MEA LFP Analysis Toolbox

F. Klopfer

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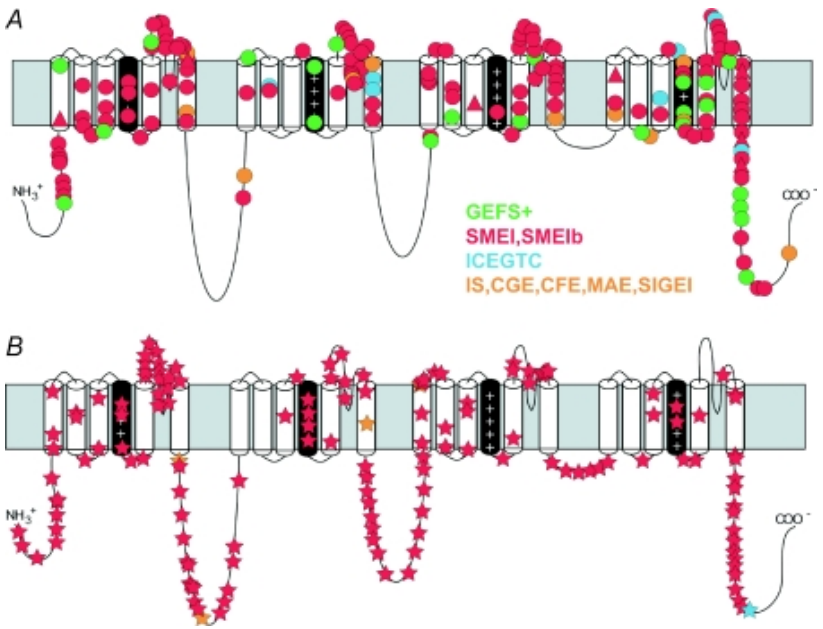
Hertie-Institut
für klinische Hirnforschung

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

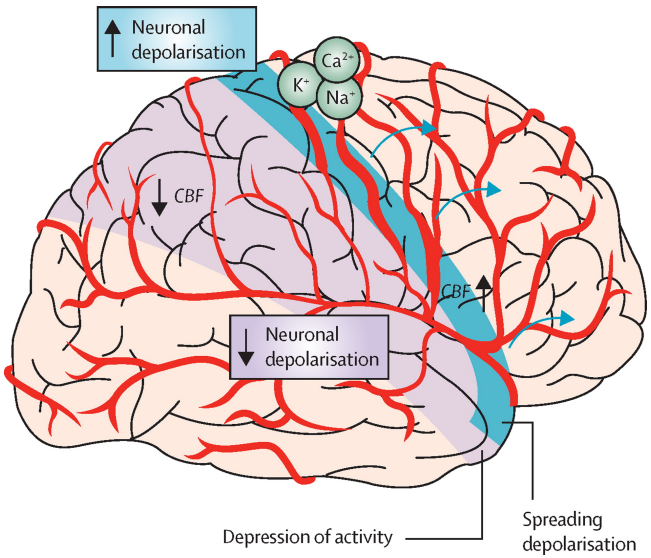
GRADUATE TRAINING CENTRE
OF NEUROSCIENCE
International Max Planck Research School

