



HealthGrid 2007 Conference  
24.04. – 27.04.2007, Geneva, Switzerland  
„Sleep Medicine as a Scenario for Medical Grid Application“



Philipps-University Marburg – Faculty of Medicine  
Dept. for Internal Medicine with focus Respiratory Medicine – Sleep Disorders Centre

# Sleep Medicine as a Scenario for Medical Grid Application

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# Grid technology in the investigation of sleep disorders – Whys and Hows



- Roughly 20% of the population suffer from sleep disorders
  - Major symptom: excessive daytime sleepiness (EDS) with consecutive microsleep episodes during the day → major cause for accidents
- New investigational approaches for sleep disorders with high prevalence and/or limitations in daytime performance
  - Prevalence of Obstructive Sleep Apnea Syndrome (OSAS): 2-4%
  - Prevalence of Restless Legs Syndrome (RLS): 4-5%
  - Prevalence of Narcolepsy: 47 out of 100.000, but dramatic effects, immense socioeconomic impact
- Current diagnostics include sophisticated overnight examinations (polysomnography)
  - Recordings of different biological signals (EEG, EMG, EOG)
  - Investigation of ECG, respiratory related signals
  - Rating of muscle activity during sleep (detection of movement disorders)



# Grid technology in the investigation of sleep disorders – Whys and Hows

- Using Grid technology in extensive amounts of data
  - Calculating multiple parameters in highly sampled signals from recordings of biosignals during sleep (polysomnography)
- Using Grid technology in distributed data
  - Phenotyping specific diseases based on recorded biosignals, e.g. obstructive sleep apnea, periodic leg movements during sleep, narcolepsy
- Using Grid technology on standardized data
  - A data format for neurophysiological biosignals exists already: EDF (European Data Format) using one channel for each biosignal, allowing splitting and distributing data to different computers





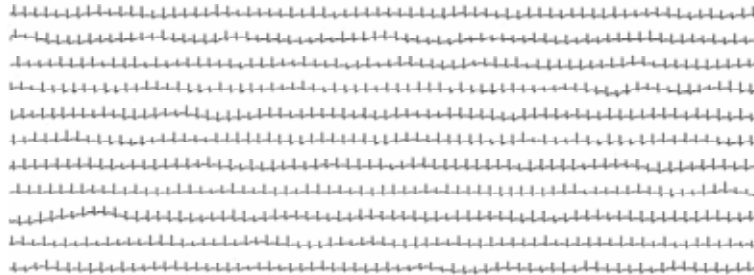
## Current Projects and Methods

- Analysis of ECG (Electrocardiogram) for the determination of heart rate variations (HRV) during sleep.
  - Development of algorithms finished, implementation in Grid environment in progress.
- Analysis of respiratory signals (airflow) for the diagnosis of sleep related breathing disorders (e.g. insp. flow limitation).
  - Development of algorithm started, implementation in Grid in development.
- Analysis of EMG (Electromyogram) for the diagnosis of movement disorders during sleep (e.g. RLS).
  - Development of algorithm finished – validation pending.

