

Mechanisms of
sharp wave - ripple activity
in area **CA3** of the hippocampus

Dávid **Nagy** + Eszter **Vértes** + Szabolcs **Káli**

behavioral state ↔ network state



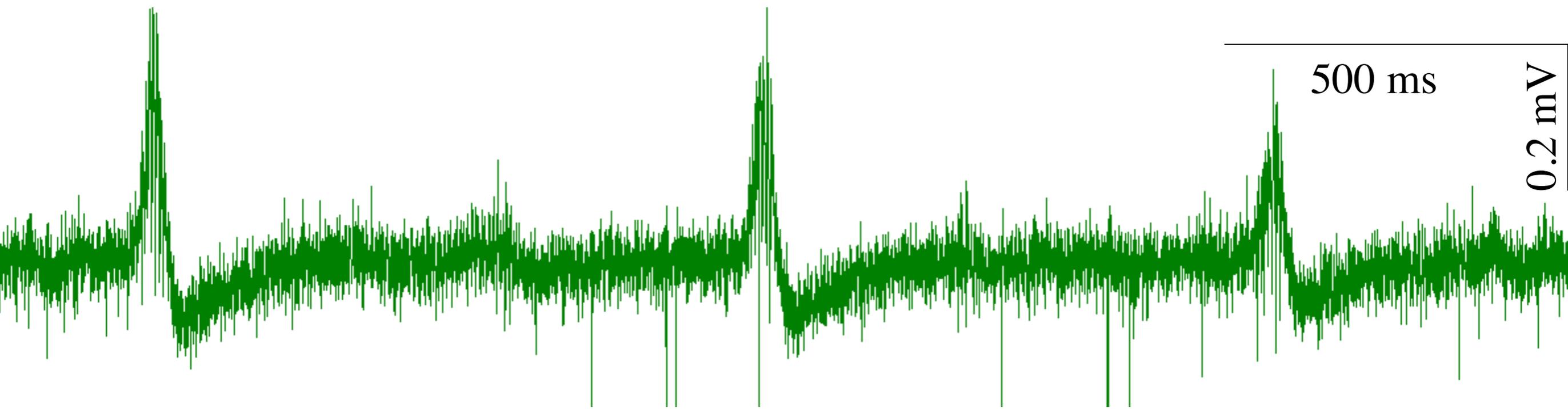
gamma

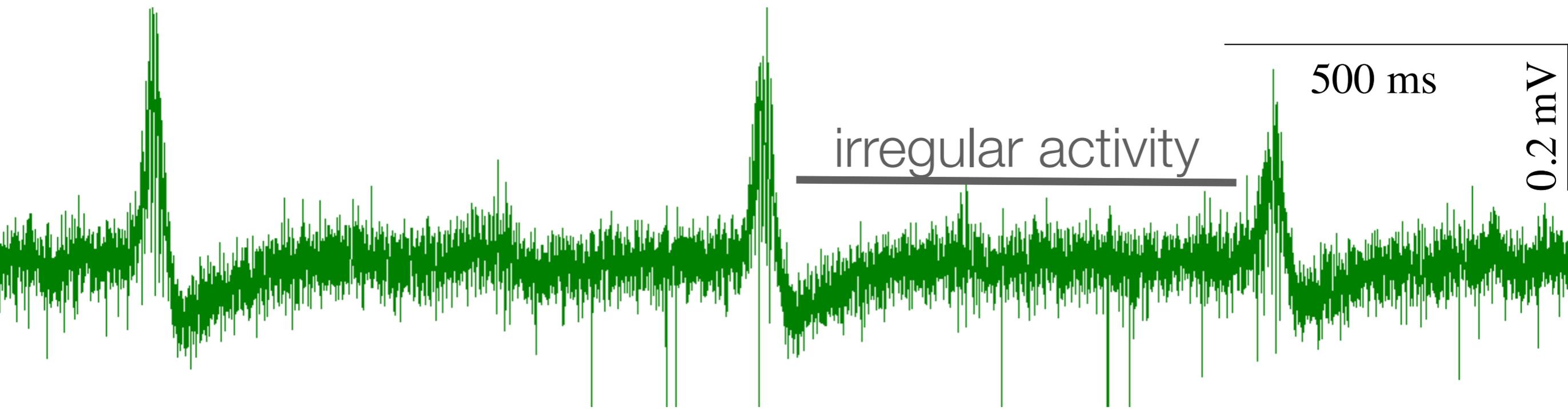


gamma



SWR

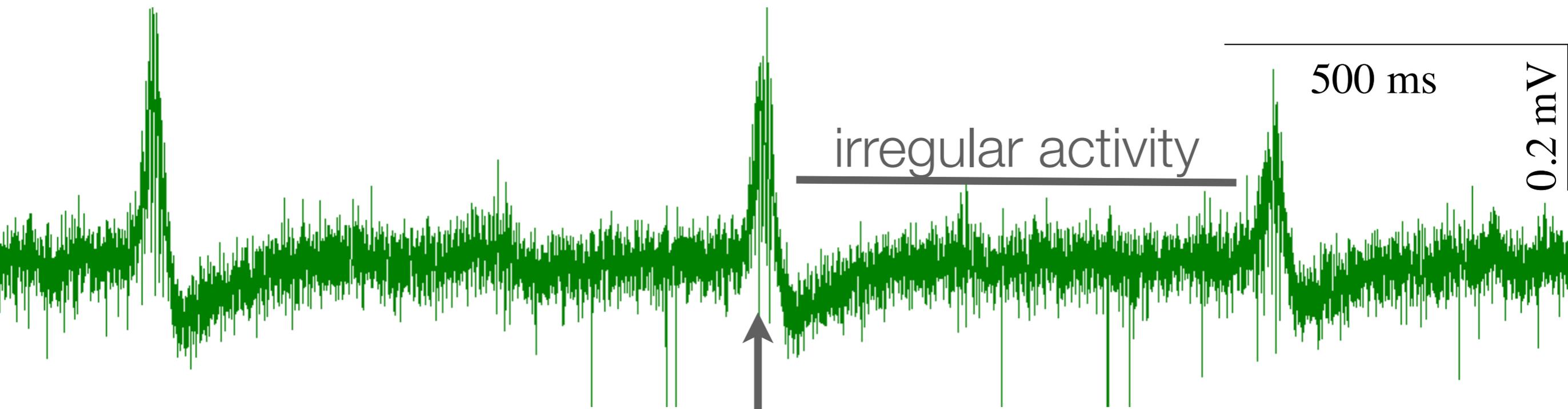




irregular activity

500 ms

0.2 mV

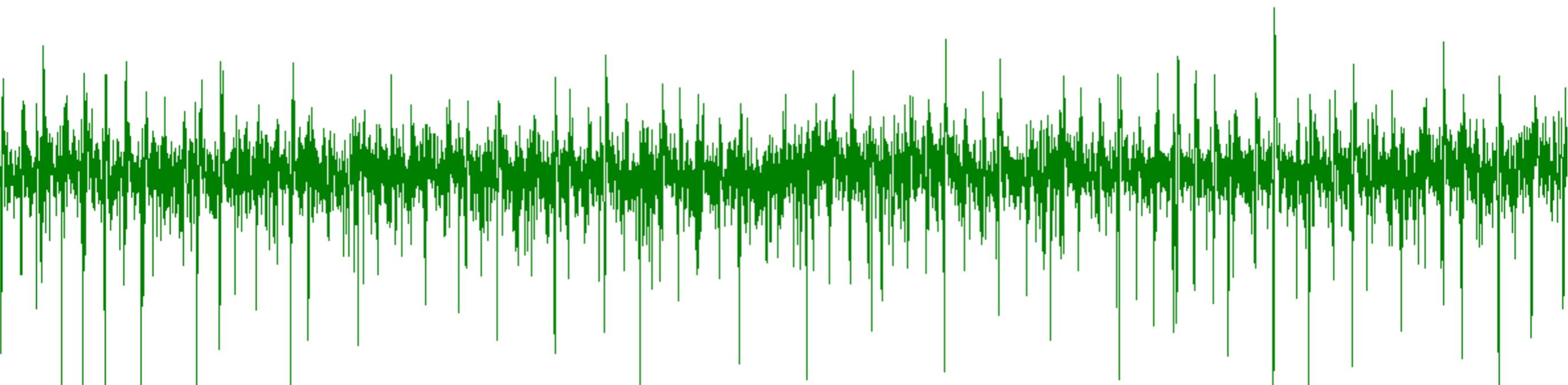


irregular activity

500 ms

0.2 mV

sharp wave



neural
network
behind this?