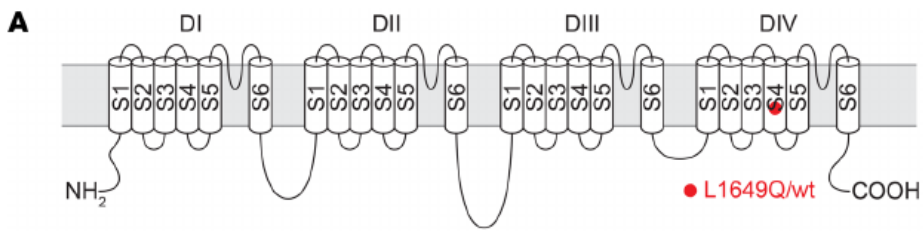
Introduction

Epilepsy & Migraine as Channelopathies I

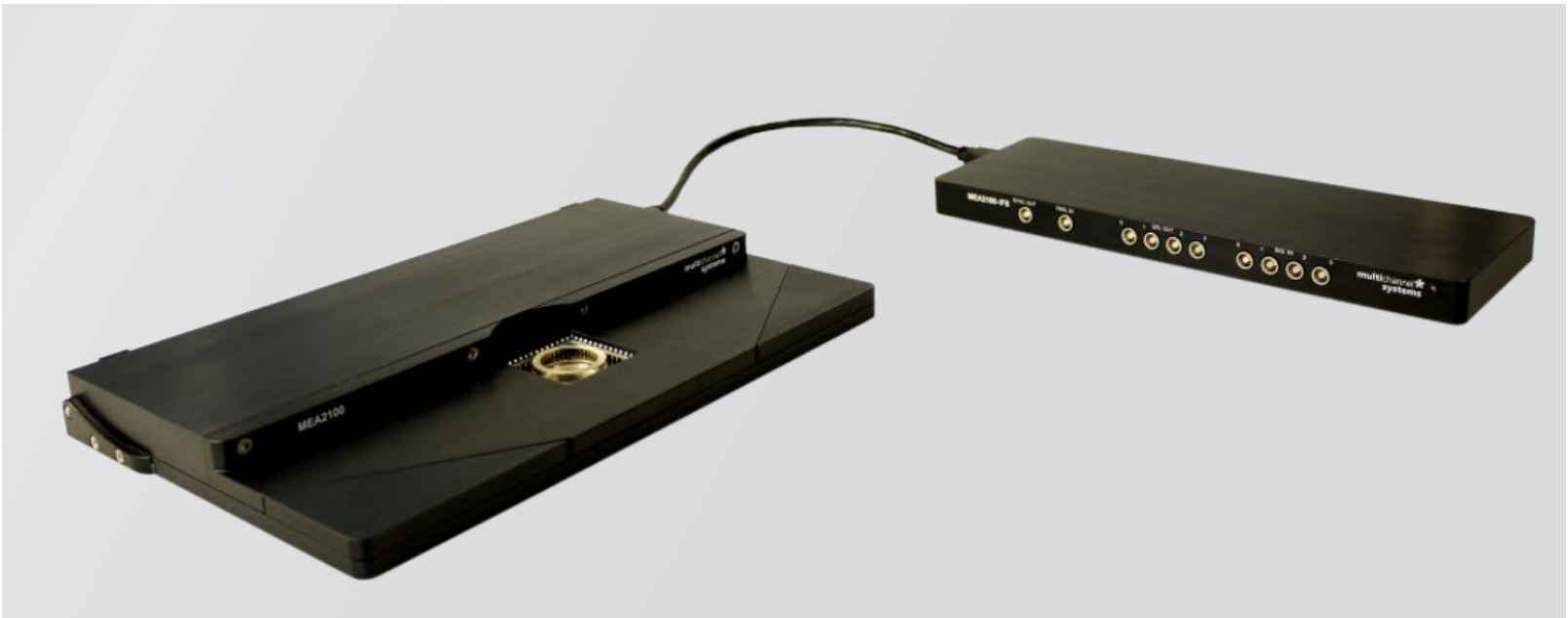


Epilepsy & Migraine as Channelopathies II

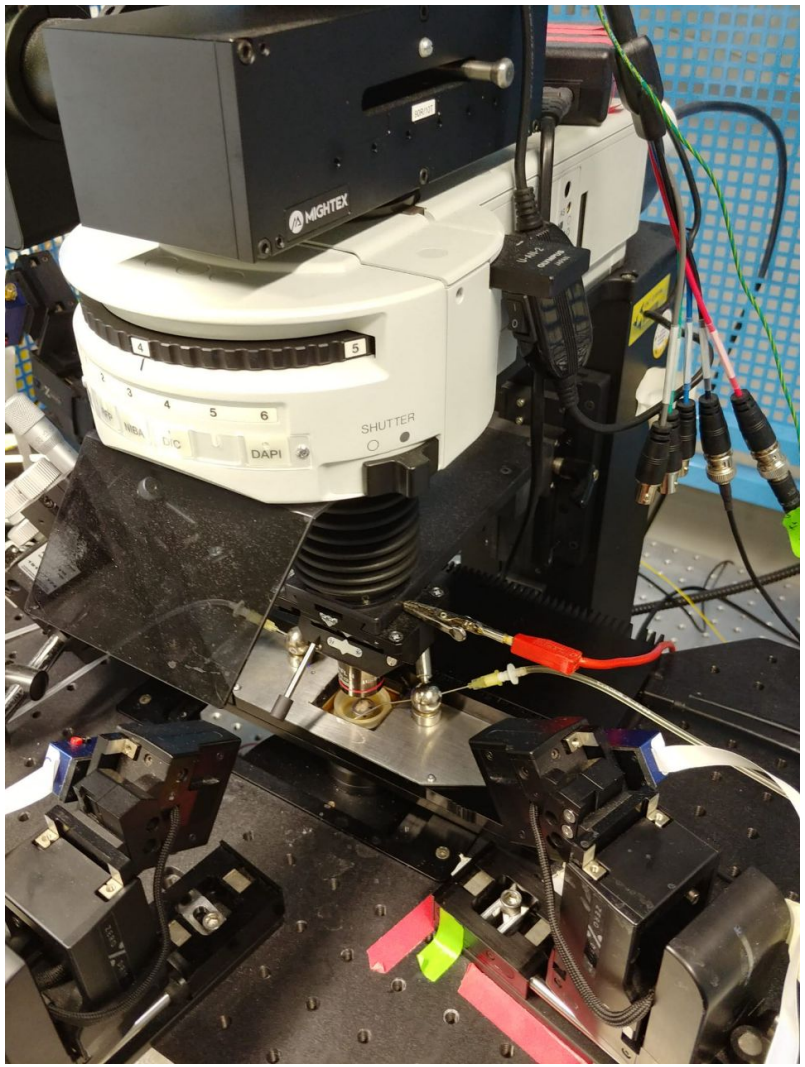




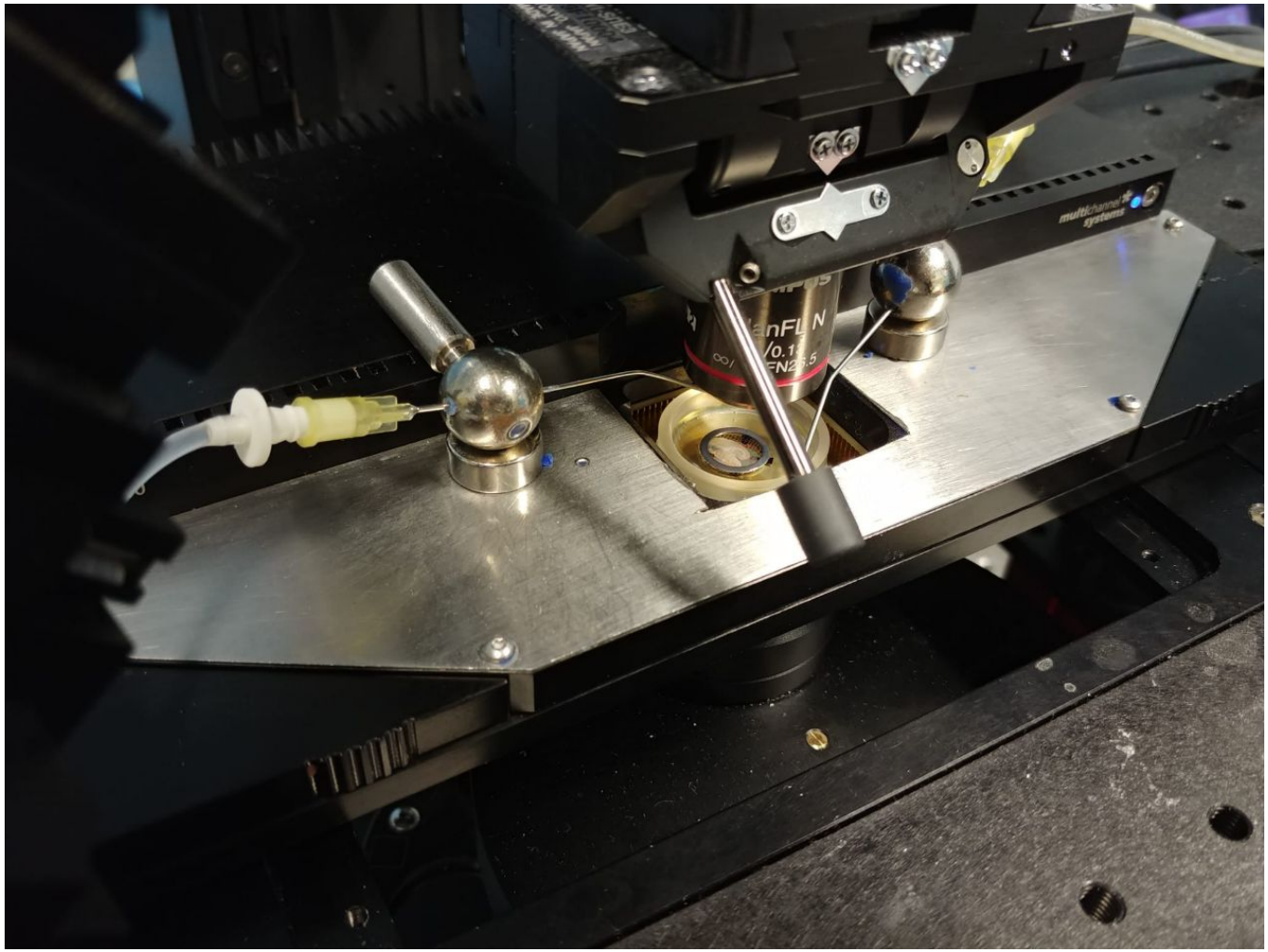
Recording Setup I



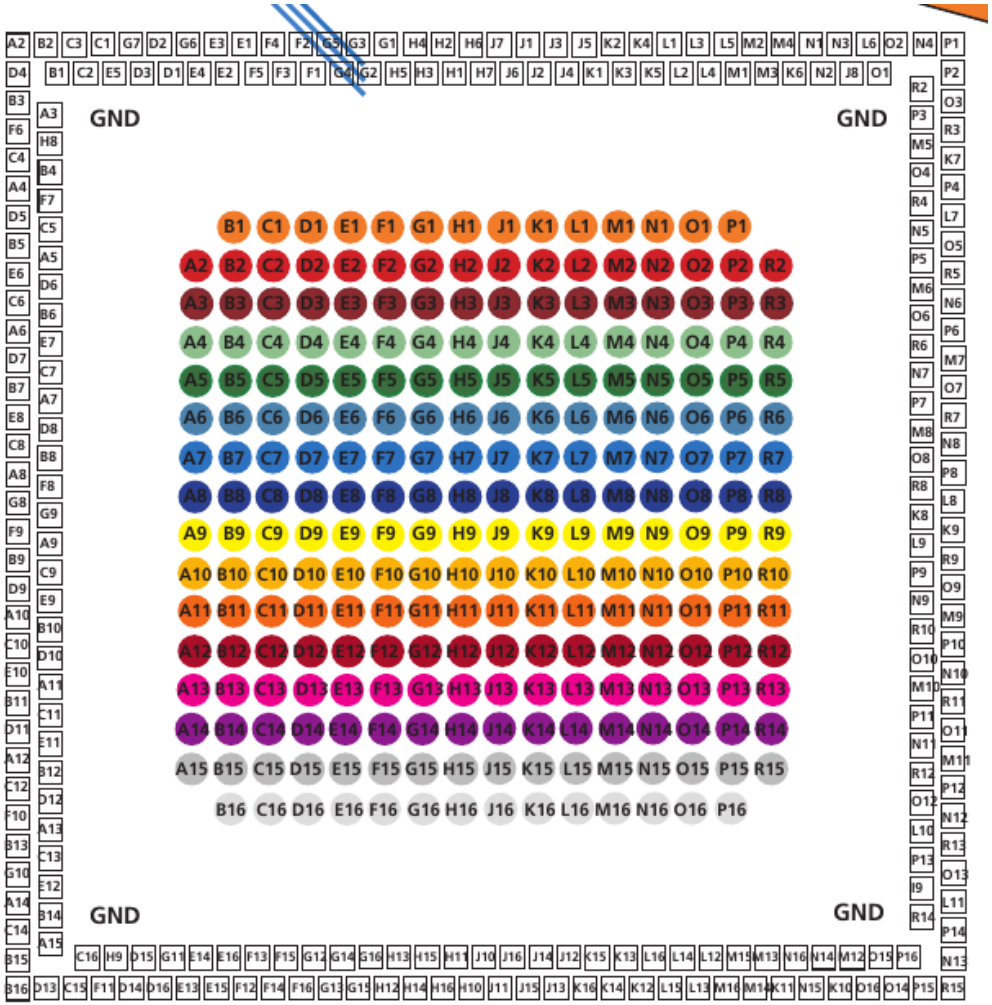
Recording Setup II



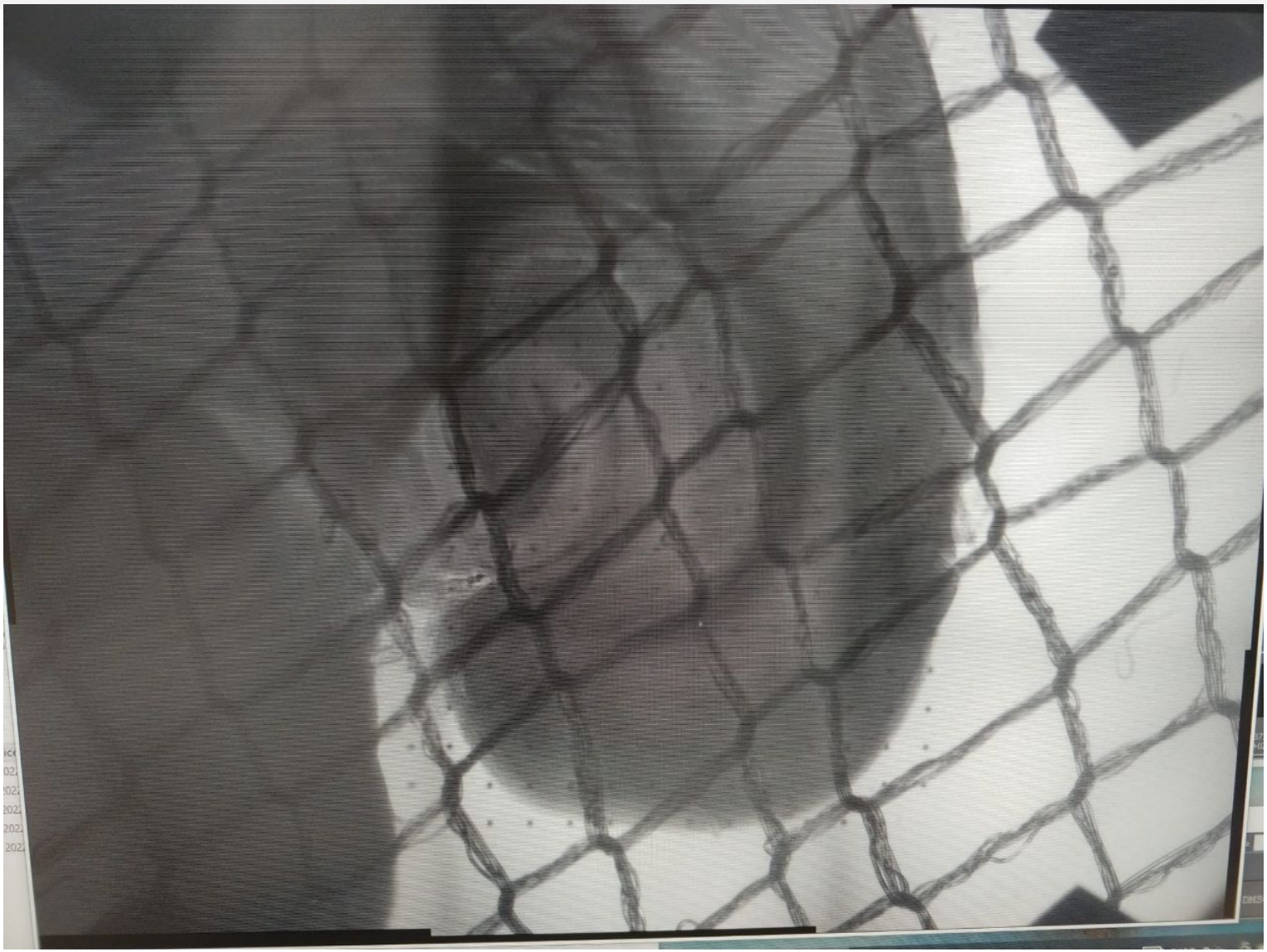
Recording Setup III



