



SHUFFLE MULTI

User Manual 1.00

BOSSA NOVA
VISION

About This Manual

This Manual describes SHUFFLE MULTI hardware and software. Use this manual as a reference when working with your SHUFFLE MULTI.

About SHUFFLE MULTI: SHUFFLE MULTI is a turnkey imaging system dedicated to hair swatch 2D volume measurement and fly-away frizz analysis. SHUFFLE MULTI allows the simultaneous acquisition of up to 8 images of hair swatch. SHUFFLE MULTI has an integrated humidity box, allowing measurement in humidity-controlled environment for curl retention experiment for example.

Application of SHUFFLE MULTI ranges from claim substantiation and product efficacy testing for cosmetic products, to basic analysis of hair swatch visual appearance.

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EU Declaration of Conformity



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EU Declaration of Conformity

The equipment which accompanies this declaration is in conformity with EU Directives:

Low Voltage Directive (LVD) 2014/35/EU

Electromagnetic Compatibility (EMC) Directive 2014/30/EU

Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS)

General Product Safety Directive 2001/95/EC

Manufacturer:

Bossa Nova Vision LLC, 5777 West Century Blvd – Suite 205, Los Angeles, CA 90045 USA

This declaration is issued under the sole responsibility of the manufacturer.

A copy of the Technical File for this equipment is available from:

Judges Scientific (Dublin) Limited,
2nd Floor, 1-2 Victoria Buildings,
Haddington Road,
Dublin 4,
Ireland

Description of Equipment:

Bossa Nova SHUFFLE Multi platform; A platform to measure hair volume inside a controlled environment chamber over connected with USB links to 3rd party generic Windows PC running Labview Shuffle Multi software version 1.00 and onwards.

Year in which CE mark was affixed: 2025

The following harmonised standards have been used:

EN 61010-1:2010+A1:2019 - Safety requirements for electrical equipment for measurement, control, and laboratory use

EN 61000-6-1:2007 EMC Generic standards - Immunity for residential, commercial and light-industrial environments

EN 61000-6-3:2007 EMC Generic standards - Emissions for residential, commercial and light-industrial environments

EN IEC 63000:2018 RoHS

EN 60204-1:2018 Electrical Equipment of machines

Authorised signatory of manufacturer:

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Safety

This manual contains important safety and operation instructions for correct use of the System. Pay special attention to the notices.

CAUTION : Failure to observe this warning may result in damage to equipment and Improper functioning of the power supply.

WARNING :

1. Do not use this equipment supply near water.
2. Do not operate or touch the system or power supply with wet hands.
3. Refer all servicing to qualified service personnel only.
4. Use a grounded 3 pin AC source for the power supply.
5. Ensure that all hair tresses loaded are free from flammable materials/gasses.

Caution :

1. This equipment is for indoor use only.
2. Ensure door is closed prior to use.
3. Do not open the door while the system is active as this will potentially lead to unexpected humidity variation during the measurement or wind perturbation during the acquisition.

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1. QUICK START

1.1. Unpacking

When unpacking SHUFFLE MULTI, please make sure you have all the following items (Figure 1):

- SHUFFLE MULTI (Camera mounts not)
- Camera mount (x2)
- USB 3.0 cable for camera-computer connection (x2)
- USB 2.0 cable for humidity controller-computer connection (x1)
- Computer and monitor
- Hair Swatch mounts (x3)
- Magnetic alligator swatch clip (x8)



SHUFFLE MULTI (cameras not mounted)



Camera Mount (x2) – LEFT and RIGHT



Computer with monitor (SHUFFLE MULTI and HUMIDITY CONTROL software installed)

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USB 3.0 cable (x2)

USB 2.0 cable (x1)



Switches mount (x3) – Small, Medium and Large



Magnetic alligator switch clip (x8)



Humidity controller 24 VDC power supply



LED Back panel power supply

Figure 1: SHUFFLE MULTI components

A close-up of SHUFFLE MULTI left side showing the humidity controller is presented on Figure 2.



Figure 2: HUMIDITY CONTROLLER

If something is missing, please contact Bossa Nova Vision immediately!

1.2. Handling

Warning: Please adhere to proper manual handling procedures when lifting and transporting the Shuffle Multi. Due to its size, the system must be lifted from the base by a minimum of two individuals with the humidity bottle empty. For relocation to a new location, it is strongly recommended that the system be moved by a qualified professional.

1.3. Quick assembly

1.3.1. SHUFFLE MULTI

The only assembly required is to lock both camera mounts in place. To do so, remove the 4 thumb screws on the front of SHUFFLE MULTI (Figure 3).

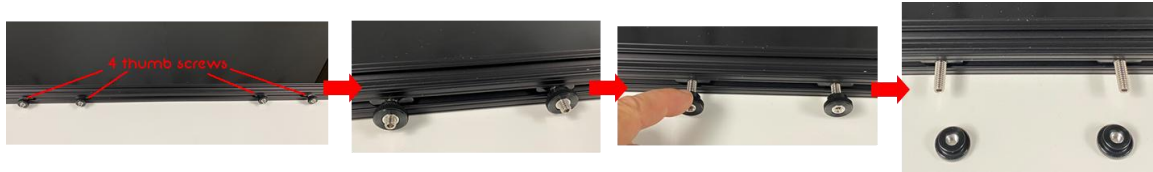


Figure 3: Removing thumb screws (x4)

Place both camera mounts (Put the left camera on the left and the right camera on the right, the left camera has a L on its back, the right camera has a R on its back.) and lock them in place using the thumb screws (Figure 4).



Figure 4: Mounting and locking the camera mounts in place

Both cameras are now mounted and locked in place (Figure 5).



Figure 5: Cameras mounted and locked

Do not forget to remove the black plastic lens cover of the camera before doing measurements.

1.3.2. Humidity Controller

If you are planning to use the Humidity controller, be sure that there is enough water in the bottle (distilled water). Refer to the **Humidity control user manual** for more details.

1.4. Connecting

1.4.1. SHUFFLE Multi

SHUFFLE MULTI is connected to a computer for data/image acquisition, processing and data visualization/analysis/management. The 2 USB 3.0 cables are the camera connection (USB 3.0, blue) from SHUFFLE MULTI to the computer. Be sure to connect to the USB 3.0 computer connection as shown on Figure 6. There are usually 2 USB 3.0 connection on the front of the desktop.

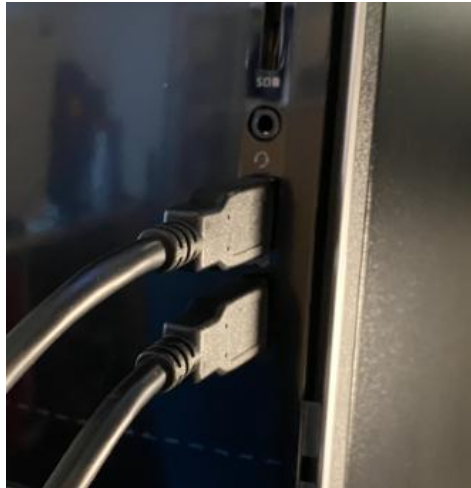


Figure 6: USB 3.0 connection

To turn on the back LED panel, just connect the power cable out of the system to a regular power cable (Figure 7).

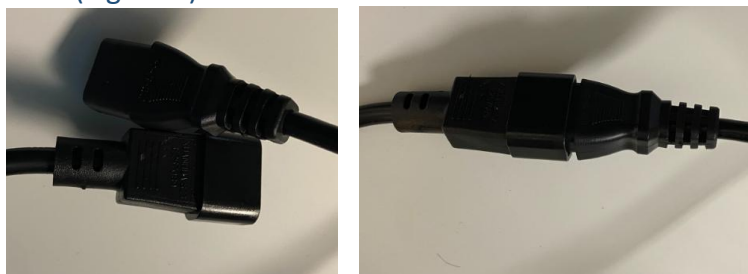




Figure 7: LED Panel on

LED panel is now on.

1.4.2. Humidity controller

The humidity controller is connected to the computer via a USB 2.0 cable. There are several USB 2.0 connections in the back on the desktop, where the keyboard and mouse are connected.

Please refer to the humidity control manual to adjust the COM port if needed.

1.5. Measurement with SHUFFLE MULTI

Start the computer. SHUFFLE MULTI icon shortcut is on the desktop (Figure 8). SHUFFLE MULTI includes an integrated humidity box but humidity control software and SHUFFLE Multi software remain two independent software running at the same time. For a quick start, you do not need to use Humidity Control.



Figure 8: SHUFFLE MULTI shortcut

Click on SHUFFLE MULTI icon. The following window appears (Figure 9).



Figure 9: SHUFFLE MULTI window

To start BOLERO Multi, just click on the BOLERO Multi button and BOLERO Multi main windows pops-up (Figure 10).



Figure 10: BOLERO Multi main window

Please click on LIVE MEASUREMENT & LOAD DATA. The following window appears, asking to remove any swatch present before the hardware initialization test (Figure 11).

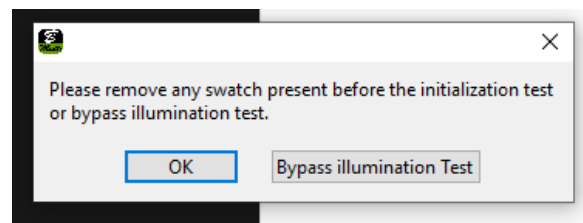


Figure 11: Remove any swatch present or Bypass illumination test

The first time SHUFFLE MULTI is used, we recommend to proceed to a full initialization test and to remove any swatch present. Click on OK. Series of hardware test occur (cameras detection and illumination level check). At the end, the following pop-up window appears (Figure 12). If another pop-up window appears signaling hardware troubles, please contact Bossa Nova Vision immediately.

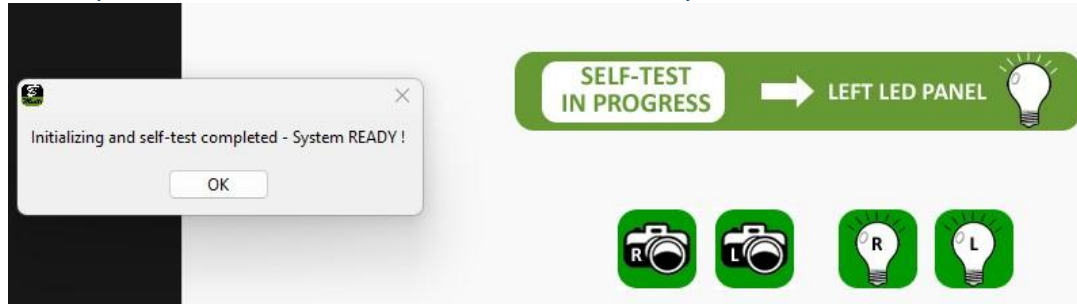


Figure 12: System READY! Pop-up window

You are now ready to proceed to surface measurement and bulk & fly-away/frizz analysis on hair tress!

Click on OK. The following window appears (Figure 13).

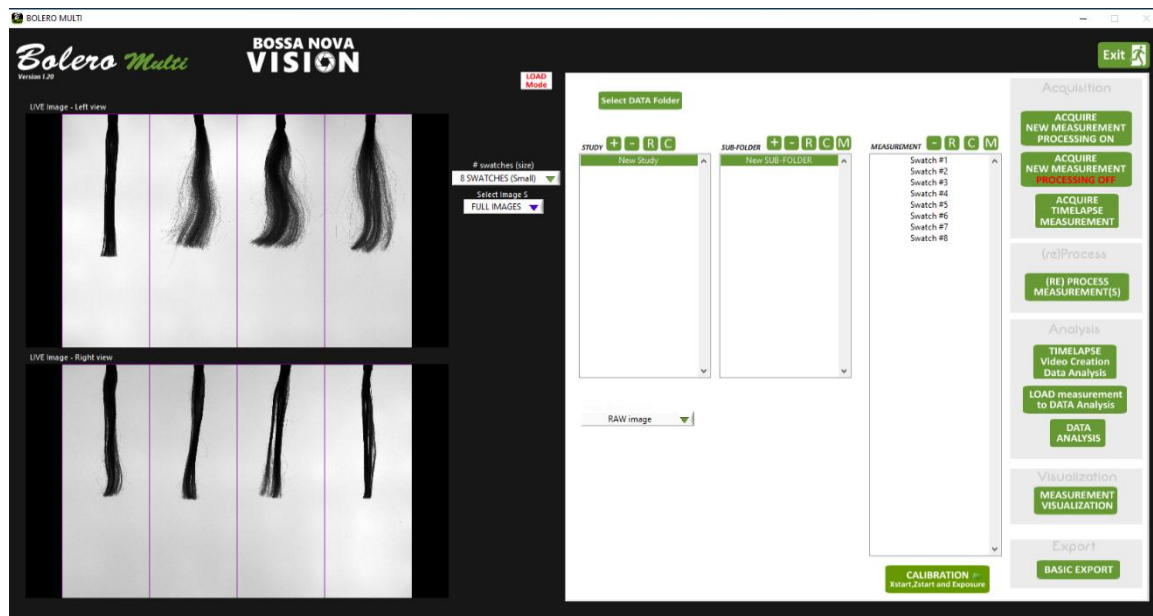


Figure 13: SHUFFLE MULTI Main window

Before acquiring a new measurement, you need to create a STUDY then a SUB-FOLDER using the  control (Figure 14) located on the right of the STUDY and the SUB-FOLDER.

STUDY     **SUB-FOLDER**     

Figure 14: Creating STUDY then SUB-FOLDER

By clicking on , a pop-up window (Figure 15) asks for the name of the study (or sub-folder).

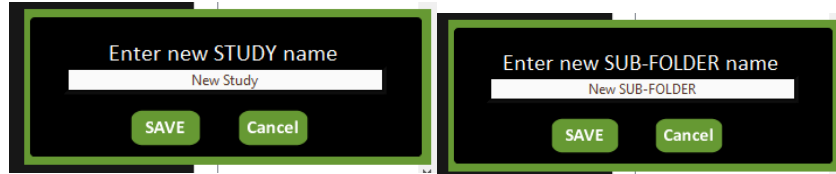


Figure 15: Pop-up window enter new STUDY (or new SUB-FOLDER)

Figure 16 shows the new STUDY (Test) and the new SUB-FOLDER (Time lapse) created.

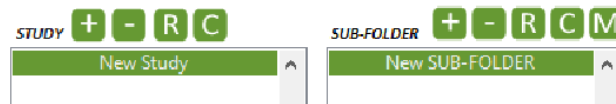


Figure 16: STUDY and SUB-FOLDER created

You are now ready to acquire the first measurement. Mount the hair swatches (up to 8) to be measured (Figure 17) using the magnetic hair swatch mount. Open the alligator mount to hold the hair swatch and simply put the swatch mount on the magnetic mount.



Figure 17: Mounting the hair swatch

Open the side door and slide the hair swatch mount out (Figure 18).



Figure 18: Side door open and hair swatches mount out

You can use different hair swatches mount depending on the swatches size - SMALL, MEDIUM or LARGE -, small accommodating a maximum of 8 swatches, medium a maximum of 6 swatches and large a maximum of 4 swatches (Figure 19).



Figure 19: Swatches mount (Large – for only 4 swatches max)

It is easy to remove the swatches mount, or you can mount the swatches directly. The hair swatches are mounted (Figure 20).



Figure 20: Hair swatches mounted

You can slide the hair swatches mount back and close the side door. The hair swatches appear on the live images (left and right) on the left of the main window (Figure 21).

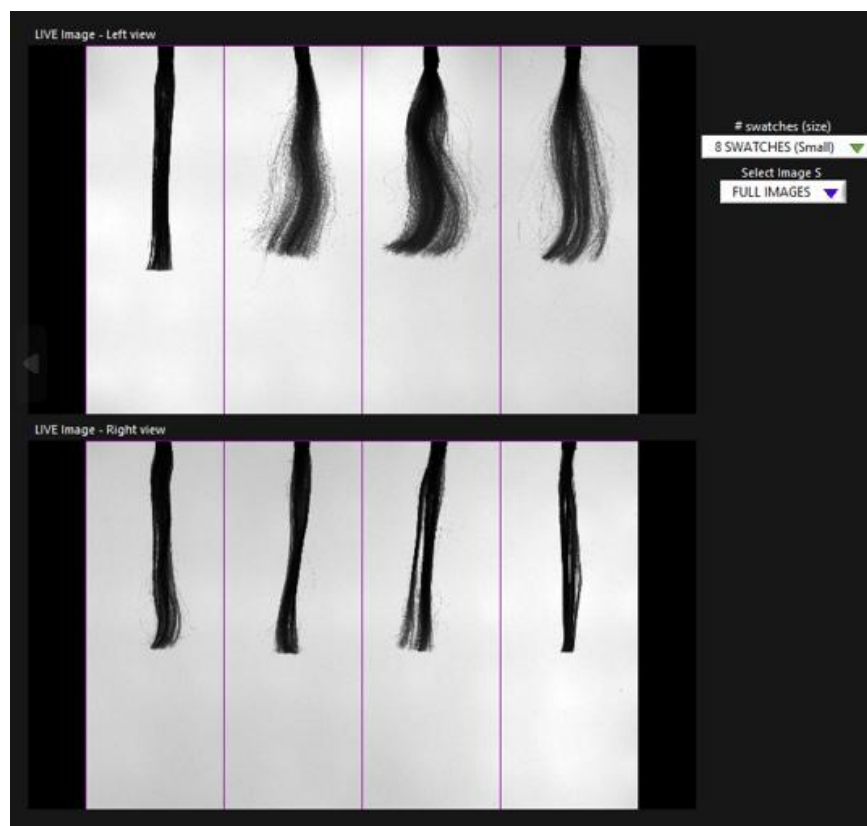
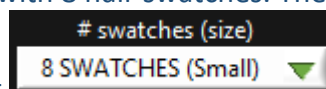


Figure 21: Live image

In that particular case, we are using the SMALL mount with 8 hair swatches. The number of swatches is selected on the right of the images using



Click on the



control to start the acquisition of a new measurement. The following window appears (Figure 22).

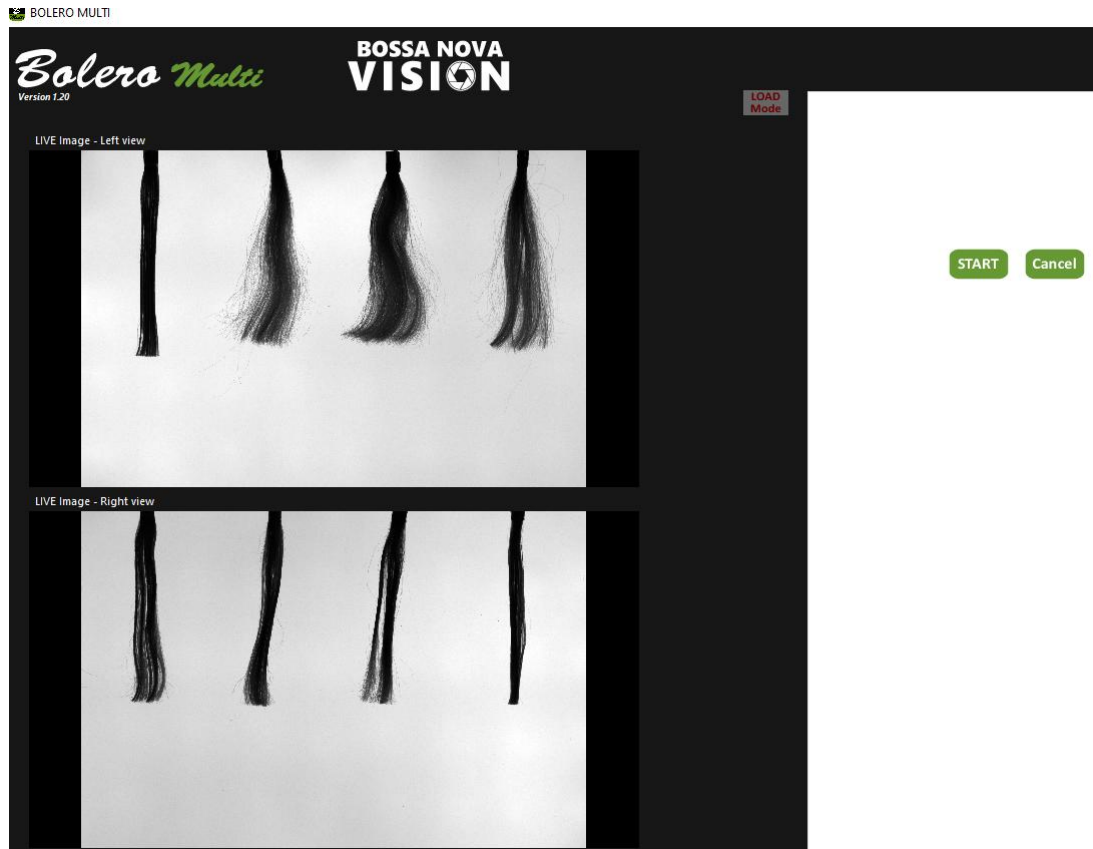


Figure 22: Acquisition Window

Click on the start control

START

and the following pop-up window appears to ask for

the name of the new measurements (Figure 23). Click on cancel

Cancel

and the

software goes back to the main window without any new measurement acquired.



Figure 23: Pop-up window – Measurements name

The user can choose if a swatch is present by selecting or deselecting the position control.



Click on the save control and the measurement starts.

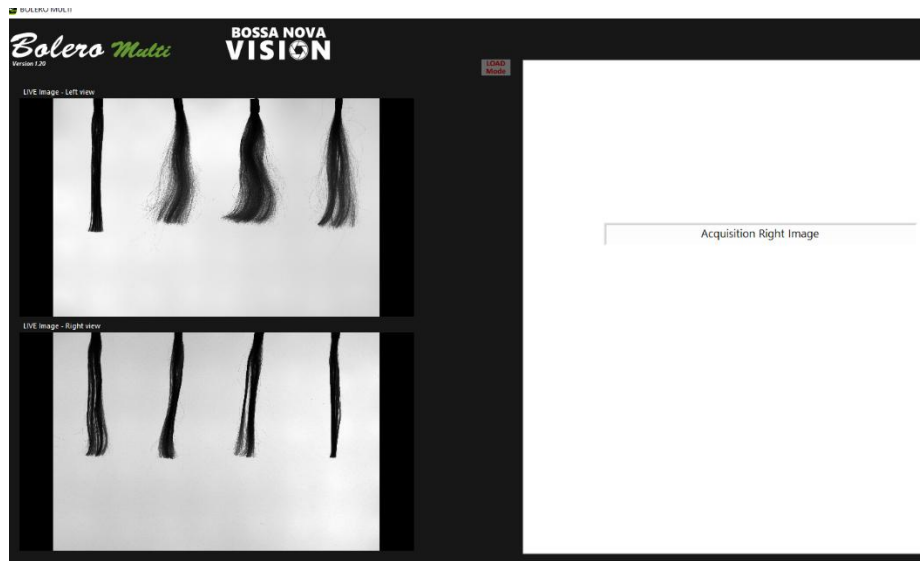


Figure 24: New Measurements acquisition

After different steps (Acquisition, image save, image processing), the software returns to the main window (Figure 25) where the new measurements are saved.

