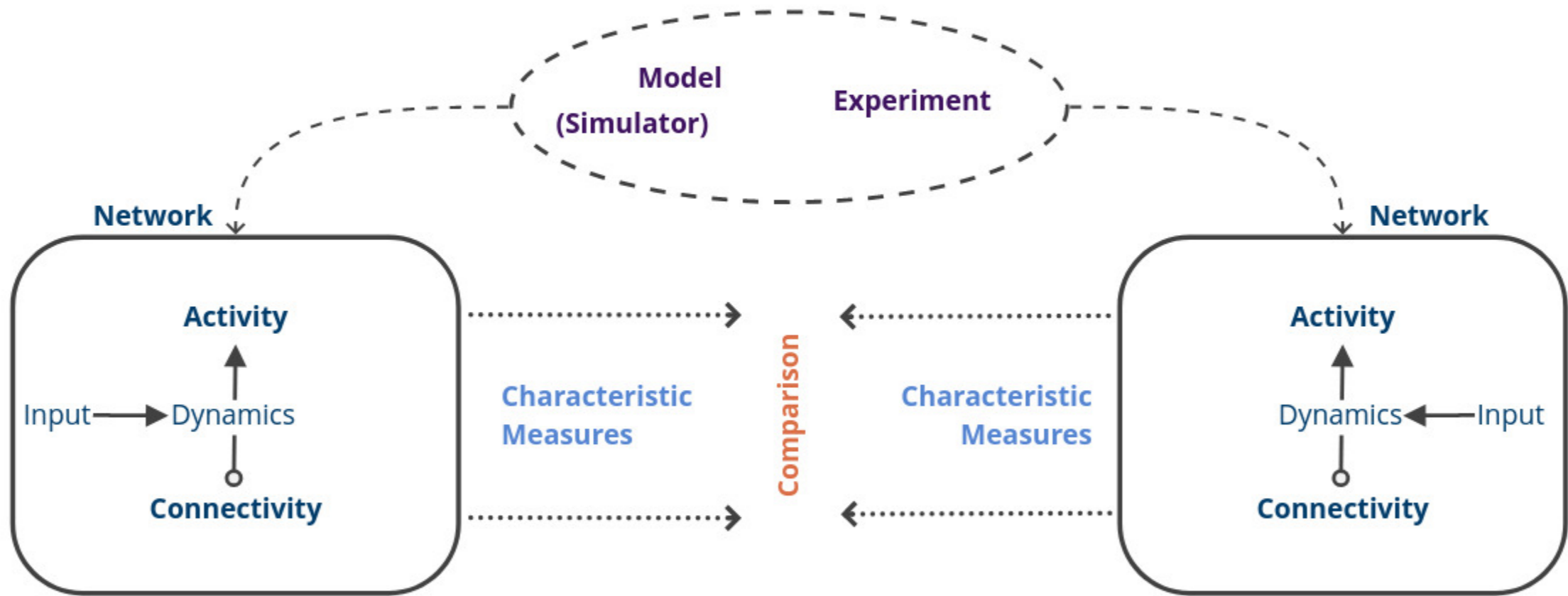


Rigorous comparison and validation of network activity data

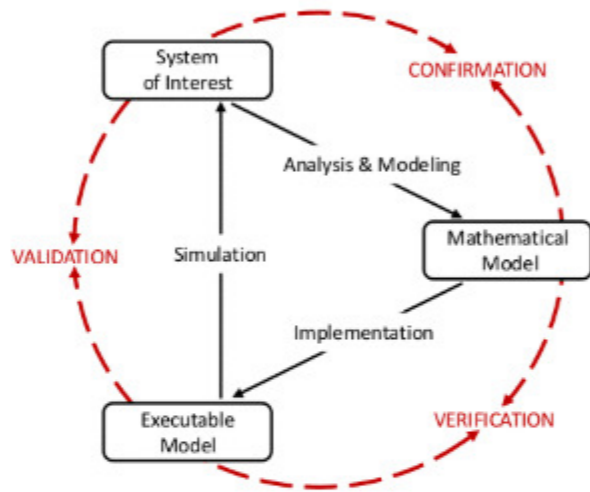
Robin Gutzen | *Research Center Juelich, Germany*

Network Comparisons



Network Comparison Scenarios

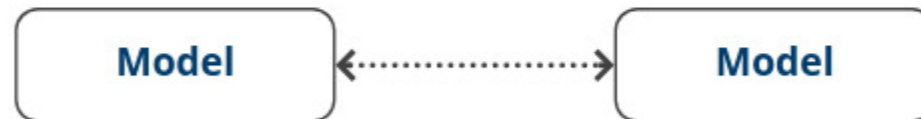
The *validation* process evaluates the consistency of the predictive simulation outcome with the system of interest.



- classical validation
- calibration



- quantify variability
- influence of external parameters

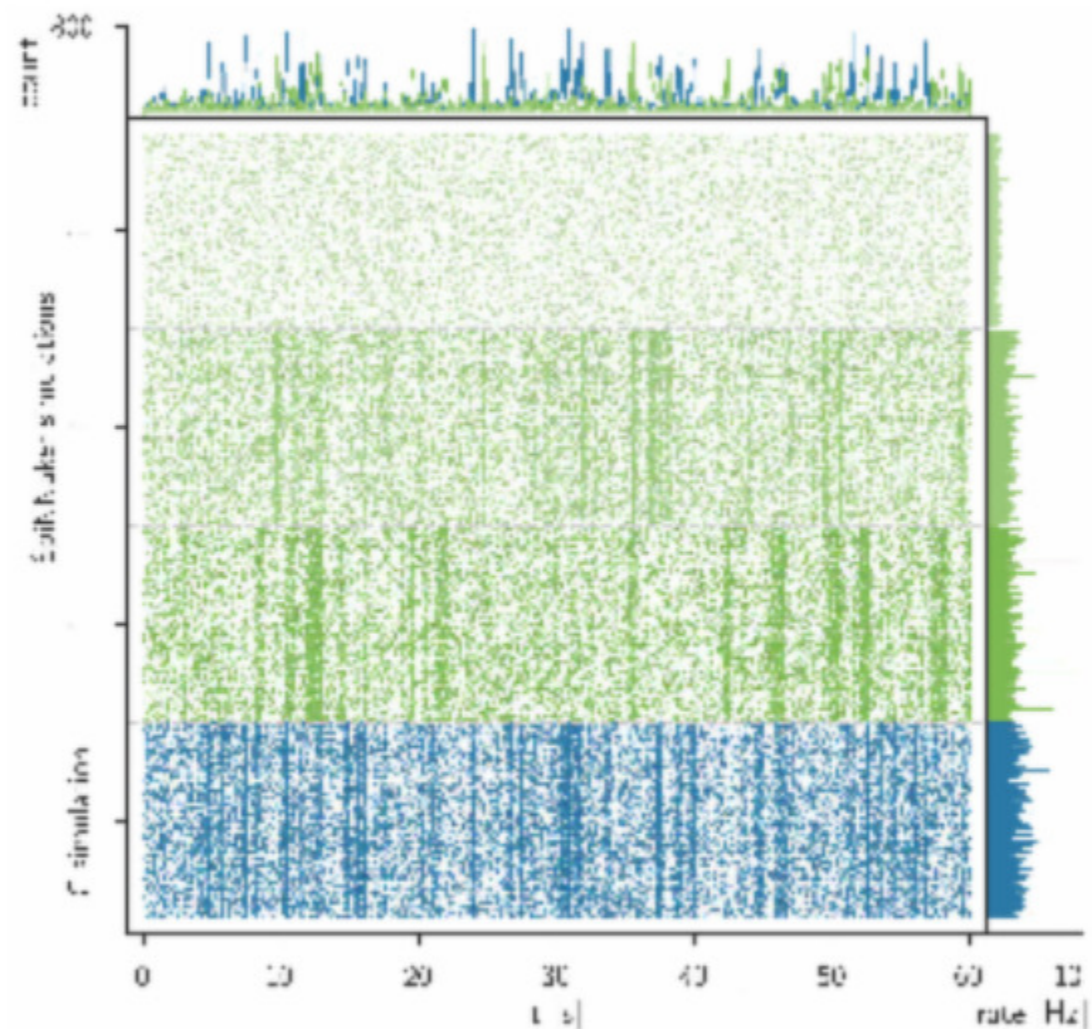
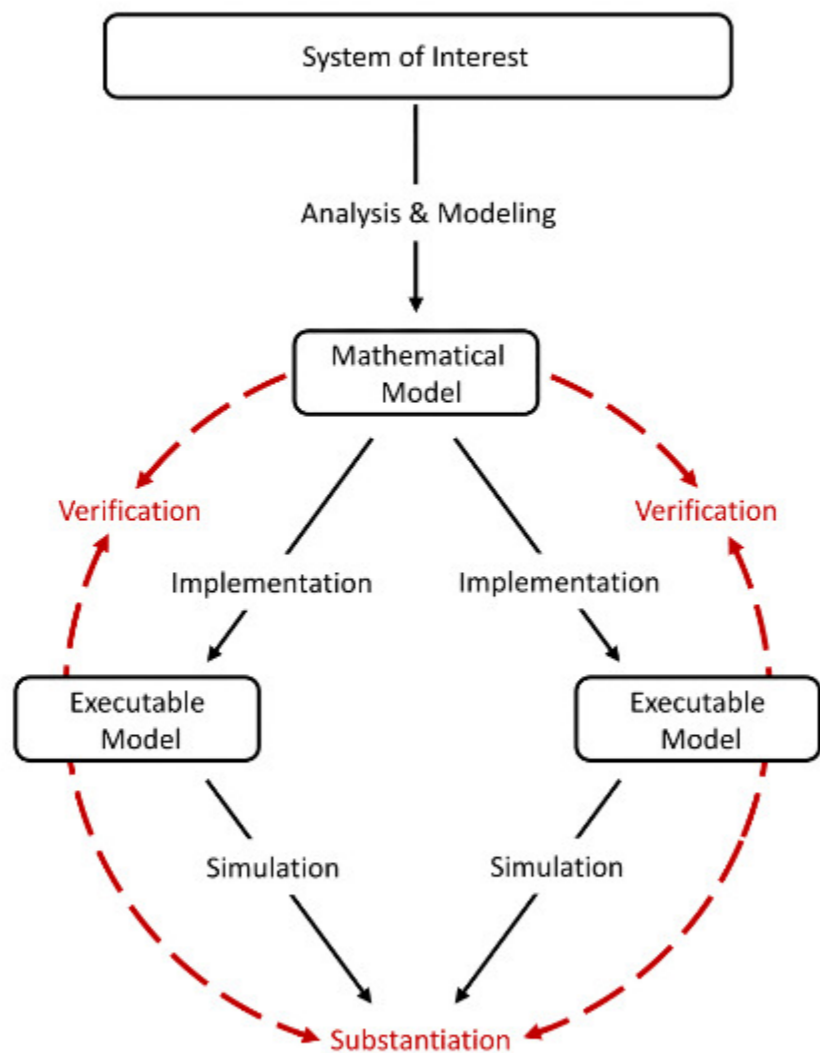
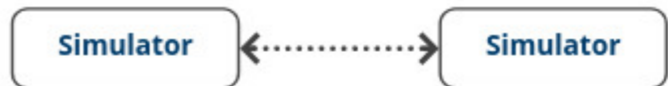


