



# Contactless measurement technologies in medicine

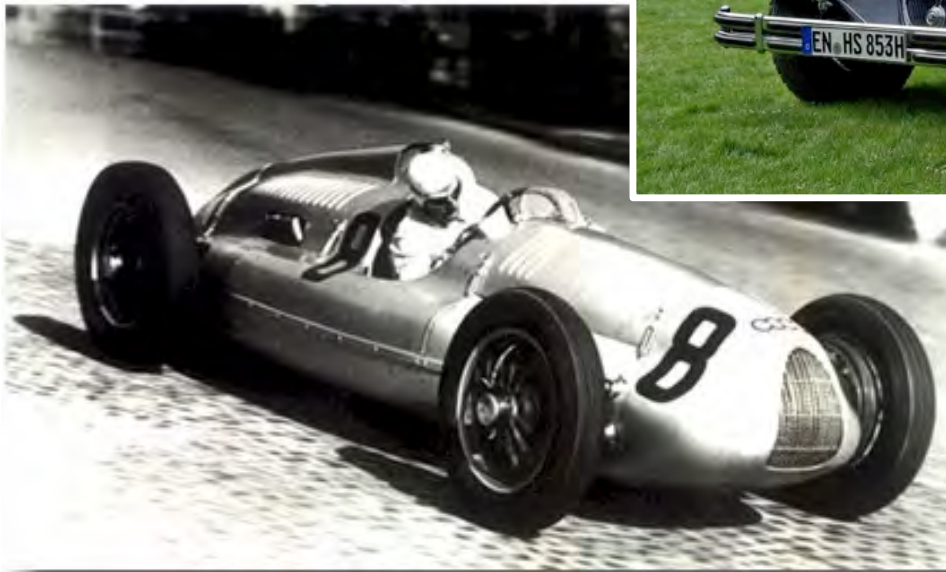
Hagen Malberg  
Institute of Biomedical Engineering  
TU Dresden

COMO, 26.07. 2017



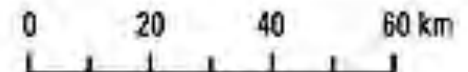






**-Zwickau-Erzgebirge**  
 montage, Motor/Antrieb,  
 i, Automobilelektronik,  
 nsassenschutz,  
 ind Werkzeugbau,  
 e Engineering,  
 und Entwicklung,  
 eurausbildung

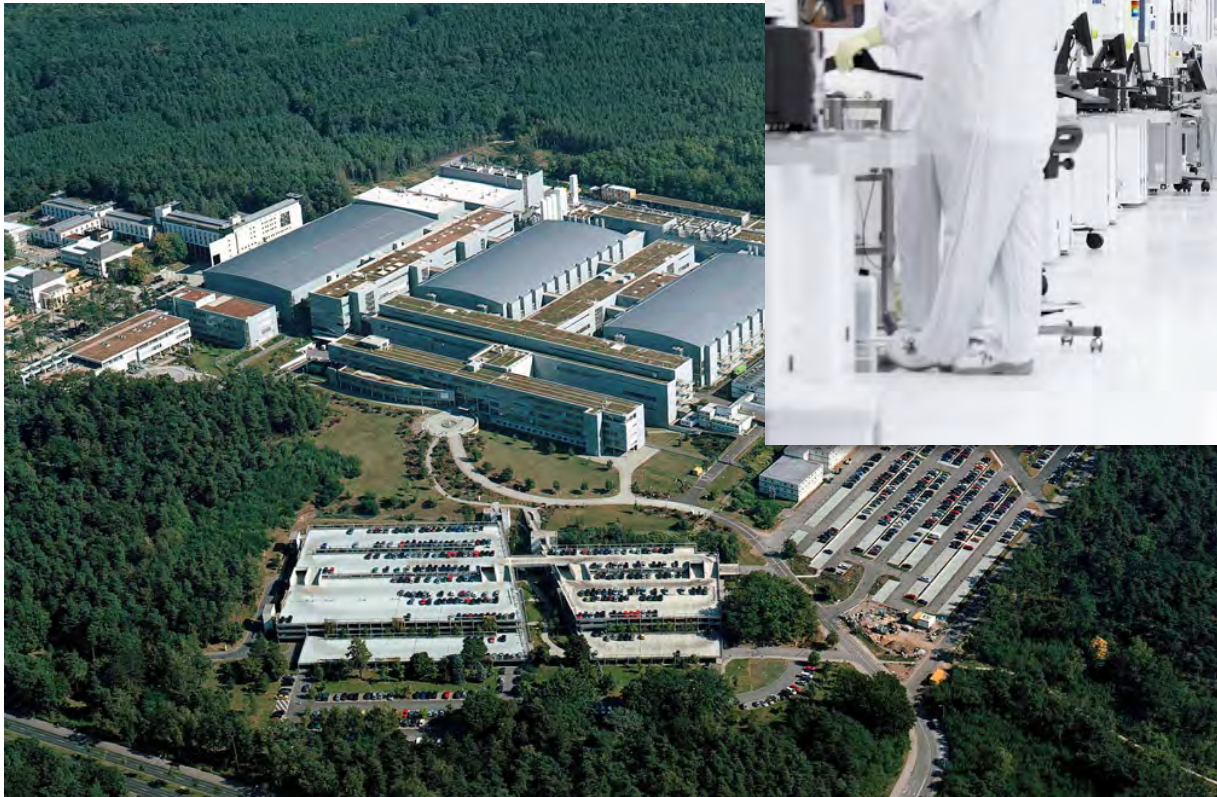
**5 Region Plauen**  
 Fahrzeugmontage,  
 Interieur, Motor/  
 Antrieb, Karosserie,  
 Maschinen- und  
 Anlagenbau













Prof. Holger Stepan  
University Gynecological Hospital Leipzig  
„The Phantastic Four“ 2012









**Investigation of out-of-clinic medical technologies: total change of paradigm**  
**Physiological Networks ?**



## Mechatronics & AUTOMED

- Dr. Ch. Thiele

## Imaging and Image Processing

- PD Dr. U. Morgenstern

## Med. Sensors & Biosignal Processing

- Dr. S. Zaunseder

## Rehabilitation

- Dr. G. Sliwinski



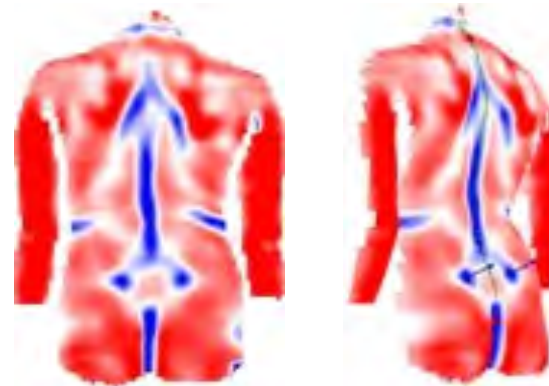
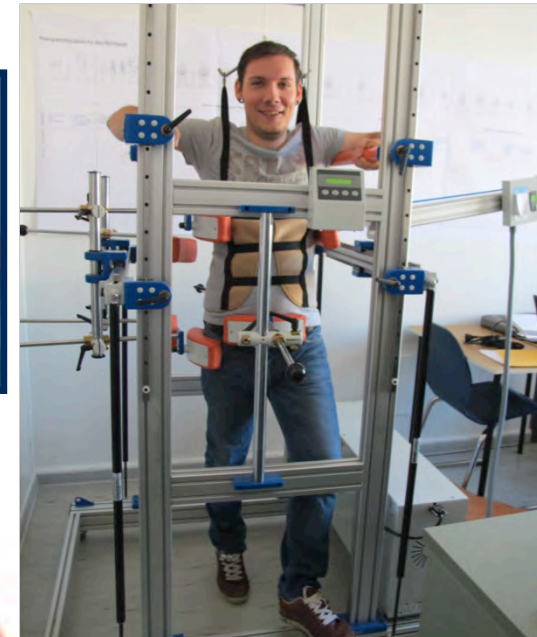


