

# SleepRT applications for routine and research



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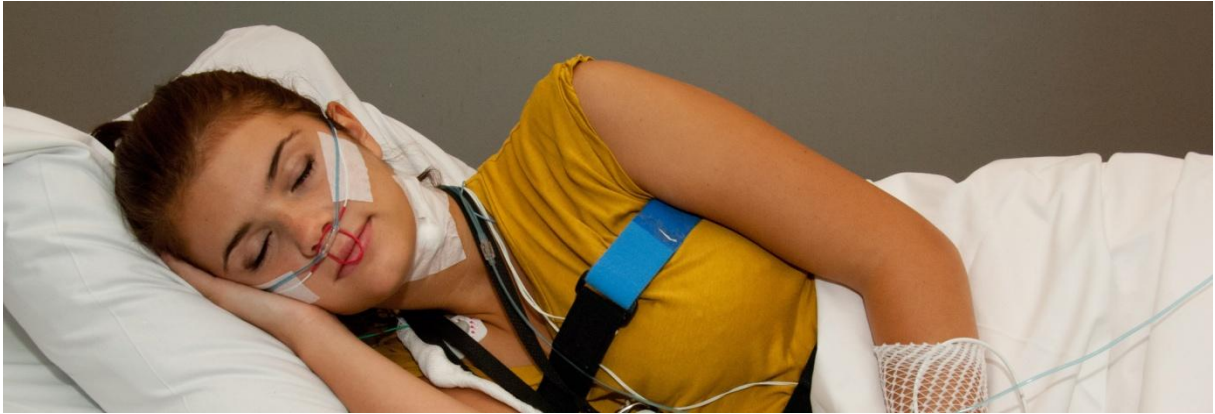
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# SleepRT Introduction

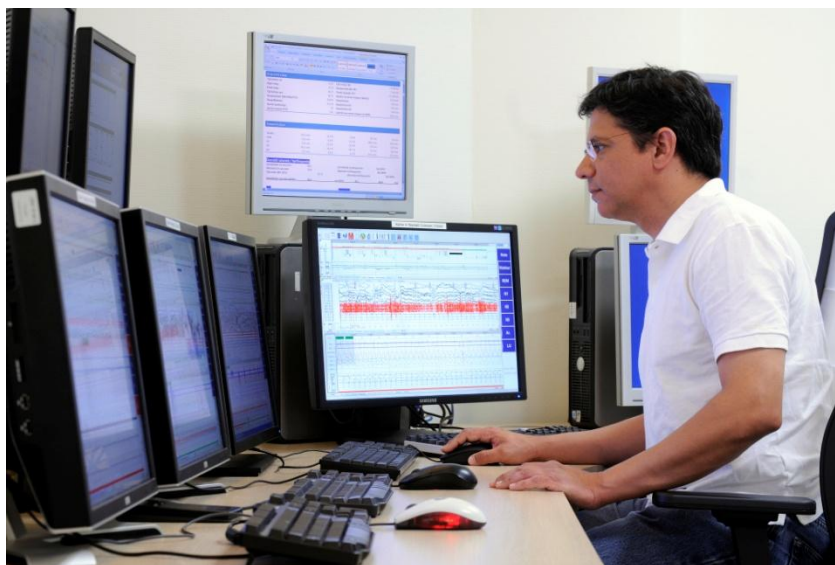
Discover our SleepRT platform to cover multiple applications!



Whether you are looking for in-lab Video-PSG with surveillance or efficient Review Software for Ambulatory PSG and PG recordings, we can provide you with the **Solutions** you need.

The SleepRT software includes Automatic Analyses for PSG and EEG signals, with default parameters according to the **Current AASM Guidelines**. Thanks to user definable analysis parameters, the analyses can be adapted to follow the rules required in your clinical practice or research projects.

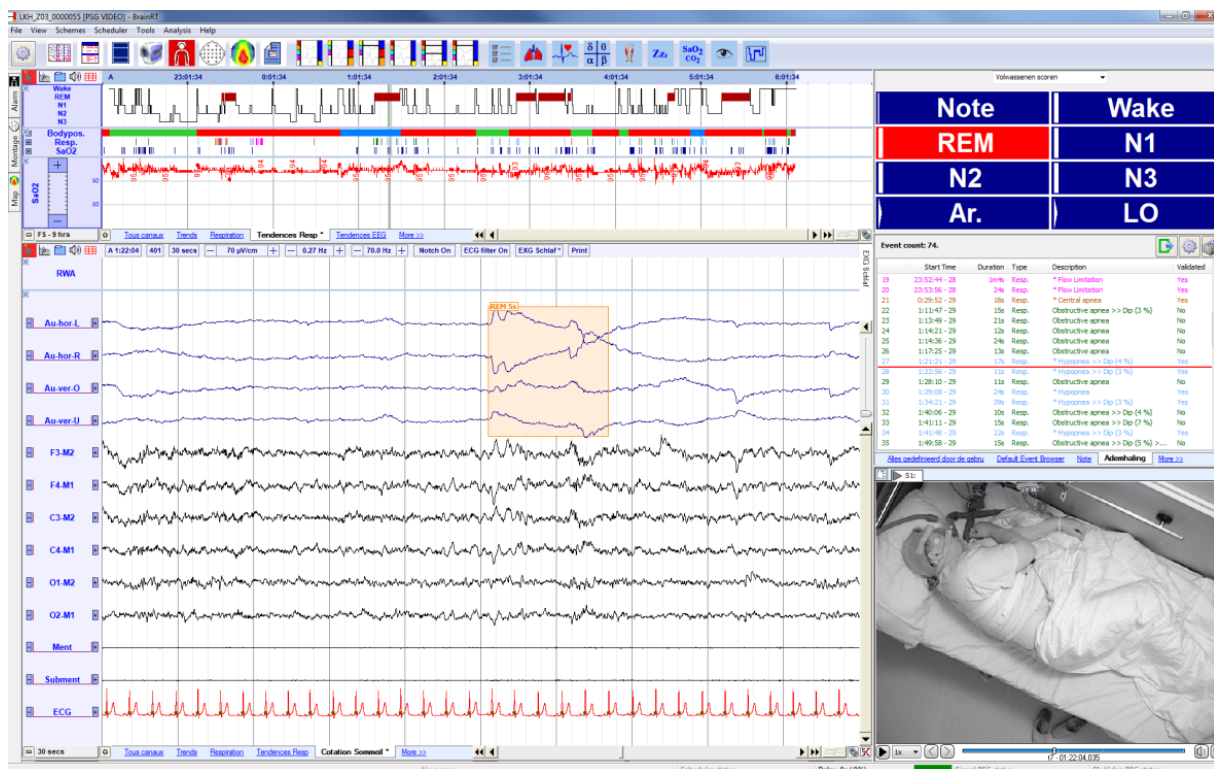
To ensure a comfortable **User experience**, the SleepRT software is intuitive and easy to work with. In addition, the SleepRT is fully integrated in the hospital infrastructure, offering a **Closed Loop communication** with the Hospital Information System.