methods
topology
dynamics

methods

topology

dynamics

methods

topology

dynamics

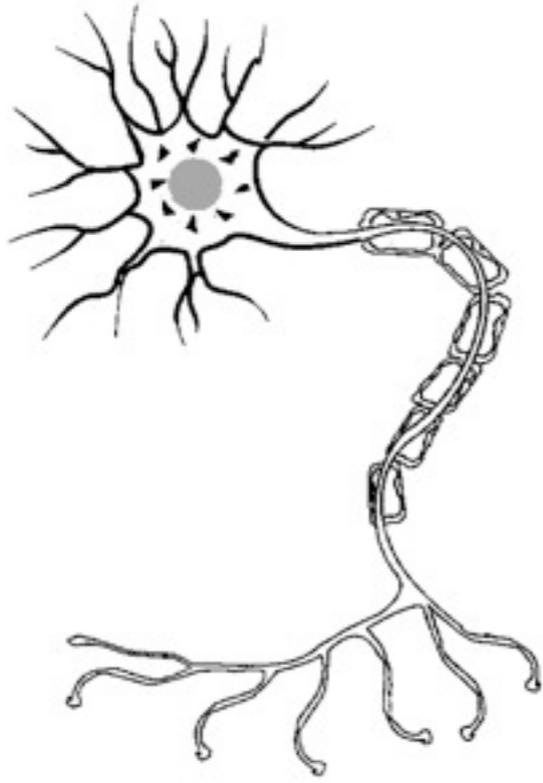
methods

topology

dynamics

Part 1 : **methods**

computational neuroscience



=

$$I(t) - \frac{V_m(t)}{R_m} = C_m \frac{dV_m(t)}{dt}$$

10000 x  = 10000 x $I(t) - \frac{V_m(t)}{R_m} = C_m \frac{dV_m(t)}{dt}$

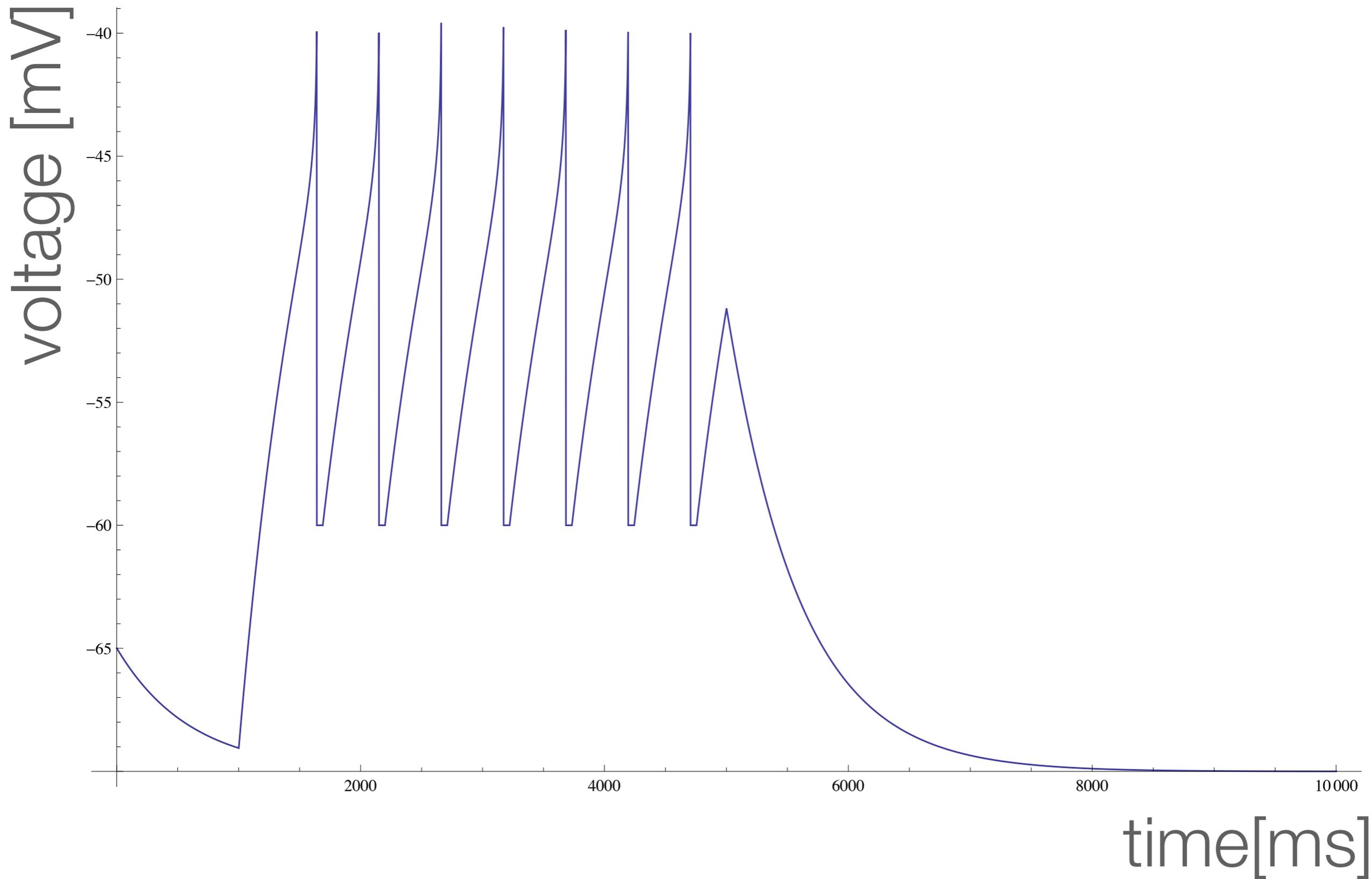
specialized software

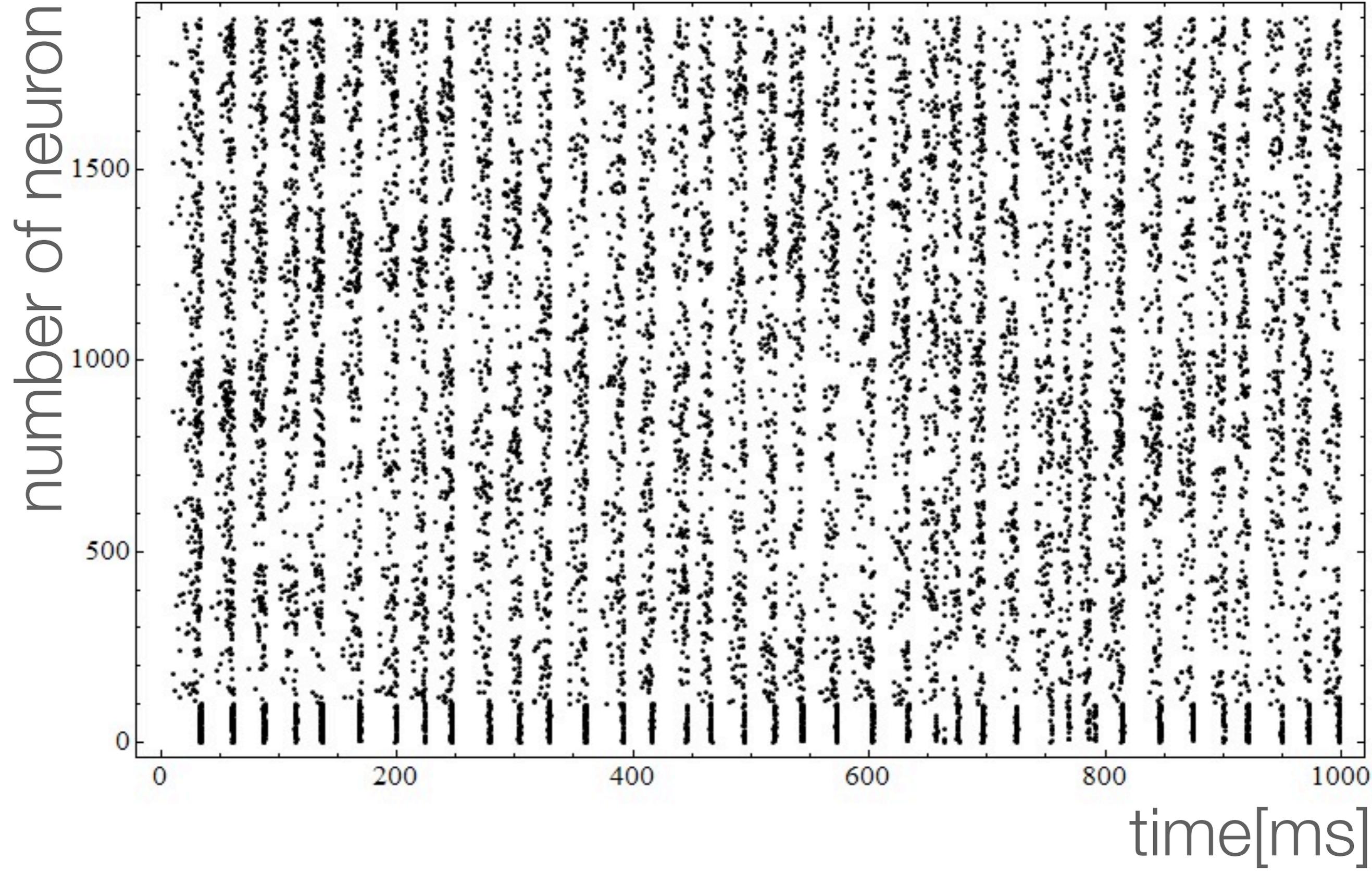


PyNN



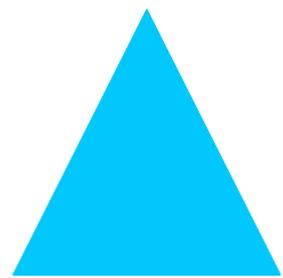
NEURON



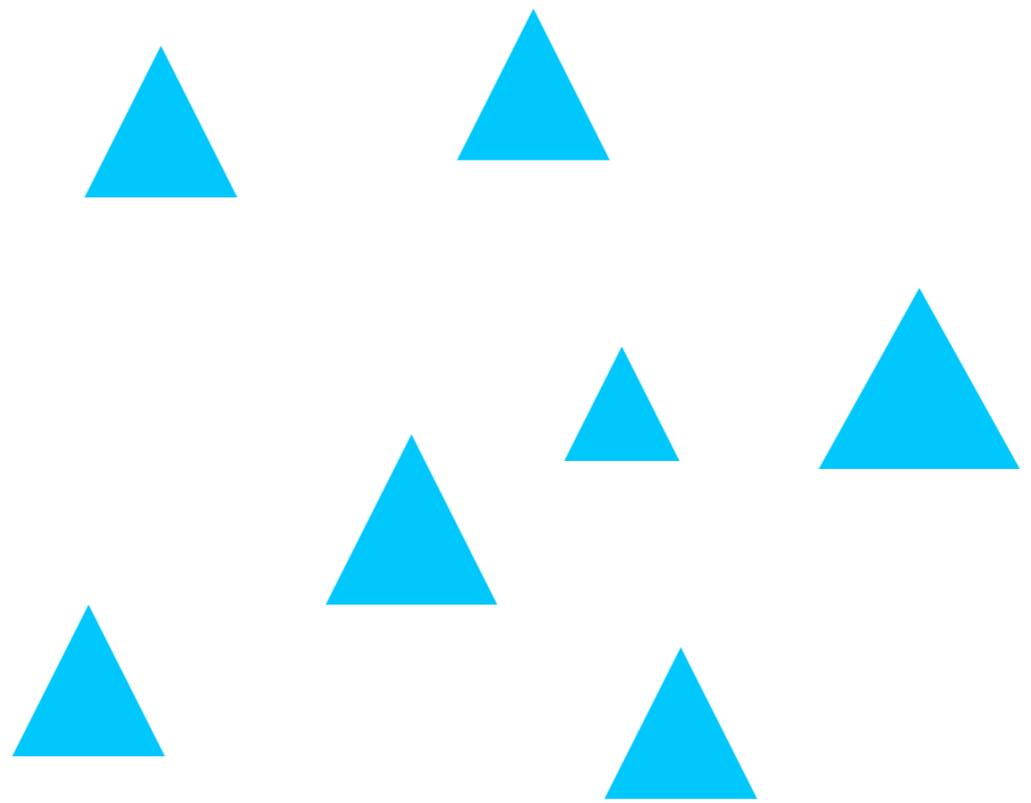


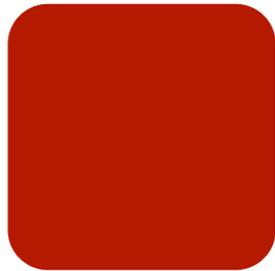
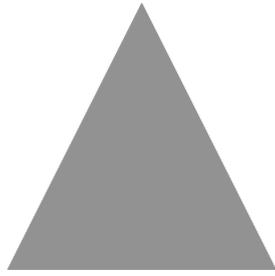
time[ms]

Part 2: **the network**

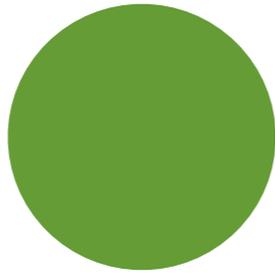
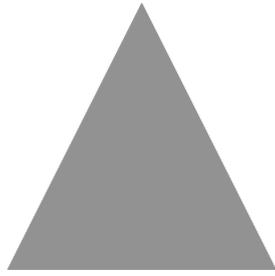


