

# M1 Layer 2/3 Network Summary

Oct 1, 2024

## Single Cells

We will use a 87,9,4 ratios for PN,FSI and LTS cells in our model. The ratio of excitatory:inhibitory neurons is 87:13[9]. The FSI:LTS cells ratio is 70:30[7][14]. The network consists of 10,000 cells, the same size as Ziao's model. The PN cell was adapted from the L5 CP cell to make it more L2/3-like[4]. The interneurons use the same template as the L5 model.

Table 1: Cell properties

Cell	Apical Length (um)	V-Rest (mV)	R_in (Mohms)	Tau_m (ms)	Rheobase (pA)	FI curve slope
PN:	324[8]	-77.11[4]	112.85[4]	14.87[4]	200[4]	~100[4]
FSI:	*150	-69.94[13]	223.12[13]	12.03[13]	40	~500
LTS:	*250	-70.00[13]	289.81[13]	19.43[13]	40	~160

\*The FSI and LTS cells are not modeled with apical dendrites, so the basal dendrite lengths are given instead.

## Synapses

The synapses are mostly the same as Ziao's L5 model except the reversal potential of the FSI2PN and LTS2PN synapses has been updated to -75mV to better match biological data[1]. There is also slightly better fitting to the synaptic properties from the literature.

Table 2: Synaptic Properties from literature

Cell Pair	latency	amp	rise time	decay time	half width	PPR
PN2PN	1.6±0.3[11]	32.2±27.4[11]	1.2±0.45[11]	6.9±1.9[11]	12.3±2.2[1]	1.27±0.34[11]
PN2FSI	1.3±0.38[10]	32.0±25.5[10]	0.56±0.18[10]	3.6±1.2[10]	4.9±1.6[1]	1[10]
PN2LTS	1.5±0.51[10]	4.6±3.5[10]	1.2±0.47[10]	5.1±2.0[10]	8.9±2.9[1]	2[10]
FSI2PN	NA	1.1±0.8[1]	1.5±0.7[1]	NA	24±10.8[1]	NA
LTS2PN	NA	0.48±0.45[1]	2.1±1.0[1]	NA	22.6±13.7[1]	NA
FSI2FSI	NA	23.9±7.8pA[3]	0.89±0.04[3]	5.9±0.5[3]	NA	0.66[3]
LTS2FSI						
FSI2LTS						
LTS2LTS						

Table 3: Synaptic Properties in Network

Cell Pair	baseline	sign	latency	amp	rise time	decay time	half width	PPR
PN2PN	0.1734	-1.0000	1.6500	0.0155	1.2000	7.1844	10.1000	1.3474
PN2FSI	0.0376	-1.0000	1.6500	0.0077	0.5500	3.6355	4.9500	0.9974
PN2LTS	0.0345	-1.0000	1.6500	0.0026	1.2000	5.1287	6.9000	2.2518
FSI2PN	0.1734	1.0000	0.0250	0.0171	1.0500	7.6791	8.5750	1.0398
FSI2FSI	-0.0691	1.0000	1.6500	0.0750	0.8500	5.4614	7.2750	0.7276
FSI2LTS	0.0345	1.0000	1.6500	0.0675	0.3250	5.0295	5.8500	0.7252
LTS2PN	0.1734	1.0000	0.0250	0.0043	1.1250	31.5004	24.7750	2.1033
LTS2FSI	-0.0691	1.0000	1.6500	0.0060	1.4250	20.1433	18.8250	1.7405
LTS2LTS	0.0345	1.0000	1.6500	0.0113	1.4250	20.1433	18.8250	1.7405

Table 4: Synaptic Parameters Used in Synaptic Templates

Cell Pair	initW	tau r AMPA	tau d AMPA	Use	Dep	Fac	level of detail	e
PN2PN	3.2000	0.2000	5.2000	0.3700	31.7000	519.0000	AMPA NMDA STP	0
PN2FSI	3.5000	0.4000	2.9000	0.0350	500.0000	0.0000	AMPA NMDA STP	0
PN2LTS	1.0000	0.4000	3.9000	0.0500	0.0000	200.0000	AMPA NMDA STP	0
FSI2PN	3.8000	1.4000	7.0000	0.3000	400.0000	0.0000	GABA AB STP	-75.0
FSI2FSI	10.0000	0.7000	5.2000	0.3000	400.0000	0.0000	GABA AB STP	-75.0
FSI2LTS	15.0000	0.2000	5.0000	0.3000	400.0000	0.0000	GABA AB STP	-75.0
LTS2PN	1.0000	0.9000	30.0000	0.3000	25.0000	200.0000	GABA AB STP	-75.0
LTS2FSI	0.8000	0.9000	20.0000	0.3000	25.0000	200.0000	GABA AB STP	-75.0
LTS2LTS	2.5000	0.9000	20.0000	0.3000	25.0000	200.0000	GABA AB STP	-75.0

## Connectivity

The network connectivity has been altered from Ziao's L5 model. The PN2PN[5], PN2FSI[5], FSI2PN[5], PN2LTS[12][6] and LTS2PN[2] connection functions have been modified based on L2/3 data. The interneuron to interneuron functions have not been altered. However since the cell ratios have been altered the same connection rules will give slightly different connection numbers.

# Probabilities not updated yet !

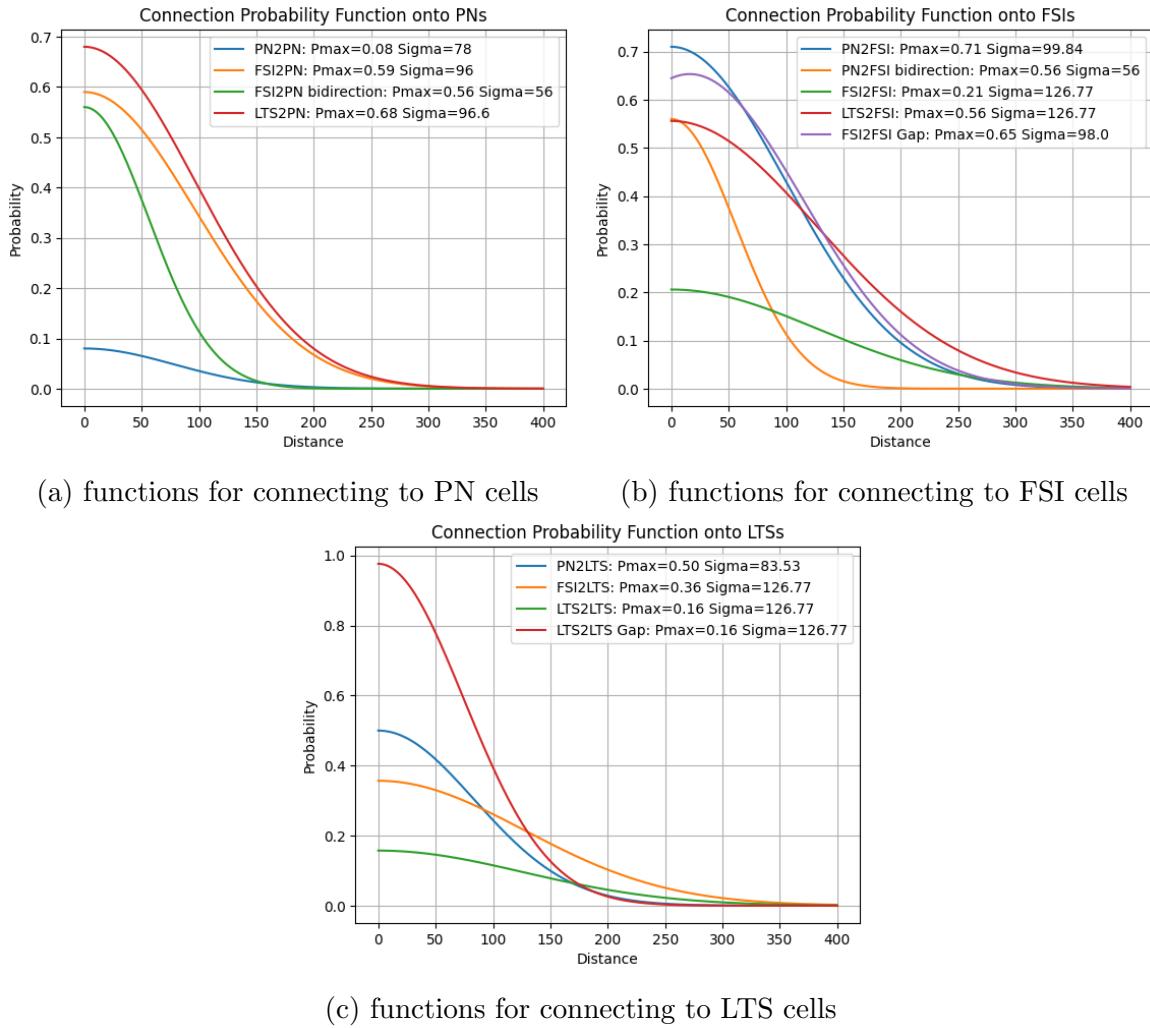
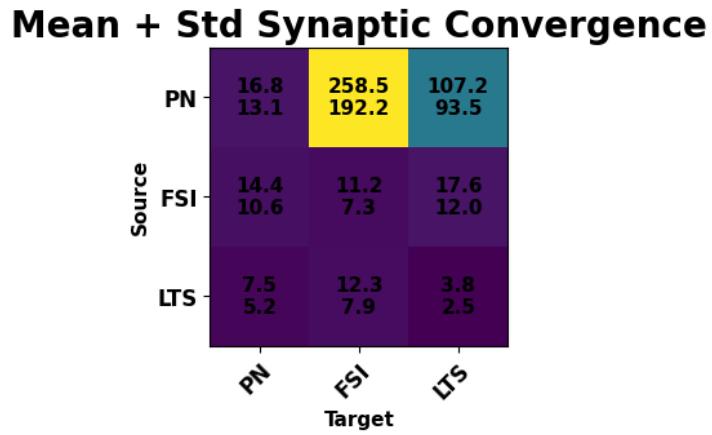
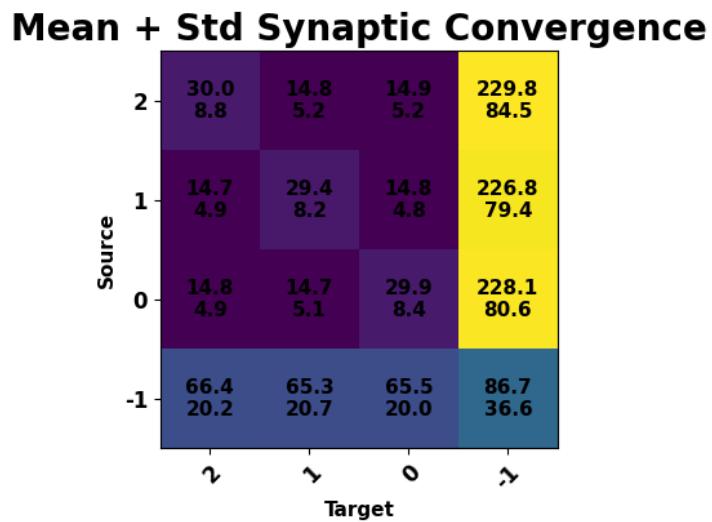