**TOPLiver<sup>®</sup>, NephroTOP<sup>®</sup>**





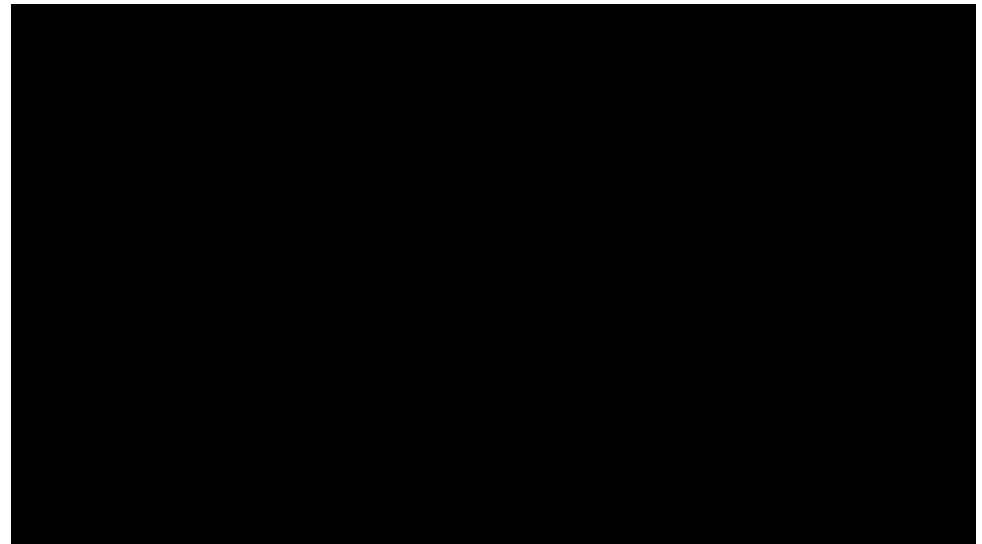
## Diagnosis of Scoliosis



## Therapy

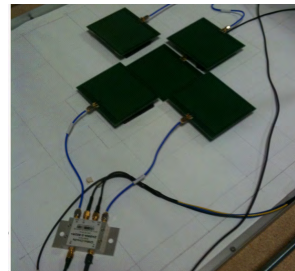


**Imaging for intraoperative  
identification of active brain regions**





**„out-of-clinic“ technologies:  
mobile, preventive, low-cost, contactless**



**Competences  
(Research, Industry)**

**Microelectronics,  
telecommunications, sensor-/  
control- / micro technologies,  
materials, ....**

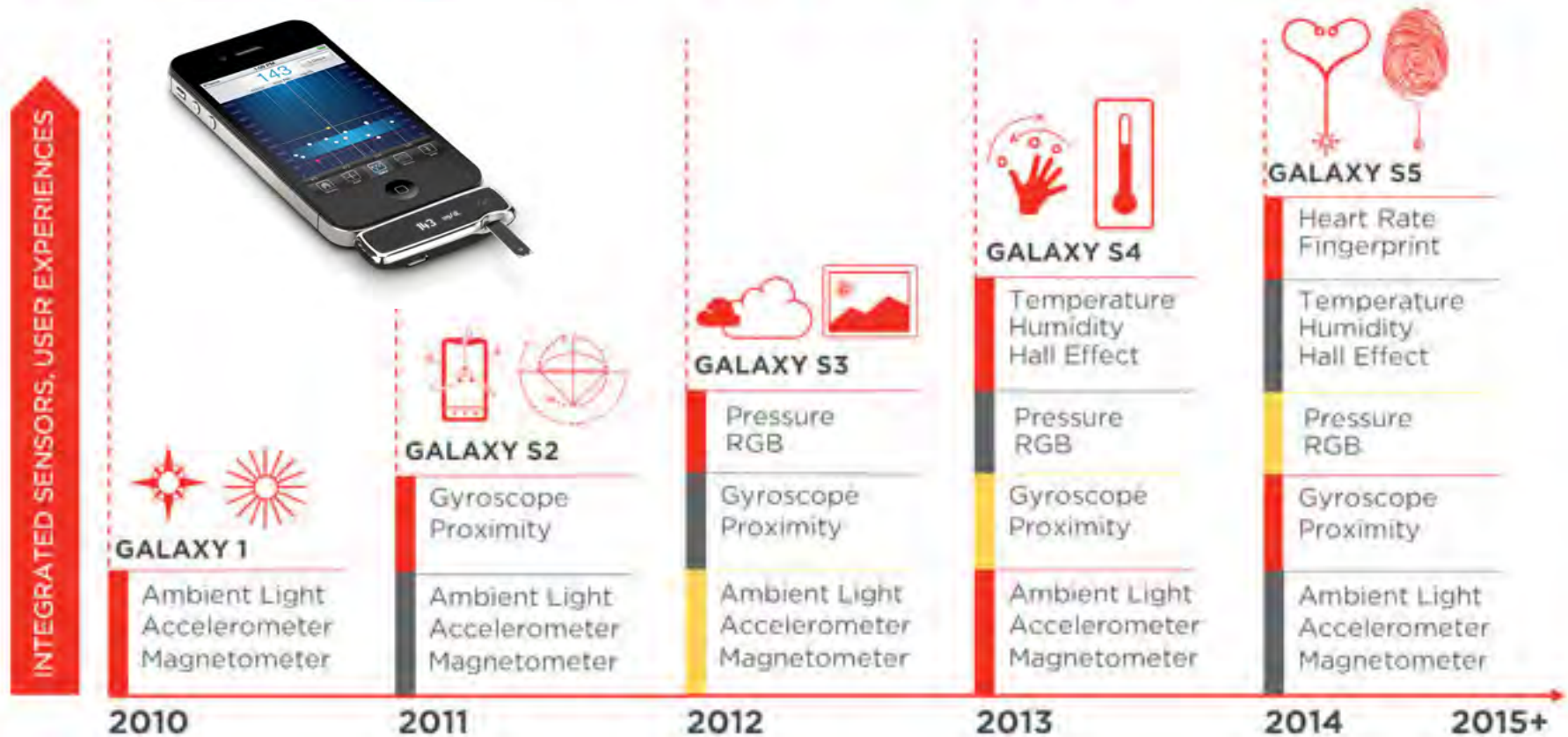


Quelle: <http://jonatasmattes.blogspot.de/>

OS: Paul Weißbach



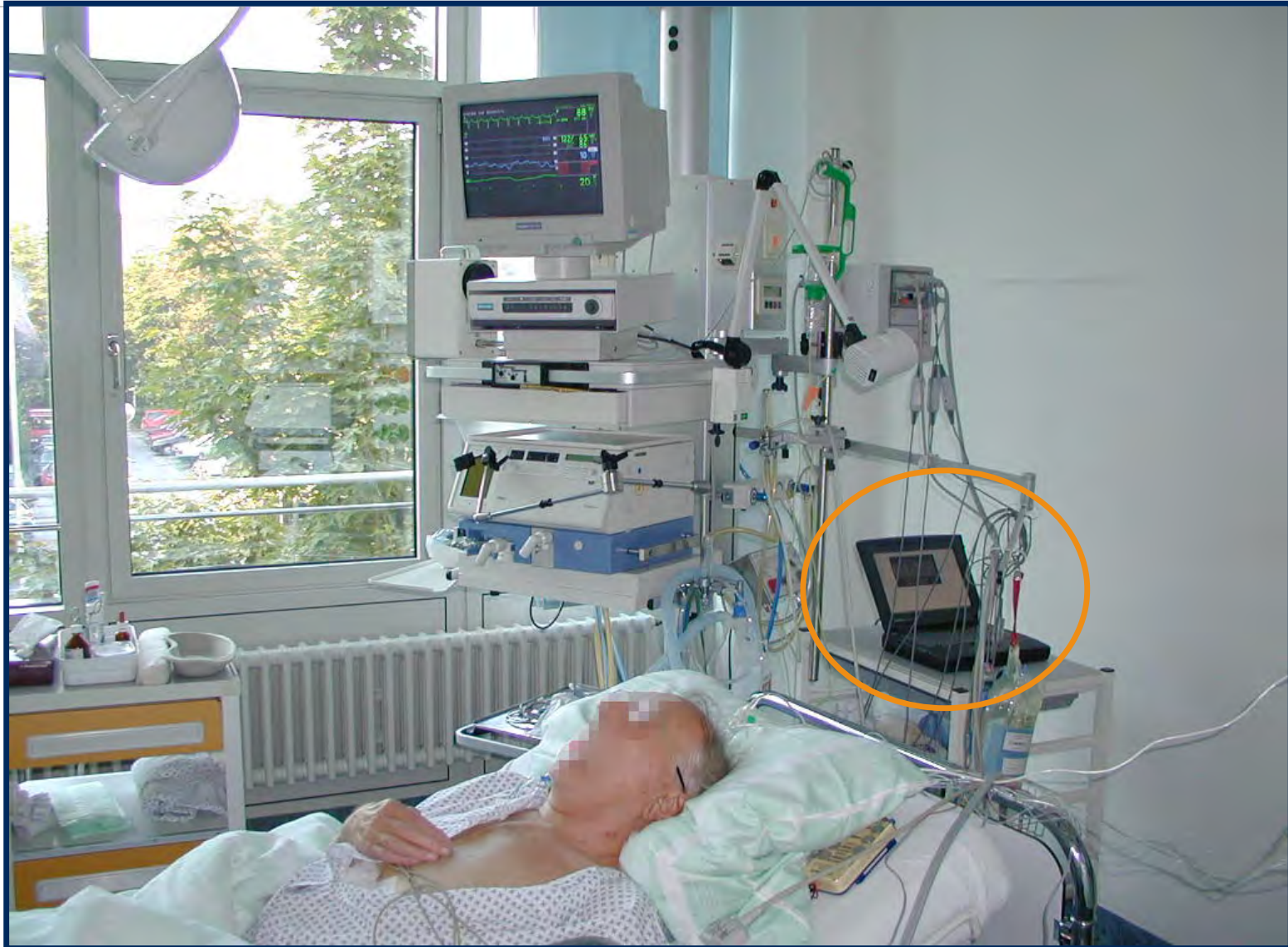
# SENSOR GROWTH IN SMARTPHONES





Q: Thomas Penzel







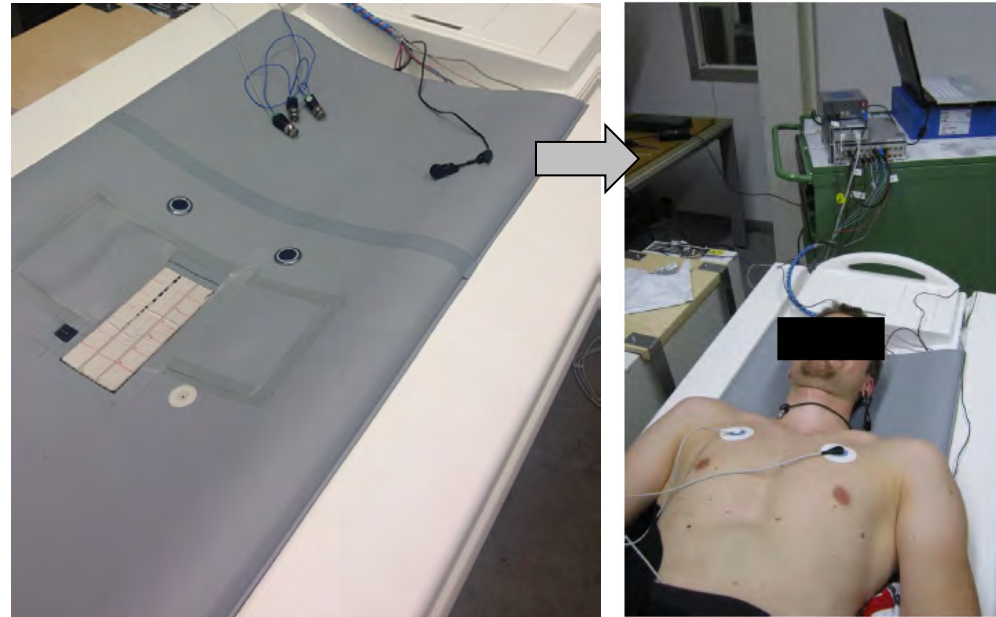
# BIOSIGNAL- RECORDING



- ~~EKG, Monitoring~~
- Capacitive ECG
- Photoplethysmography
- Piezoelectric Sensors
- Ballistocardiography
- Doppler-Radar
- **Optical Cameras, Near-IR**
- 
- Ultrasonic

## Multisensing

Sensor set up



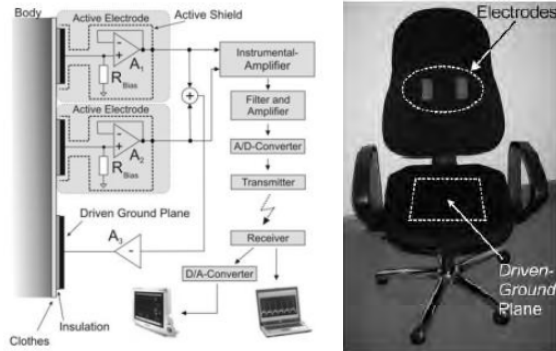


Abb. 25: Aachen SmartChair 2009

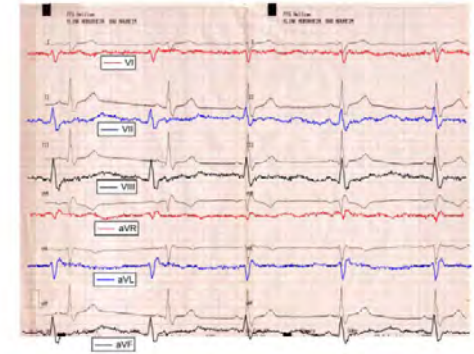
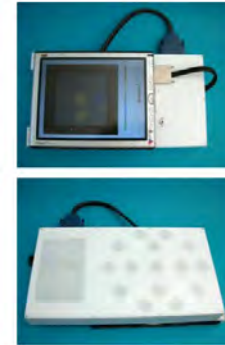
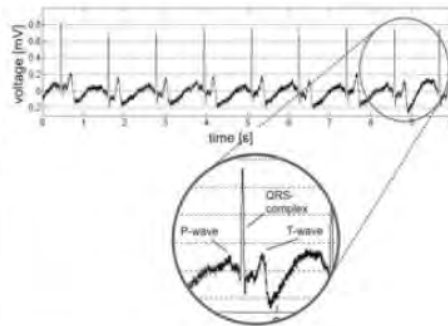