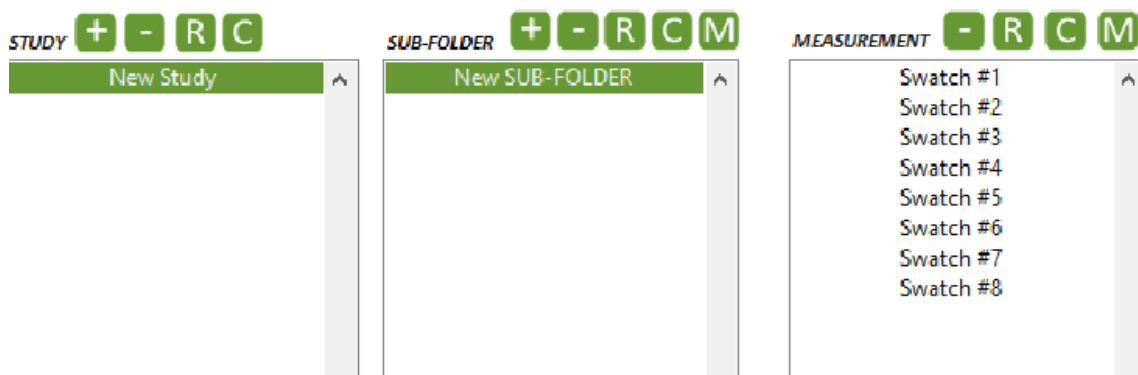


Figure 25: Main window – New measurement saved

Because one data acquisition can lead to up to 8 individual measurements, automatic data visualization does not exist and to visualize ONE measurement, just select it in the measurement list (Figure 26) and the image will appear under the sub-folder list.

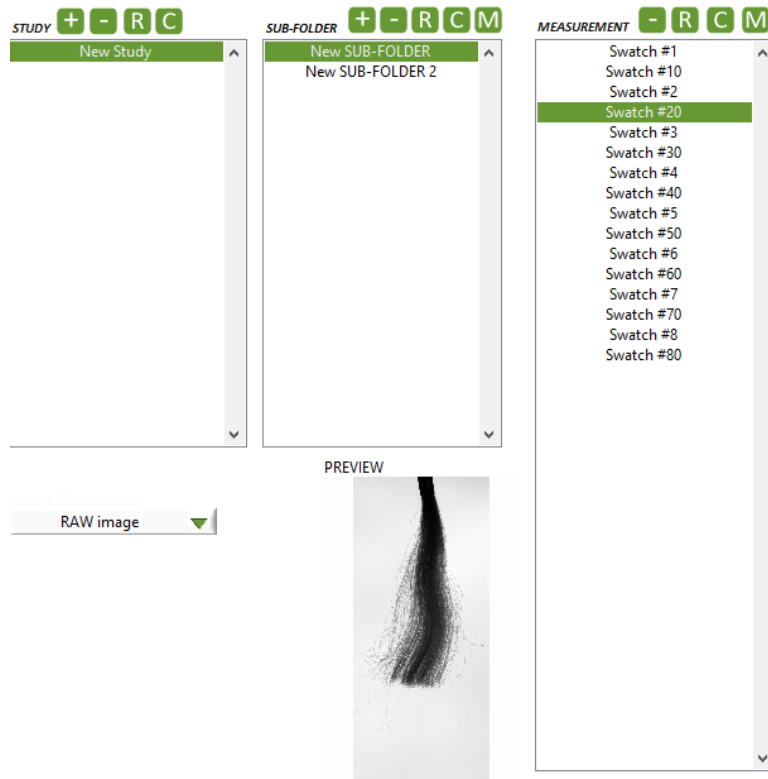
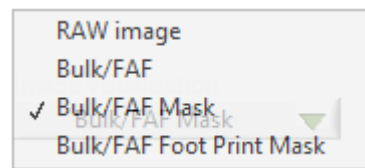


Figure 26: image visualization



The user can change the visualization by using the **Image Visualization** control. To get all the data – graph, etc. – the user selects the measurement and clicks on



, to be detailed in the following.

2. SHUFFLE MULTI SOFTWARE

SHUFFLE MULTI software allows to control SHUFFLE Multi hardware i.e. acquire, process, visualize and export data for hair volume and fly-away frizz analysis. A calibration button at the bottom of the window, as seen on Figure 27, allows the user to re-calibrate the system if necessary.

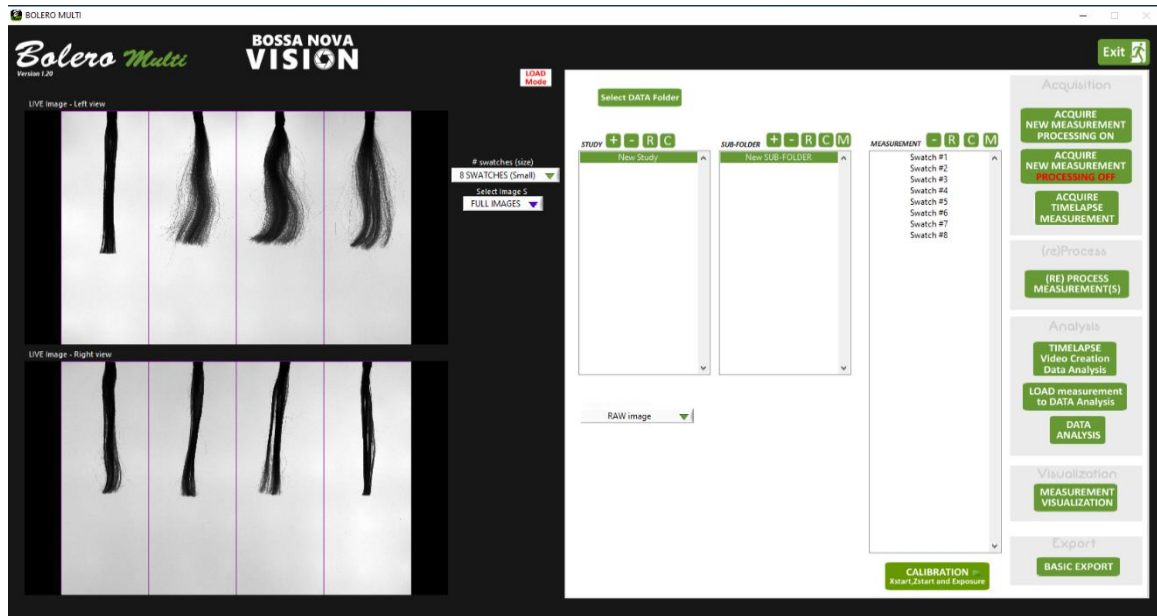


Figure 27: SHUFFLE MULTI main window software

2.1. Startup

At startup (shown on Figure 28 below), the user can choose the operation mode between **Live measurement & Load data** or **Load data only** if no hardware is connected or no measurement is scheduled.

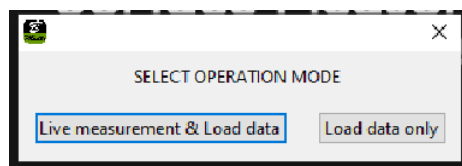


Figure 28: Start-up pop-up window

- Choosing **Load data only** will lead to the main window. The software does not need hardware to be turned on or connected. The user will only be able to load existing data, and visualize, process and export data.
- Choosing **Live measurement & Load data** leads to an automated test procedure that insures all hardware components (Left and right cameras, illumination level of LED panel) are working properly to the factory specifications.

2.1.1. Hardware test

Before going into a full initialization and self-test of the different hardware components, a dialogue window is asking the user to remove any hair swatch present before the full test or to bypass the illumination self-test and leave the hair swatch if present (Figure 29).

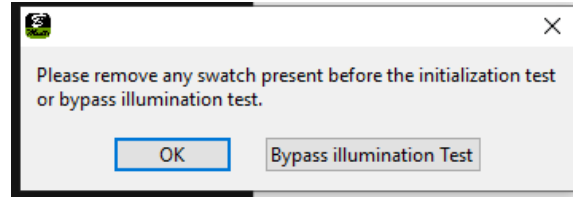


Figure 29: Initialization and self-test

A full test requires no swatch present in the system in order to capture and save a picture of the background level (LED panel). We recommend to proceed to a full initialization and self-test at least every day.

When the user selects **OK** for a full test, sequential steps are done:

- STEP 1 - Camera initialization and test
- STEP 2 - Illumination initialization and test (measurement of background level and uniformity)

If the two steps are successful, image acquisition will be possible. If nothing is activated, the user will only be able to load data.

If the user has selected **Bypass illumination test**, only STEP 1 will be done. STEP 2 - Illumination initialization and test (measurement of background level and uniformity) is considered ok. Background images and data stored in the computer will be used.

If STEP 1 is successful, measurement and image acquisition will be possible. If not, the user will only be able to load data.

The software goes to STEP 1 - Cameras initialization and test is on (Figure 30)

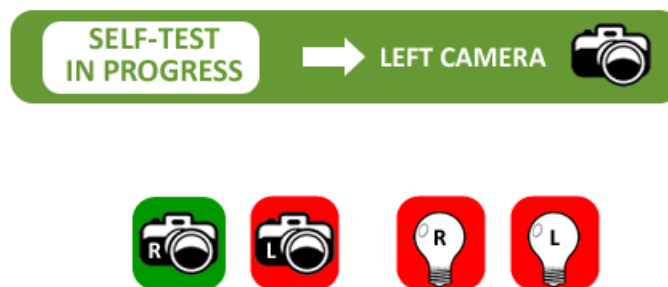


Figure 30: STEP 1 - Cameras initialization and test

Figure 31 shows the dialog window if there is an issue with the cameras.

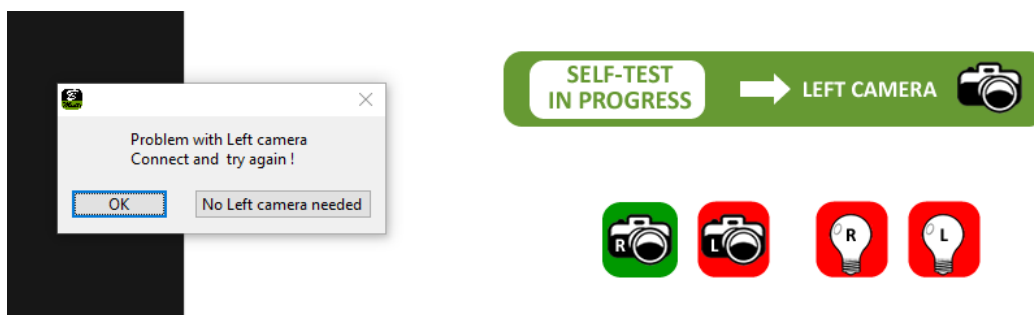


Figure 31: Dialog window if there is an issue with the camera

The user can select **OK** while reconnecting the camera. This option will proceed to STEP 1 - Cameras initialization and test again. The user can also select **No camera needed – Load data only**. This option will by-pass next steps and go to SHUFFLE Multi main window. If after few tries, the camera is not correctly initialized, please contact Bossa Nova Vision. If the full test was select i.e. **by-pass illumination test** was not clicked, the software proceeds to STEP 2 for a measurement of the LED panel level and the LED panel uniformity. Be sure no swatch is present when this step is running.



Figure 32: STEP 2 - Illumination initialization and test (measurement of background level and uniformity)

Figure 33 shows the dialog window if there is an issue with the illumination.

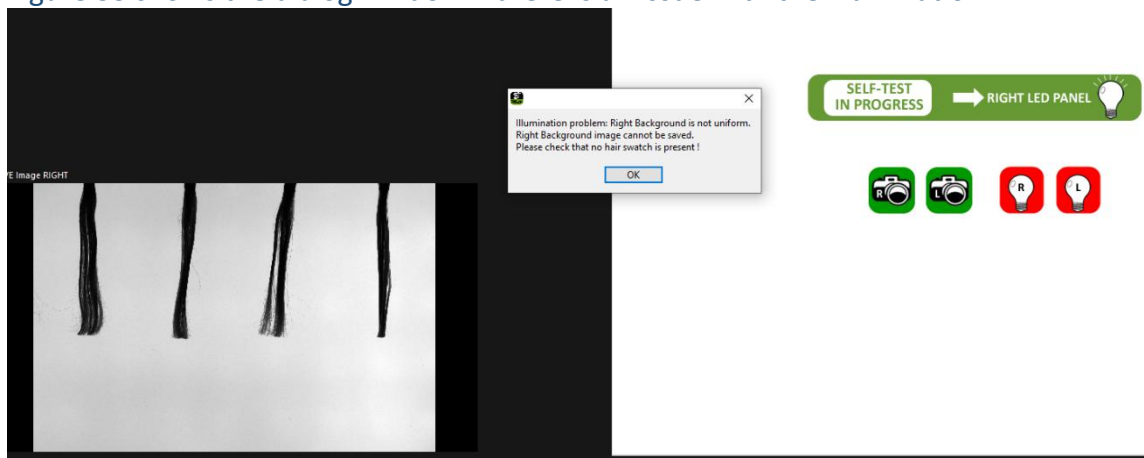


Figure 33: Dialog window if there is an issue with the illumination

2 problems can occur: Level too low or background non uniform. In case of a non-uniform background, please check that there is no swatch present in the system or anything on the LED panel (like on the example above). If after a few tries, the illumination is not correctly initialized, please contact Bossa Nova Vision. If STEP 2 is successful, a dialog window appears (Figure 34) indicating to the user that the initialization and self-test are successful. The user can also notice that all indicators are green and the image acquisition is authorized.

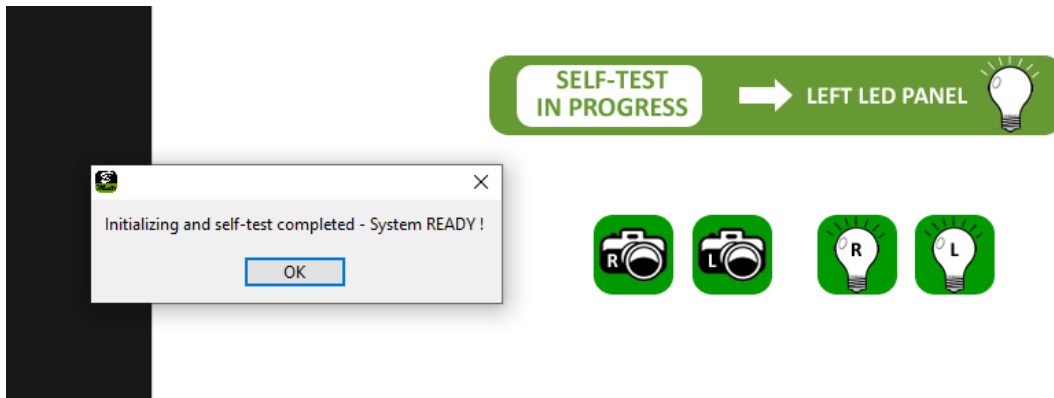


Figure 34: Dialog window – Initialization and self-test successful

2.2. SOFTWARE

The main window is presented on Figure 35.

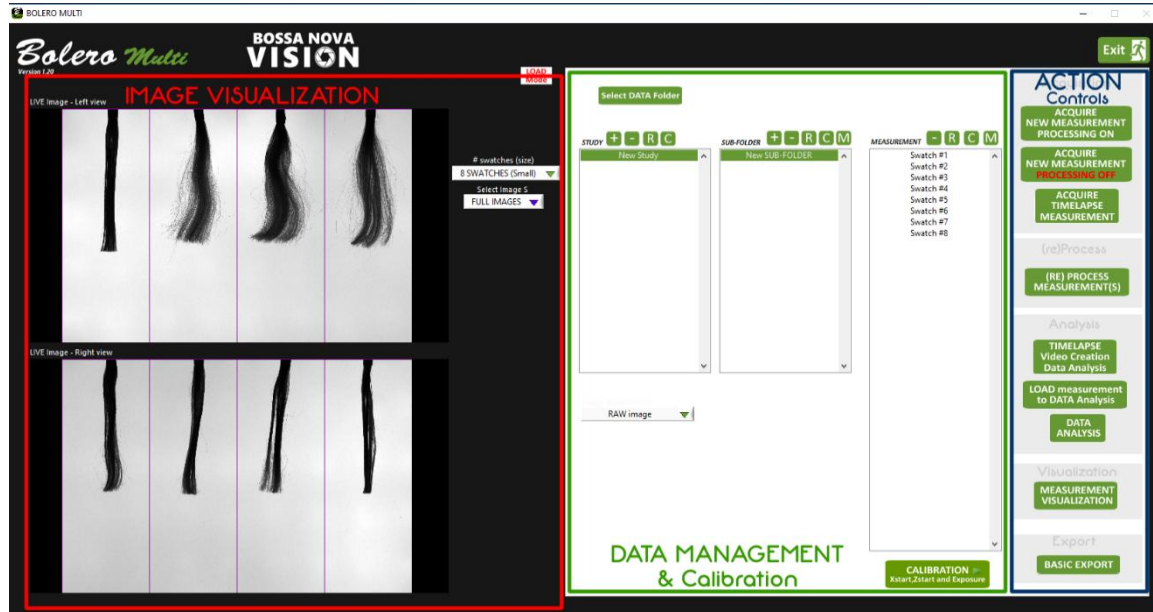


Figure 35: SHUFFLE MULTI – Main window architecture

On the left of the window is the **IMAGE VISUALIZATION**.

In the main window center is the **DATA MANAGEMENT**, to create, delete, rename study, subfolder etc.

On the right of the **DATA MANAGEMENT** are the **ACTION CONTROLS**, allowing to acquire new measurements, process measurements, provide data analysis and comparison and data export, etc.

On the top right of the window, at the top is the **EXIT SOFTWARE** control  to exit the software.

2.3. Live IMAGES VISUALIZATION

The left side of the main window consists of live images visualization (Figure 36).



Figure 36: Live image visualization (left live image on top)

If **Load data only** is selected , the LIVE IMAGE shows (Figure 37) a *SHUFFLE MULTI* – no live measurement – Open data only image.



Figure 37: Load data only – LIVE image

On the right of the live image are 2 controls (Figure 38).

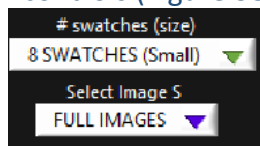
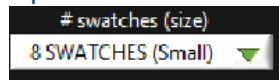


Figure 38: Images controls

These 2 controls allow to change the size of the individual images acquired and to visualize

the full images or the individual images. The # swatches control  is used to adjust the individual images size from SMALL, MEDIUM or LARGE. SHUFFLE MULTI can adapt on the size of the hair swatches to be measured and provide simultaneous measurement of 8 swatches for SMALL, 6 swatches for MEDIUM and 4 swatches for LARGE. The table bellows summarizes the individual image size, the corresponding dimensions on the hair swatch and the maximum numbers of hair swatches.

SIZE	SMALL	MEDIUM	LARGE
Individual image size (pixels)	900 x 2,400	1,200 x 2,400	1,800 x 2,400
Individual image size (cm)	12.15 x 32.4	16.2 x 32.4	24.3 x 32.4
# of individual HAIR SWATCHES	8	6	4

The image below shows the dimensions for SMALL hair swatches (Figure 39) on the live image.

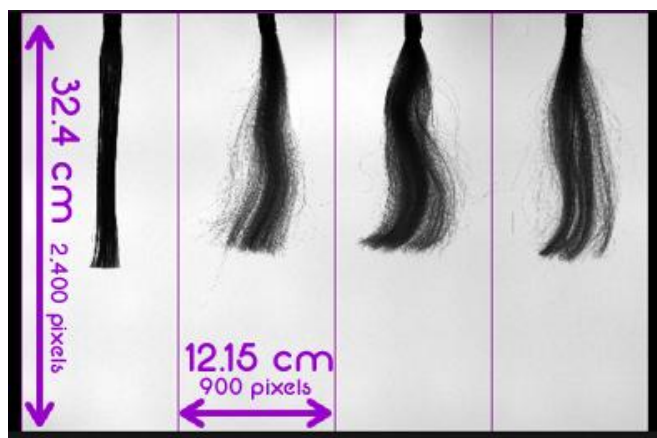


Figure 39: SMALL Hair swatches

So depending on the size of the hair swatches to be measured, the user can adapt the size of the individual images. For larger hair swatches, the user can switch to the LARGE mount for only 4 swatches (Figure 40).

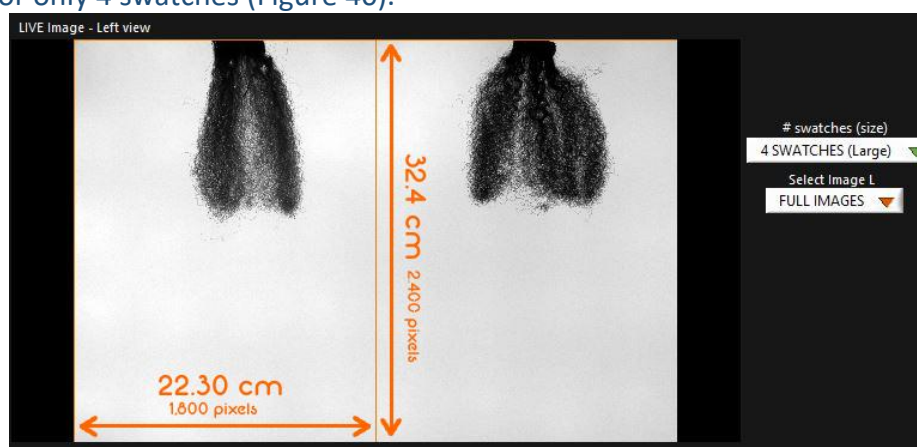


Figure 40: LARGE Hair swatches

Be sure to select the correct mount and corresponding size (Figure 41).

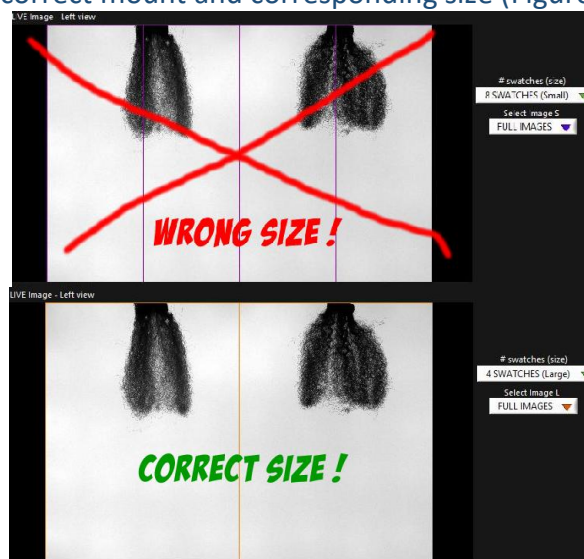
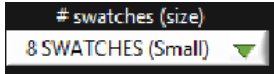


Figure 41: correct mount and corresponding size

The size control  can adjust the # of swatches and their corresponding size from SMALL, MEDIUM and LARGE (Figure 42).