Figure 1: Gaussian connection functions for each cell type

(a) Biophysical Convergence



(b) Shell Convergence



(c) Assembly Convergence

Figure 2: Convergence Matrix

# NOT FIXED YET!

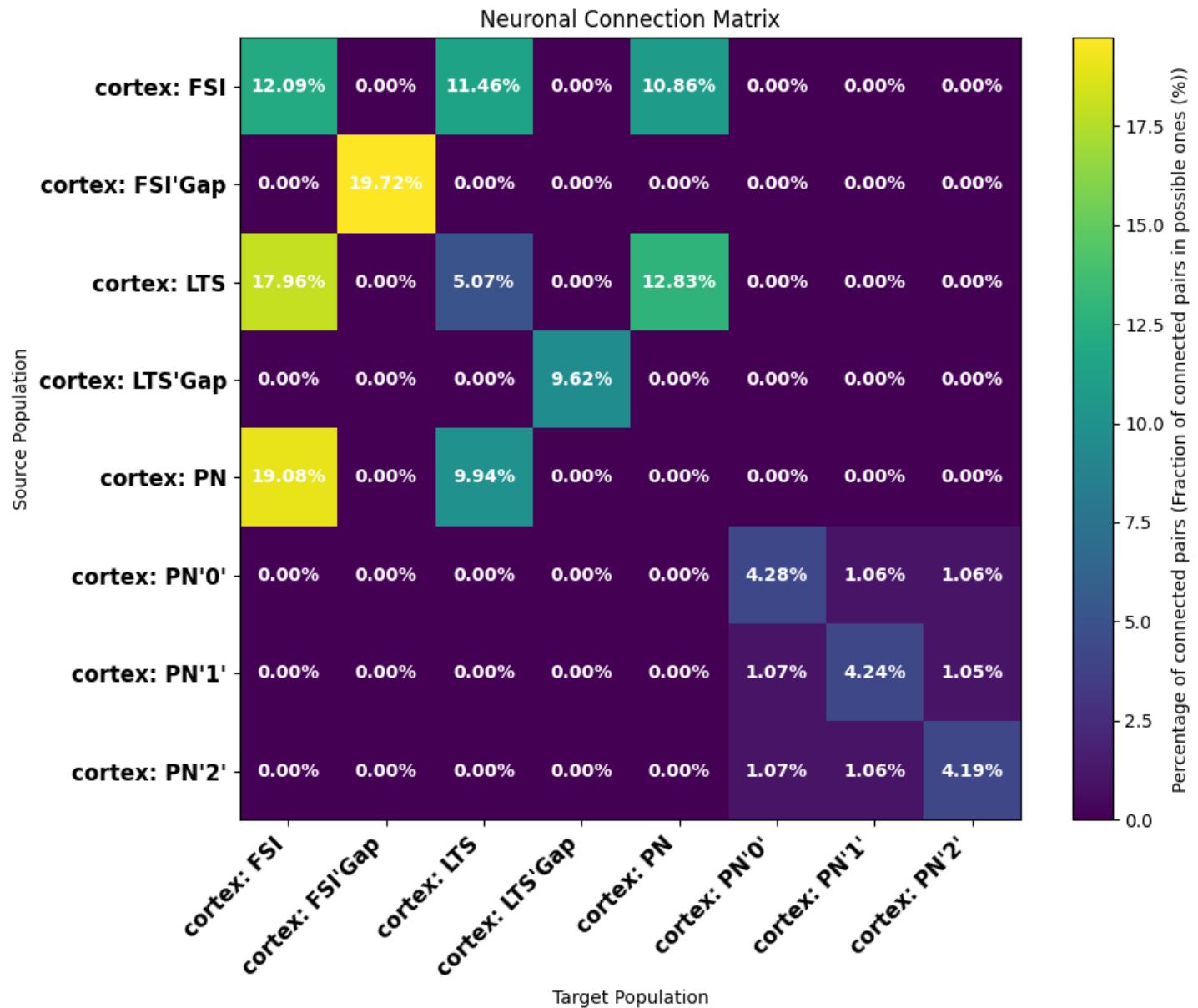
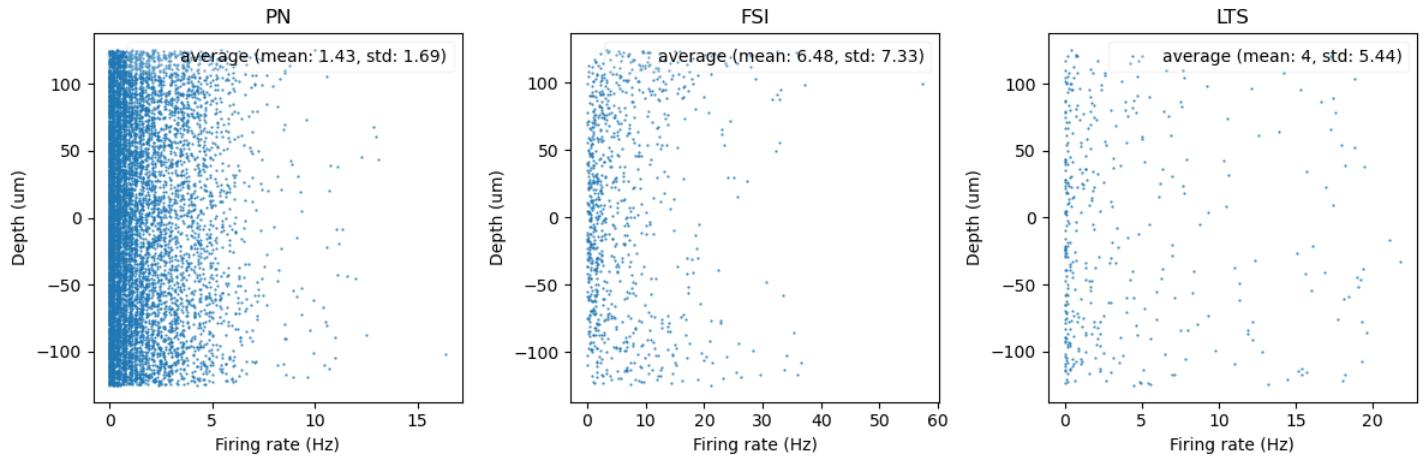


