INSTRUCTION MANUAL

Norsonic

nor848
ACOUSTIC CAMERA

Nor848 User Guide – March 2015 Edition
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nor848

ACOUSTIC CAMERA

Introduction – what is an acoustic camera ?

The Nor848 acoustic camera offers the possibility to visually represent the level of the sound approaching the camera from different directions, and to listen and make recordings and analyse sound from a chosen direction.

The operation is based on signals coming from a large number of individual microphones. These microphones are placed on a dish called the microphone dish. Due to the propagation delay of sound, the sound from different directions will reach the various microphones at different times. By analysing these delays and the level of the signal reaching each microphone, it is possible to indicate the level of sound from different directions and even listen to the sound in one particular direction.

The microphone dish also has an optical camera for recording live video. Using this, we can superimpose a visual representation of the level of the sound on top of the picture, and use different colours to indicate the various levels of the sound.

The acoustic camera Nor848 has been designed with the operator in mind and is easy to use.

The operator can use an on-screen cursor to select a specific sound source, and then perform further analysis using the frequency analysis tools provided.

The sound level for any direction is also indicated as a numerical decibel-value and represents the sound pressure levels at the receiver much like that indicated on a sound level meter. The operator can calculate the strength of the sound source based on the level indicated, the distance and the estimated directivity of the source.

Measurement ranges from 0,5 m to infinity, however the situation is much like taking a picture with an ordinary optical camera: A small light source may become invisible if too far away. Resolution is also lower as the distance is increased. However, due to the size of the dish and the high number of microphones even levels below what in normally measured with a sound level meter may be analysed.

The video from the wide-angle optical camera and the audio signals from every microphones can be recorded on the solid-state disk of the computer. The filename is automatically generated from the time and date of the recording but can also be given a more descriptive name.

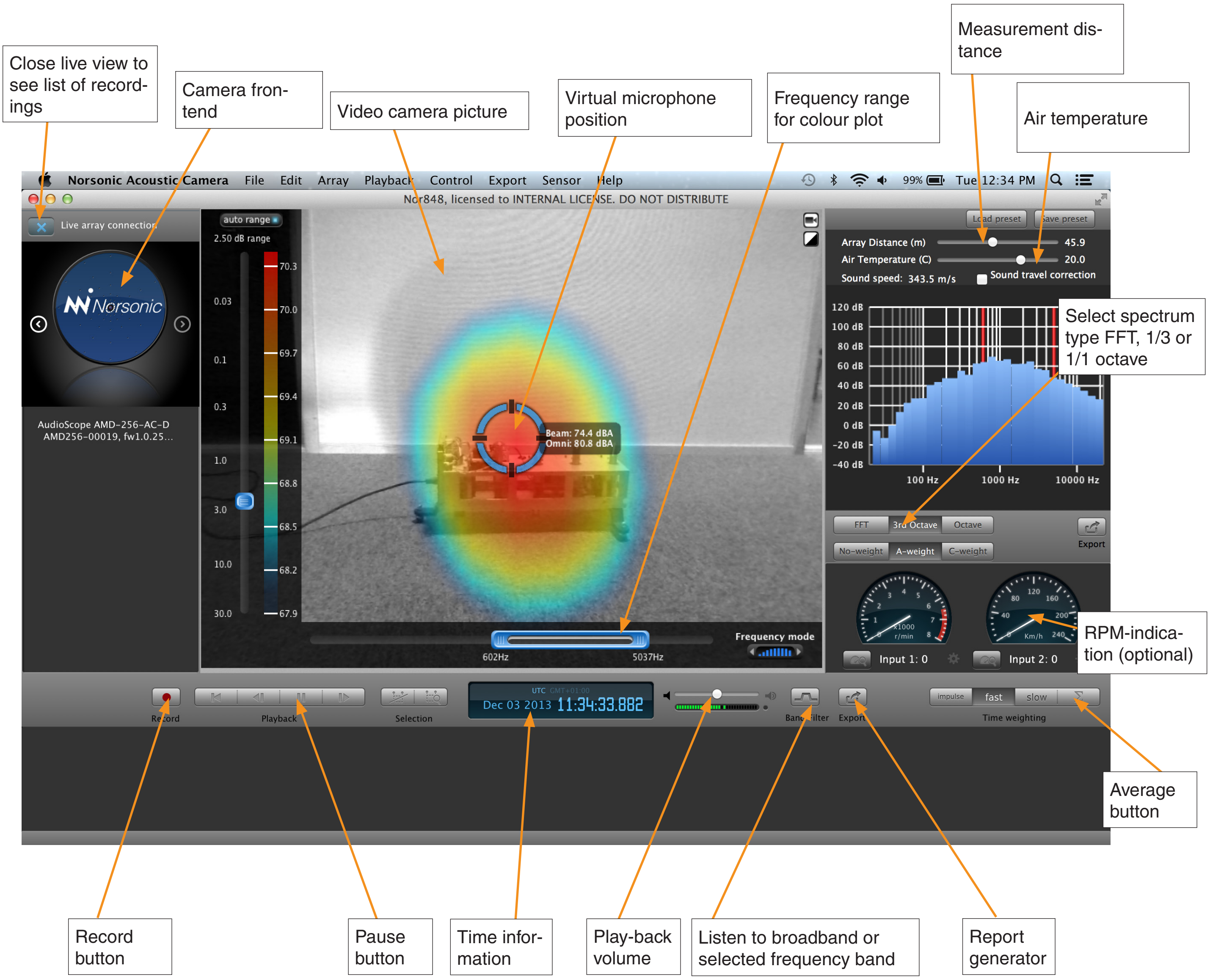
When the recording is made, sound from all of the microphones is recorded at the same time. This means, that only the initial placement of the dish requires careful thought. All of the important parameters such as focal distance, level, frequency-range, can be selected at a later time during playback of the recording. There are no initial settings to be made wrong.

Optionally, additional information such as rotational speed of the device to be measured may be logged with two other measurement parameters and used for further analysis.

Quick start guide

This quick start guide is intended as a reminder for those who have previous experience with the acoustic camera. If not, please read the full description.

- Connect the microphone dish to the computer using the LAN-cable – you need a Thunderbolt to Gigabit Eternet adapter for 2012 and later MacBook Pro series
- Power the microphone dish and the computer
- Start the application program
- Select the microphone dish as data source by clicking in the field for detected camera frontend (upper left)



Software installation

The Nor848 software can be found on the memory stick provided with the Nor848.

Before you install the Norsonic Acoustic Camera software, make sure you have a computer with an Intel Core i7 and that the Operating System is fully updated. The computer need a SSD (Solid State Drive) disk drive, due to the high amount of data being written to disk and at least 8 GB RAM. All MacBook's shipped from Norsonic will have an SSD disk. MacBook's with other specifications may be unable to perform suitably due to too low signal processing capability.

To install the Acoustic Camera application, double-click the downloaded file (.zip). This will extract the application to the same folder as the zip file. When the application is extracted, you can also move (drag) the file to the Applications folder, located in the Finder (Favorites).

To create a shortcut to this application, drag the icon to the dock (the menu bar at the bottom of the screen). When you hold the icon over the dock, an open space for it will be made in which you can let it go. This will create a shortcut on the dock.

Activating the software

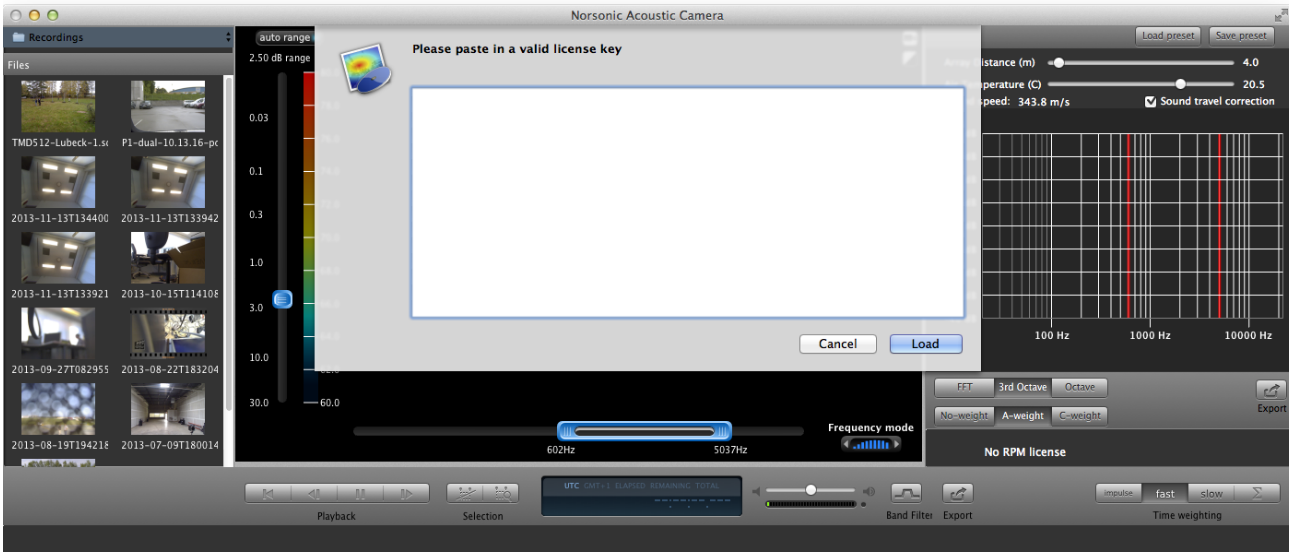
If you have created the shortcut on the dock, click the Norsonic Acoustic Camera to run the software.

First time you launch the software, you will see the screen shown in the figure below.

Please paste in the license provided by Norsonic.

If the license is valid, the application will be launched. This registration is only required the first time you run the software.

If you have problems or questions, please contact support: support@norsonic.com

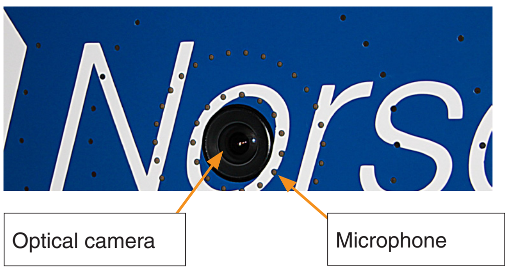


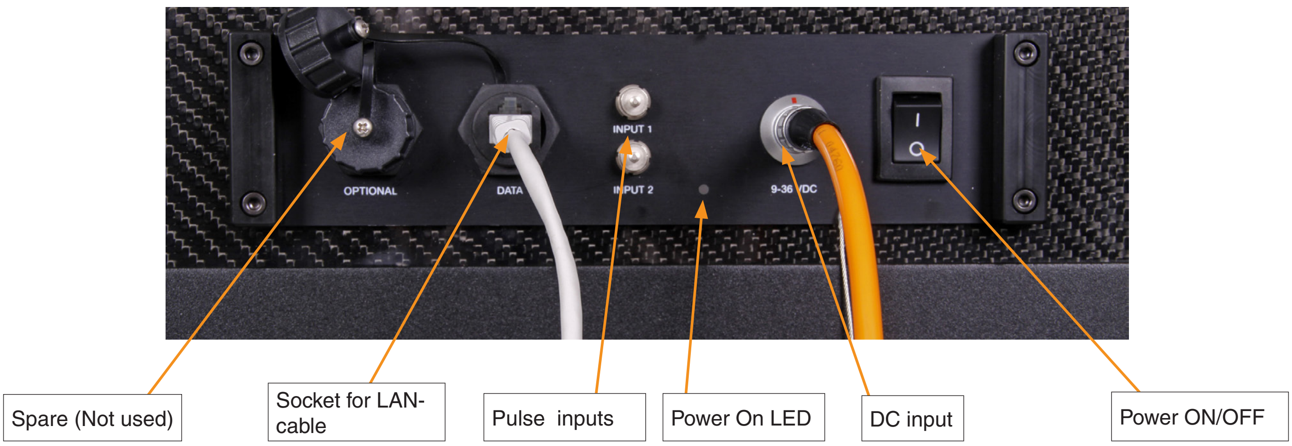
Assembling and setup

The assembling and setup of the acoustic camera Nor848 is simple and takes just a few minutes:

- Unfold the legs of the tripod fully. Place the tripod on a flat, horizontal plane and mount the microphone dish on top of it. The tripod may optionally be equipped with wheels for easy movement. Greater stability is ensured by placing one of the legs in the same direction as the microphone dish. One of the legs may optionally be extended.
- Power the camera with DC input from the mains adaptor or from the optional battery pack
- Place the computer on a suitable table adjacent to the microphone dish
- Connect the microphone dish to the computer using a LAN-cable
- Switch on the power to the microphone dish. You can tell whether the dish has power from the lit LED on the front just above the optical camera and the LED on the rear side adjacent to the Power switch. The LEDs will light some seconds after power On
- Switch on the power to the computer (mains or battery)
- Start the application program by clicking the icon “Norsonic Acoustic camera”
- After a few seconds the connected microphone dish will be listed in the upper left hand side of the program. Click on the field “Connect” to select the microphone dish as data source. Live pictures from the current measurement are shown in real time.

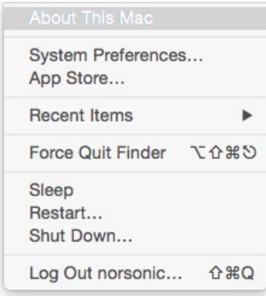
Do not place the dish on a hard surface with the front pointing downwards as this may harm the optical camera!





Operating system

For the Norsonic Acoustic Camera software to function properly, make sure you have the latest version of the OS X operating system on your Mac by pressing the apple symbol on the top left of the screen and "About This Mac". The version should be 10.9.X (OS Mavericks) or higher. The newest version of the operating system may be downloaded for free by pressing the "Software Update.." button.



Troubleshooting network connection

If the Mac has been connected to Wifi or other internet connection, the IP configurations may change, and the Mac will no longer connect to the array, and no arrays will be shown in the panel marked "Connected arrays" on the upper left-hand side. If this is the case follow the steps listed below to change the network configurations back to normal.

- Run the software "System Preferences". This can be found under the Applications folder in the Finder or via spotlight (cmd-space).

- Click the "Network" icon in the icon list, and the network settings will be exposed.

