



TANGO

USER MANUAL



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ABOUT THIS MANUAL

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

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PART 1 – Hardware description

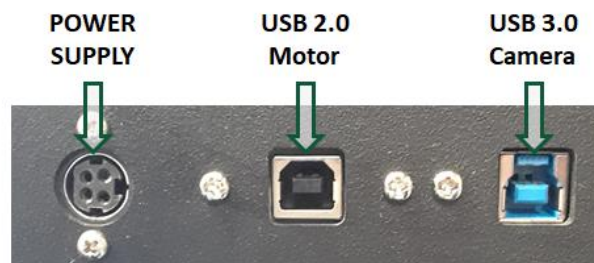
1.1 List of components

The TANGO system comes with the following items. Please make sure you have all those components upon reception of the system:

TANGO <i>Head sensor</i>	Tripod	Computer <i>Laptop or All-in-one</i>
		
KPPX Cable + Power cord <i>Power Supply</i>	USB 2.0 cable <i>(Motor control)</i>	USB 3.0 cable <i>(Camera control)</i>
		

1.2 Connections

Connect the aforementioned cables to the following port connectors on the back of the TANGO Head sensor. There is no switch on/off, the system just need to be plugged in to be powered. Both USB cables are connected to the computer. Make sur that you connect the USB 3.0 blue port on the TANGO head sensor to the USB 3.0 blue port on the computer.

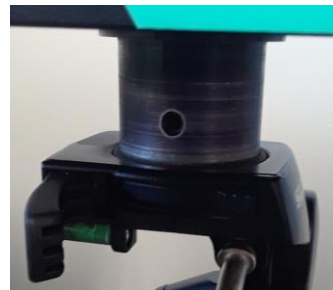


1.3 Setup instructions

To set up the system, please follow the instruction below:

Head sensor needs to be put on the tripod and clipped (see images on the right), and then positioned in the direction of the sample.

Adjustment (focus, position, direction) can be done visually by using the TANGO software (cf. Software section)



Cables need to be connected to the appropriate port (cf. image). There is no switch, the system is powered on as soon as the power supply is connected.



The light in the room needs to be turned off. Because this is a polarization imaging system (cf. next section), any additional light other than the illumination from the system will affect the image acquisition.



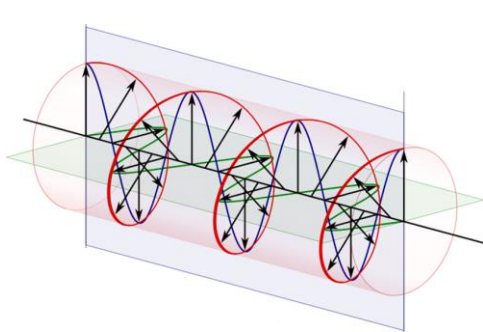
Turn on the software (cf. Software section for instruction on software usage)

PART 2 – Technical Background

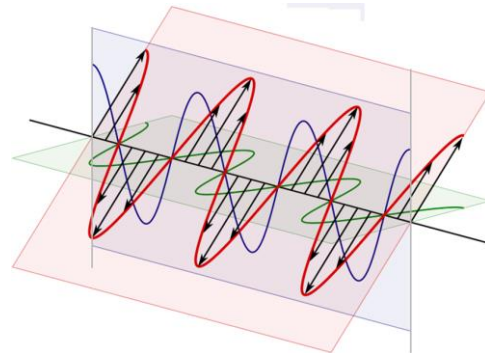
2.1 Measurement principle

2.1.1 Polarization of light

Polarization is a property of an electro-magnetic wave – like its amplitude or its wavelength – that describes the 3-dimensional geometrical orientation of its oscillations.



Example of circular polarization



Example of linear polarization

Light coming from most natural sources is called *unpolarized light* as it is composed of a mixture of different polarization states.

