

SHUFFLE

MULTI-PLATFORM

User Manual 2.0

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Shuffle software is constantly being updated with new methods and features. Not all features may be available depending on the software version of the instrument control unit being used. Bossa Nova Vision will be pleased to advise.

About This Manual

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

About SHUFFLE: SHUFFLE is a turnkey multi-platform imaging system dedicated to hair swatch measurement. SHUFFLE allows:

1. Hair swatch 2D volume measurement and fly-away/frizz analysis 3 swatches at the same time using BOLERO TRIO
2. Hair swatch 2D volume measurement and fly-away/frizz analysis using BOLERO WIDE
3. Hair swatch 3D volume measurement and fly-away/frizz analysis using BOLERO 360
4. Hair swatch movement analysis using HULA
5. Hair Swatch perturbation analysis using HOP
6. Hair swatch orientation and alignment analysis using RUMBA

SHUFFLE Basic configuration comes with BOLERO TRIO/BOLERO WIDE hardware allowing 2D volume measurement and fly-away/frizz analysis. For BOLERO 360, HULA/HOP and RUMBA measurement, additional specific hardware is required.

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

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1. Safety

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

WARNING: Failure to observe this warning may cause injury to people and damage to power supply or connected equipment.

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

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

CAUTION:
Do not operate the system in an area with too much light or varying light intensity as this can lead to inferior images and/or measurements and/or processing errors.

2. QUICK START

Shuffle basic configuration comes with BOLERO TRIO/BOLERO WIDE hardware.

2.1. Unpacking

2.1.1. BASIC CONFIGURATION (BOLERO TRIO/WIDE)

When unpacking the system basic configuration (BOLERO TRIO/WIDE), please make sure you have all the following items (Figure 1):



SHUFFLE (BOLERO TRIO/WIDE mount attached) | Computer (with cables) – Laptop or All-in-one (Optional) | USB 3.0 Cables (x1) | SHUFFLE LED back panel power supply

Figure 1: SHUFFLE components – Basic configuration

A close-up of BOLERO TRIO/WIDE hair swatch mount is presented on Figure 2.



Figure 2: BOLERO TRIO/WIDE Hair swatch mount

2.1.2. BOLERO 360

BOLERO 360 hardware consists of a hair swatch mechanical mount with an integrated motorized rotation, a controller, a 5V power supply and a USB 2.0 cable (Figure 3).



Figure 3: BOLERO 360 components

2.1.3. HULA/HOP

HULA and HOP share the same hardware that consists of a hair swatch mechanical mount with an integrated motorized shaker, a controller, a 5V power supply and a USB 2.0 cable (Figure 4).

.



Figure 4: HULA components

An external SSD Hard drive to be connected by USB 3.0 to the computer for HULA operation is attached (Figure 5).



Figure 5: SSD Hard drive

2.1.4. RUMBA

RUMBA consists of a forward looking illumination using far red LEDS coupled with a dual polarizer rotation system to provide fiber angle measurement. A diffuse acrylic background and a power cable for the back panel LED.
The system is powered by a 12V power supply and connected to the computer via USB 2.0 (Figure 6).



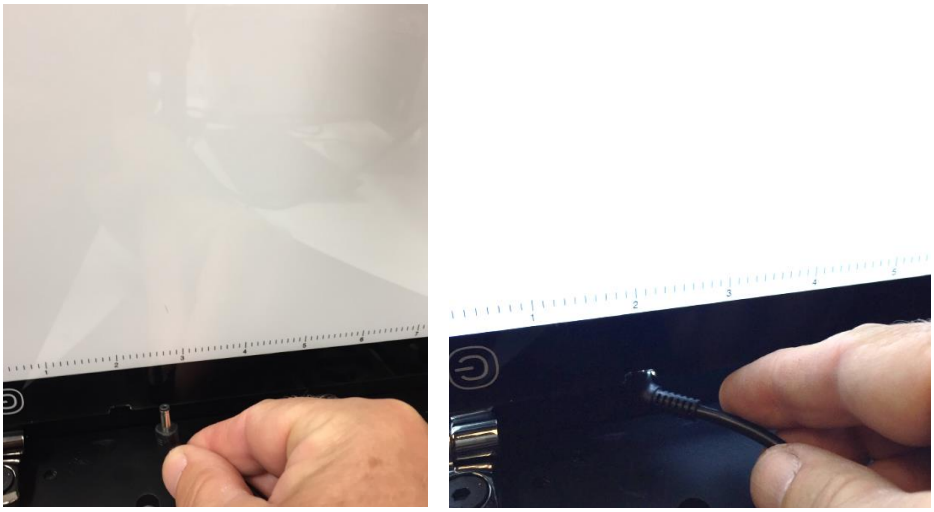
Forward looking illumination | Diffuse acrylic background | 12V power supply | USB 2.0 cable | LED back panel cable

Figure 6: RUMBA components

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

2.2. Connecting – Basic Configuration

SHUFFLE is connected to a computer for data/image acquisition, processing and data visualization/analysis/management. The USB 3.0 cable is the camera connection (USB 3.0, blue) from SHUFFLE to the computer. A power supply to power ON the illumination connects to the LED back panel (Figure 7) on the bottom left of the panel using a jack.



OFF ON

Figure 7: LED back panel power supply

2.3. Measurement with SHUFFLE – Basic Configuration

Connect the LED back panel power supply to the power. You should see the LED background panel on (Figure 8).



Figure 8: LED Panel on

Start the computer. SHUFFLE icon shortcut is on the desktop (Figure 9).



Figure 9: SHUFFLE shortcut

Click on SHUFFLE icon. The following window pops-up (Figure 10).



Figure 10: SHUFFLE pop-up window

The main window allows to select between 6 types of measurement. With the basic configuration, please select BOLERO Wide. The following window appears (Figure 11).

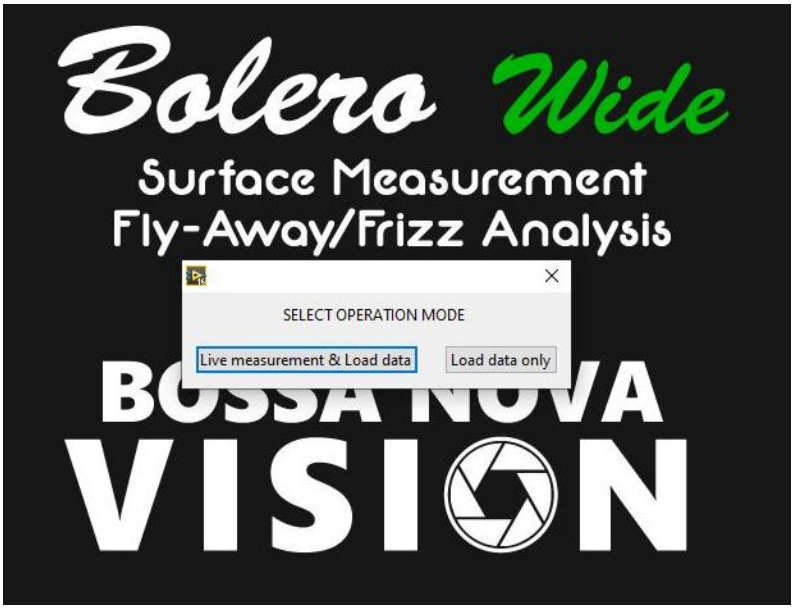


Figure 11: BOLERO Wide

Please click on LIVE MEASUREMENT & LOAD DATA. The following window appears, asking to remove any swatch present before the hardware initialization test (Figure 12).

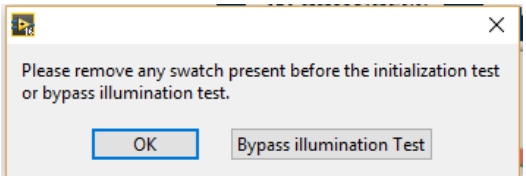


Figure 12: Remove any swatch present or Bypass illumination test

The first time BOLERO Trio 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. At the end, the following pop-up window appears (Figure 13). If another pop-up window appears signaling hardware troubles, please contact Bossa Nova Vision immediately.

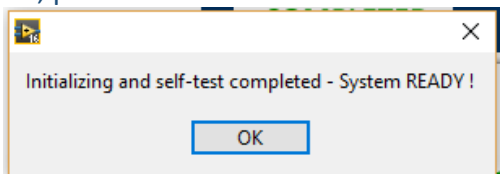


Figure 13: System READY! Pop-up window

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 14).

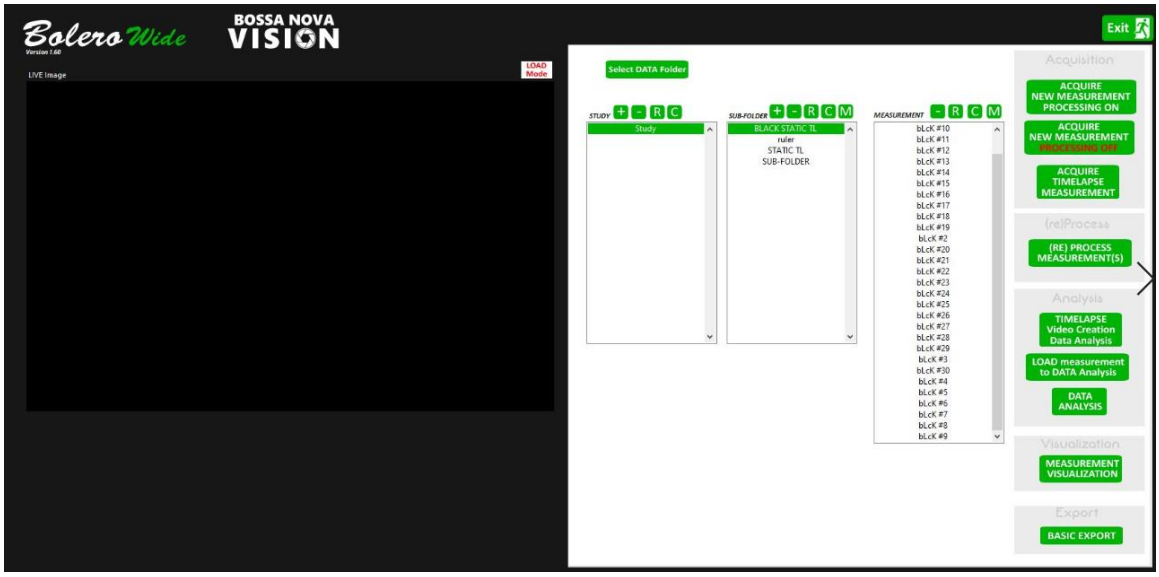


Figure 14: BOLERO Wide Main window

Before acquiring a new measurement, you need to create a STUDY then a SUB-FOLDER using the + control (Figure 15) located on the right of the STUDY and the SUB-FOLDER.



Figure 15: Creating STUDY then SUB-FOLDER

By clicking on +, a pop-up window (Figure 16) asks for the name of the study (or sub-folder).

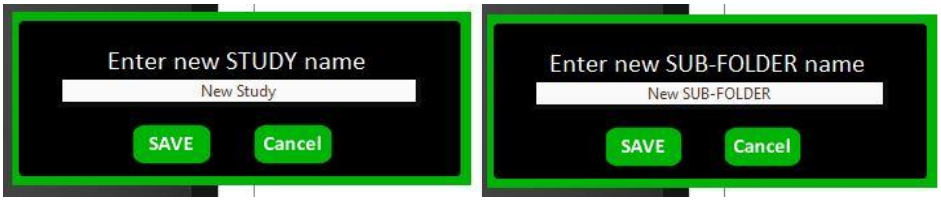


Figure 16: Pop-up window enter new STUDY (or new SUB-FOLDER)

Figure 17 shows the new STUDY (Test) and the new SUB-FOLDER (Time lapse) created.



Figure 17: STUDY and SUB-FOLDER created

You are new ready to acquire the first measurement. Mount the hair swatches (up to 3) to be measured (Figure 18) 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 18: Mounting the hair swatch

The hair swatch is mounted (Figure 19).

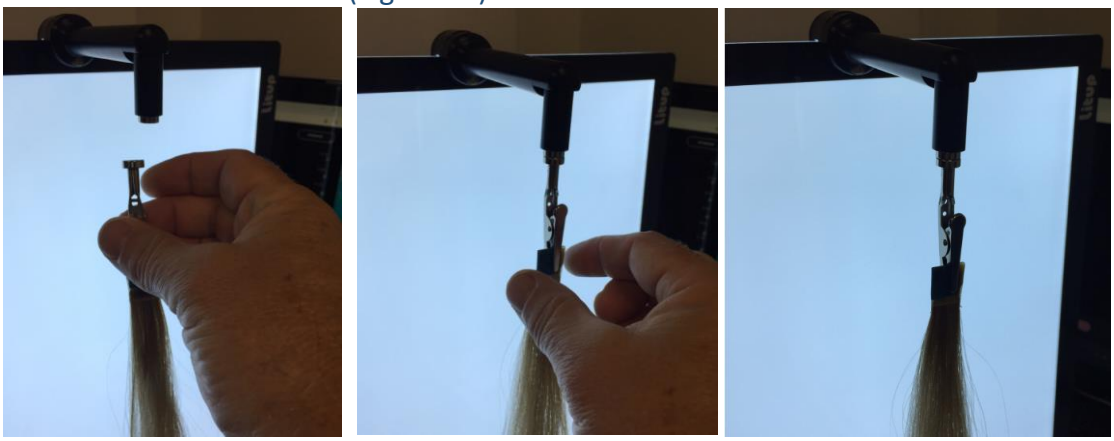


Figure 19: Hair swatch mounted

You can see the hair swatch mounted on the live image on the left of the window (Figure 20).



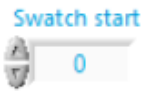
Figure 20: Live image

Click on the 

control to start the acquisition of a new measurement. The following window appears (Figure 21).



Figure 21: Acquisition Window

Adjust the swatch start value and the swatch limit value using the swatch controls 

and 

in order to define the zone of the image to be processed (Figure 22). Do not click on the other controls.

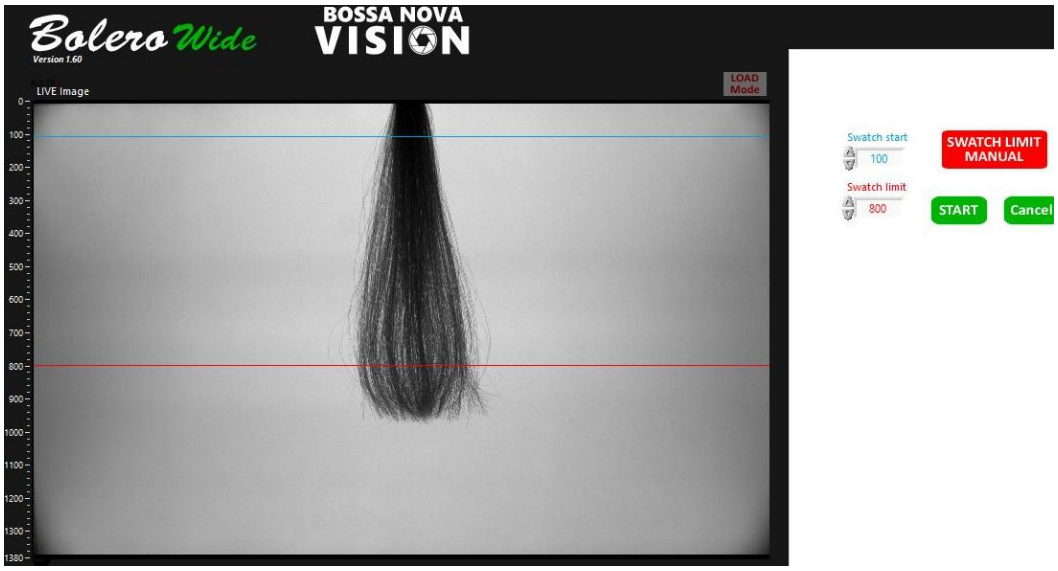


Figure 22: Swatch start/limit adjustment

Once it's done, click on the start control 

. The following pop-up window appears to ask for the name of the new measurements (Figure 23).



Figure 23: Pop-up window – Measurement name

Click on the save control 

and the measurement starts. After different steps (Acquisition, image save, image processing), the visualization window appears (Figure 24).

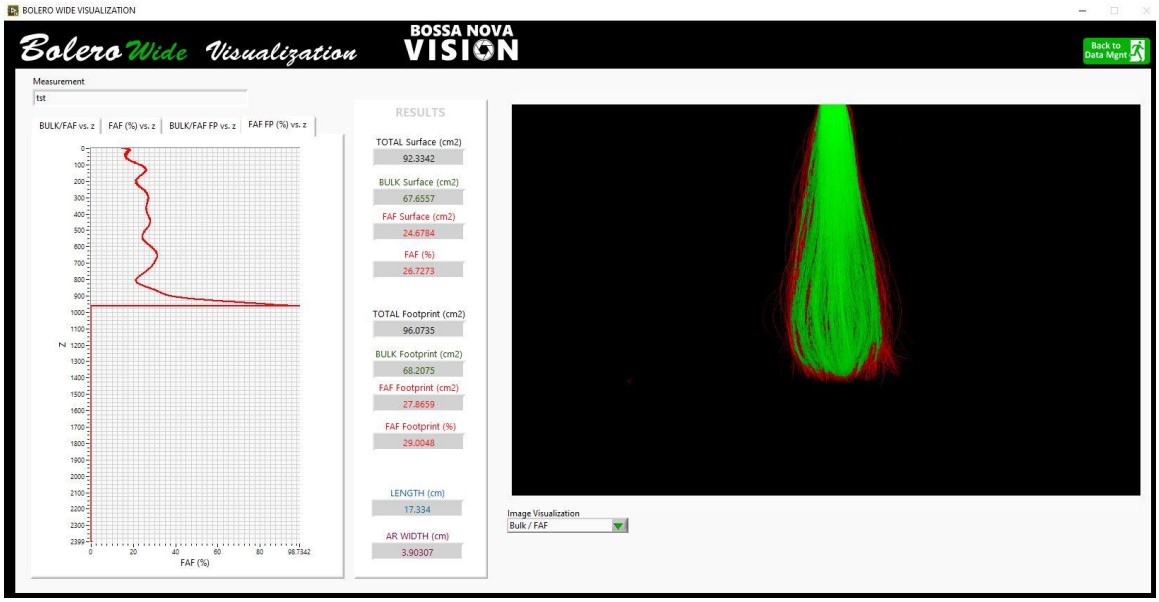


Figure 24: Results window

The results window show the processed image on the left. The bulk is in green, the fly-away/frizz in red. Different graphs, to be detailed in the following, are also shown. Surface of the bulk, FAF and total in cm^2 and the fly-away/frizz volume percentage are given. The tab on the top allows to navigate between the 3 measurements.

To go back to the management window, click on 

.

2.4. BOLERO 360 Configuration

2.4.1. Hardware installation

Using a 4-40 screw driver, driver and x4 4-40 screws, the user can install the BOLERO 360 mount (Figure 25).



Figure 25: BOLERO 360 in place

2.4.2. Computer connection

Connect the controller to the hair swatch mount (Figure 26).



Figure 26: Connection between controller and hair swatch mount

Using the USB 2.0 cable, connect the controller to the computer (Figure 27).

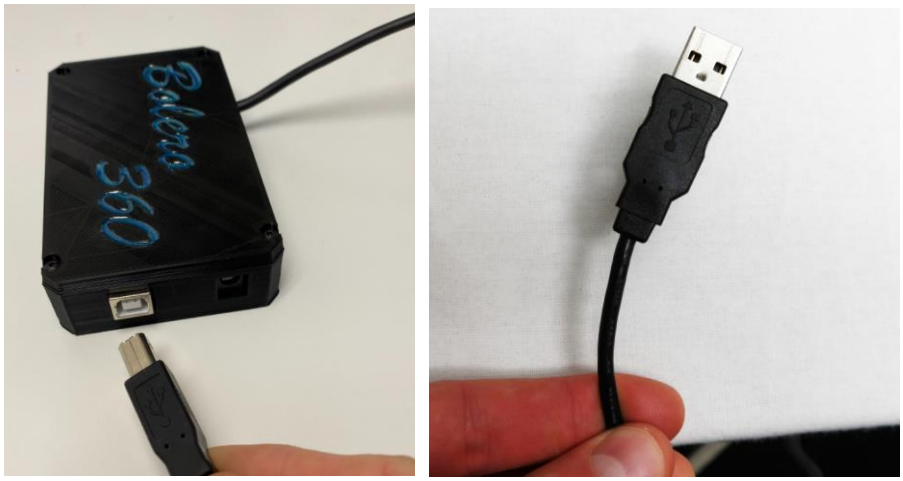


Figure 27: USB 2.0 connection to computer

Do not forget to connect the controller to its power supply (Figure 28)



Figure 28: Controller with power supply

2.5. HULA/HOP Configuration

2.5.1. Hardware installation

Using a 4-40 screw driver and x2 4-40 screws, the user can install the Hula mount (Figure 29).



Figure 29: Hula mount in place

It is easy to remove/mount the BOLERO TRIO/WIDE mount (Figure 30).

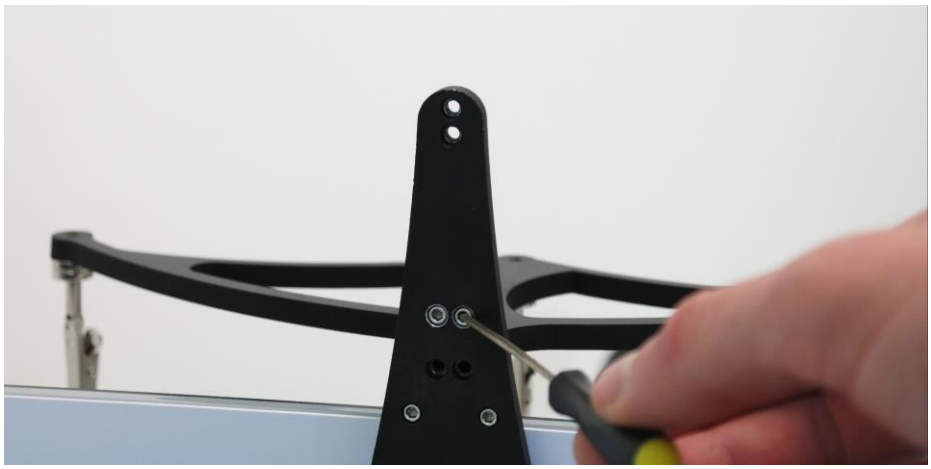


Figure 30: BOLERO Trio/Wide mount

2.5.2. Computer connection

Connect the controller to the hair swatch mount (Figure 31).



Figure 31: Connection between controller and hair swatch mount

Using the USB 2.0 cable, connect the controller to the computer (Figure 32).

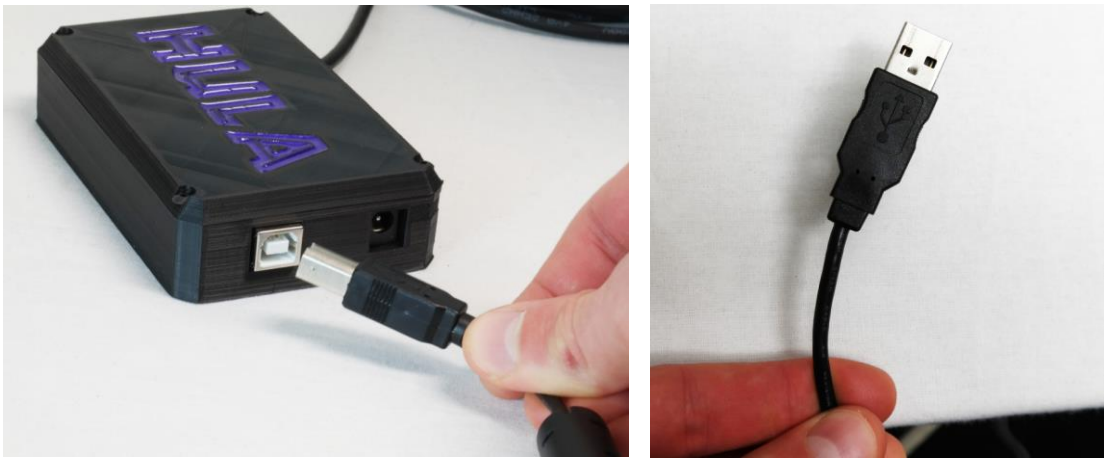


Figure 32: USB 2.0 connection to computer

Do not forget to connect the controller to its power supply (Figure 33).



Figure 33: Controller with power supply

If you are using the Shuffle with the humidity box, please put the controller outside the box. You can sneak the cable on the humidity controller side (Figure 34).



Figure 34: Cable on the side of the humidity box

2.6. RUMBA configuration

To operate RUMBA, a clear matte diffuse panel is needed in order to reduce the direct reflection of the forward-looking far-red illumination. It is used to cover the white LED back panel. If it is not in place, please secure the panel on top of the LED back panel (Figure 35).

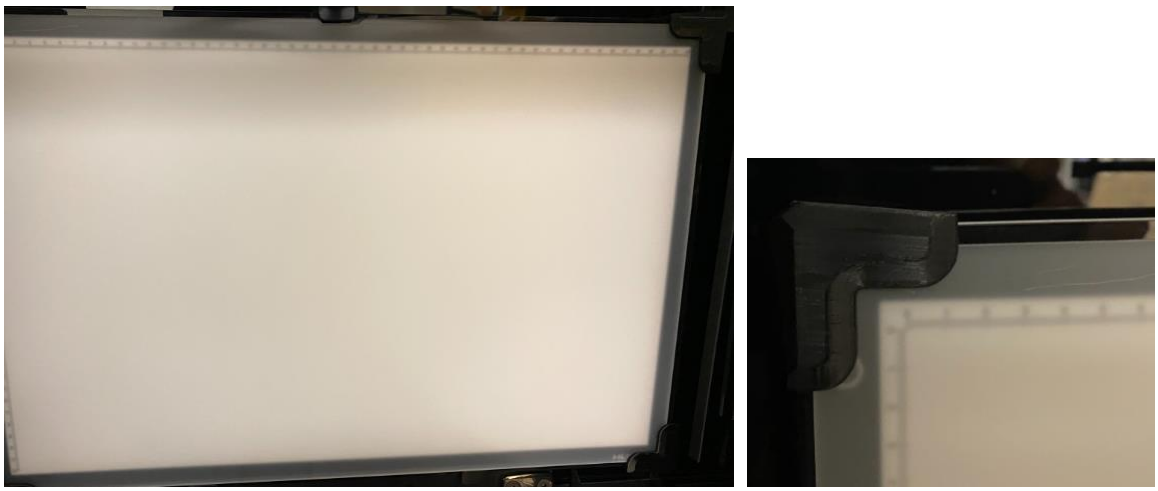


Figure 35: Diffusive matte panel on top of LED back panel

Be sure that the matte side is on the front. You should have SHUFFLE cutoff on the top right corner (Figure 36).

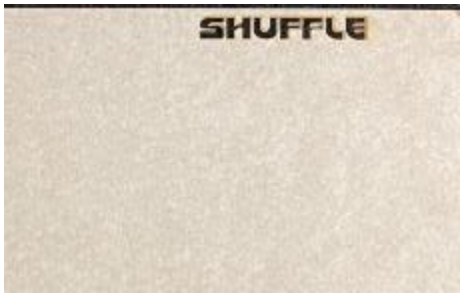


Figure 36 SHUFFLE cut-off – Top right corner

Next step is to mount RUMBA in front of the camera. Just place RUMBA carefully in front of the camera, guided by the slot on the bottom (Figure 37).



Figure 37: Mounting RUMBA in front of the camera

Secured RUMBA in position by tightening the screw (Figure 38).



Figure 38: Securing RUMBA in place

RUMBA is now in place (Figure 39)



Figure 39: RUMBA in place

Last step is to connect RUMBA to the computer and the power (Figure 40).



Figure 40: Connections

The back panel connection is to connect RUMBA to the LED back panel in order to switch the LED back panel ON and OFF with the software (Figure 41).



Figure 41: RUMBA to LED back panel connection

Connect the Power to the 12Vdc power supply (Figure 42).



Figure 42: RUMBA connected to power supply

Connect the USB 2.0 to the computer (Figure 43) and click on the ON/OFF button.

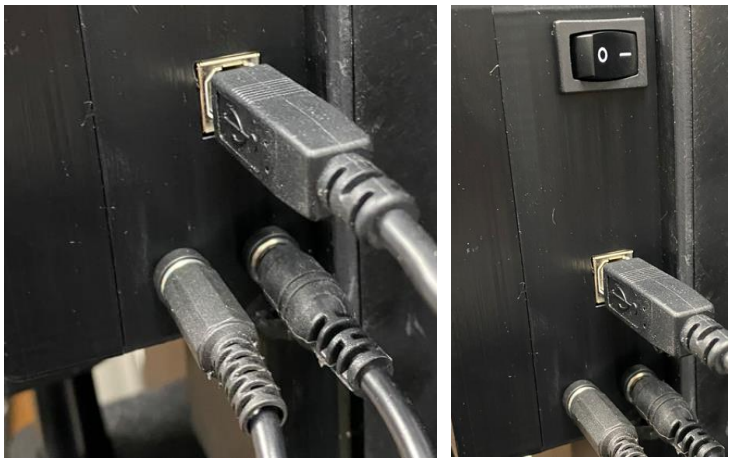


Figure 43: USB 2.0 connected – Switch ON

RUMBA is now ready.

3. SHUFFLE SOFTWARE

Shuffle software allows to shuffle between 6 different measurements corresponding to 5 different software, activated by the 5 buttons:

- BOLERO TRIO
- BOLERO WIDE
- BOLERO 360
- HULA
- HOP
- RUMBA

Plus a CALIBRATION button at the bottom of the window, as seen on Figure 44.



Figure 44: SHUFFLE software

Each buttons allow to start the corresponding software (Figure 45). Each software use the same architecture. Only the measurement and data analysis sections are specific to the measurement. In the following, we will detail the software using BOLERO WIDE software and detailed the parts that are specific to each measurement when needed.



Figure 45: 6 different software

The calibration software will be explained in 11.

3.1. Startup

Once the shuffle software is running, the user selects one measurement to be done. This opens the corresponding software. At startup (shown on Figure 46 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.

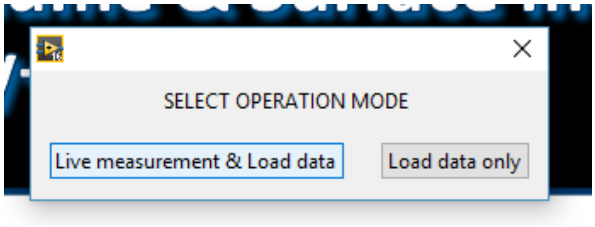


Figure 46: Start-up pop-up window

- 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.
- Choosing **Live measurement & Load data** leads to an automated test procedure that insures all hardware components (camera, LED panel, motors, etc.) are working properly to the factory specifications.

3.1.1. 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 47).

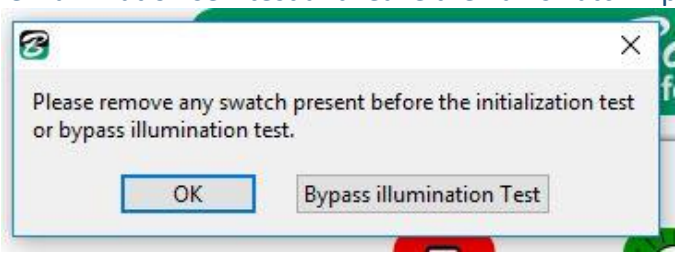


Figure 47: Initialization and self-test

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 – Motor initialization and test (for HULA, HOP, BOLERO 360 and RUMBA)
- STEP 3 - Illumination initialization and test (measurement of background level and uniformity)

If the three 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 and STEP 2 will be done. STEP 3 - 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 and 2 are 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 - Camera initialization and test is on (Figure 48)



Figure 48: STEP 1 - Camera initialization and test

Figure 49 shows the dialog window if there is an issue with the camera.

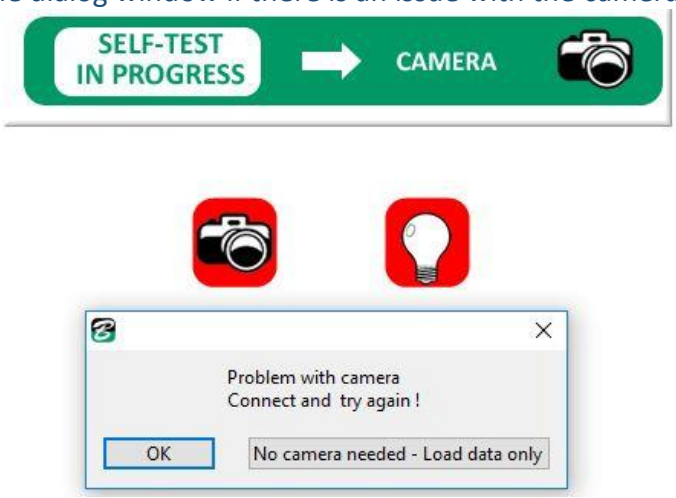


Figure 49: Dialog window if there is an issue with the camera

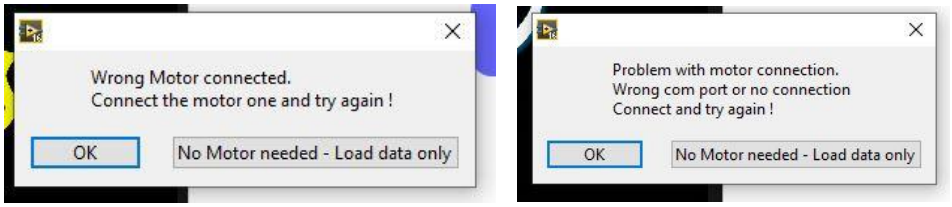
The user can select **OK** while reconnecting the camera. This option will proceed to STEP 1 - Camera initialization and test again. The user can also select **No camera needed – Load data only**. This option will by-pass next steps and go to BOLERO Trio main window. If after few tries, the camera is not correctly initialized, please contact Bossa Nova Vision.

If STEP 1 is successful, STEP 2 - Motor initialization and test is on (for HULA, HOP, BOLERO 360 and RUMBA) (Figure 50).



Figure 50: STEP 2 - Motor initialization and test

Figure 51 shows the dialog window if there is an issue with the motor.



(a) (b)

Figure 51: Dialog window if there is an issue with the motor

2 problems can occur: No motor is connected (and detected) or the wrong one is connected (HULA motor when BOLERO 360 is running or vice versa).

If the full test was select i.e. **by-pass illumination test** was not clicked, the software proceeds to STEP 3 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 52: STEP 3 - Illumination initialization and test (measurement of background level and uniformity)

Figure 53 shows the dialog window if there is an issue with the illumination.

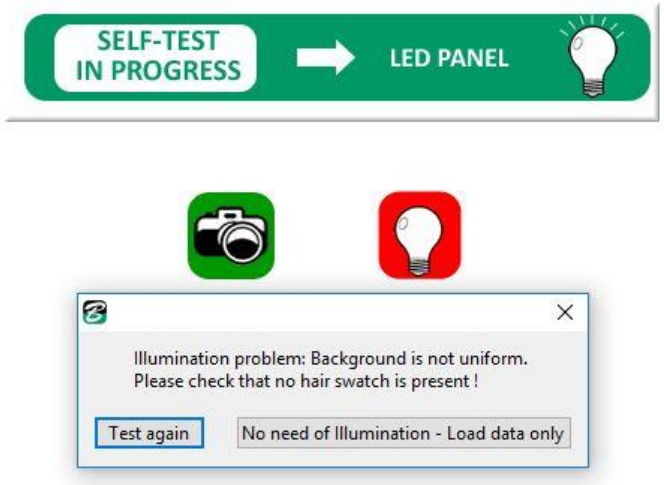


Figure 53: Dialog window if there is an issue with the illumination

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. If after a few tries, the illumination is not correctly initialized, please contact Bossa Nova Vision. If STEP 3 is successful, a dialog window appears (Figure 54) 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.

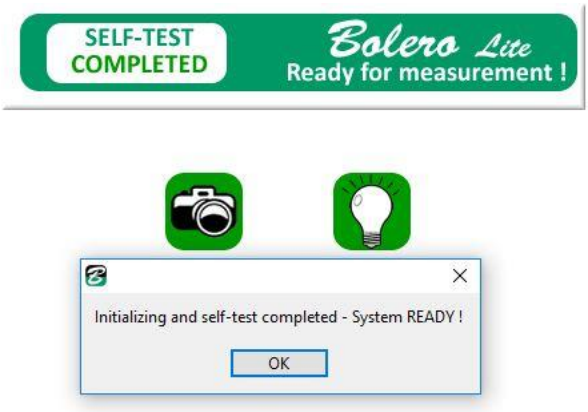


Figure 54: Dialog window – Initialization and self-test successful

3.2. SOFTWARE (BOLERO TRIO/WIDE/360/HULA/HOP/RUMBA)

Each individual software is based on the same architecture (Figure 55).
On the left of the window is the **IMAGE VISUALIZATION.**

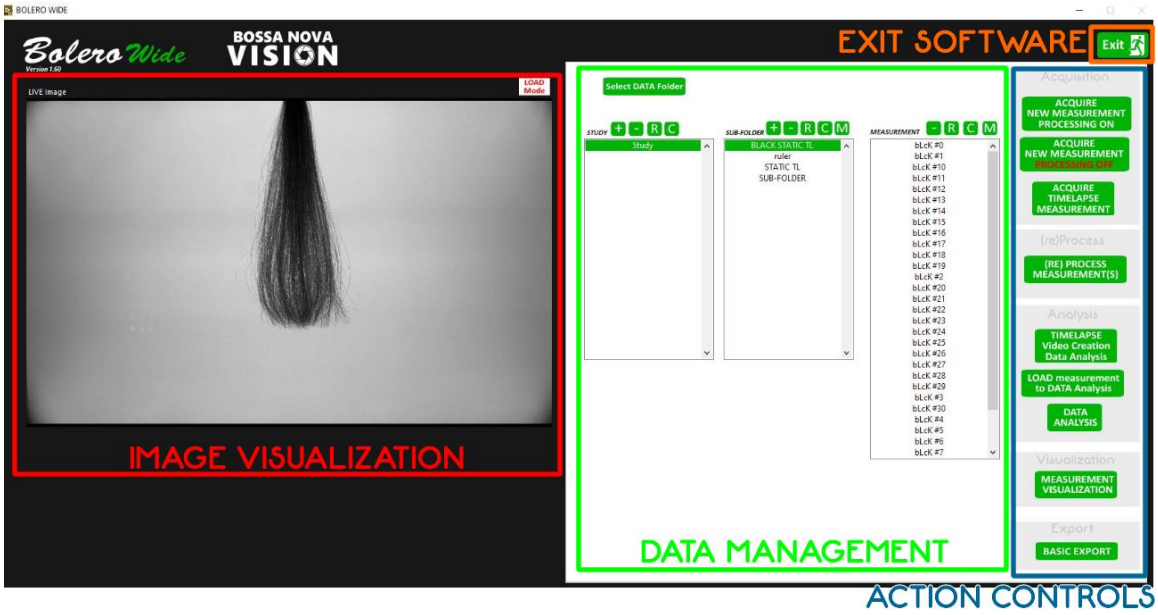


Figure 55: BOLERO WIDE – Main window architecture

On the right of the **IMAGE VISUALIZATION** is the **DATA MANAGEMENT** window. 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.

3.3. IMAGE VISUALIZATION

The left side of the main window consists of image visualization with image controls under (Figure 56).



Figure 56: image visualization

If **Load data only** is selected 

, the LIVE IMAGE shows (Figure 57) a *BOLERO WIDE – no live measurement – Open data only* image.

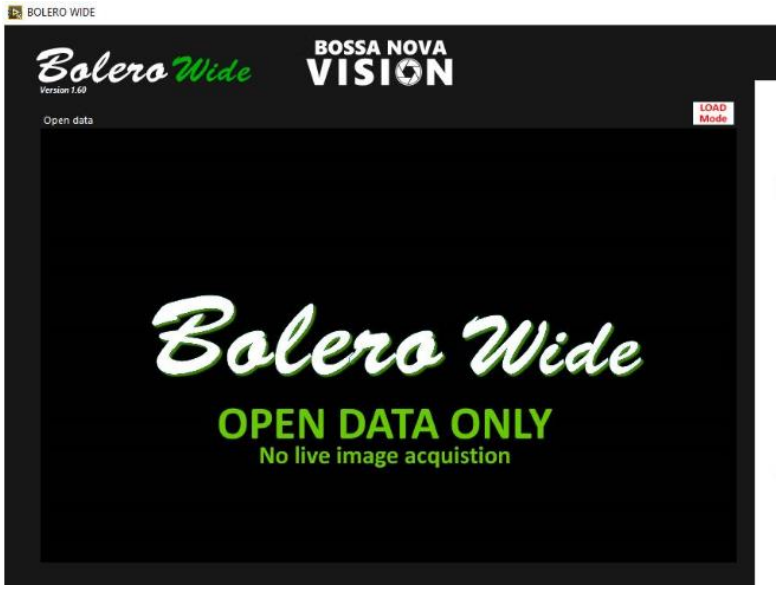
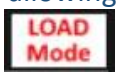


Figure 57: **Load data only – LIVE image**

The indicator/control on the top right of the image shows 

. The controls allowing the acquisition of new data (image or video) are not visible. If the user clicks on 

, a pop-up window appears (Figure 58) asking the user to choose the operation mode similar to the start of the software.

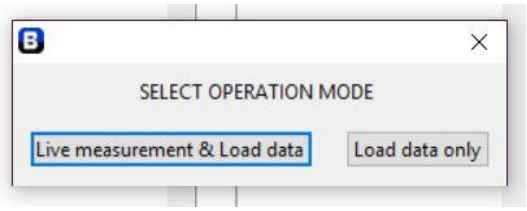


Figure 58: Live or load pop-up window

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 except for HULA (Figure 59).

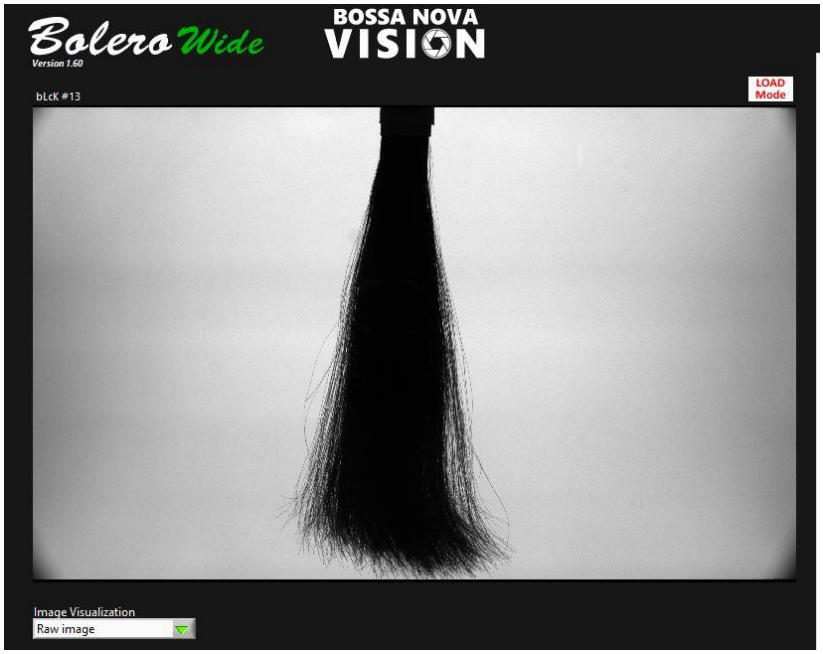
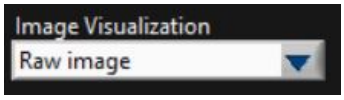
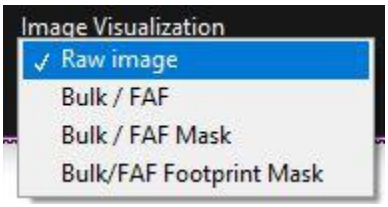


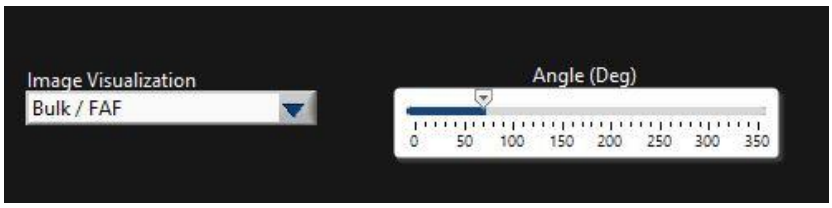
Figure 59: Load only – Measurement selected

The image visualization control 

appears when a measurement is selected (under the image). 4 different images can be displayed (Figure 60). For BOLERO 360, another control appears, to select the image angle.



(a) For BOLERO TRIO and BOLERO WIDE



(b) for BOLERO 360

Figure 60: 4 types of image

1) The raw image – acquired by BOLERO WIDE
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 (Figure 61).

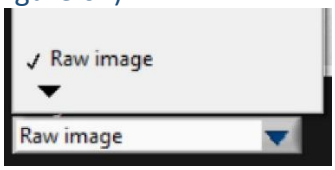


Figure 61: Unprocessed data – Only raw image

In the LIVE mode 

, the image shown is the live image from the camera and the selected measurement image appears in a small preview window (Figure 62) under the sub-folder list except for HULA.



Figure 62: Preview window – Live and measurement selected

In the LOAD mode 

, the selected measurement image appears in the image window (Figure 59). Note that if more than 1 measurements are selected, only the first on is displayed.

3.4. DATA MANAGEMENT

Data Management window allows to manage the data to be saved and processed (Figure 63). The user can create, delete, copy, rename, etc. different folders and measurements.

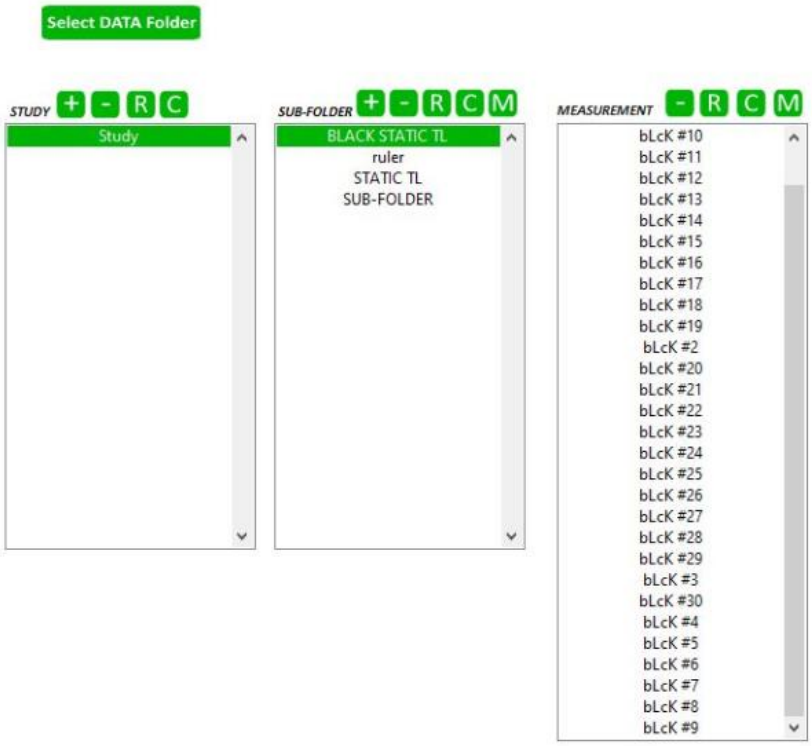


Figure 63: Data Management window

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 italic in the list (Figure 64).

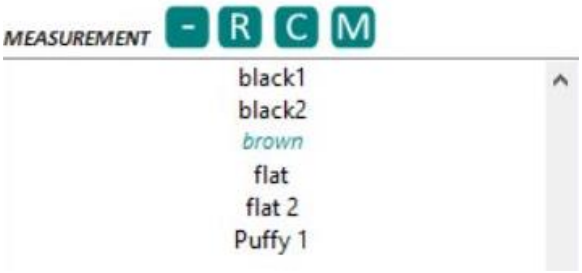


Figure 64: Measurement List – Processed and not processed

This unprocessed measurement (brown 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: 

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

The R control  allows to RENAME a folder.

The C control  allows to COPY a folder.

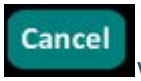
The M control  allows to MOVE a folder.

3.4.1. 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 65).



Figure 65: 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.

3.4.2. 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 66).

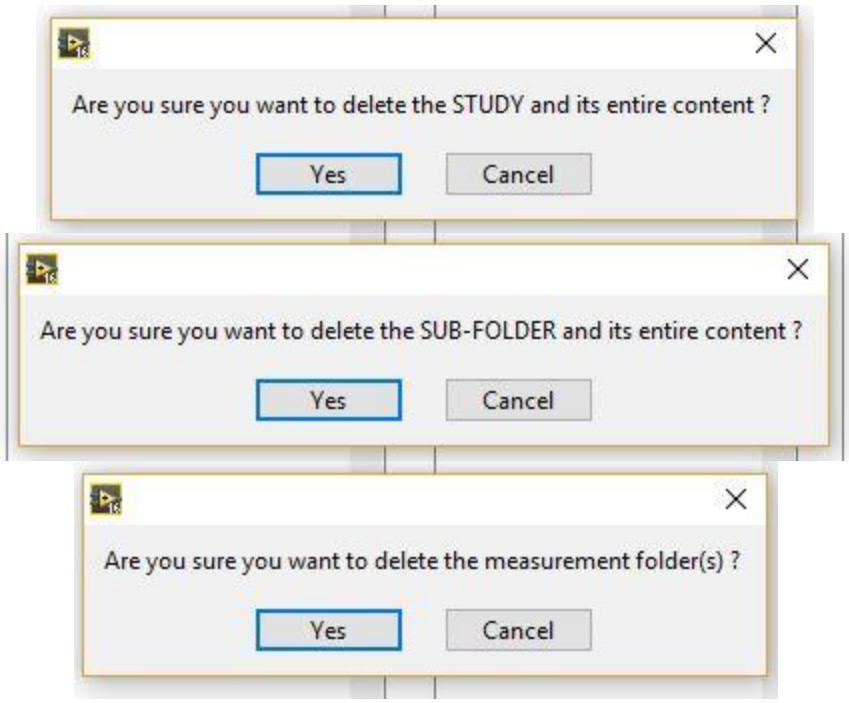


Figure 66: Pop-up window for deleting Study, Sub-folder or measurement

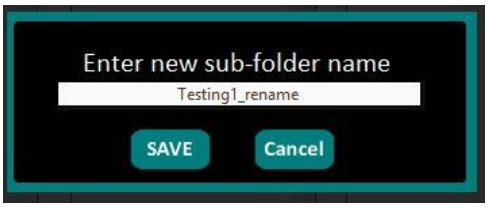
Note that when a folder is deleted, everything it contains is also deleted. For example, if the user deletes a study folder, the sub-folders and measurements folder contained in the study will also be deleted.

3.4.3. RENAME

The user can rename a study, a sub-folder or a measurement. Clicking on the R control  triggers a pop-up window (Figure 67) to enter the new name (pre-populated with name_rename).



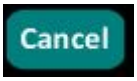
or



or



Figure 67: 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.

3.4.4. 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 68) pre-populated with name_copy. Note that the original remains the same.



or



Or



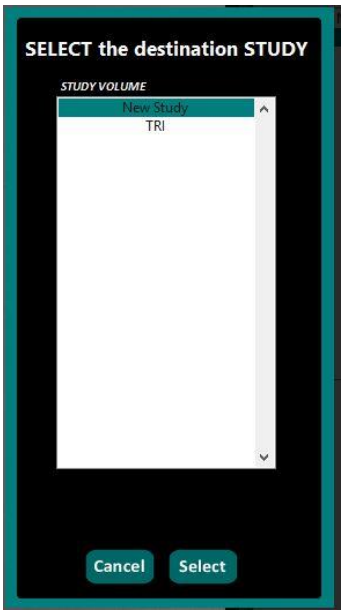
Figure 68: Pop-up window for copying study, sub-folder or measurement

Clicking on the cancel control 

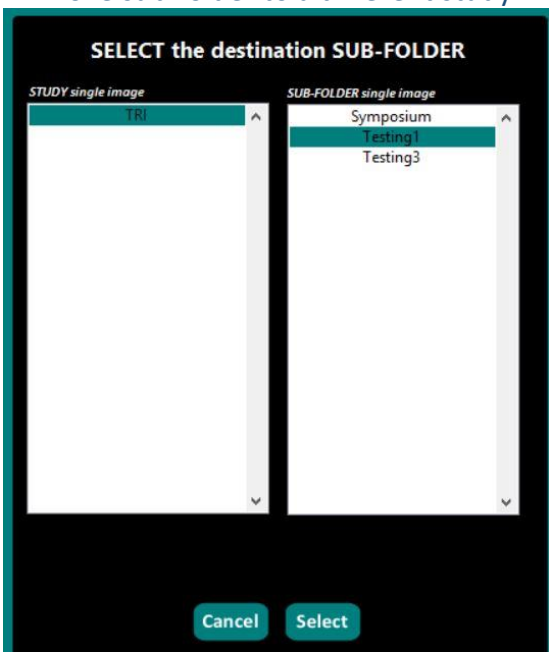
will cancel the copying of the study, sub-folder or measurement and close the pop-up window.
Note that the copy will be in the same location i.e. a sub-folder cannot be copied to a different study or a measurement cannot be copied to a different sub-folder. The control Move needs to be used for that purpose.

3.4.5. 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 69).

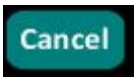


Move sub-folder to a different study



Move Measurement(s) to a different sub-folder

Figure 69: Pop-up window for the destination selection

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 70).

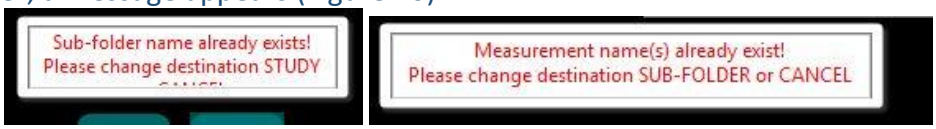


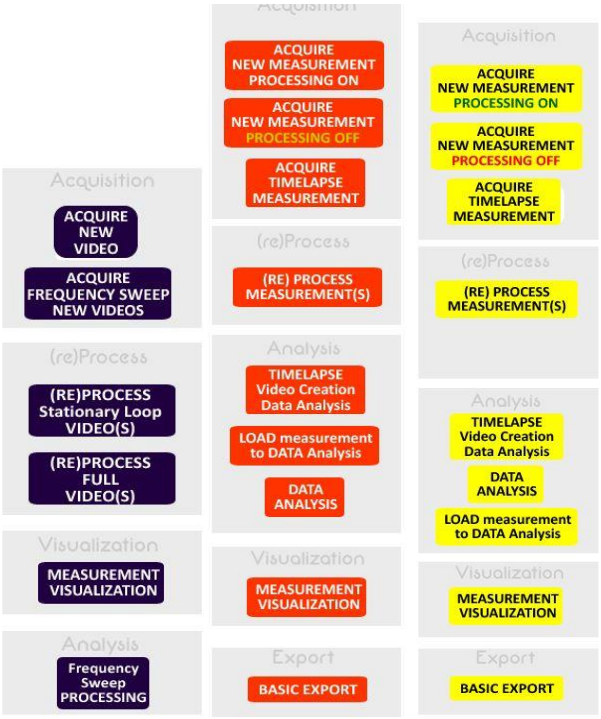
Figure 70: Sub-folder or measurements already present

3.5. ACTION CONTROLS

Action controls (Figure 71) allow to:

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





HULA HOP RUMBA

Figure 71: Action controls for BOLERO WIDE, BOLERO TRIO, BOLERO 360, HULA, HOP and RUMBA

The action controls are similar for BOLERO WIDE, BOLERO TRIO, BOLERO 360, HOP, RUMBA and different for HULA as HULA acquires videos instead of images.

3.5.1. ACQUISITION

Acquisition controls allow to acquire new data (images & videos).
For BOLEROs (TRIO, WIDE and 360), HOP and RUMBA, three options are possible (Figure 72):

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



Figure 72: Acquisition controls for BOLEROs, HOP and RUMBA

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.

For HULA, two options are possible (Figure 73):

- Acquire new Video
- Acquire Frequency new sweep videos



Figure 73: Acquisition controls for HULA

Acquire Frequency sweep videos allows to acquire a set of new videos with automatically varying the frequency of the hair swatch motion.

3.5.2. (RE) PROCESS

The **(re)process measurement** control 

allows the user to process an unprocessed measurement or reprocess a processed measurement.
For HULA, because of the duration of the video process, two options are possible (Figure 74)



Figure 74: (re)process

The stationary loop video has been extracted from the full video and is of short duration compared to the full video. Its processing time is way shorter than the processing of the full video. This will be detailed later on.

3.5.3. DATA ANALYSIS

Data analysis and comparison allows (Figure 75):

- 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 75: Data analysis controls

For HULA, data analysis is limited to Frequency Sweep Processing (Figure 76).



Figure 76: Hula frequency sweep processing

3.5.4. BASIC EXPORT (BOLERO WIDE/TRIO/360/HOP/RUMBA)

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.

3.5.5. VISUALIZATION

The visualization control 

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

4. ACQUISITION

To acquire a new measurement, software must be in live mode 

and the hardware test must have been completed successfully for the camera and the illumination. In 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 77) for BOLERO WIDE, TRIO, 360, HOP and RUMBA.

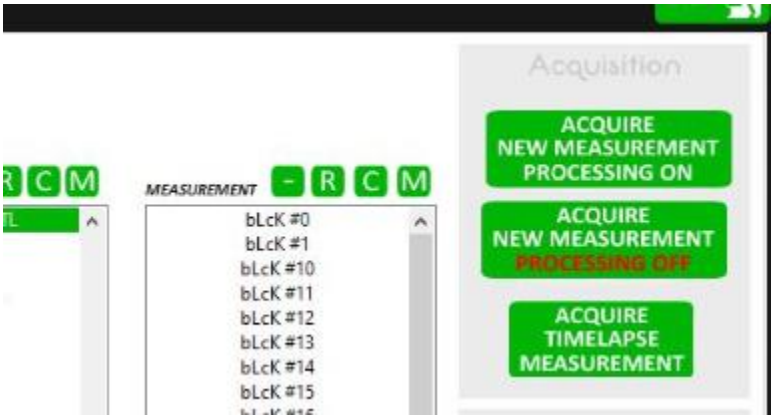


Figure 77: Acquisition controls for BOLERO WIDE, TRIO, 360, HOP and RUMBA

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.
For HULA, only 2 new measurements controls are present (Figure 78).



Figure 78: Acquisition controls for HULA

4.1. BOLERO TRIO ACQUISITION

4.1.1. Processing OFF

Clicking on **Acquire new measurement Processing off** control 

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 79).

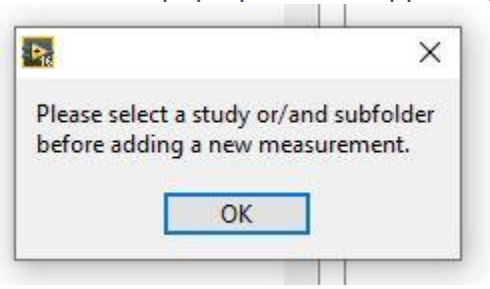


Figure 79: Pop-up window asking for a study/sub-folder selection before adding a new measurement

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 80).



Figure 80: New measurement – Processing off – Single image acquisition windows

Figure 81 shows the different controls.



Figure 81: **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 82).



Figure 82: Pop-up window BOLERO TRIO

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 83).

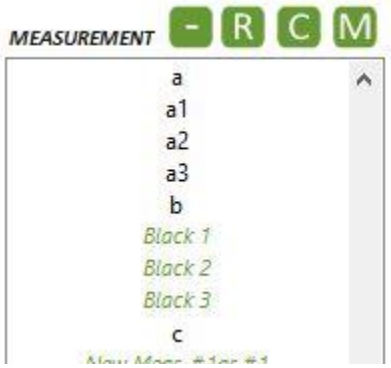


Figure 83: Measurements saved

Because the measurements are not processed, they appear in green italic in the measurements list.

4.1.2. 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 84) to adjust the parameters of the time lapse.

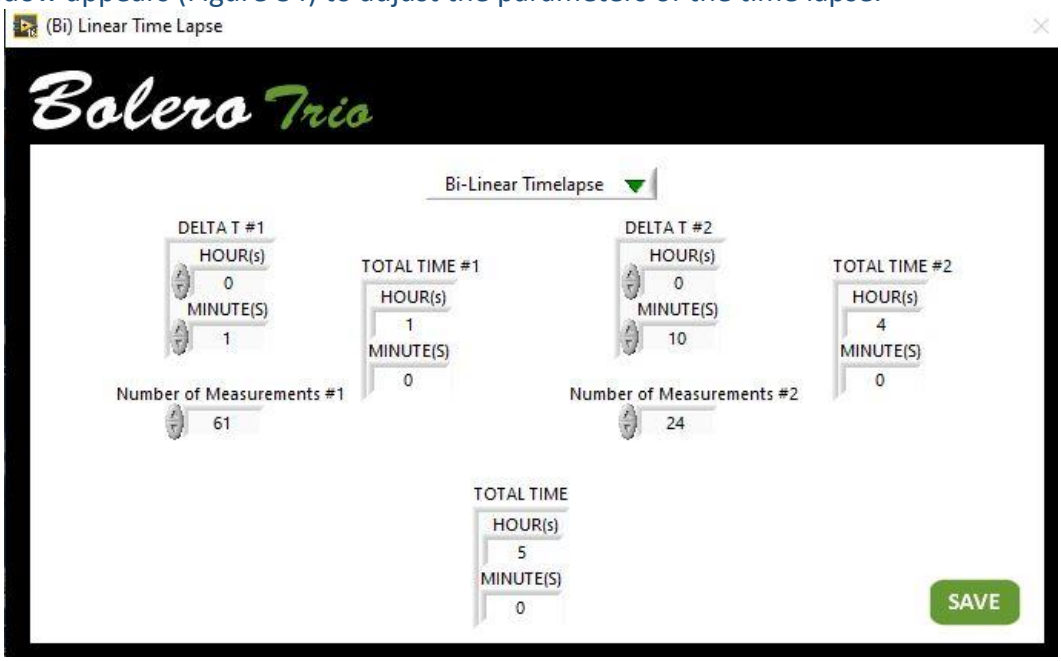


Figure 84: Time lapse parameters – Bi-linear Time lapse

The user can choose between a linear time lapse or a bi-linear time lapse using the 

control at the top of the window.

If the linear time lapse is selected, only Delta T #1 is shown (Figure 85).

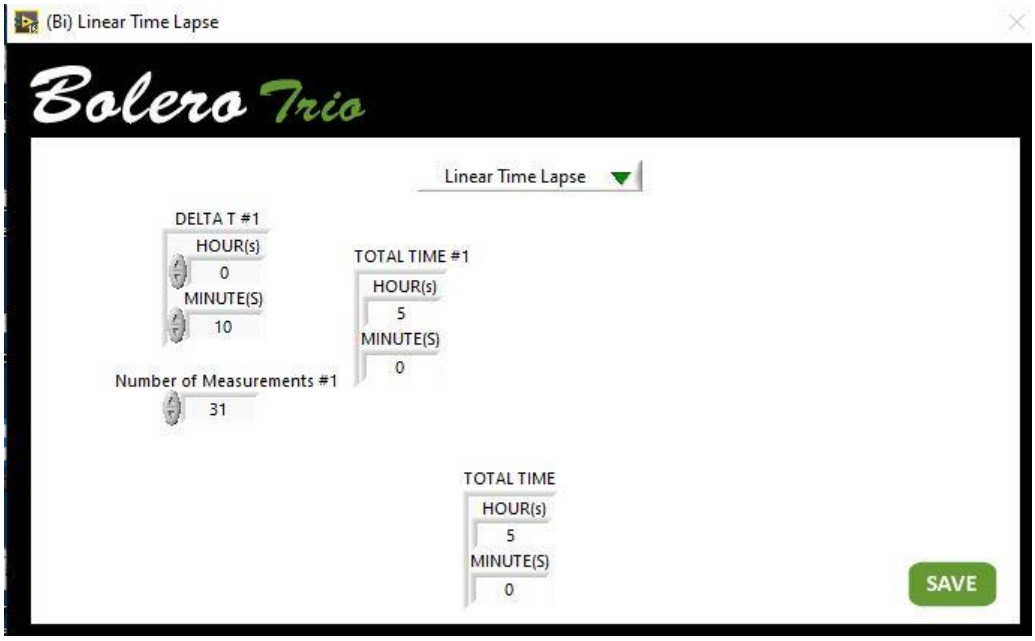


Figure 85: Linear time lapse selected

Linear time lapse selected means than the software will acquire an image every DELTA T #1 (Figure 86) for a number of images N#1. The total duration of the time lapse is DELTA T #1 x (N#1-1).

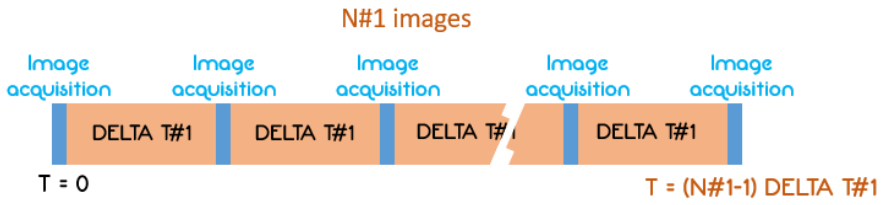


Figure 86: Linear time lapse

The total duration of the time lapse is DELTA T#1 x (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 87).

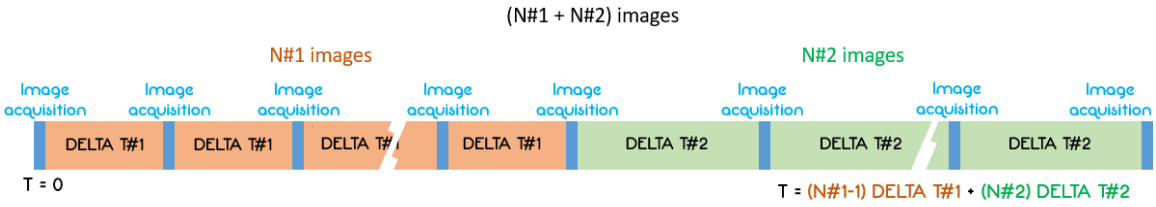


Figure 87: Bi-Linear Time lapse

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 x (N#1-1) + DELTA #2 x N#2.

Clicking on Save will save the parameters and open the measurement page (Figure 88).



Figure 88: Time lapse measurement

To start the time lapse measurement, the user clicks on START and the usual pop-up windows appears (Figure 89).



Figure 89: 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 90).

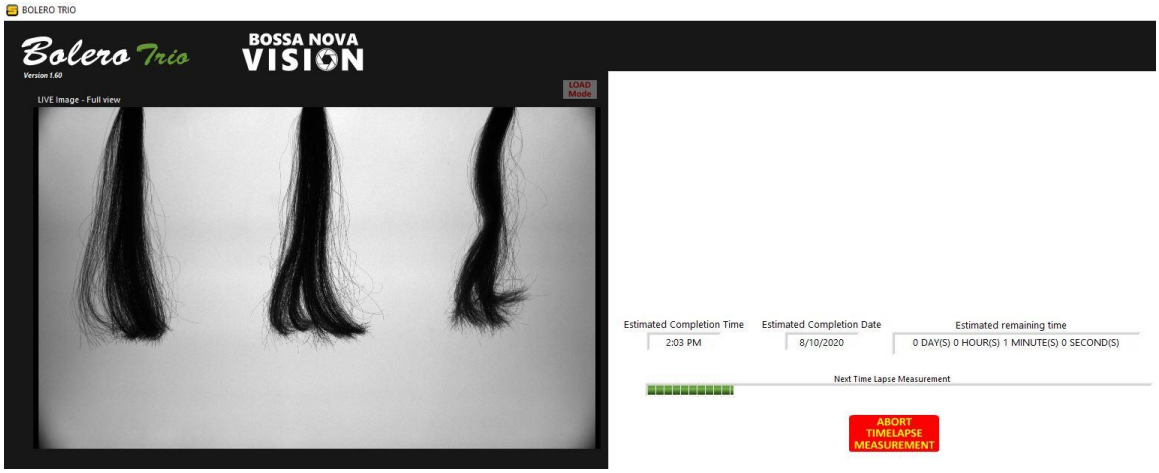


Figure 90: Time lapse acquisition window

On the right of the live image, the following indicators and control appear (Figure 91).



