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BOLERO

Hair volume/surface measurement fly-away/frizz analysis system


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BACKGROUND

Hair swatch is not easy to analyze because it is composed of a multitude of individual fibers. Its boundaries are not well defined.

Consequence :

It is nearly impossible to use a commercial 3D scanner to reconstruct the 3D shape of the hair swatch.
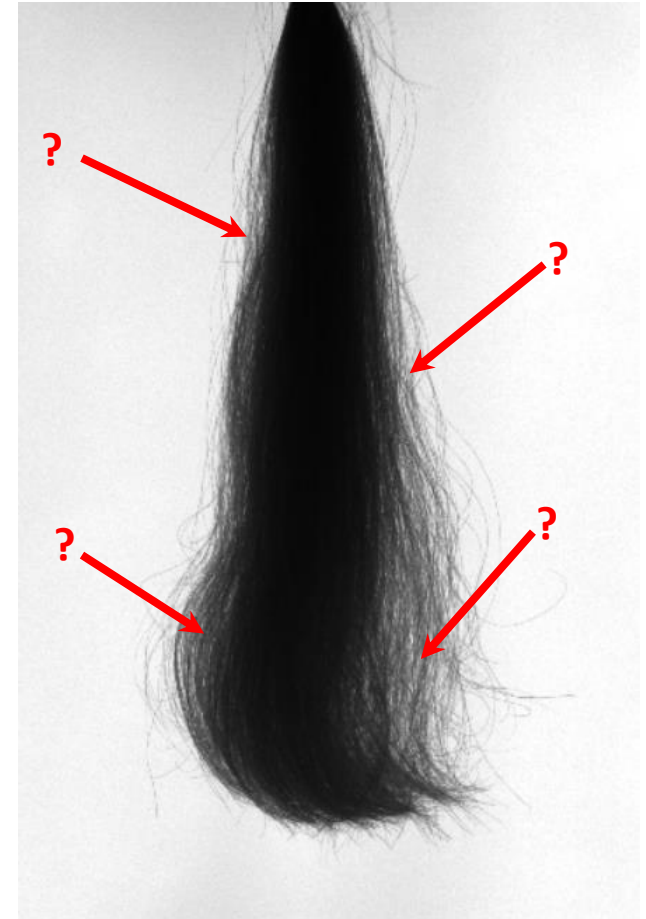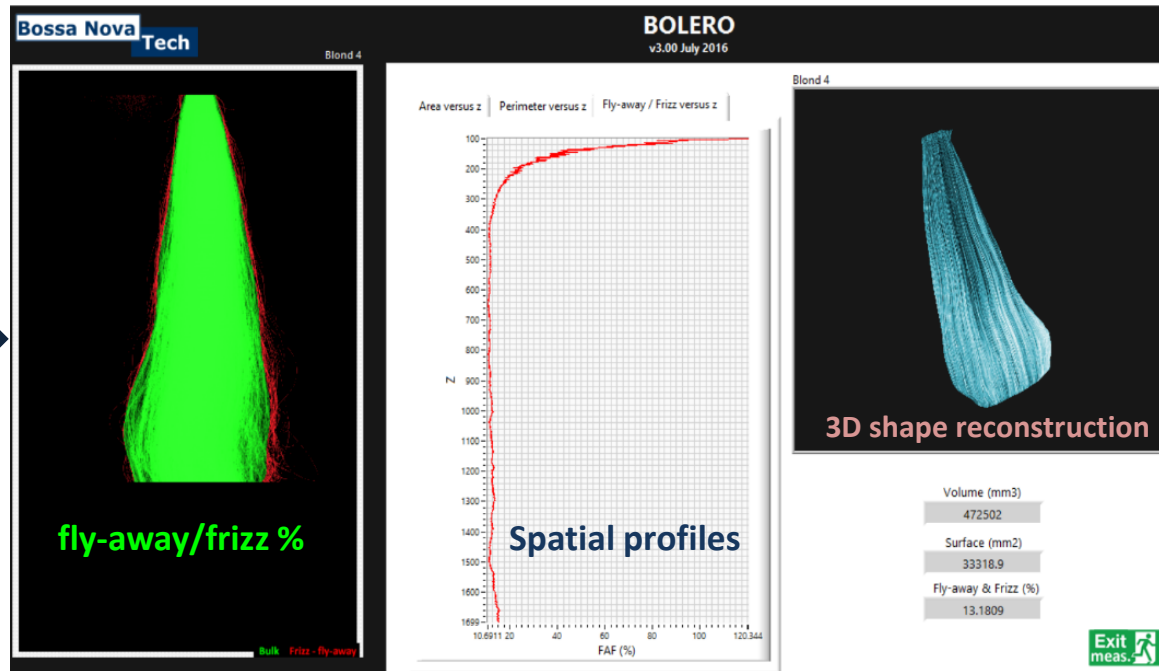
CONCEPT

Provide an instrument that:

- ✓ Reconstructs the 3D shape of the hair swatch
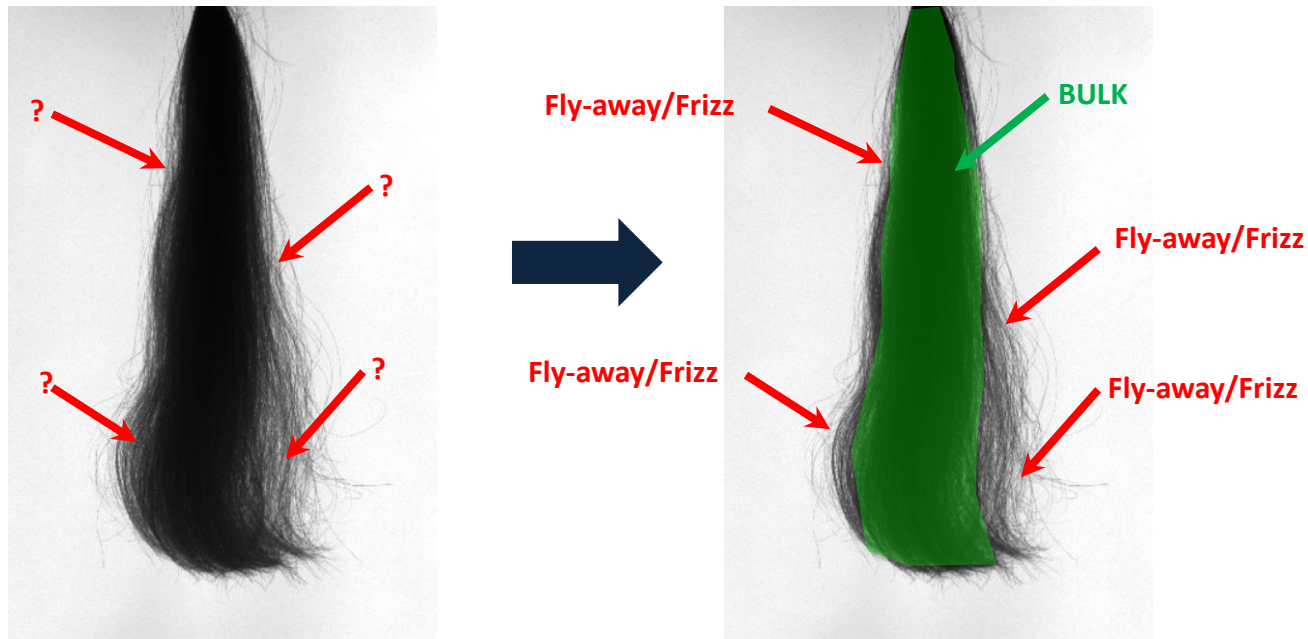- ✓ Delivers fly-away/frizz analysis

CONCEPT

Idea : We can simply describe the hair swatch as composed of a **bulk** plus a multitude of **fly-away/frizz**.

