



**NEUROSOFT**  
Since 1992

# **NEURON-SPECTRUM SOFTWARE**

**USER MANUAL  
(VOLUME 2)**

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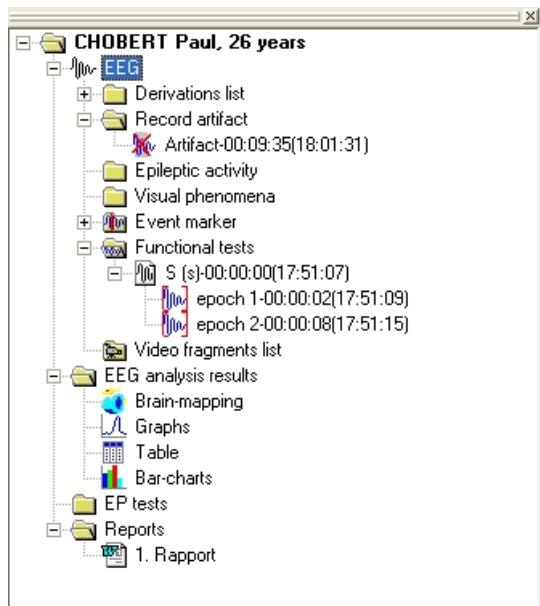
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# **CHAPTER 14**

# **CHECKUP INSPECTOR**



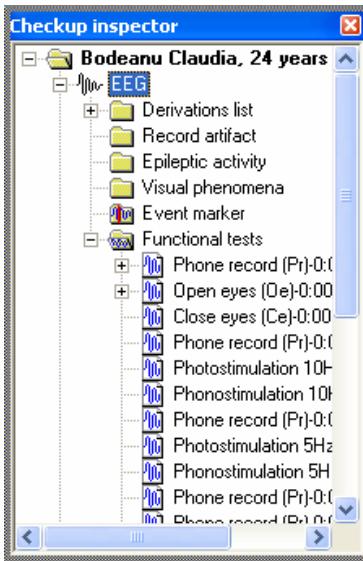
1. *Checkup inspector* is a hierarchical list, each item of which presents an element of the EEG checkup: EEG traces, derivations, functional tests, analysis epochs, analysis results and reports (Pic. 14.1).



Pic. 14.1

The purpose of *Checkup inspector* is to help in checkup navigation and orientation as well as in access to checkup elements.

2. To show or hide *Checkup inspector*, use the **View|Checkup inspector** command, the  button or the **[F11]** key. Normally *Checkup inspector* is “docked” to the left side of the screen. But still you can “dock” it to any other place (Pic. 14.2). Position the cursor so that it is touching the double line on the top of the *Checkup inspector* window (). Click on the line, hold the mouse button down and “drag” the window to the desired position.



Pic. 14.2

3. The items of the hierarchical list may include sub-elements or not. If an item includes any sub-elements, it is called a folder and has the  or  sign before it. The  sign means that the folder is closed and sub-elements are hidden. The  sign means that the folder is open and you can see the sub-elements. Clicking on the  and  signs opens or closes the folder.

If an item has no sub-elements, it is normally a window, marker, or another element of the EEG. Double-click on an item shows the corresponding element (opens the window, positions the marker on the EEG etc.).

4. *Checkup Inspector* represents every checkup as a folder with patient identification data. Every folder includes sub-elements: *EEG*, *EEG analysis results*, *EP tests*, *Reports*, etc. The *EEG* folder contains all the elements of the EEG traces: derivations, recording parameters change markers, artifact markers, epileptic activity markers, visual phenomena, event markers, functional tests, analysis epochs, and video fragments markers, fragments. The *Analysis results* folder includes the results of EEG analysis: maps, tables, bar charts and graphs. The *Reports* folder keeps all the checkup reports.

5. Below (Table 14.1) you will find the description of all the *Checkup inspector* elements that are used in the **Neuron-Spectrum** software.

Table 14.1

Name of checkup element	Owner	Icon	Correspondent EEG element	Comment
Checkup	No		No	Checkup root item. Includes all the rest checkup elements.
EEG (EEG traces)	Checkup		EEG review and analysis window	To open the window, double-click on the icon.
EEG analysis results	Checkup		No	Includes the list of analysis results windows, if the EEG has been analyzed.
EP tests	Checkup		No	Contains the list of all the performed EP tests
Reports	Checkup		No	Includes the list of all the checkup reports.
Derivations list	EEG		No	Includes all the derivations of the current montage.
List of change markers of recording parameters	EEG		No	Includes all markers of recording parameters change. They are show the place where it occurs.
Record artifacts	EEG		No	Includes all the record artifacts set on the EEG manually.
Epileptic activity	EEG		No	Includes all the epileptic activity markers set on the EEG manually.
Visual phenomena	EEG		No	Includes all the visual phenomena markers set on the EEG.
Event markers	EEG		No	Includes all the event markers set during EEG recording or viewing.
Functional test	EEG		No	Includes all the recorded functional tests.
Video fragments list	EEG		No	Contains all the recorded video fragments

## Neuron-Spectrum Program

Table 14.1 continue

Name of checkup element	Owner	Icon	Correspondent EEG element	Comment
EEG fragment	EEG		Selected EEG fragment	To go to the selected fragment, double-click on the icon.
Derivation	Derivations list		EEG derivation	Derivation visibility control.
Artifact	Record artifacts		Artifact marker	To go to the artifact marker, double-click on the icon.
Recording parameters change marker	Recording parameters change markers list		Invisible EEG parameters change marker	To move to the moment of changing EEG parameter during recording
Epiphénoménon	Epileptic activity		Manually set epileptic activity marker	To move to the epileptic activity marker, double-click on the icon.
Visual phenomenon	Visual phenomena		Visual phenomenon marker	To go to the visual phenomenon marker, double-click on the icon.
Event marker	Event markers		Event or commentary marker	To go to the event marker, double-click on the icon.
Functional test	Functional tests		Functional test marker	To go to the functional test, double-click on the icon.
Analysis epoch	Functional tests		Epoch analysis marker	To go to the analysis epoch, double-click on the icon.
Video fragment	Video fragments list		Video fragment	Go to the beginning of the video fragment and start to play it
Brain mapping	EEG analysis results		Mapping window	Shows the analysis results mapping window.
Tables	EEG analysis results		Table window	Shows the analysis results tables window.
Bra charts	EEG analysis results		Bar charts window	Shows the analysis results bar-charts window.
Graphs	EEG analysis results		Graphs window	Shows the analysis results graphs window.
EP test	EP tests		EP tests	Show the EP test curves
Report	Reports	or	Report window	Shows the report window (built-in or Word 97/2000).

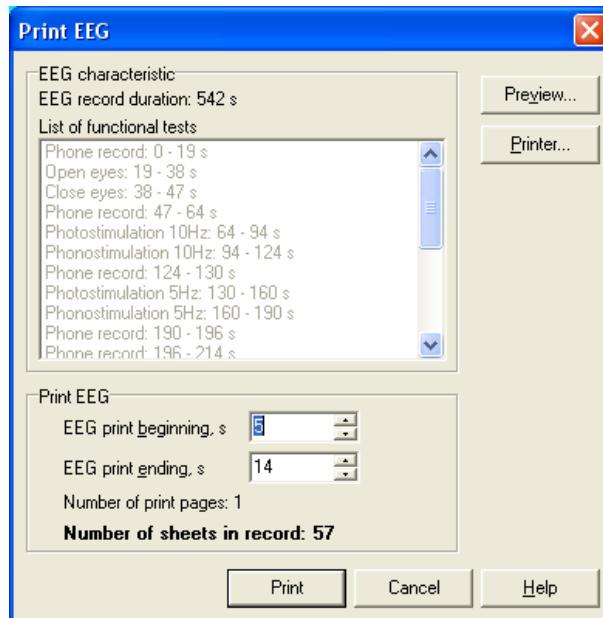
# **CHAPTER 15**

## **EEG PRINTING**



1. The **Neuron-Spectrum** software enables high-quality printing of an EEG traces using any types of printers. Best results are obtained when using laser printers. An electroencephalogram is printed on separate paper sheets. Their size (A4 or A3) depends upon the printer being used. If printing is performed on several sheets, paste them to get a continuous paper roll.

2. To print an EEG use the **EEG|Print** command or click on the  button on the toolbar of the EEG review and analysis window. The **Print EEG** dialog box will appear on the screen (Pic. 15.1).



Pic. 15.1

The *EEG characteristic* group displays EEG parameters: record duration in seconds, the list of functional tests performed.

The *Print EEG* group informs about the number of sheets, necessary for printing either of the whole record or of an interval. Printing is performed in a determined time interval of the EEG record. It is set in the *EEG print beginning* and *EEG printing ending* edit lines.

The “*Preview*” button starts preview of the sheets before printing.

The “*Printer*” button activates the dialog box of printer settings.

To start printing, click on the “*Print*” button or press [**Enter**].

3. To preview EEG sheets, you can use the **EEG|Preview** command, click on the  button on the toolbar of the EEG review and analysis window or on the “*Preview*” button of the **Print EEG** dialog box. The **Preview** window will appear on the screen (Pic. 15.2).



Pic. 15.2

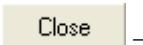
If you have chosen the **Preview** menu command, the printer will print only one EEG sheet by default. When you click on the “*Preview*” button from **Print EEG** dialog box, the printer will print the number of sheets that are given in the panel.

The window displays sheet layout with all the elements being printed.

On the top of the window, there is a toolbar with control buttons (Pic. 15.3).



Pic. 15.3

-  – EEG printing;
-  – printer setup;
-  – pages navigation (beginning, end, next, previous);
-  – page layout during the preview;
-  – close the preview window.

4. If printer markers are set on EEG, use the **EEG|Print selected fragment** menu command. The printing process is described above in details.

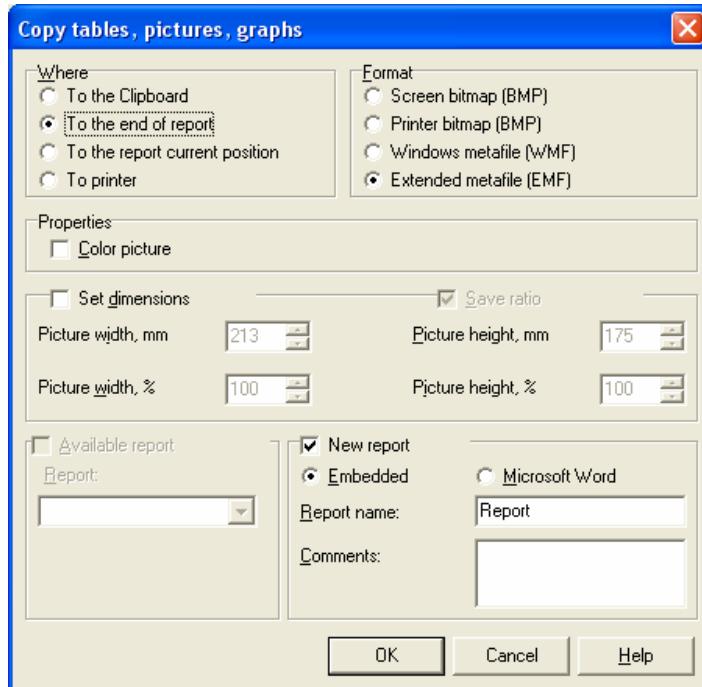
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## **CHAPTER 16**

# **WINDOWS DATA COPYING TO CLIPBOARD, REPORT OR PRINTER**



1. The **Neuron-Spectrum** software enables copying of EEG data (fragments of EEG, EEG epochs), view and analysis windows, analysis results windows, amplitude and spectrum analysis windows, spikes and sharp waves search windows to clipboard, report or printer. Use the **Copy** command of the properties menu or the main menu in these windows. The **Copy tables, pictures, graphs** dialog panel will appear on the screen (Pic. 16.1).



Pic. 16.1

2. Select the copy direction in the “*Where*” radio-buttons: clipboard, report or printer. Copying to report is always performed for current report. Tables can be copied to report only.

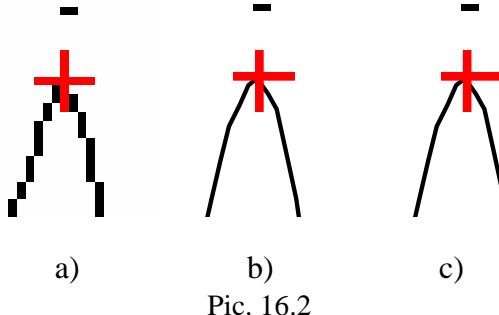
3. The “*Format*” radio-buttons specify graphic format for the picture or graph being copied. Pictures (graphs or curves) can be copied to the report in different formats. *Screen bitmap (BMP)* is well displayed, but provides imperfect printing. *Printer bitmap (BMP)* is perfect for printing, but does not look good on your screen and, besides, takes much of memory and thus slows down editor operation. When this format is used, the resolution of the picture being created is scanned from printer parameters. If you change the picture size and printer resolution after you have created the picture, printing quality may deteriorate. Try not to use this format. *Windows metafile (WMF)* and *Extended metafile (EMF)*, though imperfect in displaying, provide perfect printing even after changing of the picture size.

The Pic. 16.2 shows enlarged *Screen bitmap (BMP)*, *Printer bitmap (BMP)* and *Extended metafile (EMF)*.

Here are some recommendations on choosing the picture format when copying to the report or to the printer:

- Choose *Screen bitmap (BMP)* if the picture is only for screen viewing.
- Use *Extended metafile (EMF)* for printing. If there appears any picture distortions (typical for some matrix printers), use the *Printer bitmap (BMP)* format.

- Thus, when printing, it is better to use the *Extended metafile (EMF)* or *Printer bitmap (BMP)* formats.



4. If you want to print in color, check the “*Color picture*” check box. Color printing may be useful for printing of brain maps and analysis results bar charts.

5. The “*Set dimensions*” check box sets the size of the picture. When the dialog box first appears on the screen, the size is preset by default. If you mark the “*Save ratio*” flag, width and height of the picture will be automatically adjusted depending upon the size of one or another. This prevents picture distortion.

6. *Available report* or *New report* groups allow you to select one of the existing reports or create new one in which the window content will be copied. These groups are activated only when checkup report is selected as a copying direction (tick *To the report end, in the current report position* of *Where* switch).

7. To copy the picture, click “*OK*” or press [**Enter**].

## **CHAPTER 17**

# **NEURON-SPECTRUM-1 (V.1) DIGITAL SYSTEM**



**Neuron-Spectrum-1 (V.1)** is a portable 8-channel digital EEG system. It enables the recording of EEG channels for both hemispheres using its “own” ear electrode for a hemisphere. There are 4 EEG-channels reserved for each hemisphere and one derivation reserved for the ear electrode. Besides, one channel registers the difference between right and left ear electrodes A2A1. This derivation is used for correct referent reconstruction of the initial record. The **Neuron-Spectrum-1 (V.1)** EEG system also has the channel that records one of the ECG derivations (normally the second standard derivation).

Derivations cables of EEG unit are three wire sets: wires of the left hemisphere EEG-channels; wires of the right hemisphere EEG-channels; and the ECG channel. In wire sets of hemisphere derivations EEG-channels differ in color.

A referent (ear) derivation is always **red** (it is connected to the ear or mastoid electrode of the corresponding hemisphere).

A grounding derivation is always **black** (it is connected to the grounding electrode). The wire is included in each hemisphere set.

Derivations of EEG channels for each hemisphere have the following colors:

- **white** – channel **1** of the left hemisphere and channel **0** of the right one;
- **yellow** – channel **2** of the left hemisphere and channel **3** of the right one;
- **green** – channel **7** of the left hemisphere and channel **5** of the right one;
- **blue** – channel **8** of the left and channel **6** of the right one.

The cables set of ECG channel (second standard derivation) uses the following colors:

- **yellow** – to the electrode, fixed on the left hand (**L**);
- **red** – to the electrode, fixed on the right hand (**R**);
- **black** – to the electrode, fixed on the right leg (**N**).

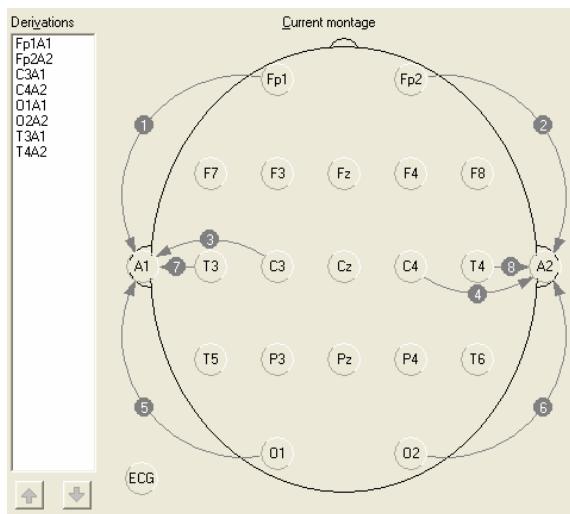
Here is the order of derivation cables connection to the electrodes according to standard the 8-channel “10-20%” scheme of derivation (Pic. 17.1). Those derivations and the connection are used in the EEG registration on the **Neuron-Spectrum-1 (V.1)** when choosing any 8-channel montage from the list of the standard montages.

The set of cables for the left hemisphere:

- **black** wire – grounding electrode;
- **red** wire – ear electrode **A1**;
- **white** wire – electrode of **Fp1** derivation;
- **yellow** wire – electrode of **O1** derivation;
- **green** wire – electrode of **C3** derivation;
- **blue** wire – electrode of **T3** derivation.

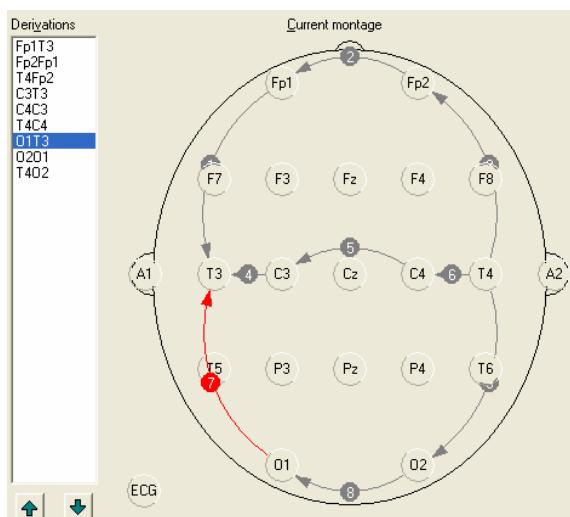
The set of cables for the right hemisphere:

- **black** wire – grounding electrode
- **red** wire – ear electrode **A2**;
- **white** wire – electrode of **Fp2** derivation;
- **yellow** wire – electrode of **O2** derivation;
- **green** wire – electrode of **C4** derivation;
- **blue** wire – electrode of **T4** derivation.



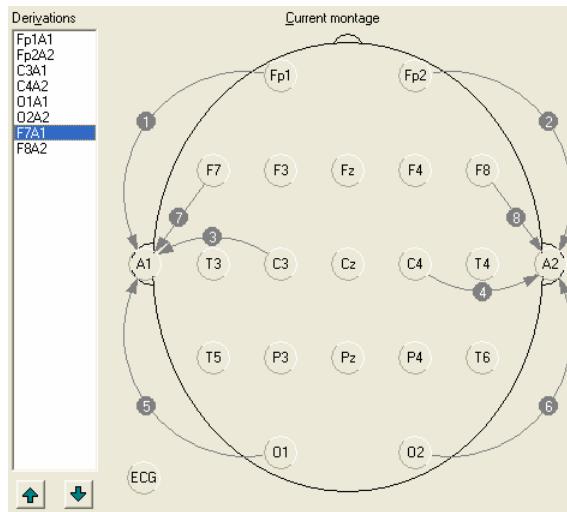
Pic. 17.1

It should be taken into account that the **Neuron-Spectrum-1** EEG channels in **Neuron-Spectrum (V.1)** software are rigidly bound to the certain derivation in the montage. For example, the white cable of each hemisphere is connected with the derivations Fp1A1, Fp2A2. Therefore, to register the EEG signal on all eight channels one should use the standard 8-channel montage (Pic. 17.1) or the montages obtained from the same electrodes set. (Pic. 17.2).



Pic. 17.2

Even if one should set the electrode on the derivation, different from the derivation indicated in the standard montage (for example, to the derivation F3A1, F4A2 instead of Fp1A1, Fp2A2), please use the standard 8-channel montage and the electrodes set on F3A1, F4A2 connect to the white cable. If you form the montage containing, for instance, derivations F7A1 and F8A2, instead of T3A1 and T4A2 derivations (Pic. 17.3), when recording in these derivations you will get an isoline instead of EEG signal.



Pic. 17.3

Thus, to register the 8 EEG channels on the **Neuron-Spectrum-1 (V.1)** EEG when forming any montage the derivations Fp1, Fp2, C1, C2, O1, O2, T5, T6 should be used (Pic. 17.1).

# **CHAPTER 18**

## **EVOKED POTENTIALS STUDY (NEURON-SPECTRUM-LEP)**



## **18.1. INTRODUCTION**

The **Neuron-Spectrum-1, 4 (v.1), 4/BII, 4/EP, 1, 2, 3, 4, 4/P, 4/EPM, 5** EEG systems can be used for record and analysis of:

- visual evoked potentials on photic (*VEP*);
- long latency auditory evoked potentials on audio stimulation (*AEP*).

The **Neuron-Spectrum-4 (v.1), Neuron-Spectrum-4/EP, Neuron-Spectrum-2, Neuron-Spectrum-3, Neuron-Spectrum-4** EEG can be used for the registration and analysis of:

- long-latency visual evoked potentials on photic, on LED goggles stimulation and on pattern stimulation (*VEP, VEPP*);
- long latency auditory evoked potentials on audio stimulation by audiometric headphones (*AEP*);
- cognitive evoked potentials using the P300, MMN and CNV methods;
- long-latency somatosensory evoked potentials (*SEP*).

To provide long-latency EP registration, the EEG delivery should be completed by the **Neuron-Spectrum-LEP** software that enables:

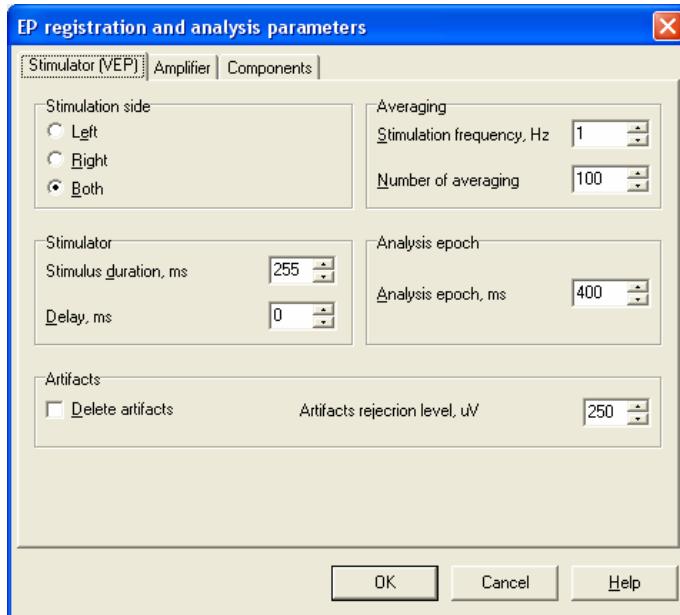
- EP registration (with EEG registration at the same time) using arbitrary derivations and montages with artifacts rejection by amplitude criteria;
- displaying of both the EP total curve and separate EP on even and odd stimuli;
- the registration of arbitrary number of EP realizations (functional tests) and overlapping them in the same axes when displaying;
- EP record editing by deleting some artifact epochs from the EP total curve;
- EP components markers placing with their further placement editing (specific for every curve or common for all the curves markers);
- EP components latency and amplitude calculation;
- EP amplitude analysis and EP amplitude components brain mapping;
- EP curves filtration and spectrum-frequency analysis;
- using the 3-D localization of the sources in brain structures program;
- EP curves and their analysis results printing in a report.

## **18.2. EP REGISTRATION AND ANALYSIS PARAMETERS SETUP**

The **Neuron-Spectrum-LEP** program enables you to previously setup registration parameters for all types of EP (stimulator, amplifier parameters etc.) and form the list of the components, which will be automatically set on EP curves after registration (common components for all the curves).

### 18.2.1. VISUAL EVOKED POTENTIALS (VEP) PARAMETERS SETUP

1. To setup the parameters of visual EP use the **Setup|VEP (flash)** menu command. The **EP registration and analysis parameters** dialog box will appear on the screen (Pic. 18.1).



Pic. 18.1

2. The *Stimulator (VEP)* page.

*Stimulation side.* Only for **Neuron-Spectrum-4 (v.1), 4/EP, 1, 2, 3, 4, 4/P, 4/EPM, 5**. It indicates the patient eye being stimulated for EEG photic or LED goggles. Only one side of the stimulation is indicated if the patient's eye is closed with a special shutter. For other types of **Neuron-Spectrum** this option is not active.

*Stimulus duration.* Stimulator glowing duration during stimulation.

*Delay.* Stimulus offset from the EP registration epoch beginning. If the parameter value is positive – the stimulus is behind of the epoch beginning, if negative – the stimulus is before the epoch beginning. If the value is zero – the stimulus and the epoch begin at the same time.

*Stimulation frequency.* Stimuli frequency (their amount per second).

*Number of averaging.* Maximal number of averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing [**Ctrl+Esc**] or [**Esc**].

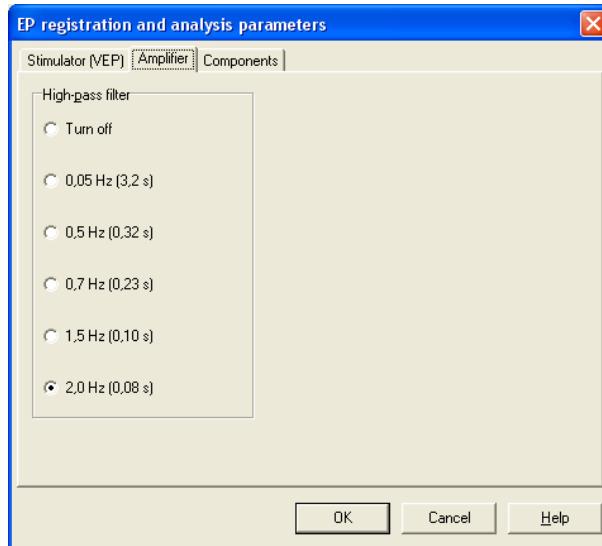
*Analysis epoch.* Duration of the registered EP curve.

*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

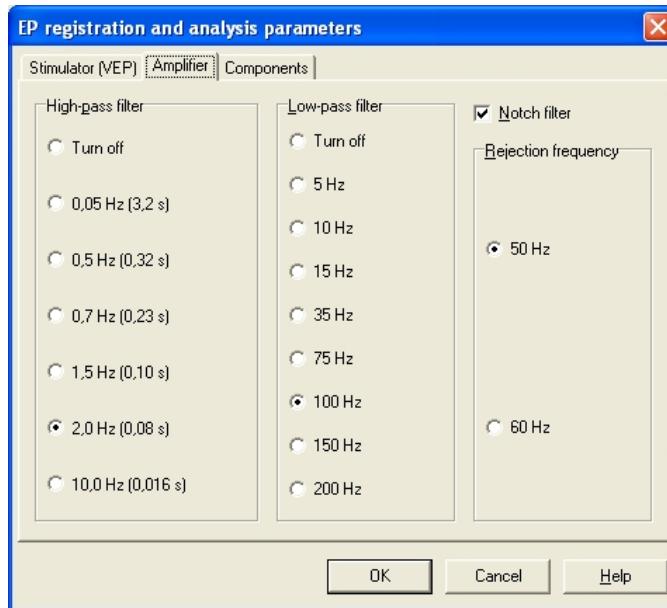
### 3. The *Amplifier* page.

For every type of EEG unit there are amplifier setup parameters (mainly filters state) on this page. These settings will be used during EP registration. For **Neuron-Spectrum-1, 2, 3 (v.1)** you can set the lower cut-off frequency of the high pass filter (Pic. 18.2).



Pic. 18.2

For **Neuron-Spectrum- 4 (v.1), 4/EP, 1, 2, 3, 4, 4/P, 4/EPM, 5** (Pic. 18.3) you can set the lower and higher cut-off frequency and the notch filter state.



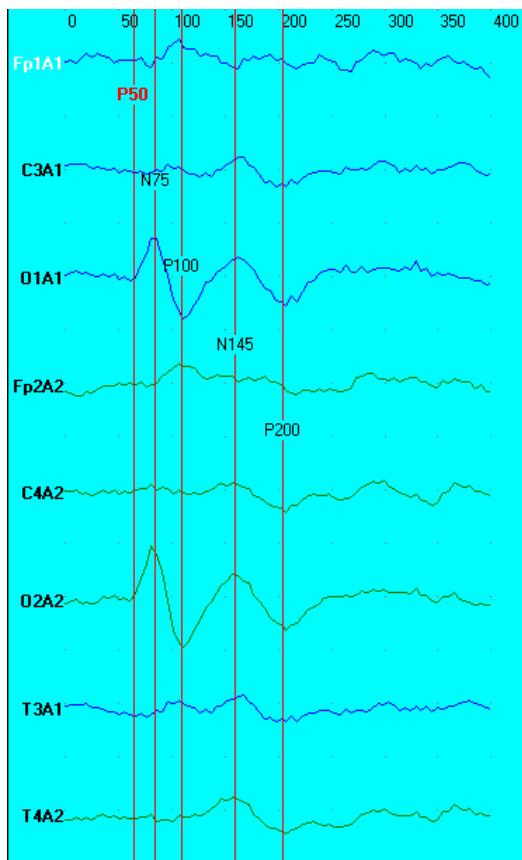
Pic. 18.3

### 4. The *Components* page.

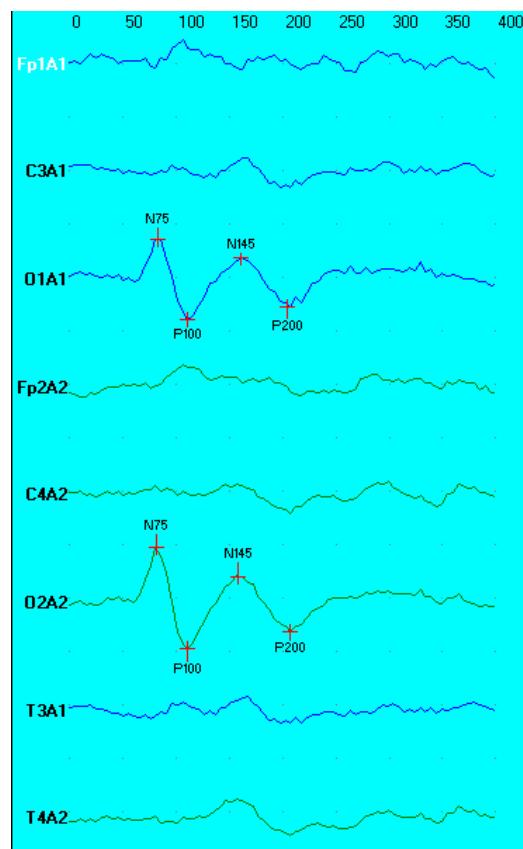
On this page you can set names and placement on the curves of the component markers common for all the EP curves for this type of EP. After EP registration finishing, these markers will be set on the preset places, if their displaying mode is activated.

You should remember that there are two types of markers, which can be set on EP curves. The first type is common for all the curves component markers. For every component there is one marker, common for all the curves, that actually defines a time point (latency) (Pic. 18.4a). It is convenient to use these markers for EP mapping and the measuring of EP curves amplitude at one time point. These component markers are called *common*.

The second type of markers is an individual marker for each component on each curve (Pic. 18.4b). It means that for each component you can set so many markers as there are EP curves, each marker defining its own point of time (latency). It is convenient to use these markers for EP components latency and amplitude calculation in each derivation (curve). These component markers are called *individual*.



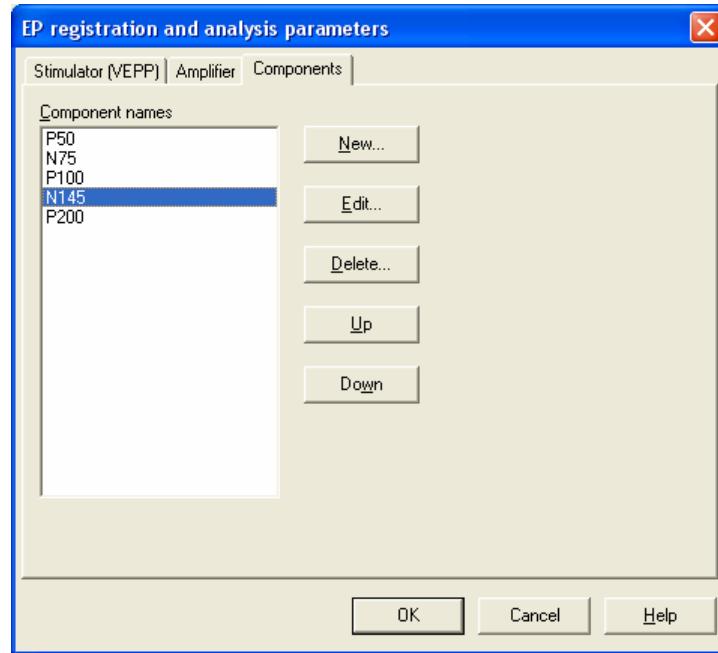
a)



b)

Pic. 18.4

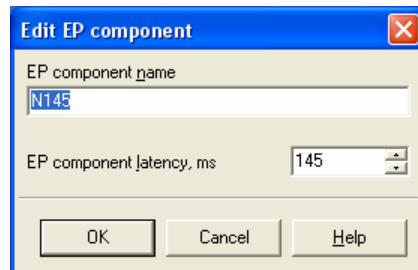
The page will have the state shown below for all types of EP (Pic. 18.5).



Pic. 18.5

The *Component names* list. There are all the common components that will be set on EP curves after registration finishing. The place of a component on an EP curve (latency) is set when you create or edit the component.

To add a new component, click on the “*New*” button. The **Edit EP component** dialog box will appear on the screen (Pic. 18.6).



Pic. 18.6

Insert the new component name in the *EP component name* edit line, and the place of the component marker in the *EP component latency* edit line. Click “*OK*” and component will be added to the component list.

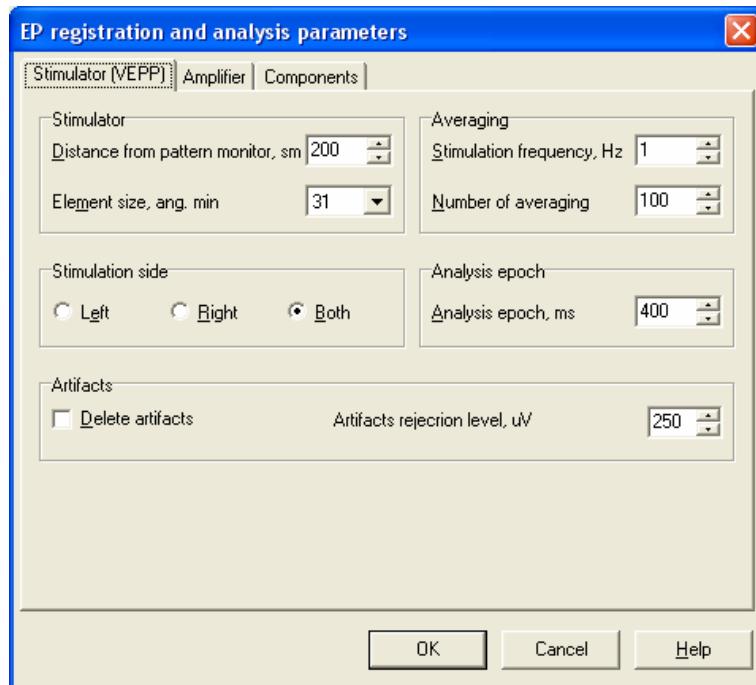
To edit the component name and latency select it in the component list and click on the “*Edit*” button. In the **Edit EP component** dialog box input the new component name and the component latency. Click on the “*OK*” and the component will be edited.

To delete the selected component, click “*Delete*”.

To replace the selected component within the list use the “*Up*” and “*Down*” buttons.

### 18.2.2. VISUAL EP ON PATTERN (VEPP) PARAMETERS SETUP

1. Visual EP on pattern (VEPP) can be registered using **Neuron-Spectrum-4 (v.1), 4/EP, 1, 2, 3, 4, 4/P, 4/EPM, 5** only. To setup VEPP registration and analysis parameters use the **Setup|VEP (pattern)** menu command. The **EP registration and analysis parameters** dialog box will appear on the screen (Pic. 18.7).



Pic. 18.7

#### 2. The *Stimulator (VEPP)* page.

*Distance from pattern monitor.* Set the distance from patient's eyes to the pattern monitor screen. It is necessary for the right setting of the pattern element angular size. You should also set the monitor diagonal axis in the **Stimulators Setup** dialog box on the *EP* page using the **Setup|Stimulators** menu command or the  button.

*Element size.* The pattern element size (for example, height and width of pattern element) for patient's eyes. A pattern is formed from elementary figures (squares), the height of which is 1/72 of display height and the width of which is 1/96 of display width. The size of a pattern element is accurate to the elementary square size.

*Stimulation side.* The stimulated patient's eye. Only one stimulation side is checked, if a special shutter closes the other patient's eye.

*Stimulation frequency.* Stimuli frequency supply (the stimuli amount per second).

*Number of averaging.* Maximal number of signal averaging. After attainment of this number EP registration stops automatically. But you can stop it earlier by pressing **[Ctrl + Esc]** or **[Esc]**.

*Analysis epoch.* Duration of the registered EP curve.

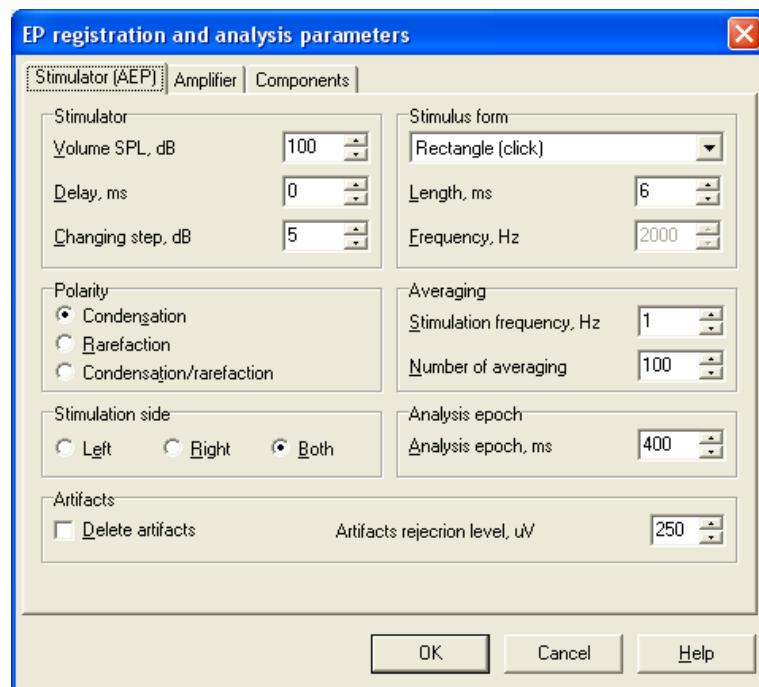
*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

3. *Amplifier and Components* pages are similar to those described above in 18.2.1.

### **18.2.3. AUDITORY EP (AEP) PARAMETERS SETUP**

1. To setup auditory EP (AEP) registration and analysis parameters use the **Setup|AEP** menu command. The **EP registration and analysis parameters** dialog box will appear on the screen (Pic. 18.8).



Pic. 18.8

2. The *Stimulator (AEP)* page.

*Volume, SPL.* Stimuli intensity by SPL scale (0 Db level corresponds to the sound pressure of 20 micro Pascal). Volume can be set for **Neuron-Spectrum-4 (v.1), 4/EP, 1, 2, 3, 4, 4/P, 4/EPM, 5** only if audiometric headphones are used.

*Delay.* Stimulus offset from the EP registration epoch beginning. If the parameter value is positive – the stimulus is on specified number of milliseconds behind of the EP registration epoch beginning. If the parameter value is negative – the stimulus is on specified number of milliseconds before the EP registration epoch beginning. If the value is zero – the stimulus and the epoch begin at the same time.

*Changing step.* Step of stimulus volume changing during AEP registration using the **EP|Stimulator|Zoom in** or **EP|Stimulator|Zoom out** menu commands.

*Polarity.* The stimulation manner: condensation or rarefaction of headphones diaphragm or their combination (half the stimuli with condensation and the other half with rarefaction). The last mode is used for minimizing of the stimulus artifact amplitude that can distort the beginning of the curve.

*Stimulation side.* The patient's ear being stimulated. For **Neuron-Spectrum-4 (v.1), 4/EP, 1, 2, 3, 4, 4/P, 4/EPM, 5** only.

*Stimulus form.* Stimulus form: rectangle or symmetrical meander. For rectangular stimulus the duration is set, for meander – its duration and frequency. For **Neuron-Spectrum-4 (v.1), 4/EP, 1, 2, 3, 4, 4/P, 4/EPM, 5** only.

*Stimulation frequency.* Stimuli frequency (their amount per second).

*Number of averaging.* Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing [Ctrl + Esc] or [Esc].

*Analysis epoch.* Duration of the registered EP curve.

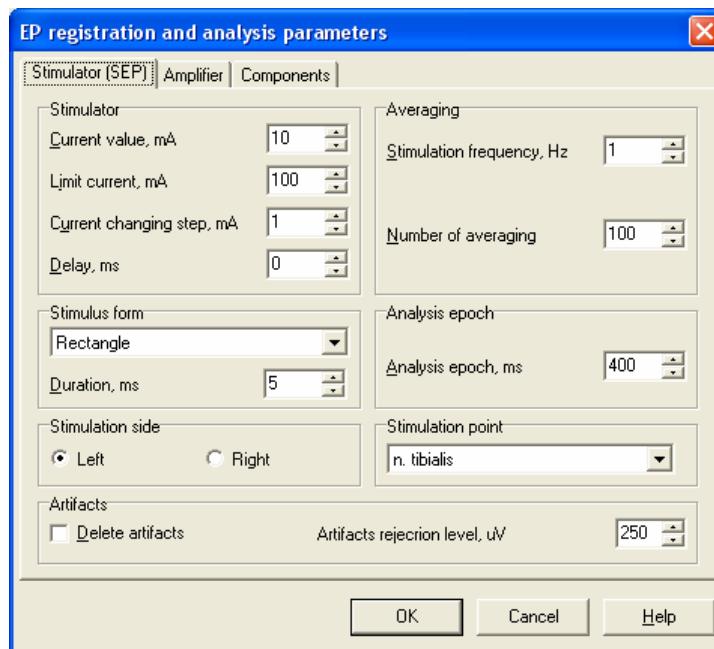
*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

3. *Amplifier* and *Components* pages are similar to those described above in 18.2.1.

### 18.2.4. SOMATOSENSORY EP (SEP) PARAMETERS SETUP

1. Somatosensory EP (SEP) can be registered on **Neuron-Spectrum-4 (v.1), 4/EP, 4/EPM, 5** only. To setup SEP registration and analysis parameters use the **Setup|SEP** menu command. The **EP registration and analysis parameters** dialog box will appear on the screen (Pic. 18.9).



Pic. 18.9

### 2. The *Stimulator (SEP)* page.

*Current value.* Stimulation amplitude.

*Limit current.* Limit for the **EP|Stimulator|Zoom in** menu command. In any case maximum current value can not be more than 90..100 mA because of build-in hardware lock in the stimulator.

*Current changing step (mA).* Current changing step during registration when using **EP|Stimulator|Zoom in** and **EP|Stimulator|Zoom out**.

*Delay.* Stimulus offset from the EP registration epoch beginning. If the parameter value is positive – the stimulus is on specified number of milliseconds behind of the EP registration epoch beginning. If the parameter value is negative – the stimulus is on specified number of milliseconds before the EP registration epoch beginning. If the value is zero – the stimulus and the epoch begin at the same time.

*Stimulus form.* For electro stimulus, only rectangular stimuli are used. For rectangular stimulus you set its duration in the *Duration* edit line.

*Stimulation frequency.* Stimuli frequency (their amount per second).

*Number of averaging.* Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing **[Ctrl+Esc]** or **[Esc]**.

*Analysis epoch.* Duration of the registered EP curve.

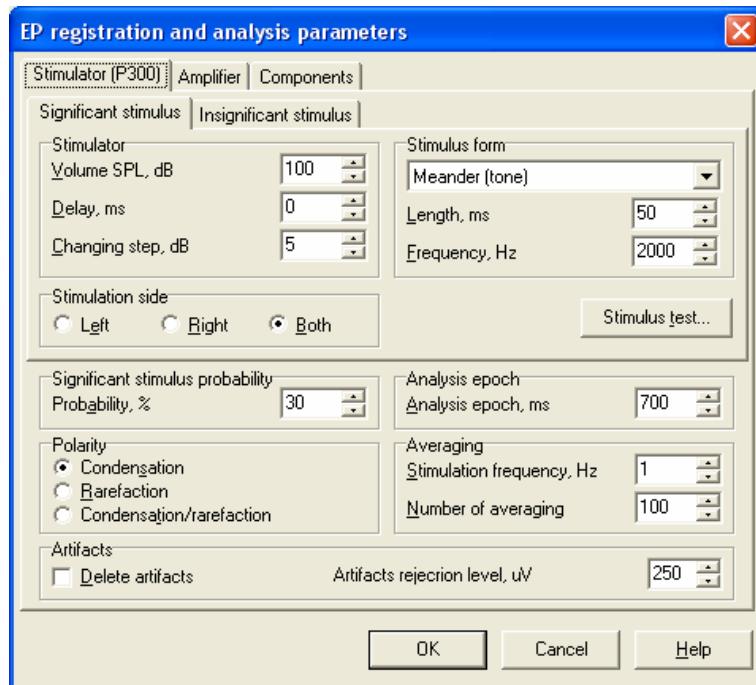
*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

3. *Amplifier* and *Components* pages are similar to those described above in 18.2.1.

### 18.2.5. COGNITIVE EP (P300, MMN) PARAMETERS SETUP

1. Cognitive EP can be registered on **Neuron-Spectrum-4 (v.1), 4/EP, 1, 2, 3, 4, 4/P, 4/EPM, 5** only. To setup P300 or MMN registration and analysis parameters use the **Setup|CEP (P300)** or **Setup|CEP (MMN)** menu command. The **EP registration and analysis parameters** dialog box will appear on the (Pic. 18.10).



Pic. 18.10

2. The *Significant stimulus* page (*Deviant stimulus*) for MMN. Significant (rare, deviant) stimulus characteristics..

*Volume, SPL.* Significant stimulus stimulating tone intensity by SPL scale (0 Db level corresponds to the sound pressure of 20 microPa).

*Delay.* Stimulus offset from the EP registration epoch beginning. If the parameter value is positive – the stimulus is on specified number of milliseconds behind of the EP registration epoch beginning. If the parameter value is negative – the stimulus is on specified number of milliseconds before the EP registration epoch beginning. If the value is zero – the stimulus and the epoch begin at the same time.

*Changing step.* Stimulus intensity changing step during registration when using **EP|Stimulator|Zoom in** and **EP|Stimulator|Zoom out**.

*Stimulation side.* The patient's ear being stimulated.

*Stimulus form.* Stimulus form: rectangle or symmetrical meander. For rectangular stimulus the duration is set, for meander – its duration and frequency.

Click on the “*Stimulus test*” button to demonstrate the significant (deviant) stimulus for the patient.

*Significant stimulus probability (%)*. The probability of a significant stimulus during P300 registration.

*Polarity*. The stimulation manner: condensation or rarefaction of headphones diaphragm or their combination (half the stimuli with condensation and the other half with rarefaction). The last mode is used for minimizing of the stimulus artifact amplitude that can distort the beginning of the curve.

*Stimulation frequency*. Stimuli frequency (their amount per second).

*Number of averaging*. Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing [Ctrl+Esc] or [Esc].

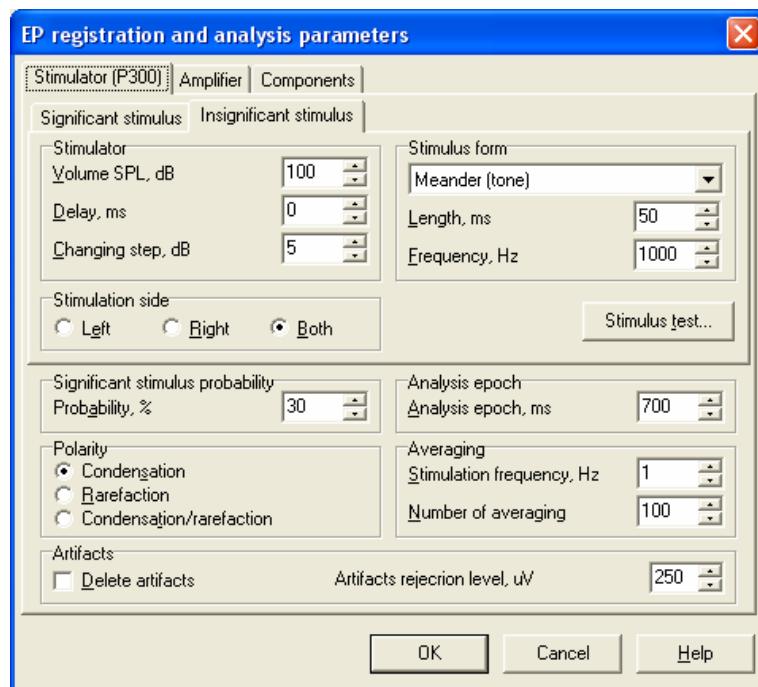
*Analysis epoch*. Duration of the registered EP curve.

*Delete artifacts*. Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level*. The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

3. *Amplifier and Components* pages are similar to those described above in 18.2.1.

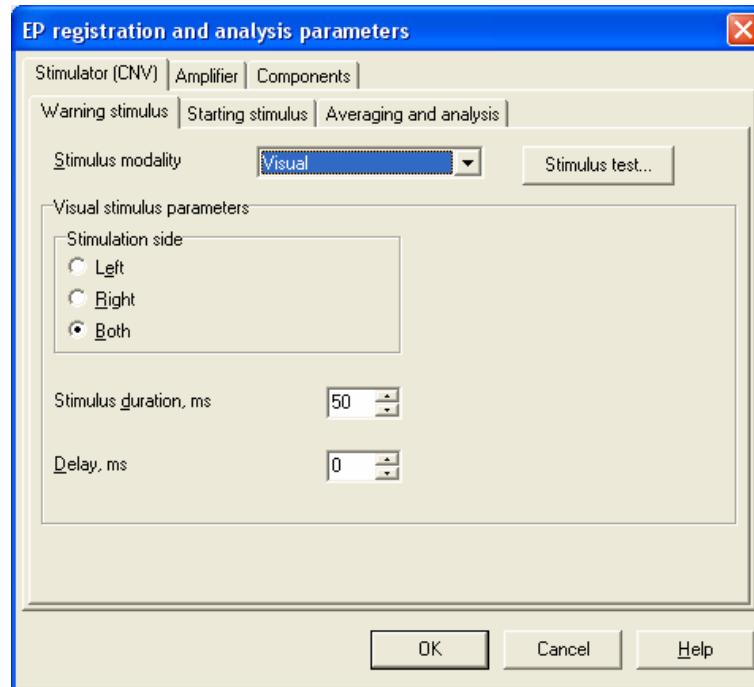
4. The *Insignificant stimulus* page (*Standard stimulus*) for MMN. Insignificant (standard, frequent) stimulus parameters (Pic. 18.11). The *Insignificant stimulus* page is similar to the *Significant stimulus* one and contains the setup for insignificant (frequent) stimulus



Pic. 18.11

### 18.2.6. CONTINGENT NEGATIVE VARIATION (CNV) PARAMETERS SETUP

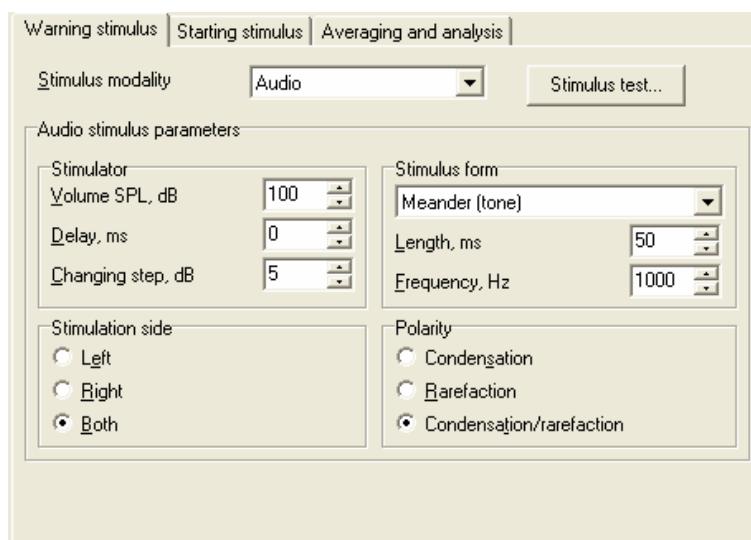
- To setup CNV registration and analysis parameters use the **Setup|CNV** menu command. The **EP registration and analysis parameters** dialog box will appear on the screen (Pic. 18.12).



Pic. 18.12

- The *Warning stimulus* page. Warning stimulus parameters (Pic. 18.13).

*Stimulus modality*. Enables setting of the stimulus type: *Visual* or *Audio*. For every stimulus type its own parameters are set. They are similar to the ones of visual and audio EP (18.2.1, 18.2.3).

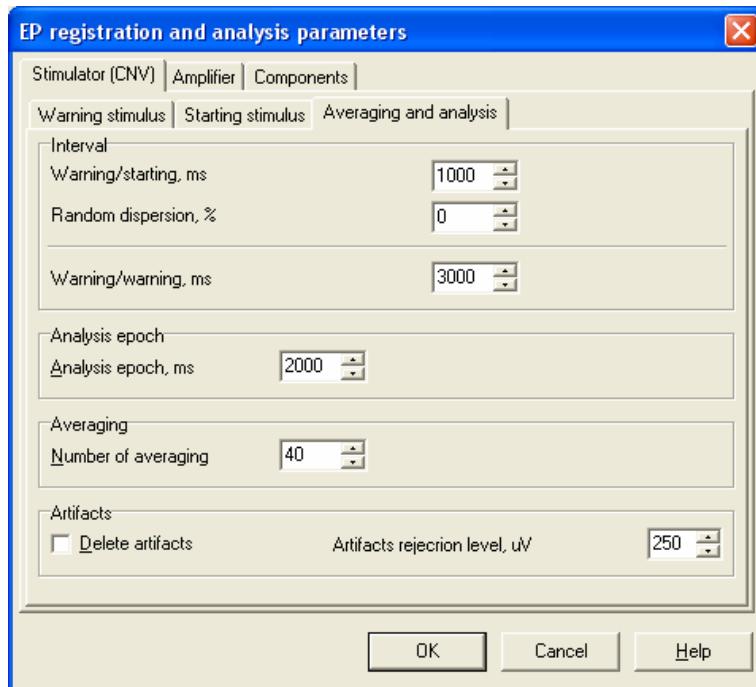


Pic. 18.13

3. The *Starting stimulus* page. Starting stimulus parameters.

*Stimulus modality*. Enables setting of the stimulus type: *Visual* or *Audio*. For every stimulus type its own parameters are set. They are similar to the ones of visual and audio EP (18.2.1, 18.2.3).

4. The *Averaging and analysis* page. Sets averaging parameters and analysis epoch for CNV (Pic. 18.14).



Pic. 18.14

*Warning/startling*. The interval between the warning and starting stimuli.

*Random dispersion*. The dispersion of the interval between the warning and starting stimuli.

*Warning/warning*. The interval between series of warning and starting stimuli, i.e. from one warning to another one. This interval can't be lower than the warning/startling interval.

*Analysis epoch*. The analysis epoch value is duration of the registered EP curve (shouldn't be higher than the interval between the warning stimuli).

*Number of averaging*. Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing [Ctrl+Esc] or [Esc].

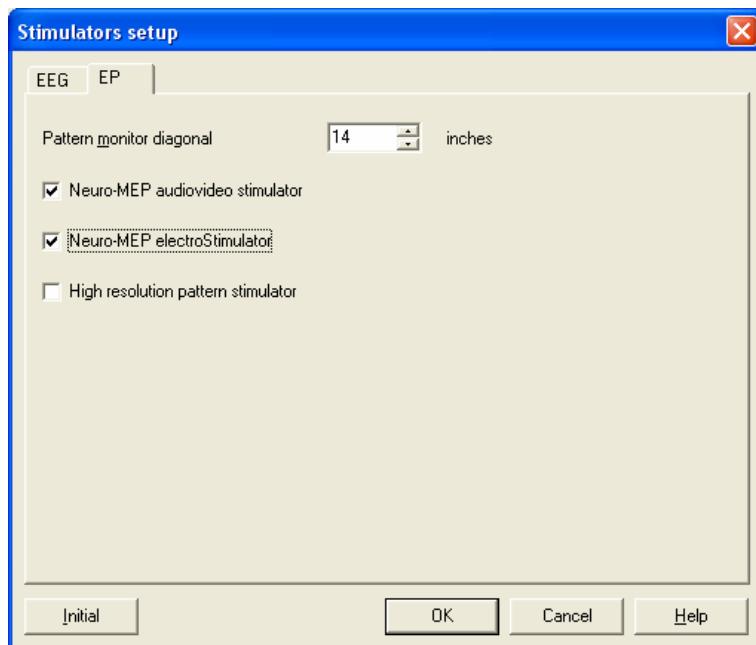
*Delete artifacts*. Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level*. The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

5. *Amplifier* and *Components* pages are similar to those described above in 18.2.1.

### **18.3. EP REGISTRATION USING NEURO-MEP EXTERNAL STIMULATORS**

To register EP on **Neuron-Spectrum-4/EP, 1, 2, 3, 4, 4/P, 4/EPM, 5**, you can use the **Neuro-MEP** external stimulator units – auditory-visual stimulator, electrical stimulator, high-resolution pattern stimulator and external stimulators with the synchronization signal input. External stimulator units are connected to the USB connector or to the splitter of USB-socket or to the EEG system synchronization input in a standard manner. To initiate the stimulators work with the **Neuron-Spectrum-LEP** you should check in either *Neuro-MEP auditory-visual stimulator* or *Neuro-MEP electrical stimulator* or *High-resolution pattern stimulator* or *External stimulator* check box in **Stimulators setup** dialog box on the *EP* page (Pic. 18.15). Use the **Setup|Stimulators** menu command or the  button.



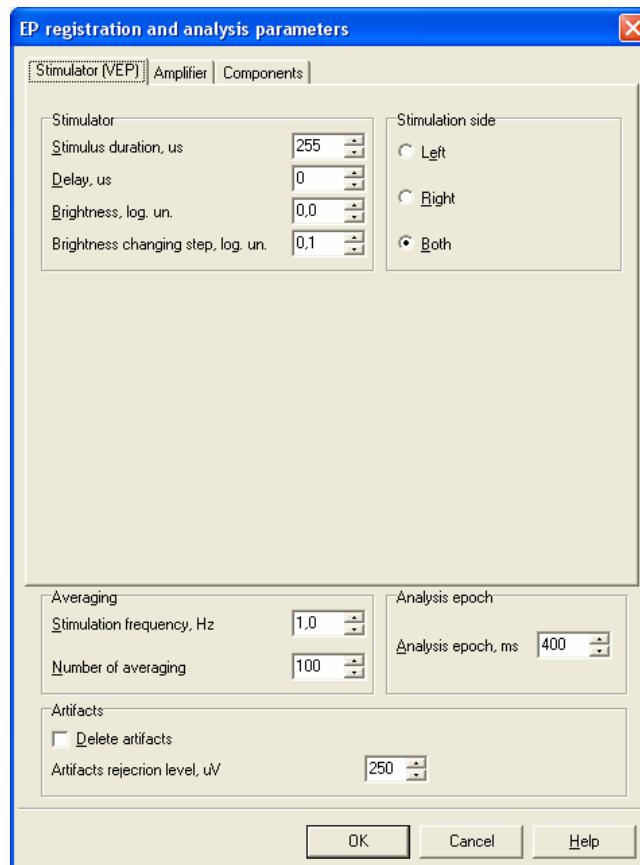
Pic. 18.15

*Pattern monitor diagonal.* The monitor diagonal size used as a pattern-stimulator in inches.

When using **Neuro-MEP** stimulators, you also can fulfill the preset of the stimulators parameters, using the same **Setup** menu commands.

### 18.3.1. VISUAL EP PARAMETERS SETUP (VEP)

- To setup the parameters of visual EP on flash use the **Setup|VEP (flash)** menu command. The **EP registration and analysis parameters** dialog box will appear on the (Pic. 18.16).



Pic. 18.16

- The *Stimulator (VEP)* page.

*Stimulus duration.* Flash duration. The stimulus shape is rectangular.

*Delay.* Stimulus offset from the EP registration epoch beginning. If the parameter value is positive – the stimulus is behind of the epoch beginning, if negative – the stimulus is before the epoch beginning. If the value is zero – the stimulus and the epoch begin at the same time.

*Brightness.* Stimulus brightness in logarithmic units. Maximum of brightness corresponds to the value of zero logarithmic units, minimum – minus three of logarithmic units.

*Brightness changing step.* Step of stimulus changing in logarithmic units using the **EP|Stimulator|Zoom out** or **EP|Stimulator|Zoom in** menu commands (“hot” keys [F6] and [F5] correspondingly).

*Stimulation side.* Stimulated patient’s eye.

*Stimulation frequency, Hz.* Stimuli amount per second.

*Number of averaging.* Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing **[Ctrl+Esc]** or **[Esc]**.

*Analysis epoch.* The analysis epoch value is duration of the registered EP curve (shouldn't be higher than the interval between the warning stimuli).

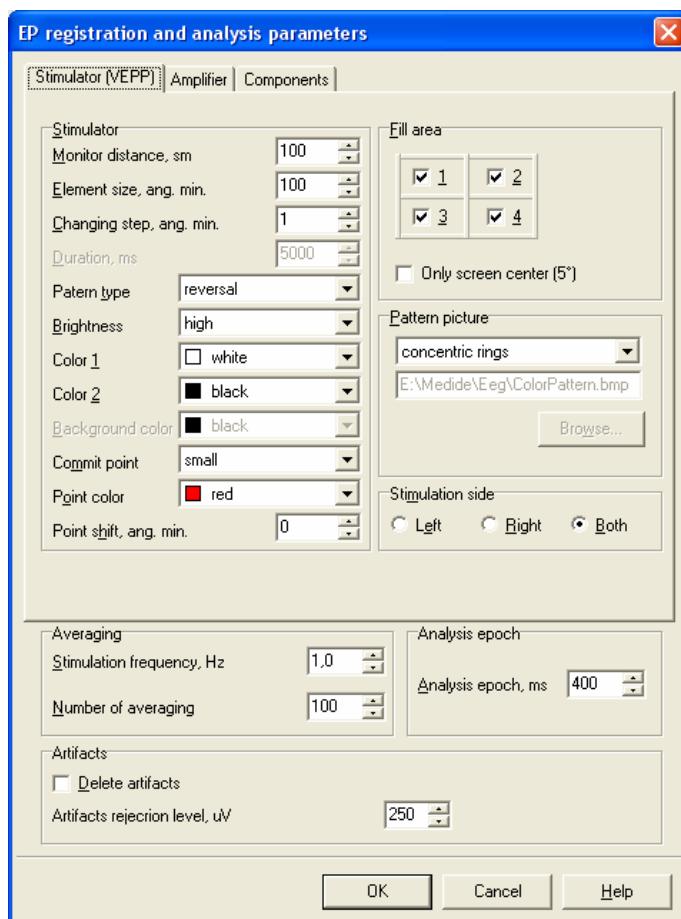
*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

3. *Amplifier* and *Components* pages are similar to those described above in 18.2.1.

### 18.3.2. VISUAL EP ON PATTERN PARAMETERS SETUP (VEPP)

1. To setup VEPP registration and analysis parameters use the **Setup|VEP (pattern)** menu command. The **EP registration and analysis parameters** dialog box will appear on the (Pic. 18.17).



Pic. 18.17

2. The *Stimulator (VEPP)* page.

*Monitor distance.* Set the distance from patient's eyes to the pattern monitor screen. It is necessary for the right setting of the pattern element angular size. You should also set the monitor diagonal axis in the **Stimulators setup** dialog box on the EP page using the **Setup|Stimulators** menu command or the button.

*Element size.* The pattern element size (for example, height and width of reversal pattern square) for patient's eyes. The size of a pattern element for pictures "windmill" (Pic. 18.18d) and "darts target" (Pic. 18.18e) is excellently fit to the picture element size at the middle of upper and lower parts of monitor screen.

*Changing step.* Step of element's angular size changing using the **EP|Stimulator| Zoom out** or **EP|Stimulator|Zoom in** menu commands ("hot" keys [F6] and [F5] correspondingly).

*Duration.* Pattern's presentation duration (only for pattern's presentation or disappearance).

*Pattern type.* EP registration is possible to the reversal as well as to the direct (presentation or disappearance) pattern.

*Brightness.* The pattern's brightness can be high and low.

*Color 1. Color 2.* The basic colors for the pattern's picture formation.

*Background color.* Background color (only for pattern presentation or disappearance).

*Commit point.* Commit point of an eye in the center of reversal pattern monitor: small, medium, big or absent.

*Point color.* Color of the eye commit point.

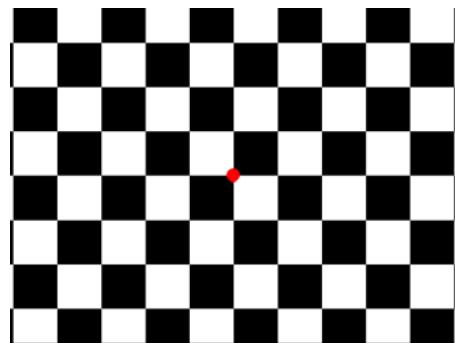
*Point shift, angular minute.* The eye commit point shifting into the unstimulated field during the half field or quarter visual field examination. If the whole pattern monitor is chosen, the value is ignored.

