

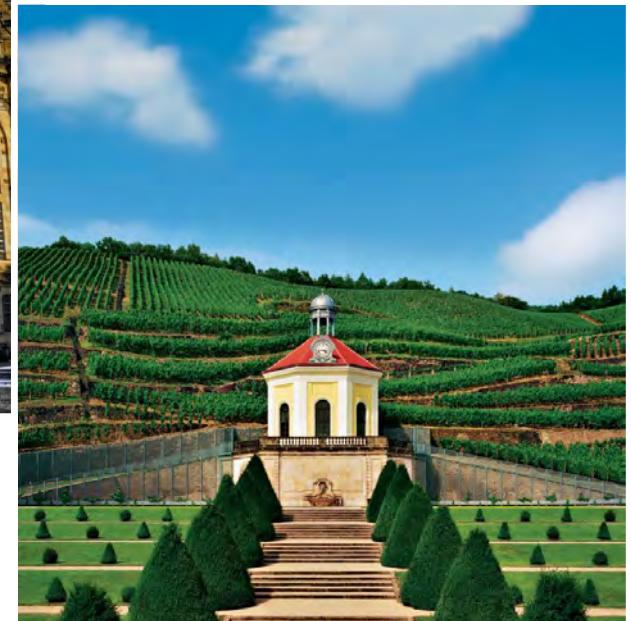
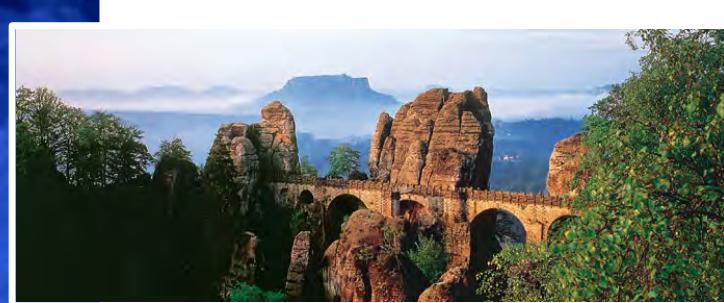
Contactless measurement technologies in medicine

Hagen Malberg
Institute of Biomedical Engineering
TU Dresden

COMO, 26.07.2017

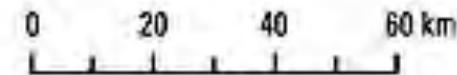


DRESDEN
concept
Exzellenz aus
Wissenschaft
und Kultur





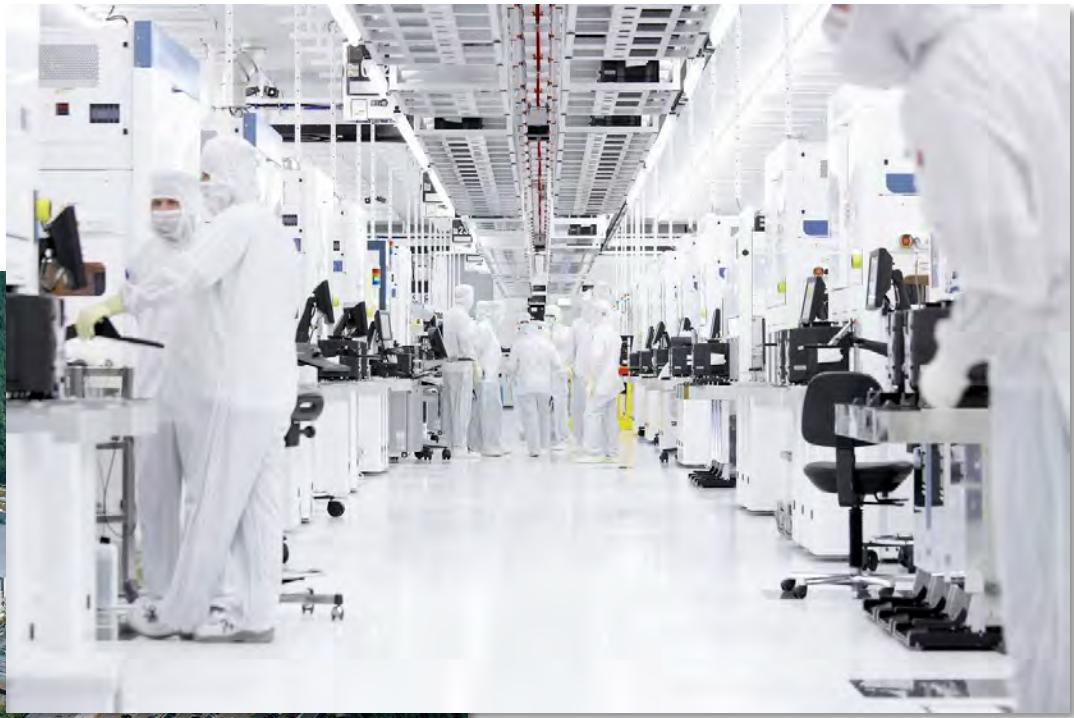
-Zwickau-Erzgebirge
Fertigung, Motor/Antrieb,
Automobilelektronik,
Insassenschutz,
und Werkzeugbau,
Engineering,
und Entwicklung,
Berufsausbildung



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

CAR MANUFACTURING IN SAXONY





IN SAXONY: BABY BOOM



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



THE HOSPITAL





**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

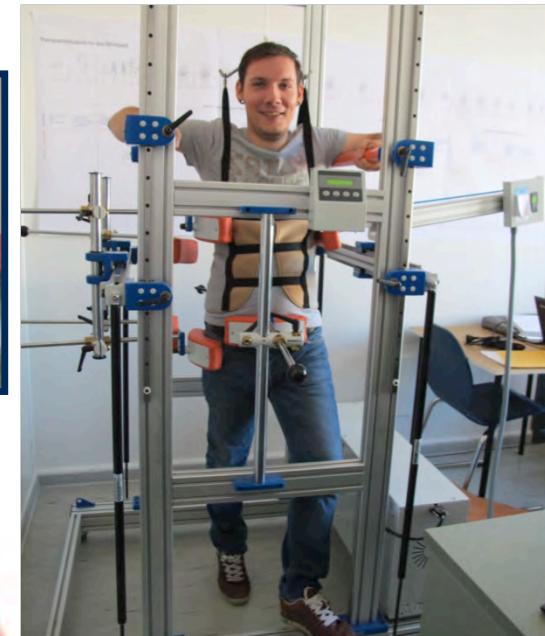
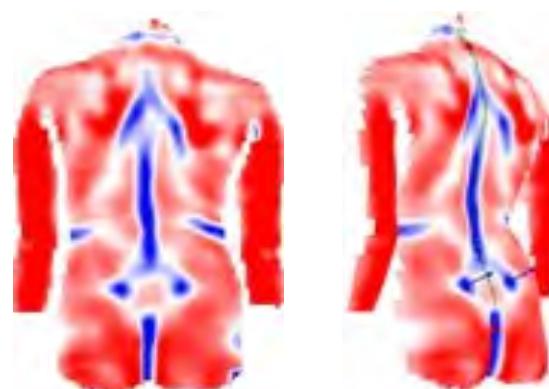
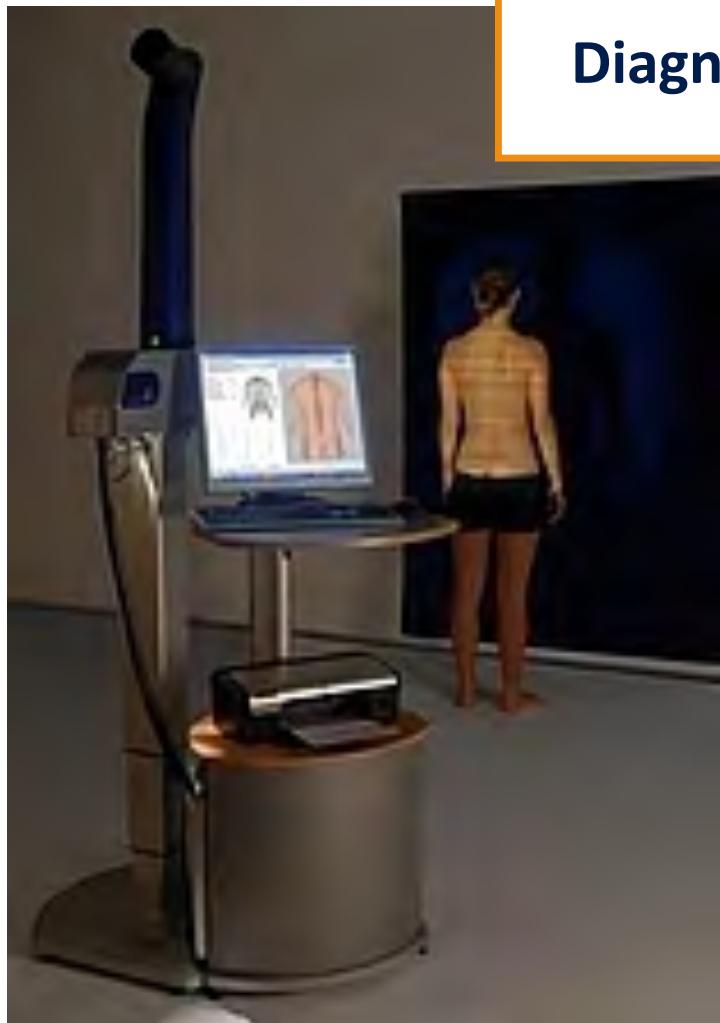
- Dr. G. Sliwinski



TOPLiver[®], NephroTOP[®]



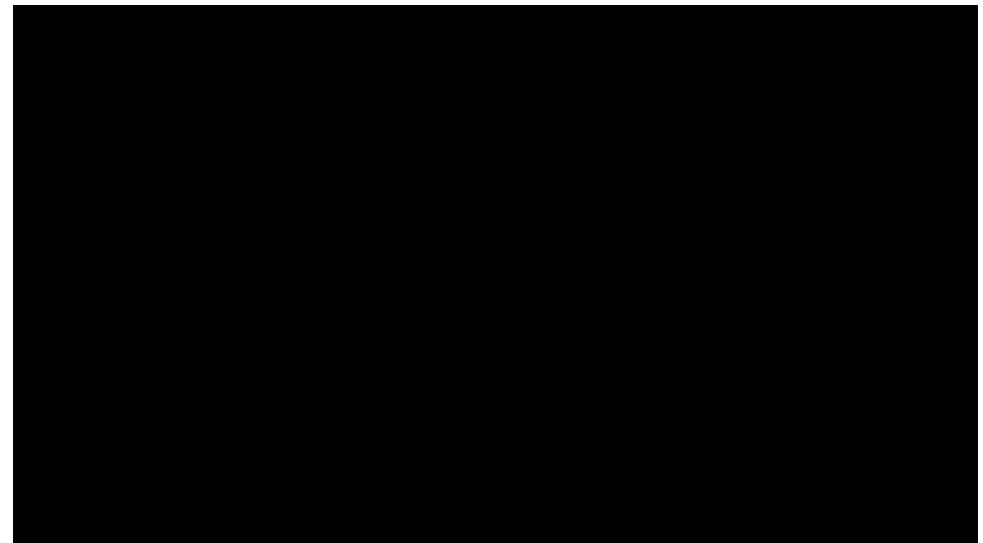
Diagnosis of Scoliosis



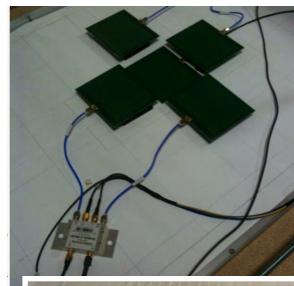
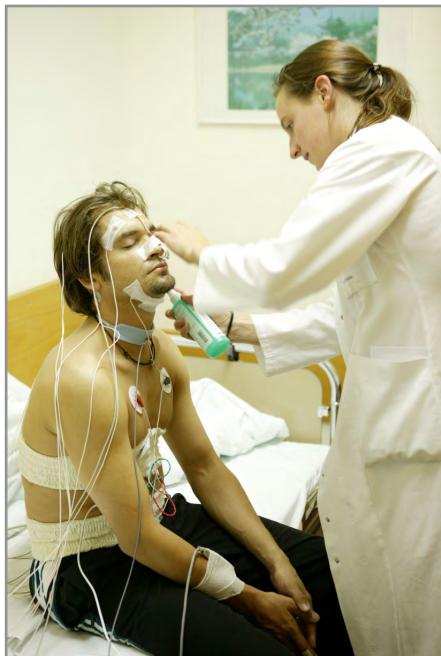
Therapy