- benchmarking to a reference model
- robustness w.r.t to parameters / input
- consistency between versions

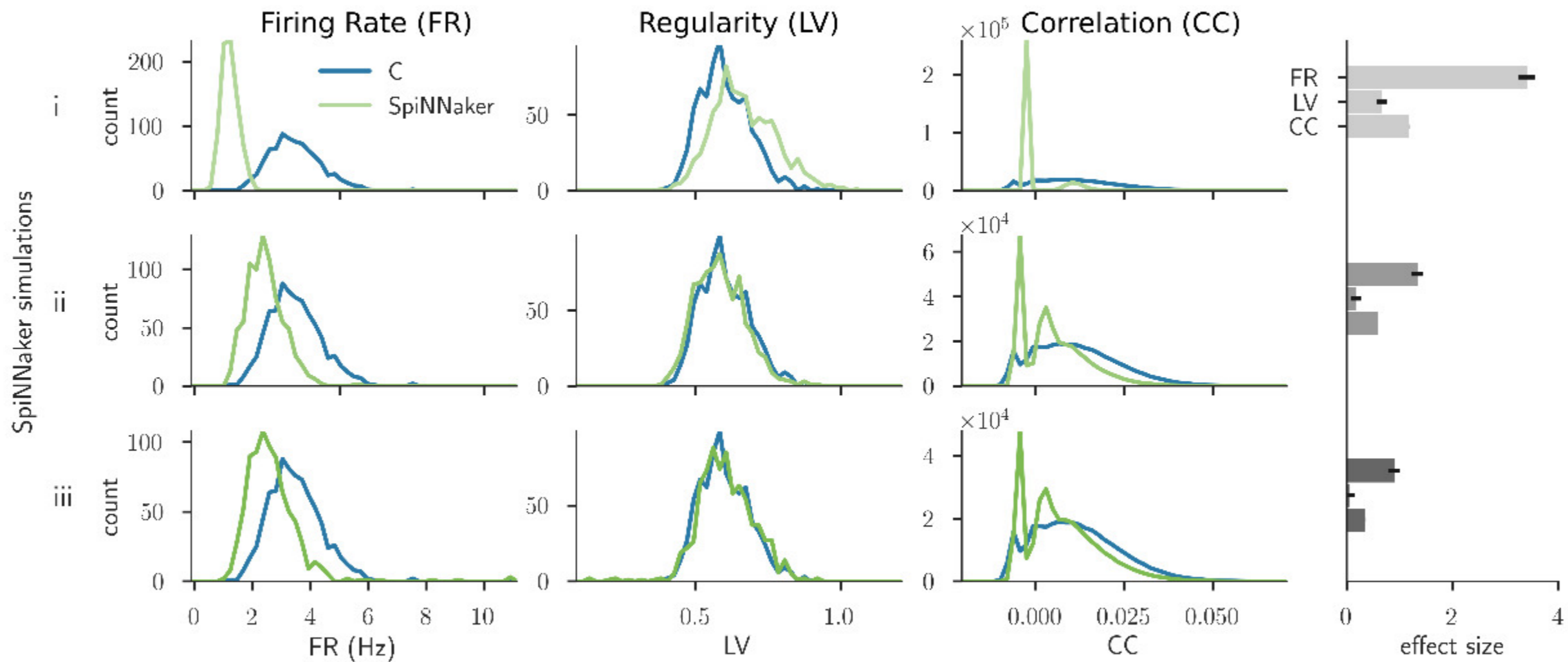
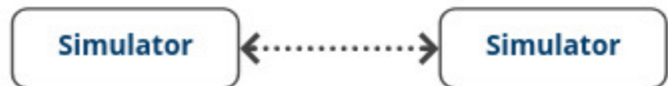


- benchmarking to a reference simulator
- robustness w.r.t. simulator configuration
- consistency of implementations

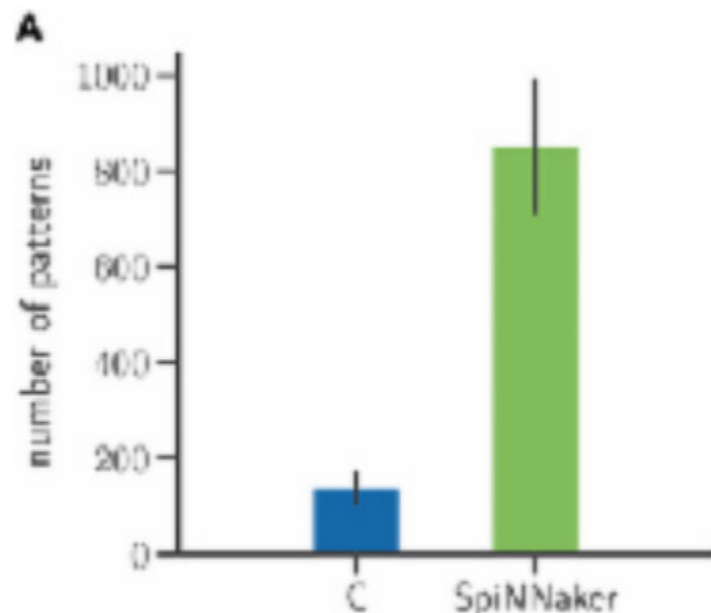
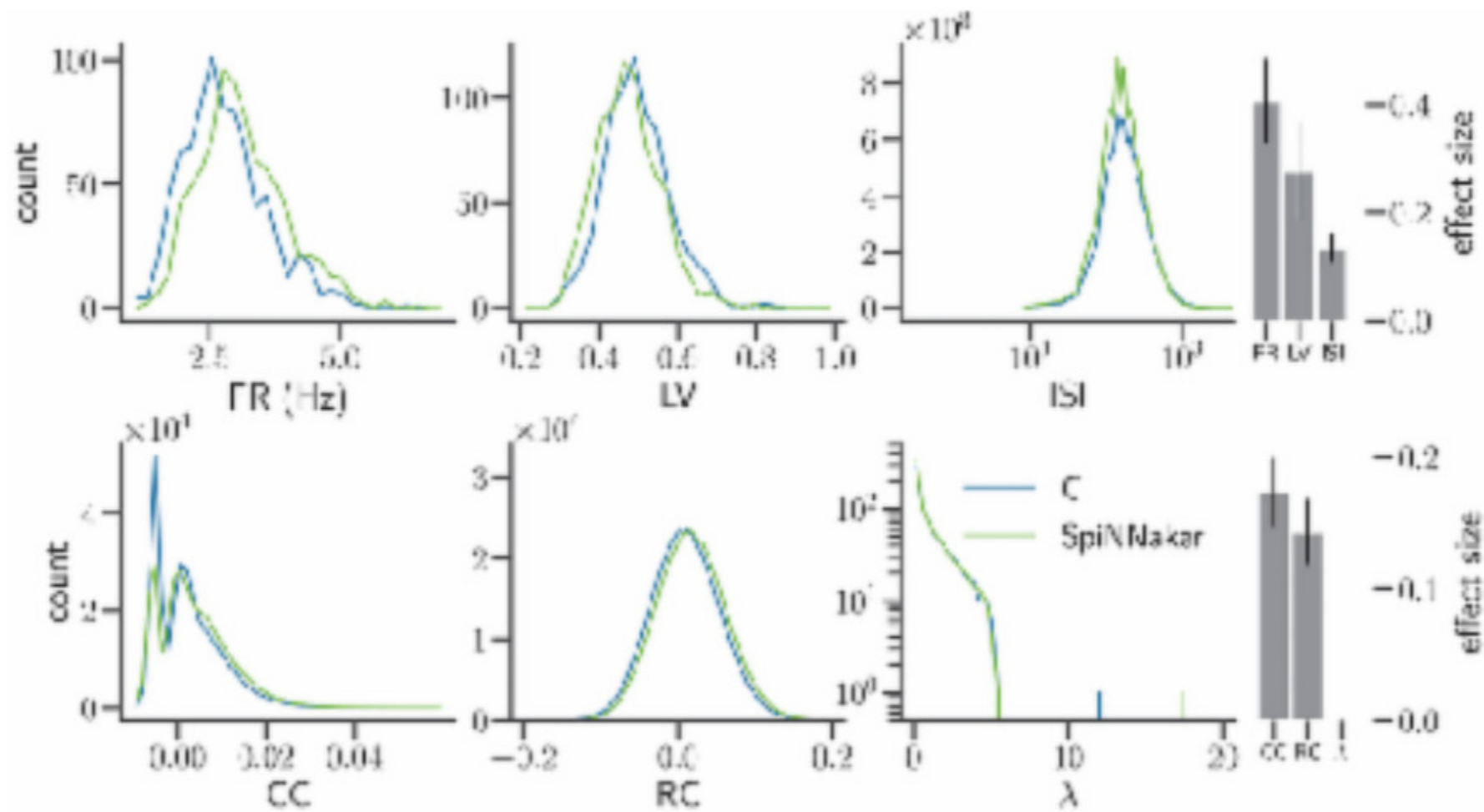
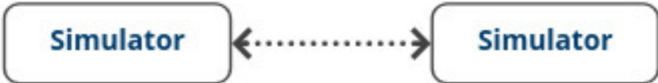
Simulator Comparison Case Study