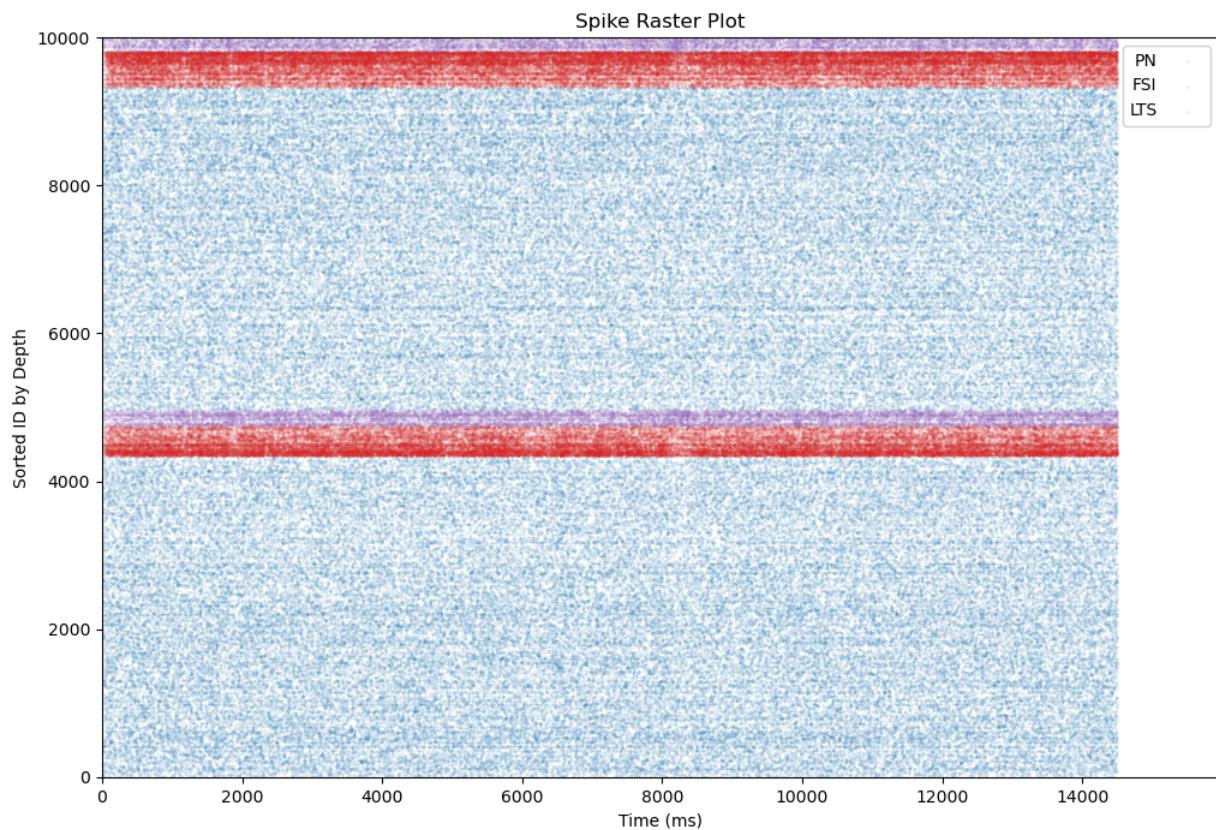
Figure 3: Percent Connectivity of Possible Connections (Factoring in Distance rules)

# Model Output

## Baseline



(a) Firing Rate during Baseline



(b) Raster

Figure 4: Firing Rate Analysis for Baseline

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## FOOOF - POWER SPECTRUM MODEL

The model was run on the frequency range 8 - 100 Hz  
Frequency Resolution is 2.00 Hz

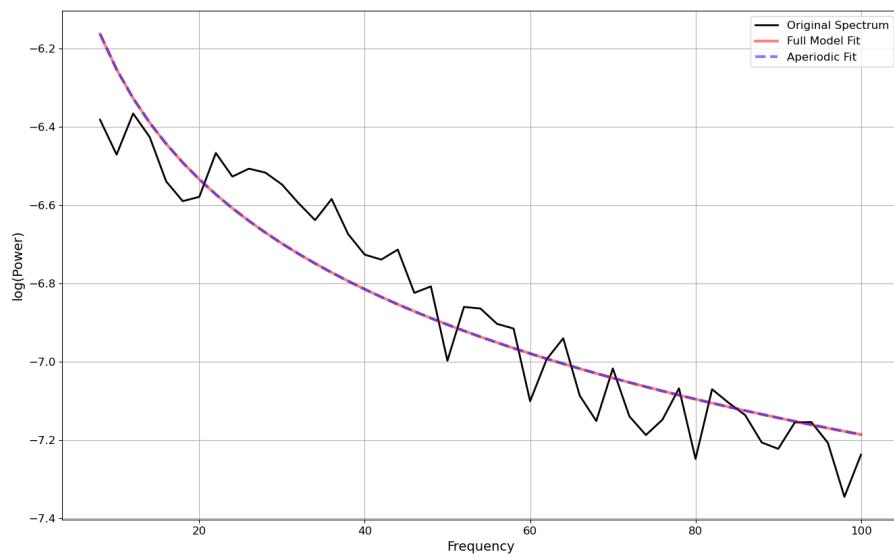
Aperiodic Parameters (offset, exponent):  
-5.3209, 0.9327

0 peaks were found:

Goodness of fit metrics:  
 $R^2$  of model fit is 0.8727  
Error of the fit is 0.0857

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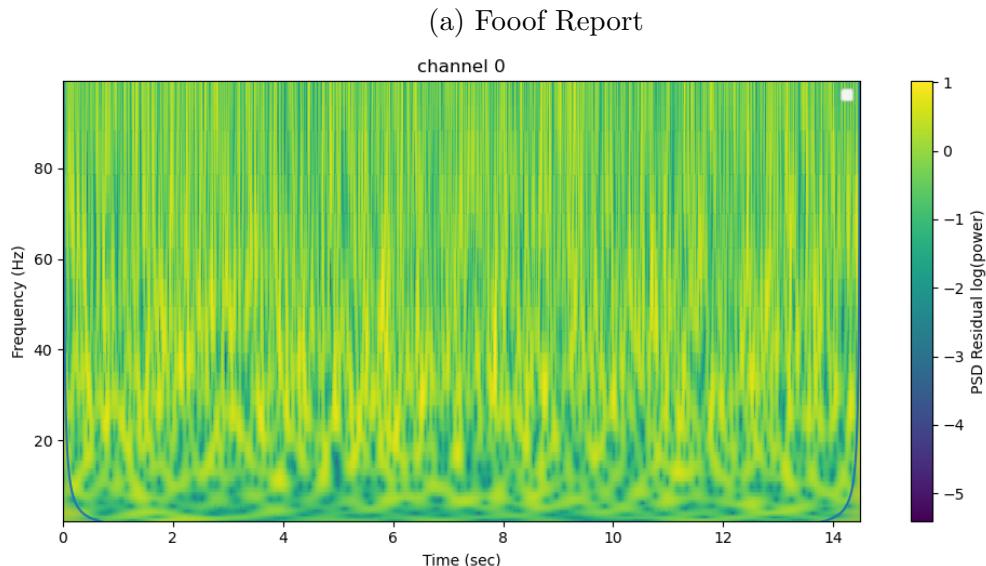
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## FOOOF - SETTINGS

Peak Width Limits : [4.0, 100.0]  
Max Number of Peaks : 10  
Minimum Peak Height : 0.3  
Peak Threshold: 0.0  
Aperiodic Mode : fixed

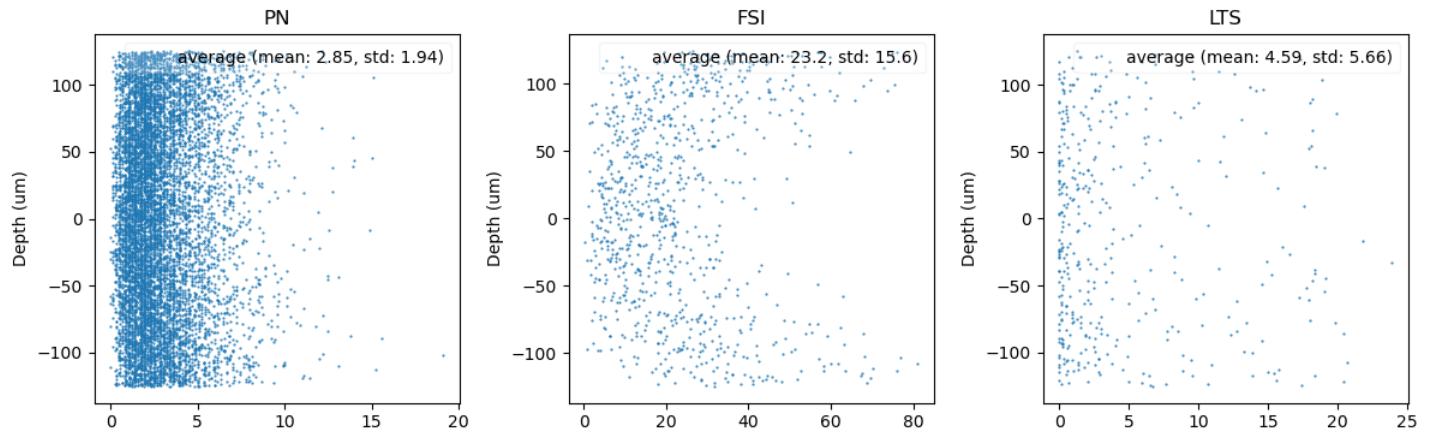
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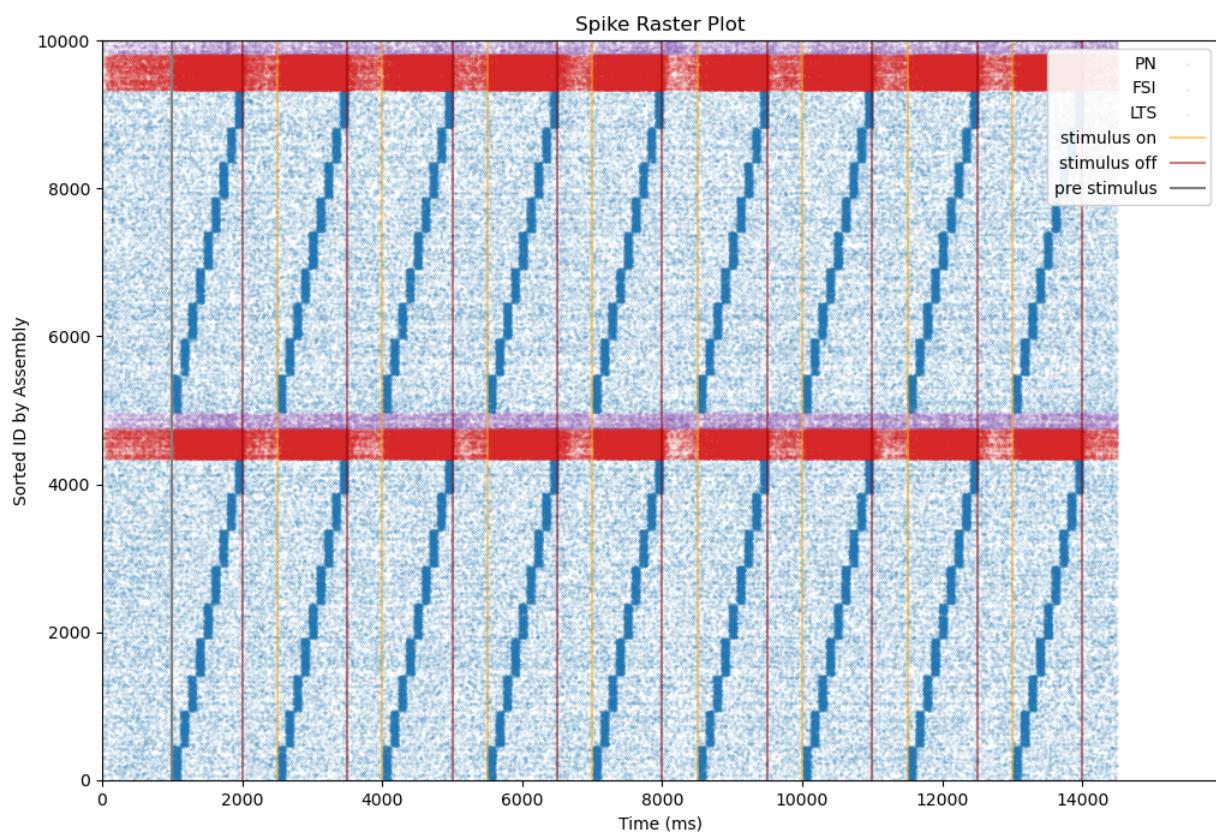