Abb. 26: Oehler 2009



Abb. 27: Plessey 2010



Abb. 28: Congionics 2010

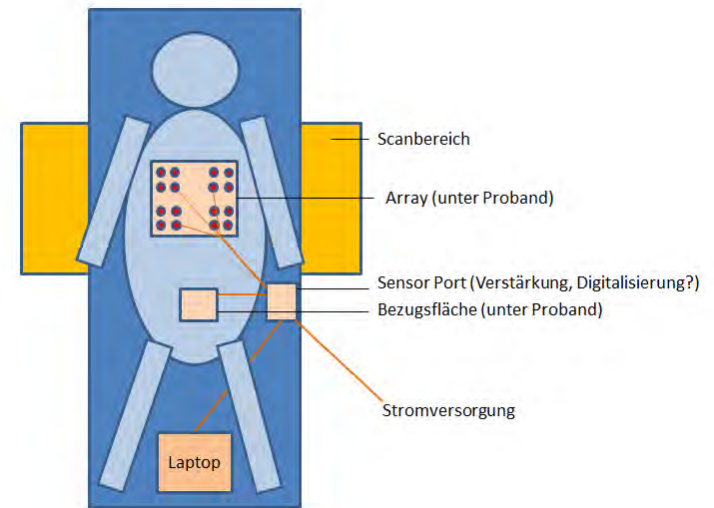


Abb. 29: Grundidee Integration cECG in bildgebendes System



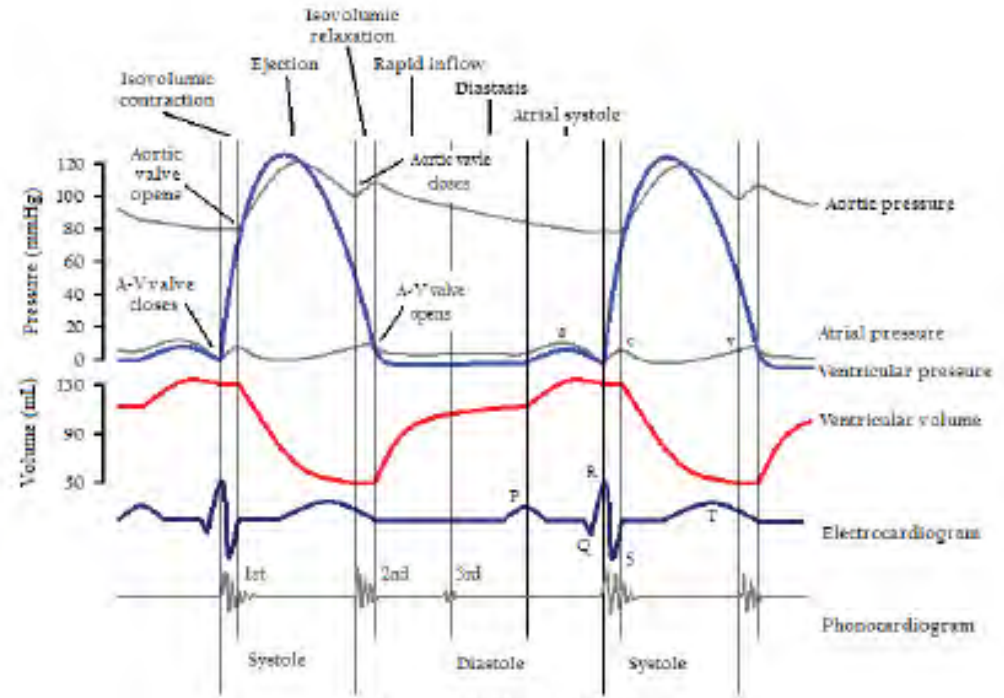
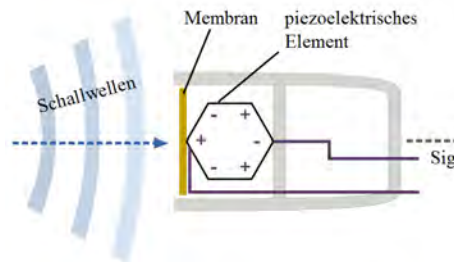
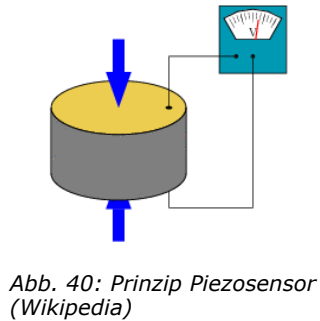


Abb. 42: Entstehung der Herztöne

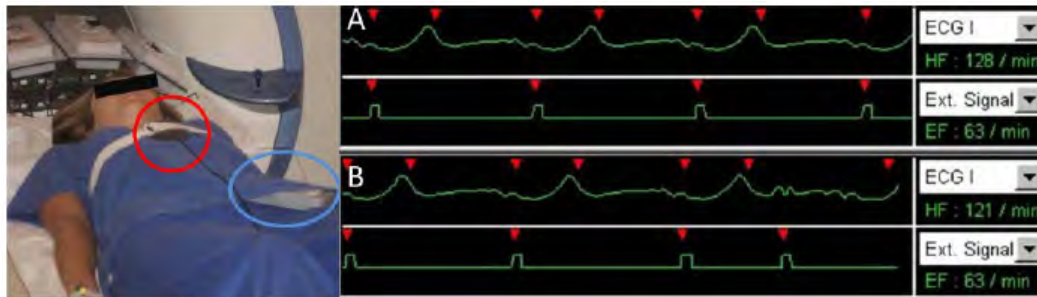


Abb. 43: PKG als Triggergerät für 7-Tesla-MR-Bildgebung, Maderwald et.al 2011

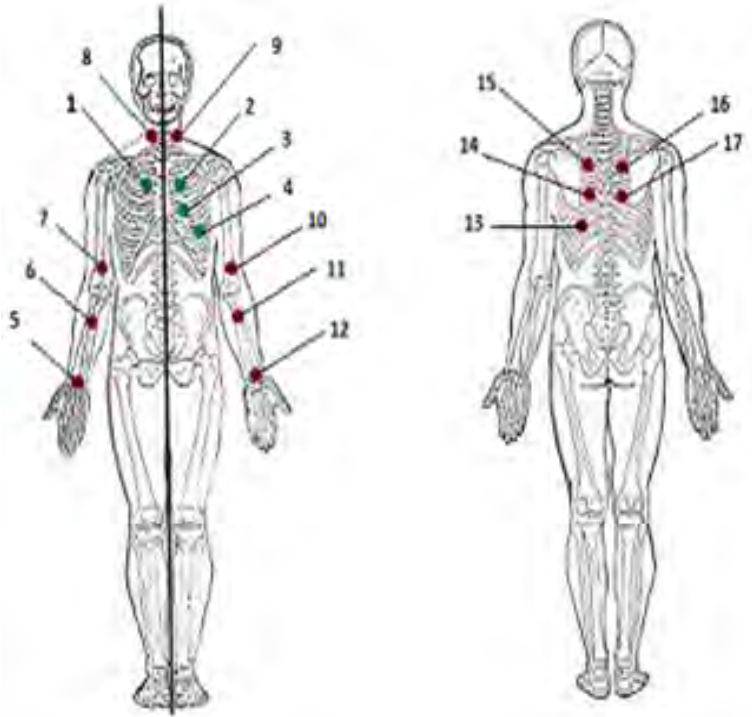


Abb. 44: Messpunkte zur Bewertung der Positionierung piezoelektrischer Sensoren

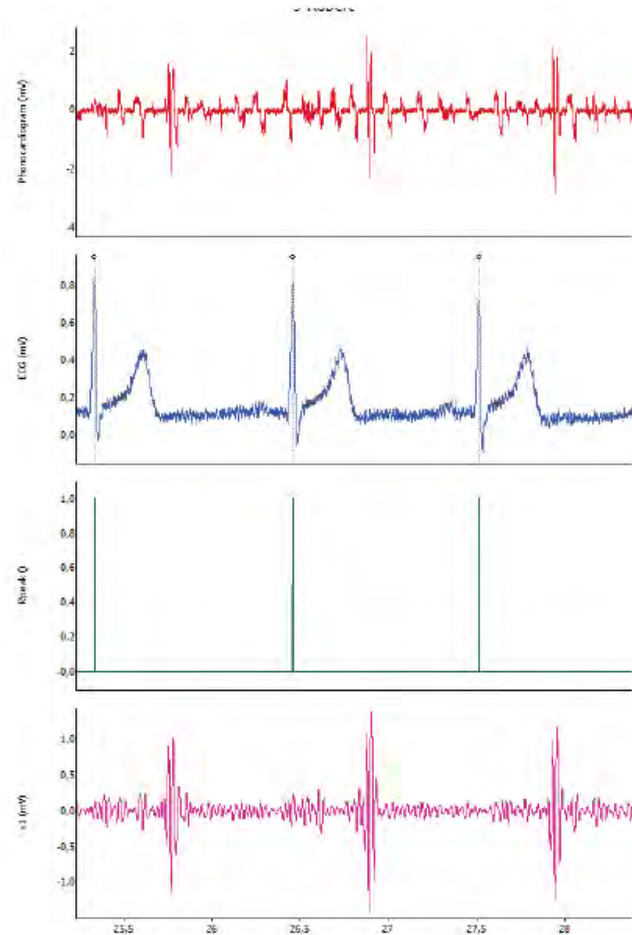


Abb. 45: Signalbeispiel in der Vormessung: oben ungefiltertes PKG, darunter EKG, darunter R-Zacke, unten gefiltertes PKG bei carotisnahe Messung



## Piezo cable

- Piezo electric film works as dielectric medium in a coax-cable
- Forces  $>$  voltage
- 17,8nF cable, Sensitivity 10n = 100mV/nC
- Sampling frequency 50Hz

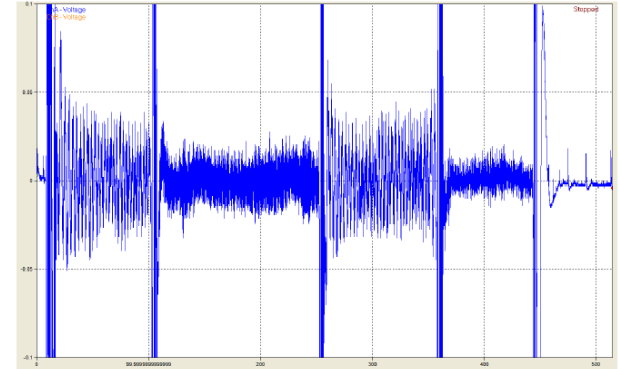


Abb. 57: Mess-Sequenz: Rückenlage, Linksseitig, Rückenlage, Rechtsseitig



Abb. 56: Mess-Setup für Messung durch Matratze hindurch

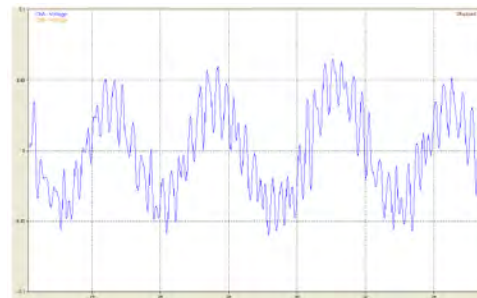


Abb. 58: Resonanz zu Beginn der Messung (Matratzeinfluss)

