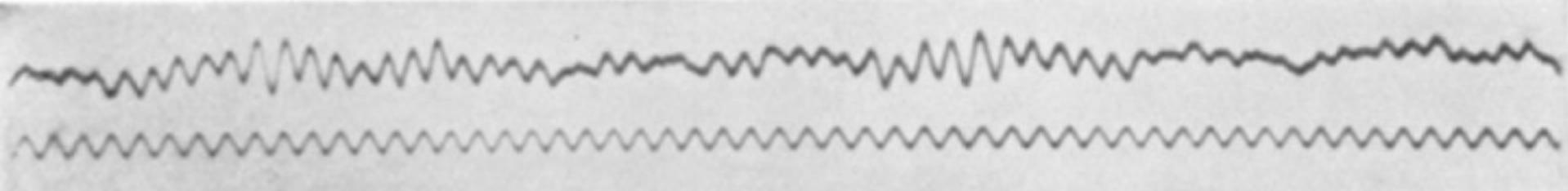


# Basics of EEG

Dr Fabó Dániel  
OKITI – Dept. of Neurology

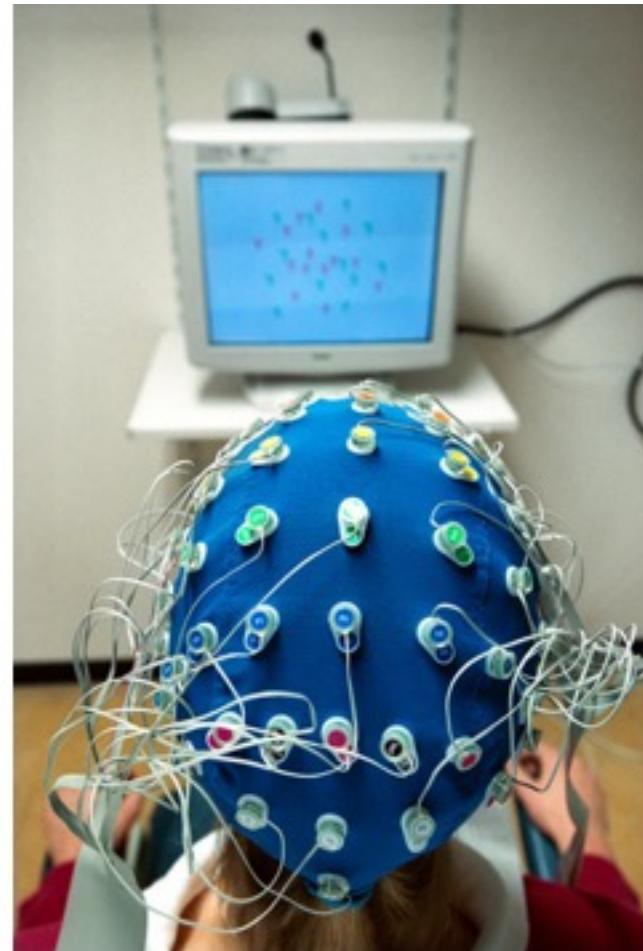
# EEG History

- Hans Berger
  - Sister had a dream about an accident
  - Tried to study telepathie
  - First human EEG: 1924

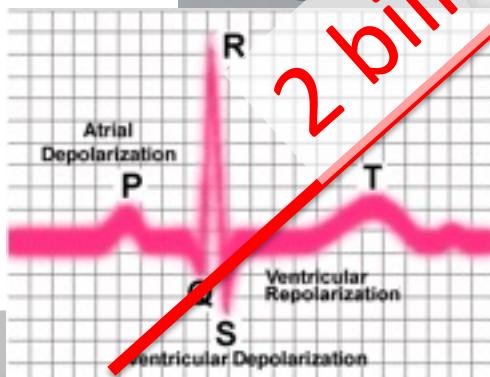
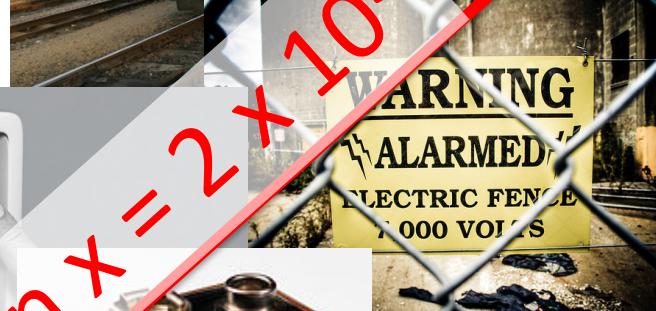


# EEG technical background

- Brain surface potentials
- Reference amplifier
- Potential differenced
- Physiological signal magnitude
  - 20-300  $\mu$ V



- 220kV
- 25kV
- 7kV
- 220V
- 9V
- 1mV
- 100µV



# EEG specifications

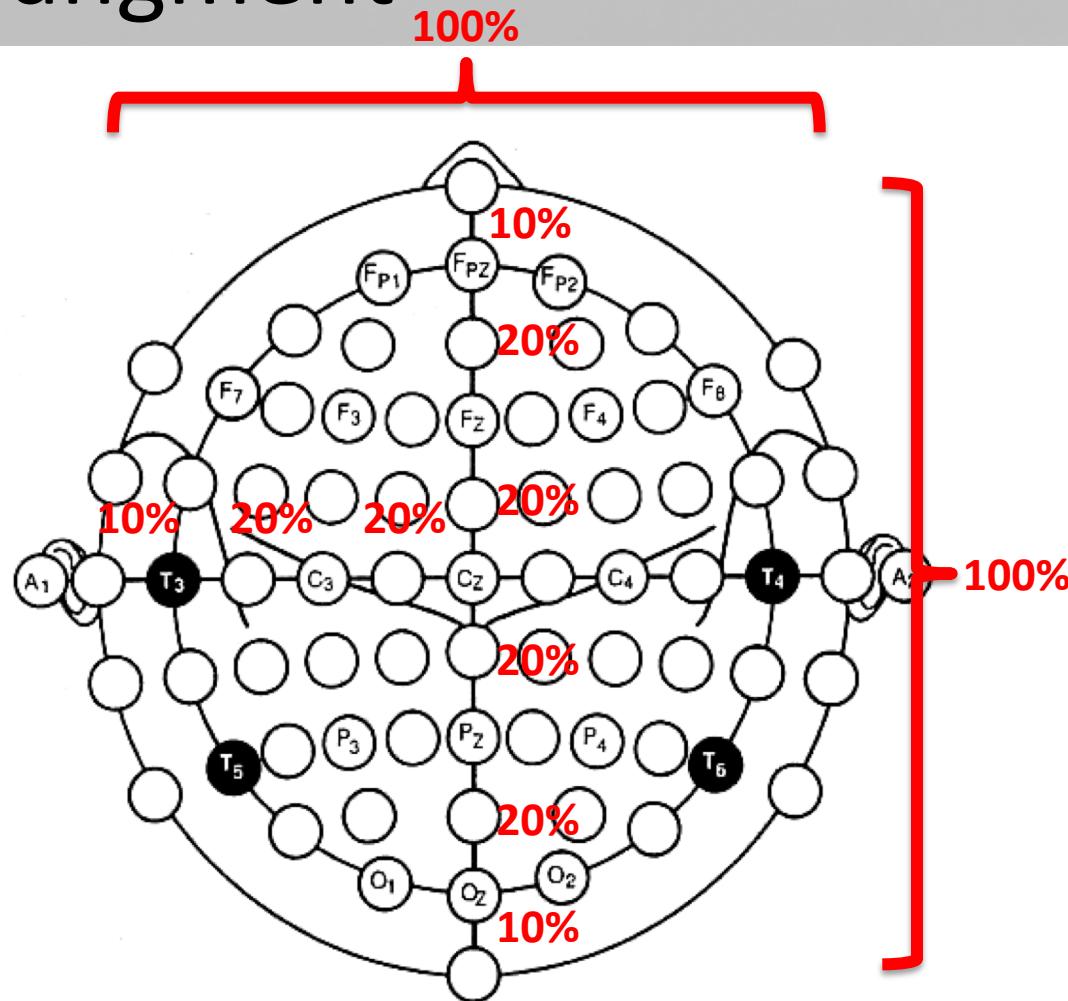
EEG SPECIFICATIONS	
Maximum Signal Magnification (Gain)	200,000 x
Nominal Output Voltage	+/- 5V
Electrode impedance	5-20 kOhm
Noise Level (Referred to Input)	<0.1uV
Input Impedance	>1000 MOhm
Low Frequency Response min (-3dB)	0.01Hz
High Frequency Response max (-3dB)	see LPF
Common Mode Rejection	110dB
Subject Isolation (optical / magnetic)	>5kV

