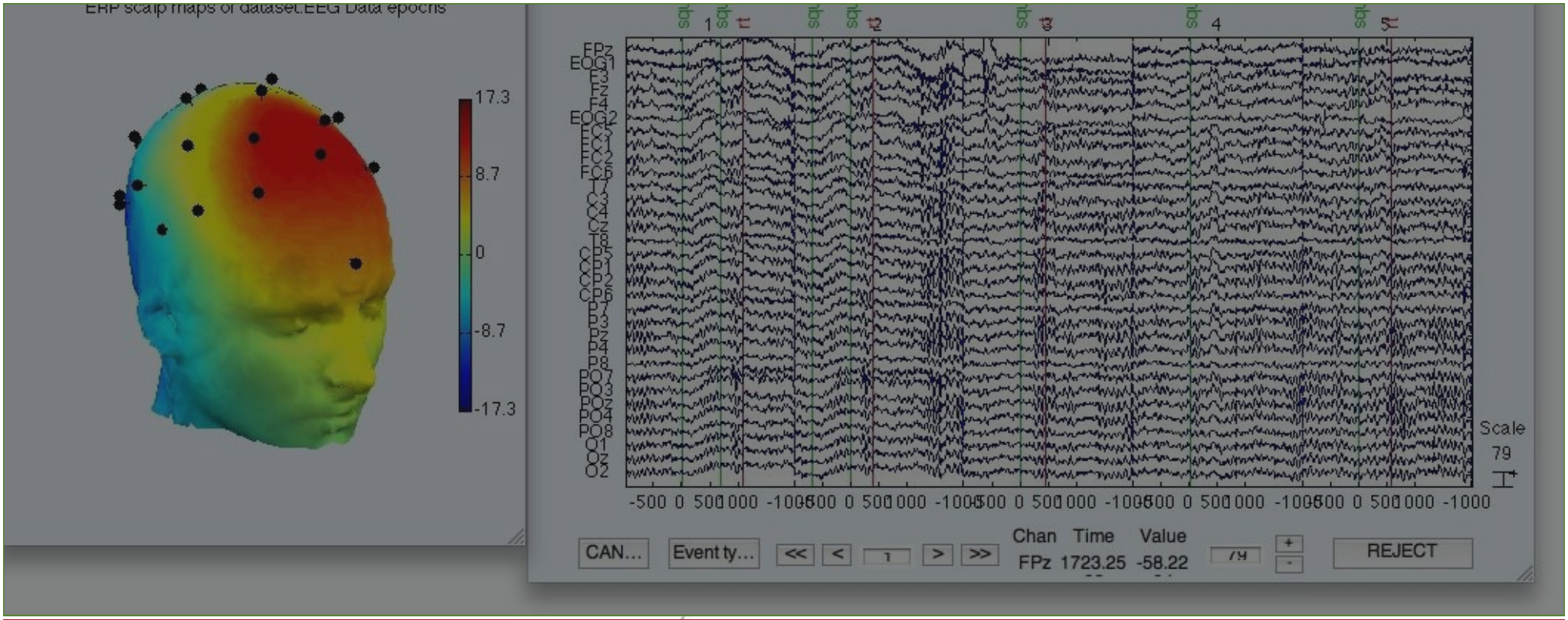
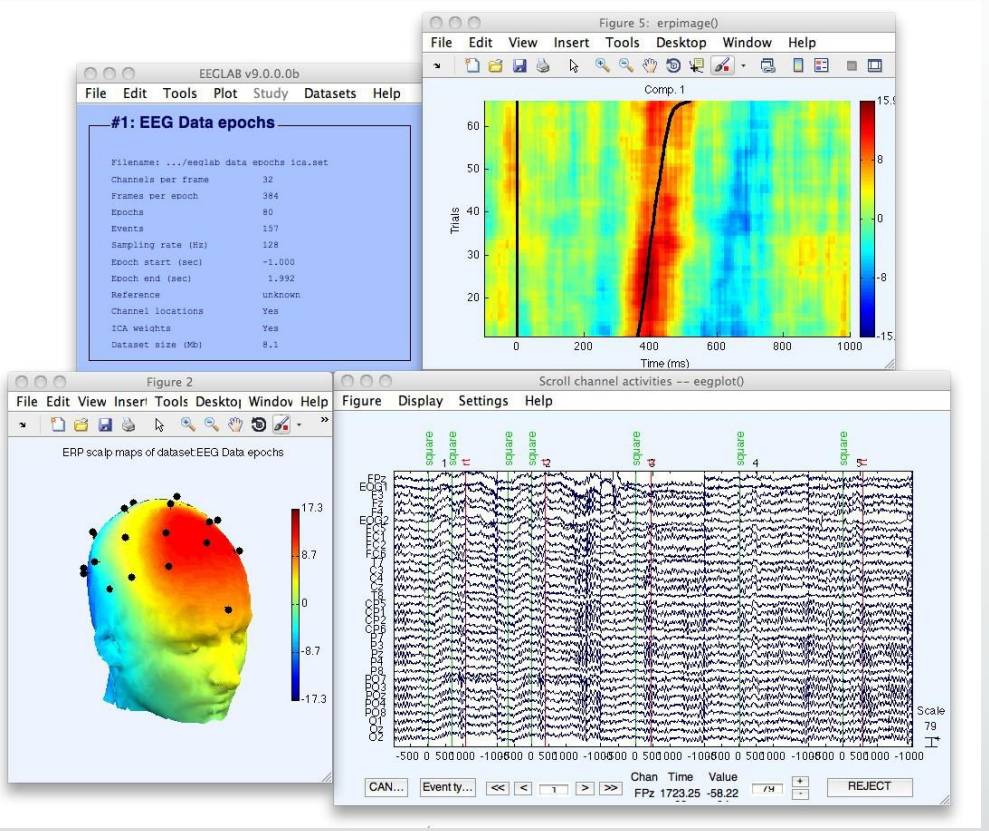


Topic 4 – EEG Analysis

By. Dr. Chris S. Crawford

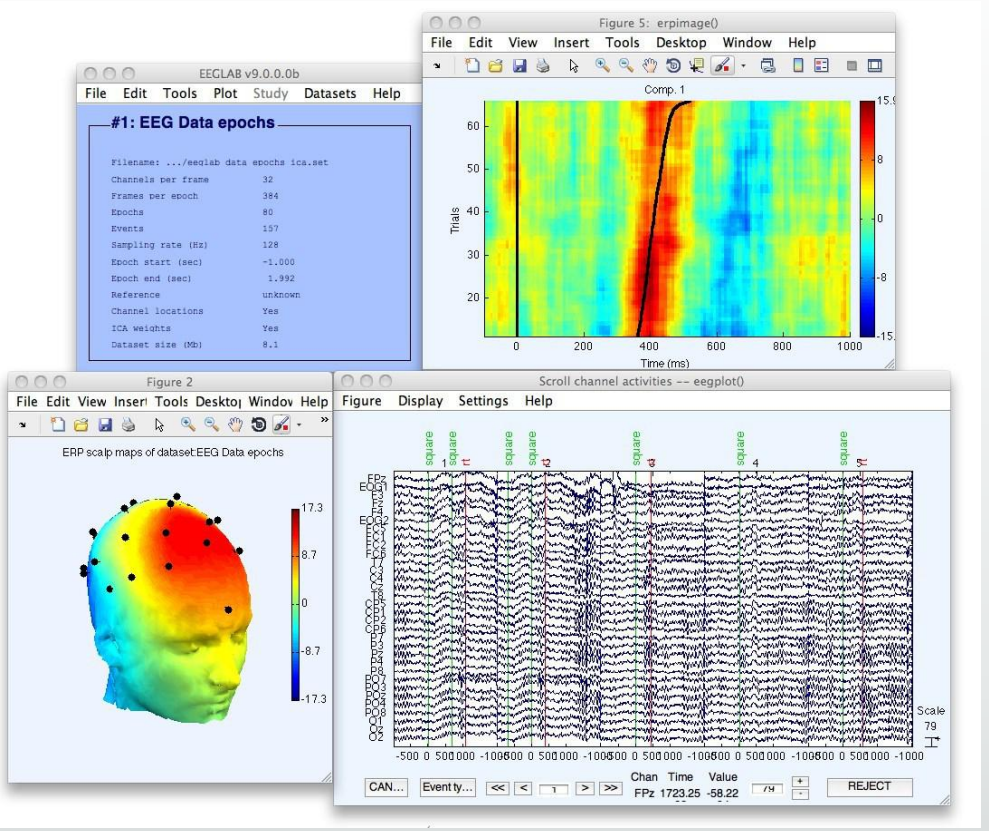
EEGLAB

- MATLAB toolbox & graphic user interface for EEG data analysis
- Over 600 functions
- Over 100k downloads
- Over 10k subscribers



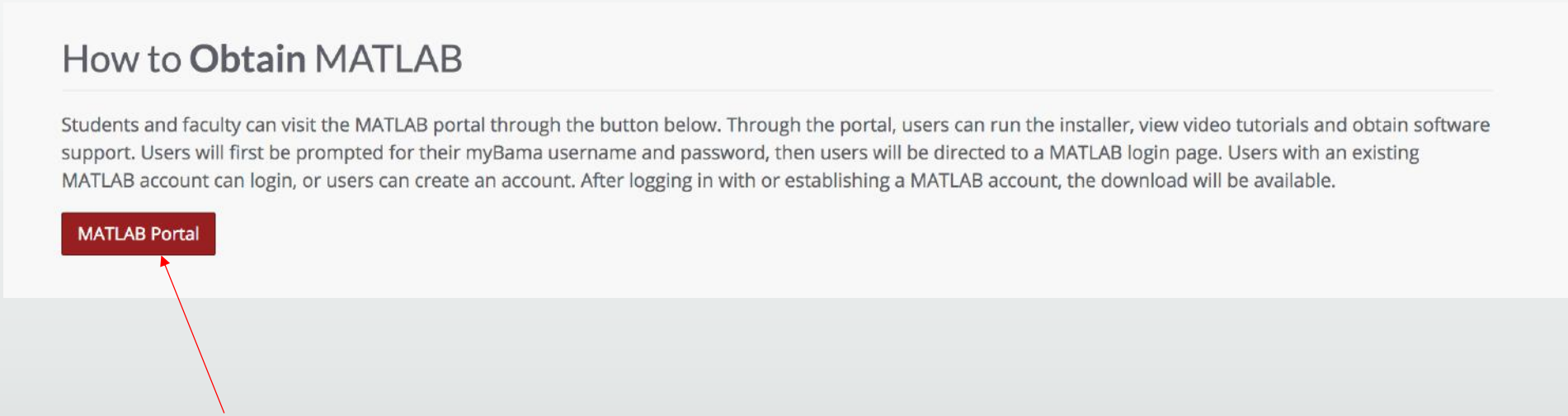
EEGLAB Goals for Today

- Install MATLAB
- Install EEGLAB Plugin
- Load EEG data using MATLAB / EEGLAB
  - Import raw data
  - Load Channel locations
  - Re-reference data
  - Remove Unwanted channels
  - Filter data
  - Remove Line noise
- Scroll through raw EEG data
- Create Plots
- Compare TD vs. ASD



