HAIP

Look beyond the visible

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The HAIP BlackIndustry SWIR 1.7 / Max

Quick Start Guide

Look beyond the visible

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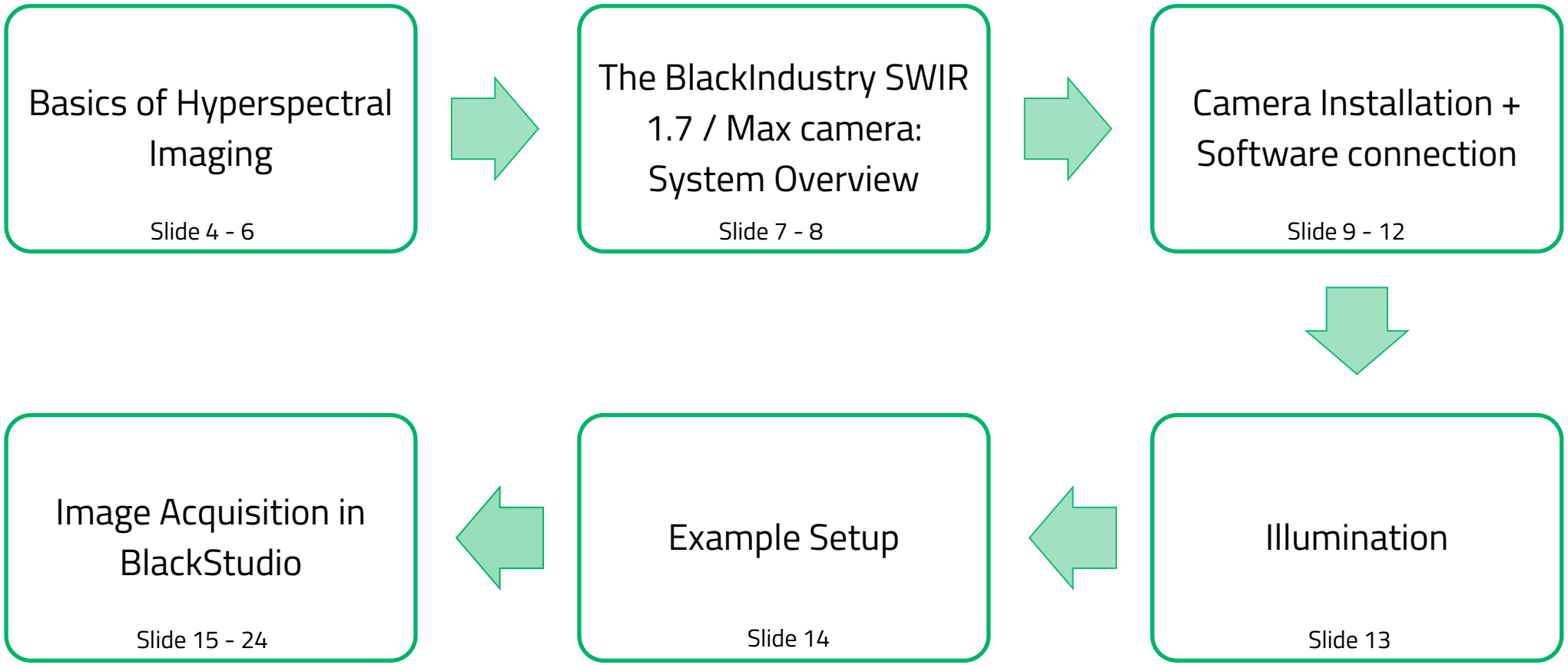
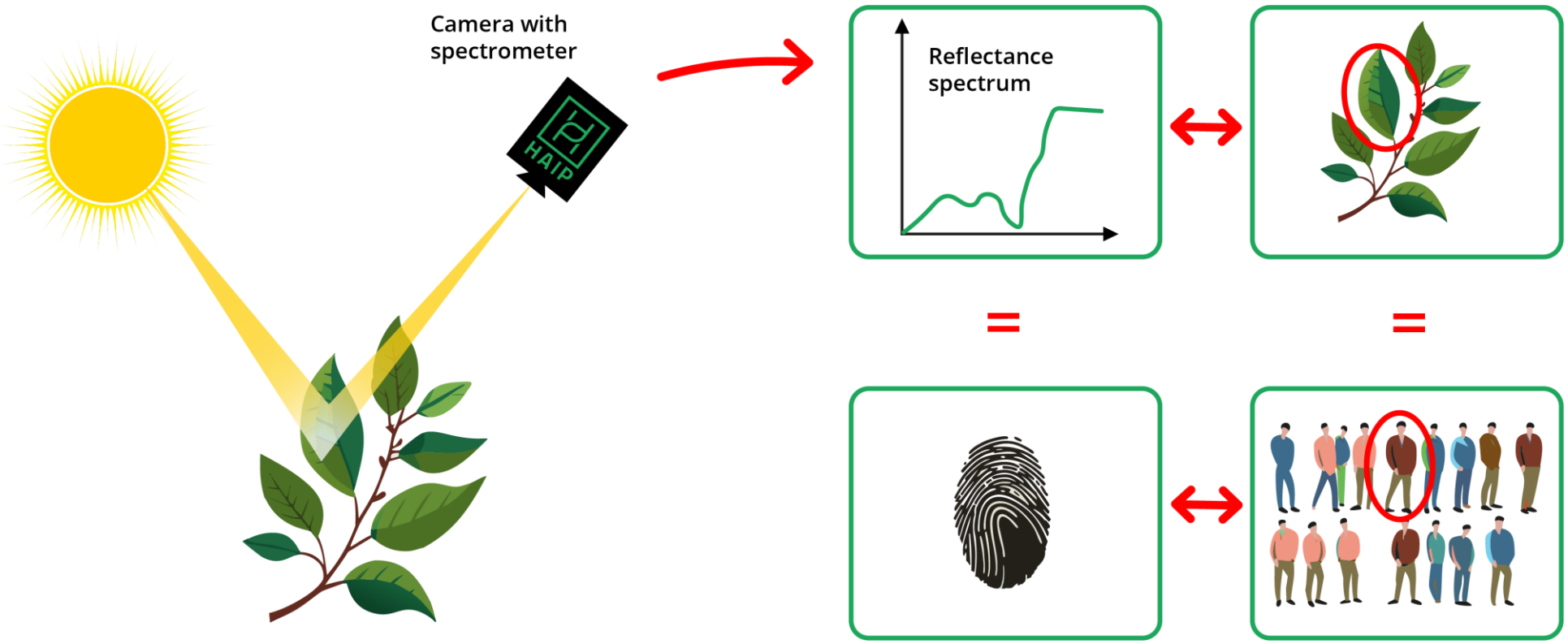
General Procedure



The Idea of Hyperspectral Imaging

Hyperspectral Imaging, also known as **Imaging Spectroscopy**, is the technology to measure the intensity of reflected light for each pixel of an image. The intensity is captured for each wavelength of the light and is displayed as an intensity spectrum, a so-called **reflectance spectrum**.