*Fill area.* The choice of reversal pattern fields (quarters) to stimulate. When the four quarters are chosen, the pattern seizes the whole monitor.

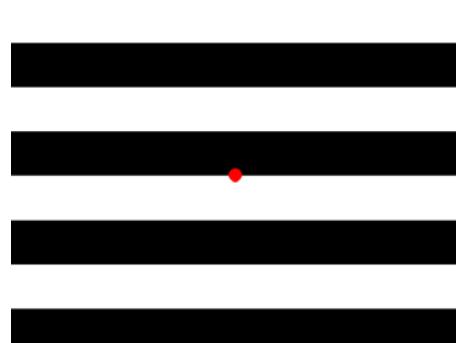
*Only screen center (5°).* Using of only the central part of the monitor with visibility angle of 5 degree.

*Pattern picture.* Reversal pattern picture: chess field (Pic. 18.18a), horizontal strips (Pic. 18.18b), vertical strips (Pic. 18.18c), concentric rings (Pic. 18.18d), “windmill” (Pic. 18.18e), darts target (Pic. 18.18f) or arbitrarily selected image, downloaded from file. In last described case it is necessary to preset file name. In the file **Pattern.bmp** you can find the example of black-and-white arbitrarily determined reversal pattern supplied with the program, in the file **ColorPattern.bmp** – for the colored pattern.

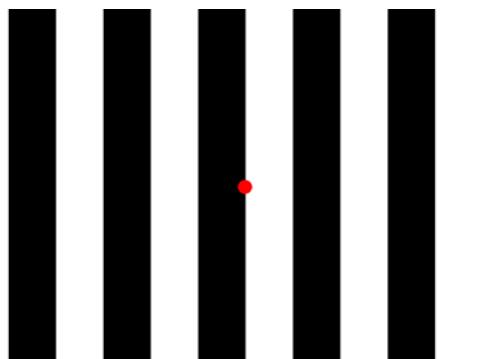
*Stimulation side.* The stimulated patient’s eye. Only one stimulation side is checked, if a special shutter closes the other patient’s eye.



a)



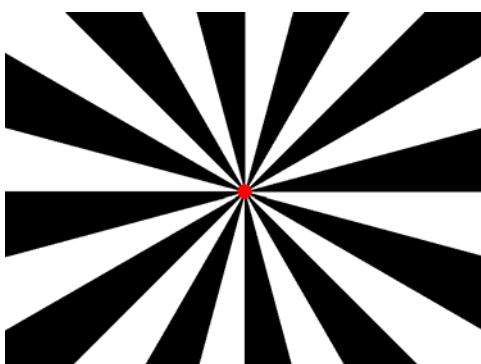
b)



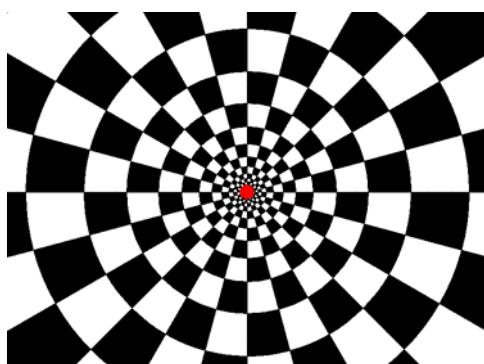
c)



d)



e)



f)

Pic. 18.18

*Stimulation frequency, Hz.* Stimuli amount per second.

*Number of averaging.* Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing [Ctrl + Esc] or [Esc].

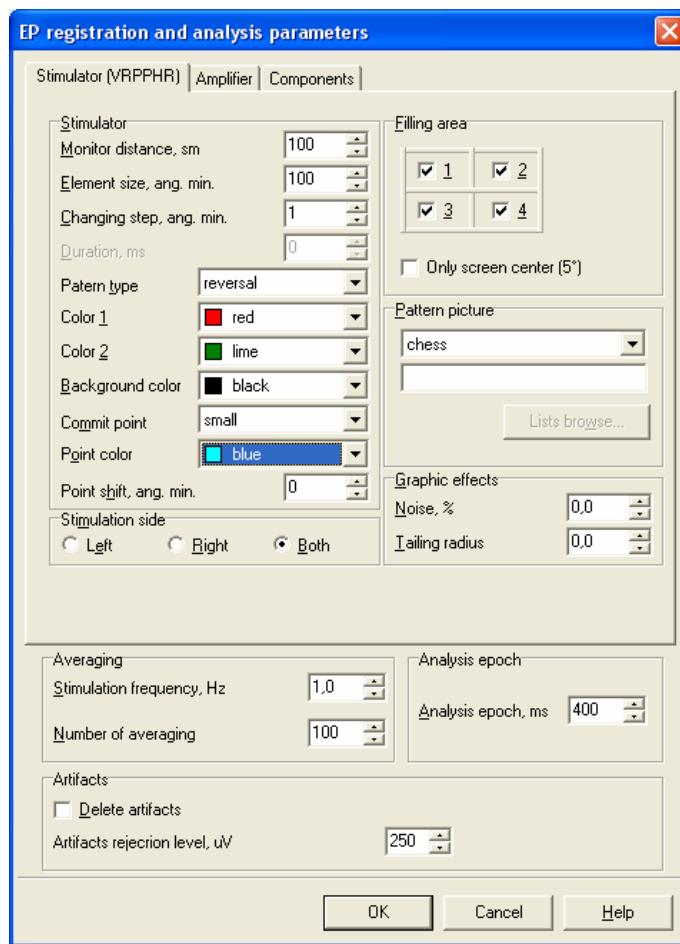
*Analysis epoch.* The analysis epoch value is duration of the registered EP curve (shouldn't be higher than the interval between the warning stimuli).

*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

*Amplifier* and *Components* pages are similar to those described above in 18.2.1.

3. To set up visual EP on high resolution pattern registration and analysis parameters, use menu command **Setup|VEP (pattern)**. The **EP registration and analysis parameters** dialog box will appear on the screen (Pic. 18.19).



Pic. 18.19

*Monitor distance, sm.* The distance from the patient to the monitor with the reversal pattern. It is necessary for the right set up of angular size of image element and also for the monitor size which can be adjusted using the menu command **Setup|Stimulators** or  button in the **Stimulators setup** dialog box on *EP* page.

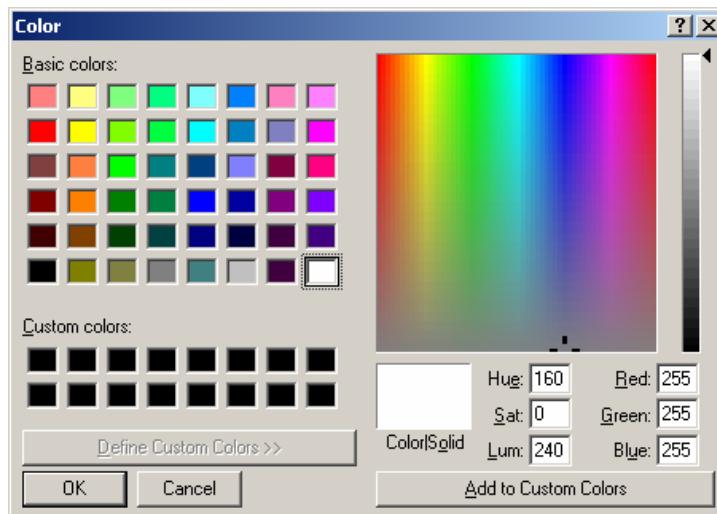
*Element size, ang. min.* The image element size (for example, width and altitude of the reversal pattern cell) for the patient eyes. For the images “windmill” (Pic. 18.18e) and “darts target” (Pic. 18.18f) the image element size approximately coincide with the picture element size at the middle of the upper and bottom parts of the screen.

*Changing step, ang. min.* The changing step of angular size of image element by menu commands **EP|Stimulator|Zoom out** or **EP|Stimulator|Zoom in**.

*Duration, ms.* The duration of pattern presentation (only for pattern presentation or disappearance). For high resolution pattern stimulator this parameter can not be setup as far as the modes of pattern presentation and disappearance do not work.

*Pattern type.* EP registration is possible only on the reversal pattern. The modes of direct pattern (presentation and disappearance) in this case do not work.

*Color 1. Color 2.* The main colors for the generation f the pattern image. You can choose 16 colors from the combo-box. To choose the other color (the palette includes 16 millions of colors), it is necessary to take the option *user...*, and the standard dialog of color selection will appear on the screen (Pic. 18.20).



Pic. 18.20

*Background color.* Background color (only for pattern presentation or disappearance or incomplete filling of the screen).

*Commit point.* The commit point of look in the center of reversal pattern monitor: small, middle, big or it is absent.

*Point color:* point color of the look fixation.

*Point shift, ang. min.* Point shift of look fixation in nonstimulated area when studying the split image or the quarter of field of view. If the whole screen of pattern is chosen, then the value is ignored.

*The filling area.* The choice of areas (quarters) of reversal pattern for stimulation. When you choose all the quarters, the pattern will occupy the whole screen.

*Only center of the screen (5).* The use of only the central part of the screen with the visibility angle of 5 degree.

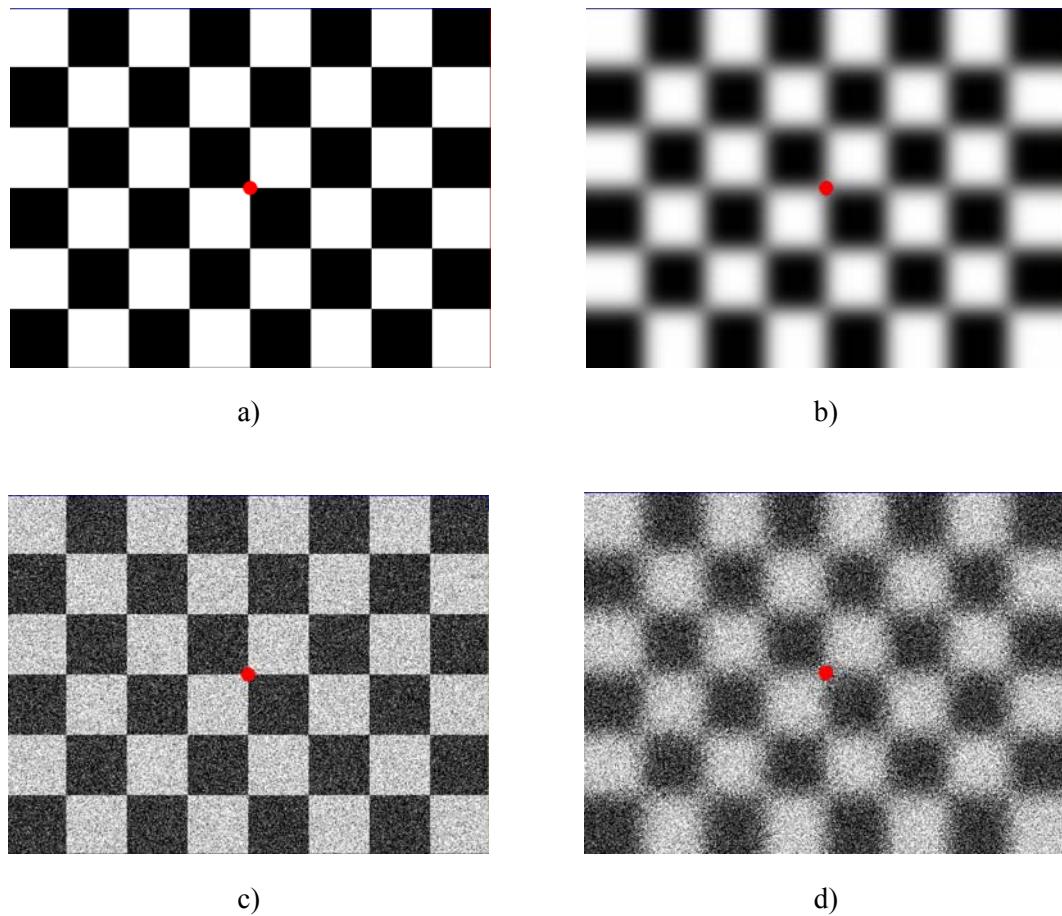
*Pattern image.* The image of reversal pattern: chess area (Pic. 18.18a), horizontal stripes (Pic. 18.18b), vertical stripes (Pic. 18.18c), concentric circles (Pic. 18.18d), “windmill” (Pic. 18.18e),

“darts target” (Pic. 18.18f) or arbitrary defined image loaded from the list of files with pictures. In the last case it is necessary to set the name from the list (Pic. 18.21). The order of work with the lists of images is described below in this chapter.



Pic. 18.21

*Graphic effects.* The settings of the special graphic filters overlaid on the images of the reversal pattern. On the Pic. 18.22a the example of the reversal pattern without any graphic effects is given, on the Pic. 18.22b – with tailing which is equal to 15, on the Pic. 18.22c – with 30 % noise one, on the Pic. 18.22d – with the tailing and noise at the same time.



Pic. 18.22

*Noise, %.* Intensity of the monochromatc noise, overlaid on the images, in percents.

*Tailing radius.* The radius of Gaussian tailing of reversal pattern images in screen pixels (points).

*Stimulation side.* The stimulated patient's eye. Only one stimulation side is checked, if a special shutter closes the other patient's eye.

*Stimulation frequency, Hz.* Stimuli amount per second.

*Number of averaging.* Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing [Ctrl + Esc] or [Esc].

*Analysis epoch.* The analysis epoch value is duration of the registered EP curve (shouldn't be higher than the interval between the warning stimuli).

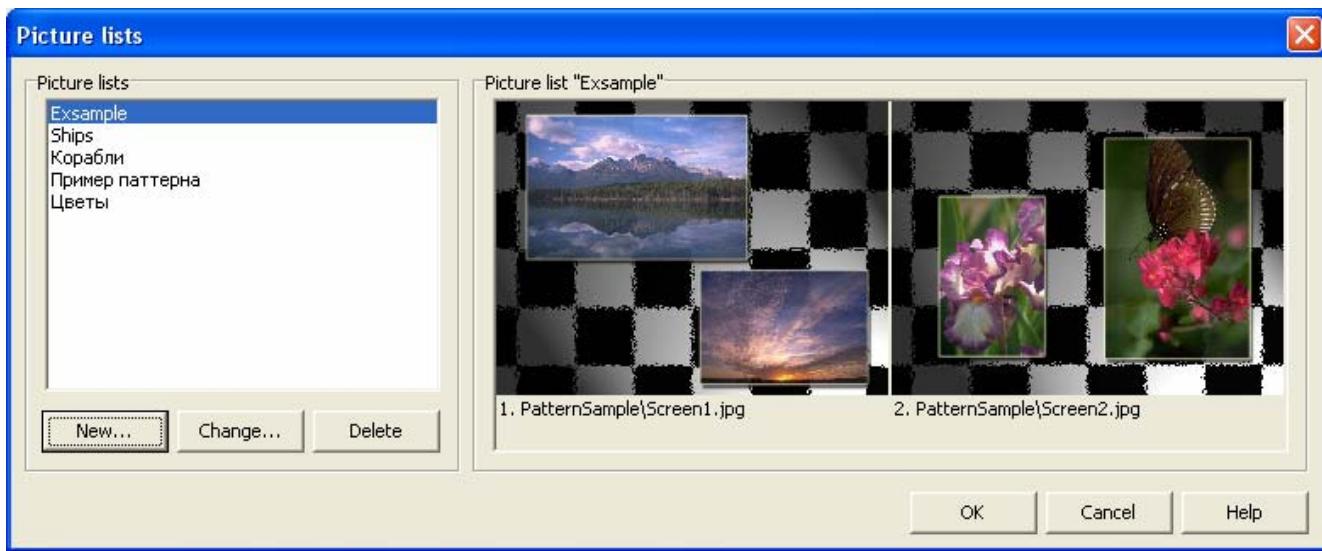
*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

*Amplifier and Components* pages are similar to those described above in 18.2.1.

As the samples of the reversal patterns, you can use any images in \*.bmp, \*.jpg, \*.jpeg, \*.gif, \*.wmf, \*.emf, \*.ico formats which are saved on the PC hard disc. The image size can be any but before reversal pattern displaying on the screen, it is brought to the 800×600 pixels size taking into consideration the image proportion. For the usability these images are formed in a list presented as a list of file names. When studying the visual EP on the reversal pattern, this list should consist of the names of two files (two changed one by the other screens); when studying the cognitive EP, the number of files is unlimited.

The button “*Lists browse*” (Pic. 18.21) is for choosing the arbitrarily defined image as a reversal pattern image and creating the list of pictures. If you press this button, you will see the dialog box **Picture lists** (Pic. 18.23).



Pic. 18.23

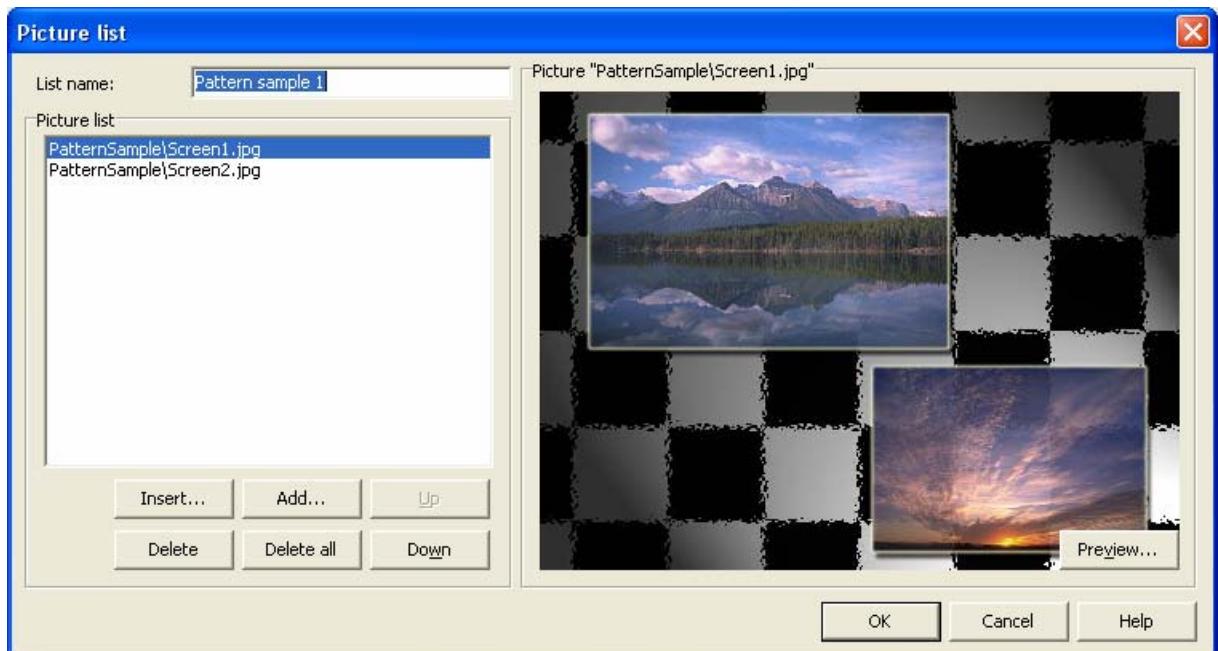
In the left part of the window are all available lists of pictures, in the right one are all the pictures from the list highlighted to the left (pictures list “*Пример паттерна*”). If you want to choose the necessary list, then mark it and press “*OK*” button.

“*New*” button. It is used for the creation of the new list of pictures. At the same time, the highlighted list is the basis of the created one. If there is no need in basis for the new list, press the “*Delete all*” button in the appeared window **Picture list** (Pic. 18.24).

“*Change*” button. The modification of the highlighted list (addition, images replacement, etc.).

“*Delete*” button. The removal (deletion) of the highlighted list. Please, pay attention that in this case only the picture is deleted from list, and the files with pictures are not changed.

If you press the “*New*” and “*Change*” buttons, the dialog box **Picture list** will appear (Pic. 18.24).



Pic. 18.24

*List name*. Any name of pictures list which will allow find and identify it easily.

*Picture list*. The list of files names with the graphic pictures included in this list. If you want to edit it, use the keys “*Insert*”, “*Add*”, “*Delete*”, “*Delete all*”, “*Up*” and “*Down*”.

“*Insert*” button. The inset of the new picture in the current list.

“*Add*” button. The addition of the new picture at the end of the list.

“*Delete*” button. The removal of the picture from the current list. In this case the file with picture is not deleted.

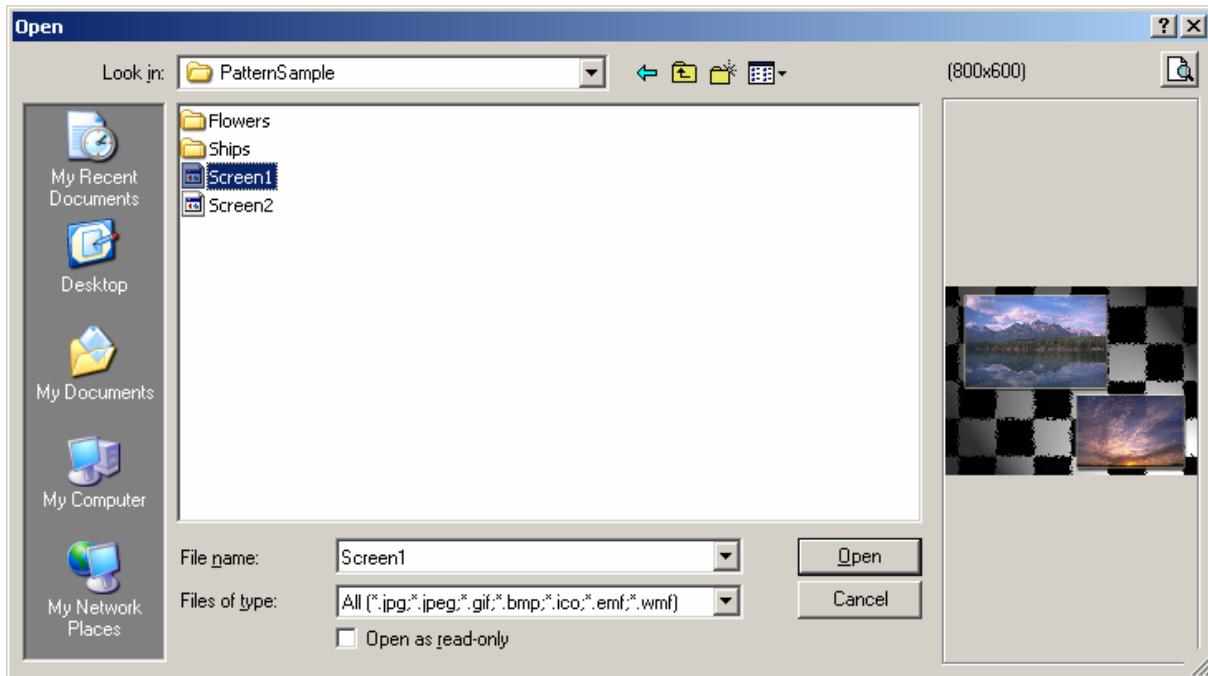
“*Delete all*” button. The removal of all the images from the list (list cleanup). In this case the files with images are not deleted.

“*Up*” and “*Down*” buttons are for the change of the order of the images sequence in the list.

“*Review*” button. The review of the current image in such a view it will be presented on the monitor of the reversal pattern, that is with 800×600 resolution.

## Neuron-Spectrum Program

By pressing the “*Insert*” and “*Add*” buttons you will see the standard file selection window with graphic picture (Pic. 18.25). When adding the pictures, you can select several files in one time using keys [Shift] and [Ctrl].



Pic. 18.25

### 18.3.2.1. THE CREATION OF YOUR OWN IMAGES OF THE REVERSAL PATTERN FOR THE NEURO-MEP AUDITORY-VISUAL STIMULATOR

1. As the images for the reversal pattern you can use any two-colored pictures of  $320 \times 240$  pixels size recorded in bitmap format (file with **bmp** extension). For the creation of these images you can use any graphic editor supporting this format, for example **Paint** editor, supplied with **Windows™**. The colors chosen by you are automatically adjusted to the colors available in **Neuro-MEP** auditory-visual stimulator.
2. The reversal pattern pictures are necessary for the use of pattern when EP registration, so the picture size should be  $640 \times 240$  or  $320 \times 480$  pixels, in other words, two pictures should be “glued” together along the vertical or horizontal lines. The files **Pattern.bmp** (black-and-white pattern example) and **ColorPattern.bmp** (colored pattern example) are delivered with the **Neuron-Spectrum** software as the examples. These files can be found in the program folder (by default **C:\Program Files\Neurosoft\Neuron-Spectrum**).

3. When registration of cognitive EP, the number of significant and insignificant stimuli (standard and deviant, warning and starting), that is frames following each other on the screen, is unlimited. For this purpose you can create bmp files with an image of any size. You can “glue” files vertically or horizontally. The examples of frames location is given on Pic. 18.26. Any number of the frames can be in the lines and columns. As the examples you can use files **MeanMoney.bmp** (10 pictures with money) and **NonMeanAnimals.bmp** (30 pictures with animals) delivered with the **Neuron-Spectrum**

software. If the given number of stimuli exceeds the number of frames in the file, the frames can be repeated.

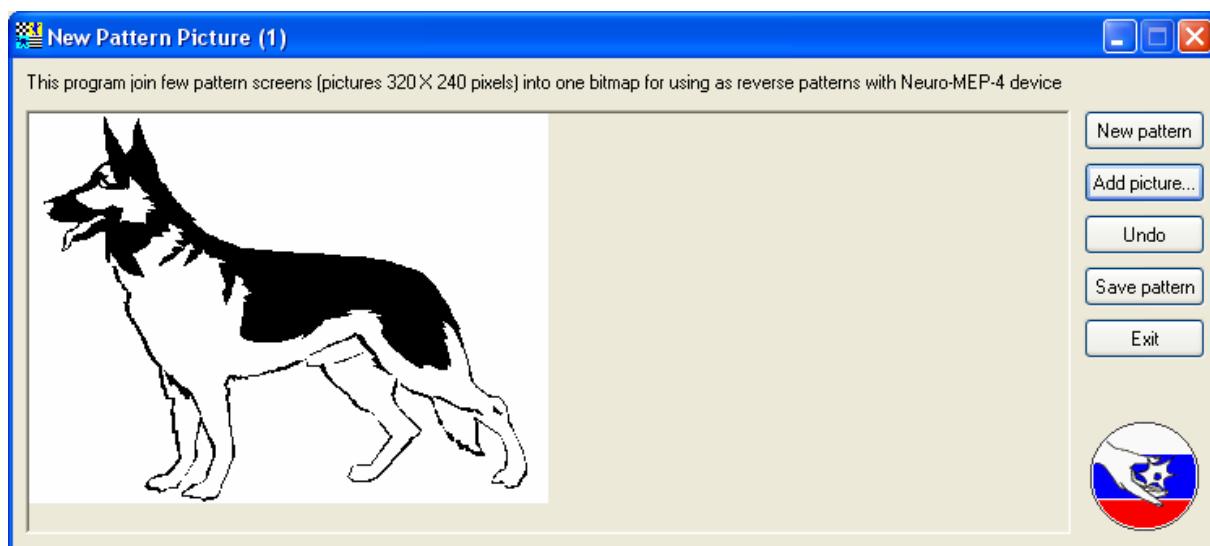
1	2	3	4
5	6	7	8
9	10	11	12

1	2	3	4	5	6	7	8	9	10	11	12
---	---	---	---	---	---	---	---	---	----	----	----

Pic. 18.26

4. For “gluing” of several pictures of  $320 \times 240$  size in one file, you can use **PatternJoin** program delivered with **Neuron-Spectrum** software and located in the program folder (Pic. 18.27).



Pic. 18.27

The software can “glue” the pictures of different formats (bmp, gif, jpg, jpeg, ico, emf, wmf) in one pattern file, the only limitation is that the frame should have the size of  $320 \times 240$  pixels.

“*New pattern*” – the creation of new pattern image (new file with pattern).

“*Add picture*” – the addition of the new frame to the existing sequence of frames.

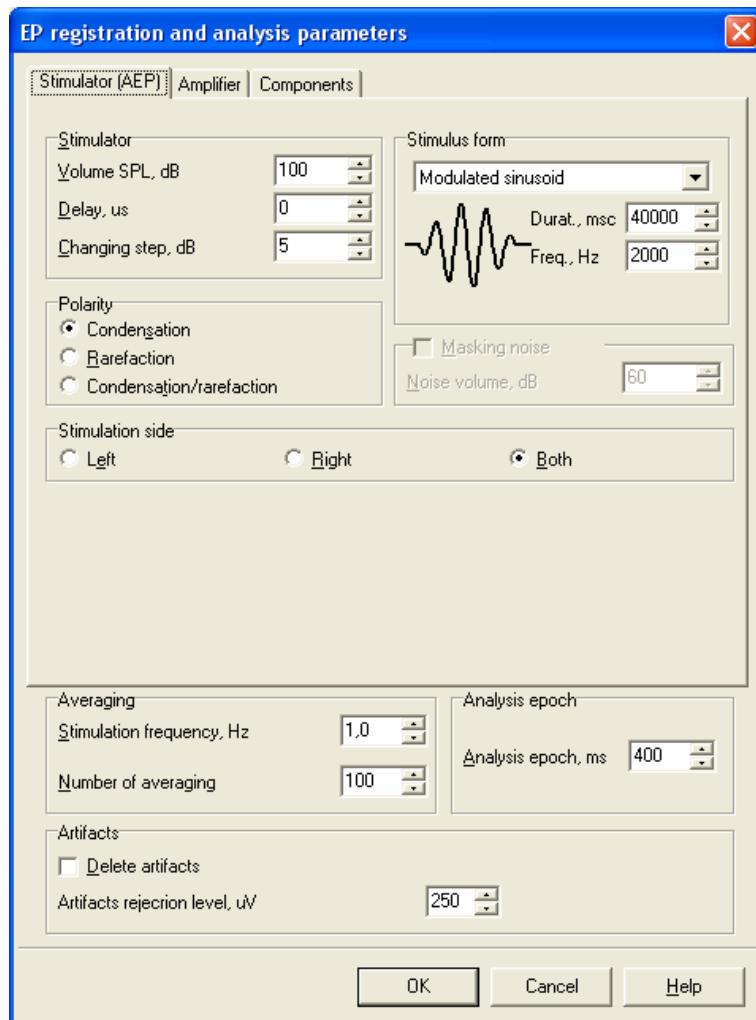
“*Undo*” – the removal of the last added frame.

“*Save pattern*” – the saving of the received sequence of frames in a file on the PC hard disc.

“*Exit*” –exit the program.

### 18.3.3. AUDITORY EP PARAMETERS SETUP (AEP)

- To setup auditory EP registration and analysis parameters use the **Setup|AEP** menu command. The **EP registration and analysis parameters** dialog box will appear on the screen (Pic. 18.28).



Pic. 18.28

- The *Stimulator (AEP)* page.

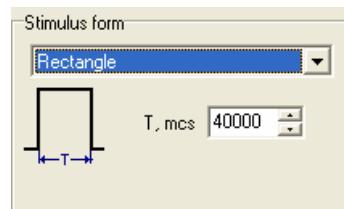
*Volume SPL.* Stimulus intensity in SPL scale (0 Db level corresponds to the sound pressure of 20 micro Pascal).

*Delay.* Stimulus offset from the EP registration epoch beginning. If the parameter value is positive – the stimulus is on specified number of milliseconds behind of the EP registration epoch beginning. If the parameter value is negative – the stimulus is on specified number of milliseconds before the EP registration epoch beginning. If the value is zero – the stimulus and the epoch begin at the same time.

*Changing step.* Step of stimulus volume changing during AEP registration using the **EP|Stimulator|Zoom in** or **EP|Stimulator|Zoom out** menu commands (“hot buttons [F6] and [F5] correspondingly).

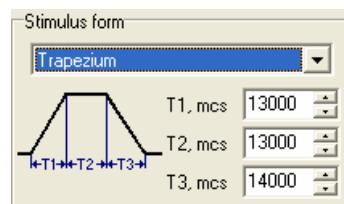
*Polarity.* The stimulation manner: condensation or rarefaction of headphones diaphragm or their combination (half the stimuli with condensation and the other half with rarefaction). The last mode is used for minimizing of the stimulus artifact amplitude that can distort the beginning of the curve.

*Stimulus form.* Forms of stimulus: rectangle, trapezium, unidirectional meander, meander, sinusoid or modulated sinusoid. For rectangular stimulus (Pic. 18.29) the duration is set (T, micro seconds).



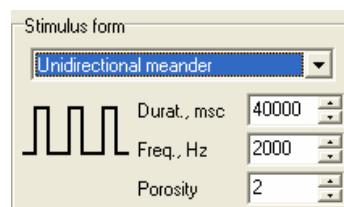
Pic. 18.29

For trapezium stimulus (Pic. 18.30) – the duration of leading edge (T1, mcs), the duration of master phase (T2, mcs) and the duration of trailing edge (T3, mcs). To obtain triangular form of the stimulus you should preset T2 and T3 are equal zero, for example.



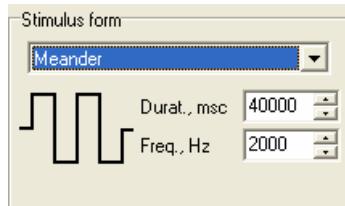
Pic. 18.30

For unidirectional meander (Pic. 18.31) you should set the duration (mcs), frequency (Hz) and porosity. The porosity is equal to the ratio of pulse spacing to the duration of one pulse. For example, porosity equals to three means one rectangular pulse is half the duration of the next pause



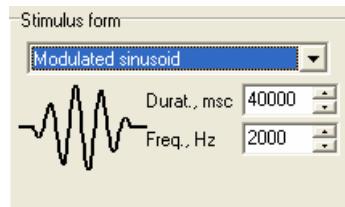
Pic. 18.31

For meander (unidirectional meander) (Pic. 18.32) – its duration (mcs) and frequency (Hz).



Pic. 18.32

For sinusoid stimulus (Pic. 18.33) duration (mcs) and frequency (Hz) are set.



Pic. 18.33

For modulated sinusoid (Pic. 18.28) duration (mcs) and frequency (Hz) are set. Envelope for the signal is the half of sine period.

*Masking noise.* Delivery of masking noise into unstimulated ear. This option is available in case of one ear being stimulated.

*Stimulation side.* The patient's ear being stimulated.

*Stimulation frequency, Hz.* Stimuli amount per second.

*Number of averaging.* Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing [Ctrl + Esc] or [Esc].

*Analysis epoch.* The analysis epoch value is duration of the registered EP curve (shouldn't be higher than the interval between the warning stimuli).

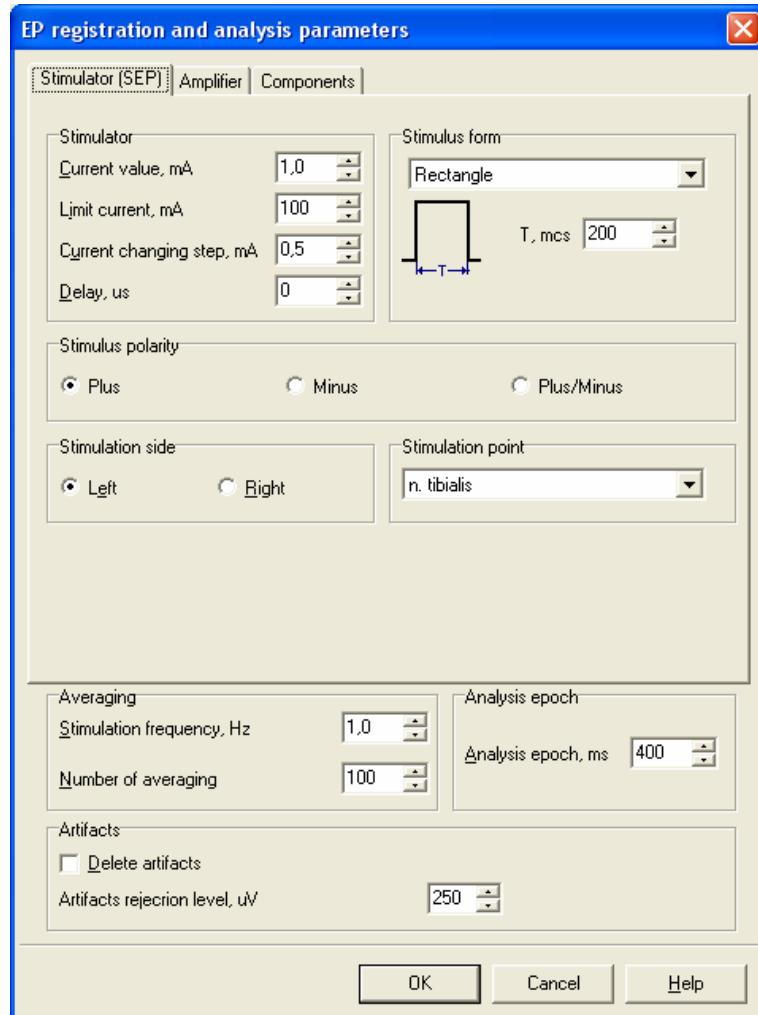
*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

3. *Amplifier* and *Components* pages are similar to those described above in 18.2.1.

### 18.3.4. SOMATOSENSORY EP PARAMETERS SETUP (SEP)

- To setup somatosensory EP registration and analysis parameters use the **Setup|SEP** menu command. The **EP registration and analysis parameters** dialog box will appear on the (Pic. 18.34).



Pic. 18.34

- The *Stimulator (SEP)* page.

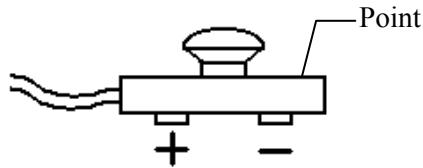
*Current value.* Stimulation amplitude.

*Limit current.* Limit for the **EP|Stimulator|Zoom in** menu command. In any case maximum current value can not be more than 100 mA because of build-in hardware lock in the stimulator.

*Current changing step.* Current changing step during registration when using **EP|Stimulator|Zoom in** and **EP|Stimulator|Zoom out** (“hot buttons [F6] and [F5] correspondingly).

*Delay.* Stimulus offset from the EP registration epoch beginning. If the parameter value is positive – the stimulus is on specified number of milliseconds behind of the EP registration epoch beginning. If the parameter value is negative – the stimulus is on specified number of milliseconds before the EP registration epoch beginning. If the value is zero – the stimulus and the epoch begin at the same time.

*Stimulus polarity.* The polarity of current stimulus – positive or negative (reversal). The polarity “plus/minus” corresponds to the alternate stimuli delivery with positive and negative polarity that is used to reduce the stimulus artifact, but may cause the distortion of the response. When the polarity on the stimulator is positive, the following potentials are occurred (Pic. 18.35).



Pic. 18.35

*Stimulus form.* For current stimulus, rectangle, trapezium, unidirectional meander, bidirectional meander, sinusoid or modulated sinusoid can be set.

*Stimulation frequency, Hz.* Stimuli amount per second.

*Number of averaging.* Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing [Ctrl + Esc] or [Esc].

*Analysis epoch.* The analysis epoch value is duration of the registered EP curve (shouldn't be higher than the interval between the warning stimuli).

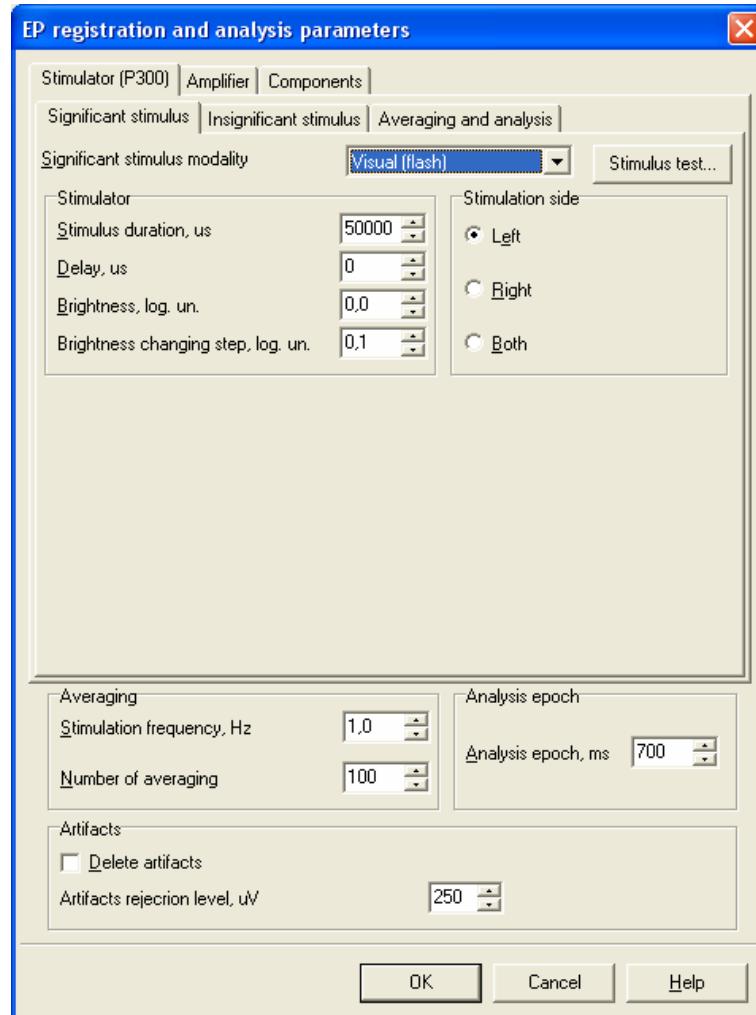
*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

3. *Amplifier* and *Components* pages are similar to those described above in 18.2.1.

### 18.3.5. COGNITIVE EP (P300, MMN) PARAMETERS SETUP

- To setup P300 registration and analysis parameters use the **Setup|CEP (P300)** menu command. The **EP registration and analysis parameters** dialog box will appear on the (Pic. 18.36).



Pic. 18.36

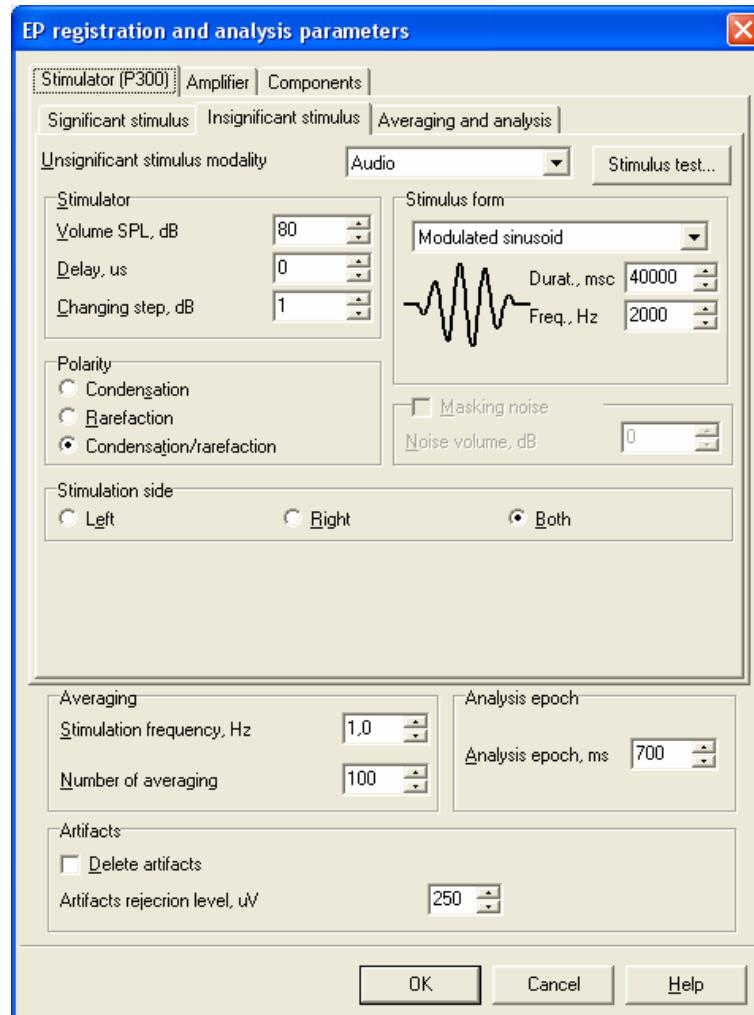
- The test can be carried out with the patient's reaction button as well as without it. When the button is used, the patient should press the button after each significant stimulus. Either button on the device can be used. When connecting the patient's button to the computer, make sure it is connected to the same USB-splitter (USB-Hub) as the EEG; otherwise the patient's response would be incorrect.

- The *Significant stimulus* page (Pic. 18.36). Significant (rare) stimulus characteristics.

*Significant stimulus modality.* Stimuli of any modality can be used as a significant stimulus: auditory, flash and pattern. The settings for the corresponding stimuli are described before in the following sections: *VISUAL EP PARAMETERS SETUP (VEP)*, *VISUAL EP ON PATTERN PARAMETERS SETUP (VEPP)*, *AUDITORY EP PARAMETERS SETUP (AEP)*.

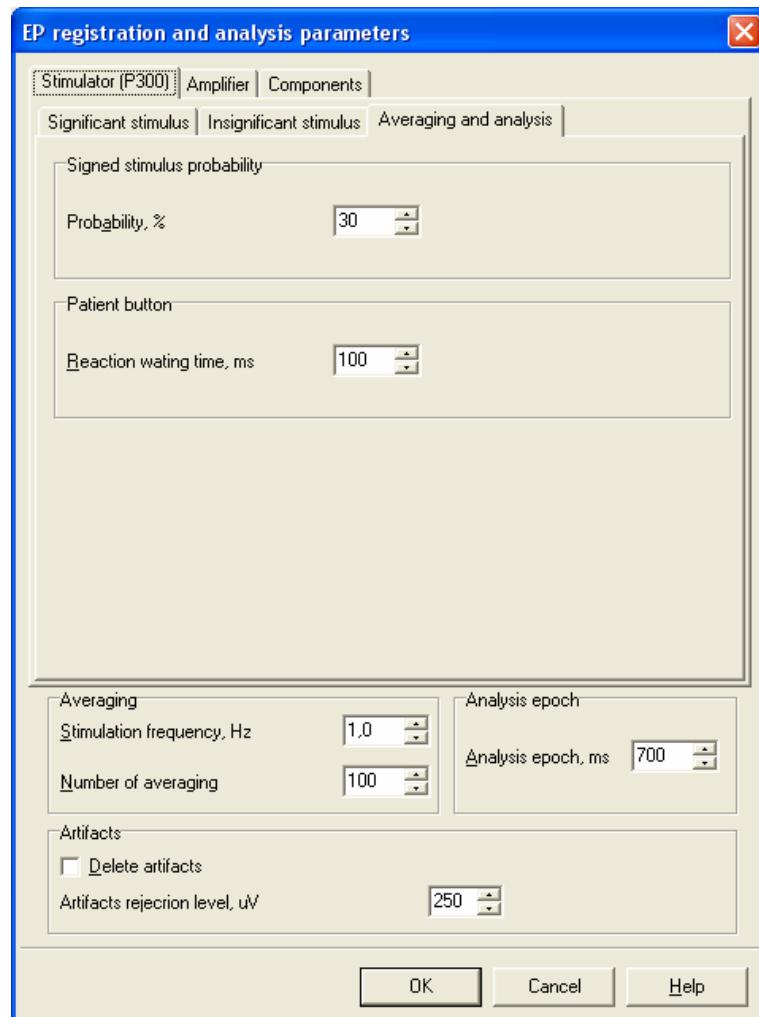
“*Stimulus test*” – permanent presentation of the significant stimulus for the patient.

4. The *Insignificant stimulus* page (Pic. 18.37). The *Insignificant stimulus* page is similar to the *Significant stimulus* one and contains the setup for insignificant (frequent) stimulus.



Pic. 18.37

5. Averaging and analysis page (Pic. 18.38).



Pic. 18.38

*Significant stimulus probability. Probability.* The probability of a significant stimulus during the stimulation (significant stimulus amount per hundred stimuli).

*Patient button. Reaction waiting time.* Highest possible time for the patient's reaction, i.e. time lag after the significant stimulus, during that the button's pressing is estimated as the correct one.

6. *Stimulation frequency.* Stimuli amount per second.

*Number of averaging.* Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing [Ctrl + Esc] or [Esc].

*Analysis epoch.* The analysis epoch value is duration of the registered EP curve (shouldn't be higher than the interval between the warning stimuli).

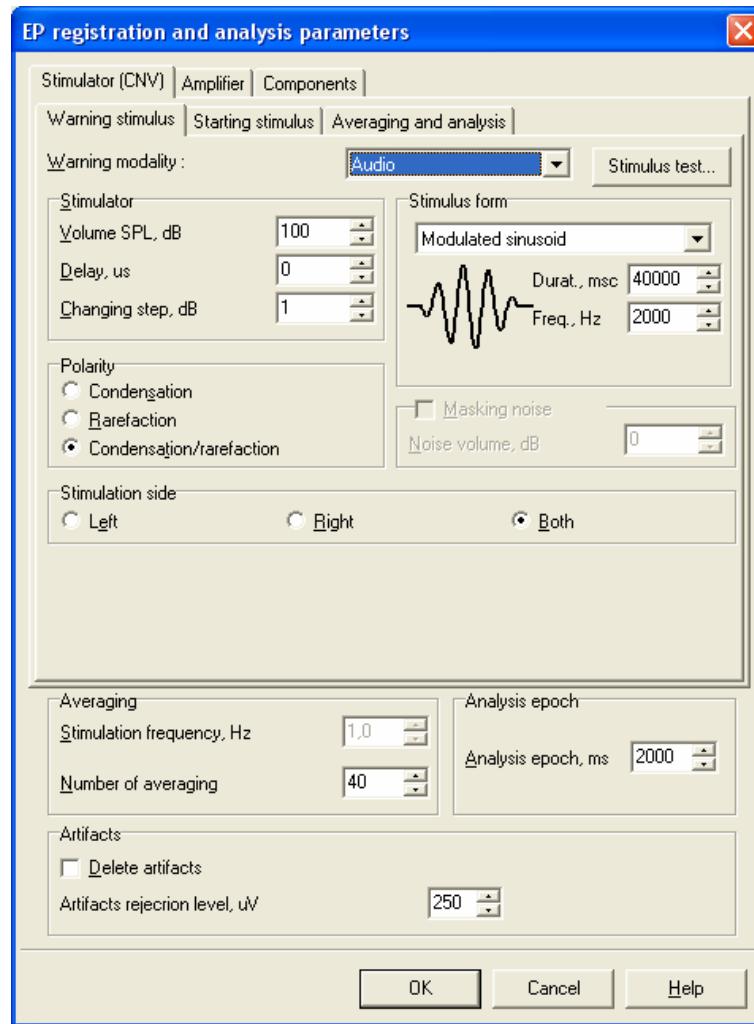
*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

7. To setup registration and analysis parameters on MMN method, use the **Setup|CEP (MMN)**. The **EP registration and analysis parameters** dialog box are similar to the cognitive EP on method P300, with the exception of the fact that the *significant* stimulus are corresponds to *deviant* ones and *insignificant* – to *standard*.

#### 18.3.6. CONTINGENT NEGATIVE VARIATION (CNV) PARAMETERS SETUP

1. To setup CNV registration and analysis parameters use the **Setup|CNV** menu command. The **EP registration and analysis parameters** dialog box will appear on the (Pic. 18.39).



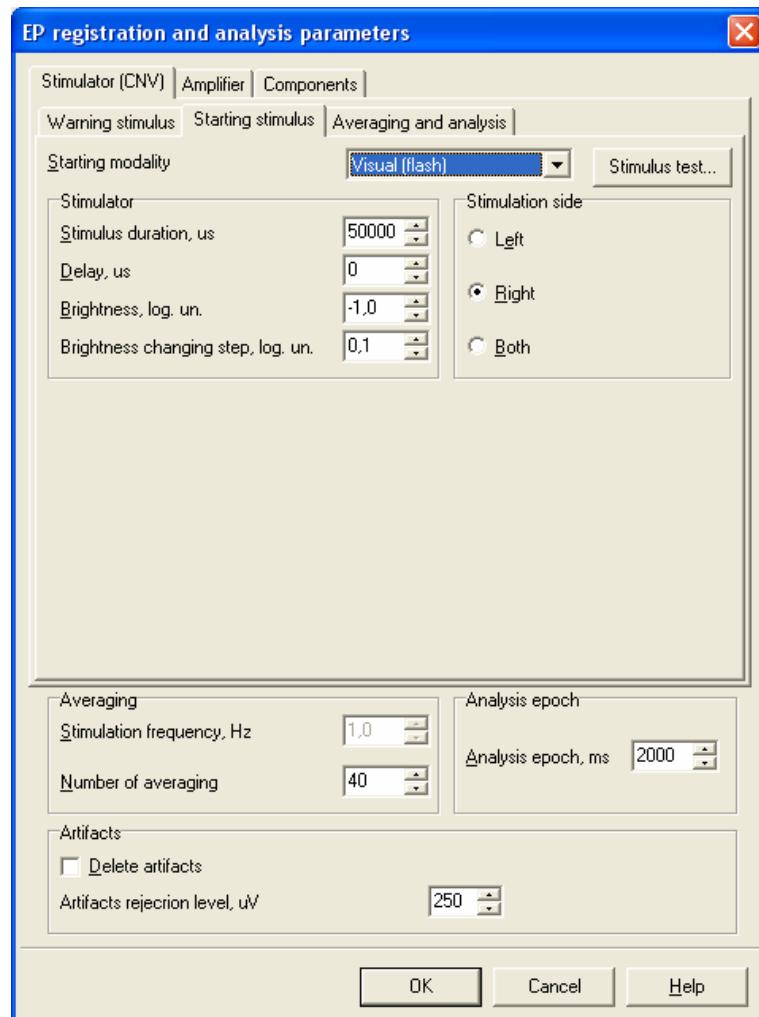
Pic. 18.39

2. The *Warning stimulus* page (Pic. 18.39). Warning (first) stimulus parameters.

*Warning modality*. Stimuli of any modality can be used as a warning stimulus: auditory, flash and pattern. The settings for the corresponding stimuli are described in the following sections: *VISUAL EP PARAMETERS SETUP (VEP)*, *VISUAL EP ON PATTERN PARAMETERS SETUP (VEPP)*, *AUDITORY EP PARAMETERS SETUP (AEP)*.

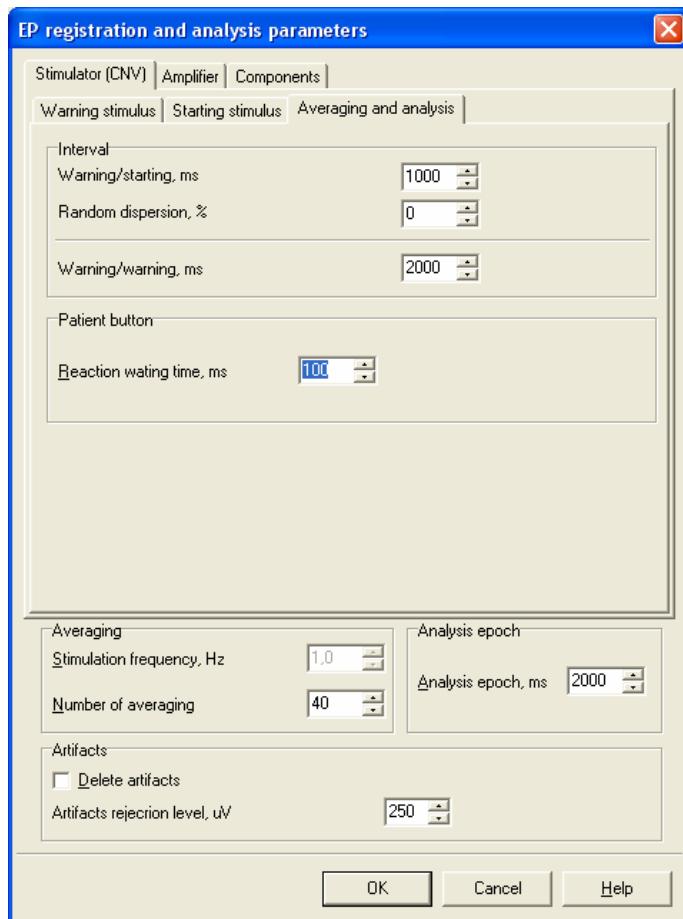
“*Stimulus test*” – Permanent presentation of the warning stimulus for the patient.

3. The *Starting stimulus* page (Pic. 18.40) is similar to the *Warning stimulus* page and contains settings for the starting (second).



Pic. 18.40

### 4. The Averaging and analysis page (Pic. 18.41).



Pic. 18.41

#### *Interval.*

*Warning/startng.* The interval between the warning (first) and starting (second) stimuli.

*Randomized dispersion.* The dispersion of the interval between the warning and starting stimuli (in percentage terms).

*Warning/warning.* The interval of the warning stimuli repetition.

*Patient button. Reaction waiting time.* Highest possible time for the patient's reaction, i.e. time lag after the significant stimulus, during that the button's pressing is estimated as the correct one.

#### *5. Stimulation frequency.* Stimuli amount per second.

*Number of averaging.* Maximal number of signal averaging. After attainment of this number EP registration stops automatically. You can stop it earlier by pressing [Ctrl+Esc] or [Esc].

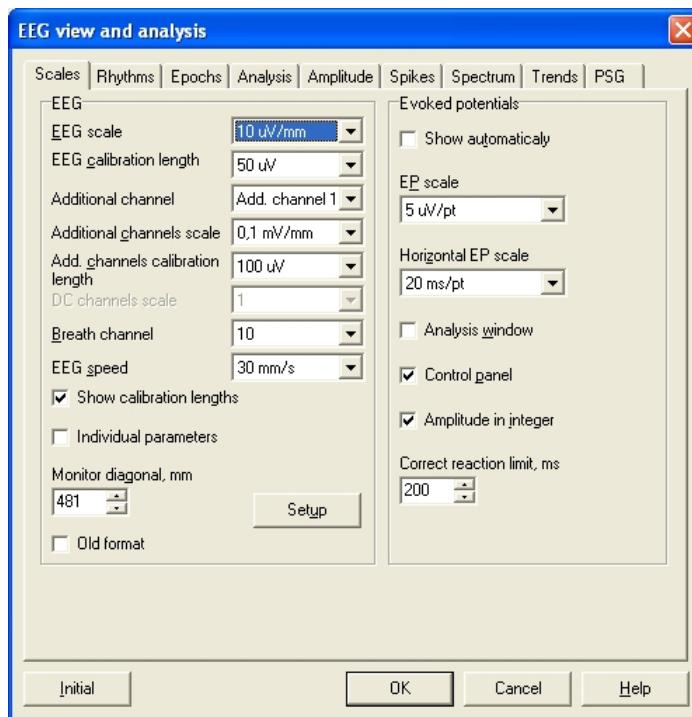
*Analysis epoch.* The analysis epoch value is duration of the registered EP curve (shouldn't be higher than the interval between the warning stimuli).

*Delete artifacts.* Switches on the artifact-deleting mode during EP registration. If the EEG amplitude in an epoch is more than the amplitude limit, the epoch is not added to the result EP curve when averaging is performed.

*Amplitude rejection level.* The value of amplitude limit for artifact fixation. The epochs with higher amplitudes are not added to the sum when averaging is performed.

## 18.4. PROGRAM PARAMETERS SETUP

1. To setup EP software parameters use the **Setup|Analysis** menu command or click on the  button on the *Setup* toolbar. The **EEG view and analysis** dialog box will appear on the screen (Pic. 18.42).



Pic. 18.42

### 2. The *Evoked potentials* group.

*Show automatically*. If the EP recording was performed during the examination process, the first recorded EP test is displayed automatically on examination opening when the check box is checked.

*EP scale*. Sensitivity or scale of EP representation.

*Horizontal EP scale*. The number of milliseconds in one grid unit horizontally.

*Analysis window*. If the check box is checked and the common component markers are set, the analysis results window will be automatically shown after registration.

*Control panel*. If the check box is checked, the EP control panel is automatically shown on the screen.

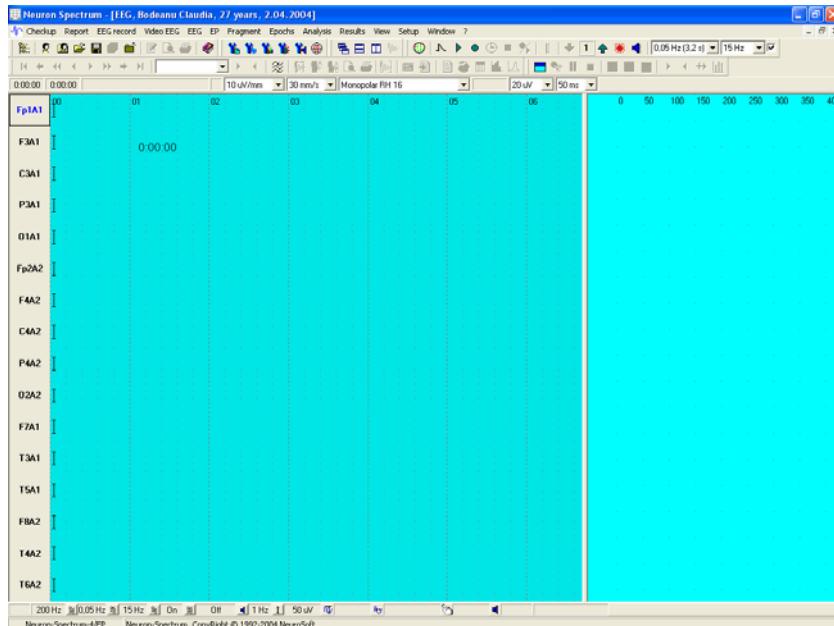
*Amplitude in integer*. If the check box is checked, the amplitude of EP components in analysis results table is in integer, otherwise – in real numbers.

*Correct reaction limit*. The patient button should be pressed during this time at the recording of the cognitive EP after the stimulus. If the button is pressed beyond the specified interval limits, the pressing is considered incorrect.

## 18.5. EP RECORDING

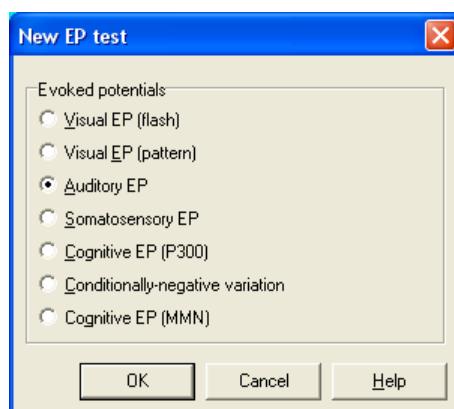
1. The registration of any EP begins with new checkup creation. The order of new checkup creation is described in details early in this manual.

2. To initialize EP registration, select **View|EP** in the EEG registration window or use [**Ctrl+F12**]. An EP registration panel will appear on the screen (Pic. 18.43).



Pic. 18.43

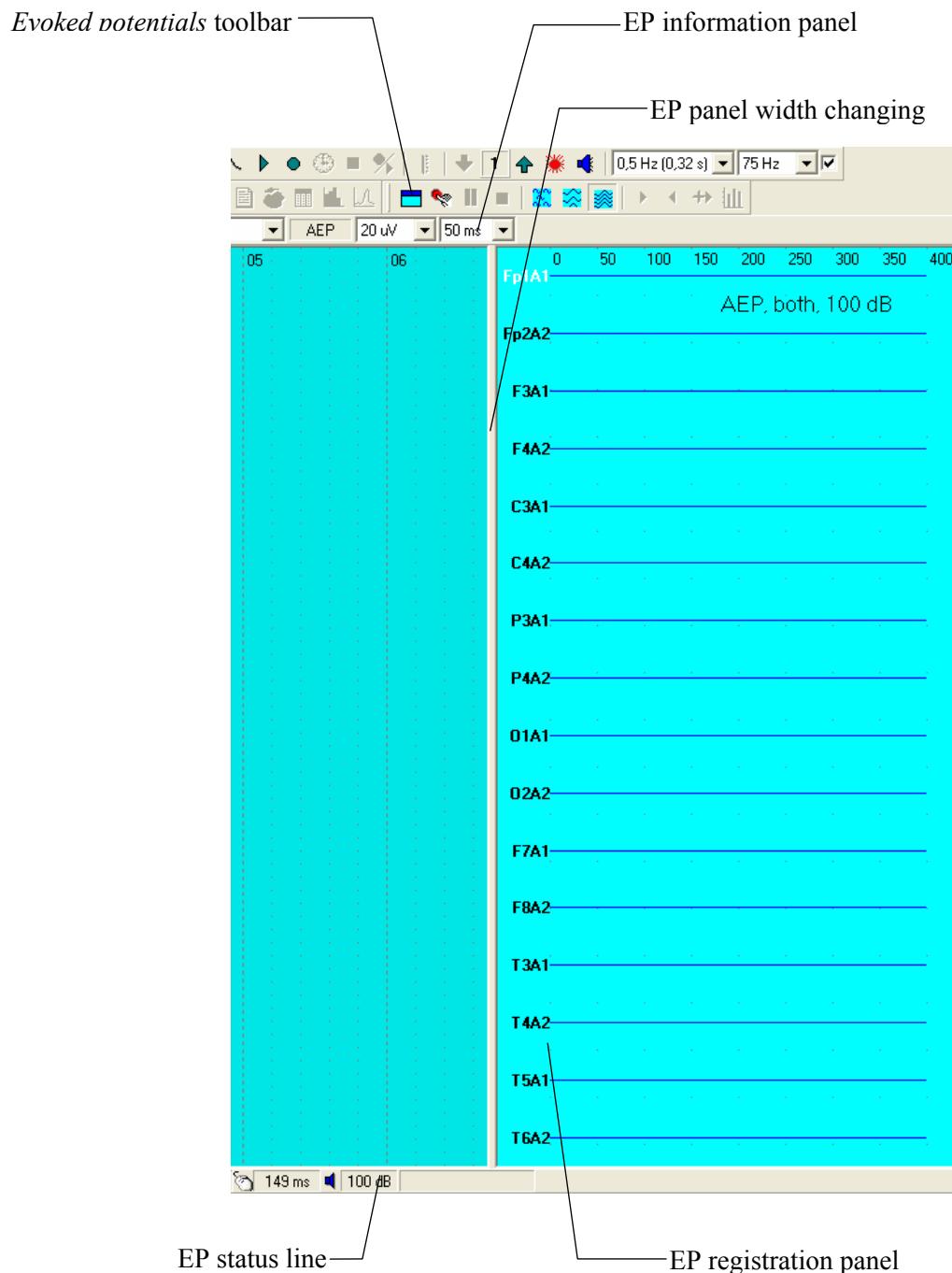
3. Select the type of the EP being registered using the **EP|New EP test** menu command or the button on the *Evoked potentials* toolbar. The **New EP test** dialog box will appear on the screen (Pic. 18.44).



