Détection de chute en utilisant des techniques Radar

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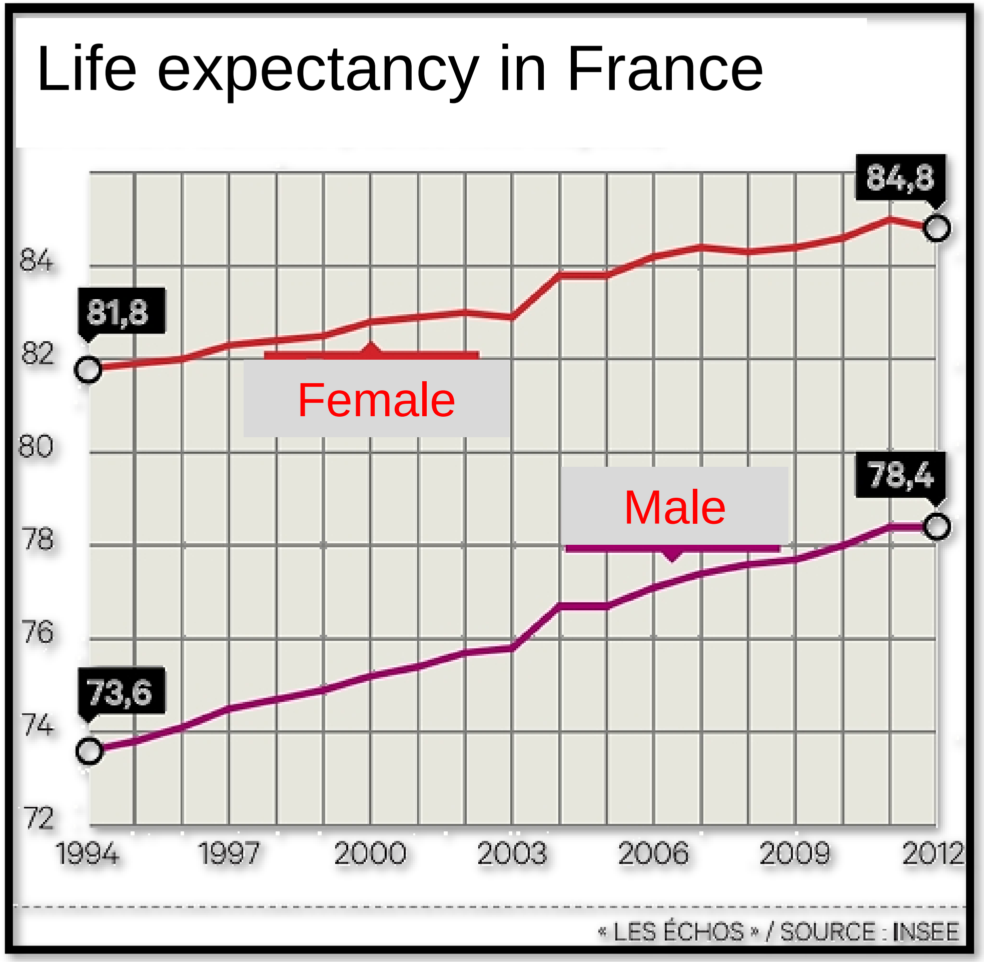
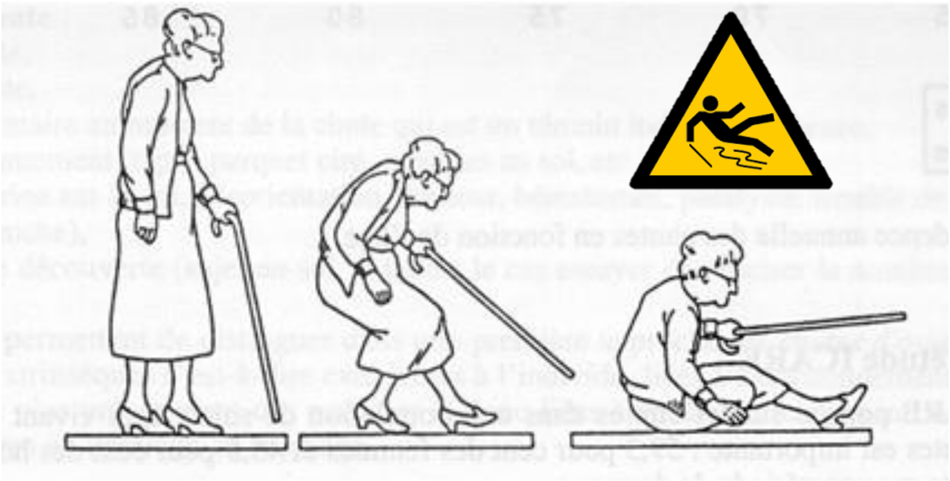
Outline

- Context
- Objective
- Proposed solution
- Experimental results
- Conclusions and perspectives

Context



- **Elderly people fall: 2 millions per year in France (leading to 10,000 deaths)**
- **For people >80 years old: 50% falls once per year**