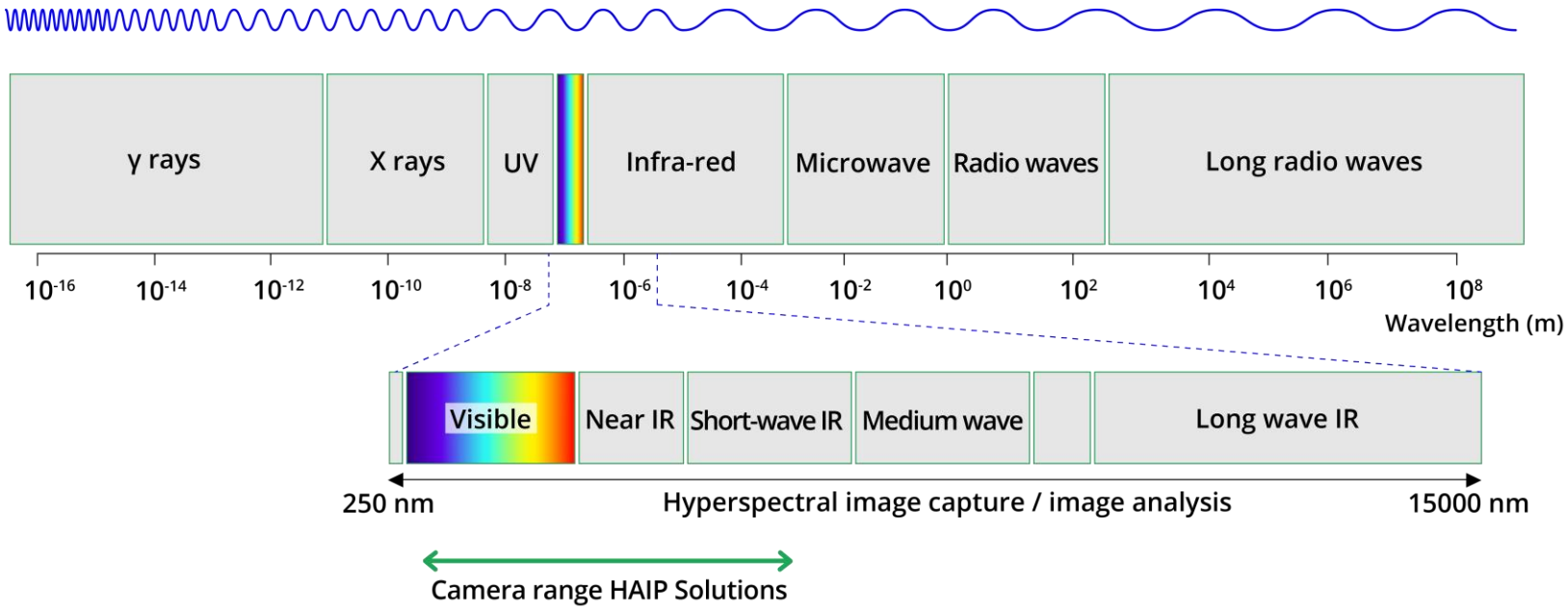
Each material reflects light differently. Therefore, the reflectance spectrum of each material is unique. Similar to a human fingerprint, the reflectance spectrum can be used to identify the corresponding material. In addition, various properties of materials and objects can be analyzed via the reflection spectrum.



The electromagnetic spectrum

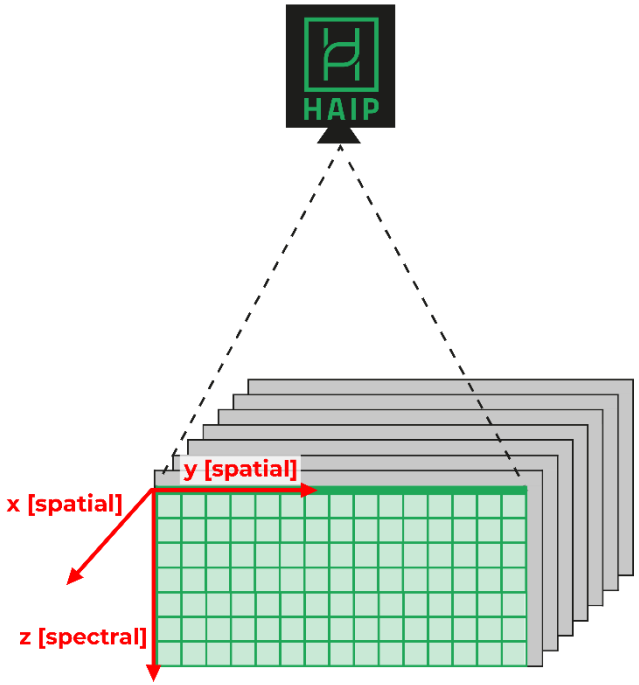
Electromagnetic radiation is the transmission of energy in the form of **electromagnetic waves** that propagate in space. An example is the sunlight that occurs as electromagnetic waves. Such a wave can be characterized by the parameter **wavelength λ**, **frequency ν**, **amplitude A** and its propagation velocity, the speed of light c.

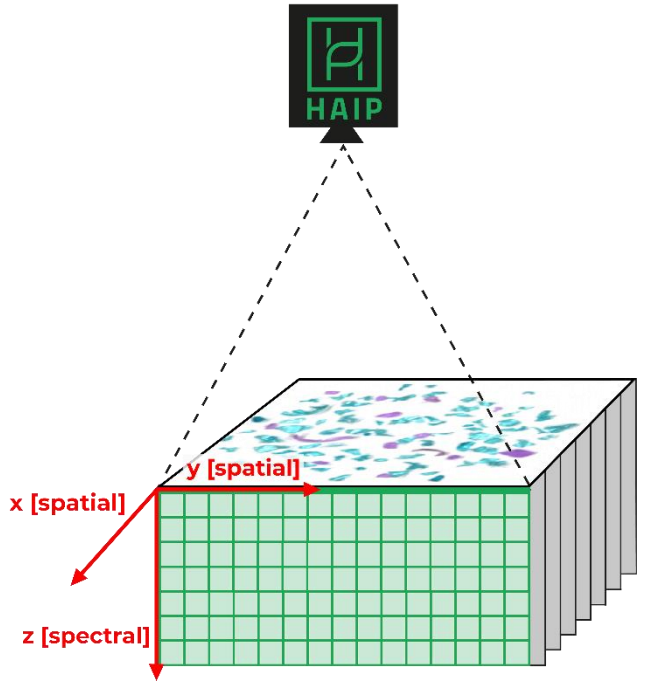
Different compositions of frequencies and wavelengths occur naturally on earth. This range of characteristics is represented as an **electromagnetic spectrum**. The human eye can see the electromagnetic waves in the range between 400 – 800 nm. That is what we call **visible light**.
The hyperspectral cameras from HAIP Solutions capture electromagnetic radiation in the visible light (**VIS**), the near infrared (**NIR**) or the short-wave infrared (**SWIR**) range. The considered wavelength ranges of HAIP Solutions' products are 400 - 800 nm (VIS), 700 - 1000 nm (NIR) and 900 - 1750 nm (SWIR).



The Line Scanning Method

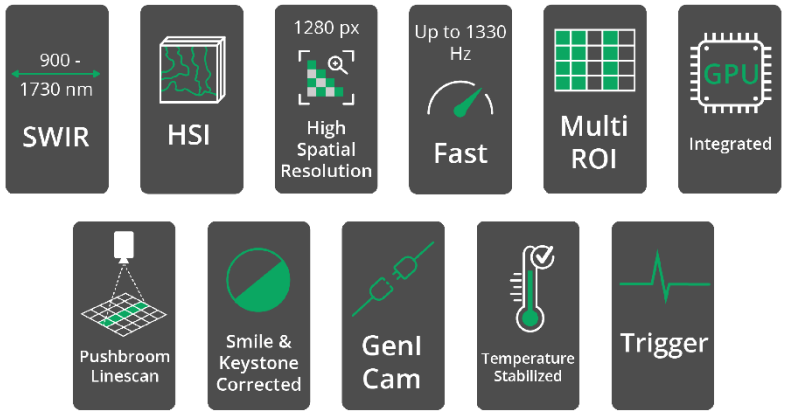
Generally, there are four different types of hyperspectral sensors. They all have different ways to acquire a hyperspectral data cube.
The **line scanner** or push broom scanner scans one pixel line of an image at a time, simultaneously capturing the spectral information of this pixel line. To acquire an entire image or hyperspectral data cube, the camera needs to be moved to scan the next line of pixels.
The great advantage of this scanning method is the high level of spectral detail that can be achieved and the high frame rate. All HAIP Solutions cameras are equipped with line scanning sensors.