# EEG measurement

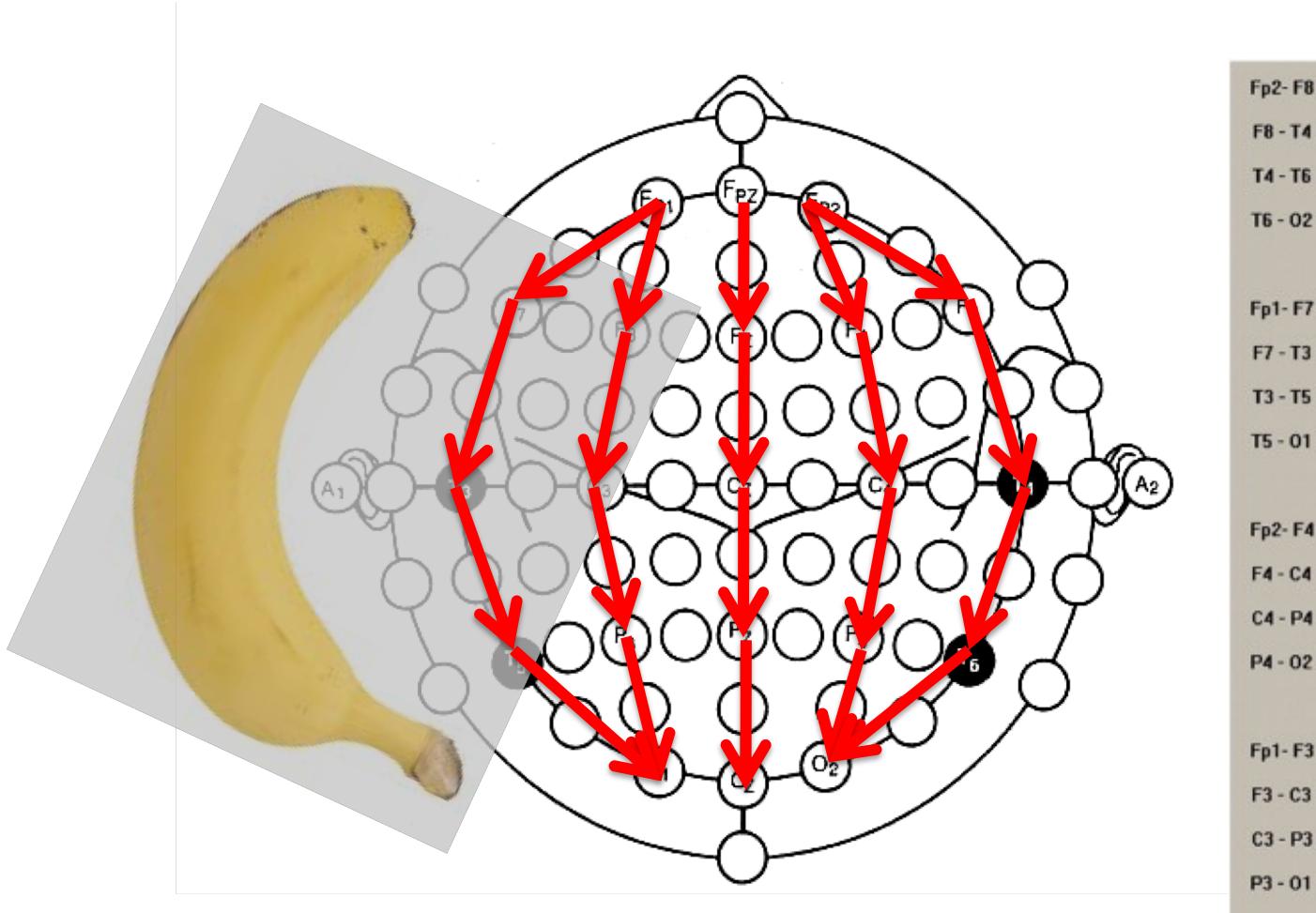
- Physical arrangement of sensors (sometimes called montage, but it is not)
  - Position of reference
    - vertex
    - ear (linked)
    - Mastoid (linked)
- Montage (really)
  - Combinations of electrodes on the head
  - Subtracting one from the other
  - Derivations: which potential difference should be seen
  - Paper EEG: decided when recorded: unchangeable
  - Digital EEG: rerefencable
    - Reference free : trying to get rid of the signal within the reference