Figure 91: 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 92).

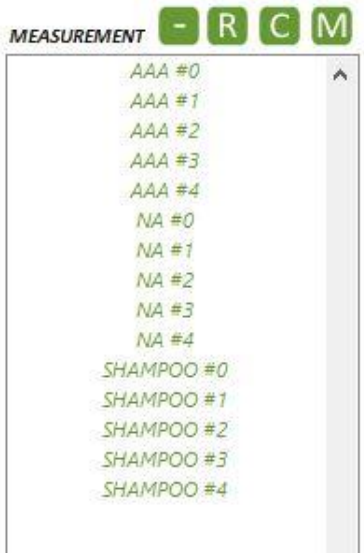


Figure 92: Main window after time lapse measurement

The time lapse measurements (#n) now need 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).

4.1.3. Processing ON



Clicking on **Acquire new measurement Processing on** control 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 93).

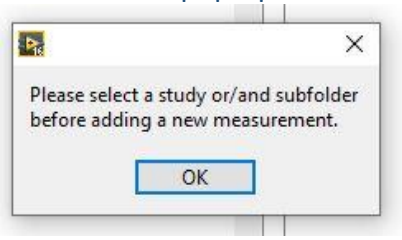


Figure 93: Pop-up window asking for a study/sub-folder selection before adding a new measurement

When the study/sub-folder selection is correct, a new measurement can be done and the measurement page appears once the **Acquire new measurement Processing off** control is clicked (Figure 94).



Figure 94: Measurement windows

The **swatch start/limit** adjustments, coupled with **manual/automatic** control are now shown, with the ruler on the left of the image. If the user selects SWATCH LIMIT MANUAL, both Swatch start and Swatch limit are visible (Figure 95)

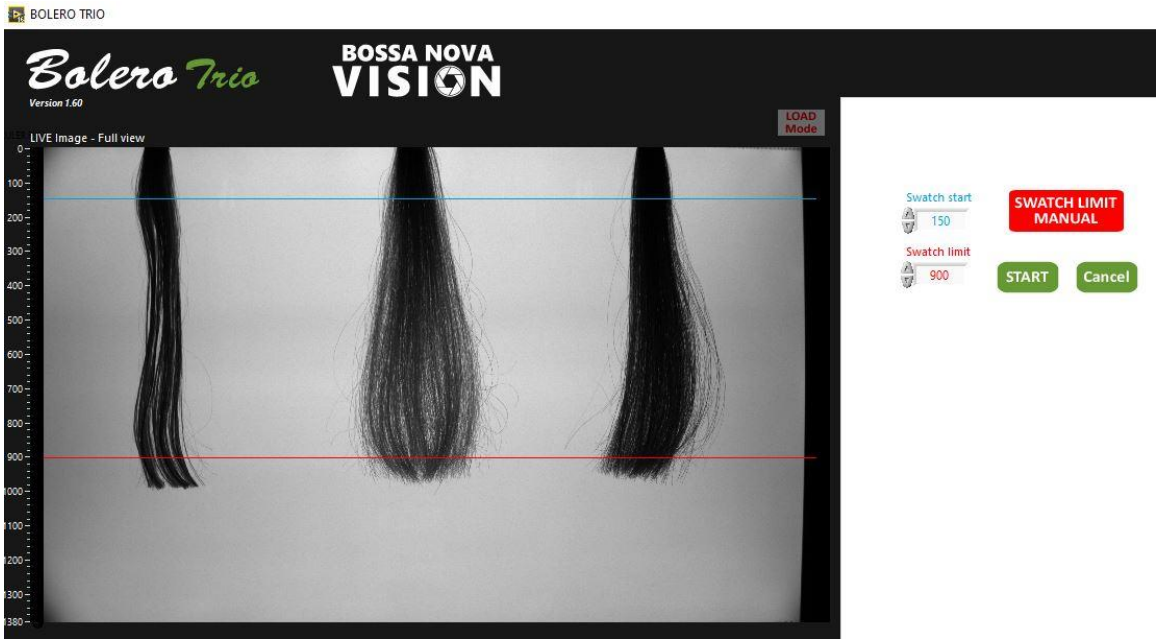


Figure 95: SWATCH LIMIT MANUAL

If the user switches to SWATCH LIMIT AUTOMATIC 

, the Swatch limit for each swatches will be determined by the software (Figure 96). This is very important when the length of the swatch(es) will be measured. The length of the swatches is Swatch limit minus Swatch start.



Figure 96: SWATCH LIMIT AUTOMATIC

Once the swatch limits and the angle of the image are adjusted, the user can click on the start control. A pop-up window will ask for the filename (Figure 97).



Figure 97: Pop-up window – Filename

After clicking on SAVE, the acquisition and processing take few seconds. The result page appears (Figure 98) in the data visualization page if only ONE swatch was selected (why use BOLERO TRIO for only one swatch?). If more than one swatch was selected, the data visualization window does not appear and the software is back on the main window.

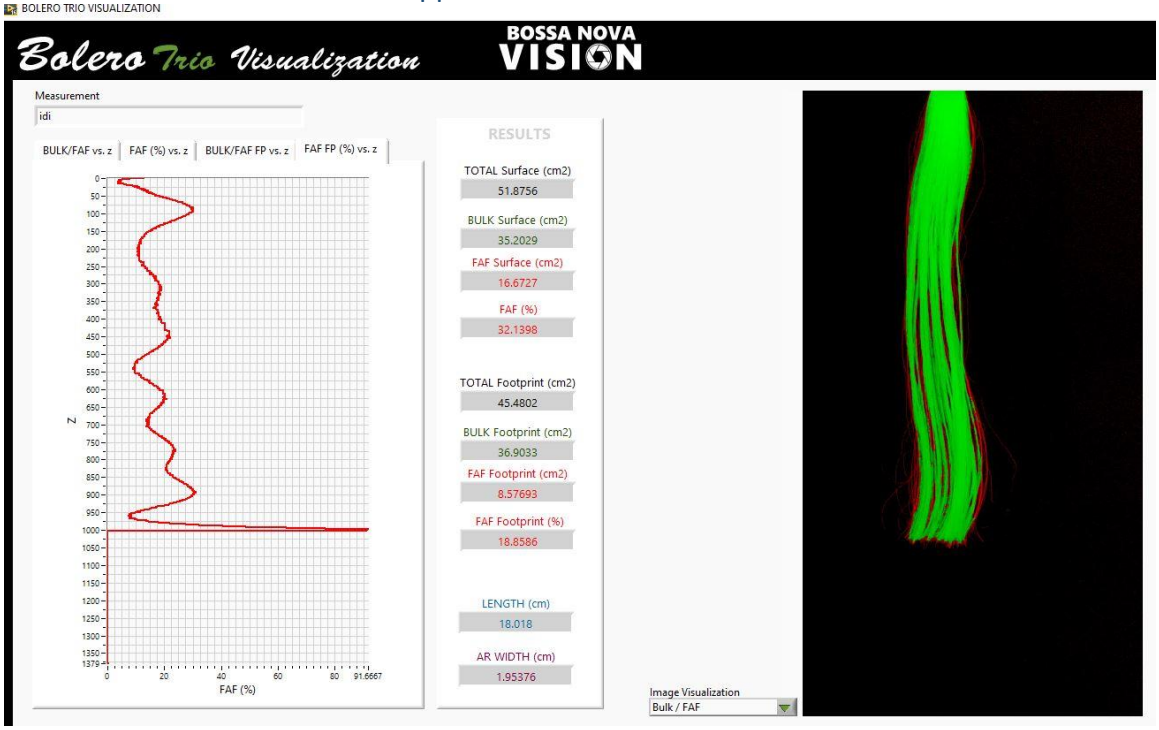


Figure 98: Data visualization page

This window is similar to the results window presented in **Error! Reference source not found.**.

Note that this measurement is automatically loaded in the data analysis loaded measurement. Clicking on **Back to Data management** control 

will go back to the **data management** page.

4.2. BOLERO WIDE ACQUISITION

It is similar to BOLERO TRIO with only one swatch measured at a time.

4.2.1. Processing OFF

Clicking on **Acquire new measurement Processing off** control 

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 99).

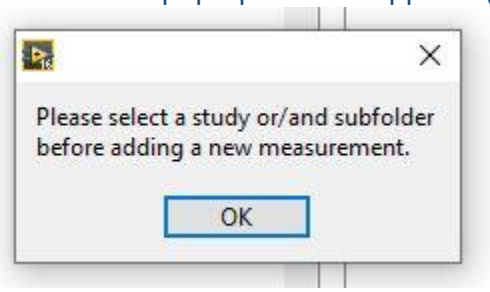


Figure 99: Pop-up window asking for a study/sub-folder selection before adding a new measurement

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 100).



Figure 100: New measurement – Processing off – Single image acquisition windows

Figure 101 shows the different controls.



Figure 101: **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 102).



Figure 102: Pop-up window BOLERO WIDE

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 (Figure 103).



Figure 103: Measurements saved

Because the measurements are not processed, they appear in green italic in the measurements list.

4.2.2. 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.

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 will open to adjust the time lapse parameters (Figure 104).

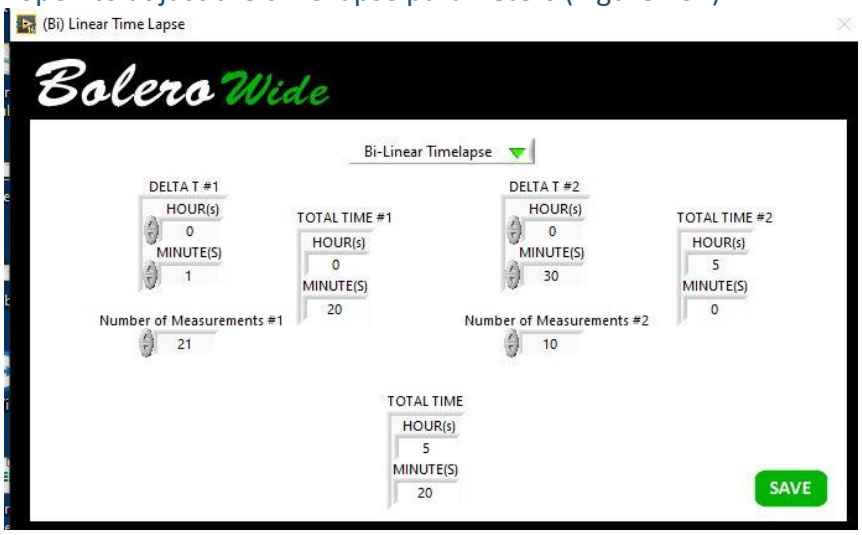


Figure 104: Time lapse parameters

It is similar to the pop-up window of BOLERO TRIO time lapse parameters. Please check 4.1.2 for more details. Click on save to save the parameters and go to the measurement window (Figure 105).



Figure 105: Time lapse measurement

To start the time lapse measurement, the user clicks on START and the usual pop-up windows appears (Figure 106).



Figure 106: 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. Between each image acquisition, the following indicators and control appear (Figure 107).



Figure 107: 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 92).

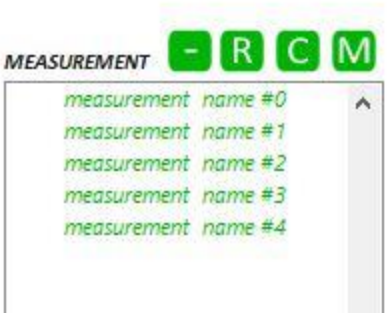


Figure 108: Main window after time lapse measurement

The time lapse measurements (#n) now need 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).

4.2.3. Processing ON

Clicking on **Acquire new measurement Processing on** control 

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 109).

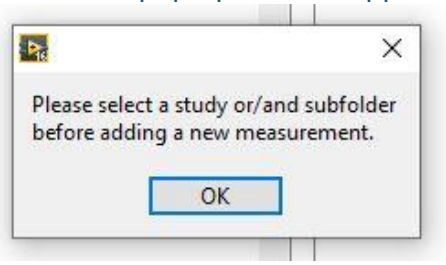


Figure 109: Pop-up window asking for a study/sub-folder selection before adding a new measurement

When the study/sub-folder selection is correct, a new measurement can be done and the measurement page appears once the **Acquire new measurement Processing off** control is clicked. The **swatch start/limit** adjustments, coupled with **manual/automatic** control are now shown, with the ruler on the left of the image. If the user selects SWATCH LIMIT MANUAL, both Swatch start and Swatch limit are visible (Figure 110)

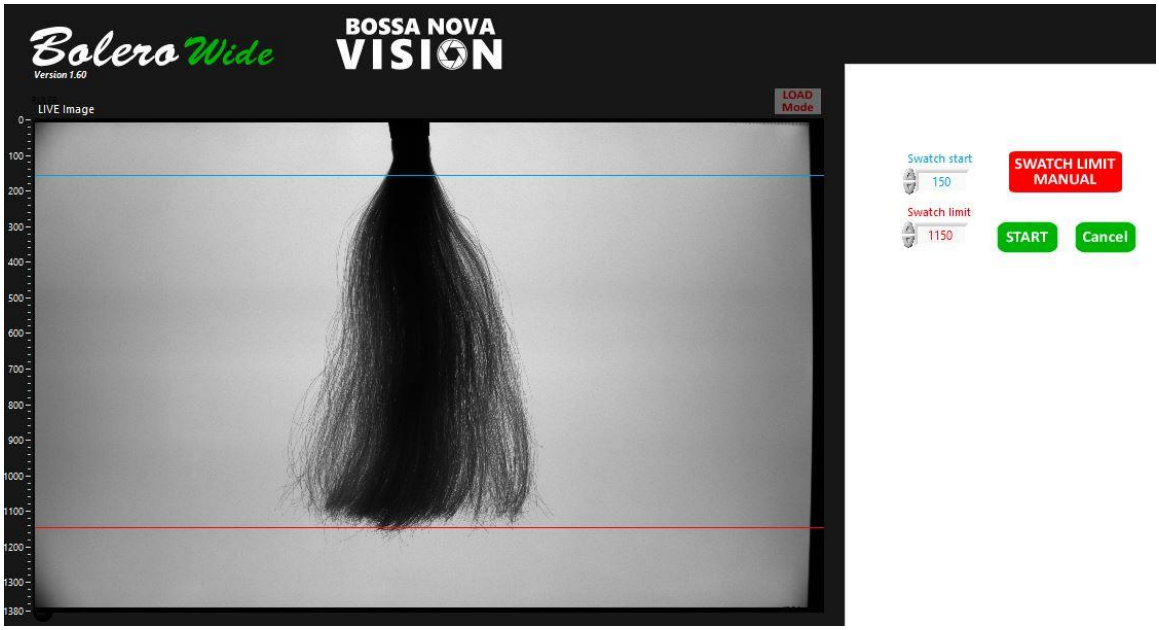


Figure 110: SWATCH LIMIT MANUAL

If the user switches to SWATCH LIMIT AUTOMATIC 

, the Swatch limit for each swatches will be determined by the software. This is very important when the length of the swatch(es) will be measured. The length of the swatches is Swatch limit minus Swatch start. Once the swatch limits and the angle of the image are adjusted, the user can click on the start control. A pop-up window will ask for the filename (Figure 111).



Figure 111: Pop-up window – Filename

After clicking on SAVE, the acquisition and processing take few seconds. The result page appears (Figure 112) in the data visualization page.

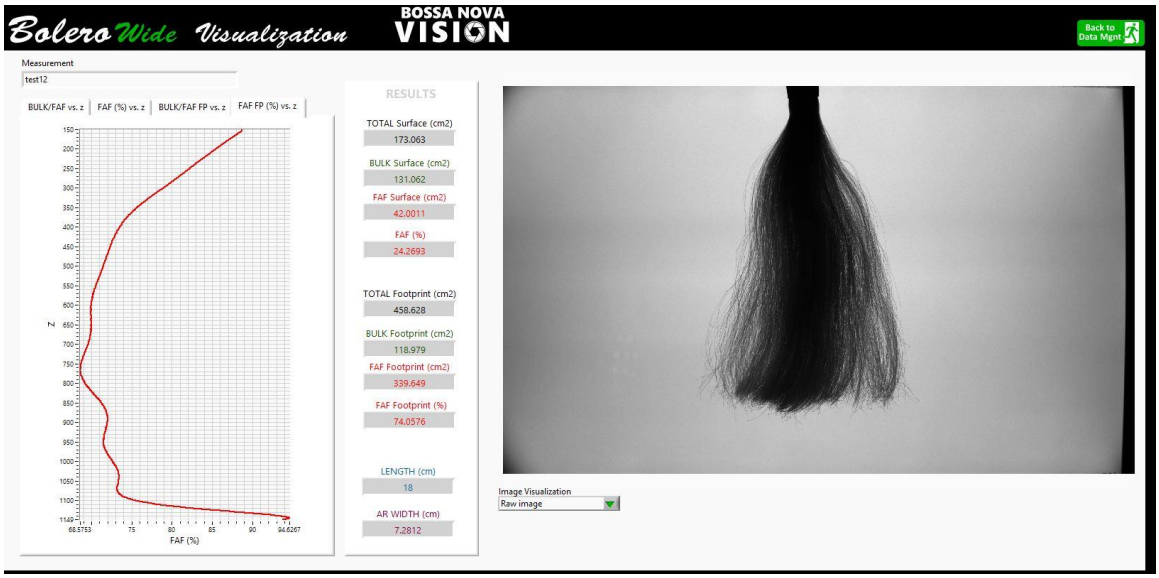


Figure 112: Data visualization window

This window is similar to the results window presented in **Error! Reference source not found.**.

Note that this measurement is automatically loaded in the data analysis loaded measurement. Clicking on **Back to Data management** control 

will go back to the **data management** page.

4.3. BOLERO 360 ACQUISITION

4.3.1. Processing OFF

Clicking on **Acquire new measurement Processing off** control 

will open the measurement page (Figure 113).



Figure 113: Measurement page

Figure 114 shows the different controls.



Figure 114: **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 115).

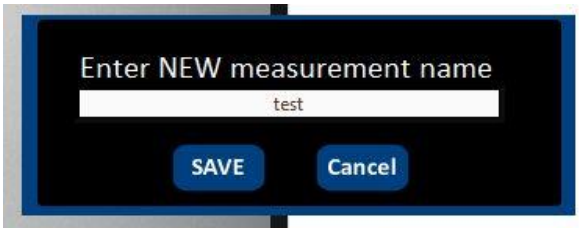


Figure 115: Pop-up window BOLERO 360

Once the different parameters are entered, the user click on save or cancel to cancel the measurement). The acquisition window appears (Figure 116).

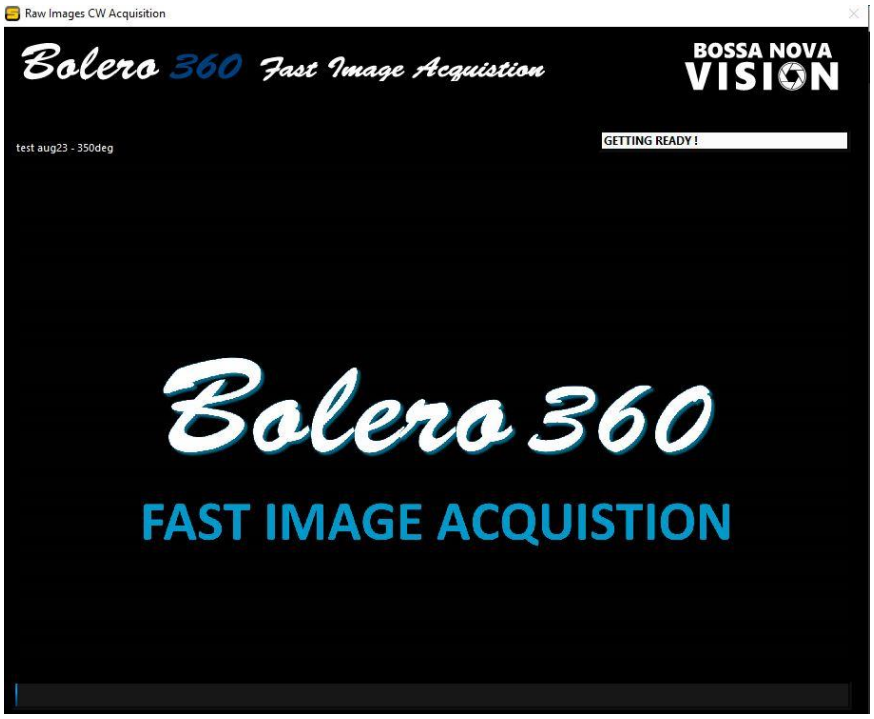


Figure 116: Measurement window

The measurement is fast. The swatch rotates continuously at 90 degrees per second and the camera acquires an image every 10 degrees. Because of the fast acquisition, the live images are not displayed when acquired but only when they are save (Figure 117).

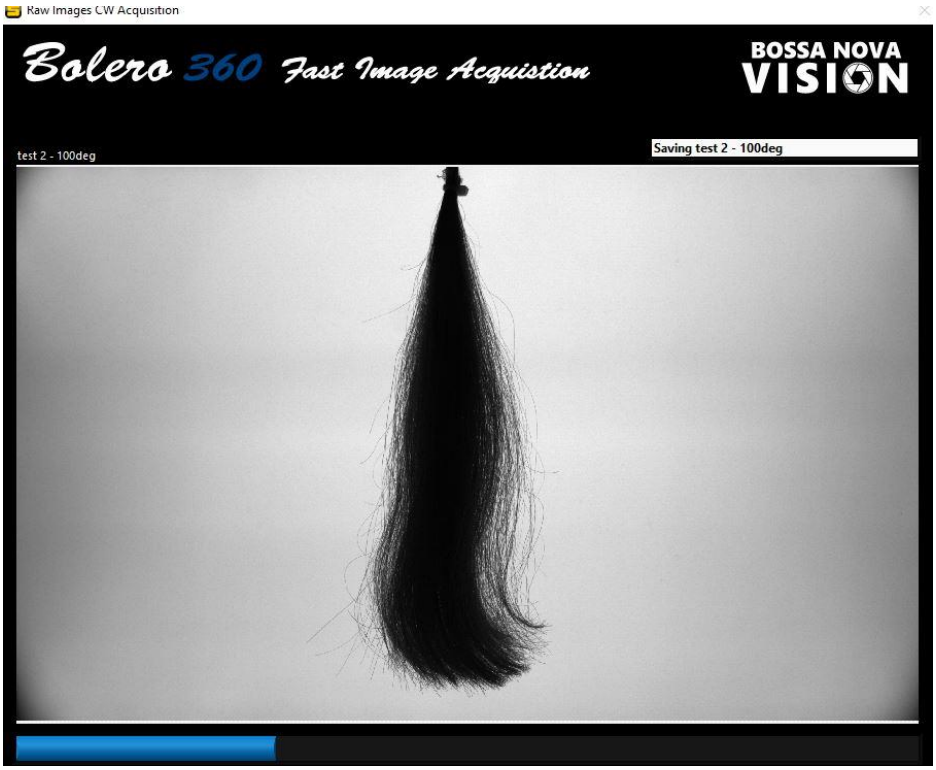


Figure 117: Images displayed when saved

Once the images are saved, the acquisition window closes and the software goes back to the data management window. Because the measurements are not processed, they appear in blue italic in the measurements list.

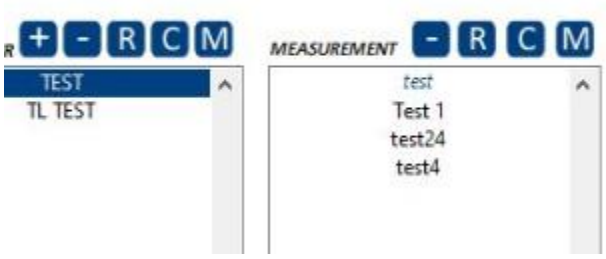


Figure 118: Measurements saved

4.3.2. 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.

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 

will open the time lapse parameters pop-up window (Figure 119).

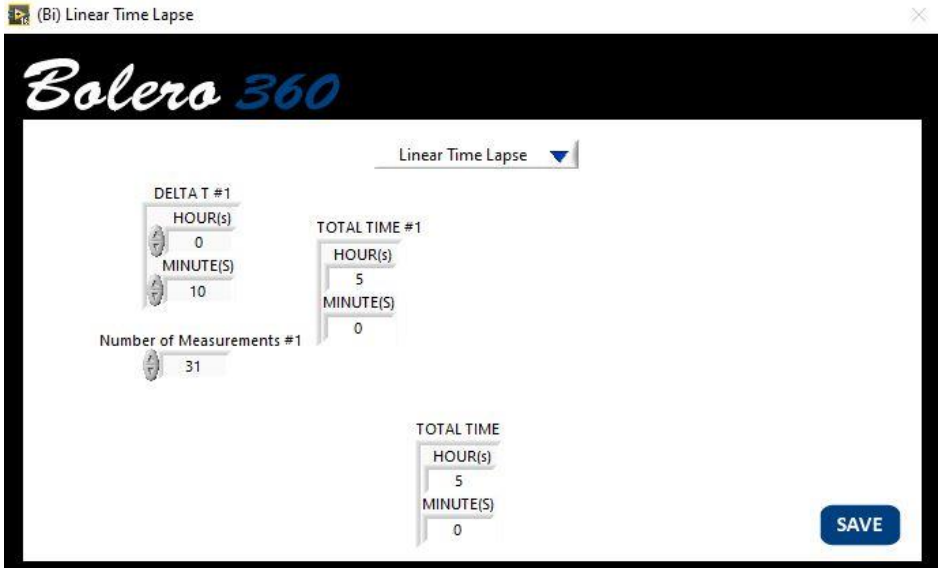


Figure 119: time lapse parameters

Click on save to save the parameters and open the measurement window (Figure 120).

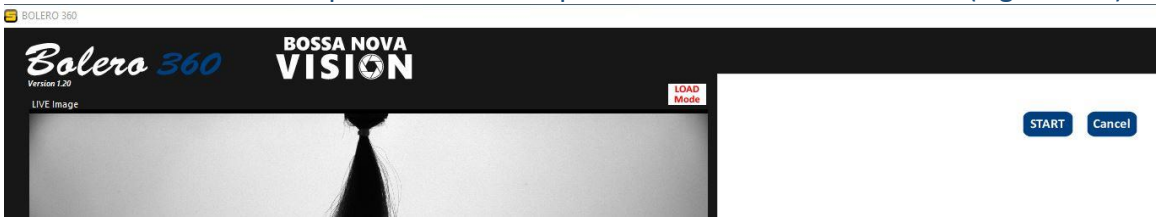


Figure 120: Time lapse measurement

To start the time lapse measurement, the user clicks on START and the usual pop-up windows appears (Figure 121).



Figure 121: 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.
For each acquisition, the image acquisition window opens and closes when done (Figure 122).



Figure 122: Time Lapse Acquisition

Between each image acquisition, the following indicators and control appear (Figure 123).



Figure 123: Abort control and Status/Remaining time indicators

If the user wants to abort the time lapse measurement, he clicks on the ABORT TIMELAPSE MEASUREMENT 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. The time lapse measurements (#n) now need 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).

4.3.3. Processing ON

Clicking on **Acquire new measurement Processing On** control ACQUIRE NEW MEASUREMENT PROCESSING ON will open the measurement page (Figure 124)

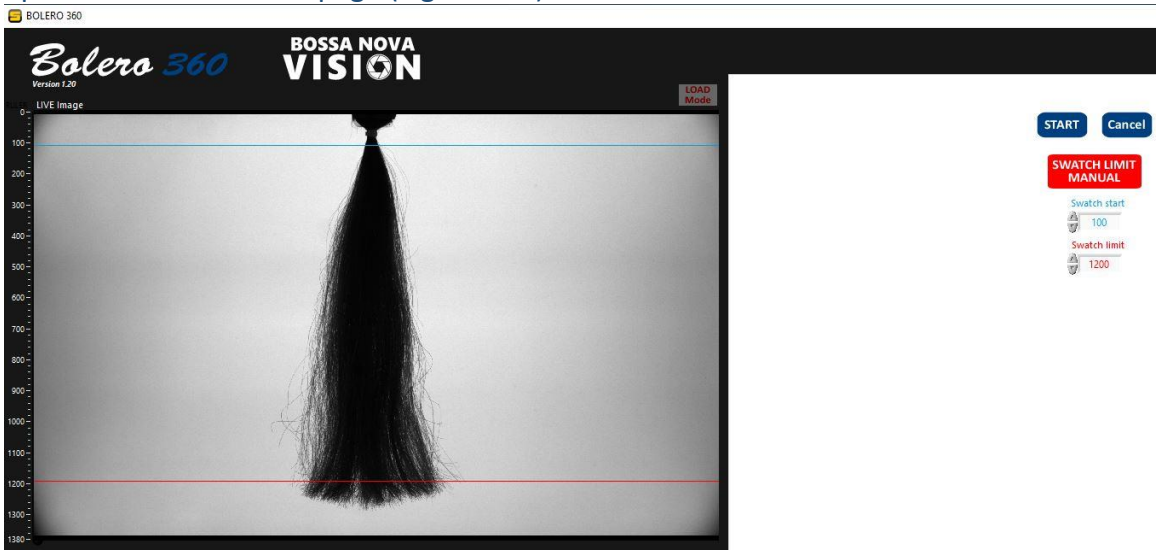


Figure 124: New measurement – Processing on

The user can switch between SWATCH LIMIT MANUAL SWATCH LIMIT MANUAL or SWATCH LIMIT AUTOMATIC SWATCH LIMIT AUTOMATIC (Figure 125).



Figure 125: Swatch limit adjustment

When Swatch limit is adjusted to automatic, the software will automatically find the swatch limit which helps to measure the swatch length.
Once the user clicks on start, the data acquisition window appears, similar to the other acquisition mode. Once the acquisition is done, the window closes and the processing window opens (Figure 126).

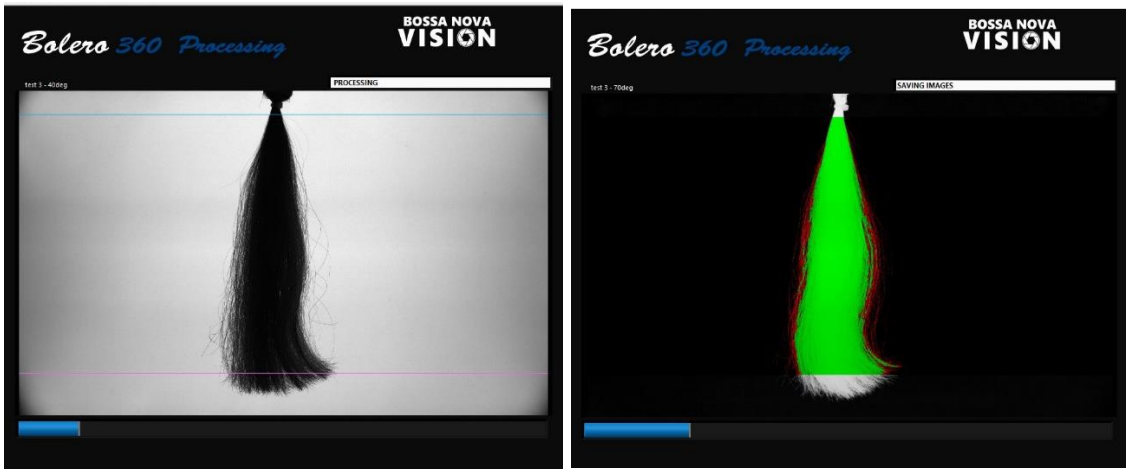


Figure 126: Processing window

Once the processing is done, the processing windows closes and the data visualization window opens (Figure 127).

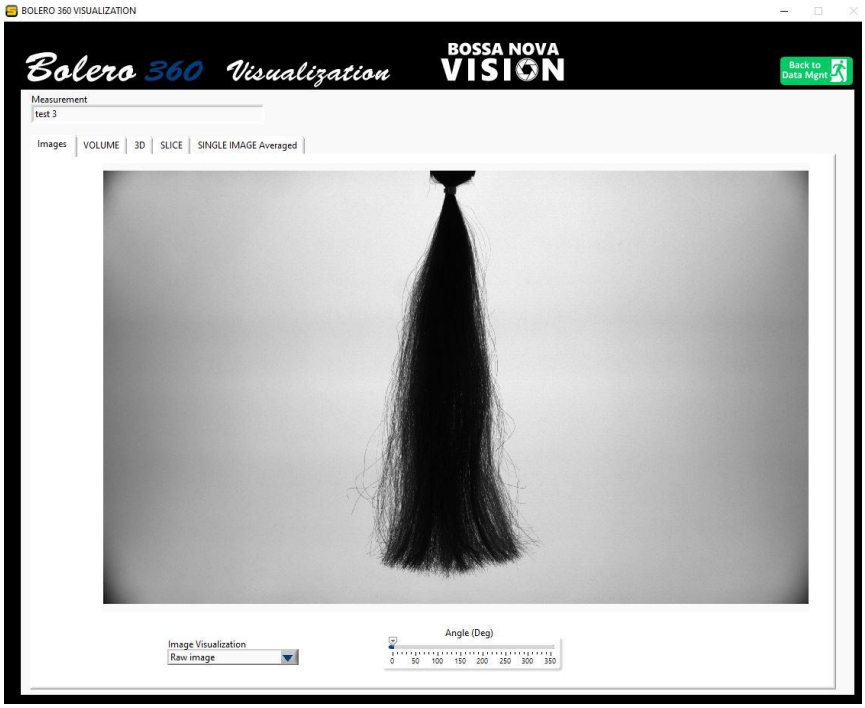


Figure 127: Data visualization

The Data visualization window is detailed in 6.2.

4.4. HOP ACQUISITION

HOP acquisition is very similar to BOLERO 360 and BOLERO Wide acquisition.

4.4.1. Processing OFF

Clicking on **Acquire new measurement Processing off** control 

will open the measurement page (Figure 128).

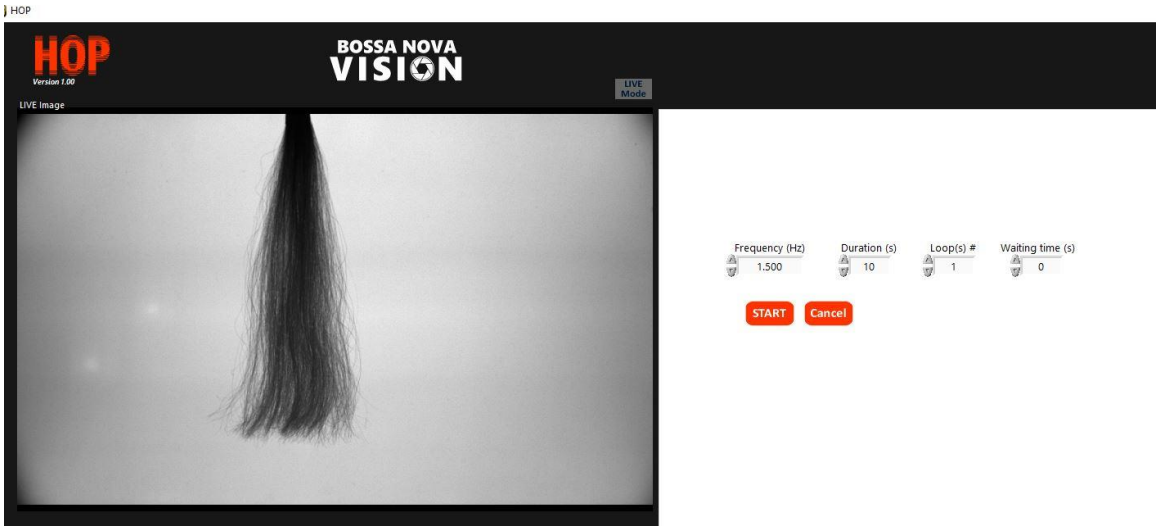


Figure 128: Measurement page

Figure 129 shows the different controls.

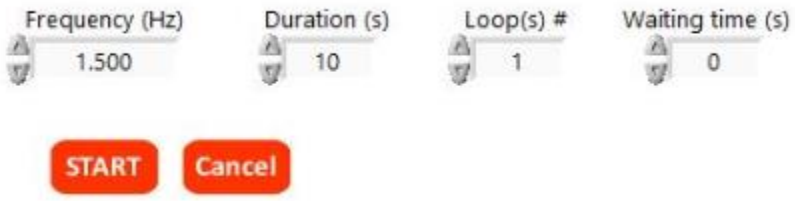


Figure 129: **HOP** controls

The user can adjust the Frequency of the shaker, between 1.0 Hz and 2.5 Hz, the duration of the shaking process, up to 30 seconds, the number of loops for the shaking process to reach a longer shaking duration (Duration(s) x Loop(s) #) and a waiting time when the shacking process stops.
The total time between before and after measurement will be:

TOTAL TIME(s) = Duration (s) x Loops (#) + Waiting time (s) + 5 s.

There is a mandatory 5 seconds waiting time at the end of the shaking process for the swatch to stop moving.
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 130).



Figure 130: Pop-up window HOP

Once the different parameters are entered, the user click on save or cancel to cancel the measurement). The acquisition window appears (Figure 131).

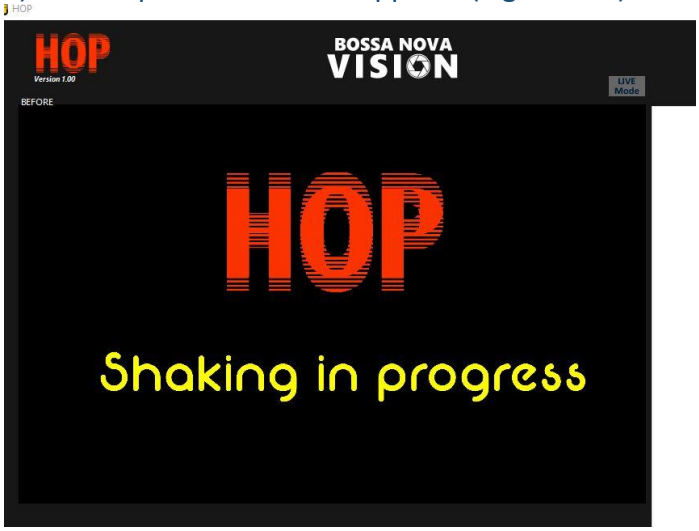


Figure 131: Measurement window

Once the images are saved, the acquisition window closes and the software goes back to the data management window. Because the measurements are not processed, they appear in orange italic in the measurements list.



Figure 132: Measurement saved

4.4.2. 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.
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 

will open the time lapse parameters adjustment pop-up window (Figure 133).

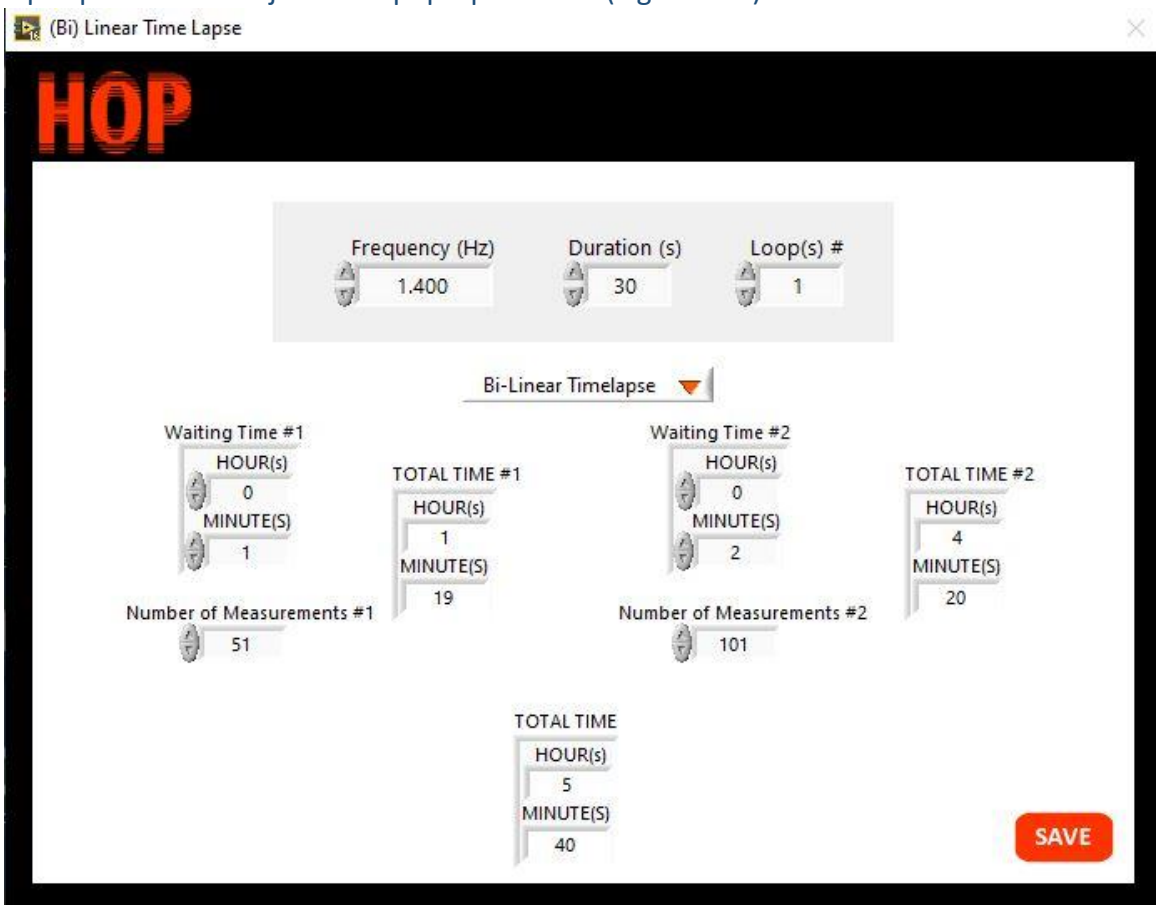


Figure 133: Time lapse measurement

Contrary to BOLERO TRIO, WIDE and 360, the user adjusts the waiting time i.e. the time after the motion of the swatch and its 5 seconds delay. For a linear time lapse, it is given on Figure 134

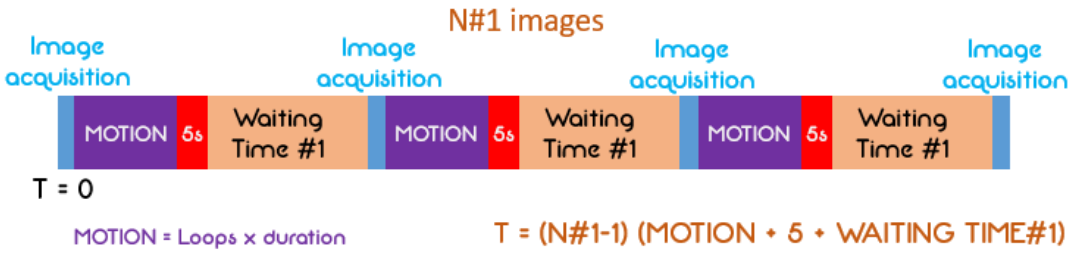


Figure 134: Linear time lapse

Figure 135 shows the time line for a bilinear time lapse.



Figure 135: Bi-linear time lapse

Click on save will save the parameters and open the measurement window. To start the time lapse measurement, the user clicks on START and the usual pop-up windows appears (Figure 121).



Figure 136: 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.
Between each image acquisition, the following indicators and control appear (Figure 137).



Figure 137: 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. The time lapse measurements (#n) now need 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).

4.4.3. Processing ON

Clicking on **Acquire new measurement Processing On** control 

will open the measurement page (Figure 138).

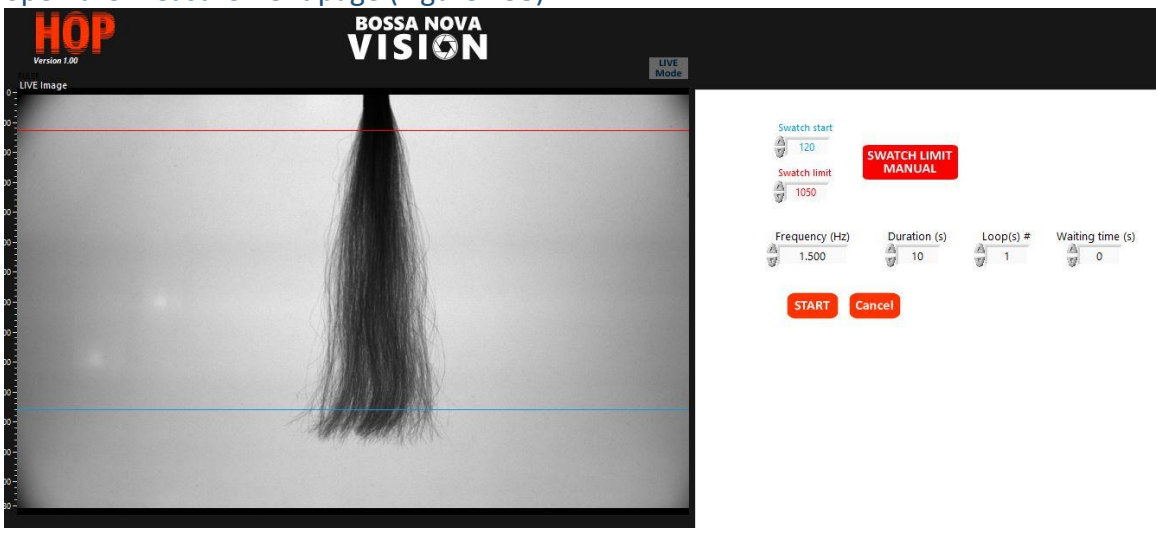


Figure 138: New measurement – Processing on

The user can switch between SWATCH LIMIT MANUAL 

or SWATCH LIMIT AUTOMATIC 

(Figure 139).



Figure 139: Swatch limit adjustment

When Swatch limit is adjusted to automatic, the software will automatically find the swatch limit which helps to measure the swatch length.
Once the user clicks on start, the data acquisition window appears, similar to the other acquisition mode. Once the acquisition is done, the processing window starts. Once the processing is done, the data visualization window opens (Figure 140).

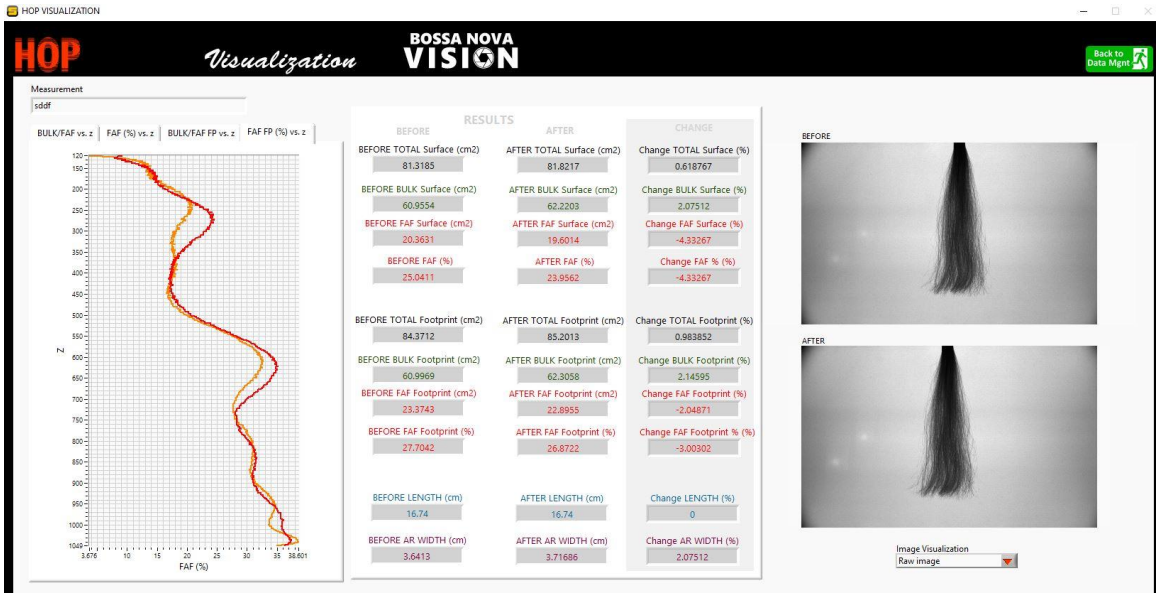


Figure 140: Data visualization

The Data visualization window is detailed in 6.2.

4.5. HULA ACQUISITION

2 types of video acquisition are possible (Figure 141).



Figure 141: Video(s) acquisition

The first control, Acquire new video 

allows the user to acquire one video at a defined frequency. The second control, Acquire Frequency Sweep new videos 

allows the user to automatically acquire new videos at different frequencies.

The length of the video is 15 seconds, at a rate of 35 frames per second, for a total of 525 frames. The shaker operates for 11 seconds (385 frames), allowing 4 seconds (140 frames) at the end of the video to analyze the damping of the swatch. During the continuous motion of the swatch, from 3 seconds to 12 seconds, the software will automatically extract the stationary loop corresponding to only one oscillation of the swatch. Figure 142 below shows the vertical angle of the hair swatch along the frame acquired (Obtained when the full video is processed) with the 3 “zones” of the motion, Start, stationary motion and damping. The frequency range of the shaker is 1.0 Hz to 2.5 Hz.

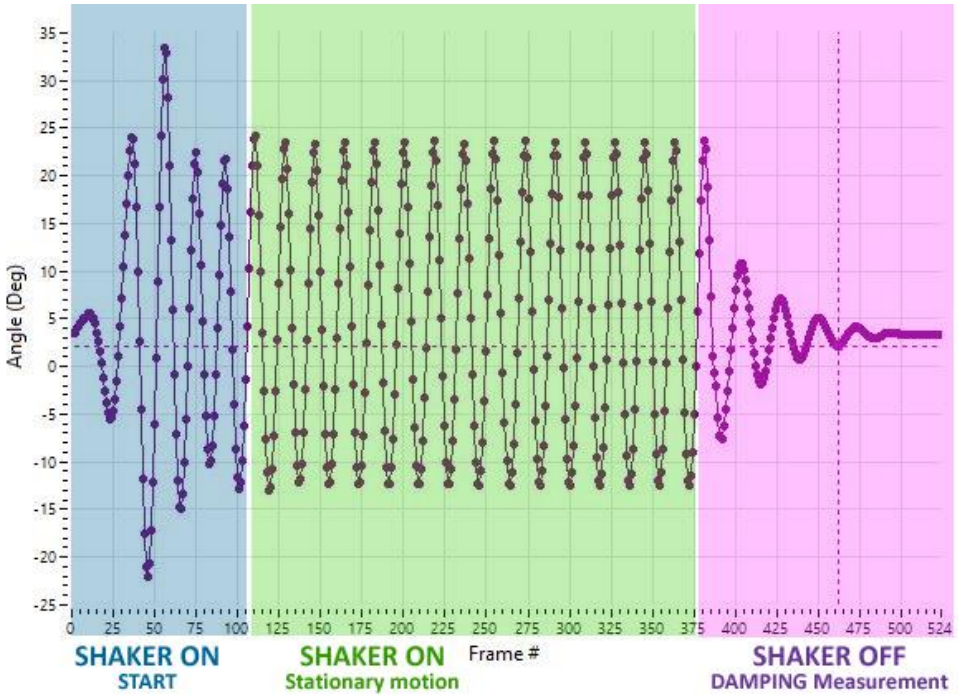


Figure 142: Full angle motion

4.5.1. New VIDEO

Once the user clicks on Acquire new video control, the acquisition window appears (Figure 143).

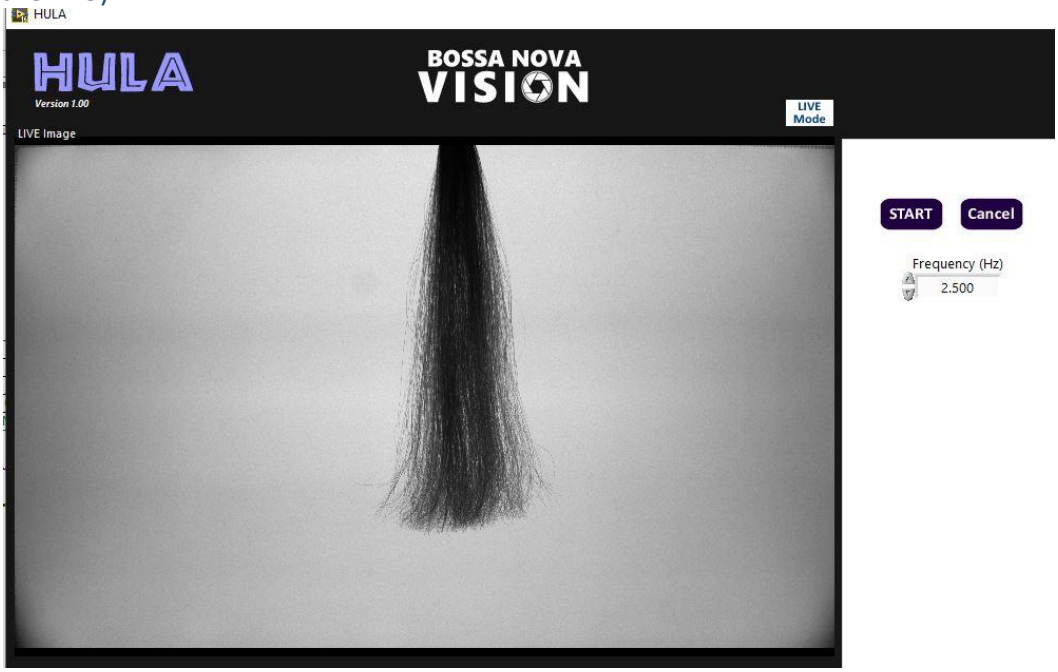


Figure 143: Acquisition new video

The user can select the frequency of the motion (from 1.0 Hz to 2.5 Hz). Once it is done, the user clicks on start and the measurement name pop-up message appears (Figure 144).



Figure 144: Pop-up message measurement name

If the user clicks on cancel, the software goes back to the main window. Once the user clicks on save, the video acquisition starts (Figure 145).

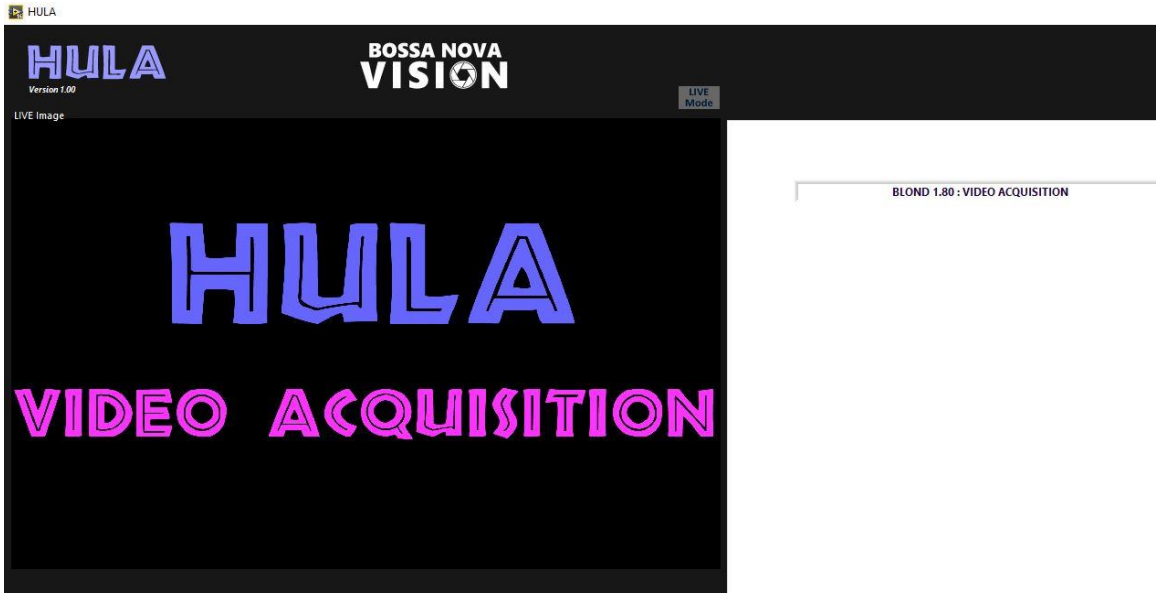


Figure 145: Video acquisition

The live image is not shown (and replaced by a HULA Video Acquisition image) as the computer needs all the resources possible to record the video on the SSD drive. Once the video is recorded, the video is cut and compressed (Figure 146).

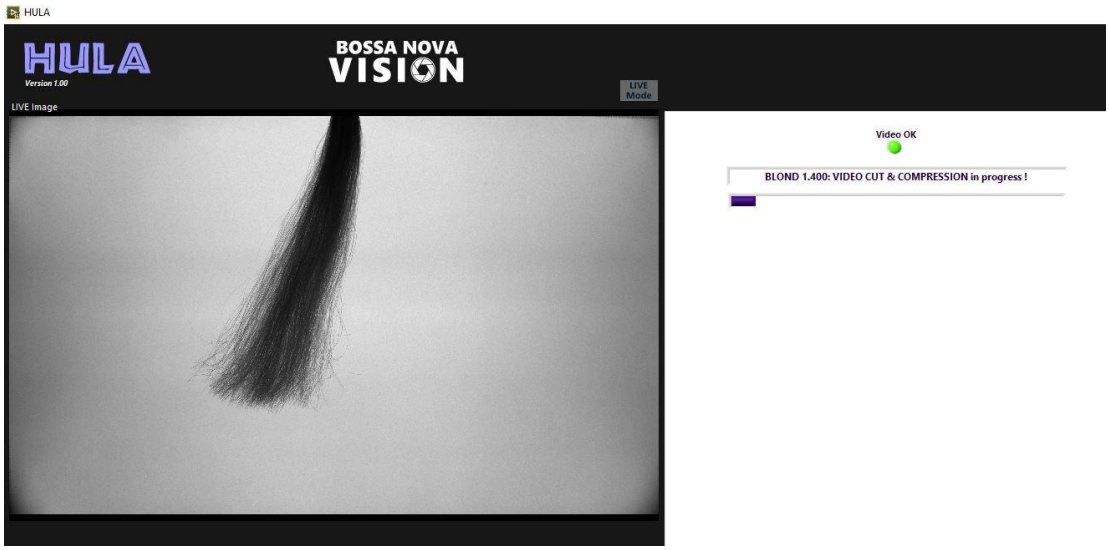


Figure 146: Video cut/compression

Once the video is cut, compressed and saved, the Stationary Loop extraction appears (Figure 147).

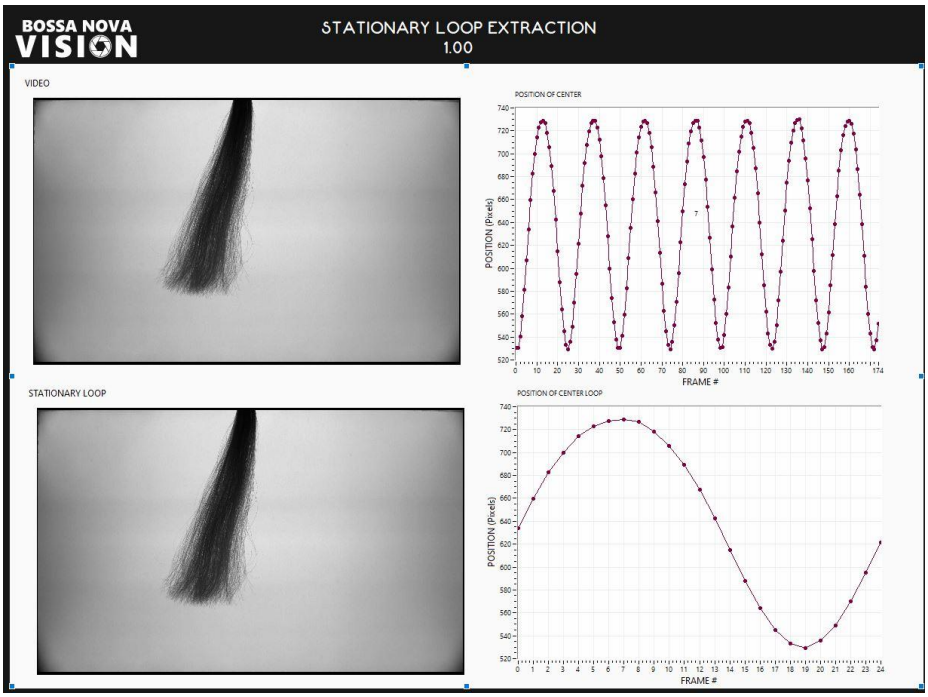


Figure 147: Stationary Loop extraction

Once the stationary loop is extracted, the software goes back to the main window. Because the new video is not processed, the measurement appears in (Figure 148).



Figure 148: New measurement acquired

- When the measurement has not been processed (Full video or Stationary Loop), it appears in RED Italic like *BLOND 1.40*.
- When the measurement is fully processed (Full video AND Stationary loop), it appears in black normal like BLOND 1.40.
- When only the full video has been processed, it appears in blue italic like *BLOND 1.40*.
- When only the stationary loop video has been processed, it appears in purple italic like *BLOND 1.40*.

4.5.2. Frequency sweep new VIDEOS

Similar to the new video acquisition, the user can automatically acquire many videos of the same swatch at different frequencies. When the user clicks on the Acquire Frequency sweep new Videos control 

, the following pop-up window appears (Figure 149).

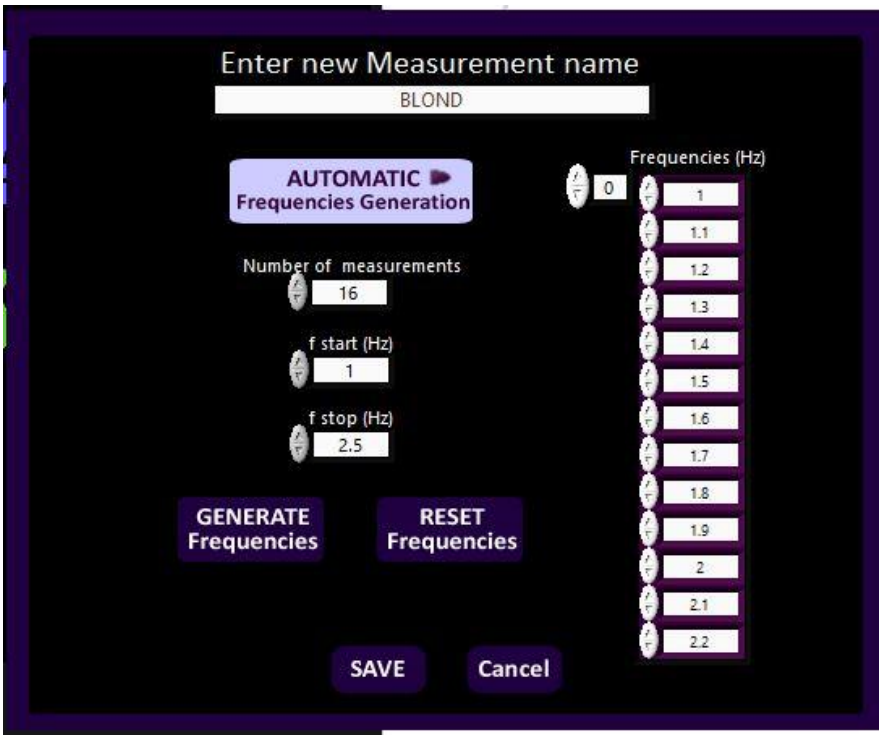


Figure 149: Acquire Frequency sweep new Videos

At the top of the window is the measurement name. The software will automatically add the frequency to the name when the measurement is saved. For example, if the user select 3 frequencies 1 Hz, 1.5 Hz and 2 Hz, the measurement name will be name_1Hz, name_1.5Hz and name_2Hz in the measurement list. The user can generate the frequencies automatically choosing the number of measurements, the frequency start and the frequency stop, and the frequencies list on the right of the window will be automatically populated. If not, the user can click on generate frequencies control 

to populate the list. The reset frequencies control 

will reset the list. The frequencies generated by this technique are equidistant from each other. If the user does not want a linear sweep of frequencies and prefer to enter frequencies manually, it clicks on the control (Figure 150)

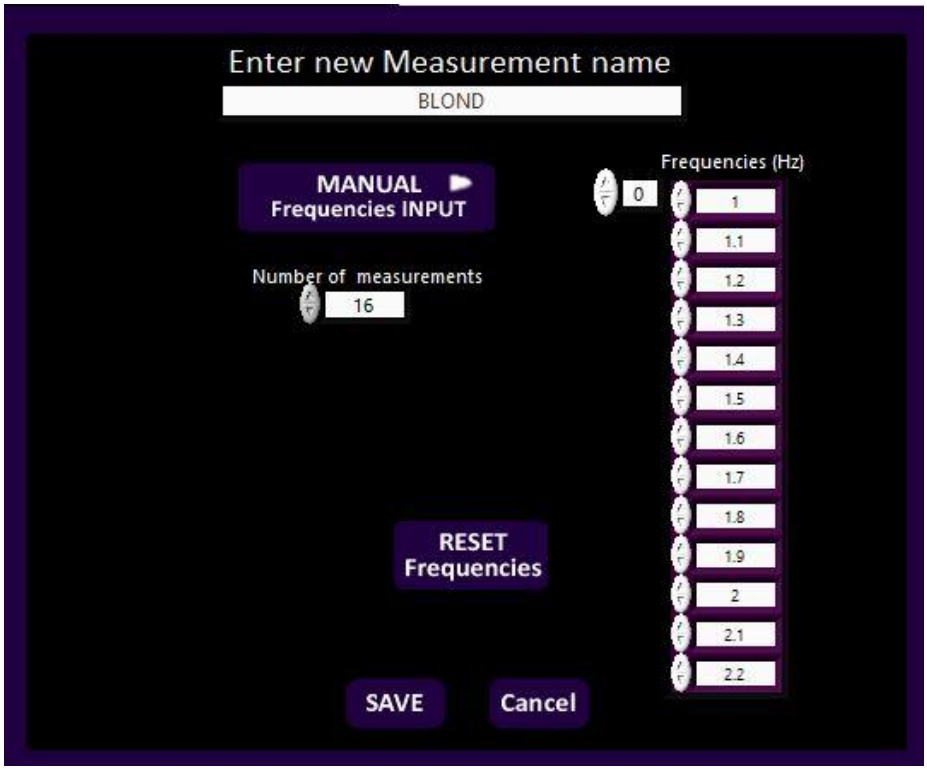


Figure 150: Manual Frequencies input

The best is to reset the frequencies list first and then enter manually the frequencies (Figure 151).

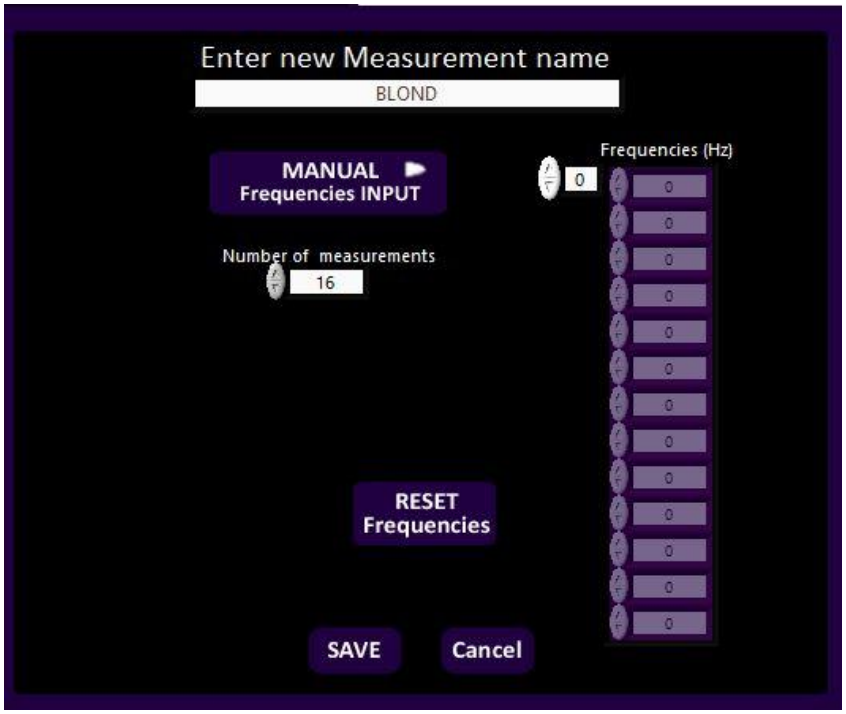


Figure 151: Reset Frequencies

Once it is done, the user clicks on save and the acquisition starts. A similar window appears with a progression bar. Once the measurement are acquired, the software goes back to the main window (Figure 152)



Figure 152: Back to the main window

4.6. RUMBA ACQUISITION

RUMBA acquisition is very similar to BOLERO 360 acquisition as one measurement consists of the acquisition of multiple images. Instead of changing the swatch orientation between each image acquisition like BOLERO 360, it is the orientation of both polarizers that is changed between each image acquisition.

