

BOLERO

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



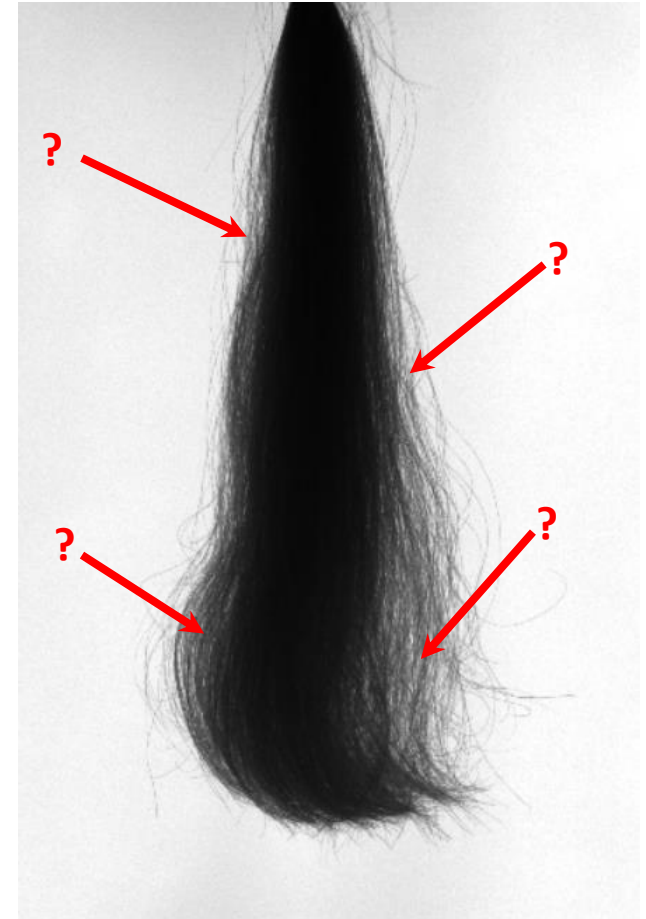
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Bossa Nova Technologies

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.



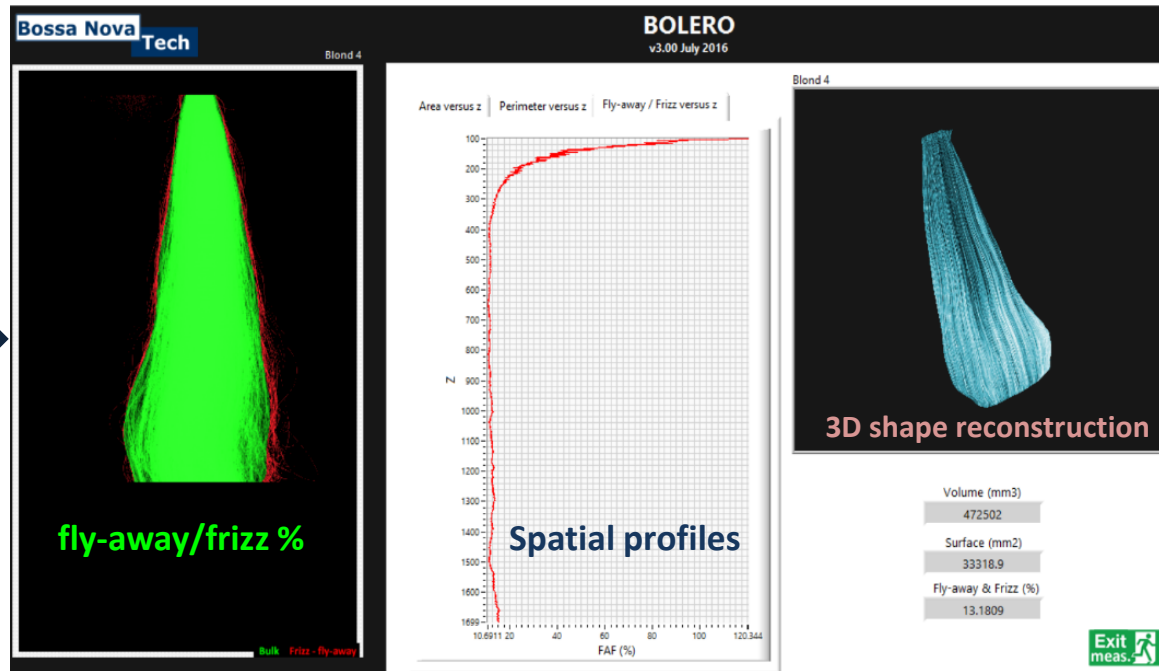
CONCEPT

Provide an instrument that:

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

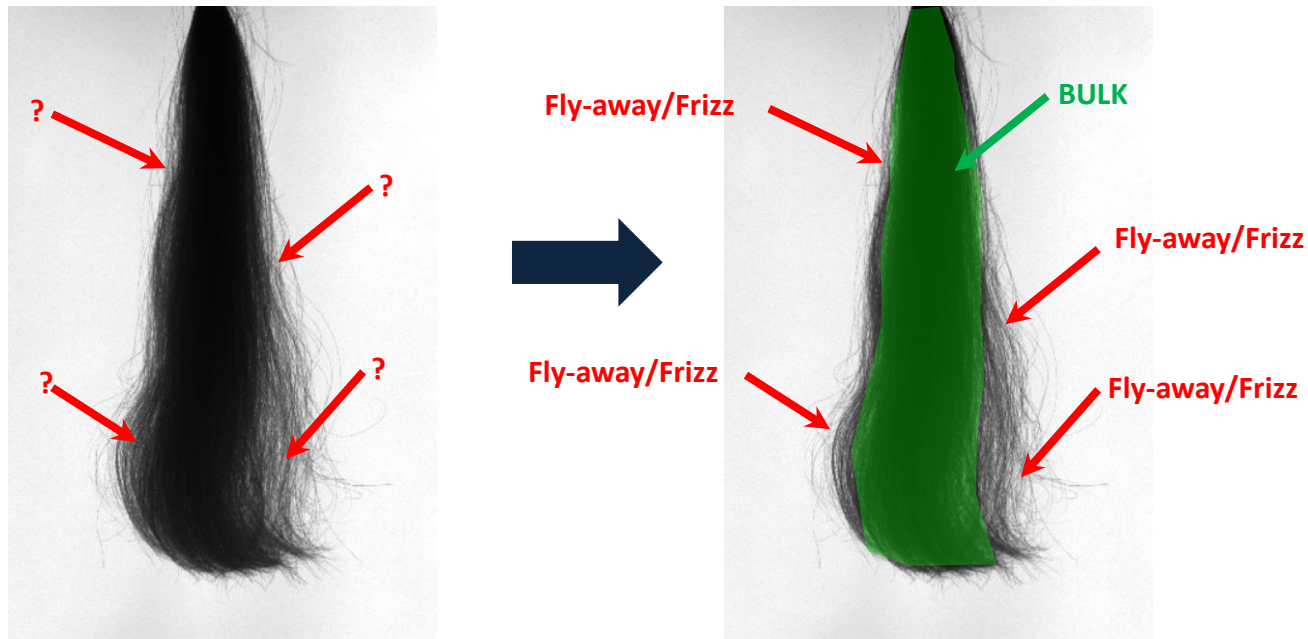


BOLERO



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**.

