FREELY MOVING ELECTROPHYSIOLOGY

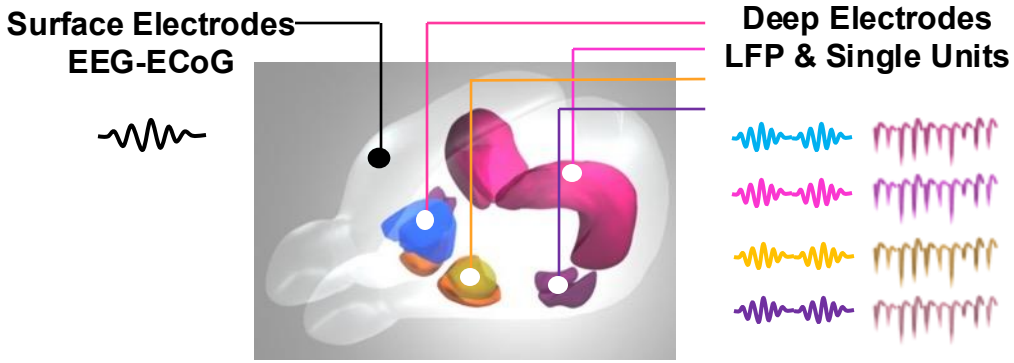
PHARMACOLOGY & OPTOGENETICS

In vivo brain Electrophysiology Detailed Capacities

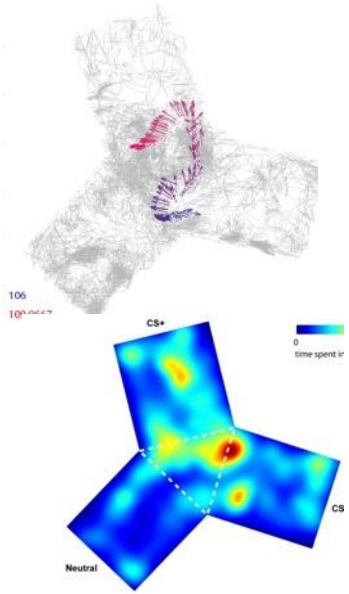
neuroservices ALLIANCE X OptoPath™

OPTOPATH: IN VIVO ELECTROPHYSIOLOGY PLATFORM TO :

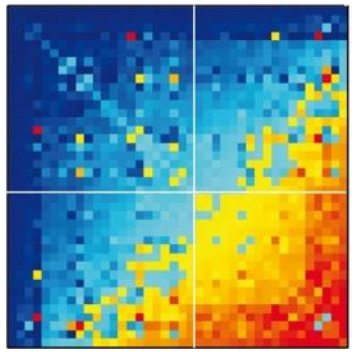
RECORD NEURONAL SIGNALS



PERFORM BEHAVIOR



ANALYSE NEURAL SIGNALS



Multiple recording systems (7 64 channels systems)

- **Dedicated space and ressources**
  - **Mice and rats (male and female) animal facilities (240 rats, 600 mice)**
  - **Experimental space (400 m2)**
  - **Dedicated team of technicians and researchers**
  - **Average timeline (6-8 weeks) for recordings in 8-12 mice**
  - **Recordings up to several weeks-months**

AGENDA

1. METHODOLOGY

What type of neuronal signal can we record ?

2. ANALYSES

What information can we extract from recorded signals

3. STUDY CASE

4 Hz oscillations as a biomarker of defensive states

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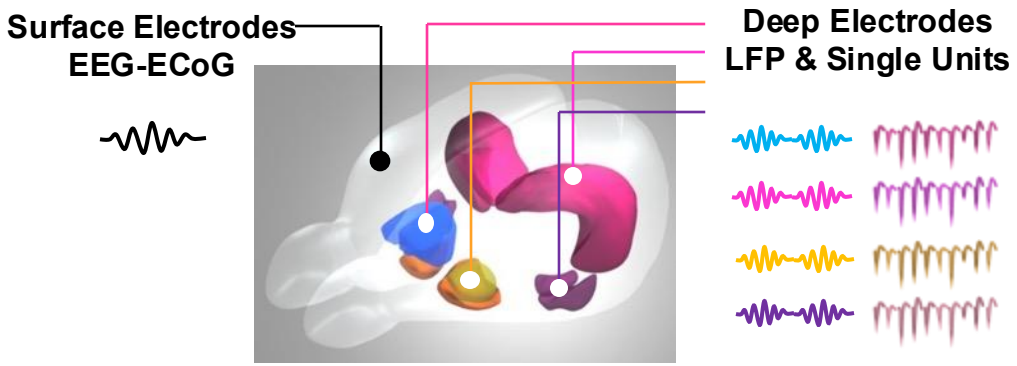
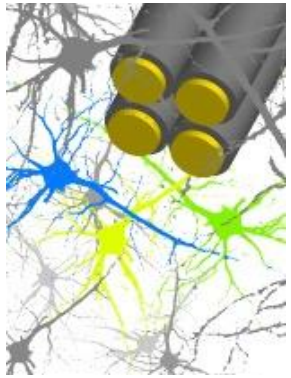
METHODOLOGY

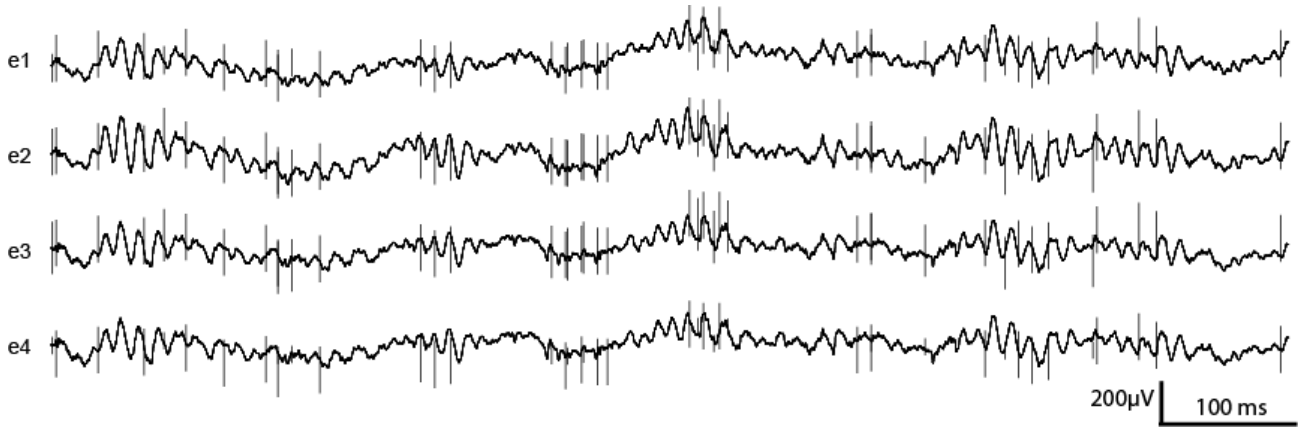
WHAT TYPE OF NEURONAL SIGNAL CAN WE RECORD ?



