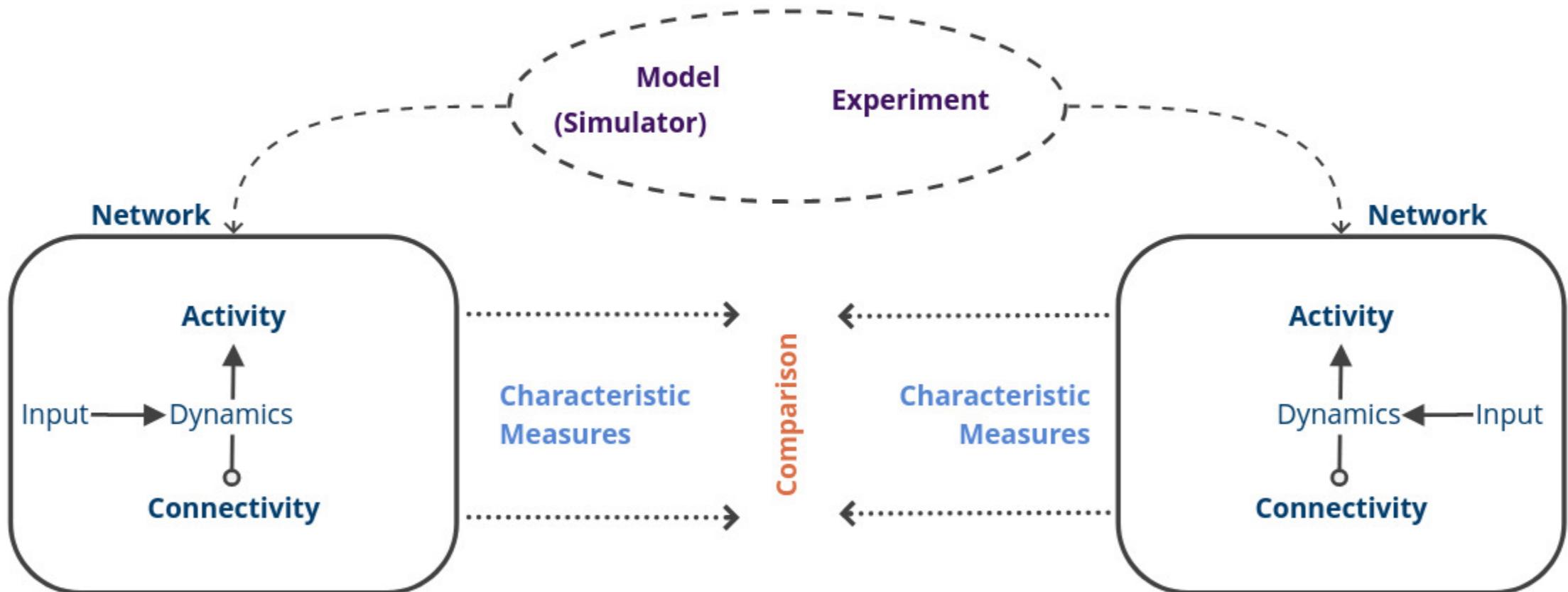


# Rigorous comparison and validation of network activity data

**Robin Gutzen** | *Research Center Juelich, Germany*

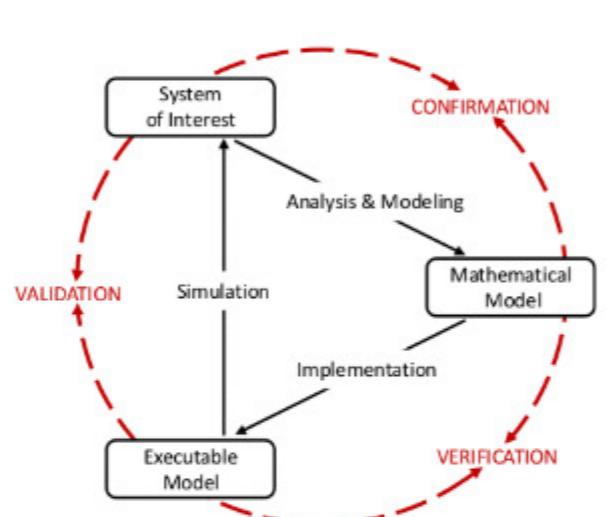
2022-05-18 Topic 3 Talk Series

# 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

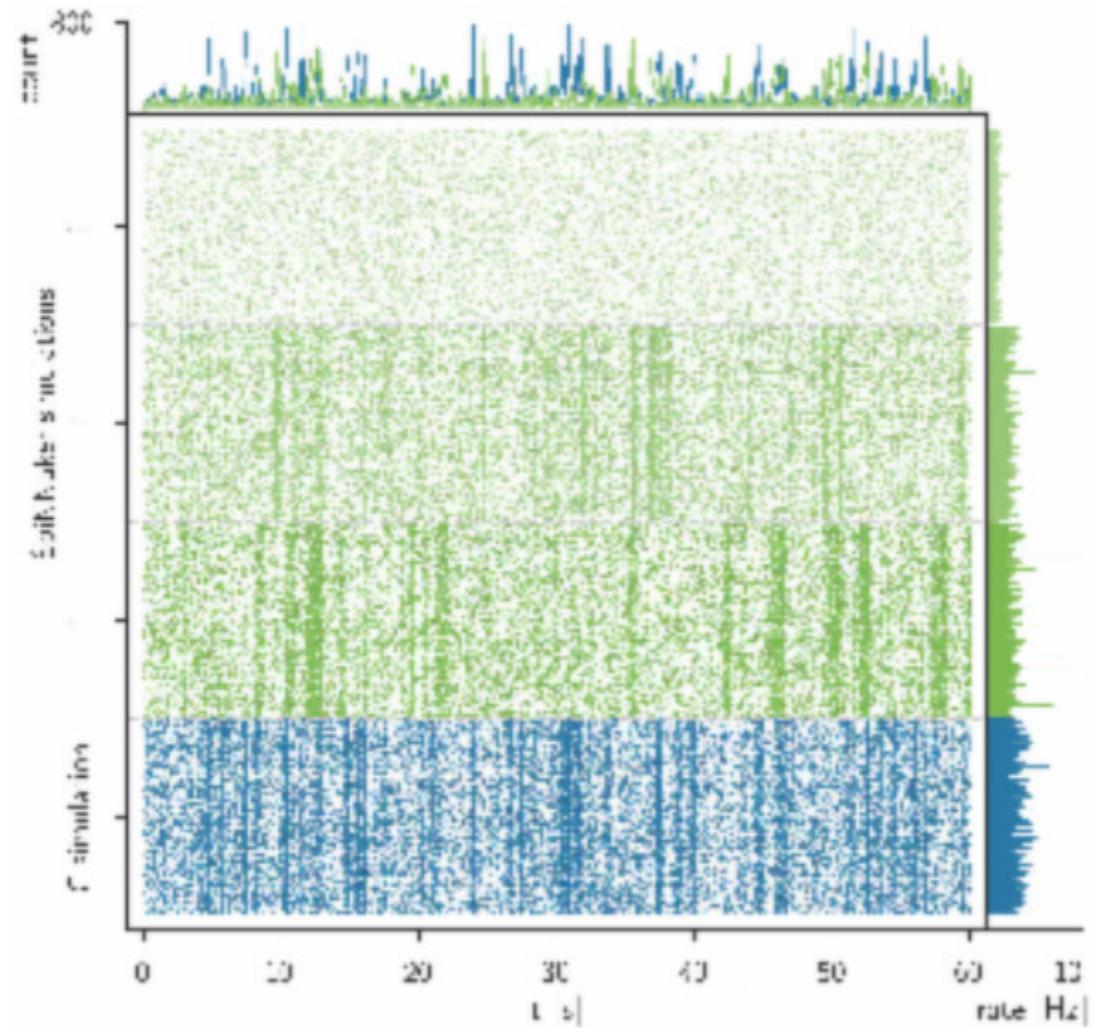
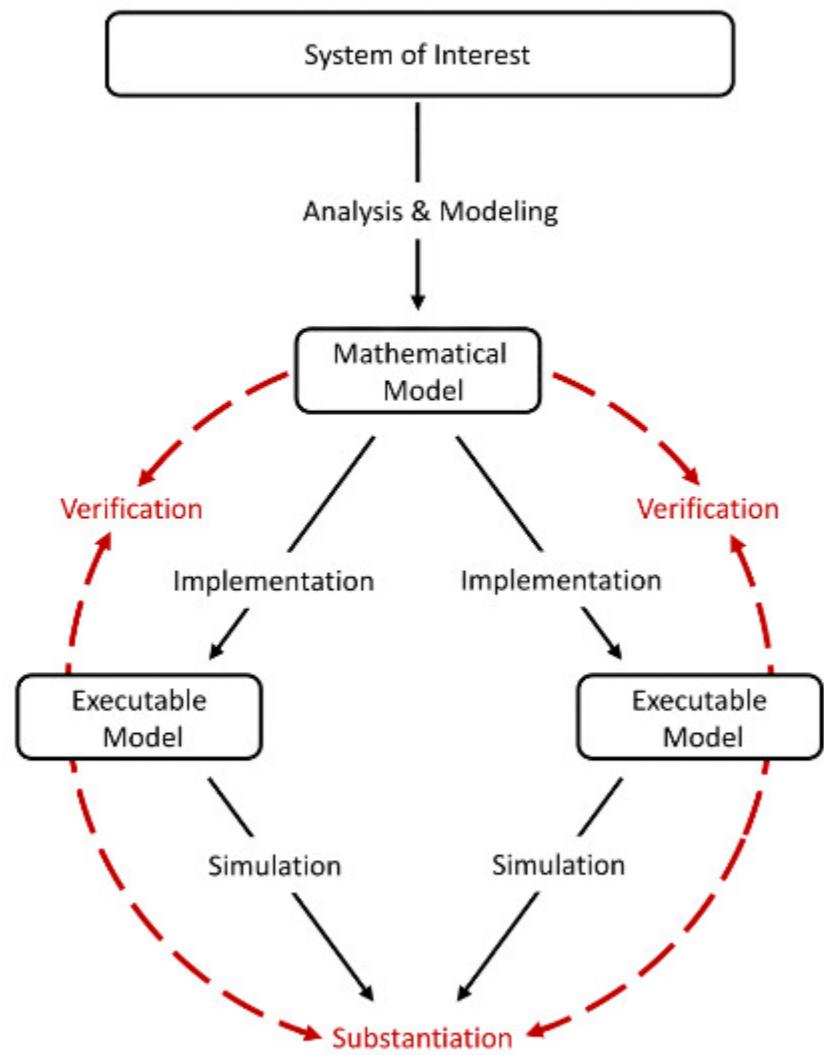
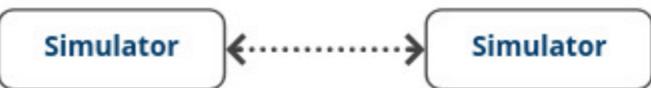