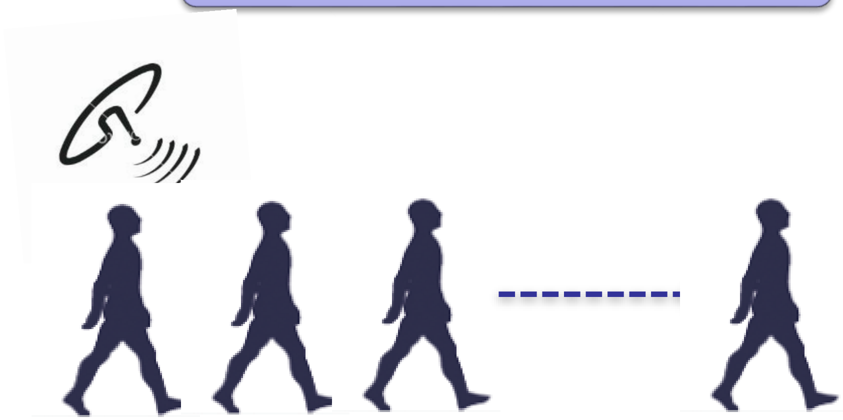
- **Quick medical assistance may save life**
- **Problem of slow falls**

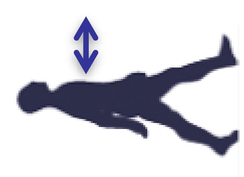
Objective

Monitoring emergency situations

Active

Motionless





Tracking

+

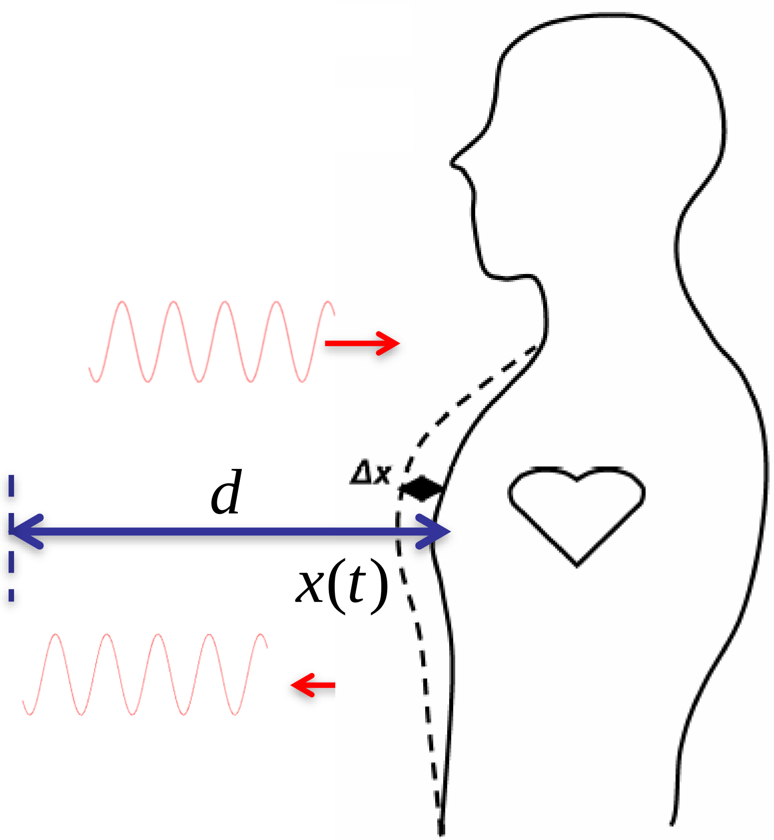
Physiological rythm:
Breathing and Heartbeating

Solution: Doppler radar

- **Doppler radar at 60 GHz**
  - **Wavelength: 5 mm**

$$T(t) = A_e \cos(2\pi f t)$$

$$R(t) = A_r \cos\left(2\pi f t + \frac{4\pi d}{\lambda} + \frac{4\pi x(t)}{\lambda} + \phi^{res}(t)\right)$$