TYPE OF ELECTRODES AND RECORDINGS

- **Single tungstene electrodes (EcoG-EEG)**
- **Custom made electrodes NiChrome bundles (LFP, Units)**
- **Stereotrodes- tetrodes – silicones probes (LFP, Units)**
- **Multisite recordings**
- **EMG recordings**
- **during behavior or using head-fixed preparations**





Action Potentials (spikes)

Single neuron activity (action potentials)

Local Field Potentials (LFP)

Global activity (synaptic inputs)

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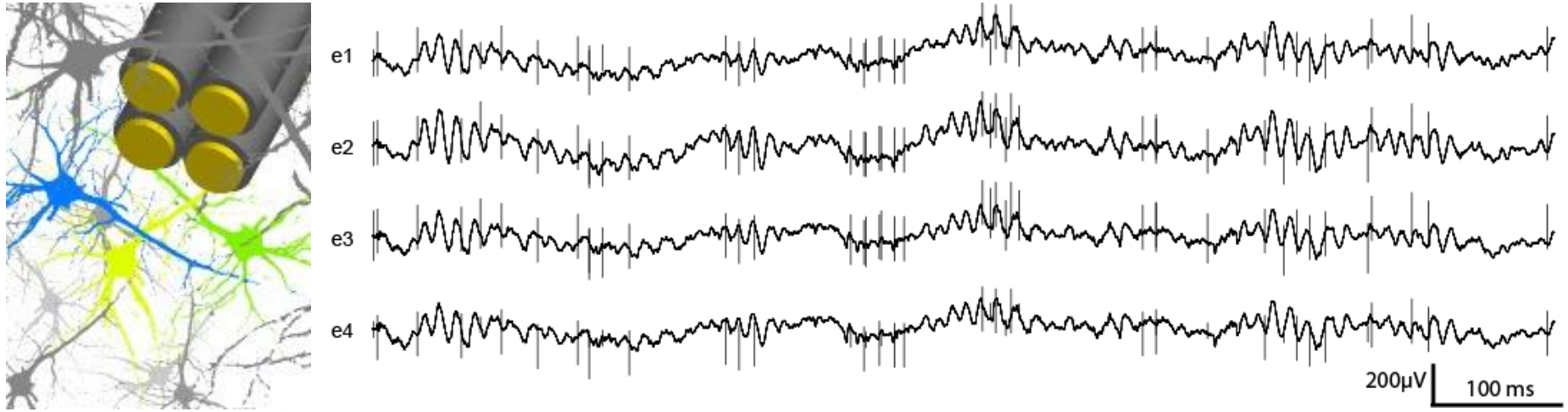
METHODOLOGY

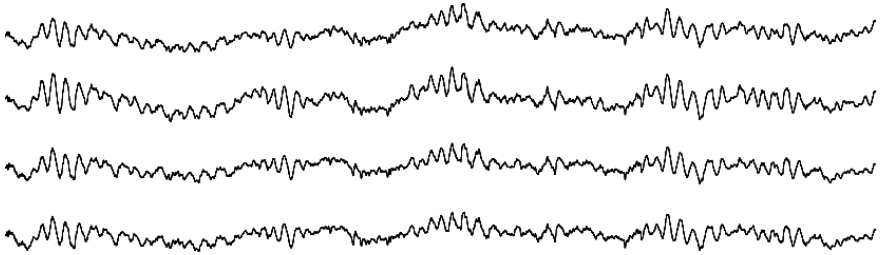
WHAT TYPE OF NEURONAL SIGNAL CAN WE RECORD ?



Different frequency components :

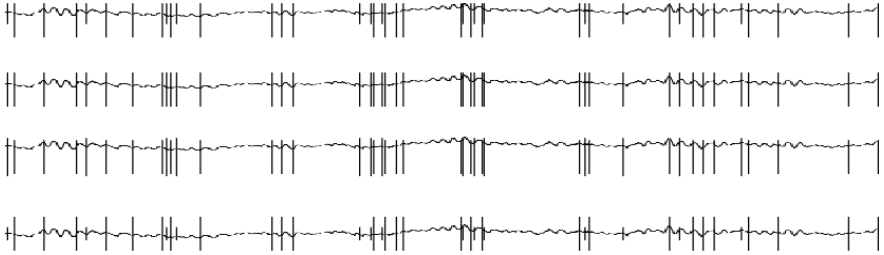
LFP are Slow (< 100-200 Hz)

→ Downsample (Lowpass <500 Hz)



Spikes are fast (> 300 Hz)

→ Highpass (100 Hz – 20 KHz)



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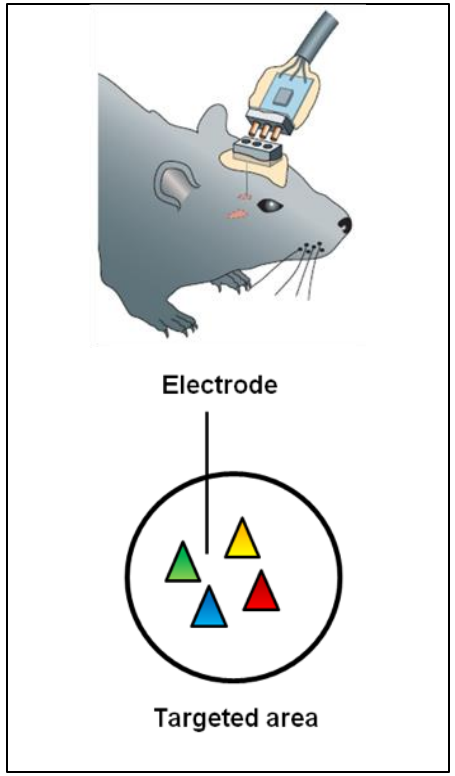
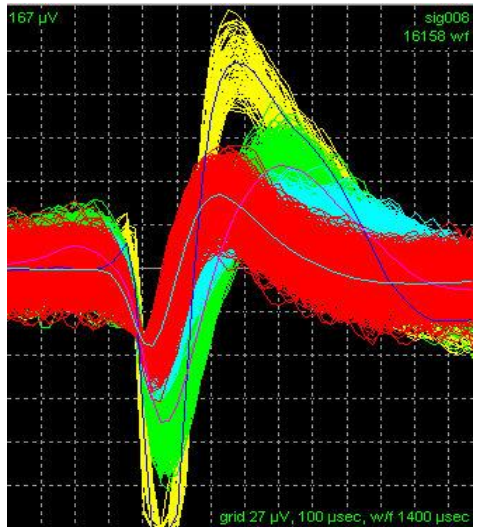
METHODOLOGY

WHAT TYPE OF NEURONAL SIGNAL CAN WE RECORD ?