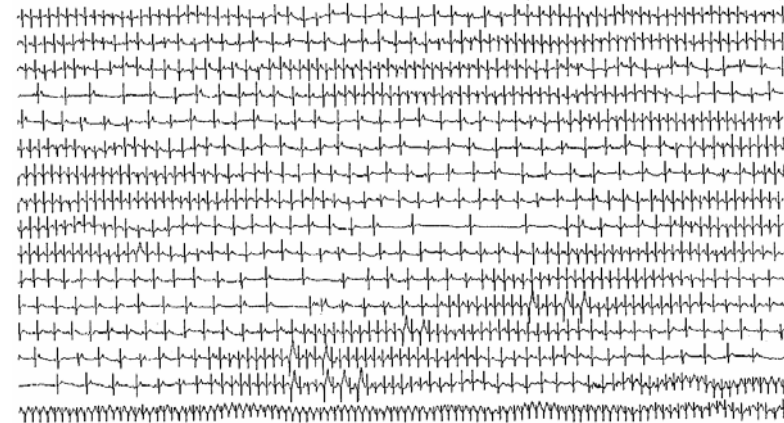




# Analysis of ECG – Impact of HRV during sleep



Healthy Subject



Patient with OSAS

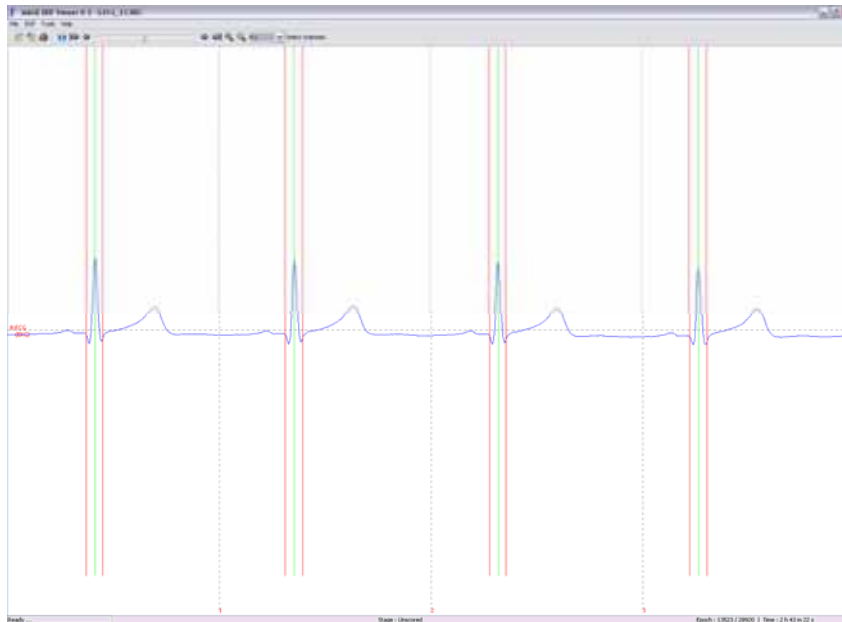
The heart rate shows characteristic cyclic variations in patients with OSAS

*Penzel T et al. IEEE Trans. Biomed. Eng. 50: 1143-1151 (2003)*  
*Stein PK et al. J. Cardiovasc. Electrophysiol. 14: 467-473 (2003)*  
*DeChazal P et al. Physiol. Meas. 25: 967-983 (2004)*

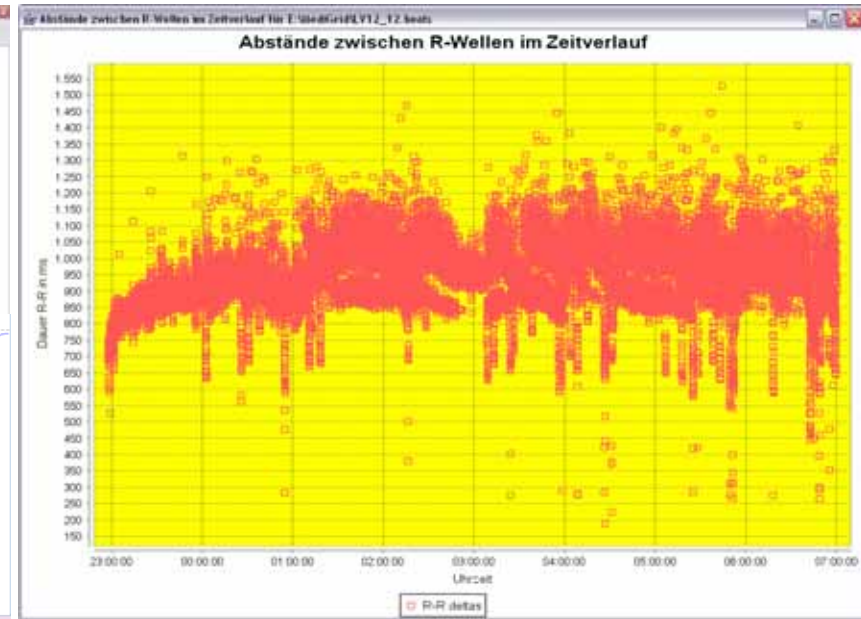




# Grid based analysis of ECG



Automatic detection of QRS complex within ECG signal



Duration of R-R-Intervals throughout the night recording (y-axis: duration of R-R, x-axis: time)