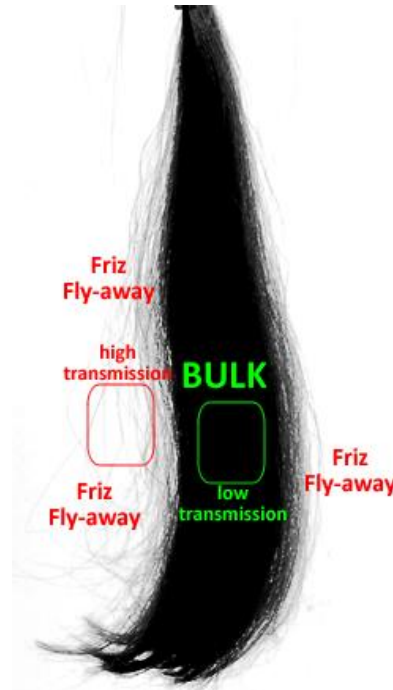
BOLERO : Principle

Background

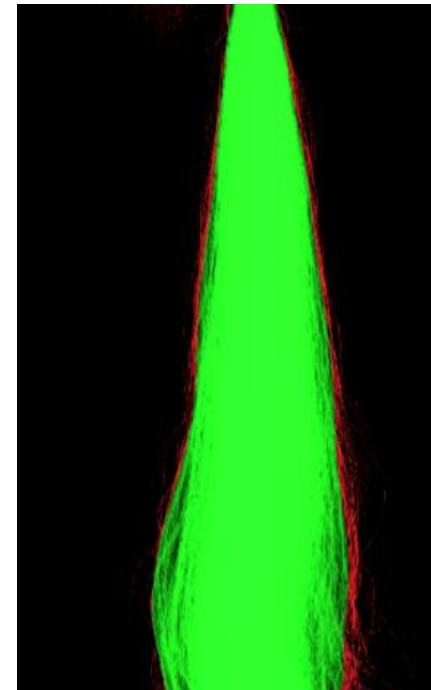
- Uniform back-light illumination
- The light transmitted through the hair swatch is measured for each pixel.

Bulk/Frizz separation

- The **BULK** pixels are defined as:
Transmitted light $< 50\%$
- The **Fly-away/Frizz** pixels are as:
Transmitted light $> 50\%$



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



BOLERO : Principle

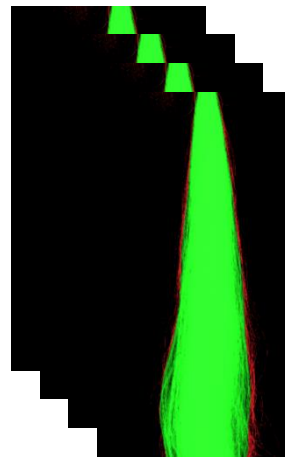
3D shape calculation

- 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

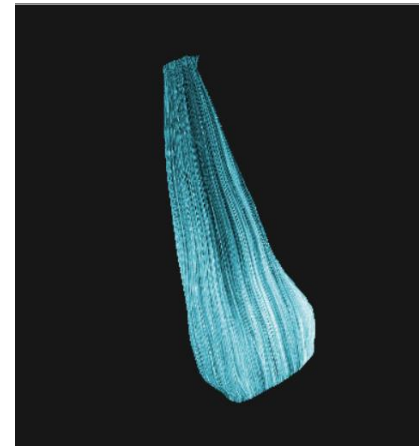
ROTATION



SILHOUETTES ACQUISITION



3D SHAPE RECONSTRUCTION



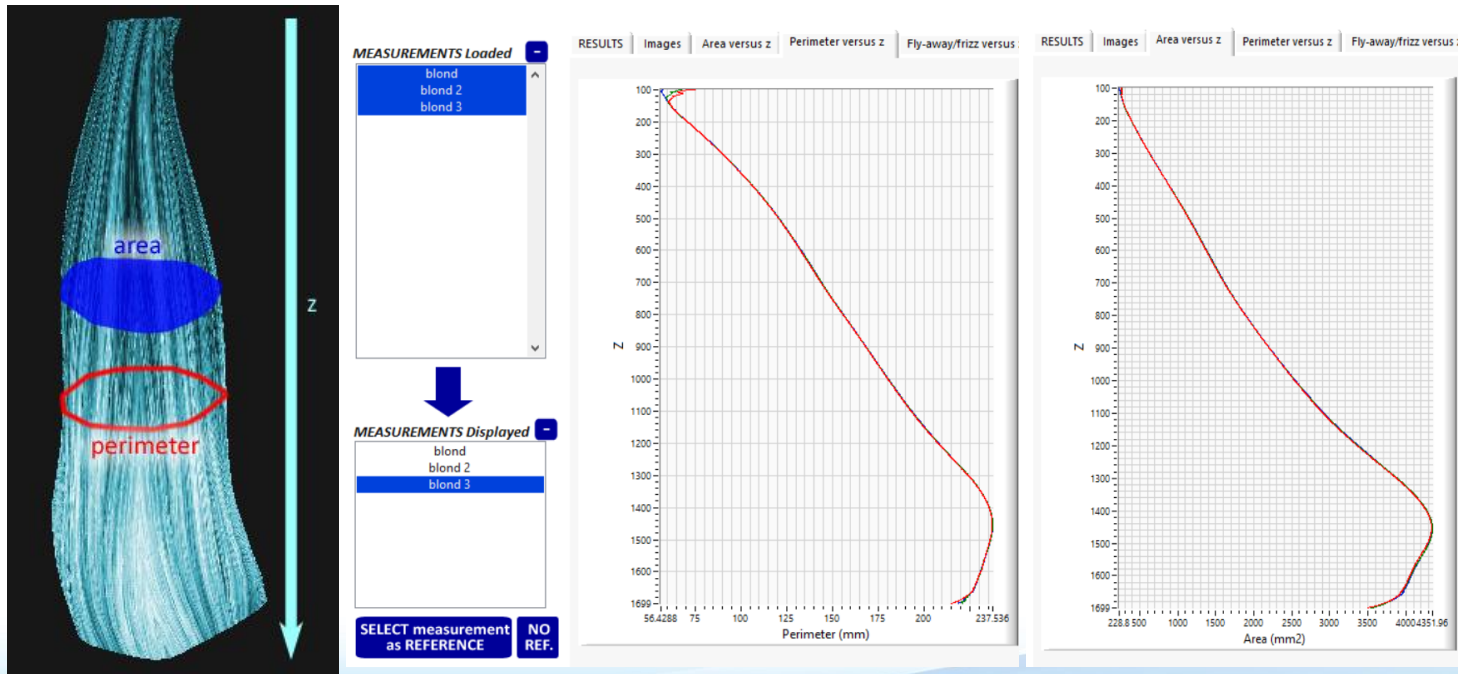
(*) "Acquiring 3-D models from sequences of contours", J. Y. Zheng, IEEE transactions on pattern analysis and machine intelligence, Vol. 16, N0 2, February 1994

