Counts:

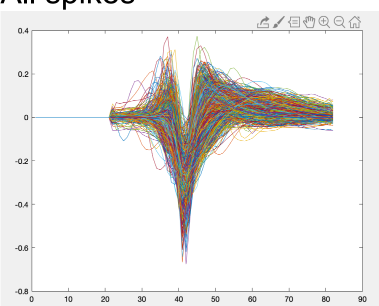
Total = 9404 (Cortex + HP + Thalamus)

Cortex = 1413
HP = 1569
Thalamus = 6422

HP:
CA1 = 492
DG = 696
CA3 = 285
molDG = 43
Oriens = 53

Extract features and waveforms
extractFeatures.m

All spikes

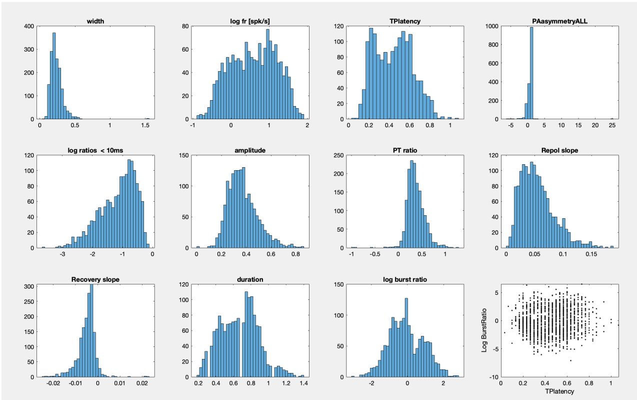


From Senzai DG paper:

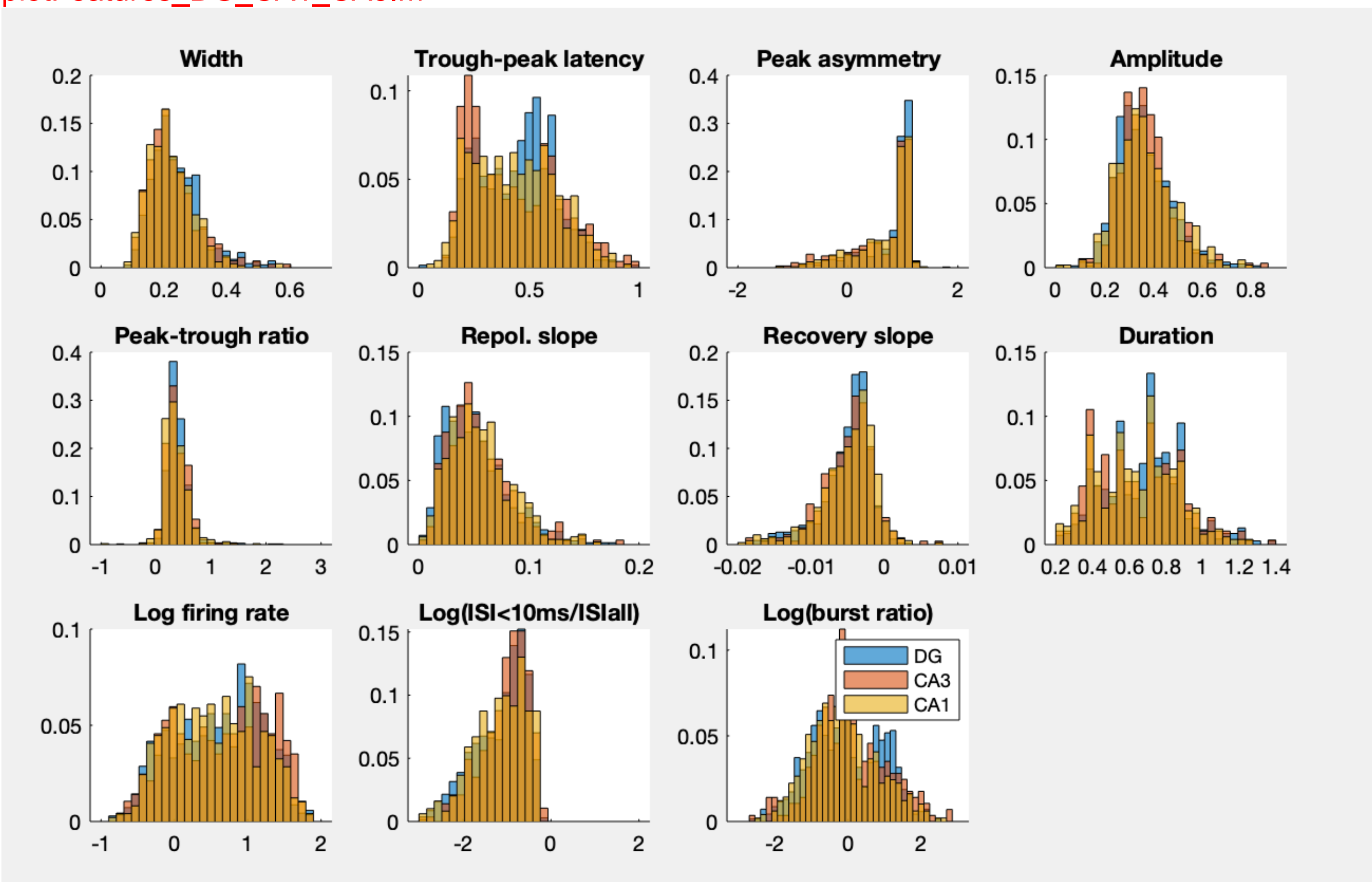
were also used for the waveform PCA (see later). Units with TP latency < 0.425ms were classified as narrow-waveform putative interneurons (n-I interneurons; Figure 1). Wide-waveform units were heuristically classified into putative excitatory cells (E cells; burst index > 1.2) and wide-waveform putative interneurons (w-I interneurons) based on the bimodality of the marginal distribution for the burst index. CA3 region units were also classified in a similar way into n-I interneurons (TP latency < 0.525ms), w-I interneurons (burst index < 0.18 and TP latency > 0.525ms), and E cells (burst index > 0.12 and TP latency > 0.525ms). Criteria for separation were chosen as a trough of the bimodal distribution of each marginal distribution.

In the second stage, excitatory cells (E) of the dentate gyrus were further divided into putative granule cells and mossy cells. First, a PCA was performed on the average E waveforms. Average waveforms were normalized by the peak amplitude and up-sampled to 100kHz with a spline interpolation method. Waveform PCA was performed using the time between 0 to 0.8ms period of the second derivative of the up-sampled average waveform (Figure 1). As a result of the waveform PCA, w-PC1 and w-PC2 were obtained. The amplitude of the LFP DS2 at the recording site where the units' maximum waveform amplitude was observed was used to estimate the unit's anatomical location. Third, we calculated the firing rate ratios for each unit between nonREM sleep (NREM) and waking. We classified dentate E cells into two clusters with k-means method based on w-PC1, w-PC2, DS2 amplitude, and the ratio of the firing rate during NREM and waking (Figure 1).

Features:

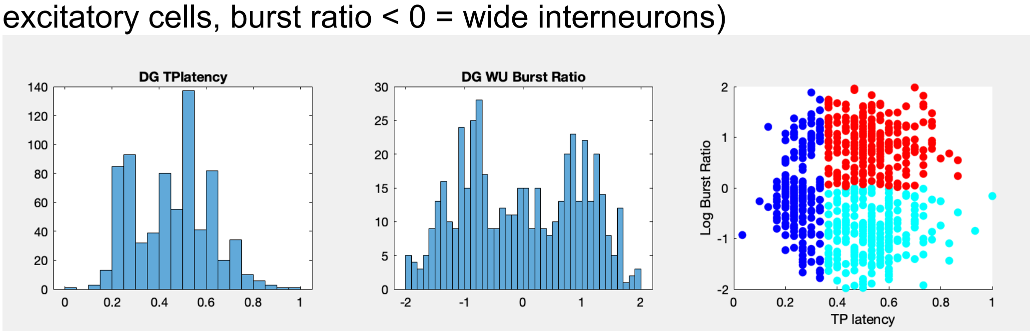


plotFeatures_DG_CA1_CA3.m

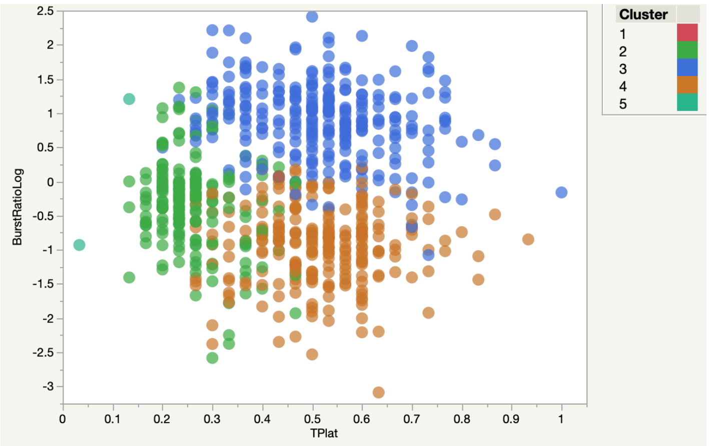


DG

Using hard thresholds (TPlat < 0.3 = INT, TPlat >= 0.3 = Wide Units, from those Burst ratio > 0 excitatory cells, burst ratio < 0 = wide interneurons)



Using k-Means (5 classes) E = 3, In = 2, Iw = 4



K Means NCluster=5

Columns Scaled Individually

Cluster Summary

Cluster	Count
1	1
2	198
3	276
4	247
5	2

Step	Criterion
46	0

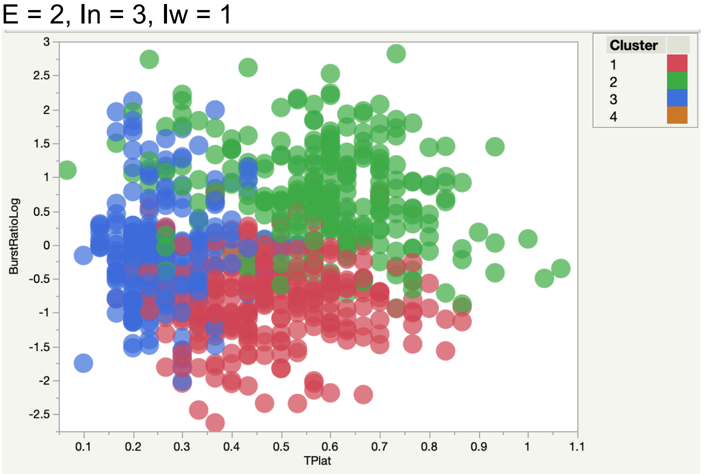
Cluster Means

Cluster	width	TPlat	PAassym	frLog	ratio10msLog	amp	PTratio	RepSlope	RecSlope	Duration	BurstRatioLog
1	0.46666667	0.43333333	25.0412254	0.60247283	-1.0590248	0.19330719	0.94247246	0.02113988	-0.0029353	0.56666667	0.06794632
2	0.16868687	0.26346801	0.77089167	0.77231931	-1.108434	0.46158887	0.51291005	0.08597023	-0.0092206	0.4486532	-0.3122252
3	0.27285024	0.52028986	0.82711841	0.19102256	-0.7632274	0.3265573	0.32078872	0.03947018	-0.0032648	0.78164251	0.89673834
4	0.25879892	0.51390013	0.75017972	0.88624261	-1.6690722	0.33097902	0.36423417	0.04055669	-0.0040891	0.7562753	-0.9433476
5	0.37666667	0.08333333	0.97358185	0.33005779	-1.4427081	0.05168933	-0.7897356	0.01778521	0.02083239	0.38333334	0.13692156

Cluster Standard Deviations

Merged (CA1+CA3)

E = 2, In = 3, Iw = 1



Control Panel

K Means NCluster=4

Columns Scaled Individually

Cluster Summary

Cluster	Count
1	270
2	264
3	276
4	1

Step	Criterion
37	0

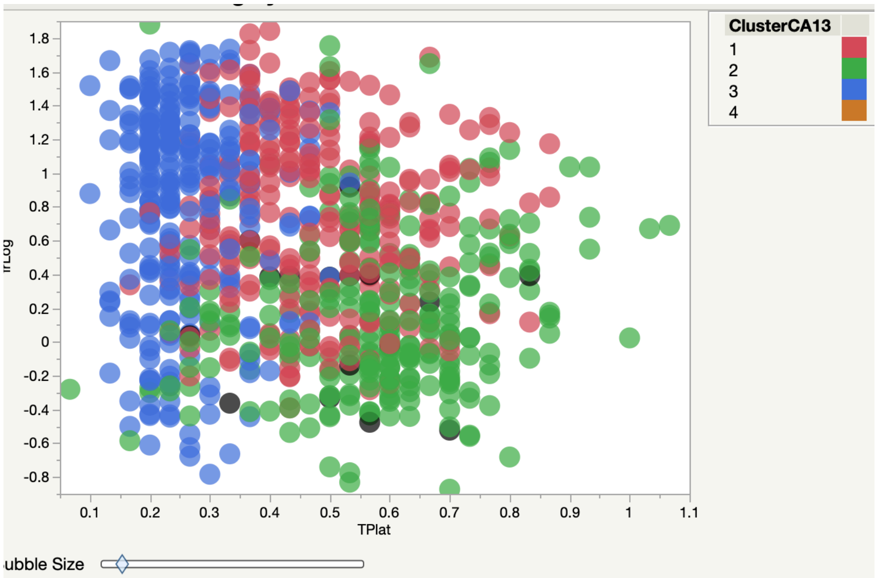
Cluster Means

Cluster	width	TPlat	PAassym	frLog	ratio10msLog	amp	PTratio	RepSlope	RecSlope	Duration	BurstRatioLog
1	0.23649383	0.48555556	0.79486981	0.75244761	-1.6458753	0.37334019	0.34129222	0.05112995	-0.0042801	0.72074074	-0.8183182
2	0.26734849	0.58510101	0.33087391	0.17567363	-0.8099421	0.29612058	0.26318811	0.03402934	-0.0024131	0.80378788	0.72431378
3	0.1647343	0.25990338	0.76769122	0.80886126	-0.9514629	0.45049088	0.46539974	0.08405477	-0.008322	0.43961353	-0.1058518
4	0.35	0.36666667	0.69323117	0.52977074	-1.9121381	0.26891887	7.11483955	0.01032446	-0.0137087	0.56666667	-1.1987487

Cluster Standard Deviations

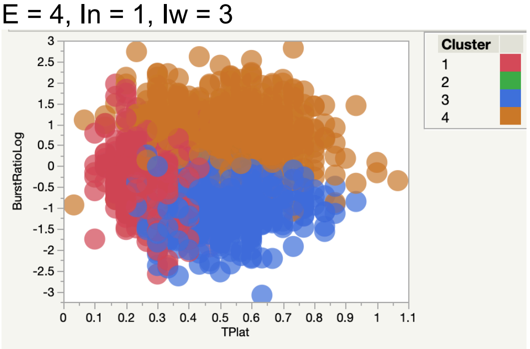
TPlat vs log(fr)

E = 2, In = 3, Iw = 1



Merged (CA1+CA3+DG) = needs to be updated

E = 4, In = 1, Iw = 3



K Means NCluster=4

Columns Scaled Individually

Cluster Summary

Cluster	Count
1	480
2	1
3	520
4	534

Step	Criterion
39	0

Cluster Means

Cluster	width	TPlat	PAassym	frLog	ratio10msLog	amp	PTratio	RepSlope	RecSlope	Duration	BurstRatioLog
1	0.16760417	0.26180556	0.78135434	0.82478869	-1.0332913	0.45730217	0.47594775	0.0850578	-0.0086822	0.44729167	-0.2355004
2	0.46666667	0.43333333	25.0412254	0.60247283	-1.0590248	0.19330719	0.94247246	0.02113988	-0.0029353	0.56666667	0.06794632
3	0.25247436	0.50967949	0.73317388	0.80765252	-1.6596463	0.34727004	0.34874401	0.04425759	-0.0041139	0.75102564	-0.8747559
4	0.26551186	0.53913858	0.61772924	0.15475614	-0.7659139	0.31505062	0.28210994	0.03839911	-0.0026575	0.77777778	0.86276877

What's ratio between individual classification and merged classification?

classify_cells_get_overlap.m

DG

In = 0.973821989528796

Iw = 0.98046875

E = 0.956204379562044

CA3

In = 1

Iw = 0.558823529411765

E = 0.855769230769231

CA1
In = 0.878947368421053
Iw = 0.785365853658537
E = 0.893129770992366

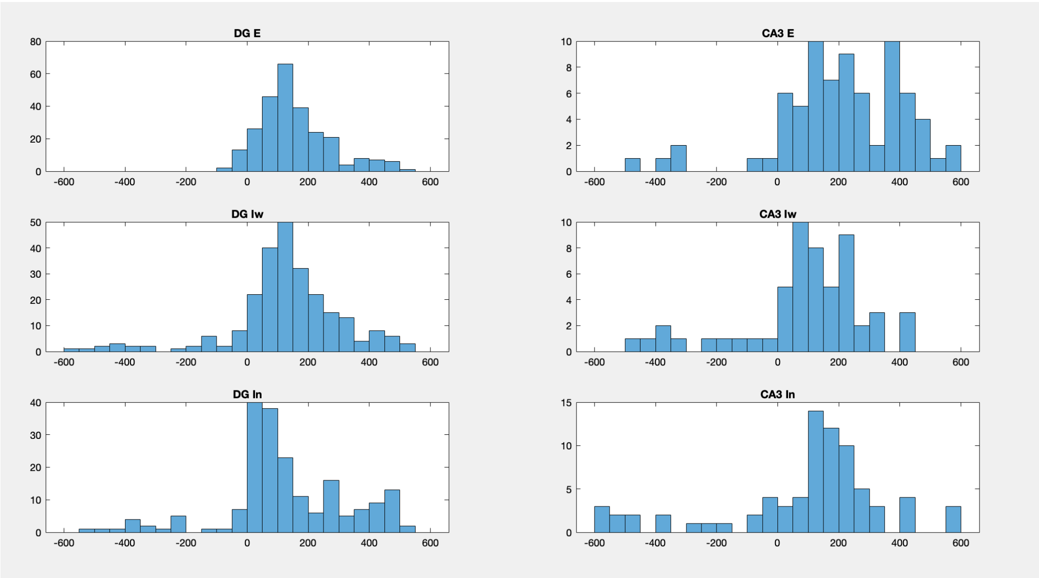
Over 85% agreement between general and individual for E and In

