Modeling the population dynamics with adaptive exponential integrate and fire (AdExp) model neuron in newborn rat cortical networks

11th of July at OCNC 2019
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The aim of the project

- To model population dynamics of the excitatory and inhibitory neurons
- To model the contribution of AMPA, NMDA and ($GABA_A$) receptor conductance on to the population activity
- To compare the simulated population dynamics to the experimentally recorded multi-unit spike activity under AMPA and NMDA receptor antagonists

Spiking AdExp neuron model for excitatory and inhibitory neurons with synapse model

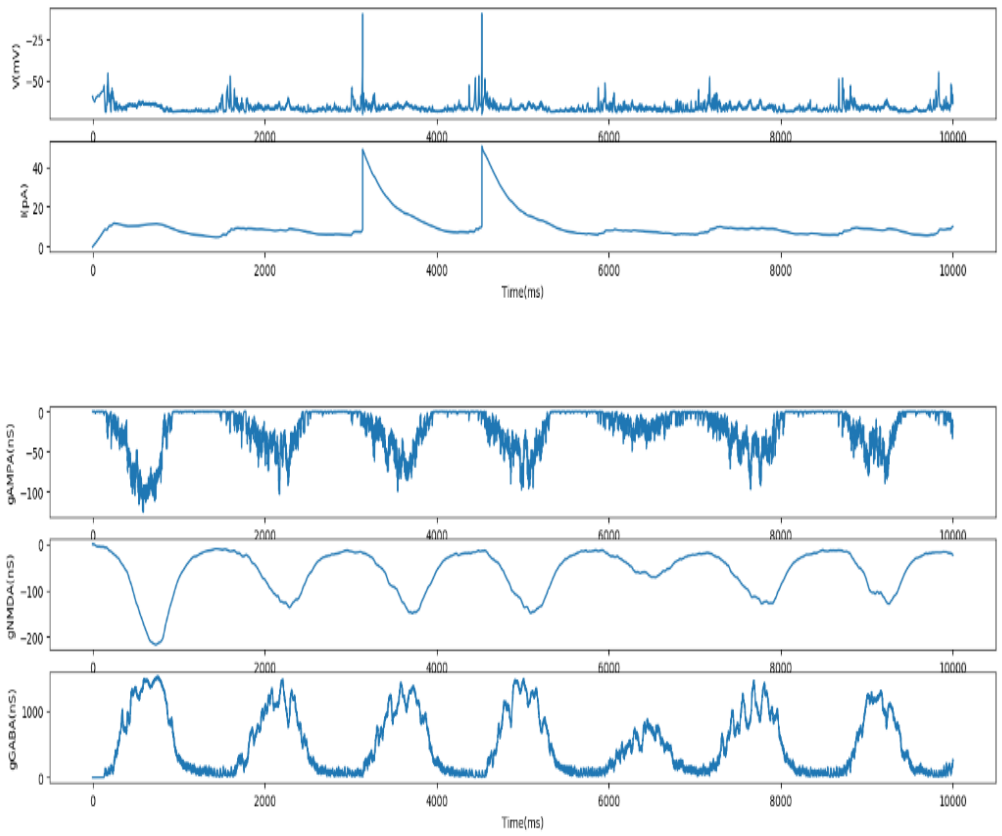
$$\begin{cases} C\dfrac{dV}{dt} = -g_L(V - E_L) + g_L\Delta Te^{\left(\frac{V - V_T}{\Delta T}\right)} - w + \sum I_{syn} + I_{bg} \\ \tau_w \dfrac{dV}{dt} = a(V - E_L) - w \end{cases}$$