# SleepRT applications

## Video-PSG

The SleepRT equipment offers a perfect solution for **PSG acquisitions in the daily clinical practice**. Not only can you start an acquisition and start saving signals and video in one smooth procedure; thanks to the use of multiple measuring protocols it takes only the correct protocol choice to switch between different types of acquisition.



Example of a Video-PSG recording with HD video

## MWTs and MSLTs

Making an MSLT or MWT report is easy with SleepRT: We automatically detect start and stop times of the subsequent tests and provide automatic calculation of the mean sleep latency for each sleep stage.

MSLT									
Number of SLT's				5					
SLT#	Start	Stop	Duration	B. Sleep	Latency	Lat. N1	Lat. N2	Lat. REM	SOREM
1	08:59	09:30	31,0 min	09:02	2,5 min	2,5 min	24,5 min	5,0 min	2,5 min
2	11:00	11:31	31,0 min	11:02	1,5 min	1,5 min	4,0 min	18,0 min	16,5 min
3	13:00	13:31	31,0 min	13:07	7,0 min	7,0 min	10,0 min		
4	15:00	15:31	31,0 min	15:04	4,5 min	4,5 min	8,0 min	10,0 min	5,5 min
5	17:00	17:31	31,0 min	17:01	1,5 min	1,5 min	21,0 min	3,5 min	2,0 min
Average					3,4 min	3,4 min	13,5 min	9,1 min	6,6 min

# PSG for Paediatric and Infant patients

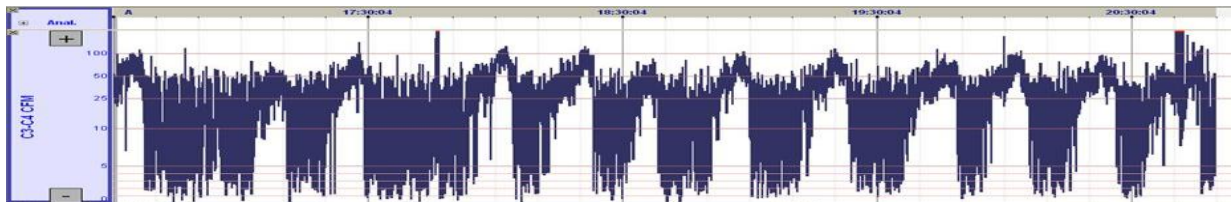
In order to facilitate PSG recordings for **Infants as well as for Pediatric patients**, the SleepRT software integrates a number of adaptations made especially for this group of patients.

## *Cardio-respiratory analysis for infants and pediatric patients*

SleepRT automatically detects respiratory disturbances such as apneas and hypopneas by means of specific **Automatic Analysis parameters for children and infants**. Related events such as oxygen desaturation and high CO<sub>2</sub> values are detected automatically in the SleepRT software, adding to the Quality and Completeness of the Sleep Report.

## *CFM analysis to determine sleep patterns*

The Cerebral Function Monitor (CFM) is often used as a visual interpretation of the EEG signals. The CFM trend is easy to interpret for non-neurologists and contains useful information about the evolution of the sleep pattern of the patient.



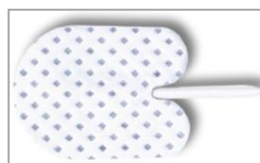
Example of automatic CFM trend in SleepRT

## *Disposable sleep sensors for infants*

To minimize chances of infection, a range of disposable sensors was tested for quality and robustness with the SleepRT equipment. This includes disposable sensors for EEG, EMG, EOG and ECG, as well as disposable sensors for respiratory effort bands, SaO<sub>2</sub>, airflow sensors and cannula's. Some examples are shown here:



Disposable EEG sensor



Disposable sensor for EMG, EOG, ECG signals



All-in-one disposable thermistor + cannula



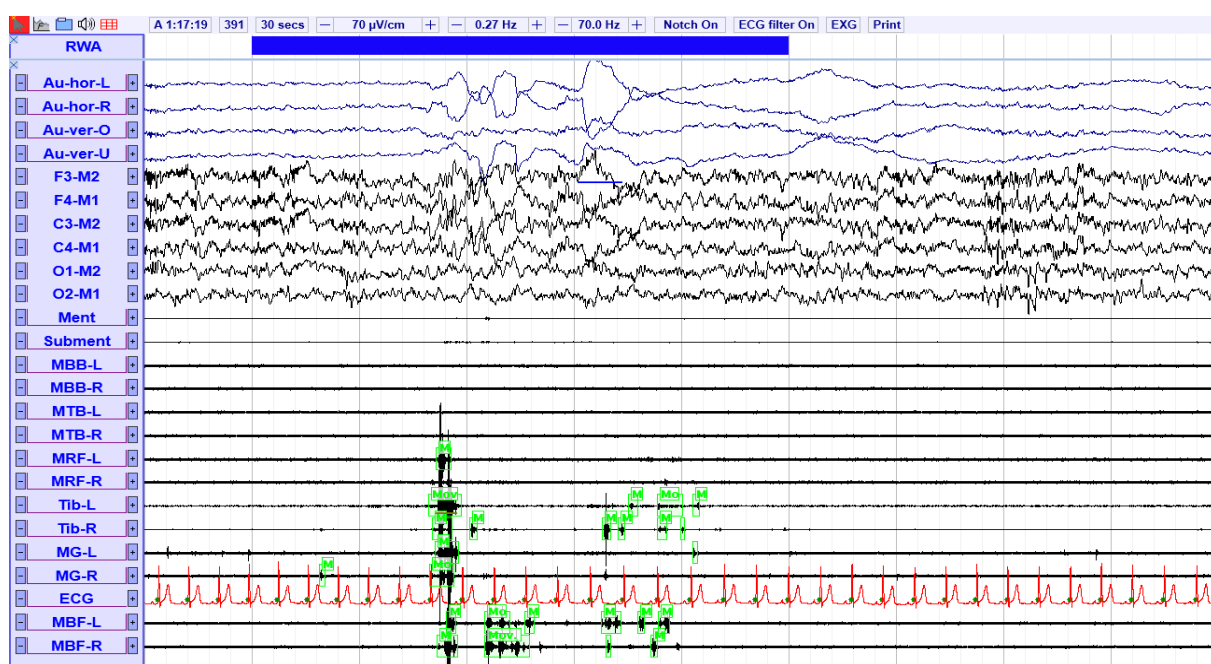
All-in-one disposable thermistor + cannula + connection for capnograph