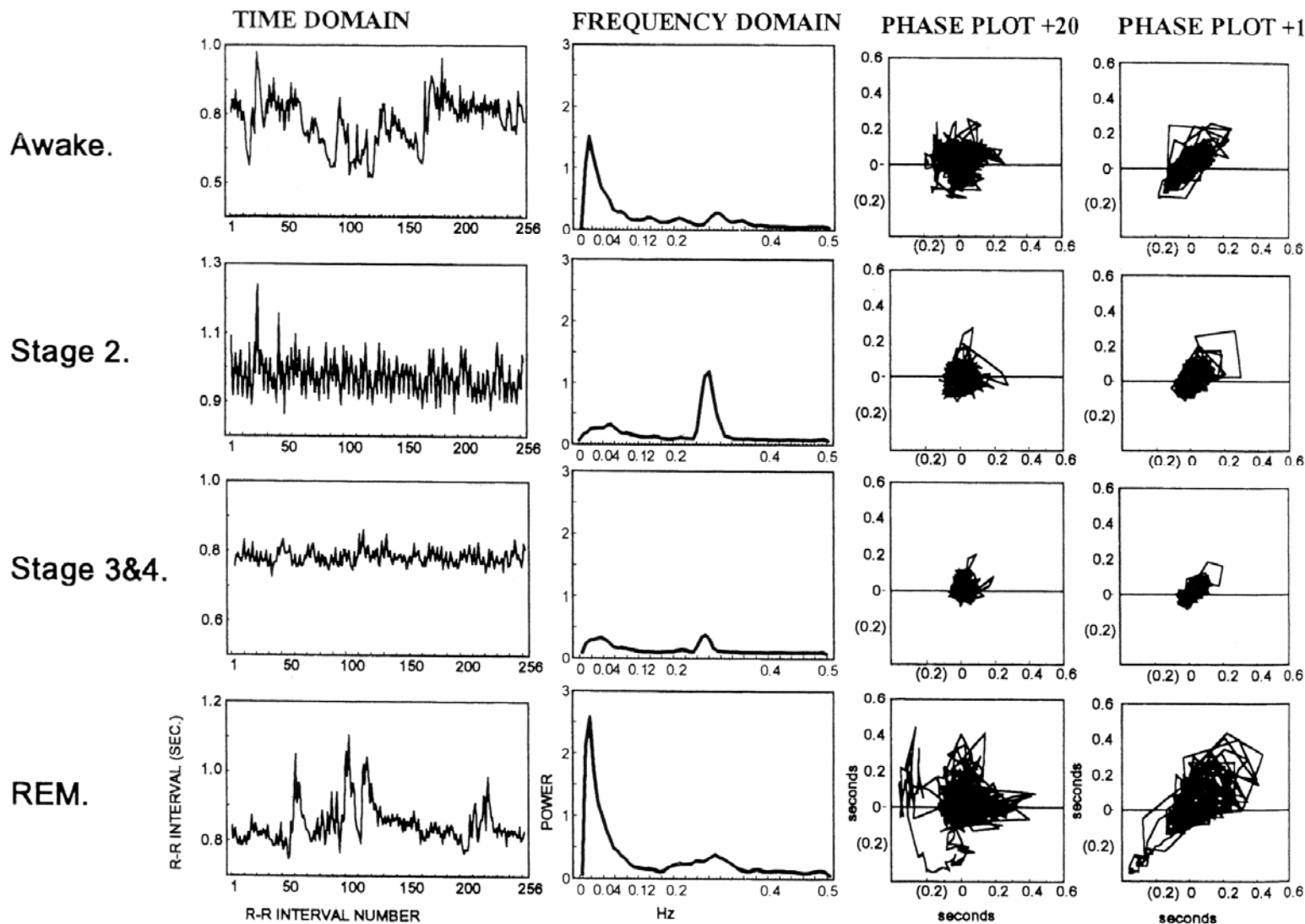
- Analysis of ECG signal → Development of algorithm finished with Grid toolkit (JAVA based analysis)
- Implementation and testing in GRID-environment in preparation





# Analysis of heart rate variability

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Vaughn BV et al. Heart period variability in sleep. *Electroencephal. Clin Neurophysiol.* 94: 155-162 (1995)







# Grid based analysis of Respiratory Signals

## Detection of Inspiratory Flow Limitation (IFL)

- OSAS → breathing cessations during the night → awakening reactions (arousals)
- Severity rating by counting breathing cessations and hypoventilations using standard criteria
- Awakening reactions can also be caused by limitations in inspiratory airflow → detection of flow limitations very difficult
- Pressure variations in the esophagus indicate inspiration (negative pressure) and expiration (positive pressure)
- Analysis of pressure variations in the esophagus in combination with the airflow signal → detection of IFL