# 10-20 international electrode arrangement

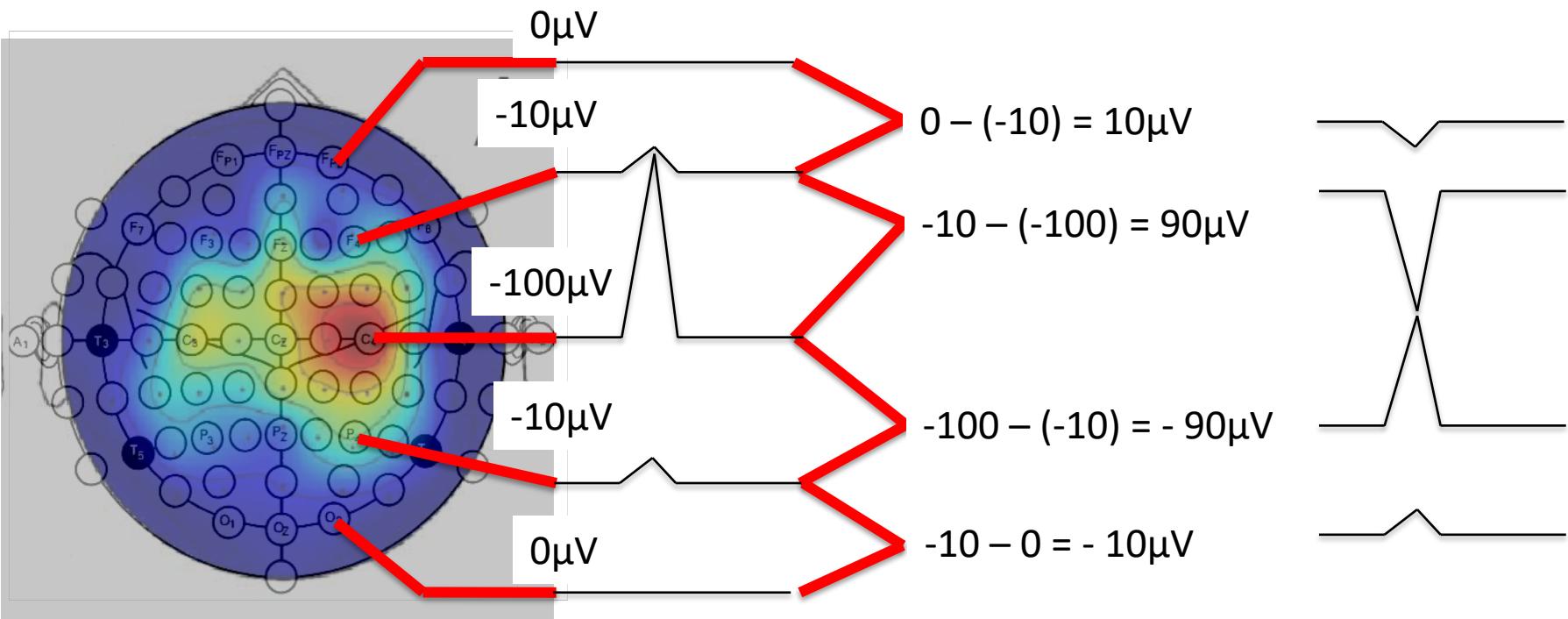
- Lobes
  - F – frontal
  - T – temporal
  - C - Central
  - P – parietal
  - O – occipital
  - A – ear
- Side
  - even: right
  - odd: left