The BlackIndustry SWIR 1.7 Max - Features

Features	Smart Hyperspectral Line Scanner
	SWIR (900 – 1748 nm)
	Up to 420 selectable spectral bands (Multi-ROI)
	Spatial resolution: 1280 pixel
	Framerate: 210/1330 Hz (Full Frame/Multi-ROI)
	Internal GPU for pre-processing and classification



BlackIndustry SWIR 1.7 / Max - Camera Overview

1. Toggle switch (On/Off)
2. Status LED 1
3. Status LED 2
4. Status LED 3
5. Name plate
6. Ethernet port
7. Power supply
8. Lens
9. Mounting plate

Camera Installation

Select your preferred mounting option

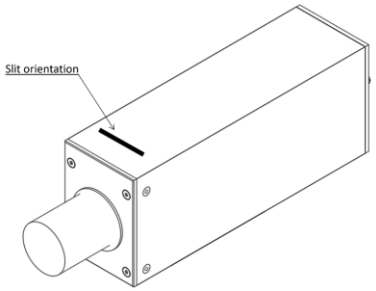
1

- Standard camera threads (UNC)
- Metric threads (M5)

Mount the camera on setup

2

- Respect the slit orientation (parallel to mounting plate)



Connect cables

3

- Power cord to power supply
- Ethernet cable to computer

Camera is switched on

4

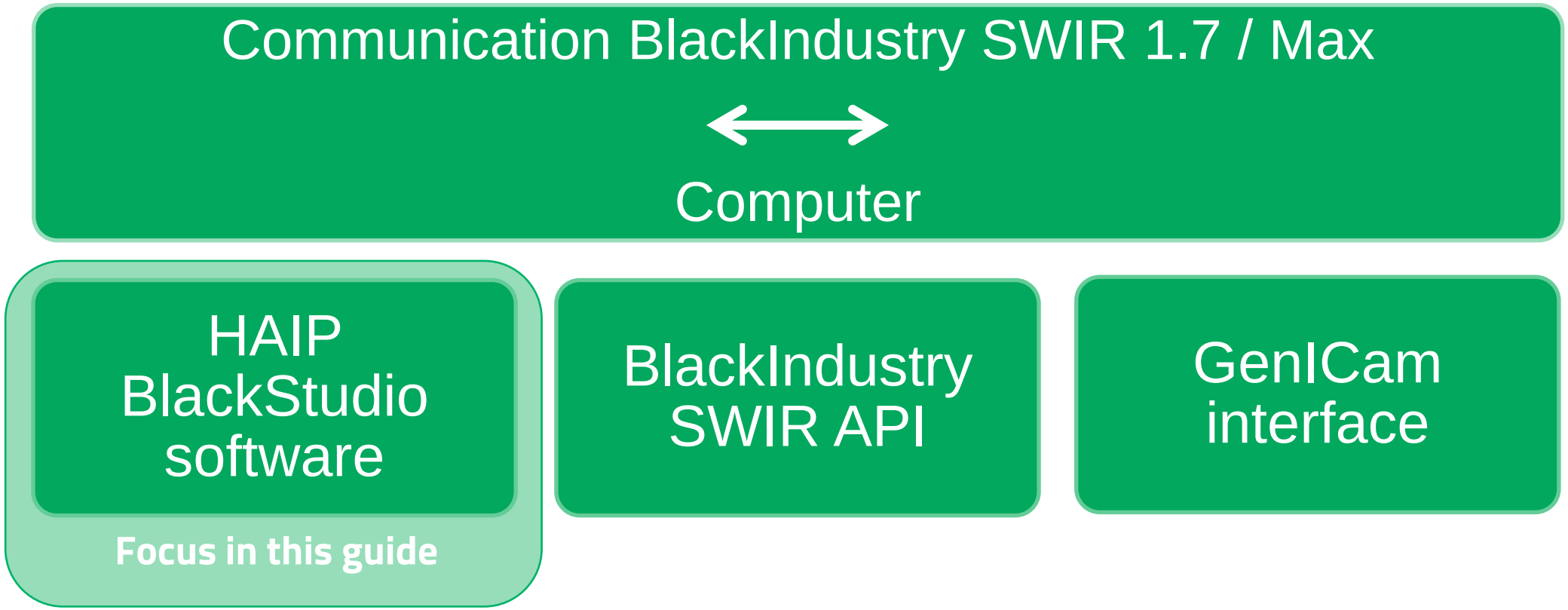
- Check the color coding of the three status LEDs (see next slide)

Camera Installation – Status LEDs

- Each of the three status LEDs on the back of the camera present different information
  - **LED 1**: information on power supply
  - **LED 2**: information on data transfer via Ethernet
  - **LED 3**: information on system status

LED	Signal of LED	Description
1	Continuous green light	System has voltage and hardware is errorless
2	Flashing yellow light (Sec-by-sec rhythm)	Flashing while data transfer via Ethernet
3	Slow flashing of blue light	Camera is switched on
3	Fast flashing of blue light	Camera on & Streaming on & system temperature not ok
3	Continuous blue light	Camera on & Streaming on & system temperature ok (~ 55 °C)

Software connection - Overview



Software connection:
BlackStudio – BlackIndustry SWIR 1.7 Max

1. Check that the cables are connected to the computer
2. Install and open the latest version of the BlackStudio software
3. Set the correct IP address of the BlackIndustry SWIR 1.7 / Max camera
    1. Default IP address of the camera: **192.168.7.1**
    2. The host device must have manually set an IP address with 192.168.7.**X** (**X** must be replaced by another number but not 192.168.7.1, as this is already reserved for the camera by default!)
4. Press the button **Connect to camera**
5. Select preferred Pixel Packing (for efficient utilization of Ethernet connection)
6. Start the Livestream via **Livestream: ► Start**
7. Check system temperature: ideal sensor temperature: 55 °C

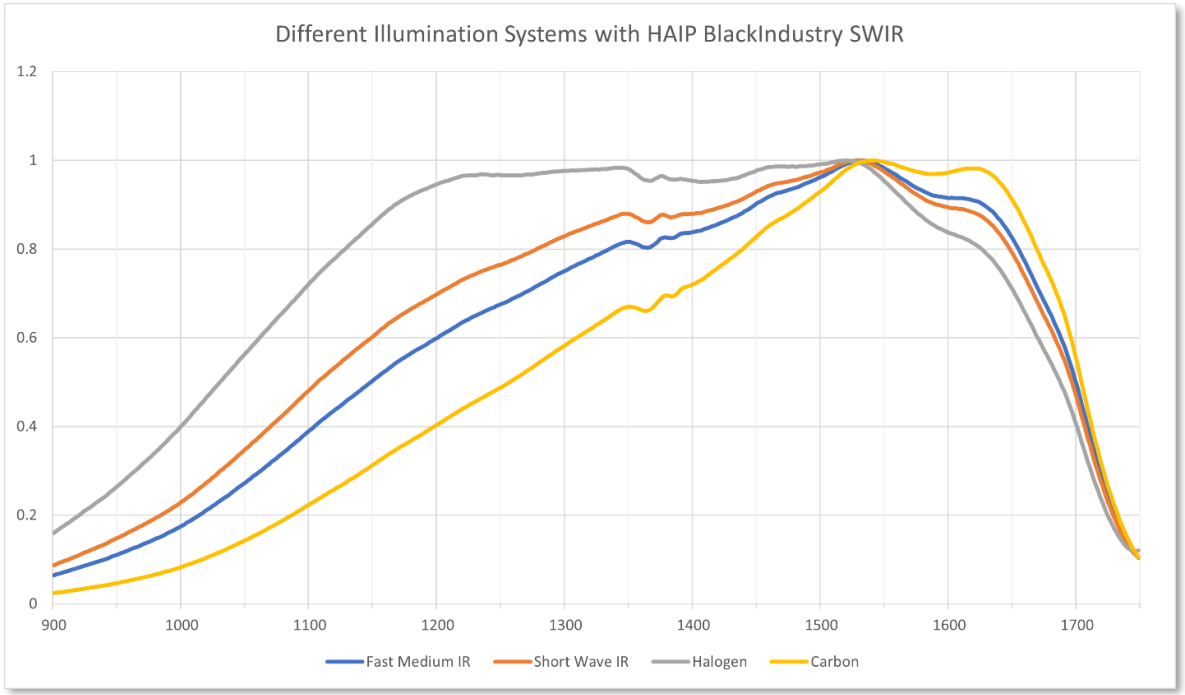
Do not start recording before the ideal temperature is reached!