Counts (needs update)
DG
In = 191
Iw = 256
E = 274

CA3
In = 75
Iw = 102
E = 104

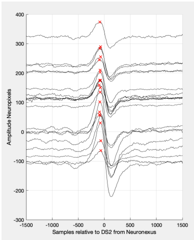
CA1
In = 190
Iw = 204
E = 131

classify_cells_DG_CA3.m



Offset between LFP (DS) and AP (spikes)

1) Offset between Neuronexus 2k (DS) and Neuropixels 30k
Not very useful, because it shows offset between Neuronexus and low frequency components in AP, not spike components in AP. Conclusion = no need to correct
DATASET_2_3_4/ getDS_aver_NP_30k_linux
Produces file dataDS_aver_30k.mat
Plot: plotDS_aver_NP_30k.m



2) Offset between Neuropixels 2.5k (DS) and Neuropixels 30k

<u>Not very useful, because it shows offset between Neuropixels 2.5k and low frequency components in AP, not spike components in AP. Conclusion = no need to correct</u>

Neuropixels_8/code_DS_aver_30k/getDSaver.m

Produces folder DS_aver_30k with variable averDS

3) Offset between Neuronexus 2k (DS) and Neuropixels 2.5k LP

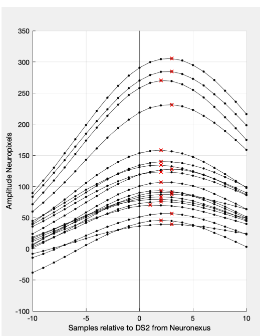
DATASET_2_3_4/getDS_aver_NP_linux.m

DATASET_2_3_4/plotDS_offset_2_5k.m

It is 2.35 samples @ 2.5k sample rate, corresponds to 0.94ms

<u>Useful. It shows that 2.5k LP is delayed behind Neuroneuxs LFP</u>

<u>Means that we need to subtract 2 samples from Neuropixels DS samples everywhere, where 2.5k LP band was used to detect DS</u>

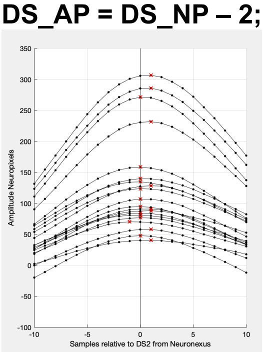


Apply offset 2 samples = **add 2 samples to Neuronexus DS sample**

DS_NN = 0, DS_NP = 2 -> DS_NP = DS_NN + 2

If DS is detected from LP (DS_NP), and need to find DS location in AP (basically NN), I have to do

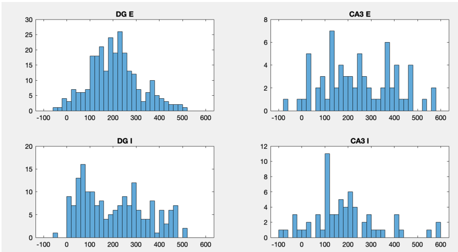
DS_AP = DS_NP – 2;



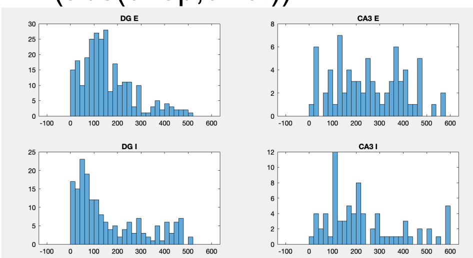
Distance of units from GC

get_spike_distFromGC.m

From top

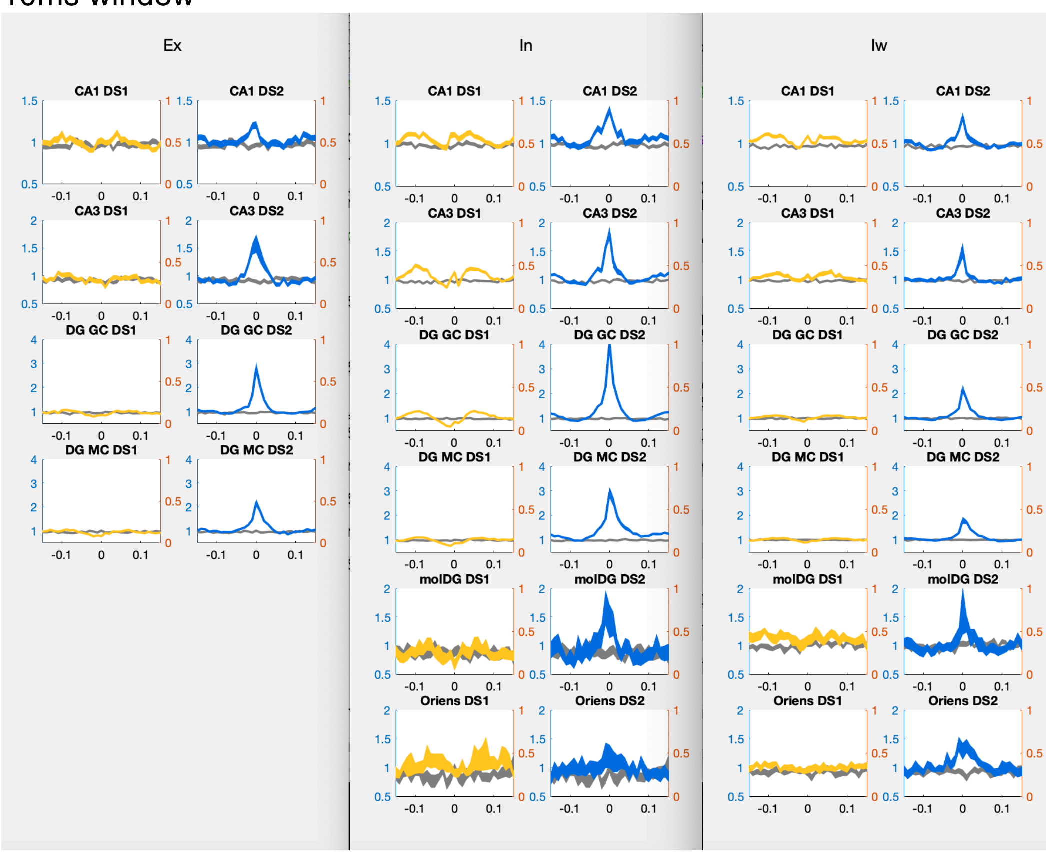


Min(abs(dTop,dBot))



DG: Abs < 150um GC
CA3 – no limit

Change of firing rate around DS
code firing rates DS
10ms window



CA1
Ex CA1 DS1 r=1.0575 T144=1.2876 p=0.19994
Ex CA1 DS2 r=1.2475 T144=4.4634 p=1.6161e-05

In CA1 DS1 r=1.1362 T147=4.0489 p=8.2949e-05

In CA1 DS2 r=1.4275 T147=8.1447 p=1.5017e-13

Iw CA1 DS1 r=1.1211 T167=5.2787 p=4.0013e-07
Iw CA1 DS2 r=1.3535 T167=6.3158 p=2.3442e-09

CA3
Ex CA3 DS1 r=1.0085 T103=0.14264 p=0.88685
Ex CA3 DS2 r=1.7599 T103=4.0719 p=9.1695e-05

In CA3 DS1 r=1.1873 T101=4.1028 p=8.2798e-05
In CA3 DS2 r=1.909 T101=7.4603 p=3.086e-11

Iw CA3 DS1 r=1.1259 T71=2.4719 p=0.015837
Iw CA3 DS2 r=1.5806 T71=3.824 p=0.00027926

GC
Ex DG GC DS1 r=0.91616 T140=-1.7704 p=0.078837
Ex DG GC DS2 r=3.0345 T140=7.0961 p=5.8635e-11

In DG GC DS1 r=0.88159 T95=-3.0348 p=0.0031049
In DG GC DS2 r=4.2582 T95=13.0472 p=6.6936e-23

Iw DG GC DS1 r=0.96638 T130=-0.98554 p=0.32619
Iw DG GC DS2 r=2.1673 T130=7.0304 p=1.046e-10

MC
Ex DG MC DS1 r=0.76467 T139=-5.921 p=2.3844e-08
Ex DG MC DS2 r=2.1775 T139=7.3018 p=1.9998e-11

In DG MC DS1 r=0.86412 T88=-3.5055 p=0.00071951
In DG MC DS2 r=2.9546 T88=8.929 p=5.7469e-14

Iw DG MC DS1 r=0.89697 T105=-4.6144 p=1.1189e-05
Iw DG MC DS2 r=1.7954 T105=5.7713 p=8.0431e-08

Exclude SWR – used in paper
code firing rates DS
getDS_spikes_excludeSWR.m

Ex CA1 DS1 r=0.9323 T144=-1.4893 p=0.1386
Ex CA1 DS2 r=1.0902 T144=1.6503 p=0.10105
In CA1 DS1 r=1.0909 T147=2.4022 p=0.017547
In CA1 DS2 r=1.2541 T147=4.3909 p=2.1454e-05
Iw CA1 DS1 r=1.0832 T167=3.4534 p=0.00070164
Iw CA1 DS2 r=1.2601 T167=4.5555 p=1.0044e-05

Ex CA3 DS1 r=0.91049 T103=-1.3637 p=0.17564
Ex CA3 DS2 r=1.4744 T103=3.0177 p=0.00321
In CA3 DS1 r=1.1632 T101=3.723 p=0.00032416
In CA3 DS2 r=1.7155 T101=6.281 p=8.5605e-09

Iw CA3 DS1 r=1.0319 T71=0.63816 p=0.52542
Iw CA3 DS2 r=1.407 T71=2.891 p=0.0050912

Ex DG GC DS1 r=0.87125 T140=-2.9175 p=0.004112
Ex DG GC DS2 r=2.0591 T140=5.8252 p=3.7447e-08
In DG GC DS1 r=0.90329 T95=-2.6554 p=0.0092904
In DG GC DS2 r=3.6329 T95=9.5169 p=1.7811e-15
Iw DG GC DS1 r=0.9859 T130=-0.47825 p=0.63327
Iw DG GC DS2 r=1.7448 T130=5.6225 p=1.0995e-07

Ex DG MC DS1 r=0.81236 T139=-3.5392 p=0.00054633
Ex DG MC DS2 r=2.0846 T139=6.146 p=7.9096e-09
In DG MC DS1 r=0.92925 T88=-1.9966 p=0.048958
In DG MC DS2 r=1.5829 T88=3.4196 p=0.00095245
Iw DG MC DS1 r=0.94661 T105=-2.2639 p=0.025633
Iw DG MC DS2 r=1.4773 T105=4.8287 p=4.6947e-06

Co-firing around DS
Done for all combinations between DG and CA1
code sync DS
res_sync_v7 EX INT
res_sync_v8 EX INT
res_sync_v9 EX INT
res_sync_v10 EX vs INT

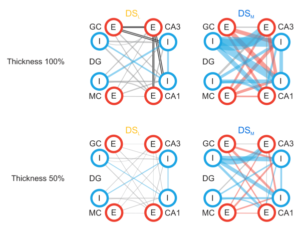
DSM ratio vs RND / DSL ratio vs RND   DSM pval vs RND

24 combos
0.05/24 = 0.002 Bonferoni corrected p-value 2e-3

%DG_GC INT vs CA1 INT	6.5 / 1.3	3e-26/8e-6	beforeDS	0
%DG_MC INT vs CA1 INT	3.4 / 1.2	6e-12/6e-3	afterDS	-
%DG_GC INT vs CA1 EX	4.1 / 1.3	2e-14/6e-3	beforeDS	0
%DG_MC INT vs CA1 EX	2.1 / 0.9	2e-5/7e-2	afterDS	-
%DG_GC INT vs CA3 INT *	8.2 / 1.3	5e-18/8e-2	beforeDS	-
%DG_MC INT vs CA3 INT *	2.5 / 1.6	3e-7/1e-4	0	-
%DG_GC INT vs CA3 EX *	10.1 / 0.5	6e-6/0.28	beforeDS	0
%DG_MC INT vs CA3 EX *	1.8 / 0.9	3e-3/0.16	0	0
%CA3 INT vs CA1 INT *	3.1 / 1.6	2e-18/1.1e-9	beforeDS	+
%CA3 INT vs CA1 EX *	1.8 / 1.0	1e-9/0.6	before DS	+
%CA3 EX vs CA1 INT *	3.0 / 0.9	1e-4/0.017	0	0
%CA3 EX vs CA1 EX *	0.8 / 0.5	0.14/0.34	0	0
%DG_GC EX vs CA1 EX	2.2 / 0.8	9e-9/0.76	afterDS	-
%DG_GC EX vs CA3 EX *	1.0 / 0.2	0.004/0.29	afterDS	-
%DG_MC EX vs CA1 EX	1.4 / 0.6	0.0004/0.014	afterDS	-
%DG_MC EX vs CA3 EX *	2.0 / 0.6	0.0017/0.39	afterDS	-

%DG_GC EX vs CA1 INT	4.1 / 1	2e-21/0.27	0	0
%DG_GC EX vs CA3 INT *	3.5 / 0.8	8e-8/0.01	afterDS	-
%DG_MC EX vs CA1 INT	2.5 / 1.0	3e-10/0.35	after	-
%DG_MC EX vs CA3 INT *	3.2 / 0.8	2e-8/0.04	after	-

%DG_GC EX vs INT	7.3 / 0.6	1e-34/1e-6
%DG_MC EX vs INT *	2.3 / 0.6	7e-9/0.33
%CA3 EX vs INT	2.2 / 1.2	2e-12/2e-4
%CA1 EX vs INT *	1.6 / 1.4	2e-10/1e-7



DS1 0.05/24 = 0.002 Bonferoni corrected p-value 2e-3, window +/- 3ms

DS_L	GC INTn	MC INTn	CA3 E	CA3 INTn	CA1 E	CA1 INTn
GC E	0.6541±0.88 T630 = 4.9045 P = 1.1937e-06 Pn = 0.52415	0.5746±0.74 T170 = 2.9052 P = 0.0041583 Pn = 0.044767	0.22363 ± 0.42 T88 = 1.0536 P = 0.29494 Pn = 0.0074986	0.80781 ± 0.87 T91 = 2.5095 P = 0.013859 Pn = 0.16045	0.76384 ± 0.90 T478 = 0.31105 P = 0.7559 Pn = 0.61979	1.0636 ± 1.45 T502 = 1.1078 P = 0.26847 Pn = 0.43732
GC INTn		0.67507±0.54 T129 = 4.7465 P = 5.4124e-06 Pn = 0.25511	0.54401 ± 1.05 T128 = 1.0952 P = 0.2755 Pn = 0.050884	1.3343 ± 1.26 T111 = 1.7268 P = 0.086981 Pn = 0.47376	1.3449 ± 2.11 T301 = 2.7839 P = 0.0057116 Pn = 0.065283	1.2752 ± 1.35 T333 = 4.54 P = 7.857e-06 Pn = 0.08118
MC E		0.64339 ± 0.61 T169 = 0.97434 P = 0.33128 Pn = 0.22485	0.60018 ± 0.65 T98 = 0.85903 P = 0.39242 Pn = 0.8539	0.81985 ± 0.74 T107 = 2.0965 P = 0.038392 Pn = 0.19918	0.58118 ± 0.96 T294 = 2.455 P = 0.014666 Pn = 0.41358	1.0124 ± 1.57 T238 = 0.93032 P = 0.35315 Pn = 0.7523
MC INTn			0.8671 ± 1.36 T53 = 1.3954 P = 0.16871 Pn = 0.26114	1.6433 ± 1.39 T61 = 3.9906 P = 0.00017934 Pn = 0.19238	0.89563 ± 1.03 T143 = 1.8167 P = 0.071357 Pn = 0.18377	1.1534 ± 1.07 T117 = 2.7746 P = 0.0064355 Pn = 0.49864
CA3 E				1.1515 ± 1.26 T725 = 3.7233 P = 0.00021186 Pn = 0.059145	0.48686 ± 0.75 T220 = 0.94817 P = 0.34408 Pn = 0.026174	0.90452 ± 0.99 T318 = 2.385 P = 0.017665 Pn = 8.2363e-06
CA3 INTn					1.0028 ± 1.14 T290 = 0.52045 P = 0.60315 Pn = 0.14006	1.60 ± 2.17 T330 = 6.2672 P = 1.1482e-09 Pn = 0.47855
CA1 E						1.3583 ± 1.68 T542 = 5.2996 P = 1.6914e-07 Pn = 0.30116