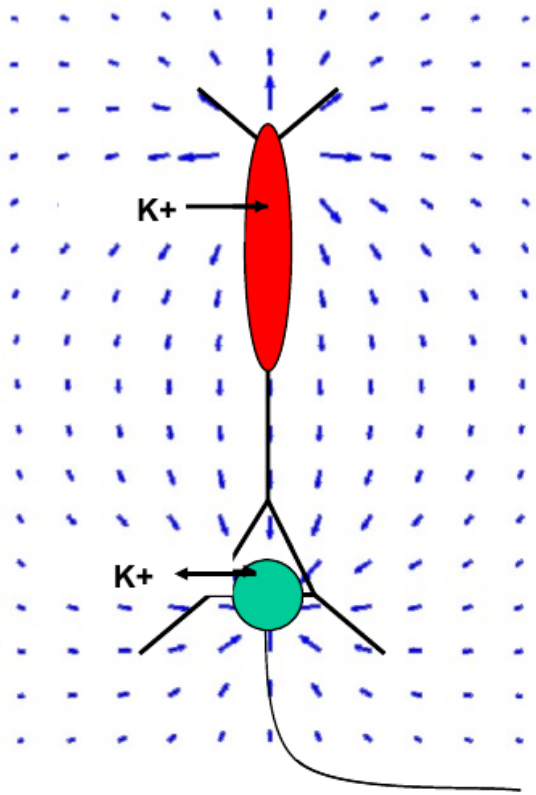
Recording Setup IV

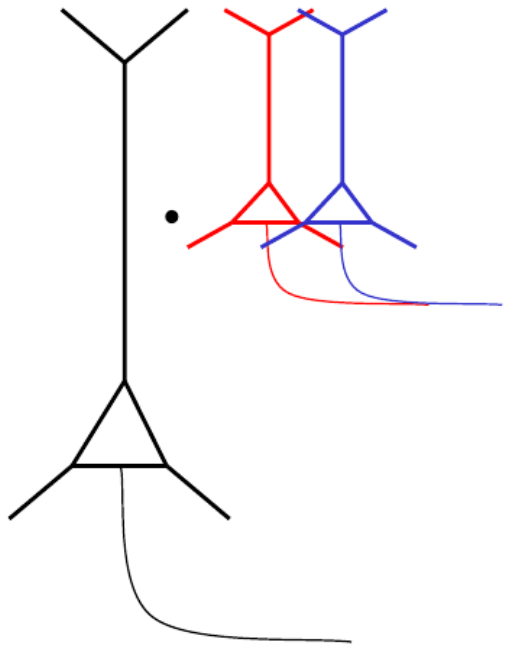


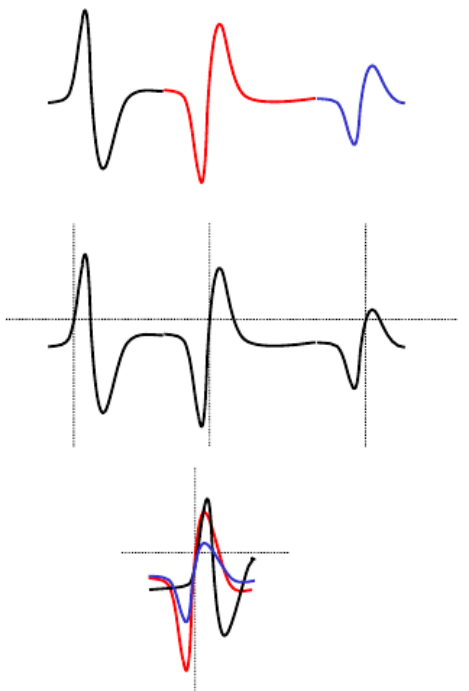
Recording Setup V



Data I



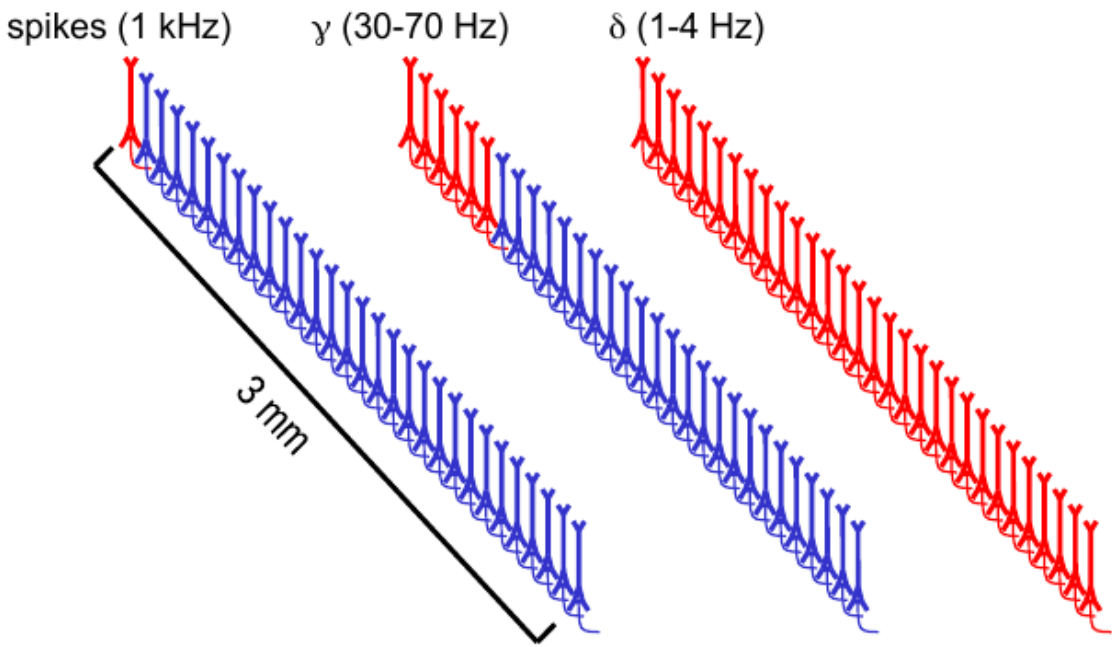




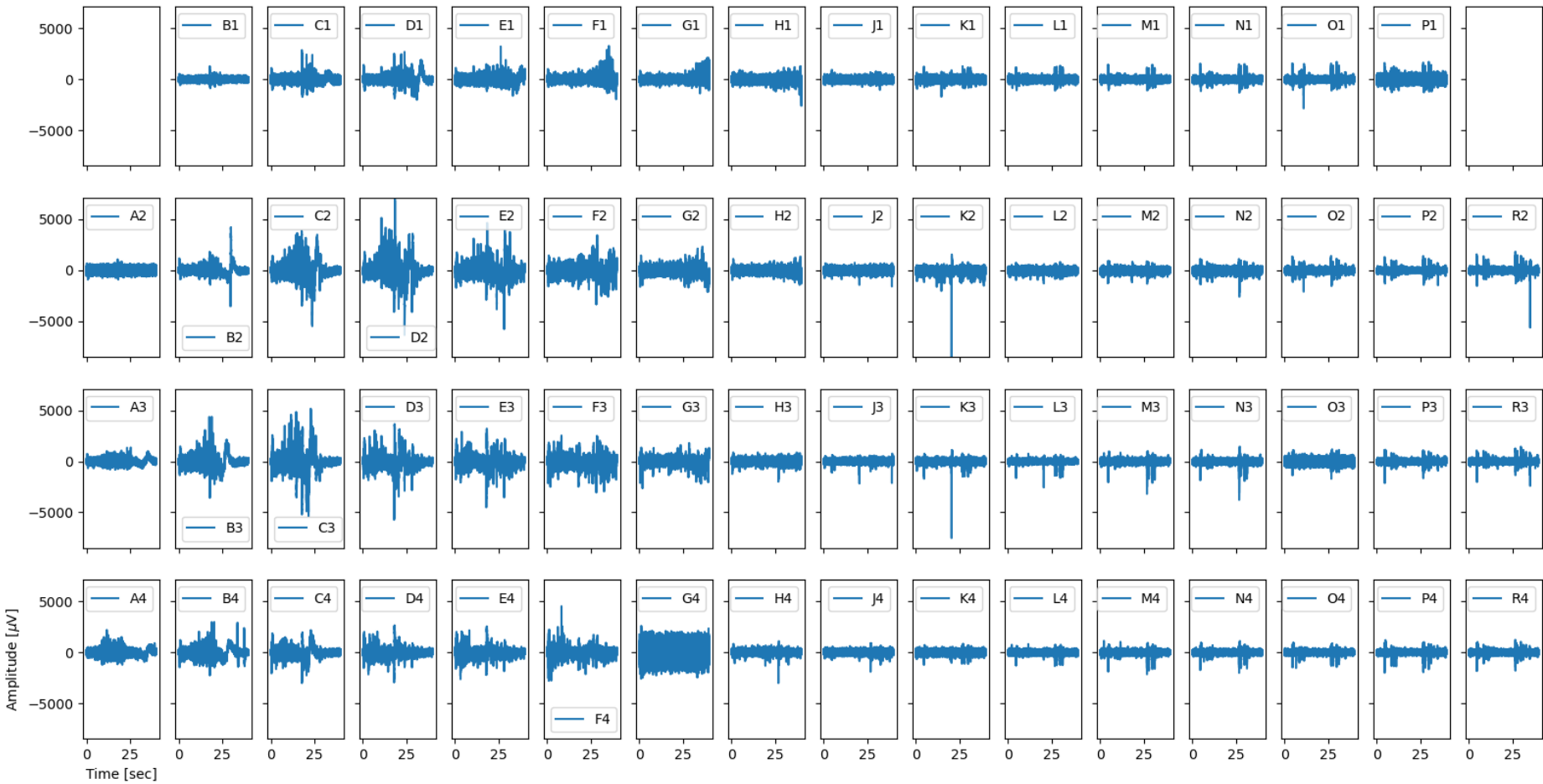
Data II

Local field potential is the sum of all potentials generated by axons, somas and dendrites in the vicinity of the electrode.