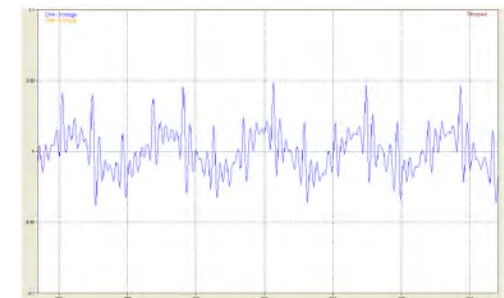


Abb. 59: Eingeschwungenes Verhalten

## Force measurement

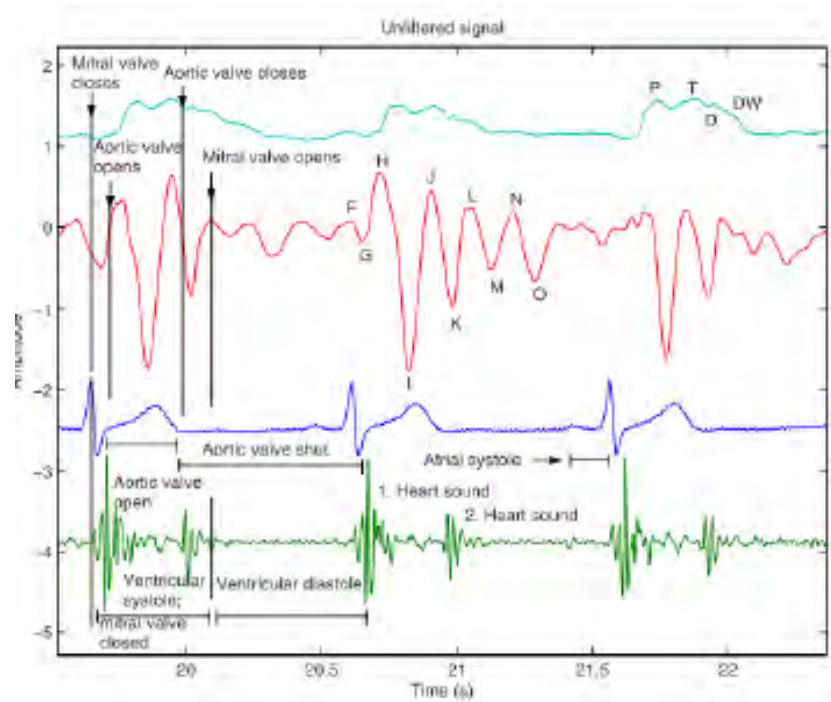


Abb. 61: Typ. BKG-Signalverlauf nach Alametsä 2009

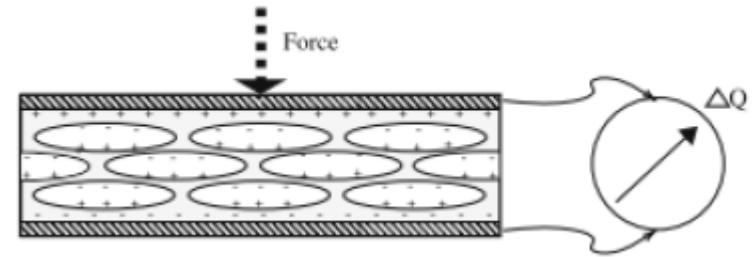


Abb. 60: EMFi-Material nach Junnila 2009

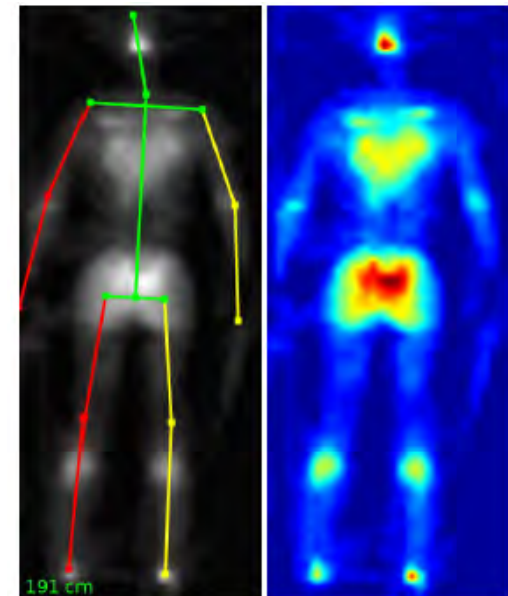


Abb. 62: Einsatz einer XSensor-Matte zur Positionsbestimmung im MR-System, Grimm 2009



## Tests of mattresses

Abb. 63: Aufnahme mit der großen XSensor-Matte

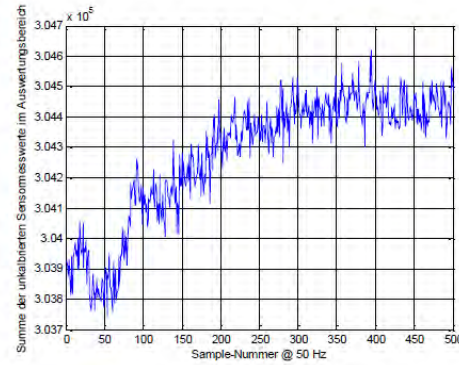
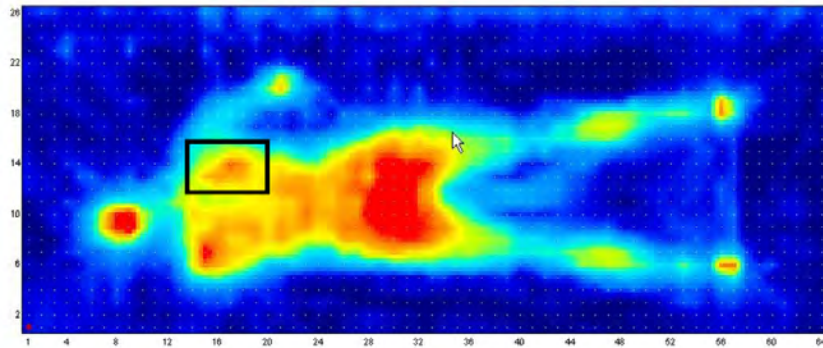


Abb. 64: Messung ohne Atmung

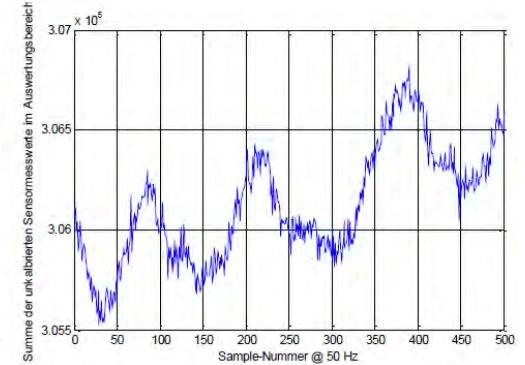


Abb. 65: Messung mit Atmung



Abb. 66: XSensor-Matte PX100

- Electromagnetic field in the body
- Phase delay > heart activity,
- altering distances: low spectra,

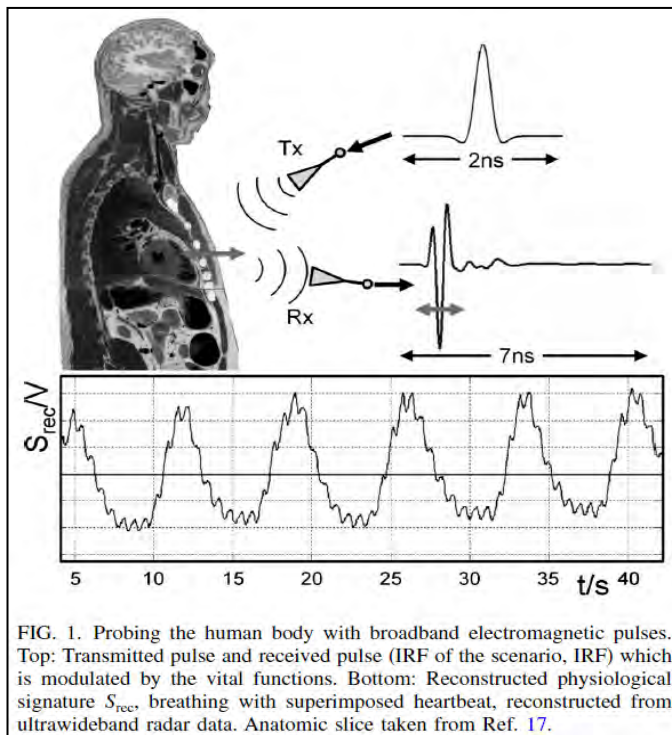
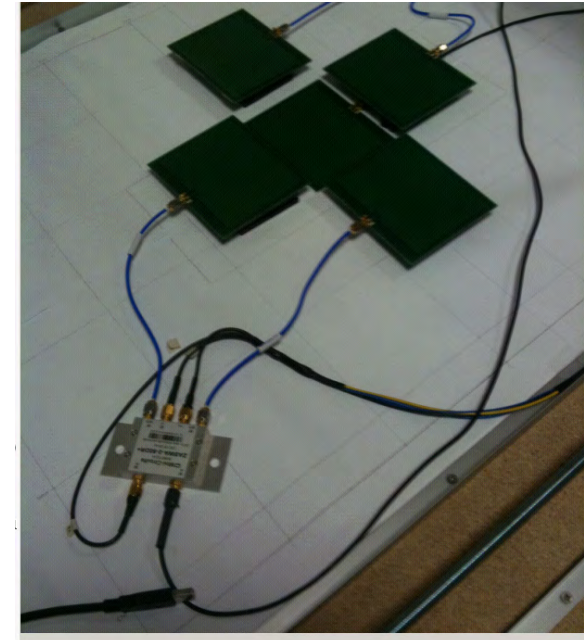


Abb. 77: UWB-Signal bei 1-5 GHz,  
Thiel 2009



Frequenz	Wellenlänge Luft	Wellenlänge Fett	Wellenlänge Muskel	Eindringtiefe Fett	Eindringtiefe Muskel
433 MHz	69,2 cm	29,0 cm	8,83 cm	30,4 cm	5,17 cm
868 MHz	34,5 cm	14,7 cm	4,58 cm	24,8 cm	4,29 cm
2,4 GHz	12,5 cm	5,42 cm	1,71 cm	12,0 cm	2,28 cm
24 GHz	12,5 mm	6,31 mm	2,23 mm	7,05 mm	1,01 mm
60 GHz	5,00 mm	2,80 mm	1,23 mm	3,37 mm	0,41 mm

Abb. 73: Wellenlänge und Eindringtiefe verschiedener Frequenzen in den Körper, nach IFAC Dielectric Properties of Body Tissues  
<http://niremf.ifac.cnr.it/tissprop/html/clie/htmlclie.htm>



