

MAMBO

Hair Color Analysis

User Manual 1.40



**BOSSA NOVA
VISION**

About This Manual

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

About MAMBO: MAMBO is a turnkey hair color analysis instrument. Thank to our proprietary color calibration, MAMBO delivers Lab values to analyze the hair swatch color. MAMBO allows to compare the hair swatch color to various database and identify the closest color database element. MAMBO can also be used to create custom database.

Applications of MAMBO range from simple hair color measurement to hair color repair product efficiency analysis and color fading measurement.

Copyright and Manual Notice

Bossa Nova Vision reserves the right to make changes to this manual and to the items described therein without notice. Bossa Nova Vision has taken considerable effort to ensure that the information in this manual is accurate and complete. However, Bossa Nova Vision will not be liable for any technical or editorial errors or omissions made herein or for incidental, special or consequential damages of any nature resulting from the furnishing of this manual, or operation and performance of equipment in connection with this manual.

CONTENTS

1. QUICK START	4
1.1. Unpacking.....	4
1.2. MAMBO HARDWARE	4
2. MAMBO SOFTWARE	6
2.1. Startup.....	6
2.1.1. Hardware test for LIVE MEASUREMENT & LOAD DATA	7
2.2. MAIN WINDOW architecture.....	10
2.3. IMAGE VISUALIZATION	10
2.4. DATA MANAGEMENT	12
2.4.1. CREATE	14
2.4.2. DELETE	14
2.4.3. RENAME	15
2.4.4. COPY.....	15
2.4.5. MOVE	16
2.5. ACTION CONTROLS	18
2.5.1. ACQUIRE NEW MEASUREMENT	18
2.5.2. COLOR FADING STUDY.....	19
2.5.3. COLOR ANALYSIS.....	19
2.5.4. GREY HAIR ANALYSIS	19
2.5.5. DATABASE MANAGEMENT	19
2.5.6. DATABASE COMPARISON	19
2.5.7. COLOR CHECKER CALIBRATION	19
2.5.8. MAMBO CALIBRATION	19
3. ACQUIRE NEW MEASUREMENT.....	20
4. COLOR FADING STUDY.....	24
5. COLOR ANALYSIS	36
6. GREY HAIR ANALYSIS	42
7. DATABASE MANAGEMENT	43
8. DATABASE COMPARISON	45
9. COLOR CHECKER CALIBRATION.....	48
10. MAMBO CALIBRATION	52
10.1.WHITE BALANCE	53
10.2.BLACK LEVEL	54
10.3.Xstart Zstart.....	56
10.4.EXPOSURE	56

10.5.FLAT.....	57
11. Data format	59
12. Technical Background.....	60
13. Technical Specifications.....	61

1. QUICK START

1.1. Unpacking

When unpacking MAMBO, please make sure you have all the following items (Figure 1),



Figure 1: MAMBO components

1.2. MAMBO HARDWARE

MAMBO hardware is composed of (Figure 3):

- A sensor named MAMBO

MAMBO - User Manual

- A power supply to power the LED illumination
- A USB 3.0 cable to connect MAMBO to the computer



Figure 2: MAMBO Hardware

2. MAMBO SOFTWARE

MAMBO software allows to:

- Acquire data
- Process data
- Visualize data
- Manage data

2.1. Startup



Once the user clicks on the MAMBO software icon, a window appears (Figure 3).



Figure 3: SIRTAKI software window

At startup (shown on Figure 4 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.

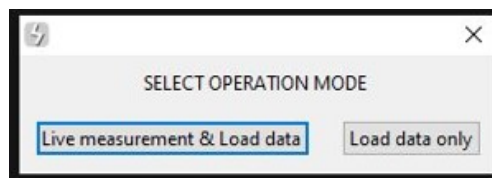


Figure 4: Start-up pop-up window

- 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, process and visualize existing data.
- Choosing **Live measurement & load data** leads to an automated test procedure that insures all hardware components (Camera and LED panel) are working properly to the factory specifications. Another pop-up window appears, allowing the user to by-pass the illumination test (Figure 5). Only the camera connection will be tested.

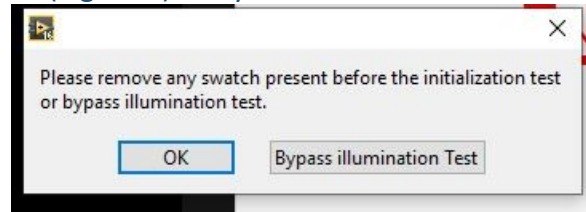


Figure 5: Illumination test by-pass pop-up window

This option can be used if the user already did the test before, as the self-test is faster. However, we strongly recommend to proceed to the illumination self-test at least once a day or each time the LED has just being switched ON.

2.1.1. Hardware test for LIVE MEASUREMENT & LOAD DATA

When the user selects **OK** for a full test, sequential steps are done (Bypassing illumination test will validate the illumination level without checking it i.e. no STEP 2):

- STEP 1 - CAMERA initialization and test
- STEP 2 - ILLUMINATION test (measurement of LED level)

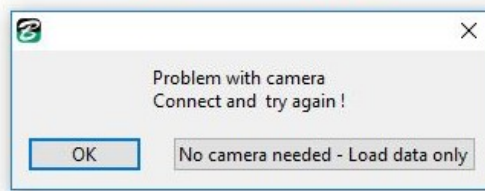
If the two steps are successful, image acquisition will be possible. If nothing is activated, the user will only be able to load data.

STEP 1 – CAMERA initialization and test is on (Figure 6).



Figure 6: STEP 1 - CAMERA initialization and test

Figure 7 shows the dialog window if there is an issue with the camera.



(a)

(b)

Figure 7: Dialog window if there is an issue with the motor

MAMBO - User Manual

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 MAMBO main window.

If after few tries, the camera is not correctly initialized, please contact Bossa Nova Vision.

The software proceeds to STEP 2 for a measurement of the LED level and the LED uniformity. Be sure no swatch is present when this step is running and that MAMBO is placed on the WHITE tile of the color checker (Figure 8).

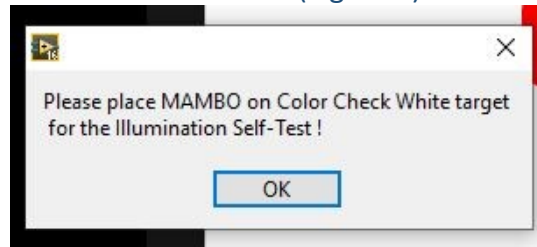


Figure 8: illumination level check – Pop-up message

Once the user place MAMBO on the WHITE tile of the color checker and then click ok, the illumination test starts (Figure 9).



Figure 9: STEP 2 - Illumination test (measurement of background level and uniformity)

Figure 10 shows the dialog window if there is an issue with the illumination.



Figure 10: Dialog window if there is an issue with the illumination

Level is out of range. If after a few tries, the illumination is not correctly initialized, please contact Bossa Nova Vision. If STEP 2 is successful, a dialog window appears (Figure 11) 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.

MAMBO - User Manual

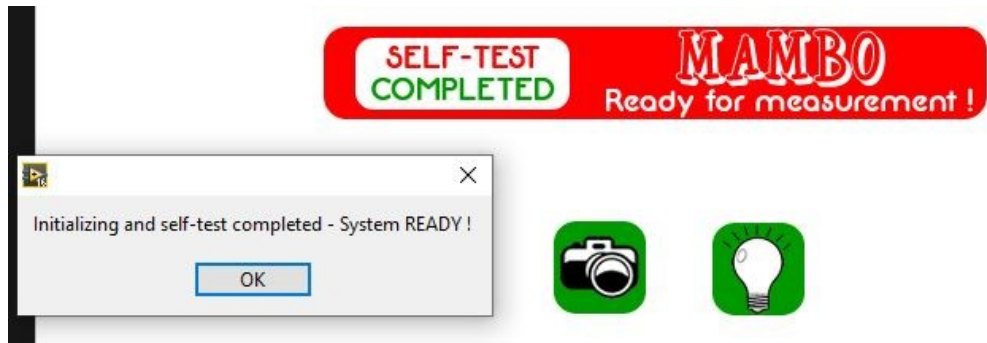


Figure 11: Dialog window – Initialization and self-test successful

2.2. MAIN WINDOW architecture

The main window is presented on Figure 12.

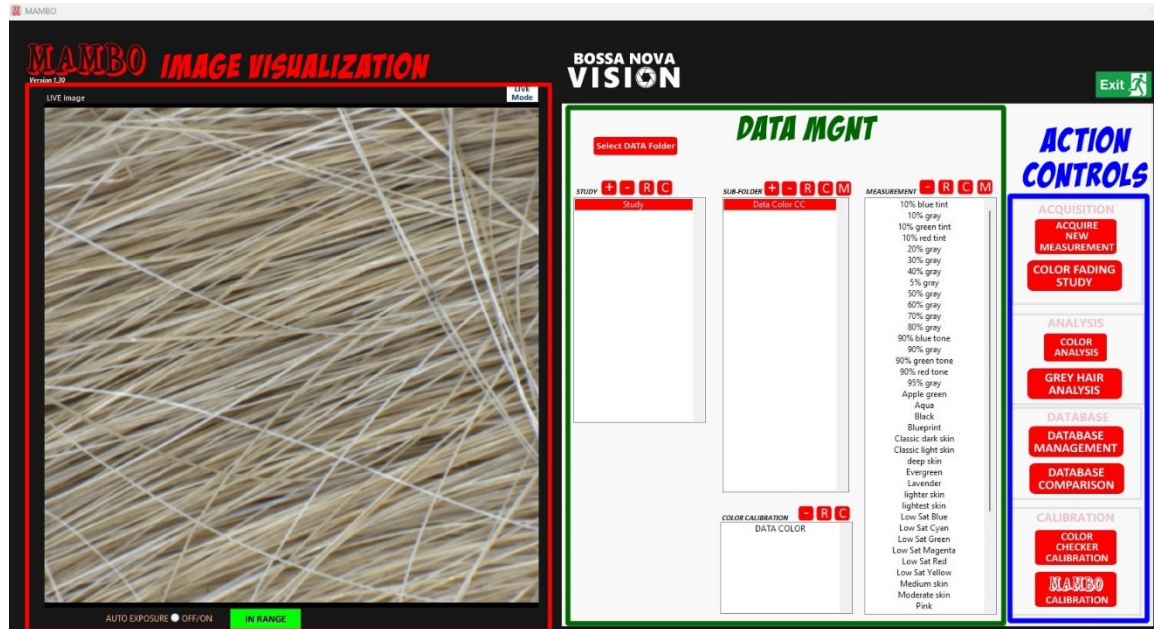
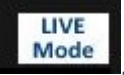


Figure 12: MAMBO – Main window architecture

On the left of the window is the **IMAGE VISUALIZATION**. 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, visualize measurements, process measurements and calibrate MAMBO.

On the top right of the window, at the top is the **EXIT SOFTWARE** control  to exit the software.

2.3. IMAGE VISUALIZATION

The left side of the main window consists of the image visualization (Figure 13) showing a live image, at the bottom, an Auto-exposure button  and an In Range indicator  and on top of the image, a control/indicator Live or Load mode .

MAMBO - User Manual

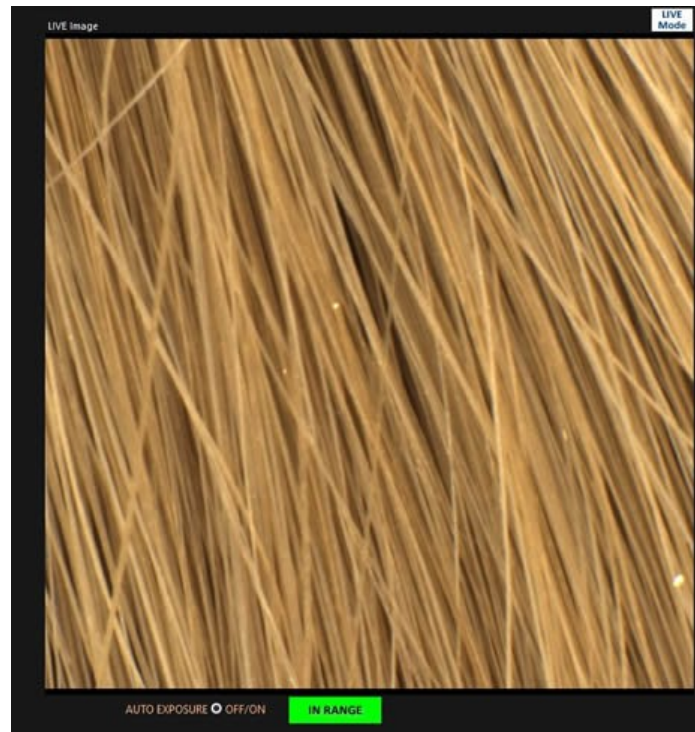
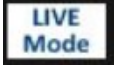


Figure 13: Image visualization

When **Live measurement & load data** is selected , the image shows (Figure 14) the live output of MAMBO.

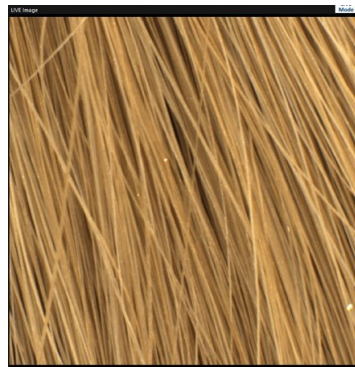


Figure 14: Live measurement & load data - Image

If **Load data only** is selected , the image shows (Figure 15) a *MAMBO– no live measurement – Open data only image*.

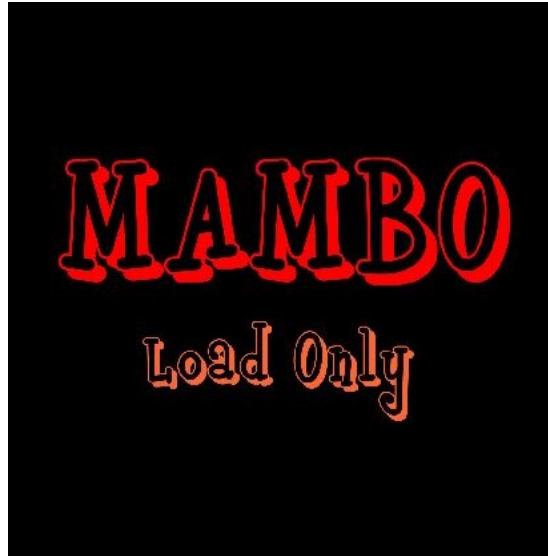


Figure 15: Load data only - Image

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 16) asking the user to choose the operation mode similar to the start of the software.

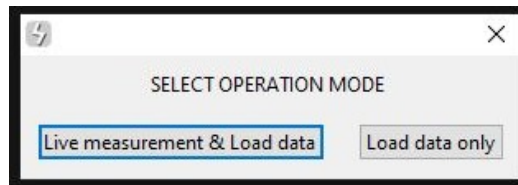


Figure 16: Live or load pop-up window

Choosing **Live measurement & load data** will trigger the hardware check-up procedure previously explained.

2.4. DATA MANAGEMENT

Data Management window allows to manage the data to be saved and processed (Figure 17). The user can create, delete, copy, rename, etc. different folders and measurements.

MAMBO - User Manual

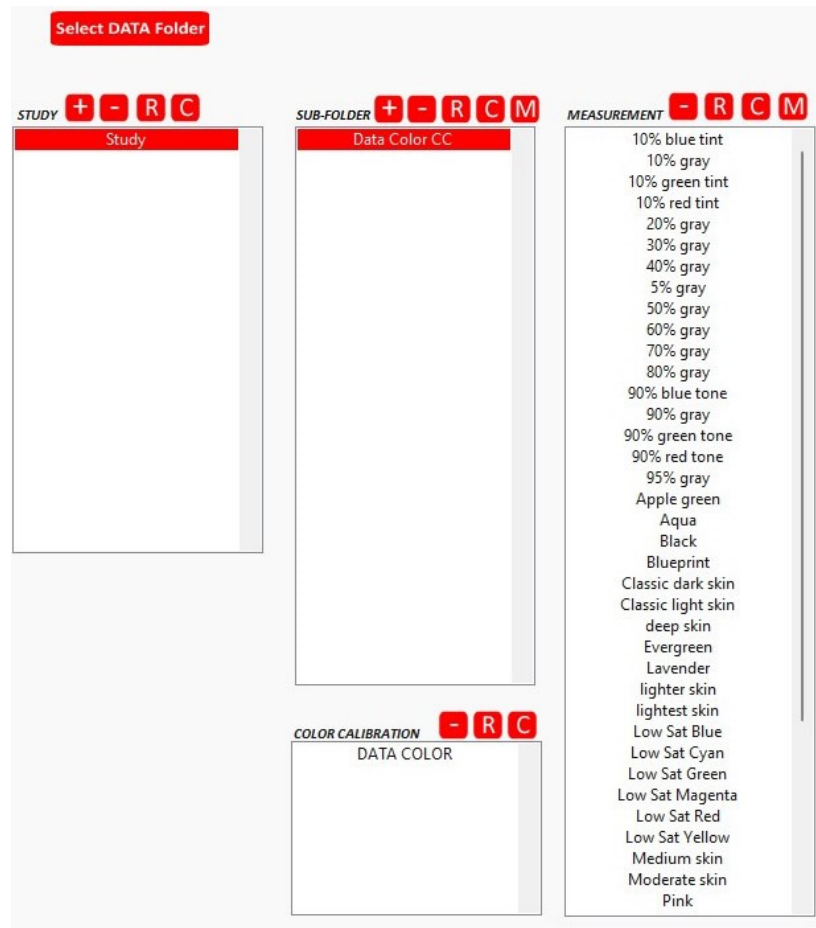


Figure 17: Data Management window

4 lists are present:

- Study
- Sub-folder
- Measurements
- Color Calibration

These correspond to list of folders where the raw data are saved

On top of each list are controls: **+ - R C M**

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

The R control **R** allows to RENAME a folder.

The C control **C** allows to COPY a folder.

The M control **M** allows to MOVE a folder.

2.4.1. 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 18).