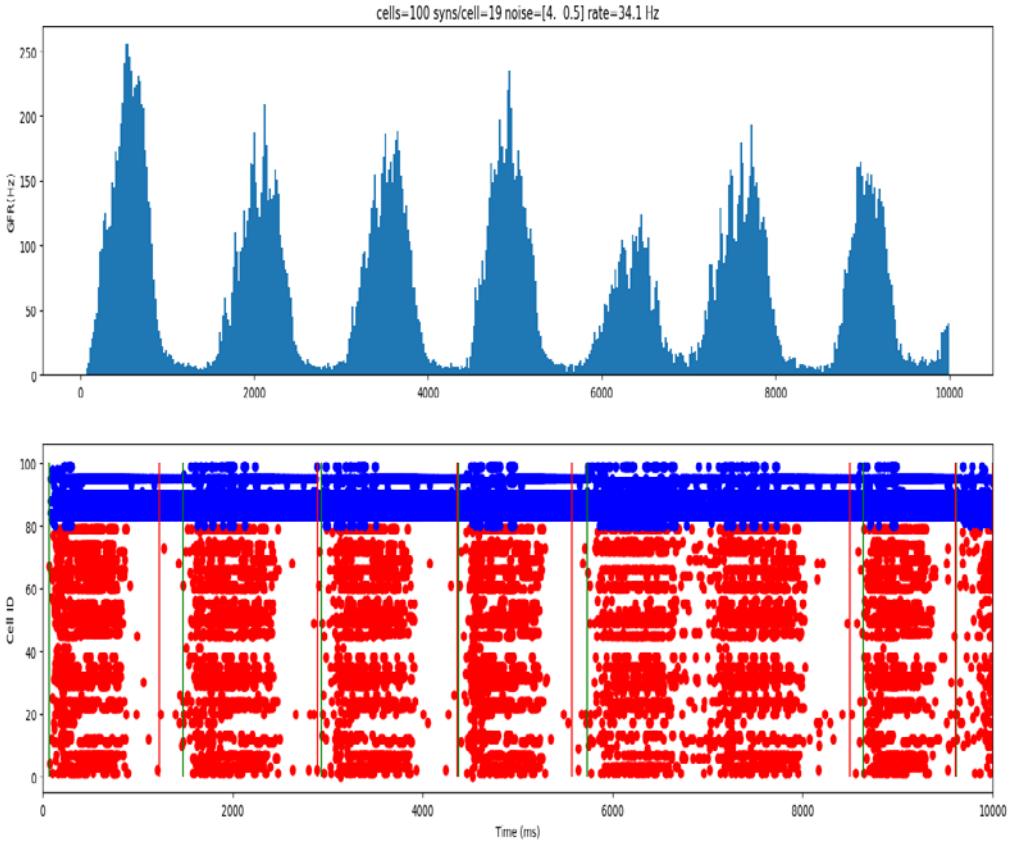
Brette R, Gerstner W. Adaptive exponential integrate-and-fire model as an effective description of neuronal activity. J Neurophysiol. 2005 Nov; 94: 3637–3642. 10.1152/jn.00686.2005. https://doi.org/10.1152/jn.00686.2005 PMID: 16014787

$$\begin{cases} I_{syn} = g_{syn}(v - E_{rev}) \\ \tau_{syn}\dfrac{dg_{syn}}{dt} = -g_{syn} \end{cases}$$

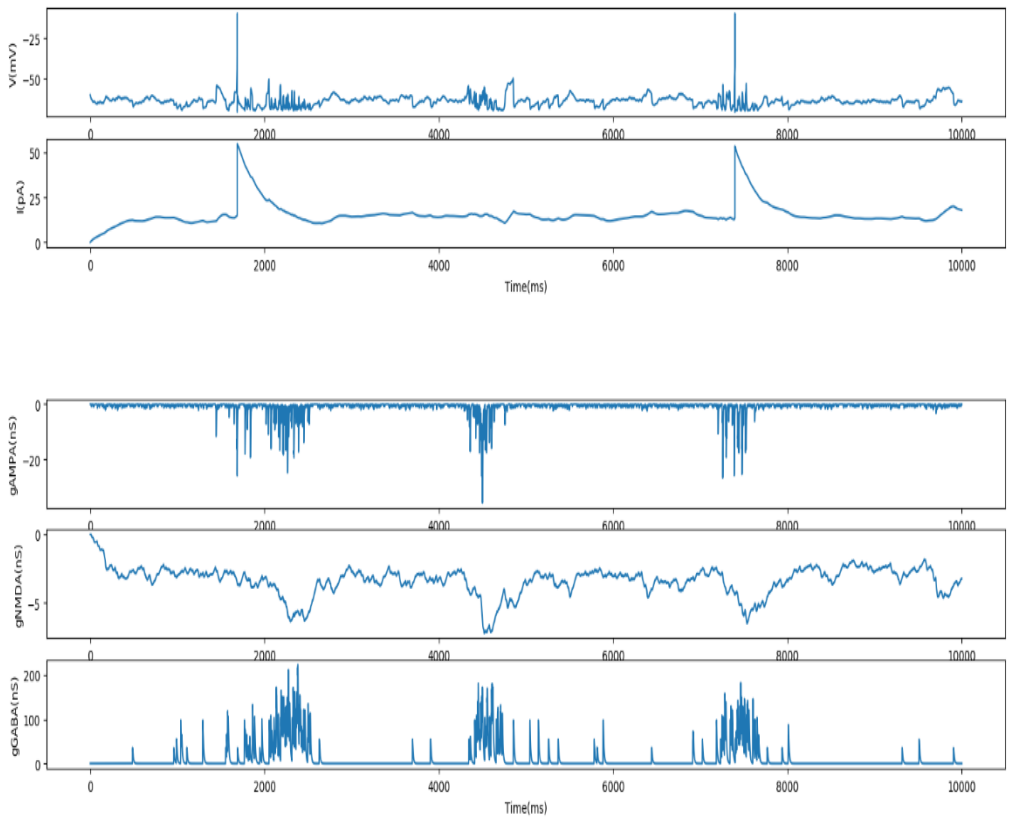
$$\begin{cases} \tau_{syn}\dfrac{dg_{syn}}{dt} = -g_{syn} \\ \tau_{rise}\dfrac{dg_{rise}}{dt} = -g_{rise} \\ I_{syn} = (g_{syn} - g_{rise})(v - E_{rev}) \end{cases}$$