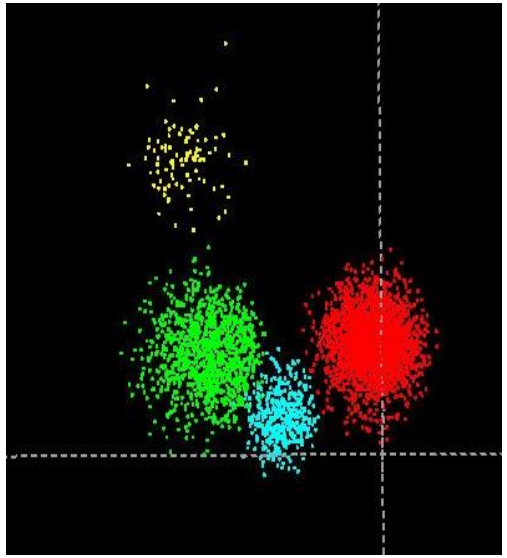
SINGLE CELL ACTIVITY





Action potential clusters

Extracellular action potentials



Fast signals (> 300 Hz)

Spike sorting

* **Spikes isolation**
* **selection of best discriminative features (amplitude, length...)**
* **Cluster quality check (refractory period, similar waveforms, isolation quality, crosscorrelograms)**

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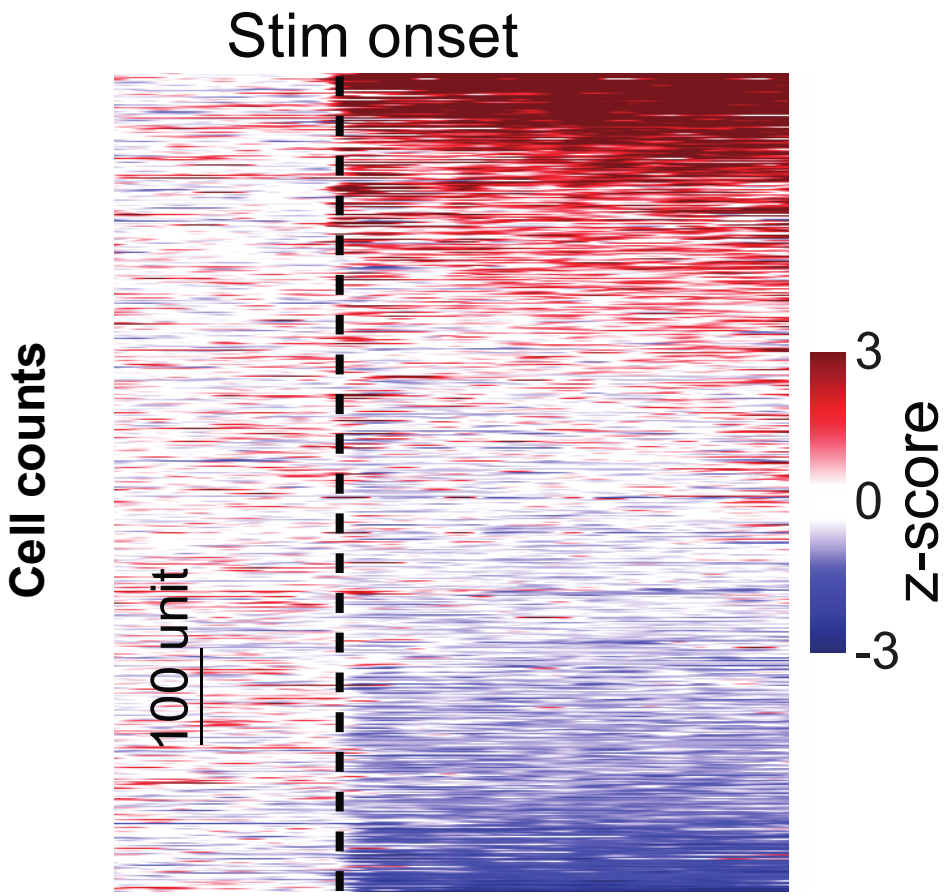
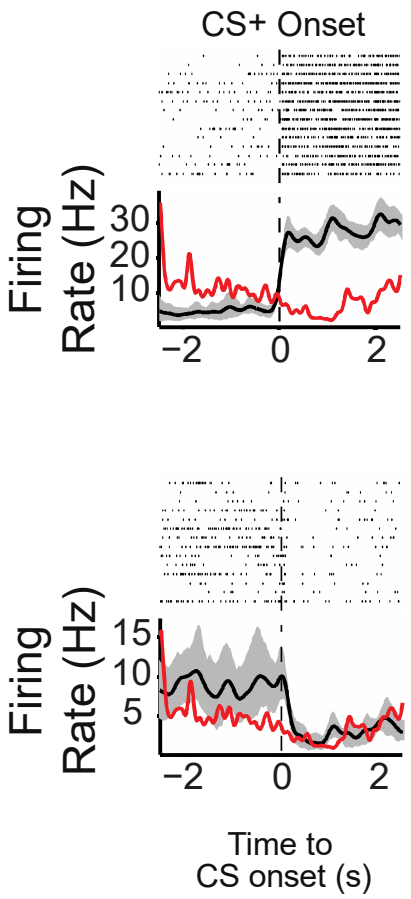
METHODOLOGY

WHAT TYPE OF NEURONAL SIGNAL CAN WE RECORD ?





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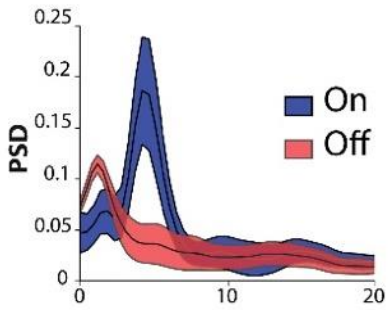
ANALYSES

WHAT INFORMATION CAN WE EXTRACT FROM RECORDED SIGNALS ?

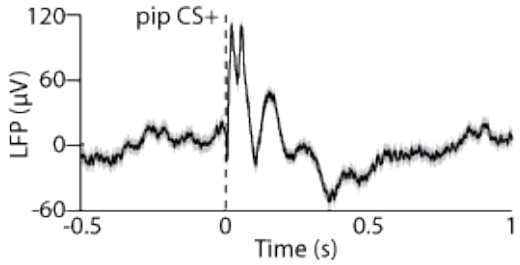
STATIC ANALYSES

EEG/ECoG/LFP



Power Spectrum

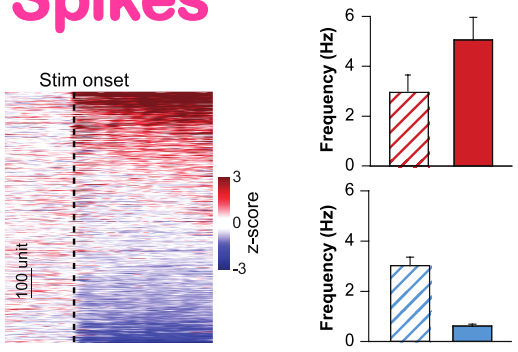
Preferred oscillation frequencies or frequency range of a given structure



Evoked Potentials

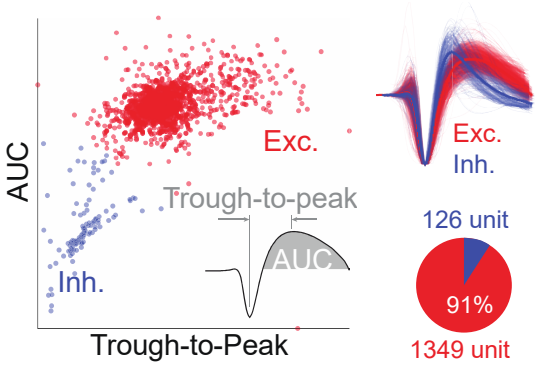
Net effect of the stimulation on synaptic inputs to a given structure

Spikes



Firing rate

Averaged firing rate



Cell type

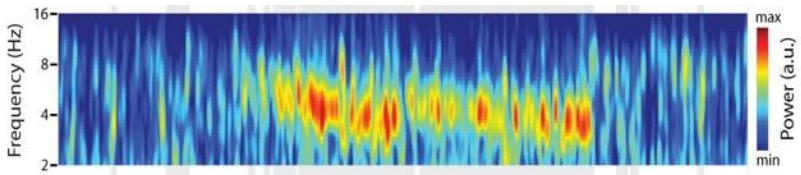
Identification of putative inhibitory interneurons and excitatory cells

ANALYSES

WHAT INFORMATION CAN WE EXTRACT FROM RECORDED SIGNALS ?

