Human Brain Project

EBRAINS

Blocks instead of puzzles pieces

analyzing cortical wave activity across scales in an adaptable framework

Robin Gutzen | *Research Center Juelich, Germany*

EBRAINS Workshop BASSES | 13-15 June 2022 | Rome, Italy & virtual

Co-funded by the European Union

Science is collaborative

Jülich Forschungszentrum

Sonja Grün
Michael Denker

INFN Istituto Nazionale di Fisica Nucleare

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Elena Pastorelli
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Chiara De Luca
Pier Stanislao Paolucci

students of the INM-6 2019

LENS European Laboratory for Non-Linear Spectroscopy — Università degli Studi Firenze

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Francesco Resta
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IDIBAPS Institut D'Investigacions Biomèdiques August Pi i Sunyer

Arnau Manasanch
Maria V.Sanchez-Vives

CNRS

Andrew Davison

Istituto Superiore di Sanità

Maurizio Mattia

Science is collaborative

How can we bring our data, methods, models, and results together more effectively?

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How to combine and compare heterogeneous data?

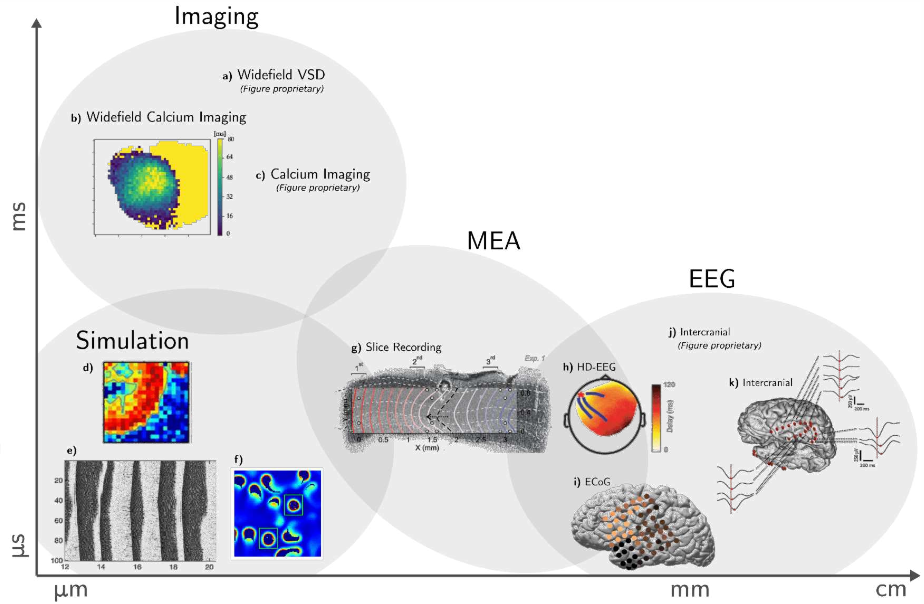

Figure references in Appendix

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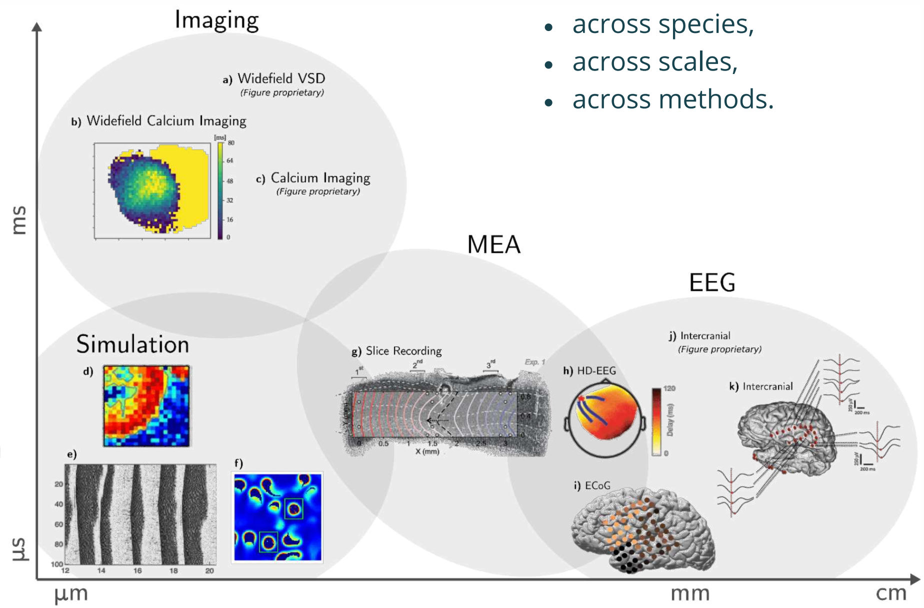

Slow cortical waves are observable

- across species,
- across scales,
- across methods.

Figure references in Appendix

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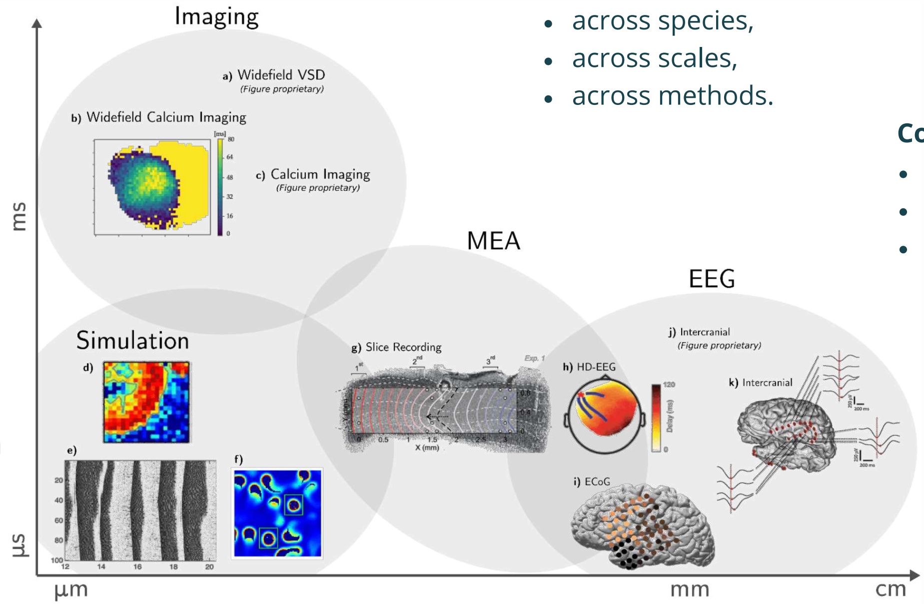

