load class data from Reference:**
- Previously saved reference ROIs in \*.hpr format are imported and displayed in the **ROI + Ref.** tab. The number behind it is highlighted in green. If the number is 0, only the reference spectra are displayed in the **Spectral View**. If an ROI is added to the currently open view with the +, the spectral information from it is displayed in the **Spectral View**.
6. **Export to database:**
- (RECOMMENDED FOR BEST MANAGEMENT OF SAMPLES) Export a selected area from **Cube 2D View** with all associated information to the **database**. These "Snippets" can later be loaded together in the **Canvas View**. (More information see chapter 8.2 & 8.3).

#### 4.5.2 SETTINGS SECTION – ANALYSIS

In this section on the left side in the **Analysis tab**, you can define a project name for the upcoming analysis. The capture settings for the currently displayed image are reported (**Framerate**, **Exposure**, **Gain**). If a white balance was performed, **WB done** will be checked.



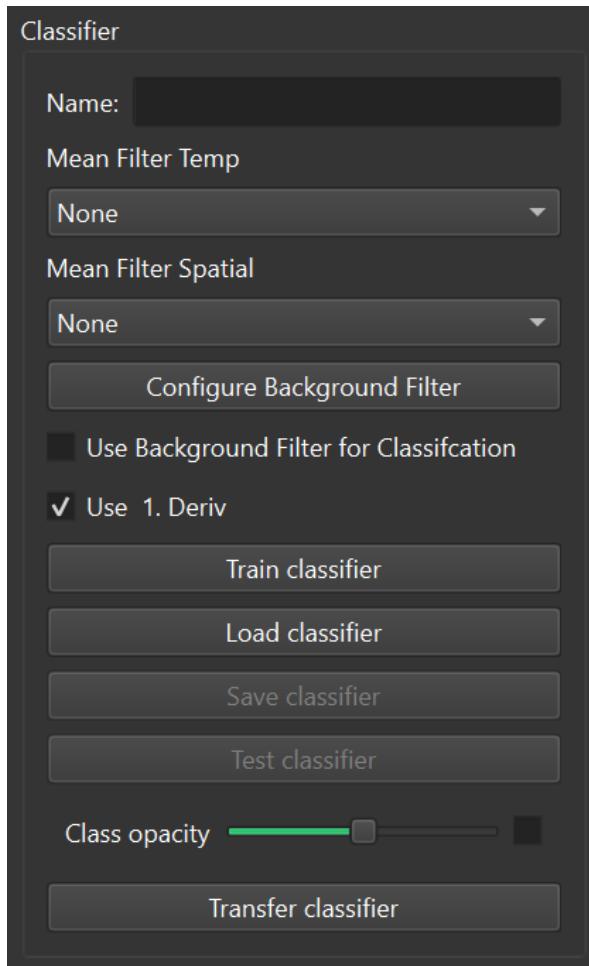
- **Load capture + ROIs:** Load previously captured images including ROI-classes into the **Cube 2D View**.
- **Save capture + ROIs:** Save the current hyperspectral image + ROI-classes (ROI-classes are written into the .hdr file of each ENVI format hyperspectral data cube).
- **Crop analysis:** Crop the region of analysis either in the spatial dimension in x- or y- direction or in the spectral dimension by cropping the wavelength range.
  - Choose **Select Spatial Region with mouse** to select an area on the **Cube 2D View** with the mouse which is to be cut out.
  - Press **Crop Analysis** to confirm the entry.



- **Show ROIs:** To hide all ROIs, uncheck the box next to **show ROIs**.

#### 4.5.3 SETTINGS SECTION – CLASSIFIER

A classifier can be trained and applied via the **Classifier** menu. How to create an ideal classifier is explained in chapter 8.4.



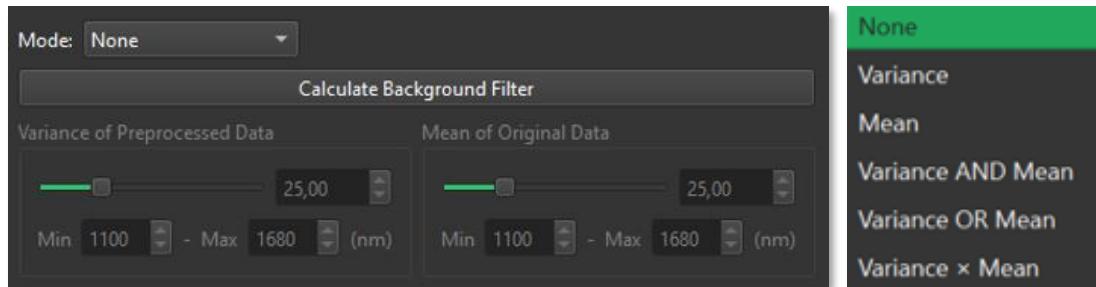
7. **Name:** Assigning a name to the classifier makes it easier to identify it later when the classifier is saved.

- **Mean Filter Temp:** By setting a mean filter in the temporal direction, pixel values in a defined neighborhood (3 or 5 pixels) are replaced by their mean values. This leads to an effective noise reduction.
- **Mean Filter Spatial:** By setting a mean filter in the spatial direction, pixel values in a defined neighborhood (3 or 5 pixels) are replaced by their mean values. This leads to an effective noise reduction.

8. **Configure Background Filter** (see also chapter 8.4.2):

- The background filter filters out the background of the image so that it is not included in the later classification.
- a) Select a **Mode** (None / Variance / Mean / Variance AND Mean / Variance OR Mean / Variance x Mean) (More information see chapter 8.4.2).

- b) Depending on the Mode, change the settings of **Variance of Preprocessed Data** and/or **Mean of Original Data**.
- c) Press **Calculate Background Filter** to calculate the background filter with the currently set variance and /or mean values. Depending on the image size, it may take a few seconds. The background filter is displayed in the **Cube 2D View** or **Canvas View**. The darker areas are marked as background. The light areas should mark the objects of interest (see chapter 8.4.2).
- d) The background filter can now be modified in real time using the variance and/or mean settings.

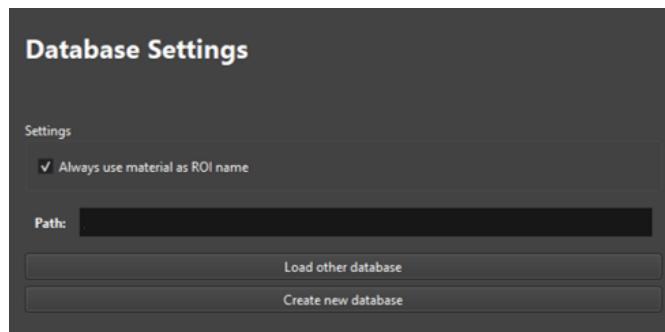


9. **Use Background Filter for Classification:** Activate the checkbox to include the Background Filter in the Classification.
10. **Use 1. Deriv:** Activate the checkbox to consider the 1st derivation of the data for the training of the classifier. For more information, see chapter 8.4.1.
11. **Train classifier:** Press as soon as all relevant settings have been made, and the classifier is to be trained. This may take a few seconds.
12. **Load classifier:** Load an existing classifier.
13. **Save classifier:** Save the currently loaded classifier so that it can be applied to a different dataset.
14. **Test classifier:** Press to apply the currently loaded classifier to the data in the Cube 2D View or Canvas View.
15. **Class opacity:** Slider for setting the opacity of the classification display. Uncheck the box on the right to hide the classification results.
  - **Transfer classifier:** For BlackIndustry SWIR cameras with software version 1.0.13 and later only. Once a classifier was created, it can be transferred to the currently connected camera. More information on On-camera classifier handling, see chapter 8.5.

## 5 BACKSTUDIO – DATABASE

The **BlackStudio Database** enables storage, sorting and filtering of collected data, the so-called **Snippets**. This chapter introduces the structure and main features of the database. Step-by-step instructions for creating and working with snippets can be found in chapter 8.2 and 8.3.

When the BlackStudio software is started for the first time, you will be asked for the storage location of the database. If this is not subsequently changed, it remains unchanged. In the **Settings tab** of the software in the **Database settings**, the storage path can be checked at any time, another database can be loaded, or a new one can be created. As the database is stored externally, it can also be copied and thus backed up.



### 5.1 DATABASE – OVERVIEW

The database consists of the **Snippets Collection** and seven tabs for each database category. On the left-hand side there is a filter option and the preview area of the snippets.