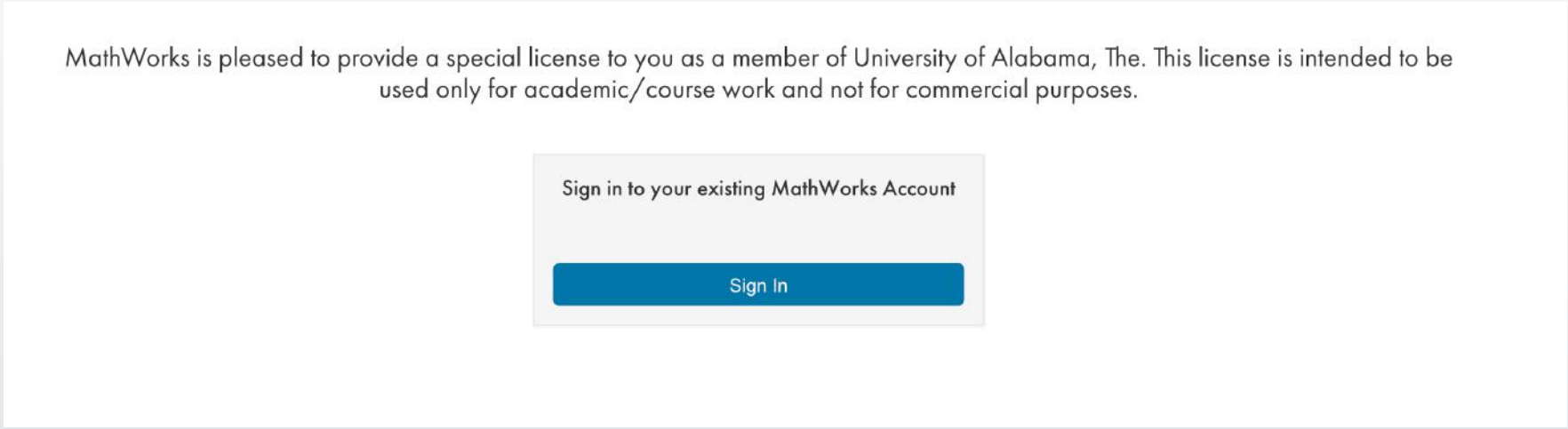
Install MATLAB

- https://oit.ua.edu/software/matlab/



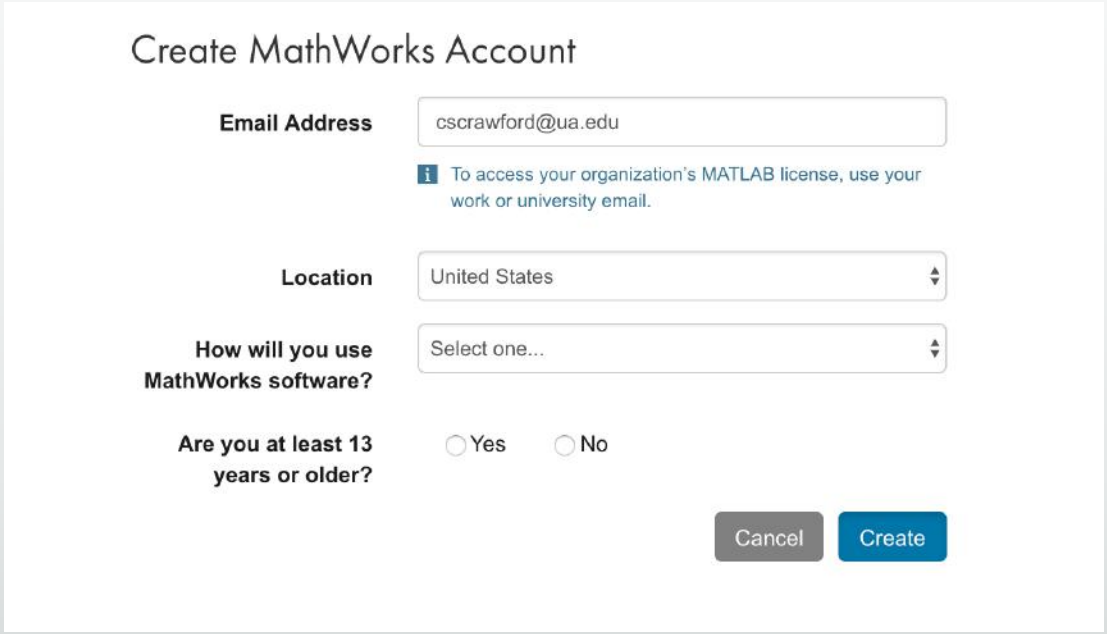
Install MATLAB

- Sign in / Create MathWorks Account



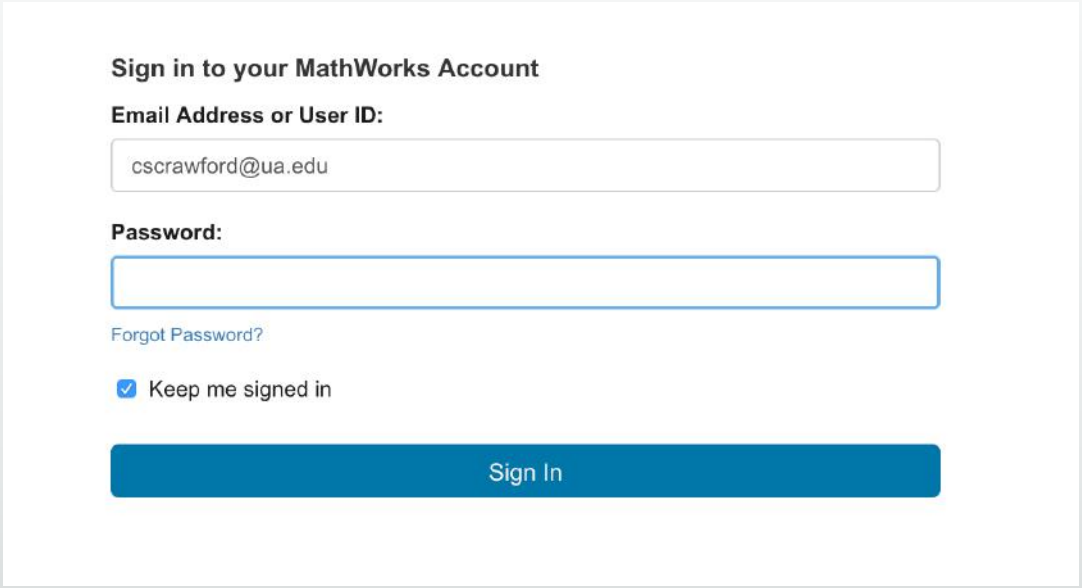
Install MATLAB

- Create MathWorks Account



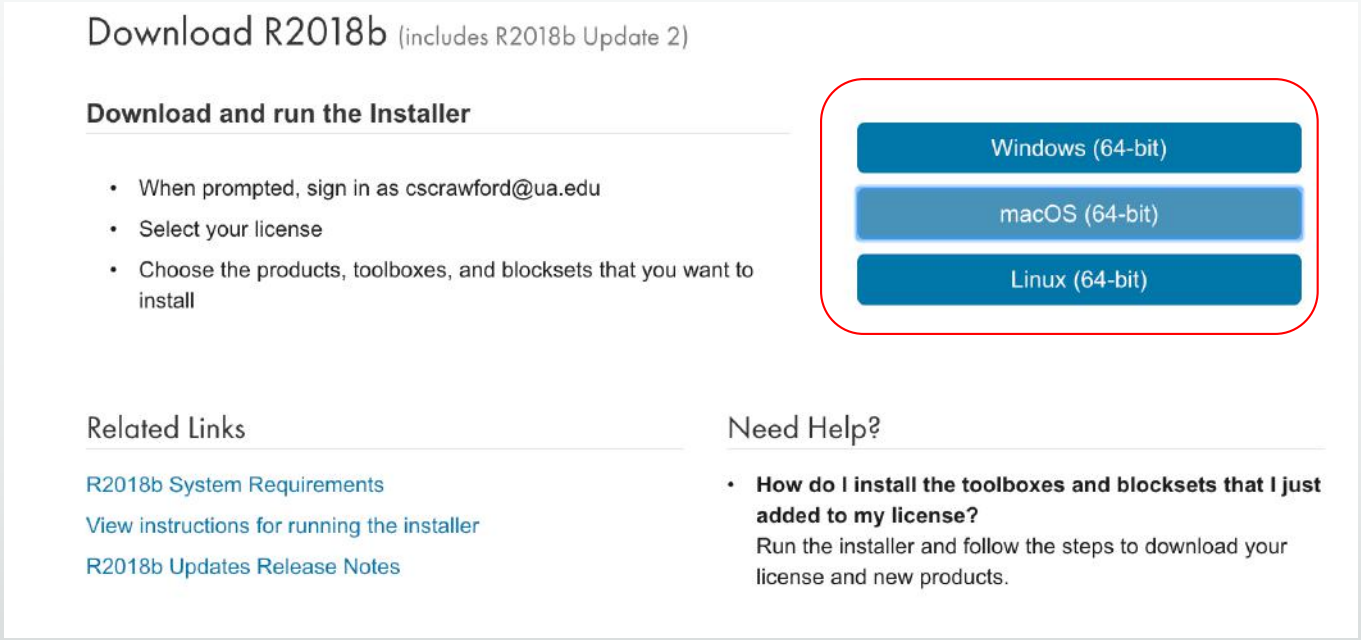
Install MATLAB

- Sign in using your MathWorks Account



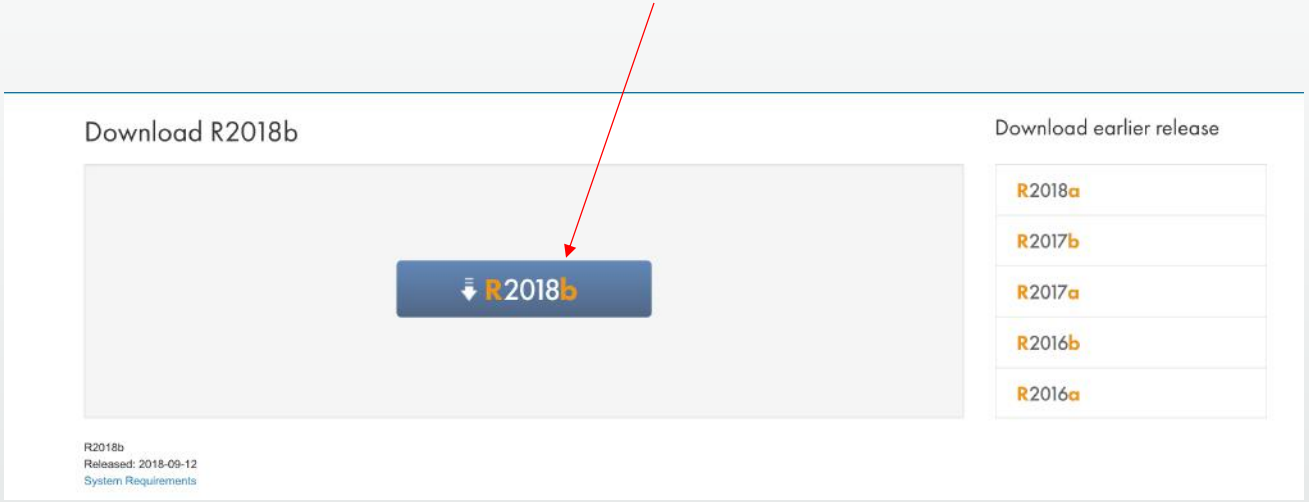
Install MATLAB

- Sign in using your MathWorks Account



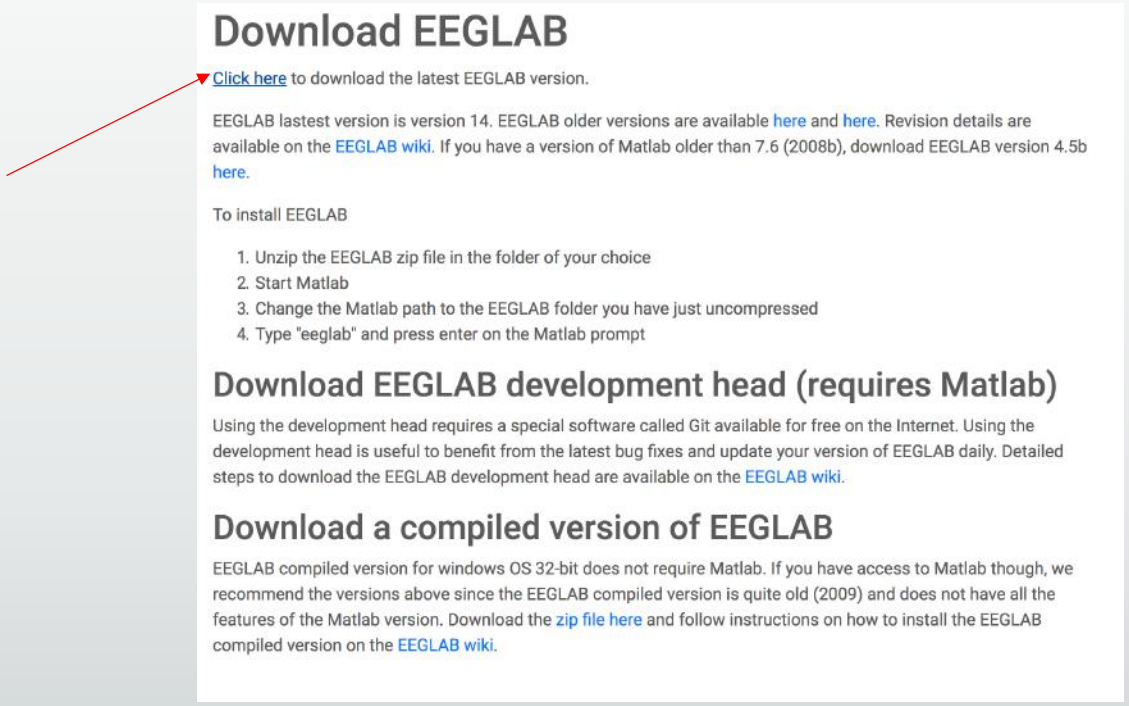
Install MATLAB

- Download version **R2018b**



Install EEGLAB Plugin

- https://sccn.ucsd.edu/eeglab/downloadtoolbox.php



Download EEGLAB

Click here to download the latest EEGLAB version.

EEGLAB lastest version is version 14. EEGLAB older versions are available here and here. Revision details are available on the EEGLAB wiki. If you have a version of Matlab older than 7.6 (2008b), download EEGLAB version 4.5b here.

