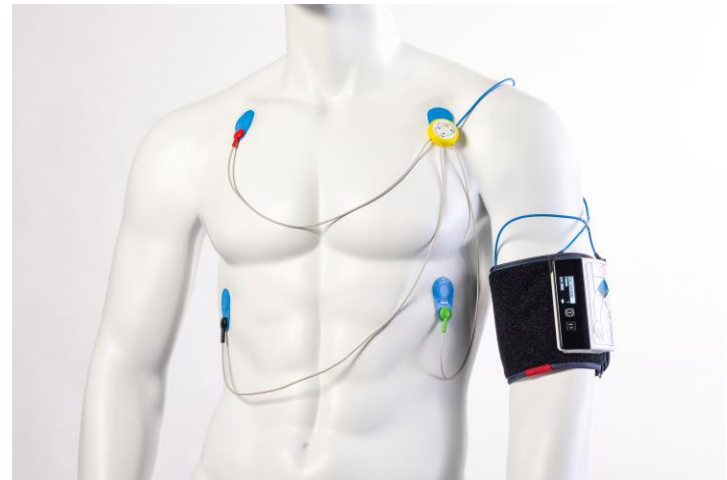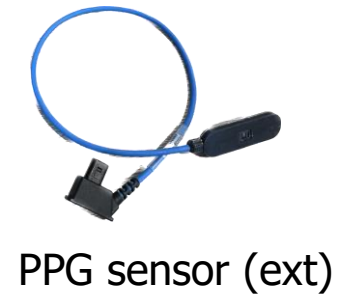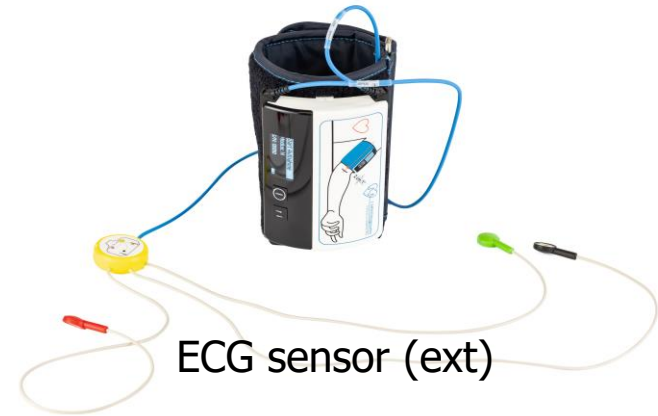# ABPMpro

A multi-sensor recording unit, including the measurement of ambulatory (24h) blood pressure

Made in Germany

Technical design

- Oscillometric sensor
- 1-channel-ECG sensor (cuff)
- Actigraphy sensor (X/Y/Z)
- Body position sensor
- PPG (optical) sensor (ext)
- 3-channel-ECG sensor (ext)

- 125 gram weight (4.4 oz)
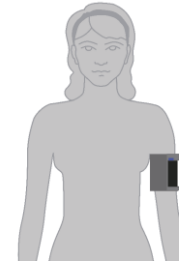 incl. battery, pump, valve, etc.

ECG sensor (ext)

PPG sensor (ext)

Internal ECG electrodes   Display   Connections for external sensors: 3-channel ECG / Pleth

Internal sensor for activity / body position

Operating buttons   USB connection

Device configurations

ABPMpro Classic:
Oscillometric (cuff) blood pressure
Accelerometry (tri-axial)
Body position
ECG heart rate variability (internal)

ABPMpro Cardio (adding 3-lead ECG cable):
3-channel ECG recording (external)
Respiration rate
Pre-ejection period

ABPMpro Research (adding ECG and PPG):
PTT beat-to-beat blood pressure
Sleep arousals
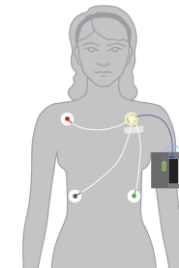
ABPMpro Classic

ABPMpro Cardio

ABPMpro Research

Device configurations

ABPMpro Classic:
Oscillometric (cuff) blood pressure
Accelerometry (tri-axial)
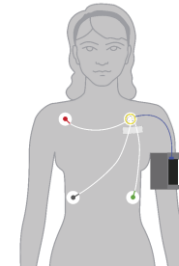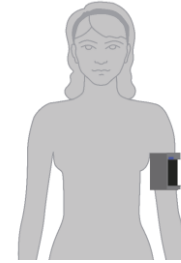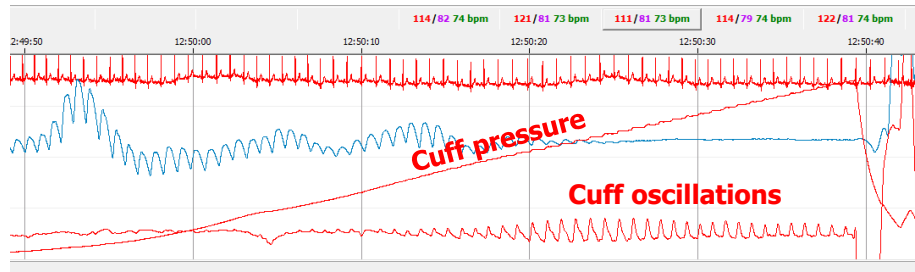Body position
ECG heart rate variability (internal)

