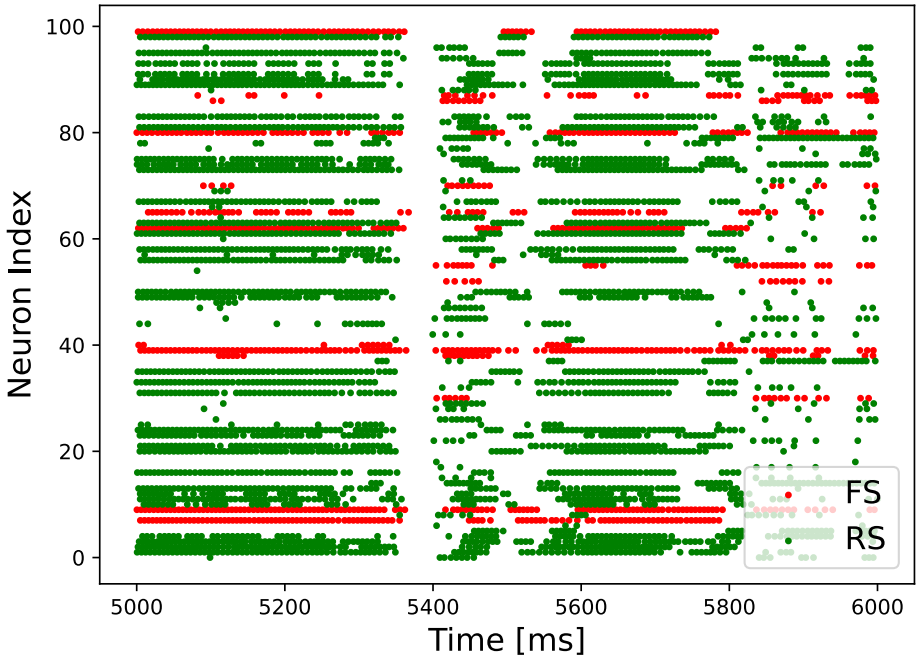
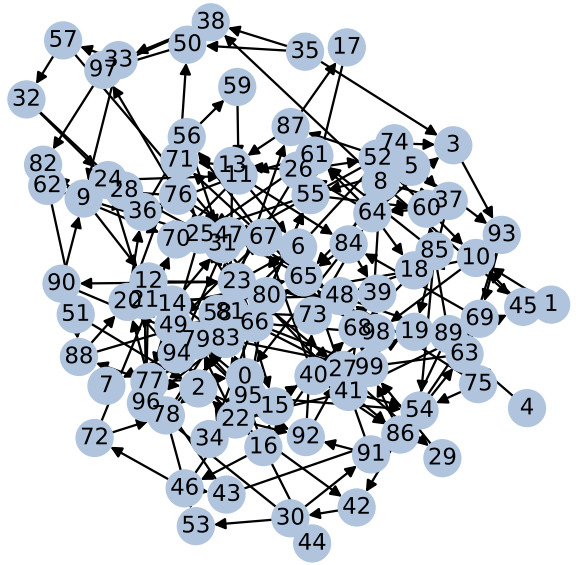
From Raster to Graph

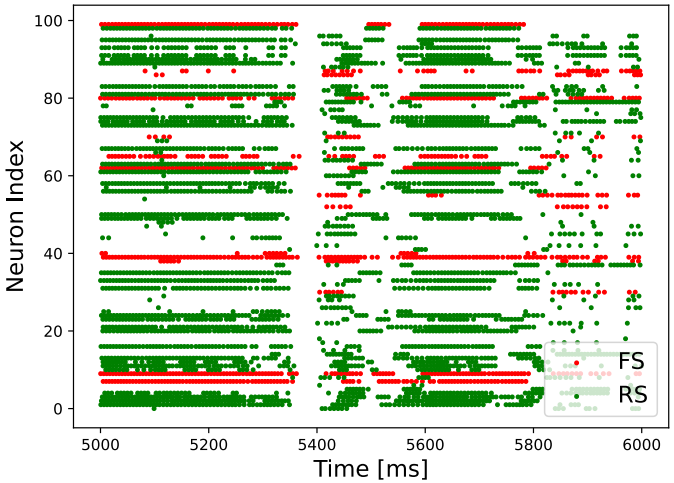
Evaluating the impact of network synchrony and topology on functional connectivity inference



