Multi-scale, multi-species, multi-methodology experiments, analysis tools and simulation models of **Brain States** and **Complexity** in **SP3-UseCase002**

Human Brain Project

Giulia De Bonis[1], Elena Pastorelli[1], Cristiano Capone[1], Robin Gutzen[2], Alessandra Camassa[3], Arnau Manasanch Berengué[3], Francesco Resta[4], Anna Letizia Allegra Mascaro[4,5], Antonio Pazienti[6], Andrea Pigorini[7], Thierry Nieus[7], Alessandro Arena[8], Johan Frederik Storm[8], Marcello Massimini[7], Francesco Saverio Pavone[4,9], Maria V. Sanchez-Vives[3,10], Maurizio Mattia[5], Andrew Davison[11], Michael Denker[2], Pier Stanislao Paolucci[1]

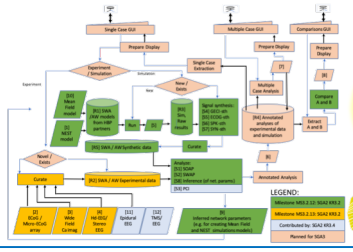
1.National Institute for Nuclear Physics (INFN), Rome, Italy; 2. Inst. of Neuroscience and Medicine (INM-6), Inst. for Advanced Simulation (IAS-6) and JARA Inst. Brain Structure-Function Relationships (INM-10), Jülich Research Centre, Germany; 3. Institut d'Investigacions Biomediques August Pi i Sunyer (IDIBAPS), Barcelona, Spain; 4. European Laboratory For Non-Linear Spectroscopy (LENS), Florence, Italy; 5. Neuroscience Institute (CNR), Pisa, Italy; 6. Istituto Superiore di Sanità (ISS), Rome, Italy; 7. Dept. of Biomedical and Clinical Sciences "Luigi Sacco", University of Milan (UniMI), Italy; 8. Dept. of Molecular Medicine, University of Oslo (UiO); 9. Dept. of Physics, University of Florence, Italy; 10. Institució Catalana de Recerca i Estudis Avançats (ICREA), Barcelona, Spain; 11. Paris-Saclay Institute of Neuroscience, CNRS, France.

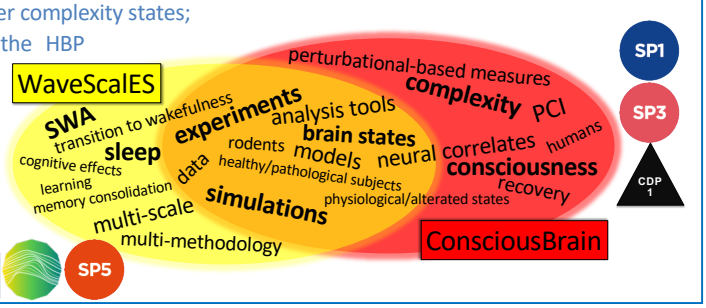
Goals of SP3-UseCase002

→Join **WaveScalES** & **ConsciuosBrain,** Scientific Mission: multi-scale, multi-methodology, multi-species investigation of brain states, their transitions, their complexity and their specific cognitive functions, starting from deep sleep to higher complexity states;

→Offer experimental data, simulation models, results and analysis tools to the HBP Community (and beyond) through **EBRAINS**;

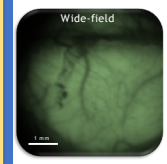
→Define a solid workflow for addressing specific scientific quests, create a reproducible and cooperative scientific framework providing **FAIR** access to experimental data, analysis tools and simulation models and supporting their comparison.



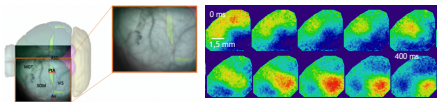


Experimental Data

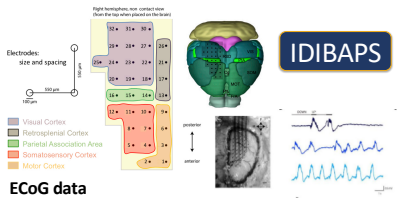
LENS



Ca-imaging data
Wide-field fluorescence microscopy on transgenic mouse model (GCaMP6f) expressing a calcium indicator (GECI). Ketamine-anesthetised subjects exhibit spontaneous SWA. Data curation in the KnowledgeGraph is in progress.