Filter + Preview		Categories		Snippets Collection																																																																																																																																																																																																																																																																																																										
<input type="button" value="Capture"/> <input type="button" value="Analyze"/> <input type="button" value="Database"/> <input type="button" value="Settings"/> <input type="button" value="Menue"/>		<input type="button" value="Sel. Effects"/>		<table border="1"> <thead> <tr> <th colspan="2">Snippets Collection</th> <th colspan="2">Material Category</th> <th colspan="2">Materials</th> <th colspan="2">Background material</th> <th colspan="2">Owner</th> <th colspan="2">Location</th> <th colspan="2">Application Area</th> <th colspan="2">Camera model</th> <th colspan="2">Serial number</th> <th colspan="2">Camera mode</th> <th colspan="2">Record date</th> <th colspan="2">Wavelength</th> <th colspan="2">Whitebalanced</th> <th colspan="2">Frame rate</th> <th colspan="2">Exposure</th> <th colspan="2">Gain</th> <th colspan="2">Verified</th> <th colspan="2">Verified by</th> </tr> <tr> <th>Preview</th> <th>Name</th> <th>Description</th> <th>Materials</th> <th>Background material</th> <th>Owner</th> <th>Location</th> <th>Application Area</th> <th>Camera model</th> <th>Serial number</th> <th>Camera mode</th> <th>Record date</th> <th>Wavelength</th> <th>Whitebalanced</th> <th>Frame rate</th> <th>Exposure</th> <th>Gain</th> <th>Verified</th> <th>Verified by</th> </tr> </thead> <tbody> <tr> <td></td> <td>Wood_13</td> <td>Wood 100% full red Maple</td> <td>WC</td> <td>White</td> <td>HAIP Solutions</td> <td>Hammer</td> <td>Research</td> <td>BlackStudio SWIR 1.7 Max (DP)</td> <td>3821-000018</td> <td>Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm</td> <td>2023-01-23, 16:56:41</td> <td>950nm - 1740nm</td> <td>Yes</td> <td>100</td> <td>4000</td> <td>1</td> <td>No</td> <td>UNDEFINED</td> </tr> <tr> <td></td> <td>Wood_10</td> <td>Wood 100% full</td> <td>WC</td> <td>White</td> <td>HAIP Solutions</td> <td>Hammer</td> <td>Research</td> <td>BlackStudio SWIR 1.7 Max (DP)</td> <td>3821-000018</td> <td>Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm</td> <td>2023-01-23, 16:56:41</td> <td>950nm - 1740nm</td> <td>Yes</td> <td>100</td> <td>4000</td> <td>1</td> <td>No</td> <td>UNDEFINED</td> </tr> <tr> <td></td> <td>Wood_2</td> <td>Wood 100% densit</td> <td>WC</td> <td>White</td> <td>HAIP Solutions</td> <td>Hammer</td> <td>Research</td> <td>BlackStudio SWIR 1.7 Max (DP)</td> <td>3821-000018</td> <td>Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm</td> <td>2023-01-23, 16:56:41</td> <td>950nm - 1740nm</td> <td>Yes</td> <td>100</td> <td>4000</td> <td>1</td> <td>No</td> <td>UNDEFINED</td> </tr> <tr> <td></td> <td>Silk_100_4</td> <td>Silk 100% Musk</td> <td>S</td> <td>White</td> <td>HAIP Solutions</td> <td>Hammer</td> <td>Research</td> <td>BlackStudio SWIR 1.7 Max (DP)</td> <td>3821-000018</td> <td>Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm</td> <td>2023-01-23, 16:56:41</td> <td>950nm - 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1740nm</td> <td>Yes</td> <td>100</td> <td>1000</td> <td>0</td> <td>No</td> <td>UNDEFINED</td> </tr> <tr> <td></td> <td>43_PES_100%</td> <td>100% PES</td> <td>PES</td> <td>White</td> <td>HAIP Solutions</td> <td>UNDEFINED</td> <td>UNDEFINED</td> <td>BlackStudio SWIR 1.7 Max</td> <td>3821-000018</td> <td>Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm</td> <td>2024-09-11,11:22:01</td> <td>950nm - 1740nm</td> <td>Yes</td> <td>100</td> <td>1000</td> <td>0</td> <td>No</td> <td>UNDEFINED</td> </tr> <tr> <td></td> <td>177_CO_70%, PES_30%</td> <td>70% PES 30% Cotton</td> <td>Cotton 100%</td> <td>White</td> <td>HAIP Solutions</td> <td>UNDEFINED</td> <td>UNDEFINED</td> <td>BlackStudio SWIR 1.7 Max</td> <td>3821-000018</td> <td>Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm</td> <td>2024-09-11,11:22:01</td> <td>950nm - 1740nm</td> <td>Yes</td> <td>100</td> <td>1000</td> <td>0</td> <td>No</td> <td>UNDEFINED</td> </tr> <tr> <td></td> <td>34_PES_50%, CO_30%</td> <td>50% PES 30% Cotton</td> <td>PES</td> <td>White</td> <td>HAIP Solutions</td> <td>UNDEFINED</td> <td>UNDEFINED</td> <td>BlackStudio SWIR 1.7 Max</td> <td>3821-000018</td> <td>Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm</td> <td>2024-09-11,11:22:01</td> <td>950nm - 1740nm</td> <td>Yes</td> <td>100</td> <td>1000</td> <td>0</td> <td>No</td> <td>UNDEFINED</td> </tr> <tr> <td></td> <td>155_CO_50%, PES_40%</td> <td>50% Cotton 40% Polyester</td> <td>Cotton 100%</td> <td>White</td> <td>HAIP Solutions</td> <td>UNDEFINED</td> <td>UNDEFINED</td> <td>BlackStudio SWIR 1.7 Max</td> <td>3821-000018</td> <td>Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm</td> <td>2024-09-11,11:22:01</td> <td>950nm - 1740nm</td> <td>Yes</td> <td>100</td> <td>1000</td> <td>0</td> <td>No</td> <td>UNDEFINED</td> </tr> <tr> <td></td> <td>165_Kat_Cordex</td> <td>PABA 7%</td> <td>Cordex 1%</td> <td>UNDEFINED</td> <td>White</td> <td>HAIP Solutions</td> <td>UNDEFINED</td> <td>UNDEFINED</td> <td>BlackStudio SWIR 1.7 Max (DP)</td> <td>3821-000018</td> <td>Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm</td> <td>2024-12-16,14:20:35</td> <td>950nm - 1740nm</td> <td>Yes</td> <td>100</td> <td>2500</td> <td>0</td> <td>No</td> <td>UNDEFINED</td> </tr> </tbody> </table>															Snippets Collection		Material Category		Materials		Background material		Owner		Location		Application Area		Camera model		Serial number		Camera mode		Record date		Wavelength		Whitebalanced		Frame rate		Exposure		Gain		Verified		Verified by		Preview	Name	Description	Materials	Background material	Owner	Location	Application Area	Camera model	Serial number	Camera mode	Record date	Wavelength	Whitebalanced	Frame rate	Exposure	Gain	Verified	Verified by		Wood_13	Wood 100% full red Maple	WC	White	HAIP Solutions	Hammer	Research	BlackStudio SWIR 1.7 Max (DP)	3821-000018	Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm	2023-01-23, 16:56:41	950nm - 1740nm	Yes	100	4000	1	No	UNDEFINED		Wood_10	Wood 100% full	WC	White	HAIP Solutions	Hammer	Research	BlackStudio SWIR 1.7 Max (DP)	3821-000018	Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm	2023-01-23, 16:56:41	950nm - 1740nm	Yes	100	4000	1	No	UNDEFINED		Wood_2	Wood 100% densit	WC	White	HAIP Solutions	Hammer	Research	BlackStudio SWIR 1.7 Max (DP)	3821-000018	Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm	2023-01-23, 16:56:41	950nm - 1740nm	Yes	100	4000	1	No	UNDEFINED		Silk_100_4	Silk 100% Musk	S	White	HAIP Solutions	Hammer	Research	BlackStudio SWIR 1.7 Max (DP)	3821-000018	Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm	2023-01-23, 16:56:41	950nm - 1740nm	Yes	100	4000	1	No	UNDEFINED		Linen_100_4	Linen 100% full Individu	L	White	HAIP Solutions	Hammer	Research	BlackStudio SWIR 1.7 Max (DP)	3821-000018	Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm	2023-01-23, 16:56:41	950nm - 1740nm	Yes	100	4000	1	No	UNDEFINED		Linen_100_4	Linen 100% full Individu	L	UNDEFINED	HAIP Solutions	Hammer	Research	BlackStudio SWIR 1.7 Max (DP)	3821-000018	Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm	2023-01-23, 16:56:41	950nm - 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1740nm	Yes	100	1000	0	No	UNDEFINED		165_Kat_Cordex	PABA 7%	Cordex 1%	UNDEFINED	White	HAIP Solutions	UNDEFINED	UNDEFINED	BlackStudio SWIR 1.7 Max (DP)	3821-000018	Mode 1: 950-1740nm, 1000-1800nm, 1800-1900nm, 1900-2000nm	2024-12-16,14:20:35	950nm - 1740nm	Yes	100	2500	0	No	UNDEFINED
Snippets Collection		Material Category		Materials		Background material		Owner		Location		Application Area		Camera model		Serial number		Camera mode		Record date		Wavelength		Whitebalanced		Frame rate		Exposure		Gain		Verified		Verified by																																																																																																																																																																																																																																																																												
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## 5.2 DATABASE – SNIPPETS COLLECTION

A **snippet** is a previously defined section of a hyperspectral image cube that is to be saved in the database. Further information on creating snippets can be found in chapter 8.2.

The following information is stored in the **Snippets Collection** for each snippet:

Information on snippet	Added manually / automatically?
ID	Auto
Preview image	Manual
Name	Manual (via Category)
Description	Manual (via Category)
Materials	Manual (via Category)
Background material	Manual (via Category)
Owner	Manual (via Category)
Location	Manual (via Category)
Application Area	Manual (via Category)
Camera model	Auto
Serial number	Auto
Camera mode	Auto
Record date	Auto
Wavelengths	Auto
Whitebalanced	Auto
Framerate	Auto
Exposure	Auto
Gain	Auto
Verified	Manual
Verified by	Manual (via Category)
Verification time	Auto
Change time	Auto
Creation time	Auto

The following actions can be executed in the **Snippets Collection**:

- **Select all:** Press to select all snippets in the database. Selected snippets will be marked in green.
- **Edit:** Select one snippet to edit its information.
- **Delete:** Select at least one snippet to delete them.

- **Visible columns:** Press to select which information columns will be shown in the Snippets Collection. **Tip:** Deactivating the preview image reduces the size of the rows.
- **Export data to new Database (DB):** Select at least one snippet and press the button to export the data to a new database folder.
- **Load into Canvas:** Select at least one snippet that should be imported into the Canvas View in the Analysis tab (More information see 8.3).

### 5.3 DATABASE – CATEGORIES

There are seven category groups, which help to categorize the snippet as desired:

- **Material Category:** A material category can be assigned to each snippet. For example, a snippet made of cotton belongs to the material category textiles, pure fibers, or similar.
- **Materials:** Assign a material to each snippet. These are listed here. Each material can also be assigned an ROI color.
- **Owners:** If there are different owners of the snippets, they can be defined. Different editors can also be defined here.
- **Locations:** To assign different locations to the snippets, they can be created here.
- **Application Area:** Define any application areas to which the snippets can be assigned.
- **Background Materials:** Possibility to define different background materials that are visible in the background of the snippets.
- **Verified by:** If it is a verified snippet or is to be assigned to a particular person, any number of names/abbreviations, etc. can be added to this category.

Any number of features can be added to each category, allowing the best possible categorization of the snippets.

A new feature can be **added**, **edited** and **deleted** in each of the seven tabs. You can also select a feature that will be displayed by **default** when a new snippet is created.

Material Categories			Default:	UNDEFINED	Set default
	Label	Color			
1	WO	96,127,61	Textiles		
2	SI	69,89,127	Textiles		
3	LI	127,127,127	Textiles		
4	Cordura	255,170,127	Textiles		
5	EL	130,253,255	Textiles		
6	PA	255,170,255	Textiles		
7	PES	0,170,0	Textiles		
8	Cotton 100%	253,255,0	Textiles		
9	PVC	170,85,127	Plastics		
10	PET	85,170,255	Plastics		
11	UNDEFINED	No color			

## 5.4 DATABASE – FILTER

The database **Filter** offers the option of filtering the snippet collection according to the saved categories or capture settings. After applying the filter, only the snippets that match the selected categories are displayed.

Filter:

**Materials (0)**  

- UNDEFINED
- Plastics
- Textiles
- cotton

**Background materials (0)**  

- UNDEFINED
- White
- Black

**Owner (0)**  

- UNDEFINED
- HAIP Solutions
- Customer 1

**Locations (0)**  

- UNDEFINED
- Hannover
- Germany
- World

**Application area (0)**  

- UNDEFINED
- Research
- Optical Sorting

**Capture settings**

Framerate  - 
Exposure  - 
Gain  -

Reset filter
Refresh

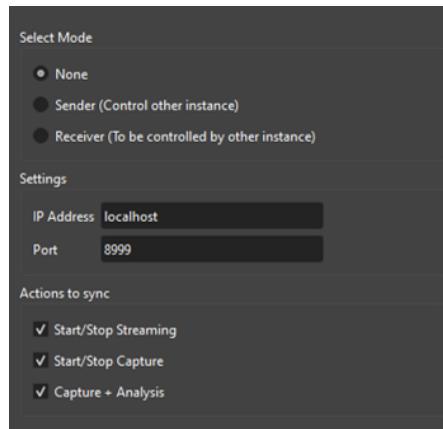
**Options**

- Whitebalance
- Verified

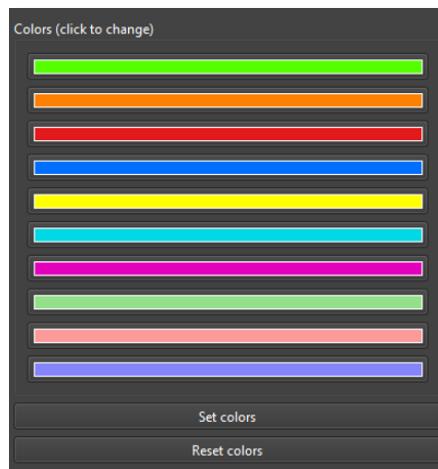
## 6 BLACKSTUDIO – SETTINGS TAB

The **Settings tab** in BlackStudio offers the opportunity to make general settings for software use. The settings are divided into the following categories:

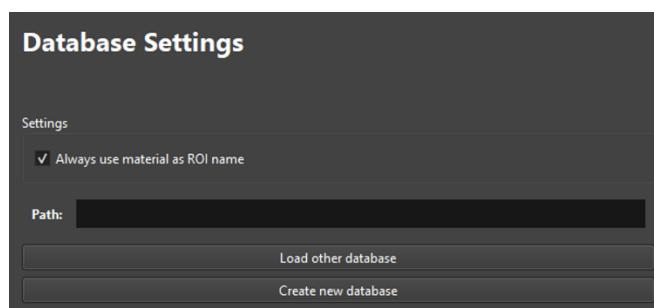
- **About:** Retrieve information about the software version, contact information of HAIP Solutions, etc.
- **Sync:** Settings to synchronize two separate BlackStudio applications so that desired actions will also be activated on the receiver when triggered on the sender.



- **Colors:** Settings to change the color coding that is used in BlackStudio for displaying ROIs and the corresponding spectral curves.



- **Database:** View and change the storage location of the database. Load or create another database.

