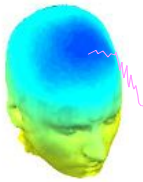
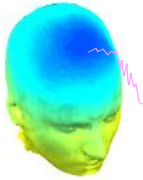


EEGLAB Processing

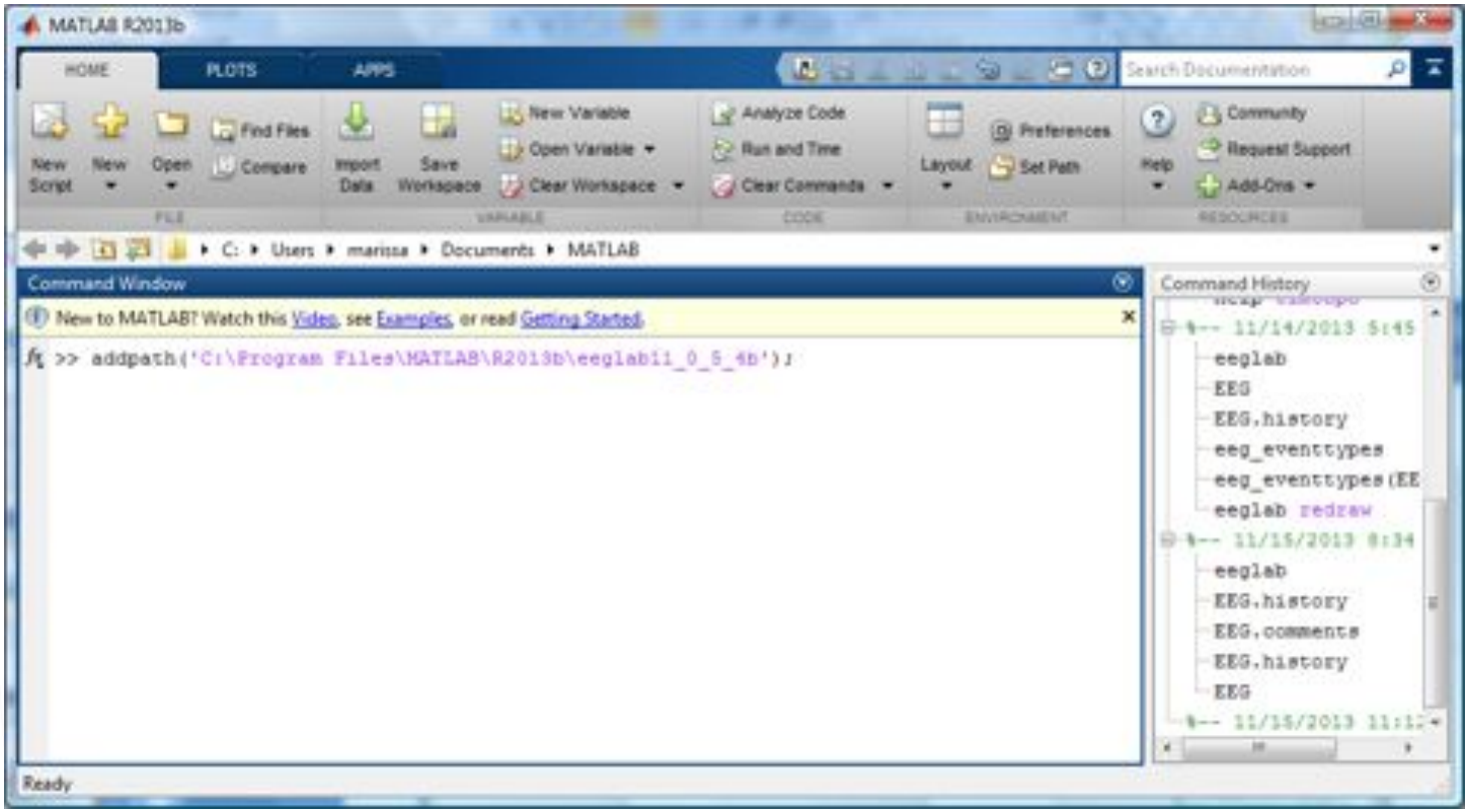
Data import
Basic ERP visualization

Arnaud Delorme
(thanks to Marissa Westerfield)

