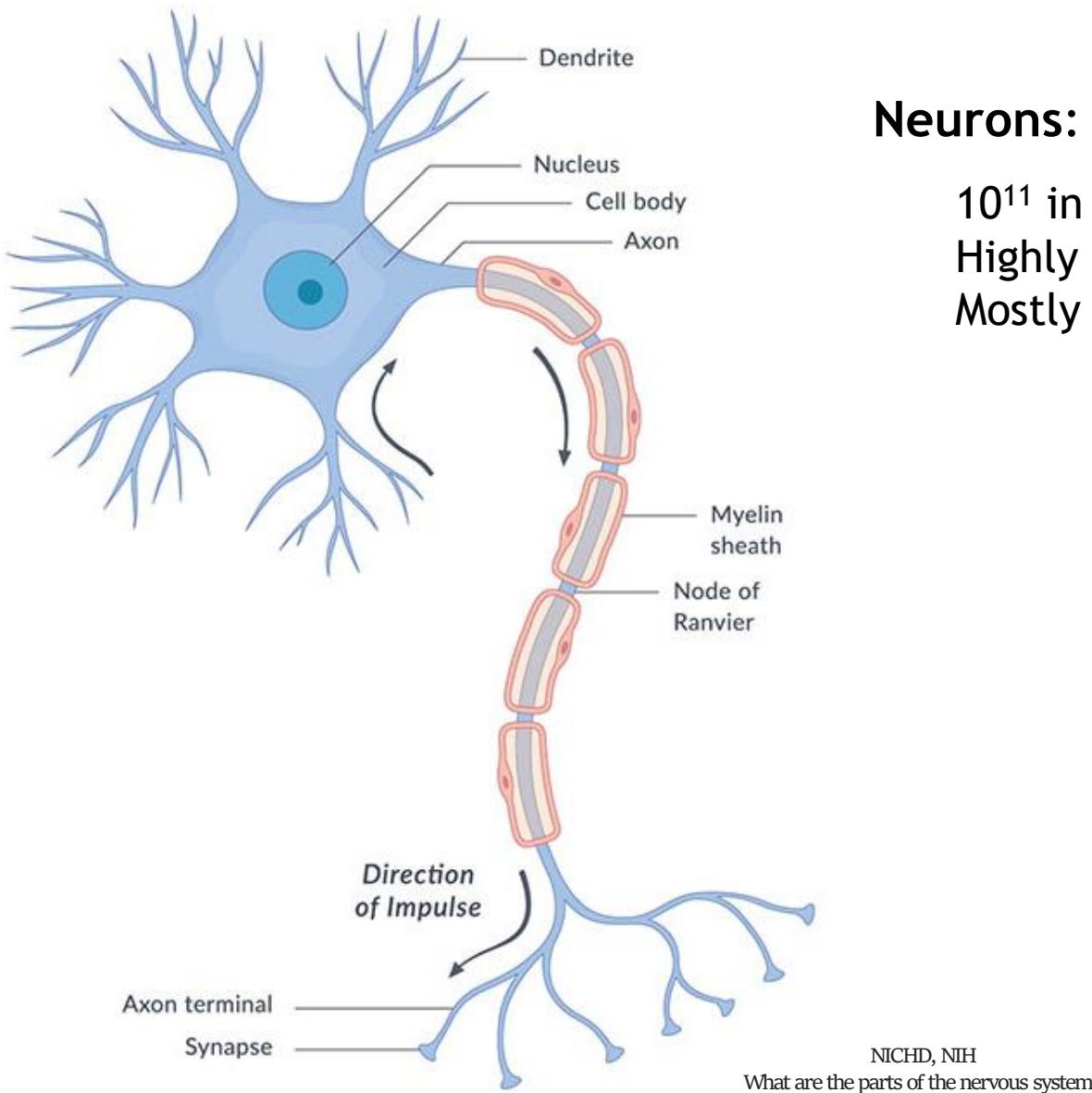


INTRODUCTION TO NEURAL OSCILLATION ANALYSIS



Cantin Ortiz, Letizia Signorelli
OBiWoW 2025 – 12/12/2025

IN THE BRAIN, INFORMATION IS PROCESSED BY NEURONS THROUGH ELECTRICAL SIGNALS

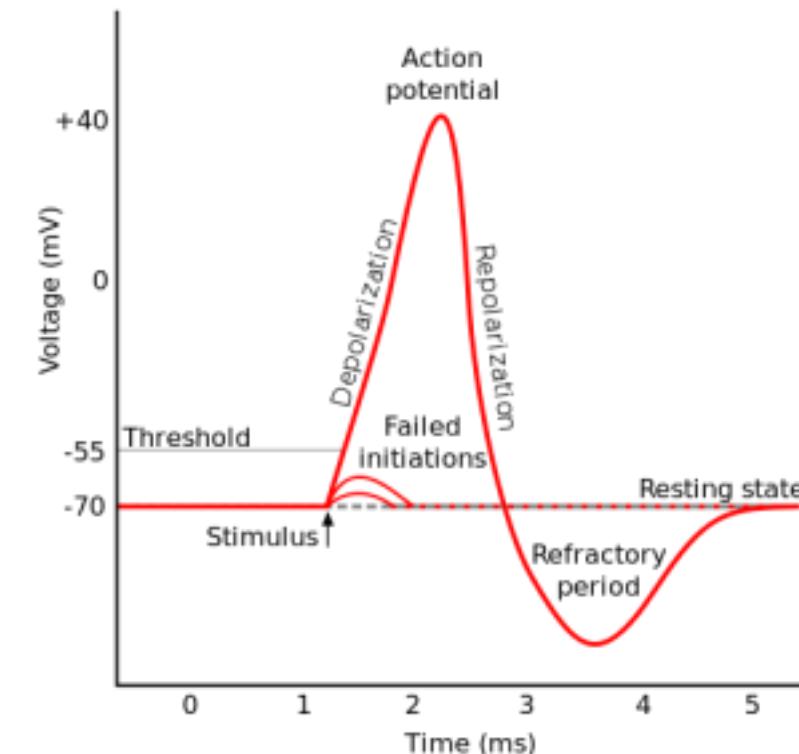


Neurons: dedicated cell type to process information

10^{11} in the human brain, $10^7 – 10^8$ in rodents

Highly interconnected (1000s synapses per neuron)

Mostly communicate via action potentials: non-linear responses



NEURAL OSCILLATIONS EMERGE FROM SYNCHRONOUS MEMBRANE POTENTIAL FLUCTUATIONS

Current superimpose forming 'electric field'