4.6.1. Processing OFF

Clicking on **Acquire new measurement Processing off** control 

will switch to the measurement window (Figure 153).



Figure 153: RUMBA ACQUISITION

The user can cancel the measurement and go back to the main window. Clicking on Start will the following pop-up window asking for the measurement name (Figure 154).



Figure 154: Pop-up window – Measurement name

Once the user clicks on SAVE, the acquisition window pops-up (Figure 155).

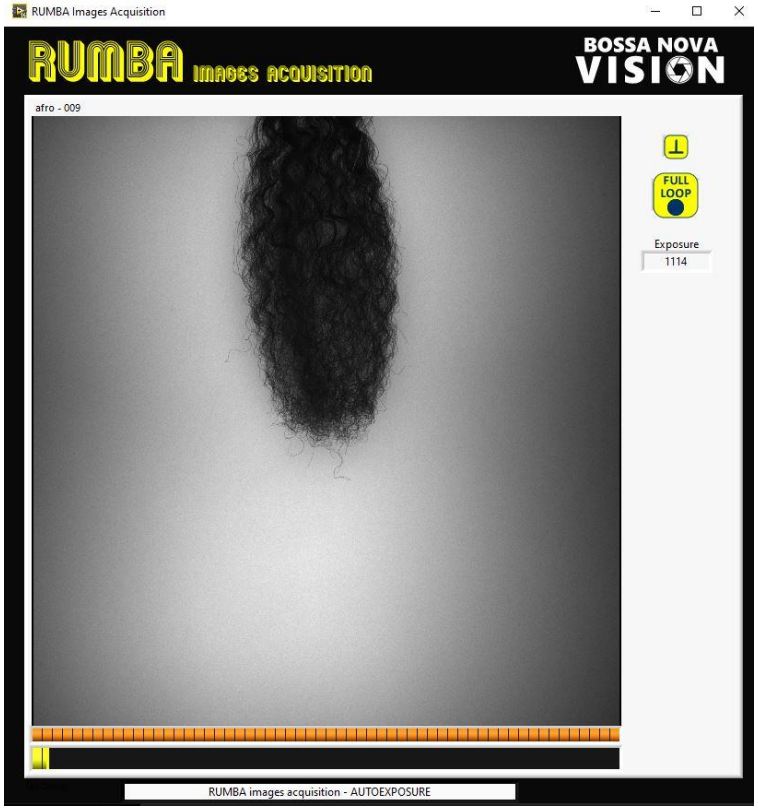


Figure 155: Acquisition Window

First step is to move the polarizers to the start. Once it is done, the LED back panel is on for the acquisition of the mask (similar to BOLERO). Once the mask is acquired, the LED back panel switches to OFF and the RED LED are switched ON for the RUMBA images acquisition. A progress bar shows the progress of the acquisition. Once all the images are acquired, they are re-calculated with the same exposition value and saved for processing. The software goes back to the main page. The user can see the new measurement in the measurement list. Because it is not processed yet, it appears in blue italic i.e. afro2 (Figure 156) compared to the one processed (afro).



Figure 156: New unprocessed measurement

4.6.2. 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.

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 

will open a pop-up window (Figure 157).

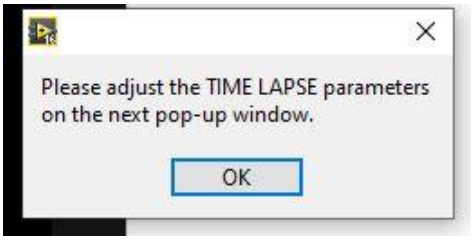


Figure 157: Time lapse pop-up window

Clicking on ok opens the time lapse parameters window, similar to the ones presented previously (Figure 158).

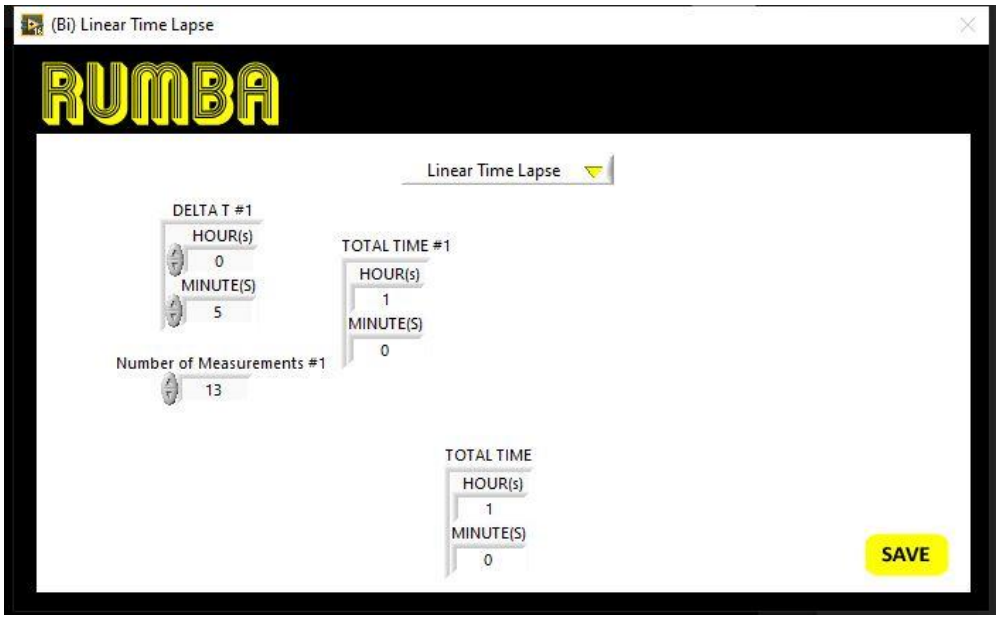


Figure 158: Time lapse parameters window

The user can adjust the time lapse to be linear or bi-linear, with an adjustment of the lapse parameters (hours & minutes) between each acquisition. Once the parameters are adjusted the user clicks on SAVE and the software goes back to the measurement main window (Figure 159).



Figure 159: Time lapse measurement main window

The user can START or Cancel the time lapse measurement. An indication of the estimated completion time and date, and remaining time is shown. If the user clicks on START, a pop up window asking for the name of the measurement appears (Figure 160).



Figure 160: Time lapse measurement name

The user can still cancel the process or click on SAVE, This will start the time lapse measurement. In the time lapse measurement, the file names will be automatically generated with the following structure filename#n, n being the measurement number. Between each images acquisition, the following indicators and control appear (Figure 161).



Figure 161: Between measurement

When the progression bar reaches the end, it is time for a new images acquisition and the images acquisition window appears. 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 images acquisition will be done.
When the time lapse measurement is done, the software returns to the main window. The time lapse measurements (#n) now need 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).

4.6.3. Processing ON

Clicking on **Acquire new measurement Processing ON** control 

will switch to the measurement window (Figure 162).

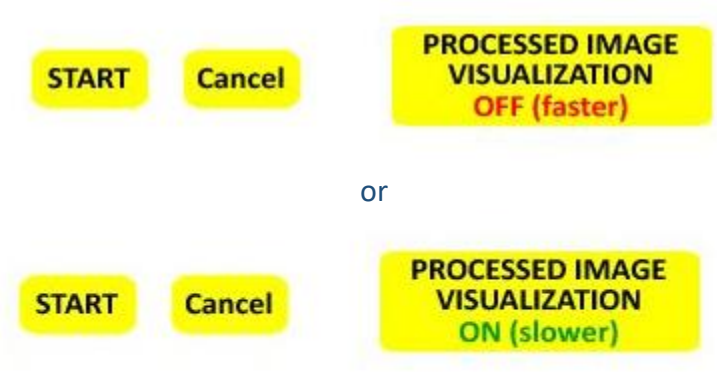
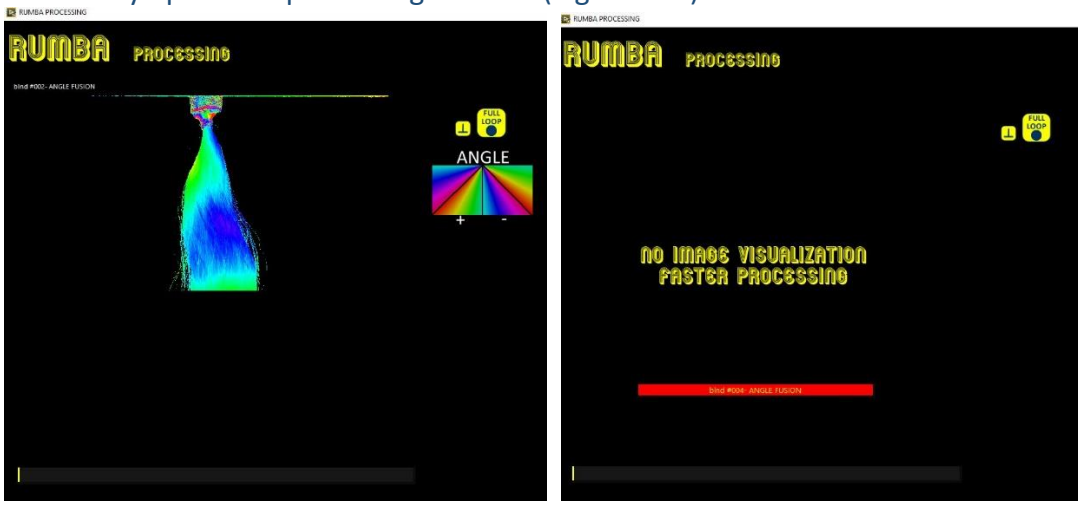


Figure 162: Measurement window – Processing ON

The acquisition of the images will be followed by the automatic processing. Two options are possible for the processing, allowing the visualization or not of the processed images. Visualization of the processed images leads to a longer processing time. Once the user clicks on START, the same steps as on **Acquire new measurement Processing off** happen. Once the acquisition is finished, the software closes the acquisition window and automatically opens the processing window (Figure 163).



(a) Visu ON (b) no visu

Figure 163: Processing window

Once the processing is done, the software goes back to the visualization window where the user can visualize processed images and data. When back to the main window, the processed measurement appears in black normal font (Figure 164).



Figure 164: Processed measurement

5. (RE)PROCESS

5.1. BOLERO TRIO/ BOLERO WIDE (RE)PROCESS

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 165 shows the pop-up window in case no measurement to be reprocessed has been selected.

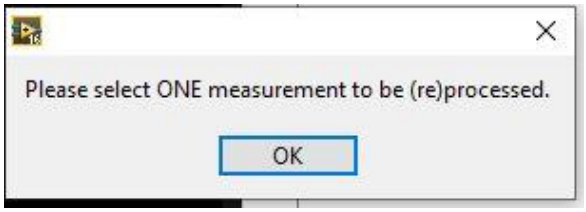


Figure 165: No measurement selected pop-up window

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 166).

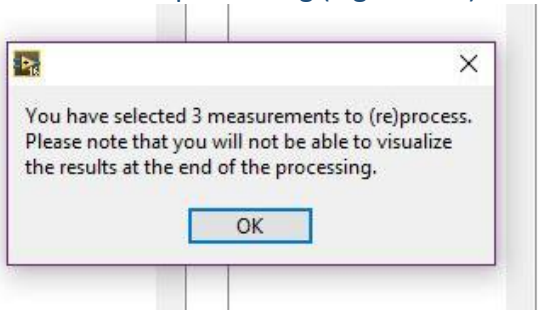


Figure 166: Warning pop-up window

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 167).

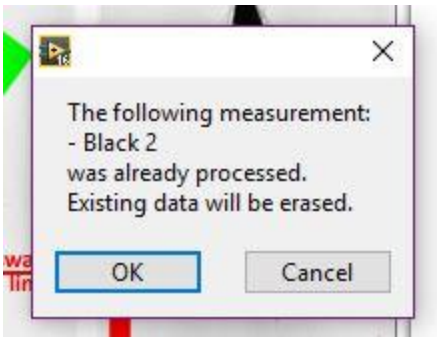


Figure 167: Processed measurement pop-up message

The following steps are similar to the Acquire new measurement – Processing On steps. Please note that when there are more than one measurement to be processed or reprocessed, the values for the swatch start and the swatch limit will be the same for each measurements if manually selected. To change the values for each measurement, please process data one at a time. If only one measurement was selected, the usual results window appears (Figure 168).

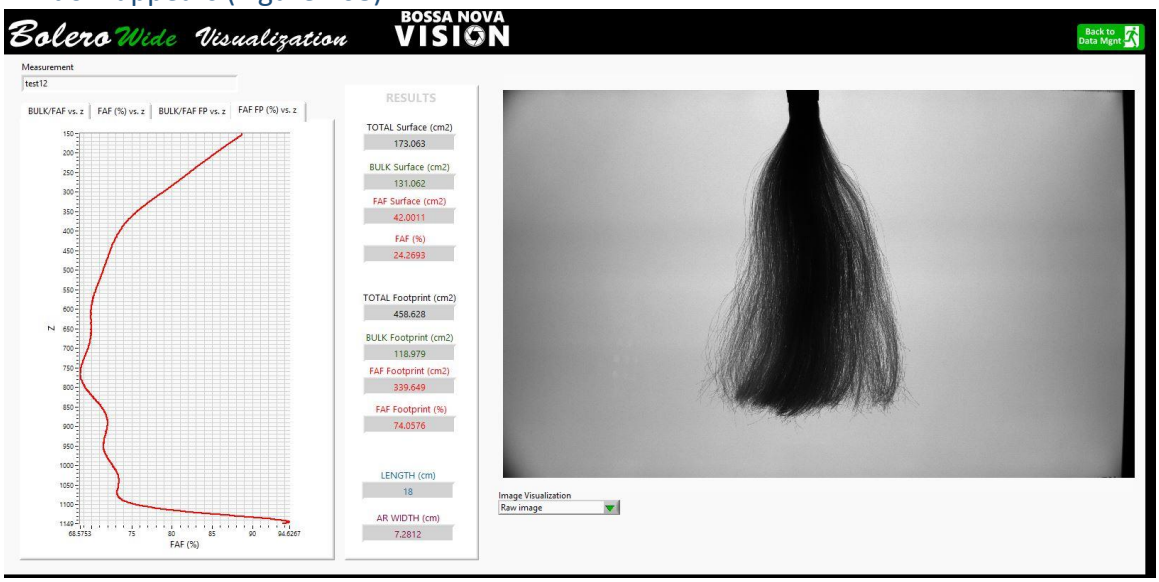


Figure 168: results window

5.2. BOLERO 360 (RE)PROCESS

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 new images as it reprocesses existing images (raw images). You can refer to the **Add new measurement – Processing** On for more detailed info. Please note that when there are more than one measurement to be processed or reprocessed, the values for the swatch start and the swatch limit will be the

same for each measurements if manually selected. To change the values for each measurement, please process data one at a time. If only one measurement was selected, the usual results window appears.

5.3. HOP (RE)PROCESS

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 new images as it reprocesses existing images (raw images). You can refer to the **Add new measurement – Processing** On for more detailed info. Please note that when there are more than one measurement to be processed or reprocessed, the values for the swatch start and the swatch limit will be the same for each measurements if manually selected. To change the values for each measurement, please process data one at a time. If only one measurement was selected, the usual results window appears.

5.4. HULA (RE)PROCESS

There are 2 (re)process controls (Figure 169).



Figure 169: HULA (Re)process controls

The first one, (Re)process stationary loop videos 

allows the user to only process the stationary loop video.

The second one, (Re)process full videos 

allows the user to only process the full video.

The processing consists of:

- Analyzing the BULK and FAF components on each frame of the videos, as done for BOLERO TRIO, WIDE and 360.

- Measuring the vertical angle of the swatch for each frame
- Measuring the damping coefficient (for the full video processing) when the shaker stops

5.4.1. (RE)PROCESS Stationary Loop Video

When the user clicks on (Re)process stationary loop videos 

, the pop-up message appears (Figure 170).

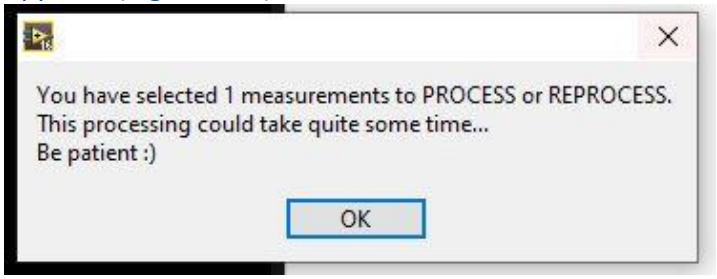


Figure 170: Re)process stationary loop videos pop-up message

After clicking on ok, the stationary loop video processing window appears and the processing starts (Figure 171).

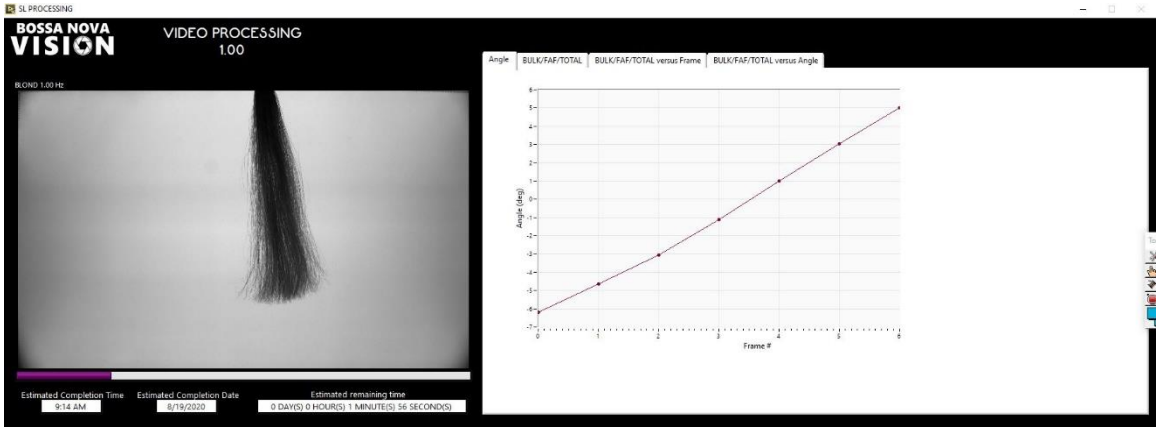


Figure 171: Stationary loop video processing window

On the left of the window is the image of the frame processed. Below the image is a progression bar with estimated completion time, date and remaining time (Figure 172).



Figure 172: Progression bar with estimated completion time, date and remaining time

On the right of the windows is a tab allowing the user to visualize various graphs and data during the processing (Figure 173).

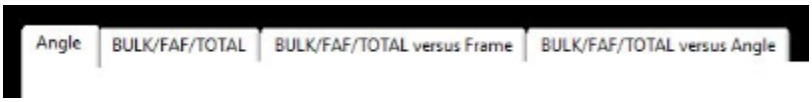


Figure 173: Stationary Loop – Tab

The first tab, Angle, shows the vertical angle of the swatch versus the frame # (Figure 174).

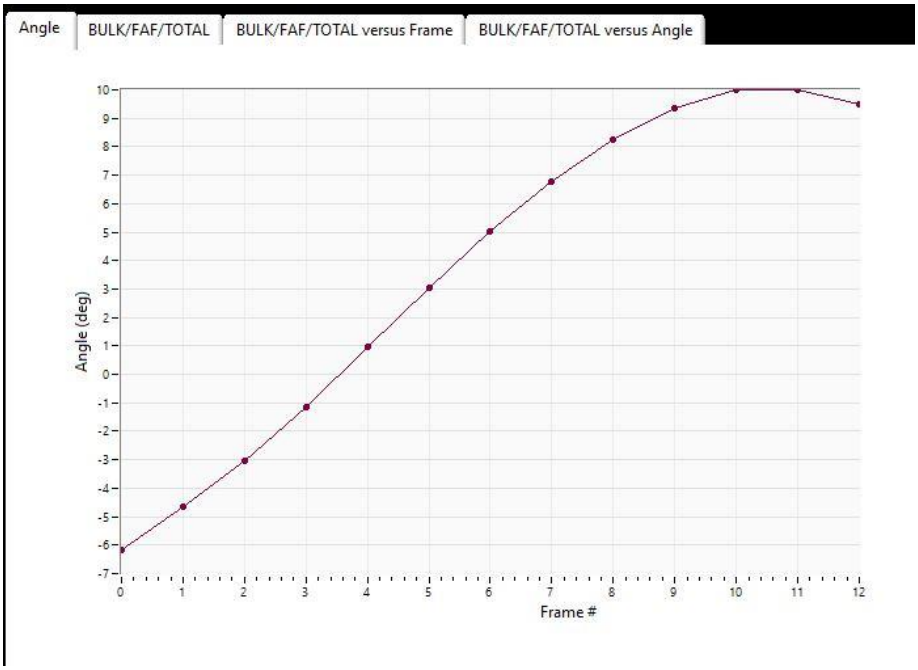


Figure 174: Angle versus frame #

The second tab, Bulk/Faf/total shows the profile of the BULK/FAF/TOTAL versus z for each frame #. This graph update during the processing (Figure 175). A calculation of the TOTAL, BULK and FAF surface is shown on the right of the graph.

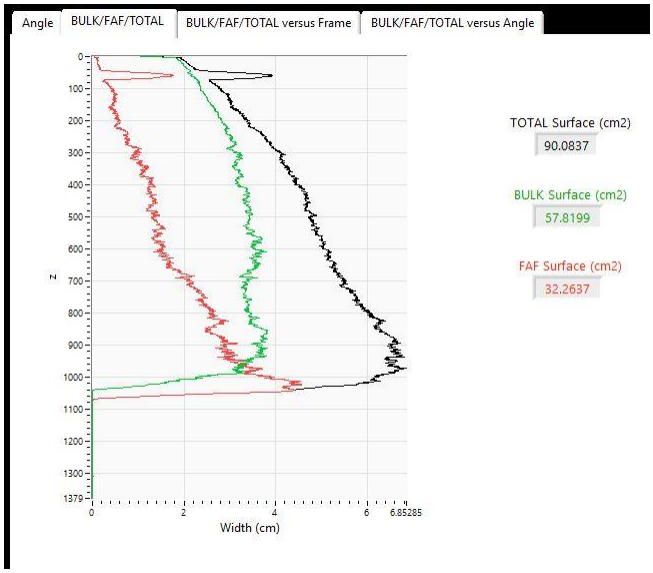


Figure 175: Bulk/FAF/Total versus z

Next tab is the BULK/FAF/TOTAL versus the frame # (Figure 176).

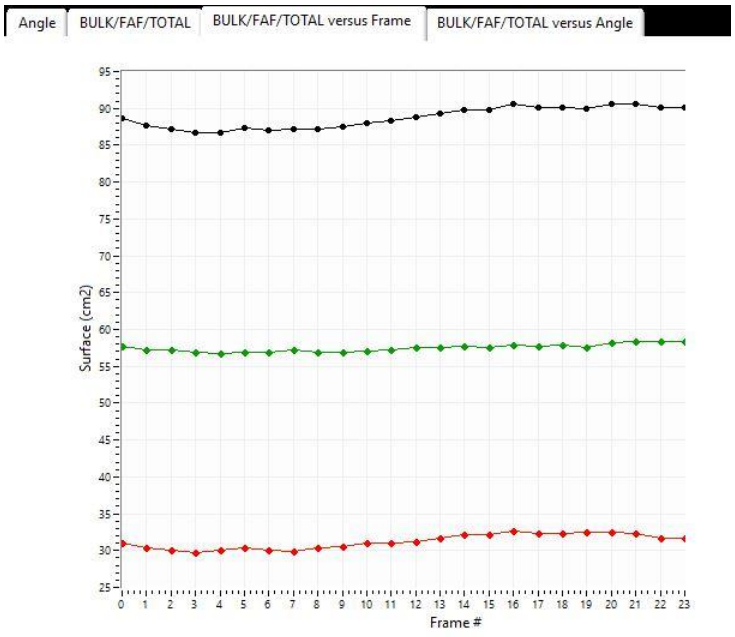


Figure 176: BULK/FAF/TOTAL versus the frame #

This allows to monitor the change of the different surfaces versus the frame #. The last tab shows 3 graphs corresponding to the BULK/FAF/TOTAL versus the angle, in a Lissajoux graph (Figure 177).

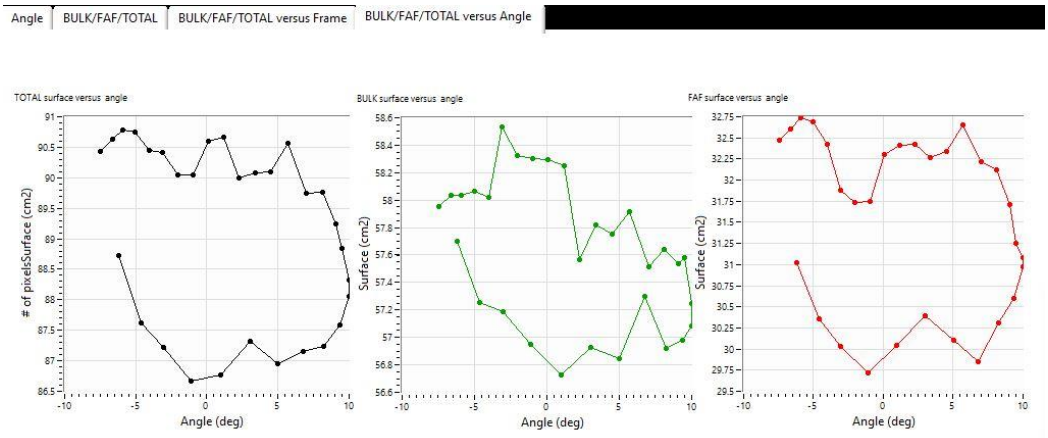


Figure 177: BULK/FAF/TOTAL versus the angle

The shape of these Lissajoux graphs carries information about how the surface evolves with the angle. Once the processing is done, the processing window closes and the visualization window appears (Figure 178).



Figure 178: Visualization window

The data visualization window will be detailed further. After clicking on EXIT to go back to the main window, the measurement list is now updated (Figure 179).

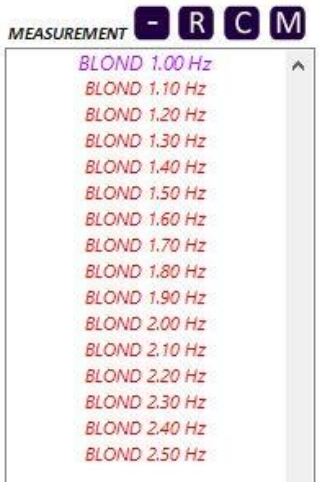


Figure 179: Measurement list – Stationary Loop processed

The measurement appears in purple italic.

5.4.2. (RE)PROCESS FULL Video

It is exactly the same as the stationary loop processing except a new tab about the damping measurement (Figure 180)

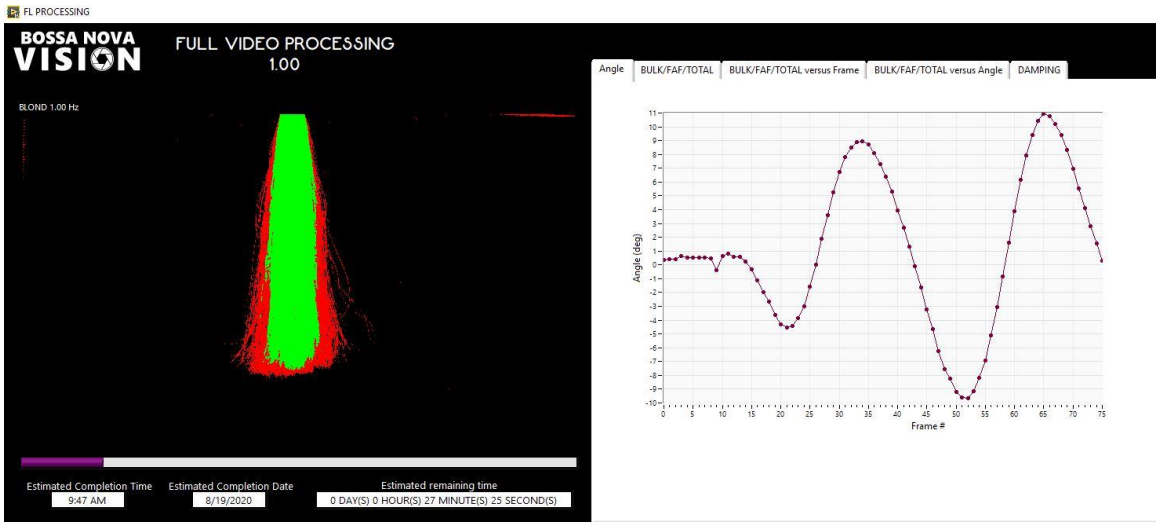


Figure 180: Full video processing window

This processing takes more time as the 525 frames are now processed. When the processing is completed, the window closes and the data visualization window opens. After clicking on EXIT to go back to the main window, the measurement list is now updated (Figure 181)



Figure 181: Measurement list – Stationary Loop and FULL video processed

The measurement appears in black.

5.5. RUMBA (RE)PROCESS

The **Reprocess** control 

allows to process unprocessed data or reprocess processed data. Figure 182 shows the pop-up window in case no measurement to be reprocessed has been selected.

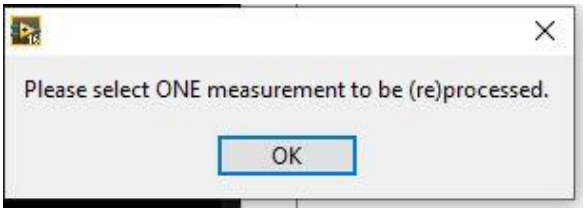


Figure 182: No measurement selected pop-up window

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 183).

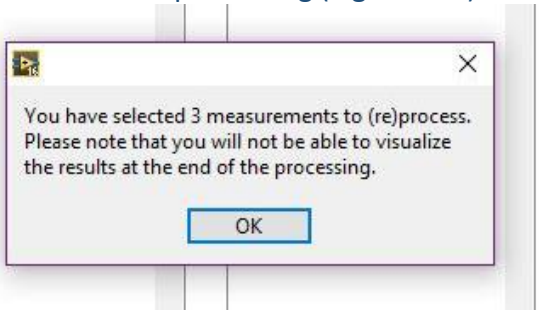


Figure 183: Warning pop-up window

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 184).

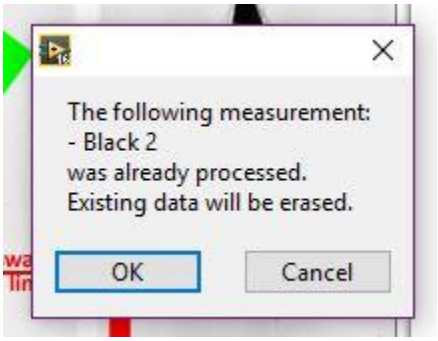


Figure 184: Processed measurement pop-up message

(Re)process follows the same steps as **Add new measurement – Processing On** with the exception of acquiring images as it reprocesses existing raw images (Figure 185).



Figure 185: Reprocess window

The user can choose between visualizing or not the processed image, knowing that the visualization of the processed image leads to a longer processing time. Once the user clicks on START, the processing windows pops-up starting with the angle image calculation (Figure 186).

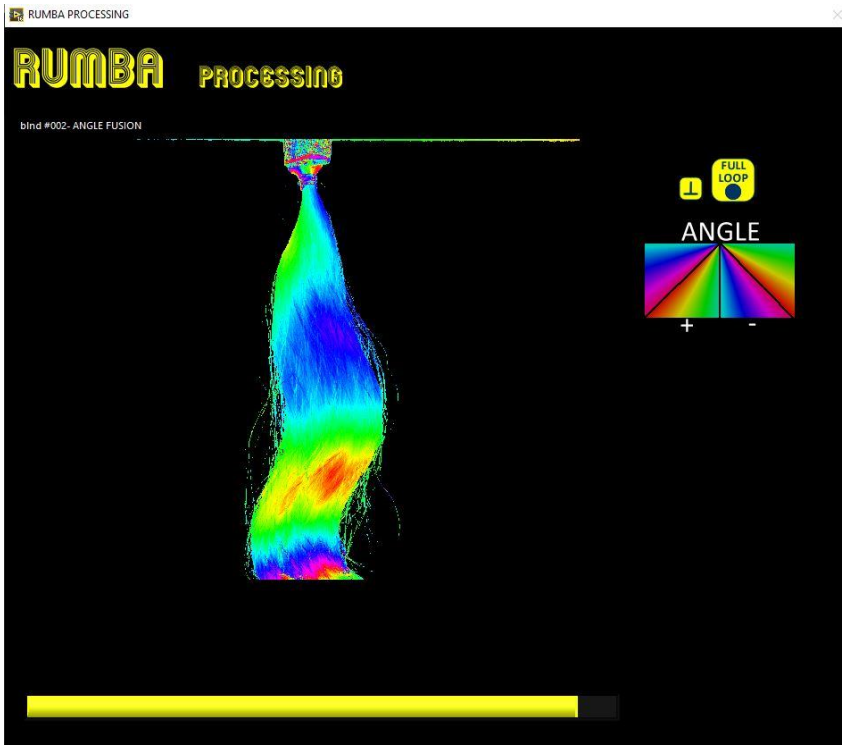


Figure 186: Processing – Angle image calculation

On the right side is the color scale of the angle image. Under the image is the progress bar. If no visualization was selected, only a message appears along the progress bar(Figure 187).

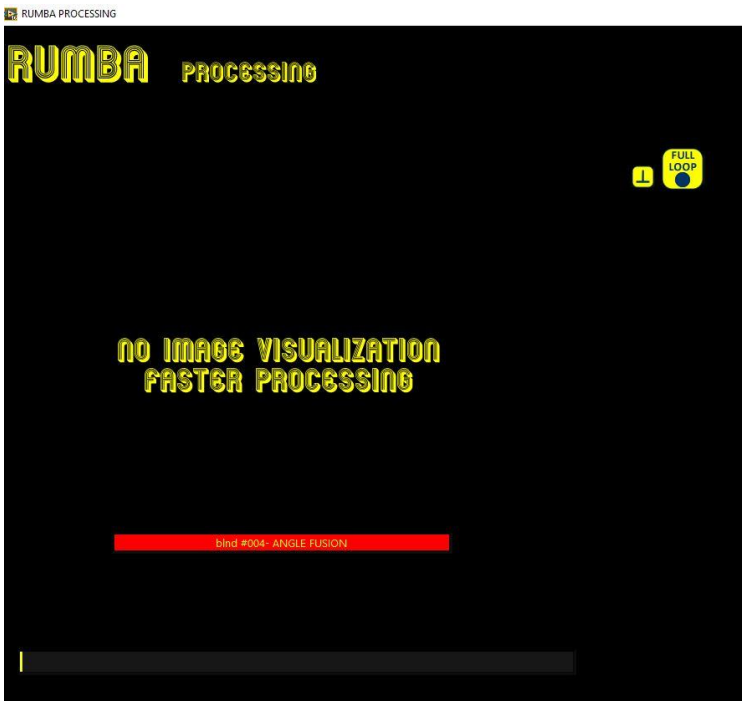


Figure 187: Processing – Visualization OFF

Once the angle image is calculated, the alignment image is processed (Figure 188).

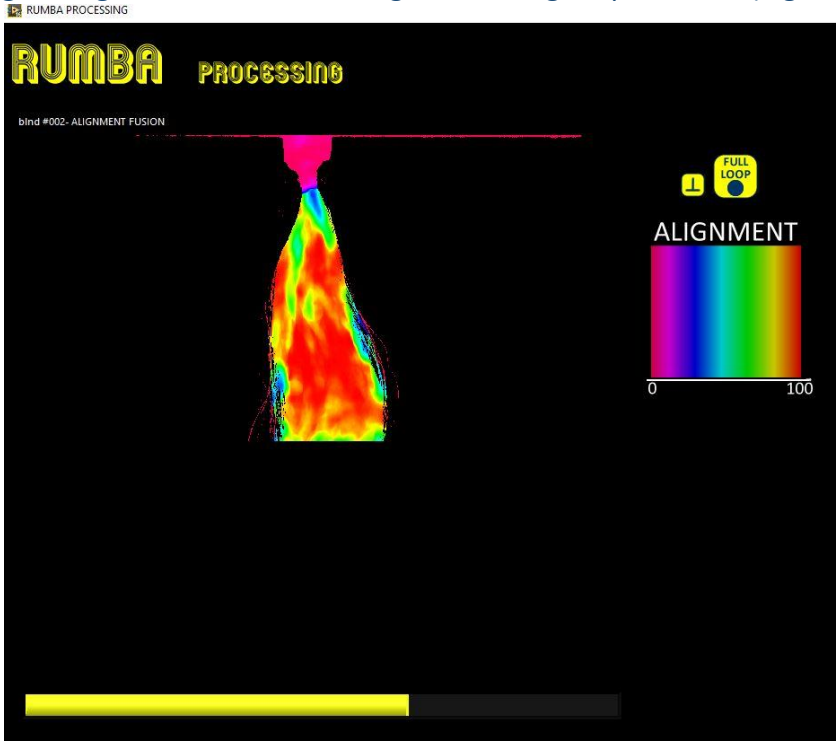


Figure 188: Alignment image processing

Similarly to the angle image calculation, the color scale is given on the right of the image and the progress bar is shown under the image. Once it is done, if there was only one measurement to be processed or reprocessed, the measurement is shown in the visualization window. If there were multiple measurements, the software goes back to the main window.

6. 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.

6.1. BOLERO TRIO/WIDE DATA VISUALIZATION

BOLERO TRIO and BOLERO WIDE data visualization are similar (Figure 189).

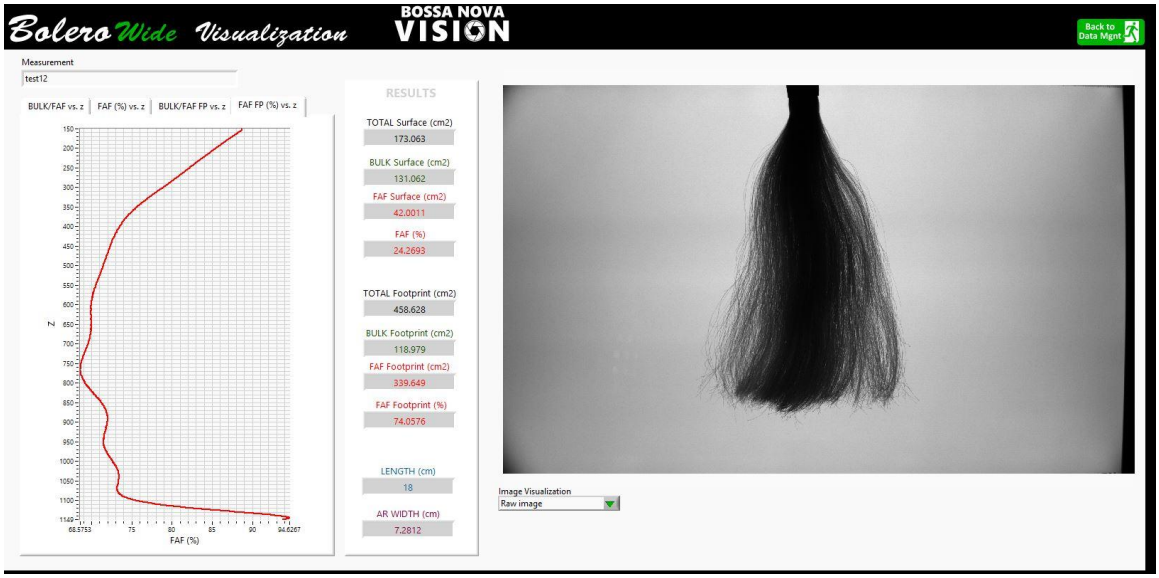
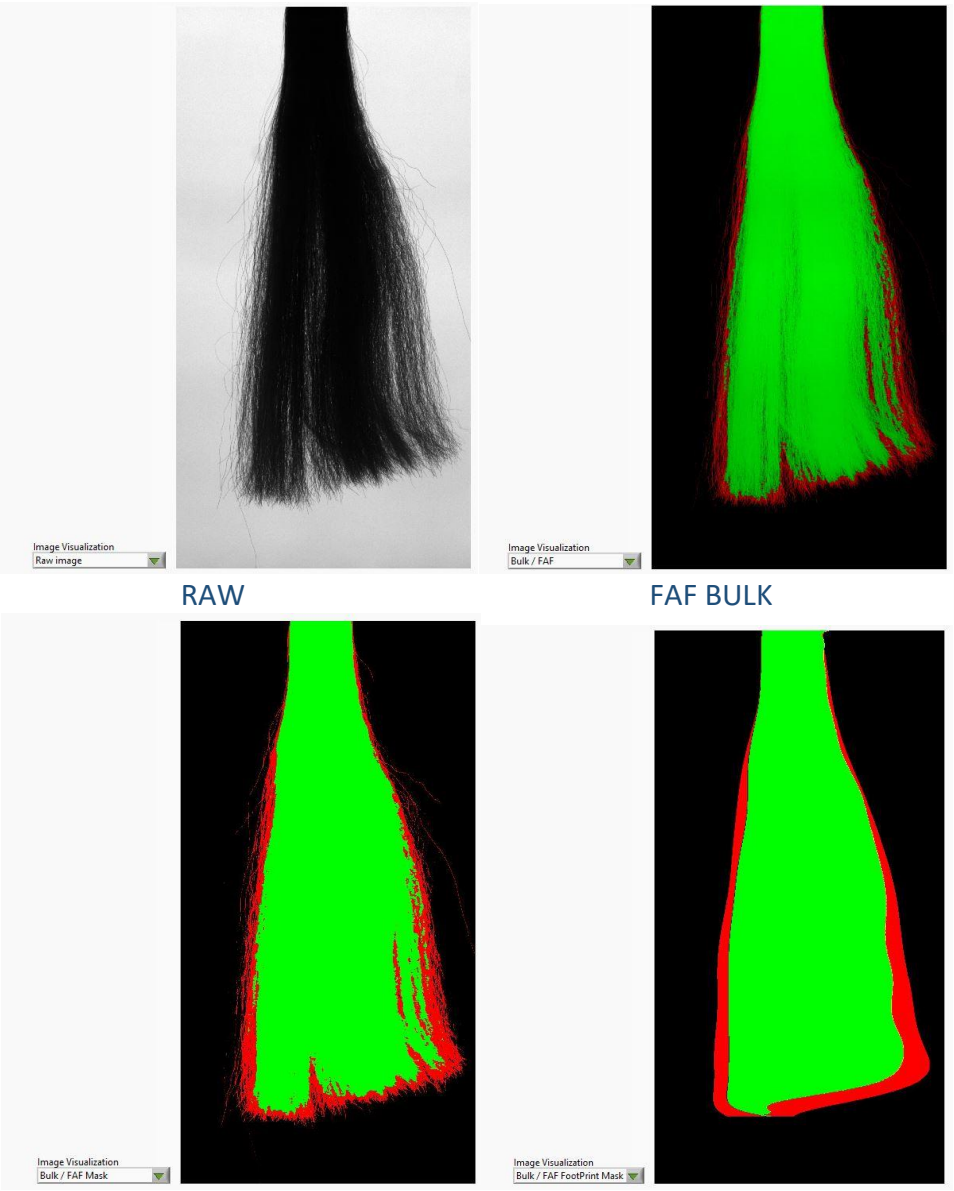


Figure 189: Data visualization window

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 190).



RAW FAF BULK

FAF BULK MASK FOOT PRINT MASK

Figure 190: 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 191.

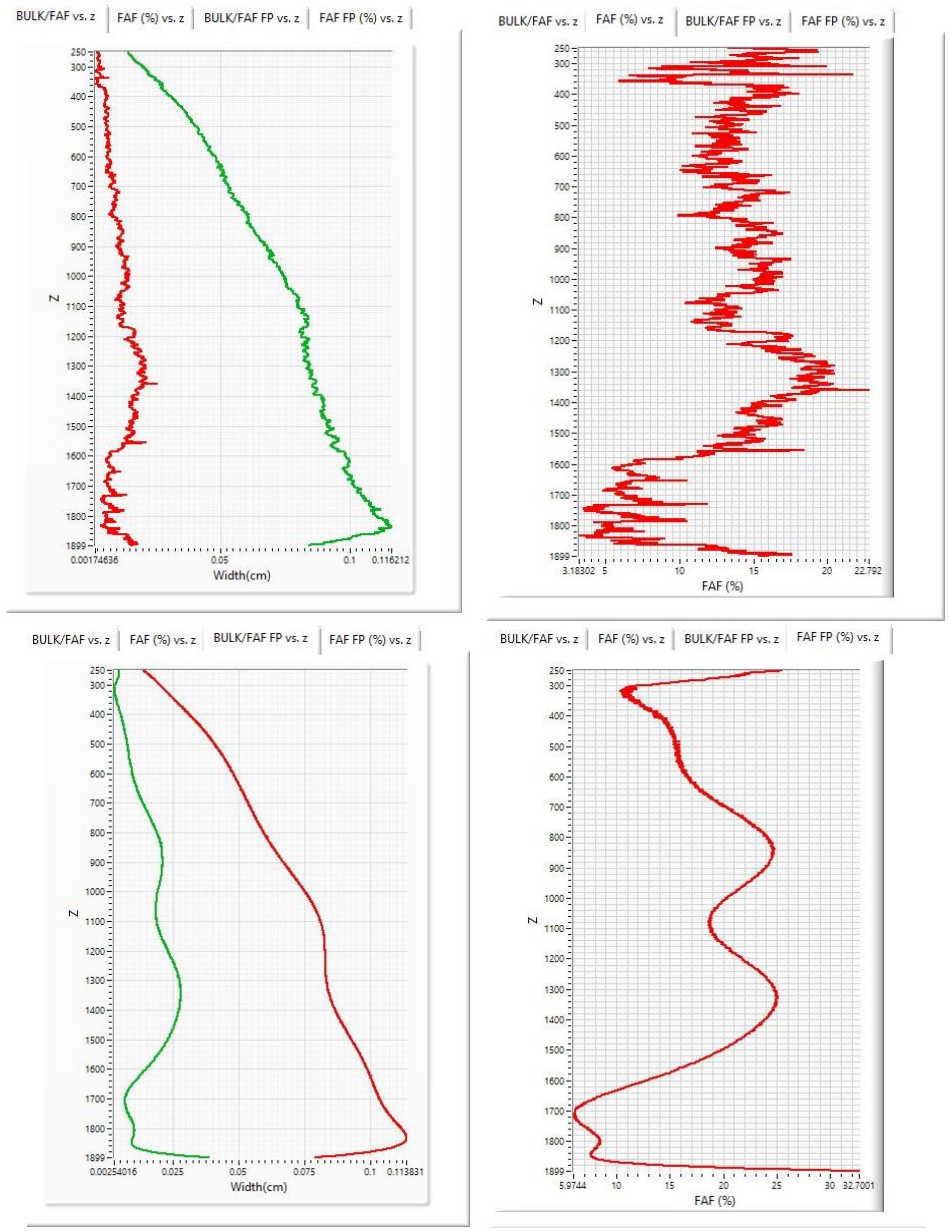


Figure 191: Various graphs

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 192)

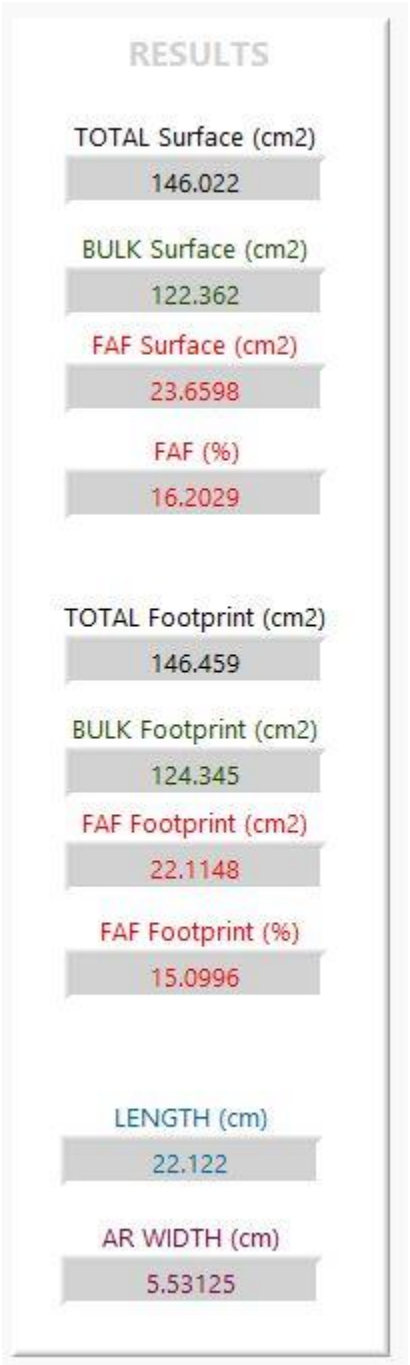


Figure 192: Various surface calculation

If the user does not select a measurement and clicks on the data visualization tab, the following pop-up message appears (Figure 193).

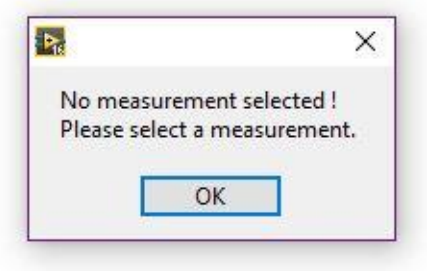


Figure 193: Pop-up message – No measurement selected

If the user selects a non-processed measurement, only the raw image appears (Figure 194).



Figure 194: Measurement no processed

6.2. BOLERO 360 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 a measurement. When the user selects a measurement in the data measurement window and clicks on the data visualization button 

, the data visualization appears (Figure 195).

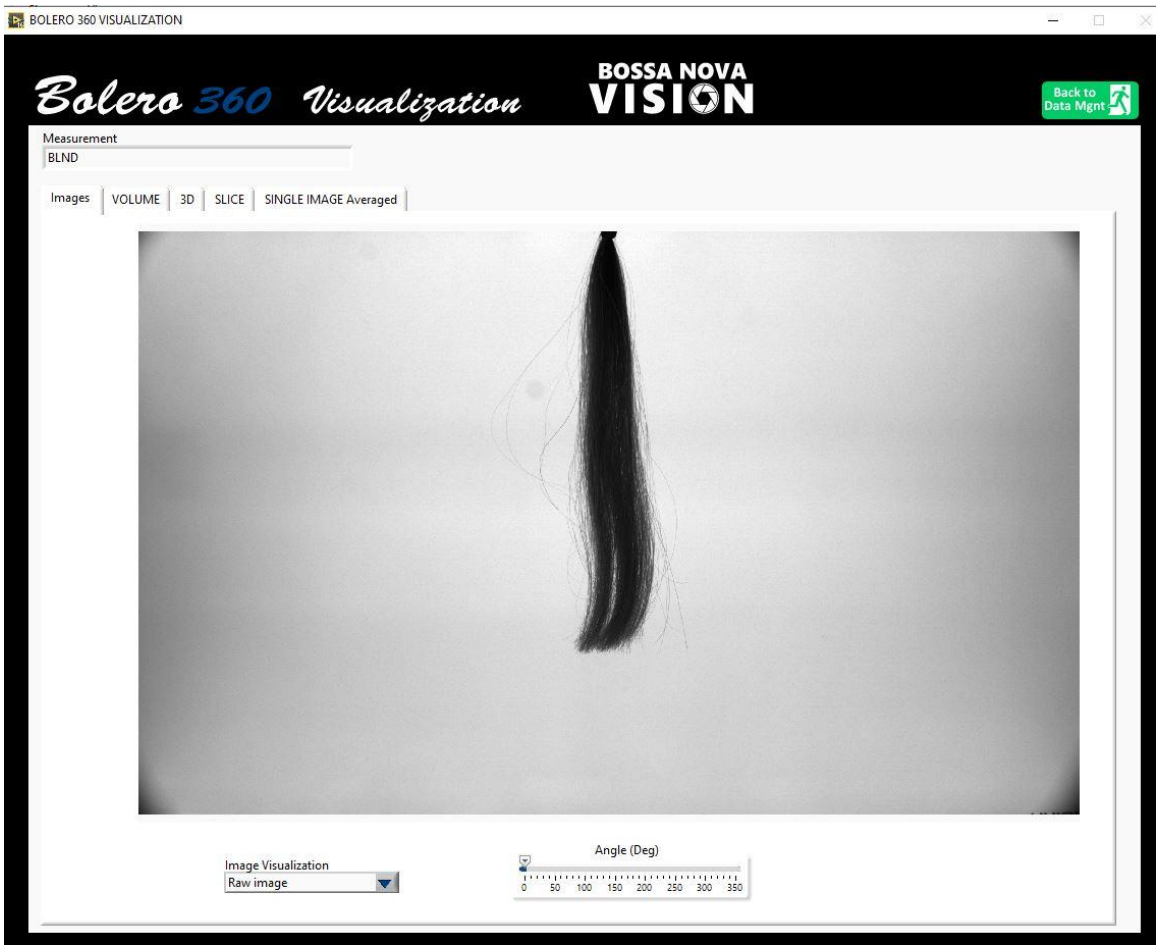


Figure 195: Data visualization window (images tab selected)

At the top of the window is the name of the measurement. Below is a tab 

where the user can select between the images, Volume, 3D, Slice and Single image averaged results (Figure 196).

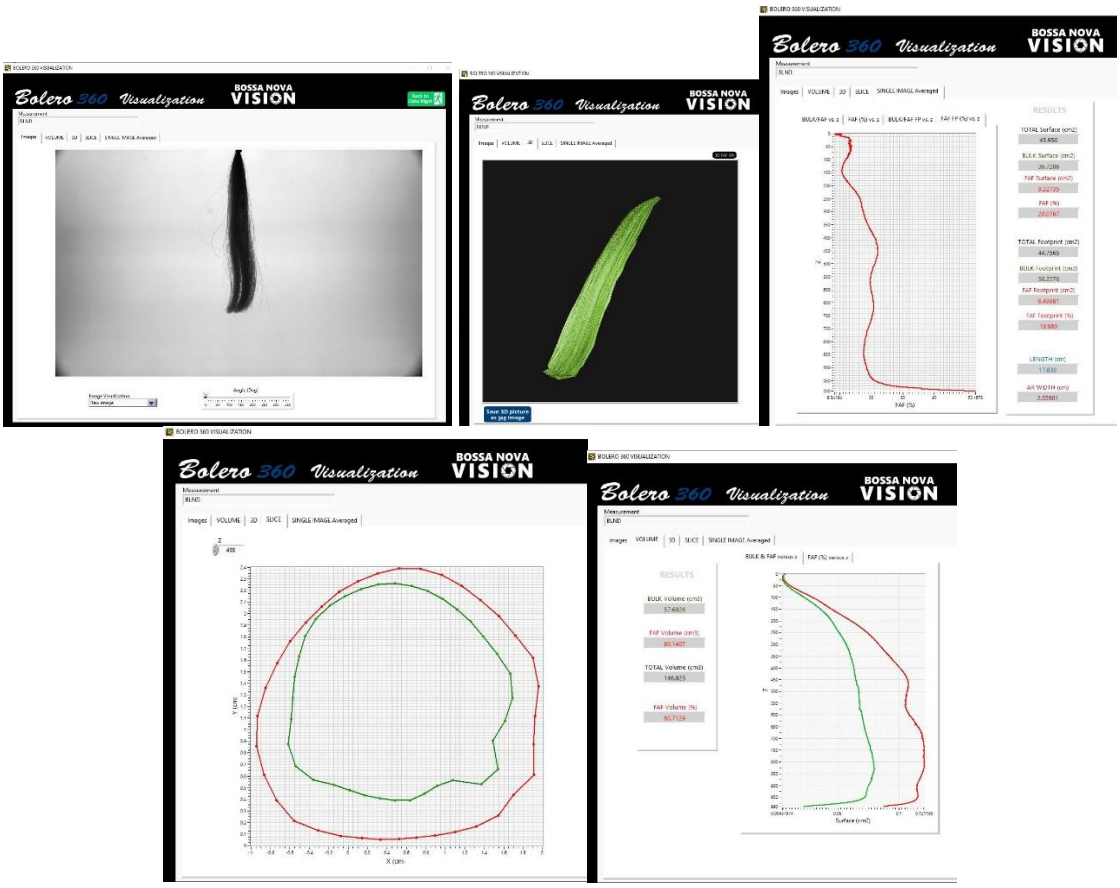


Figure 196: Using Tab

The first tab – IMAGES – present the different images (Raw, Bulk/faf, Bulk/faf mask and Bulk/Faf Mask Foot print for the different angles (Figure 197).

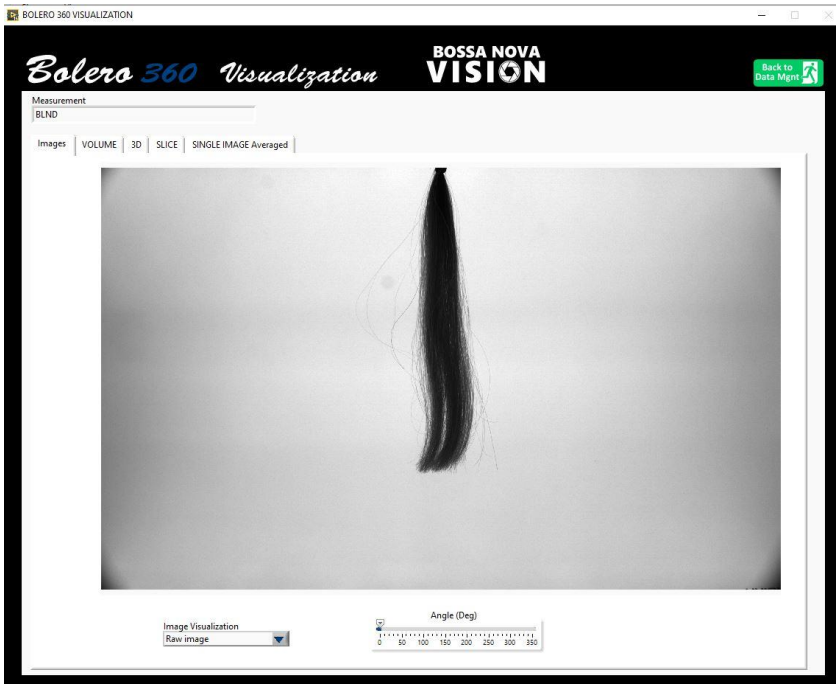
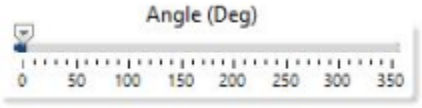


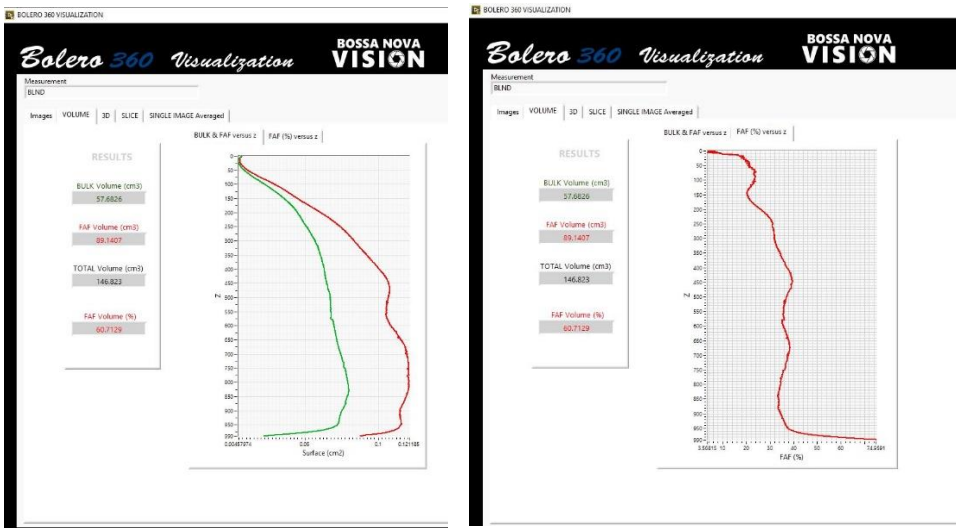
Figure 197: IMAGES Tab

The user can scroll through the different images using 

and 

.

The second tab – VOLUME – shows the volume results and the different corresponding profiles (Figure 198).



(a) BULK and FAF surface versus z (b) FAF(%) versus z

Figure 198: Volume results and profiles

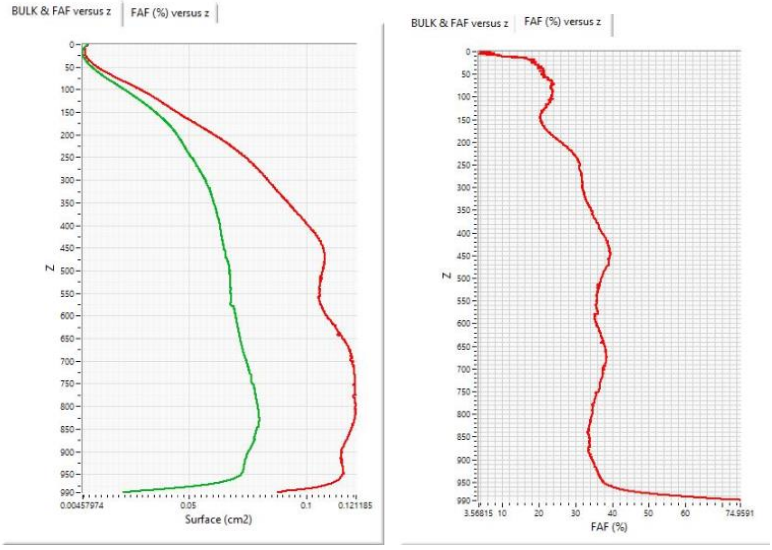
The results (Figure 199) presents the BULK Volume, the FAF Volume and the TOTAL volume (in cm^3) plus the FAF(%).



Figure 199: Volume results

Using the Tab 

, the user can visualize the BULK and FAF Surface versus z, or the FAF (%) versus z graphs (Figure 200).



(a) (b)

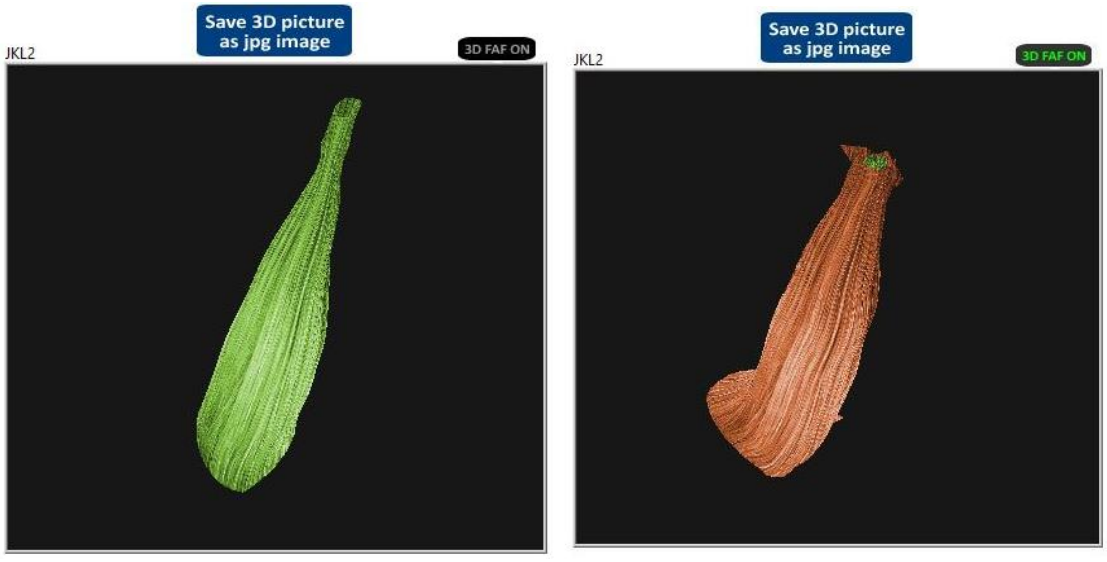
Figure 200: (a) BULK and FAF Surface versus z; (b) the FAF (%) versus z graphs

The third tab - 3D – shows the 3D shape reconstructed (Figure 201).



Figure 201: 3D shape

The user can visualize BULK or FAF using 3D FAF ON. The user can change the angle of visualization for the 3D, visualize the BULK or the BULK + FAF using the 3D FAF ON control 3D FAF ON and save the current image as jpg using the save 3D picture as jpg image control Save 3D picture as jpg image. Clicking on the 3D FAF ON allows to switch between the 3D visualization of the Bulk only or the bulk and the FAF (Figure 202).



(a) BULK (b) BULK + FAF

Figure 202: (a) 3D BULK; (b) BULK+FAF visualization

When BULK + FAF visualization is on, the control changes to 

. The user can also save the current 3D image as a jpg image using the save 3D picture as jpg image control. A pop-up window appears with the image name already populated (Figure 203). The file name can also be changed to something else.

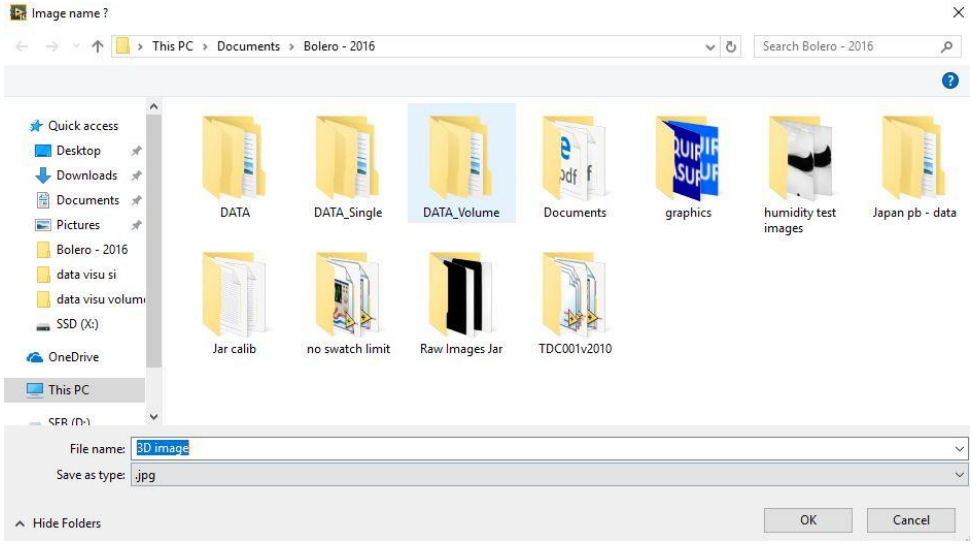


Figure 203: 3D image saving window

The fourth tab – SLICE – shows a slice of the 3D shape (Figure 204) for the BULK and the FAF.



Figure 204: SLICE

The user can visualize different slice by changing the Z value using 

.

The fifth tab – Single Image Averaged – is similar to as it shows the BOLERO WIDE/TRIO results obtained by averaging the data over the rotation angle (Figure 205).