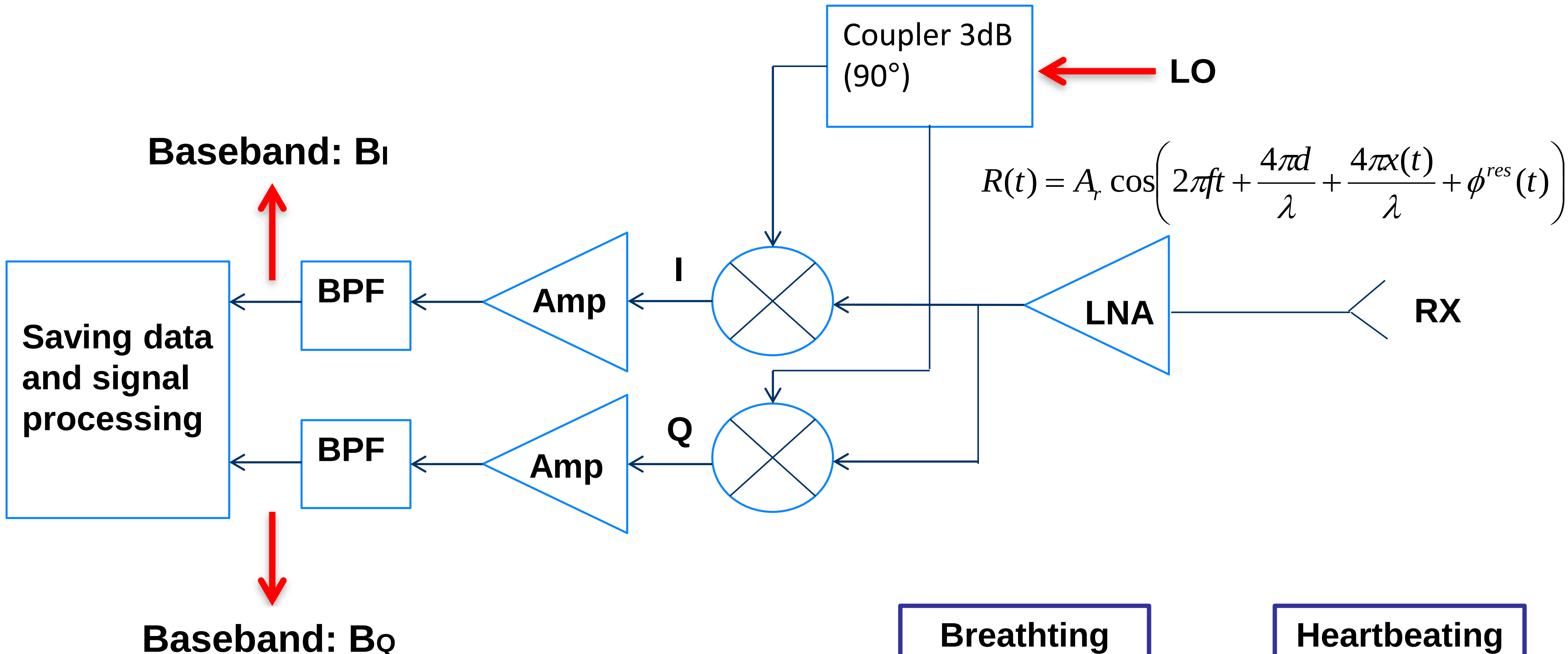
- **Person keeping still: d is a constant**

Physiological movements $x(t)$

Breathing	**Heartbeating**

$$m_r \sin(\omega_r t + \phi_r) \quad + \quad m_h \sin(\omega_h t + \phi_h)$$

I/Q quadrature demodulation



$$R(t) = A_r \cos\left(2\pi f t + \frac{4\pi d}{\lambda} + \frac{4\pi x(t)}{\lambda} + \phi^{res}(t)\right)$$