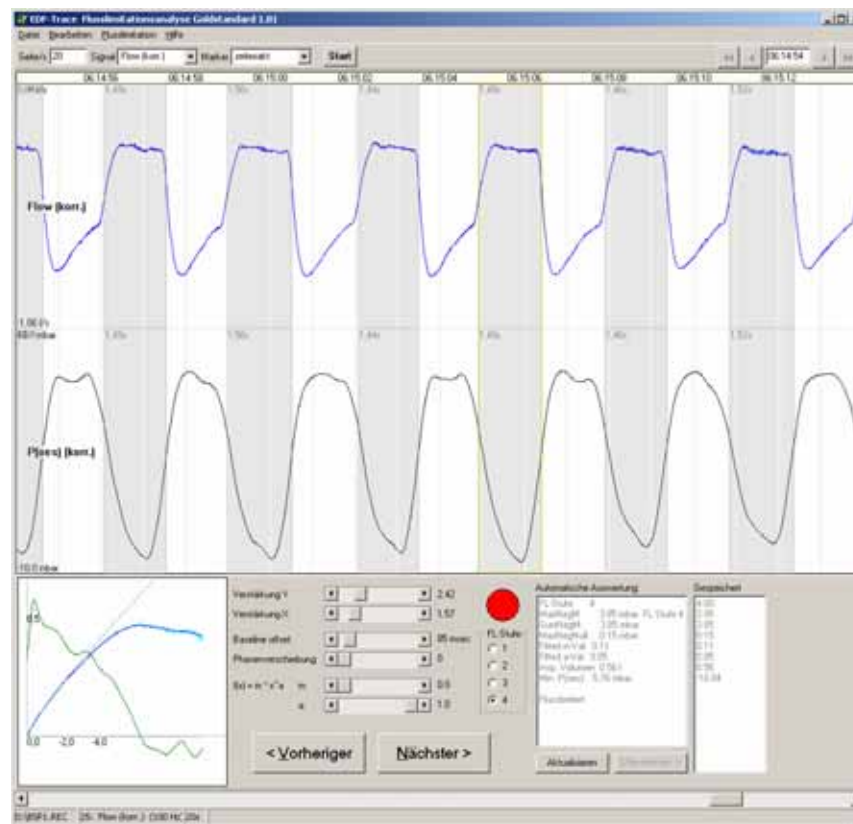






# Grid based analysis of Respiratory Signals

## Detection of Inspiratory Flow Limitation (IFL)



Computer based recognition of inspiration (grey background) and expiration (white background), recognition and classification of flow limitation based on respiratory airflow.





# Grid based analysis of EMG

## Detection of sleep related movement disorders

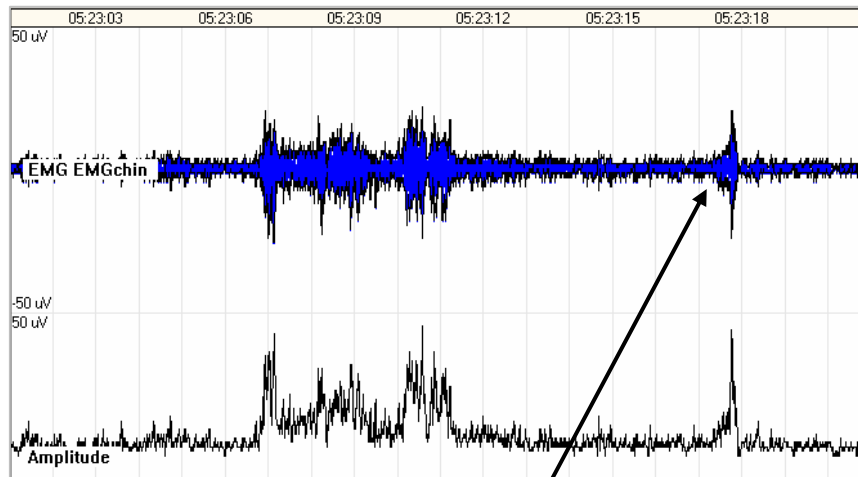
- Neurologic disorders RLS and narcolepsy are often accompanied by motor events in the EMG.
  - Events between 0.5 and 5 sec → RLS
  - Short twitches < 1 sec → narcolepsy
- Analysis of EMG is time consuming (app. 1-2 hours for one 8-hour recording) and requires a lot of experience.
- Motor events are counted for severity rating of RLS, detection of twitches can alleviate diagnosing narcolepsy.



