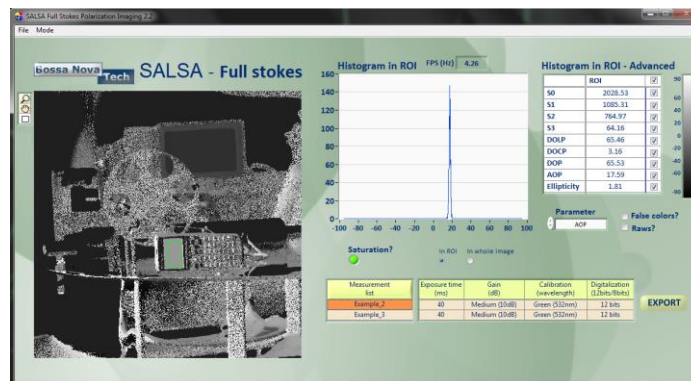




SALSA

Full Stokes Polarization Imaging 2.3.6



SOFTWARE User Manual

Version 2.3.6

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1 About this manual

This Manual describes *SALSA Full Stokes Polarization Imaging* software. Use this manual as a reference when working with your SALSA camera.

2 Copyright and Manual Notice

Bossa Nova Vision reserves the right to make any change to this manual and to the items described therein without prior 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.

3 SALSA camera overview

Polarization imaging has been widely used in various scientific fields. Mainly achieved by rotating linear polarizers combined with various wave plates, polarization imaging has been restricted to laboratory experiments on inanimate objects. Thanks to the recent technical improvement in liquid crystal technology, it is now possible to acquire polarization image in real time (using an Optical Active Filter). SALSA is an Advanced Vision System of Polarization Imaging. It allows fast acquisition of 4 polarization images that are acquired successively at video framed rate. The analysis of those 4 images allows calculating the polarization state of each pixel of the camera. The polarization state of an object depends on the polarization state of the illuminating environment, on physical properties of the object (water, window, metallic surfaces, etc.) and geometrical parameters (angle of incidence of light and angle of observation). The Liquid Crystal elements are extremely sensitive to the temperature. **In order to work at its best performances, the camera needs to be operated in a temperature-controlled environment: 21°C to 25°C. A stabilization period of 30 to 45min is also necessary to reach the best capabilities.**

4 Analysis performed with SALSA camera

The Stokes vector contains 4 parameters [S_0 , S_1 , S_2 , S_3]. Therefore, at least 4 measurements are necessary in order to estimate its value. The SALSA camera is based on "Division of Time polarimeter" architecture. It encloses a patented polarization modulator that changes the polarization state between each frame acquired. The SALSA camera acquires 4 consecutive images called **raw frames** (referred as "**Raws**") and computes the corresponding Stokes vector for each pixel of the scene. The 4 intensity values measured (the "**Raws**") are related to the incident Stokes vector according to the **Eq.1** below:

$$\mathbf{X} = \begin{bmatrix} I_{raw1} \\ I_{raw2} \\ I_{raw3} \\ I_{raw4} \end{bmatrix} = \mathbf{C} \cdot \begin{bmatrix} S_{0,in} \\ S_{1,in} \\ S_{2,in} \\ S_{3,in} \end{bmatrix} \quad \widehat{\mathbf{S}}_{in} = \mathbf{C}^{-1} \cdot \begin{bmatrix} I_{raw1} \\ I_{raw2} \\ I_{raw3} \\ I_{raw4} \end{bmatrix}$$

Eq.1: Intensities measured by the camera **Eq.2:** Estimation of the incident Stokes vector

The matrix **C** is a 4 x 4 calibration matrix of the camera. Its values are obtained through a calibration procedure performed at Bossa Nova Vision's laboratory. The polarization modulator features a different response depending on the wavelength; therefore, a calibration is performed with each filter and the user will have to select the right mode once in live mode ([Section 7](#)).

Once the Stokes parameters are known, the polarization data is calculated according to **Eq.2** and displayed on the screen. This process is continuously repeated. In video mode, only the Raws are acquired and saved into .avi file. A post-processing step will be necessary in order to convert the films into a polarization data film ([Section 10](#)).

5 SALSA Full Stokes Polarization imaging software overview

SALSA Full Stokes Polarization Imaging software combines basic and advanced features to use the SALSA camera.

SALSA Full Stokes Polarization Imaging allows to:

- Control the polarization camera
- Acquire polarization images and short movies at a video frame rate
- Calculate/visualize advanced polarization images (Degree Of Polarization, Angle Of Polarization, Ellipticity, etc.).
- Load various saved measurements

6 Camera first use

Please follow indications given in the document **SALSA Quick Start** in order to plug the different cables properly to the computer and controller. Run the software by double clicking on the SALSA 2.3.6 software icon. The following prompt screen should pop up:

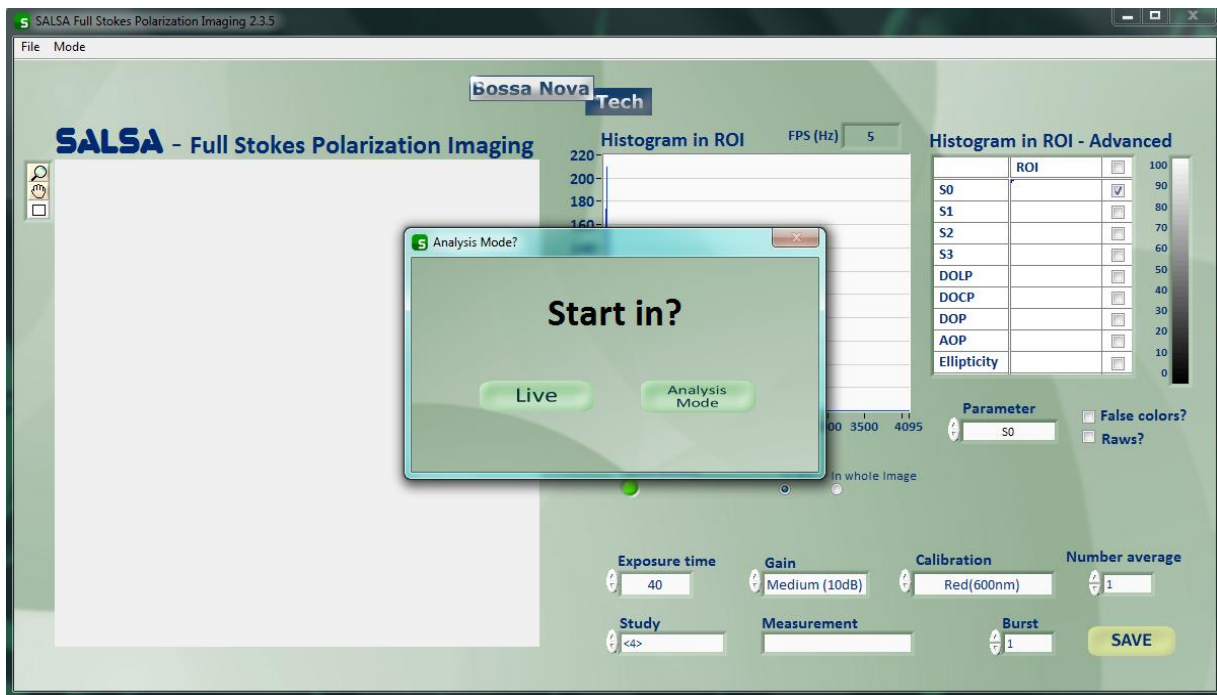


Figure 1: SALSA Full Stokes Polarization Imaging front panel

Please select **“Live Mode”**. The **“Analysis Mode”** will be described in [Section 11](#).

7 Live Mode

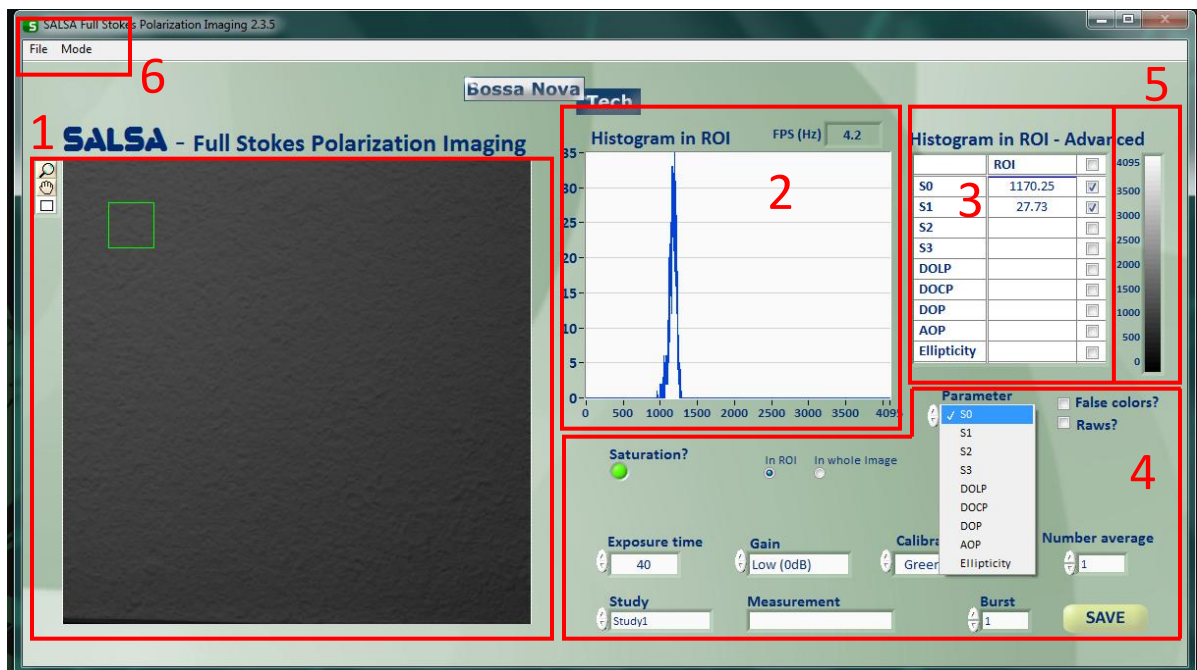


Figure 2: Live Mode.