Breathting

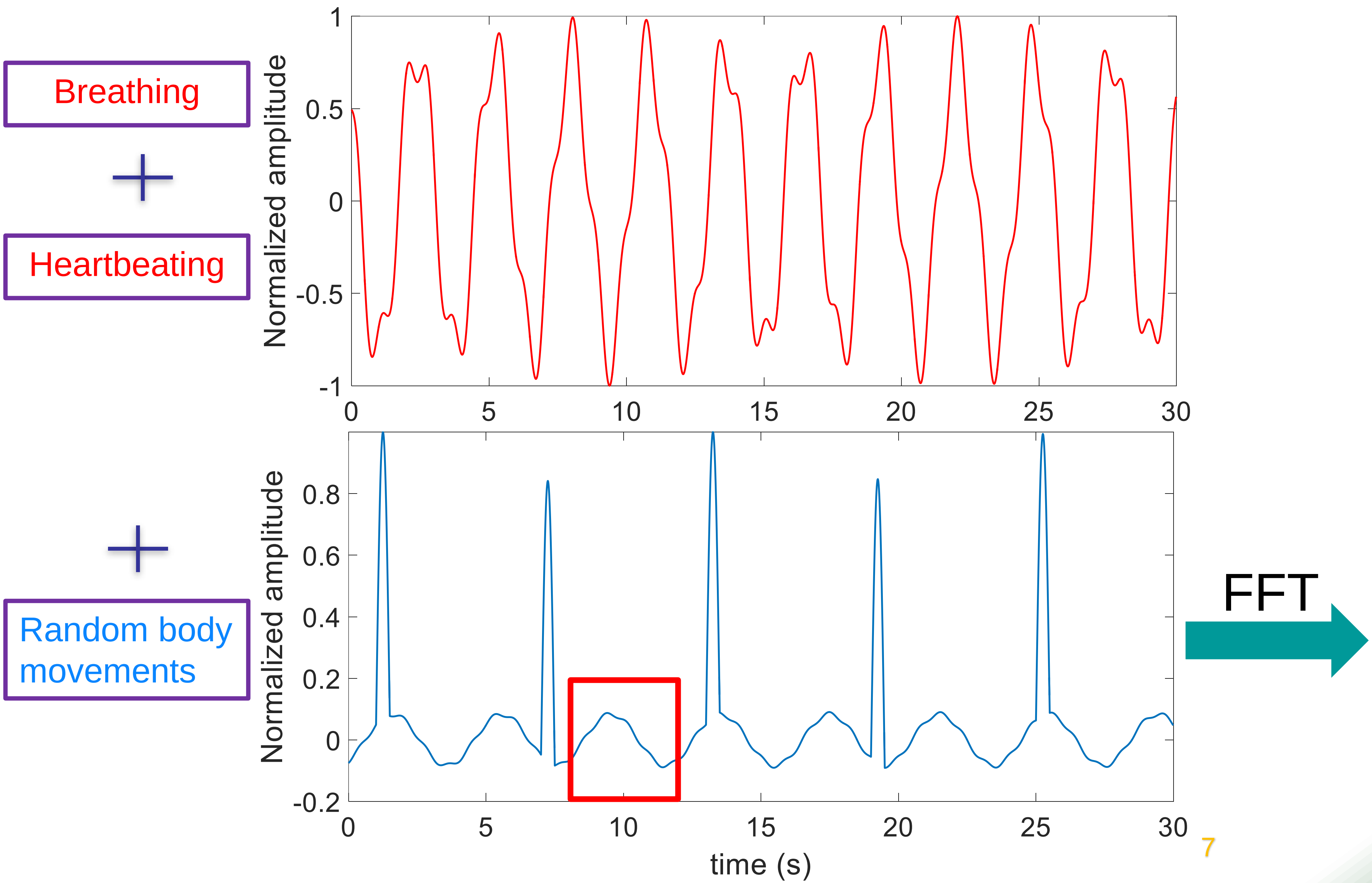
Heartbeating

Complex demodulation

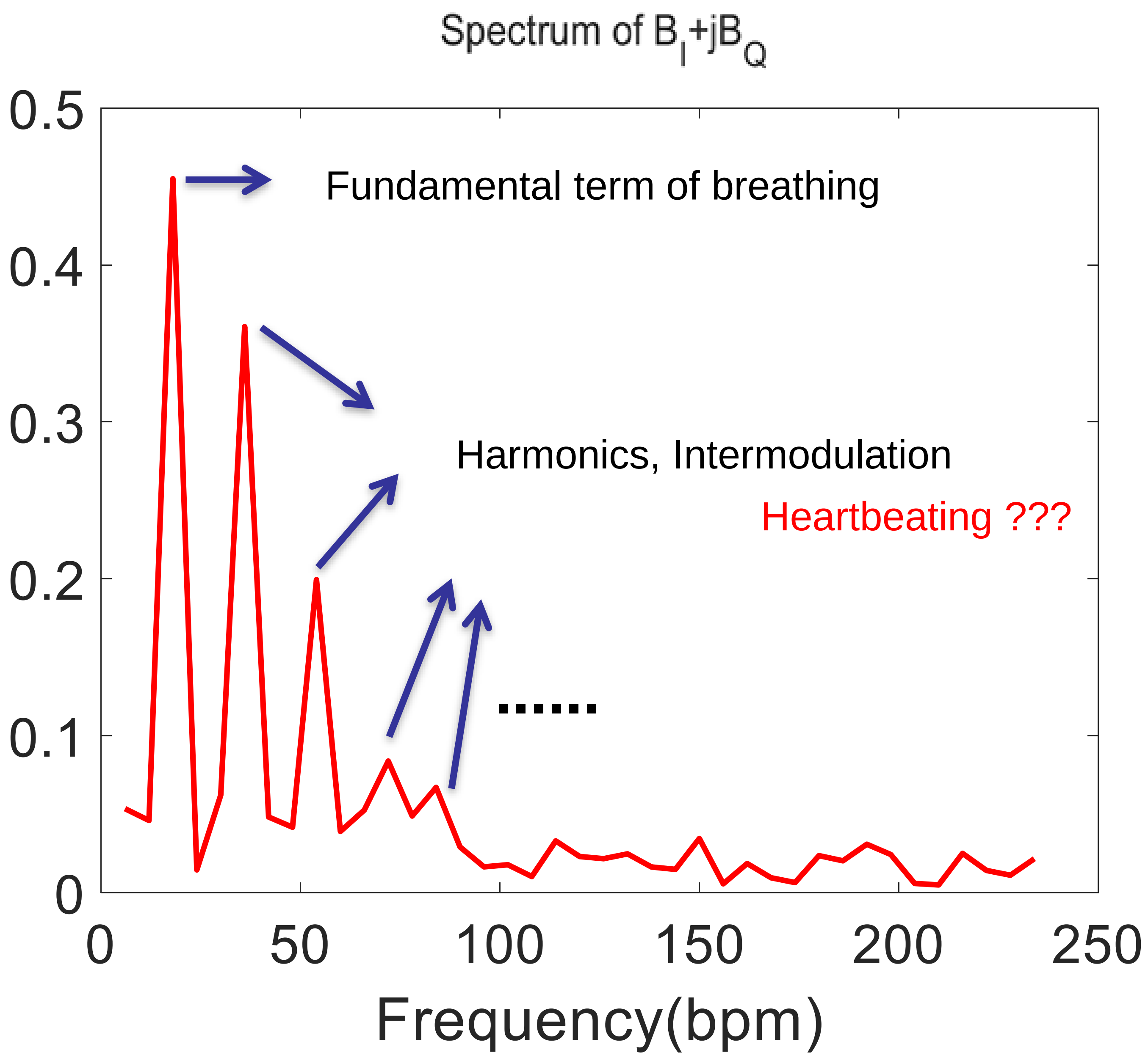
$$B(t) = B_I + jB_Q$$
$$= \exp(i\theta)\exp\left\{i\left[\frac{4\pi m_r}{\lambda}\sin(\omega_r t + \phi_r) + \frac{4\pi m_h}{\lambda}\sin(\omega_h t + \phi_h)\right]\right\}$$