Pic. 18.44

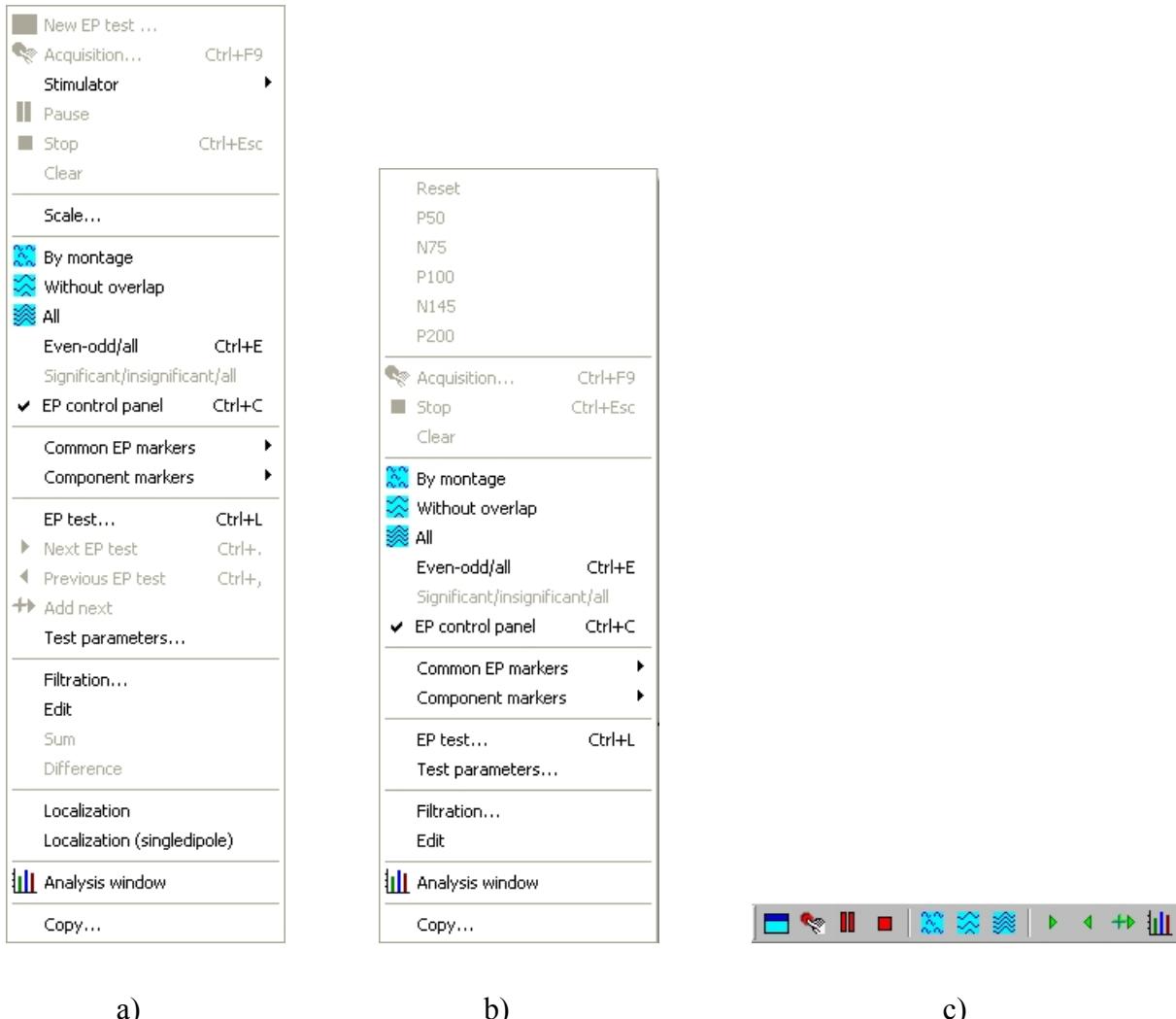
Select the EP test and click "OK" or press [**Enter**].

4. The selected montage derivations names on EP panel will appear, and the electroencephalograph will be ready to register the selected EP (Pic. 18.45).



Pic. 18.45

5. The EP registration and analysis window has its own **EP** menu (Pic. 18.46a), a properties menu (Pic. 18.46b) and the **Evoked potentials** toolbar (Pic. 18.46c). If you don't see EP toolbar on the screen, select **View|Toolbars** and in the **Toolbars** dialog box displayed activate the *Evoked potentials* check box.



Pic. 18.46

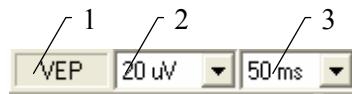
The list of the menu commands that are used during EP registration is given below (Table 18.1).

Table 18.1

Menu command	Button	Shortcut key	Description
New EP test			New EP test creating (new EP type)
Acquisition		[Ctrl+F9]	Start EP registration
Stimulator   Zoom in		[F5]	Increase stimulus value in compliance with EP test setup
Stimulator   Zoom out		[F6]	Decrease stimulus value in compliance with EP test setup
Pause			Stop EP averaging, but not stops EEG monitoring and stimulation
Stop		[Ctrl+Esc]	Stop EP registration
Clear			Delete EP record

6. On the information panel (Pic. 18.47) you can see the information about:

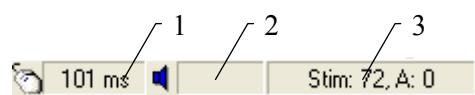
- EP type (1);
- vertical scale (2);
- horizontal scale (3).



Pic. 18.47

7. In the status line there are (Pic. 18.48):

- mouse cursor position in milliseconds (1);
- stimulus value (2);
- number of stimulus and artifacts (3).



Pic. 18.48

8. To start EP acquisition use the **EP|Acquisition** menu command, the button on the *Evoked potentials* toolbar or the [Ctrl+F9] key combination. You can preliminary measure electrode impedance using the **EEG record|Impedance** menu command, the button or the [Shift+F9] key combination.

After EP acquisition starting, EEG monitoring begins. Some seconds later the corresponding stimulator begins working and EP registration (averaging) starts. The number of stimuli and artifacts (rejected epochs) is displayed during registration in the status line.

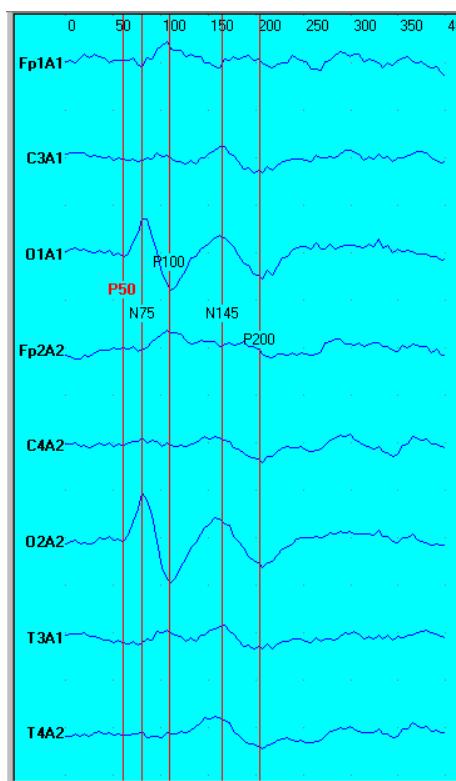
You can change the audio or electro stimulus value during registration using the **EP|Stimulator|Zoom in** or **EP|Stimulator|Zoom out** menu commands or the **[F5]** and **[F6]** keys. The stimulus value changes for one step set in the EP parameters setup.

If external stimulators of the **Neuro-MEP** device are used, the value of the stimulus can be changed for all types of stimuli.

9. After getting the number of stimuli set in the EP setup, the registration automatically stops. You can stop EP registration manually using the **EP|Stop** menu command, the  button or the **[Ctrl+Esc]** keys combination.

10. You can temporarily stop EP averaging without interruption of the stimulation and EEG registration. Use the **EP|Pause** menu command or the  button for it.

11. If you have formed the component list during EP parameters setup, after the end of EP registration the common components markers will be automatically set on the EP curves (Pic. 18.49).



Pic. 18.49

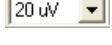
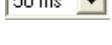
12. You can record any number of various EP tests in one checkup.

13. In case of abortive attempt of EP acquisition you can delete this record using the **EP|Clear** menu command. All the EP curves are cleared and you can register this EP test once more.

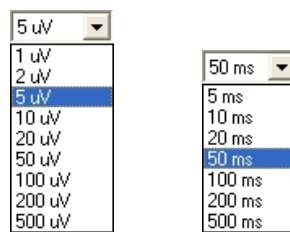
## 18.6. EP REVIEW AND ANALYSIS

1. During EP review and analysis you can apply many functions using the **EP** menu commands and the buttons on the *Evoked potentials* toolbar (Pic. 18.46).
2. To change EP curves scales use the menu commands listed below (Table 18.2).

Table 18.2

Menu command	Panel	Shortcut keys	Description
		[Gray +]	Increase vertical EP scale for one step
		[Gray -]	Decrease vertical EP scale for one step
Scale...	 		Set vertical and horizontal EP scale
		[Gray *]	Increase horizontal EP scale for one step
		[Gray /]	Decrease horizontal EP scale for one step

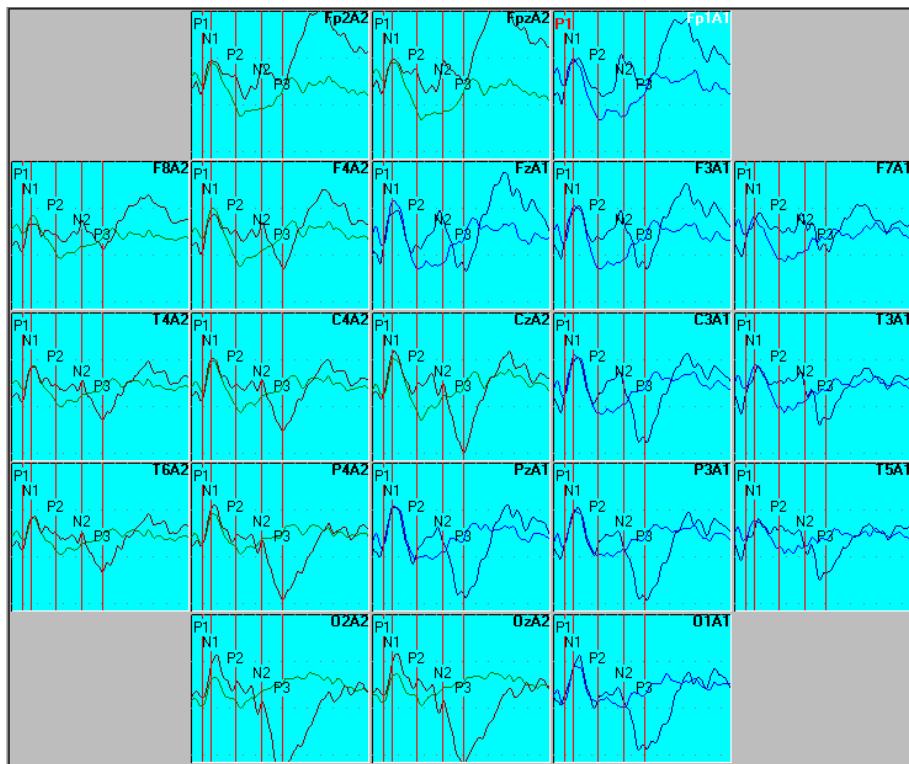
EP curves scale can be changed using menu commands, “hot keys”, or combo boxes on the information panel (Pic. 18.47). The possible values of scales on horizontal and vertical lines are below (Pic. 18.50).



Pic. 18.50

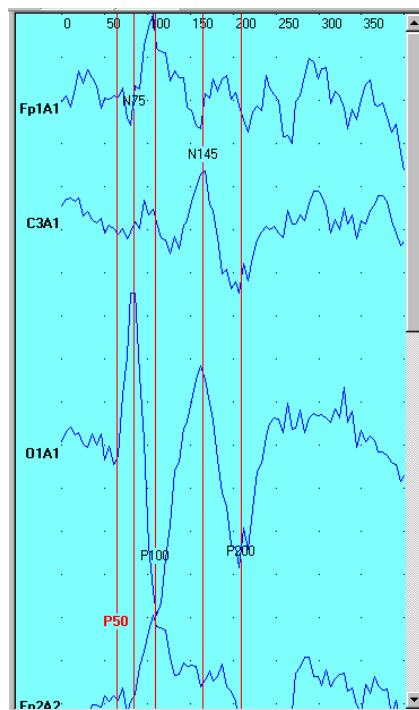
3. Using the **EP|By montage** () , **EP|Without overlap** () , **EP>All** () menu commands you can change the curves displaying on the screen

The “**By montage**” displaying is schematic placing of every curve on the EEG electrode position (Pic. 18.51).



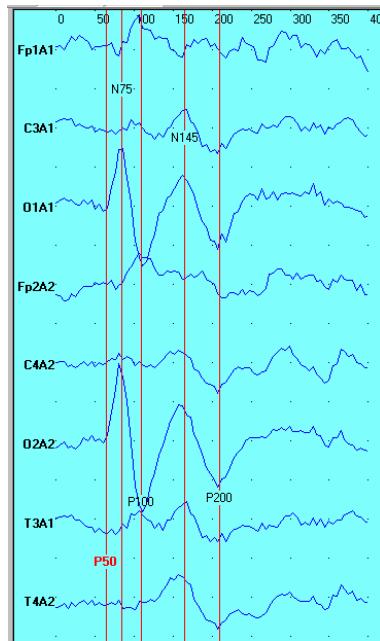
Pic. 18.51

The “**Without overlap**” displaying means that all the curves placed one under another are not intersected (Pic. 18.52). To view curves what are not visible, use vertical scroller.



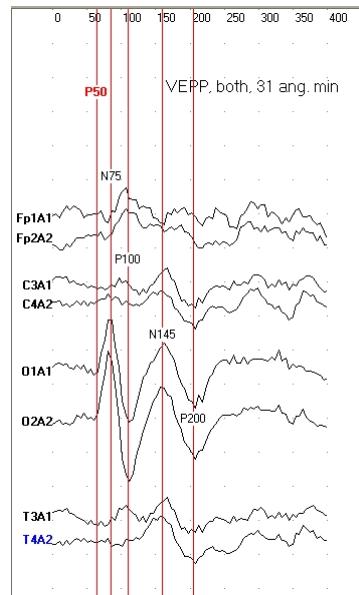
Pic. 18.52

The “All” displaying means that all the curves are placed in the visible part of the screen may be with overlapping (Pic. 18.53).



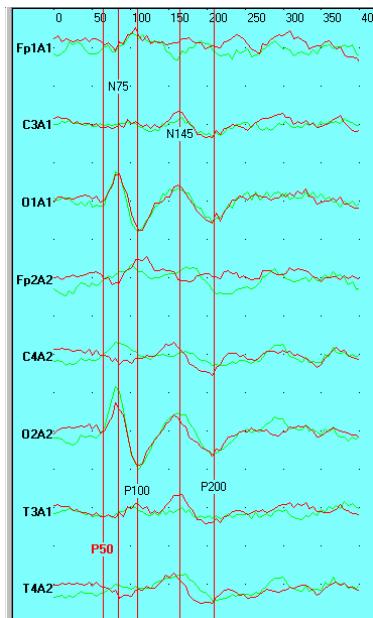
Pic. 18.53

The EP curves can be arranged on the screen arbitrary. To move the EP curve vertically on the screen, drag the EP derivation name with the left mouse button, at that the [Shift] key should be pressed. Holding the mouse button, drag the curve in a required place and release the mouse button and [Shift] key. Thus, you can arrange the curve as you need (Pic. 18.54).



Pic. 18.54

4. Using the **EP|Even-odd/all** menu command ([**Ctrl+E**]) you can show and hide curves that were averaged for odd and even stimuli separately (Pic. 18.55).



Pic. 18.55

Using **EP|Significant/insignificant/all** you can show and hide curves that have been averaged for significant and insignificant stimuli (or other stimulus of different types) separately when cognitive EP are registered.

5. You can show or hide the control panel of curves and analysis results display on the screen control using **EP|EP Control panel** or [**Ctrl+C**] key combination (see chapter 18.8)

6. You can make common and individual component markers visible or invisible using submenu of the **EP|Common EP markers** and **EP|Component markers** menus. These markers cannot be visible simultaneously, only separately.

You can show or hide markers using the **Hide>Show** command of the corresponding menu (Pic. 18.56 a, b). To delete a current common component marker (when it is highlighted) use **EP|Common EP markers>Delete current** or markers properties menu (by clicking with the right mouse button on the marker). To delete single components on a curve (in a derivation), make the derivation current (by clicking on its name with the left mouse button) and then use the **Delete** command of the corresponding menu. To delete all the common component markers, use the **Delete all** command of the menu. To reset the markers, use the **Setup** command.



a)

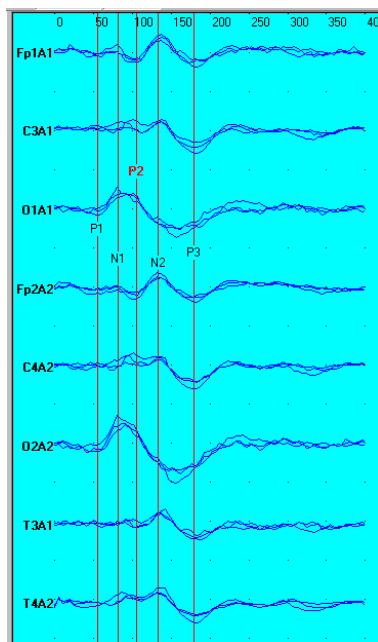
b)

Pic. 18.56

7. To navigate within recorded EP tests use the EP menu commands group. To display the next recorded EP test use the **EP|Next EP test** menu command, the  button on the toolbar or the **[Ctrl+>]** key combination. To display the previous recorded EP test use the **EP|Previous EP test** menu command, the  button on the toolbar or the **[Ctrl+<]** key combination.

To display several EP tests of one type on one graph use the **EP|Add next** menu command (the  button on the toolbar) or the **EP|EP test** menu command (the **[Ctrl+L]** key combination).

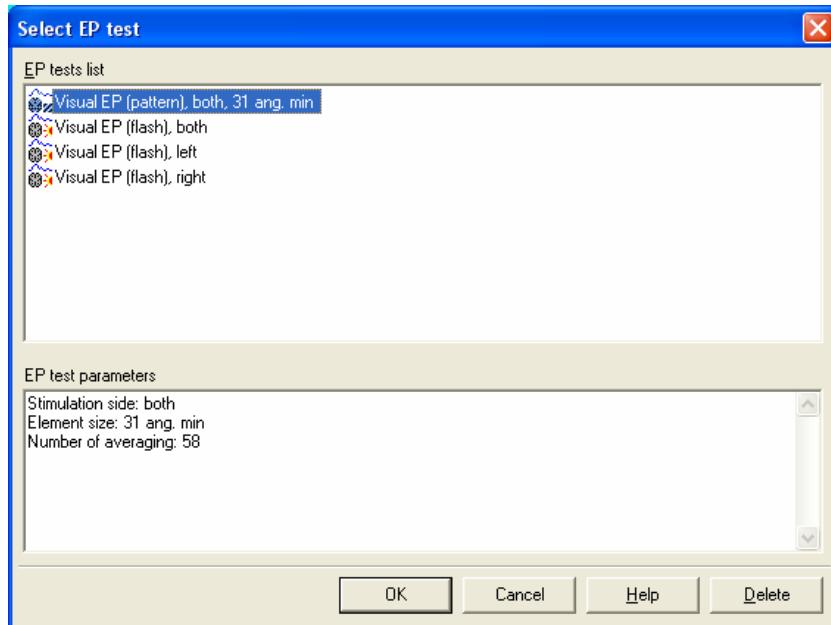
If a new test is added, it is displayed in the same axes (Pic. 18.57). So you can control repetition of EP registration results of the same tests.



Pic. 18.57

If there are several tests on the screen, the component markers only for the “current” test are displayed. Current test is the test added last.

If you select the **EP|EP test** menu command, the **Select EP test** dialog box with the list of all the registered EP tests will appear on the screen (Pic. 18.58).



Pic. 18.58

*EP tests list.* The list of all the recorded EP tests. If several tests are displayed on the screen, all of them are highlighted, and the current test is outlined by a dashed line. If you want to display several EP tests on the screen, select them by clicking on them while holding the **[Ctrl]** key (Pic. 18.59).



Pic. 18.59

*EP test parameters.* In this box you can see the parameters of stimulation during test recording and the EP recording conditions for current test (current tests in the list is outlined by a dashed line).

Click “OK” and all the selected EP tests will be displayed.

To delete an EP test select it in the EP test list and click on the “Delete” button. The selected test will be deleted.

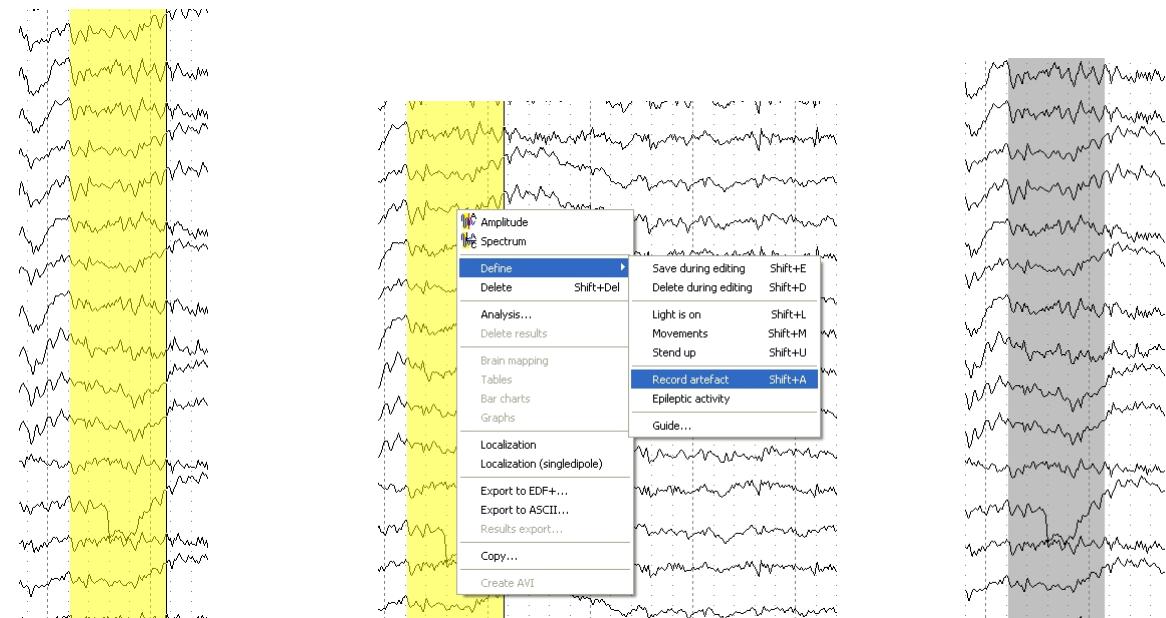
If you select the **EP|Test parameters** menu command, you will see a dialog box with EP test registration parameters corresponding to the current EP type (Pic. 18.1-Pic. 18.11).

8. You can use band-pass filter for EP curves that is similar to EEG curves filtration. Use the **EP|Filtration** menu command for it.

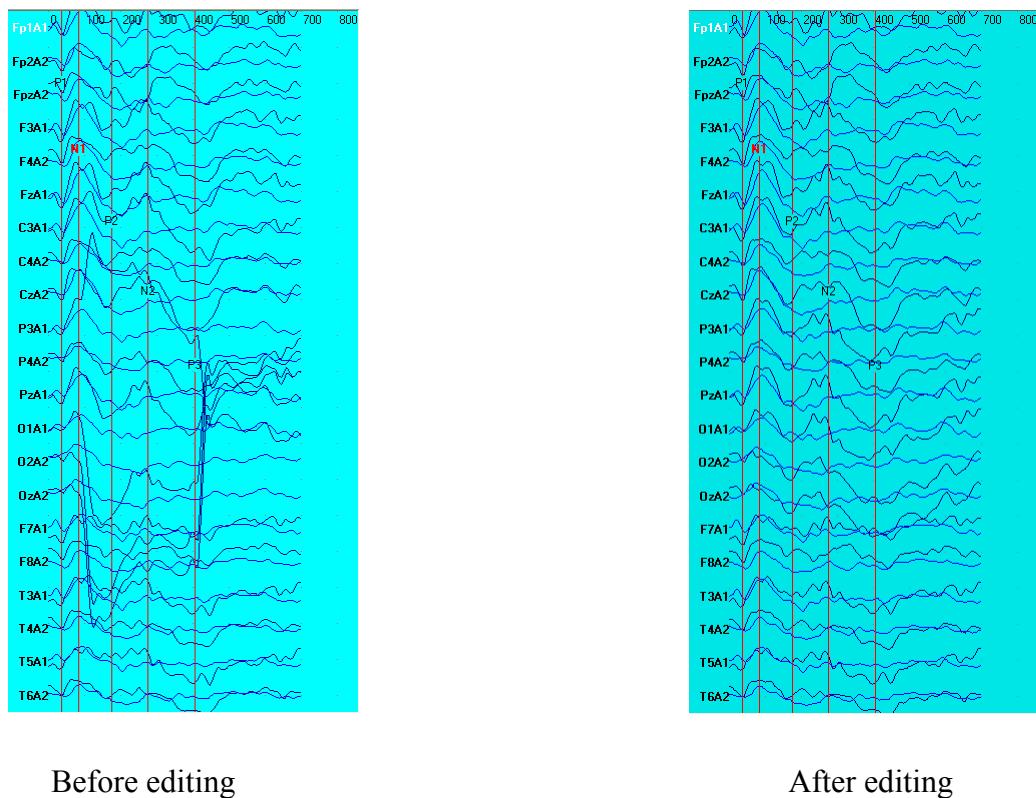
If during EP acquisition the artifacts rejection was turn off, **Neuron-Spectrum** software enables editing of EP curves after recording. To exclude artifacts influence on the EP curve, do the following:

- Mark in series all the artifact EEG fragments (select each as a fragment and define it as an artifact) (Pic. 18.60).

- Use the **EP|Edit** menu command, which enables reaveraging of EP without artifact fragments (Pic. 18.61).



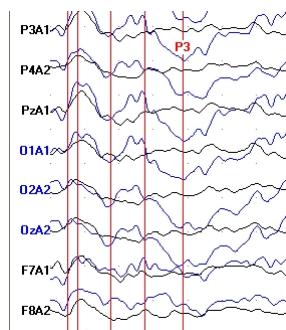
Pic. 18.60



Pic. 18.61

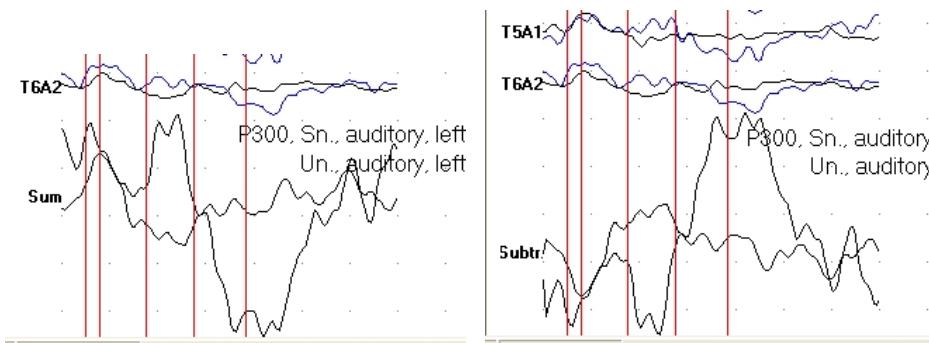
9. To perform a spatial averaging of EP curves, i.e the averaging of the derivations, one can select several derivations and make the curves summation. Thus, you can detect the peaks on the EP curves which can be less notable on a separate curve. To select several derivations, click

each required derivation with the left mouse button, at that hold the [Ctrl] key. The selected curves will be colored, for example, O1, O2 and Oz (Pic. 18.62).



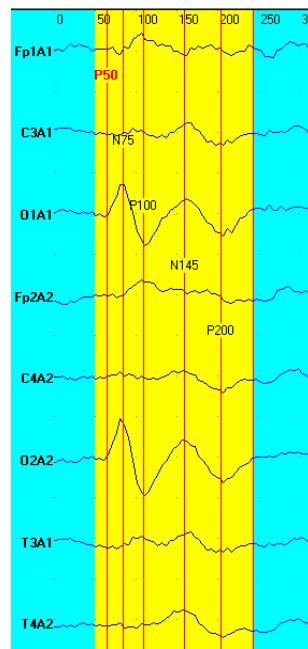
Pic. 18.62

10. If you choose the **EP|Sum** menu command, you can sum up the selected curves and get the accumulation curve on the screen (Pic. 18.63). If you choose the **EP|Difference** menu command, you can subtract the curves and get the difference curve (Pic. 18.63).



Pic. 18.63

11. You can select a fragment on EP curves as well as on EEG curves. To select a fragment press and hold down [Shift] and position mouse cursor at the beginning of the fragment being marked. Press the left mouse button, hold it down, and move the cursor to the end of the fragment. It will be highlighted (Pic. 18.64). Then release mouse button. You can also use the **Fragment|Mark fragment** menu command



Pic. 18.64

To delete the fragment selection use the **Fragment|Delete visir/fragment** menu command. Working with EP fragments is similar to working with EEG fragments.

You can do amplitude and frequency-spectrum analyses of the selected EP fragment as it is done of an EEG fragment.

12. If you have 3-D localization software on your computer, you can transfer curves to the 3-D localization program. Use **EP|Localization** menu command for this purpose.

13. You can look through analysis results of EP amplitudes and latencies for common and individual component markers using the **EP|Analysis window** menu command or the  button on the *Evoked potentials* toolbar.

Analysis results for common markers are presented as amplitude tables (Pic. 18.65) (the amplitudes in the cross points of markers and curves) and brain maps (Pic. 18.66).

Analysis results for individual markers are presented as latencies and amplitude tables (the amplitudes of the components on the curves) (Pic. 18.67). If there are no components on the curve, you see a dash in the corresponding table cell.

## Neuron-Spectrum Program

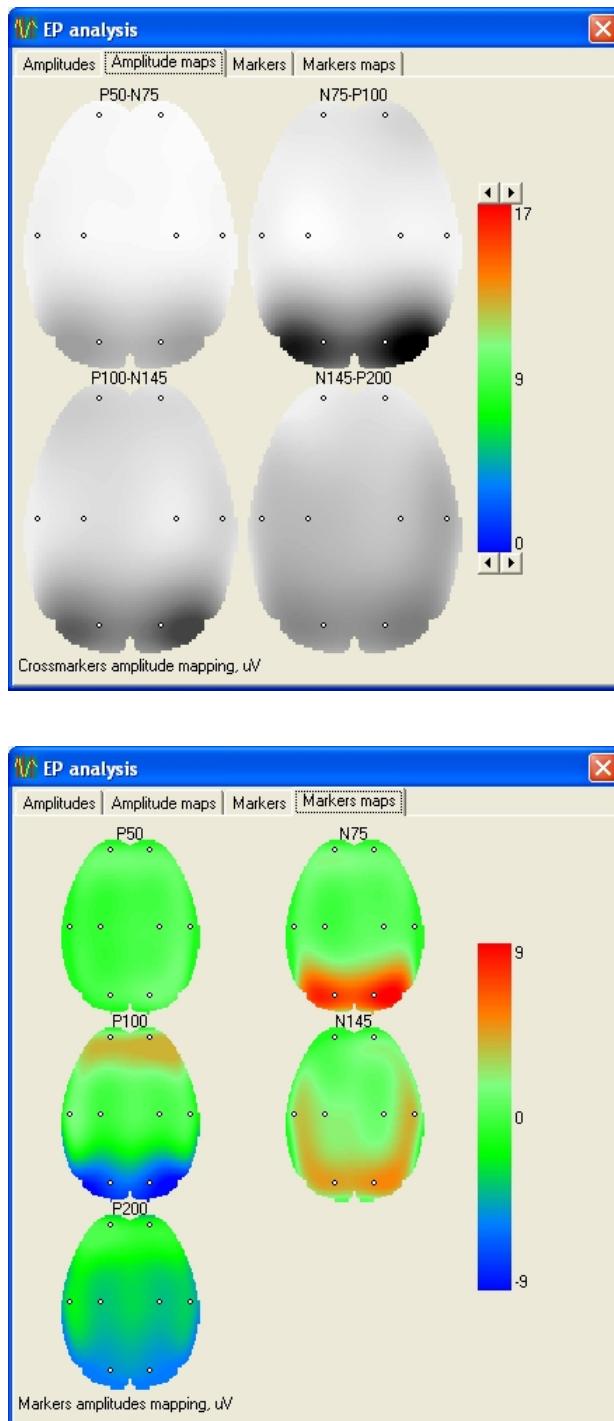
EP analysis					
	Amplitudes	Amplitude maps	Markers	Markers maps	
Drv.	P50	N75	P100	N145	P200
Lat.	64	85	110	160	205
Fp1A1	1	1	3	-1	0
C3A1	-1	0	0	2	-3
O1A1	0	7	-8	4	-5
Fp2A2	0	1	4	1	-1
C4A2	0	1	0	2	-4
O2A2	1	9	-9	5	-6
T3A1	-1	0	1	2	-2
T4A2	0	-1	0	3	-4

Lat. - markers latency, ms  
Markers amplitudes,  $\mu$ V

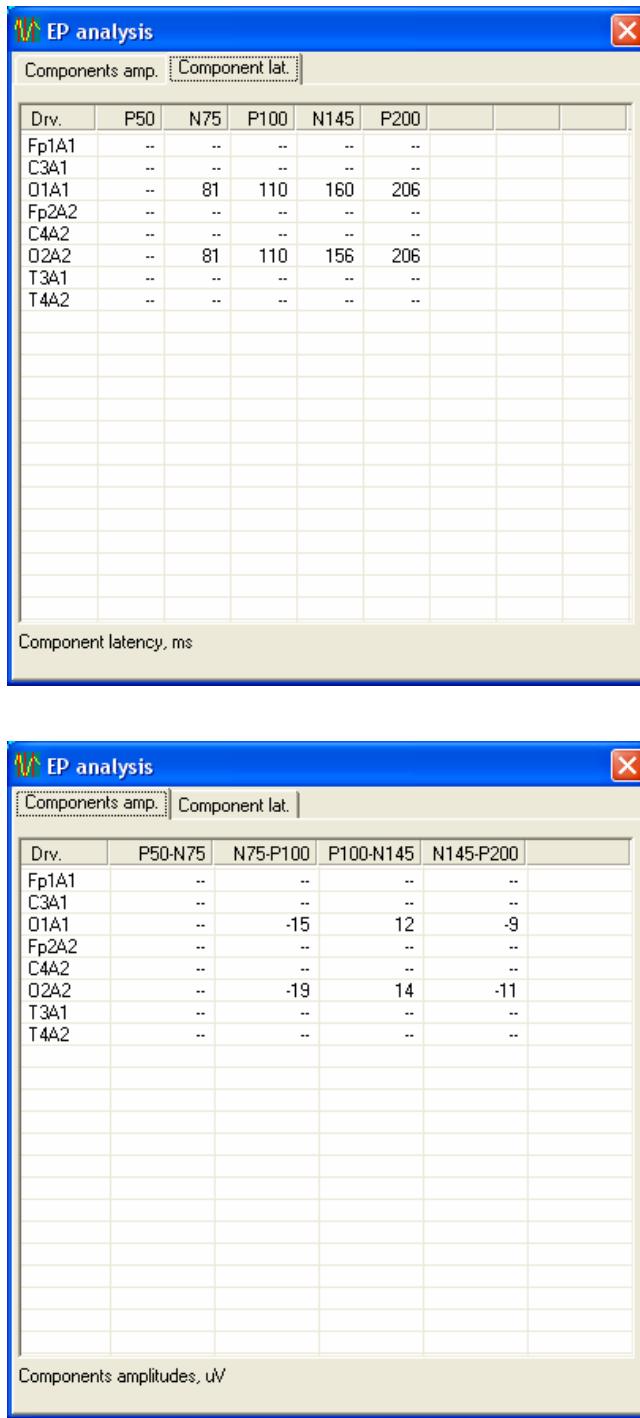
EP analysis					
	Amplitudes	Amplitude maps	Markers	Markers maps	
Drv.	P50-N75	N75-P100	P100-N145	N145-P200	
Przed.	21	25	50	45	
Fp1A1	1	2	4	1	
C3A1	1	0	2	6	
O1A1	8	15	12	9	
Fp2A2	0	3	3	2	
C4A2	0	1	2	5	
O2A2	7	17	14	10	
T3A1	1	1	1	5	
T4A2	1	1	3	7	

Intrv. - crossmarkers intervals, ms  
Crossmarkers amplitudes,  $\mu$ V

Pic. 18.65



Pic. 18.66



The image contains two side-by-side windows titled "EP analysis".

The left window is titled "Component lat." and displays a table of component latencies in milliseconds (ms). The columns represent Drv., P50, N75, P100, N145, and P200. The rows list electrode names: Fp1A1, C3A1, O1A1, Fp2A2, C4A2, O2A2, T3A1, and T4A2. Latencies are shown in milliseconds.

Drv.	P50	N75	P100	N145	P200		
Fp1A1	--	--	--	--	--		
C3A1	--	--	--	--	--		
O1A1	--	81	110	160	206		
Fp2A2	--	--	--	--	--		
C4A2	--	--	--	--	--		
O2A2	--	81	110	156	206		
T3A1	--	--	--	--	--		
T4A2	--	--	--	--	--		

The right window is titled "Components amp." and displays a table of component amplitudes in microvolts (uV). The columns represent P50-N75, N75-P100, P100-N145, and N145-P200. The rows list electrode names: Fp1A1, C3A1, O1A1, Fp2A2, C4A2, O2A2, T3A1, and T4A2. Amplitudes are shown in microvolts.

Drv.	P50-N75	N75-P100	P100-N145	N145-P200		
Fp1A1	--	--	--	--		
C3A1	--	--	--	--		
O1A1	--	-15	12	-9		
Fp2A2	--	--	--	--		
C4A2	--	--	--	--		
O2A2	--	-19	14	-11		
T3A1	--	--	--	--		
T4A2	--	--	--	--		

Pic. 18.67

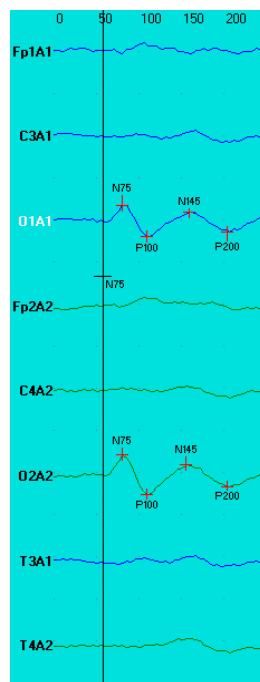
14. You can copy EP curves and EP analysis results (tables and brain maps) to a report or clipboard using the **EP|Copy** menu command. Using of this command was described in the main part of this manual.

15. To set individual components on EP curves first of all make the common components invisible and the individual ones – visible. Use **EP|Component markers|Hide/show** for this purpose. Then click with right mouse button on the EP panel. The properties menu will be displayed, in the upper part of the menu there will be the list of EP components registered during (Pic. 18.68).



Pic. 18.68

To set a component select it on the menu, highlight it and press the left mouse button. The cursor is changed to a vertical line (Pic. 18.69).



Pic. 18.69

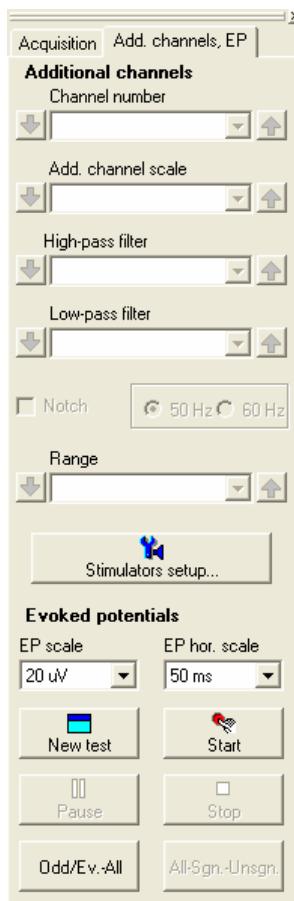
Moving the mouse horizontally, you move the vertical bar left and right. Moving the mouse vertically, you move the dagger vertically. Position the cursor dagger on the required point and press the left mouse button. On this point of the curve the selected component will be set. If you hold the [Alt] button down, the name of the component will not be changed after setting and then you will set the same component on the other curve. If not, the name of the component will be changed to the next one in the list and you will set another component. First method is convenient for setting the same component to different curves and the second – for setting different components to one curve.

To finish components markers setting press the right mouse button and select the **Reset** menu command. The cursor will be changed to the arrow form again.

You can move individual component markers along the curve or the component marker name vertically by clicking on it with the left mouse button and dragging it to the required position without releasing the left mouse button.

### 18.7. EEG AND EP RECORD PANEL

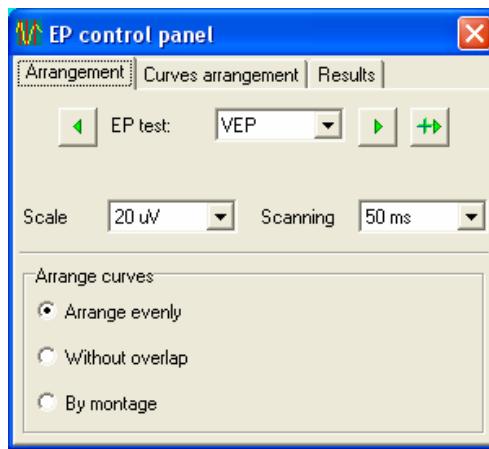
1. During EP acquisition you can use EEG and EP registration panel described in early. To show or hide it you can use **View|EEG record panel** or **[Ctrl+R]** key combination. EP curves scales setup combo boxes, buttons of EP registration mode control are on the page **Add. channels, EP** (Pic. 18.70).



Pic. 18.70

## 18.8. EP CONTROL PANEL

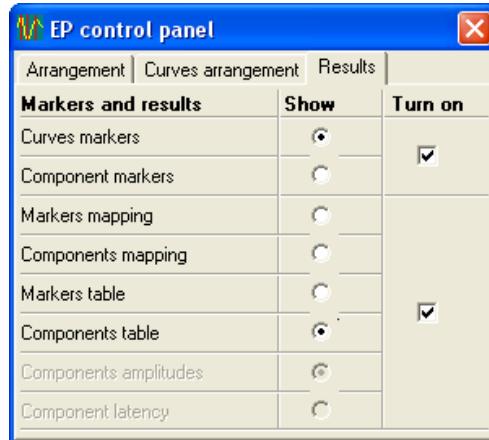
1. To simplify EP curves and EP analysis results control you can use *EP control panel*. You can show or hide the panel on the screen using **EP|EP control panel** or **[Ctrl+C]** key combination. To display *EP control panel* automatically on examination opening, you should set the check box *Control panel* in **EEG view and analysis** dialog box on the *Scales* page.
2. The control panel has the following pages: *Arrangement* (Pic. 18.71), *Curves Arrangement* (Pic. 18.72), *Results* (Pic. 18.73).



Pic. 18.71

Curve type	Color	Show	<input type="checkbox"/> Select
Total	■ ■	<input checked="" type="checkbox"/>	<input type="radio"/>
Even	■ ■	<input type="checkbox"/>	<input type="radio"/>
Odd	■ ■	<input type="checkbox"/>	<input type="radio"/>
Significant	■ ■	<input checked="" type="checkbox"/>	<input type="radio"/>
Unsignificant	■ ■	<input checked="" type="checkbox"/>	<input type="radio"/>
Difference	■ ■	<input type="checkbox"/>	<input type="radio"/>

Pic. 18.72



Pic. 18.73

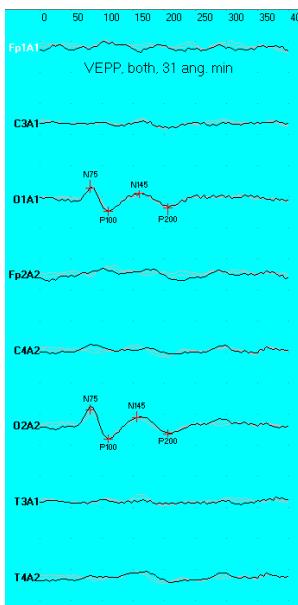
3. Using the *Arrangement* page (Pic. 18.71) you can:

- to select EP test displayed on the screen in *EP test* combo box;
- to navigate on recorded EP tests using the buttons and
- to change vertical and horizontal scales of EP curves using *Scale*, *Scanning* combo boxes;
- to change EP curves arrangement on the screen using *Arrange curves* radio buttons.

4. You can control visibility and extraction of the each type of curves on the *Curves arrangement* page (Pic. 18.72).

In the **Show** column with the help of check boxes you can select the curves type are shown on the screen. For example, it is possible to show even or odd curves only, which is not possible with the rest menu commands.

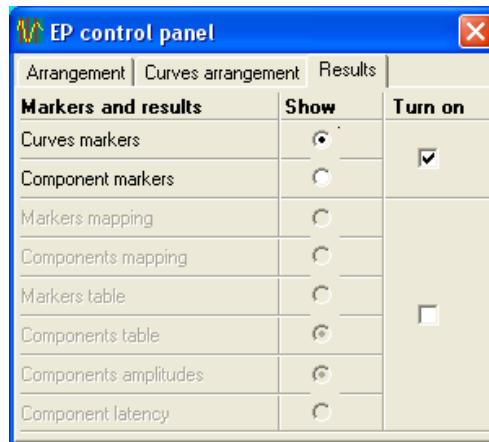
If you select the radio button in the **Select** column, you can choose the curve that will be marked by the color against the background of others (Pic. 18.74).



Pic. 18.74

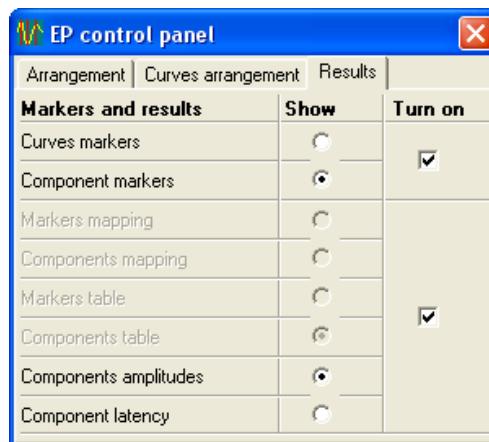
5. The *Results* page (Pic. 18.73) enables:

- To control component markers show/hide (common as well as individual) with the help of the check boxes in the **Turn on** column and the radio buttons in the **Show** column. For example to show common component markers, check the check box in the **Turn on** column and select the radio button *Curves markers* in the **Show** column (Pic. 18.75).



Pic. 18.75

- To control EP analysis results pages show/hide (on common markers as well as individual ones) by the check box in the **Turn on** column and radio buttons in the **Show** column. For example, to show individual components amplitudes table, check the check box in the **Turn on** column and select *Component amplitude* radio button in the **Show** column. The visibility of individual component markers should be turn on (Pic. 18.76).



Pic. 18.76

# **CHAPTER 19**

## **NEURON-SPECTRUM-VIDEO VIDEO EEG SOFTWARE**



### 19.1. BASIC INFORMATION

**Neuron-Spectrum-Video** is video-EEG monitoring system which enables simultaneous EEG video recording via one or two (connected to a computer) camera-recorders and recording of one or two audio channels (sound channels).

You can save video records together with EEG records in the database and view them synchronously with EEG review. Each EEG sample corresponds to a video frame (if the video recording took place at the moment). And vice versa, each video frame has a corresponding EEG sample.

While recording both the events defined before and the events being defined during the recording can be marked.

Video recording can be performed by fragments; thus, not every EEG fragment will have a corresponding video image.

You can edit a video record by deleting video fragments and EEG fragments being of no importance.

The edited video-EEG record can be written to a compact disc (CD or DVD) along with the program which sets a special view program on the computer, reads the recorded video-EEG and starts the viewer program for reviewing this video-EEG record automatically when you insert the disc into a disc drive of any computer.

Any fragment with both EEG- and video recording can be converted to multimedia AVI-file and viewed on any computer by means of **Windows Media™** player.

If you have the special equipment (a computer video card with video output, a video cassette recorder – VCR), it is possible to record a simultaneous playback of video record and EEG from the computer monitor to a videocassette.

## **19.2. NEURON-SPECTRUM-VIDEO SYSTEM CONNECTION**

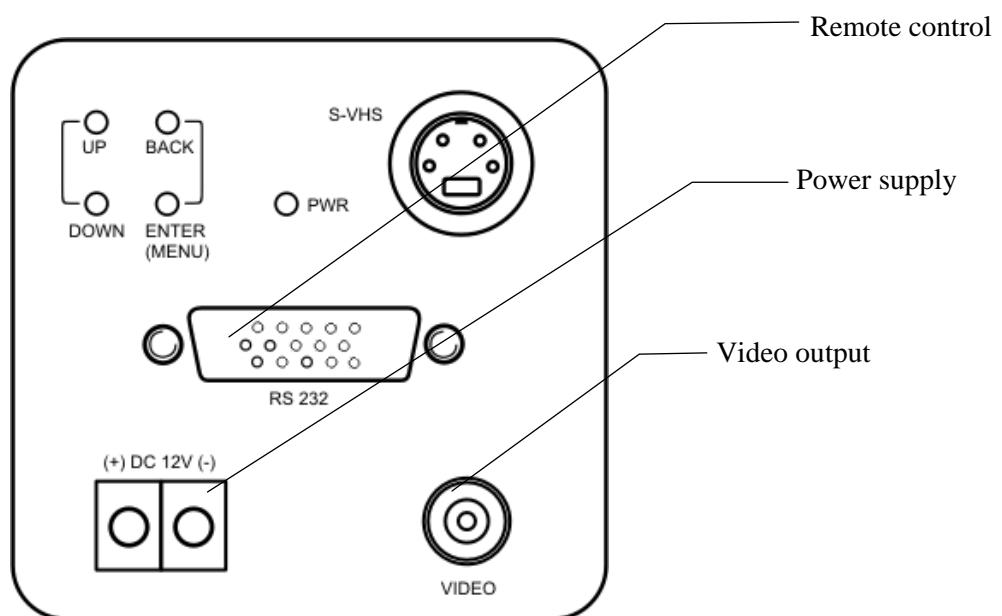
### **19.2.1. TYPES OF VIDEO CAMERAS USED WITH NEURON-SPECTRUM-VIDEO SYSTEM**

1. Color video camera with the possibility of zoom lens remote control by means of wired remote control (Pic. 19.1) comes with the standard delivery set of **Neuron-Spectrum-Video** system.

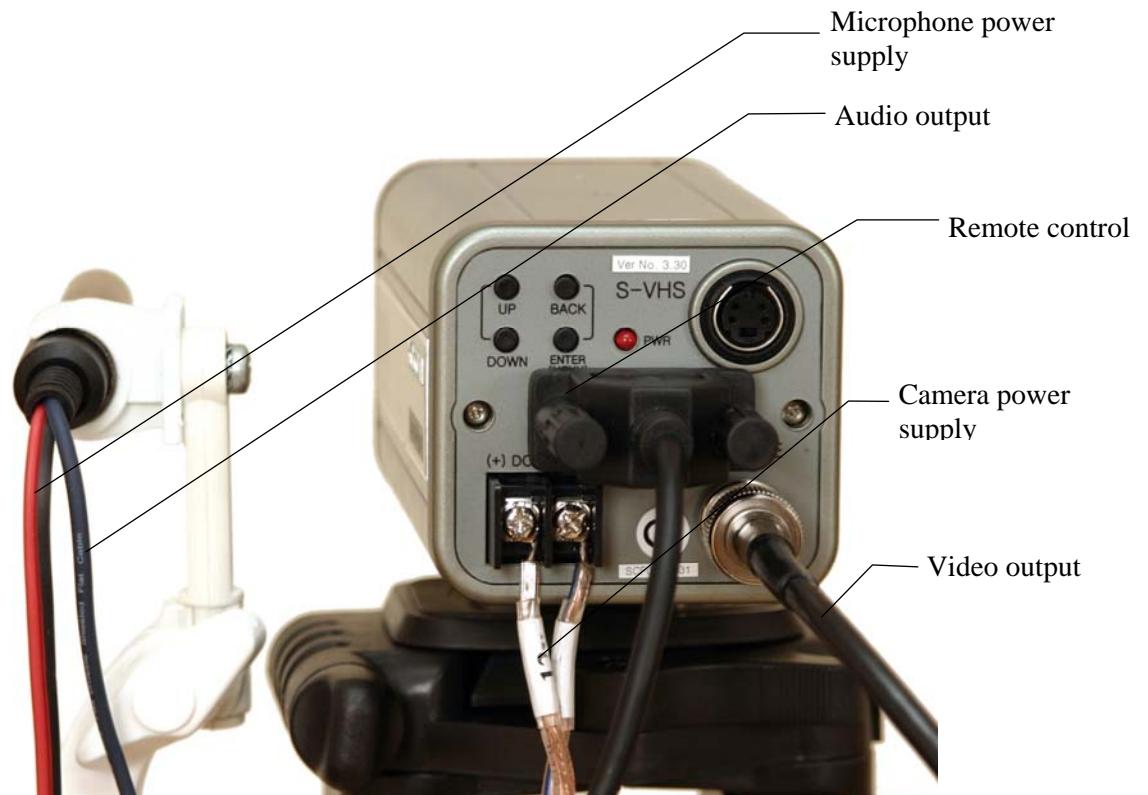


Pic. 19.1

The connection of all the cables is made on the rear panel of the camera, which approximate view is shown on Pic. 19.2. The example of connection is shown on Pic. 19.3.



Pic. 19.2



Pic. 19.3

Usually the following cables are connected to the camera:

- video cable to the analog video output; at that composite output is usually used but you can also use S-Video output;
- camera power cable; camera power supply is usually under 12 V;
- wired remote control cable, if there is a possibility to control the camera by means of the wired remote control;
- computer control cable, if there is a possibility to control the camera via computer.

2. Besides the abovementioned camera with **Neuron-Spectrum-Video** system the following types of cameras can be delivered:

- Black and white video camera without possibility of adjustment (Pic. 19.4).



Pic. 19.4

## Neuron-Spectrum Program

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The schematic of the video cable and power cable connection to the camera is shown on Pic. 19.5.



Black and white video camera

Pic. 19.5

- Black and white video camera with special sensitive lens for night video monitoring and possibility of optical zoom manual adjustment (Pic. 19.6).



Pic. 19.6

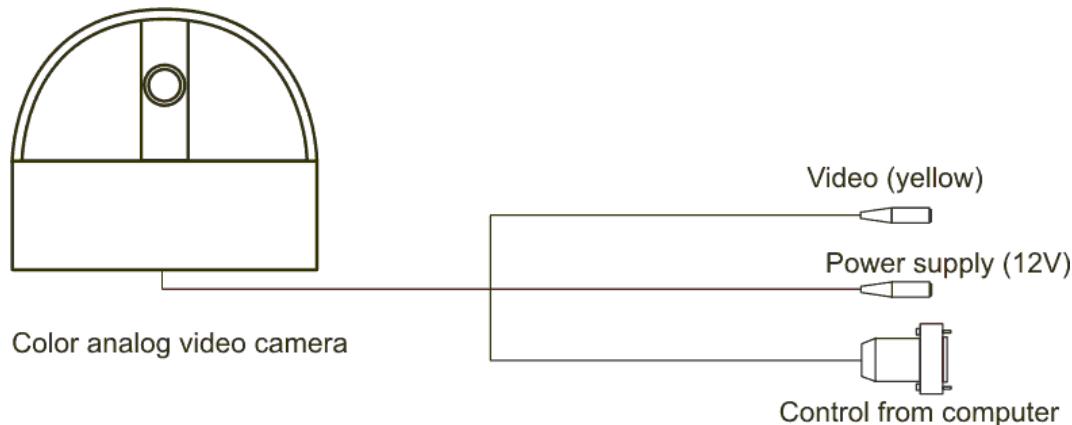
Video cable and power cable are connected to the camera similarly to the previous type of camera.

- Domical color analog video camera with possibility of position remote control via IR or computer (Pic. 19.7).



Pic. 19.7

The schematic of video cable, power cable and computer control cable connection to the camera is shown on Pic. 19.8.



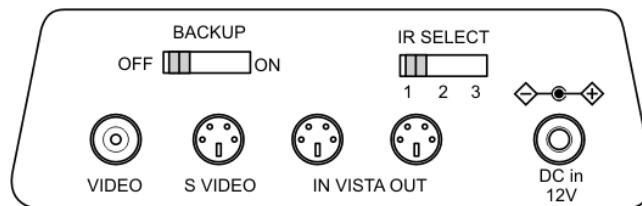
Pic. 19.8

- Color video camera with possibility of zoom and camera position remote control via computer or wireless remote control (Pic. 19.9). You can store 6 (six) presets of position and zoom in the camera memory and then during the process of recording you can switch the camera to the position you need with only one key press.

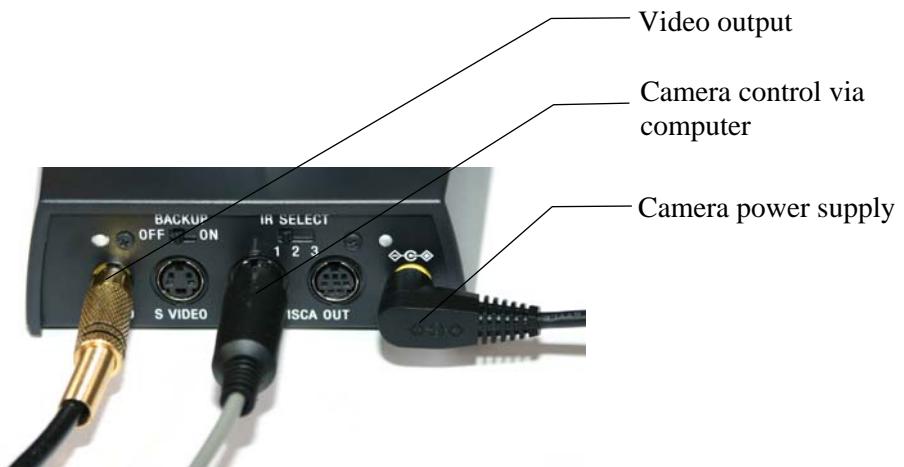


Pic. 19.9

The layout of the rear panel of the camera is shown on Pic. 19.10, the example of cable connection to the camera is shown on Pic. 19.11.



Pic. 19.10



Pic. 19.11

For video recording you can also use a simple digital web-camera connected to a computer's USB-port. But the timing accuracy while using such a camera will be lower.

3. To record a patient's audio channel sensitive microphones are used (Pic. 19.12) as a rule. The microphone output is usually connected to the microphone input of the computer's sound card. For audio signal recording a sound card in your computer is required.



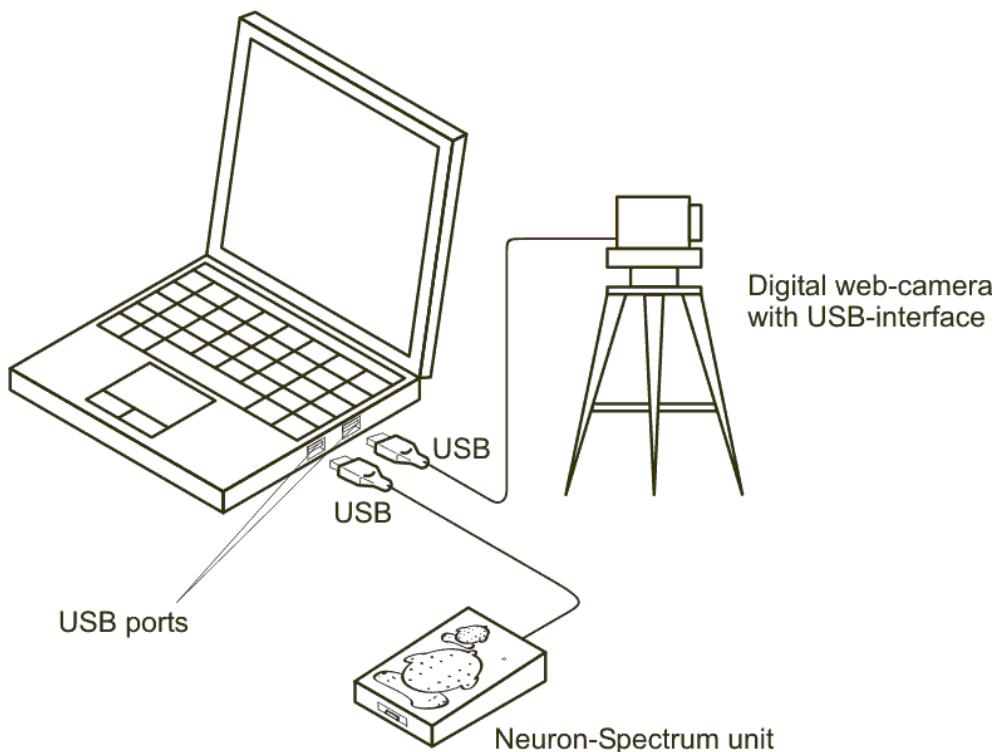
Pic. 19.12

The video cameras can be placed on holders. For that purpose on the bottom side of the cameras there is a thread hole for screwing on the holder base. If there is a possibility to control zoom and camera position via computer such a camera can be placed on special shelves which are fixed to a wall. If such a fully controlled camera has domical shape (is not shown on the pictures above) it can be fixed to the ceiling.

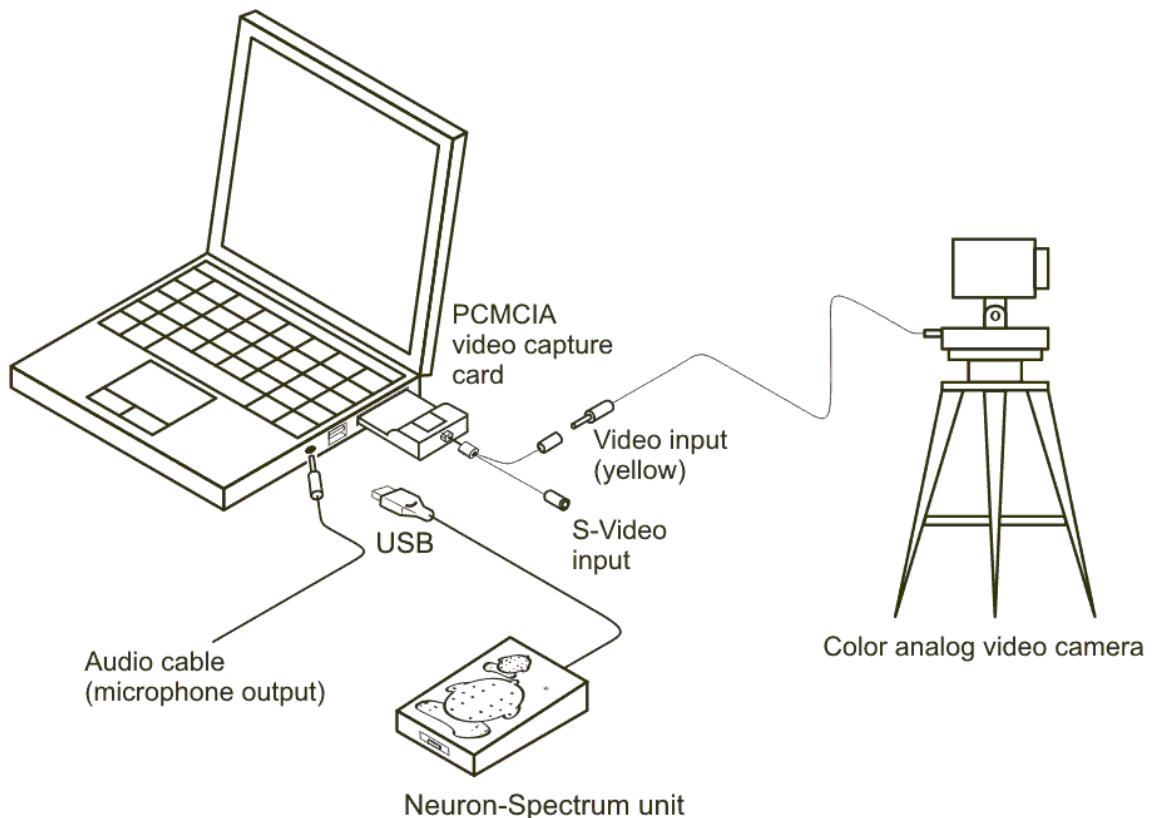
### 19.2.2. CONNECTION OF NEURON-SPECTRUM-VIDEO TO NOTEBOOK PC

1. To enter video recording from analog video camera into computer, the special devices called “video capture devices” are used. They take analog video signal from video camera, convert it to digital one and enter it into computer. Such devices are usually expansion boards inserted into desktop PC, PCMCIA cards for notebook PC or blocks with USB interface. Among these devices we recommend you to use expansion boards for desktop PC or PCMCIA cards for notebook PC.

2. While connecting **Neuron-Spectrum-Video** to notebook PC it is possible to use video capture blocks connected via USB or PCMCIA interfaces. The schematic of **Neuron-Spectrum-Video** connection to notebook PC using a simple digital web-camera with USB interface is shown on Pic. 19.13. The schematic of **Neuron-Spectrum-Video** connection to notebook PC using analog video camera and PCMCIA video capture card is shown on Pic. 19.14.



