Summer Research Project Report

Neel Maniar, supervised by Dr Johannes Pausch

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Contents

1 Testing the intervals between flashes

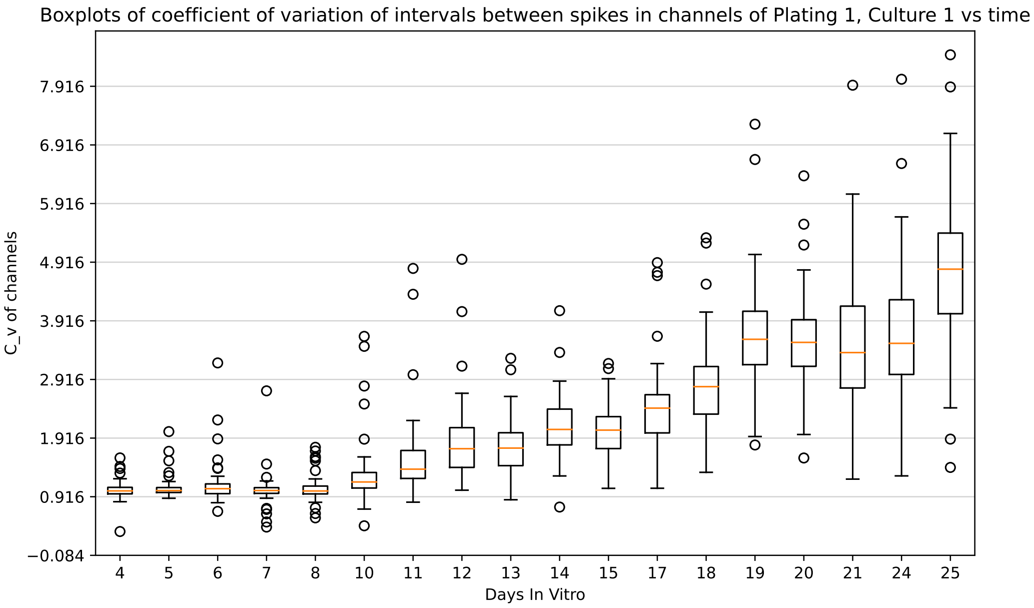
1.1 Individual channels, for a particular culture

If we have assume that there are no patterns and just random noise, then we expect that for each channel in every culture and plating, the time between spikes is distributed exponentially, as we expect that the system has no memory of previous spikes, or surrounding spikes. Let X be the length of the interval before the next spike

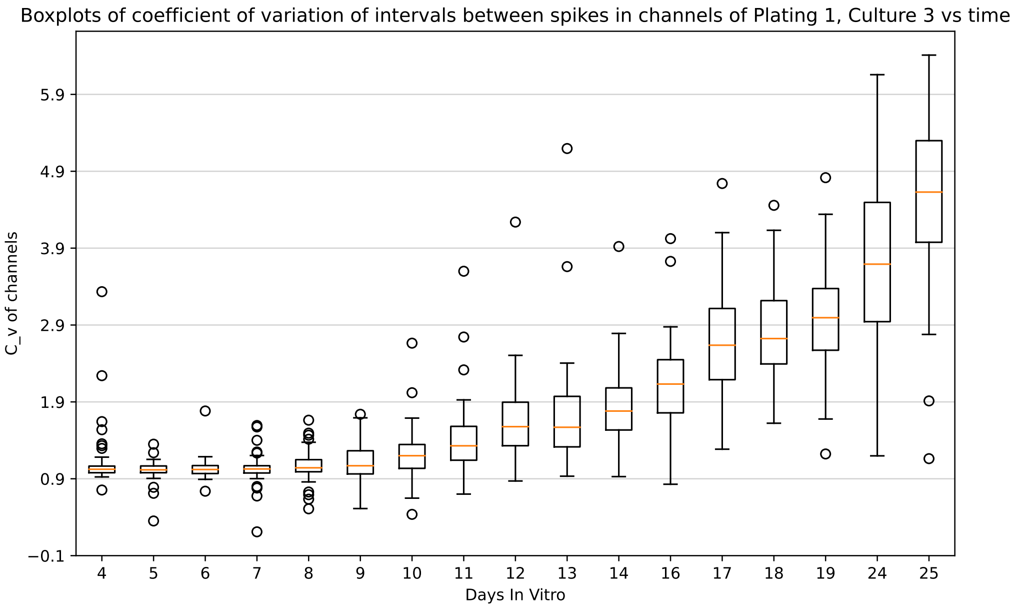
So under the null, we expect that $X \sim \text{Exp}(\lambda)$, so $\mathbb{E}[X] = \frac{1}{\lambda}$ and $\text{Var}(X) = \frac{1}{\lambda^2}$, and so $C_v = \frac{\sigma}{\mu} = 1$

By observation, we can see that in some cultures, this is certainly not true, and the value of C_v seems to deviate significantly from 1, often getting larger than 1 as time goes on. This indicates that the spikes are getting more dispersive.