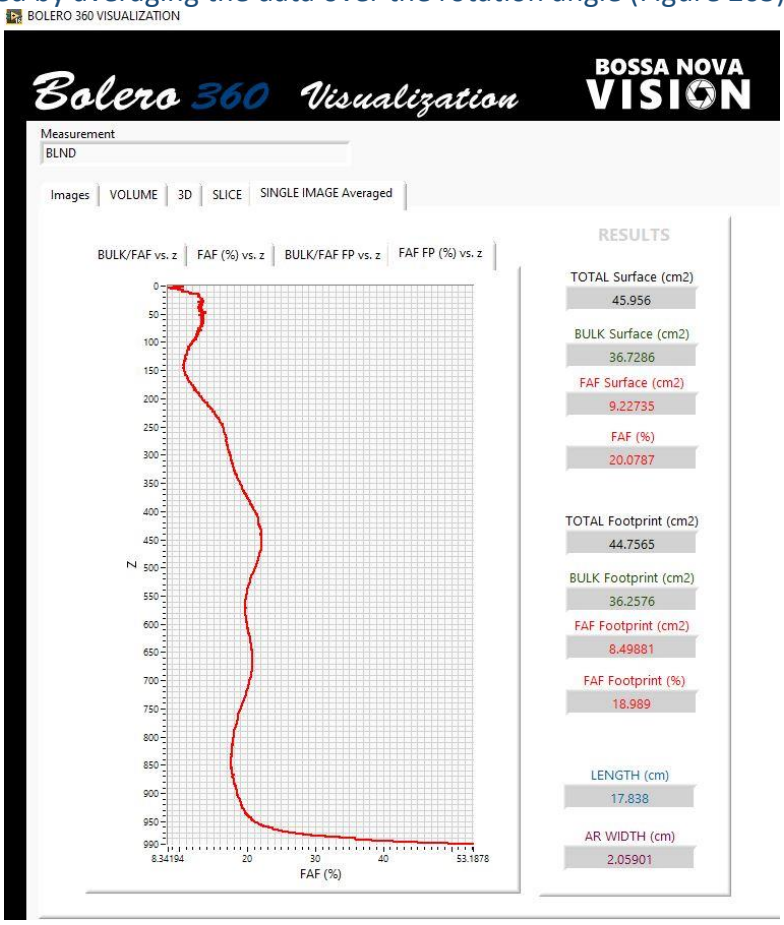


Figure 205: Single Image Averaged

For more info, check BOLERO TRIO/WIDE DATA VISUALIZATION.
If the user does not select a measurement and clicks on the data visualization button, the following pop-up message appears (Figure 206).

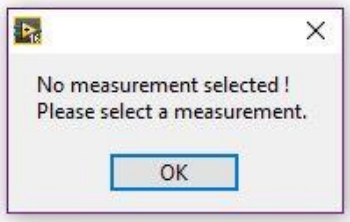


Figure 206: Pop-up message – No measurement selected

If the user selects a non-processed measurement, the data visualization appears (Figure 207).

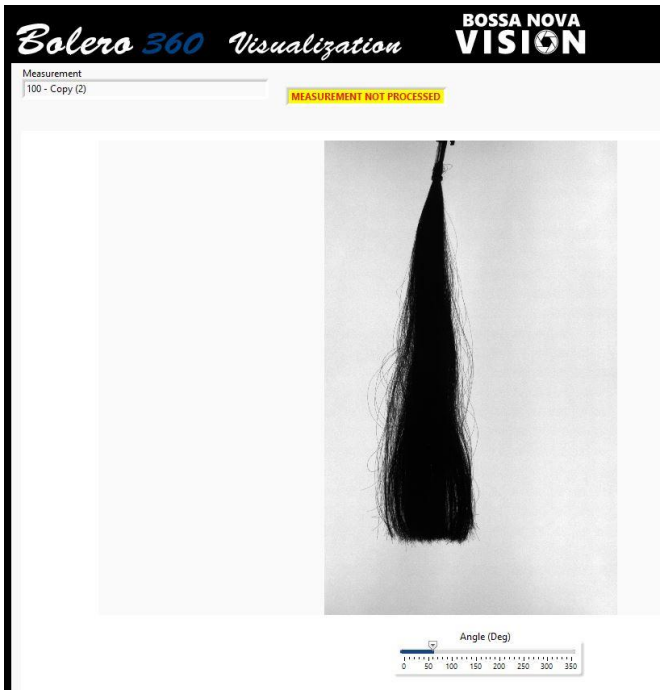


Figure 207: Un-processed measurement

Only the RAW images are visible (and the angle control).

6.3. HOP 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 a measurement. When the user selects a measurement in the data measurement window and clicks on the data visualization button 

, the data visualization appears (Figure 208).

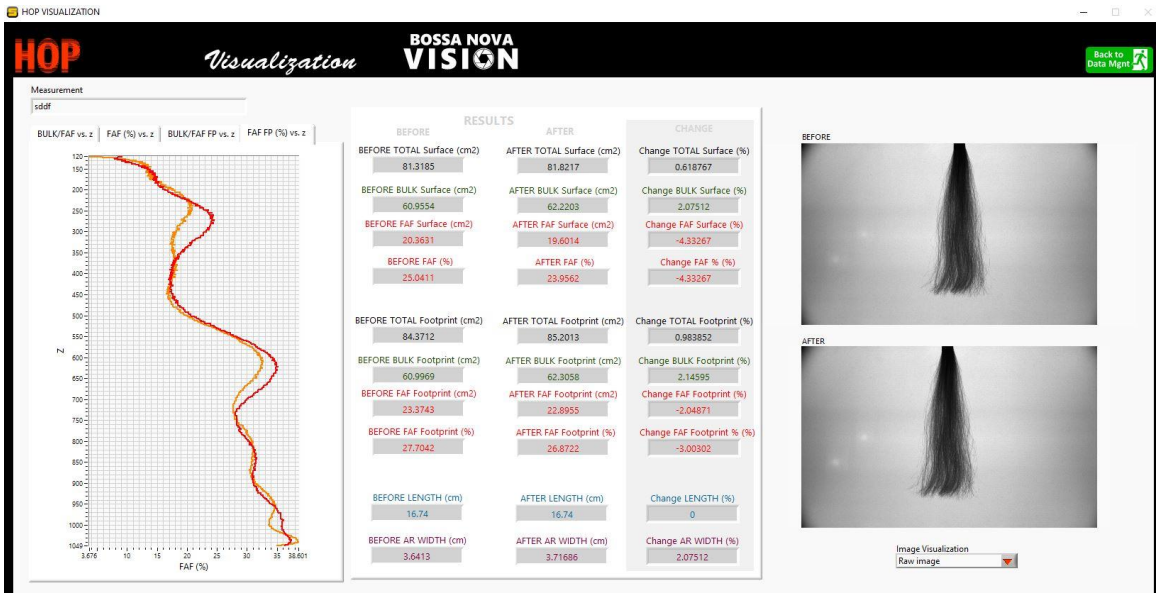


Figure 208: Data visualization window

The BEFORE and AFTER images are shown on the right (Figure 209) of the window.

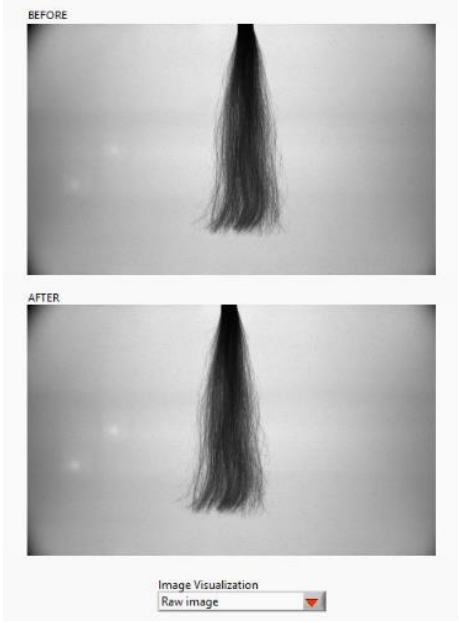
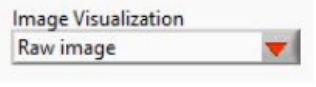


Figure 209: BEFORE and AFTER Image

Under the 2 images is the Image visualization control allowing to visualize the raw, the bulk/faf, the bulk/faf mask and bulk/faf footprint mask images 

.

The corresponding graphs - BULK/FAF vs. z | FAF (%) vs. z | BULK/FAF FP vs. z | FAF FP (%) vs. z - are shown on the left (Figure 210) of the window.

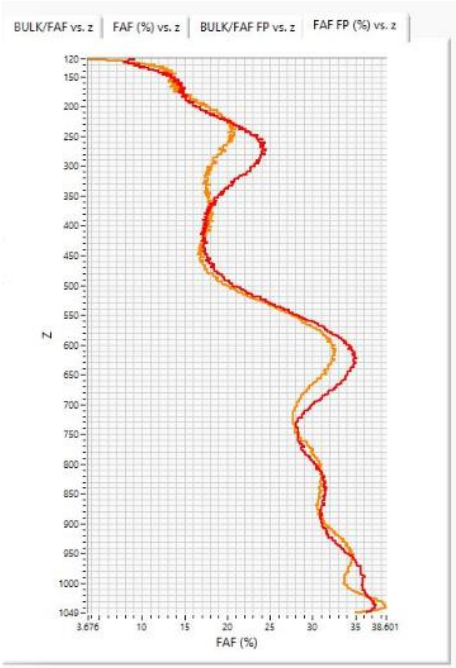


Figure 210: Graphs Tab

In the center are the calculated parameters or each image, and the change in % (



Figure 211).



Figure 211: Parameters

The parameters are identical as the ones for BOLERO TRIO and BOLERO WIDE except that we have 2 sets of parameters, one set for the BEFORE image, one set for the AFTER image. The Change in % is calculated.

6.4. HULA 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 a measurement. When the user selects a measurement in the data measurement window and clicks on the data visualization button 

, the data visualization appears (Figure 212).

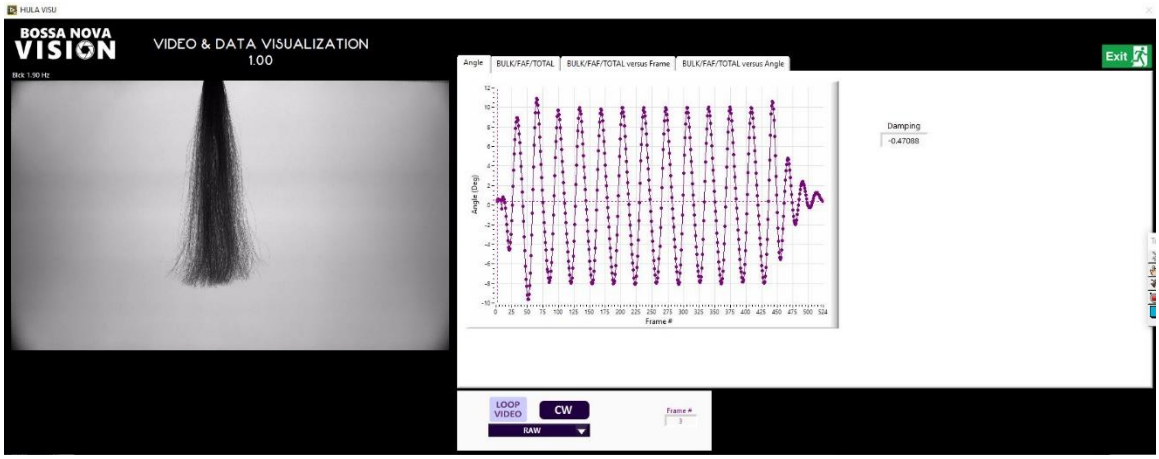
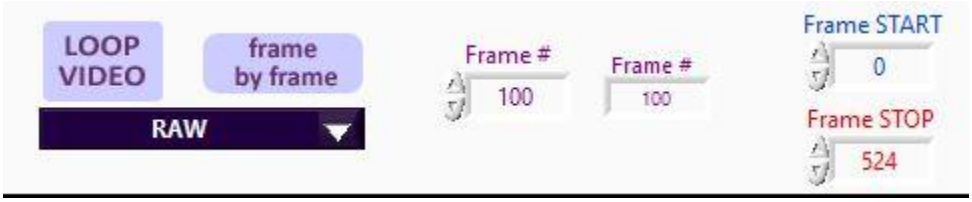


Figure 212: HULA data visualization

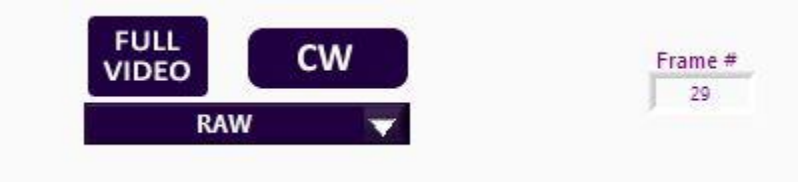
On the left is the image corresponding to the frame number. On the right of the image is the tab allowing to visualize various graphs and data. Under the tab are controls (Figure 213) allowing to select the video visualized (stationary loop or full video), the way the video is played – (CW or frame by frame) and the type of video (Raw, processed and in case of the stationary loop, processed and derotated).



Full raw video visualized in CW mode



Full raw video visualized in frame by frame mode



Stationary loop video in CW mode

Figure 213: Controls

When the measurement has not been processed - stationary loop or full video -, the tab are not visible as shown on Figure 214.

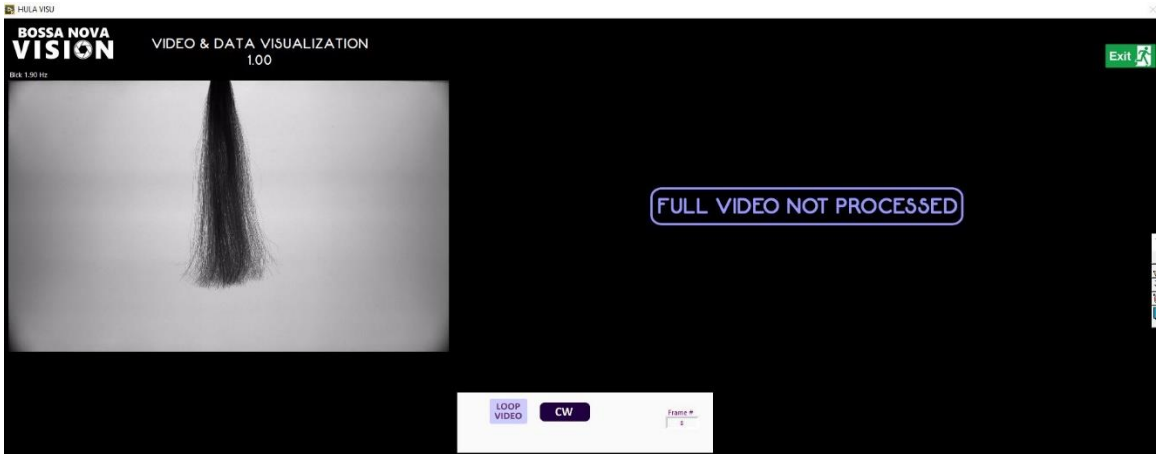
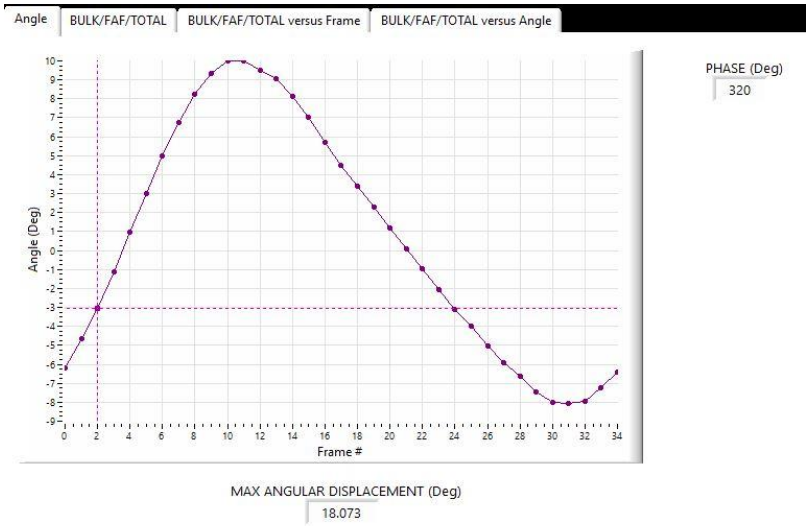
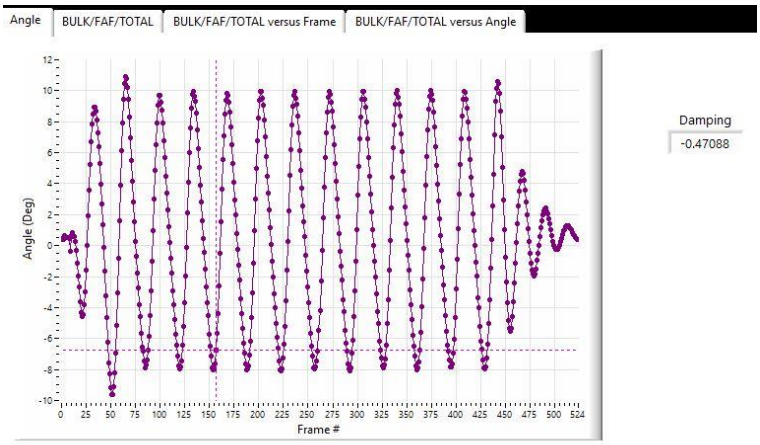


Figure 214: Full video not processed

When the video is fully processed, the user can visualize different graph and data, detailed in the following. First tab is the angle tab (Figure 215).



(a) Stationary loop



(b) Full

Figure 215: Angle versus frame # (a) stationary loop (b) full

Depending on the video selected - stationary loop or full – the variation of the vertical swatch angle versus the frame # is displayed on a graph. On the right of the graph is displayed for the stationary loop, the PHASE in degree and for the full video, the damping coefficient, to be detailed further.

Next tab is the BULK/FAF/TOTAL profile versus z and the surface calculation for the current visualized frame (Figure 216).

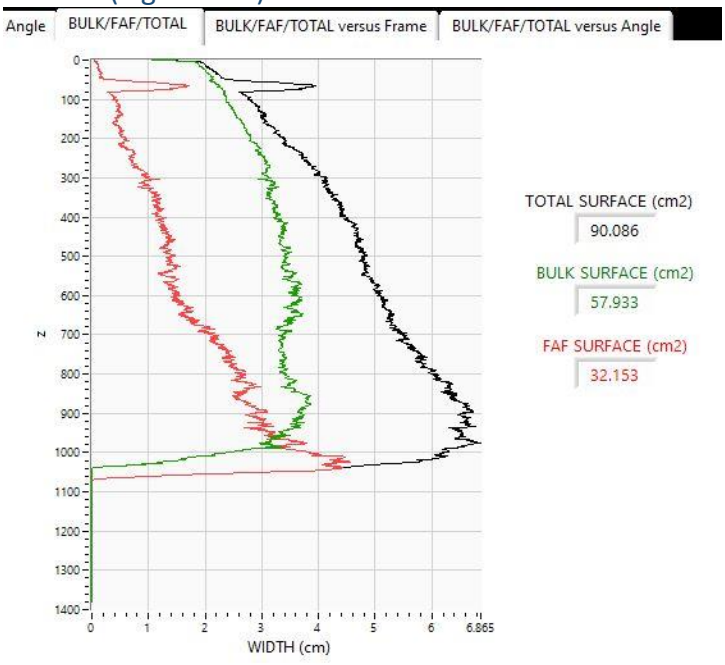
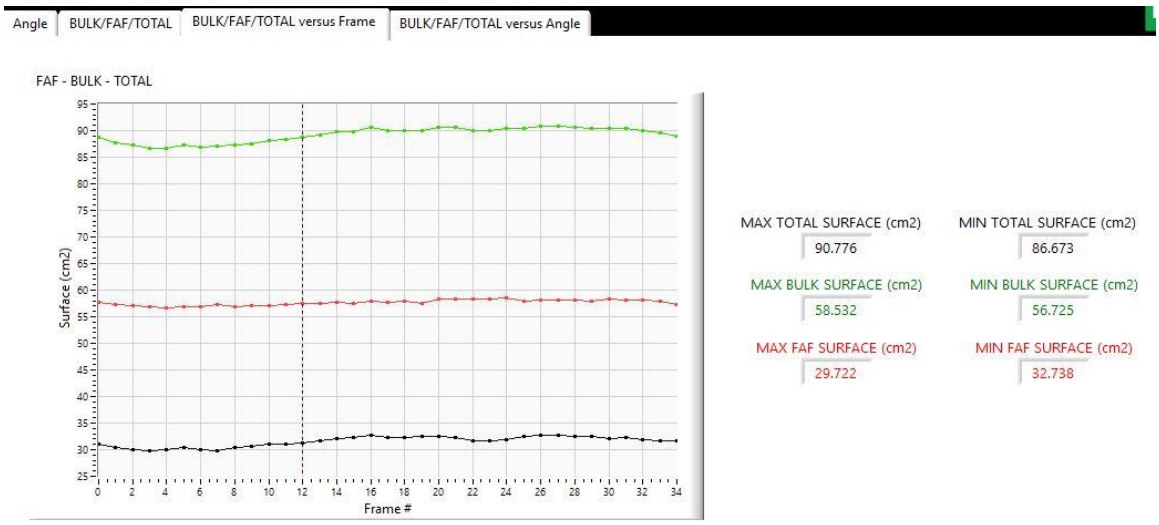
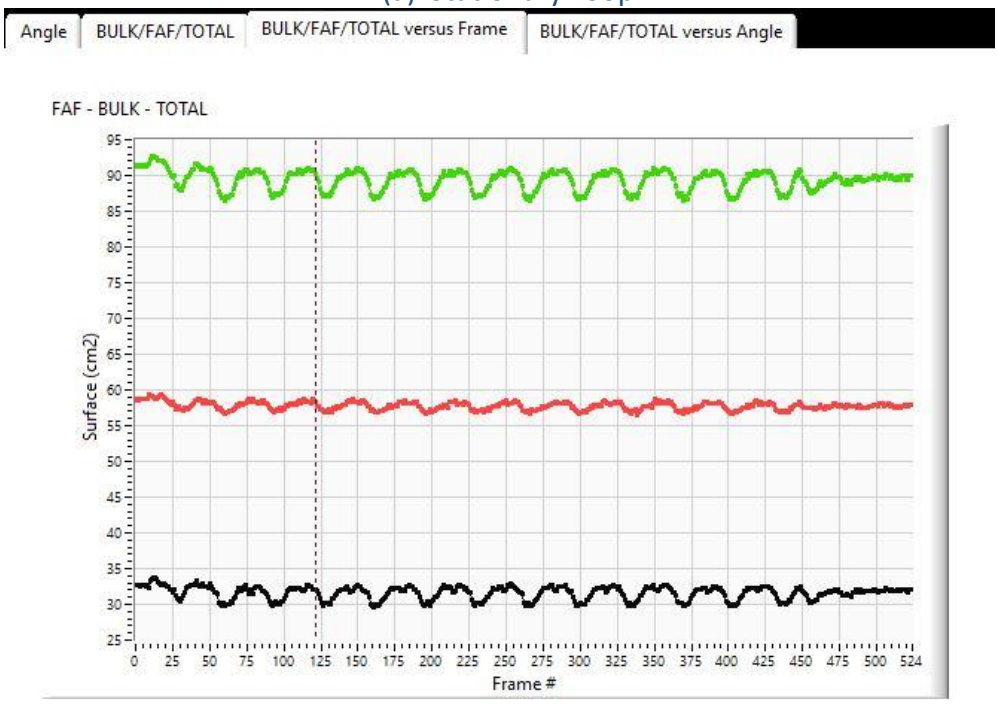


Figure 216: BULK/FAF/TOTAL profile versus z and the surface calculation

Next tab is the BULK/FAF/TOTAL versus frame showing the variation of the different parameters versus the frame number (Figure 217)



(a) Stationary Loop



(b) Full

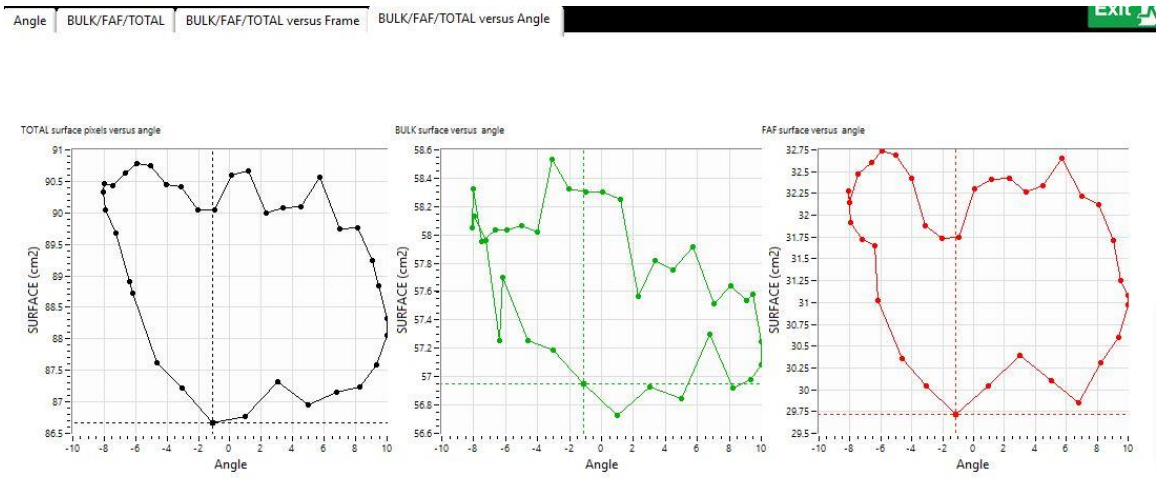
Figure 217: BULK/FAF/TOTAL versus frame # (a) stationary loop (b) full

For the stationary loop video, the maximum and minimum surface are displayed (Figure 218).

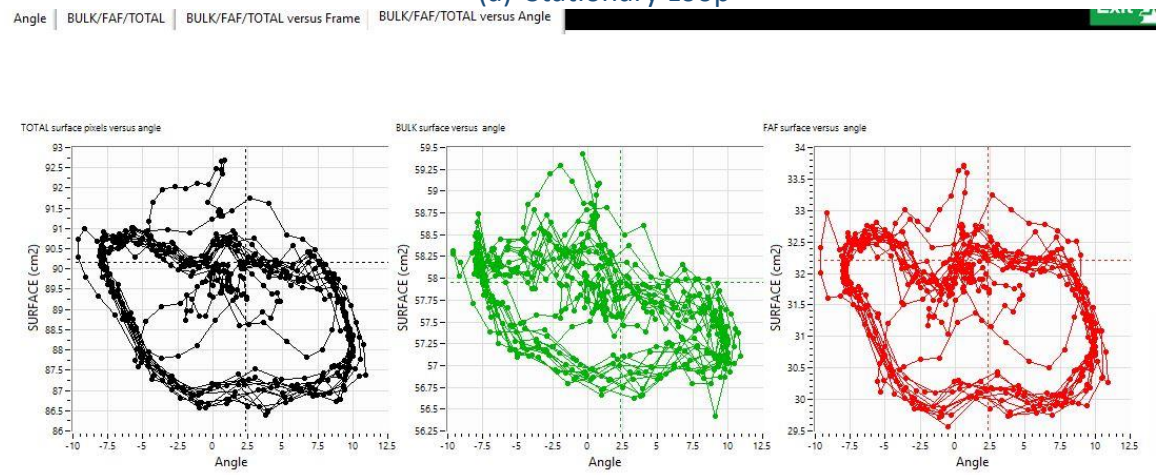


Figure 218: MAX and MIN Surface

Next tab is the surface versus angle graphs (Figure 219).



(a) Stationary Loop

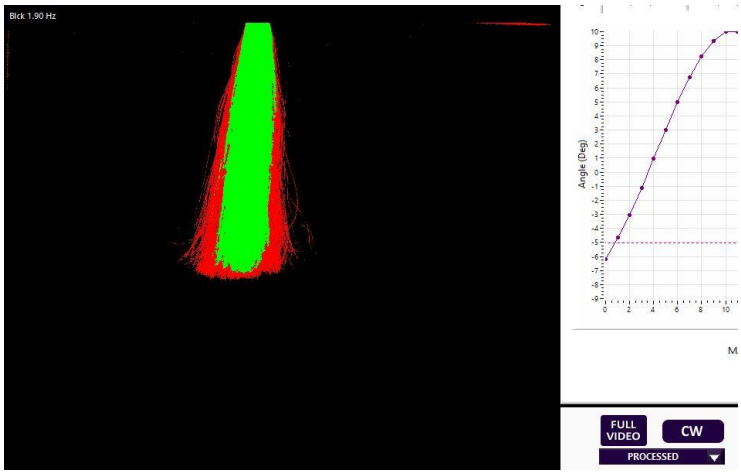


(b) Full

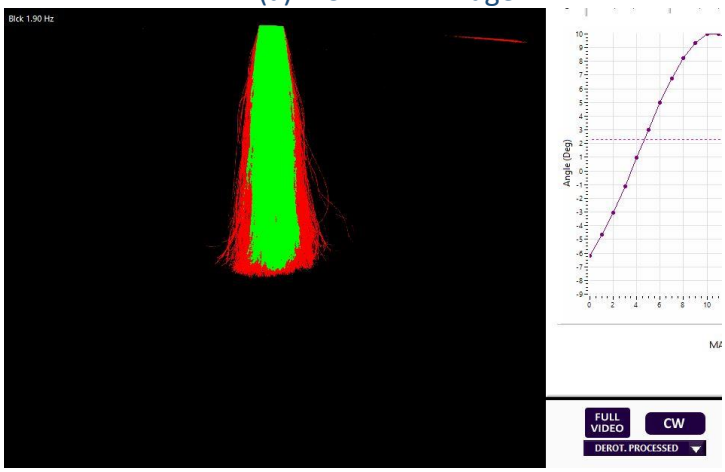
Figure 219: Surface versus angle graphs - (a) stationary loop (b) full

The user can also change the image visualized using the image control 

(Figure 220).



(a) BULK FAF image



(b) BULK FAF image DEROTATED

Figure 220: Image visualized

When the user is visualizing the full video, he can adjust the Frame start and Frame stop using the 2 controls 

.

This does not modify the full angle graph or the Bulk-FAF Total graph but it adds cursors (blue for start and red for stop) to visualize the frame start and frame stop (

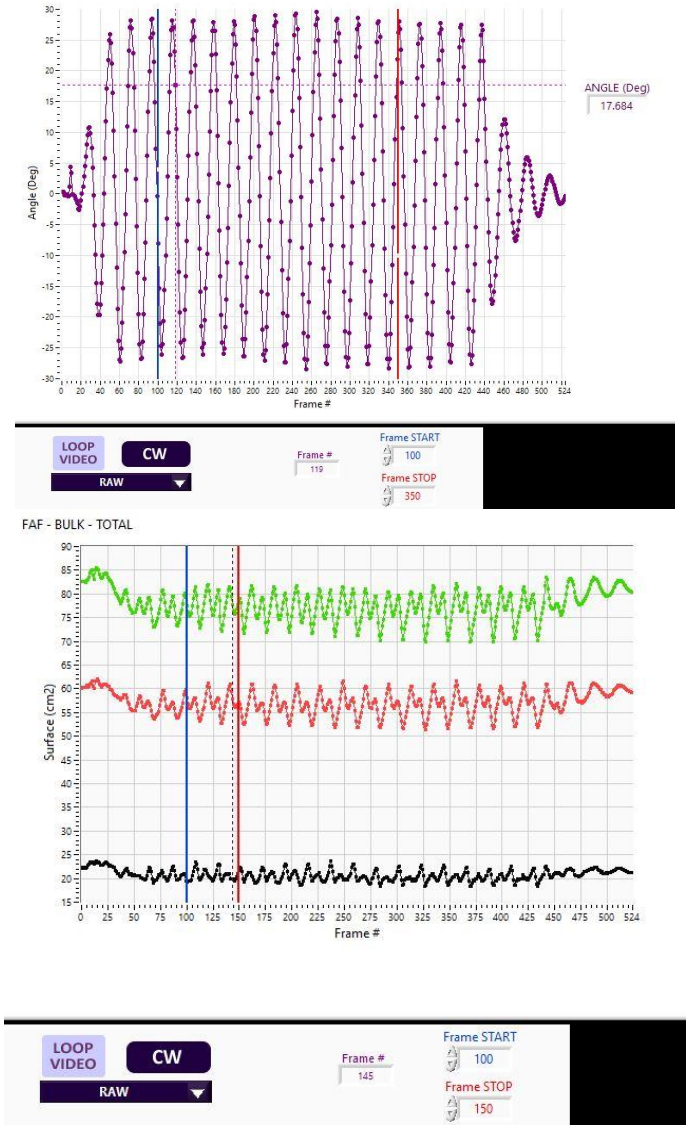


Figure 221).

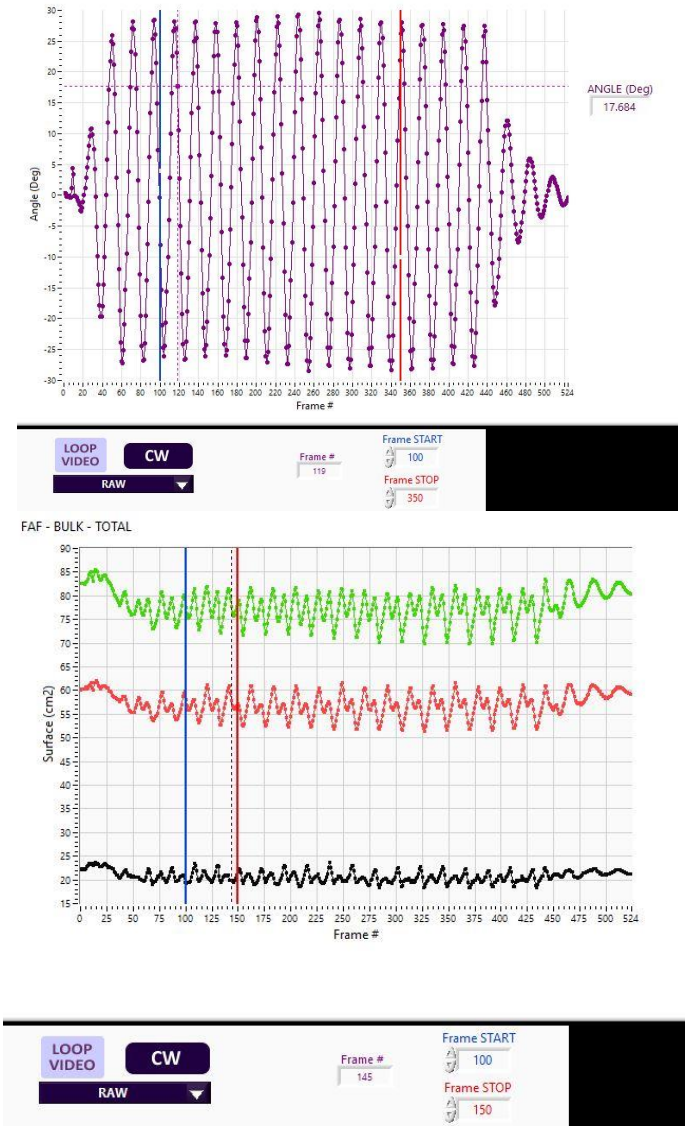


Figure 221: Frame start and Frame stop – Cursors on graphs

The visualization of the video and of BULK/FAF/TOTAL profile versus z is now only from frame start to frame stop. The Lissajoux graphs - surface versus angle – are now only displayed between frame start and frame stop, allowing a clear view of the selection (Figure 222).

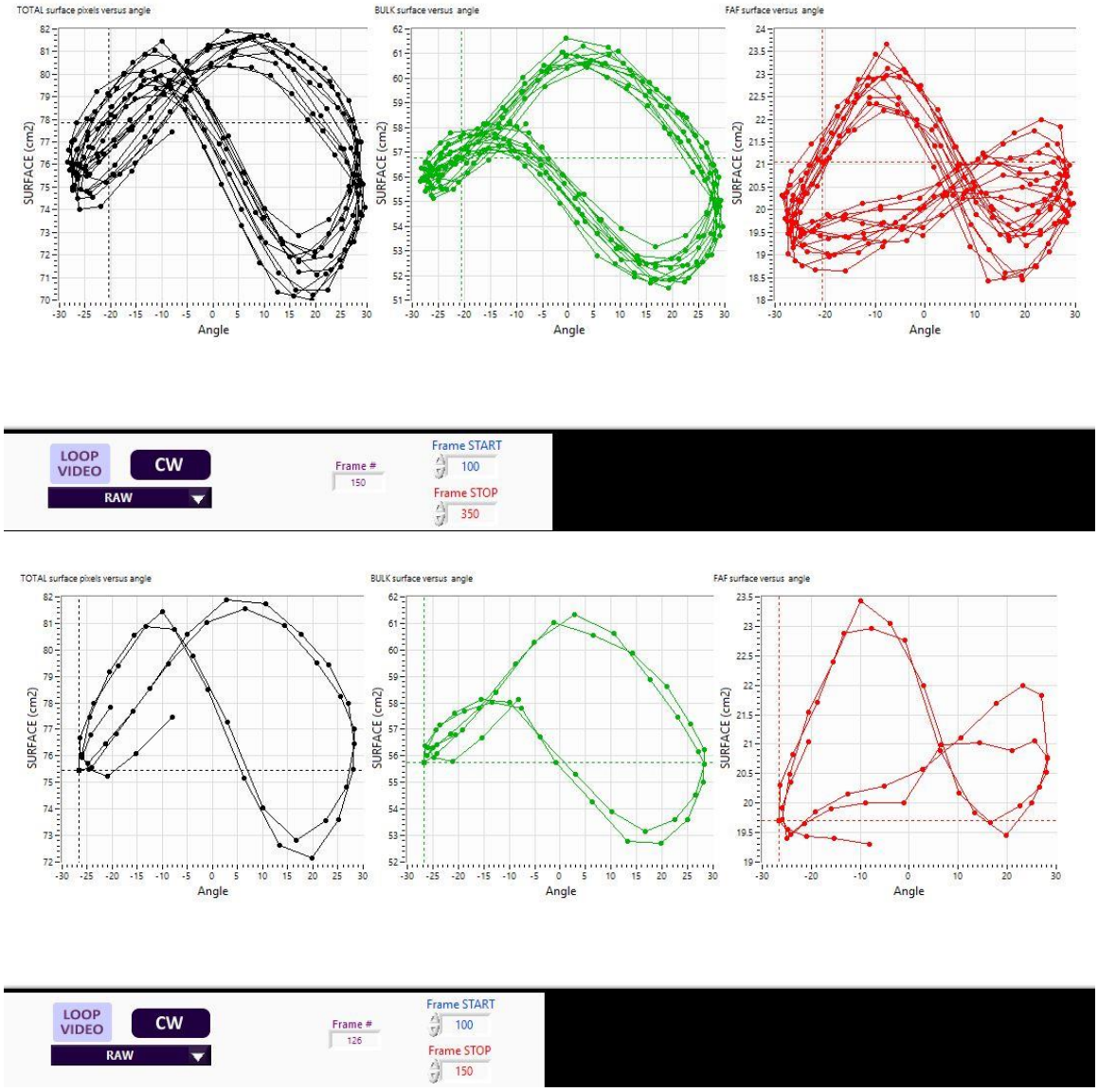


Figure 222: Surface versus angle

By click right on any graph, the user can export the data (

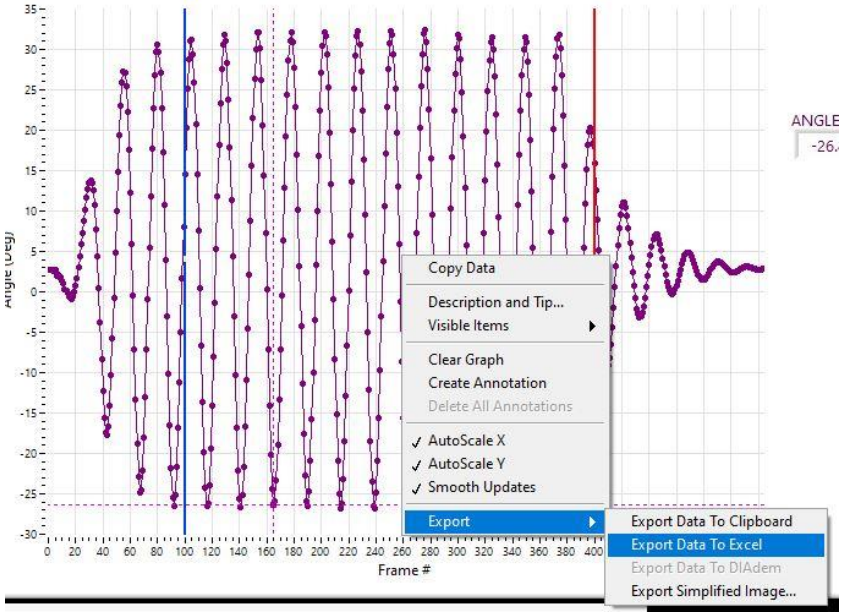


Figure 223).

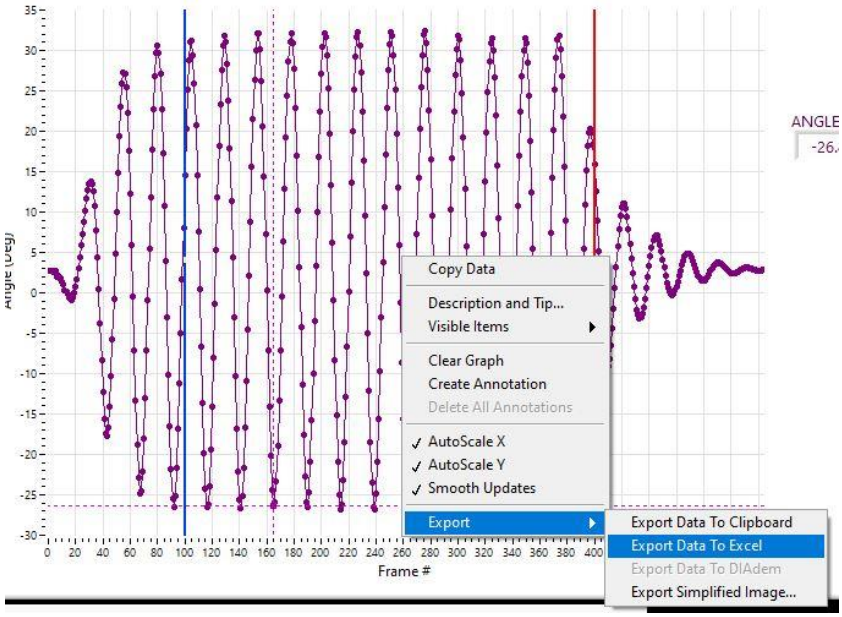


Figure 223: Right click to export data

6.5. RUMBA VISUALIZATION

The data visualization window allows to visualize the results of a single selected measurement, similar to the final window at the end of a measurement. When the user

selects a measurement in the data measurement window and clicks on the data visualization button MEASUREMENT VISUALIZATION, the data visualization windows appears (Figure 224).

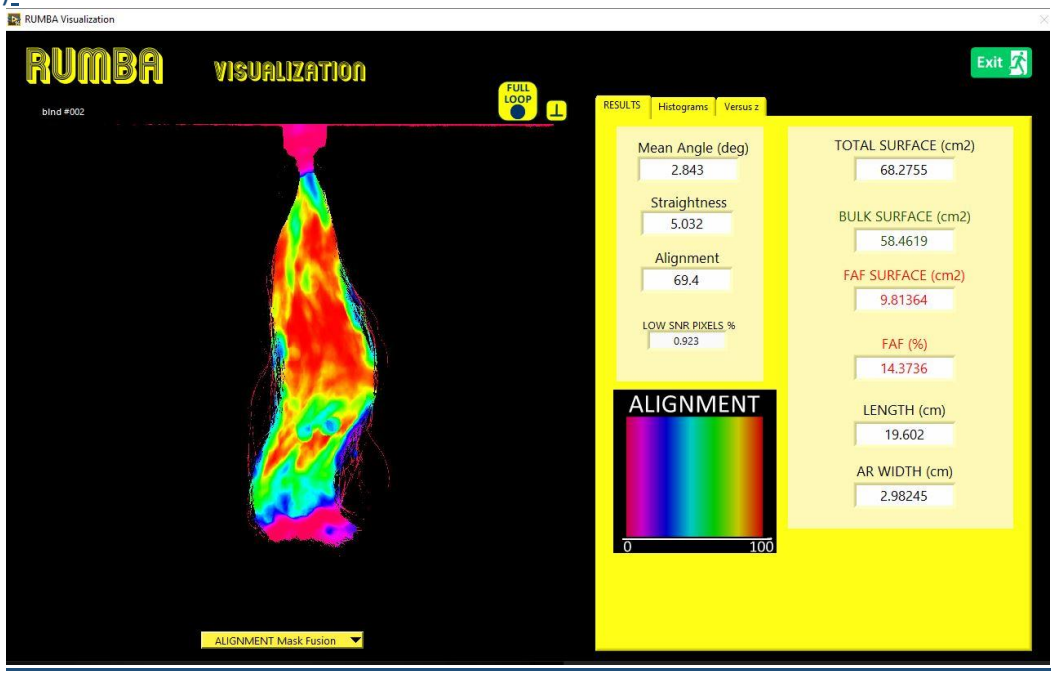


Figure 224: RUMBA Data Visualization

On the left of the visualization window is the image visualization. On the right are the data and graph. Under the image is an image selector (Figure 225)

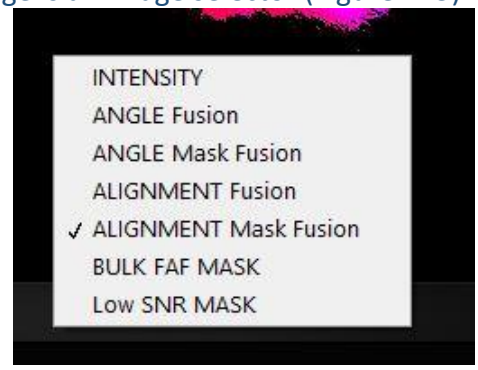


Figure 225: Image selector

The user can select between 7 images.

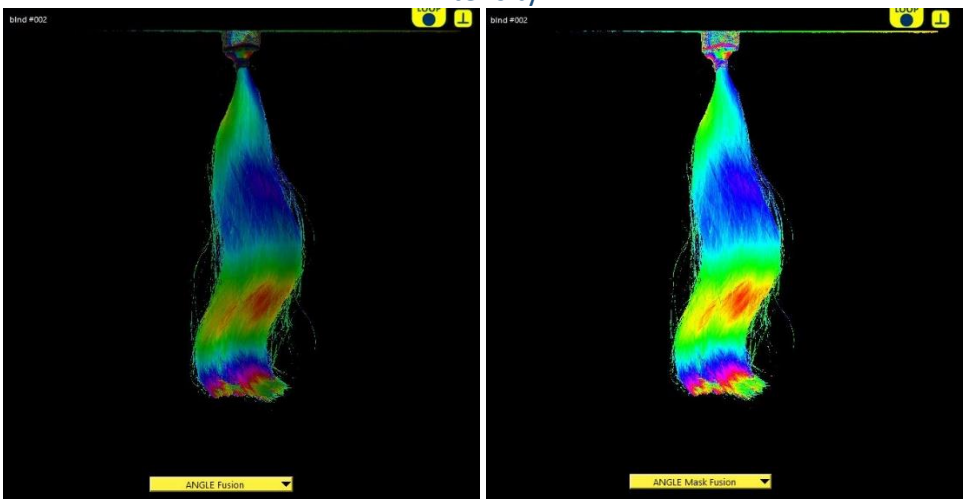
- INTENSITY is the average of the N raw images acquired
- ANGLE Fusion is the angle image color coded.
- ANGLE Mask Fusion is the angle image color coded where the pixel level is set at 255 (mask)
- ALIGNMENT Fusion is the alignment image color coded
- ALIGNMENT Mask Fusion is the alignment image color coded where the pixel level is set at 255 (mask)

- BULK FAF MASK is the BOLERO type image where the bulk is depicted in Green and the fly-away Frizz is red.
- Low SNR MASK is the image where the pixel are set at 255 when the SNR is larger than the threshold defined in the ini file.

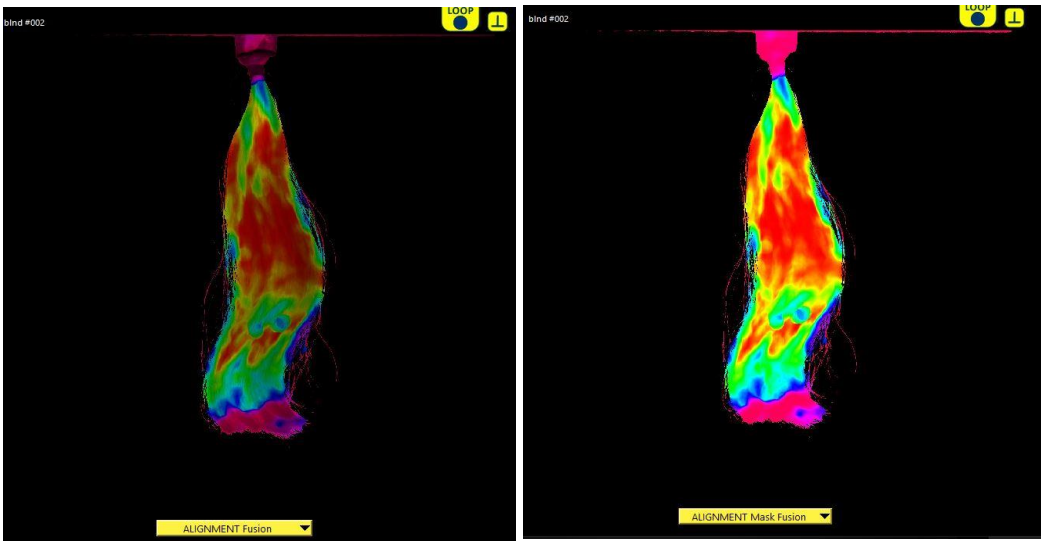
The different images are presented on Figure 226.



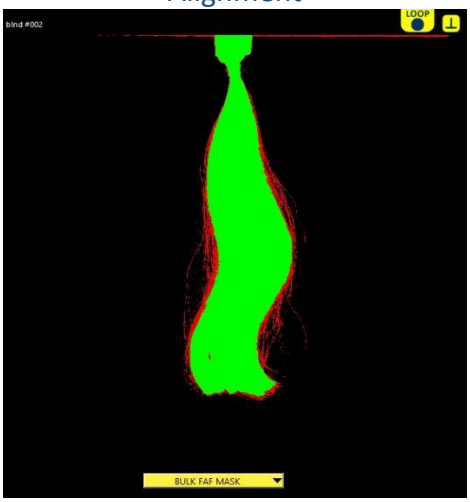
Intensity



Angle



Alignment



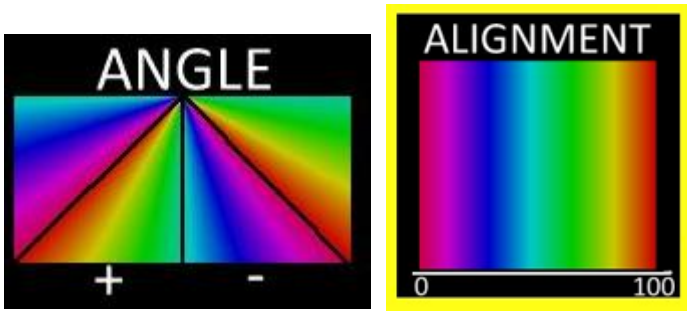
BUL FAF (~BOLERO)



SNR

Figure 226: images

Color code are shown on the right of the image (Figure 227).



Angle Alignment

Figure 227: COLOR CODE

The RESULTS tab shows the main output data (Figure 228).

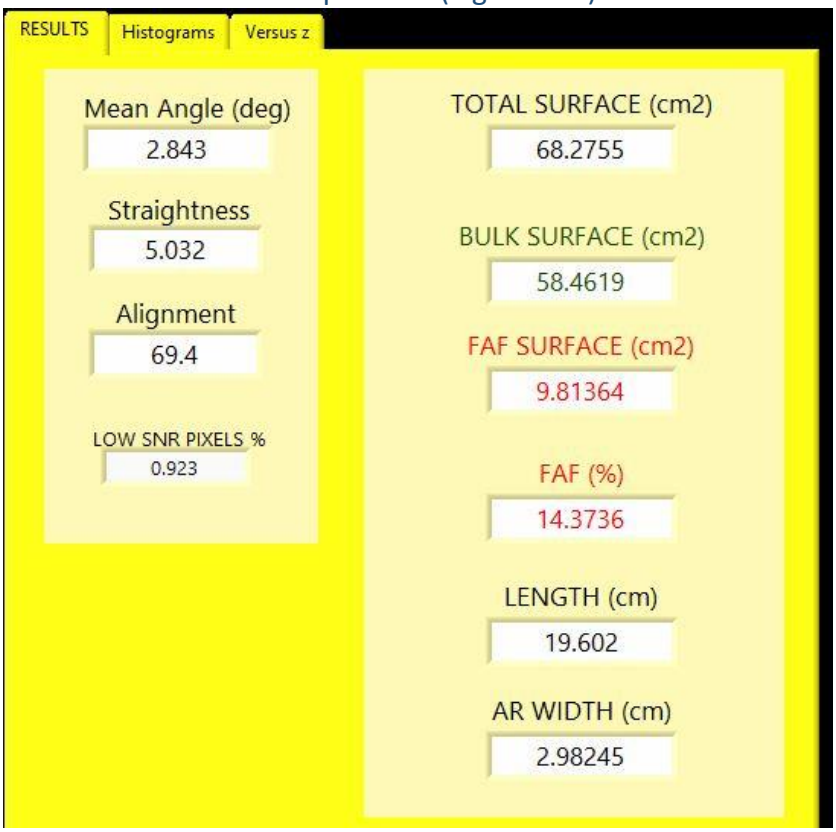


Figure 228: Results

The mean angle (deg) is the average angle of the total hair swatch.
The straightness (from 0 to 100%) quantifies the angle distribution inside the hair swatch. If the hair swatch is straight (all the pixels have similar angle), straightness is 100%. If the hair swatch is an ethnic hair swatch where the individual fibers are going in every direction, straightness is 0%.
Alignment is the LOCAL straightness allowing to quantify non straight swatches that are still organized and styled i.e. locally the fibers are aligned. Alignment varies from 0 to 100%.

A straight swatch will also have a high alignment. On the right are the data delivered by the “BOLERO” measurement (Total surface, bulk surface, etc.). Figure 229 shows the histogram of the Angle and alignment images.

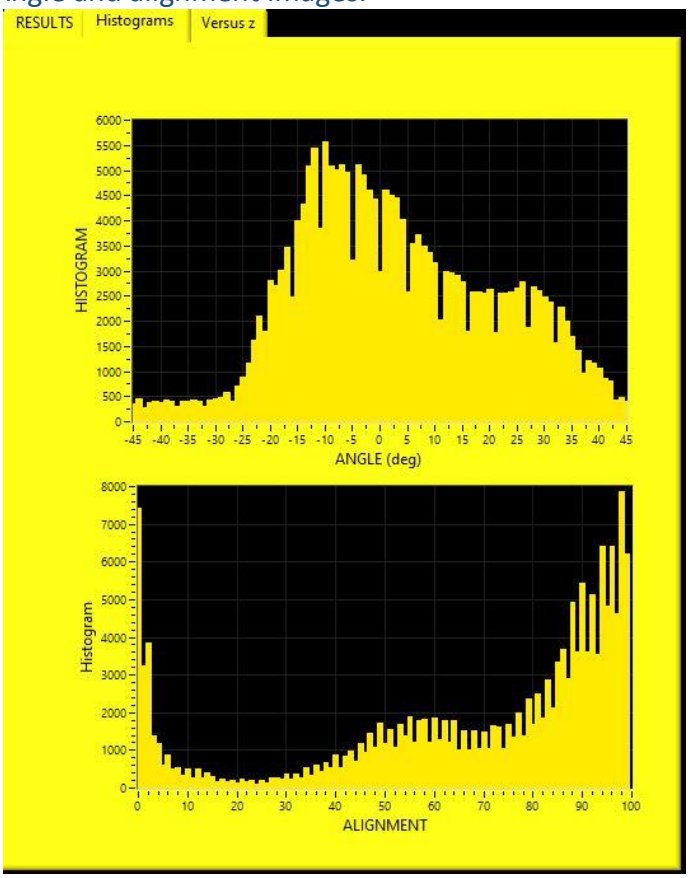


Figure 229: Histogram of Angle and alignment image

The last tab – versus z – shows the variation of the angle, straightness and alignment along the vertical z axis (Figure 230).

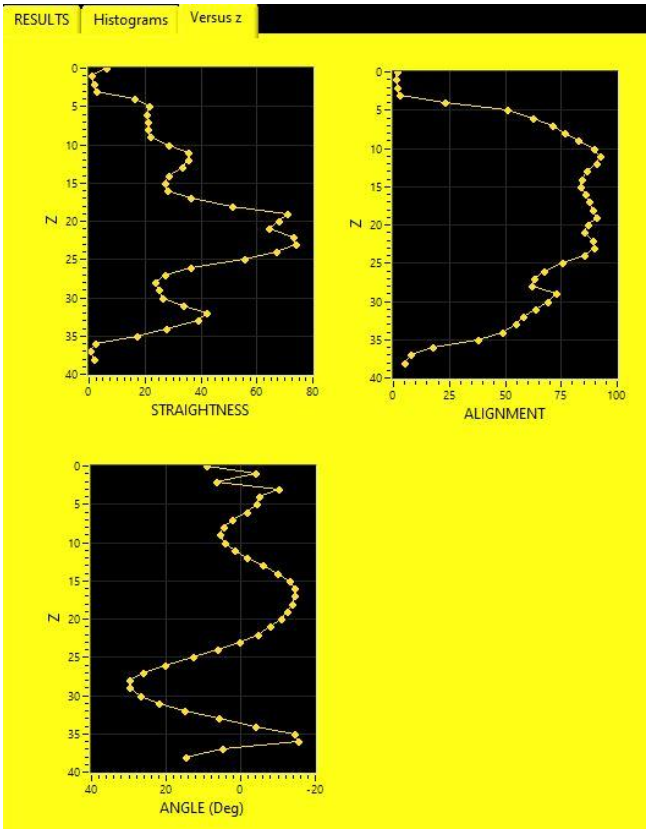


Figure 230: Variations along vertical axis z

7. DATA ANALYSIS

7.1. BOLERO TRIO/WIDE 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 231) and the selected measurements are added to the loaded measurement list.



Figure 231: 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 232).

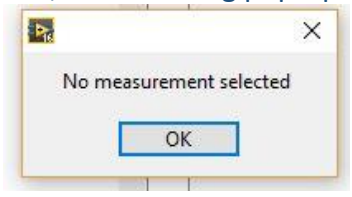


Figure 232: No measurements selected

If some selected measurements are not processed, the following message appears and no measurement are loaded (Figure 233).



Figure 233: 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 234).



Figure 234: Measurements displayed

If the user selects more than 12 loaded measurements to be displayed, the following dialog box pops-up (Figure 235).

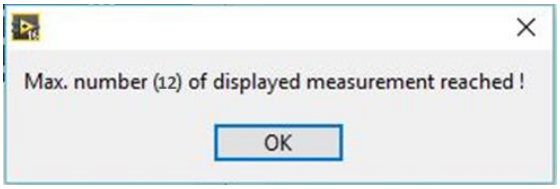


Figure 235: More than 12 loaded measurements selected – Dialog box

The Results table is now visible and populated with the corresponding measurement and values and the Export Results control 

is now visible on the bottom right of the window. The tab selection (Figure 236) is explained in the following.



Figure 236: Tab selection for single image results

7.1.1. Results

The results tab shows 2 tables that summarize the various parameters calculated (Figure 237).

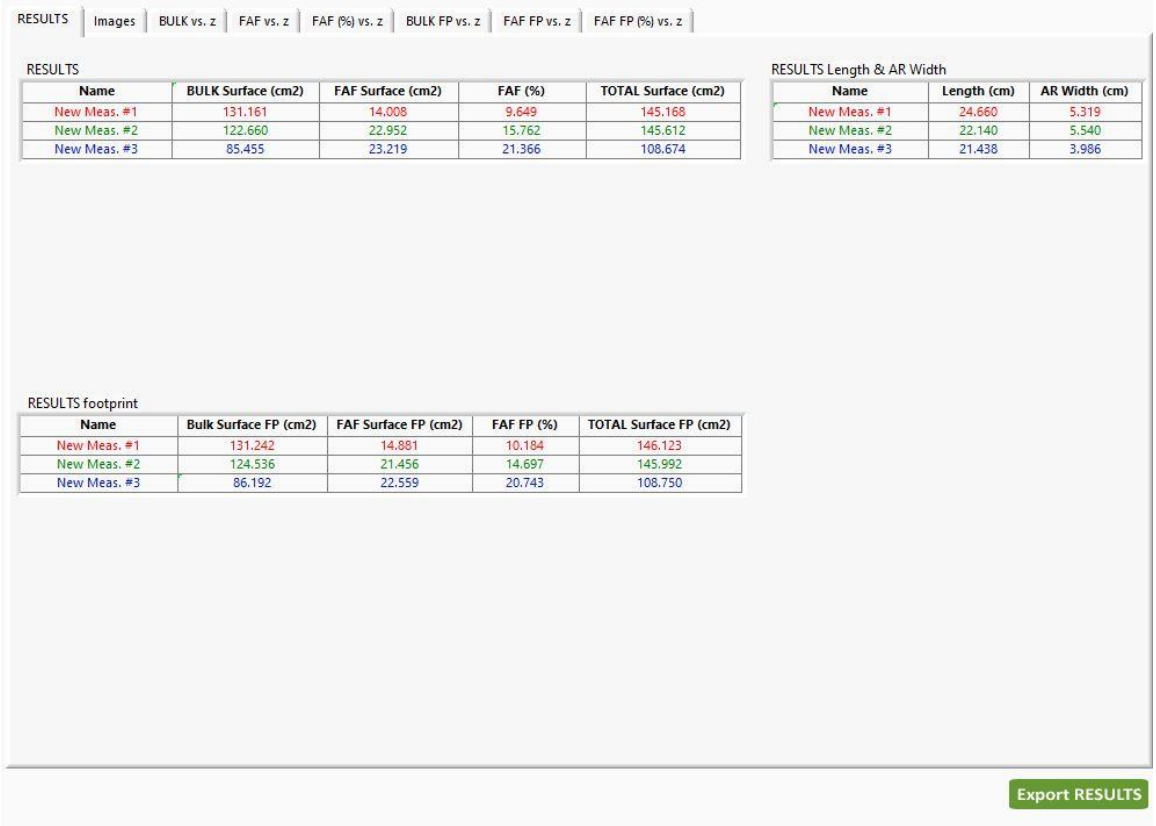


Figure 237: Results table

The first table named RESULTS has 5 columns:

- Measurement Name
- BULK Surface (cm^2)
- FAF Surface (cm^2)
- FAF (%)
- Total Surface (cm^2)

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 (cm^2)
- FAF Surface Foot Print (cm^2)
- FAF Foot Print (%)
- Total Surface Foot Print (cm^2)

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)

7.1.1.1. 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 Control 

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

is activated, both tables are updating (Figure 238).

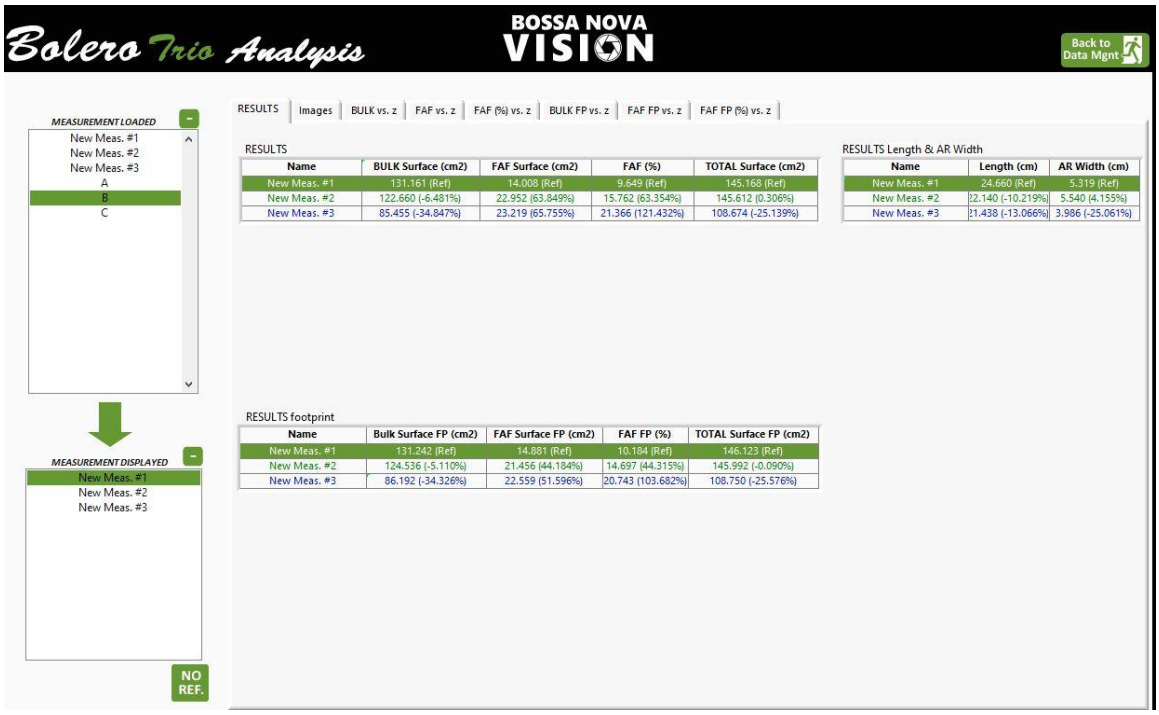


Figure 238: Reference measurement

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 239).

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 239: Reference

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

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 240).

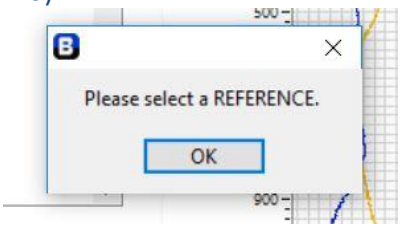


Figure 240: Pop-up message – No displayed measurement selected

7.1.1.2. 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 241).

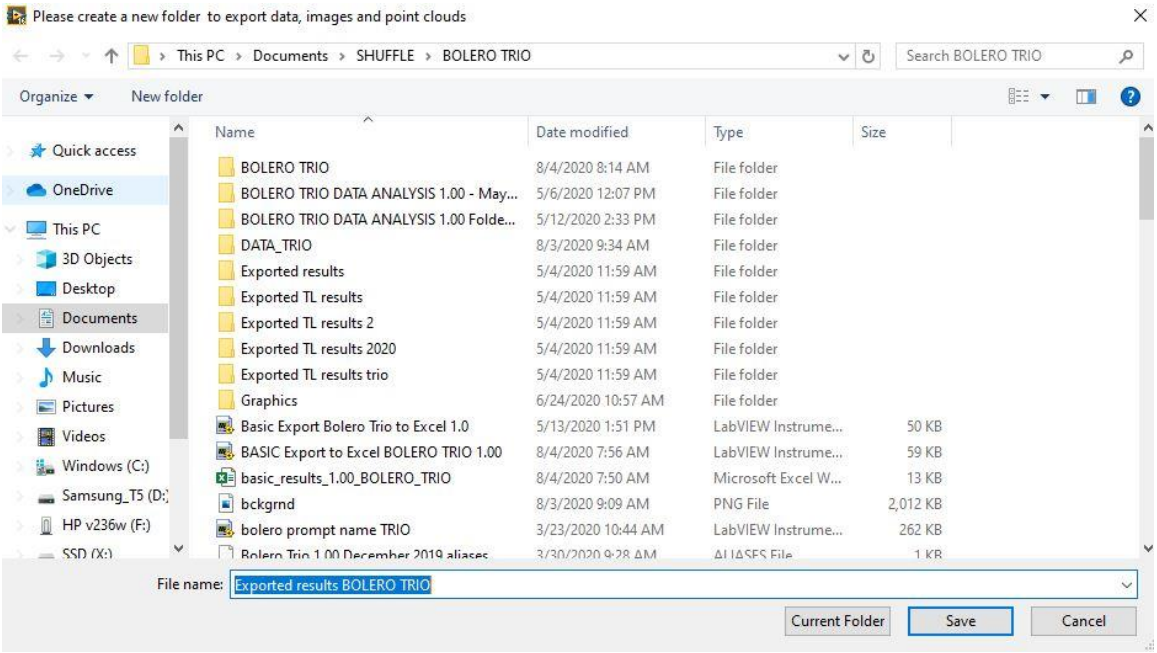


Figure 241: Pop-up message – Export Results

The name of the folder to be saved is already populated – Exported Results BOLERO TRIO – but can be changed, along with the destination (Figure 242).



Figure 242: Export Folder

Inside the folder are an Excel file named Results and a folder named Pictures (Figure 243).

