



# Photoplethysmographic blood pressure measurement

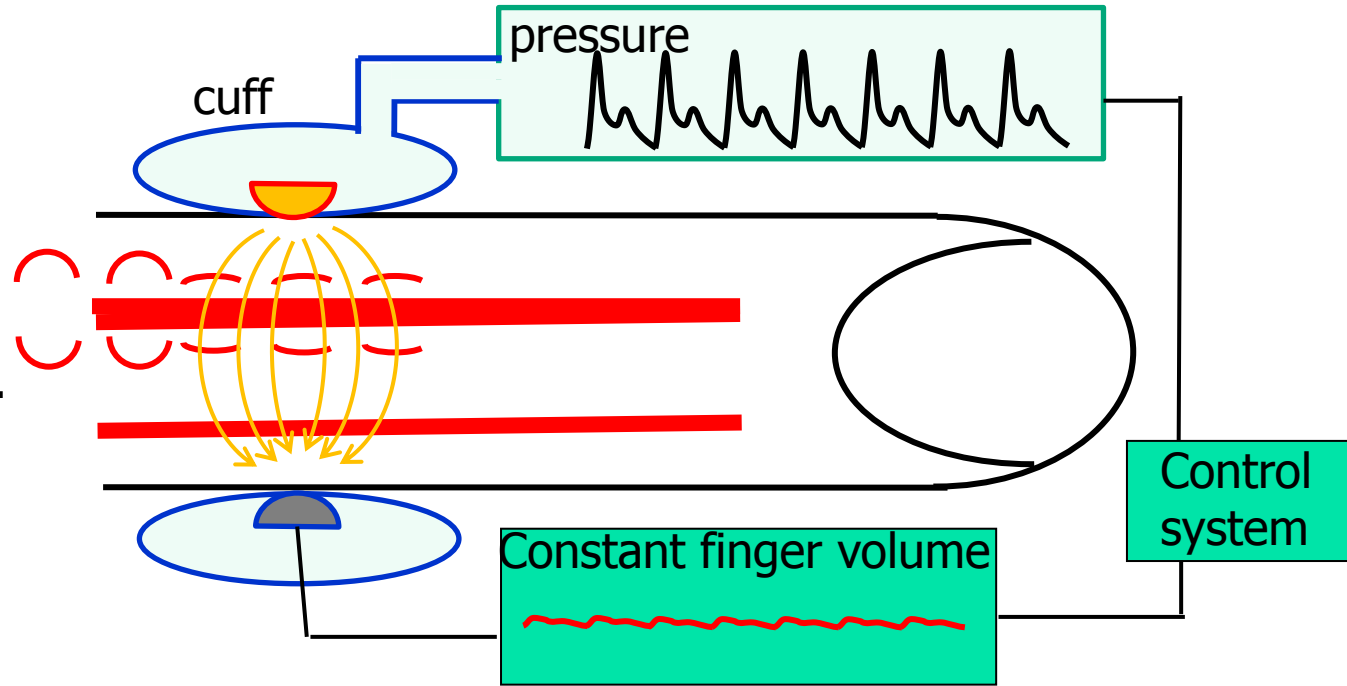
Peňáz's method,  
volume-clamp  
method



# Principle of continual blood pressure measurement

## Control system:

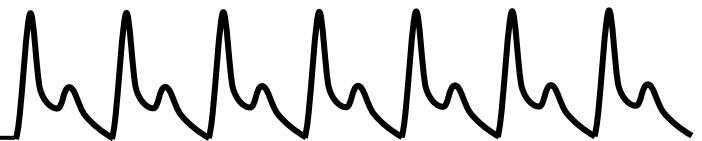
Correction of the pressure in the finger cuff according to the arterial lumen changes. Aim: maintaining of constant arterial lumen through pressure changes in the cuff.