**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,

THE FUTURE (HISTORIC)



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

OS: Paul Weißbach

SENSOR GROWTH IN SMARTPHONES

INTEGRATED SENSORS, USER EXPERIENCES



GALAXY 1

Ambient Light
Accelerometer
Magnetometer

2010



GALAXY S2

Gyroscope
Proximity

2011



GALAXY S3

Pressure
RGB

2012

Ambient Light
Accelerometer
Magnetometer



GALAXY S4

Temperature
Humidity
Hall Effect

2013

Ambient Light
Accelerometer
Magnetometer



GALAXY S5



GALAXY S5

Heart Rate
Fingerprint

Temperature
Humidity
Hall Effect

Pressure
RGB

Gyroscope
Proximity

Ambient Light
Accelerometer
Magnetometer

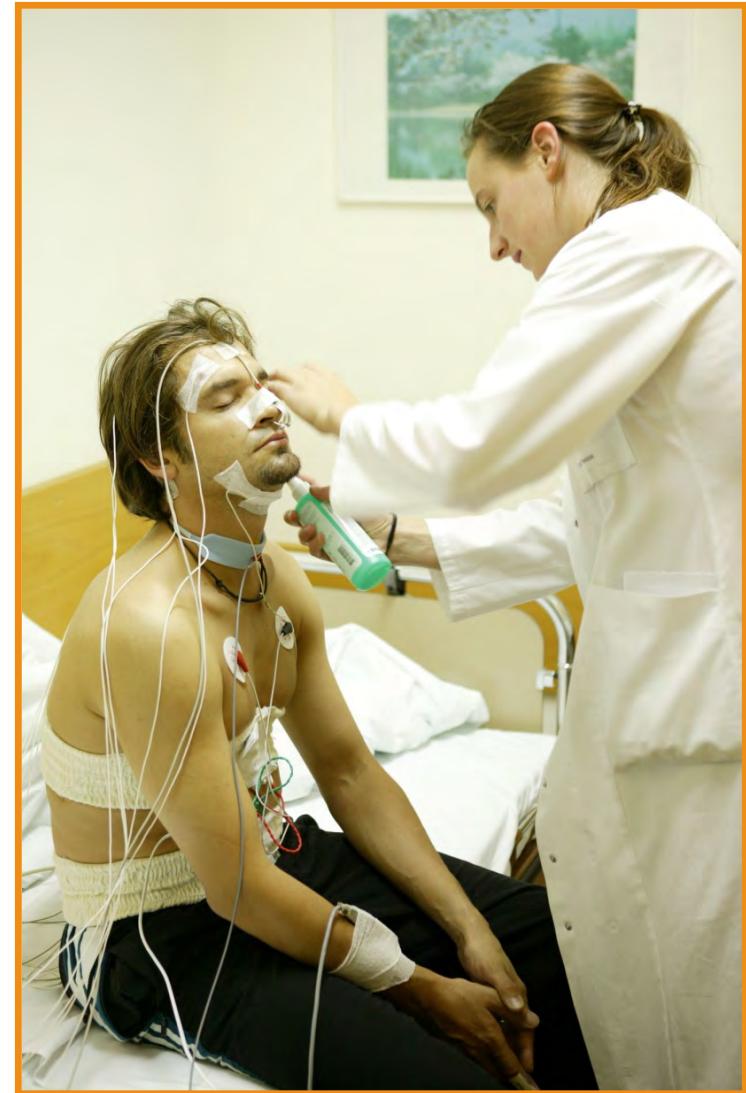
2014

2015+

#1: NETWORK PHYSIOLOGY



Q: Thomas Penzel



2: NETWORK PHYSIOLOGY



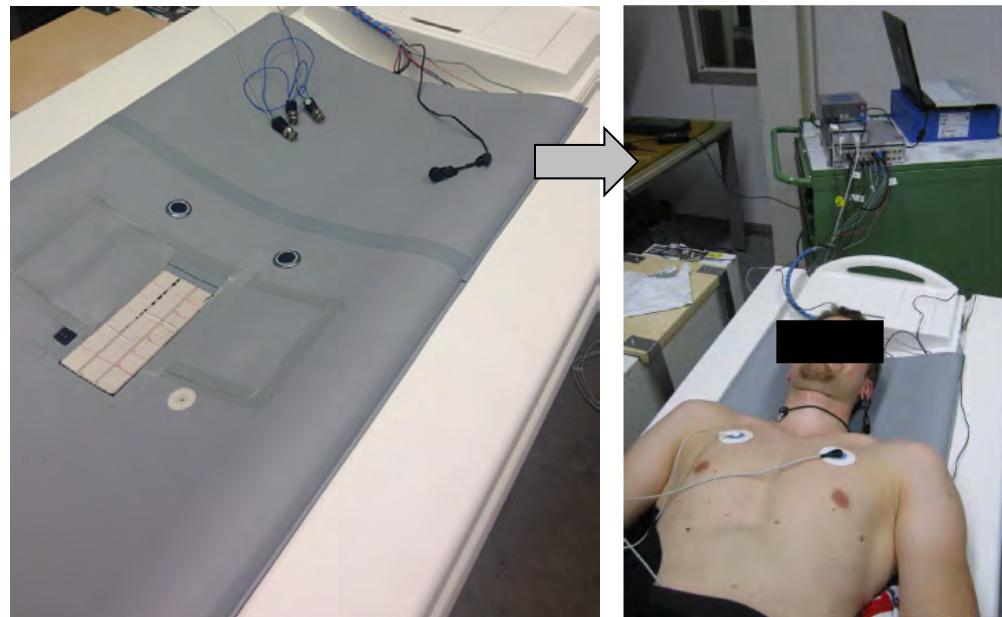


BIOSIGNAL- RECORDING

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

Multisensing

Sensor set up



CAPACITIVE ECG

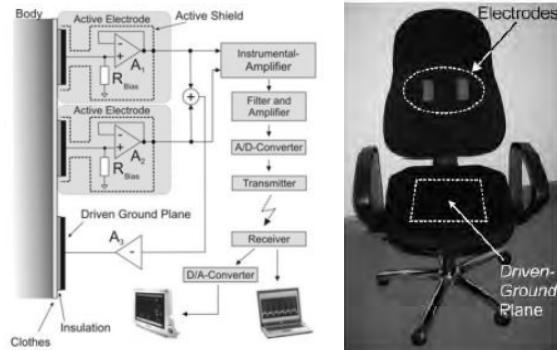


Abb. 25: Aachen SmartChair 2009

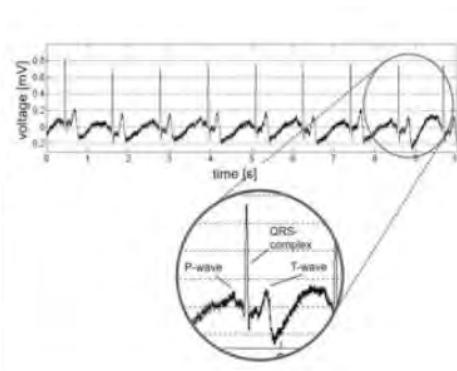


Abb. 26: Oehler 2009



Abb. 27: Plessey 2010



Abb. 28: Congionics 2010

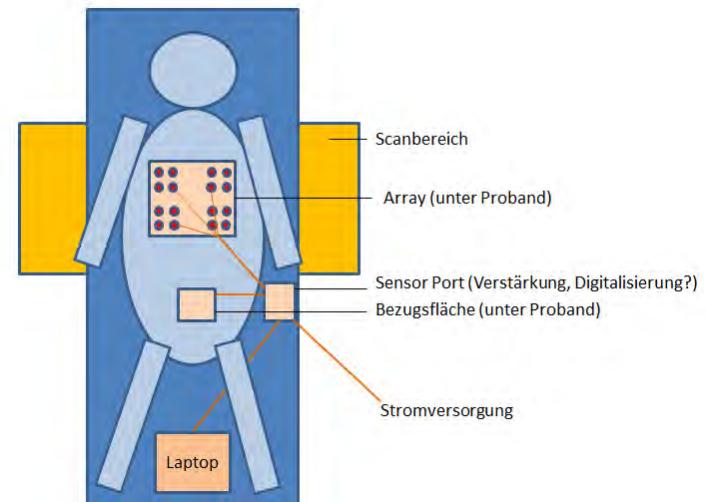


Abb. 29: Grundidee Integration cECG
in bildgebendes System

PIEZOELECTRIC SENSORS BODY SOUND

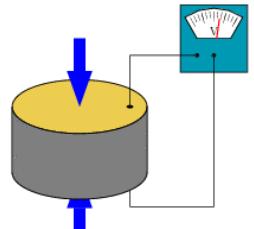


Abb. 40: Prinzip Piezosensor
(Wikipedia)

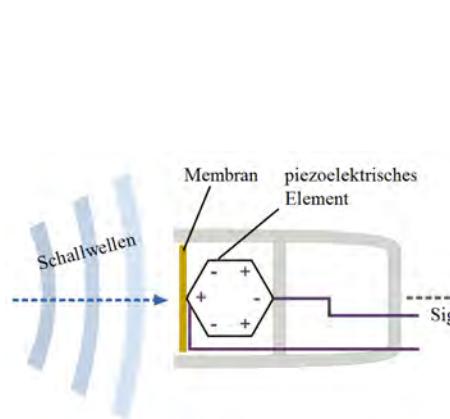


Abb. 41: Prinzip Piezomikrofon
(Wikipedia)