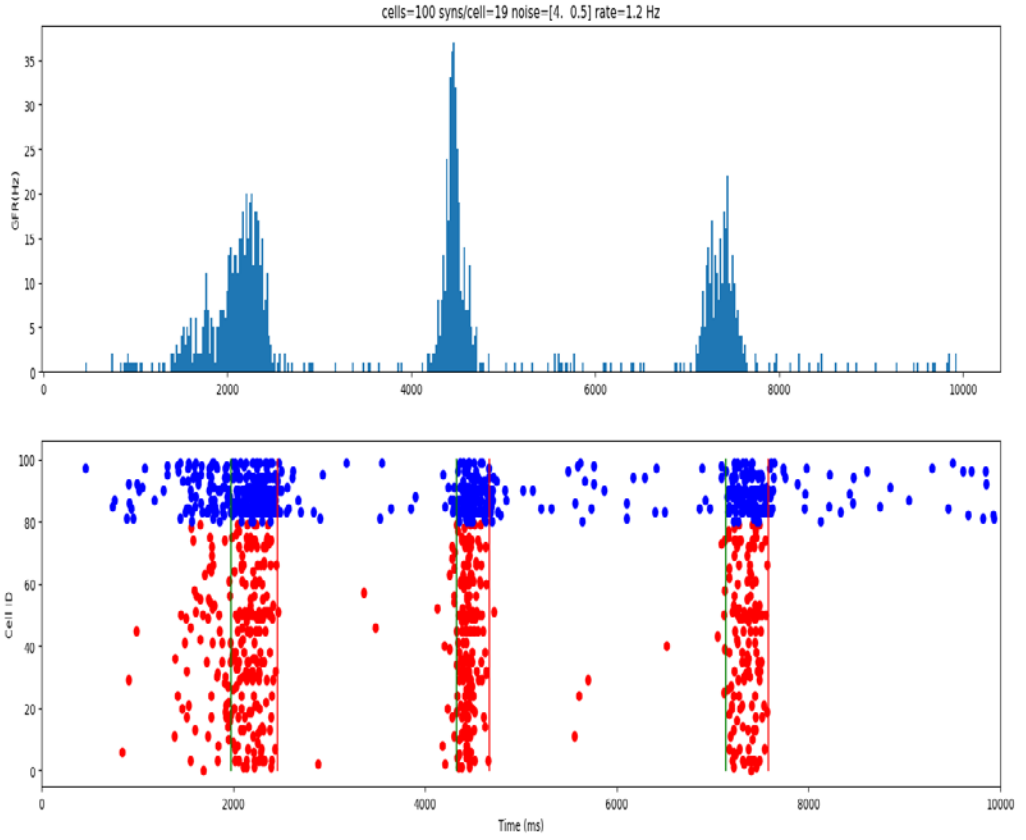
Simulation of population activity with all conductances