# Neurological Sleep Disorders

The SleepRT equipment offers validated tools of excellence for the detection of neurological disorders in Sleep. Not only has the **PLM analysis been validated** against the latest AASM scoring rules, the SleepRT software also has Advanced Automatic Tools for the detection of **REM sleep Behavior Disorder** in the Clinical Practice. Enjoy our highly efficient Automatic Analysis and save time during Review!

## *Automatic analysis of REM Sleep Behavior Disorder*

Manual scoring of phasic and tonic EMG activity during REM is a time consuming and complicated task, especially when recording additional EMG channels. In cooperation with the neurological sleep center in Innsbruck, we have developed an **automatic detection algorithm for Phasic, Tonic and Any EMG activity during REM Sleep**.



SleepRT example of the automatic detection of phasic EMG activity during REM sleep for a recording with 14 EMG channels. Each REM epoch is divided into 3 second epochs and evaluated for presence of phasic EMG activity.

REM SLEEP EMG ACTIVITY OVERVIEW	
Total REM duration: 54.0 min	
Phasic EMG activity	97.8 %
Tonic EMG activity	60.2 %
REM Atonia Index	39.8 %
Total EMG activity (tonic + phasic)	99.3 %



# PSG in the ICU

If you are interested in the sleep pattern and respiration of patients in the **Intensive Care Unit**, SleepRT offers a highly flexible recording tool to record all relevant data. Not only can you connect the PSG recorder provided by OSG, you can also add Vital Data from the Patient Monitor, CO2 data and other parameters relevant for ventilation. OSG offers a Real-Time interface to the following Patient Monitors: Philips IntelliVue MP and MX, Dräger.



Dräger Infinity



Philips IntelliVue MP70

In addition to the PSG and Patient Monitor data, you can add Video recordings to give extra insight into the patient's status. In this way, movement and caregiving moments are easily distinguished from actual events. Using the automatic analyses, you can get a quick overview report of respiratory trends, desaturation events, hypoventilation etcetera.

## Blood pressure monitoring during PSG

As cardiovascular complications with respect to periodic leg movements and respiratory problems during the night have been reported as a reason for treatment, non-invasive blood pressure monitoring during sleep is becoming a practice in sleep research as well as in clinical sleep labs. With SleepRT it is possible to interface to a blood pressure monitor or to a Philips IntelliVue monitor in order to acquire and analyze the blood pressure signal.

### *Interface to blood pressure monitor*

Noninvasive continuous blood pressure can be measured with devices such as the Nexfin, Finapres or CNAP monitor. The analogous signals of these devices can be recorded synchronously with the PSG signals from the SleepRT amplifiers. SleepRT provides a real time analysis of these data as well as an automatic calculation of the Baroreflex Sensitivity.



CNAP™ 500 Monitor

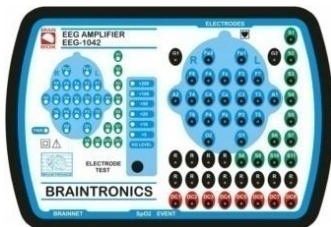
# Amplifiers for PSG recordings

Sleep<sup>RT</sup> provides **recording solutions to suit every kind of sleep lab**. Whether you wish to ensure maximal patient freedom through a wireless device, cross a large distance between the nurses' ward and the patient's room or record a large number of EEG/EMG/respiratory channels for research purposes: Sleep<sup>RT</sup> offers a choice of different recorders to suit every need. In addition, Sleep<sup>RT</sup> has interfaces to a multitude of ambulatory recording devices.



## Online & Ambulatory PSG/EEG with Morpheus

- Up to 34 channels (24 EEG channels)
- 1 Gb CF memory card
- 2 AA 1.5V batteries for power supply
- Up to 24 hours of ambulatory recording
- Internal Bluetooth® communication unit
- Size: 11 x 8 x 3 cm
- Weight: 250 grams (including batteries)



## Online PSG/EEG with Brainbox-1042

- 40 channels (32 EEG channels) + 4 DC channels
- Braintronics IP amplifier: Brainbox® connected to PC via **Ethernet cable**
- Maximum sampling rate: 1024 Hz for 32 EEG channels
- Amplifier resolution: 16 bit
- Input impedance: 10 MΩ ± 1 %