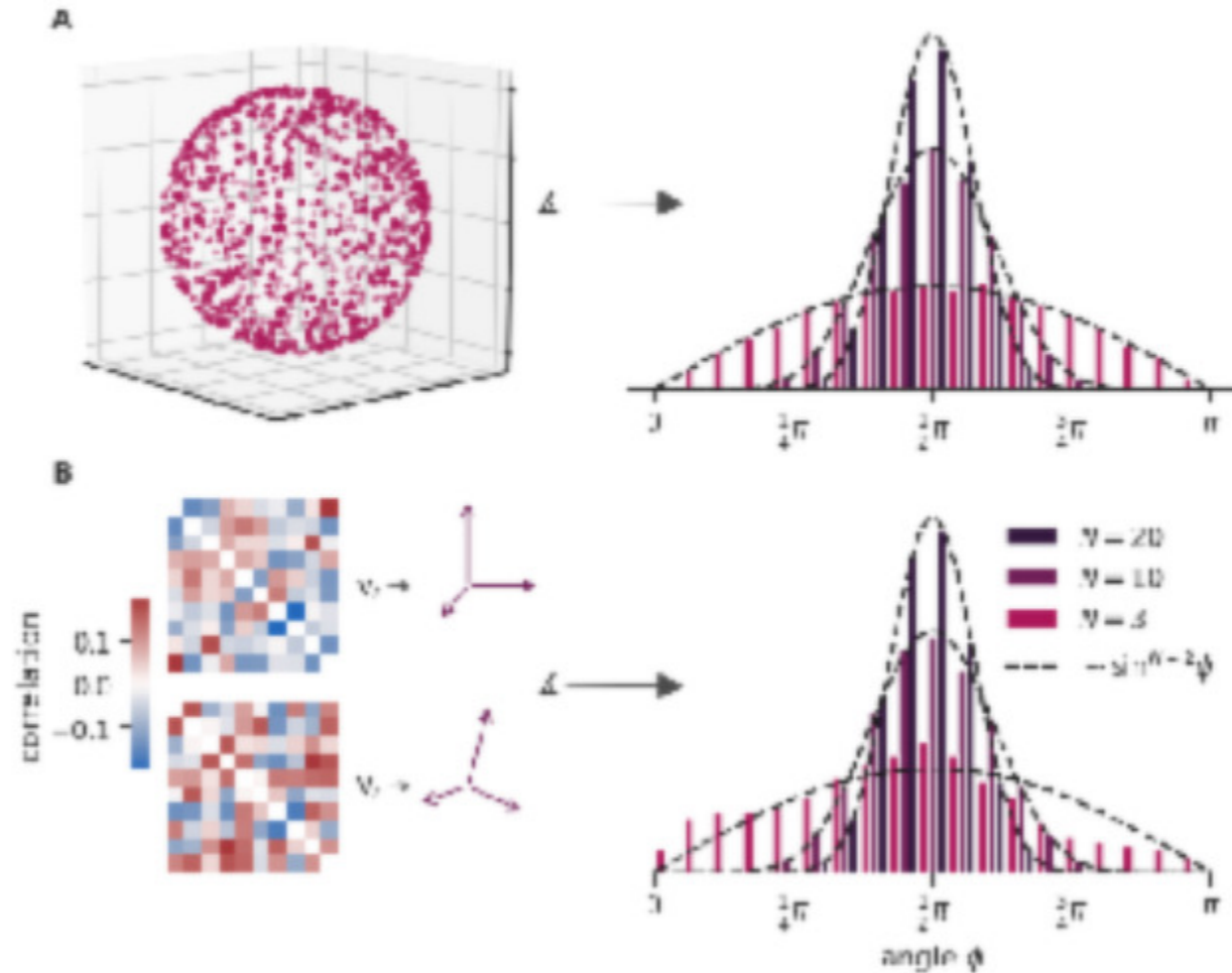
Simulator Comparison Case Study



Simulator Comparison Case Study

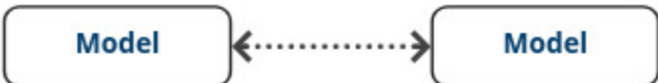


Higher-order characteristic measures

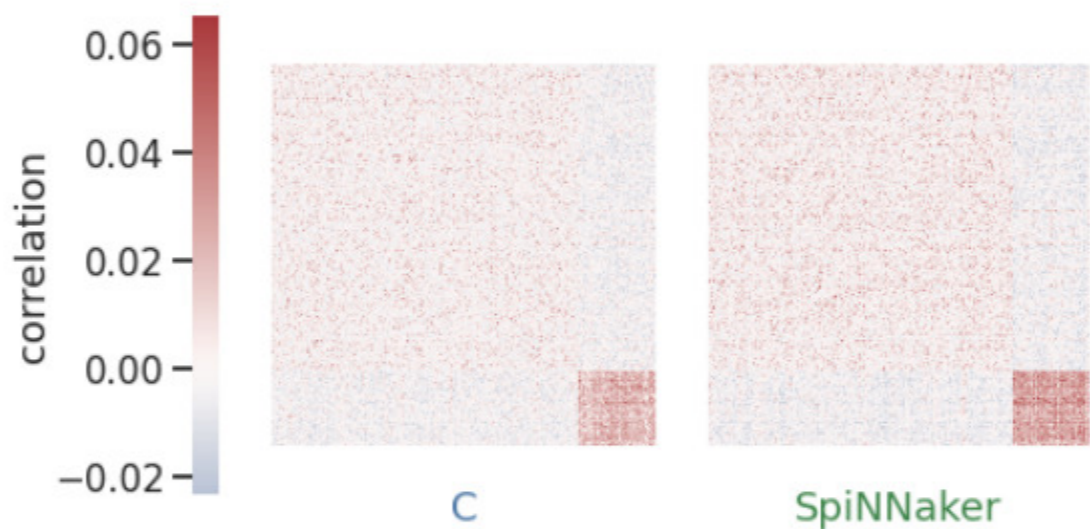


A similarity score based on the angles between pairs of eigenvectors can quantify the structural alignment between sets of pair-wise measures (i.e., correlation, connectivity).

Higher-order characteristic measures

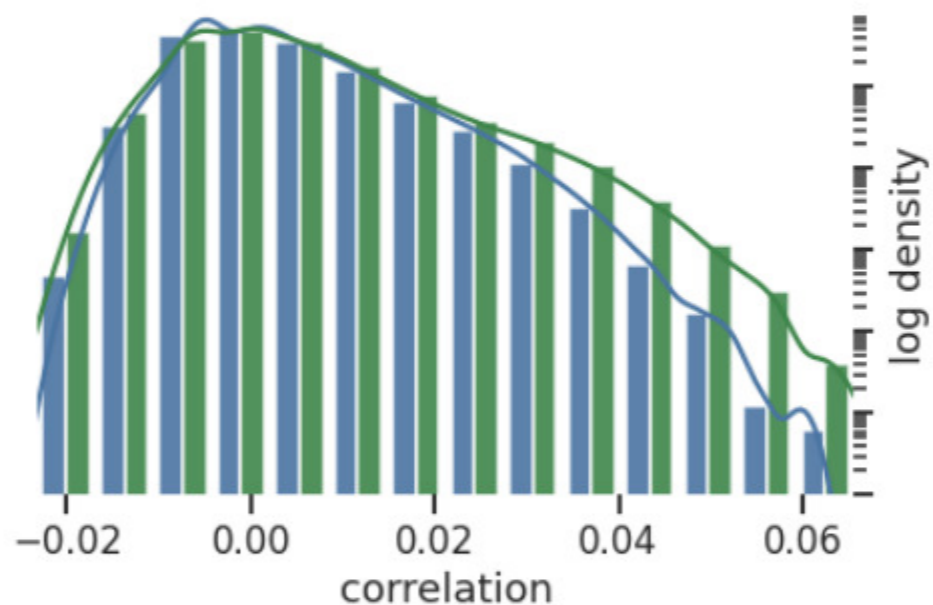


Eigenangle test ($p = 10^{-62} - 10^{-80}$)