Pic. 19.13



Pic. 19.14

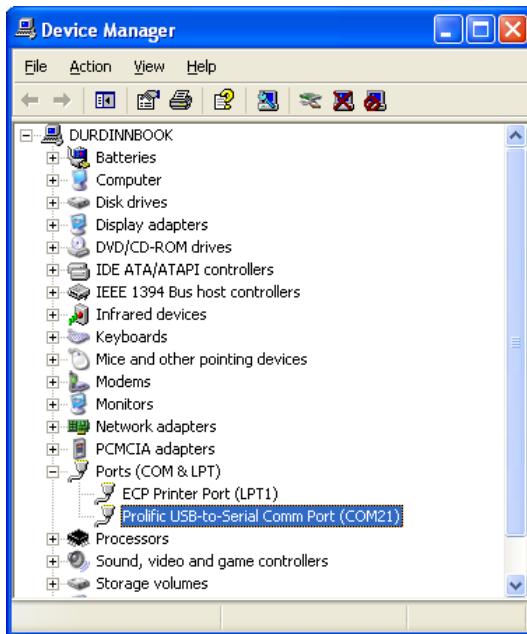
3. To connect a digital web-camera:

- Install the drivers included in the camera delivery set on your notebook PC.
- Connect the camera to a free USB port.
- After completion of the identification procedure and setting the camera on the computer you can run **Neuron-Spectrum-Video** program and begin working with the system having made the set up procedure in advance (see next chapter).

4. To connect analog video camera:

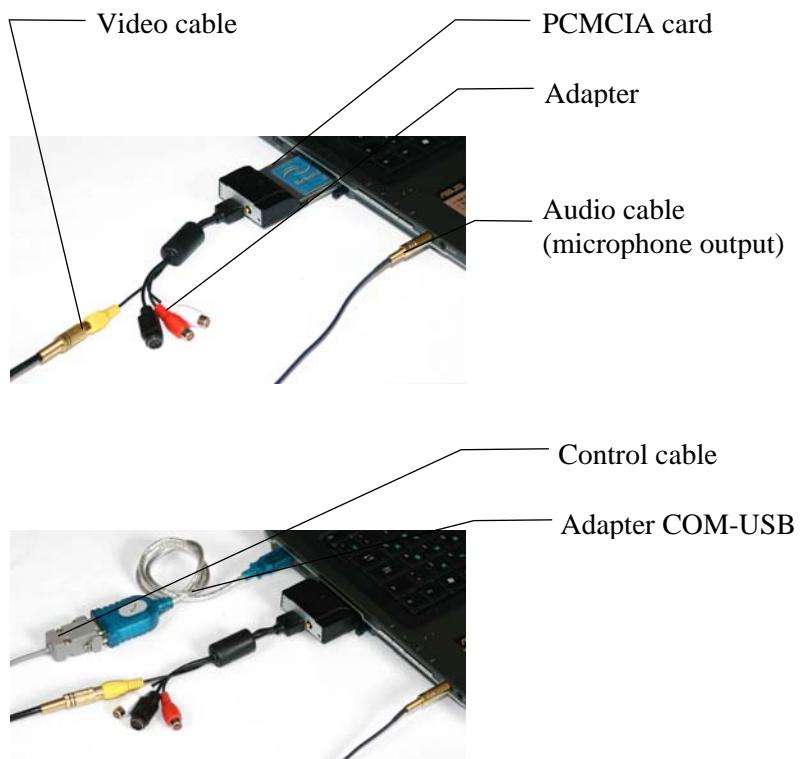
- Install PCMCIA drivers for video capture card included in the card delivery set on your notebook PC.
  - Insert PCMCIA card into the corresponding slot. After completion of the identification procedure and setting the card on the computer connect the equipment. Be sure to connect a special adapter to PCMCIA card included in the delivery set in advance. Connect the video cable (analog camera video output) to a yellow slot of the adapter.
  - If a microphone is used in the system, connect audio output of the microphone to a microphone input slot of the Notebook PC.
  - Connect the power unit of the video camera and, if necessary, the power unit of the microphone to the mains supply.
  - If there is a possibility to control video camera via computer, connect the control cable to a serial port (if it is available on your notebook) or, via adapter COM-USB, to a free USB port on your notebook PC.

Write down the serial port number which was assigned for adapter COM-USB by the system. You will need it during system setup. You can find a number of COM-port in the system dialog box **System properties** on the bookmark *Hardware* by pressing “*Device Manager*” button (Pic. 19.15). The box will appear on the screen if you right-click **My Computer** and select **Properties** menu command.



Pic. 19.15

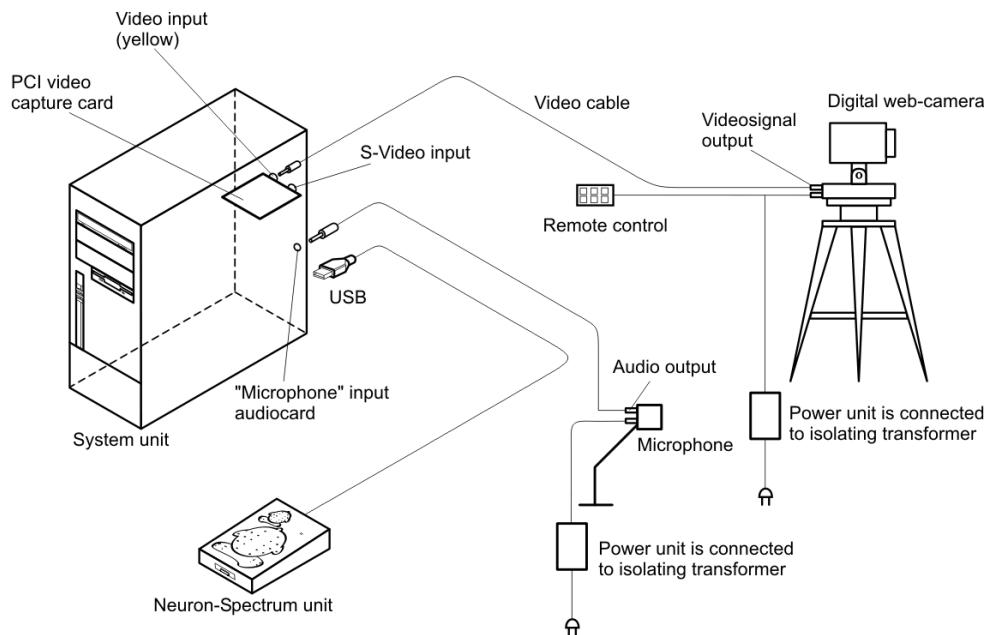
**Neuron-Spectrum-Video** system is ready for work (Pic. 19.16).



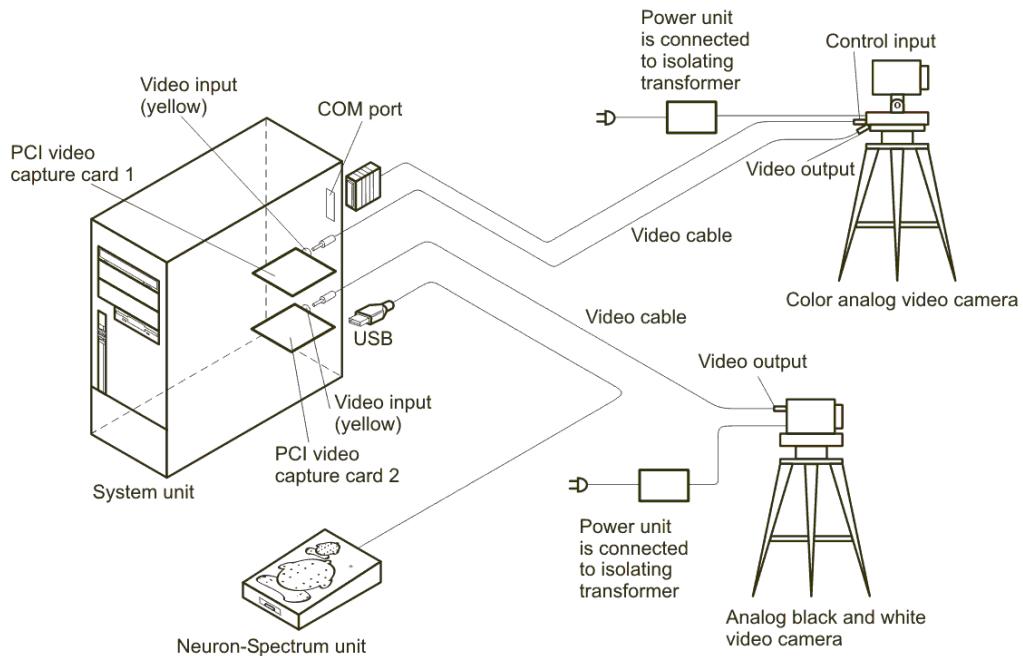
Pic. 19.16

### 19.2.3. CONNECTION OF NEURON-SPECTRUM-VIDEO TO DESKTOP PC

1. To connect video cameras to a desktop PC you would better use video PCI capture cards mounted into computer. In that case you can connect either one video camera (Pic. 19.17) or two of them (Pic. 19.18).



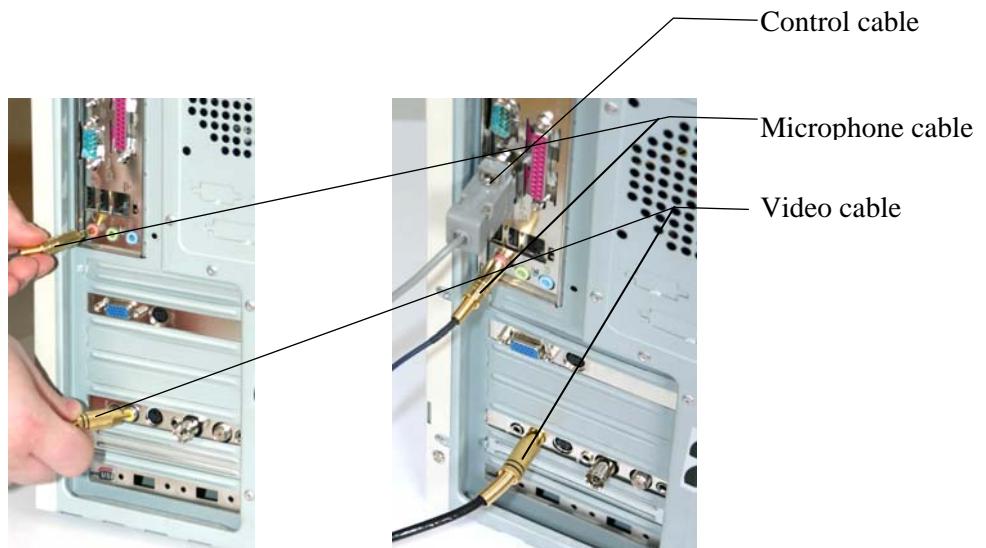
Pic. 19.17



Pic. 19.18

2. The connection is made in the following order:

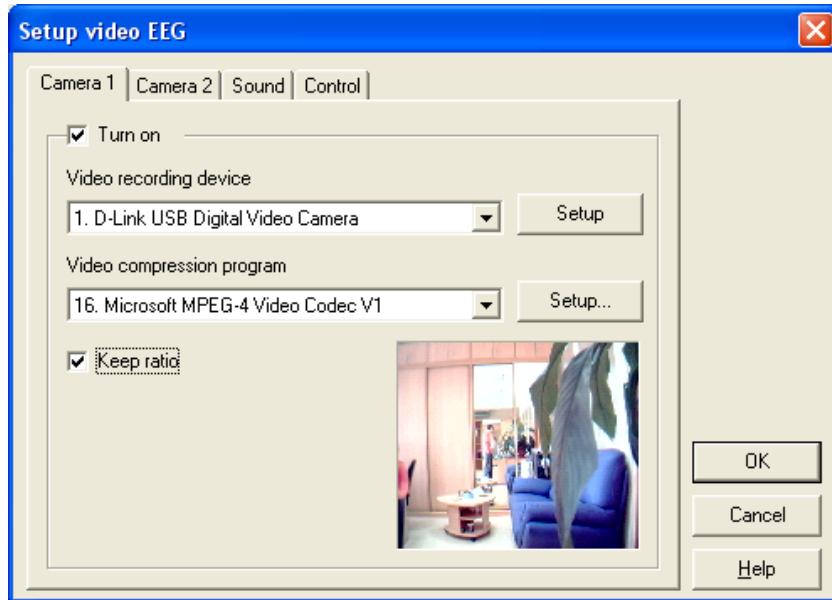
- Install one or two video capture cards into the system unit of your computer.
- Install the drivers for video capture cards included in the delivery set.
- Connect the video cable from analog video output of the camera to a yellow video input on the video capture card. If two video cameras are used in the system, connect the video cable from the second camera to a yellow video input of the second video capture card.
- If a microphone is used in the system, connect the audio cable from the microphone to the microphone (pink) input of the computer's sound card.
- If there is a possibility to control video camera via computer, connect the control cable to a serial port of the computer. Write down the serial port number. You will need it during setup of **Neuron-Spectrum-Video** system.
- Connect the power units of the video cameras and, if necessary, the power unit of the microphone to the mains supply.
- Place the video cameras in the recording room where necessary. **Neuron-Spectrum-Video** system is ready for work (Pic. 19.19).



Pic. 19.19

### **19.3. VIDEO-EEG PARAMETERS SETUP**

1. To set up video-EEG parameters and parameters of video recorders use the **Setup|Video-EEG** menu command. The **Setup video EEG** dialog box will appear on the screen (Pic. 19.20).



Pic. 19.20

The *Camera 1* and *Camera 2* pages enable setting up of the parameters of each camera-recorder. *Turn On* check box indicates whether a camera-recorder is used in the software or not.

*Video recording device* combo box enables selecting of the camera-recorder type. If one camera is used, usually there is one line in the list. If two cameras are used, select different lines for each page to equip both cameras into the work.

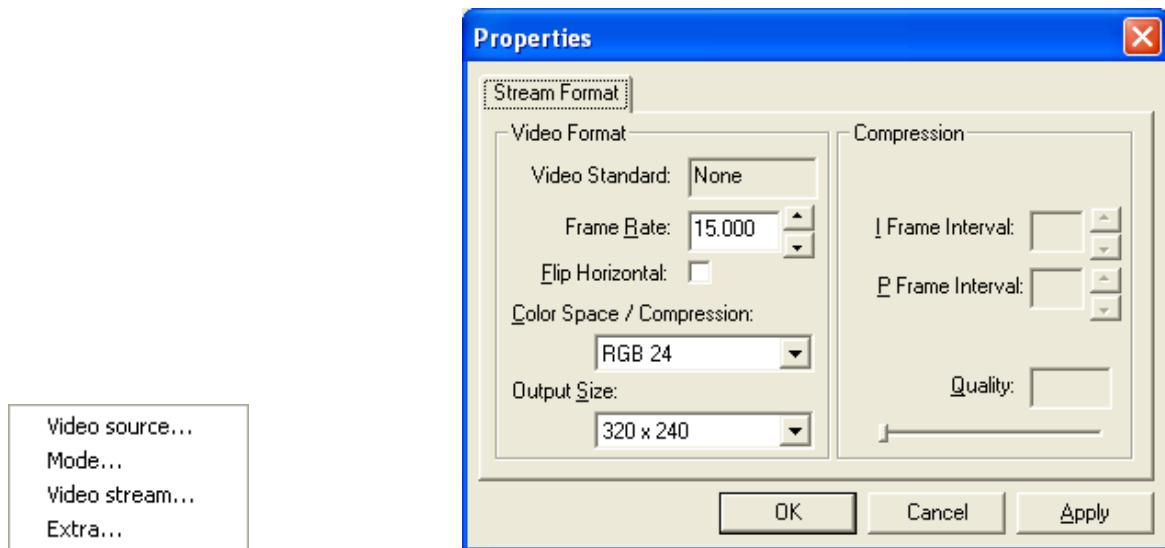
*Video compression program* combo box enables selecting of the video record compression. As a rule there are several video compression programs on the computer. Select one of those having **MPEG4** (We recommend to use *Microsoft MPEG-4 Video Codec V1* or *Microsoft MPEG-4 Video Codec V2 for Windows XP* and *Microsoft MPEG-4 Video Codec V3 for Windows Vista*).

*Setup* buttons next to the combo boxes are active only if the appropriate camera-recorder is turning on – working (see below). These buttons enable you to adjust the parameters of the camera and the compression program depending on the camera or program type selected.

To keep the right video picture aspect ratio at any video registration window size changes, you should check *Keep ratio* check box.

In the bottom part of the dialog box you can see the picture from the selected video camera. You can tune the image picture using *Setup* buttons.

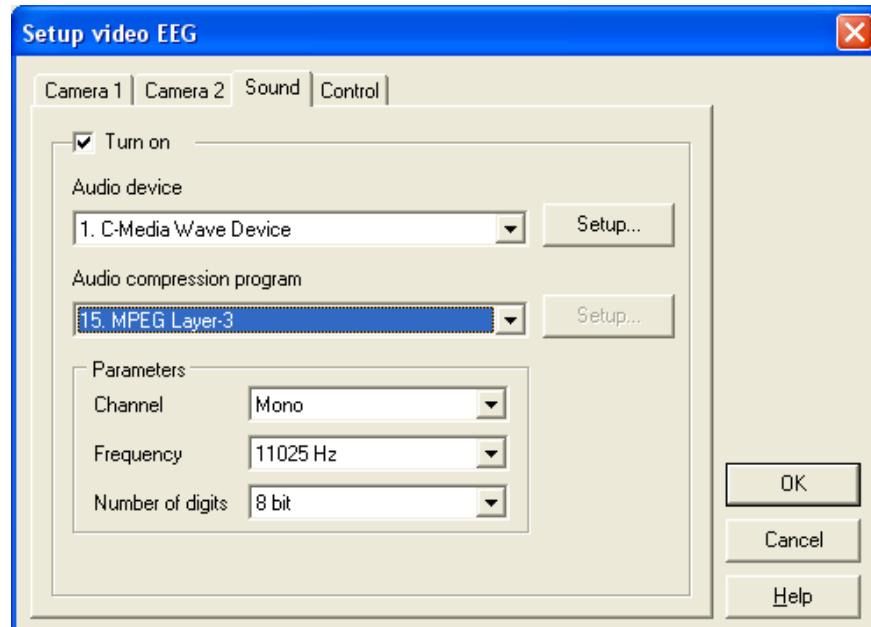
We recommend you to limit the frame frequency if your computer is of low capacity or if you want to decrease the size of the video-EEG records archive. To follow this recommendation, turn on the camera-recorder and click on the *Setup* button next to the *Video recording device* combo box of the **Setup video EEG** dialog box. Select *Video stream* in the dropdown menu. Set the frame rate for the camera-recorder in the dialog box appeared (Pic. 19.21).



Pic. 19.21

If there is no picture on the turn on camera, select PAL-D mode in video camera setup (**Mode** command menu).

2. The *Sound* page (Pic. 19.22) enables setting of the sound channel parameters.



Pic. 19.22

*Turn on* check box indicates whether the sound channel is used in the program.  
*Audio device* combo box enables selecting of the sound recorder.

## Neuron-Spectrum Program

Audio compression program combo box enables selecting of the audio signal compression program (We recommend to use *MPEG-Layer-3* for Windows XP and Microsoft ADPCM for Windows Vista).

You can select either monophonic or stereophonic channel of the audio-recorder in the *Channel* combo box.

You can select the frequency of audio signal sampling rate in the *Frequency* combo box.

You can select the digit capacity of audio signal form in the *Number of digits* combo box.

The “Setup” buttons next to the combo boxes *Audio device* and *Audio compression program* are active only if the video recording mode is activated (see below). These buttons enable you to adjust the parameters of the audio-recorder and the audio-compression program depending on the type of the recorder and program selected.

To record the sound we recommend you to use the audio compression program (codec) *MPEG Layer-3*. The recommended parameters of the sound recording: *Channel* – mono, *Frequency* – 11025 Hz, *Number of digits* – 16 bit.

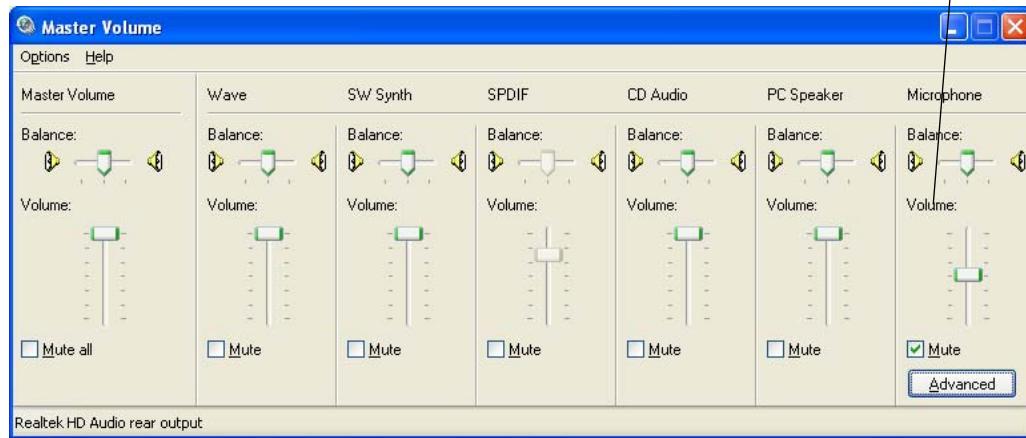
After switching the image picture you can readjust the volume level. For that purpose double-click **Volume**  on the taskbar (Pic. 19.23). Set the microphone volume in the appeared dialog window (Pic. 19.24).

If there is loud noise in your phones, press *Setup* button. Remove the check against *MicBoost* checkbox in the dialog box of the advanced controls for microphone (Pic. 19.25).



Pic. 19.23

Microphone volume control

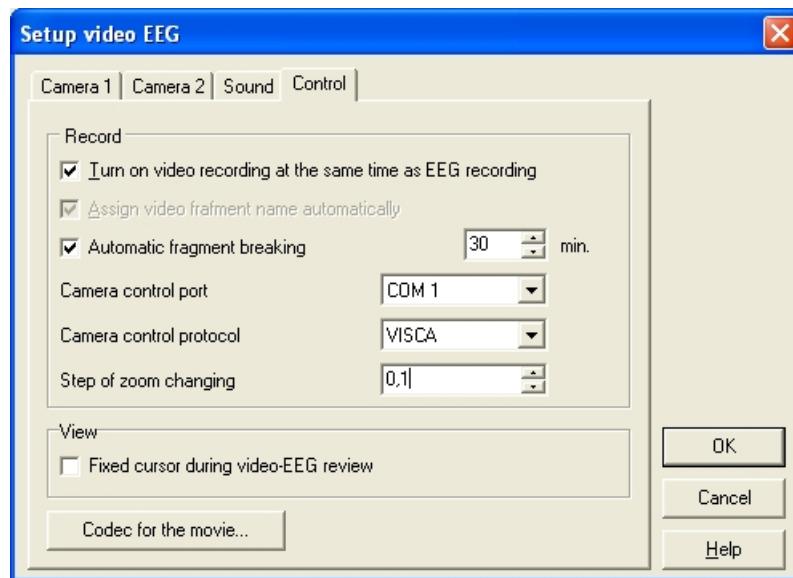


Pic. 19.24



Pic. 19.25

3. The *Control* page (Pic. 19.26) enables you to set the parameters of video-EEG recording mode and some parameters of video-EEG review mode.



Pic. 19.26

If the *Turn on video recording at the same time as EEG recording* check box is checked, video signal recording starts together with EEG-recording. If the check box is unchecked, they start independently.

If the *Assign video fragment name automatically* check box is checked, the name of a new video fragment is set automatically. It saves time preventing you from entering of the video fragment name during recording.

If the *Automatic fragment breaking* check box is checked, video record is automatically divided into fragments of the length set in the edit line. It is recommended to use video record fragmentation. It increases the accuracy of video picture synchronization with EEG.

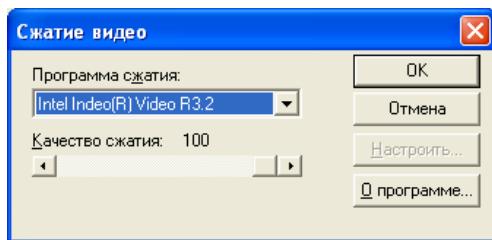
*Camera control port.* If you use a video camera with a possibility to control some of its parameters via computer (such as position or zoom) then, in this field, enter the number of a serial port to which the control cable is connected. If there is no possibility to control the abovementioned parameters of the camera via computer, this field is not used. If there are no serial ports on your computer (for example, a modern notebook PC is used) COM-USB adapter is used to connect the control cable (it is connected to an open USB port via this adapter). At that, in the list of system devices of the computer, you can find the number of a serial port assigned by the system to a connected COM-USB adapter (Pic. 19.15).

*Camera control protocol.* You can set the camera control protocol if there is a possibility to control the camera parameters via computer. If any control protocol is selected the camera control window is displayed on the screen automatically while switching the video window. *VISCA* protocol is supported by SONY cameras, *PELCO D* protocol is supported by domical cameras.

*Step of zoom changing.* **Neuron-Spectrum-Video** program permits to perform digital scaling of a video image in video window. In this field the step of zooming should be entered when zoom is in or out. The minimal step value is 0.1.

*Fixed cursor during video-EEG review* determines the method of synchronization of video image and EEG during video-EEG review. If the check box is checked, the fixed synchronizing cursor is located in the center of the screen and fixes the current position of EEG with respect to video image. While watching “video film” the cursor remains motionless and EEG moves leftward relative to the cursor. If the mark against the check box is removed, the synchronizing cursor moves along the still EEG while watching “video film”. On the border of the screen EEG moves leftward on one page.

*Codec for the video film.* It allows choosing the codec to be used for the video film preparation in AVI format. When you choose a codec, pay attention, that this codec should be installed on the computer to play an AVI file on it. That is why it is better to choose the standard codec. If you press the button, the dialog box for the codec selection will appear on the screen (Pic. 19.27).



Pic. 19.27

Choose a codec in a *Compression program* combo box and specify the compression quality. Pay attention that the quality increase enlarges the time of the video film generation and vice versa.

4. **Neuron-Spectrum-Video** system is delivered with a video capture card. Install the drivers for this card from CD which comes with each card.

If there is not enough computer power while working with video it is recommended to decrease the number of frames per second (videobitrate) or a frame size. For this purpose, turn on the camera and use the **Video-EEG|On** menu command; select Properties menu by clicking right mouse button on the picture and select the **Video stream** menu command.

If there is no picture – check camera connection. For this purpose turn on the camera and select in Properties menu **Video source** command. In the appeared dialog box select *Composite in* video source.

If there is no picture in the camera window or loud noise it is recommended to check the selected camera mode. For this purpose turn on the camera and select Properties menu and use **Mode** command to install *PAL\_D* mode.

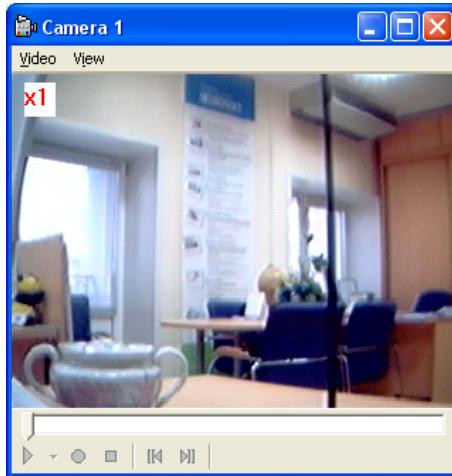
## **19.4. VIDEO-EEG RECORDING**

1. To start EEG and video recording turn on the EEG recording mode. The **Video EEG** menu item will appear in the main menu (Pic. 19.28).



Pic. 19.28

2. Select the **Video EEG|On** menu command to turn on camera-recorders. One or two windows of video registration will appear on the screen according to the number of connected camera-recorders (Pic. 19.29). Information from the camera-recorders is displayed in the windows.



Pic. 19.29

3. One of the video registration windows contains the menu and the toolbar with buttons for video registration and video playback control. It duplicates the **Video EEG** menu (Pic. 19.28) of the EEG recording, review and analysis window.

The video window can operate in two modes:

- the video recording mode;
- the video playback mode.

4. The video recording mode is set automatically for a new checkup.

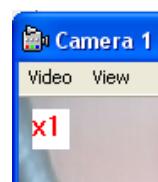
5. Together with one or two video windows the camera control window (Pic. 19.30) appears on the screen. If a connected camera can be controlled via computer this window will allow you to control optical zoom (“+” and “-” buttons) and position of the camera (arrow buttons). If the camera has a possibility of zoom and position memorizing and then, during the process of recording, you can switch it to the state you need with only one key stroke, the numerical buttons “1” – “6” and also “*Home*” and “*Rec*” buttons are used. To memorize the set state first press “*Rec*” button and then one of the numerical buttons “1” – “6”. The current state will be assigned to the selected numerical button. If you press one of the numerical buttons during the process of recording the camera will set the state (optical zoom and position) assigned to this button. “*Home*” button is reserved for the initial camera position (when you turn the camera on).

If there is no possibility to control the camera via computer, the control window is used for digital zooming (“+” and “-” buttons) and for picture movement in the video window (arrow buttons). You can zoom in the picture in step-by-step increments (Pic. 19.26). A current zoom value is shown on the top left corner of the video window (Pic. 19.31).

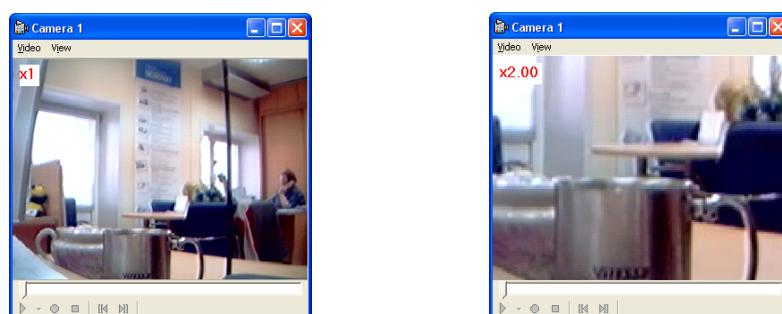
Besides, it is possible to zoom in the picture in one step increment in relation to a certain video fragment, i.e. this fragment will remain in the video window. For this purpose, press [Ctrl] and, holding it, click the left mouse button on the fragment you need. With every click the picture will zoom in one step increment and remain in the window. To get back to the initial zoom position, click the mouse button. At that [Ctrl] key should be released (Pic. 19.32).



Pic. 19.30



Pic. 19.31

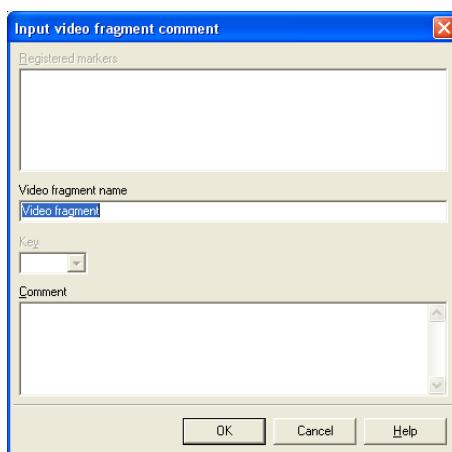


Pic. 19.32

6. If EEG and video recording is set to be started simultaneously (*Turn on video recording at the same time as EEG recording* check box on Pic. 19.26 is checked), video recording is turned on automatically at EEG recording (recording of any functional test). When EEG recording is finished video recording is also finished automatically.

7. To start video recording with the unchecked *Turn on video recording at the same time as EEG recording* check box, first start the recording of any EEG functional test. The **Video|Record** menu command will be available (the  button on the video window toolbar). Select the **Video|Record** menu command in the video window or click on the  button – the video recording will start. You can also start the recording by selecting the **Video EEG|Record** menu command of the EEG recording window.

8. To stop video recording without interrupting of EEG recording, click on the  button once more (or select the **Video|Record** menu command) of the video window. You can also stop video recording by selecting **Video EEG|Record** menu command of the EEG recording window one more time. The video recording will be stopped. The program will create a video fragment and ask for its name and comment (Pic. 19.33) if the *Assign video fragment name automatically* mode is not activated. If this mode is activated, the fragment will be created automatically.



Pic. 19.33

To start the recording of a new video fragment, use the **Video|Record** menu command of the video window again, or click on the  button of the toolbar or use the **Video EEG|Record** menu command in the EEG recording window.

If EEG and video recording are set to be started simultaneously, the video recording begins and stops together with the EEG-recording.

When the *Automatic fragment breaking* check box is checked, the video fragments are formed automatically in the process of the long time EEG recording.

9. In case a patient button is connected to the computer on which video-EEG recording is in progress, you can press any of two buttons on the unit to set the patient's event marker. It means that there is a possibility to record the events connected with the patient (i.e. changes in the state of health etc.) during the long-term recording if the button is located near the patient.

## 19.5. VIDEO RECORDING WINDOW

1. Let's give the detailed description of the menu commands in the video recording window (Pic. 19.29). The menu consists of the **Video** and the **View** items (Pic. 19.34). The main commands of the **Video** menu are duplicated in the **Video EEG** menu of the EEG recording, review and analysis window (Pic. 19.28).



Pic. 19.34

2. The **View** menu (Pic. 19.35) controls the visibility of the basic elements of the video recording window.

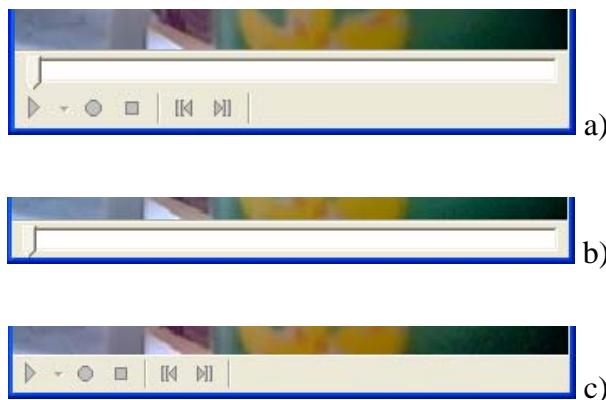


Pic. 19.35

The **Toolbar** command shows or hides the toolbar of the video recording window.

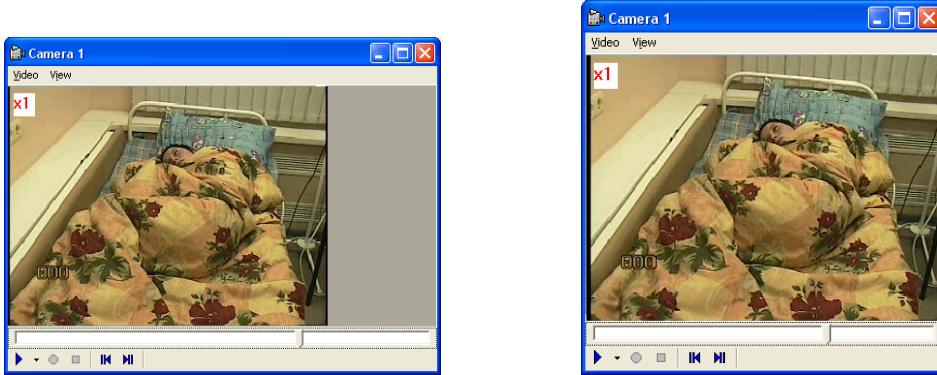
The **Scrollbar** command shows or hides the scrollbar of the video recording window.

The video recording window with the toolbar and the scrollbar is shown on Pic. 19.36 a). The video registration window without the toolbar is shown on Pic. 19.36 b). The video registration window without the scrollbar is shown on Pic. 19.36 c).



Pic. 19.36

The **Adjust** command sets the window size according to proper proportions of video image (Pic. 19.37).



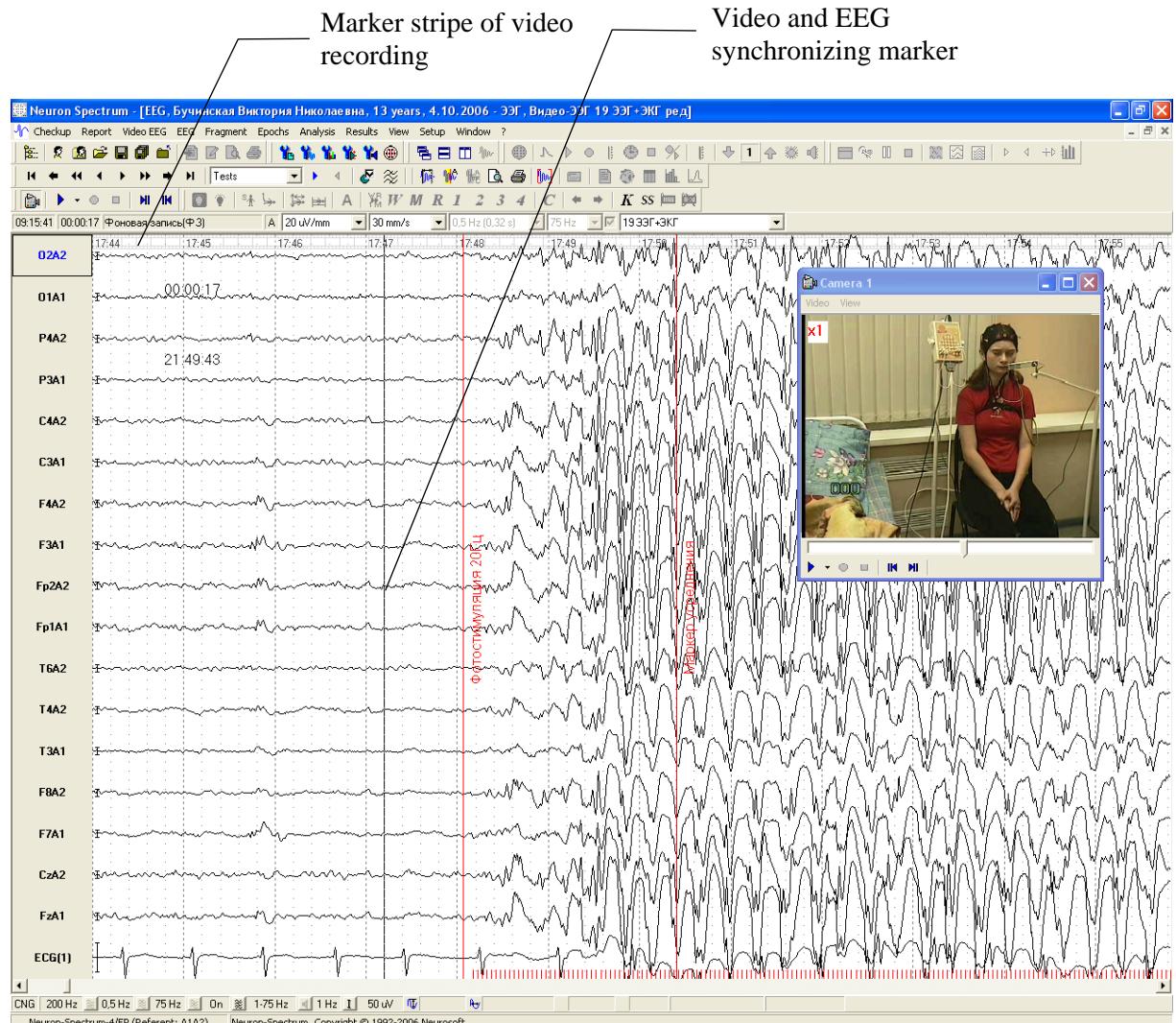
Pic. 19.37

3. The **Video** menu (Pic. 19.34) controls the process of video recording and playback of the recorded video fragments.

4. The **On** command (the button of the toolbar, the **Video EEG|On** menu command of the EEG review and analysis window) turns on video-camera in the video recording mode and turn on video fragment playback from the current EEG position in the view mode.

During a video fragment playback a video marker, a vertical line on the EEG (Pic. 19.38) synchronizes the current video image and the EEG. During the video playback and according to the settings (Pic. 19.26) the video marker can either move along the EEG or stand still on the EEG; at that the EEG moves left in relation to the marker (Pic. 19.38). So you can follow the EEG changes together with video-record review.

If there is a video-record on the selected EEG fragment (the video fragment is marked by the special stripe at the top of EEG) and the video window is active, click on the selected EEG segment with the left mouse button holding the **[Alt]** key pressed. The video marker will be set at this very point of the EEG and the video frame corresponding to the current moment will be displayed in the window. If the video marker is set to be immovable you can change its position in the window in such a way.



Pic. 19.38

5. You can adjust the playback speed (to playback video on higher speed). On the toolbar of the video window (as well as on the toolbar of the **Video EEG** review and analysis window) there is the button. If you press the button the dropdown menu of changing the playback speed appears (Pic. 19.39). The current speed is marked with a check. To change the playback speed, select the value you need and click on it with the left mouse button. The dropdown menu will be closed and the proper playback speed will be set. When you playback a video fragment it will be shown at the selected speed. You can adjust the playback speed in the playback mode only.



Pic. 19.39

6. The **Record** command (the  button of the toolbar, the **Video EEG|Record** menu command of the EEG window) is active only in the video recording mode and starts video recording on the first clicking (after this it becomes “dropped”). The recording will stop if you click on the button once more. When video recording is being performed in the video window a red indicator **REC** lights up in the upper right corner of the window. This command cannot be performed in the playback mode.

It is important to keep in mind that during the synchronous video and EEG recording (the button  is “dropped”) you can stop the video recording only but not the EEG recording by clicking on this button. Click on the button  once more to continue video recording, in case the EEG recording is not interrupted. While the EEG recording is not started the button is not active. If the video and EEG recordings are synchronized in the settings (Pic. 19.26), the start up of the EEG recording leads to the synchronous start up of the video recording. Precisely this operation mode is recommended.

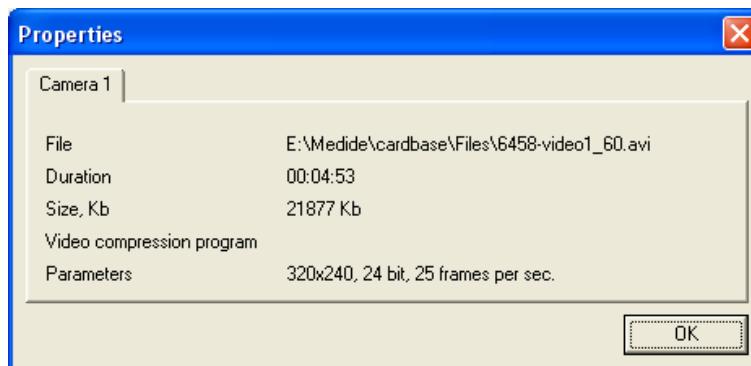
7. The **Stop** command (the  button of the toolbar, the **Video EEG|Stop** menu command of the EEG window) in the video recording mode turns the camera-recorder off, and in the playback mode stops the video fragment playback.

8. The **Mode** submenu enables setting of the video window operation mode: video recording mode (camera-recorder) or playback mode (video player). During the recording you can change the window operation mode when the recording is stopped temporarily for reviewing of recorded materials.

9. The commands **By frame** (the  button on the toolbar, the menu command **Video EEG|By frame** of EEG window) and **Backward by frame** (the  button on the toolbar, the menu command **Video EEG|Backward by frame** of EEG window) enable only in the playback mode and allow re-viewing the video record one by one frames. At each  or  buttons pressing, the next or the previous video frame is displayed in the video window. The EEG position in relation to the video marker is changing simultaneously.

10. The **Setup** submenu commands enable only in the video recording mode and allow setting of video-recorder parameters in the same way as in the setup video-EEG window (Pic. 19.20).

11. The **Properties** command enables displaying of the information about the current video fragment (a file name, its size, record duration, resolution and frame frequency) (Pic. 19.40).



Pic. 19.40

12. In the playback mode use the scrollbar of the video window to perform video record positioning on the selected frame (Pic. 19.36).

13. The digital video zooming in the playback mode is done in the same way as it is in recording mode. For this purpose, click the left mouse button on that place of the video image which should be zoomed; at that [Ctrl] key must be pressed. When [Ctrl] key is released the video image returns to original size. At each click the video zooming changes for one step (Pic. 19.26).

For zooming you can also use the camera control panel (Pic. 19.30) (zoom and navigation buttons), which can be displayed on the screen by the **Video EEG|Camera control** menu command of the EEG review and analysis window.

14. While clicking by the right mouse button on the **Video** window the window properties menu appears (Pic. 19.41). The first four menu items are used for video adjustment in the video-EEG recording mode and they are similar to the **Video|Setup** menu commands.

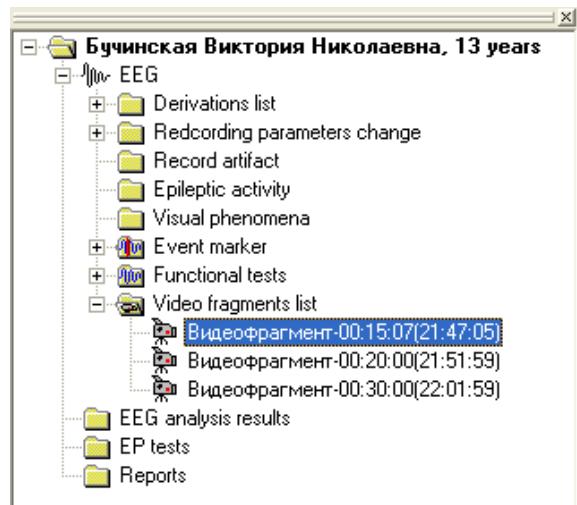
To copy contents of the video window to the clipboard use the **Copy** command. Then you can use the received picture in a checkup report or in the other documents. Only this method can be used to get the picture from the video window.



Pic. 19.41

## 19.6. VIDEO-EEG REVIEWING AND EDITING

1. In the EEG review and analysis mode you can review and edit the video fragments recorded simultaneously with EEG. If you have already performed video recording, the **Video fragments list** group will be created in the *Checkup Inspector* (Pic. 19.42). This list will contain the names of all the video fragments recorded and the time of their beginning concerning the EEG.



Pic. 19.42

You also can use the **Video EEG|Videofragments list** menu command (Pic. 19.43) to look through the list of the video fragments recorded.

2. To review the video fragments recorded, activate the video window using the **Video EEG|On** menu command or the button on the toolbar of the Video EEG review and analysis window. One or two video windows will appear on the screen. They will be automatically set into the playback mode. The software will start playing the fragment recorded first. After that the next fragment will be playing and so on to the record stop or on reaching the end of the last fragment.

3. Use the commands of the **Video** menu of the video window or the **Video EEG** menu commands of the EEG review and analysis window to control the video fragment playback.

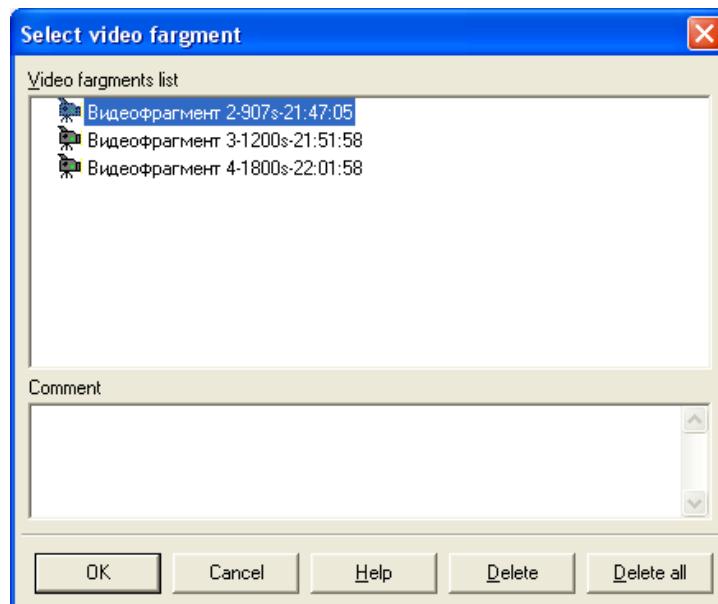
To start video fragment playback, use the **Video|Turn on** menu command of the video window (the button of the toolbar) or the **Video EEG|Play back** menu command of the EEG review and analysis window (the button of the video EEG toolbar of the EEG review and analysis window).

To change the playback speed, use the dropdown menu activated when you press the button located next to the button on the toolbar of the video window or on the toolbar of the Video EEG review and analysis window.

To stop the playback, use the **Video|Stop** menu command of the video window (the button of the toolbar) or the **Video EEG|Stop** menu command of the EEG review and analysis window (the button on the video EEG toolbar of the EEG review and analysis window).

To playback a video record frame-by-frame, use the menu commands **Video|Forward by frame** or **Video|Backward by frame** of the video window (the or button of the toolbar) or the **Video EEG|By frame** or the **Video EEG|Backward by frame** menu command of the EEG review and analysis window (the and buttons on the toolbar of the video window or on the video EEG toolbar of the EEG review and analysis window).

4. You can start video fragment playback by double-clicking on the node of the selected video fragment in the *Checkup Inspector* window. The **Select video fragment** dialog box will appear on the screen if you click on the **Video EEG|Video fragments list** menu command (Pic. 19.43).



Pic. 19.43

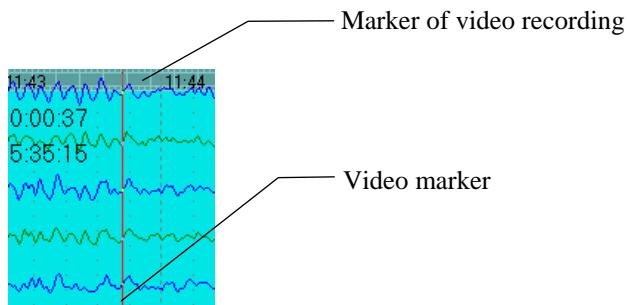
Select the required video fragment and press “OK”. If the video window is activated, the EEG and video-record will be placed to the beginning of the video fragment and the playback of the selected fragment will start. If the video window is not activated, the EEG will be placed to the beginning of the video fragment, the video window will be opened and the playback of the fragment will start.

Using the dialog box you can add and edit comments to the video fragment as well as delete the selected fragment (using the “Delete” button).

The “Delete all” button enables to delete the video recording completely saving the EEG only. It saves the place in the database significantly as the video recording (especially long-term) takes a lot of space.

The **Video EEG|Next video fragment** and **Video EEG|Previous video fragment** menu commands start the playback of the next or previous video fragment. At that if the video window is not activated it will be opened in advance.

5. During the video reviewing a special video marker (a vertical line) moves along the EEG (or the EEG moves in relation to the still marker) and points at the time moment on the EEG corresponding to the current video frame (Pic. 19.44). It helps to synchronize the process of video and EEG reviewing.



Pic. 19.44

6. If there is a video record corresponding to the EEG fragment (there is a special marker (Pic. 19.44)) and the video window is active, you can set a video marker on the selected place of the EEG holding the [Alt] key and clicking on the EEG with the left mouse button. The video frame corresponding to this moment of time will appear in the video window. Now from this place you can start the playback of the video record.

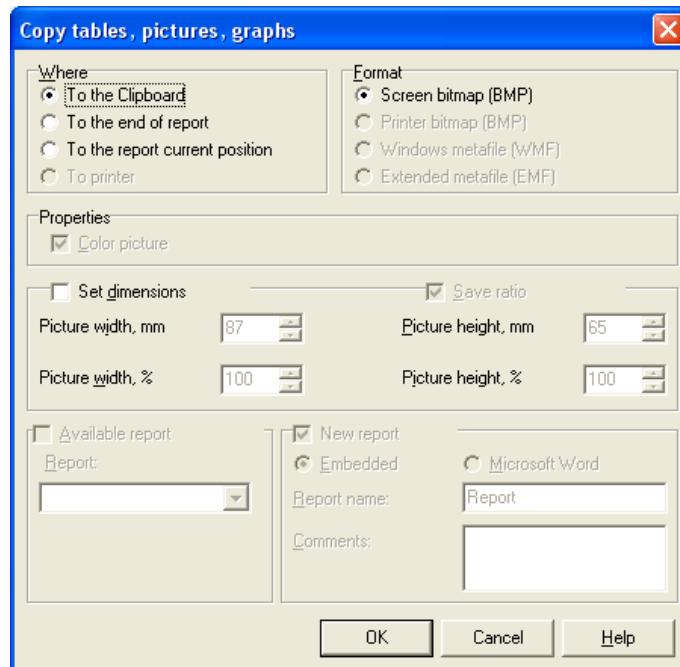
7. If you move along the EEG when the video reviewing is stopped but the video window is available on the screen, the video image will synchronize with these movements.

If in the **Video EEG** settings (Pic. 19.26) the video marker is set still in relation to the EEG, then, while using navigation commands along the EEG, the video marker remains in fixed position in relation to the screen and thus it synchronizes the EEG and video image moving along the EEG.

If the moving video marker mode is set, then, while moving along the EEG, the video marker and video recording are located in the leftmost point of the EEG review and analysis window. At playback startup it starts from the left side of the EEG review and analysis window.

8. The **Video EEG|Start position** menu command of the EEG review and analysis window is active if there is no video window (video windows) on the screen. By this command you can set the video window in the starting position near the top left corner of the EEG review and analysis window. This command is necessary if two monitors operating mode was used and the video window (video windows) was located on the second monitor. As **Neuron-Spectrum-Video** memorizes the location of the video window, then while switching to one monitor operating mode the video windows will not be observed on the screen. By the **Start position** menu command you can set the video window (video windows) at the observable position on the screen even if you use a monitor with lower resolution.

9. You can copy any frame of the video window to the clipboard or checkup report. For this purpose use the **Video EEG|Copy** menu command or the **Copy** command of the properties menu of the video window (click the right mouse button on the video image). **Copy tables, pictures, graphs** dialog box (to report or clipboard) will appear on the screen. Select where to copy the frame and it will be copied there (Pic. 19.45).



Pic. 19.45

## **19.7. VIDEO-EEG EDITING**

1. **Neuron-Spectrum-Video** software allows video records and EEG editing. This editing permits the removal of unnecessary fragments of only video or video fragments with EEG from the record. As far as the long-term records of EEG, especially long-term video records, take much place on the hard disc, the removal of unnecessary fragments saves it very much.

Besides, in the process of editing you can “cut” distinctive fragments from the long-term record and get the recording which consists only of these distinctive fragments. Then you can write this “cutting” to a compact disc (CD or DVD) along with the viewer program and give it to a patient or his attending doctor or recommend a patient to show the disc to his doctor and ask for advice. Such specific “cutting” can also be written as a multimedia clip in AVI format that helps to playback your recording on any computer by means of multimedia player without **Neuron-Spectrum-Video** software.

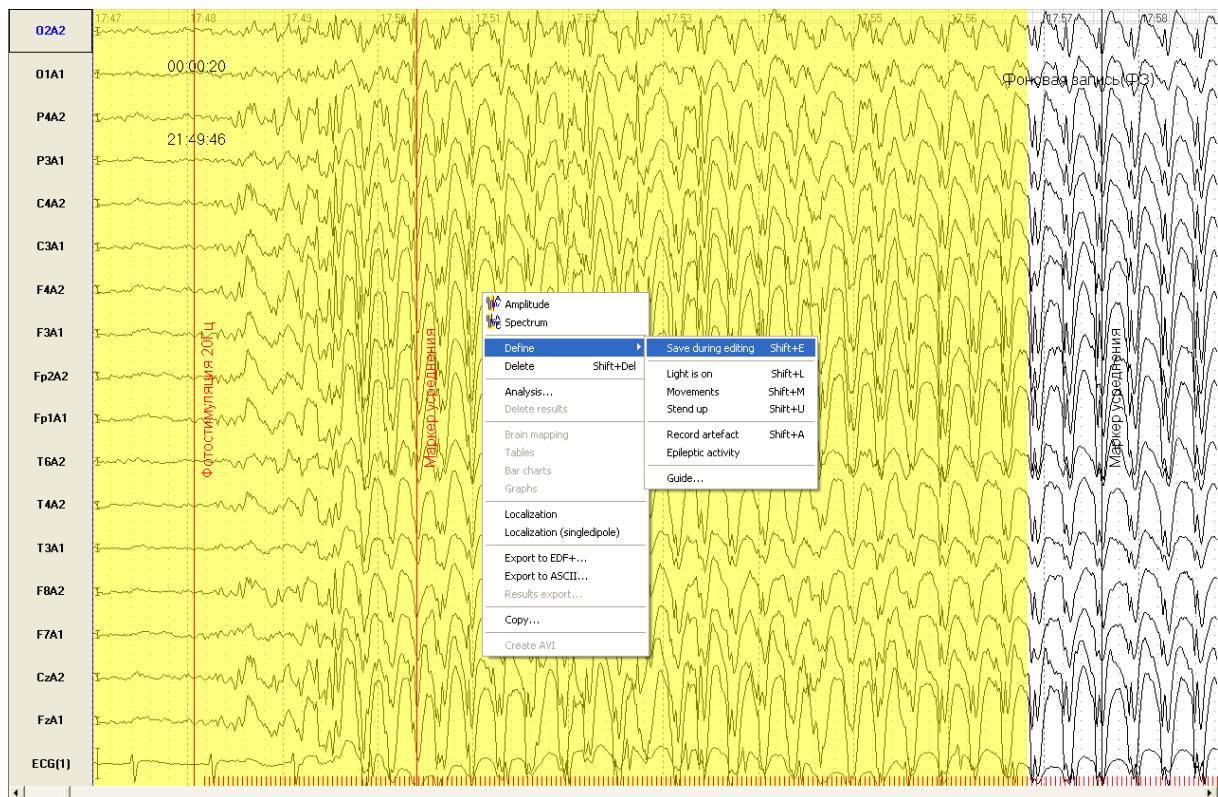
In the process of editing the program removes all the results of EEG analysis and epochs marked earlier and also the areas of epiphomena marked automatically or manually. That is why the editing is better to do before the EEG mathematical analysis.

It is important to remember that the editing process takes quite much time that is why it is necessary to prepare this process carefully.

You can prepare the process of editing when the video window (windows) is enabled. But disable the video window to start the process of editing.

If a polysomnogram is being editing then for the analyzed PSG with a creared hypnogram it is possible to edit video only.

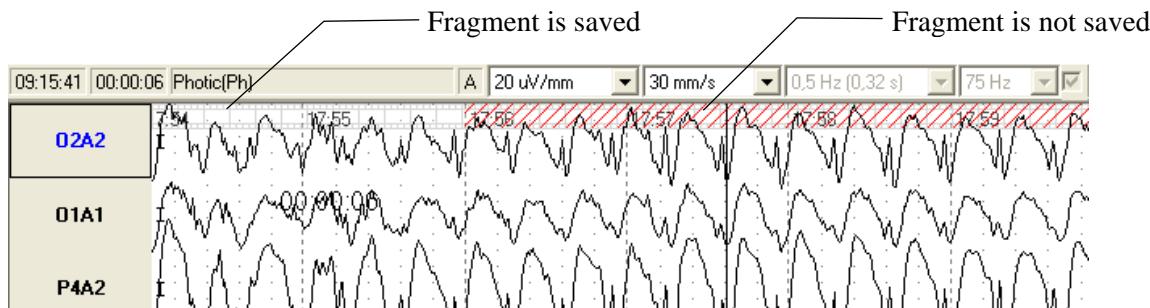
First you should review the whole record and select the fragments which will ***be left in the record***. All the rest record areas will ***be deleted***. For the preparation of the necessary fragments list left, in the process of video EEG review, use the fragments marking by mouse and the following fragment selection as a record area saved during editing (Pic. 19.46). Click the right mouse button at the beginning of the fragment you want to highlight and select the command **Fragment beginning**. Look through the recording and determine where the end of the fragment will be located. Then click at this place by the right mouse button and select the command **Fragment ending**. Click the right mouse button on the highlighted fragment and select the **Define|Save during editing** menu command. In such a way mark all the fragments of the recording which should be saved during editing (make your special “cutting”).



Pic. 19.46

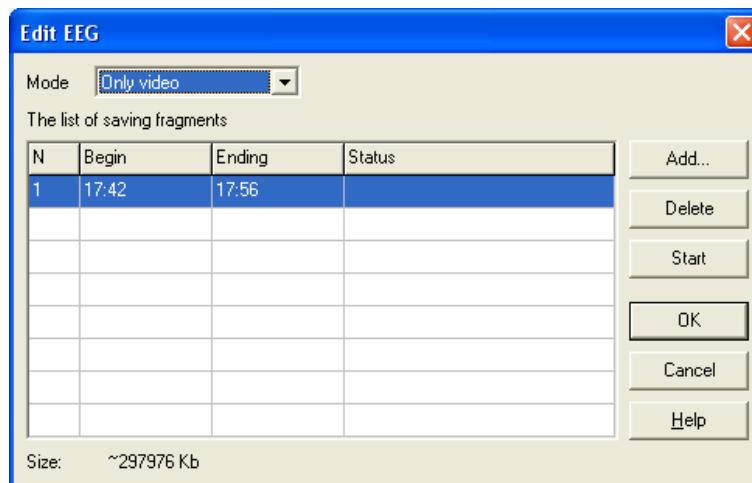
## Neuron-Spectrum Program

Fragments of the recording which are not saved during the editing are marked specially on the marker of video recording (Pic. 19.47). It helps to make visual control the EEG fragments which will be left in the recording after editing.



Pic. 19.47

2. For the review of fragments list which will be left in the record when editing, for starting the process of editing or for the addition of the left fragments manually, you can use the **EEG>Edit** menu command. If you select this command, you will see the **Edit EEG** dialog box (Pic. 19.48).



Pic. 19.48

*Mode*. It defines what is to be edited: only video (*Only video* value) or video record and EEG (*EEG and video* value).

*The list of saving fragments*. It defines the fragments which will be left in the recording after editing. *Begin* is the fragment beginning. *Ending* is the fragment end. The number of such fragments can be optional. Of course, the fragments should not cross at time.

*Size*. It defines the approximate size of the EEG and video recording which will be left after editing. This value is helpful to control the size of the checkup if you want to write it, for instance, to a compact disc.

“*Add*” button. Add new fragment in a list to leave in the record.

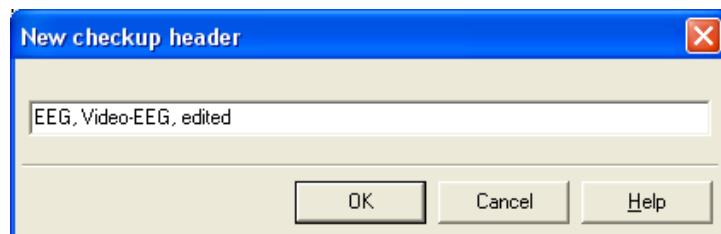
“*Delete*” button. It removes the current (highlighted) fragment from the list.

“*Start*” button. It starts the process of editing. Keep in mind that this procedure can take too much time.

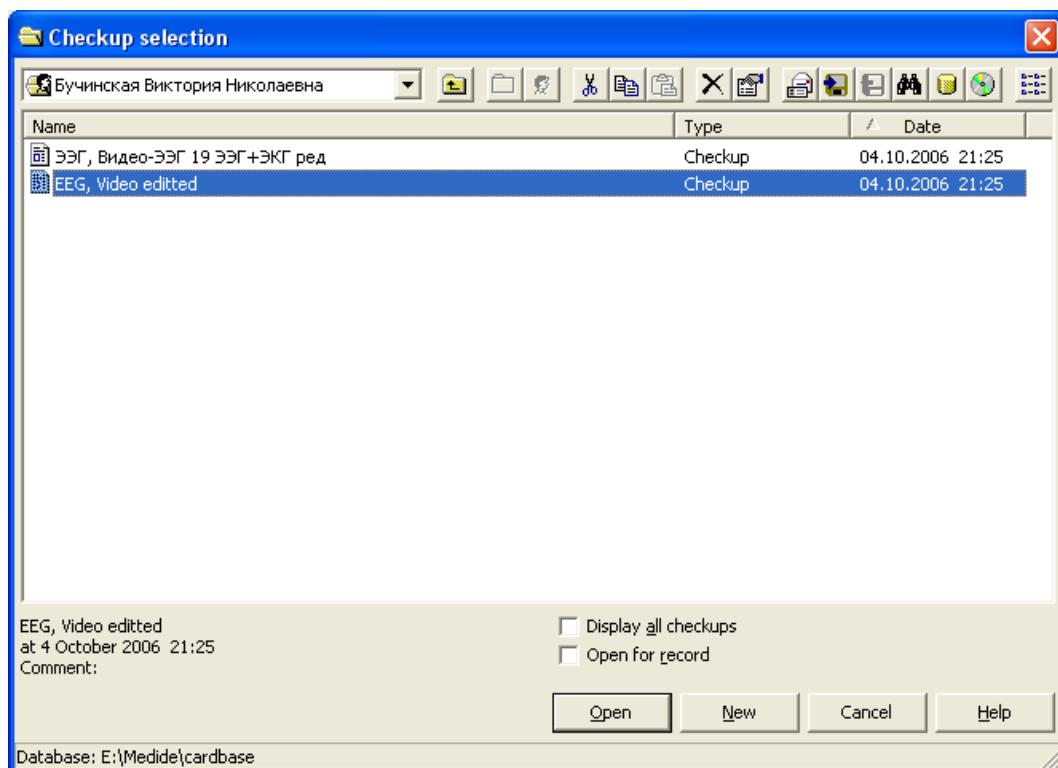
In “*Status*” column the state of current fragment in the process of editing is shown.

3. We can recommend the following order of actions while video EEG editing. In the process of EEG review you should select EEG and video record areas which will be left in the record, mark them as EEG fragments and define as areas which are to be saved during editing. In this case they are automatically added to the *List of saving fragments* of **Edit EEG** dialog box. After that you call **Edit EEG** dialog box and select editing mode (please remember that only video fragments or video fragments with EEG fragments can be deleted from the record). After having checked and corrected the list of saved fragments, and using for this purpose “Delete” and “Add” buttons if necessary, start the process of editing by pressing the “Start” button. After finishing the editing process, press “OK” for editing results saving.

4. After you finish editing it is better to save the edited checkup as a new one. For this purpose select the **Checkup|Save as** menu command immediately after the process of editing. In the appeared window (Pic. 19.49) change the checkup name and press *OK*. The edited checkup will be saved as a new one. This new checkup with a new name will appear in the database in the patient’s card (Pic. 19.50).



Pic. 19.49



Pic. 19.50

## **19.8. CREATING A DISC FOR AUTOMATIC CHECKUP REVIEW ON ANY COMPUTER**

1. You can write any checkup to a compact disc (CD or DVD) along with a special viewer program and software which starts the viewer program automatically for reviewing the recorded checkup when you insert the disc into a disc drive. You can give such a disc to a patient or to the doctors.