DS2 0.05/24 = 0.002 Bonferoni corrected p-value 2e-3

DS$_M$	**GC INTn**	**MC INTn**	**CA3 E**	**CA3 INTn**	**CA1 E**	**CA1 INTn**
GC E	7.3205 ± 7.92 T630 = 13.0485 P = 1.2874e-34 Pn = 2.3645e-09	4.7988±4.63 T170 = 6.8566 P = 1.2488e-10 Pn = 9.957e-11	1.0289 ± 0.92 T88 = 2.9224 P = 0.0044136 Pn = 1.3392e-09	3.5295 ± 3.23 T91 = 5.8413 P = 7.9342e-08 Pn = 4.5458e-11	2.2256 ± 2.91 T478 = 5.8578 P = 8.7358e-09 Pn = 6.6359e-12	4.1186 ± 6.01 T502 = 9.9702 P = 1.7533e-21 Pn = 1.0377e-11
GC INTn		7.4803±7.28 T129 = 8.5847 P = 2.5198e-14 Pn = 2.7828e-06	10.063 ± 9.30 T128 = 4.7247 P = 5.9718e-06 Pn = 5.6084e-05	8.1949 ± 6.44 T111 = 10.3581 P = 5.342e-18 Pn = 1.5806e-05	4.086 ± 5.50 T301 = 8.0371 P = 2.1138e-14 Pn = 2.1032e-05	6.5427 ± 5.95 T333 = 11.5452 P = 3.6681e-26 Pn = 3.7738e-05
MC E		2.2688 ± 2.38 T169 = 6.0863 P = 7.5154e-09 Pn = 0.023698	1.9849 ± 2.41 T98 = 3.2284 P = 0.0016937 Pn = 0.10534	3.1591 ± 3.33 T107 = 6.0442 P = 2.2261e-08 Pn = 0.1028	1.376 ± 1.75 T294 = 3.5867 P = 0.00039204 Pn = 0.036659	2.4816 ± 2.88 T238 = 6.5874 P = 2.8444e-10 Pn = 0.049713
MC INTn			1.8334 ± 1.64 T53 = 3.0375 P = 0.0036971 Pn = 0.00068909	2.4801 ± 2.52 T61 = 5.7403 P = 3.1782e-07 Pn = 0.0093615	2.0729 ± 2.04 T143 = 4.3761 P = 2.3164e-05 Pn = 0.0013555	3.3982 ± 4.23 T117 = 7.6482 P = 6.2772e-12 Pn = 0.0041939
CA3 E				2.2205 ± 2.88 T725 = 7.1611 P = 1.9693e-12 Pn = 2.1807e-07	0.75755 ± 1.39 T220 = 1.4746 P = 0.14176 Pn = 4.7971e-05	3.0024 ± 3.66 T318 = 3.7866 P = 0.0001826 Pn = 7.1796e-07
CA3 INTn					1.8525 ± 2.18 T290 = 6.2674 P = 1.3257e-09 Pn = 0.067971	3.0831 ± 3.54 T330 = 9.3017 P = 1.9644e-18 Pn = 0.012153
CA1 E						1.5949 ± 1.98 T542 = 6.5143 P = 1.6703e-10 Pn = 0.02035

DG GC EX vs DG GC INT DS1xDS2 t 630 = -13.0028 P = 2.0622e-34
DG MC EX vs DG MC INT DS1xDS2 t 169 = -5.9363 P = 1.6111e-08
CA3 EX vs CA3 INT DS1xDS2 t 725 = -5.9861 P = 3.3794e-09
CA1 EX vs CA1 INT DS1xDS2 t 542 = -4.5777 P = 5.8351e-06

Window 20ms (+/- 10ms)

DS$_L$	**GC INTn**	**MC INTn**	**CA3 E**	**CA3 INTn**	**CA1 E**	**CA1 INTn**
GC E	0.6541±0.88 T630 = 4.9045 P = 1.1937e-06 Pn = 0.09774	0.5746±0.74 T170 = 2.9052 P = 0.0041583 Pn = 0.039166	0.22363 ± 0.42 T88 = 1.0536 P = 0.29494 Pn = 0.054793	0.80781 ± 0.87 T91 = 2.5095 P = 0.013859 Pn = 0.03989	0.76384 ± 0.90 T478 = 0.31105 P = 0.7559 Pn = 0.13281	1.0636 ± 1.45 T502 = 1.1078 P = 0.26847 Pn = 0.15028

GC INTn		0.67507±0.54 T129 = 4.7465 P = 5.4124e-06 Pn = 0.047755	0.54401 ± 1.05 T128 = 1.0952 P = 0.2755 Pn = 0.020502	1.3343 ± 1.26 T111 = 1.7268 P = 0.086981 Pn = 0.033251	1.3449 ± 2.11 T301 = 2.7839 P = 0.0057116 Pn = 0.0267	1.2752 ± 1.35 T333 = 4.54 P = 7.857e-06 Pn = 0.043317
MC E		0.64339 ± 0.61 T169 = 0.97434 P = 0.33128 Pn = 0.09802	0.60018 ± 0.65 T98 = 0.85903 P = 0.39242 Pn = 0.06673	0.81985 ± 0.74 T107 = 2.0965 P = 0.038392 Pn = 0.49095	0.58118 ± 0.96 T294 = 2.455 P = 0.014666 Pn = 0.29765	1.0124 ± 1.57 T238 = 0.93032 P = 0.35315 Pn = 0.39909
MC INTn			0.8671 ± 1.36 T53 = 1.3954 P = 0.16871 Pn = 0.14321	1.6433 ± 1.39 T61 = 3.9906 P = 0.00017934 Pn = 0.117	0.89563 ± 1.03 T143 = 1.8167 P = 0.071357 Pn = 0.24458	1.1534 ± 1.07 T117 = 2.7746 P = 0.0064355 Pn = 0.37055
CA3 E				1.1515 ± 1.26 T725 = 3.7233 P = 0.00021186 Pn = 1.5382e-05	0.48686 ± 0.75 T220 = 0.94817 P = 0.34408 Pn = 0.00027834	0.90452 ± 0.99 T318 = 2.385 P = 0.017665 Pn = 0.00013832
CA3 INTn					1.0028 ± 1.14 T290 = 0.52045 P = 0.60315 Pn = 0.11203	1.60 ± 2.17 T330 = 6.2672 P = 1.1482e-09 Pn = 0.044613
CA1 E						1.3583 ± 1.68 T542 = 5.2996 P = 1.6914e-07 Pn = 0.066841

Realistic connections
Alpha 0.05/14 = 0.0036, window +/- 5ms

	DS_L	DS_M
GC/E x GC/I	0.79051+/-0.9138 T581 = -3.329 P = 0.00092671	8.33+/-8.3685 T581 = -3.0203 P = 0.0026359
GC/E x MC/I	0.68043+/-0.87865 T157 = -2.7506 P = 0.0066478	5.3043+/-5.9361 T157 = -2.6321 P = 0.0093323
GC/E x MC/E	0.54088+/-0.72423 T279 = 0.85573 P = 0.39288	3.5608+/-3.467 T279 = 0.0088691 P = 0.99293
GC/E x CA3/E	0.37644+/-0.45507 T70 = -1.8746 P = 0.065015	0.87582+/-0.86173 T70 = -0.96291 P = 0.33891
GC/E x CA3/I	0.83239+/-0.69035 T76 = -0.87671 P = 0.38341	4.303+/-4.0833 T76 = -2.2783 P = 0.02552
MC/E x GC/I	0.95666+/-1.0645 T182 = 0.988 P = 0.32446	5.255+/-7.22 T182 = -2.747 P = 0.0066185
MC/E x MC/I	0.8245+/-1.0462 T148 = -1.7079 P = 0.089747	2.6615+/-2.5867 T148 = -0.82058 P = 0.4132
MC/I x GC/I	0.75667+/-0.55853 T126 = -0.5836 P = 0.56053	6.322+/-6.9517 T126 = -6.0352 P = 1.6482e-08
CA3/E x CA1/E	0.85477+/-0.85883 T151 = 1.123 P = 0.26323	0.96712+/-1.5636 T151 = 0.40078 P = 0.68915

CA3/E x CA3/I	1.4343+/-1.4713 T609 = -2.4588 P = 0.014219	2.865+/-3.6455 T609 = -3.7632 P = 0.00018401
CA3/E x CA1/I	1.0065+/-0.90614 T286 = -1.242 P = 0.21526	2.7201+/-3.2973 T286 = -1.8477 P = 0.065675
CA3/I x CA1/E	1.3507+/-1.0954 T240 = -1.4874 P = 0.13822	2.0325+/-1.8885 T240 = -1.4545 P = 0.14711
CA3/I x CA1/I	1.5198+/-1.7283 T293 = -3.7089 P = 0.00024896	2.9068+/-3.1371 T293 = -3.2945 P = 0.0011071
CA1/E x CA1/I	1.2066+/-1.1722 T484 = -1.2258 P = 0.22085	1.5474+/-1.3616 T484 = -1.2683 P = 0.2053

Alpha 0.05/14 = 0.0036, window +/- 3ms **used in the paper v1**
res_sync_v14 all combs raw

	DS_L	DS_M
GC/E x GC/I	0.64525+/-0.9753 T528 = -3.6531 P = 0.00028489	6.8433+/-7.8829 T528 = -3.4934 P = 0.00051697
GC/E x MC/I	0.53546+/-0.59818 T157 = -0.75862 P = 0.44922	4.1806+/-3.9294 T157 = -0.89164 P = 0.37395
GC/E x MC/E	0.41684+/-0.69974 T239 = -0.60228 P = 0.54756	2.3013+/-2.5752 T239 = 0.37576 P = 0.70743
GC/E x CA3/E	0.26182+/-0.44948 T67 = 0.22677 P = 0.82129	1.4058+/-1.1116 T67 = 3.19311 P = 0.0032182
GC/E x CA3/I	1.059+/-1.3195 T489 = -2.7115 P = 0.0069345	2.5374+/-3.2899 T489 = -4.111 P = 4.6201e-05
MC/E x GC/I	0.61238+/-0.80391 T148 = -1.308 P = 0.19289	4.6083+/-4.4352 T148 = -0.93348 P = 0.35209
MC/E x MC/I	0.77923+/-1.1844 T127 = -0.62512 P = 0.53302	2.6634+/-3.0418 T127 = 0.44085 P = 0.66007
MC/I x GC/I	0.74627+/-0.57876 T123 = -0.027293 P = 0.97827	6.4834+/-6.482 T123 = -4.6454 P = 8.5866e-06
CA3/E x CA1/E	0.68613+/-0.78322 T157 = 1.3825 P = 0.16879	0.92334+/-1.2632 T157 = -1.3315 P = 0.18494
CA3/E x CA3/I	1.059+/-1.3195 T489 = -2.7115 P = 0.0069345	2.5374+/-3.2899 T489 = -4.111 P = 4.6201e-05
CA3/E x CA1/I	1.2189+/-1.3417 T203 = -1.1276 P = 0.26083	2.7736+/-6.2367 T203 = -1.7636 P = 0.079304

CA3/I x CA1/E	0.93271+/-0.92321 T200 = -1.9879 P = 0.048182	1.3423+/-1.1487 T200 = 0.48817 P = 0.62597
CA3/I x CA1/I	1.4789+/-1.7341 T269 = -1.687 P = 0.092761	2.8174+/-2.4641 T269 = -1.3502 P = 0.17809
CA1/E x CA1/I	1.2641+/-1.2788 T450 = -1.1563 P = 0.24819	1.5162+/-1.5487 T450 = -0.92222 P = 0.35691

Excluded SWR

6ms window, SWRs excluded from 300ms window around DS

Code sync DS/ res_sync_v15 exclude SWR / 6ms_win_300ms_SWR_excludewindow

Alpha 0.05/14 = 0.0036

T-test computed from raw values i.e. (Ncell1 & Ncell2) /N, not using marginal probabilities

	DS_L	DS_M
GC/E x GC/I	0.65159+/-1.0831 t_{464} = -4.8941 P = 1.3649e-06	6.4937+/-7.3429 t_{464} = 11.239 P = 4.371e-26
GC/E x MC/I	0.37777+/-0.51238 t_{146} = -5.8711 P = 2.7995e-08	2.6215+/-2.5673 t_{146} = 6.1239 P = 8.0347e-09
GC/E x MC/E	0.36983+/-0.56928 t_{205} = -2.848 P = 0.0048481	2.507+/-3.2264 t_{205} = 5.9746 P = 1.0068e-08
GC/E x CA3/E	0.62202+/-0.64689 t_{54} = 0.36696 P = 0.71508	2.3396+/-1.9221 t_{54} = 2.117 P = 0.038886
GC/E x CA3/I	0.71057+/-0.70674 t_{72} = -2.0925 P = 0.039915	2.7956+/-2.2425 t_{72} = 5.6702 P = 2.7718e-07
MC/E x GC/I	0.83923+/-1.0263 t_{128} = -0.97357 P = 0.33211	4.6776+/-4.9512 t_{128} = 5.5327 P = 1.7059e-07
MC/E x MC/I	0.73545+/-0.79413 t_{113} = -1.0451 P = 0.2982	2.5696+/-2.0566 t_{113} = 5.7945 P = 6.2935e-08
MC/I x GC/I	0.83834+/-1.1095 t_{121} = -4.9891 P = 2.0546e-06	6.2324+/-6.7617 t_{121} = 8.897 P = 6.7828e-15
CA3/E x CA1/E	0.70343+/-1.0584 t_{129} = 2.05 P = 0.042394	0.74643+/-0.7919 t_{129} = 2.8737 P = 0.0047466
CA3/E x CA3/I	0.88858+/-0.87775 t_{518} = 2.265 P = 0.023926	2.3265+/-2.9999 t_{518} = 7.1865 P = 2.3315e-12
CA3/E x CA1/I	0.77526+/-0.84038 t_{224} = 0.7284 P = 0.46713	3.2339+/-4.6558 t_{224} = 3.4198 P = 0.00074447
CA3/I x CA1/E	0.8705+/-0.92127 t_{196} = -0.084586 P = 0.93268	1.8035+/-2.1411 t_{196} = 5.5339 P = 9.952e-08

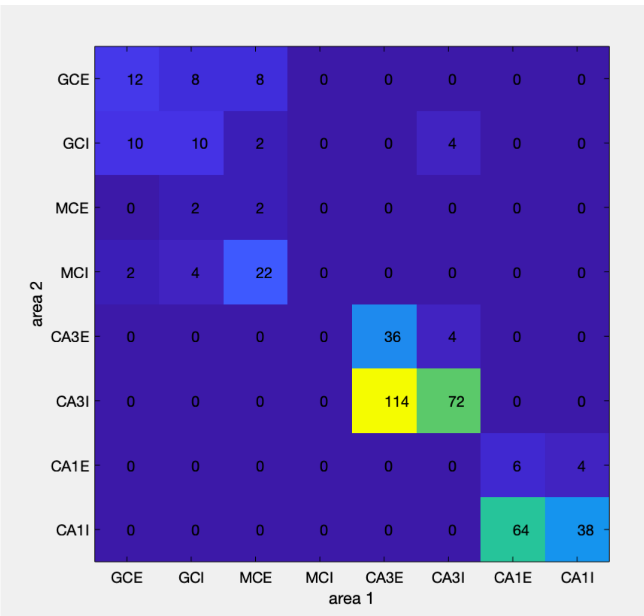
CA3/I x CA1/I	1.2217+/-1.3291 t_{281} = 4.2895 P = 2.4654e-05	2.384+/-2.6306 t_{281} = 9.0801 P = 1.9735e-17
CA1/E x CA1/I	1.0562+/-1.3194 t_{361} = 2.832 P = 0.0048857	1.3288+/-1.3742 t_{361} = 5.4662 P = 8.5931e-08