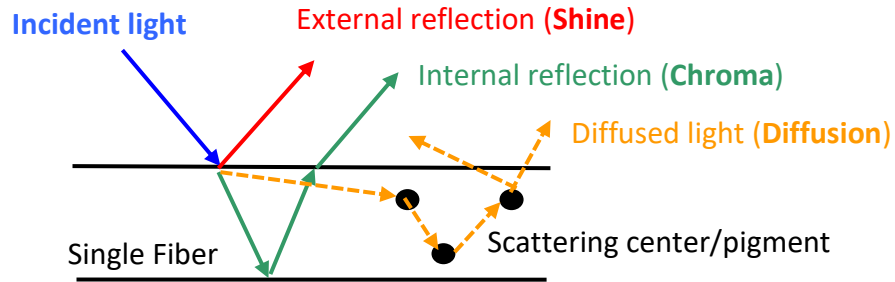
Polarized light is usually obtained using specific filters, and can be described as *linear*, *circular* or *elliptic*.

Imaging systems based on the polarization of light have been widely used in cosmetics, notably for shine/luster assessment on skin or hair or specular removal on skin.

2.1.2 Interaction of light with hair

Light interacts with hair fibers in a way that 3 components are observed:

- The light coming from the **external reflection** (surface reflection). This reflection has the same color than the incident light.
- The light coming from the **internal reflection** on the back surface of the fiber. Since light traveled through the hair, it experiences a change of color.
- Diffused light from **volume scattering**



Simple model of light interaction with single hair fiber

In the case of incident light illuminating a hair fiber - as described in the last section - if the incident light is linearly polarized, then:

- The **external reflection** remains polarized with the same polarization
- The **internal reflection** becomes elliptically polarized
- The **diffused light** becomes un-polarized

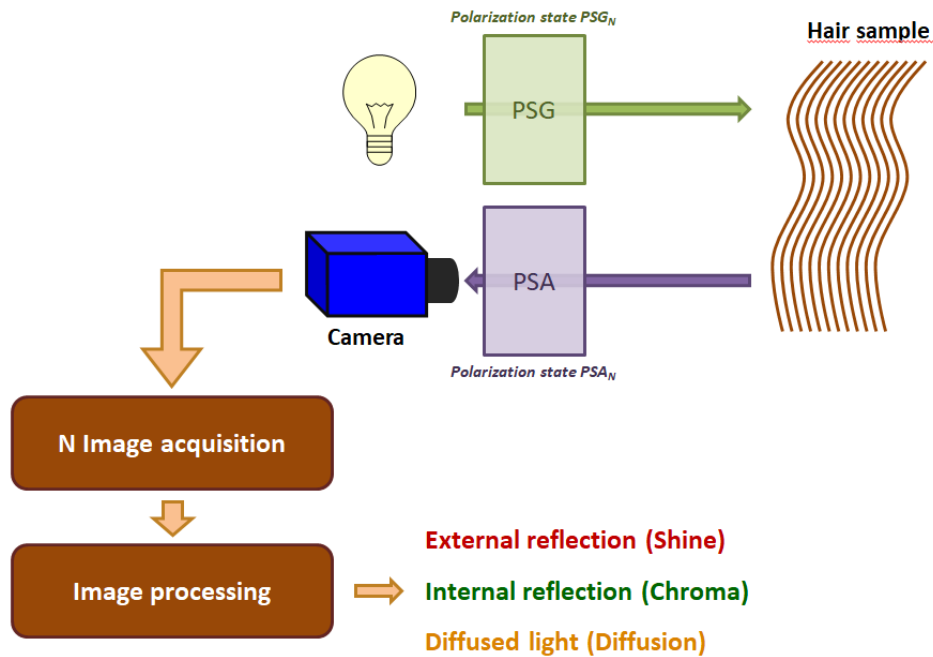
The principle of the measurement is based on the physical property and the polarization signature of the internal reflection, and with the appropriate setup, it is possible to separate those components depending on their polarization properties.

2.2 Measurement principle

The TANGO system enables the separation of all those 3 components (external reflection, internal reflection, diffusion) using a method based on the polarization signature carried by each component. This method requires the use of a pulsed polarized illumination system coupled with a polarization analysis imaging system

The illumination system goes through a Polarization State Generator (PSG). As a result, the emitted light is polarized, its polarization state being controlled by the PSG. Light coming back from the illuminated sample goes through a Polarization State Analyzer before going to the imaging system (video camera).