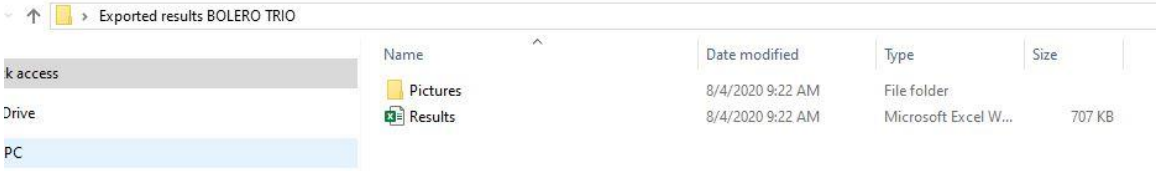


Figure 243: Exported Results Folder contents

The Pictures folder contains 4 images for each measurement (Figure 244) 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_bulkfaffpmask_#.jpg

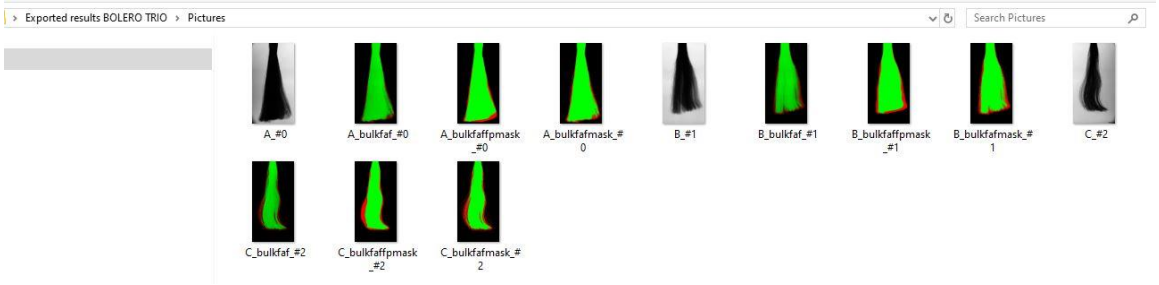


Figure 244: Images exported

The excel file RESULTS contains the tables and all the graphs visualized in the data analysis tab (Figure 245).

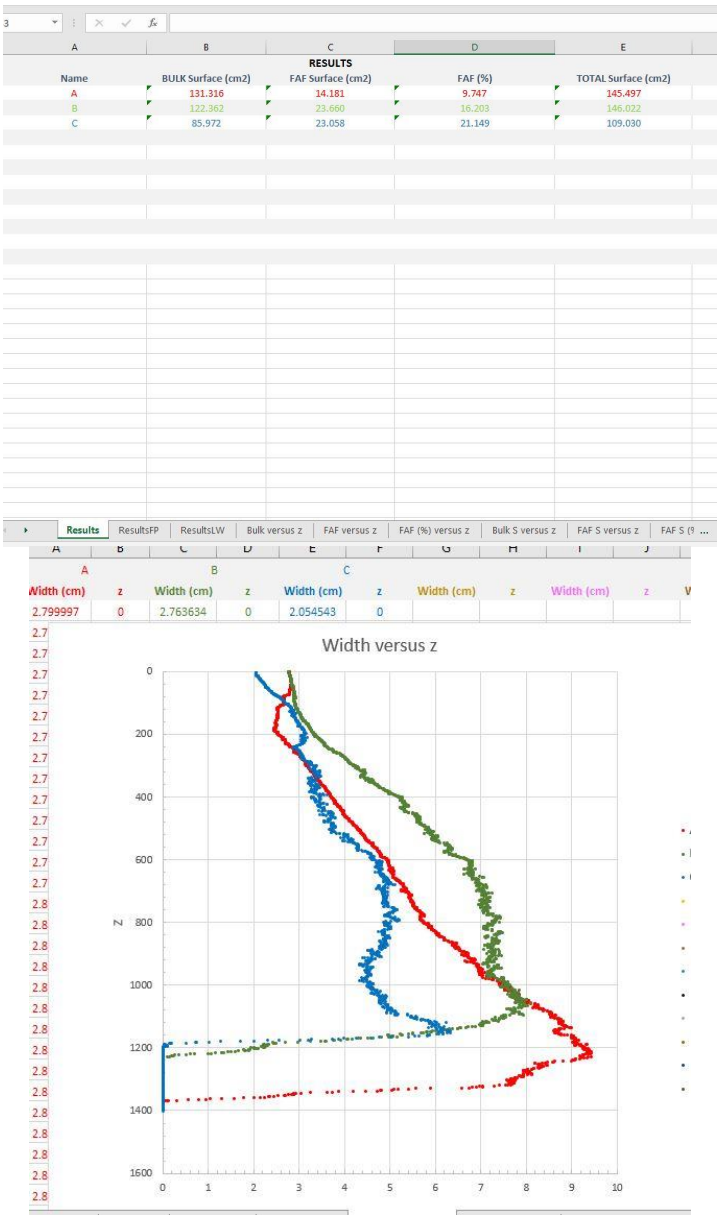


Figure 245: Results excel file

7.1.2. Images

The images tab allows the user to visualize the images from each measurement (Figure 246).

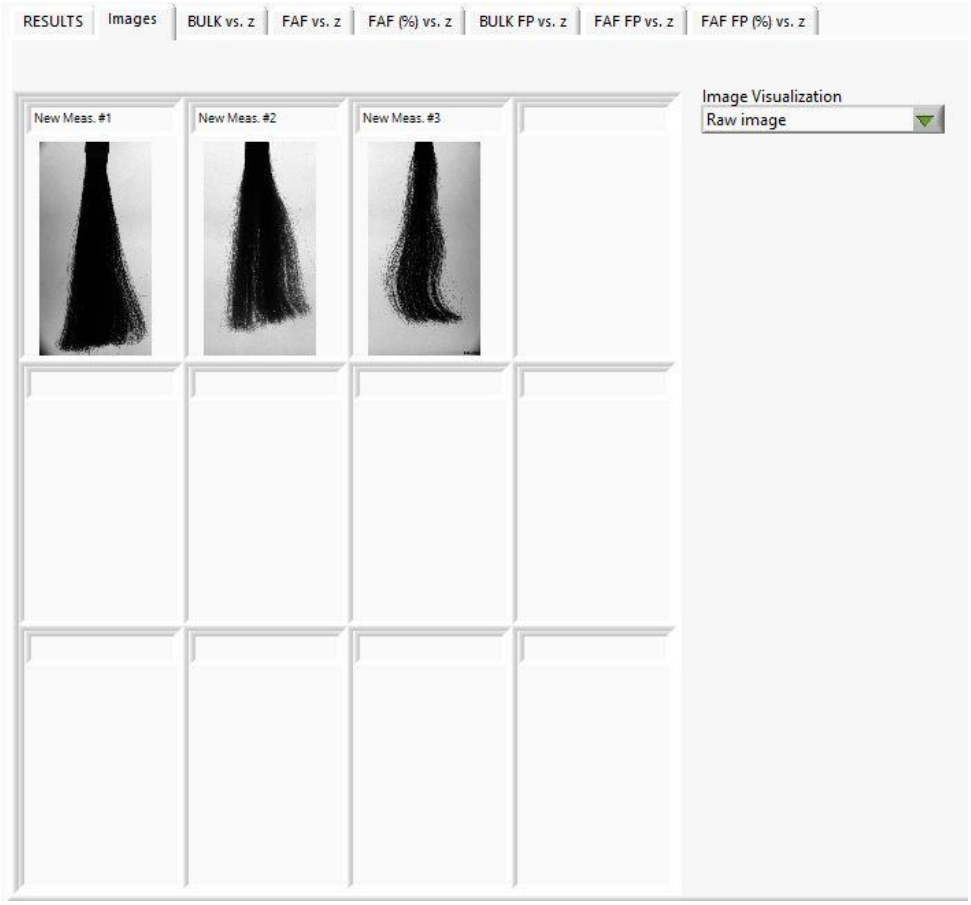
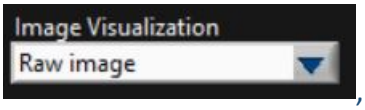


Figure 246: Images

Using the image control located under the live image 

, the user can visualize the different images (Figure 247).

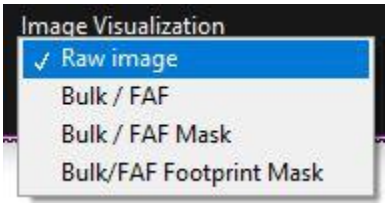


Figure 247: Various possible image

7.1.3. 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 248).

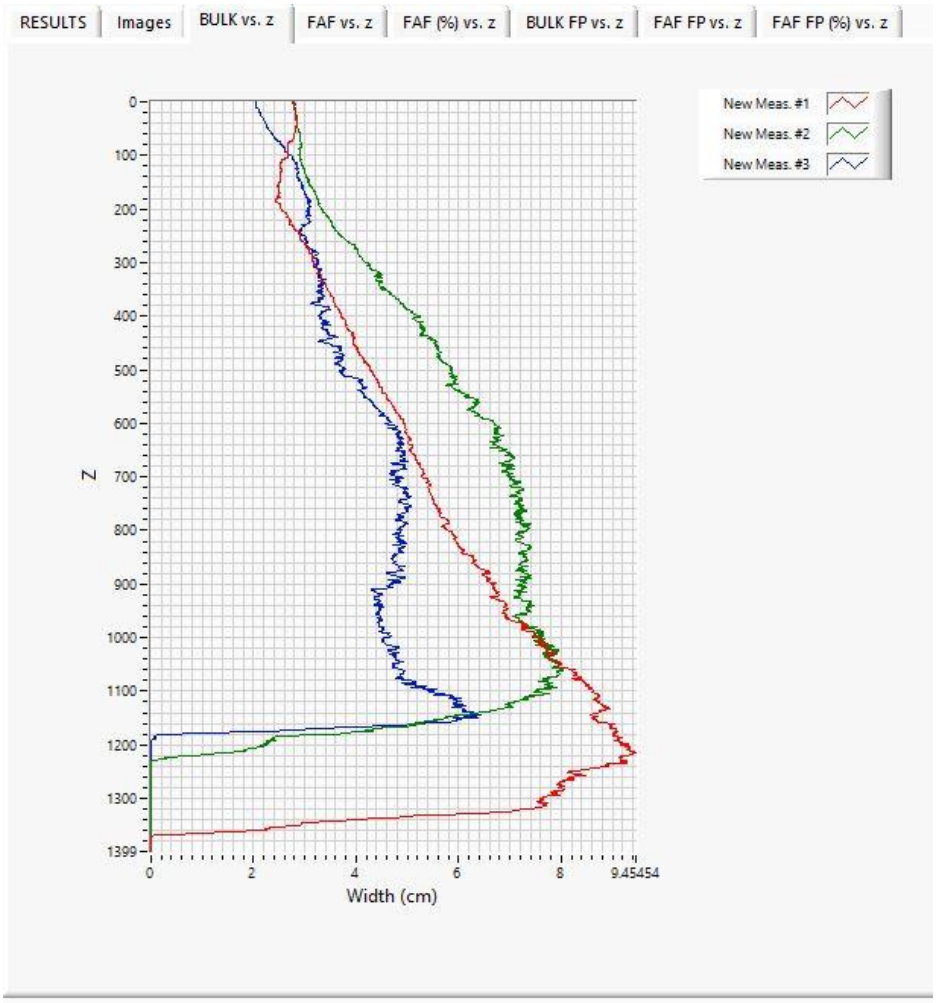


Figure 248: Bulk versus z graph

7.1.4. 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 249).

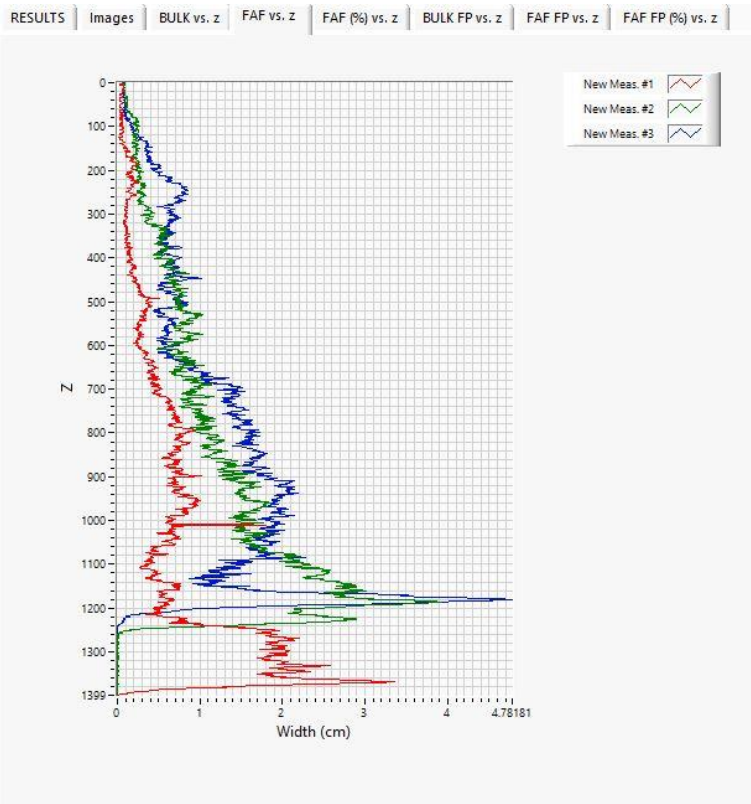


Figure 249: FAF versus z graph

7.1.5. FAF (%) versus z

The FAF (%) vs. z tab presents a graph showing the showing the evolution of the FAF % versus z for each measurement (Figure 250).

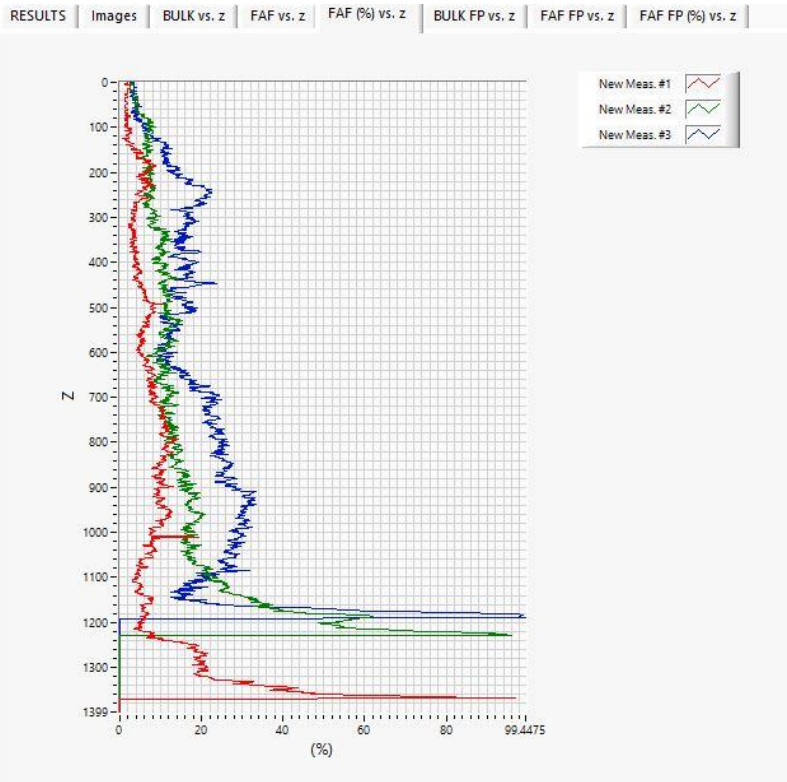


Figure 250: FAF % versus z graph

7.1.6. 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 251).

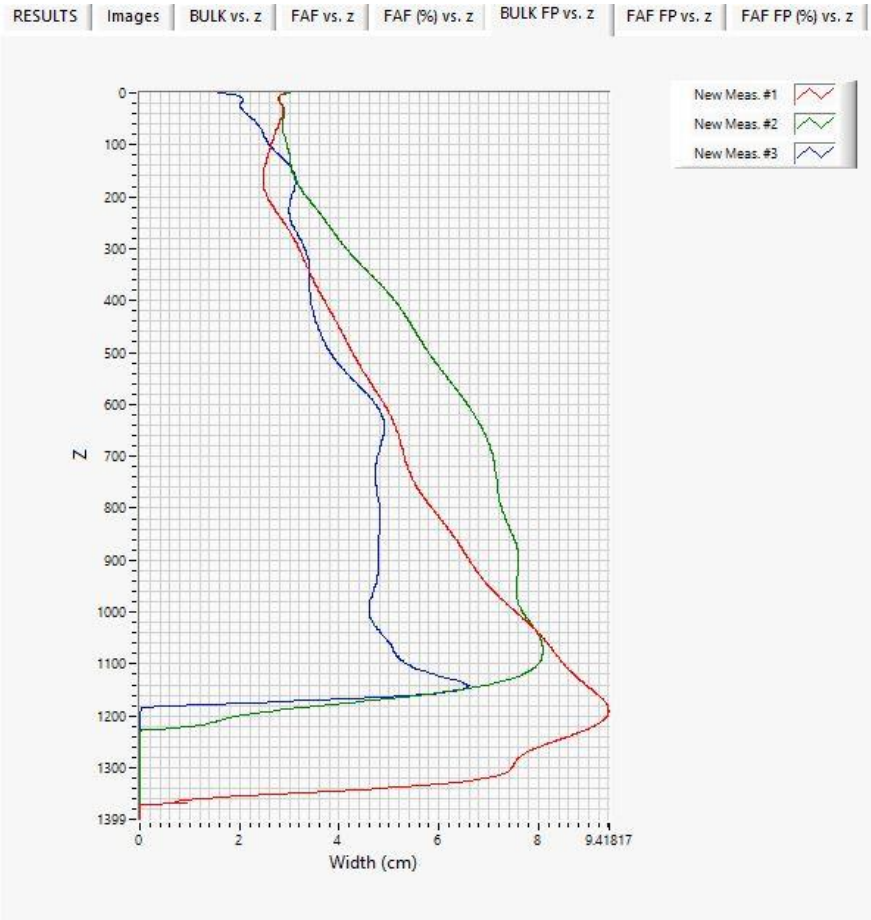


Figure 251: Bulk Foot Print versus z graph

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

7.1.7. 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 252).

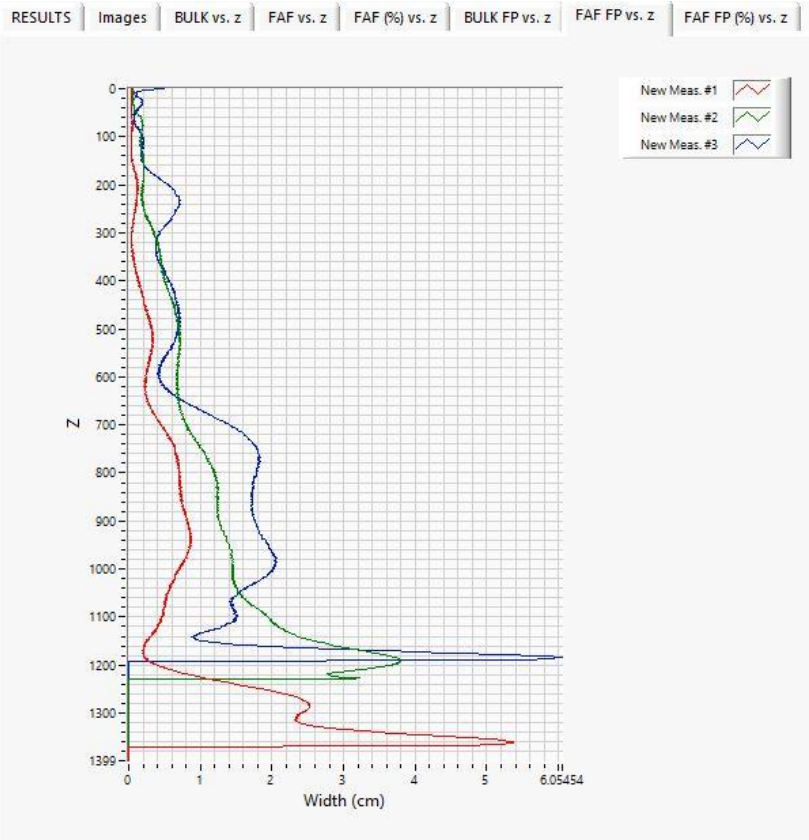


Figure 252: FAF Foot Print versus z graph

7.1.8. 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 253)

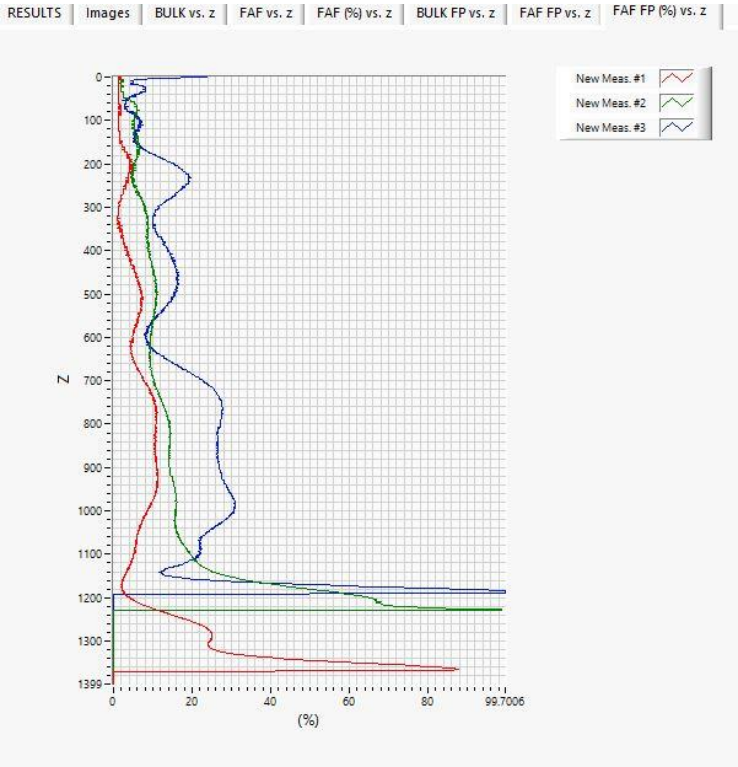


Figure 253: FAF FootPrint % versus z graph

7.2. BOLERO 360 DATA ANALYSIS

If the user clicks on **Load measurement to Data Analysis** 

while one or more measurements are selected, **Data Analysis windows opens** (Figure 254) and the selected measurements are added to the loaded measurement list.

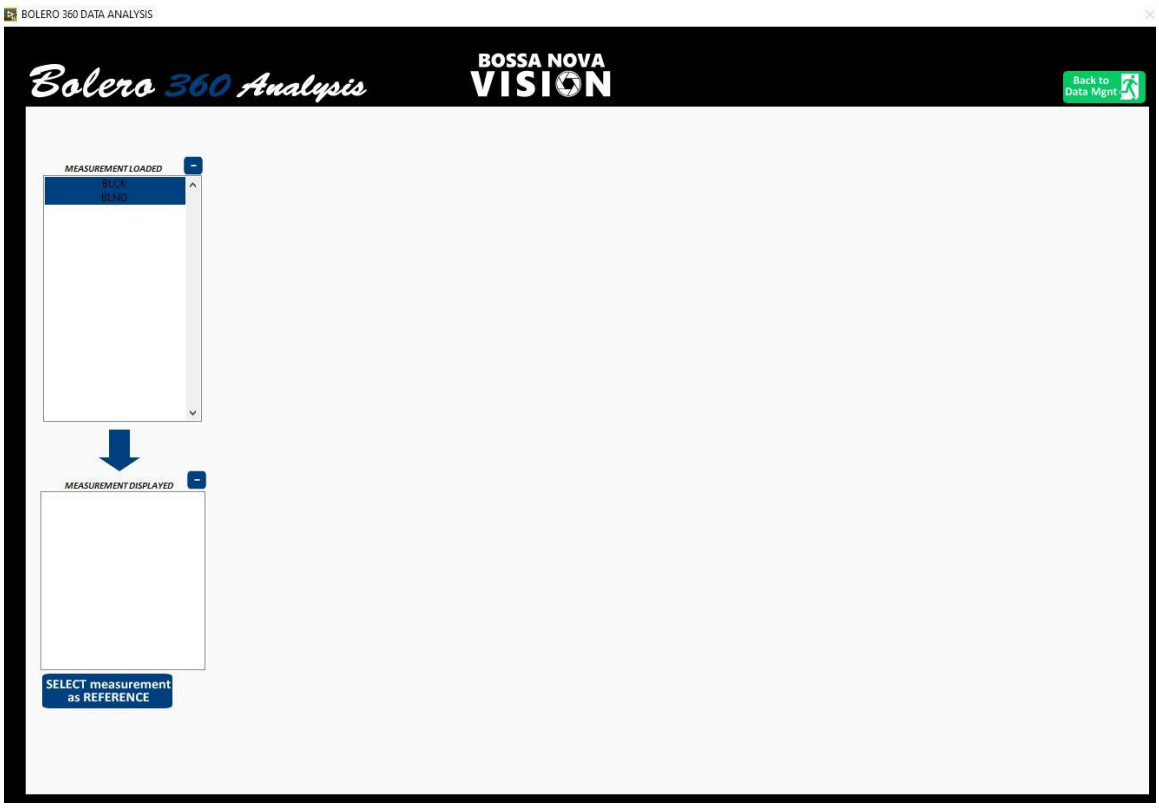


Figure 254: Data analysis – Measurements loaded

If no measurements are displayed, the tab result on the left is not visible.
If no measurements were selected, the following pop-up window appears (Figure 255).

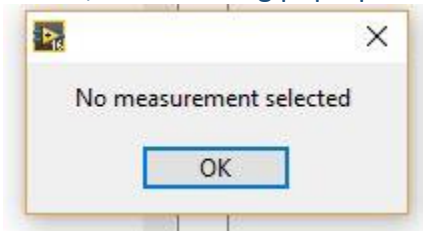


Figure 255: No measurements selected

If some selected measurements are not processed, the following message appears and no measurement are loaded (Figure 256).

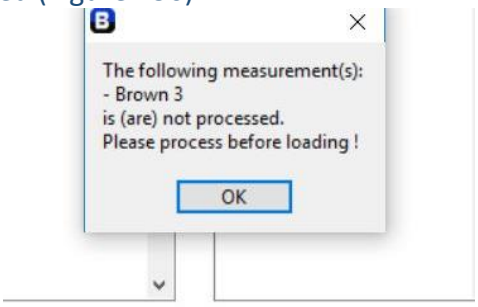


Figure 256: Pop-up message – Unprocessed measurements

A number of measurements are selected and they appear in the Measurements Loaded list (Figure 254). The software will also eliminate automatically any duplicate.
2 lists are present:

- **Measurements loaded**
- **Measurement displayed**

To display the loaded measurements, select them and click on the arrow  . Up to 12 measurements can be displayed. The tab results on the right side of the window appears (Figure 257).

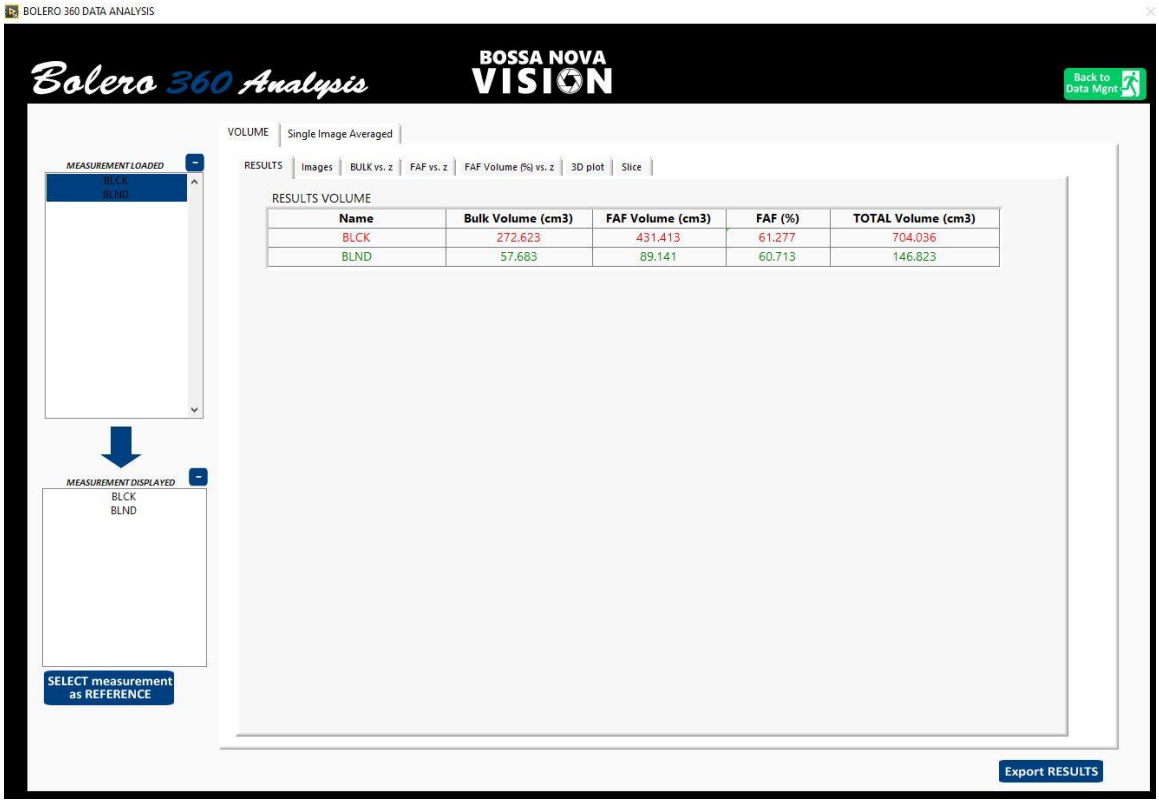


Figure 257: Measurements displayed

The Results table are now populated with the corresponding measurement and values and the Export Results control  is now visible on the bottom right of the window.

The data analysis for BOLERO 360 is decomposed into 2 tabs: Volume and Single Image averaged (Figure 258).

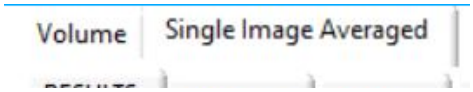


Figure 258: Volume/Single image averaged tab

The single image averaged tab is the same as the BOLERO WIDE/TRIO, with the exception of that all the calculations are AVERAGED over the 36 measurements and the images displayed are the images at 0 degree angle (Figure 259).
For more information, please refer to BOLERO TRIO/WIDE DATA ANALYSIS.

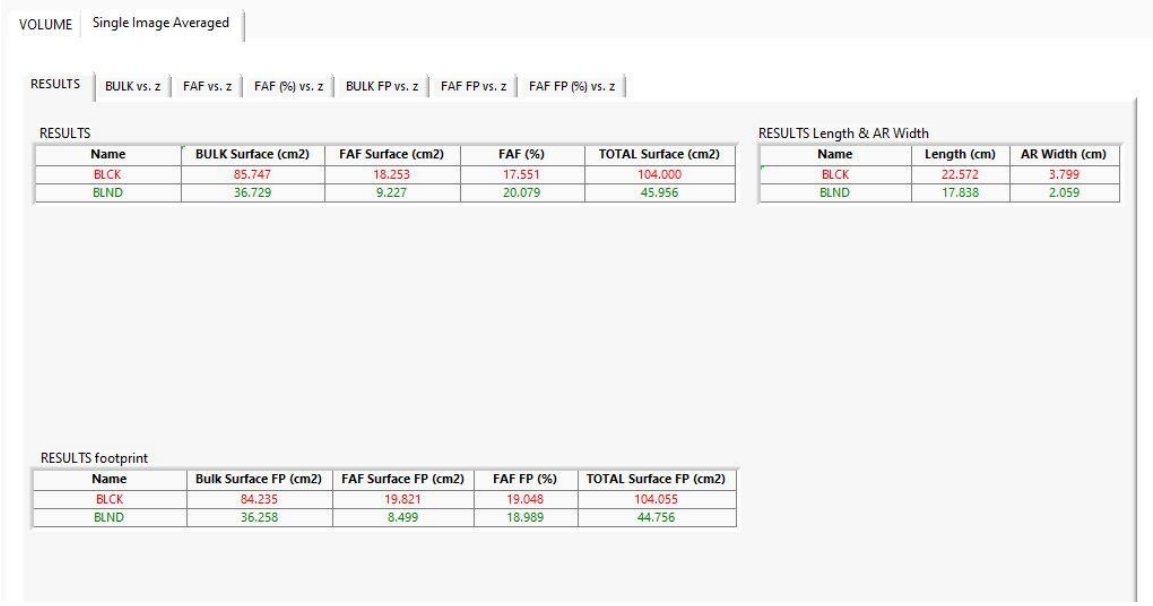


Figure 259: Single Image averaged (Results)

The volume tab presents the information related to the volume and the 3D reconstruction of the bulk and FAF. It is explained in detail below.

7.2.1. Results

The results tab shows one table that summarizes the various parameters calculated (Figure 260).

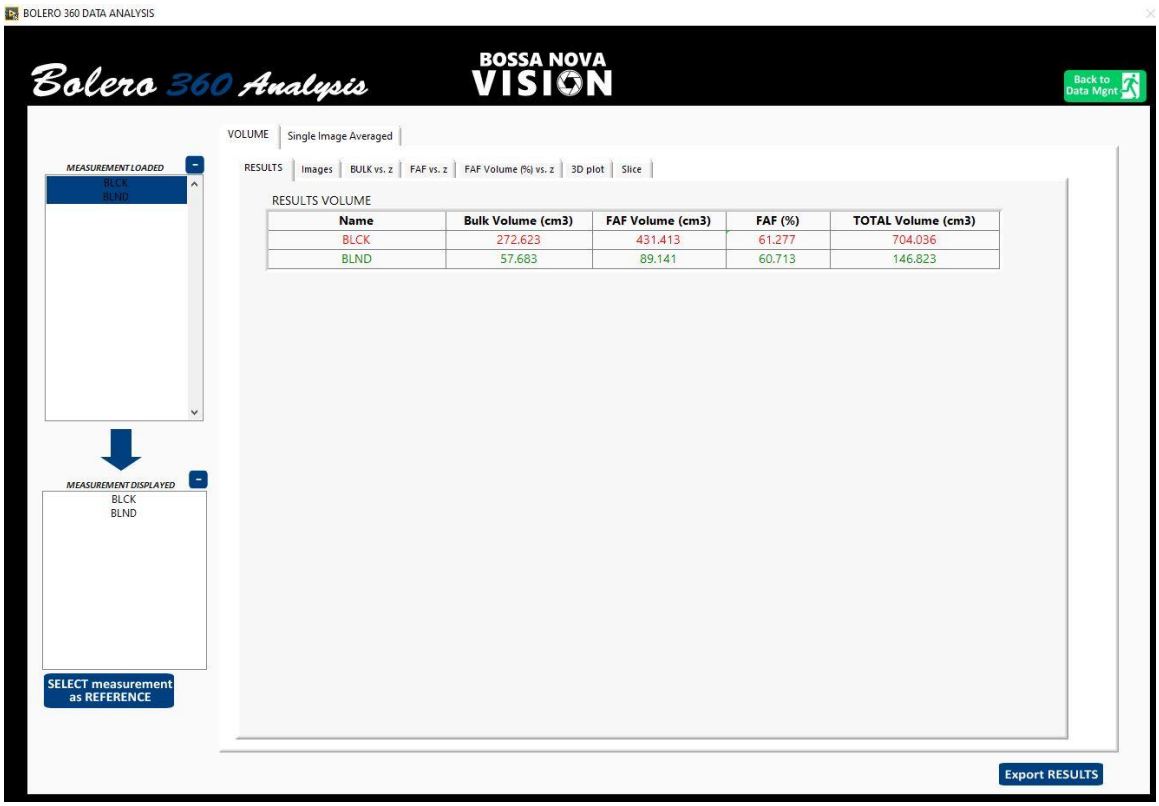


Figure 260: Results Table

The table named RESULTS VOLUME has 5 columns:

- Measurement Name
- BULK Volume (cm^3)
- FAF Volume (cm^3)
- FAF (%)
- Total Volume (cm^3)

BULK Volume and FAF Volume are the Volume occupied by the BULK and the FAF. Total Volume is the sum of the BULK Volume and the FAF Volume. 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.

7.2.1.1. Reference

Similar to BOLERO TRIO and BOLERO WIDE, the user can select a reference measurement.

Click on SELECT measurement as REFERENCE and have the results tables updated (Figure 261).

RESULTS VOLUME

Name	Bulk Volume (cm3)	FAF Volume (cm3)	FAF (%)	TOTAL Volume (cm3)
BLCK	272.623 (Ref)	431.413 (Ref)	61.277 (Ref)	704.036 (Ref)
BLND	57.683 (-78.841%)	89.141 (-79.337%)	60.713 (-0.920%)	146.823 (-79.146%)

Results Volume

RESULTS Slice

Name	BULK Surface (cm2)	FAF Surface(cm2)	TOTAL Surface (cm2)
BLCK	7.982 (Ref)	3.455 (Ref)	11.438 (Ref)
BLND	3.359 (-57.918%)	1.969 (-43.010%)	5.328 (-53.418%)

Results Slice

Figure 261: Reference

7.2.1.2. Export Results

The Export RESULTS control Export RESULTS 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 262).

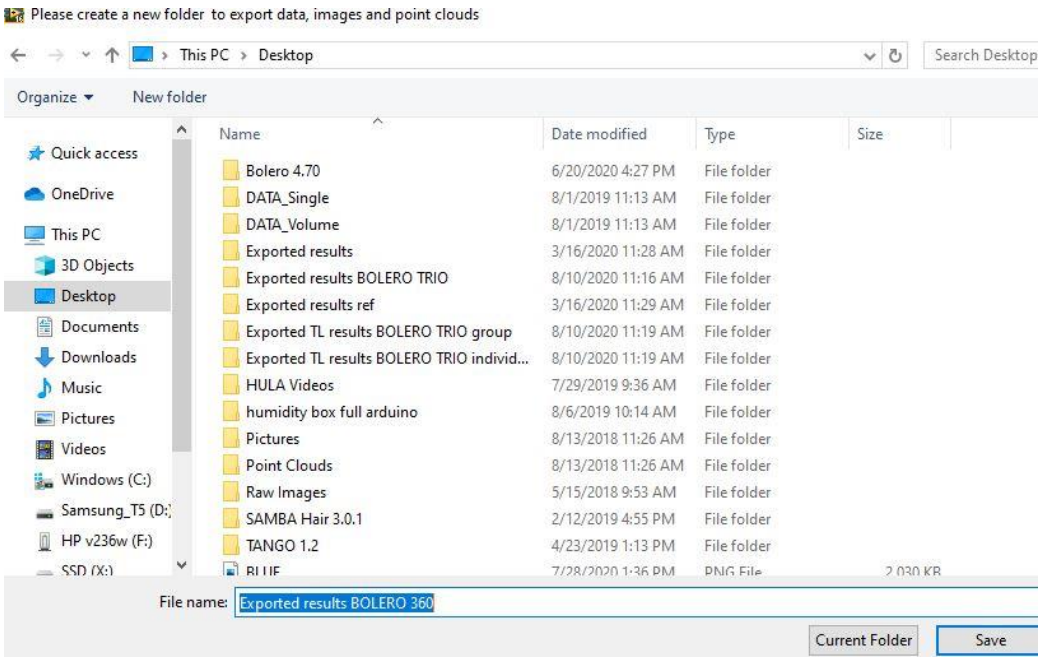


Figure 262: Pop-up message for export

The name of the folder to be saved is already populated – Exported Results BOLERO 360 – but can be changed, along with the destination.
Inside the folder are 3 Excel files respectively named Results SIA, Results Slice and Results Volume, a folder named Pictures and a folder named Point Clouds (Figure 263).

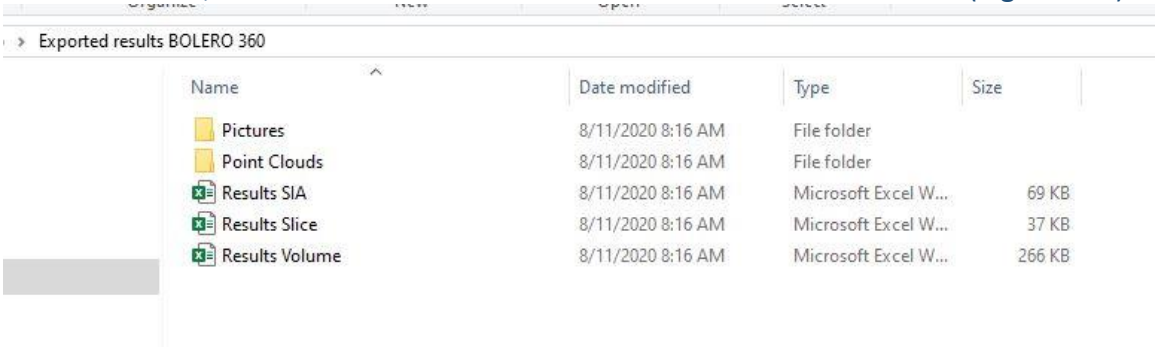


Figure 263: Export results Folder Contents

The Pictures folder contains 4 images for each measurement (Figure 264):

- Raw as measurement name_#.png
- Bulk/FAF as measurement name_bulkfaf_#.jpg
- Bulk/FAF mask as measurement name_bulkfafmask_#.jpg
- Bulk/FAF foot print mask as measurement name_bulkfaffpmask_#.jpg

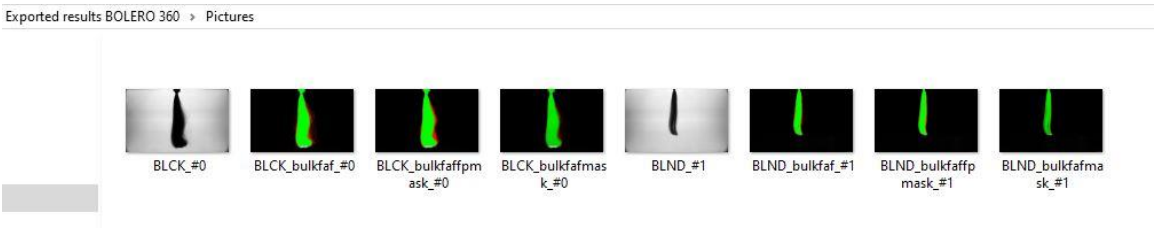


Figure 264: Pictures folder

The images saved correspond to the angle used for the visualization.
The Point Clouds folder contains the point clouds (x,y,z) of the bulk and faf 3D volume saved as text file (Figure 265).

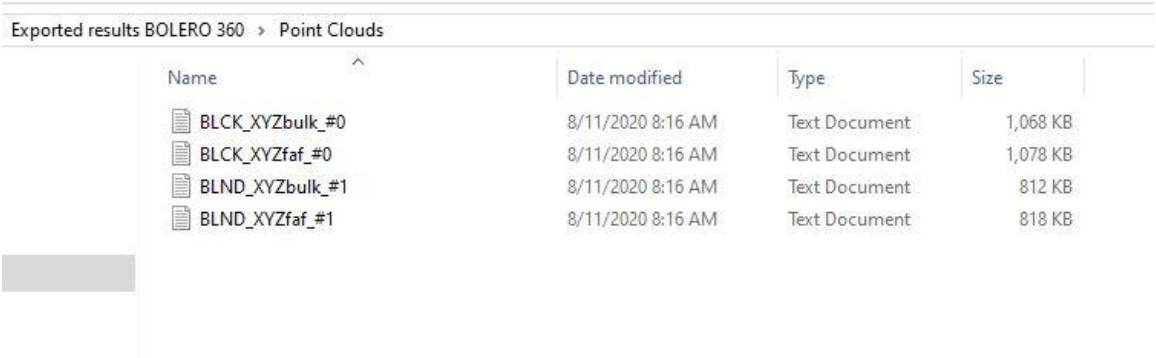


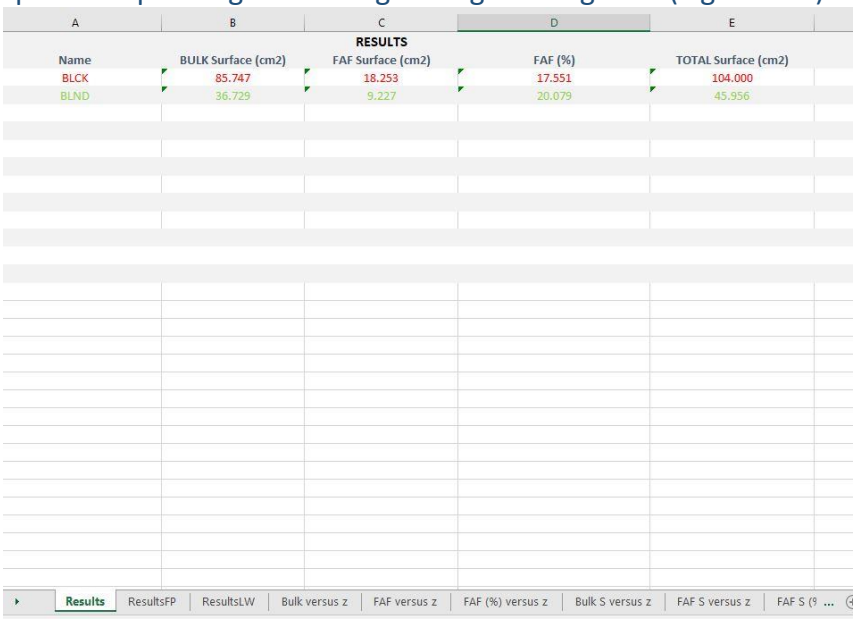
Figure 265: point clouds folder contents

There are 2 point clouds for each measurement:

- Measurement name_#.txt
- Measurement namefaf_#.txt

These file can be open by different 3D visualization software like Meshlab for example.

The Excel file named Result SIA (for Single Image Averaged) presents the table and the different graph corresponding to the Single Image average tab (Figure 266).

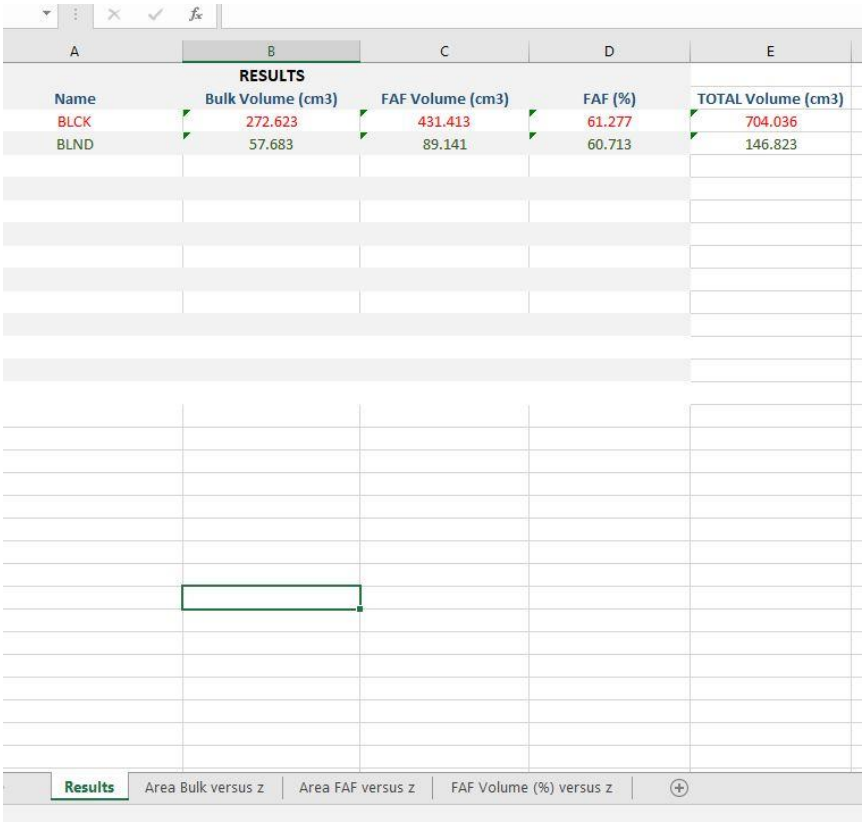


	A	B	C	D	E
			RESULTS		
	Name	BULK Surface (cm2)	FAF Surface (cm2)	FAF (%)	TOTAL Surface (cm2)
	BLCK	85.747	18.253	17.551	104.000
	BLND	36.729	9.227	20.079	45.956

Results | ResultsFP | ResultsLW | Bulk versus z | FAF versus z | FAF (%) versus z | Bulk S versus z | FAF S versus z | FAF S (% ...

Figure 266: Results SIA Excel

The Excel file named Results Volume presents the table and the various graphs from the Volume tab (Figure 267).



	A	B	C	D	E
		RESULTS			
	Name	Bulk Volume (cm3)	FAF Volume (cm3)	FAF (%)	TOTAL Volume (cm3)
	BLCK	272.623	431.413	61.277	704.036
	BLND	57.683	89.141	60.713	146.823

Results | Area Bulk versus z | Area FAF versus z | FAF Volume (%) versus z

Figure 267: Results Volume Excel

The Excel file named Results Slice presents the table and the various graphs from the SLICE tab (Figure 268).

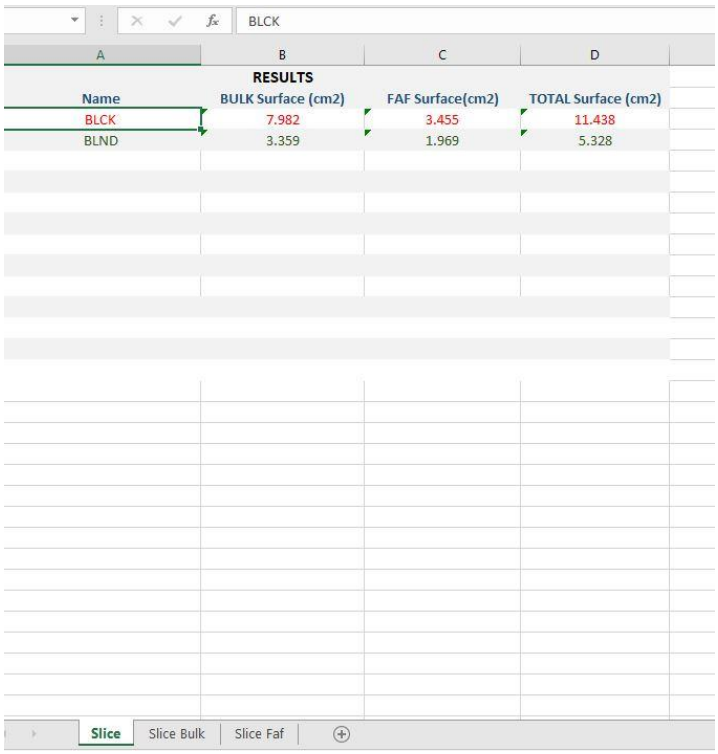


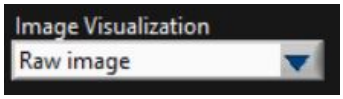
Figure 268: Results Slice Excel

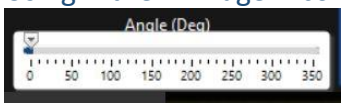
7.2.2. Images

The images tab allows the user to visualize the images from each measurement (Figure 269).



Figure 269: Images tab

Using the image control 

and the angle control 

located under the live image, the user can visualize the different images.

7.2.3. Bulk versus z

The Bulk vs. z tab presents a graph showing the evolution of the BULK surface (in cm^2) versus z for each measurement (Figure 270).

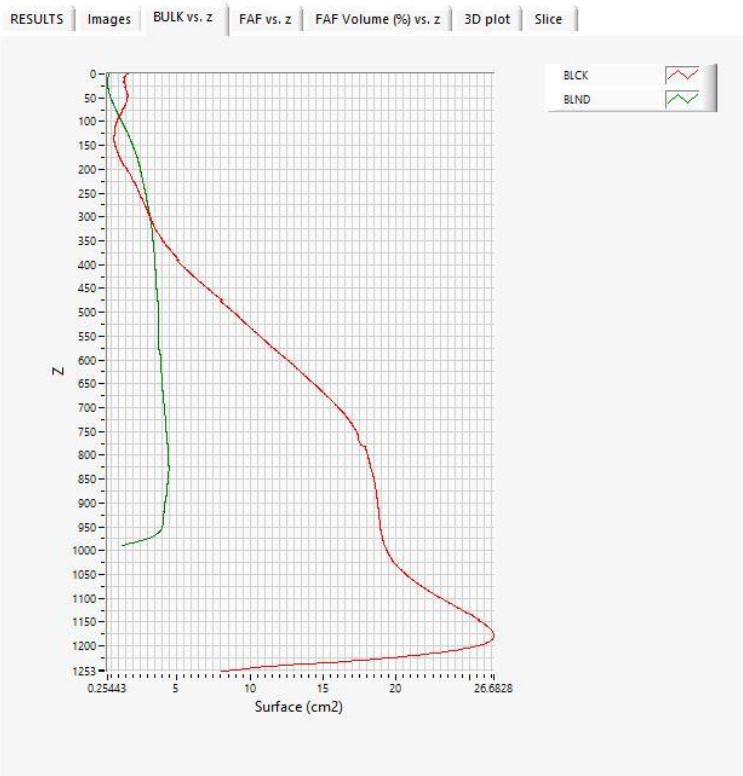


Figure 270: Bulk versus z graph

7.2.4. FAF versus z

The FAF vs. z tab presents a graph showing the evolution of the FAF surface (in cm^2) versus z for each measurement (Figure 271).

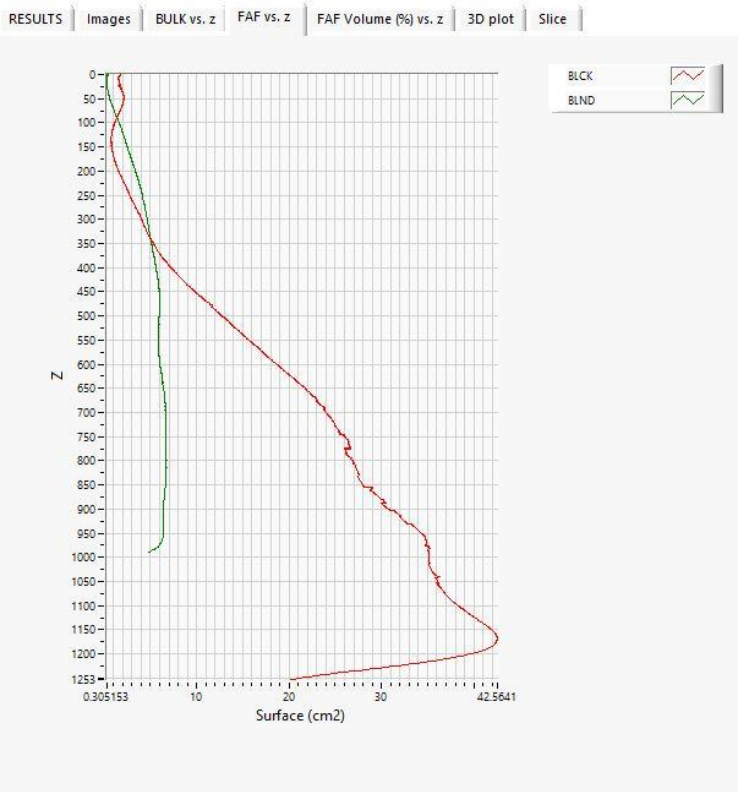


Figure 271: FAF versus z graph

7.2.5. FAF Volume (%) versus z

The FAF Volume % vs. z tab presents a graph showing the evolution of the FAF % versus z for each measurement (Figure 272).

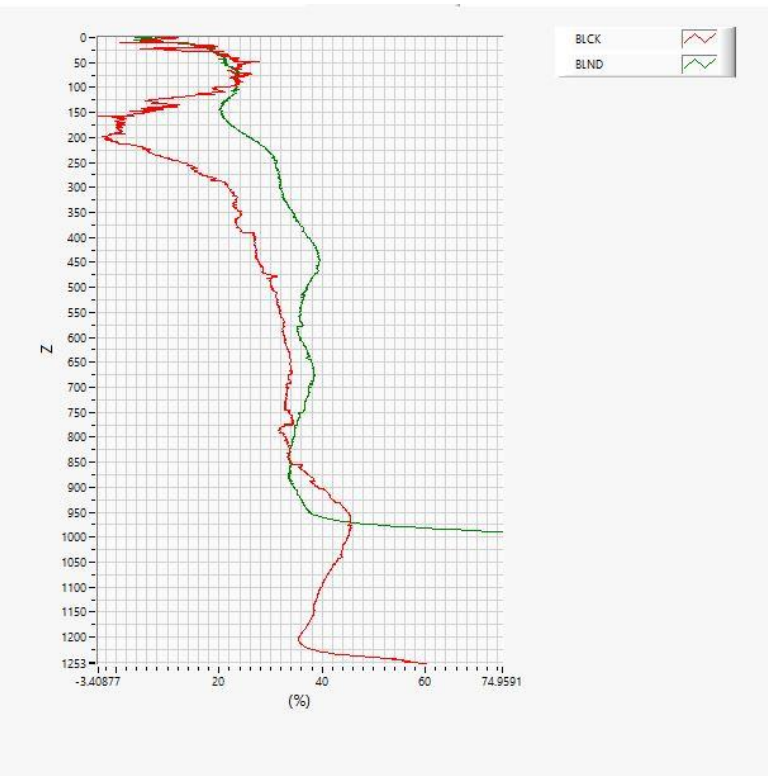


Figure 272: FAF % versus z graph

7.2.6. 3D plot

The 3D plot tab allows the user to visualize the 3D volume of the BULK and FAF. First, the user select one or more displayed measurement(s) and then click on Select Measurements for 3D plot control 

. The corresponding 3D volume(s) appear(s) in the window (Figure 273).

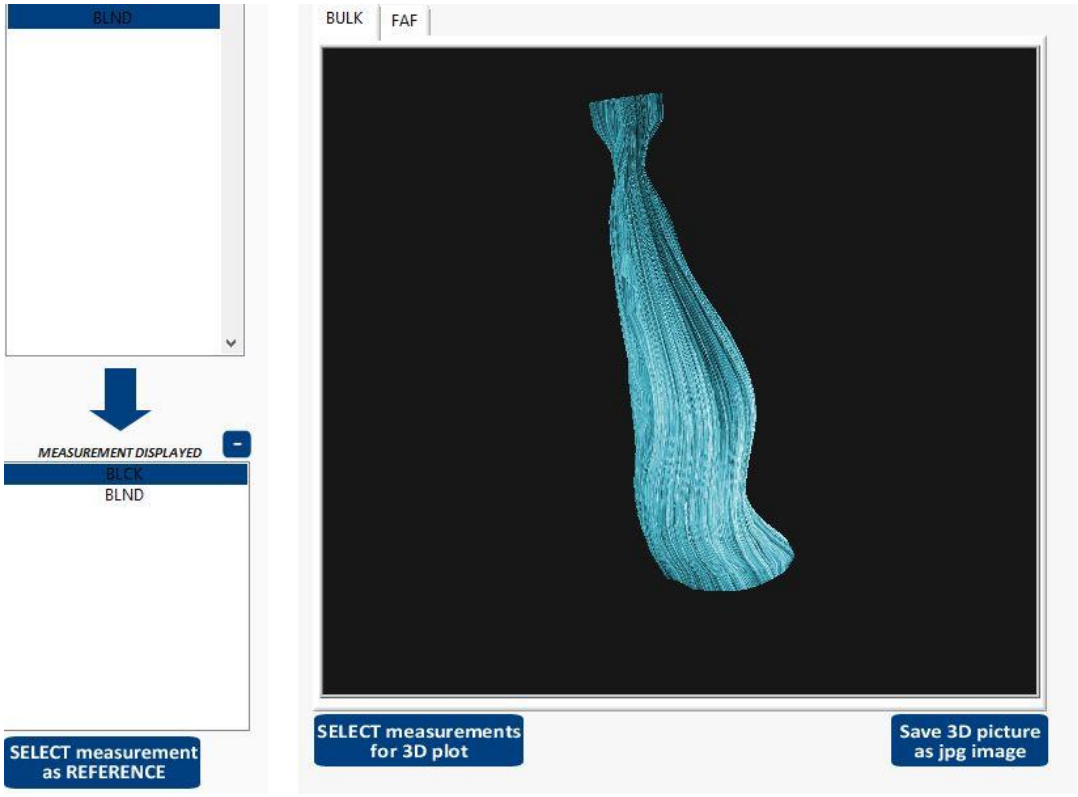


Figure 273: 3D volume – BULK

The user can change the view angle and rotate the 3D volume using the mouse.

Clicking on the FAF tab  allows to visualize the 3D faf (Figure 274).

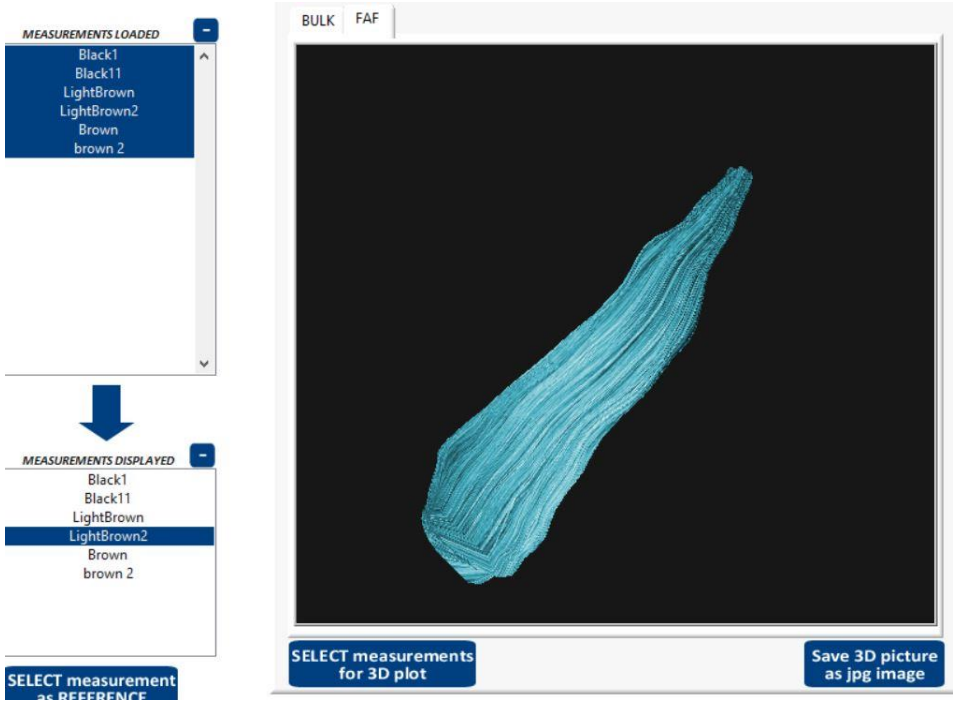


Figure 274: 3D Volume – FAF

Clicking on Save 3D picture as jpg image control 

allows the user to save the corresponding 3D view.

In case the user clicks on Select Measurements for 3D plot control 

without selecting a measurement displayed, the following pop-up message appears (Figure 275).

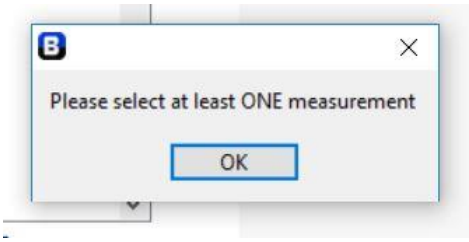


Figure 275: Pop-up message

7.2.7. Slice

The Slice tab allows the user to visualize the slice at z of the BULK and FAF (Figure 276).

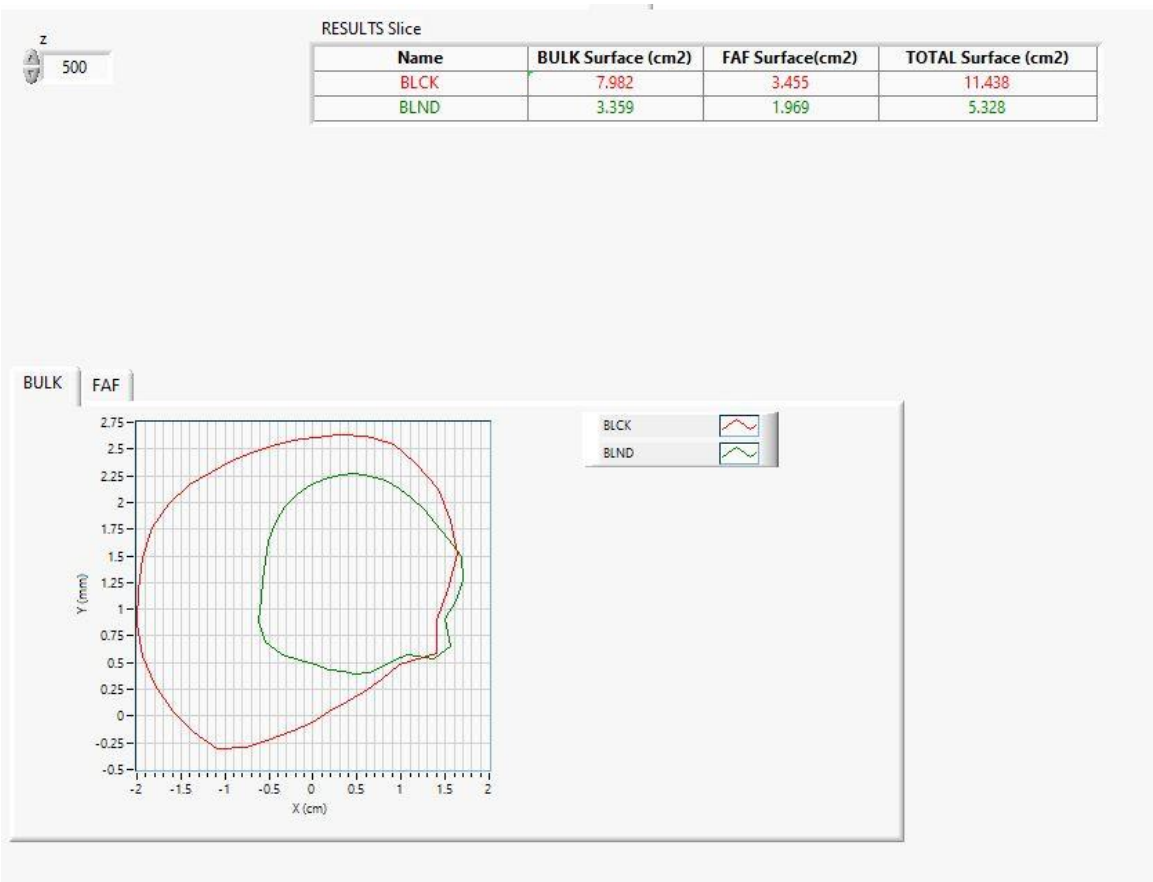


Figure 276: Slice tab

The z control  allows the vertical adjustment of the slice. A table summarizes the surface of the slice for the Bulk, FAF and total for each measurement (Figure 277).

RESULTS Slice

Name	BULK Surface (cm2)	FAF Surface(cm2)	TOTAL Surface (cm2)
Black11	3.601	7.705	11.306
LightBrown	0.871	0.753	1.624
LightBrown2	0.862	0.849	1.712

Figure 277: slice table

The slice of the BULK and FAF are visualized on a XY graph. Clicking on the selection tab  allows to switch between the bulk and the faf (Figure 278).

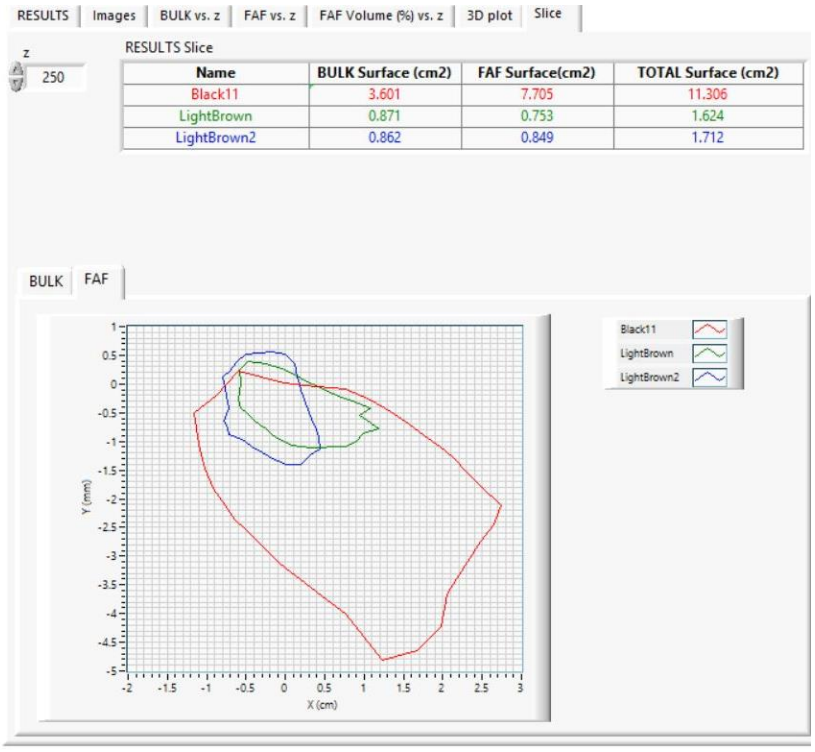


Figure 278: FAF Slice

7.3. HOP 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 279)

and the selected measurements are added to the loaded measurement list, similar to the other softwares.