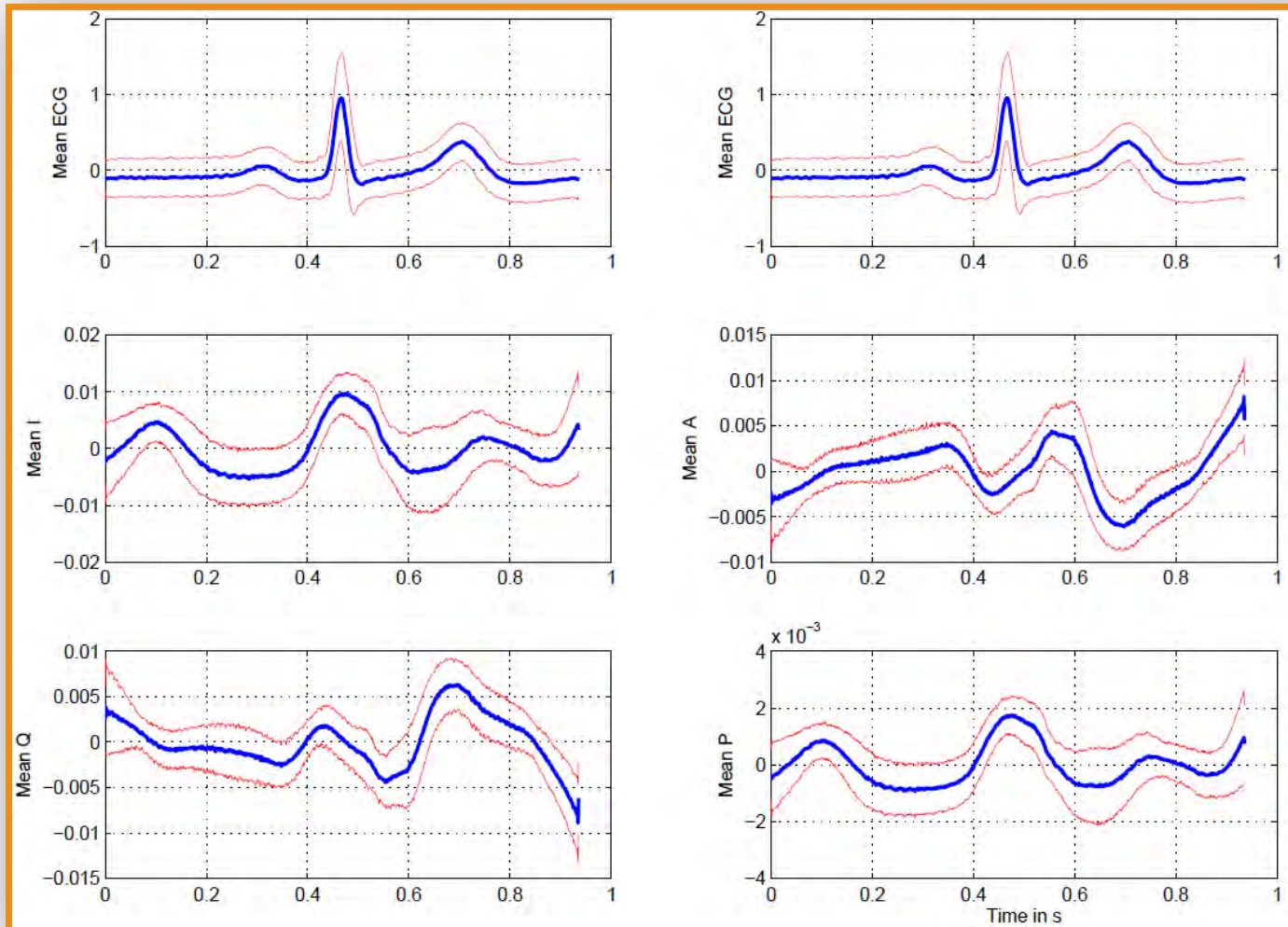


Abb. 88: gemittelttes EKG, I- und Q-Signal,  
 Normiert auf Herzzyklus

## Classical PPG



Quelle: [cardiologyforless.com](http://cardiologyforless.com)

## Camera based PPG (remote PPG: rPPG)



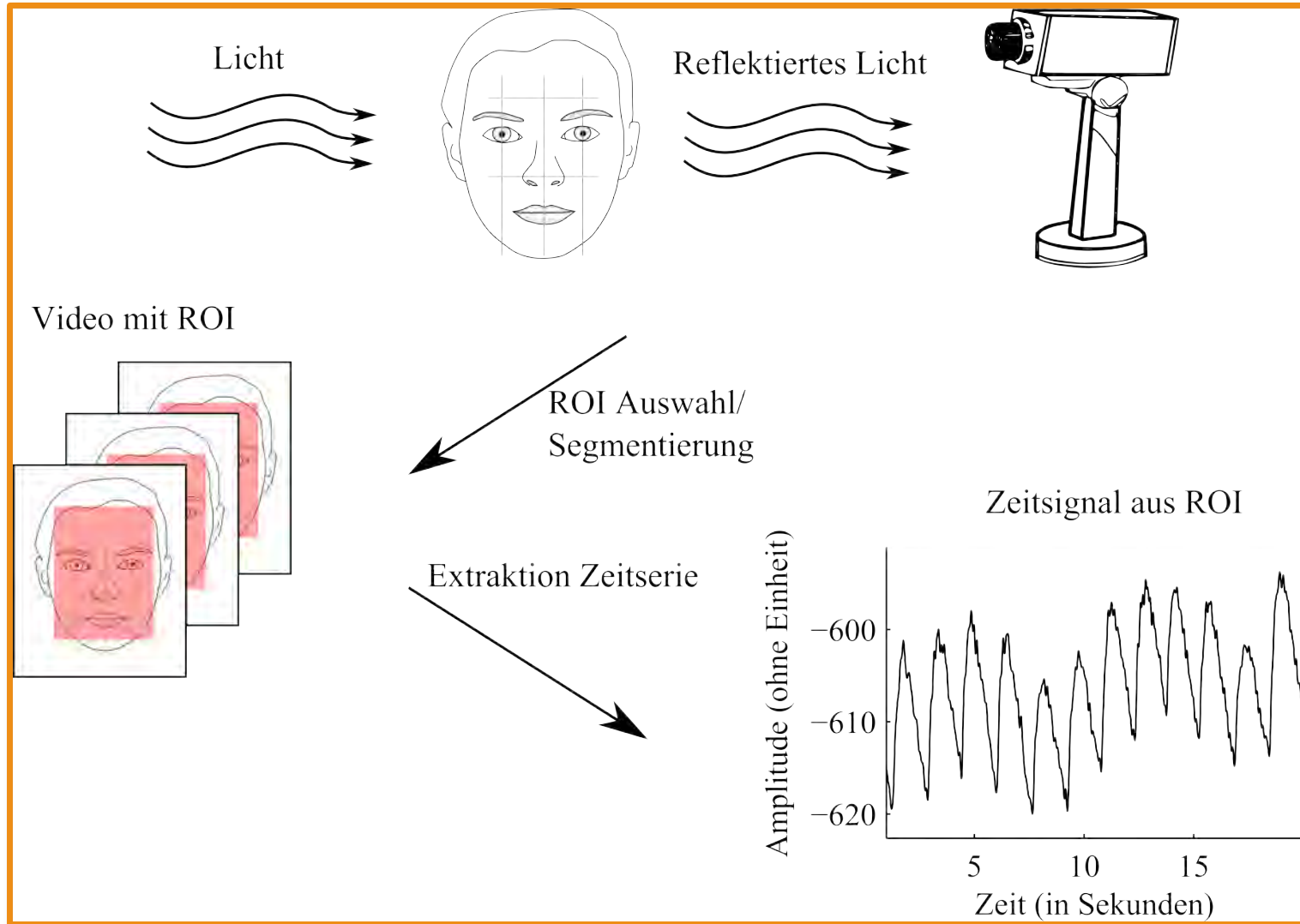
Quelle: [radio-stolberg.de](http://radio-stolberg.de)

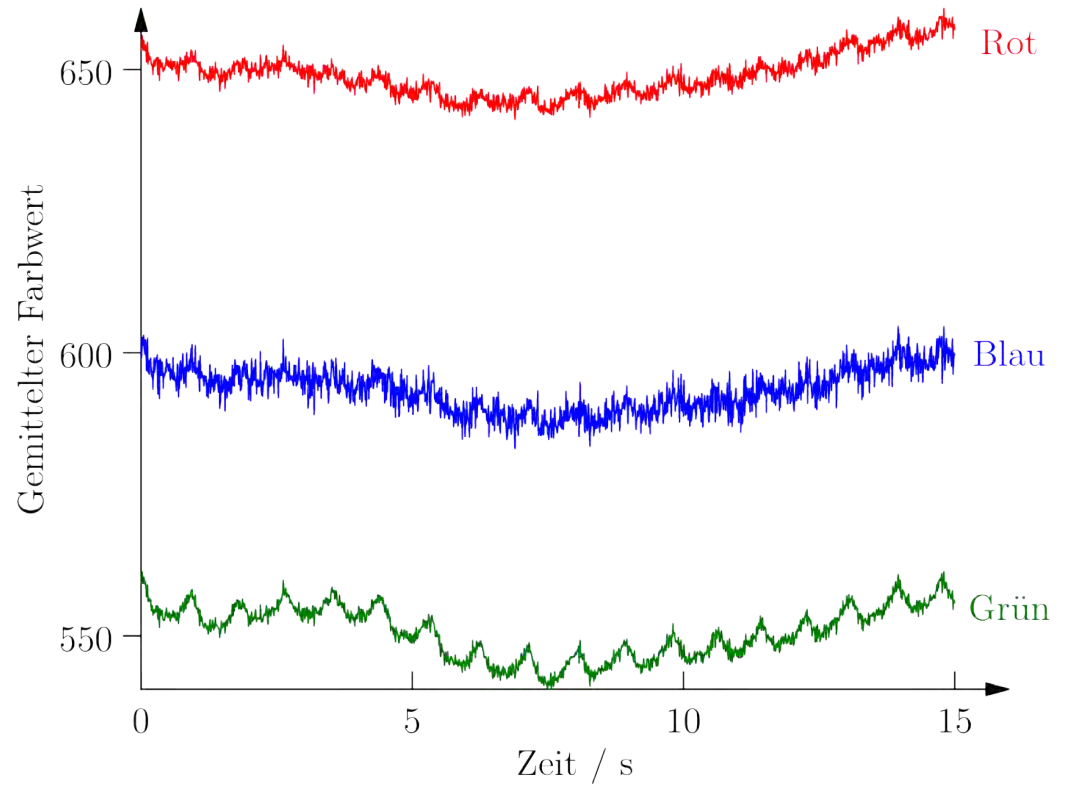
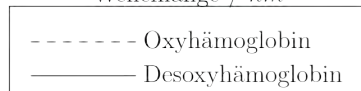
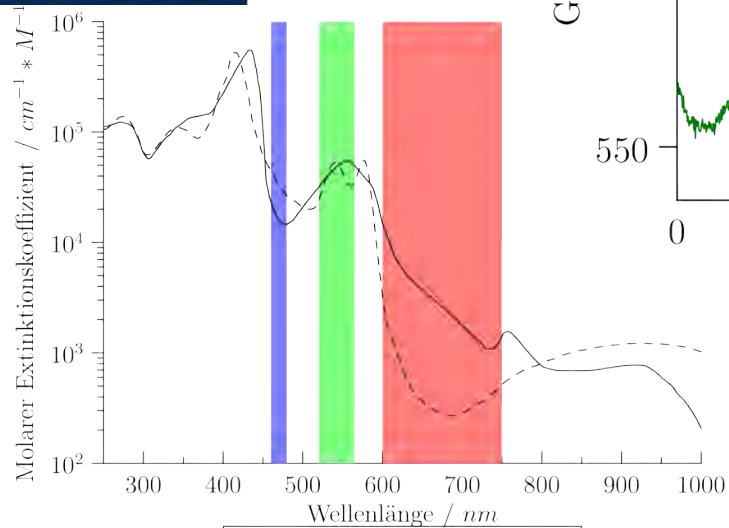
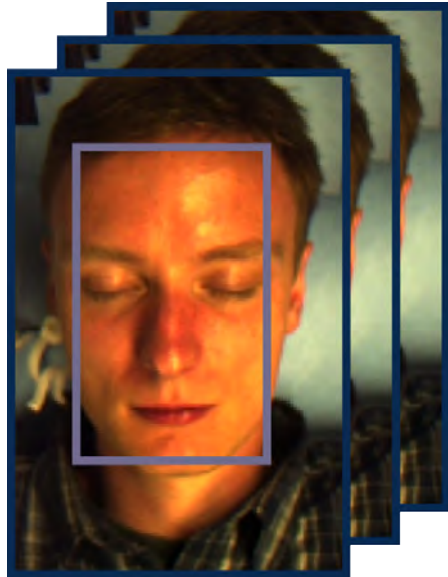