To install EEGLAB

1. Unzip the EEGLAB zip file in the folder of your choice
2. Start Matlab
3. Change the Matlab path to the EEGLAB folder you have just uncompressed
4. Type "eeglab" and press enter on the Matlab prompt

Download EEGLAB development head (requires Matlab)

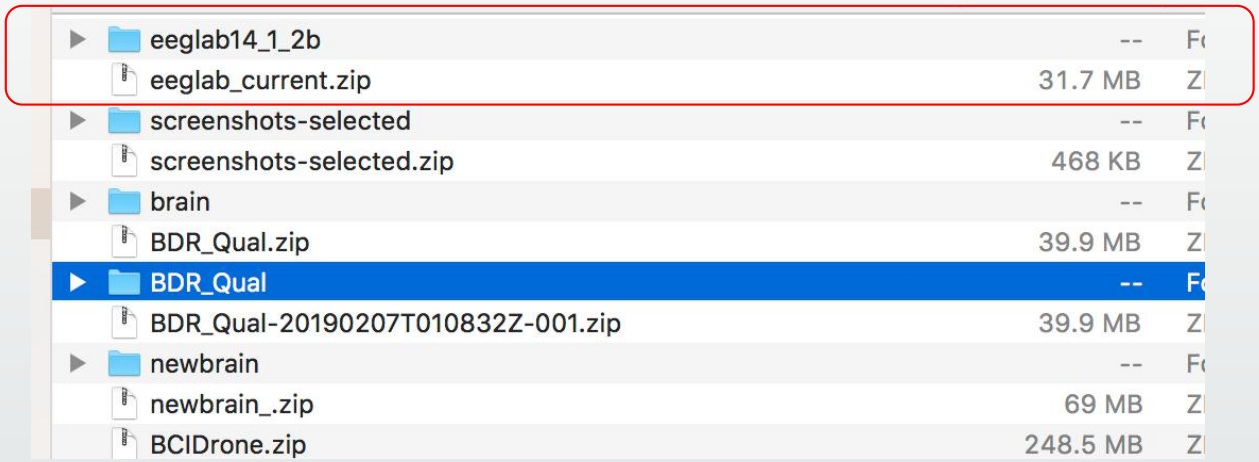
Using the development head requires a special software called Git available for free on the Internet. Using the development head is useful to benefit from the latest bug fixes and update your version of EEGLAB daily. Detailed steps to download the EEGLAB development head are available on the EEGLAB wiki.

Download a compiled version of EEGLAB

EEGLAB compiled version for windows OS 32-bit does not require Matlab. If you have access to Matlab though, we recommend the versions above since the EEGLAB compiled version is quite old (2009) and does not have all the features of the Matlab version. Download the zip file here and follow instructions on how to install the EEGLAB compiled version on the EEGLAB wiki.

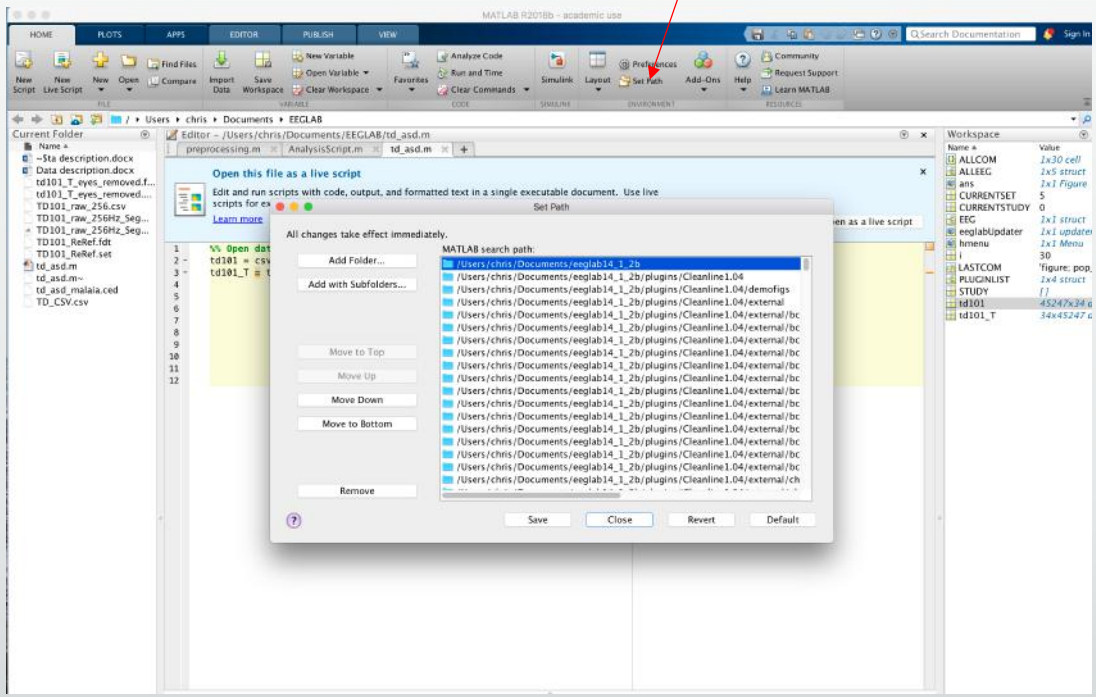
Install EEGLAB Plugin

- Unzip eeglab_current zip file



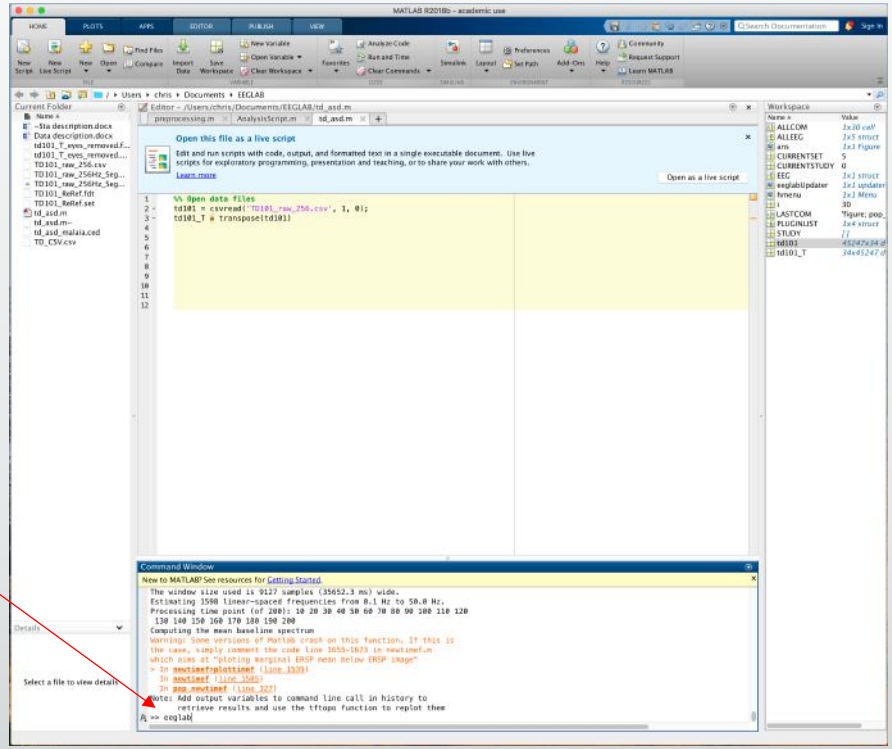
Install EEGLAB Plugin

- Add eeglab folder to MATLAB (Set Path)