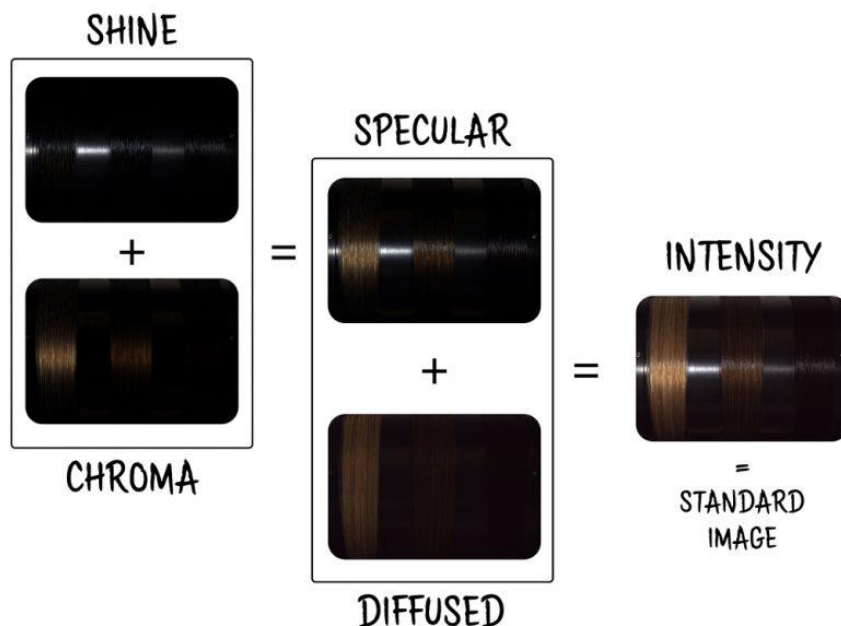
To separate the three components, N images are acquired ($N \geq 4$), corresponding to N couple of polarization states (PSG_N, PSA_N). The acquisition of each image and the control of PSG and PSA is done using a computer. The N acquired images are then analyzed and processed to separate the contributions for each pixel of the image.



The actual calculations and techniques used to do this separation are described more extensively in the patent #US8223322B2 named “Visual appearance measurement method and system for randomly and regularly arranged birefringent fibers”.

2.3 Example of images on hair

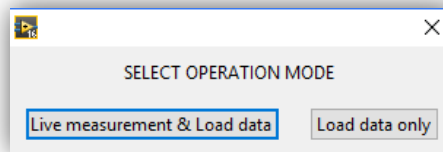
Below are some examples of images taken with the TANGO system. The three components are here called Shine (external reflection), Chroma (internal reflection) and Diffused (diffusion). Combination of those brings the specular image and the intensity image.



PART 3 – Software

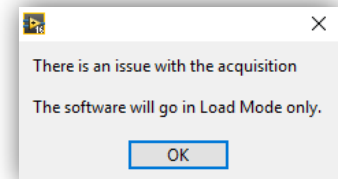
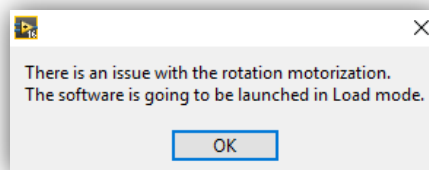
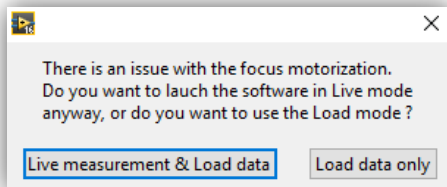
Locate the TANGO Software icon in the desktop of your computer.

The following message appears when the software is launched:



- **LIVE MODE:** If you want to perform measurements, select “*Live measurement & Load Data*”. It will check the connections with the motor and the camera, and enable the acquisition of images.
- **LOAD MODE:** If you only want to open and analyze saved measurements, click on “*Load Data Only*”.

If the camera or the motor is not connected, or if there is an issue with a component while you choose the Live mode, an error message will pop up and ask you to correctly connect the device.