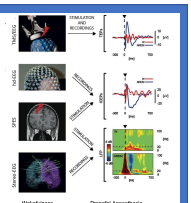
IDIBAPS



ECoG data
Spontaneous LFP activity recorded with a superficial 32-channel multielectrode array placed on the cortical surface at different levels of anaesthesia in mouse subjects. Data curated in the KG.

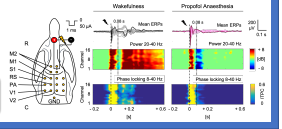
Human data
EEG acquisitions in physiological and pathological human brains; **TMS** for a perturbational-based measurement of complexity (**PCI**). Data curated in the KG:
DOI: 10.25493/NXN2-05W
DOI: 10.25493/5TNA-R5P
DOI: 10.25493/30W7-0WK

UniMI

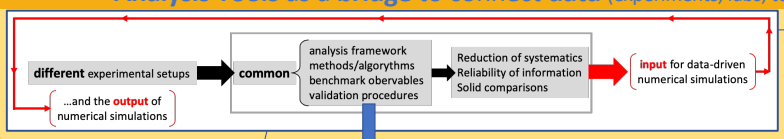


Rodent data
Epidural **EEG** and stimulations in rat brains for perturbational-based measurement of complexity (PCI). Data curated in the KG:
DOI: 10.25493/2FS0DM-BK5
DOI: 10.25493/4SPM-V00

UiO



Analysis Tools as a bridge to connect data (experiments, labs, techniques) and models (theory, simulations)



CNRS

Julich

expand/integrate general tools

neo

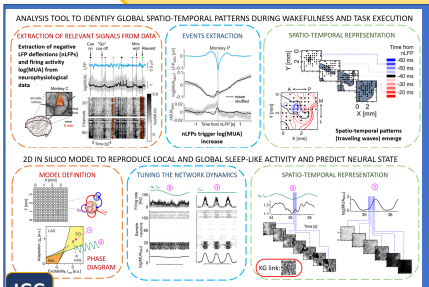
fairgraph

NetworkUnit

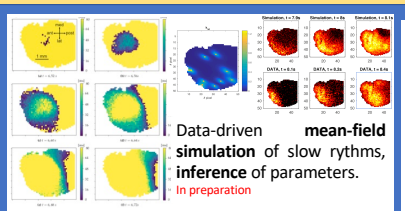
elephant

snakemake

- Reliable pipelines
- Data-driven simulations
  calibration of models
  → understanding complexity
  → simulate biological plausibility



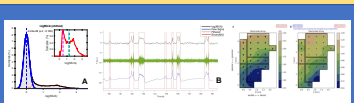
ISS



Data-driven **mean-field simulation** of slow rythms, **inference** of parameters.
In preparation

Identification and features of **propagating waves** in fluorescence recordings from anesthetised mice.
Celotto et al, in press, [q-bio.NC]1811.11687

LENS INFN

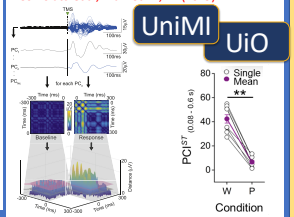


MUA estimation from ECoG recordings of LFP activity expressing **bimodality** (Up and Down states) during SWA in anesthetised mice; features of the **Slow Oscillations** extracted at each channel and cortical area, evaluating the statistical significance of the observed differences. De Bonis et al, Front. Syst. Neurosci., 22 (2019)

INFN ISS IDIBAPS

Perturbational complexity index based on state transitions (PCI_st).
Comolatti et al, Brain Stim., 12 (2019)

UniMI UiO



Models/Methods/Results

EBRAINS

Co-funded by the European Union

This research has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under the Specific Grant Agreement No. 785907 (Human Brain Project SGA2).