7.1 Overview

The front panel (Figure 2) is composed of six parts:

1. Live image: Display the selected parameter.
2. Histogram in Region Of Interest (ROI): Draw an ROI on the live image and visualize its histogram for the selected parameter (see Figure 2 and [Section 7.2](#)).
3. Histogram in ROI – Advanced: In addition to the live image the software can calculate other polarization parameters averaged within the ROI (See Figure 2 and [Section 7.2](#)).
4. Camera and live settings: Allows selecting the **Exposure time** (1 to 200ms) and the **Gain** of the sensor (see Figure 2 and [Section 7.3](#)). Also it indicates if parts of the images are saturated. If so, the **Exposure time**, the **Gain** or the lens' aperture should be reduced.

The live settings allow to select:

- a. The live **Parameter** to be displayed (top left): S_0 , S_1 , S_2 , S_3 , DOLP, DOCP, DOP, AOP, Ellipticity
 - b. The **Calibration** mode (Red, Green, Blue) according to the filter that is used (in case you purchased the custom filter wheel, changing the calibration mode will also switch the filter)
 - c. **Raw**s: This will display the raw images and their histograms. This option is to be used in case of a saturation to adjust the intensity.
 - d. **False color**: some parameters (S_1 , S_2 , S_3 , AOP, Ellipticity) can be displayed using a false color encoding.
5. Color Bar: Display the color coding and the scale for the image displayed.
 6. Menu bar: Allows to change the operating mode to "Processing", "Visualization", "Movie Center", "Live", and to exit the software.

7.2 Data in ROI

The **Histograms** on panels [1, 2] are related to the live image displayed in the live image. A ROI is a **Region Of Interest (ROI)**. It is a user-defined rectangular area drawn on the visualization window. The polarization data are averaged within this ROI and displayed in the panels 2 and 3 (Figure 2). The averaging is made on the Stokes parameters which are linear in intensity (the signal to noise ratio of the measurement increases with the

size of the ROI). Additional polarization parameters (DOLP, DOCP, DOP, AOP, Ellicpticity) are computed from these averaged Stokes parameters. The user can select which parameters to be computed, in addition to the one being displayed (Figure 3). In live mode all parameters are computed in live. Therefore, the acquisition frame rate will be reduced if many of them are calculated at the same time. However, in **Visualization Mode** ([Section 9](#)) or **Analysis Mode** ([Section 11](#)) all parameters will be automatically selected.

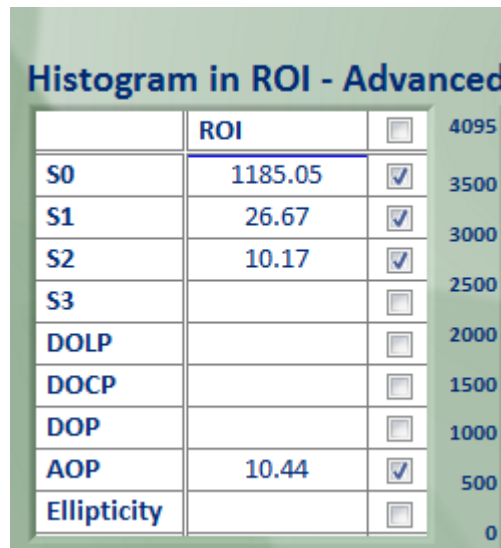


Figure 3: Polarization parameters to be computed

7.3 Camera Settings



Figure 4: Camera Settings

The **Camera Settings [4]** allow:

- Adjusting the **Exposure time** of the camera from 1ms to 200ms.
- Adjusting the **Gain** of the camera sensor; three pre-set values are available: Low (0dB), Medium (10dB), High (22dB).
- Select whether to detect saturated pixels (**Saturation** indicator) over the whole image or only inside the ROI. This indicator warns the user when a saturation occurs on one of the raw frames.

If the **Saturation** indicator turns red, it means at least one raw image contains saturated pixels. The user can visualize the images by clicking the box “**Raws**” on the **Live Settings** panel. The corresponding histograms will be displayed on part 1 (Figure 2). The user has to reduce the **Exposure time**, the **Gain** or the lens’ aperture in order to have the 4 histograms fitting within a [0; 4095] level range. Then the **Saturation** indicator will turn green again.

7.4 Parameters - Value

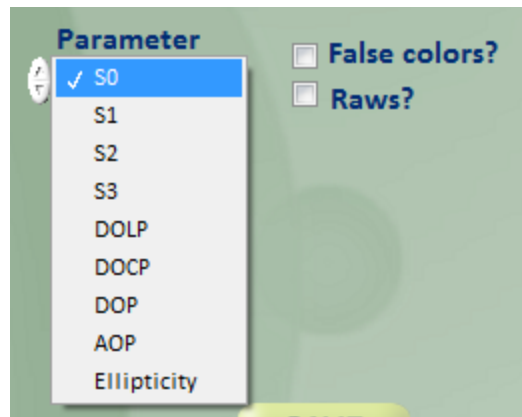


Figure 5: Parameter mode

By clicking on the Parameter control the user can select the polarization parameter to be displayed. Each of them is described below.

7.4.1 S_0

$$S_0 = I_{0^\circ} + I_{90^\circ}$$

The equation above is the theoretical definition. This image is the normal intensity image. It represents what would be seen using a regular camera.

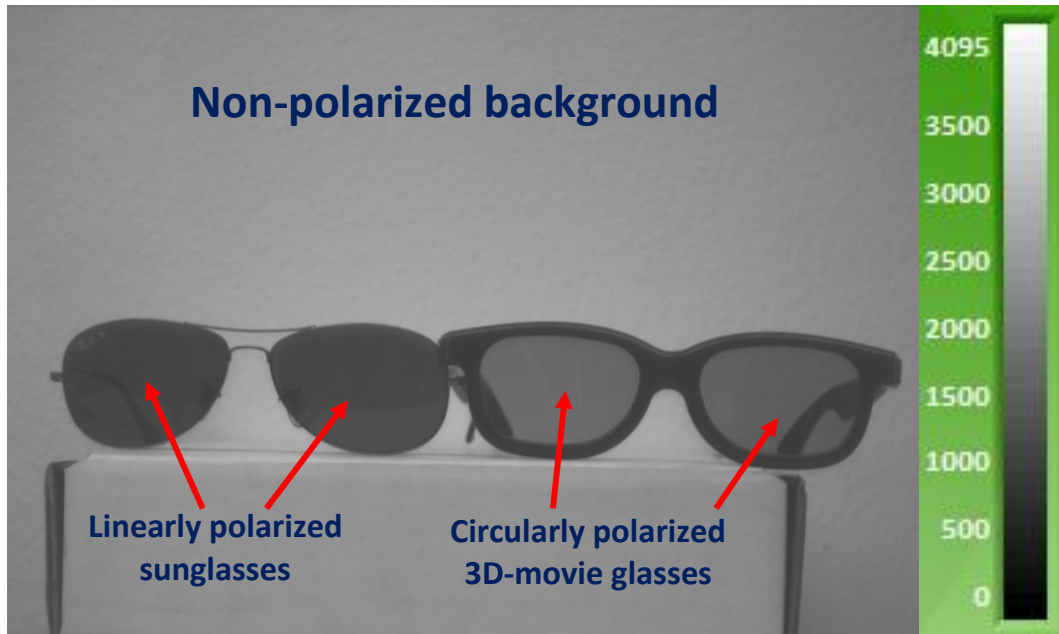


Figure 6: Intensity image S_0

This image is not just an average of the raw frames; it is calculated with the first line of the calibration matrix and the raw frames vector, according to Eq.2 ([Section 4](#)). Values range from 0 to 4095 as the digitalization of the sensor is 12-bits.

7.4.2 S_1

$$S_1 = I_{0^\circ} - I_{90^\circ}$$

This is the second Stokes parameter, defined by the equation above. It represents the light that is either horizontally (0°) or vertically polarized (90°). These areas appear bright whereas the non-polarized light appears dark. The user can also select the **False color** option. The light polarized horizontally (positive values) will appear Red, the light polarized vertically (negative values) will appear Blue. Non-polarized light (values close to 0) will remain dark. On figure 8 one can notice the sunglasses appear bright on both views whereas the background and the circularly polarized glasses are dark.

This image is not calculated using the theoretical equation above; it is calculated with the second line of the calibration matrix and the raw frames vector, according to Eq.2 ([Section 4](#)). Values range from -2047.5 to 2047.5.

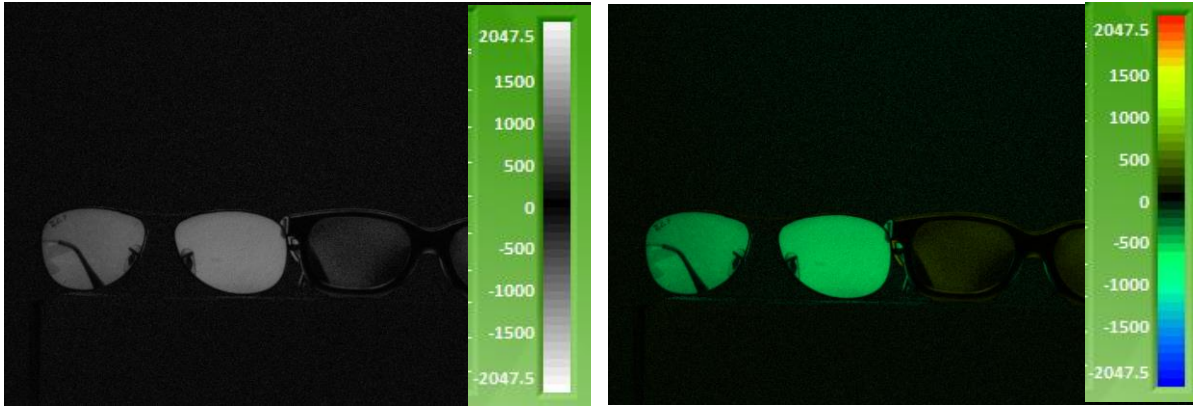


Figure 7: Stokes image S_1 . (a)Mono, (b)False Color

7.4.3 S_2

$$S_2 = I_{45^\circ} - I_{-45^\circ}$$

This is the third Stokes parameter. It represents the light that is either 45° or -45° polarized. These areas appear bright whereas the non-polarized light appears dark. The user can also select the **False color** option. The light 45° polarized (positive values) will appear Red, the light -45° polarized (negative values) will appear Blue. Non-polarized light (values close to 0) will remain dark. On Figure 8 one can notice the both pair of glasses appear dark on both views.