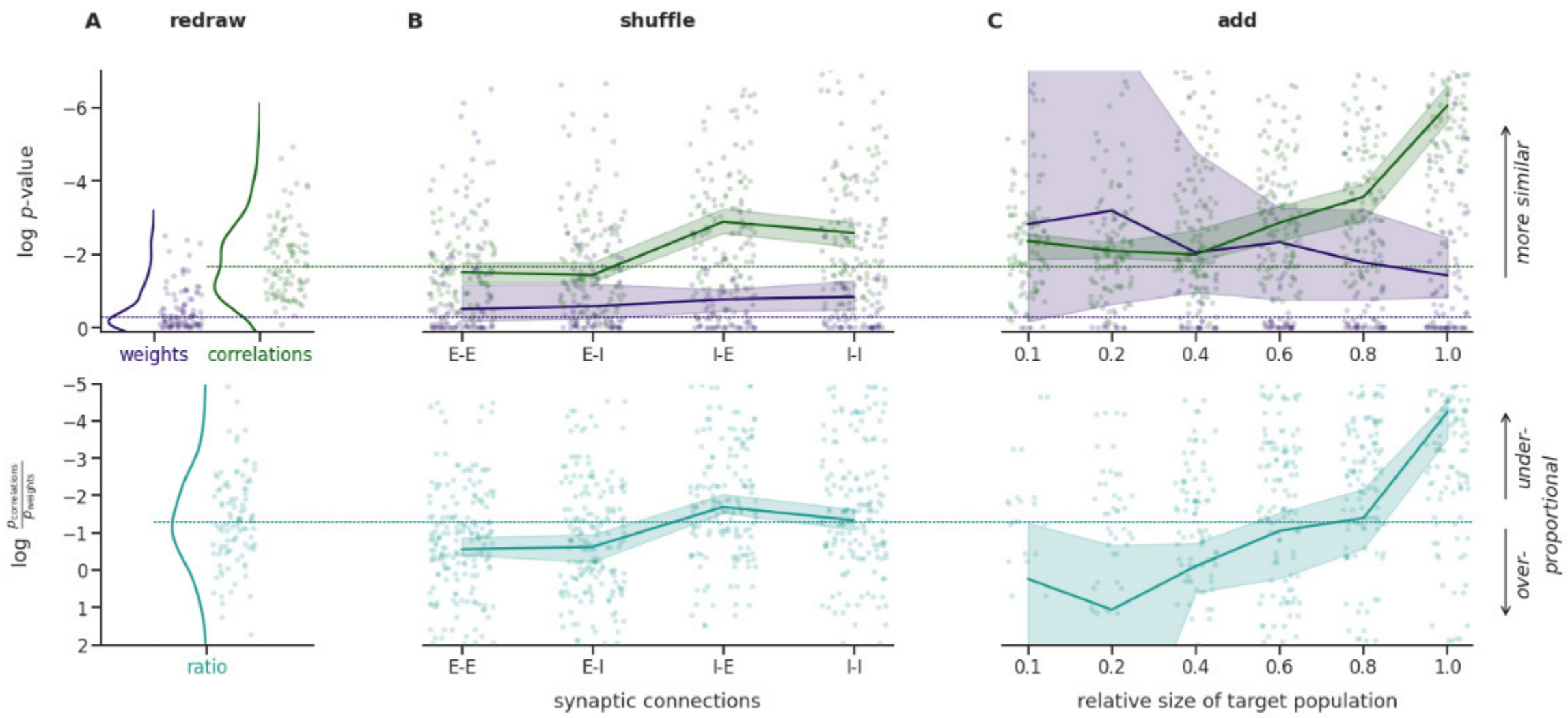
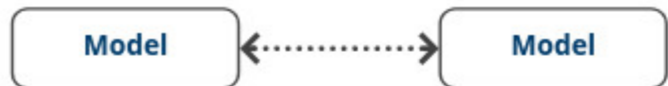
↓
indicating similarity

Kolmogorov-Smirnov test ($p = 0$)