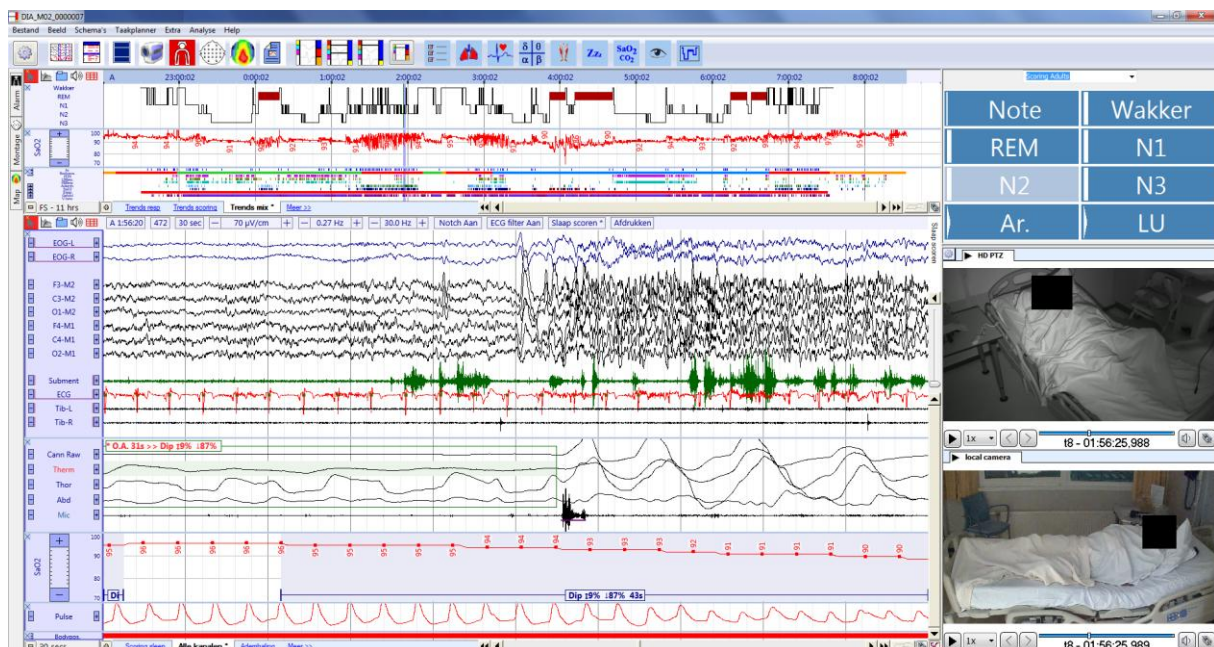
## Ambulatory PG with Somnolter

- Up to 24 channels (2 bipolar EEG channels)
- Compact size: 8.5 x 5.5 x 1.6 cm
- Weight: 80 grams
- 2 RIP belts (disposable)
- Calibrated Pressure channel + Pneumotachograph
- Internal Memory Card
- Up to 18 hours of ambulatory recordings
- Rechargeable battery

# Camera's for Video-PSG

High quality synchronized video acquisition is a key feature of the SleepRT software. SleepRT not only allows you to choose between different types of camera's for optimal ease of use, it is even possible to measure from multiple cameras at the same time. This can be particularly useful during sleep recordings when the patient turns his back to one of the cameras.

Thanks to the efficient compression of the video files, SleepRT offers the right balance between high quality and yet compact video files. In addition, you can choose to keep only a few episodes of the entire video recording by clipping the video file.



## Our State of the Art Camera Features

- Perfect **Synchronization** between camera images and PSG signals (Max error 1 to 2 frames)
- **Full HD and HD** image quality
- **Efficient compression** of data (H264 protocol & variable bit rate)
- **Easy setup** thanks to Network cameras and Power Over Ethernet possibility
- **Pan Tilt Zoom functionality**
- Practical **ZOOM** functionality during and after recording
- Possibility to record **2 or more concurrent streams** – for a multi-angle view
- Clipping tool for recorded video

# Integration in the hospital

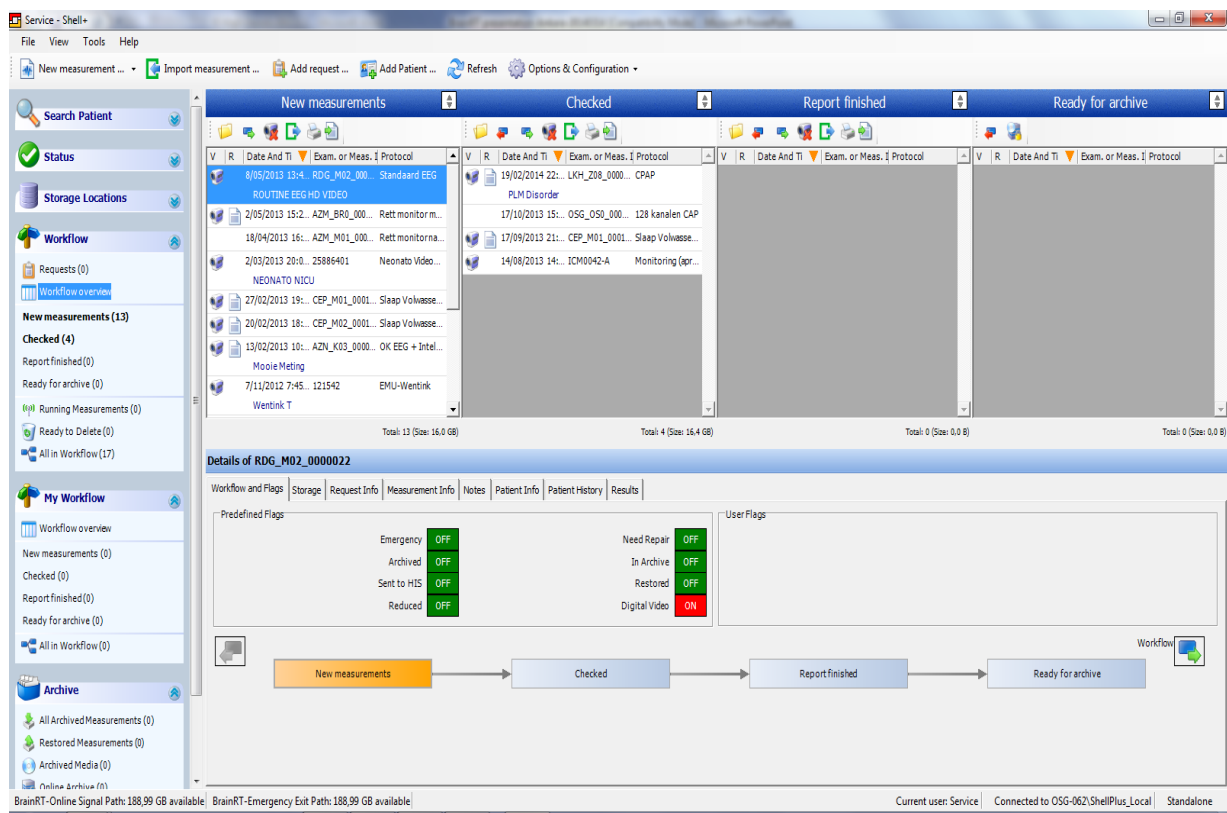
The SleepRT software is designed with an effortless integration in the hospital in mind. To accomplish this, continuous development and upgrades of the software are made in order to keep compliant with the most recent **hospital infrastructure**.

Some accomplishments of the SleepRT software:

- Database compatible with SQL Server 2008, 2012, 2014, 2016
- Client installation compatible with Windows 7, 8, 10
- Report tool compatible with Office 2012, 2013, 2016
- **Virtual software license** for easy virtual installation on the license server

## ShellPlus database

For the users of the SleepRT application, the **ShellPlus database** is an **efficient platform** where all users can access the measurements. Key features of the ShellPlus database are the central storage of the data (no local storage of data on the acquisition stations) and the central management of the software configuration.