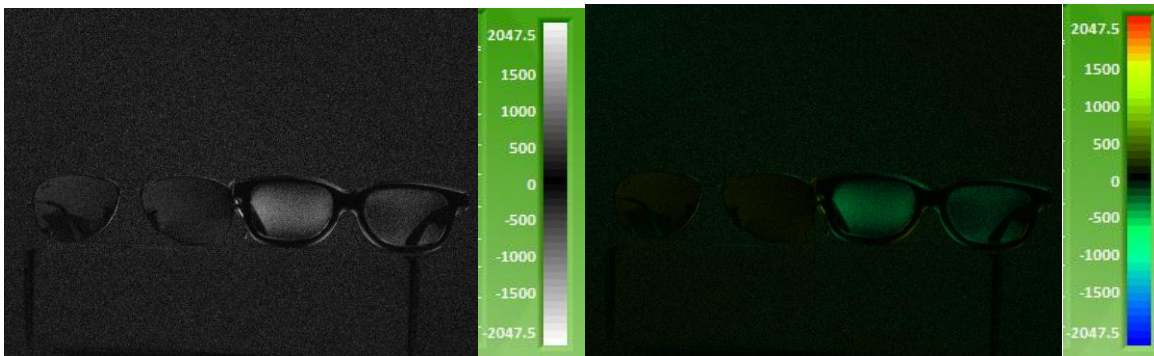


Figure 8: Stokes image S_2 . (a)Mono, (b)False Color

This image is not calculated using the theoretical equation above; it is calculated with the third line of the calibration matrix and the raw frames vector, according to Eq.2 ([Section 4](#)). Values range from -2047.5 to 2047.5.

7.4.4 S_3

$$S_3 = I_{lh} - I_{rh}$$

This is the fourth Stokes parameter. It represents the light that is either circular-left (counter clock wise) or circular-right polarized (clock wise). These areas appear bright whereas the non-polarized light appears dark. The user can also select the **False color** option. The light circular-left polarized (positive values) will appear Red; the light circular-right polarized (negative values) will appear Blue. Non-polarized light (values close to 0) will remain dark. On Figure 9 one can notice the 3D-movie glasses appear bright on the mono color view whereas the background and the linearly polarized sunglasses are dark. On the false color view, the colors are different for each glass meaning one is left-handed and the other is right-handed circularly polarized.

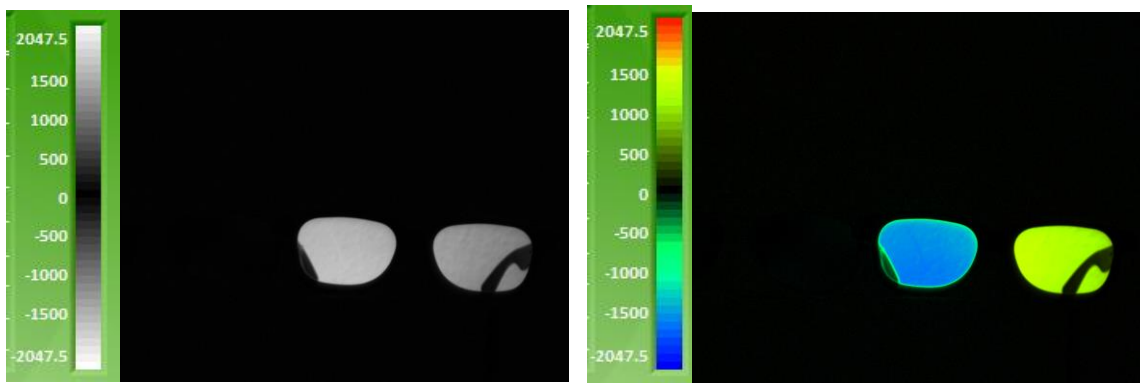


Figure 9: Stokes image S_3 . (a) Mono, (b) False Color

This image is not calculated using the theoretical equation above; it is calculated with the fourth line of the calibration matrix and the raw frames vector, according to Eq.2 ([Section 4](#)). Values range from -2047.5 to 2047.5.

7.4.5 DOLP: Degree Of Linear Polarization

$$DOLP = \frac{\sqrt{S_1^2 + S_2^2}}{S_0}$$

This displays the Degree of Linear Polarization (DOLP) for each pixel of the scene. Bright areas are associated with high degree of linear polarization (reflections, dark surfaces, polarizers...) whereas dark areas are associated with low degree of linear polarization (diffusive surfaces, white surfaces...). Dark objects are often associated with high degree of polarization as most of their light comes from reflection from the object surface. Very dark areas of the object will appear noisy as the determination of the degree of polarization is less accurate if there is only little light from the object. On Figure 10, the

linearly polarized sunglasses appear bright, so does the 3D-glasses rim, because of the specular reflection.

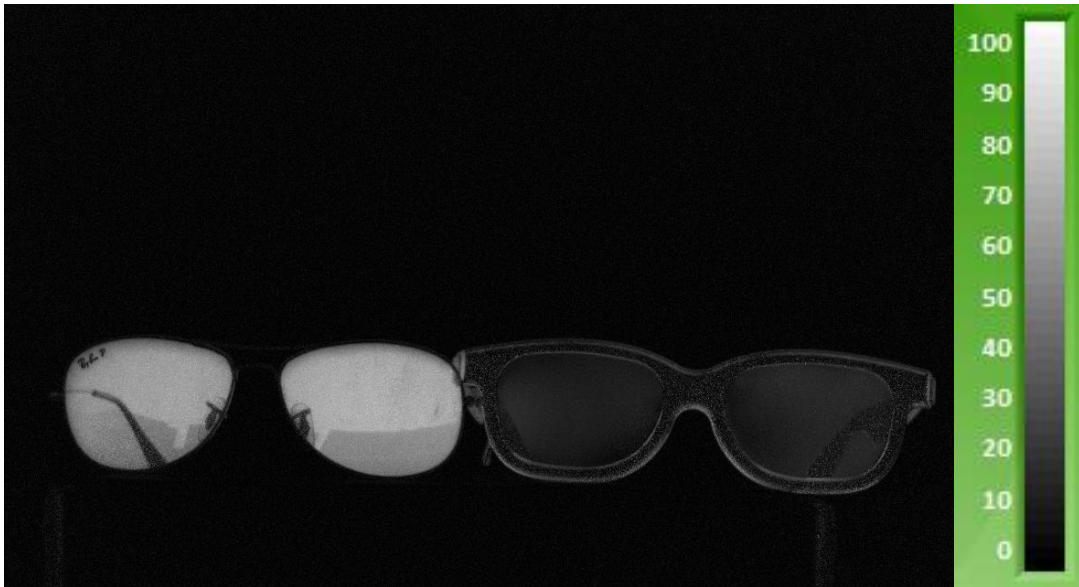


Figure 10: Degree Of Linear Polarization (DOLP) image.

As mentioned on [Section 7.2](#), the calculation of the DOLP's mean value within the ROI is made by averaging the Stokes parameters first in order to reduce the noise.

7.4.6 DOCP: Degree Of Circular Polarization

$$DOCP = \frac{|S_3|}{S_0}$$

This displays the Degree Of Circular Polarization (DOCP) for each pixel of the scene. Bright areas are associated with high degree of circular polarization (birefringence, mechanical stress...) whereas dark areas are associated with low DOCP. Very dark areas of the object will appear noisy as the determination of the degree of polarization is less accurate if there is only little light from the object. On Figure 11 one can notice that only the 3D-movie glasses appear bright. However it is not possible to differentiate if left or right circular polarization is involved as the definition uses the absolute value of S_3 .



Figure 11: Degree Of Circular Polarization (DOCP) image.

As mentioned on [Section 7.2](#), the calculation of the DOCP's mean value within the ROI is made by averaging the Stokes parameters first in order to reduce the noise.

7.4.7 DOP: Degree Of Polarization

$$DOP = \frac{\sqrt{S_1^2 + S_2^2 + S_3^2}}{S_0}$$

This displays the Degree Of Polarization (DOP) for each pixel of the scene. It combines all the Stokes parameters to provide a global ratio about the amount of polarized light. Bright areas are associated with high DOP whereas dark areas are associated with low DOP. On Figure 12 one can notice that now both pair of glasses appear bright. The 3D-movie glasses are brighter than the sunglasses indicating the polarization effect is stronger. It is not possible to differentiate linear from elliptical or circular polarization.

As mentioned on [Section 7.2](#), the calculation of the DOCP's mean value within the ROI is made by averaging the Stokes parameters first in order to reduce the noise.



Figure 12: Degree Of Polarization (DOP) image.

7.4.8 Angle of Polarization (monochrome)

$$\alpha = \frac{1}{2} \text{Arg}(S_1 + iS_2)$$

This displays the Angle Of Polarization on the image. When light is partially or totally linearly polarized any angle of polarization of -90° will be displayed as black, and angle of polarization of 0° will be displayed as medium gray, and an angle just below 90° as white. This visualization leads to a “jump” as the angle around -90° and 90° (which represents the same state of polarization) are displayed as black if just above -90° and white if just below 90° . Image of the AOP can appear noisy because of this jump. Parts of the image associated with very low degree of polarization will appear noisy as well in Angle Of Polarization image. On Figure 13 one can see this effect on the sunglasses. They polarize the light partially, with a vertical orientation (-90° or 90°). This is why the sunglasses appear white on an AOP image, with some black pixel. The background is non-polarized so it appears very noisy.