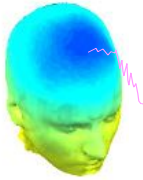
Installing EEGLAB and data folder



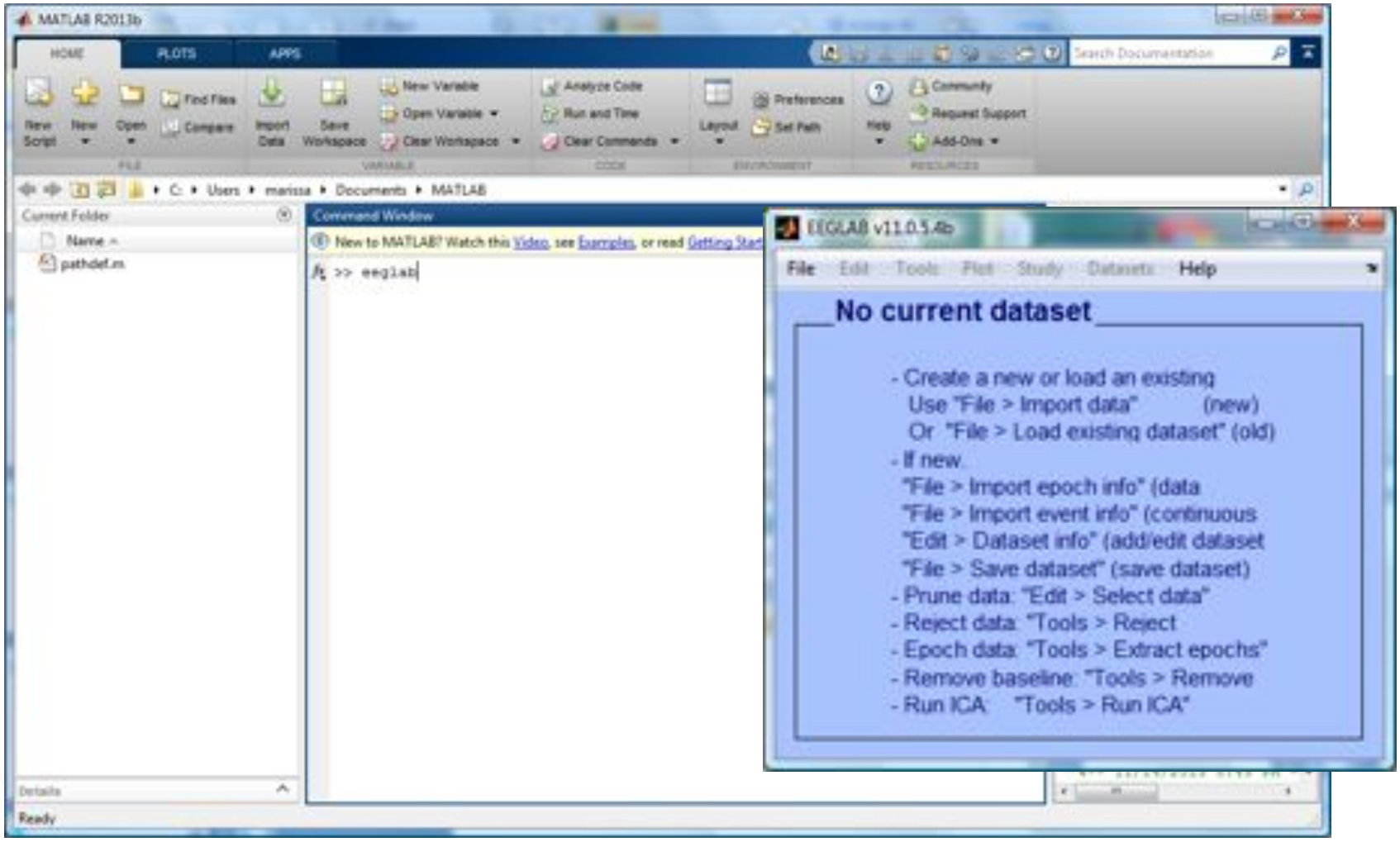
- Start Matlab
- Add the EEGLAB folder to your Matlab path:



