

***EEG Quantitative Analysis***  
***QEEGT***

**User Manual**

**Version 5.0**



**2006**



## Introduction

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**EEG Quantitative Analysis** has been designed for carrying out quantitative analysis of electrical activity. The methods used are based on EEG spectral analysis using Fast Fourier Transform (FFT) and produce several numerical parameters as output. These results are stored on different models that can be viewed and interpreted also with this module.

Models calculated with **EEG Quantitative Analysis** are:

Model	Shorthand	Meaning
Narrow Band spectral parameters	CROSS	This model localizes frequencies where an abnormal electrical activity is reached as well as its spatial distribution, avoiding the loss of frequency and spatial information inherent to the Broad Band Model.
Broad Band spectral parameters	BBSP	This model approximates spectra (Narrow Band spectral parameters) as a constant over certain frequency bands. Includes Absolute Power, Relative Power and Mean Frequency measures (see Table below)

In addition, the Z transform for every one of these models is calculated also. A sizable difference between one observed parameter and the mean value in a population of normal subjects of the corresponding age is evidence of possible abnormality. Z transform express this difference in standard deviation units facilitating its interpretation. The mean values and standard deviations were obtained from regression equations against age in a normal population. The sign of the Z magnitude indicates direction of possible abnormality: excess (+) or defect (-). If the observed parameter follows a Normal distribution probability, Z values will be inside the interval  $[-1.96, 1.96]$  with a 0.95 probability when the subject is normal.



*For a correct comparison with the norm (Z transform calculation), is very important to follow the requirements for such comparison. (see Comparison with EEG norms).*

The shorthands corresponding to the models calculated with Z transform are: ZCROSS and ZBBSP respectively for each of the previous described models.

**Broad Band Measures Table**

Measure	Shorthand	Meaning
Absolute Power	AP	Is the measured energy for each derivation on every frequency band, calculated in $\mu V^2/Hz$ .
Relative Power	RP	Express proportion of Absolute Power in the band with respect to the Total Absolute Power for every derivation, it indicates contribution from every band to the total power.
Mean Frequency	MF	Is the gravity center for band, expressed in Hz.

The module also calculates the Geometric Power (GP) which represents the EEG mean energy for every derivation and frequency. This magnitude is a scale factor depending on the frequency band, decrease with age and explain more than 40 % of the EEG variance in subjects with the same age. Correction with this factor is convenient for decreasing data variability without losing its temporal and spatial structure. Using this scale factor decrease the possibility for taking as abnormal, increments on spectral energy in patients with wide basal EEG, or sensible decrements for such energy in patients with low amplitude EEG. At the same time, allows that more details can be obtained about Z transform topographic distribution by using scales with energy absolute values substantially lower than generated with CROSS and BBSP models.

The GP is stored for every model as another measure allowing the model observation with or without it. For BBSP models it is only applied to Absolute Power measure.

All analysis results are stored in files with .MOD extension corresponding to the different calculated models. Files generated have the following naming convention:

<study name>-<model shorthand>-<state>-<order number>.MOD

where:

<study name> original name of the study when the EEG was recorded.

<model shorthand> shorthands already described for every model.

<state> letter (A,B,C,...) corresponding to the processed state.

<order number> indicates the number assigned to the analysis result for every working session. With this mechanism, it is possible to keep old results obtained in previous analysis sessions.

### **Comparison with EEG norms**

The EEG should be recorded with the subject in a resting state (decúbito supine position or seated). The recording electrodes should be placed according to the 10/20 system (Fp1, Fp2, F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T3, T4, T5, T6, FZ, CZ, PZ) or by using the recording caps supported by the system (see Montages available for comparison with EEG Norms). As reference linked ear lobes should be used (A12). Recording impedance should not be higher than 5 kΩ. The recording's quality should be monitored constantly, and the recording time should be divided in the following way:

#### ***Eyes closed***

Recording time should be long enough to obtain minute and half artifact free recording, equivalent to 24 seconds. Daily practice indicates an average recording time between 3.5 and 5 minutes in this state.

#### ***Eyes open***

Recording time should be long enough to carry out the following procedure 6 times: open eyes during 12 seconds followed by another 12 seconds with eyes closed. One to two minutes should be enough to get 12 segments ready for calculation, artifacts free.

Sampling period should be 5 or 10 ms.

With these characteristics, the obtained EEG recording can be used to compare with the EEG norms. A good segment selection assures higher accuracy for determining the distance between the subject and the normal values for his age.

After installing **TrackWalker**, the default definitions allow the comparison with norms. These definitions are:

Spectral Resolution	0.390625 Hz
Low Cut frequency	0.78 Hz
High Cut frequency	19.14 Hz

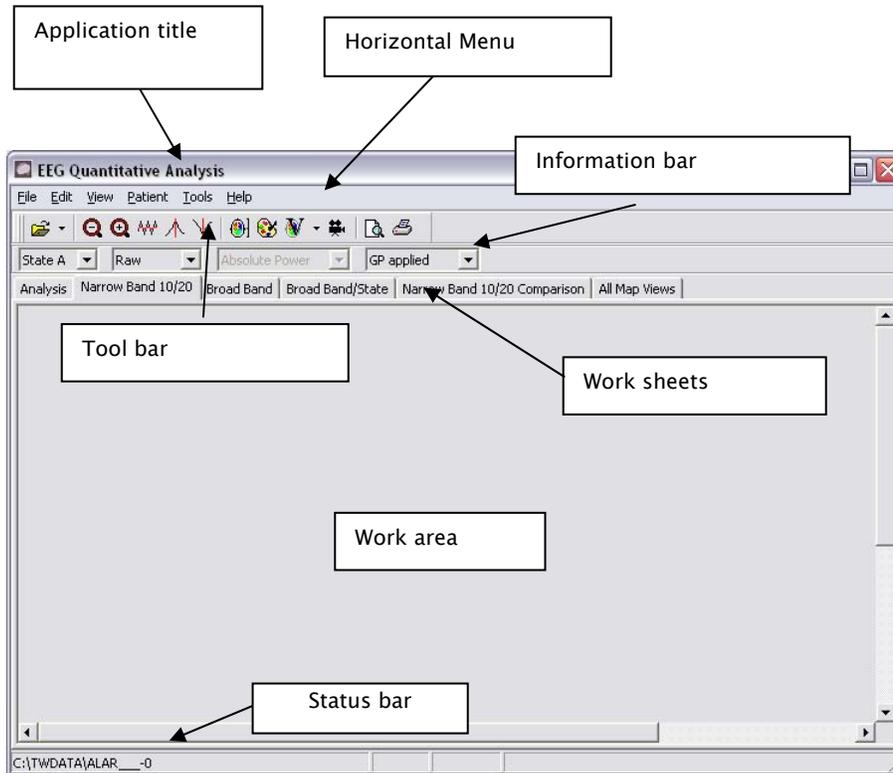
Band	Low Cut Frequency Hz	High Cut frequency Hz
Delta	1.56	3.52
Theta	3.91	7.42
Alfa	7.81	12.50
Beta	12.89	19.14
Total	1.56	19.14

The norms are available for the monopolar recording montage as well as the average reference montage.

## Screen description

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When the application starts, the working screen is presented. The module has a work area with 7 work sheets, a horizontal menu, tool bar, information bar and status bar. At the beginning of the working session the last analyzed study is loaded.



The horizontal menu has vertical menus containing most of the commands available in the module. However, there are commands whose use or activation way doesn't appear at the menus. All the commands are described in the Command description.

## Tool bar

The module has a tool bar with the most frequently used commands.

-  Open study
-  Zoom out spectra
-  Zoom in spectra
-  Smooth spectra
-  Locate maximum in spectra
-  Locate minimum in spectra
-  Scale map
-  Change map palette

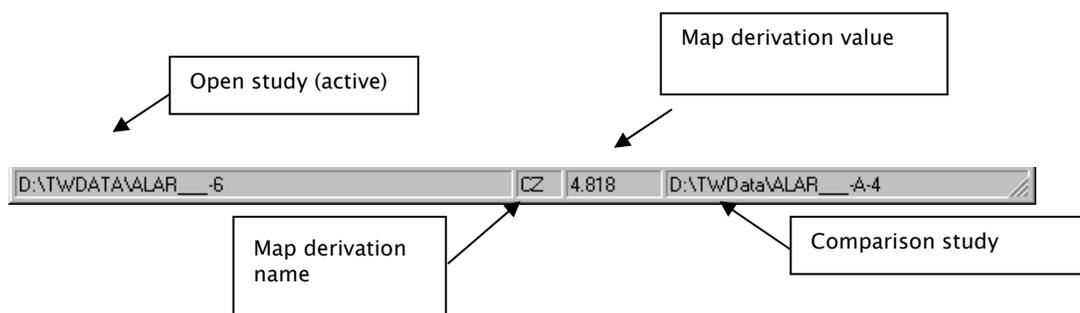
## EEG Quantitative Analysis

-  Change map view
-  Movie
-  Print preview
-  Print

A more detailed explanation will be given later in the command's description.

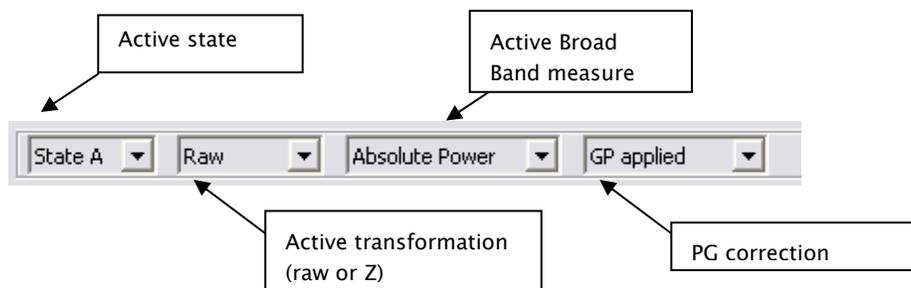
### Status bar

EEG Quantitative Analysis has a status bar for showing information about the study being analyzed.



### Information bar

EEG Quantitative Analysis has an information bar with options relative to the current work sheet.



### Work sheets

EEG Quantitative Analysis has 7 work sheets: Analysis, Narrow Band 10/20, Broad Band, Broad Band/State, Narrow Band 10/20 Comparison, Narrow Band All and All Map Views. At the beginning of the working session the last analyzed study is loaded. Depending on the models calculated, the different work sheets are enabled or not. If any model is found for the study, only the Analysis work sheet is present. If there is not

any active study, then the Open Study command should be used for activating one.

## Analysis

This work sheet carries out the model's calculation. In the group **Narrow Band definition** the parameters for calculating CROSS and ZCROSS models are set. The following table explains the parameters:

Parameter	Meaning
Spectral Resolution	Defines the equivalent parameter to the sampling period (rate) in the time domain, but for the frequency domain in this case. The value given to this parameter has implications about the segment length used for calculating. The valid segment length (SL) can be defined as: $SL = SP/SR$ , where SP is the EEG sampling period (Hz) and SR is the spectral resolution.
Initial Frequency	Defines the first spectral frequency to obtain. It should be higher or equal to the low cut frequency used in the EEG recording. Besides can not be less than the spectral resolution used.
Final Frequency	Defines the last spectral frequency to obtain. It should be less or equal to the high cut frequency used in the EEG recording.

The user can change freely the parameter's values, always keeping in mind the restrictions already explained, but in order to be able to calculate Z transform the default values must be used.

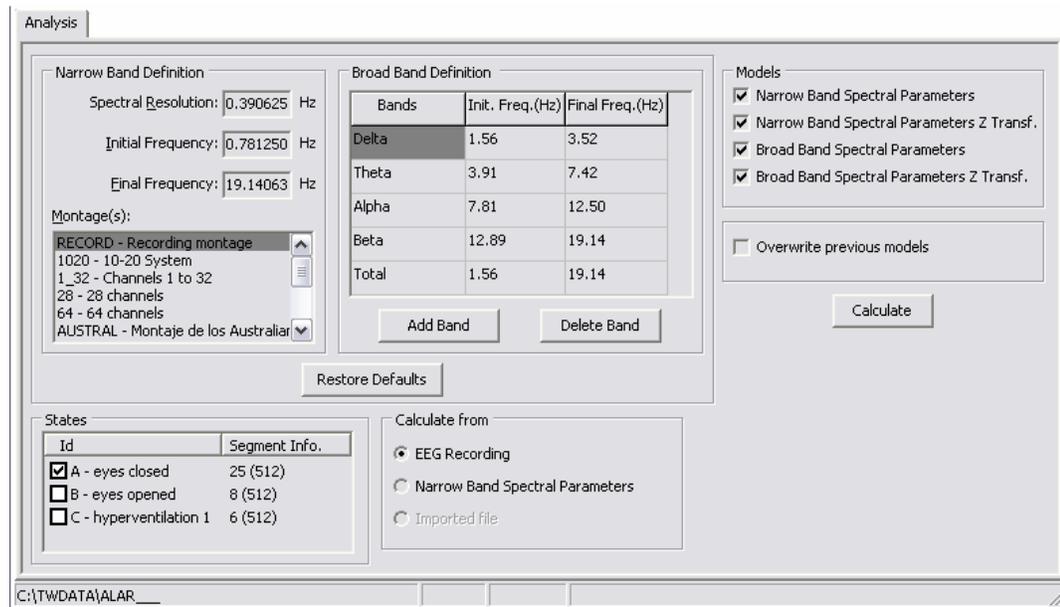
In the Montage list all the available montages in **TrackWalker** are displayed. The RECORD montage is always present and indicates the original montage used for EEG recording. As many montages as desired can be selected for calculating the models.