Baseband signal

- m_r = 1.0 mm, m_h = 0.1 mm, f_r = 18 bpm, f_h=72 bpm
- In presence of random body movements



Direct peak detection in the spectrum



Solution: Optimization problem

- Complex received signal

$$B(t)^{cal} = \exp(i\theta)\exp\left\{i\left[\frac{4\pi m_r}{\lambda}\sin(2\pi f_r t+\phi_r)+\frac{4\pi m_h}{\lambda}\sin(2\pi f_h t+\phi_h)\right]\right\}$$

- Determination of all unknown parameters

$$m_r \quad m_h \quad f_r \quad f_h \quad \phi_r \quad \phi_h \quad \theta$$

- Optimization algorithms: Particle Swarm Optimization (PSO), Genetic Algorithm (GA)
- Cost function:

$$F = \frac{\left\| B(t)^{mes} - B(t)^{cal} \right\|^2}{\left\| B(t)^{mes} \right\|^2}$$

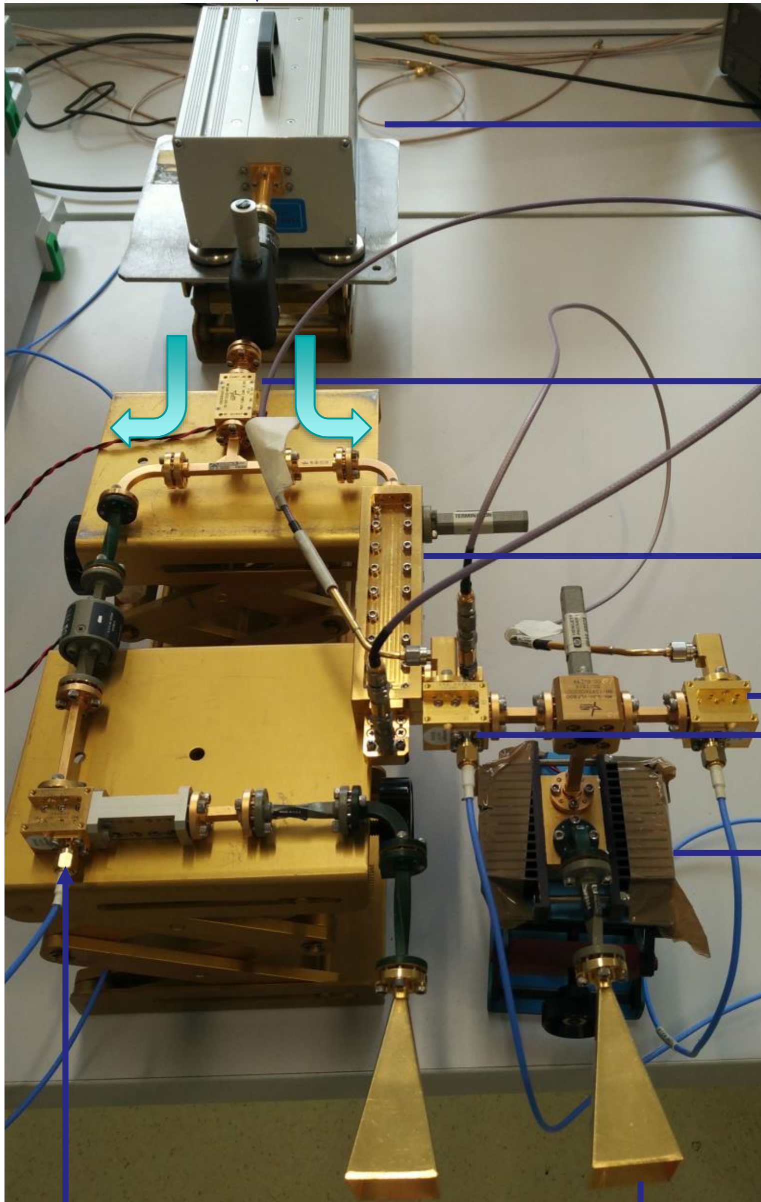
		f_r (bpm)	f_h (bpm)	m_r (mm)	m_h (mm)
At rest	lb	12	54	0	0
	ub	25	100	6.0	1.0
After sport	lb	25	100	0	0
	ub	60	180	6.0	1.0