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- integration of data sources,
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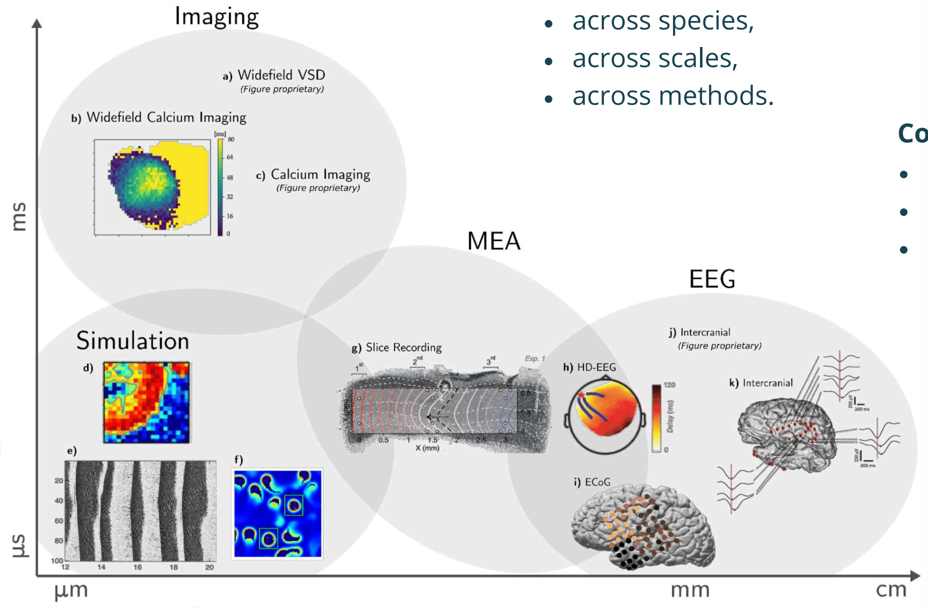

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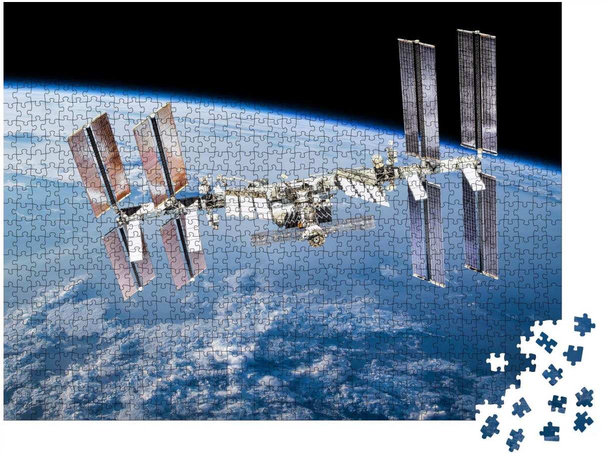
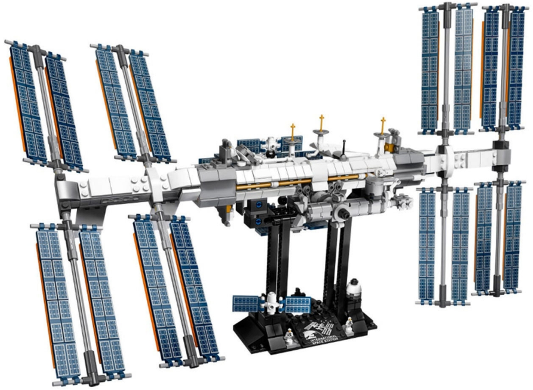
How can analysis workflows support comparability?

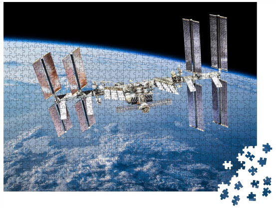
Figure references in Appendix

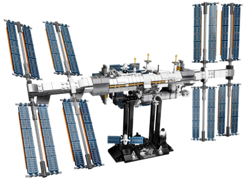
Building analysis workflows is (not) rocket science





Puzzle pieces vs. building blocks





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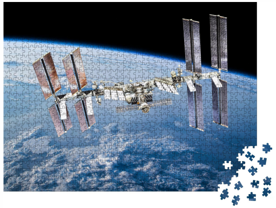

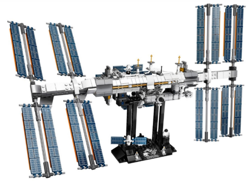

❌

Modularity
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✓

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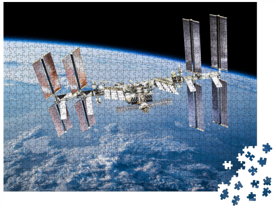

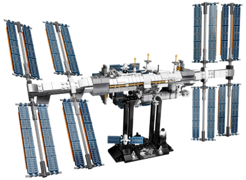

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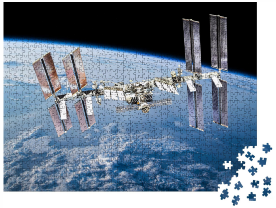