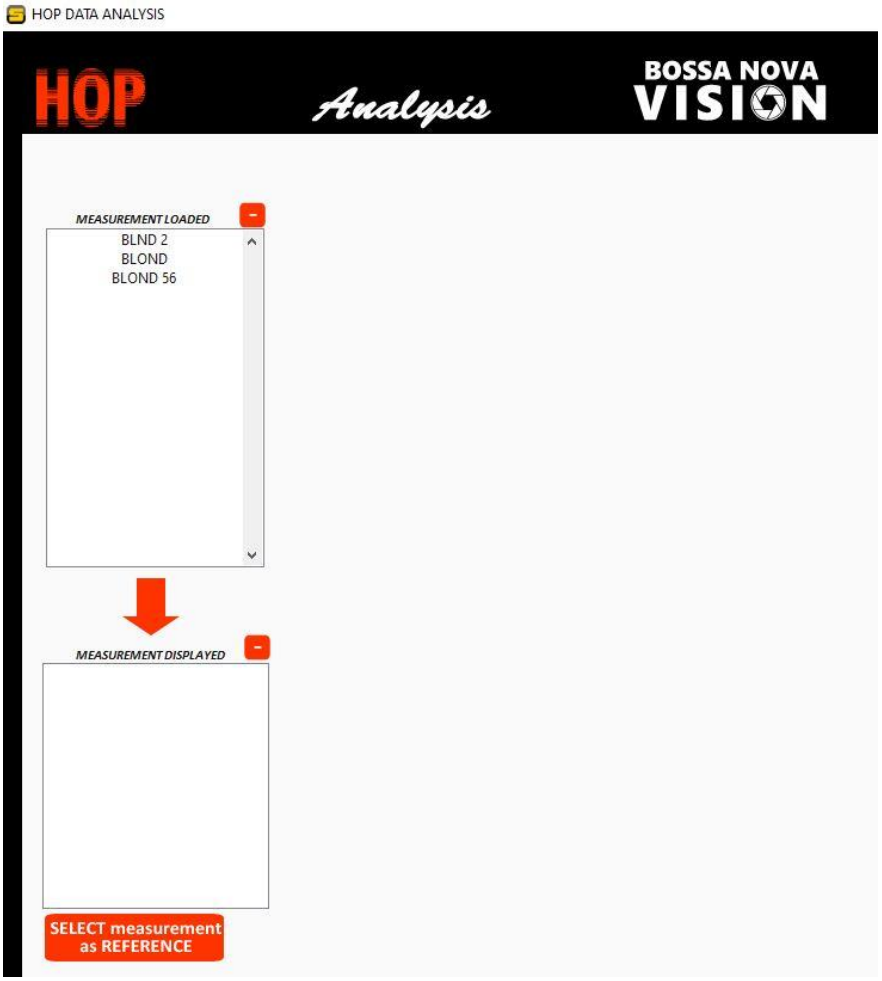


Figure 279: Data Analysis window

The user can see 2 lists:

- MEASUREMENT LOADED
- MEASUREMENT DISPLAYED

If no measurements were selected, the following pop-up window appears (Figure 280).

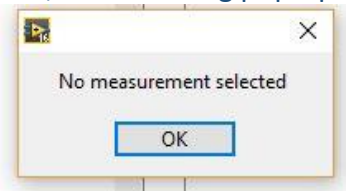


Figure 280: No measurements selected

If some selected measurements are not processed, the following message appears and no measurement are loaded (Figure 281).



Figure 281: 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 282).

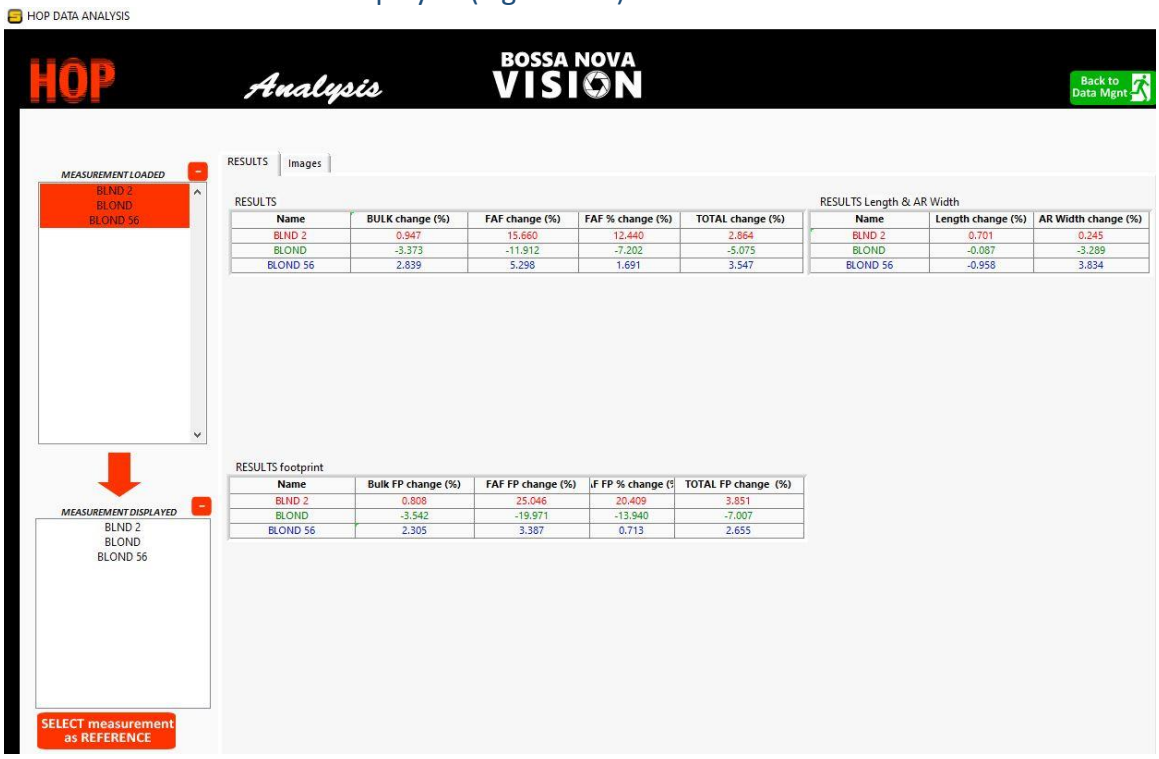


Figure 282: Measurements displayed

If the user selects more than 12 loaded measurements to be displayed, the following dialog box pops-up (Figure 283).

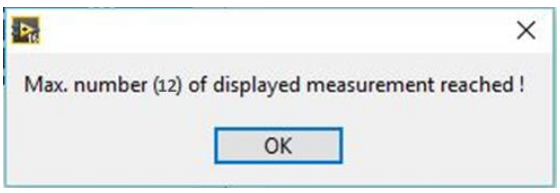


Figure 283: More than 12 loaded measurements selected – Dialog box

The Results table is now visible and populated with the corresponding measurement and values and the Export Results control 

is now visible on the bottom right of the window. The tab selection (Figure 236) is explained in the following.

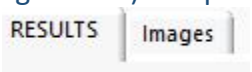


Figure 284: Tab selection for results

7.3.1. Results

The results tab shows 2 tables that summarize the various parameters calculated (Figure 285).

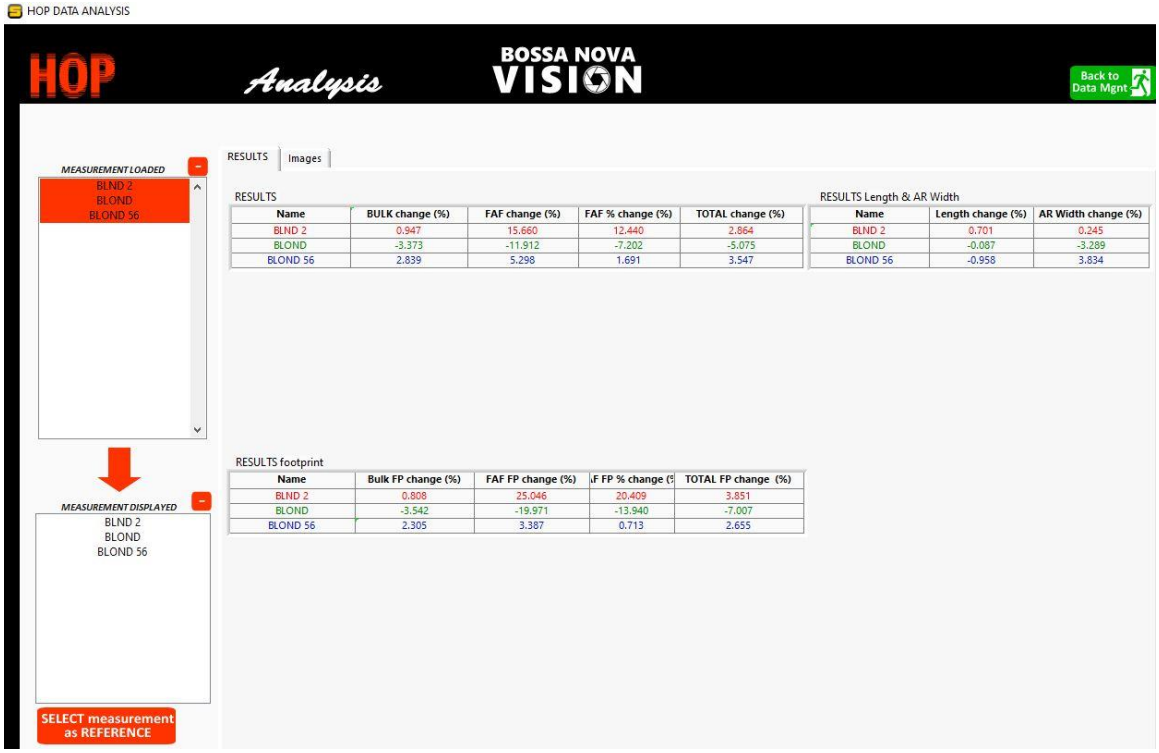


Figure 285: Results table

The first table named RESULTS has 5 columns:

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

The second table named RESULTS Footprint has 5 columns:

- Measurement Name

- BULK Surface Foot Print change (%)
- FAF Surface Foot Print change (%)
- FAF Foot Print (%) change (%)
- Total Surface Foot Print change (%)

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

- Measurement Name
- Length change (%)
- AR Width change (%)

7.3.1.1. 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 Control 

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

is activated, both tables are updating (Figure 286).

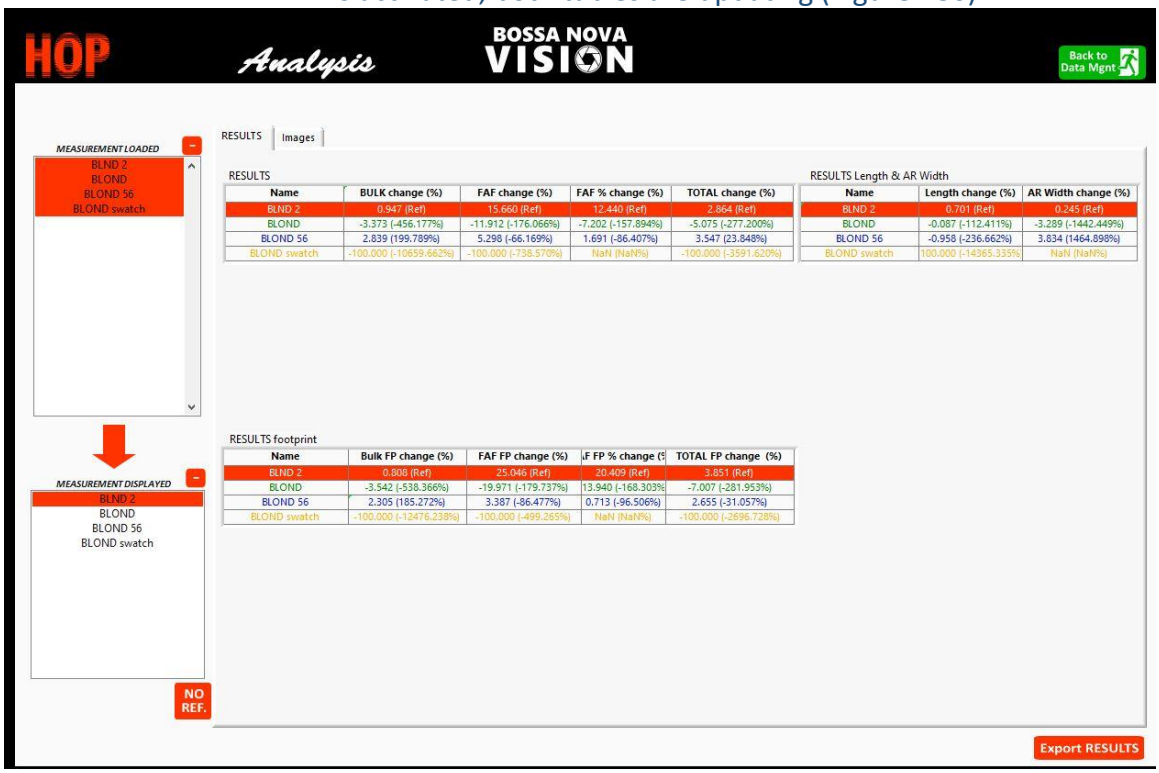


Figure 286: Reference measurement

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 287).

RESULTS

Name	BULK change (%)	FAF change (%)	FAF % change (%)	TOTAL change (%)
BLND 2	0.947 (-128.076%)	15.660 (-231.464%)	12.440 (-272.730%)	2.864 (-156.433%)
BLOND	-3.373 (Ref)	-11.912 (Ref)	-7.202 (Ref)	-5.075 (Ref)
BLOND 56	2.839 (-184.168%)	5.298 (-144.476%)	1.691 (-123.480%)	3.547 (-169.892%)
BLOND swatch	-100.000 (2864.720%)	-100.000 (739.490%)	NaN (NaN%)	-100.000 (1870.443%)

Figure 287: Reference

To return to a table with no reference, the user can click on the NO REF. control 

located under the Measurement displayed list.

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 288).

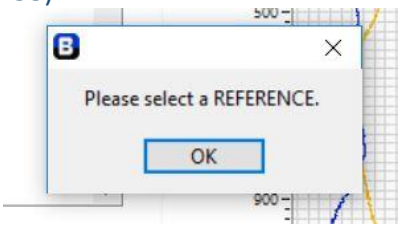


Figure 288: Pop-up message – No displayed measurement selected

7.3.1.2. 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 289).

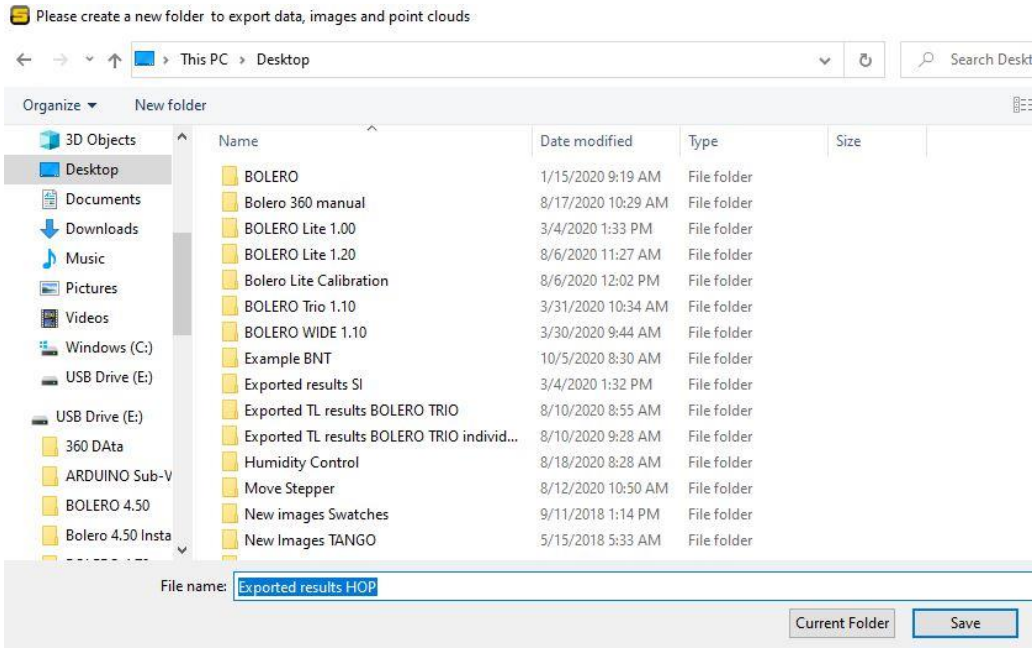


Figure 289: Pop-up message – Export Results

The name of the folder to be saved is already populated – Exported Results HOP– but can be changed, along with the destination (Figure 290).

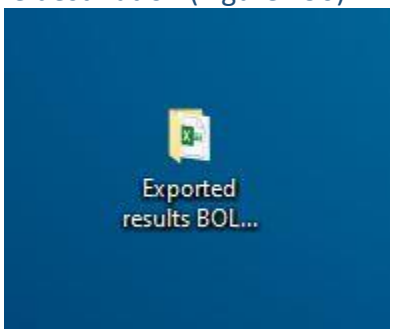


Figure 290: Export Folder

Inside the folder are an Excel file named Results and a folder named Pictures (Figure 291).

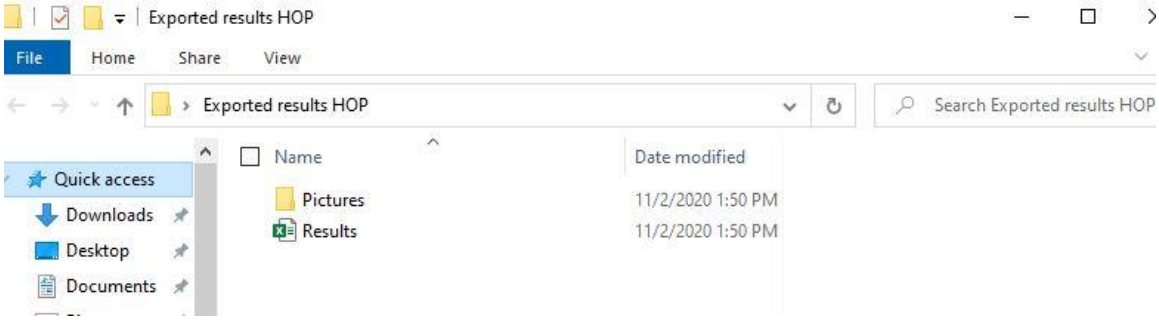


Figure 291: Exported Results Folder contents

The Pictures folder contains 4 images for each measurement 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_bulkfaffpmask_#.jpg

The excel file RESULTS contains the tables and all the graphs visualized in the data analysis tab (Figure 292).

A	B	C	D	E
		RESULTS		
Name	BULK change (%)	FAF change (%)	FAF % change (%)	TOTAL change (%)
BLND 2	0.947	15.660	12.440	2.864
BLOND	-3.373	-11.912	-7.202	-5.075
BLOND 56	2.839	5.298	1.691	3.547

Figure 292: Results excel file

7.3.2. Images

The images tab allows the user to visualize the images from each measurement (Figure 293).

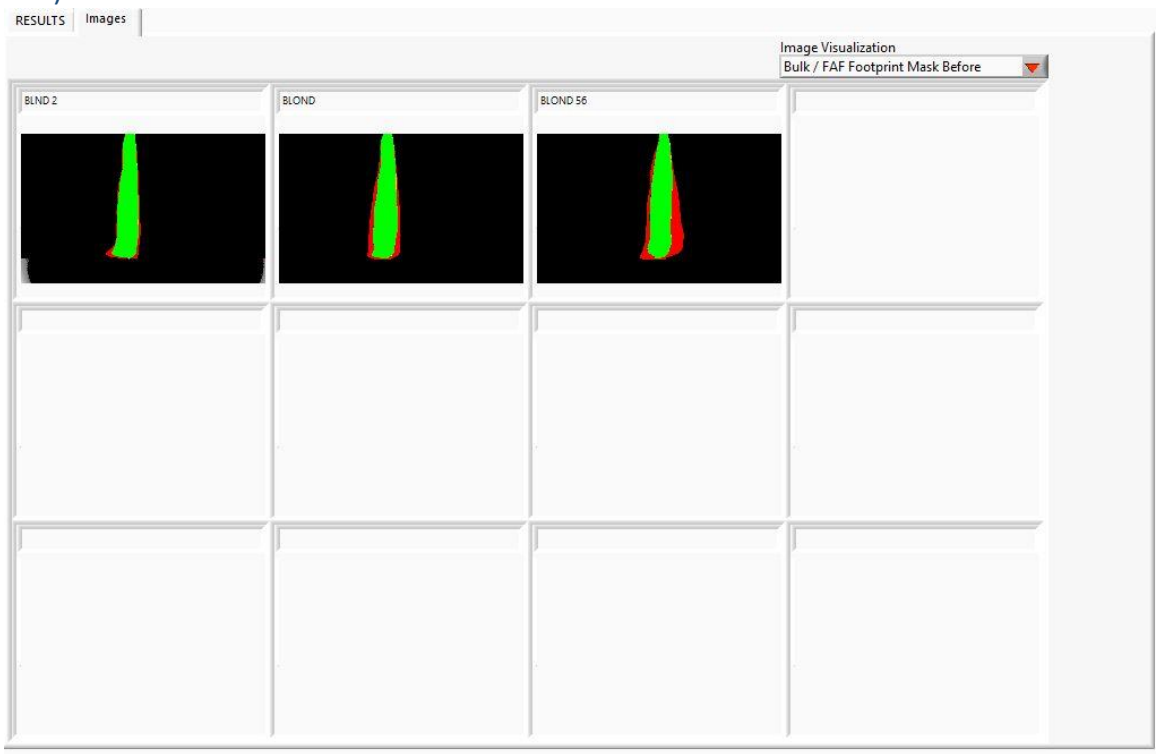
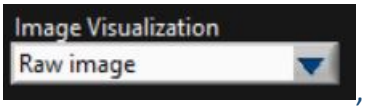


Figure 293: Images

Using the image control 

, the user can visualize the different images (Figure 294).



Figure 294: Various possible image

7.4. HULA DATA ANALYSIS

HULA analysis consists of analyzing data acquired with Frequency Sweep i.e. the same swatch whose motion has been measured and processed at different frequencies. If the user clicks on **Frequency Sweep processing** 

while frequency sweep measurements are selected, the frequency sweep processing window opens (Figure 295).

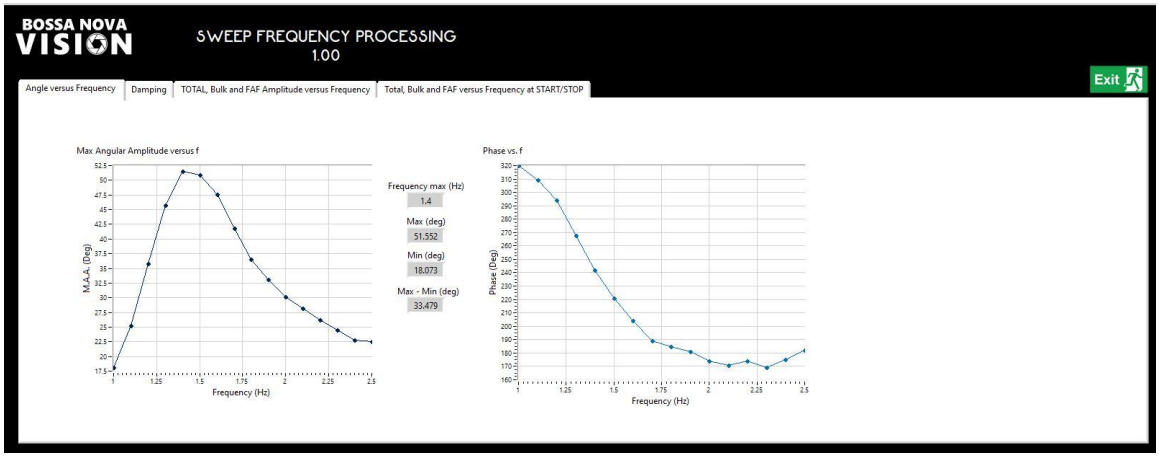


Figure 295: Frequency sweep processing window

If one of the selected measurements is not processed, the pop-up message appears and the Frequency sweep processing window does not open (Figure 296).

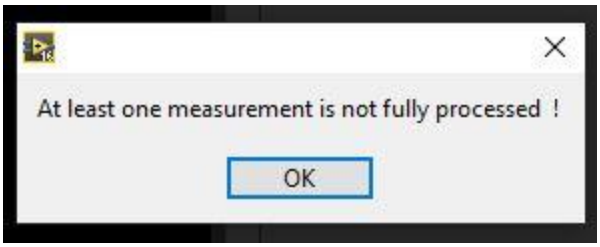


Figure 296: Selected measurements is not processed

If less than 2 measurements are selected when clicking on the control, a pop-up message appears and Frequency sweep processing window does not open (Figure 297).

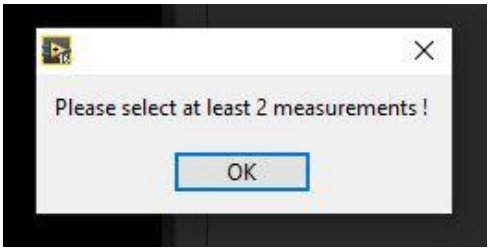


Figure 297: Less than 2 measurements selected

The selected measurements should be like the ones shown on Figure 298.

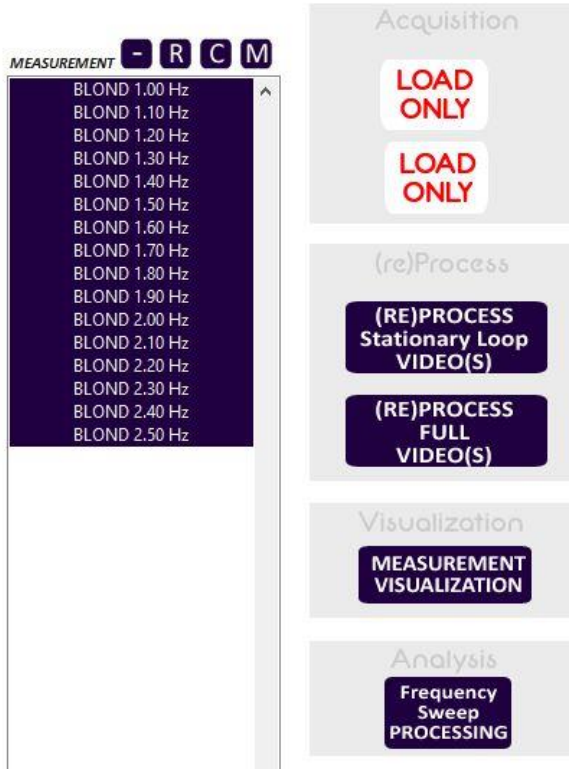


Figure 298: Selected measurements

The frequency sweep processing window shows 4 tabs (Figure 299).

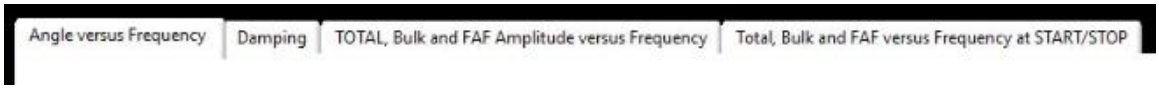


Figure 299: Frequency sweep processing window tabs

The Angle versus Frequency shows 2 graphs (Figure 300):

- The angle amplitude in degree versus frequency where the Angle amplitude = Max Angle – Min Angle is plotted versus the frequency of the motion
- The phase in degree versus frequency where the phase between the swatch motion and the swatch holder is plotted versus the frequency of the motion

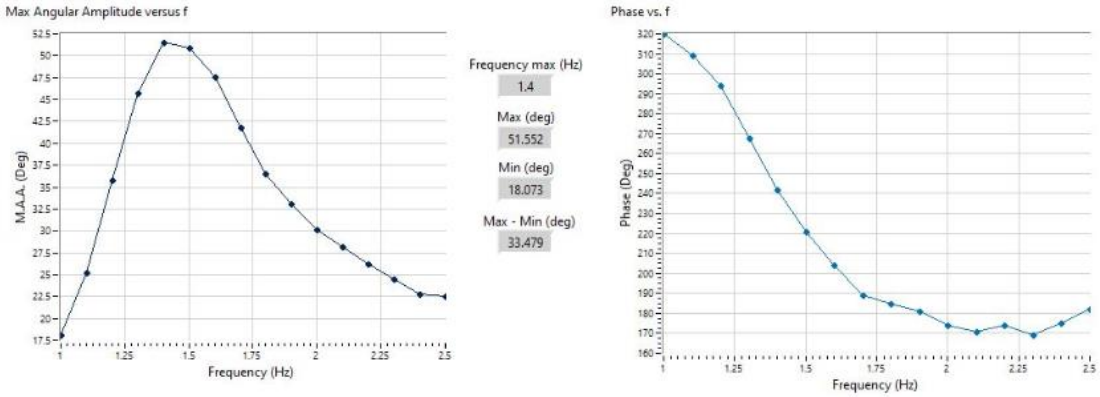


Figure 300: Angle vs Frequency tab

Next tab is the damping that shows the damping versus frequency graph (Figure 301)

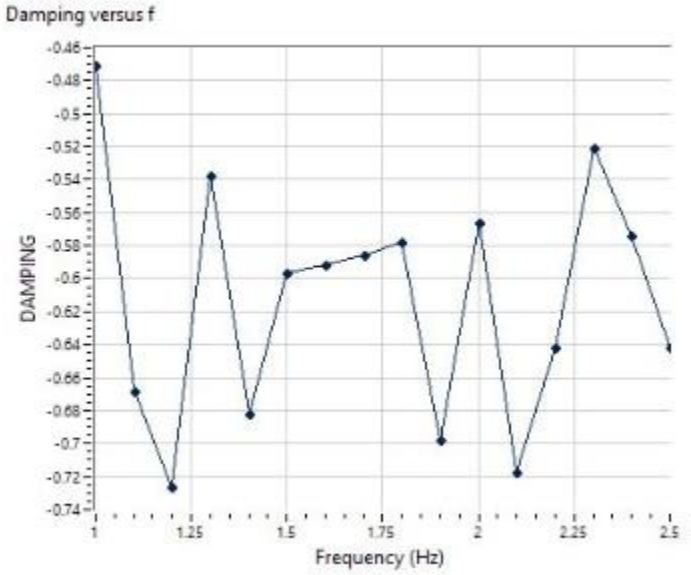


Figure 301: Damping vs Frequency graph

Next tab is the amplitude of TOTAL, BULK and FAF Surface Amplitude versus frequency graph (Figure 302).

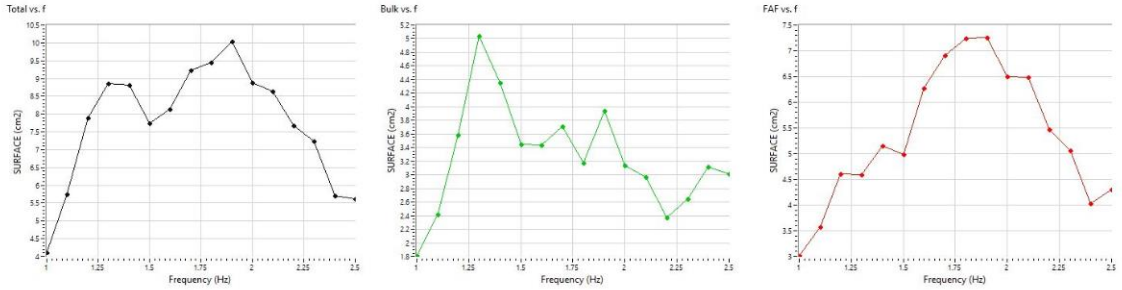


Figure 302: TOTAL, BULK and FAF Surface Amplitude versus frequency graph

These 3 graphs show the amplitude (MAX Surface – MIN Surface) of the TOTAL, BULK and FAF surface versus the frequency of the motion.
Last tab is the start and stop surfaces of TOTAL, BULK and FAF versus frequency graph (Figure 303).

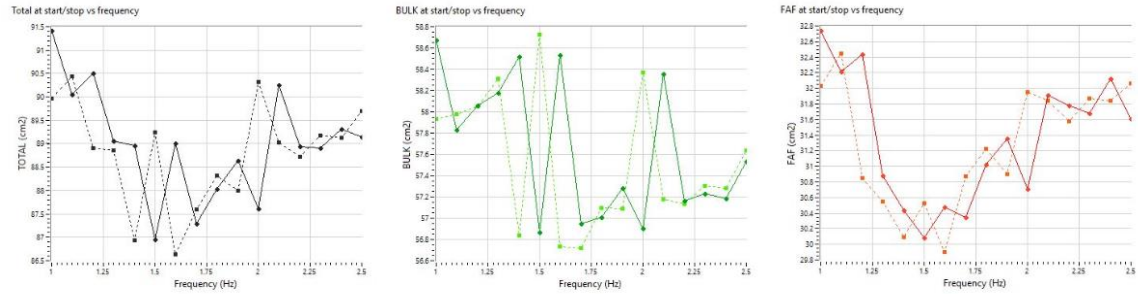


Figure 303: start and stop surfaces of TOTAL, BULK and FAF versus frequency graph

START is in plain line, STOP in dashed line. These graphs allow to monitor if the surface measurement of the swatch change during the sweep.

7.5. RUMBA data analysis

If the user clicks on **Load measurement to Data Analysis** 

while one or more measurements are selected, **Data Analysis windows opens** (Figure 304) and the selected measurements are added to the loaded measurement list.

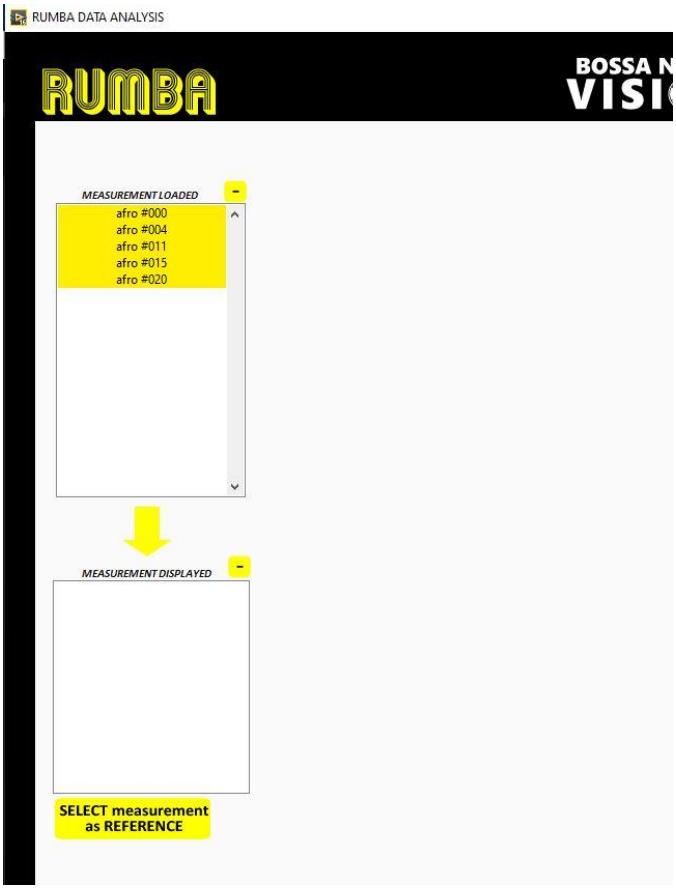


Figure 304: Data analysis windows – Measurements loaded

A number of measurements are selected and they appear in the Measurements Loaded list. The software will also eliminate automatically any duplicate. 2 lists are present:

- **Measurements loaded**
- **Measurement displayed**

To display the loaded measurements, select them and click on the arrow . Up to 12 measurements can be displayed. The tab results on the right side of the window appears (Figure 305).

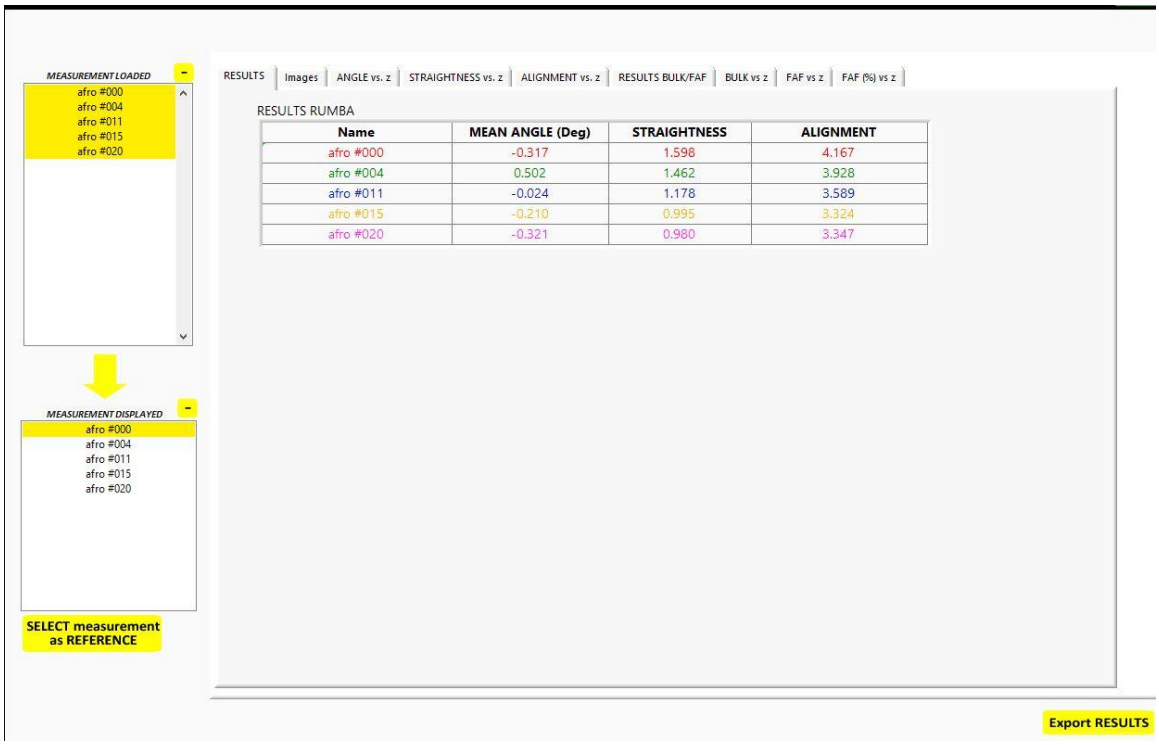


Figure 305: Data analysis window – Measurements displayed

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 306) is explained in the following.

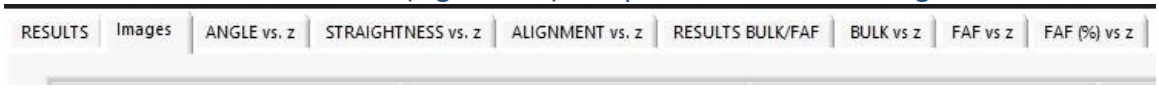


Figure 306: Tab selection for results

7.5.1. Results

Figure 307 shows the results summarized in one table.

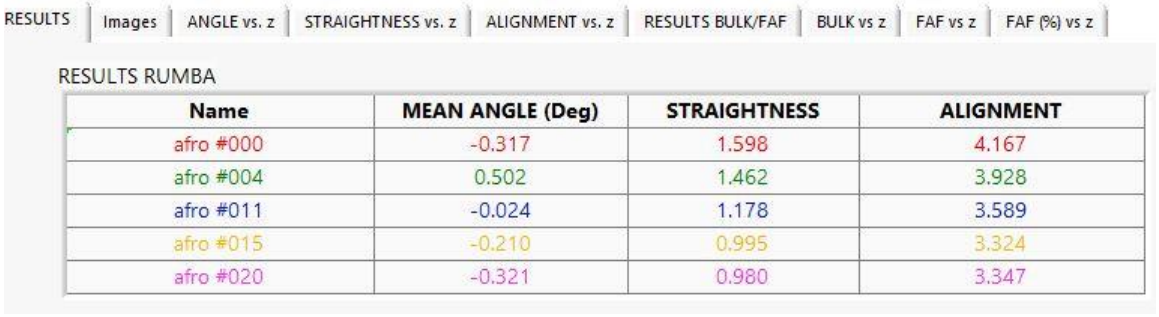


Figure 307: Results RUMBA

The table named RESULTS RUMBA has 4 columns:

- Measurement Name

MEAN ANGLE (deg)
- STRAIGHTNESS (%)
- ALIGNMENT (%)

7.5.1.1. Reference

Similar to the other software, the user can select a reference measurement. Click on SELECT measurement as REFERENCE and have the results tables updated (Figure 308) with the values in % compared to the reference.

RESULTS RUMBA

Name	MEAN ANGLE (Deg)	STRAIGHTNESS	ALIGNMENT
afro #000	-0.317 (50.952%)	1.598 (60.603%)	4.167 (25.361%)
afro #004	0.502 (-339.048%)	1.462 (46.935%)	3.928 (18.171%)
afro #011	-0.024 (-88.571%)	1.178 (18.392%)	3.589 (7.972%)
afro #015	-0.210 (Ref)	0.995 (Ref)	3.324 (Ref)
afro #020	-0.321 (52.857%)	0.980 (-1.508%)	3.347 (0.692%)

Figure 308: Reference

Clicking on NO REF. goes back to the regular table.

7.5.1.2. Export Results

The Export RESULTS control Export RESULTS 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 309).

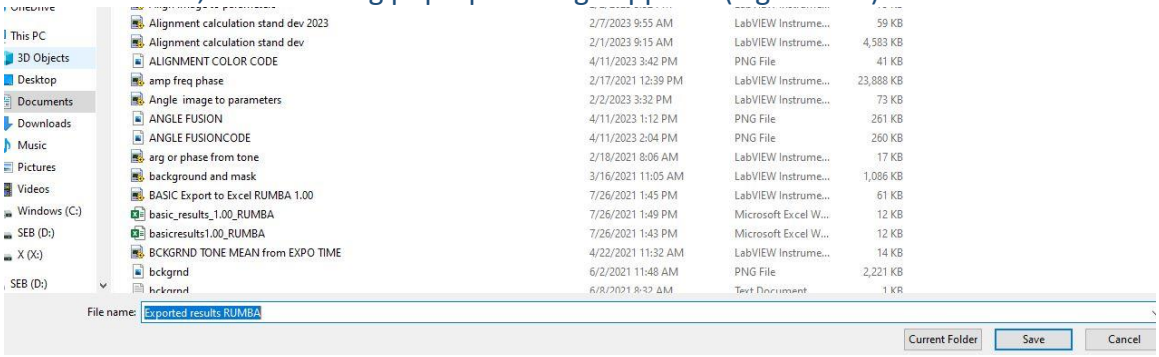


Figure 309: Export Results pop-up window

The export folder contains a folder named Pictures containing all the images and two excel files (Figure 310) named Results Rumba and Results Rumbolero.



Figure 310: Export Folder

The Results Rumba excel file contains the Rumba results table and graphs versus z (Figure 311).



	A	B	C	D
		RESULTS		
	Name	MEAN ANGLE (Deg)	STRAIGHTNESS	ALIGNMENT
	afro #000	-0.317 (50.952%)	1.598 (60.603%)	4.167 (25.361%)
	afro #004	0.502 (-339.048%)	1.462 (46.935%)	3.928 (18.171%)
	afro #011	-0.024 (-88.571%)	1.178 (18.392%)	3.589 (7.972%)
	afro #015	-0.210 (Ref)	0.995 (Ref)	3.324 (Ref)
	afro #020	-0.321 (52.857%)	0.980 (-1.508%)	3.347 (0.692%)

Results | ANGLE versus z | STRAIGHTNESS versus z | ALIGNMENT versus z

Figure 311: Results Rumba Excel file

The Results Rumbolero excel file contains the Bolero type results table and graph versus z (Figure 312).

	A	B	C	D	E
		RESULTS			
	Name	TOTAL Surface (cm2)	BULK Surface (cm2)	FAF Surface (cm2)	FAF (%)
	afro #000	36.885 (-3.3615%)	31.705 (-1.3012%)	5.180 (-14.3093%)	14.043 (-11.3335%)
	afro #004	37.537 (-1.6532%)	31.980 (-0.4452%)	5.557 (-8.0728%)	14.805 (-6.5223%)
	afro #011	38.053 (-0.3013%)	32.183 (0.1868%)	5.870 (-2.8950%)	15.426 (-2.6013%)
	afro #015	38.168 (Ref)	32.123 (Ref)	6.045 (Ref)	15.838 (Ref)
	afro #020	38.142 (-0.0681%)	32.003 (-0.3736%)	6.139 (1.5550%)	16.095 (1.6227%)

Results | Results 2 | BULK versus z | FAF versus z | FAF(%) versus z

Figure 312: Bolero type Results Excel file

7.5.2. Images

The tab images allows to visualize the different images (Figure 313).

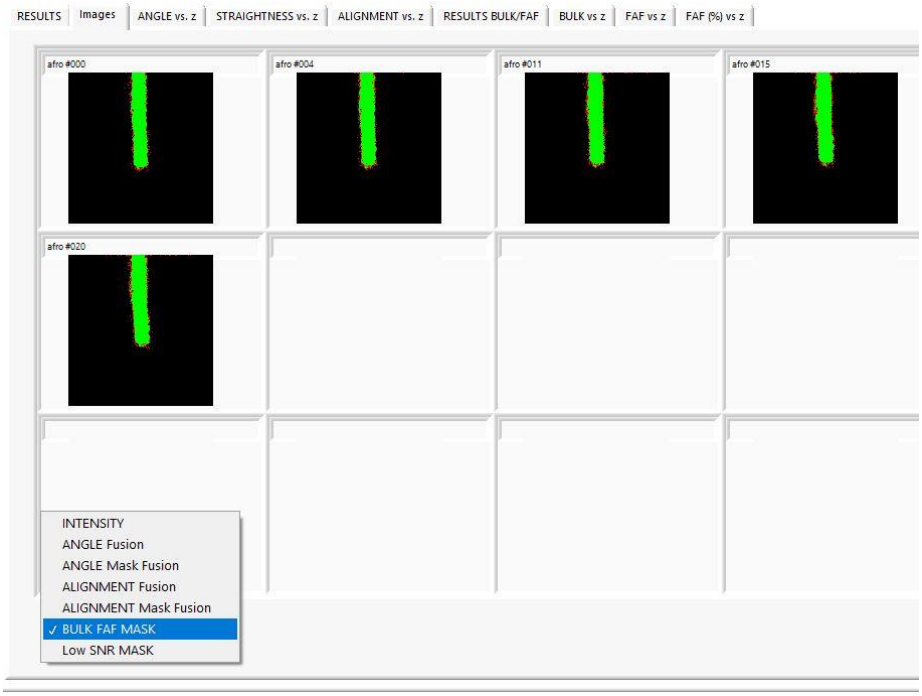


Figure 313: images

7.5.3. ANGLE vs z

The angle vs z shows the variation of the angle versus the vertical axis z for the displayed measurements (Figure 314).

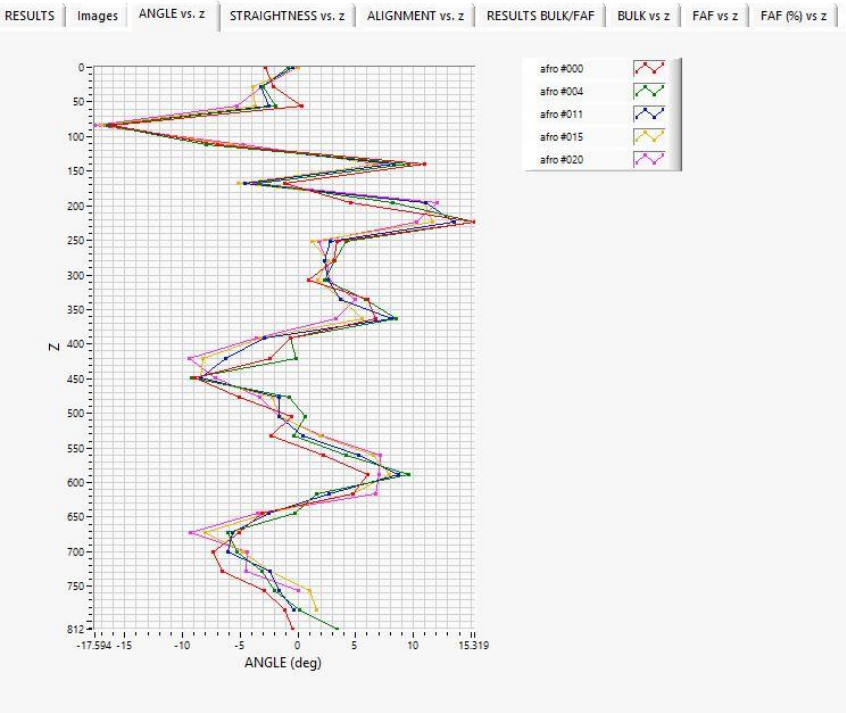


Figure 314: Angle versus z

7.5.4. STRAIGHTNESS vs z

The straightness vs z shows the variation of the straightness versus the vertical axis z for the displayed measurements (Figure 315Figure 314).

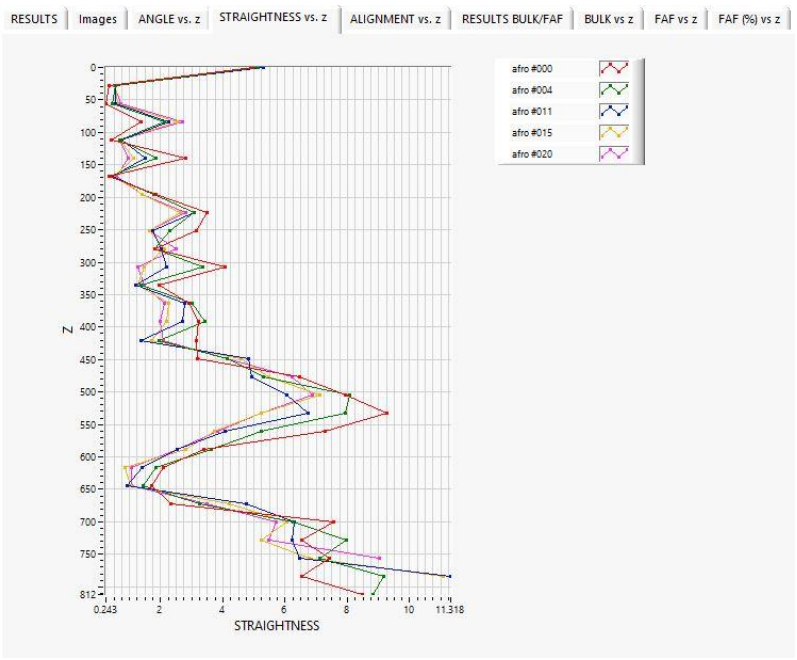


Figure 315: Straightness versus z

7.5.5. ALIGNMENT vs z

The alignment vs z shows the variation of the alignment versus the vertical axis z for the displayed measurements (Figure 316Figure 314).

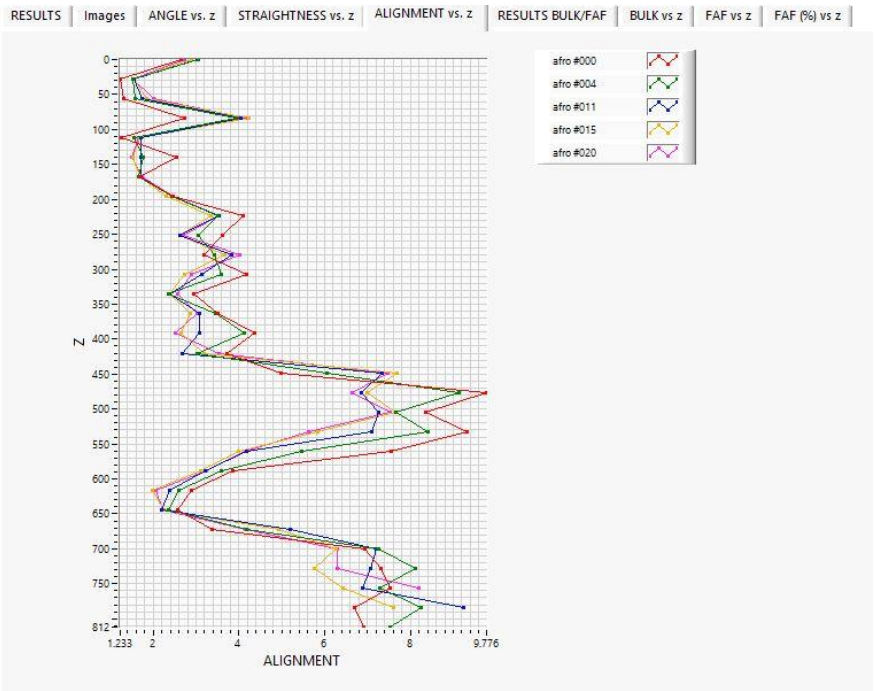


Figure 316: Alignment versus z

7.5.6. RESULTS BULK/FAF

The Results bulk/faf table summarizes the BOLERO type measurement (Figure 317).

RESULTS | Images | ANGLE vs. z | STRAIGHTNESS vs. z | ALIGNMENT vs. z | RESULTS BULK/FAF | BULK vs z | FAF vs z | FAF (%) vs z

RESULTS RUMBA BOLERO

Name	TOTAL Surface (cm2)	BULK Surface (cm2)	FAF Surface (cm2)	FAF (%)
afro #000	36.885	31.705	5.180	14.043
afro #004	37.537	31.980	5.557	14.805
afro #011	38.053	32.183	5.870	15.426
afro #015	38.168	32.123	6.045	15.838
afro #020	38.142	32.003	6.139	16.095

RESULTS RUMBA BOLERO 2

Name	Length (cm)	AR Width (cm)
afro #000	15.138	2.437
afro #004	14.994	2.503
afro #011	14.526	2.620
afro #015	14.490	2.634
afro #020	14.256	2.675

Figure 317: Results BULK/FAF

7.5.7. BULK vs z

The bulk vs z shows the variation of the bulk versus the vertical axis z for the displayed measurements (Figure 318).

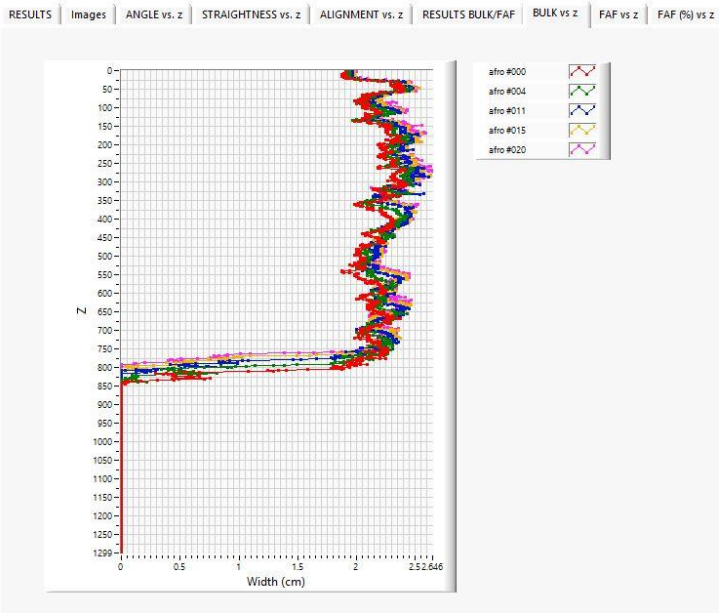


Figure 318: Bulk versus z

7.5.8. FAF vs z

The FAF vs z shows the variation of the FAF versus the vertical axis z for the displayed measurements (Figure 319).

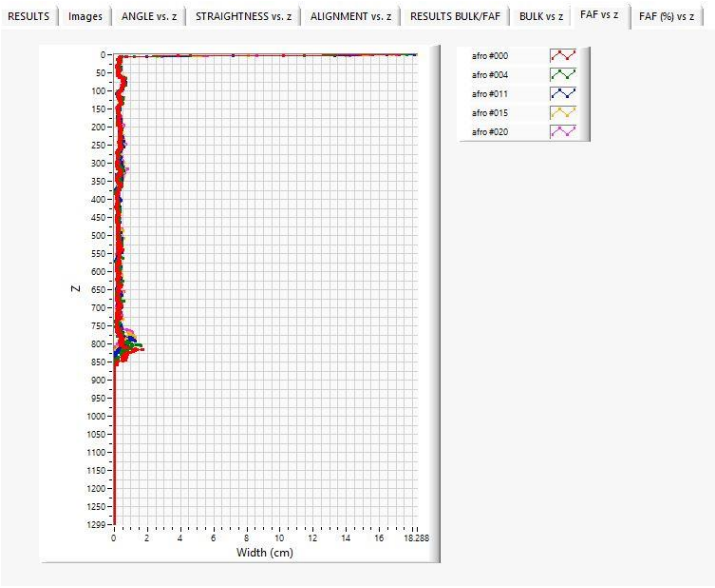


Figure 319: FAF versus z

7.5.9. FAF (%) vs z

The FAF (%) vs z shows the variation of the FAF (%) versus the vertical axis z for the displayed measurements (Figure 320).

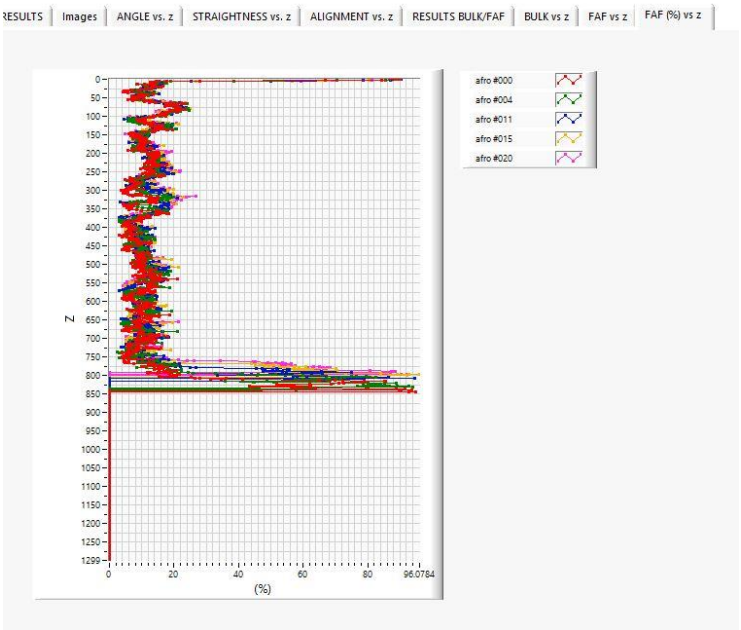


Figure 320: FAF (%) versus z

8. Time lapse Video Creation and Data Analysis

8.1. BOLERO TRIO Time lapse VC&DA

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 321) informing the user than a Time Lapse measurement has been found.

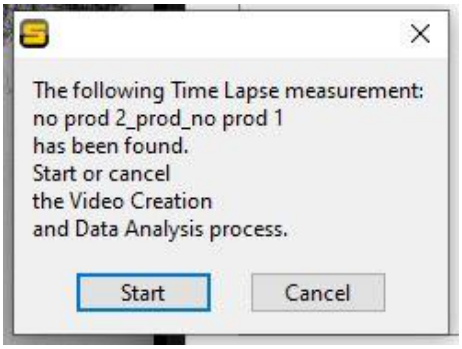


Figure 321: pop-up message

If the user clicks on Start, a new window pops-up (Figure 322). Cancel will take the user back to the main window.

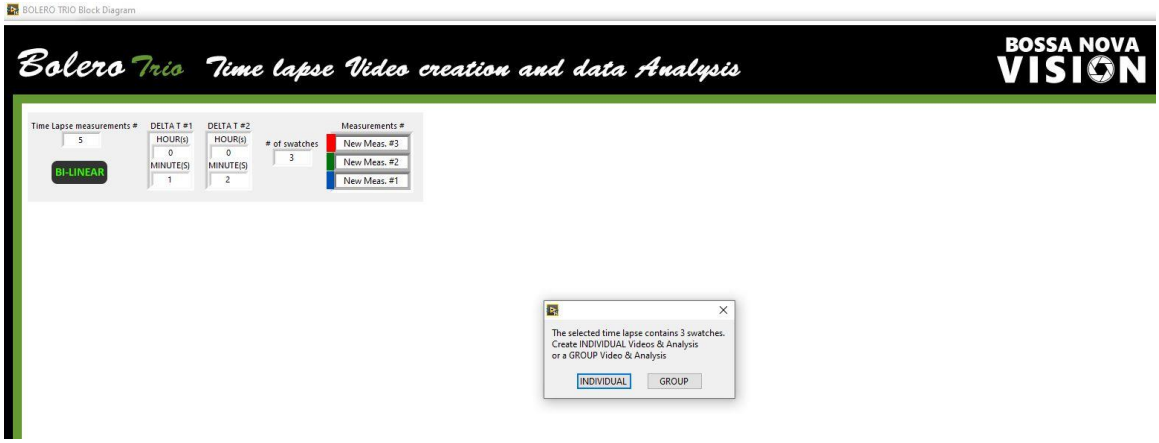


Figure 322: Time Lapse video Creation and Data analysis video

The new window shows the number of time lapse measurements, the delta Ts in hours and minutes (the time between each measurements), the information of the time lapse i.e. linear or bi-linear, the number of swatches and the measurement name (Figure 323).



Figure 323: Time lapse parameters

A pop-up message asks the user to select between INDIVIDUAL or GROUP video creation and data analysis (Figure 324Figure 324: Individual or group video creation and data analysis).

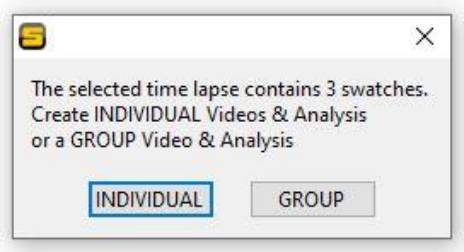


Figure 324: Individual or group video creation and data analysis

The INDIVIDUAL option will create a video and analyze the data for each individual measurement.

The GROUP option will create a video and analyze the data for the 3 (max) swatches at the same time.

8.1.1. GROUP

After clicking on GROUP, the following pop-up message appears (Figure 325).

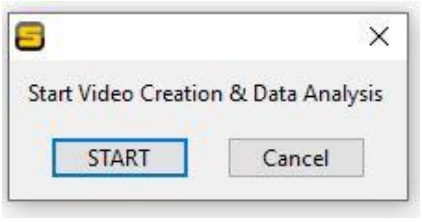


Figure 325: Pop-up message Start or Cancel

Once START is clicked, the video creation and data analysis starts (Figure 326).

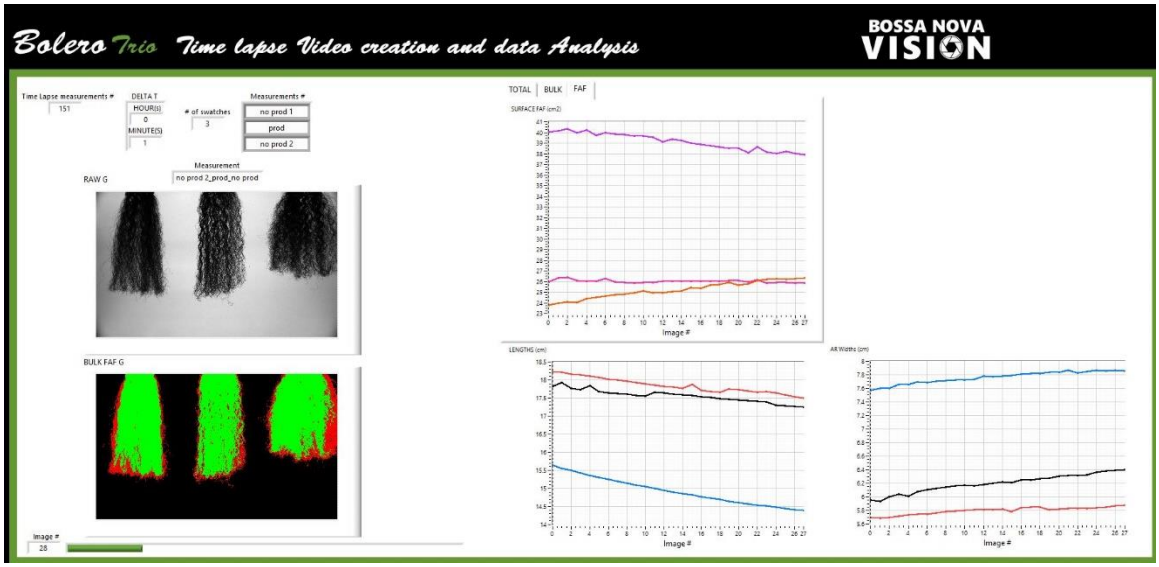


Figure 326: Group Time Lapse VC & DA in progress

A progression bar indicates where evolution of the process. On the left side of the window are both videos (RAW and Bulk-FAF) showing the 3 swatches in the same window. On the right are the corresponding graphs: Surface versus Frame # (Total, Bulk and FAF), length versus frame # and AR Width versus frame #. The tab for the surface graph allows to switch between total, bulk and FAF. Each graph shows the parameter for the 3 swatches, allowing a simple comparison.
Once the process is done, a pop-up message appears (Figure 327).

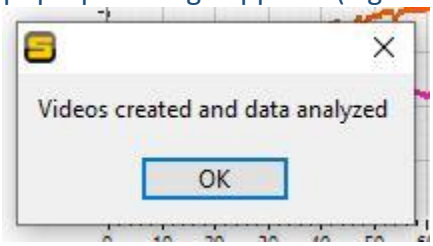


Figure 327: Process done – pop-up message

A new tab appears, allowing the user to visualize the graph versus image # or versus time in minutes (Figure 328).

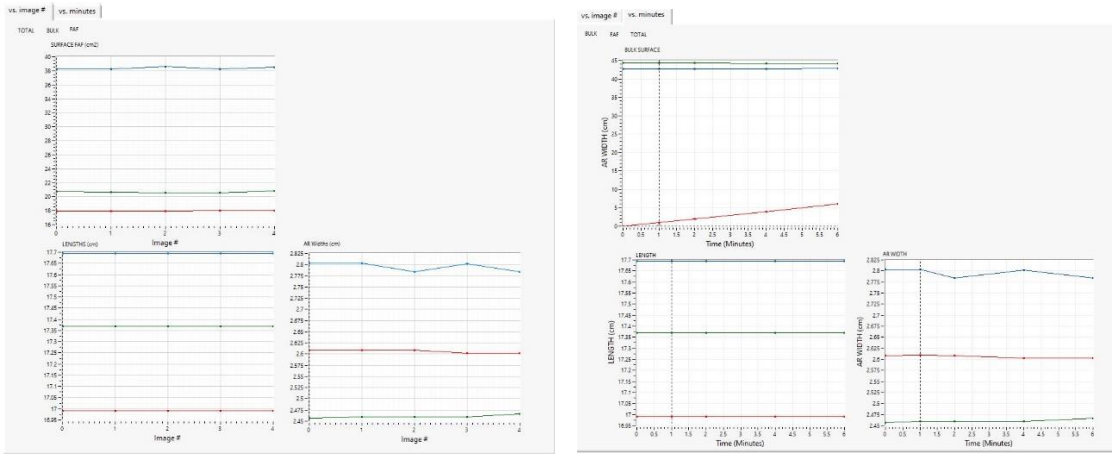


Figure 328: Graph versus image # or versus time in minutes

The user can visualize the data and export the data (videos and graph) using the controls (Figure 329).