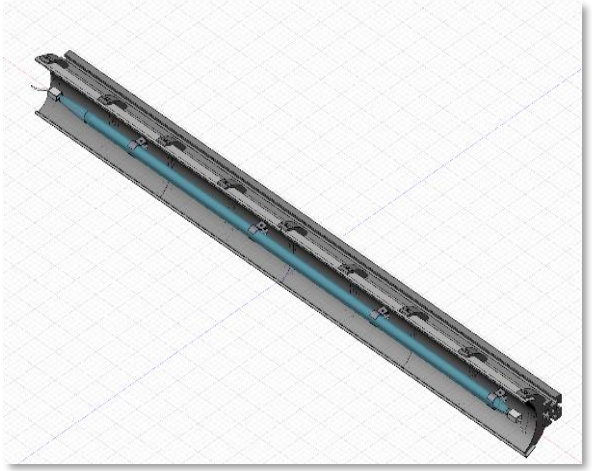
HAIP BlackStudio software

BlackStudio Download

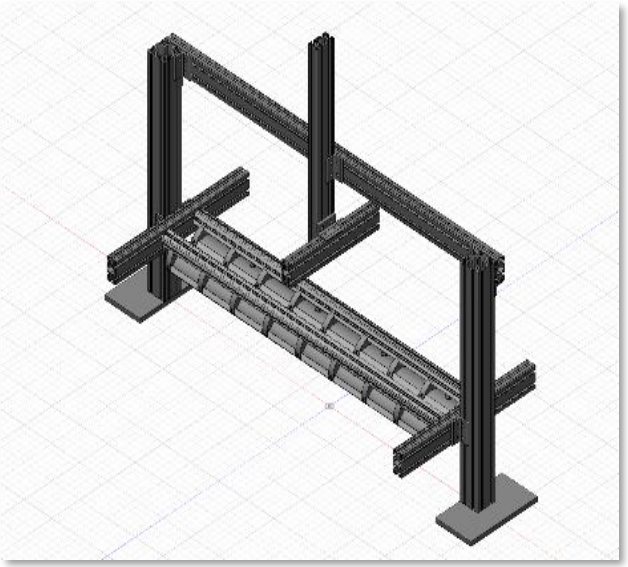
Illumination – BlackBright Fast Medium Wave IR

- Special Feature: Continuous spectral response with a **peak wavelength at ~1500 nm**
- Although standard halogen lighting is broader, its intensity decreases significantly beyond 1500 nm, making it less suitable for various sorting applications
- **900 – 1750 nm** spectral range
- For BlackIndustry SWIR 1.7 / 1.7 Max





Technical drawing BlackBright Fast Medium Wave IR



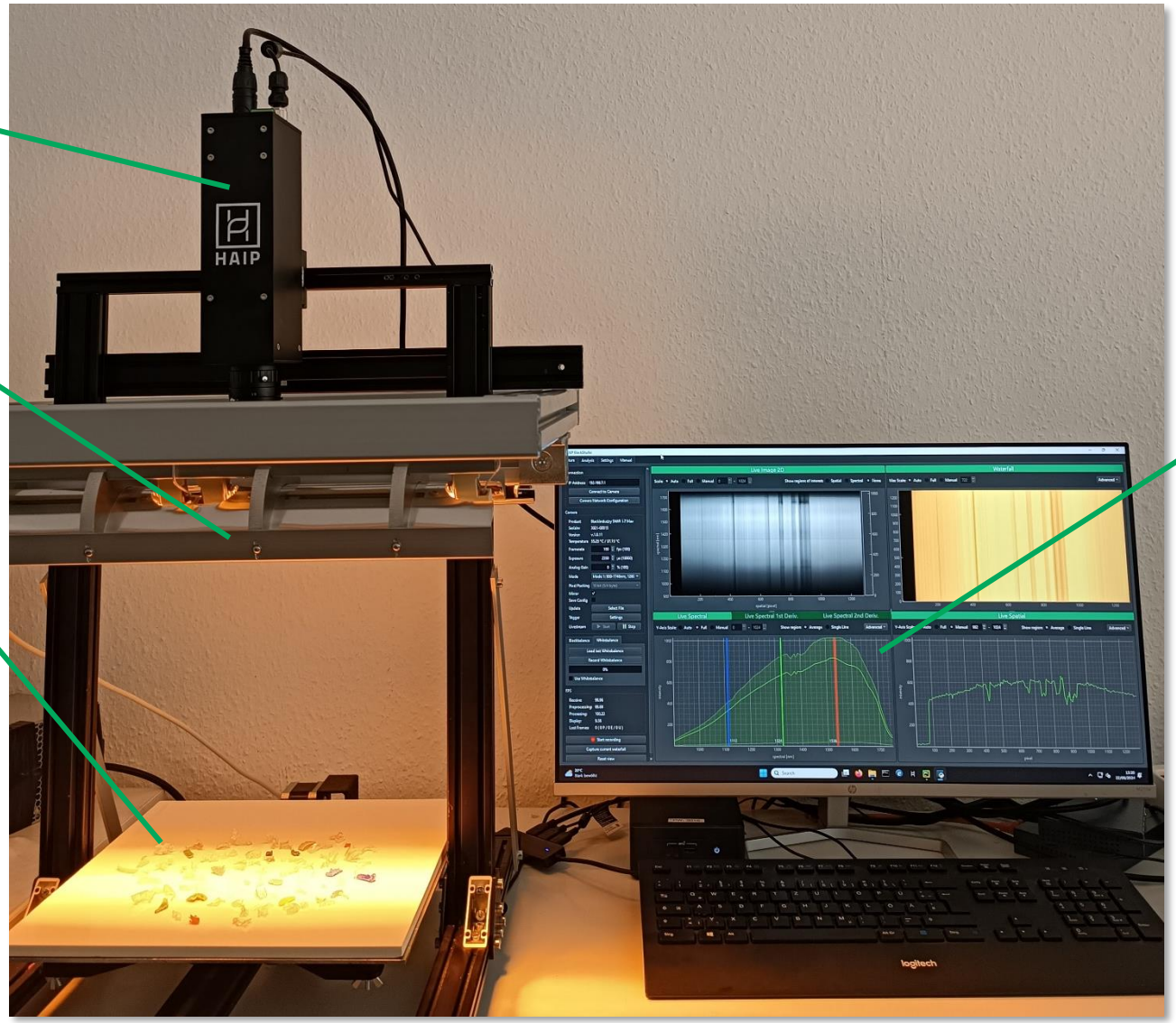
Technical drawing BlackBright Fast Medium Wave IR Setup