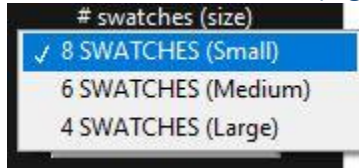
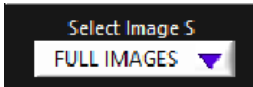


Figure 42: SMALL, MEDIUM and LARGE

The control  allows to select the full live images or individual live image (Figure 43).

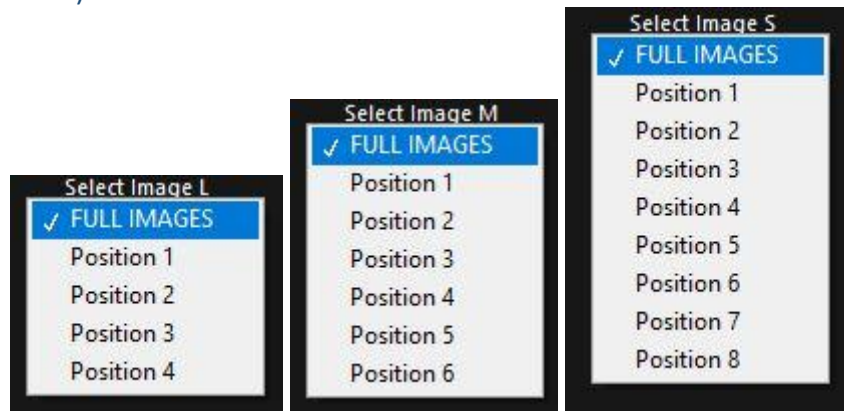


Figure 43: image visualization

Selecting an individual image (POSITION #) will replace the 2 full live images by a single individual live image (Figure 44).

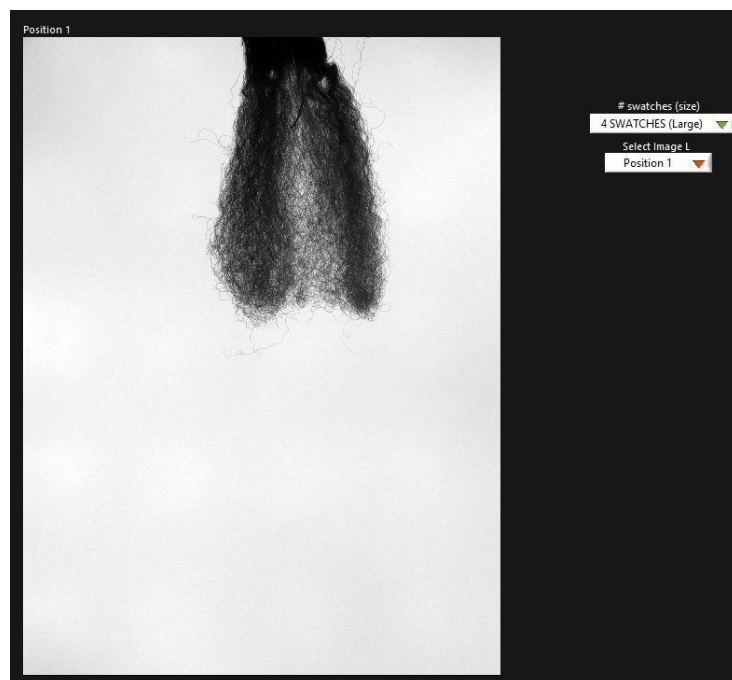


Figure 44: Individual live image

2.4. LOAD or LIVE

The indicator/control on the top right of the image shows **LOAD Mode**. The controls allowing the acquisition of new data (image or video) are not visible. If the user clicks on **LOAD Mode**, a pop-up window appears (Figure 45) asking the user to choose the operation mode similar to the start of the software.

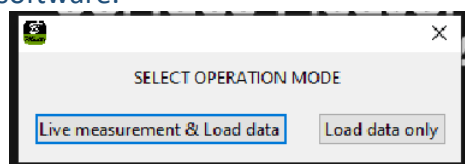


Figure 45: Live or load pop-up window

Choosing **Live measurement & load data** will trigger the hardware check-up procedure previously explained.

If a measurement is selected in LOAD DATA mode, the corresponding image appears in the live image window (Figure 46).

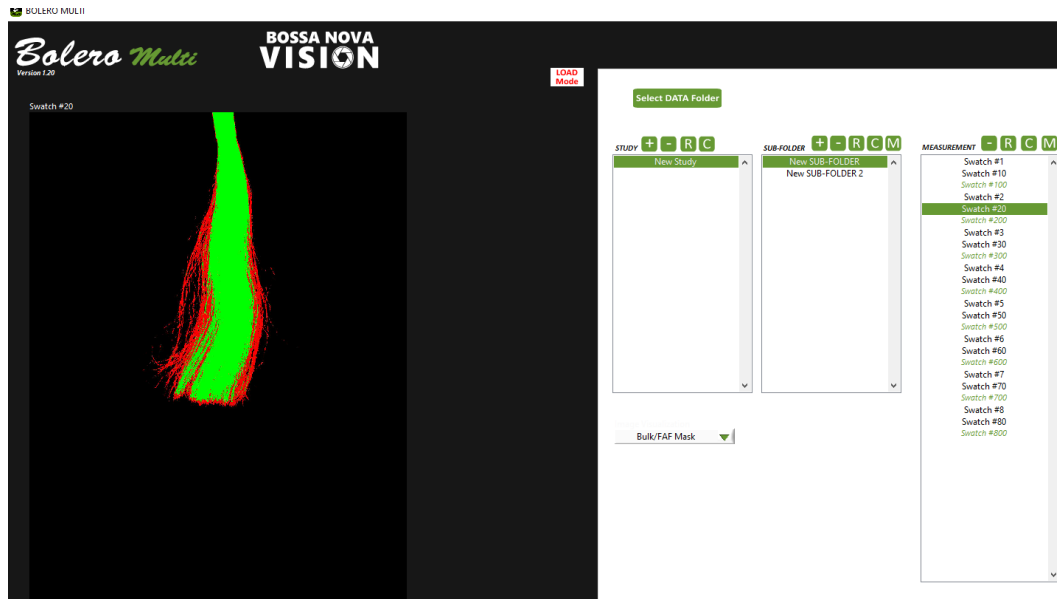
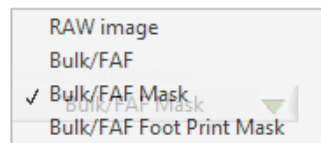


Figure 46: Load only – Measurement selected



The image visualization control appears when a measurement is selected (under the image). 4 different images can be displayed.

- 1) The raw image –
- 2) the bulk/FAF image, showing the bulk in green and the FAF in red with the intensity information
- 3) the bulk/FAF mask image, showing the bulk in green and the FAF in red without the intensity information
- 4) the bulk/FAF footprint mask image, showing the bulk in green and the FAF footprint in red without the intensity information

If the measurement selected is unprocessed (measurement name in italic), only the raw image can be displayed.

In the LIVE mode **LIVE Mode**, the image shown is the live image from the camera and the selected measurement image appears in a small preview window (Figure 47) under the sub-folder list.

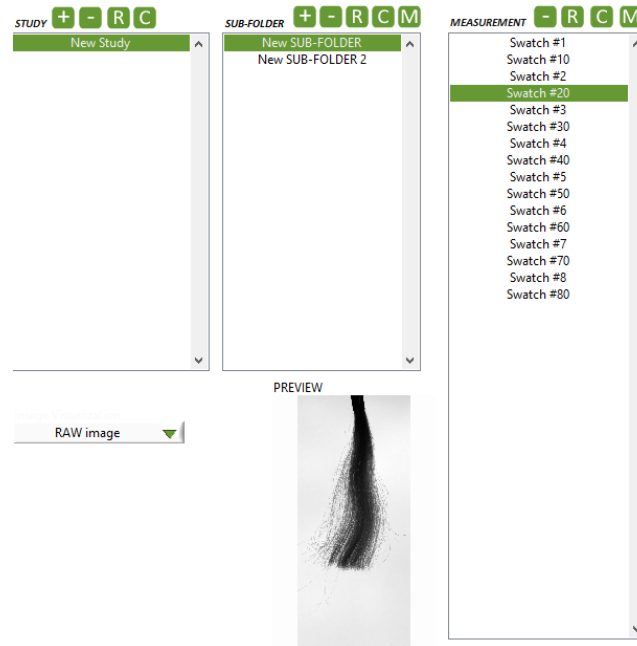


Figure 47: Preview window – Live and measurement selected

In the LOAD mode **LOAD Mode**, the selected measurement image appears in the image window (Figure 46). Note that if more than 1 measurements are selected, only the first one is displayed.

2.5. DATA MANAGEMENT

Data Management window allows to manage the data to be saved and processed (Figure 48). The user can create, delete, copy, rename, etc. different folders and measurements.

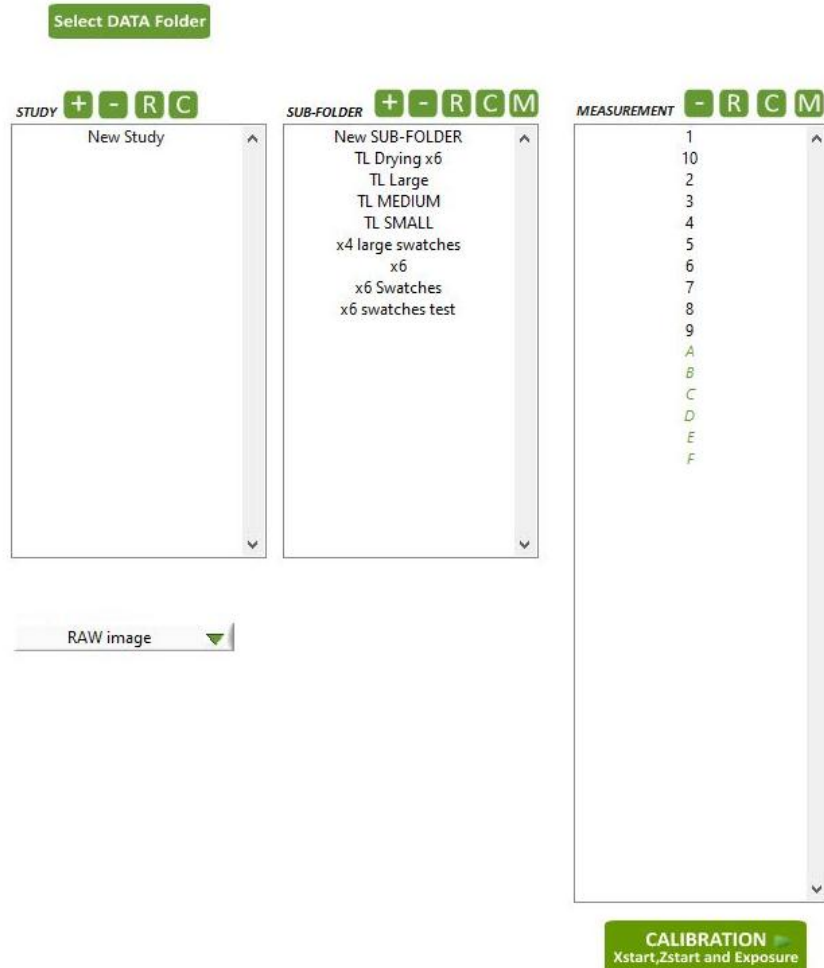


Figure 48: Data Management window

3 lists are present:

- Study
- Sub-folder
- Measurements

These correspond to list of folders where the raw data are saved. If a measurement has not been processed, it appears in *green italic* in the list (Figure 49).

Figure 49: Measurement List – Processed and *not processed*

This *unprocessed* measurement (*green italic* on this example) can still be deleted, copied, renamed and moved. The other measurements are in normal and black font and correspond to processed measurements.

On top of each list are controls: **+** **-** **R** **C** **M**

The **+** and **-** controls **+** **-** allow to CREATE and DELETE folder.

The R control **R** allows to RENAME a folder.

The C control **C** allows to COPY a folder.

The M control **M** allows to MOVE a folder.

2.5.1. CREATE

Clicking on the plus control triggers a pop-up window asking for the name of the new study or the new sub-folder (Figure 50).



Figure 50: New study or new sub-folder name

Clicking on the cancel control  will cancel the creation of the new study or sub-folder and close the pop-up window.

2.5.2. DELETE

Clicking on the minus control to delete a study, sub-folder or a measurement will trigger a pop-up window asking the user to confirm (Figure 51).

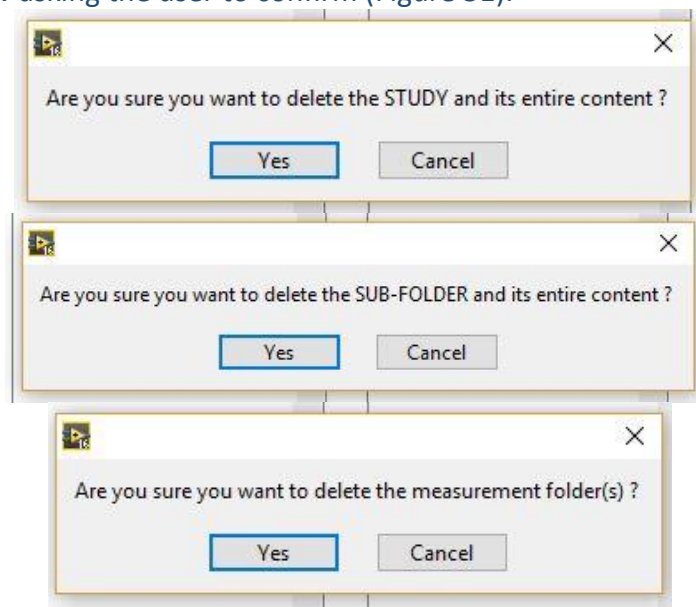


Figure 51: Pop-up window for deleting Study, Sub-folder or measurement

Note that when a folder is deleted, everything it contains is also deleted. For example, if the user deletes a study folder, the sub-folders and measurements folder contained in the study will also be deleted.

2.5.3. RENAME

The user can rename a study, a sub-folder or a measurement. Clicking on the R control  triggers a pop-up window (Figure 52) to enter the new name (pre-populated with name_rename).

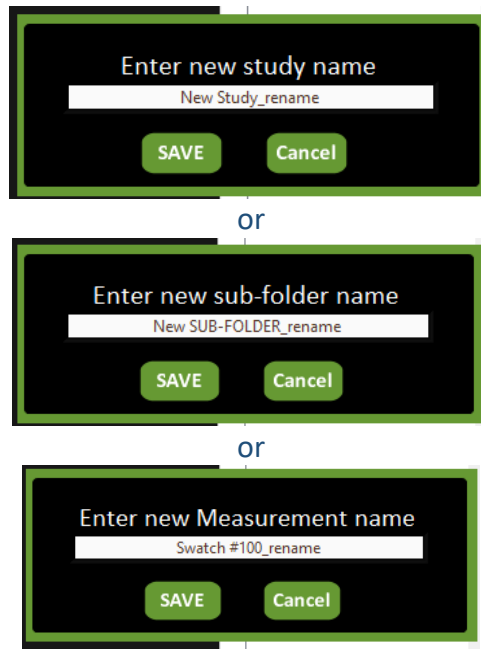
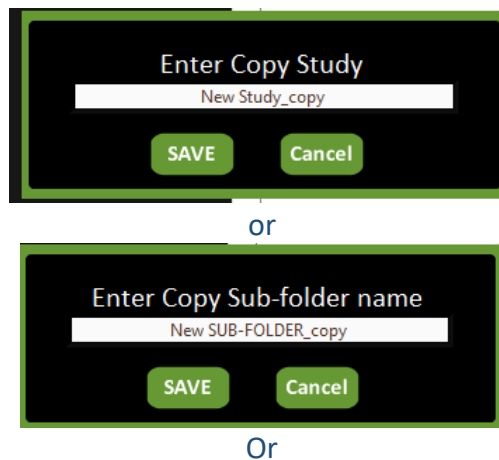


Figure 52: pop-up window for renaming study, sub-folder or measurement

Clicking on the cancel control  will cancel the renaming of the study, sub-folder or measurement and close the pop-up window.

2.5.4. COPY

The user can copy a study (and all its contents), a sub-folder (and all its contents) or a measurement. Clicking on the C control  triggers a pop-up window to enter the name of the copy (Figure 53) pre-populated with name_copy. Note that the original remains the same.



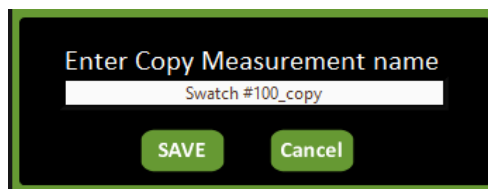


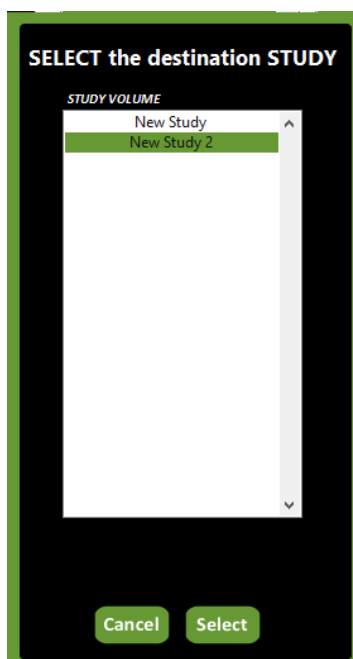
Figure 53: Pop-up window for copying study, sub-folder or measurement

Clicking on the cancel control  will cancel the copying of the study, sub-folder or measurement and close the pop-up window.

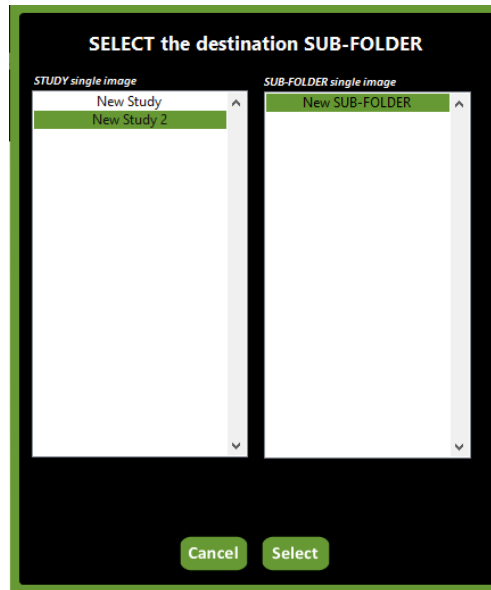
Note that the copy will be in the same location i.e. a sub-folder cannot be copied to a different study or a measurement cannot be copied to a different sub-folder. The control Move needs to be used for that purpose.

2.5.5. MOVE

The user can move a sub-folder (and all its contents) to a different study or several measurement to a different sub-folder. Clicking on the M control  opens a pop-up window (Figure 54).



Move sub-folder to a different study



Move Measurement(s) to a different sub-folder

Figure 54: Pop-up window for the destination selection

Cancel

Clicking on the cancel control will cancel the move of sub-folder or measurement and close the pop-up window.

If the sub-folder already exists in the study or if the measurements already exists in the sub-folder, a message appears (Figure 55).



Figure 55: Sub-folder or measurements already present

2.6. ACTION CONTROLS

Action controls (Figure 56) allow to:

- acquire data
- process data
- visualize data
- analyze and compare data
- export data



SHUFFLE MULTI

Figure 56: Action controls

2.6.1. ACQUISITION

Acquisition controls allow to acquire new data (images & videos). Three options are possible (Figure 57):

- Acquire new measurement processing on
- Acquire new measurement processing off
- Acquire Time lapse measurement



Figure 57: Acquisition controls

For faster measurement, we recommend the acquisition with the processing off. The measurement can be processed later. This option is useful when numerous measurements need to be done in a short period of time. **Acquire time lapse measurement** control allows to acquire a time lapse measurement i.e. a series of measurements for a period of time at a regular intervals. This is useful when analyzing the evolution of the hair swatch versus time, in a controlled humidity environment for example.

2.6.2. (RE) PROCESS



The **(re)process measurement** control allows the user to process an unprocessed measurement or reprocess a processed measurement.

2.6.3. DATA ANALYSIS

Data analysis and comparison allows (Figure 58):

- to compare data from different measurements
- to load data to the DATA analysis window
- to analyze a time lapse and create time lapse videos



Figure 58: Data analysis controls

2.6.4. BASIC EXPORT

BASIC EXPORT

The Basic Export allows the user to export multiple measurements to an Excel file. Only the processed measurements will be exported. This will be detailed further in the manual.

2.6.5. VISUALIZATION

MEASUREMENT VISUALIZATION

The visualization control allows the user to visualize the data of the selected measurement by opening the visualization window.

3. ACQUISITION

To acquire a new measurement, software must be in live mode **LIVE Mode** and the hardware test must have been completed successfully for the camera and the illumination. In Load

mode **LOAD Mode**, the acquire new measurement controls are not visible.

On the main window, three controls to acquire new measurement are present on the right side of the measurements list (Figure 59).

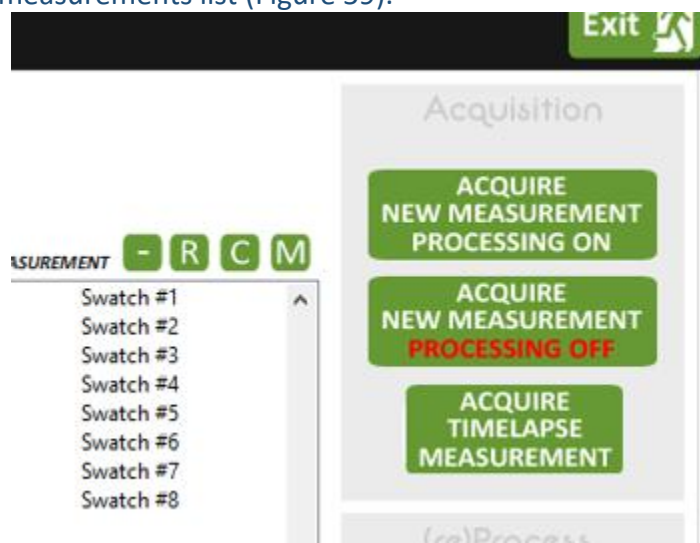


Figure 59: Acquisition controls

The 2 top acquisition controls allow to acquire a new measurement, the difference being the activation of the data processing after the acquisition of the raw data. The data processing phase takes more time so the acquisition of raw data with no processing is a faster process. The user can decide to PROCESS the data after acquiring many raw measurements.

3.1. SHUFFLE MULTI ACQUISITION

3.1.1. Processing OFF

Clicking on **Acquire new measurement Processing off** control **ACQUIRE NEW MEASUREMENT PROCESSING OFF** will open the measurement page. However, if no study or sub-folder is selected, the new measurement cannot be done and a pop-up window appears (Figure 60).

