# Studies of the effects of exposure to electromagnetic fields emitted from mobile phones on volunteers

## Investigation of sleep quality in subjects living near a mobile base station – Experimental study on the evaluation of possible psycho-logical and physiological effects under residential conditions

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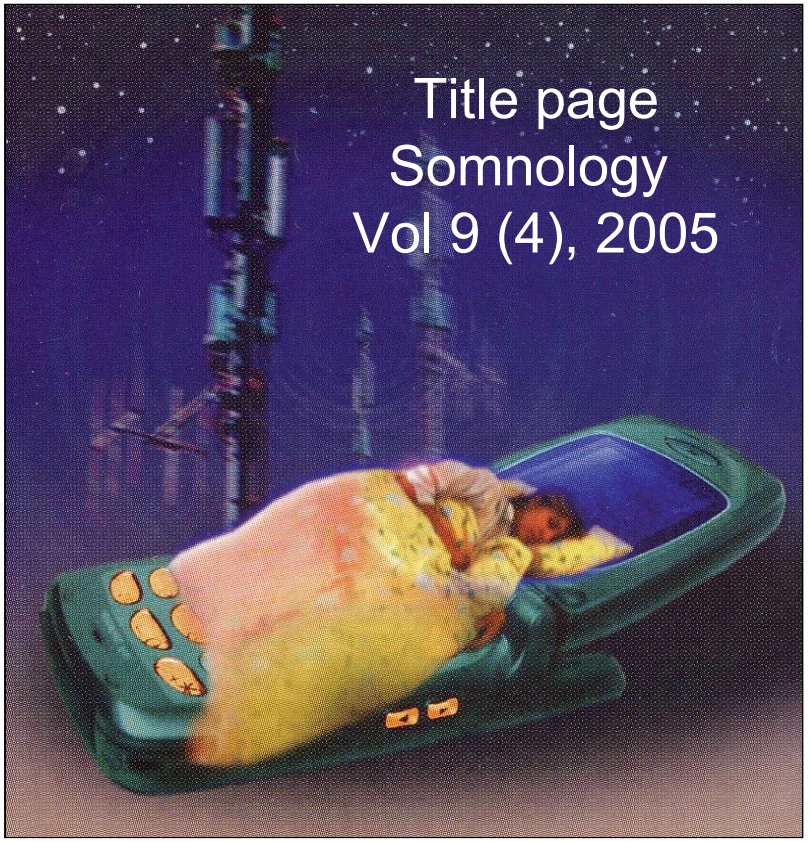
German Mobile Telecommunication Research Programme
Munich, 12./13. December 2006

# Overview




- **Sleep – basics**
- **Motivation to study sleep in the context of electro-magnetic fields**
- ***Laboratory study:*** **mobile phones and sleep**
- ***Field study:*** **base stations and sleep**

# Sleep - basics

- Behavioral definiton
- Historical aspects of physiological sleep research
- Physiological definition
- Sleep stages
- Sleep profile
- Measuring sleep

# Sleep definition: behavioral perspective

**Sleep is a behavioral state that alternates with waking. It is characterized by:**

- **recumbent posture**
- **a raised threshold to sensory stimulation**
- **a low level of motor output and**
- **a unique behavior: dreaming**

Squire et al. 2nd ed. 2003: *Fundamental Neuroscience.* Academic Press, London

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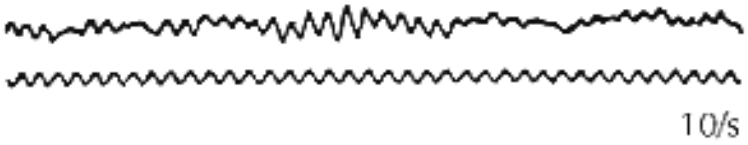
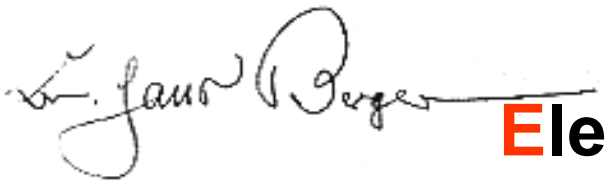
# EEG-waves during relaxed waking with closed eyes

Hans Berger (1873-1941), Professor für Psychiatrie an der Universität in Jena, Deutschland. 1929 veröffentlichte er seine Pionierarbeit «Über das Elektrenkephalogramm des Menschen».