BlackIndustry SWIR 1.7 / Max – Setup Example

BlackIndustry SWIR 1.7 / Max

BlackBright
Fast Medium Wave IR

Linear scanning stage
with samples



Connected computer
with BlackStudio

BlackStudio – Overview Capture Tab

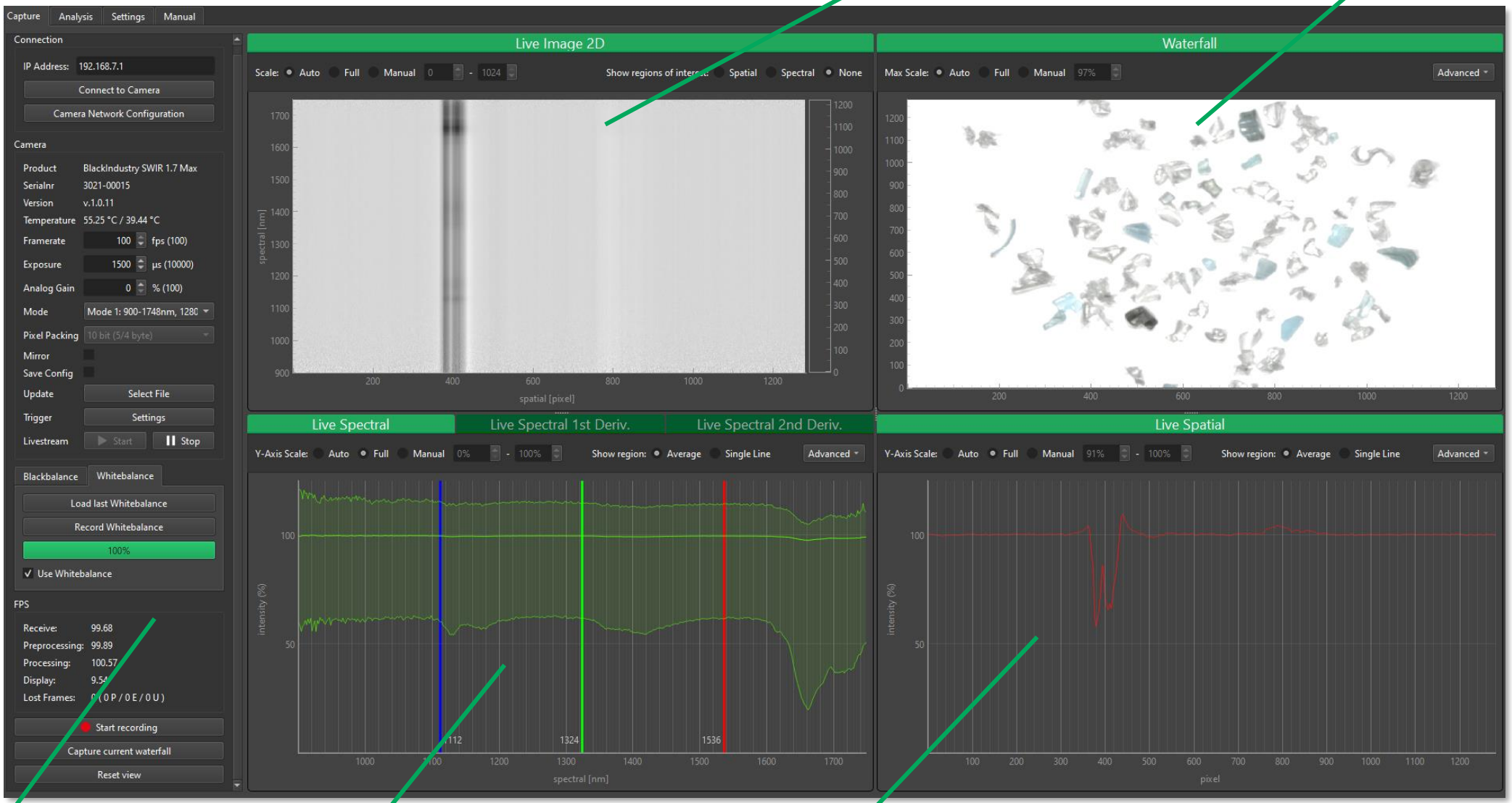


Image Acquisition – Workflow Overview

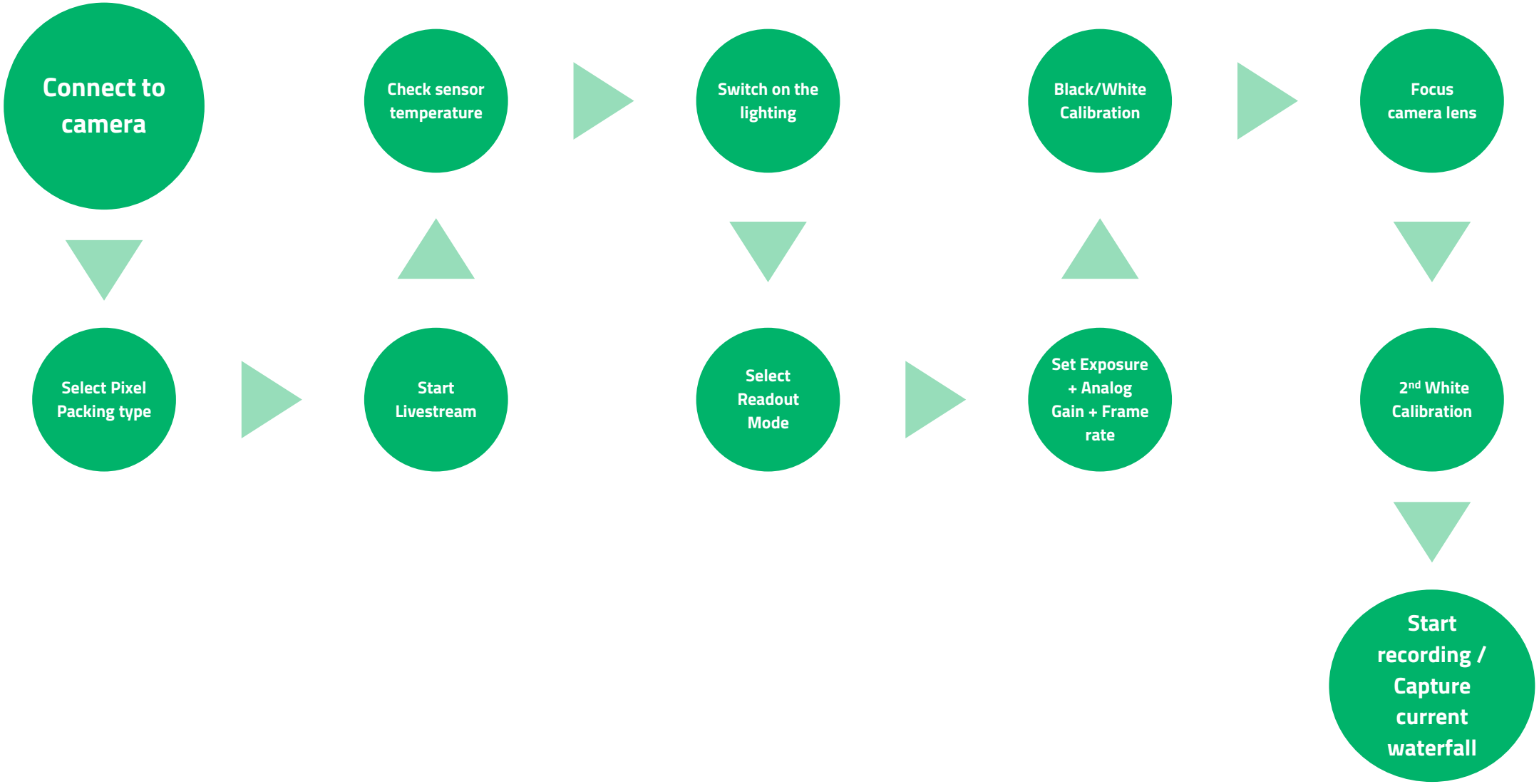


Image Acquisition – Select Readout Mode

- 4 available readout modes:

	Mode	Spectral range	Spatial x Spectral Bands	Frame rate	Spectral Sampling
Full Mode	Mode 0	900 – 1748 nm	1280 x 213	197 fps	213 bands à 4 nm
Full Mode	Mode 1	900 – 1748 nm	1280 x 425	100 fps	425 bands à 2 nm
Multi-ROI Mode	Mode 2	Max. 900 – 1748 nm	1280 x Sensor ROI	< 1330 fps	Multi-ROI à 2 nm
Multi-ROI Mode	Mode 3	Max. 900 – 1748 nm	1280 x Sensor ROI	< 1330 fps	Calibrated Multi-ROI à 2 nm