The spatial extend of correlation of these signals is frequency dependent!



Data III


B1
C1
D1
E1
F1
G1
H1
J1
K1
L1
M1
N1
O1
P1
A2
B2
C2
D2
E2
F2
G2
H2
J2
K2
L2
M2
N2
O2
P2
R2
A3
B3
C3
D3
E3
F3
G3
H3
J3
K3
L3
M3
N3
O3
P3
R3
A4
B4
C4
D4
E4
F4
G4
H4
J4
K4
L4
M4
N4
O4
P4
R4
5000
0
−5000
Amplitude [μV]
0
25
Time [sec]

Task

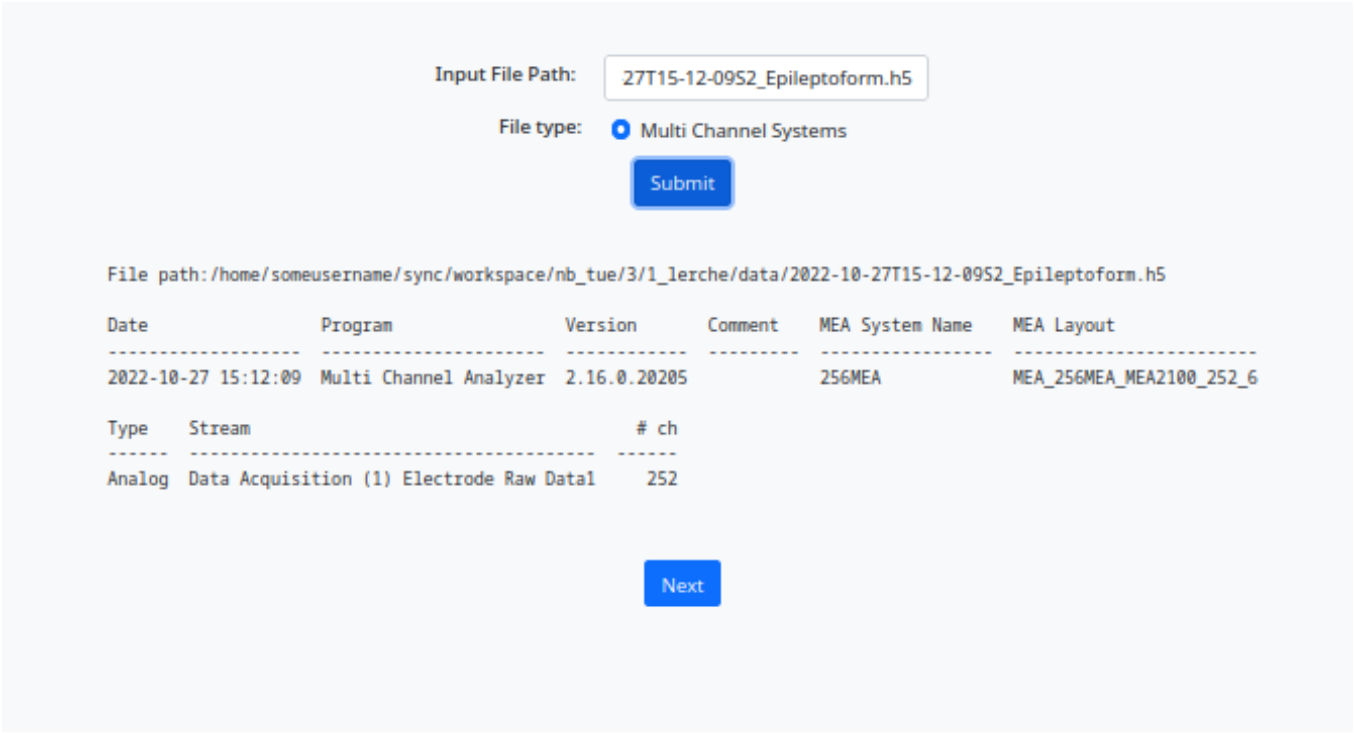
- Task: Detect peaks, seizure-like bursts & characterize them. Provide GUI.
- Contraints:
  - many channels
  - high sampling rate
  - high heterogeneity
- Existing toolboxes are
  - proprietary or vendor specific
  - scale specific (Single Unit vs. EEG/MEG)
  - quality-wise insufficient

Software

MEA LFP Analysis Toolbox I

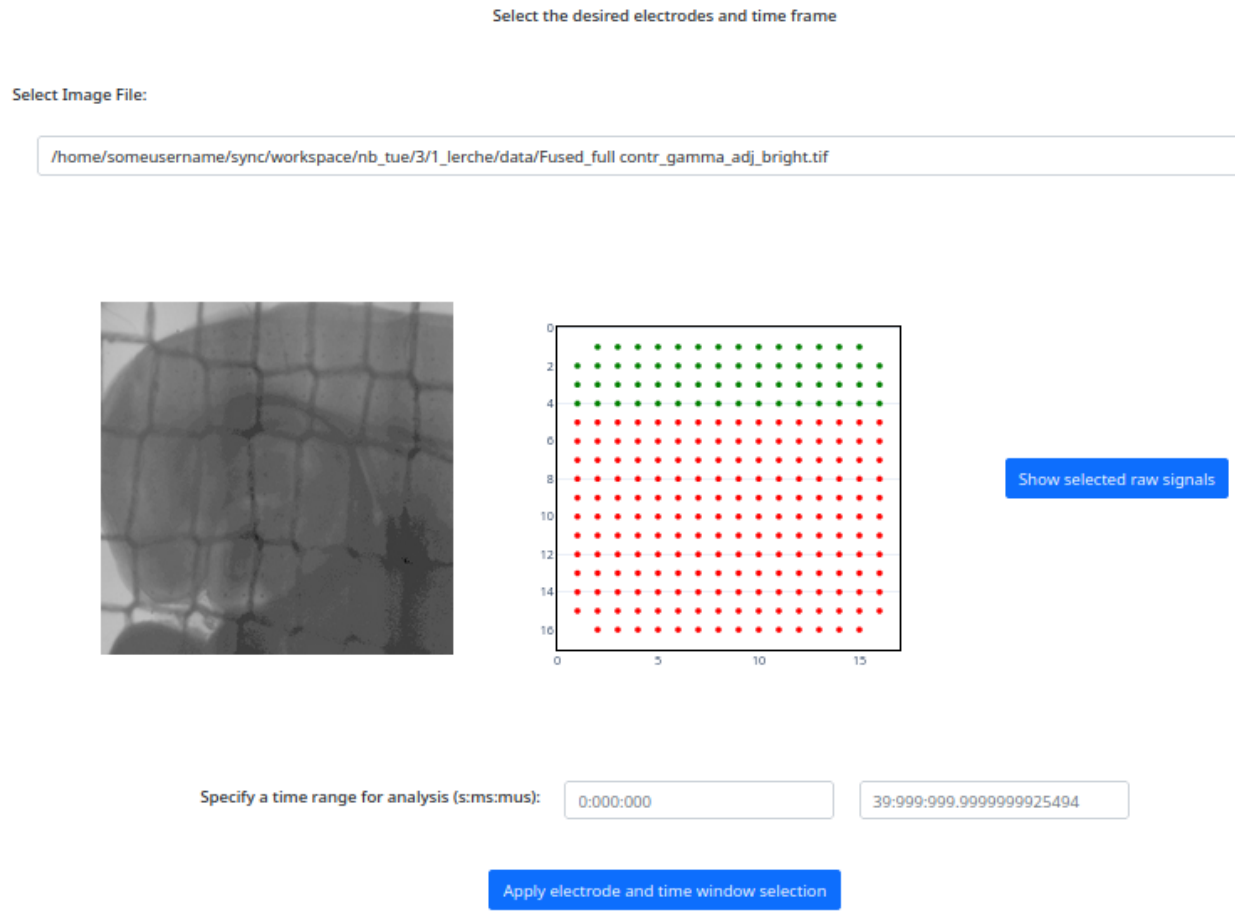
Semi-automated data analysis pipeline with UI.