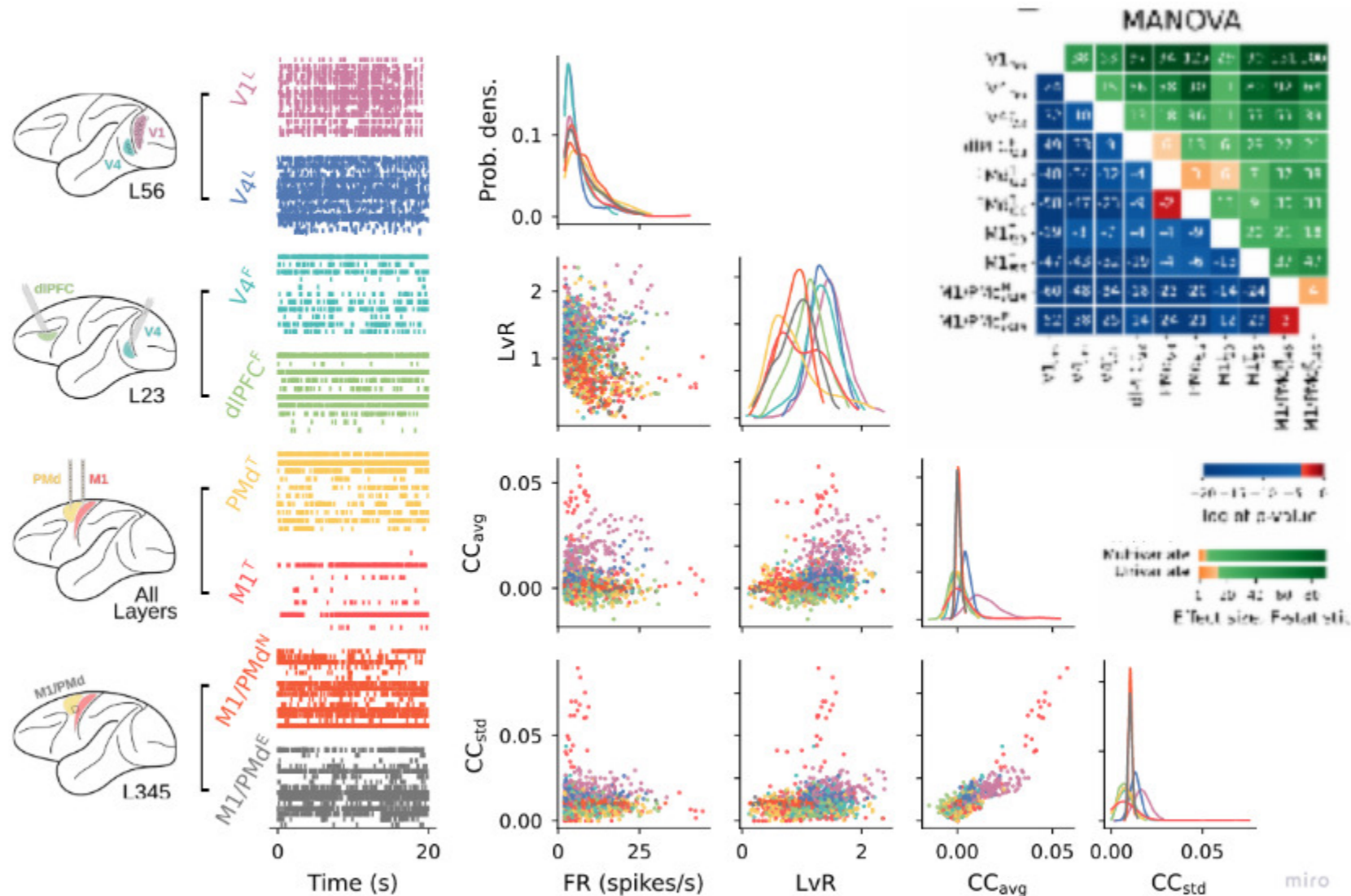


↓
indicating discrepancy

Higher-order characteristic measures



Model Connectivity Estimation via Calibration



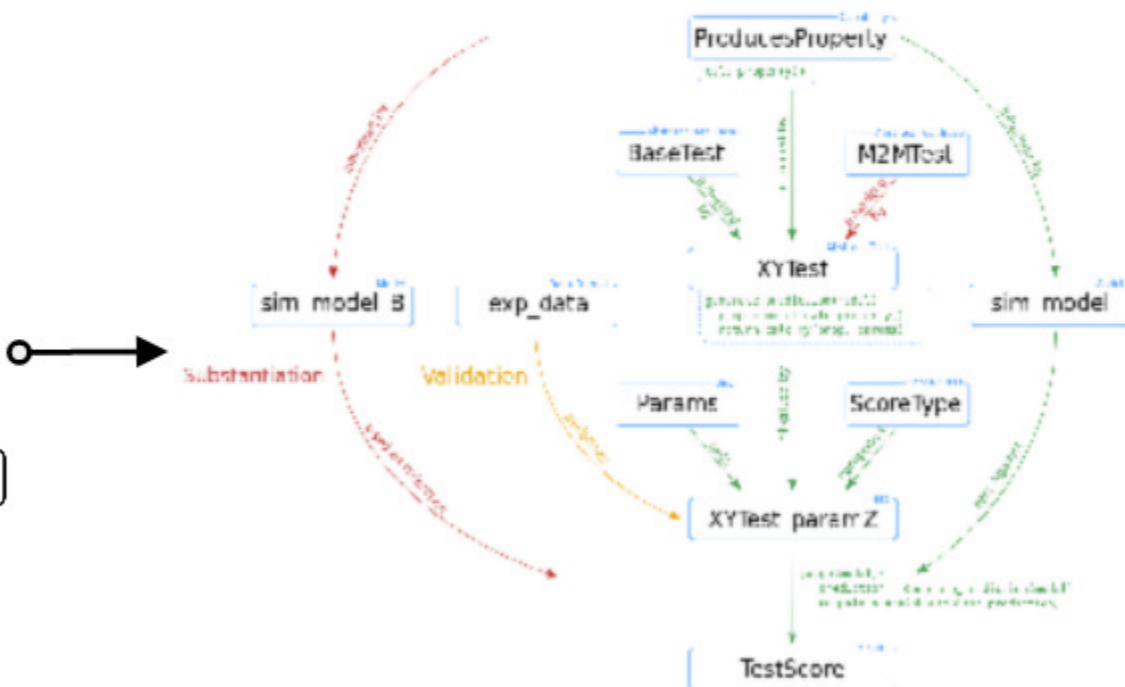
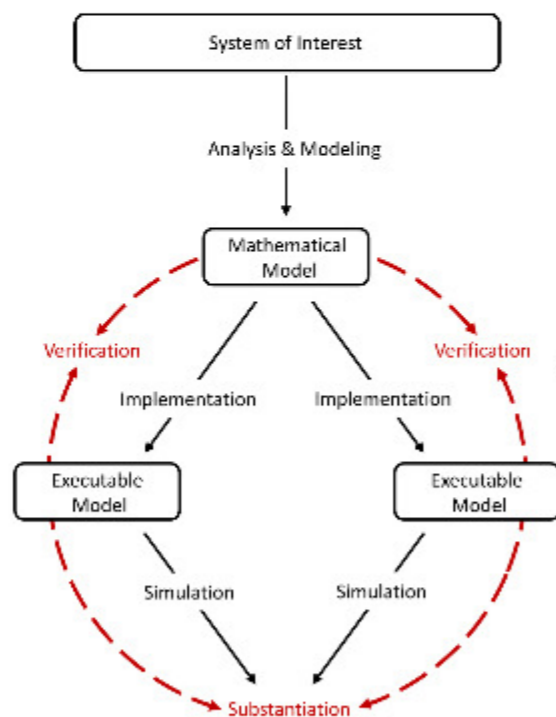
- using multiple measures, incl. their relation
- calibration by optimizing comparison scores
- validation needs to be independent
- similar activity implies similar connectivity

Reproducibility & Reusability

The more similar data is processed, the better it can be compared.



SciUnit



- ChannelUnit
- SynapseUnit
- HippoUnit
- HippoNetworkUnit
- BasalUnit
- MorphoUnit
- ...

Reproducibility & Reusability

View Current Configuration

| Models | | Tests | |
|---|---|--|--|
| Name | Author | Name | Author |
| <input type="checkbox"/> CA1_pyr_cACpyr_mpg141208_B_idA_20170915151855 | Rosanna Migliore | <input type="checkbox"/> BluePyOpt-eFEL Evaluator | Shailesh Appukuttan |
| <input type="checkbox"/> CA1_int_cNAC_97091_1C_20180120154902 | Rosanna Migliore | <input type="checkbox"/> CA1_laminar-distribution-synapses_Neyman-Test | Pedro Garcia-Rodriguez |
| <input type="checkbox"/> Surface potential models | Mario Telenczuk, Bartosz Telenczuk and Alain Destexhe | <input type="checkbox"/> PROPOSAL_Hippocampus_APPropagationAxonTest_BasketCell | Sara Saray |
| <input type="checkbox"/> CA1_pyr_cACpyr_mpg141208_B_idA_20190328144006 | Rosanna Migliore | <input type="checkbox"/> Basal Ganglia MSN D2 Type Morphology Soft Constraints | Shailesh Appukuttan |
| <input type="checkbox"/> Hippocampal formation as a hierarchical generative model | Giovanni Pezzulo | <input type="checkbox"/> Hippocampus_SomaticFeaturesTest_CA1_pyr_cACpyr | Sara Saray |
| <input type="checkbox"/> CA1_int_cNAC_36031-4AM2_20190328165336 | Rosanna Migliore | <input type="checkbox"/> HippoCircuit - Total Boutons | Armando Romani, Shailesh Appukuttan |
| <input type="checkbox"/> CA1_pyr_cACpyr_mpg150305_A_idB_20190305112012 | Rosanna Migliore | <input type="checkbox"/> AP Height | Shailesh Appukuttan |
| <input type="checkbox"/> CA1_pyr_cAC_mpg141208_B_idA | Rosanna Migliore | <input type="checkbox"/> HippoCircuit - Average Axon Length | Armando Romani, Shailesh Appukuttan |
| <input type="checkbox"/> CA1_int_cAC_970627BHP1_20180120160112 | Rosanna Migliore | <input type="checkbox"/> Basal Ganglia FS Type Morphology Soft Constraints | Pedro Garcia-Rodriguez |
| <input type="checkbox"/> CA1_pyr_cACpyr_oh140807_A0_idA_20190305112828 | Rosanna Migliore | <input type="checkbox"/> Testing synaptic plasticity: LTD | Justinas Dalnauskas, Shailesh Appukuttan |
| <input type="checkbox"/> TestModel API v2 2020-07-06T16:25:01.027452+00:00 | Frodo Beggins, Tom Bombadil | <input type="checkbox"/> CA1_laminar-distribution-synapses_Freeman-Tukey-1 Test | Pedro Garcia-Rodriguez |
| <input type="checkbox"/> Ion channel models MSN | Robert Lindroos, Alexander Kozlov | <input type="checkbox"/> Basal Ganglia FS Population Morphology Soft Constraints | Pedro Garcia-Rodriguez |
| <input type="checkbox"/> Golding dichotomy | Nelson Spruston, Nace L. Golding, William L. Kath, Timothy Mickus | <input type="checkbox"/> Hippocampus_SomaticFeaturesTest_CA1_Pyr_PatchClamp | Sara Saray |

Screenshot



EBRAINS

Characteristic population activity: slow waves

Experiment

Experiment

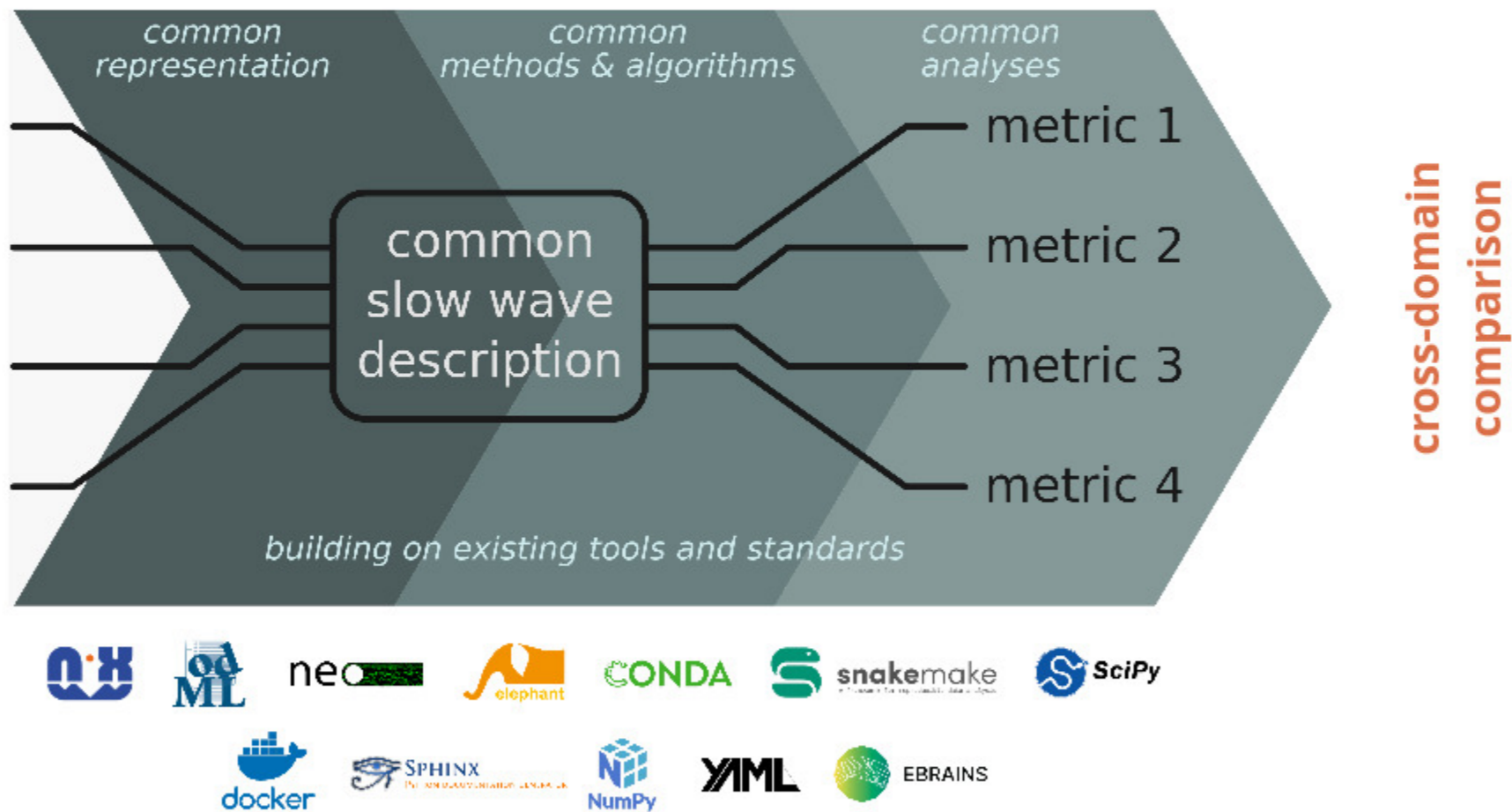
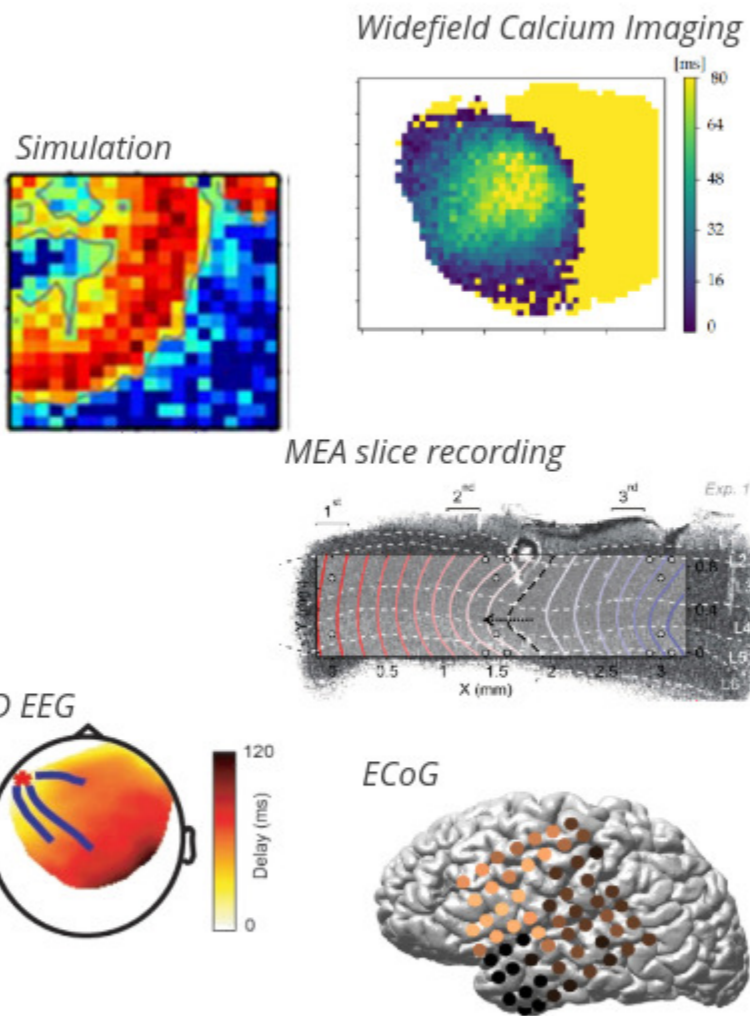