2. To create a disc it is necessary to have a rewritable drive unit on your computer. One of the **Nero** program versions must also be installed on your computer. Without this program a disc creating function will not work.

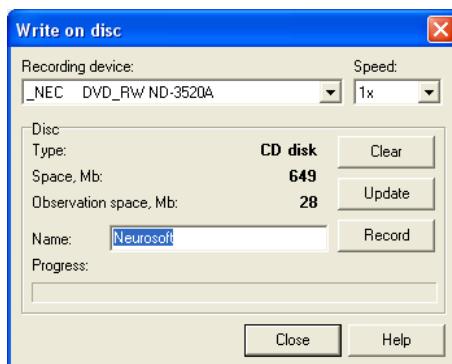
3. The viewer program is a simplified version of the **Neuron-Spectrum** software with reduced analysis functions which helps to review and print the EEG and video results.

4. To create a disc, open the checkup which you want to write to a disc. Just edited checkup can also be recorded. Select the **Checkup|Create disc** menu command (Pic. 19.51).



Pic. 19.51

5. After waiting for some time for the checkup archive to be created the **Write on disc** dialog box will appear on the screen (Pic. 19.52).



Pic. 19.52

On the dialog box the following information is shown:

*Recording device.* The type of rewritable drive unit installed in the computer.

*Speed.* Disc recording speed.

Disc characteristics:

*Type.* CD or DVD.

*Space.* Free space on the disc, which is inserted into a disc drive for recording.

*Observation space.* Approximate size of the recorded checkup. If the size of the checkup is marked by red color (Pic. 19.53), it means that there is no enough space on the disc for this checkup to be recorded.



Pic. 19.53

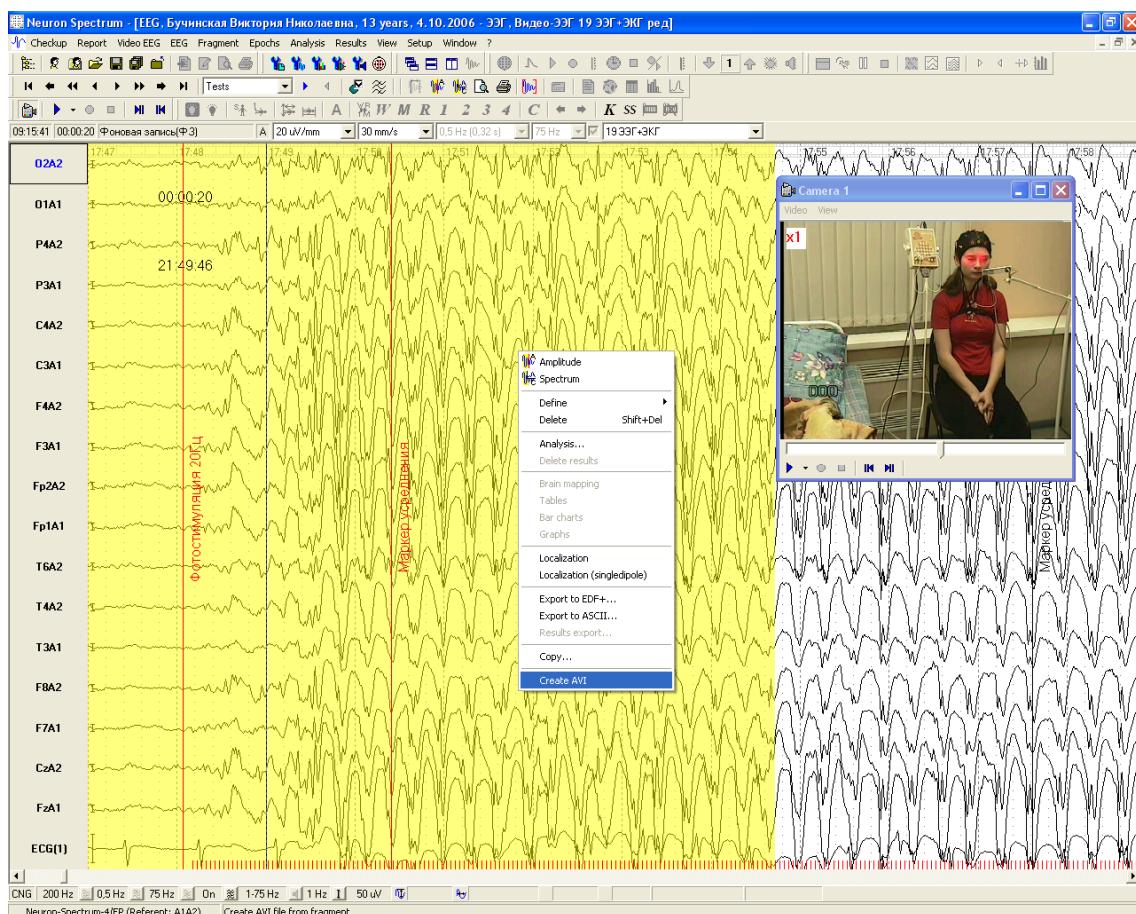
*Name.* Disc heading.

*Progress.* Indicator representing the process of recording.

6. If there is a possibility to overwrite the disc, you can erase the previous recording by the “*Clear*” button. If you insert a new disc while the **Write on disc** dialog box is active, press the “*Update*” button to update information about your disc. Press the “*Record*” button to start recording. When the recording is finished, the dialog box will be closed.

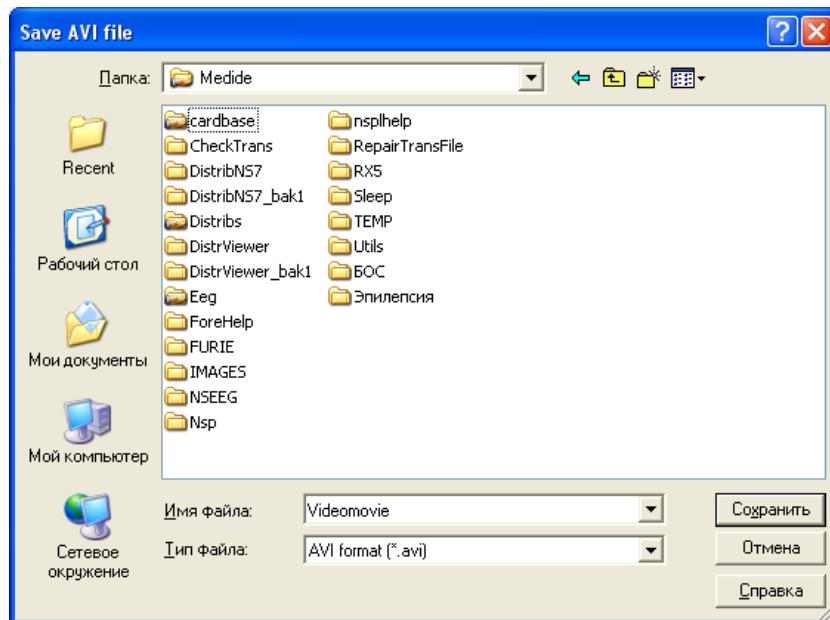
## 19.9. CREATING A MULTIMEDIA AVI-FILE FOR VIDEO-EEG REVIEW

1. To review video-EEG simply as a “movie” without human part, a multimedia AVI-file which you can open from any computer can be created from the video-EEG recording. You can watch this file as a movie on a computer. In this movie you will see the video image and EEG of the patient in the playback mode (i.e. a synchronizing marker will be moving along the EEG or the EEG will be moving in relation to the marker and, as a result, the video image in the video window will be changing). If you are not even a specialist in computer technologies or you are not experienced enough in working with **Neuron-Spectrum-Video** program, you will have a possibility to review the video-EEG results by means of this file.
2. To create an AVI-file it is necessary to highlight a fragment of the recording which should be converted into AVI-file. This process of highlighting of any fragment is described above.
3. To create an AVI-file the video window (windows) must be active.
4. Click the right mouse button on the highlighted fragment and select the **Create AVI** menu command (Pic. 19.54).



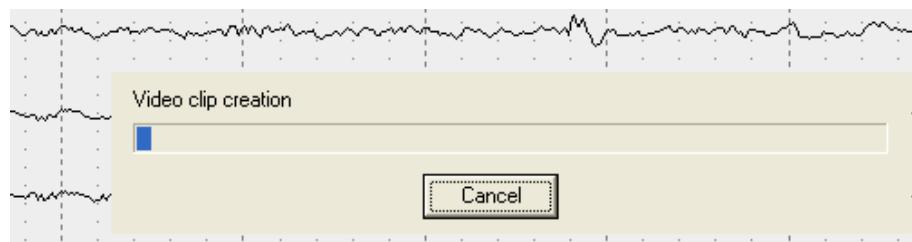
Pic. 19.54

5. In the appeared **Save AVI file** dialog box (Pic. 19.55) give the file name and press “Save”.



Pic. 19.55

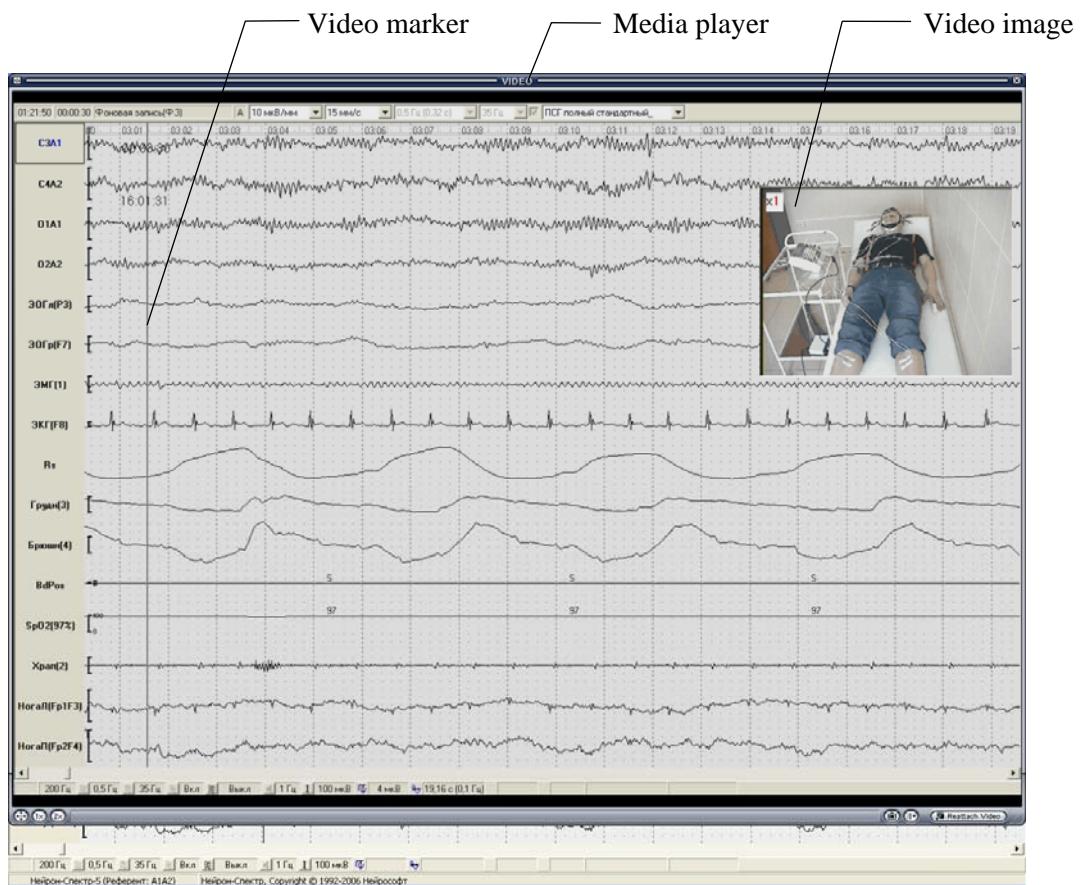
6. The message box of AVI-file creation will appear on the screen (Pic. 19.56). The process of video clip creation will be marked by the indicator. To stop the process press “*Cancel*”. The process of video clip creation will be stopped and only the fragment which corresponds to the status of indicator before the “*Cancel*” button is pressed will be saved as AVI-file. At the clip creation the codec selected in the dialog box **Setup video EEG** (Pic. 19.26, Pic. 19.27) is used.



Pic. 19.56

## Neuron-Spectrum Program

7. You can open the created AVI-file on any computer using different media players built into your operation system (for instance, **Windows Media Player**) or distributed separately (for instance, WinAmp) (Pic. 19.57).



Pic. 19.57

## **CHAPTER 20**

**NEURON-SPECTRUM-PSG –  
SOFTWARE AND EQUIPMENT  
FOR POLYSOMNOGRAPHY STUDIES  
ON DIGITAL EEG SYSTEM  
NEURON-SPECTRUM**



## **20.1. BASIC INFORMATION**

**Neuron-Spectrum-PSG** is hardware and software system for polysomnography studies which can be done by means of **Neuron-Spectrum** EEG systems.

Using **Neuron-Spectrum-1, 2, 3, 4, 4/P, 4/EP, 4/EPM, 5** EEG systems you can study sleep structure, i.e. you can record polysomnogram (PSG) and analyze sleep stages. Besides, using **Neuron-Spectrum-4/P, 4/EP, 4/EPM, 5** EEG systems, you have the possibility of cardiorespiratory monitoring and analysis of sleep-disordered breathing.

**Neuron-Spectrum-PSG** software can work together with **Neuron-Spectrum-Video** program providing synchronous recording of video image and audio signal during the process of PSG registration.

**Neuron-Spectrum-PSG** provides:

- long-term recording of the following channels during sleep: EEG, EOG, EMG from chin area, ECG, oral-nasal airflow (nasal and mouth breathing), chest movements, abdominal movements, body position, snore, SpO<sub>2</sub>, EMG from limbs (limb movements); this set of derivations helps to analyze either sleep structure (sleep stages) or sleep-disordered breathing;
- quick connection and disconnection of a patient from recording equipment without disturbance of placed electrodes by means of **Neuron-Spectrum-PEU4** or **Neuron-Spectrum-PEU5** optional patient unit (e.g., when the patient wants to visit WC etc.);
- manual and automatic sleep stages scoring, creation of hypnogram, automatic calculation of large amount of sleep parameters, making of histogram of sleep stages distribution;
- heart rate (HR), body position, SpO<sub>2</sub> trends construction, automatic search and classification of apnea and hypopnea, desaturation, snore, limb movements and periodic limb movements episodes;
- calculation of disordered breathing, desaturations, snoring, heart rate variability, limb movements parameters, body position changes during sleep; calculation of these parameters in various positions of a patient and sleep stages during the joint analysis of sleep structure and sleep-disordered breathing;
- creating report of polysomnography study, including graphs (hypnogram, trends, disordered breathing, desaturation, snore, limb movements episodes), results of calculation of sleep parameters and parameters of cardiorespiratory disorders during sleep, sleep stages distribution histogram.

## **20.2. NEURON-SPECTRUM-PSG DELIVERY SET**

For PSG recording and analysis you can use any of the following EEG systems: **Neuron-Spectrum-1, 2, 3, 4, 4/P, 4/EP, 4/EPM, 5**.

**Neuron-Spectrum-PSG** delivery set includes electrodes for recording of different PSG channels and also equipment for recording video and audio signals of a patient during PSG registration with a special video camera for night-time recording. The electrode system of **Neuron-Spectrum-PSG** includes:

- set of cup electrodes for EEG registration by 4 channels (Pic. 20.1);



Pic. 20.1

- set of cup electrodes for EOG registration by 2 channels (Pic. 20.2);



Pic. 20.2

- set of cup electrodes for one EMG channel registration from chin area (Pic. 20.3);



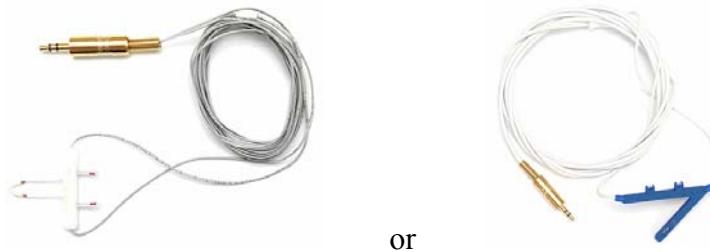
Pic. 20.3

- cup electrode for one ECG channel registration (Pic. 20.4);



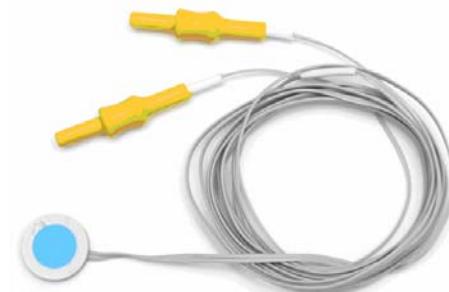
Pic. 20.4

- airflow probe for air flow registration from nostrils and mouth to record one airflow breath channel (Pic. 20.5);



Pic. 20.5

- snoring signals registration probe (Pic. 20.6);

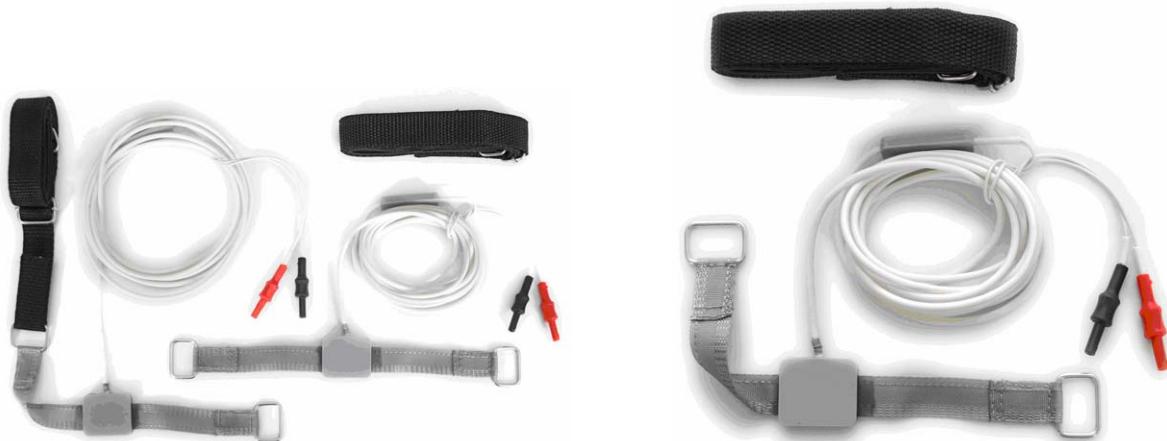


Pic. 20.6

## Neuron-Spectrum Program

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- abdominal and chest movements registration probes (with belts) to record abdominal and chest movements (Pic. 20.7);



Pic. 20.7

- body position probe with belt (Pic. 20.8), which can fix five positions of a patient: supine, right, left, prone and upright positions;



Pic. 20.8

- finger probe for recording of blood oxygenation SpO<sub>2</sub> and an individual unit for SpO<sub>2</sub> recording (for connection to USB-port of a computer) or a unit for SpO<sub>2</sub> recording built-in **Neuron-Spectrum-5** (Pic. 20.9).



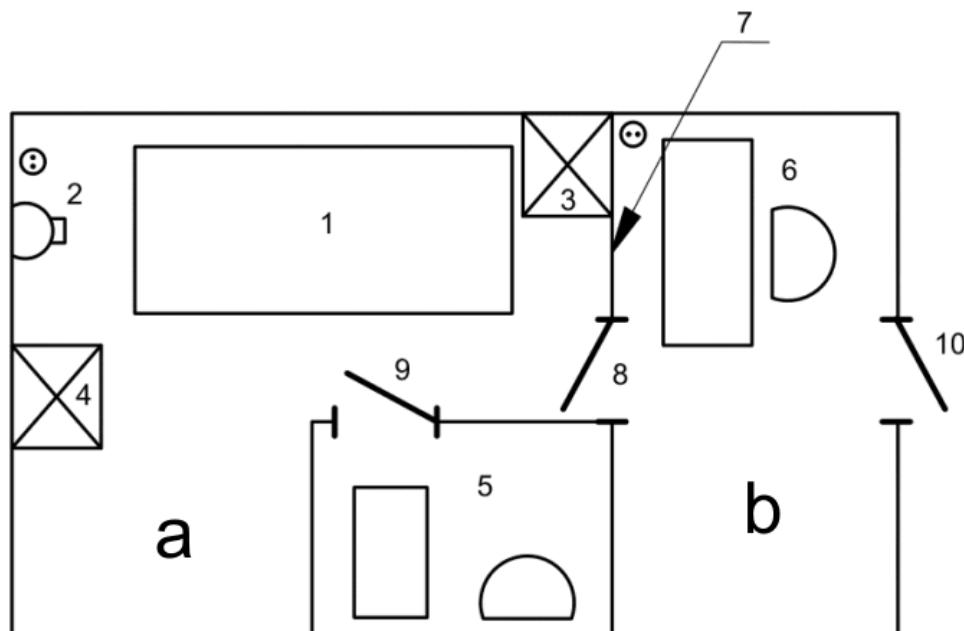
Pic. 20.9

To record the abovementioned signals the probes of other manufacturers can also be used.

### 20.3. PSG REGISTRATION

PSG registration includes careful process of getting a patient ready for the study (placing and fixation of electrodes and probes), setting of equipment for recording, control of signal registration quality from all the placed electrodes and probes and immediately the process of night-time recording.

For night-time PSG registration it is necessary to use individual equipped rooms with special space isolated for a computer and look-out post. The approximate layout of a room for night-time recording is shown on Pic. 20.10.



Pic. 20.10

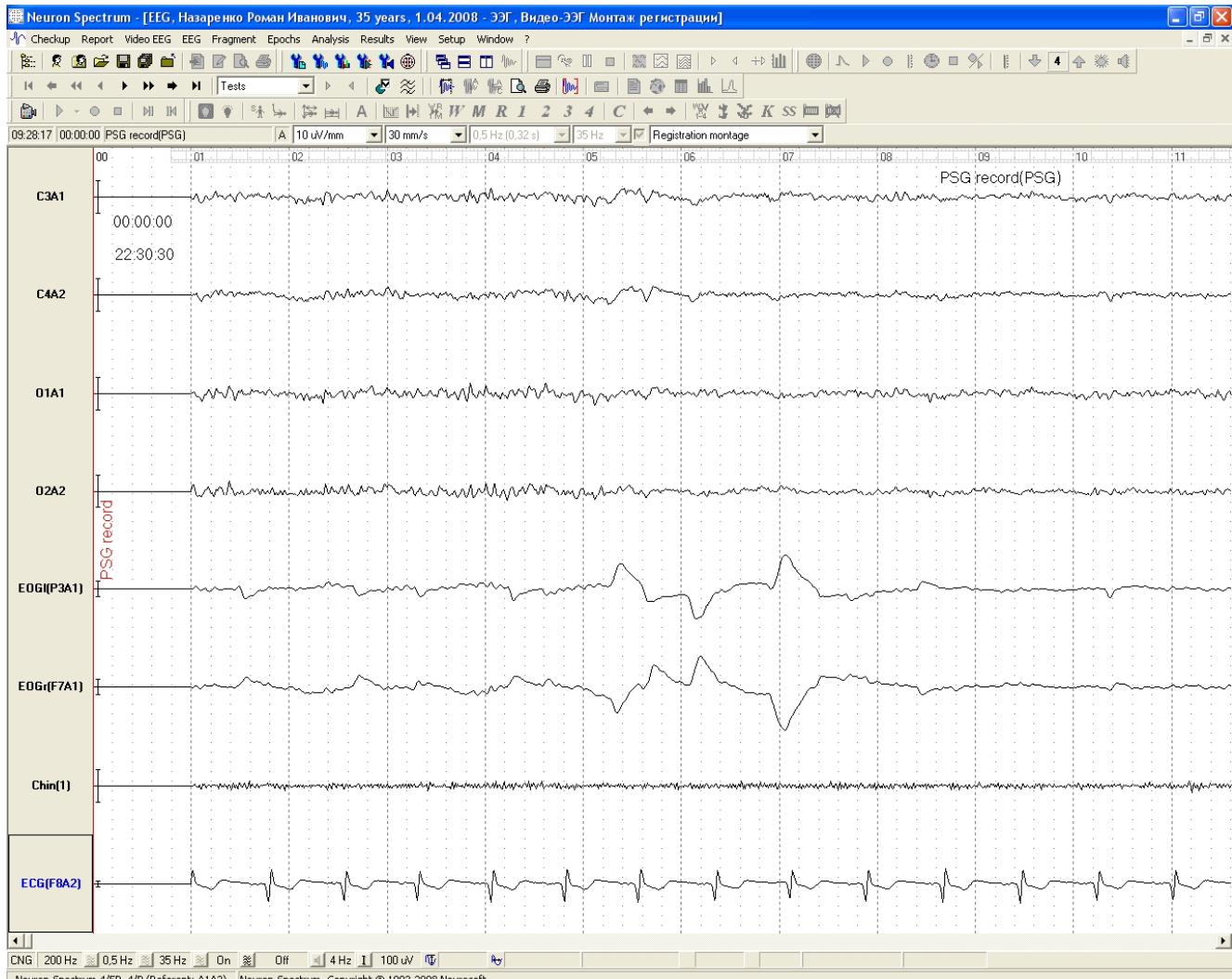
Conventional signs:

- (a) Patient's room.
- (b) Personnel's room.
- 1. Bed.
- 2. Socket for medical equipment (3 pcs.).
- 3. Bedside cabinet for medical accessories.
- 4. Patient's bedside cabinet.
- 5. WC.
- 6. Personnel's workplace.
- 7. Transparent wall.
- 8. Door to the patient's room.
- 9. Door to WC.
- 10. Door to the night-time recording room.

## Neuron-Spectrum Program

To record and analyze sleep structure (sleep stages analysis) it is necessary to record at least the following channels (Pic. 20.11):

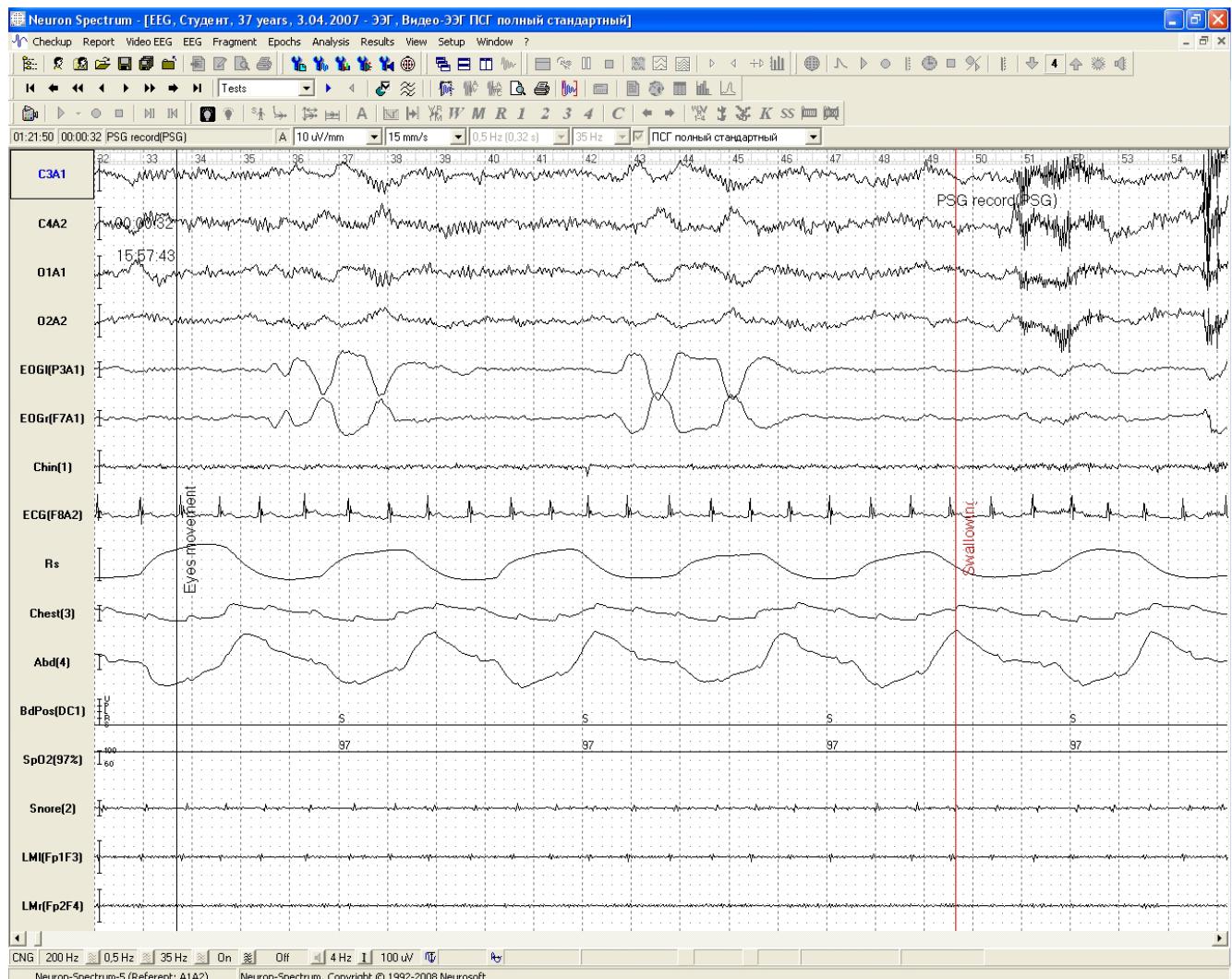
- from 2 to 4 EEG channels recorded in monopolar mode either with ears or mastoidal referents; as a rule, the following derivations are registered: C3A1, C4A2, O1A1, O2A2;
- 2 EOG channels from the right and left eye; besides, the identical ear electrode is selected as a referent which helps to separate eyes movement from artifacts;
- EMG channel from chin area;
- ECG channel to determine heart rate variability (optional).



Pic. 20.11

To record and analyze sleep-disordered breathing it is recommended to record the following channels (Pic. 20.12):

- oral-nasal airflow – breath channel;
- chest movements channel;
- abdominal movements channel;
- SpO<sub>2</sub> saturation channel;
- body position channel;
- snore channel, which helps to record sound vibrations occurred while the patient is snoring;
- one ECG channel to determine changes and analyze heart rate variability during sleep;
- one or two EMG channels from limbs to analyze the phenomenon of periodic limb movements;
- other channels depending on the doctor's aims (i.e. CO<sub>2</sub> channel, channel for erection registration etc.).



Pic. 20.12

**Neuron-Spectrum-PSG** enables to record all the abovementioned channels in any combination according to the aims of your study.

### **20.3.1. PLACEMENT OF PROBES ON A PATIENT**

The placement of electrodes and probes on a patient for a long-term night-time recording is a difficult and laborious task. The quality of the record and the results of analysis depend directly on quality and safety of this placement.

#### **20.3.1.1. Placement of electrodes for EEG channels recording**

As a rule, during PSG registration at least two monopolar EEG derivations – *C3A1* and *C4A2* are recorded. And mastoidal electrodes are often used as reference ones. Depending on the purposes of application another EEG derivations can also be recorded. For EEG registration the cup electrodes are used as a rule.

Before placing an electrode degrease with alcohol and treat with abrasive paste the place of its location. After that apply adhesive paste on inner surface of the cup electrode and press it to the head. To fix the electrode collodion, fast-drying substance on the basis of ether, is usually used. For this purpose, prepare in advance and cover the cup of the electrode and its cable with a piece of thick gauze which size is a bit larger than the electrode itself. Lubricate the gauze with collodion (e.g., with the help of a brush or you can drop collodion on the gauze using a pipette). Press the electrode to the head tightly and dry the gauze using a fan. The electrode should be fixed on the head.

All EEG electrodes fixed on the patient's head must be placed in such a way that its cables will be directed to the top of the head and further you can gather them in one bundle.

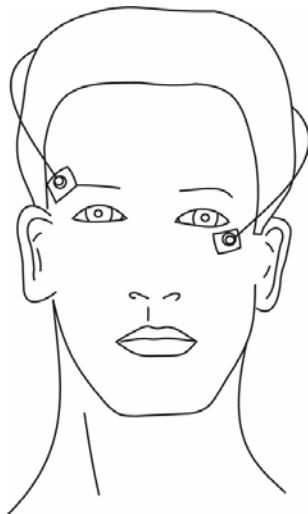
Reference electrodes (*A1* and *A2*) are usually placed on a mastoid bone and fixed by plaster or adhesive tape. To avoid artifacts occurred during jaw movement and vessels pulsation do not place reference electrodes too low.

To remove collodion and take away electrodes after the study it is recommended to use the following solution: 70% alcohol, diethyl ether and acetone in equal quantities.

Ground EEG electrode is placed in the same way as the lead ones. The electrode can be placed, for example, in *Fz* position.

### 20.3.1.2. Placement of electrodes for EOG channels recording

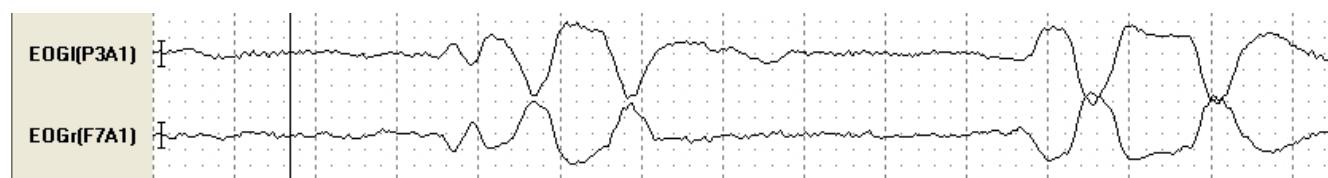
For EOG registration (eye movement registration) the same cup electrodes as for EEG registration are used. One electrode is placed 2 cm above the external angle of the right eye, the other – 2 cm below the external angle of the left eye (Pic. 20.13).



Pic. 20.13

Vertical axial displacement is necessary for registration the eye movements up and down. Electrodes are fixed on the skin by plaster or adhesive tape. The cup is filled up with adhesive conductive paste as well as the cup for EEG derivations.

EOG derivations are usually registered in relation to the same reference electrode (e.g.,  $A1$ ). By such derivations the eye movements are registered as synchronous antiphased deviations in left and right EOG channels (Pic. 20.14). That is why it is easy to separate real eye movements from artifacts during PSG analysis.

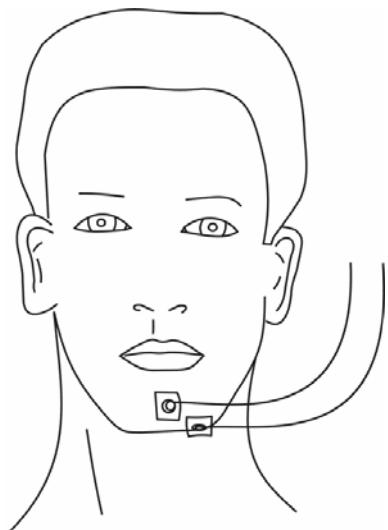


Pic. 20.14

EOG derivations are usually registered using EEG system channels. As a rule, EOG channels have EEG signal but they are used only for determination of eye movement events and EEG signal does interfere with it.

### **20.3.1.3. Placement of electrodes for EMG channel recording from chin area**

For EMG registration from chin area the cup electrodes are also used. To record EMG signal a bipolar derivation is necessary therefore it is recommended to use either additional polygraphic channel or two EEG channels. As a rule, one electrode is placed on the top of the chin and the other one – a bit lower (Pic. 20.15).

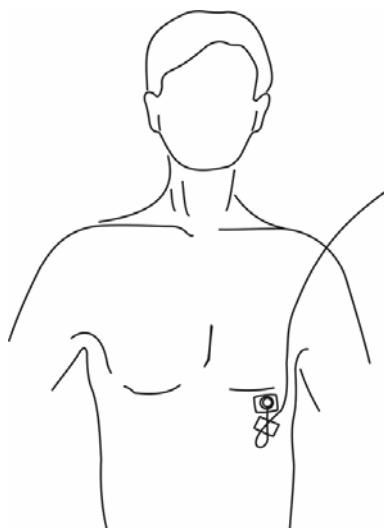


Pic. 20.15

The distance between electrodes usually makes 2-3 cm. Avoid to place the bottom electrode on soft and adipose tissues or too low. It may cause artifacts occurred during the movements of soft tissues or pulsation of cervical vessels. The fixation of electrodes on the skin is made in the same way as the fixation of EOG electrodes or, if a patient has a beard, as the fixation of EEG electrodes.

#### 20.3.1.4. Placement of electrodes for ECG channel recording

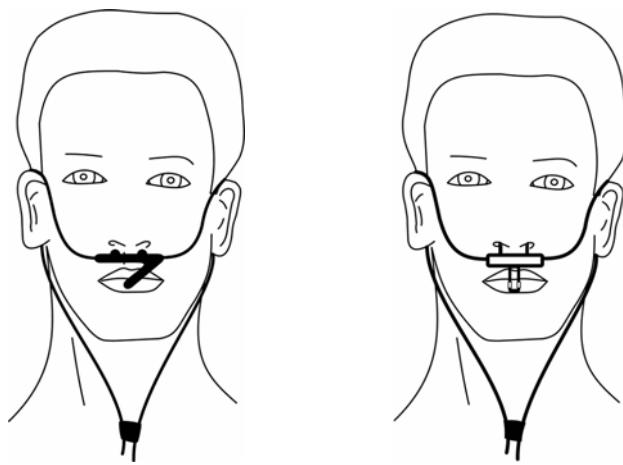
As a rule, during PSG registration one ECG derivation is recorded. The main purpose is to control the heart rate (HR) during sleep. In **Neuron-Spectrum-PSG** to record ECG signal the derivation with one cup electrode is used which is placed on the left side of the lower chest along the midclavicular line (Pic. 20.16). The fixation of electrode is made in the same way as the fixation of EOG and EMG electrodes.



Pic. 20.16

#### 20.3.1.5. Placement of flow breath probe

For air flow registration the breath probes on the basis of thermistor or thermocouple are used. The design and fixation of the probe are the same (Pic. 20.17).



Pic. 20.17

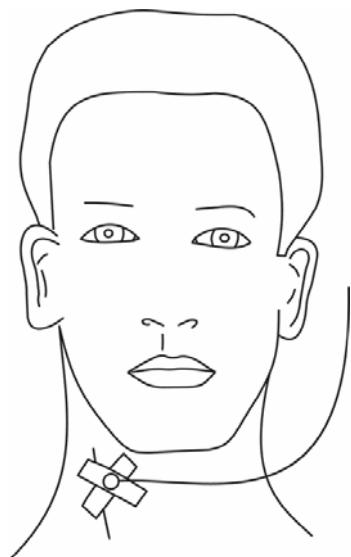
To fix the probe, make the following steps:

- Place the probe under the upper lip in such a way that sensing elements are under the nostrils and in the mouth area to provide registration of any air flow passing through the patient's mouth and nose.

- Throw over the cable coming from the probe behind the patient's ears and make the loop under the patient's chin.
- If necessary, fix the cable coming from the probe by pieces of plaster or adhesive tape.

#### **20.3.1.6. Placement of snore probe**

To place the snore probe ask your patient to imitate snoring. During the imitation find with a finger a point on the patient's neck in which the most vibration happens. That is the very point the snore probe must be placed on. The snore probe is a piezoelectric microphone therefore you should not grease it with any pastes and gels. The fixation of the probe is made by pieces of plaster or adhesive tape (Pic. 20.18).



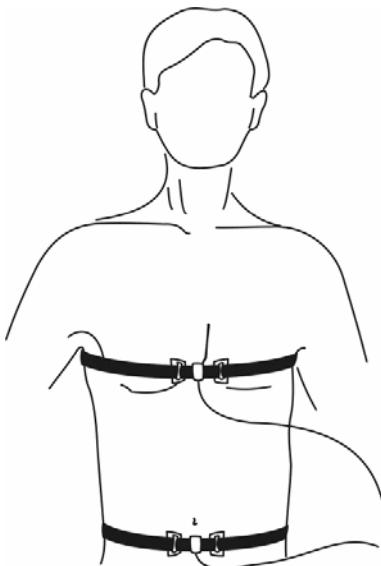
Pic. 20.18

#### **20.3.1.7. Placement of probes for chest and abdominal movements recording**

During the process of breathing alternating activity and relaxation of respiratory muscles occur, which is accompanied by change of volume in chest and abdominal cavities. It is used during registration of breathing efforts. In **Neuron-Spectrum-PSG** the piezoelectric probes for chest and abdominal movements recording are used. The probe consists of a belt and piezoelectric element with a derivation cable and straps for belt fixation. Two probes are included in the delivery set.

The belt is fixed to the straps of piezoelectric probe by Velcro fasteners. You can change the size of the belt using a special mechanism.

Using the belt fix one probe on the level of axillae (underarms), the other – a bit higher than iliac crest (Pic. 20.19). You should level the probes in such a way that the piezoelectric elements are situated on the chest and abdominal centre.



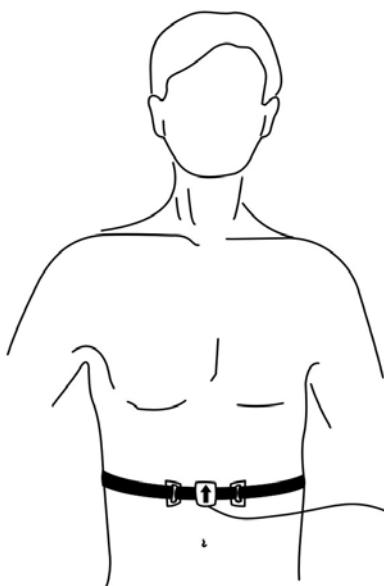
Pic. 20.19

To place the probes it is recommended to make the following steps:

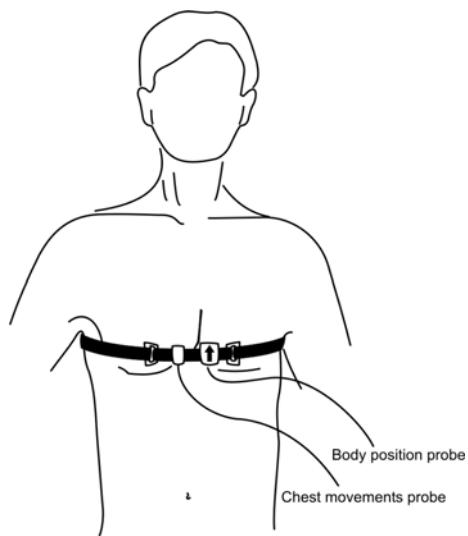
- fix the belt to one end of the probe by means of Velcro fastener;
- loose the belt at maximum length;
- turn the belt round the patient's chest or stomach and fix the other free end of the probe to the belt with one more Velcro fastener;
- fasten the belt and adjust the position of the piezoelectric element.

#### **20.3.1.8. Placement of probe for body position recording**

The probe of body position is a small box with “eyes” for fixation to the belt. The belt fixation to the probe is made in the same way as the belt fixation for the chest and abdominal movements probes. The placement of the probe is made in the same way as the placement of the abovementioned probes. While placing the probe you should follow the arrow on the probe body – it must be directed upward and located on the side of contact of the probe with the patient’s skin (Pic. 20.20). The body position probe can also be fixed to the belt of the chest movements probe (Pic. 20.21). For this purpose, pass the “eyes” of the body position probe through the belt of the chest movements probe from the side opposite to the rubber insert.



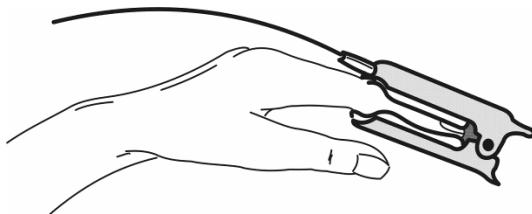
Pic. 20.20



Pic. 20.21

#### 20.3.1.9. Placement of probe for SpO<sub>2</sub> channel recording

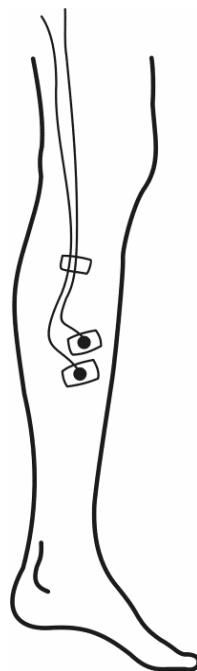
The probe for blood oxygenation recording is a clip fixed on a patient's finger (Pic. 20.22). Although a reusable plastic probe is included in the delivery set of **Neuron-Spectrum-PSG** you can also use various rubber and paper, disposable and reusable probes. All these probes are fixed on a patient's finger.



Pic. 20.22

#### 20.3.1.10. Placement of probes for recording of limb movements channels

For registration of limb movements (for the purpose to detect the syndrome of periodic limb movements) it is possible to record EMG channels from the anterior tibial muscles. The registration is made by the cup electrodes with an extended derivation cable. A bipolar derivation is used; the distance between electrodes is 2-4 cm (Pic. 20.23).



Pic. 20.23

The placement and fixation of electrodes are made in the same way as for the registration of EMG channel from chin area. While fixing electrodes it is recommended to make a loop of the cables to cushion the movements and separation of electrodes.

### 20.3.2. NEURON-SPECTRUM-PSG SOFTWARE SETUP FOR PSG REGISTRATION

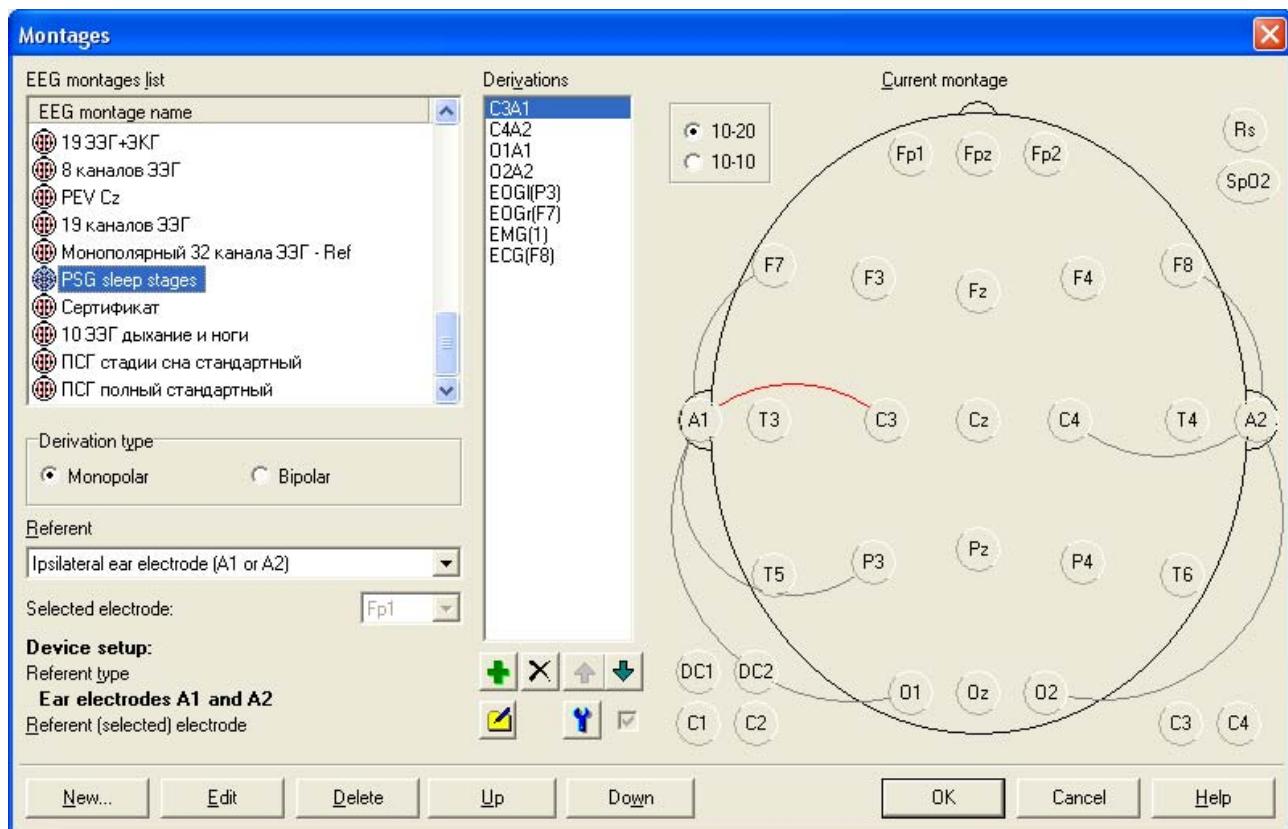
Before you start PSG registration it is necessary to setup the hardware and software for the registration, check the correctness of electrodes and probes connection to the EEG system or remote patient unit and make manipulations with a patient to make sure that the signal registration from the probes is correct.

#### 20.3.2.1. Preparing of montages for PSG registration

For PSG registration, for the purpose to study sleep structure (sleep stages analysis), the following derivations must be recorded:

- 4 EEG channels: *C3A1, C4A2, O1A1, O2A2*;
- 2 EOG channels;
- EMG channel from chin area;
- ECG channel.

Such set of derivations can be recorded by any type of EEG system starting from **Neuron-Spectrum-1**. For the registration it is recommended to use the following montage (Pic. 20.24).

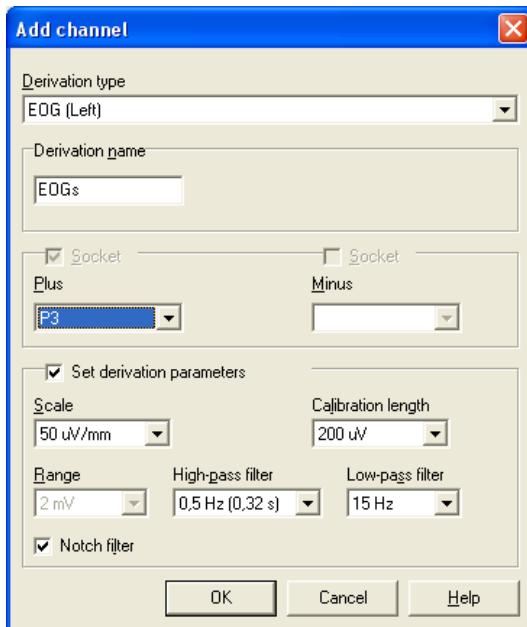


Pic. 20.24

EEG derivations are recorded with mastoidal referent electrodes *A1* and *A2*.

EOG electrode from the left eye is connected to the *P3* socket (for **Neuron-Spectrum-1** either *Fp1* or *T3* derivation can be used) of the EEG headbox. In a montage such a derivation is formed as follows:

- If it is necessary to add to a montage not the EEG derivation, which you want to record physically from the EEG channel, press  button. The dialog box **Add channel** (Pic. 20.25) will appear on the screen.



Pic. 20.25

- Select EOG (Left) from the Derivation type combo box and P3 socket (either Fp1 or T3 for **Neuron-Spectrum-1**) from the Socket-Plus list. If necessary, change the name of the derivation. The channel parameters are already set and you can change them if needed. Press “OK” and the EOG derivation from the left eye will be added to the montage. After the derivation name the socket of the EEG headbox to which the electrode is connected is shown in brackets (if it is a bipolar derivation two sockets are indicated).

The EOG derivation from the right eye is added in the same way. On the montage (Pic. 20.24) the EOG electrode from the right eye is connected to *F7* socket (for **Neuron-Spectrum-1** either *Fp1* or *T3* socket can be used) of the EEG headbox.

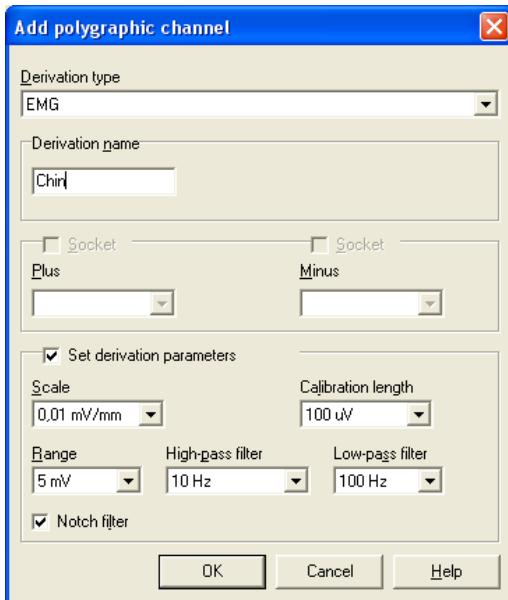
Unlike EEG and EOG derivations, the EMG derivation from chin area is bipolar. Two electrodes are necessary for its registration therefore either two sockets of free EEG derivations (moreover, both of them must have identical reference electrode) or additional polygraphic channel of the EEG system must be used. On the montage (Pic. 20.24) the first additional polygraphic channel is used for recording of EMG derivation.

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To add EMG channel recorded by the first additional polygraphic channel:

- Press “C1” (Pic. 20.24). The dialog box **Add polygraphic channel** (Pic. 20.26) will appear on the screen.



Pic. 20.26

- Select the EMG derivation from the Derivation type combo box. If necessary, change the name of the derivation. The channel parameters are already set and you can change them if needed. Press “OK” and the EMG derivation will be added to the montage. After the derivation name the number of additional polygraphic channel to which the derivation EMG electrodes from chin area are connected is shown in brackets.

How to add a bipolar derivation recorded from free EEG sockets of the EEG headbox to the montage is shown below.

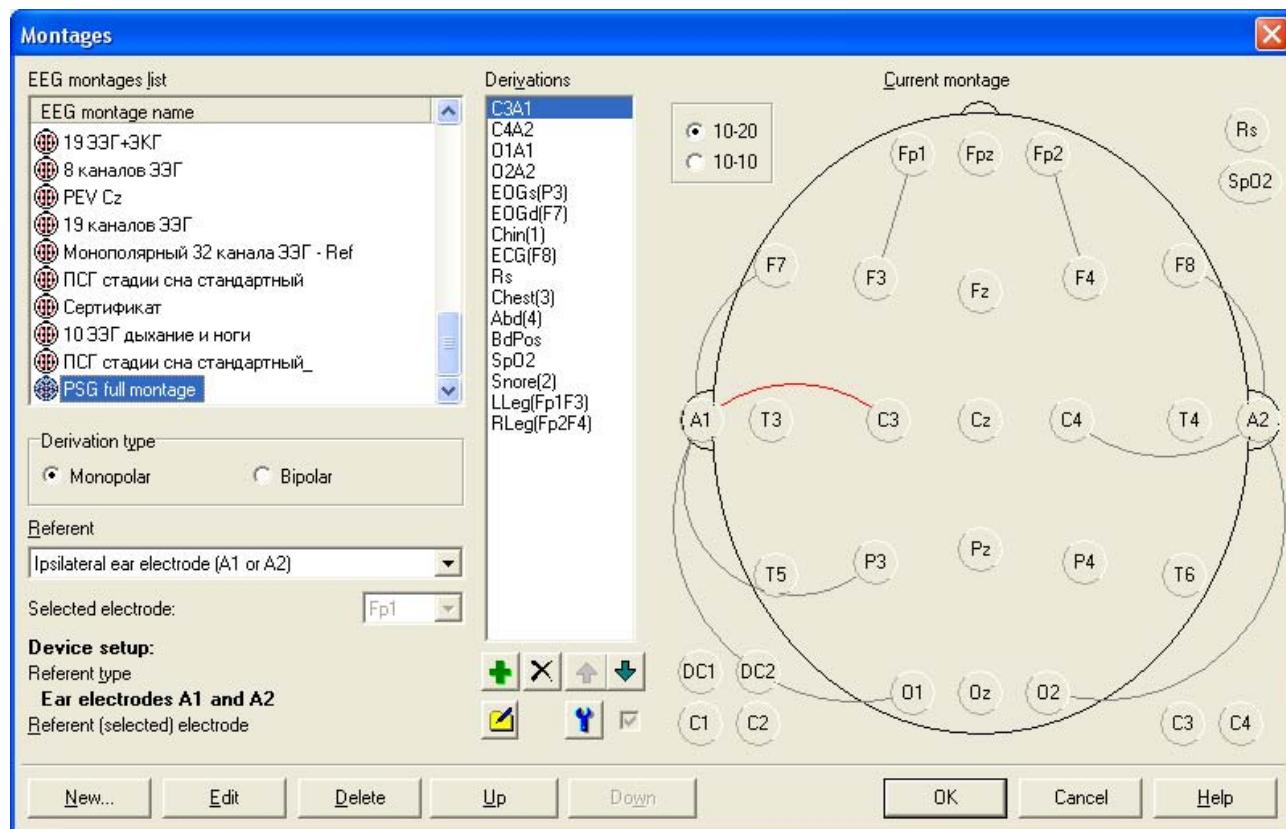
Add the ECG derivation in the same way. It is a monopolar derivation therefore one electrode connected to F8 socket is used for its recording (for **Neuron-Spectrum-1** either Fp2 or T4 socket can be used) (Pic. 20.24).

If it is necessary to record a lot of EEG derivations, add to the montage the EEG derivations you need and use any free EEG sockets of the EEG system for recording of EOG and ECG derivations. Keep in mind that both EOG derivations are recorded from one reference electrode.

For PSG registration to study sleep structure and disordered breathing a number of additional derivations must be recorded. For instance, in addition to the abovementioned derivations the following derivations should also be recorded:

- oral-nasal airflow – breath channel;
- chest movements channel;
- abdominal movements channel;
- SpO<sub>2</sub> saturation channel;
- body position channel;
- snore channel;
- two EMG channels from limbs.

This set of derivations can be registered only on **Neuron-Spectrum-4/P, 4/EP, 4/EPM, 5** EEG systems. For the registration you can use the following montage (Pic. 20.27).



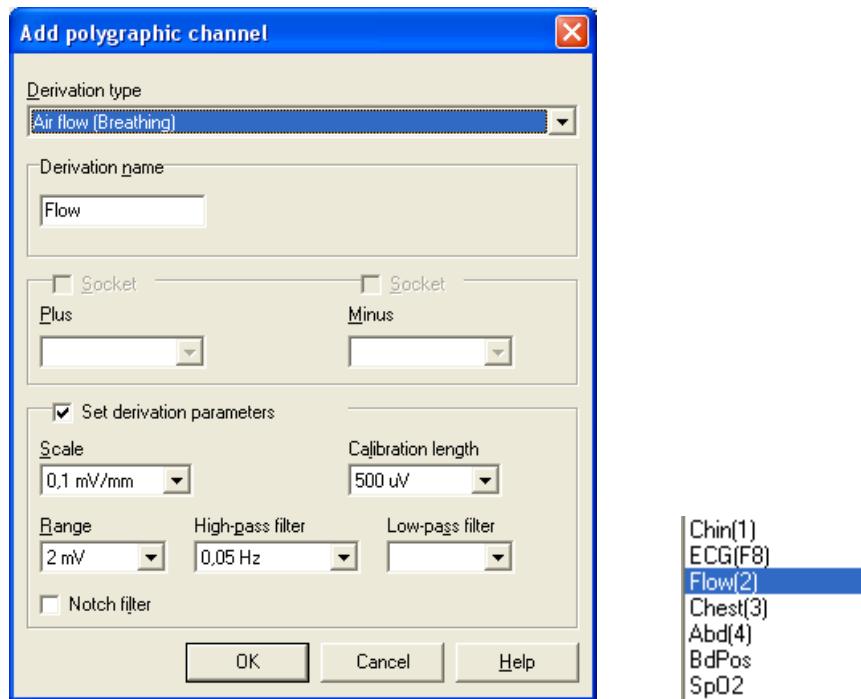
Pic. 20.27

The creation of EEG, EOG, EMG from chin area and ECG derivations was shown above.

To record the channel of oral-nasal flow either a breath channel which is included in any EEG system starting from **Neuron-Spectrum-1** or any of additional polygraphic channels can be used. To add an oral-nasal airflow channel registered by the breath channel press “Rs” (Pic. 20.27). *Rs* channel on which the breathing will be registered will appear in the list of the montage derivations. At that the breath probe is connected to the “*To breath probe*” socket on the top end part of the EEG unit.

## Neuron-Spectrum Program

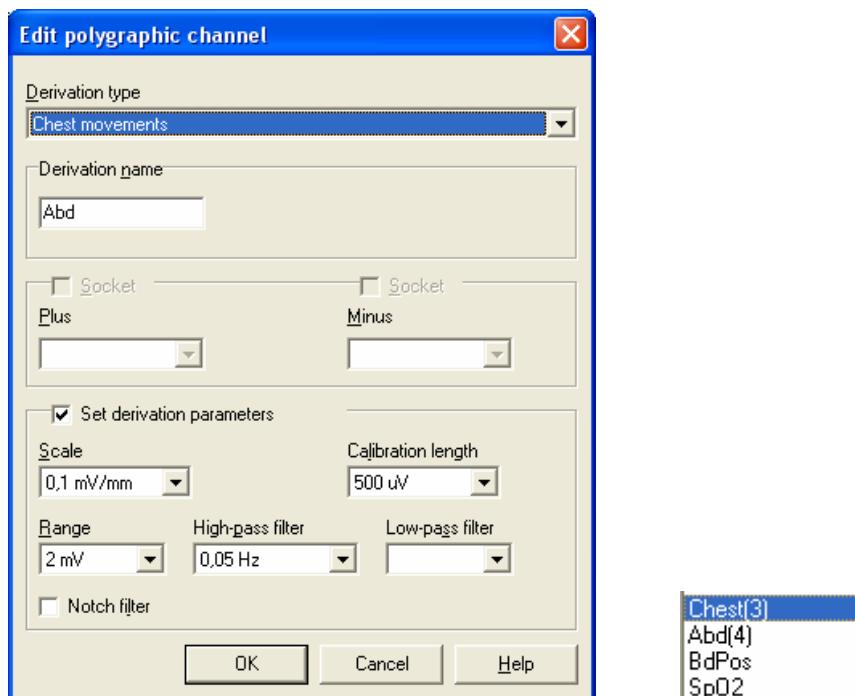
If additional polygraphic channel is used for breath channel recording, press “C1” – “C4” buttons to add the selected derivation to the montage. The dialog box **Add polygraphic channel** (Pic. 20.28) will appear on the screen.



Pic. 20.28

Select the *Air flow (Breathing)* derivation from the *Derivation type* combo box. If necessary, change the name of the derivation. The channel parameters are already set and you can change them if needed. Press “OK” and the derivation will be added to the montage. After the derivation name the number of additional channel to which the air flow probe is connected will be shown in brackets.

For recording of the chest and abdominal respiratory movements the additional polygraphic channels must be used. To add such derivations to the montage press the button of the additional derivation you have selected (e.g., “C3”). The dialog box **Edit polygraphic channel** (Pic. 20.29) will appear on the screen.



Pic. 20.29

Select the *Chest movements* derivation from the *Derivation type* combo box. If necessary, change the name of the derivation. The channel parameters are already set and you can change them if needed. Press “*OK*” and the derivation will be added to the montage. After the derivation name the number of additional channel to which the chest movements probe is connected will be shown in brackets.

The derivation, recording the abdominal movements, is added in the same way.

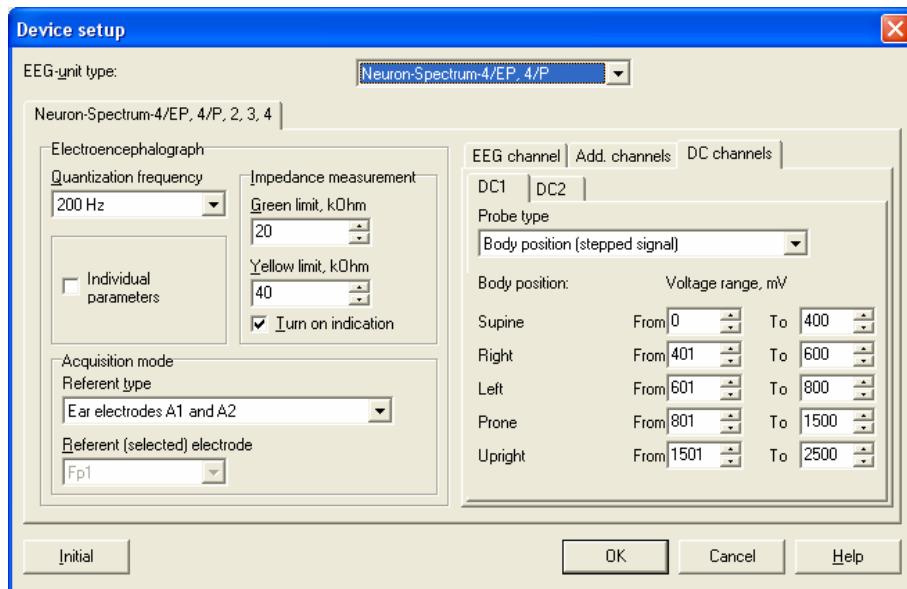
To record SpO<sub>2</sub> saturation channel, either an individual unit for SpO<sub>2</sub> recording which is connected to USB-port of a computer or a unit for SpO<sub>2</sub> recording built-in **Neuron-Spectrum-5** (the unit is built-in **Neuron-Spectrum-5** by order) are used. The finger probe for SpO<sub>2</sub> recording is connected either to the individual unit or to the socket of **Neuron-Spectrum-5** EEG unit.

To add SpO<sub>2</sub> channel to the montage press “*SpO2*” button (Pic. 20.27). After that this derivation will be added to the montage (Pic. 20.29).

The body position probe is connected to the first channel of direct current (DC) by default. In **Neuron-Spectrum-4/P**, **4/EP** EEG systems the sockets of direct current channels are located on the top end part of the device. The direct current channels of **Neuron-Spectrum-4/EPM**, **5** EEG systems are on the front panel.