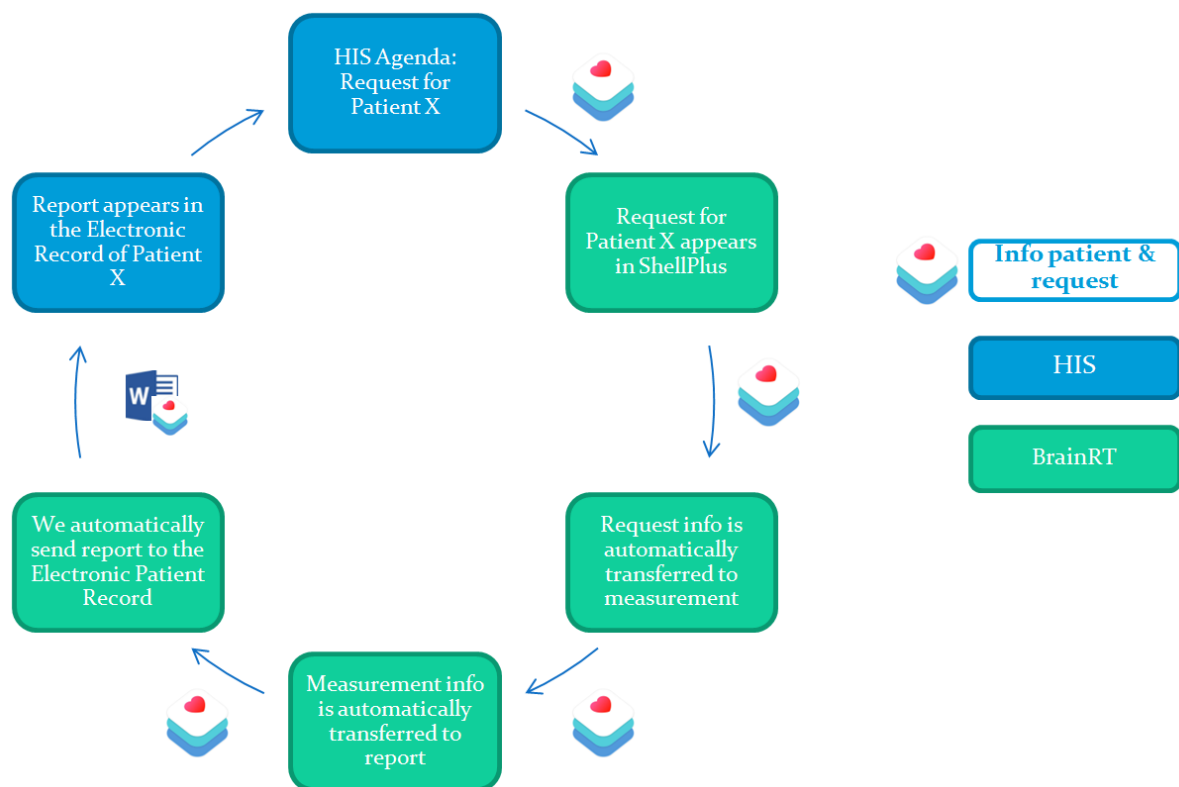


ShellPlus: Central database for management of all measurements and for centralized configuration of the program settings

The central configuration is automatically distributed to all stations in the network. The configuration can be changed on any acquisition or review station and is immediately distributed to all other stations (protected by a password).

## HL7 communication: Closed Loop System with Sleep<sup>RT</sup>

Sleep<sup>RT</sup> guarantees correct patient information through communication with the Hospital Information System in a Closed Loop System, as demonstrated in the image below.



The following functions are integrated in the Sleep<sup>RT</sup> system by means of HL7 communication:

- **Automatic filling of Patient Info** based on ID
  - First & Last Name
  - Date of Birth
  - Address
  - GP
- **Automatic list of Requests** with all necessary Request Info:
  - Patient info
  - Referring doctor
  - Indication
  - Clinical info
  - Medication
  - Type of investigation
  - Location
- **Send the report** to the patient's Electronic Medical Record

# Analysis of ambulatory recordings in SleepRT

The SleepRT software is perfectly suitable for PSG analysis of ambulatory signals. The software can read data from many different devices without preceding conversion step.

The SleepRT software is compatible with the following amplifiers:

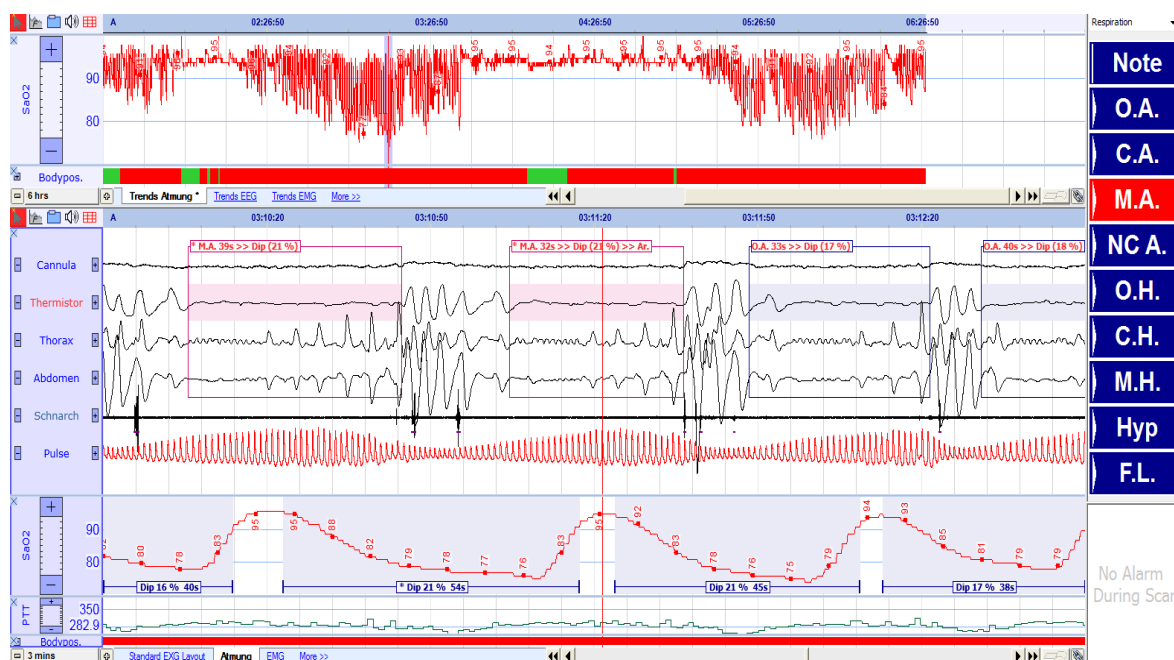
- All Embla devices
- Philips Respironics Alice 6
- All Micromed devices
- Temec recorders

In addition, the SleepRT software can analyze data in European data format **EDF and EDF+**. This last data format also includes events and hypnogram information, which is automatically recognized and imported in the SleepRT acquisition during import.