ABPMpro Classic
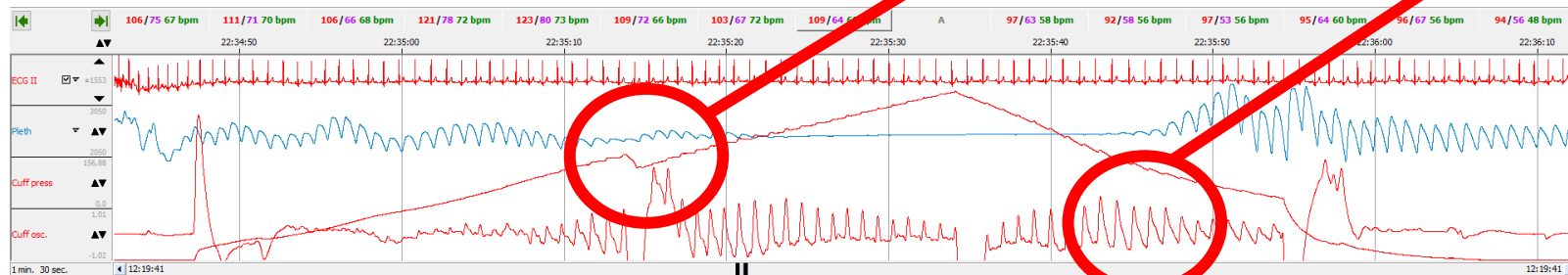
Oscillometric (cuff) blood pressure

Measurement during **cuff inflation** and/or
Measurement during **cuff deflation**

Cuff pressure

Cuff oscillations

artefact during inflation

2nd attempt during deflation

Validation data

The oscillometric measurements of blood pressure has been validated according to the **ISO 81060-2** standard for both, **inflation and deflation** recordings

Including the validation post **change in heart rate** within the same individuals (ambulatory condition)

Validation of the ABPMpro ambulatory blood pressure monitor in the general population according to AAMI/ESH/ISO Universal Standard (ISO 81060-2:2018)

Bernhard Roth[a], Tomas Lucca Bothe[b], Andreas Patzak[b] and Niklas Pilz[b]

Conclusion The ABPMpro device fulfilled the ISO 81060-2:2018 requirements in the general population and in the ambulatory setting and can therefore be recommended for clinical use. *Blood Press Monit* XXX:

Correspondence to Andreas Patzak, MD, PhD, Institute of Translational Physiology, Charite – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin, Humboldt-Universität zu Berlin, and Berlin Institute of Health, Charteplatz 1, 10117 Berlin, Germany
Tel: +49 30 450 528220; fax: + 49 (0)30 4507528972;
e-mail: andreas.patzak@charite.de

Validation data

**VALIDATED DEVICES
FOR AMBULATORY BLOOD PRESSURE MONITORING**

Preferred devices (upper-arm) (21)

A&D TM-2440 *

Microlife WatchBP O3 (BP3SZ1-1) *

A&D TM-2441

Microlife WatchBP O3 AFIB *

Andon iHealth CardioMed ABP100

Novacor Diasys 3 (DIS-0001-00)

Beneware ABP-021

Novacor Diasys 3 Plus (DIP-0001-00)

Custo Med custo screen 400

PAR Medizintechnik & Co. PHYSIO-PORT UP

Custo Med custo screen pediatric

PAR Medizintechnik & Co. TONOPORT VI

EDAN SA-10

Philips DL8760

Hingmed WBP-02A

Somnomedics ABPMpro

KANG KC-2850

SpaceLabs 90227

Meditech ABPM-06

TaiDoc TD 3127AT Uright

Microlife Watch BP O3

www.stridebp.org

Accelerometry (tri-axial)

- Allows to trigger **an accoustic signal** and/or to **slightly delay** the scheduled cuff measurement, when the sensor records too much movement (at the time of scheduled recording)

- Simultaneous recording of blood pressure and patient's activity data supports the **interpretation of blood pressure changes**
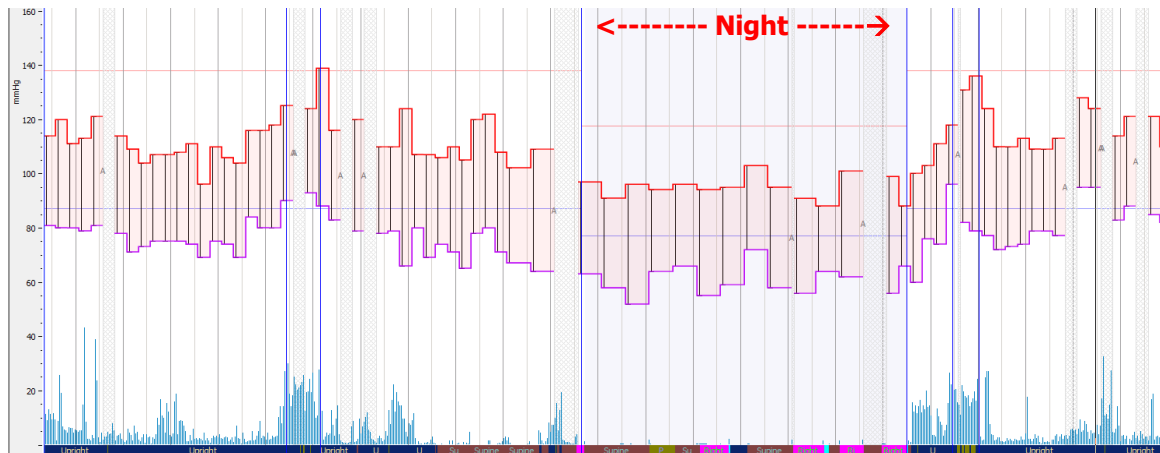