- benchmarking to a reference model
- robustness w.r.t to parameters / input
- consistency between versions



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

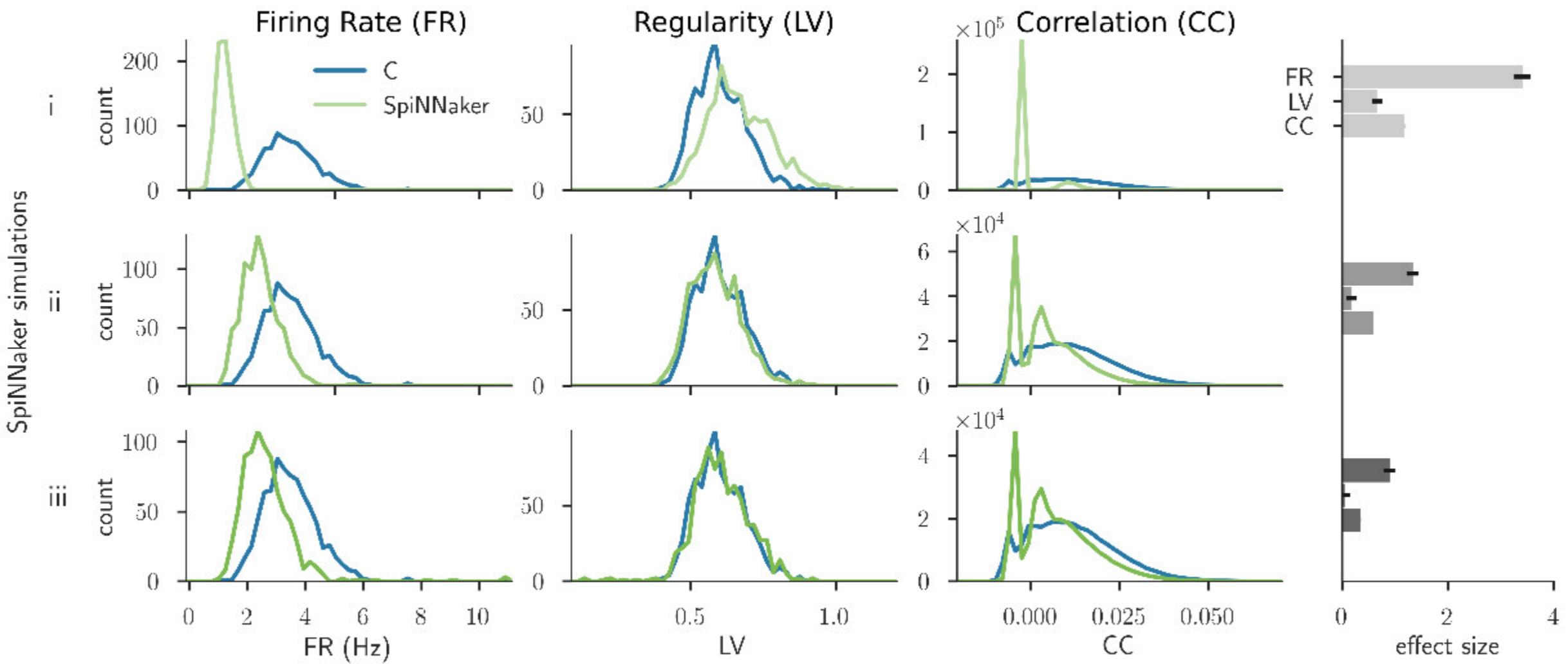
# Simulator Comparison Case Study



# Simulator Comparison Case Study

Simulator

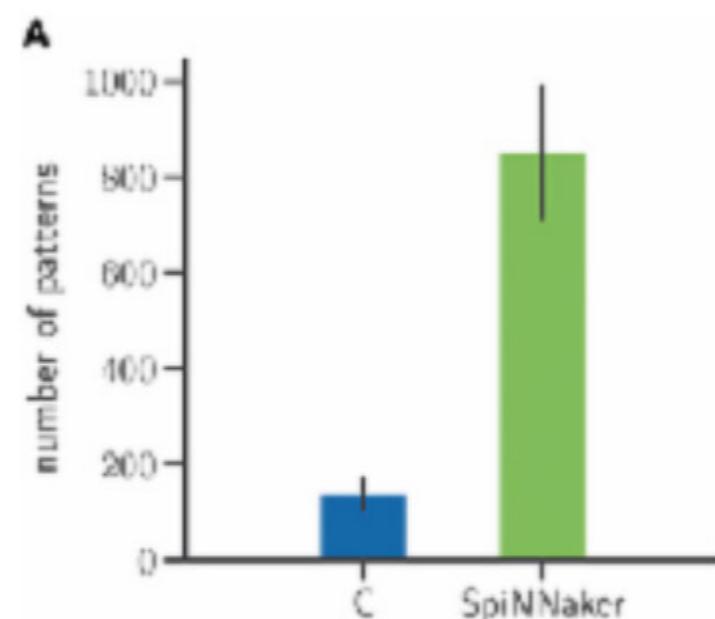
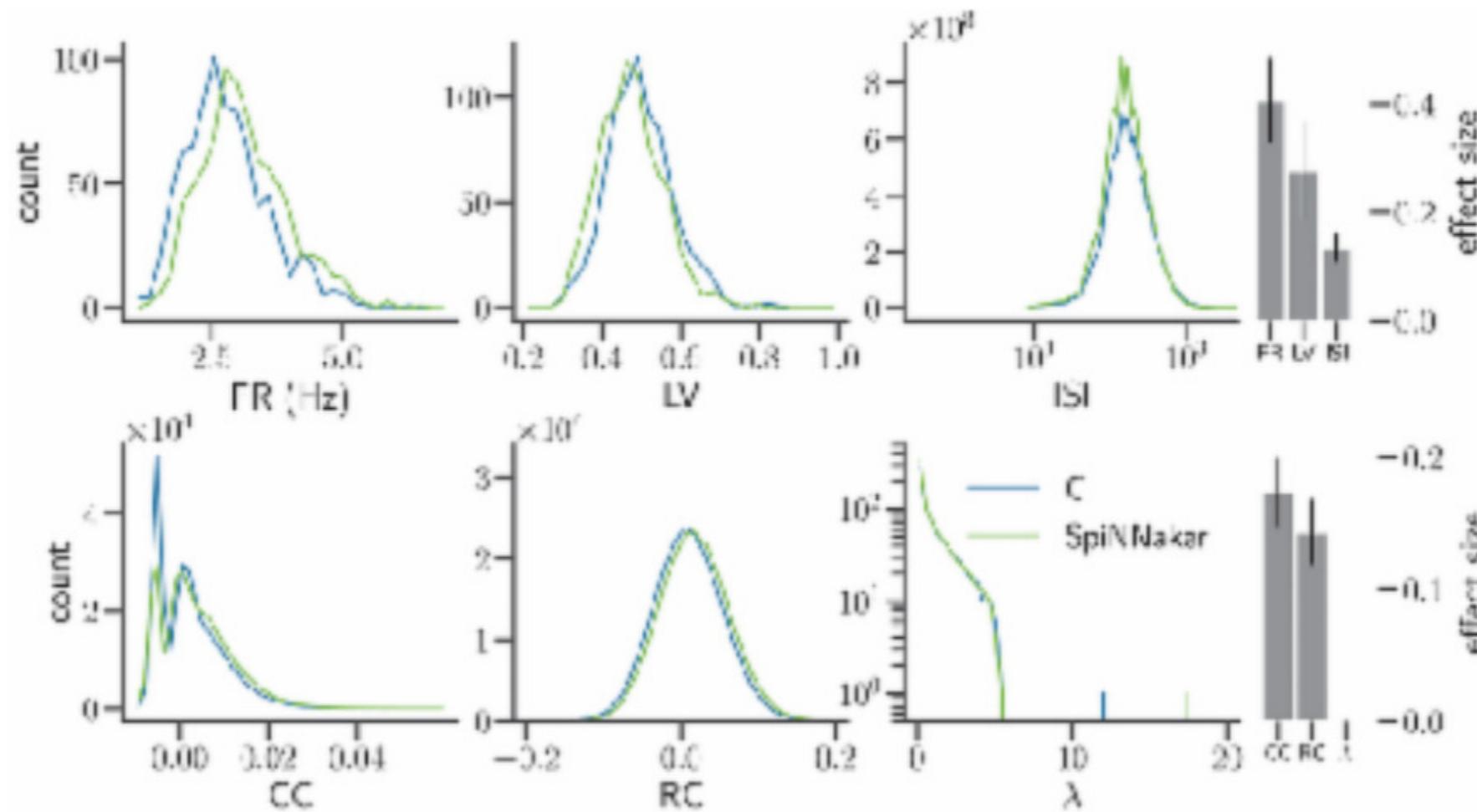
Simulator



