Modeling and Simulation

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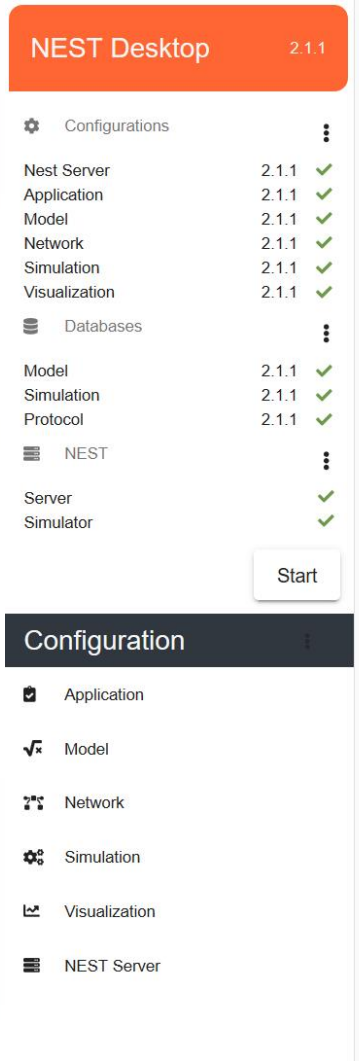
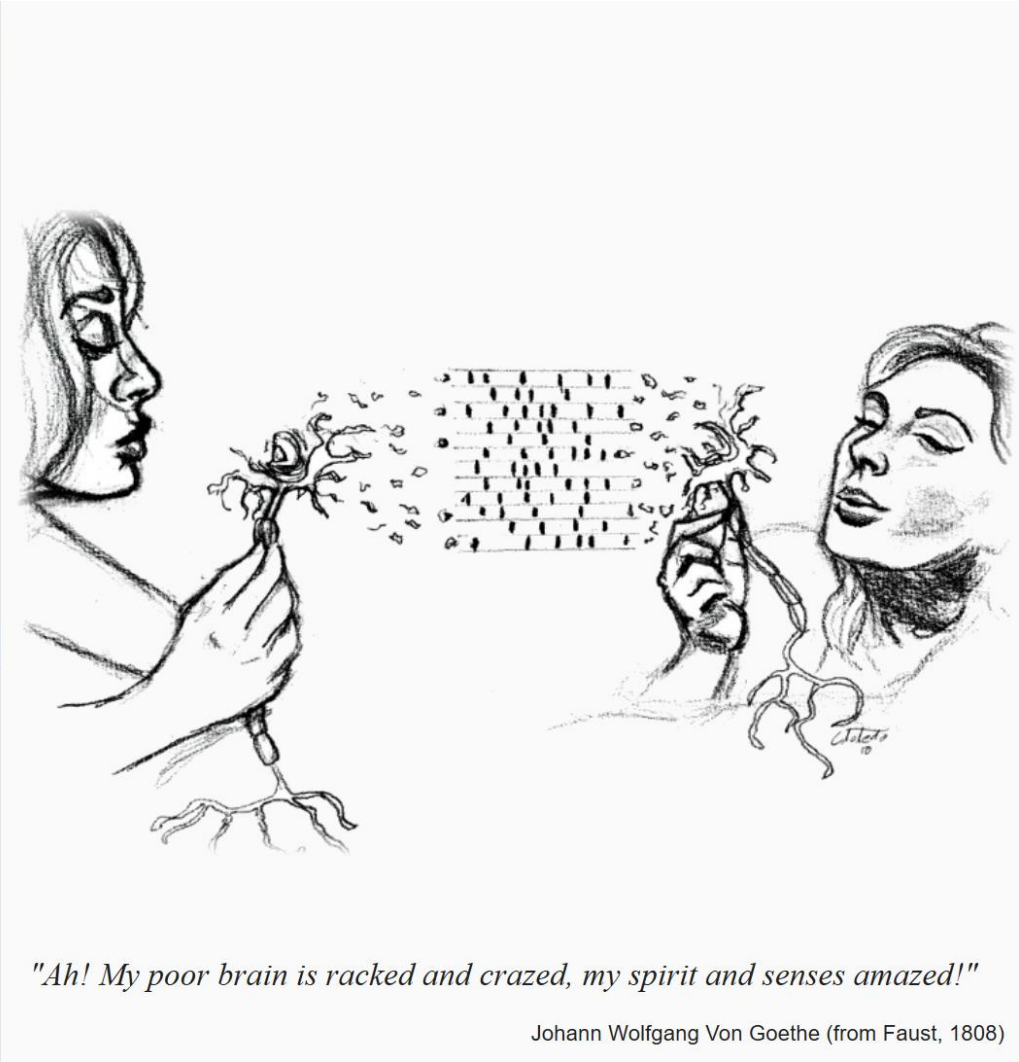
Content