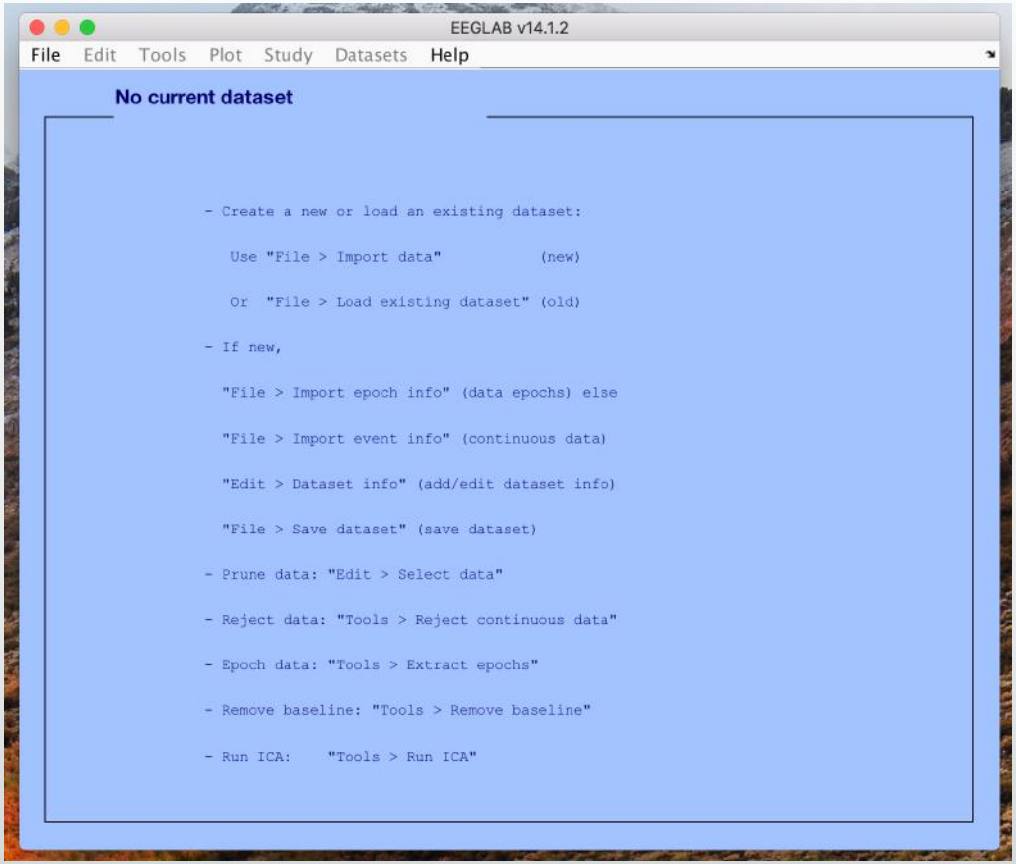


Install EEGLAB Plugin

- Enter ‘eeglab’ in command window



Install EEGLAB Plugin



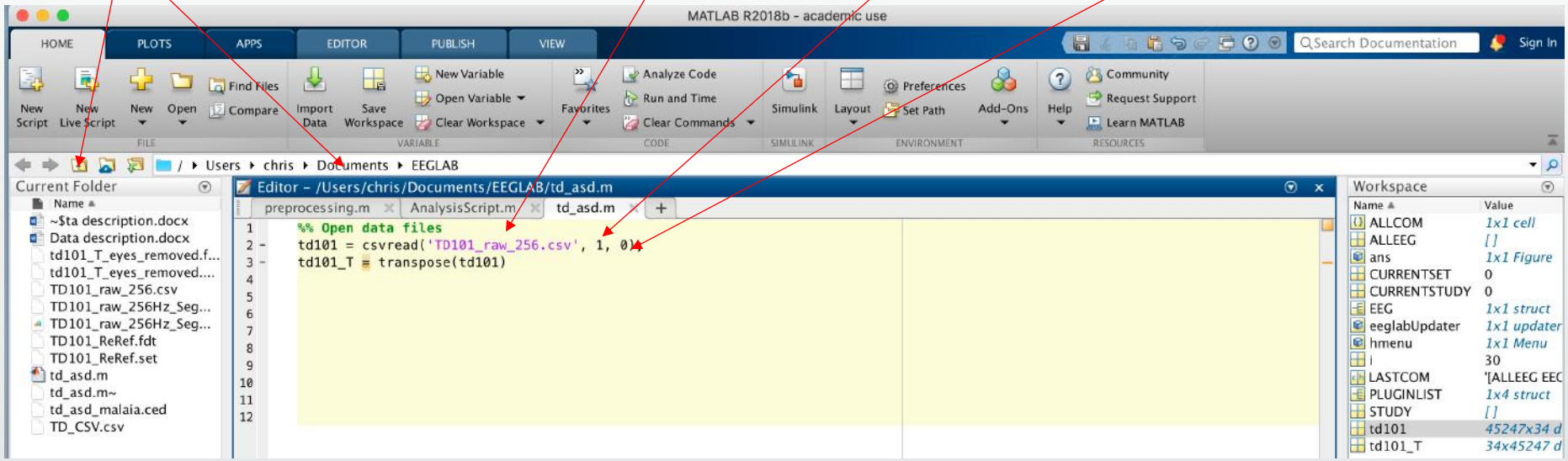
Import Raw EEG Data

Navigate to folder containing EEG data

Load .csv file

Row offset

Column offset



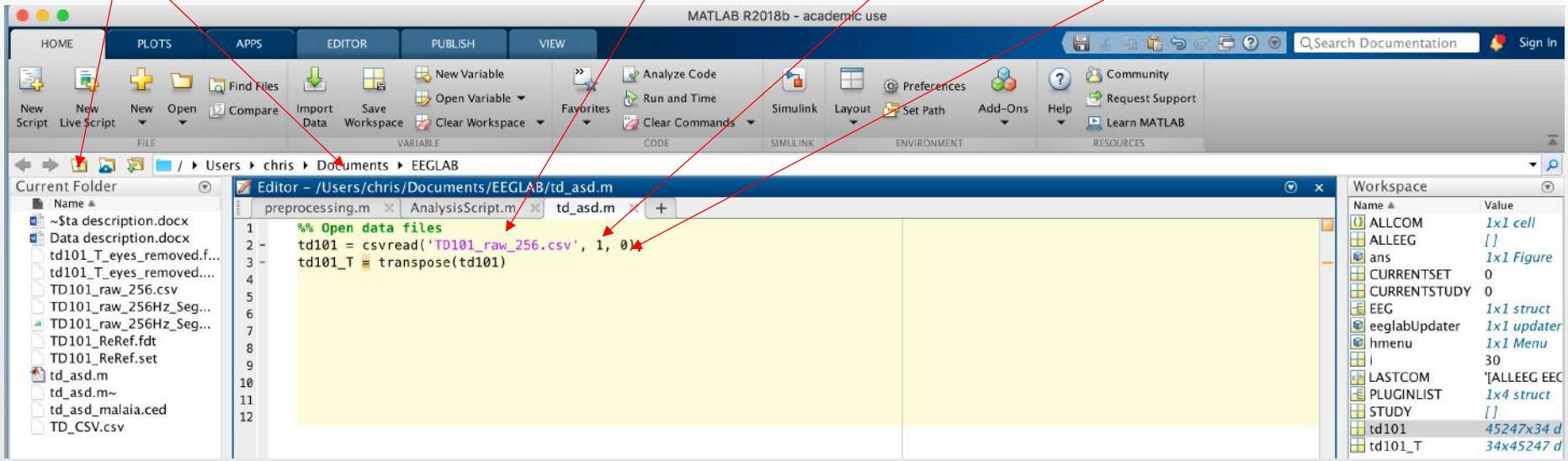
Import Raw EEG Data

Navigate to folder containing EEG data

Load .csv file

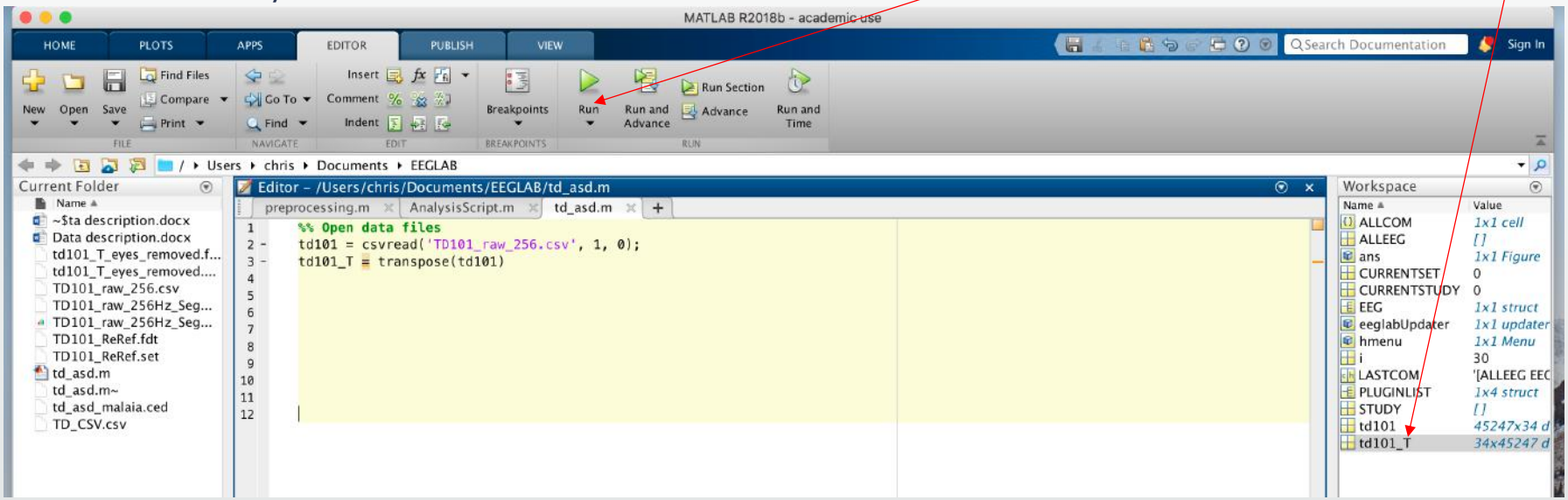
Row offset

Column offset



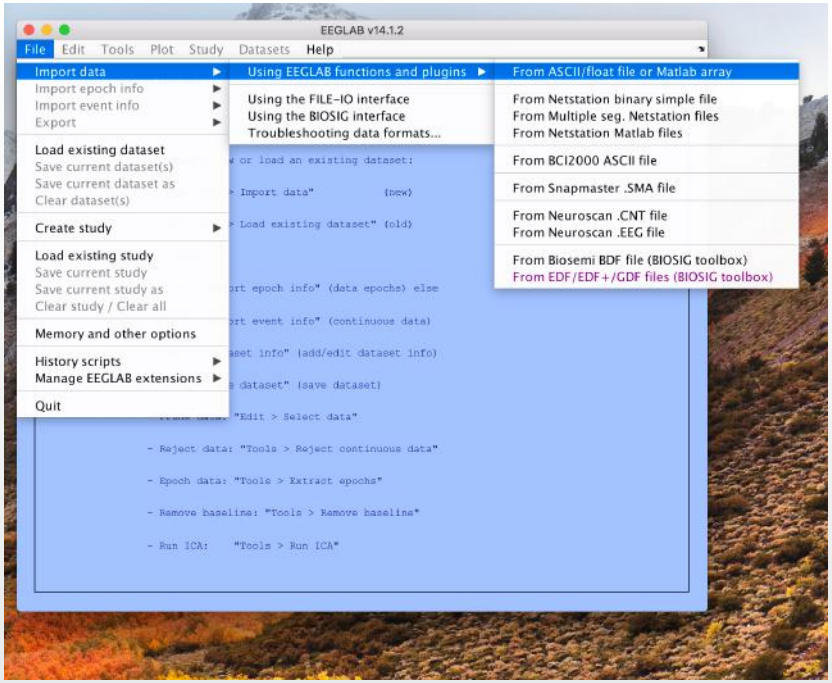
Import Raw EEG Data

- Create EEG data array from .csv file



Import Raw EEG Data

- Import EEG Matlab array

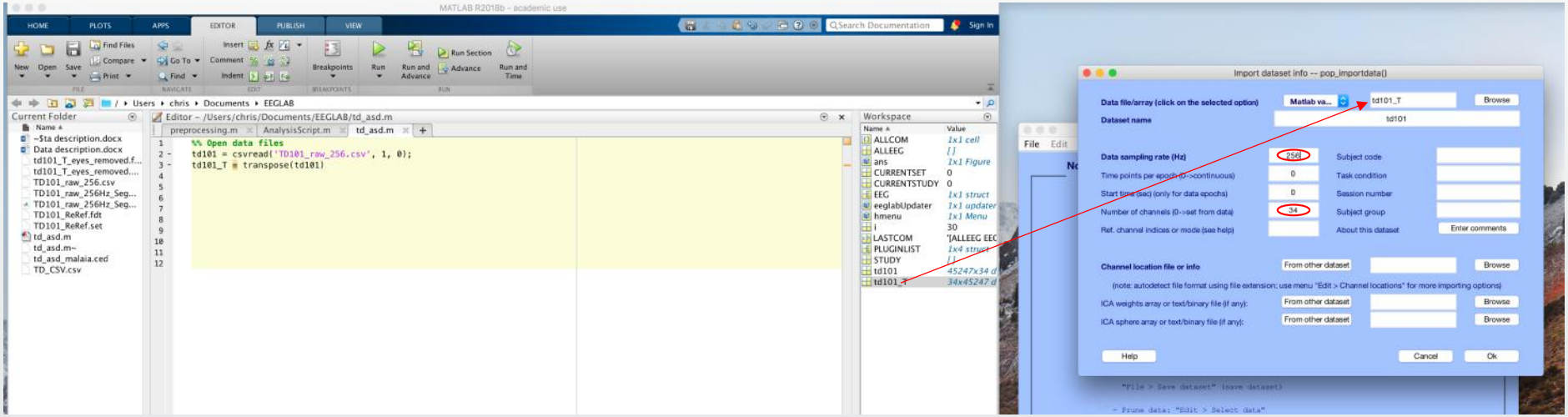


TD101_raw_256Hz_Segments_1_2

Fp1 - LkE	Fpz - LkE	Fp2 - LkE	F7 - LkE	F3 - LkE	Fz - LkE	F4 - LkE	F8 - LkE	FC5 - LkE	FC1 - LkE	FC2 - LkE	FC6 - LkE	M1 - LkE	T7 - LkE	C3 - LkE	Cz - LkE	C4 - LkE	T8 - LkE	M2 - LkE	CP5 - LkE	CP1 - LkE	CP2 - LkE
27254.956	19317.281	17631.542	148863.435	905.818	7305.244	3916.886	13269.967	9306.168	4771.267	6249.602	17139.554	-251.649	14244.619	9045.692	11544.966	17449.297	19116.443	251.649	15330.548	14030.78	6528.91
27251.737	19313.915	17628.802	148860.231	904.089	7302.871	3916.978	13264.339	9305.525	4770.44	6250.375	17140.215	-248.044	14241.952	9046.354	11543.826	17449.15	19118.391	248.044	15332.075	14030.21	6528.634
27251.076	19315.293	17629.886	148871.854	903.74	7303.809	3920.932	13266.932	9307.823	4774.633	6252.545	17145.716	-248.614	14244.564	9048.083	11546.088	17453.251	19124.148	248.614	15337.224	14035.708	6534.372
27249.77	19313.142	17629.391	148881.108	903.611	7303.57	3919.957	13268.385	9305.892	4774.155	6252.582	17146.34	-252.623	14247.469	9051.356	11546.677	17457.517	19127.44	252.623	15341.178	14039.901	6536.781
27245.577	19311.689	17625.639	148845.017	900.172	7299.709	3918.302	13268	9302.251	4771.856	6251.239	17149.577	-252.918	14248.021	9050.749	11544.856	17458.014	19128.911	252.918	15338.953	14039.239	6537.737
27247.911	19313.069	17628.692	148834.854	896.696	7298.2	3918.56	13271.714	9301.772	4772.279	6251.846	17151.747	-253.396	14250.191	9050.859	11544.452	17459.927	19132.625	253.396	15347.835	14039.735	6540.937
27247.36	19311.635	17627.405	148849.398	894.913	7298.973	3921.833	13275.649	9302.306	4772.683	6252.416	17154.45	-249.865	14252.895	9052.661	11545.096	17463.034	19132.037	249.865	15350.446	14043.8	6542.316
27246.092	19309.409	17625.859	148846.239	894.03	7297.833	3920.509	13277.397	9304.88	4773.088	6252.306	17157.301	-250.49	14256.02	9054.353	11545.481	17465.241	19134.723	250.49	15361.628	14044.186	6543.18
27246.11	19309.28	17626.539	148836.687	893.993	7297.042	3919.148	13282.197	9304.31	4773.805	6252.986	17159.929	-251.906	14258.32	9054.538	11545.831	17463.991	19135.568	251.906	15353.793	14045.933	6544.542
27242.377	19305.749	17624.903	148839.012	890.389	7292.665	3916.555	13278.886	9301.129	4770.44	6250.154	17159.691	-253.488	14255.818	9052.091	11542.815	17461.453	19133.508	253.488	15343.035	14042.255	6540.496
27242.469	19306.043	17624.24	148856.312	887.685	7289.649	3913.576	13277.01	9300.136	4765.64	6246.605	17159.453	-254.407	14256.15	9051.779	11540.258	17458.841	19131.945	254.407	15341.748	14039.497	6539.227
27245.08	19307.865	17626.686	148870.364	886.361	7287.405	3914.036	13282.491	9302.14	4766.946	6246.955	17162.707	-251.575	14261.832	9051.356	11539.891	17458.75	19136.708	251.575	15344.23	14039	6538.583
27240.152	19301.17	17620.655	148849.83	880.366	7282.937	3910.689	13279.144	9299.547	4764.757	6242.577	17160.408	-250.803	14263.027	9047.789	11535.974	17455.494	19136.028	250.803	15336.286	14034.274	6533.599