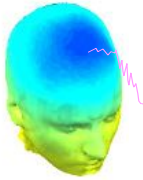
The EEGLAB Matlab software

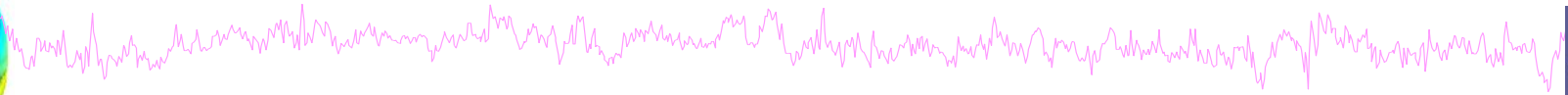


main graphic interface



Pre-processing pipeline





Swartz Center for Computational Neuroscience

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

High pass filter (~.5 – 1 Hz)

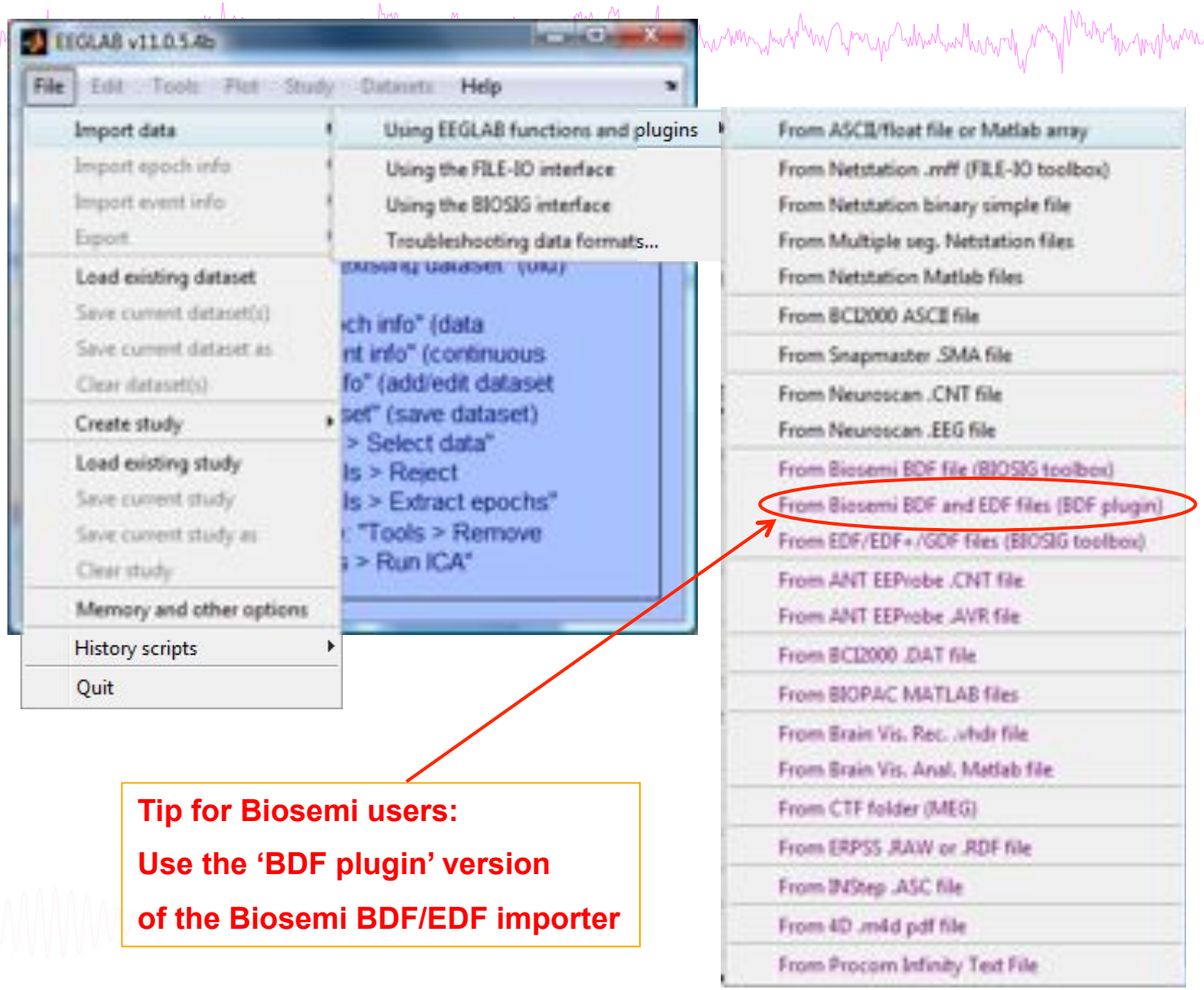
Examine raw data

Identify/reject bad channels

Reject large artifact time points

Run ICA

Importing a dataset