- NEST desktop
  - Life demo (when available)
- TVB and NEST
  - Mouse brain model with detailed cortex
  - Integration of human brain atlas and the virtual brain
- Multi scale co-simulation
  - Overview: lots of moving parts
  - Iterative & use-case driven development
  - Challenges and opportunities
  - Relationship with EBRAINS infrastructure

Nest desktop: nest-desktop.apps.hbp.eu





Sebastian Spreizer (s.spreizer@fz-juelich.de), Stefan Rotter, Benjamin Weyers, Hans E Plesser, Markus Diesmann

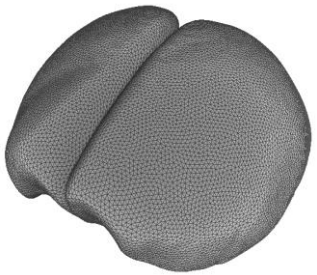
Select or make a new one

Build a network

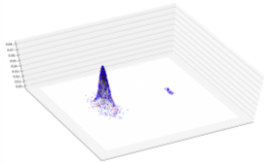
Simulate and analyze

Mouse brain model with detailed cortex

Cortical areas

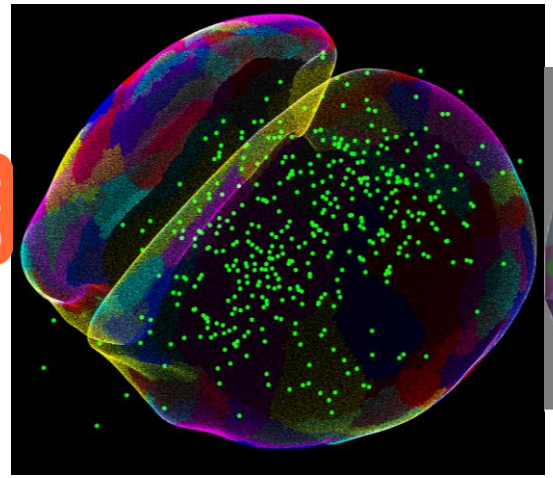


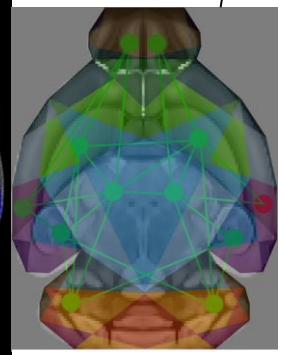
Sheet of neurons



Homogeneous local and heterogeneous connectome links.

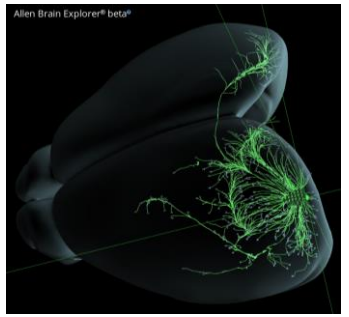
nest :: simulated()