peak in blood pressure

increased motoric activity
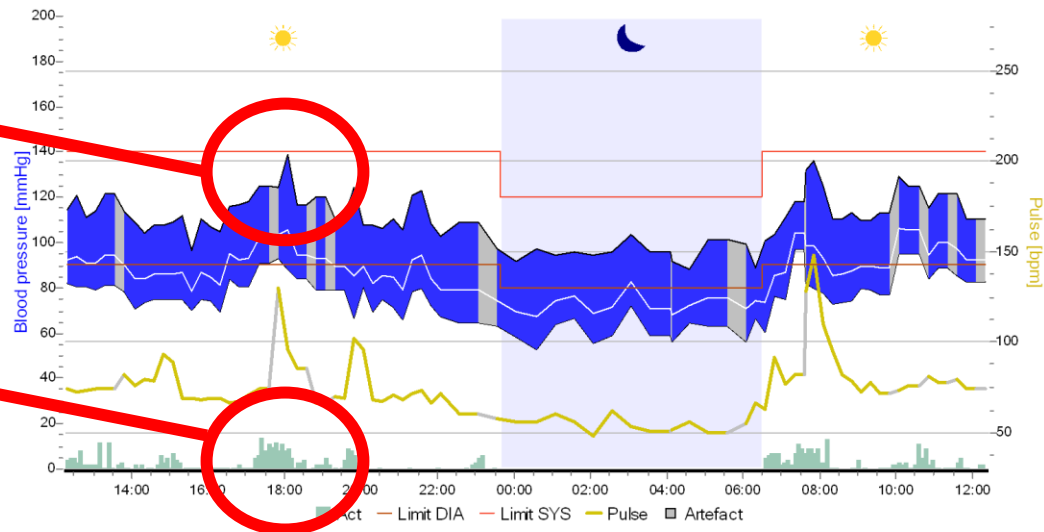
Body position

Body position sensor together with the data on motoric activity allow for a more **precise identification of day-/ versus night-time period** (in-bed time)
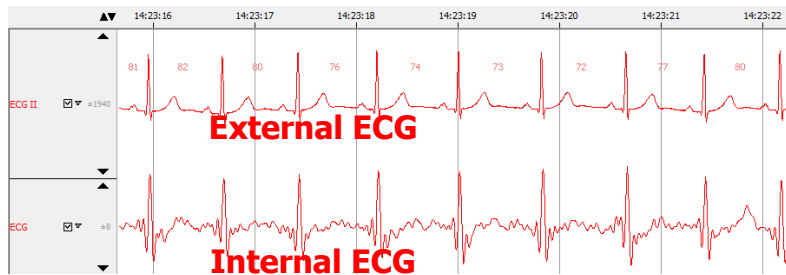

Recorded body positions: supine, prone, upright, left, right, walking

-> Objective data, not dependent on the memory of the patient.

ECG heart rate variability (internal)

Cuff-integrated ECG electrodes allow for the continuous recording of 1-channel-ECG data and subsequent analysis of heart rate variability

Device configurations

ABPMpro Classic:
Oscillometric (cuff) blood pressure
Accelerometry (tri-axial)
Body position
ECG heart rate variability (internal)

ABPMpro Cardio (adding 3-lead ECG cable):
3-channel ECG recording (external)
Respiration rate
Pre-ejection period

ABPMpro Classic

ABPMpro Cardio

3-channel ECG recording (external)
Respiration rate
Pre-ejection period

Attaching a **3-lead ECG cable** to the ABPMpro monitor allows for the simultaneous recording of 24h holter ECG data.

With the use of **impedance cardiography**, respiration rate and pre-ejection period are derived
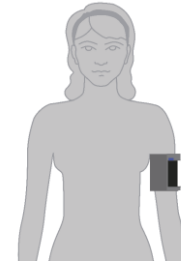
ABPMpro Cardio

