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SAMBA Hair System

Objective measurement of parameters involved in the visual appearance of hair

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Company Overview

- Located in Los Angeles (Culver City), CA, USA
- LLC (Limited Liability Company) founded in 2002
- Small business of 7 people specialized in optics, electronics, imaging and software development (4 PhDs, 2 MSc, 1 Technician)
- Manufacturer of testing equipment : laser ultrasonic inspection equipment, polarization cameras and systems for the cosmetic testing
- Provides research for NASA, NSF, DoD and corporate clients
- Well-known provider of imaging solutions for the cosmetic industry (more than 70 SAMBA Hair systems currently used worldwide)

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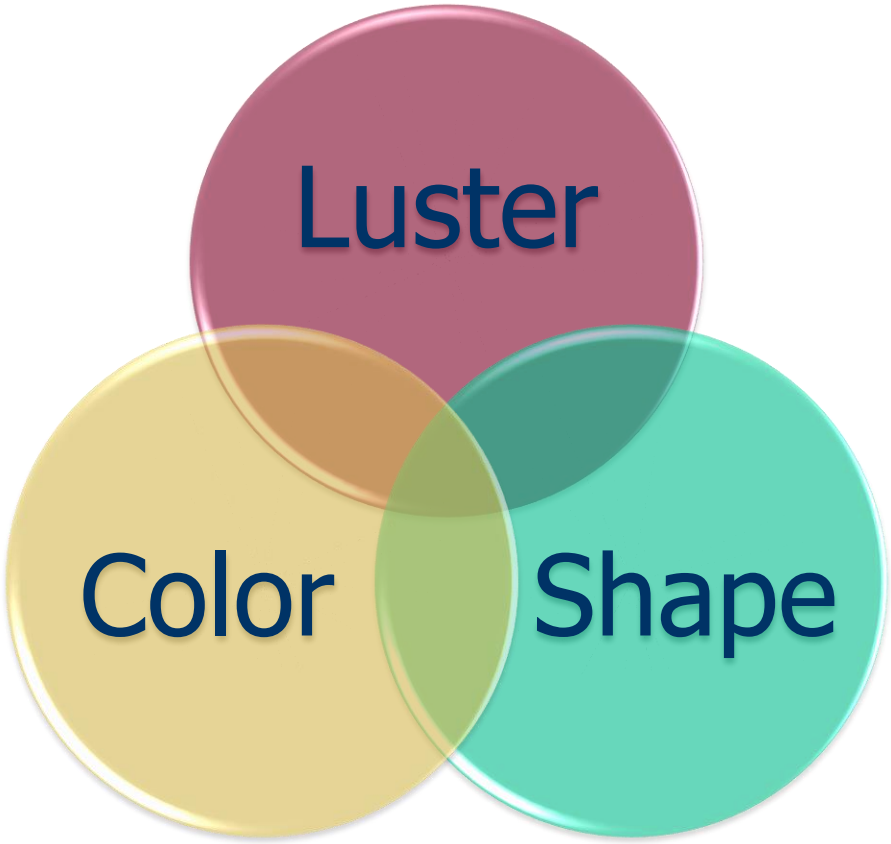
Visual appearance of hair is a combination of…



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Luster parameters

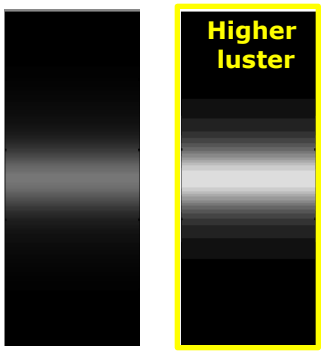
Luster qualifies the visual appearance of the object

Luster is strongly linked to the idea of quality and beauty of an object.

Scientists have tried to compute a parameter that would quantify the visual luster sensation.

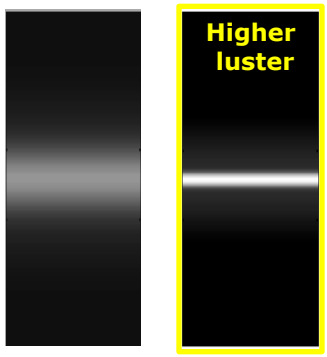
Luster sensation is considered to depend on 3 main parameters:

The amount of reflected light



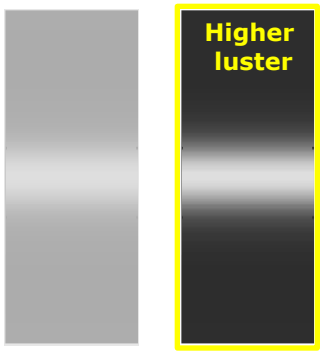
The more reflected light there is, the higher the luster is

The sharpness of the reflection



The sharper the reflection is, the higher the luster is

The background on which the reflection is observed



The darker the background is, the higher the luster is

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Luster parameters

Several Luster formulae have been developed and published by scientists using goniometers and other instruments to tentatively quantify human perception of Luster.

The parameters used in the formulae are :

- **S the total amount of the specular light**
- **D the total amount of the diffused light**
- **$\theta_{1/2}$ the width of the specular light distribution**

Examples of formulae :