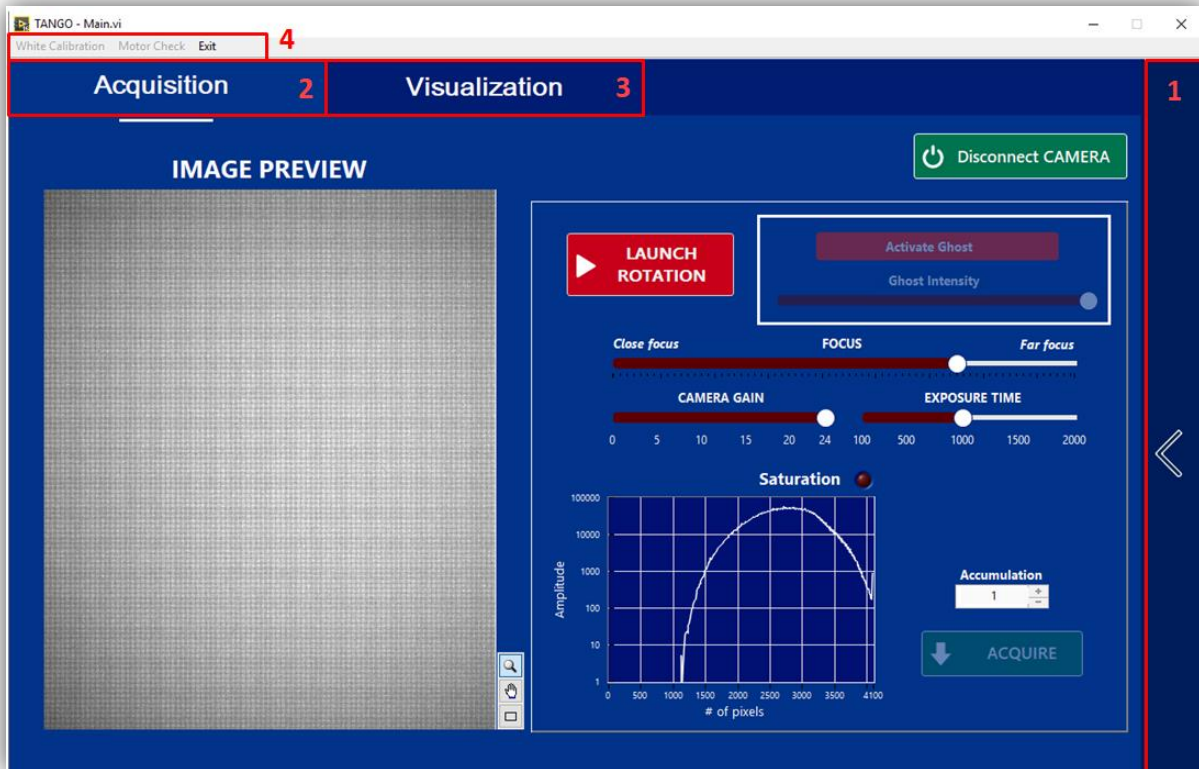
3.1 Software architecture

After enabling one of the 2 modes, you will arrive on the main window of the software, where you will be able to visualize your samples, acquire new measurements, analyze and export your data, etc.

The main window can be described as follow:

1. **Data Management Tab** : you can create/delete/rename/move/copy your folders and measurements, preview a selected measurement and select a measurement for a ghost reference

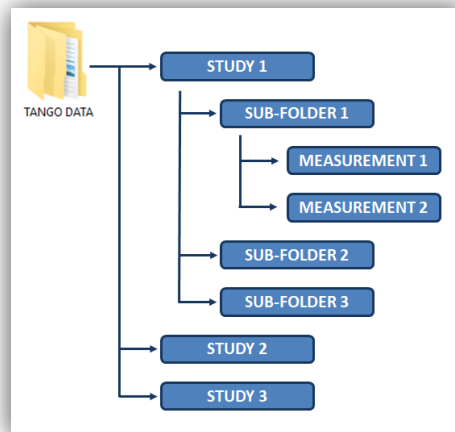
2. **Image Acquisition** : you can select the parameters of your acquisition, change live/load mode and visualize your sample (interaction possible only in Live Mode)
3. **Image Visualization** : you can visualize the images taken with the TANGO and use some basic analysis tools
4. **Menu** : you can launch calibration and check-up procedures



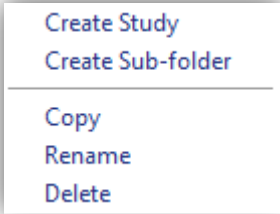
3.2 Data management

All the measurements are saved in a folder named *TANGO DATA* located by default on the desktop of the computer or in your application folder. It is separated into 3 sub-divisions: Study, Sub-folder and Measurement.