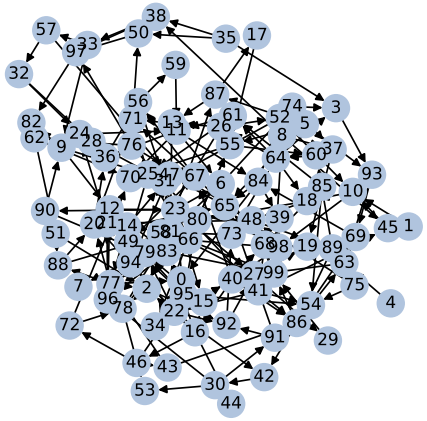


From Raster to Graph to ROC

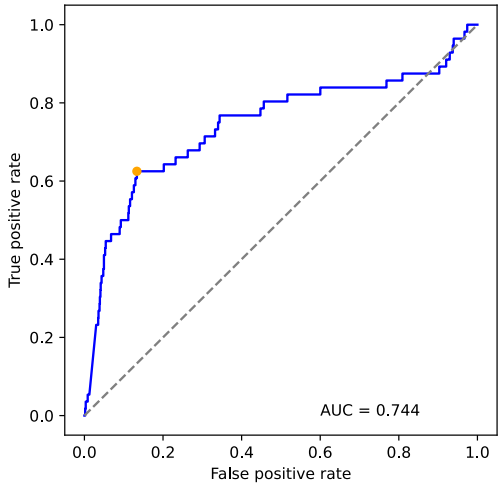
Evaluating the impact of network synchrony and topology on functional connectivity inference



Simulate neuronal networks
with aEIF model.[1]



Learn the connectivity – via
functional connectivity inference
by cross-correlation.[2]



Evaluate the performance.

Hypothesis: Synchrony = Loss of Information

[1] Brette et al. [2007]

[2] English et al. [2017]

Neuron Model with adaptive-Exponential Integrate-and-Fire neurons[1]

Governing Equations for each neuron

$$C\frac{dV}{dt} = \underbrace{-g_L(V-E_L)}_{\text{leak current}} + \overbrace{g_L\Delta_T \exp\left\{\frac{V-V_T}{\Delta_T}\right\}}^{\text{activation of Na-channels}} \underbrace{-w}_{\text{adaption current}} \overbrace{+I}^{\text{input current}}$$

$$\tau_w \frac{dw}{dt} = a(V-E_L) - w.$$

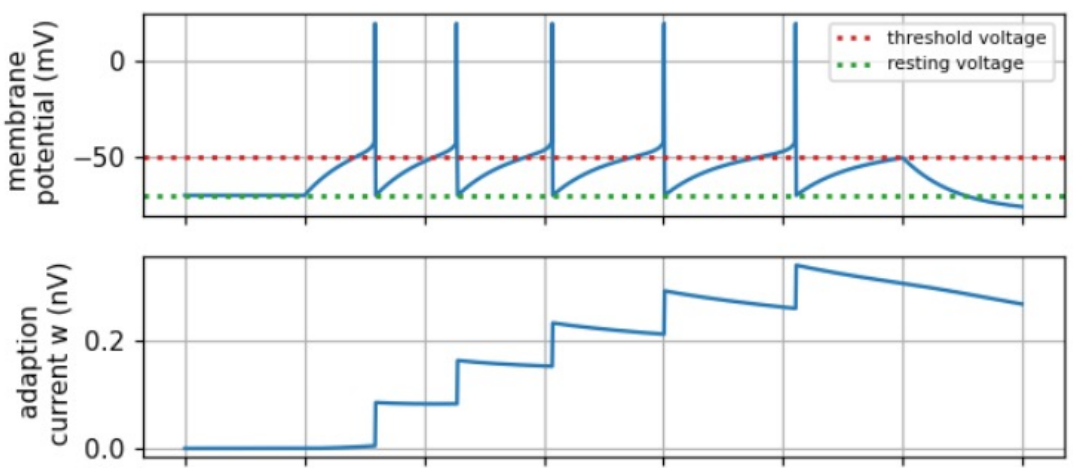
add b to w if spiked

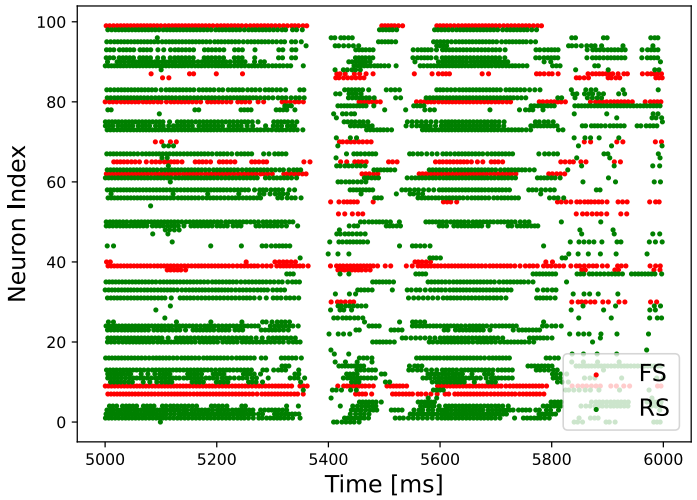
C	membrane capacitance
g_L	leak conductance
E_L	leak reversal potential
V_T	spike threshold
Δ_T	slope factor
τ_w	adaptation time constant
a	subthreshold adaptation
b	spike-triggered adaptation