## Import protocol for signals

The first time you import a new type of signal, you have to create an import protocol to determine the signal types and subtypes in the recording.

Once you have made these settings, they can be saved for future use in a protocol. The advantage of this system is that you require only one action to start importing signals in an easy way.



Import of a Polygraphy recording in SleepRT



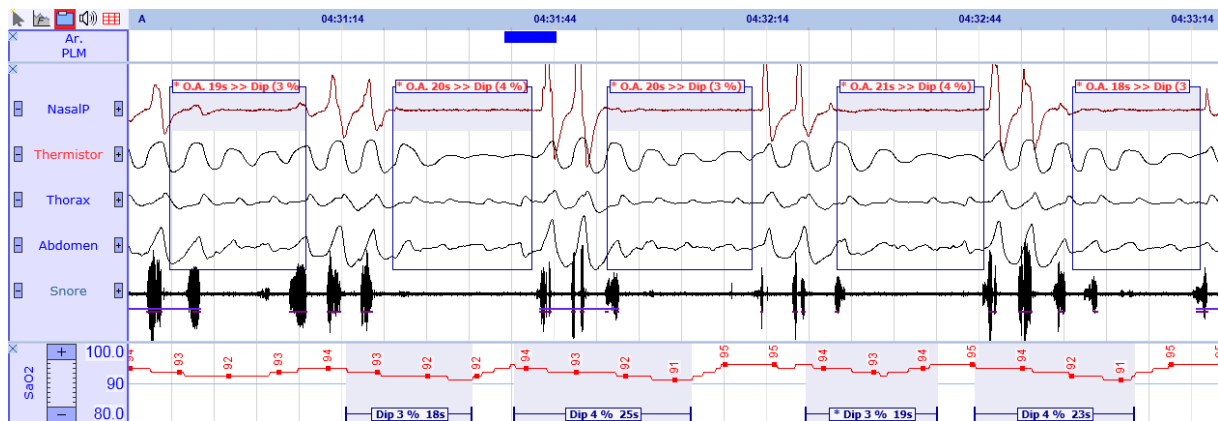
# SleepRT Automatic Analyses

SleepRT offers Automatic Sleep Analyses in order to speed up the scoring process for PSG recordings. All Analyses are executed according to the latest AASM Guidelines. During the acquisition, it is possible to run Automatic SleepRT Analyses in **real time**. That means that all data are analyzed at the exact moment that they are recorded. It is also possible to perform the analyses after the recording is finished.

## Respiratory analysis

The SleepRT software analyzes the respiratory signals in order to determine respiratory rate, phase opposition between respiratory effort bands, and respiratory events. For the automatic detection of apneas and hypopneas, standard SleepRT settings are according to the AASM Guidelines version. This involves two different flow channels for the respiratory analysis: the nasal pressure signal to determine hypopneas, and the thermistor signal to determine apneas. In addition, the analysis looks at associations with arousals and desaturations in order to count hypopneas.

It is possible to change the analysis settings in order to follow other scoring criteria.



SleepRT Respiratory and SaO2 analysis: event association between respiratory events and desaturations is detected

## SaO<sub>2</sub> and CO<sub>2</sub> analysis

The SleepRT software analyzes the SpO2 signal to determine minimum, mean and maximum SpO2 values for every sleep stage. In addition, the analysis detects oxygen desaturations and hypoxical states. Each desaturation is marked with its minimum value and its absolute drop in saturation value.

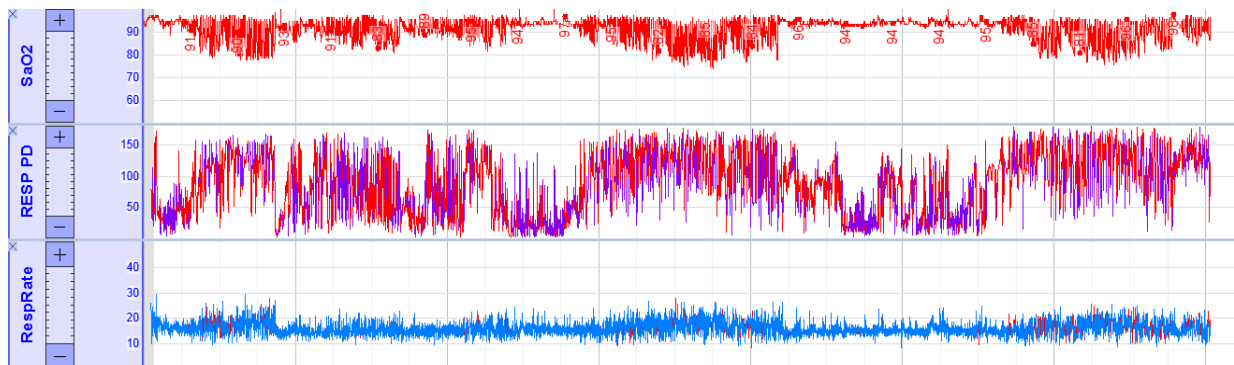
### CO<sub>2</sub> analysis

For capnograph signals, the End Tidal CO<sub>2</sub> values are determined and time passed above a certain CO<sub>2</sub> level are calculated in the report. For transcutaneous CO<sub>2</sub> signals, time passed above a certain CO<sub>2</sub> level is calculated in the report. The cut-off values can be selected by the user.