You can manage all your measurements from the Data Management tab hidden on the right side of the TANGO software interface



You can create a new folder, or copy / rename / delete a measurement by right-clicking and selecting the appropriate command.

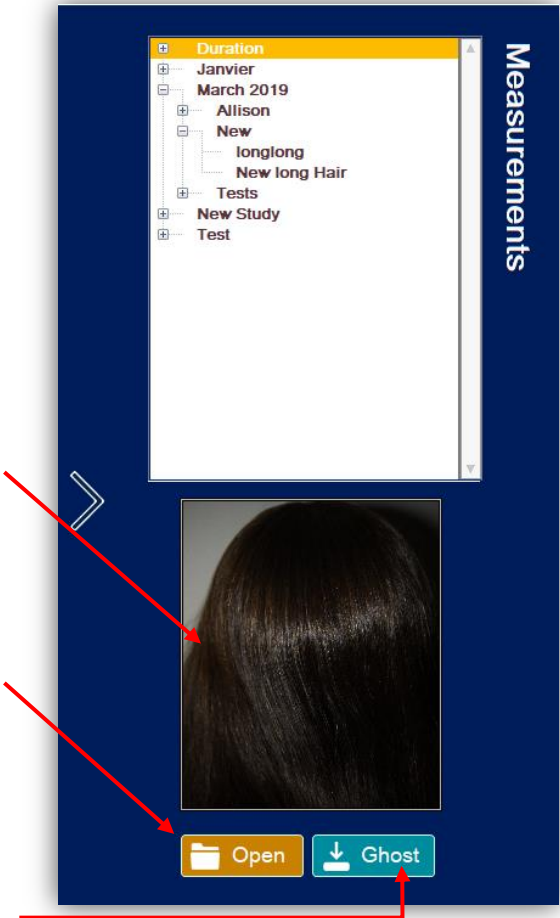


You can also drag a measurement or sub-folder to move it from one position to another

When you select a measurement, you obtain an image preview of the measurement you made in the bottom part of the tab.

With the **Open** button can open the measurement to display the images in the visualization tab and access the analysis tools

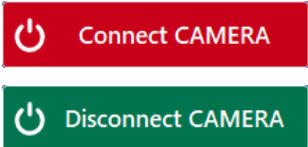
The **Ghost** button selects the measurement for the ghost comparison during the image acquisition process.



3.3 Image acquisition

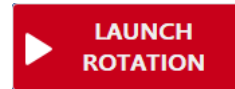
3.3.1 Connecting the camera

Using the Connect/Disconnect button, you can connect (**Live Mode**) and disconnect the camera (**Load Mode**). It is used to switch between Live and Load Mode. It can also be used to reset the communication with the camera in case of a connection issue.



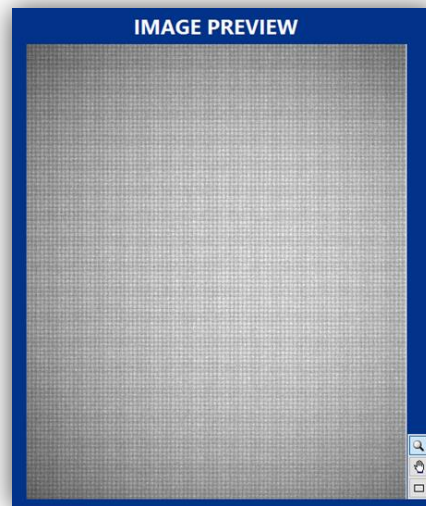
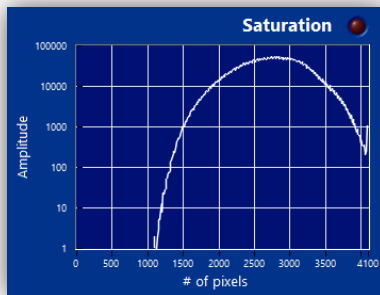
3.3.2 Setting the image intensity

When you're in Live mode, you can interact with the command on the acquisition tab. Before taking any measurement or doing any adjustment, you need to launch the motor rotation, which will turn on the wheel. You can stop the wheel rotation by clicking again on the button.