Co-firing of mono-synaptic cell pairs

code monosynaptic sync/

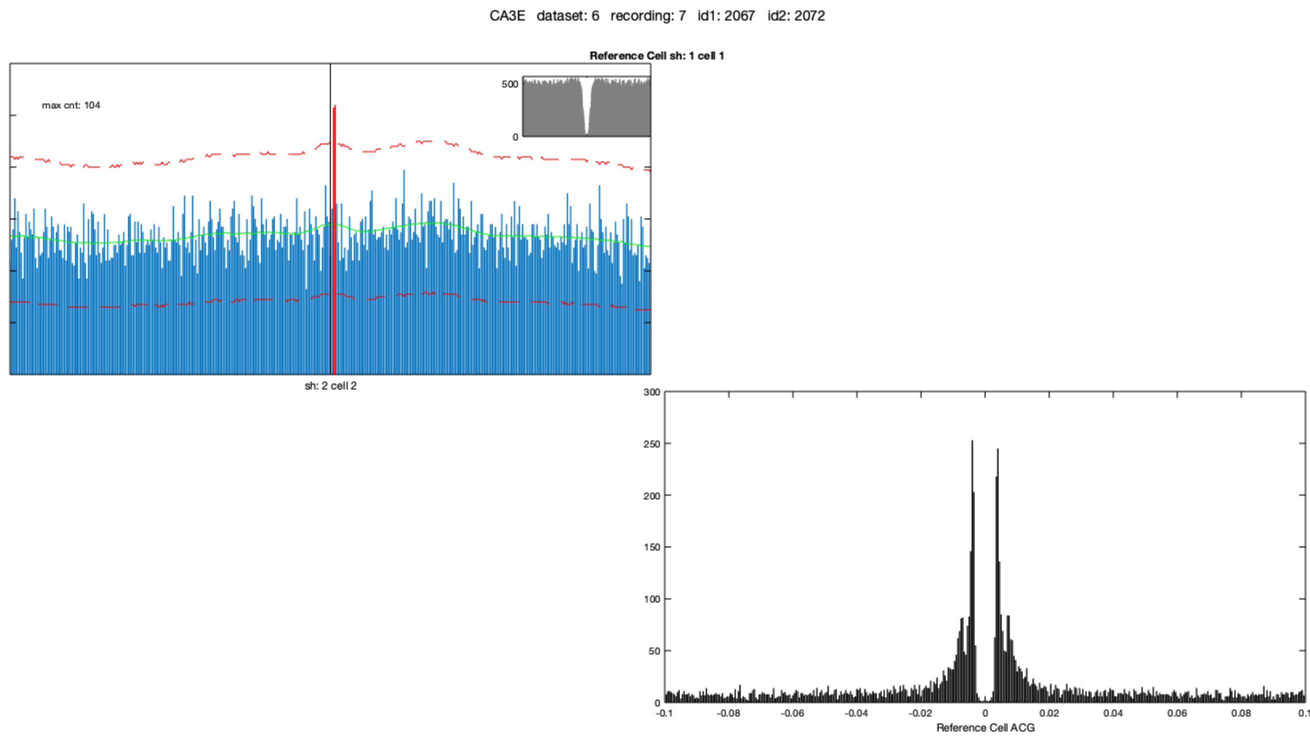
Finds pairs of cells with monosynaptic connections using code form form 2009? Stark paper (ref in code)

findSynapticPairs.m

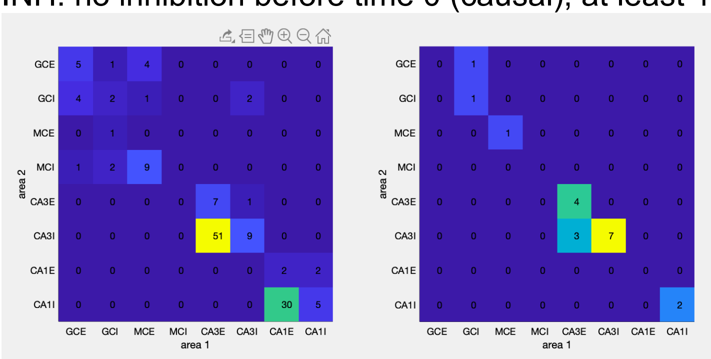


Plot all pairs

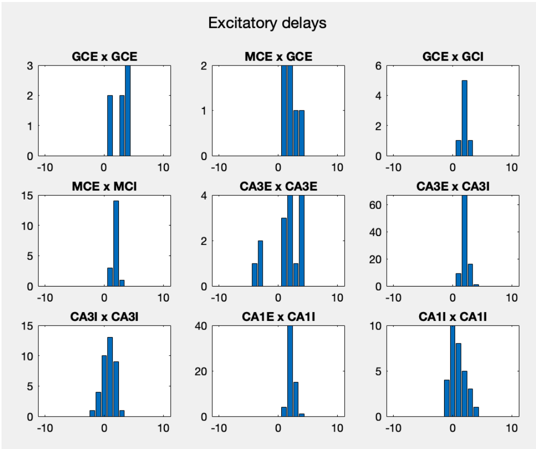
plotSynapticPairs.m



plotSynapticPairsSummary.m
only select good ones (left EXC, right INH)
EXC: no excitation before time 0 (causal), at least 1 bin significant, no inhibition
INH: no inhibition before time 0 (causal), at least 1 bin significant



Delays if we allow -10..+10ms
Notice excitatory is only positive times
Inh x inh is zero-lag synchrony

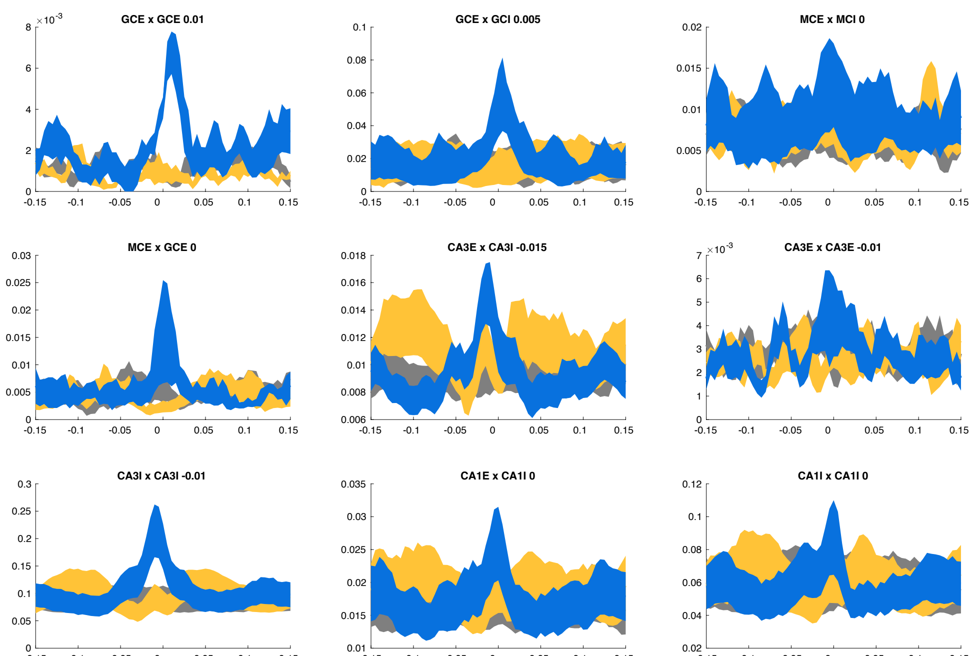


Average delays: (mean+std)
exc: 1.8689 +/- 0.6972
inh: 2 +/- 1.3292

Fig. 6G

Plot probability of seeing spike of cell2 following spike of cell1 (10ms) during DS12R
Stats measured at the peak
getDS_SynapticPairs.m

10ms half window, 5ms step – used in paper



0.05 alpha

GCE x GCE
DS1 x RND T4=1.1185 P=0.32599
DS2 x RND T4=5.9945 P=0.0038955

GCE x GCI
DS1 x RND T3=-0.70567 P=0.53125
DS2 x RND T3=3.4056 P=0.042287

MCE x MCI
DS1 x RND T8=-0.62116 P=0.55178
DS2 x RND T8=0.27891 P=0.78739

MCE x GCE
DS1 x RND T3=-1.897 P=0.15409
DS2 x RND T3=1.4455 P=0.24407

CA3E x CA3I
DS1 x RND T50=2.9681 P=0.0045892
DS2 x RND T50=4.6224 P=2.6989e-05

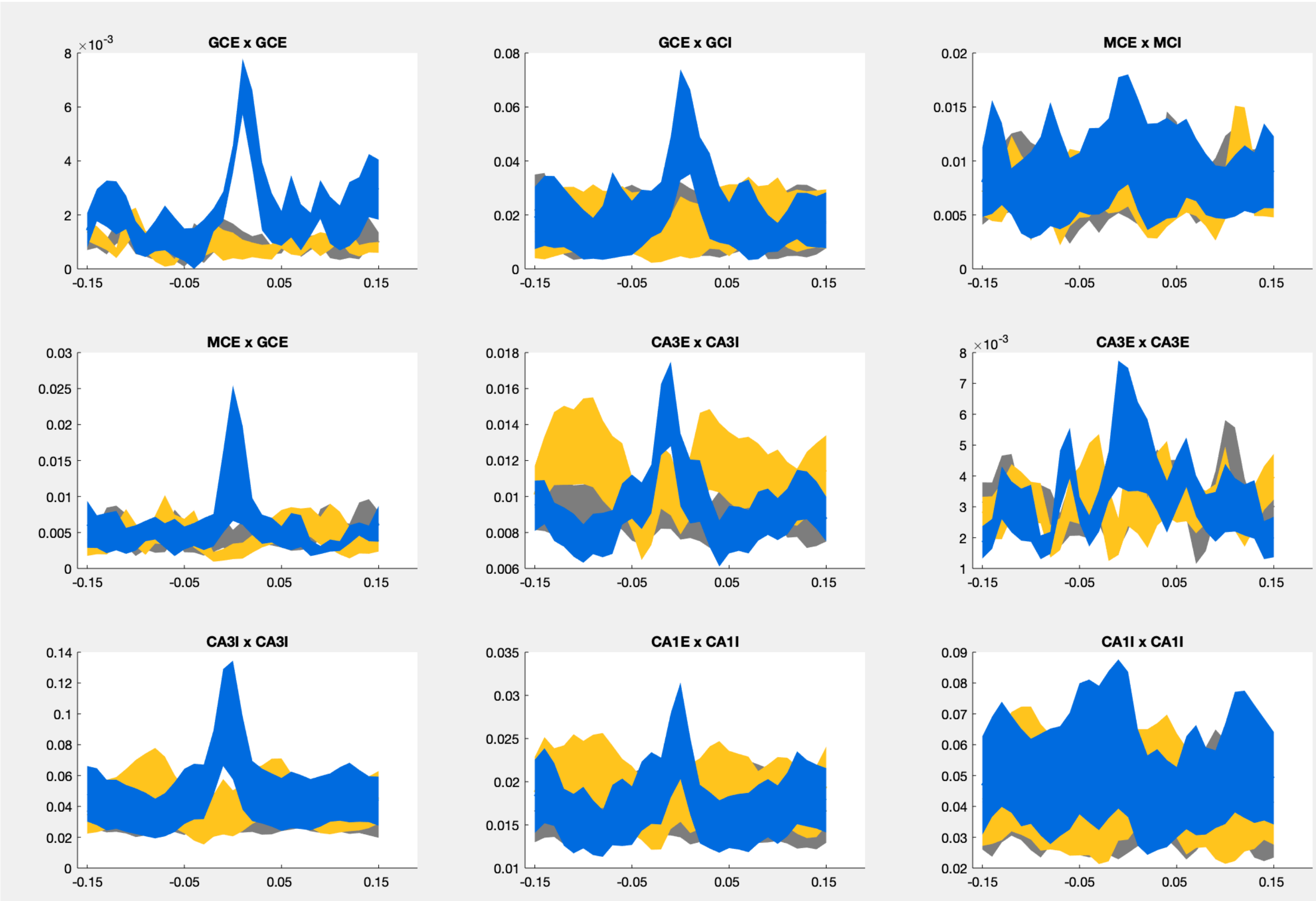
CA3E x CA3E
DS1 x RND T8=1.0588 P=0.32062
DS2 x RND T8=2.0184 P=0.07825

CA3I x CA3I
DS1 x RND T13=0.37221 P=0.71573
DS2 x RND T13=4.4929 P=0.00060514

CA1E x CA1I
DS1 x RND T29=1.4346 P=0.16211
DS2 x RND T29=4.0505 P=0.00034871

CA1I x CA1I
DS1 x RND T9=1.6088 P=0.14211
DS2 x RND T9=3.675 P=0.0051149

Monosynaptic pair cofiring – probability of spike with spike following in area 2 by 0-5ms
10ms half window, 10ms step



GCE x GCE
DS1 x RND T4=-0.3126 P=0.7702
DS2 x RND T4=4.9501 P=0.0077606

GCE x GCI
DS1 x RND T3=-3.3541 P=0.043926
DS2 x RND T3=3.5522 P=0.03803

MCE x MCI
DS1 x RND T8=1.5562 P=0.15827
DS2 x RND T8=1.83 P=0.10464

MCE x GCE
DS1 x RND T3=-2.8463 P=0.06531
DS2 x RND T3=1.4777 P=0.23601

CA3E x CA3I
DS1 x RND T50=0.65864 P=0.51315
DS2 x RND T50=1.967 P=0.054748

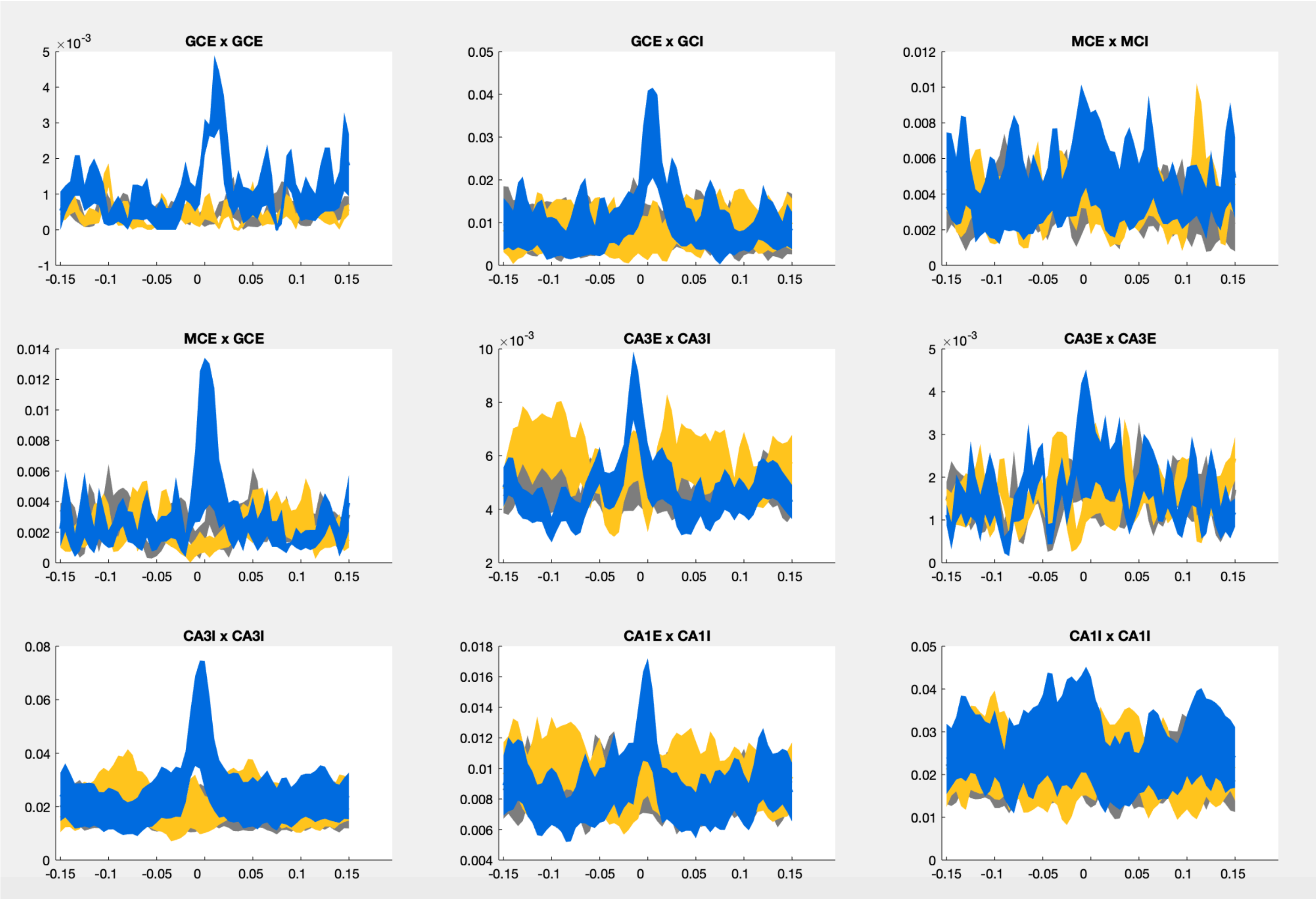
CA3E x CA3E
DS1 x RND T6=0.41202 P=0.69464
DS2 x RND T6=1.2098 P=0.27187