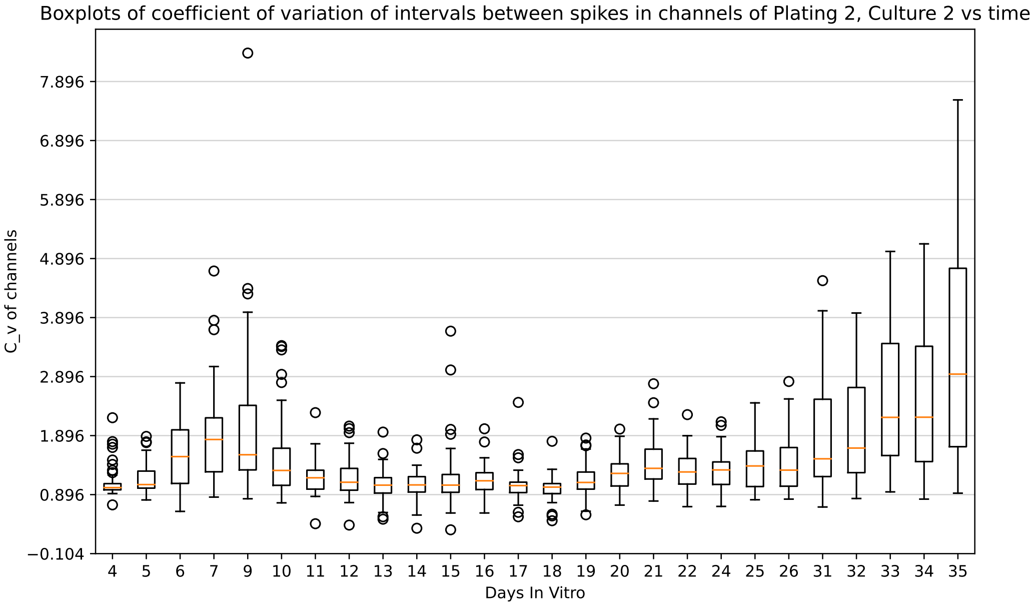
The boxplots are each for a particular culture, across every div for which data is available. For a given div, the boxplot data is from the recordings of the 60 channels.


Boxplots of coefficient of variation of intervals between spikes in channels of Plating 1, Culture 1 vs time
C_v of channels
Days In Vitro
7.916
6.916
5.916
4.916
3.916
2.916
1.916
0.916
−0.084
4 5 6 7 8 10 11 12 13 14 15 17 18 19 20 21 24 25

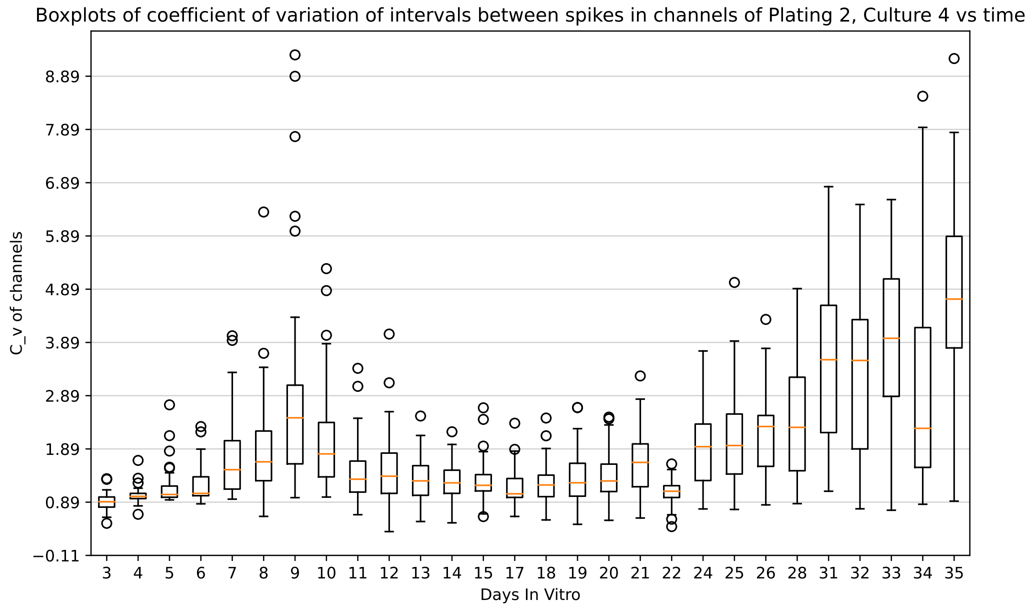
(a)


Boxplots of coefficient of variation of intervals between spikes in channels of Plating 1, Culture 3 vs time
C_v of channels
Days In Vitro
5.9
4.9
3.9
2.9
1.9
0.9
−0.1
4 5 6 7 8 9 10 11 12 13 14 16 17 18 19 24 25

(b)

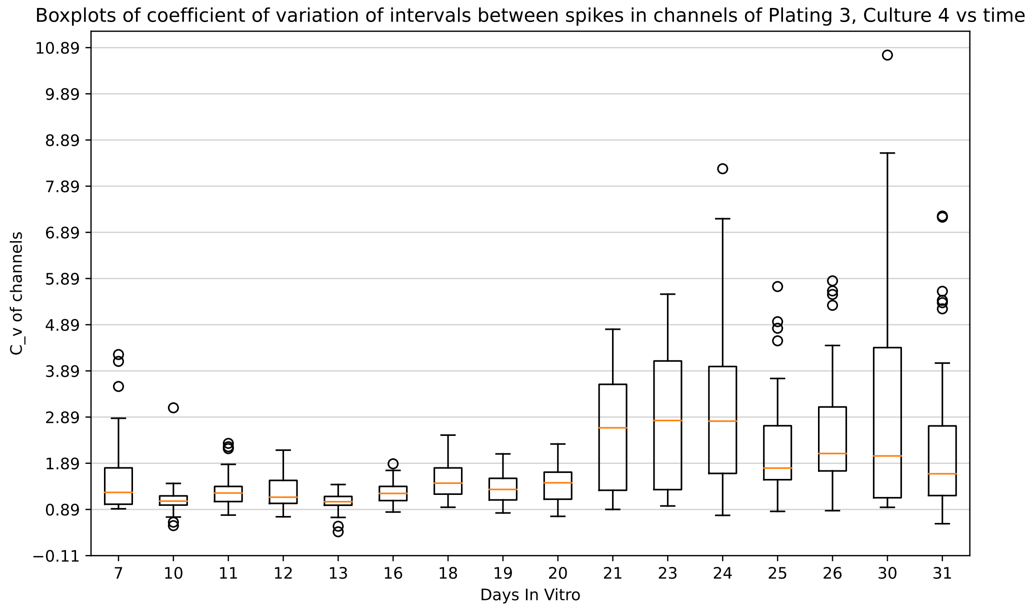

Boxplots of coefficient of variation of intervals between spikes in channels of Plating 2, Culture 2 vs time
C_v of channels
7.896
6.896
5.896
4.896
3.896
2.896
1.896
0.896
−0.104
4 5 6 7 9 10 11 12 13 14 15 16 17 18 19 20 21 22 24 25 26 31 32 33 34 35
Days In Vitro