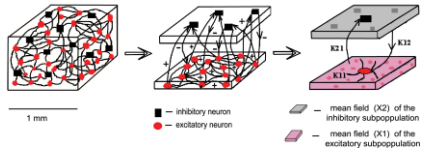
THEVIRTUALBRAIN

Subcortical areas

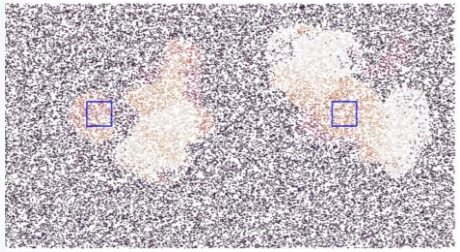


Connectome from experiments

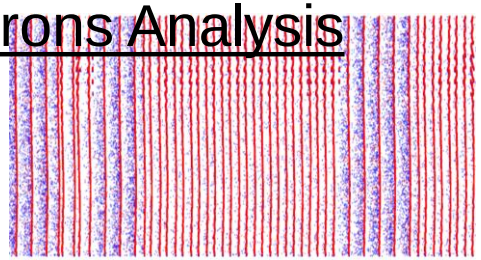
Neural mass model



Spiking Neurons Analysis

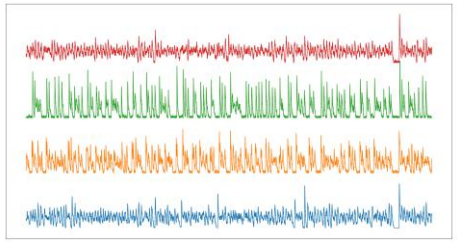


spatial dynamics

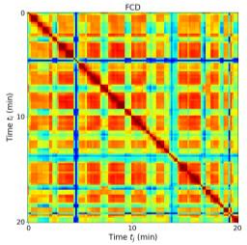


spike trains

Macro Analysis



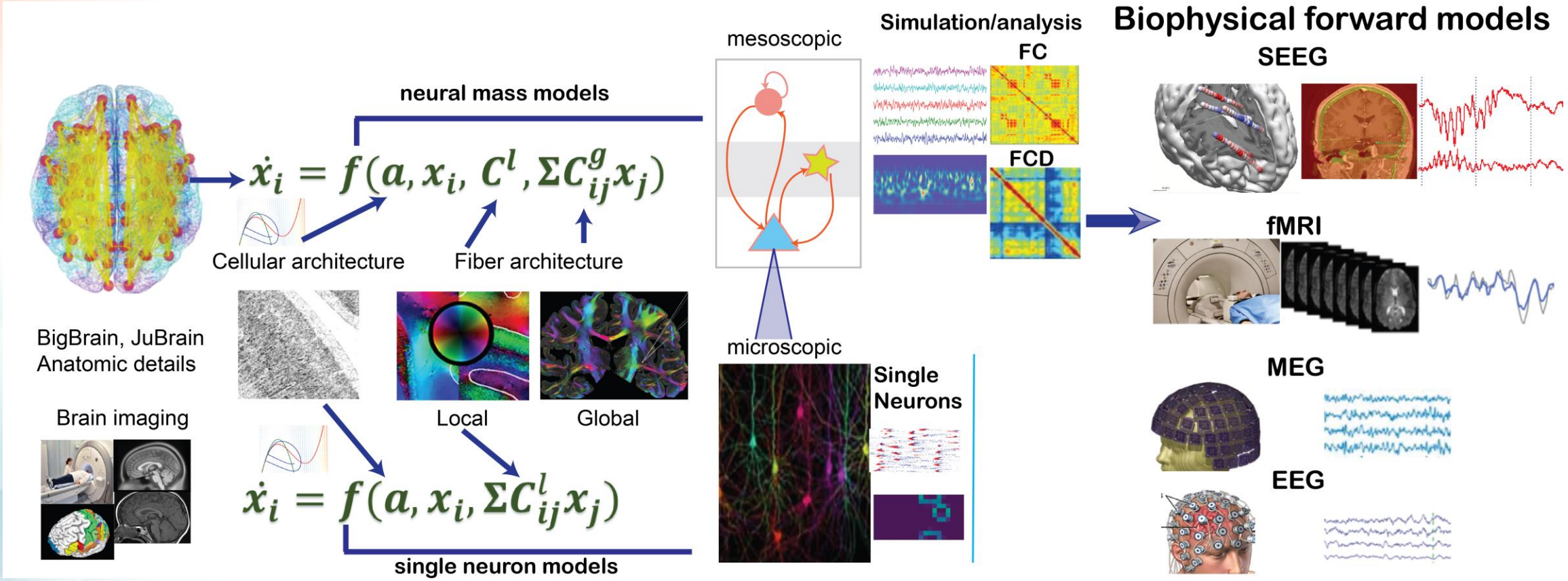
regional activity



functional connectivity dynamics

Viktor Jirsa (viktor.jirsa@univ-amu.fr)