(b) Spectrogram

## Short Pulse



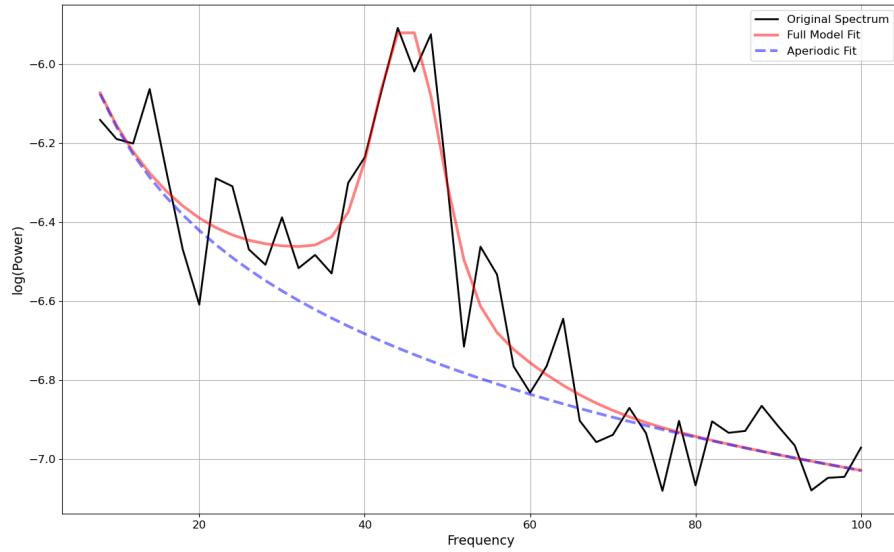
(a) Firing Rate during Short Pulse



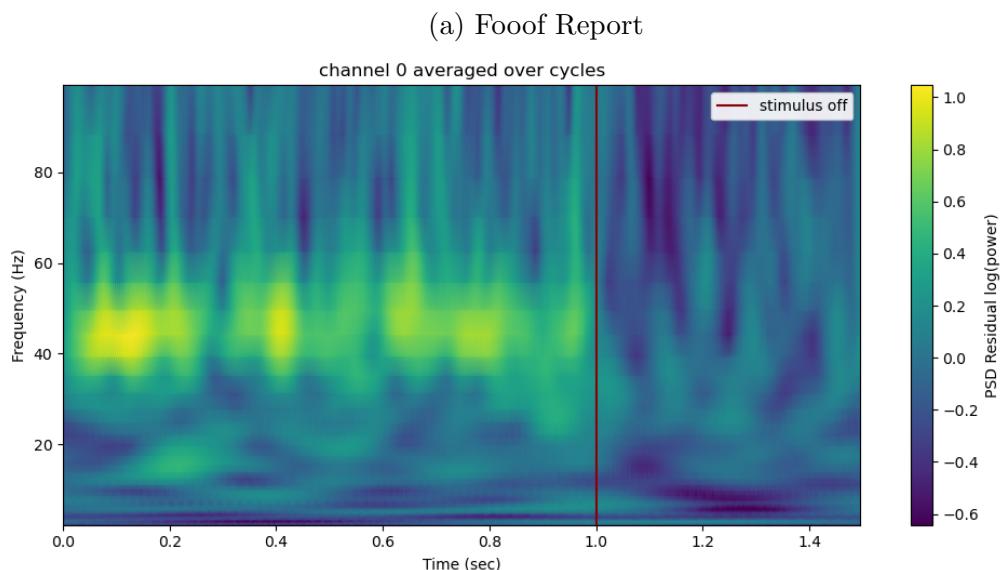
(b) Raster

Figure 6: Firing Rate Analysis for Short Pulse

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FOOOF - POWER SPECTRUM MODEL
The model was run on the frequency range 8 - 100 Hz
Frequency Resolution is 2.00 Hz
Aperiodic Parameters (offset, exponent):
-5.2910, 0.8686
2 peaks were found:
CF: 43.28, PW: 0.797, BW: 23.86
CF: 45.26, PW: 0.814, BW: 7.52
Goodness of fit metrics:
R^2 of model fit is 0.9242
Error of the fit is 0.0763
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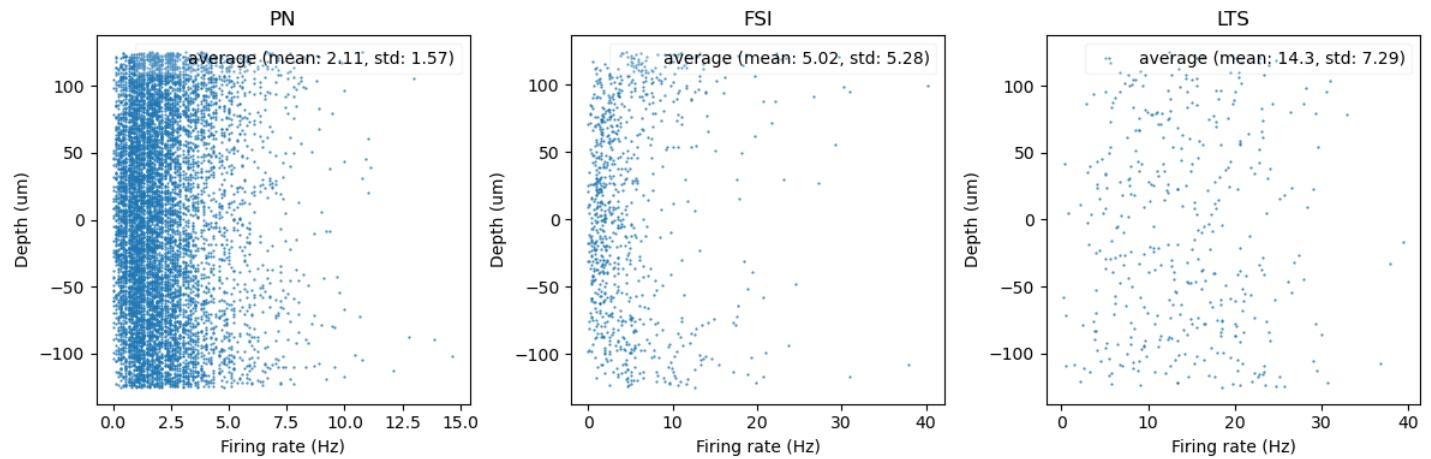