# Simulator Comparison Case Study

Simulator

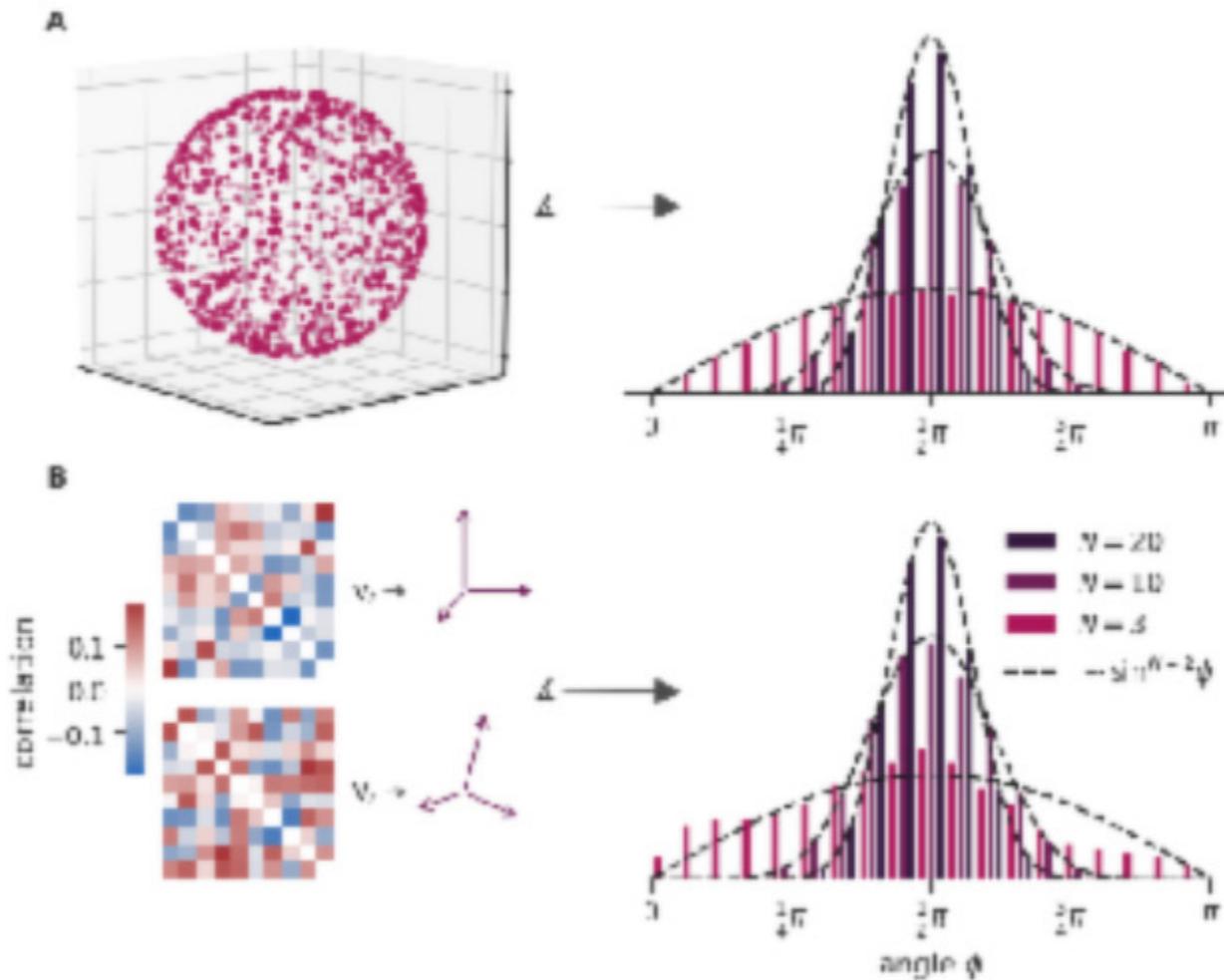
Simulator



# Higher-order characteristic measures

Model

Model

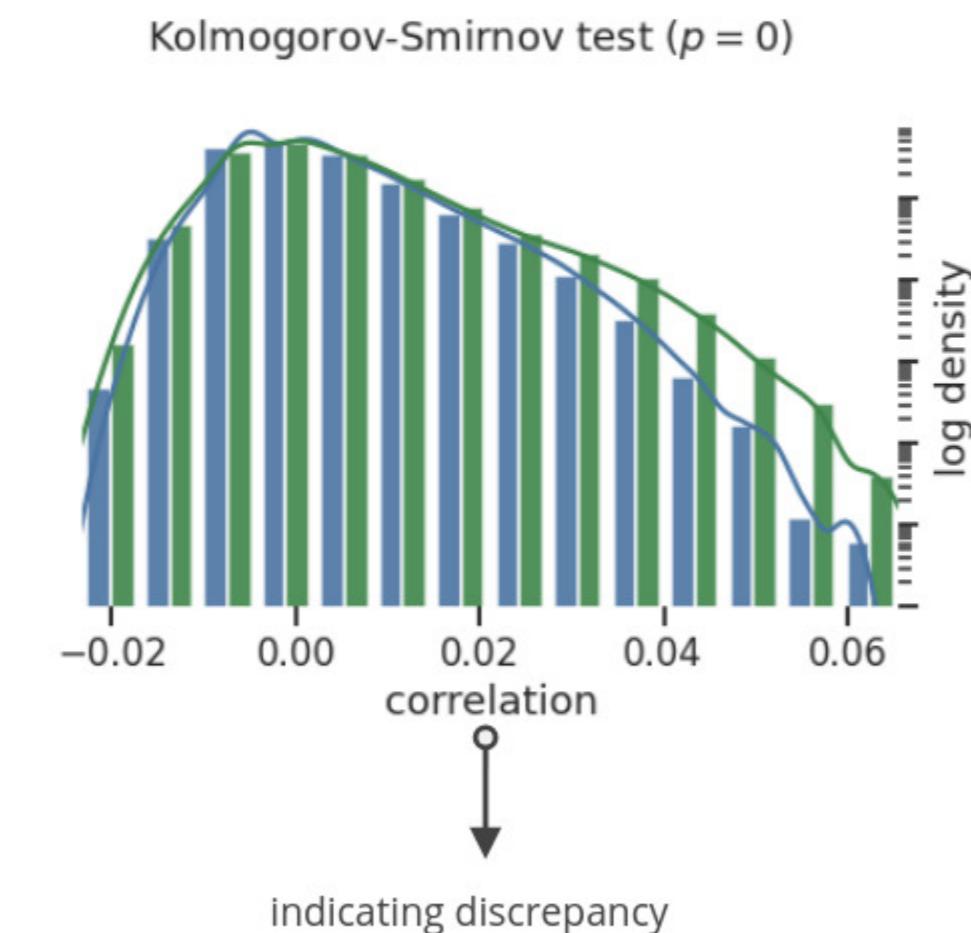
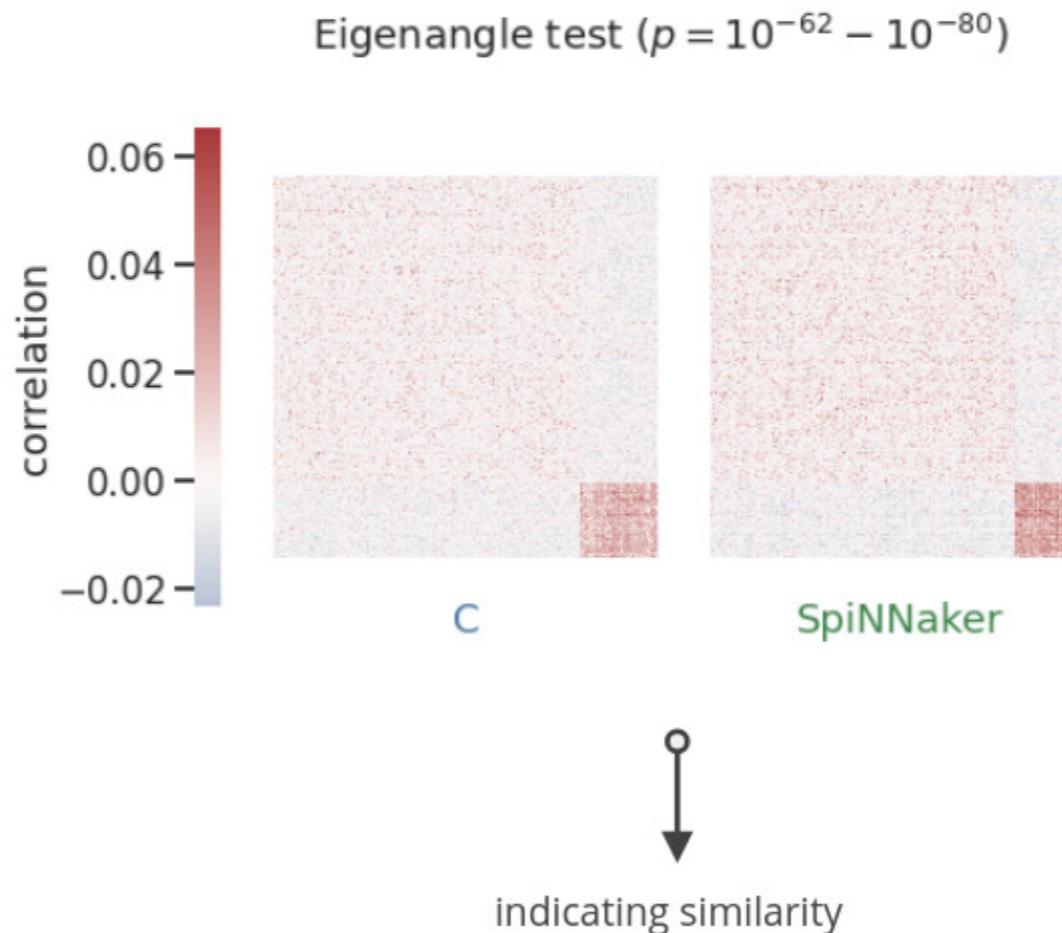