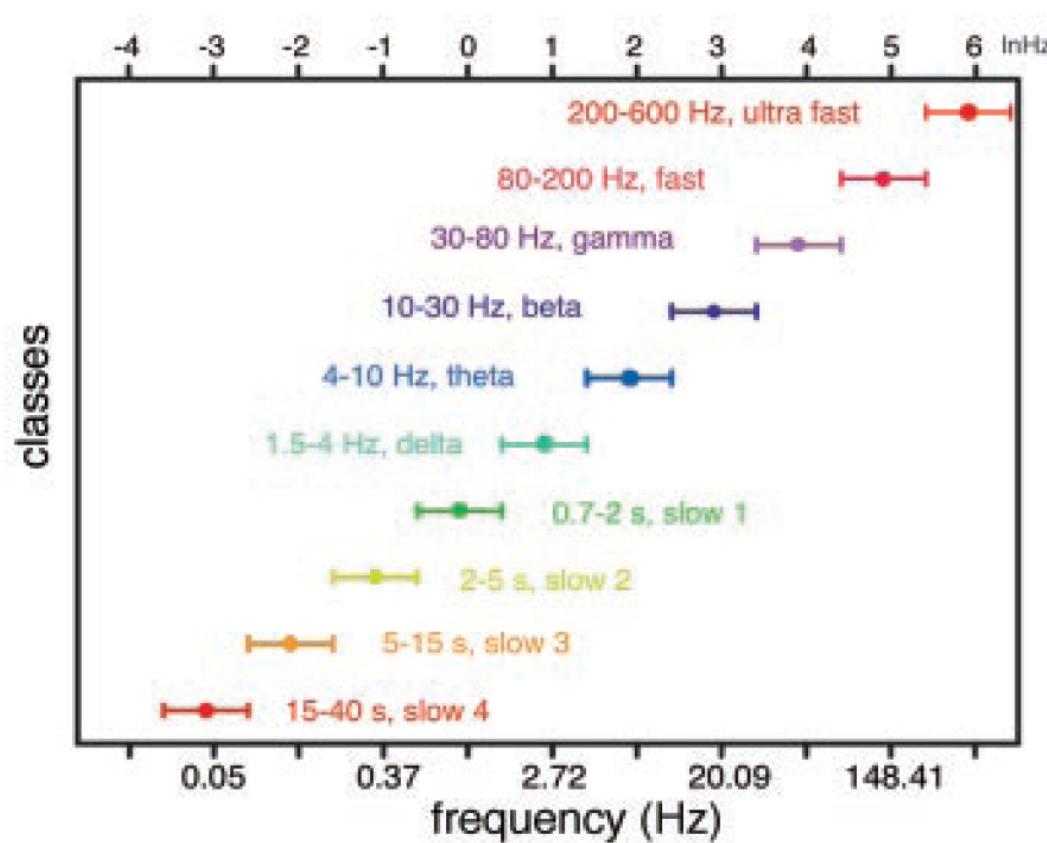
# Double banana montage



# Apperance and drawing of scalp potentials

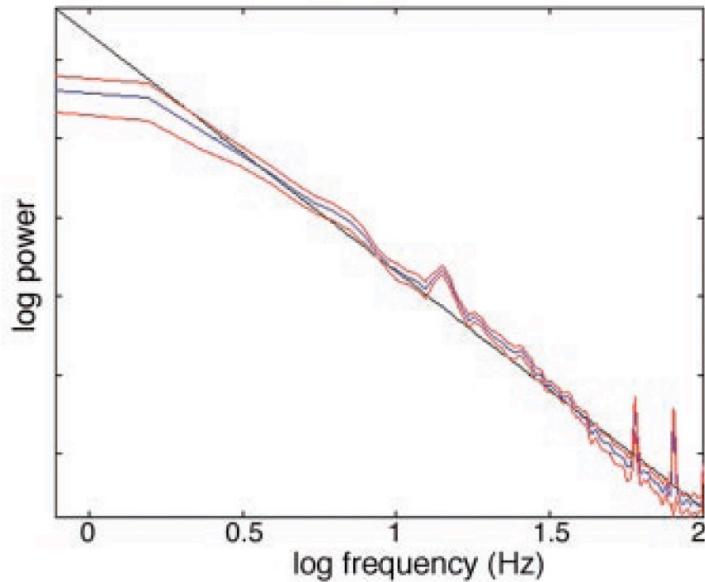


# Brain oscillations



Buzsáki, 2004, Science

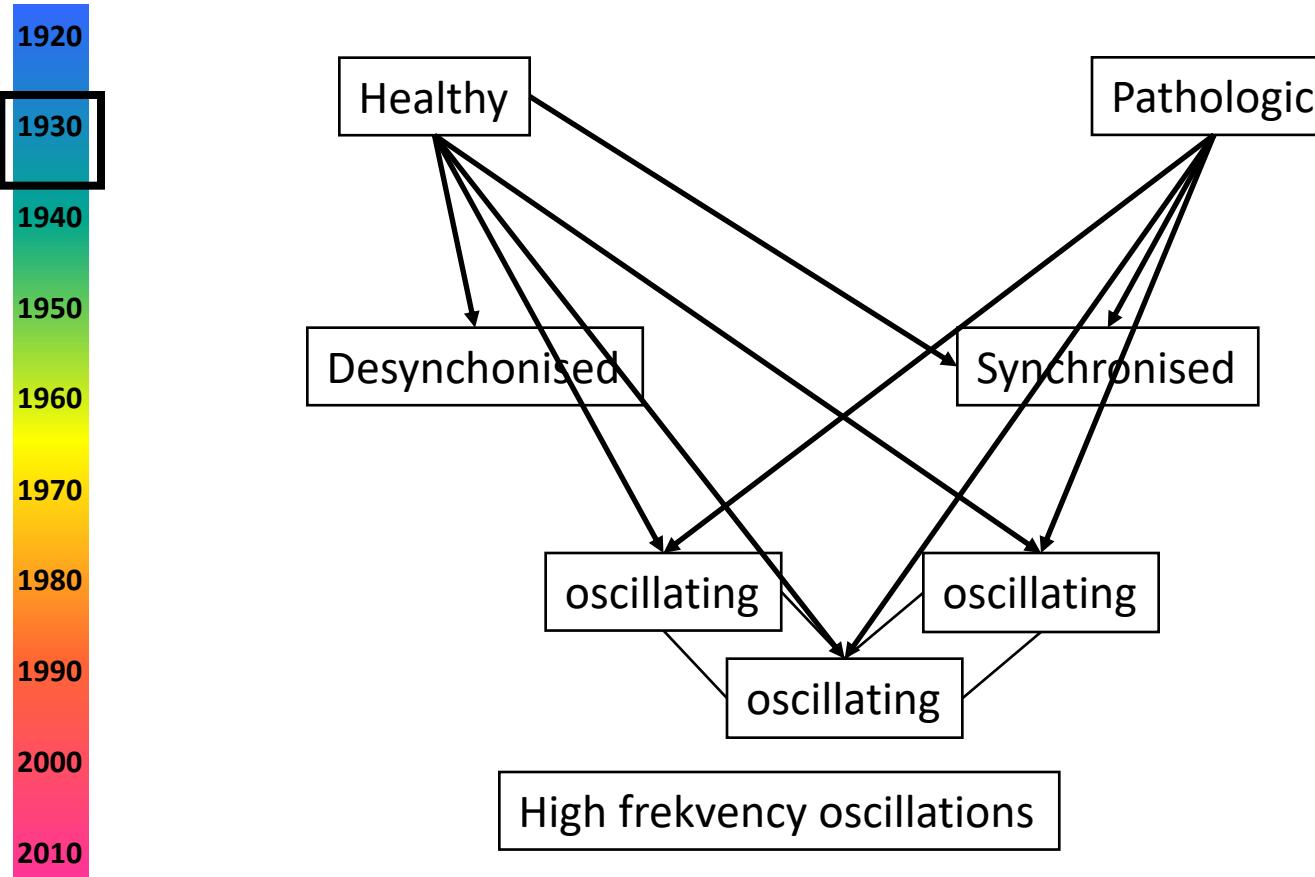
# Brain oscillations



- Inverse relationship:
  - Frequency – Power
    - $1/f$
  - Frequency – spatial extent