image references in Appendix

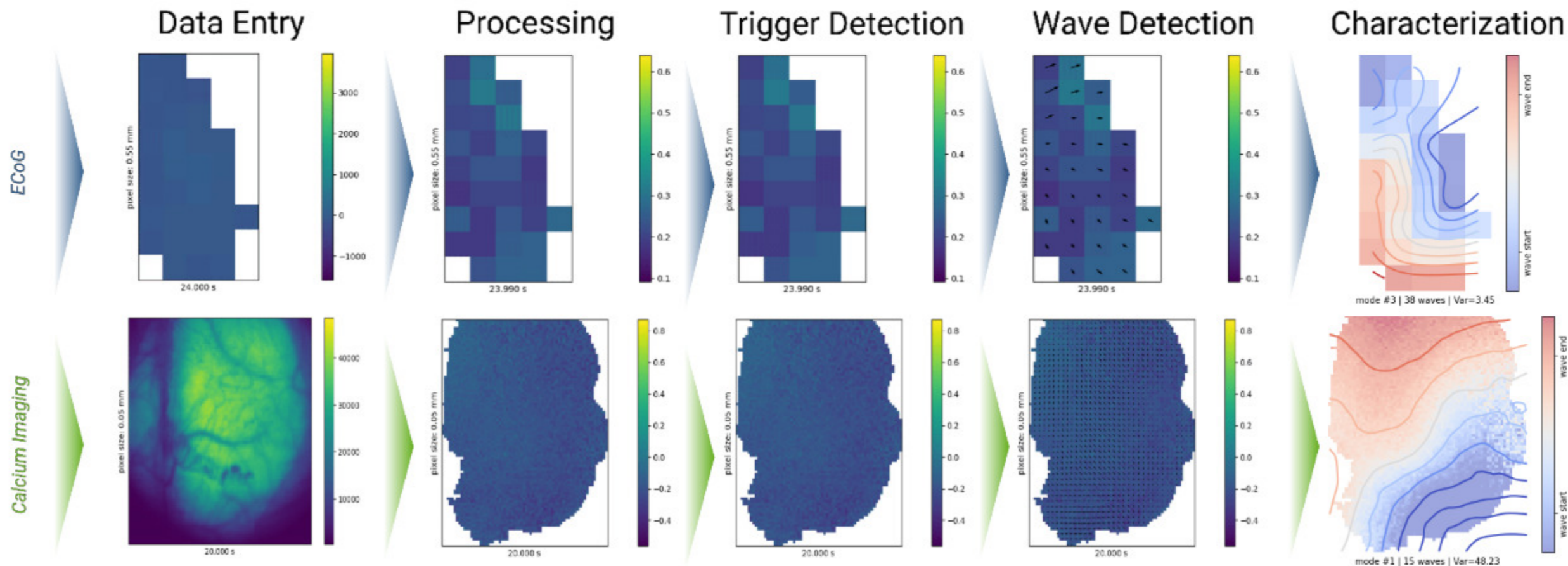
Collaborative Brain-Wave Analysis Pipeline (Cobrawap): <https://github.com/INM-6/cobrawap>

Towards "big data" analyses, and meta-studies

Experiment

Experiment

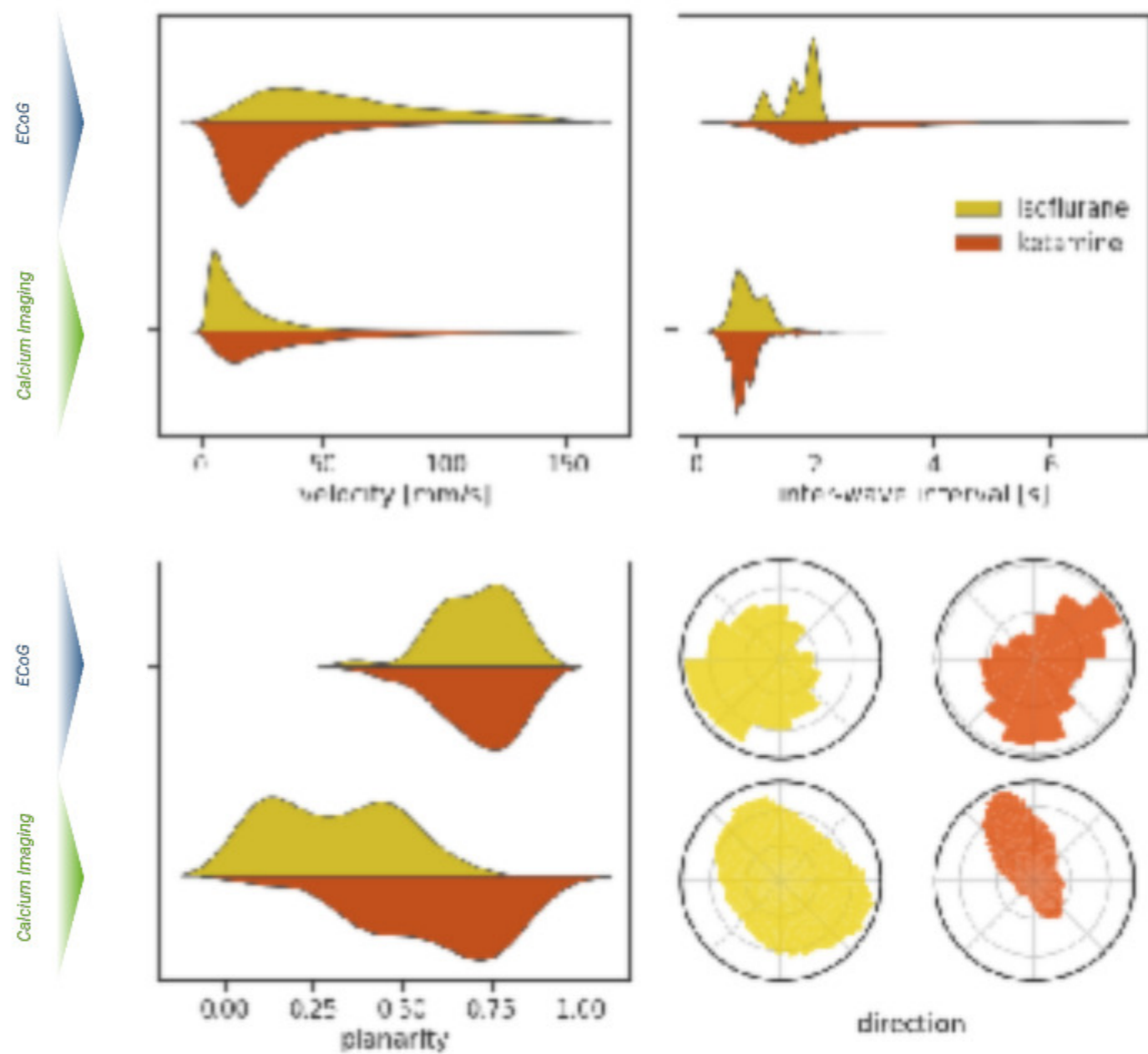
using 5 open-access datasets of 60 ecog and calcium imaging recordings