- Currently supports MultiChannel Systems 256 electrode MEA



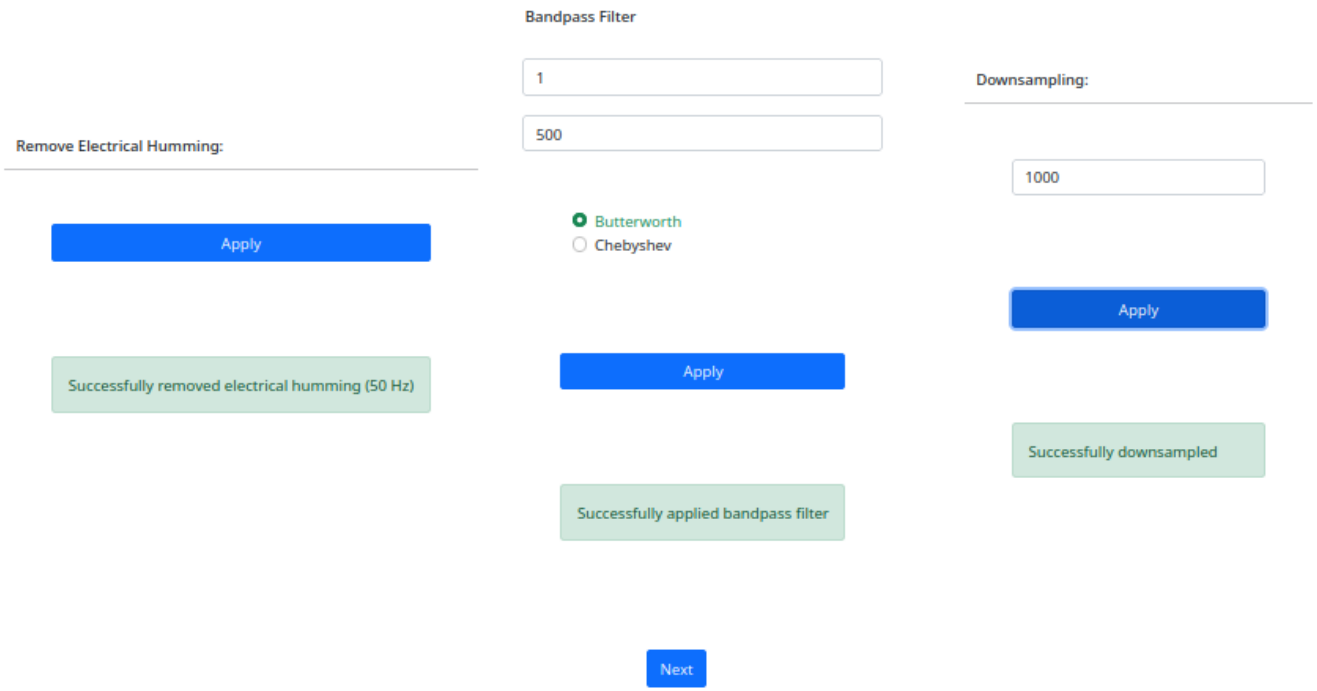
MEA LFP Analysis Toolbox II

- Allows graphical selection of electrodes and time window



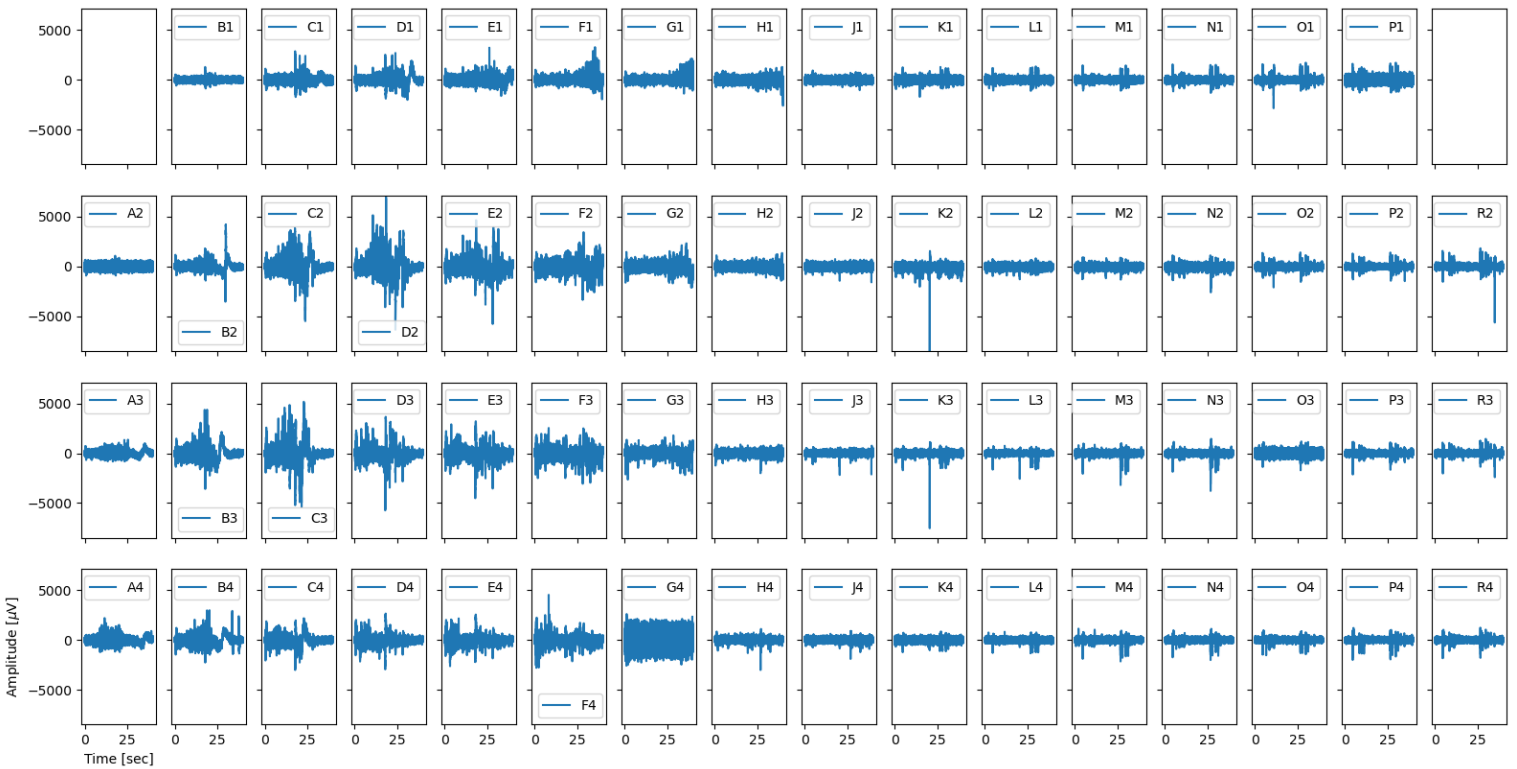
MEA LFP Analysis Toolbox III

- Preprocessing: Electrical humming filter, bandpass filter, downsampling

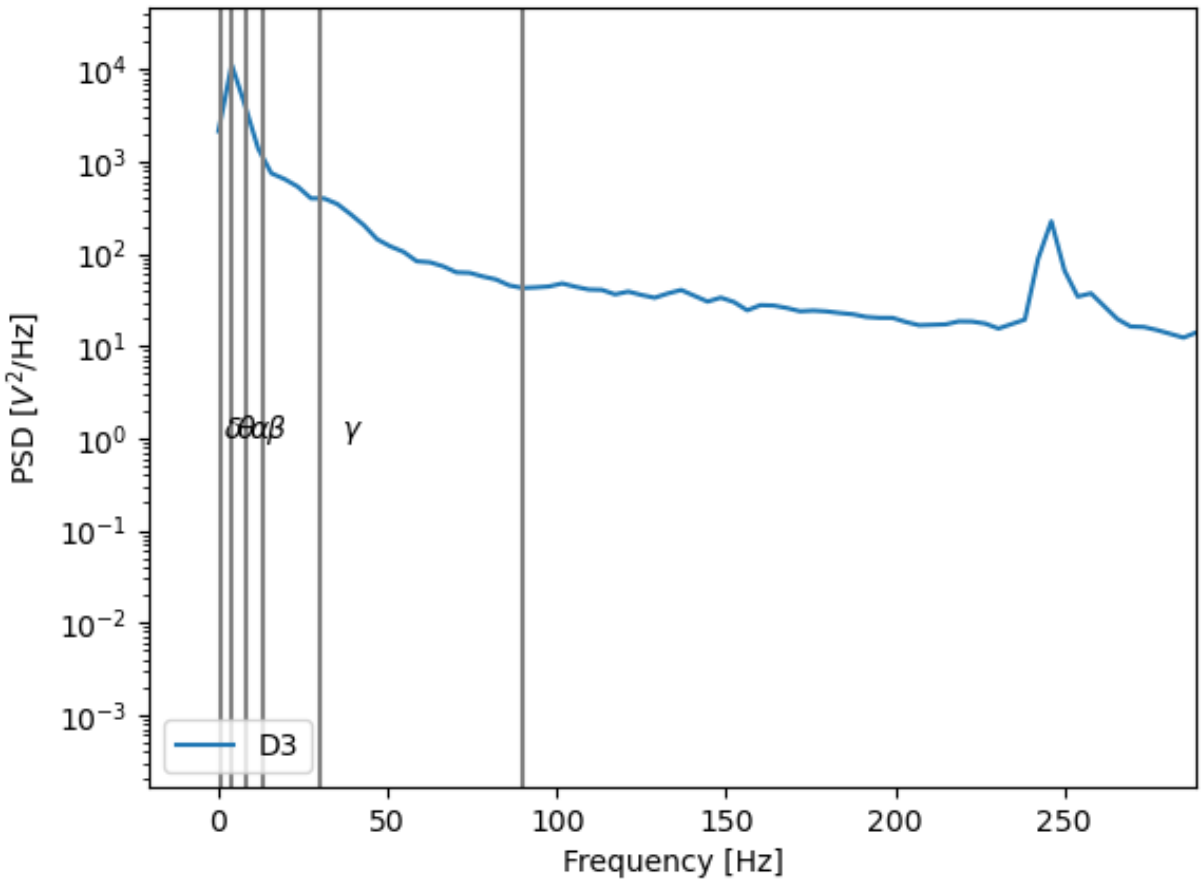


MEA LFP Analysis Toolbox IV