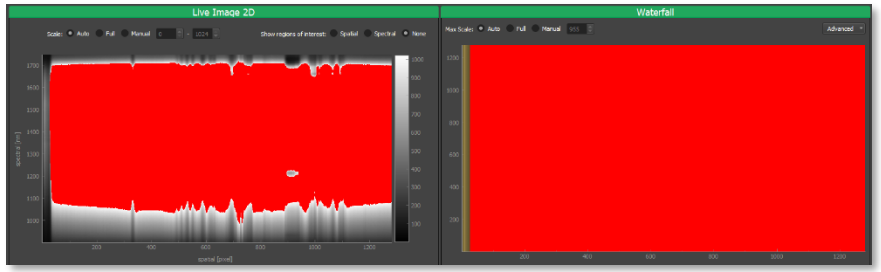
→ As soon as the readout mode is changed, new black and white balances must be performed

→ The maximum achievable frame rate may change depending on the mode

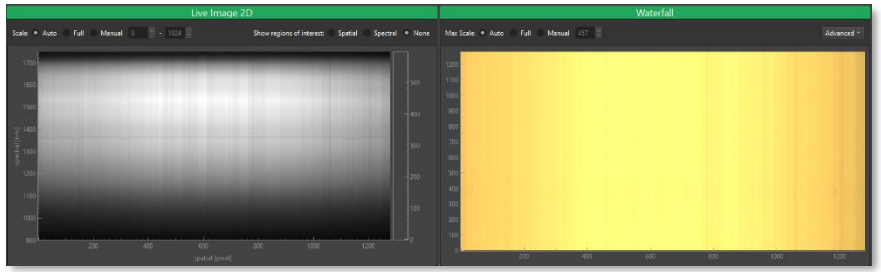
Image Acquisition – Set Exposure, Analog Gain & Frame Rate

- Adjust **Exposure** & **Analog Gain** settings to achieve an adequate illumination level and to eliminate oversaturation (for 10 bit Pixel Packing, indicated in red)
- Test the settings with your samples
- Live Spectral View: Enable **Show Min/Max**
  - Ideal **Intensity at max. 80 %**
- Set the desired **frame rate** in fps/Hz
  - Maximum frame rate depends on readout mode (max. 1330 Hz)

Ideal illumination level with a maximum at 80 %



Oversaturated areas in red



No oversaturated areas

Exposure in µs: Exposure time describes how long the incident light hits the sensor. Lower exposure time ensures darker images and should therefore be used at high intensity of the incident light. Conversely, high exposure time ensures longer incident light and should therefore be used in darker environments.

Analog Gain: This value adjusts the light sensitivity of the HSI sensor. This value is a multiplier and can be set from 10 (1x) to 155 (15,5x). The higher the value, the brighter the image, but also introduces more noise in the image.

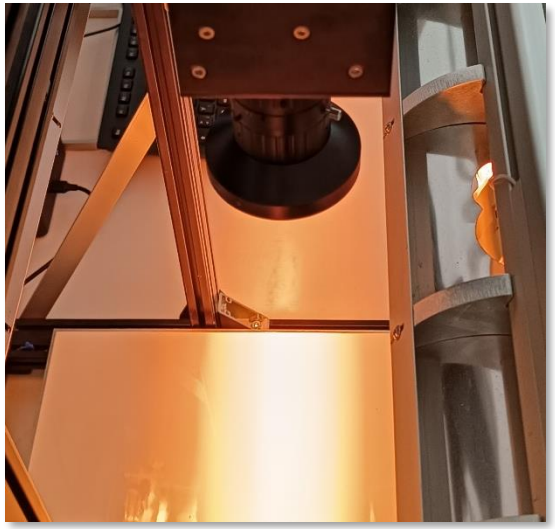
Image Acquisition – Black/White Calibration

Black Calibration

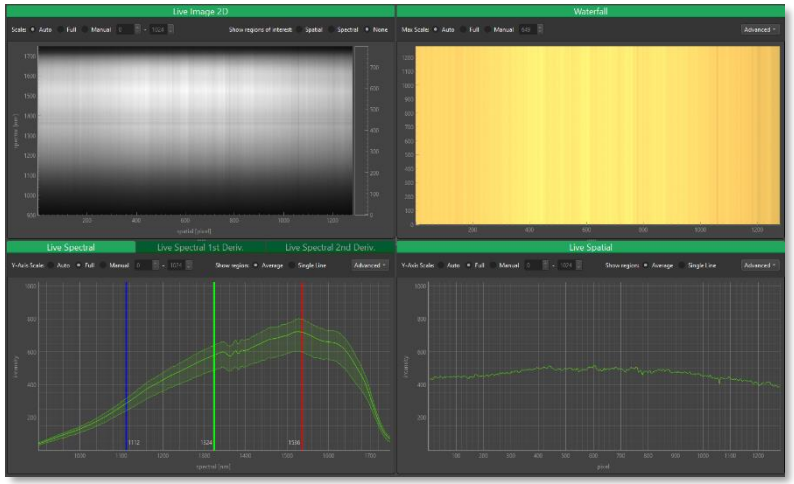
- Cover the camera lens entirely with a dark object
- Press **Record Blackbalance**

White Calibration

- Capture an image line from an entirely white surface
- Press **Record Whitebalance**



Before



After

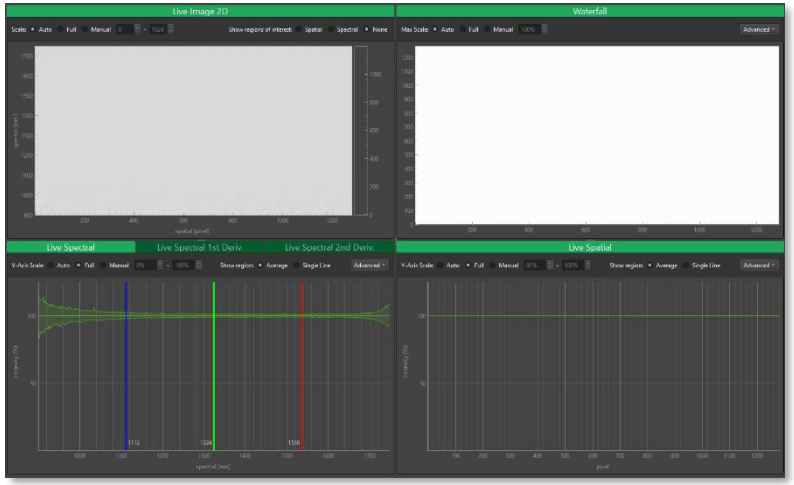
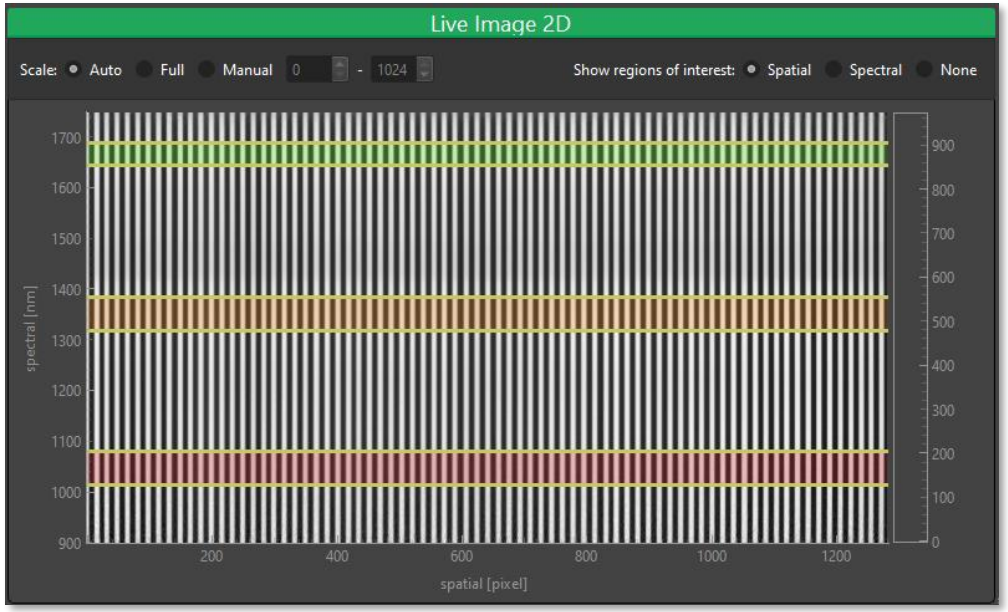
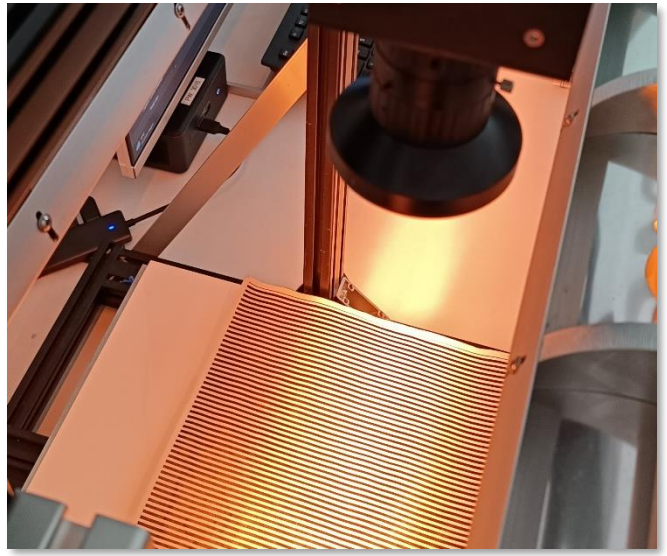