➡ Need for image processing to determine boundaries and determine **BULK** and **FLY-AWAY/FRIZZ.**
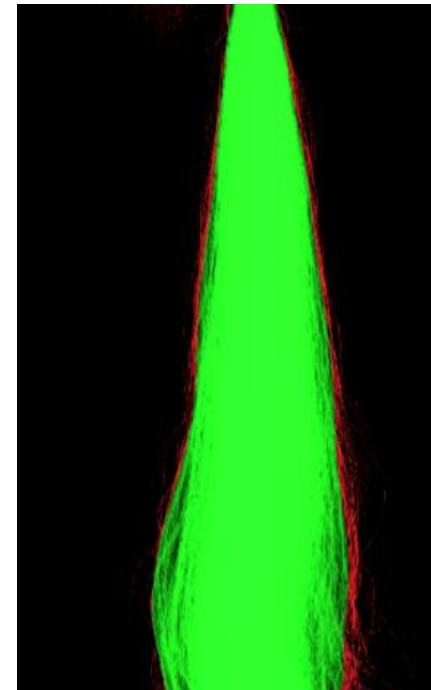
BOLERO : Principle

Background

- Uniform back-light illumination
- The light transmitted through the hair swatch is measured for each pixel.

Bulk/**Frizz** separation

- The **BULK** pixels are defined as:
  Transmitted light < 50%

- The **Fly-away/Frizz** pixels are as:
  Transmitted light > 50%

Friz Fly-away

high transmission

BULK

Friz Fly-away

low transmission
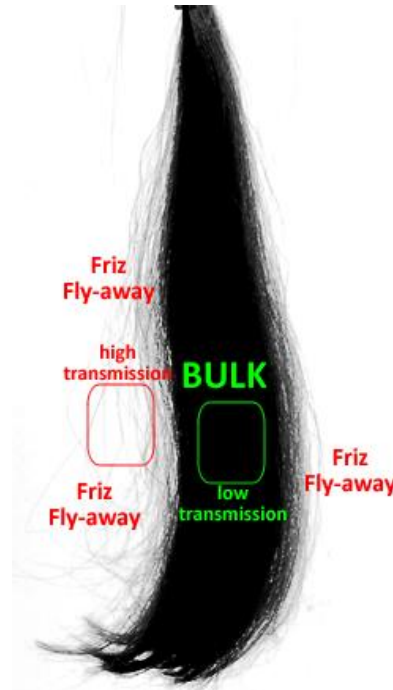
Friz Fly-away

BULK &
Fly-away/Frizz
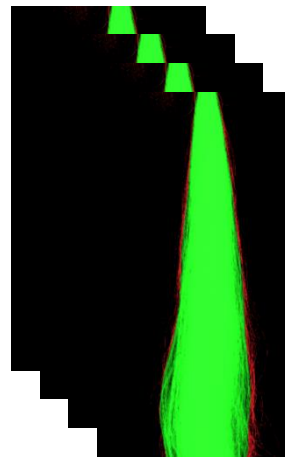**analysis**

BOLERO : Principle

3D shape calculation

- A simple technique is used to reconstruct the 3D shape: a *sequence of contours* (or silhouettes) **(*)**
- The hair swatch is hung and rotated between each image acquired
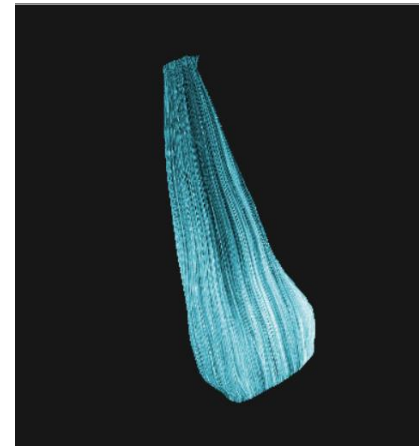- The **Bulk**/**Frizz** separation step is performed for each image

ROTATION   **SILHOUETTES ACQUISITION**   **3D SHAPE RECONSTRUCTION**

(*) "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)

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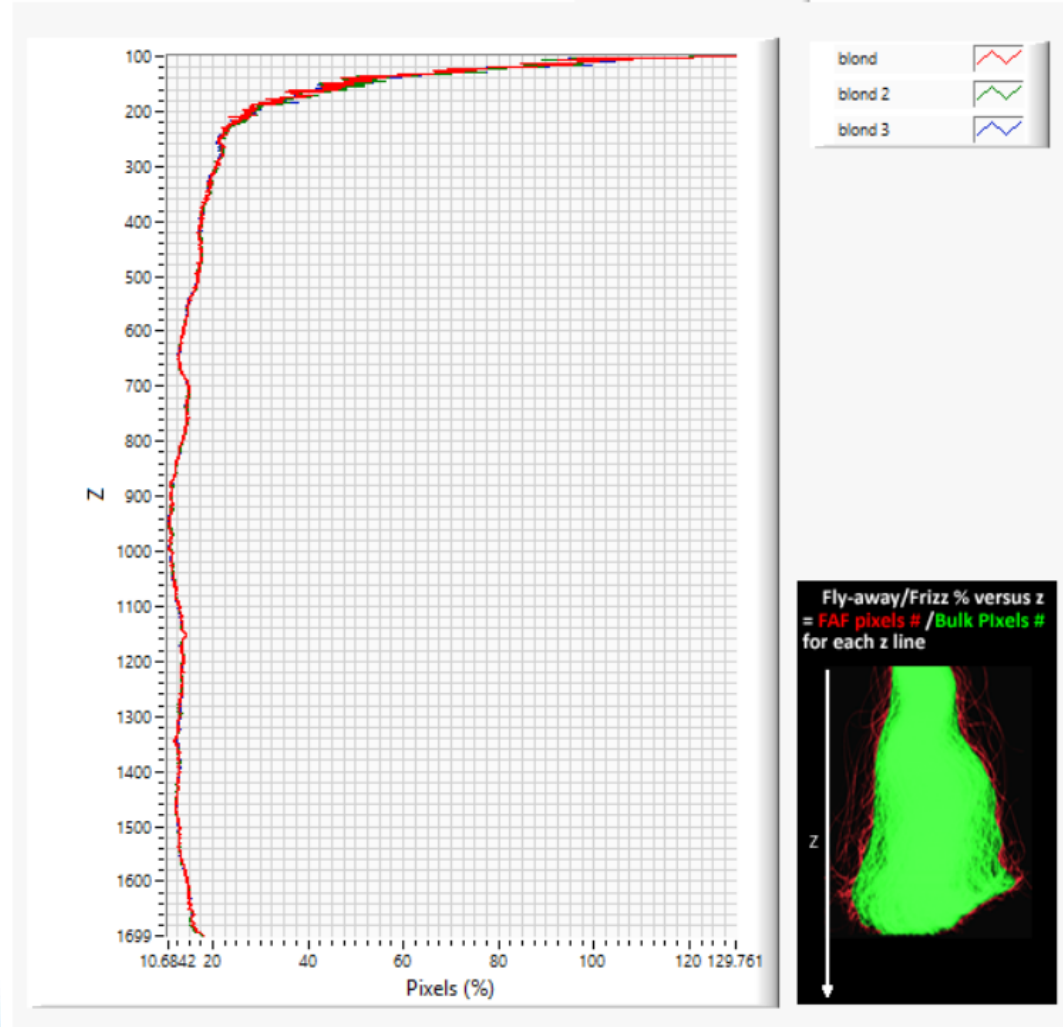
BOLERO : Principle