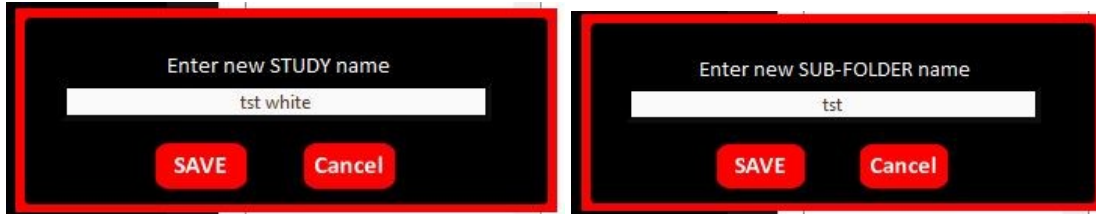


Figure 18: New study or new sub-folder name

Clicking on the cancel control  will cancel the creation of the new study or sub-folder and close the pop-up window.

2.4.2. 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 19).

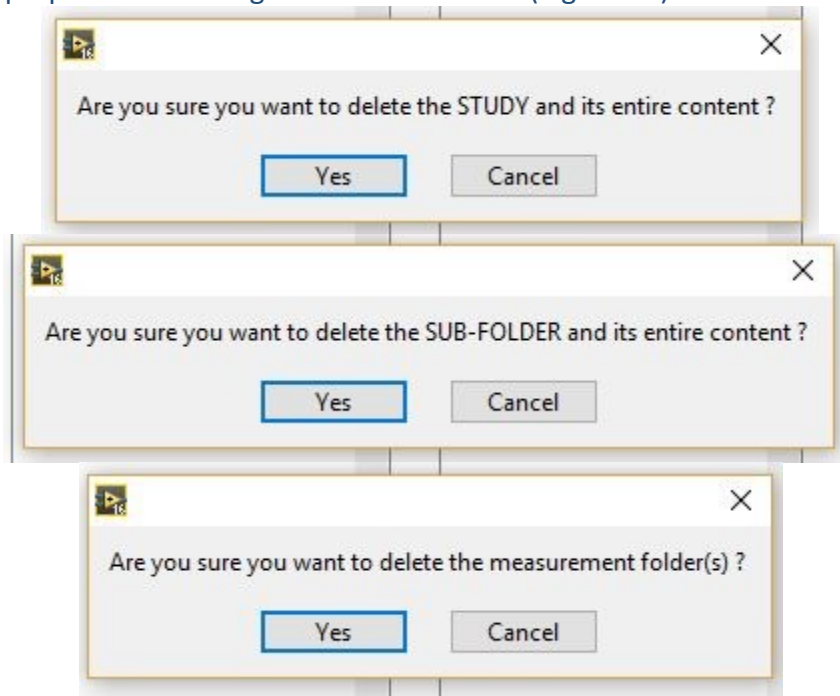


Figure 19: Pop-up window for deleting Study, Sub-folder or measurement

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.

2.4.3. RENAME

The user can rename a study, a sub-folder or a measurement. Clicking on the R control

R triggers a pop-up window (Figure 20) to enter the new name.

The figure shows three separate pop-up windows, each with a black background and a red border. The first window is titled 'Enter new STUDY name' and contains a text input field with 'tst white' and two red buttons labeled 'SAVE' and 'Cancel'. The second window is titled 'Enter new SUB-FOLDER name' and contains a text input field with 'tst' and the same 'SAVE' and 'Cancel' buttons. The third window is titled 'Enter new Measurement name' and contains a text input field with 'blue' and the same 'SAVE' and 'Cancel' buttons. The windows are arranged vertically with the word 'or' centered between each one.

Figure 20: pop-up window for renaming study, sub-folder or measurement

Clicking on the cancel control **Cancel** will cancel the renaming of the study, sub-folder or measurement and close the pop-up window.

2.4.4. 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 **C** triggers a pop-up window to enter the name of the copy (Figure 21). Note that the original remains the same.

The figure shows a single pop-up window with a black background and a red border. It is titled 'Enter Copy Study Name' and contains a text input field with 'blue' and two red buttons labeled 'SAVE' and 'Cancel'. Below the window, the word 'or' is centered.

MAMBO - User Manual

Enter Copy Sub-folder name

blue

SAVE Cancel

Or

Enter Copy Measurement name

bluesdf ds2

SAVE Cancel

Figure 21: 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.

2.4.5. 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 22).

SELECT the destination STUDY

STUDY

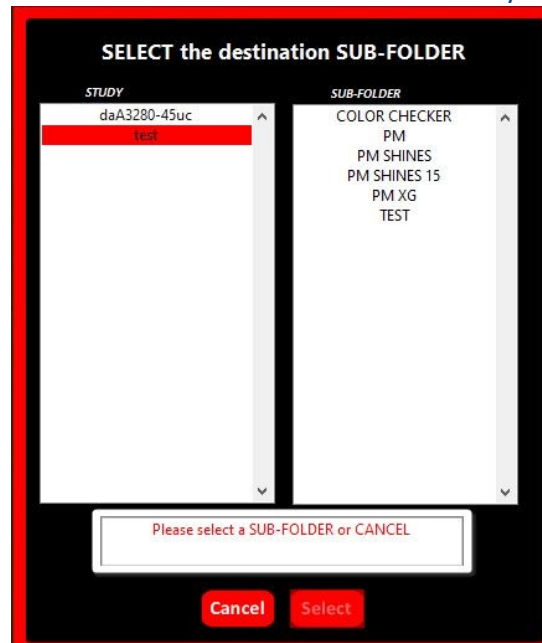
daA3280-45uc

test

Cancel Select

MAMBO - User Manual

Move sub-folder to a different study



Move Measurement(s) to a different sub-folder

Figure 22: 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 23).

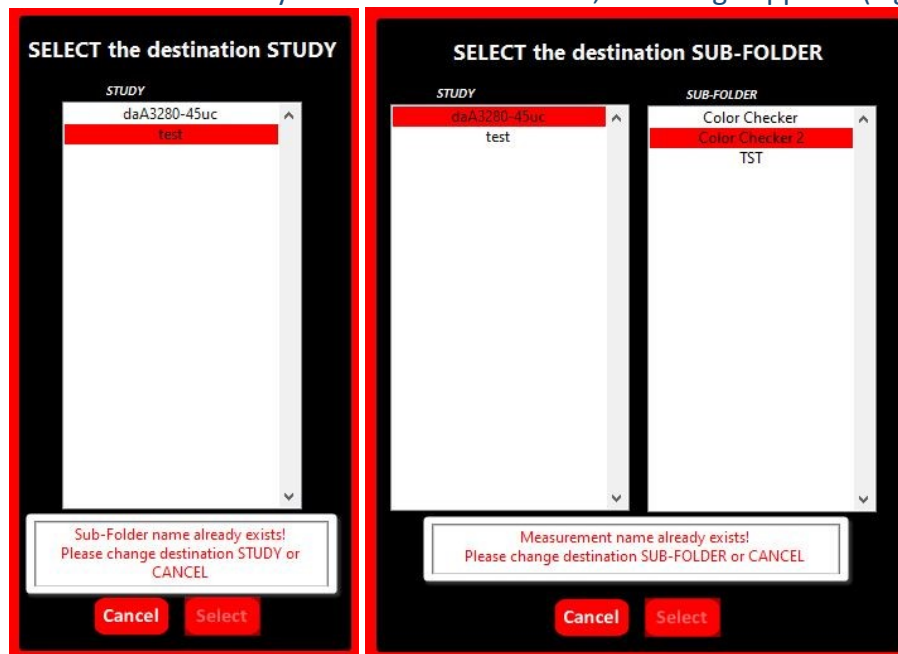


Figure 23: Sub-folder or measurements already present

2.5. ACTION CONTROLS

Action controls (Figure 24) allow to:

- acquire new data
- acquire data and manage color fading study
- analyze the color of data
- visualize data
- manage and compare database
- color calibrate the system
- calibrate MAMBO camera



Figure 24: Action controls

2.5.1. ACQUIRE NEW MEASUREMENT



Acquire New Measurement control allows to acquire new image.

2.5.2. COLOR FADING STUDY



The color fading study control allows to acquire color fading data, visualize and analyze the results by opening a color fading study window.

2.5.3. COLOR ANALYSIS



The analysis control allows the user to analyze the color of the selected measurement by opening the analysis window.

2.5.4. GREY HAIR ANALYSIS



The grey analysis control allows the measurement of grey hair % on dark hair.

2.5.5. DATABASE MANAGEMENT



The DATABASE MANAGEMENT control allows the user to manage the color database.

2.5.6. DATABASE COMPARISON



The DATABASE COMPARISON control allows the user to compare two color database.

2.5.7. COLOR CHECKER CALIBRATION



The manual processing control allows the user to manually process the data of the selected measurement by opening the Manual processing window.

2.5.8. MAMBO CALIBRATION



The manual processing control allows the user to manually process the data of the selected measurement by opening the Manual processing window.

3. ACQUIRE NEW MEASUREMENT

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 control is not visible.

Clicking on **Acquire new measurement** control  will start the measurement process. However, if no study or sub-folder is selected, the new measurement cannot be done and a pop-up window appears (Figure 25).

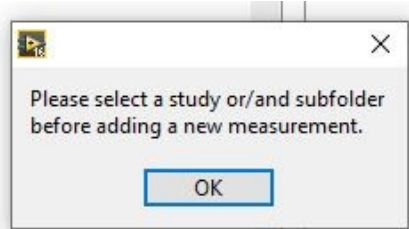


Figure 25: Pop-up window asking for a study/sub-folder selection before adding a new measurement

When the study/sub-folder selection is correct, a new measurement can be done. A pop-up message appears if the exposure is not optimized (Figure 26).

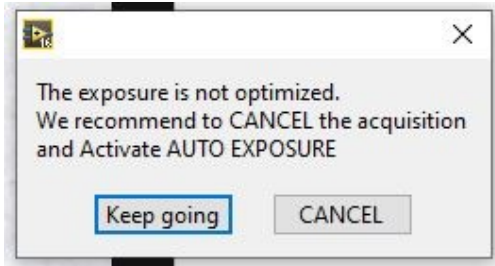


Figure 26: New measurement window

The user can still acquire the image but we strongly recommend to proceed to the auto-exposure before the data acquisition. Under the live image is the AUTO-EXPOSURE control and the IN RANGE indicator (Figure 27).

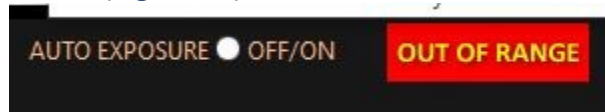


Figure 27: Auto-exposure control and In-Range indicator

MAMBO - User Manual

The user can click on AUTO EXPOSURE to optimize the exposure time of the camera. The AUTO-EXPOSURE is ON (Figure 28).

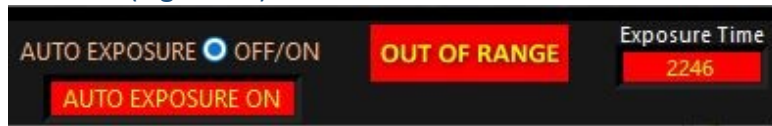


Figure 28: AUTO-EXPOSURE ON

When the exposure time is optimized, the indicator shows IN RANGE (Figure 29).

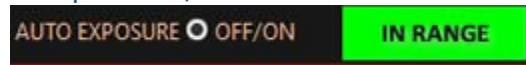


Figure 29: IN RANGE

The acquisition is then possible. After clicking on acquire new measurement, the pop-up window appears asking for the name of the measurement to be saved (Figure 30).



Figure 30: Pop-up window – Measurement name

Once the measurement name is entered, the user click on save (or cancel to cancel the measurement). The acquisition is on. On the left of the image is the indicator of the status of the acquisition with a progression bar at the bottom and a message (Figure 31).

White : DATA/IMAGE ACQUISITION



Figure 31: Acquisition status

Once the acquisition is done, the new measurement appears in the measurement list. If the user click on it, a preview image appears under the study list on the right of the color calibration list (Figure 32).

MAMBO - User Manual

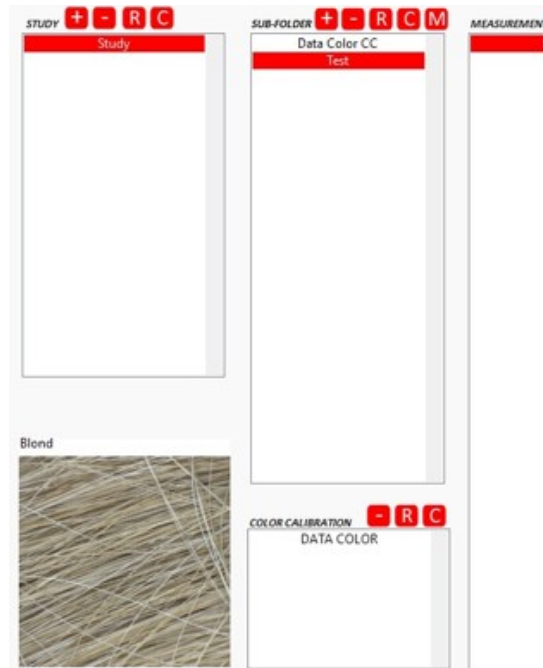


Figure 32: Measurement preview window

4. COLOR FADING STUDY

When the user clicks on color fading study, a new windows appears (Figure 33).

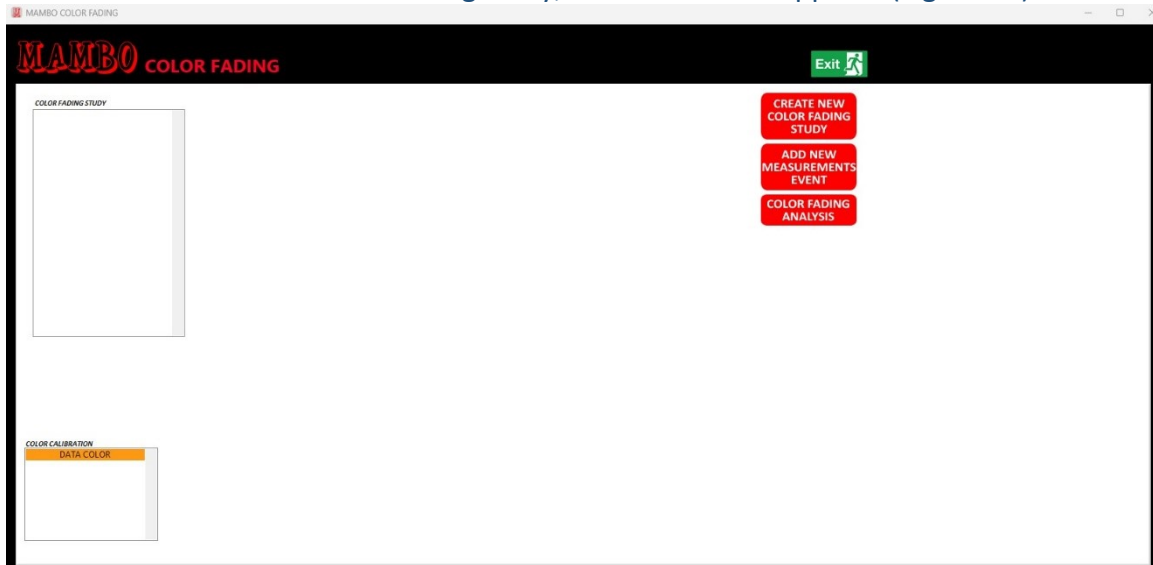


Figure 33: Color Fading Window

On the right is the list of the Color Fading Studies, below is the Calibration list (Figure 34).

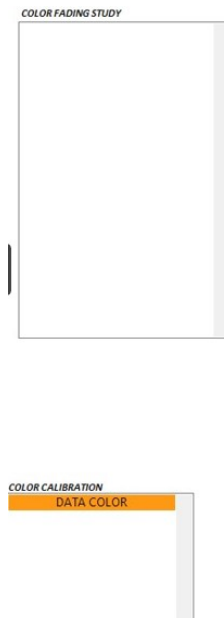


Figure 34: Color Fading Studies (Calibration)

On the right of the window are the action controls (Figure 35).

MAMBO - User Manual



Figure 35: Action controls

The actions controls allow to create a new color fading study, add new measurements event and provide a Color Fading analysis. In case of load only, the Add new measurements event control will be deactivated (Figure 36).



Figure 36: Load only – Add new measurements deactivated

The software automatically detects if there are Color Fading studies in the study list. In the case above, no color fading studies have been detected. The user can create a new Color Fading study by click on the Create new color fading study button. A window appears (Figure 37).

Figure 37: Create new color fading study window

MAMBO - User Manual

The user can define the color study name, the number of products evaluated (placebo included) and their respective name, the number of swatches per products and the naming of the swatches if needed (If not, the swatches are automatically named Swatch #n, n varying between 1 and #_of_products x #_of_swatches). Once the parameters are set, clicking on save returns to the main window where the color study and products list are now populated.