pyramidal neurons



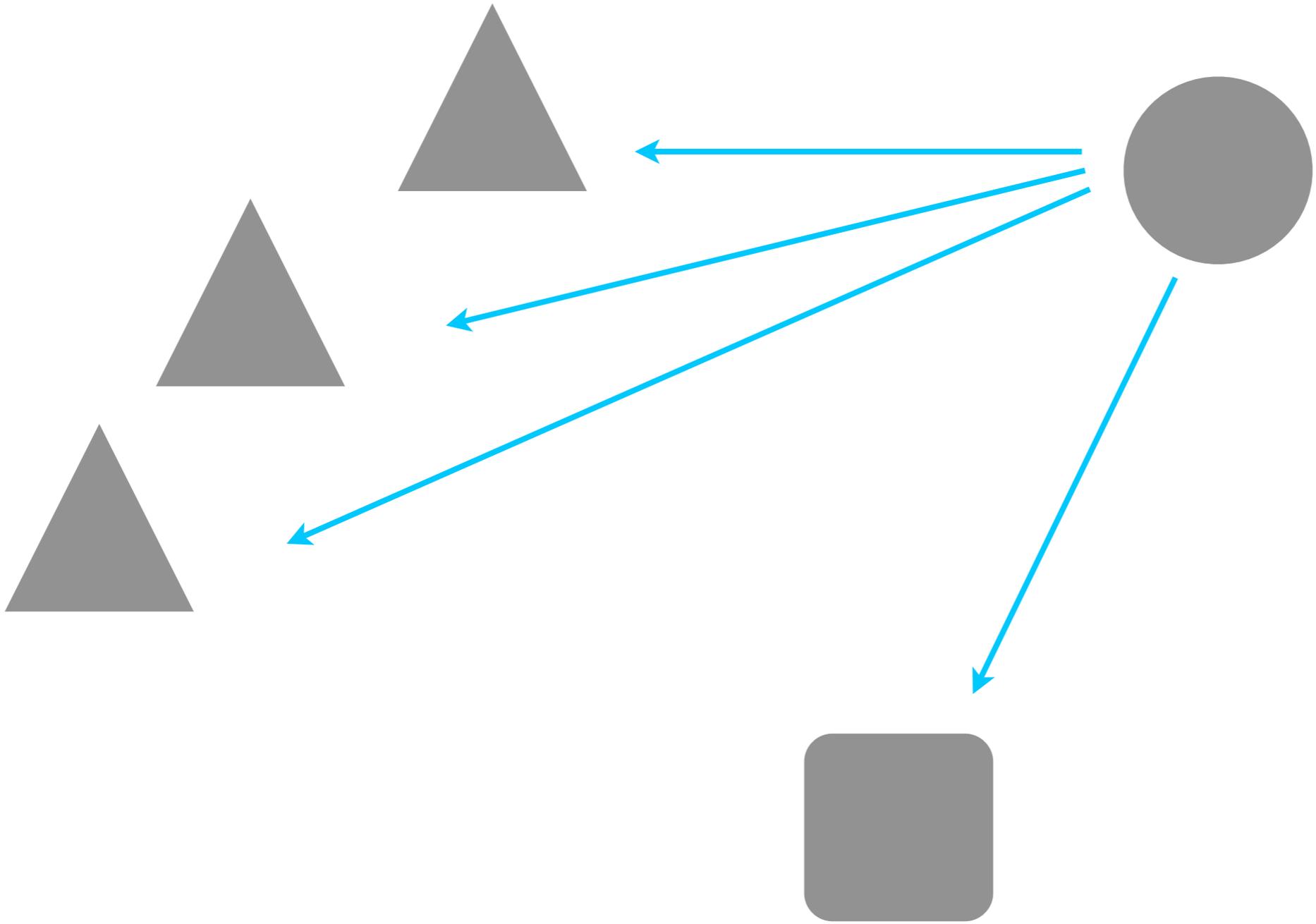


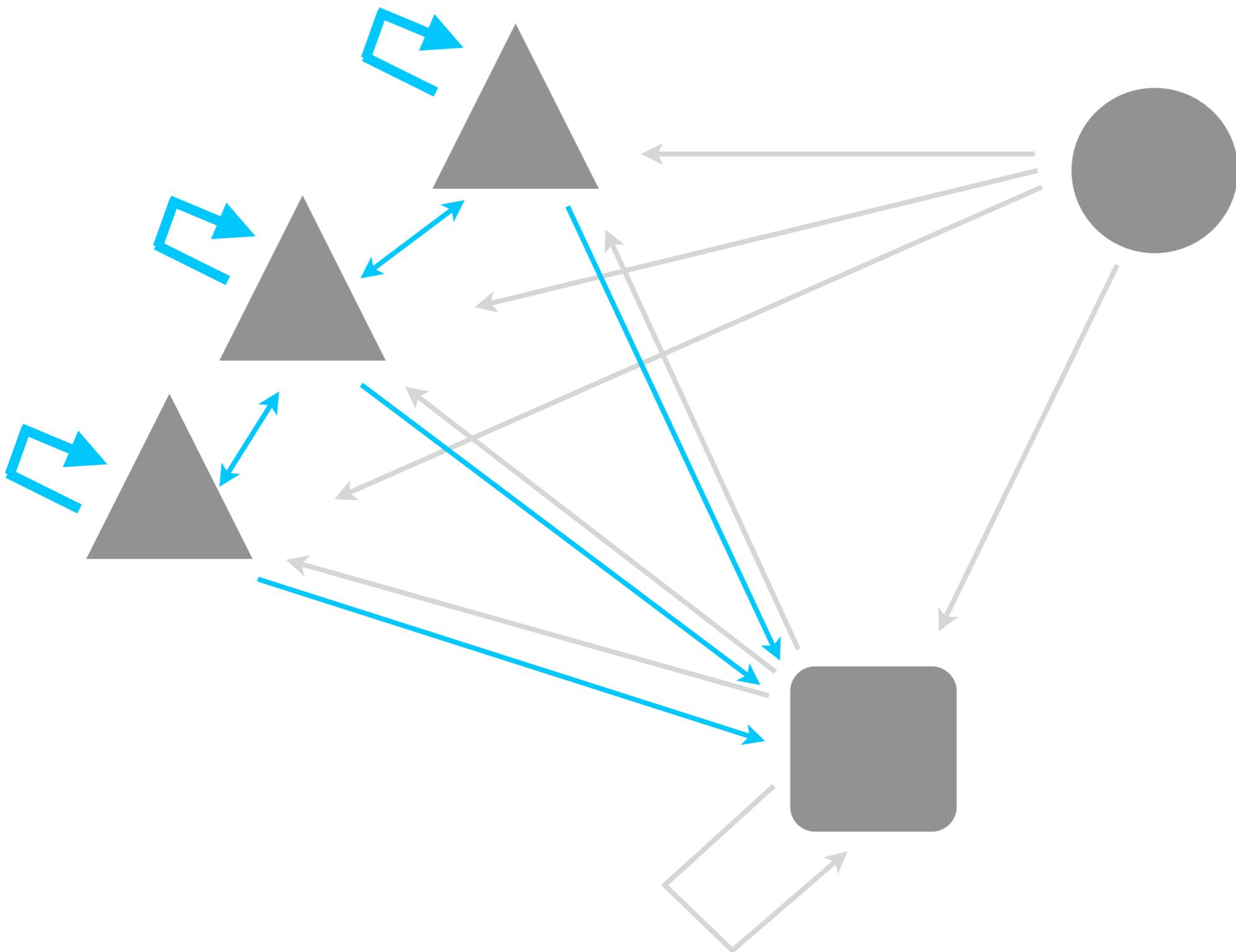
interneurons



external input

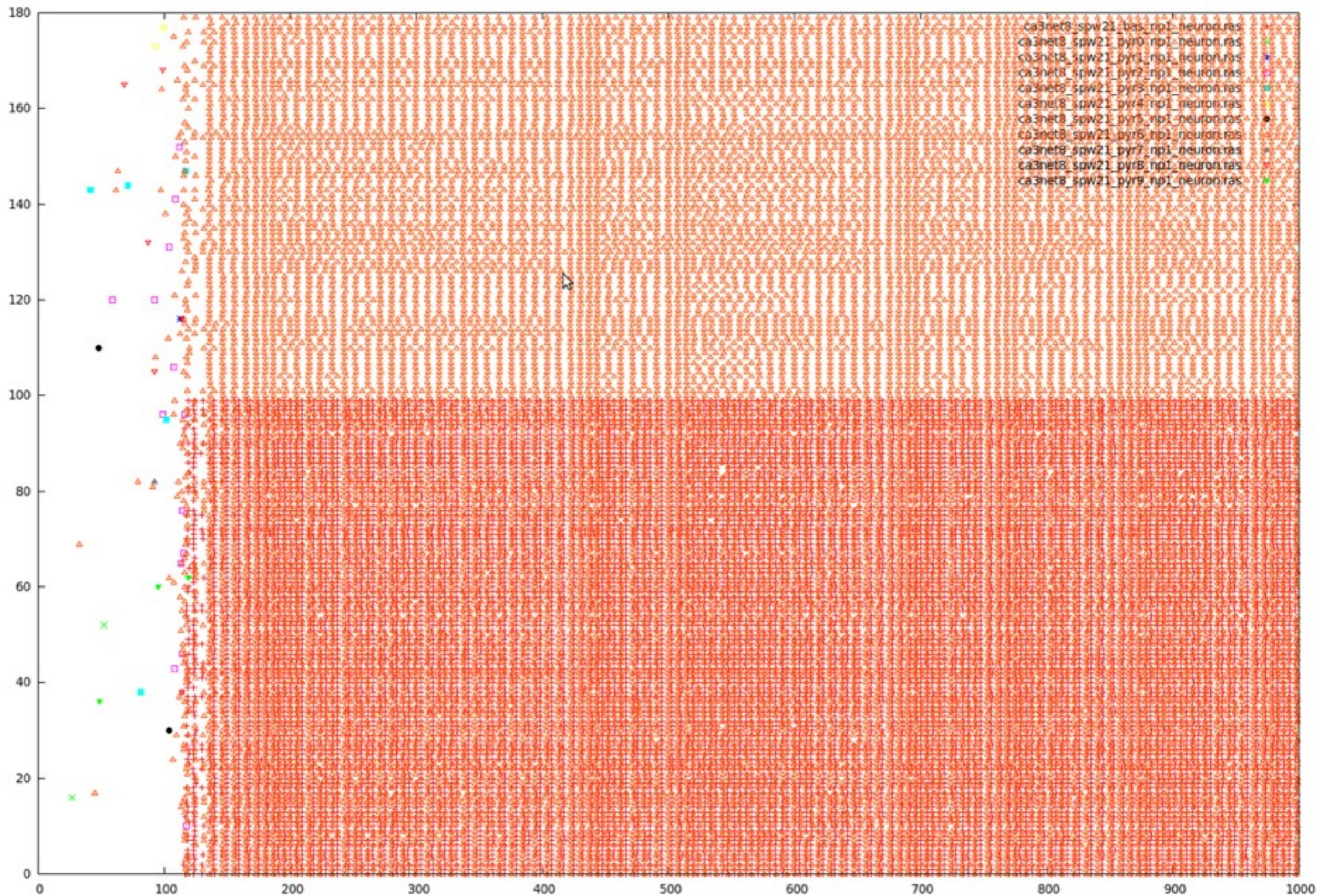






Part 3: **the dynamics**

coincident firing



time[ms]