Integration of human brain atlas and the virtual brain

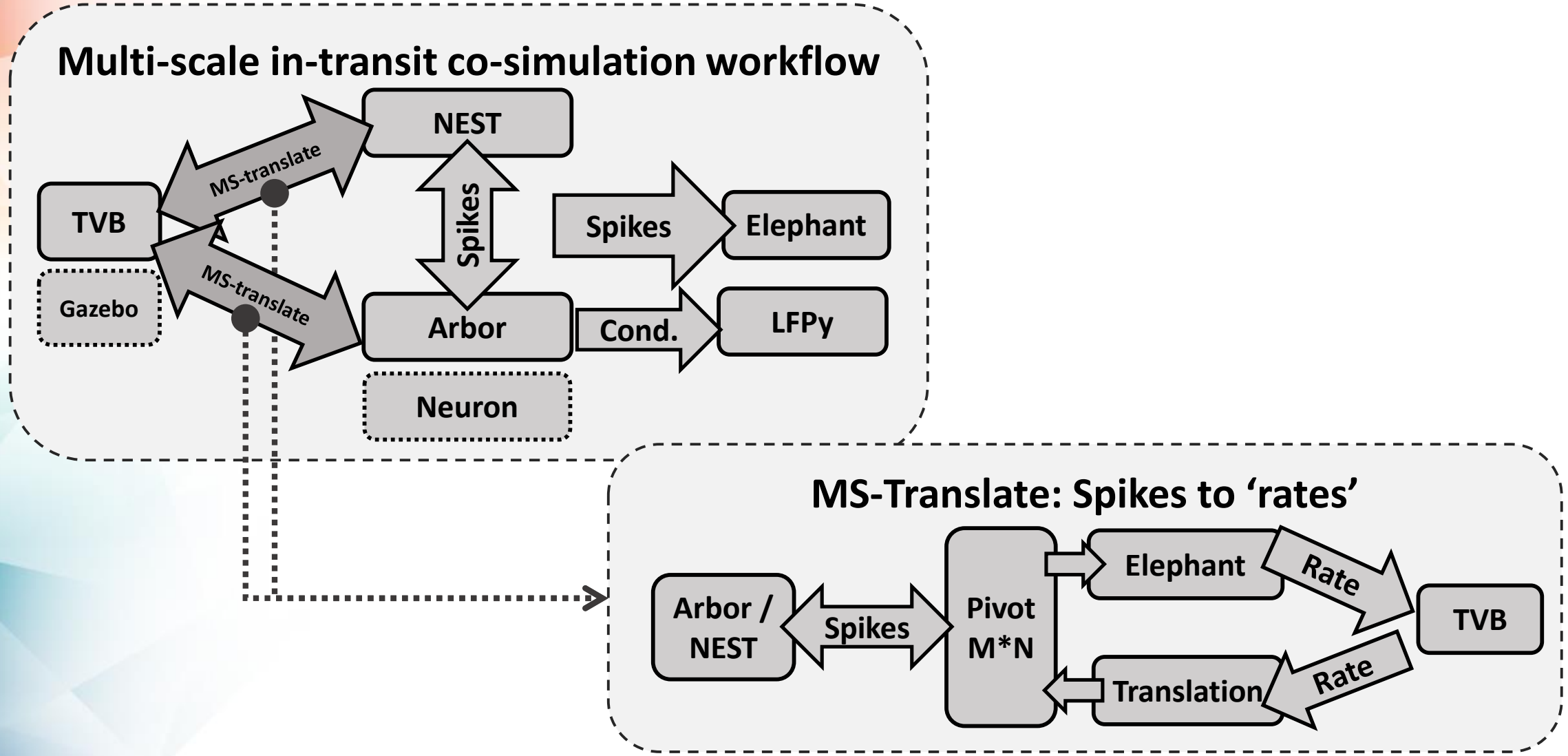


Viktor Jirsa (viktor.jirsa@univ-amu.fr)