Das erste von Berger registrierte EEG des Menschen (unten Zeitschreibung).



**Electroencephalogram**

**1929**

**It is possible to „measure“ brain activity**

**Application to the state of sleep**

# Sleep research in the 1930ies

**Following Berger waking and sleep were initially viewed as activated and non-activated states of the brain.**

**In 1937 *Alfred Loomis* and his coworkers (New York) studied the sleeping brain in more detail.**

**They distinguished 5 activity levels of the brain, which repeatedly occur during the night.**

**These activity levels were called sleep stages and referred to as stages A to E, stages B to E correspond to stages 1 to 4 of NREM sleep in modern terminology.**

# Sleep research in the 1950ies

**Until 1953 it was assumed that the sleep EEG in contrast to the waking EEG reflects a homogenous inactivation of the brain, characterized by slow (low frequency) and high amplitude EEG waves.**

**In 1953 it was discovered that repeatedly an activation of the brain occurs which is characterized by low amplitude high frequency EEG-activity.**

# Sleep research in the 1950ies

**This discovery was made by *Eugene Aserinsky*** (who was a doctoral fellow of Nathaniel Kleitmann).

**He observed that the phases of activation coincided with Rapid Eye Movements (which gave the name to this sleep stage: REM sleep), and also with an increased pulse rate and an increased respiration rate.**

# Sleep: standardisation of methods

**1967: in USA a comittee for the standardisation of recording and evaluation of sleep EEGs was founded.**

**1968: Publication of the manual:**

**A manual of standardized terminology, techniques and scoring system for sleep stages of human subjects.**

**Allan Rechtschaffen und Anthony Kales**

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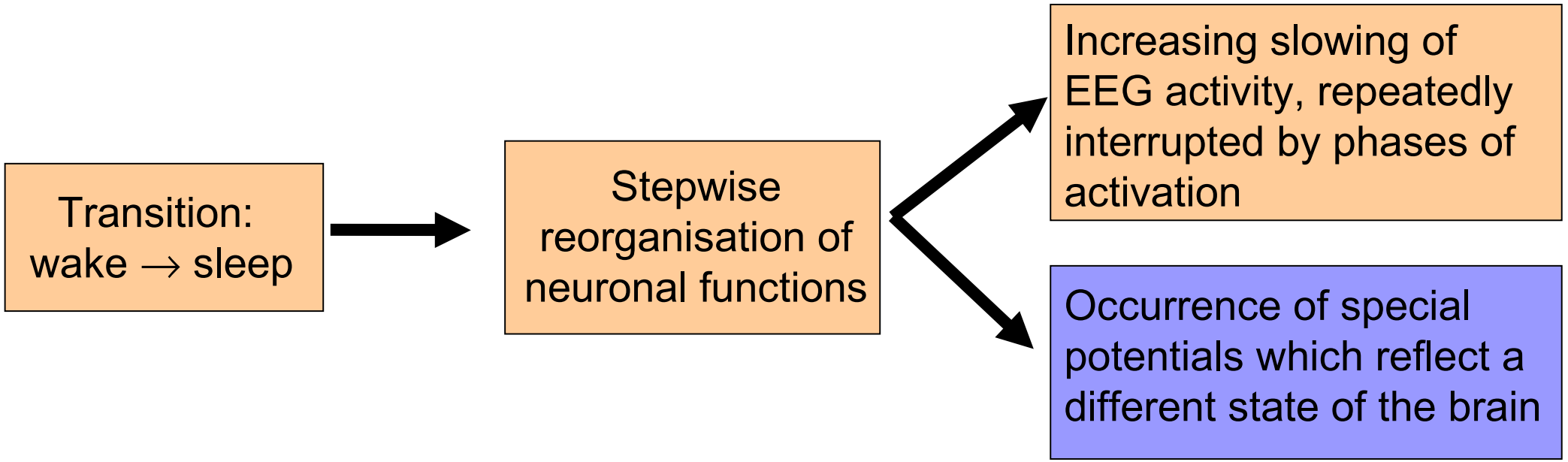
# Sleep definition: physiological perspective