Doppler Radar

Experimental results

Experimental setup

LO: 13.75 GHz



Multiplier ×4, LO 55GHz

Amplifier

90° coupler

Down-Converters

Low Noise Amplifier

IF 5GHz

Receiver

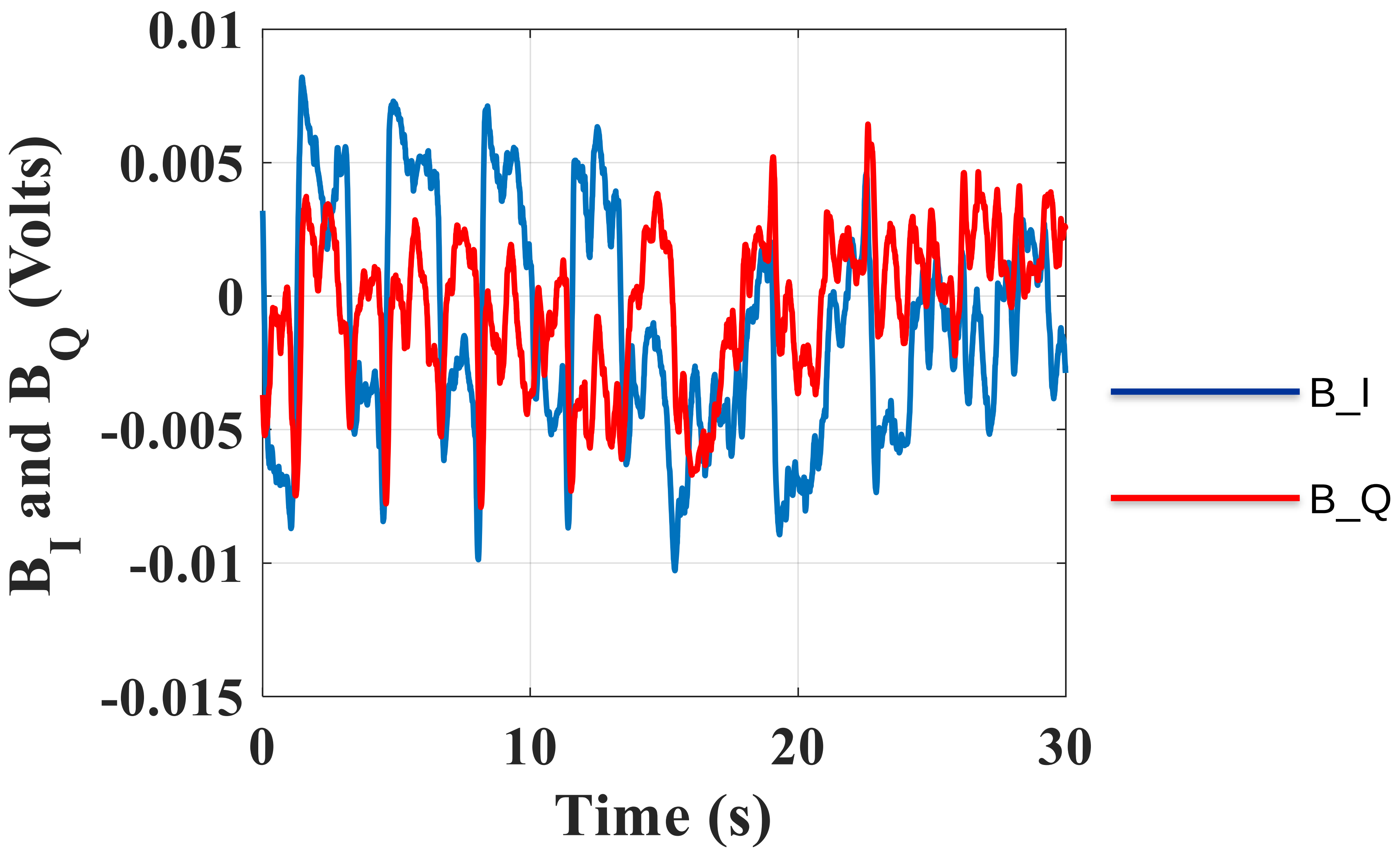
Transmitter: RF 60 GHz

1m in front of antennas

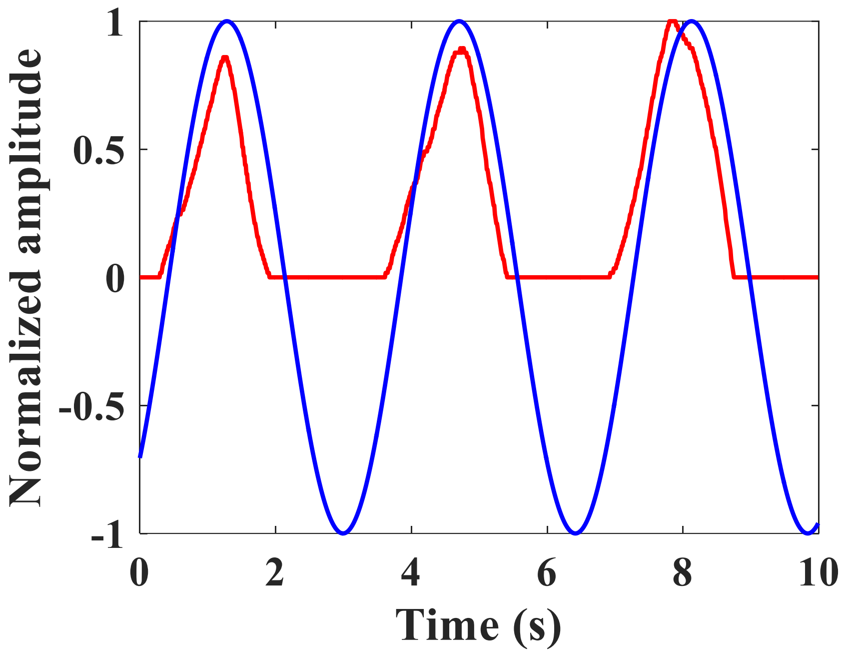
Sensors: reference

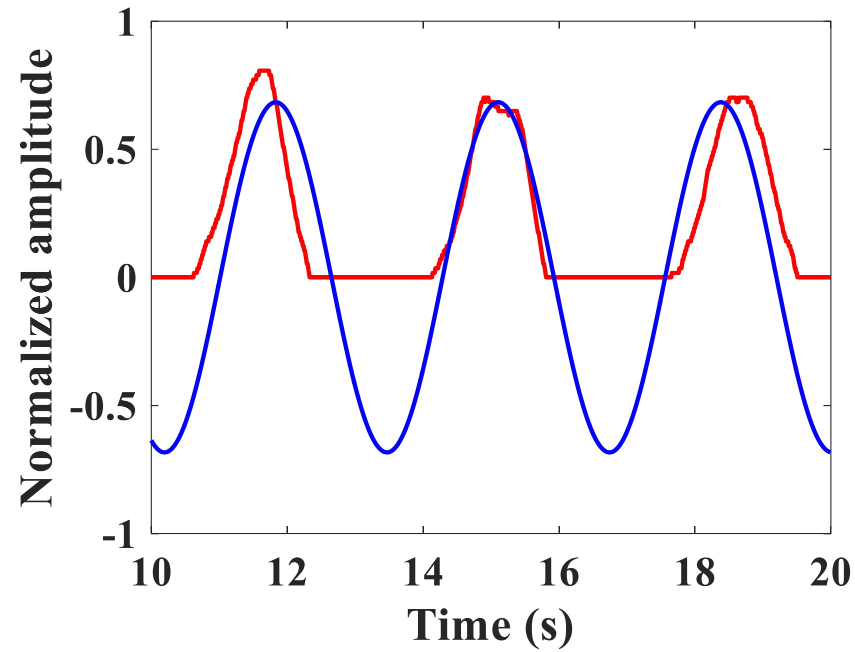
Measured baseband signal