Multi-simulator co-simulation

- Brain processes are often inherently multi-scale
- Global brain behavior while depending on local (morphological) details
- Simulate experimental characteristics at the appropriate level.
- Efficient simulation

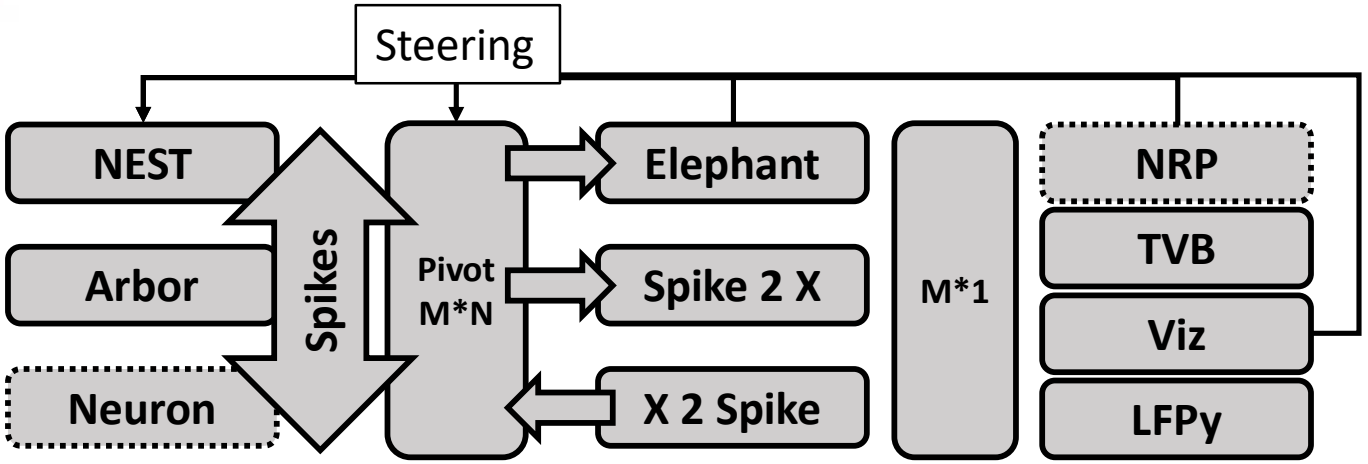
Multi-simulator co-simulation: lots of moving parts



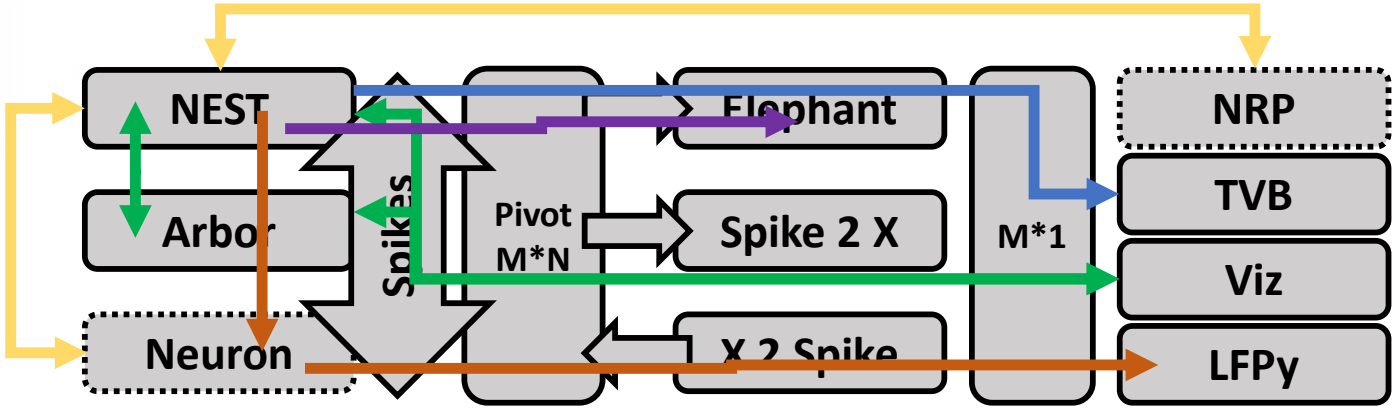
Design choices / constraints

- Exa-scale ready
  - Problem decomposition: modularity
  - Data transport at size is hard
- Static routing and model
  - The connectome is build once, no dynamic ports
  - The full config is known at start of simulation (SONATA)
- Basic steering (init, start, stop, pause)
- Iterative development