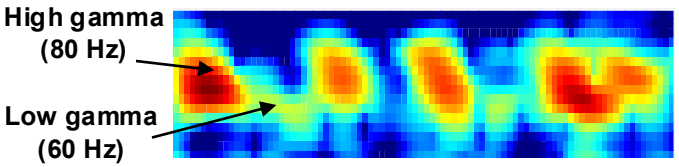
DYNAMIC ANALYSES

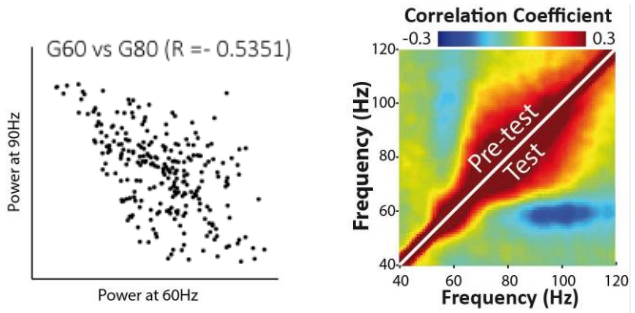
EEG/ECoG/LFP



EEG/LFP dynamics

Preferred oscillation frequencies or frequency range of a given structure over time

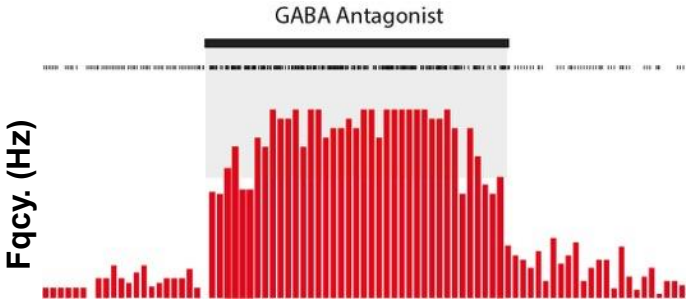




Cross-frequency spectrum

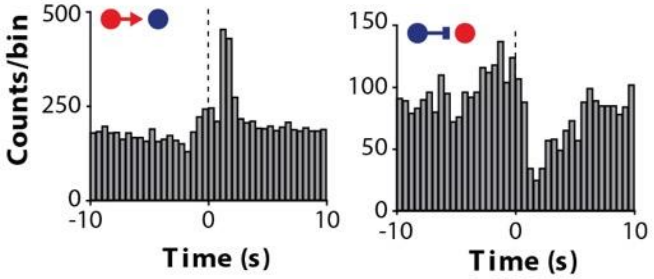
Dynamical relation between LFP bands within or between structures

Spikes



Spikes dynamics

Changes in firing frequencies over time



Crosscorrelograms

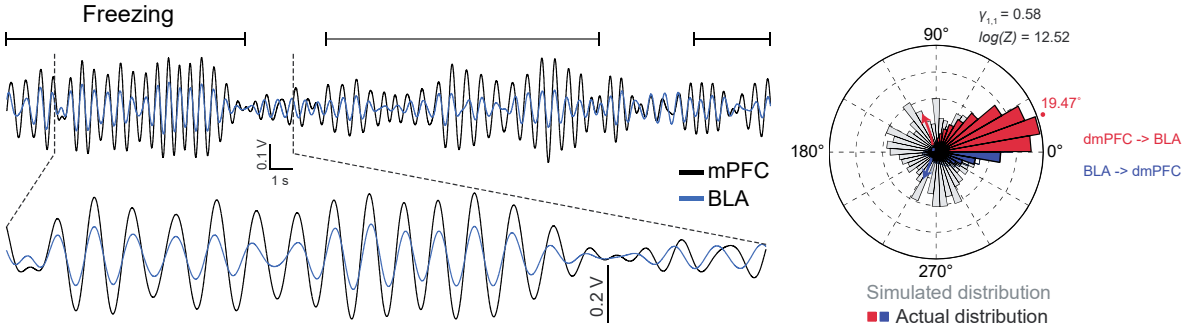
Identification of putative excitatory/inhibitory connections

ANALYSES

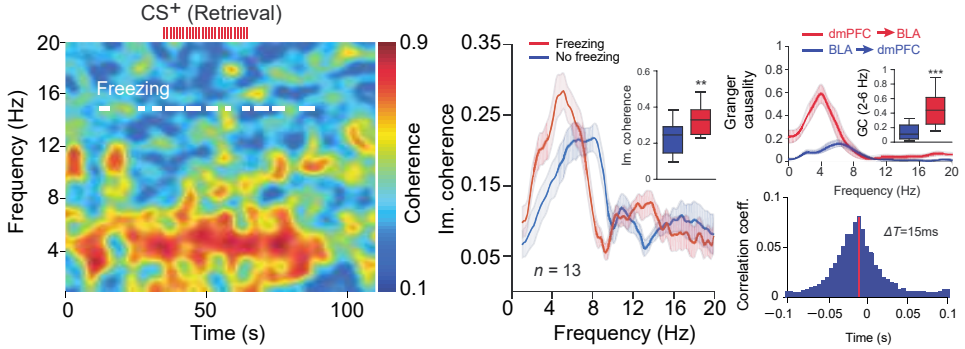
WHAT INFORMATION CAN WE EXTRACT FROM RECORDED SIGNALS ?