A similarity score based on the angles between pairs of eigenvectors can quantify the structural alignment between sets of pair-wise measures (i.e., correlation, connectivity).

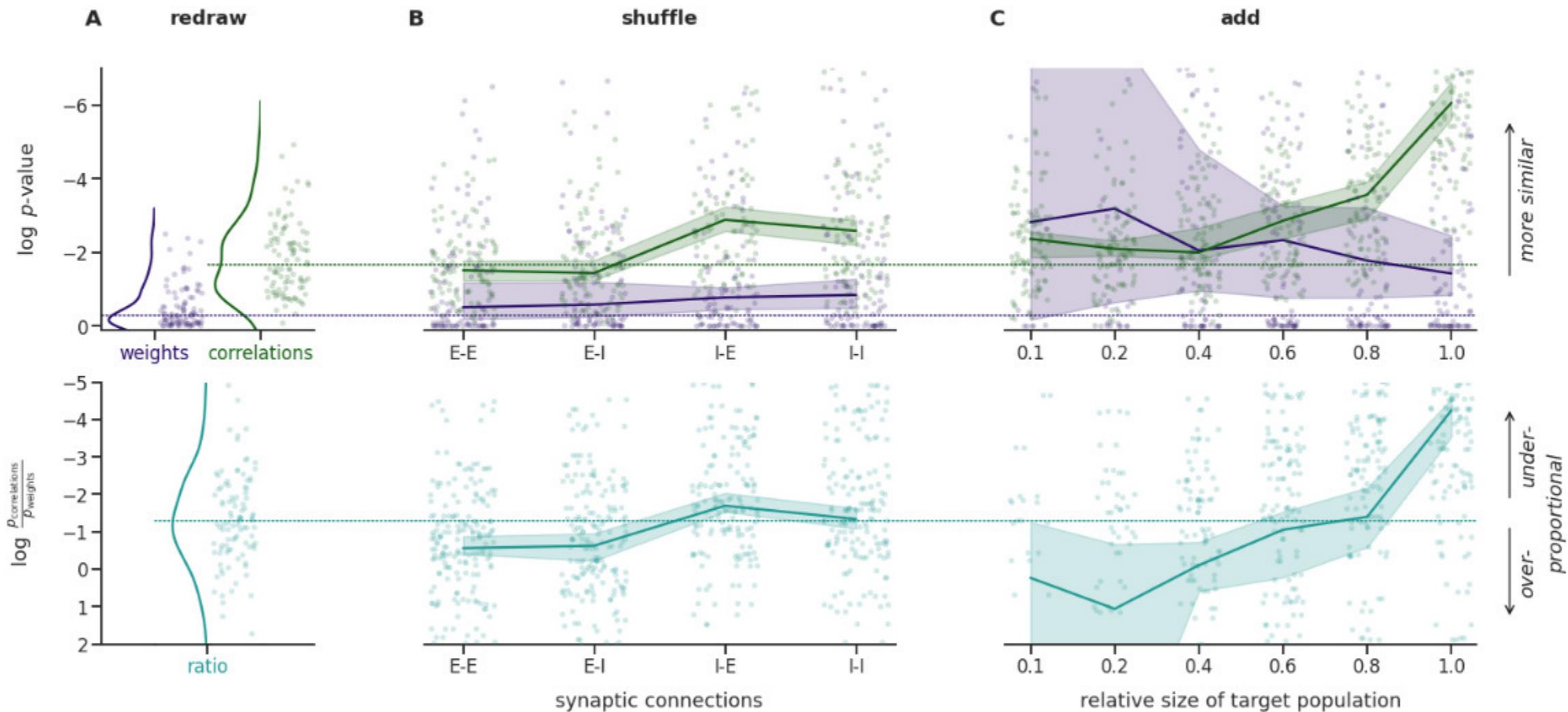
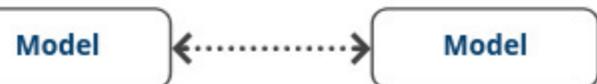
# Higher-order characteristic measures

Model

Model



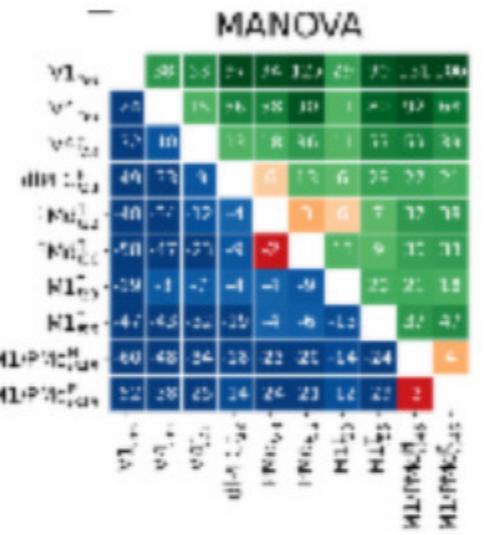
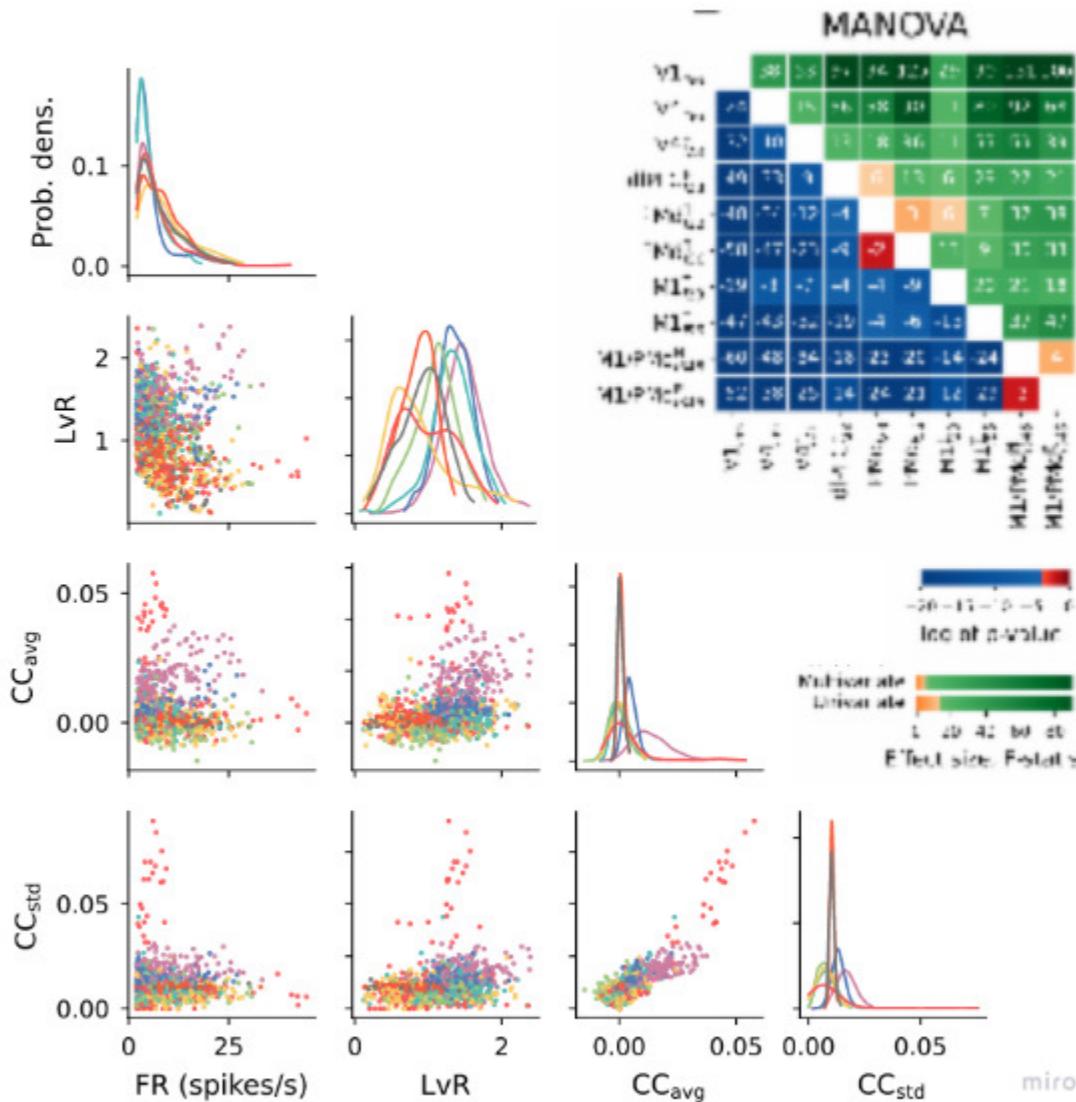
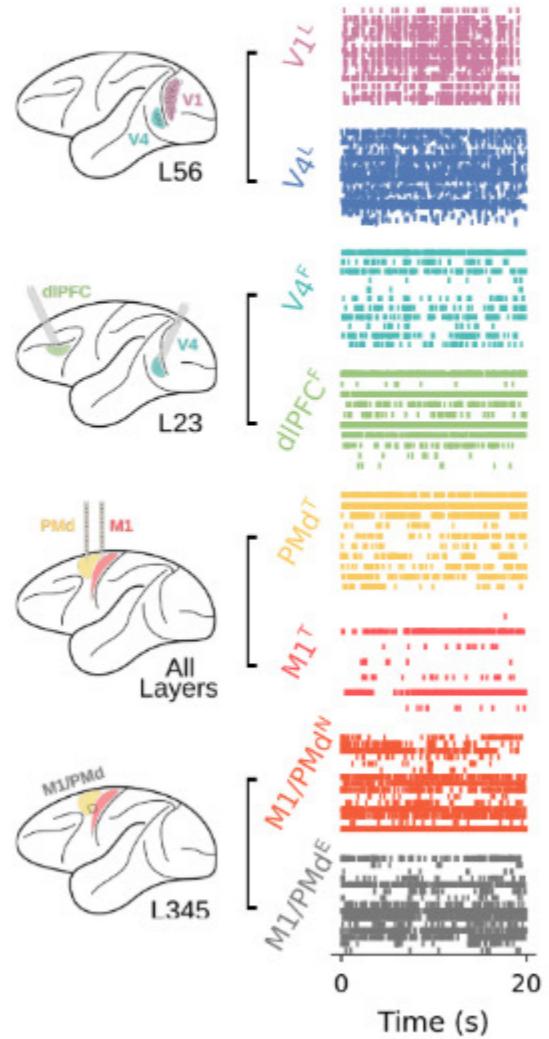
# Higher-order characteristic measures



