



KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY



„Introduction to Electrocardiography” *P. Strumillo*

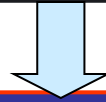
**Prezentacja multimedialna współfinansowana przez
Unię Europejską w ramach
Europejskiego Funduszu Społecznego w projekcie pt.
*„Innowacyjna dydaktyka bez ograniczeń - zintegrowany
rozwój Politechniki Łódzkiej - zarządzanie Uczelnią,
nowoczesna oferta edukacyjna i wzmacniania zdolności
do zatrudniania osób niepełnosprawnych”***



Politechnika Łódzka

Politechnika Łódzka, ul. Żeromskiego 116, 90-924 Łódź, tel. (042) 631 28 83
www.kapitalludzki.p.lodz.pl

electron - kardia - grapho

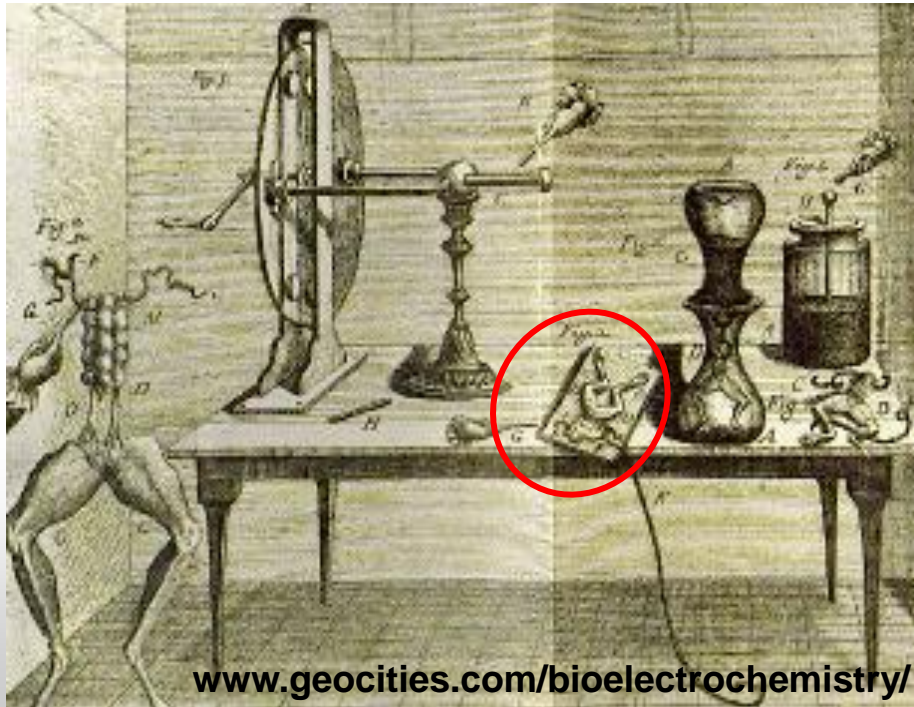


amber - heart - write



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Electrophysiology – the beginning



Frog leg moves after stimulating it
with an electrical pulse



Luigi Galvani
(1737-1798)

Electrophysiology – the beginning



Alessandro Volta (1745-1827) – postulates that electricity can occur only in metals



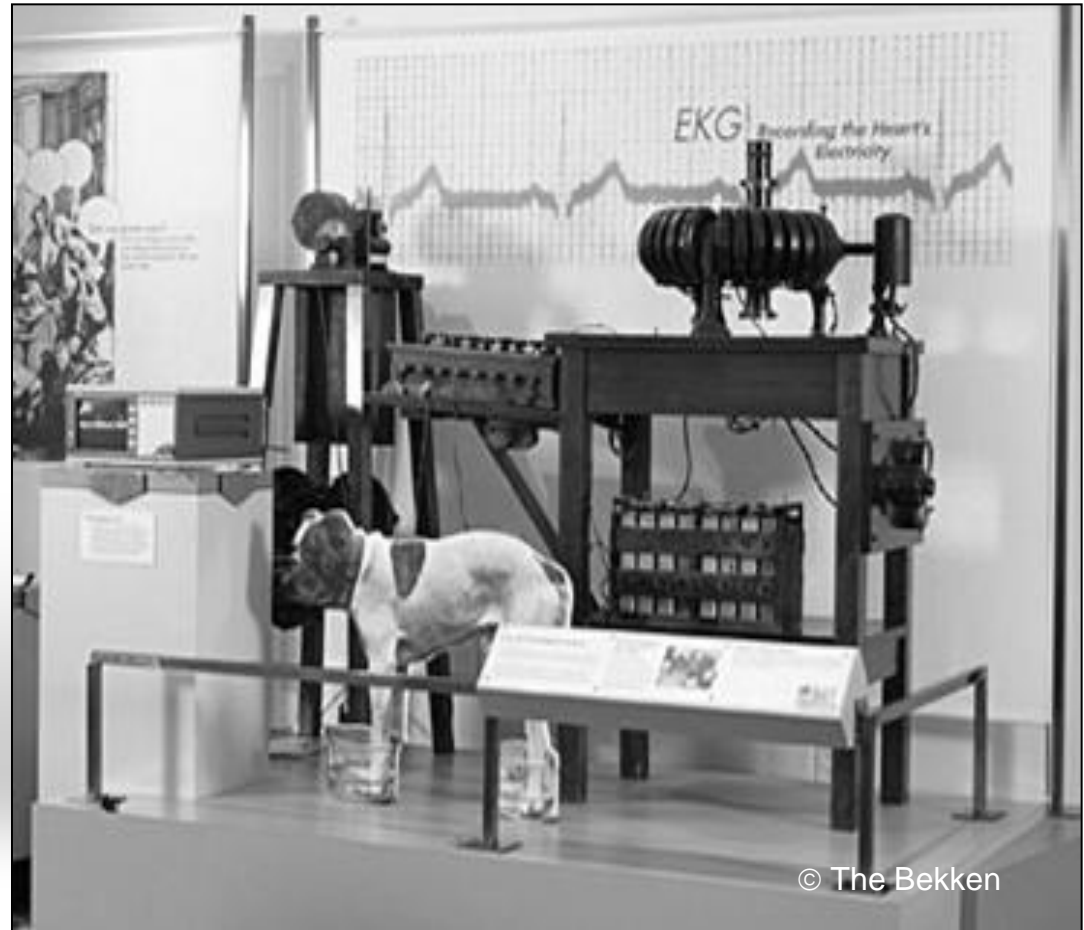
Carlo Matteucci
in 1842 shows there are
rhythmic biocurrents
in frog heart



Emil Reymond
is the first to use „action potential” term to connote electrical
activation of cells (1848)



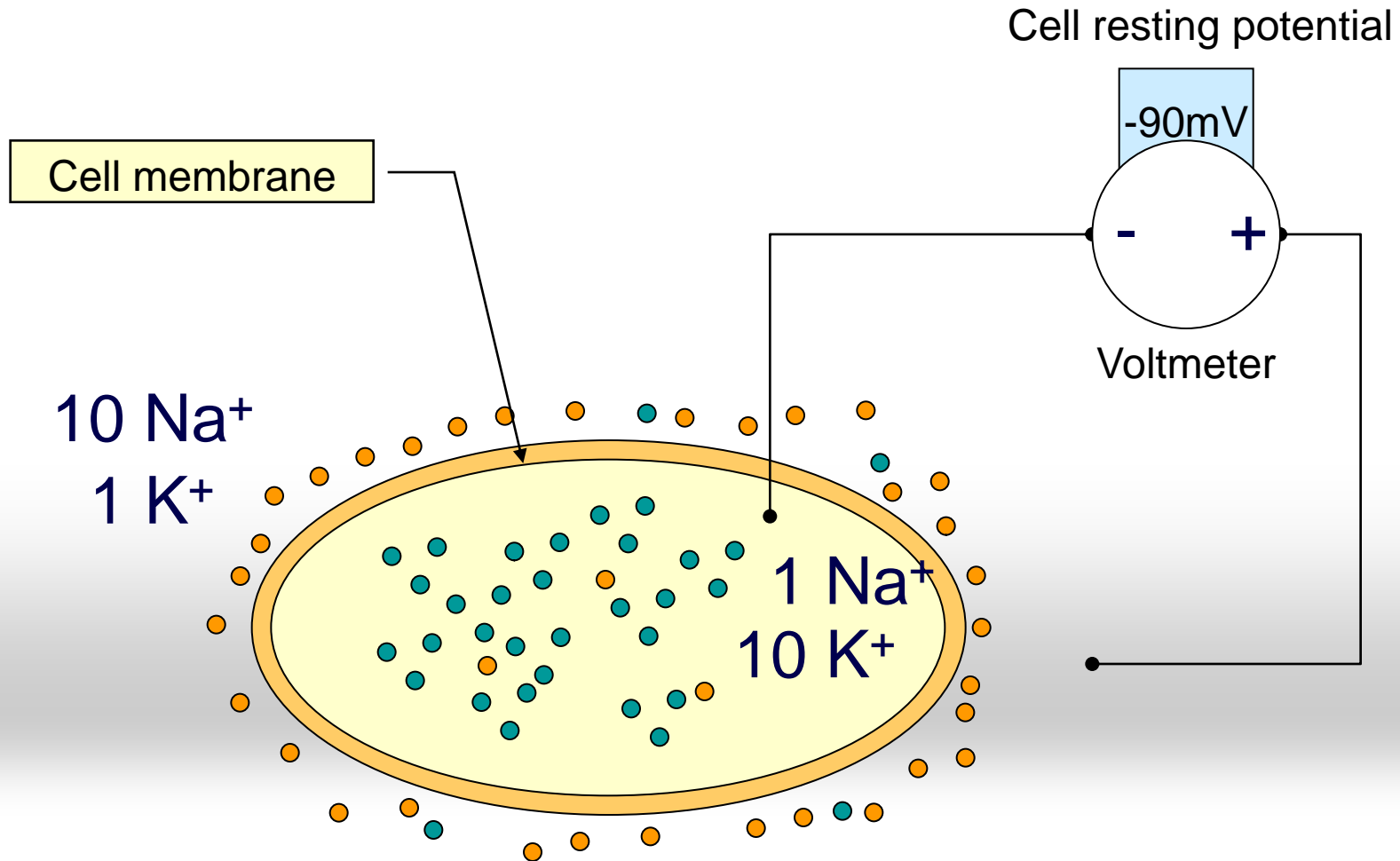
Electrocardiography – the beginning



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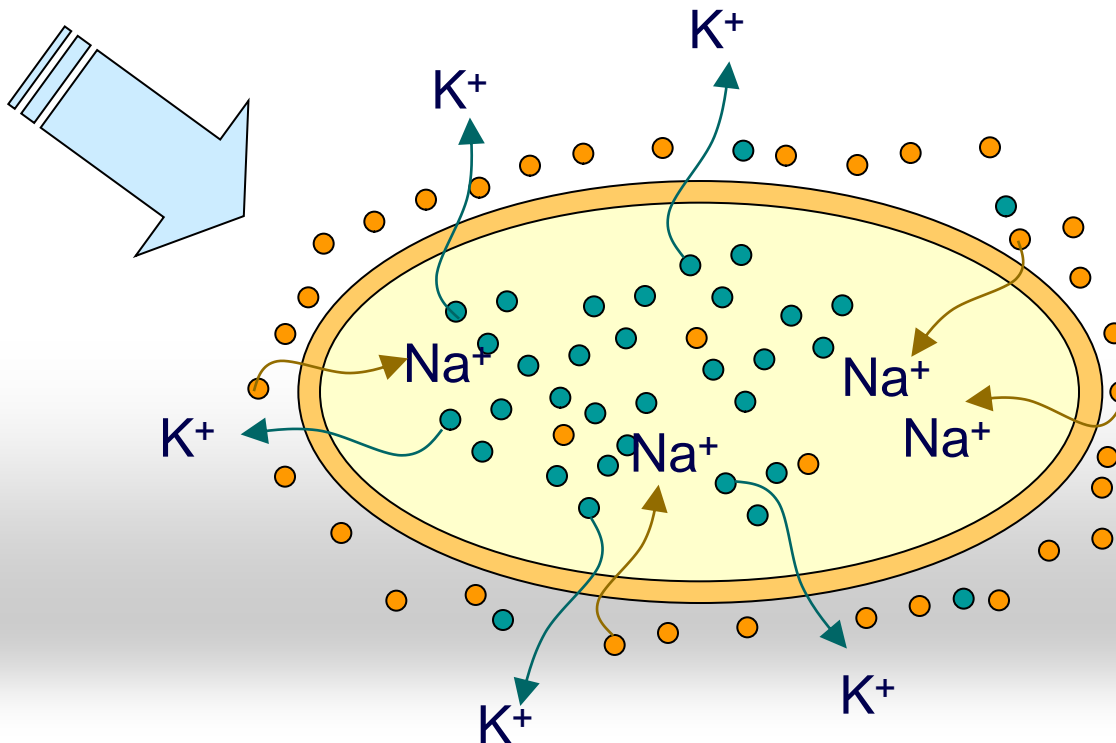
D.Waller (1856-1922) and his ECG recorder from 1887

The resting (polarized) cell



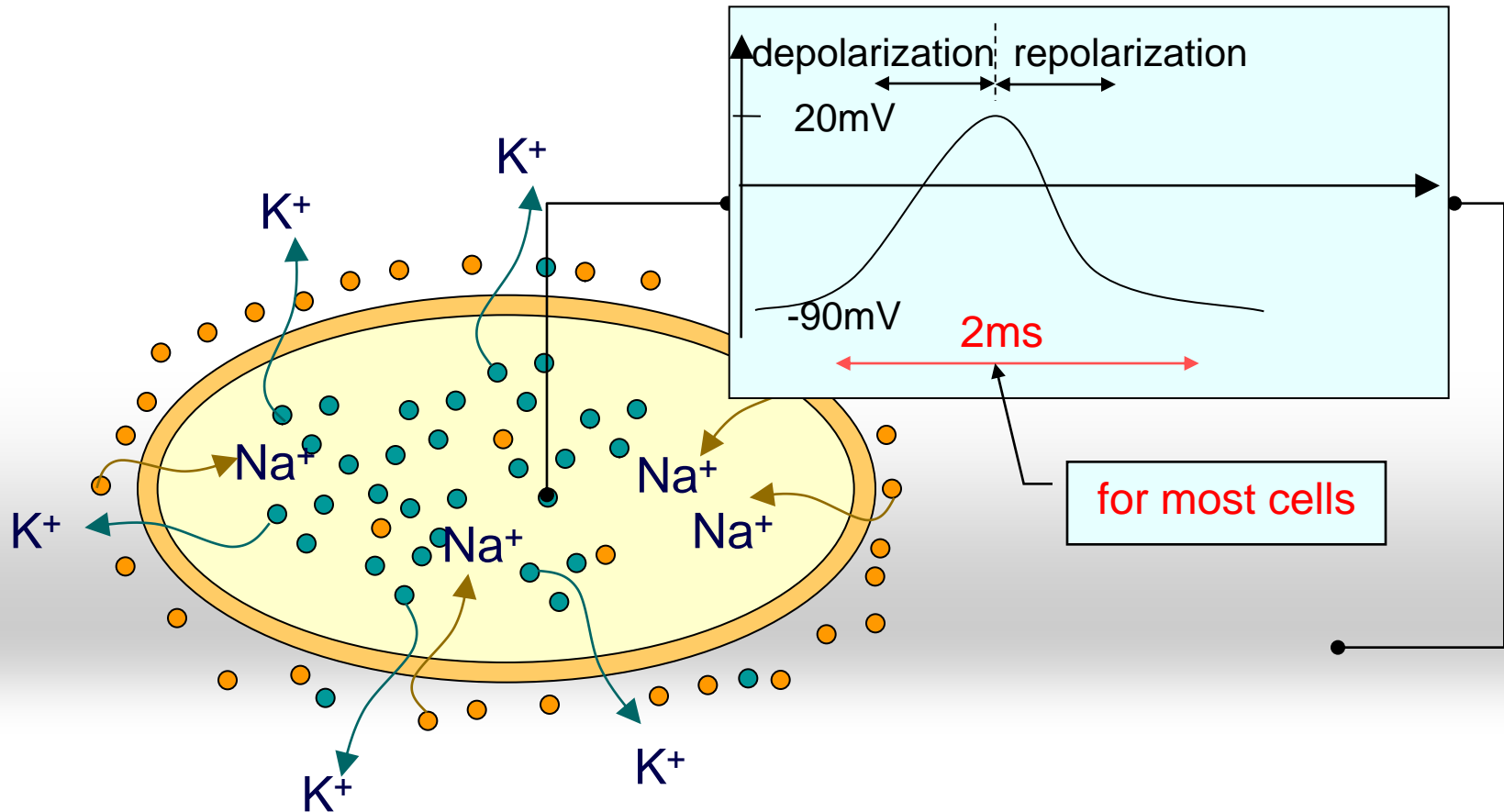
Depolarization of a cell

Electrochemical stimulus (e.g. from other cell)
is braking the resting potential balance and cell
depolarization sets in