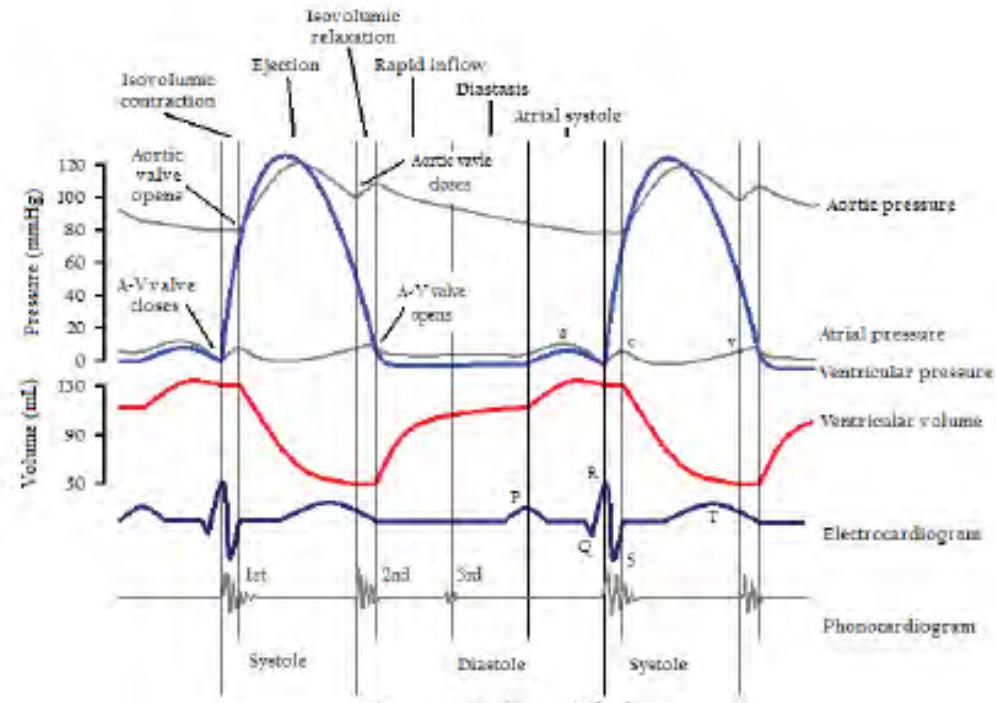


Abb. 42: Entstehung der Herztöne

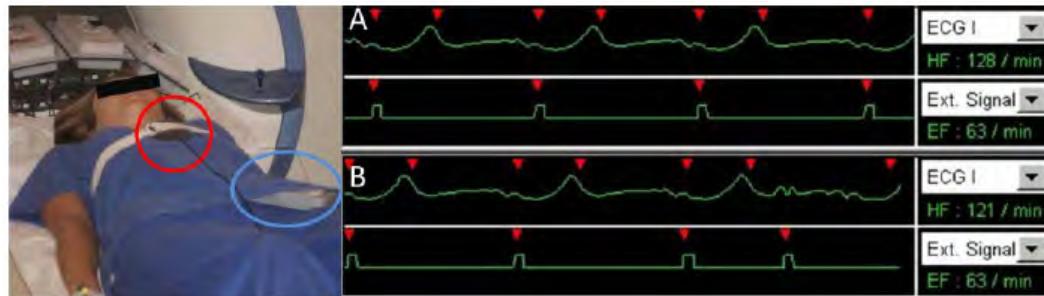


Abb. 43: PKG als Triggergerät für 7-Tesla-MR-Bildgebung, Maderwald et.al 2011

PIEZOELECTRIC SENSORS

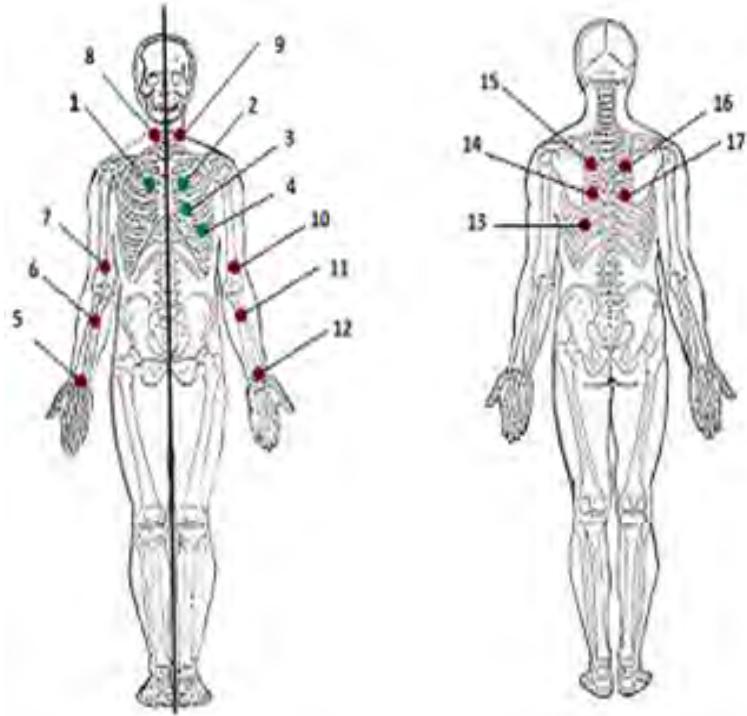


Abb. 44: Messpunkte zur Bewertung der Positionierung piezoelektrischer Sensoren

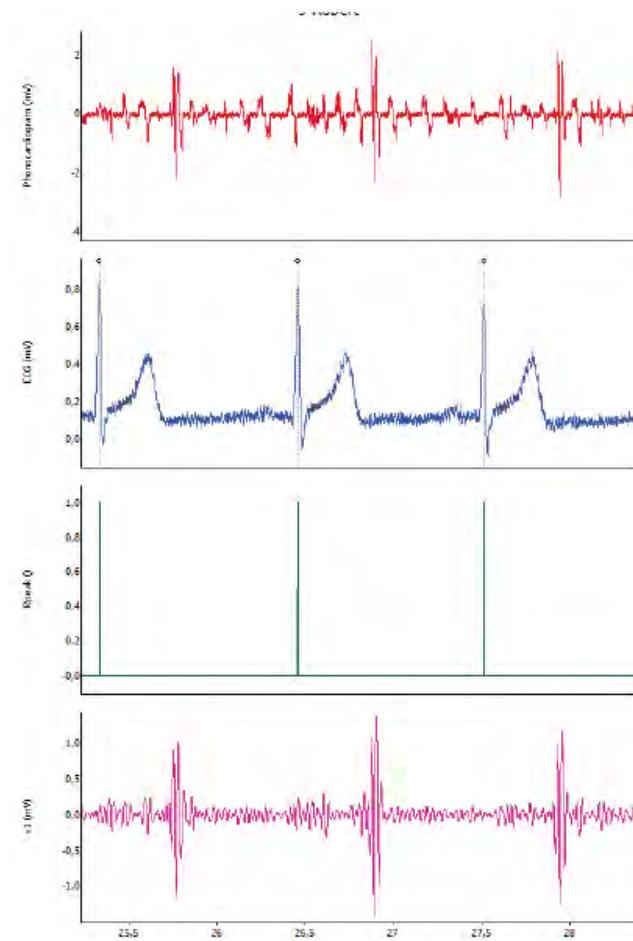


Abb. 45: Signalbeispiel in der Vormessung:
oben ungefiltertes PKG, darunter EKG,
darunter R-Zacke, unten gefiltertes PKG
bei carotisnaher Messung

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

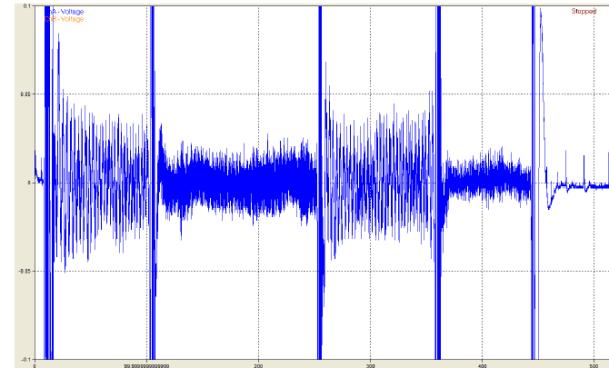


Abb. 57: Mess-Sequenz: Rückenlage, Linksseitig, Rückenlage, Rechtsseitig



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

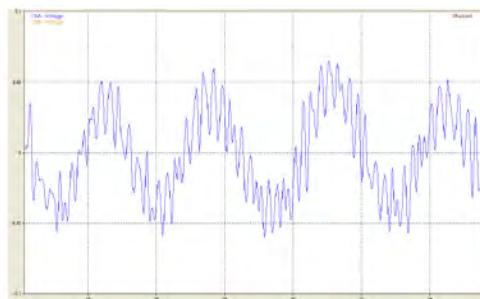


Abb. 58: Resonanz zu Beginn der Messung (Matratzeneinfluss)

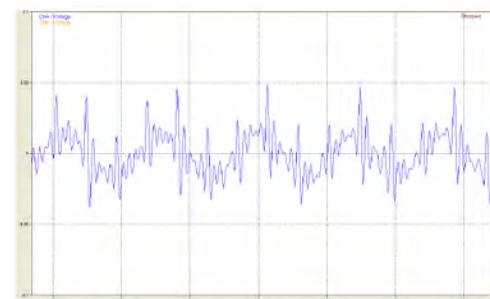


Abb. 59: Eingeschwungenes Verhalten

Force measurement

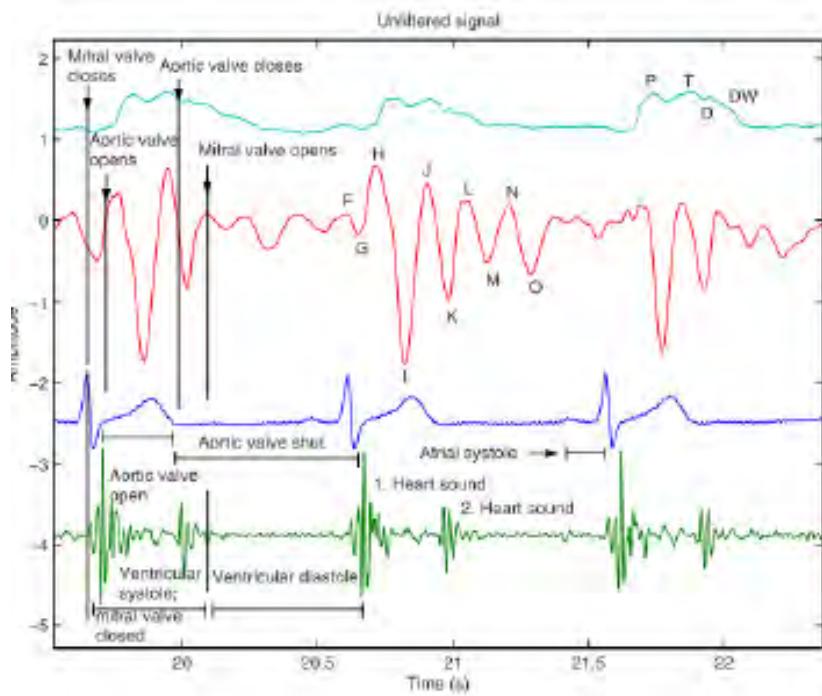


Abb. 61: Typ. BKG-Signalverlauf
nach Alametsä 2009

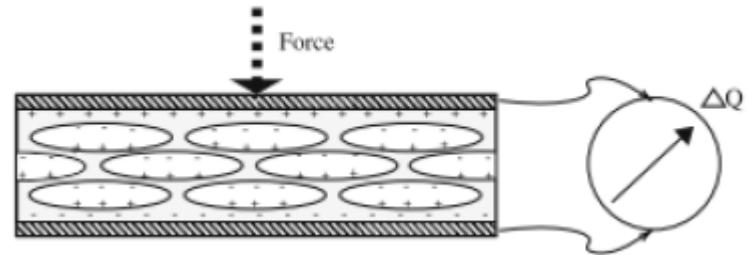


Abb. 60: EMFi-Material nach Junnila 2009

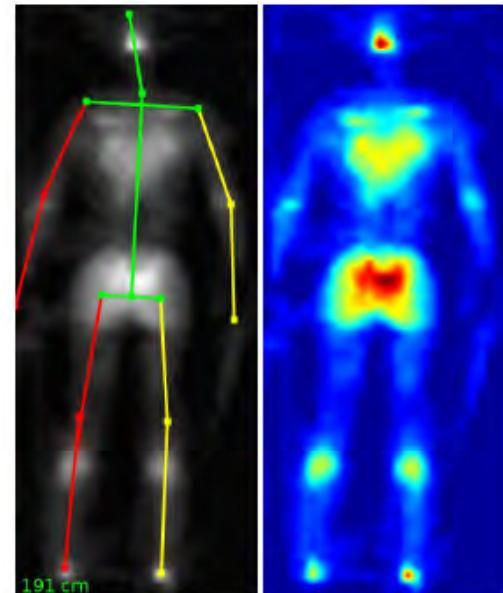


Abb. 62: Einsatz einer XSensor-Matte zur Positionsbestimmung
im MR-System, Grimm 2009