**Sleep is a very special dynamic activity of the brain**



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# Sleep stages

## Differentiation into 5 stages

### Increasing slowing
### NREM-sleep

- NREM1
- NREM2
- NREM3
- NREM4

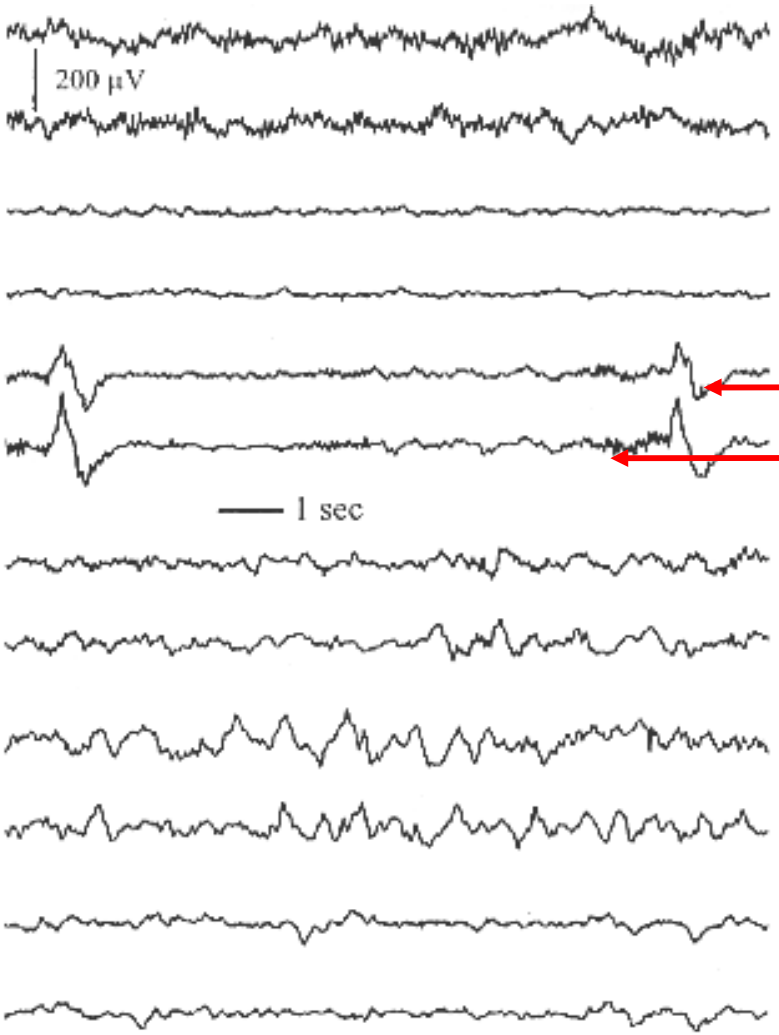
} Slow wave sleep

### Phases of activation
### REM-sleep

REM = Rapid Eye Movements