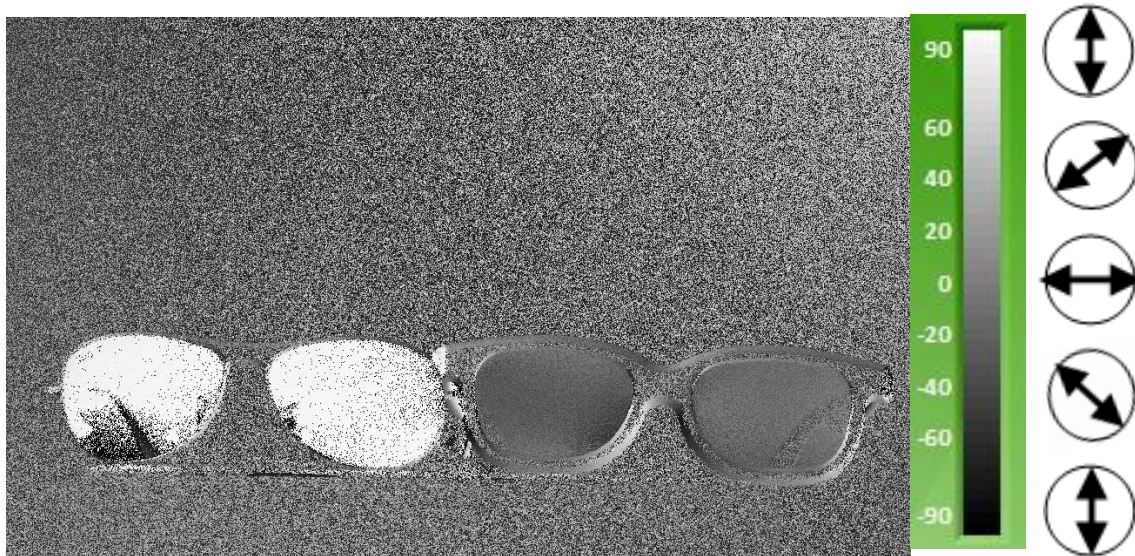


Figure 13: Angle Of Polarization (AOP) image - Monochrome

7.4.9 Angle Of Polarization as color hue

The user can select the **False color** option. It will display The Angle Of Polarization (AOP) as a color hue image. The hue is a circular visualization just like the AOP. The jump between -90° and 90° orientation disappears with this visualization. The link between color hue and angle of polarization is summarized in below.

Angle of Polarization	Color hue
-90°	Red
-60°	Yellow
-30°	Green
0°	Cyan
30°	Blue
60°	Magenta
90°	Red

This visualization is much easier to understand than the display as gray values. However areas with very low degree of polarization will remain noisy. On Figure 14 the sunglasses (vertically polarized) now appear in red.

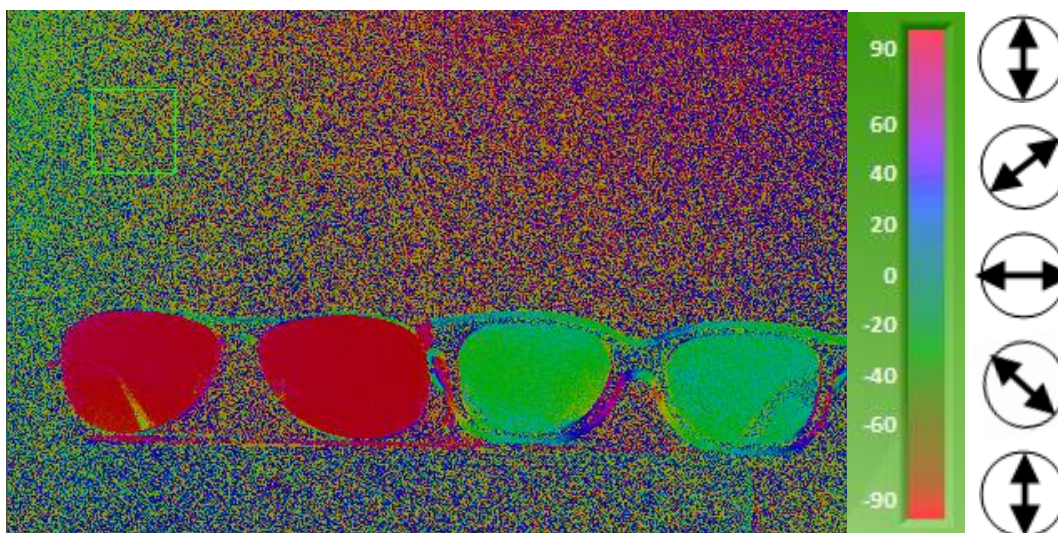


Figure 14: Angle of polarization (AOP) as a color HUE image.

7.4.10 Ellipticity (monochrome)

$$\varepsilon = \frac{1}{2} \text{Arcsin}\left(\frac{S_3}{S_0}\right)$$

This displays the Ellipticity angle on the image. The scale used is the same as the one for the Angle Of Polarization. An ellipticity angle of -45 degree will be displayed as black, and an ellipticity angle of 45 degrees will be displayed as medium gray.

In presence of partially elliptically polarized light several parameters can be measured to characterize that state. One of them is the Ellipticity, which can be geometrically visualized using the representations described on Figure 15.

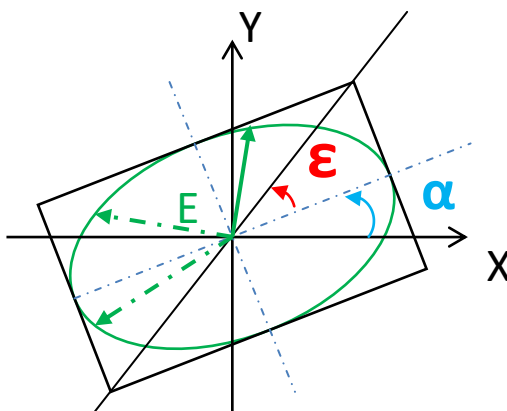


Figure 15: Elliptical polarization

The tip of the electric field vector describes an ellipse in a fixed plane crossing and orthogonal to the direction of propagation. This ellipse can be characterized by two specific angles α and ϵ .

- α is the angle between the ellipse major axis and the reference orientation axis (X-axis). It is also the **Angle Of Polarization** parameter.
- ϵ is the ellipticity angle. It ranges between $[-45^\circ; 45^\circ]$. An ellipticity of 0° means the light is either partially or totally linearly polarized. Geometrically the ellipse is degenerated into a line. An ellipticity of $\pm 45^\circ$ means the light is partially or totally circularly polarized. The sign gives the orientation: positive angle means a left-handed circular polarization state whereas negative means right-handed circular polarization.

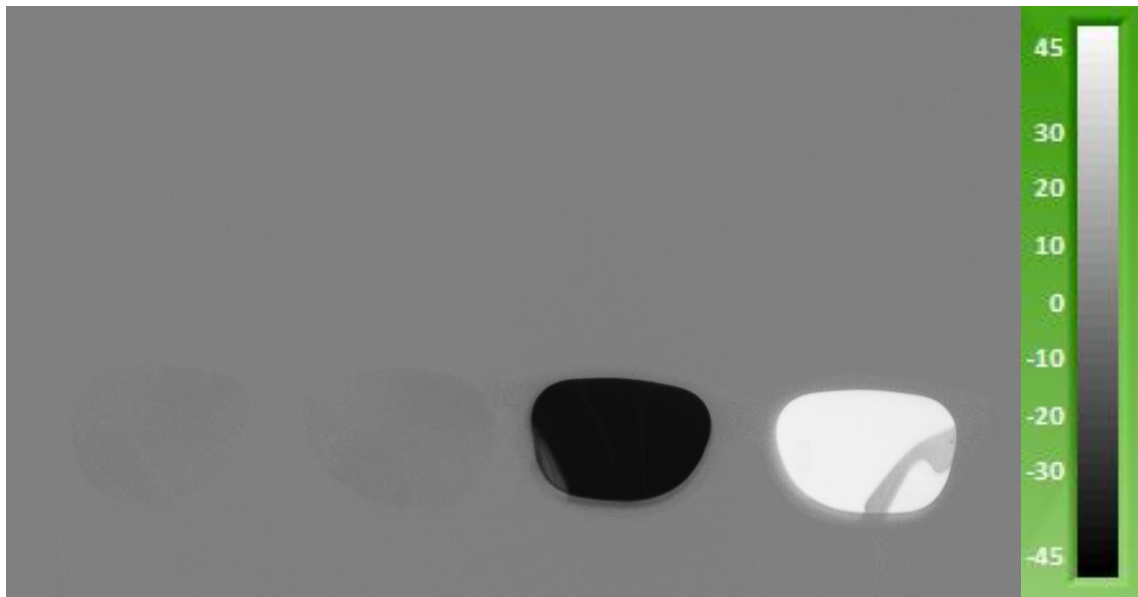


Figure 16: Ellipticity angle image

On Figure 16 one can distinguish now the left glass of the 3D-movie glasses feature an ellipticity angle of almost -45° , meaning it is right-handed circularly polarized. On the other hand, the right glass appears to have a 45° ellipticity angle which means it is left-handed circularly polarized.

7.4.11 Ellipticity as color hue

As for the AOP parameter, the user can select the **False color** option and it will display the Ellipticity angle with a false color coding. The color coding is the same as for the S_3 parameter, left-handed circularly polarized light ($+45^\circ$ ellipticity) will appear red and right-handed circularly polarized light (-45° ellipticity) will appear blue (Figure 17).