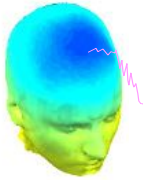


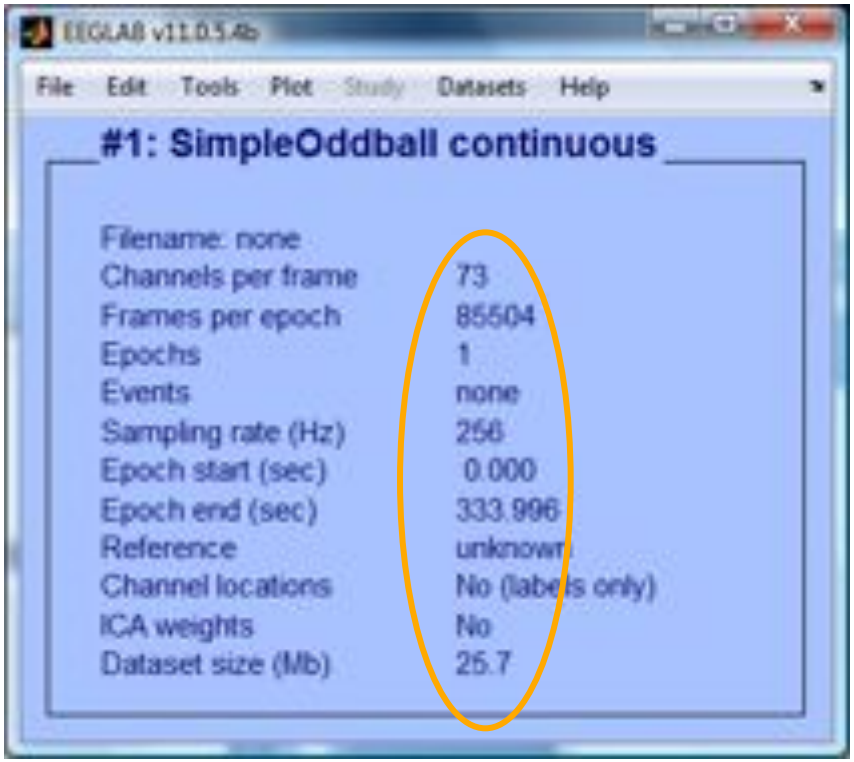
Tip for Biosemi users:

Use the 'BDF plugin' version

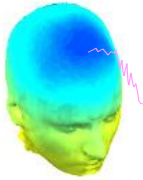
of the Biosemi BDF/EDF importer

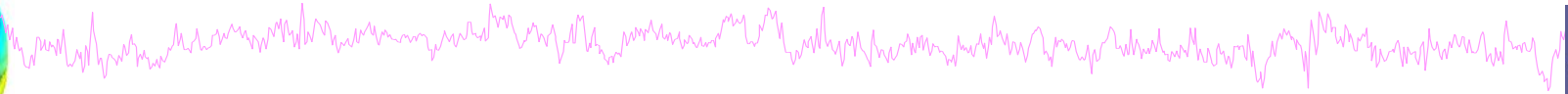
Imported EEG data





Pre-processing pipeline





Swartz Center for Computational Neuroscience

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

High pass filter (~.5 – 1 Hz)