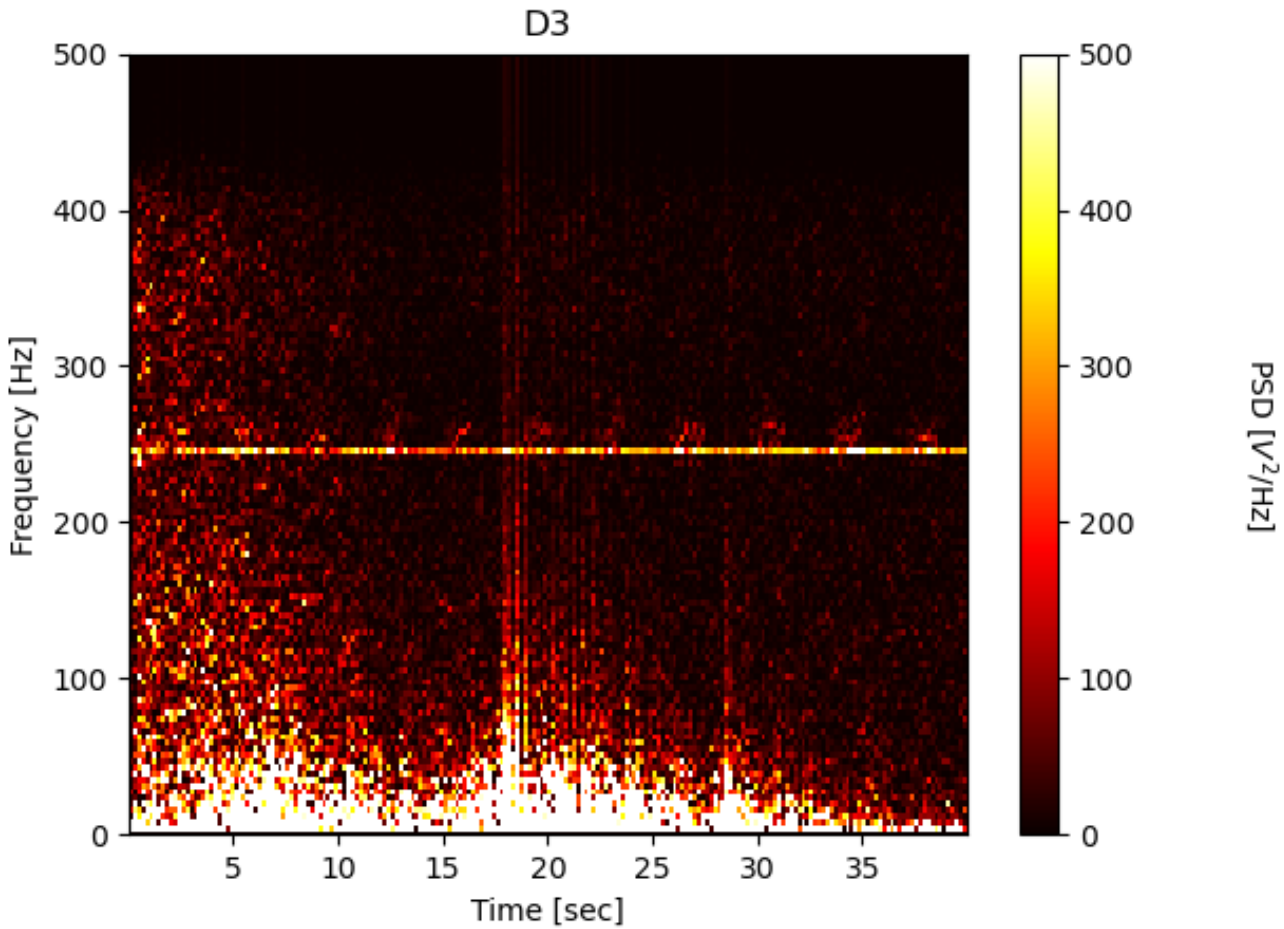
- Exploration: raw signal plots, absolute amplitude video, PSD, Spectrogram



MEA LFP Analysis Toolbox V

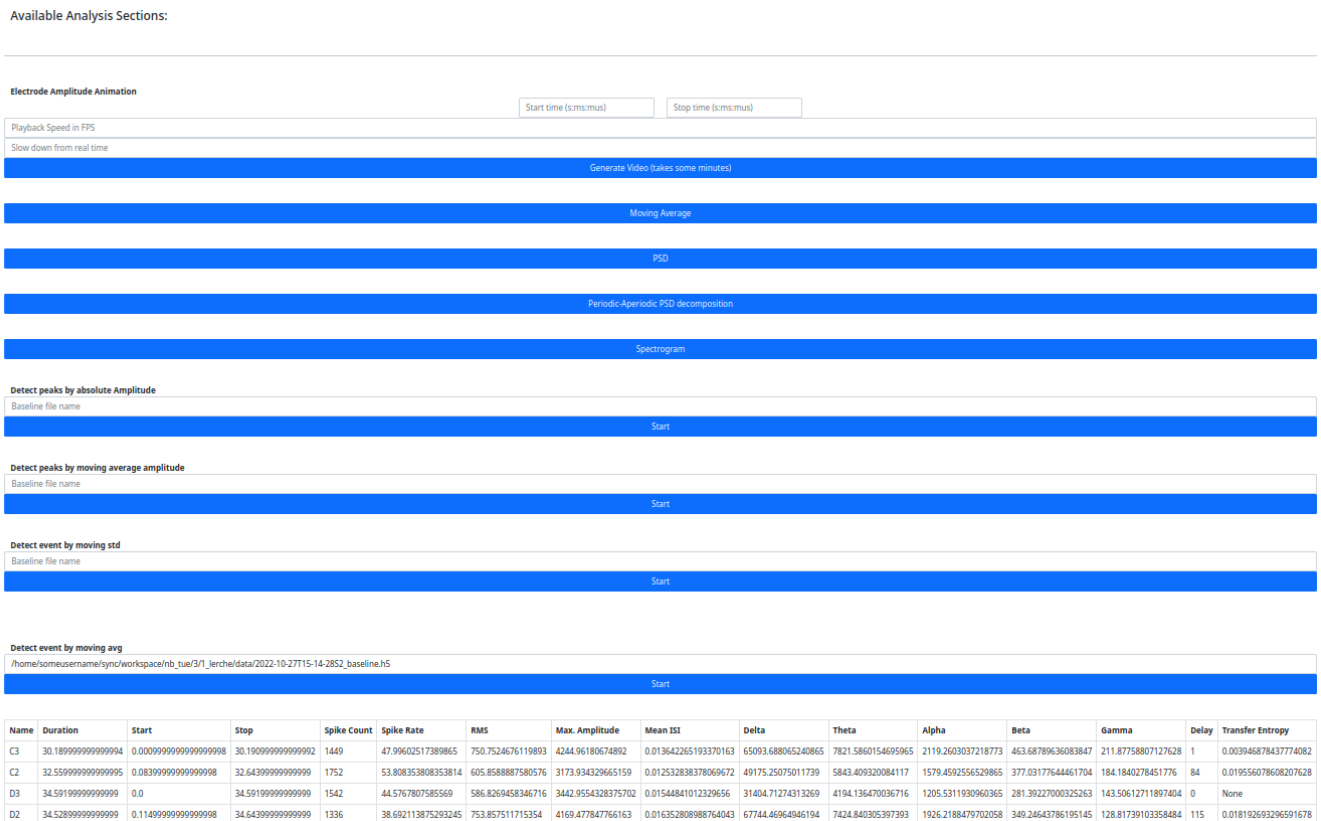


MEA LFP Analysis Toolbox VI



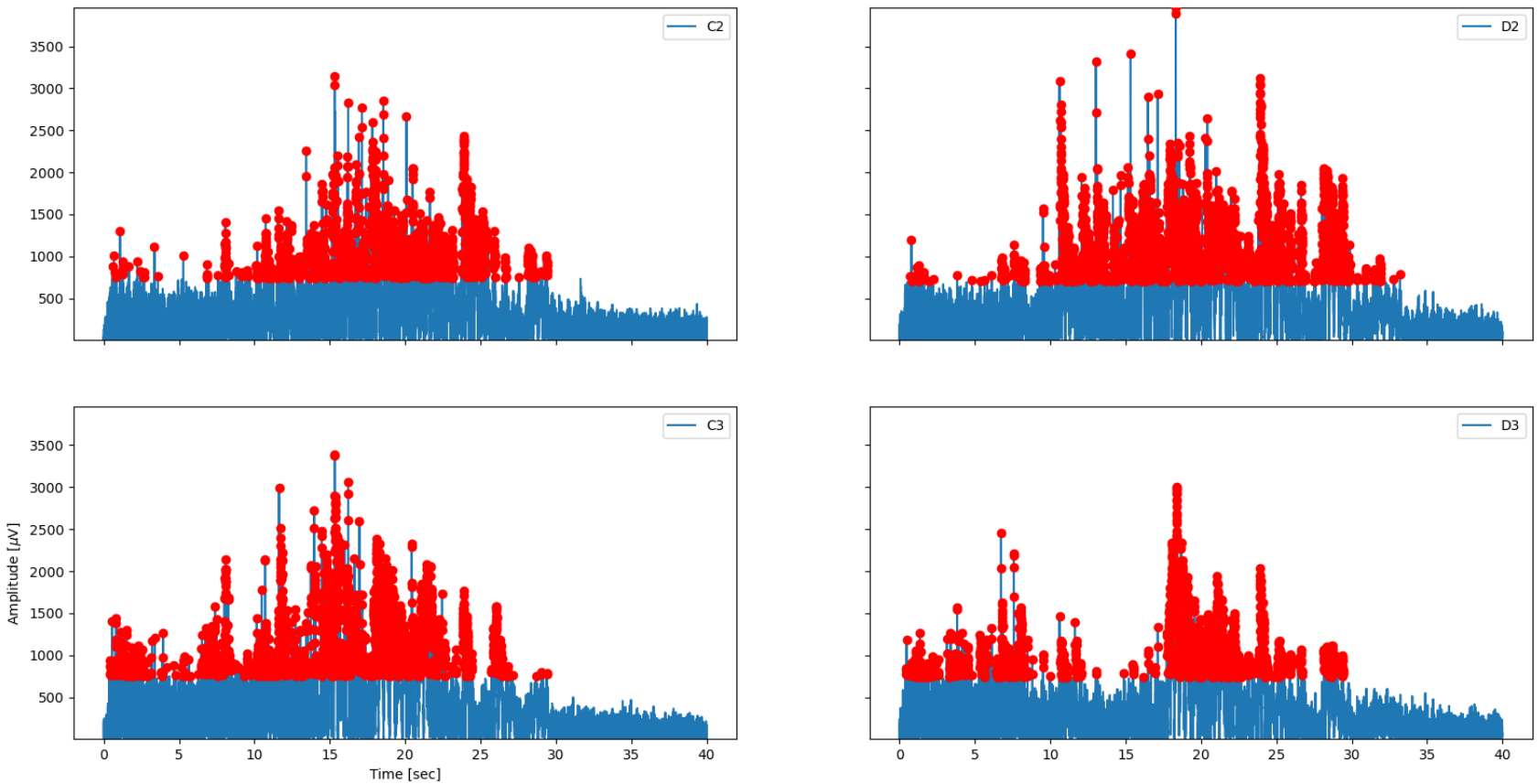
MEA LFP Analysis Toolbox VII

- Analysis: Peak detection with threshold based on std or moving average, burst detection based on moving average and moving std (instead of peaks)