## Display options for respiratory analysis results

The SleepRT analyses generate trends and events. For an optimal overview of these trends, SleepRT provides the possibility to make customized overviews. The view below shows 12 hour trends of:

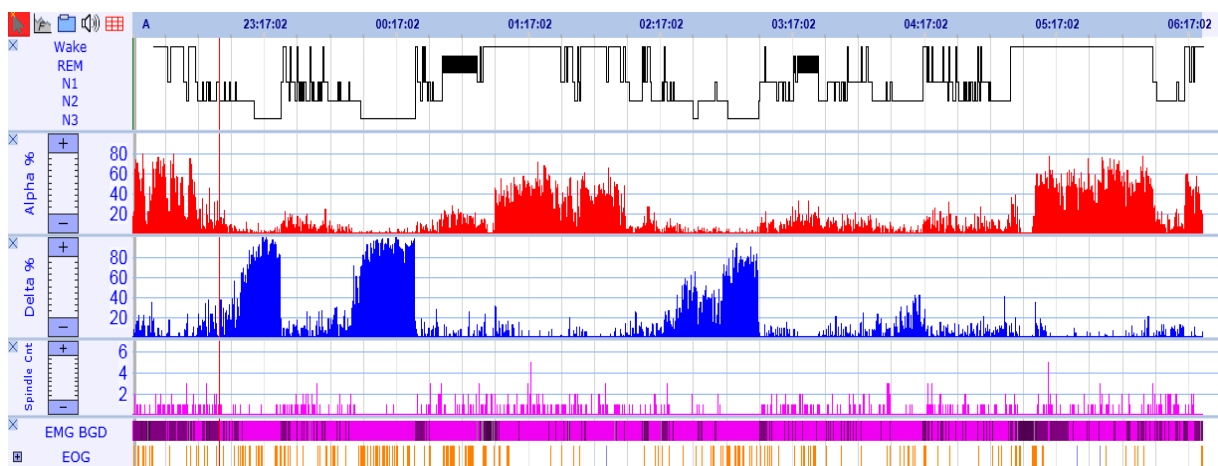
- SpO<sub>2</sub> signals (upper curve)
- respiratory phase difference between abdominal band and thoracic band (middle curve)
- respiratory rate (lower curve)



Respiratory trends: oxygen saturation trend, phase difference and respiratory rate

## Automatic hypnogram

You can generate an automatic sleep hypnogram with the SleepRT software. The software combines information from the chin electrode, EEG and EOG channels to detect the correct sleep stages. Manual correction of the automatic hypnogram is possible when making a copy of the automatic hypnogram. Alternatively, you can start from an empty hypnogram and score everything manually.



Automatic hypnogram in SleepRT

Arousals are detected and classified according to arousal type: PLM arousal, respiratory arousal snoring arousal etcetera.

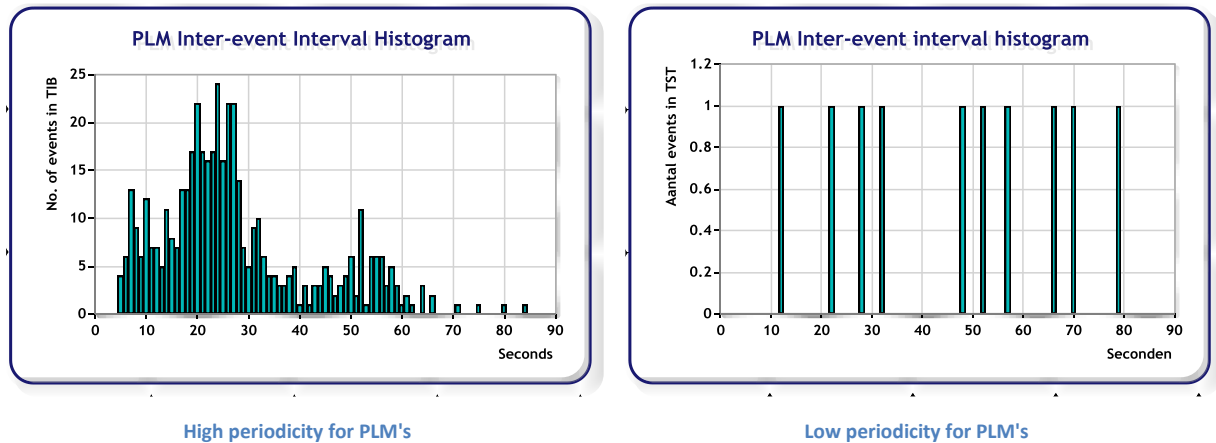
In the report, all useful parameters related to sleep stages are included, such as sleep latency, % of REM sleep etcetera.



# EMG analysis

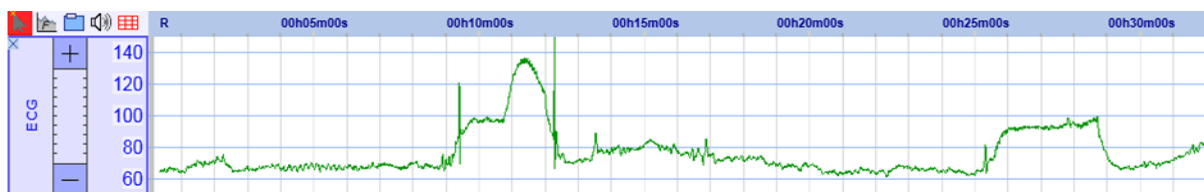
The Sleep<sup>RT</sup> automatic EMG analysis includes automatic detection of PLM's and REM Sleep behavior disorder. Apart from determination of the PLM index, Sleep<sup>RT</sup> also creates a periodicity histogram. The PLM analysis takes into account the association with respiratory events in order to exclude Leg Movement events caused by respiratory events.

Phasic and tonic EMG events during REM sleep are detected automatically with the Sleep<sup>RT</sup> software. More information about this can be found in the description of Sleep<sup>RT</sup> applications.



# ECG analysis

The ECG analysis in Sleep<sup>RT</sup> detects the R peaks of QRS complexes and calculates the heart rate as well as the mean consecutive difference in RR intervals. The ECG analysis also calculates the Pulse Transit Time. The RR intervals can be exported in ASCII format for further heart rate variability analysis.



# Analysis parameters adaptable by user

For optimal results, each analysis includes a “parameter set” which can be changed by the user. Changing the analysis parameters is even possible while the acquisition is running! Default parameter sets are available for adults, children and neonates.

# SleepRT report functions

## Use of Word templates in SleepRT

All reports in SleepRT are made in Word format. SleepRT includes a number of predefined PSG report templates which include all useful figures of the sleep registration. With the report manager you can easily add cuttings of the recording to the report. The technician can add the sleep diary of the patient, and the doctor his conclusion.

Additionally, you can make adaptations to the default templates to create your own customized report, by adding custom fields, the logo of the hospital, automatic SleepRT calculations etcetera.

## One report for multiple recordings

In the SleepRT database you can create one report to summarize multiple recordings. This is particularly useful if you want to compare different recordings of one patient.