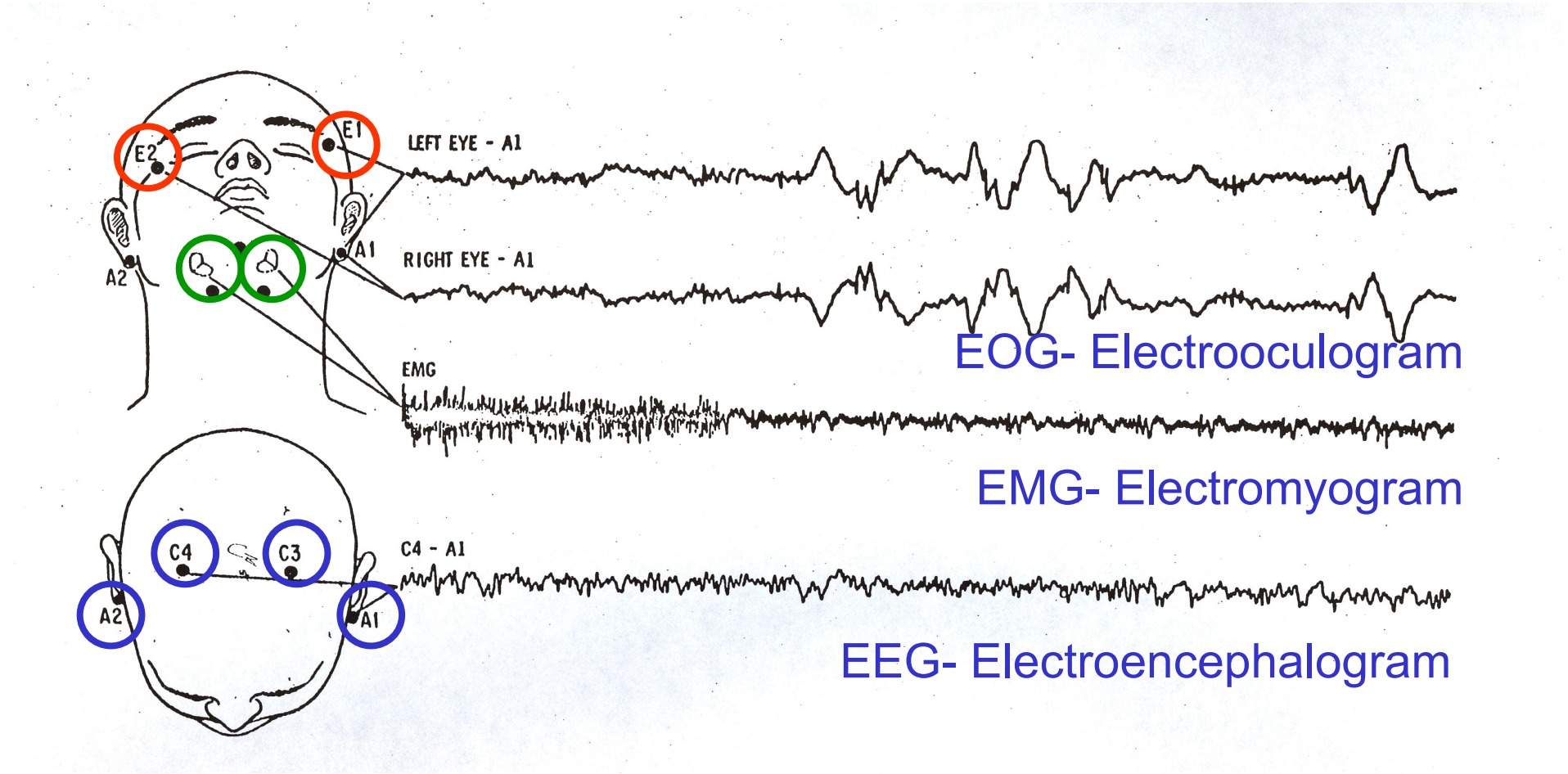
**dream sleep**

# Sleep stages




| | |
|---|---|
| Wake | Predomninance of alpha-activity (eyes closed) |
| NREM1 | Low amplitude, θ- and δ-waves |
| NREM2 | K-complexes<br>spindles |
| NREM3 | 20-50% δ-waves with high amplitude |
| NREM4 | > 50% δ-waves with high amplitude |
| REM | Low amplitude, mixed frequency, eventually saw tooth waves |