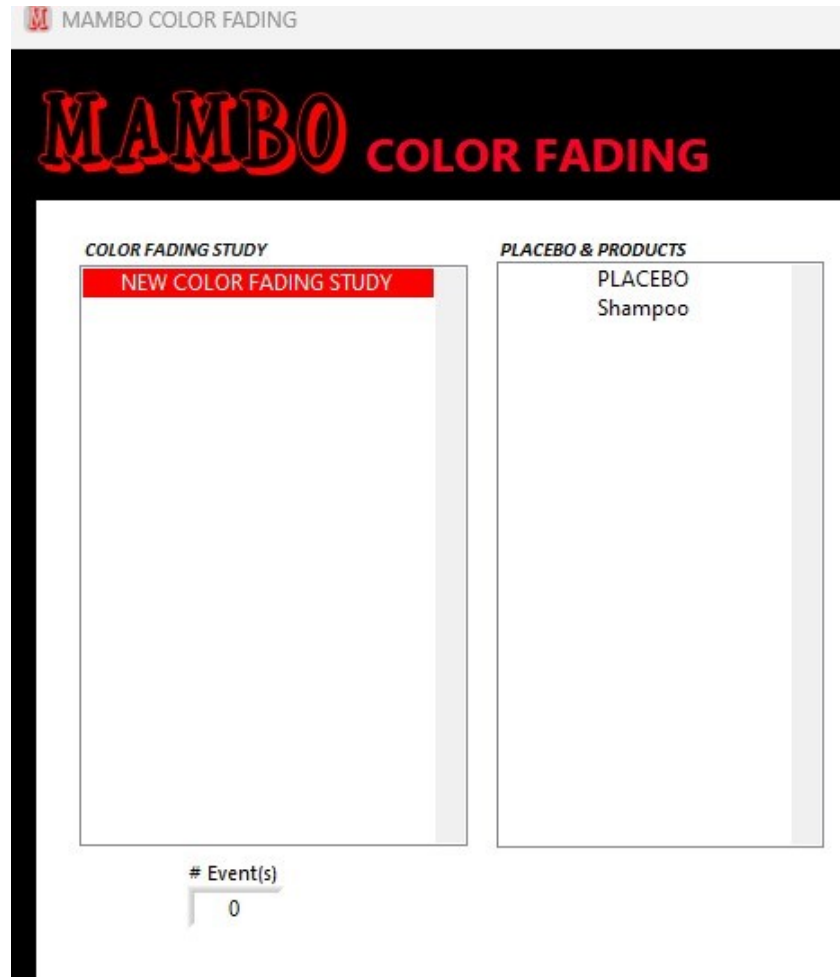


Figure 38: Color Fading main window – List populated

No measurements have been added yet, so # of events is zero. This study will also appear in the Study list on MAMBO main window. Next step is to add the first measurements, i.e. the base of the study. To do so, the user clicks on Add new measurement event. A pop-up message appears (Figure 39).

MAMBO - User Manual

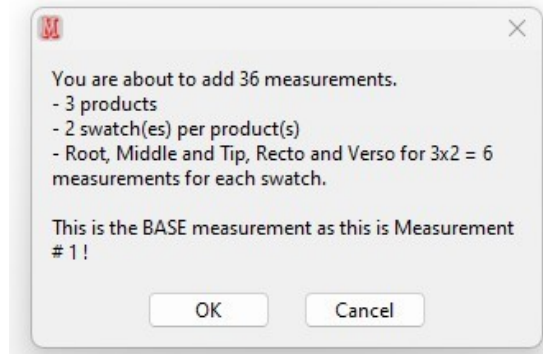


Figure 39: Pop-up message

Once the user clicks on OK, the color fading acquisition window appears (Figure 40).

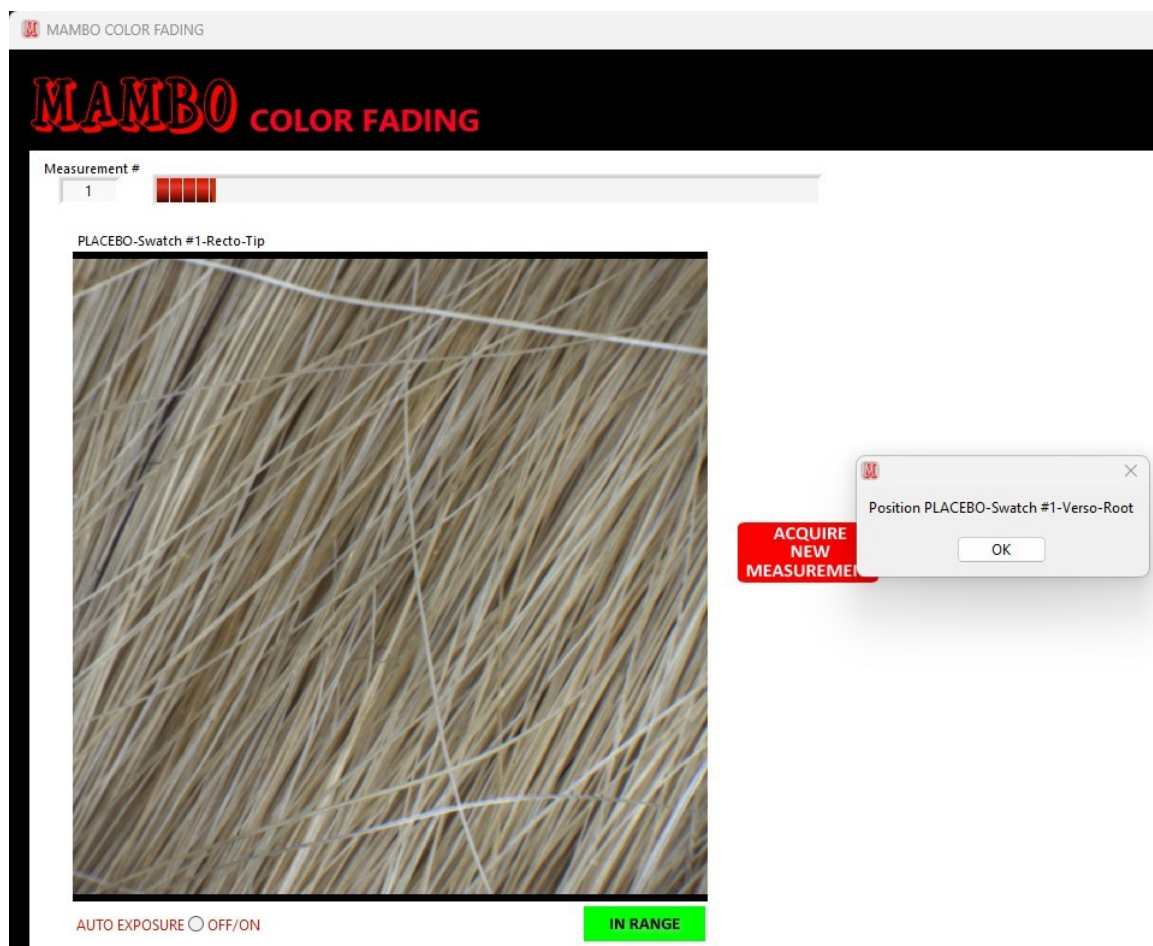


Figure 40: COLOR FADING Acquisition window

On the left is the live image. Below the live image are the AUTO EXPOSURE control and the IN RANGE indicator. If the IN RANGE indicator is RED (Out of range), the user needs to click on AUTO EXPOSURE before acquiring the data. Once the IN RANGE indicator is green, the user can click on ACQUIRE NEW MEASUREMENT to acquire the data. This can be also achieved by clicking on F1.

Note that before the acquisition of the data, a pop-up message appears (Figure 41), indicating which image (Product ,swatch, position and side) is to be acquired.



Figure 41: Pop-up message – Image

On top of the image is the measurement # indicator and the progress bar for the acquisition of the images. The number of data acquired is equal to: #products x #swatches x 2 (recto/verso) x 3 (root/middle/tip). Each measurement folder is named automatically with the following syntax: Swatch_name-side-position-measurement#.

Once all the data are acquired, a pop-up message appears (Figure 42) indicating the completion of the measurement.

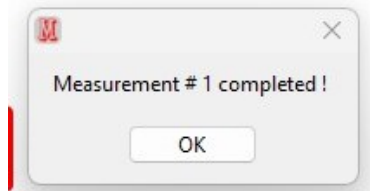


Figure 42: Pop-up message = Measurement completed

Clicking on OK takes the user to the Color Fading main window (Figure 43) where the Measurement list is now populated with the data

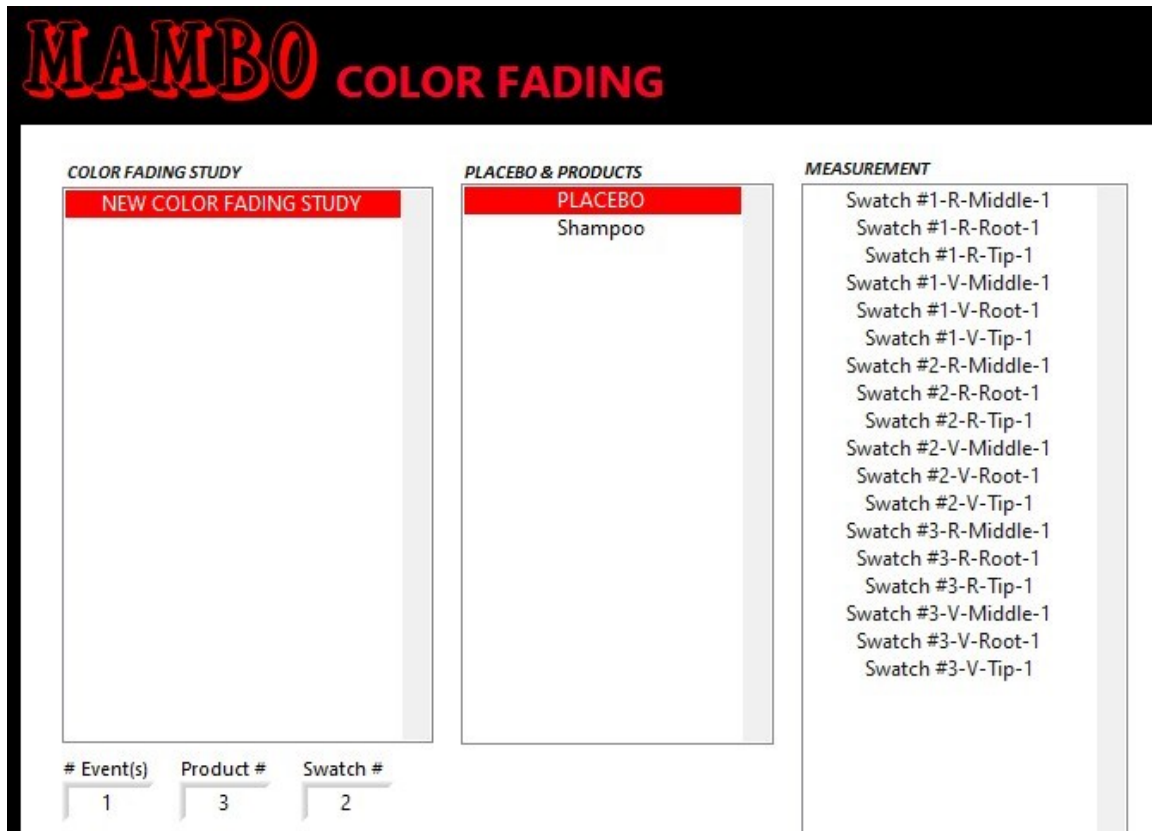


Figure 43: Color Fading main window – List populated

In that particular case above, we have 2 products, PLACEBO and Shampoo with 3 swatches each. Each products are saved as sub-folders, both containing 3 swatches x 2 sides x 3 positions = 18 measurement folders named swatch_name-side-position-measurement#. The event # is now equal to 1. Event #1 is the base.

Once the user has repeated the measurement series (event) few times as show on Figure 44,

MAMBO - User Manual

MAMBO COLOR FADING

MAMBO COLOR FADING

COLOR FADING STUDY

NEW COLOR FADING STUDY

# Event(s)	Product #	Swatch #
3	3	2

PLACEBO & PRODUCTS

PLACEBO

Shampoo

MEASUREMENT

Swatch #4-R-Middle-1
Swatch #4-R-Middle-2
Swatch #4-R-Middle-3
Swatch #4-R-Root-1
Swatch #4-R-Root-2
Swatch #4-R-Root-3
Swatch #4-R-Tip-1
Swatch #4-R-Tip-2
Swatch #4-R-Tip-3
Swatch #4-V-Middle-1
Swatch #4-V-Middle-2
Swatch #4-V-Middle-3
Swatch #4-V-Root-1
Swatch #4-V-Root-2
Swatch #4-V-Root-3
Swatch #4-V-Tip-1
Swatch #4-V-Tip-2
Swatch #4-V-Tip-3
Swatch #5-R-Middle-1
Swatch #5-R-Middle-2
Swatch #5-R-Middle-3
Swatch #5-R-Root-1
Swatch #5-R-Root-2
Swatch #5-R-Root-3
Swatch #5-R-Tip-1
Swatch #5-R-Tip-2
Swatch #5-R-Tip-3
Swatch #5-V-Middle-1
Swatch #5-V-Middle-2
Swatch #5-V-Middle-3
Swatch #5-V-Root-1
Swatch #5-V-Root-2
Swatch #5-V-Root-3
Swatch #5-V-Tip-1
Swatch #5-V-Tip-2
Swatch #5-V-Tip-3
Swatch #6-R-Middle-1
Swatch #6-R-Middle-2

COLOR CALIBRATION

DATA COLOR

Figure 44: 3 events

it is time to analyze the data by clicking on

**COLOR FADING
ANALYSIS**

opens the COLOR FADING ANALYSIS window (Figure 45).



Figure 45: Color Fading Analysis window

On the left of the Color Fading analysis window are the swatches list and products list plus various controls to select the swatch, its side and position or to select different measurement average (Figure 46).

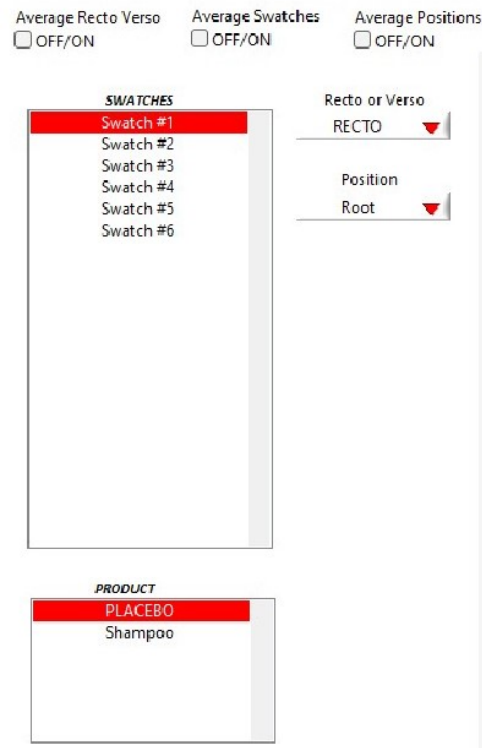


Figure 46: List and controls

The user can select any swatch, its side and position to check the results presented on the various graphs on the left of the window (Figure 47).

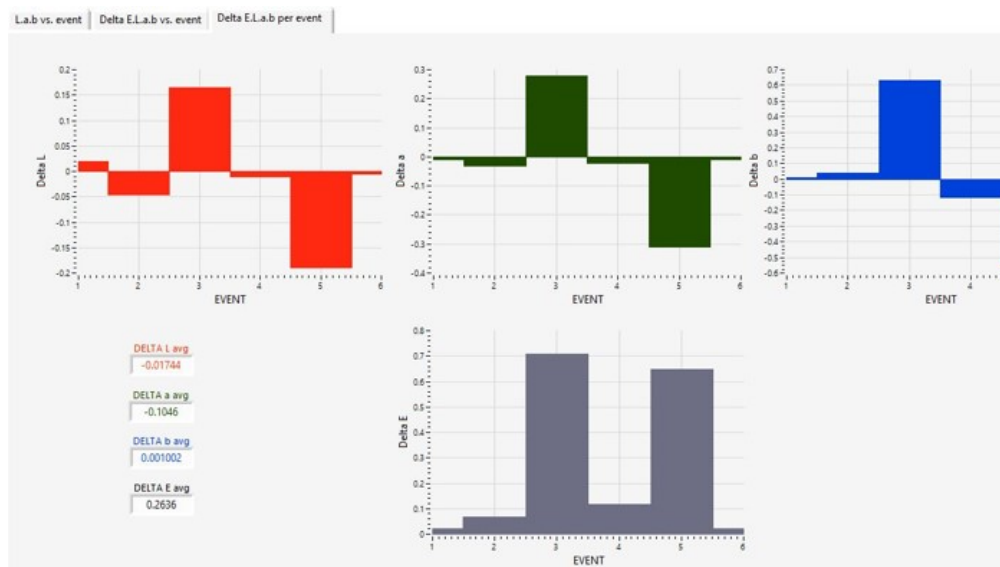


Figure 47: Results graphs

A tab control allows to select various graphs:

- L.a.b versus event shows the Lab values versus the event for the selected measurement
- Delta E.L.a.b versus event shows the Delta E, Delta L, Delta a and Delta b values versus the event for the selected measurement.
- Delta E.L.a.b per event shows the Delta E, Delta L, Delta a and Delta b values per event for the selected measurement

Each time the user selects a different configuration (Figure 48), the graphs and results are updated.

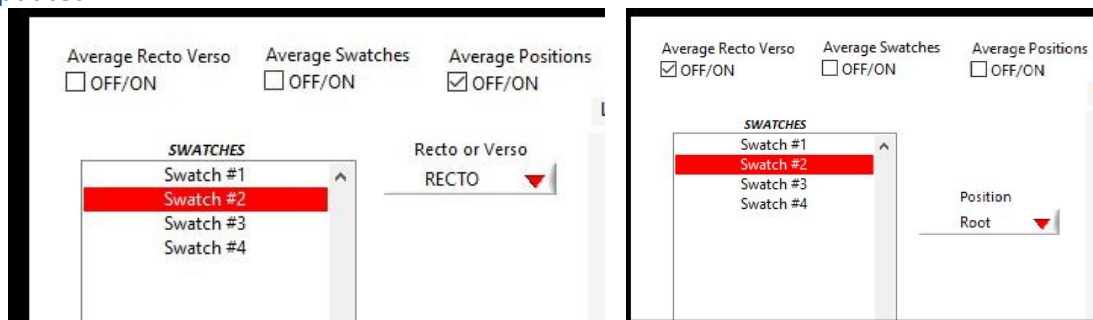


Figure 48: Swatches selection/side/position or average

When an average is selected, the corresponding control gets deactivated, as shown on the case above when the position are averaged so the position selection control is not visible anymore. In the case where the swatches are averaged, the product selection becomes a control and not an indicator anymore (Figure 49).