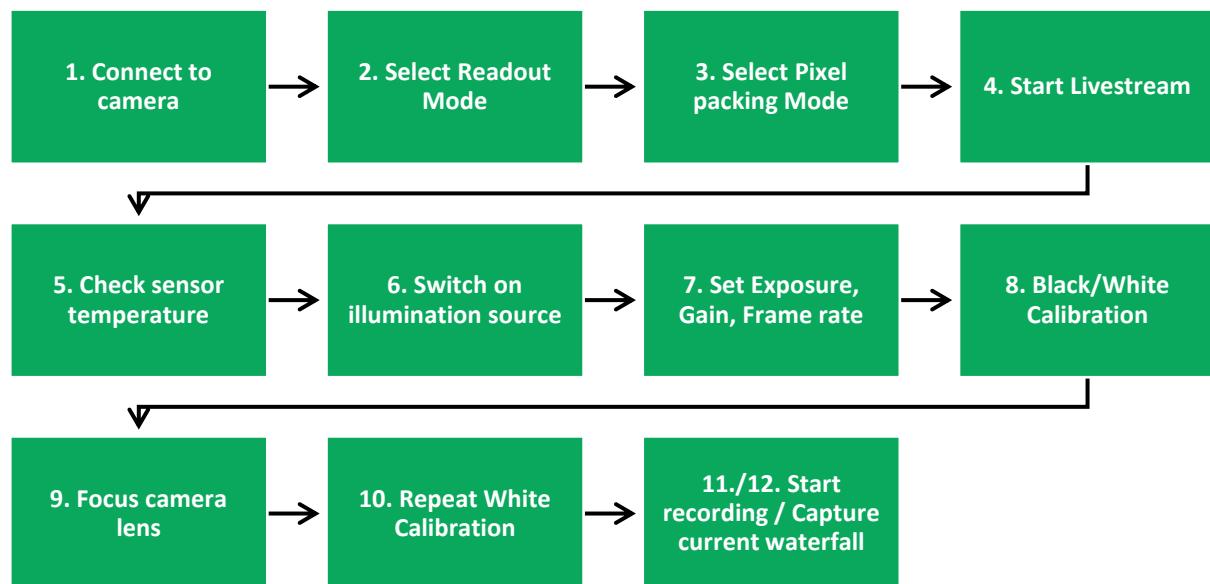


## 7 DATA ACQUISITION IN BLACKSTUDIO

This chapter describes the most important operations and functionalities that should be considered when acquiring data with BlackStudio. Please note that not all functionalities in BlackStudio are available for all BlackIndustry camera models.

### 7.1 DATA ACQUISITION WORKFLOW

For successful data acquisition with a HAIP BlackIndustry camera and the BlackStudio software, the following basic workflow should be implemented. Further functionalities, such as the external trigger functionality, are explained in later chapters. Data acquisition is performed exclusively in the **Capture tab** of BlackStudio.



1. **Connect to camera:** If the camera is connected via the IP address or another network, the product name, serial number and version number are displayed
2. **Select Readout Mode:** Select a Mode that fits your requirements. The maximum achievable frame rate may change depending on the mode. As soon as the readout mode is changed, new black and white balances must be performed.
3. **Select Pixel Packing Mode:** Select a preferred data size (**8-bit / 10-bit**). The 10-bit data can be packed for the transmission process (**5/4 or 3/2**) to utilize the Ethernet line efficiently in cost of computational overhead. Alternatively select **Classified Color Mode** (more information on this in chapter 8.5). If data is lost, this is displayed in the FPS information. The pixel packing mode should be adjusted accordingly.
4. **Start Livestream:** Livestream in all four livestream windows.
5. **Check sensor temperature:** Spectrometer temperature only for BlackIndustry SWIR 1.7 /Max series.

a. **Sensor temperature:**

Caution: Changing sensor temperature always affects the spectral data.

Always record Black/White Balance after the stabilized temperature is reached.

- i. A recording with the camera may only be started once a temperature of 55 °C [131 °F] has been reached. Otherwise, you risk incorrect data.
- ii. Once the target temperature has been reached, the camera automatically regulates the temperature level.
- iii. Please refer to the blue status LED at the back of the camera to check if the correct sensor temperature has been reached.

b. **Spectrometer temperature:**

- i. Internal temperature control. There is no target temperature required.

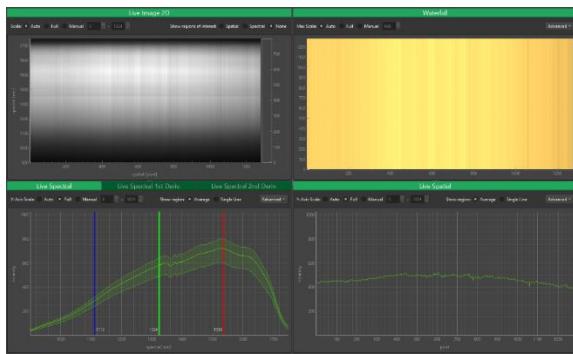
6. **Switch on illumination source** (if not yet done).
7. **Set Exposure, Gain, Frame rate:** Adjust Exposure & Analog Gain settings to achieve an adequate illumination level and to eliminate oversaturation (for 10-bit Pixel Packing, indicated in red). **Caution: The exposure value should always be increased first before the gain value is increased.**
  - a. Test the settings with your samples.
  - b. Live Spectral View: Enable **Show Min/Max** → Ideal **Intensity at max. 80 %**.
  - c. Set the desired **frame rate** in fps/Hz → Maximum frame rate depends on readout mode (max. 1330 Hz).



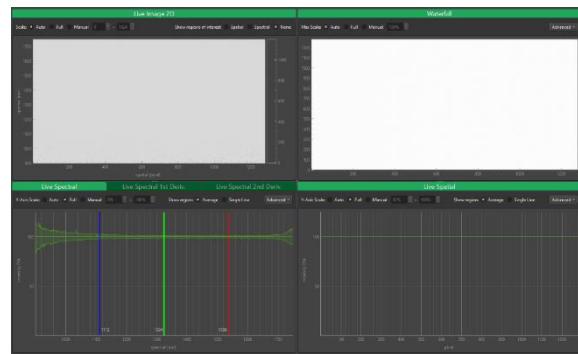
## 8. Black/White Calibration:

- Black Calibration:** Cover the camera lens entirely with dark object and press **Record Blackbalance**.
- White Calibration:** Capture an image line from an entirely white surface and press **Record Whitebalance**.
- Each black and white calibration created is automatically saved as a file in the background. If BlackStudio has been closed, the calibrations can be re-loaded using **Load last Black/Whitebalance**.

**Before Calibration**



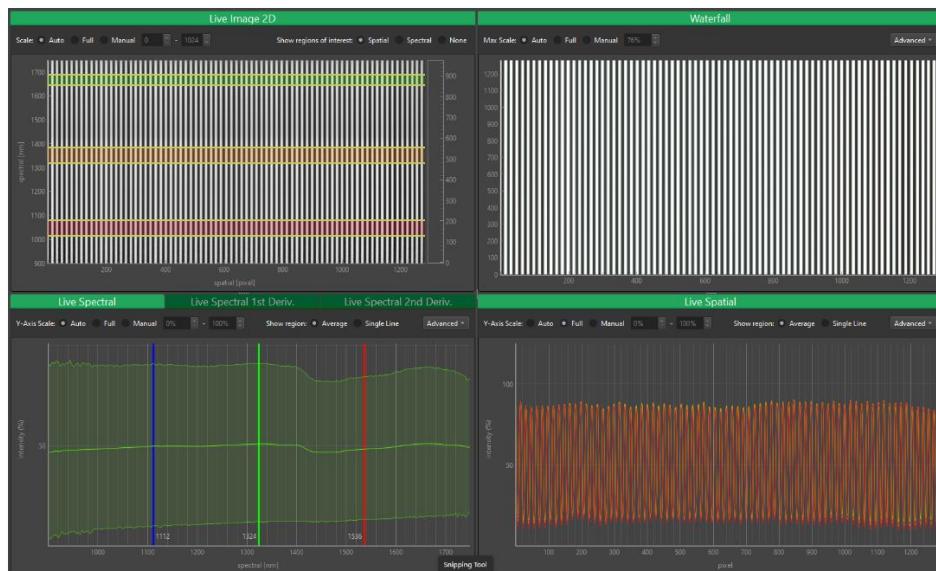
**After Calibration**



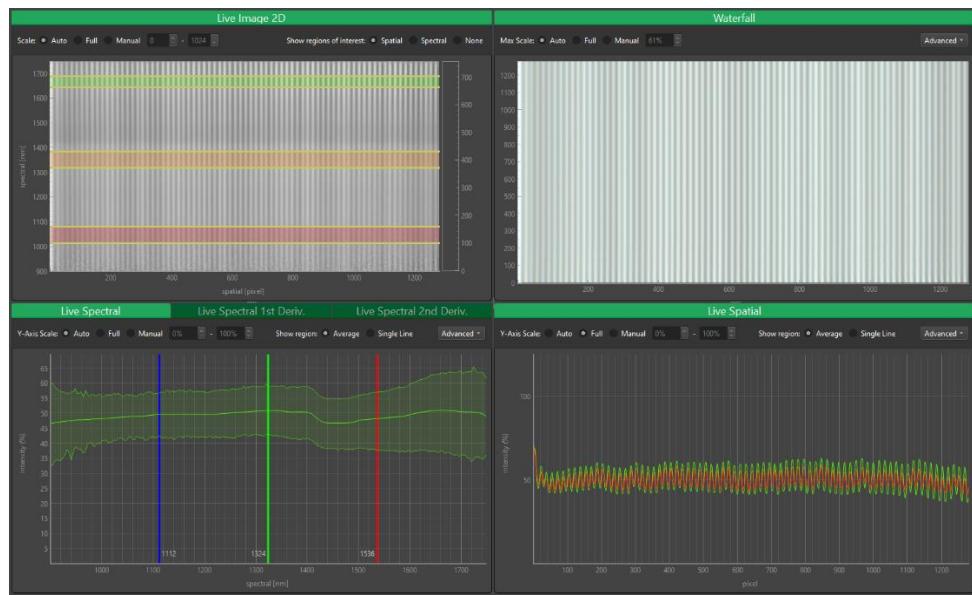
## 9. Focus camera lens:

- Place a focus control paper sheet under the camera lens so that the distance between camera lens and scanning area remains the same.
- Ensure that the lines are at a ninety-degree angle to the scanning direction of the camera.
- Place 3 spatial ROIs in the **Live Image 2D window** (top, middle, bottom).
- Focus the camera lens manually by turning the wheel on the lens.

**Focused:** Wide intensity range in **Live Spatial View**.



### Unfocused: Small intensity range in Live Spatial View.



10. **Repeat White Calibration:** see step 8.

11. **Start recording:**

- By pressing the button **Start Recording**, each pixel line scanned by the camera is recorded and consecutively chained together.
- This is represented by the **Waterfall window** where each new pixel line is appended from above to the lines already captured.
- Pressing **Stop Recording** stops the recording of the pixel lines, and the data generated is automatically opened in the **Cube 2D View** of BlackStudio.

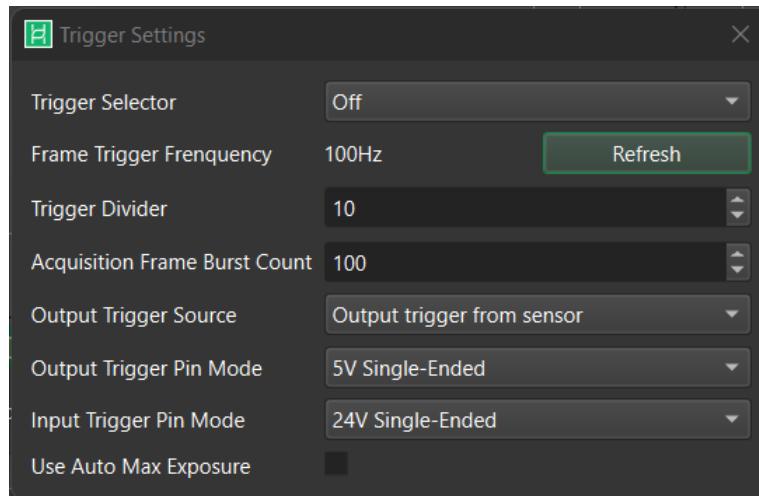
12. **Capture current waterfall:**

- Pressing the button **Capture current waterfall** captures all currently displayed pixel lines in the waterfall window.
- Afterwards you will be redirected to the **Analysis tab**, where the data is displayed in the Cube 2D window.