$$L_{Reich-Robbins} = \frac{S}{D \times \theta_{1/2}}$$

$$L_{TRI} = \frac{S}{S+D} \cdot \frac{\theta_{ref}}{\theta_{1/2}}$$

$$L_{BNT} = \frac{S_{in}}{(D + S_{out}) \times W_{visual}}$$

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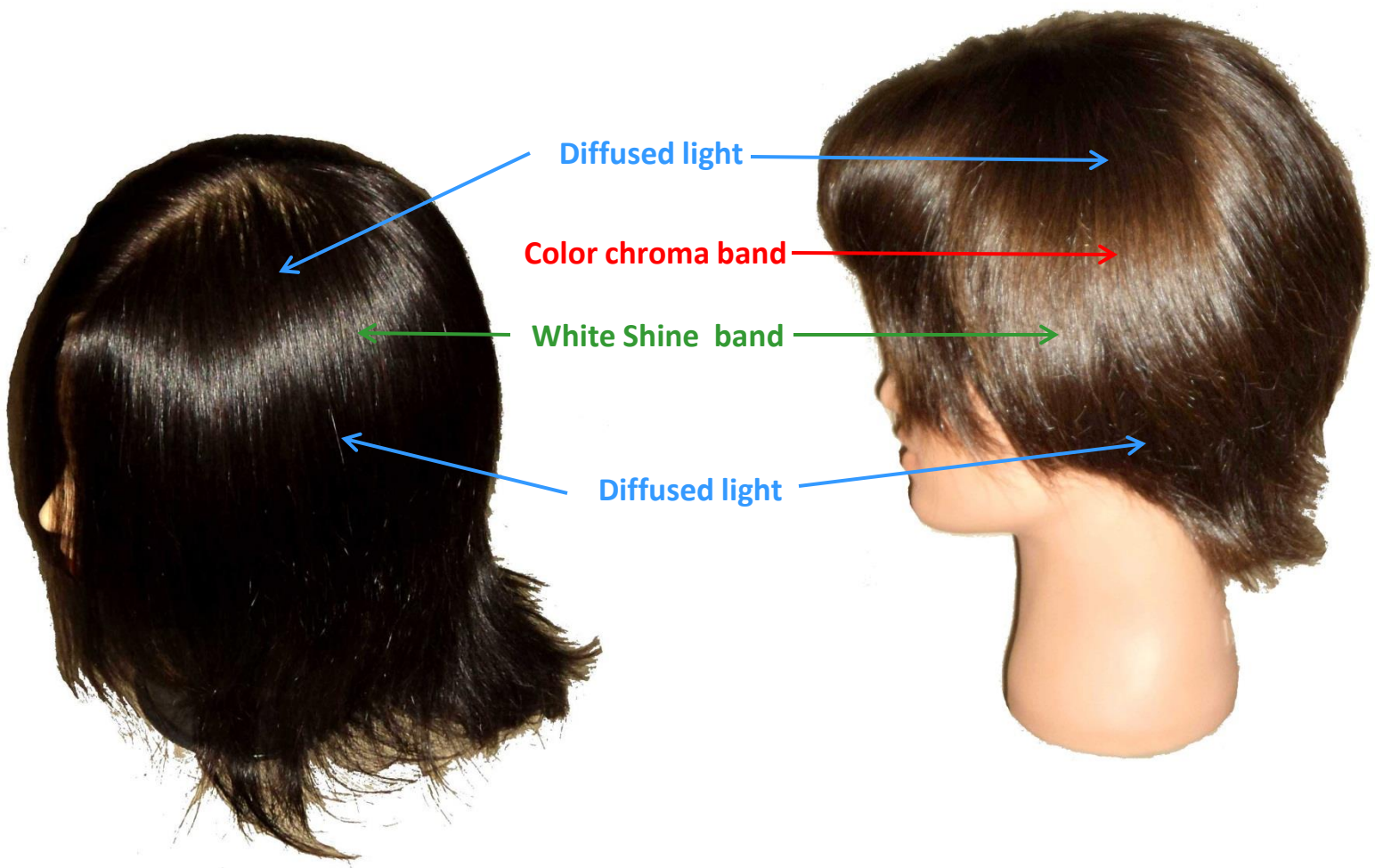
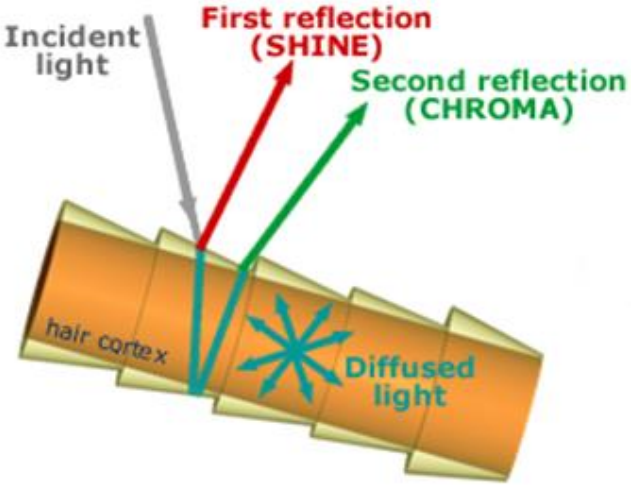
Specular & Diffused Light

Example on mannequin heads



Specular & Diffused Light

- Incident light splits into shine, chroma (specular) and diffused

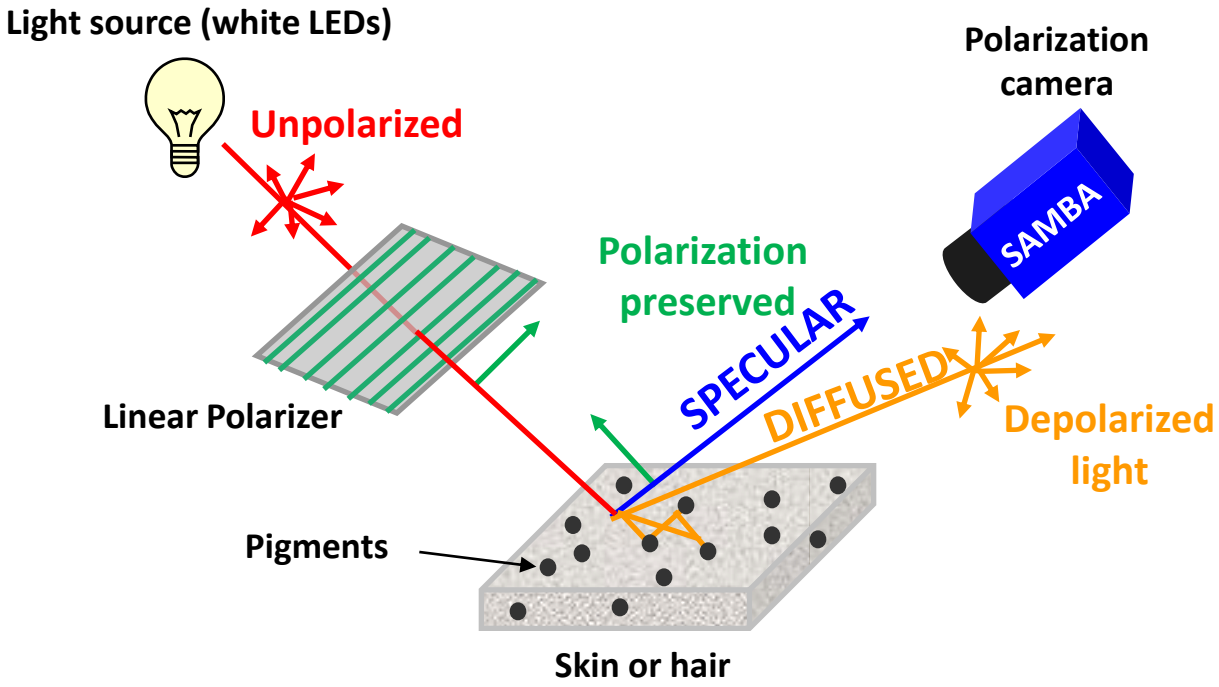


- Diffused and chroma carry color information
- Luster is highly related to the background color (diffused), surface quality and the hair style / alignment of the fibers