Buzsáki, 2004, Science

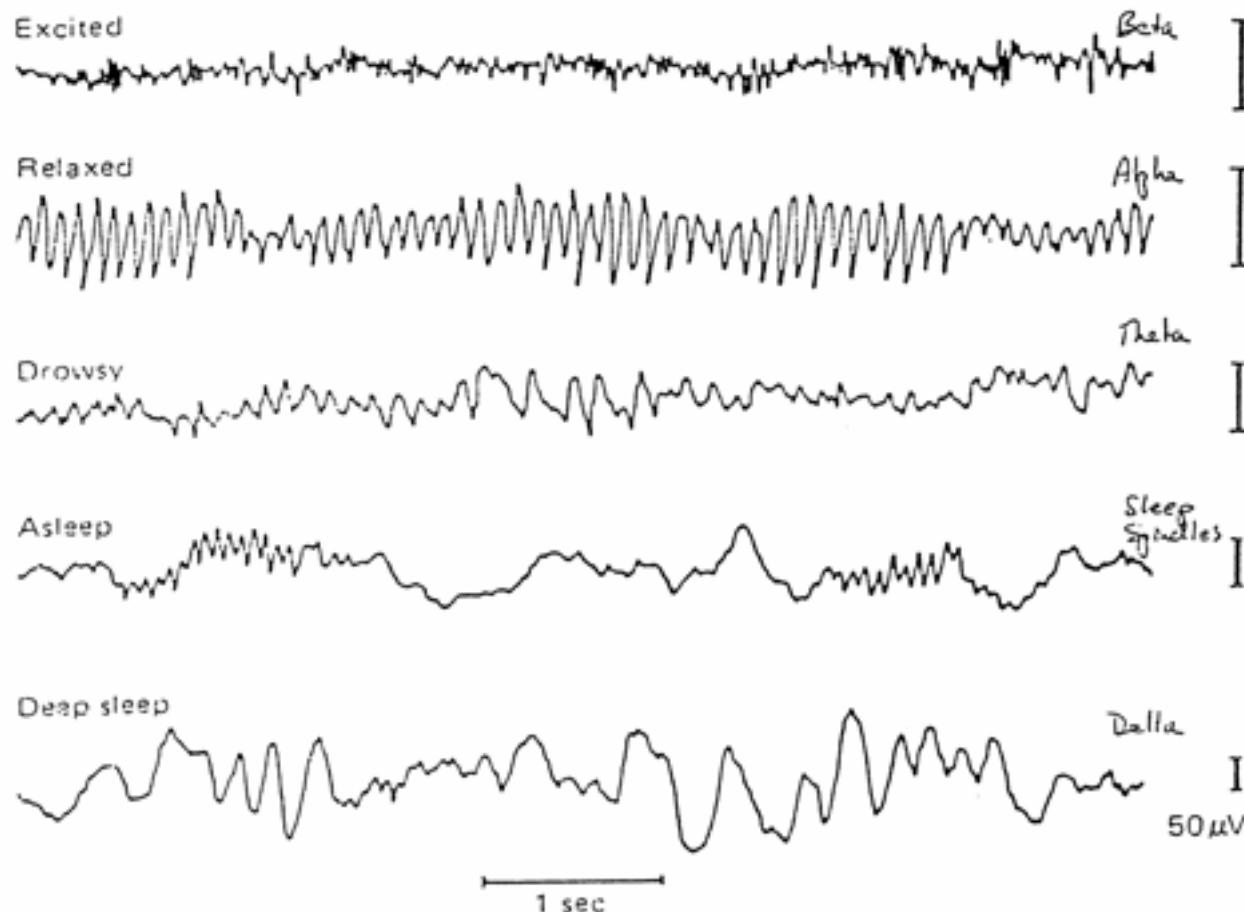
# Organisation of brain oscillations



# Brain electrical activities

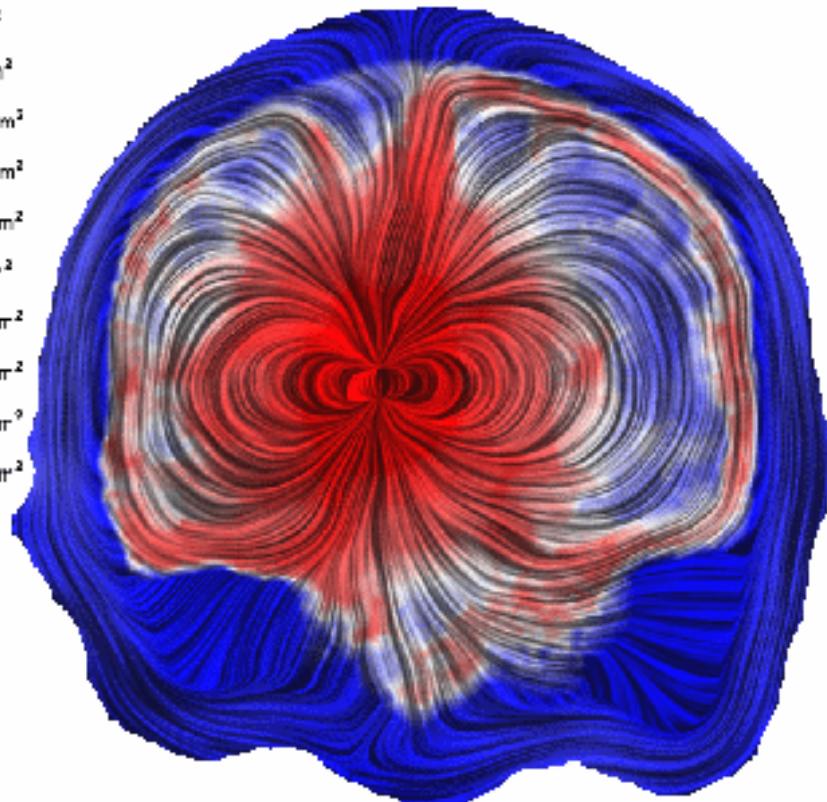
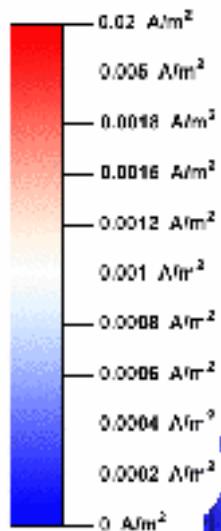
Type	Frequency (Hz)	Normal	Pathologic
<b>Delta</b>	Bellow 4	<ul style="list-style-type: none"> <li>• Adult: Slow wave sleep: frontal</li> <li>• Toddler: posterior</li> </ul>	<ul style="list-style-type: none"> <li>• Subcortical lesions</li> <li>• Diffuse lesions</li> <li>• Metabolic encephalopathy</li> <li>• Hydrocephalus</li> <li>• Deep midline lesions</li> </ul>
<b>Theta</b>	4 – 8	<ul style="list-style-type: none"> <li>• Childhood</li> <li>• Drowsiness</li> </ul>	<ul style="list-style-type: none"> <li>• Similar to delta</li> <li>• Rather focal</li> </ul>
<b>Alfa</b>	8 – 13	<ul style="list-style-type: none"> <li>• Relaxed, closed eye</li> <li>• Posterior regions</li> </ul>	<ul style="list-style-type: none"> <li>• Special coma EEG</li> </ul>
<b>Beta</b>	>13 – 30	<ul style="list-style-type: none"> <li>• Awake, thinking, active</li> </ul>	<ul style="list-style-type: none"> <li>• Benzodiazepin effect</li> </ul>
<b>Gamma</b>	30 – 80	<ul style="list-style-type: none"> <li>• Binding between remote brain regions</li> </ul>	
<b>Mu</b>	8 – 13	<ul style="list-style-type: none"> <li>• Resting motoneurons</li> </ul>	
<b>Szigma</b>	12-18	<ul style="list-style-type: none"> <li>• Sleep spindles</li> </ul>	

# Brain oscillations, falling asleep

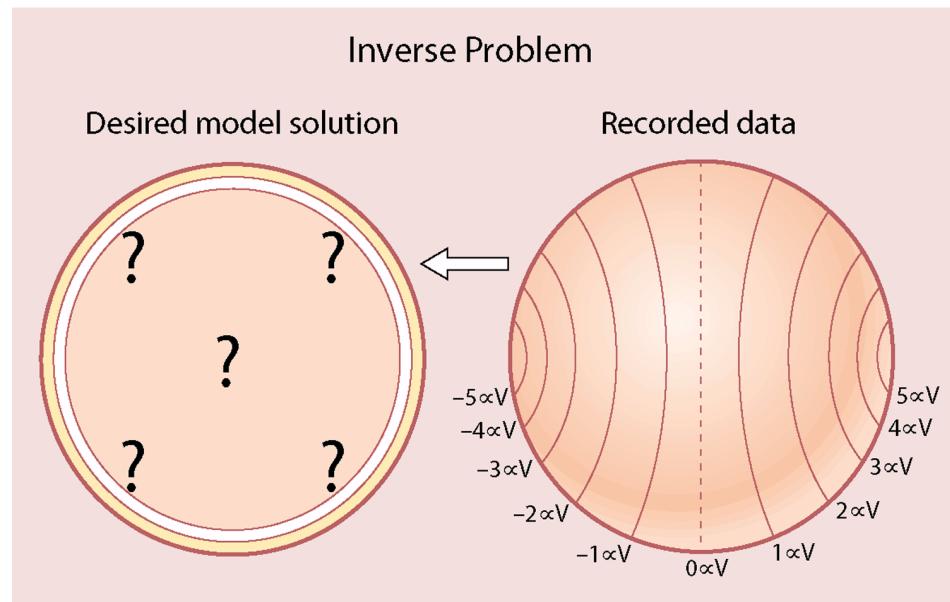
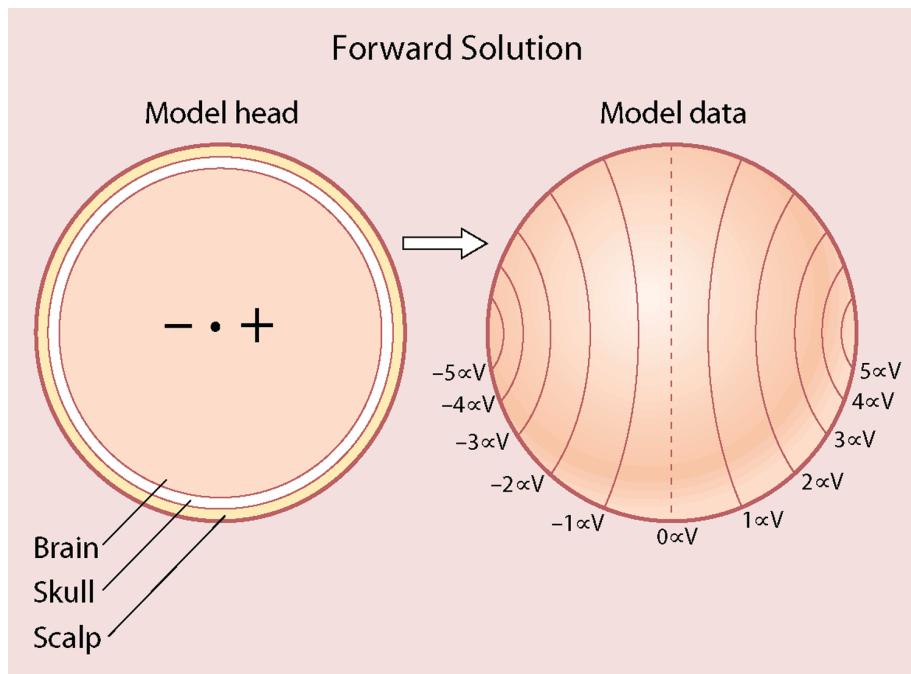