External ECG

Internal ECG

Device configurations

ABPMpro Classic:
Oscillometric (cuff) blood pressure
Accelerometry (tri-axial)
Body position
ECG heart rate variability (internal)
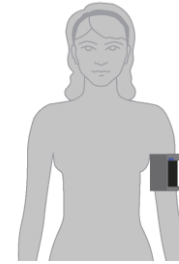
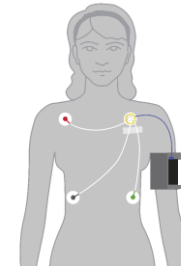ABPMpro Cardio (adding 3-lead ECG cable):
3-channel ECG recording (external)
Respiration rate
Pre-ejection period
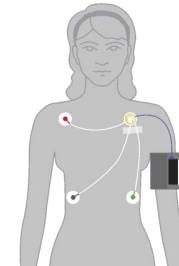
ABPMpro Research (adding PPG):
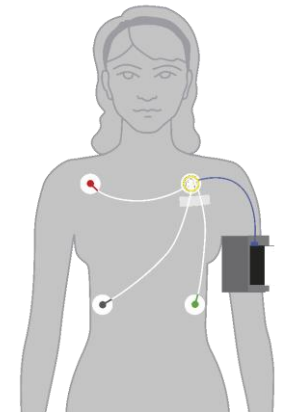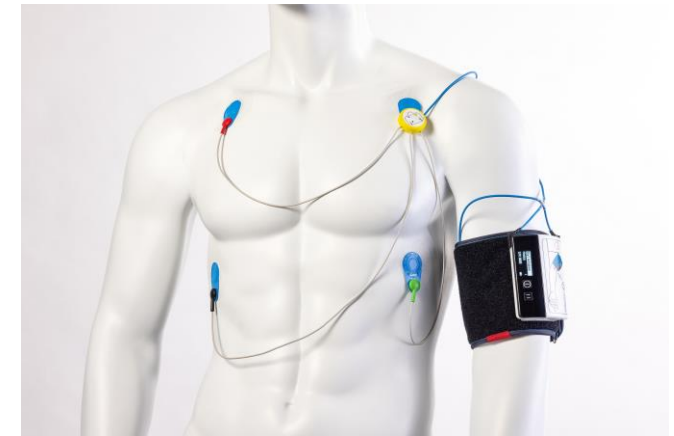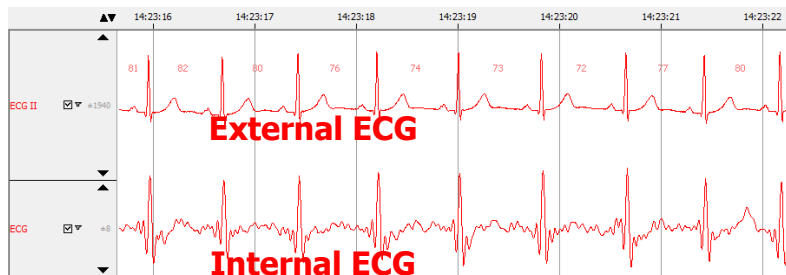PTT beat-to-beat blood pressure
Sleep arousals

ABPMpro Classic

ABPMpro Cardio

ABPMpro Research
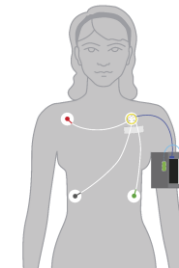
Sleep arousals

Attaching a **photoplethysmogram (PPG)** sensor to the ABPMpro monitor allows for the simultaneous recording of optical pulse waves.

The reduction in **pulse wave amplitude** is an accepted method to detect autonomous arousals

Detecting arousals by use of the PPG signal on the upper-arm is an indicator for sleep fragmentation

Arousal Sleep Disturbance

6,8 % | 31,8 % | 21,6 % | 21,1 % | 18,6 %

% Sleep Time
0 % – 100 %

0 - 1 min   1 - 5 min   5 - 10 min   10 - 30 min   > 30 min

Arousal: Undisturbed sleep intervals (% of Total Sleep Time)
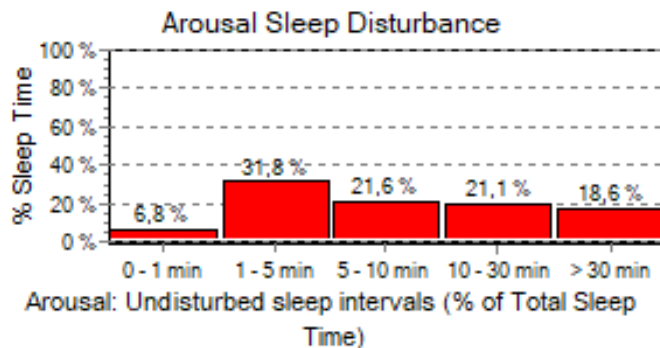
Age	Normvalue
Young and middle aged adults	15 / h
> 60 Years	27 / h

PTT beat-to-beat blood pressure

Attaching a **photoplethysmogram (PPG)** sensor to the ABPMpro monitor allows for the simultaneous recording of optical pulse waves.

