# Modeling spiking networks with neuron-glia interactions in NEST

June 24, 2022

Neuron-astrocyte interactions

- Astrocytes can sense synaptically released molecules and release gliotransmitters that can modulate neuronal excitability and synaptic transmission

- A standardized and reliable modeling tool is required for the computational study of neuron-astrocyte interactions
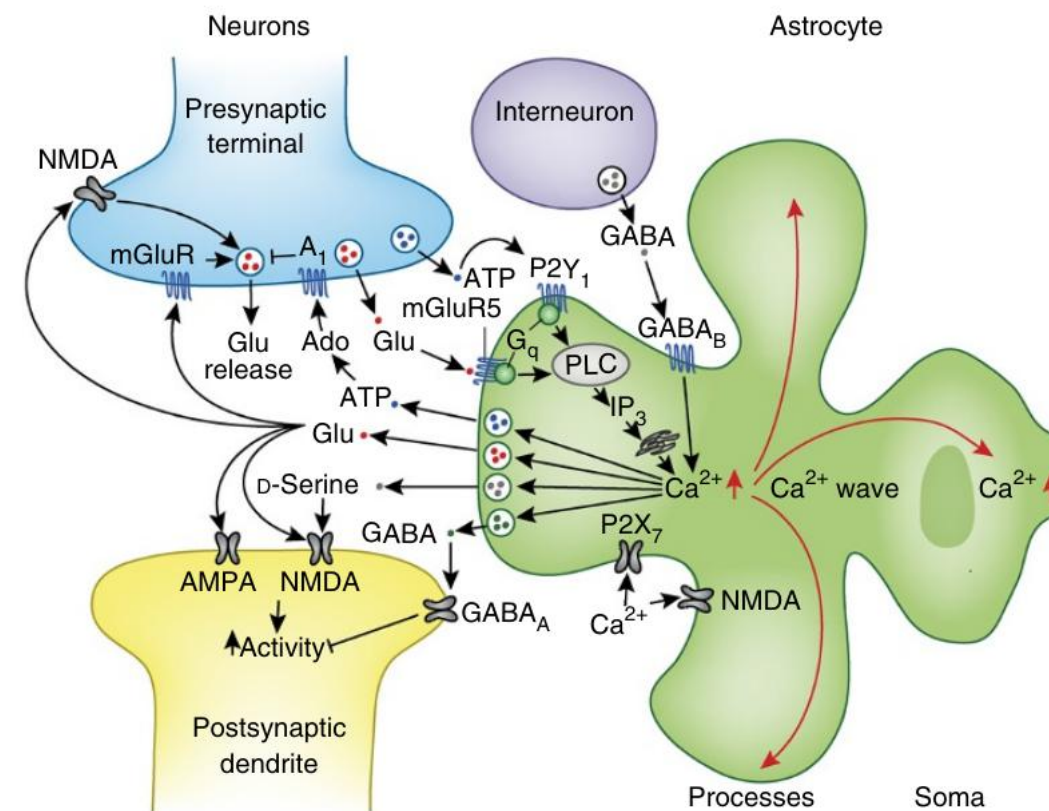
Bazargani & Attwell, 2016

# NEST vs. other tools for astrocyte modelling

Simulator	ARACHNE	ASTRO	Brian 2	NEST	STEPS
Modeling formalism, supported models	neuron-glia networks	detailed synapse and multi-compart. cell models	neuron-glia networks	neuron-glia networks	detailed synapse and multi-compart. cell models
Programming language	C++, MATLAB	NEURON, C++, MATLAB	Python	Python, C/C++	Python, C/C++
Web address	https://github.com/LeonidSavtchenko/Arachne	https://github.com/LeonidSavtchenko/Astro	https://briansimulator.org	https://www.nest-simulator.org	http://steps.sourceforge.net/STEPS/default.php
Reference	Aleksin et al. (2017)	Savtchenko et al. (2018)	Goodman and Brette (2008)	Gewaltig and Diesmann (2007)	Hepburn et al. (2012)

NEST's advantages: Open source, standardized, optimized, well-documented, good for large-scale simulations and parallel computing

Linne et al. (2022) Neuron-Glia Interactions and Brain Circuits. In: Computational Modeling of the Brain. https://doi.org/10.1007/978-3-030-89439-9_4