*All the files (models) generated for each montage will have a common order*

*number.*

In the group **Broad Band definition** the parameters for calculating BBSP and ZBBSP models are set. The user can define the bands and its limits. The bands can be overlapped and the Total band doesn't have to cover the full range defined by the others. As in Narrow Band definition default values must be used in order to be able to calculate Z transform. The buttons **Add Band** and **Delete Band** allow adding and deleting bands respectively. The button **Restore Defaults** allows to set default values for CROSS and BBSP models valid for comparison with norms. In this case, the RECORD montage as well as montages with average reference are considered default also.



In the group **Models** the models available for calculation are selected. The CROSS model is always calculated. The states desired for calculating models are selected in the group **States**. Only states with windows marked for analysis in the EEG recording appear in the group. The **Id** column has the letter identifying the state as well as its description. The column **Segment Info.** has the number of valid segments available for calculating models. Between parentheses the segment length is presented in this field. The number of valid segments as well as the segment length depends on the EEG sampling period and the spectral resolution as

explained before (see Spectral Resolution parameter). If the spectral resolution is changed the segment information is updated accordingly in the group States.

In the group **Calculate from** the starting point for calculating is selected. There are 3 possibilities depending on the specific situation: calculate from EEG recording, calculate from a previous calculated CROSS model and calculate from an imported file (if the Import EGG command was used previously). When calculating from a CROSS model, the Narrow Band parameters are taken from the starting model and thus the parameter's edition is disabled. In this case the group **States** only shows the state identifier, because the segment information doesn't have any sense.

When the option **Overwrite previous models** is selected, all the models calculated in previous working sessions are deleted.

The **Calculate** button starts the calculation process, which can be aborted by using the Cancel button present in the progress window. When the process is finished, the user is prompted to load the recently calculated models. Moreover, with the **Analysis log** command (View menu) is possible to get information about the calculation process.

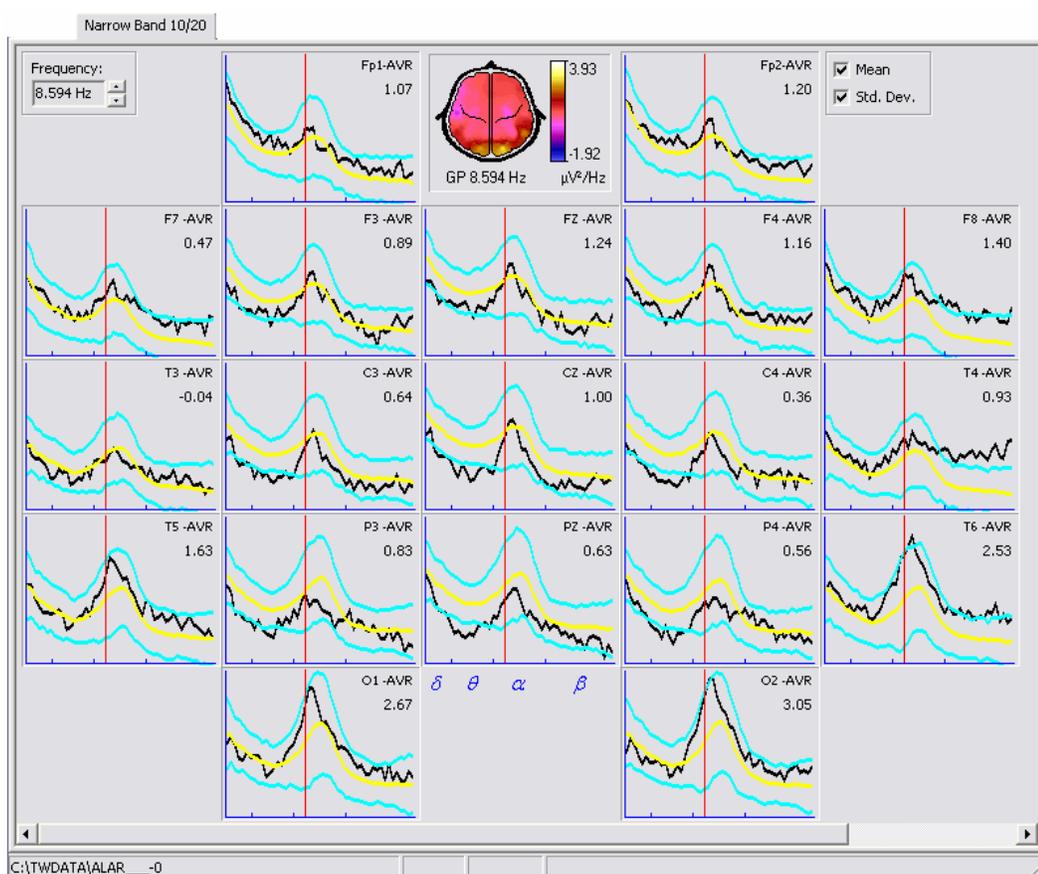
### Narrow Band 10/20

In this work sheet the CROSS and ZCROSS models are visualized, with the restriction that only the channels belonging to the 10/20 system are shown. The windows where the spectra are plotted are painted with a spatial distribution corresponding to the 10/20 system. On every window the derivation name as well as the current value of the vertical cursor are displayed. The horizontal axis shows divisions indicating the limits for the classic bands ( $\delta, \theta, \alpha, \beta$ ). The vertical cursor can be placed over the different frequencies by using the left button mouse or by selecting the desired frequency in the **Frequency** box selector. The topographic map shows the distribution corresponding to the current frequency. Initially the map is scaled to the best possible fit over the whole spectra (see command **Scale map**).

There are options at the information bar for selecting the state to visualize, the transformation (raw or Z) as well as PG correction. Depending on the calculated variants for the loaded study, these options will have available the different possibilities.

When the Z transform is selected, two horizontal bars are plotted for every window indicating the thresholds  $-1.96$  and  $1.96$  respectively.

When the raw transformation is selected it is possible also to plot the mean and standard deviations of the normal population over the current spectra. This is possible only if the loaded study can be compared with the norms. The interval represented by the standard deviations is obtained from adding and subtracting  $1.96$  to the mean spectra corresponding to the age of the study.



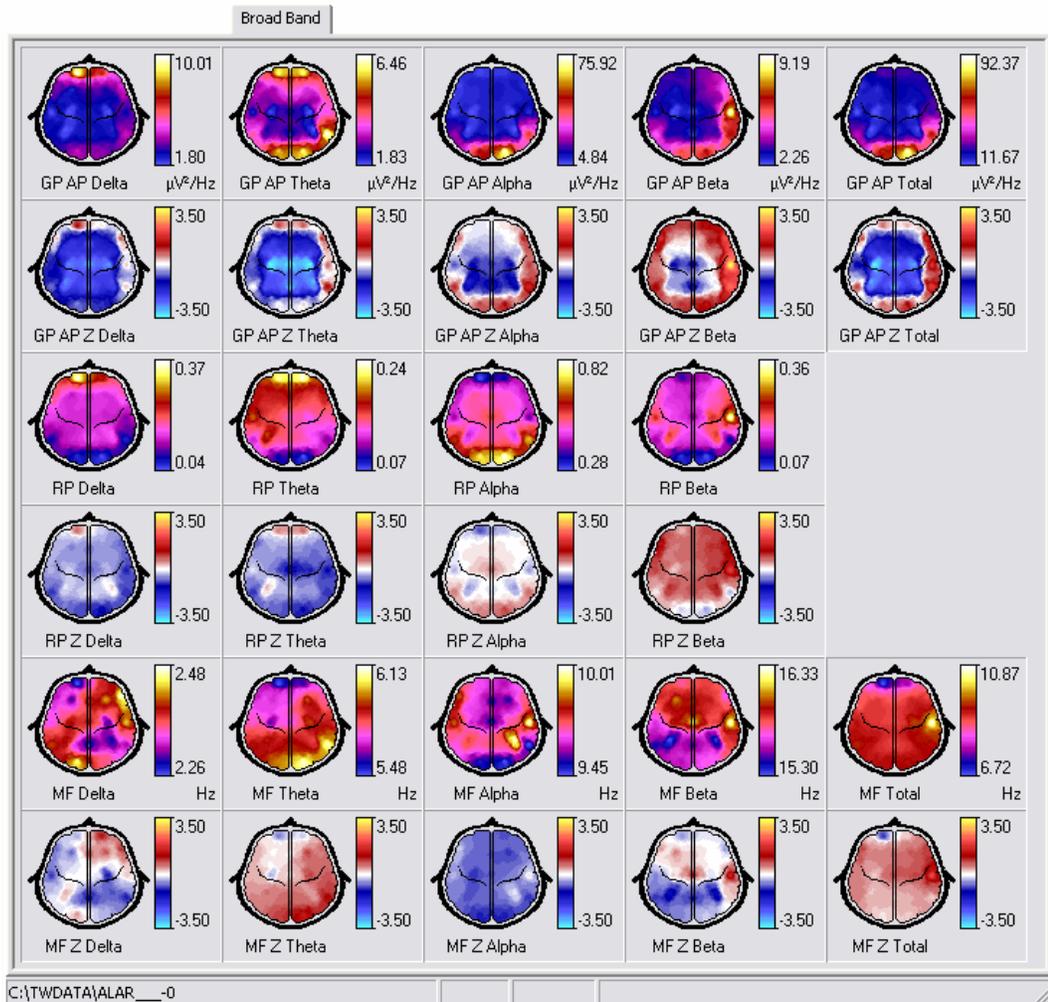
*When pressing the right button mouse over the different elements at the work sheet a pop-up menu will be displayed with the available commands for those elements.*



*When the mouse cursor is over the map the derivation name and its value are shown at the status bar.*

**Broad Band**

In this work sheet the BBSP and ZBBSP models are visualized. From these models are visualized using topographic maps 3 measures: Absolute Power, Relative Power and Mean Frequency for every band calculated. The maps are plotted on screen in matricial way, where the rows correspond to the measures and the columns to the bands. The first row for every measure shows the raw measure and the second one shows the Z transform. There are options at the information bar for selecting the state to visualize as well as PG correction. The raw measures are displayed using a best fit data MaxMin scale and the Zs are displayed with a Threshold scale with 3.0 as threshold value (see **Scale map** command).



If the left button mouse is pressed over the map window, the map can be marked/unmarked. There are several commands for working only over marked maps. The marked map is identified by a colored frame surrounding the map window.



*When pressing the right button mouse over the different elements at the work sheet a pop-up menu will be displayed with the available commands for those elements.*



*When the mouse cursor is over the map the derivation name and its value are shown at the status bar.*

### **Broad Band/State**

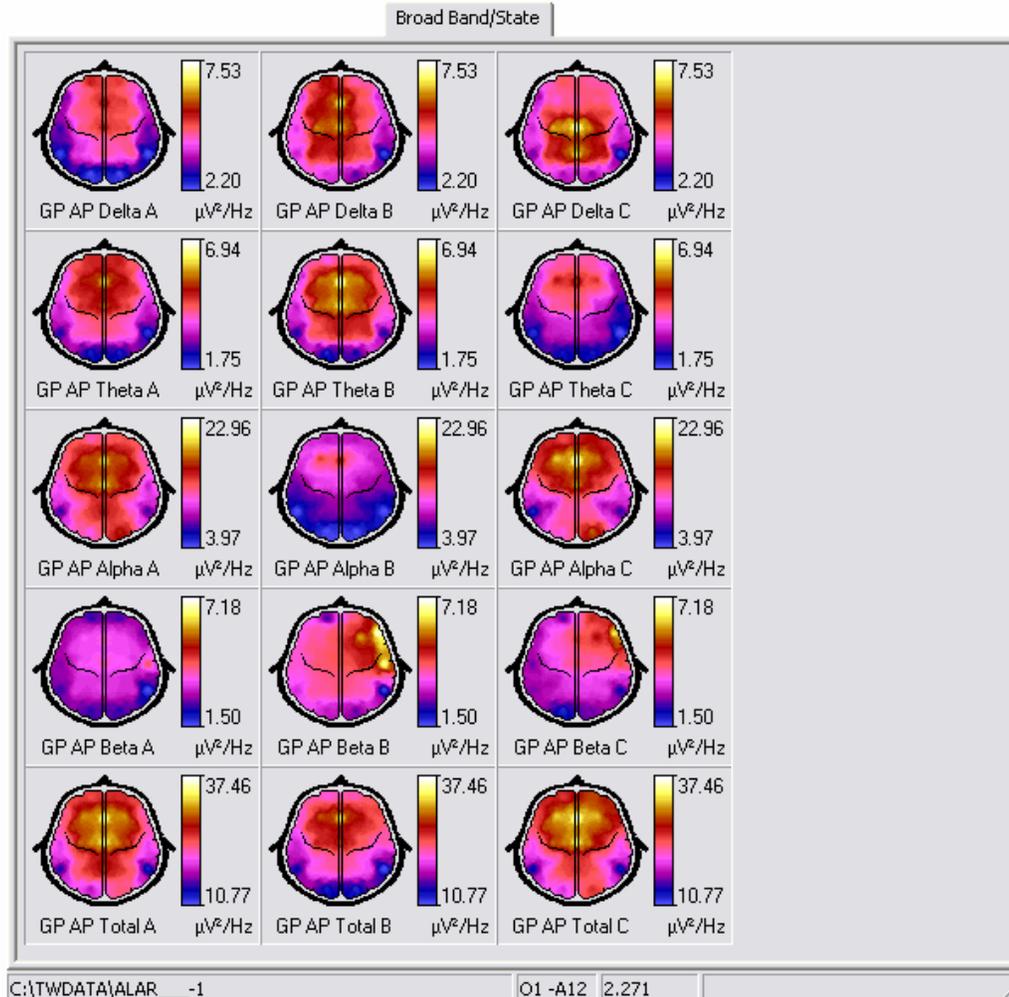
In this work sheet the BBSP and ZBBSP models can be visualized also, but here instead of displaying only the selected state, all the calculated states for the loaded study are shown. By using the option present at the information bar the desired measure can be selected. Maps are displayed in a matricial way also, where the rows correspond to the bands and the columns to the calculated states. In order to facilitate the comparison, a common scale is used for every band. There are options at the information bar for selecting the transform to visualize as well as PG correction. As in the Broad Band page is also possible to mark/unmark maps for restricting the scope of several commands to the marked maps.