Cell Types:

- excitatory regular spiking (RS)
  $a_e = a$, $b_e = b$
  g_e
- inhibitory fast spiking (FS)
  $a_i = 0$, $b_i = 0$
  g_i

Parameters based on Susin and Destexhe [2021]

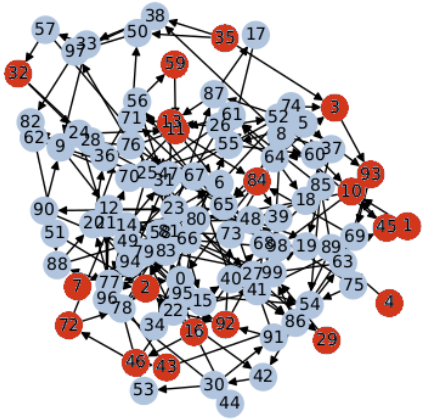




[1] Brette et al. [2007]

Network Setup

1)
generate
random
graph



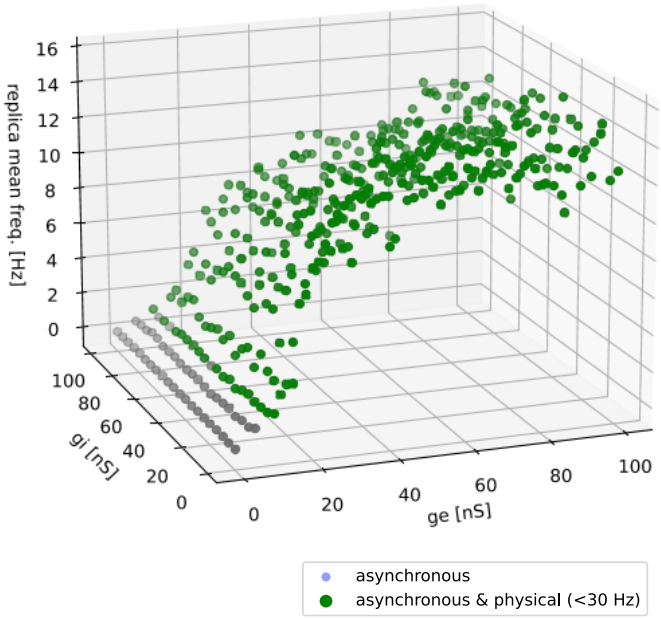
N=100
RS (80%)
FS (20%)

2)
parametric
search in:

2.1)
conductance space (g_e, g_i)

for physical:

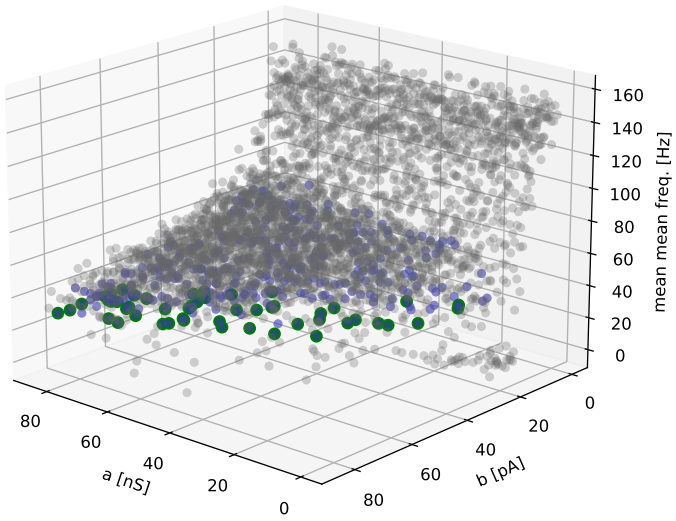
Firing frequency 1-30 *Hz*



2.2)
adaptation space (a, b)