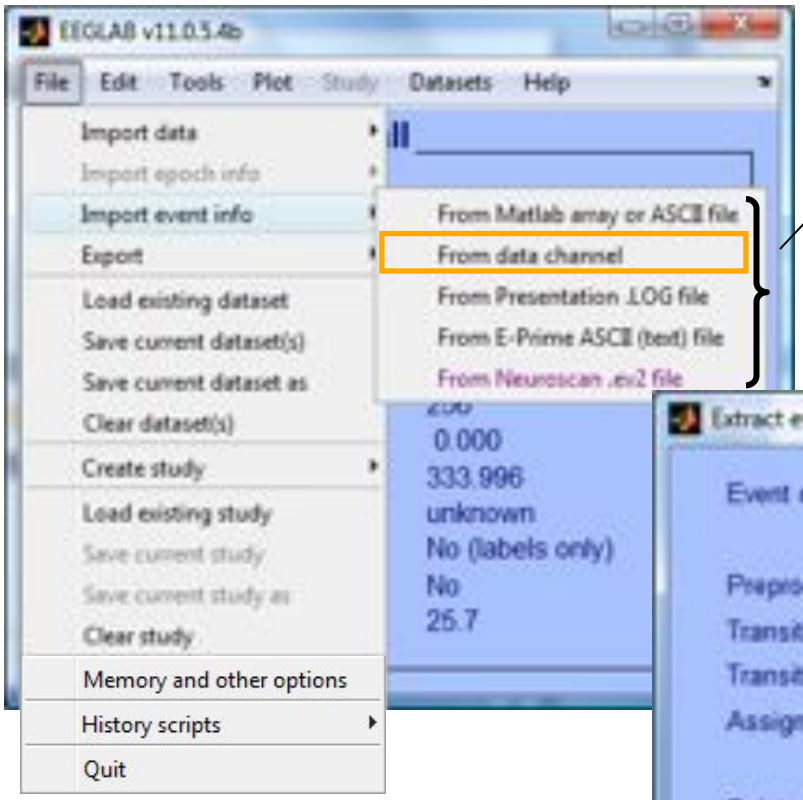
Remove line noise (if necessary)