## Videos, please visit

<https://www.youtube.com/user/ibmttud>

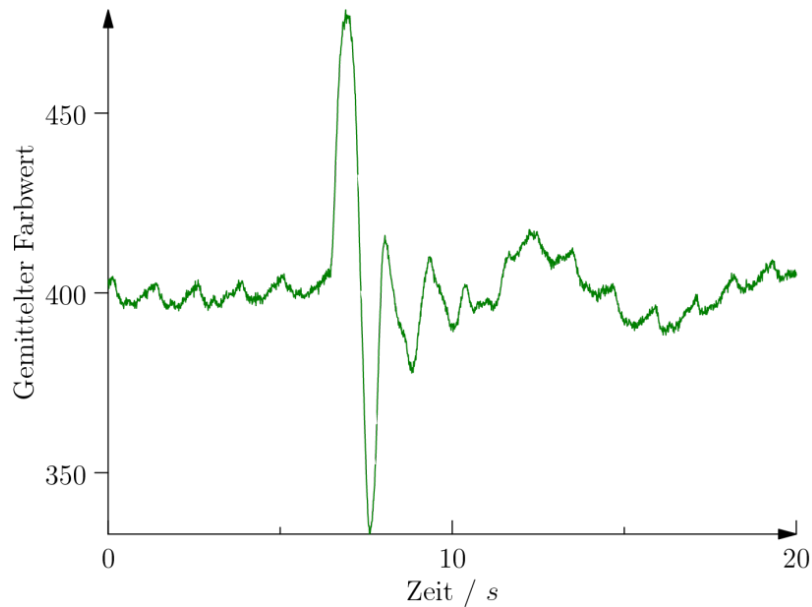




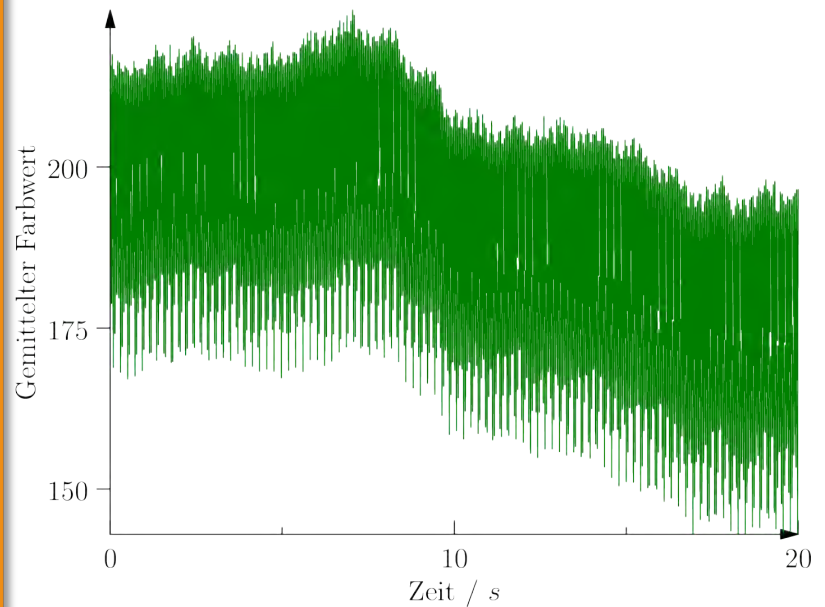




## MOVEMENT



## NEON LIGHT




Source separation, data fusion,  
biosignal processing



Messung der Blutperfusion durch Videoaufnahmen

Originalvideo      Farbverstärkt      Falschfarben



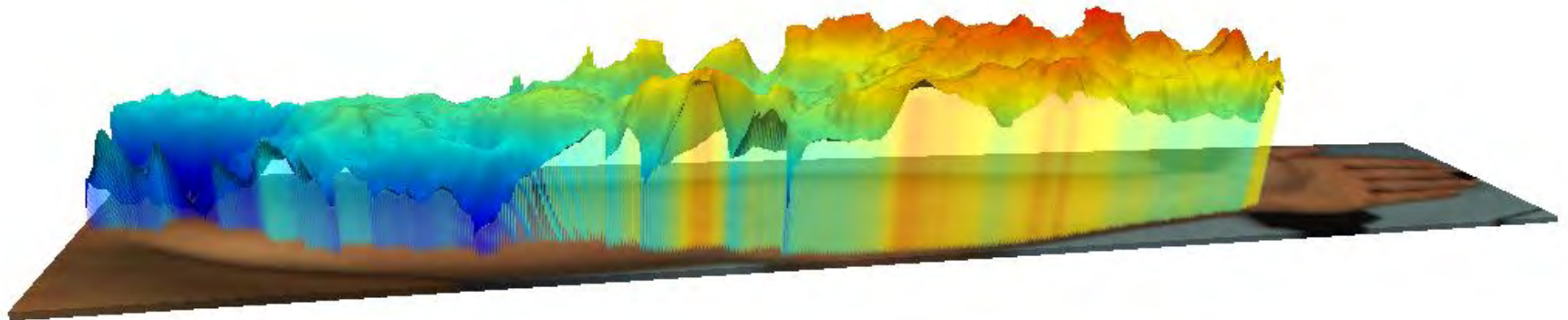
The image displays three vertical panels showing a person's face. The first panel, labeled 'Originalvideo', shows a standard video frame. The second panel, 'Farbverstärkt', shows the same face with enhanced color contrast, highlighting facial features. The third panel, 'Falschfarben', shows a false-color perfusion map where the face is rendered in a color gradient from blue to red, representing blood flow intensity. A play button icon is visible in the top right corner of the video frame area.





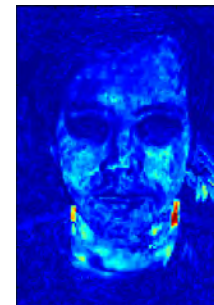
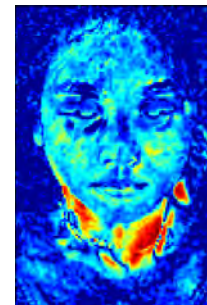
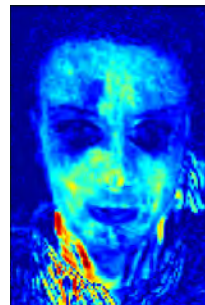
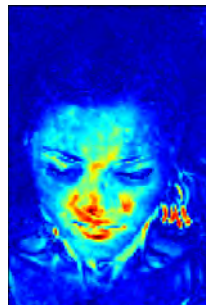
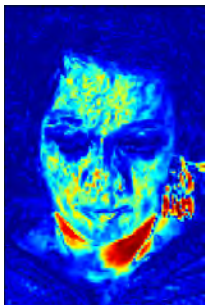
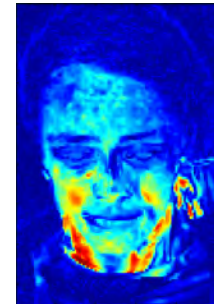
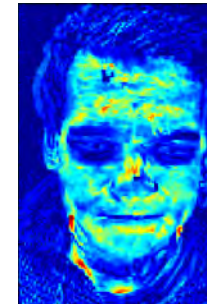
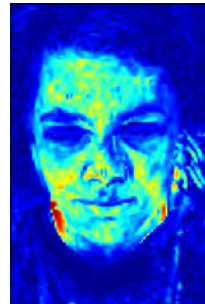
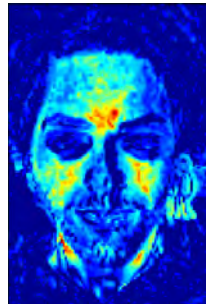
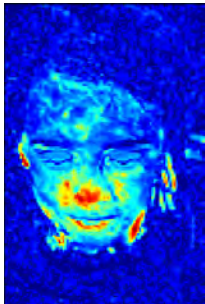
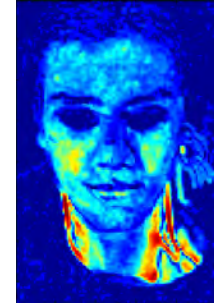
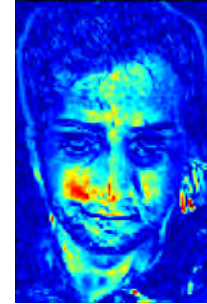
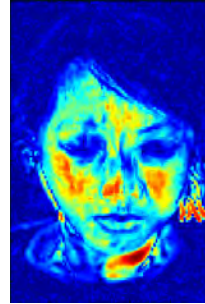
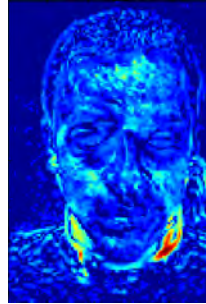
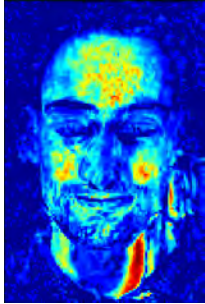
**! Video in 160-facher Zeitlupe !**

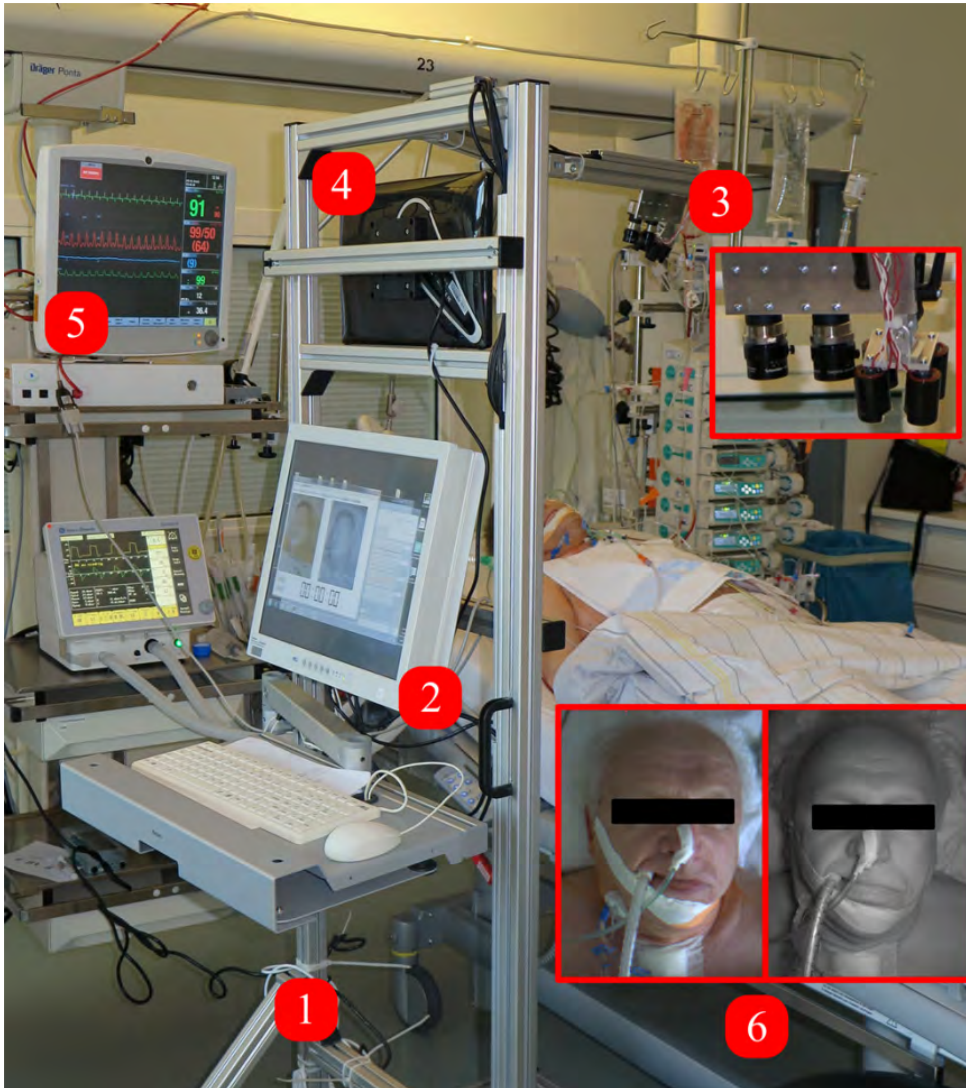
Weitere siehe <https://www.youtube.com/user/ibmttud>