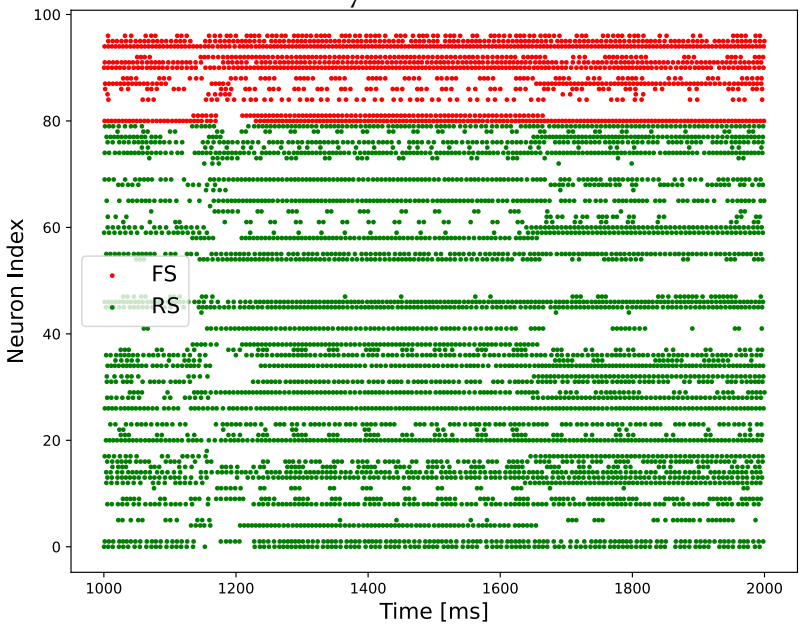
for asynchronous:

Pairwise correlation < 0.1
Coefficient of variation > 1



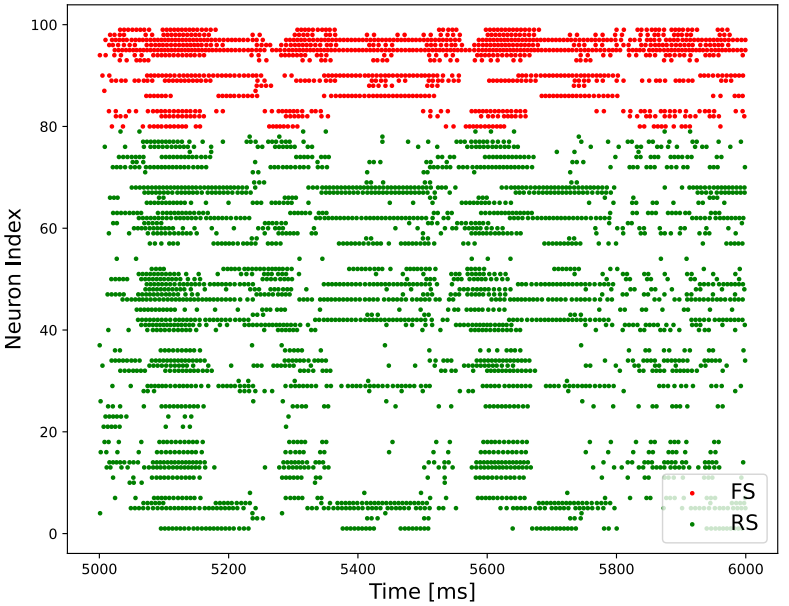
Network Setup: extrema of synchrony

synchronous



(a, b) = (5 nS, 14 pA)
(ge, gi) = (40, 80) nS

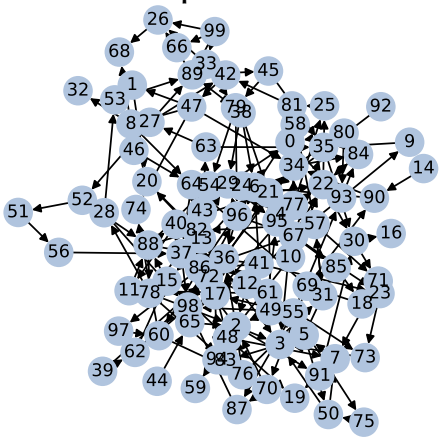
asynchronous



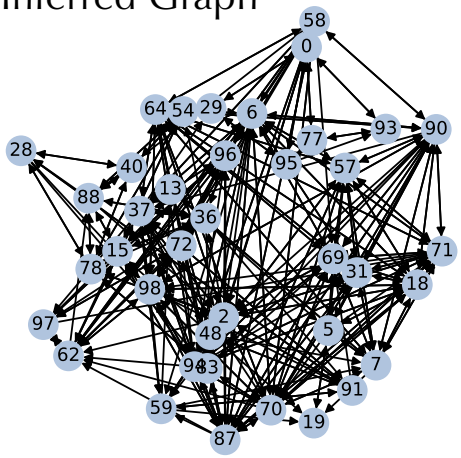
(a, b) = (28 nS, 21 pA)
(ge, gi) = (40, 80) nS