# Sources of EEG – what do we record

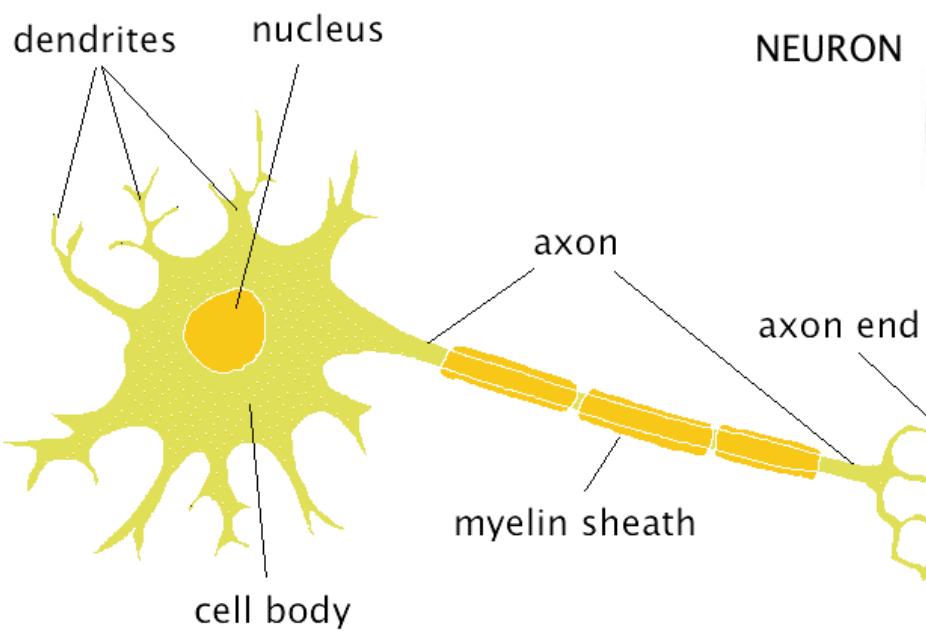
- Mostly noise!
- Volume conduction
  - Current flows through, and scattered
  - between the generator and recording site
  - Meninges, bone, scalp, skin
- 2D representation of a 3D reality
- Inverz problem
  - Where is the source?



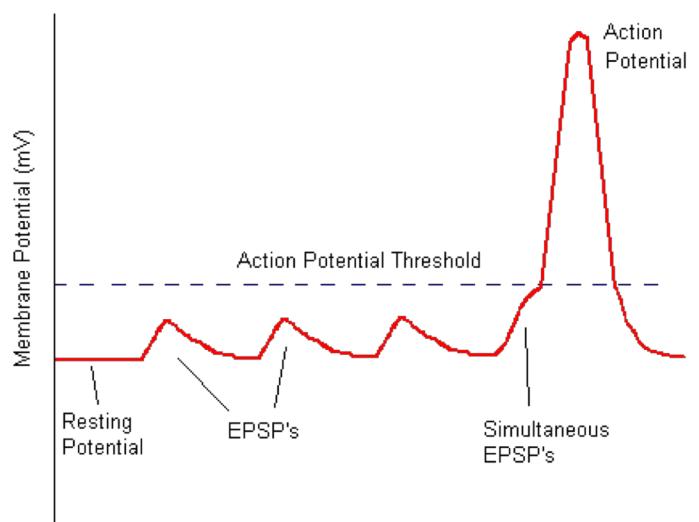
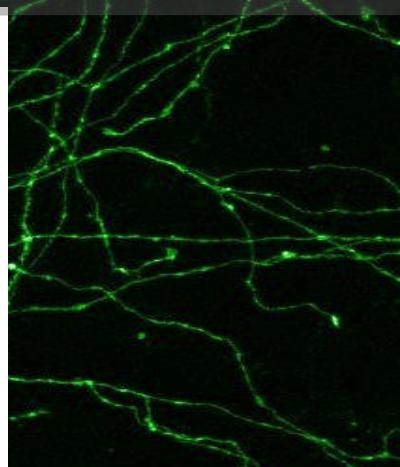
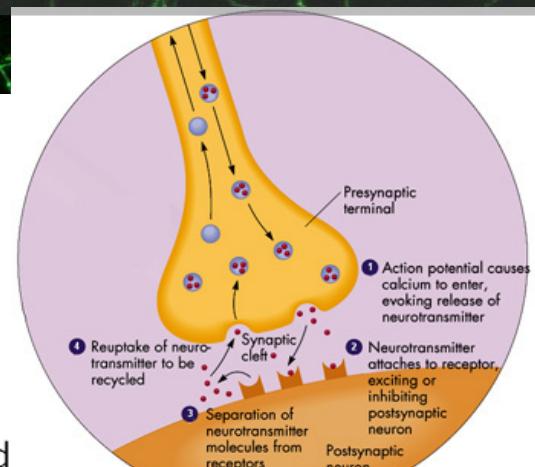
# Source – location problems