(c)

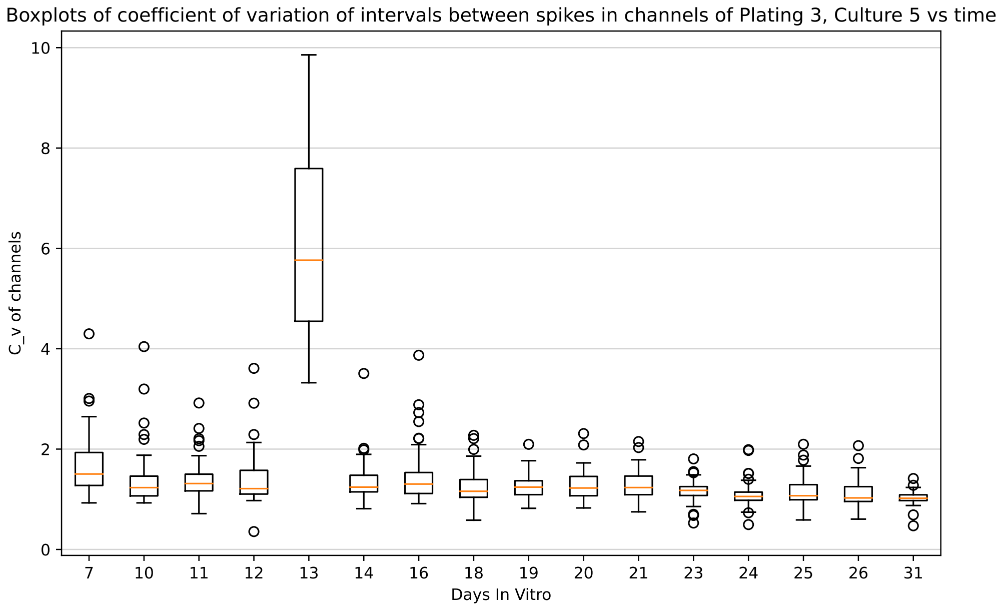

Boxplots of coefficient of variation of intervals between spikes in channels of Plating 2, Culture 4 vs time
C_v of channels
8.89
7.89
6.89
5.89
4.89
3.89
2.89
1.89
0.89
−0.11
3 4 5 6 7 8 9 10 11 12 13 14 15 17 18 19 20 21 22 24 25 26 28 31 32 33 34 35
Days In Vitro

(d)

Figure 1

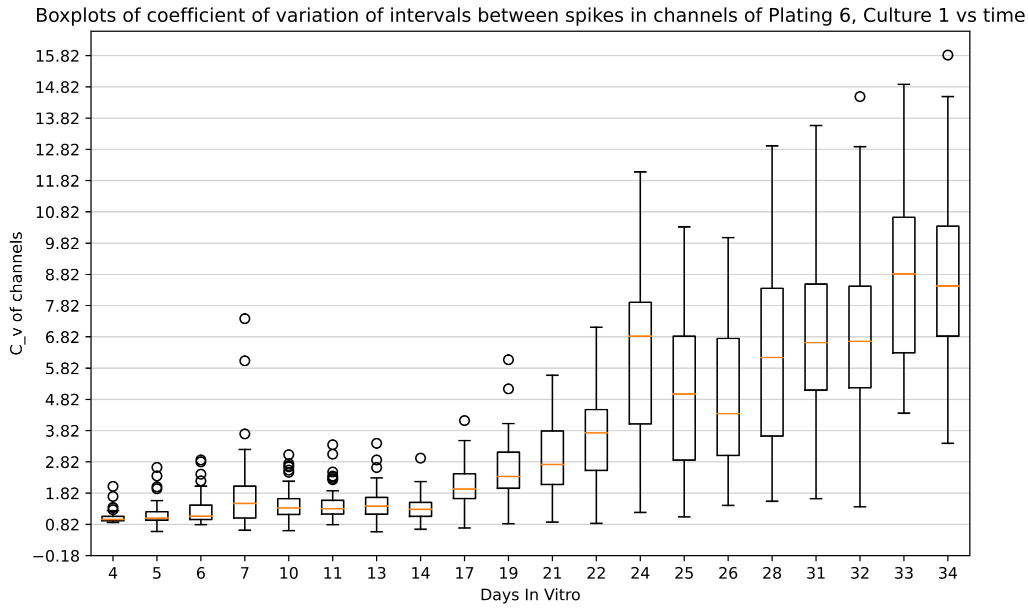

Boxplots of coefficient of variation of intervals between spikes in channels of Plating 3, Culture 4 vs time
C_v of channels
Days In Vitro
10.89
9.89
8.89
7.89
6.89
5.89
4.89
3.89
2.89
1.89
0.89
−0.11
7
10
11
12
13
16
18
19
20
21
23
24
25
26
30
31

(e)