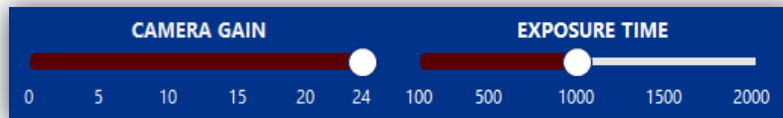


Once the rotation is on, you should be able to see a live image (unprocessed grayscale image) in the image tab. The intensity distribution of the pixel is displayed on the graph on the right side of the window. You can select a specific ROI (Region Of Interest).

A Saturation indicator will light up if your image is saturated (too much intensity on some pixels in the ROI).



Once the image is displayed, you can adjust the image intensity by changing the camera gain* and the exposure time**.

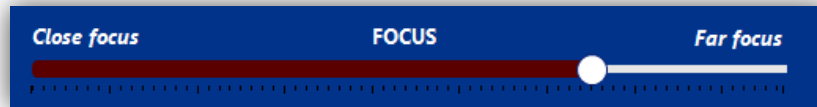


* **Camera gain:** Sensitivity of the camera (arbitrary unit). A higher number means that the camera will deliver a stronger signal for the same amount of light coming on the sensor. By using too much gain, you may obtain saturation on your image which will result in faulty measurements.

** **Exposure time:** Duration of time (here in microseconds) during which the camera is open to the light coming from the sample. A higher exposure time means that the detector in your camera will get more light, and that the image will be brighter. By using an exposure time too high, you may obtain saturation on your image which will result in faulty measurements.

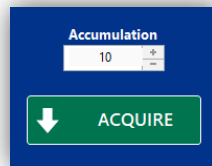
3.3.3 Adjusting the focus

You can adjust the focalization of the camera visually by changing the focus directly from the software. Adjust until the image appears clear on the display. If you change the distance between the system and the sample, the focus will need to be readjusted.



3.3.3 Acquiring images

When the wheel is rotating, you have the possibility to acquire images. You can also enable an accumulation of images. Instead of acquiring only 1 image by default, you can acquire several in a row to increase the signal and improve your signal to noise ratio.



Images are taken with a 12 bit depth but are saved with a 16 bit depth, which means that you can safely accumulate up to 16 images without any saturation, as long as the raw images are not saturated either (cf. image preview and graph in earlier section).

3.4 Image visualization

Once an image is acquired or opened from the main tab, it will be displayed on the visualization tab where several analysis tools are available.

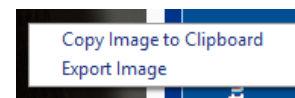
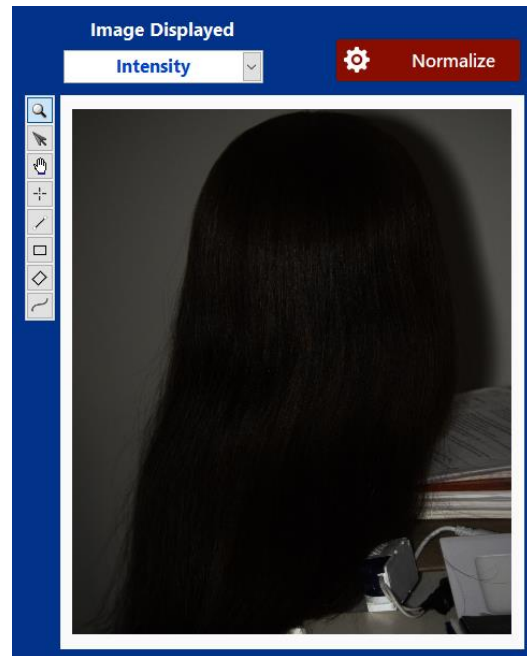
3.4.1 Image display

The image display on the left side of the tab can show the following images depending on the choice of image displayed. You can display :

- The **Intensity** image (normal image)
- The **Specular** image (external and internal reflection)
- The **Shine** image (external reflection)
- The **Chroma** image (internal reflection)
- The **Diffused** image (diffusion)

You have the possibility to normalize the image to better visualize the image. The normalization will be done on the most intense pixel in the selected Region of Interest (ROI). You can select different type of ROI in the toolbox on the left side of the image.