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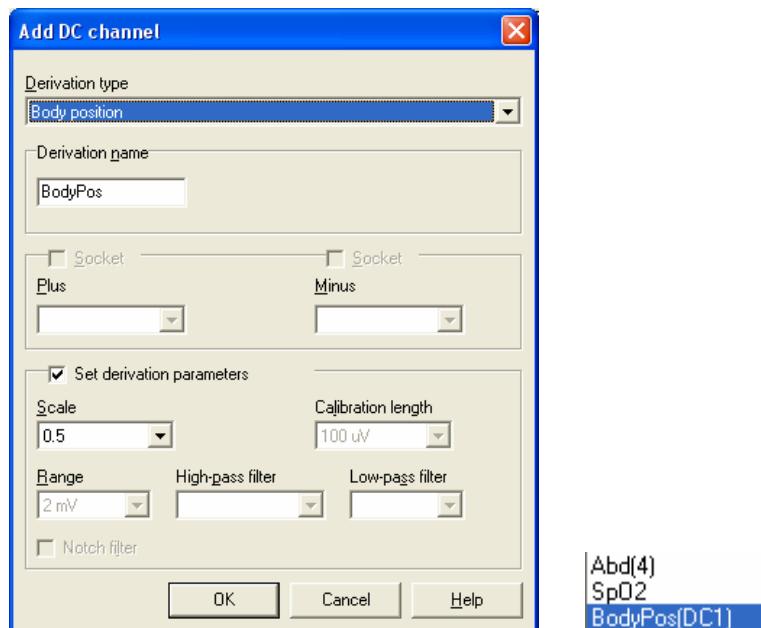
By default, the first direct current (DC) channel is set for the connection of the body position probe which is included in the standard delivery set of **Neuron-Spectrum-PSG**. To set the direct current (DC) channel, use the dialog box **Device setup**, the *DC channels* page (Pic. 20.30).



Pic. 20.30

To set the direct current channel select *Body position (stepped signal)* from the *Probe type* combo box. Then in the edit lines of the values for output voltage range of the probe, for each position, it is necessary to enter the corresponding values (they are usually indicated in the registration certificate of the sensor).

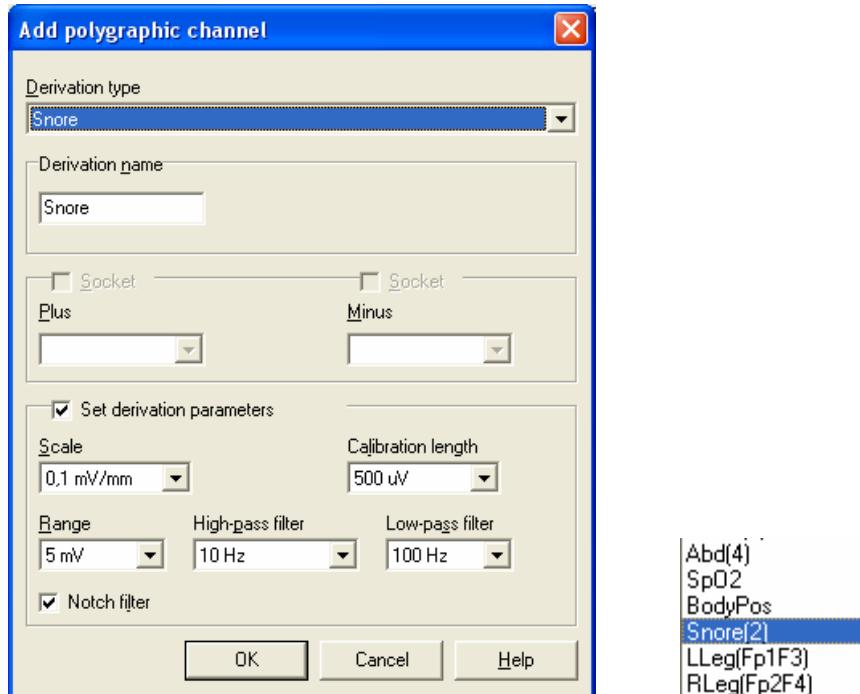
While adding the body position derivation to the montage for PSG registration it is necessary to press “*DCI*” button of the first direct current channel (Pic. 20.27). The dialog box **Add DC channel** (Pic. 20.31) will appear on the screen.



Pic. 20.31

Select *Body position* from the *Derivation type* combo box. If necessary, change the name of the derivation. Press “*OK*” and the derivation will be added to the montage.

The snore channel must be recorded from one of the additional polygraphic channels of the EEG system. To add the snore channel to the montage for PSG registration, press “*C1*”...“*C4*” button of additional polygraphic channel you have selected for recording. The dialog box **Add polygraphic channel** (Pic. 20.32) will appear on the screen.

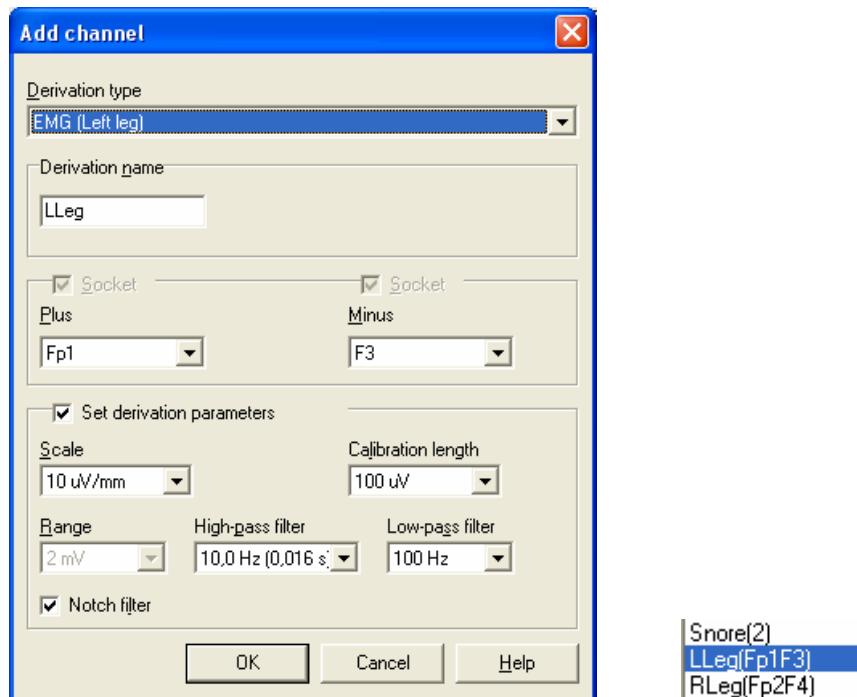


Pic. 20.32

Select the *Snore* derivation from the *Derivation type* combo box. If necessary, change the name of the derivation. The channel parameters are already set and you can change them if needed. Press “*OK*” and the derivation will be added to the montage. After the derivation name the number of additional channel to which the snore probe is connected will be shown in brackets. Keep in mind that unlike the most of probes which have *red (plus)* and *black (minus)* sockets for connection to the EEG unit the snore probe has two yellow sockets and it means that the signal polarity is not important while connecting of the probe.

To include EMG derivations from limbs to the montage (if limb movements registration is necessary) either additional polygraphic channels or free EEG channels can be used. EMG derivations from limbs are bipolar so while their recording with using free EEG channels a bipolar derivation (two sockets) must be used. At that both electrodes must be recorded from one referent.

To add the EMG channel from limb to the montage (leg movements derivations), mark the *Bipolar* radio button in the *Derivation type* and press  button (Pic. 20.27). The dialog box **Add channel** (Pic. 20.33) will appear on the screen.



Pic. 20.33

Select the *EMG (Left leg)* derivation from the *Derivation type* combo box. If necessary, change the name of the derivation. The channel parameters are already set and you can change them if needed. From the *Socket Plus* and *Socket Minus* combo boxes select the sockets of the EEG channels to which the electrodes placed on the leg will be connected. In the given example they are the sockets of *Fp1* and *F3* channels. Pay attention that both channels are registered from the same referent *A1*. Press “OK” and the derivation will be added to the montage. After the derivation name, the names of EEG sockets to which the electrodes are connected will be shown in brackets. The EMG derivation from the right leg is added in the same way.

If the additional polygraphic channel is used for the derivations registration, it is added to the montage in the same way as the abovementioned channels.

When the montages are prepared you can place the electrodes on a patient, connect them to the EEG unit and start PSG registration.

### 20.3.2.2. Setting of direct current channels

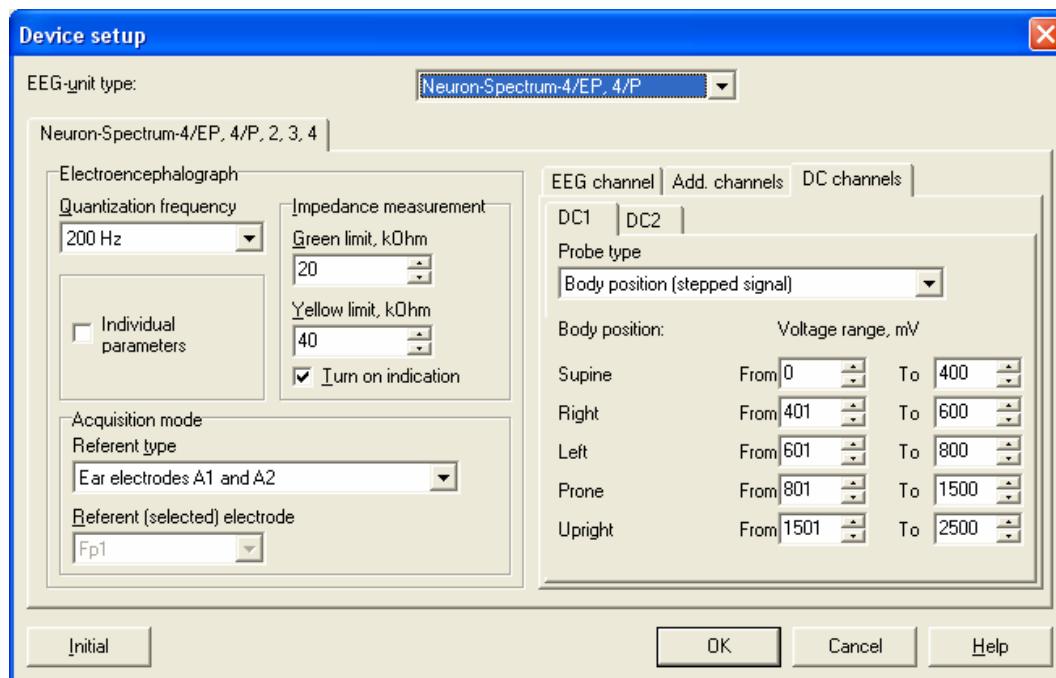
To the direct current (DC) channels the probes of two types can be connected.

The first type is the probes with stepped output signal (e.g. body position probe). Their peculiarity is that in a definite probe position (in a definite mode) the signal level changes stepwise and becomes steady at a new (another) level. Thus, the probe makes it possible to divide the output signal into several levels (positions). As it was mentioned above, the body position probes are the probes with stepped output signal and they are always connected to the direct current channels.

The second type is the probes which change the output signal in proportion to the changes of the input signal. As a rule, the input signal is changing continuously. For example, SpO<sub>2</sub> saturation probes belong to such type of probes. And for this type of probes the proper level of the probe output voltage corresponds to each level of the input signal (e.g., percentage of saturation). Besides, the dependence of the output signal on the input one is linear and can be specified by two “input-output” pairs.

Both probe types can be used with **Neuron-Spectrum** EEG systems and **Neuron-Spectrum-PSG** program makes it possible to set the parameters of direct current channel according to the selected probe type. Keep in mind that the input range of direct current channels is from -3V up to 3V and thereafter the output signal range of the probes must correspond to this range.

To connect the body position probe to the selected direct current channel, the appropriate channel parameters must be set in the setup of the EEG system hardware (the **Setup|Hardware** menu command, the  button of the toolbar). The dialog box **Device setup** will appear on the screen. Select the *DC channels* page (Pic. 20.34).



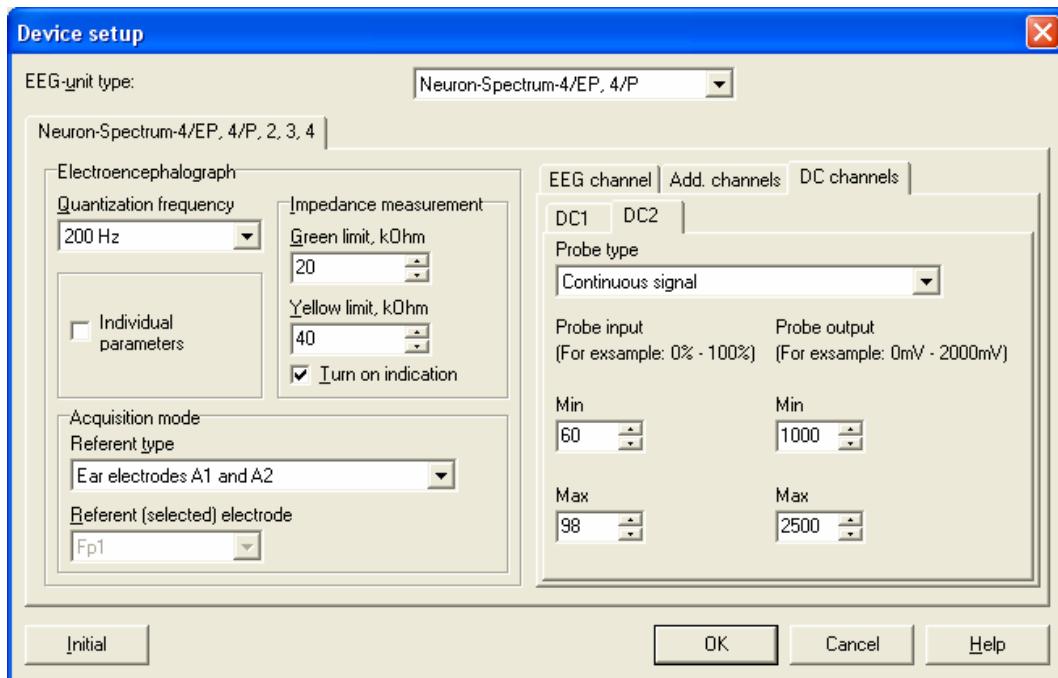
Pic. 20.34

Select one of two direct current channels to which the body position probe will be connected (e.g., the first channel – *DC1* page). Select the *Body position (stepped signal)* from the *Probe type* combo box. Then, according to the parameters of your body position probe set the output voltage range for each position of the body (for each probe state). For the body position probe included in **Neuron-Spectrum-PSG** delivery set the output voltage range is set by default. Press “OK” and save the setup parameters.

While creating a montage in which the body position derivation will be used, select the first direct current channel and select the body position derivation in the dialog box **Add DC channel** (Pic. 20.31). Then add the derivation *Body position* registered by the first direct current channel.

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To connect the probe with continuous proportional output signal (e.g., SpO<sub>2</sub> saturation probe from the individual unit) to the direct current channel, select the number of the direct current channel on the **Device setup** dialog box, *DC1* or *DC2* page (Pic. 20.34). Select *Continuous signal* on the parameters of direct current channel page (e.g., *DC2*) of the *Probe type* combo box (Pic. 20.35).



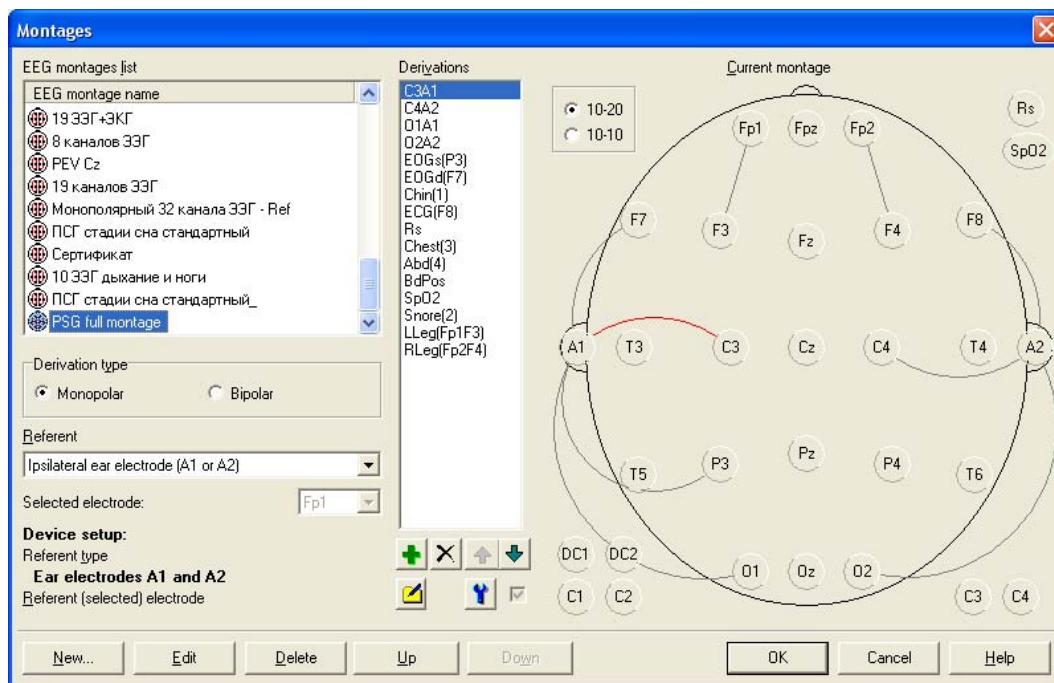
Pic. 20.35

According to the parameters of your probe, set the pair of appropriate “input-output” values of the probe. For instance, on Pic. 20.35 1000 mV output signal of the probe corresponds to 60% of input saturation signal and 2500 mV output signal corresponds to 98% of input signal. Press “OK” and save the settings.

While creating a montage in which the oxygen saturation derivation from the external probe (or any other derivation from the probe with continuous signal) will be used, select the second direct current channel and select *SpO<sub>2</sub>* or *DC* derivation in the dialog box **Add DC channel** (Pic. 20.31). Specify the name of the derivation in the *Derivation name* field and add the derivation registered by the second direct current channel.

### 20.3.2.3. Connection of electrodes and probes to the EEG unit. Use of the external patient units

After you have set the direct current channels, created and selected the montage necessary for PSG registration and placed electrodes and probes on a patient you should connect them to the EEG unit. Let's take the montage which was created before as an example (Pic. 20.36).



Pic. 20.36

The electrodes of EEG derivations are connected accordingly to  $C3$ ,  $C4$ ,  $O1$ ,  $O2$  sockets. Mastoidal electrodes are connected to  $A1$  and  $A2$  sockets. Do not forget to place ground electrode (e.g., on  $Fz$  position of the patient's head) and connect it to the grounding socket of the EEG unit.

The electrode of EOG derivation from the left eye is connected to  $P3$  socket, and the electrode of EOG derivation from the right eye – to  $F7$  socket.

The electrodes of EMG derivation from chin area are connected to “+” and “-” sockets of the first additional polygraphic channel.

The electrode of ECG derivation is connected to  $F8$  socket to the EEG unit.

The breath probe is connected to the breath channel socket on the top end part of the EEG unit.

The chest and abdominal movements probes are connected to “+” and “-” sockets of the third and fourth additional polygraphic channels. The red socket is connected to the red or “+” socket of the additional channel; the black socket is connected to the black or “-” socket of the additional channel.

$SpO_2$  probe is connected to the individual unit for  $SpO_2$  recording or to the socket for sensor connection situated on the top end part of **Neuron-Spectrum-5** EEG headbox if the  $SpO_2$  unit is built-in.

The body position probe is connected to the first direct current channel. **Neuron-Spectrum-4/P, 4/EP** EEG units have the sockets of direct current channels situated on the top end part of the device (for mini-jack connector). **Neuron-Spectrum-4/EPM, 5** EEG units have the sockets of direct current

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channels situated on the front panel of the device (for two Touch Proof connectors). To connect the probe, the adapter with two Touch Proof connectors at the end must be used (Pic. 20.8).

The snore probe is connected to the second direct current channel of the EEG unit. It makes no difference which socket of the probe cable will be connected to “+” and “-” socket as both sockets are yellow (Pic. 20.6).

The electrodes of EMG derivation from the left leg are connected to *Fp1* and *F3* sockets. As EMG channel is registered in a bipolar mode it is necessary to use two sockets. The electrodes of EMG derivation from the right leg are connected to *Fp2* and *F4* sockets.

For PSG registration it is convenient to use special switching units – **Neuron-Spectrum-PEU4** (Pic. 20.37a) and **Neuron-Spectrum-PEU5** (Pic. 20.37b) patient units.



Pic. 20.37

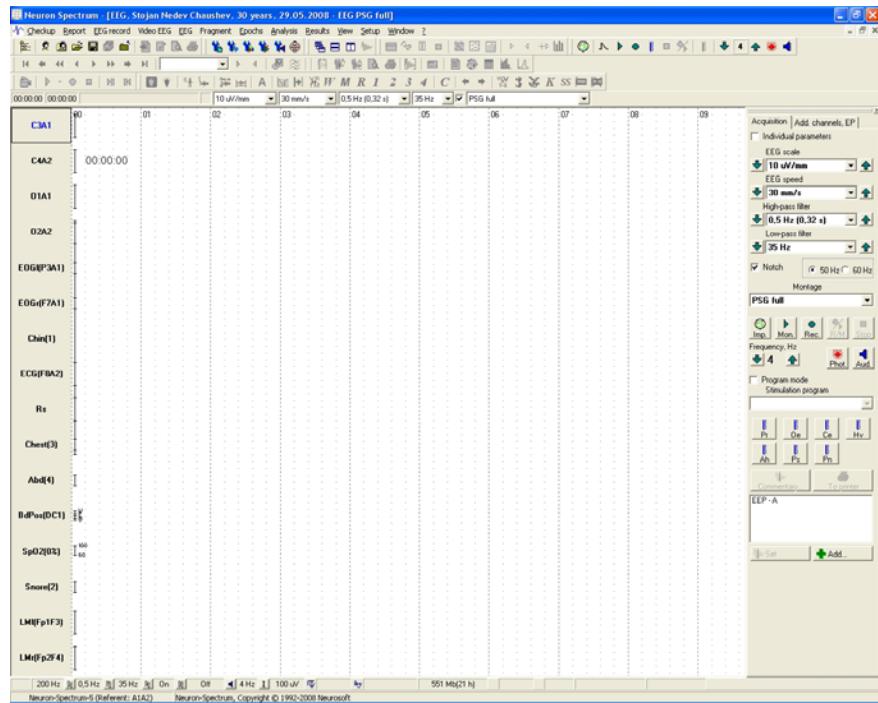
The switching unit consists of the light commutator unit and the cable, one end of which is connected to the EEG unit and the other – to the switching unit. It is easy to connect or disconnect the cable from the switching unit side that helps to stop recording for some time and leave the room without disturbance of electrodes and probes placed on a patient.

From the EEG unit side, the switching unit is connected to the electrode cap socket (for **Neuron-Spectrum-PEU5** and **Neuron-Spectrum-5** two sockets are used). Besides, several derivations come from the cable. They are connected to the sockets of all the additional channels (four polygraphic channels, breath channel, direct current channels and ECG channel for **Neuron-Spectrum-4/EPM, 5**). Electrodes and probes placed on a patient are connected to the sockets situated directly on **Neuron-Spectrum-PEU4** (**Neuron-Spectrum-PEU5**) unit.

Pull the cable socket to disconnect the cable easily from the switching unit.

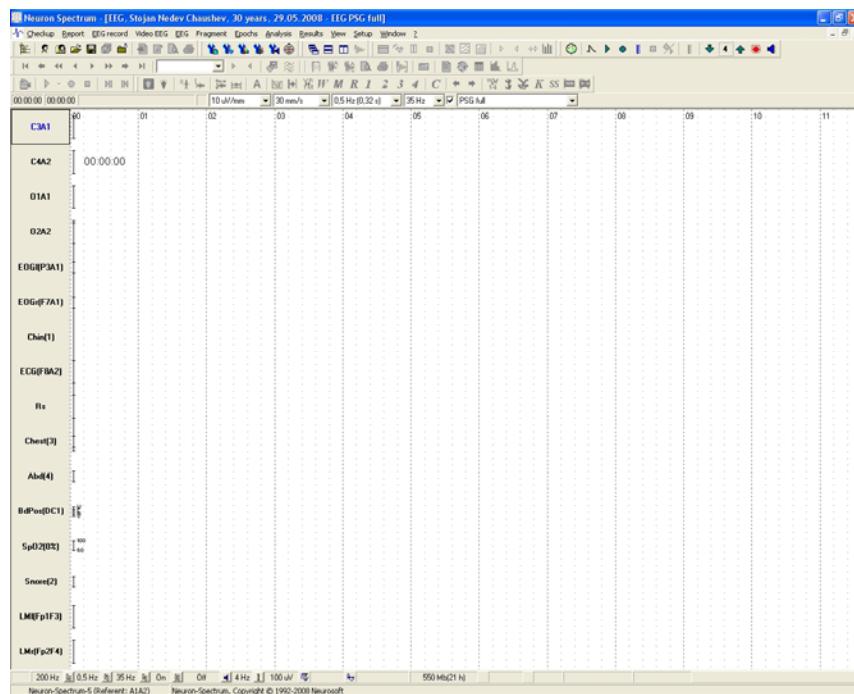
### 20.3.3. PSG REGISTRATION

After the patient's data is entered and the montage for PSG registration is selected (see chapter 6 of the present manual) the registration window will appear on the screen (Pic. 20.38).



Pic. 20.38

If you do not need the EEG recording panel on the right side of the screen, press [Ctrl+R] and it will disappear (Pic. 20.39).



Pic. 20.39

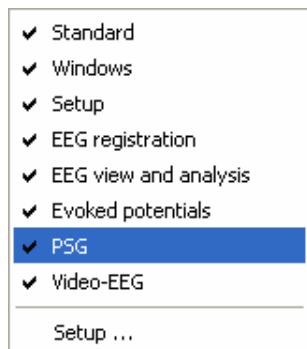
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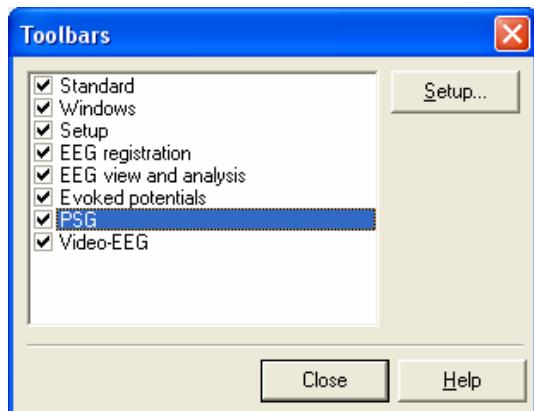
In PSG mode the PSG toolbar must be visible (Pic. 20.40). If it is invisible, click on the toolbar by the right mouse button and, in the appeared menu of the toolbar properties, click on *PSG* by the left mouse button (Pic. 20.41). Or you can select the **View|Toolbars** menu command, mark *PSG* item with a check and press “OK” in the appeared **Toolbars** dialog box (Pic. 20.42).



Pic. 20.40



Pic. 20.41



Pic. 20.42

If PSG and video recording are used together, the **Video-EEG** toolbar (Pic. 20.43) must be activated.



Pic. 20.43

During PSG registration the following toolbar buttons can be used:

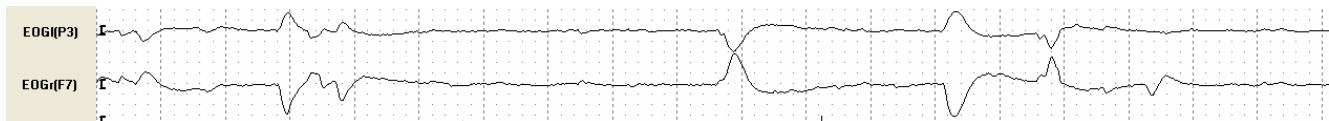
1. “*Light is off*” - to set “*Light is off*” marker on PSG.
2. “*Light is on*” - to set “*Light is on*” marker on PSG.
3. “*Patient is not lying*” - to set “*Patient in upright position*” marker on PSG.
4. “*Patient is lying*” - to set “*Patient in supine position*” marker on PSG.
5. “*Start of patient’s movements*” - to set “*Start of patient’s movements*” marker on PSG.
6. “*End of patient’s movements*” - to set “*End of patient’s movements*” marker on PSG.

The correct setting of these markers during the recording will provide the proper PSG analysis in future.

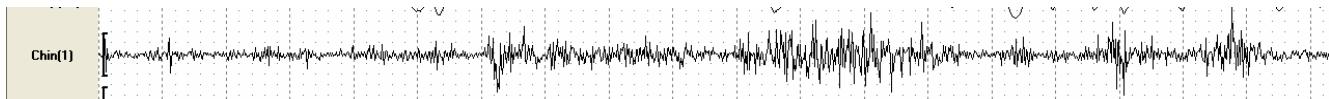
After checking the quality of electrodes placement start the monitoring (**EEG record|Monitoring** menu command,  toolbar button) and make sure that the signals from all the placed probes are registered correctly. Start the recording (**EEG record|Record** menu command,  toolbar button). At the beginning of the recording biocalibration must be carried out. Biocalibration is the set of tests verifying and recording the validity of operation of all the probes and PSG channels in response to the various maneuvers of a patient. During biocalibration you can select the proper scale of signal displaying on the monitor screen and also correct the values of filters. The maneuvers which are usually carried out during biocalibration are described below:

- PSG registration in calm and relaxed state – lie on back with open eyes for 30 seconds.
- Checking of EOG channels (Pic. 20.44) – without moving the head look right, then left two times.
- Checking of EOG channels (Pic. 20.44) – without moving the head look up, then down two times.
- Checking of EOG channels (Pic. 20.44) – blink slowly and diligently 5-8 times.
- Checking of EMG channel from chin area (Pic. 20.45) – clench the teeth and try to move them.
- Checking of EMG channels from legs (Pic. 20.46) – bend and straighten the left foot several times, bend and straighten the right foot several times.
- Checking of breath and movements channels (Pic. 20.47) – breathe calm and slowly (“inhale-exhale”).
- Checking of breath and movements channels (Pic. 20.47) – stop breathing for 10-15 seconds.
- Checking of snore channel (Pic. 20.48) – imitate snoring several times.
- Checking of body position probe – take left lateral position and lie for 20-30 seconds then take right lateral position and lie for 20-30 seconds.
- PSG registration in calm and relaxed state – lie on back with closed eyes for 30 seconds (Pic. 20.49).

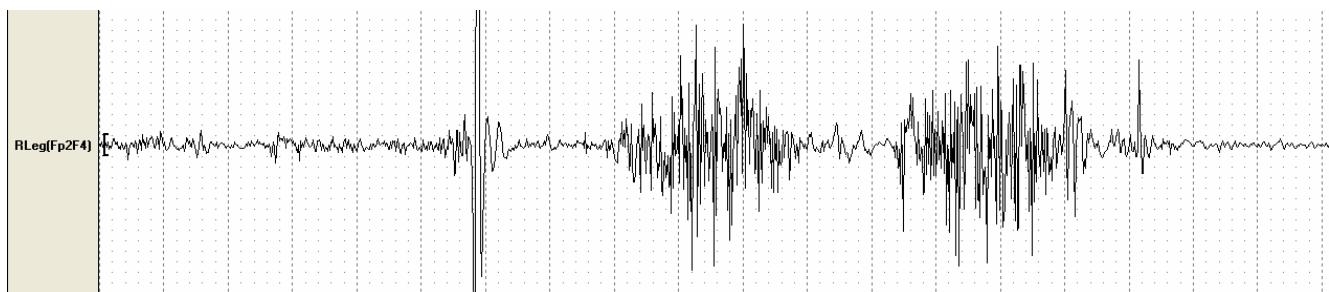
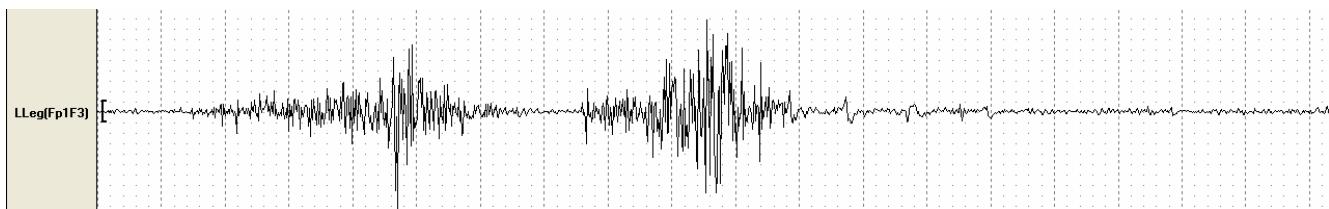
It is recommended to mark the beginning of each maneuver. At the end of PSG registration bio-calibration must be repeated to record the state of electrodes, probes and PSG channels.



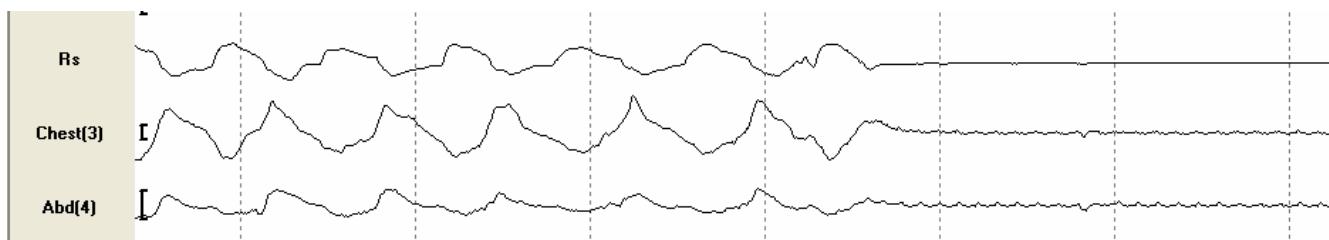
Pic. 20.44



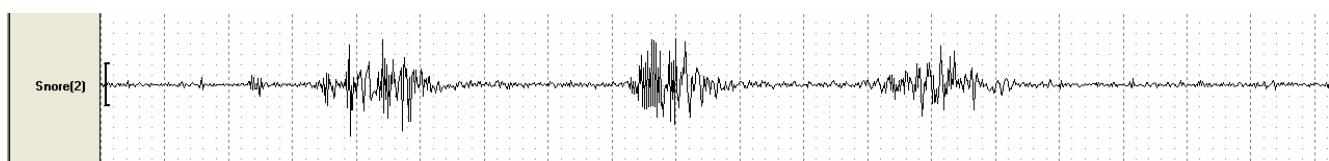
Pic. 20.45



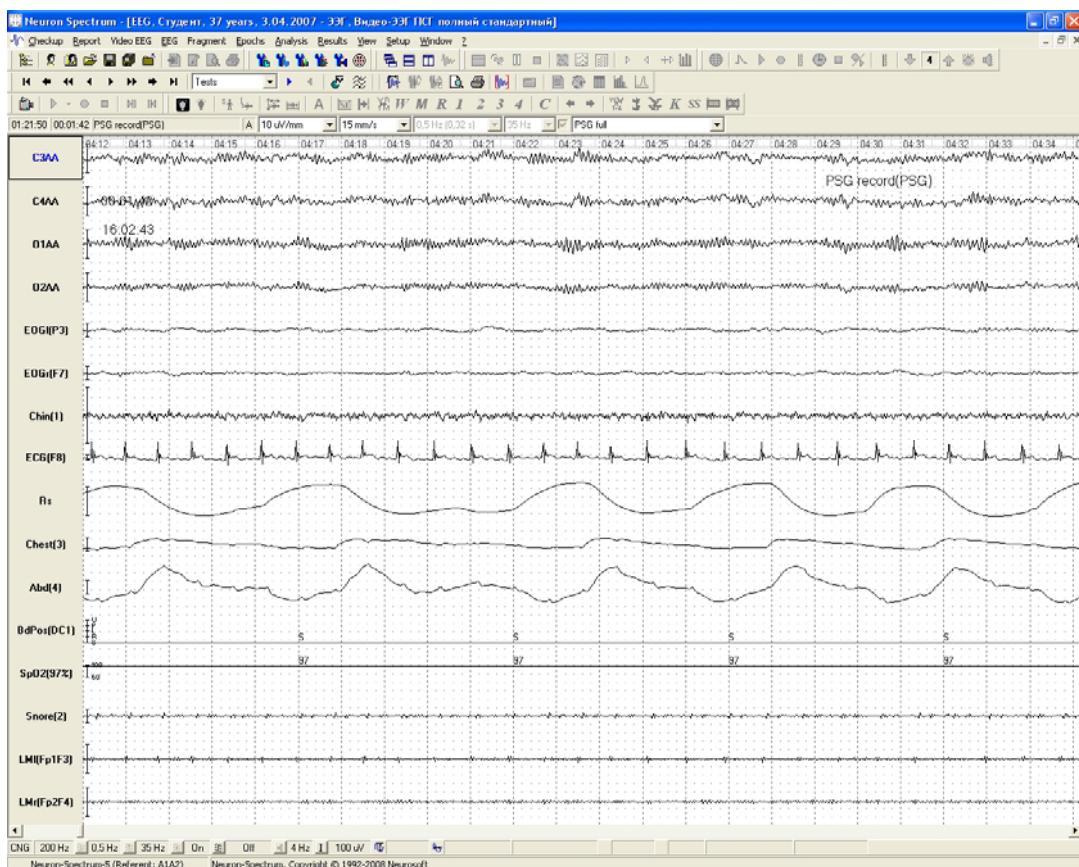
Pic. 20.46



Pic. 20.47



Pic. 20.48



Pic. 20.49

When the maneuvers of biocalibration are over, PSG recording can be started. During biocalibration the record mode is already on. The patient is left in the room alone; the light is turned off. When the light is turned off, set the marker “*Light is off*” on the record. To set this marker, press button on **PSG** toolbar. During the process of recording if the light is turned on or off you can mark these events by pressing “*Light is on*” (when the light is turned on) and “*Light is off*” (when the light is turned off). After the sleep, when the recording is over and the light is turned on in the room, do not forget to set the marker “*Light is on*”. It is strongly recommended to repeat the biocalibration process at the end of the PSG record after morning awakening of the patient. It will help to determine any changes in electrodes placement after night registration.

If, during PSG registration, the patient is being watched by means of video control system or visually, the markers “*Start of patient’s movements*” and “*End of patient’s movements*” can be used to record the time intervals of the patient’s movements. To set these markers, use either or button on **PSG** toolbar. In future, during PSG analysis, this information will be used by the system.

If, during PSG registration, the body position channel is not used, then, during the recording, two positions of the patient can be marked - “*Patient is lying*” and “*Patient is not lying*”. To set the marker “*Patient is lying*”, press button on **PSG** toolbar; to set the marker “*Patient is not lying*”, press button on **PSG** toolbar. The marking of patient’s position in the absence of the body position channel during the recording is also necessary at the process of PSG analysis.

All the abovementioned markers can also be set during PSG review and analysis.

If, during the recording, the patient wants to leave the room (e.g., he wants to visit WC), proceed as follows:

- stop recording by **EEG record|Stop** menu command ( button on **EEG record** toolbar);
- if the patient is connected to the EEG unit directly, detach the EEG unit from the stand and give it to the patient not to damage the fixation of electrodes and probes;
- when the patient comes back, put him to bed and place the EEG unit to the stand;
- start recording by **EEG record|Record** menu command ( button on EEG record toolbar).

If, during the recording, either **Neuron-Spectrum-PEU4** or **Neuron-Spectrum-PEU5** is used, disconnect the cable going from the EEG system to the switching unit. For this purpose, pull the cable socket to disconnect the cable easily from the switching unit. When the patient comes back, connect the cable again.

If, during PSG recording, **Neuron-Spectrum-Video** video EEG program is used, see the peculiarities of work with the program in Chapter 19.

When PSG recording is over, stop it by **EEG record|Stop** menu command ( button on **EEG record** toolbar) and save the results in the database by **Checkup|Save** menu command or by pressing  button on the toolbar. After that, disconnect electrodes and probes from the patient.

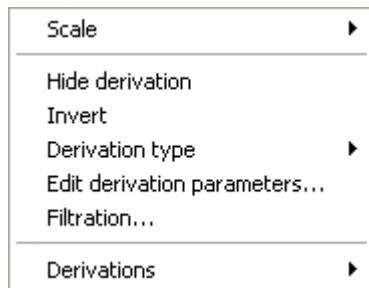
### 20.4. PSG REVIEW AND ANALYSIS

The recorded PSG is stored in the database. How to load a checkup from the database for review and analysis is described in Chapter 8 of this manual.

**Neuron-Spectrum-PSG** enables to make the following types of PSG analysis:

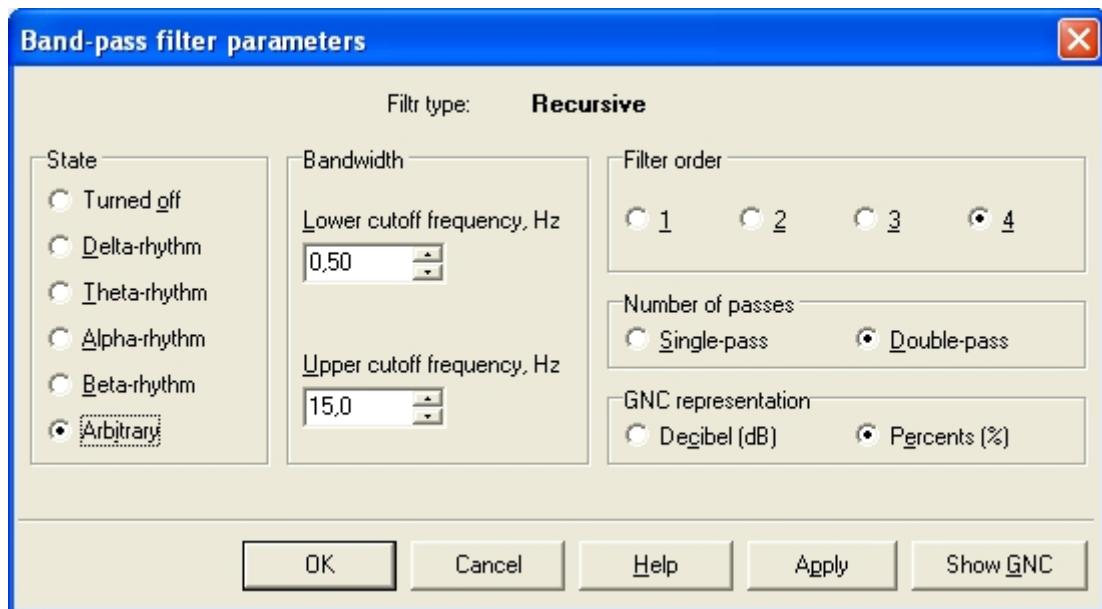
- sleep stages analysis – manual and automatic setting of sleep stages, creating of hypnogram, automatic calculation of large set of hypnogram parameters, creating report including graphs and calculated data;
- sleep-disordered breathing analysis – creating trends of ECG, body position, saturation level, automatic search and classification of apnea and hypopnea, desaturation, snore and periodic limb movements episodes, calculation of disordered breathing parameters, creating report including graphs and calculated data;
- combined analysis of sleep stages and sleep-disordered breathing.

For instance, the parameters of a channel were set wrong during PSG recording. Click on the derivation name by the right mouse button and select the **Filtration** menu command (Pic. 20.50) in the appeared menu of the channel properties.



Pic. 20.50

Then the **Band-pass filter parameters** dialog box will appear on the screen (Pic. 20.51).



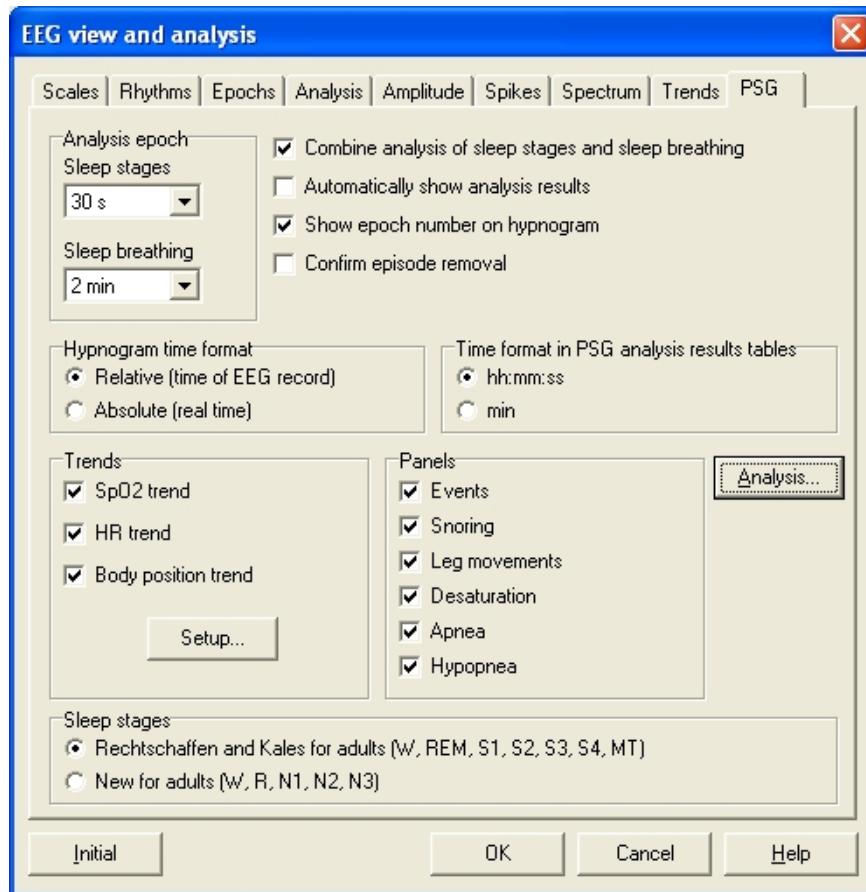
Pic. 20.51

Select the parameters you need and press “OK”. The selected derivation will be filtered by the preset band-pass filter.

If necessary, you can also change the scale of the selected derivation (the **Scale** command in the channel properties menu), invert a signal (the **Invert** command) in case the wrong polarity was selected or change derivation type (the **Derivation type** command) if the derivation type was selected wrong in the montage in the same way.

#### 20.4.1. NEURON-SPECTRUM-PSG SETUP FOR PSG ANALYSIS

To set the parameters of PSG review and analysis, use **Setup|Analysis** menu command ( button on the toolbar). **EEG view and analysis** dialog box will appear on the screen. Select *PSG* page (Pic. 20.52).



Pic. 20.52

*Analysis epoch. Sleep stages.* The value of analysis epoch used during sleep stages analysis and hypnogram creation. The recommended value is 30 seconds.

*Analysis epoch. Sleep breathing.* The value of analysis epoch used during sleep-disordered breathing analysis. The recommended value is 2 minutes.

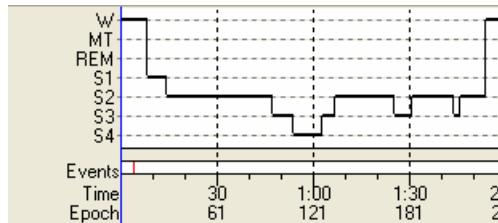
These values are used in a separate analysis of sleep stages and sleep-disordered breathing. If a combined analysis is used, then the analysis epoch of sleep stages is used.

*Combine analysis of sleep stages and sleep breathing.* If the check box is not checked, the sleep stages and sleep-disordered breathing are analyzed separately. At that the analysis epoch of its own is used for each type of analysis. If the check box is checked, both types of analysis are performed simultaneously in one screen. At that the analysis epoch of sleep stages is used. In this mode the process of analysis is performed as follows:

- creating of hypnogram – sleep stages analysis;
- sleep-disordered breathing analysis with consideration for hypnogram structure;
- creating a general checkup report.

*Automatically show analysis results.* If the check box is checked, then, while loading the analyzed checkup from the analysis results tables database, the graphs of hypnogram, trends and episodes are shown on the screen automatically.

*Show epoch number on hypnogram.* If the check box is selected, besides time scale, the number of epoch is also shown on the graph of hypnogram (Pic. 20.53).

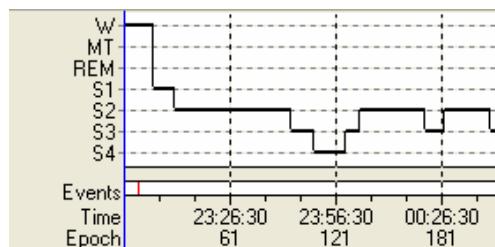


Pic. 20.53

*Confirm episode removal.* If the check box is not selected, the removal of disordered breathing (apnea and hypopnea), desaturation, snore and limb movement episodes is done without confirmation.

*Hypnogram time format.* The time scale on a hypnogram can be shown in two formats:

- in relative format – time of EEG record, i.e. time is measured from the start of recording from zero (Pic. 20.53);
- in absolute format – real time of the day shown on the scale (Pic. 20.54).



Pic. 20.54

*Time format in PSG analysis results tables.* In the analysis results tables the data with time format value can be represented either as one number – minutes (Pic. 20.55) or in the format of HH:MM:SS where HH – hours, MM – minutes, SS – seconds (Pic. 20.56).

Total time in bed (TB), min	06:25:50
Falling asleep duration, min	06:03:03
Total sleep time (TST), min	05:50:03

Pic. 20.55

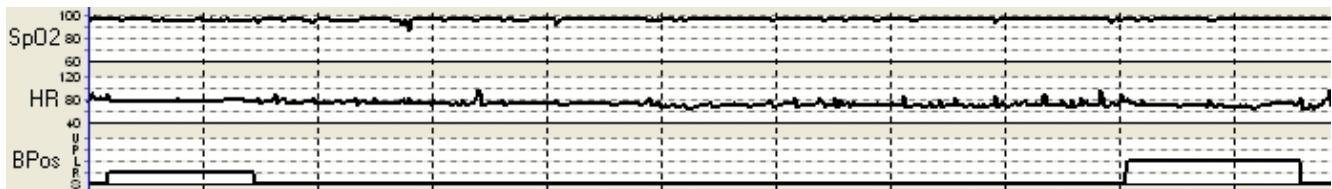
Total time in bed (TB), min	385.8
Falling asleep duration, min	363.1
Total sleep time (TST), min	350.1

Pic. 20.56

*Trends.* If the check boxes *SpO<sub>2</sub> trend*, *HR trend*, *Body position trend* are checked, the graphs of the corresponding trends are shown in the mode of sleep-disordered breathing analysis (if in PSG record the corresponding derivations are present (*SpO<sub>2</sub>*, *ECG*, *Body position*) (Pic. 20.57)). It is important that the type of these derivations (which is selected during the montage creation and can be

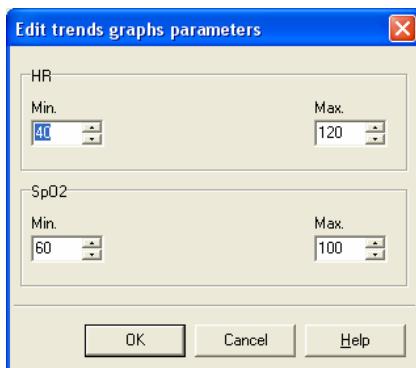
## Neuron-Spectrum Program

changed immediately in the process of PSG review and analysis) is the very type of *SpO<sub>2</sub>*, *ECG* and *Body position*. If the corresponding check box is not checked, the trend of the channel is not displayed.



Pic. 20.57

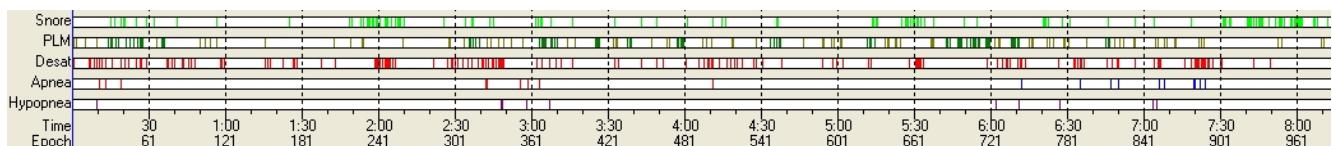
While pressing “*Setup*” button, the dialog box **Edit trends graphs parameters** appears on the screen (Pic. 20.58).



Pic. 20.58

In this dialog box it is possible to set the maximum and minimum values of *HR* and *SpO<sub>2</sub>*, which are shown on graphs of the trends (the range of these signals on trends). The low level signal displayed on *SpO<sub>2</sub>* channel is also limited by the minimum signal. *Body position* signal is stepped discrete so, on the graph of body position trend, there are always 5 steps – positions: supine, right, left, prone and up-right positions.

*Panels*. If the corresponding check box of the group is checked, then the panels of the corresponding episodes are shown below the graphs of the trends (Pic. 20.59).



Pic. 20.59

*Events* panel is always displayed, when the corresponding check box is selected.

*Snoring* panel is displayed, if in PSG record the snore channel is activated and this check box is checked.

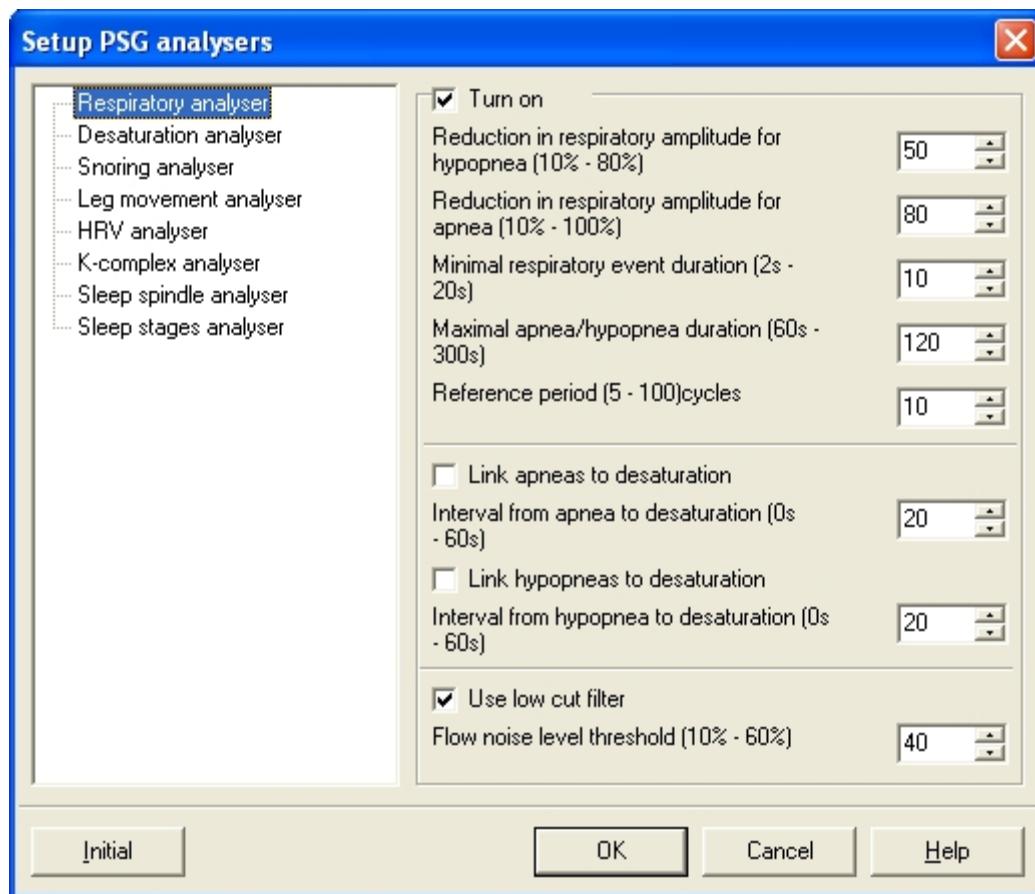
*Leg movements* panel is displayed, if in PSG record even one leg movements channel (EMG from the right or left leg) is activated and this check box is selected.

*Desaturation* panel is displayed, if in PSG record *SpO<sub>2</sub>* channel is present and this check box is checked.

*Apnea* and *Hypopnea* panels are displayed if in PSG record breath channel and also chest and abdominal movements channels are present and these check boxes are checked.

On the panels the episodes of snoring, leg movements, desaturation, apnea and hypopnea are displayed. Besides the corresponding check boxes must be checked, these channels must be of particular type (e.g., snore channel – *Snore* type, movements channels – *Chest movements* and *Abdominal movements* type etc.). If the type of channels does not correspond to the proper type, the panel will not be displayed.

While pressing “*Analysis*” button, **Setup PSG analysers** dialog box appears on the screen to set the automatic analysers parameters of breathing disorders, desaturation, snore episodes etc. (Pic. 21.60).



Pic. 20.60

The dialog box consists of several pages, each for setting of the corresponding analyser.

*Sleep stages*. By means of these check boxes you can select either classical Rechtschaffen & Kales scoring system for sleep stages for adults (W, S1, S2, S3, S4, REM, MT) or new scoring system for sleep stages for adults suggested by AASM (W, N1, N2, N3, R) where the fourth sleep stage and “movement time” epochs are absent.

#### **20.4.1.1. Parameters of respiratory analyser (Pic. 20.60)**

*Turn on.* If the check box is checked, the respiratory analyser will be active during the sleep-disordered breathing analysis.

*Reduction in respiratory amplitude for hypopnea.* The analyser fixes a hypopnea episode during the reduction of respiratory wave amplitude for the value more than indicated in this line.

*Reduction in respiratory amplitude for apnea.* The analyser fixes an apnea episode during the reduction of respiratory wave amplitude for the value more than indicated in this line.

*Minimal respiratory event duration.* The presence of apnea or hypopnea episode is fixed by the analyzer if the corresponding reduction in the respiratory wave amplitude has been lasting for not less than it is indicated in this line.

*Maximal apnea/hypopnea duration.* The presence of apnea or hypopnea episode is fixed by the analyzer if the corresponding reduction of the respiratory wave amplitude has been lasting for not less than it is indicated in this line.

*Reference period.* The respiratory analyser calculates constantly the value of maximal respiratory wave amplitude to measure correctly the reduction of respiratory wave amplitude and fix the apnea or hypopnea episodes. This parameter indicates under which last respiratory cycles before the current analyzable cycle the maximum amplitude is calculated, i.e. 100% base value.

*Link apneas to desaturation.* If this check box is checked, the presence of apnea episodes is determined only if the corresponding reduction in the respiratory wave amplitude is accompanied with desaturation episode.

*Interval from apnea to desaturation.* The maximal time when desaturation episode must start after the beginning of apnea episode.

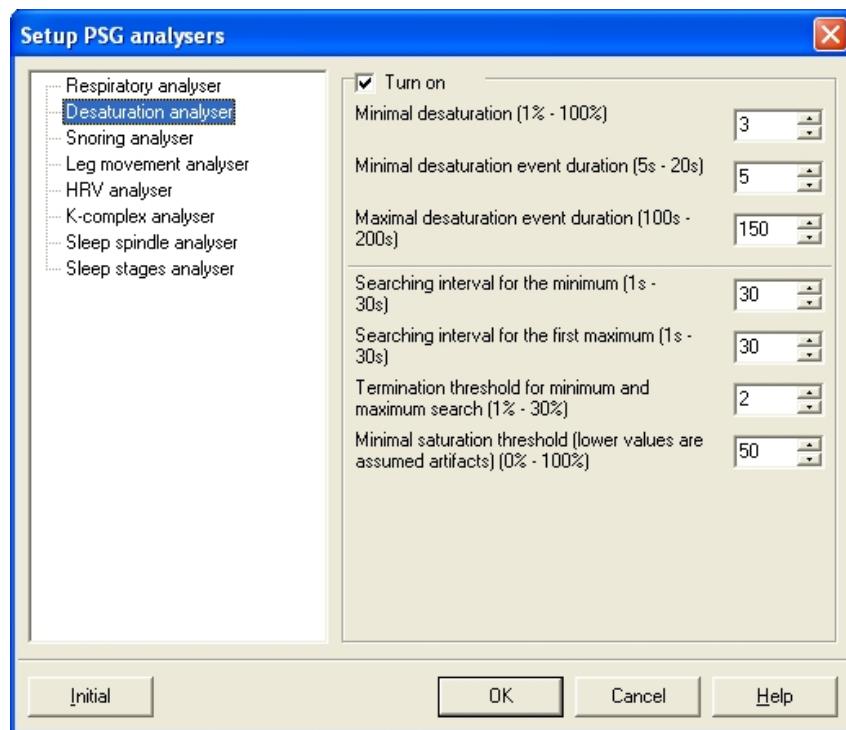
*Link hypopneas to desaturation.* If the check box is checked, the presence of hypopnea episodes is determined only if the corresponding reduction in the respiratory wave amplitude is accompanied with desaturation episode.

*Interval from hypopnea to desaturation.* The maximal time when desaturation episode must start after the beginning of hypopnea episode.

*Use low cut filter.* It determines whether the analyser uses the breath channel filtration during the analysis. It is recommended to select this check box if a thermistor or thermocouple probe is used.

*Flow noise level threshold.* While calculating the maximal amplitude for a certain quantity of cycles, respiratory cycles with the amplitude lower than this threshold are not taken into account.

#### 20.4.1.2. Parameters of desaturation analyser (Pic. 20.61)



Pic. 20.61

*Turn on.* If the check box is checked, the desaturation analyser will be active during the sleep-disordered breathing analysis.

*Minimal desaturation.* The reduction in desaturation from the base value, which is considered as desaturation.

*Minimal desaturation event duration.* The minimal value of desaturation event duration. If reduction in saturation has been lasting less than the indicated time this reduction is not considered as desaturation.

*Maximal desaturation event duration.* The maximal value of desaturation event duration. If reduction in saturation has been lasting more than the indicated time this event is not considered as desaturation.

The other parameters are used by the analyser for searching the events of desaturation which are not recommended to be changed without knowledge of operation algorithm for searching the events of desaturation.

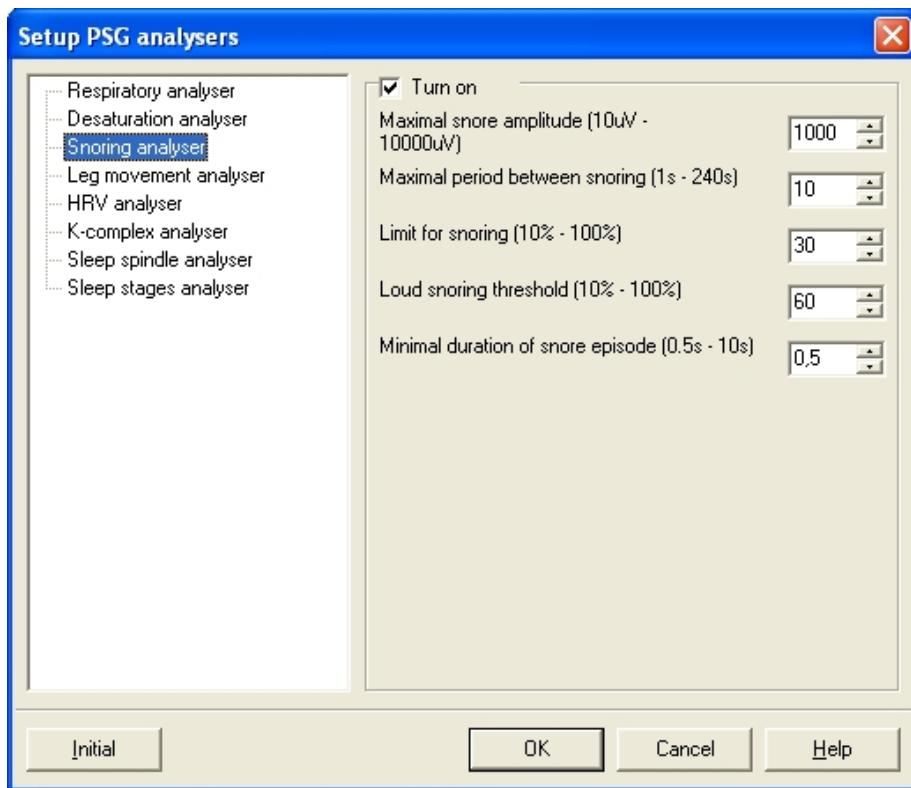
*Searching interval for the minimum.* The maximum time interval on which the search for saturation minimum is conducted after the beginning of desaturation event is detected.

*Searching interval for the first maximum.* The maximal time interval on which the inverted search for desaturation maximum is conducted from the detected point of minimum.

*Termination threshold for minimum and maximum search.* The range of deviation in saturation values in which the changes in saturation are ignored.

*Minimal saturation threshold (lower values are assumed artifacts).* The minimal saturation value. The reduction in saturation lower than the indicated value is considered as artifact.

#### 20.4.1.3. Parameters of snoring analyser (Pic. 20.62)



Pic. 20.62

*Maximal snore amplitude.* The maximal signal value produced by the snore probe. It is usually specified in the technical parameters of the used probe.

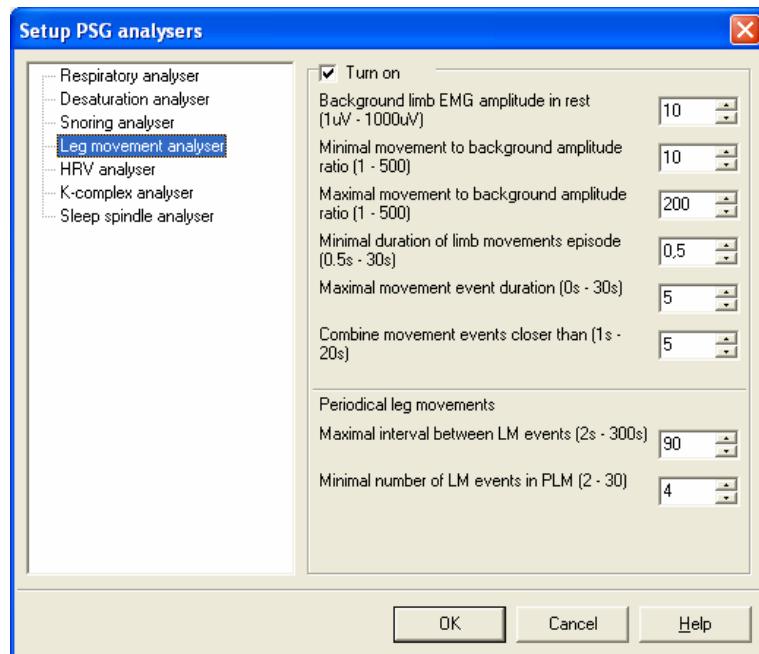
*Maximal period between snoring.* The maximal period between separate snores when the sequence of snores is still considered to be one sleep event with snoring.

*Limit for snoring.* The minimal signal amplitude of snore channel which elevation is fixed as the event of snoring. The threshold is assigned in percents from the maximal snoring amplitude.

*Loud snoring threshold.* The minimal signal amplitude of snore channel which elevation is fixed as the event of loud snoring. The threshold is assigned in percents from the maximal snoring amplitude.