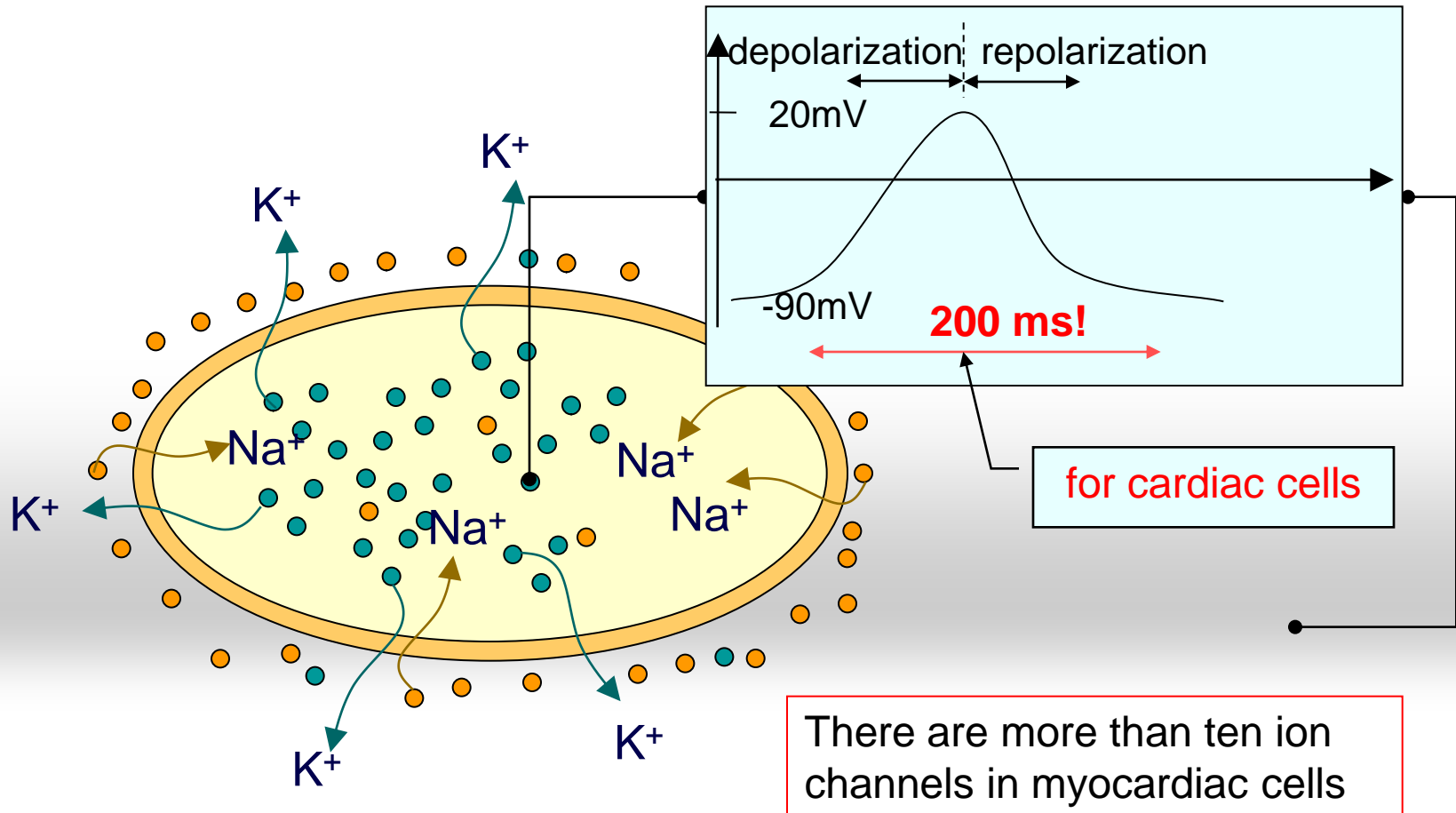
Depolarization of a cell

Cell action potential

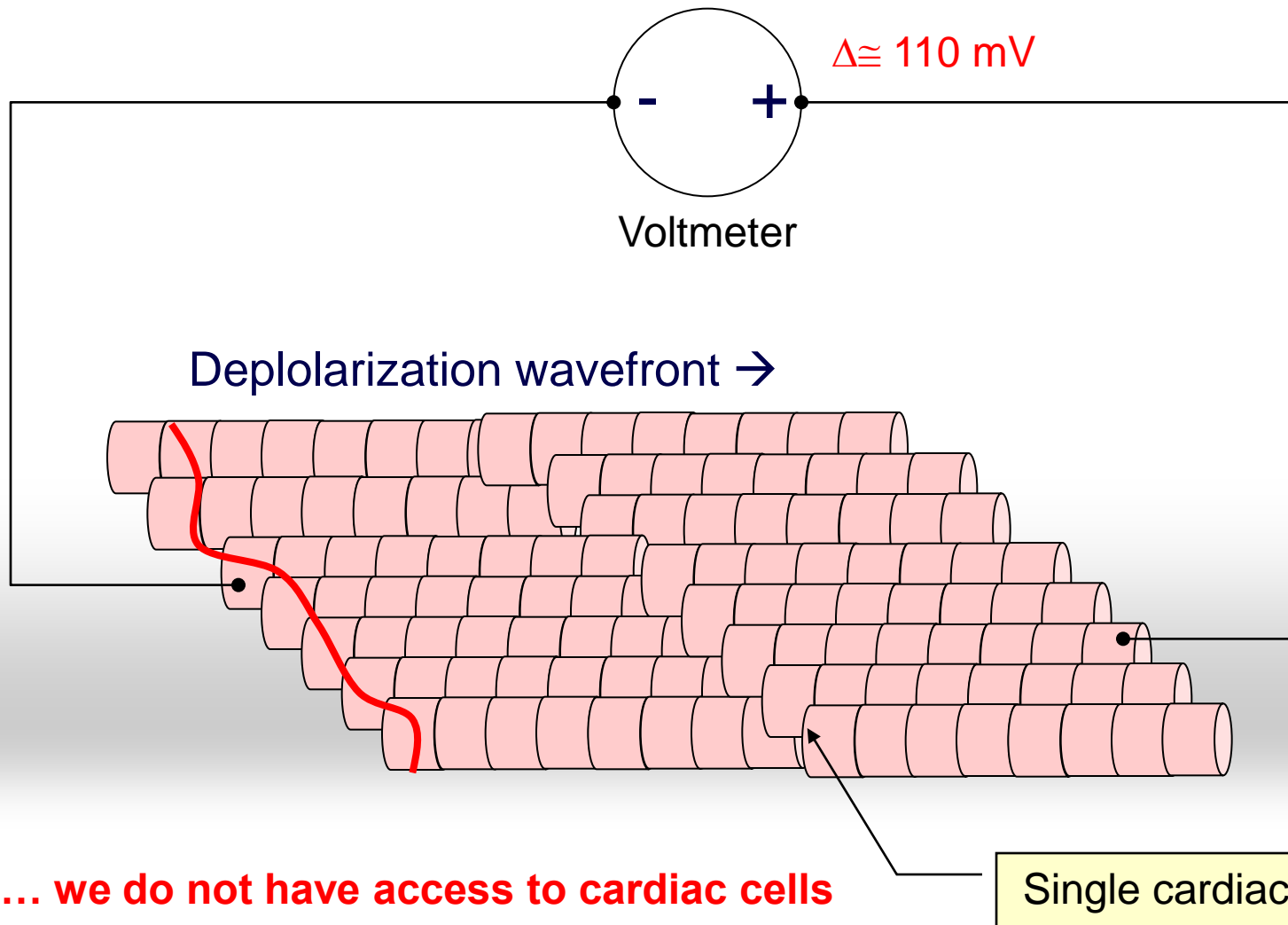


Depolarization of a cell

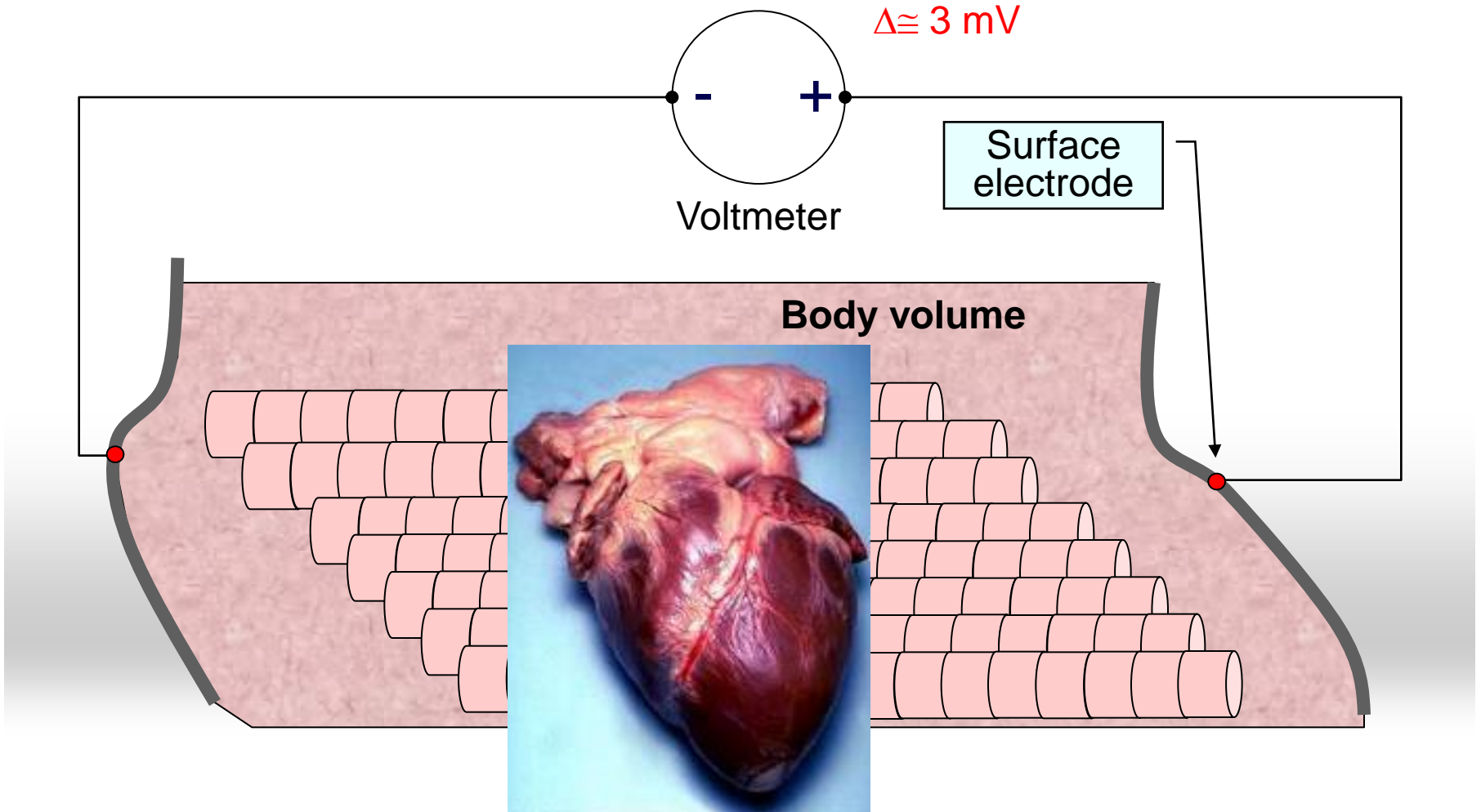
Cell action potential



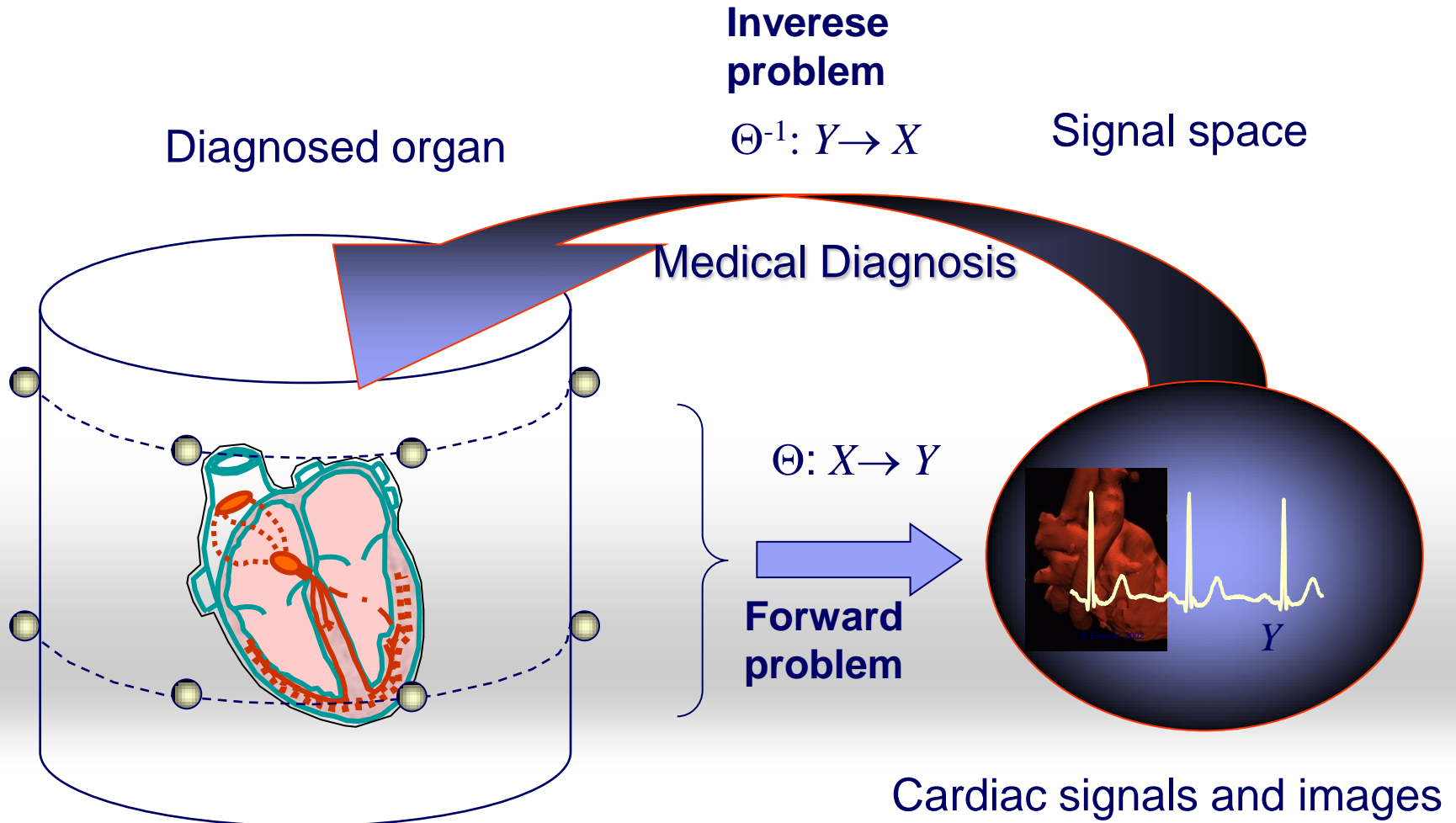
Tissue depolarization



Tissue depolarization



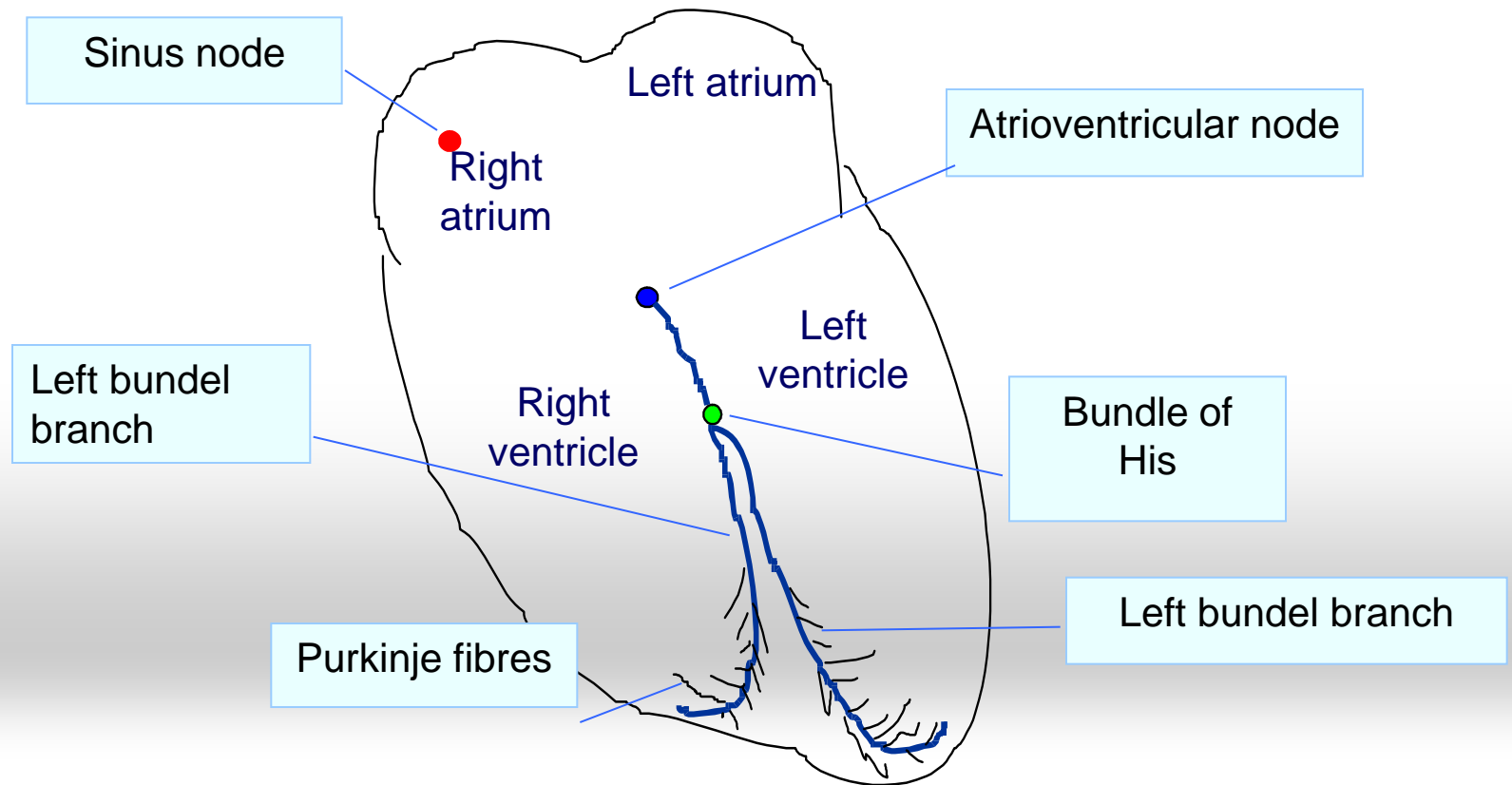
Inverse problem of electrocardiography (diagnosis)



Example ECG recording

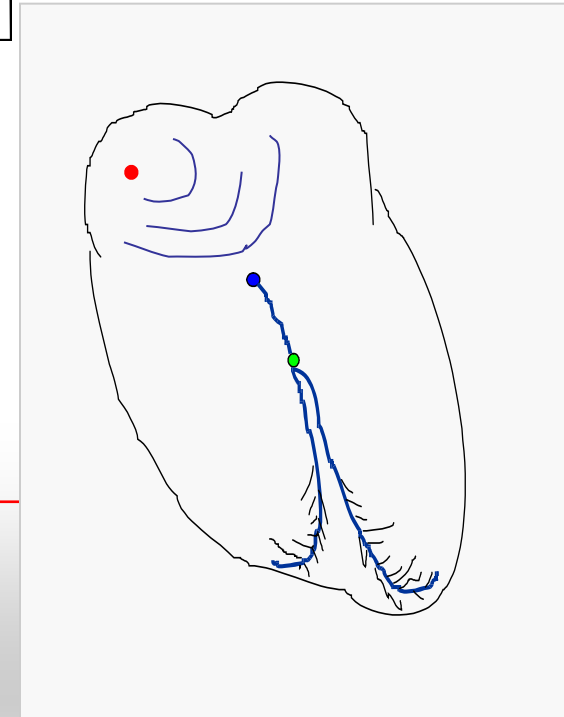
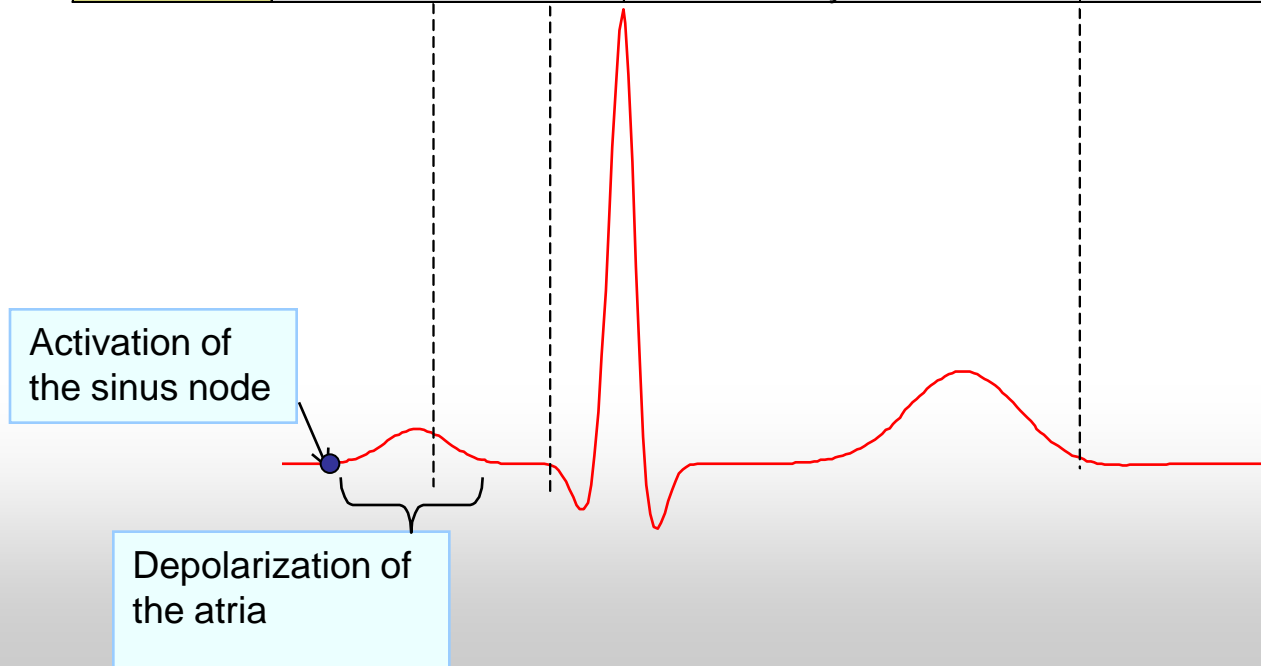


The heart conduction system



Generation of ECG cycle

Atria	Diastole	Systole	Diastole
Chambers	Diastole	Systole	Diastole

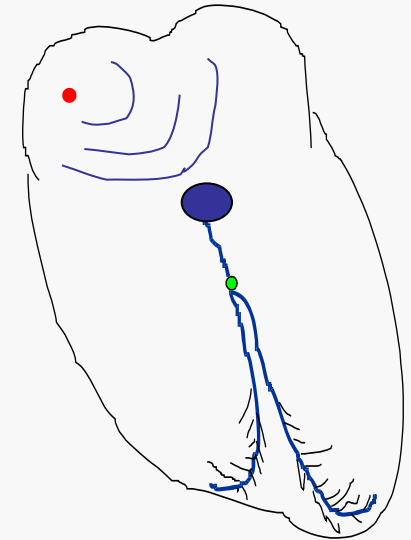
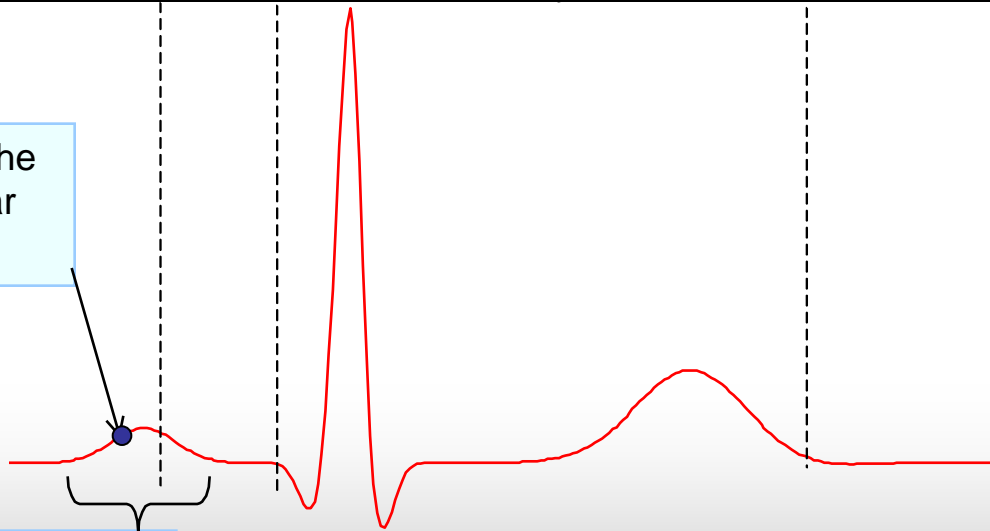


Generation of ECG cycle

Atria	Diastole	Systole	Diastole
Chambers	Diastole	Systole	Diastole

Activation of the
atrioventricular
node

Activation of the
atria

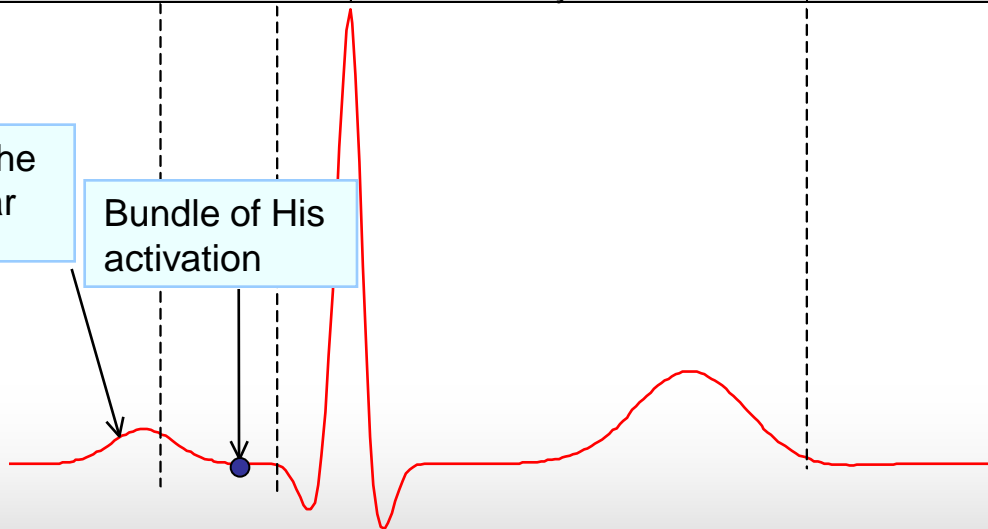


Generation of ECG cycle

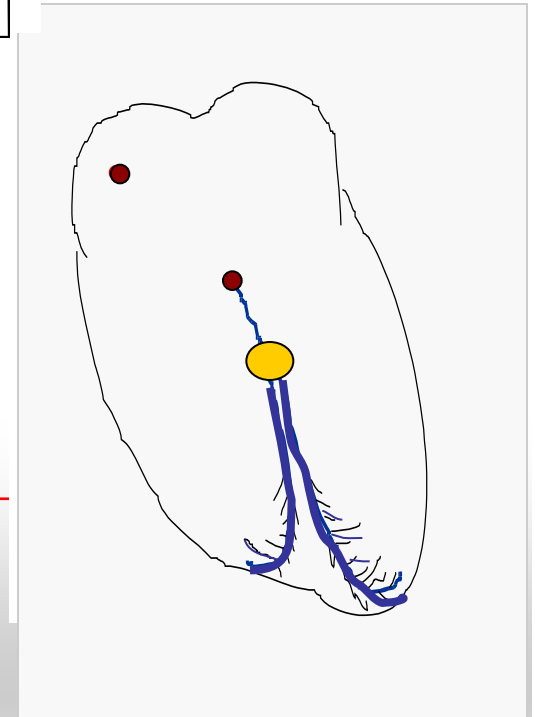
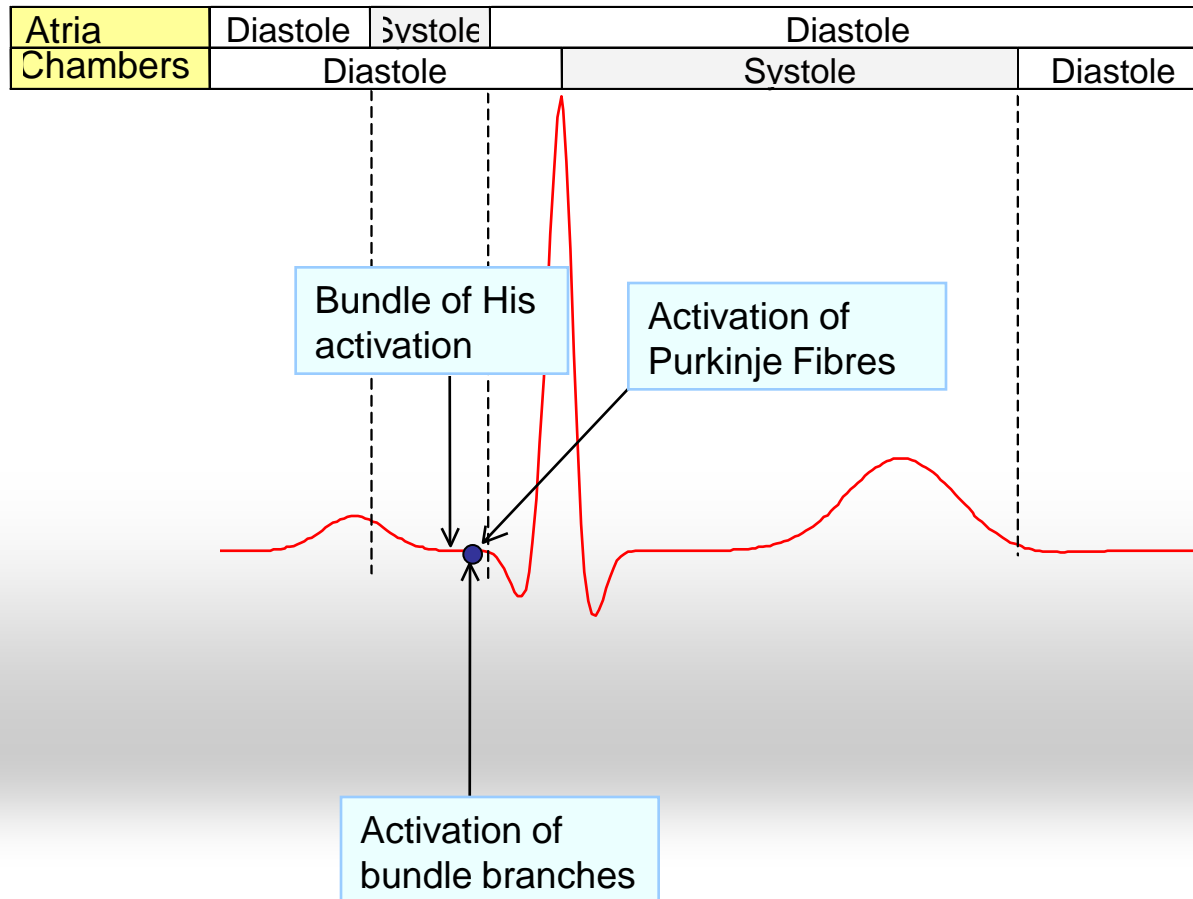
Atria	Diastole	Systole	Diastole
Chambers	Diastole	Systole	Diastole