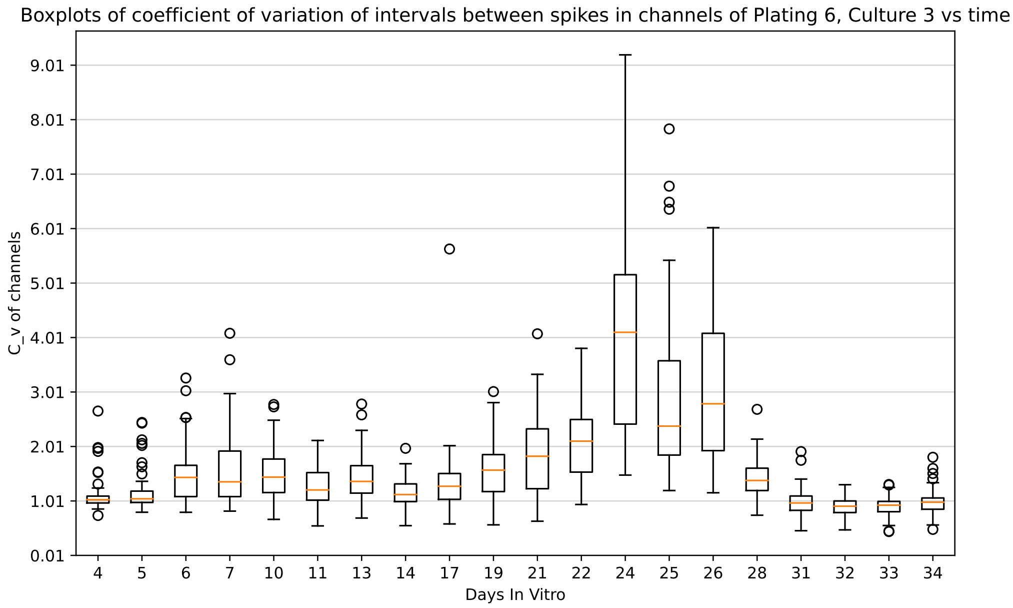

Boxplots of coefficient of variation of intervals between spikes in channels of Plating 3, Culture 5 vs time
C_v of channels
Days In Vitro
10
8
6
4
2
0
7
10
11
12
13
14
16
18
19
20
21
23
24
25
26
31

(f)

Figure 1


Boxplots of coefficient of variation of intervals between spikes in channels of Plating 6, Culture 1 vs time
C_v of channels
15.82
14.82
13.82
12.82
11.82
10.82
9.82
8.82
7.82
6.82
5.82
4.82
3.82
2.82
1.82
0.82
−0.18
4 5 6 7 10 11 13 14 17 19 21 22 24 25 26 28 31 32 33 34
Days In Vitro

(g)


Boxplots of coefficient of variation of intervals between spikes in channels of Plating 6, Culture 3 vs time
C_v of channels
9.01
8.01
7.01
6.01
5.01
4.01
3.01
2.01
1.01
0.01
4 5 6 7 10 11 13 14 17 19 21 22 24 25 26 28 31 32 33 34
Days In Vitro

(h)

Figure 1

1.2 Finding λ

In order to find λ, we need to take the reciprocal of the sample expectation.

In the rest of the document, I focus on the culture 1-3. I look at an individual channel, 49, and also the collection of all channels. These are both arbitrarily chosen.

Table 1: Expected interval lengths between flashes in culture 1-3, and estimation of lambda (channel 49)

Div	Sample Expectation	Estimate for λ
4	7.278349	0.137394
5	2.380654	0.420053
6	6.209933	0.161032
7	4.463837	0.224022
8	3.93533	0.254108
9	1.090983	0.916604
10	0.210622	4.747841
11	0.241741	4.13666
12	0.198811	5.02991
13	0.135562	7.376717
14	0.095558	10.46481
16	0.085162	11.74236
17	0.153134	6.530233
18	0.135885	7.359139
19	0.145544	6.870797
24	0.20867	4.792261
25	0.176588	5.662894

Similarly, we can look at all of the channels in the culture 1-3:

Table 2: Expected interval lengths between flashes in culture 1-3, and estimation of lambda (over all channels)

Div	Sample Expectation	Estimate for λ
4	0.081648	12.24766
5	0.054219	18.44384
6	0.068725	14.55073
7	0.033982	29.42738
8	0.024016	41.63885
9	0.022305	44.83354
10	0.017574	56.90181
11	0.020831	48.00558
12	0.023867	41.89802
13	0.015685	63.75628
14	0.017571	56.91138
16	0.014759	67.7562
17	0.014465	69.1305
18	0.0145	68.96681
19	0.012917	77.42008
24	0.010573	94.57647
25	0.007715	129.6119

2 Number of spikes in a time bin, div 4

The following analysis is all done for Culture 1-3, div 4

If we let N_Δ be the number of spikes which occur in time bins of size Δ for a particular group of channels for a particular culture on a particular div, then we expect $N_\Delta \sim \text{Poi}(\lambda\Delta)$.

Therefore, we must have $C_v = (\lambda\Delta)^{-\frac{1}{2}}$

Since we looked at culture 1-3 previously (arbitrarily), we will do the same now. We plot a few graphs of $\ln C_v$ against $\ln \Delta$, expecting a slope of $-\frac{1}{2}$ and an intercept of $-\frac{1}{2}\ln\lambda$