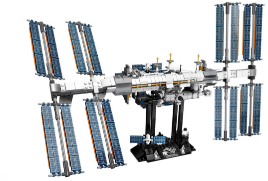

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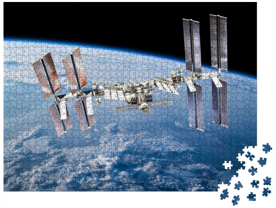

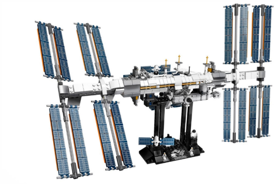

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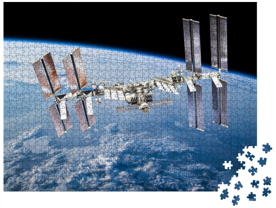

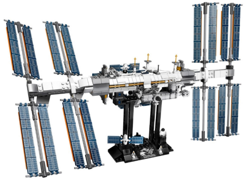

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A modular analysis pipeline from building blocks: Cobrawap

ECoG, Calcium Imaging,
EEG, Spikes, LFP, Simulation, ...

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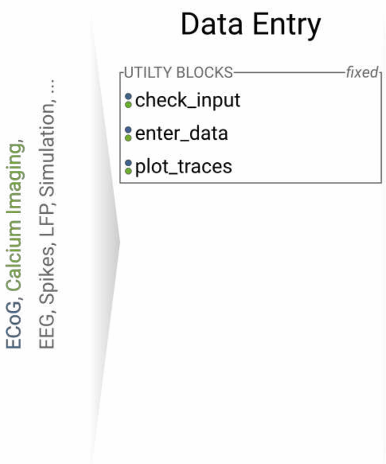

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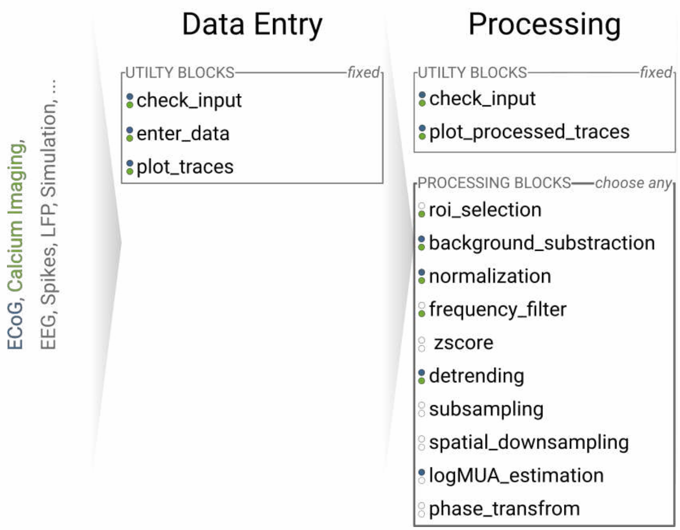

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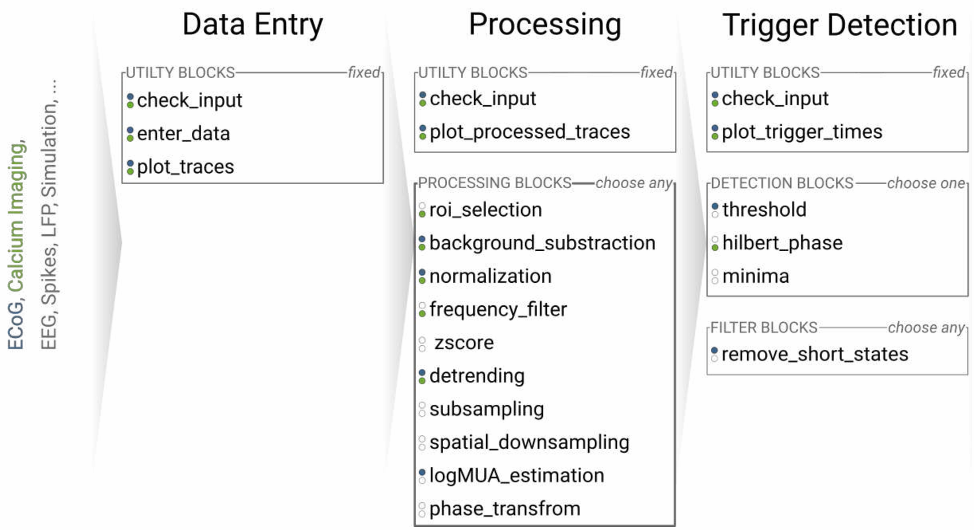

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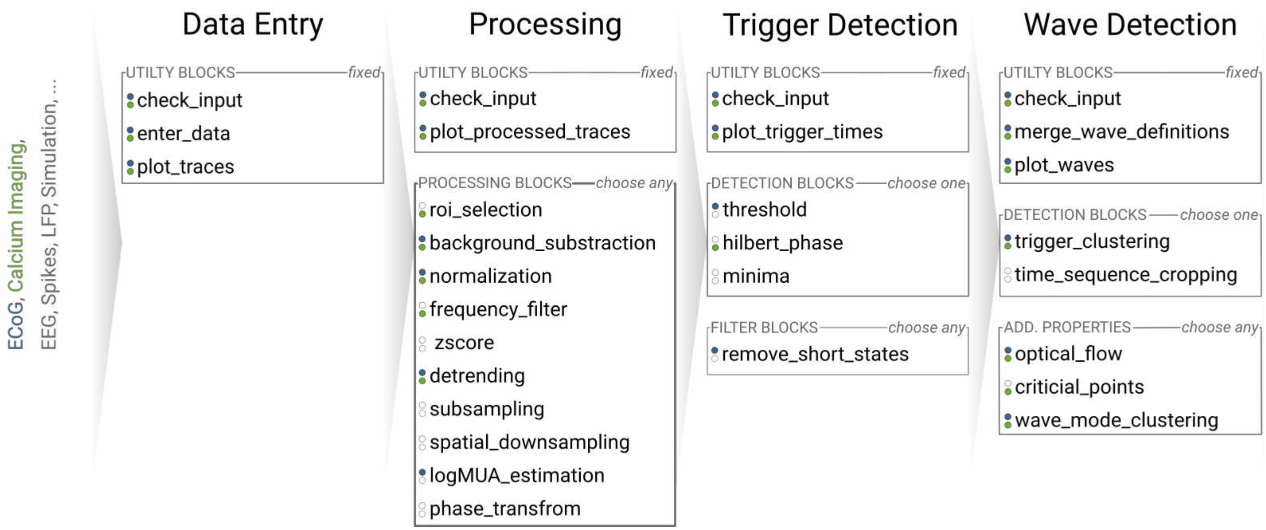