CA3I x CA3I
DS1 x RND T8=-0.35213 P=0.73383
DS2 x RND T8=1.9335 P=0.089243

CA1E x CA1I
DS1 x RND T29=1.6209 P=0.11586
DS2 x RND T29=3.6556 P=0.0010103

CA1I x CA1I
DS1 x RND T4=1.8491 P=0.13814
DS2 x RND T4=2.214 P=0.091224

5ms half window, 5ms step



GCE x GCE
DS1 x RND T4=-0.061246 P=0.9541
DS2 x RND T4=4.5475 P=0.010438

GCE x GCI
DS1 x RND T3=-3.7808 P=0.032425
DS2 x RND T3=3.2824 P=0.046343

MCE x MCI
DS1 x RND T8=0.0059193 P=0.99542
DS2 x RND T8=1.8892 P=0.095537

MCE x GCE
DS1 x RND T3=-0.79902 P=0.48269
DS2 x RND T3=1.4747 P=0.23674

CA3E x CA3I
DS1 x RND T50=-0.96877 P=0.33733
DS2 x RND T50=1.5553 P=0.12618

CA3E x CA3E
DS1 x RND T6=0.74201 P=0.4861
DS2 x RND T6=1.0237 P=0.34546

CA3I x CA3I
DS1 x RND T8=0.1334 P=0.89717
DS2 x RND T8=1.5743 P=0.15406

CA1E x CA1I
DS1 x RND T29=2.5549 P=0.016132
DS2 x RND T29=3.1325 P=0.0039409

CA1I x CA1I
DS1 x RND T4=0.014081 P=0.98944
DS2 x RND T4=2.3764 P=0.076283

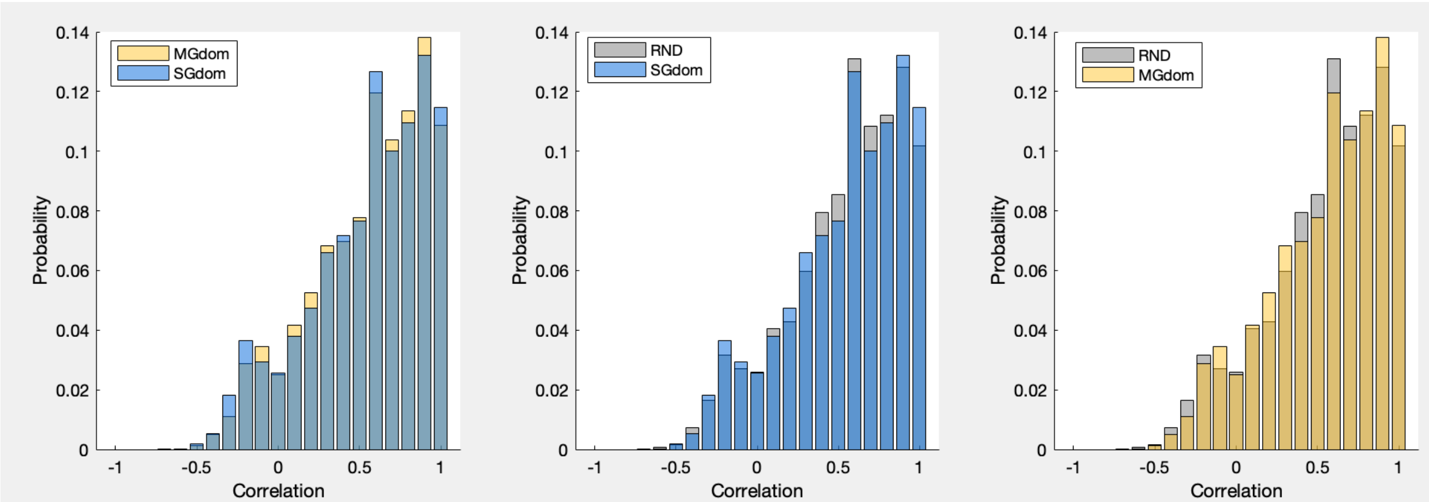
Sequences

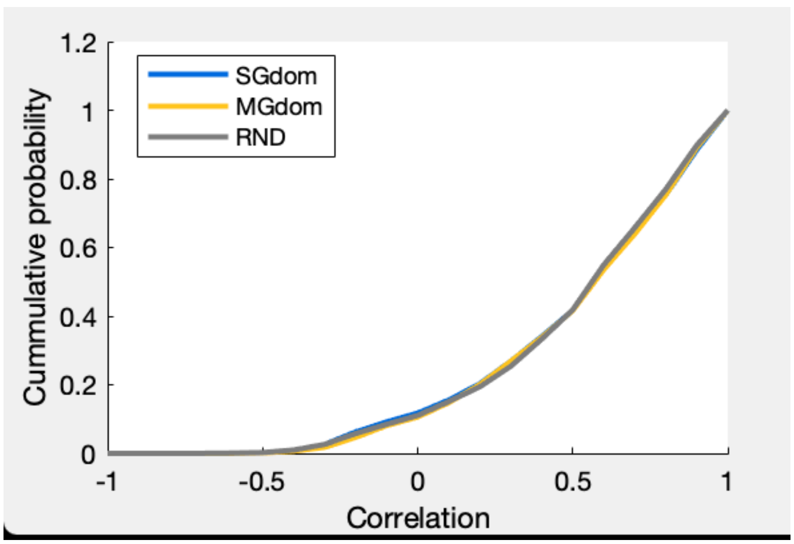
6 2020-03-13_14-00-04 DG: 6 CA3: 3 CA1: 7
6 2020-03-13_14-27-47 DG: 6 CA3: 0 CA1: 11
6 2020-03-13_14-51-33 DG: 4 CA3: 2 CA1: 2
6 2020-03-13_15-53-43 DG: 3 CA3: 2 CA1: 2
6 2020-03-13_16-13-35 DG: 0 CA3: 1 CA1: 3
6 2020-03-13_16-35-07 DG: 1 CA3: 2 CA1: 2
6 2020-03-13_16-54-24 DG: 2 CA3: 10 CA1: 5 7
6 2020-03-13_17-14-09 DG: 1 CA3: 24 CA1: 3 8
6 2020-03-13_17-34-13 DG: 2 CA3: 1 CA1: 9
6 2020-03-13_17-57-33 DG: 0 CA3: 2 CA1: 0
6 2020-03-13_18-19-05 DG: 0 CA3: 6 CA1: 0
6 2020-03-13_18-49-27 DG: 1 CA3: 8 CA1: 0
6 2020-03-13_19-11-00 DG: 1 CA3: 13 CA1: 0 13

CA3 sequences

Correlation between spiking during SGdom vs MGdom

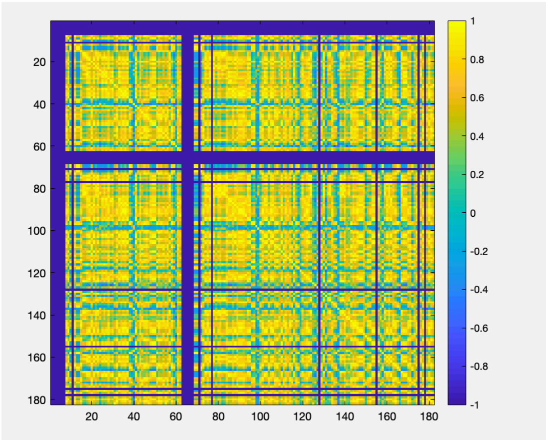
M32/NEUROPIXELS/code xcorr SGMG/getXcorrSGMG.m
CA1: +/-500ms around





%Kolmogorov-Smirnov test
[h,p,ks2stat] = kstest2(resTA{1},resTA{2})

Correlation matrices
getXcorrSGMG_ca1_corr_matrix.m



CA1: +/-150ms around

CA3:

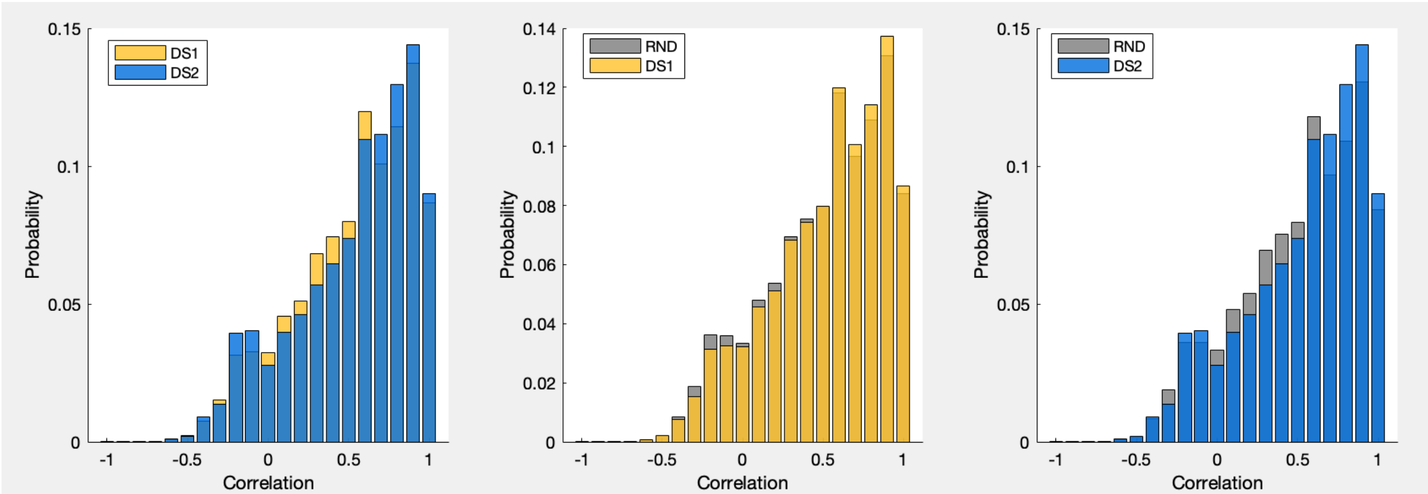
DG:

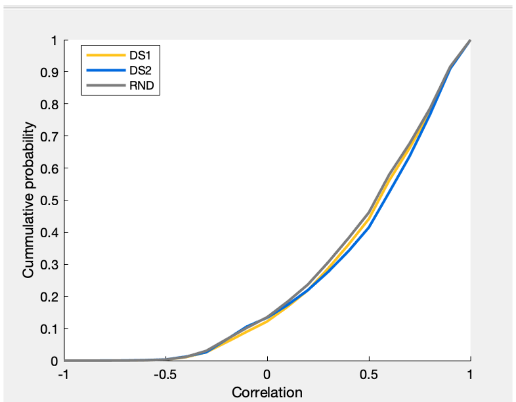
Thalamus and Cortex:
M32/NEUROPIXELS/code xcorr SGMG/getXcorrSGMG_thalamus_cortex.m
Thalamus:
stats_thalamus.dat

Cortex:

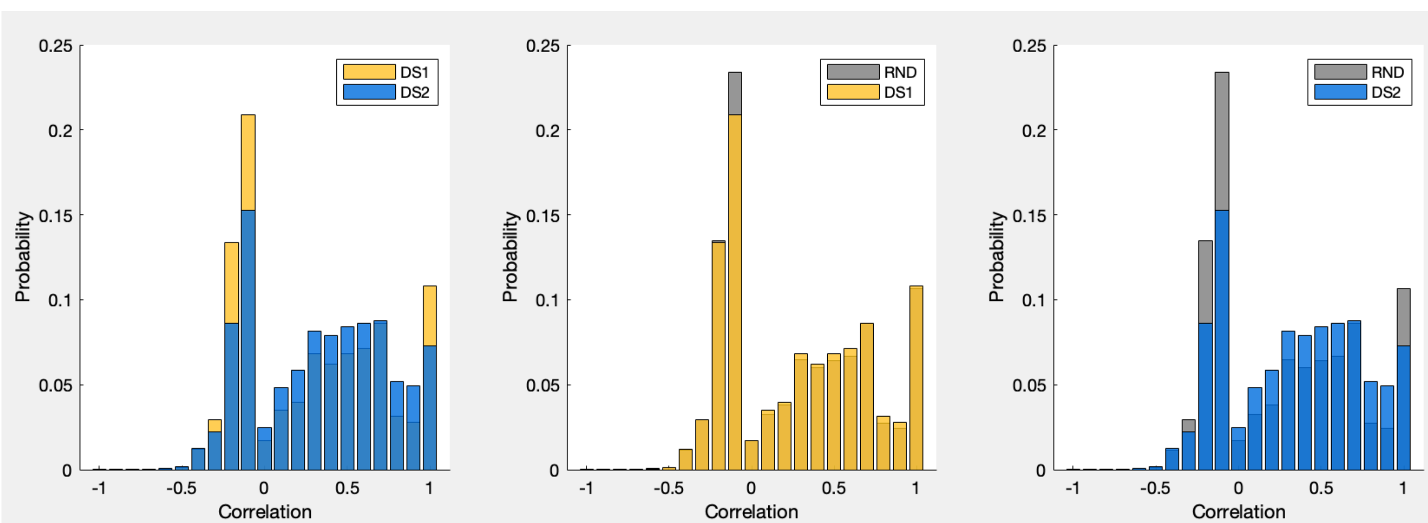
DS1/DS2/RND:
getXcorrDS1DS2.m

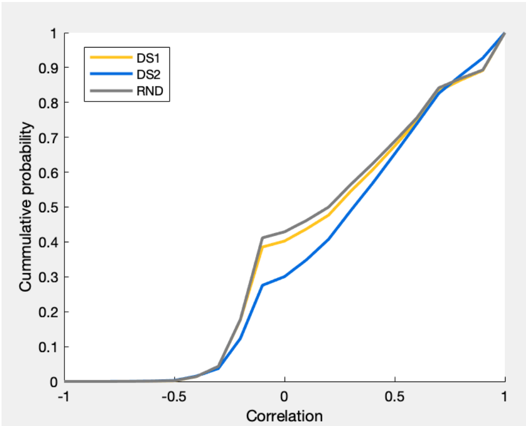
+/- 500ms around DS, CA1



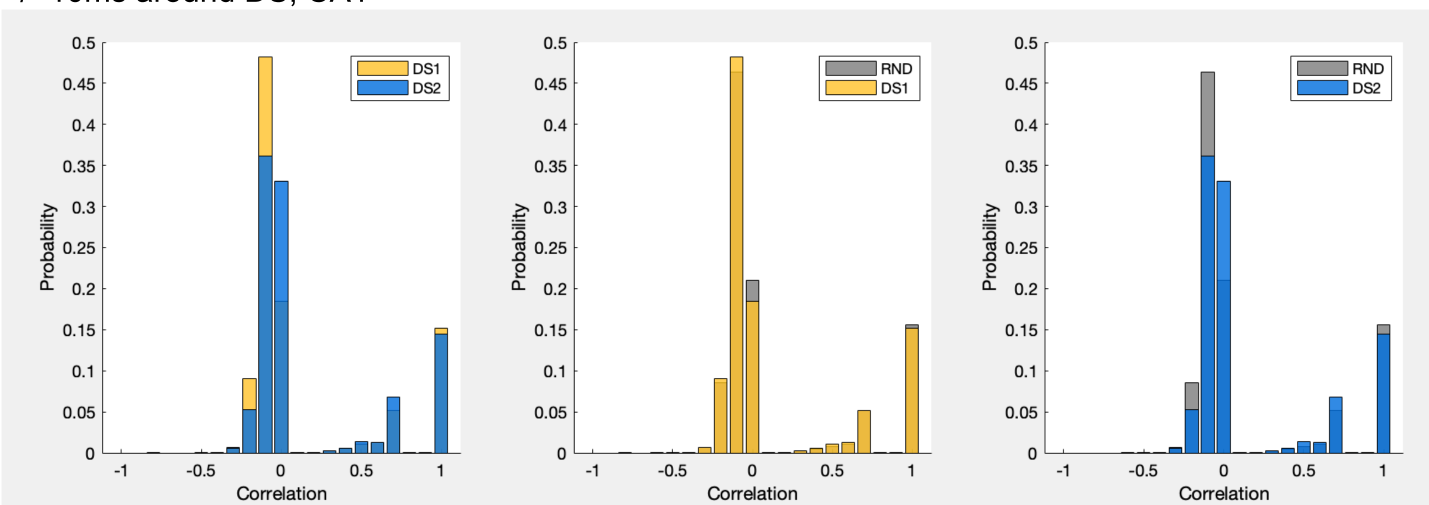


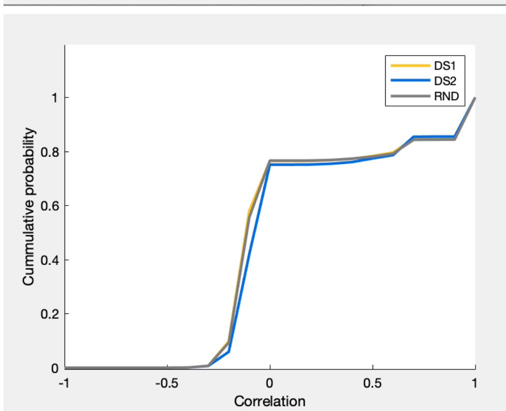
+/- 100ms around DS, CA1
DS1 more similar to RND, either very dissimilar or very similar
DS2 more average similarity