2.1 Individual channel, for a particular culture and div

To begin with, we just look at just channel 49

2.1.1 Bar Charts of Frequency vs N_Δ

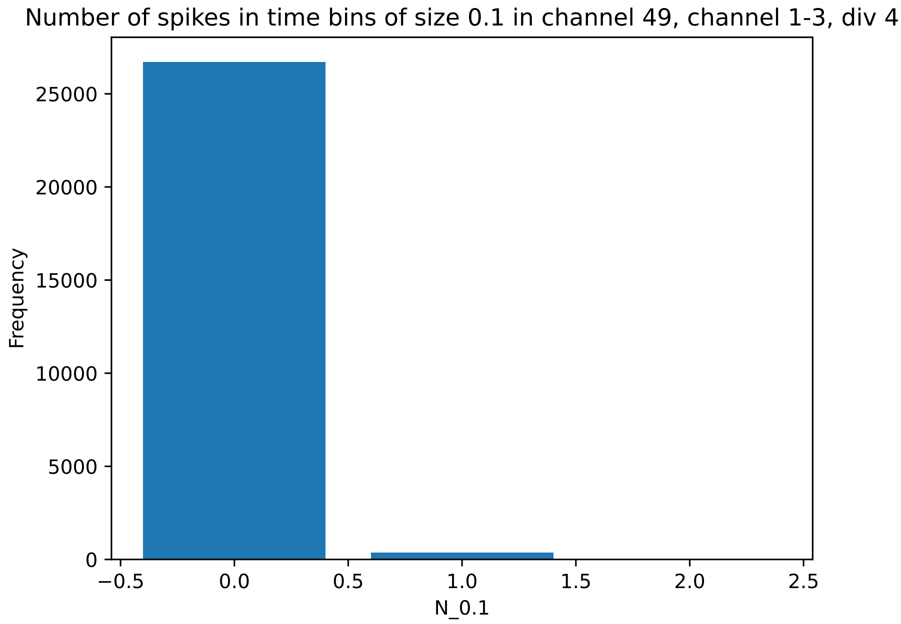


Figure 2

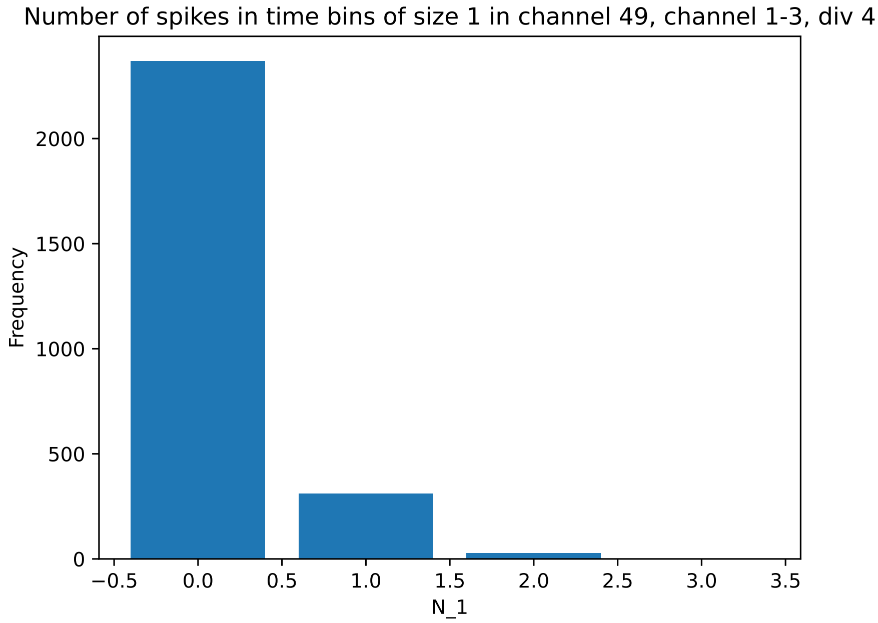


Figure 3

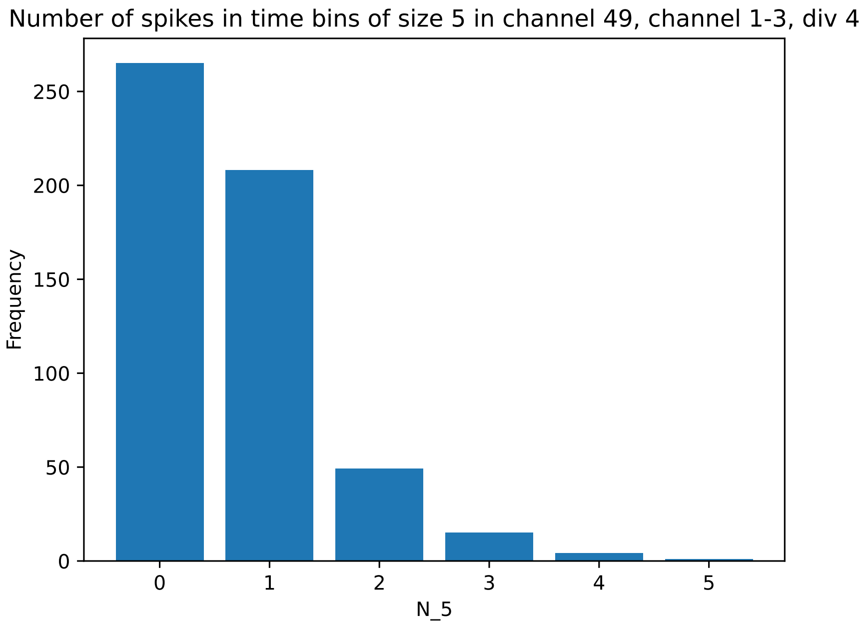


Figure 4

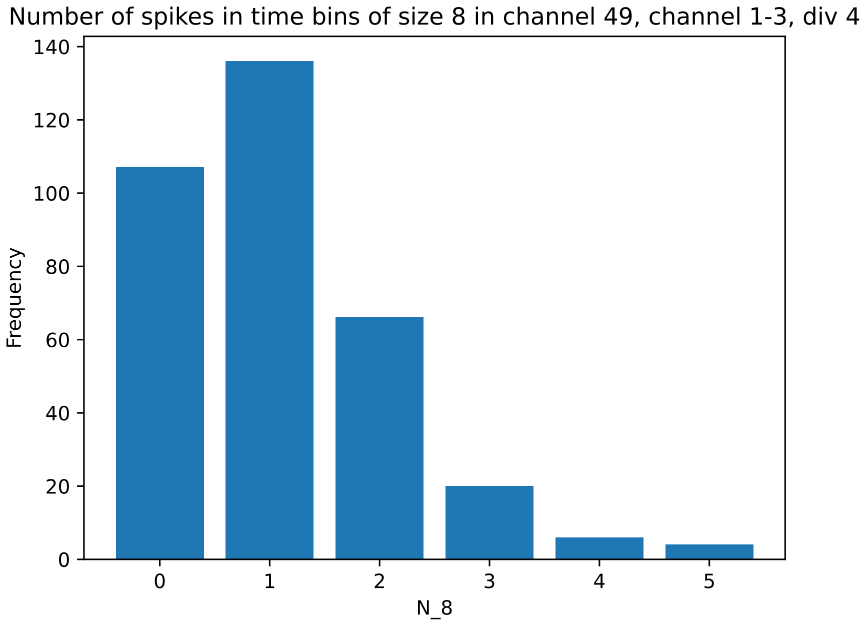


Figure 5

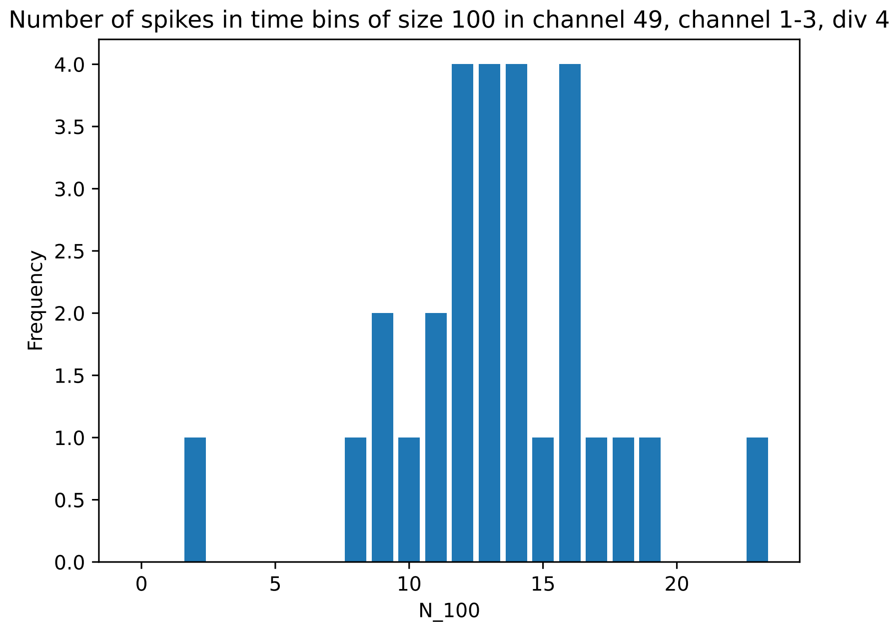


Figure 6

2.1.2 Log-log plot

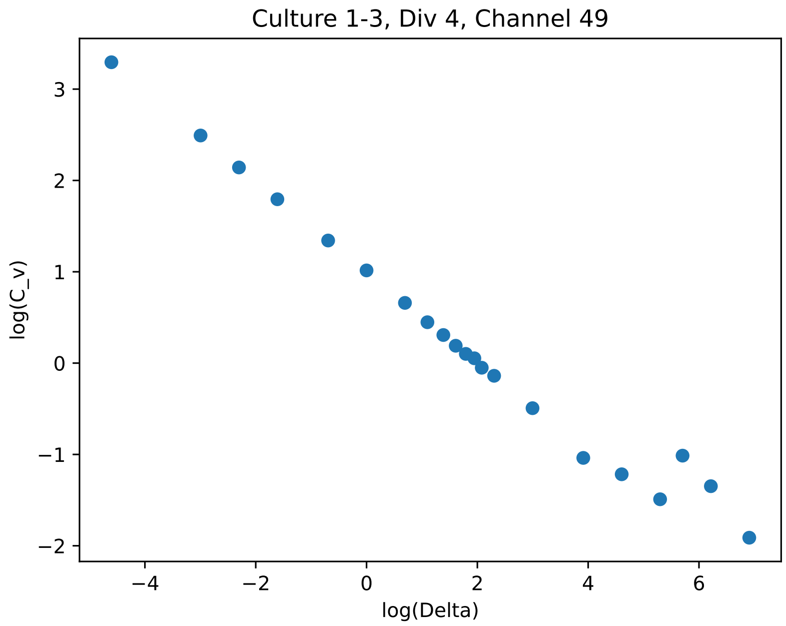


Figure 7

Large values of Δ do not fit the trend, so dismissing the final three, after performing a linear regression, we get (with an R-value of -0.999437) a gradient of -0.492335 and an intercept of 1.001749.

This fits the Poisson distribution very well! It also implies that for div 4, culture 1-3, channel 49 has $\lambda = 0.13486$

This is compared with the Exponential model, which gave $\lambda = 0.1374$

So this is strong evidence that channel 49 was "random" on div 4.