## 7.2 DATA ACQUISITION - EXTERNAL TRIGGER FUNCTIONALITY

The HAIP BlackIndustry SWIR 1.7 / Max camera supports external trigger functionality. A trigger is an electrical signal that triggers the sensor and starts the exposure. By using the **Trigger** function, the trigger can be activated from outside the camera. This enables optimal synchronization between the camera and the transmitter of the signal, for example a conveyor belt.

The following **Trigger settings** can be selected in BlackStudio:



- **Trigger Selector:**

Choose between two external trigger modes. Detailed information on both modes in chapters 7.2.1 and 7.2.2.

- **Frame Start**
- **Frame Burst Start**

- **Frame Trigger Frequency:**

Displays the currently selected frame rate / frame trigger frequency in Hertz (Hz).

- **Trigger Divider:**

Select the even integer divider for the external trigger signal (1:1 - 1:100).

- **Acquisition Frame Burst Count:**

Select how many frames should be acquired in Frame Burst Start Mode.

- **Output Trigger Source:**

Select the desired signal output. More information on the output options, see chapter 7.2.3.

- **Output trigger from sensor**
- **Rising edge output trigger from external**
- **Falling edge output trigger from external**

- **Output Trigger Pin Mode:**

Please select the desired output pin assignment. More information on Pin assignment see User Manual BlackIndustry SWIR 1.7 / Max camera, chapter 5.5.

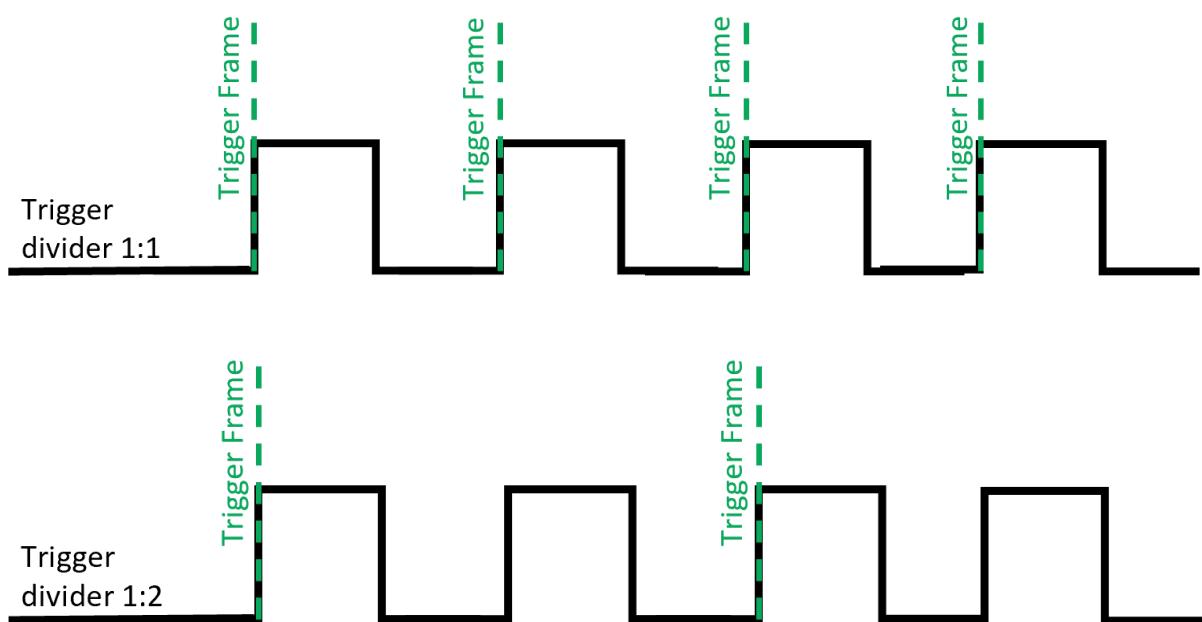
- **5 V Single-Ended**
- **24 Single-Ended**

- **Differential**
- **Input Trigger Pin Mode:**  
Please select the desired output pin assignment. More information on Pin assignment see User Manual BlackIndustry SWIR 1.7 / Max camera, chapter 5.5.
  - **5 V Single-Ended**
  - **24 Single-Ended**
  - **Differential**
- **Use Auto Max Exposure:**  
The maximum value of exposure varies depending on the frame trigger frequency/framerate. Activate the checkbox to ensure that the maximum exposure is set automatically. Otherwise, exposure can be set manually.

## 7.2.1 EXTERNAL TRIGGER - FRAME START MODE

The **Frame Start Mode** enables the integration of a constant external trigger signal into the camera system. Depending on the desired frequency, the sensor is triggered when the edge of the signal rises.

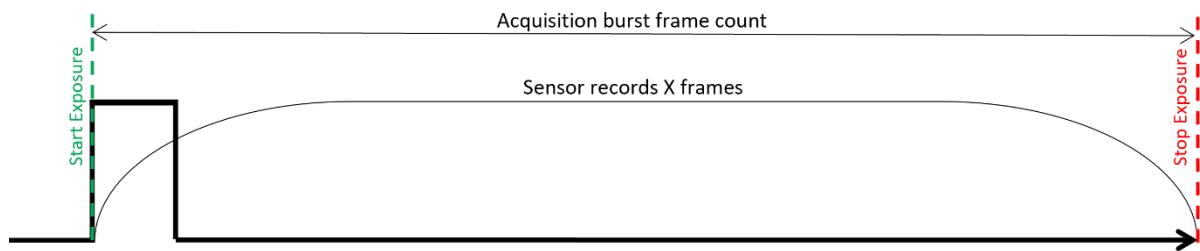
1. The external trigger signal is fed through one of the pins of the M12 connector into the trigger divider of the camera. The divider divides the signal by even integer values or 1 (1, 2, 4, 6, 8, 10, ..., 100). The selectable integer dividers range from 1:1 to 1:100.
2. The processed trigger signal is sent to the sensor to start the exposure.



## 7.2.2 EXTERNAL TRIGGER - FRAME BURST MODE

With the **Frame Burst Start Mode**, an external trigger signal can also be integrated into the BlackIndustry SWIR 1.7 / Max camera. With this mode, it is possible to specify how many frames/lines are to be transmitted. Thus, a series of frames/lines is captured. If, for example, a signal is triggered by an object on a conveyor belt, the trigger of the camera sensor is activated for a defined interval so that the entire object can be scanned. Once this is done, the transmission stops automatically.

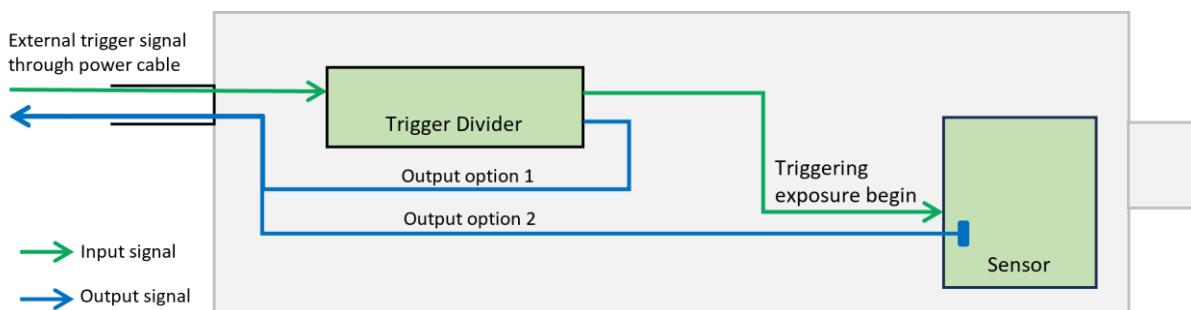
- The external trigger signal is fed through one of the pins of the M12 connector and sent to the camera sensor to directly start the exposure.
  - No trigger divider is utilized in this mode.
  - The frame rate, exposure and gain settings are specified by the user.



## 7.2.3 EXTERNAL TRIGGER - TRIGGER OUTPUT

In addition to receiving, the BlackIndustry SWIR 1.7 / Max camera can also be used as a transmitter by emitting various trigger signals. You may select your preferred output option:

- **Output trigger from sensor:** The output signal is generated by the camera's sensor. The rising edge signal is output only when the sensor is streaming.
- **Rising edge output trigger from external:** The processed input trigger signal is provided. The rising edge signal is output as soon as an external signal comes in and gets divided.
- **Falling edge output trigger from external:** The processed input trigger signal is provided. The falling edge signal is output as soon as an external signal comes in and gets divided.



## 7.3 DATA ACQUISITION – MULTI ROI MODES

The BlackIndustry SWIR 1.7 / Max camera has 4 available readout modes. You may select between two **Full modes** and two **MULTI-ROI modes**. By choosing one of the **MULTI-ROI modes** (Mode 2 / Mode 3), you can select multiple **spectral Regions of Interest (spectral ROI)** that reduce the number of considered spectral bands and consequently increase the achievable frame rate. The output data is generated either **calibrated** or **uncalibrated**:

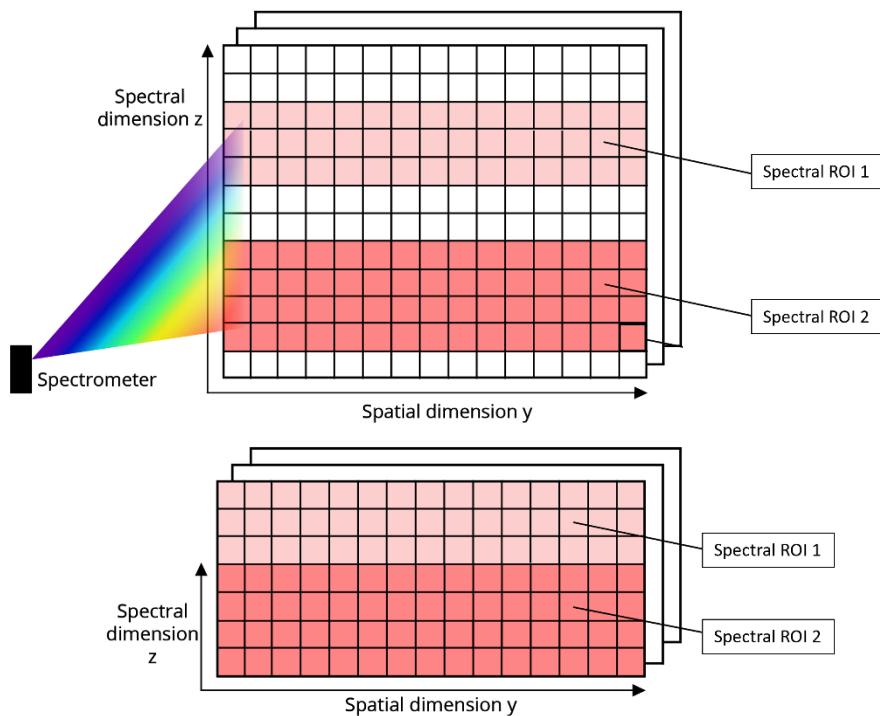
- Mode 2: (Uncalibrated) **MULTI-ROI Mode**
- Mode 3: **CALIBRATED MULTI-ROI Mode**

The other cameras in the BlackIndustry series do not support MULTI-ROI functionality in the strict sense, but they have predefined spectral ROI modes, each consisting of one spectral ROI.

### 7.3.1 FUNCTIONALITY OF SPECTRAL ROIs

When using the HAIP BlackIndustry SWIR 1.7 / Max camera, it is possible to increase the frame rate by selecting individual relevant spectral sensor regions. This selection is made by creating **spectral ROIs** that cover the desired sensor regions. The sensor in the camera then only reads the spectral information from the sensor pixels within the spectral ROIs. Sensor pixels outside the spectral ROIs are not captured. For the output, all selected spectral ROIs, and the spectral information they contain are added together (see below).