The 3D shape allows to calculate and display:

- The **volume** of the hair swatch (mm³ /cm³)
- The **surface** area of the hair swatch (mm² /cm²)
- The **area** and **perimeter** of the hair swatch slices along the z axis (vertical)
- The average **Fly-away/Frizz (%)** of the whole hair swatch **or** along the z axis
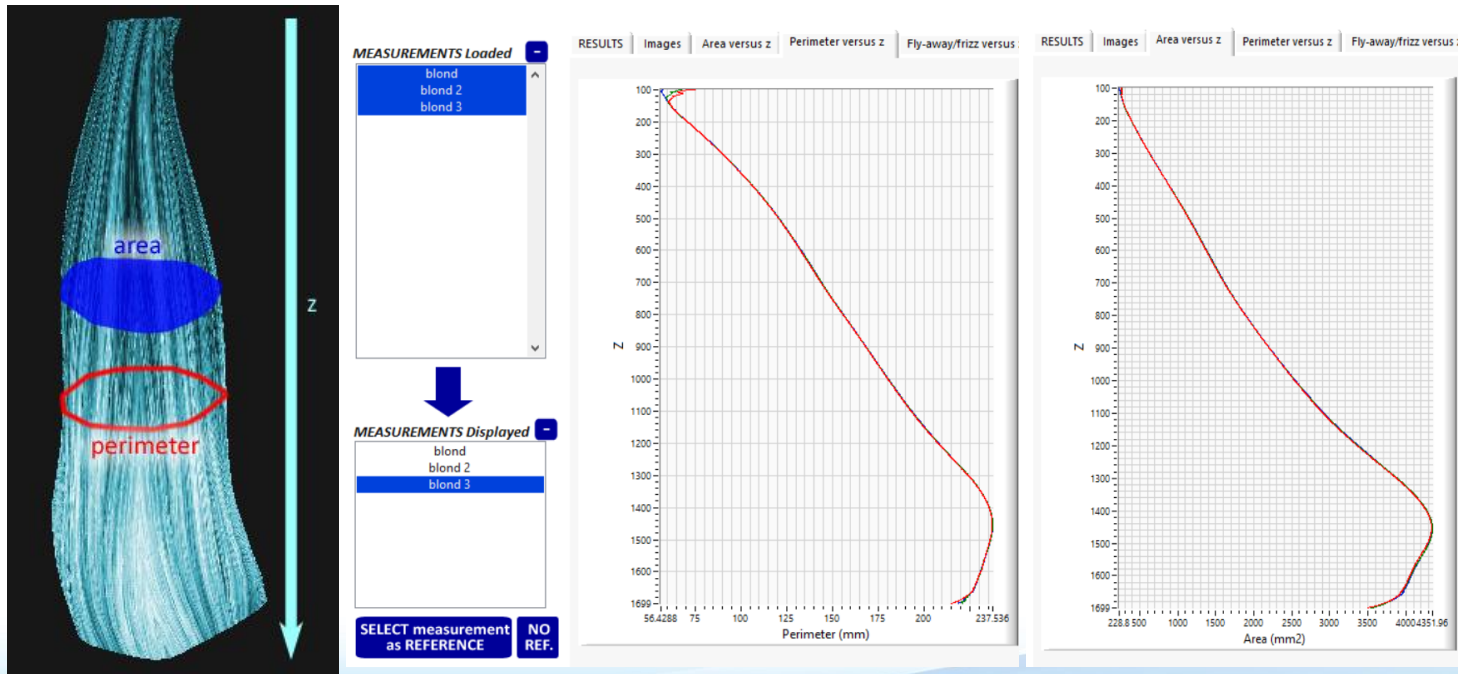
BOLERO : Principle

Fly-away - Frizz (%)

=

$$\frac{\text{Fly-away/Frizz (PIXELS \#)}}{\text{Bulk (PIXELS \#)}}$$
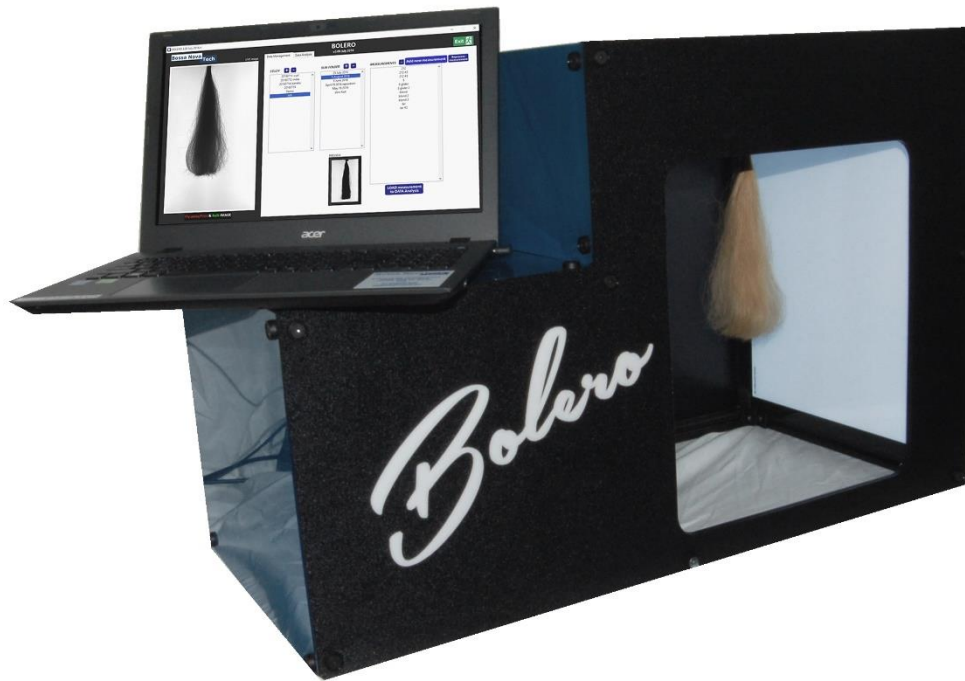
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Hair volume/surface measurement
*Fly-away/frizz analysis system*