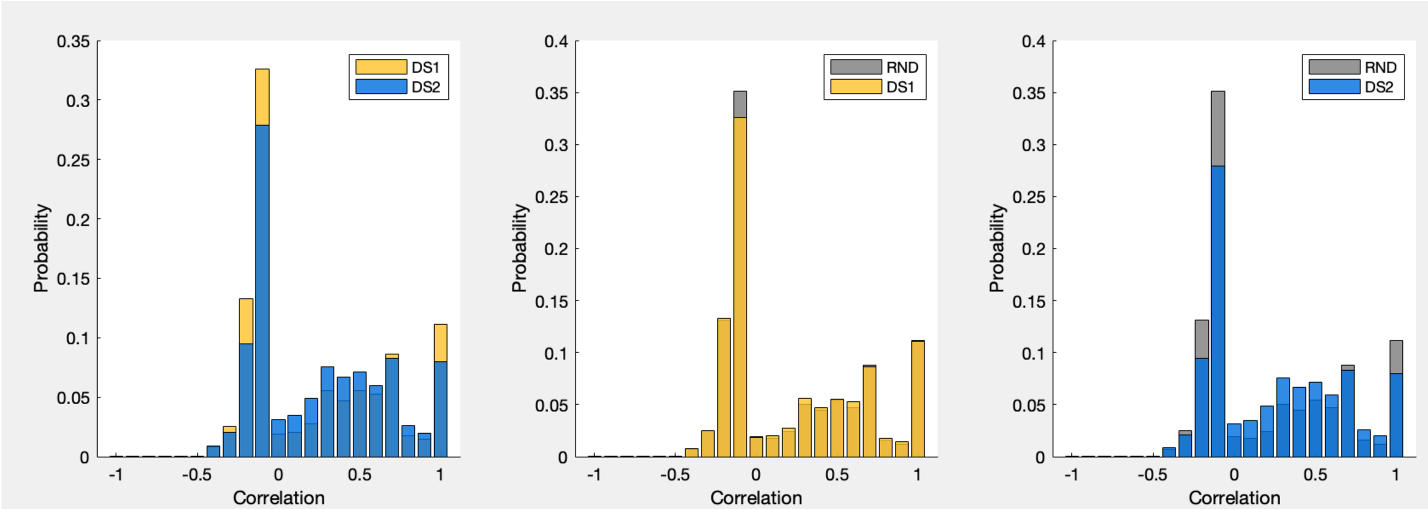


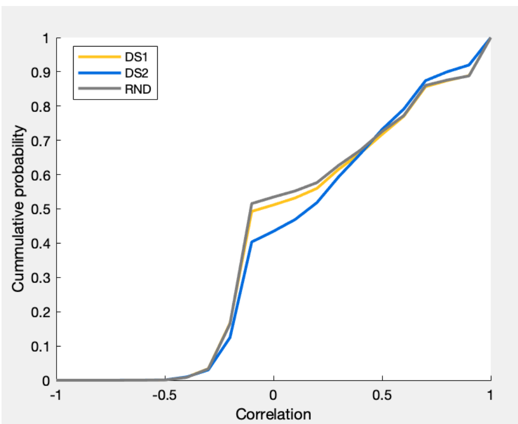
+/- 10ms around DS, CA1



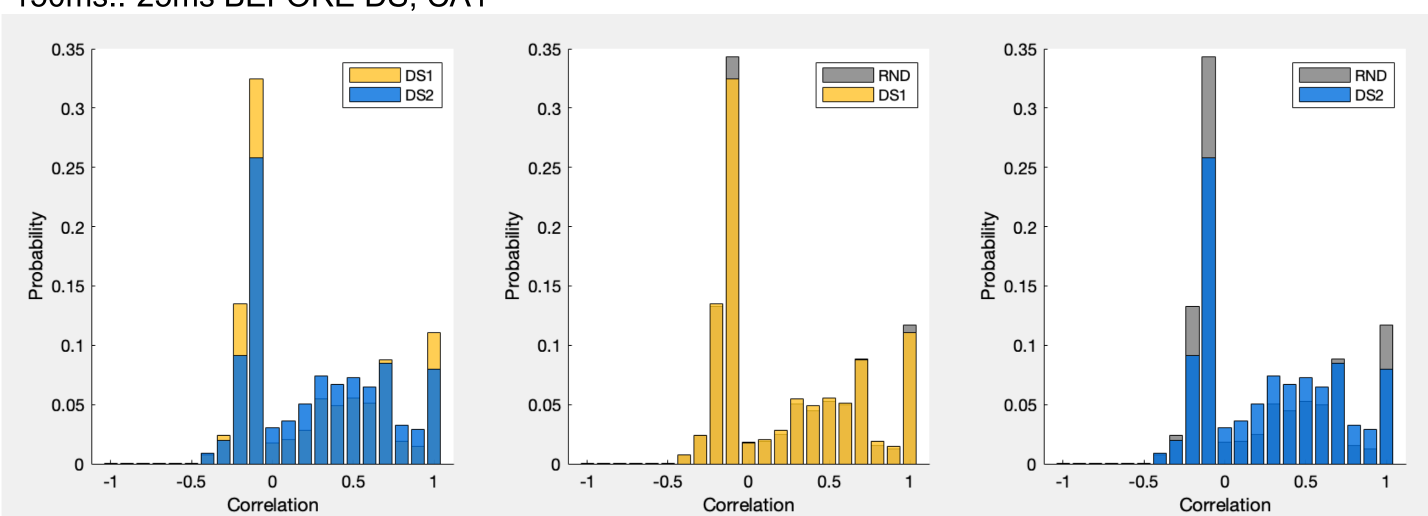


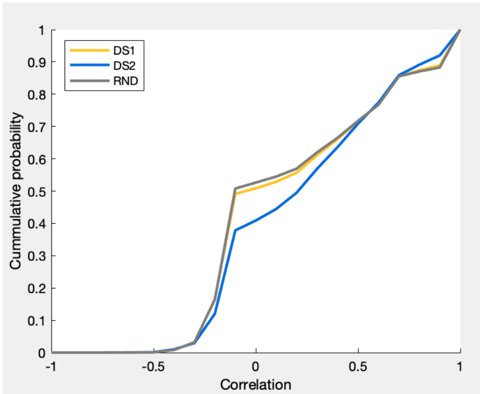
+25ms..+150ms AFTER DS, CA1





-150ms..-25ms BEFORE DS, CA1





Using mutual information

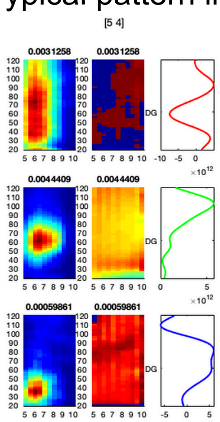
res_sync_v10 mutual info

20 combos
0.05/20 = 0.0025 Bonferoni corrected p-value 2.5e-3

Comparison, mean difference from RND for DS1, pvalue, mean diff from RND for DS2, pvalue

ICA/

Typical pattern in DG (bottom SG, middle MG)

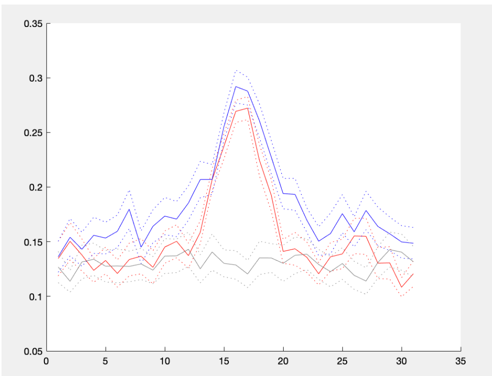


Sanity check - ICA power around DS – to replicate Fig 3 w Neuropixel data
getDS_OSC.m

Sanity check – PLV bw SG in DG and CA1
getDS_PLV.m

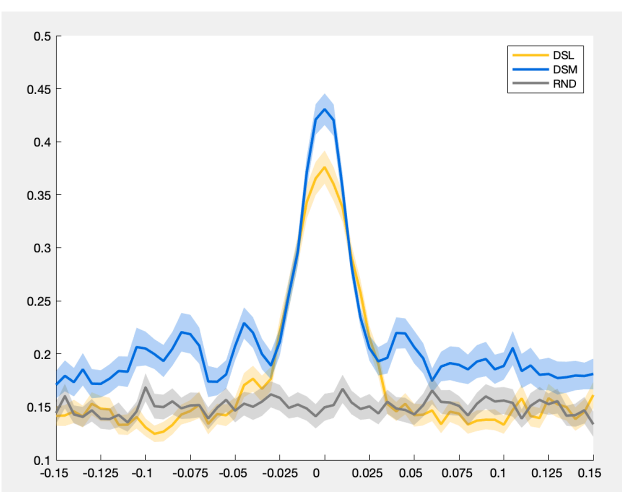
Spike-field coherence

Rayleigh vector of LPP DG ICA phases of spikes in CA1 around DS
Idea is to show that around DS, CA1 spikes are more organized around DG SG phase
But there is no difference between DS1 and DS2
getDS_OSC_spiking.m
PROBLEM: probe 1 and probe2 don't have same timestamps, fix!



Early attempts: not have probe1 and 2 synchronized!
getDS_OSC_spiking_freq.m
getDS_OSC_spiking.m

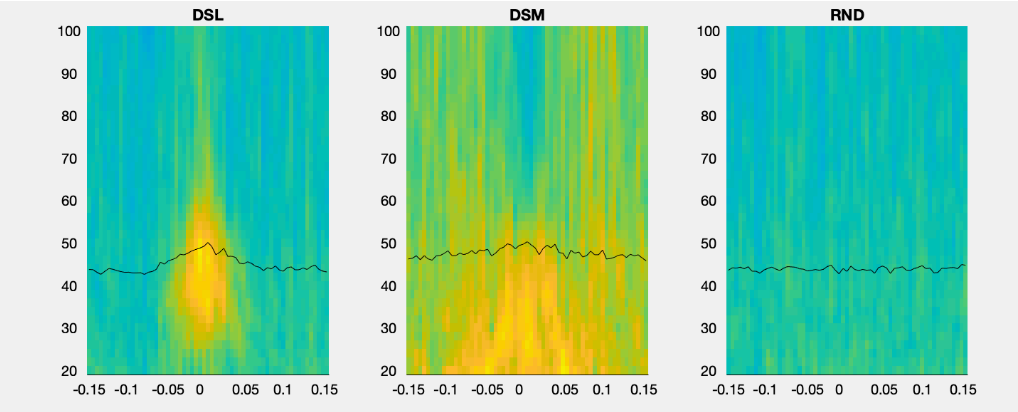
For single band (linux)
code spike-field
getDS_OSC_spiking_DGunits_srLFP.m



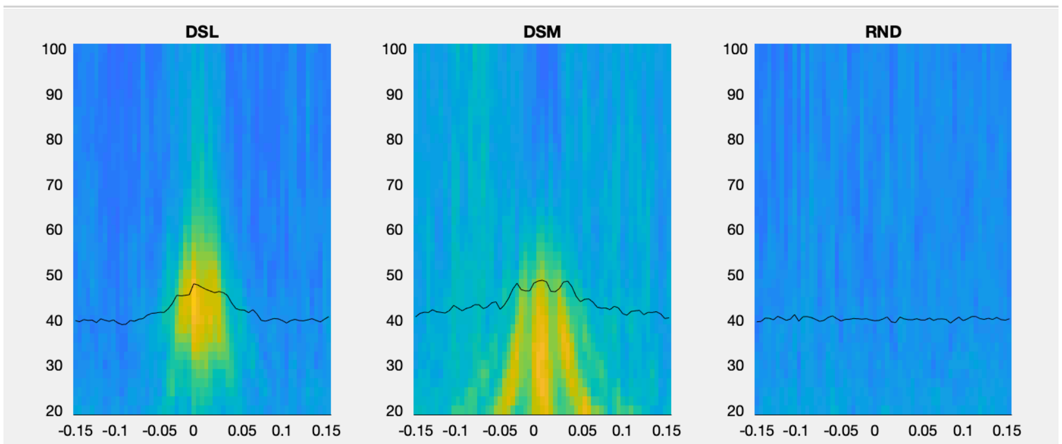
For multiple bands (linux)
code spike-field
getDS_OSC_spiking_DGunits_srLFP_bands.m

Color is Rayleigh vector (scale 0-0.4) between SR ICA in different bands (y axis) and spikes detected around dentate spikes

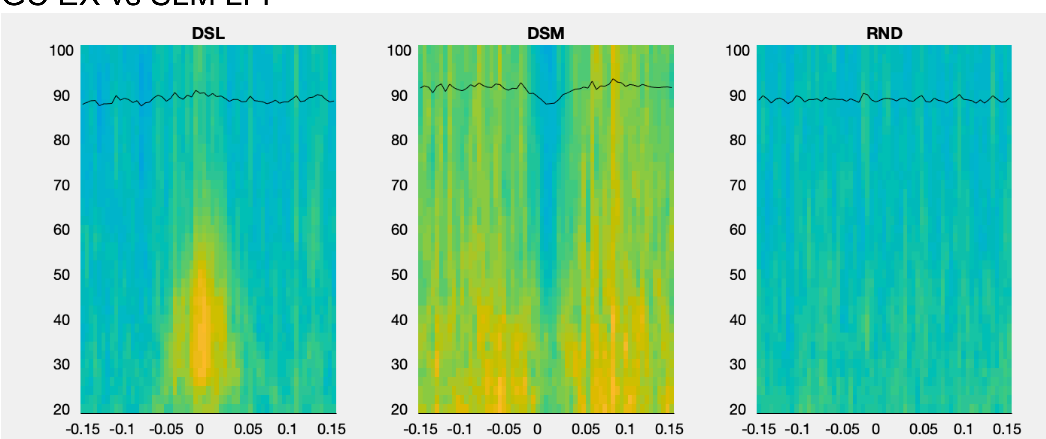
GC EX vs SR LFP



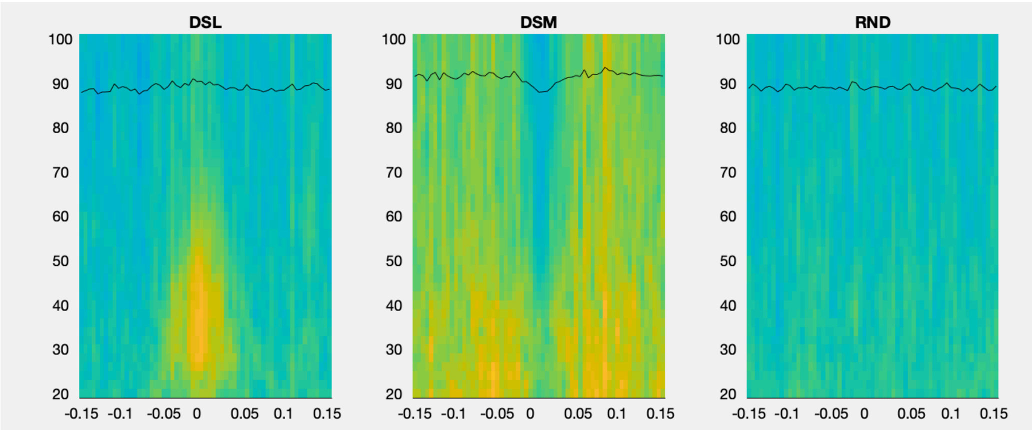
GC INTn vs SR LFP



GC EX vs SLM LFP



GC INTn vs SLM LFP



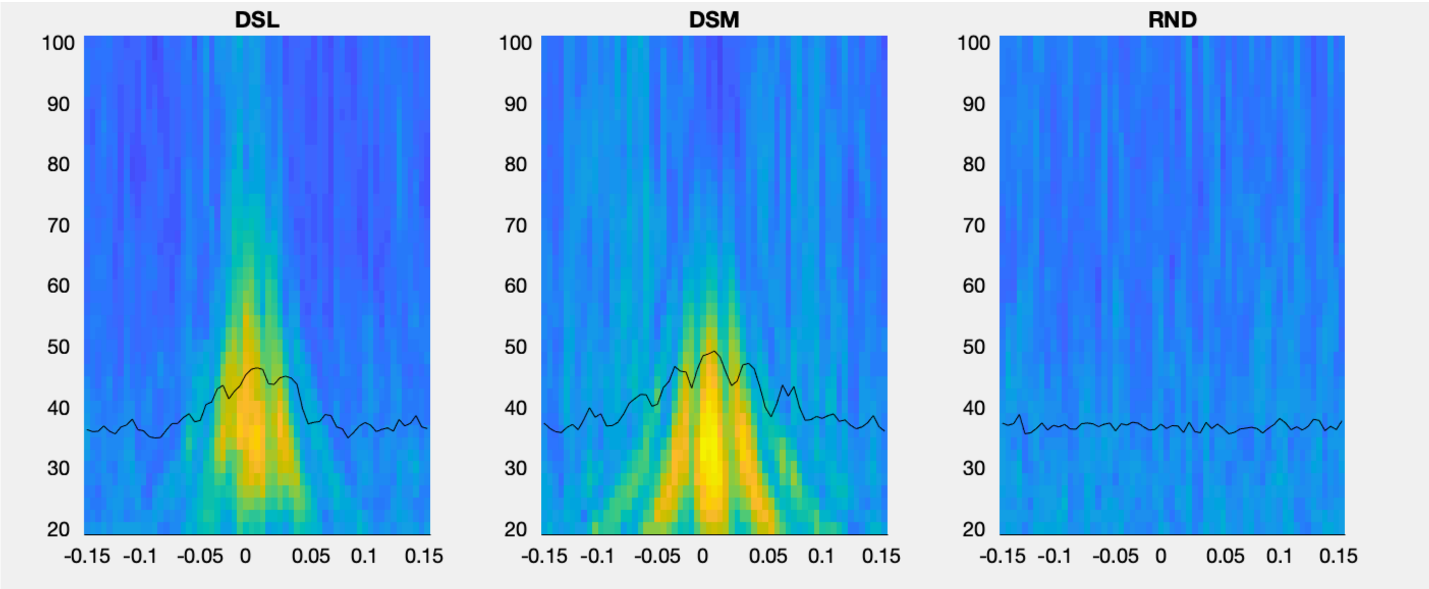
CA3 slow gamma LFP vs spiking in DG
ICAv2 – ICA done again only for datasets with 2 probes (5,8,9)
Several improvements:
1) probe1 and probe2 LFPs get synchronized so only use timestamps from probe1
2) for theta use only SP theta from probe 1 ca1
3) used wider filters 20-150Hz
4) used max resolution of the probe (20um skipping every 2nd site), i.e. sites on one side

Code get ICA – get ICA
ICA_analysis – review extracted ICAs
ICA_analysis_plotALL – plot all components
Code extract ICA – extract marked ICAs
getPolarity – get polarity of components