(*) "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)

BOLERO : Principle

The 3D shape allows to calculate and display:

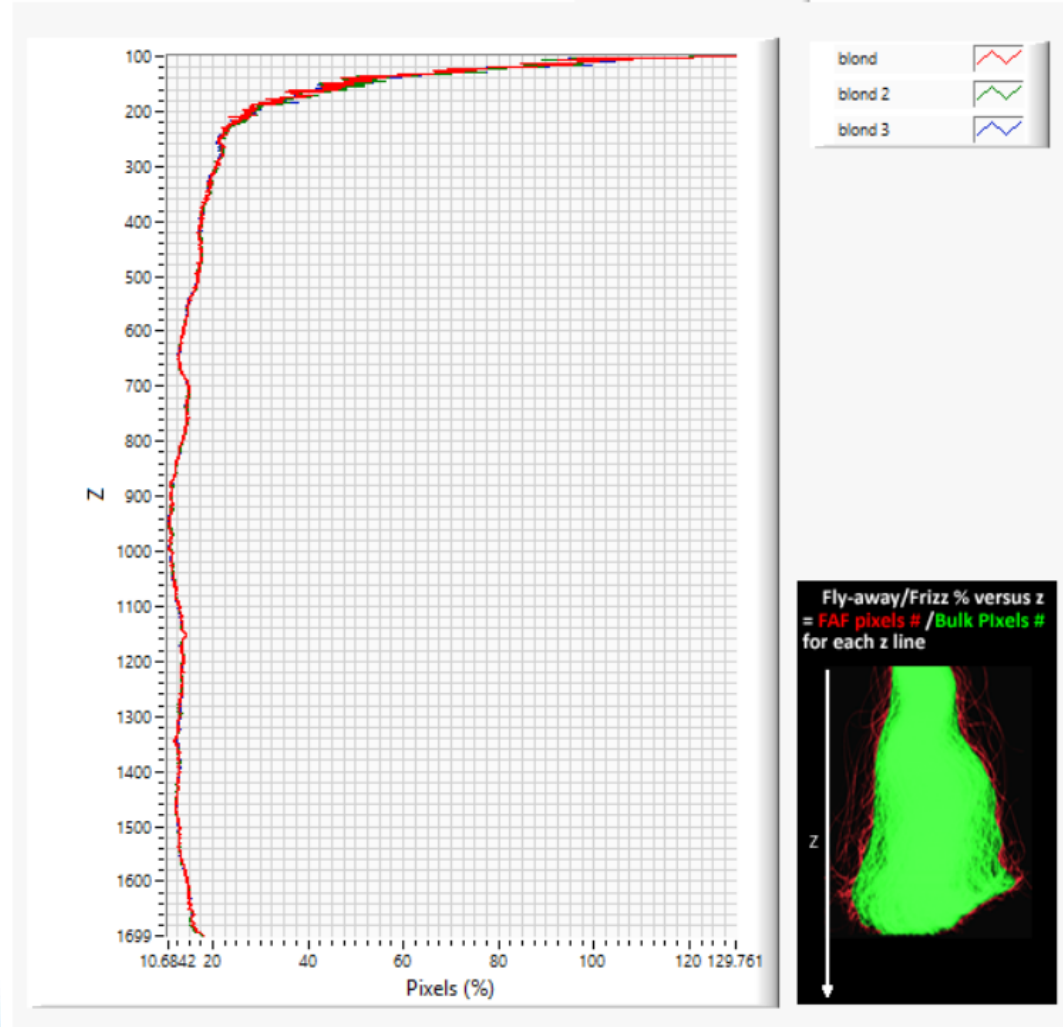
- The **volume** of the hair swatch ($\text{mm}^3 / \text{cm}^3$)
- The **surface** area of the hair swatch ($\text{mm}^2 / \text{cm}^2$)
- The **area** and **perimeter** of the hair swatch slices along the z axis (vertical)
- The average **Fly-away/Frizz (%)** of the whole hair swatch **or** along the z axis



BOLERO : Principle

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

$$\text{Fly-away - Frizz (\%)} = \frac{\text{Fly-away/Frizz (PIXELS \#)}}{\text{Bulk (PIXELS \#)}}$$



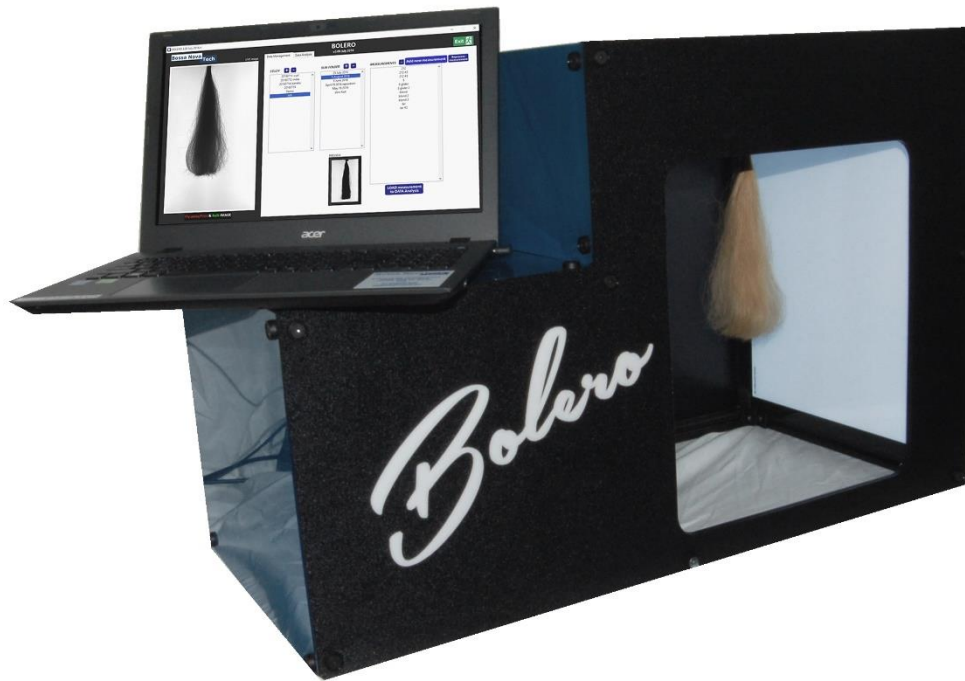
BOLERO

*Hair volume/surface measurement
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Hardware