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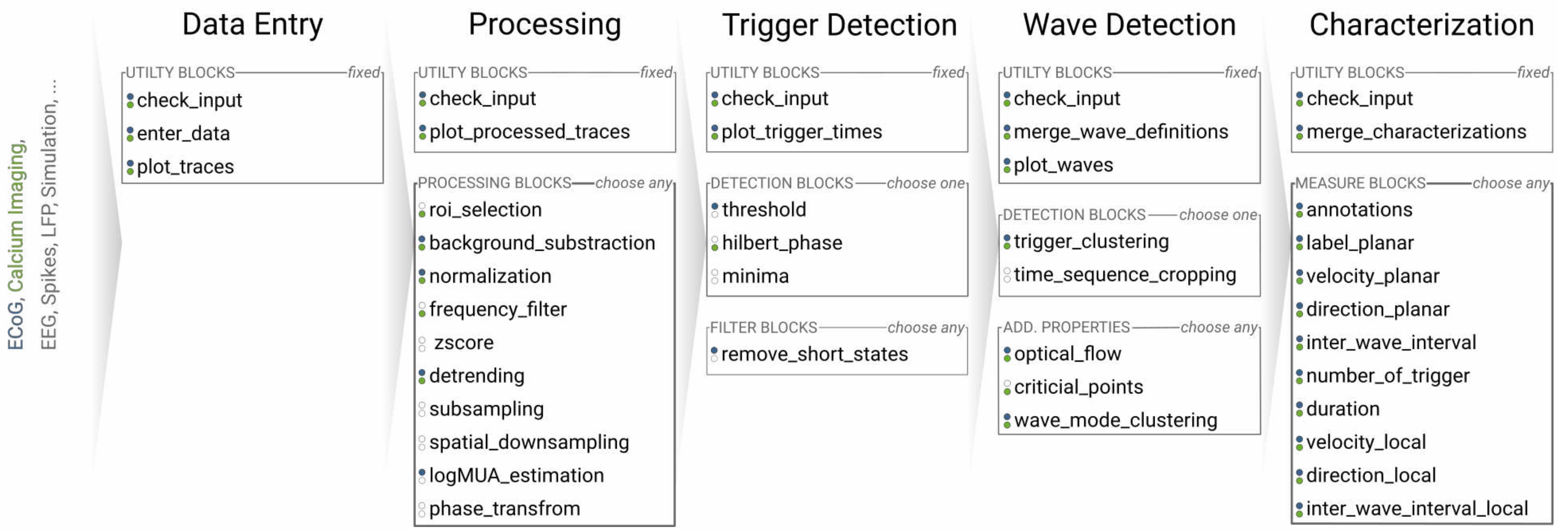


A modular analysis pipeline from building blocks: Cobrawap

ECoG, Calcium Imaging,
EEG, Spikes, LFP, Simulation, ...

Data Entry

UTILTY BLOCKS — *fixed*
- check_input
- enter_data
- plot_traces

Processing

UTILTY BLOCKS — *fixed*
- check_input
- plot_processed_traces

PROCESSING BLOCKS — *choose any*
- roi_selection
- background_substraction
- normalization
- frequency_filter
- zscore
- detrending
- subsampling
- spatial_downsampling
- logMUA_estimation
- phase_transfrom