*Minimal snore episode duration.* The minimal time interval during which the snoring must be registered for analyser to fix the event of snoring. If the snoring duration is less than the indicated interval, the event of snoring is not fixed.

#### 20.4.1.4. Parameters of leg movement analyser (Pic. 20.63)



Pic. 20.63

The parameters for searching of single limb movement events:

*Background limb EMG amplitude in rest.* The average value of EMG signal from the limb in rest.

*Minimal movement to background amplitude ratio.* The minimal value of EEG amplitude during limb movement. The less amplitude value is not considered as limb movement.

*Maximal movement to background amplitude ratio.* The maximal value of EEG amplitude during limb movement. If the signal amplitude is more than this value, EMG signal is considered as artifact.

*Minimal movement event duration* assigns the minimal time interval during which a limb movement must be fixed (EMG amplitude must be between the minimal and maximal values for movement) to be classified as a limb movement event.

*Maximal movement event duration* assigns the maximal time interval during which a limb movement event is fixed.

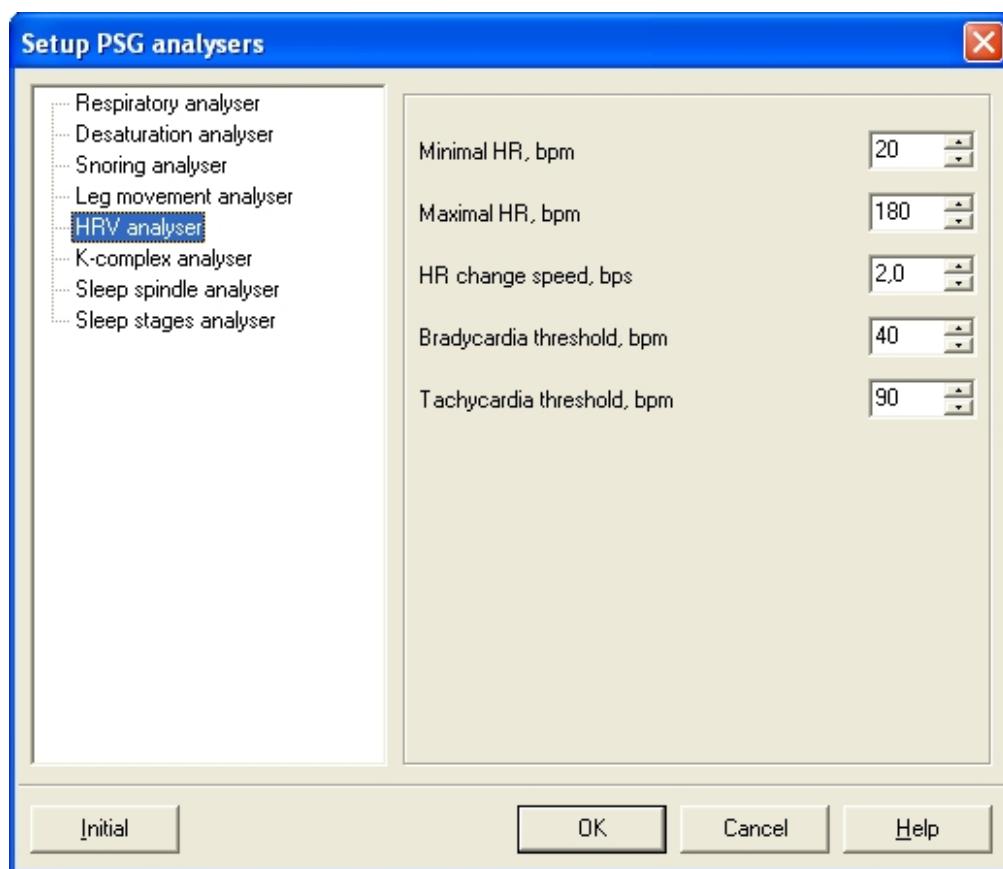
*Combine movement events closer than...* If two limb movement events are separated from each other by the time interval less than indicated, they are combined in one leg movement event.

The parameters for searching of periodical limb movement events:

*Maximal interval between LM events.* If single limb movement events are separated from each other by the time interval less than indicated, they are combined in periodical limb movements' event.

*Minimal number of LM events in PLM.* The minimal number of single limb movement events necessary for making of periodical limb movements' event. If single limb movement events in specified number or more are separated from each other by the time interval less or equal to the value of the preceding parameter, these single events are combined in one periodical limb movements' event.

#### 20.4.1.5. Parameters of HRV analyser (Pic. 20.64)



Pic. 20.64

*Minimal HR.* The minimal HR value is taken into account during analysis. The lesser values are considered to be artifacts.

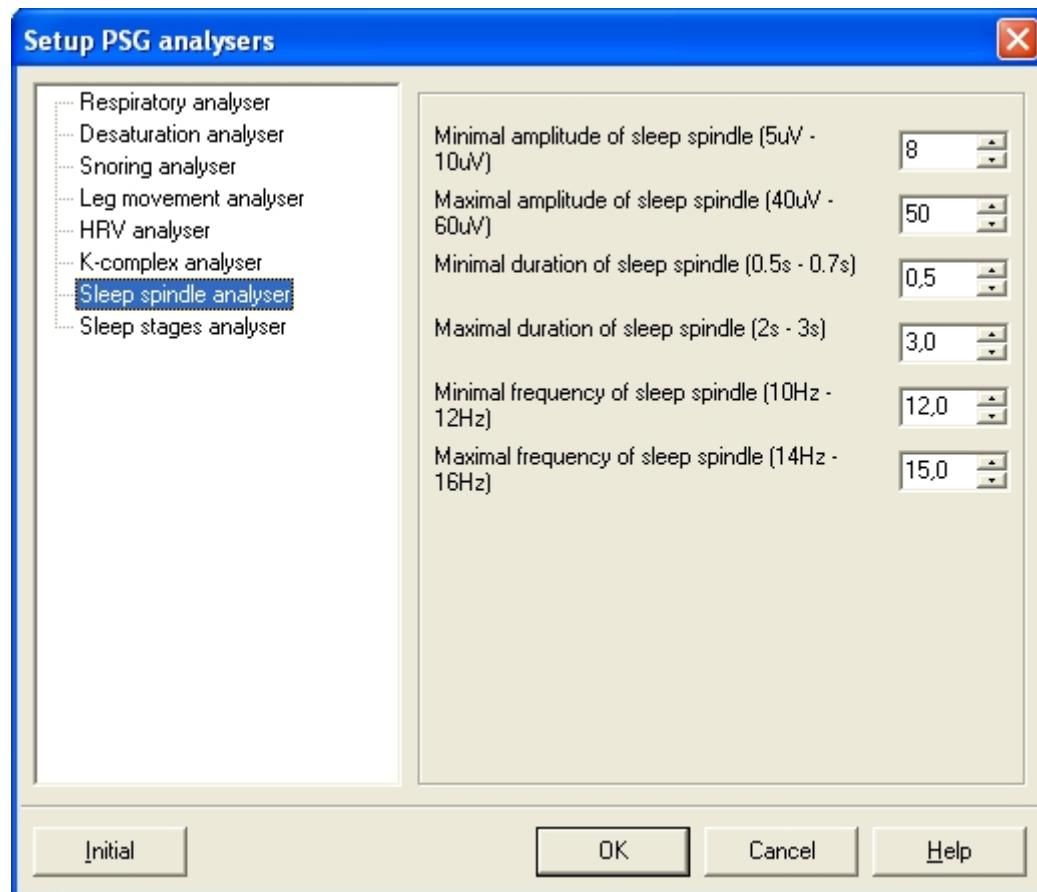
*Maximal HR.* The maximal HR value is taken into account during analysis. The greater values are considered to be artifacts.

*HR change speed.* The maximal value of HR change speed, when these changes are taken into account during analysis. In case HR speed changes faster, these changes are considered to be artifacts.

*Bradycardia threshold.* In case HR values are less than the specified threshold, they are classified as bradycardia.

*Tachycardia threshold.* In case HRV values are more than the specified threshold, they are classified as tachycardia.

#### 20.4 1.6. Parameters of sleep spindle analyser (Pic. 20.65)



Pic. 20.65

*Minimal amplitude of sleep spindle.* Minimal amplitude of sleep spindle oscillations.

*Maximal amplitude of sleep spindle.* Maximal amplitude of sleep spindle oscillations.

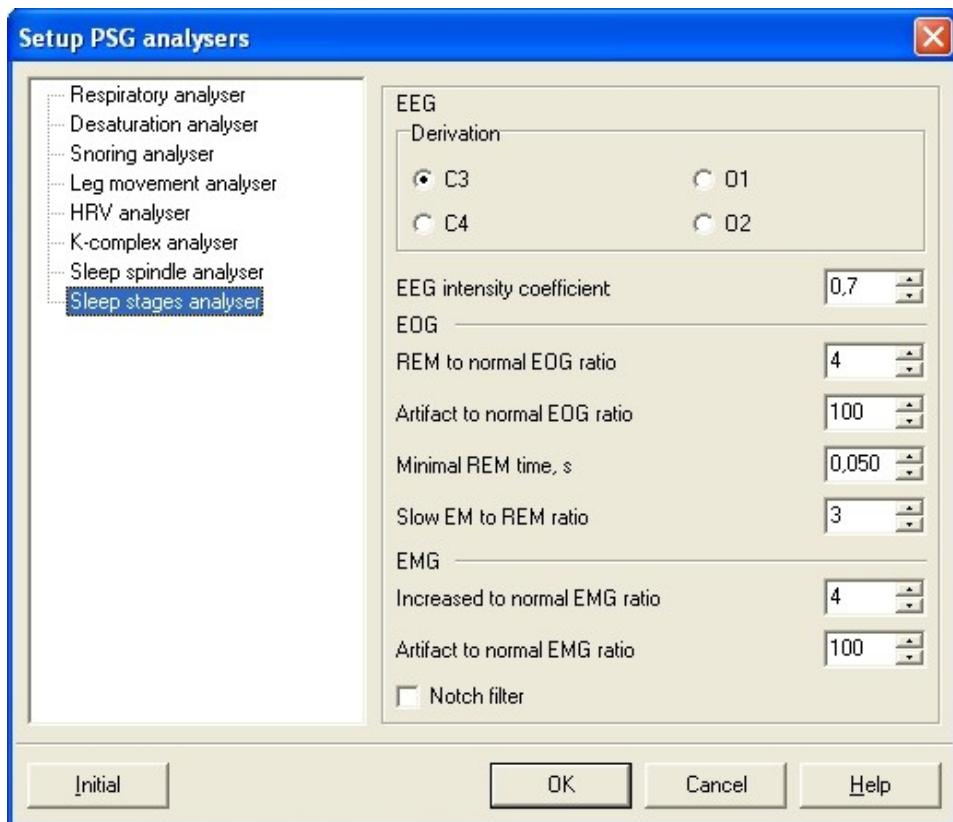
*Minimal duration of sleep spindle.* Minimal duration of one sleep spindle episode.

*Maximal duration of sleep spindle.* Maximal duration of one sleep spindle episode.

*Minimal frequency of sleep spindle.* Minimal value of sleep spindle frequency.

*Maximal frequency of sleep spindle.* Maximal value of sleep spindle frequency.

### 20.3.1.9.Parameters of sleep stages analyser (Pic. 20.66)



Pic. 20.66

*Derivation.* Selection of EEG derivation on which the automatic sleep stages scoring is carried out.

*EEG intensity coefficient.* EEG intensity coefficient. The value varies from 0.5 up to 0.9. The recommended value is 0.7.

*REM to normal EOG ratio.* Minimal REM amplitudes to normal EOG ratio.

*Artifact to normal EOG ratio.* Minimal artifact amplitudes to normal EOG ratio.

*Minimal REM time.* Minimal REM episode time.

*Slow EM to REM ratio.* Minimal slow eyes movement to REM duration ratio.

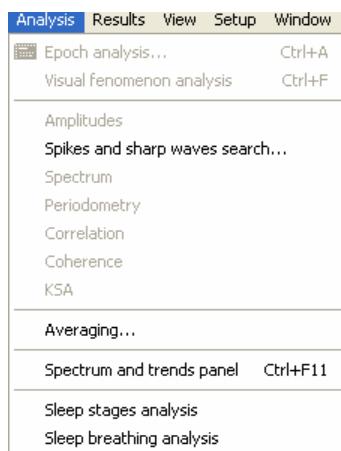
*Increased to normal EMG ratio.* Minimal increased EMG from chin area to normal EMG signal amplitude ratio.

*Artifact to normal EMG ratio.* Minimal EMG signal artifact from chin area to normal EMG signal amplitude ratio.

*Notch filter.* If this check box is checked, the notch filter for EMG channel is used.

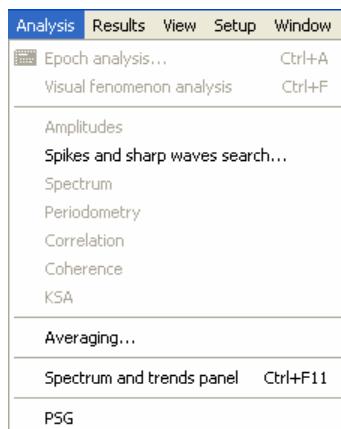
#### 20.4.2. ANALYSIS OF SLEEP STAGES

If in PSG review and analysis setup dialog box *Combine analysis of sleep stages and sleep breathing* check box is not checked, it is possible to make the analysis of sleep stages and sleep-disordered breathing separately. In the **Analysis** menu there are two commands: **Sleep stages analysis** and **Sleep breathing analysis** which start either the mode of sleep stages analysis or the mode of sleep-disordered breathing analysis (Pic. 20.67).



Pic. 20.67

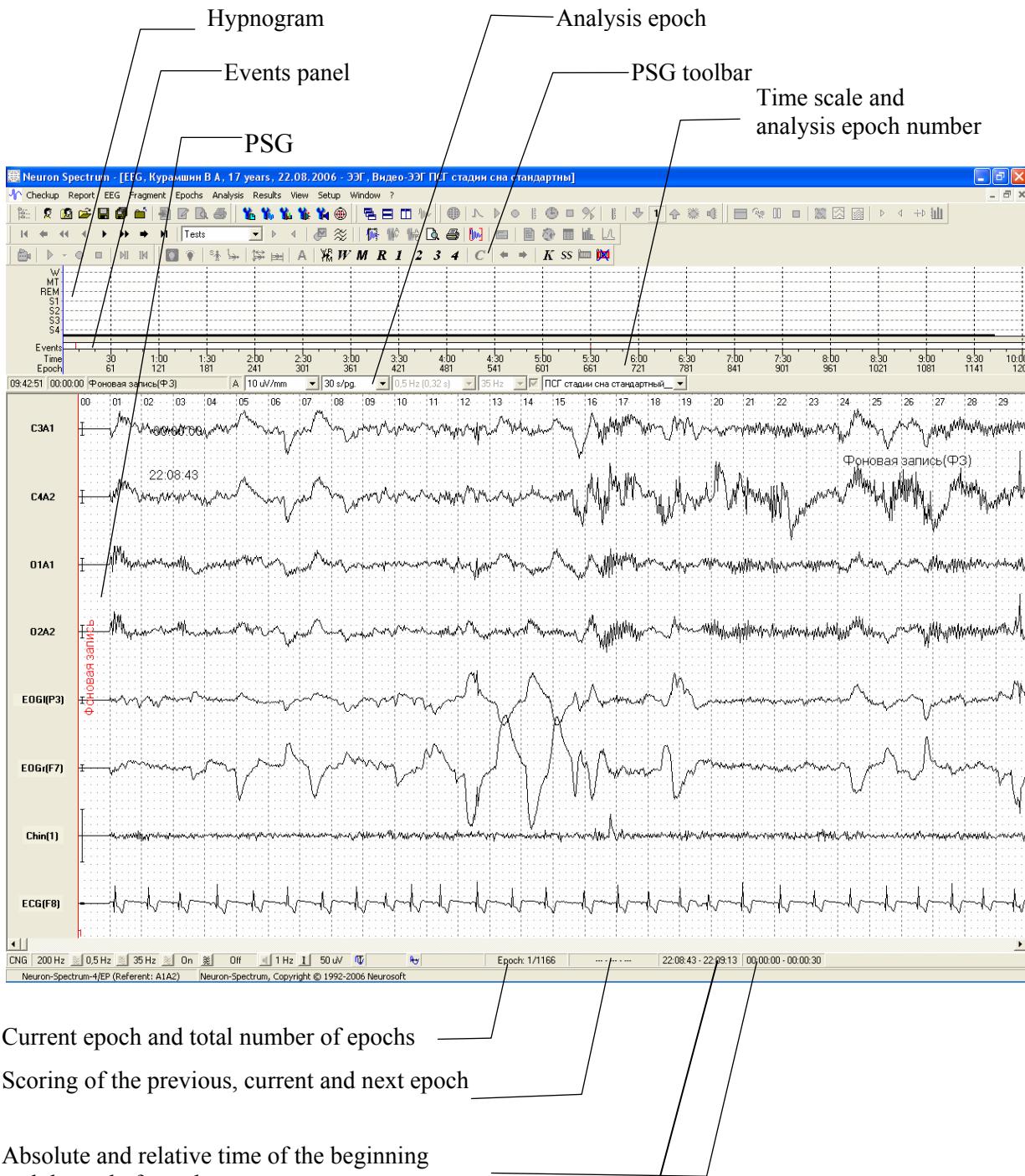
If this check box is selected, in the **Analysis** menu there is only one **PSG** command (Pic. 20.68) which starts the mode of combined PSG analysis.



Pic. 20.68

## Neuron-Spectrum Program

To run the sleep stages analysis and to create a hypnogram, select the **Analysis|Sleep stages analysis** menu command. The program will switch to the mode of creating a hypnogram (Pic. 20.69).



Pic. 20.69

In the mode of sleep stages analysis **Hypnogram** and **Events panel** are displayed on the screen.

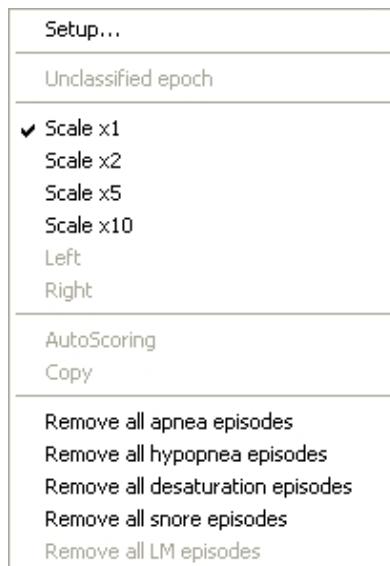
**Hypnogram** is a graph, where the time (analysis epoch number) is marked on X-axis and the sleep stages for each epoch are marked on Y-axis. When all the points are connected, a polygonal line (i.e. a hypnogram) comes out. If an epoch of analysis is equal to 30 seconds, one point corresponds to each epoch of analysis on the graph. Conventional signs of sleep stages (by Rechtschaffen & Kales):

- **W** – awake state (**W** stage).
- **MT** – movement time. If movement activity exceeds 50% of epoch time, this epoch is marked as **MT** stage.
- **REM** – fast sleep stage (rapid eye movement, **REM** stage).
- **S1, S2, S3, S4** – the first, second, third and fourth stages of sleep (**S1, S2, S3, S4** stages).

Conventional signs of sleep stages (according to new scoring system by AASM):

- **W** – awake state (**W** stage).
- **REM** – fast sleep stage (rapid eye movement, **REM** stage).
- **N1, N2, N3** – the first, second and third stages of slow sleep.

If necessary a hypnogram can be scaled by width, i.e. one epoch of analysis can be displayed on the hypnogram by large quantity of points. Along with the hypnogram all the panels which are displayed under the hypnogram are also scaled. To change the horizontal scale of the hypnogram, click on it with the right mouse button. The menu of hypnogram properties will appear on the screen (Pic. 20.70).



Pic. 20.70

Click the left mouse button on the proper scale and the hypnogram scale will change.

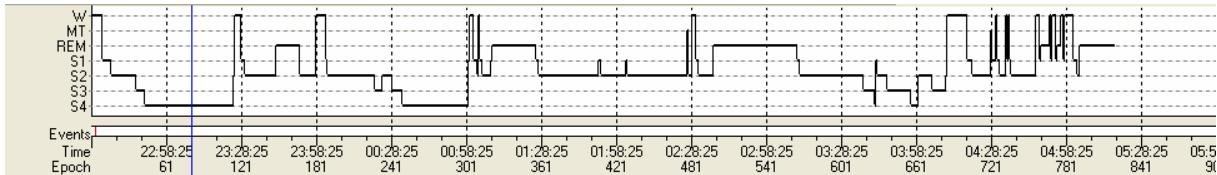
The dialog box for PSG review and analysis setup appears on the screen with the help of the **Setup** menu command (Pic. 20.52).

**Unclassified epoch** menu command enables to go to the first unclassified PSG epoch if it is available. This command is useful when some epochs were not analyzed and classified (they were not given a stage) during the hypnogram creation. So you will not be able to make the hypnogram analysis and get the results table.

**Left** and **Right** menu commands enable to move the hypnogram left and right on the time axis if it wouldn't fit into one screen.

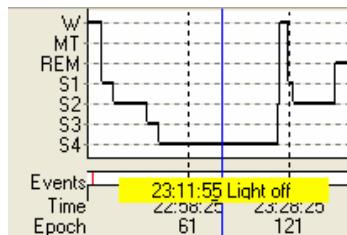
## Neuron-Spectrum Program

The view of the created hypnogram is shown on Pic. 20.71.



Pic. 20.71

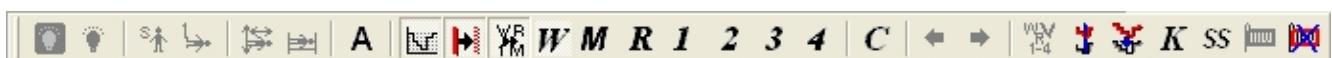
Under the hypnogram the **Events panel** is located. All the event markers set on PSG are displayed on this panel. The event marker set in the range of any epoch of analysis is displayed as a vertical line on the events panel of this epoch. If you move a mouse cursor to the event marker on the events panel, the prompt with the name of event and the time of its setting on PSG will appear near the mouse cursor (Pic. 20.72).



Pic. 20.72

Hypnogram is synchronized with PSG window. The vertical marker indicates the current position (current epoch of analysis) on PSG (Pic. 20.71, Pic. 20.72). During PSG movement in a PSG review window the marker on hypnogram moves simultaneously and always shows the current epoch of analysis. And vice-versa, during the marker movement on the hypnogram, PSG moves simultaneously in a window. To move the marker drag it (at that the mouse cursor changes from to ) and, holding the left mouse button, move it. The marker will be moving after the cursor. When the movement is over, release the left mouse button and PSG will synchronize with the marker position. Or even click on the hypnogram by the left mouse button and the marker will move to this point of hypnogram.

On the toolbar panel **PSG** toolbar is located (Pic. 20.73).



Pic. 20.73

On this toolbar those buttons are available which are used in creating of hypnogram (classification of epochs of analysis by sleep stages).

The epoch of analysis size (30 seconds for one page on Pic. 20.69) is displayed in the dropdown list on the information panel of PSG window.

On the right part of the parameters panel of PSG window the following data is shown:

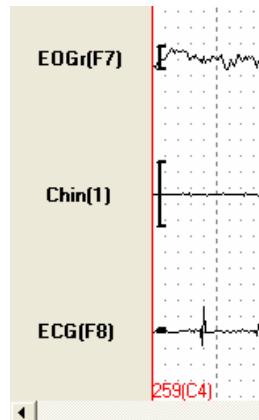
- current epoch of analysis and total number of epochs of analysis in PSG with the current size of epoch of analysis

- classification of the previous, current and next epochs of analysis S3 - S4 - S4; if any of the epoch is not classified, a dash is displayed;
- absolute time (real time) of the beginning and the end of the current epoch 22:49:55 - 22:50:25;
- relative time (time from the start of recording) of the beginning and the end of the current epoch 00:21:30 - 00:22:00.

#### 20.4.2.1. Hypnogram creation (manual scoring)

While analyzing sleep structure (analysis of sleep structure and creating a hypnogram), 30 seconds analysis epoch is usually used.

In the sleep stages analysis mode the functions of several commands for PSG record movements are changed. In this mode one epoch of analysis is displayed on the screen and it is recommended to “page” PSG record by epochs of analysis. On PSG the epochs of analysis markers appear, the number of epoch is indicated on the right side at the marker’s bottom (Pic. 20.74). If the epoch is classified (if it is referred to one of the sleep stages), it is indicated in brackets after the number to which sleep stage this epoch is referred.



Pic. 20.74

All the commands for record movements by page back and forth always move the record to the border of the immediate back or forth epoch of analysis (Pic. 20.75 – back movement).



Pic. 20.75

The current analysis epoch, total number of epochs in the record, classification of the previous, current and next epochs, absolute and relative time of the beginning and the end of the current epoch are displayed on the right part of the parameters panel of PSG window (Pic. 20.76).

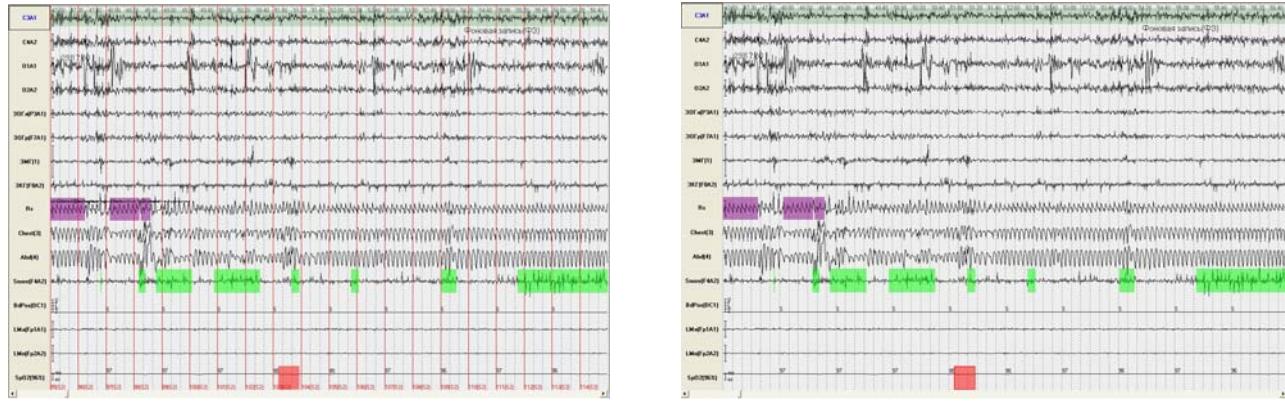
Epoch: 204/1068 | S4 - S4 - S4 | 00:43:41 - 00:44:11 | 01:41:30 - 01:42:00

Pic. 20.76

## Neuron-Spectrum Program

While creating a hypnogram the following commands are used (buttons on **PSG** toolbar or keyboard):

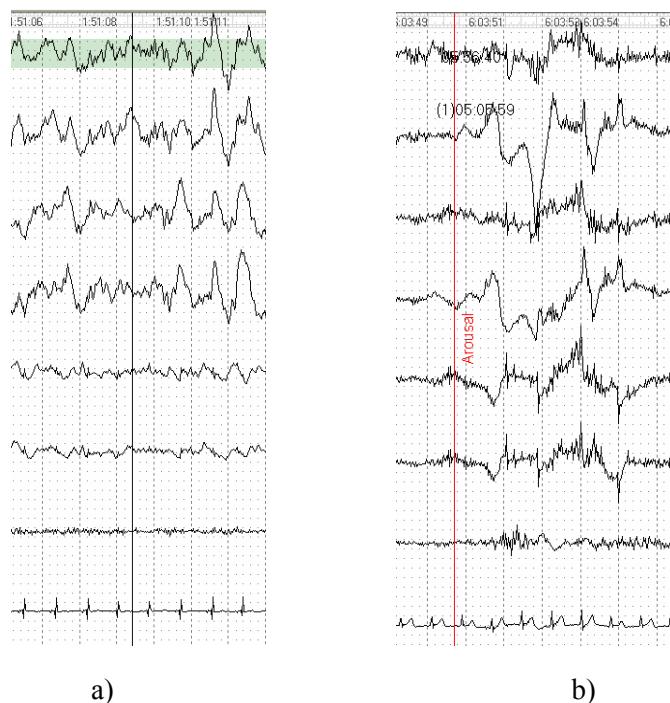
-  - show/hide markers of PSG epochs. The epochs markers are displayed on the screen by default. Sometimes, while changing the screen sweep, it is convenient to hide these markers from the screen to view PSG freely. For this purpose the mentioned command is used (Pic. 20.77).



Pic. 20.77

-  ([Alt+A] key combination) – setting of activation marker. The activation marker is usually set at the beginning of the activation fragment. During the analysis of hypnogram the total number of activations is calculated and the activation index is determined – the amount of activations for one sleep hour. Setting of activation event marker is made as follows: at pressing the button the vertical marker appears on the screen and follows the mouse movements (Pic. 20.78a).

Set the vertical marker in the proper position of the screen and press the left mouse button. The activation marker will be set (Pic. 20.78b). To cancel the setting of the activation marker press [Esc].

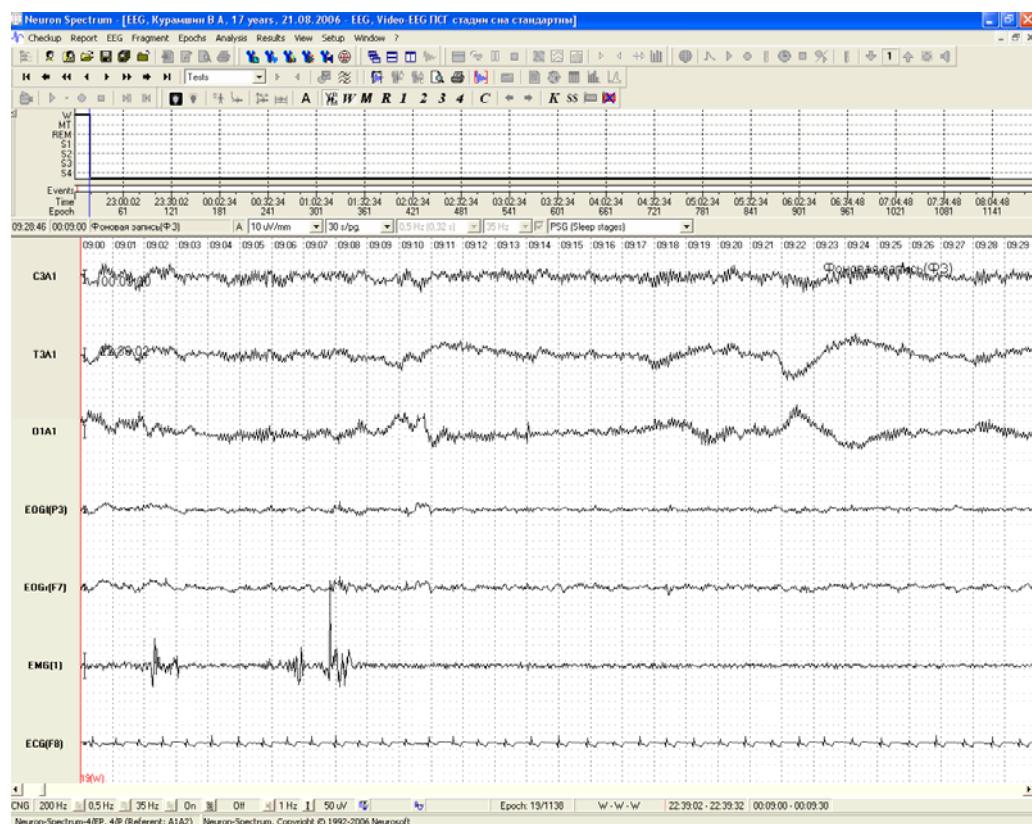


Pic. 20.78

-  ([E] key) – switch on/off the edit mode of PSG marking (hypnogram editing). The edit mode is switched on automatically if one of the keys for classification of epoch analysis is pressed (“W”,..., “4”) in case the current epoch is not classified. To change the classification of the current epoch of analysis, if it is already referred to the certain sleep stage and the edit mode is off, first it is necessary to switch on the edit mode by pressing this key.
-  ([W] key) – assignment of **Awake** stage to the current epoch of analysis.
-  ([M] key) – assignment of **Movement time** stage to the current epoch of analysis – only for Rechtschaffen & Kales classification.
-  ([R] key) – assignment of **Rapid eyes movement (REM)** stage to the current epoch of analysis.
- ,  ([1],..., [4] keys) – assignment of one of the slow sleep stages **S1**,..., **S4** or **N1**, **N2**, **N3** (according to the new AASM classification) to the current epoch of analysis.
-  – clear PSG marking – cancellation of the classification for all the epochs of analysis, nulling of hypnogram graph.
- ,  – movement of hypnogram for one hour left or right. These commands are used if the hypnogram wouldn't fit into one screen because of prolonged sleep of the patient or if the hypnogram scaling is on.

As a rule, the following sequence of hypnogram making is used. The epoch classification is made in consecutive order starting from the first one. For the classification of the first epoch it is necessary to determine its sleep stage. On **PSG** toolbox press the button (“W”,..., “4”) corresponding to the selected stage or key on the keyboard ([W],..., [4]). The program will switch to the hypmogram edit mode and the first epoch will be referred to the selected sleep stage. The button of the selected stage remains pressed. While moving the record to the next epoch of analysis, if it is not classified, in the edit mode this epoch is referred to the stage of the previous epoch automatically. For instance, if epoch 1 is referred to **W** stage, then, while moving to epoch 2, it will be referred to **W** stage automatically etc. (Pic. 20.78). All classifications are shown on the hypnogram immediately, i.e. the hypnogram is created simultaneously with the epoch classification. Thus, while moving forward along the PSG, the mode of automatic assignment of the previous epoch stage value to every next unclassified epoch is sustained.

## Neuron-Spectrum Program



Pic. 20.79

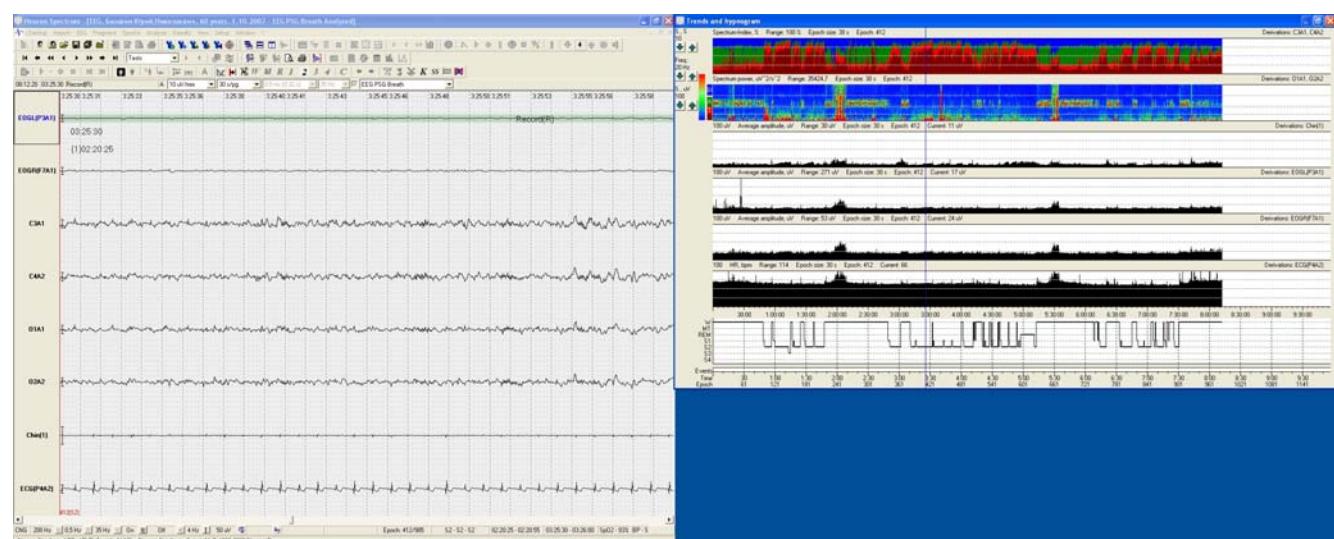
If the classification of the current epoch must be changed, just press the button (“W”,..., “4”) corresponding to the selected stage or the corresponding key on the keyboard ([W],..., [4]) on **PSG** toolbox. The stage assigned to the current epoch will be changed.

If you return to the previous or to the next classified epochs, their classification is not changed. To change their classification, press the corresponding button of the stage assignment on **PSG** toolbar.

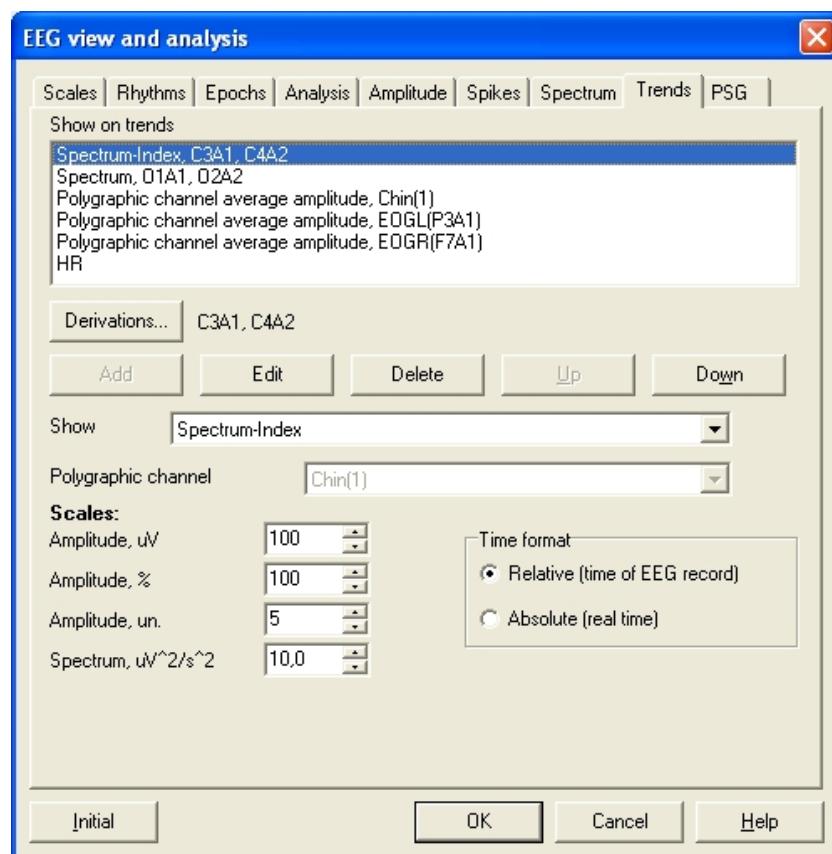
During PSG analysis of the current epoch all the analysis tools included in **Neuron-Spectrum** program can be used. For instance, in the mode of PSG analysis the spectrum and trends panel is recalculated in the mode of parameters determination for each epoch of analysis and displayed synchronously with hypnogram (Pic. 20.79). It simplifies greatly the PSG analysis taking into consideration that the various trends can be displayed on the trends panel: spectral characteristics of EEG channels, amplitude characteristics of polygraphic channels, HR etc. To display the spectrum and trends panel the **Analysis|Spectrum and trends panel** menu command is used.

To select the list of displayed trends and derivations for trend calculation, use the **Setup|Analysis** menu command (the button on PSG toolbar). The **EEG view and Analysis** dialog box will appear on the screen. Open the Trends page (Pic. 20.81). Add to the list the trends you need and set the necessary parameters. If you have two-monitor system, the window with hypnogram and trends can be displayed on the second monitor (Pic. 20.80).

## Chapter 20. Neuron-Spectrum-PSG



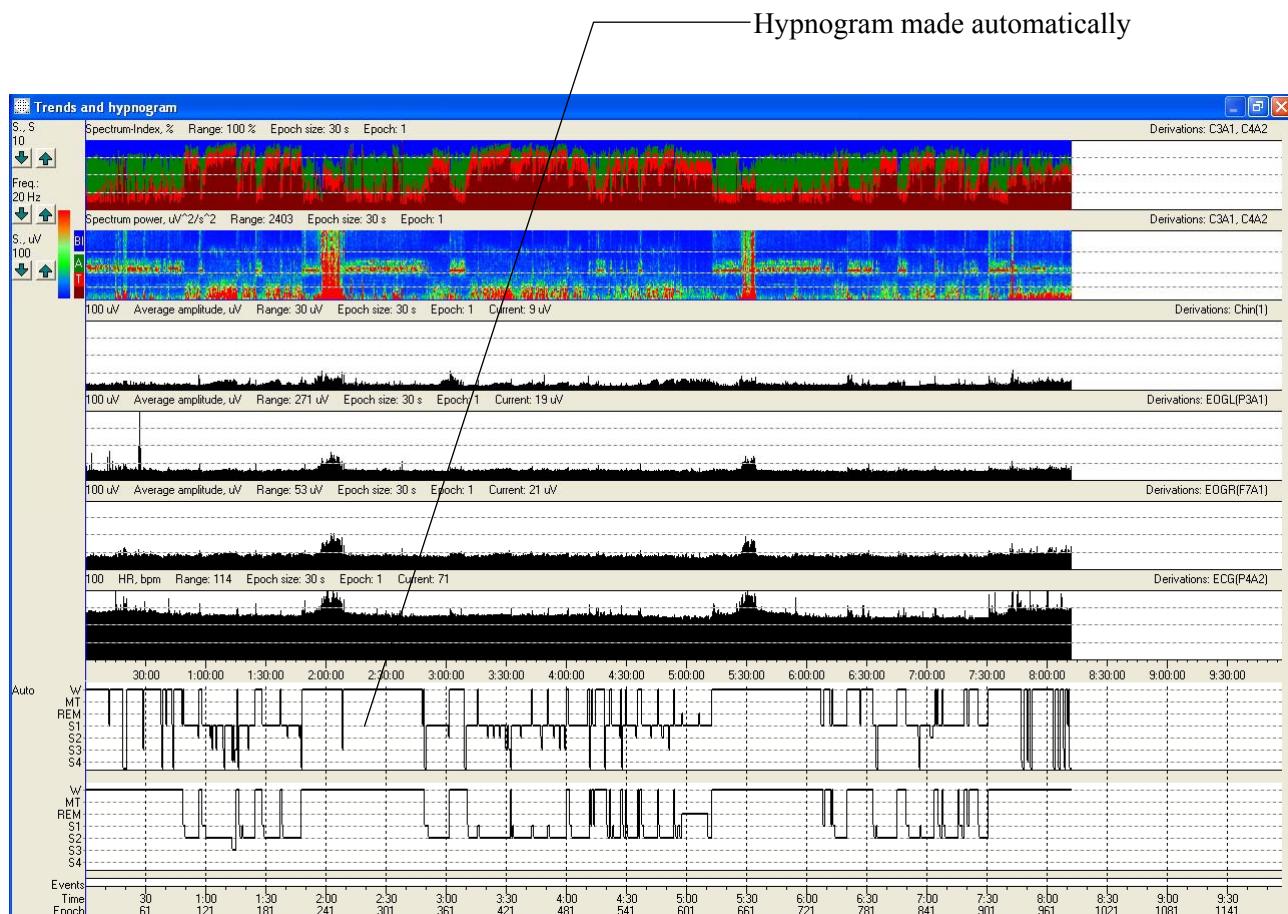
Pic. 20.80



Pic. 20.81

#### 20.4.2.2. Automatic hypnogram creation (automatic scoring)

By means of Neuron-Spectrum-PSG you can automatically score PSG and create a hypnogram. This method of scoring takes very little time but it is not accurate. To create a hypnogram automatically, use the  button on **PSG** toolbar. To activate the PSG automatic scoring program, switch the PSG edit mode on (the  button must be pressed). Later, when PSG is analyzed, one more hypnogram with **Auto** mark will appear in the hypnogram and trends window (Pic. 20.82).



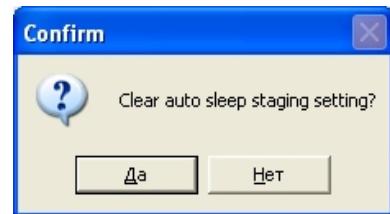
Pic. 20.82

Pay attention to the fact that the analysis of hypnogram and calculation of sleep parameters are carried out according to the hypnogram created manually, but not automatically. That is why there are the **Copy current epoch** (the  button) and **Copy hypnogram** (the  button) menu commands on **PSG** toolbar. These commands help to copy the automatic hypnogram either wholly or by epochs to the manually created hypnogram according which the calculation of sleep parameters is made.

If you press the hypnogram clear button () , the separate confirmation request for manually created hypnogram clearance appears first (Pic. 20.83) and only then the confirmation request for automatically created hypnogram clearance appears (Pic. 20.84). Thus, you can clear each hypnogram separately.



Pic. 20.83

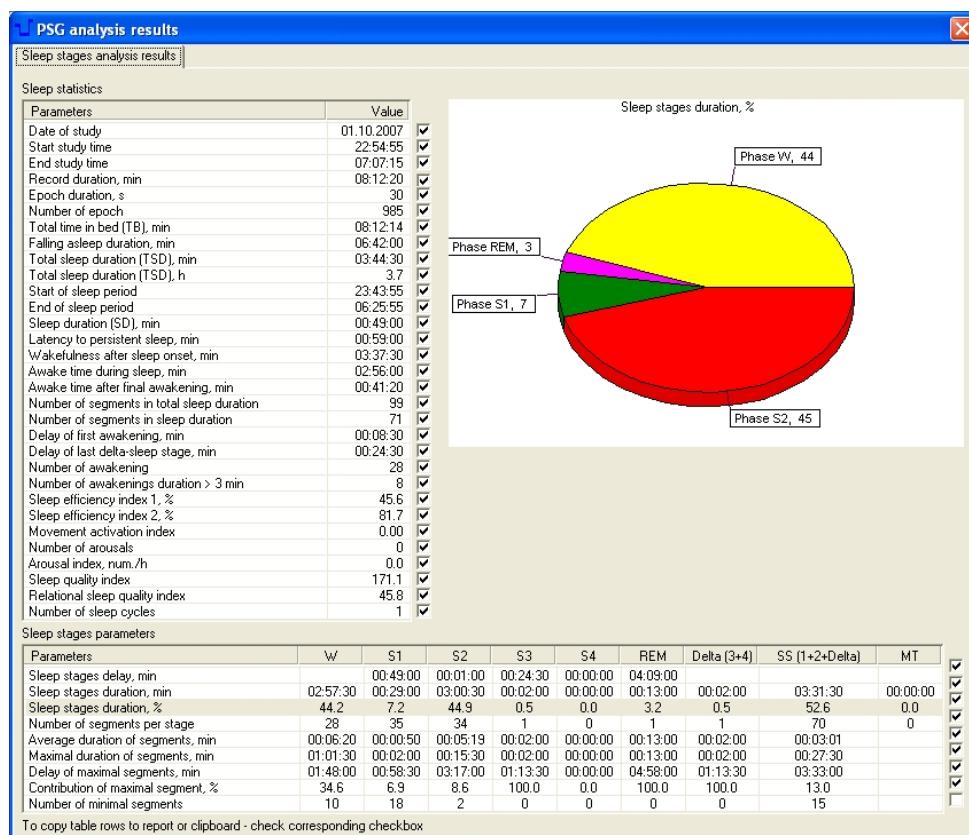


Pic. 20.84

#### 20.4.2.3. Sleep stages analysis results. Checkup report

After PSG and hypnogram creation is completed it is possible to calculate the hypnogram parameters and create a checkup report. For this purpose, select **Results|PSG (Sleep stages)** menu command. If this menu command is not enabled, it means that not all the epochs are classified. To find the unclassified epochs use **Unclassified epoch** command of the hypnogram property menu (see above).

After the hypnogram parameters are calculated, the panel with tabular and graphic data of PSG analysis results will appear on the screen (Pic. 20.85).



Pic. 20.85

During hypnogram analysis the following parameters of sleep statistics are calculated and shown in **Sleep statistics** table:

- *Date of study* – the date when the study was made.
- *Start study time* – the time when the study (record) was started – astronomical time.
- *End study time* – the time when the study (record) was finished – astronomical time.
- *Record duration* – the record duration in minutes. All the parameters calculated in minutes can be displayed in results tables in two formats (Pic. 20.55, Pic. 20.56).

• *Epoch duration* – the value the analysis epoch used during the sleep stage analysis.  
• *Number of epoch* – the number of analysis epochs in the record.  
• *Total time in bed* – the time from the first marker “*Light is off*” up to the last marker “*Light is on*”. If no one marker “*Light is off*” was set, it is suggested that one of such markers was set at the beginning of the record. If no one marker “*Light is on*” was set, it is suggested that one of such markers was set at the end of the record.

• *Falling asleep duration* – the time from falling asleep to awakening taking into consideration the periods of wake time during sleep.

• *Total sleep duration* – the time from falling asleep to awakening without taking into consideration the periods of wakefulness during sleep, i.e. total time of all sleep stages without wake time stages.

- *Start of sleep period* – astronomical time of sleep period start.
- *End of sleep period* – astronomical time of sleep period end.
- *Sleep duration* – the time from the first marker “*Light is off*” up to the first of the three sequential epochs of the first sleep stage or up to the first epoch of any other sleep stage. If no marker “*Light is off*” was set, it is suggested that one of such markers was set at the beginning of the record.

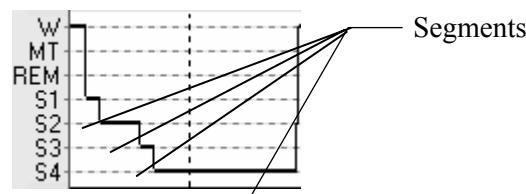
• *Latency to persistent sleep* – the time from the first marker “*Light is off*” up to the first of the twenty continuous epochs of any sleep stage. If no marker “*Light is off*” was set, it is suggested that one of such markers was set at the beginning of the record.

• *Wakefulness after sleep onset* – the time of wakefulness from the first epoch of persistent sleep up to the last “*Light is on*” marker. If no marker “*Light is on*” was set, it is suggested that one of such markers was set at the end of the record.

• *Awake time during sleep* – the time of wakefulness from the first epoch of persistent sleep up to the last sleep epoch (up to the awakening).

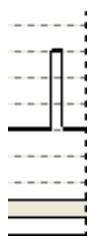
• *Awake time after final awakening* – the time of wakefulness from the awakening and up to the last “*Light is on*” marker. If no marker “*Light is on*” was set, it is suggested that one of such markers was set at the end of the record.

• *Number of segments in sleep duration* – the total number of segments during sleep duration. A segment on the hypnogram is a sequence of epochs of analysis (one epoch is also possible) with similar sleep stage (Pic. 20.86).



Pic. 20.86

- *Number of segments in total sleep duration* – the total number of segments during total sleep time.
- *Delay of first awakening* – the time from falling asleep up to the first awake time during sleep.
- *Delay of last delta-sleep stage* – the time from falling asleep up to the beginning of the delta-sleep last episode. Delta-sleep is a sleep at S3 or S4 stages.
- *Number of awakening* – the number of awakenings during sleep (number of segments of W stage).
- *Number of awakening duration > 3 min* – the number of awakenings of more than 3 minutes during sleep.
- *Sleep efficiency index 1* – the relative index of sleep efficiency calculated as the ratio of total sleep time to total time in bed in percents.
- *Sleep efficiency index 2* – the relative index of sleep efficiency calculated as the ratio of sleep duration to total time in bed in percents.
- *Movement activation index* – the number of movement time segments after which the current sleep stage changes (Pic. 20.86) in recalculation for one sleep hour.



a) The stage has not changed



b) The stage has changed

Pic. 20.87

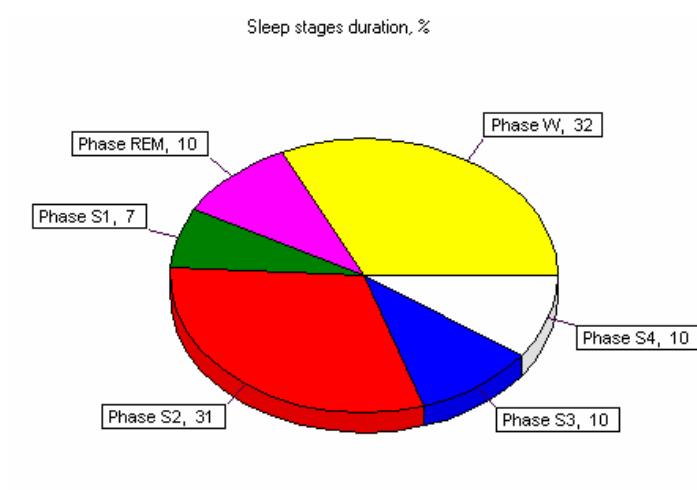
- *Number of arousals* – the number of arousals for total sleep time.
- *Arousal index* – the ratio between number of arousals and total sleep time in hours, i.e. number of arousals for one sleep hour.
- *Sleep quality index* – the complex parameter characterizing sleep quality based on hypnogram segmental structure analysis (developed in the laboratory of somnology of Professor I. Levine).
- *Relational sleep quality index* – the ratio between sleep quality index and total sleep time in percents.
- *Number of sleep cycles*. The first sleep cycle is the period from the first sleep epoch up to the last epoch of the first period of the rapid eye movements (REM) cycle. All the REM periods occurred within 60 minutes after the first, are included in the first cycle. The second and all other sleep cycles

are the periods from the first epoch of any (except REM) sleep stage, which follows the last REM period, included into the previous sleep cycle, and up to the end of the next REM period (which includes REM periods occurred within 60 minutes after it as well). If the period is not terminated by REM, it is not considered to be a sleep cycle (for instance, if the awakening takes place not from REM stage).

During hypnogram analysis the following parameters of sleep stages are calculated and shown in **Sleep stages parameters** table:

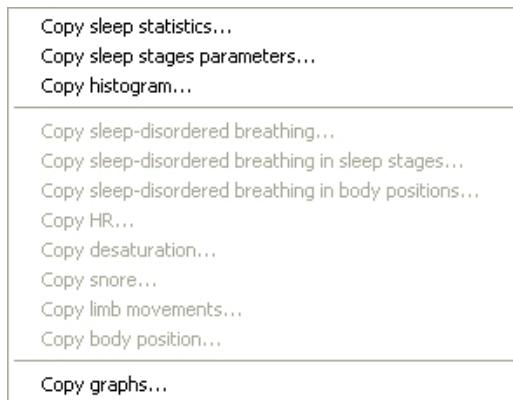
- *Sleep stages delay* – for the first sleep stage – the time from the light is off up to the first sleep stage (up to falling asleep); for the rest sleep stages – the time from falling asleep up to the corresponding sleep stage.
- *Sleep stages duration* – the duration of each sleep stage. Delta-sleep is the third and the fourth sleep stages. Slow sleep is the sleep stages from the first up to the fourth.
- *Sleep stages duration, %* – the percentage of sleep stages, i.e. the ratio between sleep stage duration and sleep duration in percents.
- *Number of segments per stage* – the number of segments per each sleep stage.
- *Average duration of segments* – the average duration of segments per each sleep stage.
- *Maximal duration of segments* – the maximal duration of segments per each sleep stage.
- *Delay of maximal segments* – the delay of maximal segment per each sleep stage, i.e. time of maximal segment appearance from falling asleep.
- *Contribution of maximal segments* – the ratio between duration of maximal segment per each stage and total duration of all the segments of the current stage in percents.
- *Number of minimal segments* – the number of minimal segments per each stage. Minimal segment is a segment with duration of one analysis epoch.

The value ratio for any parameter of various sleep stages is shown on circular histogram in the top right part of the window (Pic. 20.88). Parameter, shown on the histogram, is selected by clicking on the corresponding line of the **Sleep stages parameters** table. By default, *Sleep stages duration, %* is displayed on the histogram while opening the window of sleep stages analysis results.



Pic. 20.88

Any table or histogram of the analysis results window can be copied to the report or clipboard. To copy a table or histogram click the right mouse button on the results window. The property menu will appear on the screen (Pic. 20.89).

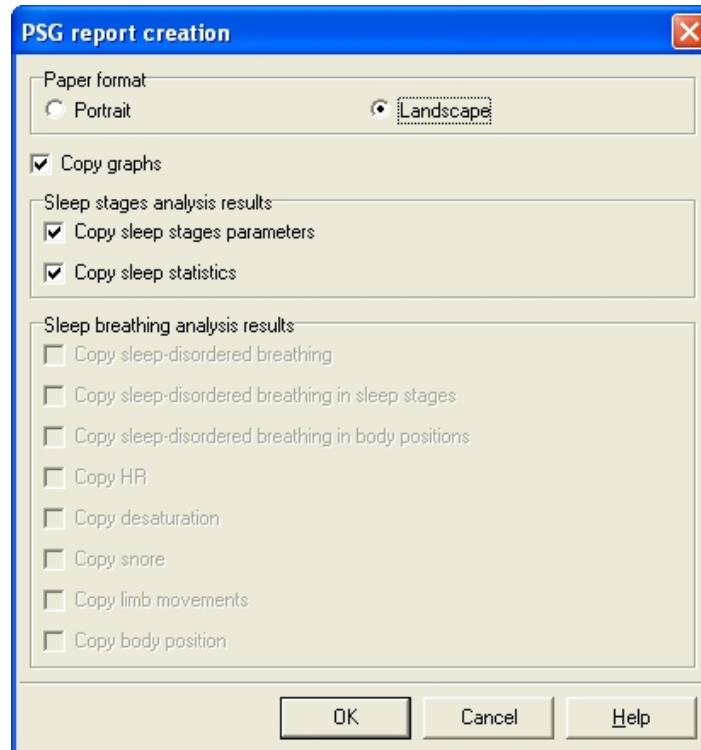


Pic. 20.89

The first three commands refer to the copying of window elements to the report or clipboard, the next two commands are intended for the copying of sleep-disordered breathing analysis results (see below), the last command refers to the copying of a hypnogram graph to the report (it is impossible to copy a histogram graph to the clipboard).

To select the lines of PSG analysis result tables which should be copied to the report or clipboard, use the check boxes on the right of each line (Pic. 20.85). If the check box is checked, the line is copied to the report or clipboard when the command of table copy is being executed. If the check box is not checked, the line is not copied.

If the analysis results window is displayed, you can create PSG report. To create it, use **Report|PSG** menu command. **PSG report creation** dialog box will appear on the screen (Pic. 20.90).



Pic. 20.90

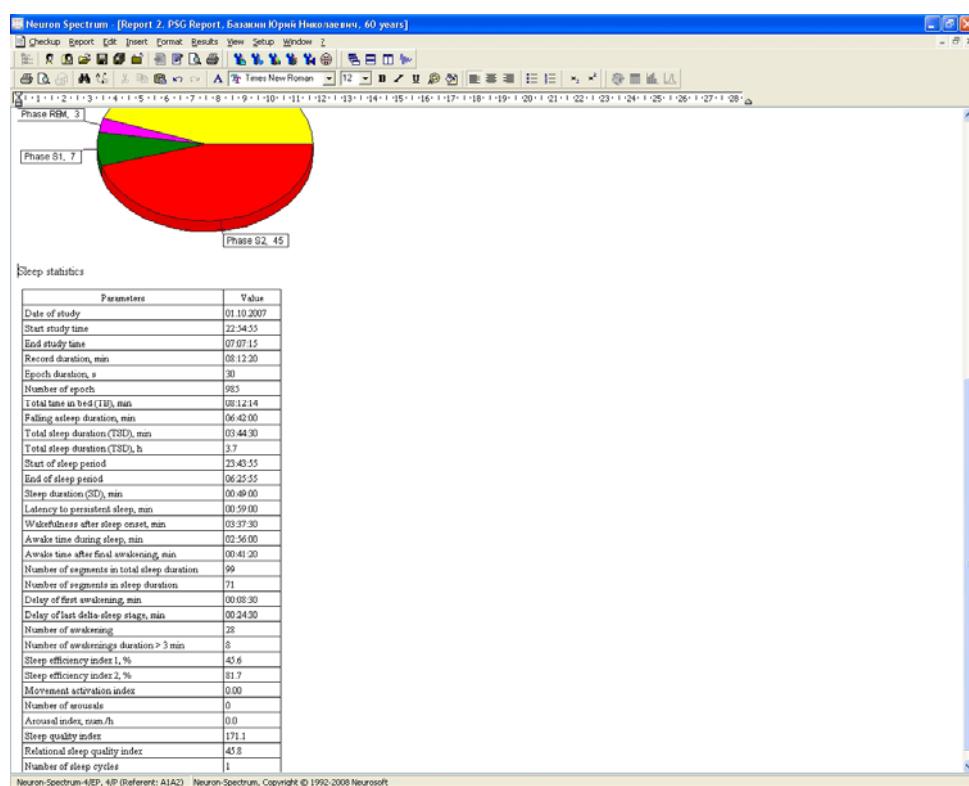
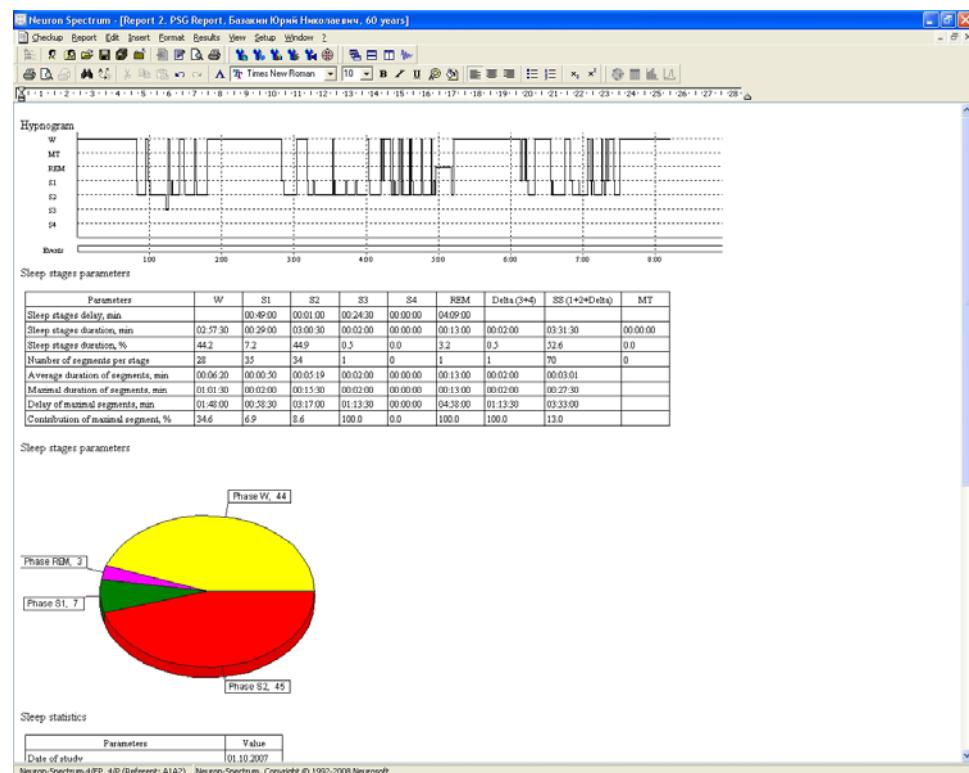
*Paper format.* While creating PSG report determine the paper format – portrait or landscape.

*Copy graphs.* If the check box is checked, the hypnogram graph will be included in the report.

*Sleep stages analysis results.* These check boxes determine the elements of analysis results included in the report.

Select the parameters you need and press “OK”. The report with the heading and selected elements will be created (in our case the report consists of hypnogram, table of sleep stages parameters and histogram and table of sleep statistics) (Pic. 20.91).

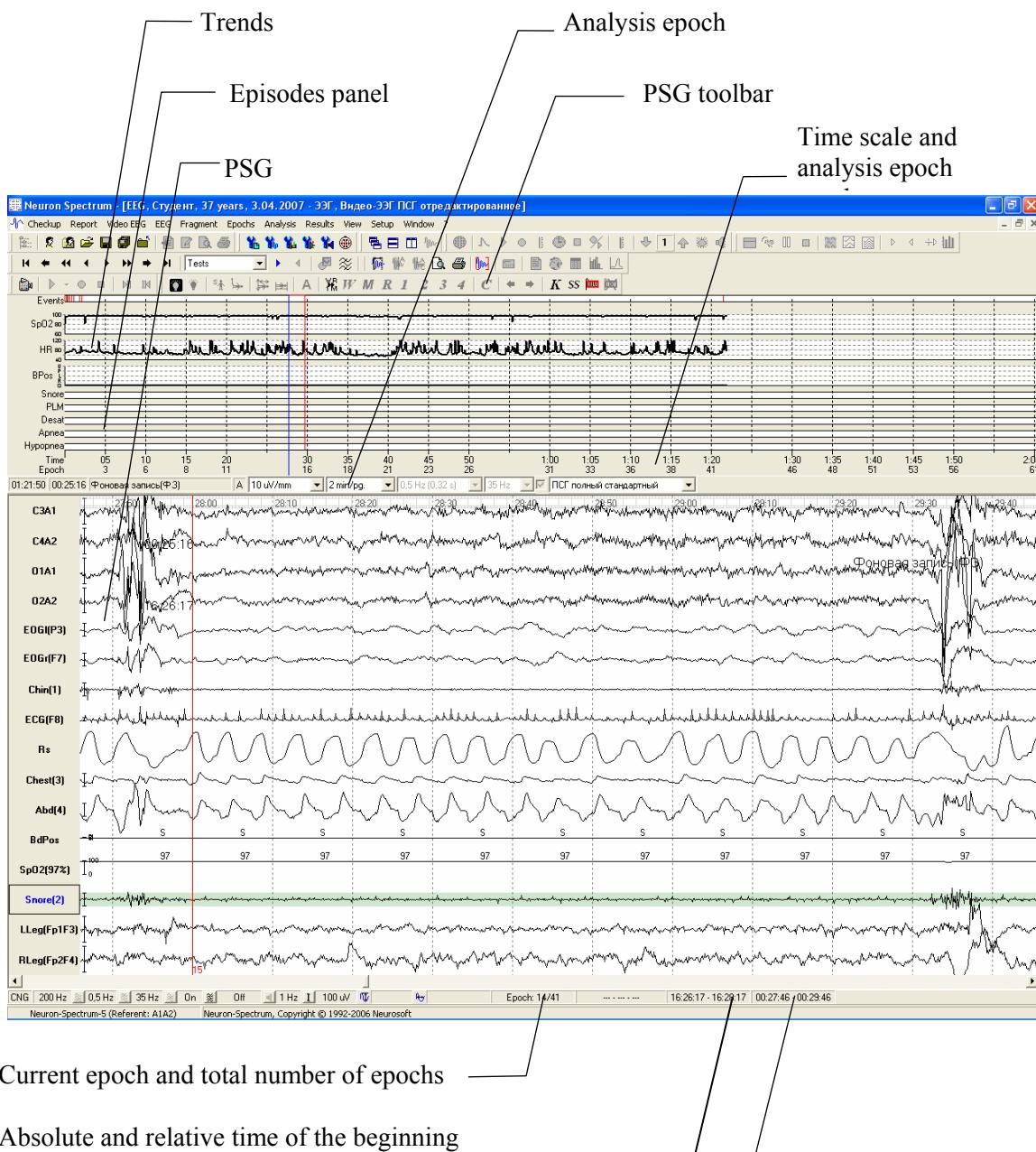
## Chapter 20. Neuron-Spectrum-PSG



Pic. 20.91

#### 20.4.3. SLEEP-DISORDERED BREATHING ANALYSIS

To switch to the mode of sleep-disordered breathing analysis, select **Analysis|Sleep breathing analysis** menu command. The program will switch to the sleep-disordered breathing analysis mode (Pic. 20.92).