Figure 329: 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 

to export the videos and the graph into an excel file (Figure 330).

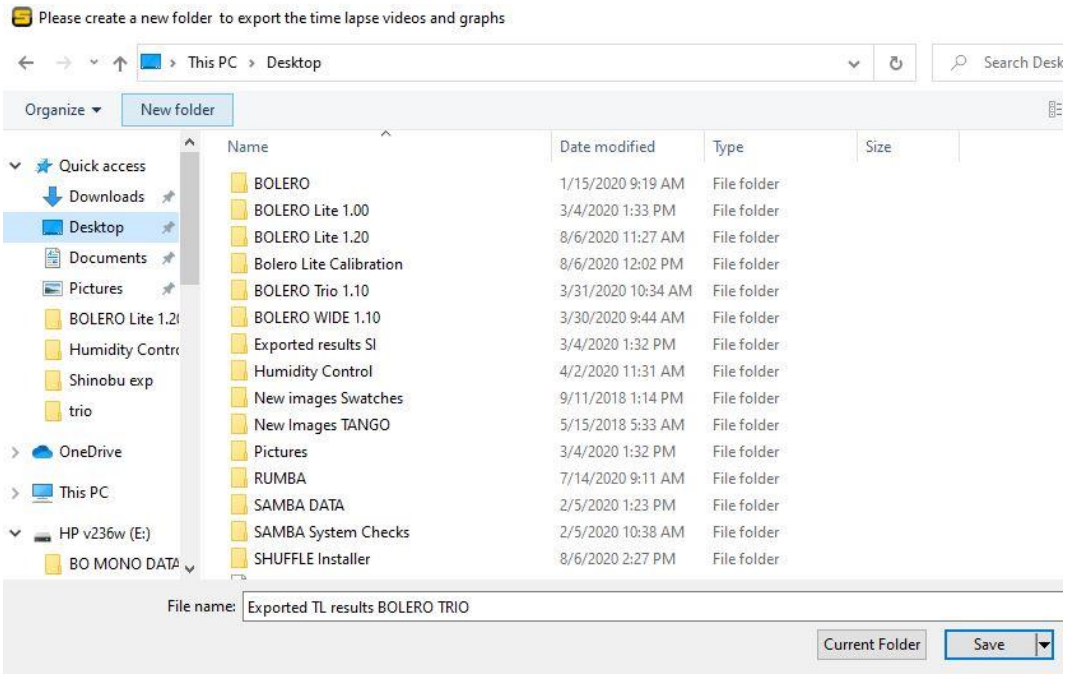


Figure 330: Time Lapse Group Export

The content of the exported folder is shown on Figure 331.



Figure 331: 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 332).

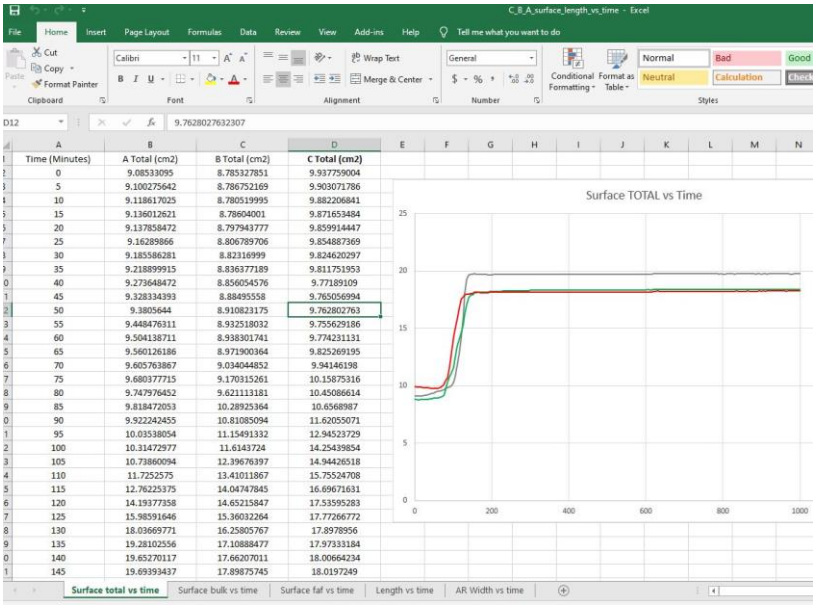


Figure 332: Excel file – Group Export

8.1.2. INDIVIDUAL

When the user clicks on individual, a pop-up message appears (Figure 333).

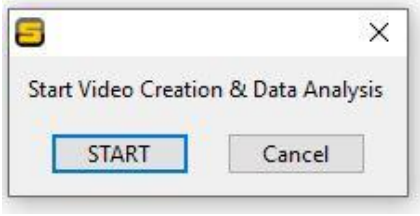


Figure 333: Start or cancel pop-up message

Once the user clicks on Start, the windows updates, showing the raw & processed images, the bulk/faf/total surface versus image # graph, the swatch length versus image # graph and the AR width versus frame # graph. It will sequentially happens for the 3 swatches.

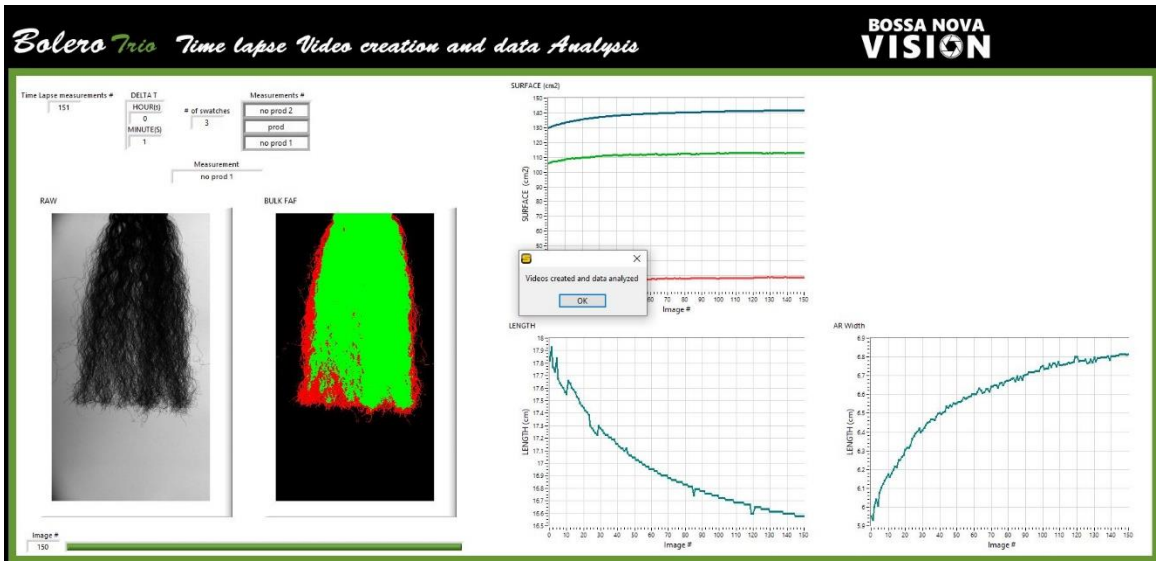


Figure 334: Individual Video creation and data analysis done

Once the progressing is done, a pop-up message appears (Figure 335).

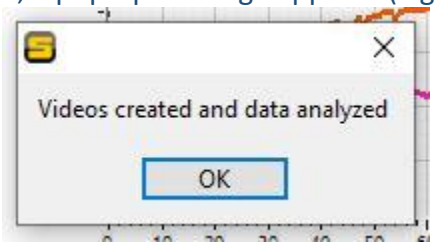


Figure 335: Processing done

The control 

appears and allows to export the videos and graphs to a folder (Figure 336).

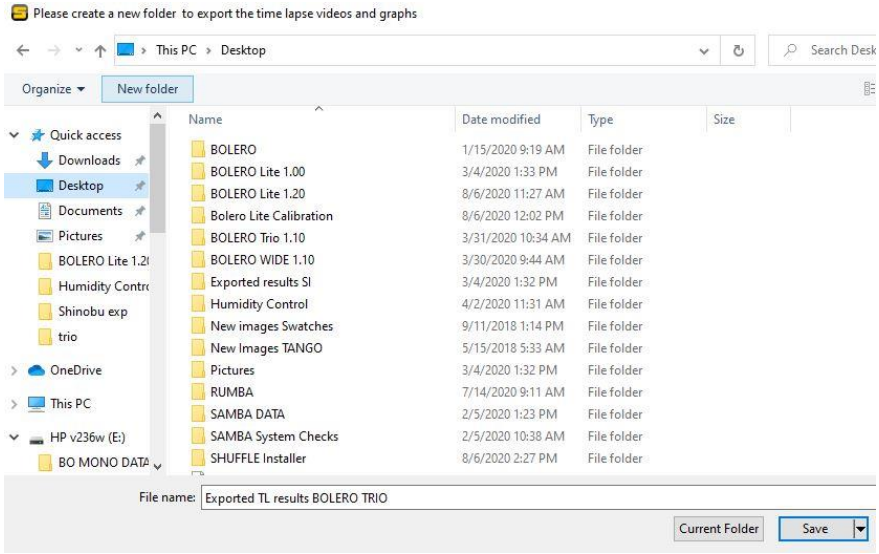


Figure 336: Export videos and graphs to a folder

The Exported TL results folder contains the 3x2 videos in avi and the 3 excel individual files (Figure 337).

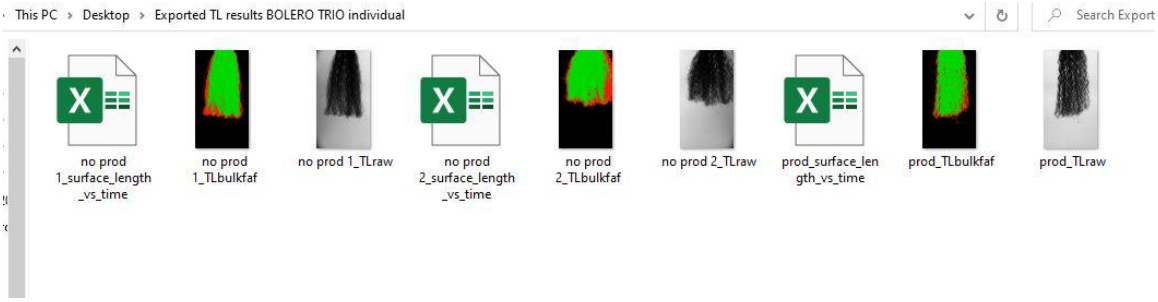
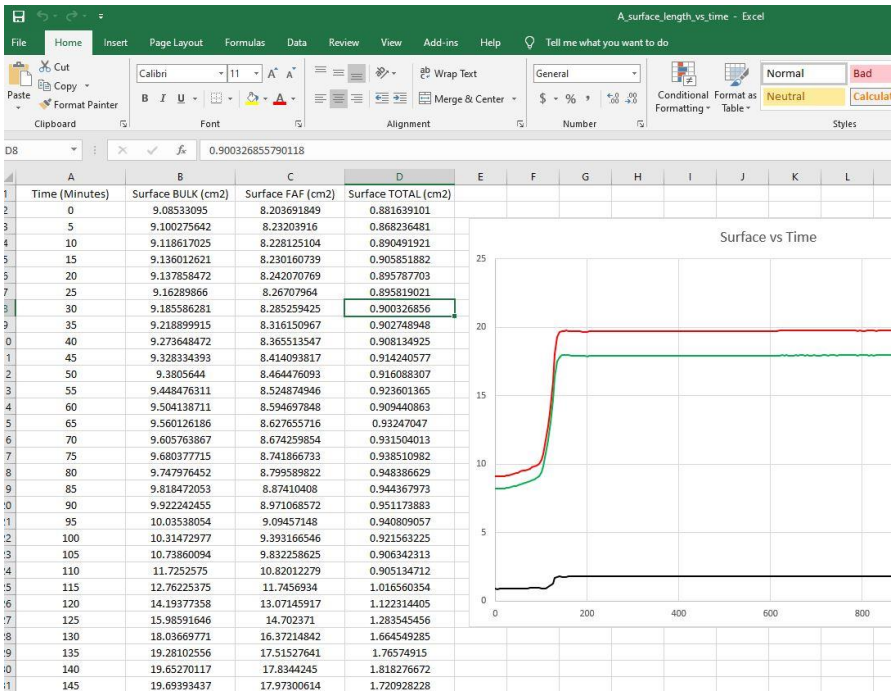


Figure 337: Exported TL results folder contents - Individual

The videos are named measurement_TLraw.avi and measurement_TLbulkfaf.avi. The excel file is named measurement_surface_length.xls (Figure 338).



Time (Minutes)	Surface BULK (cm2)	Surface FAF (cm2)	Surface TOTAL (cm2)
0	9.08533095	8.203691849	0.881639101
5	9.100275642	8.23203916	0.868236481
10	9.118617025	8.228125104	0.890491921
15	9.136012621	8.230160739	0.905851882
20	9.137858472	8.242070769	0.895787703
25	9.16289866	8.26707964	0.895819021
30	9.185586281	8.285259425	0.900326856
35	9.218899915	8.316150967	0.902748948
40	9.273648472	8.365513547	0.908134925
45	9.328334393	8.414093817	0.914240577
50	9.3805644	8.464476093	0.916088307
55	9.448476311	8.524874946	0.923601365
60	9.504138711	8.594697848	0.909440863
65	9.560126186	8.627655716	0.93247047
70	9.605763867	8.674259854	0.931504013
75	9.680377715	8.741866733	0.938510982
80	9.747976452	8.799589822	0.948386629
85	9.818472053	8.87410408	0.944367973
90	9.922242455	8.971068572	0.951173883
95	10.03538054	9.09457148	0.940809057
100	10.31472977	9.393166546	0.921563225
105	10.73860094	9.832258625	0.906342313
110	11.7252575	10.82012279	0.905134712
115	12.76225375	11.7456934	1.016560354
120	14.19377358	13.07145917	1.122314405
125	15.98591646	14.702371	1.283545456
130	18.03669771	16.37214842	1.664549285
135	19.28102556	17.51527641	1.76574915
140	19.65270117	17.8344245	1.818276672
145	19.69393437	17.97300614	1.720928228

Figure 338: Excel export - Individual

Note that if the measurements are not processed, only the raw video will be created (Figure 339).

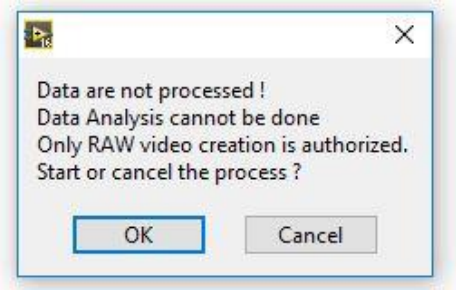


Figure 339: Time lapse data not processed – Pop-up message

In case no time lapse measurements are found in the subfolder, a pop-up message appears (Figure 340).

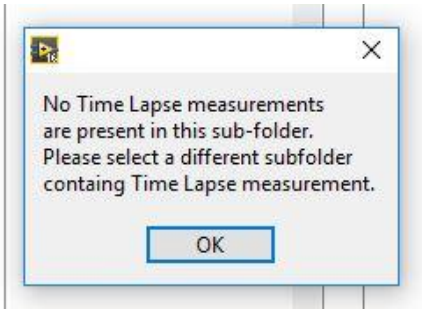


Figure 340: No time lapse measurement found pop-up message

Clicking on Ok will take the user back to the main window.
In the case where more than one time lapse measurements have been saved in the same sub-folder, the following pop-up message appears, asking the user to select only one time lapse measurement (Figure 341).

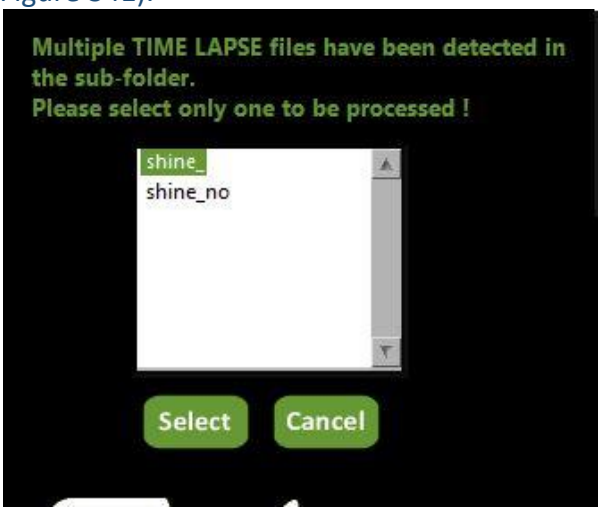


Figure 341: multiple time lapse measurement detected. Select only one

There could be a problem with the time lapse if there is some data missing. The time lapse acquisition time can be very long and sometime the camera get disconnected during the acquisition etc. 9Computer going to sleep, etc.) In that case the time lapse processing cannot be done and a pop-up message appears (Figure 342).

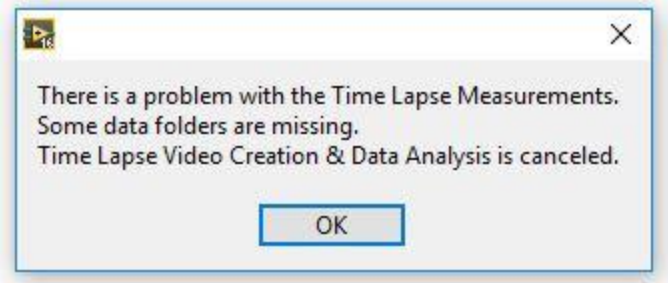


Figure 342: Problem with the time lapse measurements – Data missing – Pop-up message

8.2. BOLERO WIDE Time lapse VC&DA

It is similar to 8.1.2.

8.3. BOLERO 360 Time lapse VC&DA

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, versus the time. The user clicks on



control. A pop-up message appears (Figure 343) informing the user than a Time Lapse measurement has been found.

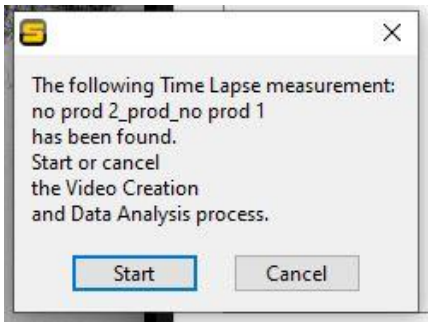


Figure 343: pop-up message

After clicking on Start, the Time Lapse Video Creation & Data Analysis appears (Figure 344).

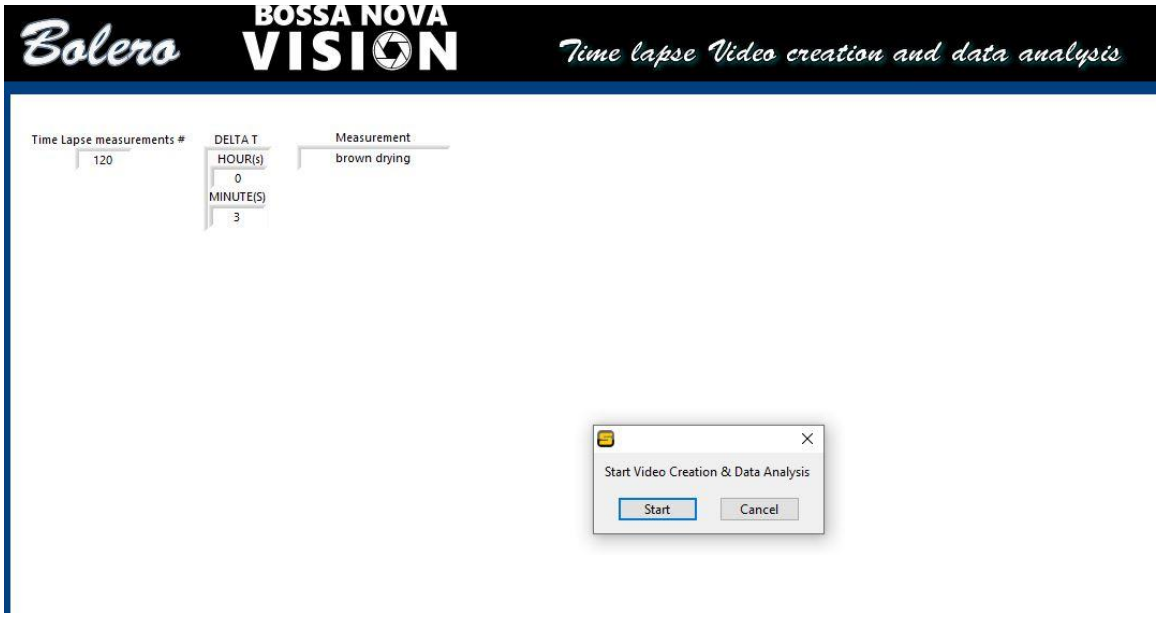


Figure 344: Time Lapse Video Creation & Data Analysis

A pop-up message is asking to Start or cancel the Video Creation and Data analysis (Figure 345)

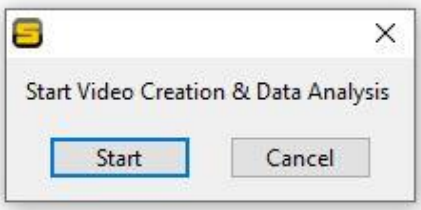


Figure 345: Pop-up message

Once the user clicks on START, another pop-up message appears, asking to adjust the angle of the images, the view of the 3D images and the z for the slice (Figure 346)

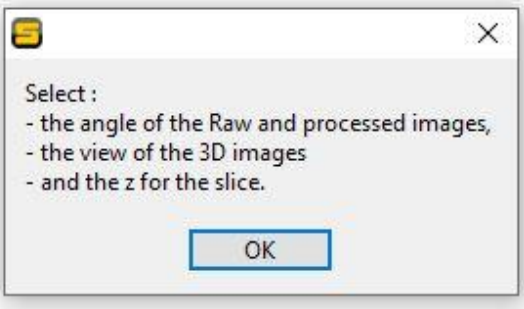


Figure 346: Pop-up message (Configuration)

Single images | 3D Bulk | 3D FAF | Slice | Volume Graph

On the right side of the window is a tab selection where the user can visualize the raw and processed images, the 3D of the Bulk and Fly-away/frizz, a slice of the 3D and a graph of the total, bulk and faf volume (Figure 347).

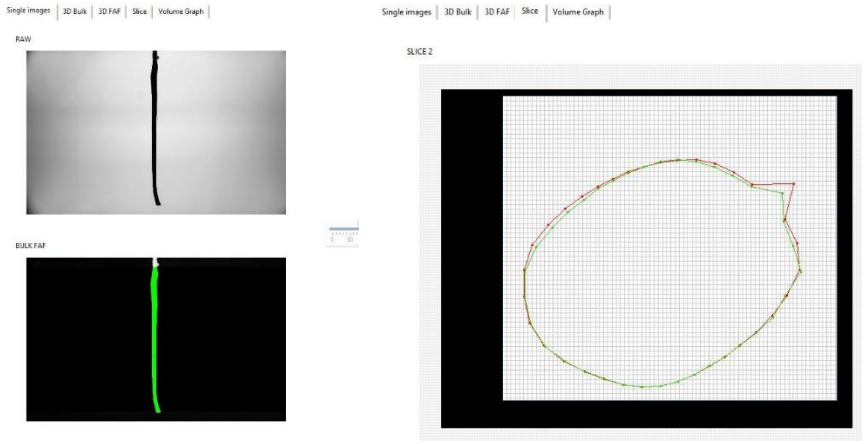


Figure 347: Tab

Once the user is satisfied with his selection, he can click on START to start the video creation and data analysis process. The process starts and a progression bar appears at the bottom of the window (Figure 348).



Figure 348: the Video Creation and Data analysis in progress

Once the processing is done, a pop-up message appears (Figure 349).

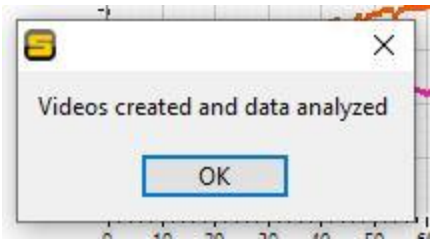


Figure 349: Processing done

The user can visualize the data and export the data (videos and graph) using the controls (Figure 350).



Figure 350: 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 

to export the videos and the graph into an excel file (Figure 351).

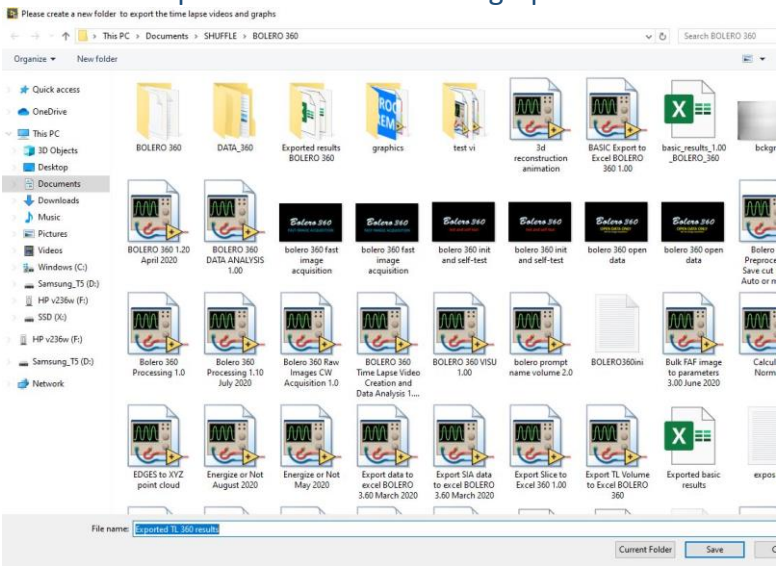


Figure 351: Export Folder

The Exported TL results folder contains 5 videos in avi and one excel individual file (Figure 352).

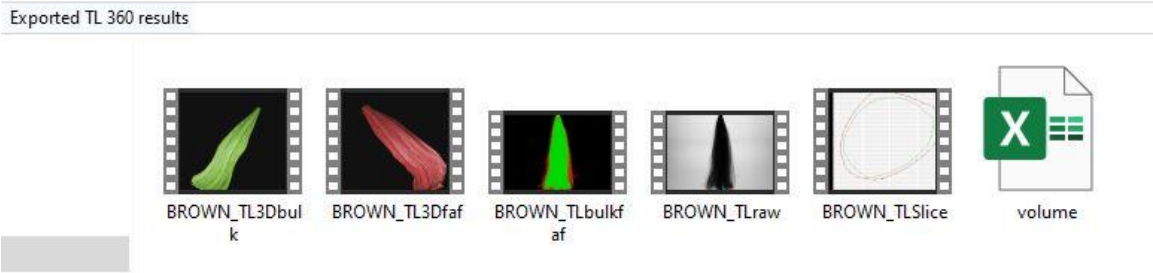


Figure 352: Exported TL results folder contents

The videos are named measurement_TL3Dbulk.avi, measurement_TL3Dfaf.avi, measurement_TLSlice.avi measurement_TLraw.avi and measurement_TLbulkfaf.avi. The excel file is named volume.xls (Figure 353).

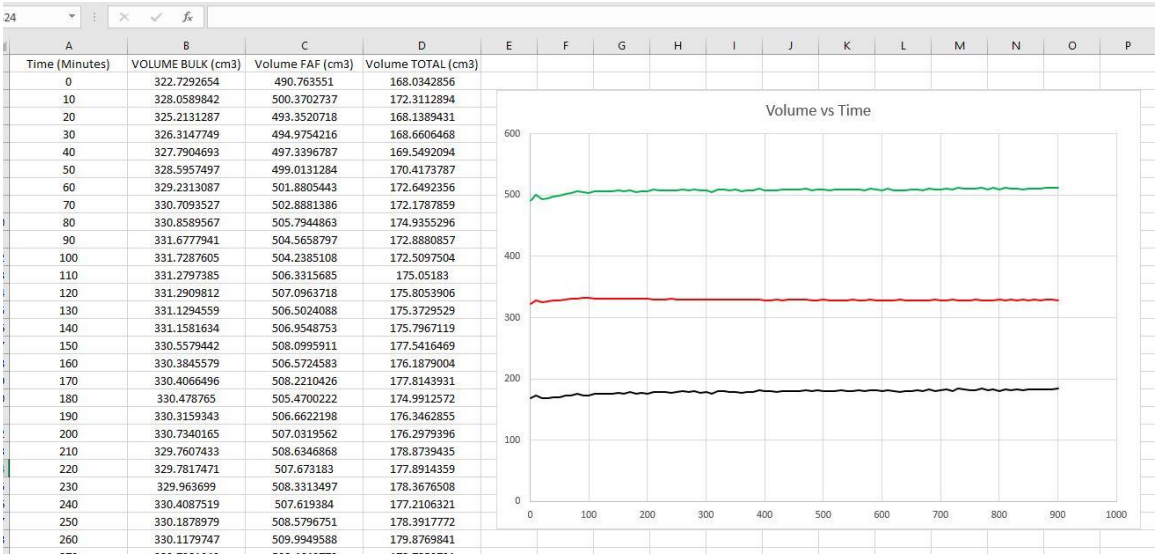


Figure 353: Excel export

It contains the bulk, faf and total volume versus time (and the graph associated).

8.4. HOP Time lapse VC&DA

It is similar to 8.1.2.

8.5. RUMBA Time lapse VC&DA

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,

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the length of the swatch and AR width versus the time. The user clicks on control. A pop-up message appears (Figure 354).

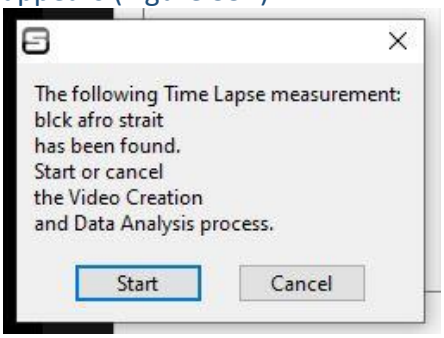


Figure 354: Pop-up message TL found

If the user clicks on start, another pop-up window appears (Figure 355).

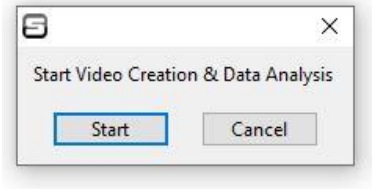


Figure 355: pop-up message – Start or cancel

If the video and data were already processed, a pop-up message appears (Figure 356).

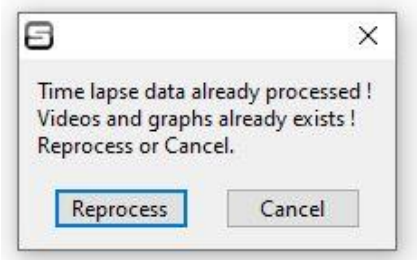


Figure 356: Video and data already processed

Clicking on reprocess and the Time Lapse Video Creation and Data Analysis appears (Figure 357).

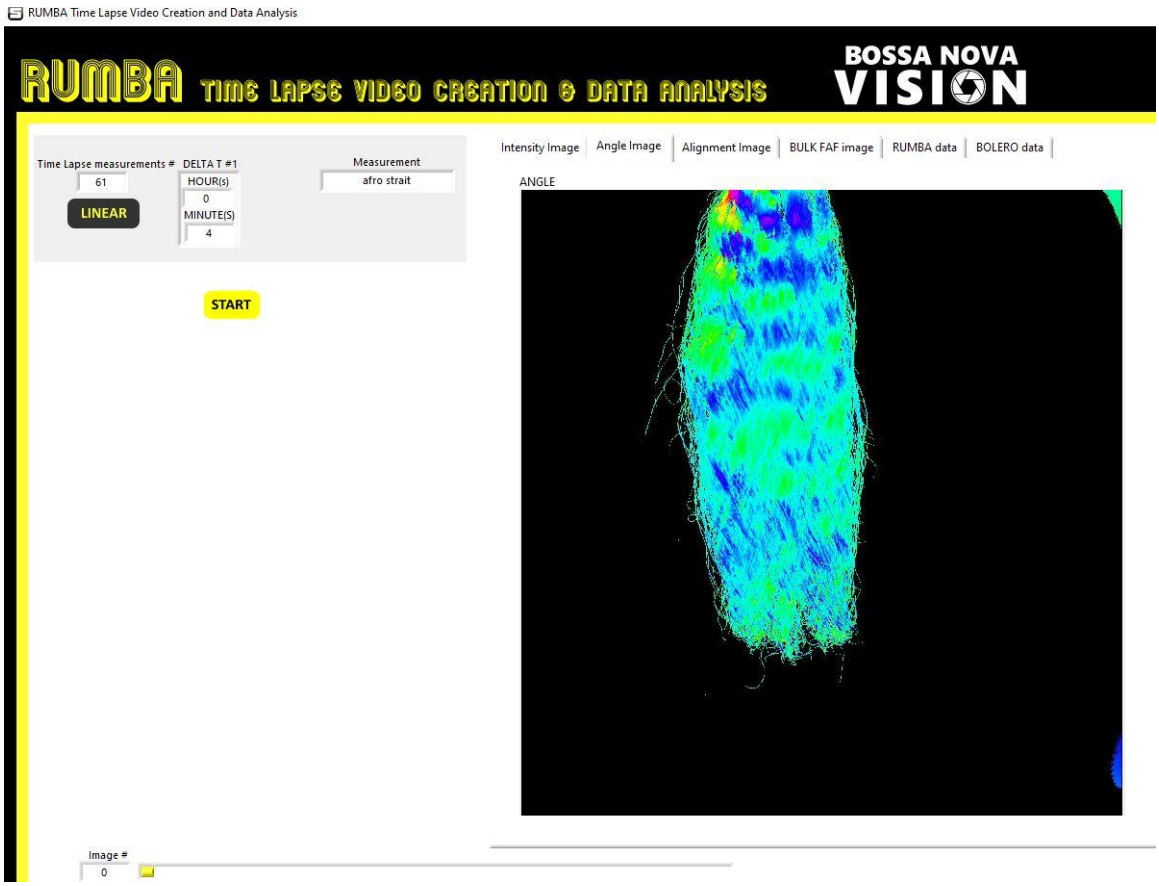


Figure 357: Time Lapse Video Creation and Data Analysis window

On the top left corner are the information about the time lapse. On the right are the different tabs showing the intensity, angle, alignment and BULK FAF images, followed by the RUMBA graphs and BOLERO graphs. On the bottom is the progress tab.
Clicking on start will process the video and data. Once it is done, a pop-up window appears (Figure 358).

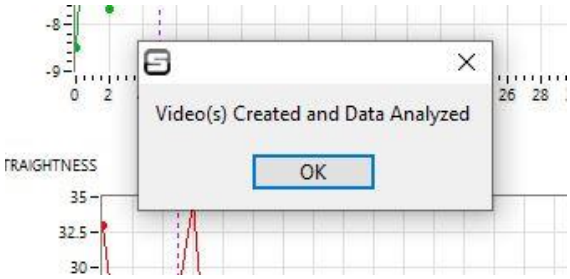


Figure 358: Video/data process done

The user can visualize the video and graph using the play/stop/pause buttons similar to the other software time lapse or export the time lapse data using (Figure 359).



Figure 359: play/pause/stop and export

Clicking on export allows to export the videos and data to a folder. The folder contains the 4 videos (angle, alignment, intensity and mask in avi format) and the excel file with the data/graphs (Figure 360).

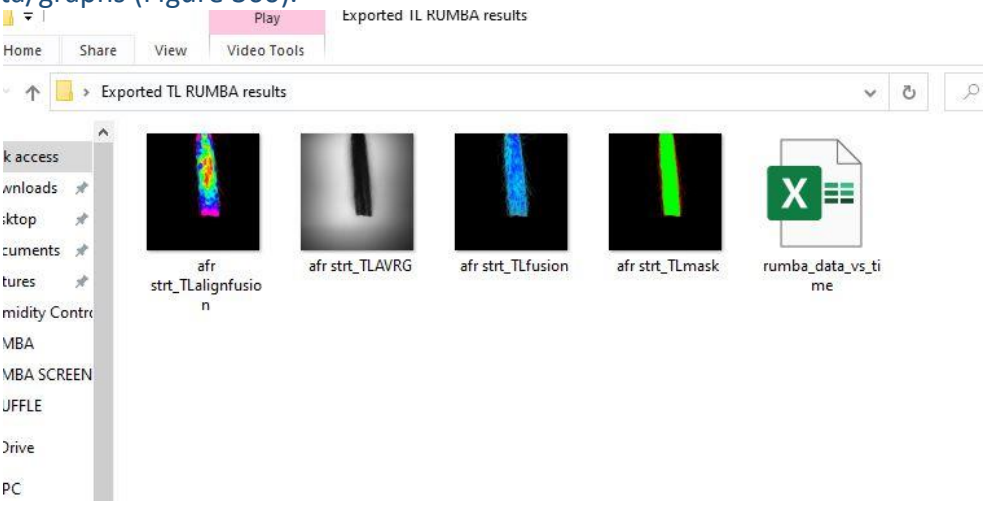


Figure 360: time Lapse exported folder

The excel file contains the data and graph of the various parameters (Figure 361).

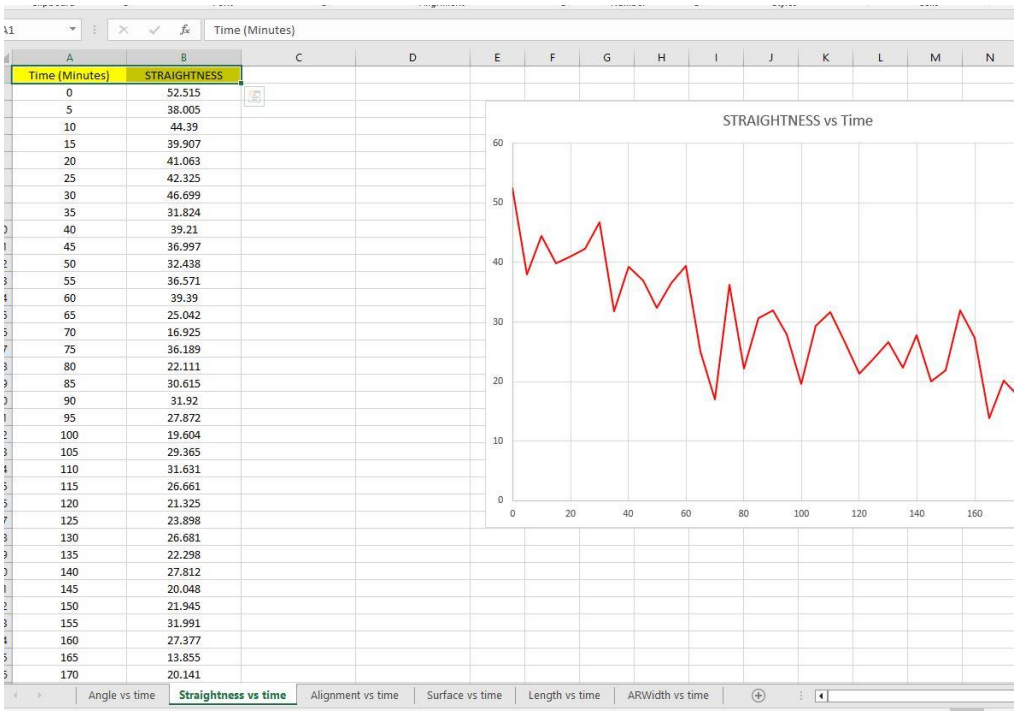


Figure 361: time lapse excel file

9. Basic Export

9.1. BOLERO TRIO/ BOLERO WIDE 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 362: 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 363).

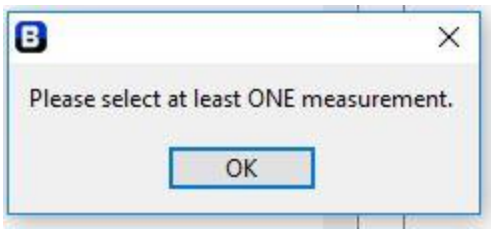


Figure 363: Pop-up window – No measurement selected

If measurements are selected, the following pop-up window appears (Figure 364), indicating the number of measurements to be exported and signaling that un-processed measurements will not be exported.

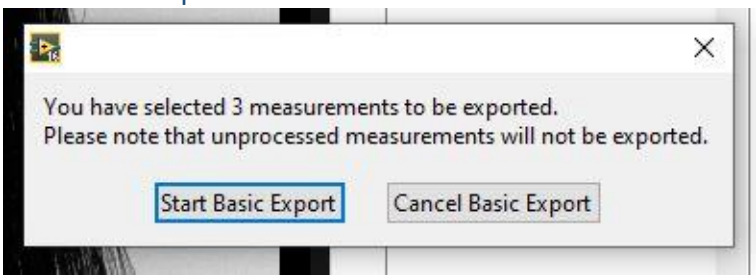


Figure 364: Pop-up window – Start or Cancel

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 365), already populated with Exported basic results BOLERO TRIO.

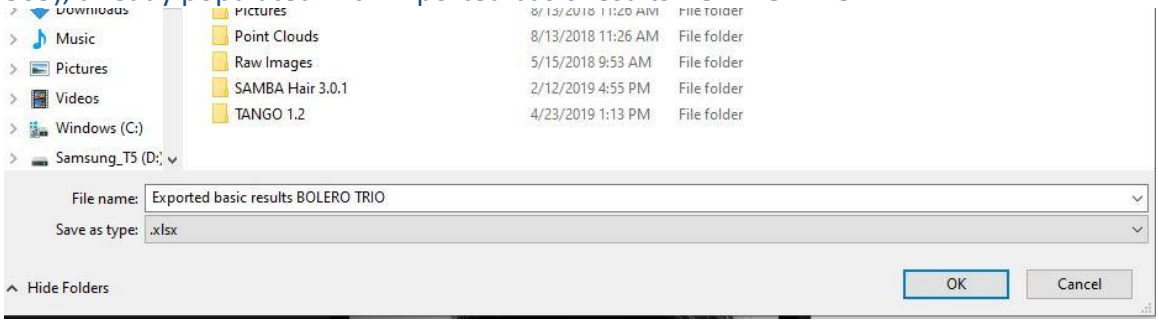
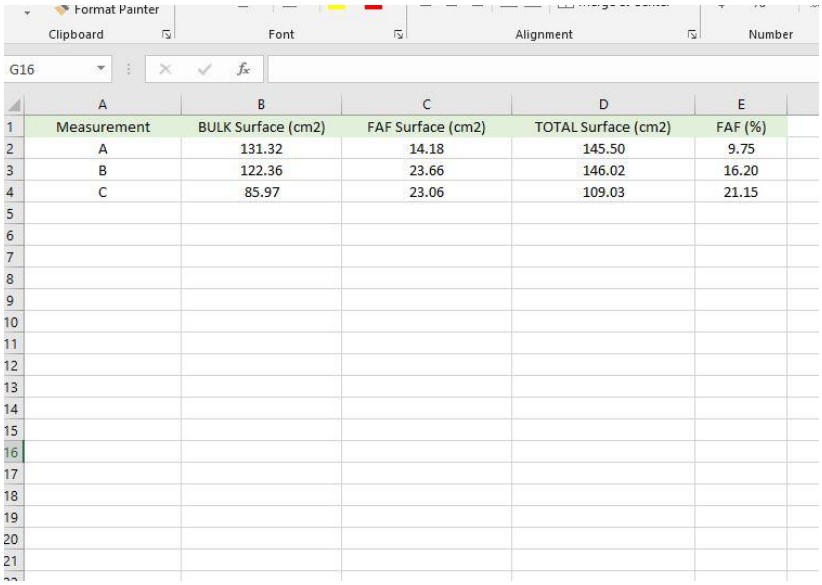


Figure 365: Pop-up window – Destination Filename

The excel file contains 3 tabs, corresponding the normal and Footprint results (Figure 366).

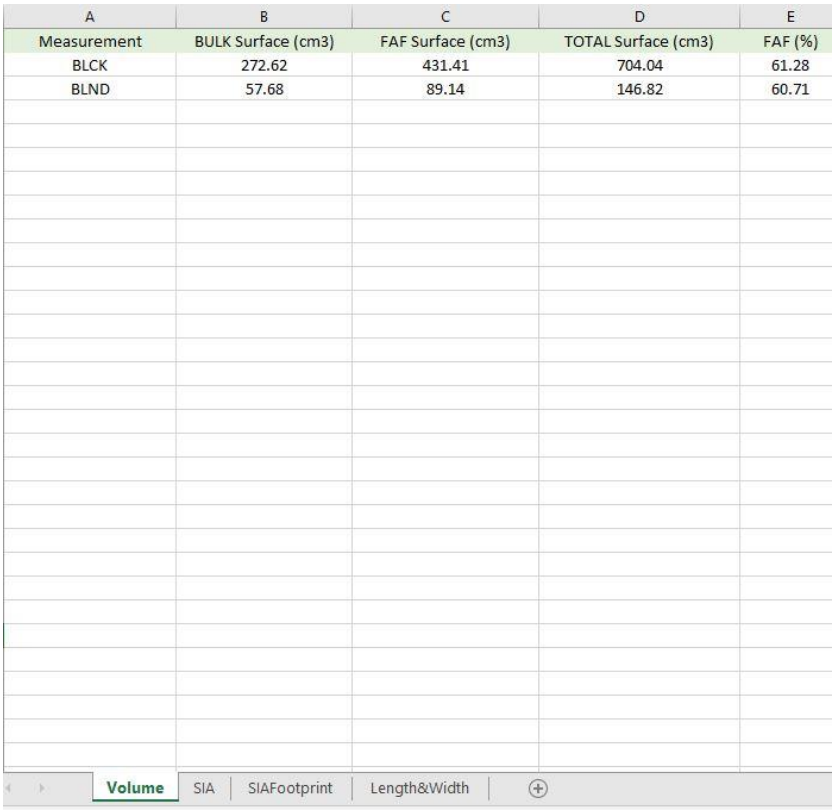


	A	B	C	D	E
1	Measurement	BULK Surface (cm2)	FAF Surface (cm2)	TOTAL Surface (cm2)	FAF (%)
2	A	131.32	14.18	145.50	9.75
3	B	122.36	23.66	146.02	16.20
4	C	85.97	23.06	109.03	21.15

Figure 366: Excel File

9.2. BOLERO 360 Basic Export

Similar to BOLERO TRIO and BOLERO WIDE, 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. The results are summarized in an Excel File (Figure 367).



A	B	C	D	E
Measurement	BULK Surface (cm3)	FAF Surface (cm3)	TOTAL Surface (cm3)	FAF (%)
BLCK	272.62	431.41	704.04	61.28
BLND	57.68	89.14	146.82	60.71

Volume | SIA | SIAFootprint | Length&Width

Figure 367: Bolero 360 Basic Export Excel

For each measurements selected to exported, the Volume, SIA, SIA Footprint and Length/Width results are summarized in the Excel file.

9.3. HOP Basic Export

Same as BOLERO WIDE.

9.4. RUMBA Basic Export

Same as the other software, 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. Once the user selected the measurement to be exported and clicked on Basic export, a pop-up window appears to inform the user that only processed measurement will be exported (Figure 368).

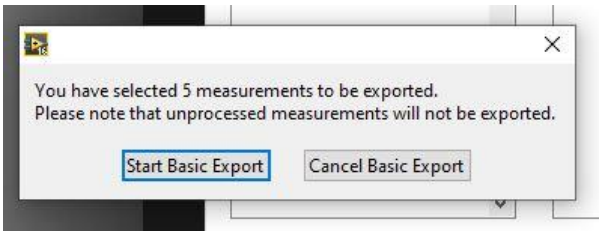


Figure 368: Pop-up window

Once the user clicks on Start Basic Export, a pop-up window asking for the excel filename appears (Figure 369).

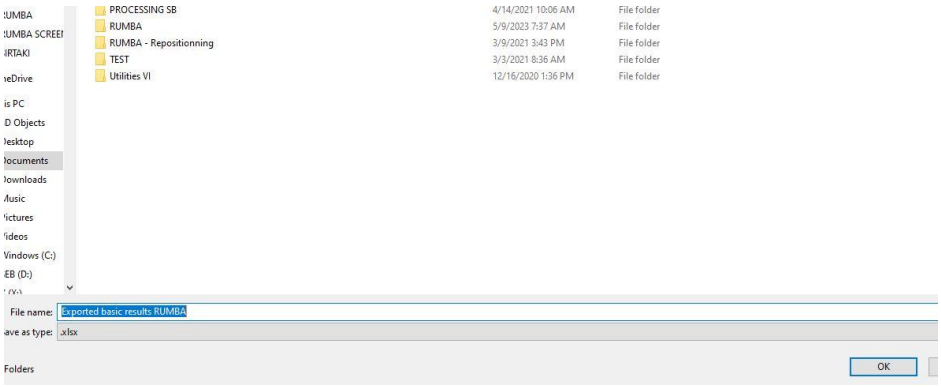
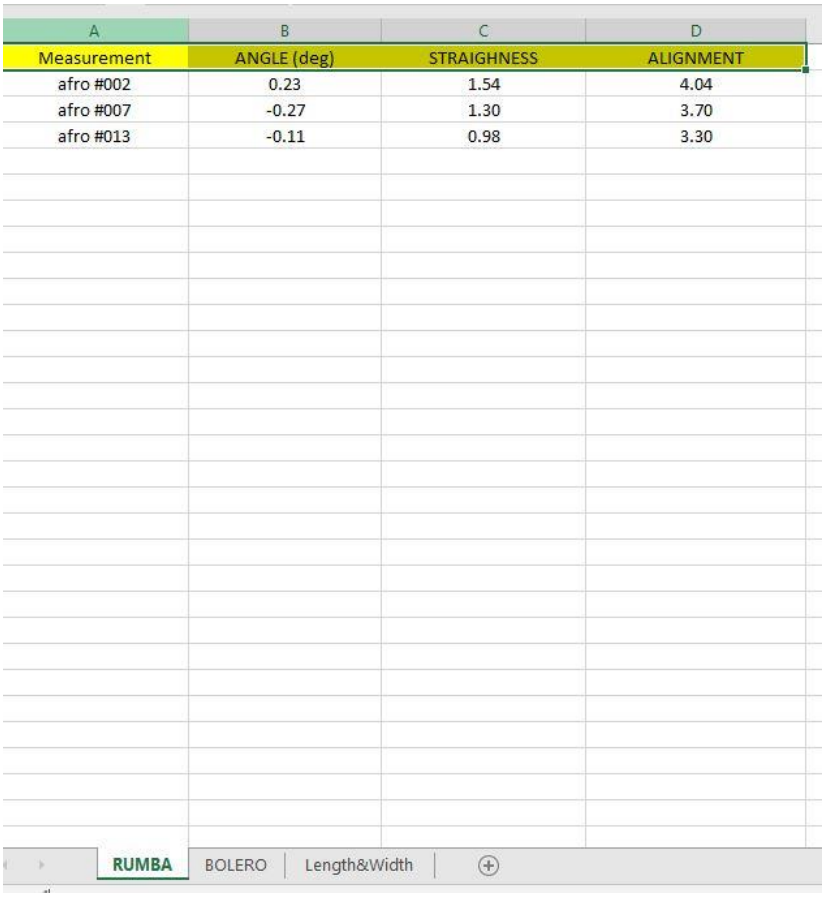


Figure 369: Filename basic export window

The results are summarized in an Excel File (Figure 370).



	A	B	C	D
1	Measurement	ANGLE (deg)	STRAIGHNESS	ALIGNMENT
2	afro #002	0.23	1.54	4.04
3	afro #007	-0.27	1.30	3.70
4	afro #013	-0.11	0.98	3.30

RUMBA | BOLERO | Length&Width

Figure 370: Basic Export – Excel file

3 tabs are present in the excel file:

- RUMBA with the angle, Straightness and alignment
- BOLERO for the total, bulk, faf surface and faf %
- Length and Width

10. Data format

10.1. BOLERO TRIO/BOLERO WIDE data format

The data are stored in the software root folder (containing the executable file) respectively in DATA_TRIO (DATA_WIDE for BOLERO WIDE) 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 or Select DATA Folder for BOLERO WIDE control on the data management page and the usual pop-up window appears (Figure 371) allowing to select a different folder containing data. If the DATA_TRIO (DATA_WIDE) Folder does not exist in the new location, the software will immediately create them.

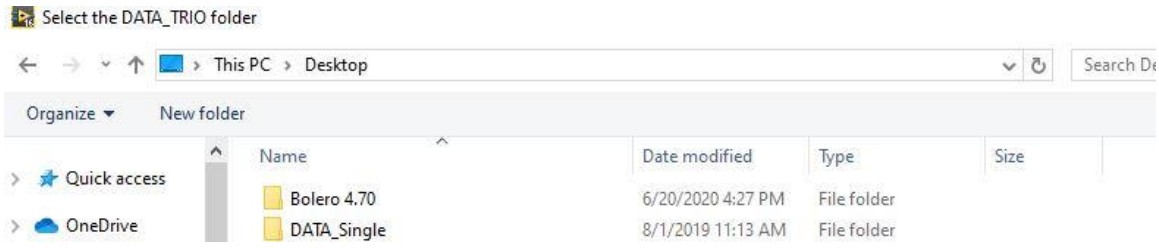


Figure 371: Window to change data folder location

The software will update the data architecture (study, sub-folder and measurement). The data format is the following (Figure 372). Each new measurement creates of folder with the measurement name.

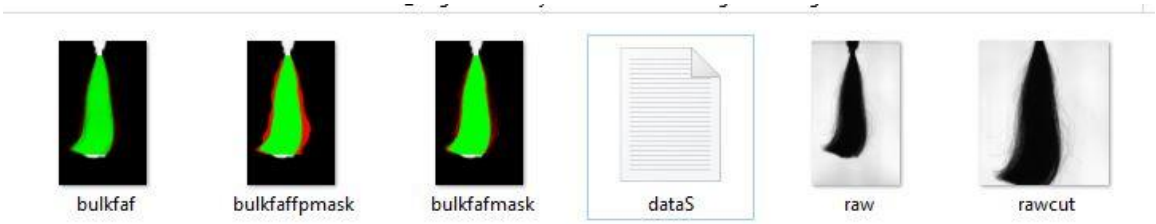


Figure 372: Data format - folder

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.

10.2. BOLERO 360 data format

The data are stored in the software root folder (containing the executable file) respectively in DATA_360 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 373) allowing to select a different folder containing data. If the DATA_360 Folder does not exist in the new location, the software will immediately create them.

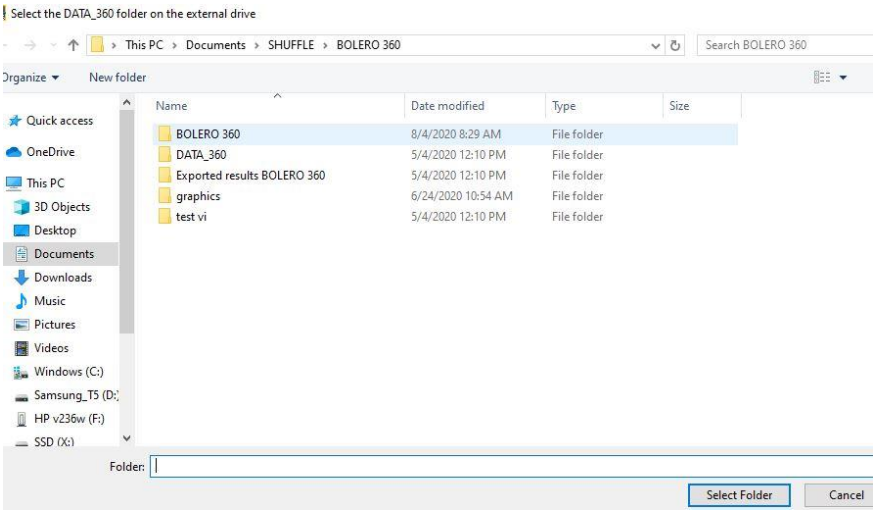


Figure 373: Window to change data folder location

The software will update the data architecture (study, sub-folder and measurement). The data format is the following (Figure 374). Each new measurement creates of folder with the measurement name.

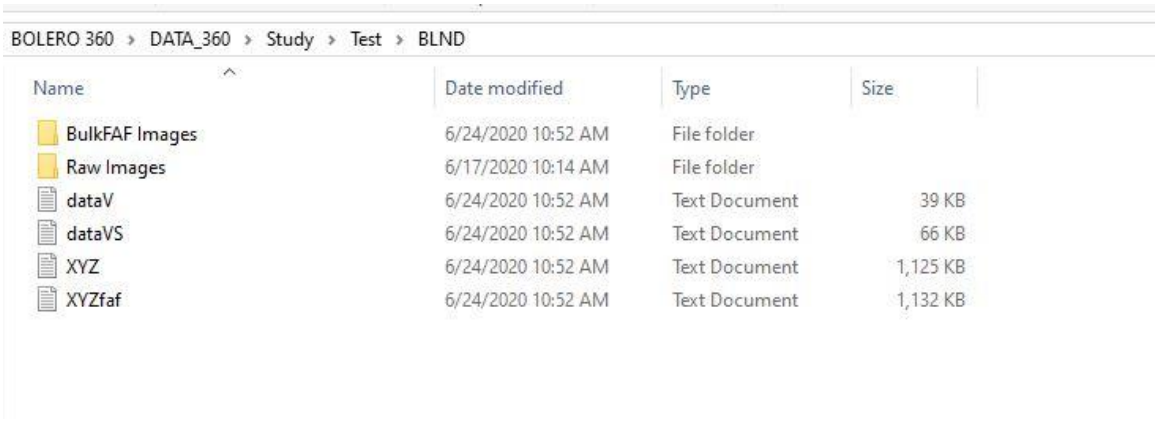


Figure 374: Data format - folder

The folder contains:

- A folder named BulkFAF images
- A folder named Raw Images
- An image named bulkfaf (jpg format)
- A text file named dataV.txt
- A text file named dataVS.txt
- A text file named XYZ.txt
- A text file named XYZfaf.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 **dataV.txt** contains the information about the volume of the bulk, FAF, total and Fly-Away & Frizz (%) versus z (z varies from swatch start to swatch

limit). The text file **dataVS.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 for the averaged image over the angle, plus the same information for the footprint processing.

The text file **XYZ.txt** is the point cloud of the BULK 3D volume reconstructed by the software.

The text file **XYZfaf.txt** is the point cloud of the FAF 3D volume reconstructed by the software.

The folder **Raw Images** contains all the raw images and the cut images (images cut between swatch start and swatch limit) acquired and processed by the software (Figure 375), for each angle, in png format.

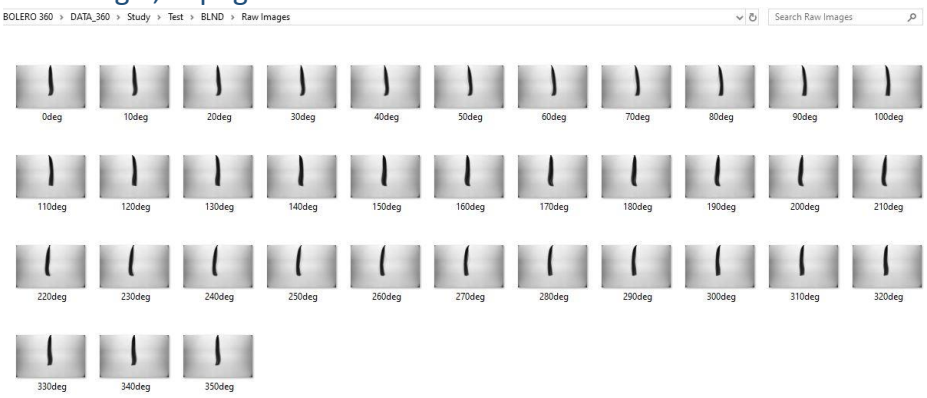


Figure 375: RAW IMAGES FOLDER

Each raw image is named imagexdeg.png with x = 0, 10,..350.

The folder **BulkFAF Images** contains all the processed images processed by the software (Figure 376), in jpg format.

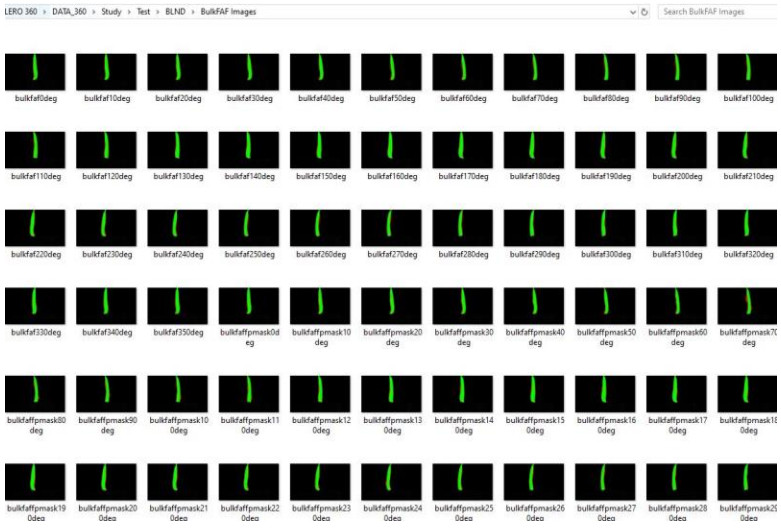


Figure 376: BULKFAF images FOLDER

Each bulk FAF image is named bulkfafxdeg.jpg with x = 0, 10,..350.

Each bulk FAF mask image is named bulkfafmaskxdeg.jpg with x = 0, 10,..350.

Each bulk FAF footprint mask image is named bulkfaffpmaskxdeg.jpg with x = 0, 10,..350. When the user reprocesses the data, only the images named imagexdeg remains the same. The other images and data are updated with new swatch start and swatch limit values.

10.3. HOP data format

The data are stored in the software root folder (containing the executable file) in DATA_HOP folders. It is possible to change the location of the data to be used, for example on an external hard drive. Just click on Use external drive for data on the data management page and the usual pop-up window appears allowing to select a different folder containing data. If the DATA_HOP Folder does not exist in the new location, the software will immediately create them.
The software will update the data architecture (study, sub-folder and measurement).
The data format is the following (Figure 377). Each new measurement creates of folder with the measurement name.

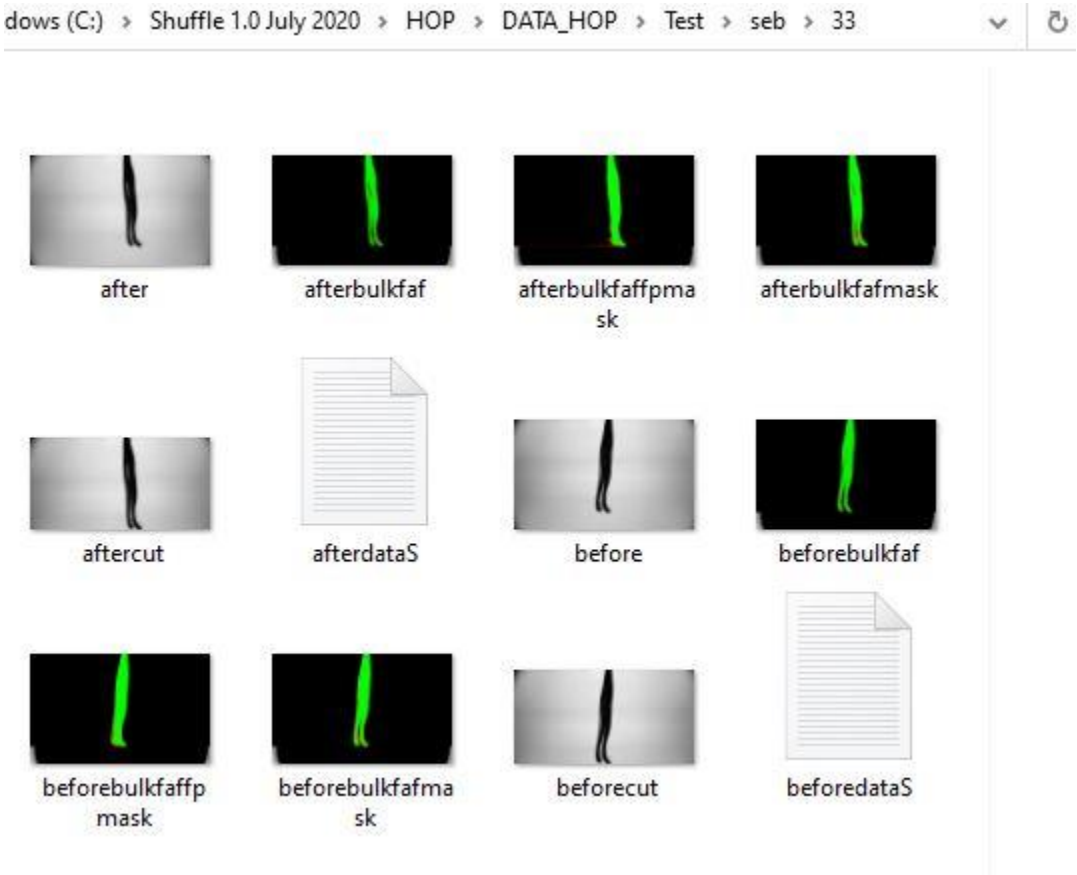


Figure 377: Data format - folder

The folder contains:

- An image named after (png format)

- An image named aftercut (png format)
- An image named afterbulkfaf (jpg format)
- An image named afterbulkfafmask (jpg format)
- An image named afterbulkfaffpmask (jpg format)
- A text file named afterdataS.txt
- An image named before (png format)
- An image named before cut (png format)
- An image named beforebulkfaf (jpg format)
- An image named before bulkfafmask (jpg format)
- An image named before bulkfaffpmask (jpg format)
- A text file named before 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 files x**dataS.txt** contain 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.

10.4. HULA data format

The data are stored in the software root folder (containing the executable file) respectively in DATA_HULA folders. The data format is the following (Figure 378). Each new measurement creates of folder with the measurement name.

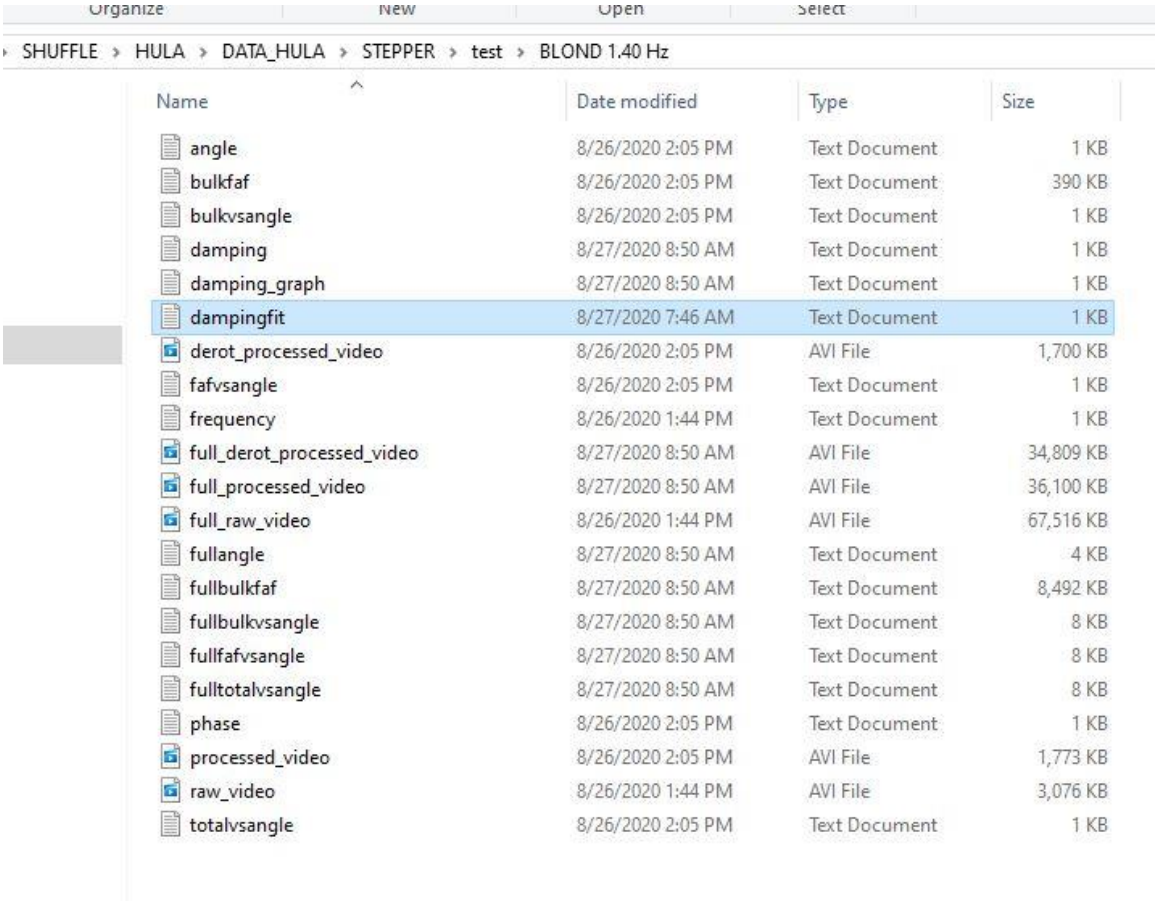


Figure 378: Data format - folder

The folder contains:

- 6 videos in avi format
- 14 text files

The 6 videos are below and self-explanatory:

- raw_video.avi
- processed_video.avi
- full_raw_video.avi
- full_processed_video.avi
- derot_processed_video.avi
- full_derot_processed_video.avi

The 14 text files:

- angle.txt contains the angle versus the frame # for the stationary loop video
- bulkfaf.txt contains the bulk and faf versus the frame # for the stationary loop video
- bulkvsangle.txt contains the bulk versus the angle information for the stationary loop video
- damping.txt contains the damping coefficient

- dampingfit.txt contains the damping fit
- fafvsangle.txt contains the faf versus the angle information for the stationary loop video
- frequency.txt contains the frequency of the stationary loop video
- fullangle.txt contains the angle versus the frame # for the full video
- fullbulkfaf.txt contains the bulk and faf versus the frame # for the full video
- fullbulkvsangle.txt contains the bulk versus the angle information for the full video
- fullfafvsangle.txt contains the faf versus the angle information for the full video
- fulltotalvsangle.txt contains the total (bulk+faf) versus the angle information for the full video
- phase.txt contains the phase in degree, between the hair swatch motion and the mount motion
- totalvsangle.txt contains the total (bulk+faf) versus the angle information for the stationary loop video

10.5. RUMBA data format

The data are stored in the DATA RUMBA folder. Each measurement has a folder (Figure 379) containing the Raw Images folder and various images and text file.