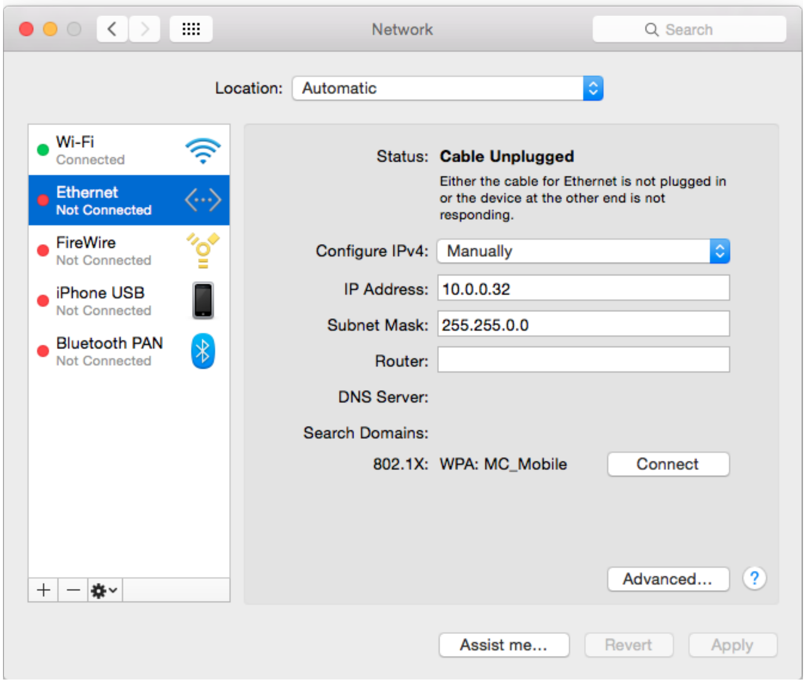
- In the menu to the left, select the interface called "Ethernet X" or "Thunderbolt Ethernet" (The one that is connected to the array). This will be the wired network settings.

- Select Manually in the drop down next to "Configure IPv4".

- Type 10.0.0.32 in the "IP Address" field

- Type 255.255.0.0 in the "Subnet Mask" field

- Click Apply, and launch the Nor848 software to discover arrays.



Operation

Starting the program

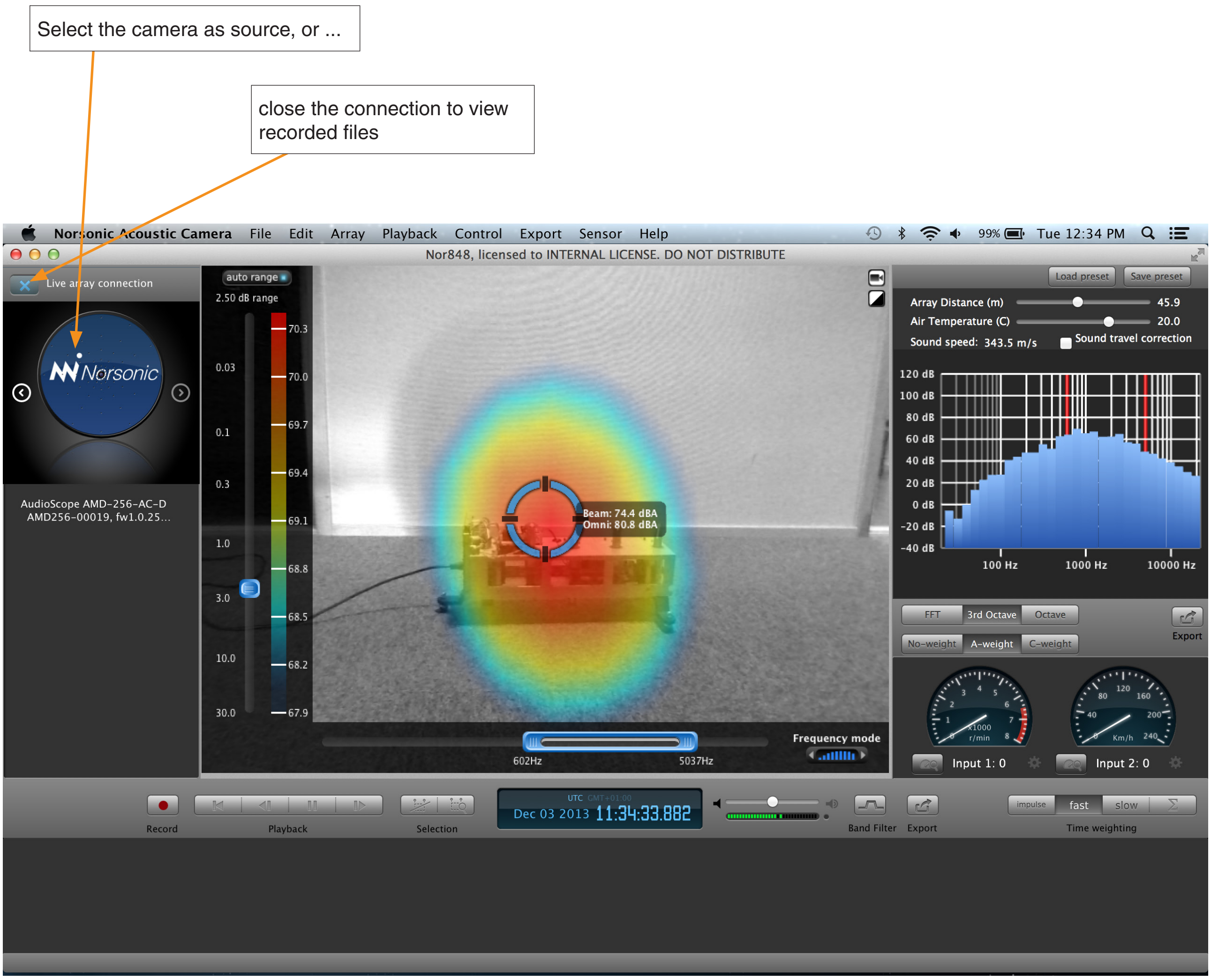
Start the program by double-clicking the "Norsonic Acoustic camera" icon normally placed on the desktop of the computer. The main screen will be shown.

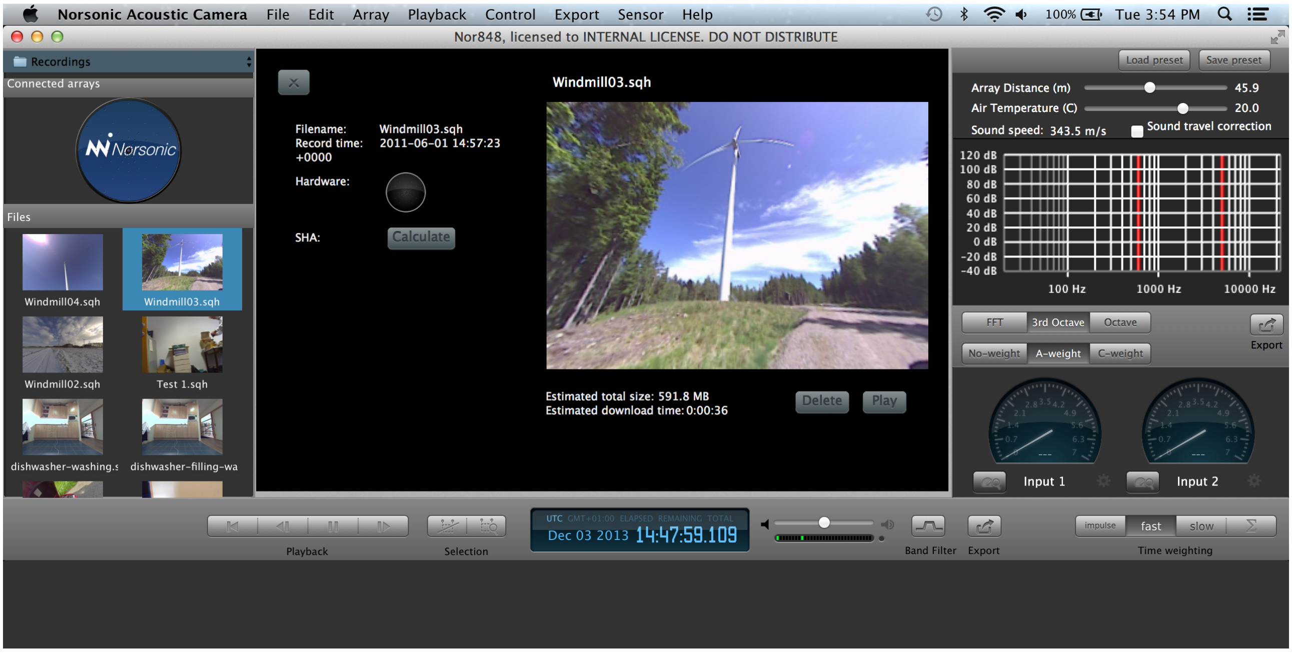
Selecting the source: camera or recorded files

If the camera is connected and powered, it will be shown in the panel marked "Connected arrays" on the upper left-hand side. The signals from the microphone dish are selected by clicking in the field for the camera disc. When the camera is selected as a source, a live view is shown in the display.

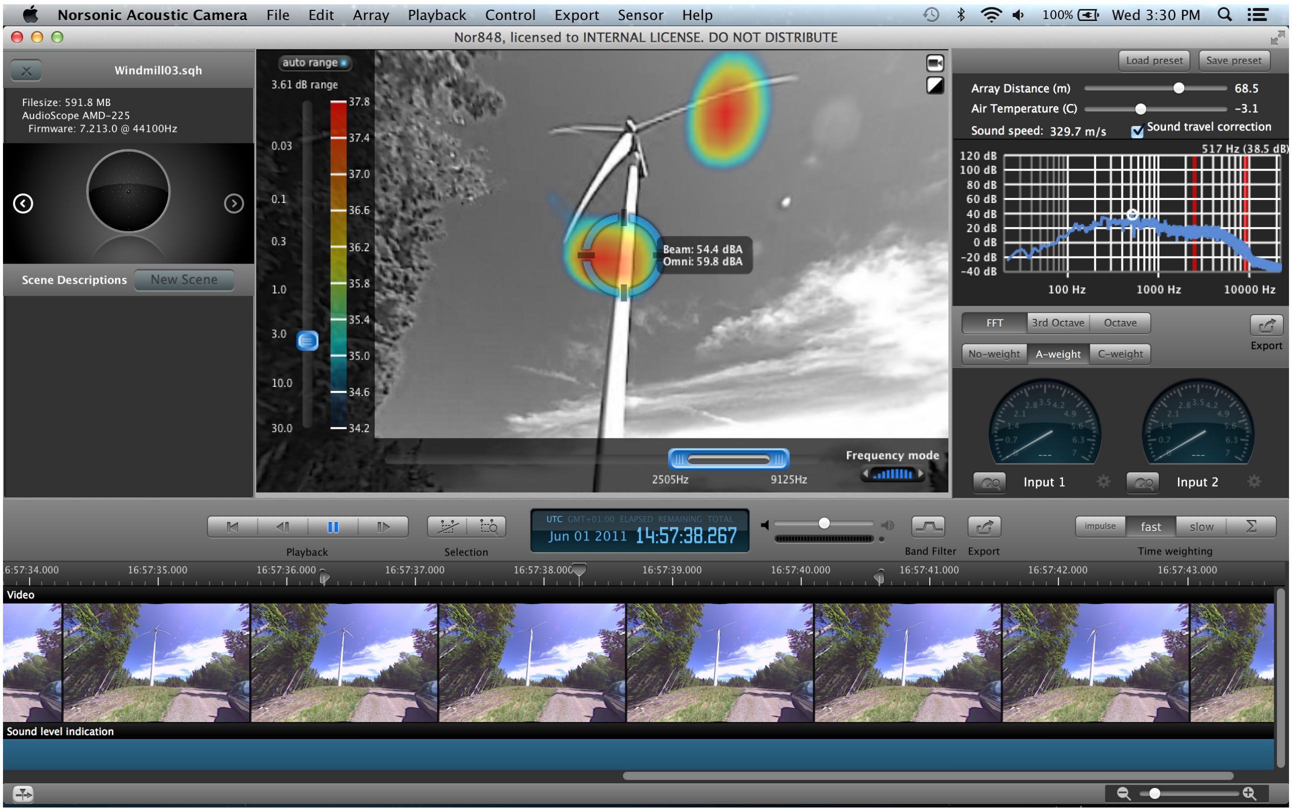
Alternatively, a previous recording may be selected and played. This is done by closing the live array connection. The list of the stored files in the default directory (normally "Recordings") is shown in the panel to the left. The default directory may be selected in the "File" menu in the line at the top of the screen. Select the recording by clicking the name of the record.

A picture from the recording is shown together with some additional file information. See the figure below. Select "Play" to play the recorded file.





When the recorded file is played, a sequence of pictures from the video is shown along the time scale



Adjusting windows

The screen consists of a combination of different windows. Note that the size of each window may be adjusted by dragging the boundary between the windows.

Beam or single microphone

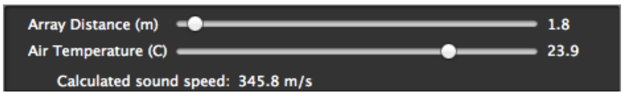
When connected to a Live array, the signal to be frequency analysed and listened to is obtained by the beamforming and selected by the cursor. Alternatively, it is possible to hear how one microphone is sounding instead of the whole beamformed signal. This can be reached by using the arrow buttons in the array picture and go to the left. This will show an omnidirectional microphone signal and if “connect” is pressed, one single microphone will be selected.

The single microphone can be useful to see/hear the difference between a signal obtained from an array and a single omnidirectional microphone.

Display Settings

Adjusting the focal distance

In the same way as you need to focus on an object when taking an ordinary picture, you need to specify a distance from the microphone dish to the object under investigation. However, since this setting does not influence the recorded signal from the microphones, the adjustment can be done after the recording has been made.
The focal distance is the distance between the microphone dish and a plane parallel to the dish and through the object under investigation. The selector for distance and temperature is placed in the upper right side of the display. The distance can be adjusted from 0,5 m to 100 m (infinity) by the slider called “Array distance” in the upper right corner of the display or entered manually.