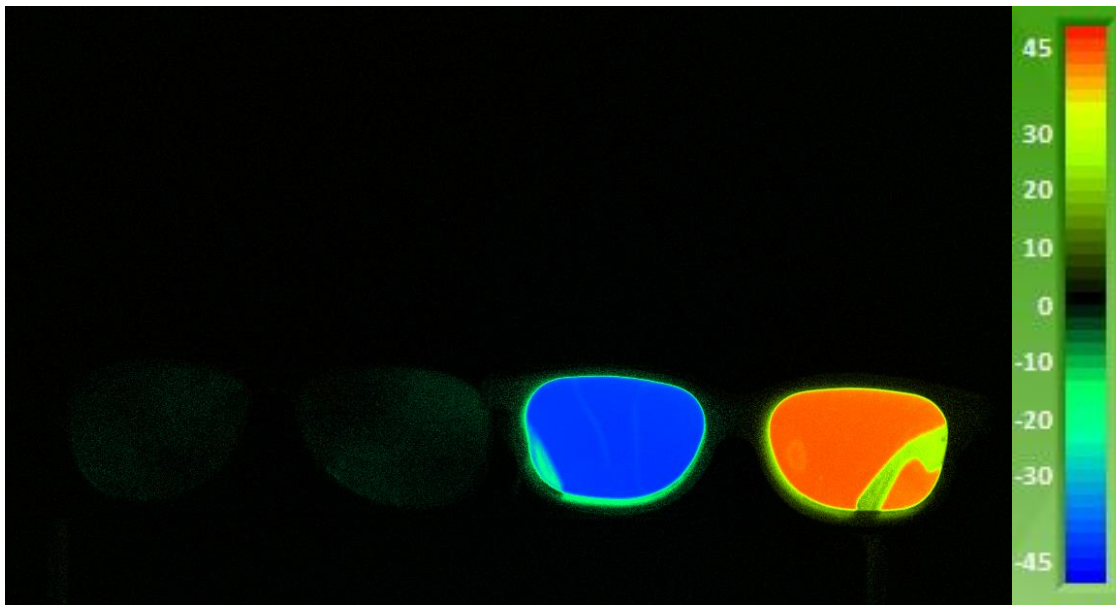


Figure 17: Ellipticity angle – false color

7.5 Calibration (wavelength)

The SALSA camera can operate at different wavelength. The camera acquires 4 images successively, called raw frames. Then a calibration matrix is used to calculate the Stokes parameters from these 4 raw images. This matrix is different for each color filter. A calibration process is performed by Bossa Nova Vision in order to calculate these matrices. The user has to select the right calibration mode (the one matching the color filter) as shown on Figure 18.

Exposure time	Gain	Calibration	Number average
40	Low (0dB)	☒ Blue(395/480nm) ☐ Green(520/550nm) ☐ Red(600nm)	1
Study	Measurement		
Study1		1	

SAVE

Figure 18: Calibration Mode

The standard version of the camera is calibrated for one single wavelength of the visible spectrum. For additional calibrations, please contact Bossa Nova Vision.

If you are using the custom version of the SALSA camera that comes with a motorized filter wheel, changing the calibration will automatically switch the position of the wheel for the right filter.

7.6 Number average



Figure 18: Number average

The SALSA camera can operate an average of up to 10 measurements selected by the number enter in “Number average” (by default, this number is one which means no averaging process).

The operation of the camera consists of acquiring sets of 4 raw frames and makes an average of all raw frames independently.

Note that if you increase the number average, the acquisition time will increase since the camera will now take 4xNumber average frames to reconstruct a polarized image.

Taking images with this method, when there is no time-dependency of the system, is recommended since it permits to reduce random signal noise measurements.

It is also possible to save images taking with this method using the “save image” procedure described below.

7.7 Raws

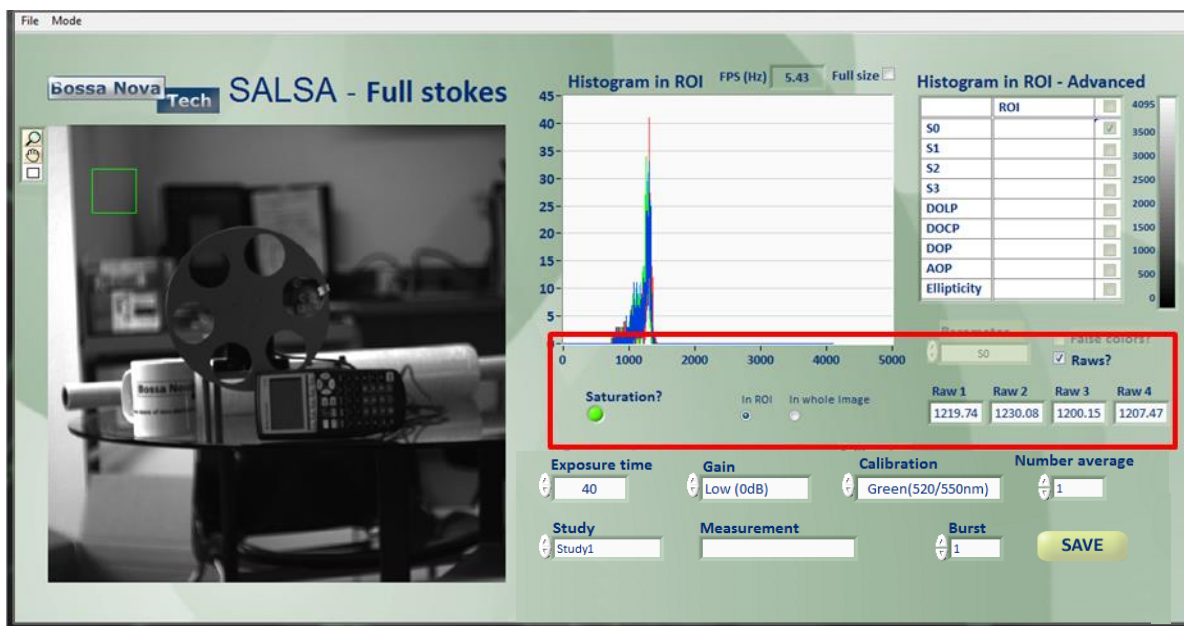


Figure 19: Raws mode

This mode allows to visualize the raw frames. There is no processing at all, the images are just acquired and displayed. The live histogram of each frame is displayed as well.

Live raw images are useful to set the camera focusing, to aim the camera at the target and to make sure none of the frames is saturated. The user can select whether to calculate the histograms and detect the saturated pixels over the whole image or only inside the Region Of Interest.

7.8 Save Image



Figure 20: Save image

Images can be saved very quickly using the button “SAVE” at the bottom left of the front panel. All images saved are organized in “Studies”. Each study can contain as many “Measurements” (image saved) as necessary. The user has to select a “Study” and enter a “Measurement” name before clicking on “SAVE”. It is possible to create/delete a “Study” in the “**Processing Mode**” ([Section 8](#)).

It is also possible to acquire and save several images in a row (up to ten images at a time) by selecting the value of the “Burst”. They will be saved as “myMeasurement_1, my_Measurment_2, ...”.

Any saved images needs to be processed before being able to visualize it. The “**Processing Mode**” ([Section 8](#)) allows to manage all past measurements. It will be described in the next part.

The images are saved in a folder at a specific location on the SALSA’s PC hard drive: **“C:/SALSA 2.3.6/DATA/StudyName/myMeasurement”**. **Do not delete that folder directly or you will not be able to see your past Studies and Measurement in the Processing Mode.**

You will be able to Export your data in any format (text file, image PNG) at a specific location using the Export option in the **Visualization Mode** ([Section 9](#)).

8 Processing Mode

The **Processing Mode** is selected from the main menu as on Figure 21.

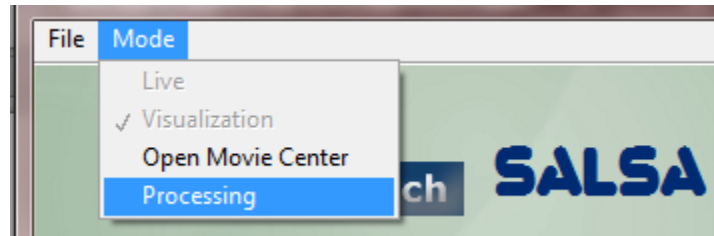


Figure 21: Menu: Select Processing Mode

This mode allows the user to manage all past measurements saved since the SALSA camera's first use.

8.1 Overview

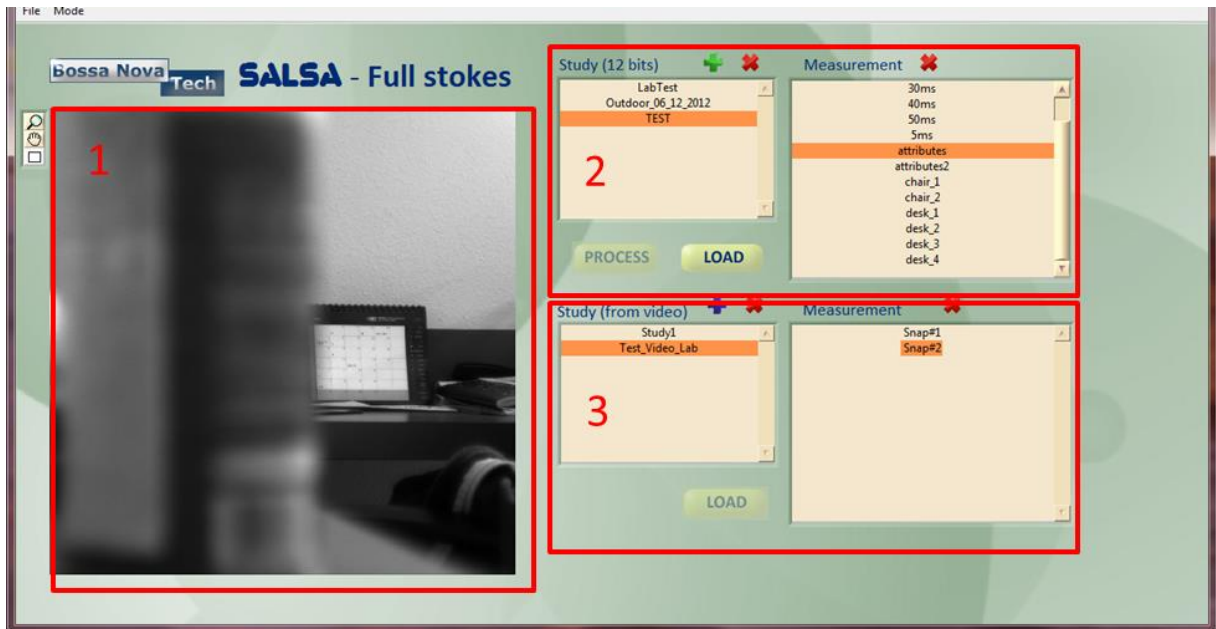


Figure 22: Processing Mode - Front Panel

The front panel (Figure 22) is composed of 3 parts:

1. Image Preview: Display the first raw frame corresponding to the selected measurement.
2. Study and Measurement from Live Mode: Lists all the studies the user created (list on left part) and all the measurements contained in each study (right) for the **Live Mode** (12 bits). The user can process, load for visualization, or delete any measurement. Studies can be created or deleted as well.