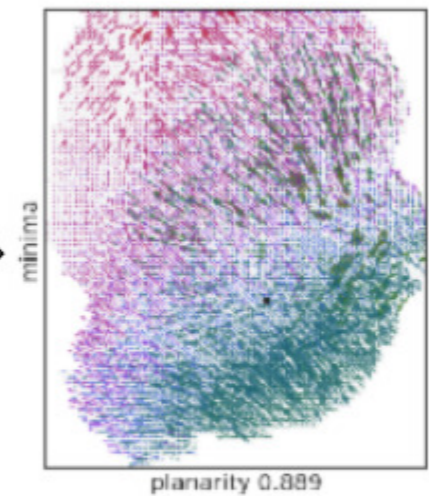
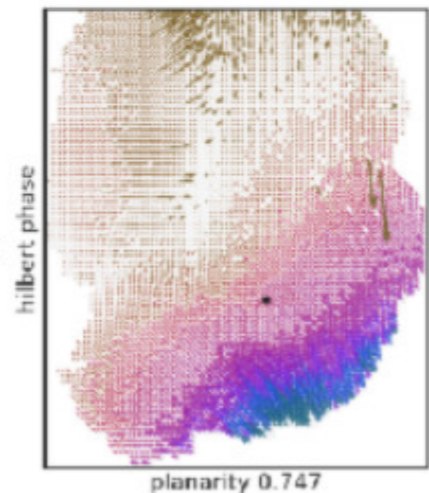
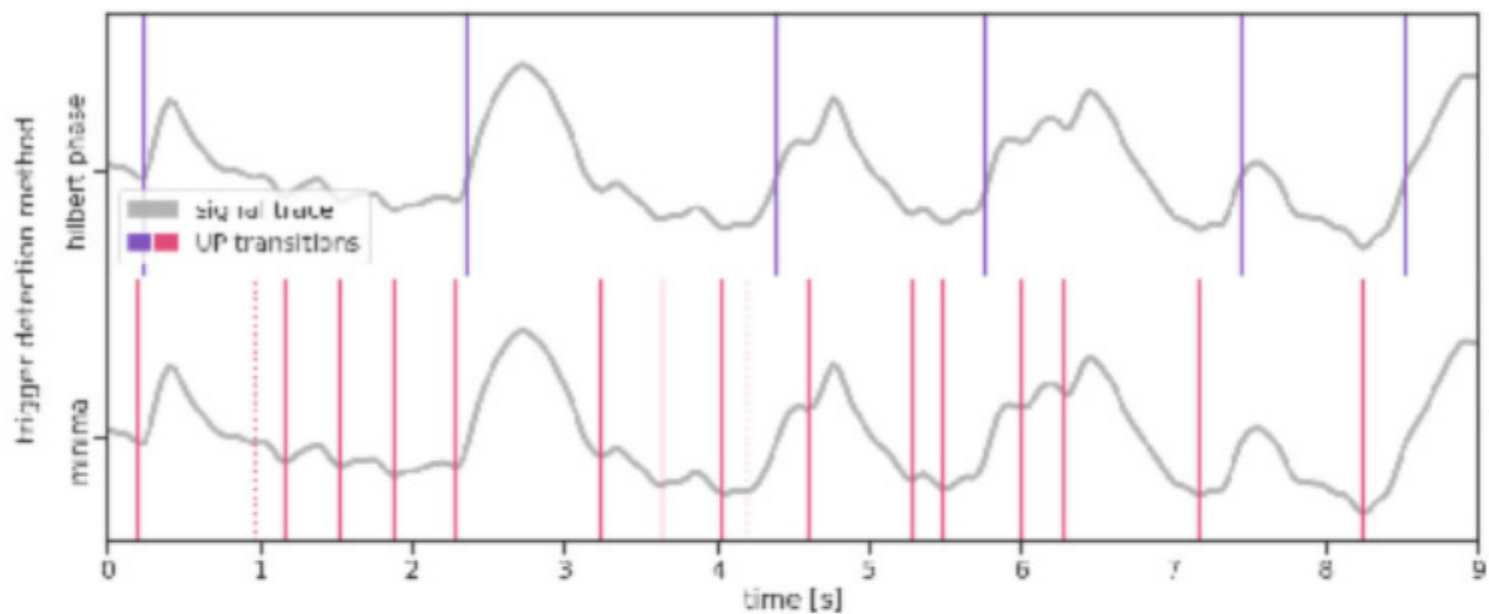
Comparing Heterogeneous Data

Experiment

Experiment



Comparing Methods on Same Data

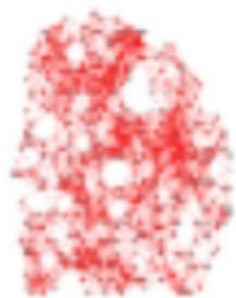


Calibrating & Validating Models

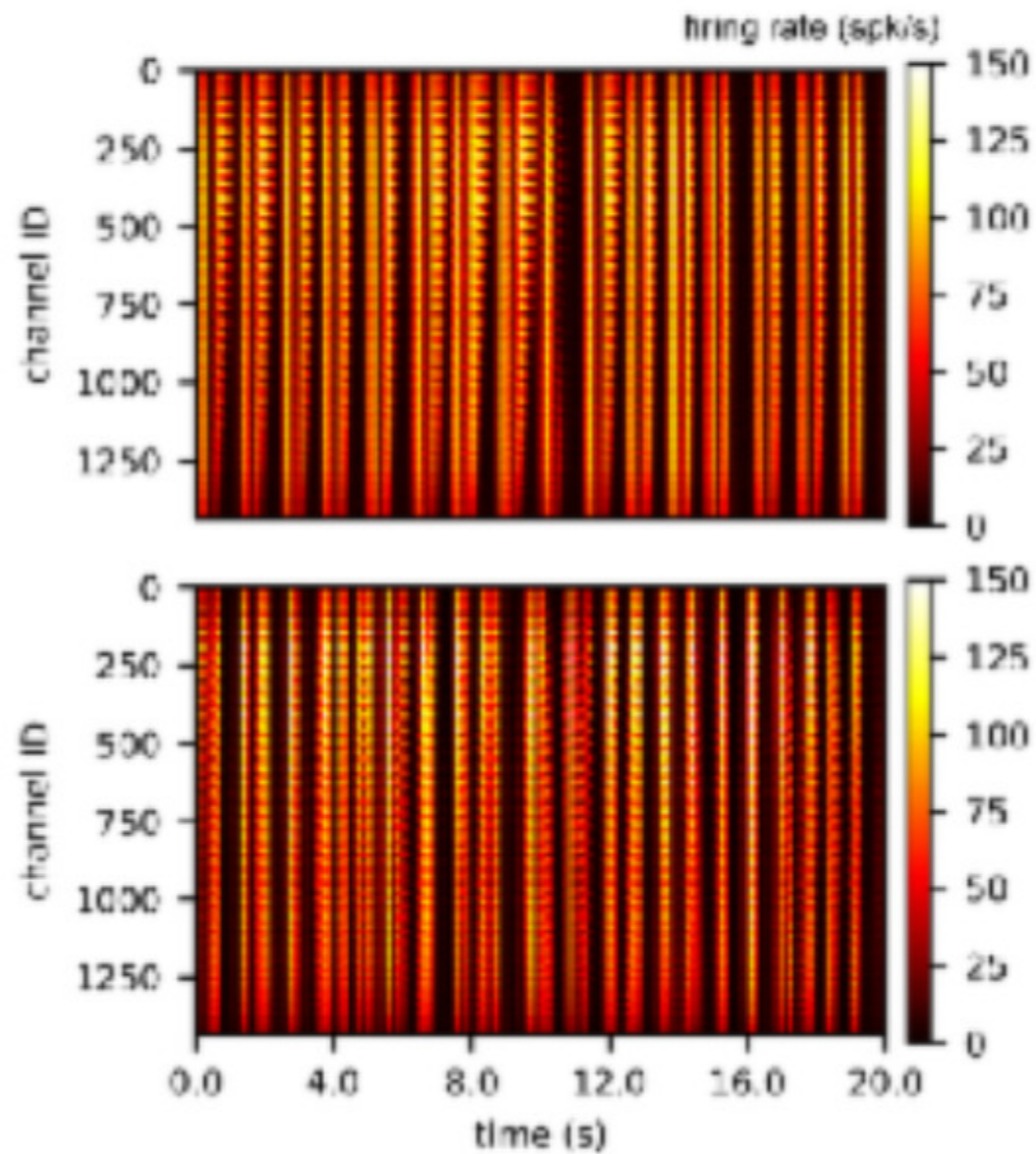
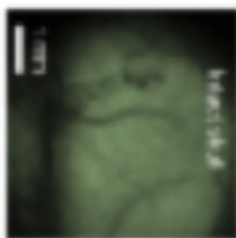
Experiment