Activation of the
atrioventricular
node

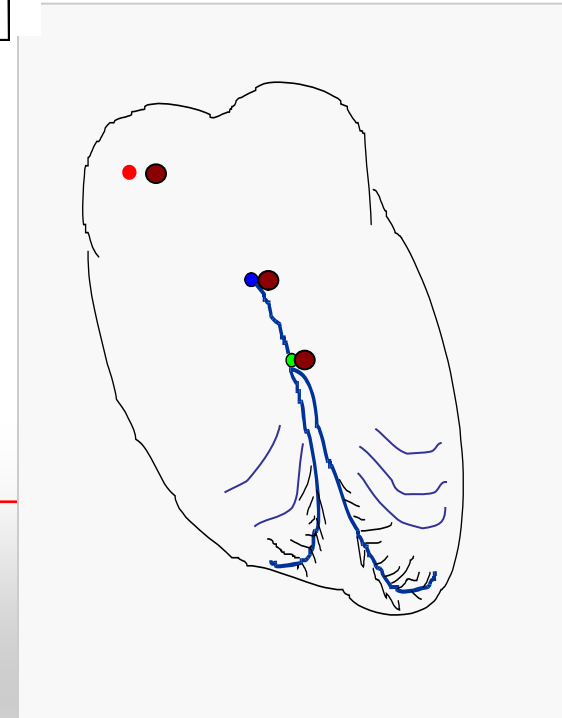
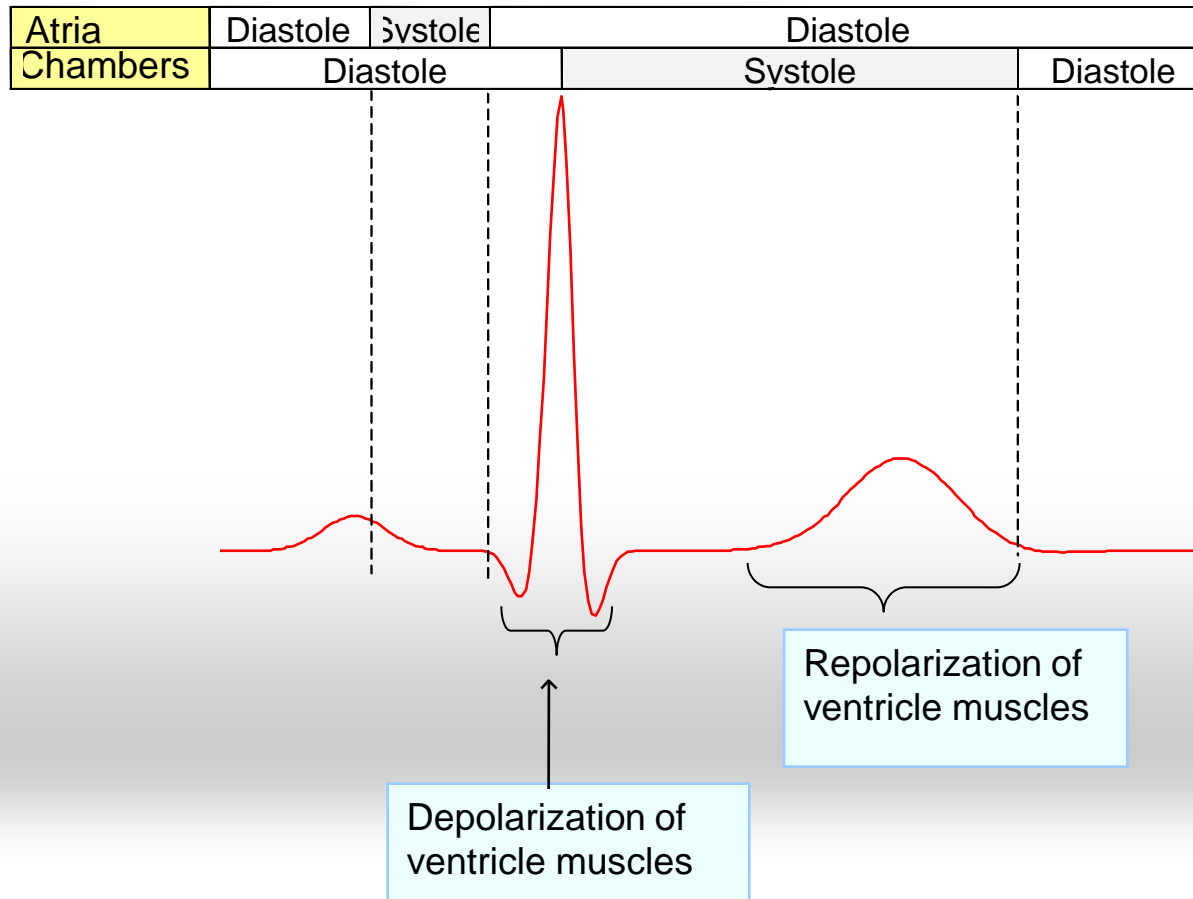
Bundle of His
activation



Generation of ECG cycle



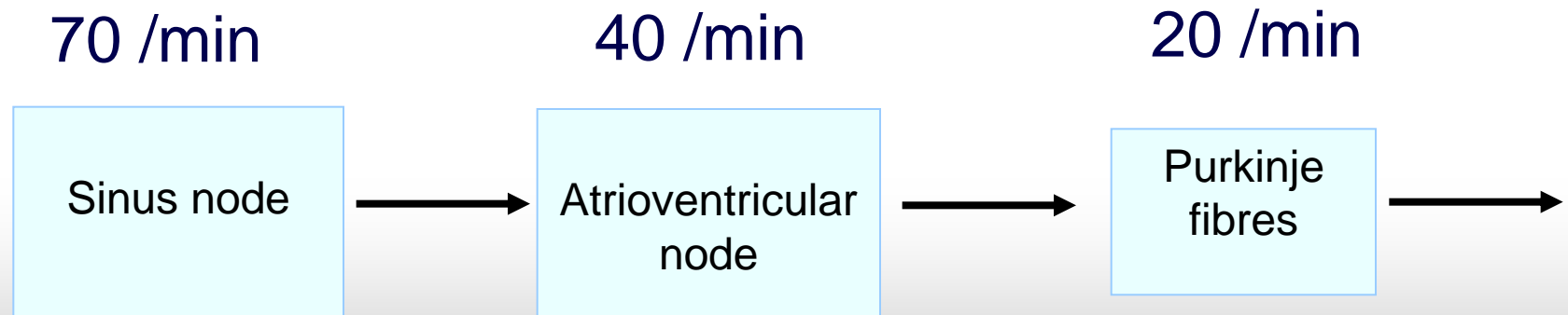
Generation of ECG cycle





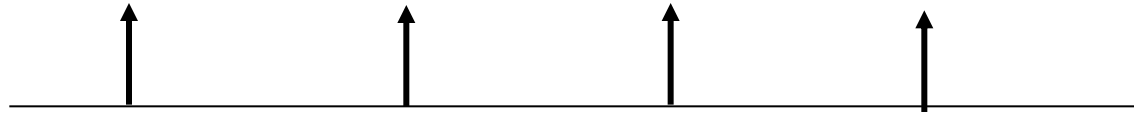
The cardiac oscillators

Autonomous oscillators frequency

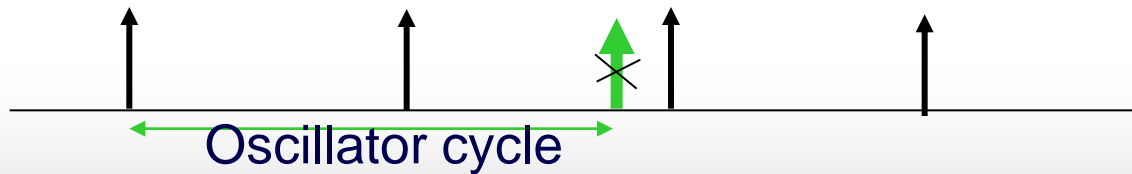


The cardiac oscillators

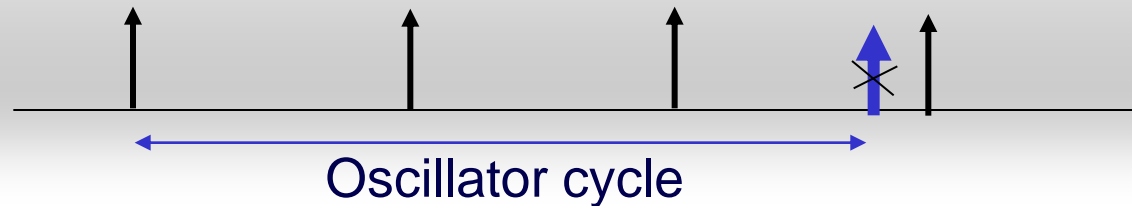
Sinus node
oscillator



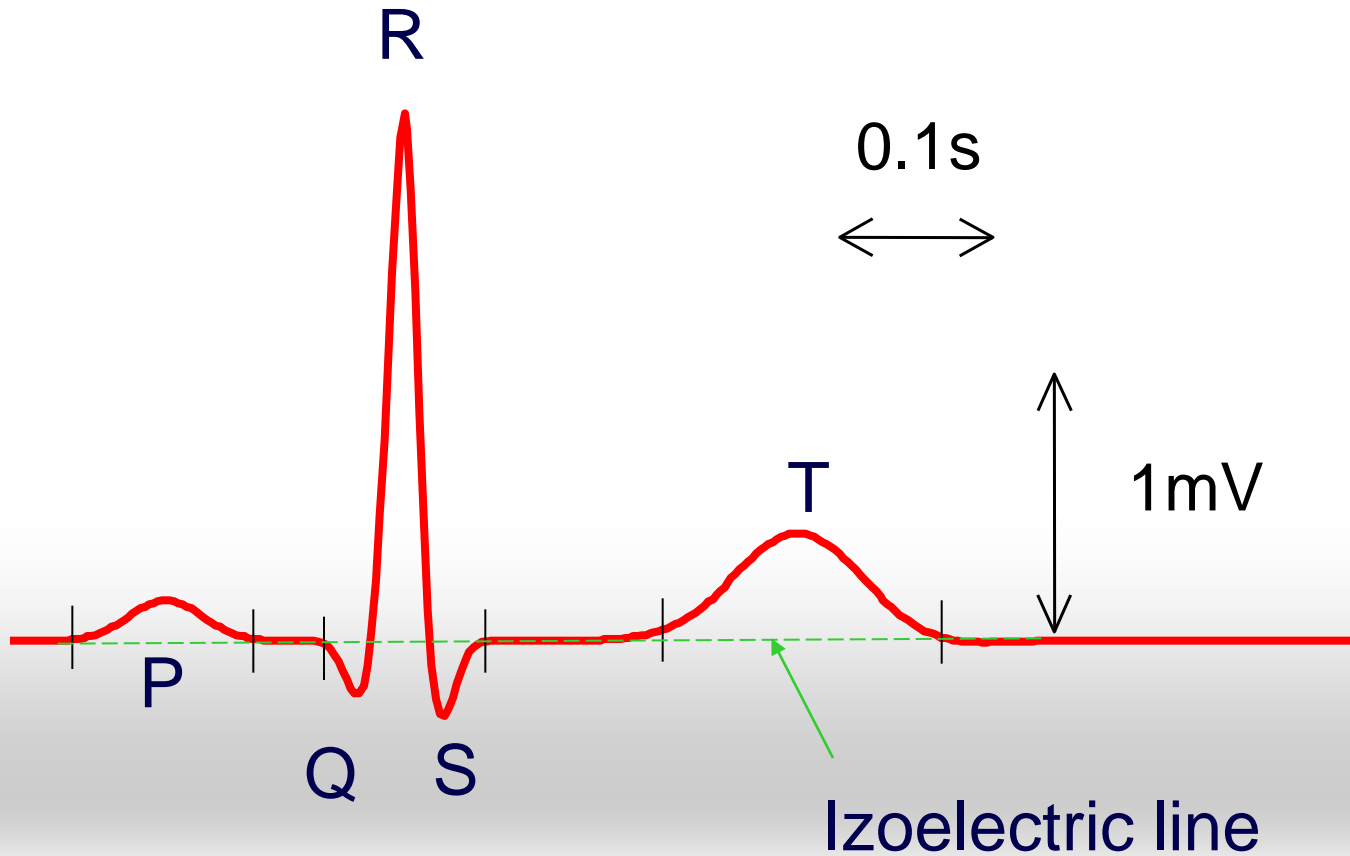
Atrioventricular
node oscillator



Purkinje
fibres

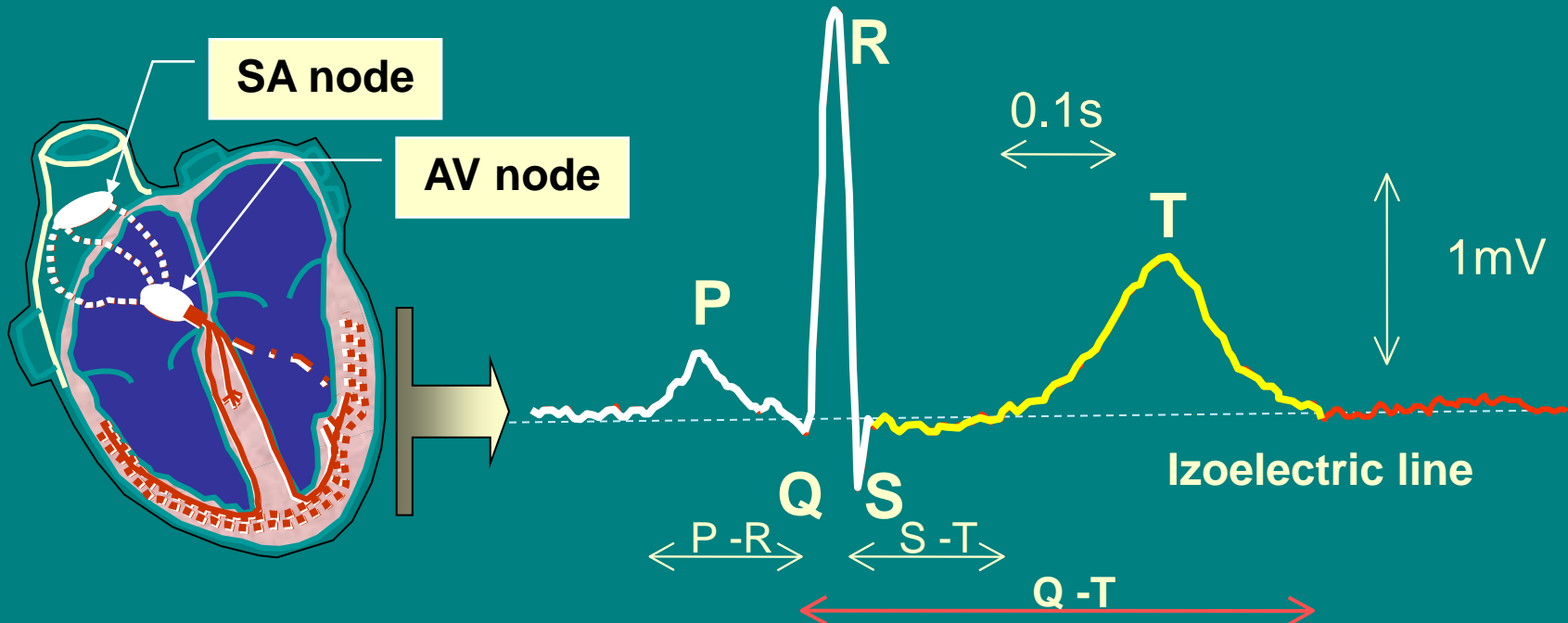


ECG waveforms



The electrocardiogram

~7500 liters daily!