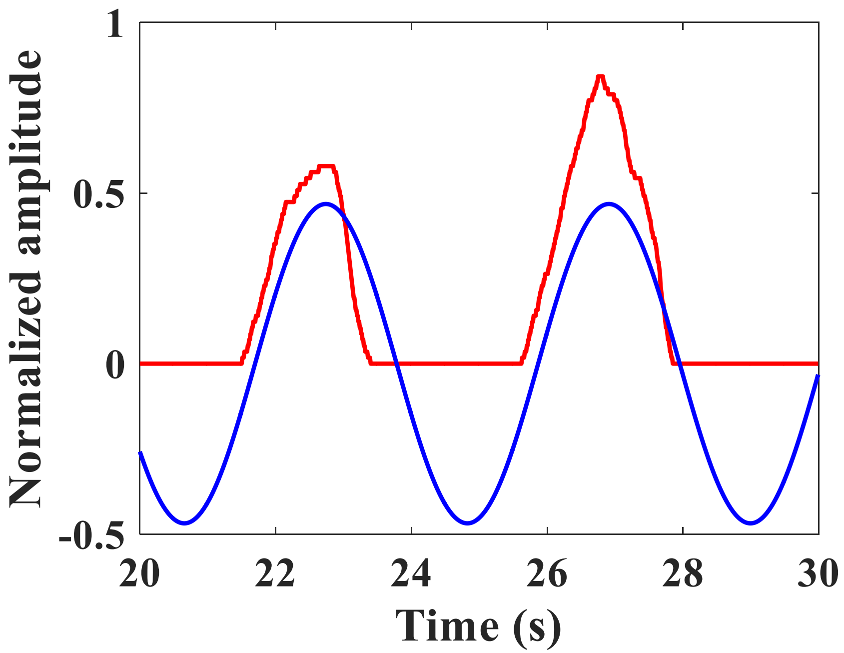
- Each measurement: 30 seconds



Optimization results: breathing







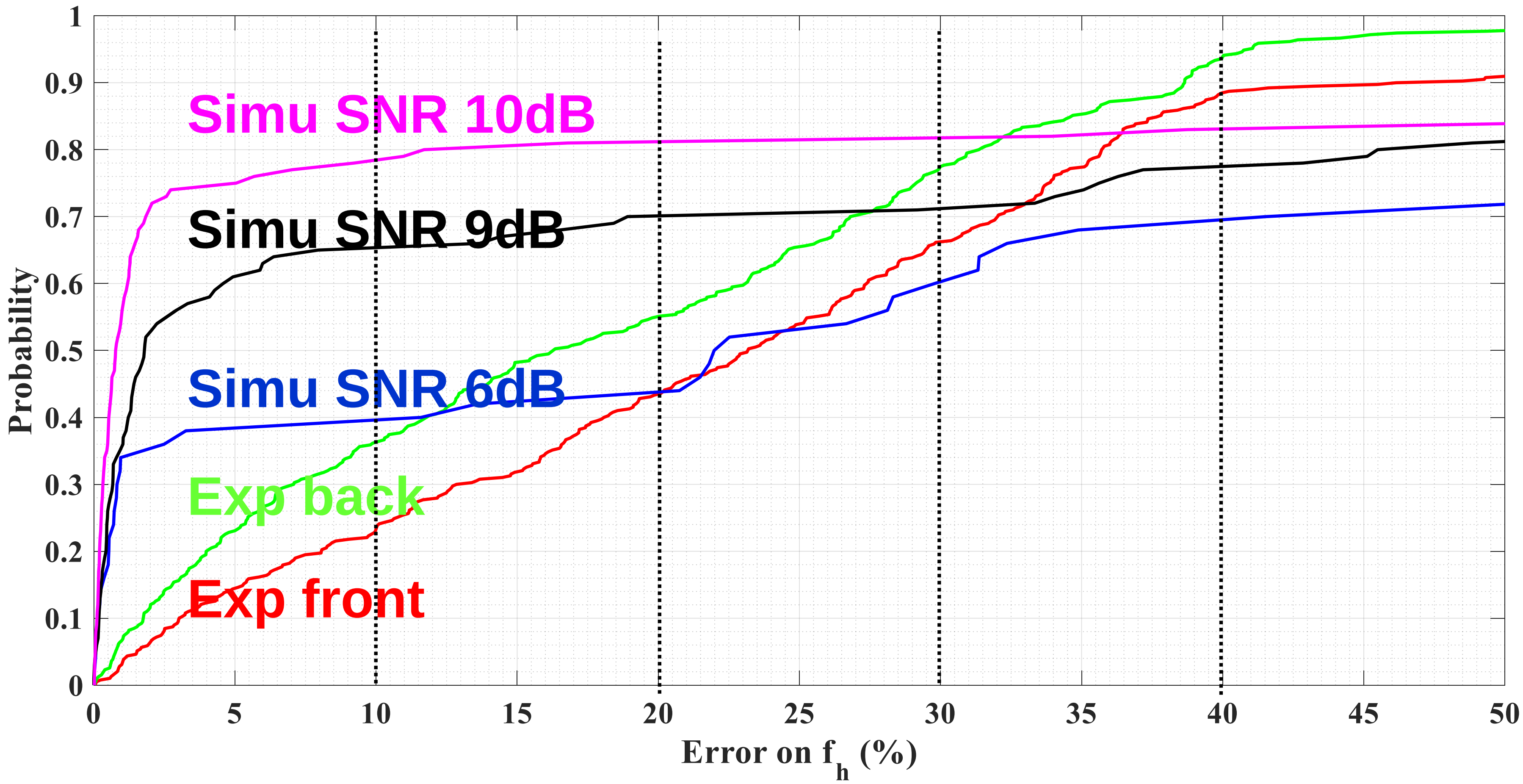
Optimization results

Respiratory belts

- The frequency is correctly estimated
- Variation of the amplitude of movement is detectable

Optimization results: heartbeating

- 5 people, front and back, 80 mesurements for each scenario
- SNR of the actual system: between 6 and 9 dB



Conclusion and Perspective

Conclusion

- 60 GHz Doppler radar with optimization algorithm enables autonomous vital signs estimation
- We can detect not only the frequencies, but also the displacements introduced by the physiological movements

Perspective

- Improving the system for a better accuracy of estimation
- Use wavelet transform

Thank you