*When pressing the right button mouse over the different elements at the work sheet a pop-up menu will be displayed with the available commands for those elements.*



*When the mouse cursor is over the map the derivation name and its value are shown at the status bar.*



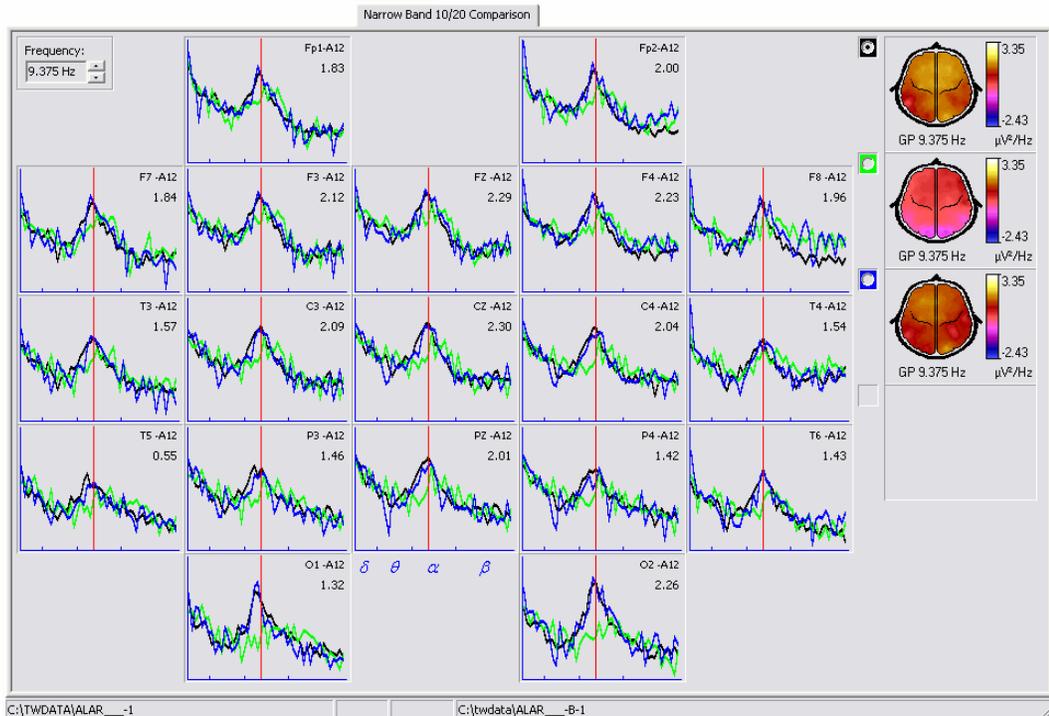
### Narrow Band 10/20 Comparison

In this work sheet the CROSS and ZCROSS models can be visualized. Here is possible to compare until 4 different spectra over the 10/20 system. The spectra are plotted in the same window. The first spectra loaded in the sheet corresponds to the current spectra shown in the Narrow Band sheet, that's why whenever the active spectra in the Narrow Band is change this sheet is reset.

In this work sheet the windows where the spectra are plotted are also placed spatially resembling the 10/20 system, but here the maps are displayed to the right. With the radio button control present to the left of every window map is possible to set the current spectra for comparison. The color of the radio button control indicates also the spectra's color.

The values shown on every window spectra are taken from the current vertical cursor position for the current spectra.

There are options at the information bar for selecting the transform to visualize as well as PG correction. The commands **Add file to comparison** and **Remove file from comparison** add and remove different spectra respectively.



*When pressing the right button mouse over the different elements at the work sheet a pop-up menu will be displayed with the available commands for those elements.*



*When the mouse cursor is over the map the derivation name and its value are shown at the status bar.*

As in the other sheets that plot maps, it is also possible to mark/unmark maps for restricting the scope of several commands to the marked maps.

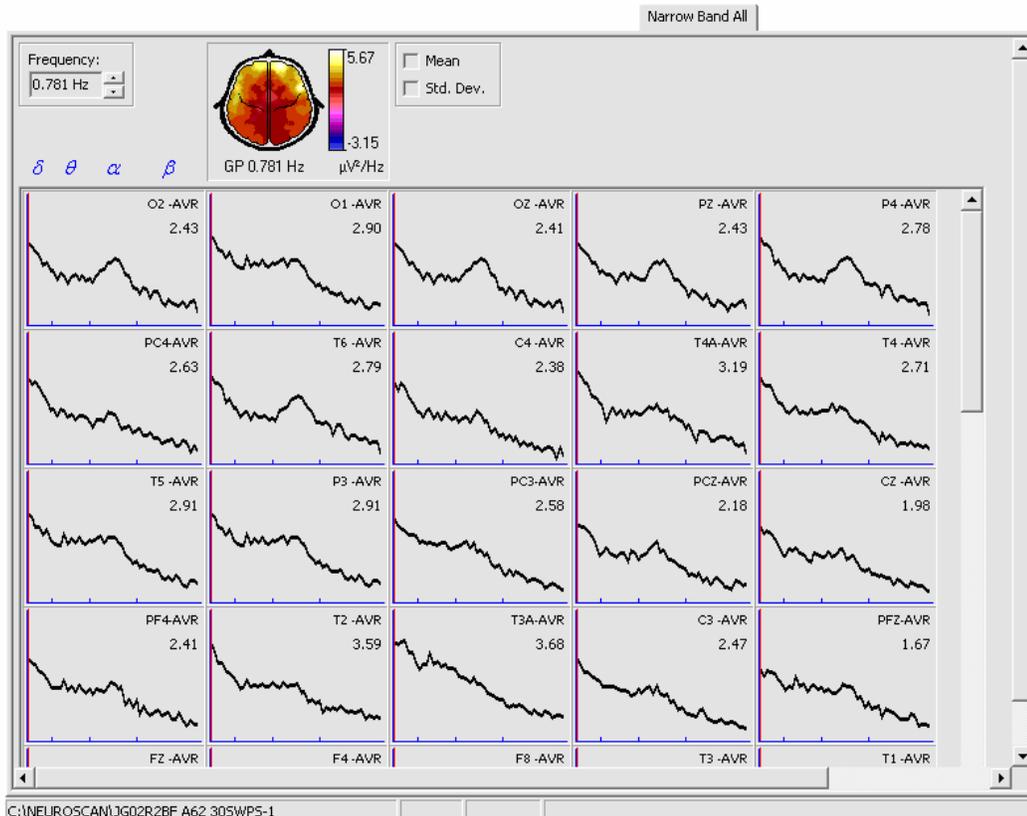
## Narrow Band All

In this work sheet the CROSS and ZCROSS models are visualized and is enabled only if the loaded study has derivations not belonging to the 10/20 system. All the spectra derivations are plotted and not only the 10/20 system. The windows for plotting the spectra are placed in a matricial way following the montage order. The topographic map showing the spatial distribution of the current vertical cursor position is displayed also.

There are options at the information bar for selecting the state to visualize, the transformation (raw or Z) as well as PG correction. Depending on the calculated variants for the loaded study, these options will have available the different possibilities.

When the Z transform is selected, two horizontal bars are plotted for every window indicating the thresholds  $-1.96$  and  $1.96$  respectively.

When the raw transformation is selected it is possible also to plot the mean and standard deviations of the normal population over the current spectra. This is possible only if the loaded study can be compared with the norms. The interval represented by the standard deviations is obtained from adding and subtracting  $1.96$  to the mean spectra corresponding to the age of the study.



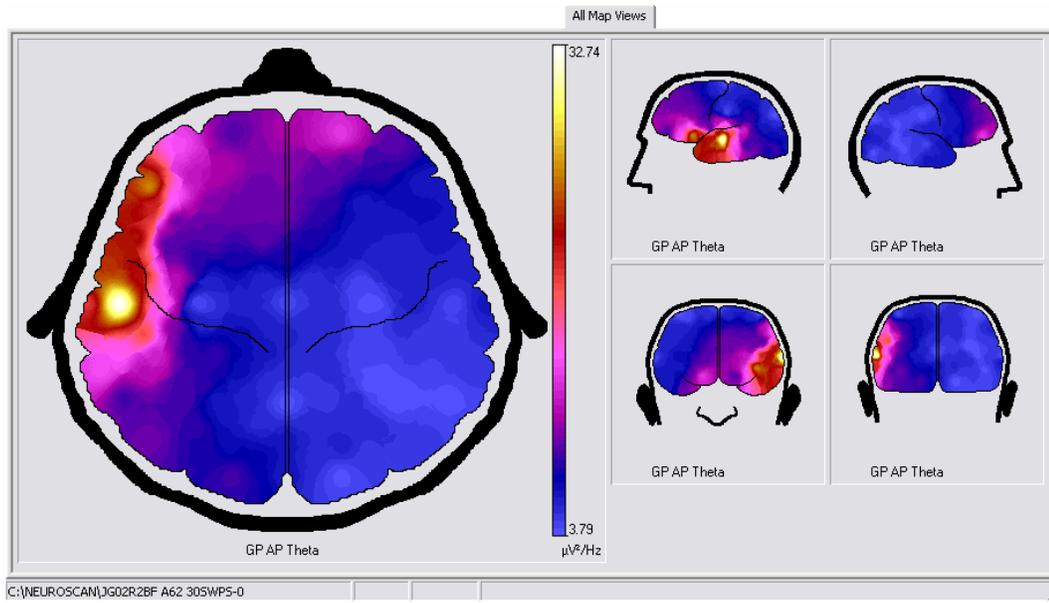
When pressing the right button mouse over the different elements at the work sheet a pop-up menu will be displayed with the available commands for those elements.



When the mouse cursor is over the map the derivation name and its value are shown at the status bar.

### All Map Views

This work sheet plots a topographic map using the five views available. The top view is displayed in the bigger size and the rest using the medium size. The sheet is initialized with the map corresponding to the first spectra frequency, but by using the **Copy to All Map Views** command is possible to update it.



Marking/unmarking maps is not allowed in this sheet. All the operations available for maps are carried out over all maps (views).



*When pressing the right button mouse over the different elements at the work sheet a pop-up menu will be displayed with the available commands for those elements.*



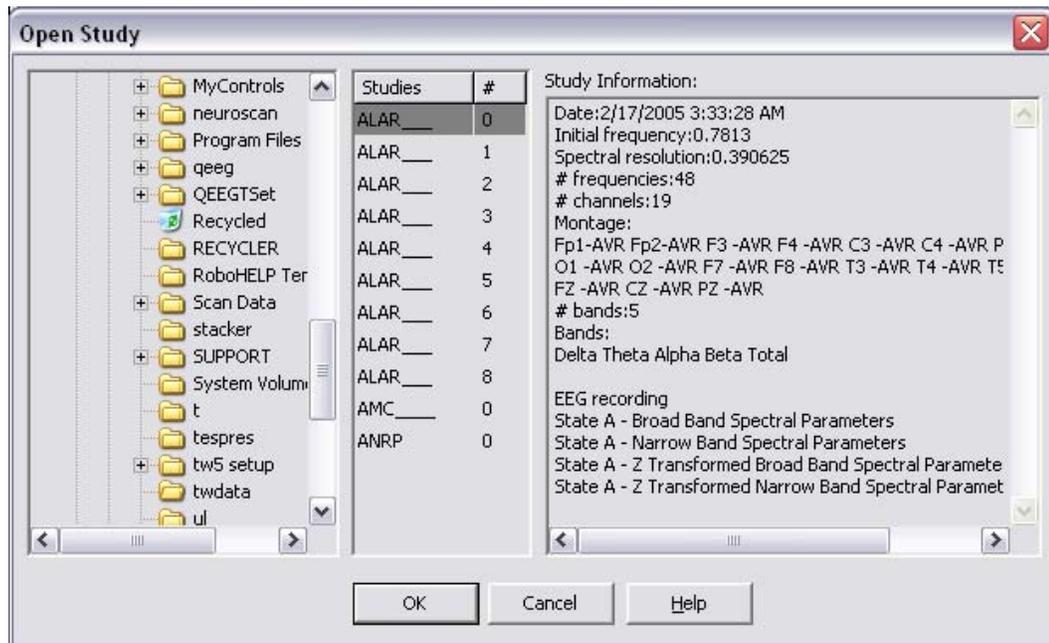
*When the mouse cursor is over the map the derivation name and its value are shown at the status bar.*

## Command description

### File

#### Open study F11

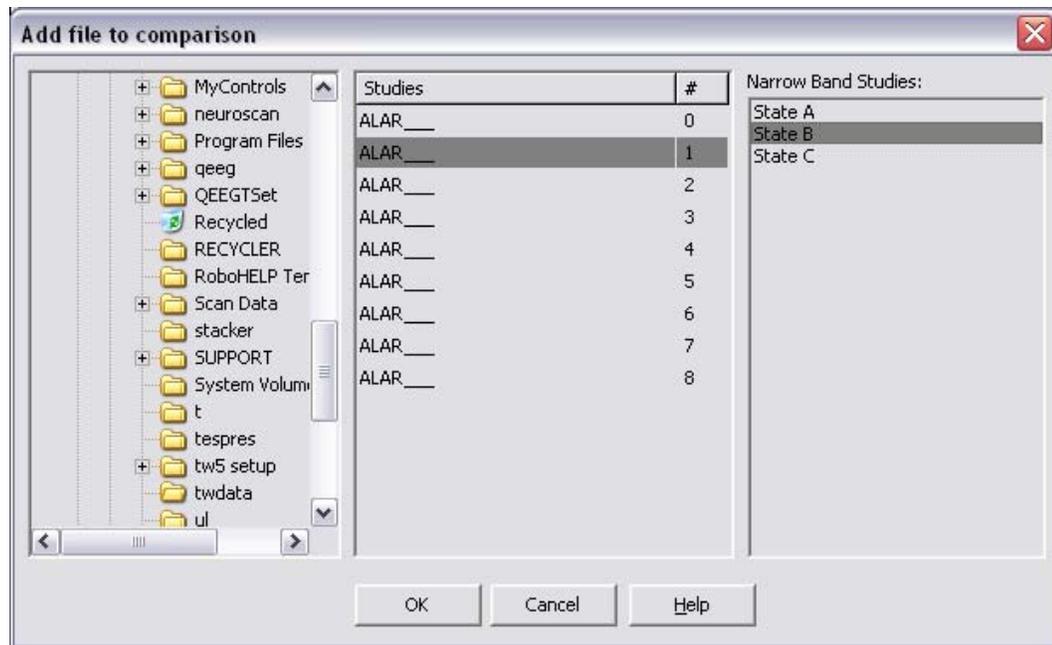
Select the study to be analyzed. When activated a dialog with 3 panels is presented. The left panel allows to select the path where the studies to be analyzed are. The central panel lists all the studies present in the path selected at the left panel. If there is more than one analysis per study, the different analyses are sorted by the order number. The right panel shows for the study selected at the central panel detailed information about the study.