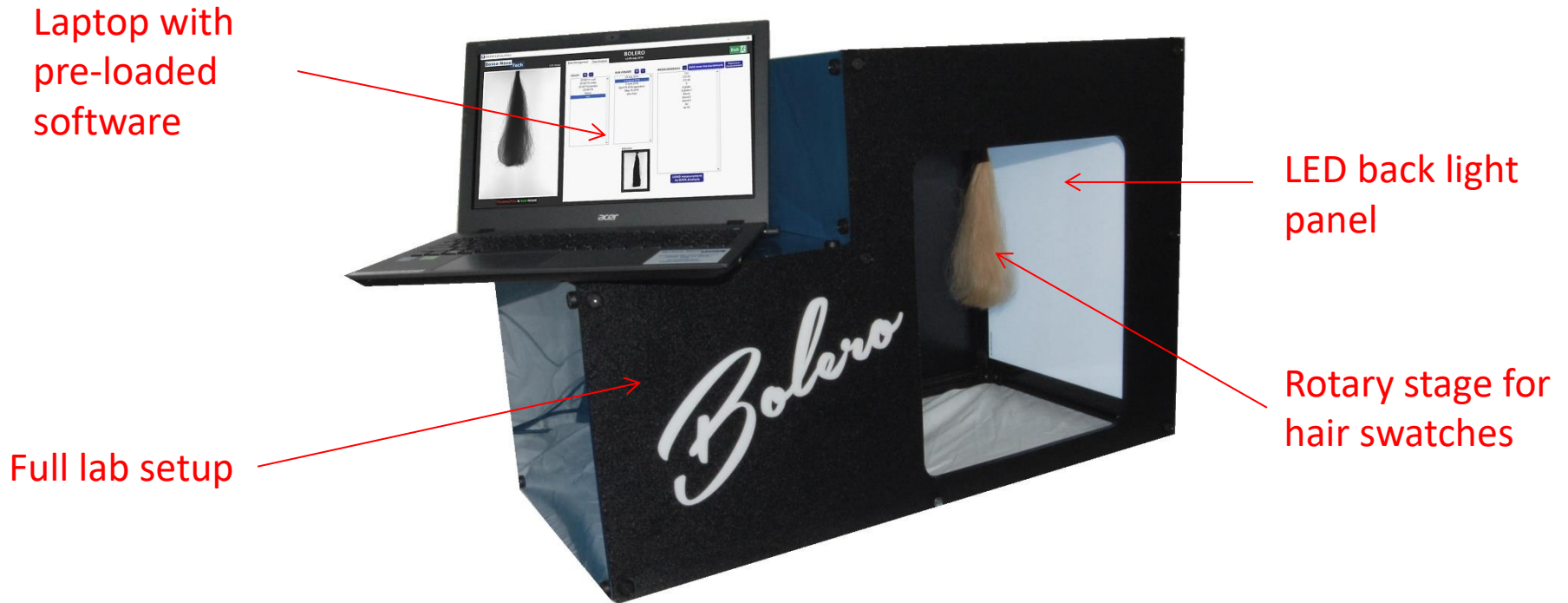
BOLERO : Hardware

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*



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*



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.



BOLERO

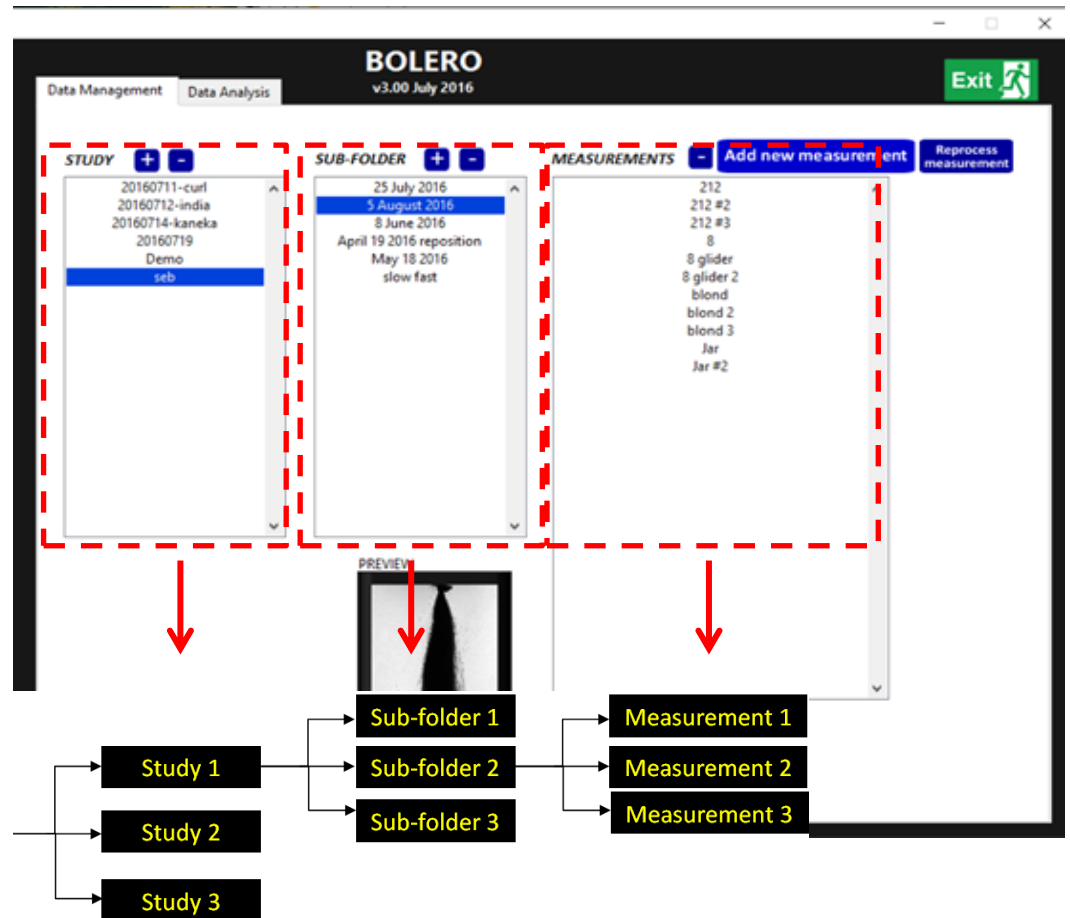
*Hair volume/surface measurement
Fly-away/frizz analysis system*