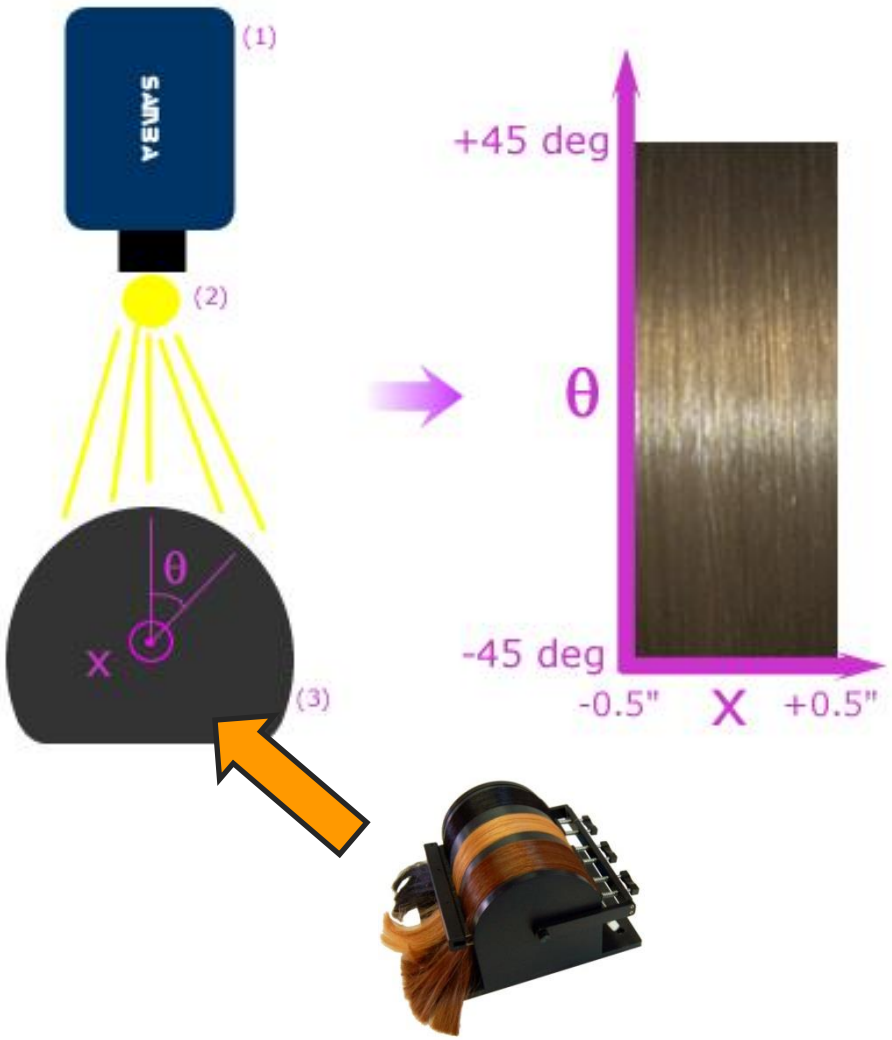
Active polarization imaging

Enable the physical separation of :

Specular (reflections)
&
Diffusion (color from the volume)



SAMBA Hair system set-up



The setup used is based on three main elements:

- **A polarized illumination (2)**
- **A cylinder on which the sample is positioned (3)**
- **A polarization camera (1)**

Polarized illumination and polarization camera allow measuring independently reflections and diffusion

Cylinder is used to record angular distribution profiles

Profile extraction

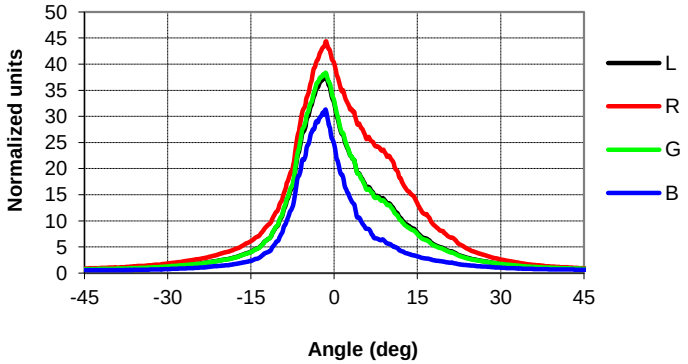
Specular image

Diffused image

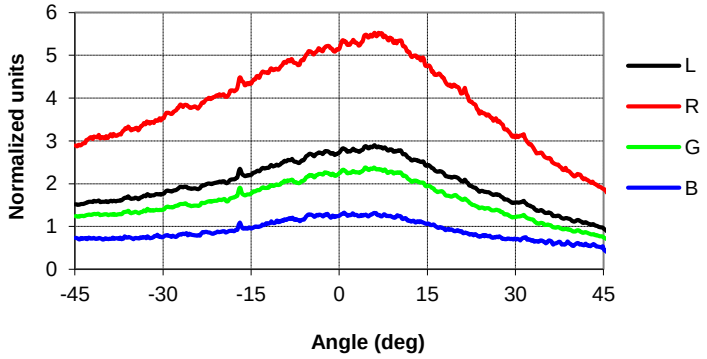
Cross sections

Averaging along the hair tress

Specular angular distributions (Luminance and color)



Diffused angular distributions (Luminance and color)



	θ_0 (deg)	W_{visual} (deg)	Max	Integral
Specular	15.17	24.03	66.98	1922
Diffused	-	-	20.04	1345

Characterization of the profiles with numerical parameters such as maxima, integrals and width → **LUSTER**