The Ok button loads the study selected at the central panel.

#### Add file to comparison

This command allows adding files (spectra) to the Narrow Band 10/20 Comparison work sheet. When activated a dialog similar to the one shown for Open Study is presented. In this dialog the right panel shows the different narrow band studies available for comparison.



The Open button loads in the next free position in the sheet the selected file.

### Remove file from comparison

With this command the files loaded at the Narrow Band 10/20 Comparison can be removed. The first file can not be removed and the command is enabled when at least one of the files present in the sheet is marked. The files can be marked by pressing the left button mouse over the map. The maps following the recently removed (if any) are moved to the beginning in order to let the free slots to the end.

### Import EEG

This command allows importing EEG recordings stored in other formats for analysis. These EEG recordings can be in EEG and CNT **Neuroscan**<sup>1</sup> formats as well as ASCII files. When activated, the command presents a dialog for selecting the filename and file type.

The text (ASCII) files must have the following characteristics:

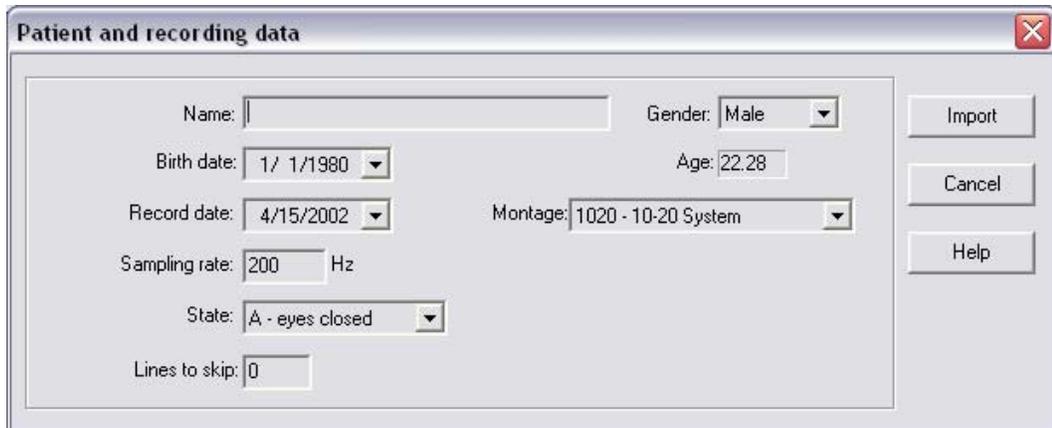
- as many lines as bursts or samples in the file.

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<sup>1</sup> **Neuroscan** is a registered trademark and protected property of its rightful owner.

- every line will have separated by spaces all the values present in the burst. As many as EEG recorded channels.
- at the beginning of the file, additional lines can be present but will be ignored when processed.

After selecting the file data type and filename, a dialog is presented for entering information needed about the EEG to import.

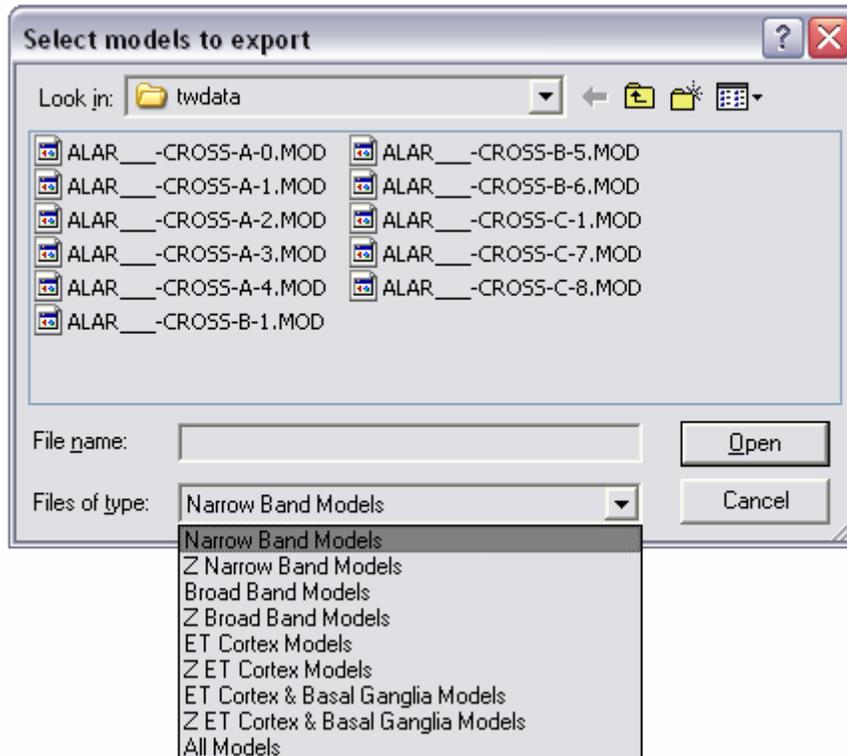


The fields **Name**, **Gender**, **Birth date** and **Recording date** allow entering the minimum information for filling patient's clinical data. The **Lines to skip** field allow to set the number of lines that will be ignores at the beginning of the file. With the **Montage** field is possible to select a montage for describing the EEG recording to be imported. If the right montage is not available it is possible to create a new one with the option existent for that in the combo box. In this case the dialog for creating and editing montages is presented (see Montage in EEG Recording chapter). The Import button stats the importation process. After that the Analysis work sheet can be used for calculating. This command doesn't make a conversion to the PLG native format used in TrackWalker.

When importing from **Neuroscan** formats, the system will read all the needed information from the original files. If data relative to age, birth date and recording date are not filled adequately, a warning message will be issued. In this case the user must use the Clinical Data command (in the Patient menu) for correcting the information. The only one data that should be entered by the user during the importing process is the wakefulness state of the patient during the recording.

## Export to text

This command exports to text (ASCII) files the content of the different models generated with the module. In this way the processing results can be used in statistical packages, reports, papers, etc. When activated a dialog is presented for selecting the models to be exported as well as its type.

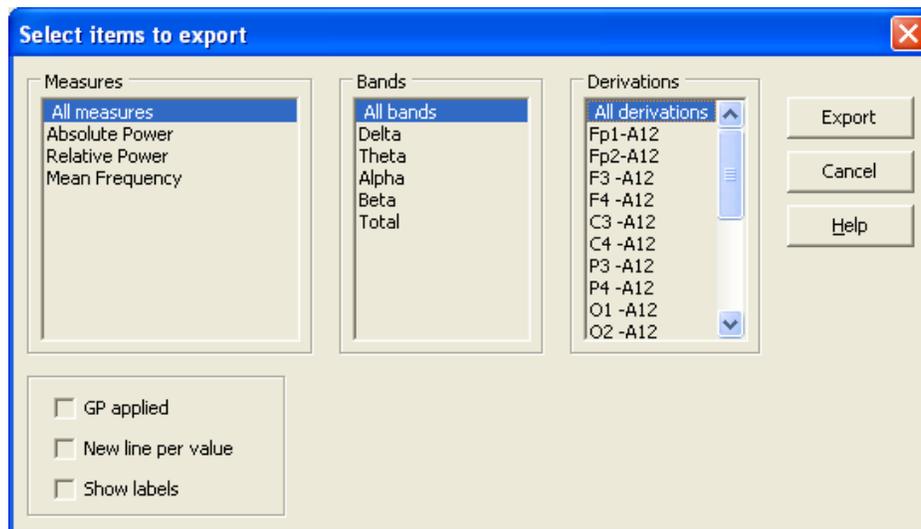
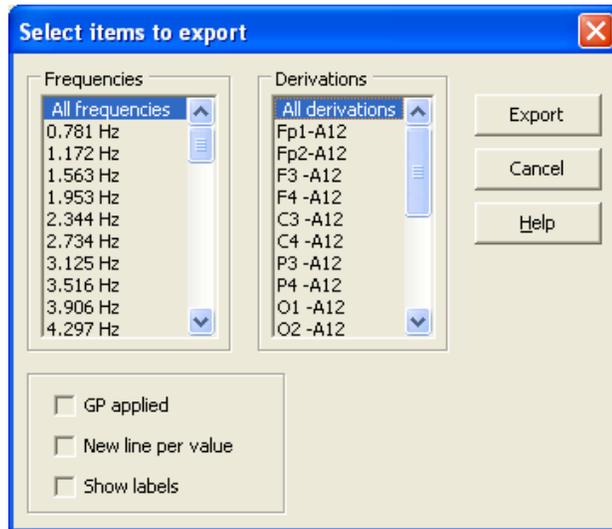


The selected models must belong to the same model type and the measures to export must have also the same dimension for every file.

Once the desired files are selected, a dialog for selecting items to export is presented. Depending on the model type different information appears on the dialog. The figure shows in the upper part the dialog configuration for CROSS models and in the lower part the configuration for BBSP models. By using the selection lists it is possible to set the item to be exported.

The dialog shows also 3 check boxes. The first one (**GP Applied**) for setting the correction by Geometric Power. With the second check box (**New line per value**) the user select if every value will appear in the output text followed by a return line or not. The third check box (**Show labels**)

sets if the labels for each item are shown in the output text file. In this case the first row in the file will show the label for every item. If there is more than one file involved in the operation, its filename will be shown at the beginning of the corresponding row in the output text file.

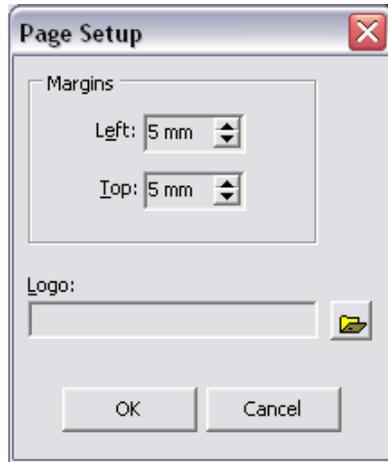


After selecting the items to export, a dialog for selecting the output text filename is presented. Another text file with the same name but with .files extension will be created for indicating for every line in the exported text file the model filename that corresponds with that line.

### Page setup

With this command the appearance of the printed pages can be set. When activated a dialog is presented for setting the different items: left and top

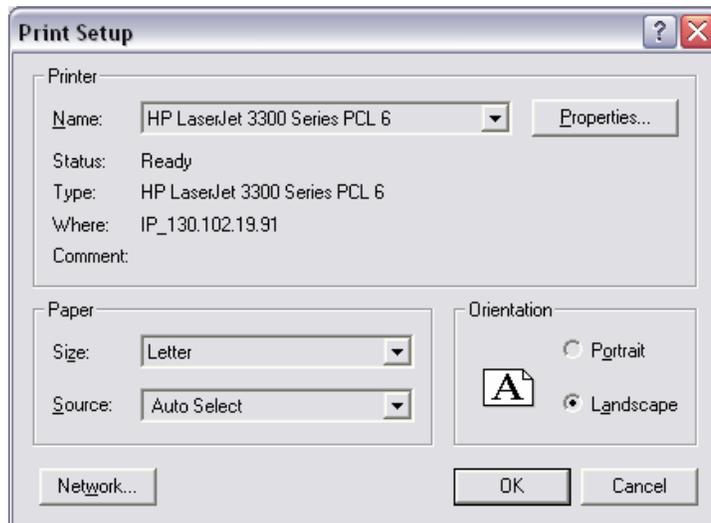
margin as well as a logo (bitmap) for being printed at the top part of every page. It must be taken into account that EEG Quantitative Analysis prints always in landscape orientation.



*The top margin is added to the space occupied by the logo if any.*

## Print Setup

This command sets the characteristics of the printer. When activated, a dialog that also sets the paper size and orientation appears.