Simplified view



Existing POCs



2 way NEST to TVB (2 versions: JSC / Aix-Marseille, Charite)

2 way Arbor to NEST to Visualization (JSC, CSCS, Aachen, Trier)

MUSIC (KTH)

High bandwidth online Analytics (JSC, INM6, NMBU)

LFPy 1 way Nest to Neuron to Python (JSC, CSCS, NMBU)

Driving use cases 1

- NEST & TVB two way coupling on HPC
  - Whole-brain behavior constrained by detailed local behavior of selected regions

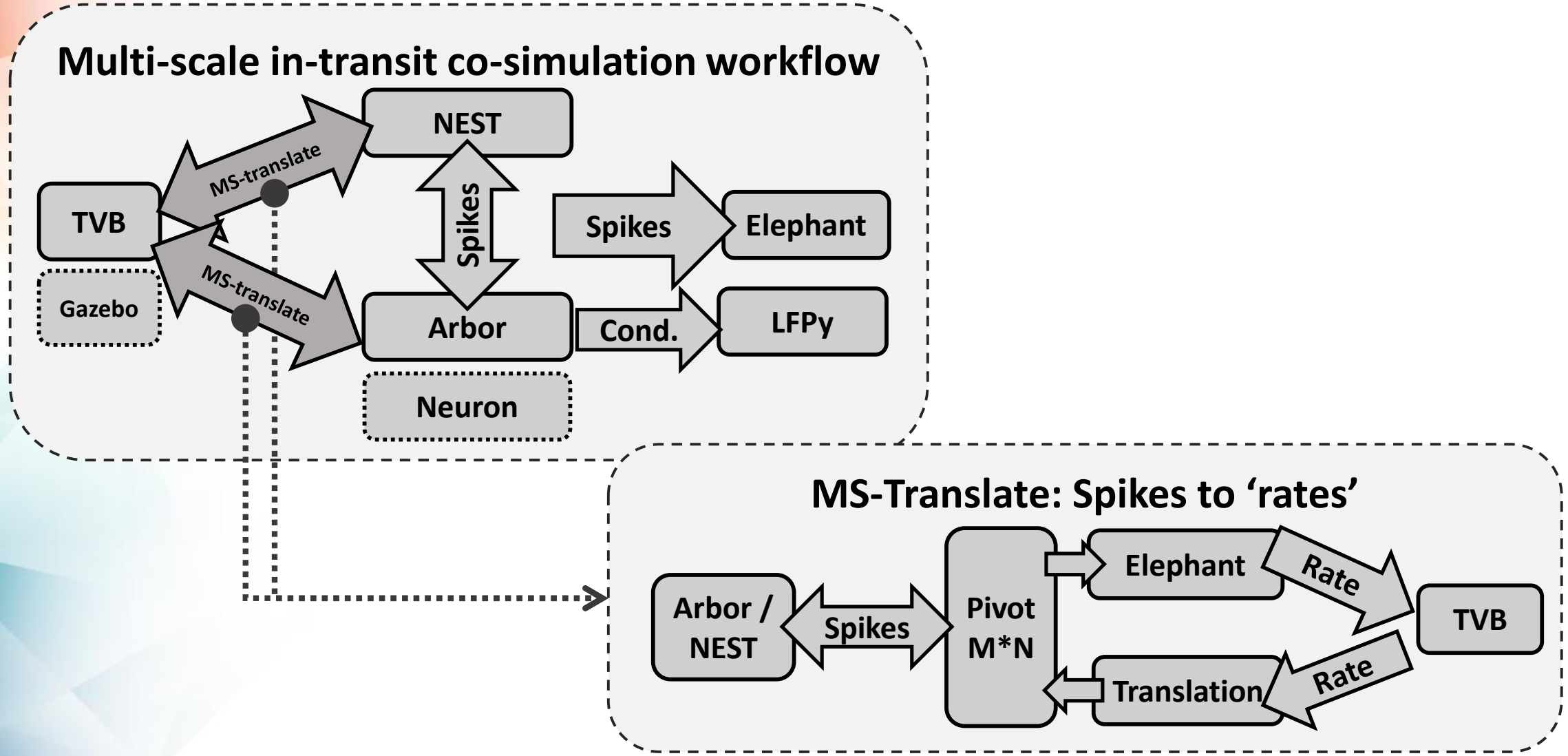
- NEST-Arbor two-way co-simulation on HPC
  - Higher-level network architecture (NEST) and local behavior of selected regions (Arbor)