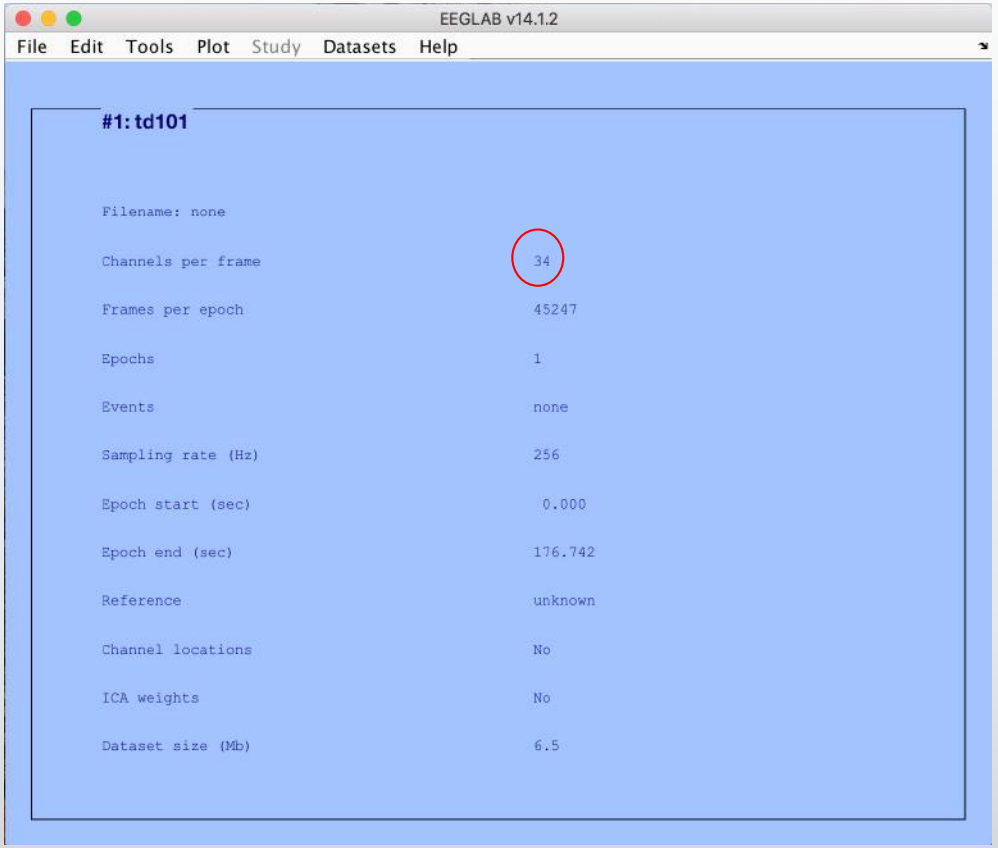
Import Raw EEG Data

- Import EEG Matlab array

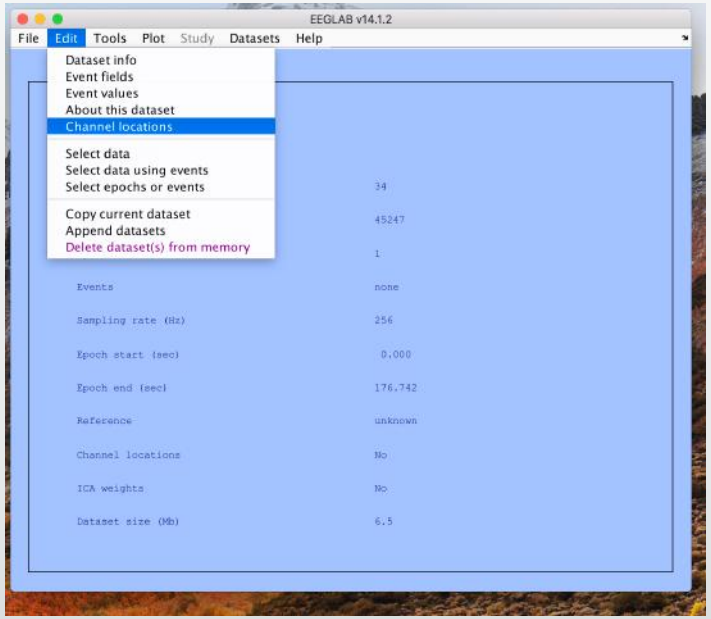


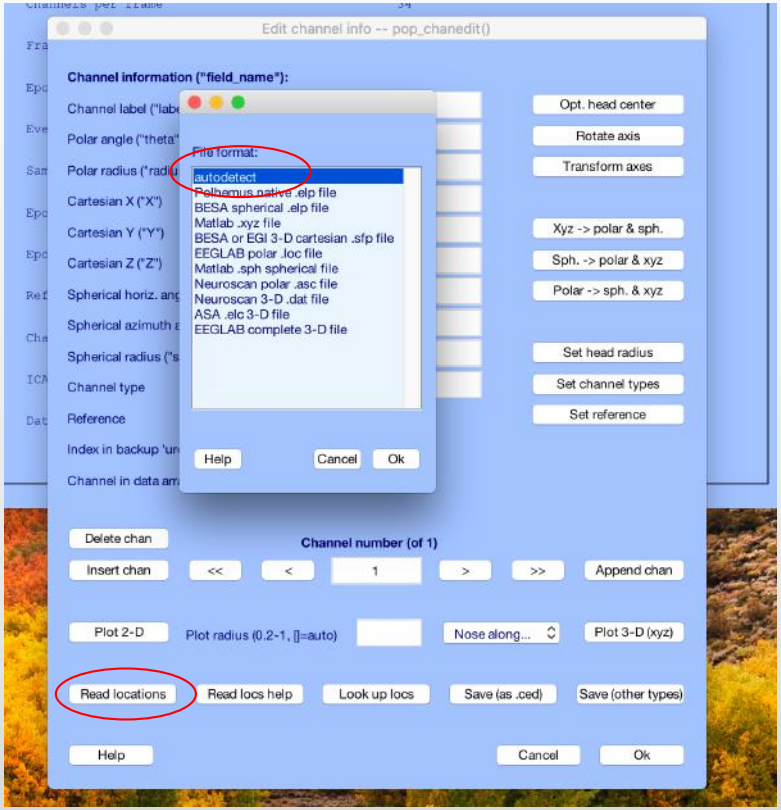
Import Raw EEG Data

- Import EEG Matlab array

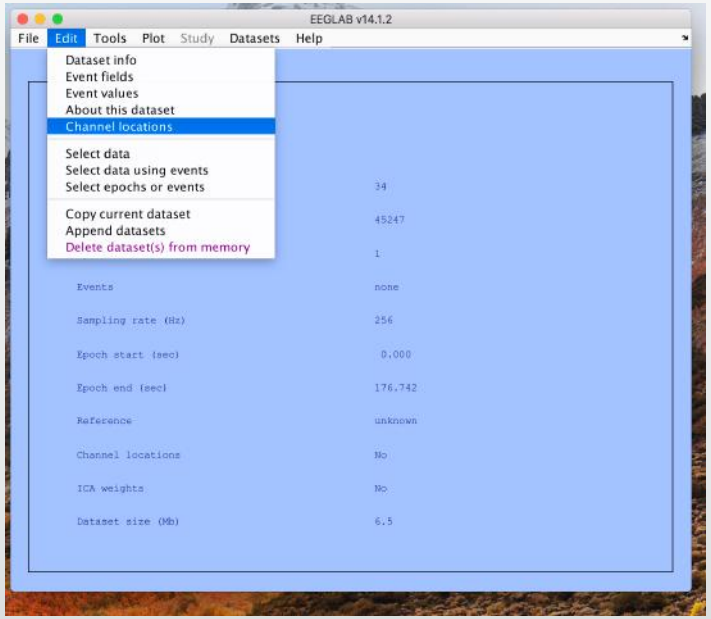


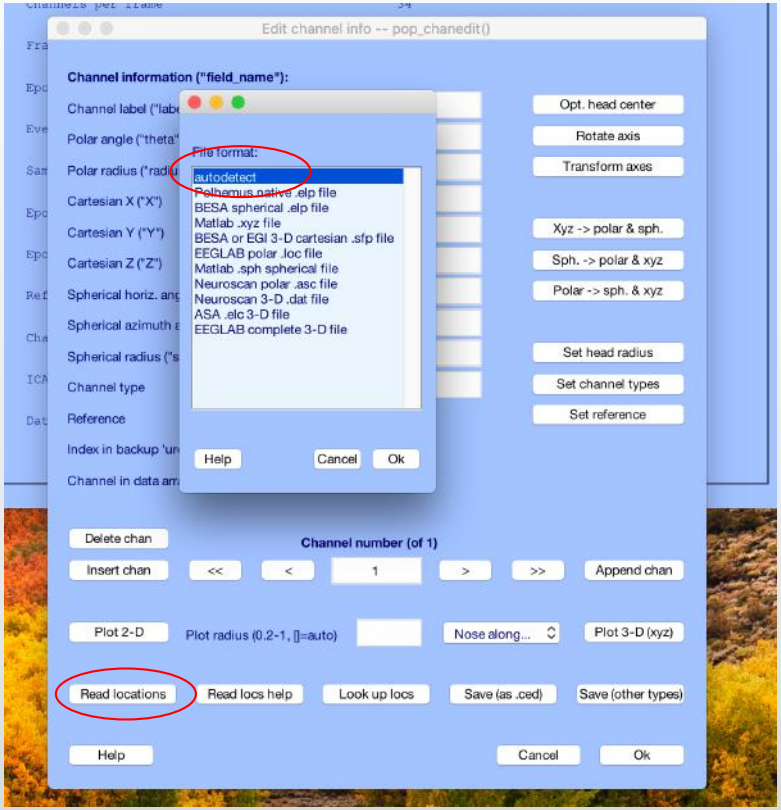
Load channel locations



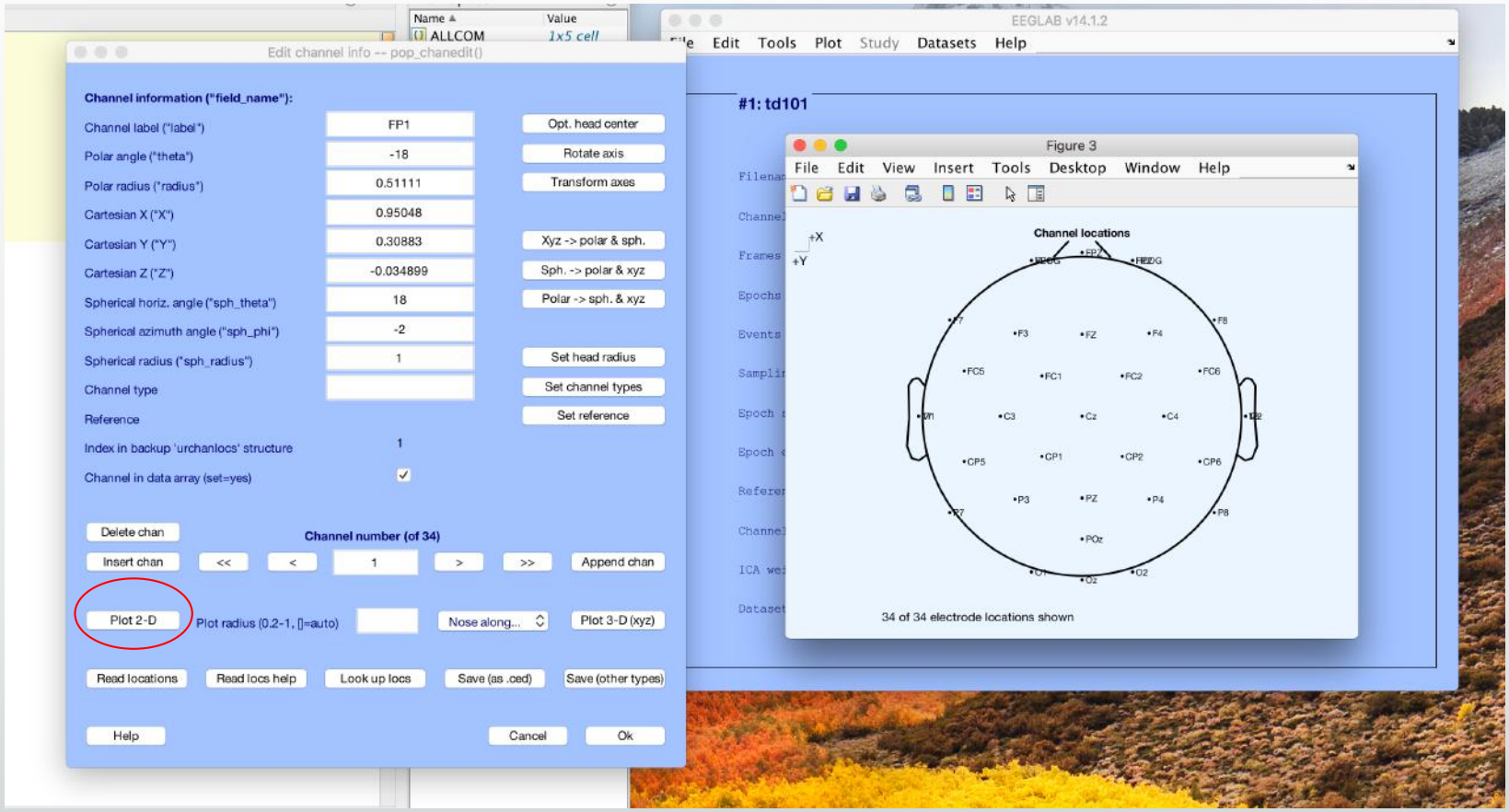


Load channel locations

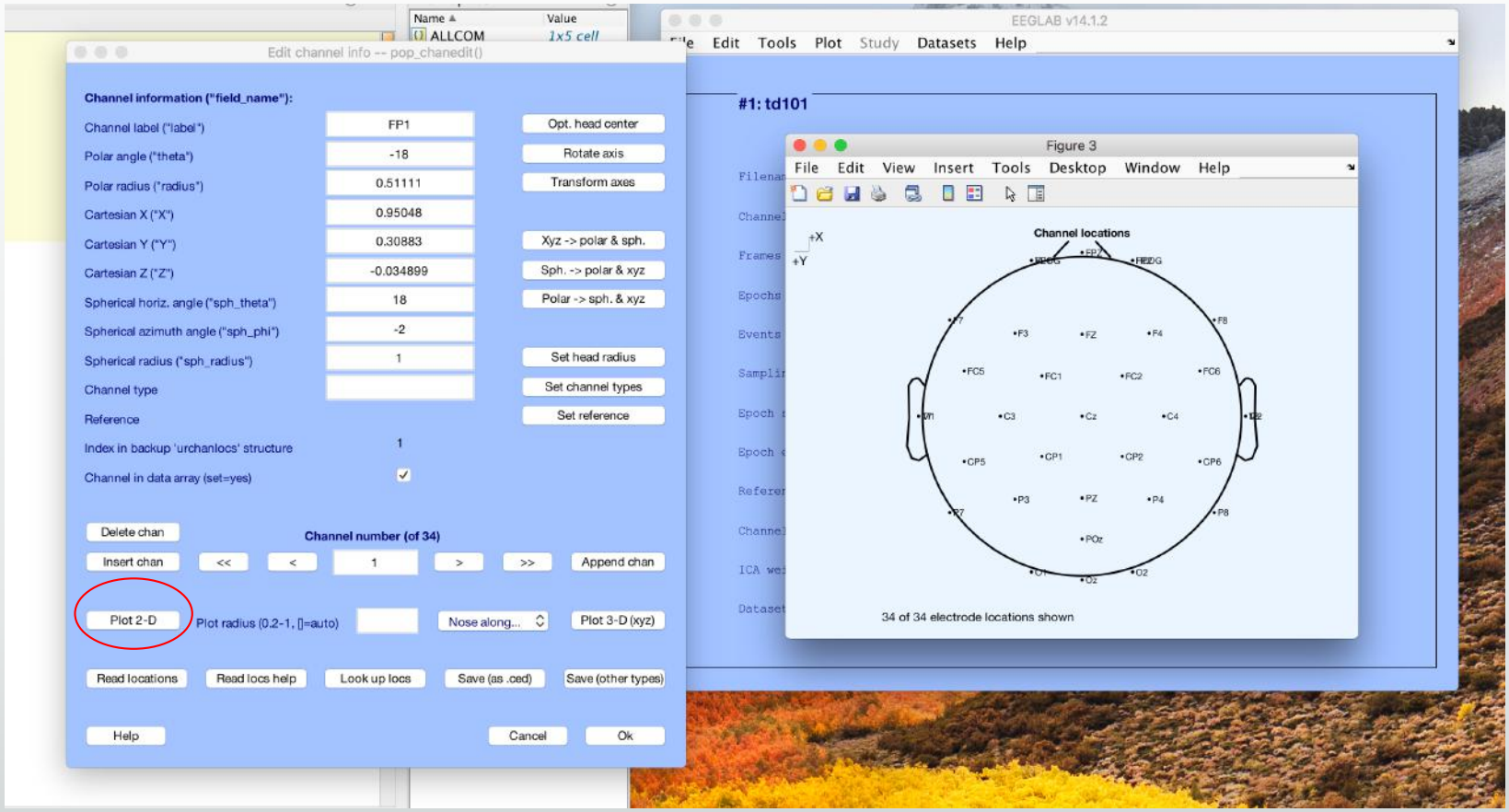




Load channel locations

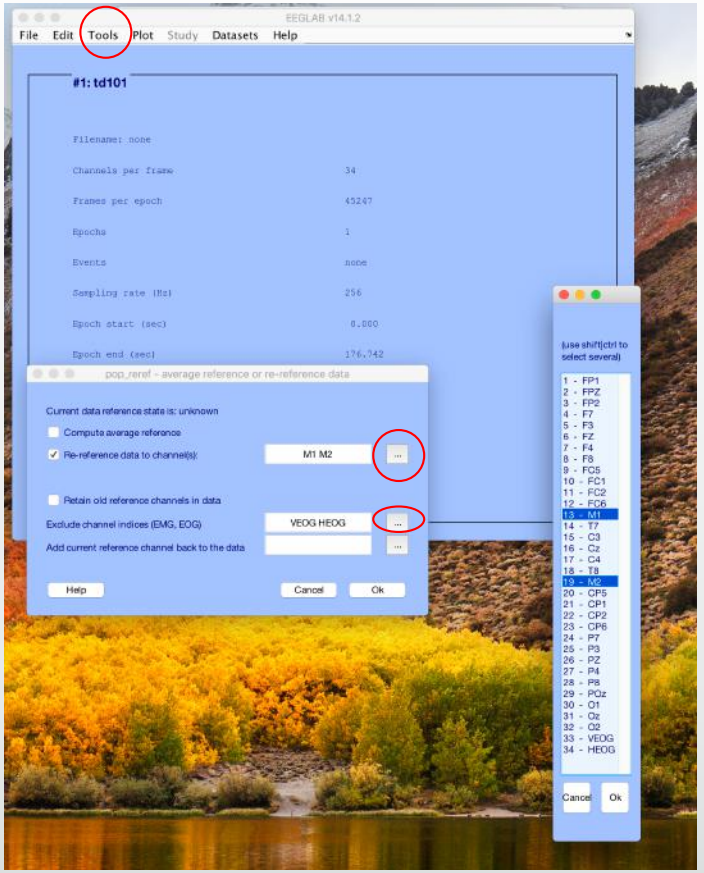


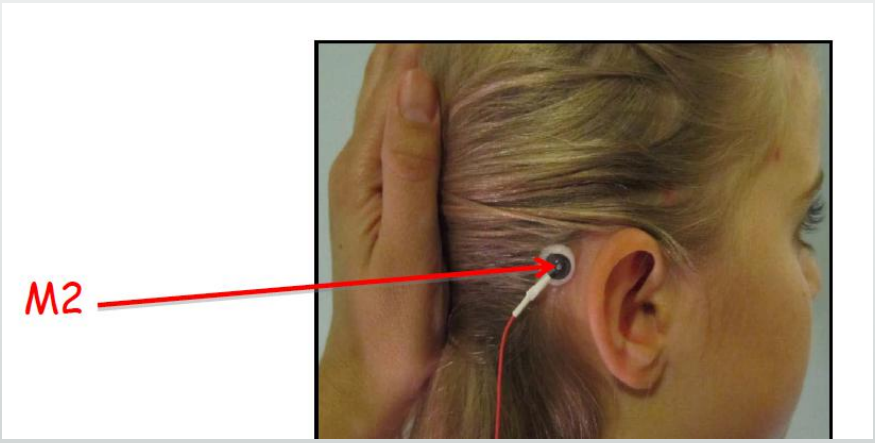
Load channel locations



Re-reference data

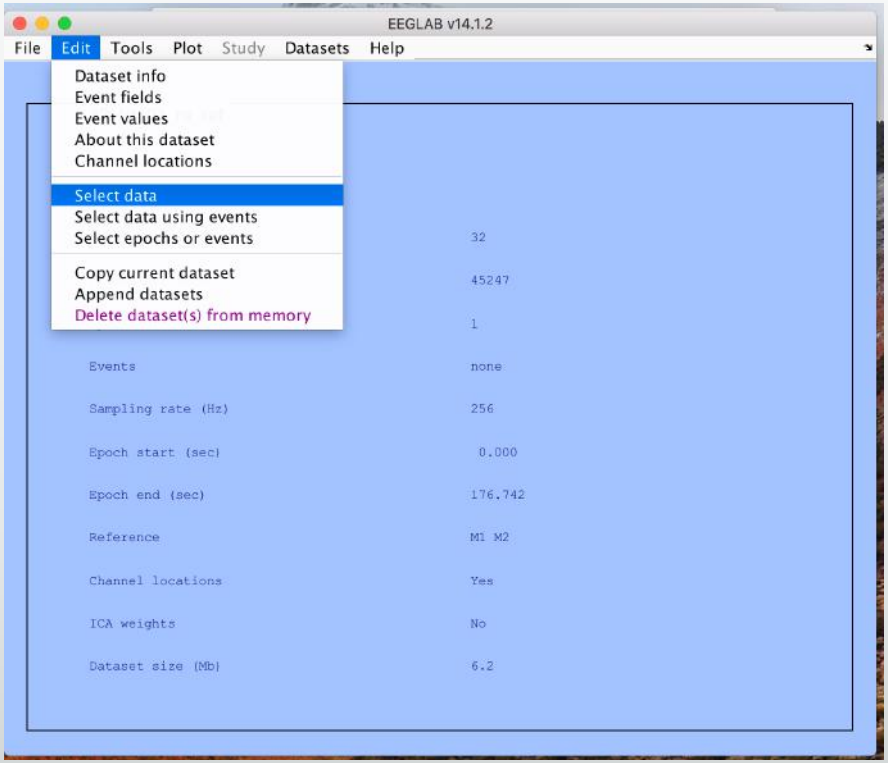
- M1 & M2 are reference electrodes
- Bony area behind ears
- Record less signal from the brain