# Model Connectivity Estimation via Calibration

Model

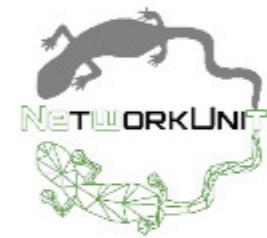
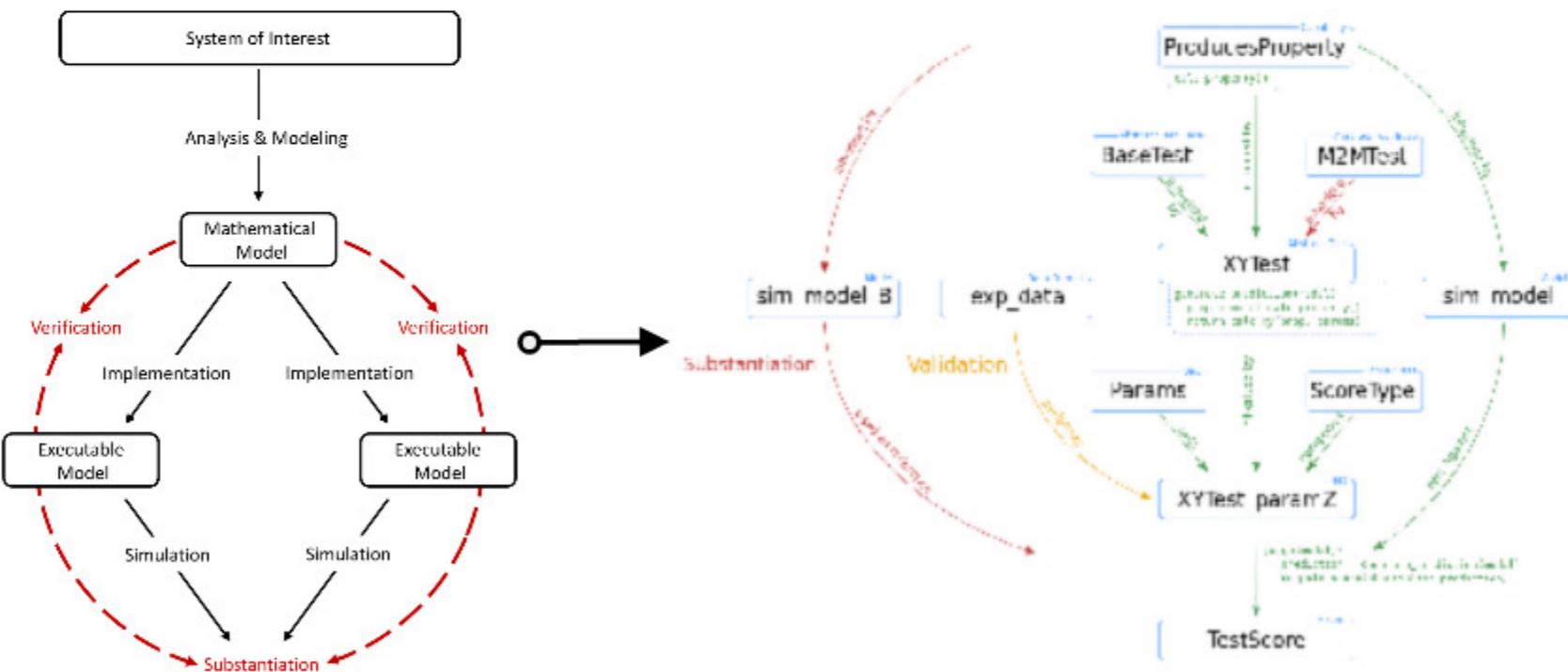
Experiment



- 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.



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

# Reproducibility & Reusability

View Current Configuration

Models		Tests			
	Name		Name		
<input type="checkbox"/>	CA1_pyr_cACpyr_mpg141206_B_idA_20170915151855	Rosanna Migliore	<input type="checkbox"/>	BluePyOpt-eFEL Evaluator	Shailesh Appukuttan
<input type="checkbox"/>	CA1_int_cNAC_970911C_20180120154902	Rosanna Migliore	<input type="checkbox"/>	CA1_laminar-distribution-synapses Neyman-Test	Pedro Garcia-Rodriguez
<input type="checkbox"/>	Surface potential models	Maria Telenczuk, Bartosz Telenczuk and Alain Destexhe	<input type="checkbox"/>	PROPOSAL_Hippocampus_APPpropagationAxonTest_BasketCell	Sara Saray
<input type="checkbox"/>	CA1_pyr_cACpyr_mpg141206_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_060314AM2_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_mpg141206_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-Hodriguez
<input type="checkbox"/>	CA1_pyr_cACpyr_mpg140807_A0_idA_20190305112828	Rosanna Migliore	<input type="checkbox"/>	Testing synaptic plasticity: LTD	Justinas Dalnaukas, Shailesh Appukuttan
<input type="checkbox"/>	TestModel API v2 2020-07-06T16:25:01.027452+00:00	Frodo Baggins, 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-Hodriguez
<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