Setting the temperature

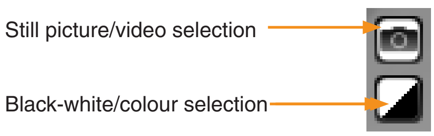
Ambient temperature affects the speed of sound. A correct value for the air temperature is therefore important in order to calculate correct angles for the sound transmission. However, since this setting does not influence the recorded signal from the microphones, the adjustment may be done after the recording has been made. The value may be keyed in in the range -30°C to +40°C or dragged by the handle. The calculated speed of sound is shown below the handle for air temperature

Optical picture – Zooming and panning

The optical camera is a wide-screen camera with fixed focus. The part of the picture to be displayed is selected by the mouse or similar operation on the touch-pad. Grab a position in the picture with the mouse pointer and move it around - panning. Use the scroll wheel for zooming in and out. On the touchpad use the pinch and pan functions for zooming.

The pictures from the optical camera can be displayed in colour or monochrome. A monochrome display is often convenient when colours are used for displaying sound levels. This selection is done by clicking the icon in the upper right part of the main display.

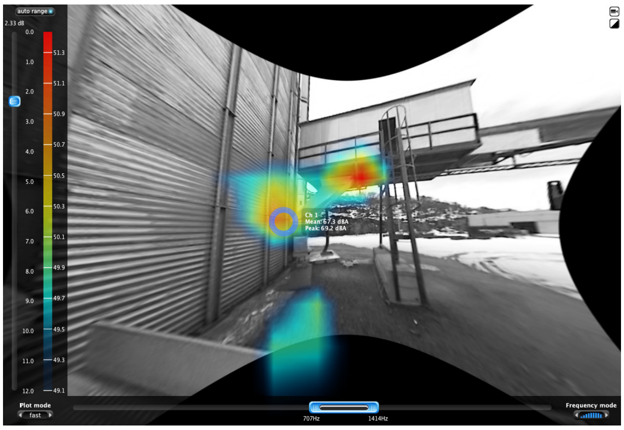
It is also possible to freeze the picture and let it be stationary. This allows you to take the picture at day time even if you are going to make the noise analysis at night. The selection is done by the photo/video camera icon in the upper right corner of the picture display.



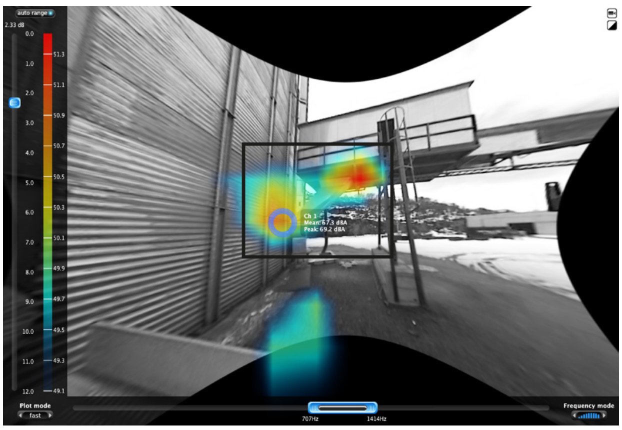
Zoom and increase beamforming resolution

The zooming and panning will also affect the acoustic analysis. The colouration is based on listening in a number of certain directions. For frequency band colouration, the number is an array of 15 x 11 directions (W x H), for single frequency colouration, the number is 60 x 45. See the description later for the difference between frequency band and single frequency.

The example on the pictures to follow illustrate the effect of zooming for frequency band colouration. We start by Zooming out to show all sources.

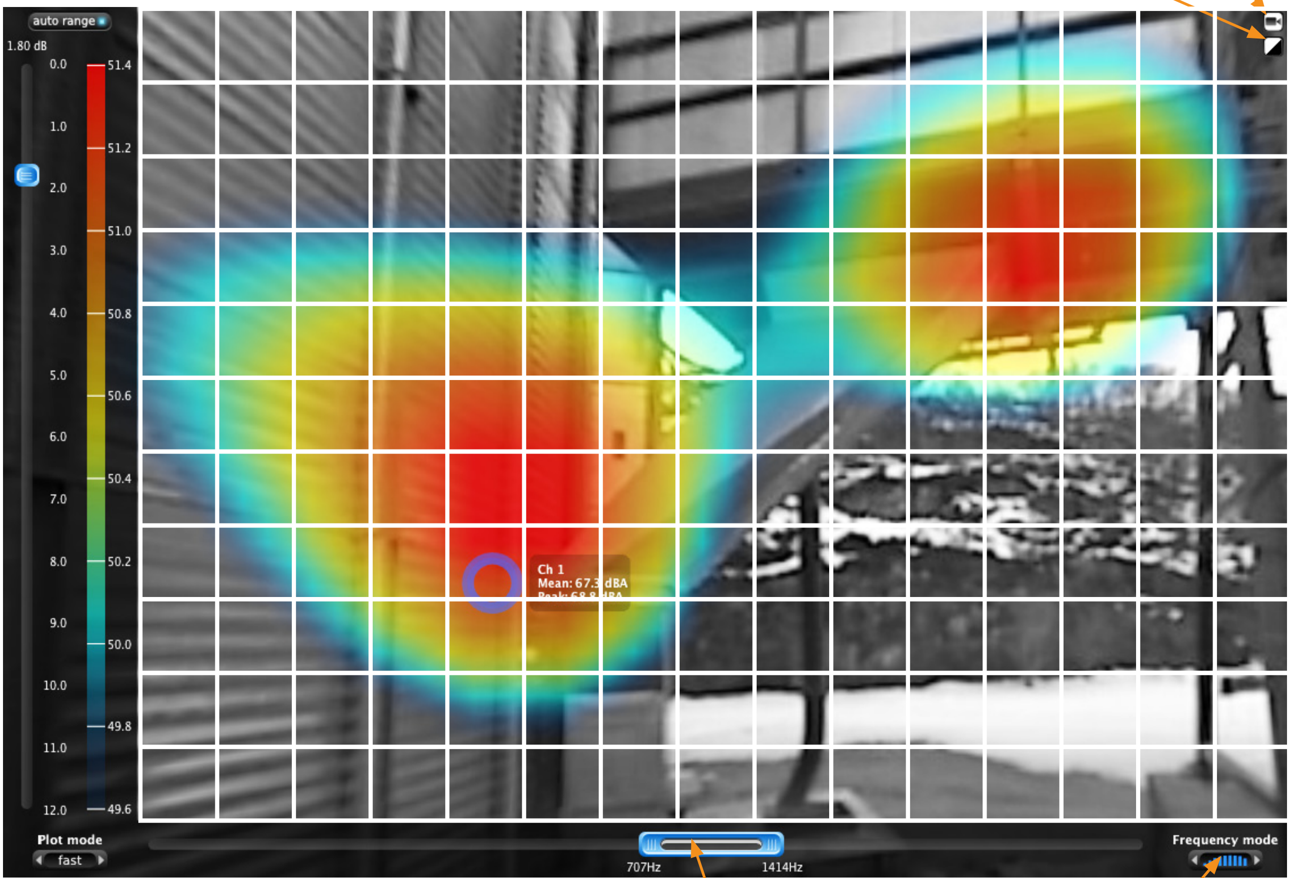


The reflection from the ground is considered to be of less interest and we want to zoom in on the two sources above the ground. This is indicated by the frame in the picture below.



By zooming in, a higher resolution is obtained for the interesting part of the picture The next picture shows the display after the zooming operation. A grid is placed on the picture to show the acoustic resolution for the level colouring (Frequency band).

For frequency band colouration in live mode the sound level is calculated from 15 x 11 directions as illustrated below. For high resolution frequency colouration the number is 41 x 31. Note however that the grid is not displayed on the screen, and is merely shown here to explain resolution.



Frequency band/signal frequency

The sounds approaching the acoustic camera from different directions are given colours dependent on the signal strength. The frequency range for this colouring is selected by specifying the frequency-band from lower to upper band-edge as shown on the figure above. This is called frequency band colouring. Alternatively, the sound-level analysis can be based on a single line in a digital Fourier transform of the microphone signals. This is obtained by clicking the Frequency mode icon shown in the figure. The displayed frequency span is then collapsed to one frequency line in the spectral computation. *The bandwidth of a single line varies with the selected time constant from 1.3 Hz to 43 Hz, see the description in the chapter of frequency analysis.*

The method used for the beam-forming when single frequency mode is selected is different from the method used when frequency band is selected. See the technical description for more detail. It is useful to experiment with both modes to obtain the best result.

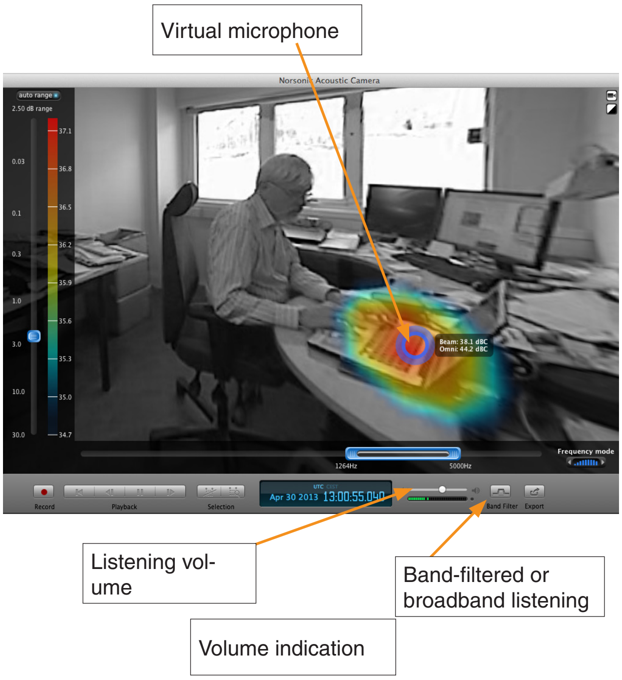
If you use the touch-pad:

One finger movement corresponds to moving the mouse; pressing with one finger corresponds to a left-click; moving two fingers up and down corresponds to scrolling the mouse-wheel, and pressing and moving two fingers corresponds to moving the mouse with the right button depressed and is used for panning the picture. You can also use the pinch and pan functionality for zooming. See the general description for the computer.

Virtual microphone

It is possible to listen in real time to the sound approaching the acoustic camera from various directions. This is done by moving a blue circular cursor called a virtual microphone to the position where you want to listen. The direction is selected by a left-click in the picture or the circle may be selected and dragged around. See figure below. Remember to set the temperature and the focal distance as this may affect the indicated direction.

Adjacent to the virtual microphone cursor is an indication of the sound pressure level. Two levels are indicated: the level as observed by the virtual microphone marked "Beam" and the sound in any direction reaching the microphone dish marked "Omni". The last value correspond to the level observed with a sound level meter in the position of the microphone dish. Both levels are frequency-weighted as selected by the frequency analysis: A-weighted, C-weighted or un-weighted (No weight).



Frequency band

You can either listen to the full frequency range (20 Hz – 20 kHz) or choose the frequency range selected for the level colouring. This is done using the selection box marked in the figure above.

Volume adjustment

Volume is adjusted by moving the volume slider. This is a software type gain adjustment (computational) and the level of the resulting signal is shown. Set the volume so the level is always green, red colour indicates a clipping of the signal and will reduce the sound quality.

Indication of sound pressure level, filtered and frequency-weighted

The sensitivities of the microphones are calibrated to display the sound pressure level referred to 20 μPa at the position of the microphones, i.e. at the microphone dish. This is similar to placing a calibrated sound level meter at the position of the microphone dish.

The frequency range for measurement is selected by the "frequency mode" function, either as a narrow frequency band or determined by the selector for the upper and lower band edge frequency.

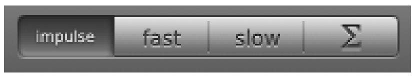
Time resolution

The value adjacent to the virtual microphone as well as the level colouring apply a time smoothing called time resolution. One of the following alternatives may be selected:

- Impulse: 0,035 second averaging time
- Fast: 0,125 second averaging time
- Slow: 1,0 second averaging time
- Sum Σ: The average of a marked time period (Stored record only)

Note that "Impulse" is a short time constant only and don't correspond to Impulse-time function in a sound level meter.

The menu for selecting the time resolution is shown below.



Frequency analysis

The spectrum of the sound from the virtual microphone is shown as a level versus frequency diagram. You can display the information as a Fourier-spectrum (FFT), or the frequency bands can be summed together to form 1/3-octave (Third octave band) or 1/1-octave (Octave band) spectral values.

The resolution in the FFT-analysis is dependent on the selected time resolution:

- Impulse: 43,1 Hz
- Fast: 10,8 Hz
- Slow: 1,3 Hz
- Sum Σ: Dependent on integration time. The selected time is truncated to a power of 2 number of samples.

If you set the "Frequency mode" to frequency band for colouring, clicking in the octave or third-octave diagram adjusts the band limits accordingly. The red lines correspond to the frequency range selected for the colouring in the main display.

The numeric value for the level may be read out by moving the cursor to the selected frequency or frequency-band. The values for the complete frequency analysis may be exported as comma-separated values by clicking the export icon.

The displayed level versus frequency may be pre-weighted by the A- or C- weighting function such as those found in sound level meters. Historically, the A-weighting was developed to mimic the sensitivity for the human auditory organ for sounds close to the threshold of hearing, whereas the C-weighting is for mimicking the response to strong sounds.

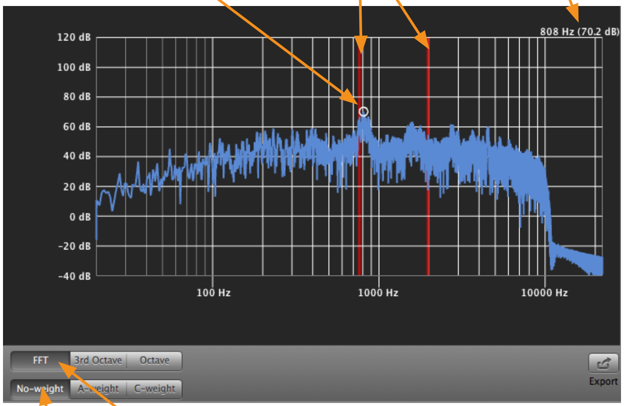
The virtual microphone will have a frequency dependent spatial resolution. This may be described by the width of the main lobe for the directivity. The width will vary with the inverse of the frequency: reducing the frequency by one octave, results in the width of the lobe increasing to the double. See the section *Technical information*.

Therefore, if you listen to or are making a frequency analysis of a distributed sound source, you will listen to a larger area of sources for lower frequencies than you do for higher frequencies. This phenomenon should always be considered when looking at the frequency distribution of the signal since this normally will enhance lower frequencies.

Level and frequency for the maximum value.