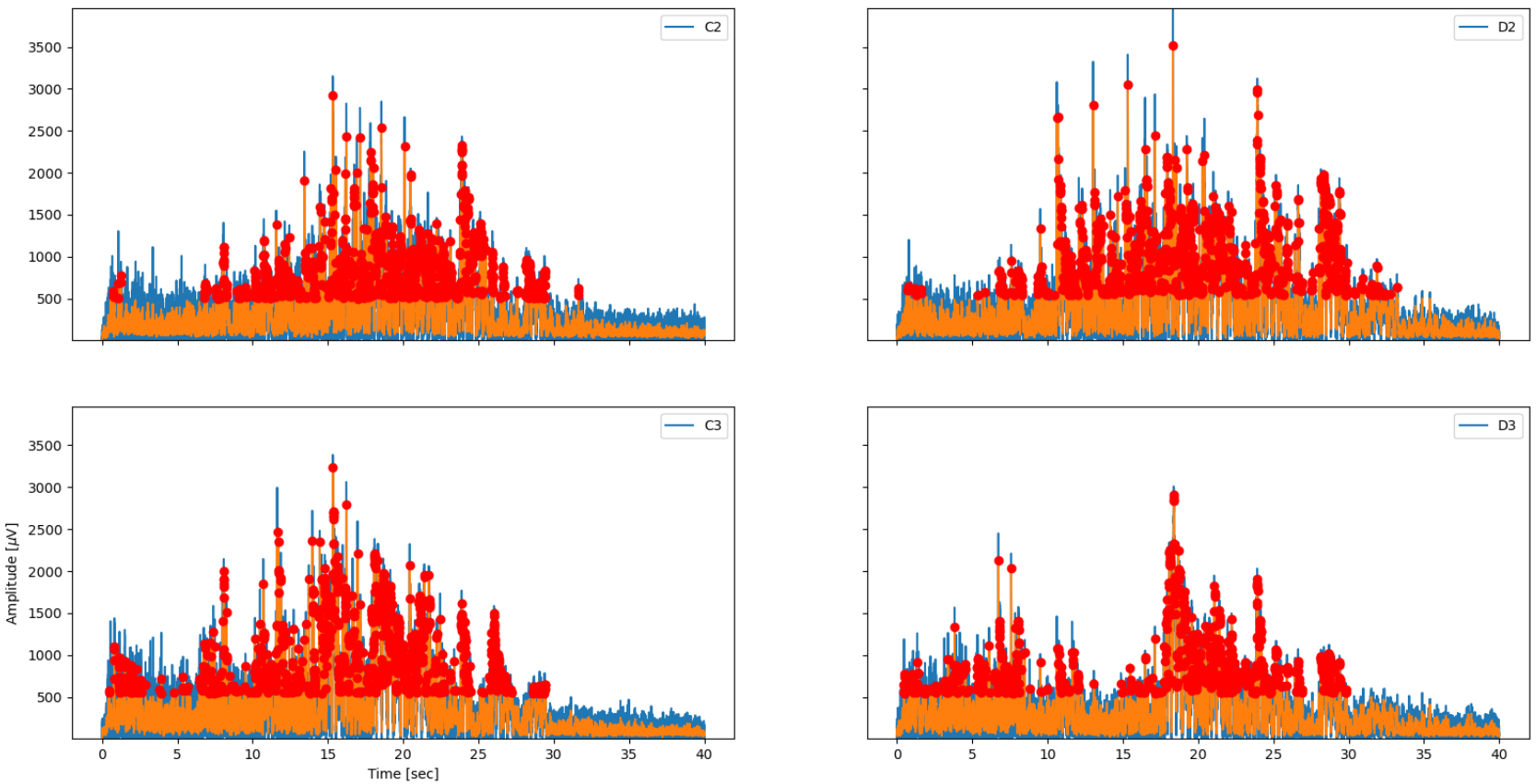


Name	Duration	Start	Stop	Spike Count	Spike Rate	RMS	Max. Amplitude	Mean ISI	Delta	Theta	Alpha	Beta	Gamma	Delay	Transfer Entropy
C3	30.189999999999994	0.0009999999999999998	30.190999999999992	1449	47.99602517389865	750.7524676119893	4244.96180674892	0.013642265193370163	65093.688065240865	7821.5860154695965	2119.2603037218773	463.68789636083847	211.87758807127628	1	0.003946878437774082
C2	32.559999999999995	0.08399999999999998	32.64399999999999	1752	53.80835380835814	605.8588887580576	3173.934329665159	0.012532838378069672	49175.25075011739	5843.409320084117	1579.4592556529865	377.03177644461704	184.1840278451776	84	0.019556078608207628
D3	34.59199999999999	0.0	34.59199999999999	1542	44.5767807585569	586.8269458346716	3442.9554328375702	0.015448410123296656	31404.71274313269	4194.136470036716	1205.5311930960365	281.39227000325263	143.50612711897404	0	None
D2	34.52899999999999	0.11499999999999998	34.64399999999999	1336	38.692113875293245	753.857511715354	4169.477847766163	0.016352808988764043	67744.46964946194	7424.840305397393	1926.2188479702058	349.24643786195145	128.81739103358484	115	0.018192693296591678