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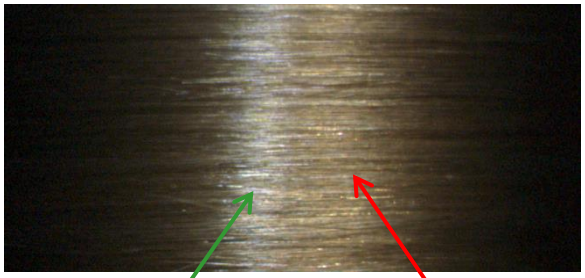
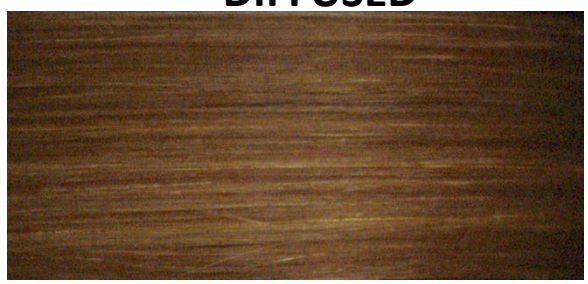
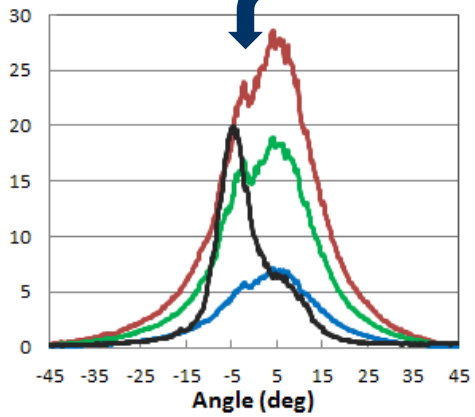
Separation of shine and chroma

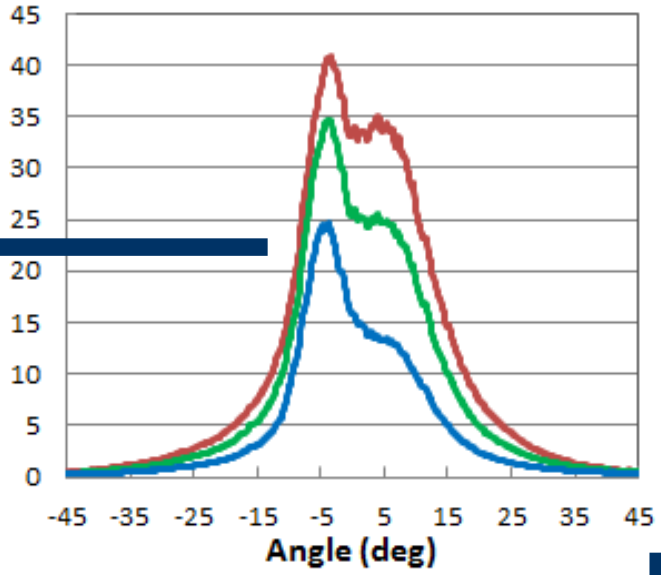
INTENSITY = SPECULAR + DIFFUSED

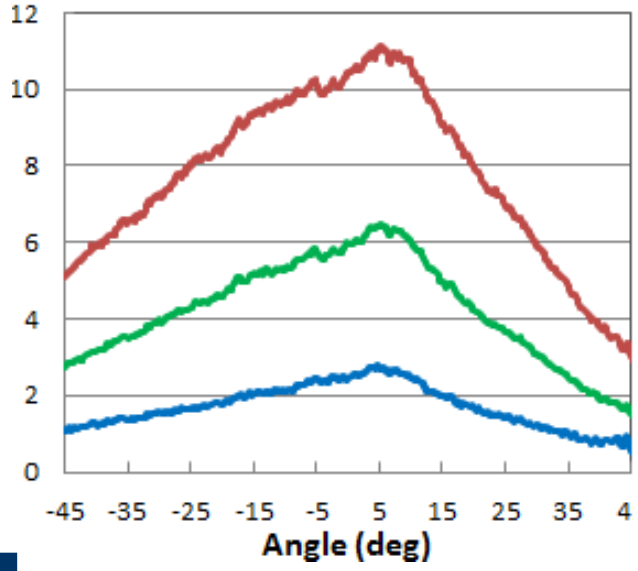




Mathematical decomposition of specular into shine and chroma based on color information