Driving use cases 2

- Data analysis and visualization coupling infrastructure
  - Common APIs and standards: (NEURON, Gazebo)

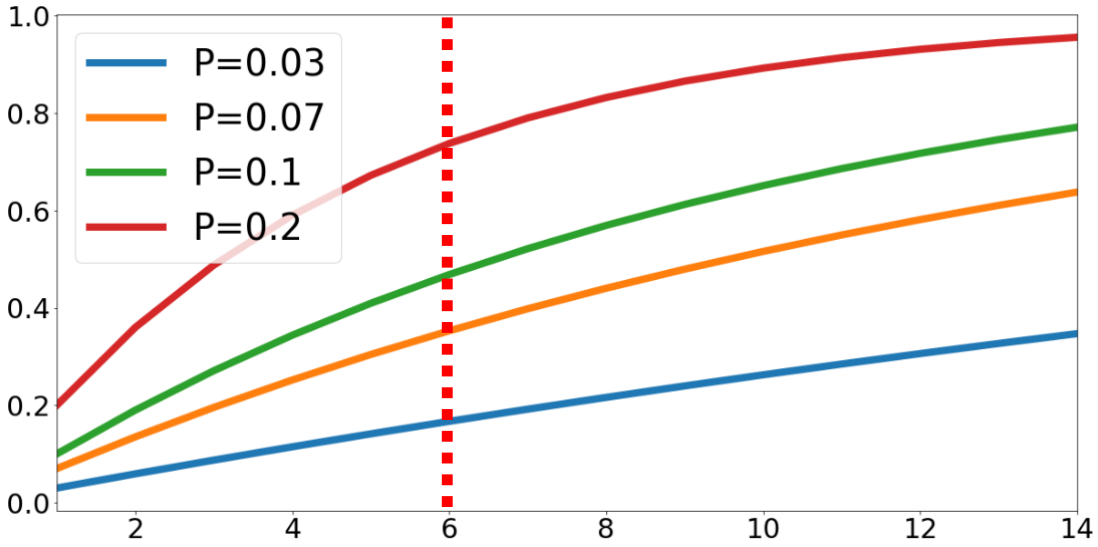
- LFPy one-way co-simulation,
  - NEST spiking results into a simplified Arbor simulation
  - producing current dipoles,
  - analysis framework to compute LFP & EEG predictions