# Neural basis of EEG



NEURON

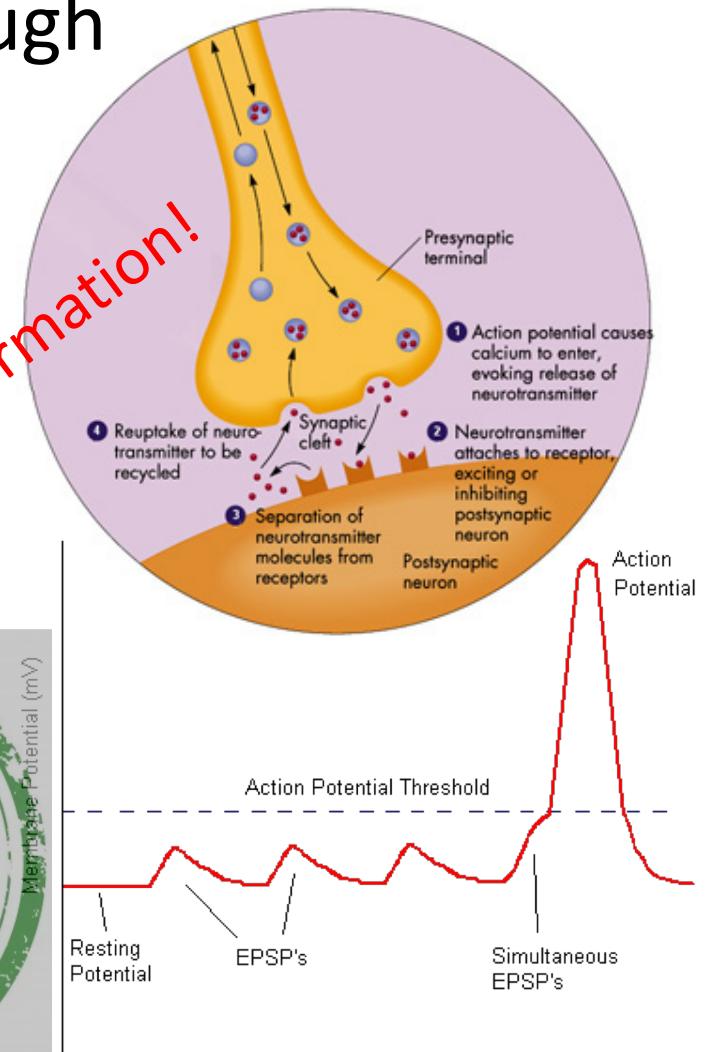


# What do give rise to EEG?

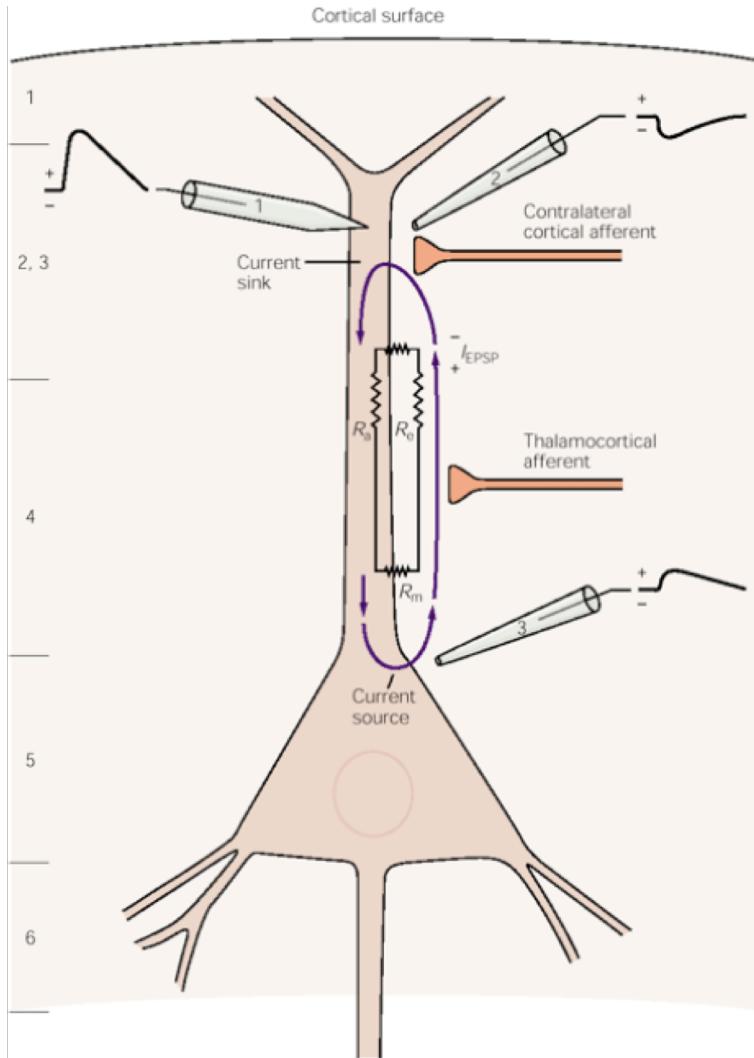
- A source must be large enough
- to be detected on the scalp.
- Action potential?
  - Large, cca. 100mV (!)
  - Fast, transient, 1ms
  - All or none
  - Spreads along the axon
- Postsynaptic potential (PSP)?
  - Small, cca 10-20mV
  - Variable amplitude
  - Slow, longer lasting, 5-15ms
  - Spreads along the membrane



No bipolar formation!

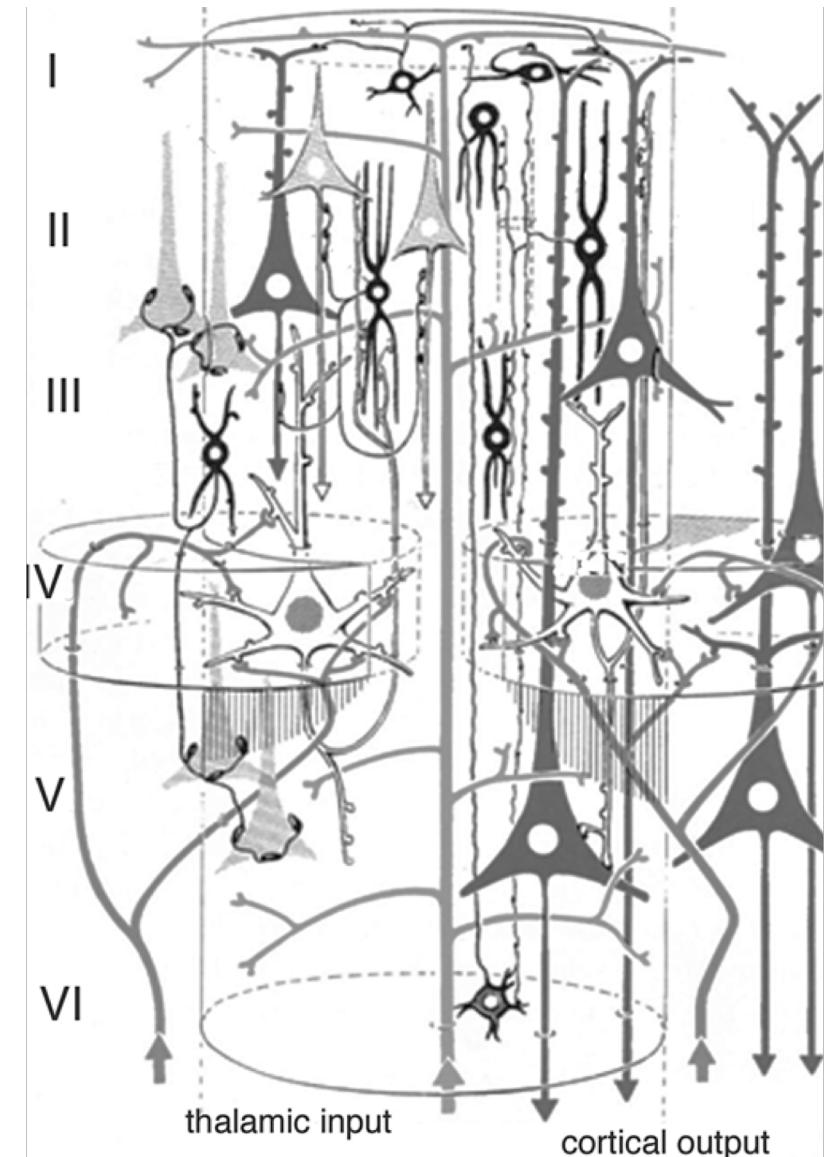
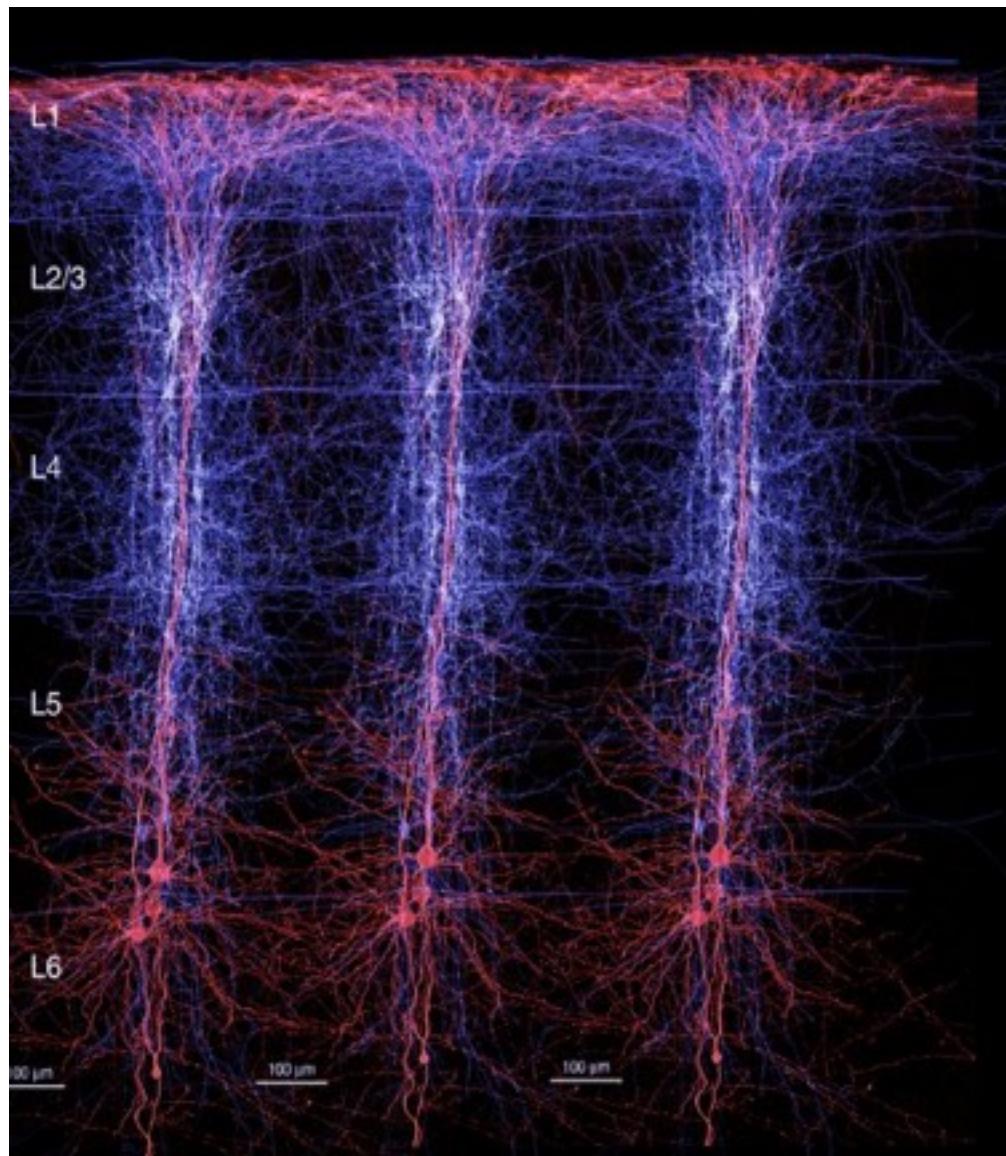