SOFTWARE

BOLERO : Software

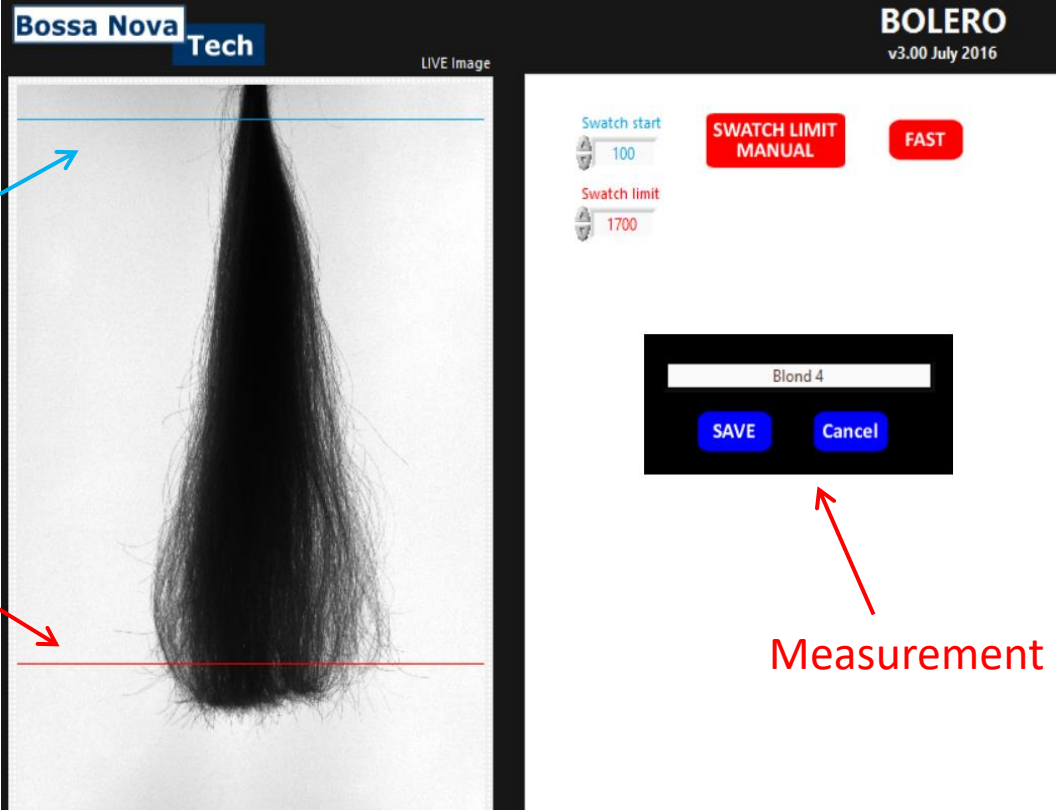
Data management

- 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



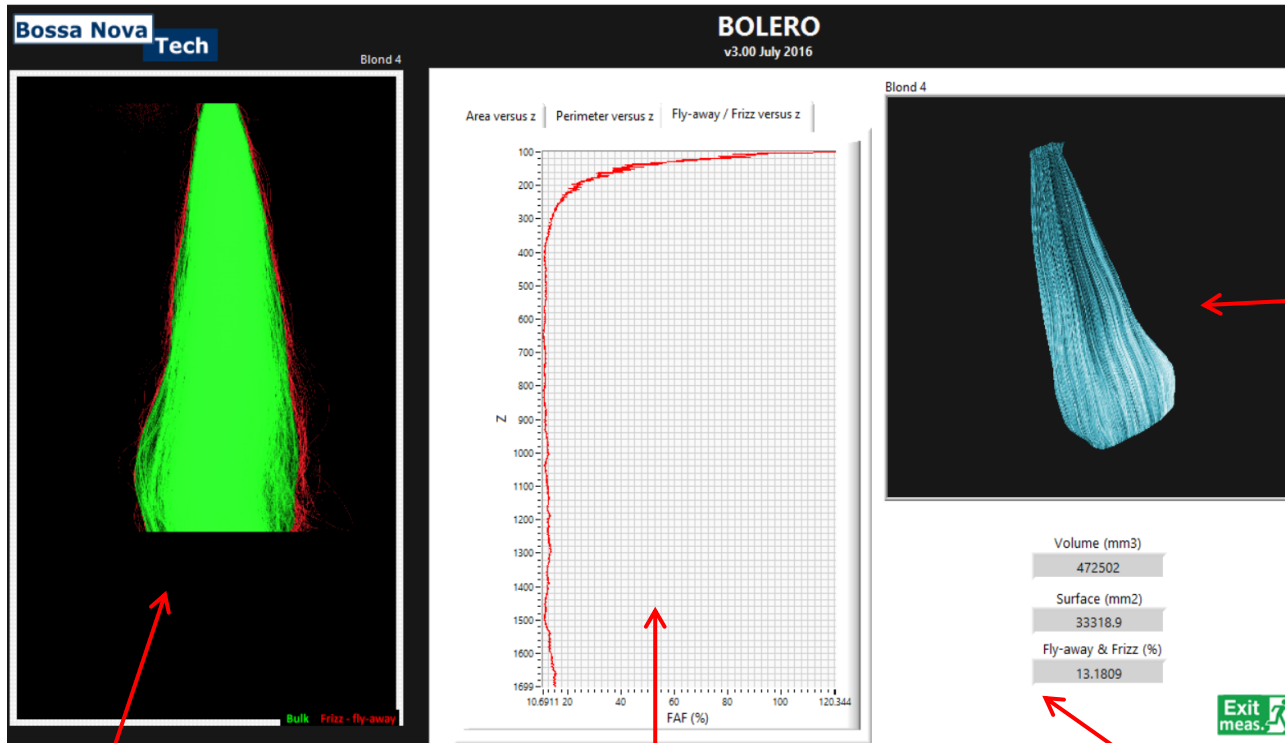
The screenshot displays the BOLERO software interface. On the left, a 'LIVE Image' shows a hair swatch with a blue horizontal line at the top and a red horizontal line at the bottom. A blue arrow points to the blue line, and a red arrow points to the red line. To the right of the image are control panels. The top panel includes 'Swatch start' (100), 'Swatch limit' (1700), and buttons for 'SWATCH LIMIT MANUAL' and 'FAST'. Below this is a dialog box with a text input field containing 'Blond 4' and 'SAVE' and 'Cancel' buttons. A red arrow points from the text 'Measurement Name' to the 'Blond 4' input field.

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

The screenshot displays the BOLERO software interface. On the left is the 'Main Display' showing a 'RAW IMAGE' of a hair sample. The central 'Data Management' and 'Data Analysis' panels show 'MEASUREMENTS Loaded' and 'MEASUREMENTS Displayed' lists for 'blond', 'blond 2', and 'blond 3'. A 'SELECT measurement as REFERENCE' button is visible. The right side features a grid of 'Images Loaded' for 'blond', 'blond 2', and 'blond 3', including regular images and flyaway images. A red dashed box highlights the central panels, and a red box highlights the 'Images Loaded' grid. Red arrows point from the labels to the corresponding UI elements.

Switching between regular/Flyaway images

Main Display

Load current/old measurements

Images Loaded

BOLERO : Software

Data visualization and comparison

The screenshot displays the BOLERO software interface. On the left, a 'LIVE Image' shows a hair sample. The central panel has two lists: 'MEASUREMENTS Loaded' and 'MEASUREMENTS Displayed', both containing 'blond', 'blond 2', and 'blond 3'. A blue arrow points from the loaded list to the displayed list, with a button below it labeled 'SELECT measurement as REFERENCE'. The right panel shows a 'RESULTS' table with columns for Name, Volume (mm3), Area (mm2), and Fly-away/Frizz (%). A red arrow points from a text box to the table.