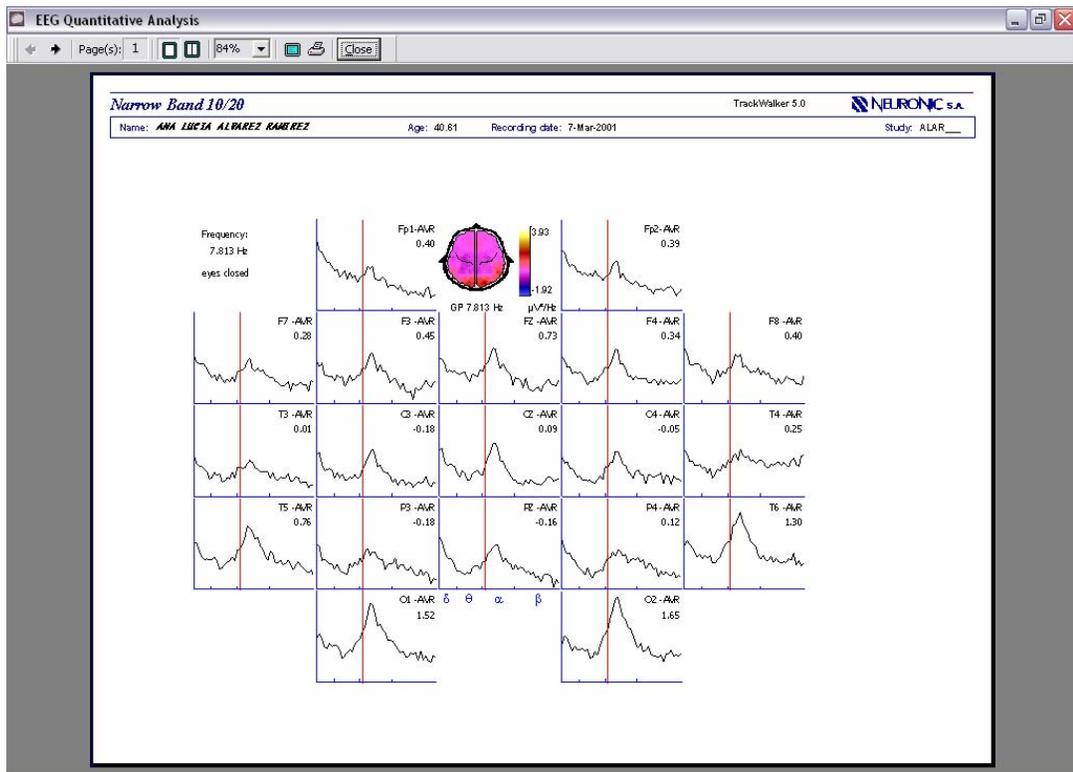
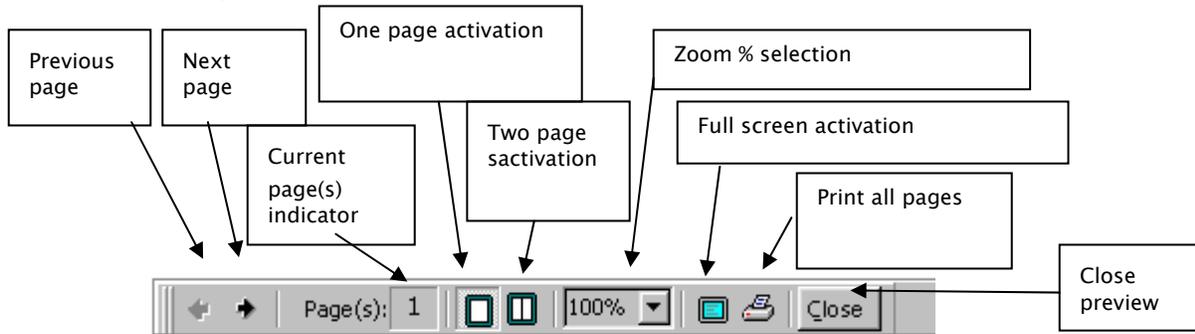


## Print preview

This command replaces the main window of the application for a window where a preview shows the work sheets as they would look on paper when

printed. The window has a toolbar with commands for adjusting the preview.

**Print preview tool bar**



All the work sheets are printed using only one page excluding the Narrow Band All sheet that could take more than one page depending on the number of channels. For identifying with the numbers every work sheet the following convention is used: 1- Narrow Band 10/20, 2- Broad Band, 3- Broad band/state, 4- Narrow Band 10/20 Comparison and 5- Narrow Band All that could take several pages if needed.

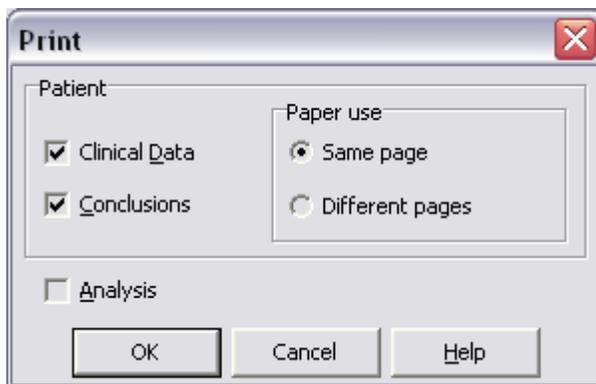


Depending on the mouse cursor image:  or , when pressing the left button mouse the page zoom will be increased or decreased respectively.

For every page the following information is present in the page header: work sheet name, application name, logo, patient name, age, EEG recording date and model filename.

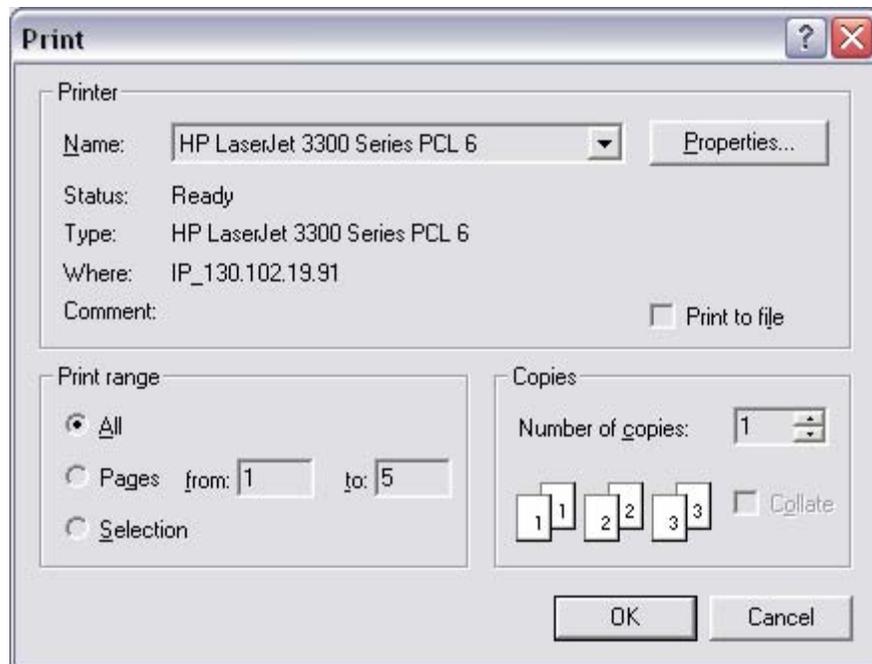
**Print**   **Ctrl+P**

Prints work sheets (see **Print preview**) as well as Clinical Data and Conclusions. When activated a dialog is presented for selecting the elements to print.



The group Paper use is enabled when Clinical Data and Conclusions are selected and also the Conclusions were edited using WordPad. If Conclusions (see command **Conclusions**) were edited with Microsoft Word then always different pages will be used.

If Analysis is selected (work sheets) another dialog is presented for setting the printer options as well as the pages to print.



When the option Selection is set at the group Print range, only the current work sheet will be printed. For selecting the work sheets by number the same convention explained in the Print Preview command should be used. After pressing Ok the printing begins.

## Studies Management

See explanation in Studies Management on EEG Recording (Chapter II).

## Application Files

See explanation in Application Files on EEG Recording (Chapter II).

## Exit

Exits from module.

## Edit

### Scale map

This command scales maps. When activated, a dialog is shown that sets the scale type and its parameters.



There are 4 scale types:

Scale	Meaning
MaxMin	In this scale type the values minimum and maximum for scaling the map are defined. When this type is selected two edit boxes are shown: <b>Minimum</b> and <b>Maximum</b> for editing the values. The toggle <b>Best Fit</b> automatically adjusts the scale based on the extreme values of the map.
Threshold	With this scale type is possible to focus on the positive and negative values in the map. When this type is selected the edit box <b>Threshold</b> is shown to define the threshold that will be used as the scale limit in both directions: positive and negative. The toggle <b>Best Fit</b> automatically adjusts the scale based on the extreme value of the map.
Percent	With this scale type it is possible to work with the values of the map in relative rather than real magnitudes. Conceptually it is similar to the MaxMin type but the values are scaled by percent. For the percent conversion the maximum value of the map is taken as 100% converting the rest of the values in relation to the maximum. When this type is selected two edit boxes are shown: <b>Minimum</b> and <b>Maximum</b> for defining the values in % and the toggle <b>Best Fit</b> which when turned on causes an automatic adjustment based on the extreme values of the map.

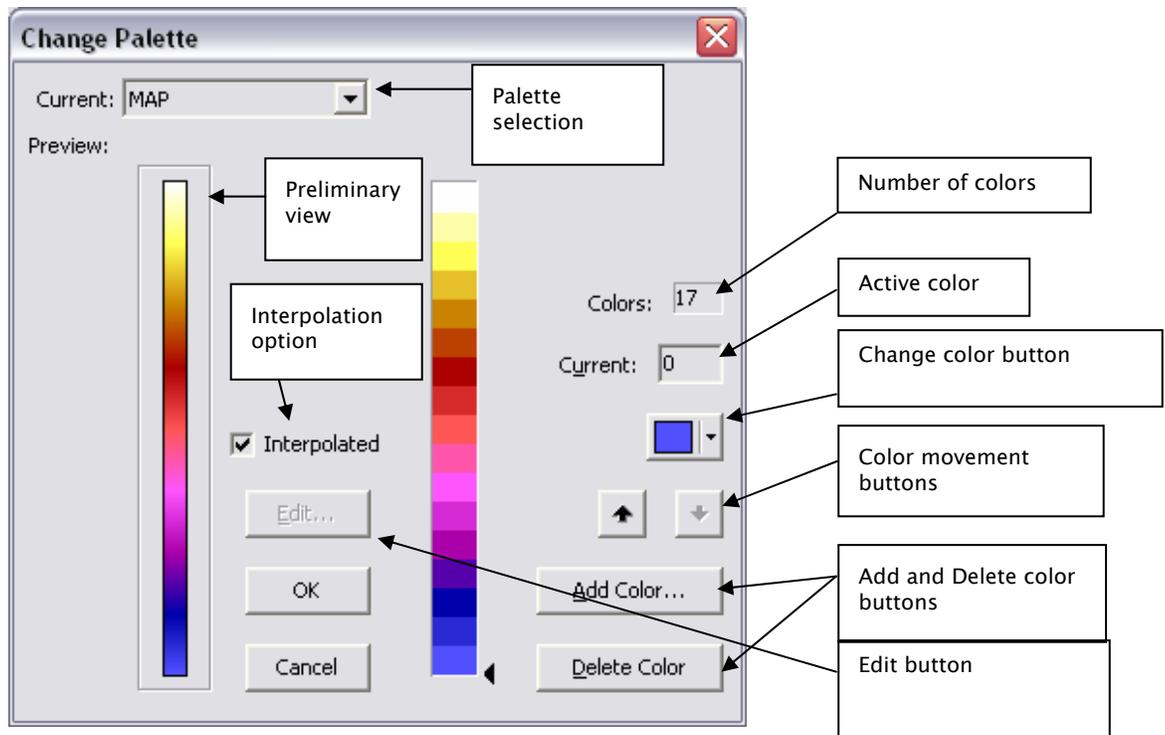
Peak Percent	This scale type is similar to Percent but here it is possible to determine the sign of the peak value that will be taken as the reference of 100%. When this type is selected the edit box <b>Minimum</b> is shown to define the minimum value in % (the maximum is always 100) as well as a radio control <b>Peak</b> to set the sign of the peak value.
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## Change palette

Using this command is possible to change the active palette by selecting a new one or by editing the present one. When this command is activated a dialog is shown with several controls: an option list indicating the active palette's name, the active palette's preview, an option for interpolating the palette and the **Edit** button for editing the palette.

The palettes can use up to 256 colors. If the palette does not have 256 colors (as usual) and the option for interpolating is set, the application linearly interpolates the present colors up to 256 to obtain the palette that is actually used in the work sheets. If the option for interpolating is not set, the palette will be used without interpolation.

By means of the option list it is possible to select any one of the available palettes. Once the dialog is closed with the **Ok** button the newly selected palette will become the active palette of the application. If the **Edit** button is pressed the window is enlarged adding new controls to change the palette.



The first element that appears is a vertical bar divided by the quantity of real colors that compose the palette. The colors are denoted in bottom up order from 0 to the number of colors-1. The number of colors is indicated in the box **Colors..** Dragging the mouse over the cursor ( ◀ ) to the right of this bar sets the active color. The active color can also be selected with the edit box **Current.**

There are also 5 buttons for editing the palette:



This button changes the active color. When pressed, opens the standard Windows dialog for selecting colors.



This button moves the active color up in the palette. It is disabled when the active color is the last one in the palette.



This button allows moving the active color down in the palette. It is disabled when the active color is the first one in the palette.