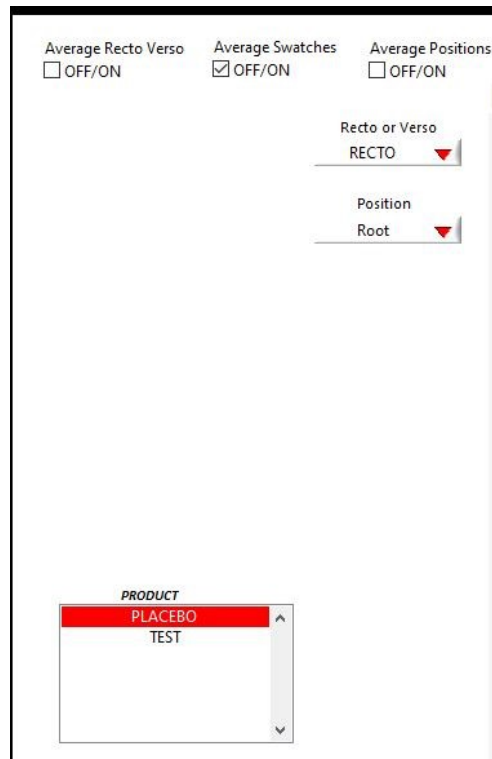


Figure 49: Swatches averaged

Each graph can be exported as a text file or an excel file by clicking right on the mouse (Figure 50)

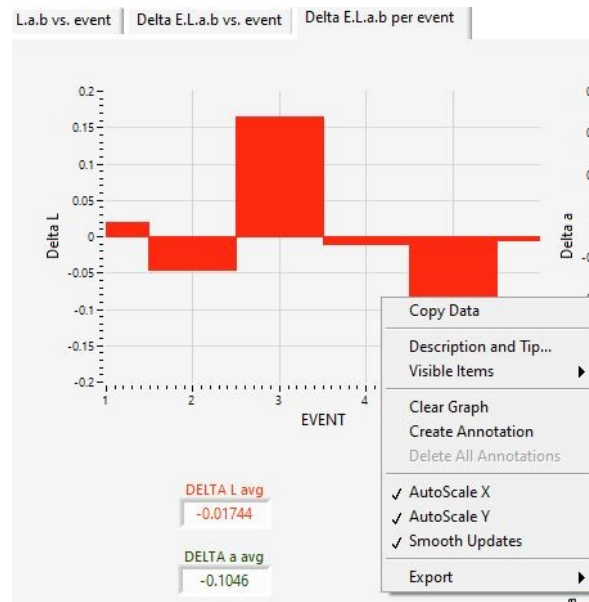


Figure 50: Export

The value of DELTA E, DELTA L, DELTA a and DELTA b between the last event and the base are also given on the Delta E.L.a.b versus event tab (Figure 51).

MAMBO - User Manual

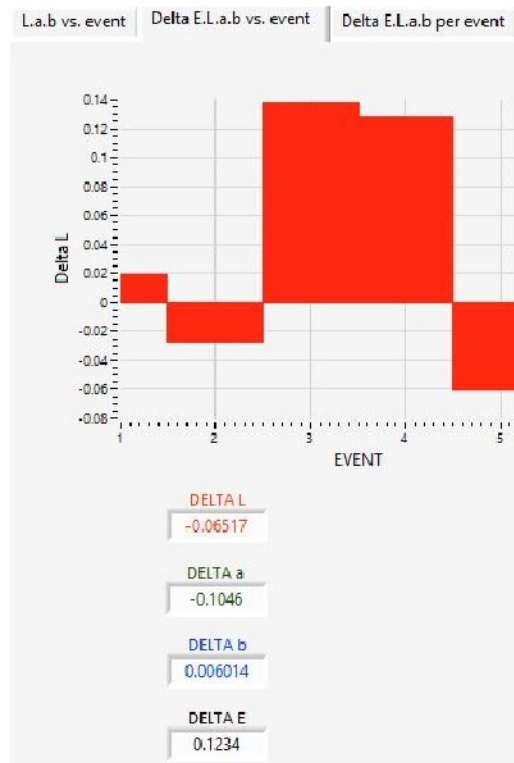


Figure 51: DELTA E, DELTA L, DELTA a and DELTA b

The average value of DELTA E, DELTA L, DELTA a and DELTA b per event are also given on the Delta E.L.a.b per event tab (Figure 52).

MAMBO - User Manual

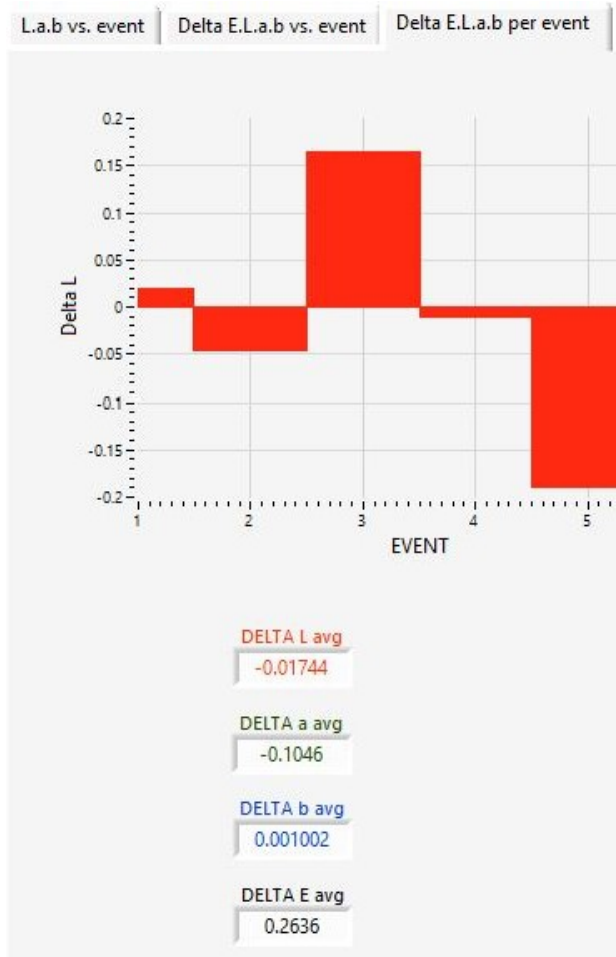


Figure 52: average value of DELTA E, DELTA L, DELTA a and DELTA b

5. COLOR ANALYSIS

The color analysis window allows to analyze the color of the measurement. When the user selects a measurement in the data measurement window and clicks on the

measurement visualization control **COLOR ANALYSIS**, the color analysis window opens (Figure 53).



Figure 53: Measurement visualization window

On the left of the window is the image. Next is the Database selection. Once the database is selected, the database elements are displayed. Results of the color analysis are displayed on the right (Figure 54).

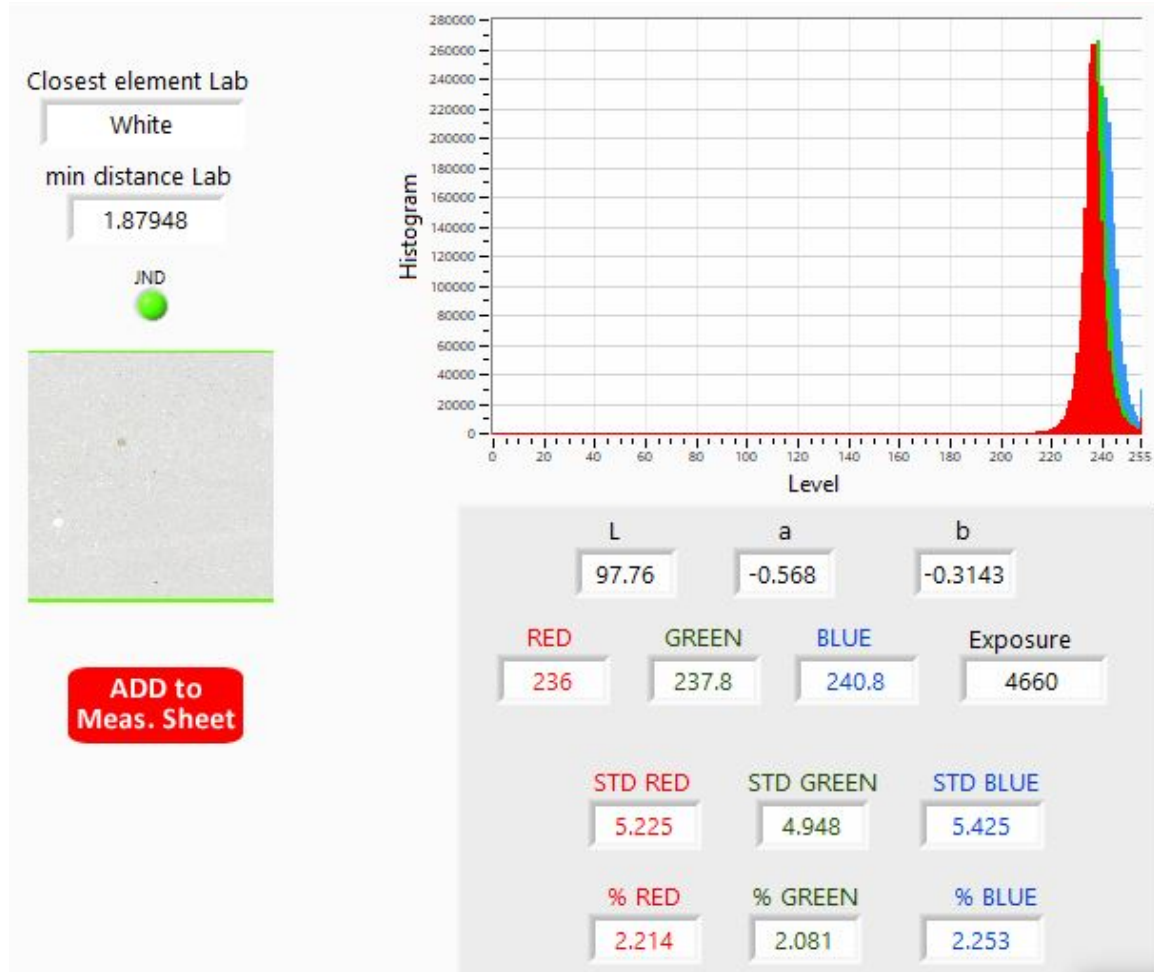


Figure 54: Results

The indicators gives the color analysis results. On the left side are the results from the database. On the right are the results from Lab analysis and histogram. Database results are shown on Figure 55.

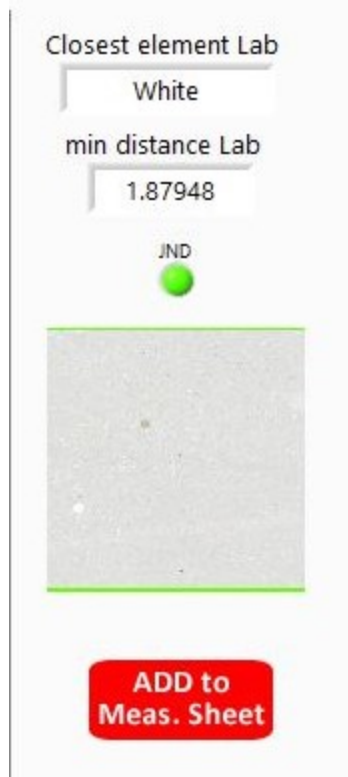


Figure 55: Database results

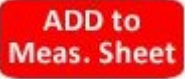
On the top is the closest element  from the selected database. Below is the distance  in Lab value calculated with the closest element.

The software calculates the distance between the measurement and each element of the selected database and select the closest element that has the smallest distance or Delta E from the measurement.

$$\Delta E = \sqrt{(L_{meas.} - L_{element})^2 + (a_{meas.} - a_{element})^2 + (b_{meas.} - b_{element})^2}$$

If the distance is less than 2.3, the JND indicator is green . JND indicator means JUST NOTICEABLE DIFFERENCE, meaning that the average normal person does not see any color difference if JND < 2.3.

Below the JND indicator is the image of the closest element. Below the image is a control

named add to measurement sheet  where the user can add the measurement to a measurement sheet.

On the right are the Lab results (Figure 56).

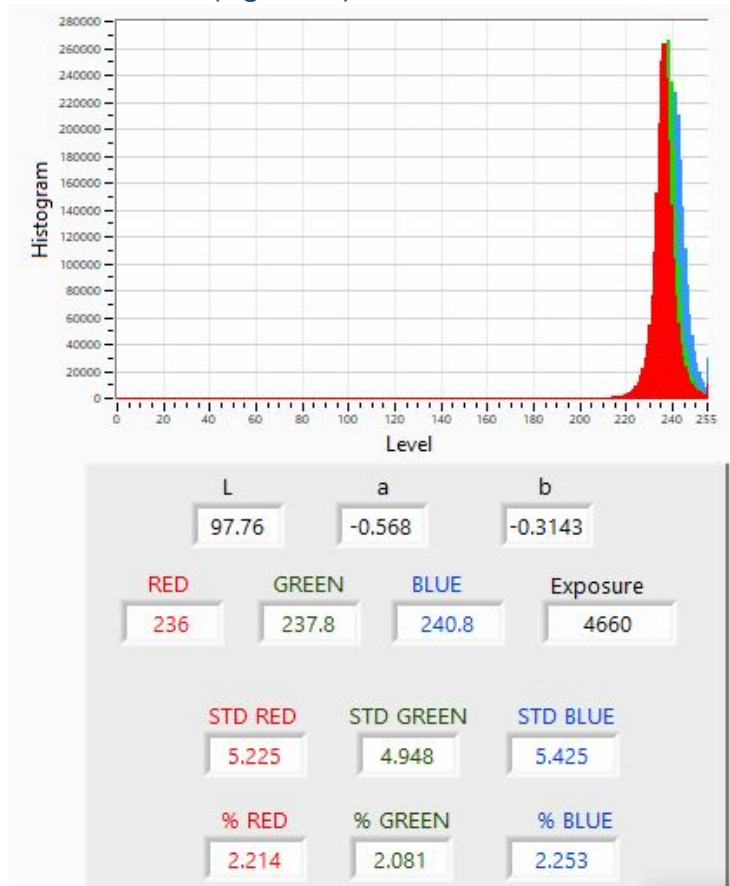


Figure 56: Lab results

On the top is the color histogram of the image, in 8 bits. Below are the Lab values

L	a	b
97.76	-0.568	-0.3143

Under the Lab values are the RGB values in 8 bits and the exposure of the camera

RED	GREEN	BLUE	Exposure
236	237.8	240.8	4660

Standard deviation for each color (R, G and B) are also displayed

STD RED	STD GREEN	STD BLUE
5.225	4.948	5.425
% RED	% GREEN	% BLUE
2.214	2.081	2.253

**ADD to
Meas. Sheet**

If the user clicks on the **ADD to Meas. Sheet** control, a new window appears (Figure 57).

MAMBO - User Manual

MEASUREMENT SHEET.vi

MAMBO MEASUREMENT SHEET

OPEN Measurement Sheet Create NEW Measurement Sheet SAVE Measurement Sheet Exit

NAME: Purplish Blue

L: 39.66 a: 9.80 b: -45.60

R: 57.53 G: 72.60 B: 213.01

Exp. Time: 13340

DATABASE: COLOR CHECKER 3280 2

Matching Element: Purplish Blue

Delta E: 1.63

NOTE: n/a

ADD MEASUREMENT to Meas. Sheet

NAME	L	a	b	R	G	B	Exp. Time	DATABASE	Matching Element	Delta E	Note
light skin	55.18	84.20	56.66	201.42	140.95	126.85	19662	COLOR CHECKER	LIGHT SKIN	1.43	n/a
Moderate Red	29.44	130.82	76.07	187.05	83.41	84.51	19687	COLOR CHECKER	MODERATE RED	3.14	n/a
RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	SEB	RED TRESS	0.89	n/a
RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	SEB	RED TRESS	0.89	n/a - seb
RED TRESS 3	19.48	41.58	18.84	127.23	42.53	42.93	41862	seb	RED TRESS	4.45	n/a
RED TRESS 3	20.05	43.33	19.78	126.80	42.64	43.40	40370	SEB	RED TRESS	0.82	n/a
TEST RED mod	41.99	53.36	27.78	200.16	72.41	64.73	30031	Color Checker	Red	0.65	n/a
test white	96.20	-0.22	0.76	195.99	195.84	195.92	8856	Color Checker	White	0.36	n/a
inc yellow	81.95	3.88	78.11	211.28	175.96	89.36	12779	Color Checker	Yellow	1.01	n/a
inc yellow	81.95	3.88	78.11	211.28	175.96	89.36	12779	Color Checker	Yellow	1.01	n/a
inc black	21.11	-0.19	-1.11	44.26	45.74	47.45	50791	Color Checker	Black	0.31	n/a
Purplish Blue	39.66	9.80	-45.60	57.53	72.60	213.01	13340	COLOR CHECKER 3280 2	Purplish Blue	1.63	n/a
Purplish Blue	39.66	9.80	-45.60	57.53	72.60	213.01	13340	COLOR CHECKER 3280 2	Purplish Blue	1.63	n/a

Figure 57: Measurement sheet

On the left is the measurement results to be added to the measurement sheet (Figure 58).

NAME: Purplish Blue

L: 39.66 a: 9.80 b: -45.60

R: 57.53 G: 72.60 B: 213.01

Exp. Time: 13340

DATABASE: COLOR CHECKER 3280 2

Matching Element: Purplish Blue

Delta E: 1.63

NOTE: n/a

ADD MEASUREMENT to Meas. Sheet

Figure 58: measurement results

The user can add some note about the measurement.