Manninen et al. (2018) Front. Neuroinform. vol. 12. https://doi.org/10.3389/fninf.2018.00020

Astrocytes in NEST: Modeled glial mechanism
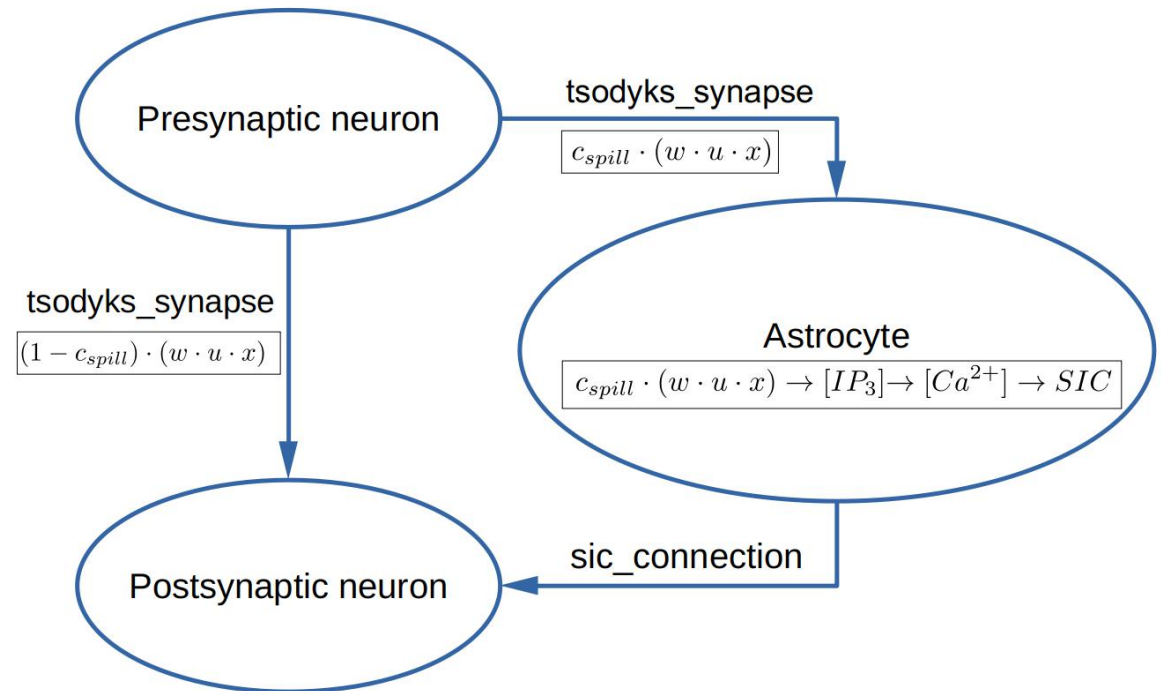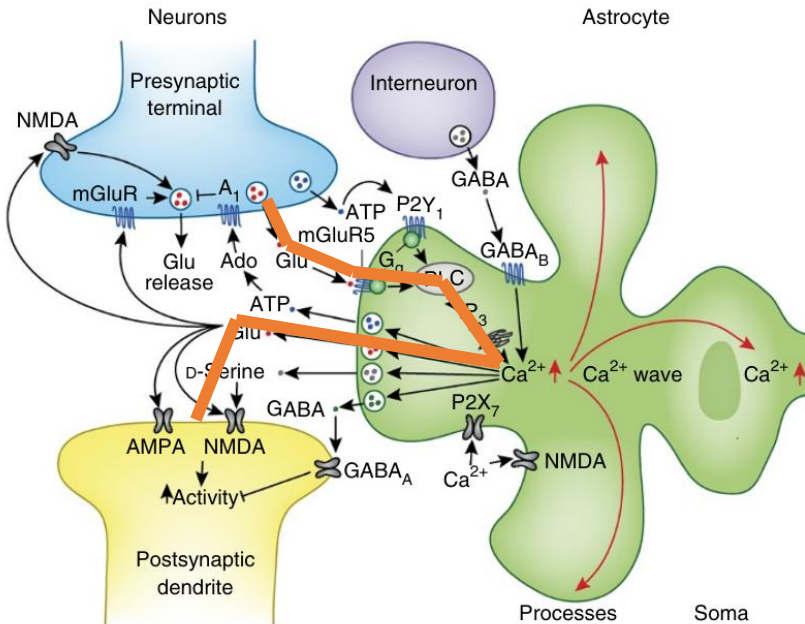
- Presynaptically released glutamate that spills from the synaptic cleft is sensed by a proximal astrocyte
- This triggers astrocytic mechanisms that lead to increase of intracellular calcium concentration
- [Ca2+] increase induces a slow inward current (SIC) to the postsynaptic neuron
- Synaptic parameters: c_spill, weight_sic