3. Study and Measurement from Live Mode: Lists all the studies the user created (list on the left part) and all the measurements contained in each study (right) for the **Video Mode** (8 bits). The videos are mainly managed inside the Movie Center; however, images can be extracted from any movie. They will be saved and managed in the same way as the ones from the **Live Mode**.

8.2 PROCESS a measurement

When an image is saved from the live mode, only the 4 raw frames are actually saved on the PC's hard drive. The images of polarization parameters (S_0 , S_1 , S_2 , S_3 , DOLP, DOCP, DOP, AOP, Ellipticity) need to be calculated for visualization. This is what happens during the **processing**.

The user has to select one of several measurements from a "Study" and click on the "Process" button (Figure 23).

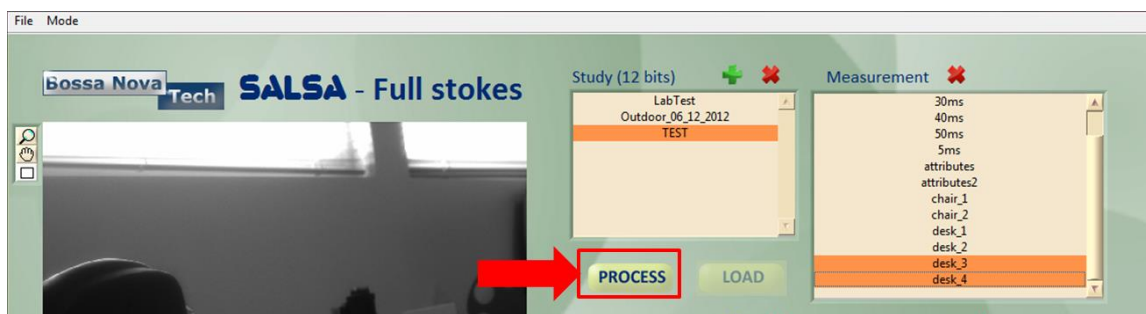


Figure 23: Processing Mode - Front Panel

It is not recommended to process too many measurements at a time as it requires much of the PC's resources.

Once the measurements are processed it is possible to "LOAD" them for visualization.

8.3 LOAD a measurement

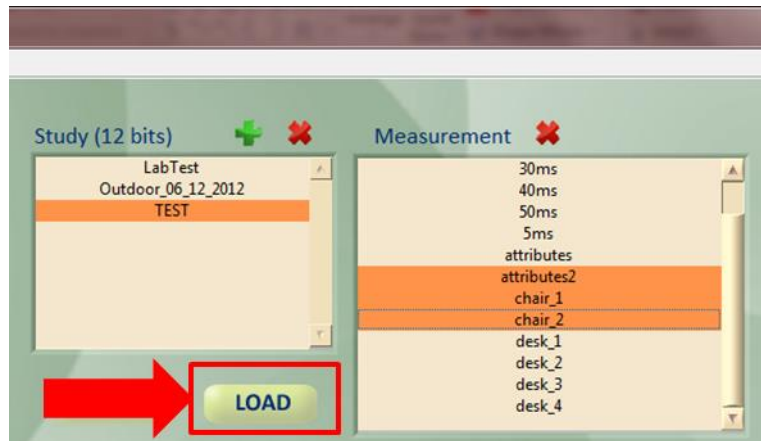


Figure 24: Processing Mode - 12bits

Once a measurement has been processed ([Section 8.2](#)), it is possible to visualize in the main window, and to study any of its polarization parameters.

Select one of several measurements (up to 5 at a time), and click on the “LOAD” button located at the bottom right. You can now switch to the **Visualization Mode** by selecting it on the menu bar.

It may take a few moments to load all the images, especially when selecting several measurements.

8.4 Create/Delete a Study or a Measurement

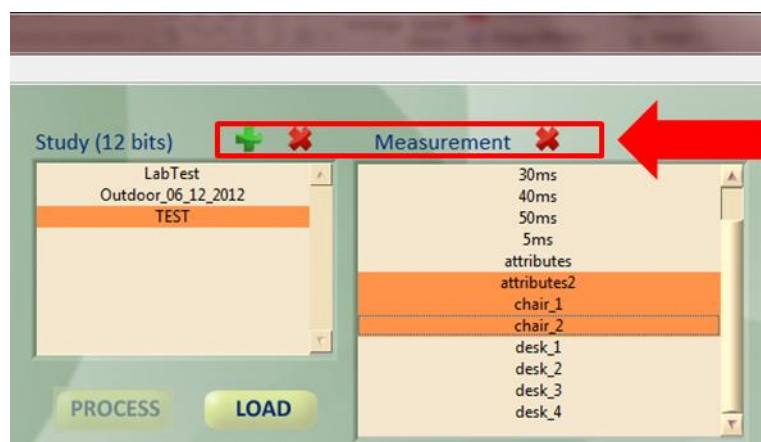


Figure 25: Processing Mode - Create/delete Studies and Measurement

The Studies can be created using the  button. You will be prompted to enter the new study name:



Figure 26: Create Study

The Study list will be instantly updated on the **Live Mode**.

The Studies and Measurements can also be deleted using the  button.

Similar controls exist for the Studies and Measurements related to the 8-bit mode (Polarization movies).

It is possible to create/delete studies directly by creating/deleting the corresponding folders. They are located at the following location:

"C:/SALSA 2.3.5/DATA/Study/myMeasurement"

DO NOT DELETE THE ENTIRE DATA FOLDER. ALL PAST MEASUREMENT WOULD BE LOST. It is therefore preferable to manage the Studies and Measurements from the SALSA 2.3.6 software.

9 Visualization Mode

The **Visualization Mode** is selected from the main menu as on Figure 27.

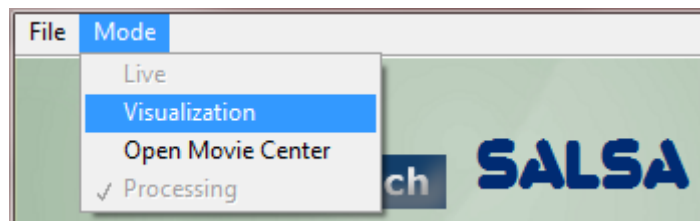


Figure 27: Select Visualization Mode

This mode allows the user to visualize and study any past measurements processed and loaded from the **Processing Mode**.

9.1 Overview

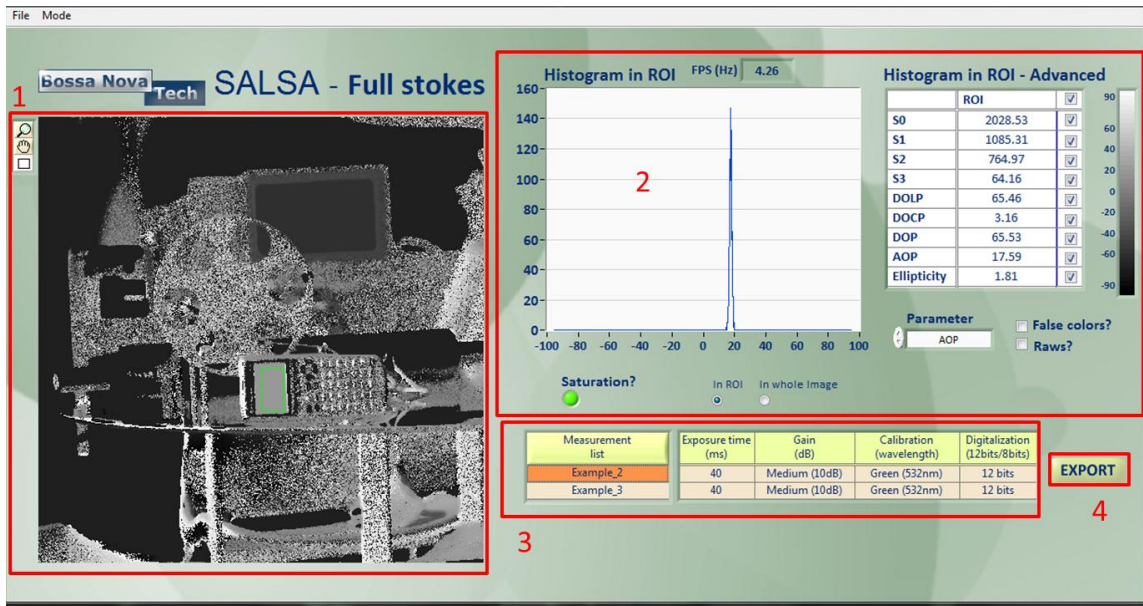


Figure 28: Visualization Mode - Front Panel

The **Visualization Mode** front panel is very similar to the **Live Mode** (Figure 28). The only difference is camera settings, no longer available for modification. It is replaced by a list of the loaded measurements, and their information.

1. Selected image: Display the selected polarization parameter.
2. Polarization parameter selection and ROI information: The user can select to visualize any polarization parameter available in the **Live Mode** ([Section 7](#)) as well as the raw frames. In the **Histogram in ROI - Advanced** panel, all parameters are selected.
3. List of the measurements loaded for visualization: The user can select which measurement to display in the main window. See [Section 9.2](#) for further details.
4. Export current measurement: Allows the user to export any polarization parameter (as txt file or PNG encoded image) at a specific location. See [Section 9.3](#) for further details.

9.2 Measurement list

The measurement list displays (Figure 29) all the measurement that were loaded from the **Processing Mode**.

Measurement list	Exposure time (ms)	Gain (dB)	Calibration (wavelength)	Digitalization (12bits/8bits)	
Snap1	20	High (22dB)	Green(520/550nm)	8 bits	EXPORT
Room_Blue	120	Medium (10dB)	Blue(395/480nm)	12 bits	
Room_Green	70	Medium (10dB)	Green(520/550nm)	12 bits	
Room_Red	70	Medium (10dB)	Red(600nm)	12 bits	

Figure 29: List of measurements

The first column displays the name of the loaded measurements. The array on the right side regroups useful information about the corresponding images. The Exposure Time when the image was saved, the gain of the camera, the calibration and the digitalization. If the image was saved from the **Live Mode**, the digitalization is 12 bits. If the measurement was extracted from a polarization movie ([Section 10](#)), the digitalization is 8 bit. The scale unit will be modified accordingly on the histogram depending on the digitalization.