Hardware

BOLERO : Hardware

BOLERO is a turn-key system for *Hair volume/surface measurement & fly-away/frizz analysis system. It comes with a laptop and pre-loaded software for analysis*

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Laptop with pre-loaded software

LED back light panel

Rotary stage for hair swatches

Full lab setup
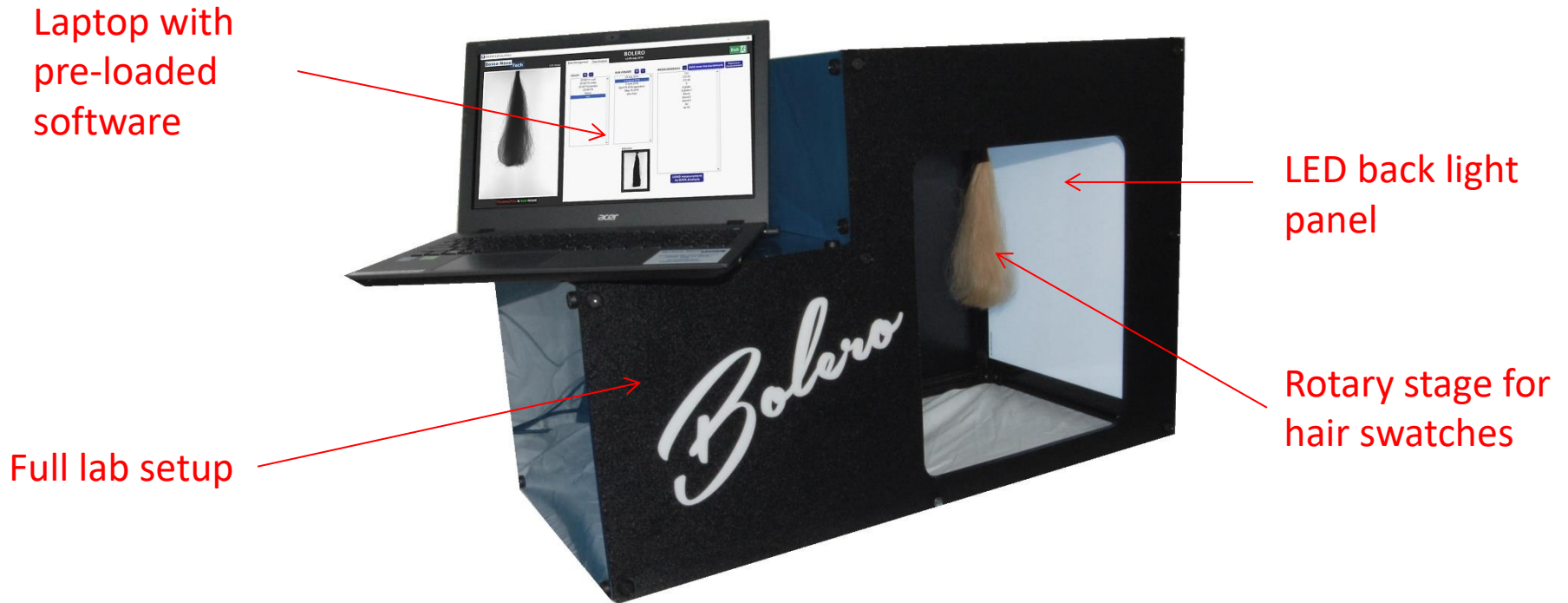
Technical Specifications

Camera	Monochrome 8 bits
Resolution	2,592 x 1,944 pixels
Illumination	Back light LED panel
Hair swatch length	From 5cm to 30 cm
Hair swatch color	Any
Software	BOLERO 3.00 – Windows 10
Measurement Time	< 1 minute
Data saved	Raw images, FAF image, XYZ point cloud, area/perimeter/FAF file
Data Export	Excel format
Calibration	Factory calibrated
Size	15" x 30" x 20" (375 mm x 750 mm x 500 mm)

Technical Specifications

For best results, we recommend to use "round" swatches and no "flat" swatches as shown on the picture below.

ROUND

FLAT - not good

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Hair volume/surface measurement
Fly-away/frizz analysis system

SOFTWARE

BOLERO : Software
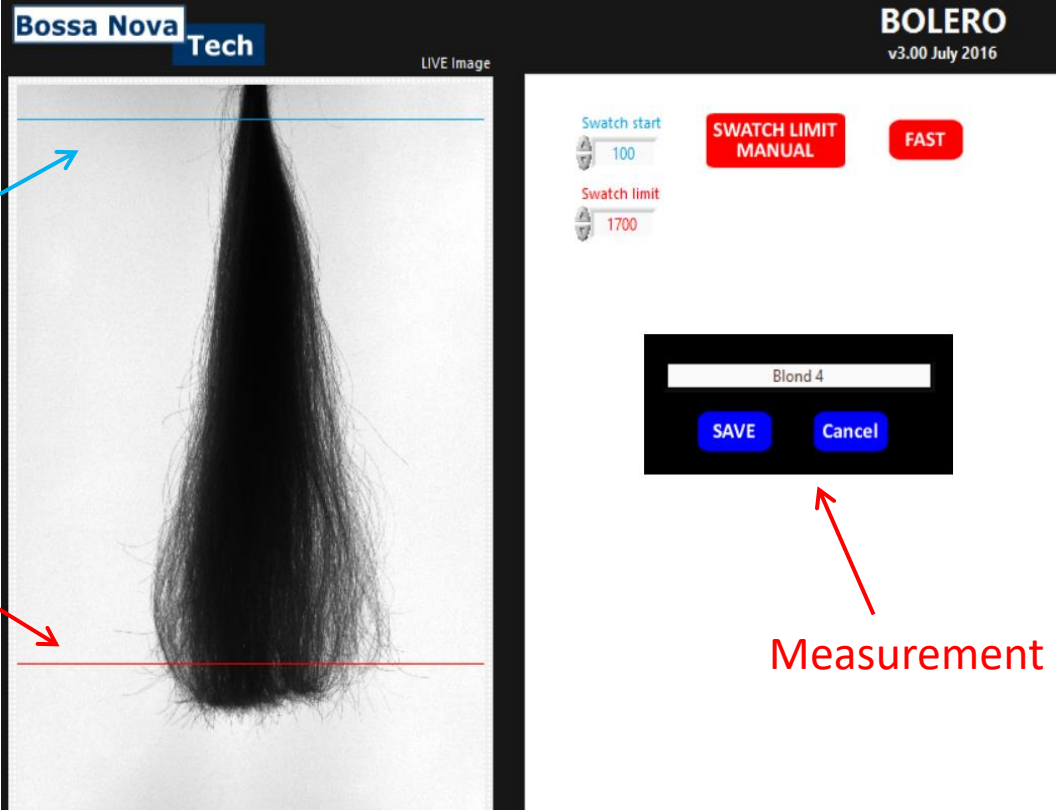
Data management

- Each measurement is automatically saved into a Main DATA Folder, then: ***Study** --> **Sub-Study** --> [**Measurement name**]*