Astrocytes in NEST: Connectivity builder

- p_astro:
  the probability of each synapse to be paired with an astrocyte

- n_neighbor_astrocytes:
  the maximal number of astrocytes that can be connected to a postsynaptic neuron
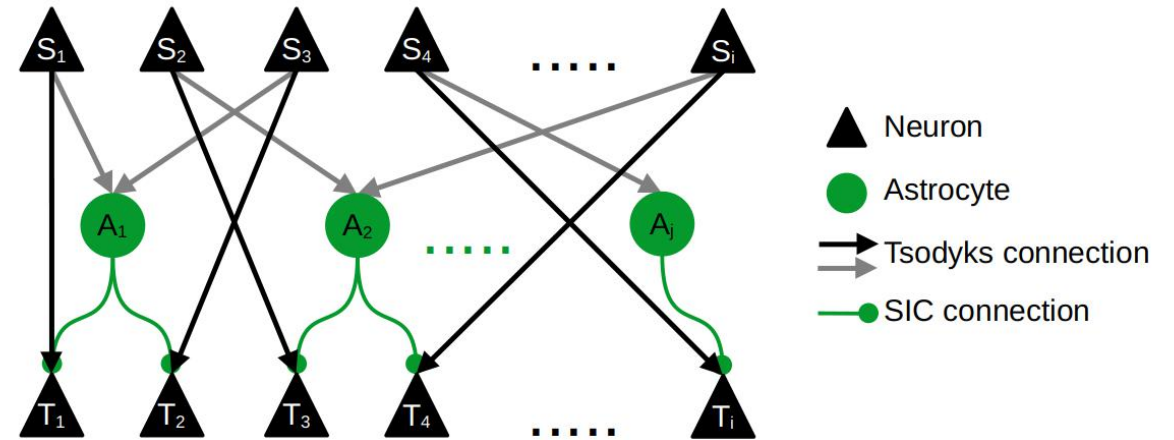

```
nest.Connect(