# Membrane currents during an EPSP



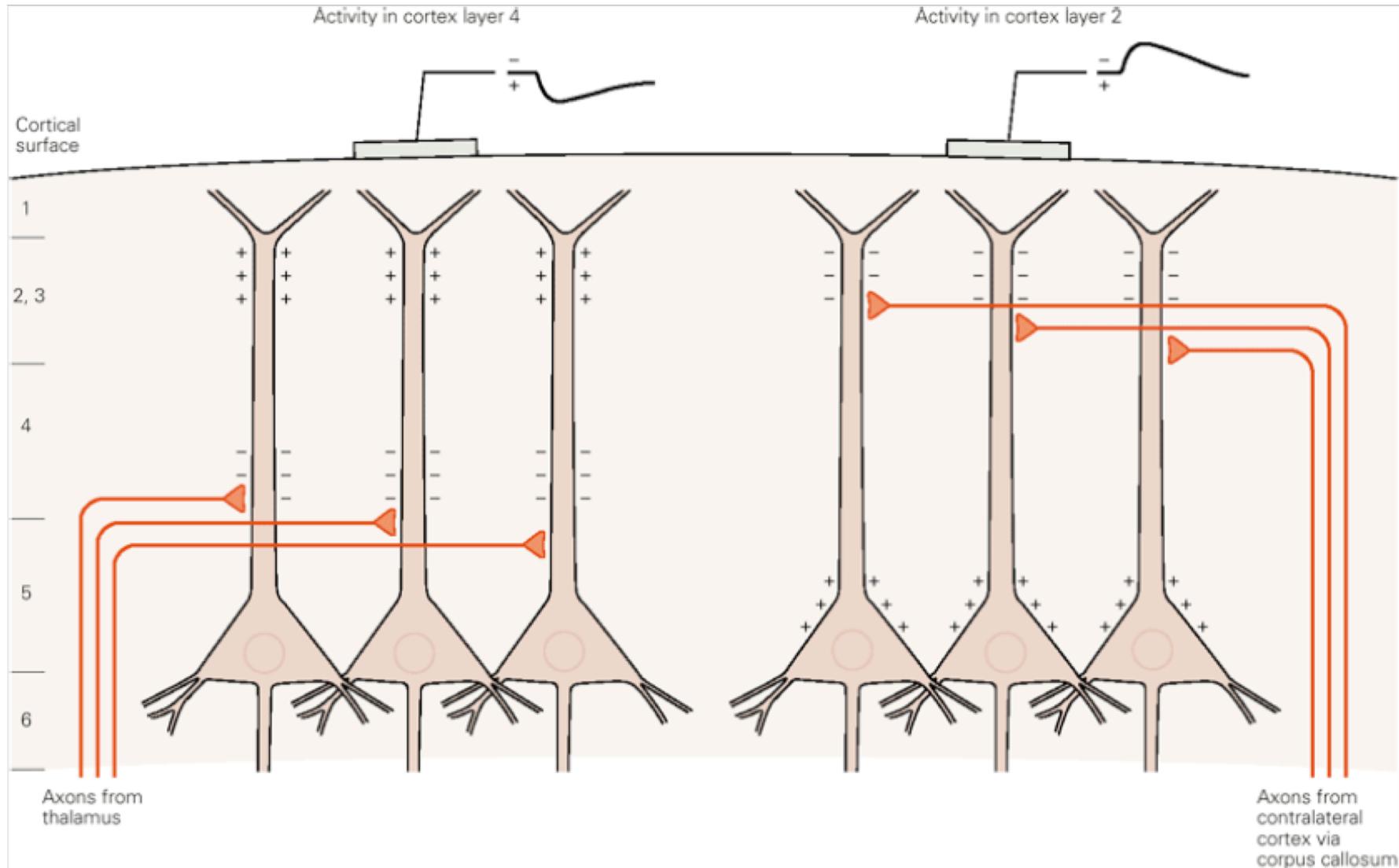
- EPSP (excitatory PSP)
  - $\text{Na}^+$  influx to the neuron
  - extracellular current formation
  - small bipole generation
- If they are multiplied by adjacent neurons
  - large bipole generation

# Cortical column



Szentagothai

# Intracortical bipols due to the most important cortical imputs



# Thank you for the attention