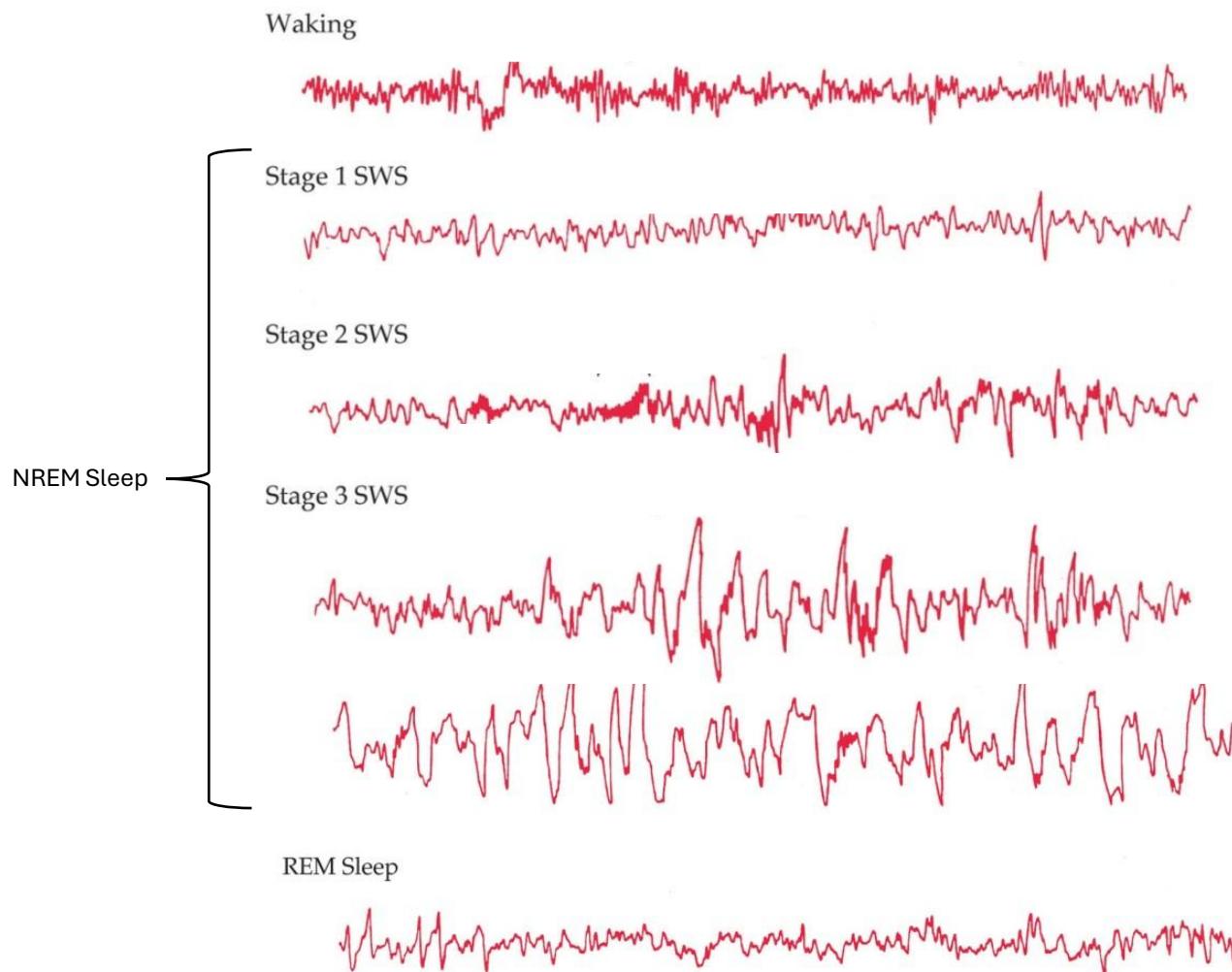
Neural oscillation: rhythmic, repetitive electrical activity generated by synchronous membrane potential fluctuations of a population of neurons