DYNAMIC ANALYSES

EEG/ECoG/LFP

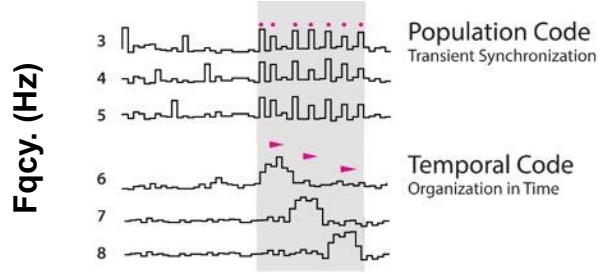


LFP phase synchronisation during behavior

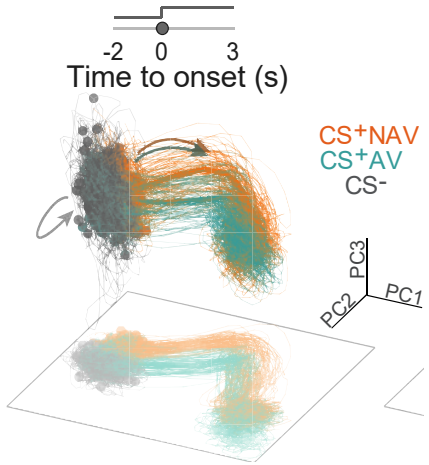


Coherence and directionality analyses during behavior

Spikes



Temporal organisation of population firing activities



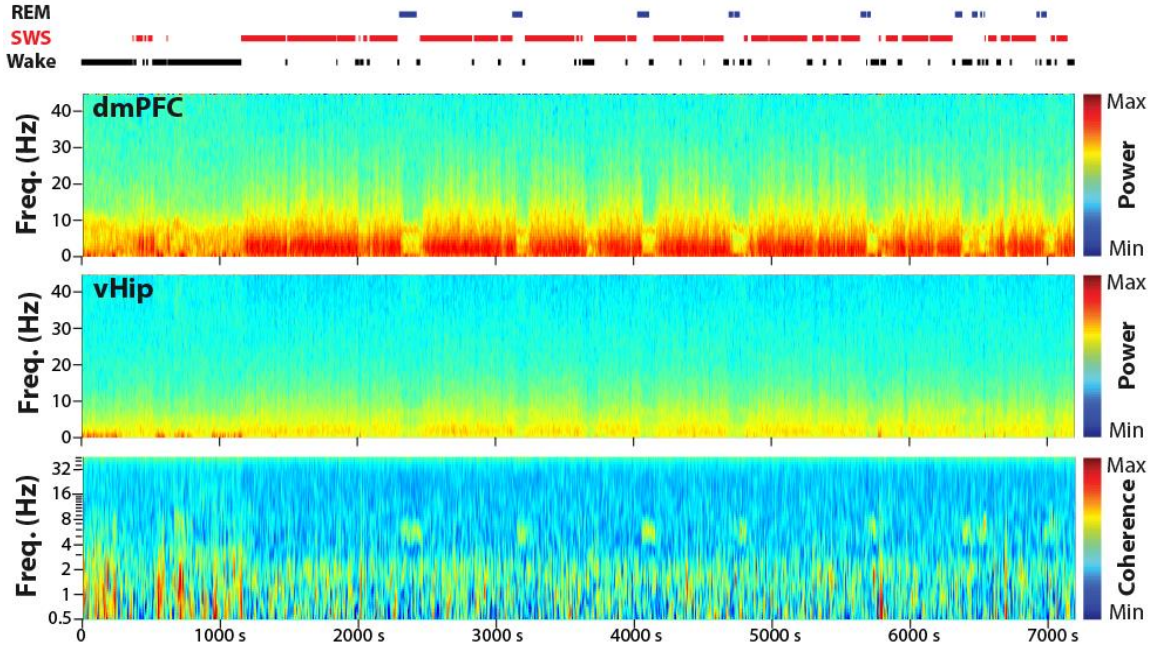
PCA population activity onset aligned

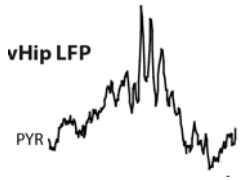
Jercog et al. 2019

ANALYSES

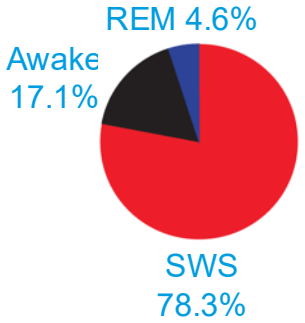
WHAT INFORMATION CAN WE EXTRACT FROM RECORDED SIGNALS ?

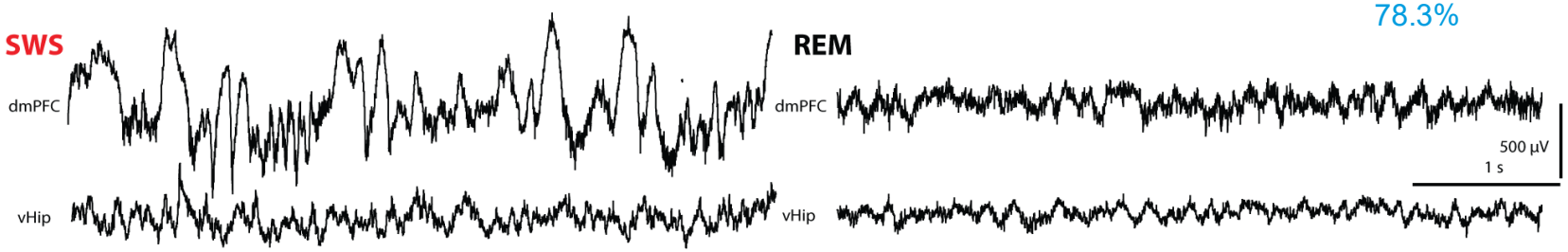
Dynamic Brain States Analyses : EEG from different structures





Percentage of Sharp Wave Ripples





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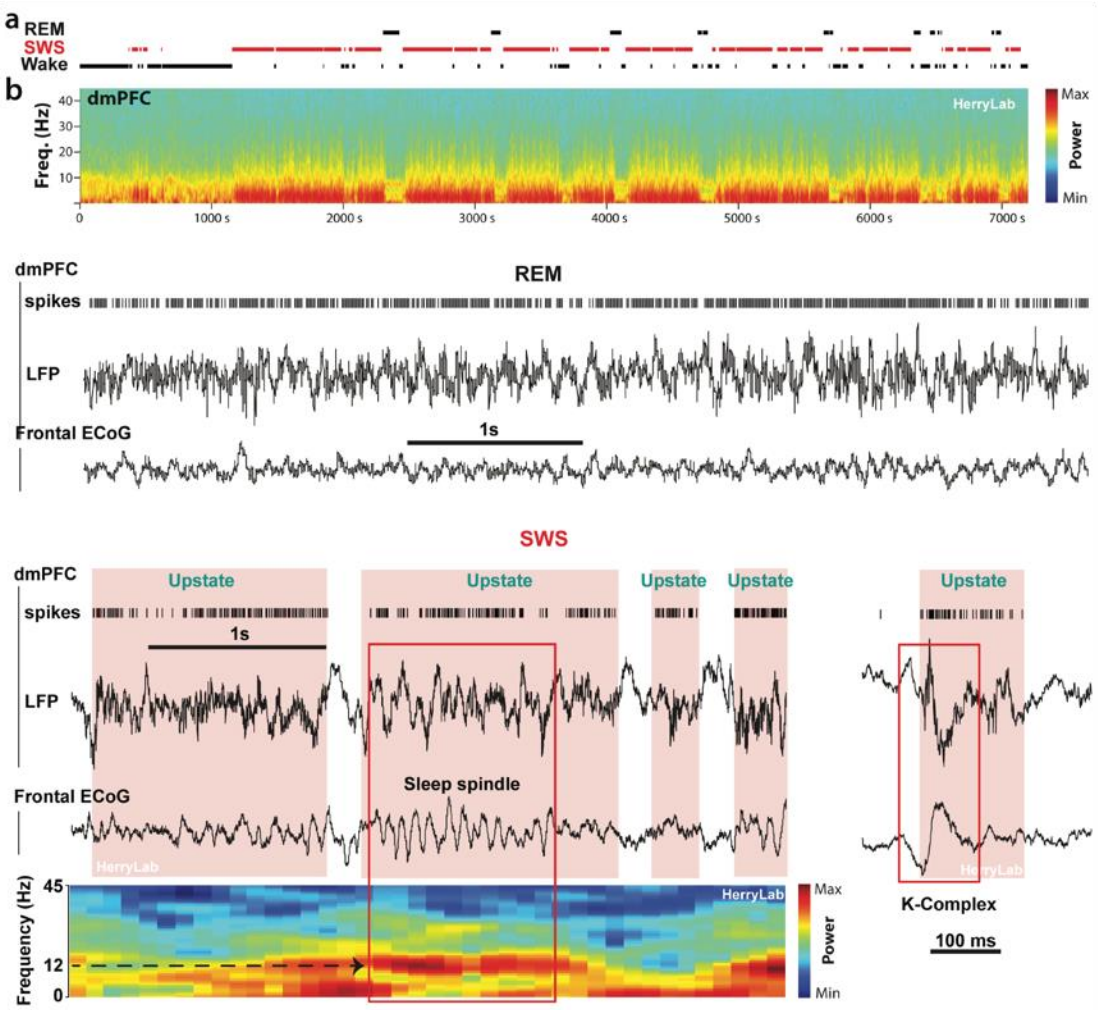
ANALYSES

WHAT INFORMATION CAN WE EXTRACT FROM RECORDED SIGNALS ?