Impact of Synchrony on Functional Connectivity Inference

True Graph



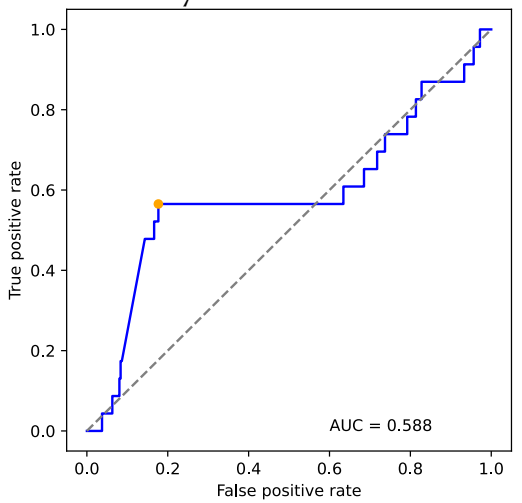
Inferred Graph



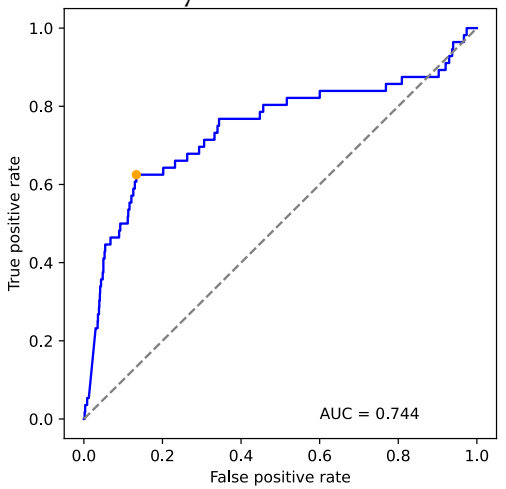
Compute Receiver Operator Curve (ROC)