Maximum value indicated by a circle.

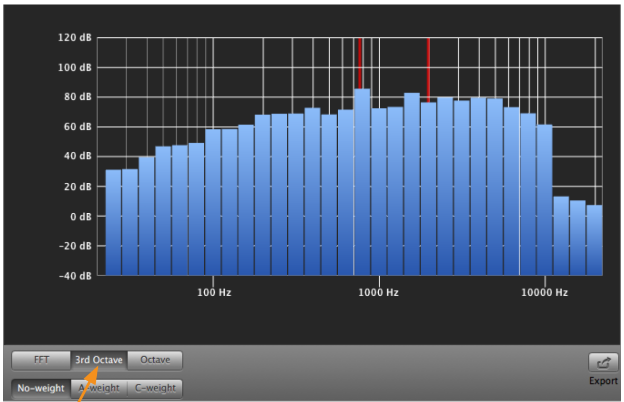
Frequency limits for the colour-plot.



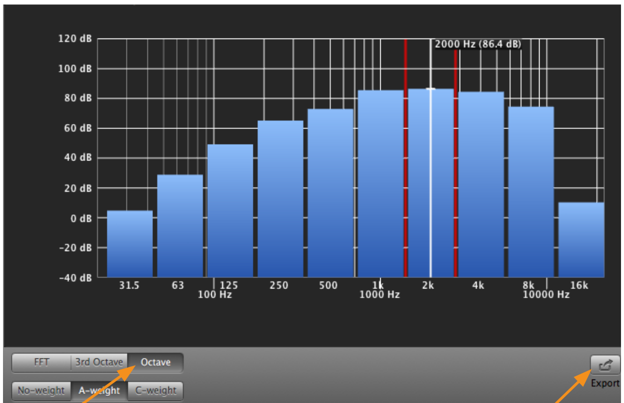
The frequency resolution for the FFT is dependent on the selected time weighting. Point with the cursor in the diagram and the resolution is displayed together with the level for the selected frequency

The spectrum may be weighted with the A- or C-weighting.

Export the numeric values

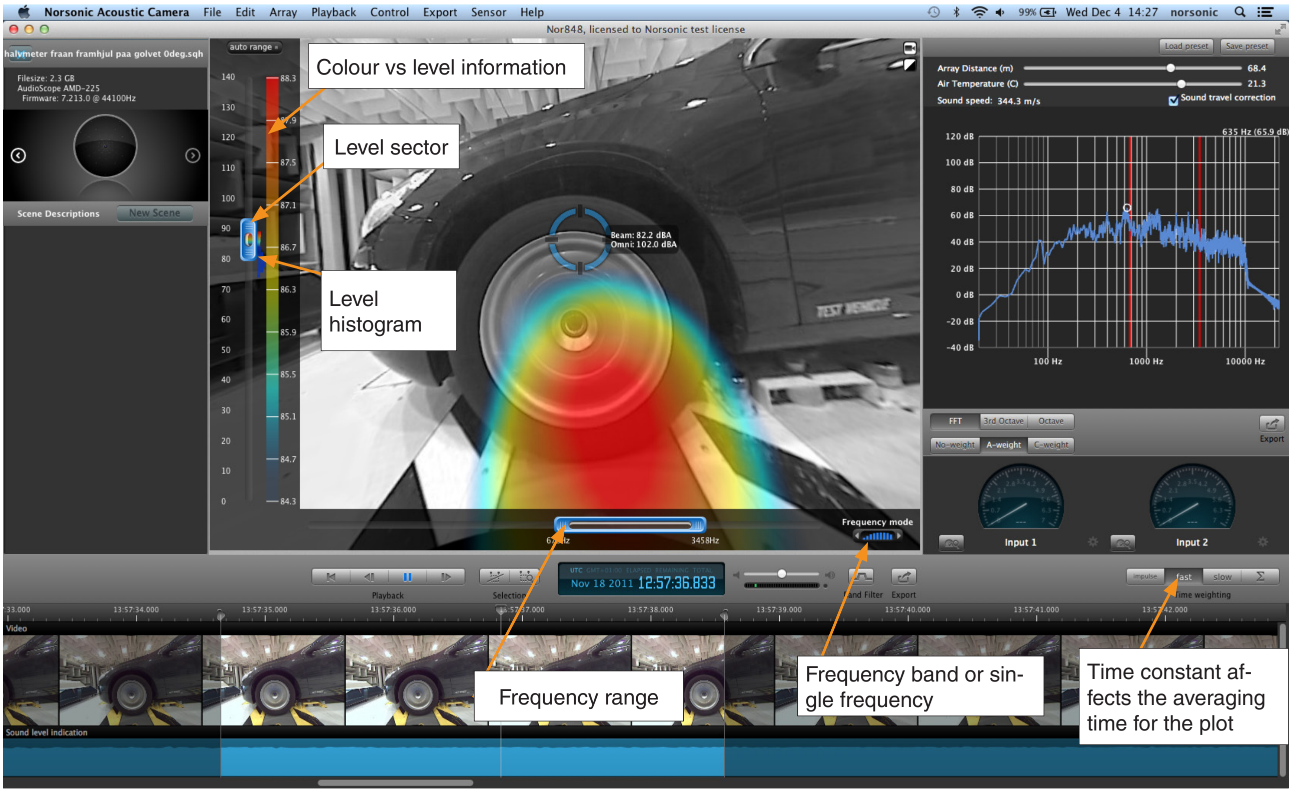


The lines in the FFT are summed to display the 1/3-octave levels.



The lines in the FFT are summed to display the 1/1-octave levels.

Export button



Manual range setting

Level chart, selecting the range for colour

The level of the sound measured in the different directions can be given a colour corresponding to the level or the strength of the sound. The colouring between the highest level (red) and the lowest level (dark blue) is adjusted by the level selector. Use the mouse pointer to drag the upper or lower part of the handle. This can be done when the “Auto range” is not selected.
A histogram adjacent to the handle for level adjustment gives an indication of the levels present in the picture for the selected frequency range.

The relation between the colours and sound levels, are shown in the colour map adjacent to the level scale.

The time dynamic for the colour plot may be selected by clicking “Time weighting”. One of three alternatives are available: “impulse”, “fast” or “slow”. When a recorded file is analysed, it is also possible to base the colour on the average over a certain time period.

Fast is a time constant averaging which corresponds to the “F-time constant” used in a sound level meter: 125 ms;

Slow corresponds to the “S-time constant”: 1 second.

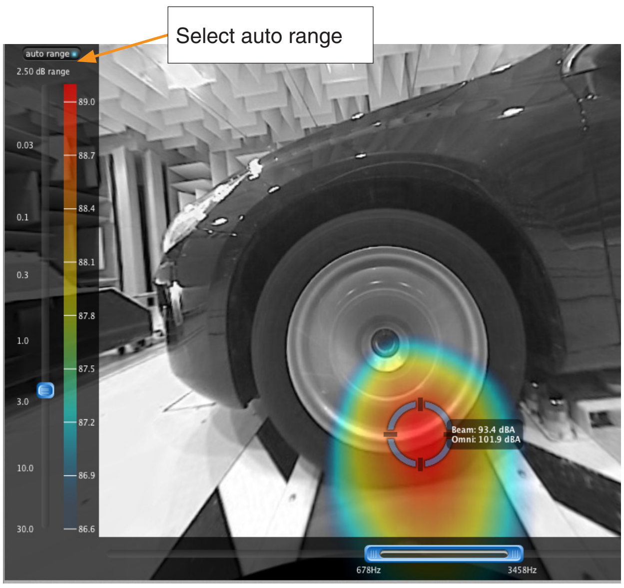
Impulse corresponds to a period of about 35 ms.

When you click the “auto range” button, the colouring is automatically referred to the highest level (red) and this level range is used for adjusting the relative range for the colouring. The “auto range” feature is very convenient for analysing signals with time variant levels.

Frequency range selection

The frequency range selector below the picture is coupled to the frequency range for frequency analysis and may be selected both places.

The low band-edge frequency for colouring may be adjusted by dragging the left part of the handle, and the high band-edge frequency by the right part. By placing the cursor in the middle and dragging, adjust both frequencies so the ratio between the upper and lower band-edge frequency are kept, e.g. octave ratio.



Automaticl range setting

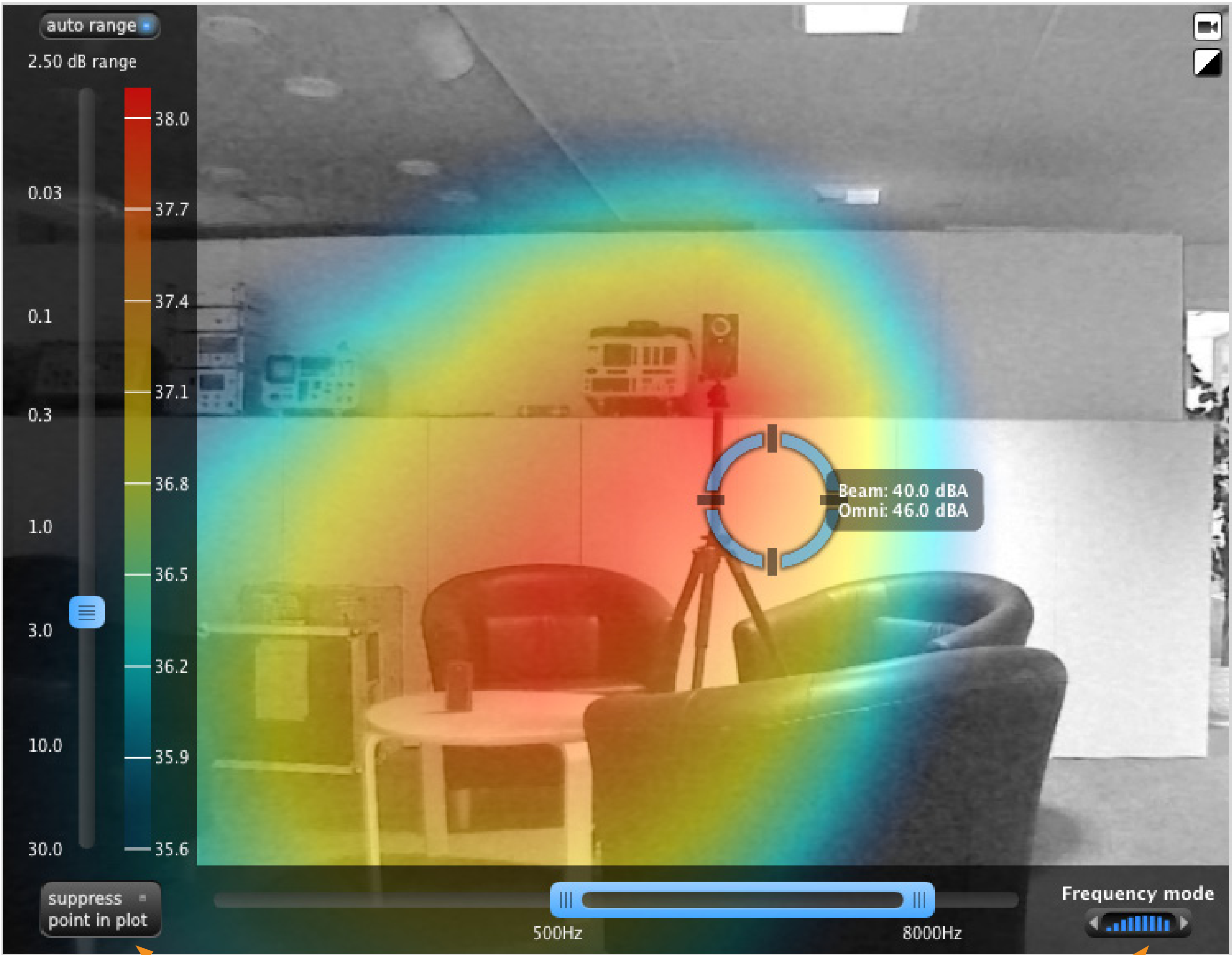
Acoustic eraser

Sometimes sources may be closely spaced apart, or a strong noise source in the area of interest is interfering with the recording and impairing the image quality. Often this will be seen as either a single large source, or the source of interest will be completely shadowed by the stronger source.

Seen in the image below is a situation where two equally strong sources are positioned close to one another., where the resulting image will display a single large source. In such situations the acoustic eraser feature may prove valuable. The acoustic eraser is found via the “suppress point in plot” button. This function will add a red circle to the screen that can be dragged to any point, and remove the source from that point. This is highly effective when several noise sources are present.

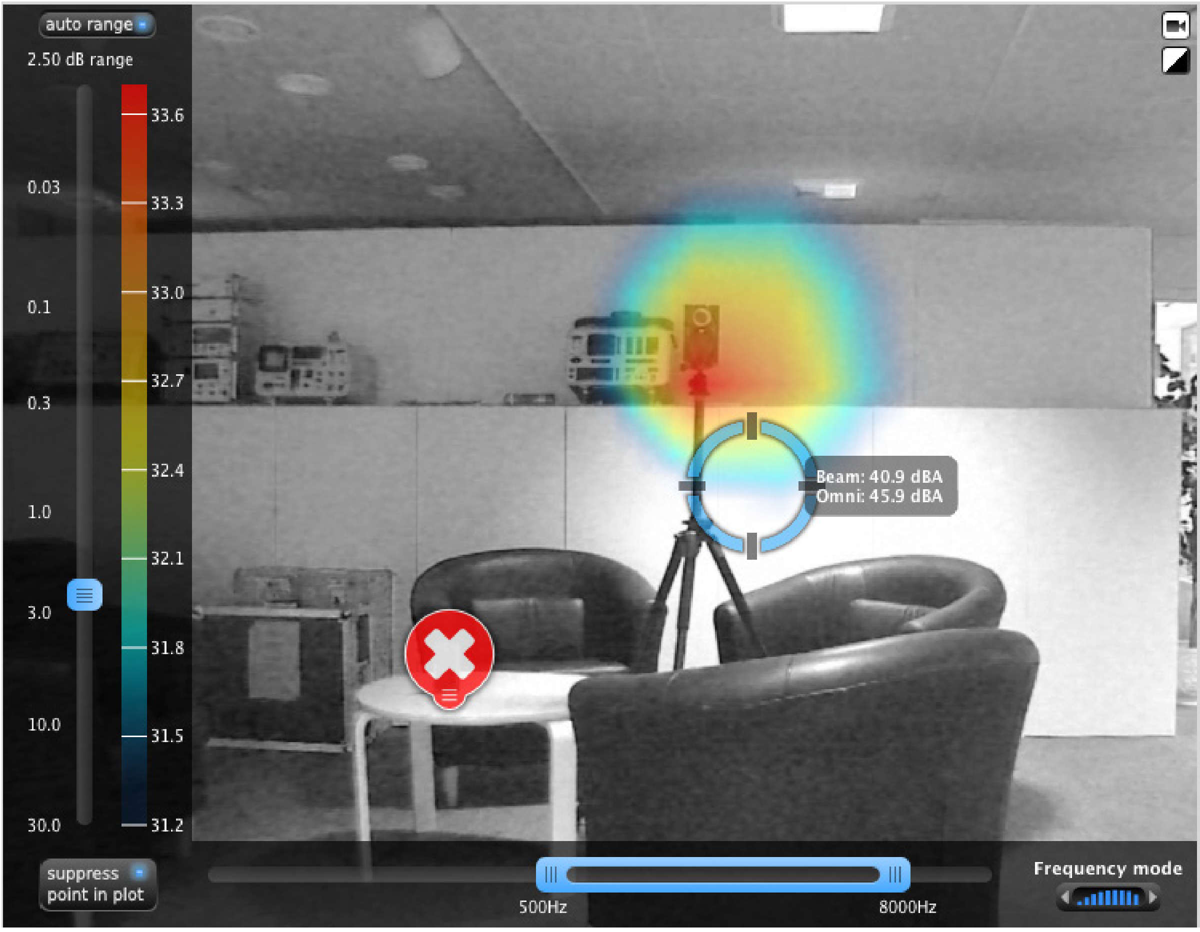
The acoustic eraser is only available when wideband frequency mode is used, and not for single frequency mode.