This button adds a new color in the palette. When pressed, opens the standard Windows dialog for selecting colors. Once chosen, the new color becomes the active color and is inserted after the previously active color. It is disabled when the palette reaches the maximum of 256 allowed

colors.



This button erases the palette's active color. The following color becomes the new active color. This button is disabled when the palette reaches the minimum of 2 colors.

When pressing the **Ok** button a dialog for saving the recently edited palette is presented if any editing was carried out. The palette files are stored as files **.LEV** in the application's directory.



*The palettes MAP, RAINBOW and BIPOLAR can not be edited because they are used by default in the module.*

### Change map view

This command changes the map view. When activated a submenu with 5 options: Top, Right, Left, Front and Back is displayed for selecting the new view.

### Copy to window

Copies the active map (the map where the mouse cursor was placed when the command was activated) to a floating window map.

### Copy to All Map Views

Copies the active map (the map where the mouse cursor was placed when the command was activated) to the All Map Views work sheet.

### View in BRainbow

Executes **BRainbow** system for displaying in three dimensions topographic maps. Once initialized, **BRainbow** loads the active topographic map (the map where the mouse cursor was placed when the command was activated). The command is disabled if **BRainbow** is not installed.

### Change map size

Changes the map size. When activated a submenu with 3 options: Little, Medium and Big is displayed for selecting the new size. The command is enabled only at the context menu in the floating window maps (see command **Copy to window**).

### Smooth spectra

This commands smoothes spectra present in the active work sheet by means of a mobil average. Smoothing is applied to all the waves present in the window. To restore the original spectra use the **Restore original** command.

### Zoom in +

### Zoom out -

These commands change the amplitude of spectra present in the active work sheet. The amplitude change is applied to all the waves present in the window. To restore the original amplitude use the **Restore original** command.

### Restore original

The original spectra shape can be restored with this command. It is also enabled in the Broad Band/State work sheet for restoring original maps after executing the Difference command.

### Move cursor right →

This command moves cursor to the next frequency in the work sheets plotting spectra.

### Move cursor left ←

This command moves cursor to the previous frequency in the work sheets plotting spectra.

### Copy Ctrl+C

Copies the active work sheet content to the clipboard.

### Copy to

Copies the active work sheet content to a bitmap file. When activated a dialog for selecting the filename is presented. The dialog gives the possibility to inspect using a preview files already present on disk.

## View

### **Toolbar**

This command works as a toggle: when turned on the toolbar is visualized under the horizontal menu of the application; otherwise the toolbar is hidden, leaving more space on screen for work sheets visualization.

### **Status bar**

This command works as a toggle: when turned on the status bar is visualized in the bottom of the main window application; otherwise the status bar is hidden, leaving more space on screen for work sheets visualization.

### **Information bar**

This command works as a toggle: when turned on the information bar is visualized below the toolbar; otherwise it is hidden, leaving more space on screen for work sheets visualization.

### **Full screen**

When activated, the window application is maximized, hiding the horizontal menu, the toolbar, the information bar and the status bar, leaving more space on screen for work sheets visualization. To return to normal mode the Esc key should be pressed.

### **Analysis Log**

This command is enabled after every calculation in the Analysis work sheet. Shows all the incidences during the calculation process: errors, warnings, suggestions, etc., as well as the models generated.

## Patient

### **Clinical Data**

See explanation on Clinical Data on EEG Recording Chapter II.

### **Conclusions**

See explanation on Conclusions on EEG Recording Chapter II.

## Tools

### Mark all

Marks simultaneously all the maps in the active work sheet.

### Unmark all

Unmark simultaneously all the maps in the active work sheet.

### Show/hide channels

This command shows the channels positions over the maps. It is a toggle, when the positions are shown, using the command hides them.

### Difference

This command carries out the difference between two maps. When activated shows a submenu with the two possible subtractions. The result is presented in a floating window map.

### State Difference

The command is enabled only at the Broad Band/State work sheet. When activated a subtraction is carried out between all the states present in the sheet and the state marked. The map windows in the sheet are replaced by the new maps obtained with the subtraction.

### Movie

This command makes a movie at the Narrow Band 10/20, Narrow Band 10/20 Comparison and Narrow Band All sheets. The movie can be generated online or can be stored in an AVI file depending on the options set at the command **Options/Movie**.

When the movie is carried out online, all the frequencies selected according to the settings (initial and last frame) in **Options/Movie** are displayed in sequence. The movie is carried out using all the elements present in the active work sheet. When activated a small dialog is presented for allowing pausing and speed changes in the movie. The movie is finished when the dialog is closed.



When the movie is stored on AVI files, a dialog for selecting the AVI filename is presented first. After that the movie is carried out and stored frame by frame on the AVI file for its posterior visualization on any player.

### Locate maximum in spectra

This command places the vertical cursor on the frequency where the amplitude maximum is reached in the spectra at the Narrow Band 10/20, Narrow Band 10/20 Comparison and Narrow Band All sheets.

### Locate minimum in spectra

This command places the vertical cursor on the frequency where the amplitude minimum is reached in the spectra at the Narrow Band 10/20, Narrow Band 10/20 Comparison and Narrow Band All sheets.

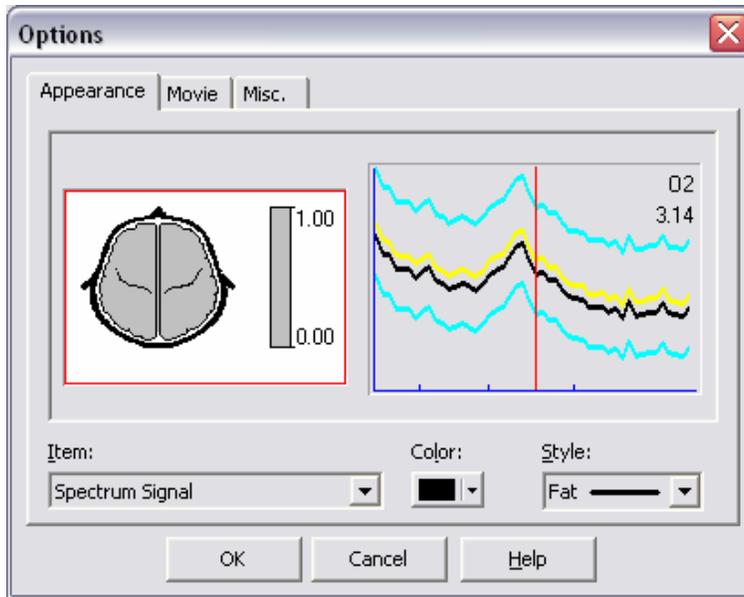
### Montage

This command allows montage edition. When activated the montage selected (if only one) at the Analysis work sheet is loaded in the Montage edition dialog (see Montage in EEG Recording Chapter II). If there is more than one montage selected, then the Montage edition dialog is presented with all the derivations of the 10/10 system available for editing.

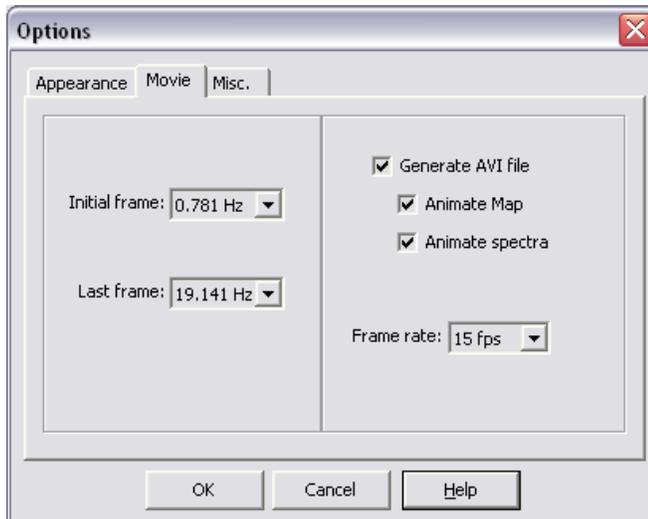
### Options

This command sets different general options used in the module. When activated a dialog with 3 tabs is presented.

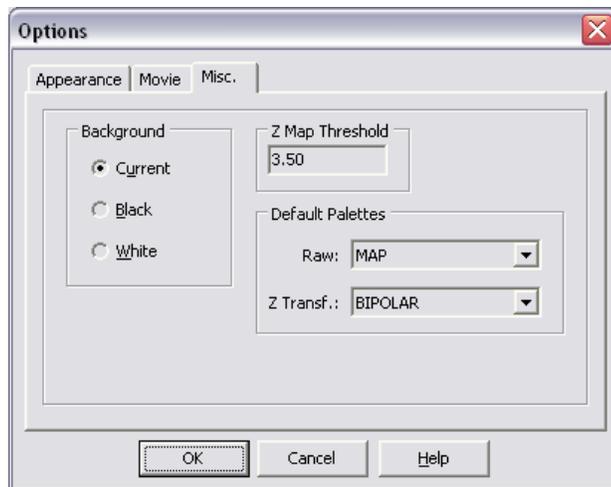
The tab **Appearance** allows setting color and style of different elements used in the module. The combo box Element selects the element to be changed. At the central part of the tab a preliminary view is presented showing the current appearance of the elements.



The tab **Movie** shows two combo boxes for selecting the initial and last frame to use in the movie. When the check box **Generate AVI file** is set (for selecting if the movie is carried out on line or not) another two check boxes are enabled for selecting which elements will be present in the movie as well as a combo box for setting the speed.



In the tab **Misc.** the background color for bitmaps saved with **Copy** and **Copy to** commands can be set as well as the threshold value for scaling maps by default when the Z Transform is set. In addition it is possible also to set the default palettes for plotting images for raw and Z transformation.



*The color background selection is used also for generating the movie with the **Movie** command.*

## Error Messages

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### **Access denied to X**

The X file could not be opened. The most probable cause is that the file is already opened in another application or its attribute is Read-Only.

### **Invalid color**

The color is already assigned to another element or is the same as the background window color.

### **Invalid Frequency Band cuts**

Some frequency band cuts for Broad Band calculation are outside the limits already set for Narrow Band.

### **Invalid High Cut Frequency**

Cut not valid because is not a valid number or the difference with the low cut is less than spectral resolution.

### **Invalid Low Cut Frequency**

Cut not valid because is not a valid number or the difference with any band cut is less than spectral resolution.

### **Invalid frequency cuts**

Some low cut frequency band is greater or equal than the high cut frequency for that band.

### **Derivations not included in recording montage**

Some derivations in the montage selected for calculation are not present in the EEG recording montage.

### **Invalid destination path**

Palette files can be saved only at the application path.

**Invalid age for norming in X**

Patient's age is outside the limits for norming.

**File does not match with previous models**

The file to be added to the Narrow Band 10/20 Comparison don't match with the files already loaded in that sheet. Maybe different spectral resolution, different starting frequency, different number of frequencies, etc.

**Study can not be processed**

The study to be opened doesn't have the files needed for calculation nor visualization.

**Number of segments not optimum for X**

The number of segments for calculation in a given state should be greater or equal than the number of channels in the calculation montage.

**Error reading file X**

File could not be read because of deletion or errors on disk.

**Error writing file X**

File could not be read because of errors on disk or not enough available space on disk.

**Study not found**

The study to be opened is not in the expected path.

**Models don't have the same size**

Models to be exported must have the same dimensions, ex: same number of frequencies, same number of bands, same number of channels, etc.

**Maximum must be greater or equal than 0**

In the Percent scale type, maximum must be greater or equal than 0.

**Maximum must be greater than Minimum**

In the MaxMin and Percent scale types, Maximum must be greater than Minimum.

**Minimum must be greater or equal than 0**

In the percent scale type, Minimum must be greater or equal than 0.

**Minimum must be greater than 0 and less than 100**

In the Peak Percent scale type, Minimum must be greater than 0 and less than 100.

**Invalid Montage**

The montage selected for calculation can not be used because has more than 32 channels, or is a bipolar montage.

**No state selected**

At least one state must be selected for calculation.

**No montage selected**

At least one montage must be selected for calculation.

**No valid montages for processing**

None of the selected montages is valid for calculation.

**No norm available for X**

No norm available for X combination in the module.

**No windows marked for analysis**

The loaded study doesn't have any analysis window marked for calculation.

**Palette files not found**

Palette files not found in the application path.

**Invalid number of segments for state X**

The number of segments available for calculation for X state is not enough for calculation.

**Invalid Band name**

Band name not defined.

**Invalid filename**

The MAP, RAINBOW and BIPOLAR palettes can not be changed, because they are used by default in the module.

**Invalid spectral resolution**

The spectral resolution to be set is not valid because is not a valid number or is less than 0.

**Invalid paper size**

Paper size selected for printing doesn't have the minimum size needed.

**Threshold must be greater than 0**

In the Threshold scale type, the value defined must be greater than 0.

**Invalid value**

The edited value is not a valid number.