Tests of mattresses

Abb. 63: Aufnahme mit der großen XSensor-Matte

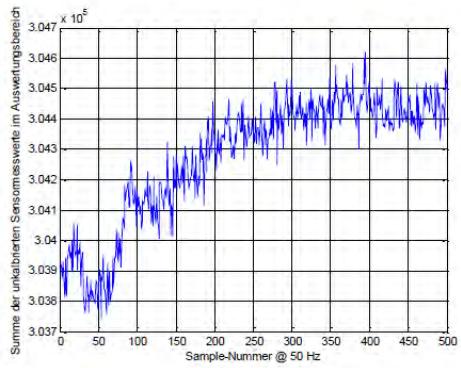
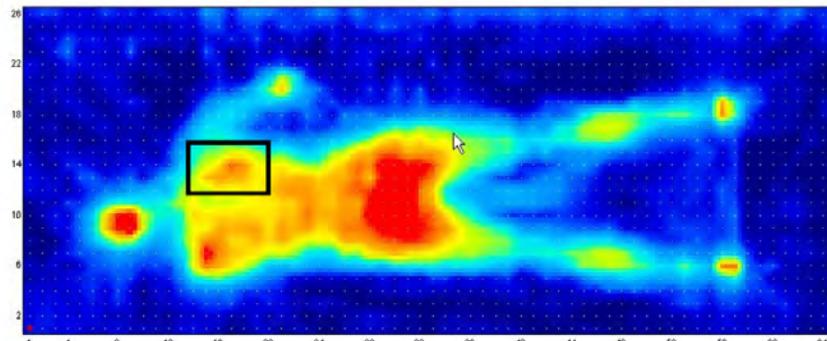


Abb. 64: Messung ohne Atmung

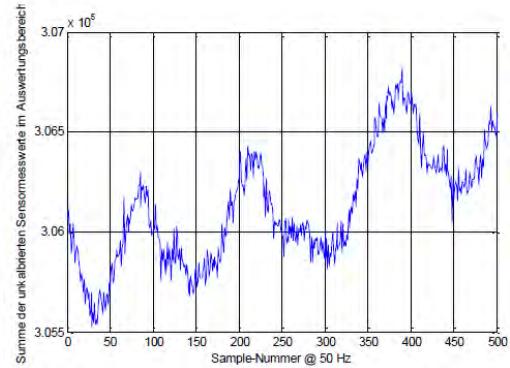


Abb. 65: Messung mit Atmung



Abb. 66: XSensor-Mattress PX100

DOPPLER/RADAR

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

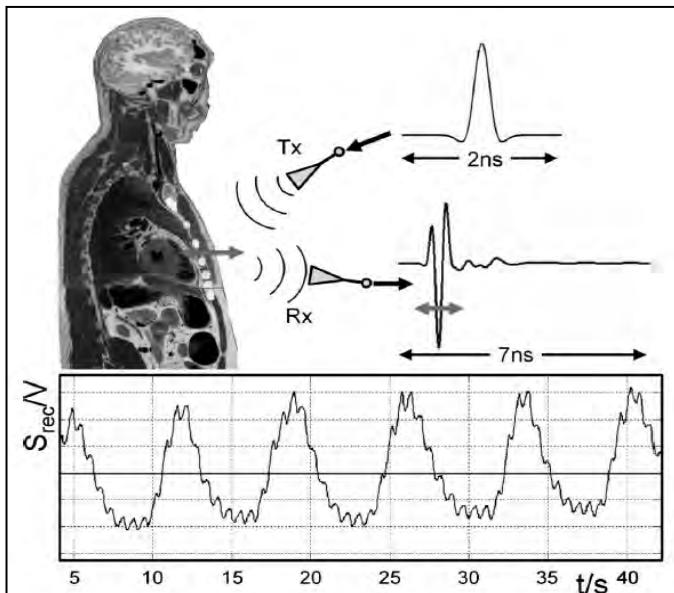
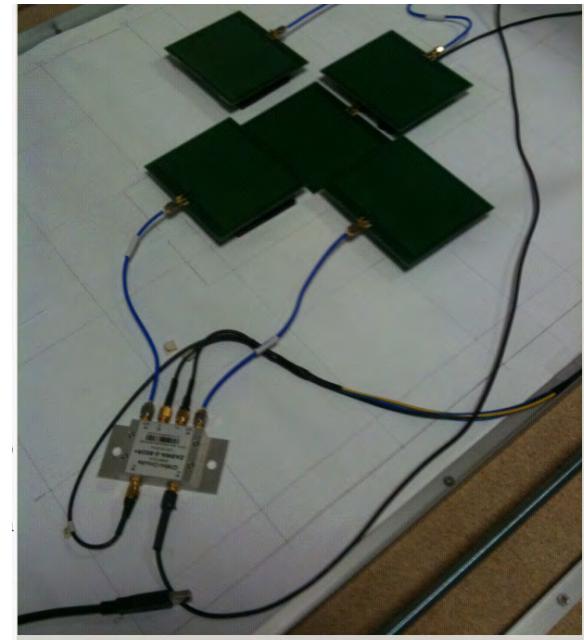


FIG. 1. Probing the human body with broadband electromagnetic pulses. Top: Transmitted pulse and received pulse (IRF of the scenario, IRF) which is modulated by the vital functions. Bottom: Reconstructed physiological signature S_{rec} , breathing with superimposed heartbeat, reconstructed from ultrawideband radar data. Anatomic slice taken from Ref. 17.

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>

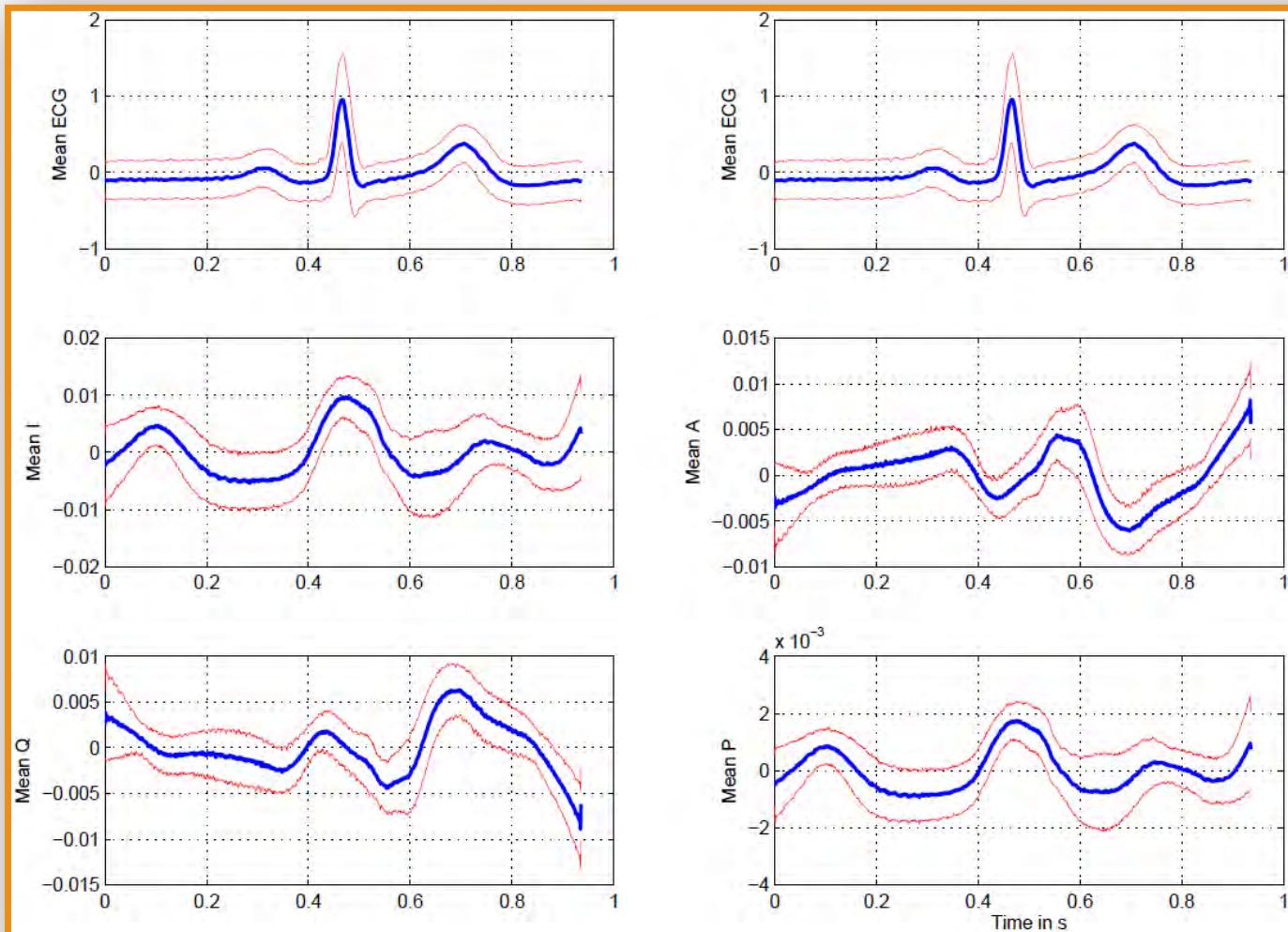


Abb. 88: gemitteltes EKG, I- und Q-Signal,
Normiert auf Herzzyklus

Classical PPG



Quelle: cardiologyforless.com

Camera based PPG (remote PPG: rPPG)