Mostly reflect synaptic activity: inputs

Characterised by their **amplitude** ("strength") and **frequency**



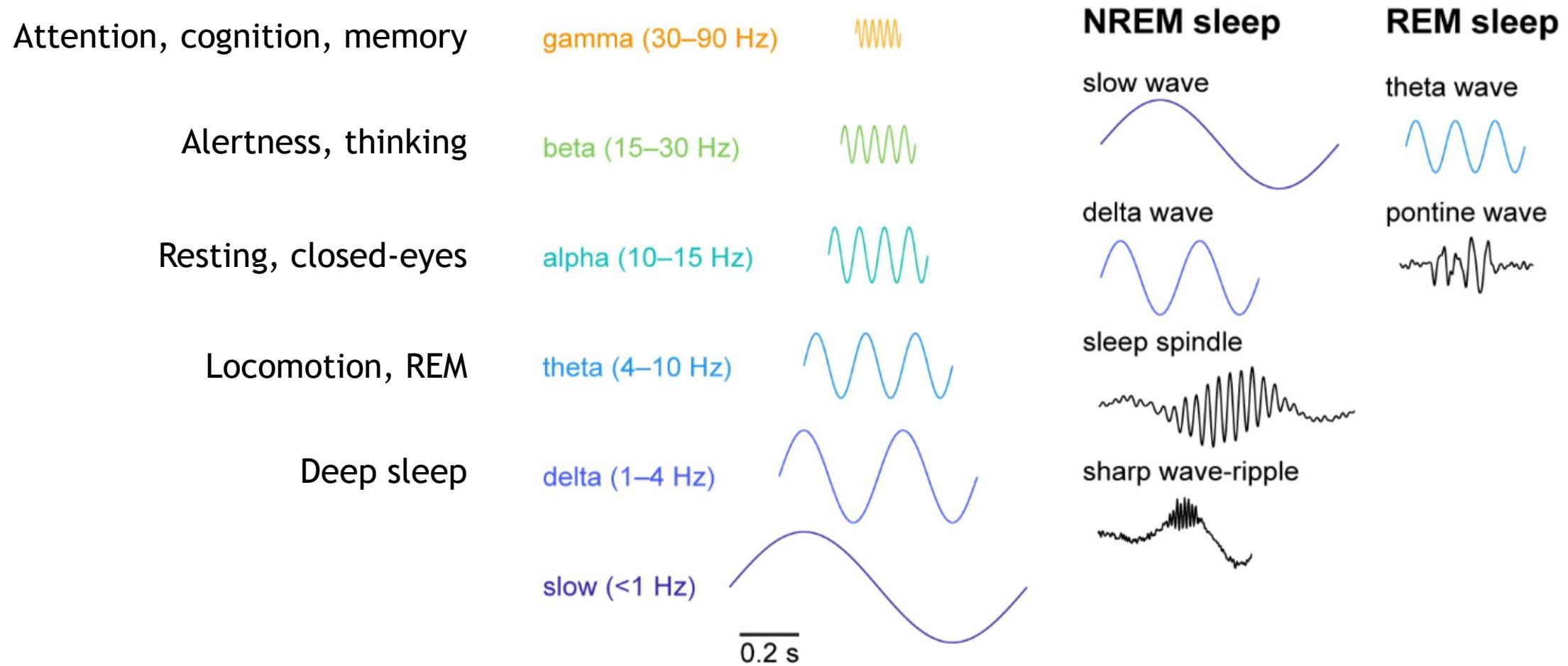
EXAMPLE: IDENTIFYING DIFFERENT SLEEP STATES BASED ON NEURAL OSCILLATIONS



DIFFERENT TYPES OF OSCILLATIONS

We can analyse neural oscillations by their **frequency bands** and link them to **brain states**

Some oscillations are composite (envelop, unit activity) and require finer methods of detection