Pulse transit time (PTT) = Pulse traveling time from **proximal** (ECG r-peak) to **distal** (optical pulse wave) site, corrected for pre-ejection-period

PPG sensor located beneath the cuff
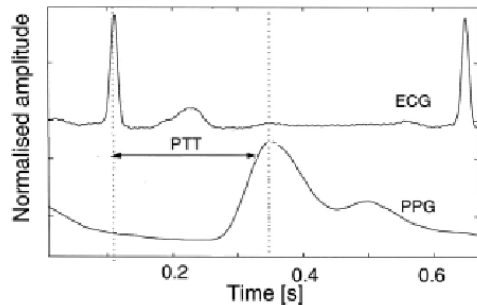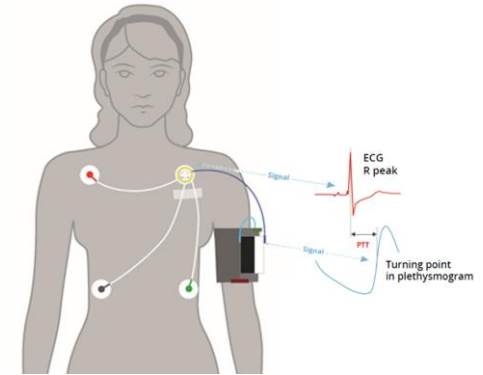
Changes in PTT translate into changes of blood pressure. An increase in PTT reflects a decrease in blood pressure and vice versa.
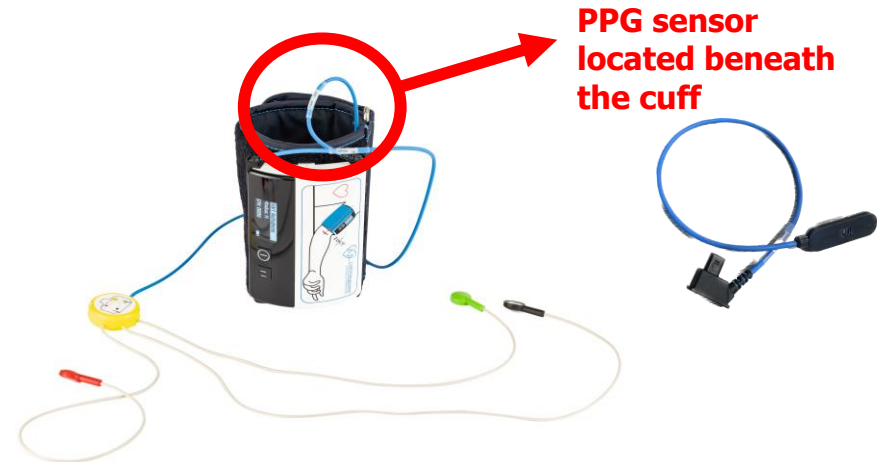
PTT beat-to-beat blood pressure

- Continuous blood pressure (beat-to-beat) based on PTT/PAT (pulse transit time / pulse arrival time)

Oscillometric recording at 9:20 pm 121 / 78 mmHg

Oscillometric recording at 9:05 pm 106 / 66 mmHg

PTT/PAT recording 15 minute beat-to-beat BP recording

Each cuff-BP (24h) used for re-calibration of PTT/PAT

Limitations

The cuff measurement of ABPMpro is obtained via the **oscillometric** measurement principle. As such, the same limitations as for all automated cuff blood pressures apply, including:

- Movement artefacts
- Severe arrythmia
- Left-ventricular assist devices ('heart pumps')
- Measurement during hemodialysis (blood volume changes)

- BP ranges (systolic) below 60 mmHg / above 230 mmHg
- BP ranges (diastolic) below 40 mmHg / above 130 mmHg

- Validation in children (< age 12) pending
- Validation in pregnancy pending
- Validation in atrial fibrillation pending
- Validation of beat-to-beat blood pressure pending

Plotting the curve – opening the black box

Plotting the pressure curves is a helpful tool to **eliminate cuff errors**
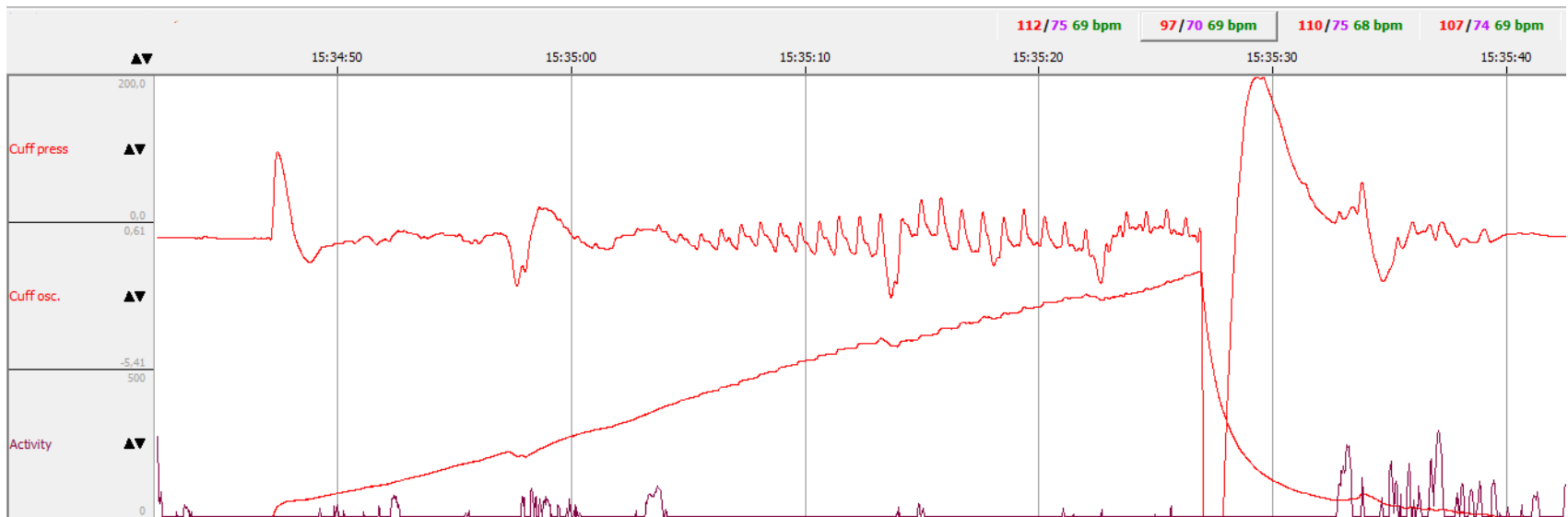
Plotting the curve – opening the black box