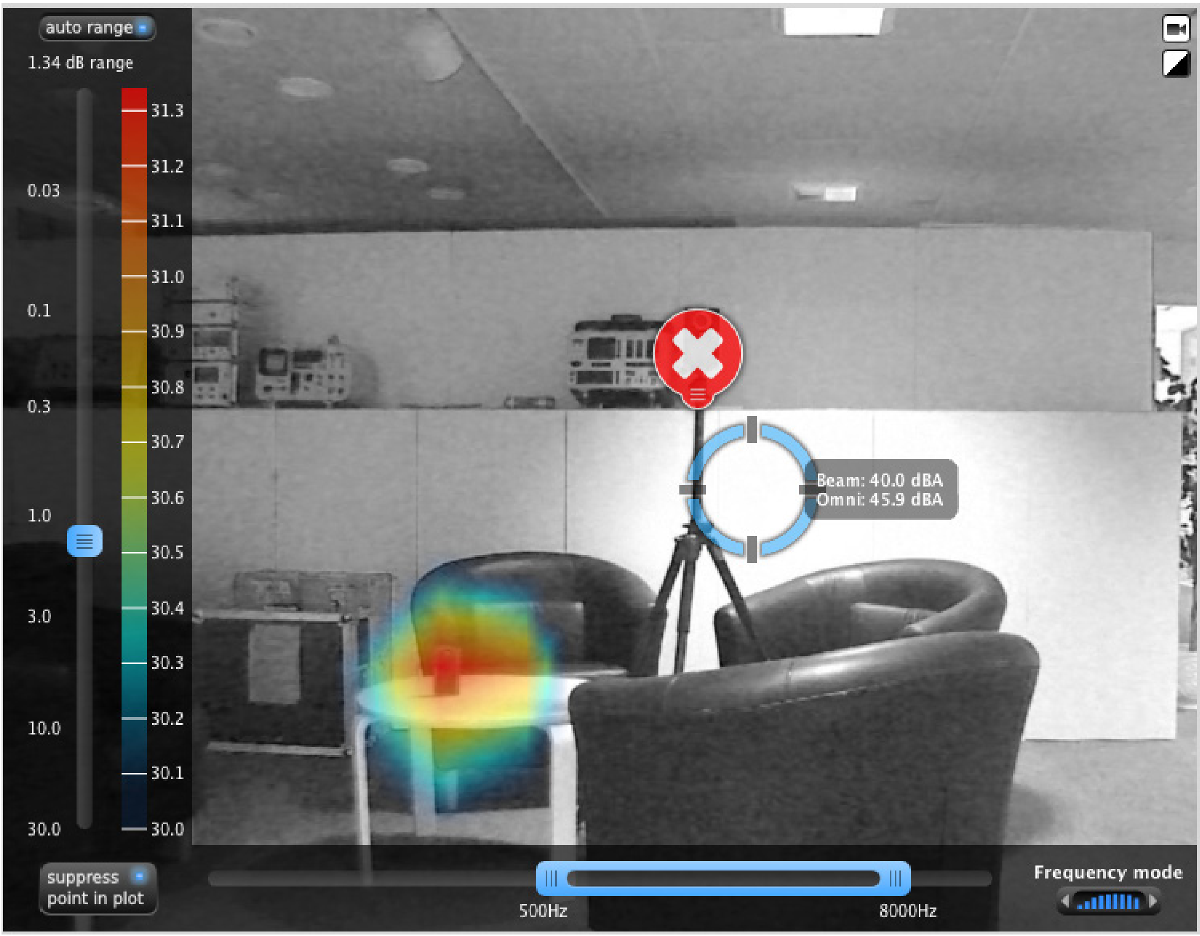
As seen on the pictures on the opposite page the acoustic eraser completely removes the source where the suppress point button is positioned. The virtual microphone can further be positioned on the source of interest. The acoustic eraser can be used both in live view mode and in post-processing.



The acoustic eraser is enabled by pressing the suppress point in plot buttonm

Frequency band mode must be enabled to use the acoustic eraser

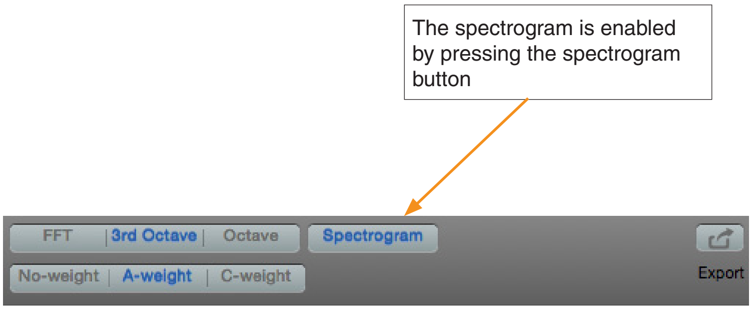

auto range
2.50 dB range
0.03
0.1
0.3
1.0
3.0
10.0
30.0
33.6
33.3
33.0
32.7
32.4
32.1
31.8
31.5
31.2
Beam: 40.9 dBA
Omni: 45.9 dBA
suppress
point in plot
500Hz
8000Hz
Frequency mode

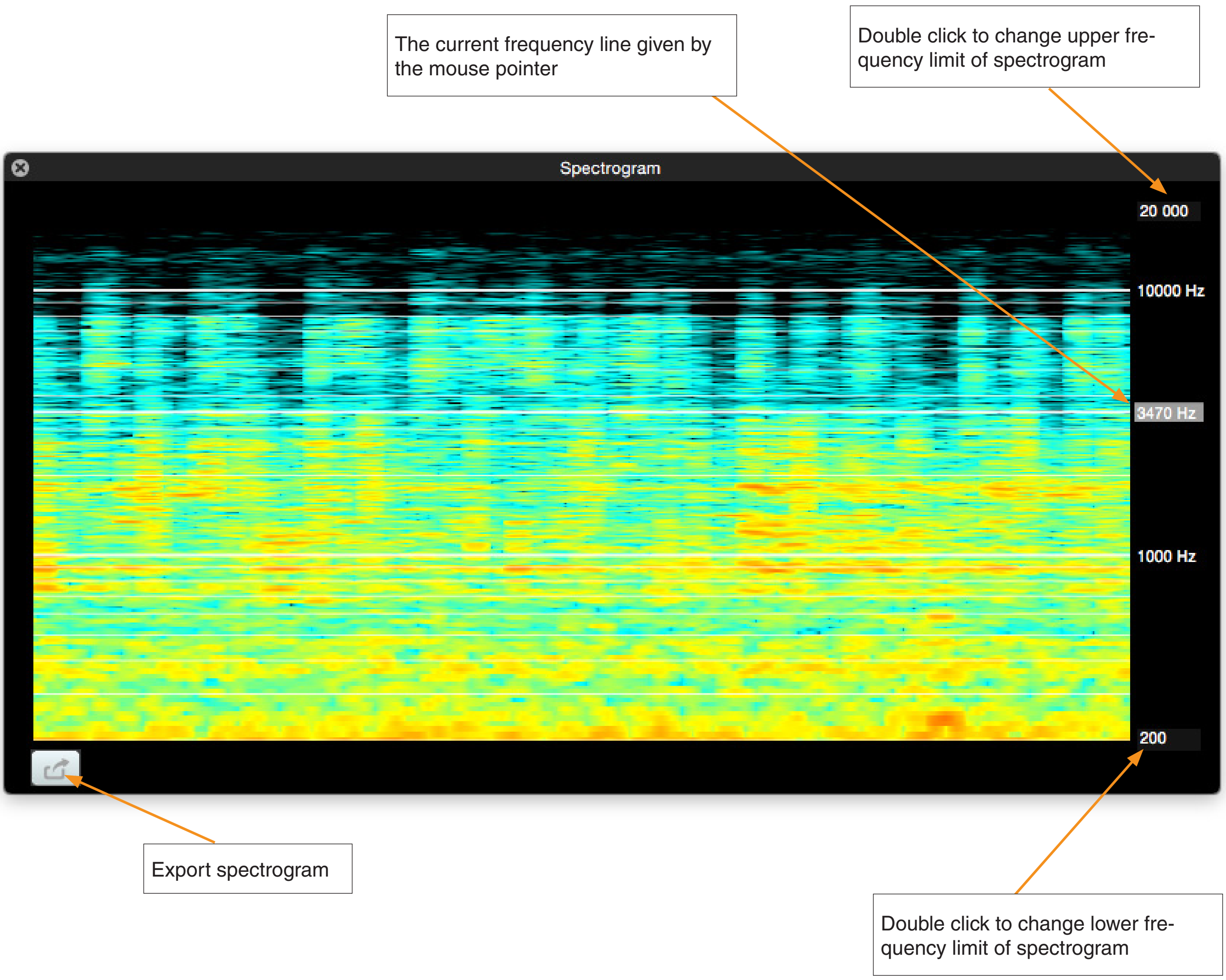

auto range
1.34 dB range
0.03
0.1
0.3
1.0
3.0
10.0
30.0
31.3
31.2
31.1
31.0
30.9
30.8
30.7
30.6
30.5
30.4
30.3
30.2
30.1
30.0
Beam: 40.0 dBA
Omni: 45.9 dBA
suppress
point in plot
500Hz
8000Hz
Frequency mode

Spectrogram

By pressing the spectrogram button beneath the frequency axis a new window will pop up displaying the spectrogram from the point where the virtual microphone is positioned. The dynamic strength of the coloring of the spectrogram is altered by setting the volume higher or lower in the volume slider in the software. The default displayed frequency is from 200 Hz to 20 kHz. By double clicking on either the lower or the upper frequency limit, these limits can be changed to whatever frequency area of interest is desirable.

The time resolution of the spectrogram is 0.046 seconds.





Making a recording

Clicking the record button will start a recording that will continue until the button is clicked again, or until the computer runs out of memory. During a recording, the video from the camera, as well as sound from all the microphones are stored. The signal from every microphone is stored in full CD-quality and generates about 0,9 – 1.8 GB of data per minute (dependent of number of microphones in the array). The storage capacity for the normal computer corresponds to more than two hours of recordings.

When you start a recording, the file is automatically given a name based on the current date and time, and is stored in the default folder. Recording are then available in the list of “recordings” on the left hand side of the screen. The recordings may later be given a more descriptive name or moved to a different folder.

Replay

If you want to study a recorded event, just click on the filename in the list of recordings in the panel on the left side of the screen. Open the “File”-menu if you want to change the directory for the files. Select the file from the list and click the “Play”-button. A replay from the start of the recording is automatically started. As the recording is played back, the running time from the start of the recording is displayed along with a time indicator, in the time-line at the bottom of the screen. The replay will automatically start over again when the end of recording is reached.

If you want to halt the replay, click the pause button.

A second click releases the halt operation. Alternatively, the space bar on the keyboard is a shortcut for the pause button.

Instead of looping the whole recording, a part of the recording can be selected for looping. This is done by making a time selection.