lots of moving parts



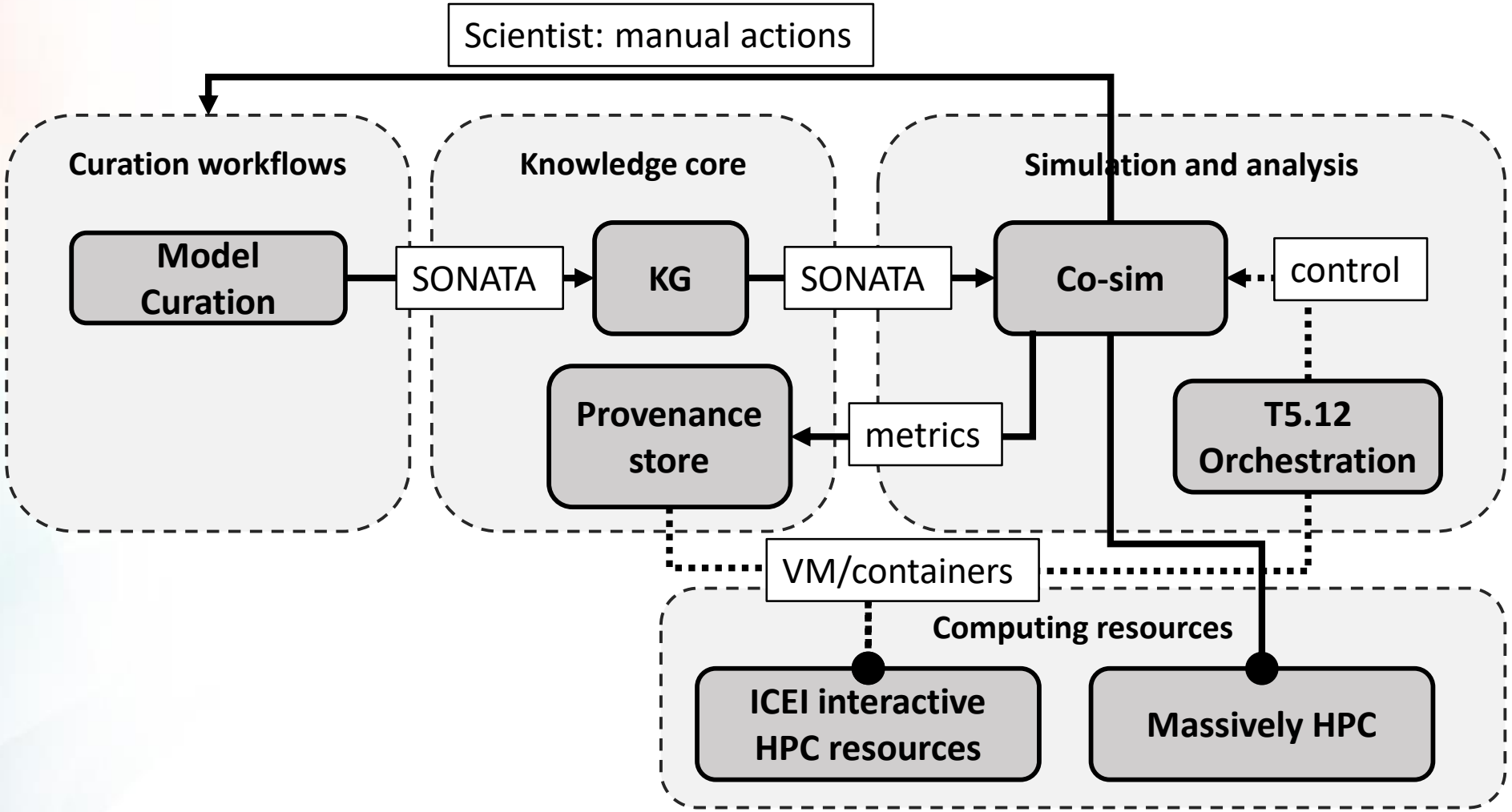
Challenges / opportunities

- Orchestration of 6 or more monolithically application
  - Compounding of error rate: $P(system\ Failure) = 1 - \prod(1 - P_i)$



- Translation between scales is an unsolved scientific problem
  - Resource requirements are unknown

Relationship with EBRAINS infrastructure



Co-simulation for modular neuronal architectures

- Modular models of brain areas
  - Specific constrains
  - Optimized
  - Stand alone
- When combining this in one ‘single‘ model
  - Constraints are additive
  - Need for new optimization
  - Replication of code/model at two location
- Solution: Each model in a simulator instance -> co-simulation

Summary

- NEST desktop: nest-desktop.apps.hbp.eu
- NEST – TVB:
  - Mouse brain model with detailed cortex
  - Integration of human brain atlas and the virtual brain
- Co-simulation
  - Lots of moving parts
  - Iterative & use-case driven development towards exa-scale neuronal simulation
  - Challenges and opportunities

Questions?

- Many thanks to:

Simlab Neuroscience:
Abigail Morrison
Alex Peyser
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Lena Oden

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Michele Migliore
Sonja Grün
Dennis Terhorst
Michael Denker

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