9.3 Export a measurement



Figure 30: Choose polarization parameters to be exported

Any measurement present in the Visualization Mode can be exported at a chosen location. Click on “EXPORT” and a custom set of polarization images related to the selected measurement will be saved. The user will be asked to enter a folder name to be created. All the files will be saved into this folder. Then, you will be prompted to select which parameters to export (Figure 30). You will have the option to save them as text files, which gives the best precision. This can be re-opened for post-processing in any third-party software, like Matlab, Labview or any image processing language.

All parameters can also be saved as PNG images. Then they can be visualized with any image display software (Windows Photo Viewer, Photoshop, Matlab, Labview, etc.)

A measurement can be exported as many times as required. It will still appear in its study when working with the Processing Mode, unless it has been deleted by the user.

10 Video Mode

The **Video Mode** is selected from the main menu as on Figure 31.



Figure 31: Start Movie Center

10.1 Overview

SALSA allows you to record short 8-bit polarization movies. The movie center can be launched from the menu bar as shown above, in live or analysis mode.

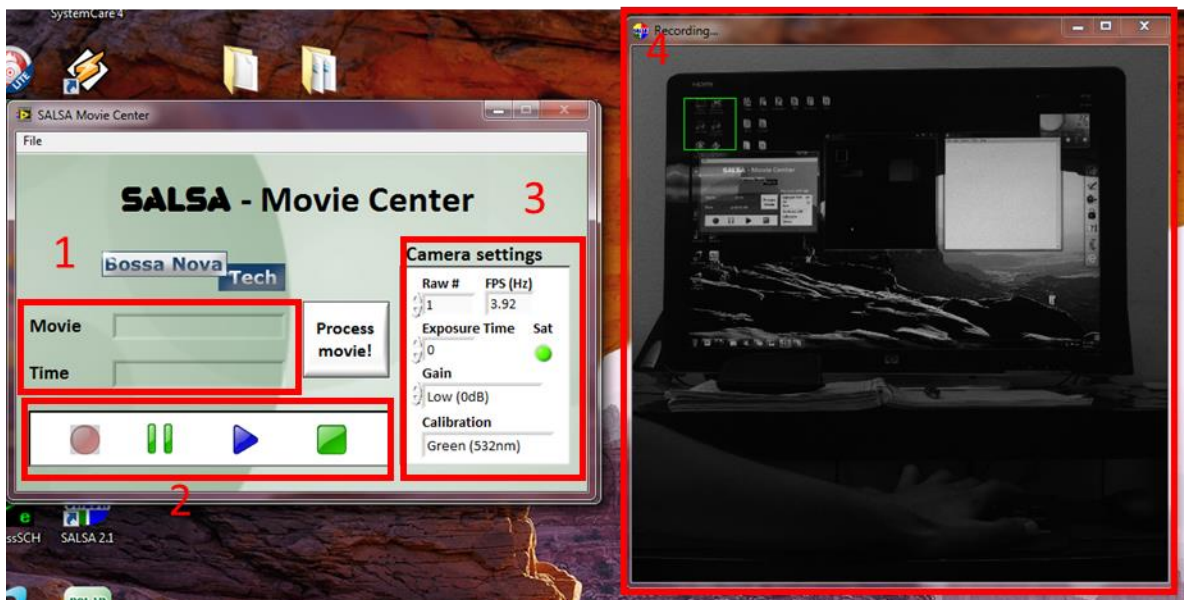


Figure 32: Screenshot of the SALSA Movie Center and the live image.

1. When **Recording** or **Playing** a processed movie this panel shows the movie title, time and frame number.
2. Controls: Basic controls allow the user to Record, Play, Pause and Stop a movie. Only accessible when a movie is played, the button  allows the user to select a particular frame of this movie. In **Analysis Mode** ([Section 11](#)) Record is disabled.
3. Camera settings: Indicates the live settings values: the **Exposure time**, the **Gain**, the **Saturation** (if any within the ROI) and the **Calibration mode** (R, G, B). Only the camera's **Exposure Time** and **Gain** can be changed here. The other live settings are to be set in the **Live Mode**, before switching to the video mode.
4. Live window: Display the live **Raws** images.

10.2 Recording (Live Mode)

Click on Record control to start recording the raw frames. You will be prompted to enter a folder name for the files.

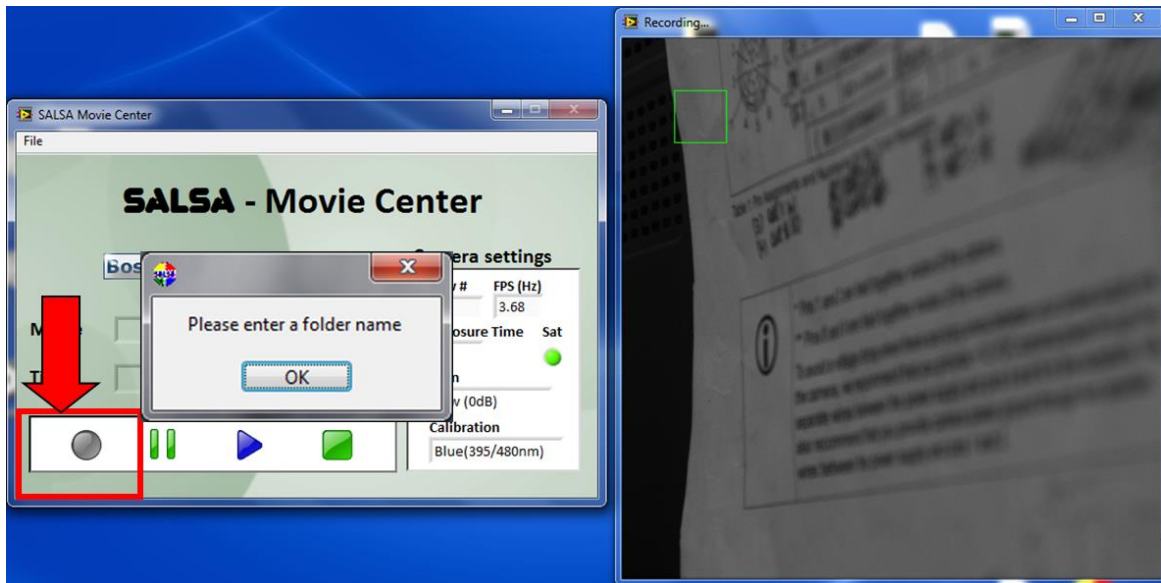


Figure 33: Start recording

The software will start record the 4 raw frames as .avi files: Frame1.avi, Frame2.avi, Frame3.avi and Frame4.avi.

Click on the STOP button when finished. **These movies will have to be processed in order to convert them as polarization movies** ([Section 10.3](#)).

10.3 Process a polarization movie

In live mode, the raw frames are processed, converted to polarization images and displayed in live. In the **video mode** the raw frames are streamed to an AVI file and need to be post-processed to obtain a polarization movie of any available parameter (S_0 , S_1 , DOP, etc.). **The representation in movies for S_1 , S_2 , S_3 is not the same that the one in pictures.** S_1 , S_2 , S_3 are coded such as S_i ($i=1, 2, 3$) = -1 correspond to a pixel value of 0 (black), S_i ($i=1, 2, 3$) = 0 to 128 (grey) and S_i ($i=1, 2, 3$) = 1 to 255 (white). In the case of S_0 , $S_0 = 0$ correspond to a pixel value of 0 (dark) and $S_0 = 1$ to 255 (white) to have access to all dynamic range of the system.

Click on "Process movie". You will be prompted to select one of the Frame#.avi file previously recorded. When recorded with SALSA Movie Center, 4 raw frame movie are saved in the folder. It also creates 3 text files: TIME.txt, Calibration.txt and Parameters.txt. **These files contain various parameters of the acquisition must be in the same folder otherwise the processing may be fatally affected.**



Figure 34: Process a movie

Choose in which polarization parameter you would like to convert the movies. You can select all of them. Then click on "CONVERT".

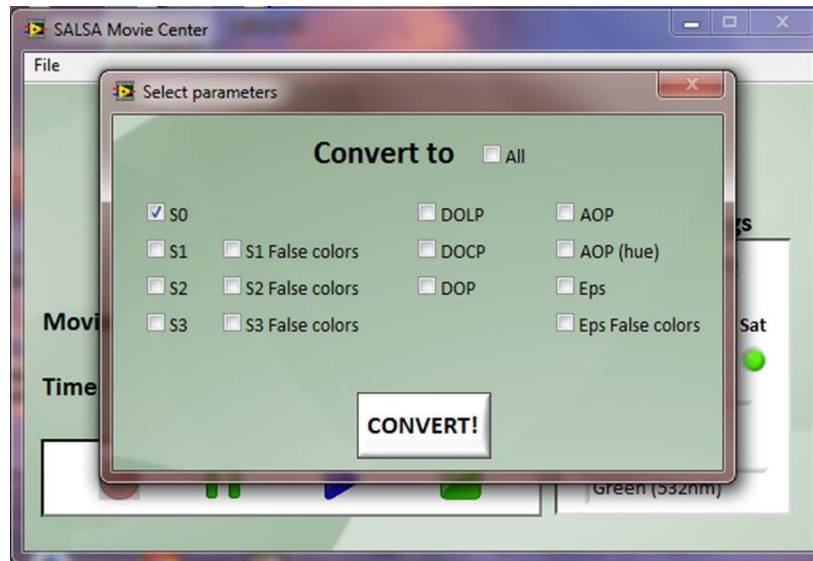


Figure 35: Select the kind of polarization movie to be processed

It may require a certain amount of time to process a polarization movie. The processing time depends on the number of frame (movie duration), and the type of parameter. False color encoding requires a lot of time to be converted. The processing also uses a lot of the computer resources. Depending on the kind of PC you are using, it may slow other application's executions while doing the processing. It is strongly recommended that any other application be closed during the processing.