Identify/reject bad channels

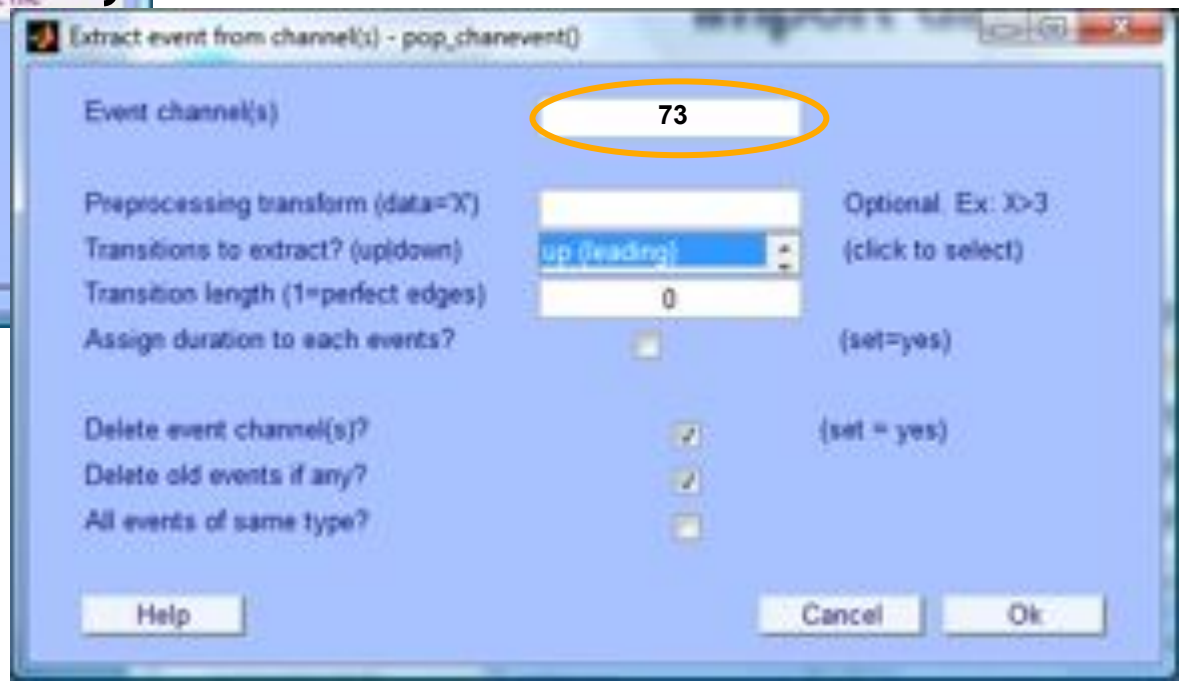
Reject large artifact time points

Run ICA

Import data events

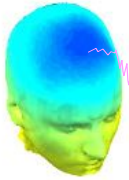


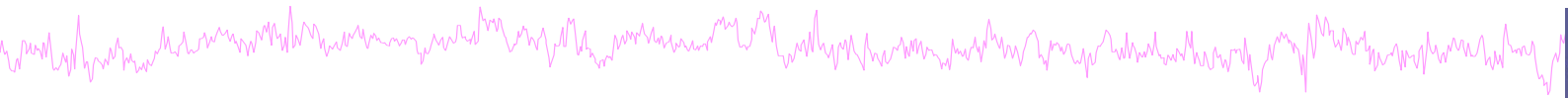
- Import events from Matlab array or ASCII file
- Import events from data channel
- Import from Presentation event file
- Import events from E-Prime event file
- Import events from Neuroscan event file