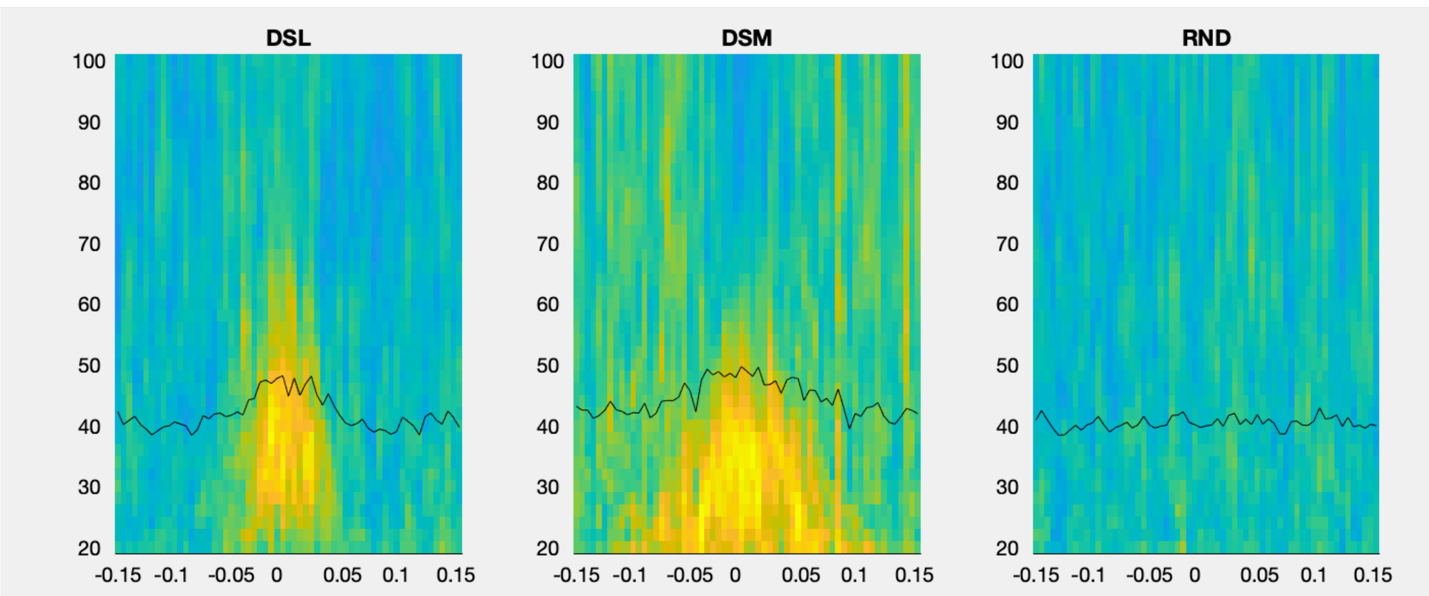
Res – results of ICA and exported components
loadLocalizations.m – all localizations and polarity

Note: files in dataset 6,7 #13 have problem with sync, which returns error (processed with code 513)

Linux:
code spike-field / getDS_OSC_spiking_DGunits_ca3sg_bands_GC_EX.m
code spike-filed / getDS_OSC_spiking_DGunits_ca3sg_bands_GC_INTn.m
plot_results_bands.m – plots results
GC INTn vs SG CA3 LFP



GC EX vs CA3 SG LFP

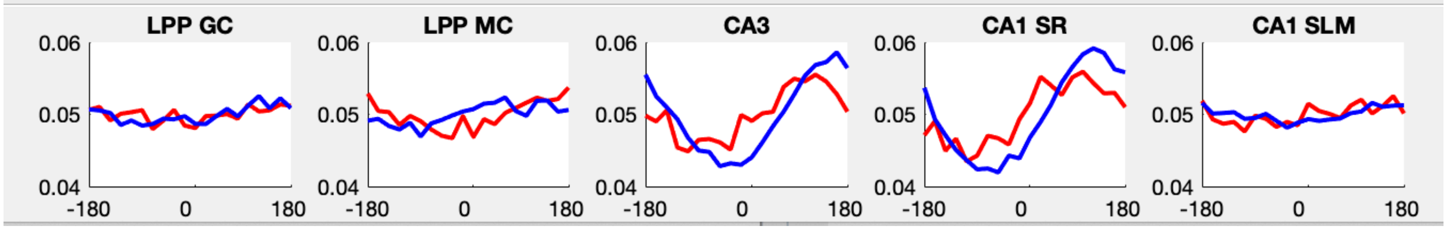


Gamma phase of spikes – old version

Used to demonstrate localization of spiking within gamma phase
code spike-field / code_gamma_phase_of_spikes_old/getSpikePhase.m (linux)
produces: spikePhase.mat
plotSpikePhase.m

LPP GC EX 337.9839 80.6185
LPP GC INT 314.9798 80.4609
LPP MC EX 330.4127 79.9901
LPP MC INT 258.4794 80.3112
CA3 EX 286.8352 79.183
CA3 INT 326.6369 77.9665
CA1 SR EX 266.1967 78.8209
CA1 SR INT 299.9514 77.552

CA1 SLM EX 292.7575 80.476
CA1 SLM INT 341.3531 80.5423



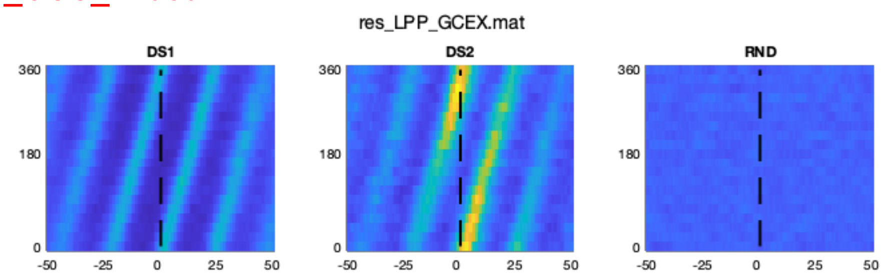
Gamma phase of spikes – all combinations

Get phases of all spikes, split into spikes close to DS1, DS2 and elsewhere
code spike-field / code_gamma_phase_of_spikes
getSpikePhase.m

Spiking vs LFP phase vs DS

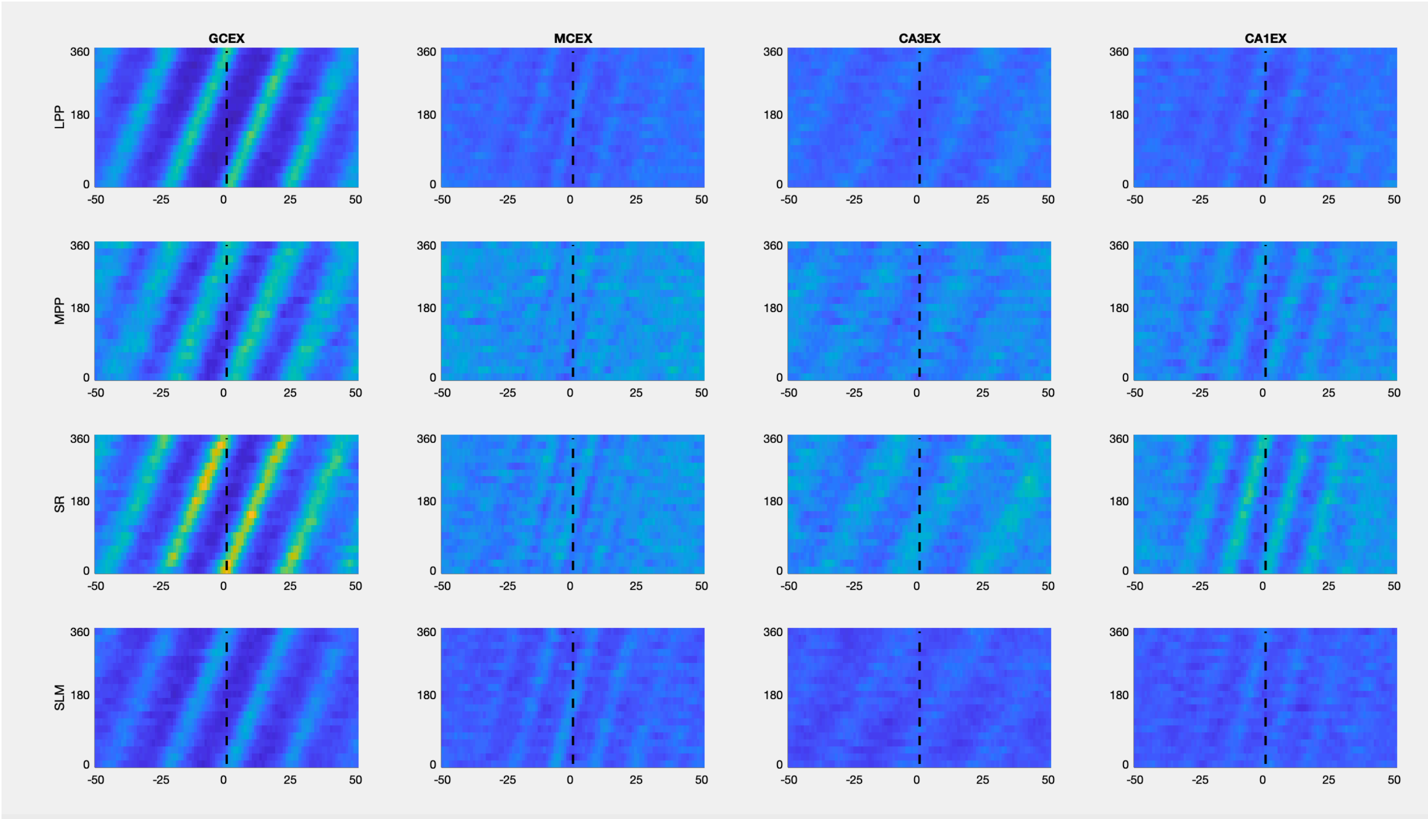
Get DS1, DS2 and DSR events, get gamma phase around those events,
Plot in DStime x GammaPhase space
code spike-field / code_spike_prob_aroundDS_and_gamma_phase