Trigger Detection

UTILTY BLOCKS — *fixed*
- check_input
- plot_trigger_times

DETECTION BLOCKS — *choose one*
- threshold
- hilbert_phase
- minima

FILTER BLOCKS — *choose any*
- remove_short_states

Wave Detection

UTILTY BLOCKS — *fixed*
- check_input
- merge_wave_definitions
- plot_waves

DETECTION BLOCKS — *choose one*
- trigger_clustering
- time_sequence_cropping

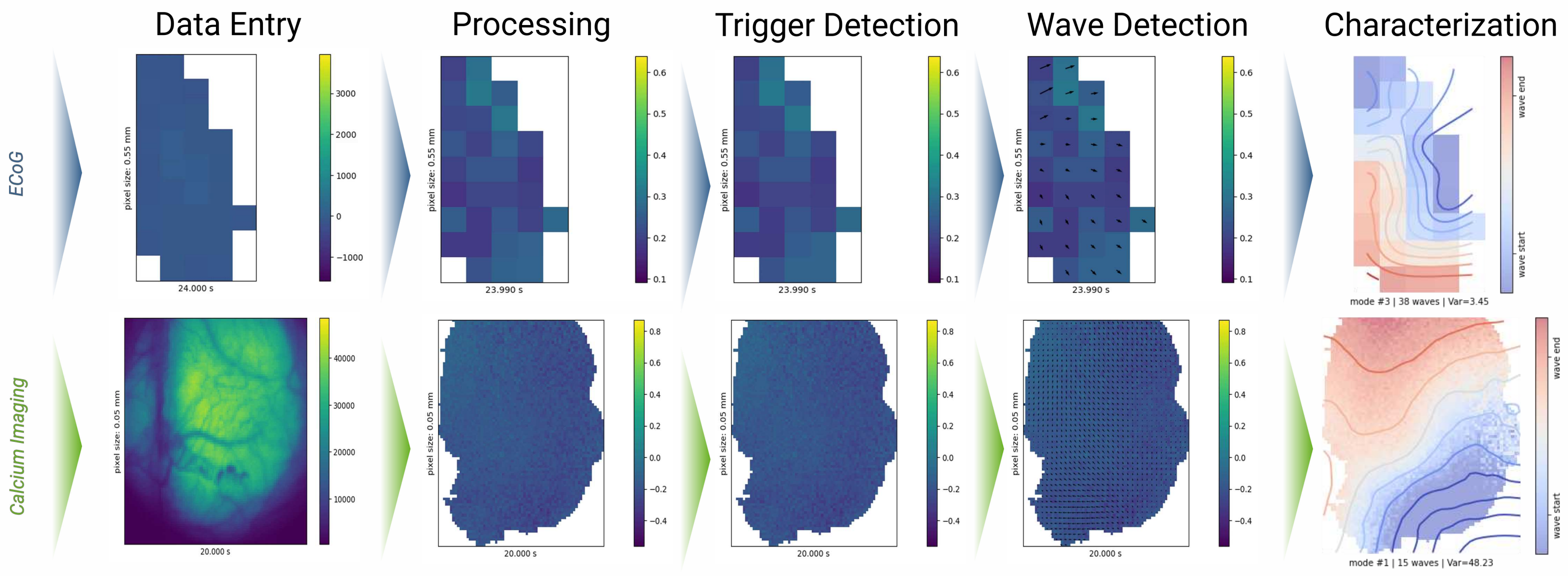
ADD. PROPERTIES — *choose any*
- optical_flow
- criticial_points
- wave_mode_clustering

Characterization

UTILTY BLOCKS — *fixed*
- check_input
- merge_characterizations

MEASURE BLOCKS — *choose any*
- annotations
- label_planar
- velocity_planar
- direction_planar
- inter_wave_interval
- number_of_trigger
- duration
- velocity_local
- direction_local
- inter_wave_interval_local

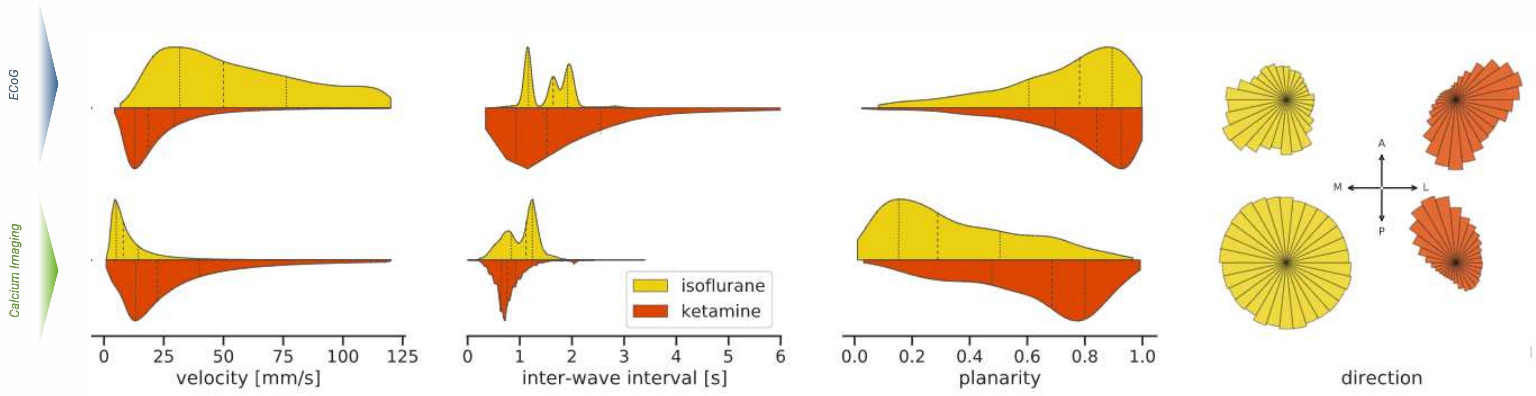
Adapting the pipeline to heterogeneous data



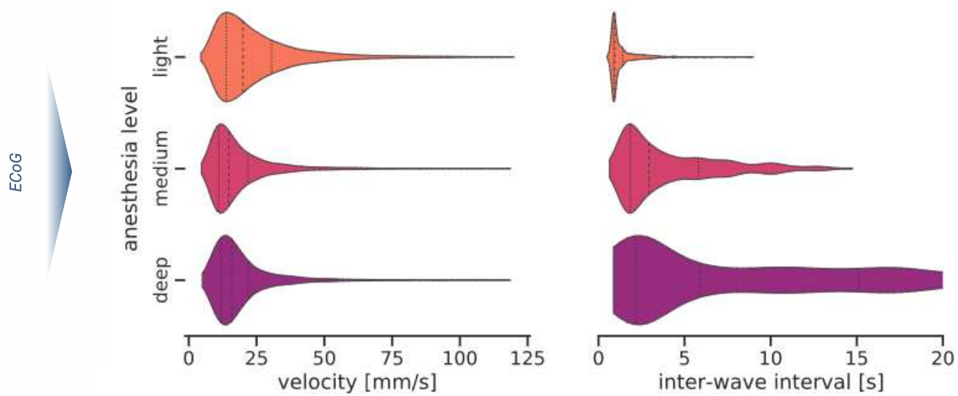
data from Resta et al. 2021, and Sanchez-Vives 2019

Comparable data enables meta-studies

Characterizing slow waves in anesthetized mice:
2 measurement techniques / 5 datasets / 60 recordings / 6.6 h activity data