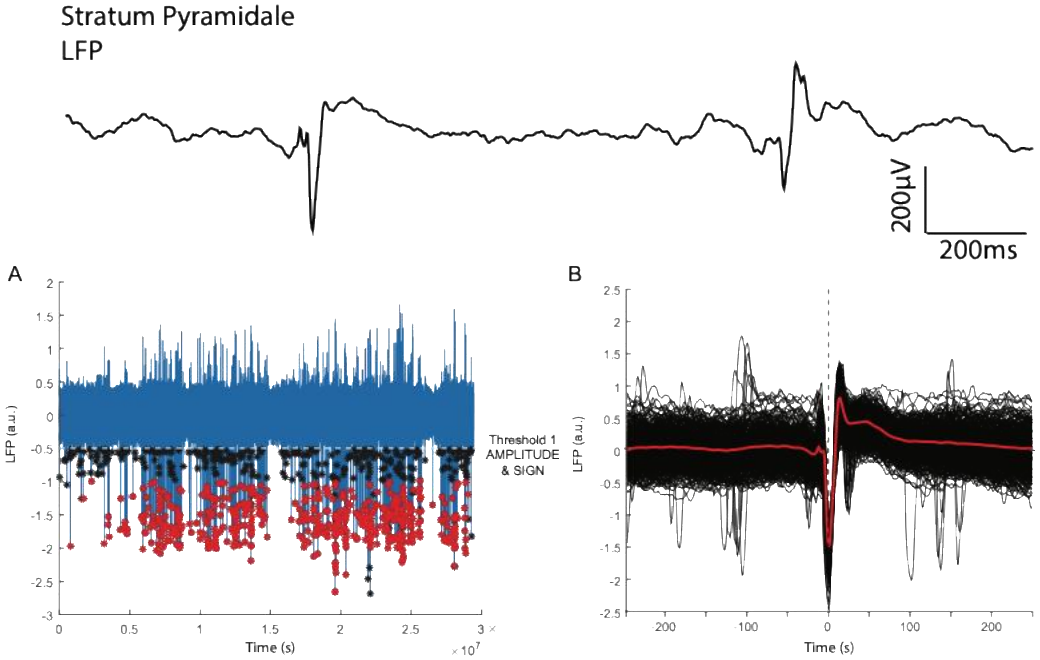
Sleep Spindle Analyses : EEG + EcoG + spiking activity

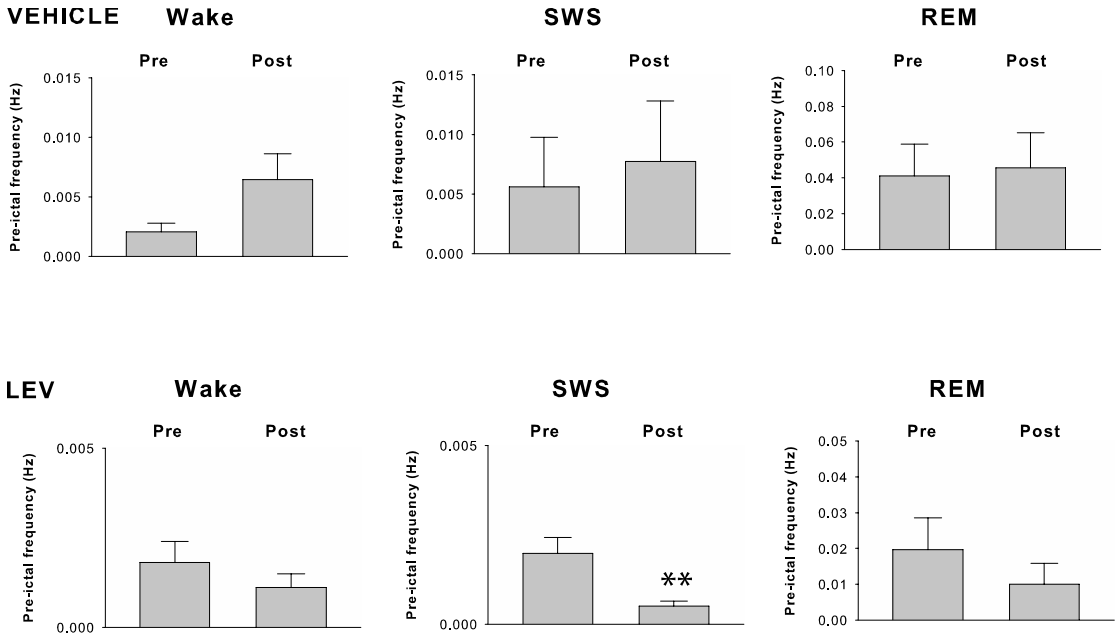


ANALYSES

WHAT INFORMATION CAN WE EXTRACT FROM RECORDED SIGNALS ?