Tri-axial accelerometer to **eliminate movement artefacts** and identifying the magnitue of influence of movement on the pressure curve

ECG (1st channel of the external electrodes)

PPG (optical pulse waves)

Cuff pressure

Cuff oscillations

Sleep/Wake detection

Activity

Position
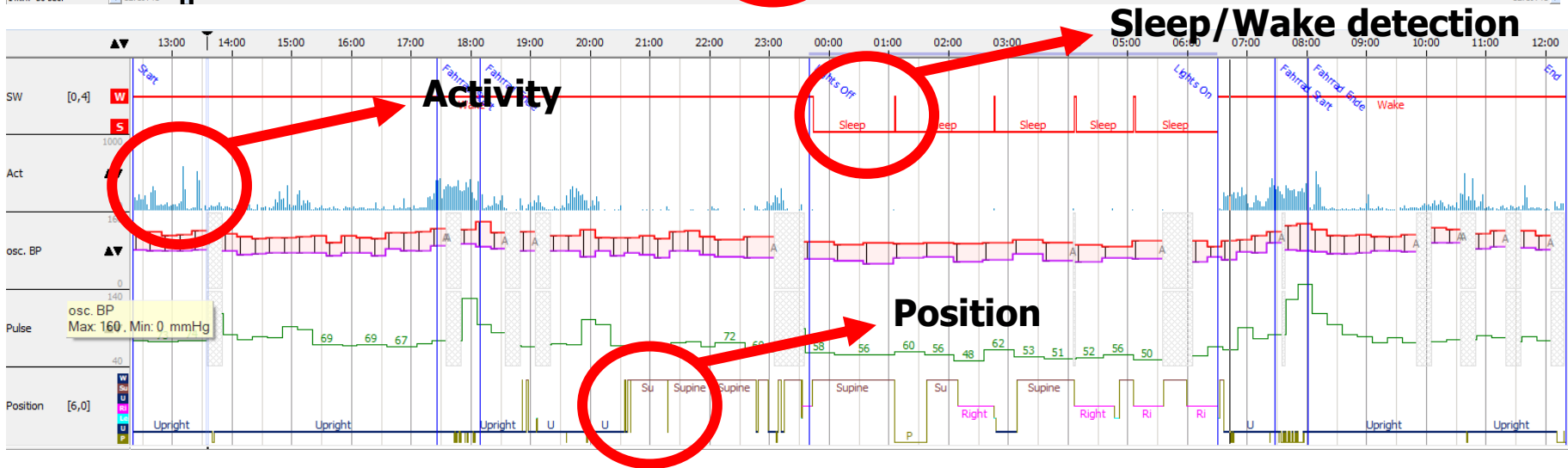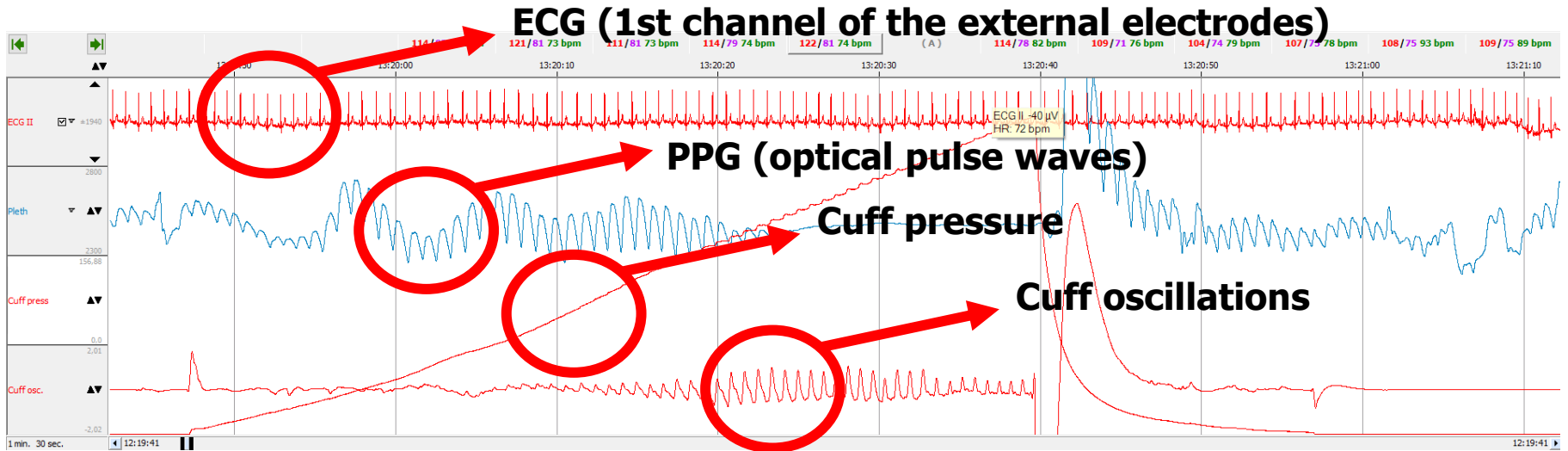
Technical features (2): Measurements