For each condition

synchronous



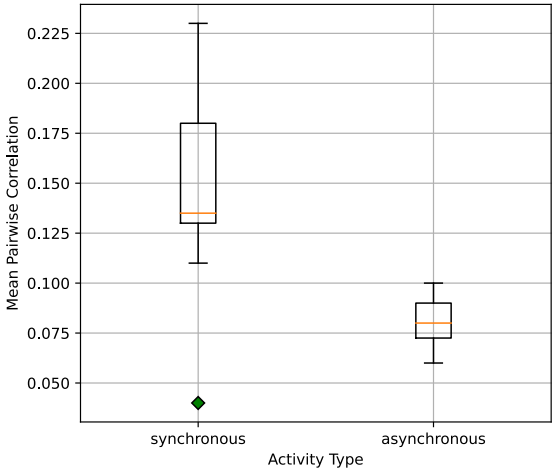
asynchronous



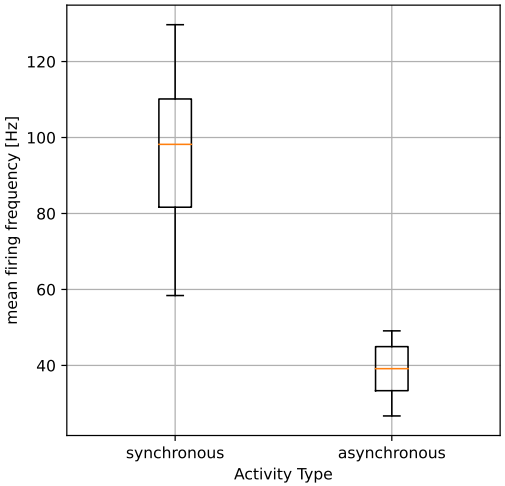
Repeat for quantitative statements

Impact of Synchrony on Functional Connectivity Inference

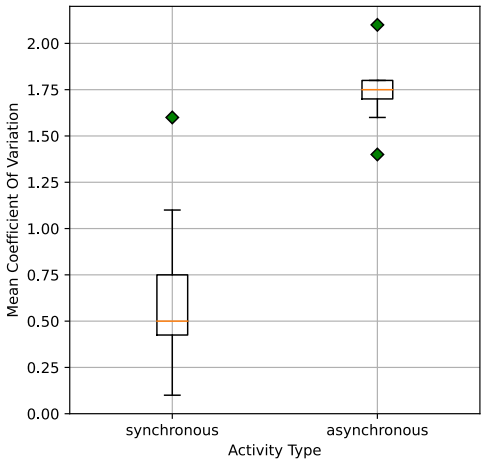
correlation



firing frequency

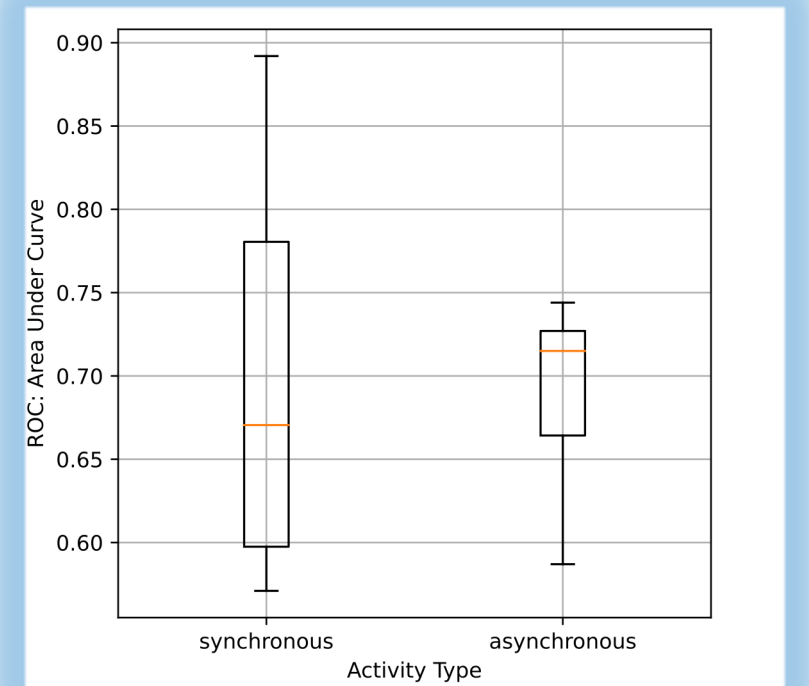


coefficient of variation



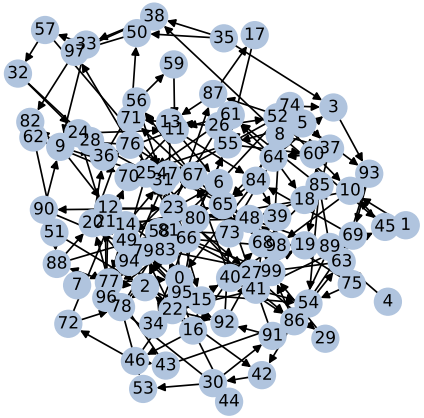
Simulations of the two groups (each n=12) are indeed different.

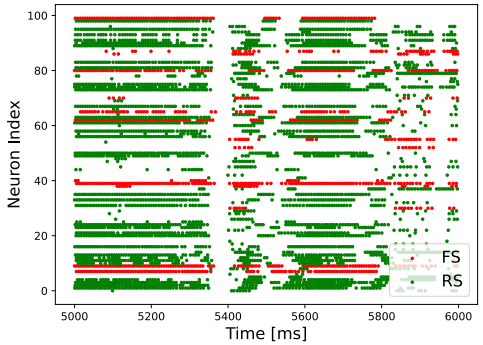
Synchrony = Loss of Information ?



No sig. difference in inference performance.