- Records noise similar to other electrodes

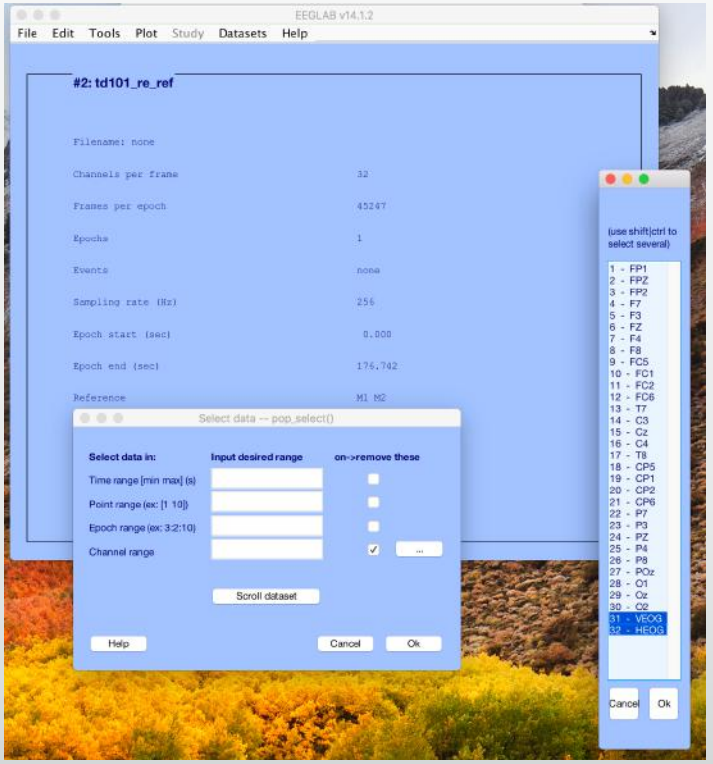




Remove unwanted channels

- Remove EOG artifacts caused by eye movements





Filter data

- Low-pass filter (**below**): all frequencies **below** a defined frequency are **passed** and all frequencies **above** this limit are **rejected**.
- High-pass filter(**above**): all frequencies **above** a defined frequency are **passed** and all frequencies **below** this limit are **rejected**.
- Band-pass filter(**between**): all frequencies **between** defined **lower** and **upper** frequency limits are passed.
- Band-stop / notch filter: **inverse of band-pass filter**; all filters **between** lower and upper frequency are **rejected**