candidate mechanisms

1 slow interneurons

adaptive cells

synaptic mechanisms

slow interneurons

2 adaptive cells

synaptic mechanisms

slow interneurons

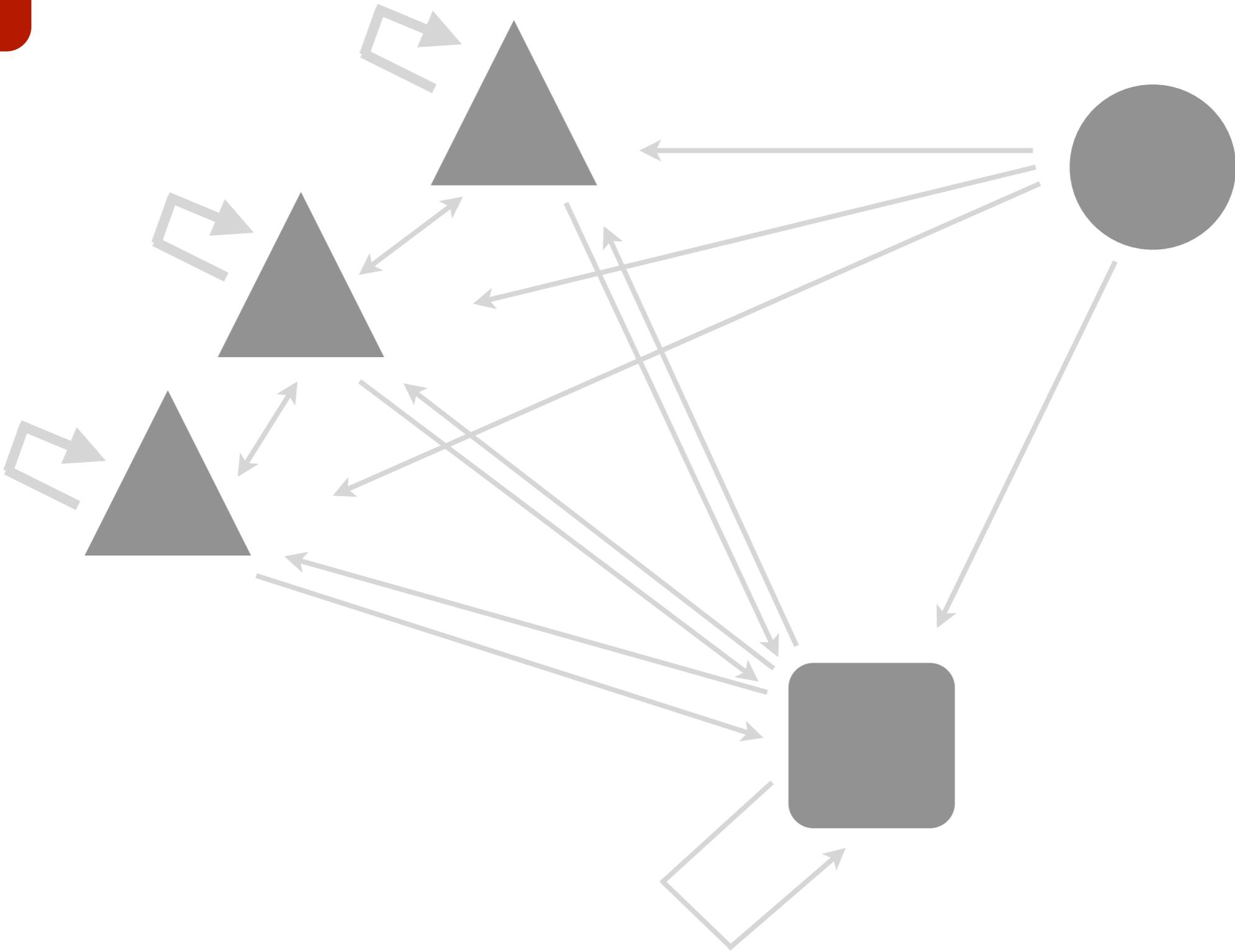
adaptive cells

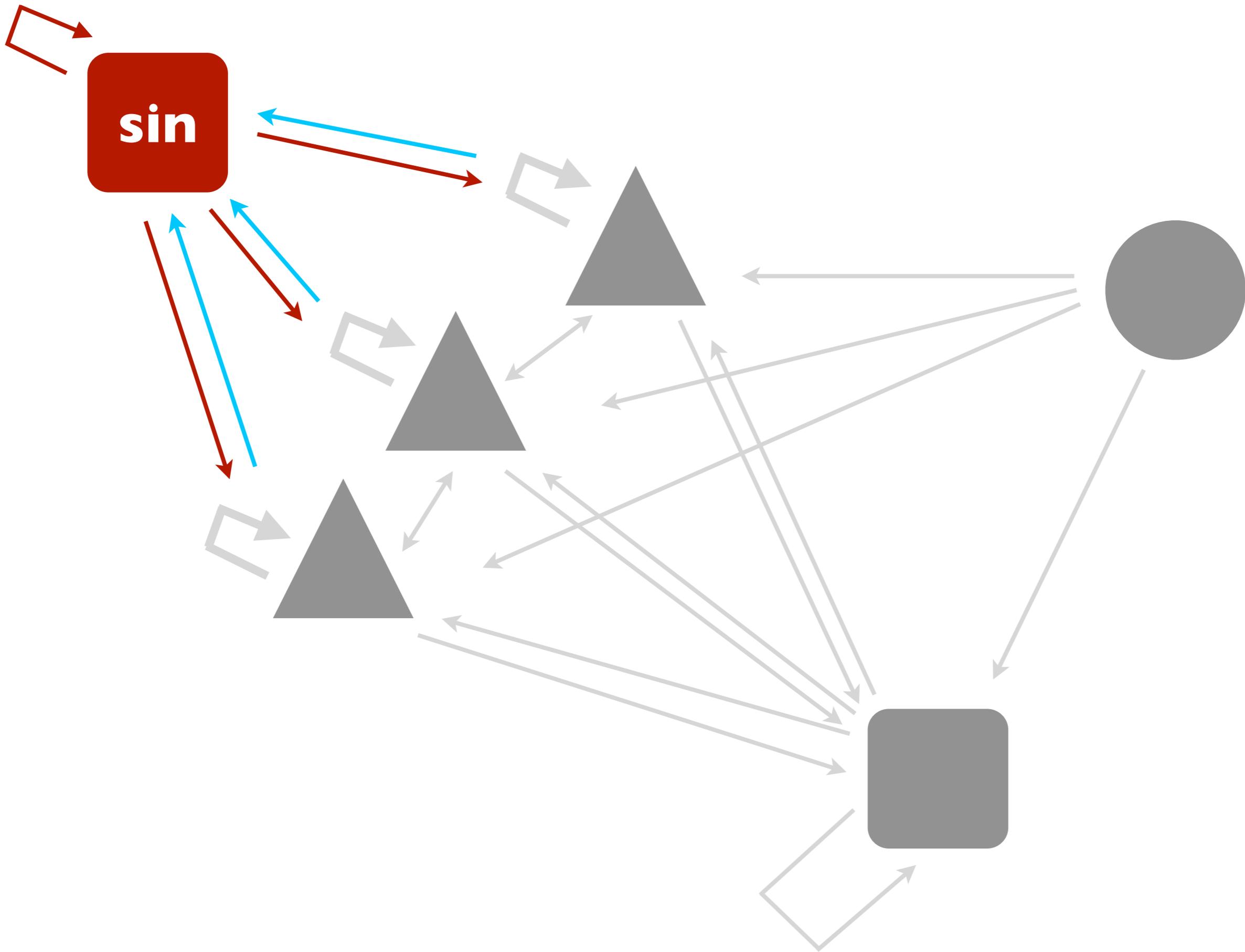
3 synaptic mechanisms

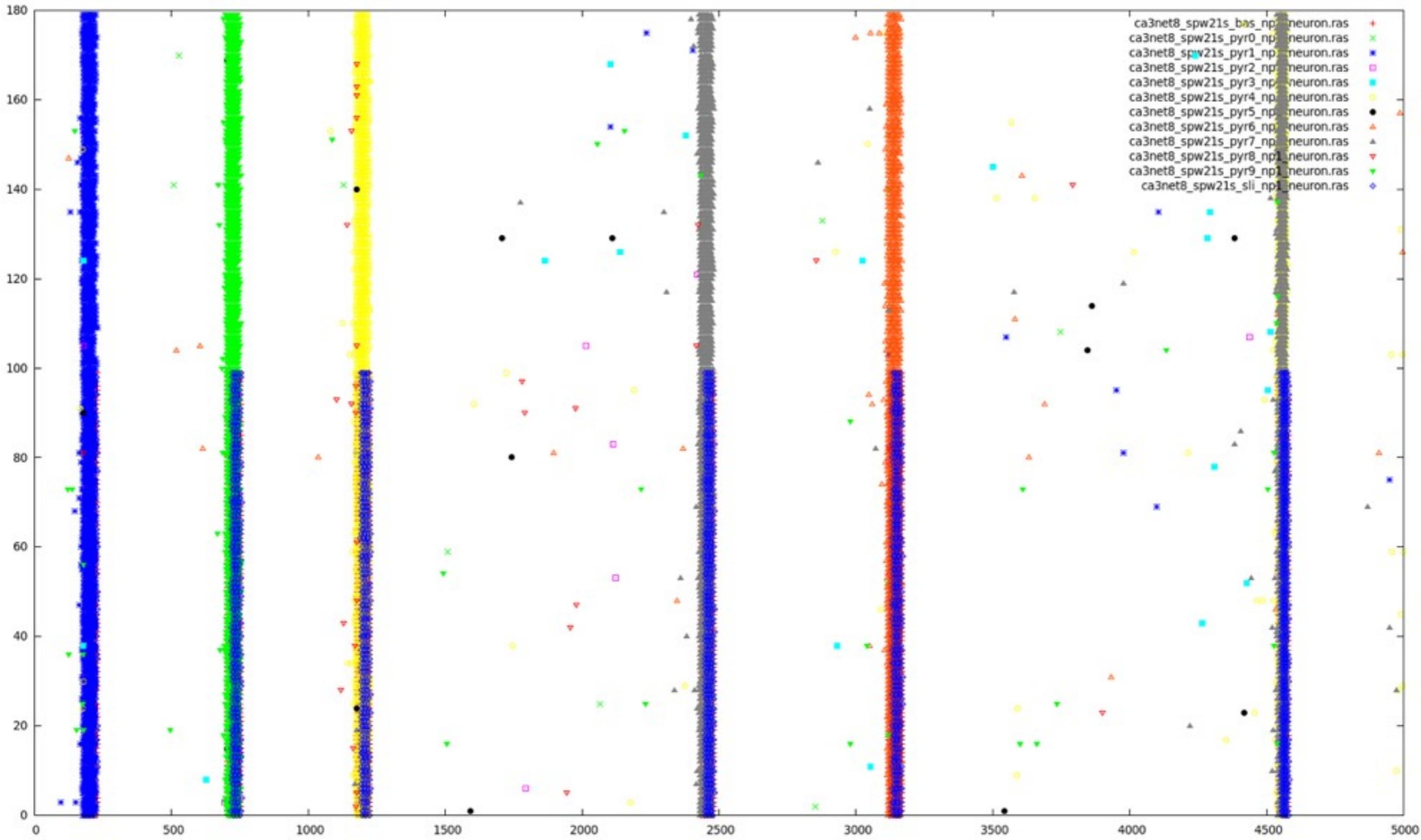


slow interneurons

sin



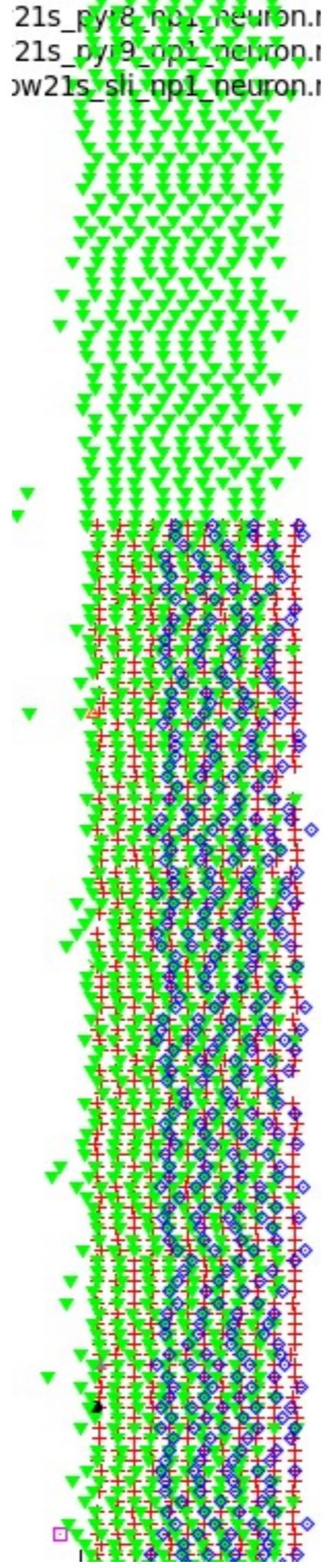




- ca3net8_spw21s_bas_np1 neuron.ras +
- ca3net8_spw21s_pyr0_np1 neuron.ras x
- ca3net8_spw21s_pyr1_np1 neuron.ras *
- ca3net8_spw21s_pyr2_np1 neuron.ras □
- ca3net8_spw21s_pyr3_np1 neuron.ras □
- ca3net8_spw21s_pyr4_np1 neuron.ras ●
- ca3net8_spw21s_pyr5_np1 neuron.ras ●
- ca3net8_spw21s_pyr6_np1 neuron.ras ▲
- ca3net8_spw21s_pyr7_np1 neuron.ras ▲
- ca3net8_spw21s_pyr8_np1 neuron.ras ▲
- ca3net8_spw21s_pyr9_np1 neuron.ras ▼
- ca3net8_spw21s_sli_np1 neuron.ras ◆

time[ms]

neuron
time[ms]

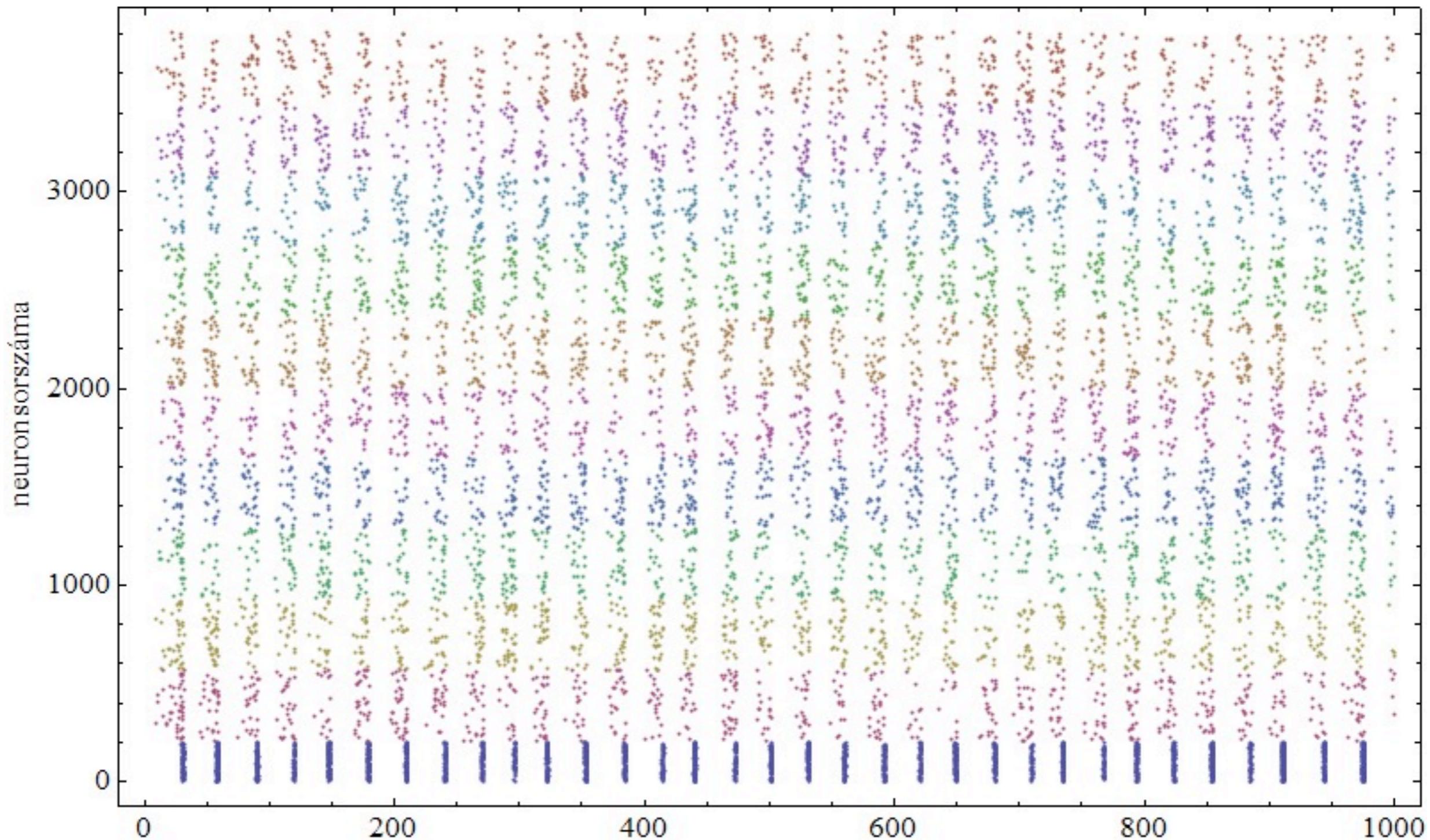


SWR ↔ gamma

cholinergic modulation

- synaptic efficacy
- + cellular excitability

- synaptic efficacy
- + cellular excitability



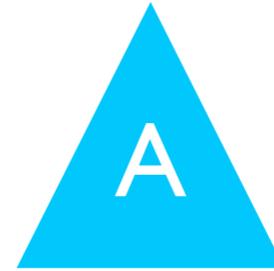
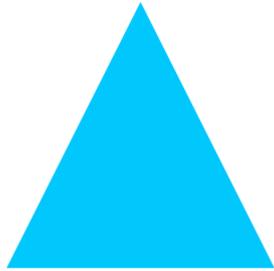
time[ms]