An example is shown below: night 1 corresponds to a diagnostic PSG recording without treatment (results on the left side), night 2 corresponds to a CPAP titration night (results on the right side).

Thanks to the summary report, it is easy to conclude that the treatment is working well.

Respiration Parameters	N1	N2
<b>RDI</b>	75.4 /h	5.1 /h
<b>AHI</b>	75.4 /h	5.1 /h
<b>ODI &gt; 4 %</b>	66.3 /h	6.1 /h
<b>Total duration Resp. Events</b>	141.5 min	10.5 min
<b>Apnea Index</b>	60.3 /h	3.5 /h
<b>Apnea Count</b>	273	25
<b>Average duration</b>	25.6 s	14.2 s
<b>Maximal duration</b>	57.8 s	24.0 s
<b>Hypopnea Index</b>	15.0 /h	1.7 /h
<b>Hypopnea Count</b>	68	12
<b>Average duration</b>	25.1 s	26.3 s
<b>Maximal duration</b>	54.6 s	44.6 s
<b>SaO2</b>		
<b>Basal SaO2 before Sleep Onset</b>	94.5 %	96.1 %
<b>Mean SaO2</b>	91.5 %	95.6 %
<b>Minimum SaO2</b>	74.4 %	88.0 %
<b>Time below 88%</b>	83.9 min	0.0 min

## Split Night Report

If you wish to compare different parts of the recording with each other, for example in the case of a Split Night, you can use the Multi-Zone report option in SleepRT to create a Split Night Report.

Simply add the different “Report zones” to the measurement, and the RT Software Suite will create a Split Night report for you, making a separate summary for the two zones.

# SleepRT during the acquisition

One of the key features of the SleepRT software is that you can start scoring acquisitions while they are running. Not only can you page back in the recording, start manual sleep scoring and add notes and events, it is also possible to perform real time analyses while the measurement is running.

In addition, you can create preliminary reports and update them as the recording gets longer. This feature is particularly useful during split night recordings, MSLT's and MWT's.

## *Camera control*

From the acquisition station you can zoom in on the camera image and change the focus point of the camera. For easy control you can switch between predefined positions. You can also switch between infrared and color images. All these functions are available directly in the SleepRT video image.

## *Dual display with live and recorded signals at the same time*

In the SleepRT software, you can page back in the recording and start scoring sleep stages while the recording is still running. All this is possible without losing the live signals out of sight.

This feature is particularly useful for MSLT and MWT recordings: while the second test is running you can start scoring the first test.

## *All signals immediately available on the review station for scoring*

SleepRT sends the recorded data immediately to the central storage location through an ingenious communication mechanism with the server.

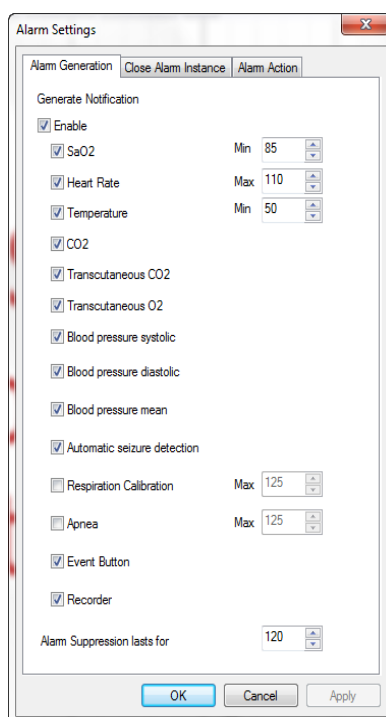
Thanks to this functionality, the signals are immediately available on the review stations once the recording is finished. There is no need to wait until the recording has been transferred to the review station to start scoring.

## *Live Monitoring function during the acquisition*

During the recording, it is possible to monitor the ongoing recordings (signals, video and analysis results) on another SleepRT station. This live monitoring function is **available to all users of the SleepRT software** and can even be used from a remote location (for example a physician's home). There is no need for external software packages to do this (such as VNC or remote desktop); the possibility for live monitoring is available within the SleepRT software. The only requirement is a network connection between the SleepRT acquisition station and the SleepRT review station.

## Alarm function for running signals

The Sleep<sup>RT</sup> software includes alarms for vital signals and other related events. These alarms can be programmed to produce sound or a flashing of the acquisition screen. It is even possible to transfer these alarms to the beeper of the attending physician or technician. For example, if the SpO2 value of the patient goes below 85 %, the Sleep<sup>RT</sup> software can generate an alarm. Sleep<sup>RT</sup> can also generate an alarm when no breathing activity was found in the last 2 minutes. Each of the alarm generators can be configured by the user.



Alarms for different types of signals, also possible: alarm on event button

## Online Scoring function

While the acquisition is running, it is possible to start scoring the recording. Both sleep stages and sleep related events can be scored.

## Online report function

While the acquisition is running, it is possible to create a report containing all information up to this point. This report can be updated with more and more information as the acquisition continues in order to obtain a more complete picture. This feature is particularly useful for MSLT and MWT recordings, but can also be used for split night recordings.

# SleepRT for Research

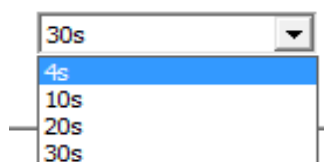
The SleepRT software offers solutions for PSG research, both for acquisition of PSG data and for the analysis afterwards. By offering a wide range of export possibilities of the recorded data, SleepRT provides an ideal interface to external analysis programs.

## *SleepRT for research with mice*

An application typically related to research is the acquisition of PSG recordings from mice. In order to guarantee easy sleep scoring and EEG analyses for these acquisitions, SleepRT includes the possibility to score sleep epochs of 4 seconds (required for scoring sleep stages for mice). In addition, you can export spectral analysis data to Excel for further analysis, in accordance with the sleep stages of the mouse.



SleepRT is suitable for PSG research on mice



Choice of durations of a sleep epoch for sleep scoring in SleepRT

## *Export possibilities in SleepRT*

SleepRT is compatible with the following export formats:

- Export to Matlab (signals and events): real time or off-line data export
- Export to ASCII (for raw data and RR intervals; possibility to select epochs for export)
- Export to Excel for events and analysis results
- Export to XML for trends and analysis results
- Export to EDF and EDF+
- Analysis in SPM, EEGLAB and Cartool
- Extensive tools for **RBD Research**