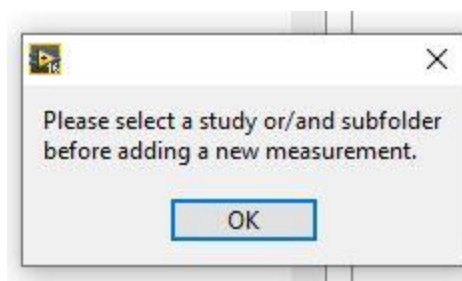


Figure 60: Pop-up window asking for a study/sub-folder selection before adding a new measurement

When the study/sub-folder selection is correct, a new measurement can be done. The measurement page appears once the **Acquire new measurement processing off** control is clicked (Figure 61).

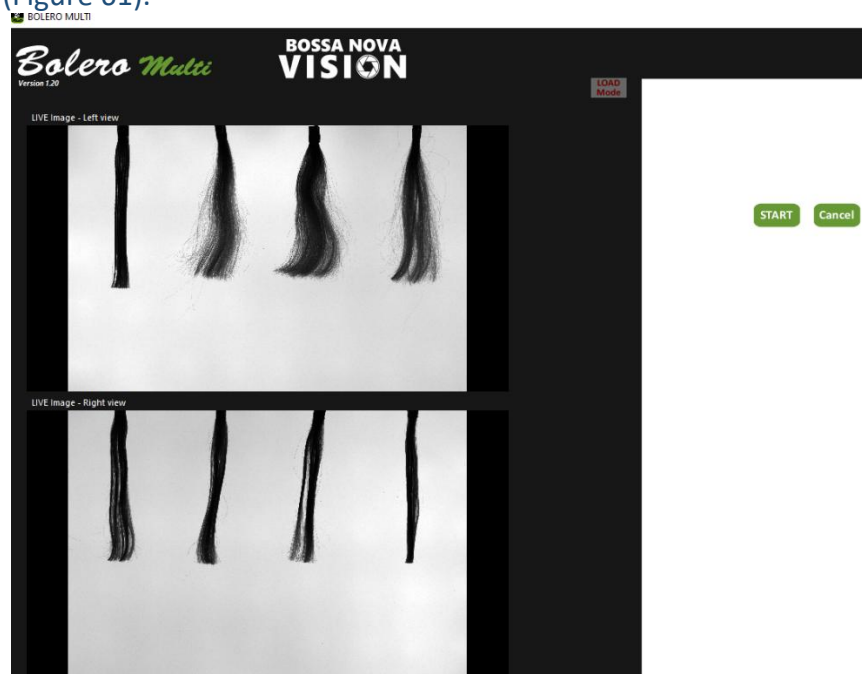


Figure 61: New measurement – Processing off – Single image acquisition windows

Figure 62 shows the different controls.



Figure 62: **Start/ Cancel** controls

To cancel the acquisition and go back to the data management page, the user clicks on

Cancel . To start the acquisition, the user clicks on the start control . A pop-up message appears. The pop-up window asks for the number of measurements, their name and their position in the image (Figure 63).

BOLERO MULTI PROMPT NAME and POSITION

FOV
SMALL (8 swatches)

Position #1	☒	Measurement name - Position #1	Swatch #1
Position #2	☒	Measurement name - Position #2	Swatch #2
Position #3	☒	Measurement name - Position #3	Swatch #3
Position #4	☒	Measurement name - Position #4	Swatch #4
Position #5	☒	Measurement name - Position #5	Swatch #5
Position #6	☒	Measurement name - Position #6	Swatch #6
Position #7	☒	Measurement name - Position #7	Swatch #7
Position #8	☒	Measurement name - Position #8	Swatch #8

SAVE Cancel

Figure 63: Pop-up window – Positions and names

Once the different parameters are entered, the user click on save (or cancel to cancel the measurement). The measurement is fast and once the image is saved, the data management page appears. Note that the different measurements will be saved individually (Figure 64).



Figure 64: Measurements saved

Because the measurements are not processed, they appear in *green italic* in the measurements list. ONE data acquisition can lead to up to 8 individual measurements, automatic data visualization does not exist and to visualize ONE measurement, just select it in the measurement list.

3.1.2. Time lapse

Similar to the previous measurement acquisition, it is possible to automatically acquire time lapse measurements i.e. many measurements every number of minutes (or hours) defined by the user, in order to analyze the evolution of swatches over time. This is very useful if used in combination with a humidity box, for curl retention experiment or humidity control product evaluation.

REMARK: We strongly recommend to only store ONE time lapse in a SUB-FOLDER at a time. One time lapse will automatically generate N individual unprocessed measurements, to be processed when the time lapse is done.



Clicking on **Acquire time lapse measurement** control , a pop-up window appears (Figure 65) to adjust the parameters of the time lapse.

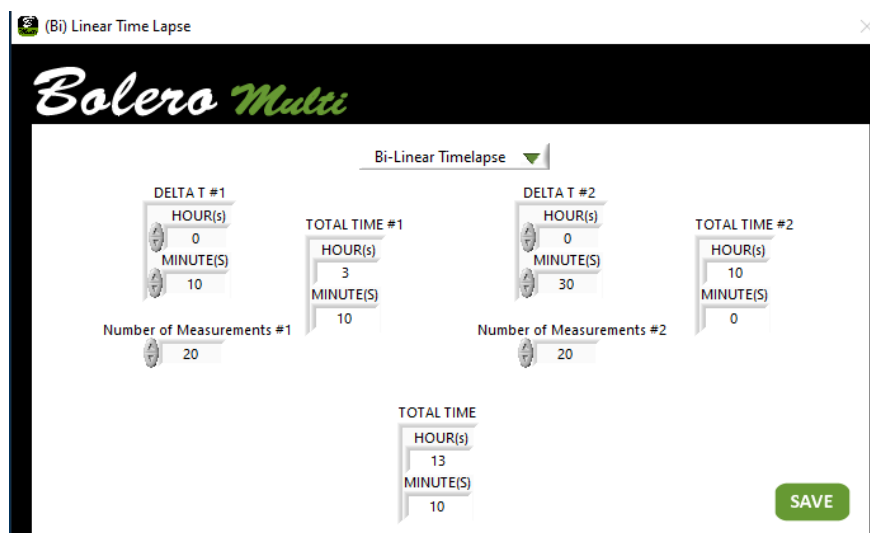


Figure 65: Time lapse parameters – Bi-linear Time lapse

The user can choose between a linear time lapse or a bi-linear time lapse using the **Linear Time Lapse** control at the top of the window.

If the linear time lapse is selected, only Delta T #1 is shown (Figure 66).



Figure 66: Linear time lapse selected

Linear time lapse selected means that the software will acquire an image every DELTA T #1 (Figure 67) for a number of images N#1. The total duration of the time lapse is DELTA T #1 x (N#1-1).

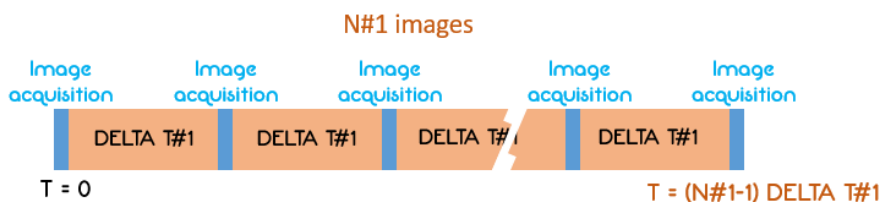


Figure 67: Linear time lapse

The total duration of the time lapse is $\Delta T\#1 \times (N\#1 - 1)$, $N\#1$ being the total number of images acquired.

Bi-linear time lapse selected means that the software will acquire an image every $\Delta T\#1$ for a number of images $N\#1$ and then acquire an image every $\Delta T\#2$ for a number of images $N\#2$ (Figure 68).

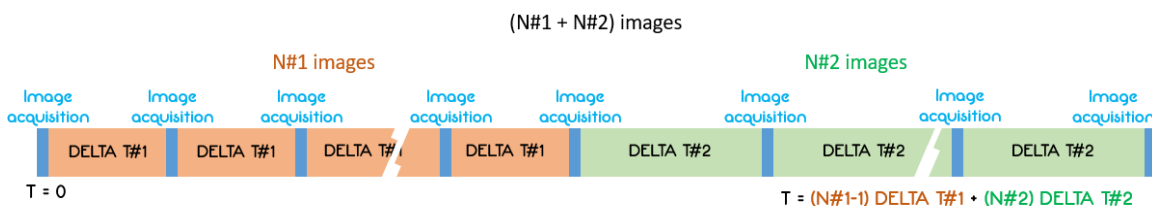


Figure 68: Bi-Linear Time lapse

This allows to analyze FAST and SLOW variation versus time in a single time lapse measurement. The total duration of the time lapse is $\Delta T\#1 \times (N\#1 - 1) + \Delta T\#2 \times N\#2$.

Clicking on Save will save the parameters and open the measurement page (Figure 69).

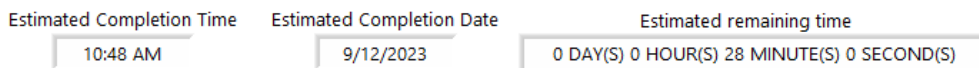


Figure 69: Time lapse measurement

To start the time lapse measurement, the user clicks on START and the usual pop-up windows appears (Figure 70).

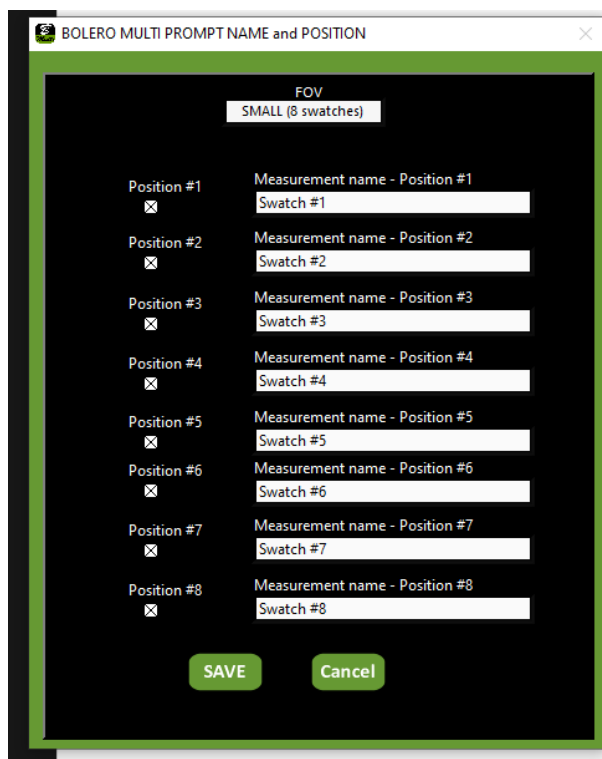


Figure 70: Pop-up window

In the time lapse measurement, the file names will be automatically generated with the following structure filename#n, n being the measurement number. Once the user clicks on START, the time lapse measurement is active (Figure 71).

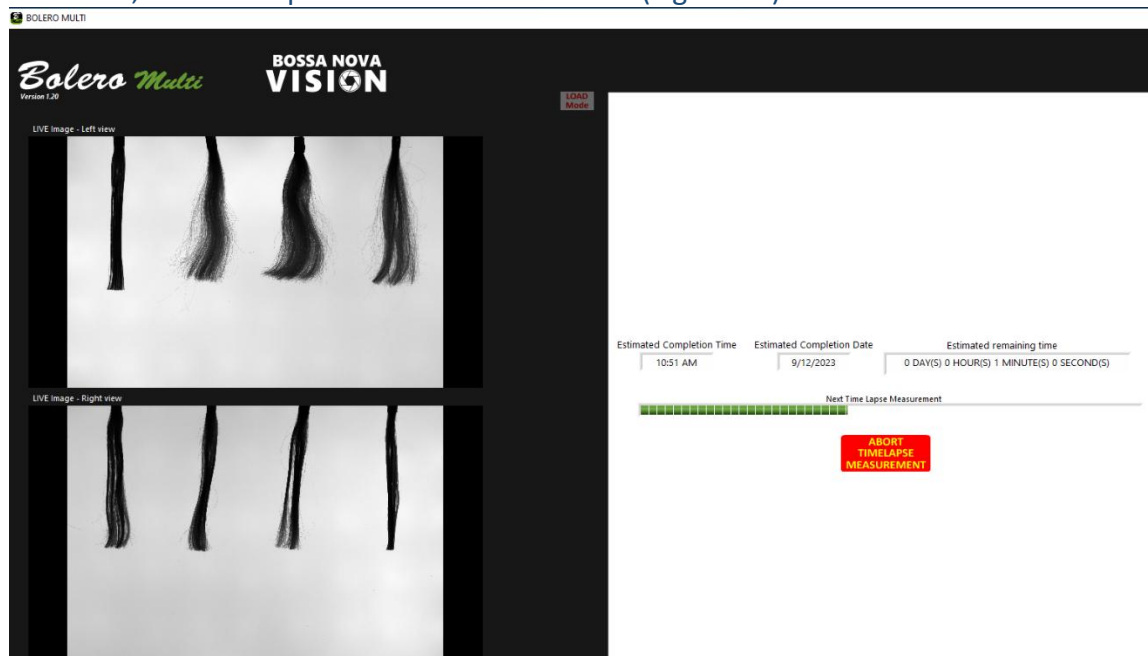


Figure 71: Time lapse acquisition window

On the right of the live image, the following indicators and control appear (Figure 72).



Figure 72: Abort control and Status/Remaining time indicators

If the user wants to abort the time lapse measurement, he clicks on the



control. An estimation of the completion time and date is given, with the estimated remaining time. A time bar shows when the next time lapse measurement will be acquired.

When the time lapse measurement is done, the software returns to the main window (Figure 73).

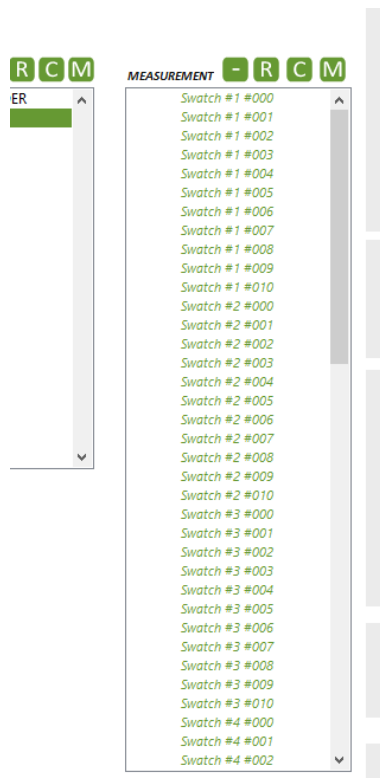


Figure 73: Main window after time lapse measurement

The time lapse measurements (#n) now needs to be processed. An additional text file named measurement_TLinfo.txt is saved in the subfolder and contains the time lapse information i.e. number of measurements and delta T (hours and minutes).

3.1.3. Processing ON

It is similar to the Processing OFF acquisition except that all the new measurements will be processed individually after the acquisition, leading to a slightly longer time. New measurements – processed – will appear in black normal font in the measurement list.

4. (RE)PROCESS

**(RE) PROCESS
MEASUREMENT(S)**

The **Reprocess** control allows to process unprocessed data or reprocess processed data. It follows the same steps as **Add new measurement – Processing On** with the exception of acquiring a new image as it reprocesses an existing image (raw image). Figure 74 shows the pop-up window in case no measurement to be reprocessed has been selected.

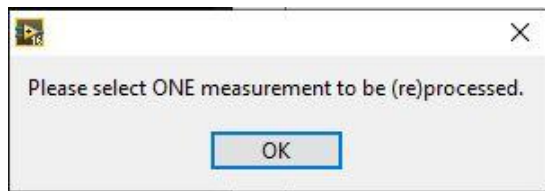


Figure 74: No measurement selected pop-up window

If more than one measurement has been selected and after the user has clicked on the **(Re)process** control, a pop-up window appears, warning the user that he will not be able to visualize the data at the end of the processing (Figure 75).

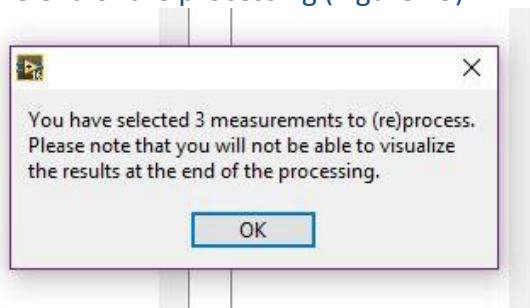


Figure 75: Warning pop-up window

If only one measurement is selected, no pop-up message will appear and the user will be able to visualize the results at the end of the processing. Another pop-up window indicates if there are already processed measurements in the list to be processed (Figure 76).

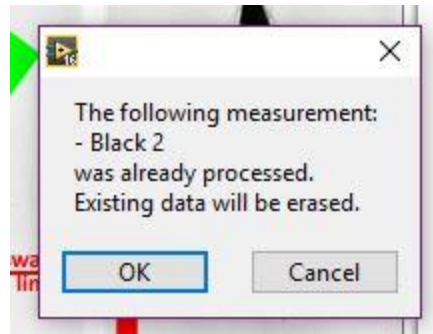


Figure 76: Processed measurement pop-up message

The following steps are similar to the Acquire new measurement – Processing On steps.

5. DATA VISUALIZATION

The data visualization window allows to visualize the results of a single selected measurement, similar to the final window at the end of an acquisition (To be detailed further in the manual). When the user selects a measurement in the data measurement window and clicks on the data visualization control, the visualization of all the results and graphs is shown (Figure 77).

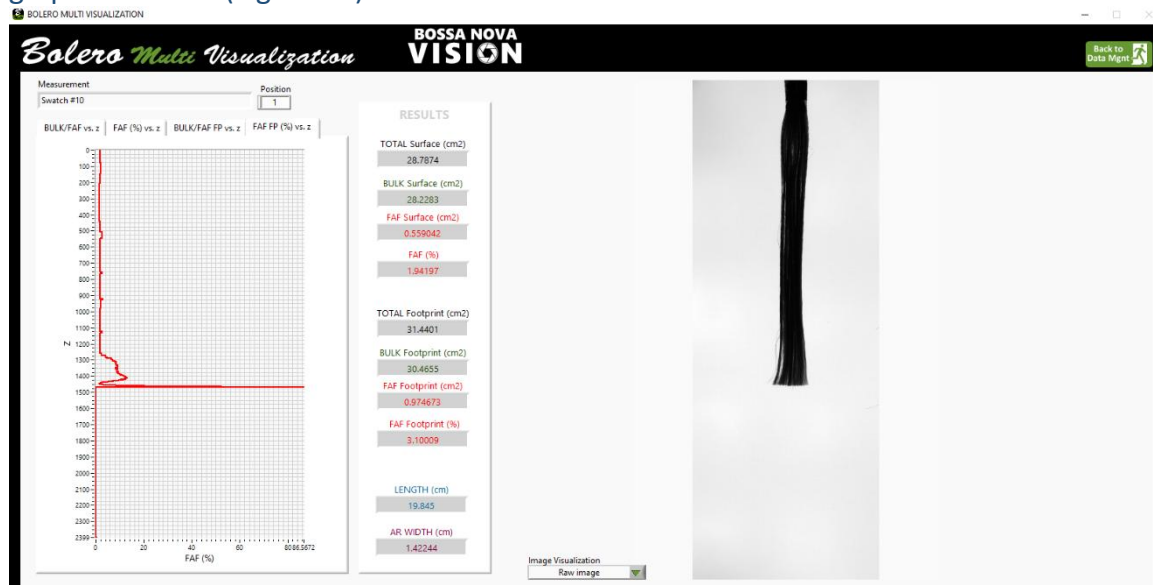


Figure 77: Data visualization window

The image is shown on the right. Using the image control under or on the left of the image, the user can select the different images (Figure 78).

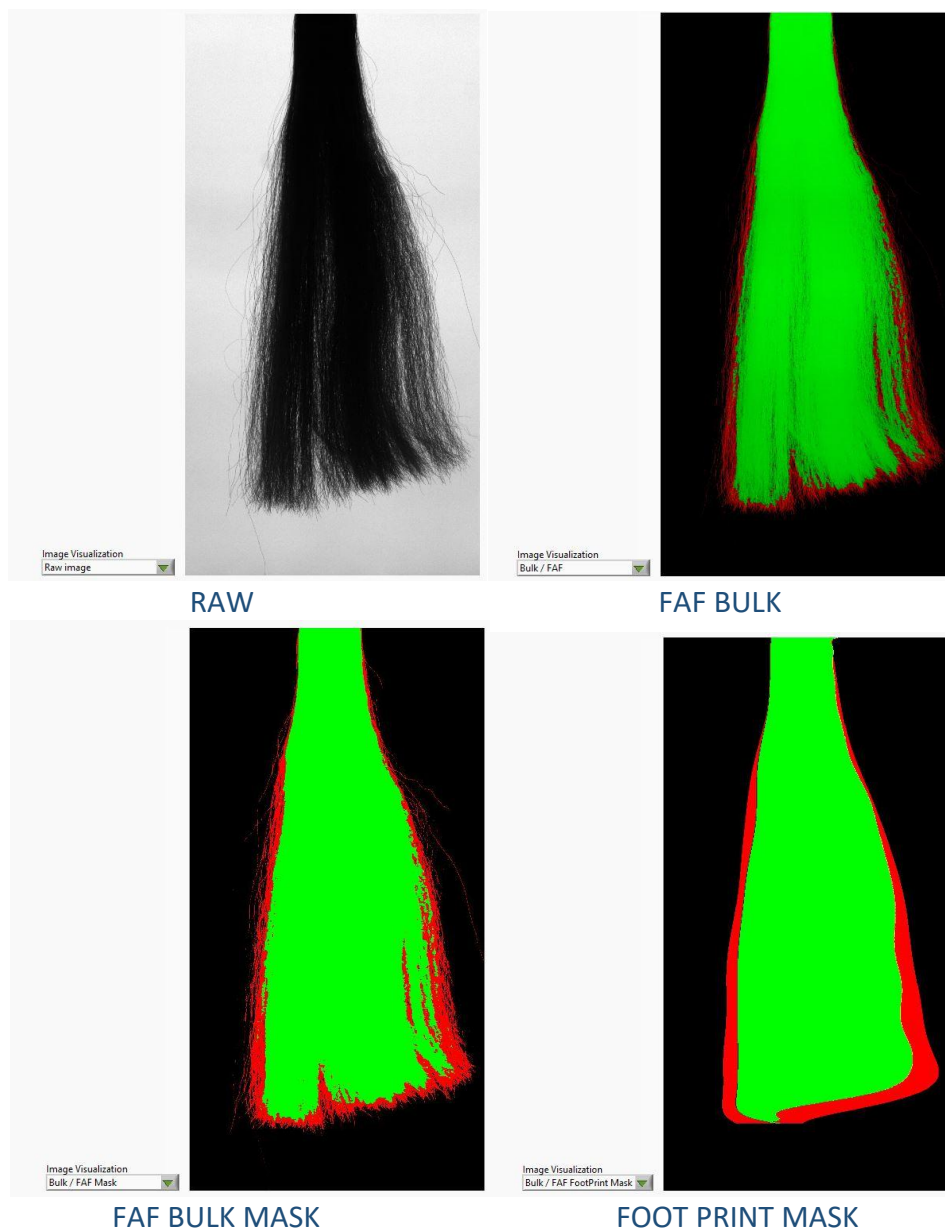


Figure 78: Images

Four graphs are shown and can be selected using the tab

BULK/FAF vs. z | FAF (%) vs. z | BULK/FAF FP vs. z | FAF FP (%) vs. z | :

- BULK width and FAF width versus z
- FAF % versus z
- BULK width and FAF width footprint versus z
- FAF % footprint versus z

As shown on Figure 79.