- Each measurement, or group of measurement can be opened again or exported
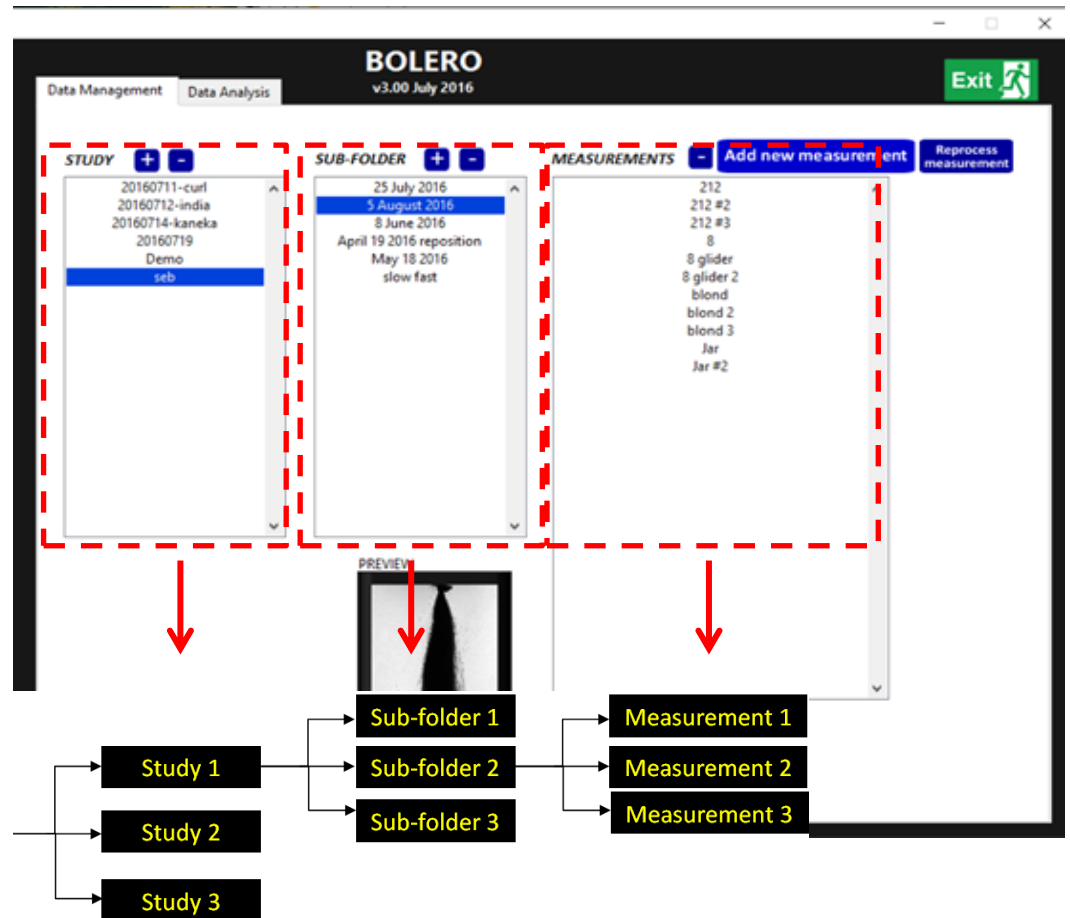
BOLERO : Software

Data acquisition

Upper and lower limits of the swatch

Measurement Name

BOLERO : Software

Data processing
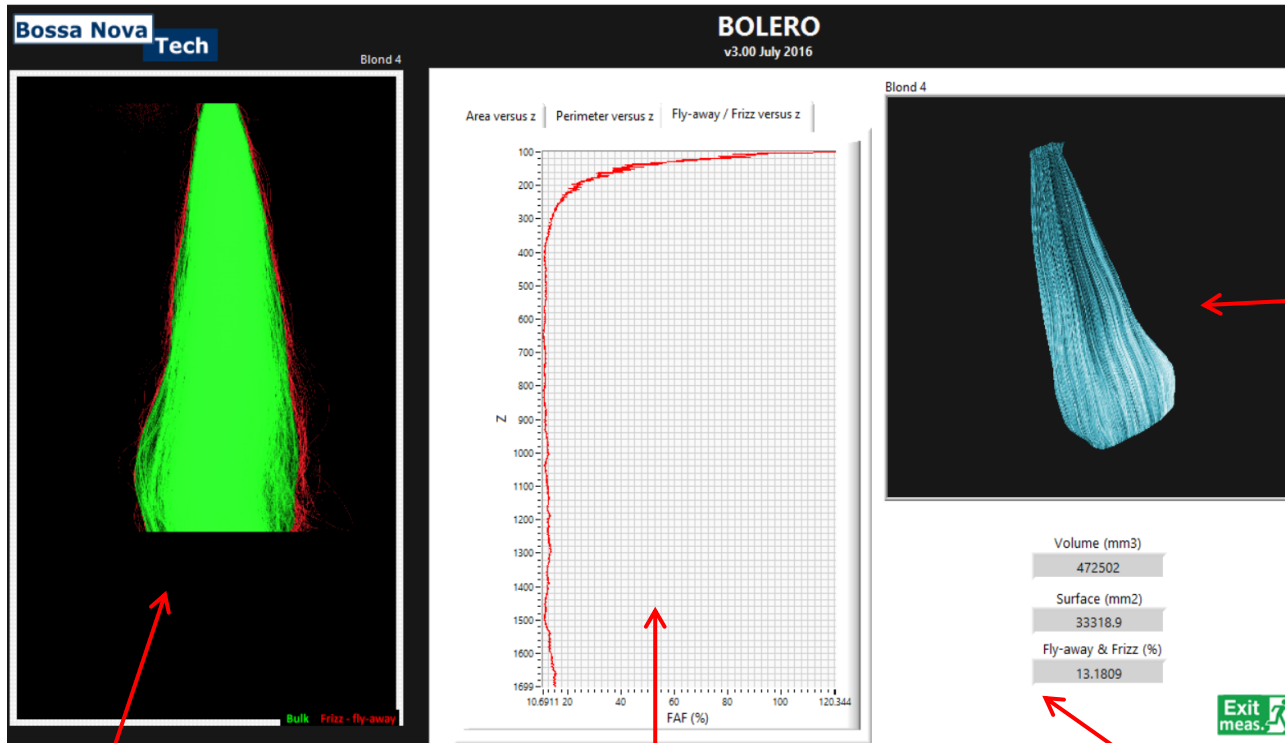
3D Shape reconstructed

Bulk/Frizz image

Graph showing the Area/Perimeter/Frizz% vs. Z-axis

Global results (Volume, Surface, Frizz/Flyaway%)

BOLERO : Software

Data visualization and comparison

Main Display

Load current/old measurements

Images Loaded

Switching between regular/Flyaway images

BOLERO : Software

Data visualization and comparison

BOLERO : Software

Data visualization and comparison

The RESULTS TABLE lists the volume (in mm^3), surface (in mm^2) and frizz/fly-away percentage (%) for each measurement.