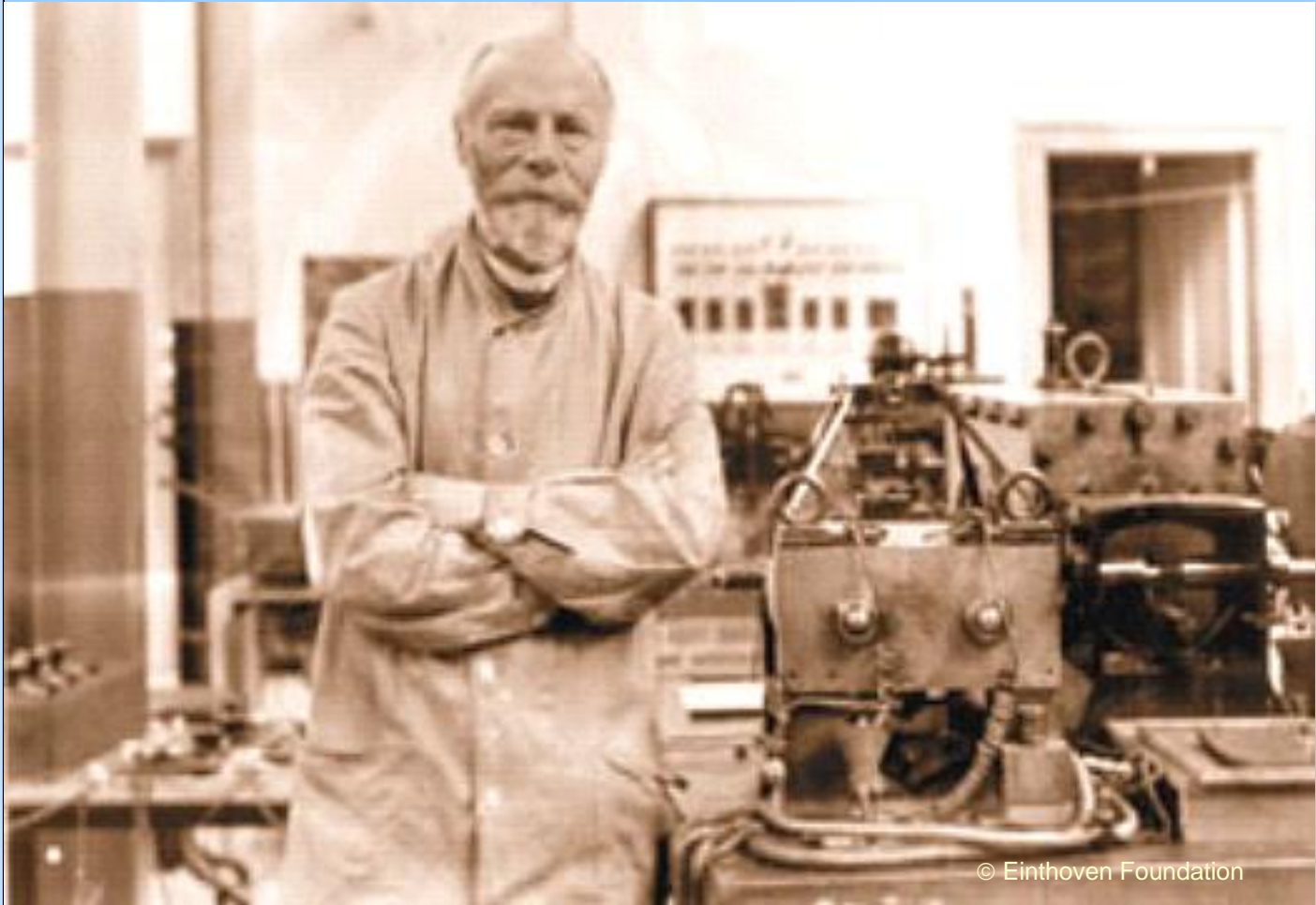




Willem Einthoven (1860-1927) – the father of modern electrocardiography

Medical Electronics

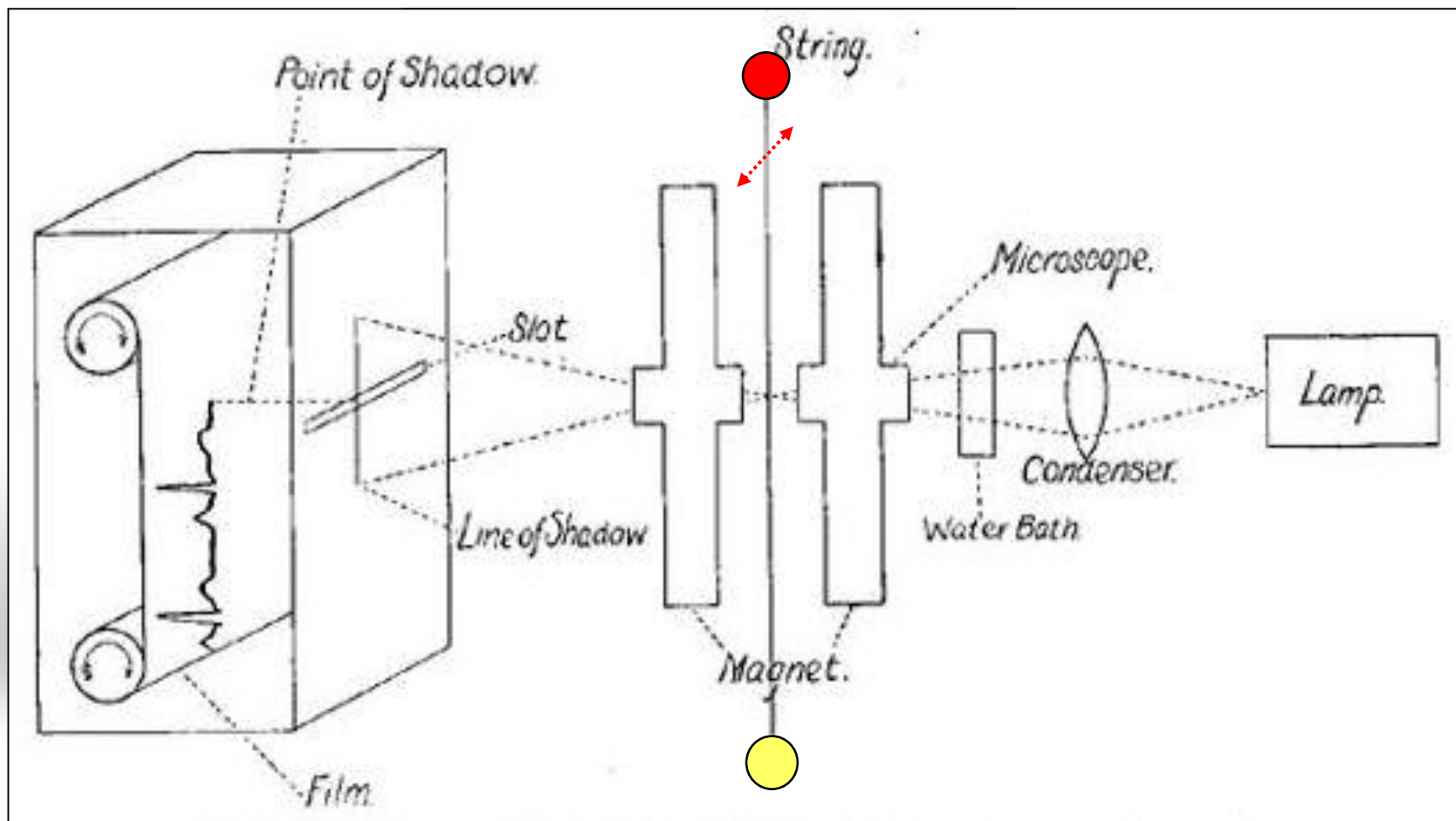
24



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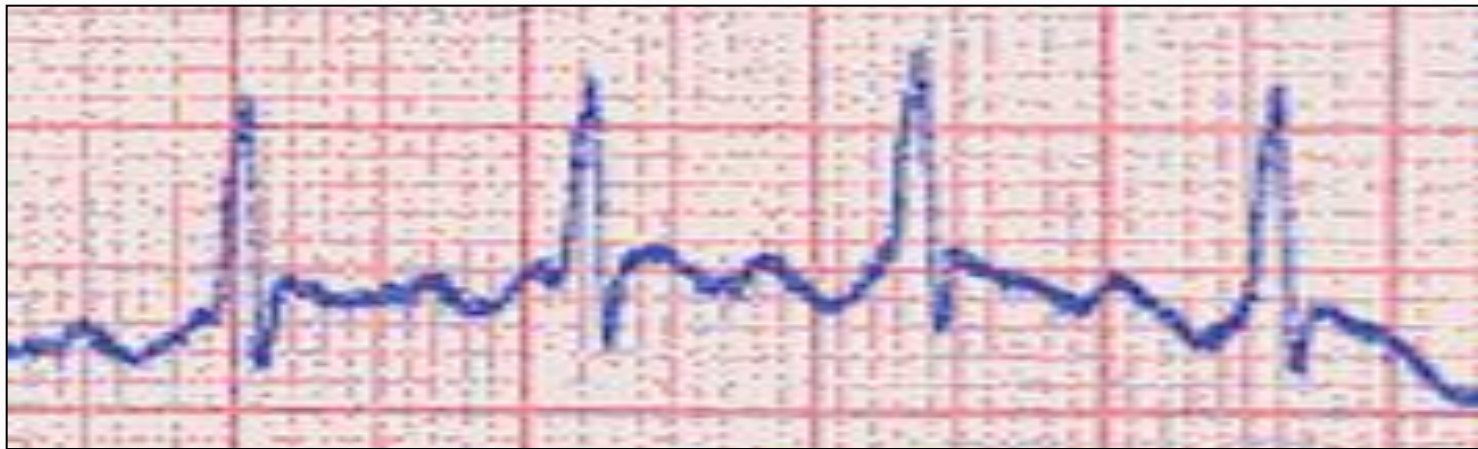
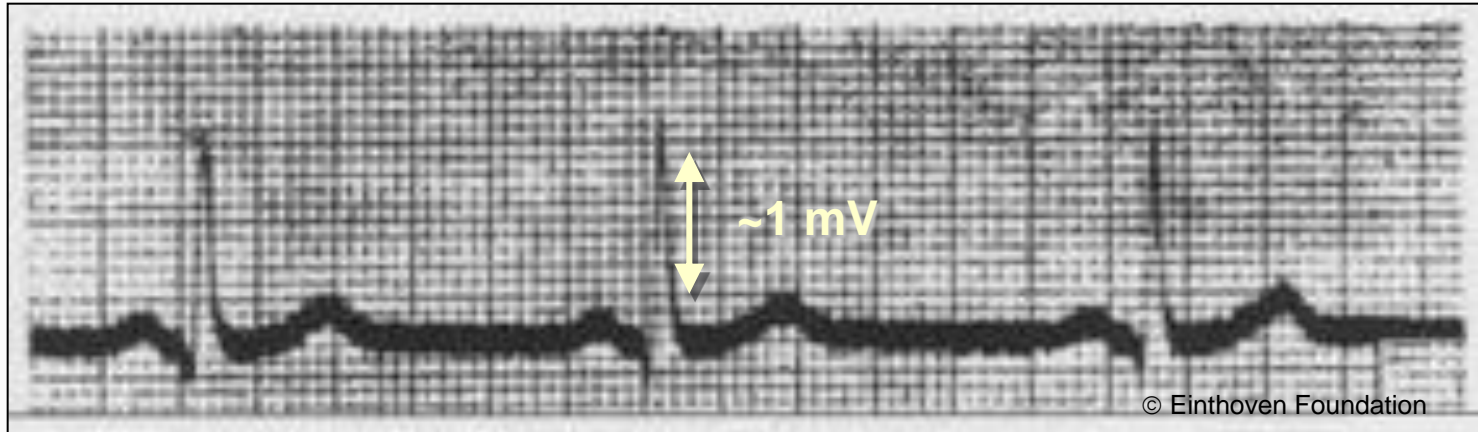


Einthoven's string galvanometer

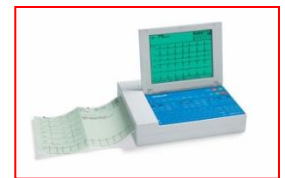
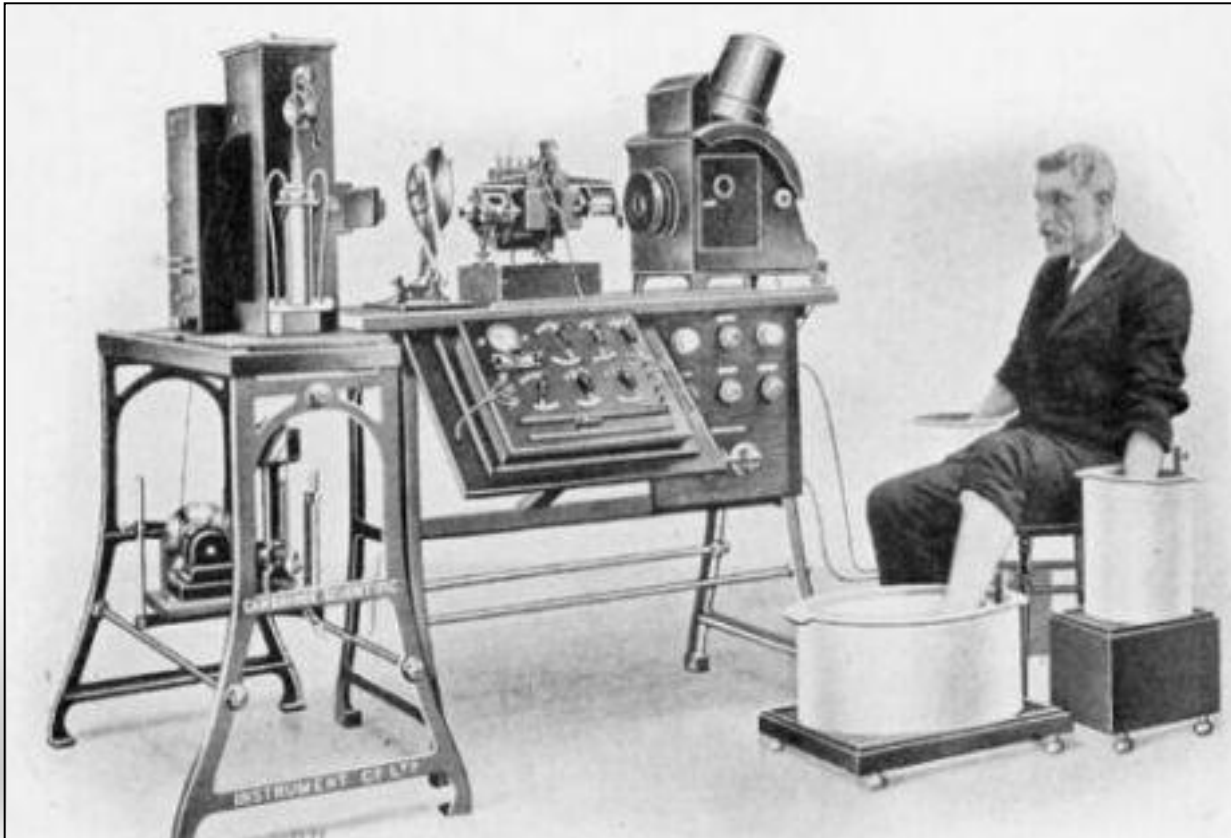


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First Einthoven's recordings



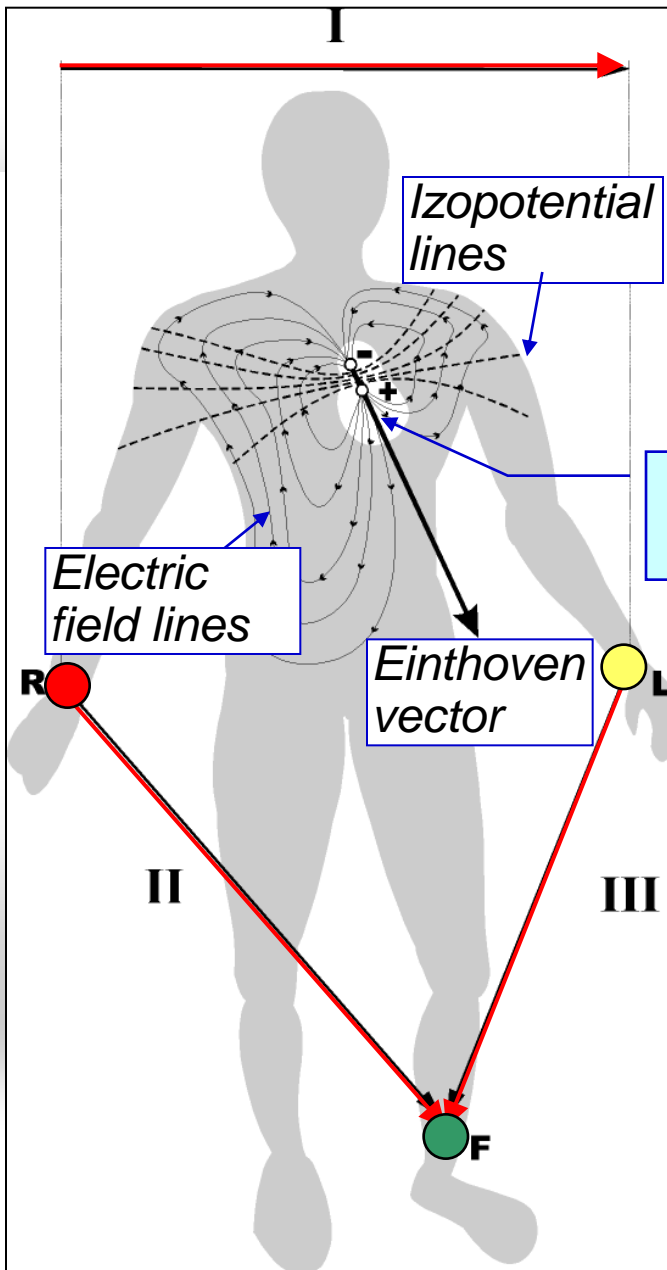
First Einthoven's recordings



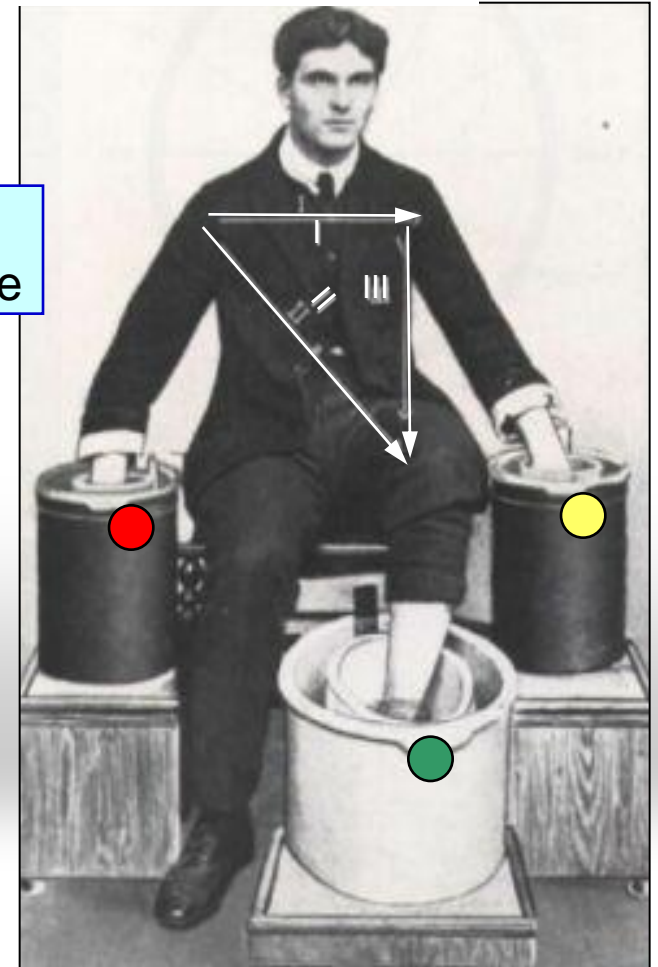
2003

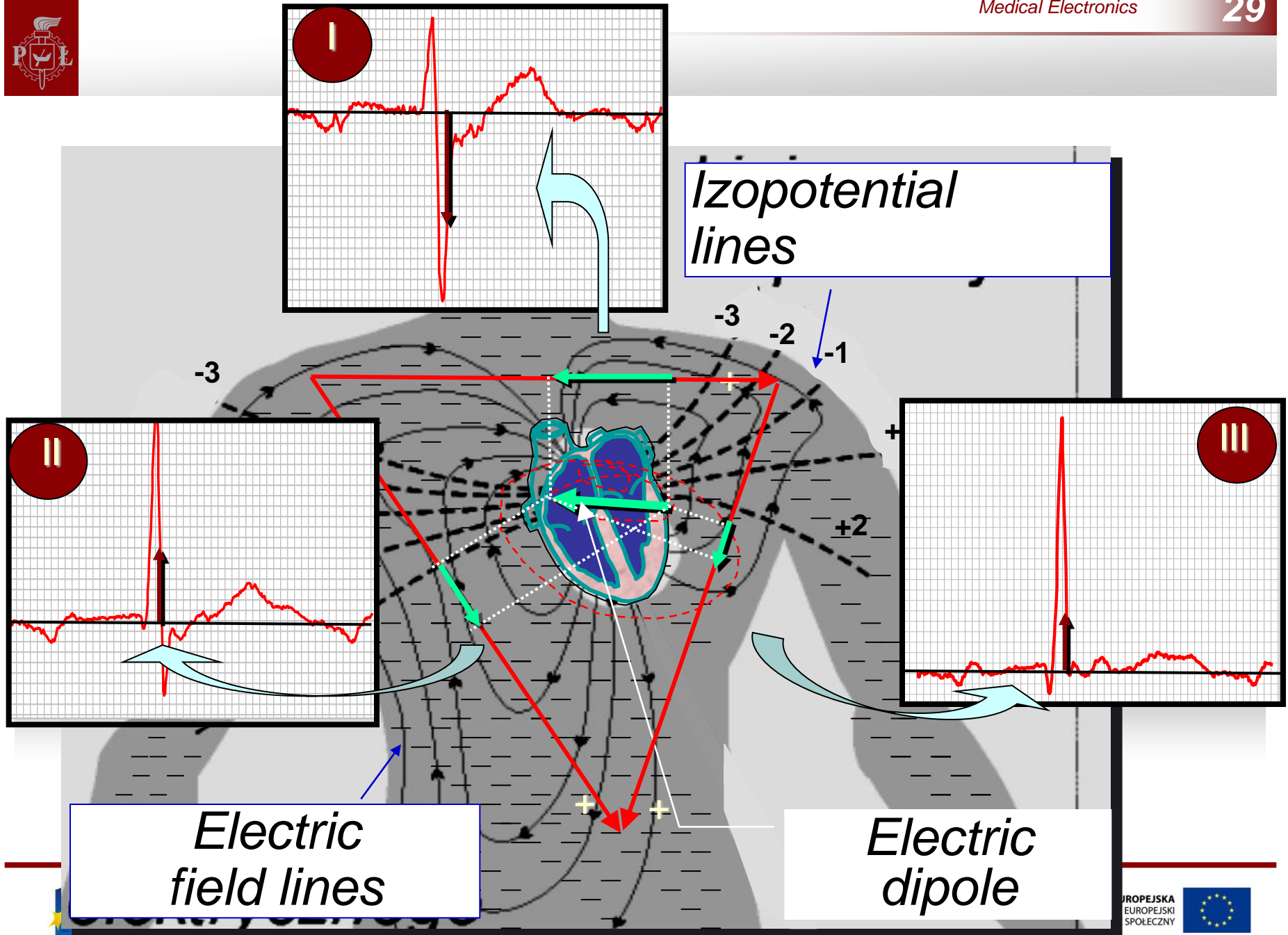
**Nobel Prize in 1924,
for „explaining the mechanism of electrocardiogram”**

The Einthoven triangle (limb leads)

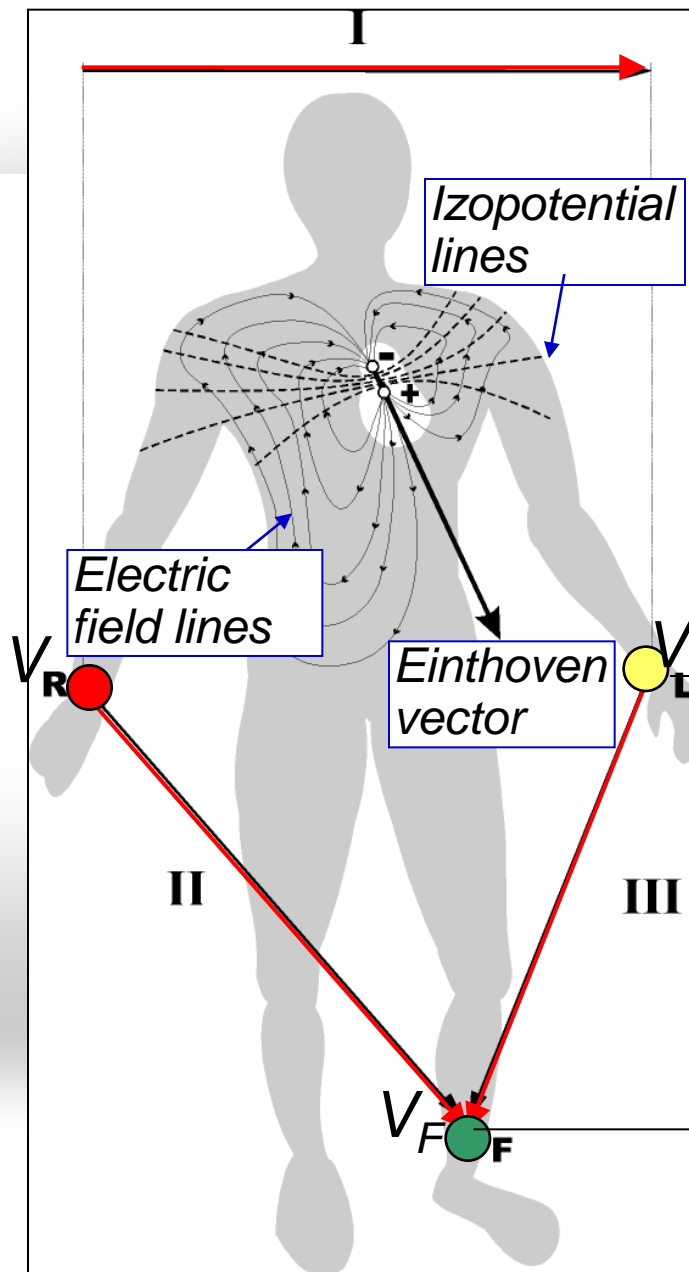


Heart as an electrical dipole





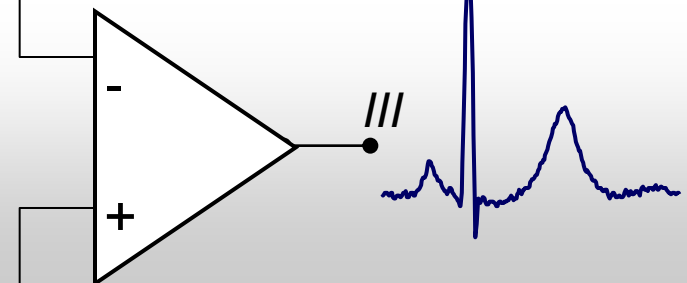
The Einthoven triangle (limb leads)



$$I = V_L - V_R$$

$$II = V_F - V_R$$

$$III = V_F - V_L$$

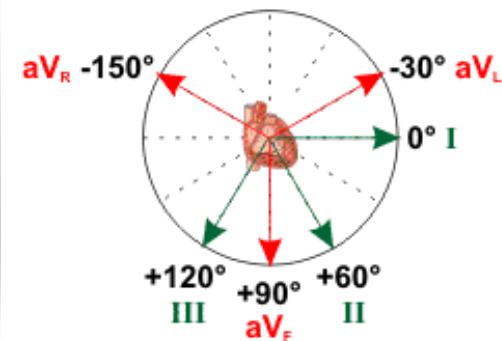
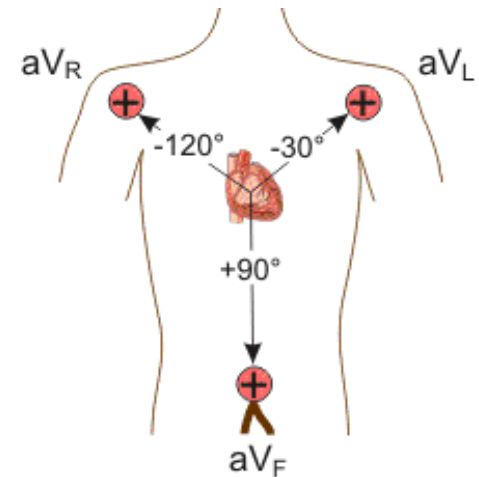
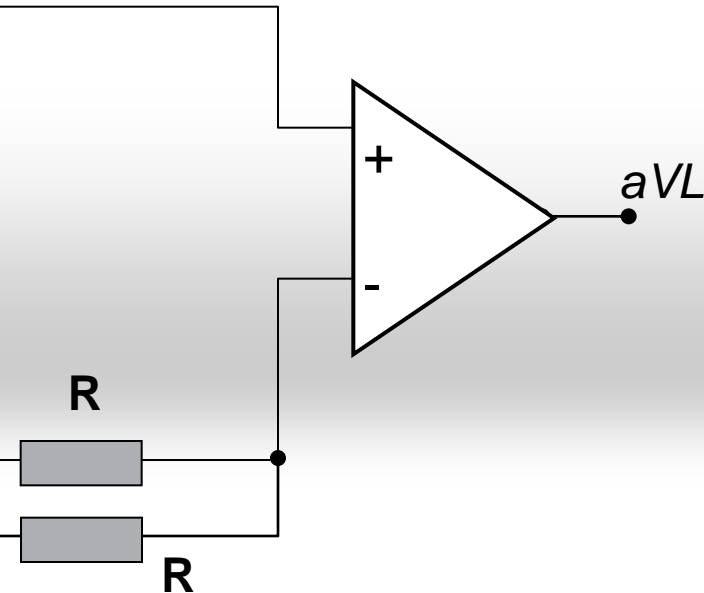
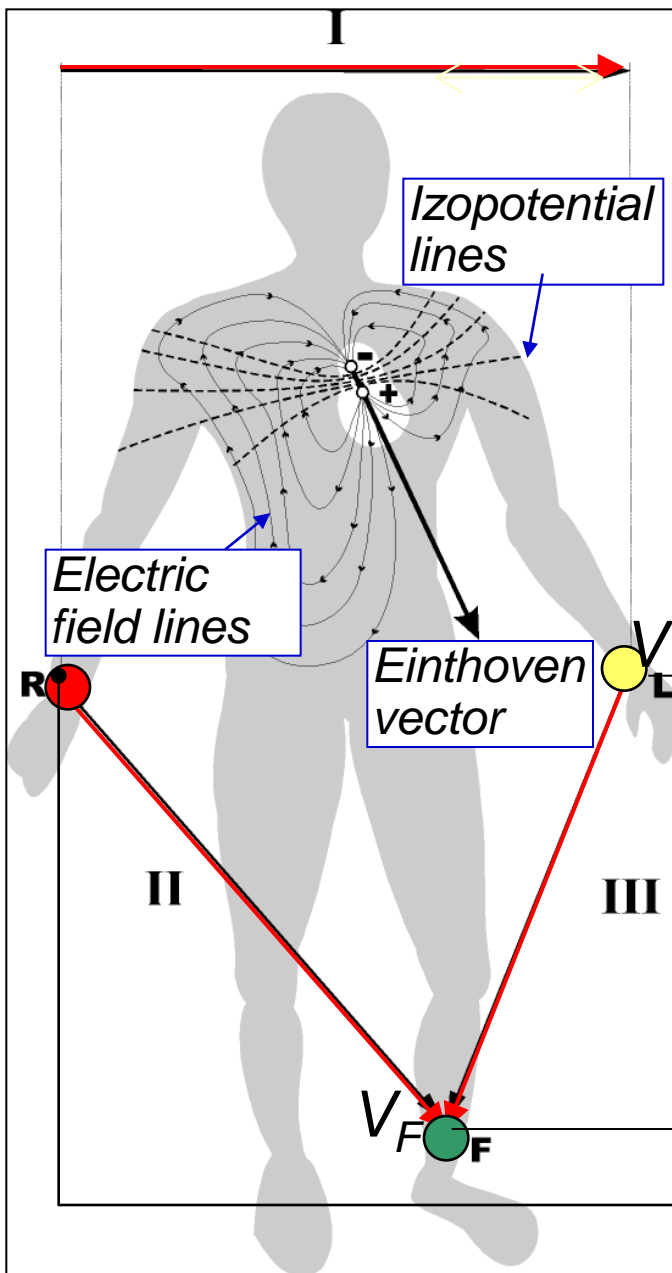