# Biosignals necessary for sleep stage classification




EOG- Electrooculogram

EMG- Electromyogram

EEG- Electroencephalogram

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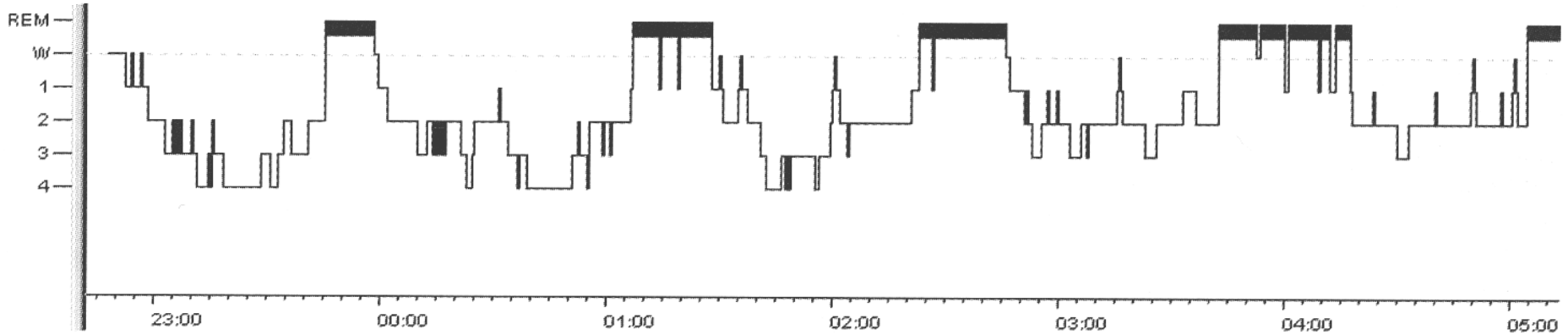
# Sleep profile / hypnogram




- sleep proceeds in cycles
- slow wave sleep declines with progress of sleep
- REM sleep increases with progress of the night

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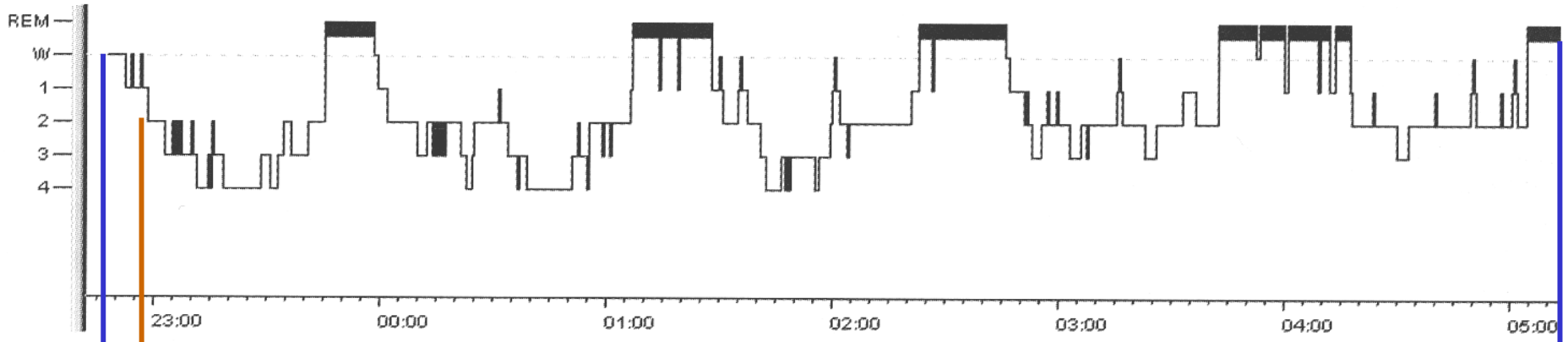
# Variables derived from the sleep profile