Arterial lumen (finger volume)  application of control system

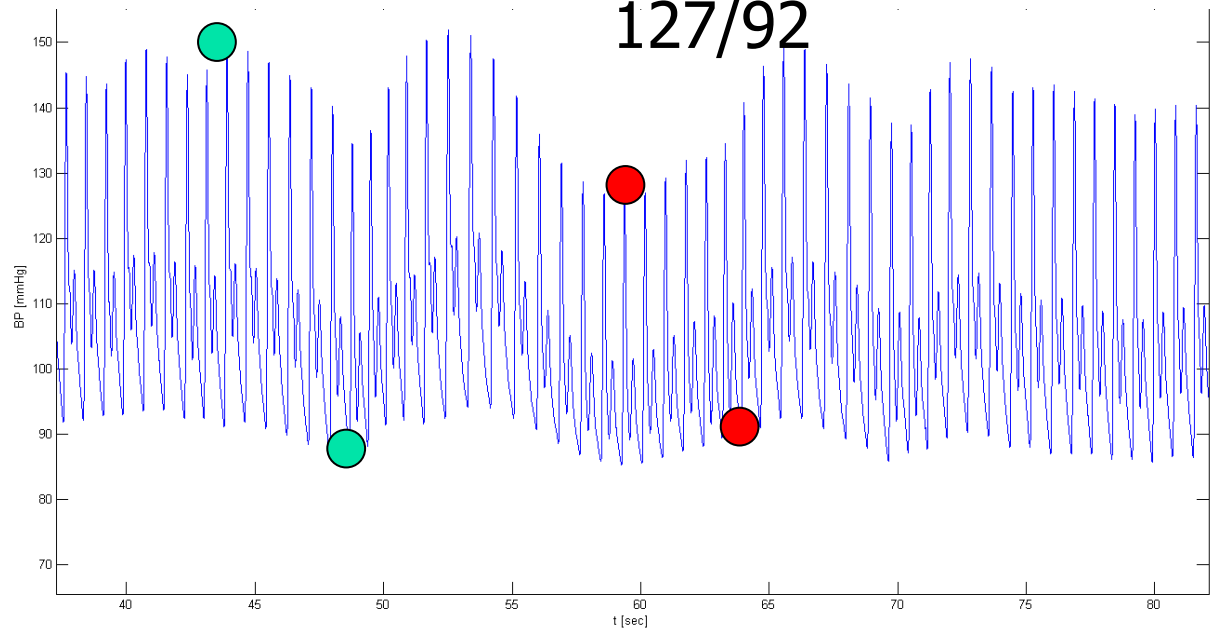
Pressure in the cuff

Before application of control system

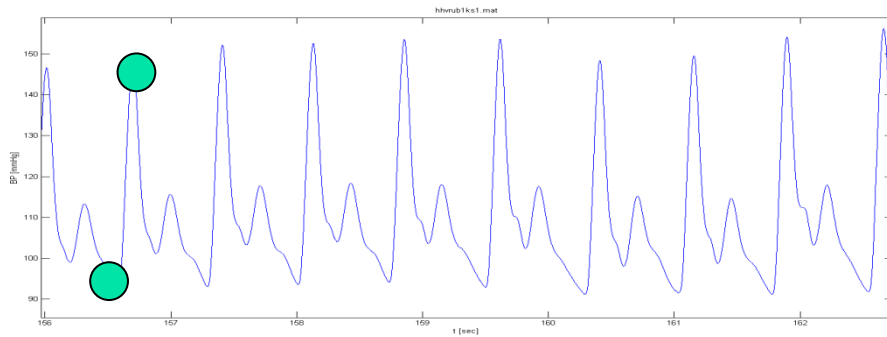


150/90

127/92



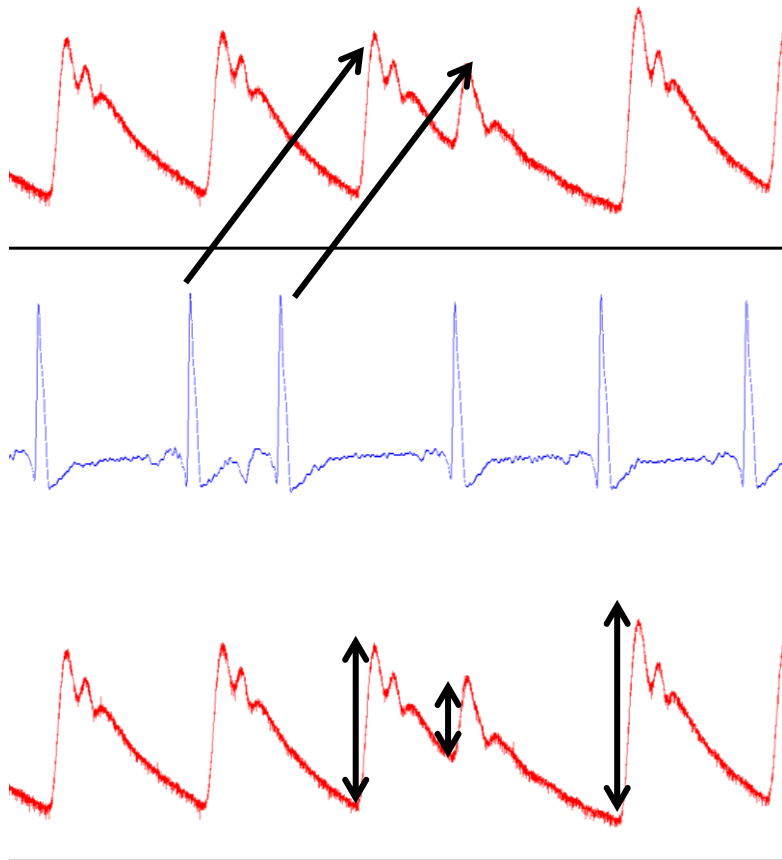
SBP



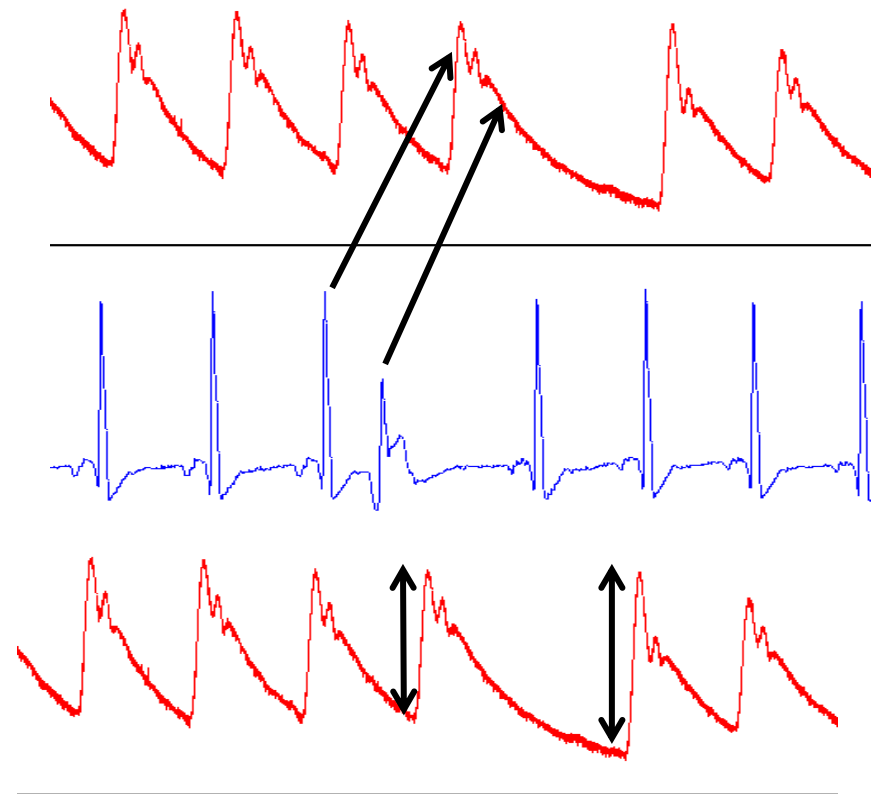
DBP

# Extrasystoles

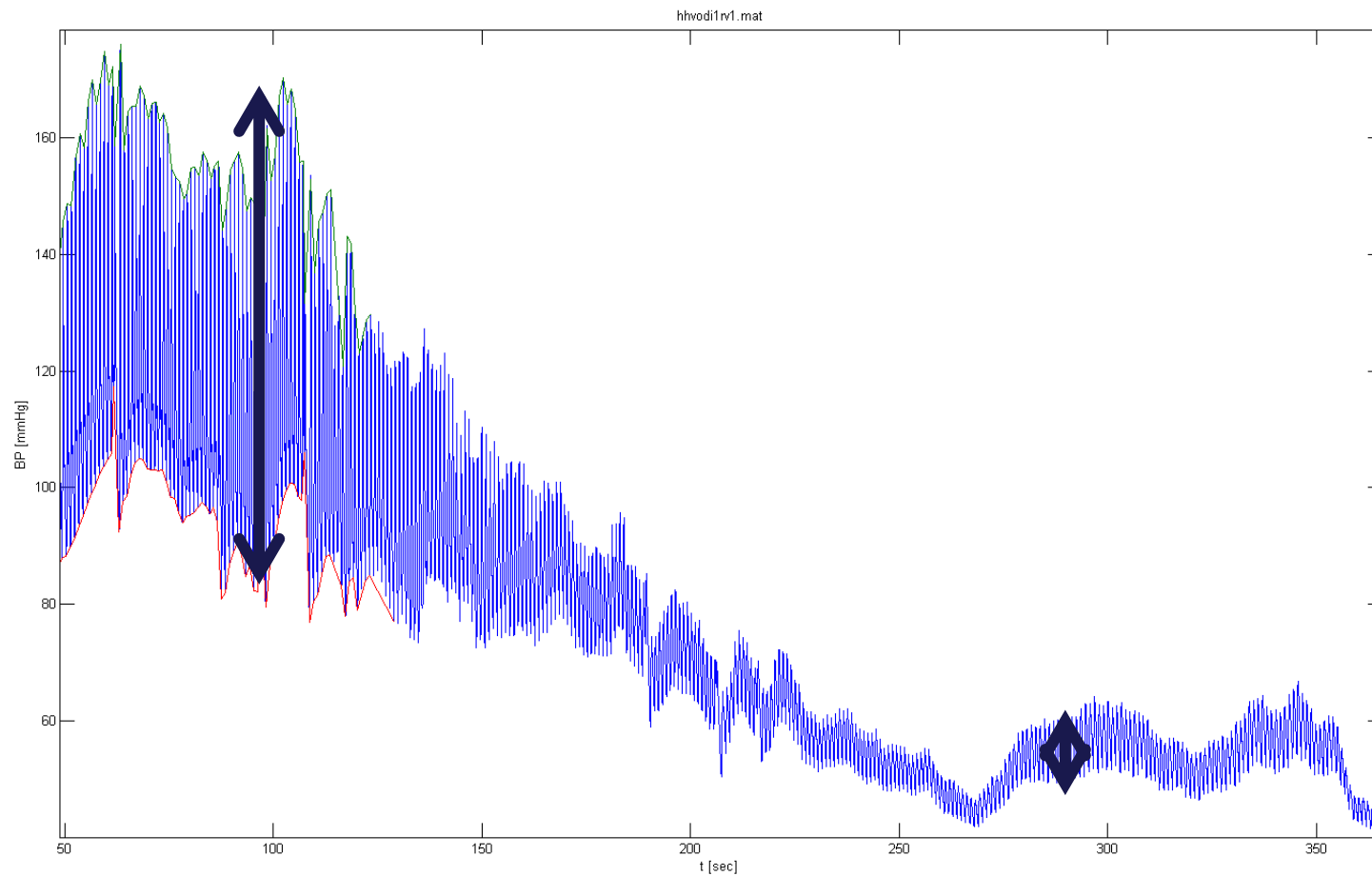
supraventricular



ventricular

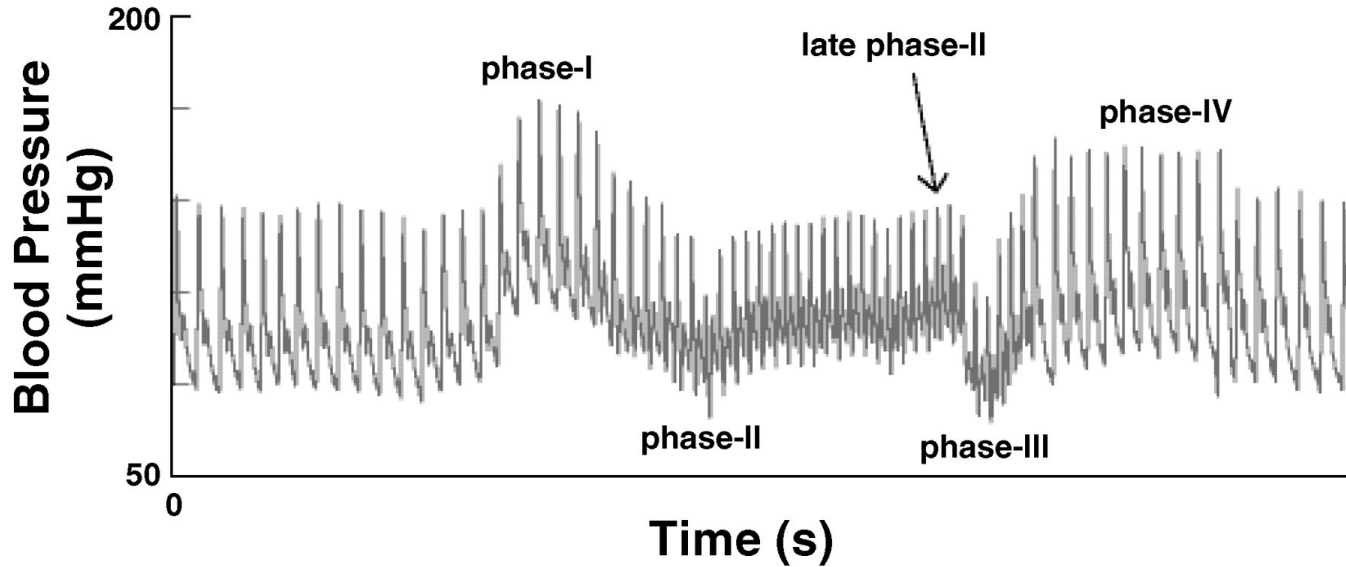