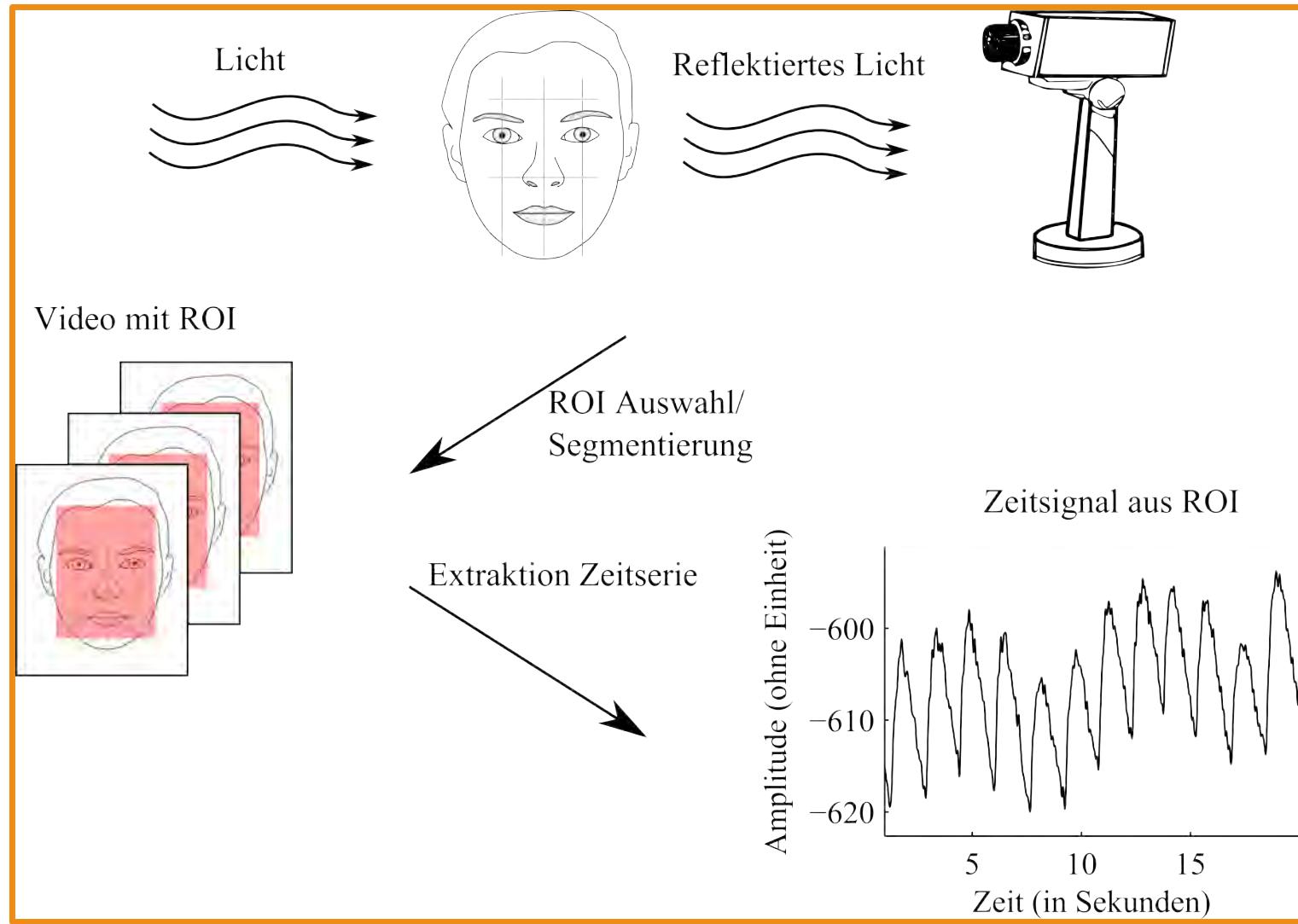
Quelle: radio-stolberg.de

Videos, please visit

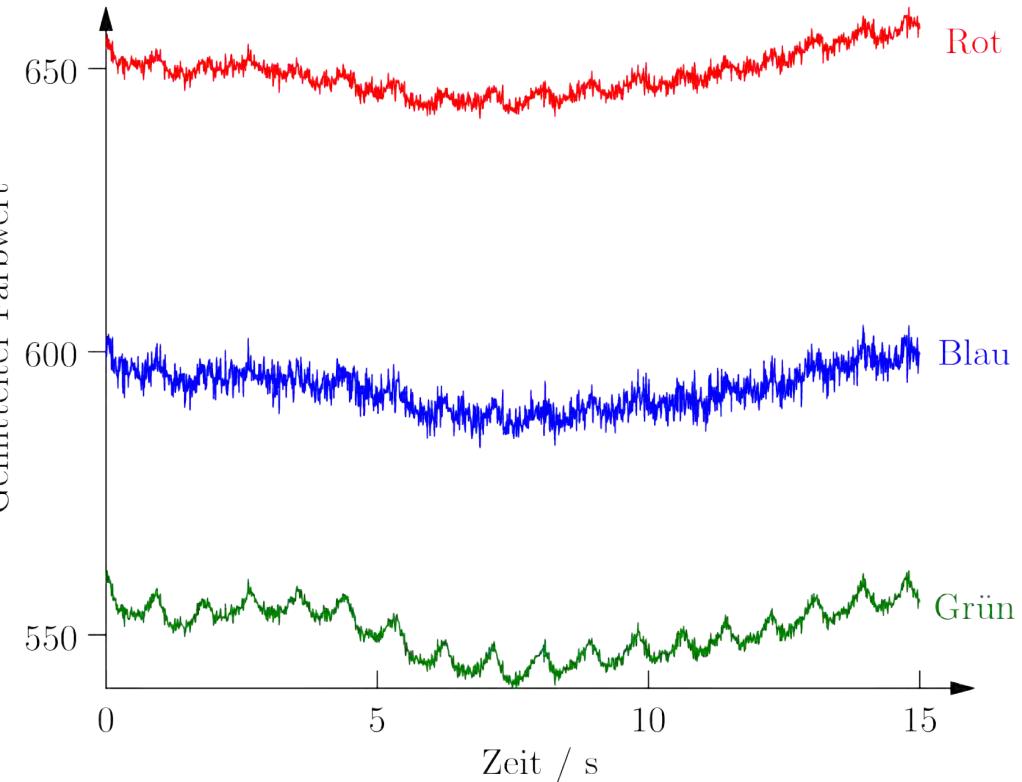
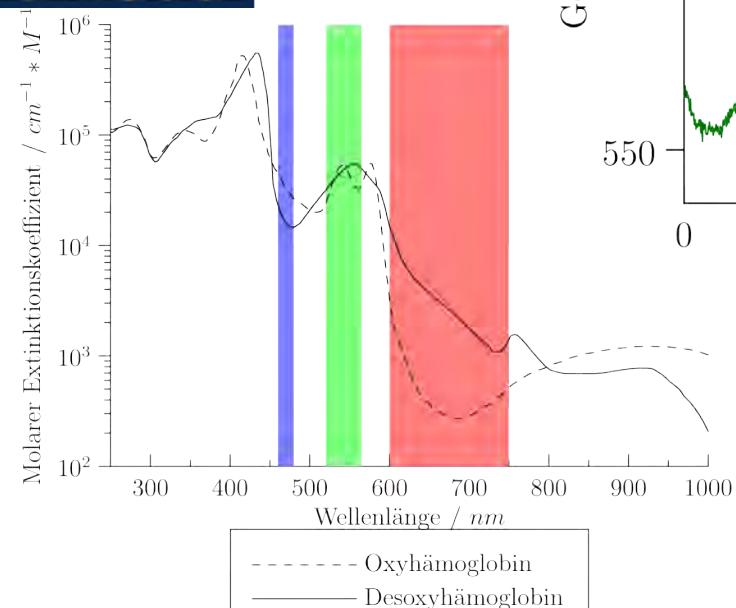
<https://www.youtube.com/user/ibmttud>