Augmented limb leads (unipolar leads)

$$aVR = V_R - (V_F + V_L)/2$$

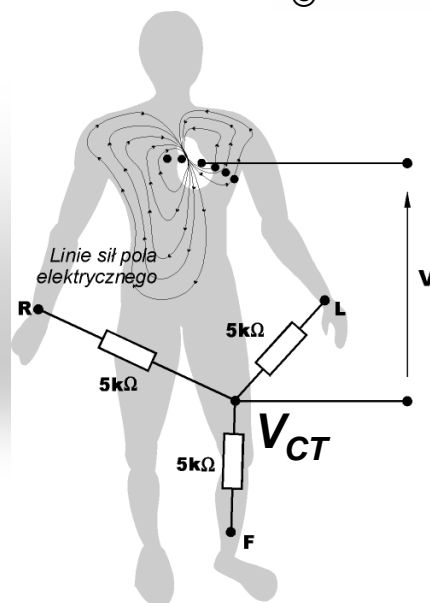
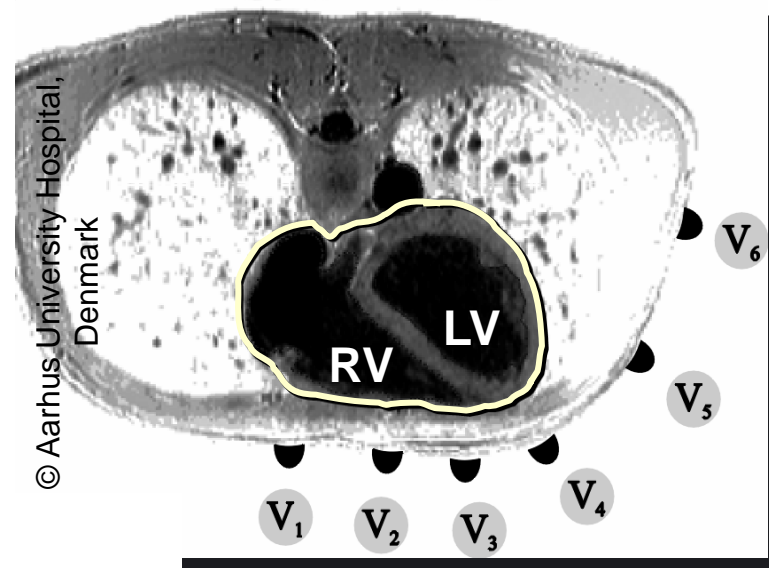
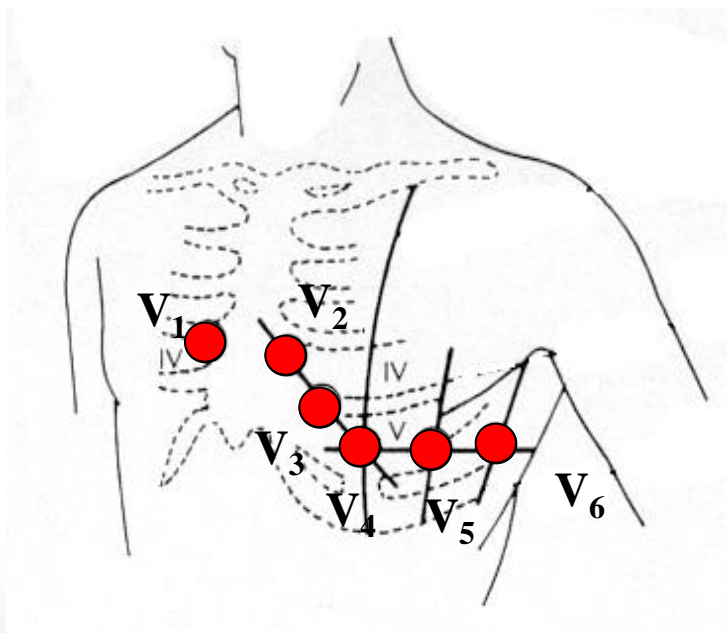
$$aVL = V_L - (V_R + V_F)/2$$

$$aVF = V_F - (V_R + V_L)/2$$



www.cvphysiology.com

Precordial leads



$$V_j = V_{V_j} - V_{CT}$$

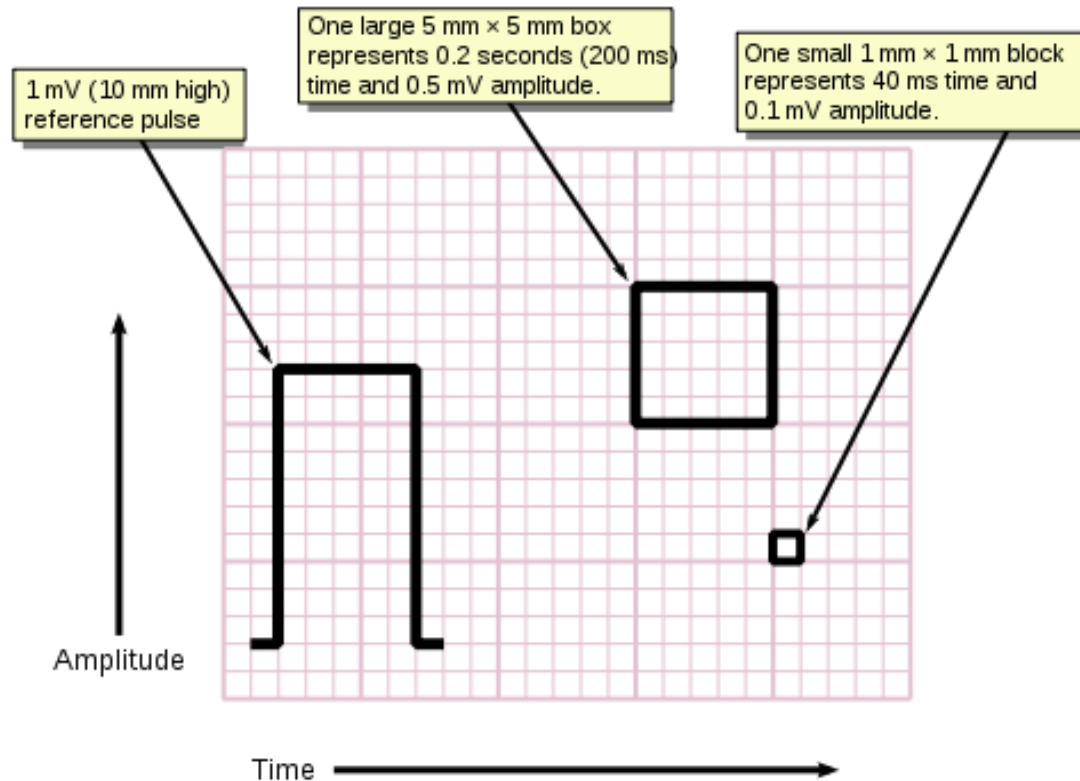
where:

$$j = \{1, 2, \dots, 6\}$$

$$V_{CT} = (V_L + V_R + V_F) / 3$$



ECG graph paper

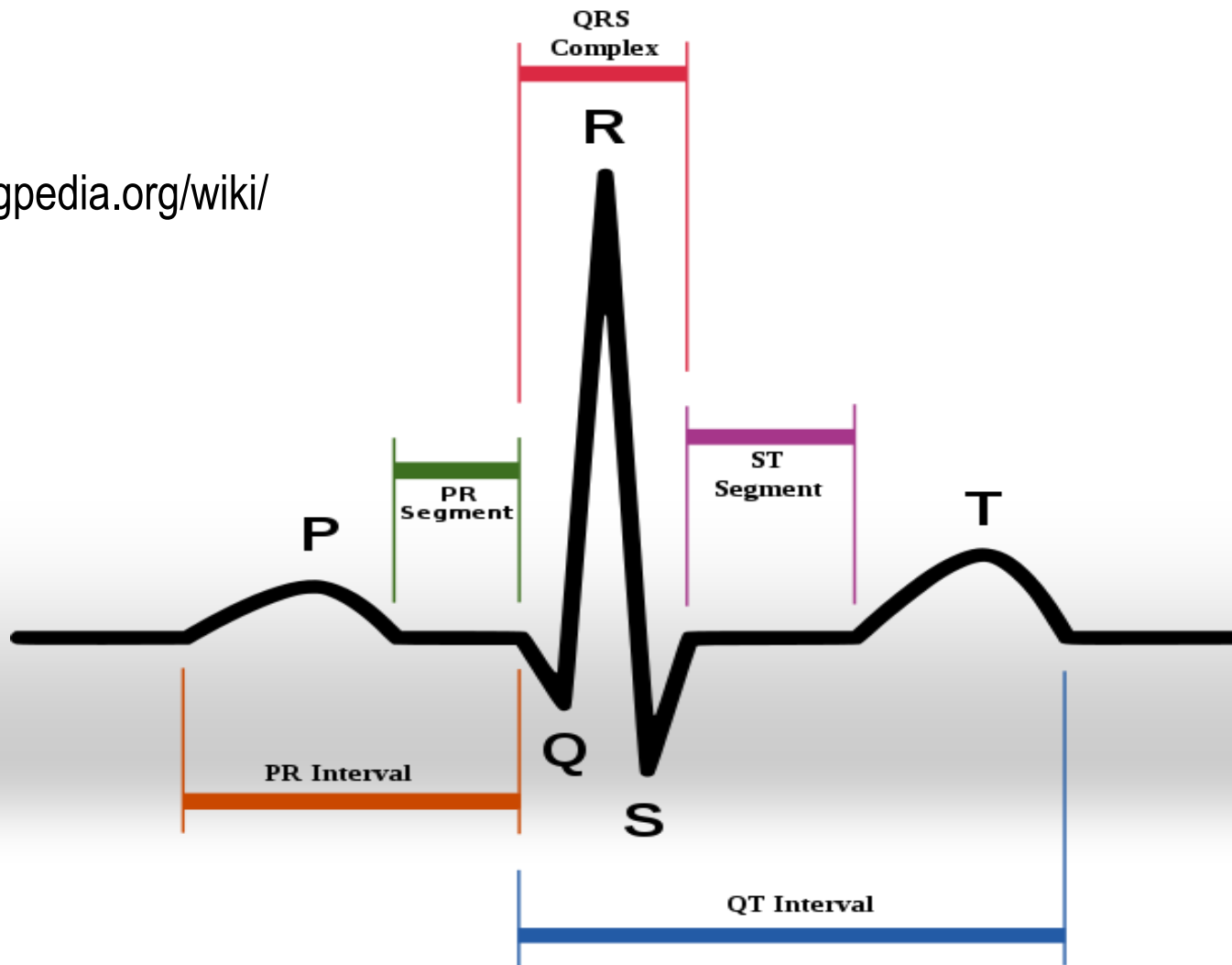




ECG intervals and segments

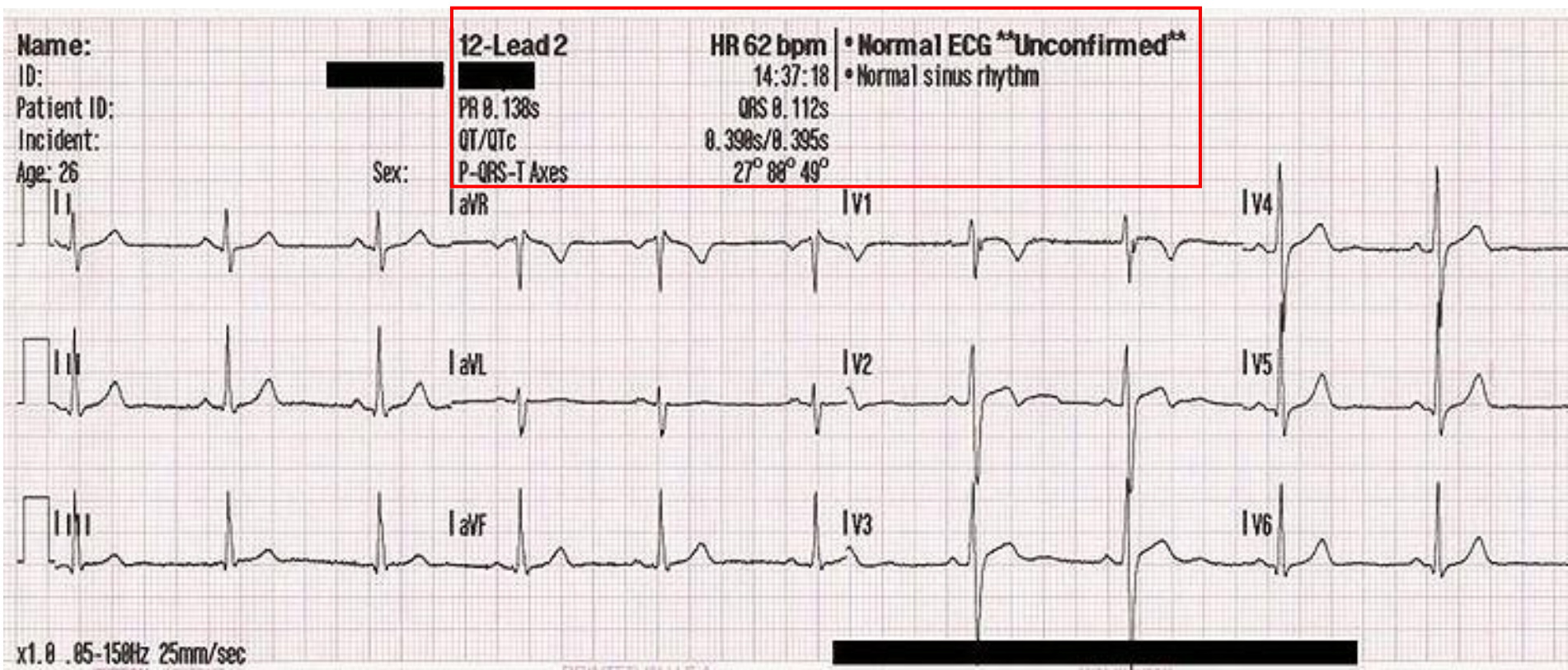
See also :

<http://en.ecgpedia.org/wiki/>





12 lead ECG plot example

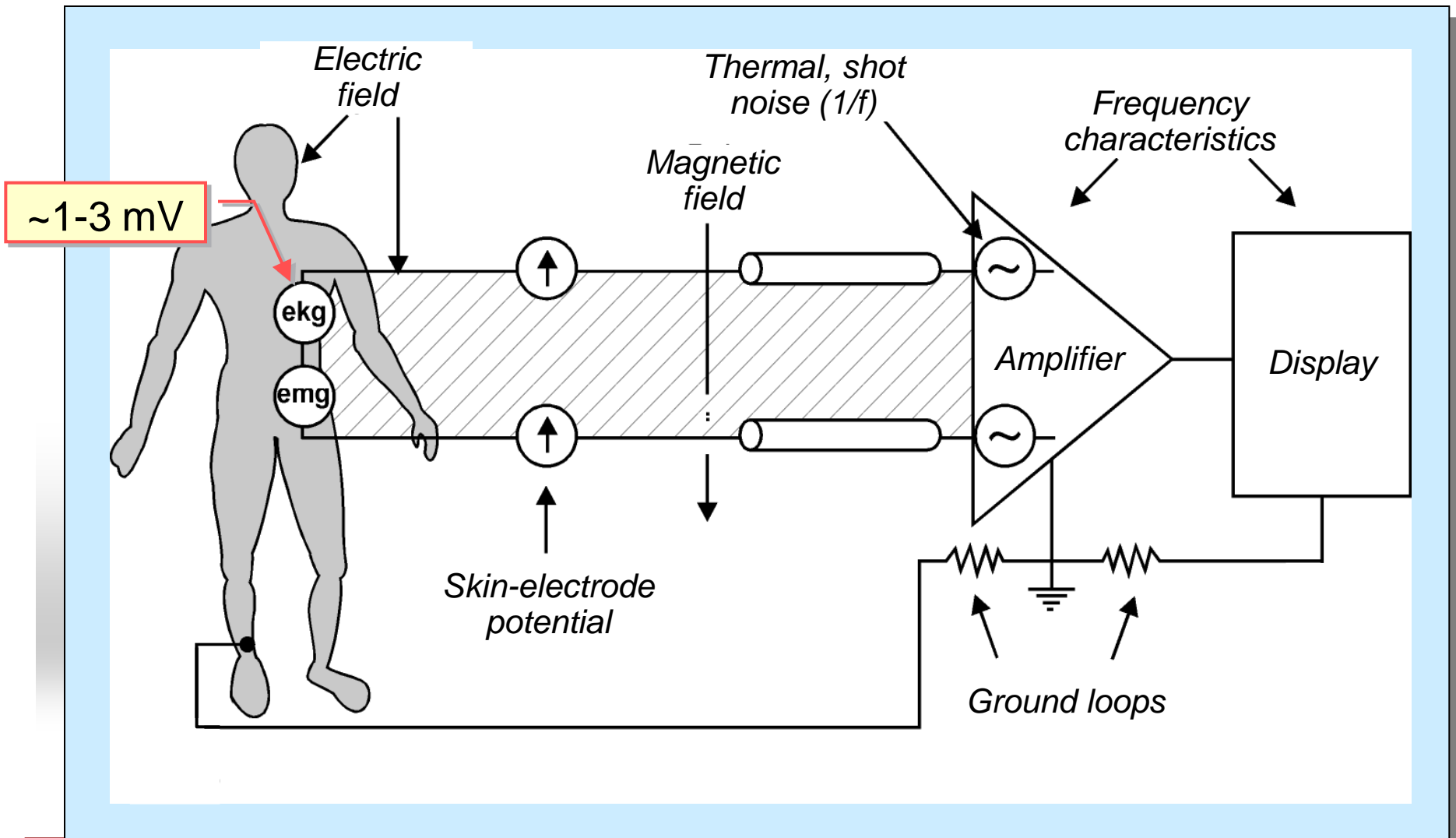


$$QTc = \frac{QT}{\sqrt{RR(sec)}}$$

- QT interval corrected for the heart rate
(normal range <0.3, 0.44>)

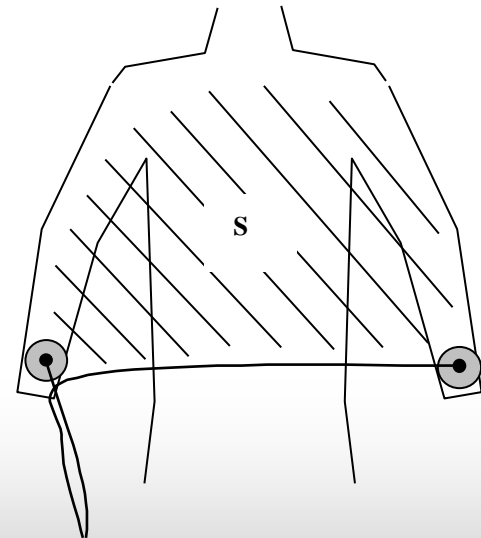
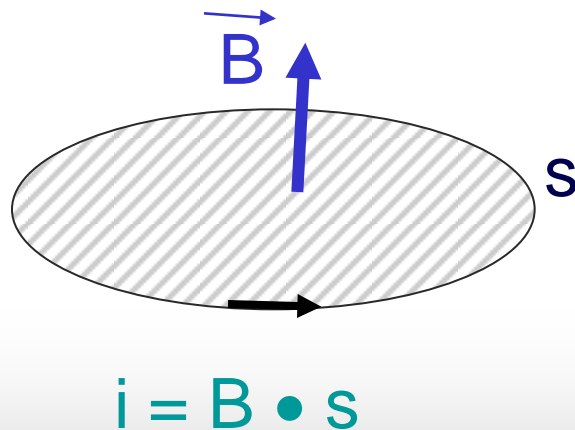


ECG recording – noise sources



Interferences – magnetic field

Electromagnetic induction

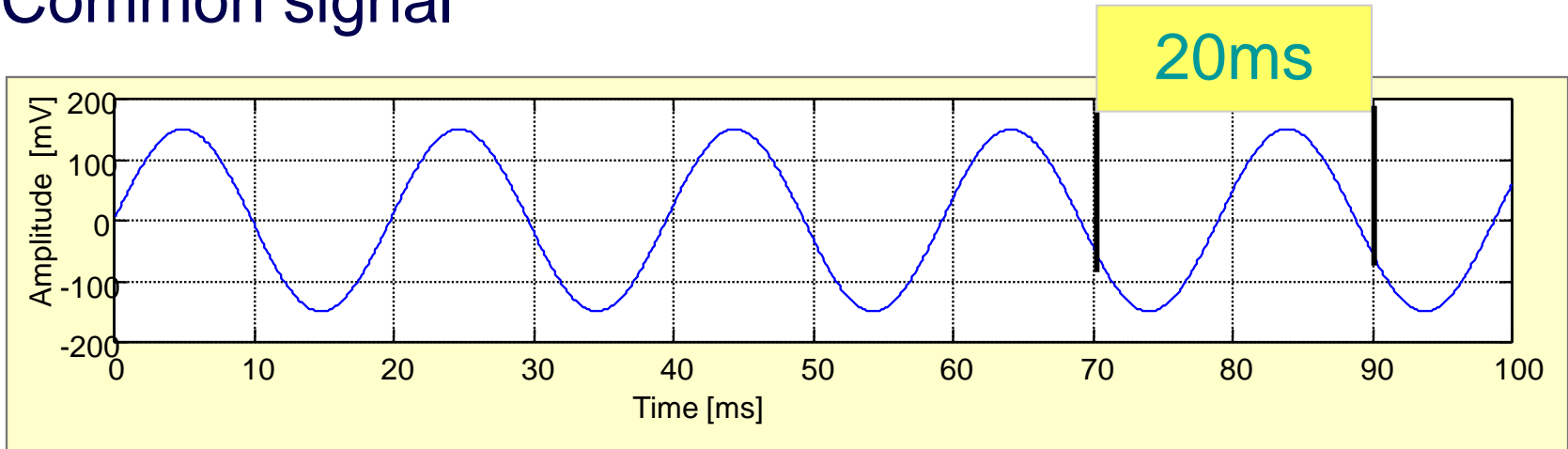


The area formed by the lead wires and the body

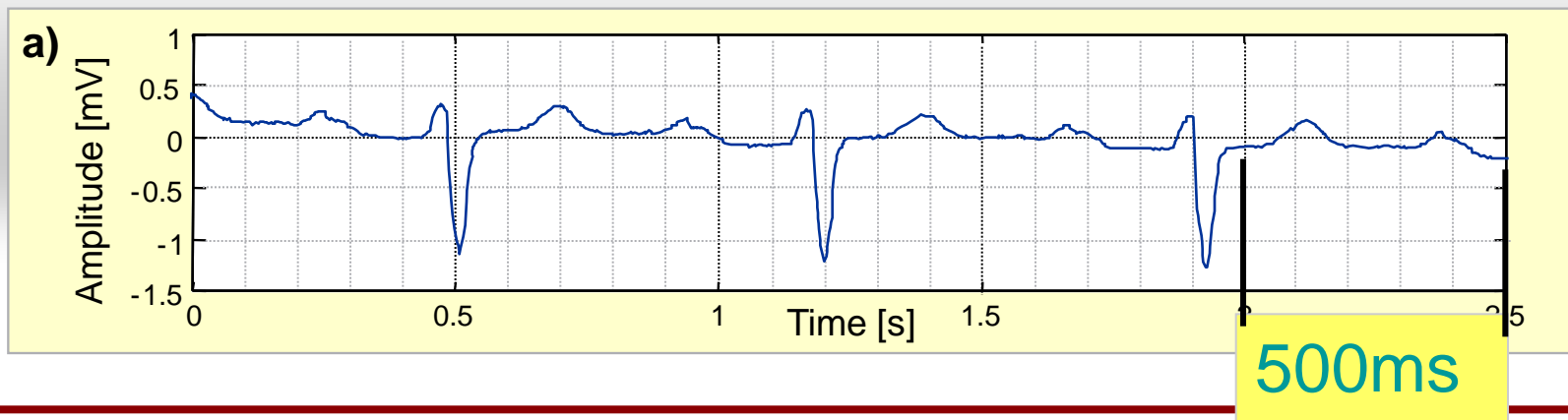
We should minimize this area!