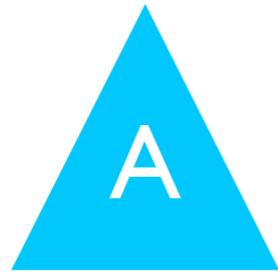
prediction

prediction

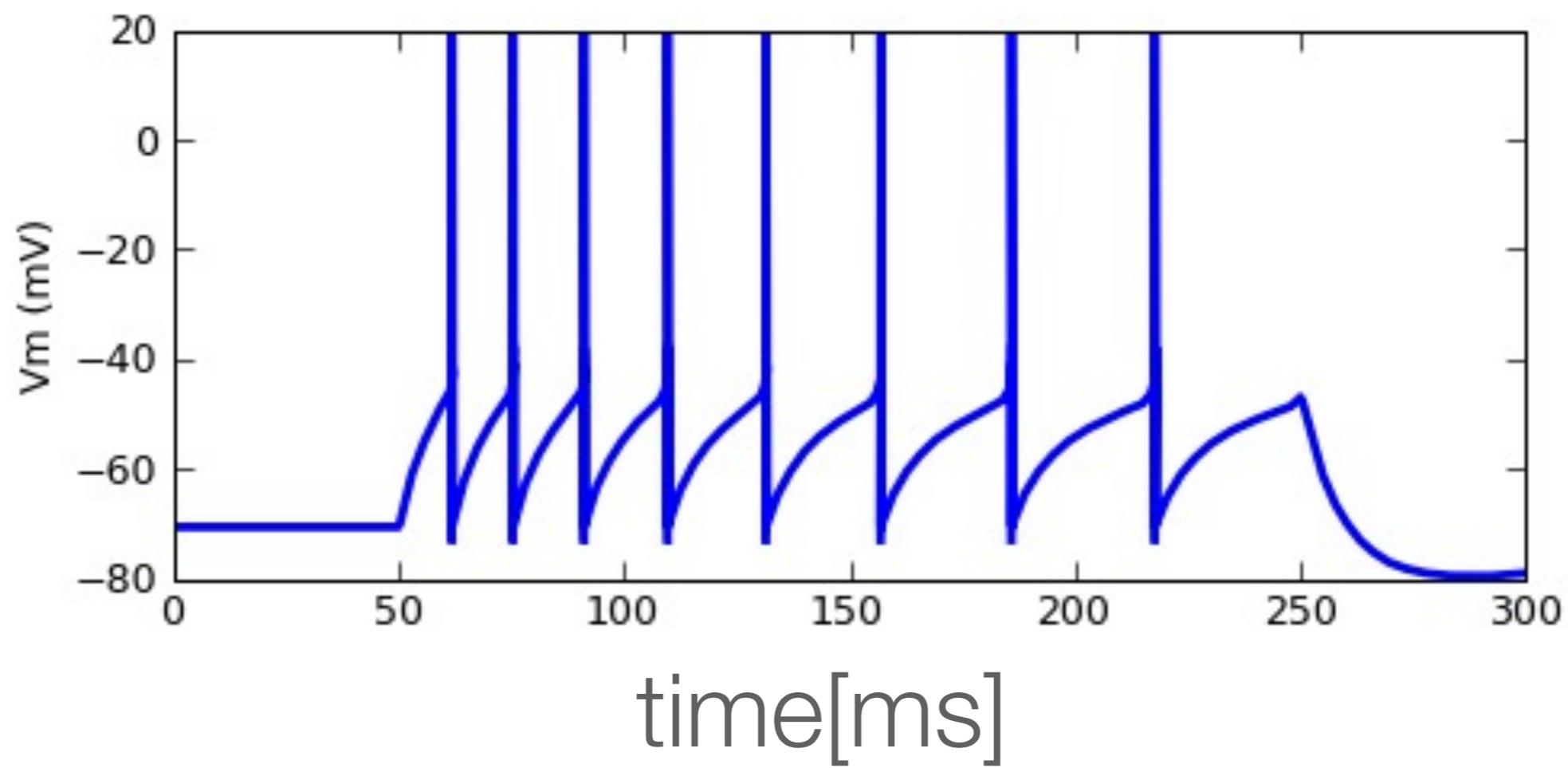


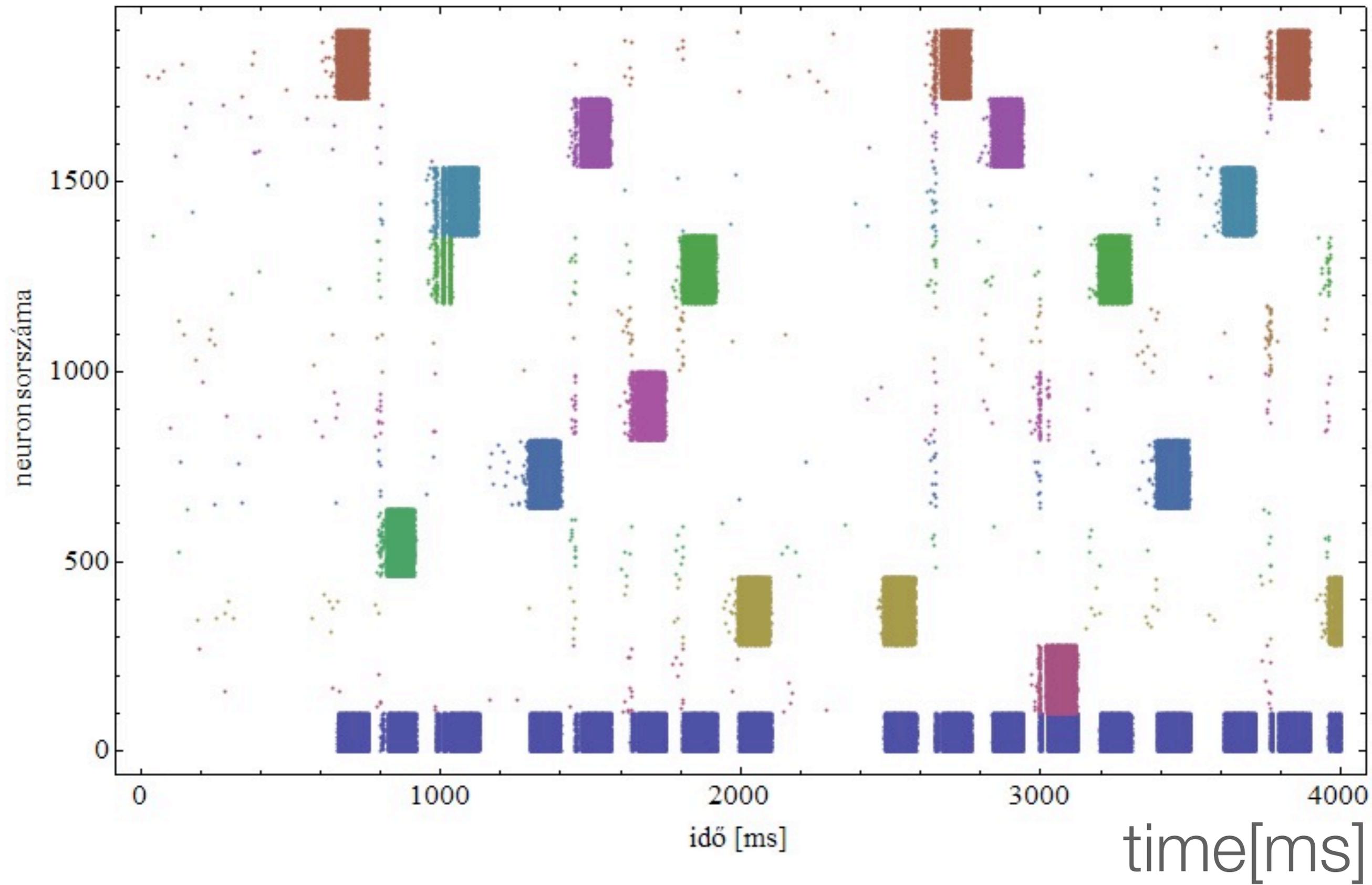
is present in CA3



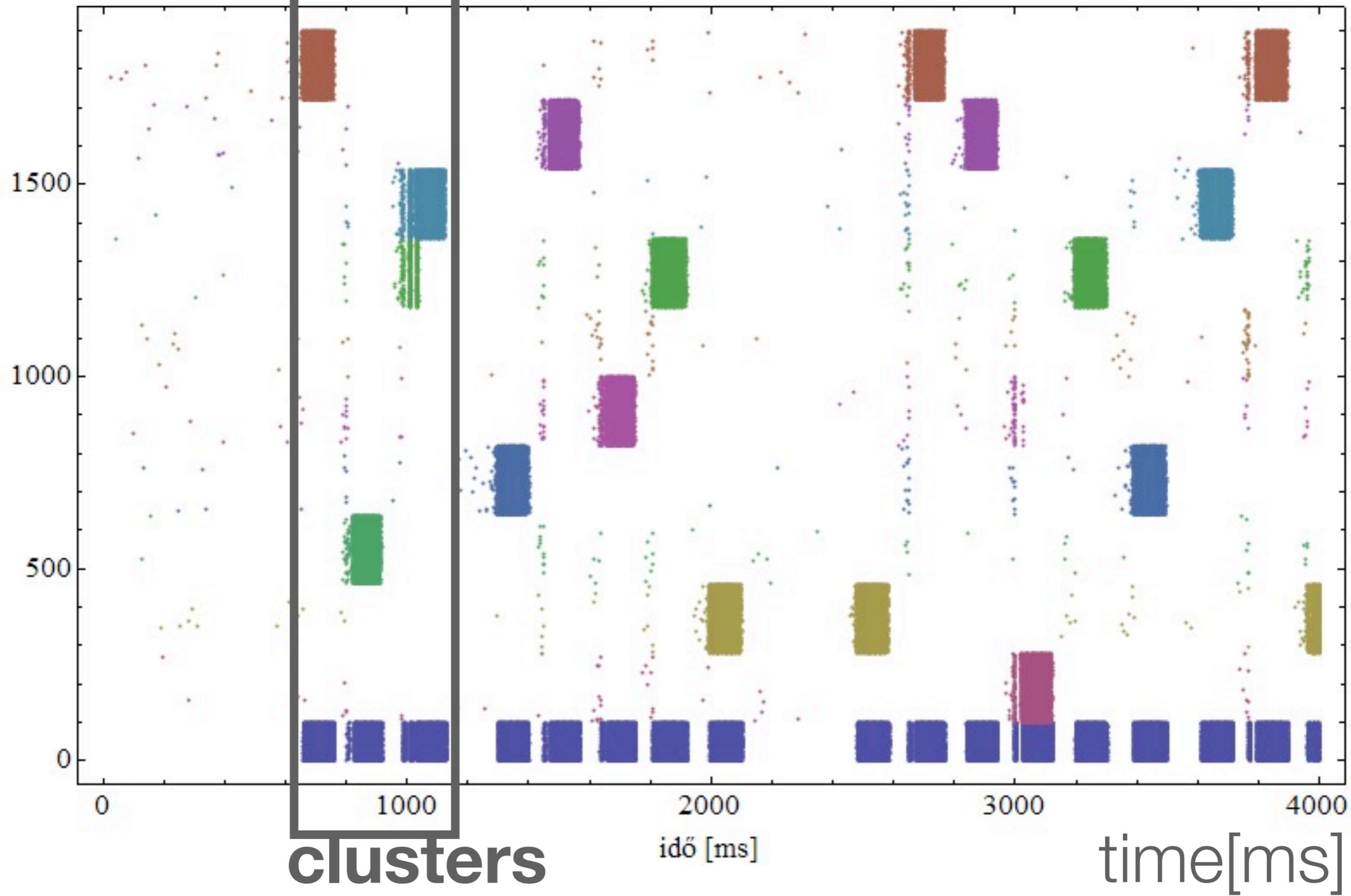


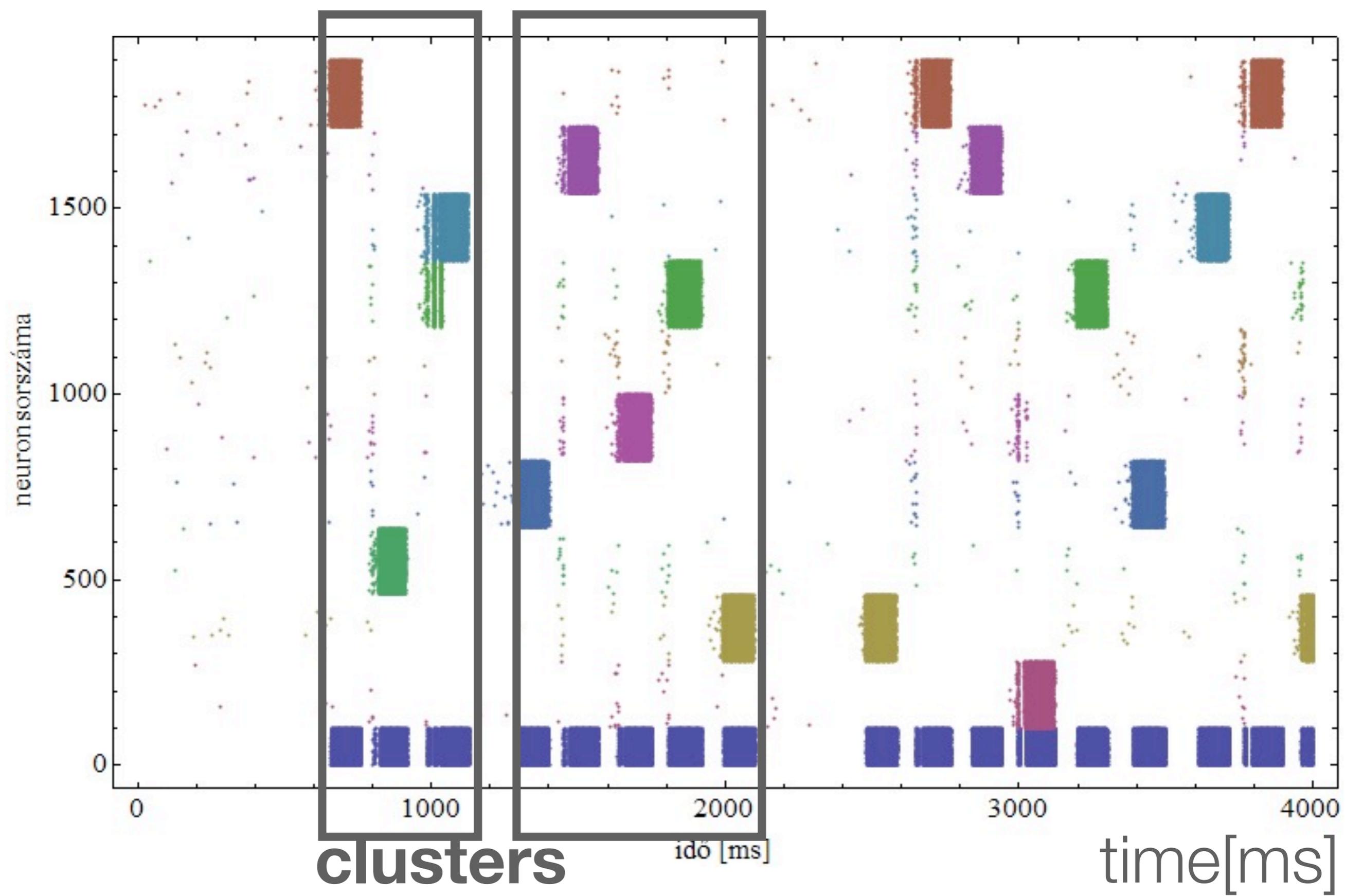
adaptive cells



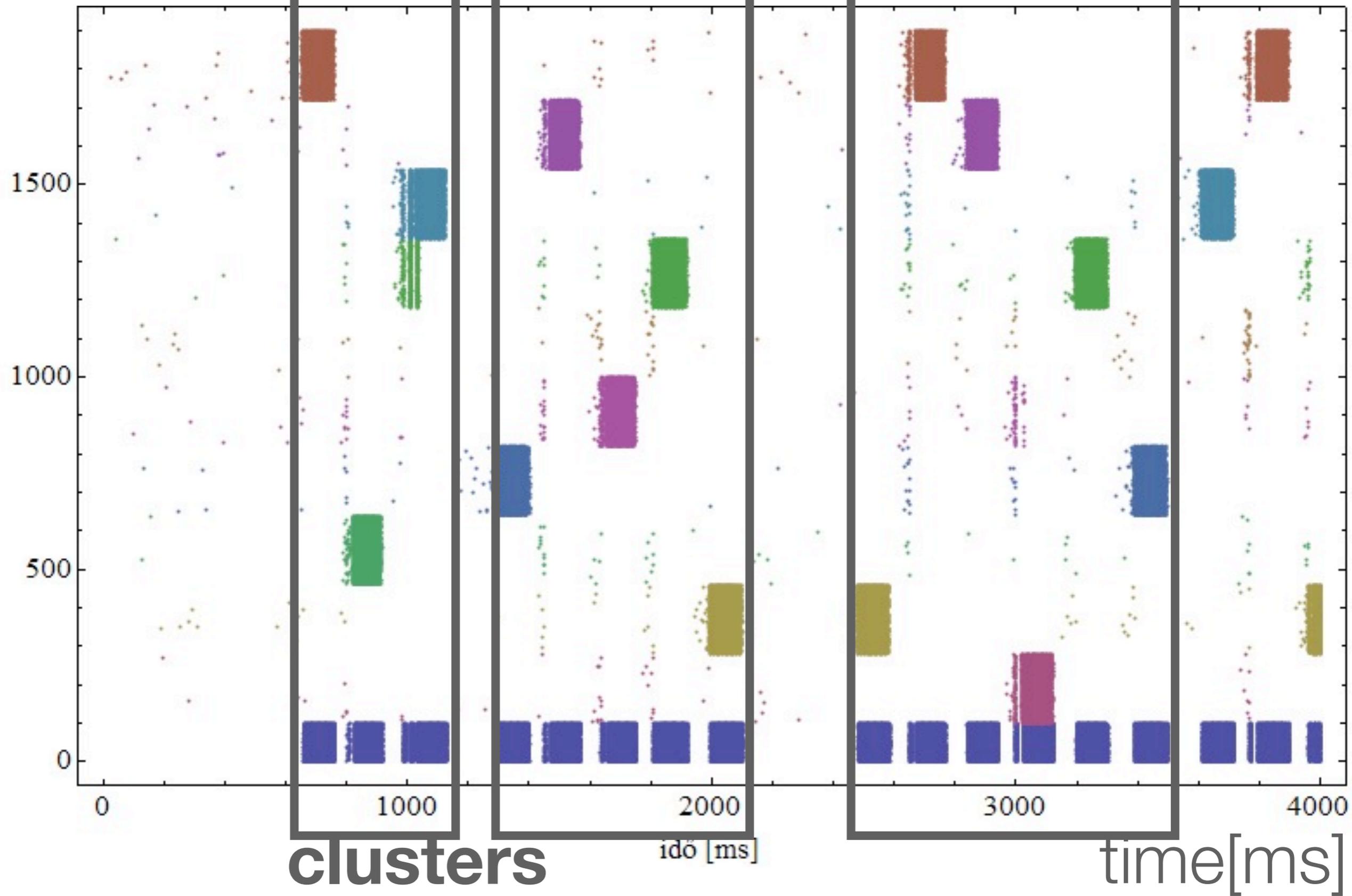


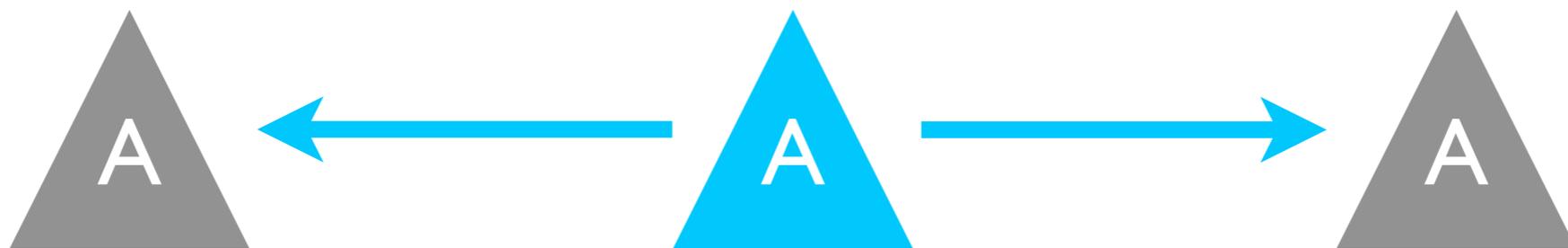
neuron sorszáma

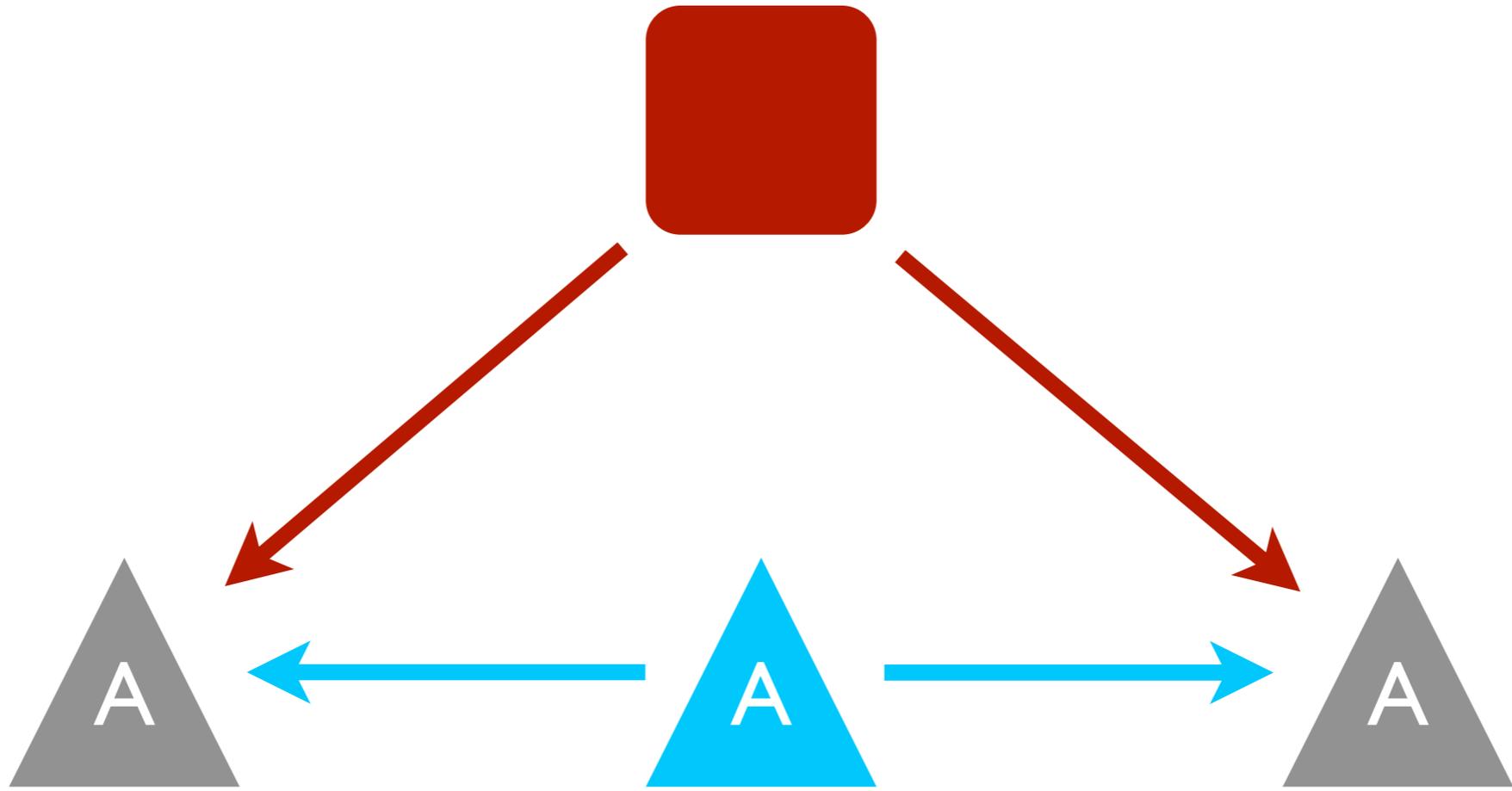


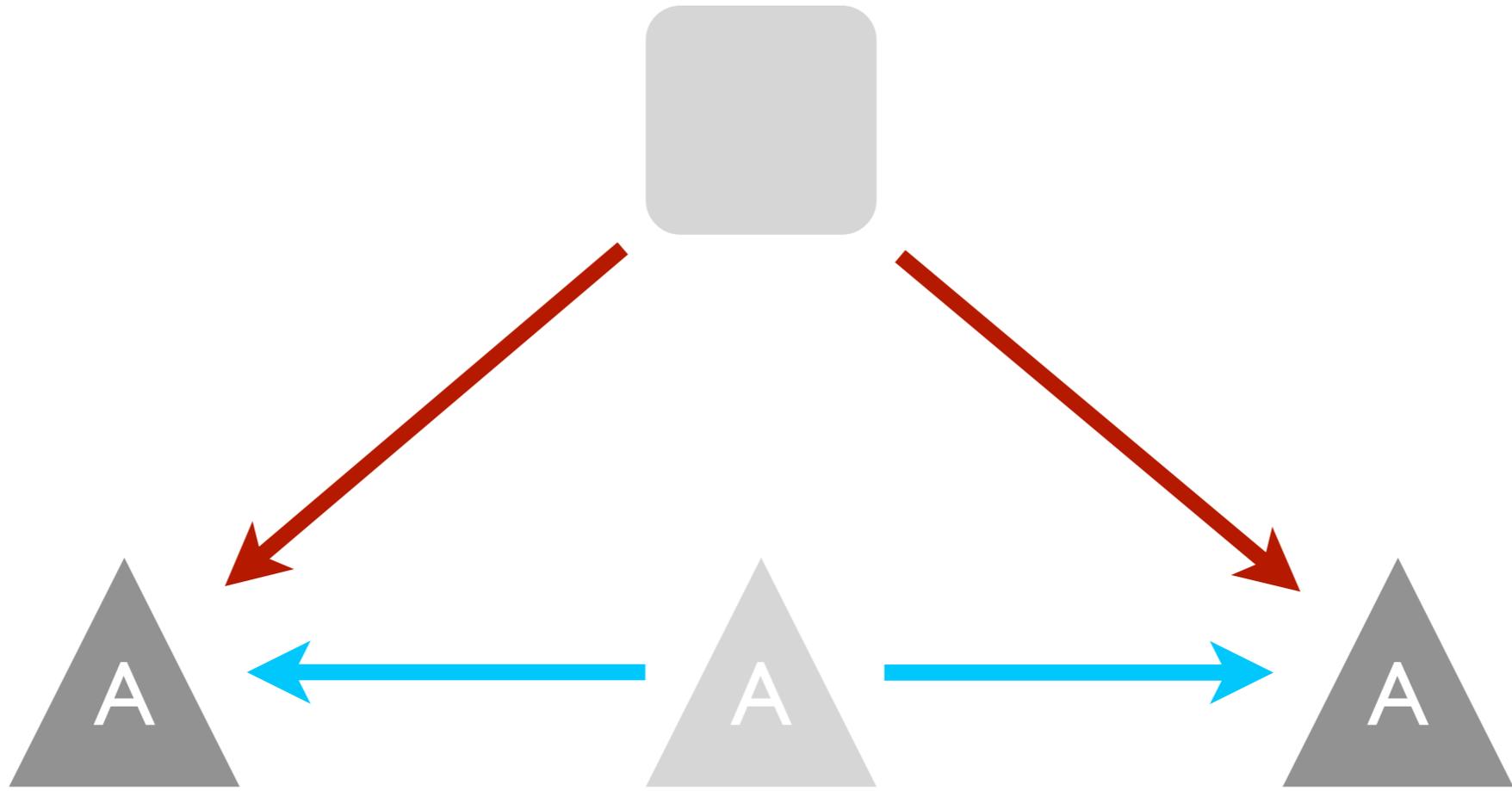