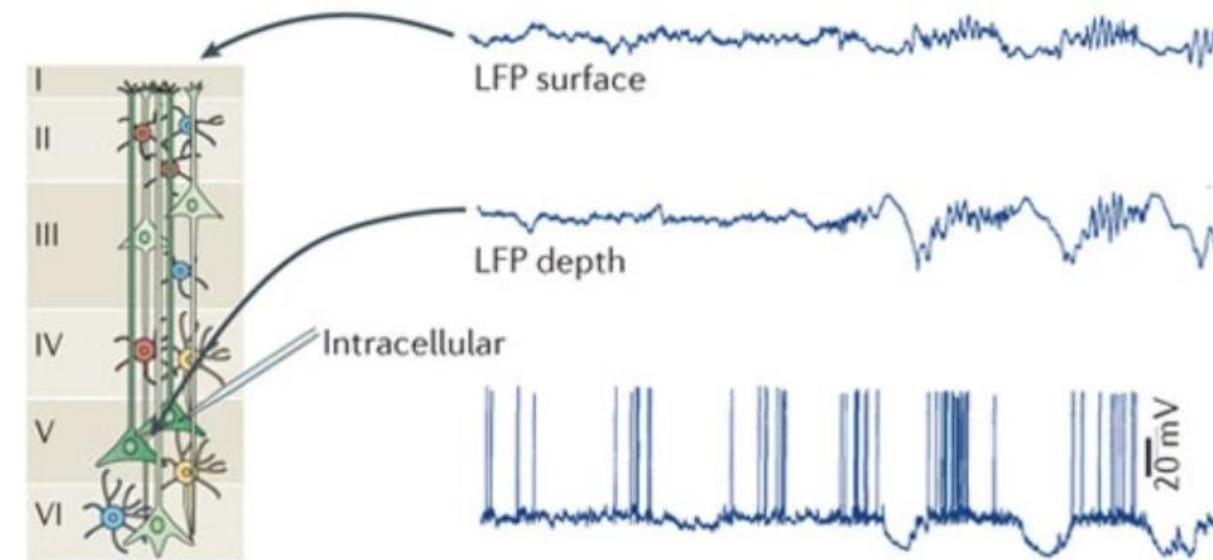
DIFFERENCES BETWEEN OSCILLATIONS (LFP) AND ACTION POTENTIALS

1. Local Field Potential (LFP)

Oscillations 0.1 - 200 Hz - acquisition > 1500 Hz

Mostly reflect synaptic inputs

Summation of activity within a small region (ca $\varnothing 300\mu$)