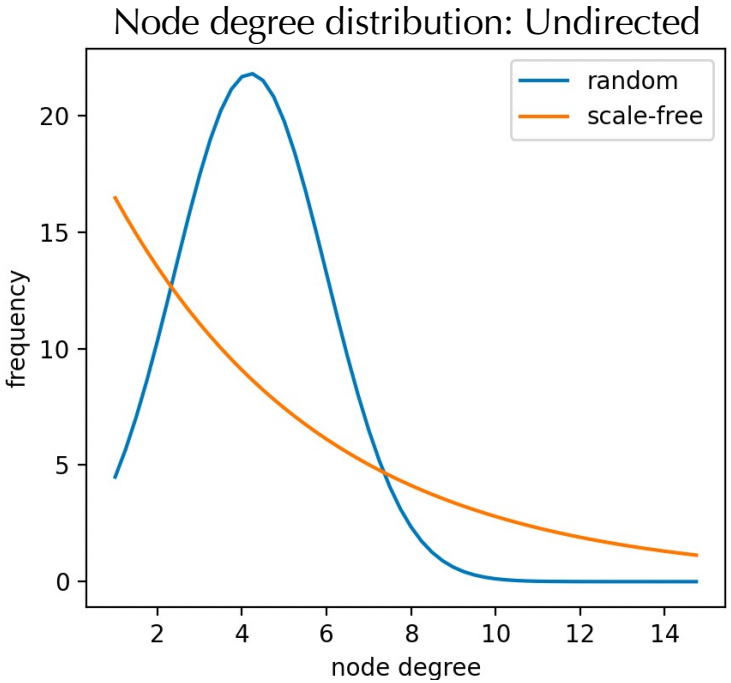
Impact of Topology on network activity

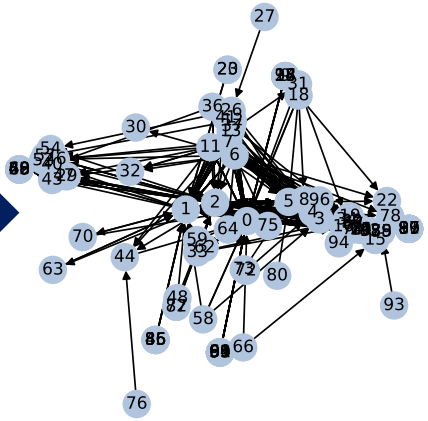


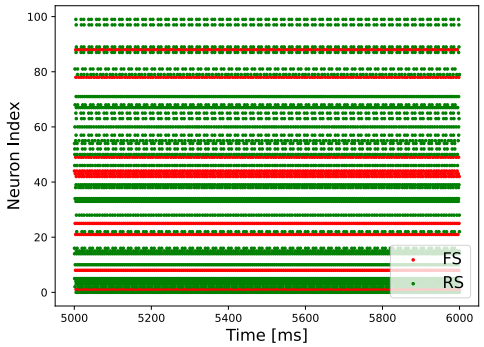


Hypothesis:
More Scale-Free networks are more synchronous.

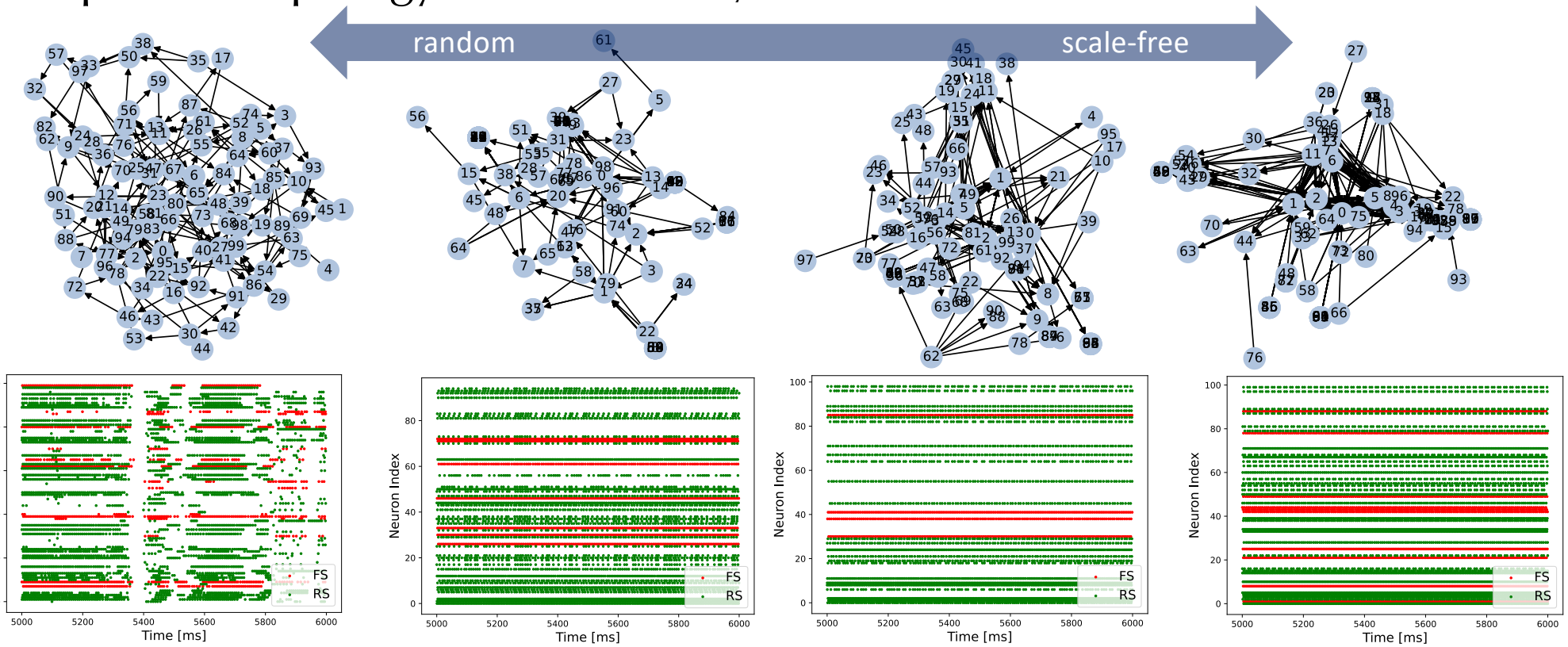
random ⟷ scale-free







Impact of Topology on network activity



	random	scale-rich	intermediate	scale-free
mean firing frequency [Hz]	85.252	109.7	120.9	133.7
mean coefficient of variation	0.14	0.21	0.22	0.31
mean pairwise correlation	0.96	0.2	0.2	0.1

Interesting trends to investigate!
Software is ready.