Powerline interferences

Common signal

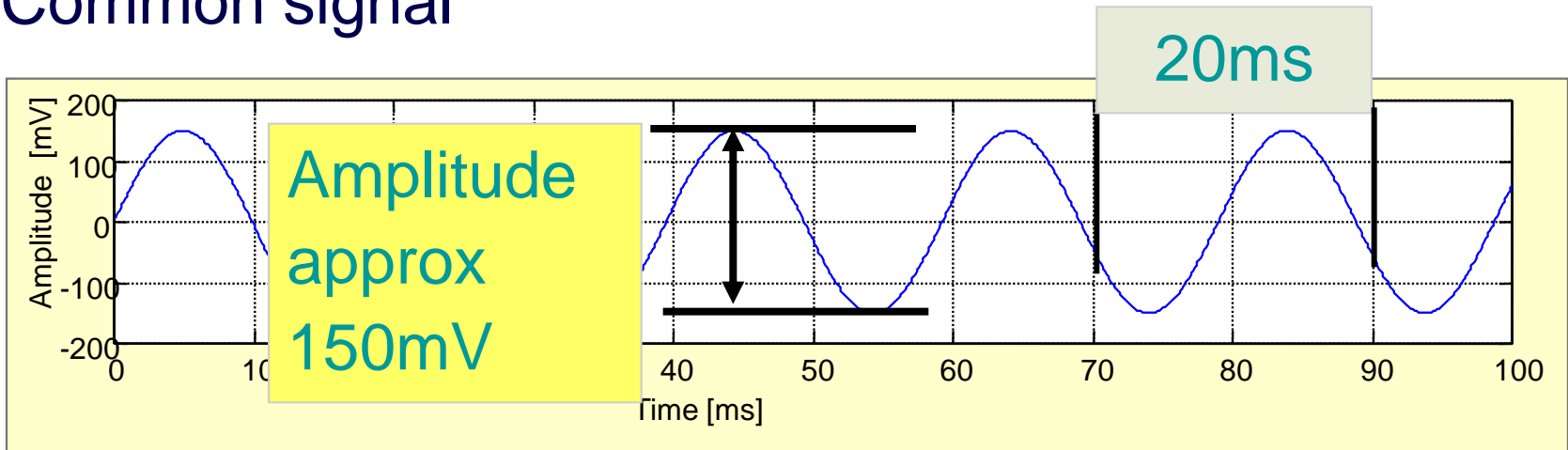


Difference signal

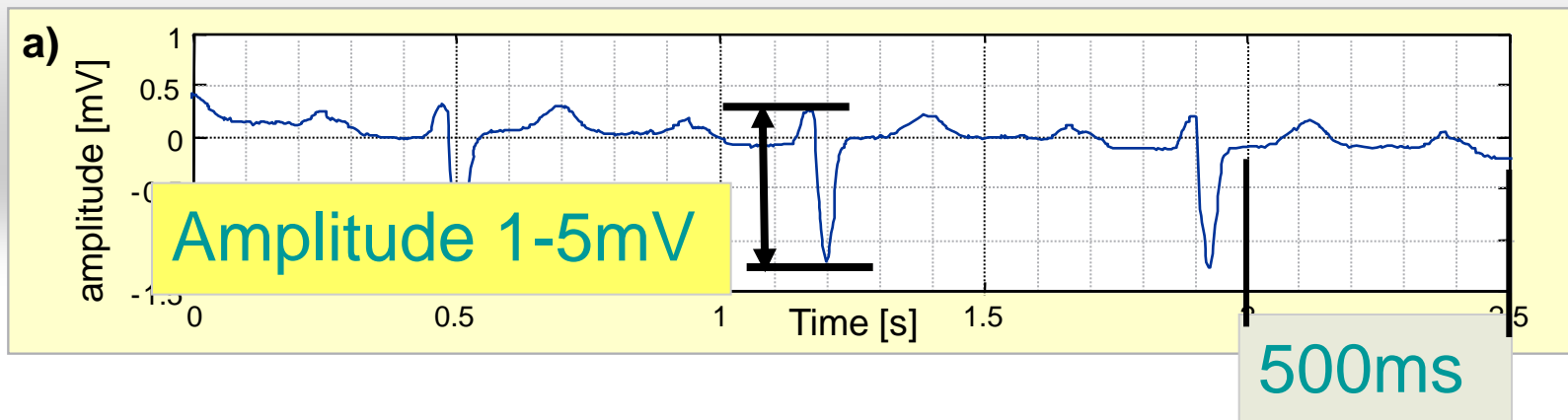


Powerline interferences

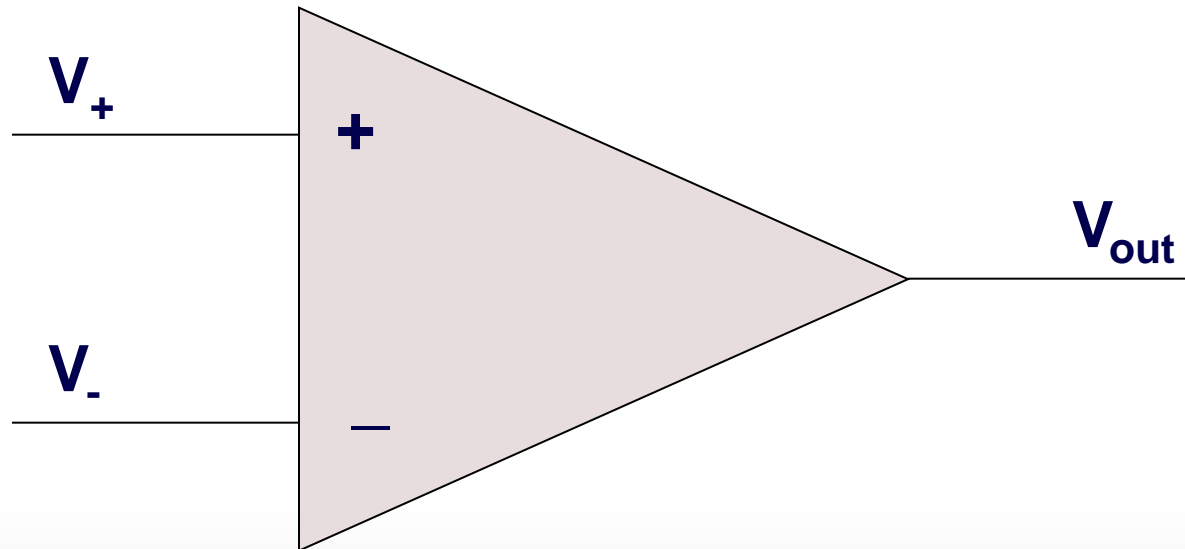
Common signal



Difference signal



Operational amplifier



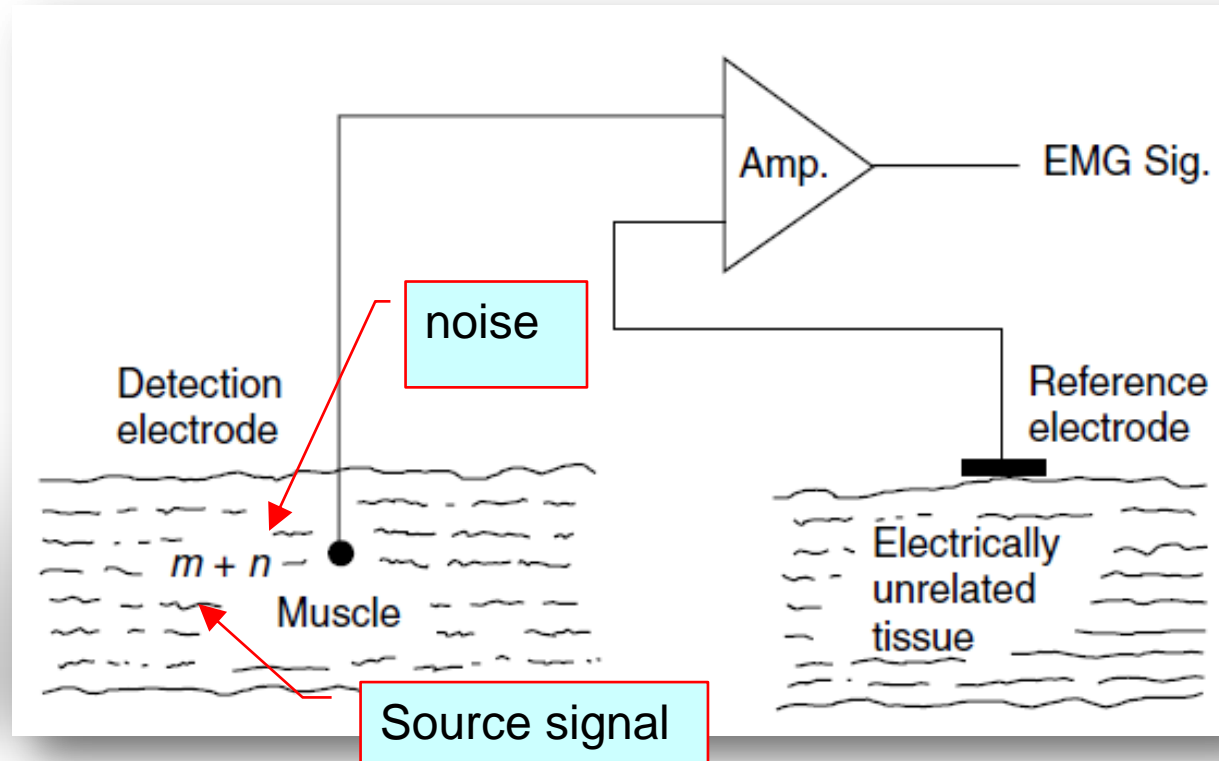
$$V_{out} = k_u(V_+ - V_-) + CMRR(V_+ + V_-)$$

CMRR – [*ang. common mode rejection ratio*]

$$CMRR = 10e^{-5} - 10e^{-6}$$

Measurement of the EMG signals

Monopolar measurement

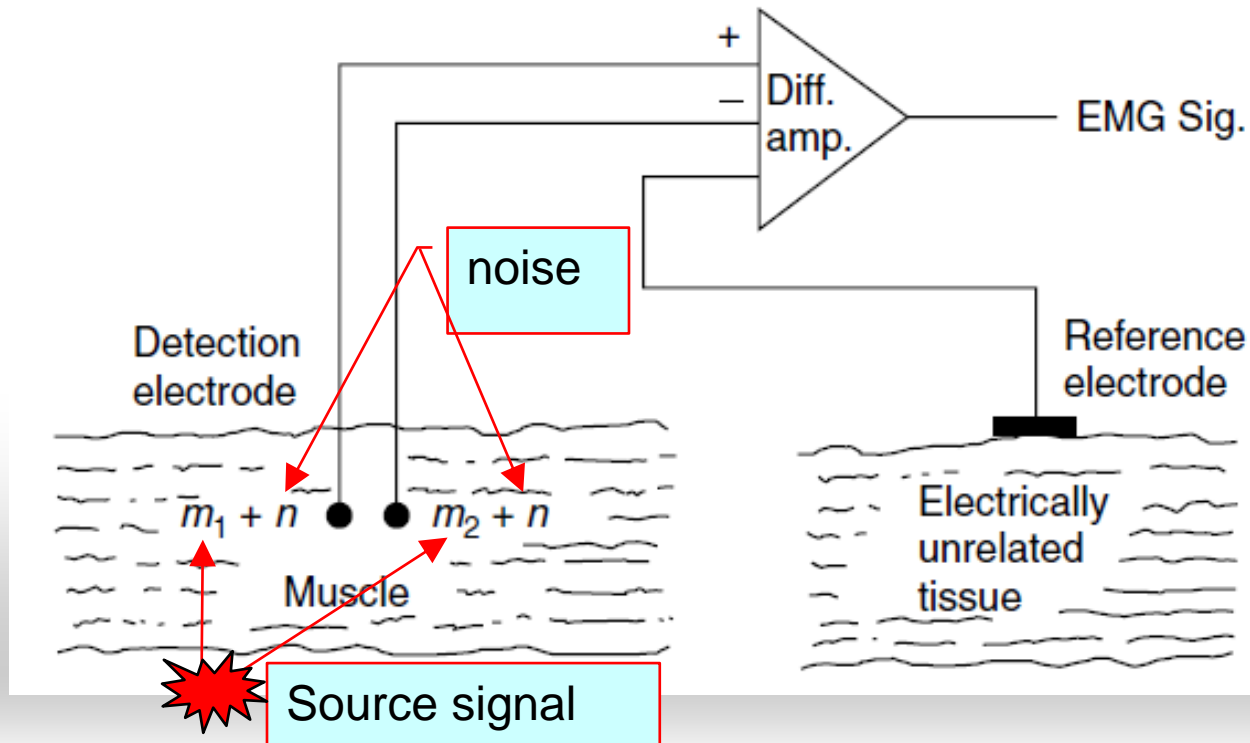


Source:

http://www.delsys.com/Attachments_pdf/Electromyography%20Medical%20Encyclopedia.pdf

Measurement of the EMG signals

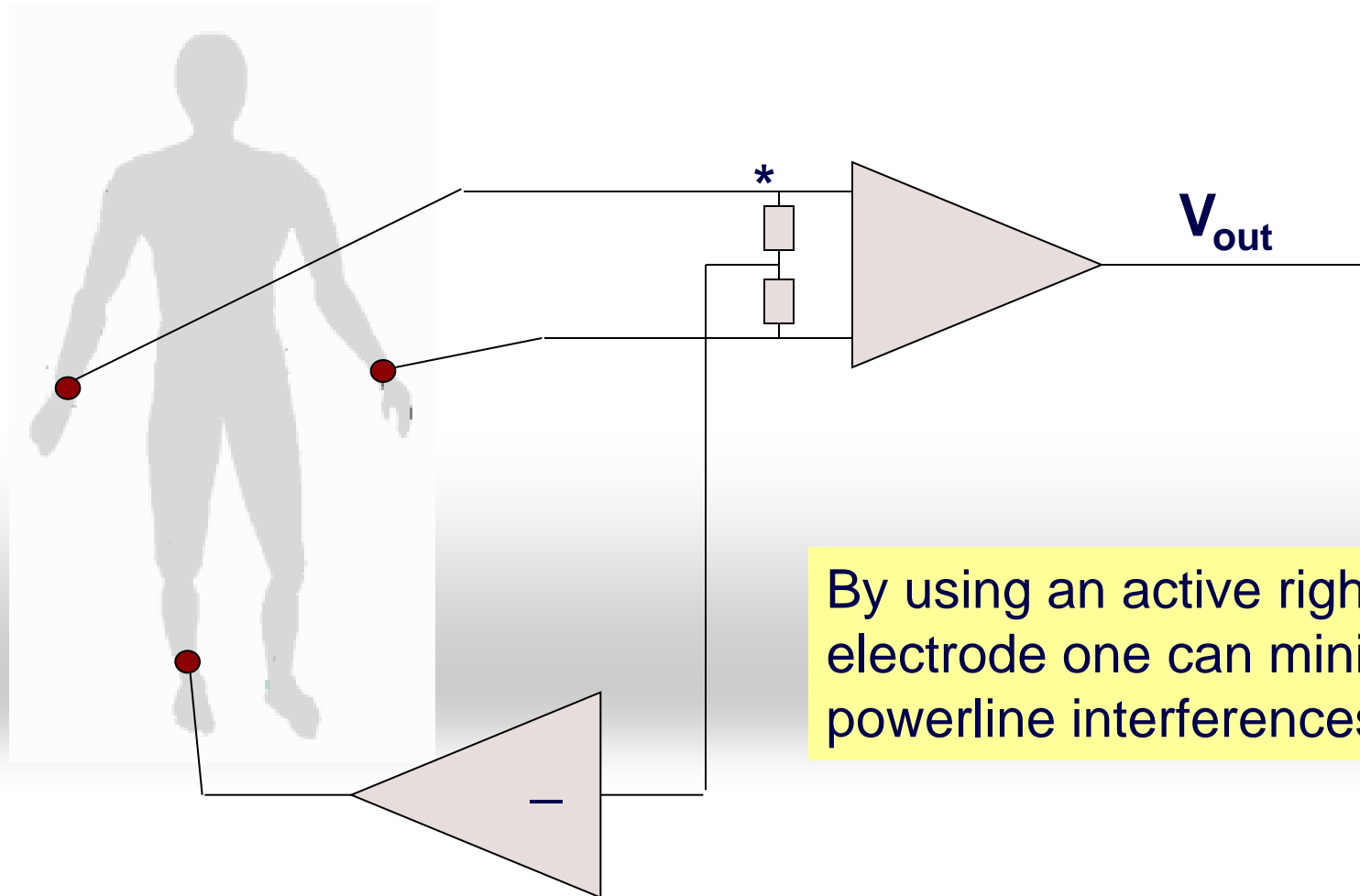
Bipolar measurement



Source:

http://www.delsys.com/Attachments_pdf/Electromyography%20Medical%20Encyclopedia.pdf

Active right leg electrode



By using an active right leg electrode one can minimise powerline interferences

Safety during medical measurements

Risks

- Direct contact of electrical devices with patient's skin
- Low resistance of electrodes (spacial gel electrodes)
- risk of device malfunction

**Even a faulty medical equipment should
be safe for the patient!**



Safety during medical measurements

Regulations

- maximum admissible current 0.1mA
- maximum admissible current during device malfunction 1mA
- there are special standards the medical equipment must conform to:
 - **IEC 60601** – technical standard for the safety of medical electrical devices
 - **IEC** - International Electrotechnical Commission

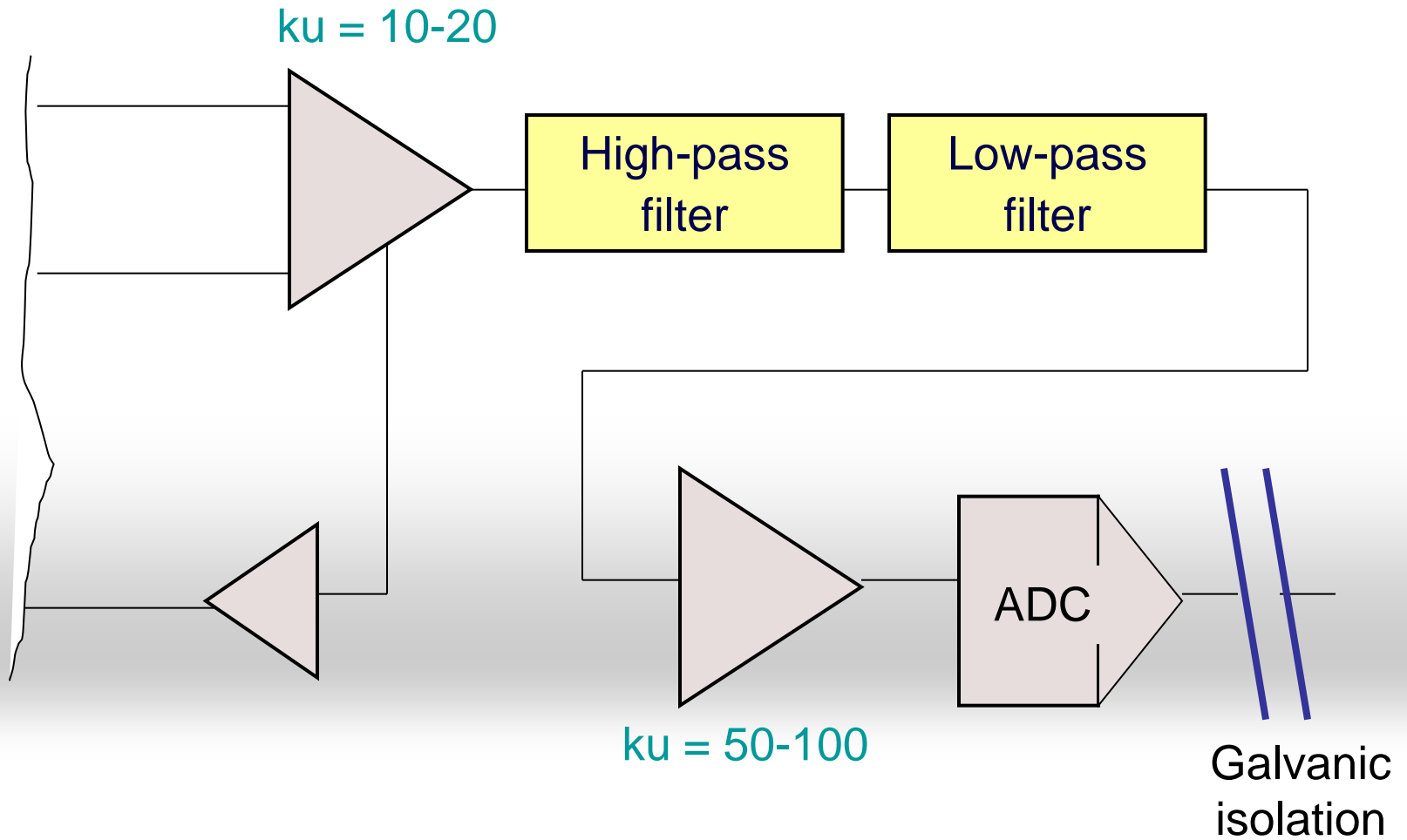




Safety during medical measurements

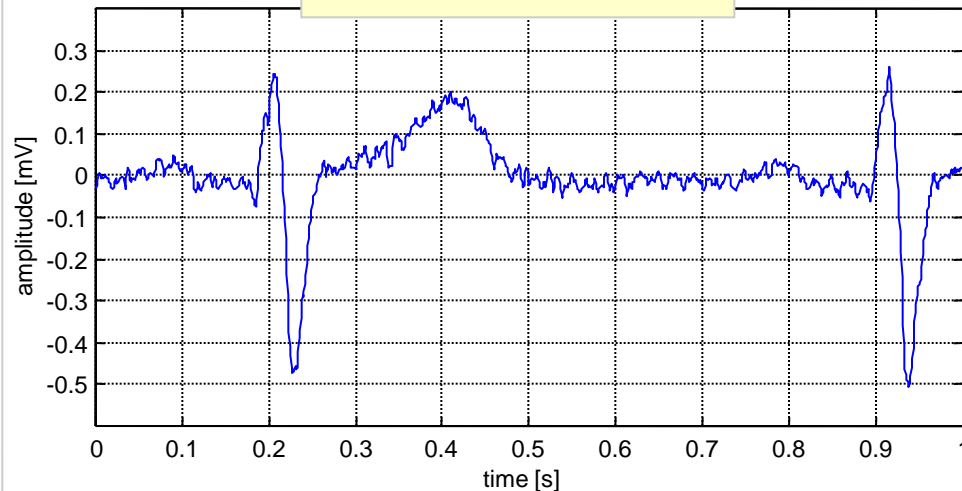
- Galvanic isolation
 - transoptors (for analog and discrete signals)
 - isolation amplifiers
 - DC-DC converters (biasing)
- limiting the current entering the patient's body (resistors in series)
- small voltages of the power supply (3V, 6V)
- no current conduction elements the patient can touch