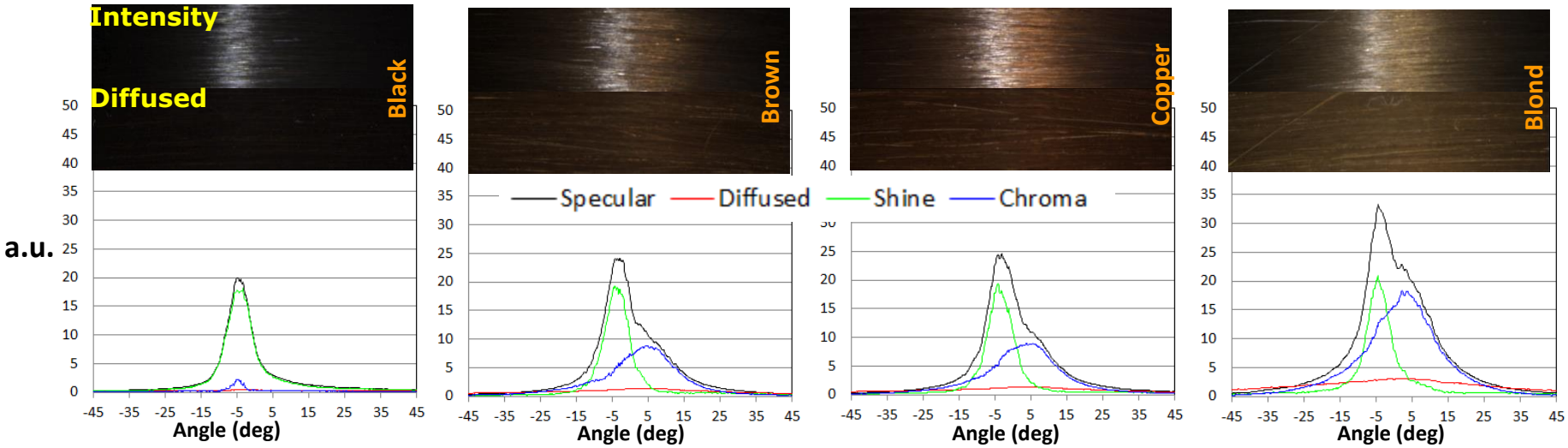


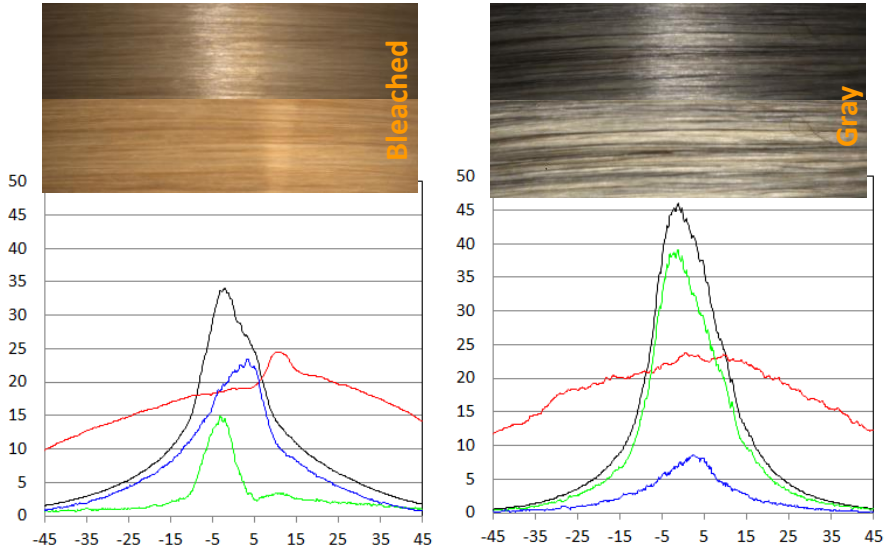




Calculation of lustre parameters such as Reich-Robbins, TRI, Bossa Nova Tech

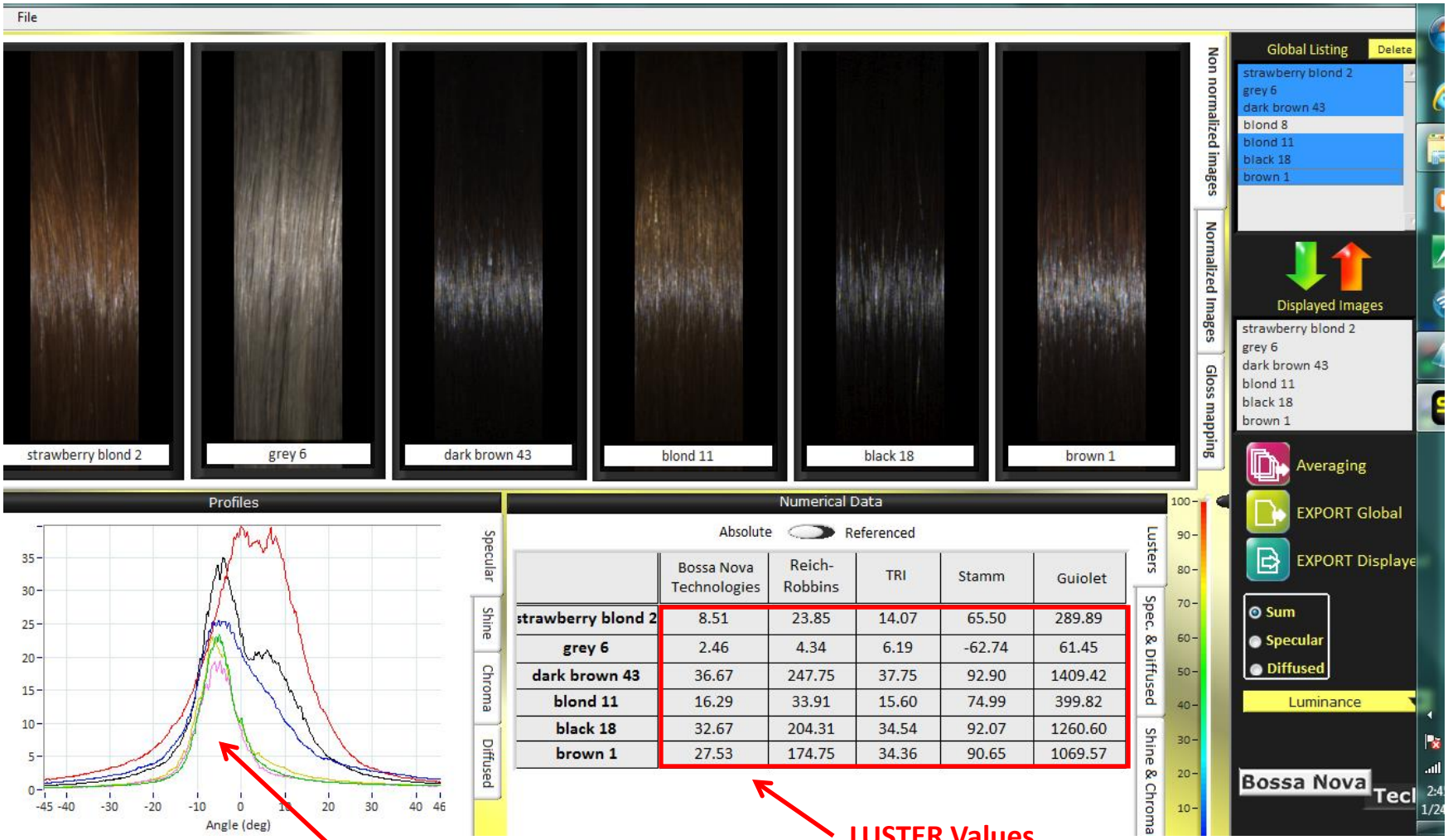
Examples on different hair colors





- On untreated healthy hair, the shine (surface reflection) is comparable for all samples
- As the hair becomes brighter, the chroma (internal reflection) increases as well as the diffused light
- Chroma and diffused (carrying color information) play an important part on the visual appearance

Software Interface (Comparison Window)