Reproducible pipeline ➔ reproducible results



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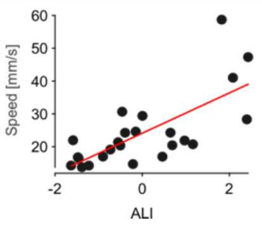
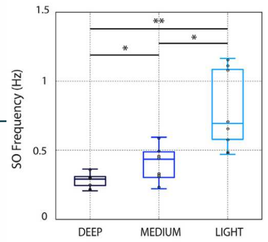
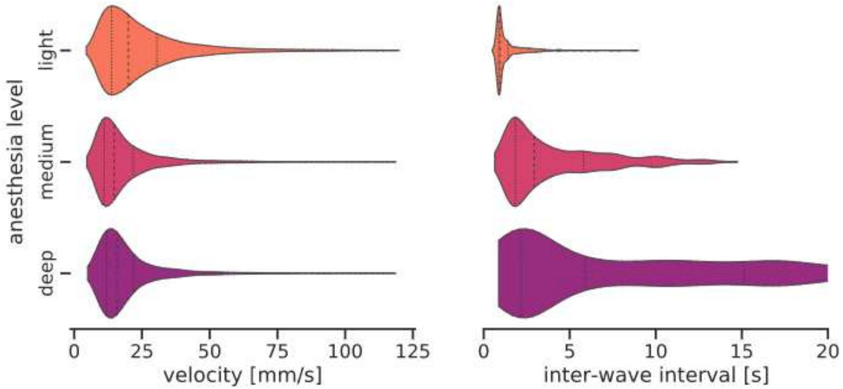