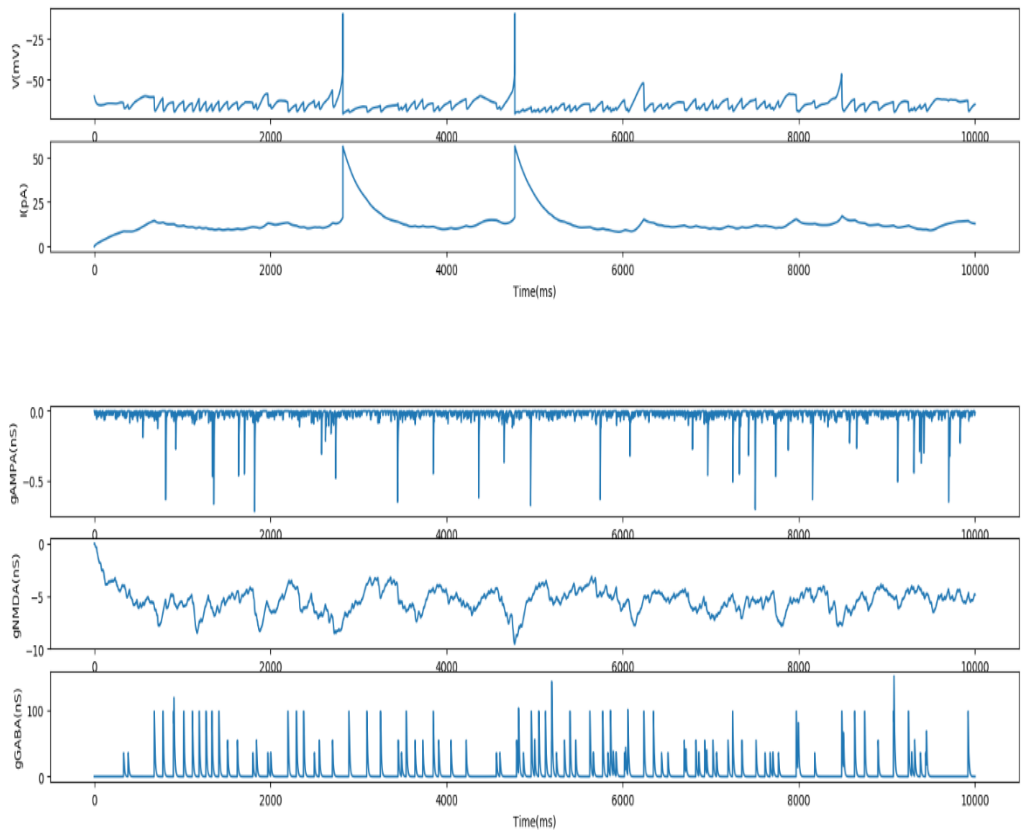


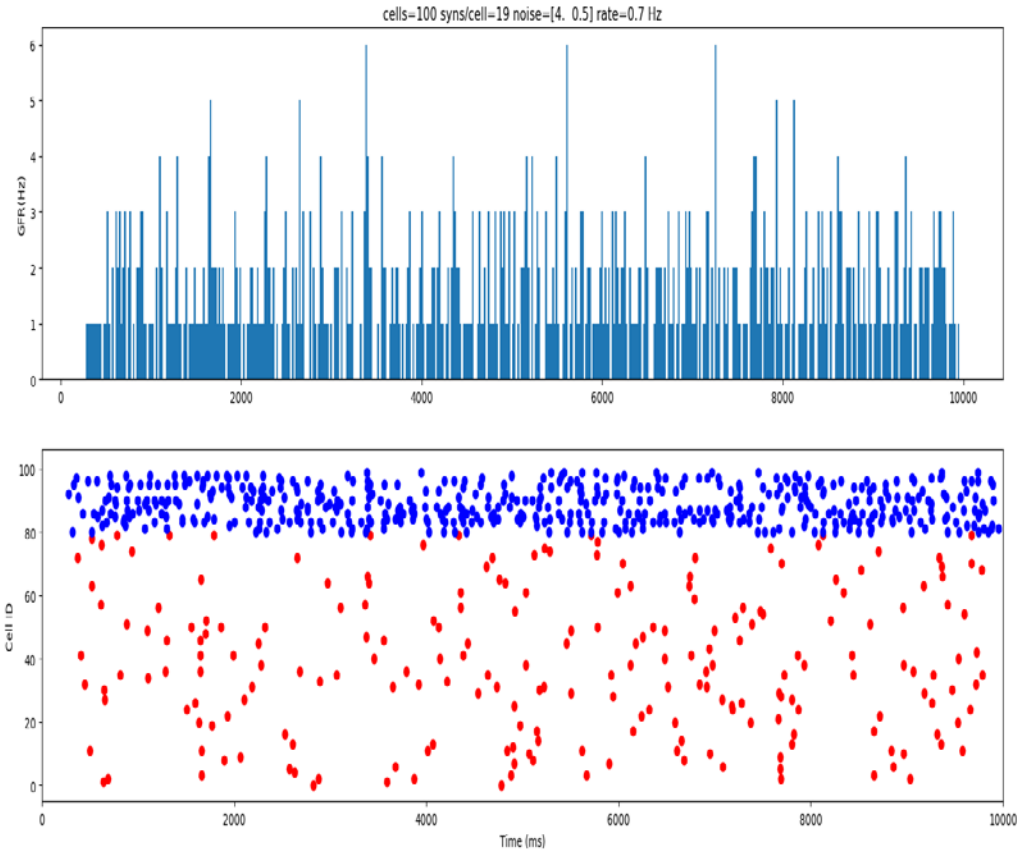
Simulation of population activity with supressed NMDA receptor conductance