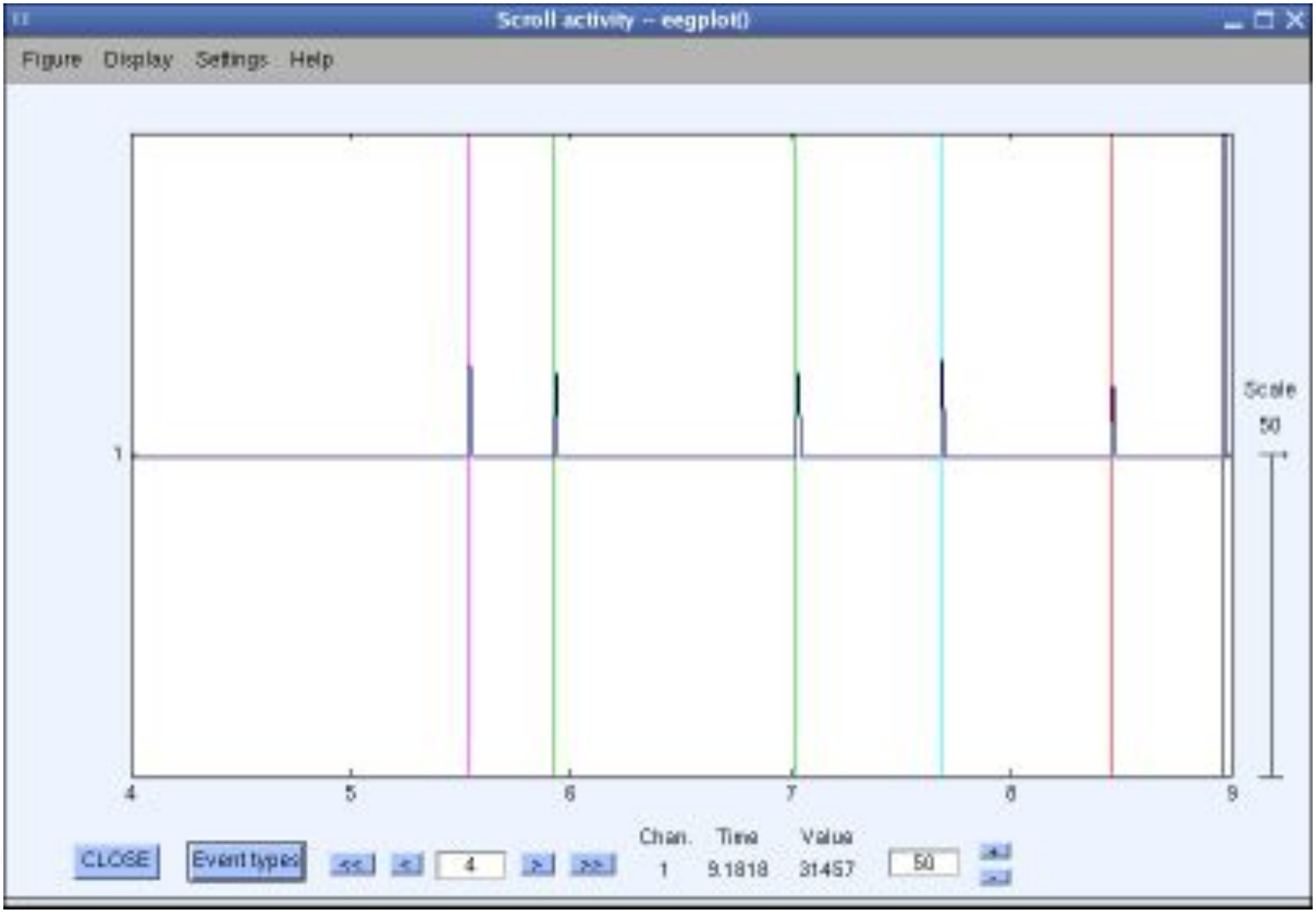


(Often imported automatically during data import)

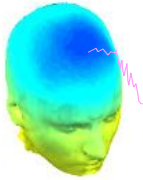
Appearance of an event channel in raw data