2. Action potential

1-2 ms (500-1000 Hz) - acquisition > 20 000 Hz

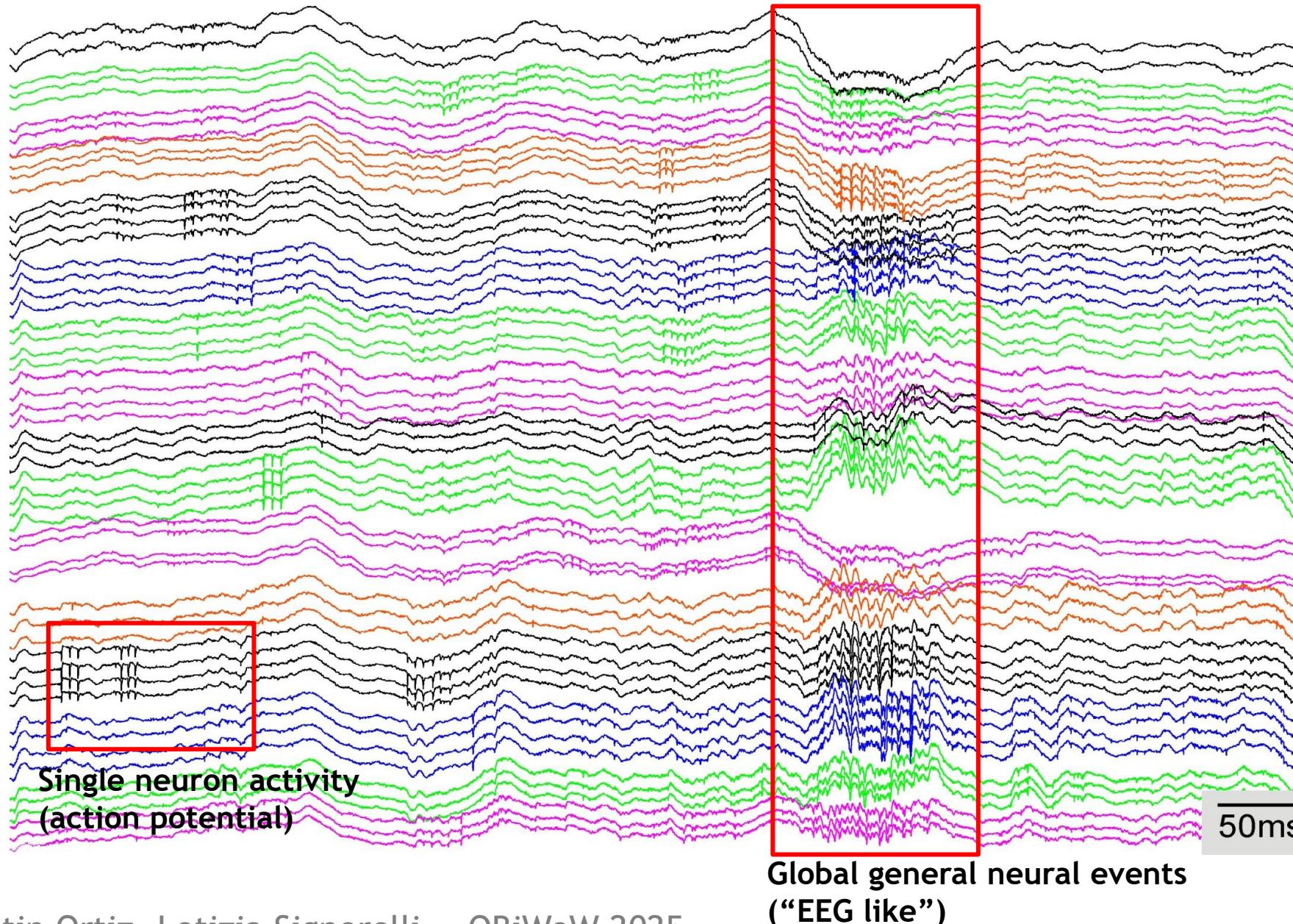
Neuronal output

Local activity (ca $\varnothing 100\mu$) - multi or single units

Buzsáki, György, Costas A. Anastassiou, and Christof Koch.
"The origin of extracellular fields and currents—EEG, ECoG, LFP and spikes."
Nature reviews neuroscience 13.6 (2012): 407-420.