RESULTS

| Name	Volume (mm3)	Area (mm2)	Fly-away/Frizz (%)
blond	4.727E+5	3.333E+4	17.173
blond 2	4.739E+5	3.336E+4	17.268
blond 3	4.745E+5	3.335E+4	17.227

It is possible to select a measurement as a reference by clicking the "SELECT measurement as REFERENCE" button, the user can then update the RESULTS table in order to easily compare different measurements relative to the selected reference .

RESULTS	Images	Area versus z	Perimeter versus z	Fly-away/frizz versus z	3D plot	Slice

RESULTS

Name	Volume (mm3)	Area (mm2)	Fly-away/Frizz (%)
blond	4.727E+5 (-0.4%)	3.333E+4 (-0.1%)	17.173 (-0.3%)
blond 2	4.739E+5 (-0.1%)	3.336E+4 (0.0%)	17.268 (0.2%)
blond 3	4.745E+5 (Ref)	3.335E+4 (Ref)	17.227 (Ref)

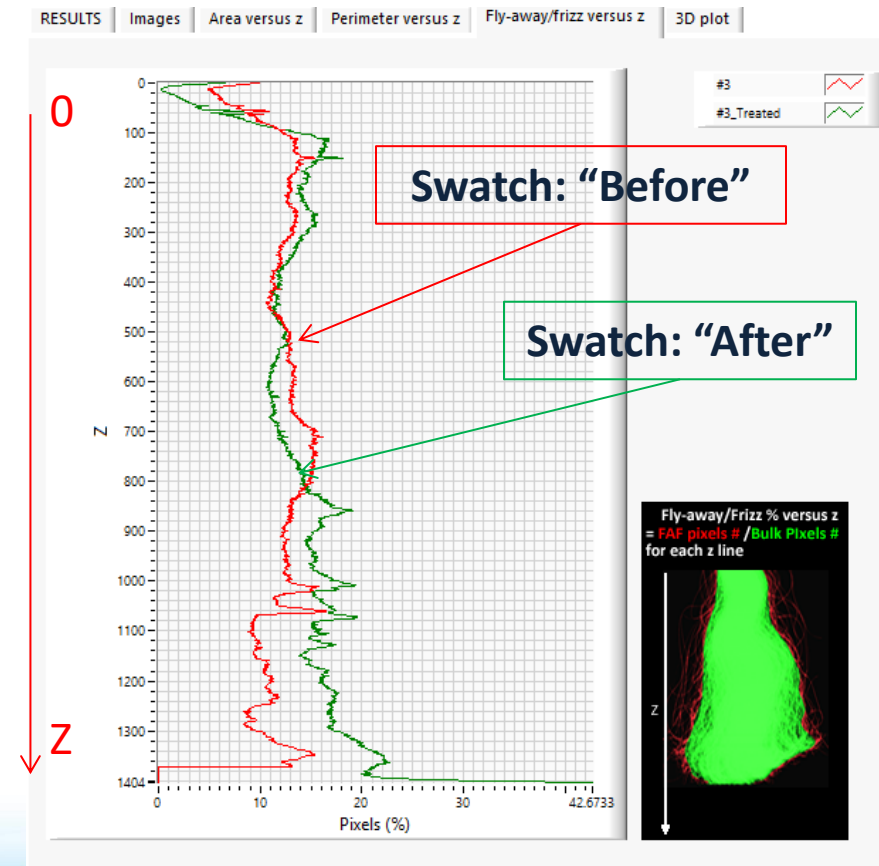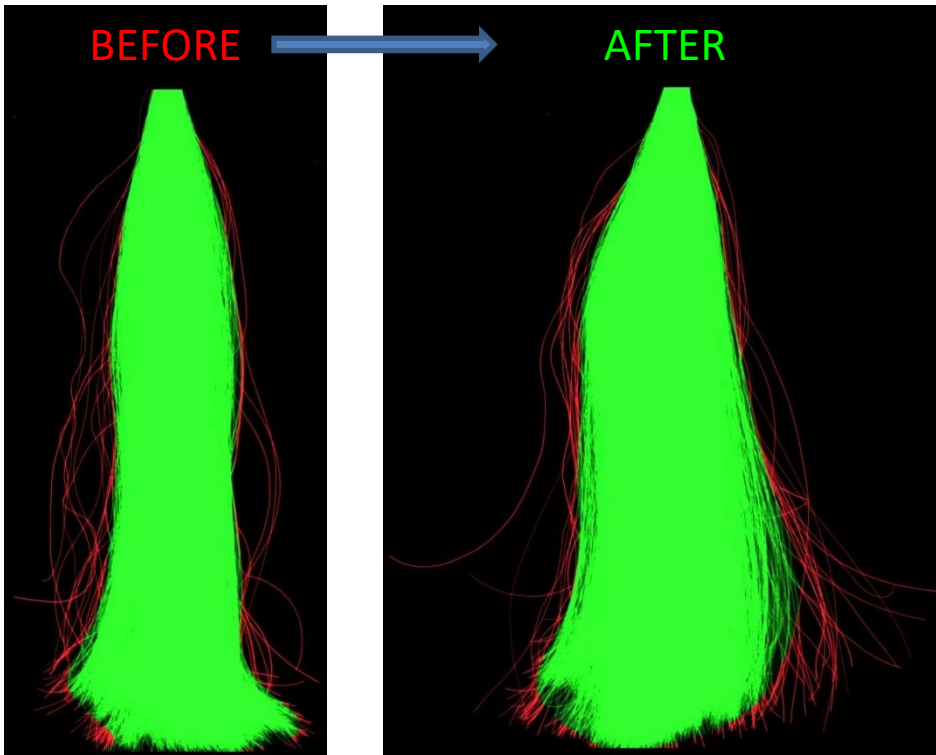Bossa Nova Tech