2.2 All channels, for a particular culture and div

2.2.1 Bar charts for Frequency against N_Δ

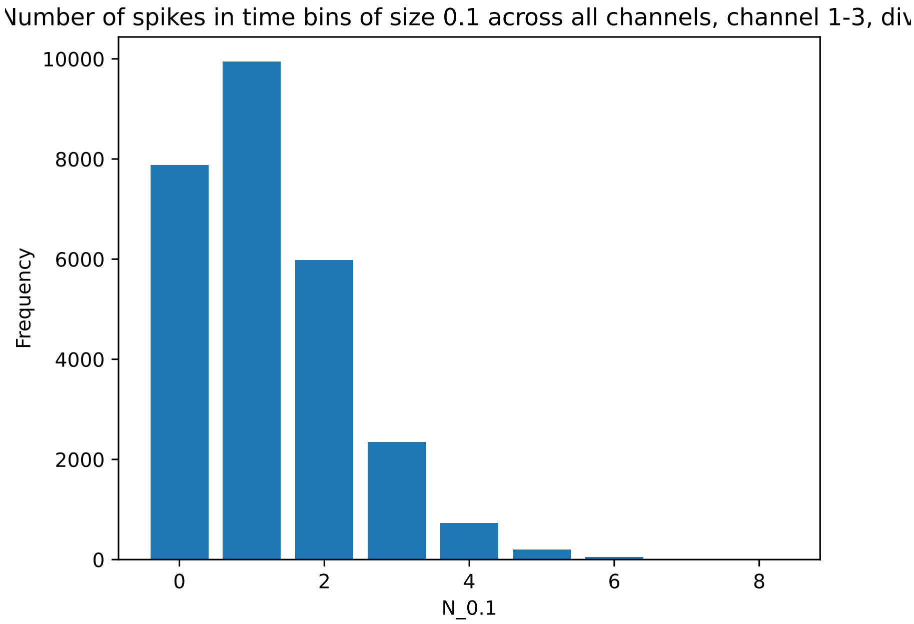


Figure 8

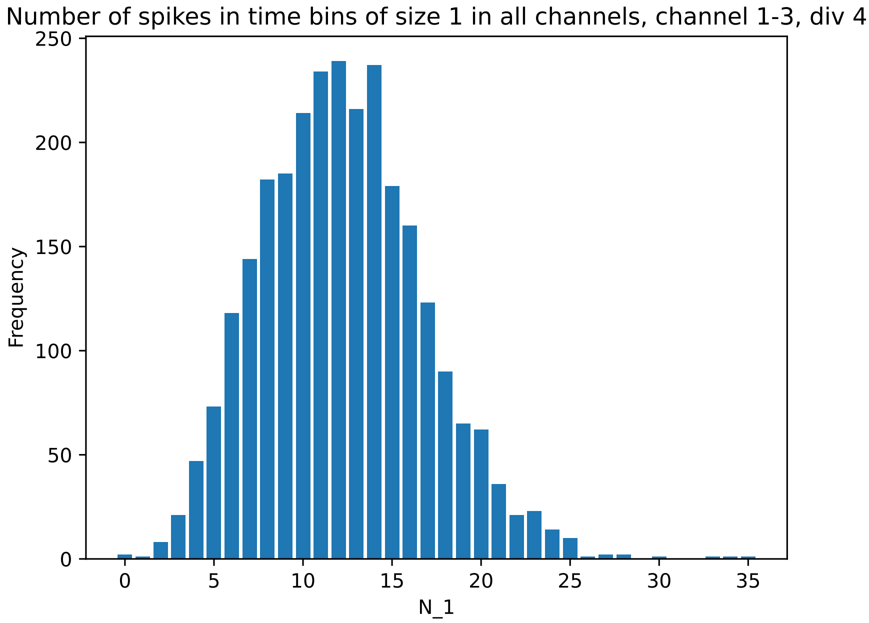


Figure 9

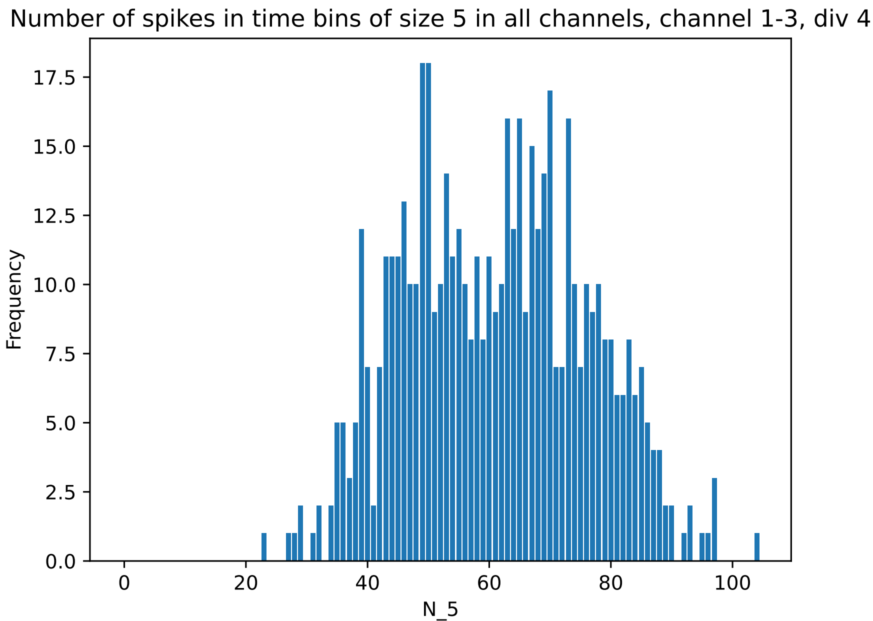


Figure 10

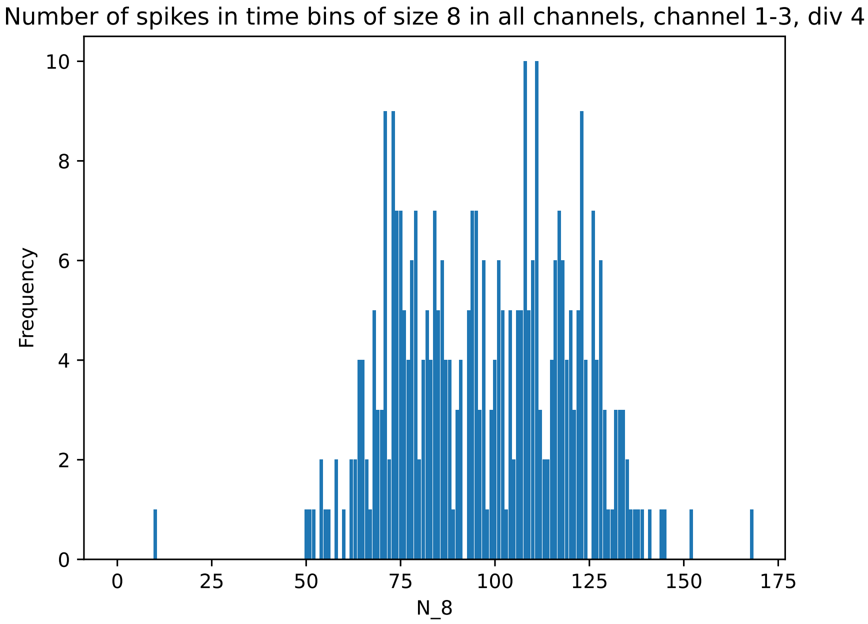


Figure 11

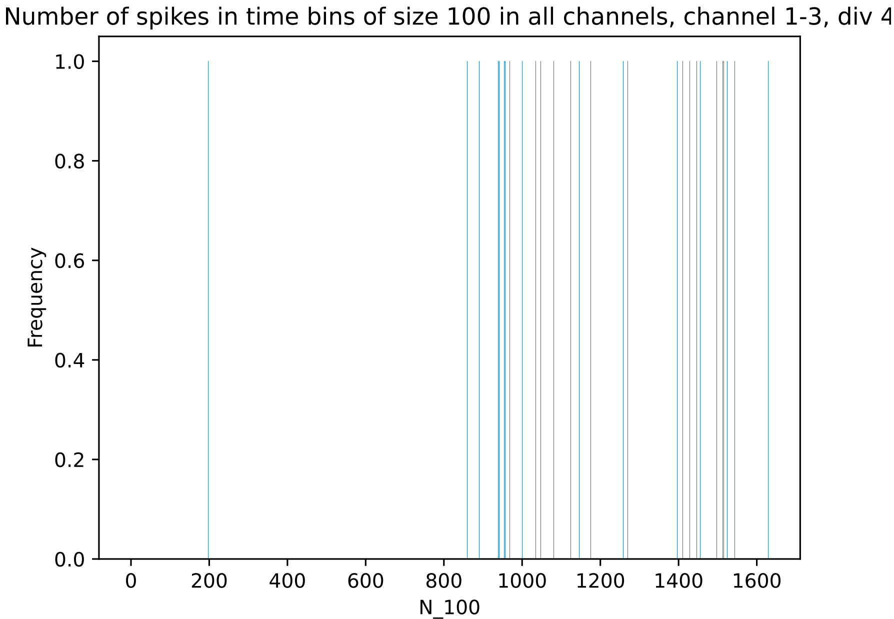


Figure 12

2.2.2 Log-log plot

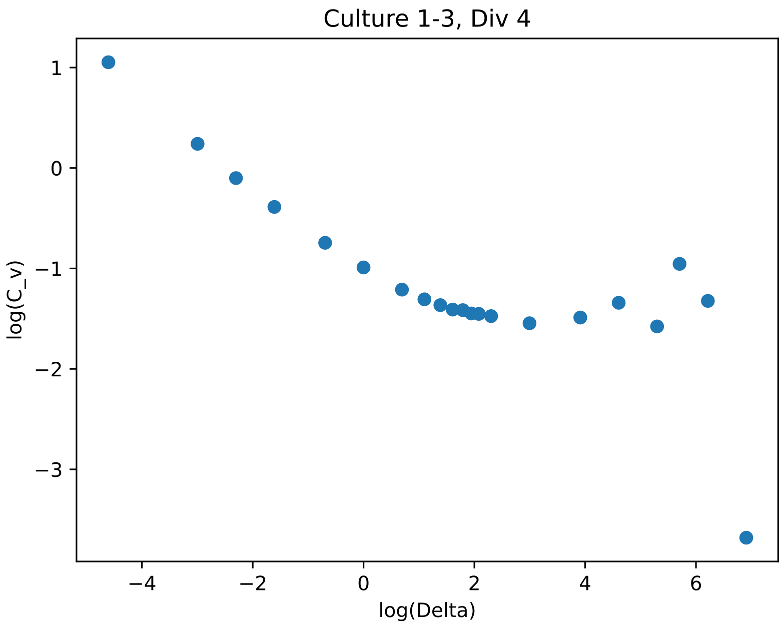


Figure 13

That's not straight, mate.

Similarly to before, we discard the final 6 values. After doing a linear regression, we find that a gradient of -0.3411653, which is quite far from the expected $-\frac{1}{2}$, and an intercept of -0.819749, which gives a value of λ of 5.1526.

(Compared with the earlier Exponential model which gave $\lambda = 12.247$)

It does not seem like the channels are random as a whole, although they are as individual channels! This is interesting.