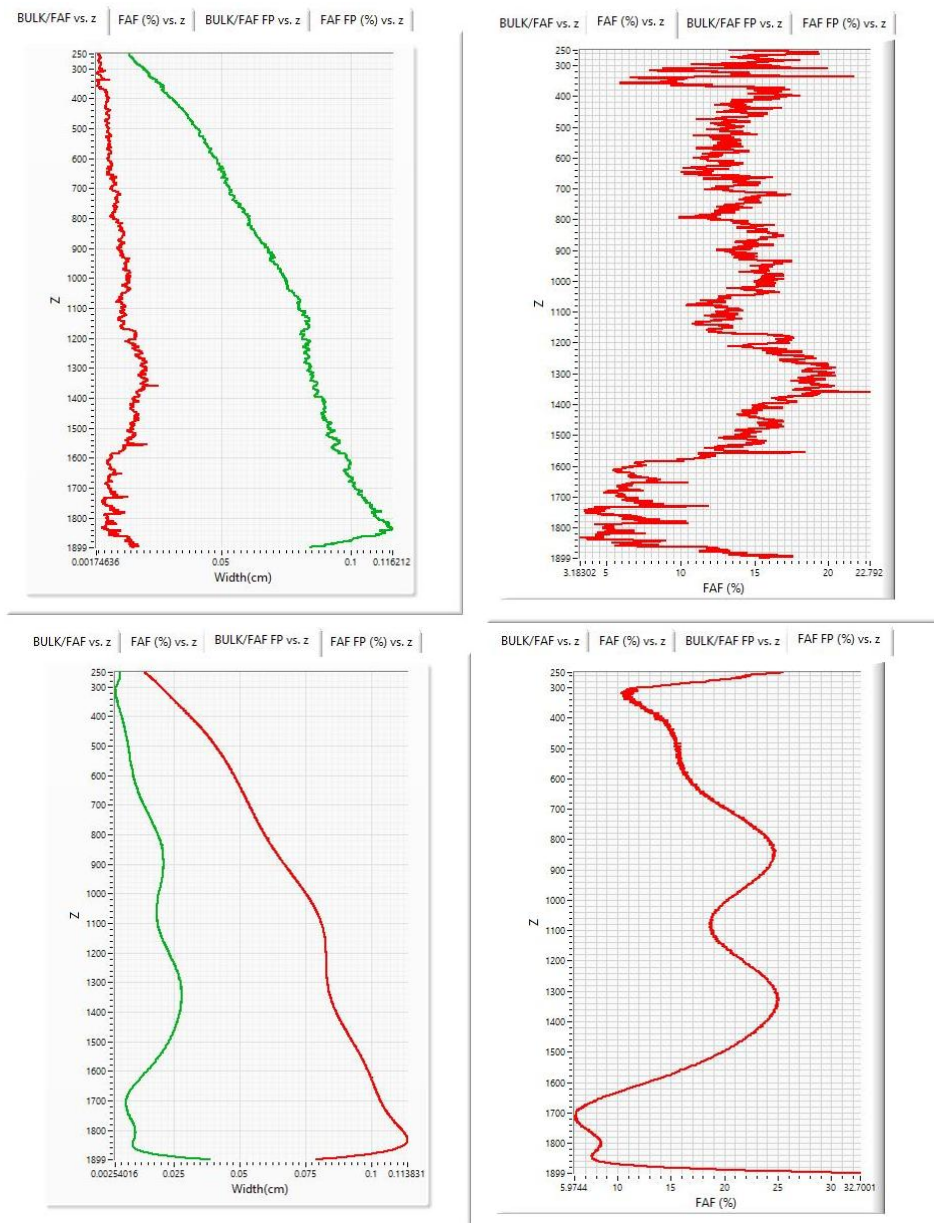


Figure 79: Various graphs

The calculation of:

- the total surface (cm^2),
- the BULK surface (cm^2)
- the FAF surface (cm^2)
- the FAF (%)
- the total footprint surface (cm^2),
- the BULK footprint surface (cm^2)
- the FAF footprint surface (cm^2)
- the FAF footprint (%)

- the Length (cm) of the swatch
- the AR Width (cm) of the swatch

is given on the right side of the graphs (Figure 80)



Figure 80: Various surface calculation

If the user does not select a measurement and clicks on the data visualization tab, the following pop-up message appears (Figure 81).

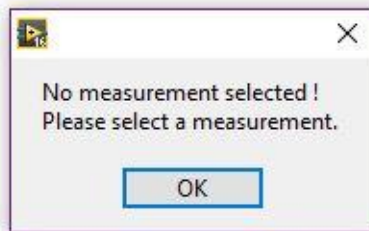


Figure 81: Pop-up message – No measurement selected

If the user selects a non-processed measurement, only the raw image appears (Figure 82).

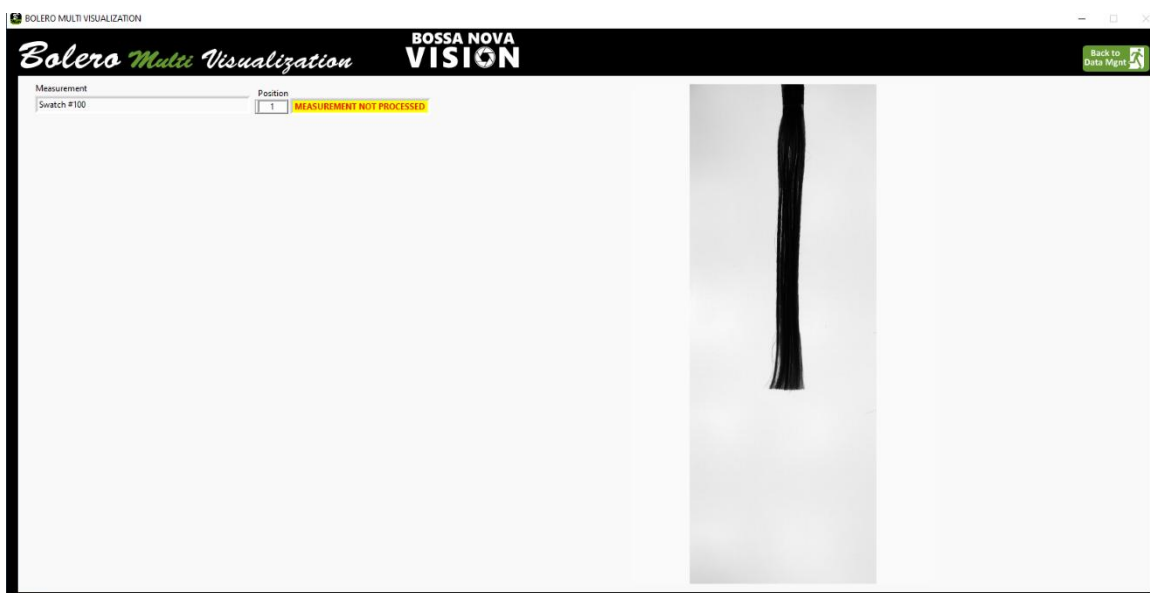


Figure 82: Measurement no processed

6. DATA ANALYSIS

If the user clicks on **Load measurement to Data Analysis** while one or more measurements are selected, the **Data Analysis** windows opens (Figure 83) and the selected measurements are added to the loaded measurement list.

LOAD measurement
to DATA Analysis



Figure 83: Data Analysis window

The user can see 2 lists:

- MEASUREMENT LOADED
- MEASUREMENT DISPLAYED

If no measurements were selected, the following pop-up window appears (Figure 84).

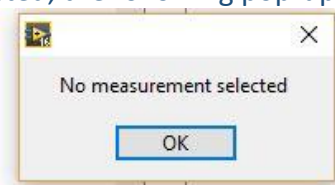


Figure 84: No measurements selected

If some selected measurements are not processed, the following message appears and no measurement are loaded (Figure 85).

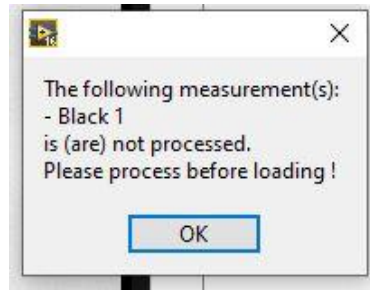


Figure 85: Unprocessed measurement(s) in the list to be loaded – Pop-up message

To display the loaded measurements, select them and click on the arrow . Up to 12 measurements can be displayed (Figure 86).

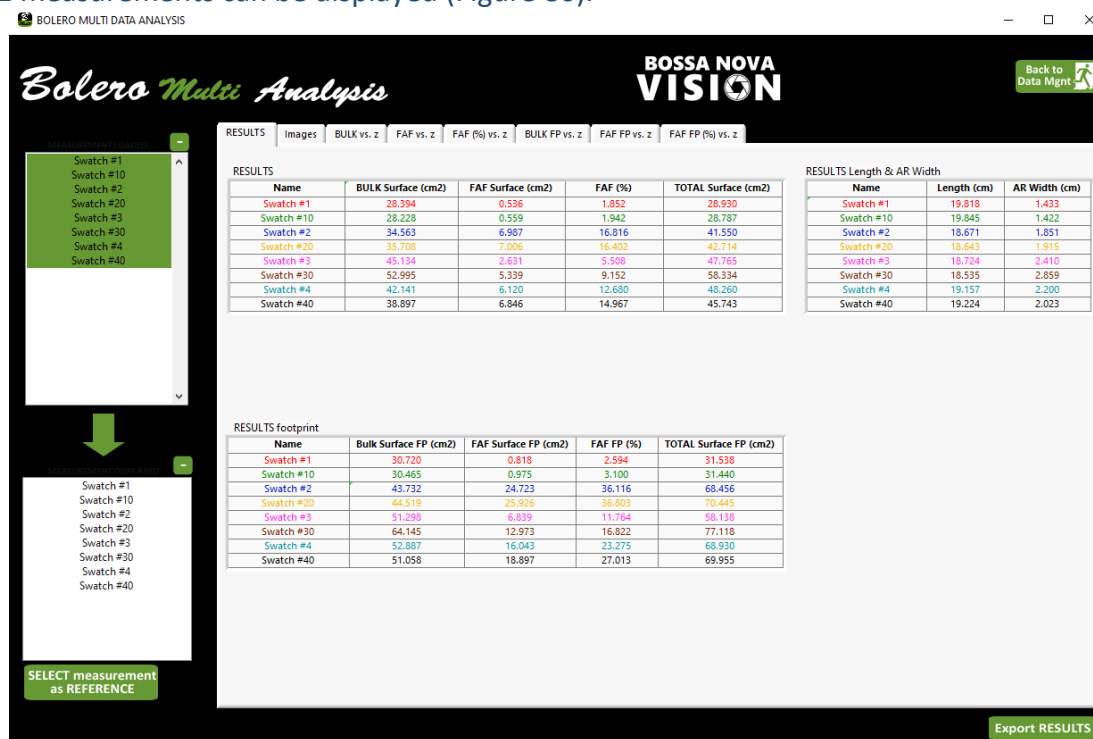


Figure 86: Measurements displayed

If the user selects more than 12 loaded measurements to be displayed, the following dialog box pops-up (Figure 87).

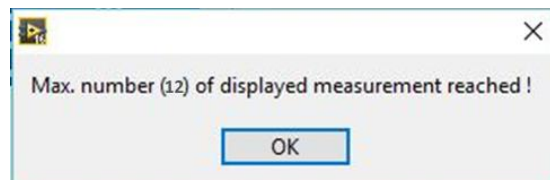


Figure 87: More than 12 loaded measurements selected – Dialog box

The Results table is now visible and populated with the corresponding measurement and values and the Export Results control **Export RESULTS** is now visible on the bottom right of the window. The tab selection (Figure 88) is explained in the following.



Figure 88: Tab selection for single image results

6.1.1. Results

The results tab shows 2 tables that summarize the various parameters calculated (Figure 89).



Figure 89: Results table

The first table named RESULTS has 5 columns:

- Measurement Name
- BULK Surface (cm²)
- FAF Surface (cm²)
- FAF (%)
- Total Surface (cm²)

BULK Surface and FAF Surface are the surface occupied by the BULK and the FAF. Total surface is the sum of the BULK surface and the FAF surface. FAF (%) represent the % of FAF in the image (between the limits). The formula is given below:

$$FAF (\%) = 100 \left(\frac{FAF}{BULK + FAF} \right)$$

FAF (%) varies from 0% to 100%. FAF (%) = 0% means no Fly-away/Frizz are present. FAF (%) = 100% means only Fly-away/Frizz are present.

The second table named RESULTS Footprint has 5 columns:

- Measurement Name
- BULK Surface Foot Print (cm²)
- FAF Surface Foot Print (cm²)
- FAF Foot Print (%)
- Total Surface Foot Print (cm²)

BULK Surface Foot Print and FAF Surface Foot Print are the surface occupied by the Foot Print of the BULK and the Foot Print of FAF. The Foot Print corresponds to the data processing that transforms the BULK and the FAF into closed surface. This processing is used for the 3D reconstruction and is explained in detail in the technical background section.

The third table named RESULTS Length and AR Width has 3 columns:

- Measurement Name
- Length (cm)
- AR Width (cm)

6.1.1.1. REFERENCE

In order to better compare the different measurements, the user can select a measurement to be the REFERENCE using the SELECT measurement as REFERENCE

**SELECT measurement
as REFERENCE**

Control located under the Measurement displayed list. Once a displayed measurement is selected and the SELECT measurement as REFERENCE Control

**SELECT measurement
as REFERENCE**

is activated, both tables are updating (Figure 90).

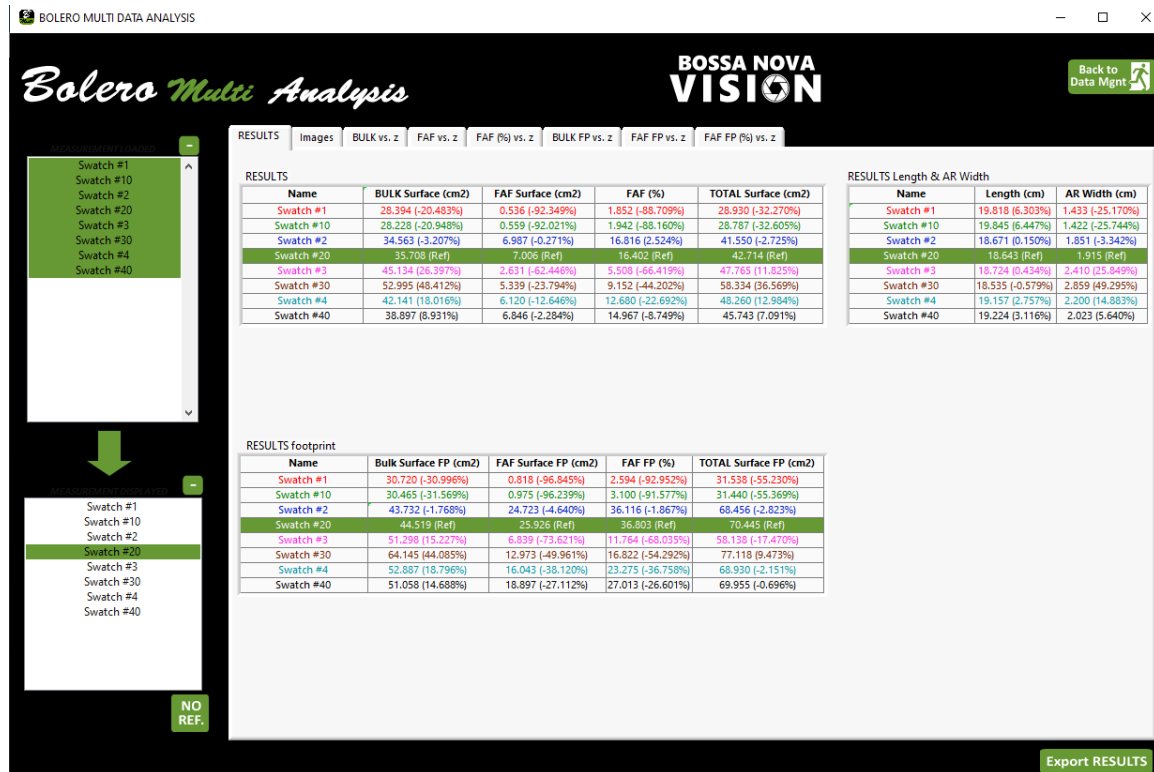


Figure 90: Reference measurement

The Reference measurement is highlighted in green, with (Ref) added at the end of each value. The % difference is added after each value of the other measurements, allowing a direct and simple analysis of the value compared to the reference (Figure 91).

RESULTS

Name	BULK Surface (cm2)	FAF Surface (cm2)	FAF (%)	TOTAL Surface (cm2)
New Meas. #1	131.161 (Ref)	14.008 (Ref)	9.649 (Ref)	145.168 (Ref)
New Meas. #2	122.660 (-6.481%)	22.952 (63.849%)	15.762 (63.354%)	145.612 (0.306%)
New Meas. #3	85.455 (-34.847%)	23.219 (65.755%)	21.366 (121.432%)	108.674 (-25.139%)

RESULTS footprint

Name	Bulk Surface FP (cm2)	FAF Surface FP (cm2)	FAF FP (%)	TOTAL Surface FP (cm2)
New Meas. #1	131.242 (Ref)	14.881 (Ref)	10.184 (Ref)	146.123 (Ref)
New Meas. #2	124.536 (-5.110%)	21.456 (44.184%)	14.697 (44.315%)	145.992 (-0.090%)
New Meas. #3	86.192 (-34.326%)	22.559 (51.596%)	20.743 (103.682%)	108.750 (-25.576%)

RESULTS Length & AR Width

Name	Length (cm)	AR Width (cm)
New Meas. #1	24.660 (Ref)	5.319 (Ref)
New Meas. #2	22.140 (-10.219%)	5.540 (4.155%)
New Meas. #3	21.438 (-13.066%)	3.986 (-25.061%)

Figure 91: Reference

NO
REF.

To return to a table with no reference, the user can click on the NO REF. control located under the Measurement displayed list.

SELECT measurement
as REFERENCE

If the user clicks on SELECT measurement as REFERENCE Control without any displayed measurement selected (Why would you that anyway ?), the pop-up message appears (Figure 92).

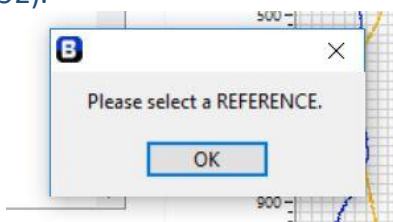


Figure 92: Pop-up message – No displayed measurement selected

6.1.1.2. EXPORT RESULTS

Export RESULTS

The Export RESULTS control allows the user to export all the data (Table in Excel file, Graph in Excel file & images). Once the user clicks on the Export Results control, the following pop-up message appears (Figure 93).

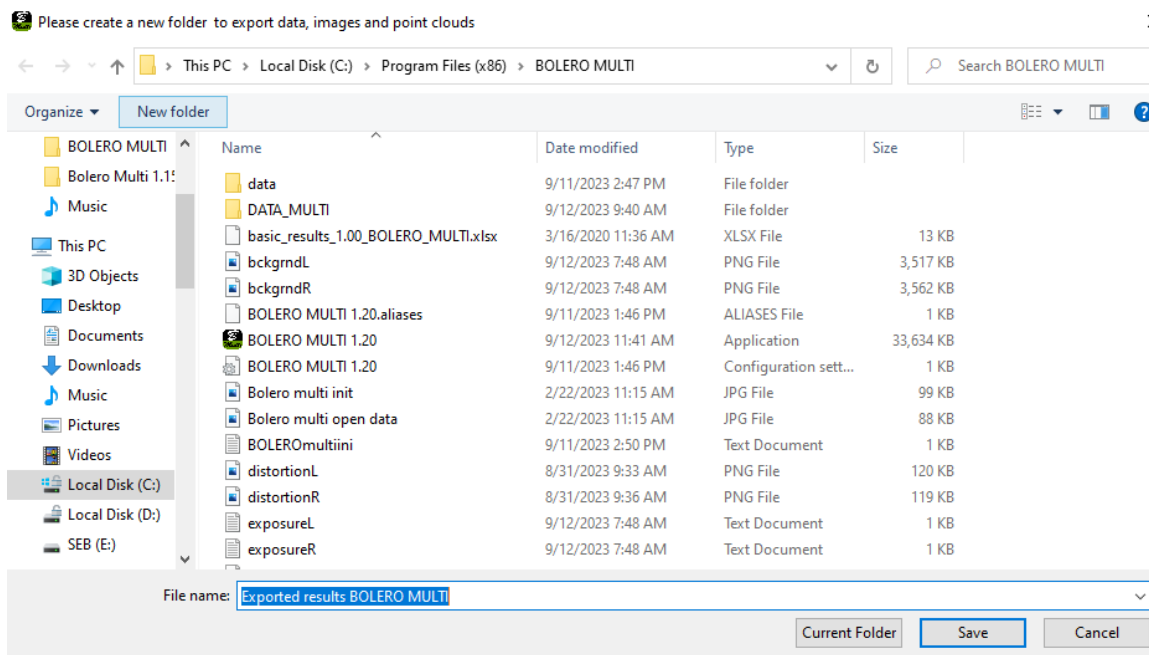


Figure 93: Pop-up message – Export Results

The name of the folder to be saved is already populated – Exported Results SHUFFLE TRIO – but can be changed, along with the destination (Figure 94).

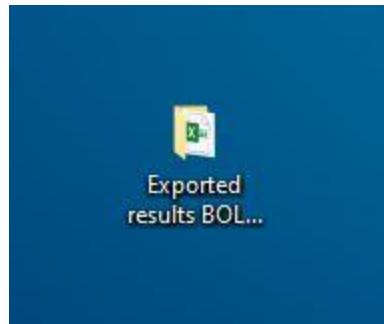


Figure 94: Export Folder

Inside the folder are an Excel file named Results and a folder named Pictures (Figure 95).