BOLERO : Software

Data analysis window

The **Area versus z** tab allows the user to visualize the variation of the area of the swatches versus z, on the same graph.
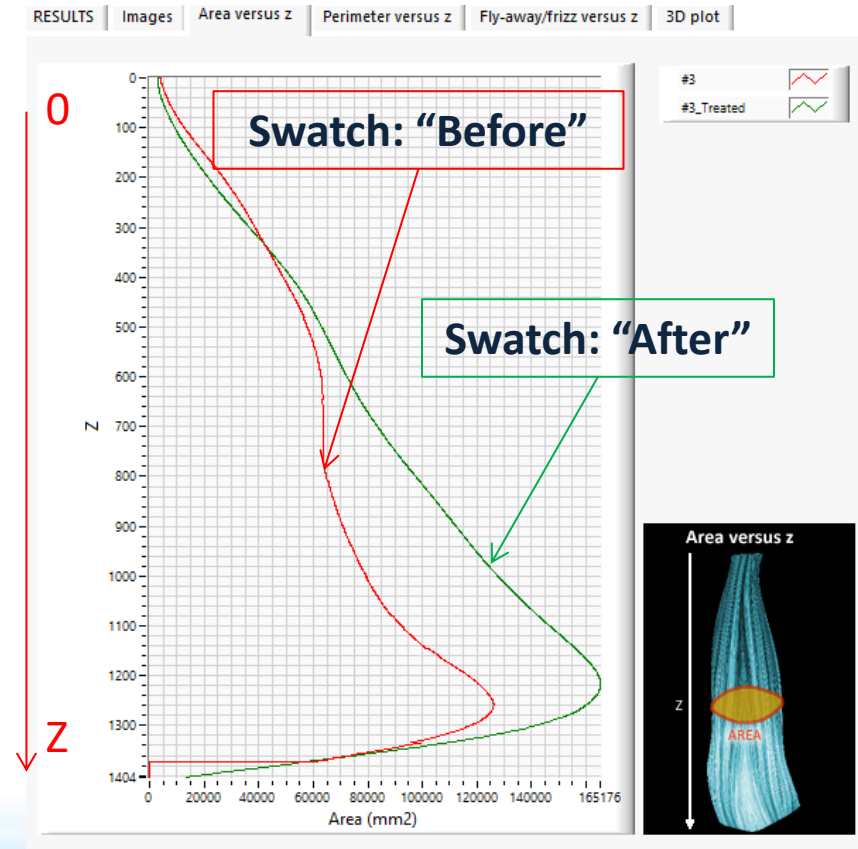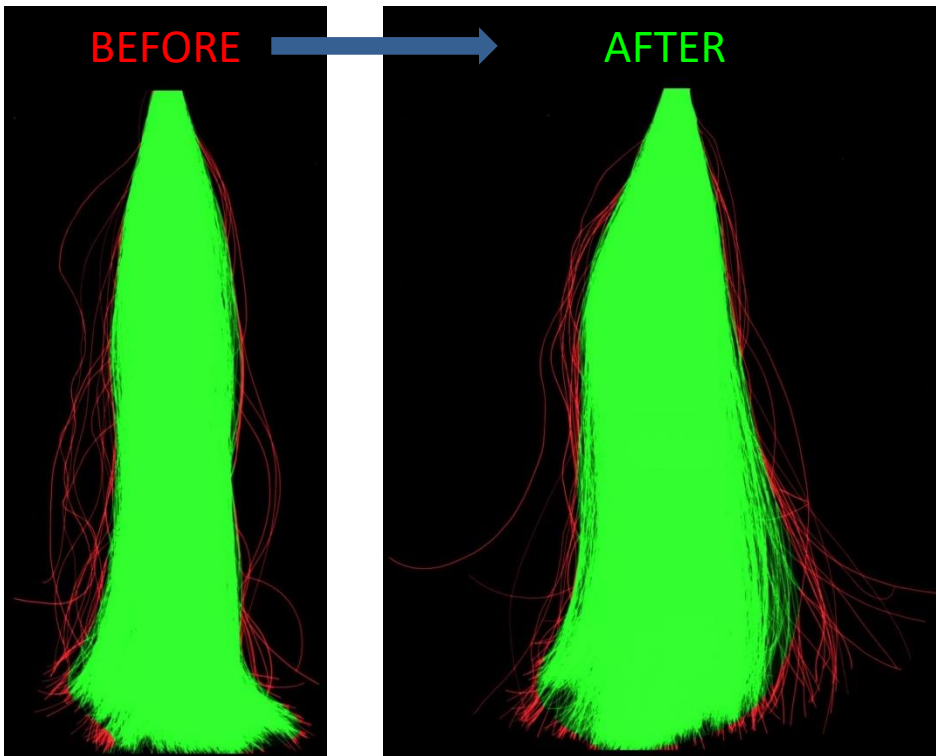
BOLERO : Software

Data analysis window

The Flyaway/Frizz versus z tab allows the user to visualize the variation of the average Frizz/Bulk %age on each swatch versus z, on the same graph.

BOLERO : Software

Data analysis window

The 3D plot tab allows the user to visualize the 3D shape of the selected loaded measurement. The user can rotate the 3D shape as needed and export the image as a jpeg file.

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BOLERO : Software

Data analysis window

The slice tab allows the user to visualize the slice of the loaded measurements and navigate through z. A calculation of the area and the perimeter of the slice(s) is given.

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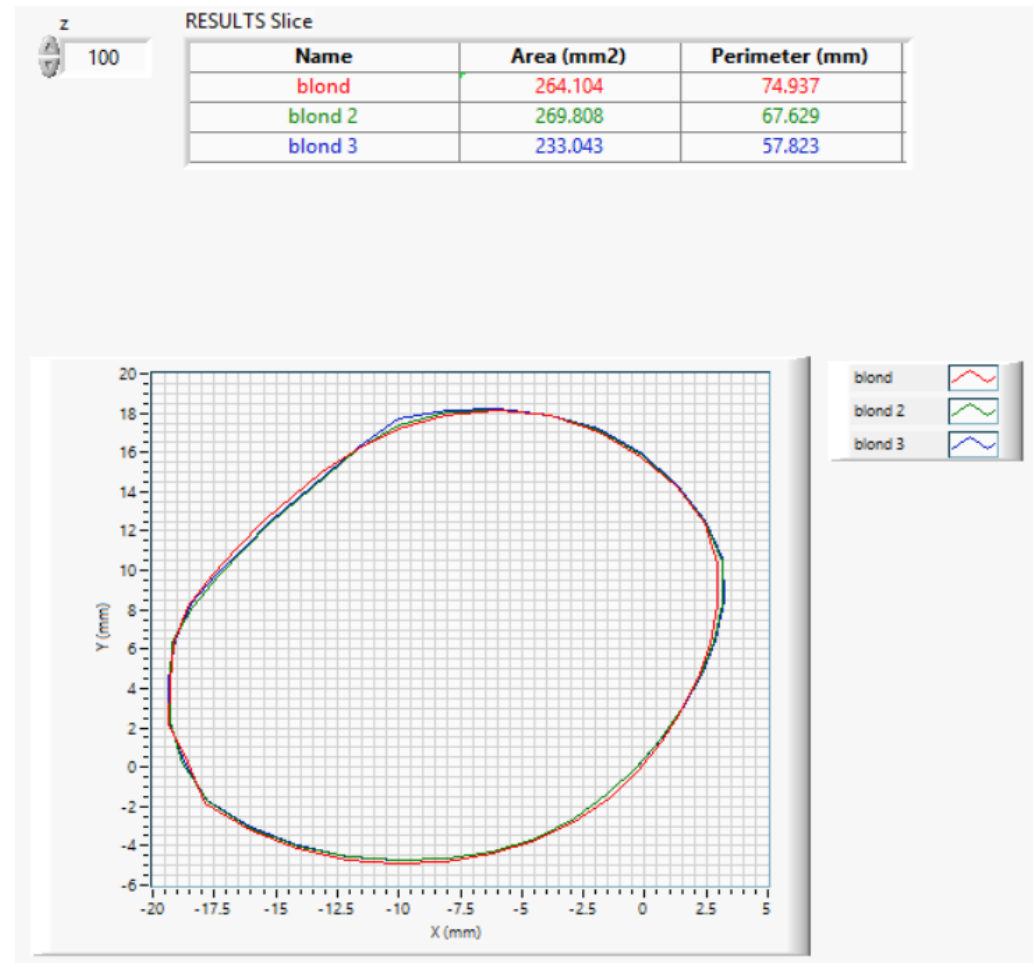
BOLERO : Software