ECG recorder - inside

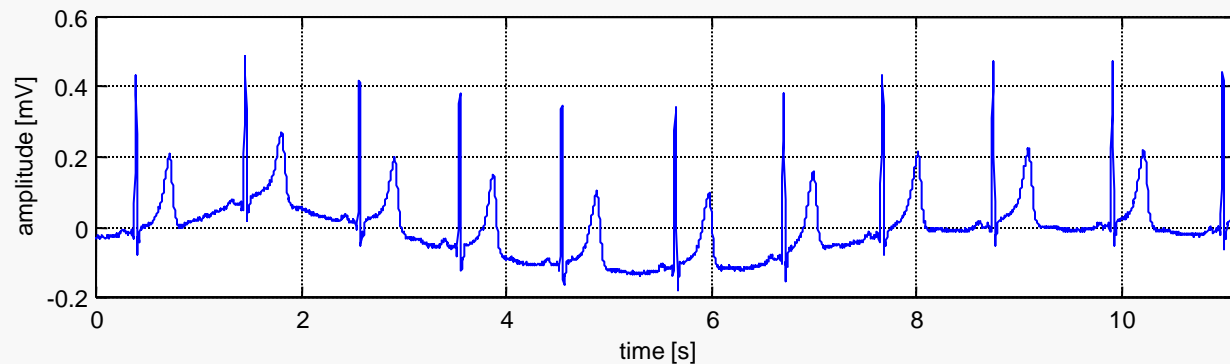
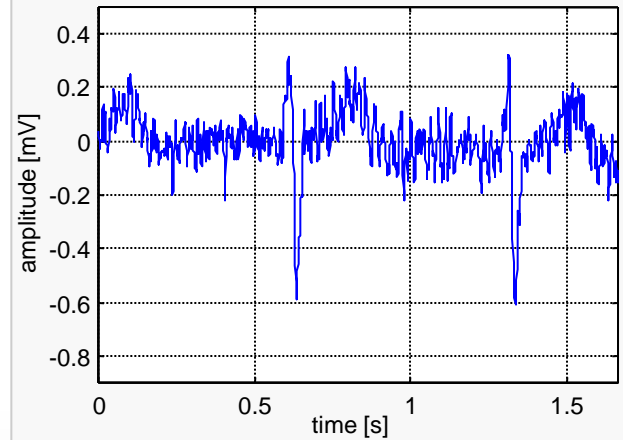


Artefacts and noise in ECGs

Power line noise



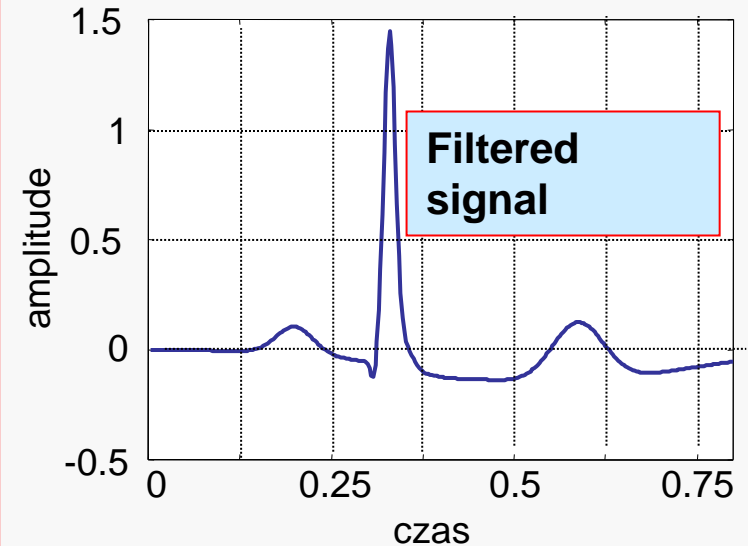
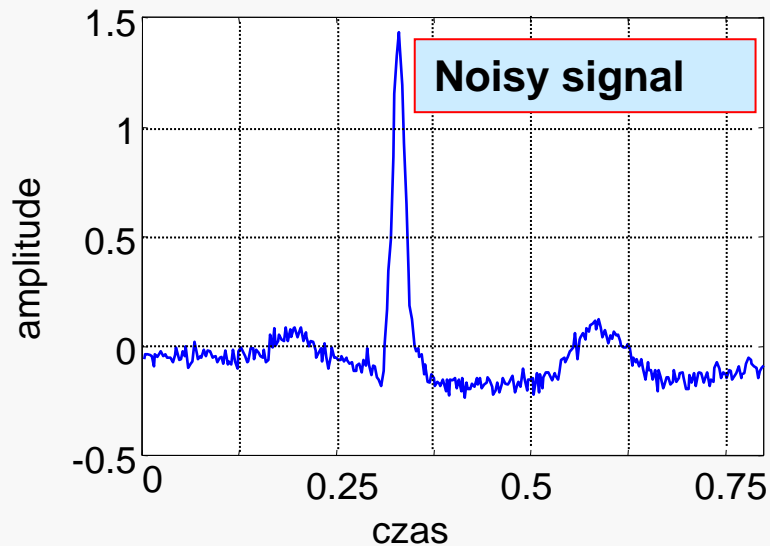
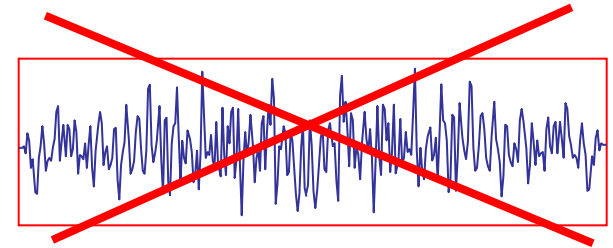
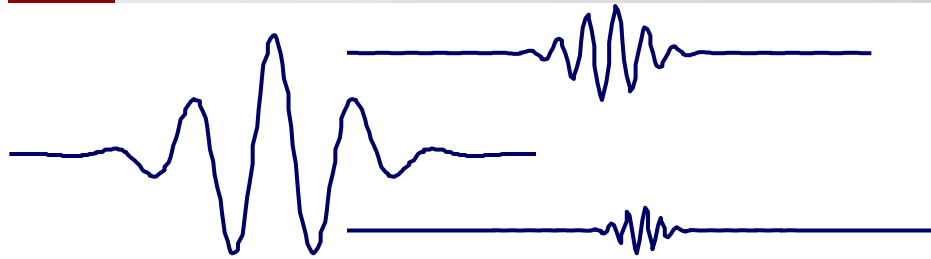
Muscle activity noise



Base line wander



Wavelet-based ECG filtering



dr P. Romaniuk
Cooperation with Institute of Cardiology

Heartbeat abnormalities - arrhythmias

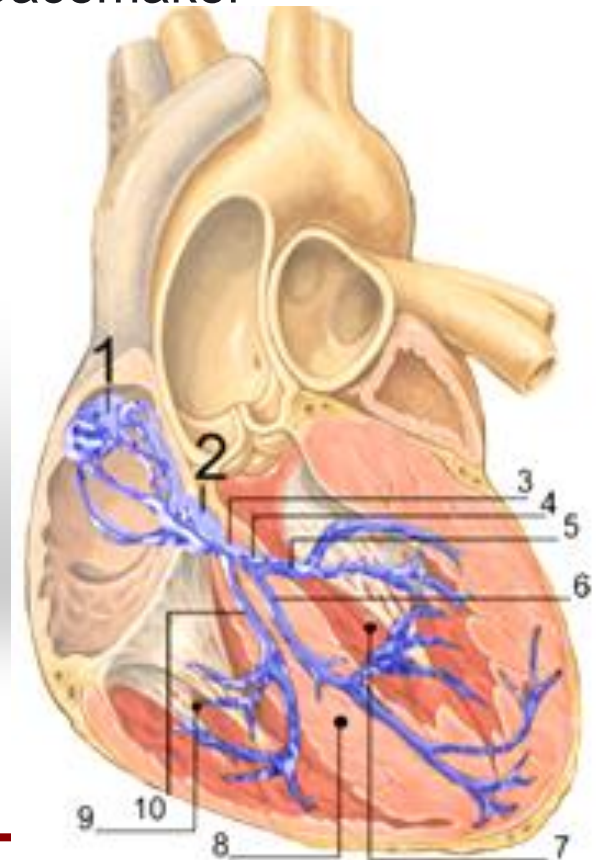
Abnormalities in heartbeat are called **arrhythmias**.

Arrhythmias can be classified according to the site of abnormality:

- Atria (Atrial Flutter, Atrial Fibrillation, Abnormal pacemaker)
- Atrio-ventricular (reentrant tachycardia, ...)
- Ventricular (Premature Ventricular Contraction, Ventricular Fibrillation, Ectopic foci)

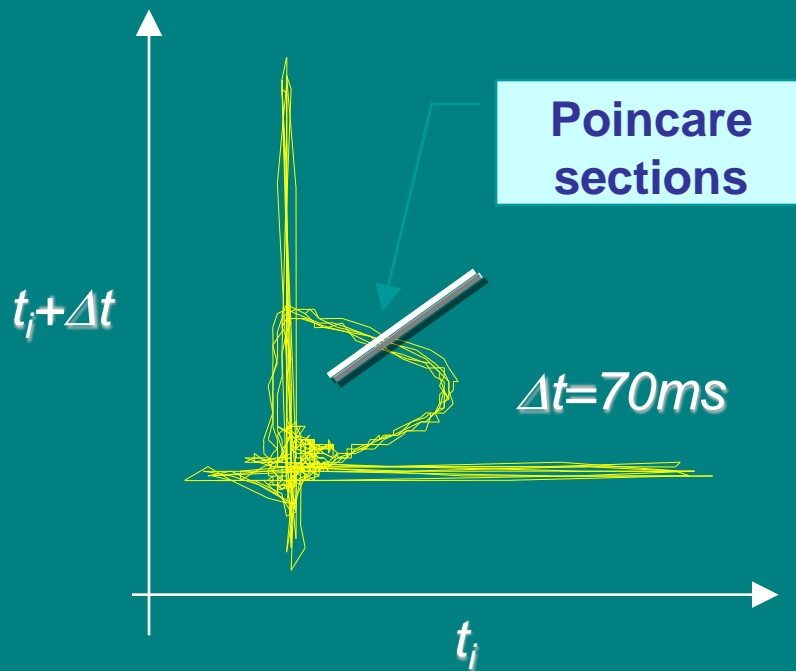
Conduction blocks:

- first degree (in atrium)
- second degree (between atria and ventricles)
- third degree (in ventricles, e.g. branch blocks)

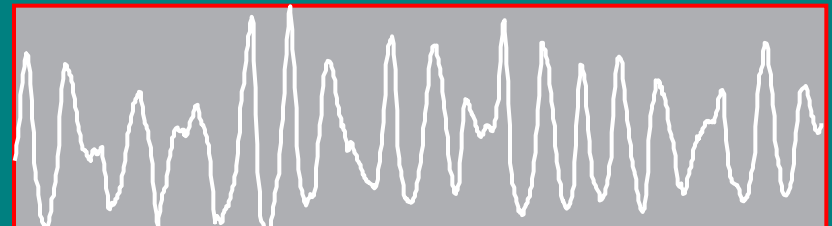
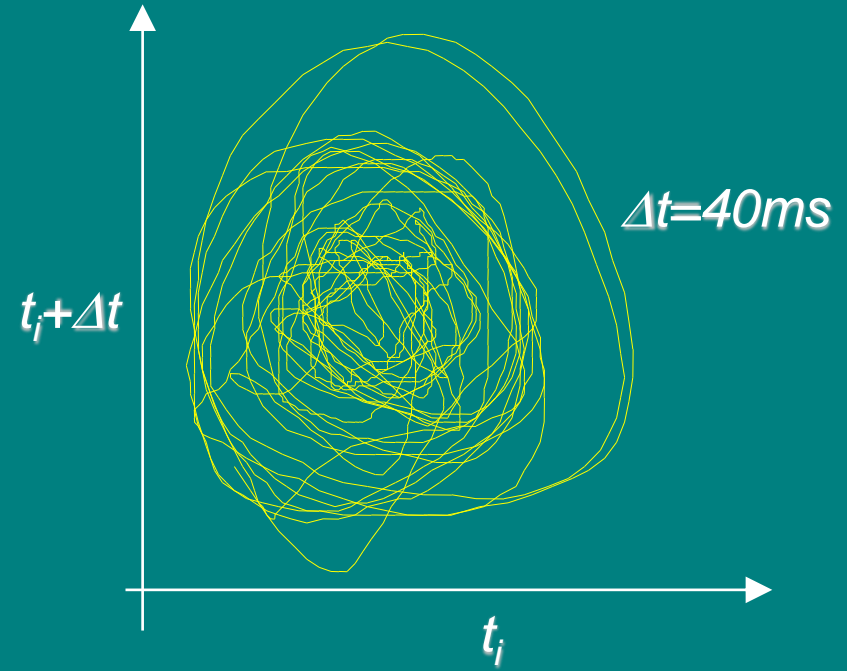


Phase plots from ECGs

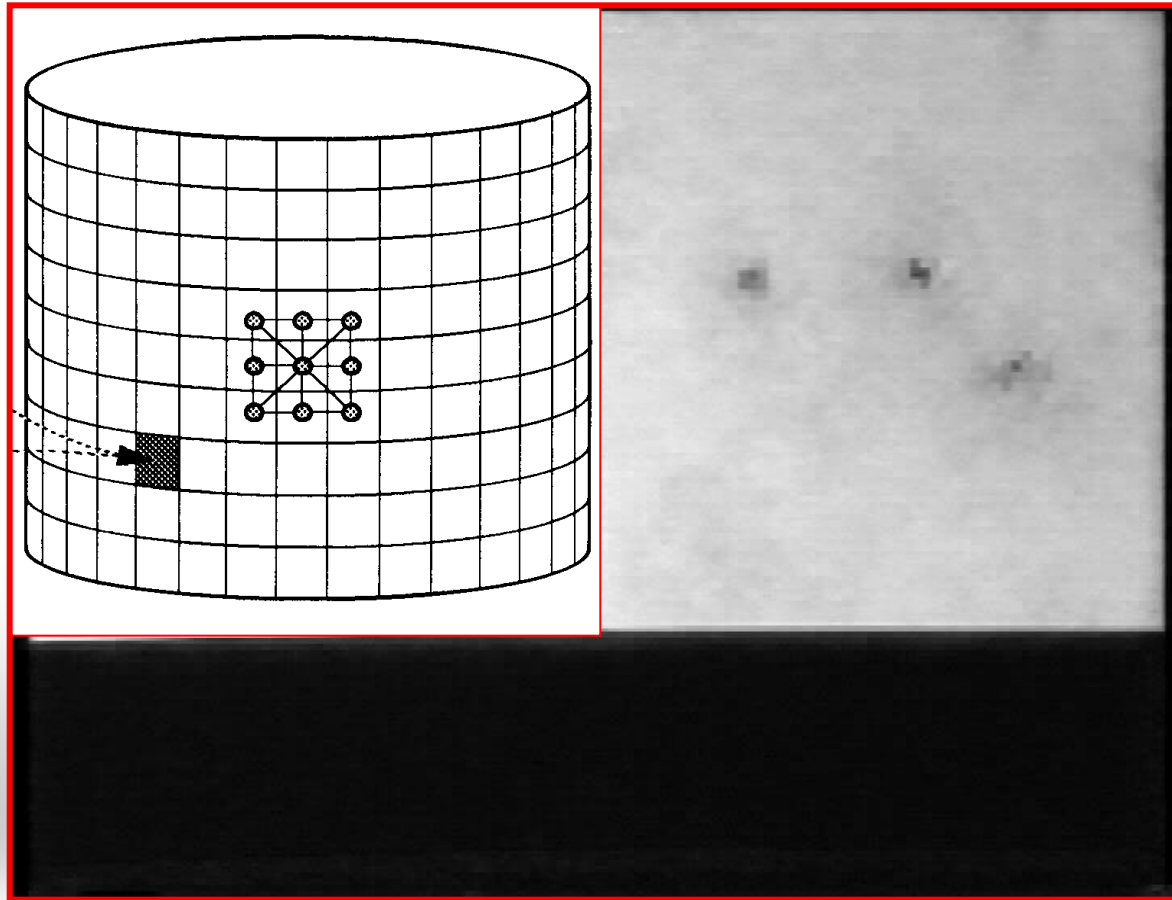
Normal rhythm



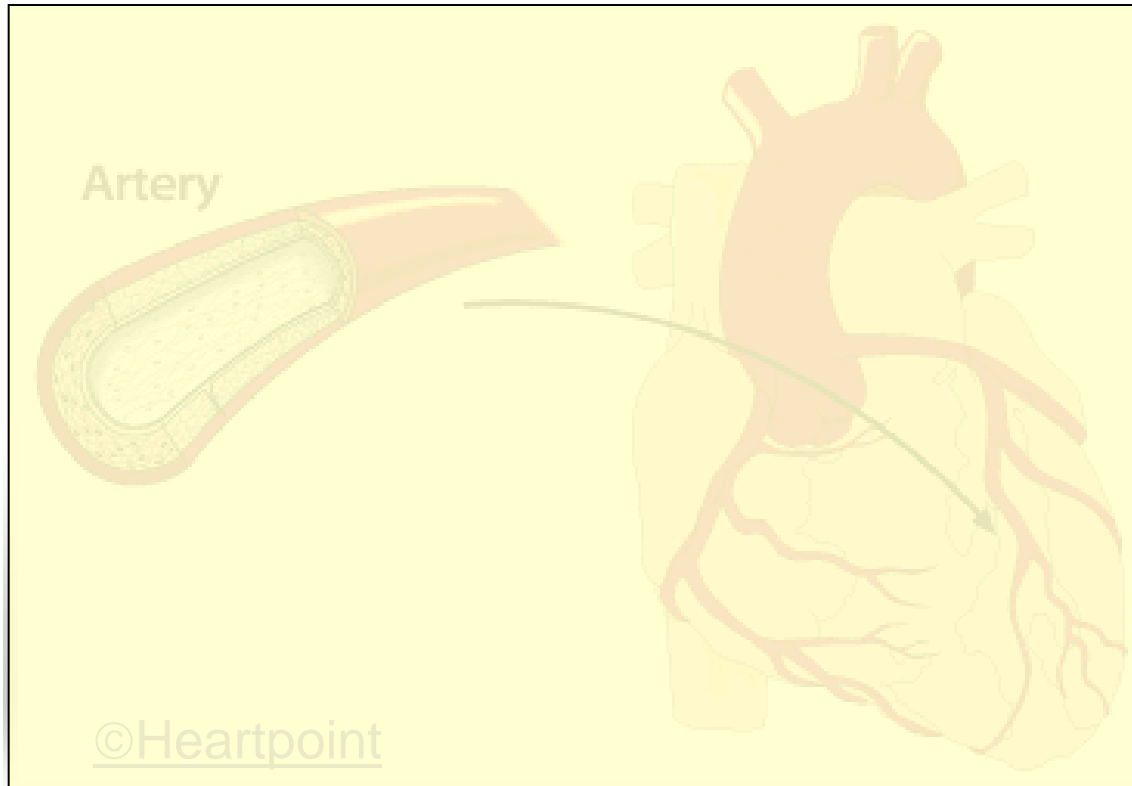
Ventricular fibrillation



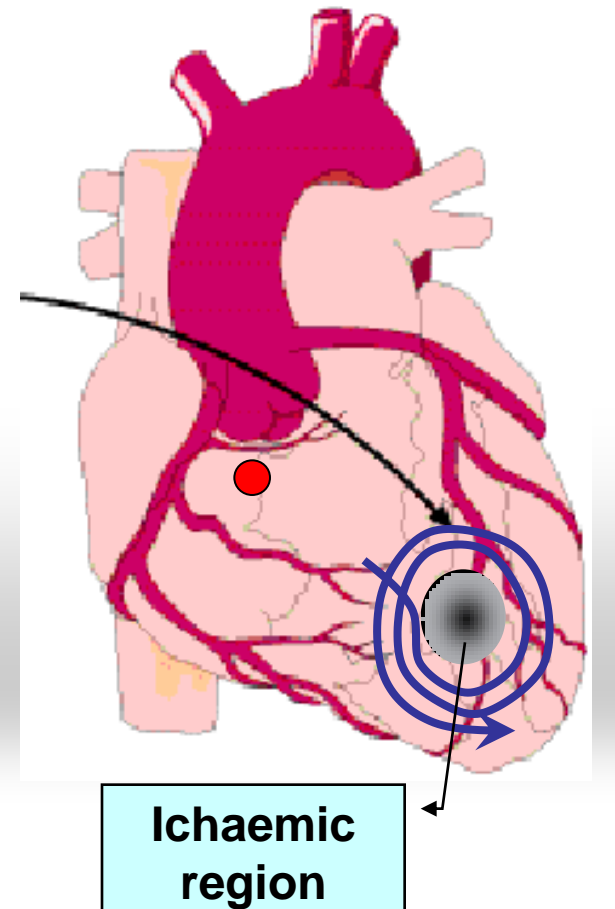
Electrical model of cardiac tissue



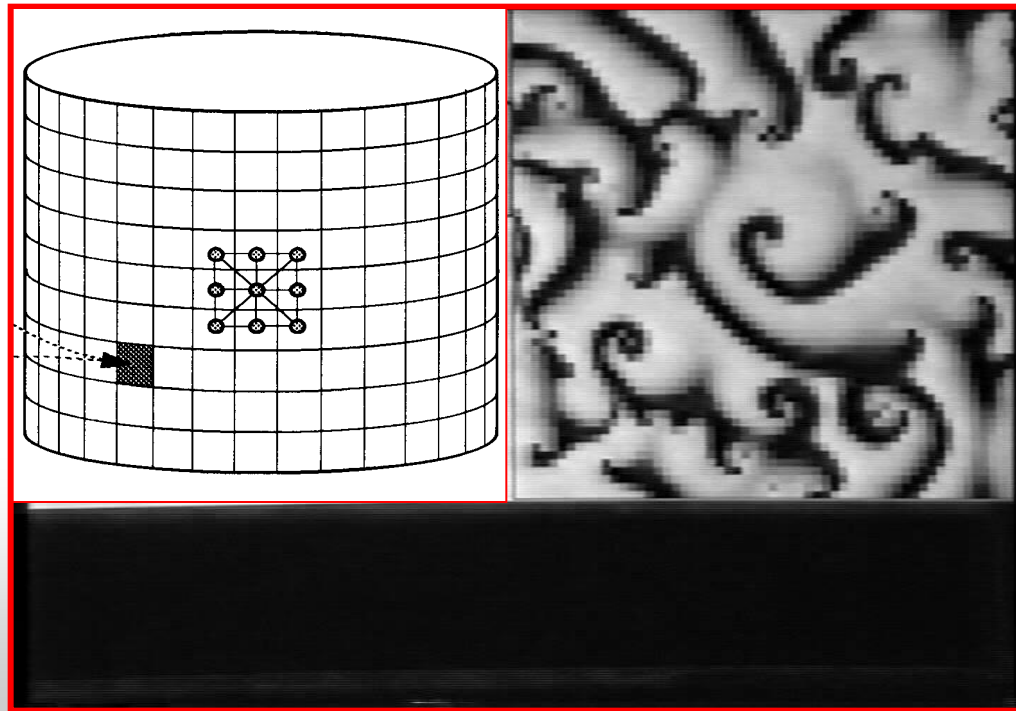
Normal rhythm



100 000 heart attacks in Poland yearly!