Image Acquisition – Focus Camera Lens

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



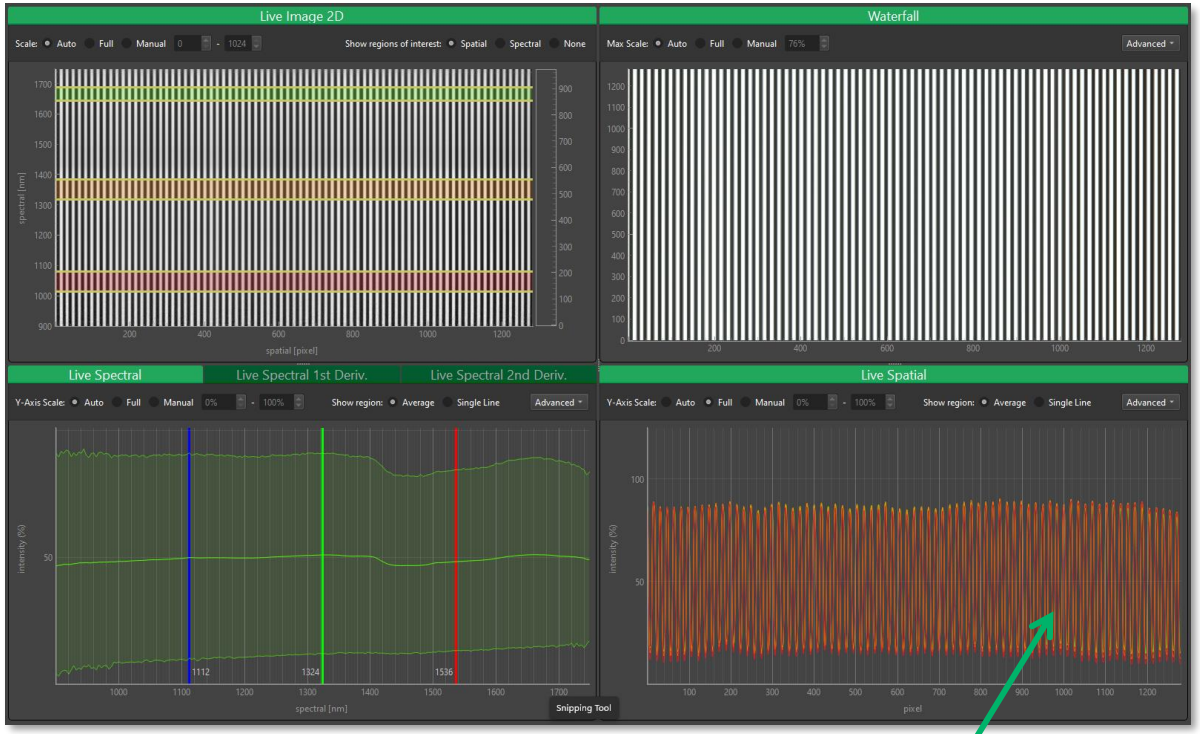


Focus Control Paper sheets

Focus Control Paper Download

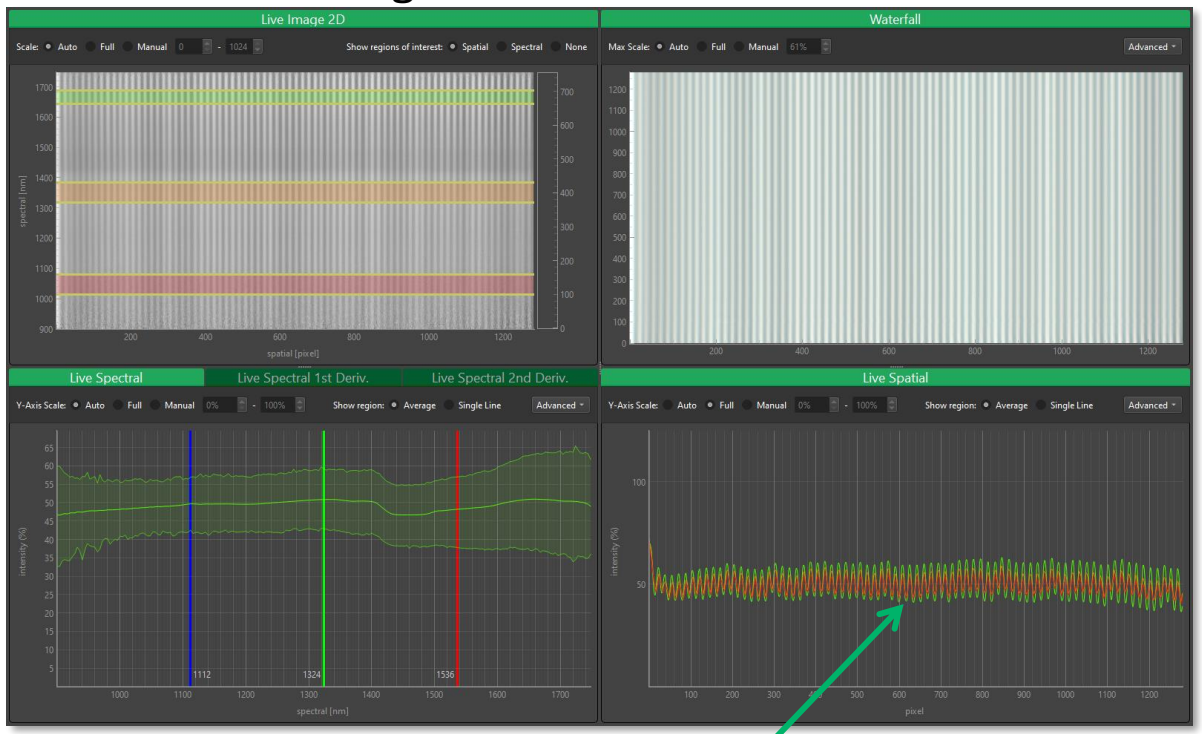
Image Acquisition – Focus Camera Lens

Focused scanning area



High contrast = Wide intensity range:
good focus

Unfocused scanning area



Low contrast = Small intensity range:
no focus

Image Acquisition –White Calibration

- After focusing the camera lens, it is recommended to carry out the **white calibration again**
- This eliminates potential effects that can arise due to poor focus
- A second black calibration does not have to be carried out

White Calibration - Reminder

- Capture an image line from an entirely white surface
- Press **Record Whitebalance**