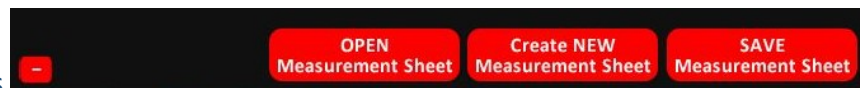
On the right is the measurement sheet (Figure 59)

NAME	L	a	b	R	G	B	Exp. Time	DATABASE	Matching Element	Delta E	Note
light skin	55.18	84.20	56.66	201.42	140.95	126.85	18662	COLOR CHECKER	LIGHT SKIN	1.43	n/a
Moderate Red	29.44	130.82	76.07	187.05	83.41	84.51	19687	COLOR CHECKER	MODERATE RED	3.14	n/a
RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	SEB	RED TRESS	0.89	n/a
RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	SEB	RED TRESS	0.89	n/a - seb
RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	seb	RED TRESS	4.45	n/a
RED TRESS 3	20.05	43.33	19.78	126.80	42.64	43.40	40370	SEB	RED TRESS	0.82	n/a
TEST RED mod	41.99	53.36	27.78	200.16	72.41	64.73	30031	Color Checker	Red	0.65	n/a
test white	96.20	-0.22	0.76	195.99	195.84	195.92	8856	Color Checker	White	0.36	n/a
inc yellow	81.95	3.88	78.11	211.28	175.96	89.36	12779	Color Checker	Yellow	1.01	n/a
inc yellow	81.95	3.88	78.11	211.28	175.96	89.36	12779	Color Checker	Yellow	1.01	n/a
inc black	21.11	-0.19	-1.11	44.26	45.74	47.45	50791	Color Checker	Black	0.31	n/a
Purplish Blue	39.66	9.80	-45.60	57.53	72.60	213.01	13340	COLOR CHECKER 3280 2	Purplish Blue	1.63	n/a
Purplish Blue	39.66	9.80	-45.60	57.53	72.60	213.01	13340	COLOR CHECKER 3280 2	Purplish Blue	1.63	n/a

Figure 59: measurement sheet



Clicking on  will add the current measurement to the measurement sheet.



Using the top controls

, the user can delete a measurement, open an existing measurement sheet, create a new one, or save the current one.

The measurement sheet is a text file (Figure 60)

meas sheet - Notepad

light skin	55.18	84.20	56.66	201.42	140.95	126.85	18662	COLOR CHECKER	LIGHT SKIN	1.43	n/a
Moderate Red	29.44	130.82	76.07	187.05	83.41	84.51	19687	COLOR CHECKER	MODERATE RED	3.14	n/a
RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	SEB	RED TRESS	0.89	n/a
RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	SEB	RED TRESS	0.89	n/a - seb
RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	seb	RED TRESS	4.45	n/a
RED TRESS 3	20.05	43.33	19.78	126.80	42.64	43.40	40370	SEB	RED TRESS	0.82	n/a
TEST RED mod	41.99	53.36	27.78	200.16	72.41	64.73	30031	Color Checker	Red	0.65	n/a
test white	96.20	-0.22	0.76	195.99	195.84	195.92	8856	Color Checker	White	0.36	n/a
inc yellow	81.95	3.88	78.11	211.28	175.96	89.36	12779	Color Checker	Yellow	1.01	n/a
inc yellow	81.95	3.88	78.11	211.28	175.96	89.36	12779	Color Checker	Yellow	1.01	n/a
inc black	21.11	-0.19	-1.11	44.26	45.74	47.45	50791	Color Checker	Black	0.31	n/a
Purplish Blue	39.66	9.80	-45.60	57.53	72.60	213.01	13340	COLOR CHECKER 3280 2	Purplish Blue	1.63	n/a
Purplish Blue	39.66	9.80	-45.60	57.53	72.60	213.01	13340	COLOR CHECKER 3280 2	Purplish Blue	1.63	n/a

Figure 60: measurement sheet

It can be easily imported into excel for more processing (Figure 61).

	A	B	C	D	E	F	G	H	I	J	K	L
	light skin	55.18	84.2	56.66	201.42	140.95	126.85	18662	COLOR CHECKER	LIGHT SKIN	1.43	n/a
	Moderate Red	29.44	130.82	76.07	187.05	83.41	84.51	19687	COLOR CHECKER	MODERATE RED	3.14	n/a
	RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	SEB	RED TRESS	0.89	n/a
	RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	SEB	RED TRESS	0.89	n/a - seb
	RED TRESS	19.48	41.58	18.84	127.23	42.53	42.93	41862	seb	RED TRESS	4.45	n/a
	RED TRESS 3	20.05	43.33	19.78	126.8	42.64	43.4	40370	SEB	RED TRESS	0.82	n/a
	TEST RED mod	41.99	53.36	27.78	200.16	72.41	64.73	30031	Color Checker	Red	0.65	n/a
	test white	96.2	-0.22	0.76	195.99	195.84	195.92	8856	Color Checker	White	0.36	n/a
	inc yellow	81.95	3.88	78.11	211.28	175.96	89.36	12779	Color Checker	Yellow	1.01	n/a
	inc yellow	81.95	3.88	78.11	211.28	175.96	89.36	12779	Color Checker	Yellow	1.01	n/a
	inc blk	21.11	-0.19	-1.11	44.26	45.74	47.45	50791	Color Checker	Black	0.31	n/a
	Purplish Blue	39.66	9.8	-45.6	57.53	72.6	213.01	13340	COLOR CHECKER 3280 2	Purplish Blue	1.63	n/a
	Purplish Blue	39.66	9.8	-45.6	57.53	72.6	213.01	13340	COLOR CHECKER 3280 2	Purplish Blue	1.63	n/a

Figure 61: Measurement sheet in Excel

6. GREY HAIR ANALYSIS

When the user selects a measurement then clicks on Grey hair analysis, the grey hair analysis windows appears (Figure 62).

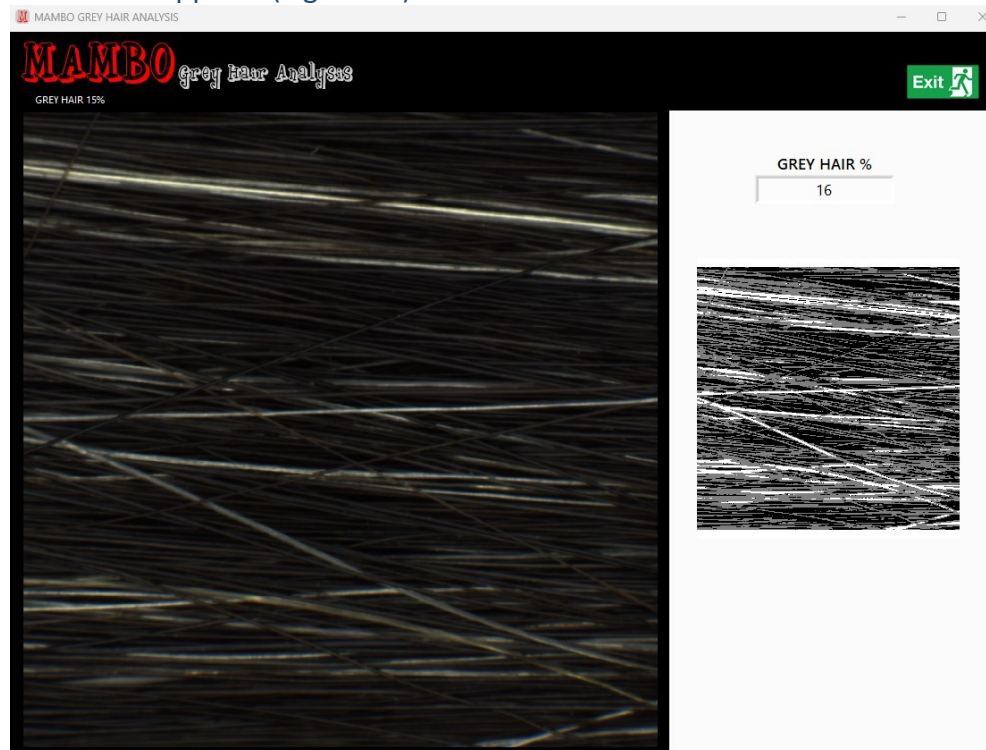


Figure 62: Grey Hair Analysis window

The grey hair % only works on dark swatches with white/grey hair.

7. DATABASE MANAGEMENT

**DATABASE
MANAGEMENT**

When the user clicks on database management control , the data management window opens (Figure 63).

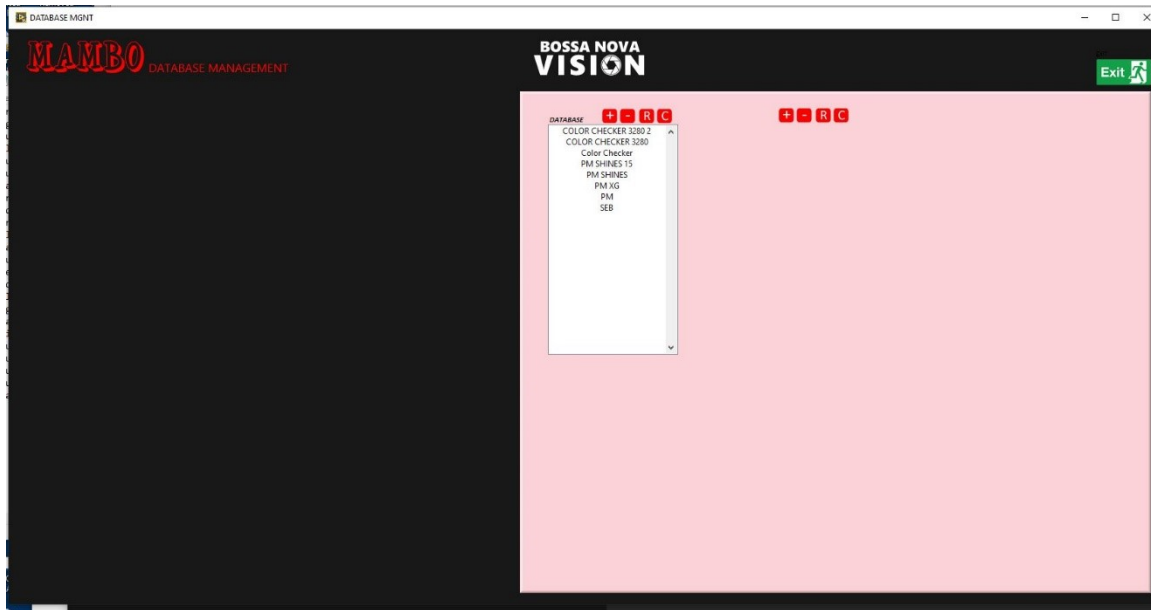


Figure 63: Data management window

When the user select a database, the elements list appears (Figure 64).

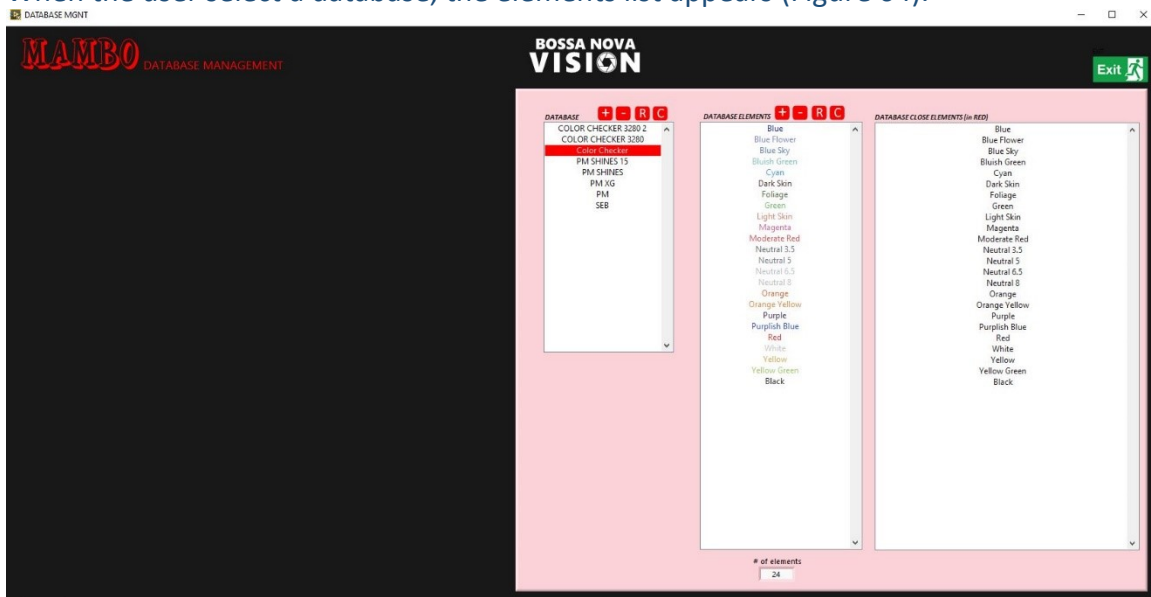


Figure 64: Database selected. Elements list

The list on the right of the list of elements is the list of the close elements (Figure 65).

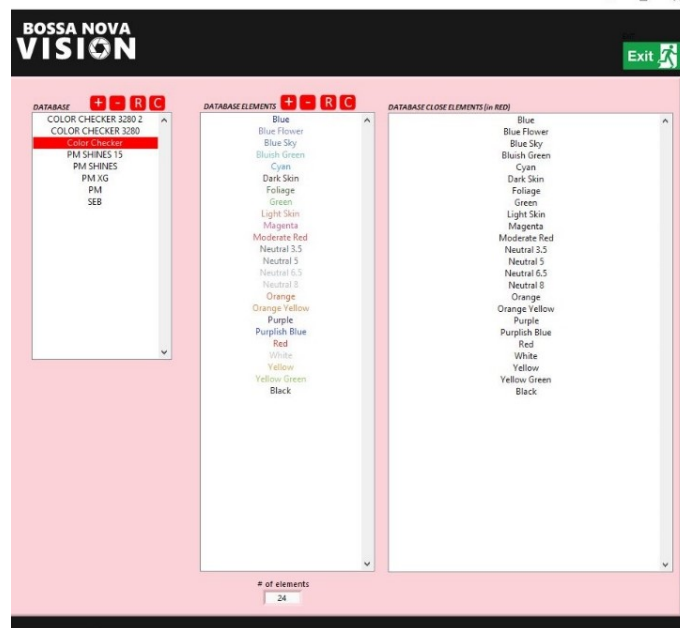


Figure 65: Close elements list

If there are some close elements in the database ($JND < 2.3$), they will appear in red in the close elements list (Figure 66)

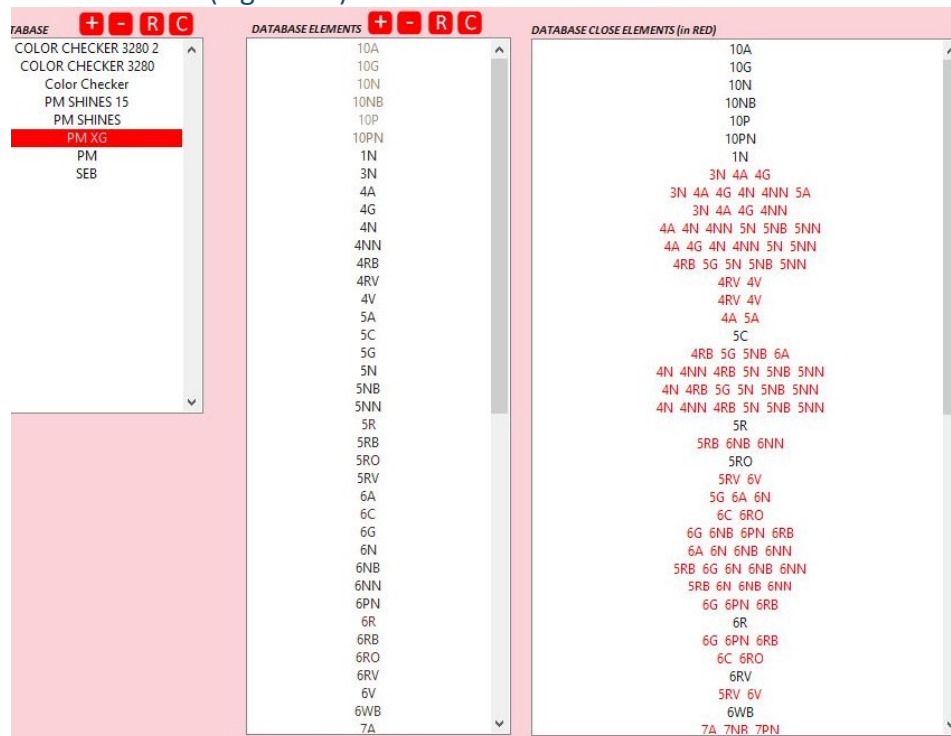


Figure 66: Close elements list

Using the usual controls located on top of the list, the user can create, delete, rename and copy database and database elements. The only way to add element to a database

MAMBO - User Manual

is to import an existing measurement using the  control on top of the database

elements list

Once the user clicks on , a new window pops-up (Figure 67).