# Orthostatic hypotension

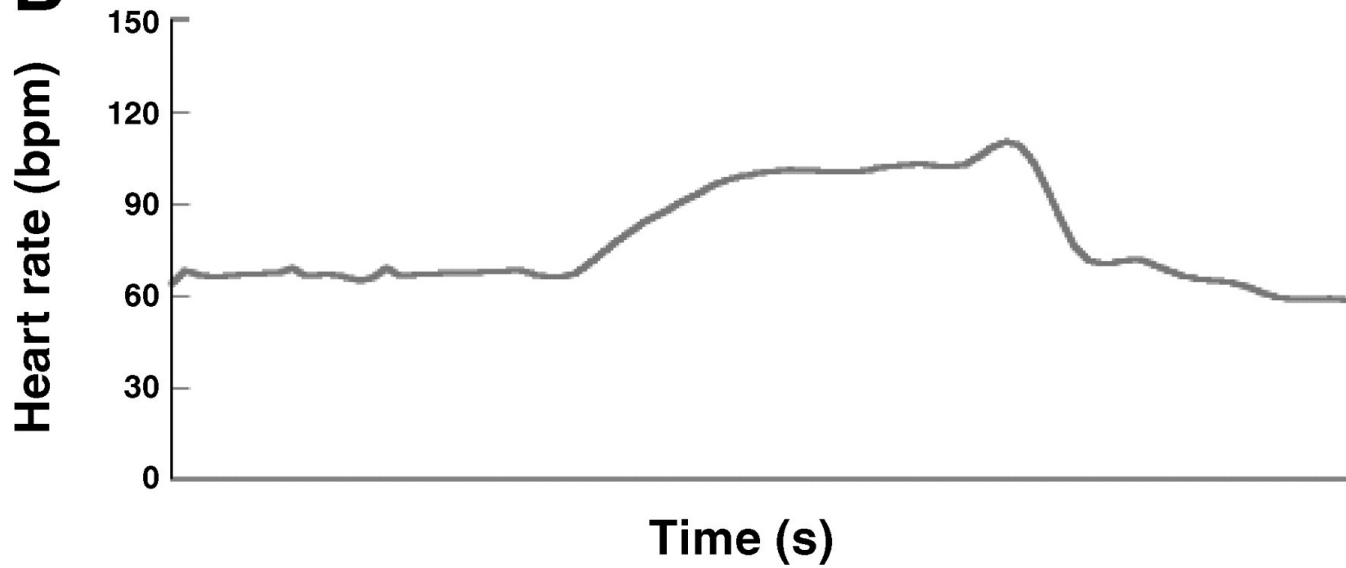


## Valsalva manoeuvre

**A**



**B**





## See videos:

**oscilometric method of BP measurement**

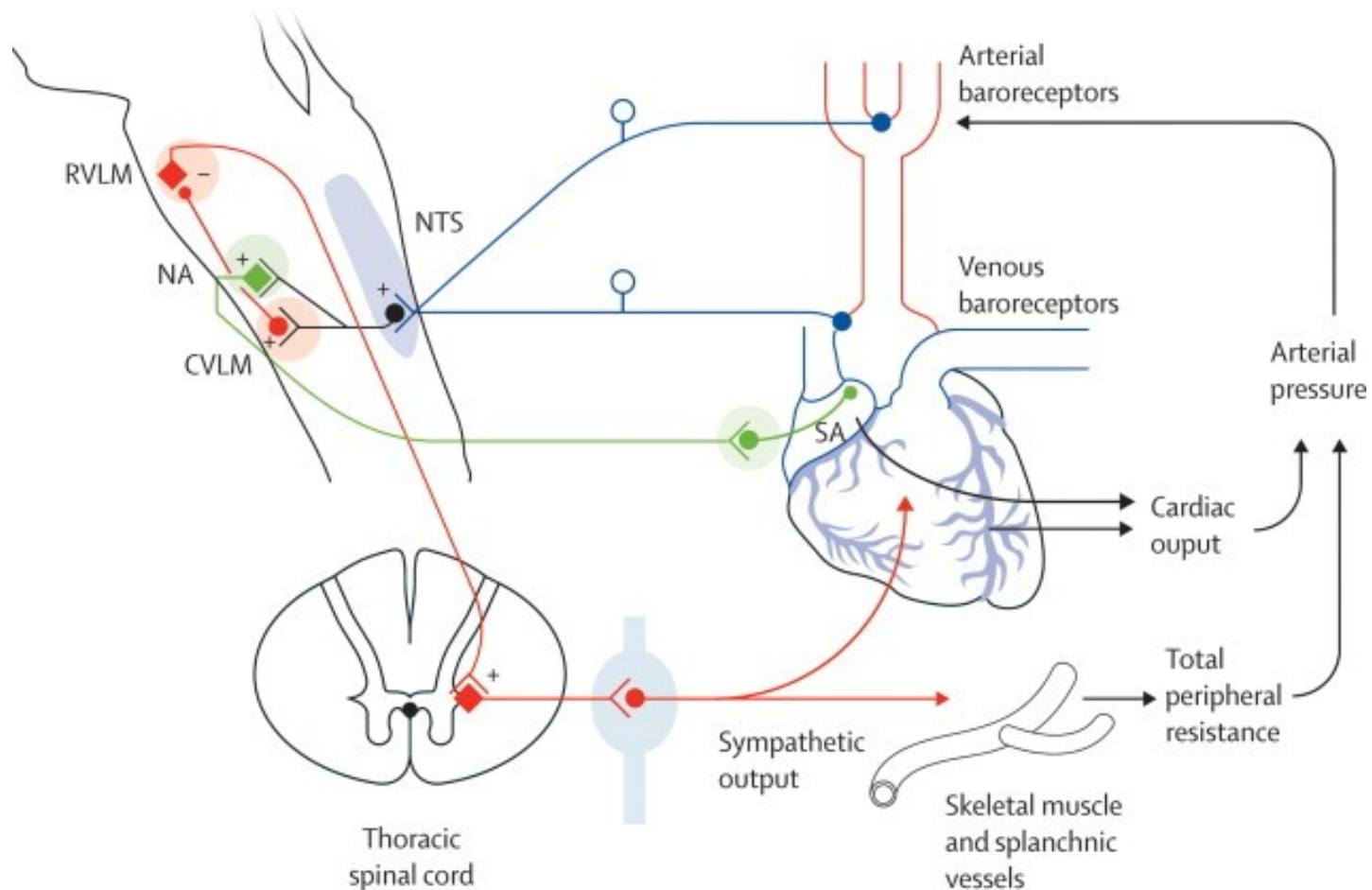
**<https://www.youtube.com/watch?v=Y-NvovSaWTc&t=113s>**

**BP changes during smoking**

**<https://www.youtube.com/watch?v=J5vPJPfNH3k&t=1s>**

# Baroreflex

Fast regulation of arterial blood pressure by changes of heart rate and peripheral vascular resistance