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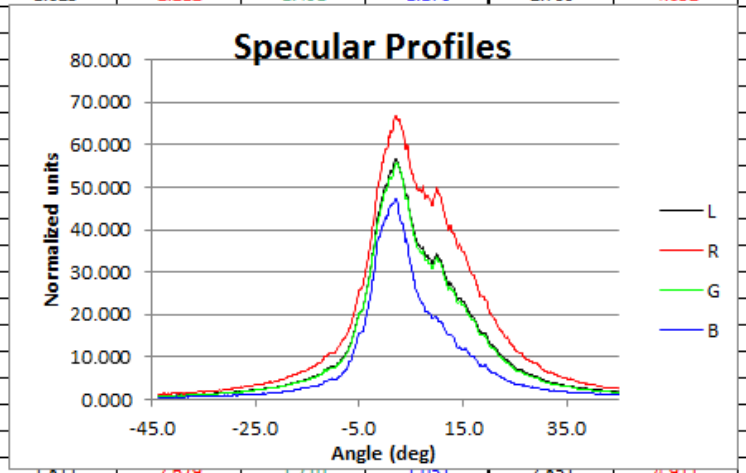
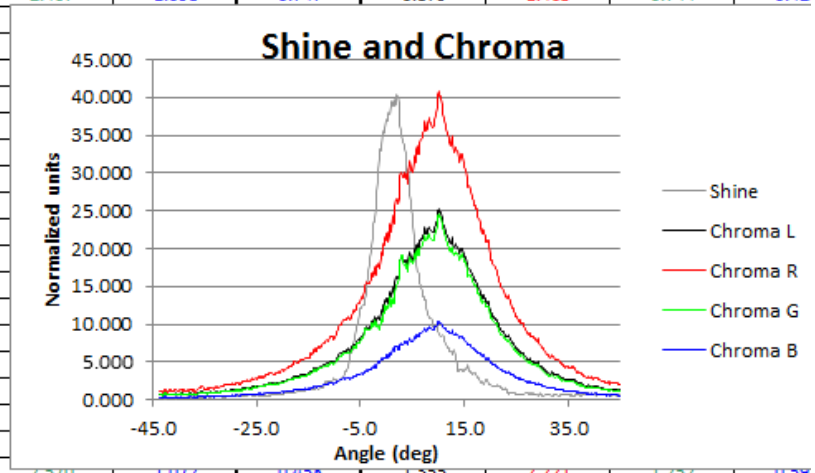
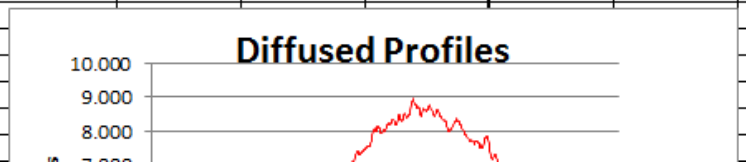
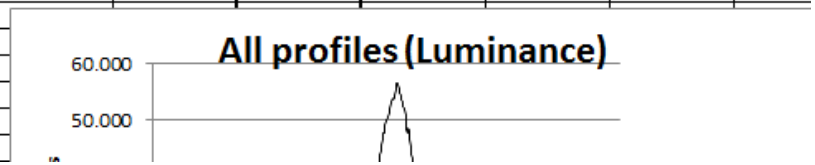
Export to MS Excel

	Specular				Diffused				Shine	Chroma			
Angle	L	R	G	B	L	R	G	B	L	L	R	G	B
47.0	1.625	2.212	1.491	1.176	2.739	4.652	2.467	1.098	0.747	0.879	1.465	0.744	0.42
46.9													
46.8													
46.6													
46.5													
46.4													
46.2													
46.1													
46.0													
45.8													
45.7													
45.5													
45.4													
45.3													
45.1													
45.0													
44.9													
44.7													
44.6	1.811	2.679	1.710	1.051	2.851	4.911	2.570	1.072	0.458	1.355	2.221	1.252	0.59
44.5													
44.3													
44.2													
44.1													
43.9													
43.8													