**Illustration of the sensor arrays per spatial pixel line. The red zones display selected spectral ROIs:**



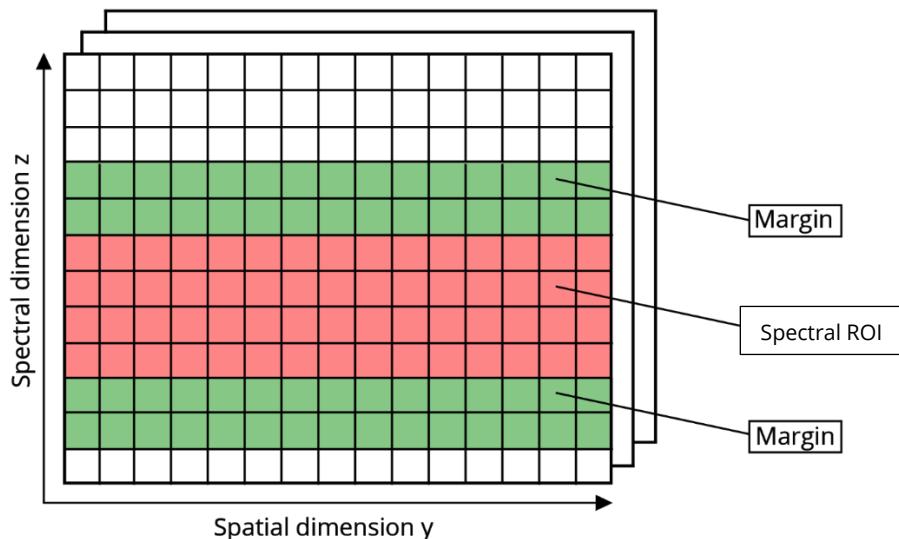
## CALIBRATED MULTI-ROI Mode:

If desired, the spectral information is pre-processed internally by the GPU in the camera. The individual spectral sensor pixels are assigned to a specific wavelength band and calibrated using:

- Dead pixel correction
- Smile correction
- Keystone correction

## **Calibration is essential if the output data needs to be compared with data from other cameras!**

As the captured spectral information arrives at the sensor in a curved shape, it is necessary that the selected spectral ROI is enlarged by a margin on each side in order to apply the calibration (see figure below). These margins are used for the internal correction and then deleted, so they are not output. Consequently, the frame rate decreases due to the additional computing power required.



## UNCALIBRATED MULTI-ROI Mode:

If a maximum frame rate is required, the spectral information can be output in an uncalibrated state. Consequently, no additional margins are added to the selected sensor ROIs. However, this entails the disadvantage that the output data is not calibrated and therefore cannot be compared with the data from other cameras. It is the customer's responsibility to further calibrate the data if desired.

### 7.3.2 SELECT SPECTRAL ROIs IN BLACKSTUDIO

In order to use the spectral MULTI-ROI functionality of the BlackIndustry SWIR 1.7 / Max cameras, the **spectral ROIs** have to be defined first. This is done via the **Spectral ROI tab** in the **Spectral View** of the **Analysis tab** (see chapter 4.4).

#### PROCEDURE FOR UNCALIBRATED SPECTRAL ROIS (MULTI-ROI MODE):

1. Uncalibrated Spectral ROIs can be selected via **Select manual ROI regions**.
  - a. Any sensor region of the camera can be selected. If several consecutive regions are selected, one single ROI is created from the sensor regions.
  - b. Please note that the regions differ depending on each specific camera (therefore the ROIs are uncalibrated).
  - c. A maximum of 8 ROIs can be created in total. The number of regions selected does not matter.
2. To confirm the selected regions and transfer them to the camera, press **Set ROIs X/8**.
3. Alternatively, use **Auto select ROIs from calibrated ROI settings** to copy ROIs that were previously set on the camera to the manual selection. BlackStudio attempts to automatically find the matching regions of your camera (please note that ROIs must first be selected and set via the **Calibrated ROIs** section).
4. Set **mode 2 MULTI-ROI** in the **camera mode settings** in the **Capture tab**.
  - a. The maximum achievable frame rate is then calculated automatically (see **Camera settings** in the **Capture tab**).
5. Perform a Black- & White Calibration.
6. Start data acquisition.

#### PROCEDURE FOR CALIBRATED SPECTRAL ROIS (CALIBRATED MULTI-ROI, MODE 3):

1. Calibrated sensor ROIs are selected via **Select>Show calibrated ROI regions**.
  - a. By clicking in the **Spectral View** window, sensor ROIs can be created, displayed as red bars. The size of the ROIs can be changed by dragging the sliders.
  - b. A maximum of 8 ROIs can be created in total. The number of selected sensor regions within the ROIs is displayed at the bottom left under **Regions used**.
2. Once all desired ROIs are created, press **Set calibrated ROI regions** to transfer the Spectral ROIs to the camera. The Spectral ROIs are stored on the camera until new Spectral ROIs are selected and set. Even rebooting the camera does not delete the Spectral ROIs.
3. If you want to access the Spectral ROIs stored on the camera, press the **Get calibrated ROI regions** button.

4. Finally, select **mode 3 CALIBRATED MULTI-ROI** in the **camera settings** in the **Capture tab**. The achievable frame rate is then calculated automatically (see camera settings in the Capture tab).
5. Perform a Black- & White Calibration.
6. Start data acquisition.

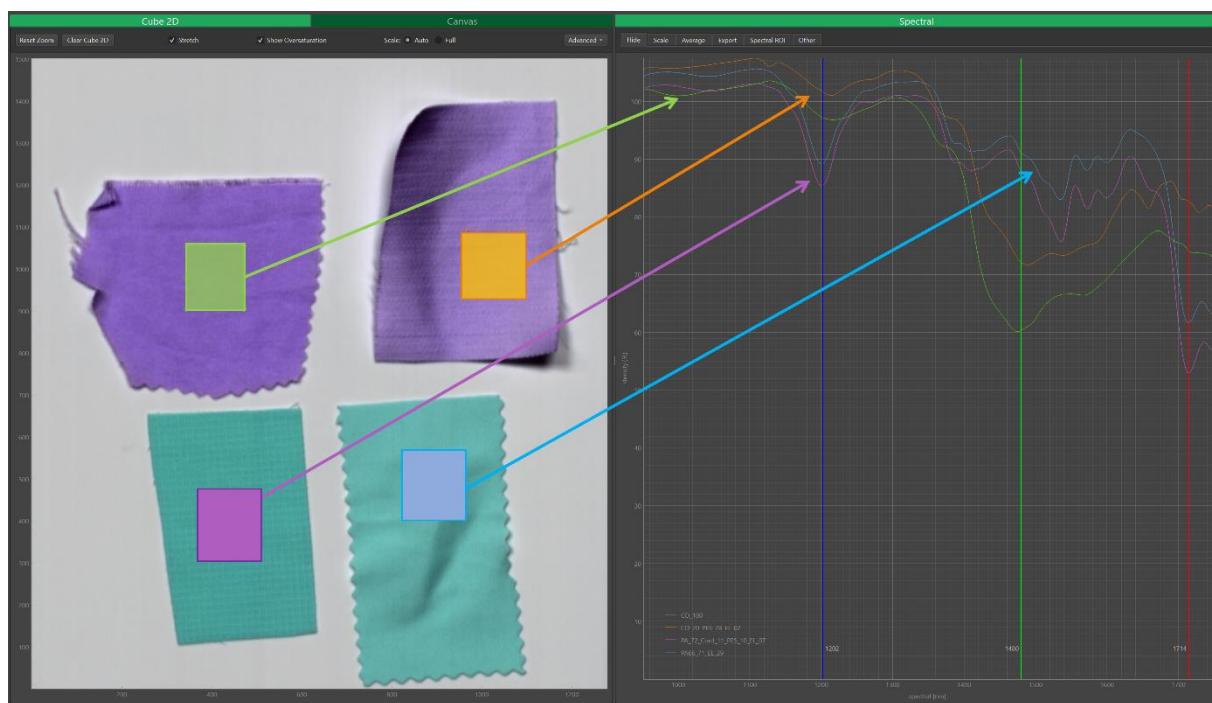
## 8 DATA ANALYSIS IN BLACKSTUDIO

This chapter describes the most important operations and functionalities that should be considered when analyzing data with BlackStudio. Please note that not all functionalities in BlackStudio are available for all BlackIndustry camera models.

### 8.1 DATA ANALYSIS – SETTING SPATIAL ROI MARKERS

**Important:** The spatial ROI markers are not the same as the spectral ROIs!

Creating a **spatial region of interest (ROI) marker** in the **Cube 2D View** or in the **Canvas View** in the **Analysis tab** enables visualization and analysis of the spectral information from the selected area. The spectral information is displayed in the **Spectral View** as intensity graph, in the same color as the ROI marker. Based on the created and saved ROI markers, classifications can be implemented, and further analyses can be performed.



The following actions are available when managing ROI markers:

- **Double click:**
  - In **Cube 2D View** or **Canvas View**: Creates a new ROI marker with a new color. A new intensity curve appears in the **Spectral View**.
  - On an existing ROI marker:Duplicates the ROI marker. Nevertheless, only one spectral intensity curve is displayed in the **Spectral View**.
- **Right click:** Right-click on an existing ROI marker to delete it.
- **Turning wheel:** Click on the turning wheel on the left border of a ROI marker and move the mouse to rotate the ROI marker.
- **Corners:** Click on a corner of a ROI marker to change its size.
- **Drag and drop:** Move the ROI marker by drag and drop.
- **Show ROIs:** To hide all ROI-classes, uncheck **Show ROIs** in the **Analysis Settings**.
- **Save capture +ROIs:** Press the button in the analysis settings to save the hyperspectral data cube including the created ROI markers. Otherwise, the ROI markers will be lost.

## 8.2 DATA ANALYSIS – PREPARE DATABASE AND CREATE A SNIPPET

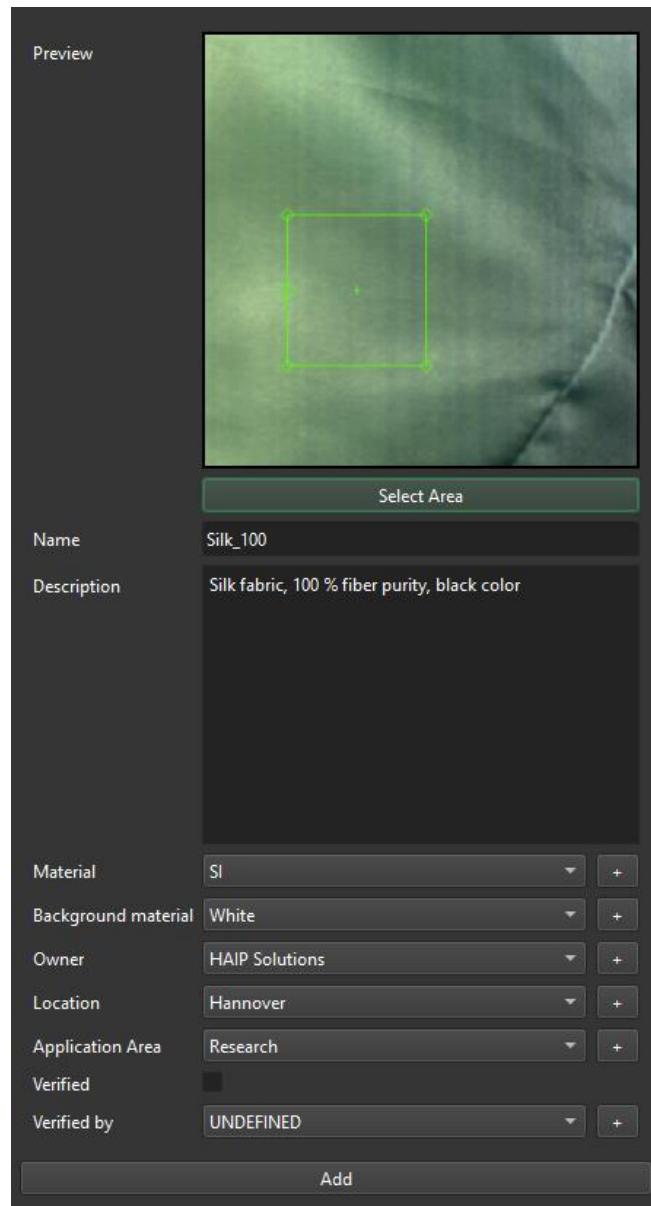
Before data snippets are added to the **database**, the following steps should be considered first:

1. Select a suitable **storage location** for the **database**. This location can also be on a network drive or USB flash drive. The current storage path can be checked in the **Database settings** (Settings Tab → Database Settings).
2. **Add content** to the seven database categories that are relevant to you (e.g. Material Category → Add new material category → 'Plastics').
  - a. It is advisable to start with the category on the far right when creating the groups and to proceed further to the left.