# Baroreflex

peripheral (vascular, sympathetic) branch of baroreflexu

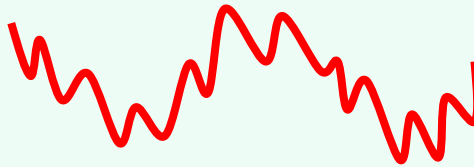
**resistance arteries**

signal: peripheral resistance



**arteries**

signal: blood pressure



**heart**

signal: heart rate

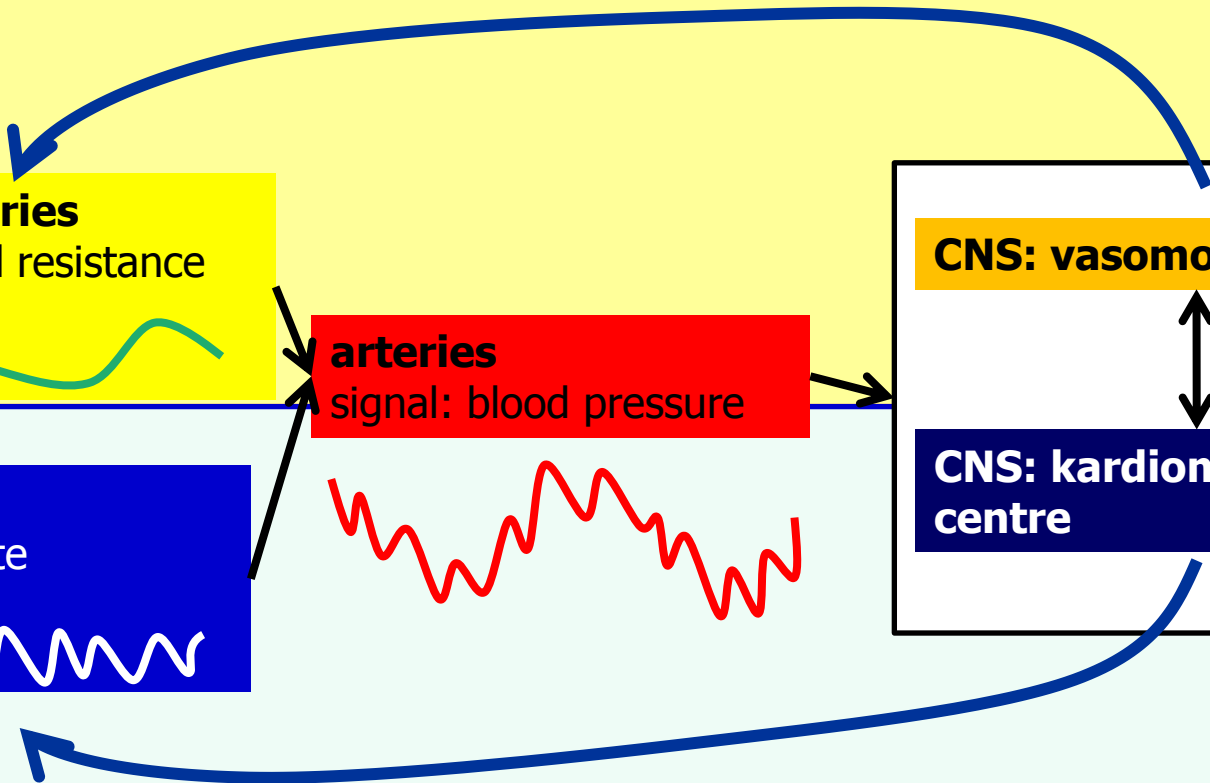


**CNS: vasomotor centre**



**CNS: kardiomotor centre**

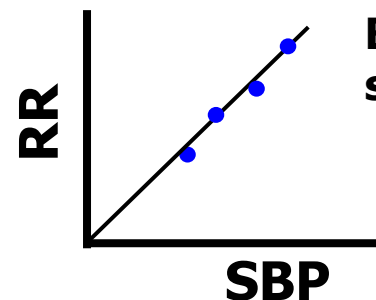
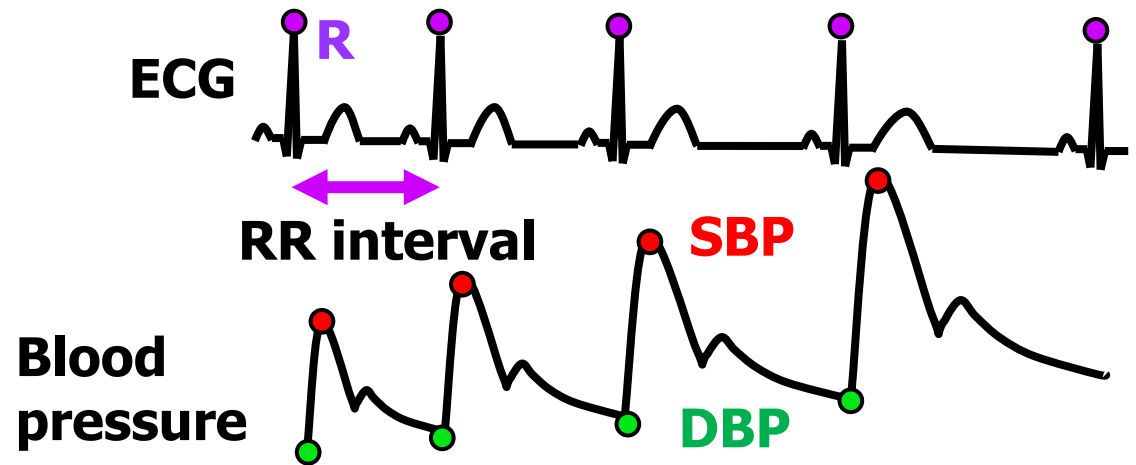
Cardiac (parasympathetic) branch



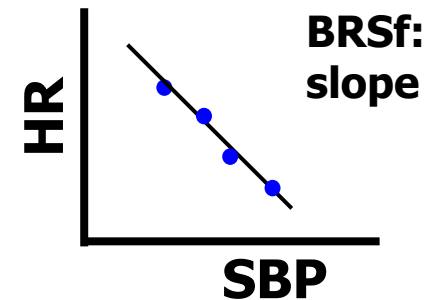
## Baroreflex sensitivity, BRS

**Evaluation of cardiac baroreflex function through SBP and heart rate (cardiac cycle) changes**

**BRS:** change of cardiac cycle caused by SBP change by 1 mmHg [ms/mmHg]



**BRS:**  
slope



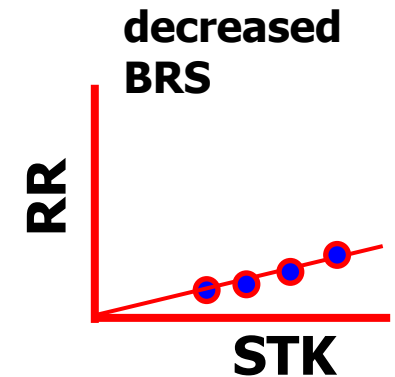
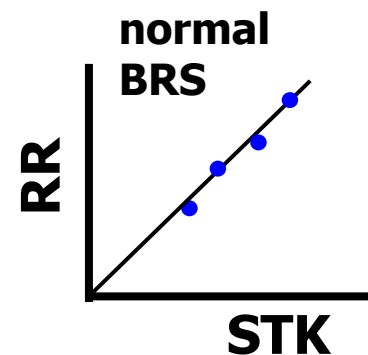
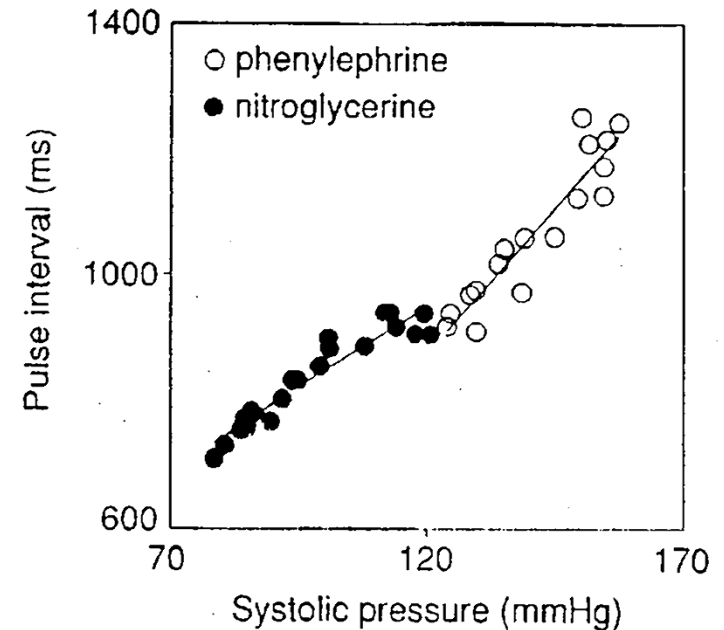
**BRSf:**  
slope

# Evaluation of BRS

## Standard(oxford) method:

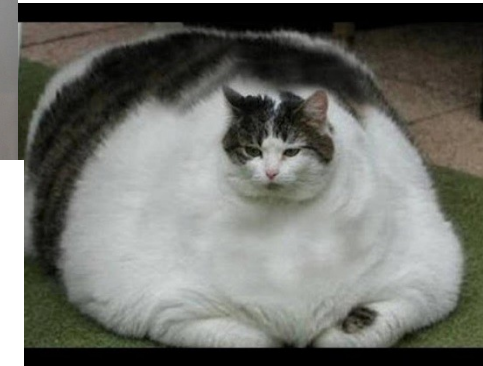
- Application of phenylephrine (vasoconstrictor)