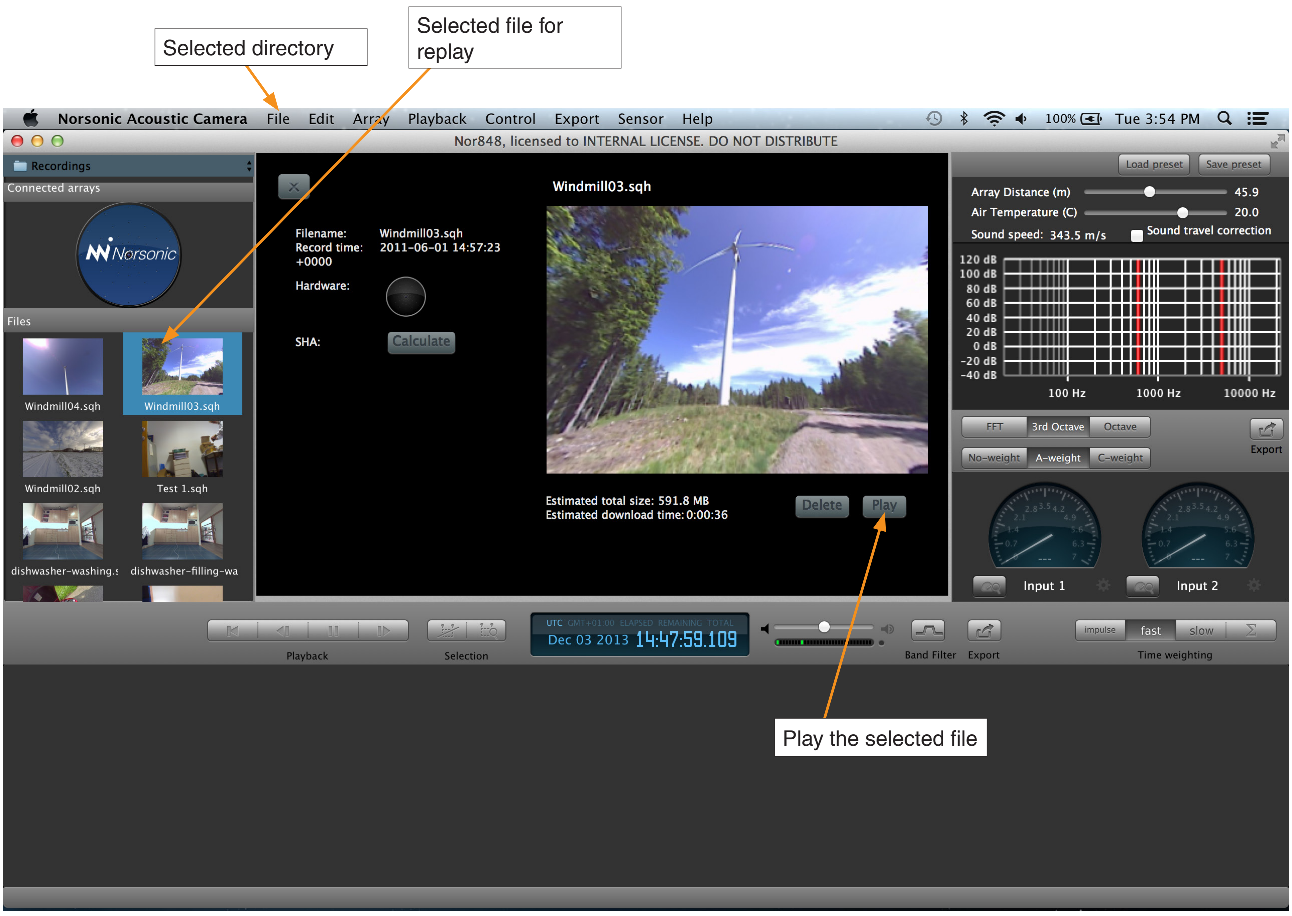
When you start a replay the start end marker for the time selection is placed at the beginning and end of the complete record, respectively. You may either drag them to the requested positions, or you click and drag the mouse pointer along the time line. The selected part of the record will then be looped.

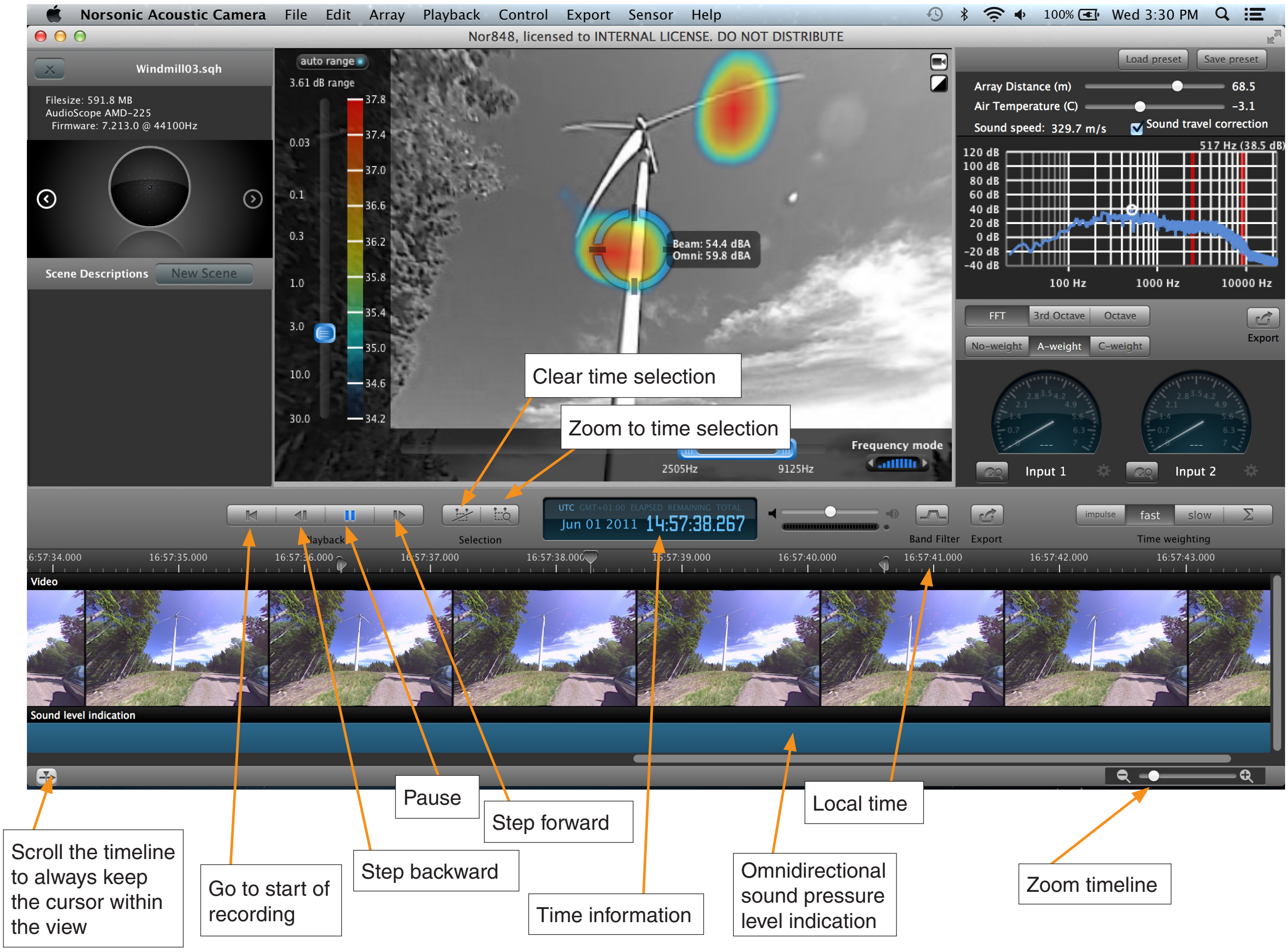
The length of the part of the recording to be looped is adjusted using the handles on the loop indicator.

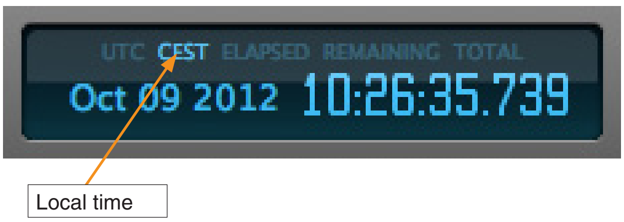
The length of the time span selected for looping, may be time-averaged. Press the Sum button, Σ, for averaging placed in the time weighting menu. The selected time period will then be used for the colouring and the frequency analysis.

The picture will be frozen at the end of the averaging period; however the colouring may be adjusted afterwards.

When you pause the replay, the colouring is redone with a higher resolution.







Click in the time information window to select the wanted time information:

- UTC as set by the applied computer for making the record;
- Local time set for your computer during recording the file;
- Elapsed time since start of the recording;
- Remaining time of the record; or
- Total length of the record.

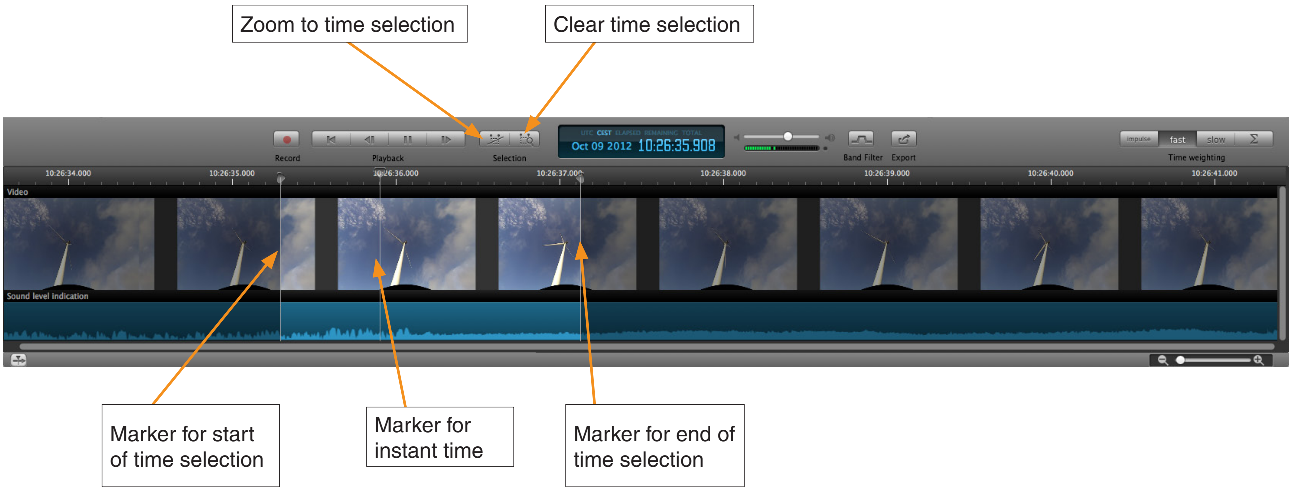
The format for the time is: Hour, minute and seconds with 0.001 second resolution.

UTC: Coordinated Universal Time is the primary time standard by which the world regulates clocks and time. It is independent of where in the world the recording is made and is not dependent on the season of the year.

CET: Central European Time is the time is the time set for the computer.

CEST: Central European Summer Time

Before you open the file, you may calculate the SHA (Secure Hash Algorithm) checksum to verify that the file is as intended.

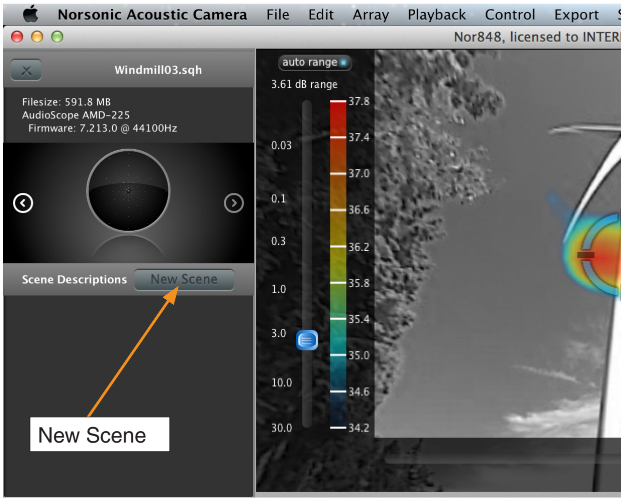


The signal from every microphone is stored in full CD-quality. This will generate about 1.8 GB per minute for the 1 m array.

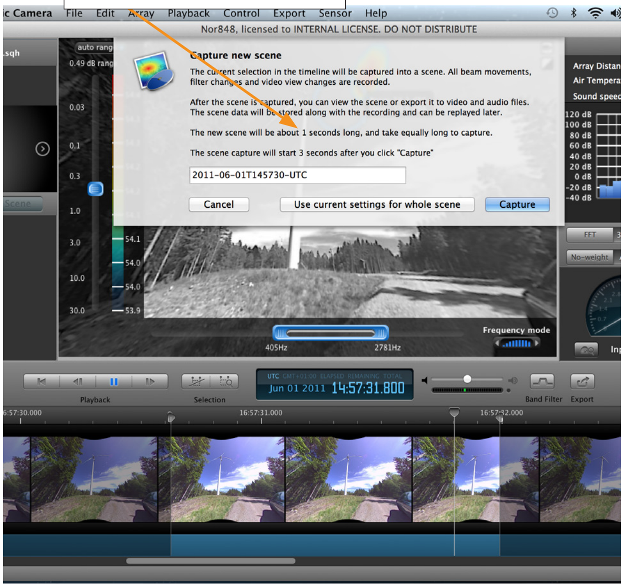
Press the Space bar to halt or start a replay!

Tip: When halted, you may step the replay forwards in small sections by pressing the right arrow key on the keyboard. This feature may be useful for looking at transient sounds. You may step backwards by pressing the left arrow.

Making Scenes



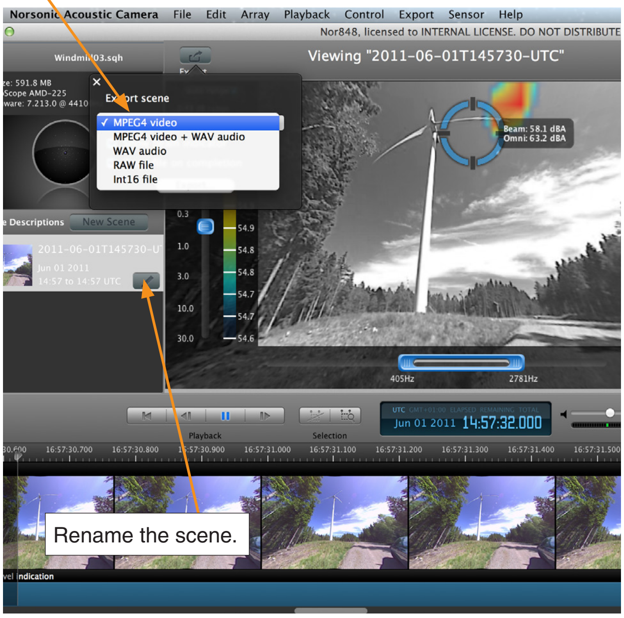
Duration information based on the actual selection



When you play a recorded file, you may select a part of it as a new scene. Mark the part you want to keep as a scene in the time-line and press the “New Scene” button. The information shown to the right will be presented. Press “Capture” to create the scene. During the creation of the scene, you may move the cursor or readjust parameters like frequency range, level range etc and this information is recorded as part of the scene. If you don’t want this possibility, press the optional “Use current settings for whole scene”.

When the scene is captured, you are asked if you want to export the scene and in which format. You may close the menu and eventually export the scene at a later time. Available formats are:

Alternative formats for the export



Video

A movie in MP4 format with sound is exported.