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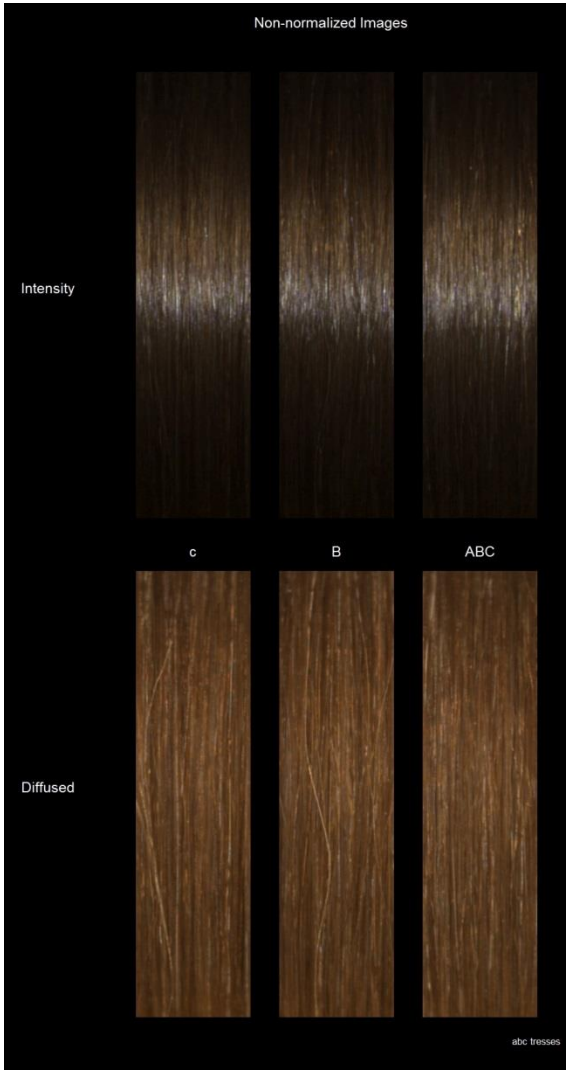
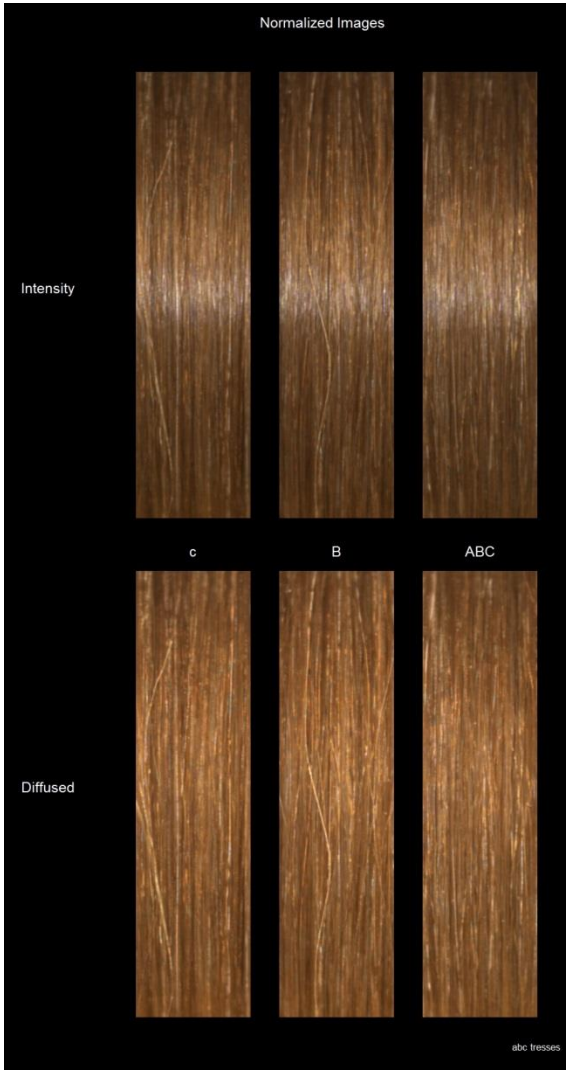
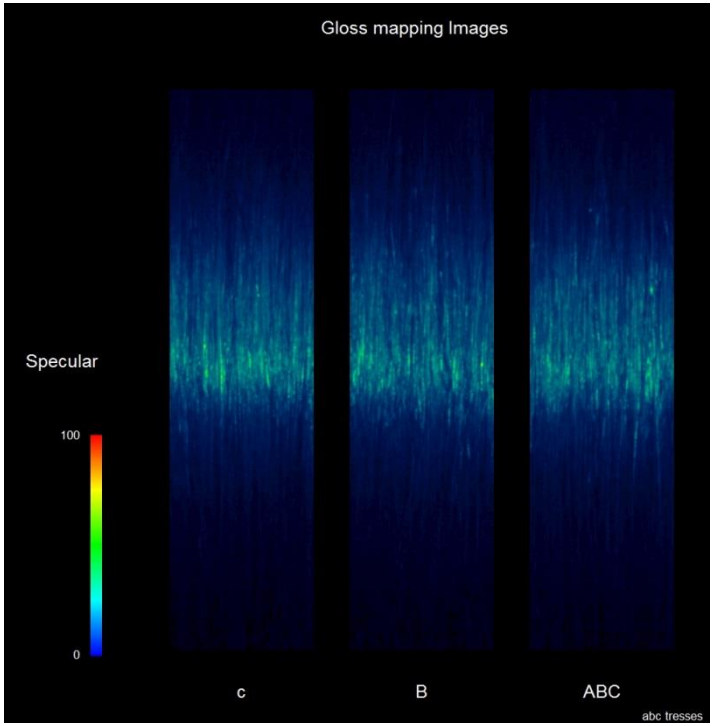
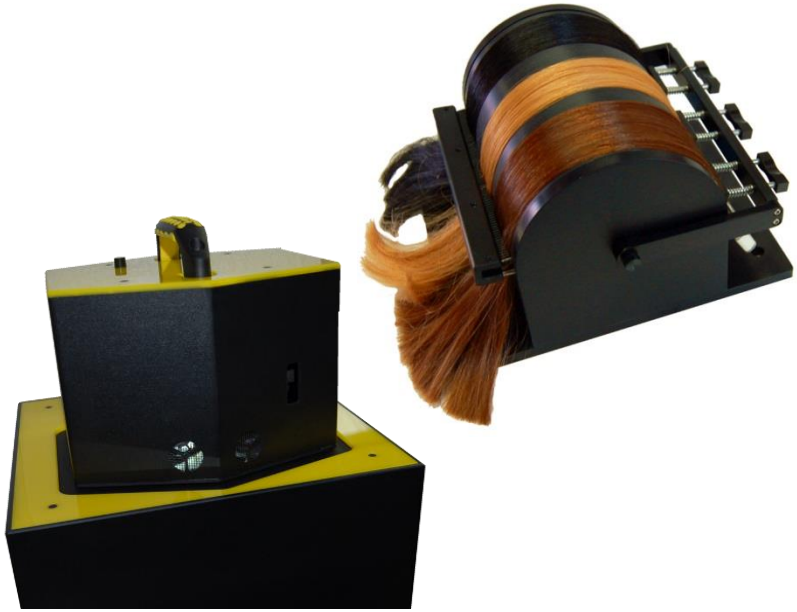
Export images for reports/presentations







In-vitro and in-vivo measurements



IN VITRO:

Sensor is on the laboratory setup.

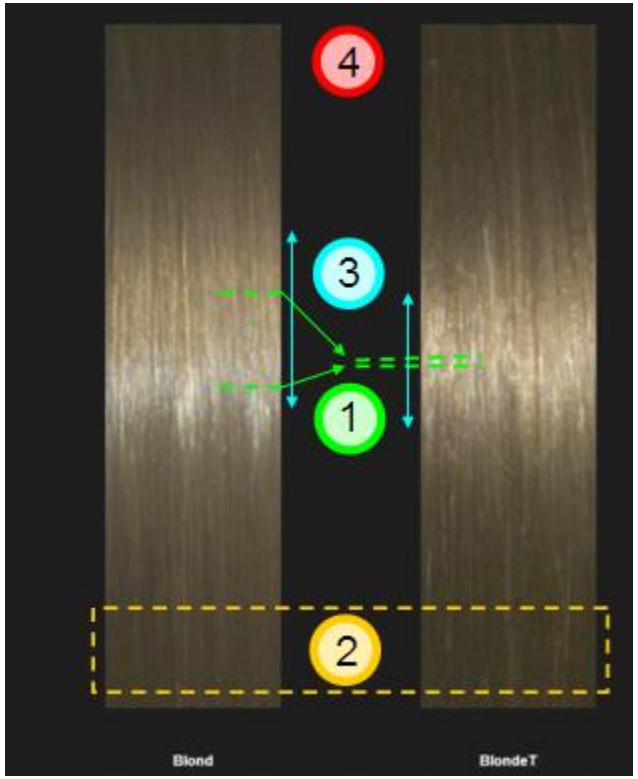
Measurements are made on hair tresses mounted on a cylinder