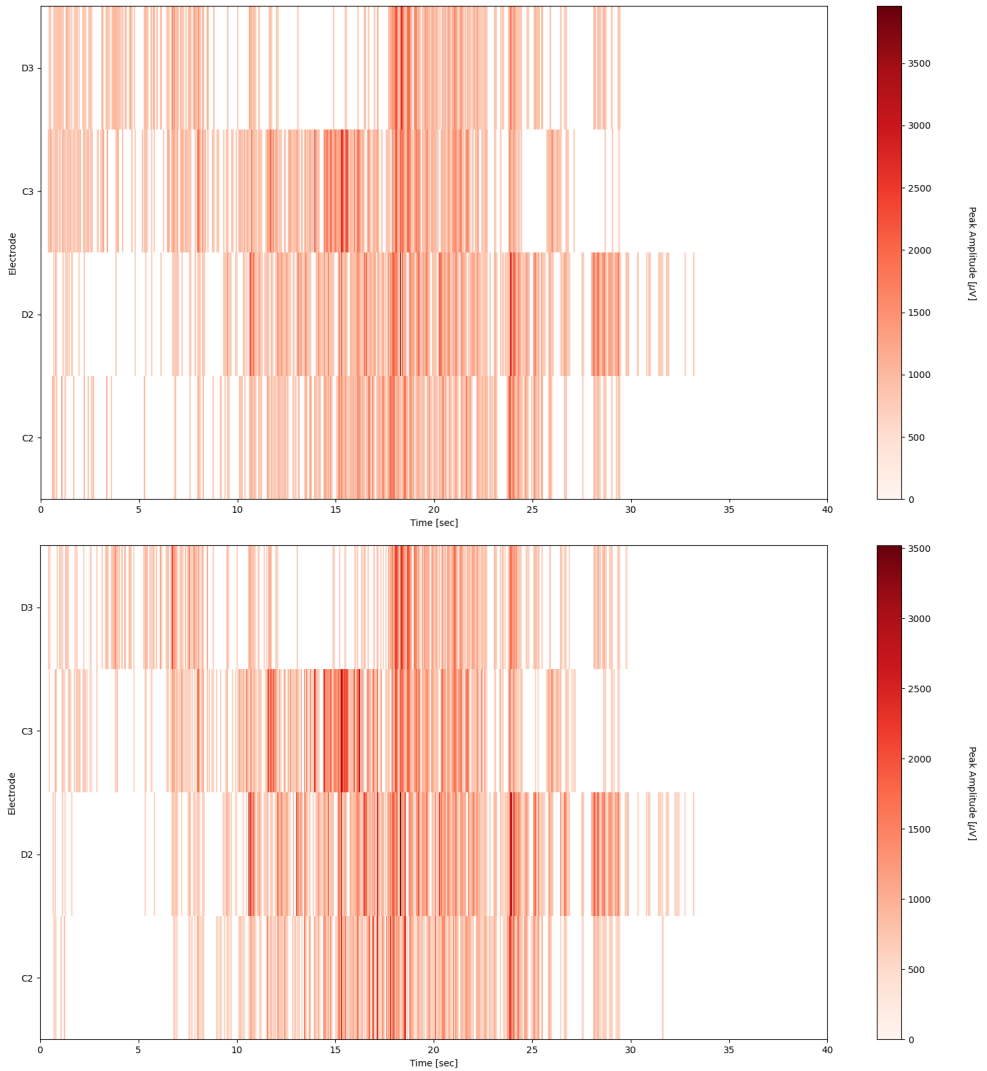
MEA LFP Analysis Toolbox VIII



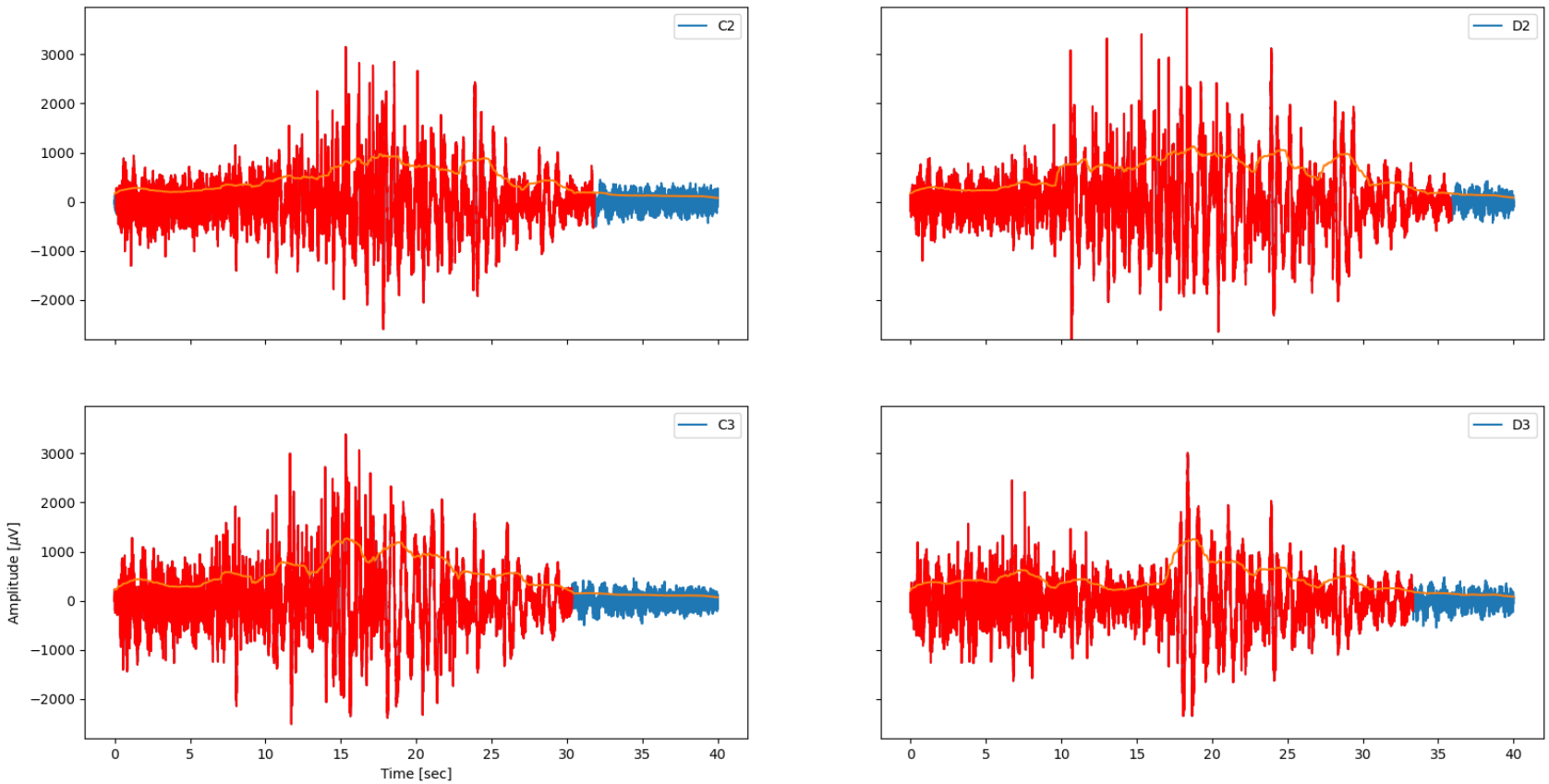
MEA LFP Analysis Toolbox IX



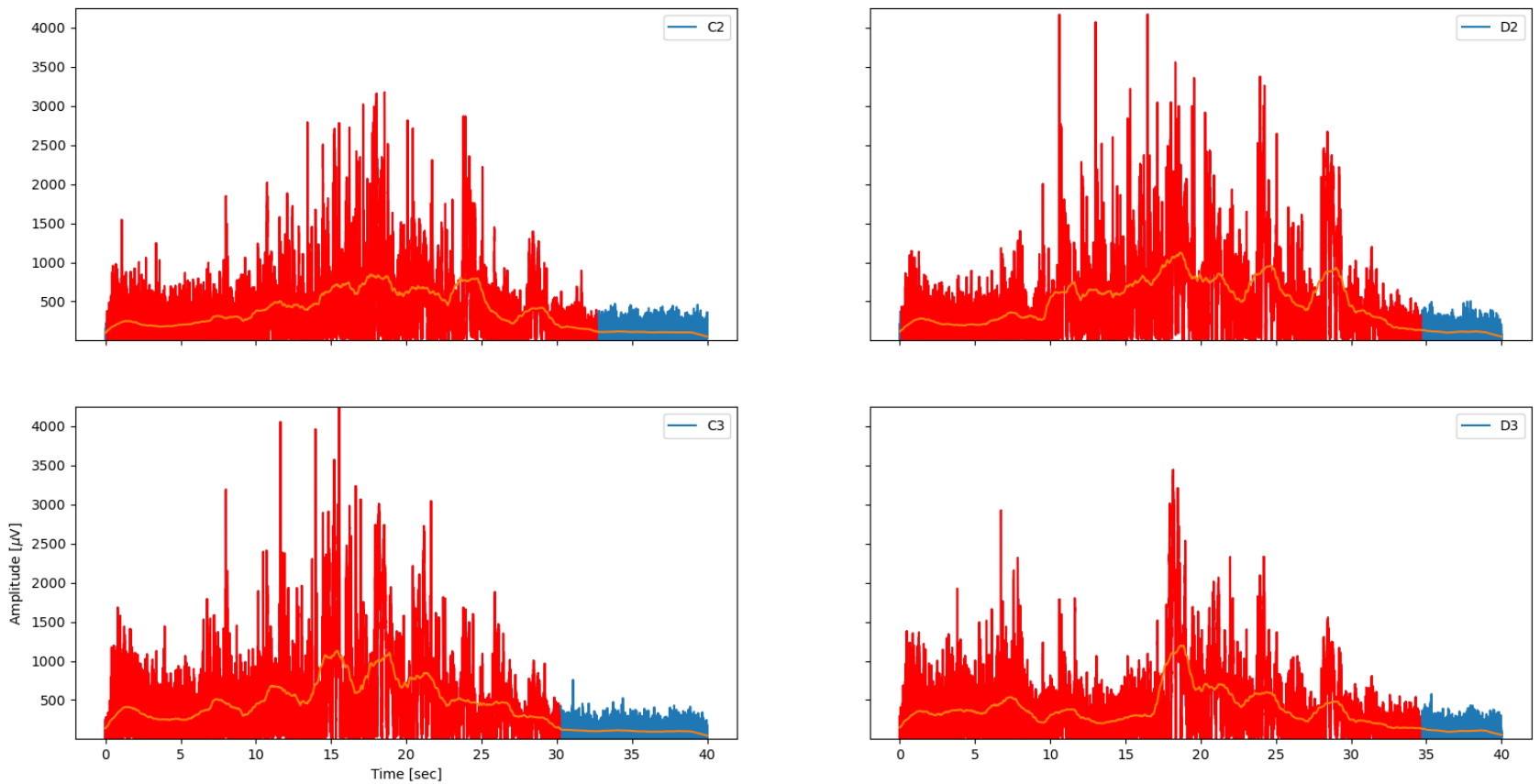
MEA LFP Analysis Toolbox X



MEA LFP Analysis Toolbox XI



MEA LFP Analysis Toolbox XII



MEA LFP Analysis Toolbox XIII

- seizure-like event quantification:

Name	Duration	Start	Stop	Spike Count	Spike Rate	RMS	Max. Amplitude	Mean ISI	Delta	Theta	Alpha	Beta	Gamma	Delay	Transfer Entropy
C3	30.343999999999994	0.0	30.343999999999994	1218	40.139731083575015	676.2694258400888	3385.7358549546693	0.016506984387838944	52884.78088679831	4946.105660920222	1424.1835364867688	405.9470873255121	159.57460302189006	0	None
C2	31.723999999999993	0.09099999999999998	31.814999999999994	1532	48.291514310931795	544.7914957818647	3149.690645015697	0.014235140431090788	40544.402819089424	3827.1513524560896	1101.0128282182766	337.4613468393034	138.7614903056342	91	0.012157223268195239
D3	33.337999999999994	0.0	33.337999999999994	1357	40.704301397804315	530.6768306622532	3009.0494199776963	0.016622418879056043	26148.683175370446	2760.411662431562	842.9915044156808	254.7014992913317	109.27190493526385	0	None
D2	35.87299999999999	0.0	35.87299999999999	1224	34.120369079809336	657.6218603310972	3957.810312831967	0.018857726901062955	52983.509791213124	4511.064715611301	1229.3361816008162	290.0630620383728	95.1573607267309	0	None

Name	Duration	Start	Stop	Spike Count	Spike Rate	RMS	Max. Amplitude	Mean ISI	Delta	Theta	Alpha	Beta	Gamma	Delay	Transfer Entropy
C3	30.189999999999994	0.0009999999999999998	30.190999999999992	1449	47.99602517389865	750.7524676119893	4244.96180674892	0.013642265193370163	65093.688065240865	7821.5860154695965	2119.2603037218773	463.68789636083847	211.87758807127628	1	0.003946878437774082
C2	32.559999999999995	0.08399999999999998	32.64399999999999	1752	53.808353808353814	605.8588887580576	3173.934329665159	0.012532838378069672	49175.25075011739	5843.409320084117	1579.4592556529865	377.03177644461704	184.1840278451776	84	0.019556078608207628
D3	34.59199999999999	0.0	34.59199999999999	1542	44.5767807585569	586.8269458346716	3442.9554328375702	0.01544841012329656	31404.71274313269	4194.136470036716	1205.5311930960365	281.39227000325263	143.50612711897404	0	None
D2	34.52899999999999	0.11499999999999998	34.64399999999999	1336	38.692113875293245	753.857511715354	4169.477847766163	0.016352808988764043	67744.46964946194	7424.840305397393	1926.2188479702058	349.24643786195145	128.81739103358484	115	0.0181926932965916 78

Outlook

Outlook

- Transfer Entropy, Granger Causality and CSD
- Group analysis
- Other setups: CMOS, deep brain stimulation electrodes
- in-vitro/MEA - in-vivo/Tetrode correlation
- 2-Photon Ca^{2+} imaging

References I

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