Sound

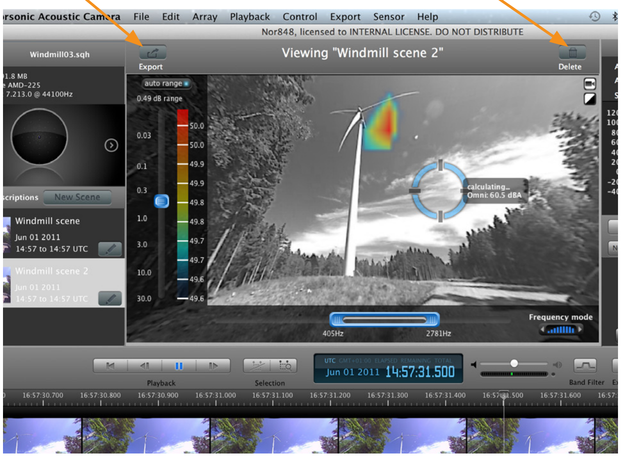
A WAV-file with the sound in the virtual microphone is generated. The quality of the sound file corresponds to CD-quality with 16 bit and a sampling frequency of 44.1 kHz. The sound is captured in the position for the cursor and may be used for listening or further analysis.

RAW-file – sqh-file

This corresponds to the original file format for the acoustic camera software, and may be used to make a file from a small section of a previous recording. In this way a smaller file with the interesting part of a longer recording may be generated. All functions like colouring and frequency analysis are available. The file will be marked xxx.sqh.

Start export of the current scene.

Delete the scene



Reporting results

Two export tools are available: one for the frequency analysis and one general. The frequency analysis export the frequency analysis in tabulated forms: frequency and level.

The general export toolbar allows you to select between:

- Report
- Images

Report

A two pages report in pdf format is generated The main optical picture with the level colouring is shown on page 1. The second page shows the frequency analysis for the sound in the virtual microphone position.

Images

The main optical picture with the level colouring is exported in png format. If FFT/Octave bands are marked the graphical frequency analysis for the sound in the virtual microphone position is exported in png format.

Shortcuts

The following is a list of available shortcuts for faster operation:

Command ⌘ R: Toggle record function on/off

Spacebar: Toggle pause function during playback on/off

RPM measurements

> **!** Please note that the RPM input connector is TTL compatible. The input circuitry is therefore not protected against over and under voltage often found in cars and from RPM signals. Precaution must be taken if signal levels are outside 0 – 5 Volts. It is recommended to have a signal conditioner connected between the RPM sensor and the camera.

Connection and recording

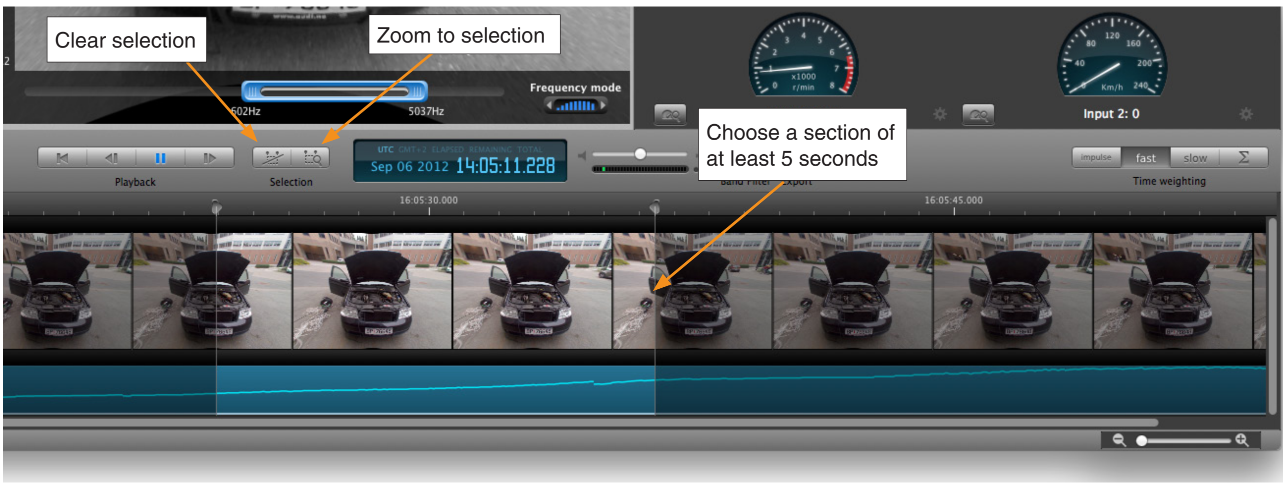
The plug for the RPM input is of type Lemo FFA.00.250. NTA, you will also need RPM input cable BNC to Lemo. Connect the logical pulse signal from RPM to input 1. Additional information such as logical pulse signal from speed may be connected to input 2.
The recording must be made while the machinery under inspection experiences a constant increase or decrease in RPM.

Opening a recording and choosing a selection

When opening an RPM recording the RPM indication will be shown at the bottom of the screen. To be able to see where the RPM indicator shows a section of constant increasing RPM, it may be wise to zoom the video out by using the zoom slider on the lower right of the screen

For further analysis it is possible to use the entire recording, or to make specific selection of the recording by selecting the part of the video of the bottom of the screen which is desirable. The selection should be from the part where the RPM indicator shows a constant increasing (or decreasing) RPM. Note that a selection has to be at least 5 seconds long to conduct further investigations by order analysis. A different selection may be made by highlighting a different part of the video. The selection may also be removed by pressing the “Clear current selection” button.

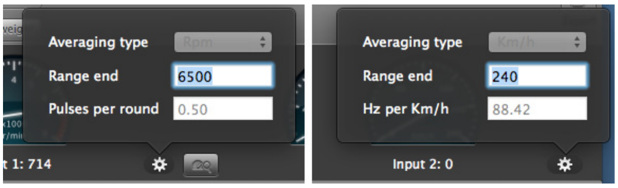
Place the virtual microphone on the area of interest for further analysis.



Changing settings

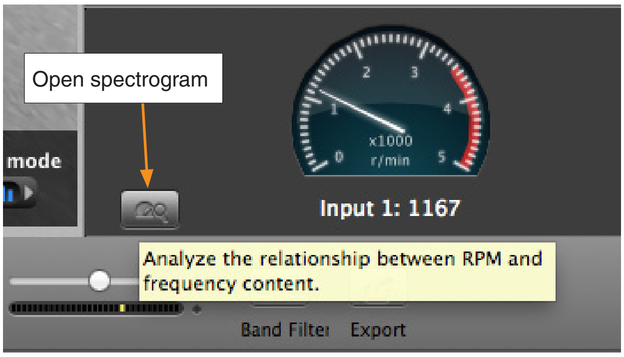
The input signal is related to either the RPM of the machine under investigation, or the speed in km/h. These are displayed on the right of the screen.

By pressing the settings button it is possible to change the range which shall be displayed.

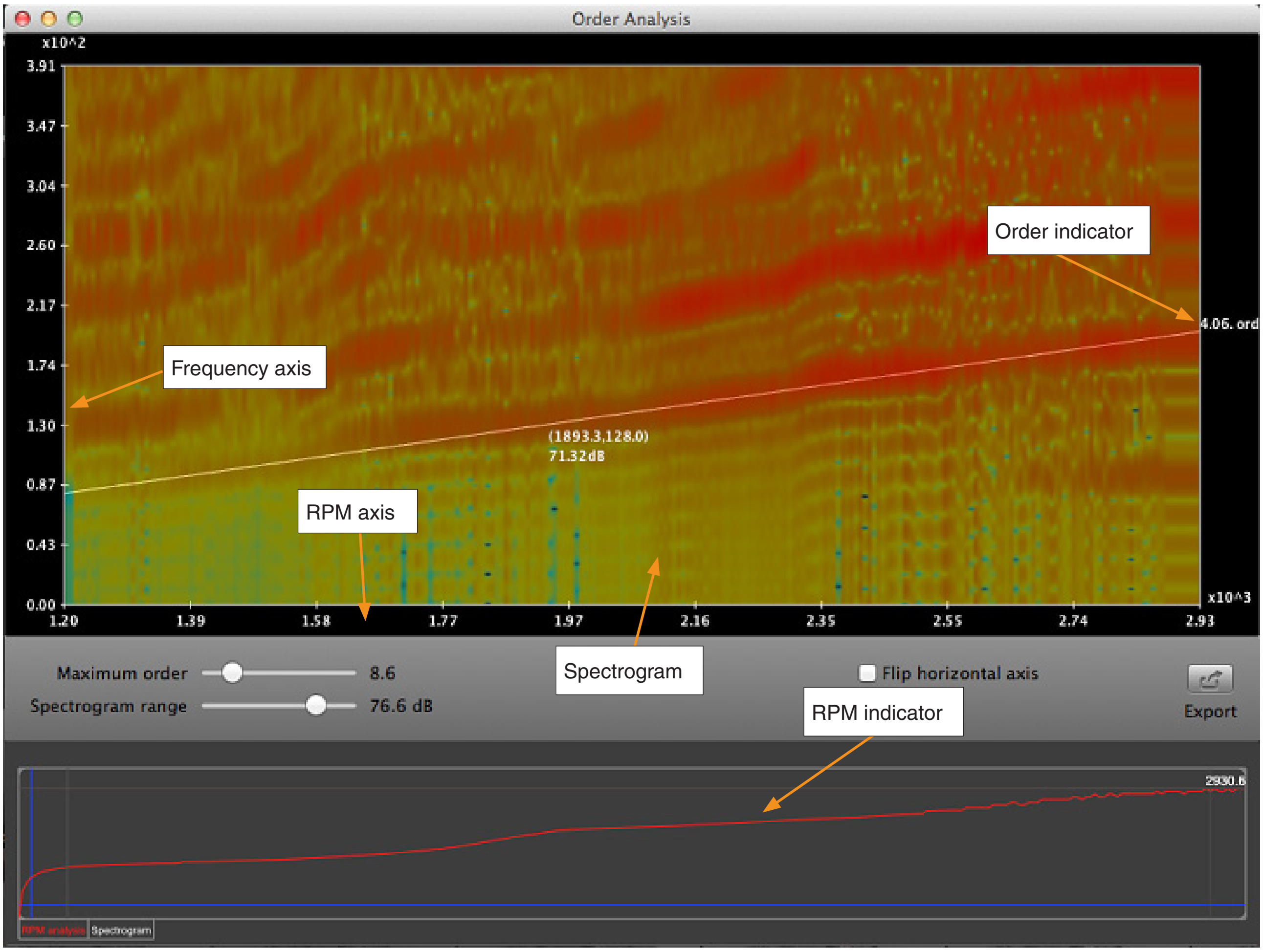


Order tracking analysis

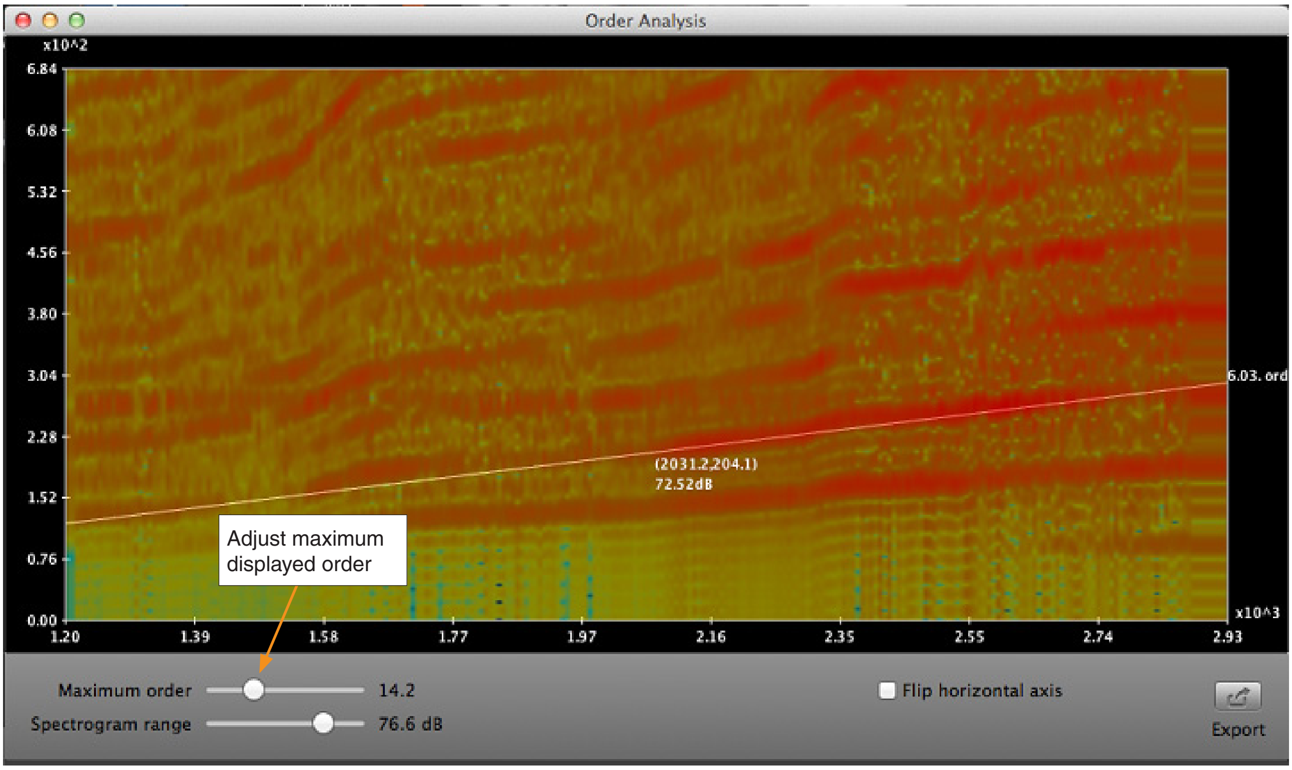
To perform order tracking analysis, press the button for analyzing the relationship between RPM and frequency content. If no selection of the video has been made, the analysis will be done over the entire recording.