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FOOOF - SETTINGS
Peak Width Limits : [4.0, 100.0]
Max Number of Peaks : 10
Minimum Peak Height : 0.3
Peak Threshold: 0.0
Aperiodic Mode : fixed
=====
```

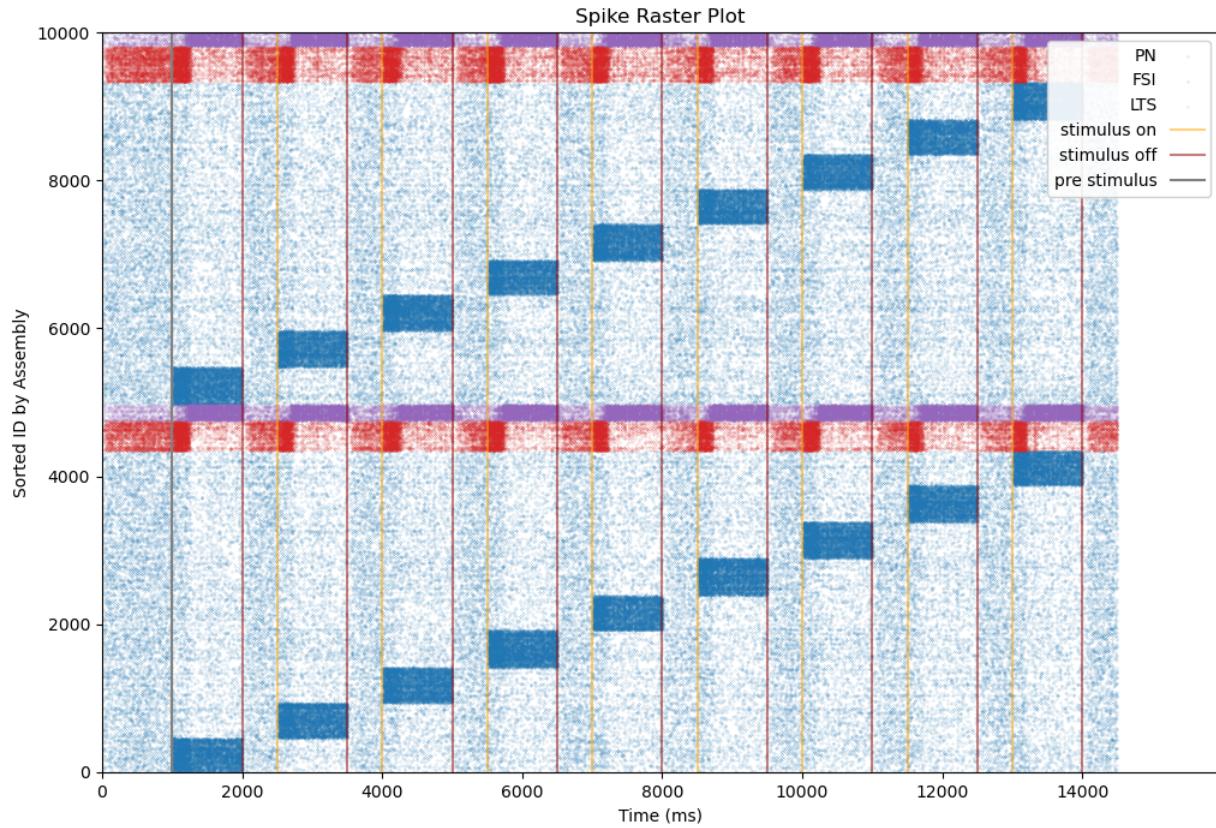


(b) Spectrogram

## Long Pulse



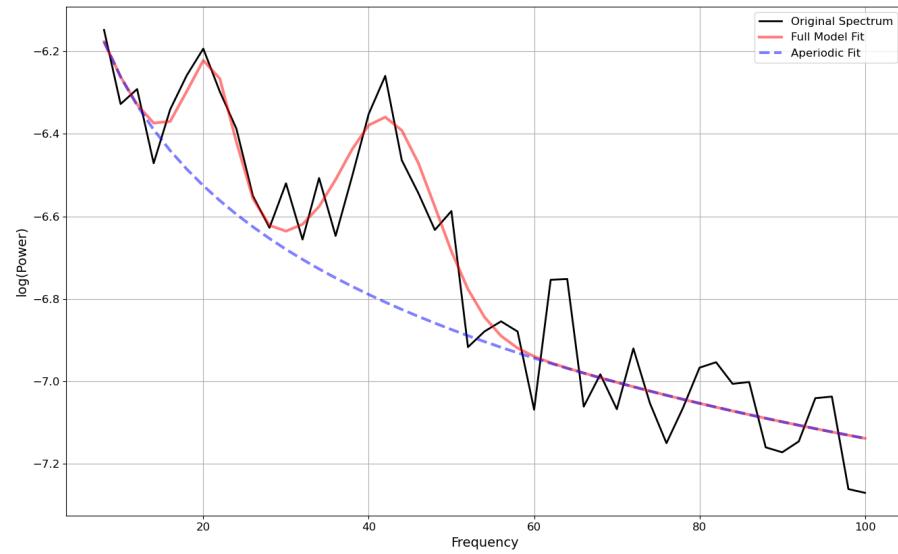
(a) Firing Rate during Long Pulse



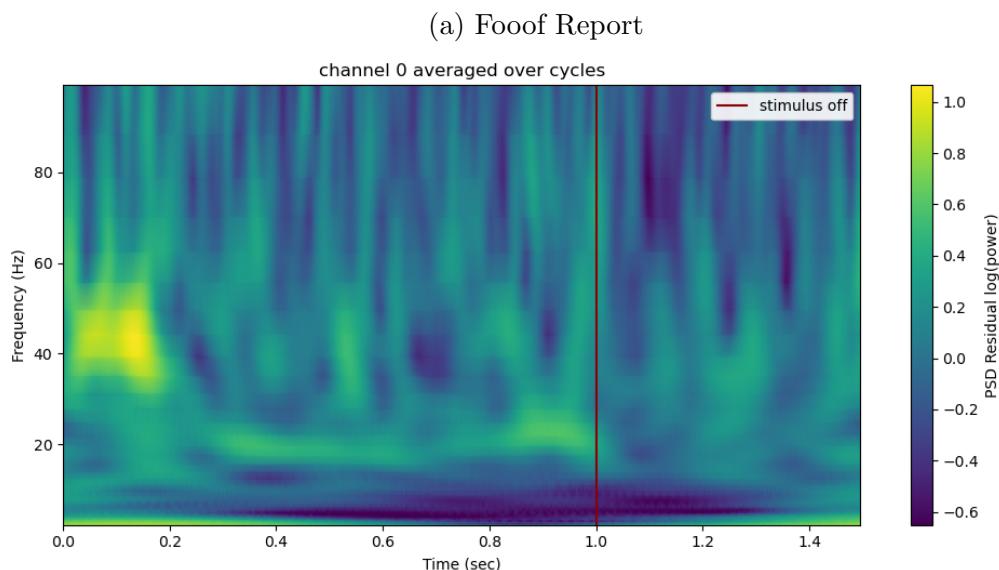
(b) Raster

Figure 8: Firing Rate Analysis for Long Pulse

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FOOOF - POWER SPECTRUM MODEL
The model was run on the frequency range 8 - 100 Hz
Frequency Resolution is 2.00 Hz
Aperiodic Parameters (offset, exponent):
-5.3855, 0.8764
2 peaks were found:
CF: 20.89, PW: 0.304, BW: 5.63
CF: 42.46, PW: 0.449, BW: 11.46
Goodness of fit metrics:
R^2 of model fit is 0.9292
Error of the fit is 0.0725
=====
```



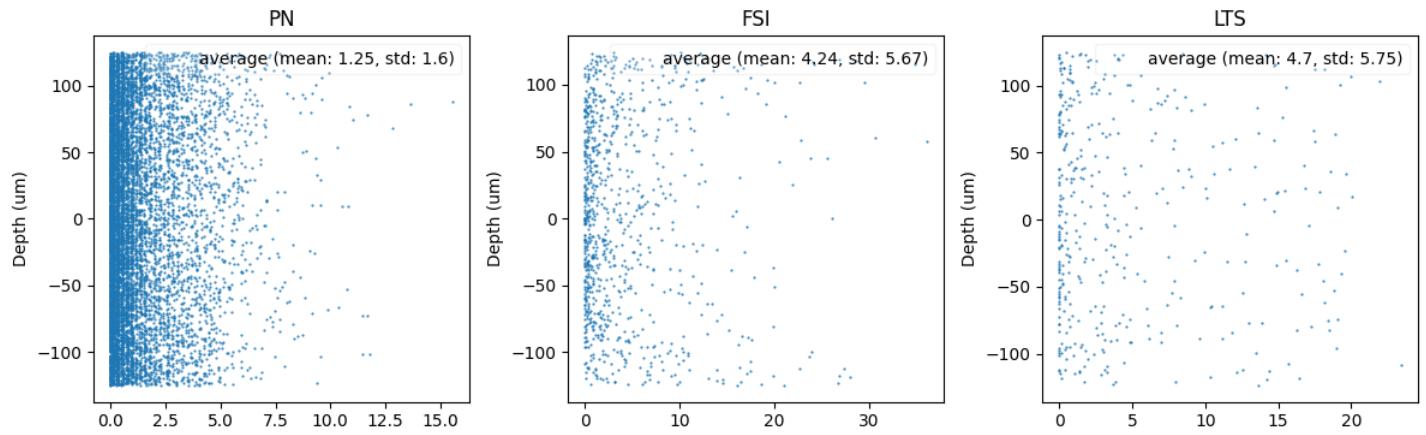
```
=====
FOOOF - SETTINGS
Peak Width Limits : [4.0, 100.0]
Max Number of Peaks : 10
Minimum Peak Height : 0.3
Peak Threshold: 0.0
Aperiodic Mode : fixed
=====
```