*Bolus injections of vasoactive drugs*



# Decreased BRS

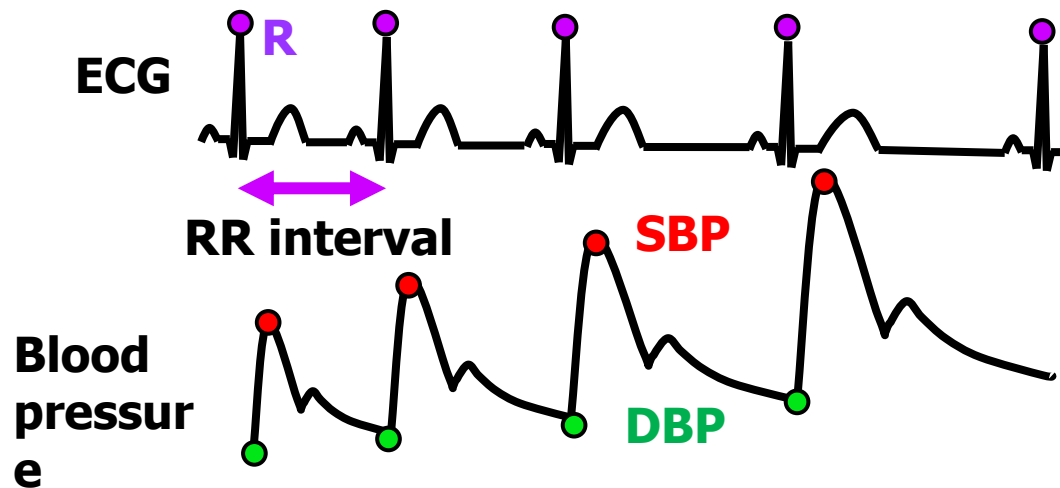
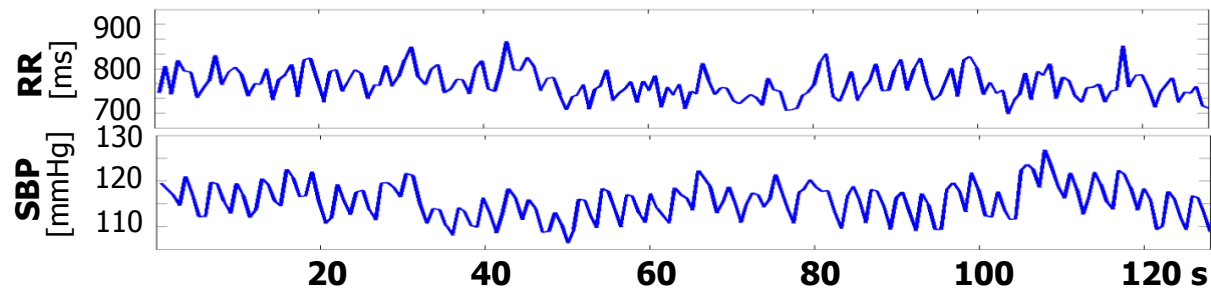
- Physiologically
  - psychic stress – increased sympathetic activity
  - Physical exercise – increased sympathetic activity
  - In old age
- Pathologically
  - hypertension – decreased baroreceptor sensitivity (atherosclerosis, increased arterial stiffness)
  - diabetes – neuropathy of autonomic nervous system
  - Chronic depression (neurogenic)
  - Heart insufficiency/failure – heart do not response
  - Transplanted heart - denervation
  - Myocardial infarction – heart do not response



# Signal: time series

Beat to beat (for example 5 minutes)

- RR interval: 805, 820, 815, 817, 822, 816,..... ms
- Hear rate: 70, 73, 68, 65, 67, 71,..... bpm
- Systolic blood pressure: 115, 117, 120, 116, 121, 119,..... mmHg





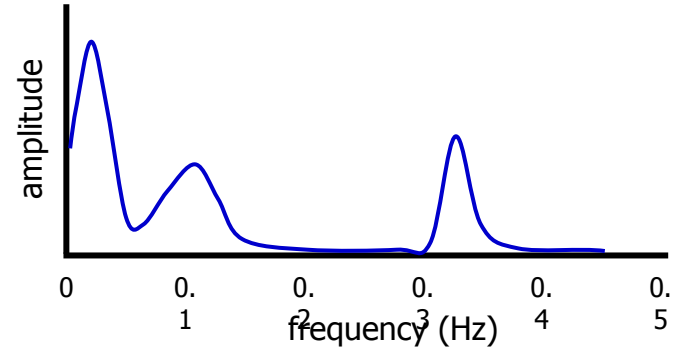
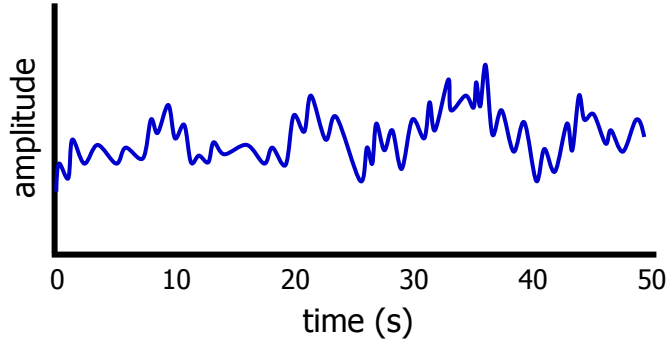
# Frequency domain methods – spectral analysis

Time series  
Signal in time domain



Spectrum  
Signal in frequency domain

Signal is decomposed in individual frequencies



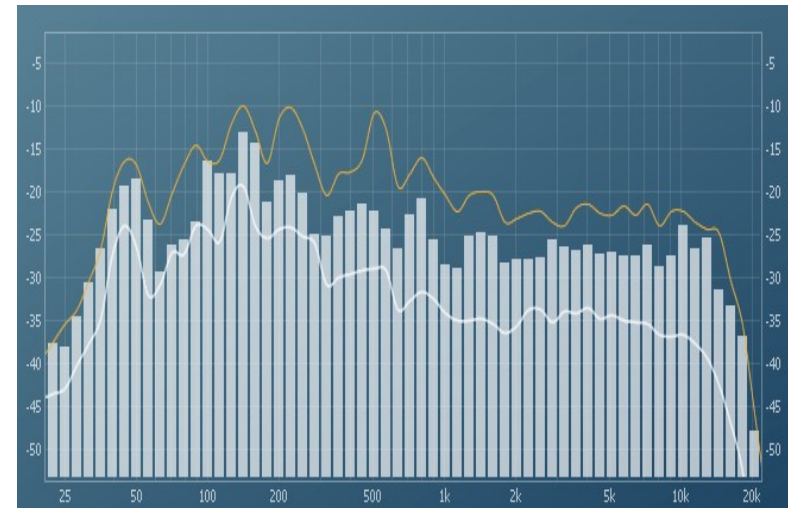
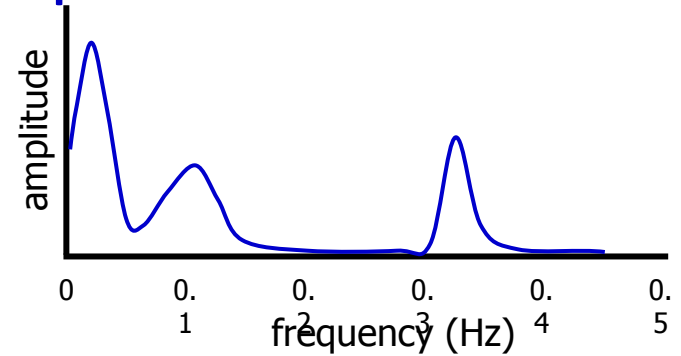
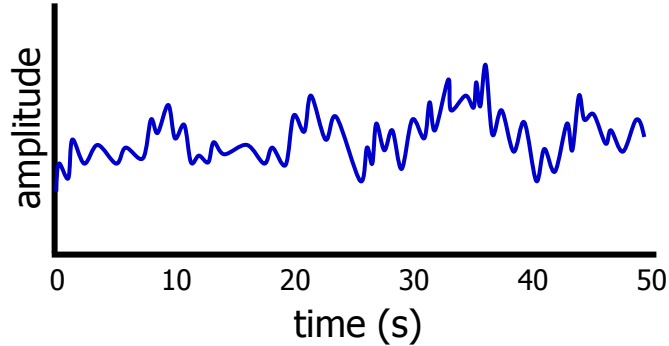
# Frequency domain methods – spectral analysis