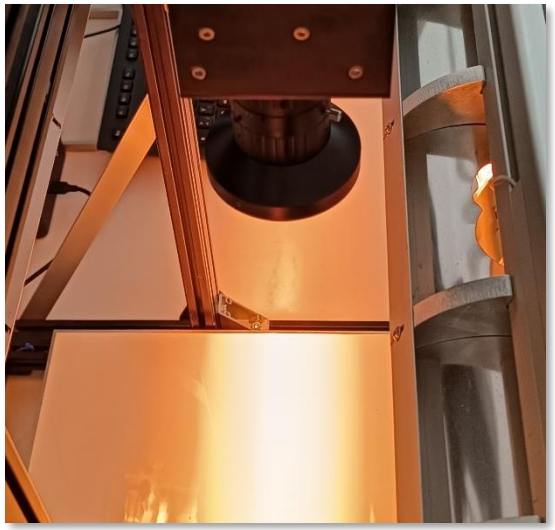
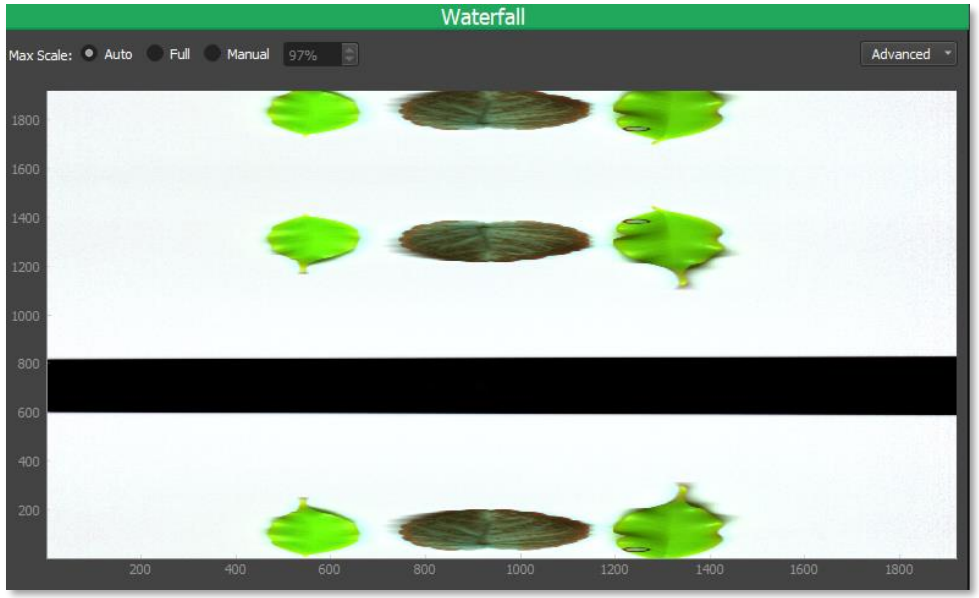
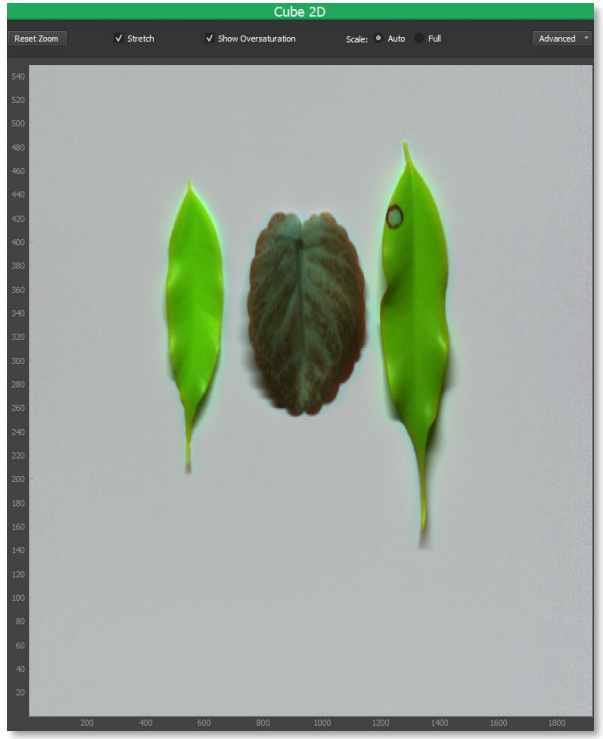


Image Acquisition – Start Recording

- 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 generated data is automatically opened in the **Analysis tab** of BlackStudio

Waterfall window with newly scanned pixel lines appearing at the top:



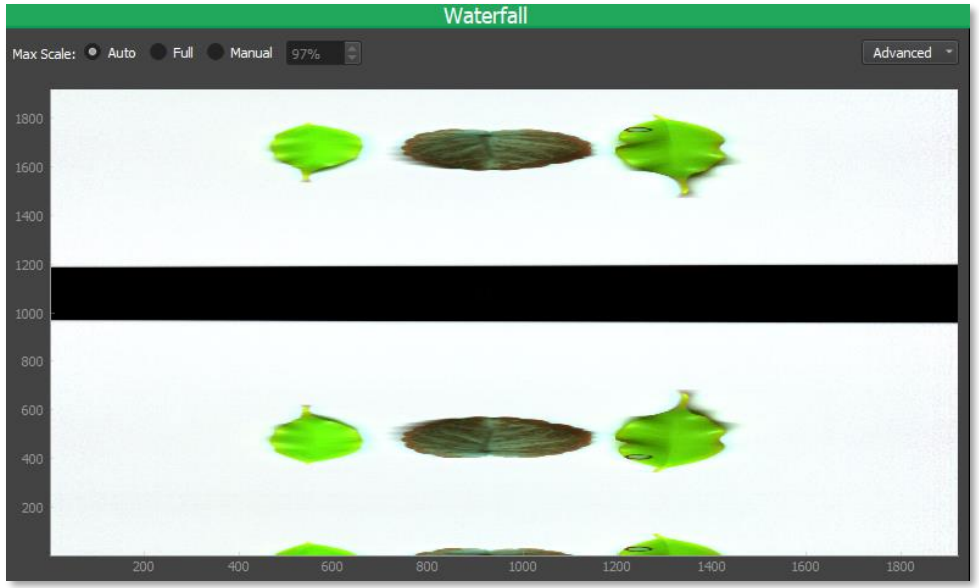


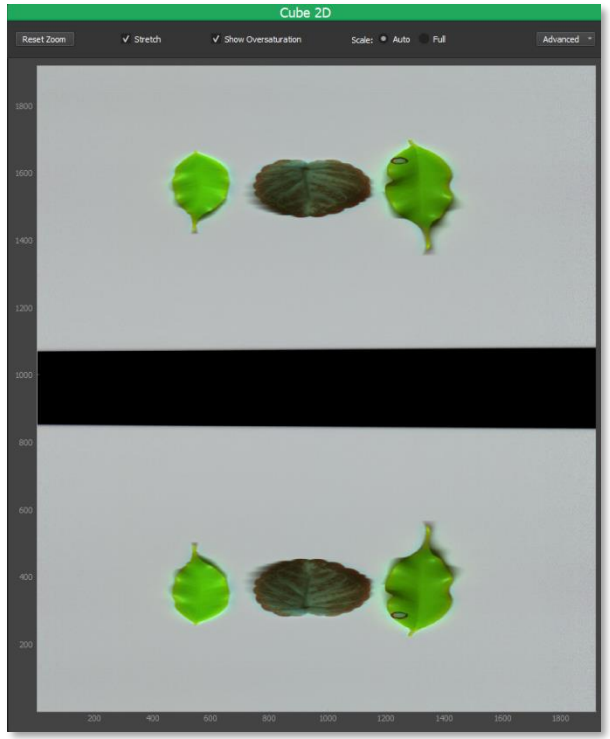
Cube 2D window in the Analysis tab displays all recorded pixel lines

Image Acquisition – 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

Waterfall window with newly scanned pixel lines appearing at the top:





Cube 2D window in the Analysis tab displays all recorded pixel lines

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