    pre_neurons, post_neurons,
    conn_spec={
        "rule": "pairwise_bernoulli_astro",
        "astrocyte": astrocytes
        "p": #,
        "p_astro": 1,
        "n_neighbor_astrocytes": 1
    })
```
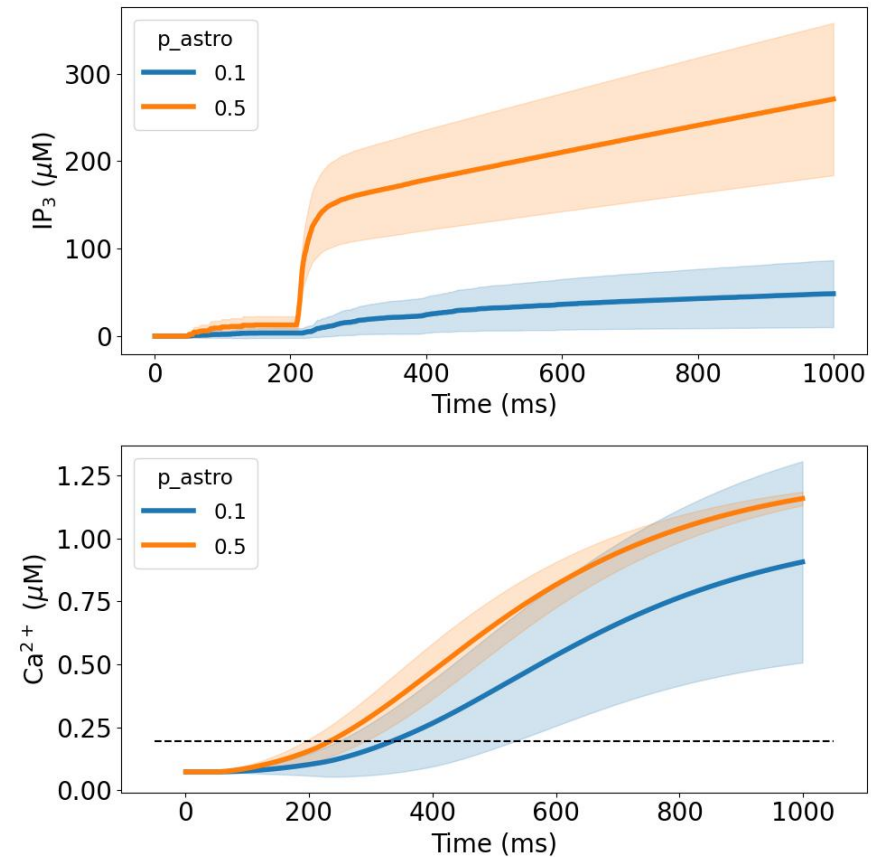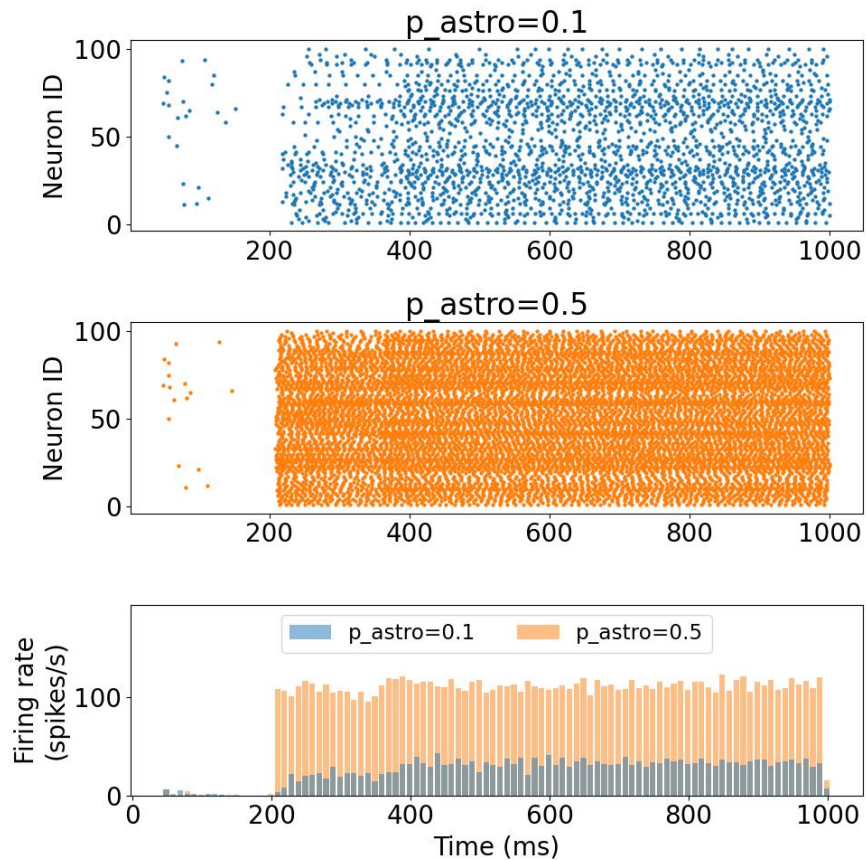
Simulation results