Conclusion

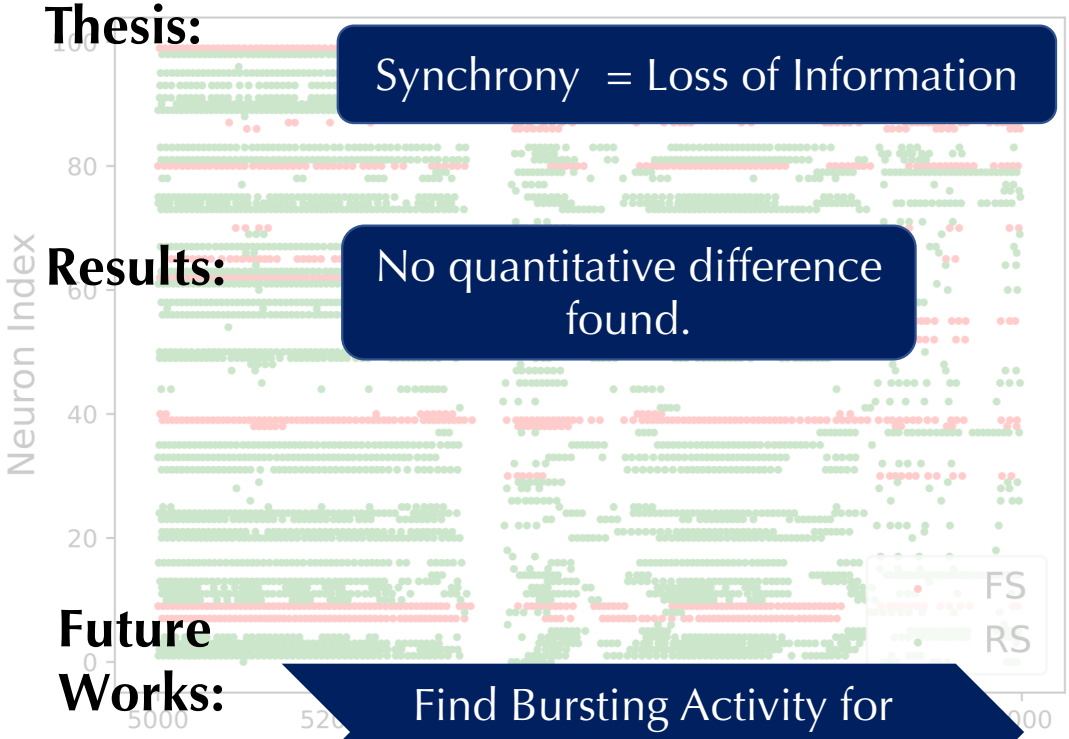
Synchrony

Thesis:

Synchrony = Loss of Information

Results:

No quantitative difference found.



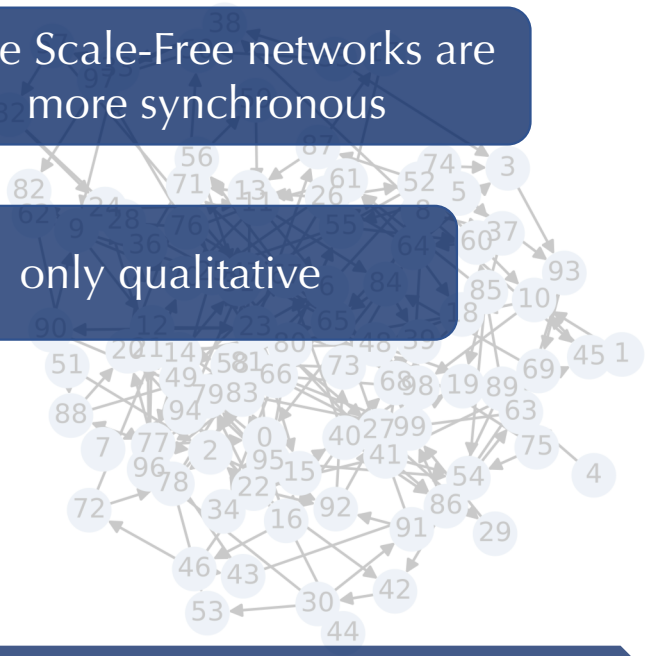
Future Works:

Find Bursting Activity for Small-Networks.

Topology

More Scale-Free networks are more synchronous

only qualitative



Software ready to go quantitative.

Thanks for welcoming me into

bel.ethz.ch !
bio engineering laboratory