Pazienti et al. 2022



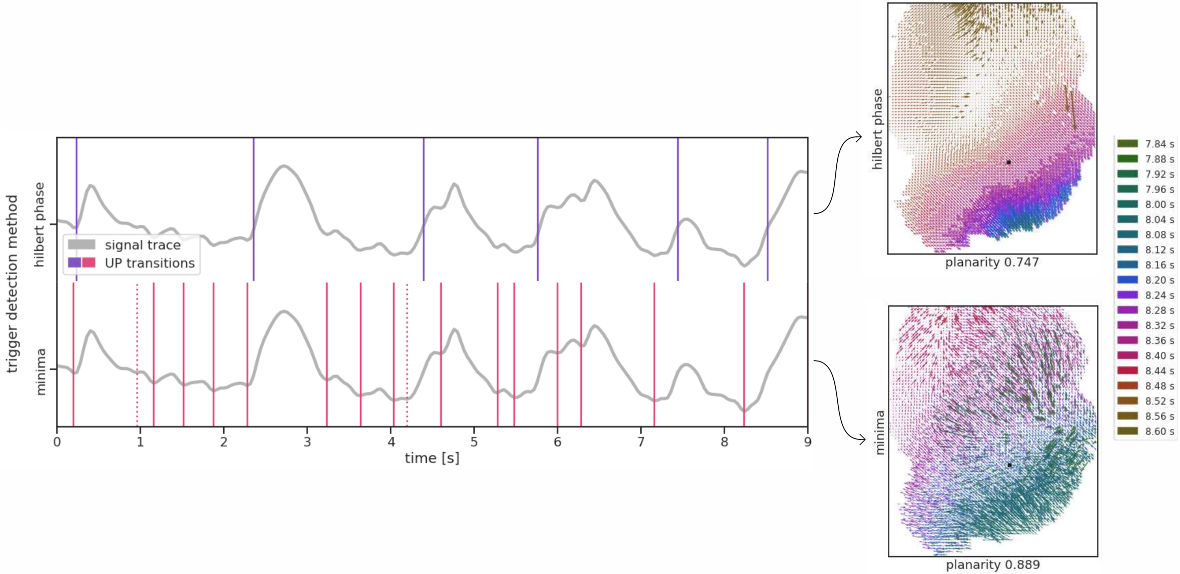
Dasilva et al. 2021

ECoG

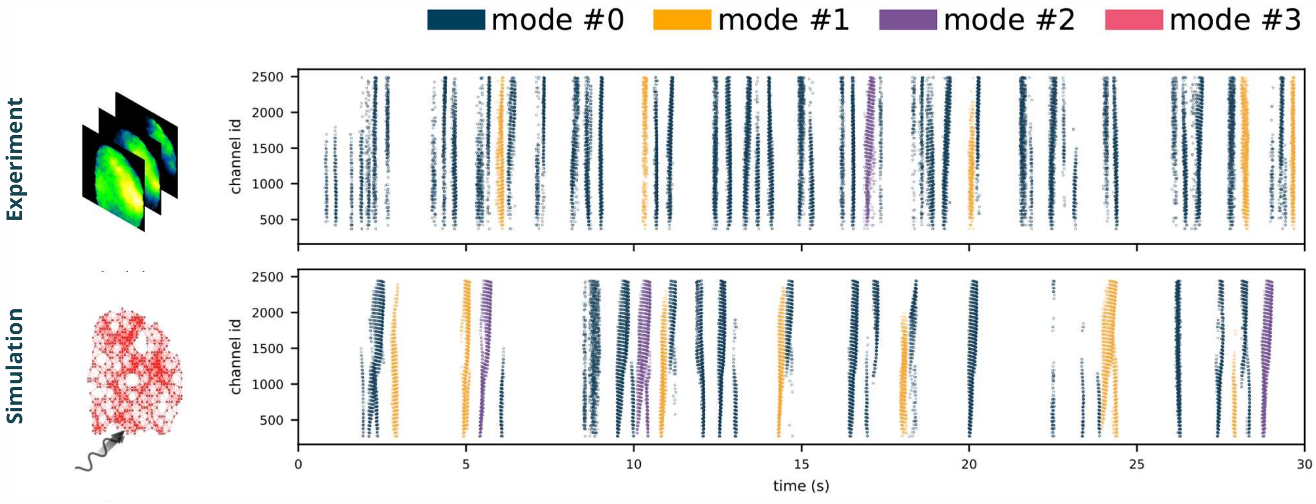


data from Sanchez-Vives 2020

Comparing methods on the same data

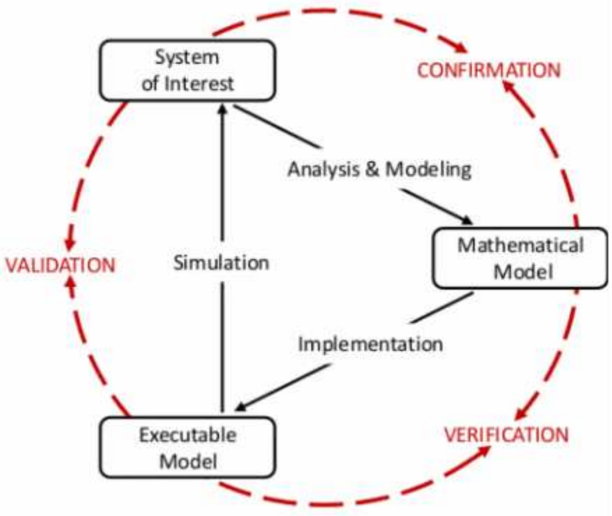


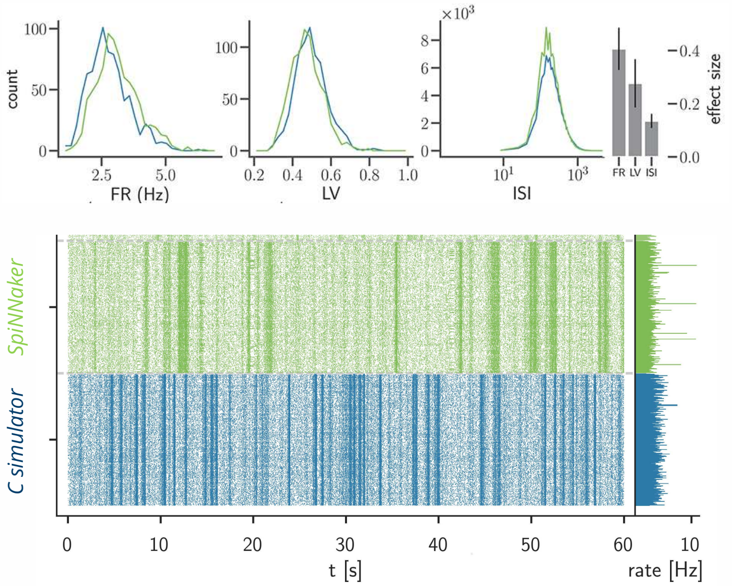
Comparison to models: Calibration & Validation



Capone et al. 2021

Network-level validation

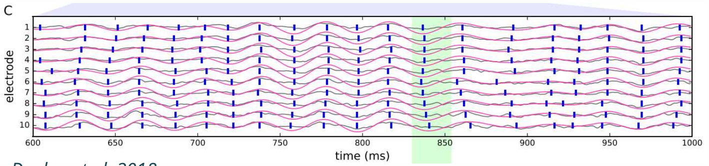




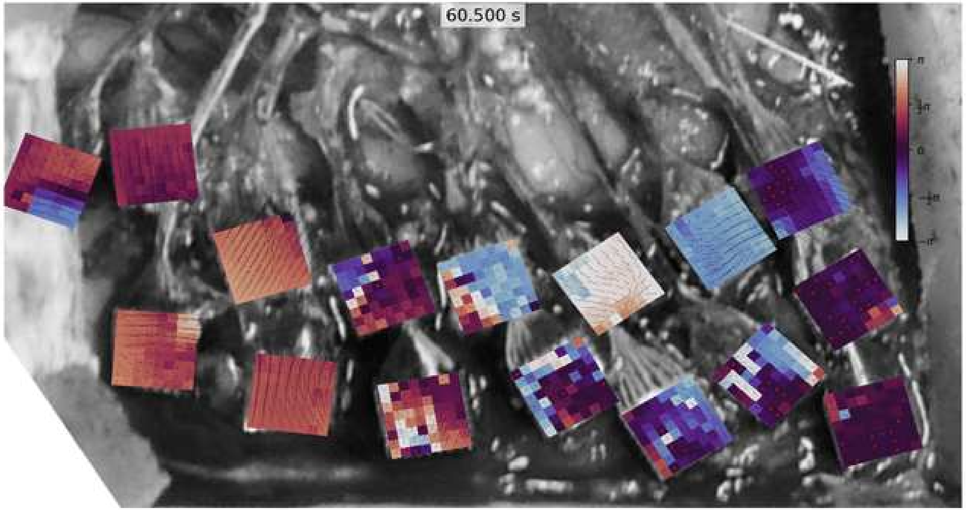
https://github.com/INM-6/NetworkUnit

Gutzen et al. 2018
Trensch et al. 2018

Reusing the pipeline for cortical beta-waves



Denker et al. 2018



data from Chen et al. 2022

The benefits of a pipeline from blocks

Modularity
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Adaptability
elements can be added, removed, or changed

Reproducibility
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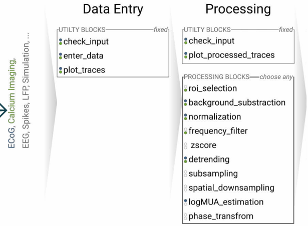

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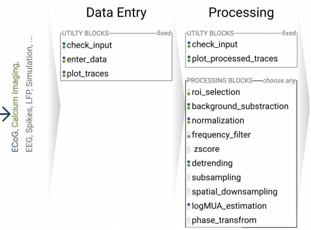

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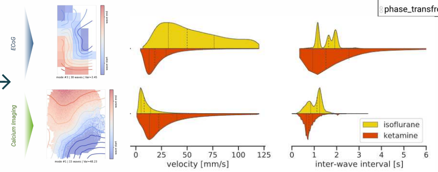