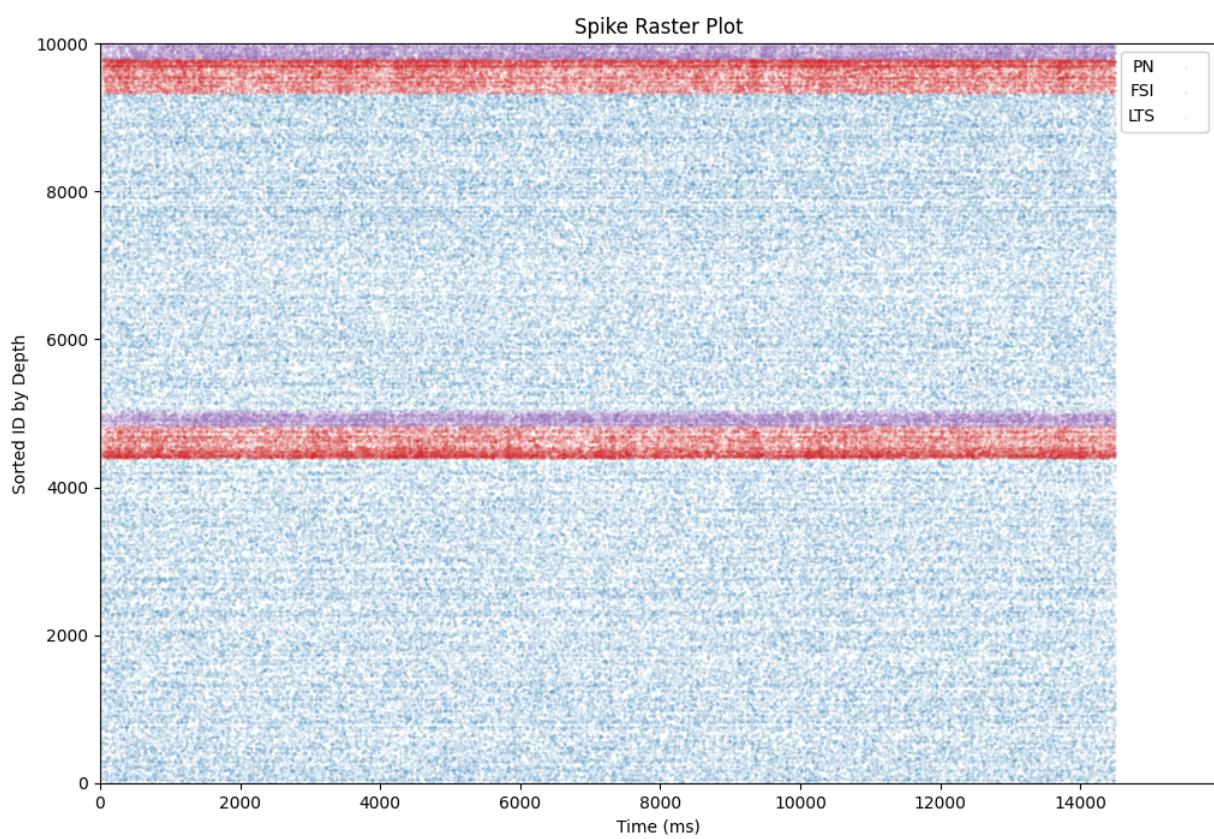
## **Model Output with increased assembly weight**

Increased assembly weight means that the synaptic connections within each assembly have been strengthened, while the connections not in the assembly have been weakened. Currently there are 3 assemblies formed only with PN cells. The assemblies have double the convergence inside the assembly compared to cells not in the assembly. The synaptic weight for the in assembly connections is also doubled compared to those connections not in the assembly.