3 Number of spikes in a time bin, div 25

Similarly, we will look at the culture 1-3 at div 25. I will omit bar charts this time because they look similar to before, and do not provide much in the way of new information.

3.1 Individual channel 49

3.1.1 Log-log plots

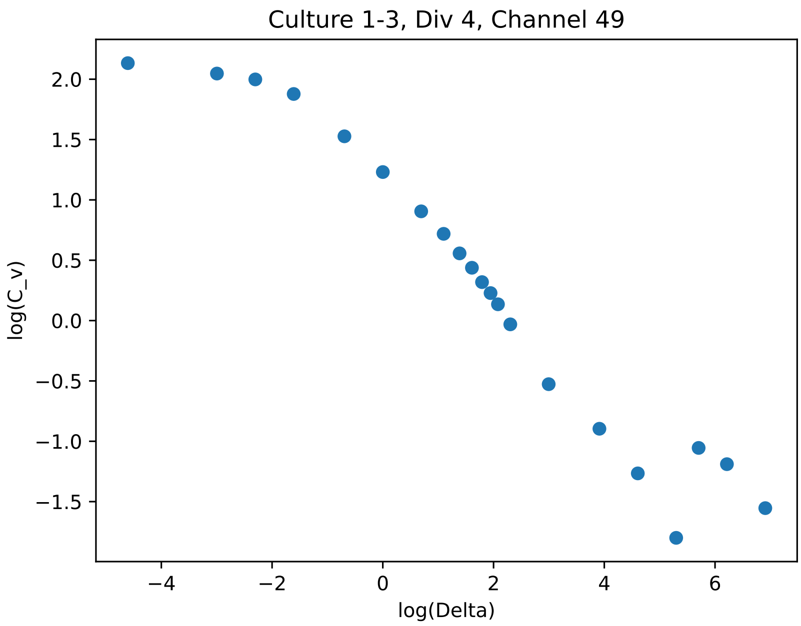


Figure 14

Here, visually it doesn't seem like we have a straight line. Still, we can omit the final three and first two values so we can try and get as close to a straight line as possible.

After performing a linear regression on this, we find a slope of -0.393579, which is somewhat similar to the expected slope of $-\frac{1}{2}$, and an intercept of 0.956988, which yields an estimated λ value of 0.14749. Compare with the earlier estimate of 5.6629! Thi is certainly very different.