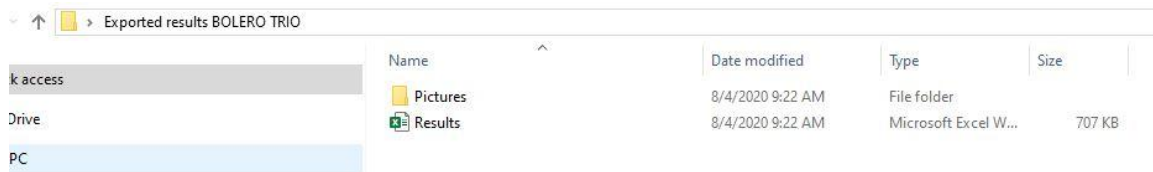


Figure 95: Exported Results Folder contents

The Pictures folder contains 4 images for each measurement (Figure 96) at the last angle used for the visualization:

- Raw as measurement name_#.png
- Bulk/FAF as measurement name_bulkfaf_#.jpg
- Bulk/FAF mask as measurement name_bulkfafmask_#.jpg
- Bulk/FAF footprint mask as measurement name_bulkfafmask_#.jpg

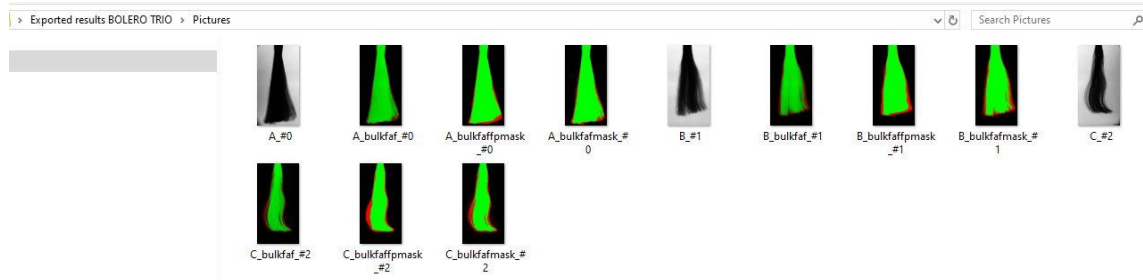


Figure 96: Images exported

The excel file RESULTS contains the tables and all the graphs visualized in the data analysis tab (Figure 97).

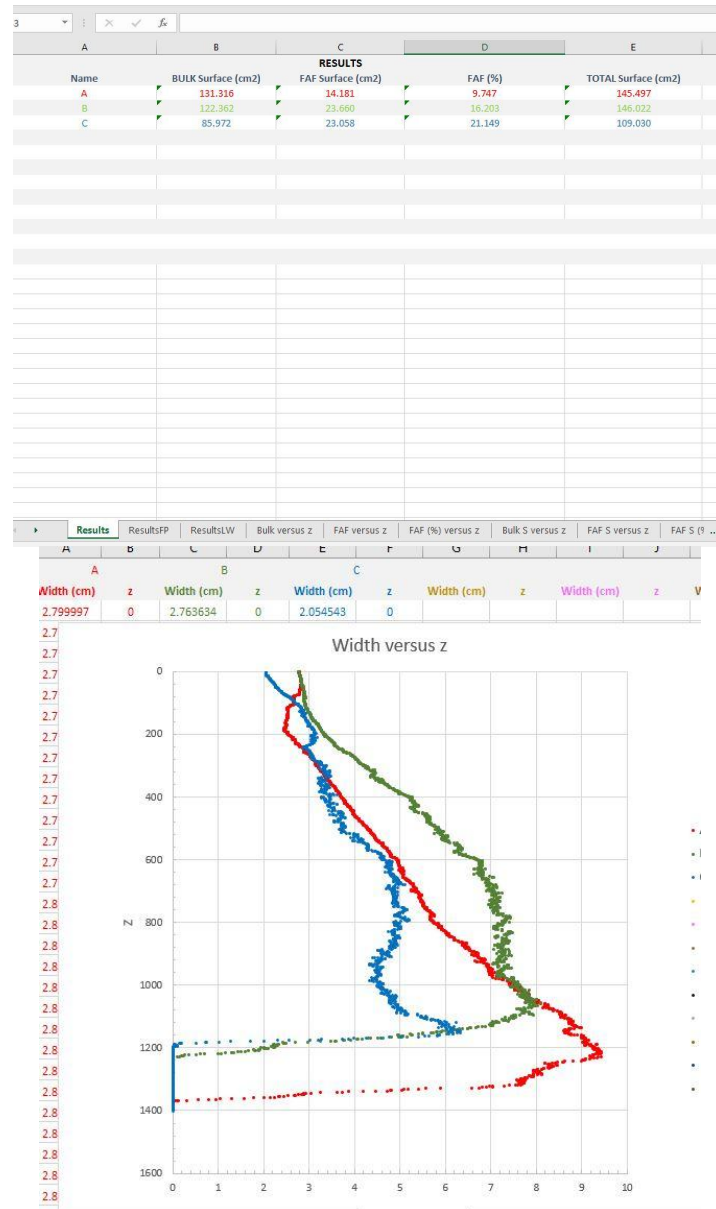


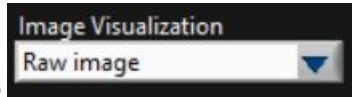
Figure 97: Results excel file

6.1.2. Images

The images tab allows the user to visualize the images from each measurement (Figure 98).



Figure 98: Images

Using the image control located under the live image , the user can visualize the different images (Figure 99).

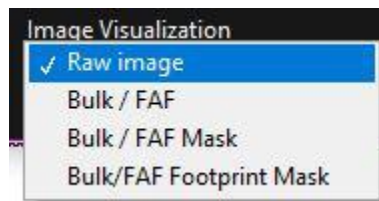


Figure 99: Various possible image

6.1.3. Bulk versus z

The Bulk vs. z tab presents a graph showing the evolution of the BULK width (in cm) versus z for each measurement (Figure 100).

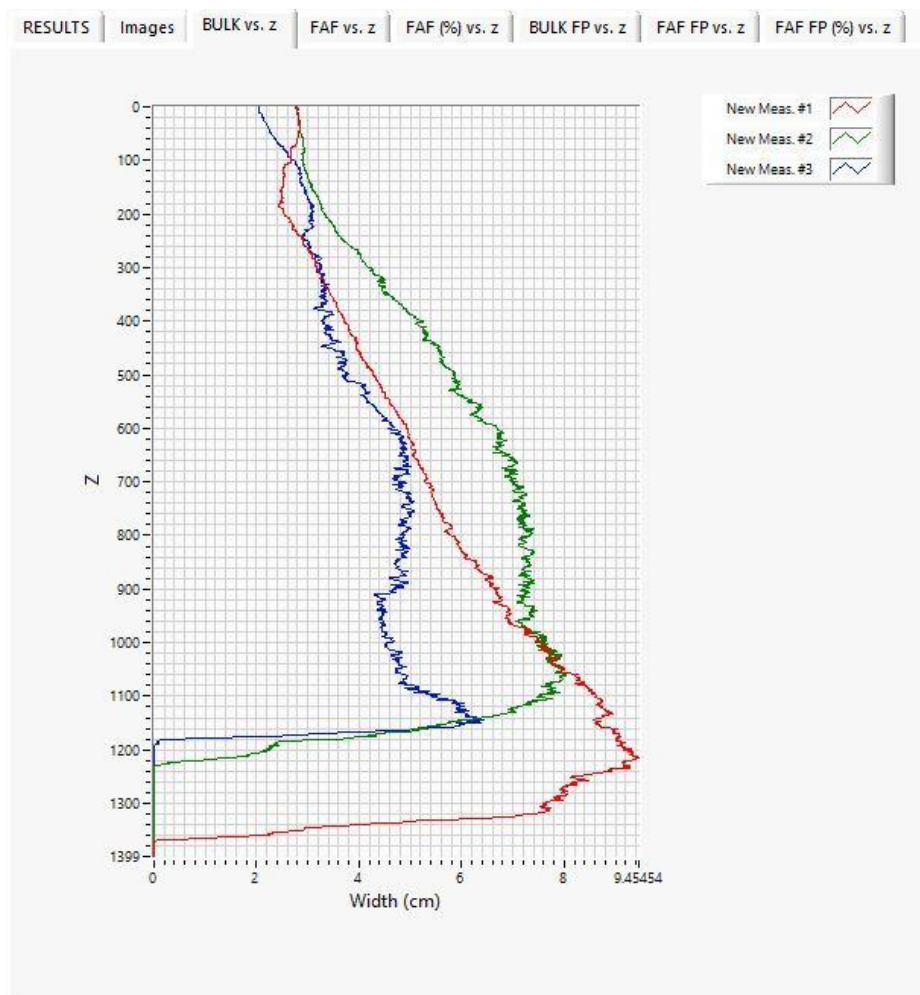


Figure 100: Bulk versus z graph

6.1.4. FAF versus z

The FAF vs. z tab presents a graph showing the evolution of the FAF width (in cm) versus z for each measurement (Figure 101).

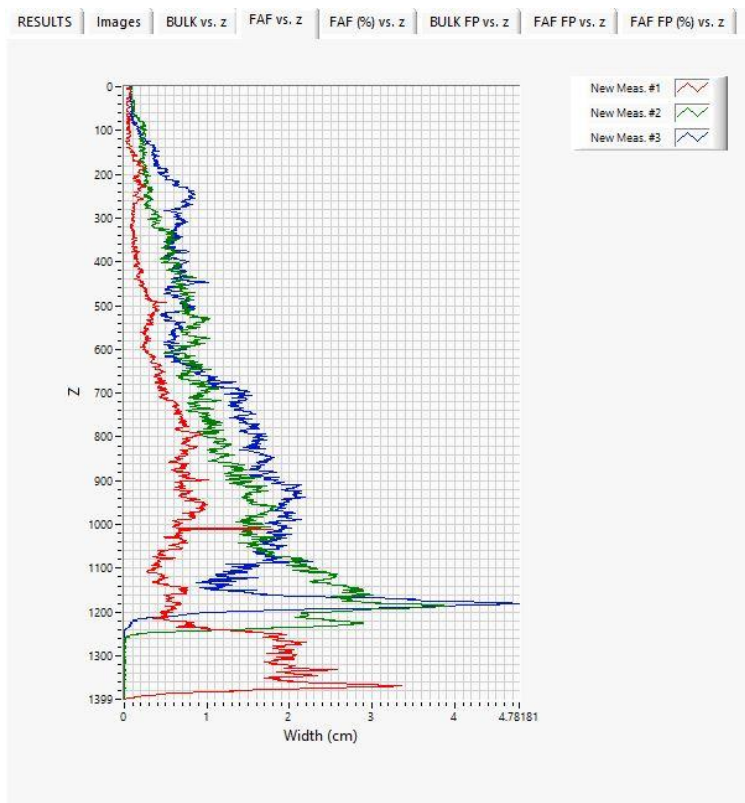


Figure 101: FAF versus z graph

6.1.5. FAF (%) versus z

The FAF (%) vs. z tab presents a graph showing the evolution of the FAF % versus z for each measurement (Figure 102).

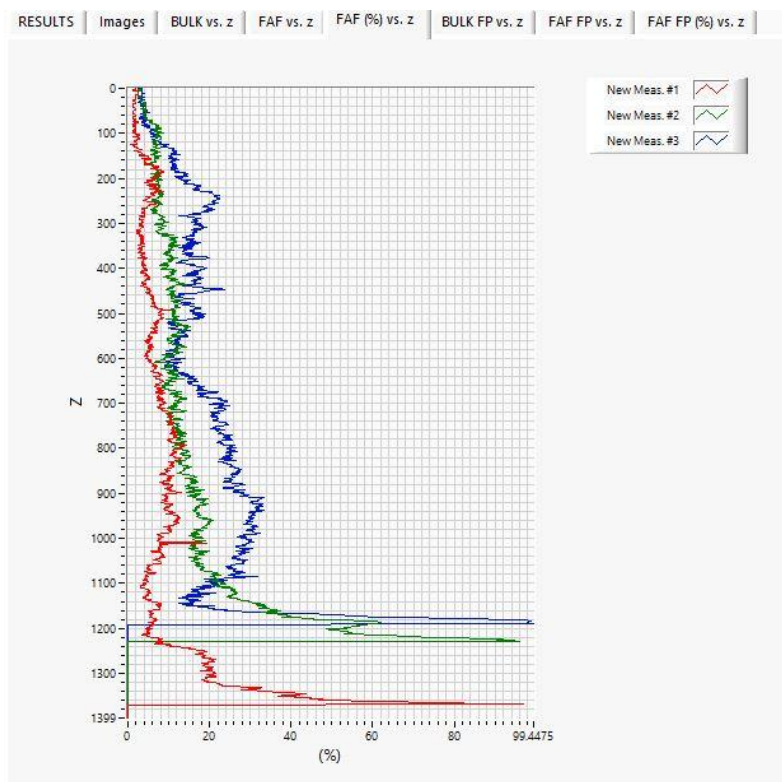


Figure 102: FAF % versus z graph

6.1.6. BULK FP versus z

The Bulk foot Print vs. z tab presents a graph showing the evolution of the BULK Foot Print width (in cm) versus z for each measurement (Figure 103).

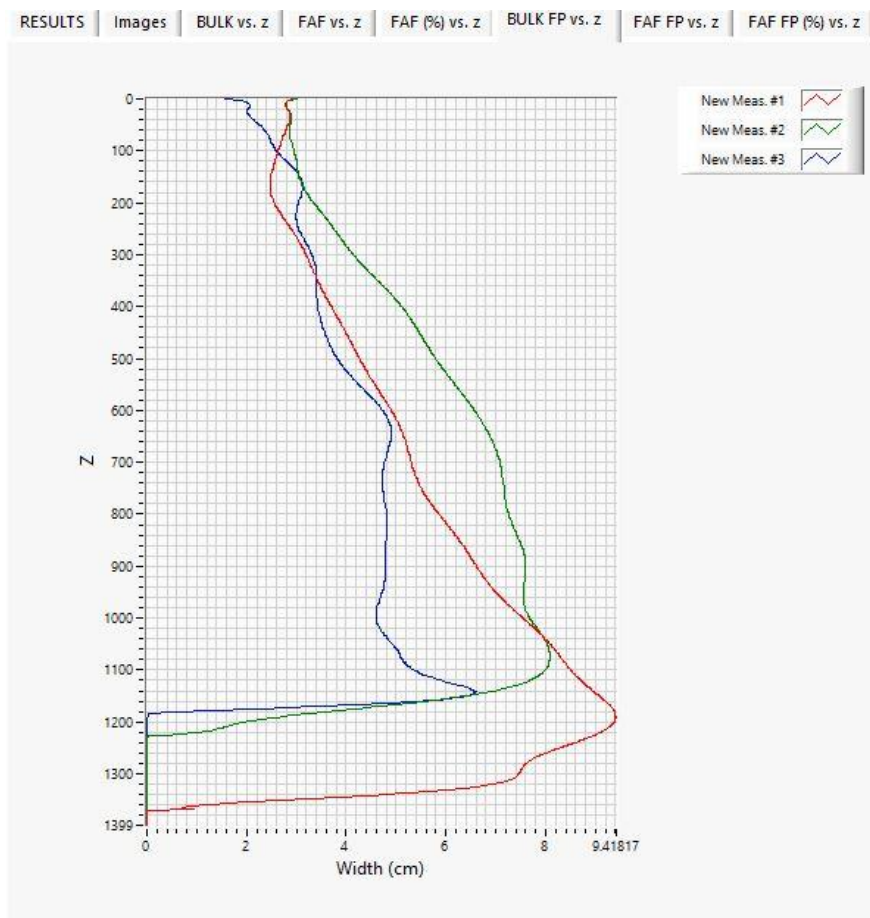


Figure 103: Bulk Foot Print versus z graph

Note that the curves are smooth when the foot print processing has been applied.

6.1.7. FAF FP versus z

The FAF foot Print vs. z tab presents a graph showing the evolution of the FAF Foot Print width (in cm) versus z for each measurement (Figure 104).

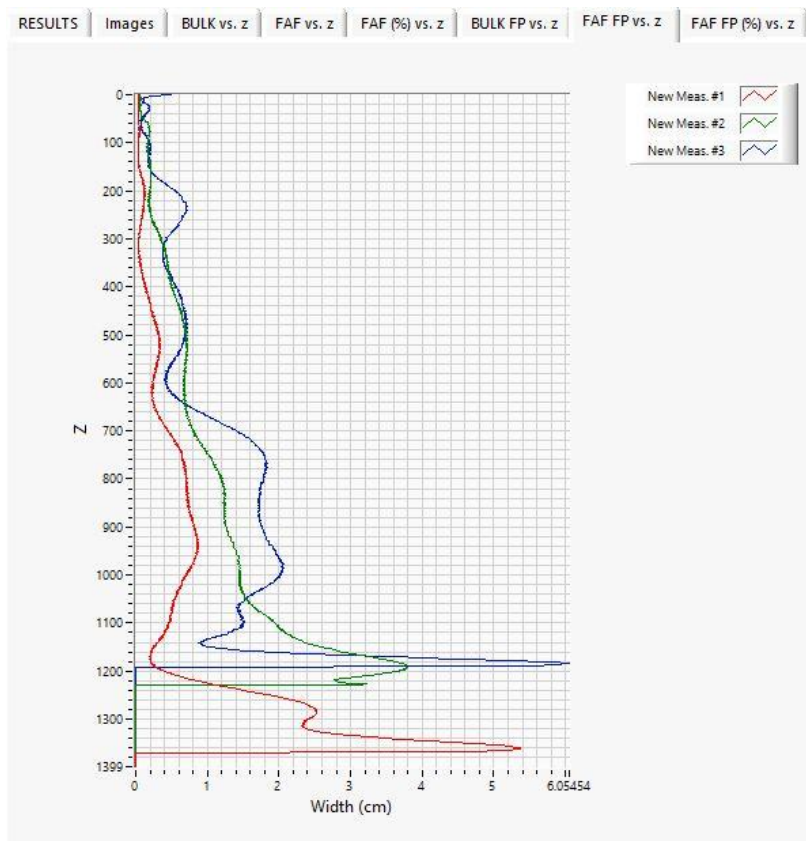


Figure 104: FAF Foot Print versus z graph

6.1.8. FAF FP (%) versus z

The FAF foot Print % vs. z tab presents a graph showing the evolution of the FAF Foot Print % versus z for each measurement (Figure 105)

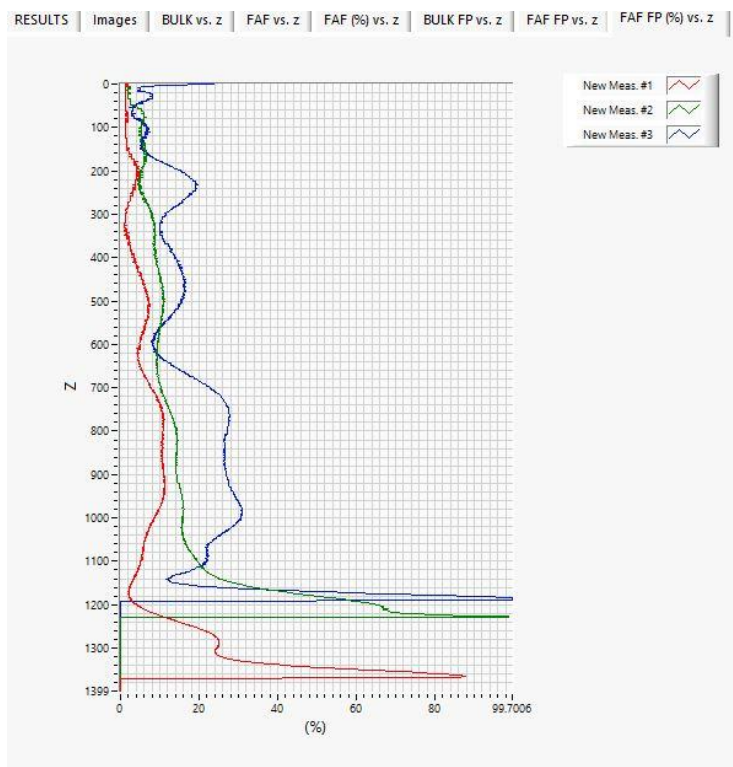


Figure 105: FAF FootPrint % versus z graph

7. Time lapse Video Creation and Data Analysis

When a time lapse measurement has been acquired, it is possible to create a video of the time lapse and automatically analyze the evolution of the bulk, fly-away, total surface, the length of the swatch and AR width versus the time. The user clicks on



control. A pop-up message appears (Figure 106) informing the user that a Time Lapse measurement has been found.

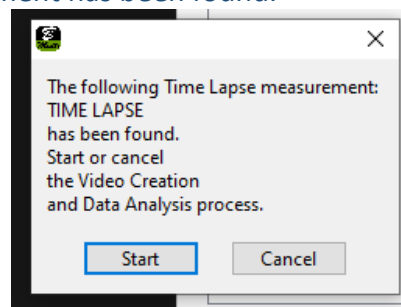


Figure 106: pop-up message

If the user clicks on Start, a new window pops-up (Figure 107). Cancel will take the user back to the main window.

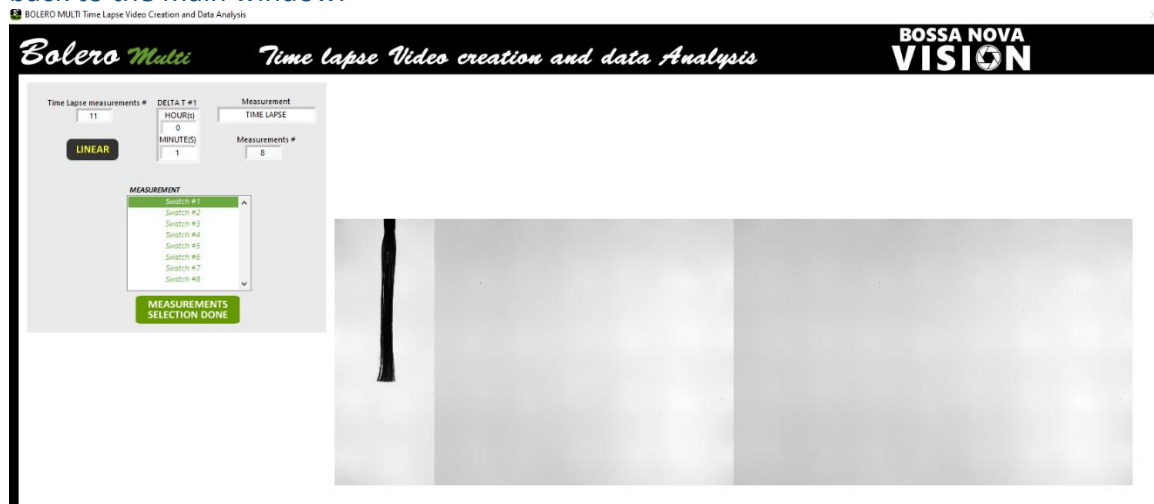


Figure 107: Time Lapse video Creation and Data analysis video

The new window shows the number of time lapse measurements, the delta Ts in hours and minutes (the time between each measurements), information of the time lapse i.e. linear or bi-linear, the number of swatches and the measurement name (Figure 108).

Figure 108: Time lapse parameters

Using the measurements selection control (Figure 109), the user can select the measurements to be processed and visualized in the videos.

Figure 109: Measurements selection

The user can visualize the selected measurements on the image (Figure 110).