**The database is now prepared.**

3. Capture data via the **Capture Tab** or import previously acquired data in the **Cube 2D View**.
4. If desired, create **ROI markers** of relevant data within the **Cube 2D View**.
5. Press the button **Export to database**, a snippet window will open:
  - a. Via **Select Area**, a snippet can be created by manually defining the spatial extent.
    - i. It is not mandatory to include a ROI marker in the snippet, but it is advantageous, as the spectral information within the ROI will also be stored (It is also possible to add an ROI at a later time).
  - b. Define a snippet **name** and add a **description**, if desired.

- c. Select a previously created **content category for six database categories** (Material, Background material, Owner, Location, Application Area, Verified by).
  - i. The **+** on the right-hand side can be used to add content categories that do not yet exist in the database categories.
- d. If the snippet is an object that has already been identified and verified, the **Verified** checkbox can be activated.
- e. Press **Add** to add the snippet to the database.
- f. The snippet will be displayed in the **Snippet Collection** Tab in the **Database**.

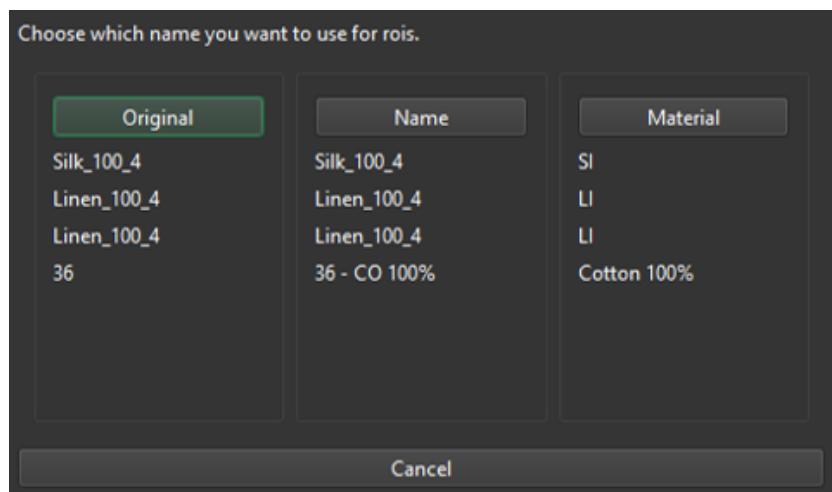


### 8.3 DATA ANALYSIS – LOAD SNIPPETS TO CANVAS

The **Canvas View** was developed to expand the capabilities of the database. Any number of snippets can be loaded into it and arranged as desired. The spectral curves of loaded or newly created ROI markers are displayed in the spectral window. The ROI markers can also be used to train a classifier (see chapter 8.4).

Please proceed as follows:

1. Open the database.
2. Select the desired snippets by clicking on the respective rows.
  - a. Selected snippets are highlighted in green.
  - b. Note that only snippets that cover the same wavelength range can be loaded together in a canvas view.
3. Press the button **Load into Canvas**.
  - a. Choose which name you want to use for the ROIs by clicking either on **Original**, **Name** or **Material**.



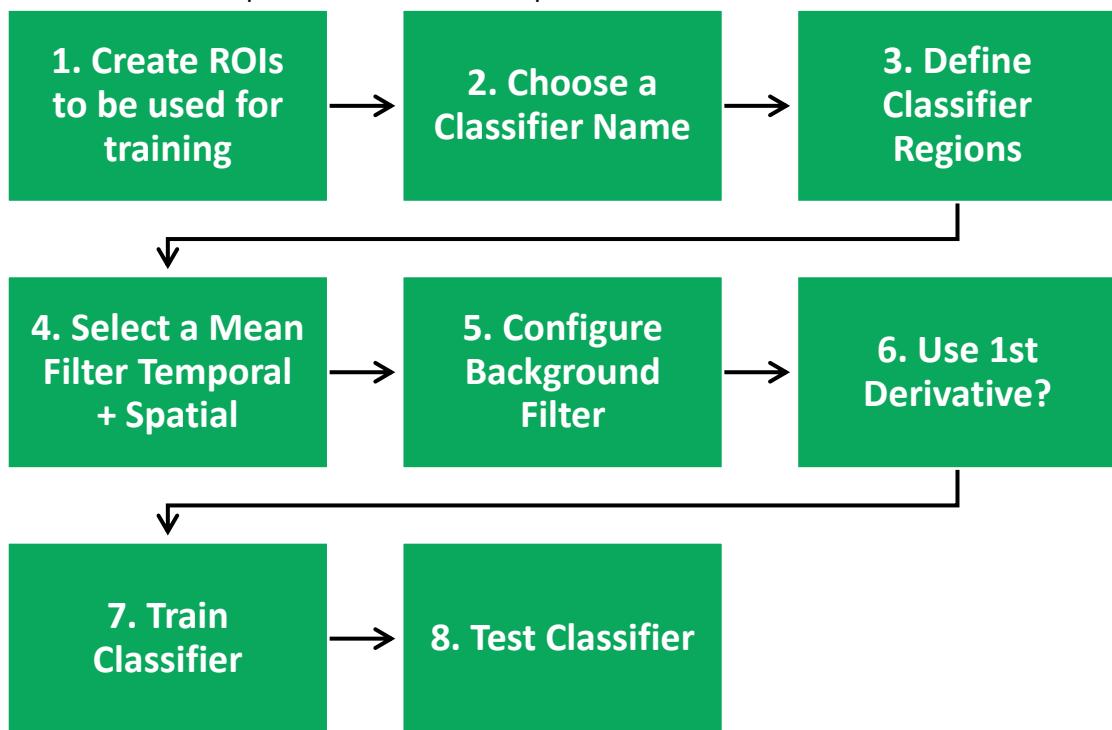
4. You will be re-directed to the **Canvas View** in the Analysis tab.
  - a. If there are still unwanted spectral curves in the spectral window, these can be deleted using the **Clear Cube 2D** button in the **Cube 2D View**.
5. The snippets can be freely arranged and sorted in the canvas window without spatial reference to each other.
  - a. The images and the ROI markers can be moved separately from each other.
6. New ROI markers can be created at any time.
7. The ROI markers can be used as training data for the classifier.
8. The **Clear Canvas** button removes all the contents of the window. However, the snippets are still saved in the database.

## 8.4 DATA ANALYSIS – TRAIN A CLASSIFIER

The **Analysis tab** of BlackStudio offers the possibility to train a specially developed classification algorithm based on self-created ROI markers. These can be created on previously acquired data in the **Cube 2D View** or from snippets in the **Canvas View**. In addition, either the entire wavelength range can be considered for classification or just specifically defined spectral regions. Which functions are available and how to proceed is explained in this chapter.

### 8.4.1 GENERAL CLASSIFICATION WORKFLOW

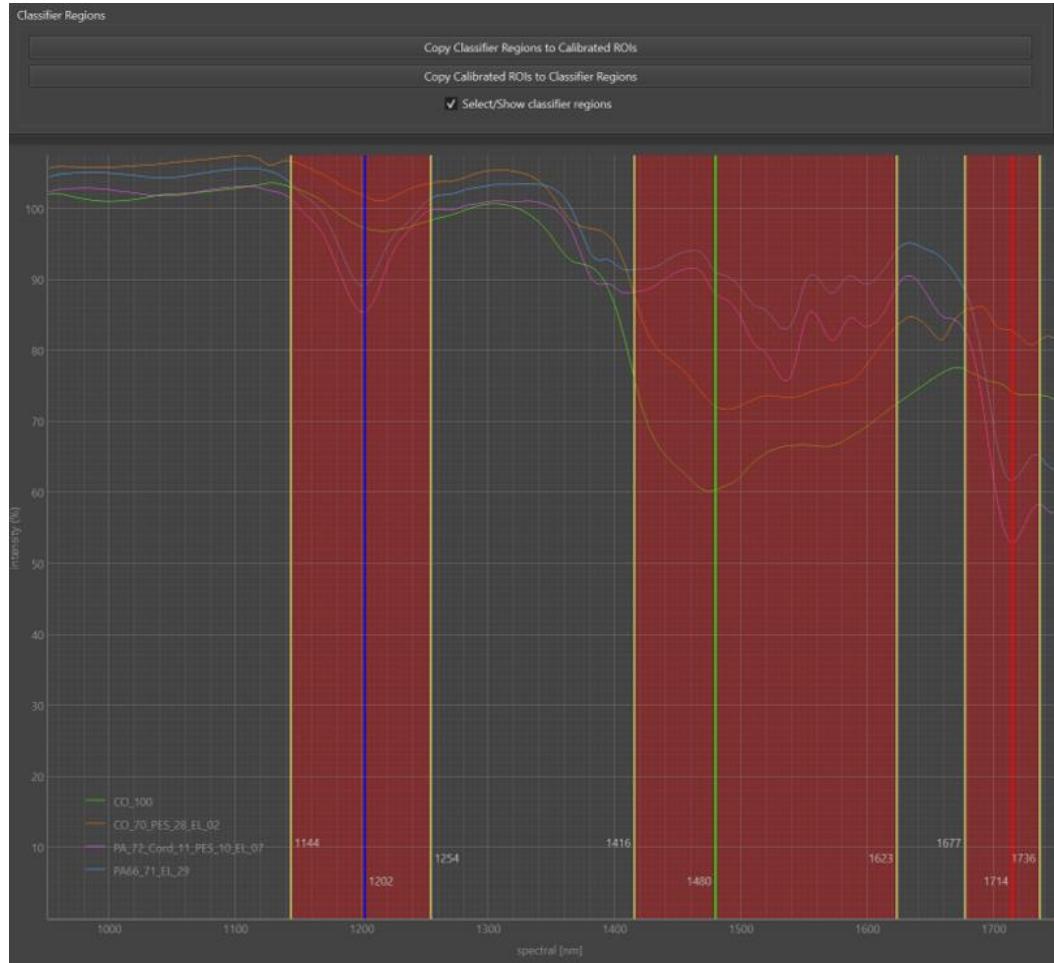
Follow the workflow presented here to implement a successful classification.



1. **Create ROIs to be used for training:** The basis of a classification are spatial ROI markers, which can be created in the **Cube 2D View** or in the **Canvas View** (see chapter 8.1). The classes that are created in this way are included in the subsequent classification. The more precise the definition of the ROI marker along with the spectral information it contains, the better the classification result will be in the end. There is no maximum or minimum number of ROI markers required for classification.
2. **Choose a Classifier name:** If the classifier shall be saved externally afterwards, a meaningful name is recommended.
3. **Define Classifier Regions:** In the Spectral ROI tab of the Spectral View, specific spectral ranges from the wavelength range of the camera can be selected. Only the spectral information from these regions is considered for the creation of a classifier

as well as for creating a background filter. For the cameras in the BlackIndustry SWIR series, this is used to later adapt the spectral ROIs to an ideal classification.