You can copy and export the image by right-clicking on the image and selecting the appropriate option.



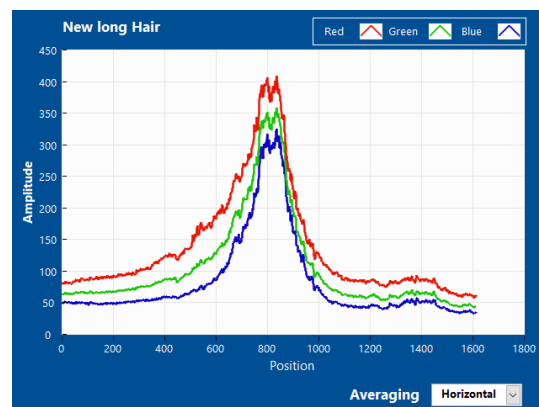
3.4.2 Analysis tools

Several analysis tools are available once a measurement has been acquired or loaded to the visualization tab:

Color Profiles :

On a given ROI, this graph will display the red, green and blue components of the image currently displayed, averaged over an horizontal or a vertical direction, depending on the option selected using the bottom selector.

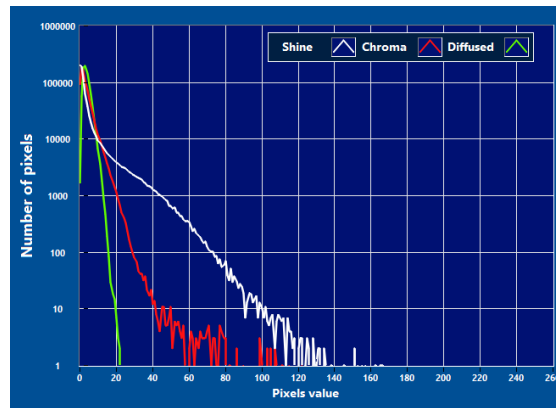
This graph will be modified depending on the type of image displayed (Intensity, Specular, Shine, etc.)



Histograms :

On a given ROI, this graph will display the Shine, Chroma and Diffused pixel intensity distribution normalized over a 0 to 255 intensity scale

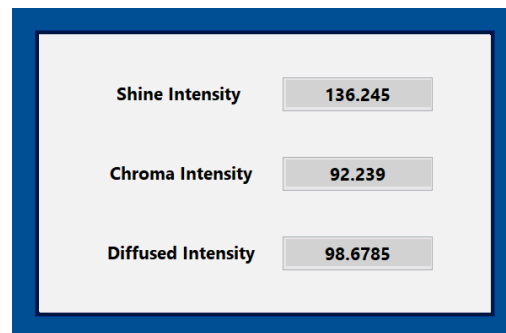
This graph will not be modified depending on the type of image displayed.



Intensities :

On a given ROI, this graph will display the overall Shine, Chroma and Diffused intensity.

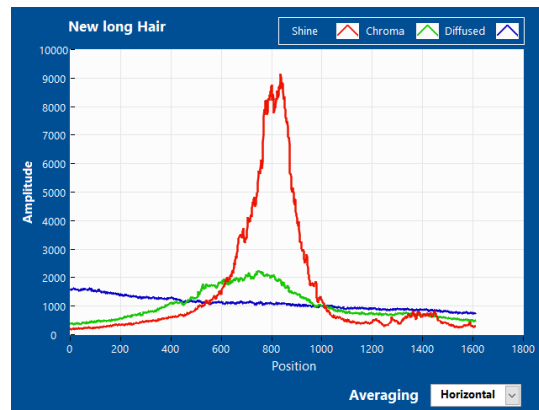
Those values will not be modified depending on the type of image displayed.



Light profiles :

On a given ROI, this graph will display the Shine, Chroma and Diffused profiles of the image, averaged over an horizontal or a vertical direction, depending on the option selected using the bottom selector.

This graph will not be modified depending on the type of image displayed.



You can copy the data from a graph and export an image of the graph by right-clicking on it and selecting the appropriate option.