Ankunftszeiten der Pulswelle entlang des Arms

# PATTERNS?





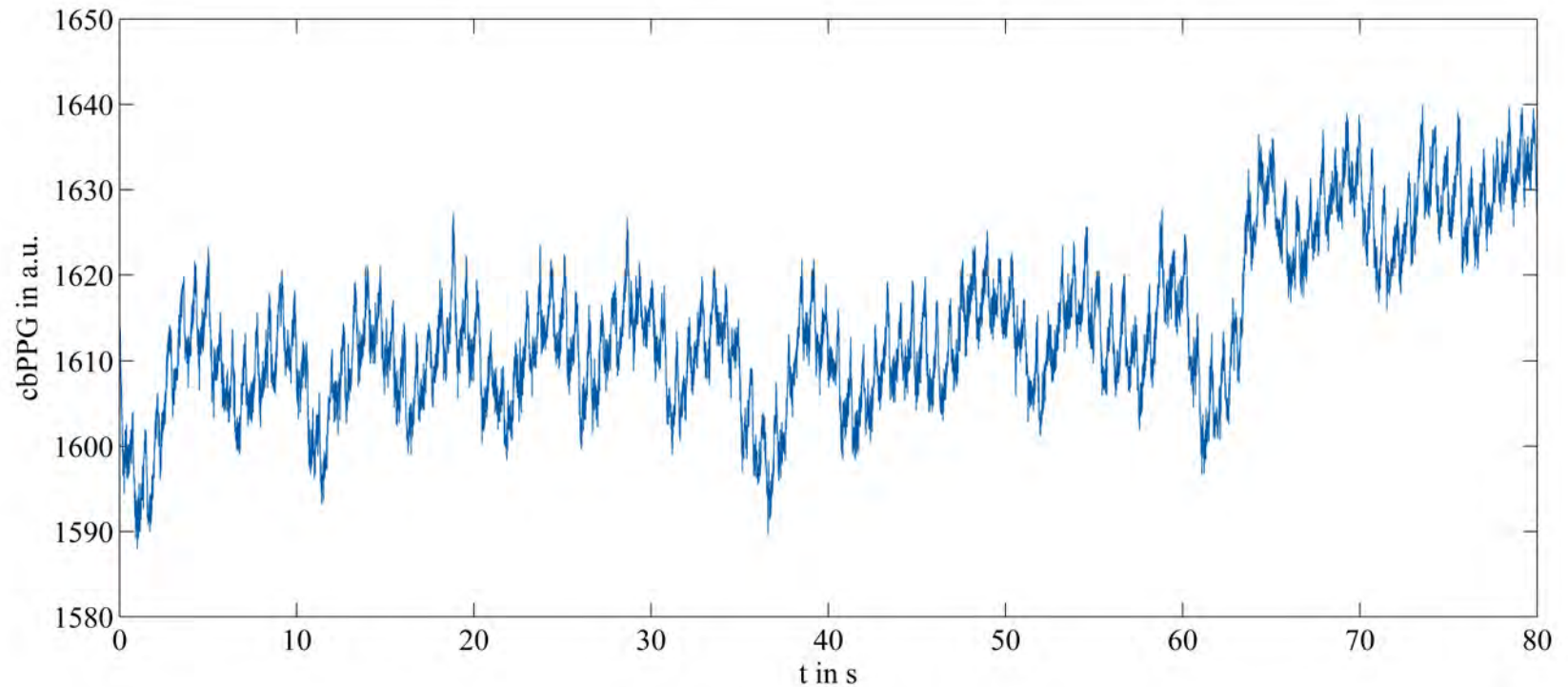
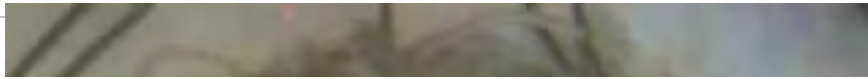
## Measured signals

- Heart rate
- Respiration
- Spatio-temporal distribution of perfusion
- movements

## Estimated Signals

- SPO2
- Puls Pressure
- Blood Pressure?







177

55

42

86

42

61

57

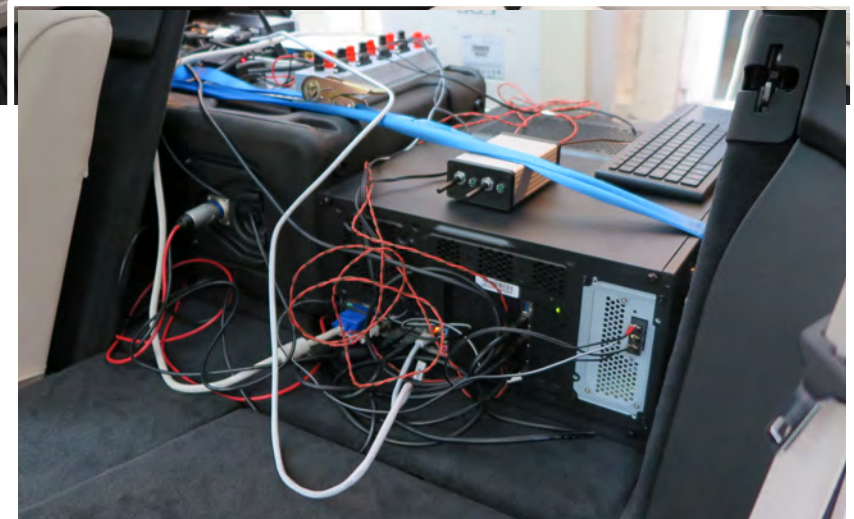
33

80







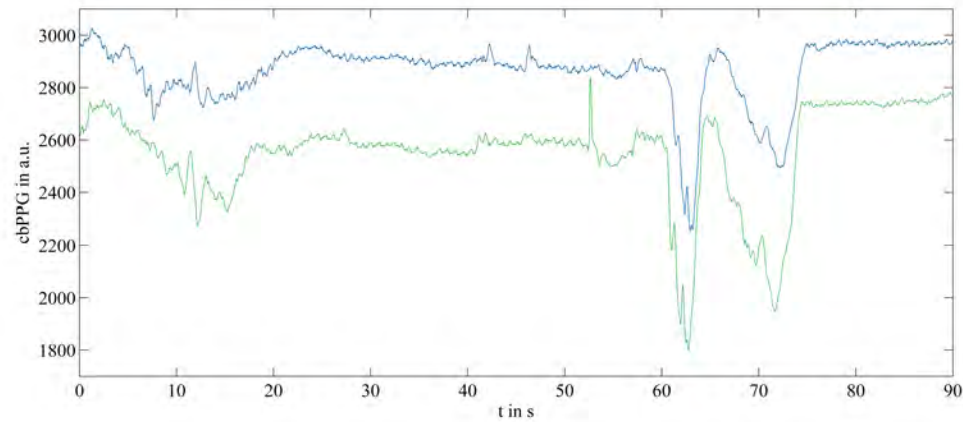




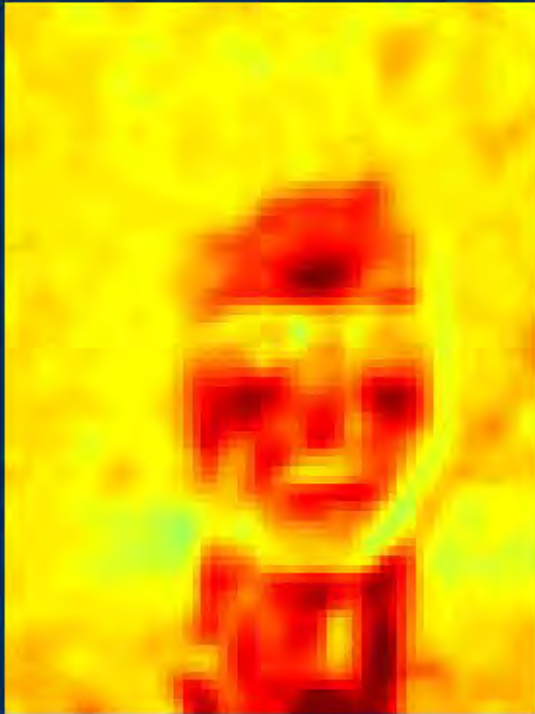




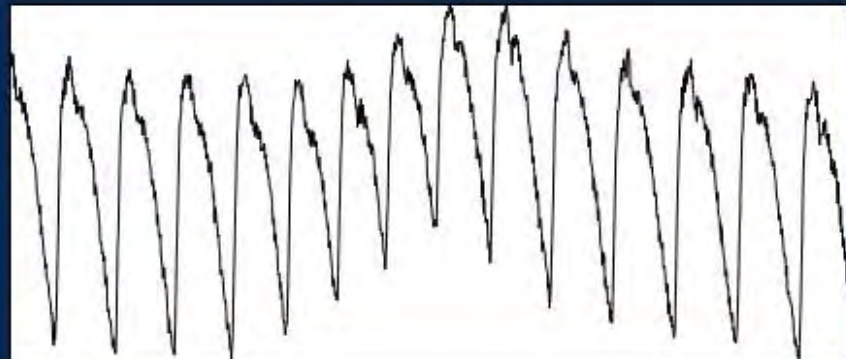




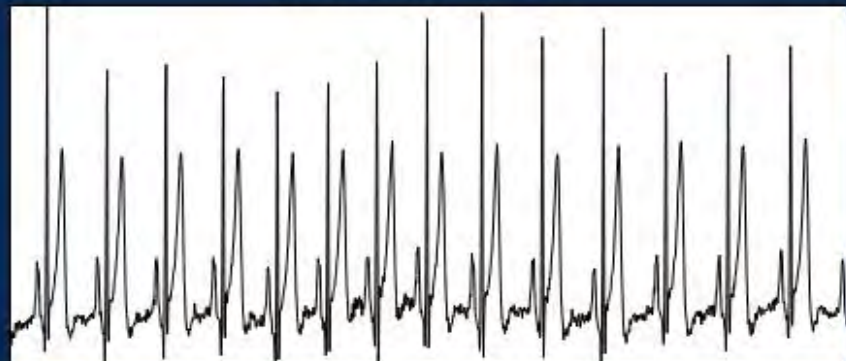
PPG Imaging

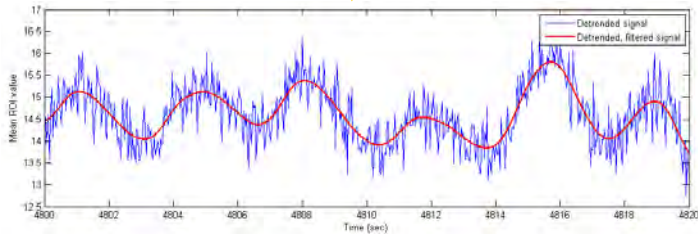


Reference PPG

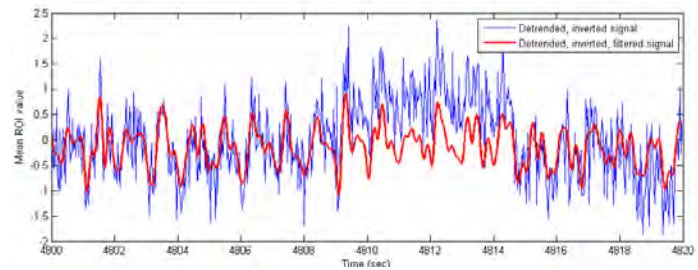
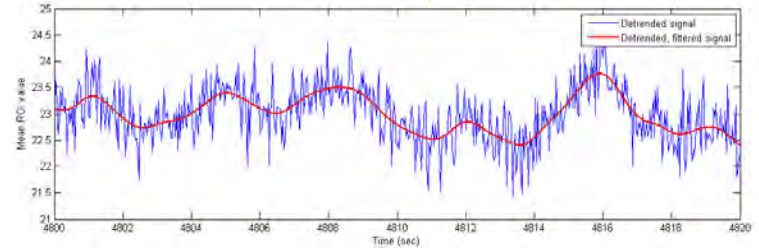