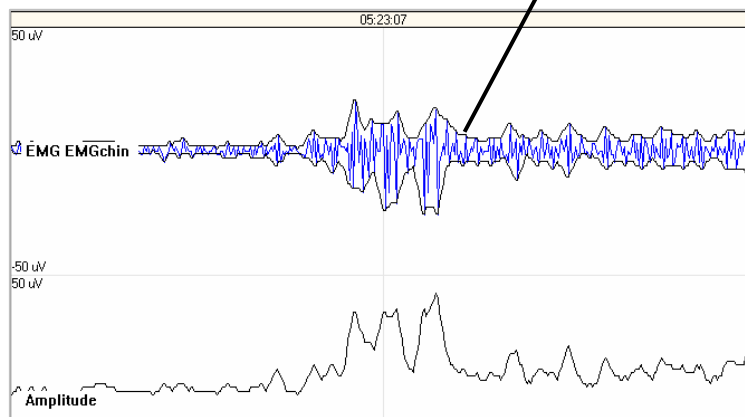


# Grid based analysis of EMG

## Detection of sleep related movement disorders



Calculation of the amplitude of the EMG signal from the difference between the upper and lower envelopes of the signal.



This results in the amplitude signal, which is used for the detection of events in the EMG signal.

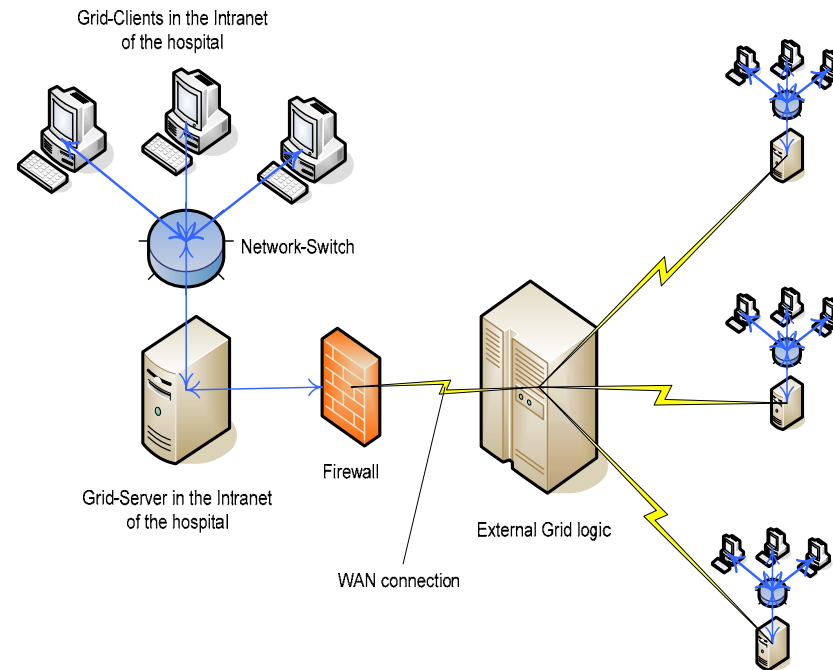






# Data Protection and Data Security

Medigrd clinical studies: rules for data protection and data security following hospital guidelines of the University hospital Gießen and Marburg



A GRID within the hospital must be set up separately.  
The communication with other GRID networks must be done through a firewall using an additional data communication server or using an external GRID logic.





## Summary

- Analysis of ECG is a promising approach, Grid implementation in progress.
- Detection of inspiratory flow limitation is important for diagnosing “non-standard” breathing disorders, Grid implementation under development.
- Diagnosing RLS and narcolepsy can be alleviated by automatic EMG analysis, validation of analysis pending.
- Data security and data protection issues have even increased importance in hospitals or clinical study centers.
- The common data format EDF is easy to anonymize.





## Limitations / Implications

- Estimation of usefulness → currently no information about consumed resources and computational power.
- All algorithms show good accordance to expert opinion ratings and are written in standard languages (Delphi, Java)  
→ easy implementation is possible.
- Polysomnographic data can be easily split into small packets  
→ Grid based analysis of polysomnographies in near future.
- Increase of effectiveness of polysomnographic recordings  
→ decrease of costs for sumptuous sleep lab examinations.







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## Our Research Team



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