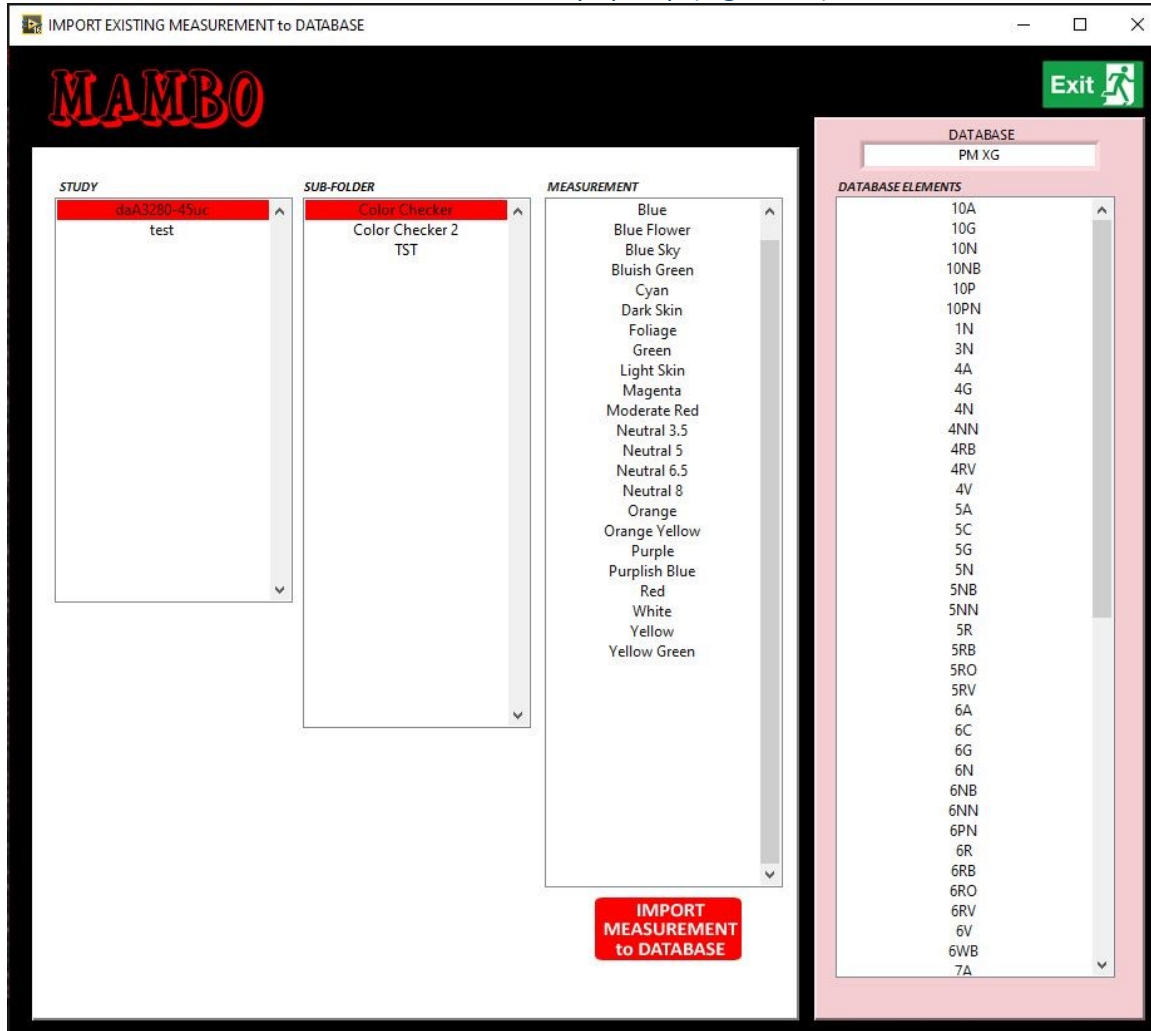


Figure 67: importing existing measurement into a database

The user can then select existing measurement to be imported to the database.

8. DATABASE COMPARISON

When the user clicks on database comparison control , the database comparison opens (Figure 68).

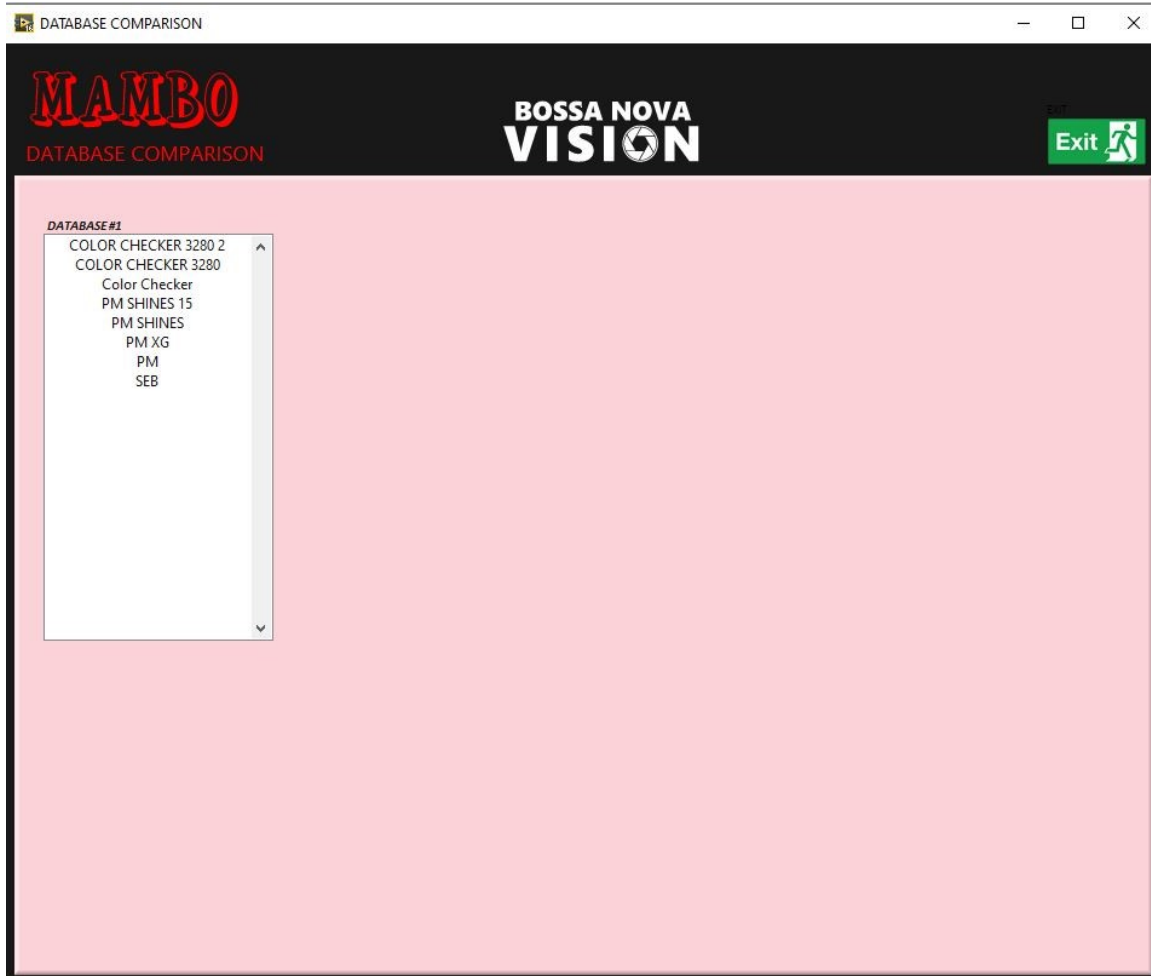


Figure 68: database comparison window

A list of the existing database is displayed. Once the user selects a database, the list of remaining database is displayed (Figure 69).

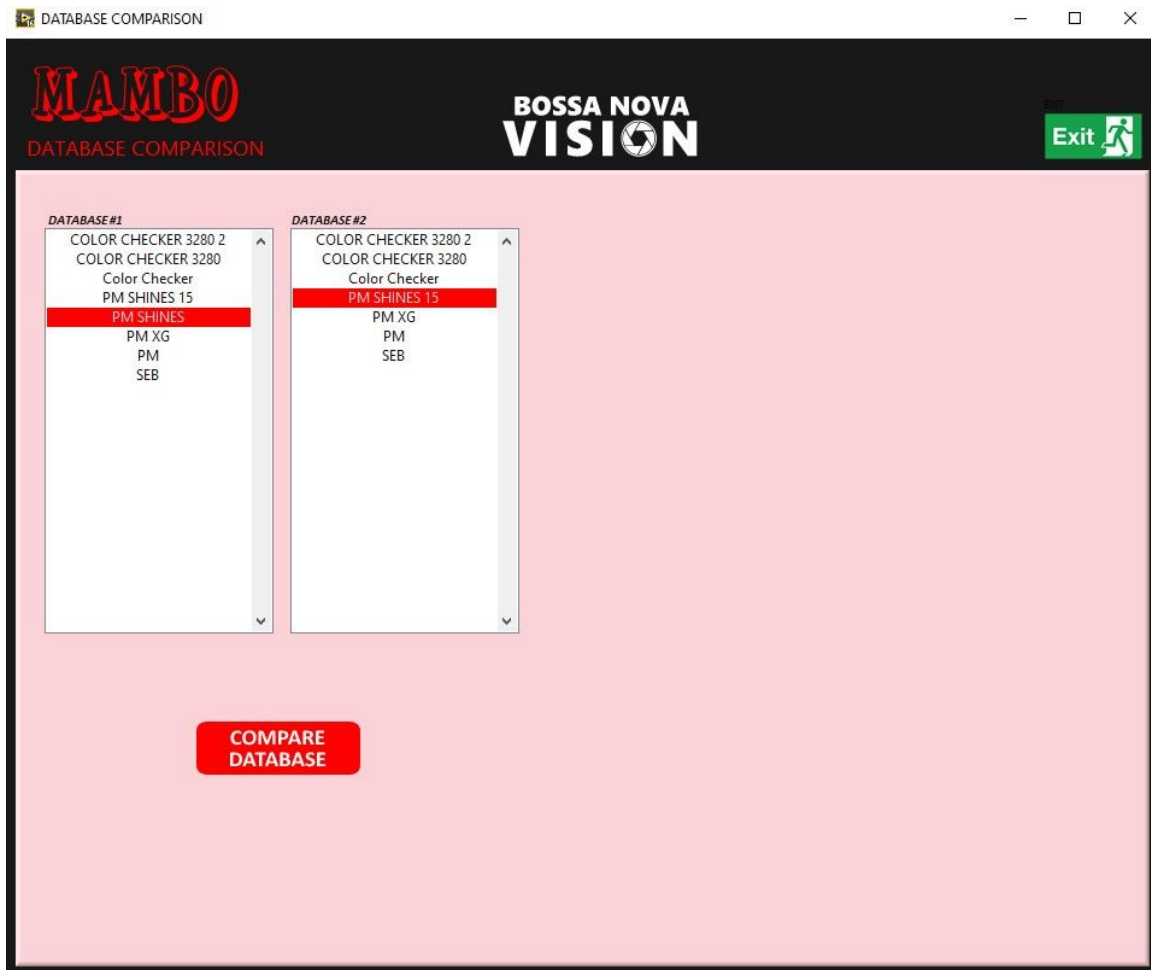


Figure 69: Database #1 and #2 to be compared

Once a database in the database #2 list is selected, the compare database control  appears. Clicking on it displays the results (Figure 70).

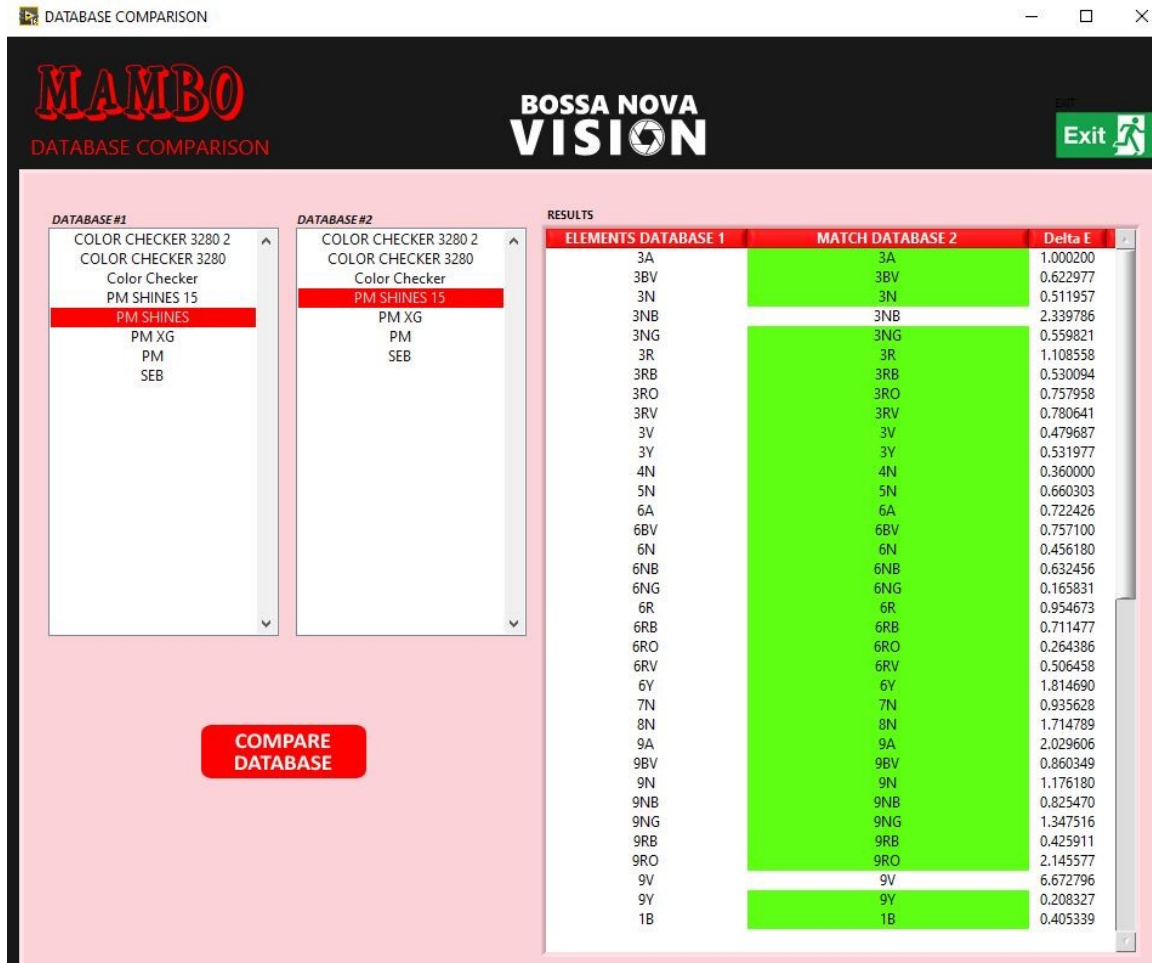


Figure 70: Database comparison results

Each element of DATABASE #1 is compared to DATABASE #2. The results list shows the match from database #2 and the corresponding Delta E. When delta E is less than 2.3, the line is highlighted in green.

9. COLOR CHECKER CALIBRATION

The user can re-do the color calibration of MAMBO using a Color Checker. This process allows MAMBO to convert RGB measurement into Lab measurement. The color calibration has been done in factory and should not be redone unless recommended by Bossa Nova Vision.



When the user clicks on color checker calibration control, a pop-up message appears (Figure 71).

MAMBO - User Manual

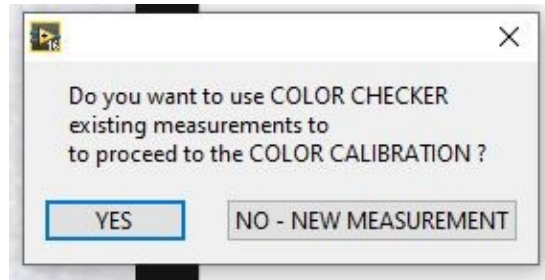


Figure 71: Color checker calibration – pop-up message

The message asks if the user wants to acquire new measurement or use existing measurement to proceed to the calibration. If the user selects NO –New measurement, the software will guide the user step by step to proceed to the acquisition of the 24 tiles images of the color checker (Figure 72).

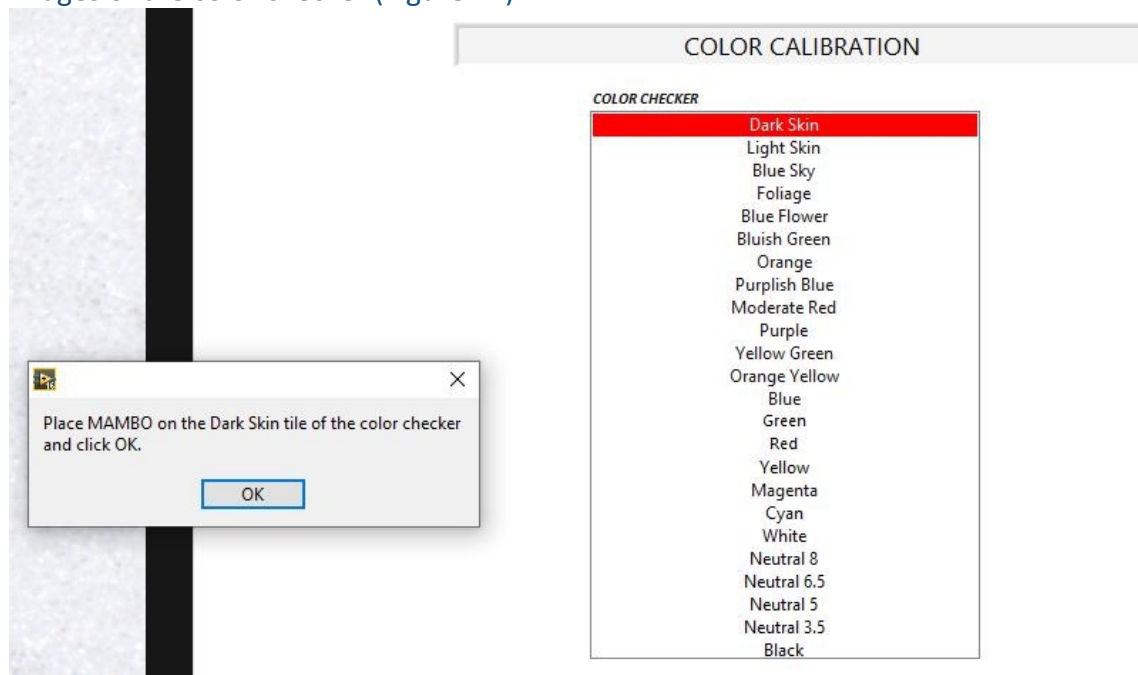


Figure 72: Step by Step

Each measurement will consist of putting MAMBO on the corresponding color tile and click ok to start auto-exposure followed by the acquisition of the tile image until the last one, the black tile (Figure 73).

Neutral 5 : DATA/IMAGE ACQUISITION



Figure 73: Step by Step

At the end the calibration matrix is calculated and the results are displayed (Figure 74).