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

**Result Table:
Comparison of up to
12 different
measurements**

BOLERO : Software

Data visualization and comparison

The RESULTS TABLE lists the volume (in mm³), surface (in mm²) and frizz/fly-away percentage (%) for each measurement.

Name	Volume (mm ³)	Area (mm ²)	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

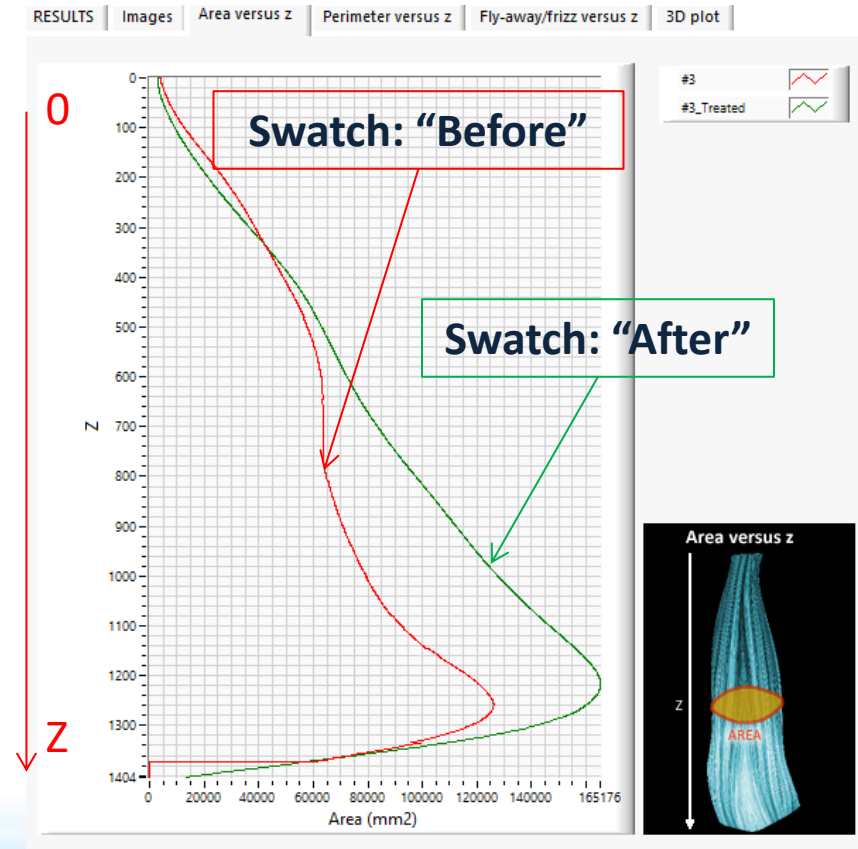
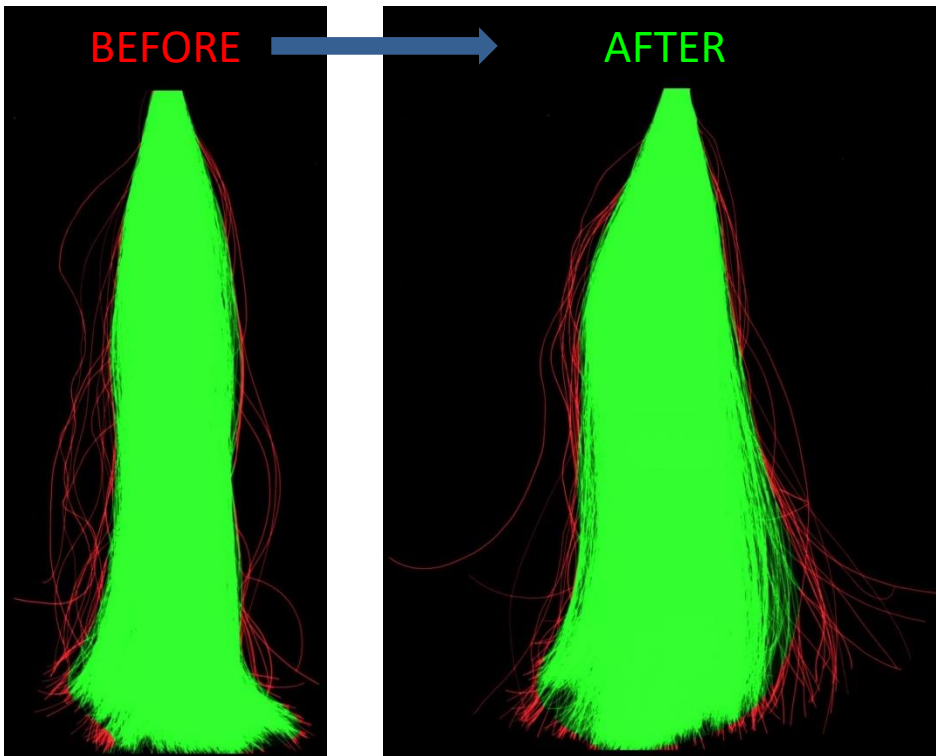
It is possible to select a measurement as a reference by clicking the “SELECT measurement as REFERENCE” button, the user can then update the RESULTS table in order to easily compare different measurements relative to the selected reference .

RESULTS	Images	Area versus z	Perimeter versus z	Fly-away/frizz versus z	3D plot	Slice
RESULTS						
Name	Volume (mm ³)	Area (mm ²)	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)			