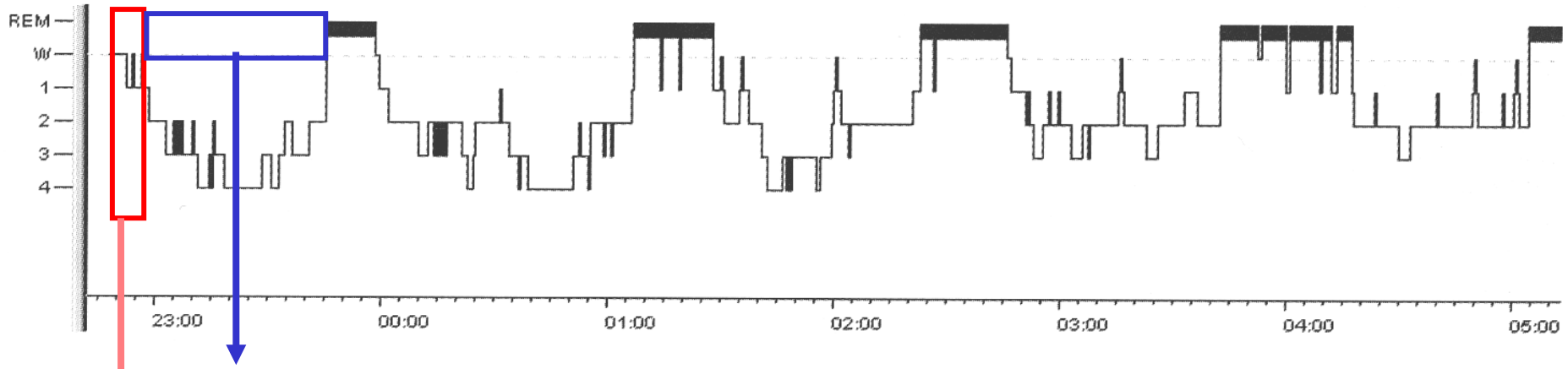

**TIB:** Time in Bed: time from „Lights out“ to „Lights on“

**SPT:** Sleep Period Time: time from sleep onset (NREM2) until final awakening

**TST:** Total Sleep Time: SPT minus time awake

**SEI:** Sleep Efficiency Index
TST / TIB * 100

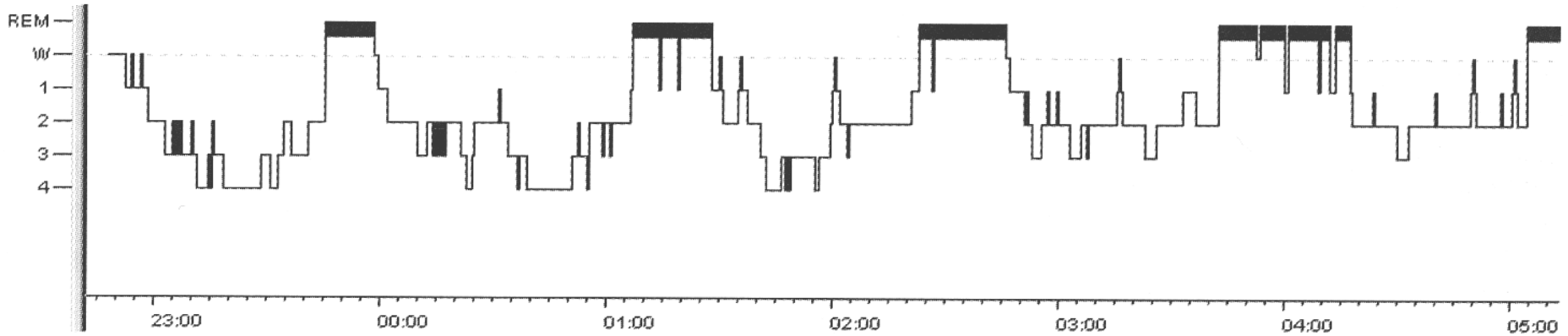
# Variables derived from the sleep profile




**REM-latency:** time from sleep onset to the first epoch of REM sleep: **Reference: 90±20 min**

**SOL:** Sleep Onset Latency: time from „Lights out“ to first occurrence of NREM2 (min) : Reference **< 30 minutes**

# Variables derived from the sleep profile




**Sleep stages (in minutes and %)**
***Wake, NREM1, NREM2, NREM3, NREM4, NREM3+NREM4 (SWS, slow wave sleep), REM***
in % SPT, in % TST

All parameters investigated by thirds or quarters of the night

Number of stage shifts Total and by (sleep) stage