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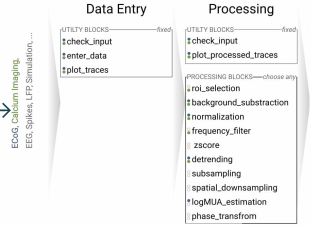

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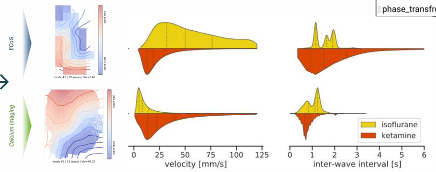

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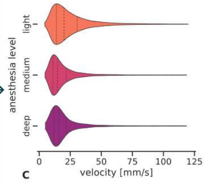

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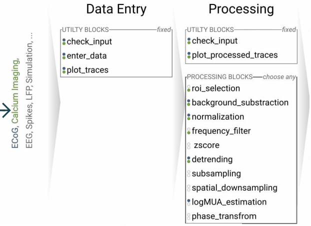

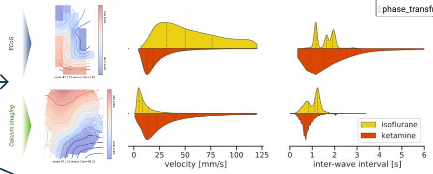

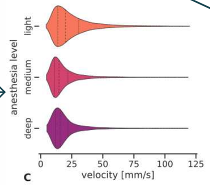

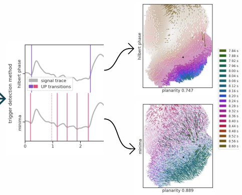

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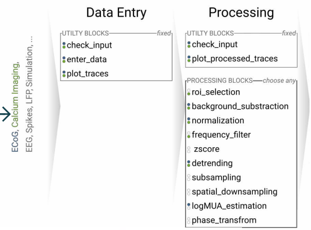

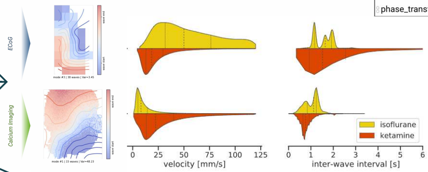

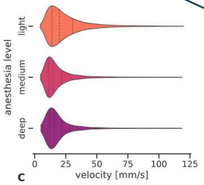

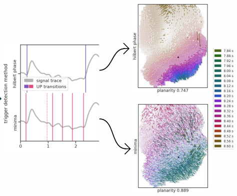

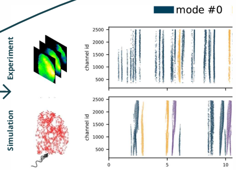

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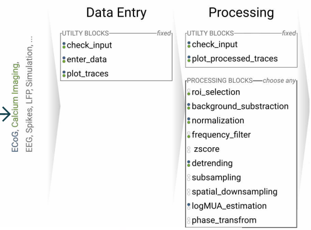

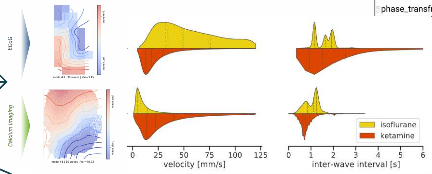

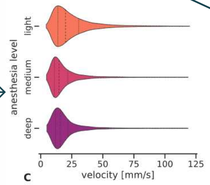

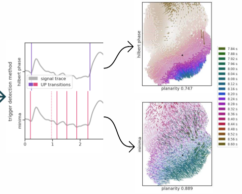

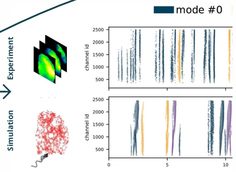

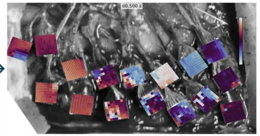

Human Brain Project

EBRAINS

Reuse and sharing of analysis pipelines can make science more collaborative!

https://github.com/INM-6/cobrawap

@rgutzen

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Human Brain Project

EBRAINS

Reuse and sharing of analysis pipelines can make science more collaborative!

And building blocks are better suited for that than puzzle pieces…

https://github.com/INM-6/cobrawap

@rgutzen

Co-funded by the European Union

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Image sources

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Software links (slide 5)

- https://github.com/G-Node/nix
- http://g-node.github.io/python-odml/
- https://neo.readthedocs.io/
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Acknowledgements

This research was funded by the European Union's Horizon 2020 Framework Programme for Research and Innovation under Specific Grant Agreements No. 785907 (HBP SGA2) and No. 945539 (HBP SGA3) and the Helmholtz Association Initiative and Networking Fund ZT-I-0003.

Affiliations

- Institute of Neuroscience and Medicine (INM-6) and Institute for Advanced Simulation (IAS-6) and JARA-Institute Brain Structure-Function Relationships (INM-10), Jülich Research Centre, Jülich, Germany
- Theoretical Systems Neurobiology, RWTH Aachen University, Aachen, Germany
- Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Roma, Rome, Italy
- Ph.D. Program in Behavioural Neuroscience, "Sapienza" University of Rome, Rome, Italy
- Unite de Neurosciences, Information et Complexite, Neuroinformatics Group, CNRS FRE 3693,Gif-sur-Yvette, France
- European Laboratory for Non-linear Spectroscopy (LENS), University of Florence, Florence, Italy
- Istituto di Neuroscienze, CNR, Pisa, Italy
- Institut d'Investigacions Biomediques August Pi i Sunyer (IDIBAPS), Barcelona, Spain
- Institucio Catalana de Recerca i Estudis Avanc ats (ICREA), Barcelona, Spain
- Istituto Superiore di Sanità, (ISS), Rome, Italy