Pre-Ictal spikes analyses during SWS





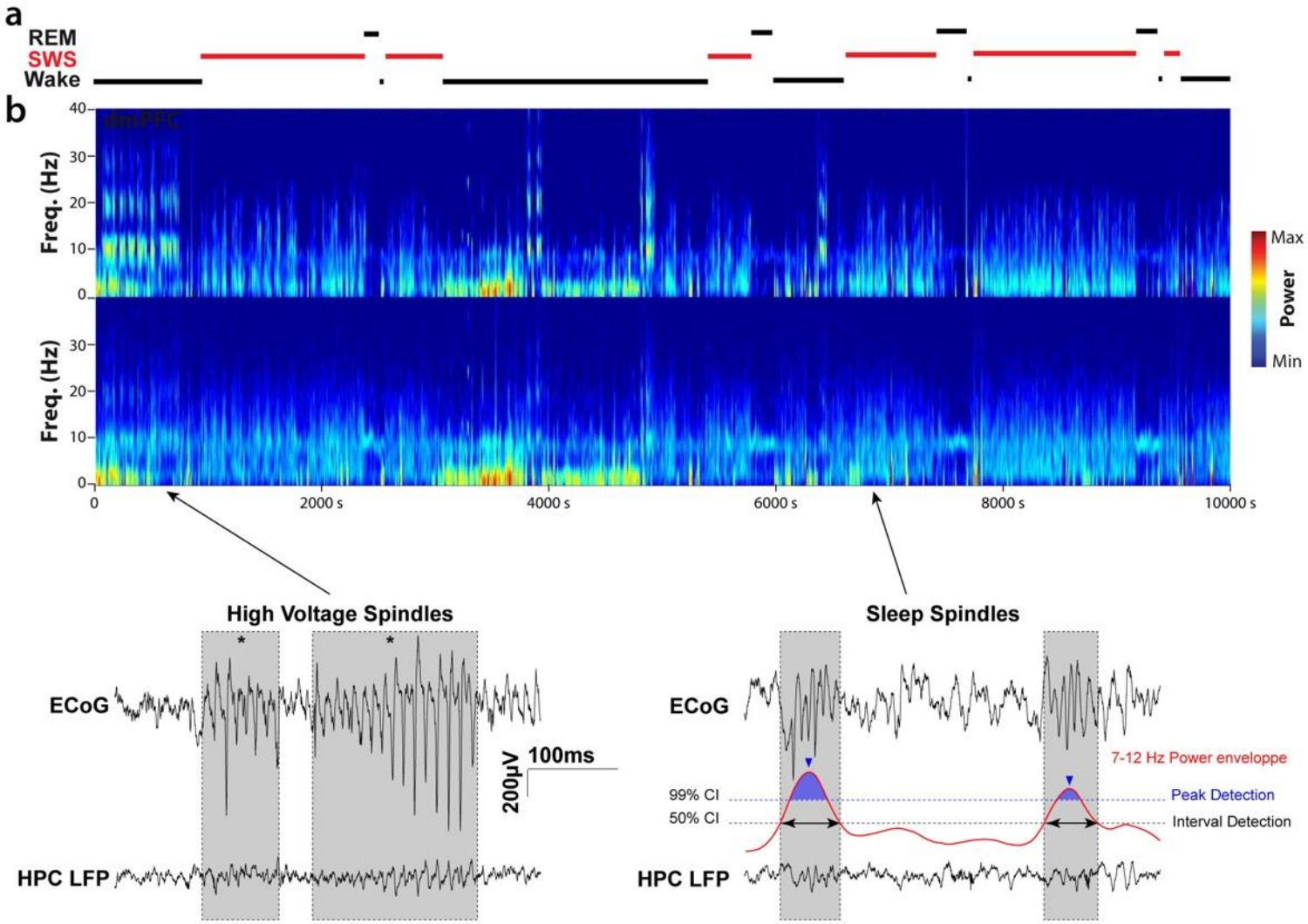
ANALYSES

WHAT INFORMATION CAN WE EXTRACT FROM RECORDED SIGNALS ?

Absent seizures and sleep spindle isolation

ECoG

Hipp



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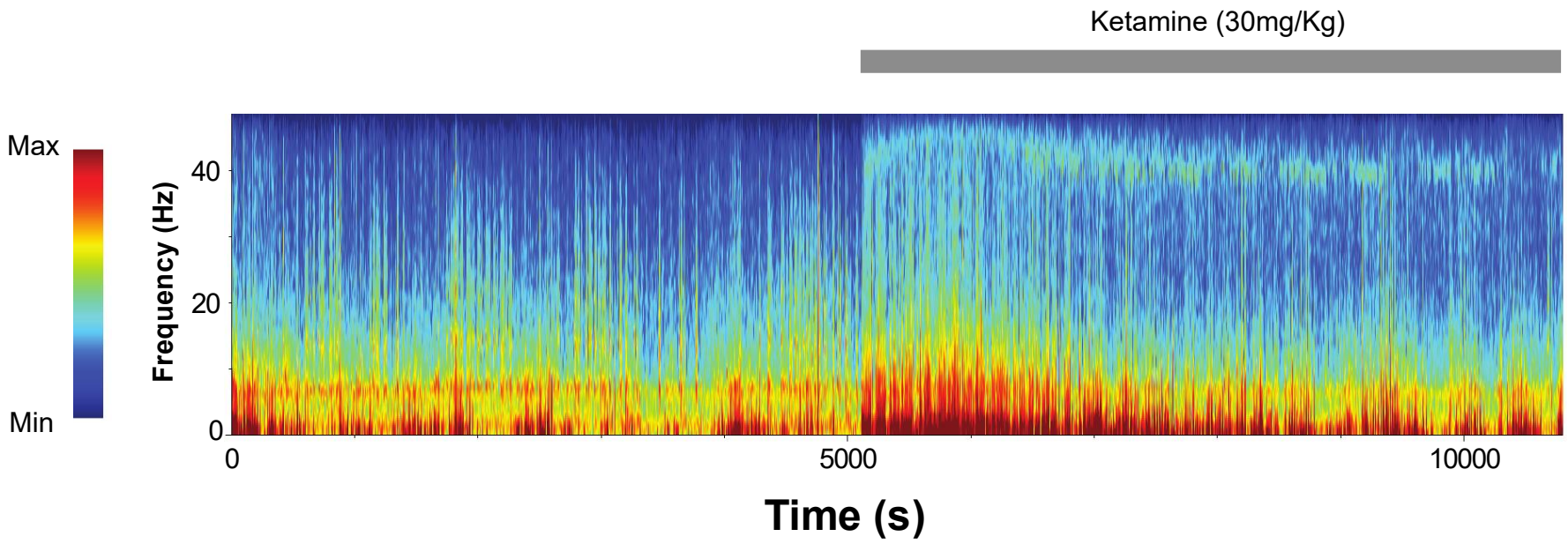
ANALYSES

WHAT INFORMATION CAN WE EXTRACT FROM RECORDED SIGNALS ?

Effect of ketamine on prefrontal neuronal oscillations



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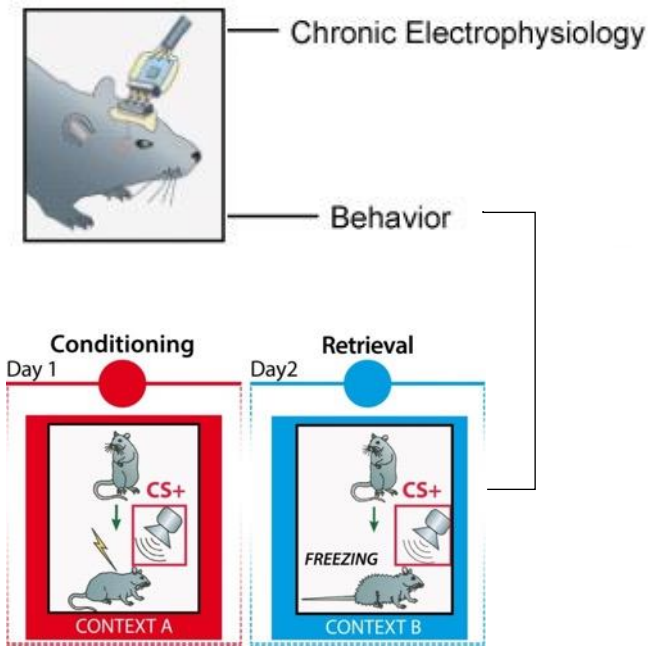
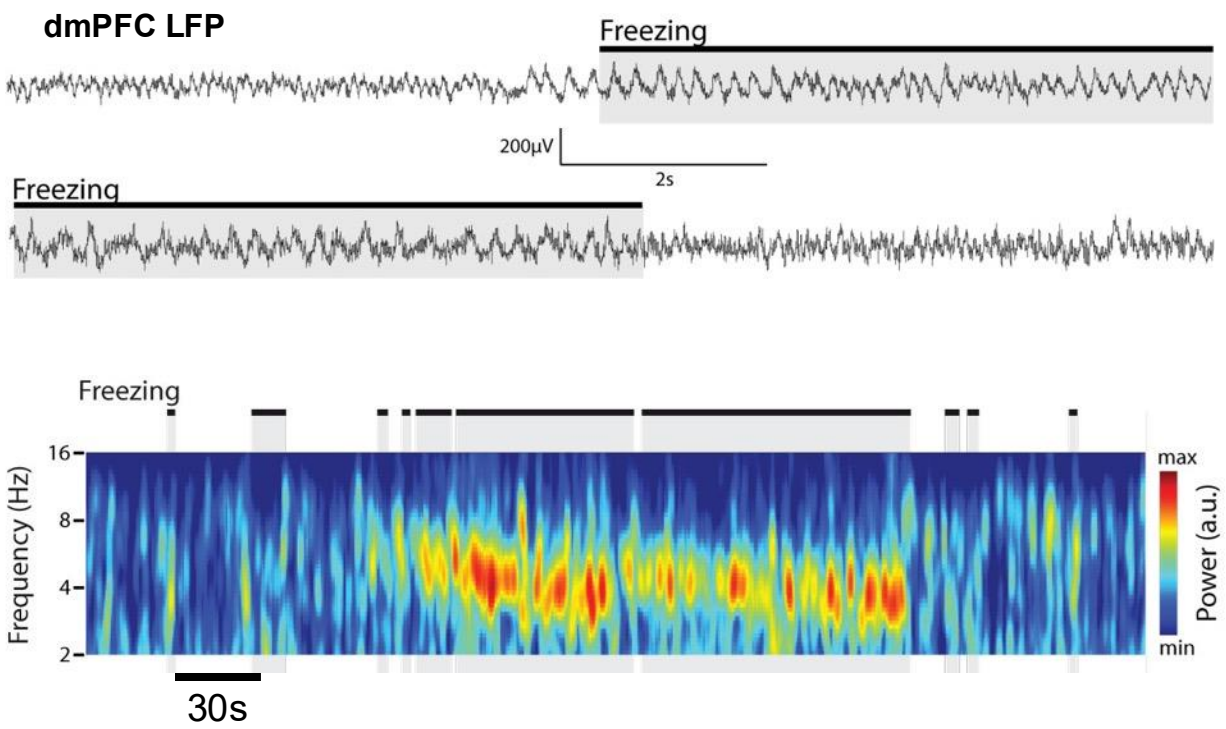
STUDY CASE