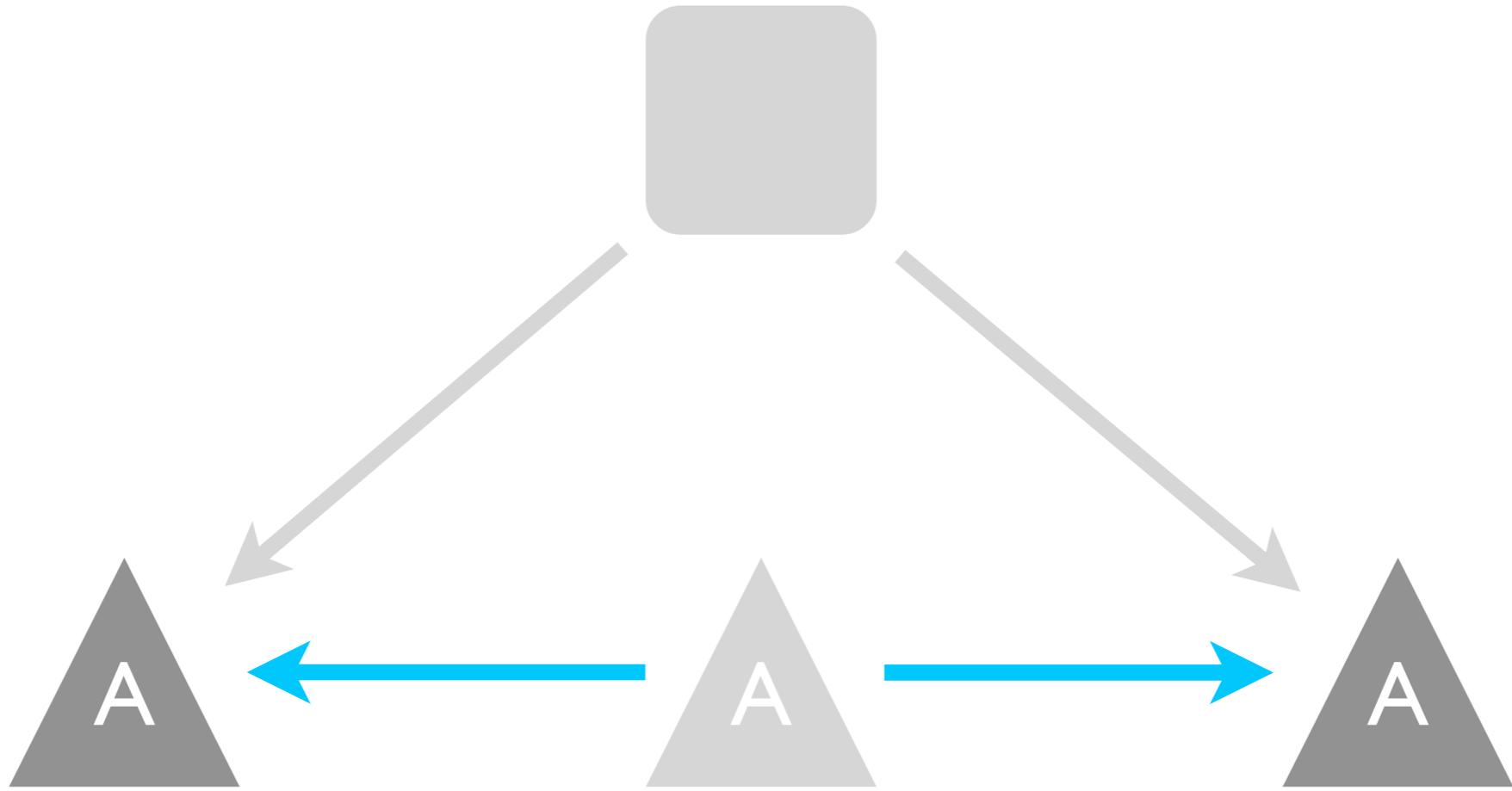
neuron sorszáma

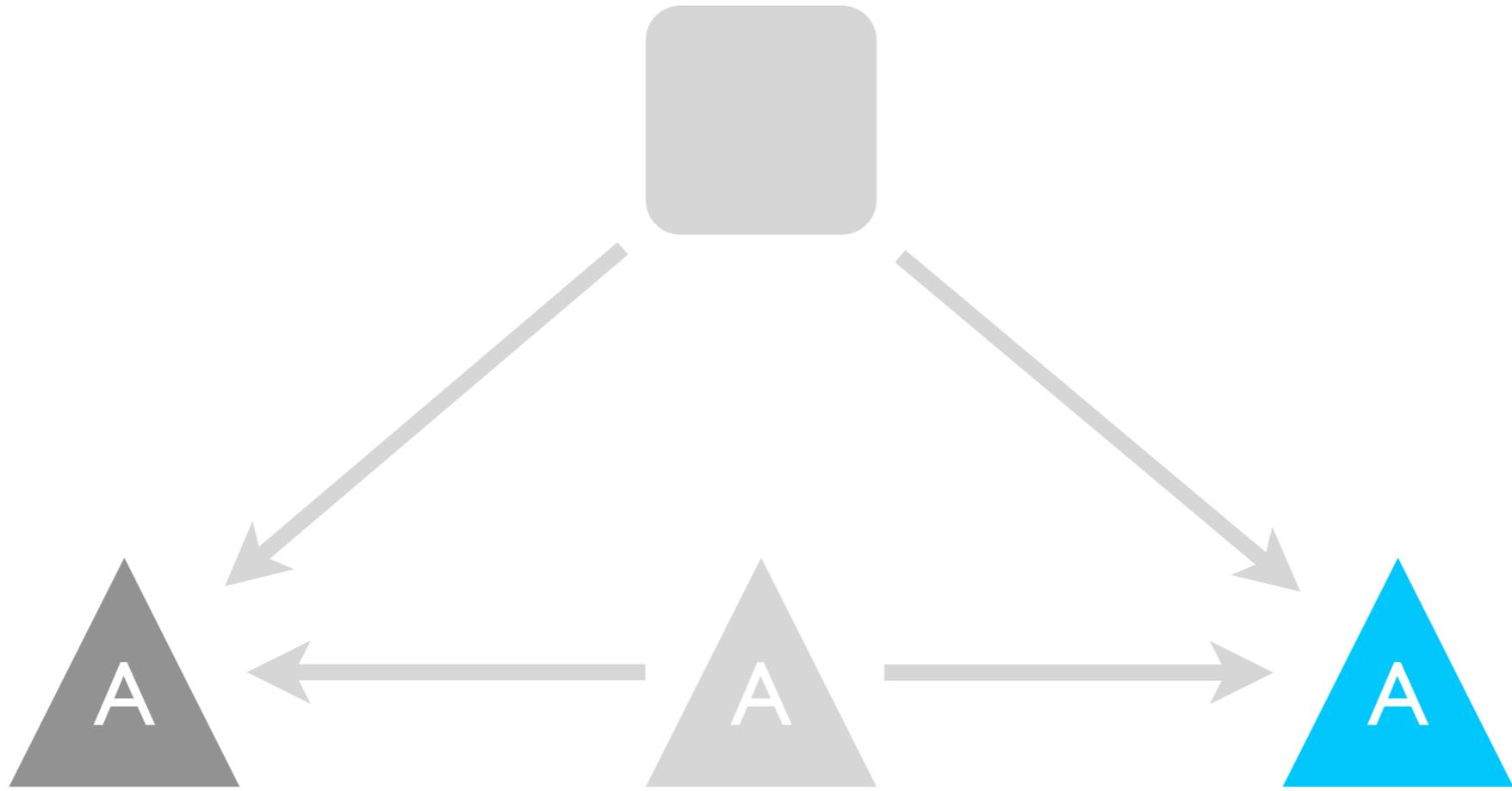


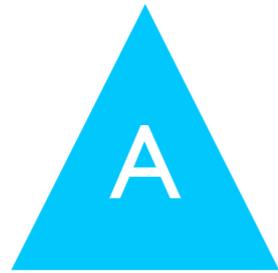








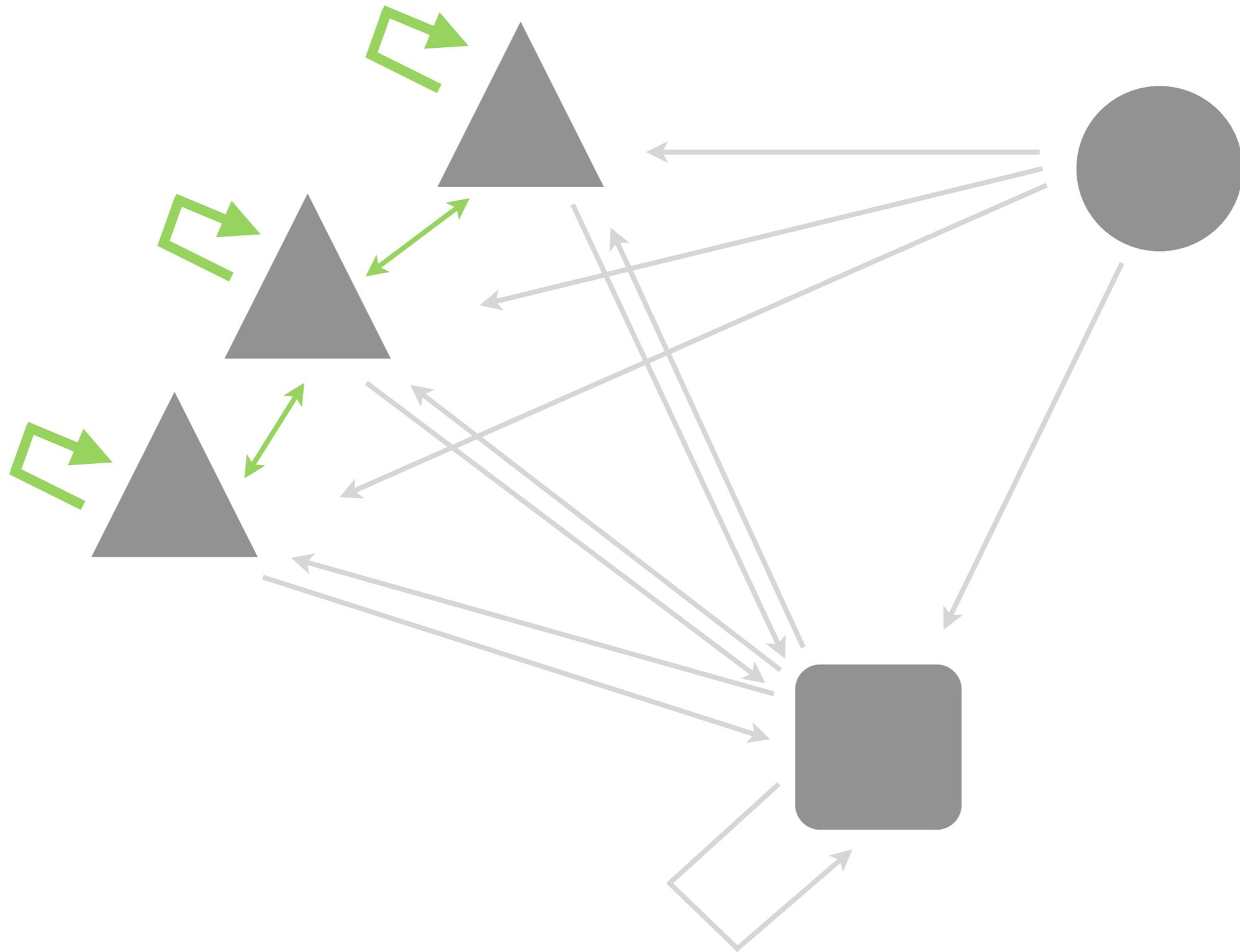


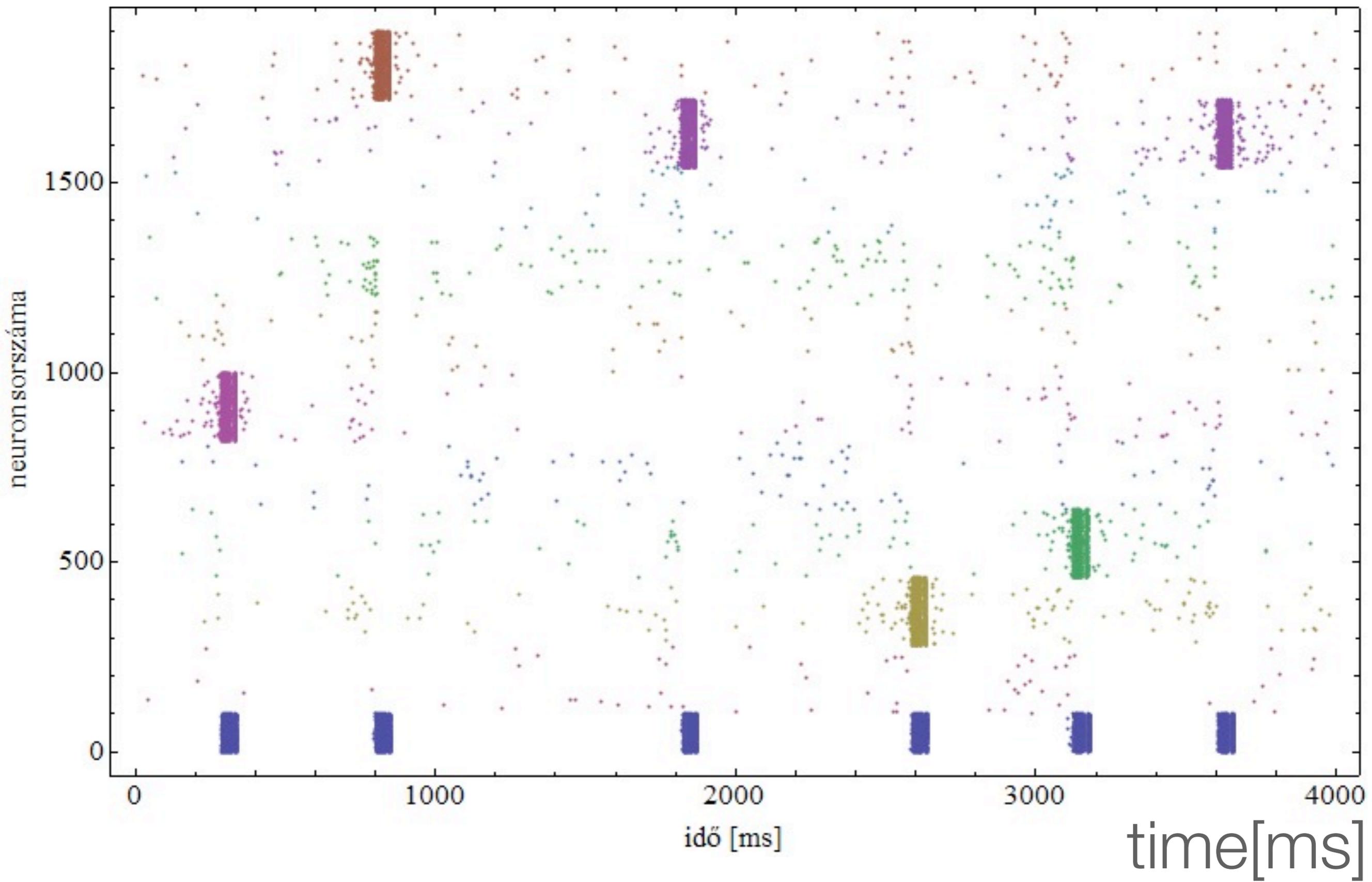


can be **ruled out**

synaptic depression

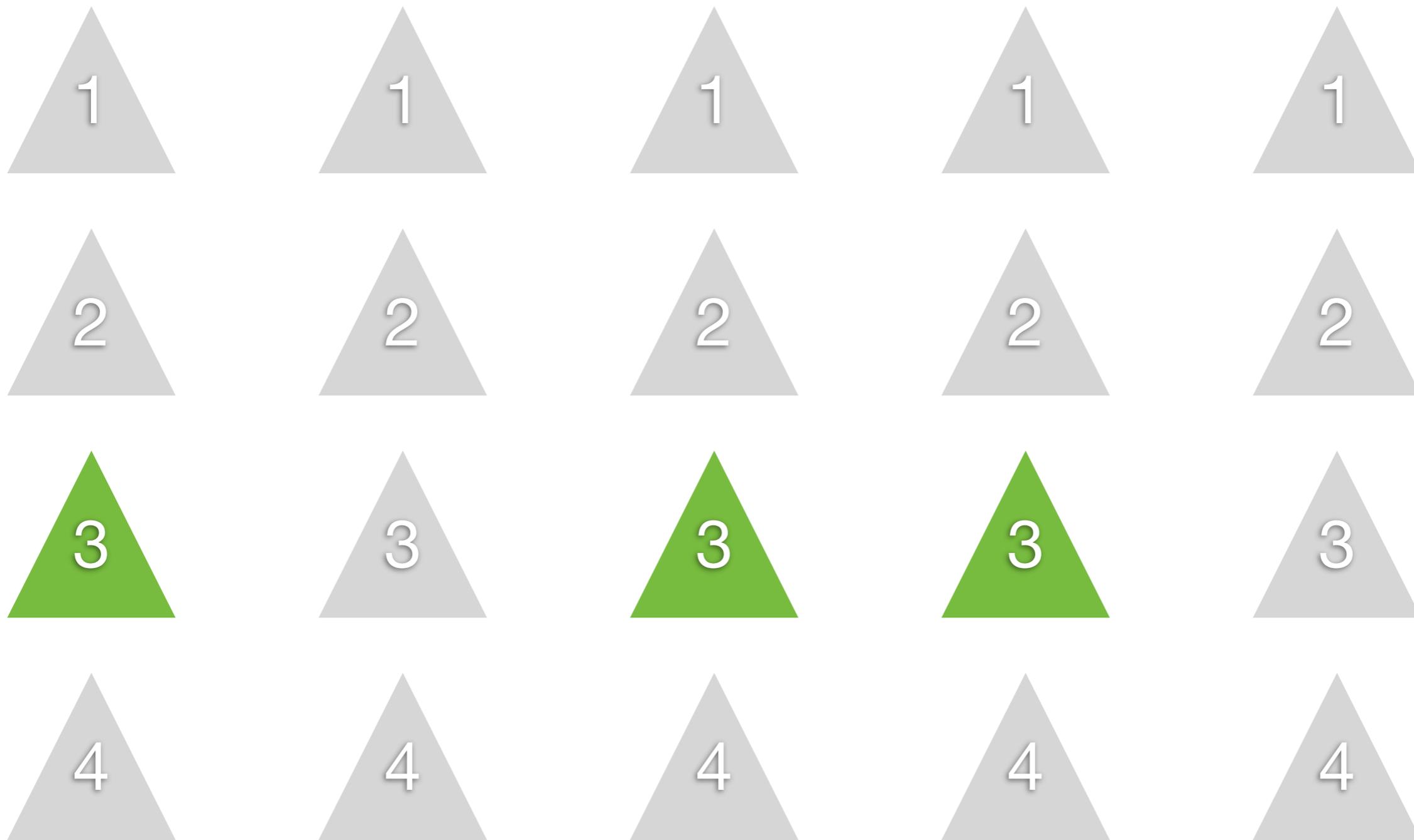






predictions

STSP parameters



time



sin

has to exist in CA3

A

conclusions

can be **ruled out** on theoretical grounds

critically depends on the **same neuron** firing **multiple times** during an event

+

STSP must have the predicted parameters

synaptic depression



sin

has to exist in CA3

A

can be **ruled out** on theoretical grounds

critically depends on the **same neuron** firing **multiple times** during an event

+

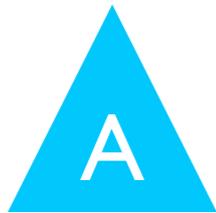
STSP must have the predicted parameters

synaptic depression





has to exist in CA3



can be **ruled out** on theoretical grounds

critically depends on the **same neuron** firing **multiple times** during an event

+

STSP must have the predicted parameters

synaptic depression



sin

has to exist in CA3

A

can be **ruled out** on theoretical grounds

critically depends on the **same neuron** firing **multiple times** during an event

+

STSP must have the predicted parameters

synaptic depression 

acknowledgements

Attila I. Gulyás

Rita Karlócai

Zsolt Kohus

Dániel Schlingloff

Norbert Hájos

Tamás F. Freund