- Time-stamped multi-sensor data
- Many more channels to chose from for graphical display

- Oscillometric (cuff) blood pressure
- PTT beat-to-beat blood pressure
- 3-channel ECG recording
- Actigraphy / accelerometry / gyroscopy
- Body poistion (arm/thorax)
- Sleep arousals
- Respiration rate
- Heart rate variability
- Pre-ejection period
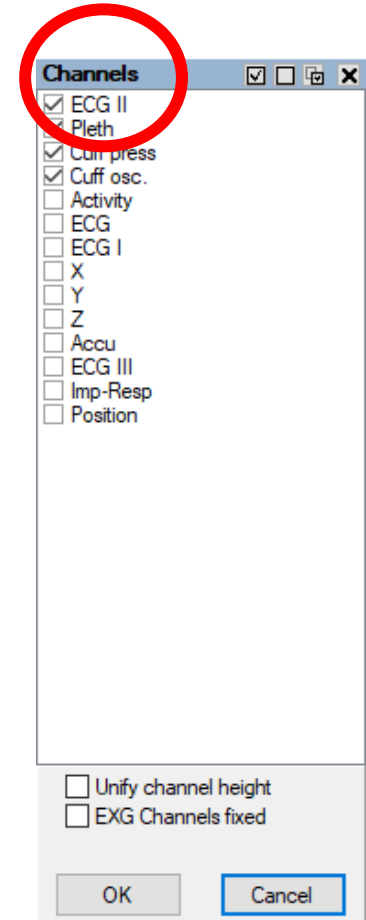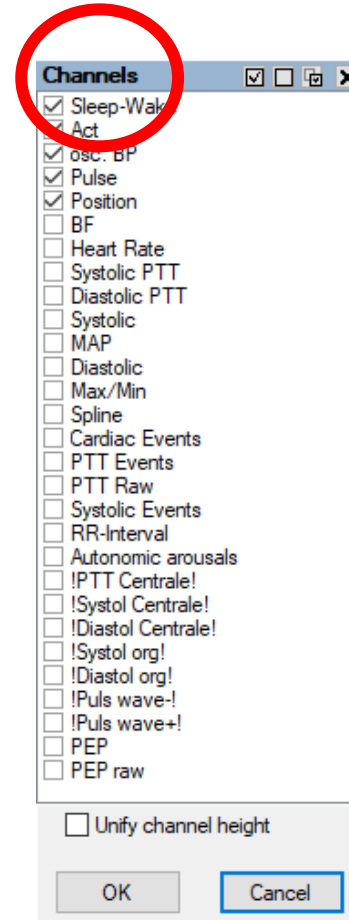
Technical features (3): Measurements

- Time-stamped multi-sensor data (track what happens)

Irrgeularity in the ECG, …

… will also show in the PPG

Technical features (4):
Export all data

High sampling rate, ...

... export of all raw data!

Patient Information Data

Identification | Diagnosis | **Montage** | Logbook | Track

Device ID: 0049
Firmware Version: J1 from 220217
Cuff size: Medium cuff

Day: 6 h (15 min.), Night: 22 h (30 min.), Maximum: 180 mmHg, Autostop

Abort Recording: Normal end of record reached

Number	Description	Signal Type (Port)	Rec. Rate (Hz)
0	Accu	Accu	4
1	Pt. Marker	Patientenmarker	4
2	X	X	32
3	Y	Y	32
4	Z	Z	32
5	Cuff press	Cuff press.	128
6	ECG	ECG	256
7	ECG I	ECG I	256
8	ECG II	ECG II	256
9	ECG III	ECG III	256
11	Imp-Resp	Imp-Resp	256
12	Position	Pos. Ext	4
13	Pleth raw	Pleth Raw	256
14	Log	Log	256

OK | Cancel

Export

Export Path ☐ Export to own subfolder
C:\Users\Achim Schwarz\Desktop\   [...]