**Time series**  
Signal in time domain



**Spectrum**  
Signal in frequency domain

Signal is decomposed in individual frequencies

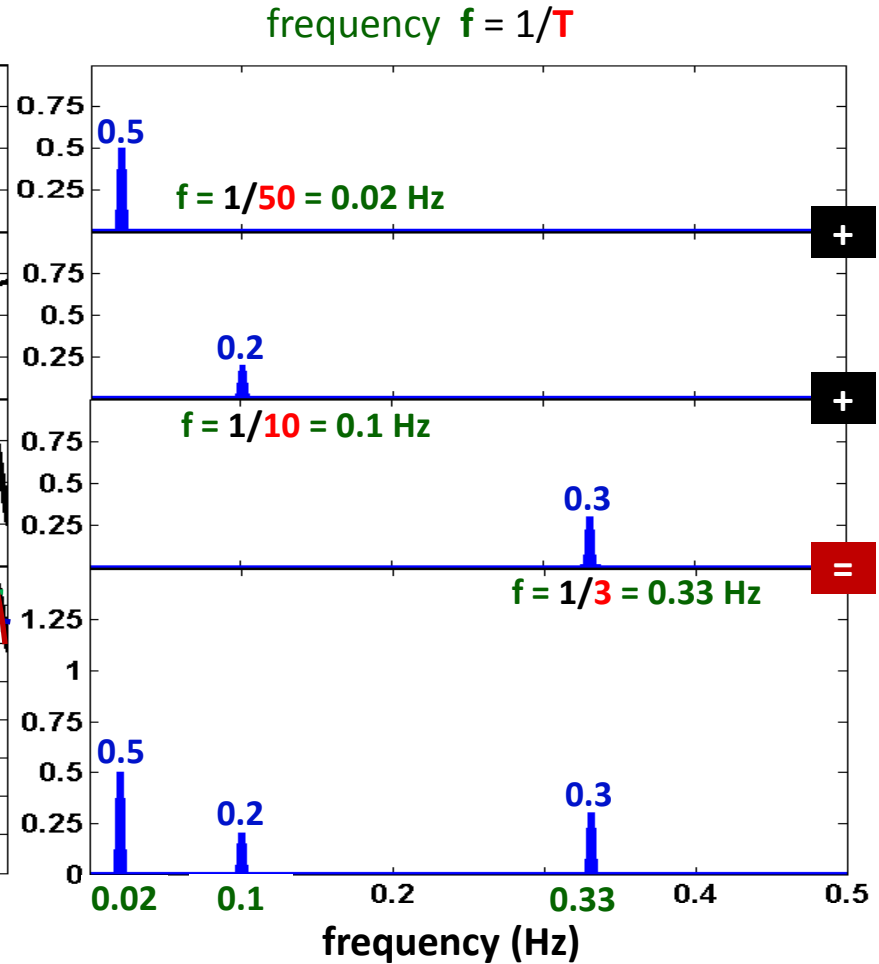
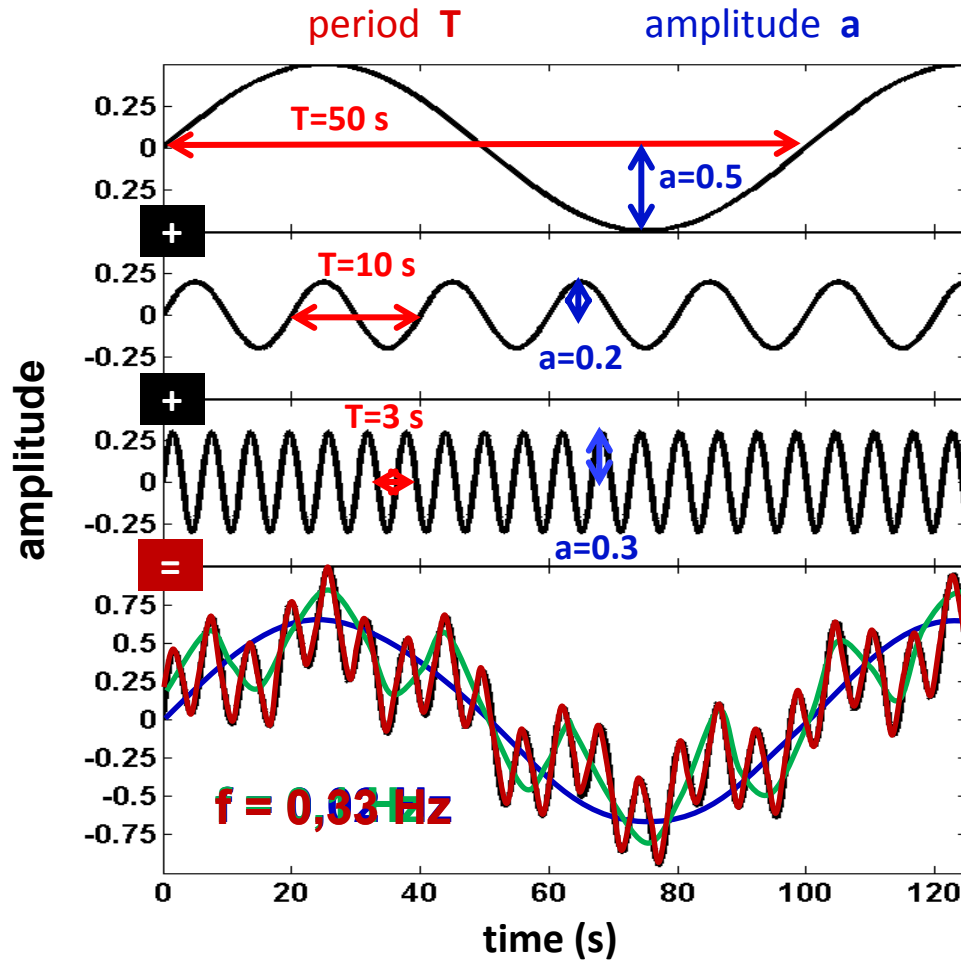




# How the spectrum is formed?

Spectrum  
Frequency domain

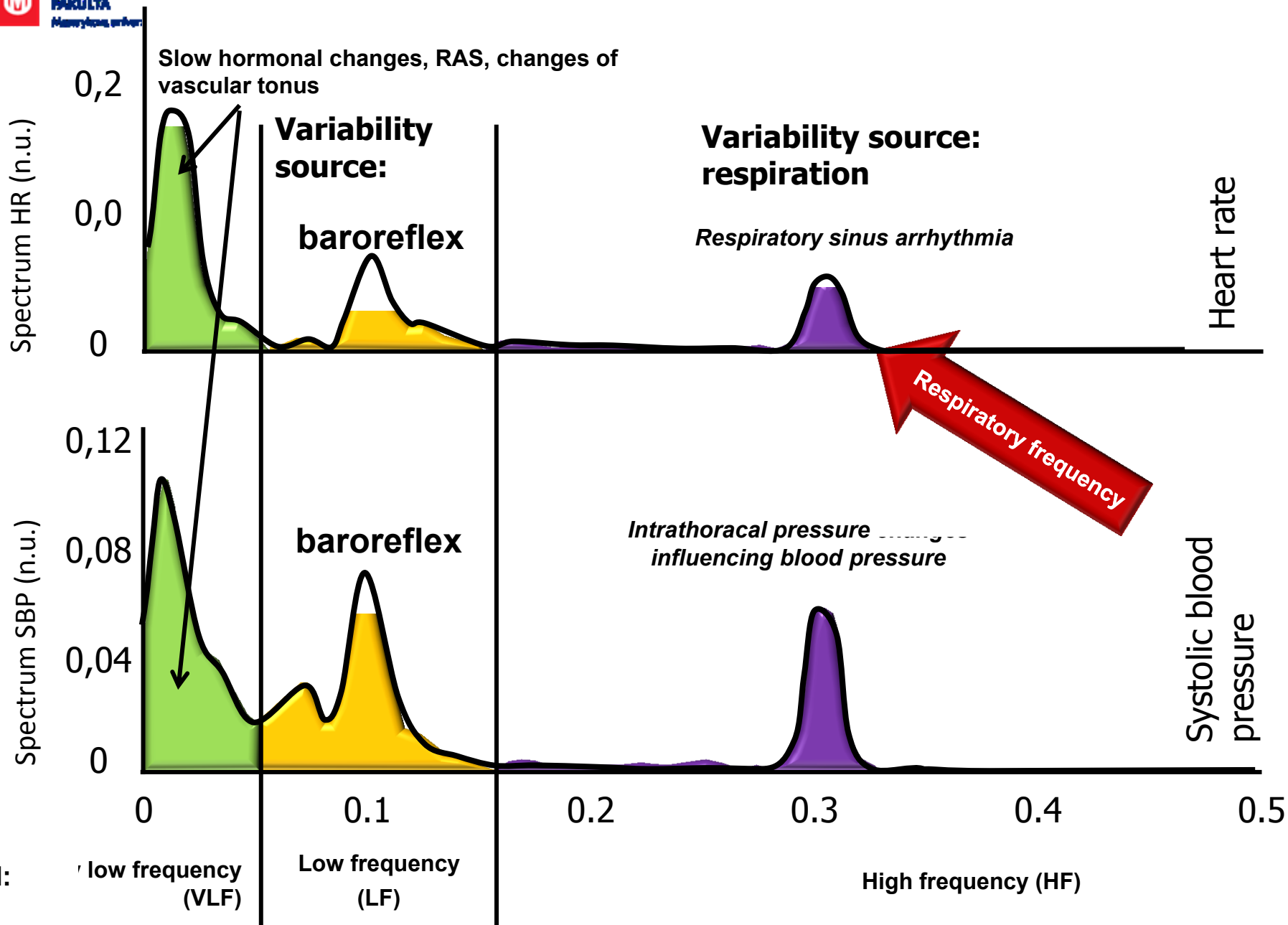
Time domain







# Physiological significance – frequency bands





parasympathetic activity

Sympathetic activity

Time lag < 1 s

Fast oscillations

Time lag > 6 s  
Slow oscillations

Spectrum HR (n.u.)

0,2  
0,0  
0

baroreflex

*Respiratory sinus arrhythmia*

Heart rate

Spectrum SBP (n.u.)

0,12  
0,08  
0,04  
0

baroreflex

*Intrathoracic pressure changes  
influencing blood pressure*

Systolic blood  
pressure

0 0.1 0.2 0.3 0.4 0.5

band:

low frequency  
(VLF)

Low frequency  
(LF)

High frequency (HF)



parasympathetic activity

Sympathetic activity

Time lag < 1 s  
fast oscillations

Time lag > 6 s  
Slow oscillations

Spectrum HR (n.u.)

0,2  
0,0  
0

Heart rate

CNS (*n. vagus*)

baroreflex

Mechanical transfer

??

Changes of TPR  
(sympathetic nerves)

Thoracic pressure changes

Spectrum SBP (n.u.)