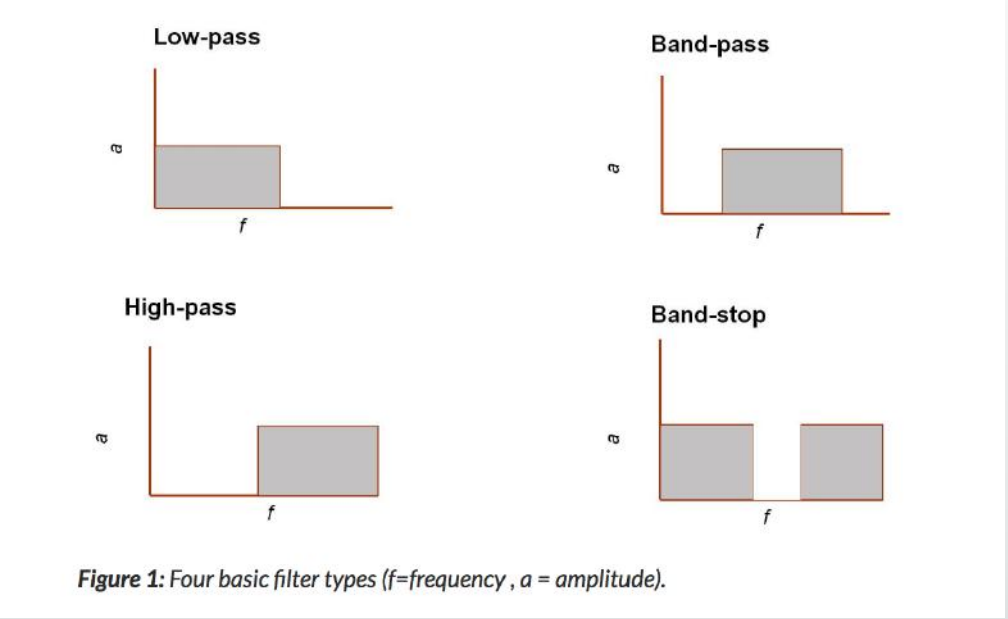
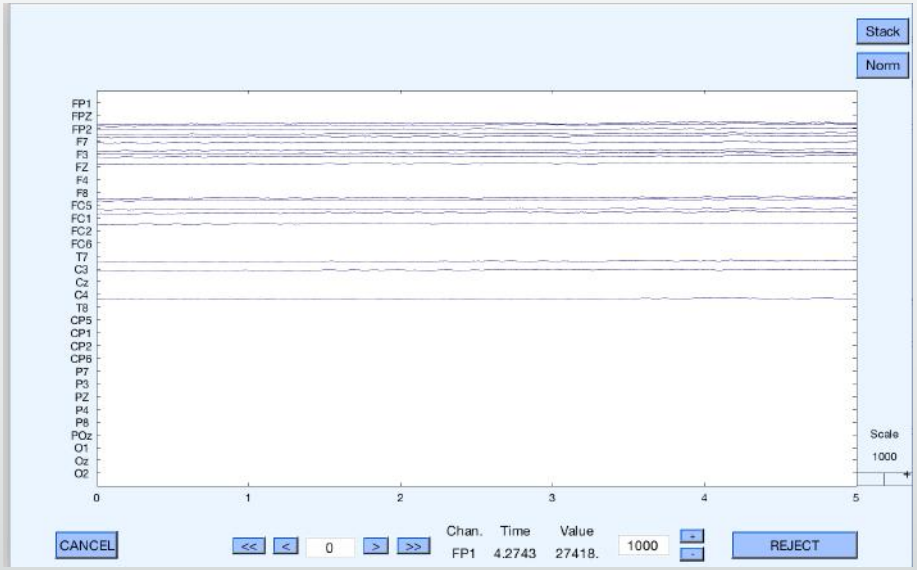
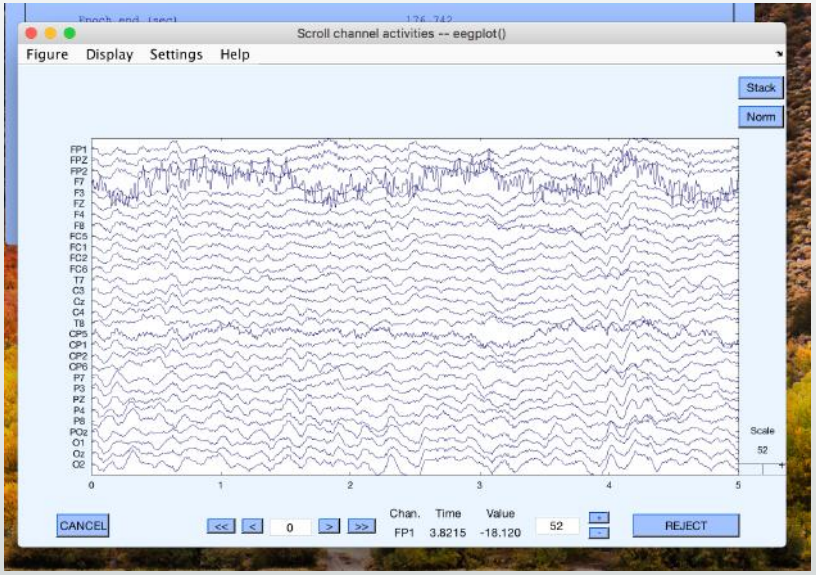


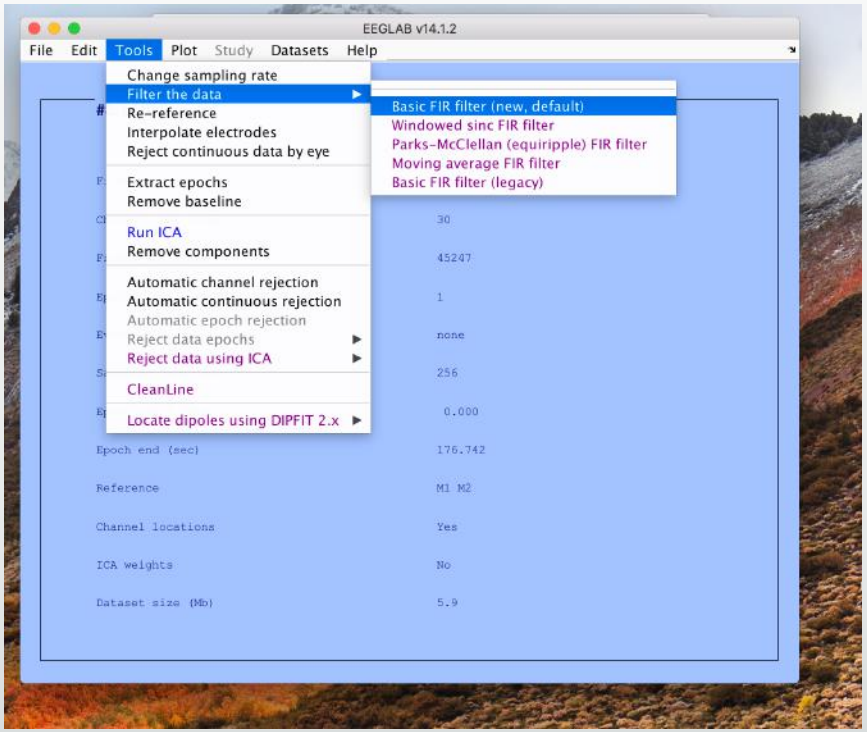
Figure 1: *Four basic filter types (f=frequency , a = amplitude).*

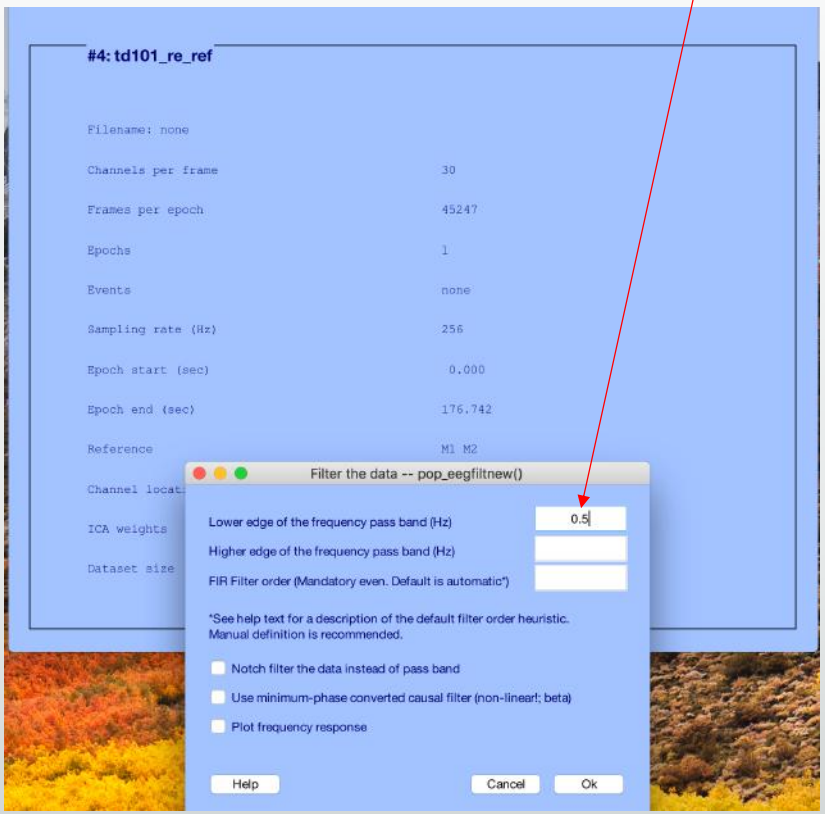
Filter data


Stack
Norm
FP1
FPZ
FP2
F7
F3
FZ
F4
F8
FC5
FC1
FC2
FC6
T7
C3
Cz
C4
T8
CP5
CP1
CP2
CP6
P7
P3
PZ
P4
P8
POz
O1
Oz
O2
Scale
1000
0
1
2
3
4
5
CANCEL
<<
<
0
>
>>
Chan.
Time
Value
FP1
4.2743
27418.
1000
REJECT

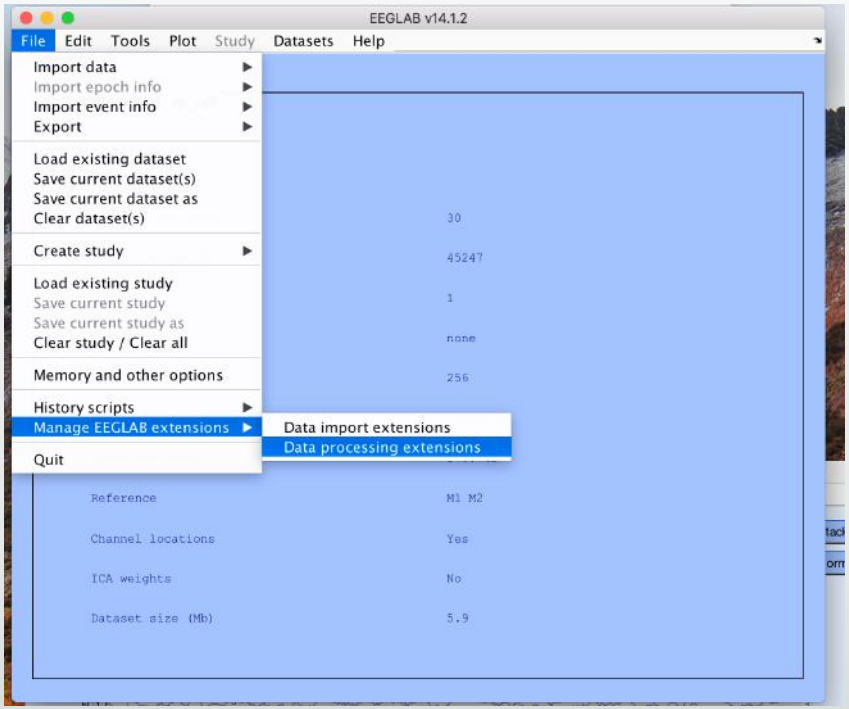

Scroll channel activities -- eegplot()
Figure
Display
Settings
Help
Stack
Norm
FP1
FPZ
FP2
F7
F3
FZ
F4
F8
FC5
FC1
FC2
FC6
T7
C3
Cz
C4
T8
CP5
CP1
CP2
CP6
P7
P3
PZ
P4
P8
POz
O1
Oz
O2
Scale
52
0
1
2
3
4
5
CANCEL
<<
<
0
>
>>
Chan.
Time
Value
FP1
3.8215
-18.120
52
REJECT

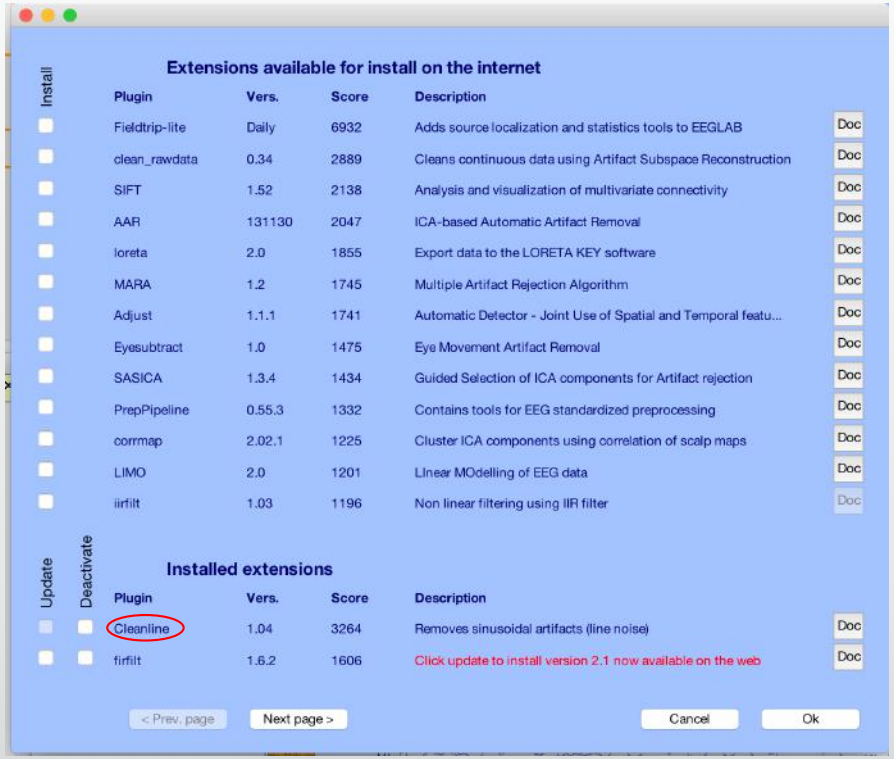
Filter data


EEGLAB v14.1.2
File Edit Tools Plot Study Datasets Help
Change sampling rate
Filter the data
Re-reference
Interpolate electrodes
Reject continuous data by eye
Extract epochs
Remove baseline
Run ICA
Remove components
Automatic channel rejection
Automatic continuous rejection
Automatic epoch rejection
Reject data epochs
Reject data using ICA
CleanLine
Locate dipoles using DIPFIT 2.x
Basic FIR filter (new, default)
Windowed sinc FIR filter
Parks-McClellan (equiripple) FIR filter
Moving average FIR filter
Basic FIR filter (legacy)
30
45247
1
none
256
0.000
Epoch end (sec) 176.742
Reference M1 M2
Channel locations Yes
ICA weights No
Dataset size (Mb) 5.9