Pic. 20.92

In the sleep breathing analysis mode the following elements are shown on the screen:

**Panels of events, trends and episodes** are the graphs where the time (analysis epoch number) is marked on X-axis and the value of the corresponding parameter (for trends) or the presence and duration of the corresponding episode (for events and episodes) are marked on Y-axis.

On standard panel displaying scale one point corresponds to 30 seconds. If necessary, you can scale the panels by width, i.e. one epoch of analysis can be displayed on the panels by large quantity of points. To change the horizontal scale of the panel, click on it with the right mouse button. The menu of panel properties will appear on the screen (Pic. 20.93).



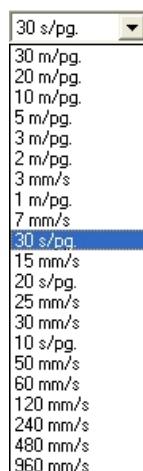
Pic. 20.93

Click the left mouse button on the proper scale and the histogram will change.

The dialog box for PSG view and analysis appears on the screen with the help of **Setup** menu command (Pic. 20.52).

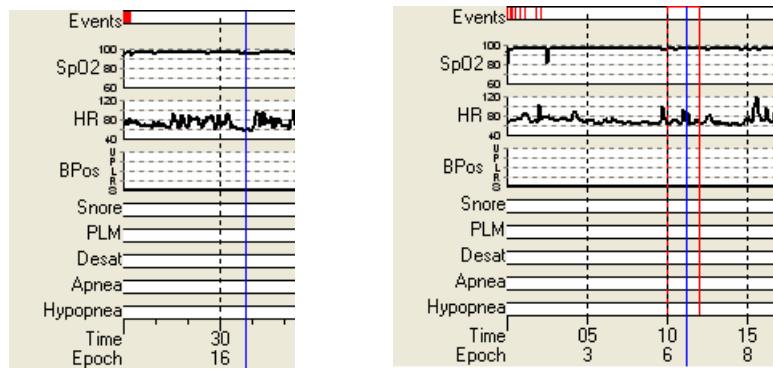
The scaling coefficient determines 2, 5 and 10 times scaling in comparison with the standard scale.

**PSG.** Under the panels of trends and episodes, PSG is shown in the scale which was set according to the value of sleep breathing analysis epoch selected in the setup (Pic. 20.52). In the sleep breathing analysis mode the value of analysis epoch determines rather PSG display scale on the screen as all the calculations and graphs are made along all the record according to the type of derivation under analysis. That is why PSG sweep speed can be changed freely. To do this, just select another sweep speed in the dropdown list (Pic. 20.94).



Pic. 20.94

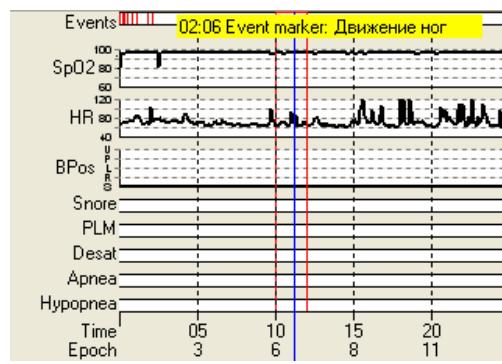
The panel of events, trends and episodes is synchronized with PSG. The vertical marker which can be displayed either as vertical line or vertical square depending of the scale set on the panel indicates the PSG view window position (Pic. 20.95). And the square width corresponds to the size of fragment displayed in PSG window. The click by the left mouse button on the panel of trends and episodes moves the marker to the selected position and locates PSG to the same time interval. Thereafter, the moving along PSG results in simultaneous moving of the marker along the panel.



Pic. 20.95

### 20.4.3.1. Events panel

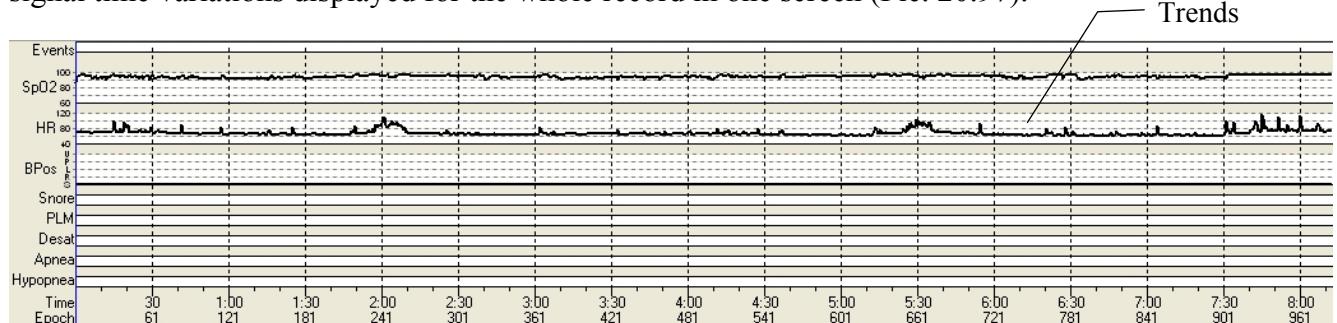
All the markers of events and also the markers of switching the light on and off, the markers of movements starting and ending, the markers of patient's position changes which are set during PSG registration by the buttons on **PSG** toolbar are displayed on the events panel. The event marker is displayed on the events panel as a vertical line. The position of the vertical line corresponds to the moment of marker setting. If you move a mouse cursor to the event marker on the events panel, the prompt with the name of event and the time of its setting on PSG will appear near the mouse cursor (Pic. 20.96). If you click the left mouse button on the events panel, PSG will be positioned on the epoch on which the selected event marker is set.



Pic. 20.96

### 20.4.3.2. Trends

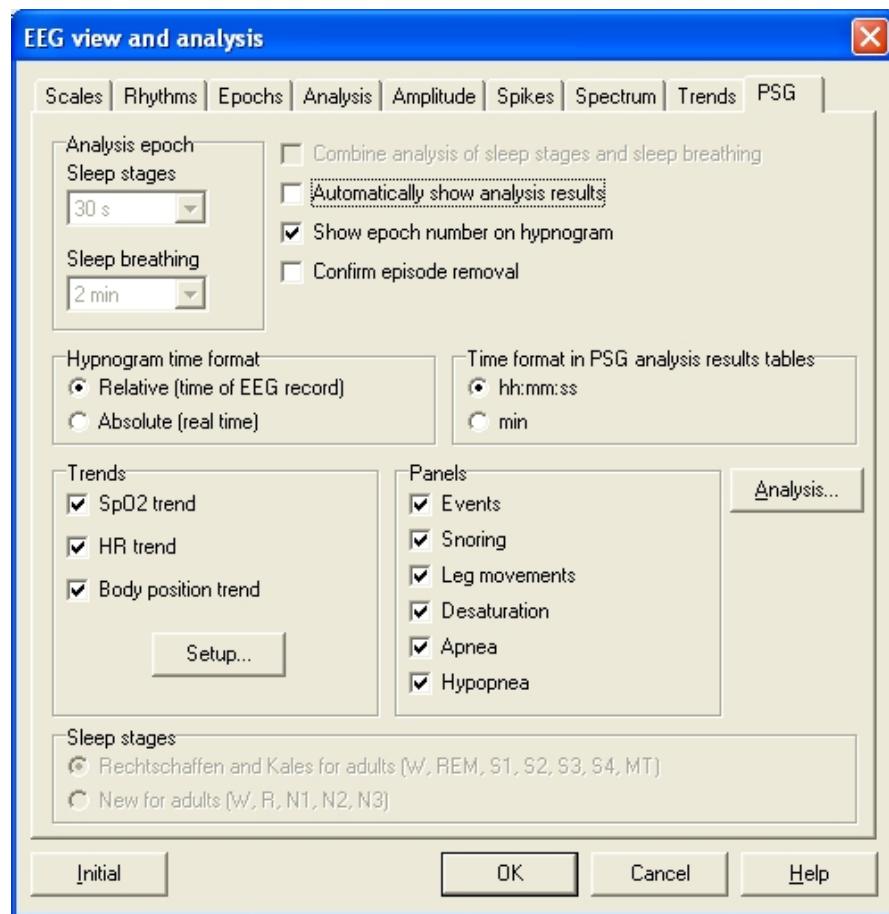
Under the events panel the trend graphs of several PSG derivations are located, i.e. the graphs of signal time variations displayed for the whole record in one screen (Pic. 20.97).



Pic. 20.97

In **Neuron-Spectrum-PSG** the signal trend graphs of the following derivations can be displayed on the screen (Pic. 20.98):

- SpO<sub>2</sub> trend;
- Heart rate (HR) trend;
- Body position trend.



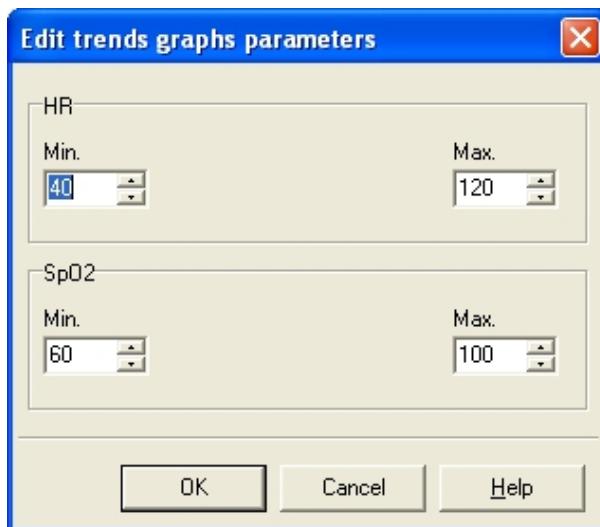
Pic. 20.98

The trend of the selected derivation is displayed on the screen if the corresponding channel is available in PSG record, this channel is visible and the corresponding check box of the *Trends* group is checked on **PSG** page of **EEG view and analysis** dialog box (Pic. 20.98). To hide the graph of the corresponding trend, if the derivation is available on PSG, proceed as follows:

- hide the derivation on PSG (derivation properties menu, **Hide derivation** command);
- uncheck the corresponding check box in the *Trends* group on **PSG** page of **EEG view and analysis** dialog box.

The body position trend always displays all the five body positions – S (supine), R (right), L (left), P (prone) and U (upright) positions.

For graphs of heart rate (HR) and SpO<sub>2</sub> trends it is possible to set the boundary values of signal display in a trend. For this purpose, press *Setup* button in the *Trends* group on **PSG** page of **EEG view and analysis** dialog box. **Edit trends graphs parameters** dialog box will appear on the screen (Pic. 20.99).



Pic. 20.99

For graphs of HR and SpO<sub>2</sub> trends the minimal and maximal value is set displayed on the graph in *Min.* and *Max.* fields of the corresponding group.

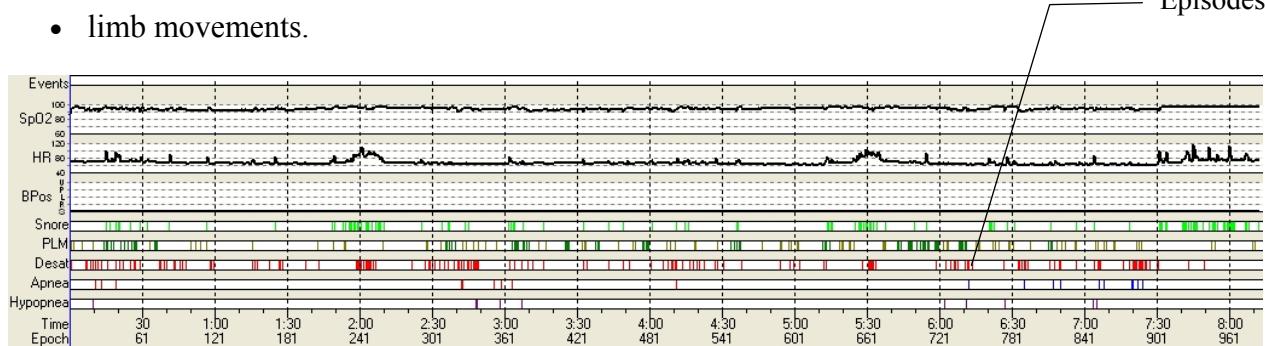
To block the display of any graph trend on the screen, uncheck the corresponding check box on **PSG** page of **EEG view and analysis** dialog box (Pic. 21.98).

Keep in mind that the calculation of trends is a long-term process. That is why, while switching to the sleep breathing analysis mode, the program calculates the trends for rather long time. At that the corresponding information box is shown on the screen. The calculated trends can be saved if the checkup will be saved after their calculation. Then, when the checkup is opened again, the calculation of the trends will not be made as they are carried out on the base of the previous calculations. Recalculation of the trends is carried out when the epoch of analysis is changed or when the cleaning of marking results and PSG analysis is made (see below).

### 20.4.3.3. Episodes

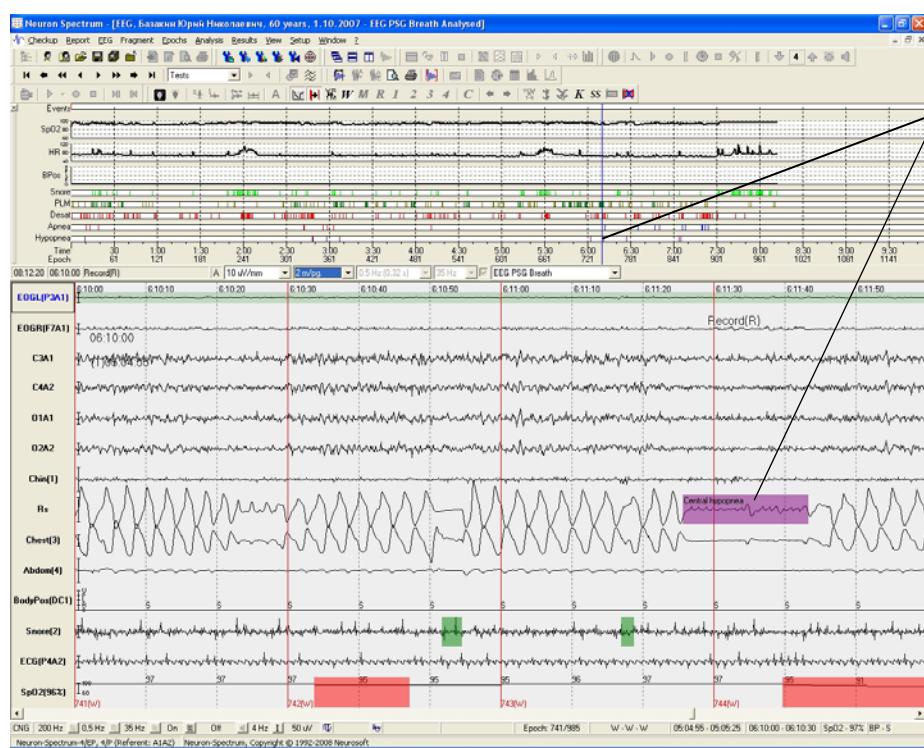
Under the graphs of trends the episode panels, the similar events panel for presence and position of the episodes, are displayed (Pic. 20.100):

- disordered breathing (apnea and hypopnea); the episodes of disordered breathing are classified as *Obstructive*, *Central* and *Mixed*;
- desaturations;
- snore;
- limb movements.

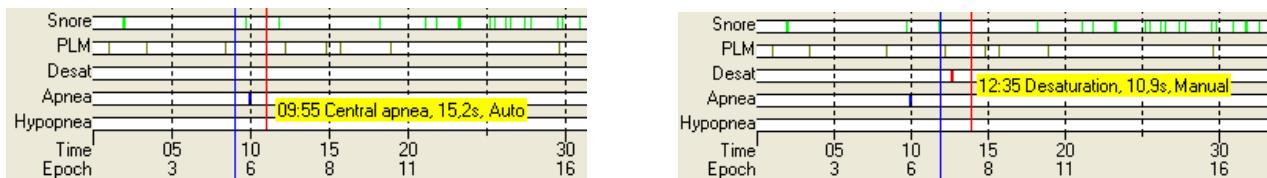


Pic. 20.100

On the panel of episodes as well as on the panel of events the presence, position and duration of the corresponding episodes are displayed (Pic. 20.101). If you move a mouse cursor to the episode marking, a yellow prompt with the name, setup time and search method (automatic search (*Auto*) or manual set (*Manual*)) of the episode lights up (Pic. 20.102).



Pic. 20.101



Pic. 20.102

The panel of the corresponding episode is displayed on the screen if the corresponding channel is available in PSG record, this channel is visible and the corresponding check box of the *Panels* group is checked on PSG page of **EEG view and analysis** dialog box (Pic. 20.97). To hide the graph of the corresponding panel, if the derivation is available on PSG, proceed as follows:

- hide the derivation on PSG (derivation properties menu, **Hide derivation** command);
- uncheck the corresponding check box in the *Panels* group on **PSG** page of **EEG view and analysis** dialog box.

### 20.4.3.4. Automatic search of episodes

Automatic search of episodes for disordered breathing, desaturation, snore and periodic limb movements is made by analysers. The analysers parameters are set in **Setup PSG analysers** dialog box (Pic. 20.60, ..., Pic. 20.63), which appears on the screen by pressing “*Analysis*” button on **PSG** page of **EEG view and analysis** dialog box (Pic. 20.98).

To start the automatic analysers, press  button on **PSG** toolbar. **Neuron-Spectrum-PSG** starts the corresponding analysers according to the availability of the proper channels in PSG. When the work of the analysers is over, the detected episodes are displayed on PSG and on the panel of episodes (Pic. 20.100). When the work of the analysers is over, the information about the number of detected episodes appears on the screen (Pic. 20.103).



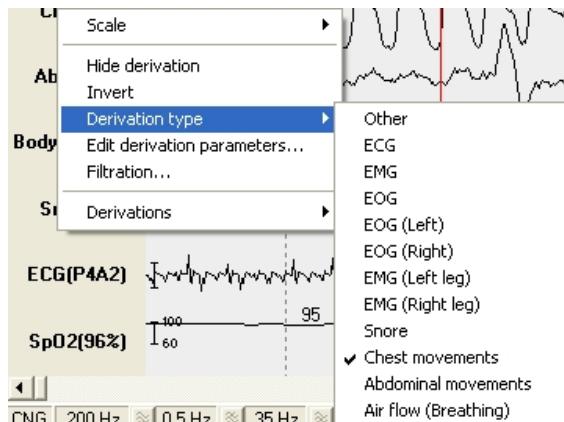
Pic. 20.103

In PSG the presence of the necessary derivation is detected by the derivation type:

- Disordered breathing episodes will be displayed on PSG and on the panel of episodes if three derivations of the following types: *Breathing (oral-nasal airflow)* channel, *Chest movements* channel, *Abdominal movements* channel are available in the record.
- Desaturation episodes will be displayed on PSG and on the panel of episodes if the derivation of SpO<sub>2</sub> type is available in the record.
- Snore episodes will be displayed on PSG and on the panel of episodes if the derivation of Snore type is available in the record.

- Limb movements episodes will be displayed on PSG and on the panel of episodes if the derivation of EMG (Left leg) or EMG (Right leg) type is available in the record.

To change the derivation type immediately in the PSG window, click the right mouse button on the selected derivation name and select **Derivation type** command in the derivation properties menu (Pic. 20.104). Then select the type you need in the dropdown submenu and click on it by the left mouse button. The current channel type is marked (*Chest movements* on Pic. 20.104).

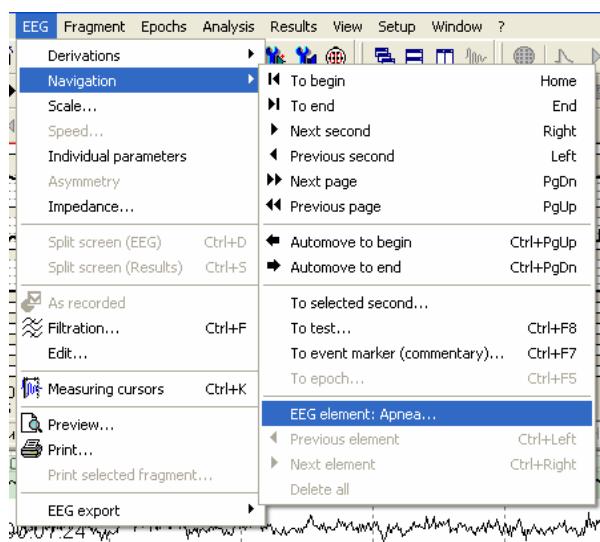


Pic. 20.104

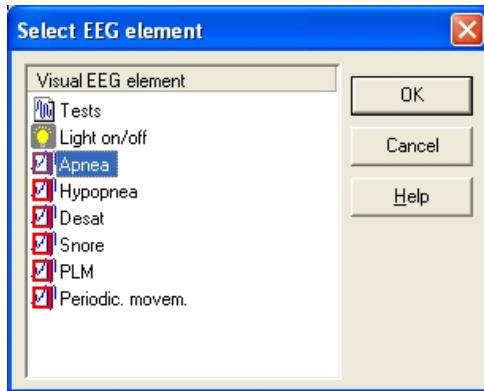
#### 20.4.3.5. Review and edit of the detected episodes. Manual marking of episodes

When the work of the automatic analysers is over, you should review the episodes detected automatically and edit them if necessary.

To review the detected episodes, you can use **EEG|Navigation|EEG element** menu command (Pic. 20.105). **Select EEG element** dialog box will appear on the screen (Pic. 20.106). In the dialog box list all PSG elements, on which the navigation back and forward from one element to another is possible, are displayed. All the detected episodes are among them.

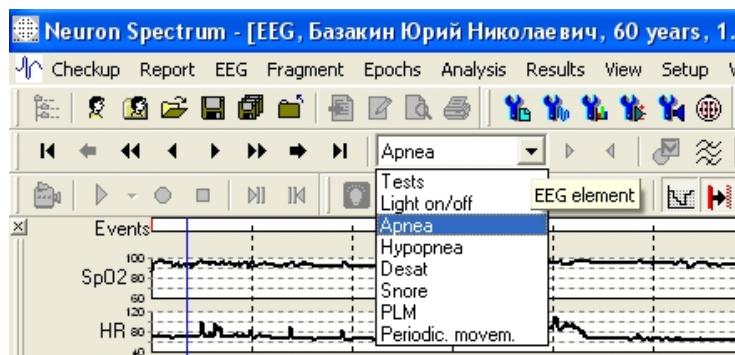


Pic. 20.105



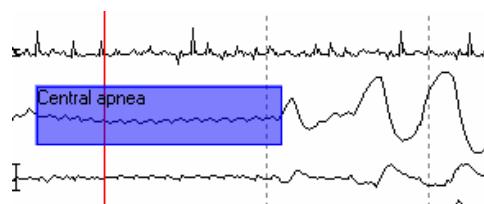
Pic. 20.106

The current element can also be selected in the combo box on **EEG view and analysis** toolbar (Pic. 20.107).



Pic. 20.107

To move from the current element to the next or the previous one, use either and buttons on **EEG view and analysis** toolbar or **[Ctrl+→]** and **[Ctrl+←]** key combinations. On PSG the current episode is put in a frame (Pic. 20.108). Besides, you can select the current episode by clicking the left mouse button on it.



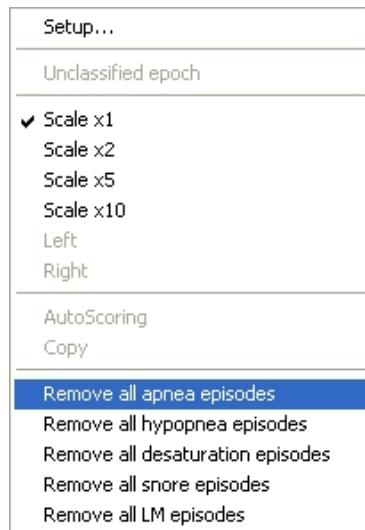
Pic. 20.108

To edit the current episode the following commands are used:

- To *delete current episode* use either **[Ctrl+Del]** key combination or the episode right-click menu. You can delete the current episode either after conformation of the command (Pic. 20.109) or without it according to the state of *Confirm episode removal* check box on PSG page of EEG view and analysis dialog box (Pic. 20.98). You can also delete all the episodes of certain type using the commands of the right-click menu of the episodes view panel (Pic. 20.110).

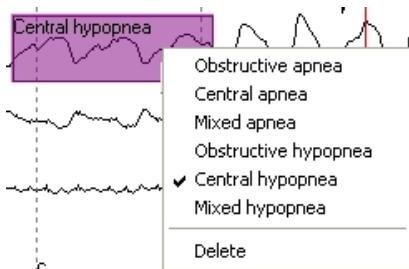


Pic. 20.109



Pic. 20.110

- *Episode movement* (you can move the episode on PSG without changing of its duration). To move the episode, place a mouse cursor into it. The mouse cursor will be changed to . Press the left mouse button and, holding it, move the mouse. The episode marker will be moving along PSG. When the movement is over, release the left mouse button – the episode marker will be in a new position.
- *Change of episode duration*. You can increase or decrease the episode duration (but not less than the minimal duration set for this type of episode). You can change the episode duration by changing the position of the episode end only. For this purpose, shift the mouse cursor to the right border of the episode marker till the mouse cursor changes to . Press the left mouse button and, holding it, move the mouse. The right border of the episode (episode duration) will be changing. When the changing is over, release the left mouse button.
- *Change of episode type (for episodes of disordered breathing)*. To change the type of disordered breathing episode click the right mouse button on the disordered breathing episode. On the screen the menu of episode properties will appear on which the episode type can be selected (Pic. 20.111). The current type of disordered breathing episode is signed on the episode and marked in the properties menu.

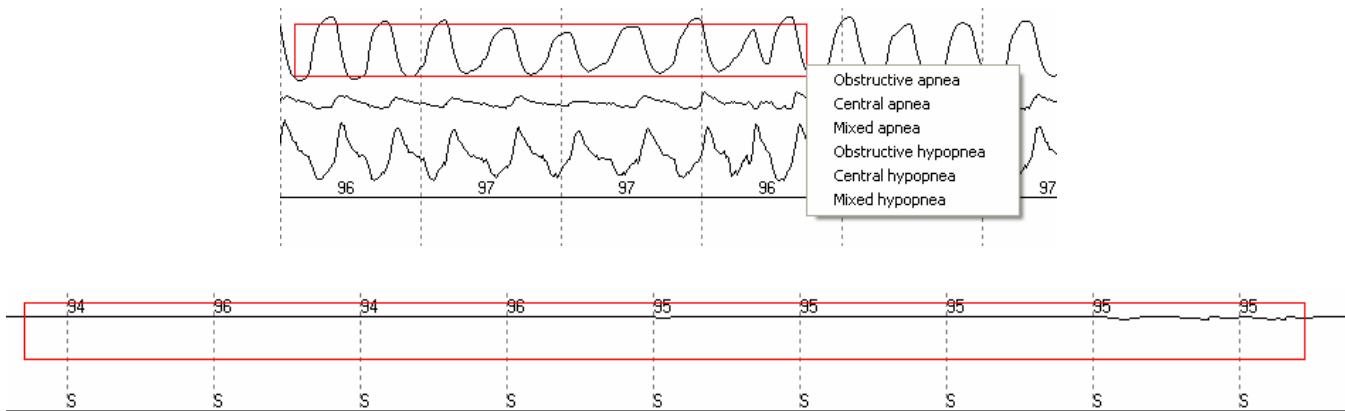


Pic. 20.111

The episode markers can be set manually. For this purpose, the edit mode ( button is pressed) must be set on **PSG** toolbar. The episodes of the certain types can be set on the curves of the certain types only:

- disordered breathing episodes – on the breath channel (air flow) curve;
- desaturation episodes – on SpO<sub>2</sub> channel curve;
- snore episodes – on the snore channel curve;
- limb movements episodes – on the EMG curves from the left and right legs.

To set the episode marker manually, move the mouse cursor to the proposed beginning of the episode on the corresponding curve. Press the left mouse button and, holding it, move the mouse to the right. On the screen the red frame – the proposed episode will be displayed on the corresponding channel (Pic. 20.111). When the frame reaches the size you need, release the mouse button. The episode marker will be set on PSG. For episodes of disordered breathing the type definition menu of disordered breathing episode will be displayed on the screen (Pic. 20.111).



Pic. 20.112

To cancel the setting of the episode marker, if its setting is already in progress (the frame is already being drawn), not releasing the left mouse button, click the right one. The frame will be deleted and the setting of the episode marker will be interrupted.

To delete all the episode markers detected automatically or set manually and also to recalculate the signal trends, use button on **PSG** toolbar. The commands for episodes deletion and trends recalculation are executed after the confirmation.

#### 20.4.3.6. Analysis of sleep-disordered breathing episodes. Checkup report creation

After sleep-disordered breathing analysis (the automatic setting and manual verification and correction of the disordered breathing episodes), the calculation of sleep-disordered breathing parameters can be carried out and the calculation results can be displayed on the screen. For this purpose, select **Results|PSG (Sleep breathing)** command in the main menu. When the calculation is over, the panel with tabular data of the calculation results will appear on the screen (Pic. 20.113, Pic. 20.114).

PSG analysis results						
Sleep stages analysis results		Sleep breathing analysis results		Comments		
Sleep-disordered breathing events <input type="checkbox"/> in sleep						
Parameters	Apnea	Obstructive	Central	Mixed	Hypopnea	Apnea & hypopnea
Maximal duration, sec	00:00:34	00:00:34	00:00:14	00:00:00	00:00:17	00:00:34
Average duration, sec	00:00:15	00:00:18	00:00:12	00:00:00	00:00:12	00:00:14
Total duration, min	00:05:00	00:02:42	00:02:17	00:00:00	00:02:06	00:07:06
Total number	20	9	11	0	10	30
Total duration to sleep time, %	1	1	0	0	0	1
Number per hour of sleep (index)	2	1	1	0	1	4
Combined analysis of sleep stages and sleep-disordered breathing						
Parameters	Apnea	Obstructive	Central	Mixed	Hypopnea	Apnea & hypopnea
Total duration (REM), min	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Total duration (NREM), min	00:01:49	00:00:50	00:00:59	00:00:00	00:01:22	00:03:12
Total number (REM)	0	0	0	0	0	0
Total number (NREM)	8	3	5	0	6	14
Number per hour of sleep (REM)	0	0	0	0	0	0
Number per hour of sleep (NREM)	2	1	1	0	2	4
Depending on body position (S-supine, NS-nonsupine, R-right, L-left, P-prone)						
Parameters	Apnea	Obstructive	Central	Mixed	Hypopnea	Apnea & hypopnea
Total duration (S), min	00:05:00	00:02:42	00:02:17	00:00:00	00:05:44	00:10:44
Total duration (NS), min	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Total duration (R), min	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Total duration (L), min	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Total duration (P), min	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
Total number (S)	20	9	11	0	19	39
Total number (NS)	0	0	0	0	0	0
Total number (R)	0	0	0	0	0	0
Total number (L)	0	0	0	0	0	0
Total number (P)	0	0	0	0	0	0
Number per hour of sleep (S)	2	1	1	0	2	5
Number per hour of sleep (NS)	0	0	0	0	0	0
Number per hour of sleep (R)	0	0	0	0	0	0
Number per hour of sleep (L)	0	0	0	0	0	0
Number per hour of sleep (P)	0	0	0	0	0	0
HR						
Parameters	Value	Parameters	Value			
Average HR, bpm	67	Average HR, bpm (REM)	63			
Minimal HR, bpm	27	Average HR, bpm (NREM)	65			
Maximal HR, bpm	150	Minimal HR, bpm (REM)	46			
Heart rate variability, 1/min	123	Minimal HR, bpm (NREM)	46			
Number of Bradycardia	0	Maximal HR, bpm (REM)	75			
Number of Tachycardia	4	Maximal HR, bpm (NREM)	150			

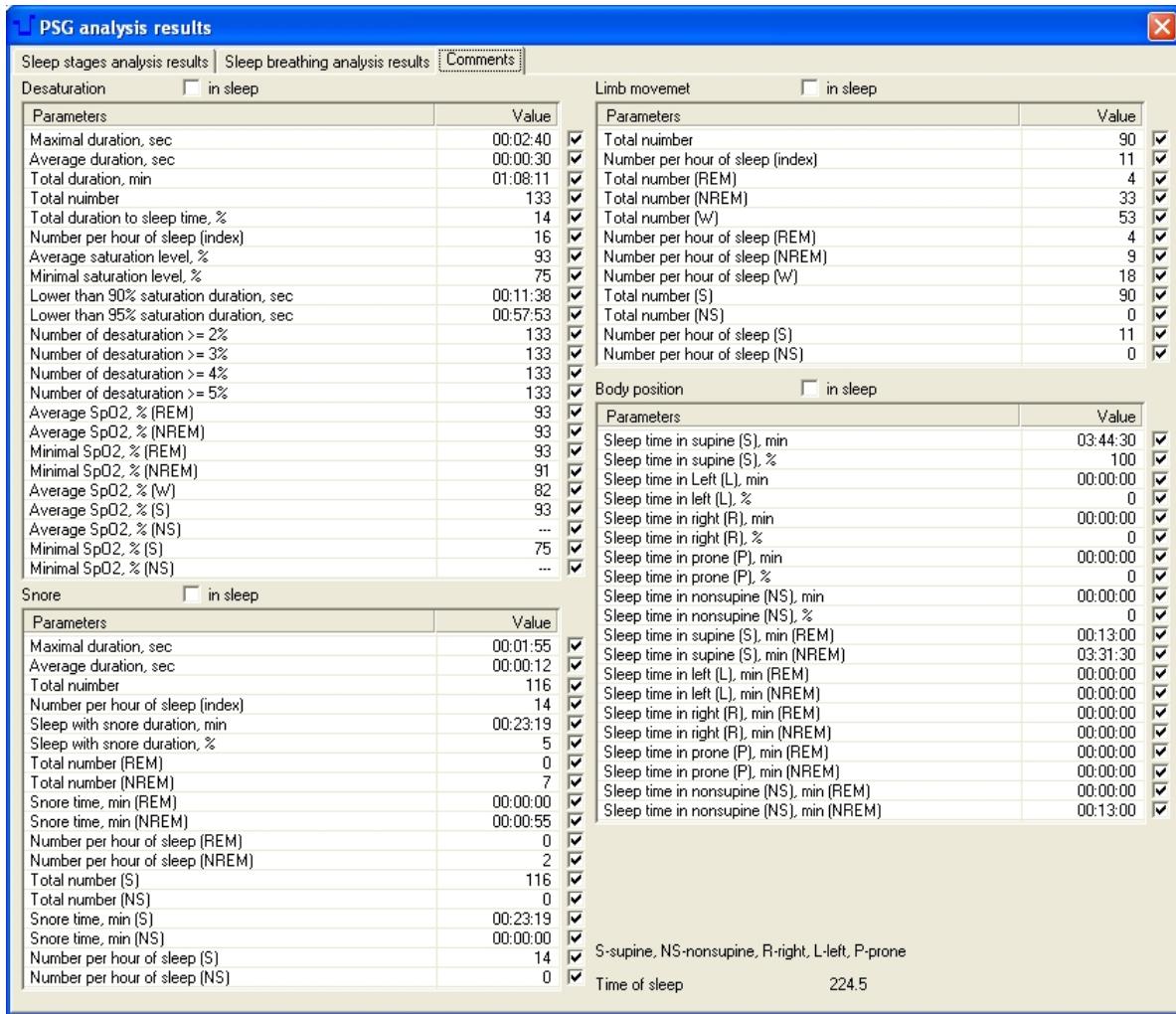
To copy table rows to report or clipboard - check corresponding checkbox

Time of sleep

224.5

Pic. 20.113

## Neuron-Spectrum Program



Pic. 20.114

In the calculation results the parameter tables of disordered breathing episodes, HR parameters, desaturation episodes, snore, limb movements and patient's body position are displayed.

*Sleep breathing analysis results page.*

*Sleep-disordered breathing events table.*

- Maximal duration* – maximal duration of the episode of a certain type.
- Average duration* – average duration of episodes of a certain type.
- Total duration* – total duration of all the episodes of a certain type.
- Total number* – total number of episodes of a certain type.
- Total duration to sleep time* – total duration of episodes of a certain type to sleep time ratio.
- Number per hour of sleep (index)* – number of episodes of a certain type per one hour of sleep.

Each parameter is calculated for the following types of episodes:

- all apnea episodes;
- all obstructive apnea episodes;
- all central apnea episodes;
- all mixed apnea episodes;
- all hypopnea episodes;

- all apnea and hypopnea episodes.

Besides, all the parameters can be calculated either for the full record time or for the patient's sleep time only. The sleep time is determined during separate analysis of sleep stages and sleep-disordered breathing as a record time without episodes when the light is on, the patient is moving or is not lying. These episodes are marked by the corresponding markers "Light is on"- "Light is off", "Patient is lying - "Patient is not lying", "Start of patient's movements"- "End of patient's movements". During the combined analysis of sleep stages and sleep-disordered breathing all the segments with REM stages (rapid eyes movement (REM)) and NREM stages (slow sleep stages: S1, S2, S3, S4) are referred to the sleep time. The display of the calculated parameters for either the full record time or for the patient's sleep time is switched by *in sleep* check box located above the corresponding table.

*Combined analysis of sleep stages and sleep-disordered breathing* table.

These parameters are calculated only if the combined analysis of sleep stages and sleep-disordered breathing is carried out.

- *Total duration (REM)* – total duration of all the episodes of a certain type in rapid eyes movement (REM) stage.
- *Total duration (NREM)* – total duration of all the episodes of a certain type in slow sleep stages (NREM) – (S1, S2, S3, S4 or N1, N2, N3).
- *Total number (REM)* – total number of episodes of a certain type in rapid eyes movement (REM) stage.
- *Total number (NREM)* – total number of episodes of a certain type in slow sleep stages (NREM) – (S1, S2, S3, S4 or N1, N2, N3).
- *Number per hour of sleep (REM)* – total duration of episodes of a certain type in rapid eyes movement (REM) stage per hour of sleep.
- *Number per hour of sleep (NREM)* – total duration of episodes of a certain type in slow sleep stages (NREM) – (S1, S2, S3, S4 or N1, N2, N3) per hour of sleep.

Each parameter is calculated for the following types of episodes:

- all apnea episodes;
- all obstructive apnea episodes;
- all central apnea episodes;
- all mixed apnea episodes;
- all hypopnea episodes;
- all apnea and hypopnea episodes.

If the combined analysis of sleep stages and sleep-disordered breathing has not been carried out, there is no information in the table.

*Depending on body position* table.

These parameters are calculated if there is a patient's body position channel in PSG record. If the channel is absent or hidden (not being analyzed), these parameters are not calculated.

- *Total duration (S)* – total duration of all the episodes of a certain type in patient's supine position.
- *Total duration (NS)* – total duration of all the episodes of a certain type in patient's nonsupine position.

## **Neuron-Spectrum Program**

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- *Total duration (R)* – total duration of all the episodes of a certain type in patient's right position.
- *Total duration (L)* – total duration of all the episodes of a certain type in patient's left position.
- *Total duration (P)* – total duration of all the episodes of a certain type in patient's prone position.
- *Total number (S)* – total number of episodes of a certain type in patient's supine position.
- *Total number (NS)* – total number of episodes of a certain type in patient's nonsupine position.
- *Total number (R)* – total number of episodes of a certain type in patient's right position.
- *Total number (L)* – total number of episodes of a certain type in patient's left position.
- *Total number (P)* – total number of episodes of a certain type in patient's prone position.
- *Number per hour of sleep (S)* – total duration of episodes of a certain type in patient's supine position per sleep time.
- *Number per hour of sleep (NS)* – total duration of episodes of a certain type in patient's non-supine position per sleep time.
- *Number per hour of sleep (R)* – total duration of episodes of a certain type in patient's right position per sleep time.
- *Number per hour of sleep (L)* – total duration of episodes of a certain type in patient's left position per sleep time.
- *Number per hour of sleep (P)* – total duration of episodes of a certain type in patient's prone position per sleep time.

Each parameter is calculated for the following types of episodes:

- all apnea episodes;
- all obstructive apnea episodes;
- all central apnea episodes;
- all mixed apnea episodes;
- all hypopnea episodes;
- all apnea and hypopnea episodes.

*HR* table.

These parameters are calculated if there is ECG channel in PSG record.

- *Average HR* – average HR for the recording time.
- *Minimal HR* – minimal HR for the recording time.
- *Maximal HR* – maximal HR for the recording time.
- *Heart rate variability* – heart rate variability for the recording time - the difference between maximal and minimal HR.
- *Number of Bradycardia* – number of Bradycardia episodes. Bradycardia is an episode with HR less than Bradycardia threshold (40 beats per minute by default) within at least for 10 seconds.
- *Number of Tachycardia* – number of Tachycardia episodes. Tachycardia is an episode with HR more than Tachycardia threshold (90 beats per minute by default) within at least for 5 seconds.

The following parameters are calculated if the combined analysis of sleep stages and sleep-disordered breathing is carried out.

- *Average HR (REM)* – average HR at rapid eyes movement (REM) stage.
- *Average HR (NREM)* – average HR at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).
- *Minimal HR (REM)* – minimal HR at rapid eyes movement (REM) stage.
- *Minimal HR (NREM)* – minimal HR at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).
- *Maximal HR (REM)* – maximal HR at rapid eyes movement (REM) stage.
- *Maximal HR (NREM)* – maximal HR at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).

*Comments* page.

*Desaturation* table.

All the parameters can be calculated either for the full record time or for the patient's sleep time only (see above). Besides, the parameters for different sleep stages are calculated only when the combined analysis of sleep stages and sleep-disordered breathing is carried out. The parameters of different patient's positions are calculated only if a body position channel is available.

- *Maximal duration* – maximal duration of desaturation episode.
- *Average duration* – average duration of desaturation episode.
- *Total duration* – total duration of all desaturation episodes.
- *Total number* – total number of desaturation episodes.
- *Total duration to sleep time* – total duration of desaturation episodes to sleep time.
- *Number per hour of sleep* – number of desaturation episodes per hour of sleep.
- *Average saturation level* – average saturation level during sleep.
- *Minimal saturation level* – minimal saturation level during sleep.
- *Lower than 90% saturation duration* – time when saturation level was less than 90%.
- *Lower than 95% saturation duration* – time when saturation level was less than 95%.
- *Number of desaturation >= 2%* – number of desaturation episodes with desaturation greater-than-or-equal-to 2%.
  - *Number of desaturation >= 3%* – number of desaturation episodes with desaturation greater-than-or-equal-to 3%.
  - *Number of desaturation >= 4%* – number of desaturation episodes with desaturation greater-than-or-equal-to 4%.
  - *Number of desaturation >= 5%* – number of desaturation episodes with desaturation greater-than-or-equal-to 5%.
- *Average SpO2 (REM)* – average SpO2 level at rapid eyes movement (REM) stage.
- *Average SpO2 (NREM)* – average SpO2 level at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).
- *Minimal SpO2 (REM)* – minimal SpO2 level at rapid eyes movement (REM) stage.
- *Minimal SpO2 (NREM)* – minimal SpO2 level at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).
- *Average SpO2 (W)* – average SpO2 level at awake state (W stage).
- *Average SpO2 (S)* – average SpO2 level in patient's supine position.
- *Average SpO2 (NS)* – average SpO2 level in patient's nonsupine position.
- *Minimal SpO2 (REM)* – minimal SpO2 level in patient's supine position.
- *Minimal SpO2 (NREM)* – minimal SpO2 level in patient's nonsupine position.

### *Snore* table.

All the parameters can be calculated either for the full record time or for the patient's sleep time only (see above). Besides, the parameters for different sleep stages are calculated only when the combined analysis of sleep stages and sleep-disordered breathing is carried out. The parameters of different patient's positions are calculated only if a body position channel is available.

- *Maximal duration* – maximal duration of snore episode.
- *Average duration* – average duration of snore episode.
- *Total duration* – total duration of snore episodes.
- *Number per hour of sleep* – number of snore episodes per hour of sleep.
- *Sleep with snore duration* – total duration of sleep with snore, in minutes.
- *Sleep with snore duration* – total duration of sleep with snore to total sleep time, in percents.
- *Total number (REM)* – total number of snore episodes at rapid eyes movement (REM) stage.
- *Total number (NREM)* – total number of snore episodes at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).

• *Snore time (REM)* – total sleep time with snore at rapid eyes movement (REM) stage.  
• *Snore time (NREM)* – total sleep time with snore at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).  
• *Number per hour of sleep (REM)* – number of snore episodes at rapid eyes movement (REM) stage per hour of sleep.

• *Number per hour of sleep (NREM)* – number of snore episodes at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3) per hour of sleep.  
• *Total number (S)* – total number of snore episodes in patient's supine position.  
• *Total number (NS)* – total number of snore episodes in patient's nonsupine position.  
• *Snore time (S)* – total sleep time with snore in patient's supine position.  
• *Snore time (NS)* – total sleep time with snore in patient's nonsupine position.  
• *Number per hour of sleep (S)* – number of snore episodes in patient's supine position.  
• *Number per hour of sleep (NS)* – number of snore episodes in patient's nonsupine position.

### *Limb movement* table.

All the parameters can be calculated either for the full record time or for the patient's sleep time only (see above). Besides, the parameters for different sleep stages are calculated only when the combined analysis of sleep stages and sleep-disordered breathing is carried out. The parameters of different patient's positions are calculated only if a body position channel is available.

- *Total number* – total number of limb movement episodes.
- *Number per hour of sleep (index)* – number of limb movement episodes per hour of sleep.
- *Total number (REM)* – total number of limb movement episodes at rapid eyes movement (REM) stage.
- *Total number (NREM)* – total number of limb movement episodes at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).
- *Number per hour of sleep (REM)* – number of limb movement episodes at rapid eyes movement (REM) stage per sleep hour.
- *Number per hour of sleep (NREM)* – number of limb movement episodes at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3) per sleep hour.

- *Total number (S)* – total number of limb movement episodes in patient's supine position.
- *Total number (NS)* – total number of limb movement episodes in patient's nonsupine position.
- *Number per hour of sleep (S)* – number of limb movement episodes in patient's supine position per sleep hour.
- *Number per hour of sleep (NS)* – number of limb movement episodes in patient's nonsupine position per sleep hour.

*Body position table.*

- *Sleep time in supine (S), min* – sleep time in patient's supine position, in minutes.
- *Sleep time in supine (S), %* – sleep time in patient's supine position to total sleep time, in percents.
- *Sleep time in left (L), min* – sleep time in patient's left position, in minutes.
- *Sleep time in left (L), %* – sleep time in patient's left position to total sleep time, in percents.
- *Sleep time in right (R), min* – sleep time in patient's right position, in minutes.
- *Sleep time in right (R), %* – sleep time in patient's right position to total sleep time, in percents.
- *Sleep time in prone (P), min* – sleep time in patient's prone position, in minutes.
- *Sleep time in prone (P), %* – sleep time in patient's prone position to total sleep time, in percents.
- *Sleep time in nonsupine (NS), min* – sleep time in patient's nonsupine position, in minutes.
- *Sleep time in nonsupine (NS), %* – sleep time in patient's nonsupine position to total sleep time, in percents.
- *Sleep time in supine (S), min (REM)* – sleep time in patient's supine position at rapid eyes movement (REM) stage.
- *Sleep time in supine (S), min (NREM)* – sleep time in patient's supine position at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).
- *Sleep time in left (L), min (REM)* – sleep time in patient's left position at rapid eyes movement (REM) stage.
- *Sleep time in left (L), min (NREM)* – sleep time in patient's left position at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).
- *Sleep time in right (R), min (REM)* – sleep time in patient's right position at rapid eyes movement (REM) stage.
- *Sleep time in right (R), min (NREM)* – sleep time in patient's right position at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).
- *Sleep time in prone (P), min (REM)* – sleep time in patient's prone position at rapid eyes movement (REM) stage.
- *Sleep time in prone (P), min (NREM)* – sleep time in patient's prone position at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).
- *Sleep time in nonsupine (NS), min (REM)* – sleep time in patient's nonsupine position at rapid eyes movement (REM) stage.
- *Sleep time in nonsupine (NS), min (NREM)* – sleep time in patient's nonsupine position at slow sleep stages (S1, S2, S3, S4 or N1, N2, N3).

While calculating sleep time the moments, which should be ignored during the calculations, can be marked by the markers “*Light is off*”, “*Light is on*”, “*Start of patient’s movements*”, “*End of patient’s movements*” and, if the body position probe is not set and the body position channel is not available on PSG, by the markers “*Patient is not lying*”, “*Patient is lying*”. The time of movements is determined according to the placed markers “*Start of patient’s movements*”, “*End of patient’s movements*”.

These markers can be set during PSG recording. If any markers were not set during PSG recording, the movements and light on/off sections can be marked during PSG review.

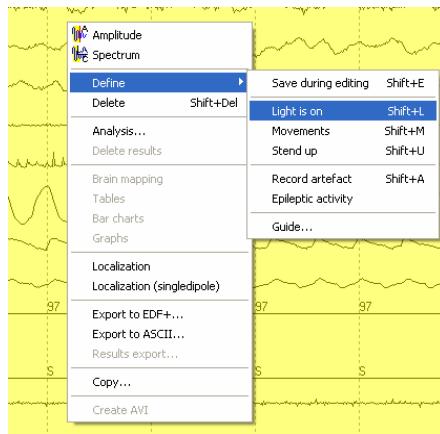
If in PSG record the light on/off markers are not set, it is suggested that the marker “*Light is off*” is set at the beginning of the record, the marker “*Light is on*” is set at the end of the record and the whole record is considered as sleeping time. If the light on/off markers are set, the beginning of the sleep is defined from the moment when the light was turned off for the first time and the end of the sleep is defined in the moment when the light was turned on for the last time. The intermediate light on/off markers define the fragments (between the markers “*Light is off*” and “*Light is on*”) excluded from the calculations. To select a fragment on the record during PSG review, when the light was off, it is necessary:

- To select the fragment of the record, for instance, by clicking the right mouse button on the beginning and the end of the selected fragment and selecting **Fragment beginning**, **Fragment ending** commands (Pic. 20.114).



Pic. 20.115

- To define the selected fragment as the fragment of the record where the light was on by clicking the right mouse button on the fragment and selecting **Define|Light is on** command in the fragment properties menu (Pic. 20.115).



Pic. 20.116

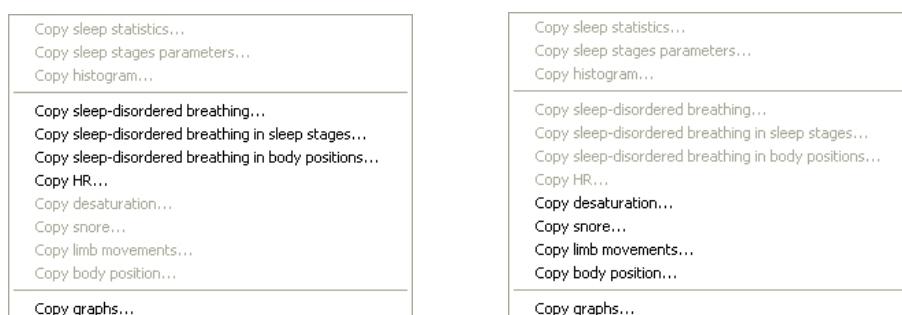
- To define PSG record fragment as the patient movements it is necessary to select the fragment of the record and define the selected fragment as the patient movements section using **Define|Movements** command in the fragment properties menu. These fragments will be excluded from the calculations of disordered breathing parameters except of the different body positions duration.

- If during PSG recording the body position probe was not used and the body position channel is not available in the record, it is possible to define the patient position fragments when he was not lying. For this purpose, use **Define|Stand up** menu command in the fragment properties menu. These fragments will be also excluded from the calculations of disordered breathing parameters.

- The simultaneous video of the patient helps to define the fragments of patient movements, the fragments with light on and the fragments when the patient was not lying.

- After the calculation of sleep-disordered breathing parameters, all the episodes included in the fragments of movements, the fragments with light on and the fragments when the patient was not lying are marked on PSG and on the panel of episodes with the different color. It goes without saying that they are ignored in the calculation of parameters during sleep.

- Using the commands from the properties menu of the sleep-disordered breathing analysis results window, you can copy the analysis results tables to the report or clipboard as well as to copy the graphs of the episodes and trends panel to the report (Pic. 20.116). The check boxes on the right side of each table line determine the necessity of copying this line to the report or clipboard.



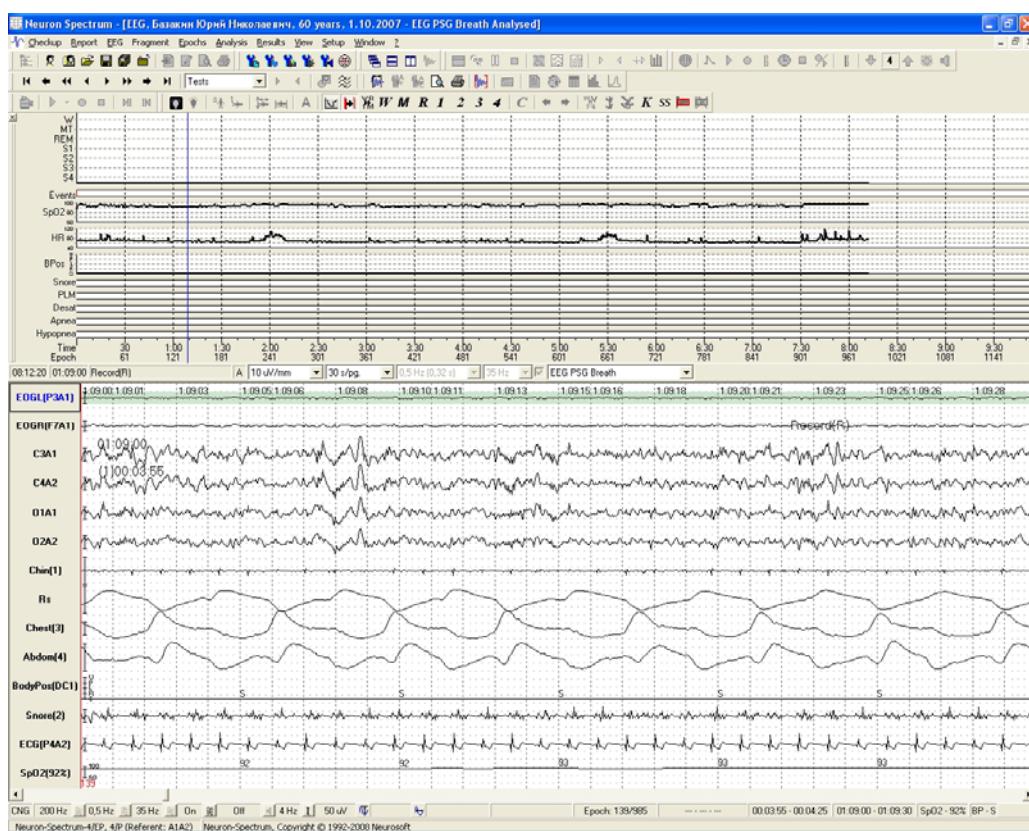
Pic. 20.117

- To create the checkup report similar to the report in the sleep stages analysis mode, use **Report|PSG** command in the main menu. The command is active if the sleep-disordered breathing analysis results window is on the screen. How to select the elements included in the report is described above (Pic. 20.89).

#### **20.4.4. COMBINED ANALYSIS OF SLEEP STAGES AND SLEEP-DISORDERED BREATHING**

If in PSG record the channels necessary for sleep structure (sleep stages) analysis as well as the channels necessary for sleep-disordered breathing analysis (even partially) are available, **Neuron-Spectrum-PSG** enables to make sleep stages and sleep-disordered breathing analysis in one and the same session. For this purpose, select *Combine analysis of sleep stages and sleep breathing* check box on **PSG** page of **EEG view and analysis** dialog box (Pic. 20.52).

For combined analysis open the record you need and select **Analysis|PSG** menu command in EEG view and analysis window. The program will switch to the PSG review and analysis mode (Pic. 20.117).

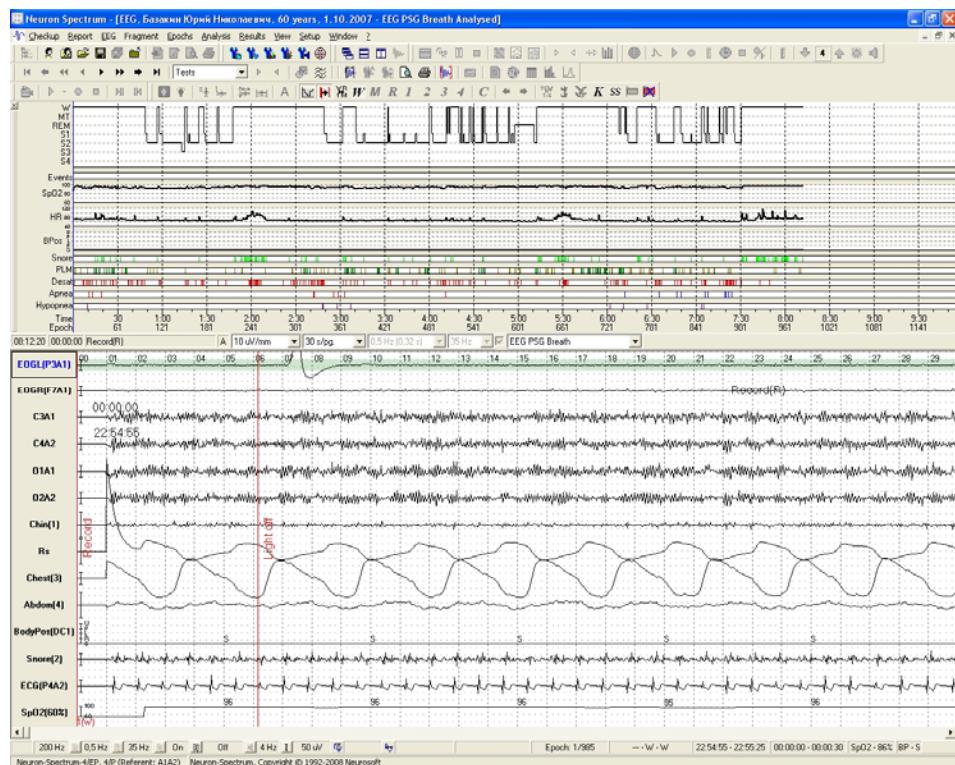


Pic. 20.118

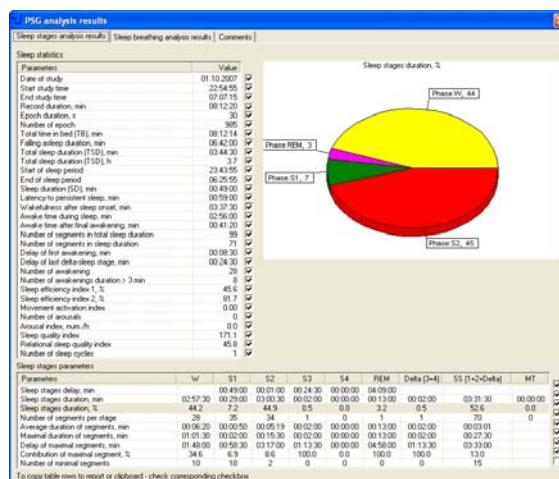
Either on the top part of the screen (or on the second monitor) the hypnogram, the panel of events, trends of HR, SpO<sub>2</sub> and body position (if these channels are available in the record), the panels of snore, desaturation, limb movements, apnea and hypopnea (if the necessary channels are available in the record) are displayed. In the bottom part of the screen PSG window is located. The reviewing is made by epochs, and the epoch value is equal to epoch value for sleep stages analysis.

The following procedure of PSG analysis can be recommended (another procedure of PSG analysis accepted in your laboratory is also possible):

- Sleep stages analysis and the hypnogram are made first.
- Then the automatic analysers for search of disordered breathing, desaturation, snore and limb movements episodes can be started. After that you should view the phenomena detected automatically and edit them if necessary.
- When the both types of analysis are completed (Pic. 20.119), the results of hypnogram analysis (sleep stages analysis) (**Results|PSG (Sleep stages)** command menu) as well as the results of sleep-disordered breathing analysis (**Results|PSG (Sleep breathing)** command menu) can be generated (Pic. 20.120).



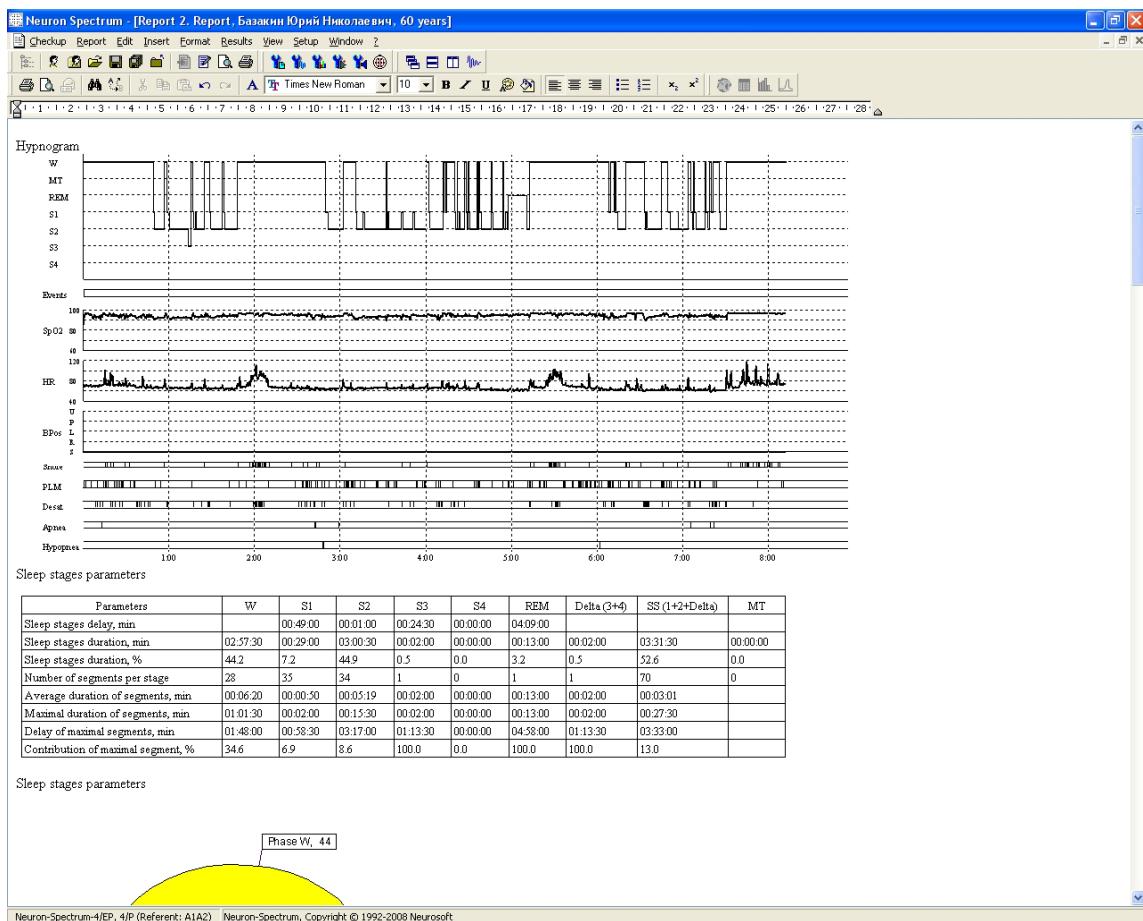
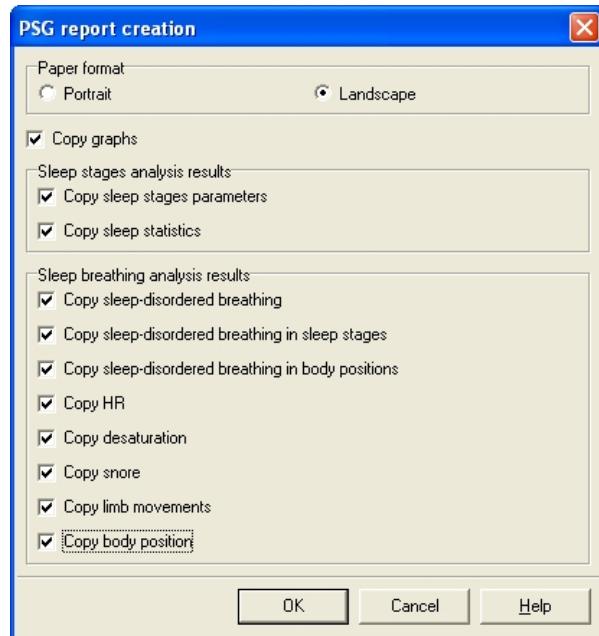
Pic. 20.119



Pic. 20.120

## Neuron-Spectrum Program

- At the end of analysis the checkup report is created. To create the report use **Report|PSG** menu command (Pic. 20.121).



Pic. 20.121

Finally, it is important to mention that when PSG analysis has been carried out, you can edit only the video fragments of it. The fragments of PSG cannot be deleted.