4 HZ OSCILLATIONS AS A BIOMARKER OF DEFENSIVE STATES

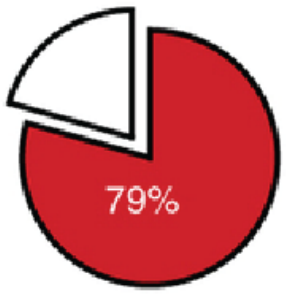
Behavioral model



Oscillations and freezing



Biomarker



SVM

Karalis … Herry 2016 Nature Neuroscience

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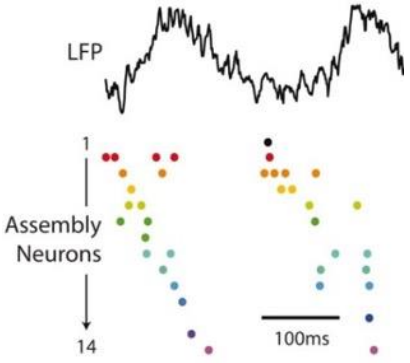
STUDY CASE

4 HZ OSCILLATIONS AS A BIOMARKER OF DEFENSIVE STATES

Rational

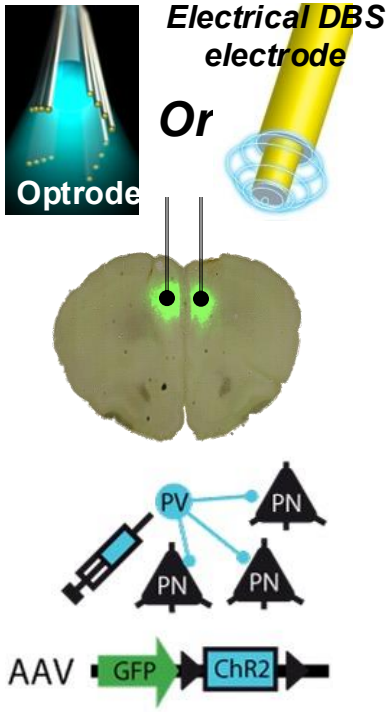
4 Hz
=
LFP Marker



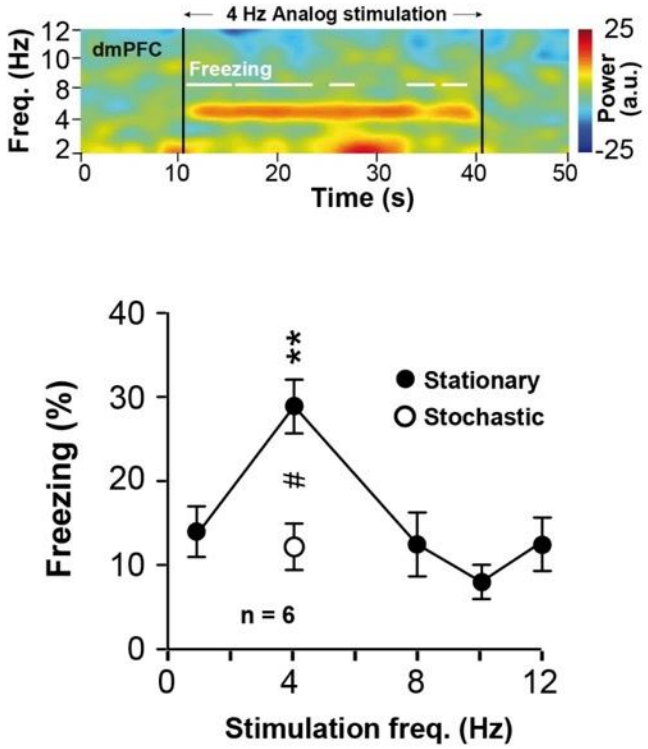
4 Hz ascending phase
=
Neuronal Coding Marker

Dejean… Herry 2016 Nature

Tech.

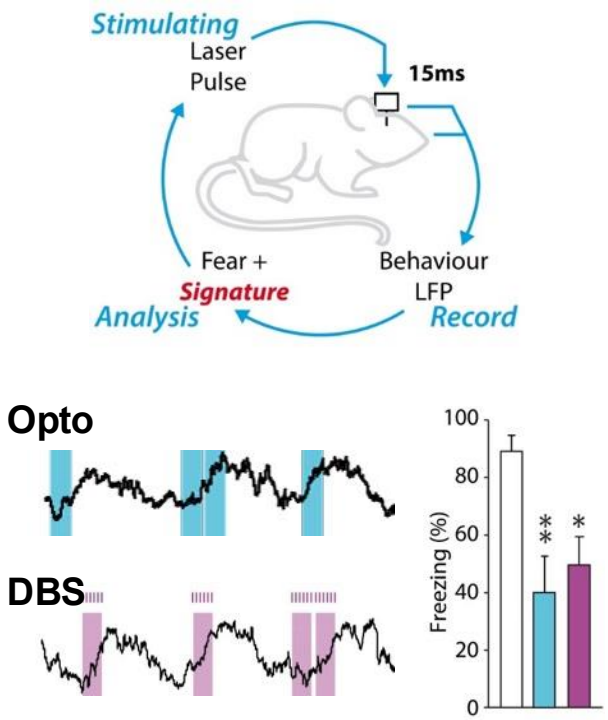


Mimick



Karalis … Herry 2016 Nature Neuroscience

Counteract



Dejean, Herry, Patent

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