**X is needed for executing the program.**

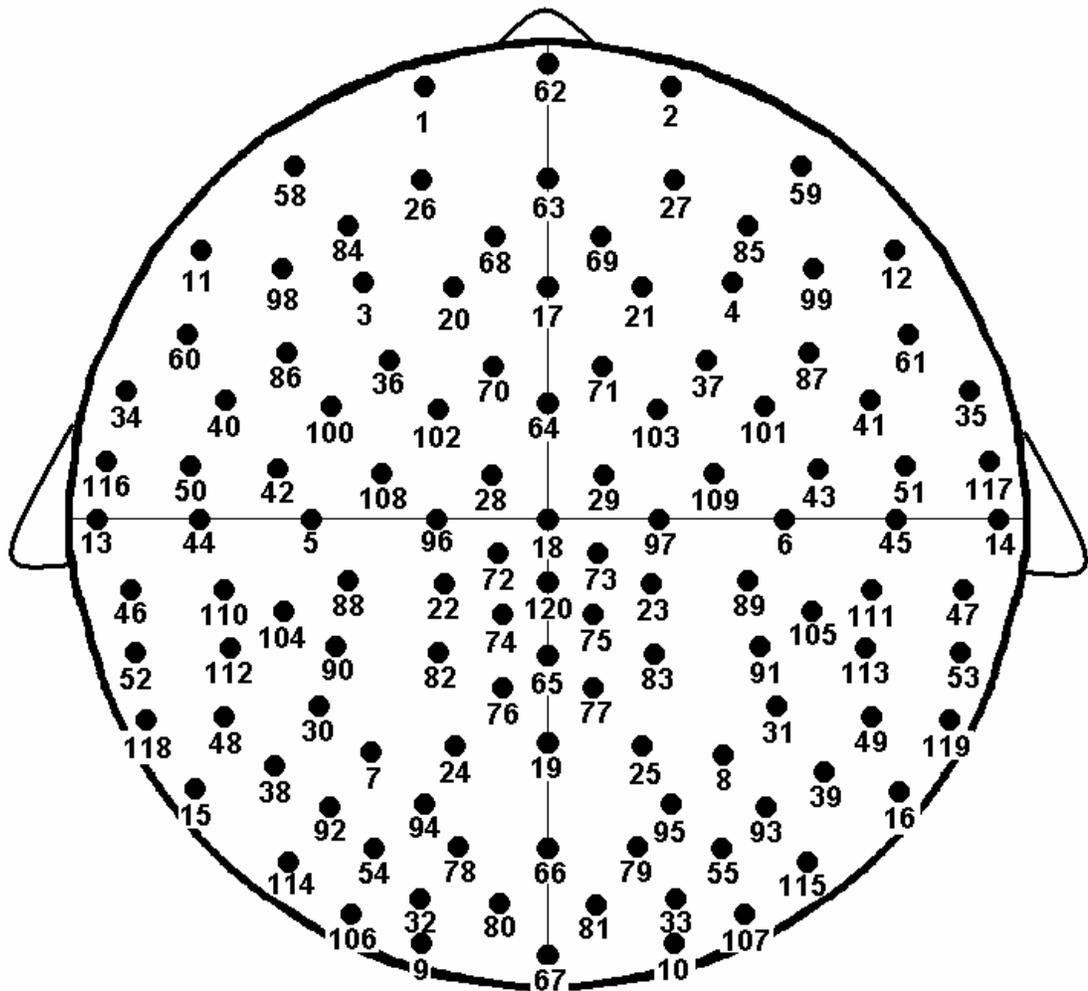
The application will be aborted because the X file is not present.

**X is not the main program**

The X application can not be executed as main program.

## Montages available for comparison with EEG Norms

EEG recordings must be carried out with the 10/20 montage (or a subset from that montage) or with a montage given by the EEG caps (64 and 128 channels) supported by the system for being able to be compared with the EEG norms. The following figure shows the naming convention used by the system for montages with multiple channels (EEG caps).



The figure shows the 118 channels for whom the EEG norms are available. Channels are named by an ordinal number between 1 and 120 (56 and 57 are not available for comparison with norms). The following table shows the correspondence between the naming convention used by the system and other naming systems.

Naming system convention	Other naming systems	Naming system convention	Other naming systems
1	Fp1	61	
2	Fp2	62	FPZ
3	F3	63	AFZ
4	F4	64	FCZ
5	C3	65	CPZ
6	C4	66	POZ
7	P3	67	OZ
8	P4	68	
9	O1	69	
10	O2	70	
11	F7	71	
12	F8	72	
13	T3, T7	73	
14	T4, T8	74	
15	P7	75	
16	P8	76	
17	FZ	77	
18	CZ	78	PO3
19	PZ	79	PO4
20	F1	80	
21	F2	81	
22		82	CP1
23		83	CP2
24	P1	84	
25	P2	85	
26	AF3	86	
27	AF4	87	
28		88	
29		89	
30		90	CP3

## EEG Quantitative Analysis

31		91	CP4
32		92	
33		93	
34	FT7	94	
35	FT8	95	
36		96	C1
37		97	C2
38	P5	98	F5
39	P6	99	F6
40	FC5	100	FC3
41	FC6	101	FC4
42		102	FC1
43		103	FC2
44	C5	104	
45	C6	105	
46		106	
47		107	
48		108	
49		109	
50		110	
51		111	
52	TP7	112	CP5
53	TP8	113	CP6
54	PO5	114	PO7
55	PO6	115	PO8
56		116	
57		117	
58	AF7	118	
59	AF8	119	
60		120	

## EEG ELECTRICAL TOMOGRAPHY

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### Introduction

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In **TrackWalker** it is possible to calculate and visualize the electrical tomography in the frequency domain. (see **What is Electrical Tomography ?**)<sup>©</sup>. In the module **EEG Quantitative Analysis** several commands have been added to carry out the calculation and visualization of the electrical tomography. Three new model types have been added:

Model	Shorthand	Meaning
Electrical Tomography over Cortex	ETC	This model localizes electrical sources only at the brain cortex of the average brain. (see <b>What Electrical Tomography is?</b> )
Electrical Tomography over Cortex and Basal Ganglia	ETCBG	This model localizes electrical sources at the brain cortex as well as basal ganglia of the average brain. (see <b>What Electrical Tomography is?</b> )
Electrical Tomography over Individual Brain	ET	This model localizes electrical sources at the regions given by the Lead Field used.

In addition, the Z transform for every one of these models is calculated also. A sizable difference between one observed parameter and the mean value in a population of normal subjects of the corresponding age is evidence of possible abnormality. Z transform express this difference in standard deviation units facilitating its interpretation. The mean values and standard deviations were obtained from regression equations against age in a normal population. The sign of the Z magnitude indicates

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<sup>©</sup> For obtaining EEG Electrical Tomography the **TrackWalker** distributor should be contacted.

direction of possible abnormality: excess (+) or defect (-). If the observed parameter follows a Normal distribution probability, Z values will be inside the interval  $[-1.96, 1.96]$  with a 0.95 probability when the subject is normal.



*For a correct comparison with the norm (Z transform calculation), is very important to follow the requirements for such comparison. (see Comparison with EEG norms in Chapter V).*

The shorthands corresponding to the models calculated with Z transform are: ZETC and ZETCBG respectively for each of the previous described models.

The module also calculates the Geometric Power (GP) which represents the EEG mean energy for every derivation and frequency. This magnitude is a scale factor depending on the frequency band, decrease with age and explain more than 40 % of the EEG variance in subjects with the same age. Correction with this factor is convenient for decreasing data variability without losing its temporal and spatial structure. Using this scale factor decrease the possibility for taking as abnormal, increments on spectral energy in patients with wide basal EEG, or sensible decrements for such energy in patients with low amplitude EEG. The GP is stored for every model as another measure allowing the model observation with or without it.

### What Electrical Tomography is?

Brain Electrical Tomography (BET) is obtained by integrating functional information given by EEG and the anatomical information provided by anatomical tomographies like Magnetic Resonance Imaging (MRI). With BET it is possible to localize spatially the sources of several processes, physiological and originated by dysfunctions of the Central Nervous system.

For obtaining the BET it is necessary to solve the EEG inverse problem. It means to assess the localization of the sources of electrical activity by using the electrical activity recorded at the scalp. By using complex calculation methods, it is possible to solve this problem using as input data the recorded electrical activity, the channel's coordinates over the scalp, as well as the anatomical information provided by anatomical tomography. This solution is represented by means of functional images.

BET calculated with EEG Quantitative Analysis has two main characteristics:

- It is calculated in the frequency domain using as input the information contained in the cross spectral matrices (CROSS model).
- It is calculated over an average brain obtained at the Montreal Neurological Institute over a sample of 305 normal MRI brains.

More details about the methodology can be found in: 3D Statistical Parametric Mapping of EEG source spectra by means of Variable Resolution Electromagnetic Tomography (VARETA) en Clinical Electroencephalography, Vol. 32, No. 2, pp 47-61 de Bosch-Bayard J., Valdés\_Sosa P. y cols.

### **DISCLAIMER**

BET software is designed for use in medical research, it has not the status of a medical product, i.e. it is not allowed to use it directly or indirectly for medical prevention, diagnostic and/or treatment of humans. It is solely for academic use in the field of scientific research. NEURONIC S.A. does not grant warranty or assume liability for the results of using the software

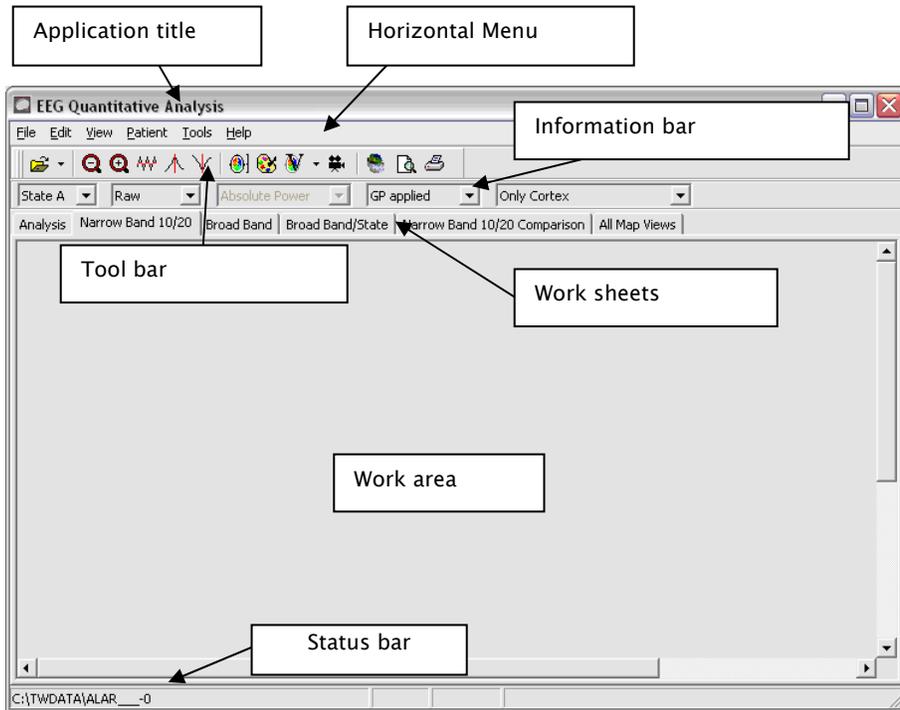


*The Z Transform is calculated for the ETC and ETCBG models ONLY with the average reference montage.*

## Screen description

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When the application starts, the working screen is presented. The module has a work area with 7 work sheets, a horizontal menu, tool bar, information bar and status bar. At the beginning of the working session the last analyzed study is loaded.



### Tool bar

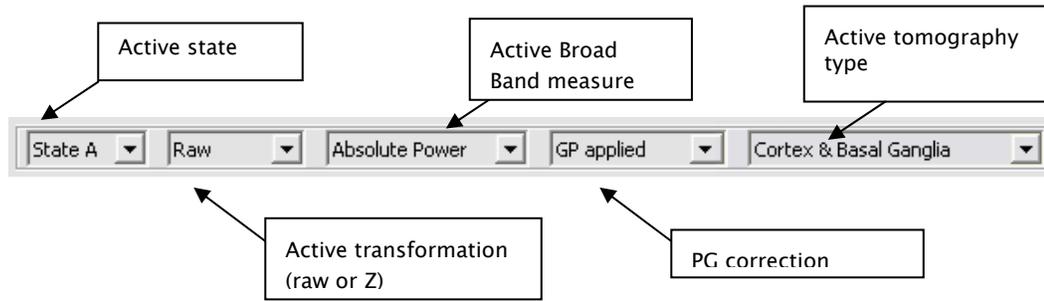
At the toolbar the following commands will be added:

 View in BET Viewer

A more detailed explanation will be given later in the command's description.

### Information bar

EEG Quantitative Analysis has an information bar with options relative to the current work sheet.

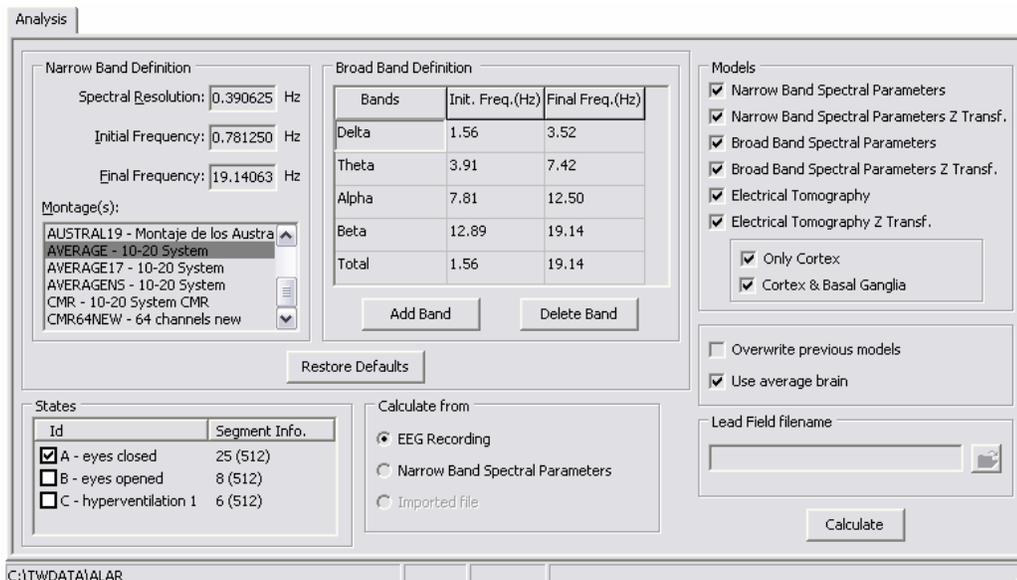


**Work sheets**

EEG Quantitative Analysis has 7 works sheets: Analysis, Narrow Band 10/20, Broad Band, Broad Band/State, Narrow Band 10/20 Comparison, Narrow Band All and All Map Views, but only at Analysis, Narrow Band 10/20, the electrical tomography is calculated or visualized. To know about the other work sheets see the EEG Quantitative Analysis chapter.