Data Export
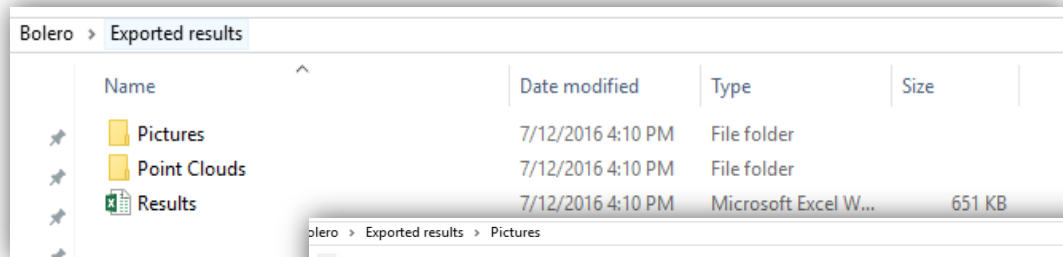
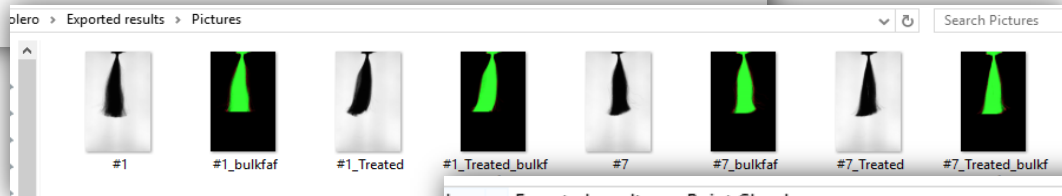The user can export groups of measurements as many times as necessary

BOLERO : Software

Data Export

The exported measurement folder contains 2 folders respectively containing **images, point clouds**, and an Excel file presenting the different results and graphs.
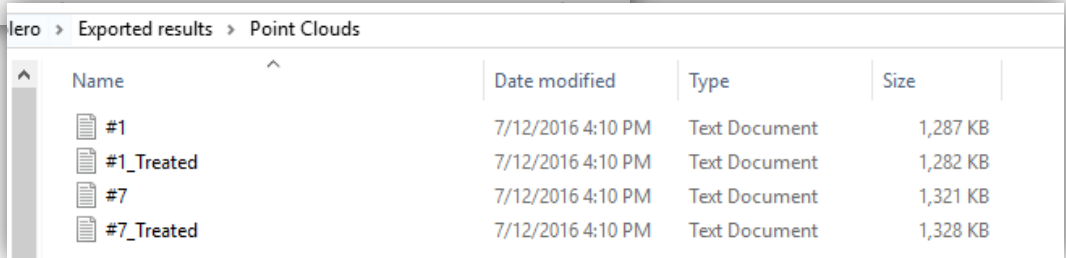
BOLERO : Software

Data Export

The Excel file contains the table comparing the volume, area and Fly-away/Frizz (%) of each exported element and the various data and graph (Area, Perimeter and Fly-away/Frizz (%)) versus z.
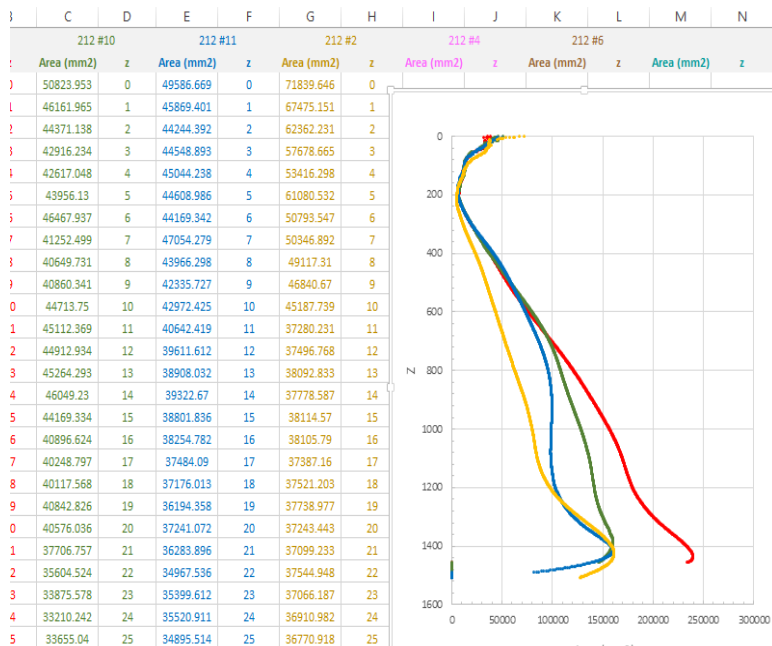
		RESULTS		
Name	Volume (mm3)	Area (mm2)	Fly-away/Frizz (%)
#1	1.541E+8 (36.5%)	1.630E+6 (10.6%)	11.094 (-5.4%)
#1_Treated	1.281E+8 (13.5%)	1.533E+6 (4.0%)	8.985 (-23.4%)
#7	1.129E+8 (Ref)	1.474E+6 (Ref)	11.729 (Ref)
#7_Treated	9.768E+7 (-13.5%)	1.388E+6 (-5.8%)	8.117 (-30.8%)

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Examples of Measurement

Product efficiency evaluation

6 swatches were used (3 dark, 3 brown) as presented in Figure 21. Volume and fly-away/frizz percentage are measured.

A "sleek and shine" styling spray was then applied on each hair swatch followed by volume and fly-way/frizz % measurement using BOLERO.

Product efficiency evaluation

Results are presented in the table below:

Hair Swatch #	Volume (mm³)	Volume (mm³) Product	Change (%)	Fly-away/frizz (%)	Fly-away/frizz (%) Product	Change (%)
200	$1.145\ 10^5$	$5.793\ 10^4$	-49.4	32.30	3.62	-88.8
201	$1.231\ 10^5$	$5.415\ 10^4$	-56	20.18	6.08	-69.9
202	$1.302\ 10^5$	$1.08\ 10^5$	-17	15.74	3.96	--74.8
210	$1.07\ 10^5$	$9.208\ 10^4$	-14	15.54	4.09	-73
211	$1.684\ 10^5$	$1.139\ 10^5$	-32.4	15.74	4.12	-73.8
212	$1.379\ 10^5$	$7.37\ 10^4$	-46.6	13.40	4.26	-68.2
AVERAGE			-28.9			-68.2

Using the BOLERO it is possible to conclude that the "sleek and shine" styling spray decreases the volume of sample hair swatches by **29%** and the percentage of fly-away/frizz by **68%**.

THANK YOU!