EBRAINS

# Characteristic population activity: slow waves

Experiment

Experiment

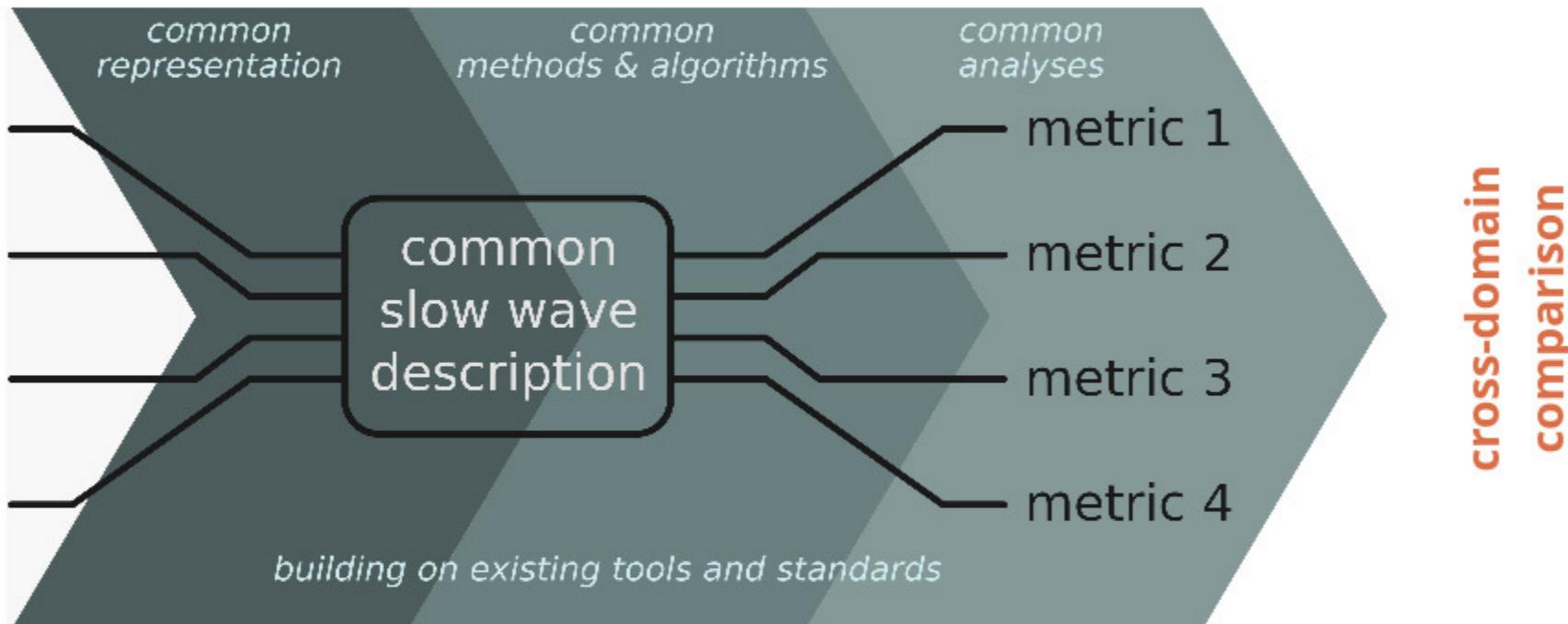
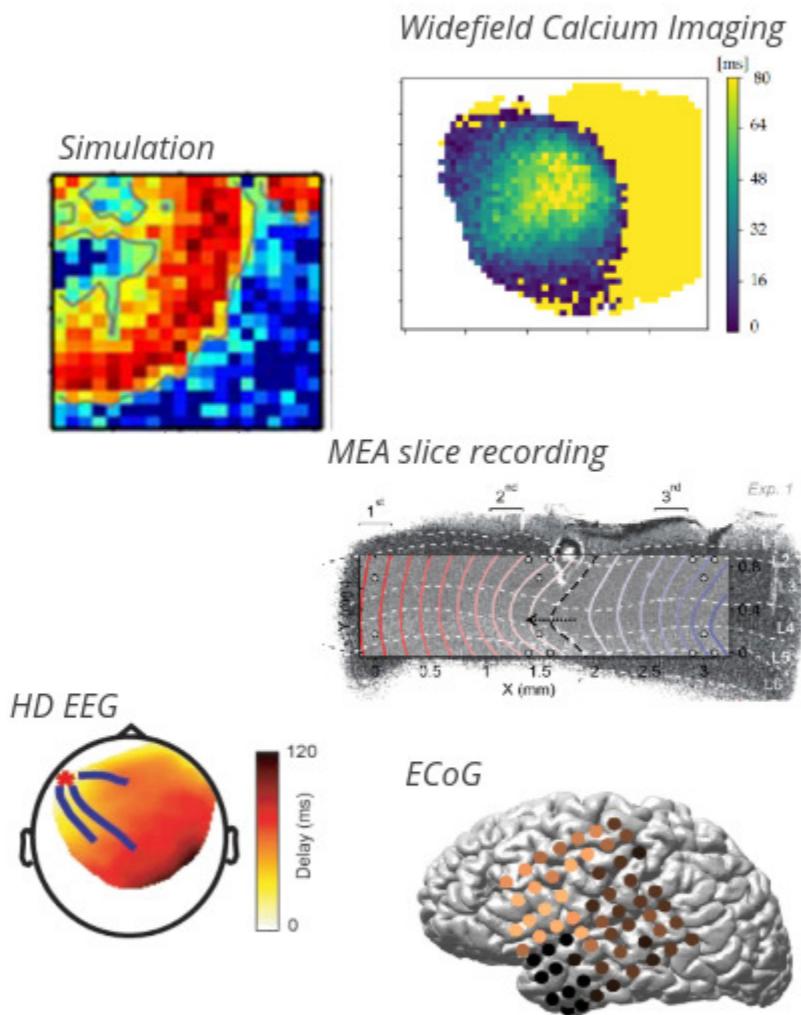


image references in Appendix

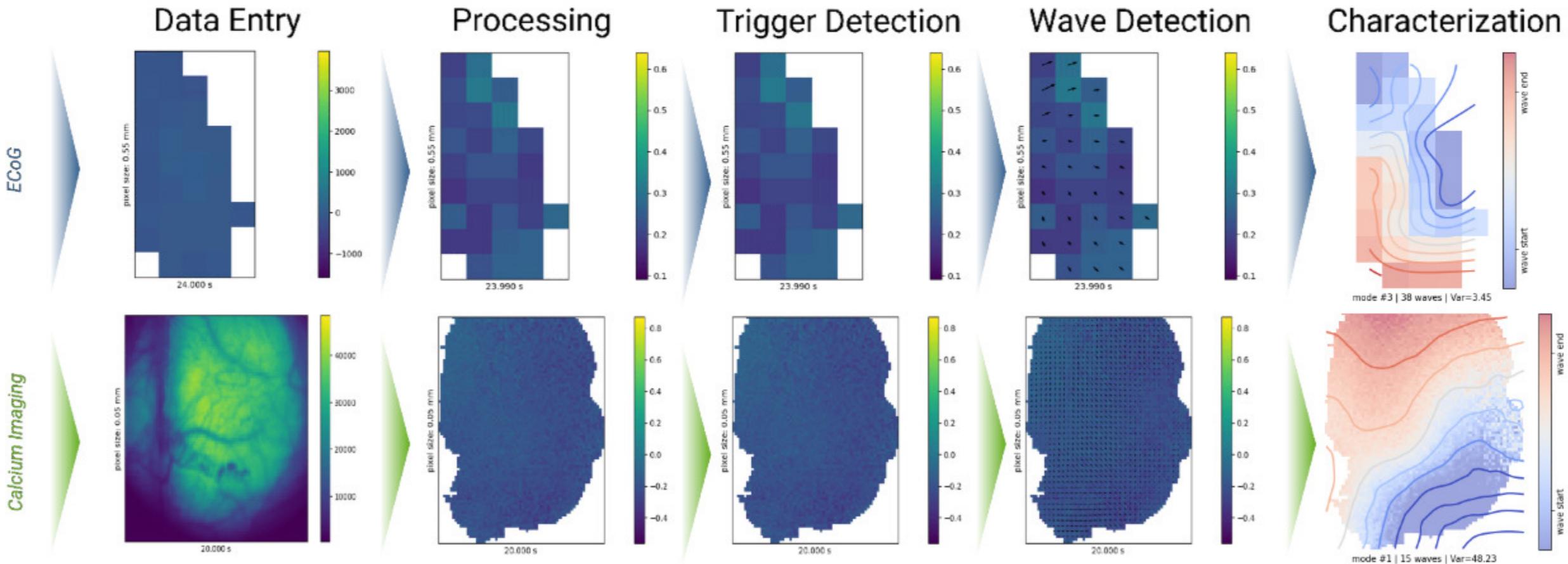
Collaborative Brain-Wave Analysis Pipeline (Cobrawap): <https://github.com/INM-6/cobrawap>