MAMBO COLOR CHECKER CALIBRATION RESULTS								Exit 
COLOR	L	a	b	L exp.	a exp.	b exp.	Delta E	
Dark Skin	37.986000	13.555000	14.059000	38.069284	14.110627	13.996254	1.541711	
Light Skin	65.711000	18.130000	17.810000	65.361521	20.151073	17.907843	2.362623	
Blue Sky	49.927000	-4.880000	-21.925000	49.920103	-5.142207	-22.011972	1.781941	
Foliage	43.139000	-13.095000	21.905000	43.138327	-13.094555	21.903837	0.919237	
Blue Flower	55.112000	8.844000	-25.399000	55.096653	8.848028	-25.390648	0.938669	
Bluish Green	70.719000	-33.397000	-0.199000	70.699855	-33.396444	-0.236926	0.838510	
Orange	62.661000	36.067000	57.096000	62.602227	35.785360	57.407160	0.757976	
Purplish Blue	40.020000	10.410000	-45.964000	40.018899	10.396383	-45.979680	1.057000	
Moderate Red	51.124000	48.239000	16.248000	51.177074	48.283898	16.560299	0.652601	
Purple	30.325000	22.976000	-21.587000	30.305723	22.823677	-21.602811	1.065501	
Yellow Green	75.732000	-23.709000	27.255000	75.549508	-23.724868	29.517568	2.676852	
Orange Yellow	71.941000	19.363000	67.857000	71.940690	19.366578	67.856294	1.323826	
Blue	28.778000	14.179000	-50.297000	28.784359	14.207330	-50.280986	0.858579	
Green	55.261000	-38.342000	31.370000	55.313135	-38.345409	30.703752	0.552381	
Red	42.101000	53.378000	28.190000	42.100372	53.374475	28.087629	0.397473	
Yellow	81.733000	4.039000	79.819000	81.784776	4.077891	79.509223	0.938748	
Magenta	51.935000	49.986000	-14.574000	51.933912	49.975142	-14.592817	1.474627	
Cyan	51.038000	-28.631000	-28.638000	51.046966	-28.576006	-28.526371	0.781701	
White	96.539000	-0.425000	1.186000	96.538895	-0.425074	1.186256	0.711187	
Neutral 8	81.257000	-0.638000	-0.335000	81.270803	-0.665257	-0.330461	0.790636	
Neutral 6.5	66.766000	-0.734000	-0.504000	66.959635	-0.720977	-0.500744	1.300558	
Neutral 5	50.867000	-0.153000	-0.270000	50.860735	-0.343994	-0.323841	0.981871	
Neutral 3.5	35.656000	-0.421000	-1.231000	35.702618	-0.515362	-1.114759	0.878885	
Black	20.461000	-0.079000	-0.973000	20.440734	-0.058236	-0.981484	1.077473	

Figure 74: Calibration Results – Theoretical and experimental Lab values

If the user chooses to use existing color checker measurement, the measurements need to match the 24 color checker tile names (Figure 75).



Figure 75: Color Checker tile names

The user can select the folder containing the color checker measurements (Figure 76).

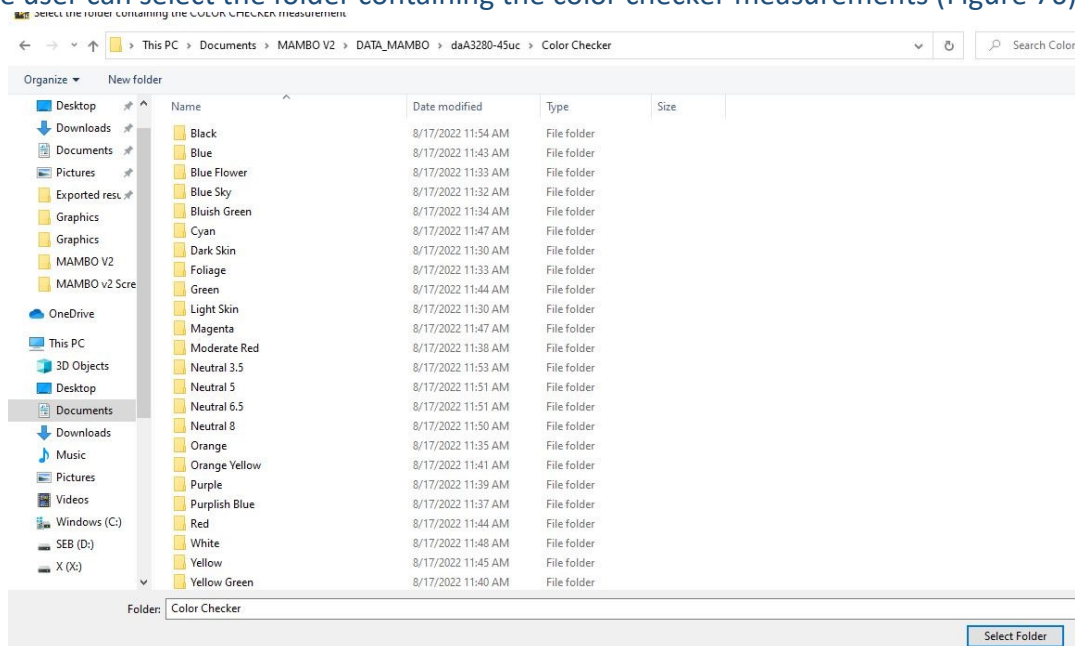


Figure 76: Folder with color checker measurements

Once the folder is selected, the software proceeds to the calibration and at the end displays the results.

MAMBO - User Manual

If the system is used as load only, a different pop-up message appears (Figure 77) asking only for existing color checker measurement to be used (same step as before).

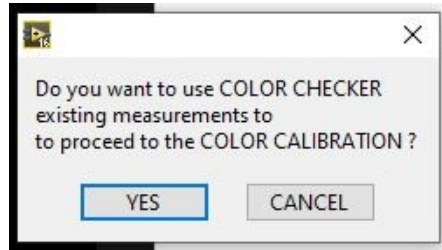


Figure 77: Pop-up message – load only

10. MAMBO CALIBRATION

The user can re-do the calibration of MAMBO using the white tile of a Color Checker. This process allows to adjust the different parameters of the camera and the set-up. The calibration has been done in factory and should not be redone unless recommended by Bossa Nova Vision.



By clicking on MAMBO Calibration button , the user will be able to calibrate MAMBO the same way it was calibrated in factory (Figure 78).

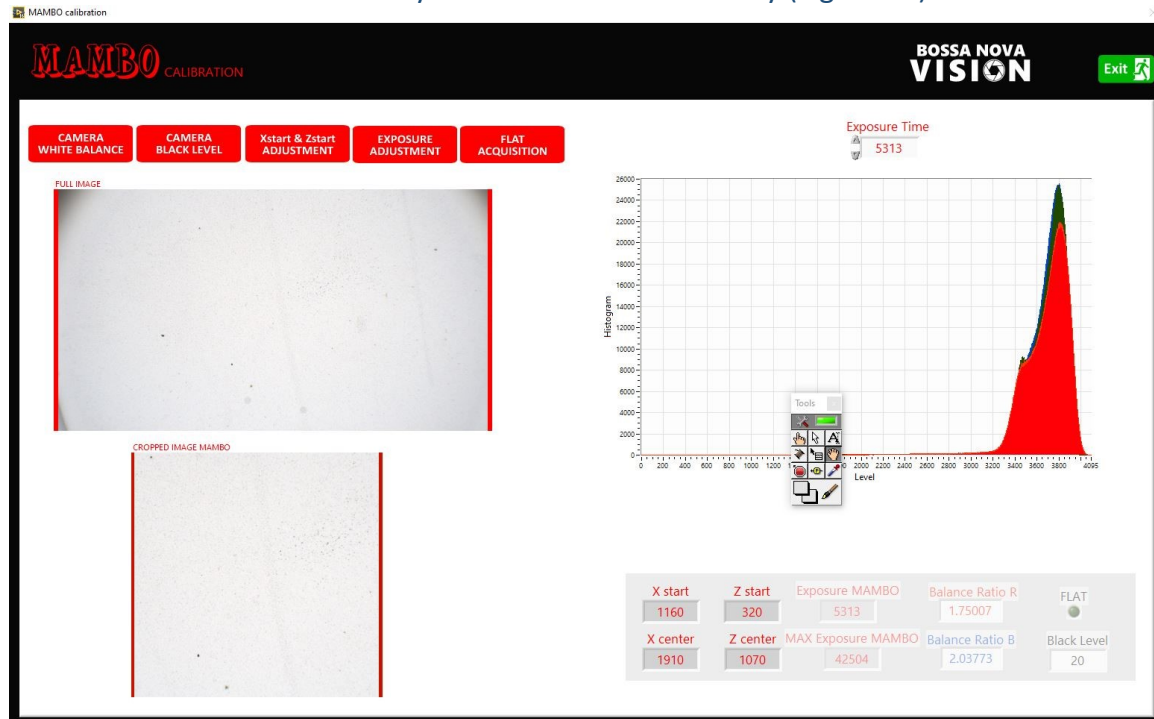


Figure 78: MAMBO Calibration – Main window

MAMBO - User Manual

MAMBO calibration allows to calibrate the color gain of the camera and its black level, Xstart and Zstart corresponding to the cropped image, the exposure time and the flat image. The 5 action controls corresponding to 5 calibration steps are on the top of the calibration windows (Figure 79).



Figure 79: MAMBO Calibration – 5 steps

10.1. WHITE BALANCE

First is the calibration of the white balance of the camera. This calibration is about adjusting the balance levels of MAMBO in order to get a WHITE reading when placed on

a WHITE target. To do so, the user clicks on **CAMERA WHITE BALANCE** (Figure 80). The other action controls are not visible and the white balance control is now disabled and greyed. A pop-up message appears, asking the user to place MAMBO on the WHITE TILE of the color checker.

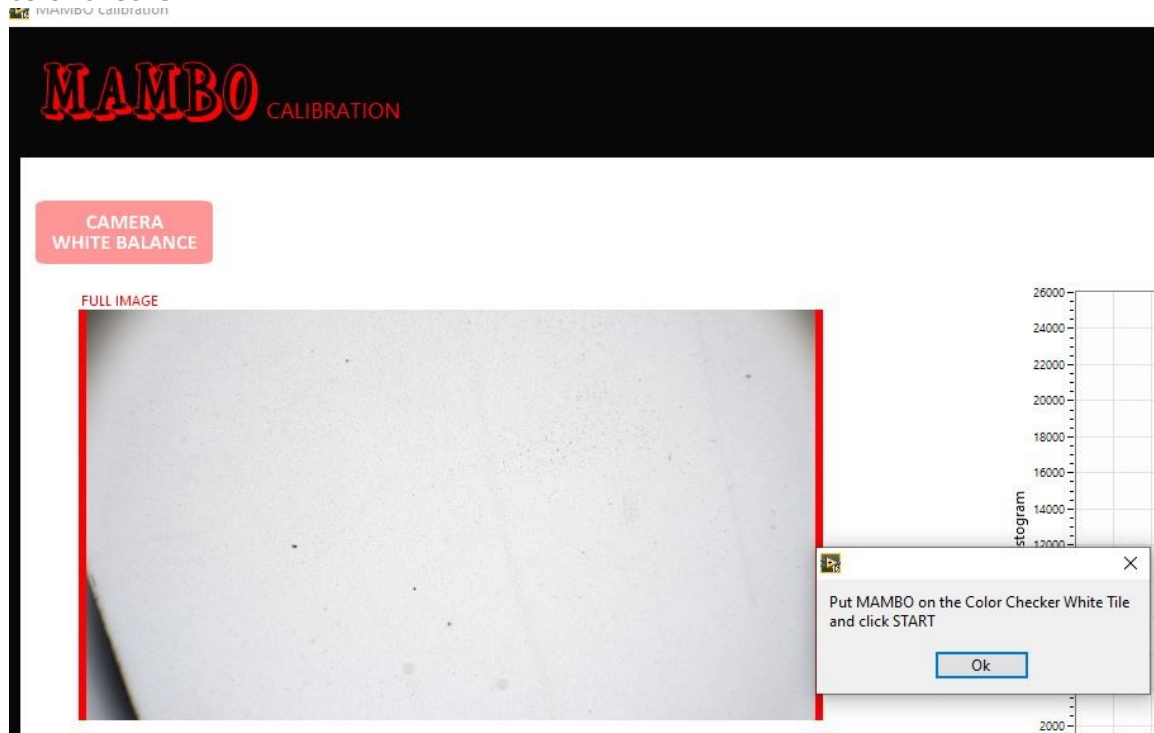


Figure 80: Camera white balance

Once MAMBO is placed on the WHITE tile of the color checker, the user clicks on start. The first is to proceed to the white balance (Figure 81).

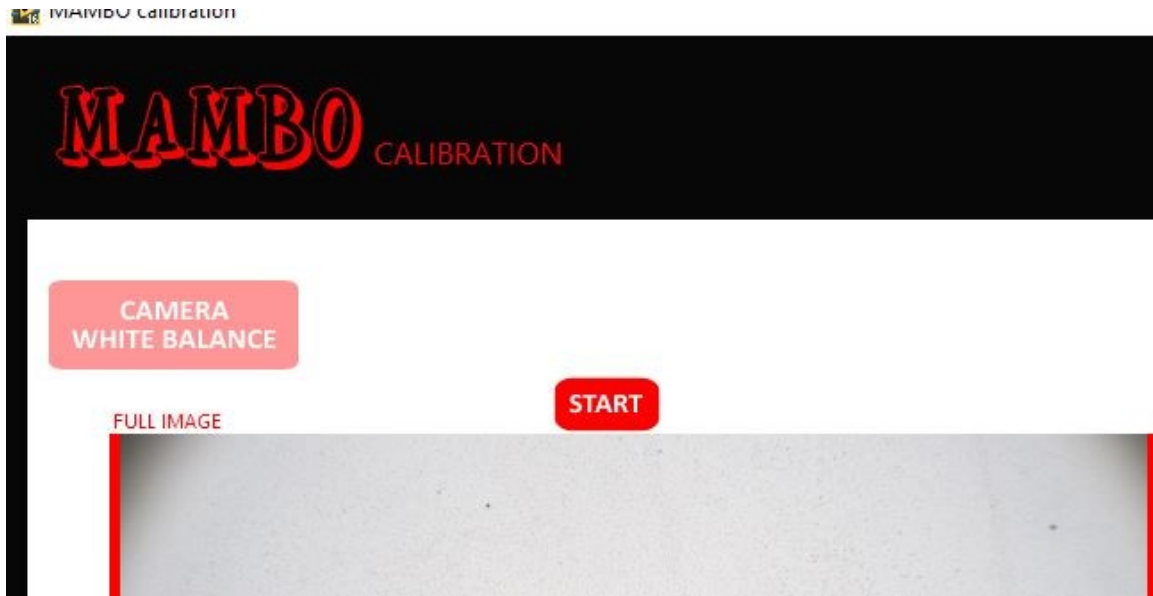


Figure 81: White balance pop-up

The software will automatically adjust the exposure of the camera and calculates the white balance parameter (Figure 82). Once it is done, a pop-up message appears.

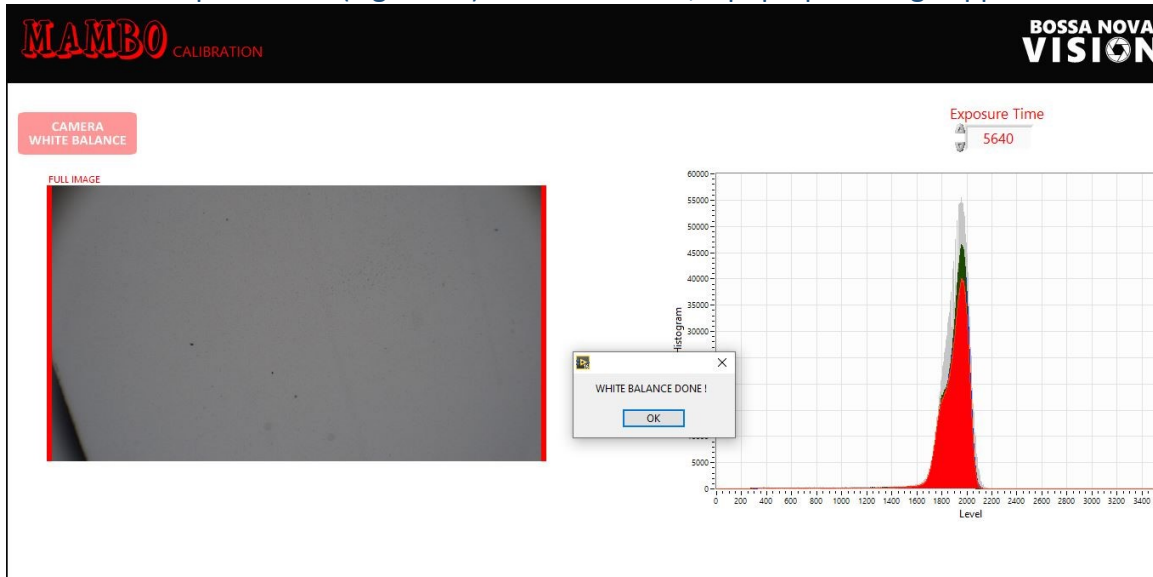


Figure 82: White balance done

10.2. BLACK LEVEL

Next is the calibration of the Black level of the camera. This calibration is about adjusting the black level of the camera and save the black level image (Camera output when no

light is present). To do so, the user clicks on

**CAMERA
BLACK LEVEL**

and a pop-up message

appears (Figure 83). The other action controls are not visible and the camera black level control is now disabled and greyed. A pop-up message appears, asking the user to switch off the LED.