0,12  
0,08  
0,04  
0

Systolic blood pressure

0

0.1

0.2

0.3

0.4

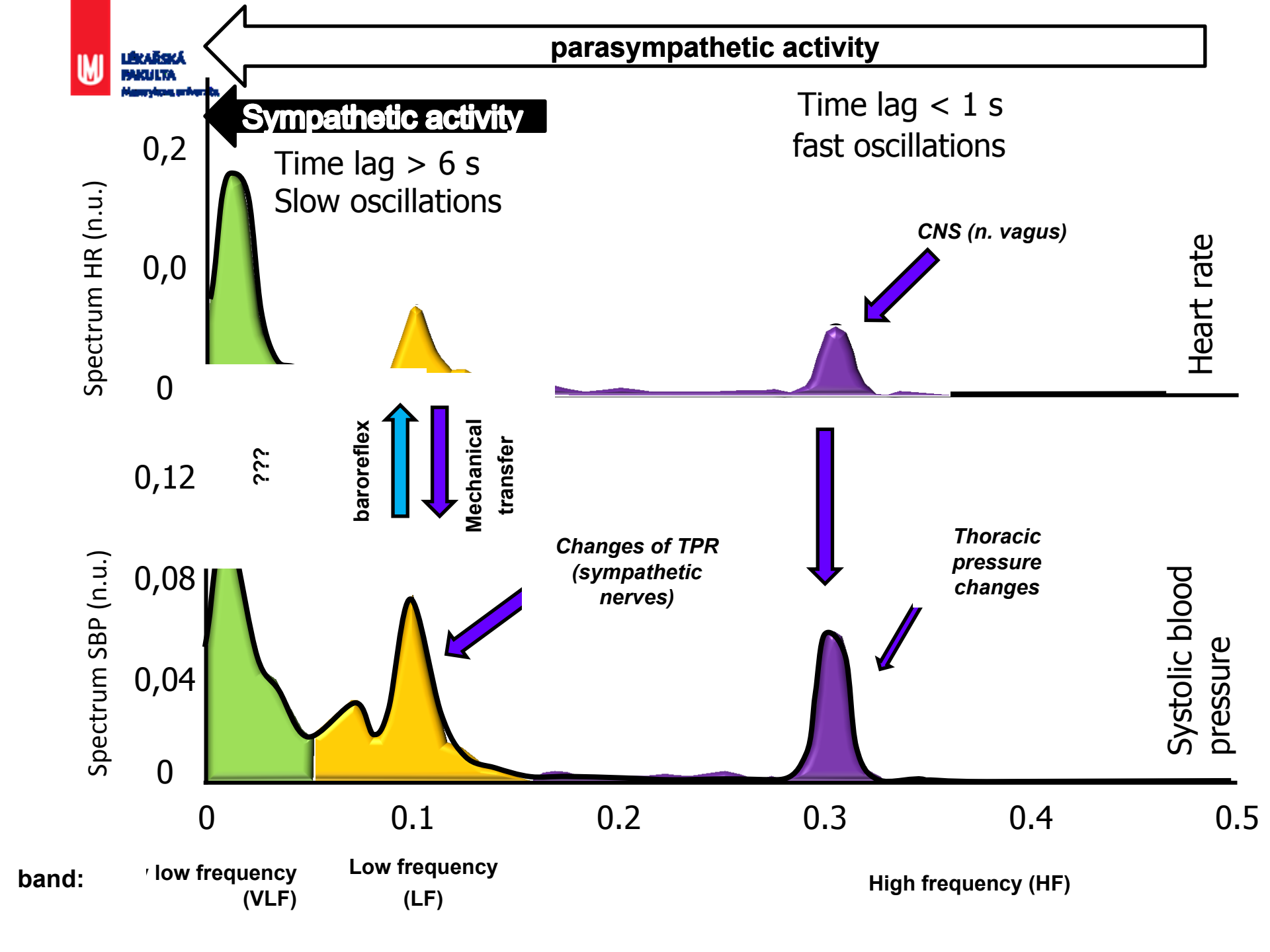
0.5

band:

low frequency (VLF)

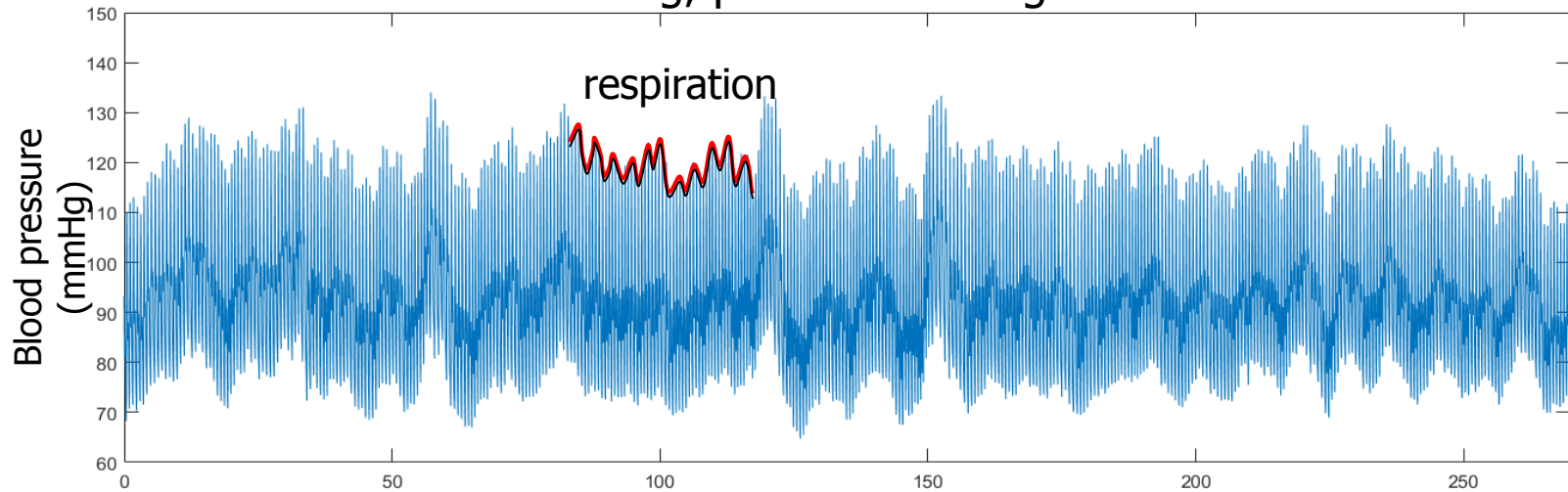
Low frequency (LF)

High frequency (HF)