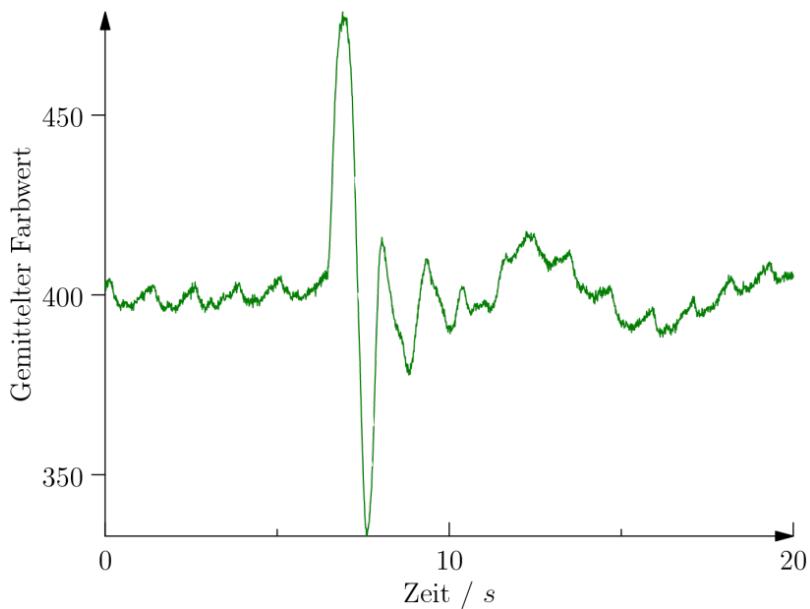
rPPG: MEASUREMENT PRINCIP



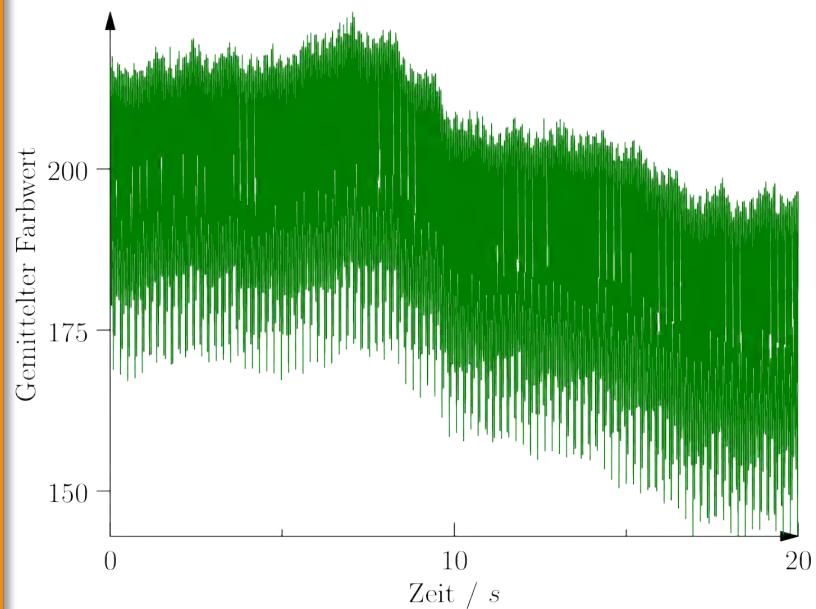
SIGNAL EXTRACTION



MOVEMENT



NEON LIGHT



Source separation, data fusion,
biosignal processing

DETECTION OF ROI

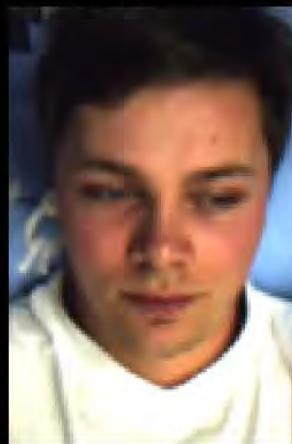


PERFUSION

Messung der Blutperfusion durch Videoaufnahmen



Originalvideo



Farbverstärkt



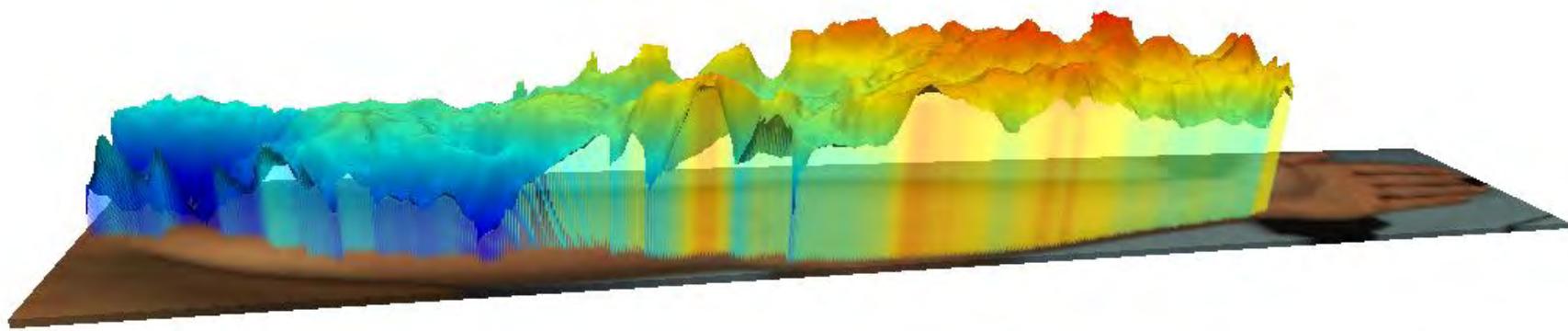
Falschfarben





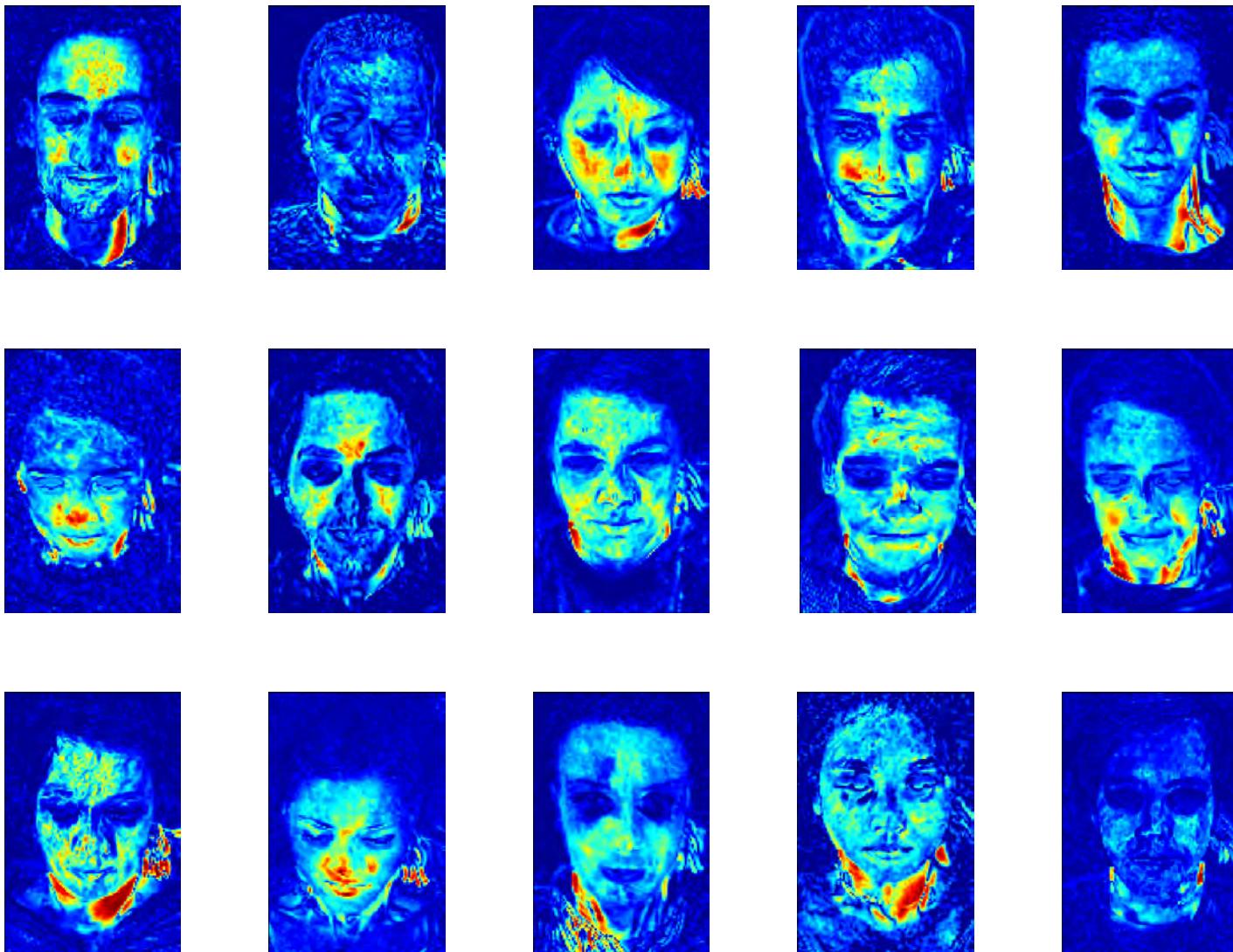
! Video in 160-facher Zeitlupe !

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

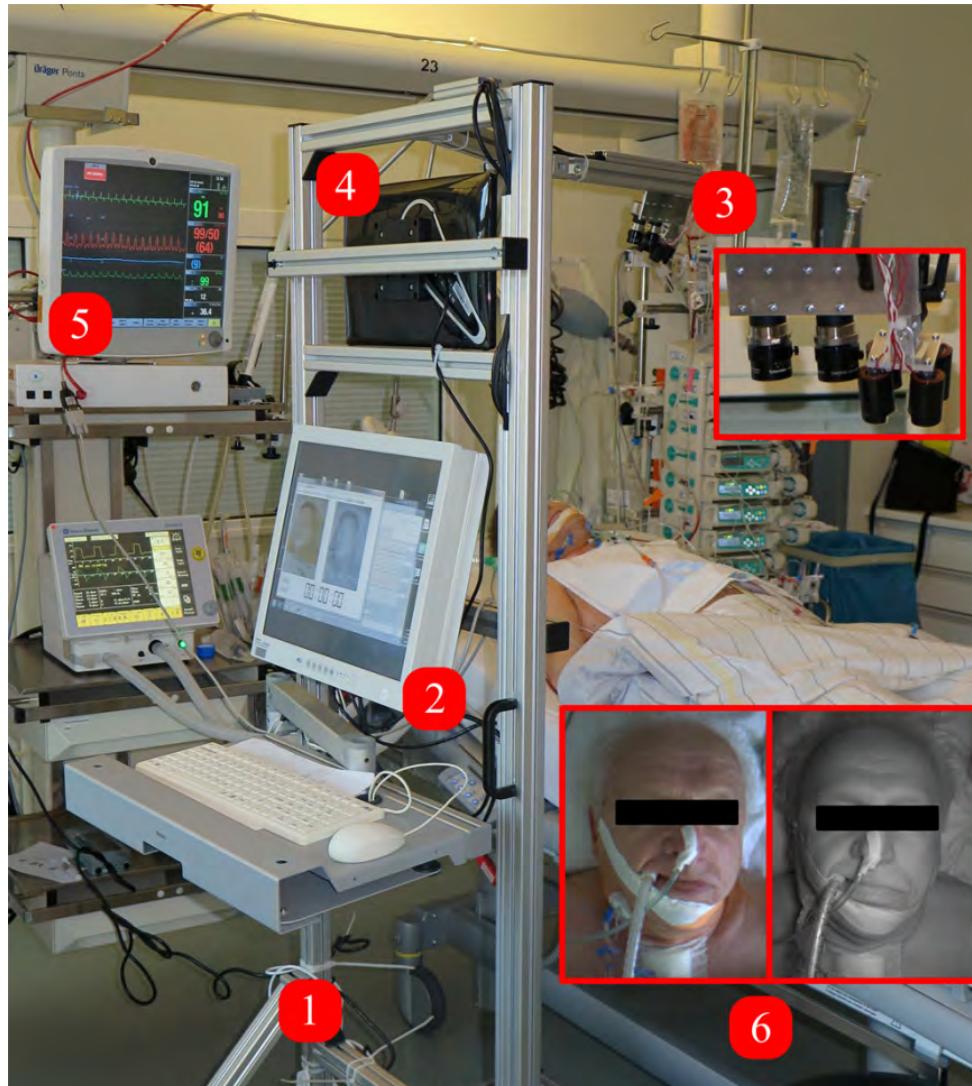


Ankunftszeiten der Pulswelle entlang des Arms

PATTERNS?



CARDIOVISIO: FIRST CLINICAL TRIAL



Measured signals

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

Estimated Signals

- SPO2
- Puls Pressure
- Blood Pressure?

Universitätsklinikum
Carl Gustav Carus
DIE DRESDNER.