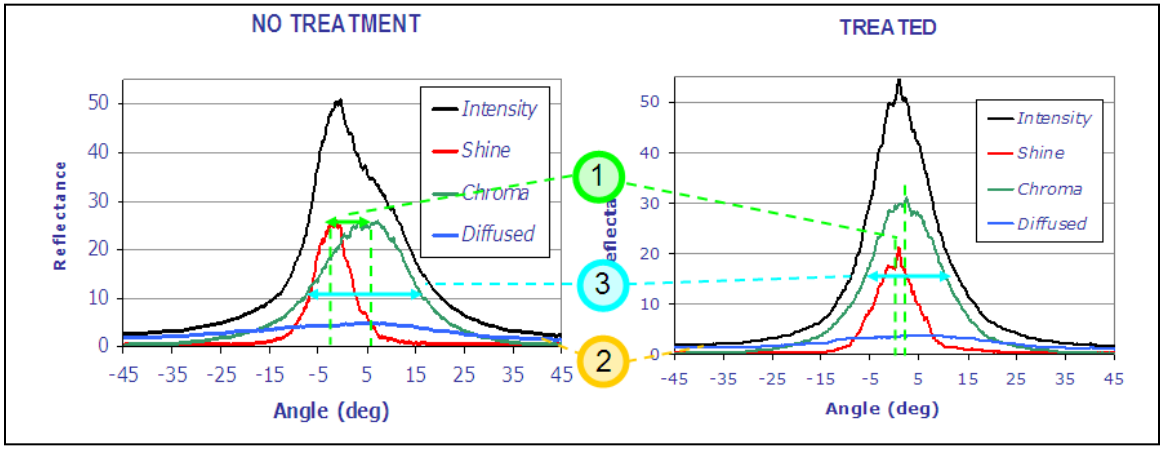
IN VIVO:

Sensor is held by the user.

Measurements are made on a consumer's head thanks to a mini-cylinder attachment

Example – Study of a hair treatment





Observations:

On the non-treated hair:

- **the first and second reflections are well separated**
- **The first reflection is shifted towards the negative angles. This is due to the cuticle of hair.**

On the treated hair:

- **The first and second reflections now overlap.**
- **The first and second reflections are now centered on the zero angle position. The treatment filled the cuticle and the hair surface is now smooth.**
- **The shine slightly widened**
- **The Chroma width decreased significantly and the maximum increased. The integral did not change much.**
- **The hair appears darker. The diffused light decreased.**

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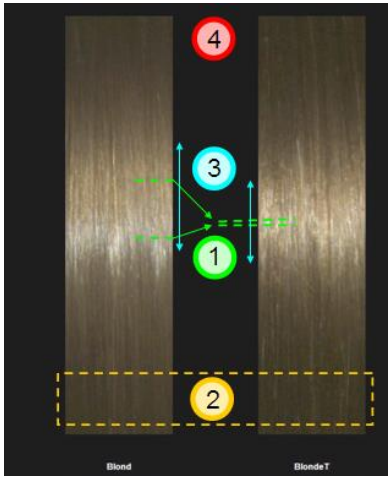
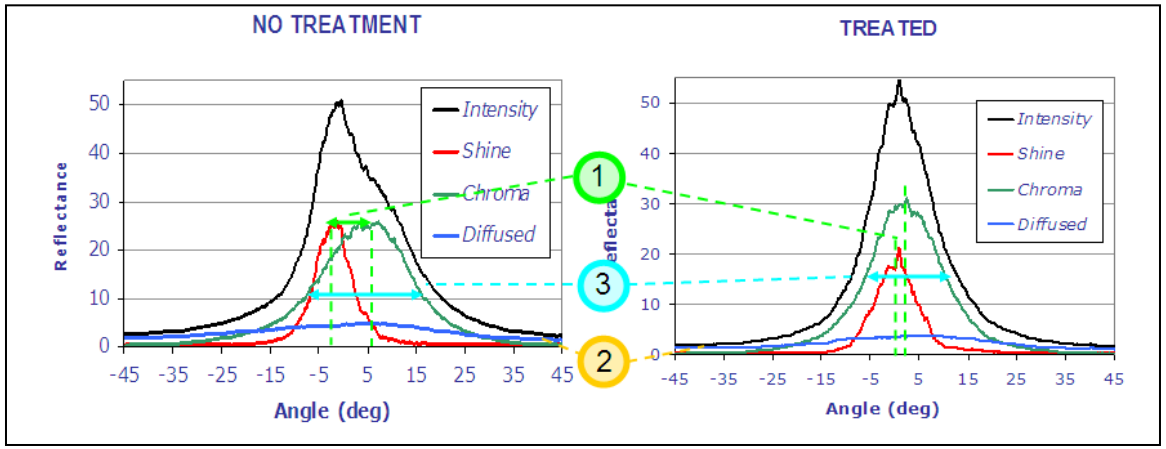
Example – Study of a hair treatment





	Lusters			Specular		Diffused	Shine				Chroma					
	Reich-Robbins $S/D.\beta_0$	TRI $S/(S+D).\beta_{ref}/\beta_0$	Bossa Nova Technologies	W_{visual} (deg)	Integral	Integral	$W_{1/2}$	Max	Integral	Shift to 0° (deg)	$W_{1/2}$	Max	Integral	Shift to 0° (deg)	$\Delta_{/Shine}$ (deg)	Overlaping (%)
No treatment	31.74	11.70	12.03	14.02	942	275	8.3	26	272.2	-1.3	21	25.7	631.2	7.3	8.7	70.4
With treatment	49.46	15.70	17.33	12.26	847	205	8.3	21.2	216.6	0.9	16.4	31	601.1	2.5	1.6	92.1
Variations (%, deg)	+56%	+34%	+44%	-13%	-10%	-25%	+0%	-18%	-20%	+2.2deg	-22%	+21%	-5%	-4.8deg	-82%	+31%

Luster is increased (4)

The amount and width of specular light are reduced

The diffused light is even more reduced (2)

The amount of shine is decrease and the shine band is shifted

(3) (1)

The width of the chroma band is reduced, it is shifted and overlapped with the shine band

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SAMBA HAIR SYSTEM
Conclusions

- SAMBA Hair is a robust, turn-key system for Shine, Chroma, Diffuse and Luster quantification
- SAMBA allows for in-vitro and in-vivo type of measurement
- Data management, comparison and export is very easy thanks to a user friendly software

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Thank you!