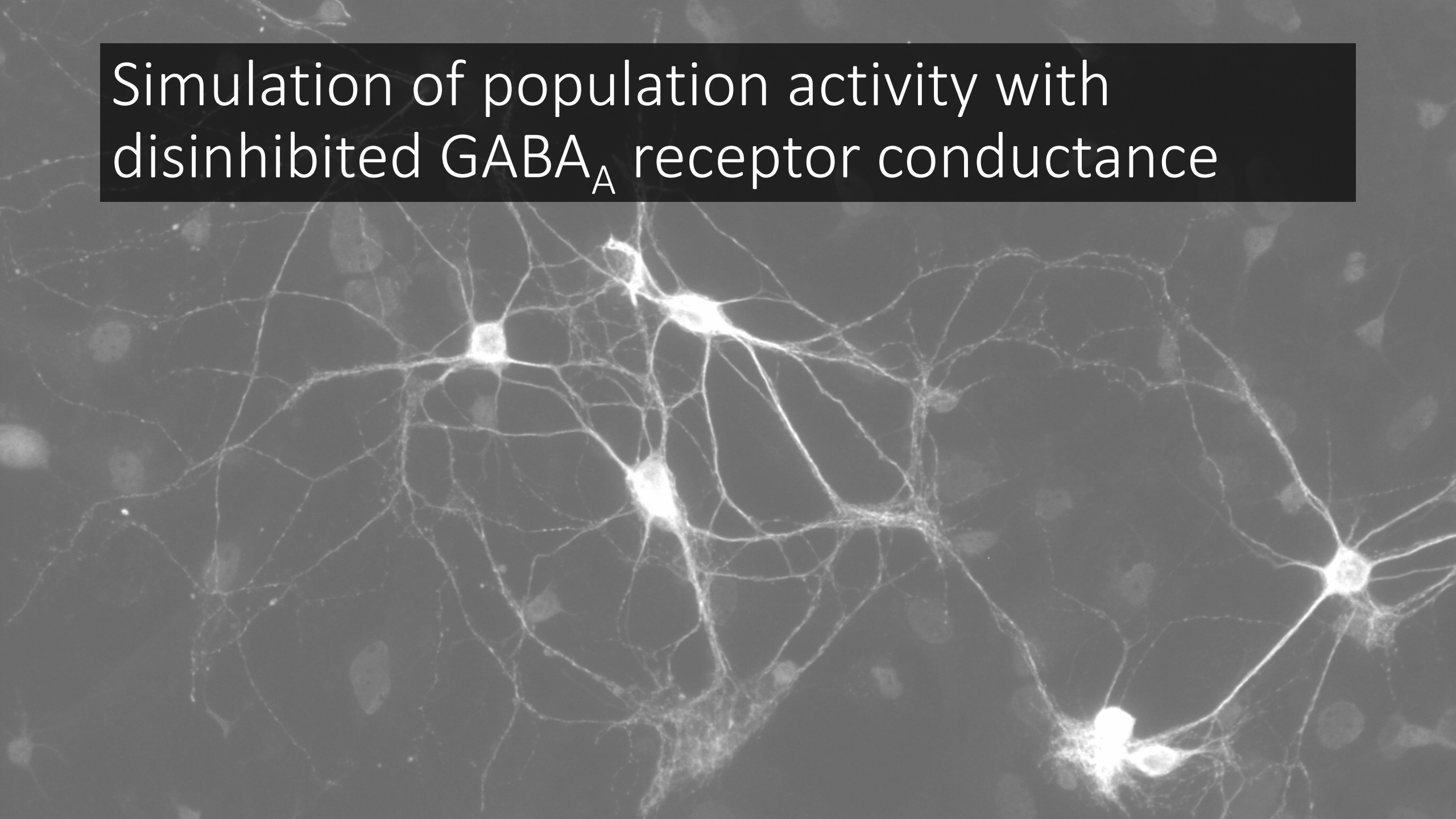


Simulation of population activity with suppressed AMPA receptor conductance

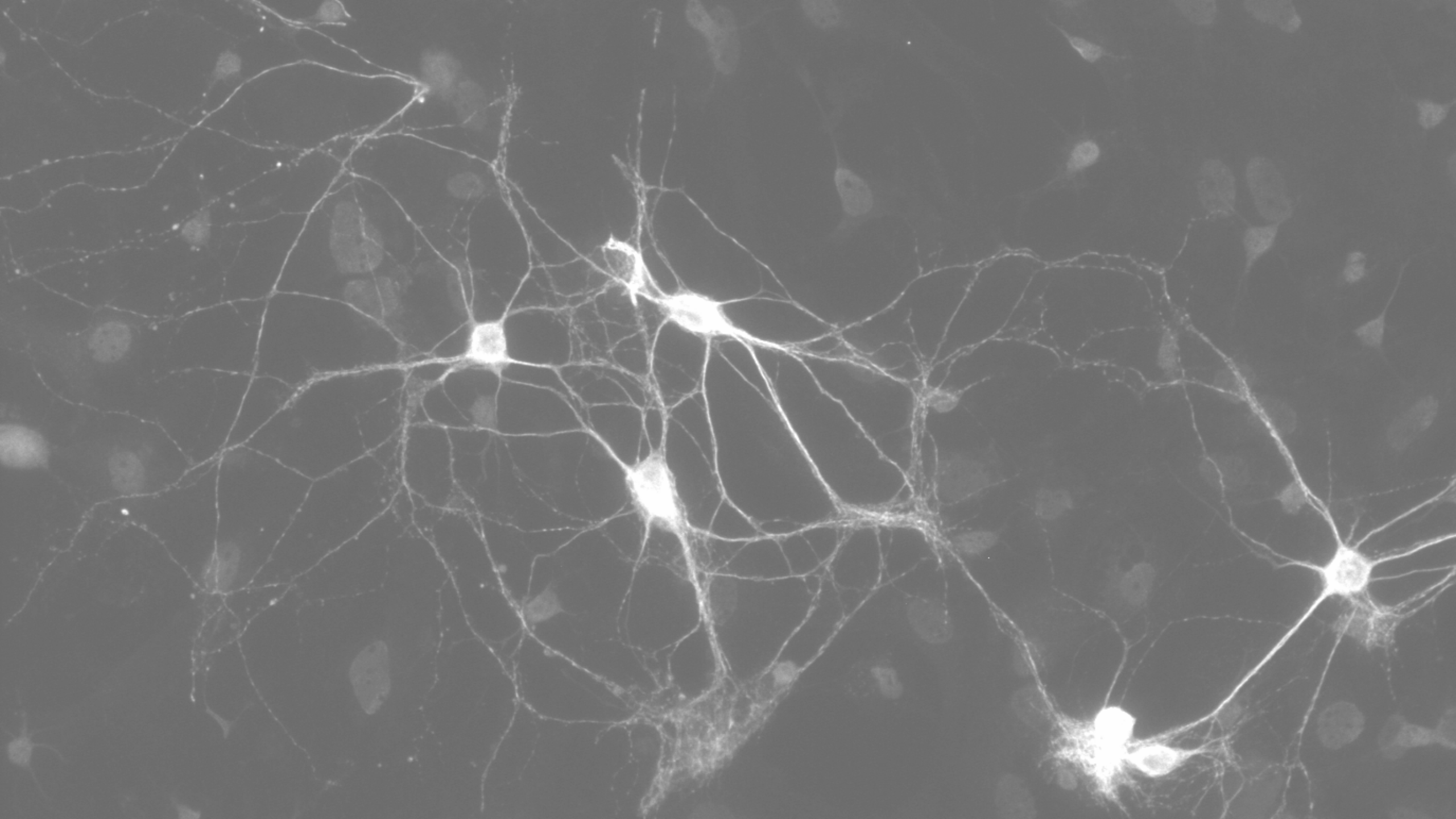




Simulation of population activity with disinhibited $GABA_A$ receptor conductance



Comparison to experimental data



Acknowledgement

My tutor: Cliff Kerr

Organizers:
Eric De Schutter
Kenji Doya

Thank you all!