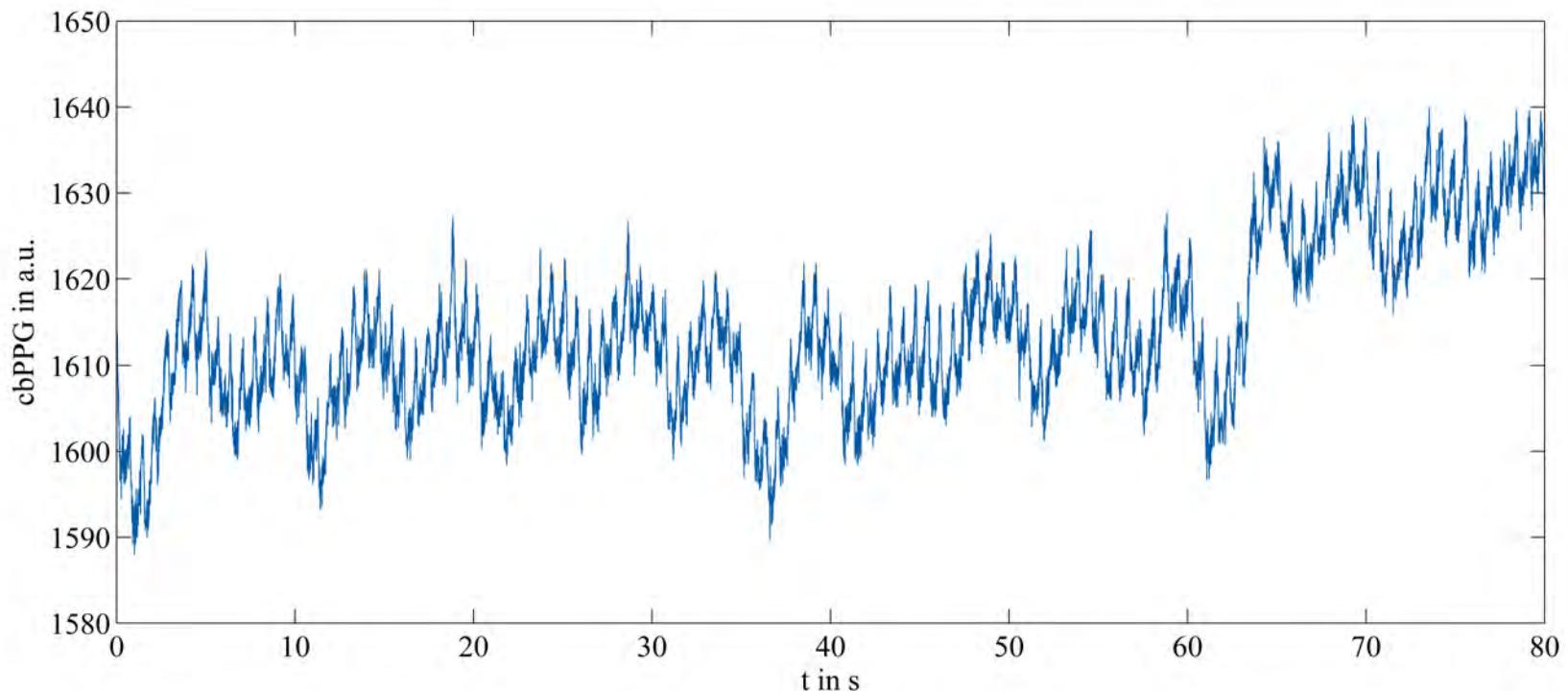
Herzzentrum Dresden
UniversitätsKlinik
an der Technischen Universität Dresden



STAATSMINISTERIUM
FÜR WISSENSCHAFT
UND KUNST

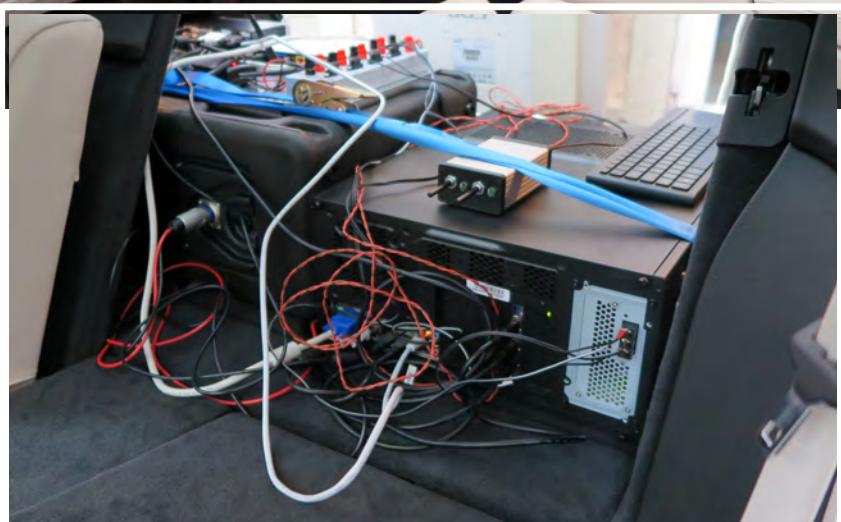
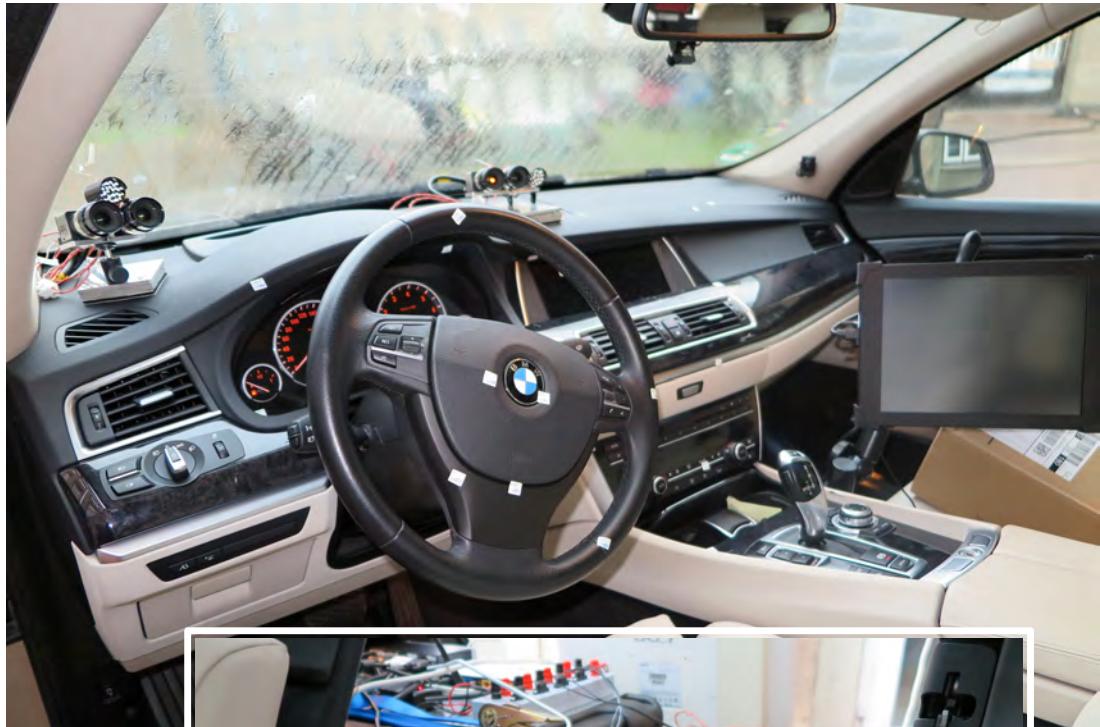


ORIGINAL VIDEO







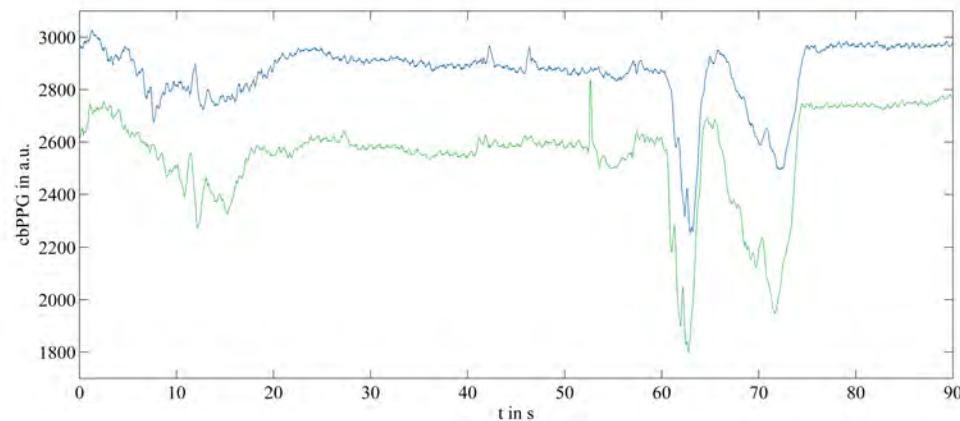




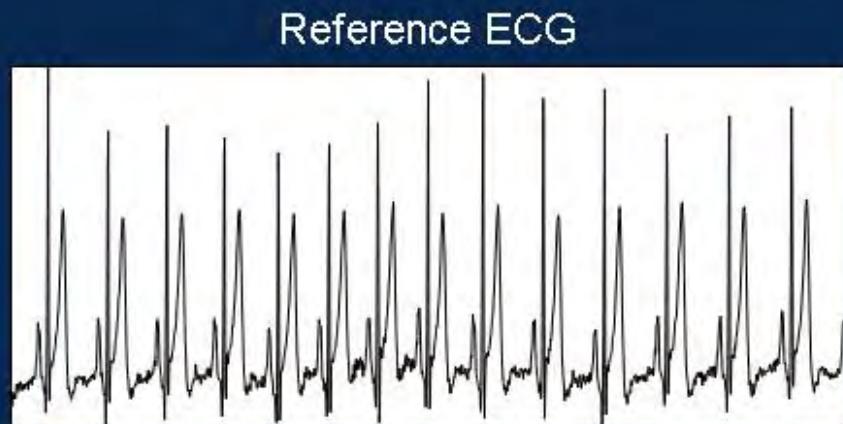
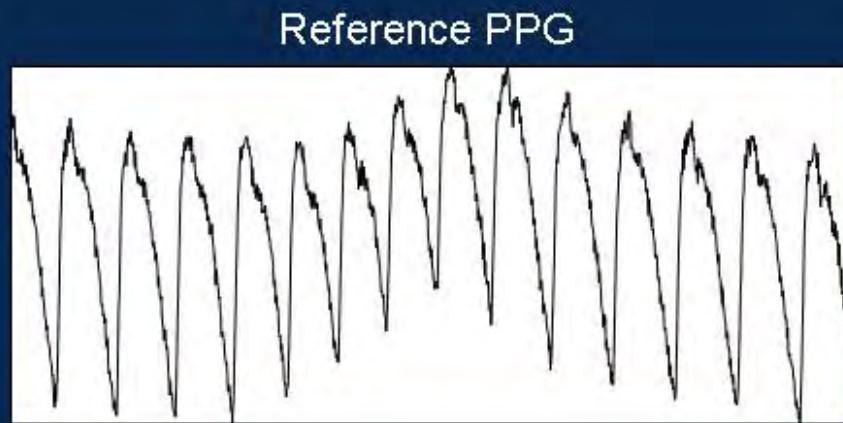
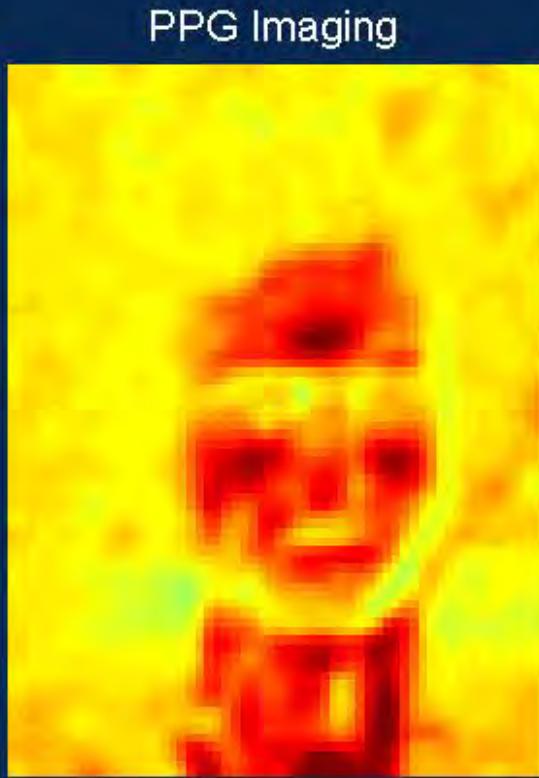
SENSORDATENFUSION: rPPG & cECG