# Towards "big data" analyses, and meta-studies

Experiment

Experiment

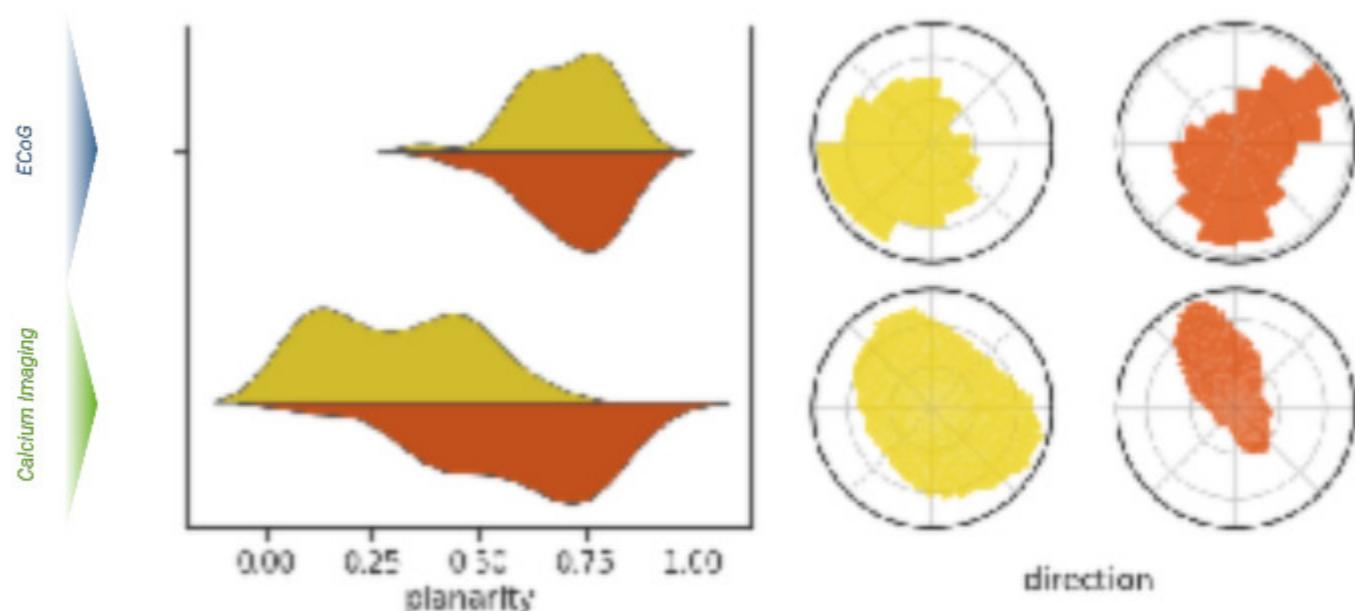
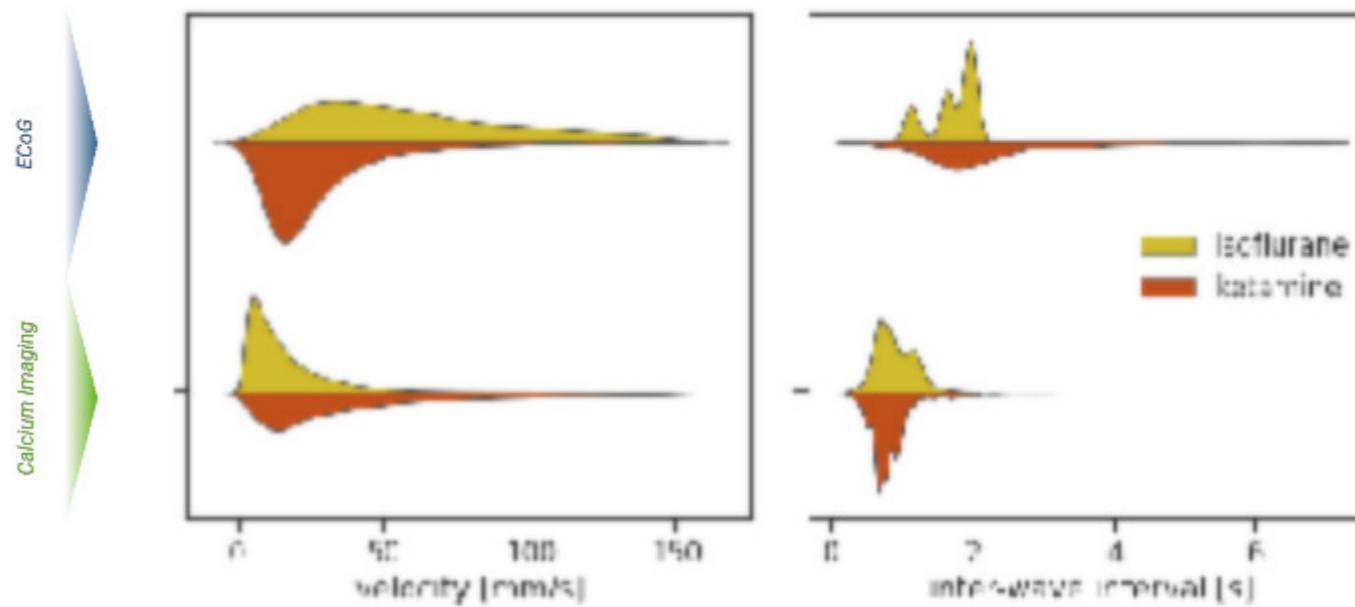
using 5 open-access datasets of 60 ecog and calcium imaging recordings



# Comparing Heterogeneous Data

Experiment

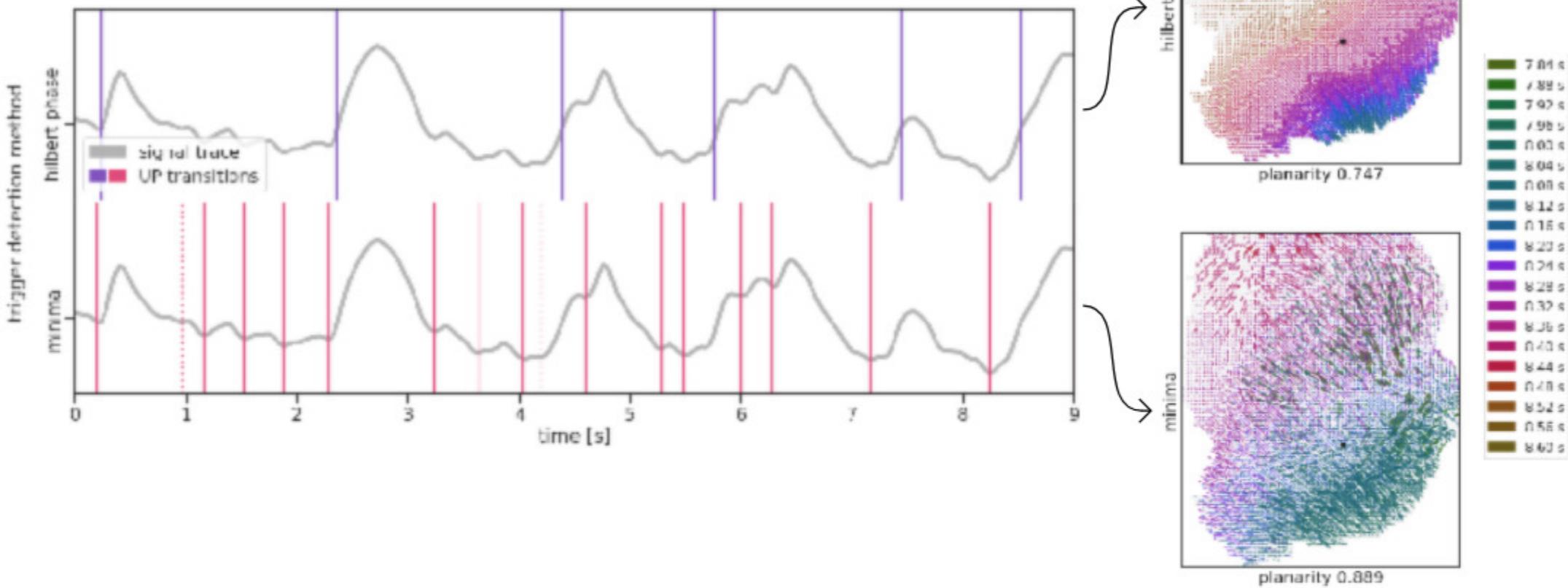
Experiment



# Comparing Methods on Same Data

Experiment

Experiment

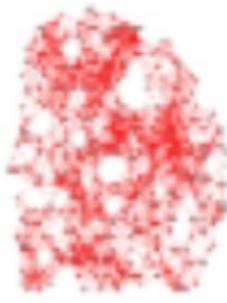


# Calibrating & Validating Models

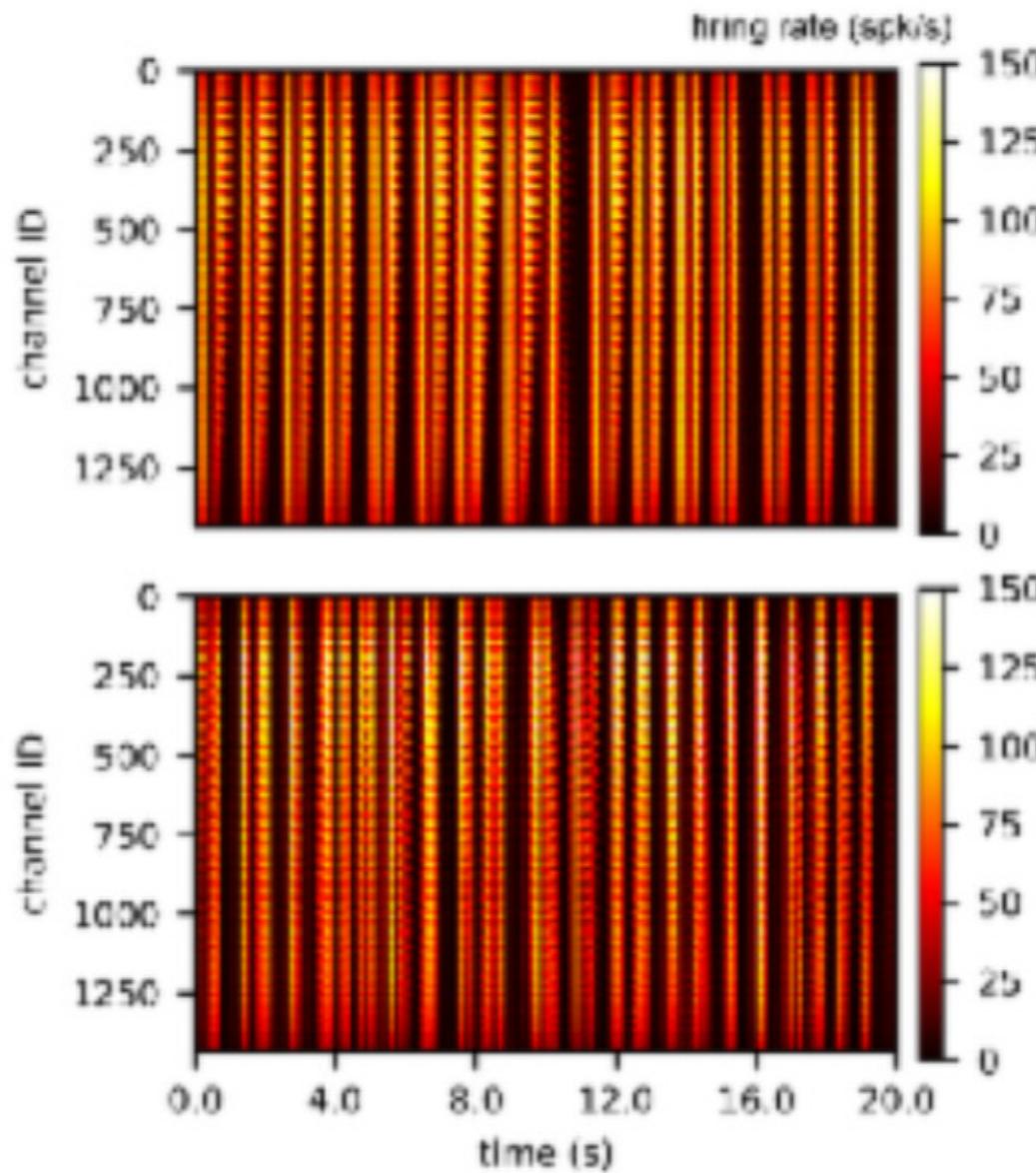
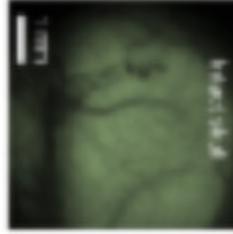
Experiment