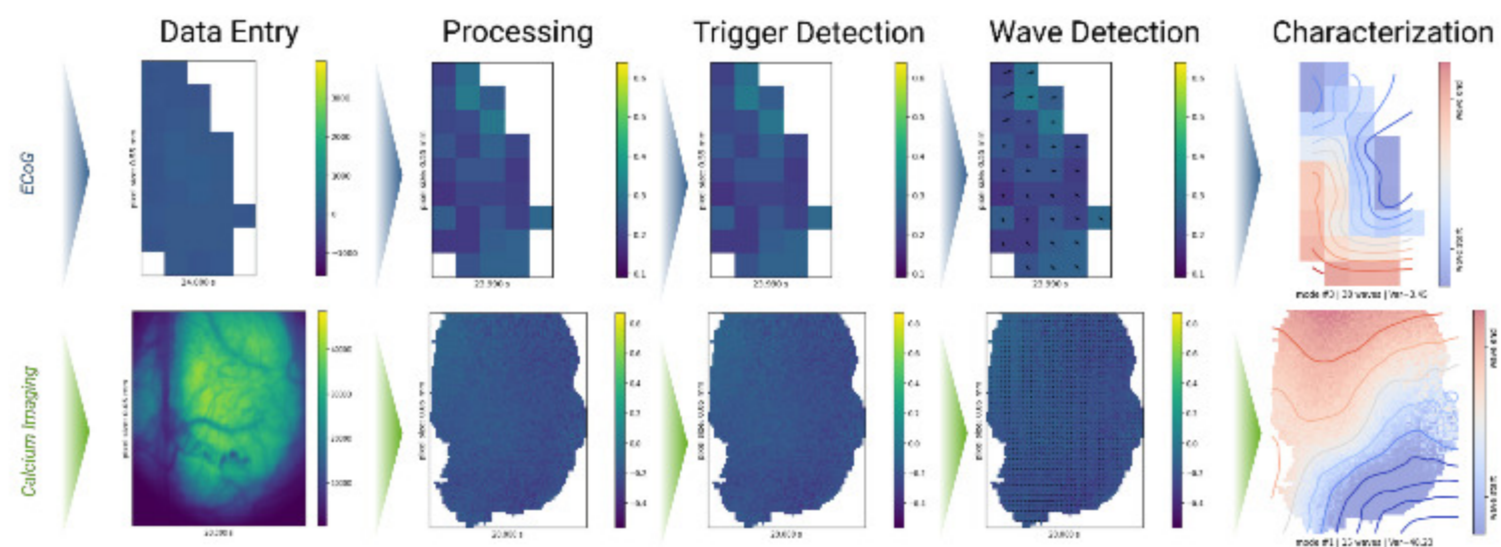
Experiment

Simulation

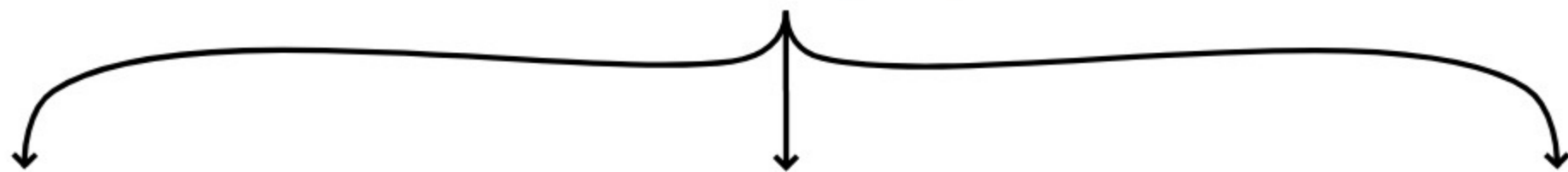


Data

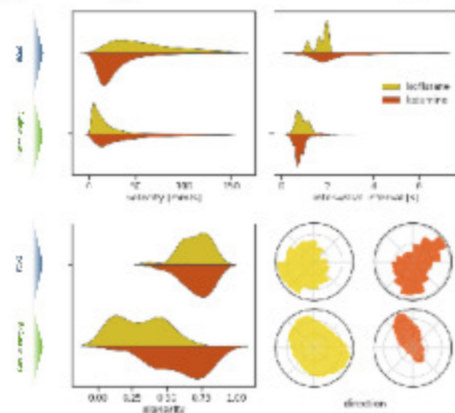




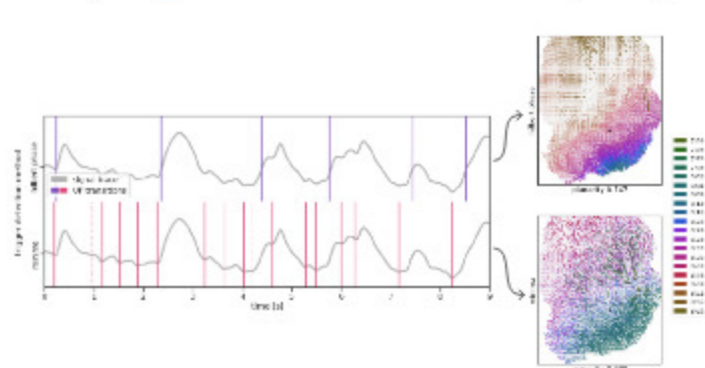
Modular Wave Analysis Pipeline



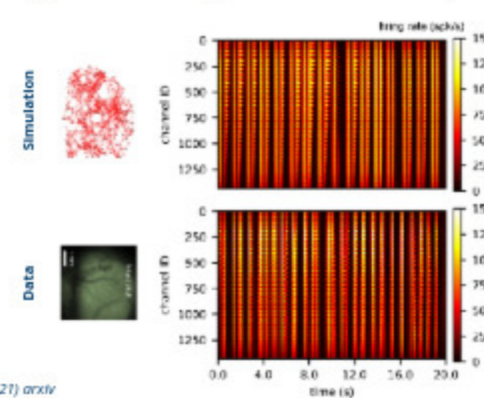
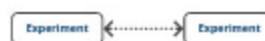
Comparing Heterogeneous Data



Comparing Methods on Same Data

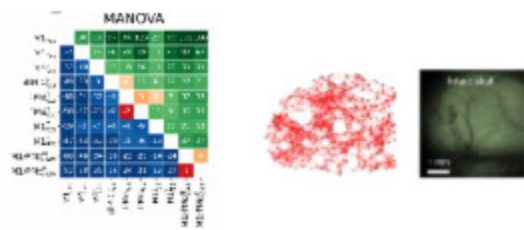


Calibrating & Validating Models

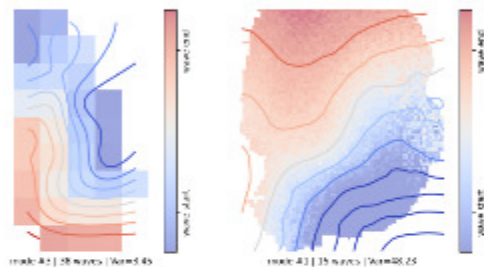
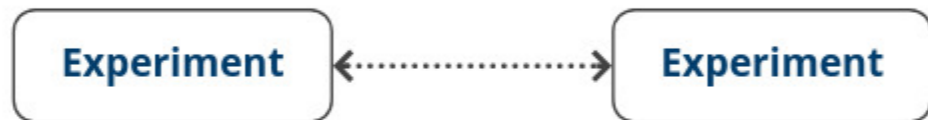


Capone et al. (2021) arxiv

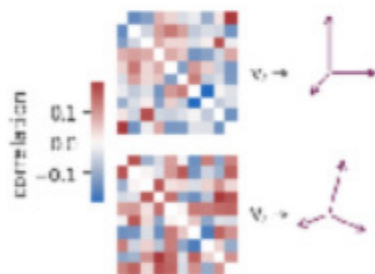
Conclusion



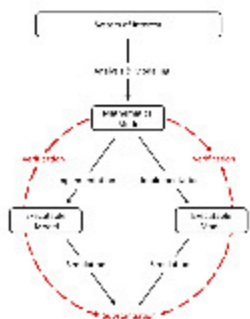
- validation testing can be used for calibration
- rigorous activity comparisons enables inference on connectivity



- modular adaptable analysis makes heterogeneous data comparable
- collaborative research and tool-sharing unveils links between domains



- structure is complementary to amount
- having comparable metrics opens doors to new insights



- implementation details matter
- a good comparison is made of many measures
- higher-order measures yield additional information

Acknowledgments



 @rgutzen



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Sacha van Albada
Johanna Senk
Pietro Quaglio
Michael von Papen
Abigail Morrison

...

and our collaborators:



Human Brain Project



Maurizio Mattia



Andrew Davison
Shailesh Appukuttan
Lungsi Sharma



Institut
D'Investigacions
Biomèdiques
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Maria V. Sanchez-Vives



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Francesco Resta
Francesco Saverio Pavone



Giulia De Bonis
Elena Pastorelli
Cristiano Capone
Chiara De Luca
Pier Stanislao Paolucci



EBRAINS Workshop: BASSES

Brain Activity across Scales and Species:
Analysis of Experiments and Simulations

13–15 June 2022 | Rome & virtual

Appendix

References for Figure on Slide 12

- Celotto et al. (2020) doi:10.3390/mps3010014
- Pastorelli et al. (2019) doi:10.3389/fnsys.2019.00033
- Capone et al. (2017) doi:10.1093/cercor/bhx326
- Massimini et al (2004) doi:10.1523/JNEUROSCI.1318-04.2004
- Muller et al. (2016) e17267. doi:10.7554/eLife.17267

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- Istituto Superiore di Sanità, (ISS), Rome, Italy

Slow Wave Datasets

- Resta et al. (2020) doi:10.25493/3E6Y-E8G
- Resta et al. (2020) doi:10.25493/XJR8-QCA
- Sanchez-Vives (2020) doi:10.25493/WKA8-Q4T
- Sanchez-Vives (2019) doi:10.25493/ANF9-EG3
- Sanchez-Vives (2019) doi:10.25493/DZWT-1T8