**Analysis**

In this work sheet the electrical tomography models can be calculated. The button **Restore Defaults** allows setting default values for models calculation valid for comparison with norms. In this case the montages with average reference are considered default also because the ETC and ETCBG are calculated only with average reference montages.



In the group **Models**, the models available for calculation are selected. When the Z transform of any electrical tomography modality is selected, then the Z transform (ZCROSS) is selected automatically.

When the option **Use average brain** is not selected, the electrical tomography will be calculated over an individual brain instead of the average brain. In this case the edit box **Lead Field filename** must be used for indicating the lead field file to use for calculating the electrical tomography. The option will be enabled only when not using average brain. The Lead Field is calculated outside the EEG Quantitative Analysis.



*The ETC and ETCBG (as well as its Z Transforms) will be calculated only if the full 10/20 montage (all 19 channels) is included in the calculation montage. If any channel (from 10/20 montage) is missing there won't be any calculation.*

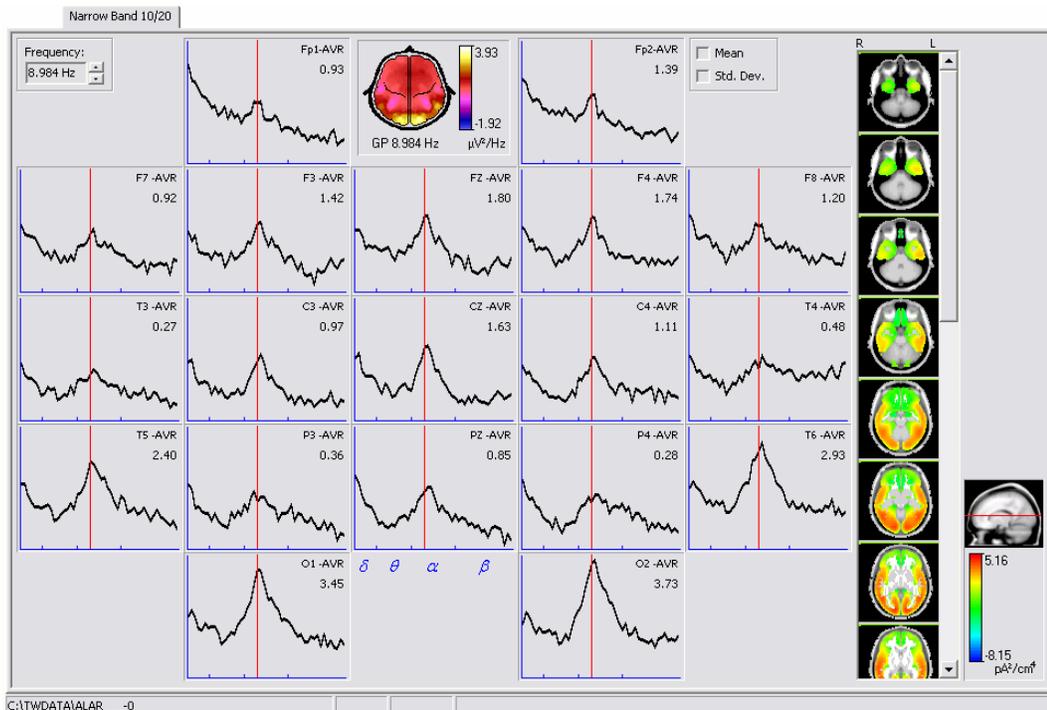
### Narrow Band 10/20

In this work sheet the CROSS, ZCROSS, ETC, ZETC, ETCBG and ZETCBG models are visualized. To the right of the work sheet the electrical tomography will be plotted by using axial slices. The letters R and L at the upper border indicate the right and left sides in the slices. By using the scroll bar it is possible to make visible the slices not shown at the sheet. The tomography is scaled to the best possible fit over the whole spectra using a MaxMin scale type.



*The electrical tomography can be displayed with higher resolution with the **BET Viewer** system (see command View in BET Viewer)*

There are options at the information bar for selecting the state to visualize, the transformation (raw or Z), PG correction as well as the tomography type. Depending on the calculated variants for the loaded study, these options will have available the different possibilities.



*When pressing the right button mouse over the different elements at the work sheet a pop-up menu will be displayed with the available commands for those elements.*

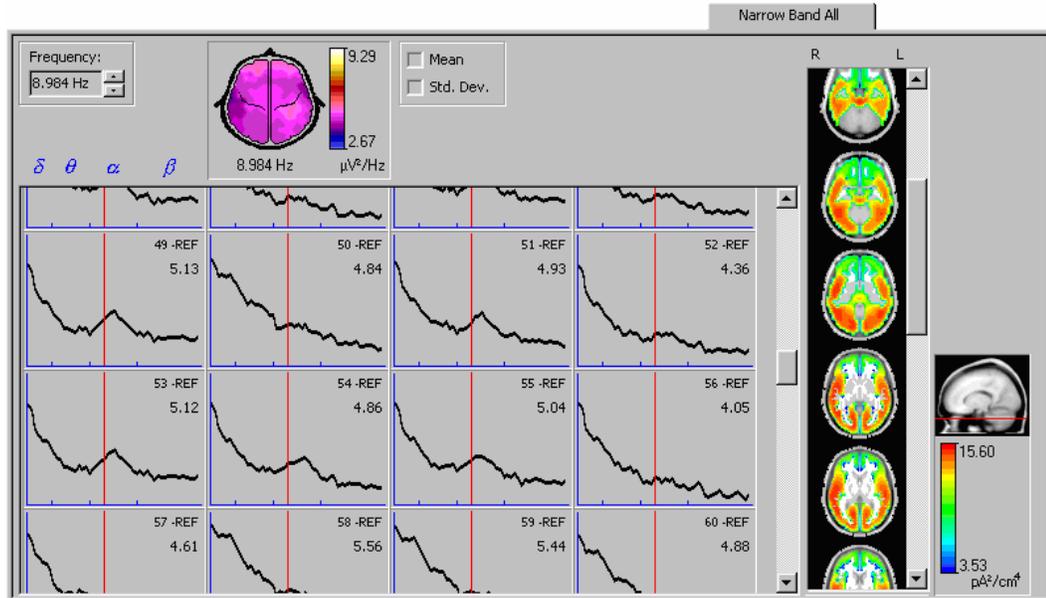


*When the mouse cursor is over the map the derivation name and its value are shown at the status bar.*

## Narrow Band All

In this work sheet the CROSS, ZCROSS, ETC, ZETC, ETCBG and ZETCBG models are visualized and is enabled only if the loaded study has derivations not belonging to the 10/20 system. All the spectra derivations are plotted and not only the 10/20 system. The windows for plotting the spectra are placed in a matricial way following the montage order. The topographic map showing the spatial distribution of the current vertical cursor position as well as the electrical tomography are displayed also.

## EEG Quantitative Analysis



*When pressing the right button mouse over the different elements at the work sheet a pop-up menu will be displayed with the available commands for those elements.*



*When the mouse cursor is over the map the derivation name and its value are shown at the status bar.*

## Command description

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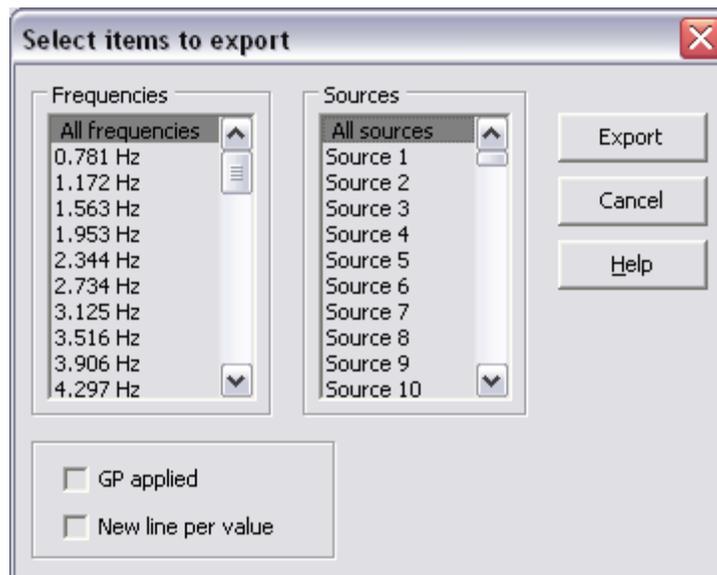
The commands for working with the electrical tomography as well as the commands with added functionality will be described in the following.

### File

#### Export to text

This command exports to text (ASCII) files the content of the different models generated with the module. In this way the processing results can be used in statistical packages, reports, papers, etc. When activated a dialog is presented for selecting the models to be exported as well as its type.

The selected models must belong to the same model type and the measures to export must have also the same dimension for every file. Once the desired files are selected, a dialog for selecting items to export is presented. Depending on the model type different information appears on the dialog. The figure shows the dialog for selecting items in the ETC and ETCBG models.



**Edit**

**Scale tomography**

With this command the electrical tomography can be scaled. When activated a dialog for selecting the scale and its parameters is presented.

There are 2 scale types for tomography:

Scale	Meaning
MaxMin	In this scale type the values minimum and maximum for scaling the tomography are defined. When this type is selected two edit boxes are shown: <b>Minimum</b> and <b>Maximum</b> for editing the values. The toggle <b>Best Fit</b> automatically adjusts the scale based on the extreme values of the tomography.
Threshold	With this scale type is possible to focus on the positive and negative values in the tomography. When this type is selected the edit box <b>Threshold</b> is shown to define the threshold that will be used as the scale limit in both directions: positive and negative. The toggle <b>Best Fit</b> automatically adjusts the scale based on the extreme values of the tomography.

**Tools**

**Movie** 

This command makes a movie at the Narrow Band 10/20, Narrow Band 10/20 Comparison and Narrow Band All sheets. The movie can be generated online or can be stored in an AVI file depending on the options set at the command **Options/Movie**.

When the movie is carried out online, all the frequencies selected according to the settings (initial and last frame) in **Options/Movie** are displayed in sequence. The movie is carried out using all the elements present including the tomography (if present) in the active work sheet. When activated a small dialog is presented for allowing pausing and speed changes in the movie. The movie is finished when the dialog is closed.

## View in BET Viewer

This command executes the **BET Viewer** system for displaying in hi-res the electrical tomography. Once initialized, BET Viewer loads the electrical tomography corresponding to the current frequency. The command is disabled if BET Viewer is not installed.

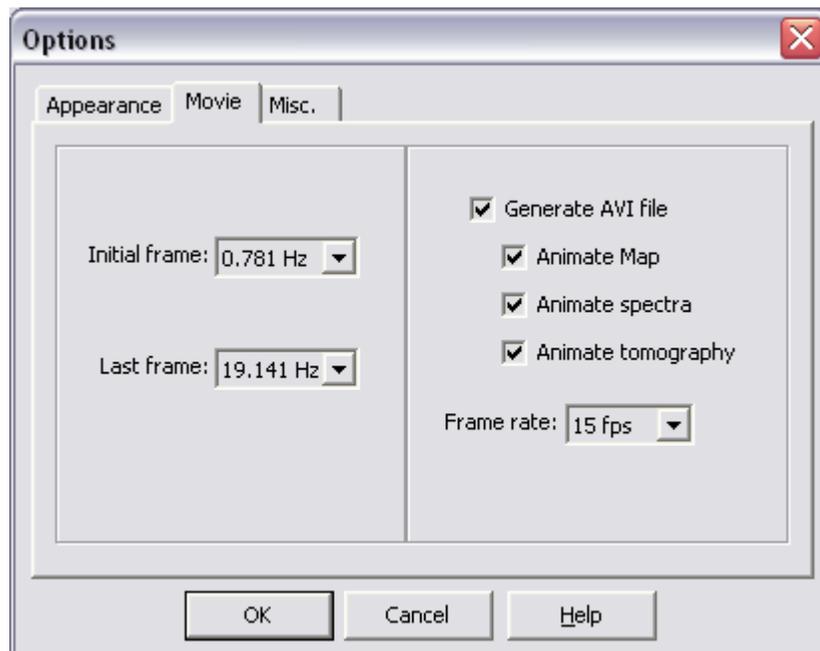


*It is recommended not to close **BET Viewer** once loaded if the user wants to use it continuously together with EEG Quantitative Analysis in order to save time needed for BET Viewer to initialize.*

## Options

This command sets different general options used in the module. When activated a dialog with 3 tabs is presented.

The tab **Movie** shows two combo boxes for selecting the initial and last frame to use in the movie. When the check box Generate AVI file is set (for selecting if the movie is carried out on line or not) another two check boxes are enabled for selecting which elements (including the electrical tomography) will be present in the movie as well as a combo box for setting the speed.



## Error messages

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**No tomography available for X**

Electrical tomography calculation is not available for the X combination.