Filename: Channel name

○ RIFF Export   ● ASCII Export

● Complete Recording   ○ TIB area
○ Selection   ○ User Areas

without Time Base

Channel name	Export rate
☑ ECG II	256 Hz
☑ Pleth	256 Hz
☑ Cuff press	128 Hz
☑ Cuff osc.	128 Hz
☑ Activity	32 Hz
☑ ECG	256 Hz
☑ ECG I	256 Hz
☑ X	32 Hz
☑ Y	32 Hz
☑ Z	32 Hz
☑ Accu	4 Hz
☑ ECG III	256 Hz
☑ Imp-Resp	256 Hz
☑ Position	4 Hz

Export | Cancel

Technical features (5a):
Export all data – data format in ASCII / RIFF / EDF

Activity	Cuff osc.	Cuff press.	ECG channel #1
Signal Type: Mag_Type	Signal Type: BD_AC_Type	Signal Type: BD_Type	Signal Type: ECG1_Type
Start Time: 28.02.2022 12:19:41	Start Time: 28.02.2022 12:19:41	Start Time: 28.02.2022 12:19:41	Start Time: 28.02.2022 12:19:41
Sample Rate: 32	Sample Rate: 128	Sample Rate: 128	Sample Rate: 256
Length: 2764800	Length: 11059200	Length: 11059200	Length: 22118400
Unit: mg	Unit: mmHg	Unit: mmHg	Unit: µV
Data:	Data:	Data:	Data:
508	0,0	0,0	986
118	0,0	0,0	958
121	0,0	0,0	997
131	0,0	0,0	1009
129	0,0	0,0	1074
133	0,0	0,0	1143
132	...	0,0	1021
132	...	0,0	927
128	...	0,0	856
131	0,01	...	886
140	0,07	...	...
141	0,13	...	...
138	0,2	127,45	...
135	0,27	127,38	25
133	0,34	127,37	25
...	0,42	127,37	22
...	0,49	127,33	20
...	0,55	127,3	14
		127,32	

Technical features (5b):
Export all data – data format in ASCII / RIFF / EDF

Imp-Resp	**Pleth**	**Position**	**X-axis**
Signal Type: ECG_Imp_Resp_Type	Signal Type: Pleth_Type	Signal Type: Pos_XYZ_Type	Signal Type: KLX_Type
Start Time: 28.02.2022 12:19:41	Start Time: 28.02.2022 12:19:41	Start Time: 28.02.2022 12:19:41	Start Time: 28.02.2022 12:19:41
Sample Rate: 256	Sample Rate: 256	Sample Rate: 4	Sample Rate: 32
Length: 22118400	Length: 22118400	Length: 345600	Length: 2764800
Unit: Ohm	Unit:	Unit:	Unit: mg
Data:	Data:	Data:	Data:
1132,4	...	Upright	-868
1132,5	...	Upright	-867
1132,4	...	Upright	-866
1132,4	2796	Upright	-866
1132,4	2802	...	-866
1132,4	2808	...	-866
1132,5	2814	...	-865
1132,5	2820	Prone	...
...	2826	Upright	...
...	2831	Upright	...
...	2836	Upright	154
1115,1	2841	Upright	155
1115,1	2846	Upright	155
1115,1	2851	Prone	154
1115,1	2855	Prone	154
1115,1	2859	Prone	...
1115,0	2863	Prone	...
1115,1	2866	...	...
1115,1	2869	...	-708
1115,1	2872	...	-778
		Supine	-916
		Supine	-1000

In addition (not shown): ECG channels #2 and #3, battery voltage, Y- and Z-axis

Blue boxes: Computed parameters

Blood pressure (oscillometry)

Oscillometric wave forms

Green boxes: Continuous raw (crude) signal data

Blood pressure (beat-to-beat)

ECG (3-channel signal)

Heart Rate Variability (3-channel ECG)

ML/AI based algorithm for enhanced diagnostic and monitoring efforts

Actigraphy (tri-axial accelerometry)

Sleep arousals (PPG derived)

Photoplethysmogr. (PPG) wave forms

Respiration rate (Impedance cardiography)

Body position

PWA / AIx / aortic blood pressure (in development)

Pulse Transit Time (PTT)

ABPMpro

SOMNO *medics*

Comparison to standard ABPM devices (page #1)

ABPMpro Classic

Characteristic	ABPMpro	Standard ABPM	
No tube design (device attached to cuff)	✔	✘	(✔)
Inflation-/deflation measurement	✔	✘	
Actigraphy / accelerometry sensors	✔	✘	(✔)
Body position (arm sensor)	✔	✘	(✔)
Internal ECG inside the cuff for heart-rate-variablility	✔	✘	
Validated ISO81060:2	✔	✘	(✔)

ABPMpro Research

Comparison to standard ABPM devices (page #2)

Characteristic	ABPMpro	Standard ABPM
Continuous blood pressure (beat-to-beat)	✓	✗
Optical sensor for detection of sleep arousals	✓	✗
3- channel ECG recording (holter ECG)	✓	✗ (✓)
Body position (thorax sensor)	✓	✗ (✓)
Impedance cardiography for detection of respiration rate	✓	✗
Export of all raw data incl. synchronized time stamp	✓	✗

Take home messages

Improved **patient acceptance** to ABPM recordings
(increased patient comfort)

More successful (valid) ABPM recordings over 24h – **less repeat exams**
(avoiding tube kinks and „two-shots-on-one-recording")

Additional data for the **interpretation of 24h blood pressure** profiles
(activity data, precise time-in-bed calculation)

ABPMpro research: Simultaneous recording of BP, ECG, activity, PPG, etc.
and the interaction among these parameters may support in the
understanding of underlying **mechanisms of intervention**
Export of all raw signal data will allow for data post-processing and the
application of machine learning and artifical intelligence