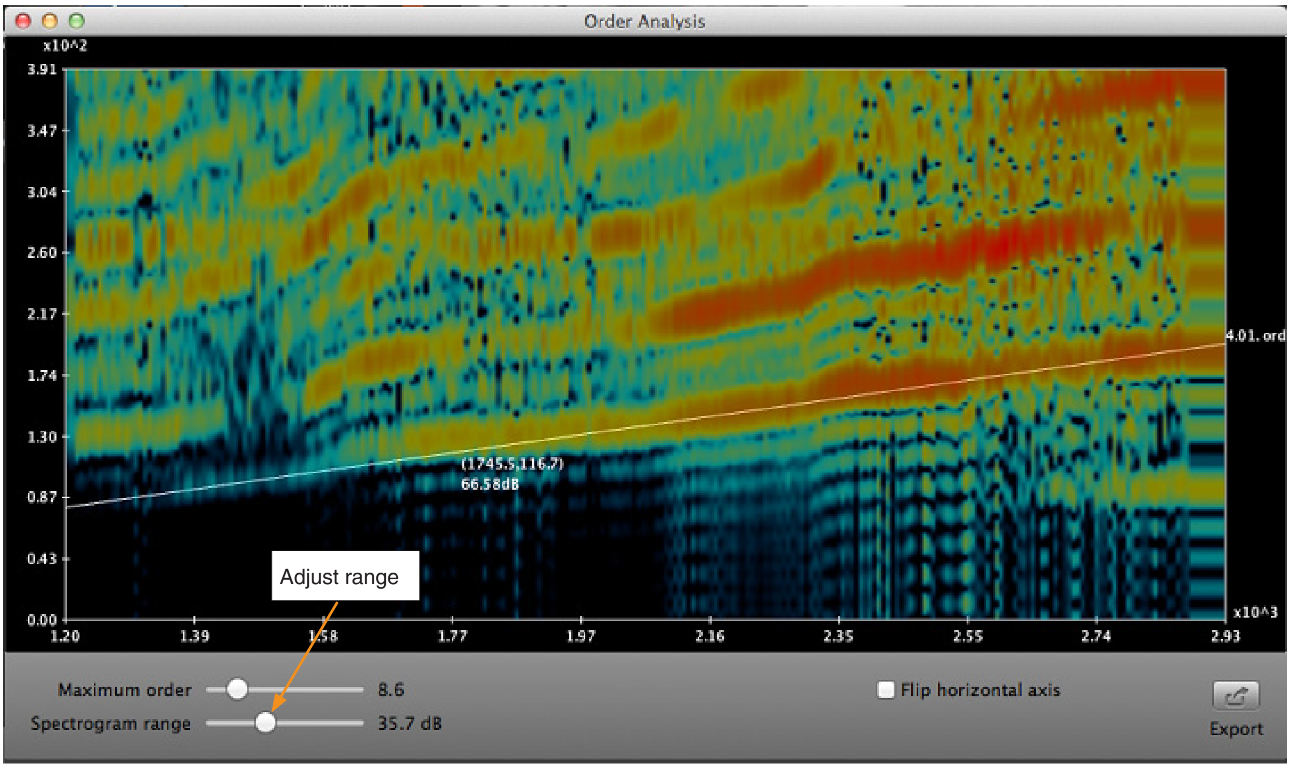


The order analysis window will pop up with the spectrogram on the top and an RPM indicator on the bottom. The grey lines in the RPM indicator are chosen automatically to select a section of constant increasing (or decreasing) RPM, which the analysis is composed of. In the spectrogram window, frequency as a function of RPM is plotted. By moving the mouse cursor inside the spectrogram window, it is possible to read off the order indicator on the right side of the screen.

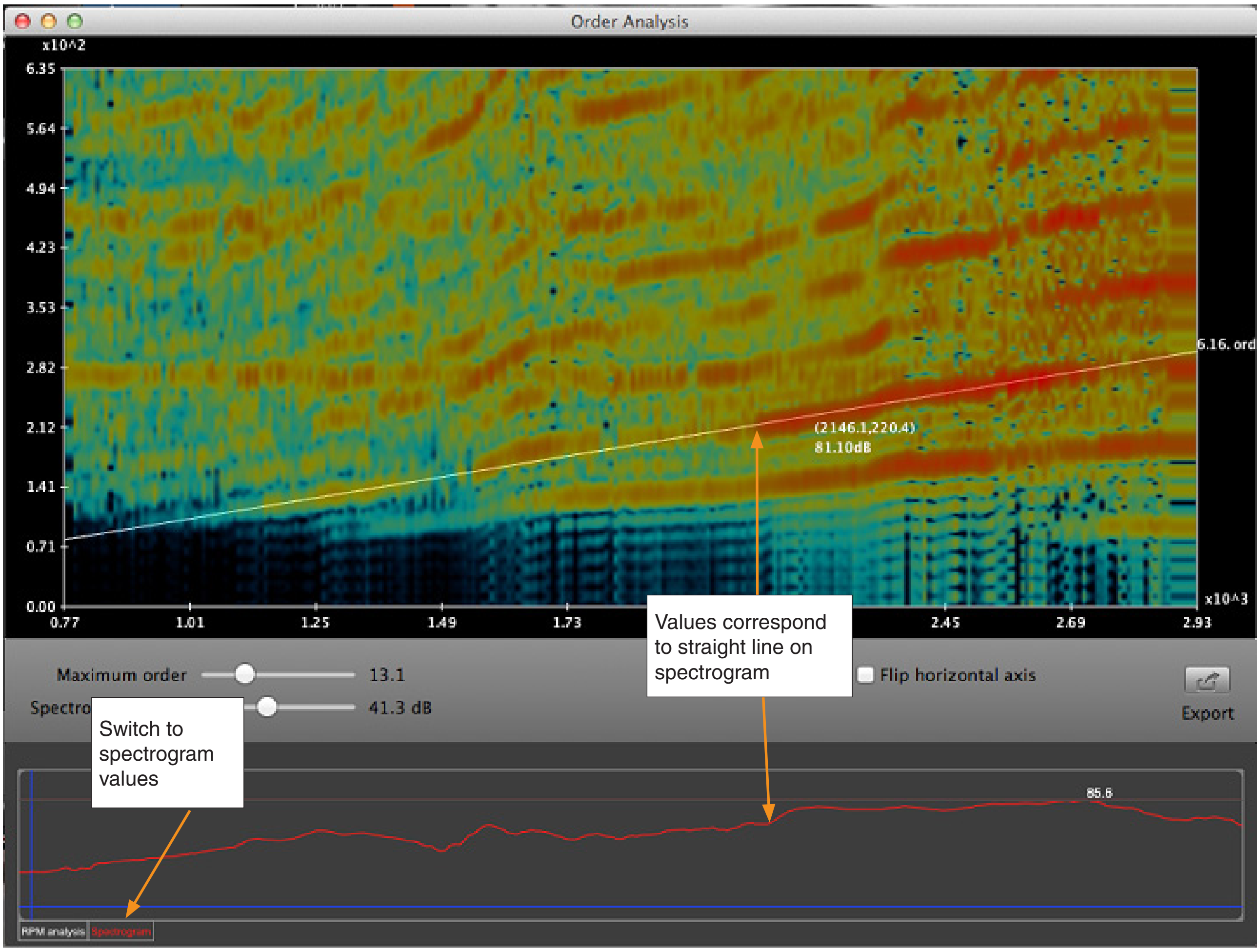


There are two adjustments for the spectrogram, either the maximum order in the spectrogram, or the dynamic range, can be adjusted





By pressing the spectrogram label on the lower left it is possible to see the values for the straight line going through the spectrogram.



Technical information

Principle of operation

The output of the acoustic camera is generated by combining the signals from the individual microphones of the array, according to the applied beamformer. Beamforming is a signal processing technique used in sensor arrays for directional signal reception. The most commonly used beamformer is delay-and-sum beamformer (DAS). As the name implies, the beamforming algorithm uses time-delays to phase-align sensor signals. This is called steering, and is done by only using spatial information about sensor positions and the direction of interest (called look-direction). When a set of delays corresponding to the selected look-direction is applied, sensor signals are summed. Due to the previous steering, the signal of interest (positioned in the look-direction) is summed in-phase and therefore amplified, while signals present from other directions are summed out-of-phase and attenuated. The degree to which the attenuation can be done depends on the array geometry and the applied beamformer. The response of the DAS beamformer can also be changed by weighting each sensor before the summation part of the algorithm (shading, or tapering). The DAS beamformer belongs to the group of fixed beamformers, meaning that the response is not data-dependent, but predefined by the chosen weighting.

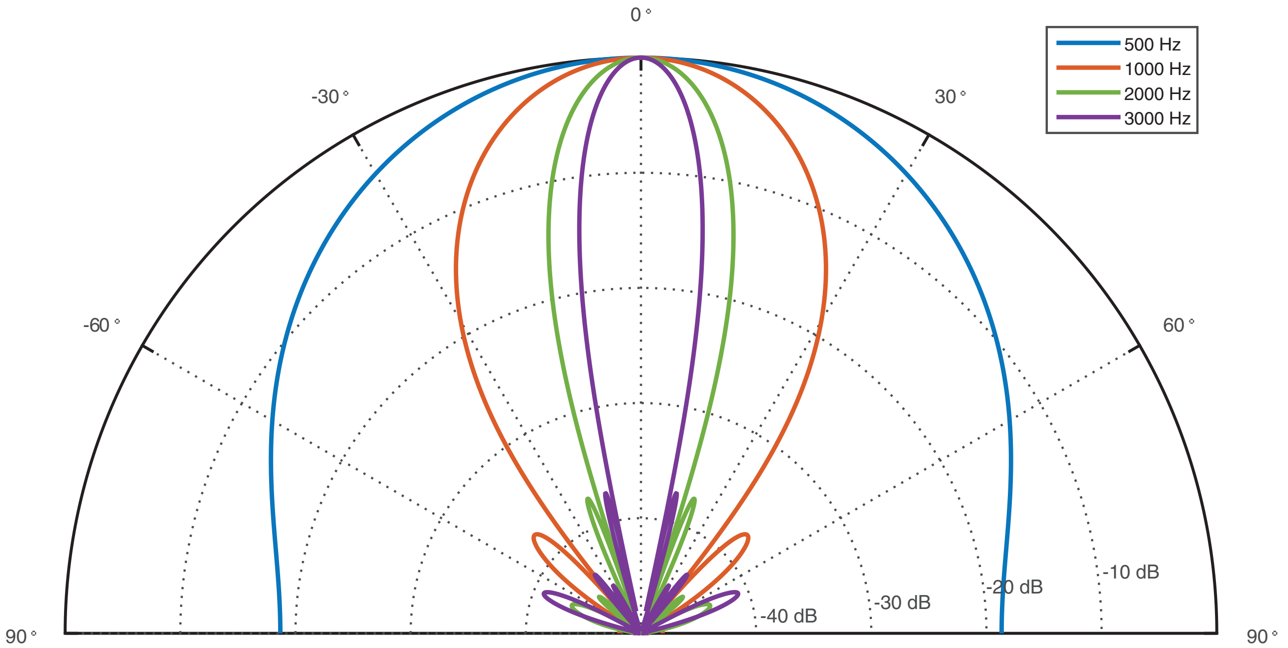
Another category of beamformers are the adaptive beamformers. These algorithms automatically adapt the response of the array to the situation at hand. The performance of the adaptive algorithms can under certain conditions be much better than that of DAS. However, these beamformers are developed under certain constraints and can break down if the acoustical conditions are not in accordance with the method specifications. In addition, the adaptive algorithms are computational expensive.

Beamforming can be done in frequency-domain or in time-domain.

Directional information

For the conventional beamformer (delay-and-sum) where spatial response has weighting for high resolution display, the spatial response at selected frequencies is shown in the polar plot below. As can be seen from the figure, the spatial response gets better (narrower) at higher frequencies. This is common for sensor arrays, as the spatial response is a function of array size. To improve the response at the lower frequency range, a larger aperture (array size in terms of the wavelength in question) is required.

As can be seen from the figure below based on Nor848A-10 with 256 microphones, the side lobes are typically 25 dB or more below the main lobe. The high attenuation of side lobes are possible due to the high number of microphones. This will also ensure a high dynamic range for the picture with reduced possibility of generating imaginary sources (ghost-spots).



Narrow band and broadband measurement

The broadband measurements are done by applying the time-domain DAS beamformer. The quality of the measurement will depend on the response shown in the polar plot, and the acoustical environment. For example, if multiple broadband sources are closely spaced together, they may appear as a single source to the beamformer, due to the low directivity (see polar plot above) at lower frequencies.

However, the details can be refined if needed, by looking at a single band at a time. This is done by selecting a frequency band in narrowband mode. The beamformer applied to the selected band is of the adaptive type and offers a better resolution than what is possible with DAS beamformer. The processing in this case is done in the frequency domain. It should be noted that the adaptive algorithm in narrowband mode does not perform optimally in the presence of multiple correlated sources. This situation can be encountered in rooms with considerable reflections. For measurements in anechoic chambers, this should not be a problem.

Frequency analysis

The signal from the virtual microphone point is frequency analysed by 4096-samples FFT-analysis with Hanning windows. The frequency resolution is thus about 11 Hz. The spectrum may be processed to obtained 1/1- or 1/3-octave band levels. The octave and fractional-octave bands are computed from the FFT-analysis.

Accessories included

- Microphone dish
- Tripod with mountable wheels
- 10 m LAN-cable
- Mains supply
- Power cord
- Record and analyser software
- MacBook Pro (dependent on country)
- Noise cancelling headphones

Optional accessories

- Reader version of the software (for analysing results already measured).
- Flight case
- Soft case
- Battery pack
- MacBook Pro

Specifications

Number of microphones:

Nor848A-4: 128
Nor848A-10: 256
Nor848A-16: 384

Max sound level (re. 20 µPa): 110 dB

Self-noise, A-weighted:

Nor848A-4: 12 dBA
Nor848A-10: 9 dBA
Nor848A-16: 7 dBA

Microphone frequency range: 20 Hz – 16 kHz

Mapping frequency range:

Nor848A-4: 315 Hz – 15 kHz
Nor848A-10: 125 Hz – 15 kHz
Nor848A-16: 80 Hz – 15 kHz

Sampling frequency: 44.1 kHz

Operating distance: 0.5 m to 200 m

Optical camera resolution:
Nor848A (4/10/16): 1600 x 1200 pixels

Optical/acoustic covering angle:

Nor848A (4/10/16):: ± 48° horiz, ± 35° vertical

Temperature range: -10°C to +40 °C

Humidity range: Up to 90 % RH

Mains supply: 100 - 230 V (50-60 Hz)

DC supply: 11–36 V

Power consumption microphone dish: 20 W

Disc size:

Nor848A-4: 45 cm/ 4,5 cm (diam./depth)
Nor848A-10: 103 cm/4,5 cm (diam./depth)
Nor848A-16: 164 cm/4,5 cm (diam./depth)

Weight microphone dish:

Nor848A-4: 3,5 kg
Nor848A-10: 11 kg
Nor848A-16: 16 kg

Ingress protection code: IP 40

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