- $N_{neuron} = N_{astrocyte} = 100$, p_astro = 0.1 or 0.5, n_neighbor_astrocytes = 2
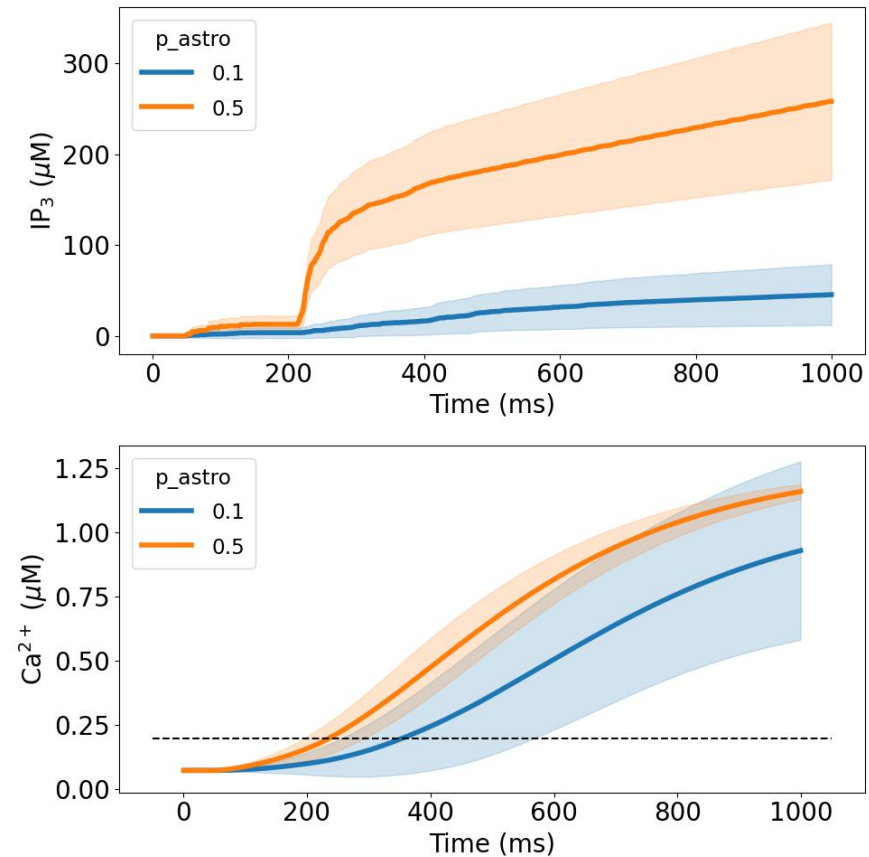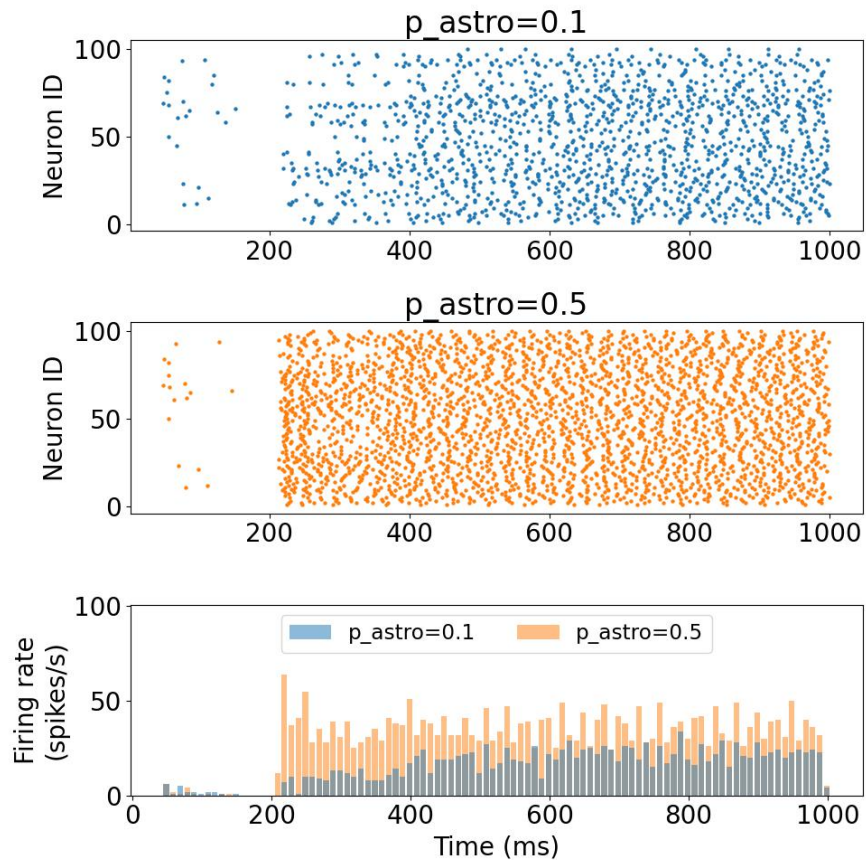
Simulation results

- N_{neuron} = $N_{astrocyte}$ = 100, p_astro = 0.1 or 0.5, n_neighbor_astrocytes = 10

Acknowledgements

Collaborators