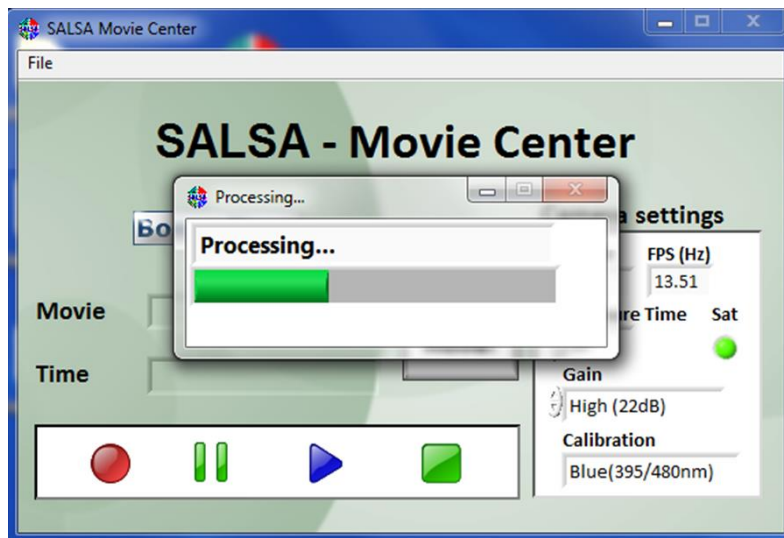


Figure 36: Processing may take a certain amount of time

Once the processing is over the user can play them using this interface or in any video player that can handle AVI files.

10.4 Play/Pause/Save

Once the movies have been converted the user can play them and extract some images for further analysis.

Click on "PLAY". You will be prompted to select a previously converted movie. This refers to a Stokes parameter (S_0 , S_1 , S_2 , S_3) or an advanced polarization parameters (DOLP, DOCP, DOP, AOP, Ellipticity) in Monochrome or false color coding.



Figure 37: Play a converted movie

It is then possible to visualize and PAUSE the film in order to extract an image (see Figure 38) by clicking on "SAVE".

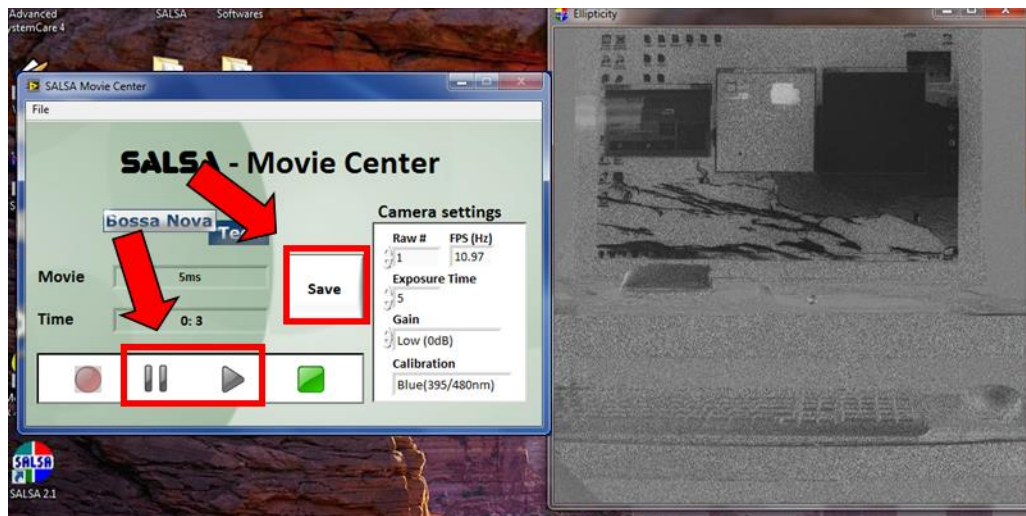


Figure 38: Pause and extract an image from a polarization movie

The images will be saved the same way as in the live mode, as text files. The only difference is that the digitalization of the images is 8-bits instead of 12-bits. Therefore,

the Stokes parameters' dynamic will be 256 compared to 4095 in live mode. The derived parameters DOLP, DOCP, DOP AOP, Ellipticity will keep the same scale but their sensitivity will be lower. The visual aspect of the images might be slightly different from the live mode. The images saved can be re-loaded into the **Processing Mode** for **Visualization**.

When clicking on "SAVE", you will be prompted to choose (or create) a Study and a Measurement name.



Figure 39: Extract an image/select a Study

The images extracted from polarization movies will appear in the lower panel of the **Processing Mode**. They will be arranged in the same way, by Studies and Measurements (Figure 40, panel 3) and can be loaded into the **Visualization Mode**.



Figure 40: Processing Mode. Panel 3 regroupes the Studies and Measurements extracted from Videos.

10.5 Exit

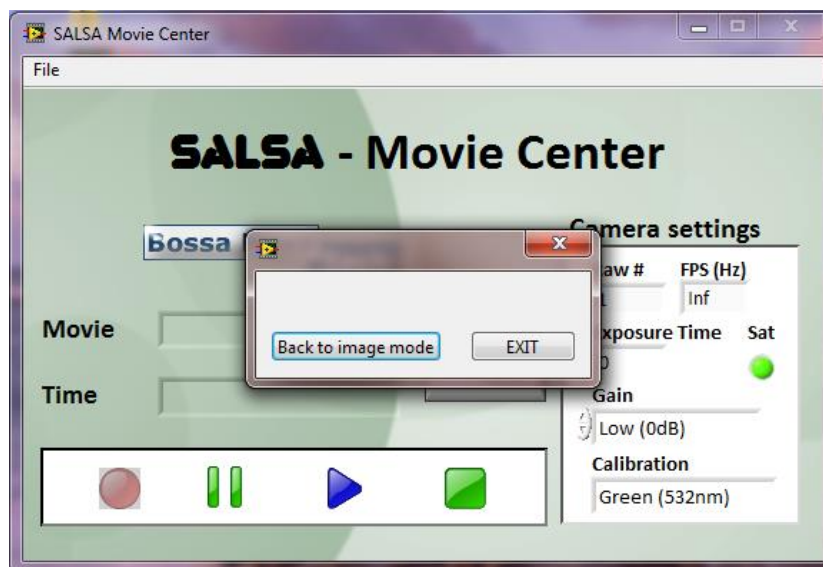


Figure 41: EXIT

The user can switch back to the main window or just exit the whole software.

11 Analysis mode

The camera does not need to be plugged for this analysis mode.

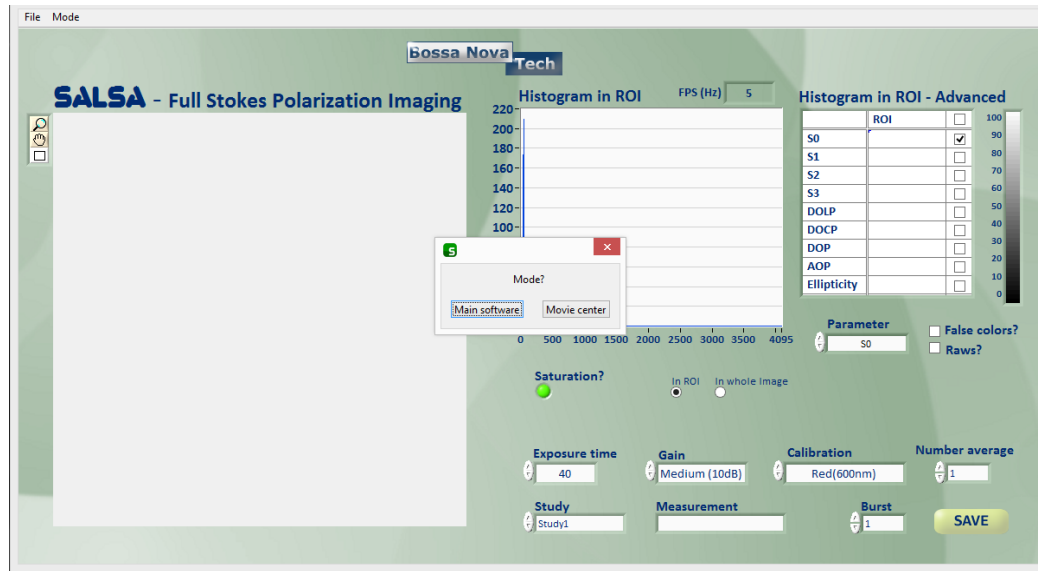


Figure 42: Analysis Mode - Options

When first running the SALSA software the user can select the Analysis Mode as shown on Figure 1. Then you will have to select whether to visualize images saved or to launch the movie center (Figure 42).

The image mode allows reviewing any saved measurement. First, the user will be directed to the **Processing Mode**. Again any file can be processed, loaded, deleted or created (Studies).

Images loaded can be analyzed using the **Visualization Mode**. And the **Movie Center** can also be started, but will not allow for live measurement, only processing, play/pause/save.

The camera does not need to be plugged for this analysis mode. However, if the user wants to perform some measurements again the following procedure should be followed:

1. Exit the software
2. Turn on the controller (if necessary)
3. Plug the camera to the computer (if disconnected)
4. Allow a few seconds for the computer to detect the camera.
5. Run SALSA software and select **Live mode**
6. If the camera has not been detected: close the software and retry. If the camera remains undetected, **reboot the computer** (keep the controller ON).

12 Exit

Stop the acquisition and exit the software.

13 Troubleshoot

If the camera or the USB controller remains undetected please perform the following check-up:

1. Reboot the computer and try to re-run the software
2. Check the connections: Camera ↔ Computer ↔ Controller
3. Is the power LED (on top to the controller's switch) ON when turning the controller ON?
4. Is the **Analysis Mode** working?

Please contact *Bossa Nova Vision* if the problem remains.

14 Reinstall

Should you have to reinstall the whole software, please follow the procedure described in the PDF document: **SALSA Installation Guide 2012**.

15 Contact

Please contact us at info@bossanovatech.com or (310) 577-8110 if you encounter any problems while using *SALSA Full Stokes Polarization Imaging* or if you need any further information regarding the software features and performances.