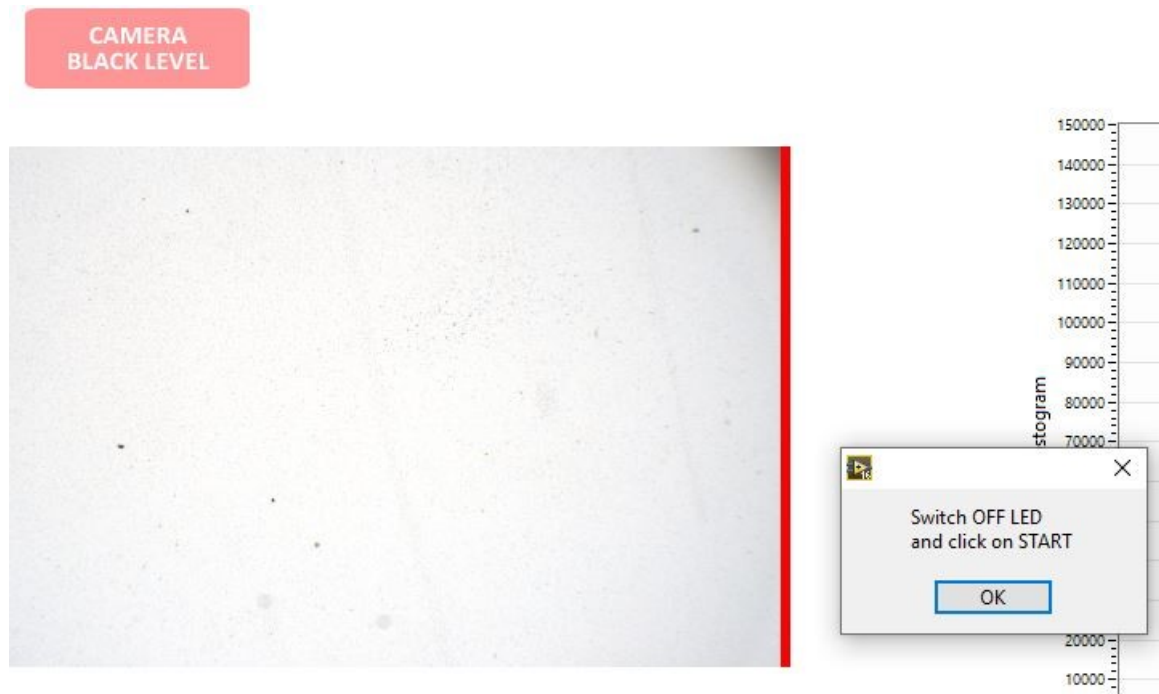


Figure 83: Next Black Level

Once clicking on start, the software automatically measure the black level (Figure 84).

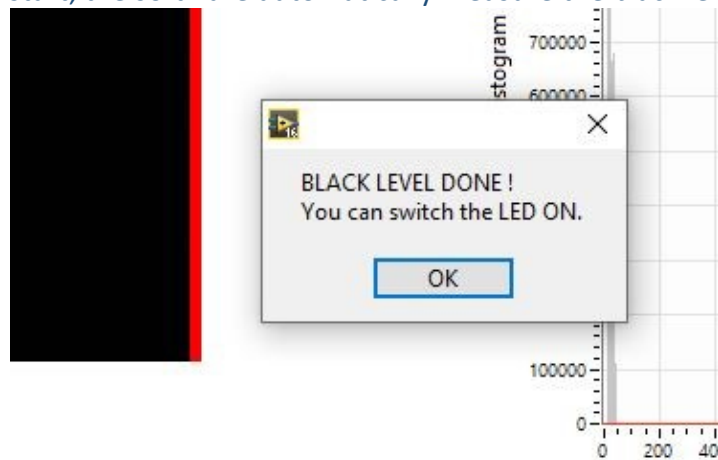


Figure 84: Black level

Once it is done, a pop-up message appears. Click on OK and get back to the main MAMBO calibration page.

10.3. Xstart Zstart

Next step is Xstart and Zstart adjustment allowing to crop the full image to get MAMBO image (Figure 85).

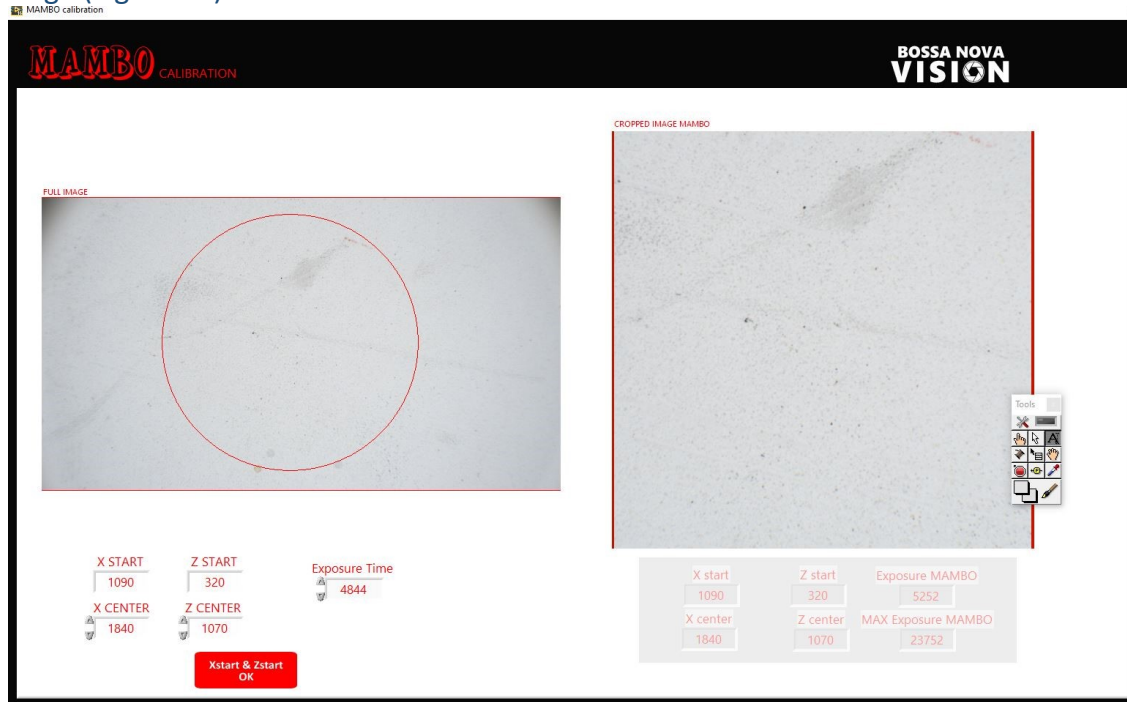


Figure 85: Xstart and Zstart adjustment

The user can adjust Xcenter and Zcenter to center the red circle in the image.

10.4. EXPOSURE

**EXPOSURE
ADJUSTMENT**

Next step is to adjust the exposure (Figure 86) by clicking on . Place MAMBO on the color checker White tile.

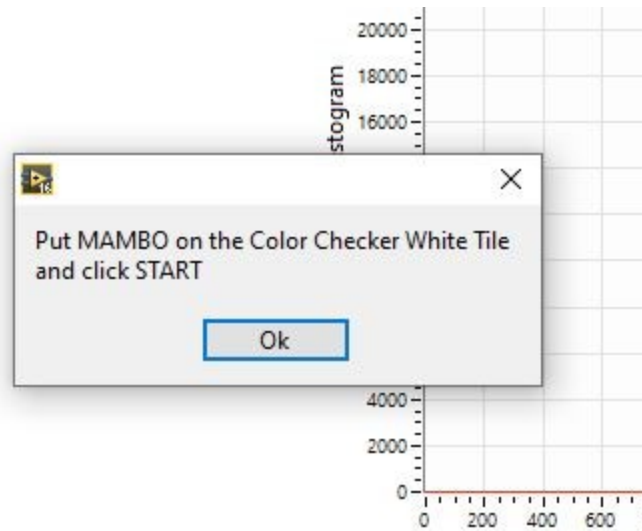


Figure 86: Exposure adjustment

Just click on start to automatically adjust the exposure. When it is done, a pop-up message appears. Click on ok to go back to the main MAMBO calibration window (Figure 87).

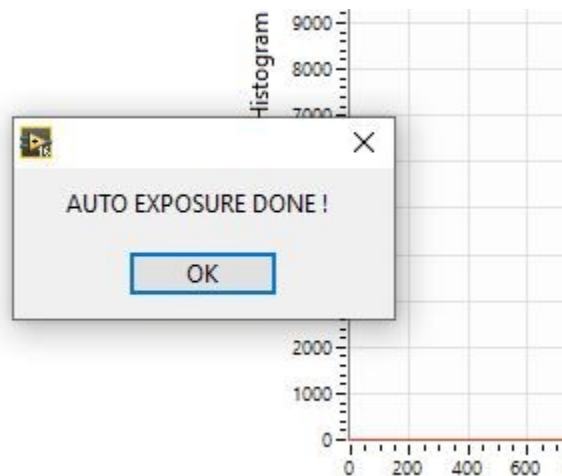


Figure 87: Exposure adjustment

10.5. FLAT

To conclude MAMBO calibration, the user needs to acquire the flat image (Figure 88) by

**FLAT
ACQUISITION**

clicking on . A pop-up message appears, asking the user to place MAMBO on the white tile of the color checker.

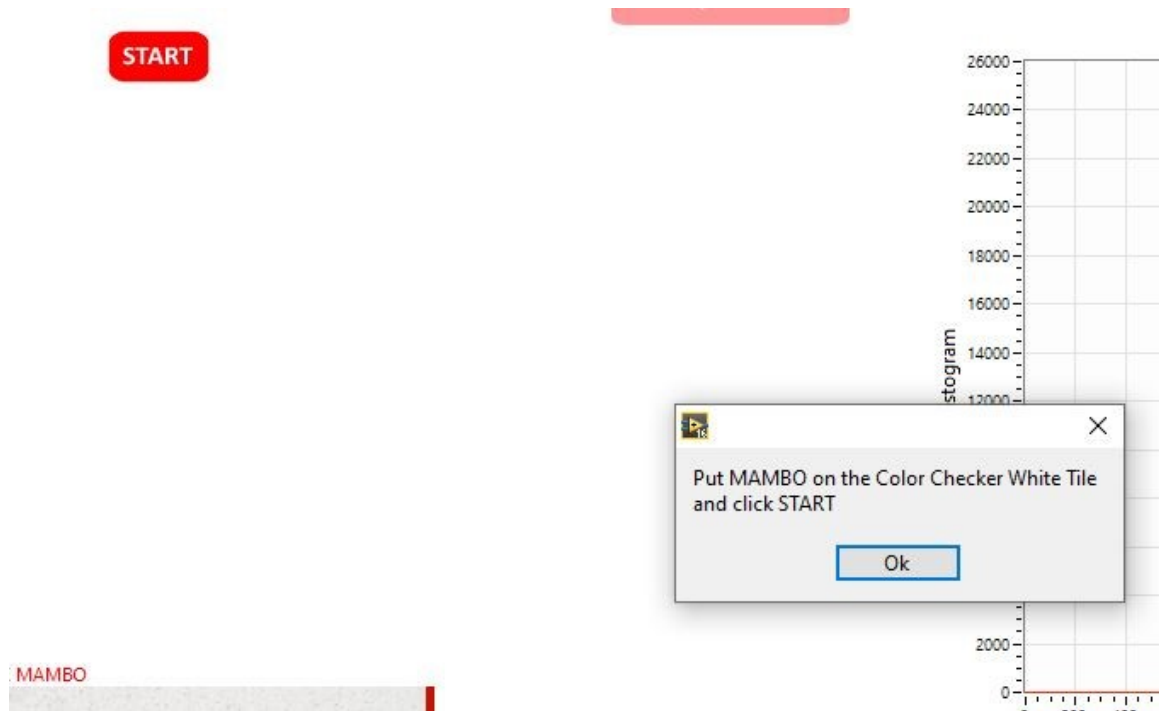


Figure 88: Flat image acquisition done

Once done, the user clicks on START to start the flat image acquisition (Figure 89).

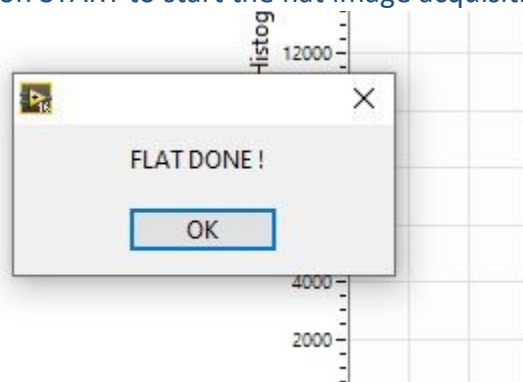


Figure 89: Flat done

Once all the calibration steps are done, all the parameters appears (Figure 90).

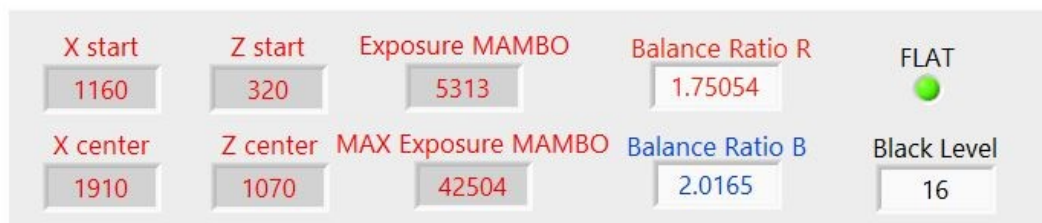


Figure 90: Calibration parameters

11. Data format

Each MAMBO image is saved as mambo.png in a measurement folder (Figure 91) with the name of the measurement.

MAMBO V2 > DATA_MAMBO > daA3280-45uc > TST > tst white

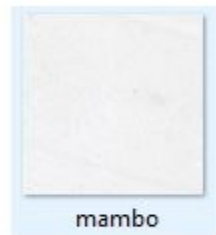


Figure 91: Measurement Folder

The measurement folder is located in MAMBO V2/DATA_MAMBO/STUDY/Sub-folder.

Each DATABASE is stored in the DATABASE folder, located in the root MAMBO V2 folder. Each DATABASE consists of a folder with the DATABASE name and a text file DATABASE.txt (Figure 92).

MAMBO V2 > DATABASE

Name	Date modified	Type	Size
Color Checker	8/11/2022 2:00 PM	File folder	
COLOR CHECKER 3280	8/17/2022 1:42 PM	File folder	
COLOR CHECKER 3280 2	8/17/2022 2:58 PM	File folder	
PM	8/16/2022 11:25 AM	File folder	
PM SHINES	8/15/2022 10:58 AM	File folder	
PM SHINES 15	8/15/2022 3:31 PM	File folder	
PM XG	8/15/2022 12:07 PM	File folder	
SEB	8/9/2022 11:28 AM	File folder	
COLOR CHECKER 3280 2	8/17/2022 2:58 PM	Text Document	2 KB
COLOR CHECKER 3280	8/17/2022 1:42 PM	Text Document	2 KB
Color Checker	8/11/2022 2:00 PM	Text Document	2 KB
PM SHINES 15	8/15/2022 3:31 PM	Text Document	2 KB
PM SHINES	8/15/2022 10:58 AM	Text Document	2 KB
PM XG	8/15/2022 12:07 PM	Text Document	4 KB
PM	8/16/2022 11:25 AM	Text Document	6 KB
SEB	8/9/2022 11:33 AM	Text Document	1 KB

Figure 92: DATABASE folder

The DATABASE.txt file contains the element names and the Exposure, R, G, B, L, a and b values (Figure 93).

Color Checker - Notepad

File	Edit	Format	View	Help						
Blue	28223	37.34	57.89	144.00	28.91	14.46	-50.57			
Blue Flower	22718	129.10	136.29	193.43	55.55	8.83	-25.38			
Blue Sky	25128	98.91	128.43	175.40	50.45	-5.24	-22.12			
Bluish Green	17319	126.41	194.59	188.05	71.76	-34.37	0.16			
Cyan	25333	78.86	151.30	212.55	51.14	-28.91	-28.42			
Dark Skin	20360	74.43	56.74	49.63	38.54	13.99	14.08			
Foliage	30405	87.43	103.61	71.13	42.88	-13.01	21.91			
Green	32804	116.41	187.56	117.63	55.57	-38.21	30.67			
Light Skin	18879	202.54	140.82	125.89	65.49	20.11	18.16			
Magenta	24100	205.70	106.80	154.44	52.56	50.08	-14.69			
Moderate Red	21567	207.38	91.82	92.15	51.61	48.26	16.36			
Neutral 3.5	49897	105.27	110.66	114.17	35.76	-0.51	-1.25			
Neutral 5	27516	125.95	131.40	134.24	51.11	-0.57	-0.12			
Neutral 6.5	20673	184.47	190.52	193.72	67.48	-0.98	-0.48			
Neutral 8	13776	189.48	193.15	195.48	81.63	-0.84	-0.46			
Orange	16799	203.11	109.31	65.67	62.68	35.96	57.67			
Orange Yellow	14483	205.90	144.03	77.54	72.27	19.18	68.15			
Purple	34734	71.35	57.28	92.11	30.33	23.30	-21.79			
Purplish Blue	27738	64.81	92.15	191.36	40.57	10.26	-45.59			
Red	30103	204.95	73.95	65.79	42.33	53.44	28.33			
White	8951	198.30	197.77	197.23	96.20	-0.22	1.12			
Yellow	12557	209.47	174.23	88.07	82.17	3.89	79.10			
Yellow Green	18067	162.13	197.00	106.38	76.23	-23.96	28.68			
Black	49897	44.38	45.85	47.41	21.39	-0.21	-0.96			

Figure 93: DATABASE.txt

The DATABASE folder contains the element folders, similar to a measurement folder.

12. Technical Background

MAMBO uses a diffuse white LED illumination to illuminate the hair swatch and a camera to acquire an image of the hair swatch. The diffuse illumination allows to minimize reflection on hair fibers and only measure the real hair color. Thanks to our proprietary color calibration using the color checker, MAMBO is able to deliver reliable Lab measurement of the hair swatch color.

Using MAMBO, it is possible to create color database and to compare measurement to the DATABASE elements using the Lab distance (Delta E) formula.

$$\Delta E = \sqrt{(L_{meas.} - L_{element})^2 + (a_{meas.} - a_{element})^2 + (b_{meas.} - b_{element})^2}$$

It is possible to calculate Delta E between the color measurement and each element of the database in order to identify the closest color database element. If $\Delta E < 2.3$, the color difference is not noticeable.

MAMBO uses that formula to analyze database and identify color element that are very similar

13. Technical Specifications

Measurement Size	12.56 mm x 12.56 mm
Image size	1,500 x 1,500 pixels
Camera	USB 3.00 12 bits color
Power Supply	12 Vdc
Software	MAMBO 1.40
Operating system	Windows 10/11
Camera computer connection *	USB 3.00
DATA Output*	8 bits monochrome image in png Text files – Lab values
Calibration	Factory calibrated
Power requirement	110/220 VAC 50/60 Hz