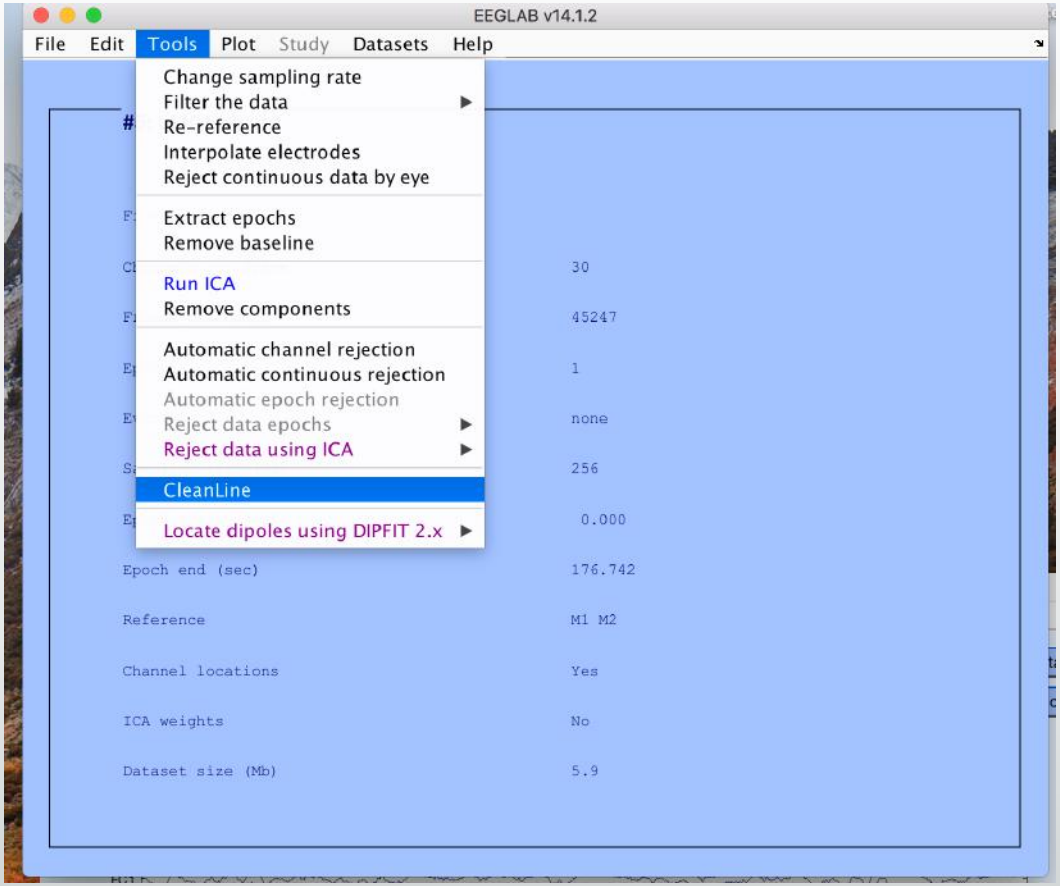

#4: td101_re_ref
Filename: none
Channels per frame 30
Frames per epoch 45247
Epochs 1
Events none
Sampling rate (Hz) 256
Epoch start (sec) 0.000
Epoch end (sec) 176.742
Reference M1 M2
ICA weights
Dataset size
Filter the data -- pop_eegfiltnew()
Lower edge of the frequency pass band (Hz) 0.5
Higher edge of the frequency pass band (Hz)
FIR Filter order (Mandatory even. Default is automatic*)
*See help text for a description of the default filter order heuristic.
Manual definition is recommended.
Notch filter the data instead of pass band
Use minimum-phase converted causal filter (non-linear!; beta)
Plot frequency response
Help
Cancel
Ok

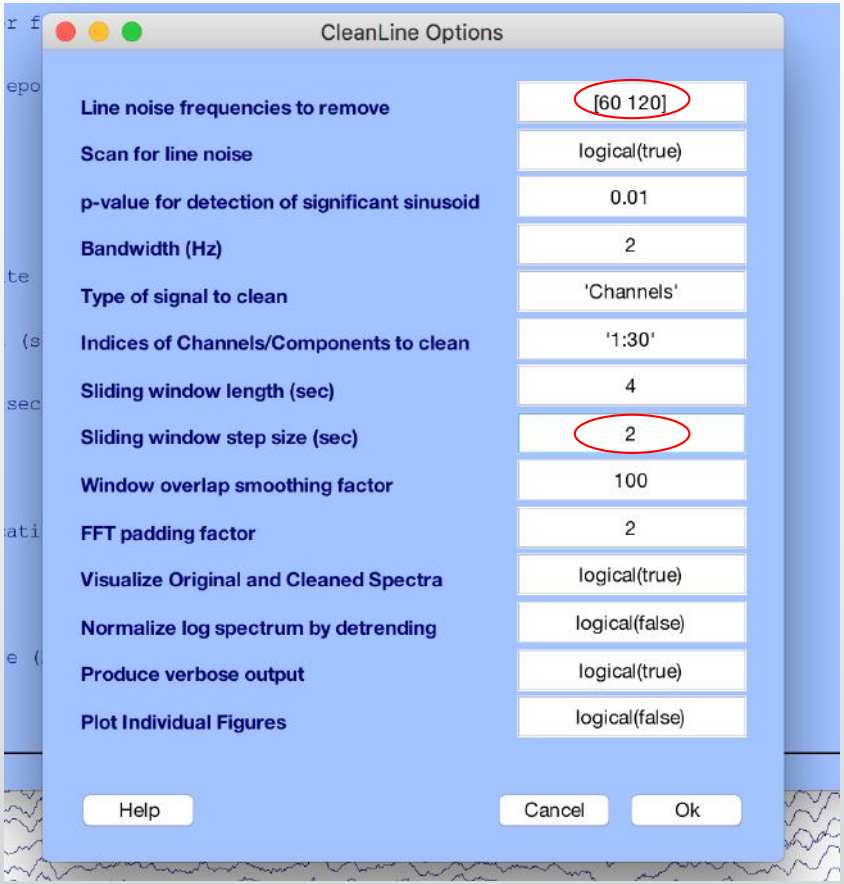
Remove Line Noise



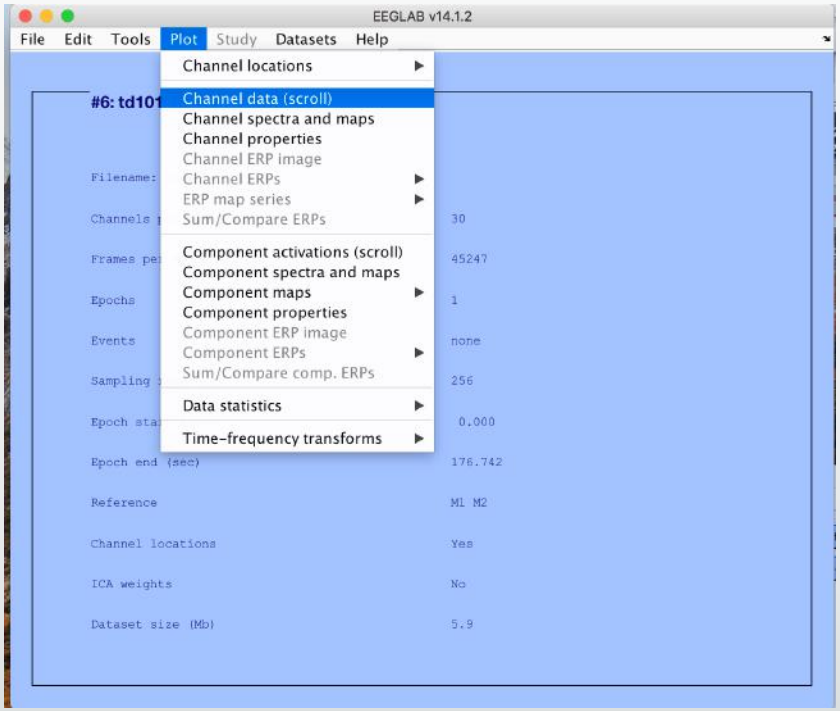


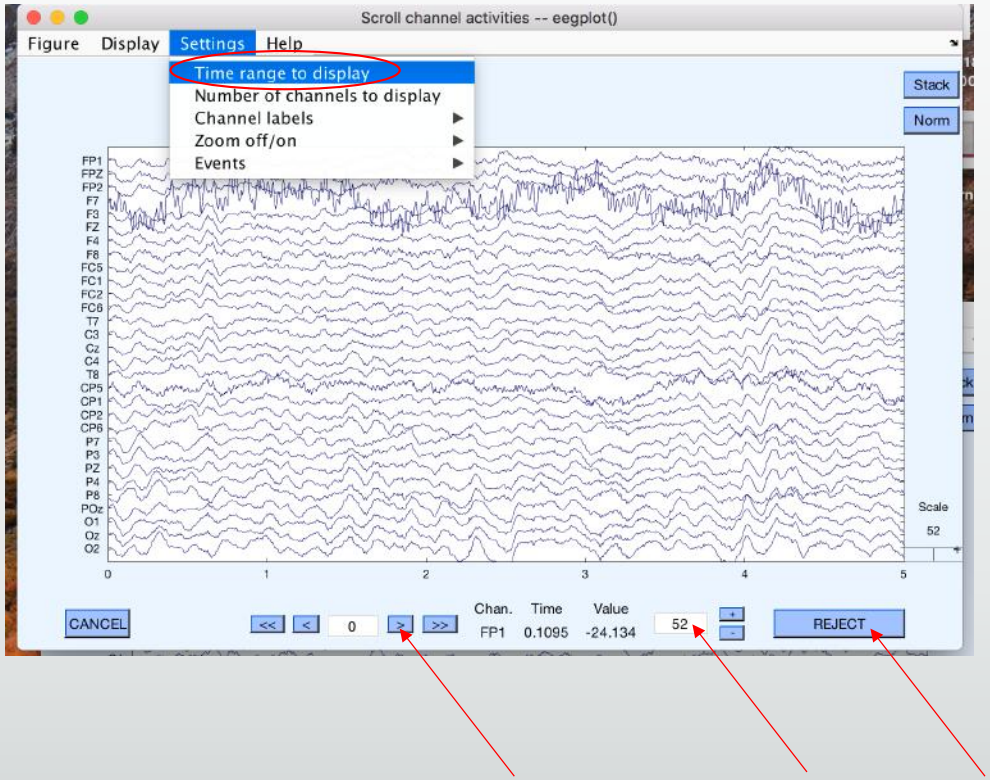
Remove Line Noise



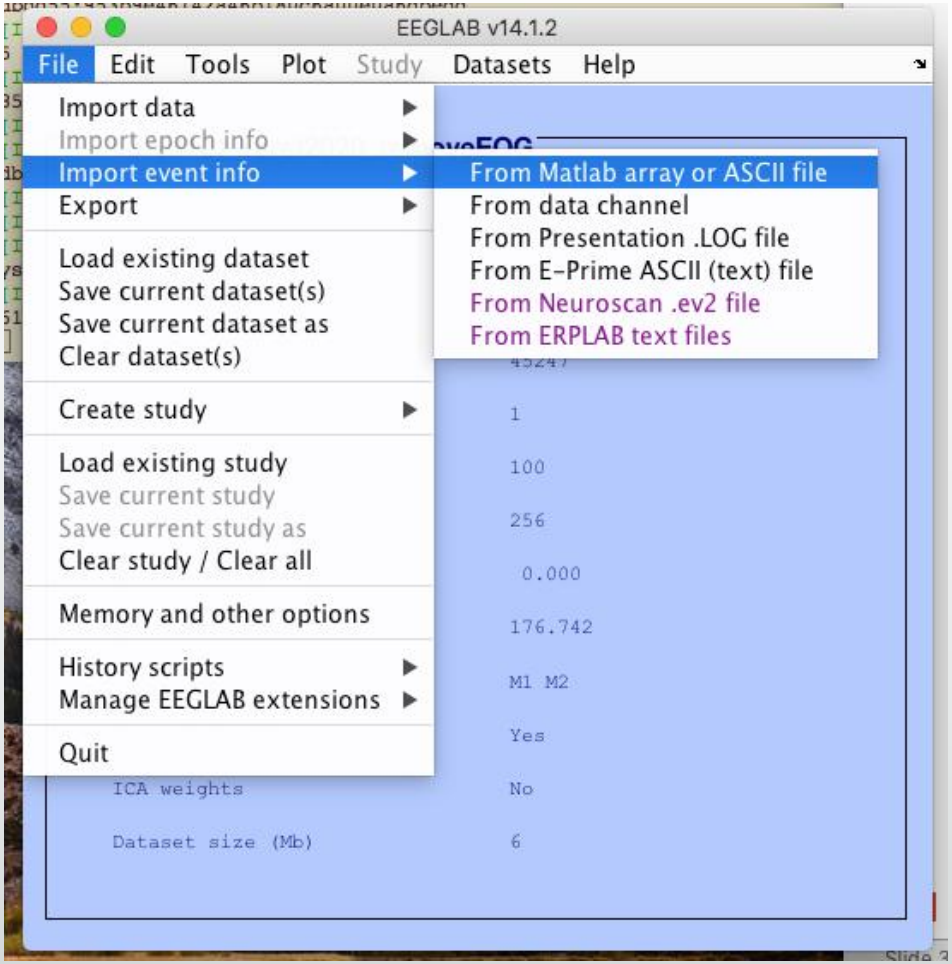


Scroll Through EEG Data





Import Events



Import Events