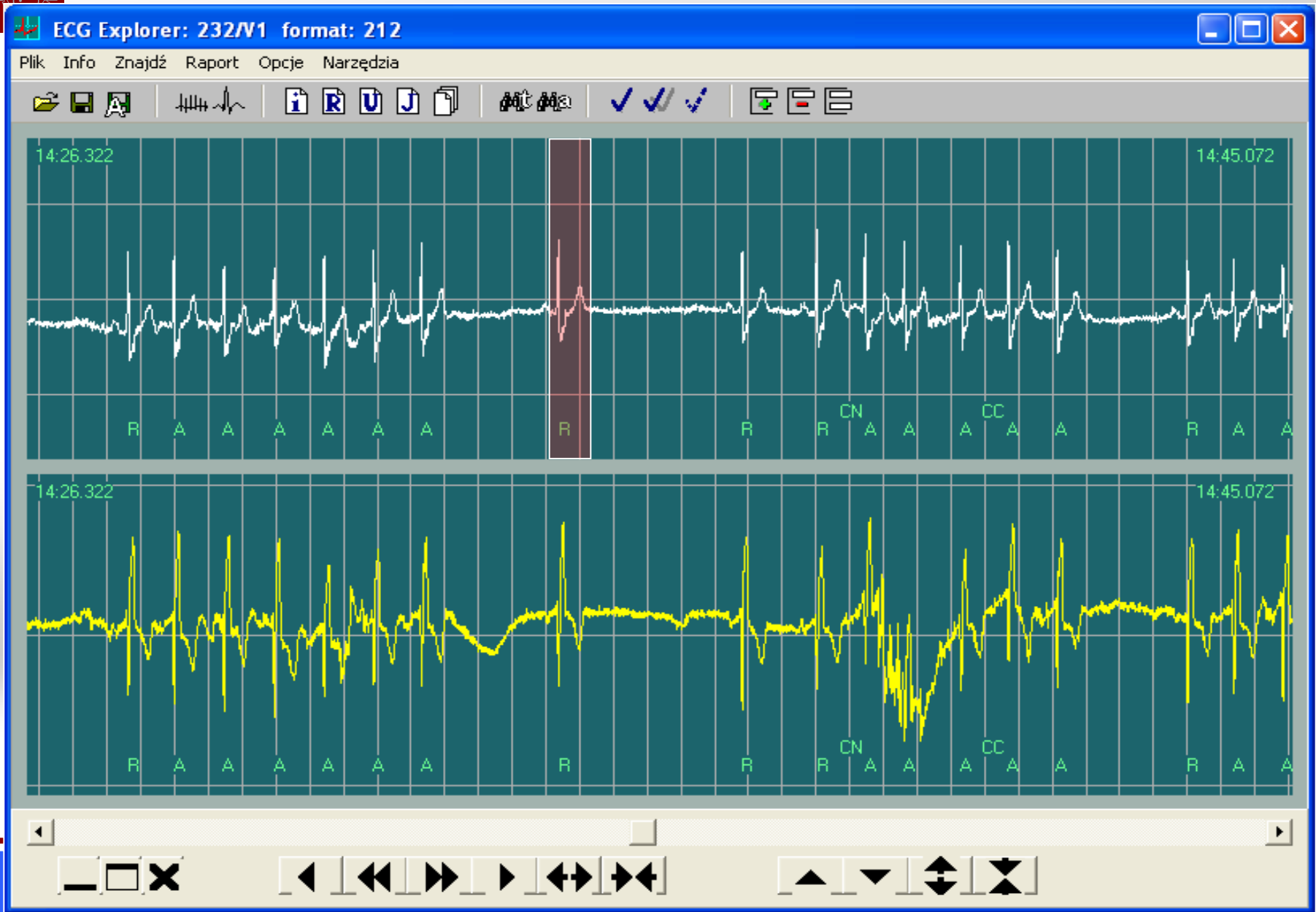
Electrical model of cardiac tissue



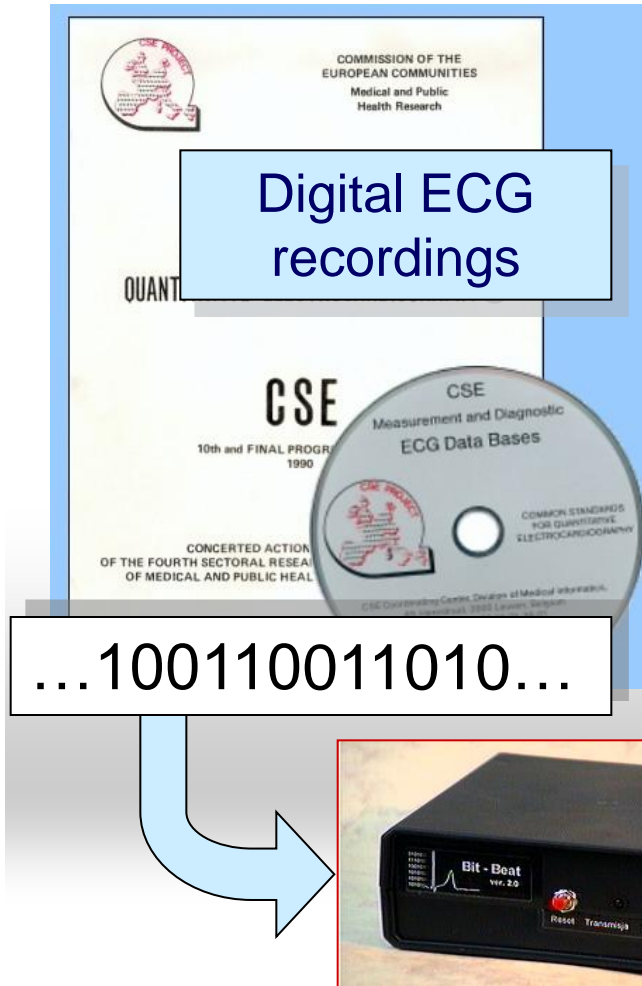
Ventricur fibrillation



MIT-BIH Explorer demo

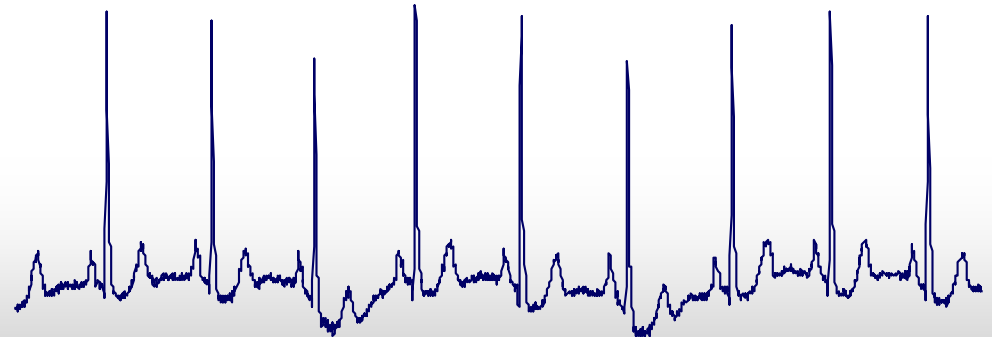


„Artificial patient” system

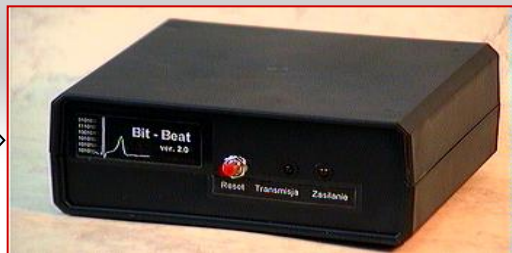


„**Bit-beat**” – is a device generating analog ECG signals from digital recordings from a database;

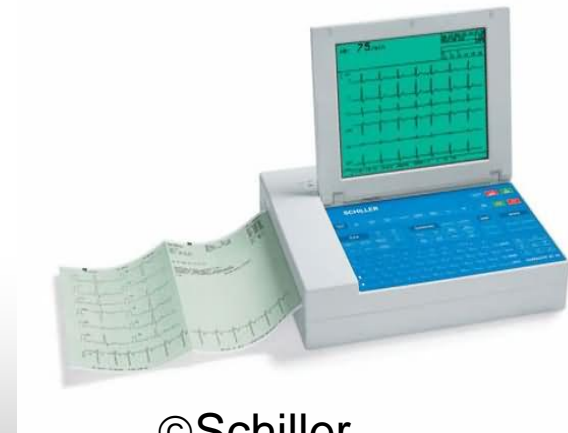
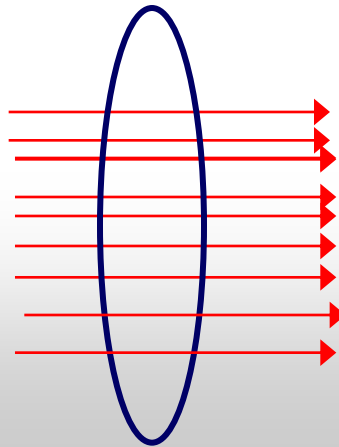
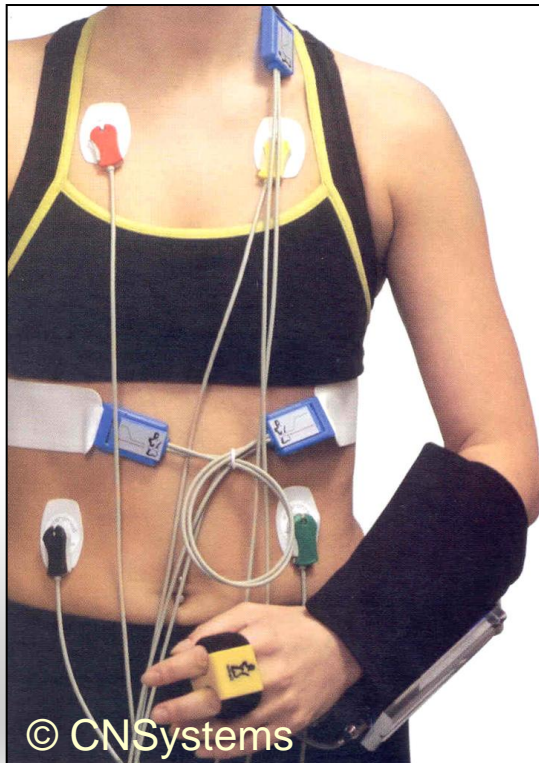
Useful for testing recording devices and for teaching



Analog ECG



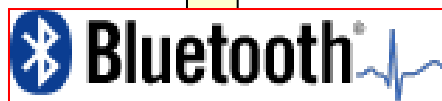
Multilead ECG – very many cables



©Schiller

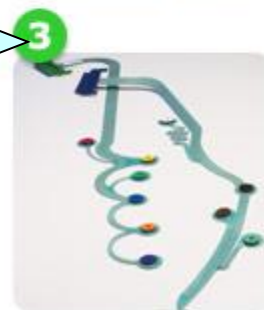


Base station ranseiver



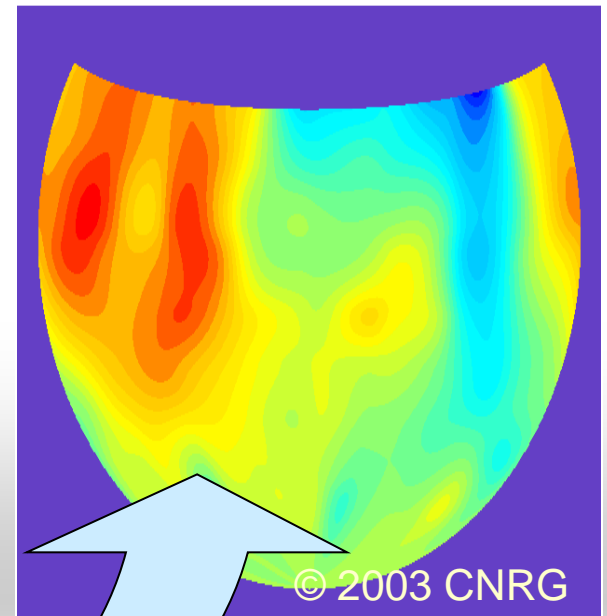
Patient transeiver

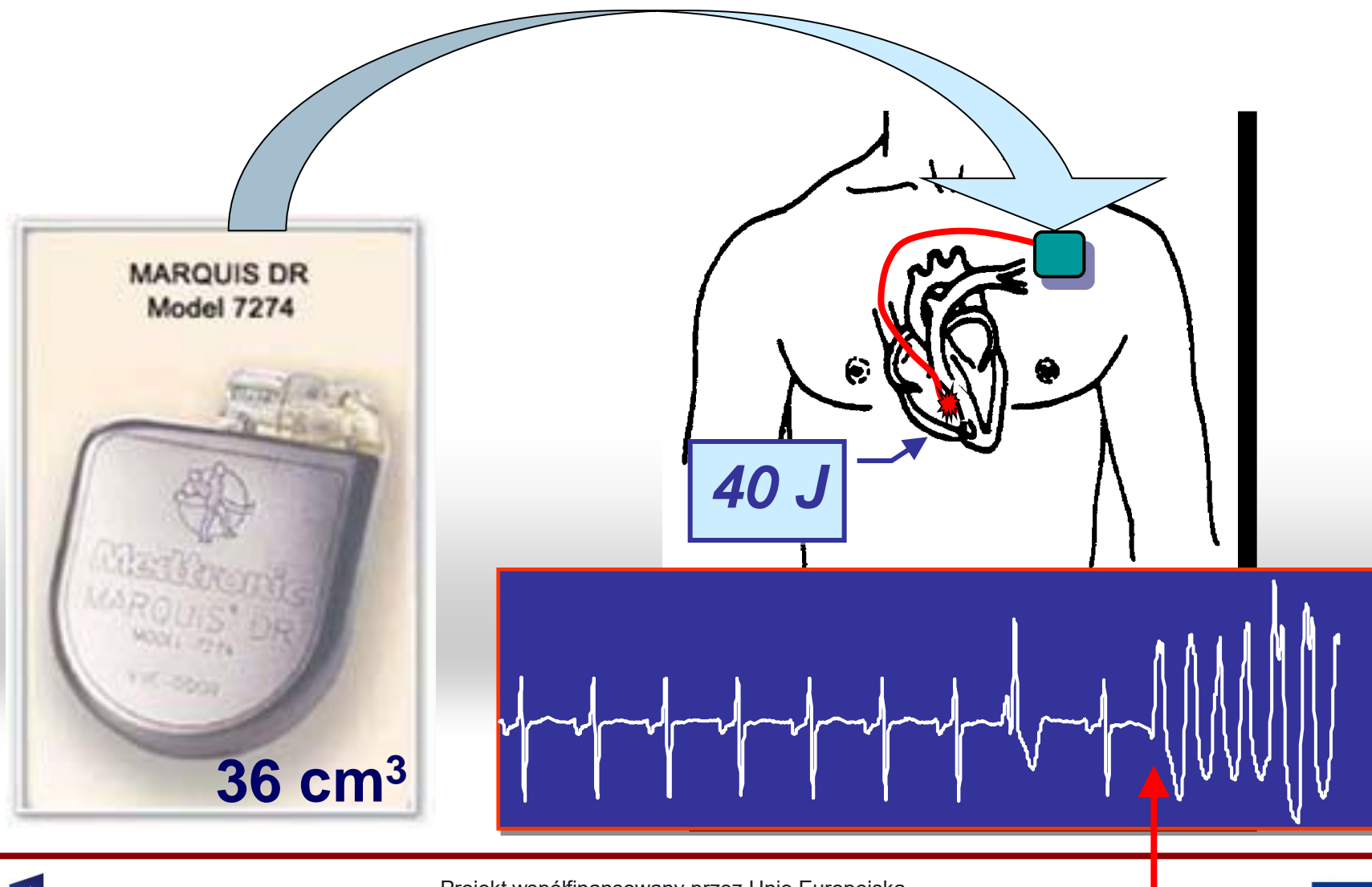
Disposable electrodes



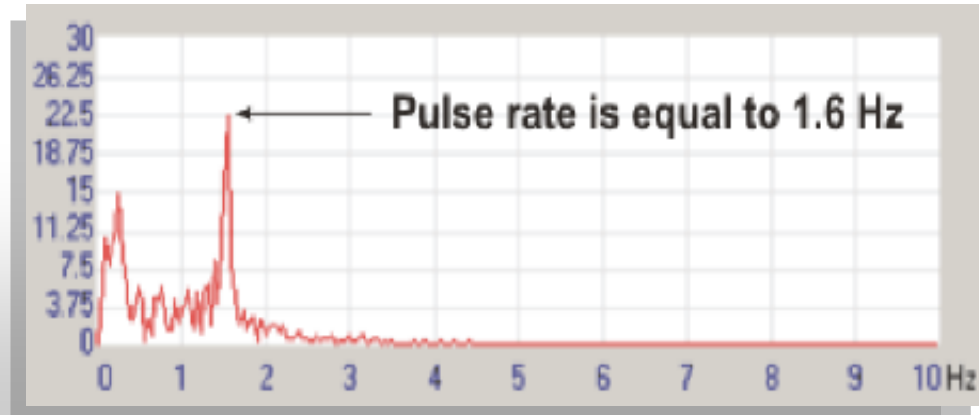
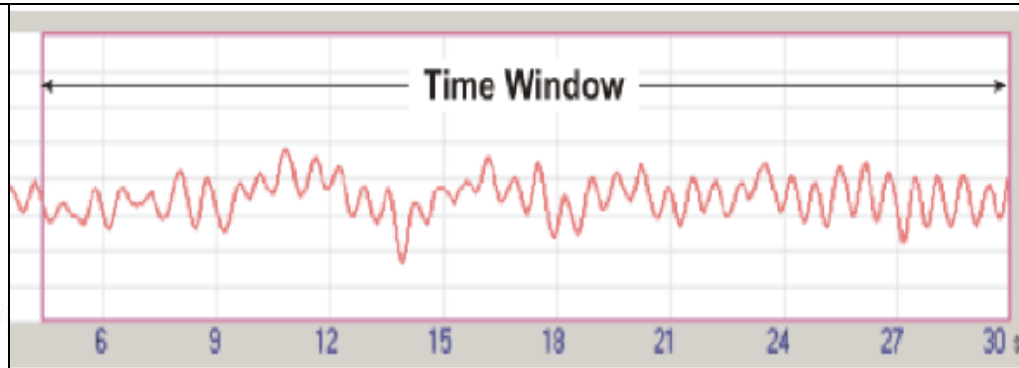
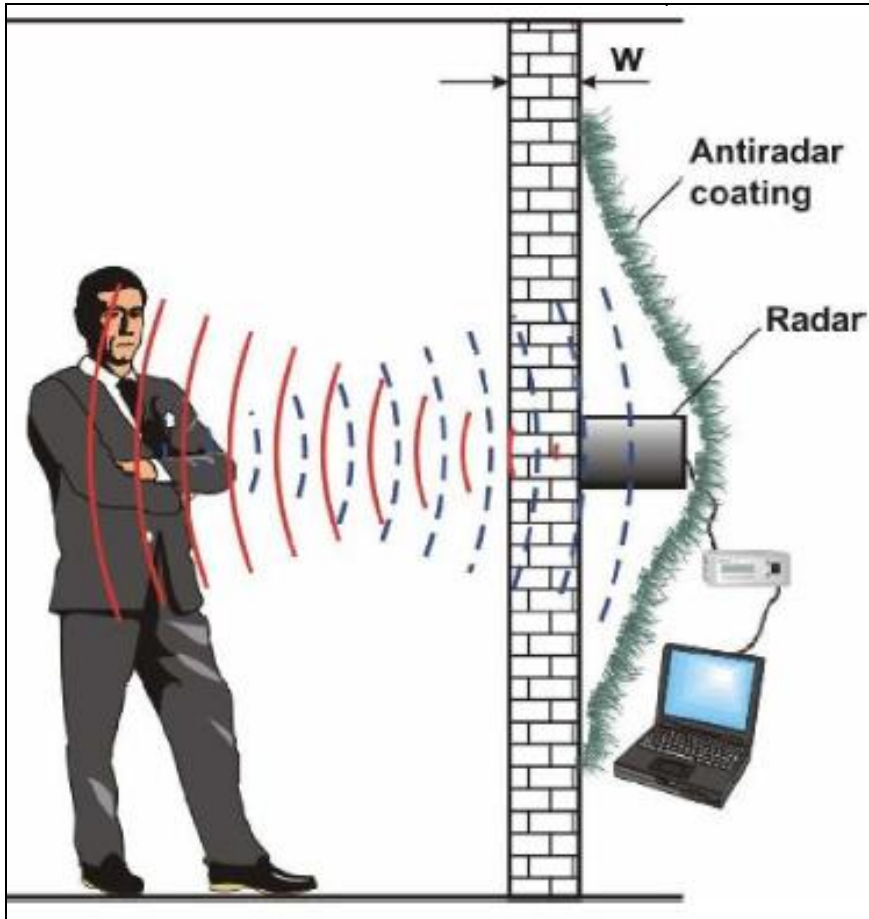
System LifeSync© ECG

Body surface mapping (BSM)



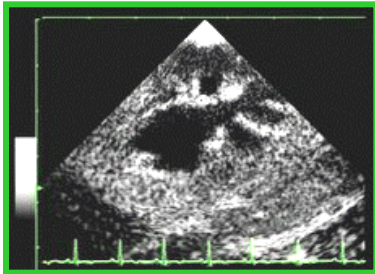


Detection of heartbeat by remote radar



Detection of Human Breathing and Heartbeat by Remote Radar
S. Ivashov, V. Razevig, A. Sheyko, I. Vasilyev
 Remote Sensing Laboratory, RUSSIA

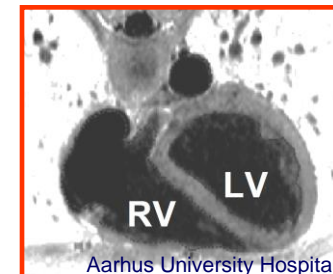
Other diagnostic methods in cardiology



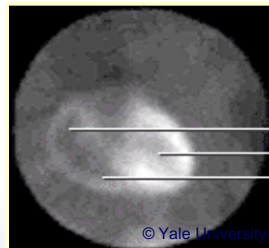
Echocardiography



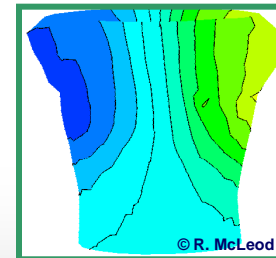
Coronarography



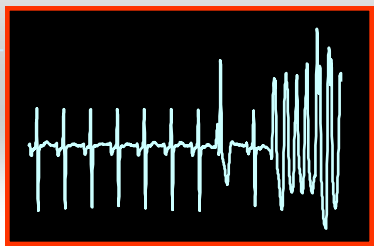
MRI



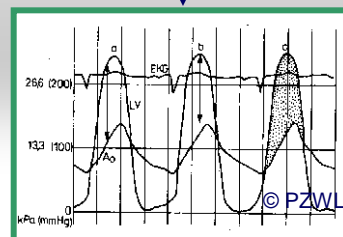
Radioisotope images



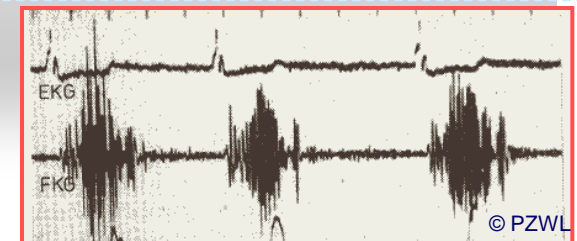
BSM



ECG



Hemodynamics



Fonokardiography



KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY



„Medical Electronics”

**Prezentacja multimedialna współfinansowana przez
Unię Europejską w ramach
Europejskiego Funduszu Społecznego w projekcie pt.
*„Innowacyjna dydaktyka bez ograniczeń - zintegrowany
rozwój Politechniki Łódzkiej - zarządzanie Uczelnią,
nowoczesna oferta edukacyjna i wzmacniania zdolności
do zatrudniania osób niepełnosprawnych”***



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www.kapitalludzki.p.lodz.pl