Figure 110: Selected measurements

Once the measurements selection is done, the user clicks on  and a pop-up message appears (Figure 111).

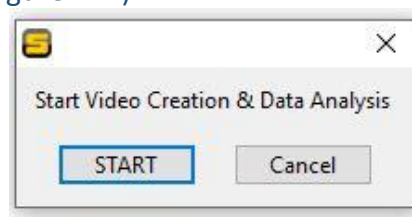


Figure 111: Pop-up message Start or Cancel

Once **START** is clicked, the video creation and data analysis starts (Figure 112).

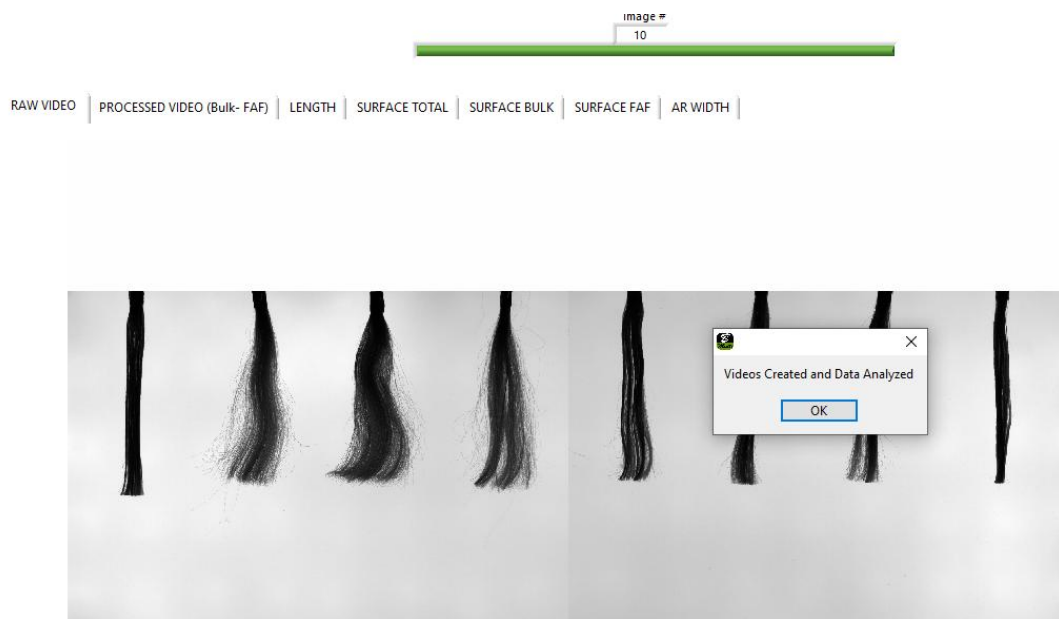


Figure 112: Group Time Lapse VC & DA in progress

A progression bar indicates where evolution of the process. A selection tab side allows to select the RAW and Processed Bulk-FAF videos and the various graphs. Once the process is done, a pop-up message appears (Figure 113).

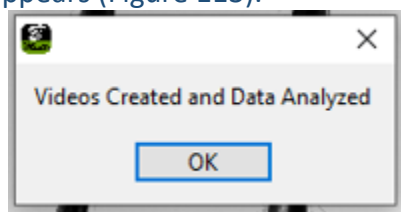


Figure 113: Process done – Pop-up message

The user can visualize the different videos (raw and processed) and graphs (lengths, total surface, etc.) versus image # (Figure 114).

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EXPORT Timelapse VIDEO & DATA

RAW VIDEO

PROCESSED VIDEO (Bulk- FAF)

LENGTH

SURFACE TOTAL

SURFACE BULK

SURFACE FAF

AR WIDTH



EXPORT Timelapse VIDEO & DATA

RAW VIDEO

PROCESSED VIDEO (Bulk- FAF)

LENGTH

SURFACE TOTAL

SURFACE BULK

SURFACE FAF

AR WIDTH

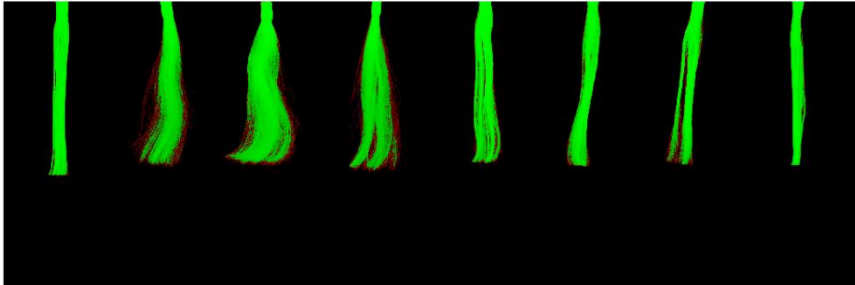
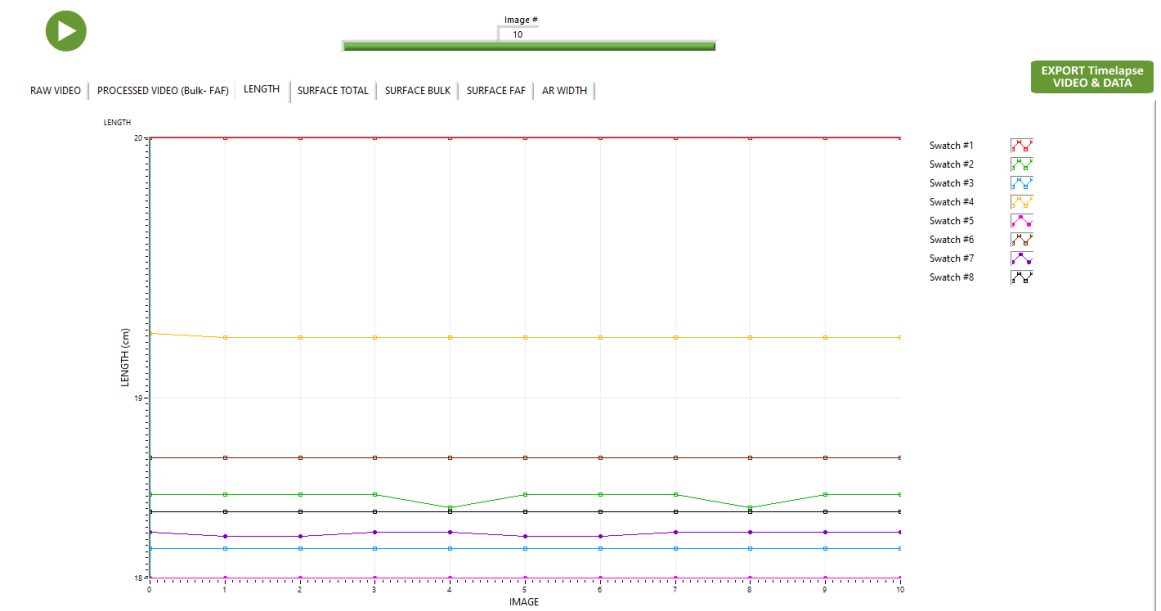



Figure 114: Videos and Graphs versus image #

The user can visualize the data and export the data (videos and graph) using the controls (Figure 115).



Figure 115: Export / play/stop/pause controls

If the user presses on play , Export Time lapse video and data control is not visible and stop/pause controls appear . Both videos play and the user can visualize the cursor of all graphs. Click on Export Time lapse video and data control

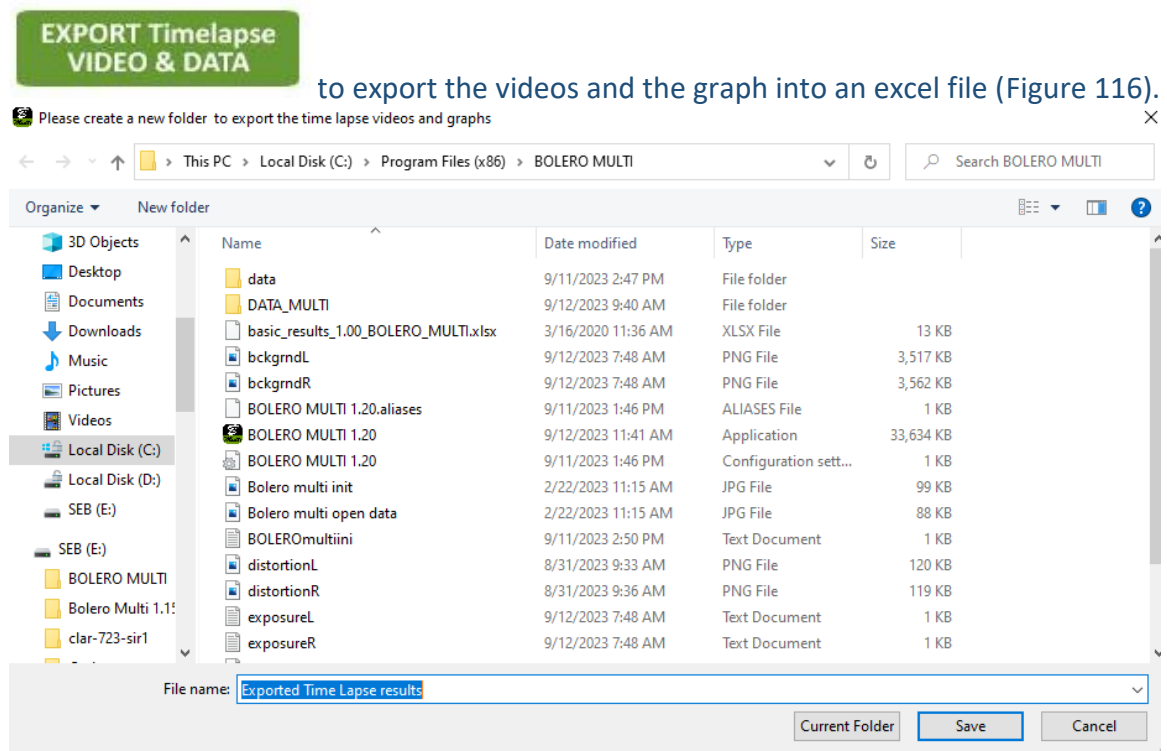


Figure 116: Time Lapse Export

The content of the exported folder is shown on Figure 117.

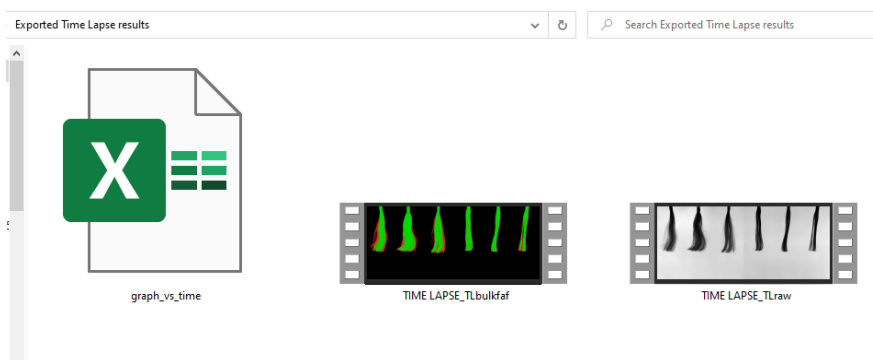


Figure 117: Exported folder

It consists of 2 videos in AVI format (RAW and BULK/FAF) and an excel file. The videos are saved in avi format, at 10 frames per second (A time lapse video of 300 measurements will be 30 seconds long). The excel file consists of the total, bulk and FAF surface, length and AR Width versus the frame # (Figure 118).

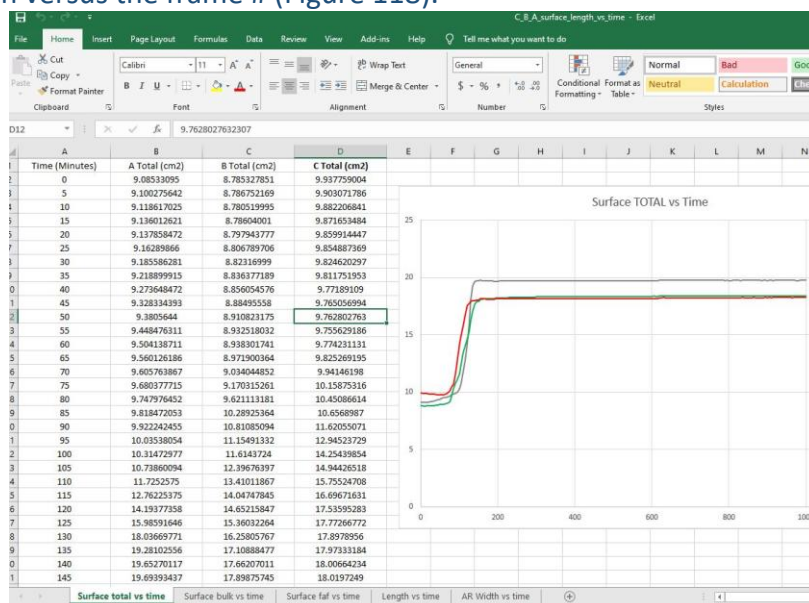


Figure 118: Excel file – Group Export

8. Basic Export

This feature allows the user to export the main results (presented in the tables from Data Analysis) without the graphs, from the data management page for a large number of measurements.



Figure 119: Basic Export

The user needs to select the measurements before clicking on the control. If no measurement is selected when the Basic Export control is clicked, a pop-up window appears (Figure 120).

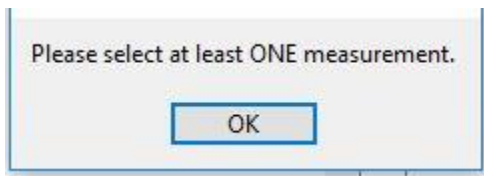


Figure 120: Pop-up window – No measurement selected

If measurements are selected, the following pop-up window appears (Figure 121), indicating the number of measurements to be exported and signaling that un-processed measurements will not be exported.

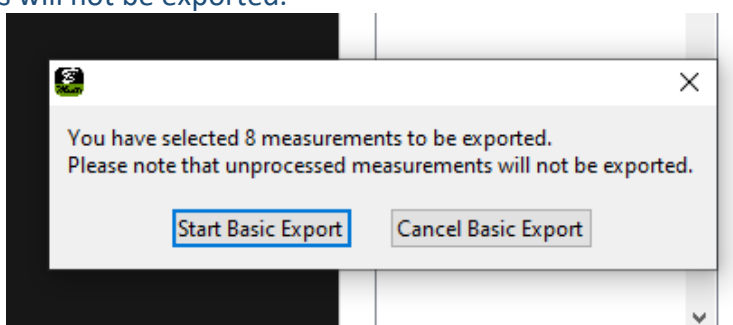


Figure 121: Pop-up window – Start or Cancel

If the user clicks on Cancel, the basic export will be cancelled. If the user clicks on Start, the following pop-up window appears, asking for the destination and the filename (Figure 122), already populated with Exported basic results.

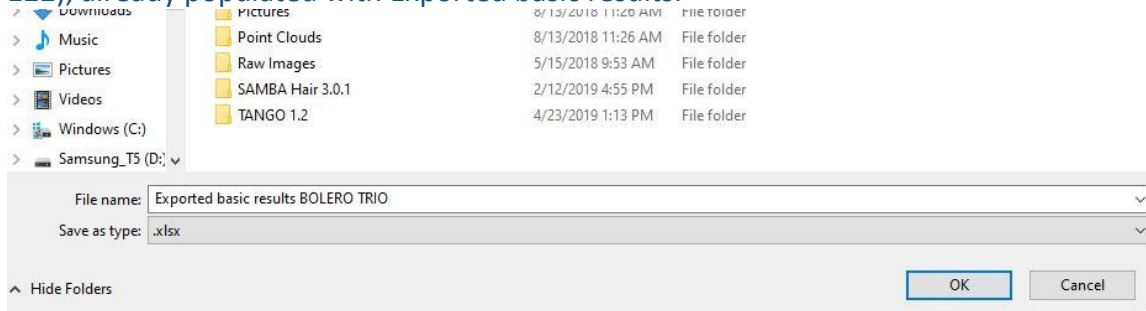


Figure 122: Pop-up window – Destination Filename

The excel file contains 3 tabs, corresponding the normal and Footprint results (Figure 123).

Clipboard

Font

Alignment

Number

B32

✕

✓

fx

A	B	C	D	E
Measurement	BULK Surface (cm2)	FAF Surface (cm2)	TOTAL Surface (cm2)	FAF (%)
Swatch #1	28.39	0.54	28.93	1.85
Swatch #10	28.23	0.56	28.79	1.94
Swatch #2	34.56	6.99	41.55	16.82
Swatch #20	35.71	7.01	42.71	16.40

Figure 123: Excel File

9. Data format

The data are stored in the software root folder (containing the executable file) respectively in DATA_MULTI folders. It is possible to change the location of the data to be

used, for example on an external hard drive. Just click on **Select DATA Folder** control on the data management page and the usual pop-up window appears (Figure 124) allowing to select a different folder containing data. If the DATA_MULTI Folder does not exist in the new location, the software will immediately create them.

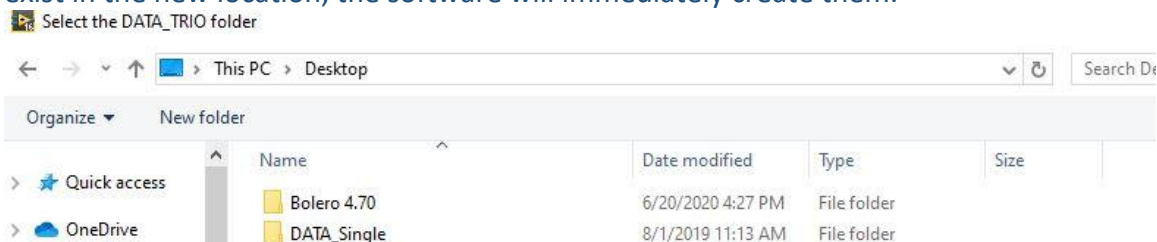


Figure 124: Window to change data folder location

The software will update the data architecture (study, sub-folder and measurement). The data format is the following (Figure 125). Each new measurement creates of folder with the measurement name.

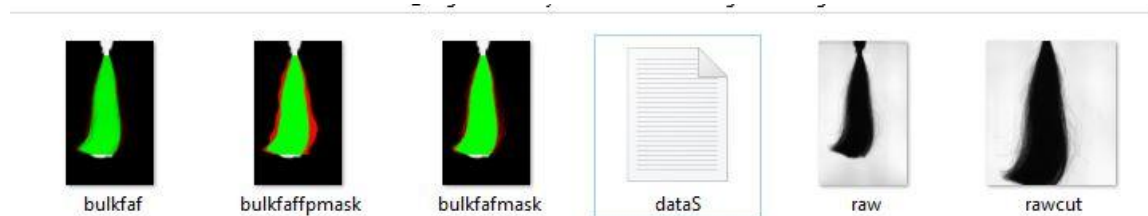


Figure 125: Data format - folder

The folder contains:

- An image named raw (png format)
- An image named rawcut (png format)
- An image named bulkfaf (jpg format)
- An image named bulkfafmask (jpg format)
- An image named bulkfaffpmask (jpg format)
- A text file named dataS.txt

The color images is the bulk – fly-away & frizz image, the bulk – fly-away & frizz mask image and bulk – fly-away & frizz footprint mask image. The raw image is the image acquired by the system. The rawcut image is the raw image cut between swatch start and swatch limit. The text file **dataS.txt** contains the information about the surface of the bulk, FAF, total and Fly-Away & Frizz (%) versus z (z varies from swatch start to swatch limit), plus the same information for the footprint processing.

10. CALIBRATION

At the bottom of SHUFFLE MULTI main page, under the measurement list, is a calibration button (Figure 126).

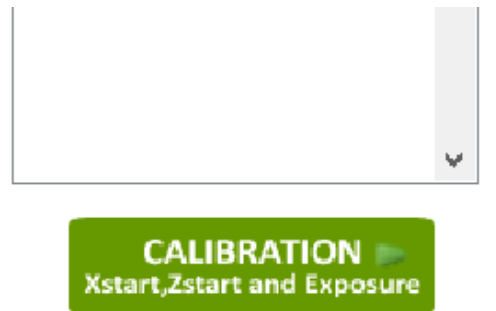


Figure 126: Calibration

Figure 127 shows the SHUFFLE 360/WIDE/TRIO/HULA/HOP calibration main window.

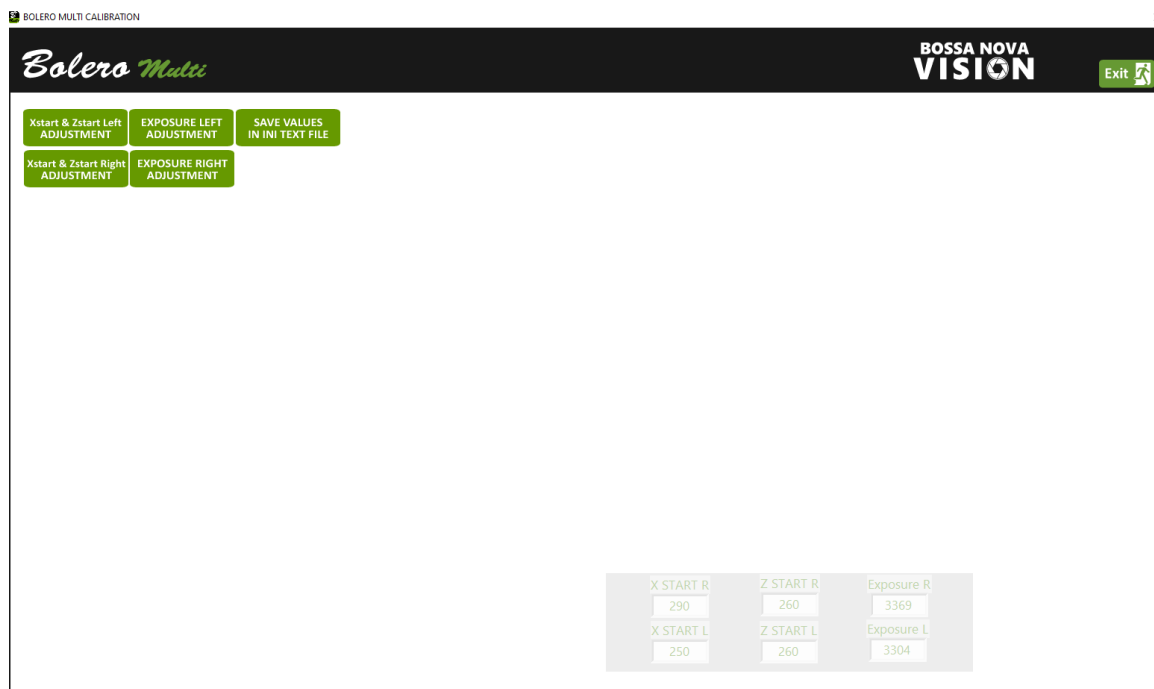


Figure 127: Calibration main window

On top, 5 buttons are present:

- Xstart & Zstart adjustment for left & right
- Exposure adjustment for left & right
- Save Values in ini

10.1.1. Xstart & Zstart adjustment

If the user clicks on Xstart & Zstart adjustment button, the following windows pops up (Figure 128).