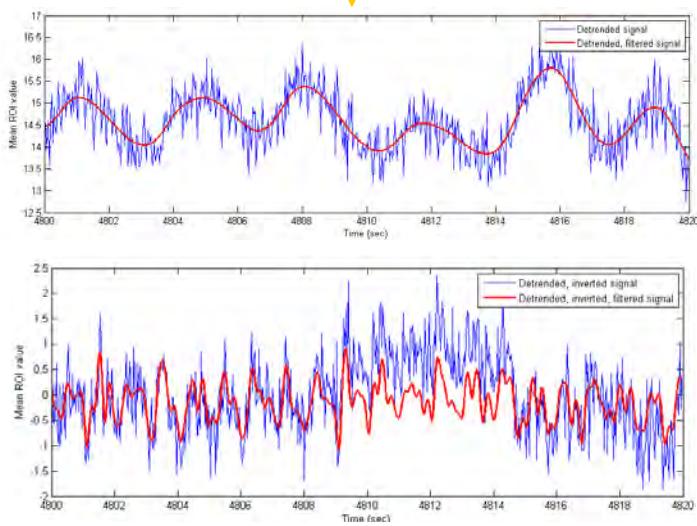
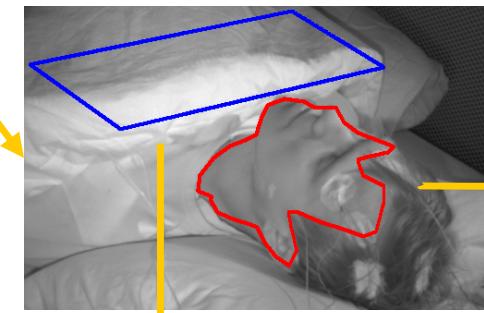
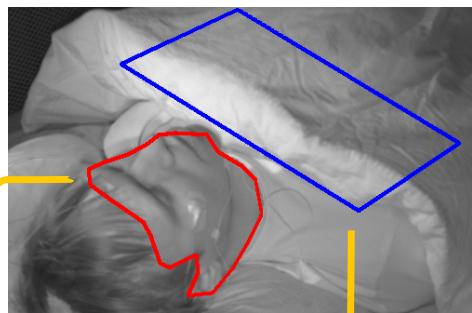


DATENBEISPIEL



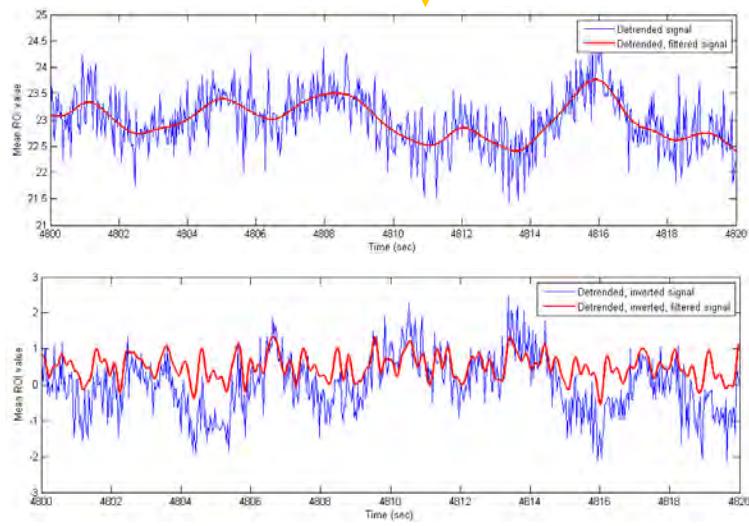
PERFUSION VS. REFERENCE





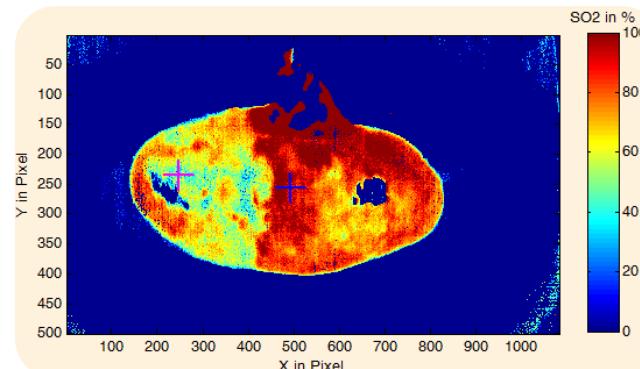
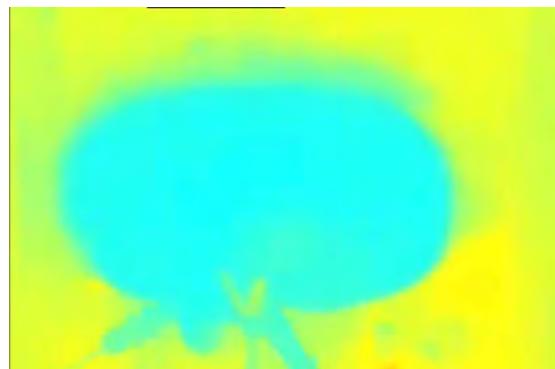
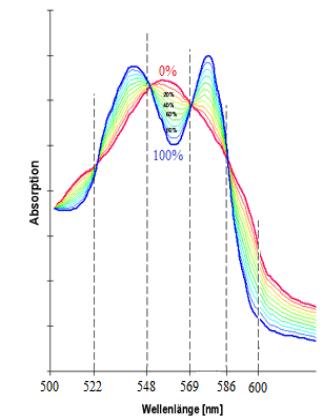
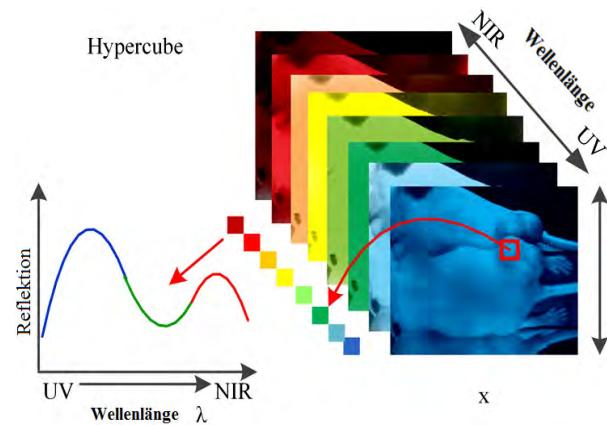
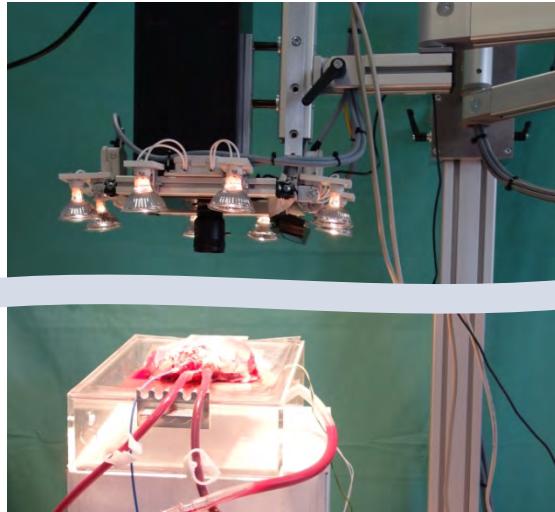
Atemrate

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)

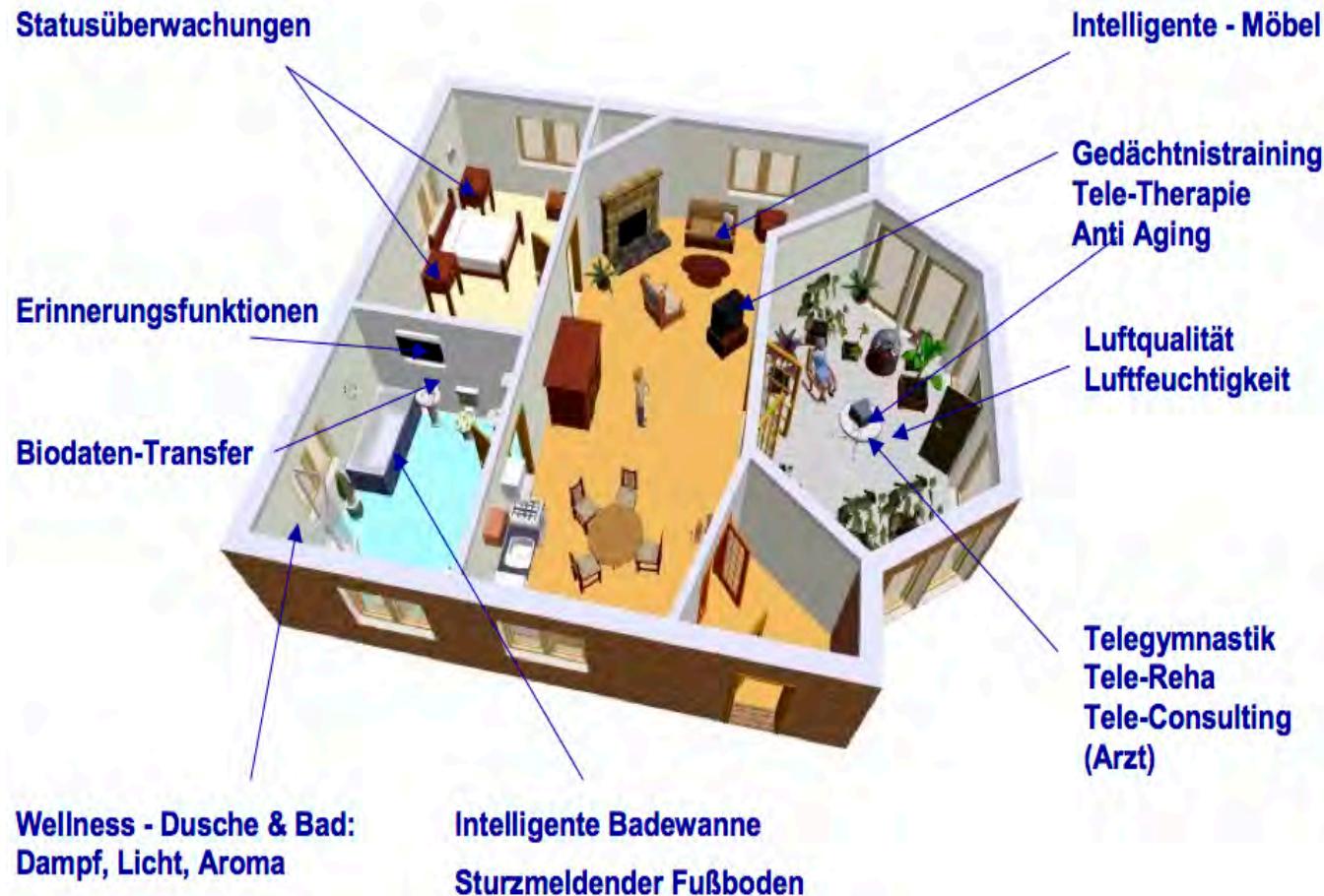
- Chronic diseases
- Healthy aging at home
- Prevention



Q: www.silicon.de

Modellwohnung „Häusliche Gesundheitsstation“

EFRE 100278533



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

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