Plot all combinations individually
plotDS_OSC_Phase.m

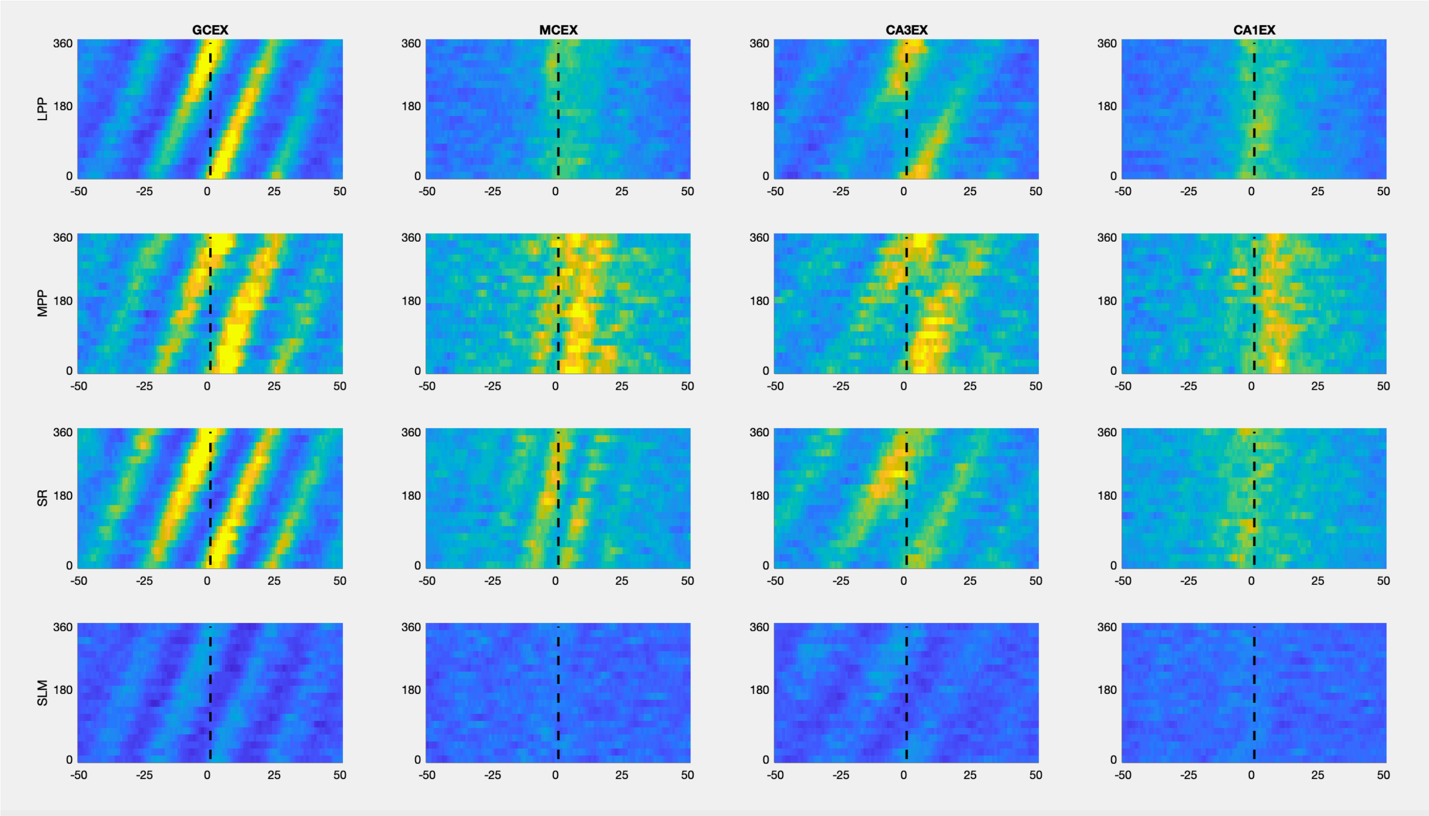


Plot as grid
plotDS_OSC_Phase_Grid.m

DS1

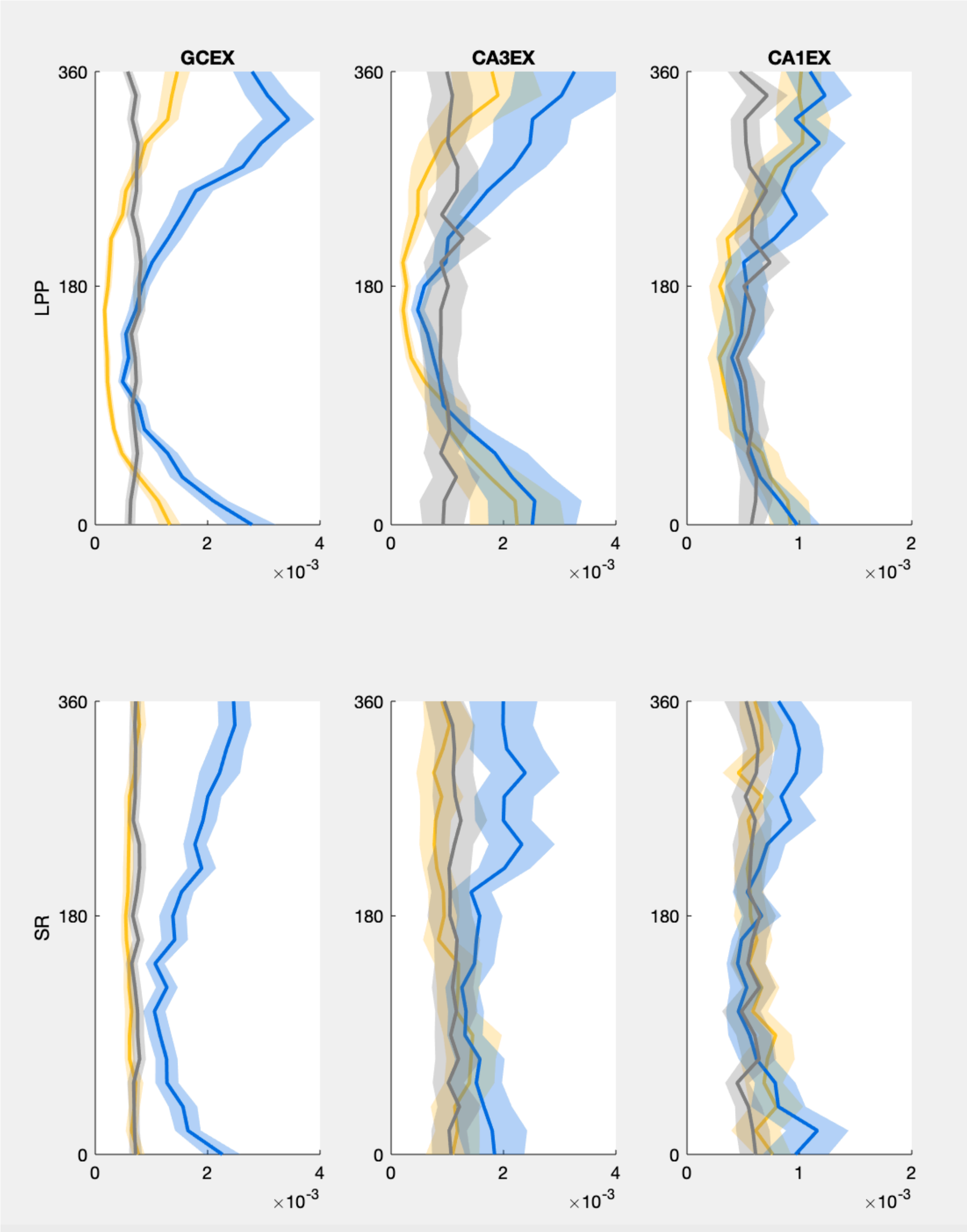


DS2



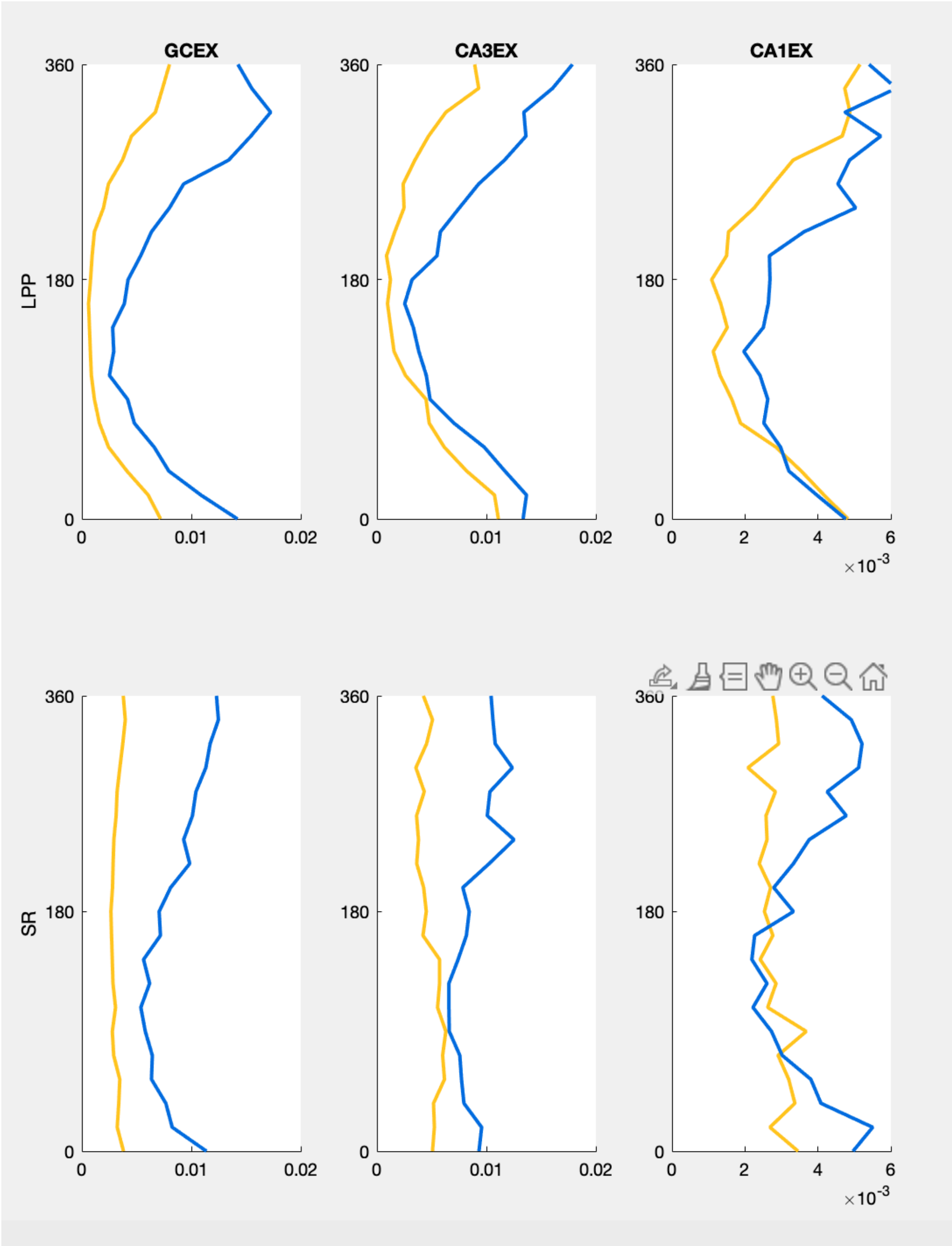
Paper: plotDS_OSC_Phase_Grid_v2.m (only SR/LPP for GCE,CA3E,CA1E)

Paper: plotDS_OSC_Phase_Grid_DSpeak.m



Ignore variance across cells – merge them to one distribution

plotDS_OSC_Phase_Grid_DSpeak_merge_cells.m



plotDS_OSC_Phase_Grid_DSpeak_stats.m
Kuiper test

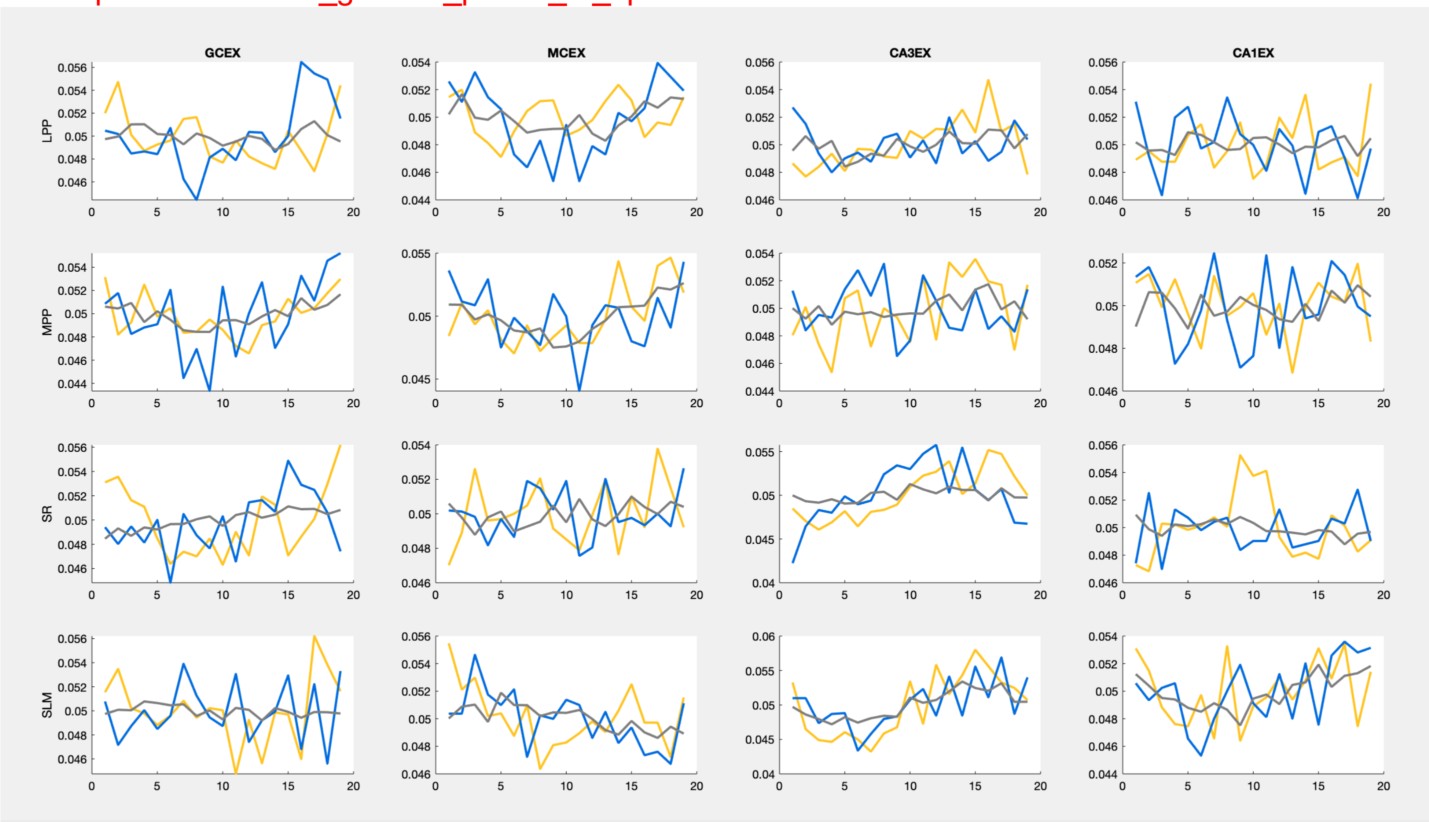
EX:
res_LPP_GCEX.mat
DS1R: k=2378 p=0.001
DS2R: k=2262 p=0.001
DS12: k=1508 p=0.001
----
res_SR_GCEX.mat
DS1R: k=826 p=1

DS2R: k=1475 p=0.001
DS12: k=1652 p=0.001
----
res_LPP_CA3EX.mat
DS1R: k=612 p=0.002
DS2R: k=340 p=1
DS12: k=374 p=1
----
res_SR_CA3EX.mat
DS1R: k=310 p=1
DS2R: k=279 p=1
DS12: k=465 p=0.02
----
res_LPP_CA1EX.mat
DS1R: k=860 p=0.002
DS2R: k=688 p=0.05
DS12: k=516 p=1
----
res_SR_CA1EX.mat
DS1R: k=484 p=1
DS2R: k=836 p=0.01
DS12: k=836 p=0.01

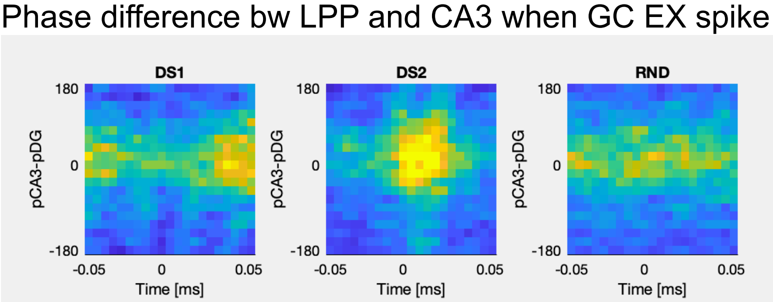
INT:
res_LPP_GCINT.mat
DS1R: k=2204 p=0.001
DS2R: k=2030 p=0.001
DS12: k=1160 p=0.02
----
res_SR_GCINT.mat
DS1R: k=1710 p=0.001
DS2R: k=1140 p=0.02
DS12: k=1653 p=0.001
----
res_LPP_CA3INT.mat
DS1R: k=2013 p=0.001
DS2R: k=1769 p=0.001
DS12: k=732 p=1
----
res_SR_CA3INT.mat
DS1R: k=2376 p=0.001
DS2R: k=1716 p=0.001
DS12: k=2838 p=0.001
----
res_LPP_CA1INT.mat
DS1R: k=2888 p=0.001
DS2R: k=2432 p=0.001
DS12: k=1596 p=0.05
----
res_SR_CA1INT.mat

DS1R: k=1971 p=0.002
DS2R: k=1825 p=0.005
DS12: k=2628 p=0.001

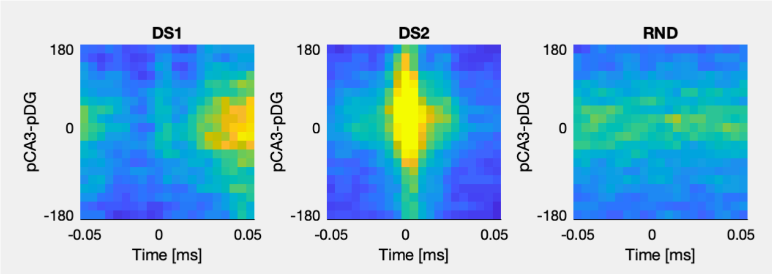
Plot gamma phase of spikes in the vicinity of DS1, DS2 and no DS
code spike-field / code_gamma_phase_of_spikes



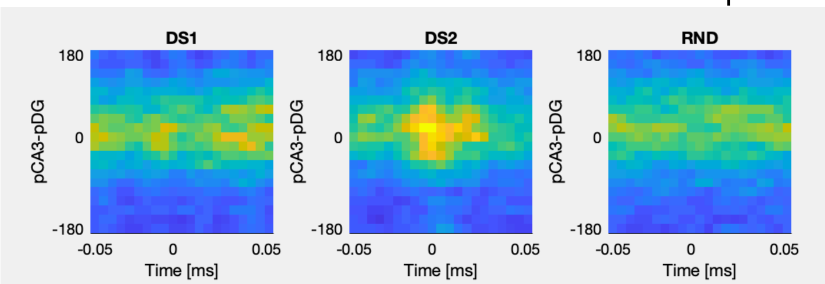
Phase difference bw LPP and CA3 when spiking in CA3/GC happens
winStep =
getDS_OSC_Phase_LPP_CA3_35Hz_diff.m
Phase difference bw LPP and CA3 when GC EX spike happens



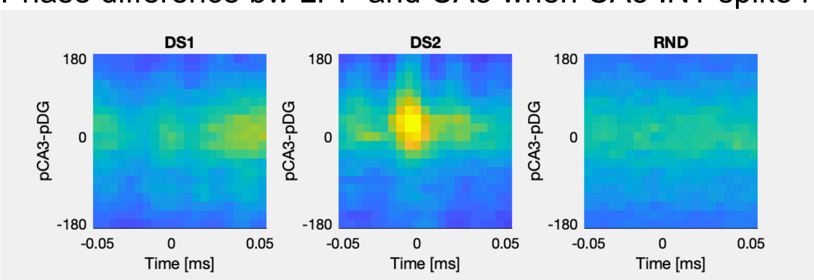
Phase difference bw LPP and CA3 when GC INTn spike happens



Phase difference bw LPP and CA3 when CA3 EX spike happens

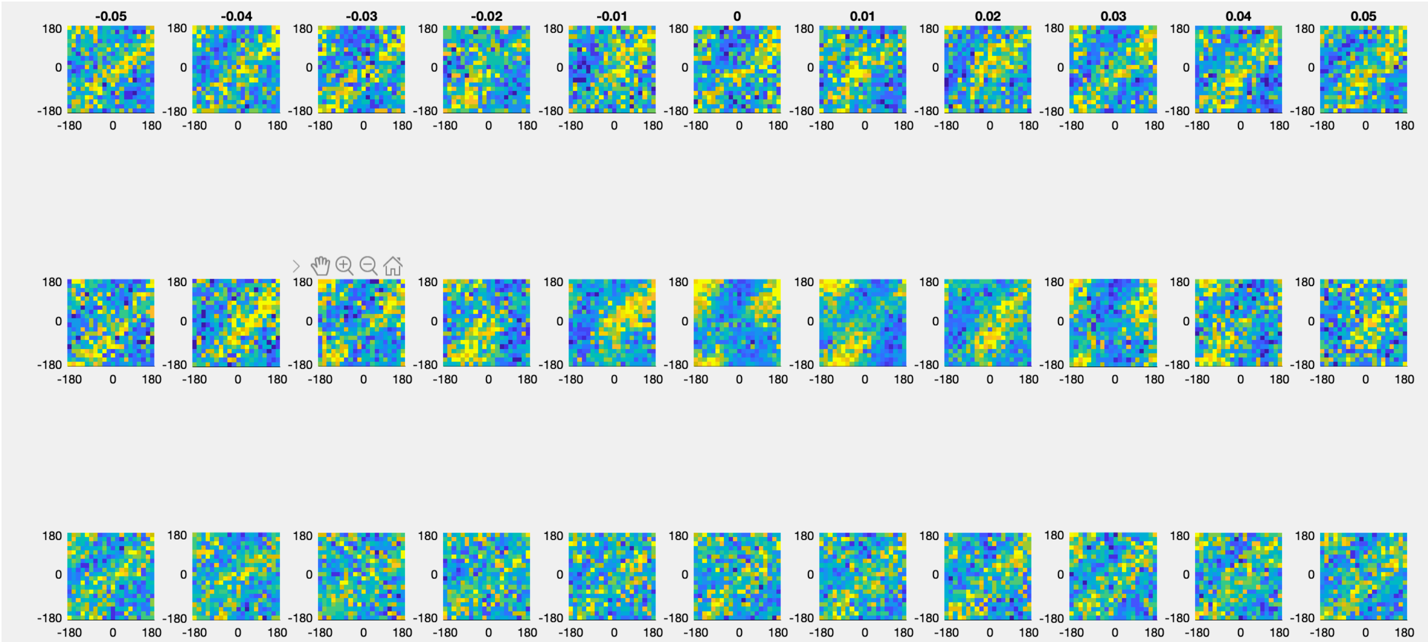


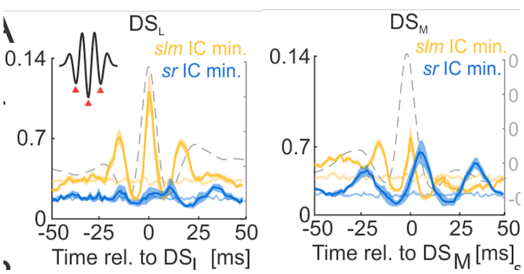
Phase difference bw LPP and CA3 when CA3 INT spike happens

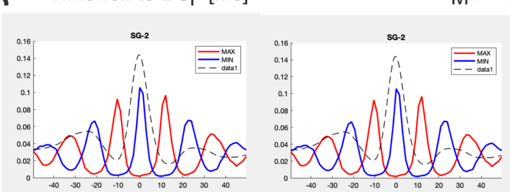


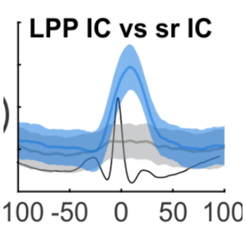
Phase 2D histogram of LPP and CA3 when GC EX spike happens around DS2

getDS_OSC_Phase_LPP_CA3_35Hz.m


-0.05
-0.04
-0.03
-0.02
-0.01
0
0.01
0.02
0.03
0.04
0.05
180
0
-180
-180 0 180


DS_L
slm IC min.
sr IC min.
0.14
0.7
0
-50 -25 0 25 50
Time rel. to DS_L [ms]
DS_M
slm IC min.
sr IC min.
0.14
0.7
0
-50 -25 0 25 50
Time rel. to DS_M [ms]


SG-2
MAX
MIN
data1
SG-2
MAX
MIN
data1


LPP IC vs sr IC
100 -50 0 50 100