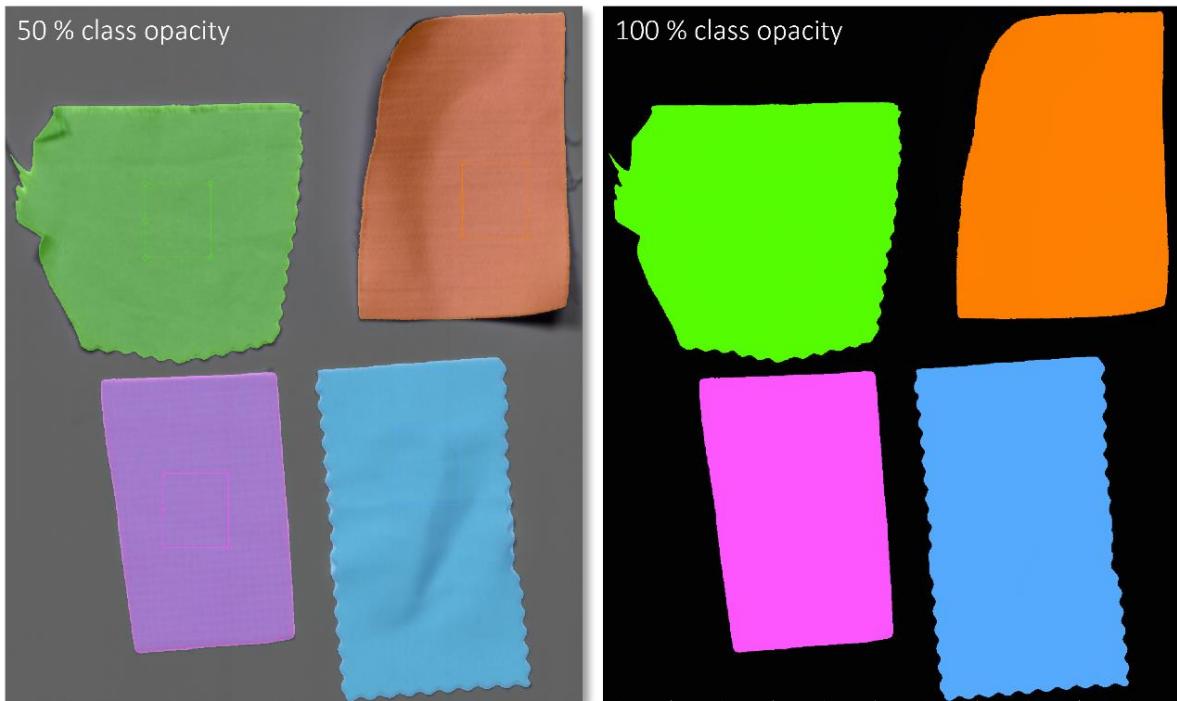
- Classifier regions can be created by double-clicking in the **Spectral View**. Their size can be adjusted as required by dragging the borders. Right-click on a classifier region to delete it. All classifier regions created are displayed in red.



- Select a Mean Filter Temporal + Spatial:** By setting a mean filter in the temporal or spatial direction, pixel values in a defined neighborhood (3 or 5 pixels) are replaced by their mean values. This leads to an effective noise reduction.
- Configure Background Filter:** A background filter can be created so that only those areas of the **Cube 2D View** or **Canvas View** that have not been marked as background are taken into account in the classification. For more information, see chapter 8.4.2.
- Use 1<sup>st</sup> Derivation:** Activate the checkbox to pre-process data with the 1<sup>st</sup> derivative before the classification.
- Train Classifier:** Press to train the classification algorithm on the basis of the configured settings. Depending on the data size, this may take a few seconds. Training

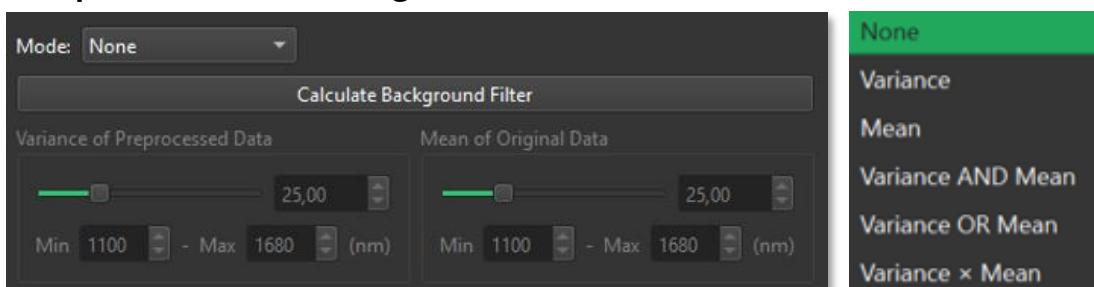
is completed as soon as the **Save classifier** and **Test classifier** buttons below are no longer grayed out.

8. **Test Classifier:** Press to apply the classification algorithm to the entire data set in the **Cube 2D View** or to the snippets in the **Canvas View**. The **Class opacity** slider can be used to select the degree of transparency of the classification result. The checkbox on the right-hand side can be used to switch the classification layer on and off.



#### 8.4.2 BACKGROUND FILTER

The background filter creates a background class in which all pixels whose values fall below a defined threshold value are categorized. The pixels within this background class are not taken into account for the actual classification. The background filter is a threshold-based background classifier that utilizes either the mean value of the original spectrum or the variance of the pre-processed spectrum. It is also possible to combine both values. **Attention: If classifier regions were previously created, only data from these areas will be processed in the background filter.**



## Configure Background Filter:

1. Select a **Mode**:
  - a. **None**: No mode.
  - b. **Variance**: If the variance of pre-processed spectrum is below the threshold value, the pixel is assigned to the Background class.  
**This mode is to be used with a bright/white background!**
  - c. **Mean**: If the mean of original spectrum is below the threshold value, the pixel is assigned to Background class.
  - d. **Variance AND Mean**: If both, variance value and mean value are below the threshold value, the pixel is assigned to Background class.
  - e. **Variance OR Mean**: If either variance value or mean value is below the threshold value, the pixel is assigned to Background class.
  - f. **Variance x Mean**: If the product of the variance value and the mean value is below a threshold value, the pixel is assigned to the background class.
2. Depending on the Mode, change the settings of **Variance of Preprocessed Data** and/or **Mean of Original Data**.
  - a. The corresponding threshold value can be adjusted using the slider or the number display.
  - b. For both values, a wavelength range can be determined in which the values are included. Outside of this range, the values are not taken into account. The default wavelength range is 1100 - 1680 nm.
  - c. **Attention**: Make sure that the set wavelength range matches the classifier regions that might have been created. The more available data the filter has, the more accurate the result will usually be.
3. Press **Calculate Background Filter** to calculate the background filter with the currently set threshold values for variance and mean.
  - a. Depending on the image size, it may take a few seconds.
  - b. The background filter is displayed in the **Cube 2D View** or **Canvas View**. The darker areas are marked as background. The light areas should mark the objects of interest (see figure below).
  - c. The opacity of the background filter display can be changed using the **Class opacity** slider.
4. The background filter can now be modified in real time when changing the threshold values for variance and mean (see step 2).
5. When the background filter is ideally set, the window can be closed.
6. Activate the **Use Background Filter for Classification** checkbox and continue with the creation of the classifier.

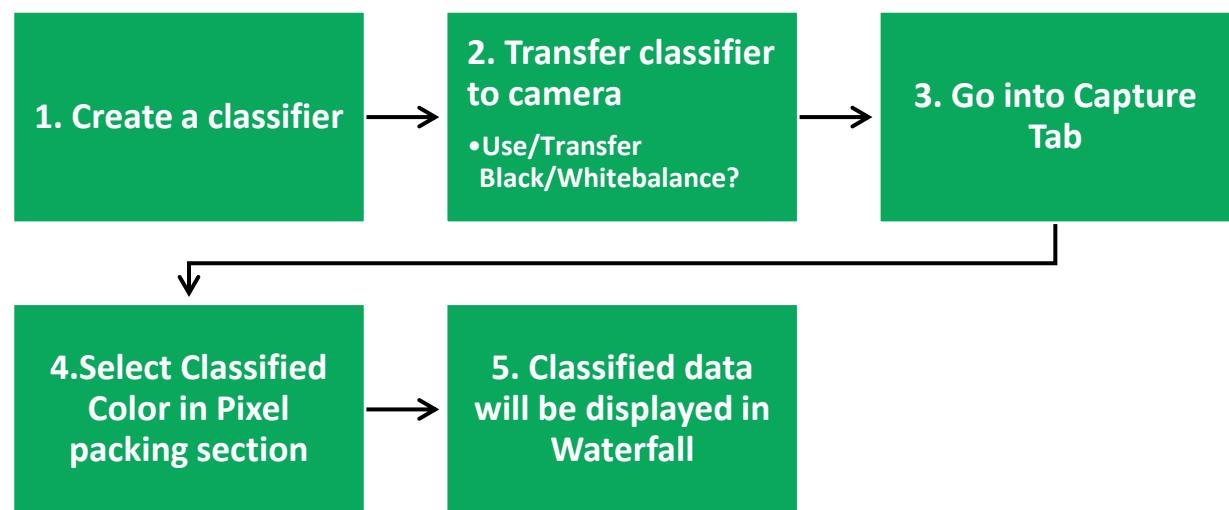
Screenshot of the Cube 2D view on which a background filter is being adjusted so that the objects to be classified later are not marked:



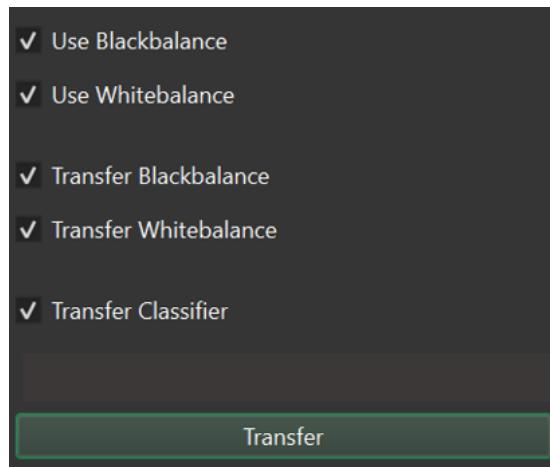
## 8.5 DATA ANALYSIS – ON CAMERA CLASSIFIER

The on-camera classifier is a new functionality for the BlackIndustry SWIR cameras with software version 1.0.13 and later. This enables a previously trained classifier to be transferred to the camera so that newly captured data will be classified **on camera** in real time using the **Classified Color** output mode. The classification results can be used directly in production without the need for additional hardware. In addition, the Ethernet bandwidth restriction and the performance overhead on the receiving device are eliminated, as the data from the camera only emerges classified.

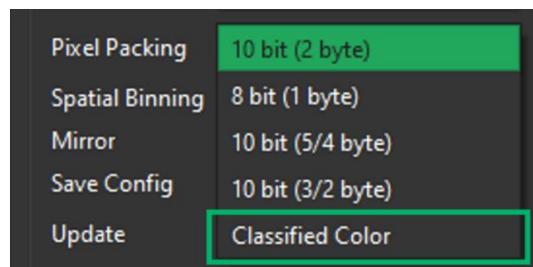
### 8.5.1 ON-CAMERA CLASSIFIER IN FULL SPECTRAL RANGE:



1. Create a classifier according to the instructions in the chapter above.
2. Press **Transfer Classifier**.
  - b) Decide whether to **use** the recorded **Blackbalance** or **Whitebalance**. If they are not used, either a suitable black balance/white balance already stored on the camera is used or an error screen appears after activating the Classified Color mode (see error screen below).
  - c) Decide whether to **transfer** and store the previously recorded **Blackbalance/Whitebalance** to the connected camera. Previously saved balances will be overwritten.
  - d) Activate the checkbox **Transfer Classifier**.
- e) Press **Transfer**.