BOLERO : Software

Data analysis window

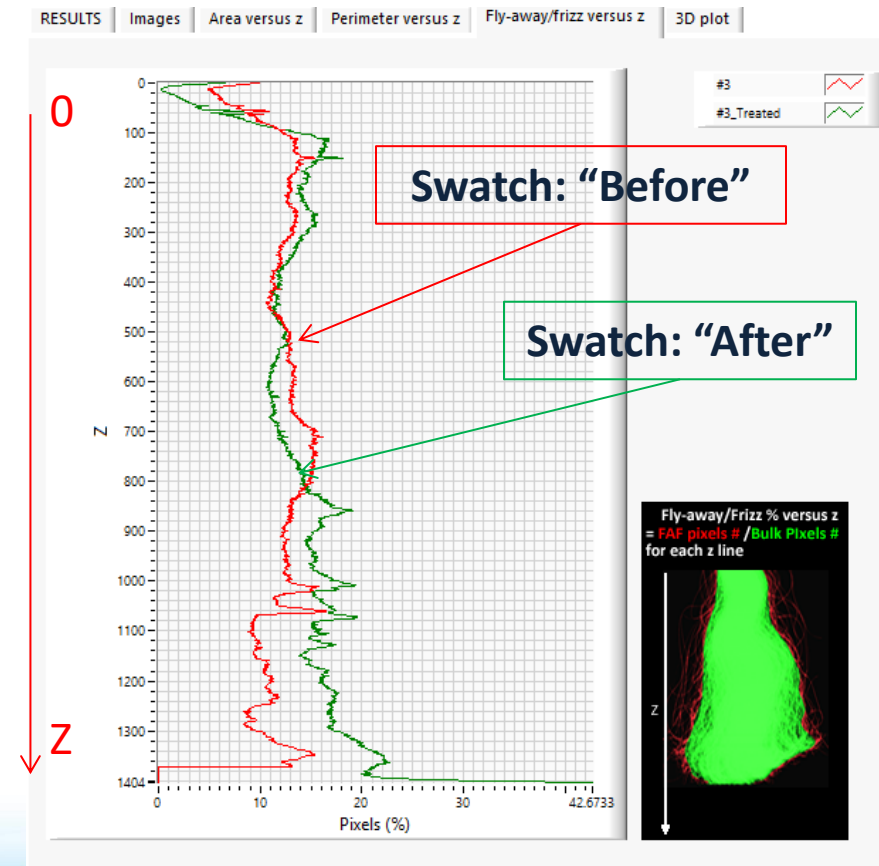
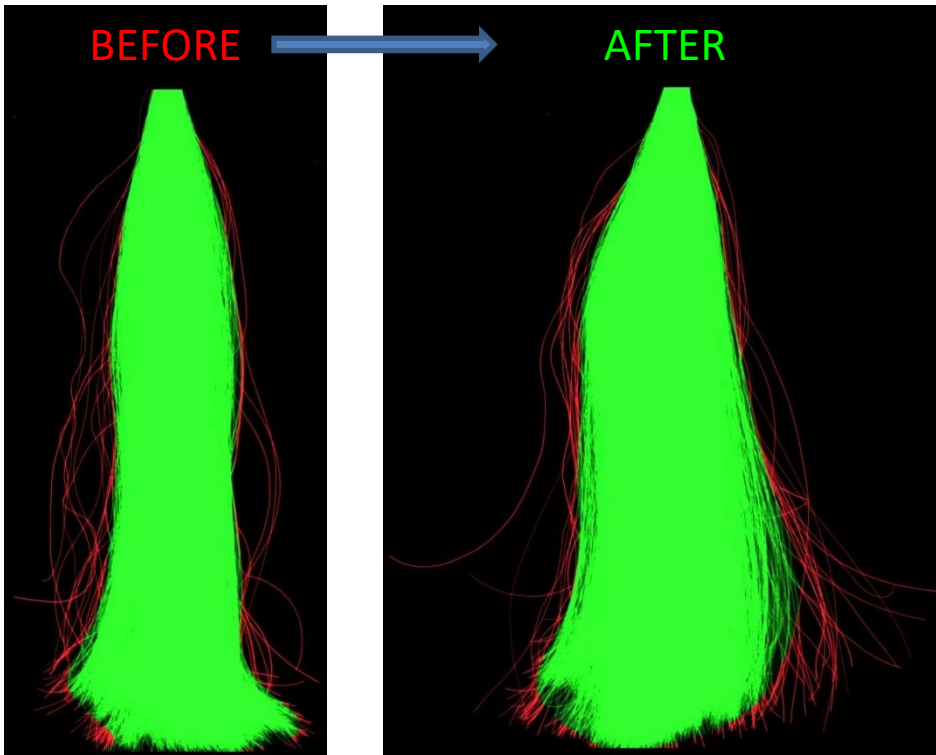
The **Area versus z** tab allows the user to visualize the variation of the area of the swatches versus z, on the same graph.



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

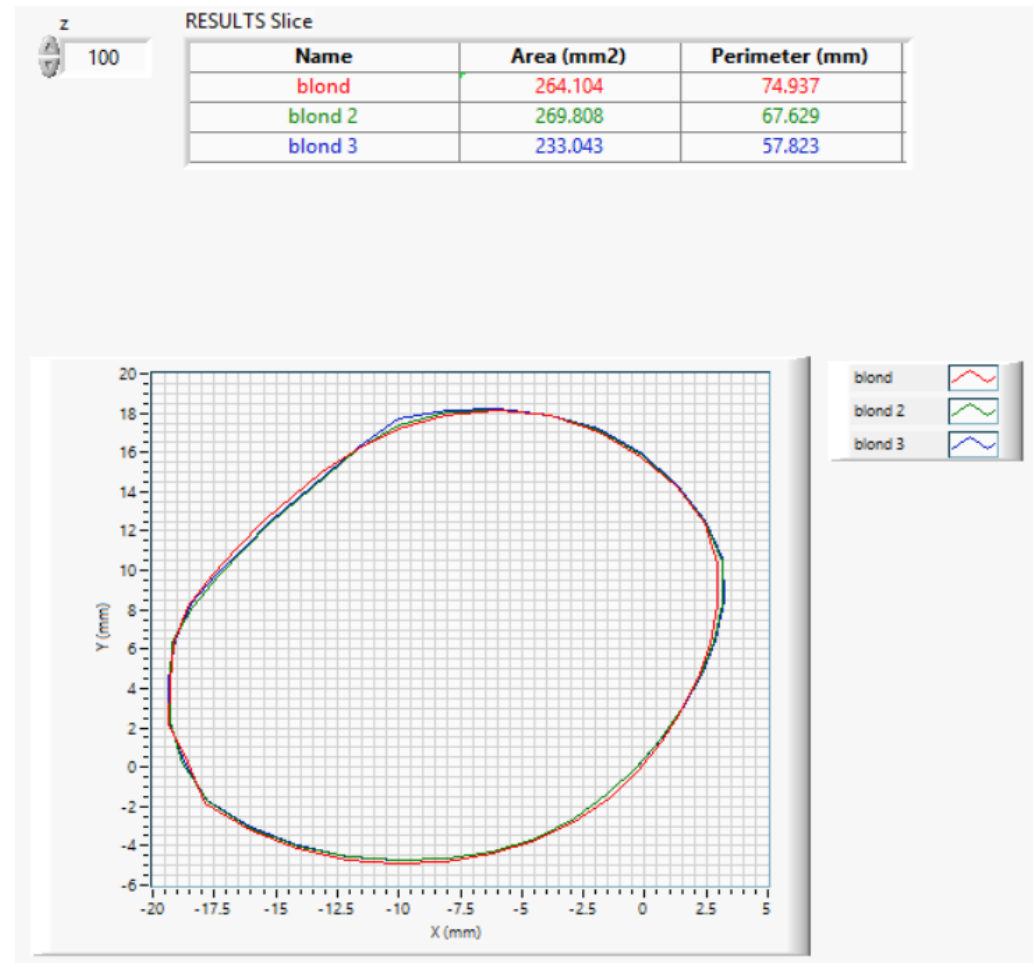
The 3D plot tab allows the user to visualize the 3D shape of the selected loaded measurement. The user can rotate the 3D shape as needed and export the image as a jpeg file.