Figure 379: Measurement folder

The images in the folder are:

- align.png (monochrome)
- align_fusion.jpg (color image)
- align_mask_fusion.jpg (color image)
- angle.png (monochrome)
- angle_fusion.jpg (color image)
- angle_mask_fusion.jpg (color image)
- intensity.jpg (monochrome, average of the raw images)
- mask.png (BOLERO image)
- maskp.png (Bulk/faf image, in color)
- snr.png (signal to noise ratio image)
- snr_thresh.png (signal to noise ratio image after threshold)
- dataR.txt: text file contained the RUMBA data
- dataR_vs_z.txt: text file contained the RUMBA versus z data
- dataS.txt: text file containing the BOLERO data
- info.txt: text file containing information about the measurement

The Raw images folder contains the images acquired by RUMBA (Figure 380).

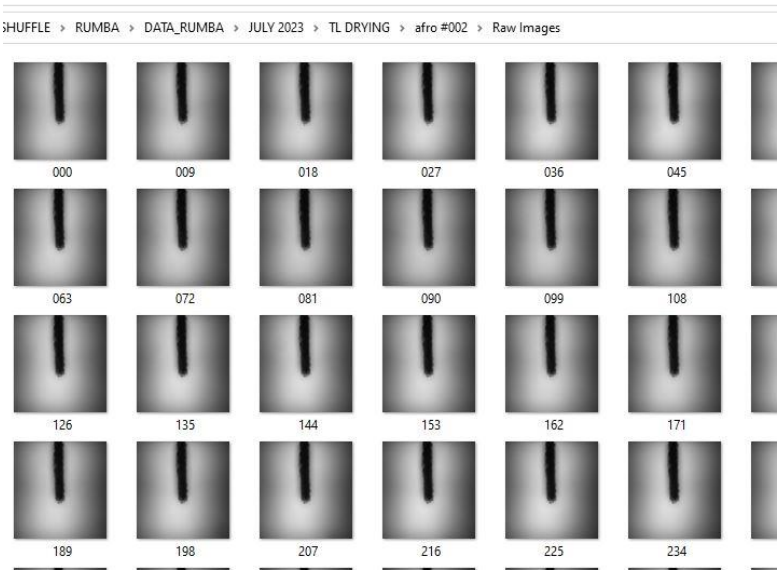


Figure 380: Raw Images folder

11. CALIBRATION

At the bottom of SHUFFLE main page is a calibration button (Figure 381).



Figure 381: Calibration

The button calibration allows to open the Shuffle calibration window (



Figure 382).



Figure 382: SHUFFLE Calibration software

Shuffle calibration software allows to calibrate Xstart and Zstart and the exposure time for each software. Because of the specifics of RUMBA and its forward looking polarized illumination, a dedicated calibration is necessary so 2 calibrations are necessary (BOLERO 360/WIDE/TRIO/HULA/HOP and RUMBA.

11.1. BOLERO 360/WIDE/TRIO/HULA/HOP calibration

Figure 383 shows the BOLERO 360/WIDE/TRIO/HULA/HOP calibration main window.

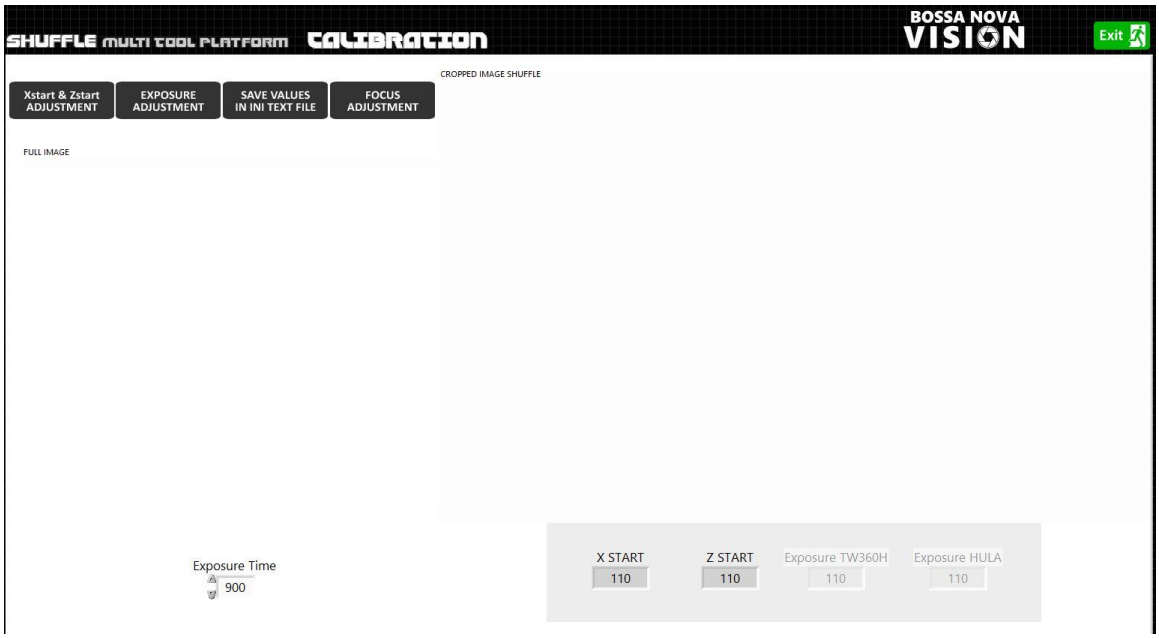


Figure 383: BOLERO 360/WIDE/TRIO/HULA/HOP calibration main window

On top, 4 buttons are present:

- Xstart & Zstart adjustment
- Exposure adjustment
- Save Values in ini
- Focus adjustment

11.1.1. Xstart & Zstart adjustment

If the user clicks on Xstart & Zstart adjustment button, the following windows pops up (Figure 384).



Figure 384: Xstart & Zstart adjustment window

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

11.1.2. Exposure adjustment

If the user clicks on Exposure adjustment button, the following windows pops up (Figure 385).



Figure 385: Exposure adjustment window

The software will automatically calculate the exposure time for BOLERO TRIO, BOLERO WIDE, BOLERO 360, HOP and HULA. Remember to have the LED back panel on. Once done, the pop up message appears (Figure 386).

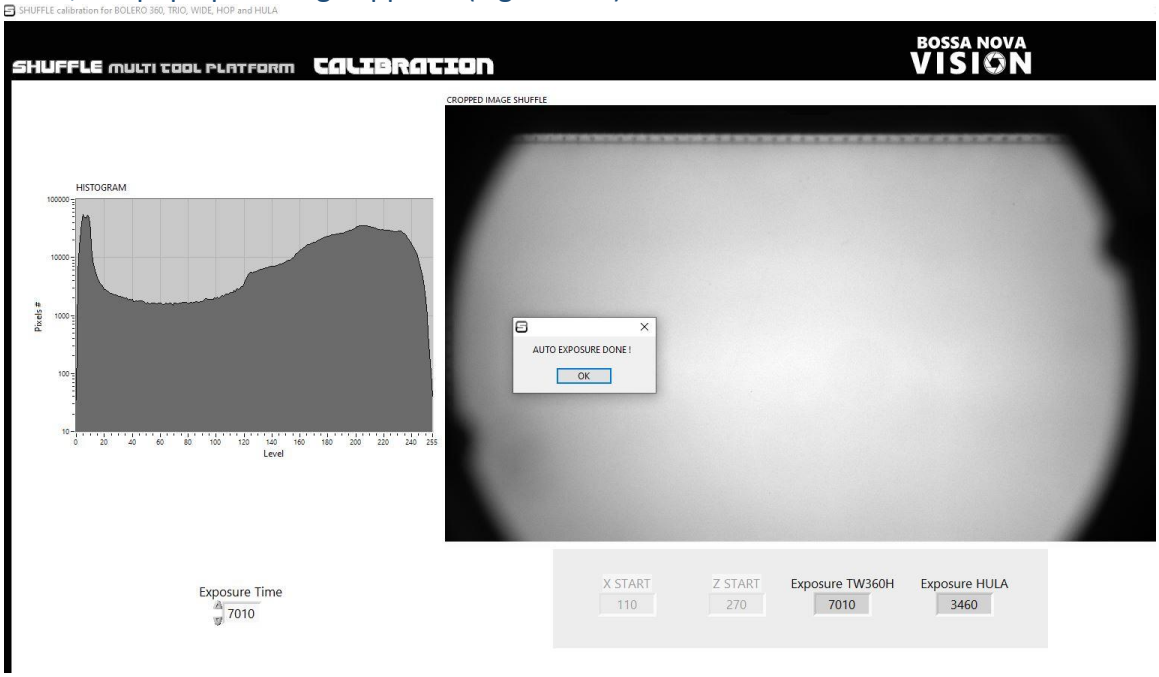


Figure 386: Auto Exposure done

Click on OK to go back to the main window.

11.1.3. 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 387).

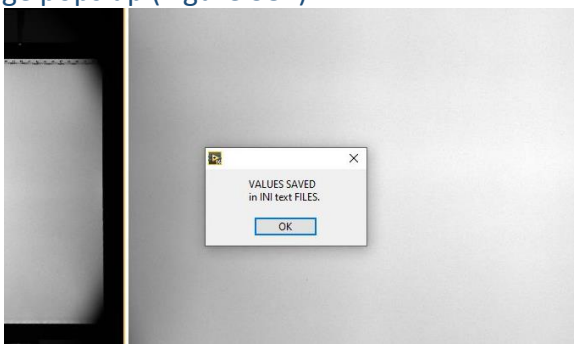


Figure 387: Values saved in ini files

11.1.4. Focus adjustment

This button helps the user to adjust the focus of the camera. This is done in our laboratory and should not be changed unless somebody unlock the focus screw on the lens and touch the focus of the lens. If the user notices that the image is blurry, he can use this option to refocus the lens. For that purpose, we recommend to place a hair swatch in the system and adjust the focus. Be careful not to change the aperture of the lens. In case it happens, the aperture is 4. Please redo the exposure adjustment once the aperture is back to its original value. A graph on the left shows the focus factor (the higher the better) but the user should check with the image on the right to be sure the focus is ok (Figure 388).

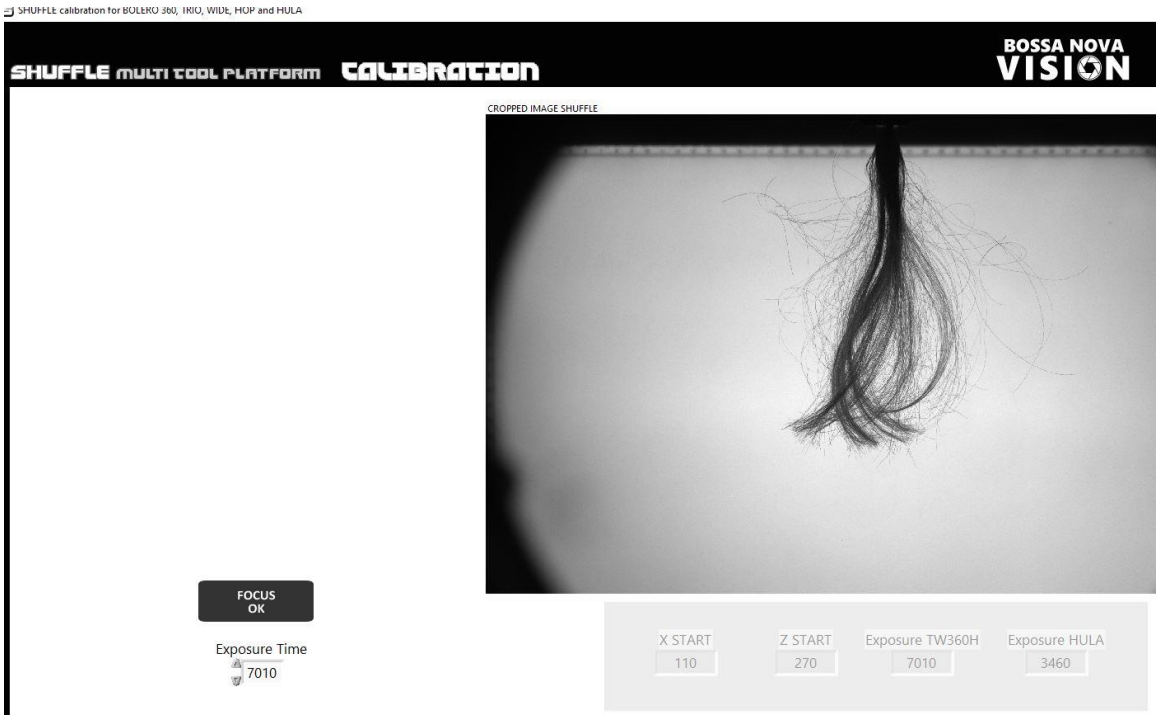


Figure 388: Focus adjustment

Once the focus is done, click on Focus ok to go back to the main window.

11.2. RUMBA CALIBRATION

Similar to the previous calibration, when the user clicks on RUMBA Calibration, a new window appears (Figure 389). The motors are homing before starting the calibration.



Figure 389: RUMBA Calibration

Once the motors are home, the software switches to the main window (Figure 390).

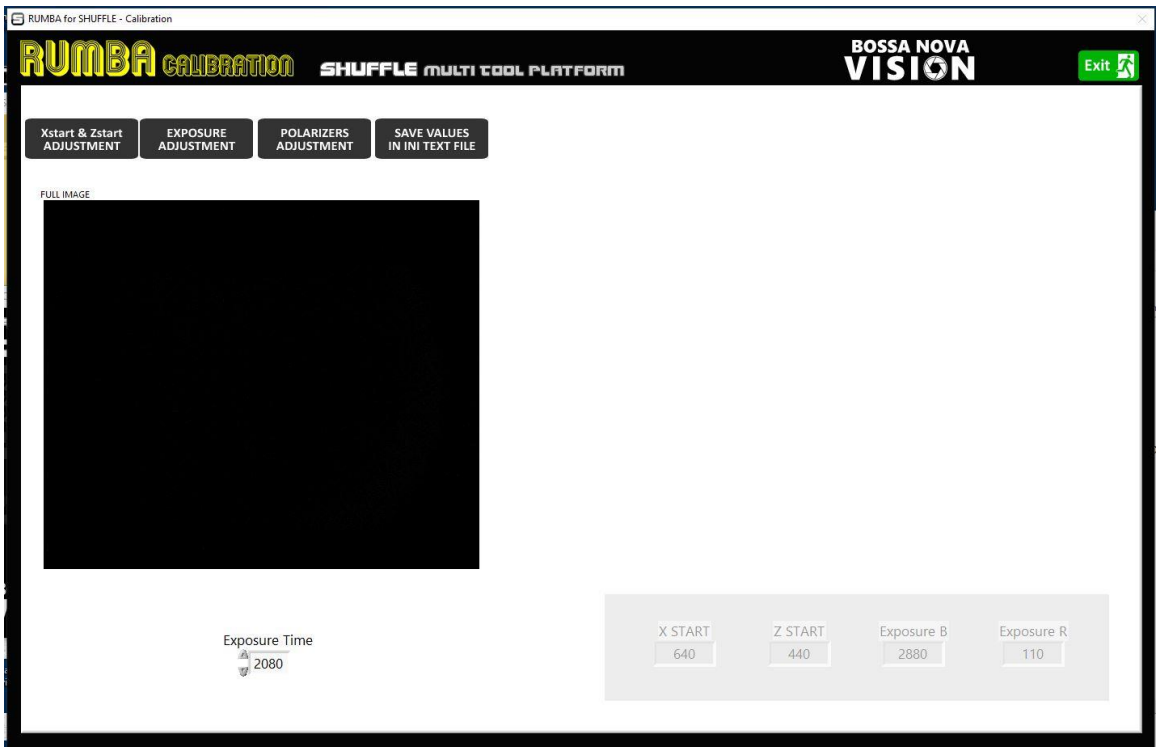


Figure 390: RUMBA Calibration – Main Window

On top, 4 buttons are present:

- Xstart & Zstart adjustment
- Exposure adjustment
- Save Values in ini
- Polarizers adjustment

11.2.1. Xstart and Zstart

If the user clicks on Xstart & Zstart adjustment button, the following windows pops up (Figure 391).

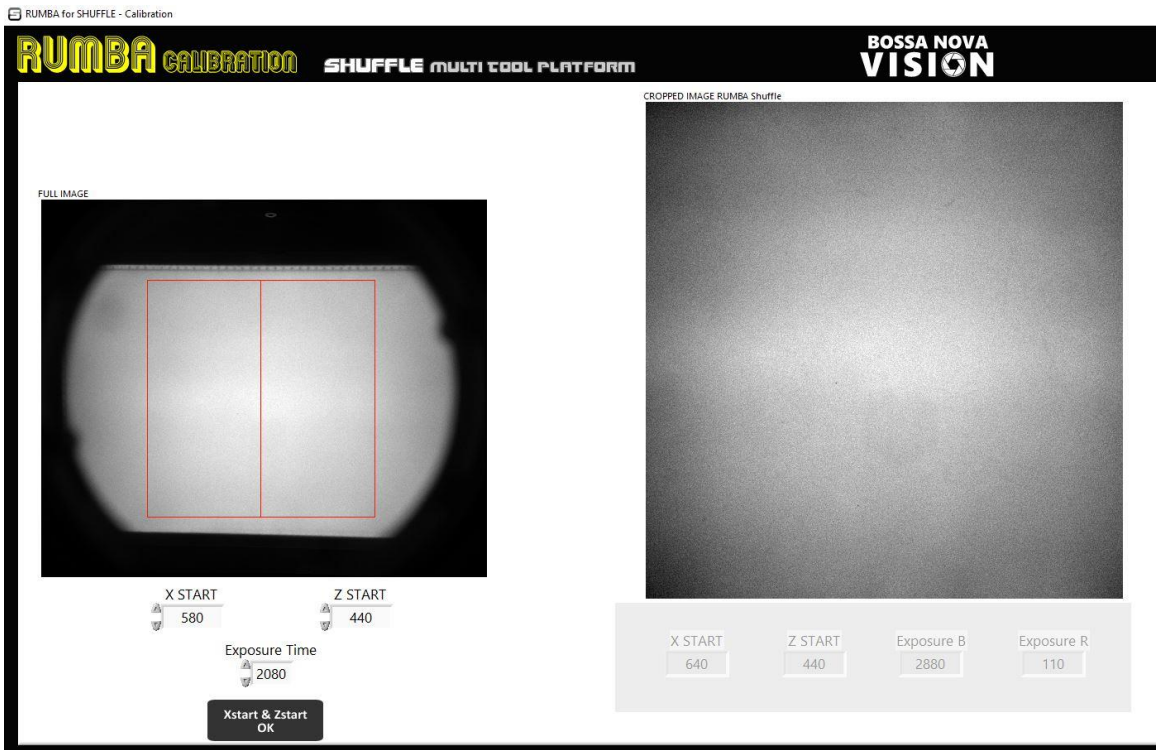


Figure 391: Xstart and Zstart

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

11.2.2. Exposure

If the user clicks on Exposure adjustment button, the following windows pops up (Figure 392).



Figure 392: Exposure

The software will automatically calculate the exposure time for the white LED background and the far red forward looking illumination. Once done, the pop up message appears (Figure 393).



Figure 393: Pop-up message – Exposure done

11.2.3. 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 394).

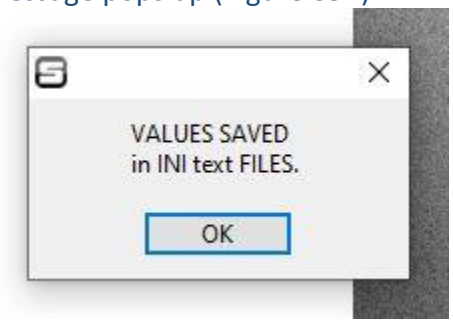


Figure 394: values saved in ini file

11.2.4. Polarizers adjustment

Please contact us for that specific calibration.

12. Technical background

12.1. 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 395).



Figure 395: Bulk and Fly-away/Frizz definition

The goal of the image processing is to extract the bulk and the fly-away/frizz (Figure 396).

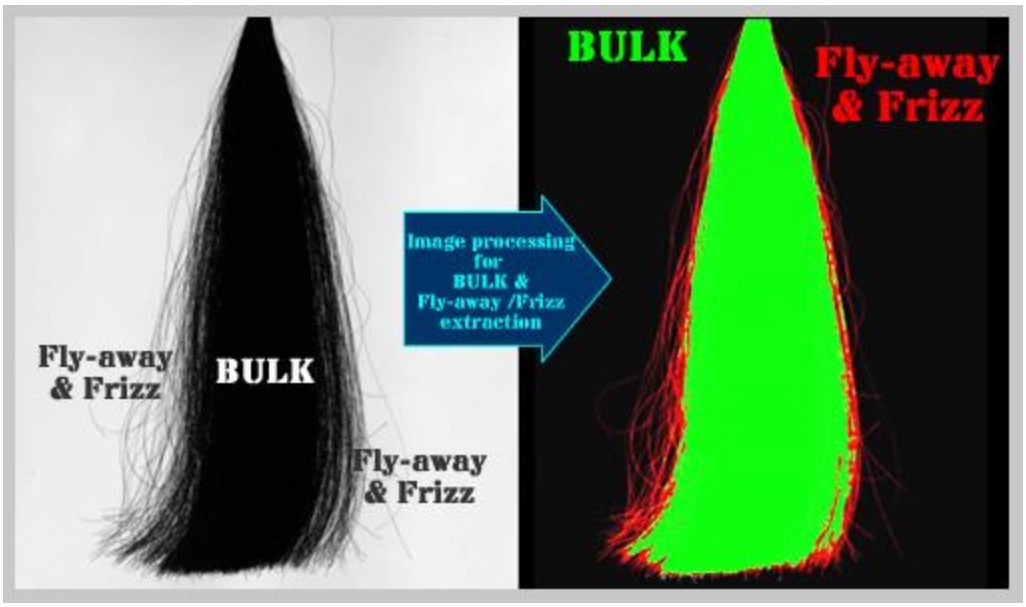


Figure 396: Bulk and Fly-away/frizz extraction

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.

12.2. 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 397).



Figure 397: Transmission image

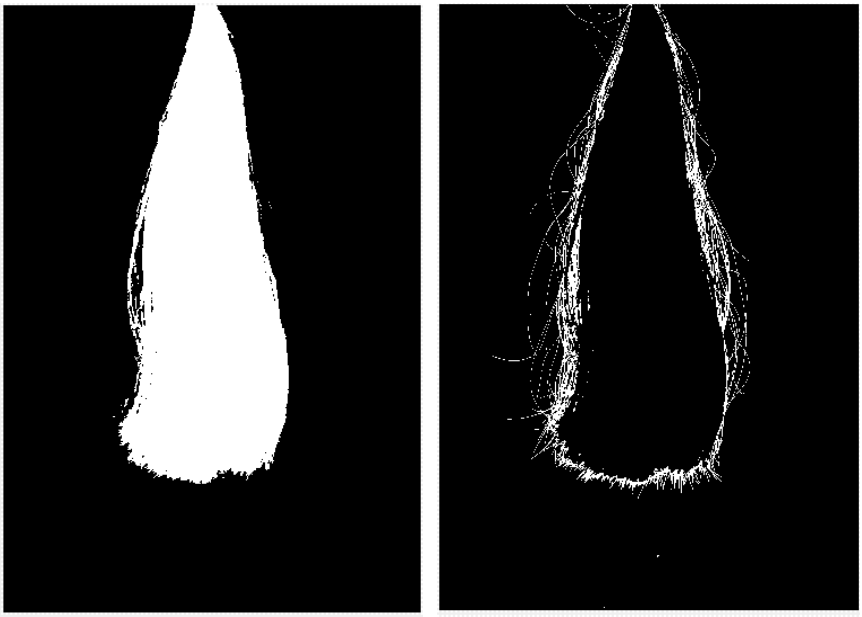
A calculation of the density for each pixel is easily done for each pixel of the image. In that case, the density is calculated with 6 neighbors, per line. The density image is given on Figure 398.



Figure 398: 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.

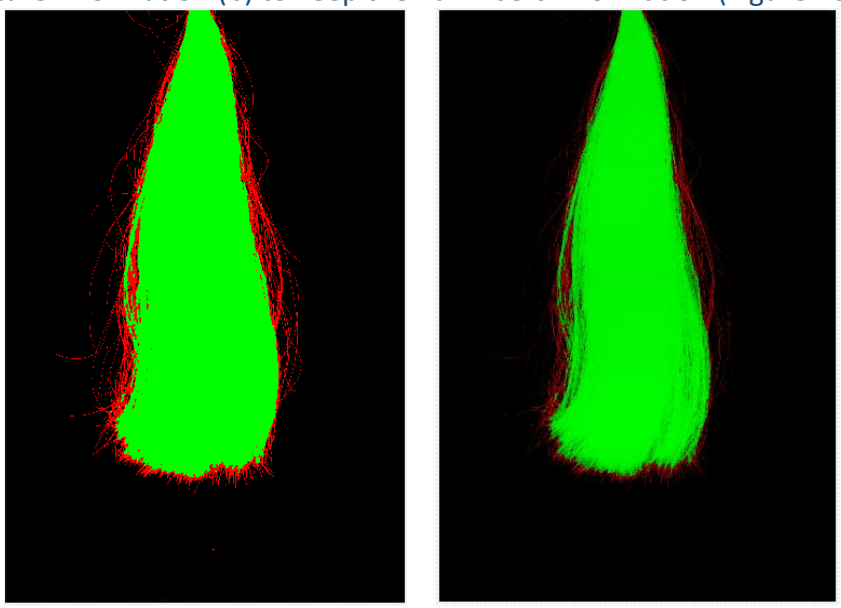
We then obtain 2 images, the bulk image and the fly-away/frizz image (Figure 399)



(a) (b)

Figure 399: (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 400).



(a) (b)

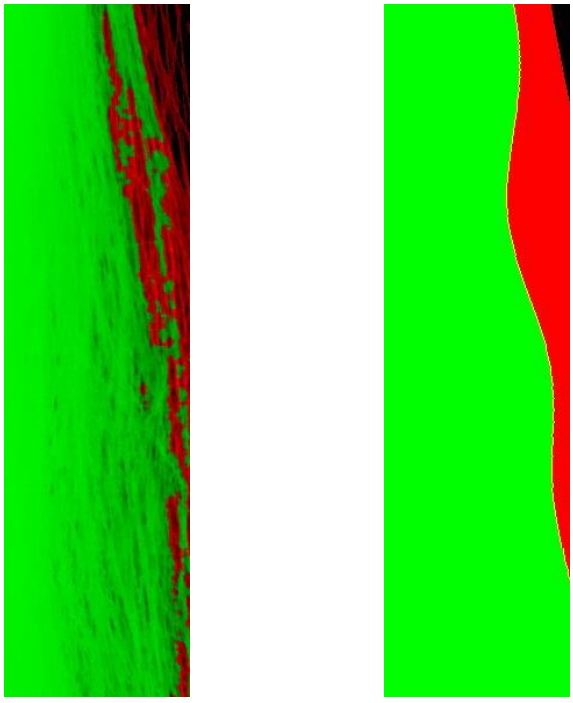
Figure 400: (a) BULK/FAF mask image (b) BULK/FAF image

This is the usual processing that is applied on regular 2D image. The Single image part of BOLERO 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.

12.3. Footprint processing

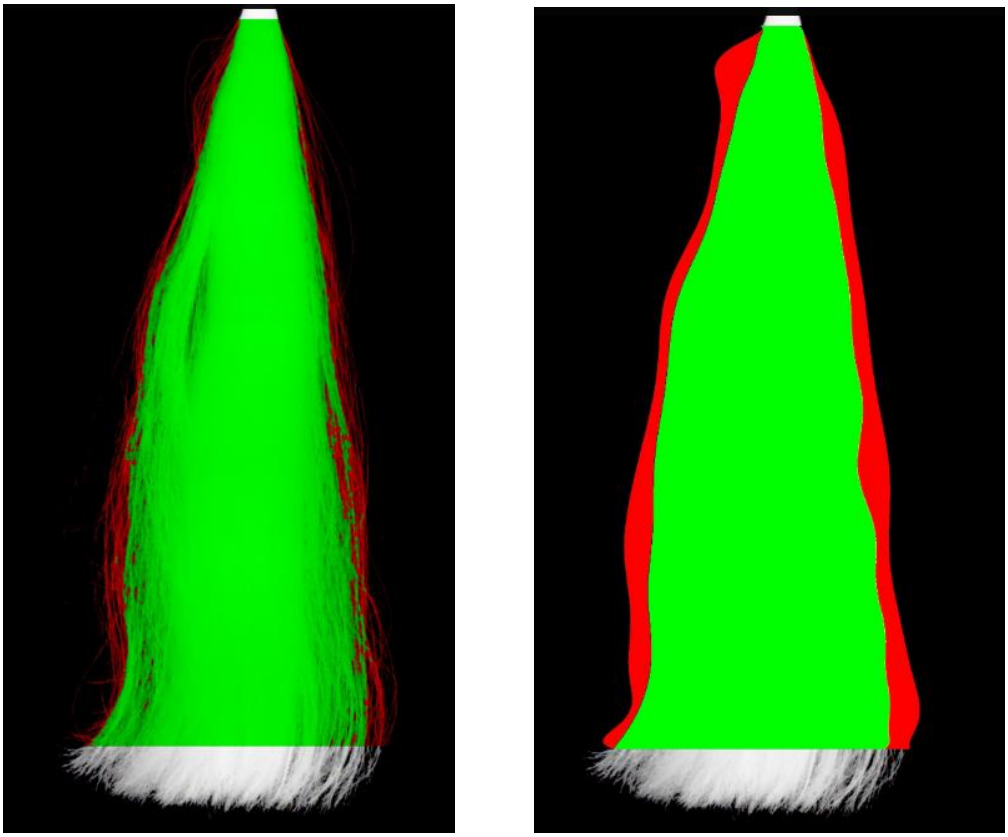
Footprint processing consists of transforming the BULK and the FAF into closed surfaces. For the BULK, it implies removing holes & peaks and for the FAF, it is based on filling the fly-away/frizz zone (Figure 401).



(a) After Bulk/FAF processing (b) After Footprint processing

Figure 401: Removing holes and peaks / filling FAF

Figure 402 shows the complete image after processing.



(a) Bulk/FAF processing (b) Footprint processing

Figure 402: Footprint processing on full image

The BULK footprint and the FAF footprint are closed surface.

12.4. 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 403) and is the width value if the hair swatch was rectangular.

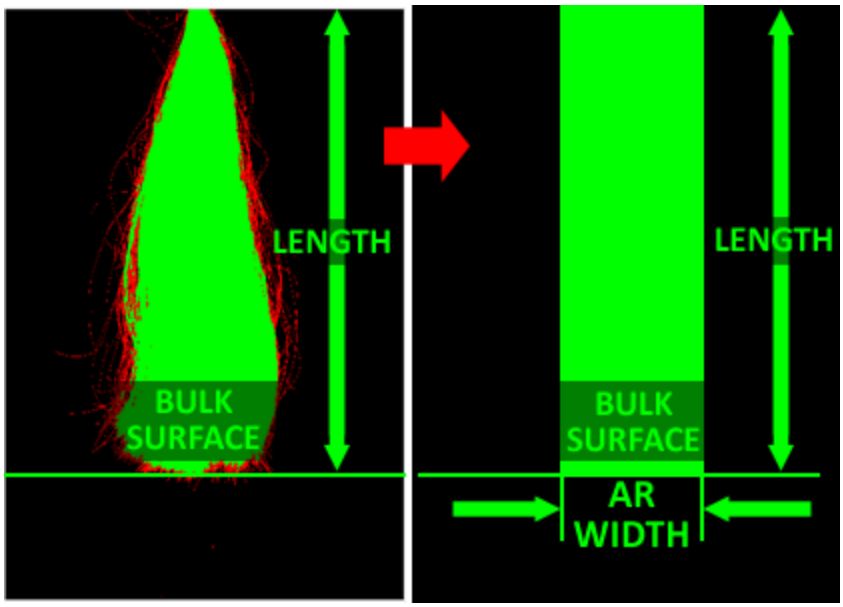


Figure 403: AR Width

12.5. 3D reconstruction – BOLERO 360

BOLERO 360 is based on the 3D reconstruction of 2D silhouette of a rotating 3D object. This method has already been demonstrated on 3D objects with well-defined boundaries. Due to the nature of the hair swatch, image processing based on density evaluation is needed to decompose the silhouette of the hair swatch into the bulk part with clear boundaries and the fly-away/frizz part mainly composed of individual fibers. The bulk part of the hair swatch presents a high density of hair fibers and blocks the back light illumination, contrary to the fly-away/frizz part that presents a low density of hair fibers and enables part of the light to go through. The bulk part can be considered a continuous area and therefore we can use the 3D reconstruction technique using the rotation of silhouette. The fly-away/frizz is not a continuous area. Similar to the bulk, we can estimate a fly-away/frizz continuous area in order to reconstruct its 3D volume. The principle of the reconstruction process is presented in Figure 404.

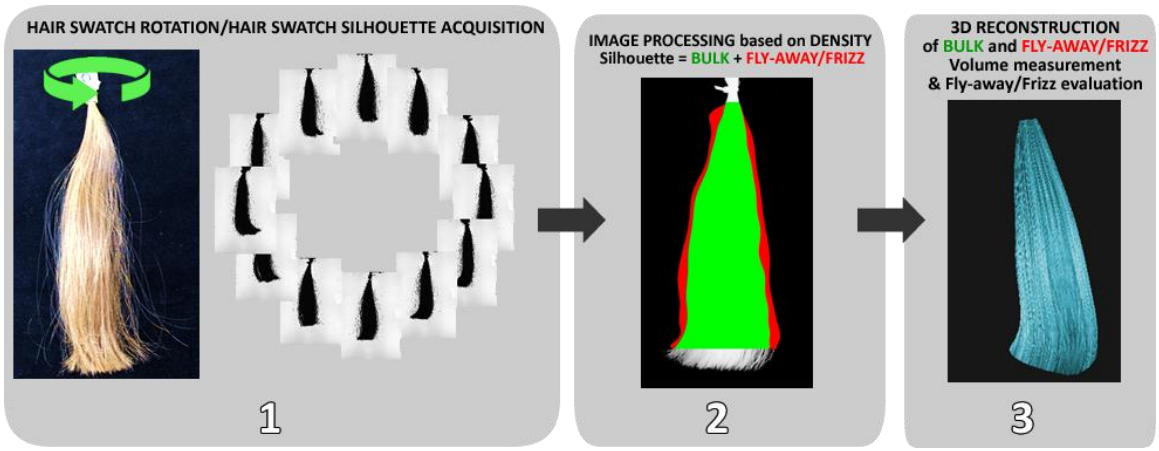


Figure 404: BOLERO 360 principle

The 3D reconstruction is decomposed into 3 consecutive steps:

1. Rotation of the hair swatch and acquisition of its silhouette for each angle

2. Image processing based on density evaluation for each pixel in order to decomposed the image into a bulk image and a fly-away/frizz image (FAF)

3. 3D reconstruction of the hair swatch bulk and FAF followed by an evaluation of their volume and fly-away/frizz %

Once the bulk and faf footprint have been extracted from the hair swatch, it is easy to extract clean contours for the BULK and FAF in order to be able to calculate their 3D volume (Figure 405).

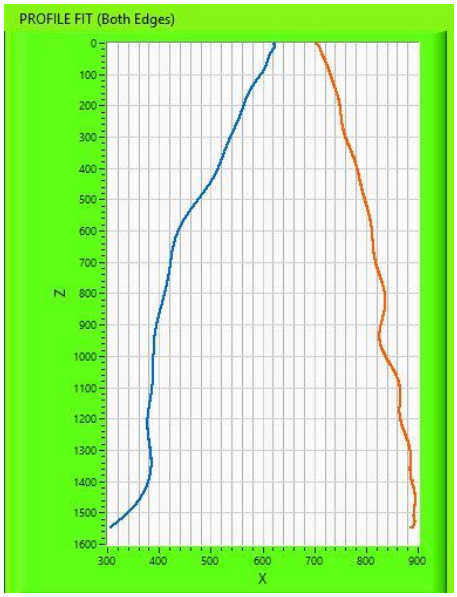


Figure 405: Contour extraction

Extraction of the contours while the hair swatch is rotated allows to reconstruct the 3D hair swatch shape employing the technique described in the references below (Figure 406).



(a) BULK (b) FAF

Figure 406: 3D shape

References:

"Acquiring 3-D models from sequences of contours", J. Y. Zheng, IEEE transactions on pattern analysis and machine intelligence, Vol. 16, N0 2, February 1994

"Area and volume measurements of objects with irregular shapes using multiple silhouettes", D.J. Lee, X. Xu, J. Eifert and P. Zhan, Optical Engineering 45 (2) 027202 (February 2016)

12.6. Angle (HULA)

The angle of the hair swatch is defined on Figure 407.

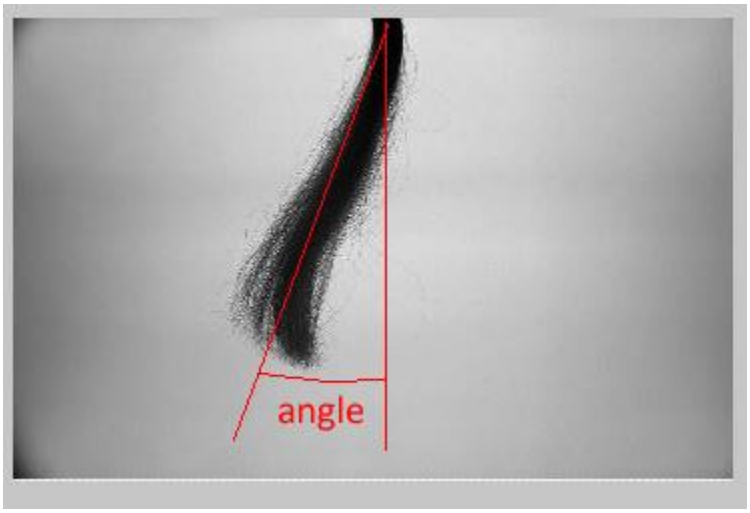


Figure 407: Hair swatch angle definition

It is the angle of the average swatch axis versus the vertical axis, counter clock wise (On the picture above, the angle is negative). The processed frame allows to detect the profile of the hair swatch and its axis. A linear fit of the hair swatch axis leads to the vertical angle measurement (Figure 408).

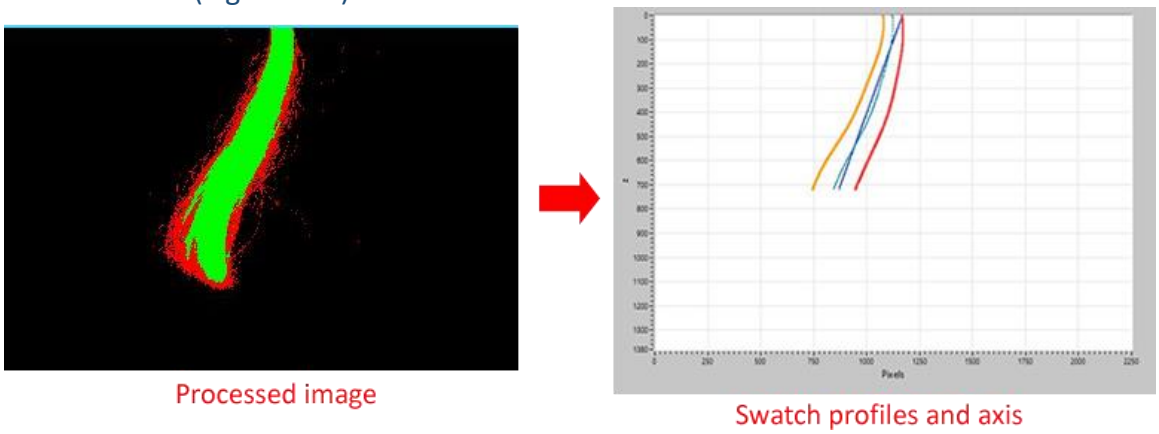


Figure 408: Profiles and axis

Note that thanks to the angle measurement, we are able to remove the rotation of the hair swatch and visualize the derotated processed video that is almost vertical and present higher order motion. The derotated processed video allows a precise measurement of the bulk and fly-away/frizz along its vertical axis.

12.7. Phase (HULA)

The phase is the measurement between the motion of the hair holder and the hair swatch (Figure 408) for the stationary loop.

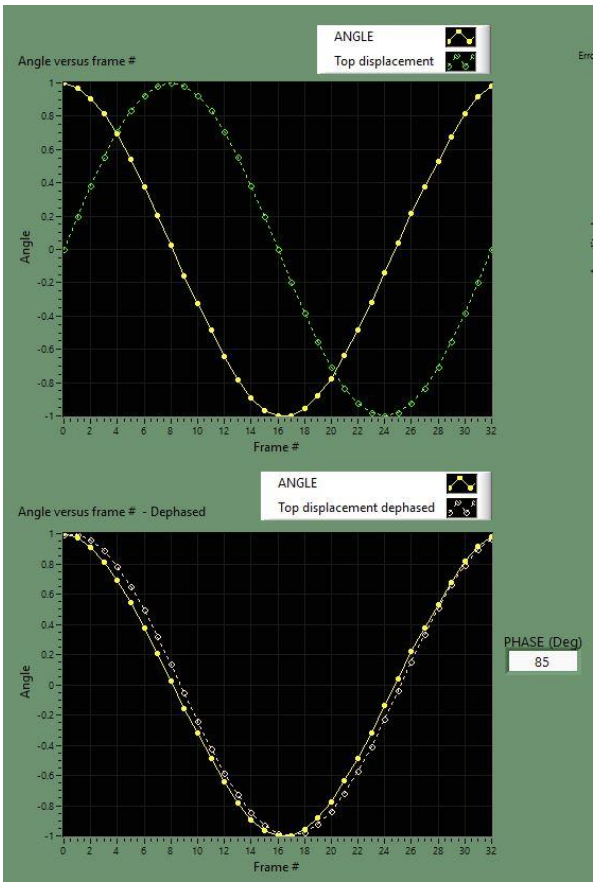


Figure 409: Phase

12.8. Damping (HULA)

The damping coefficient is measured once the motor of the shaker is turned off and the hair swatch keeps on moving until it stops as shown on Figure 410.

.

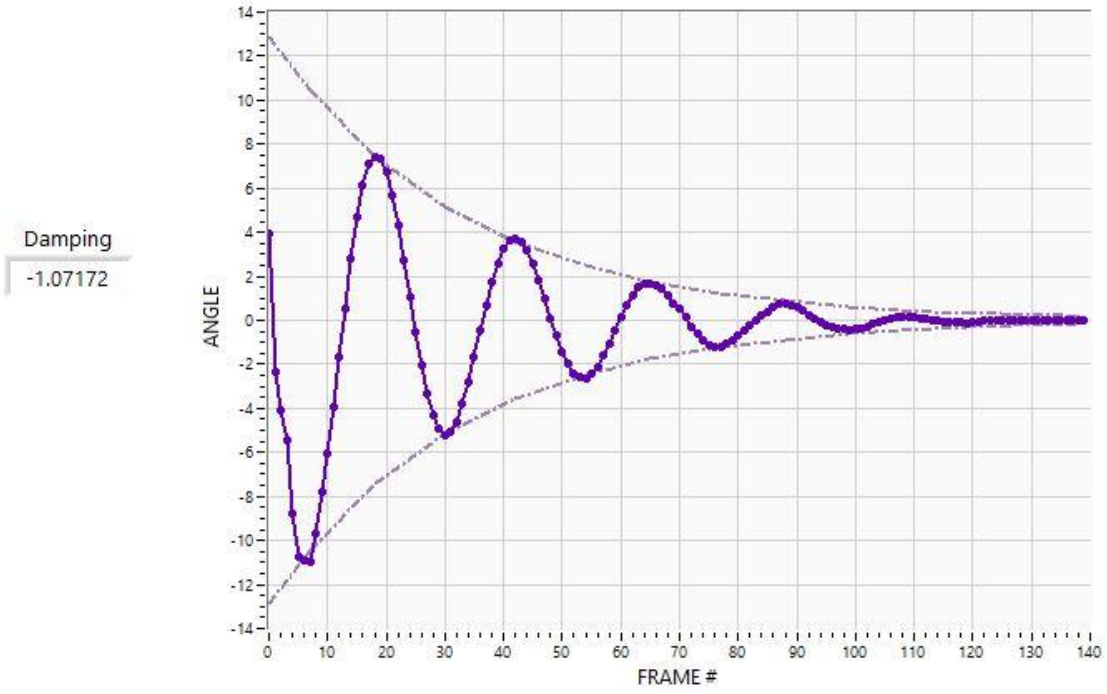


Figure 410: Hair swatch damping

A fit of the experimental measurement leads to a measurement of the damping.

12.9. Fiber orientation measurement (RUMBA)

12.9.1. Introduction

RUMBA used polarized illumination to measure the angle of the hair fiber for each pixel of the image. The detailed technical are explained in the following article - Fiber orientation measurement using polarization imaging - published in the Journal of Cosmetics Science (J. Cosmet. Sci., 62, 85–100 (March/April 2011)). RUMBA used a far red led illumination at 670 nm in order to be able to measure hair fibers from dark to light. RUMBA acquires a number of images with different polarizer positions. These images are then used to calculate an angle image, where each pixel value correspond to the angle of the hair fiber. The angle image is then processed to deliver an alignment image (Figure 411).

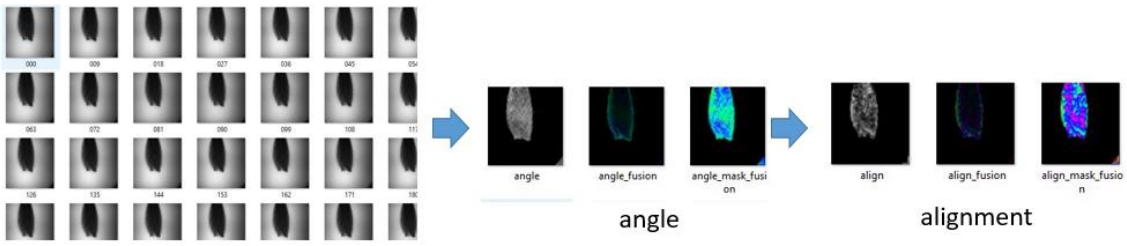


Figure 411: RUMBA processing

Figure 412 shows the angle image (color)

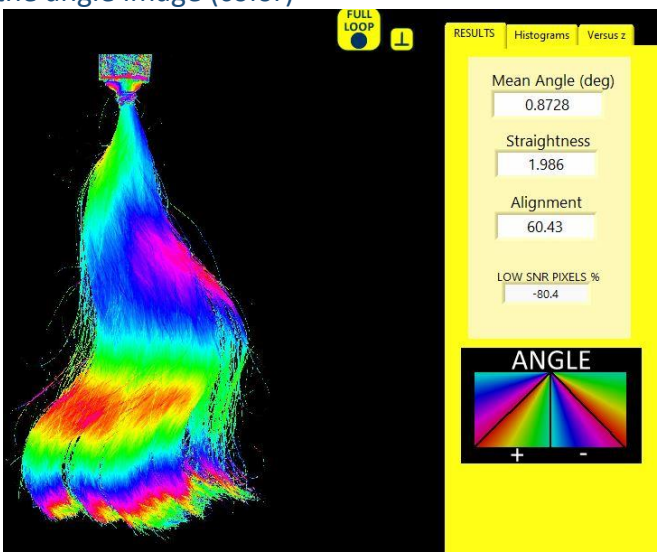


Figure 412: Angle image

The angle image shows the angle orientation for each pixel of the hair swatch, between -45 deg and + 45 deg (Figure 413).

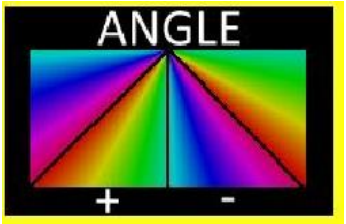


Figure 413: Color angle coding

The distribution of the angle over the full swatch allows to calculate the straightness. The straightness varies from 0% to 100% and is dependent on the angle standard deviation (Figure 414).

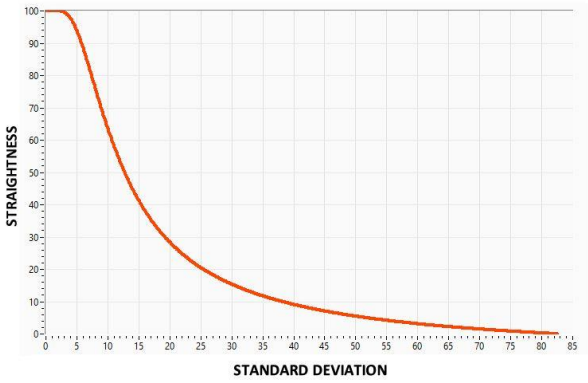
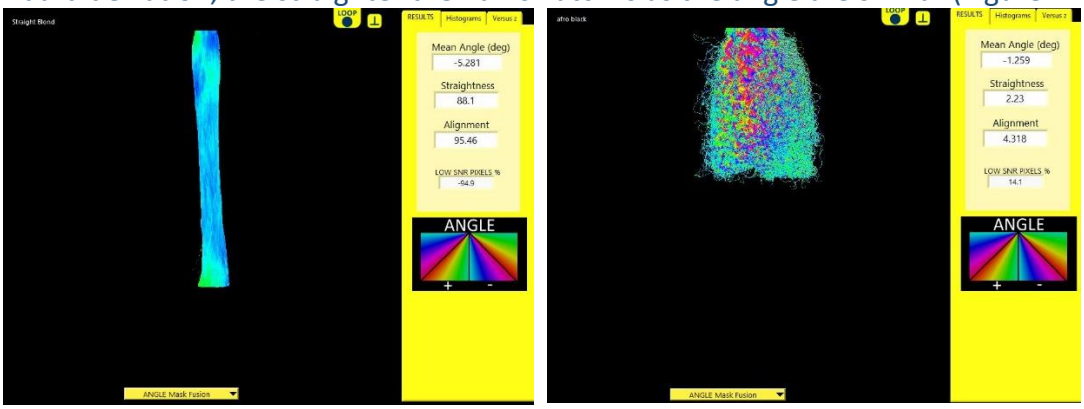


Figure 414: Straightness versus angle standard deviation

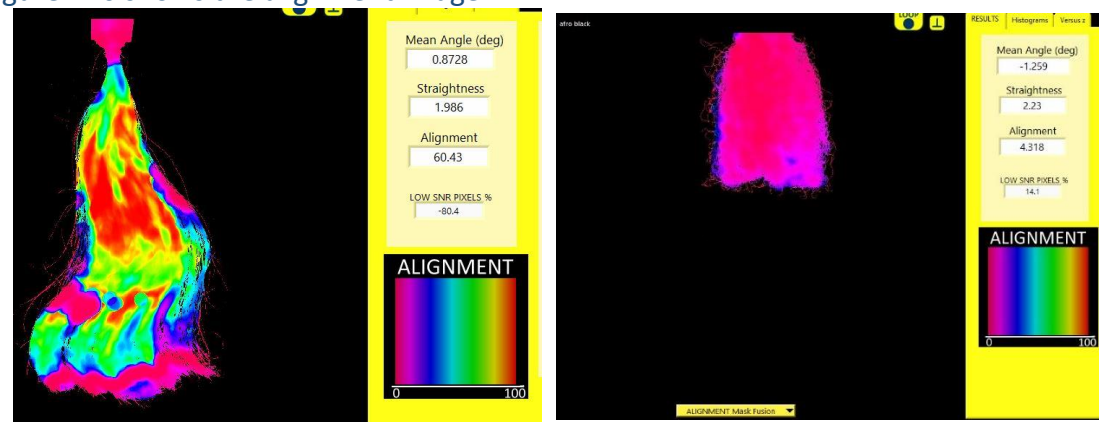
The larger the standard deviation, the less straight the hair swatch is. The smaller the standard deviation, the straighter the hair swatch is as the angle are similar (Figure 415).



(a) (b)

Figure 415: (a) Straight swatch (b) non-straight swatch

The alignment image is an image of the local straightness. If the angle standard deviation is now measured on a small region of the hair swatch (defined by Zbox), we can define the alignment of the hair swatch.
Figure 416 shows the alignment image.



(a) (b)

Figure 416: Alignment image (a) Wavy swatch (b) Afro swatch

The alignment varies between 0% and 100%, 100% corresponding to a perfect alignment (Figure 417).

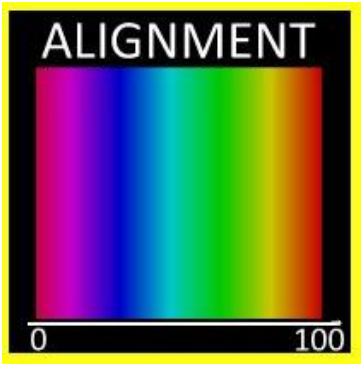


Figure 417: Alignment color coding

The alignment is the local straightness allowing to quantify wavy hair swatch.

12.9.2. Examples

12.9.2.1. Straight swatch

Below is the angle image of a straight blond swatch (Figure 418).

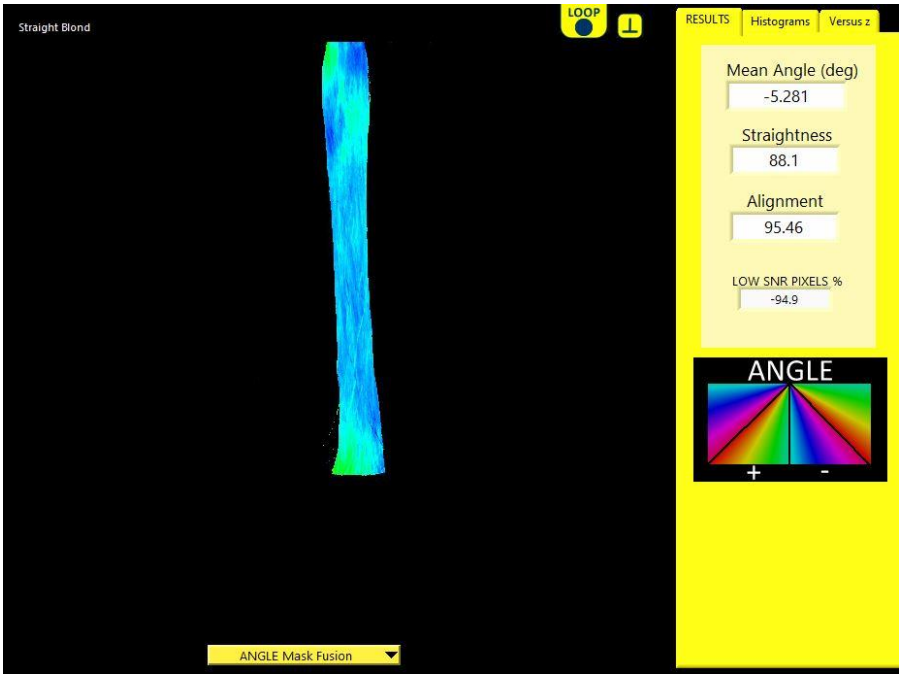


Figure 418: Straight blond swatch – Angle image

The mean angle is -5 deg as the swatch is slightly lending on the right. Straightness is high, at 88% as all the pixel have almost the same direction or angle. Alignment is also high at 95%.
Figure 419 shows the corresponding alignment image.

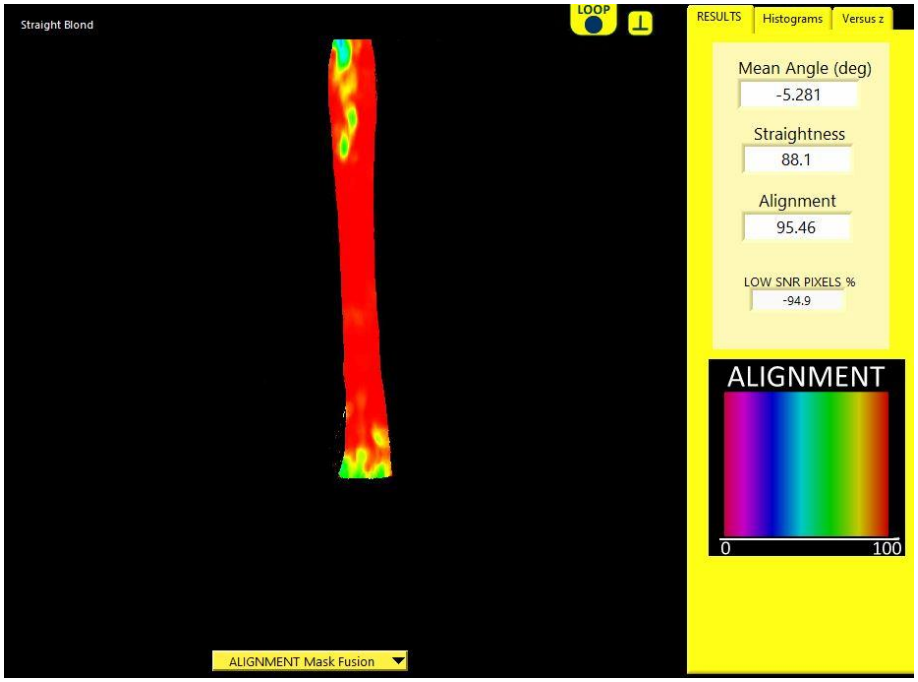


Figure 419: Straight blond swatch – Alignment image

12.9.2.2. Wavy swatch

Below is the angle image of a wavy blond swatch (Figure 420)

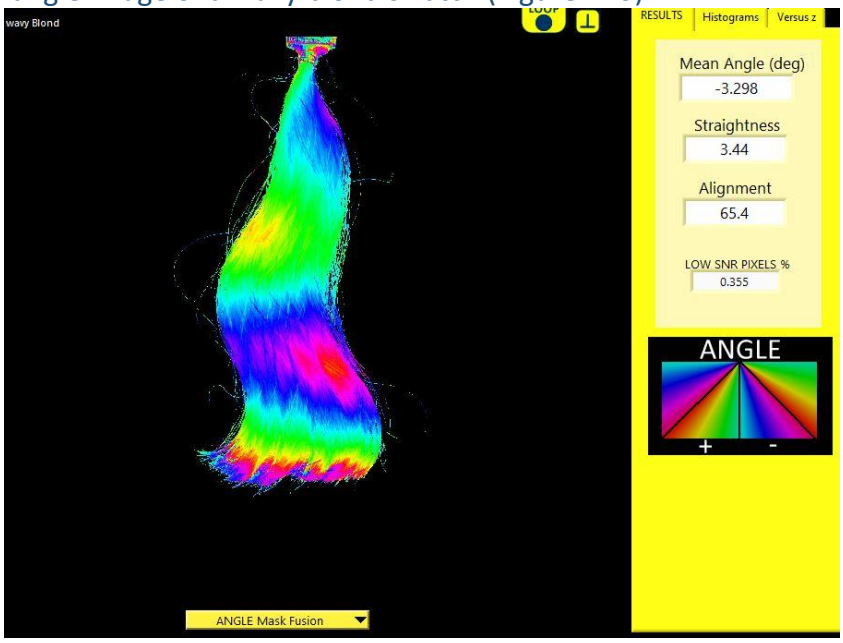


Figure 420: wavy blond swatch – Angle image

The color code allows to visualize the different angles (direction) of the hair fibers composing the swatch. Straightness is low, 3%. Alignment remains high as the hair fibers have locally the same direction, which is shown on the alignment image (Figure 421).

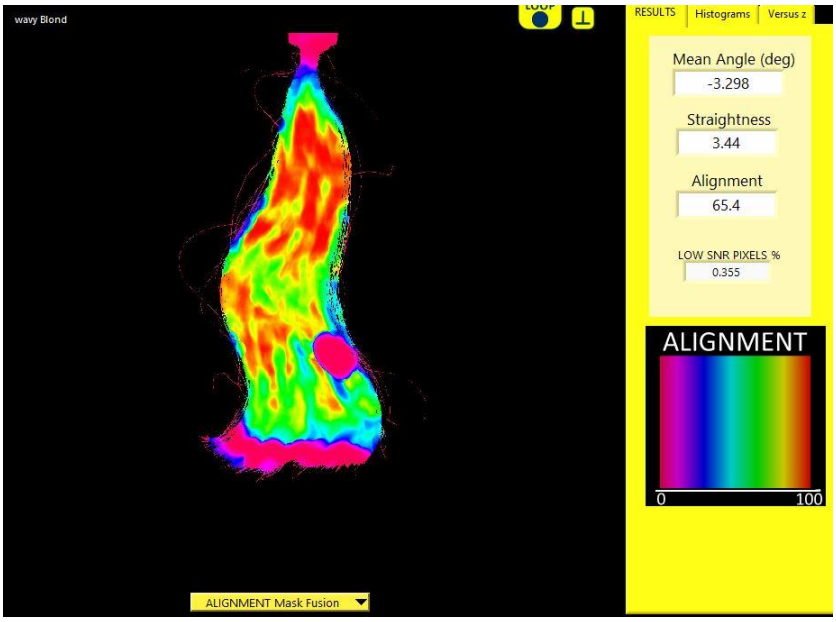


Figure 421: wavy blond swatch – Alignment image

The alignment image allows to visualize in color the alignment of the swatch.

12.9.2.3. Afro swatch

Below is the angle image of a afro swatch (Figure 422Figure 421).

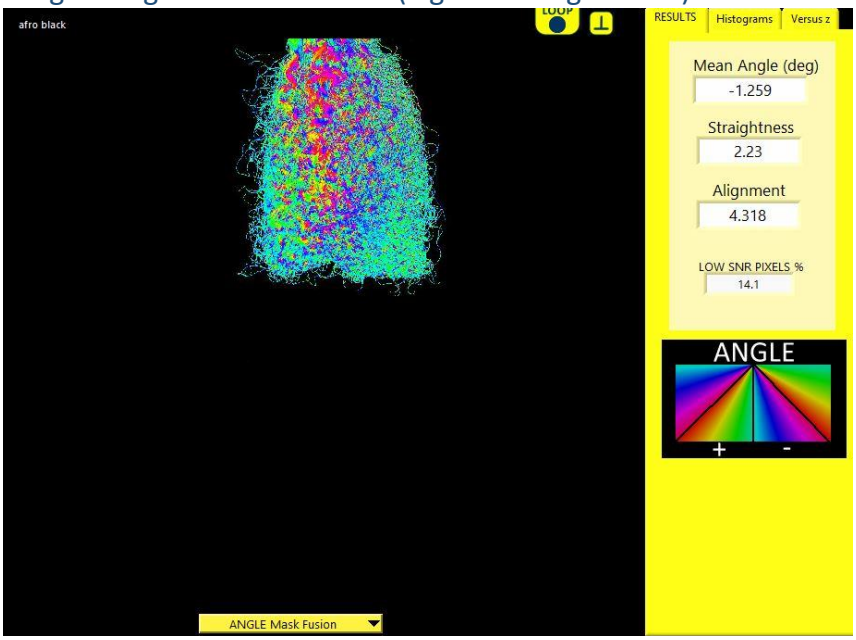


Figure 422: Afro swatch – angle image

As expected, the straightness and alignment are low, 2% and 4%, emphasized on the alignment image (Figure 423).

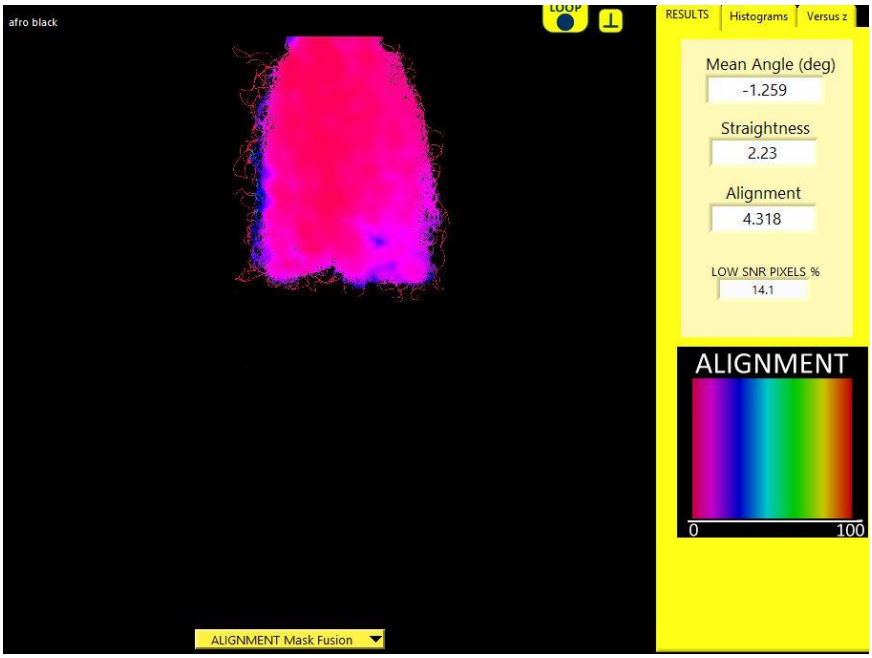


Figure 423: Afro hair – Alignment image

13. Technical Specifications

Camera	Monochrome 8 bits
Total Resolution	2,250 x 1,380 pixels
Pixel Scaling	0.01818 cm/pixel (182 µm/pixel)
Total field of view	41 cm x 24.5 cm (13.7 x 24.5 cm individual BOLERO TRIO)
Illumination	Back light LED panel
Hair swatch length/weight	From 5cm to 24 cm – 20 g
Hair swatch color / type	Any / Any (Round for BOLERO 360)
Software	SHUFFLE 1.60 – Windows 1x
Measurement Time	< 1 minute
Data saved	See data format
Data Export	Excel format
Calibration	Factory calibrated
Size	24” x 24” x 20” 61 cm x 61 cm x 50 cm

14. EU declaration of conformity

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

(424) 394-0321
info@bossanovavision.com
www.bossanovavision.com

EU Declaration of Conformity

The equipment which accompanies this declaration is in conformity with EU Directives:
Machinery Directive 2006/42/EC
Electromagnetic Compatibility Directive 2014/30/EU
Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS)

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** system; A tabletop imaging system for hair tresses controlled over USB link to 3rd party generic Windows PC running Labview Shuffle software version 1.90 and onwards.
Year in which CE mark was affixed: 2025

The following harmonised standards have been used:
EN 12100:2010 Machinery
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:

Signature:



Position in company: General Manager
Date signed: 27th January 2025
Name of signatory: Sebastien Breugnot
Place signed: Los Angeles, USA