Reference ECG

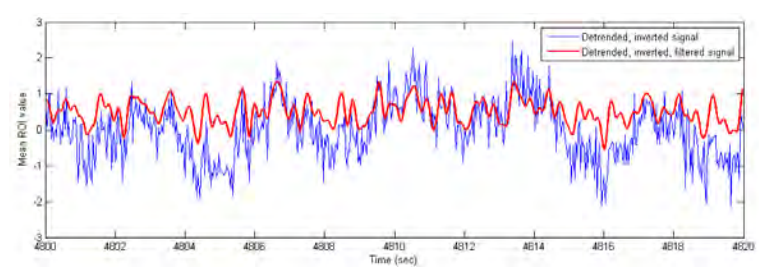




Atemrate



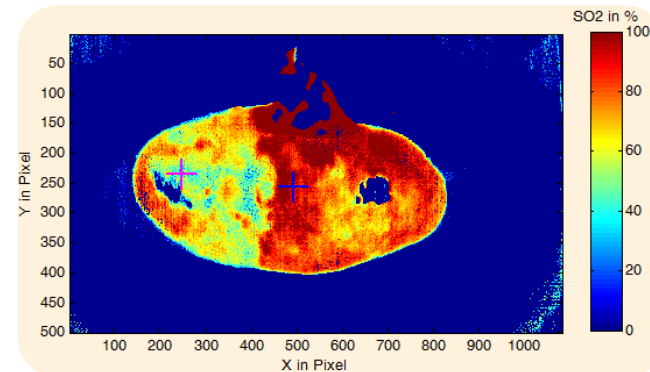
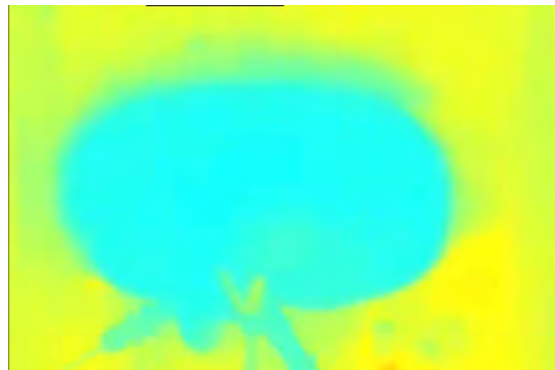
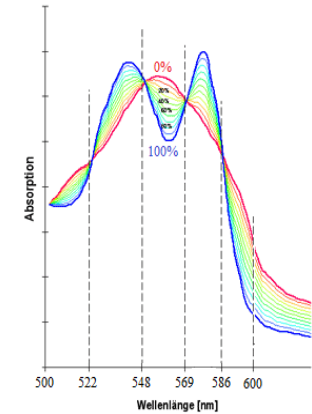
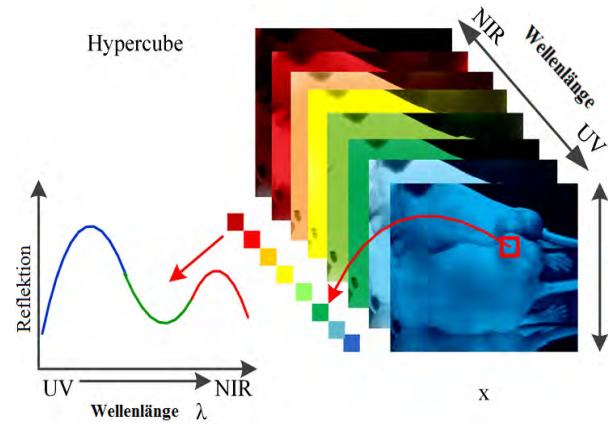
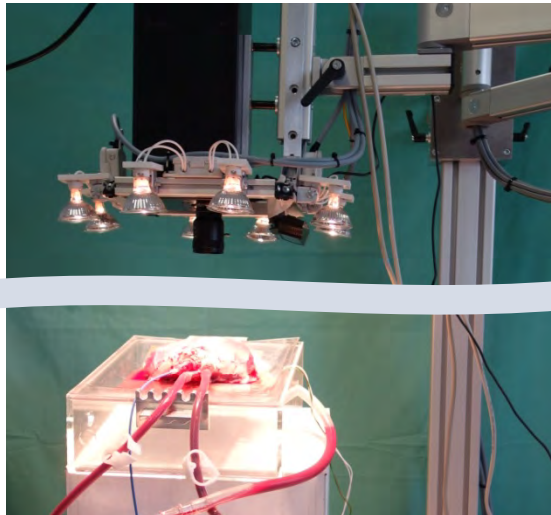
Herzrate







## Data recording and analyses: future: biochemical markers



## Several novel technologies

multimodal (mini)-sensors

mobil recording/calculating/data-transmitting

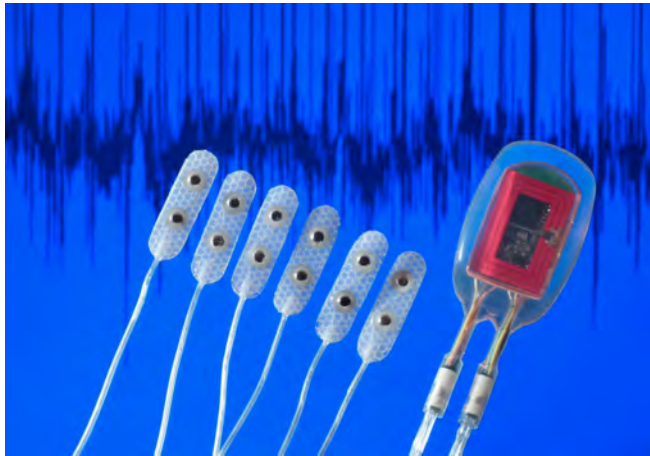
## Challenges:

- High integration, energy consumption, communication
- Handling of data masses
- Artifacts
- Clinical consequences



## Telemedicine for

### Chronic diseases (Implants)



Q: DGBMT

### Ambient-Assisted Living (AAL)

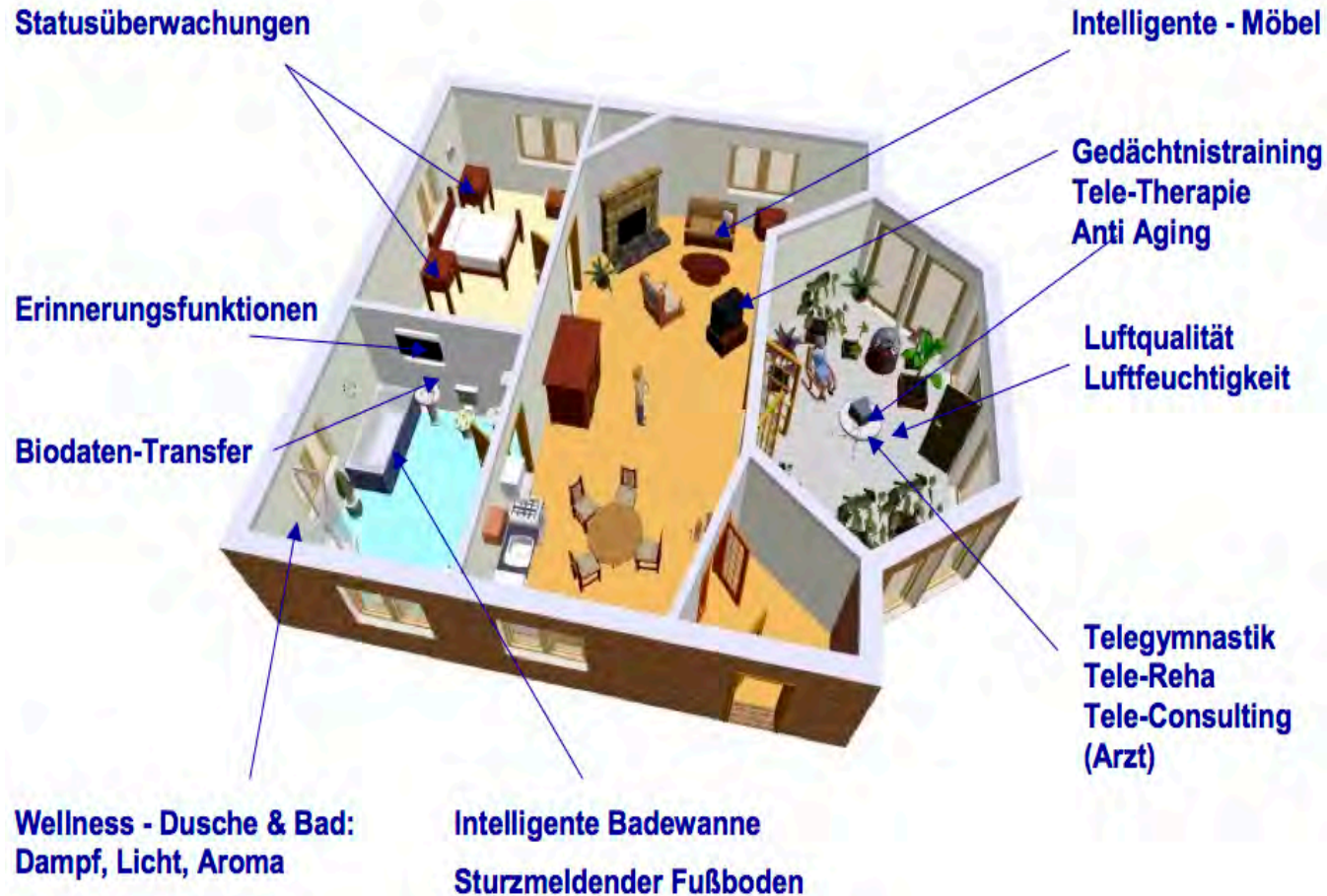
- Chronic diseases
- Healthy aging at home
- Prevention



Q: [www.silicon.de](http://www.silicon.de)

## Modellwohnung „Häusliche Gesundheitsstation“

EFRE 100278533



Zusätzlich: Vitaldatenkamera im Badspiegel, Anschlüsse für Medizintechnik, Kinect für Fitness-Übungen, Bewegungssensoren, Konsole im Flur



TECHNISCHE  
UNIVERSITÄT  
DRESDEN



FAKULTÄT ELEKTROTECHNIK  
UND INFORMATIONSTECHNIK

Faculty of Electrical and Computer Engineering ✦ Institute of Biomedical Engineering ✦ Chair: Prof. Dr.-Ing. habil. Hagen Malberg



**»Wissen schafft Brücken.«**

„Knowledge creates bridges“



**Institute of Biomedical Engineering**



**Steinbeis-Forschungszentrum  
Angewandte Medizintechnik**