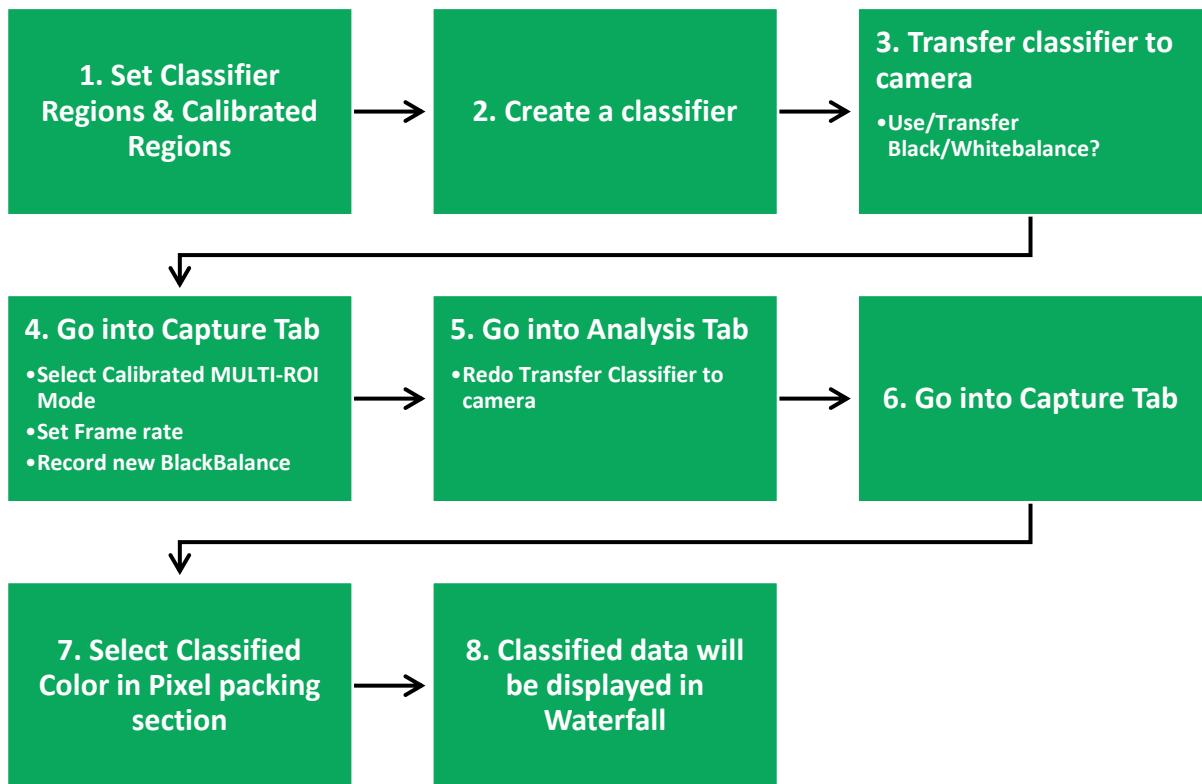


3. Go into the **Capture Tab** of BlackStudio.
4. Select **Classified Color** in the **Pixel Packing** section.



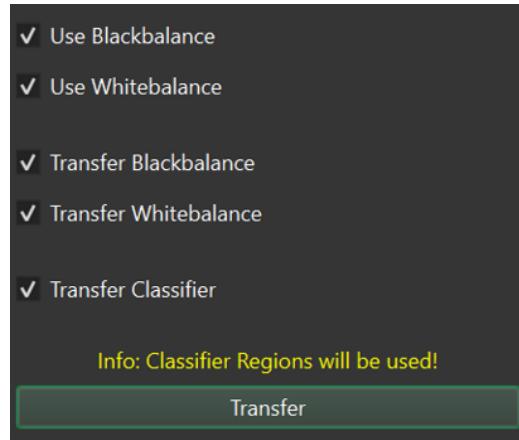
5. Newly acquired data will now be classified on camera and directly displayed in the **waterfall window** or can be received using the **API** or **GenICam**.

### 8.5.2 ON-CAMERA CLASSIFIER IN MULTI-ROI MODE USING SPECTRAL ROIS:

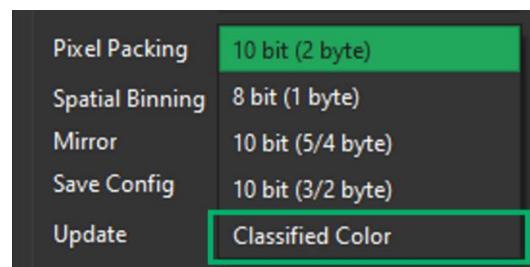


1. If the **Calibrated Multi ROI mode** is to be used, the classifier can be configured using **Classifier Regions**.
  - a. These can be defined after activating **the Select>Show Classifier Regions** checkbox.
  - b. Press **Copy Classifier Regions to Calibrated Regions**.
  - c. Press the **Set calibrated ROI Regions** button. This transfers the selected spectral ROIs to the camera and saves them.
  - d. **Important:** The applied wavelength range (full or spectral ROIs) must always match the trained classifier. Otherwise, an error screen will be displayed when the **Classified Color mode** is activated (see below).
2. Create a classifier according to the instructions in the chapter above.
3. Press **Transfer Classifier**.
  - a. Decide whether to **use** the recorded **Blackbalance** or **Whitebalance**. If they are not used, either a suitable black balance/white balance already stored on the camera is used or an error screen appears after activating the Classified Color mode (see error screen below).
  - b. Decide whether to **transfer** and store the previously recorded **Blackbalance/Whitebalance** to the connected camera. Previously saved balances will be overwritten.
  - c. Activate the checkbox **Transfer Classifier**.

- d. If the classifier to be transferred was created using Classifier Regions, this is displayed as information.
- e. Press **Transfer**.



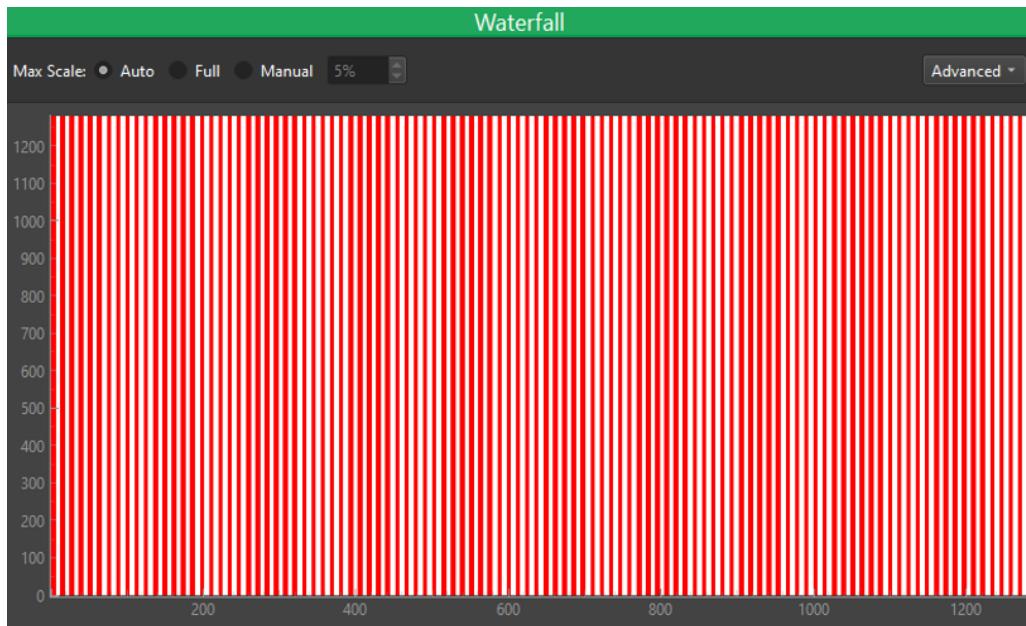
4. Go into the **Capture Tab** of BlackStudio.
  - a. Select the previously considered **camera mode** for which the classifier was trained (**Calibrated Multi-ROI mode**).
  - b. Set the desired **frame rate**.
  - c. Record a new **BlackBalance**. This must always be done when a new value is set for the frame rate.
5. Change into the **Analysis Tab** of BlackStudio.
  - a. Press **Transfer Classifier** to transfer the Classifier including the newly acquired BlackBalance once again.
6. Change back into **Capture Tab** of BlackStudio.
7. Select **Classified Color** in the **Pixel Packing** section:



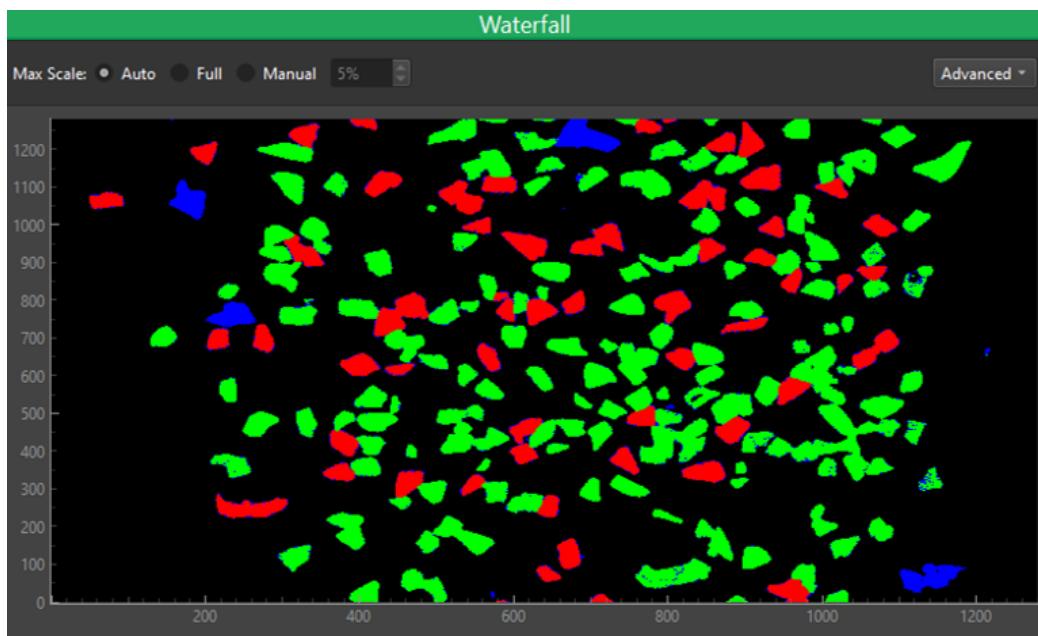
8. Newly acquired data will now be classified on camera and directly displayed in the **waterfall window** or can be received using the **API** or **GenICam**.

- Currently, a maximum of 10 different ROI classes can be applied within the on-camera classifier.
- Please consider that the use of the **Mean temporal filter** in the on-camera classifier increases the latency.
- Please note that the spectral dimension of the classifier and the transferred White and Blackbalance must match the selected camera mode. If this is not the case, an **error screen** consisting of white and red stripes is transferred to the **Waterfall View** instead:

#### Error screen in Waterfall View:



#### Classified Waterfall window via on-camera classifier:



## 9 TROUBLESHOOTING

Rest assured, when it comes to errors or problems, we are committed to offering prompt assistance. Our dedicated team will work swiftly to address any issues you encounter.

**We value your feedback!** If you come across any issues or glitches with our product, please do not hesitate to get in touch. Your insights are invaluable in helping us improve and providing you with the best experience possible.

## 10 ACCESS TO HAIP BLACKSTUDIO SOFTWARE

You can download the newest HAIP BlackStudio software, including updates, and the corresponding user manual via the following link:

[BlackStudio Download](#) (Click here)

Or by scanning the QR-Code:



## 11 SAMPLE DATA

If you are interested in sample data for the products of HAIP Solutions GmbH, please follow the link below:

[Download Sample Data](#) (Click here)

Or scan the QR code:



## 12 MAINTENANCE AND SERVICE

HAIP Solutions GmbH is responsible for providing regular maintenance and updates to ensure the optimal functioning of the software. Maintenance activities may include bug fixes, security patches, performance optimizations, and compatibility enhancements. HAIP Solutions GmbH will strive to minimize any disruption to your system during maintenance activities and provide advance notice whenever possible.

We may offer technical support to assist you with any software-related inquiries or difficulties. It is recommended to upgrade to the latest supported version to continue receiving maintenance and support services.

## 13 SYSTEM REQUIREMENTS

Operating System	Windows 10 or later
Processor	Minimum Intel i5-1135G7 or equivalent
Memory (RAM)	Minimum 16 GB RAM
Storage Space	1 GB
Graphics Card	Integrated Graphic
Ports	1x GigE
Display	1920 x 1080 px or more



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