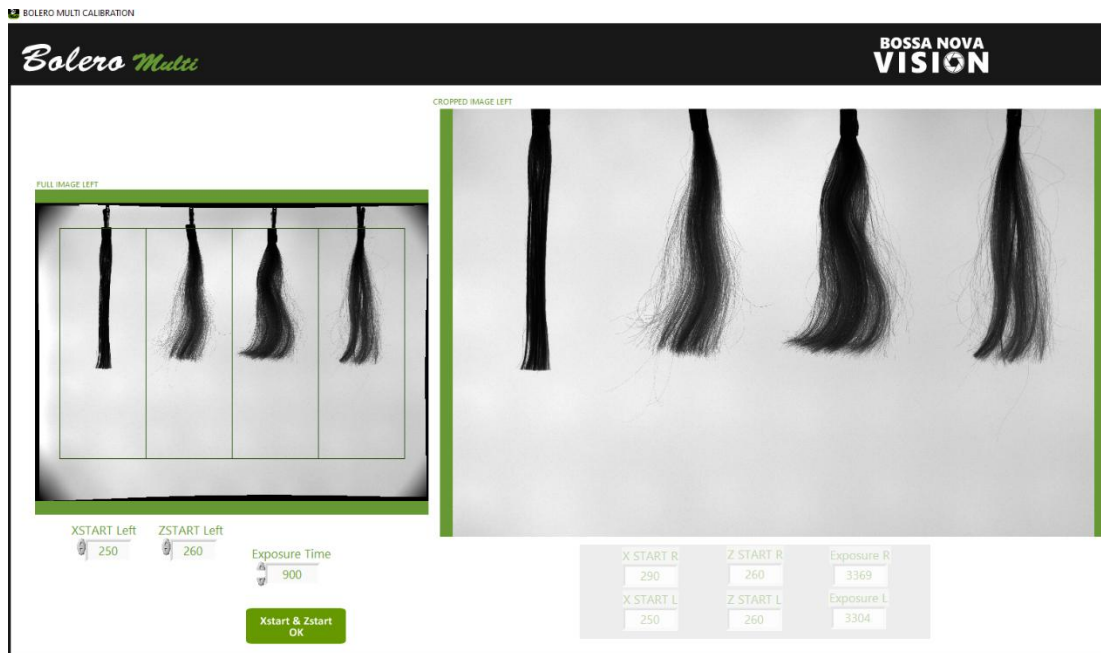


Figure 128: Xstart & Zstart adjustment window

SHUFFLE MULTI camera takes a larger image than the one acquired and saved in the software. SHUFFLE MULTI image (right image) is cropped compared to the original image (left). The cropped image (SHUFFLE MULTI image) is 2,250 x 1,380 pixels. Xstart and Zstart controls allow the user to properly crop the SHUFFLE MULTI image (centered, no marking, no ruler). Once adjusted, click on the button Xstart & Zstart ok to go back to the main window.

10.1.2. Exposure adjustment

If the user clicks on Exposure adjustment button, the following windows pops up (Figure 129).

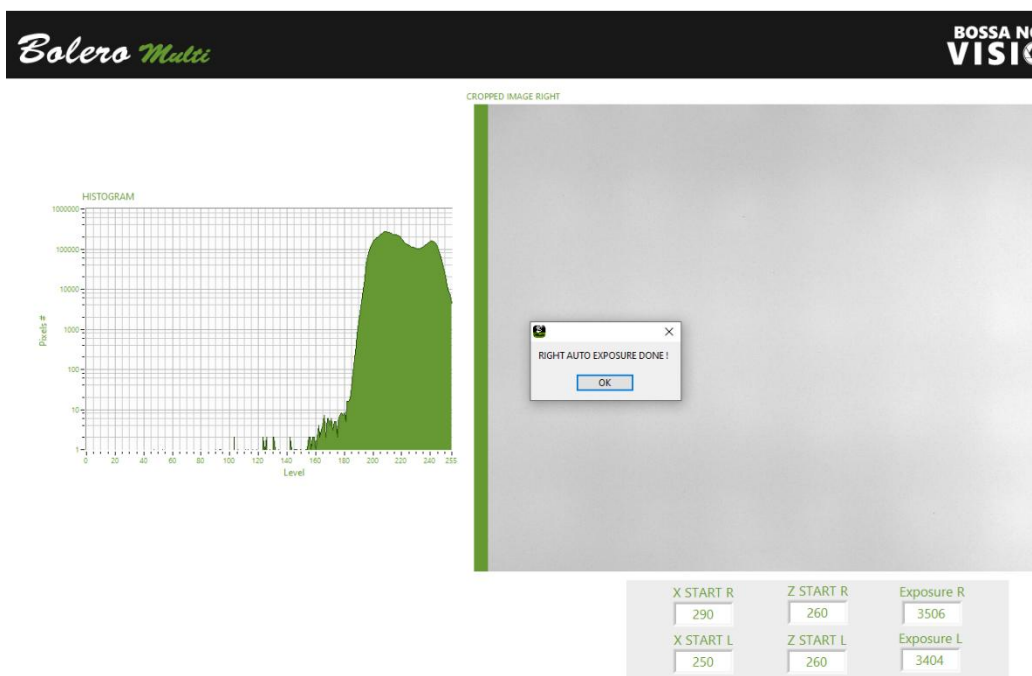


Figure 129: Exposure adjustment window

The software will automatically calculate the exposure time. Remember to have the LED back panel on. Click on OK to go back to the main window.

10.1.3. Save Values in ini

Once Xstart & Zstart and exposure are adjusted, the user can click on the Save the values in the ini text file button to automatically update all the ini text file for each software. Once done, the message pops up (Figure 130).

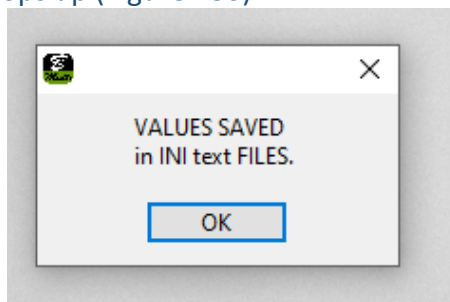


Figure 130: Values saved in ini files

11. Technical background

11.1. Definition

Hair swatches are composed of two differentiable aspects, bulk and frizz/fly-away fibers. The bulk of the tress can be defined as a 3D bounded volume (the mass of hair fibers that

comprises the body of the tress), while frizz and fly-away are individually identifiable fiber (Figure 131).

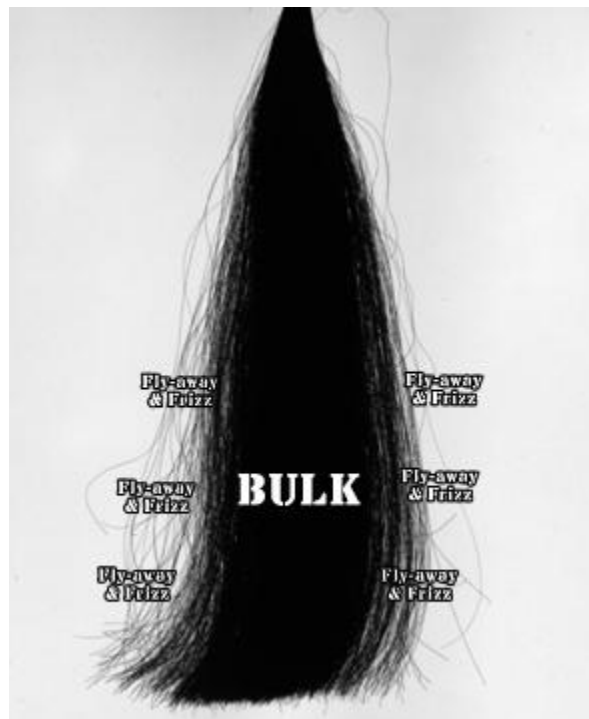


Figure 131: Bulk and Fly-away/Frizz definition

The goal of the image processing is to extract the bulk and the fly-away/frizz (Figure 132).

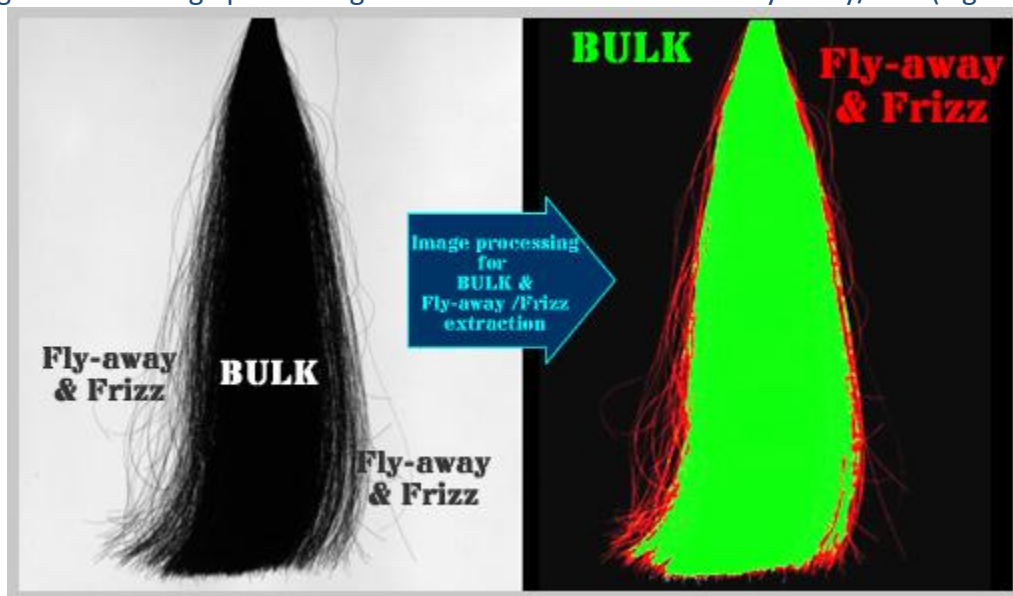


Figure 132: Bulk and Fly-away/frizz extraction

We can distinguish the bulk from the fly-away-frizz by analyzing the fiber density i.e. the number of fibers surrounding each fiber of the hair swatch. Fibers belonging to the bulk

are extremely close to each other and exhibit a high density, contrary to fibers belonging to the fly-away/frizz part of the hair swatch that are isolated and then present a low density.

11.2. Density measurement technique

A technique used to measure the density of a hair swatch pixel by pixel is to measure the amount of transmitted light when illuminated by a light source. If it appears black and blocks the light, we can define a high density of fibers and an appurtenance to the bulk of the hair swatch. On the contrary, high transmission corresponds to low density and possible fly-away/frizz fibers.

Using a LED panel to illuminate the hair swatch from the back (Back-illumination technique) and a camera to image the back-illuminated hair, we can estimate the light transmission for each pixel of the image (Figure 133).



Figure 133: Transmission image

A calculation of the density for each pixel is easily done for each pixel of the image. In that case, the density is calculated with 6 neighbors, per line. The density image is given on Figure 134.

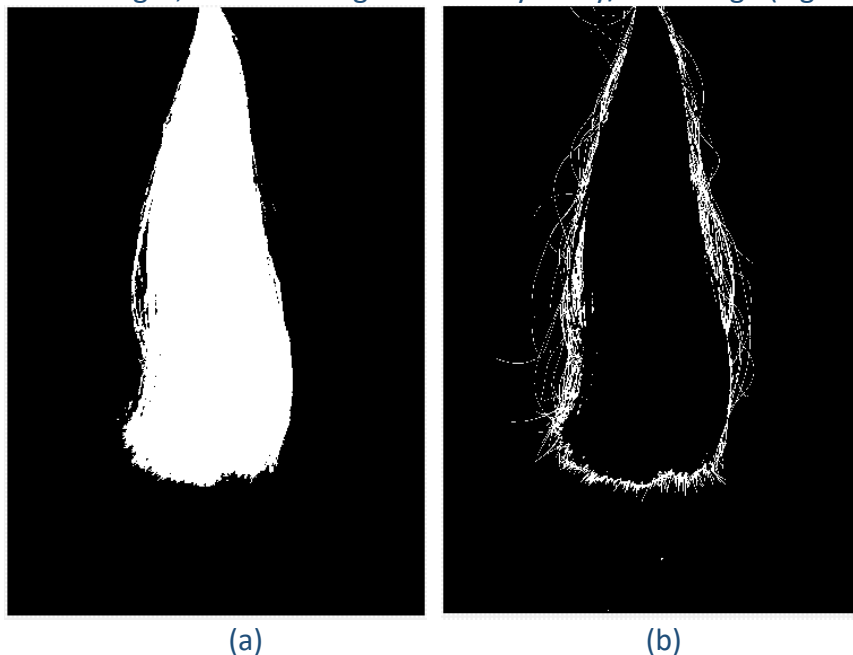


Figure 134: Density image

Each pixel level of the image represents the density of the image.

We add a threshold to the density image to classify each pixel into a BULK or a fly-away/frizz pixel. If the density is under 50%, then the pixel is a fly-away/frizz pixel. If not, it is a bulk pixel.

We then obtain 2 images, the bulk image and the fly-away/frizz image (Figure 135)



(a) (b)
Figure 135: (a) BULK and (b) FAF images

We can combine the 2 images in a color image (**BULK** in green, **FAF** in red) (a) and also add the texture information (b) to keep the hair fibers information (Figure 136).

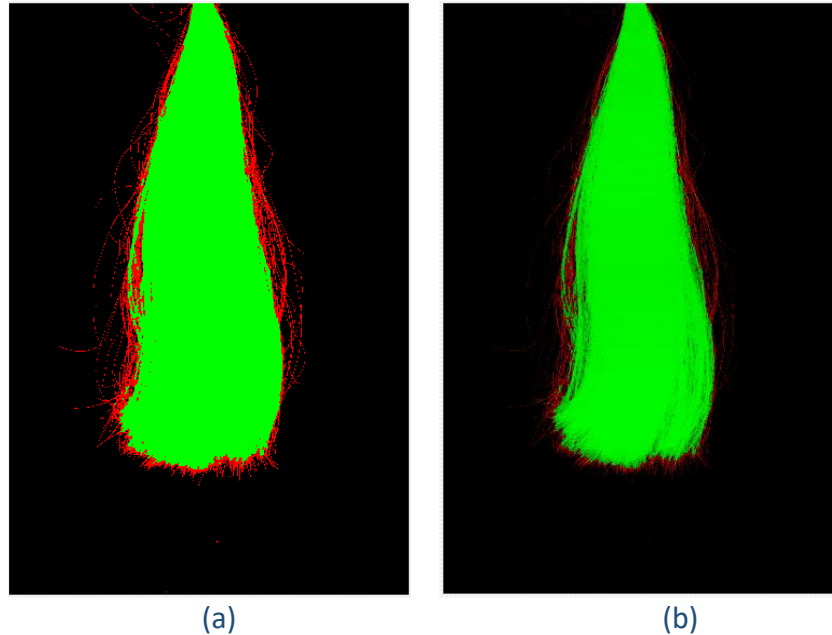
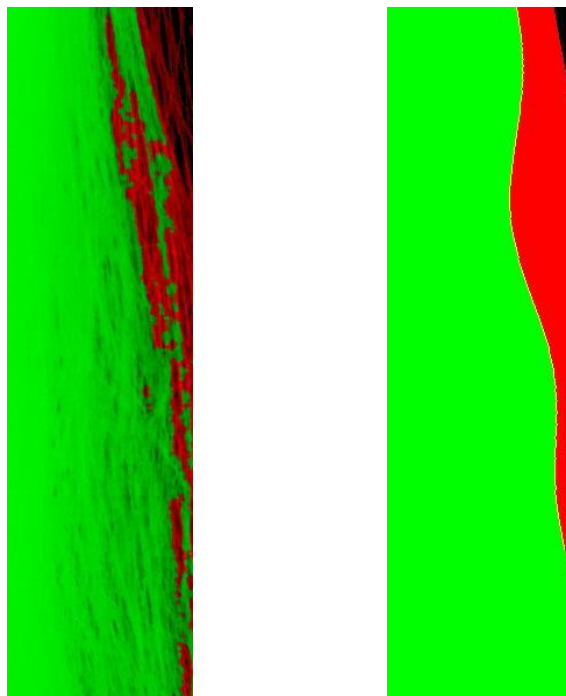


Figure 136: (a) BULK/FAF mask image (b) BULK/FAF image

This is the usual processing that is applied on regular 2D image. The Single image part of SHUFFLE proceeds to that processing and measurement. To reconstruct the 3D volume using the rotation of a silhouette technique, the silhouette must be a closed surface. This means that there should not be any no peaks or holes present in the bulk and that the faf becomes a closed surface. This is what we call the footprint processing, to be described below.

11.3. Footprint processing

Footprint processing consists of transforming the BULK and the FAF into closed surfaces. For the BULK, it implies removing holes & peaks and for the FAF, it is based on filling the fly-away/frizz zone (Figure 137).

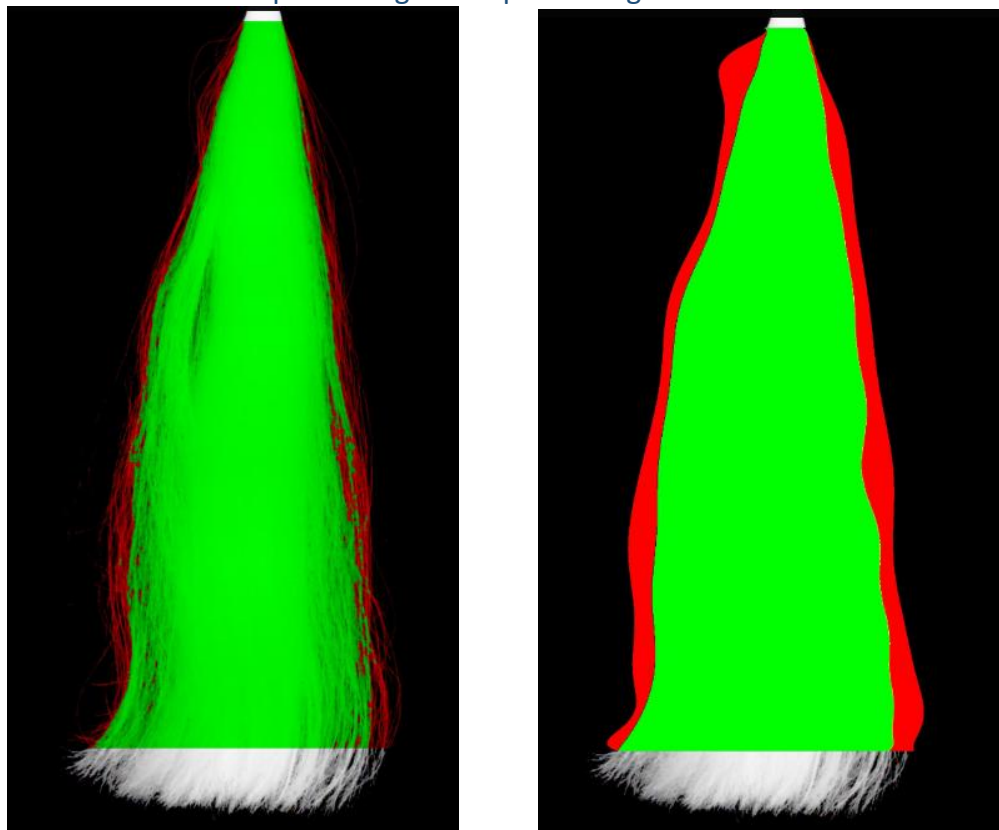


(a) After Bulk/FAF processing

(b) After Footprint processing

Figure 137: Removing holes and peaks / filling FAF

Figure 138 shows the complete image after processing.



(a) Bulk/FAF processing

(b) Footprint processing

Figure 138: Footprint processing on full image

The BULK footprint and the FAF footprint are closed surface.

11.4. Average Rectangle Width (AR Width)

Once the BULK surface and the length of the hair swatch are measured, we can establish a width parameter, the Average Rectangle Width corresponding to the BULK Surface divided by the length i.e. $AR\ Width\ (cm) = BULK\ Surface\ (cm^2) / Length\ (cm)$. This gives an evaluation of the average width of the hair swatch along the vertical axis (Figure 139) and is the width value if the hair swatch was rectangular.

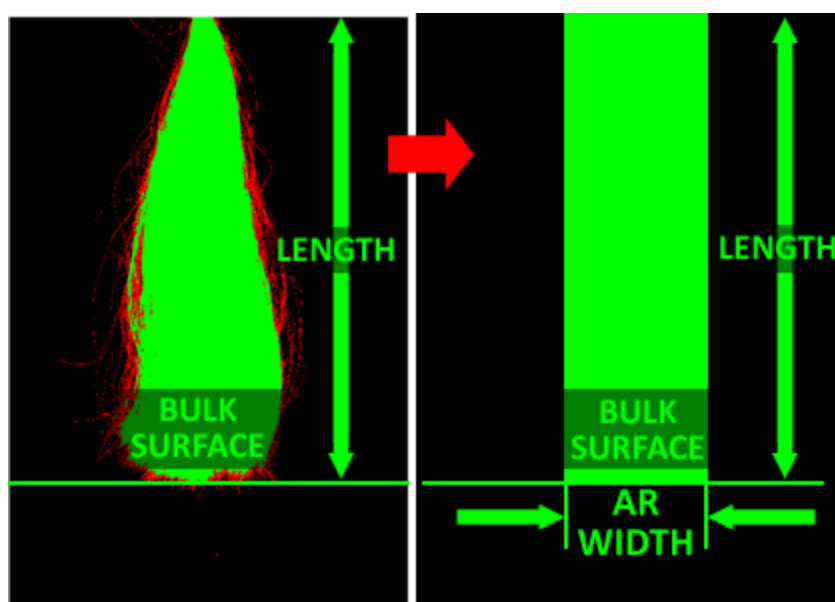


Figure 139: AR Width

12. Technical Specifications

Cameras	Monochrome 8 bits - x2
Image Resolution (left/right)	3,600 x 2,400 pixels – x2
Pixel Scaling	0.0135 cm/pixel (135 µm/pixel)
Total field of view (left & right)	97.2 cm x 32.4 cm
Individual Image Resolution	900 x 2,400 pixels SMALL 1,200 x 2,400 pixels MEDIUM 1,800 x 2,400 pixels LARGE
Individual field of view	12.15 cm x 32.4 cm SMALL 16,20 x 32.4 cm MEDIUM 22.30 cmx 32.4 cm LARGE
Illumination	Back light LED panel
Hair swatch length/weight	From 5cm to 30 cm – 1 to 20 g
Hair swatch color / type	Any / Any
Software	SHUFFLE MULTI 1.20 – Windows 1x
Measurement Time	< 1 minute
Data saved	See data format
Data Export	Excel format
Calibration	Factory calibrated
Size	52" x 16" x 30" (52"x32"x30" cameras mounted) 132cm x 41cm x 76cm (132cmx 82cm x 76 cm cameras mounted)