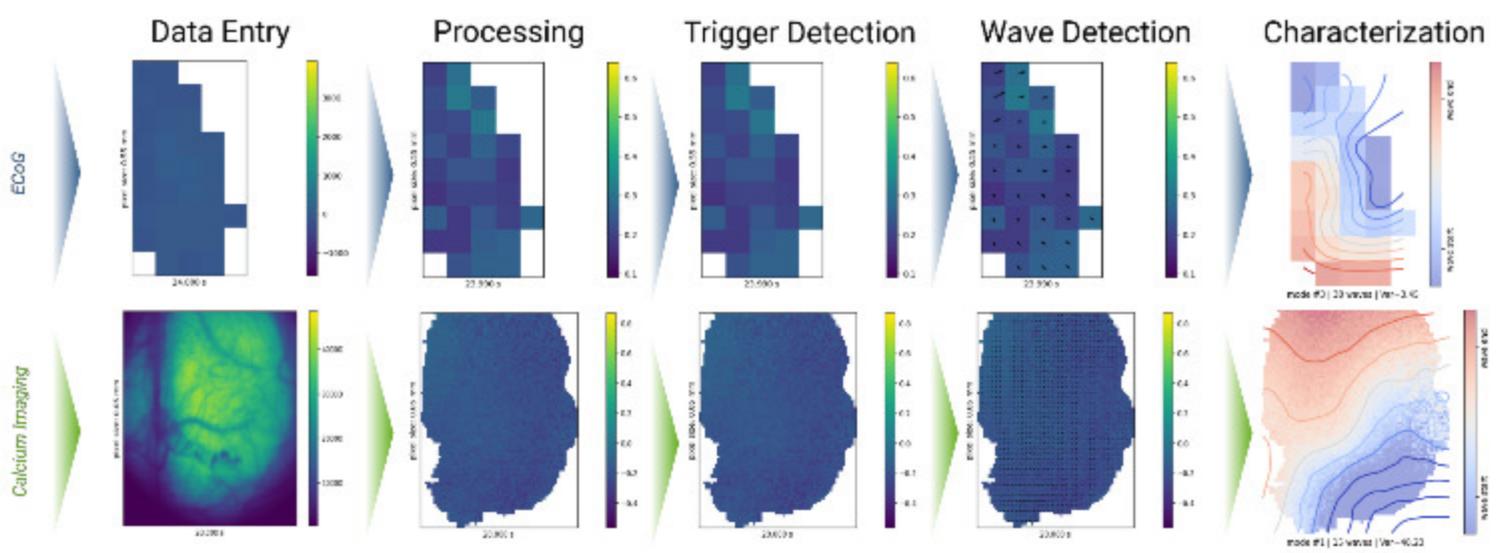
Experiment

Simulation

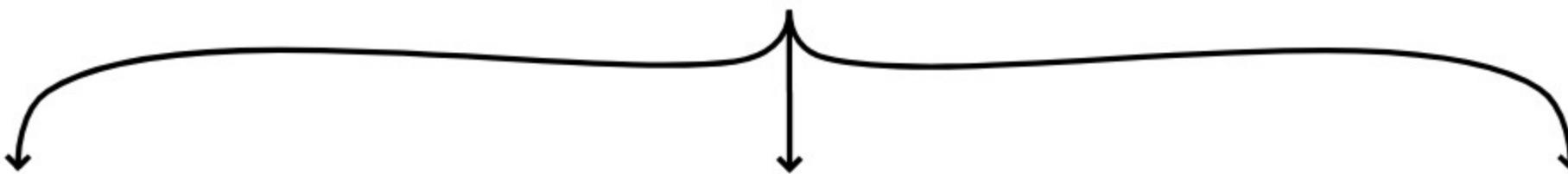


Data

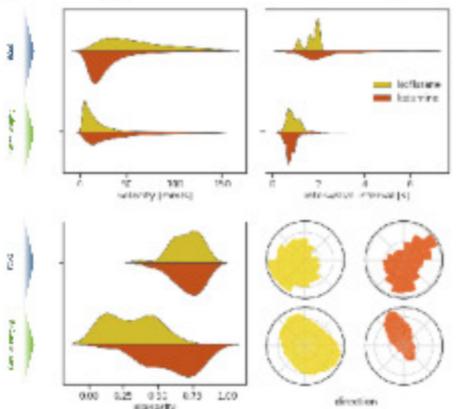




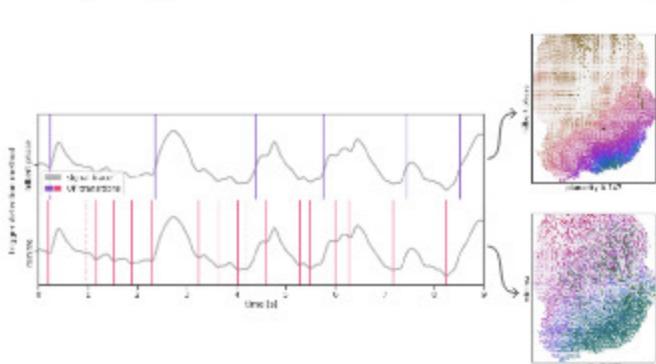
## Modular Wave Analysis Pipeline



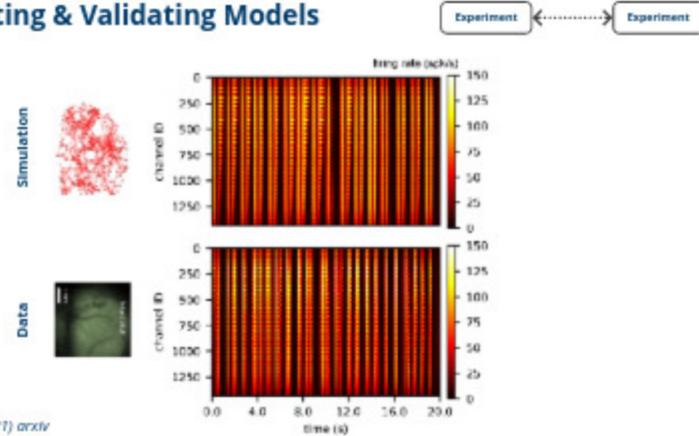
### Comparing Heterogeneous Data



### Comparing Methods on Same Data

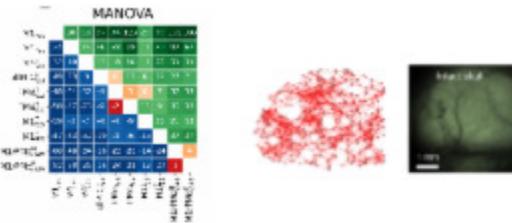


### Calibrating & Validating Models

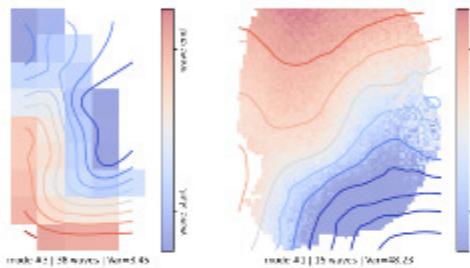
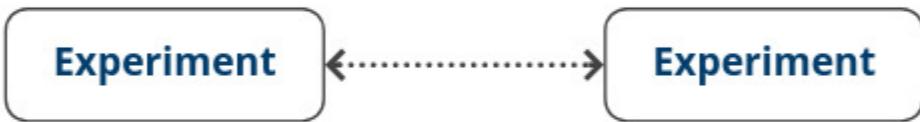


Capone et al. (2027) arxiv

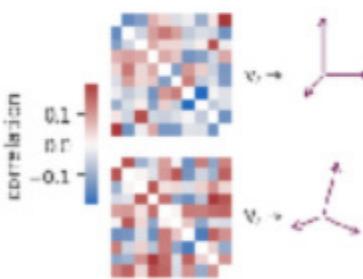
# Conclusion



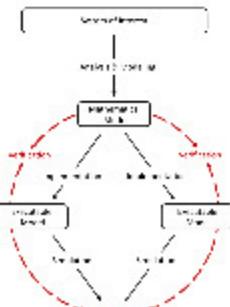
- validation testing can be used for calibration
- rigorous activity comparisons enables inference on connectivity



- 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



Human Brain Project



Maurizio Mattia



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Lungsi Sharma



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Francesco Saverio Pavone

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Guido Trensch  
Paulina Dąbrowska  
Sacha van Albada  
Johanna Senk  
Pietro Quaglio  
Michael von Papen  
Abigail Morrison

...

and our collaborators:



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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

## 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

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