## Baseline with increased assembly weight



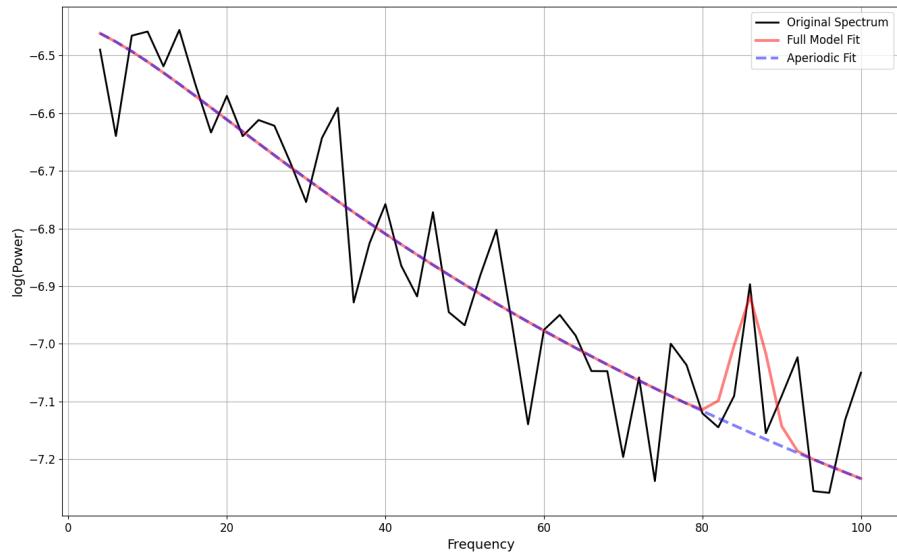
(a) Firing Rate during Baseline



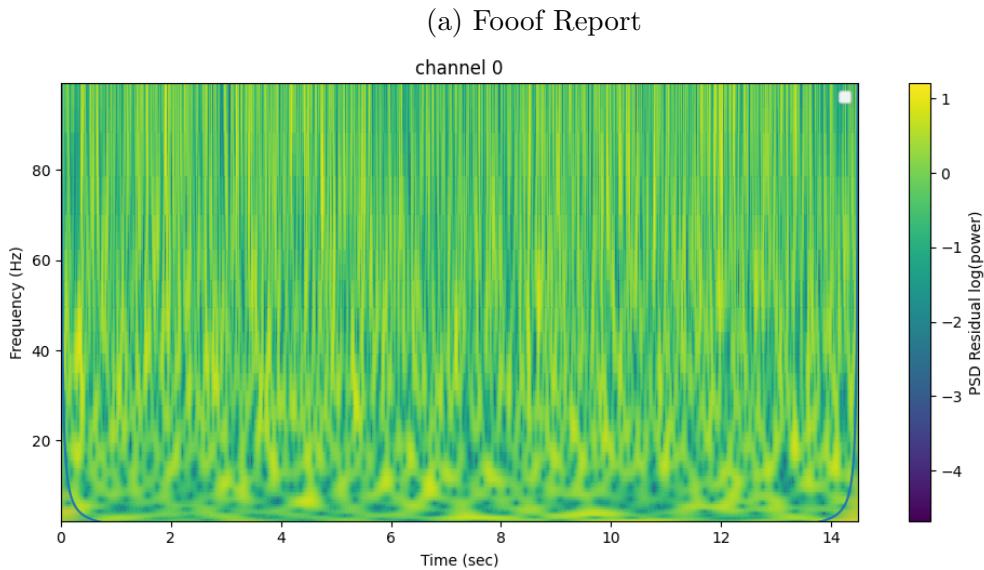
(b) Raster

Figure 10: Firing Rate Analysis for Baseline

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FOOOF - POWER SPECTRUM MODEL
The model was run on the frequency range 4 - 100 Hz
Frequency Resolution is 2.00 Hz
Aperiodic Parameters (offset, knee, exponent):
-4.1809, 182.9422, 1.4881
1 peaks were found:
CF: 86.07, PW: 0.236, BW: 4.01
Goodness of fit metrics:
R^2 of model fit is 0.8697
Error of the fit is 0.0670
=====
```

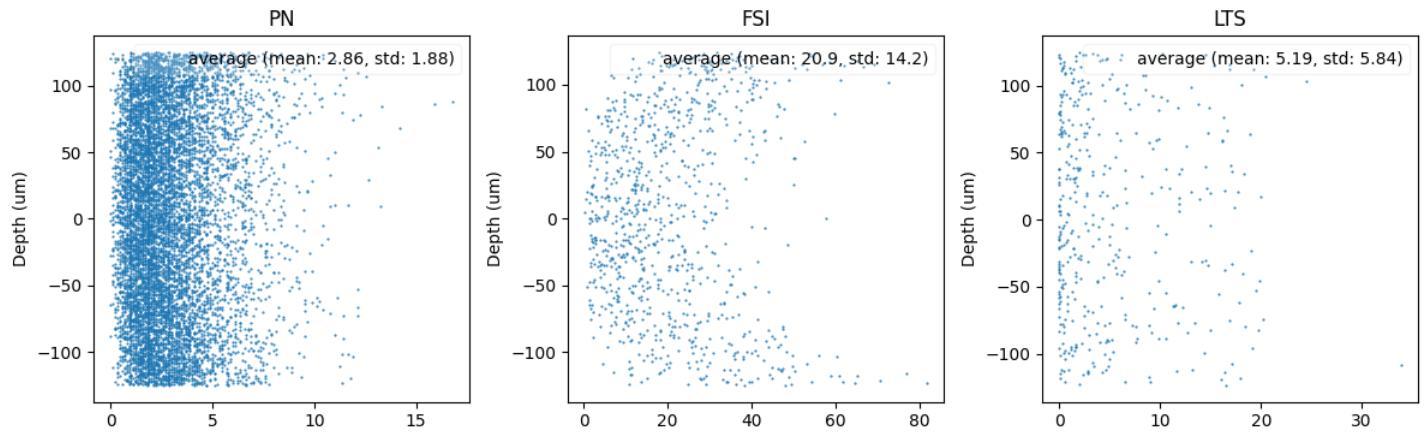


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FOOOF - SETTINGS
Peak Width Limits : [4.0, 100.0]
Max Number of Peaks : 10
Minimum Peak Height : 0.3
Peak Threshold: 0.0
Aperiodic Mode : knee
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```

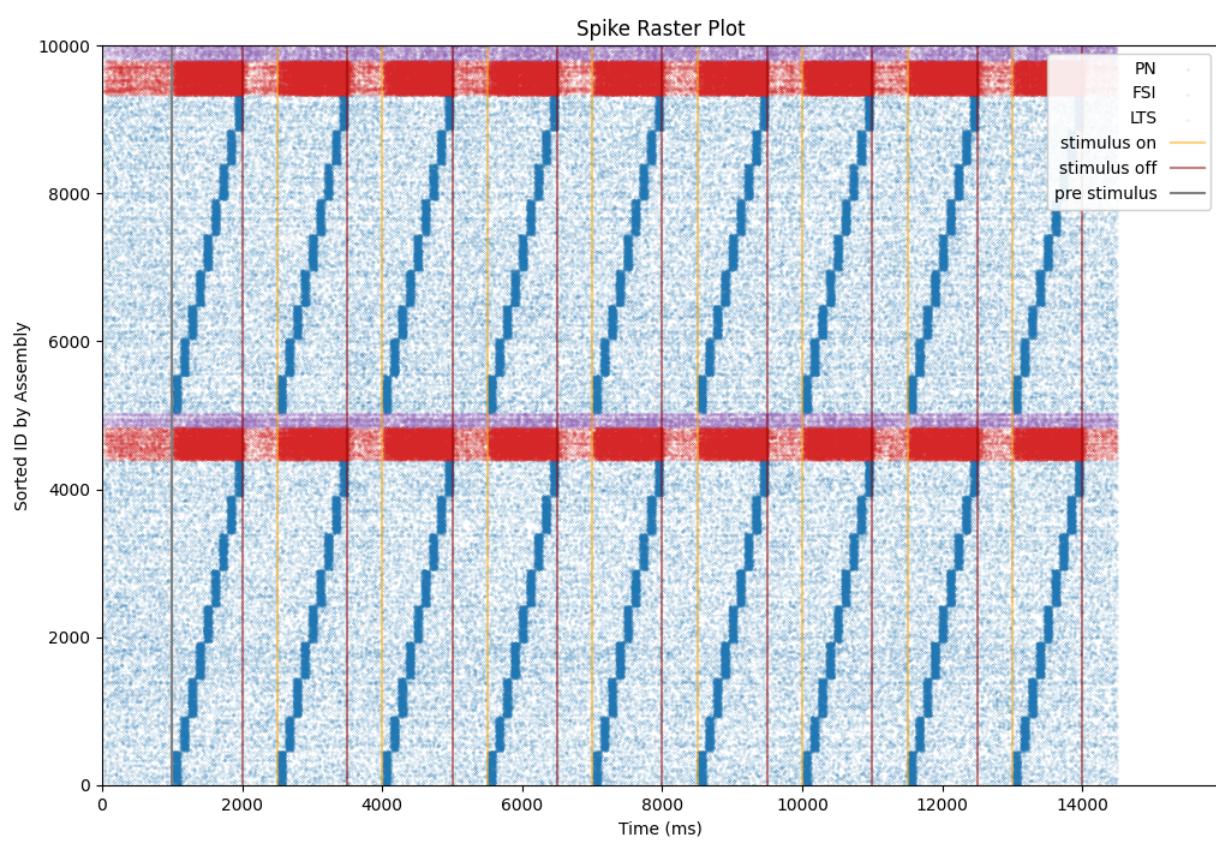


(b) Spectrogram

## Short Pulse with increased assembly weight



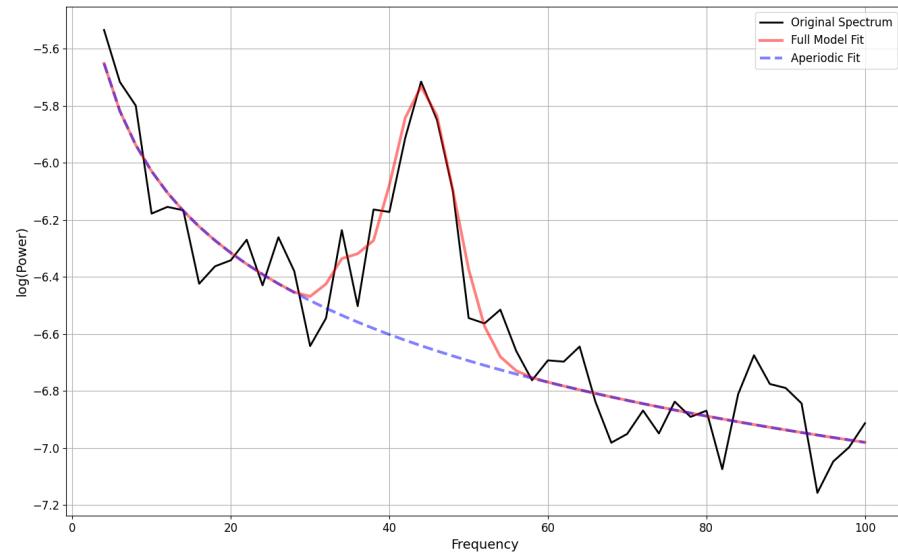
(a) Firing Rate during Short Pulse



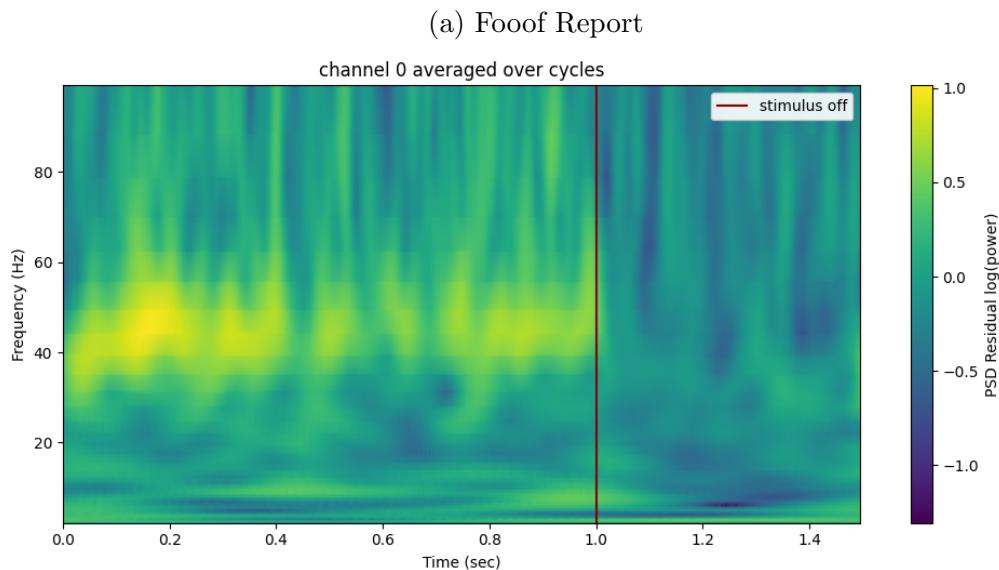
(b) Raster

Figure 12: Firing Rate Analysis for Short Pulse

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FOOOF - POWER SPECTRUM MODEL
The model was run on the frequency range 4 - 100 Hz
Frequency Resolution is 2.00 Hz
Aperiodic Parameters (offset, exponent):
-5.0786, 0.9511
2 peaks were found:
CF: 34.53, PW: 0.199, BW: 4.00