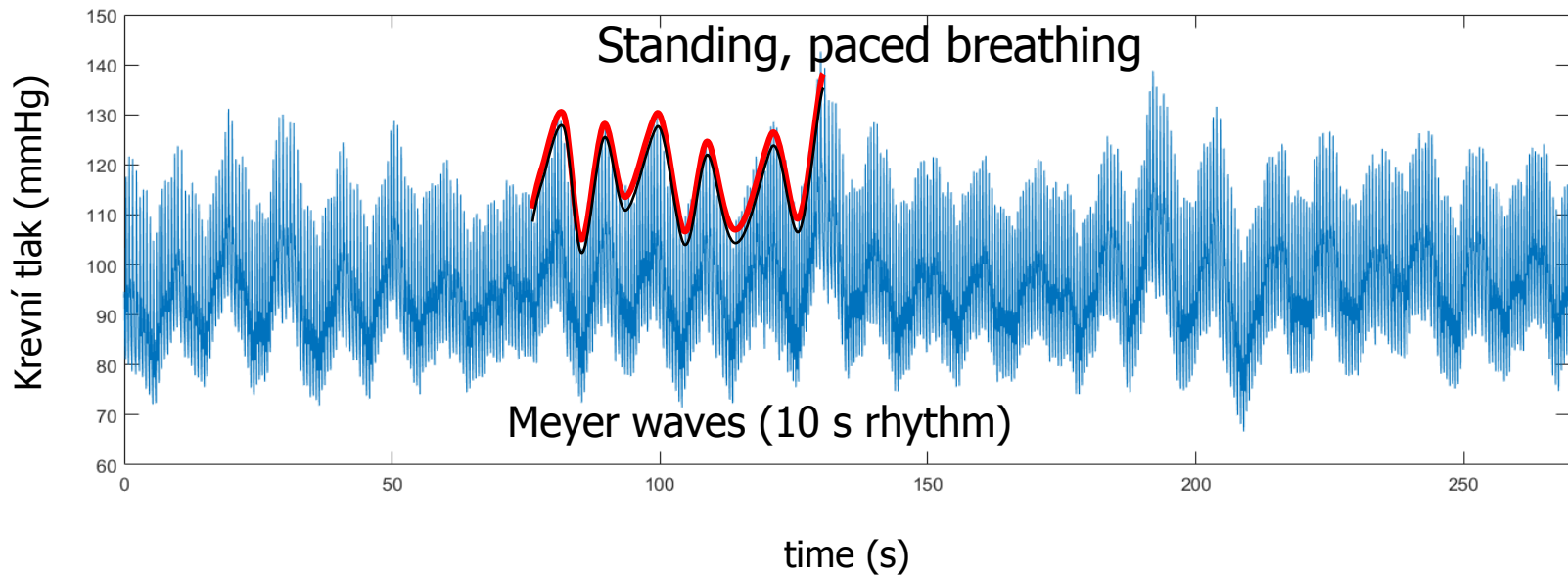


# Blood pressure signal (270 s)

Sitting, paced breathing

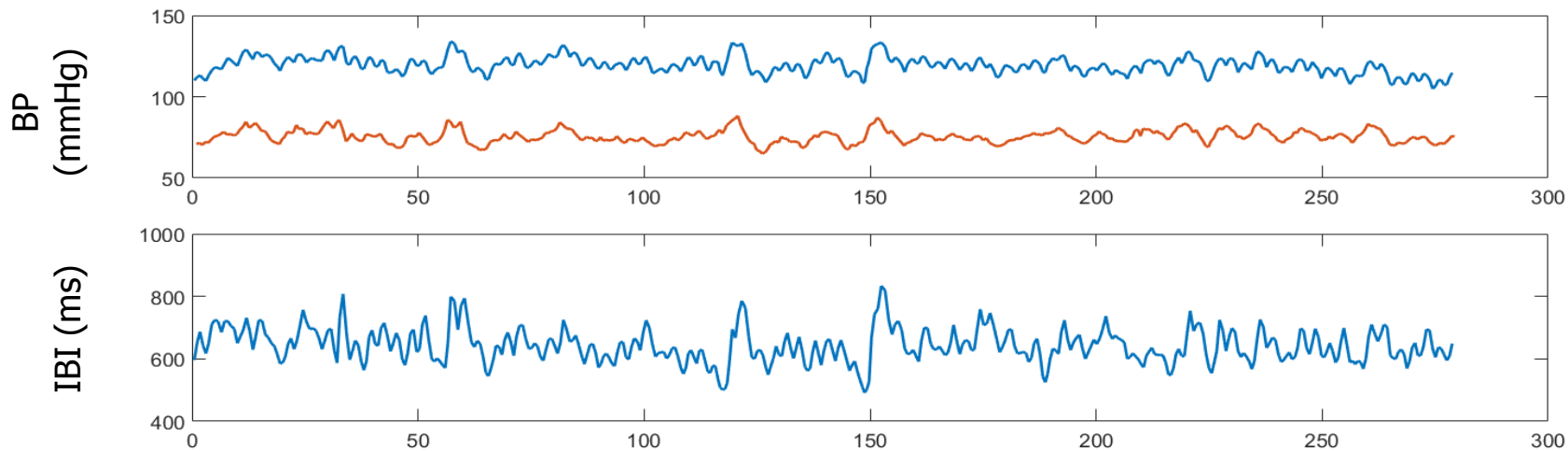


Standing, paced breathing

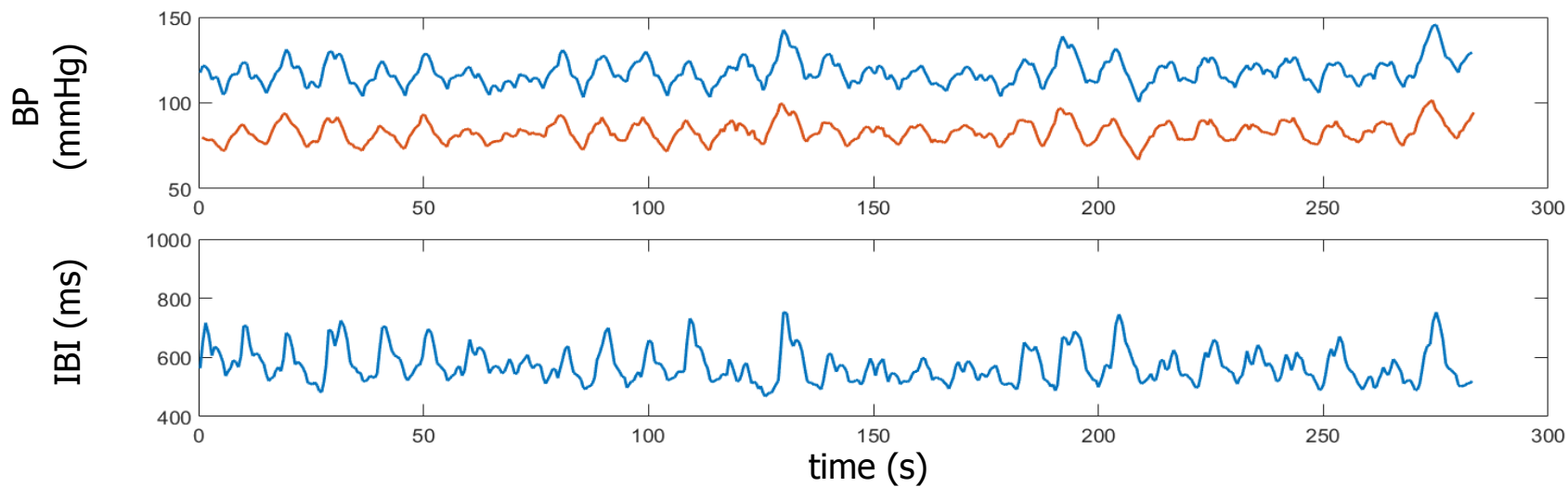


# sequences of SBP, DBP and inter-beat intervals

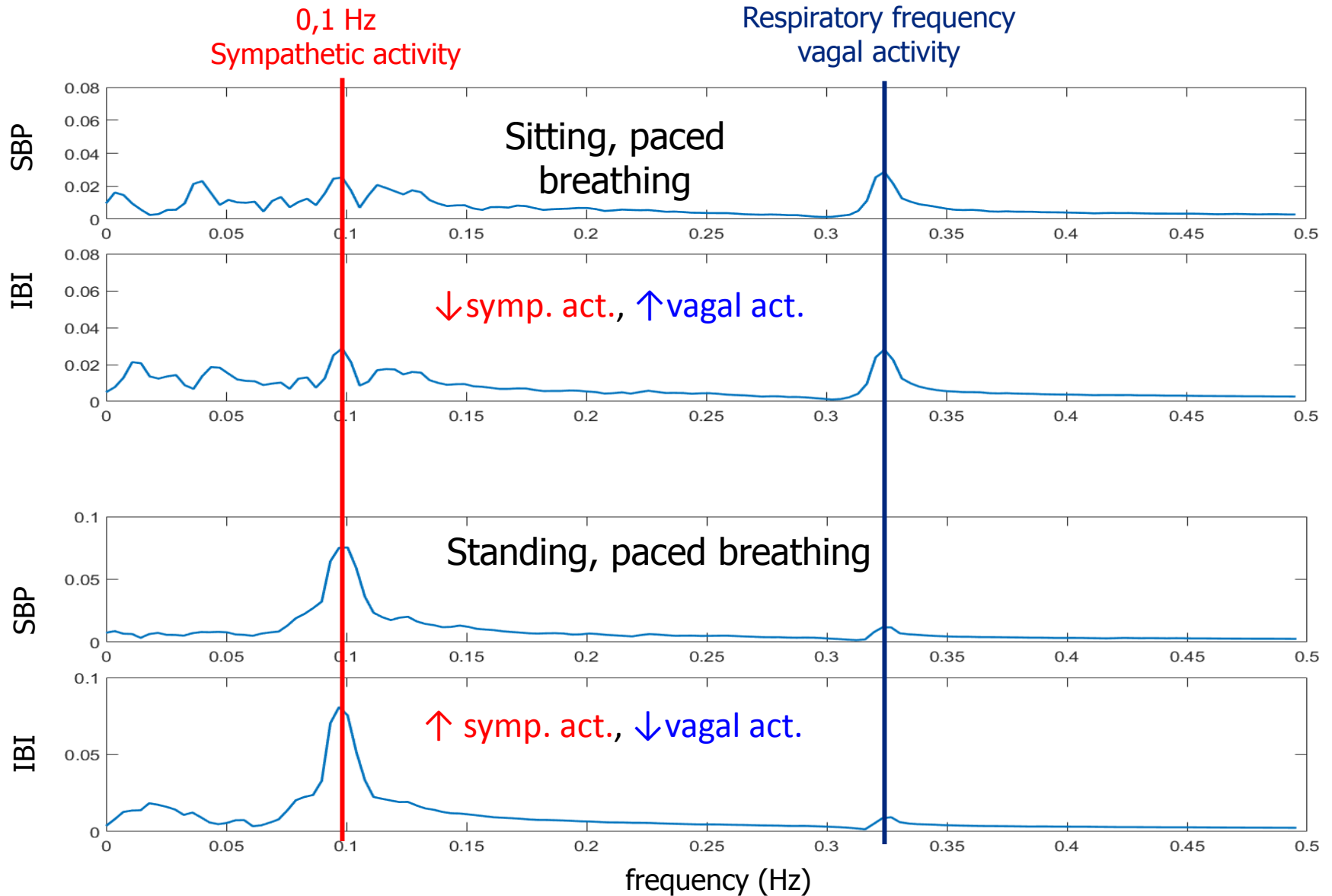
## Sitting, paced breathing



## Standing, paced breathing



# Spectra of SBP and IBI



# Coherence a BRS

coherence: synchronization between signals (correlation on particular frequency)