EXAMPLE RECORDING WITH BOTH ACTION POTENTIAL AND OSCILLATIONS

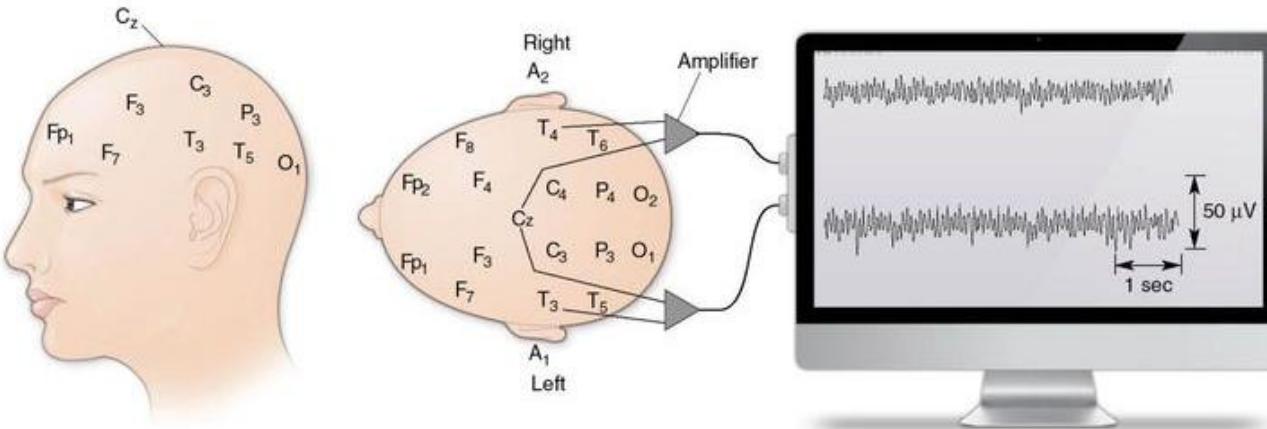
7



16 tetrodes (adult HPC)
From Charlotte Boccara

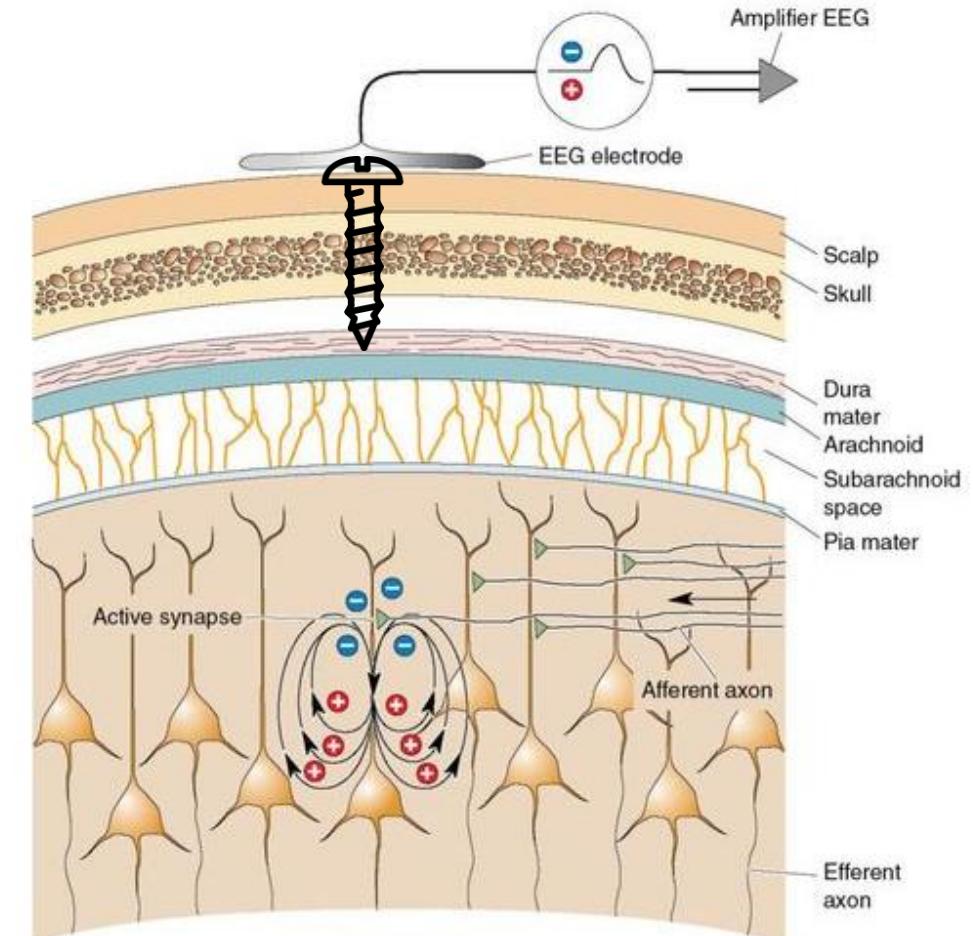
HOW TO RECORD OSCILLATIONS?

EEG: Electroencephalography

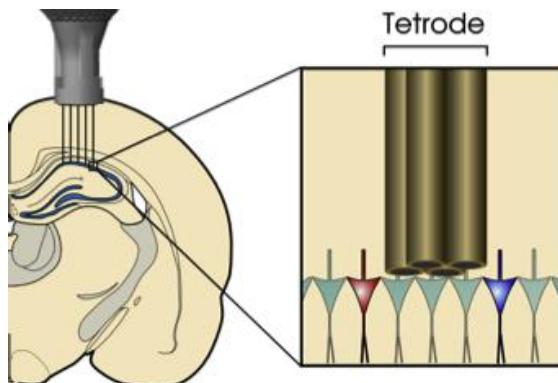


Bear et al, Neuroscience Exploring the brain 4th edition, Britton 2016

ECoG: Electrocorticography



Local Field Potential (LFP) with intracerebellar electrodes



WORKSHOP PLAN

1. 9H00 - 9H50: INTRODUCTION AND BASIC SIGNAL PROCESSING

Analog vs digital signal

Filtering

Downsampling

BREAK 1: 9H50 – 10H00

2. 10H00 – 10H50: TIME-FREQUENCY ANALYSIS

Fast Fourier Transform

Spectrograms

Important parameters

BREAK 2: 10H50 – 11H00

3. 11H00 – 12H00: SLEEP SCORING AND CONCLUSION

EMG and EEG

Wake vs Sleep

Non-REM vs REM