The screenshot displays the BOLERO software interface. At the top, a navigation bar includes tabs for 'RESULTS', 'Images', 'Area versus z', 'Perimeter versus z', 'Fly-away/frizz versus z', '3D plot', and 'Slice'. The '3D plot' tab is active, showing a 3D visualization of a hair measurement as a teal, textured, elongated shape against a black background. To the left of the 3D plot, there are two lists: 'MEASUREMENTS Loaded' and 'MEASUREMENTS Displayed'. The 'Loaded' list contains 'blond', 'blond 2', and 'blond 3'. The 'Displayed' list also contains these three items, with 'blond 3' highlighted in blue. Below the 'Displayed' list are two buttons: 'SELECT measurement as REFERENCE' and 'NO REF.'. Below the 3D plot are two buttons: 'SELECT measurements for 3D plot' and 'Save 3D picture as jpg image'. A large blue arrow points from the 'Loaded' list to the 'Displayed' list, indicating the selection process.

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.



BOLERO : Software

Data Export

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

BOLERO v3.00 July 2016

MEASUREMENTS Loaded

- blond
- blond 2
- blond 3

RESULTS

Name	Volume (mm3)	Area (mm2)	Fly-away/frizz (%)
blond	4.727E+5	3.331E+4	17.173
blond 2	4.739E+5	3.336E+4	17.268
blond 3	4.749E+5	3.339E+4	17.227

Export RESULTS

Please create a new folder to export data, images and point clouds

Save in: BOLERO

File name: Exported results

Save as type: All Files (*.*)

Save

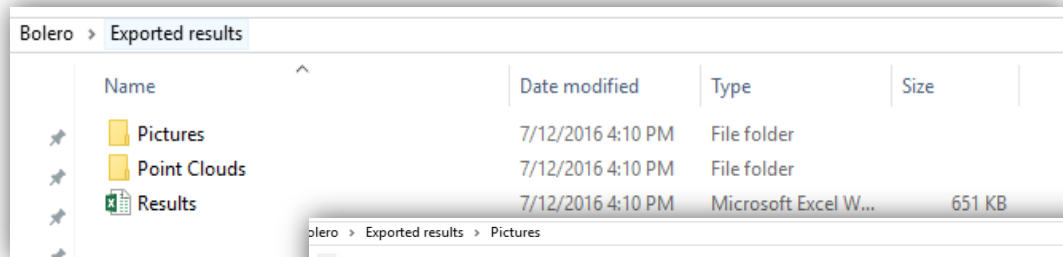
Cancel

Current Folder

BOLERO : Software

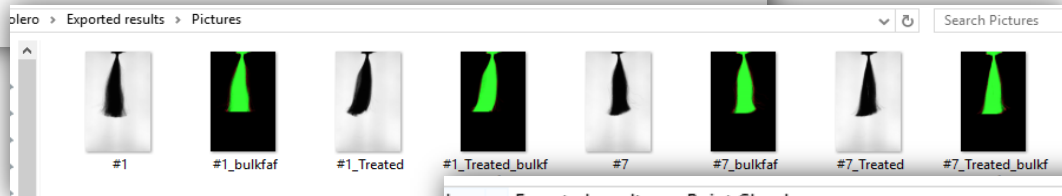
Data Export

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



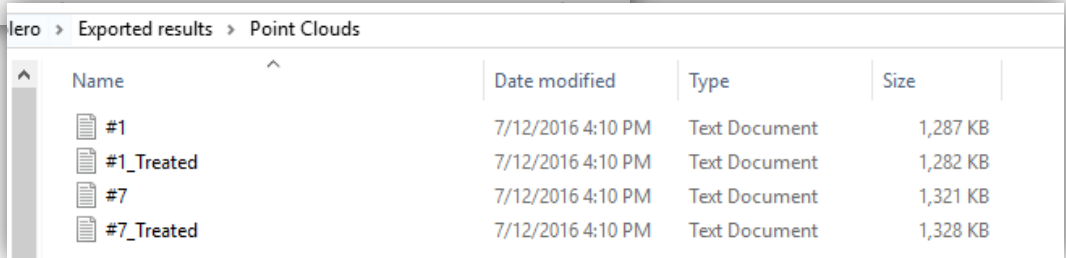
Bolero > Exported results

Name	Date modified	Type	Size
Pictures	7/12/2016 4:10 PM	File folder	
Point Clouds	7/12/2016 4:10 PM	File folder	
Results	7/12/2016 4:10 PM	Microsoft Excel W...	651 KB



Bolero > Exported results > Pictures

Name	Date modified	Type	Size
#1	7/12/2016 4:10 PM	Image	
#1_bulkfaf	7/12/2016 4:10 PM	Image	
#1_Treated	7/12/2016 4:10 PM	Image	
#1_Treated_bulkf	7/12/2016 4:10 PM	Image	
#7	7/12/2016 4:10 PM	Image	
#7_bulkfaf	7/12/2016 4:10 PM	Image	
#7_Treated	7/12/2016 4:10 PM	Image	
#7_Treated_bulkf	7/12/2016 4:10 PM	Image	



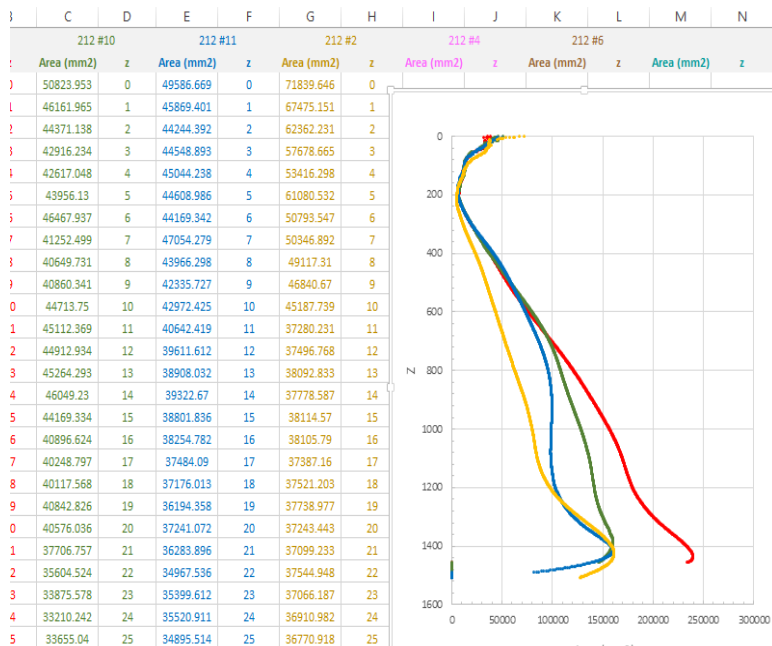
Bolero > Exported results > Point Clouds

Name	Date modified	Type	Size
#1	7/12/2016 4:10 PM	Text Document	1,287 KB
#1_Treated	7/12/2016 4:10 PM	Text Document	1,282 KB
#7	7/12/2016 4:10 PM	Text Document	1,321 KB
#7_Treated	7/12/2016 4:10 PM	Text Document	1,328 KB

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%)

BOLERO

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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 (mm ³)	Volume (mm ³) 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!