CF: 44.23, PW: 0.909, BW: 7.99
Goodness of fit metrics:
R^2 of model fit is 0.9195
Error of the fit is 0.0948
=====
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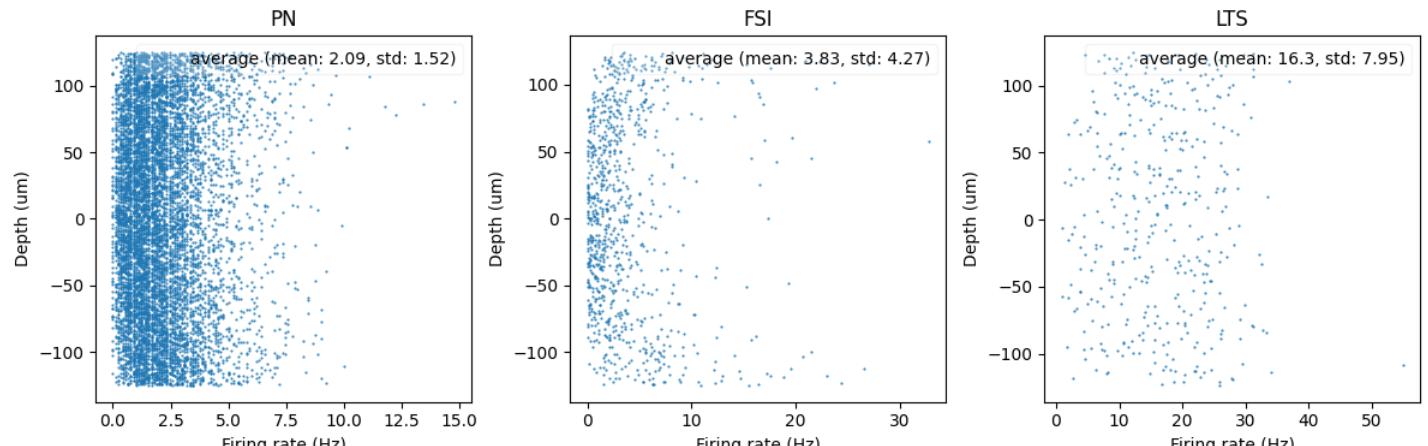


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=====
FOOOF - SETTINGS
Peak Width Limits : [4.0, 100.0]
Max Number of Peaks : 10
Minimum Peak Height : 0.3
Peak Threshold: 0.0
Aperiodic Mode : fixed
=====
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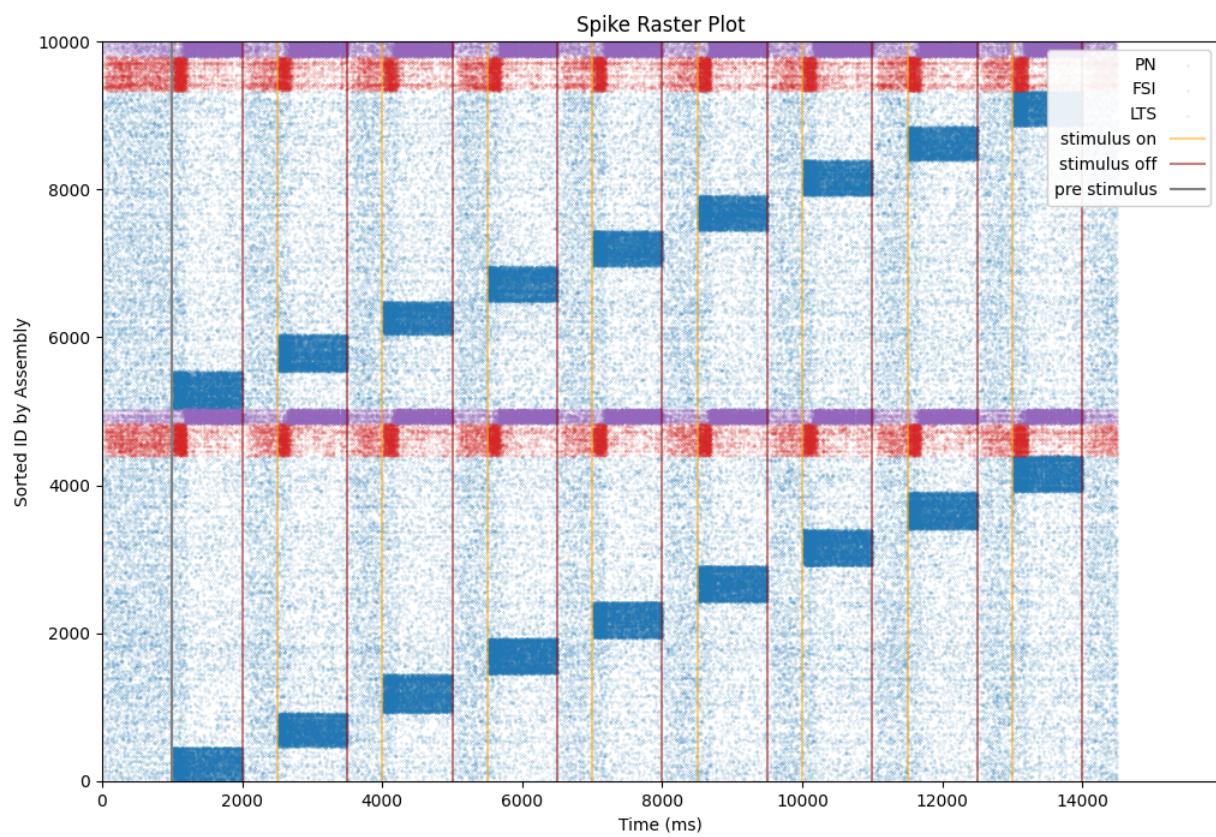


(b) Spectrogram

## Long Pulse with increased assembly weight



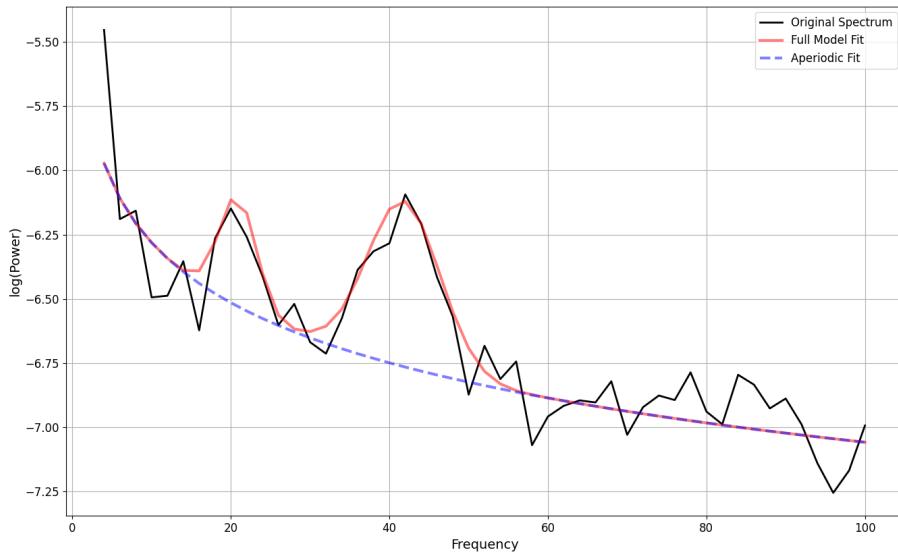
(a) Firing Rate during Long Pulse



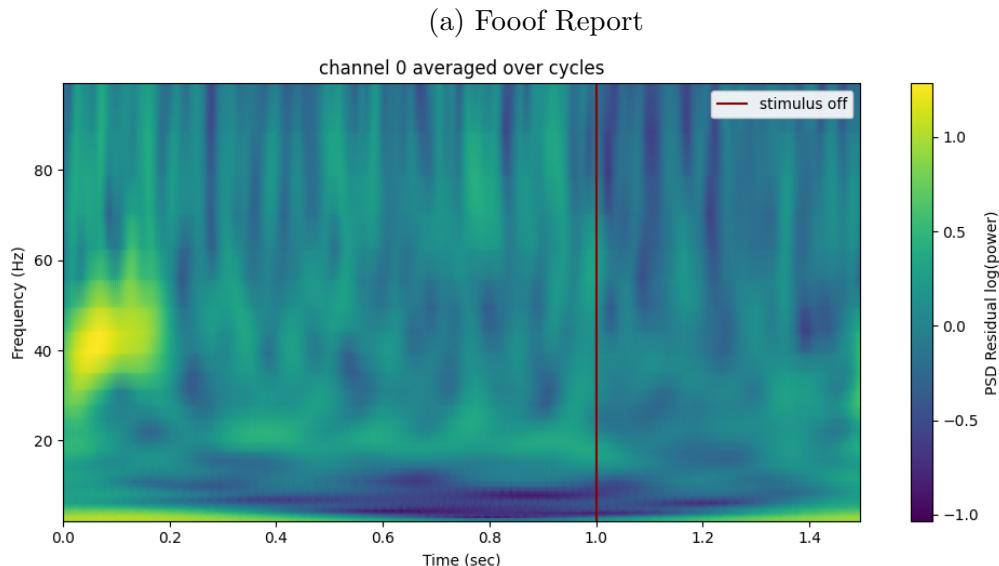
(b) Raster

Figure 14: Firing Rate Analysis for Long Pulse

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FOOOF - POWER SPECTRUM MODEL
The model was run on the frequency range 4 - 100 Hz
Frequency Resolution is 2.00 Hz
Aperiodic Parameters (offset, exponent):
-5.5644, 0.7770
2 peaks were found:
CF: 20.87, PW: 0.401, BW: 4.67
CF: 41.79, PW: 0.645, BW: 9.21
Goodness of fit metrics:
R^2 of model fit is 0.8669
Error of the fit is 0.0923
=====
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FOOOF - SETTINGS
Peak Width Limits : [4.0, 100.0]
Max Number of Peaks : 10
Minimum Peak Height : 0.3
Peak Threshold: 0.0
Aperiodic Mode : fixed
=====
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(b) Spectrogram

## References

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