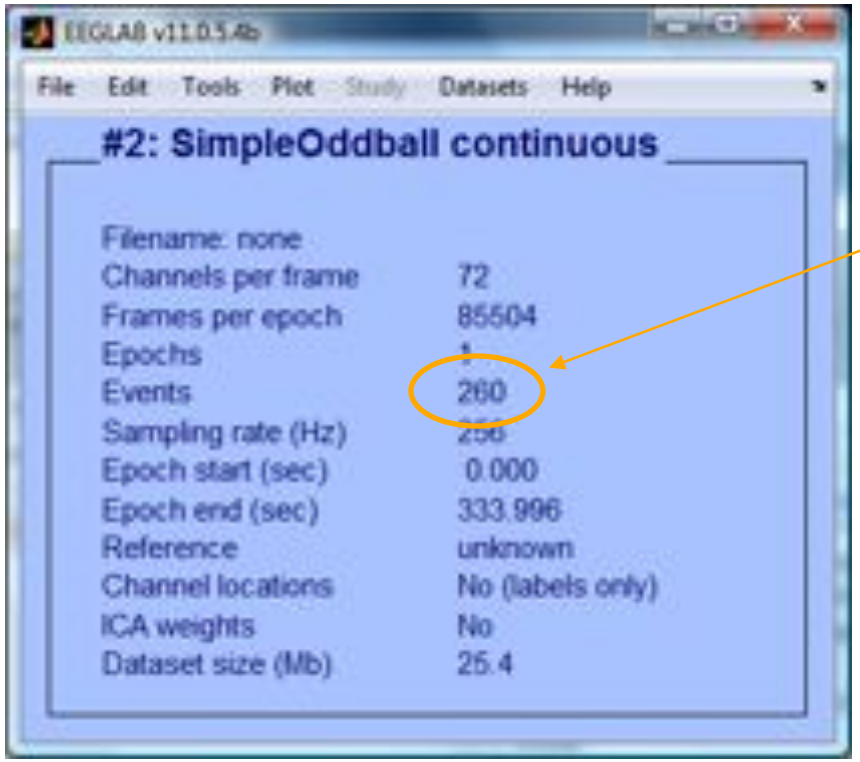






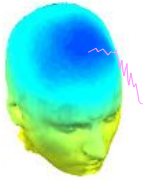
Imported data events





If event import was successful, you will see an appropriate number here

Sample data: basic P300 paradigm



File

SimpleOddball.set

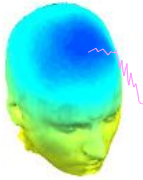
Data

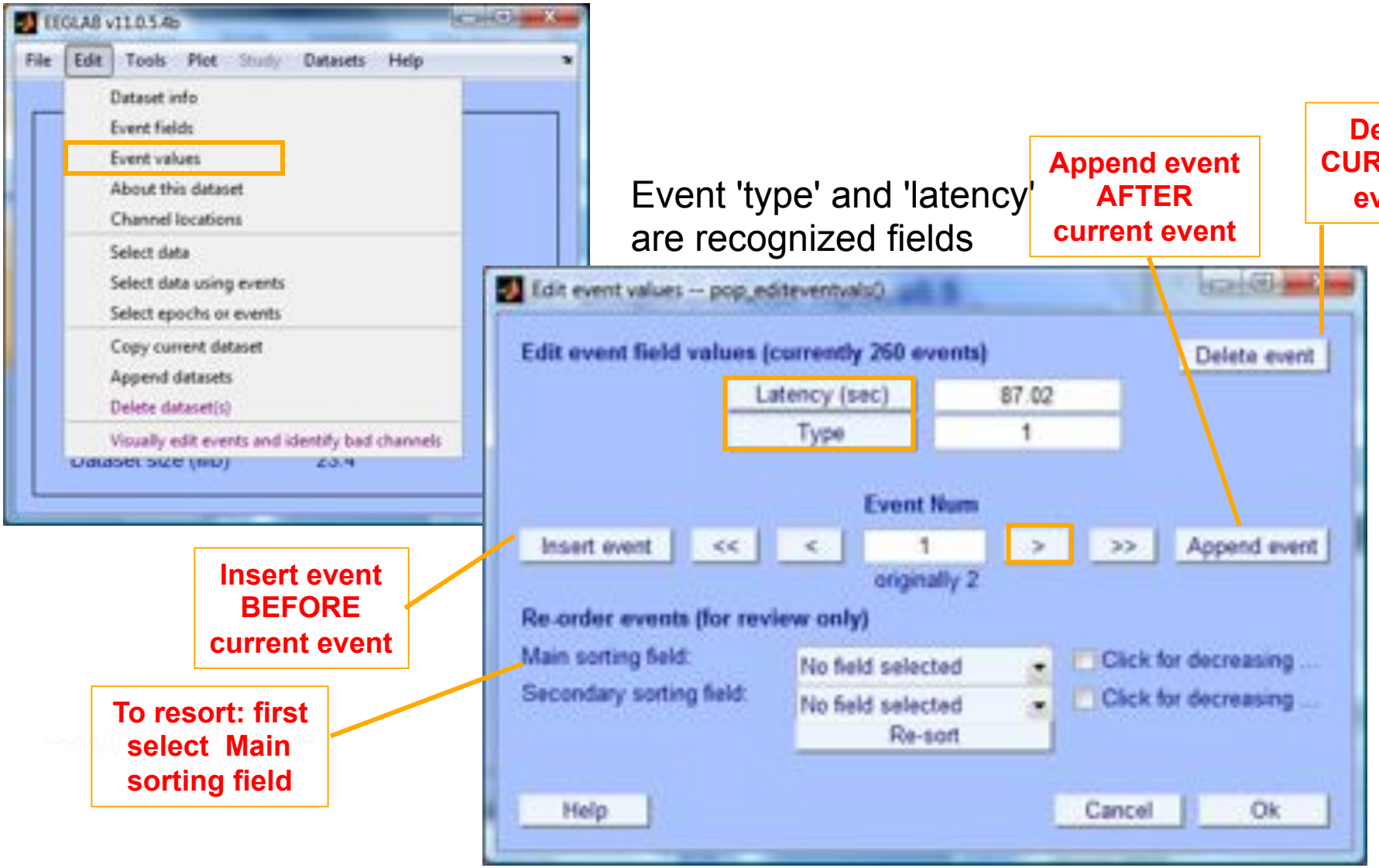
68 channel EEG, 256 Hz sampling rate, Biosemi system, re-referenced during import to averaged left and right mastoid electrodes

Task

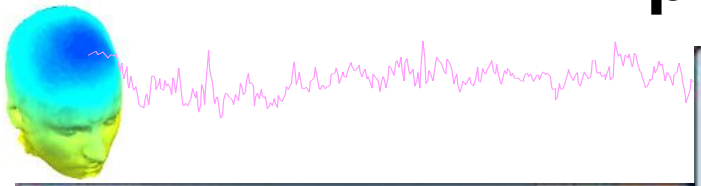
speeded button press response to star shape (no response to circle shape), 100 ms presentation duration, 200 trials

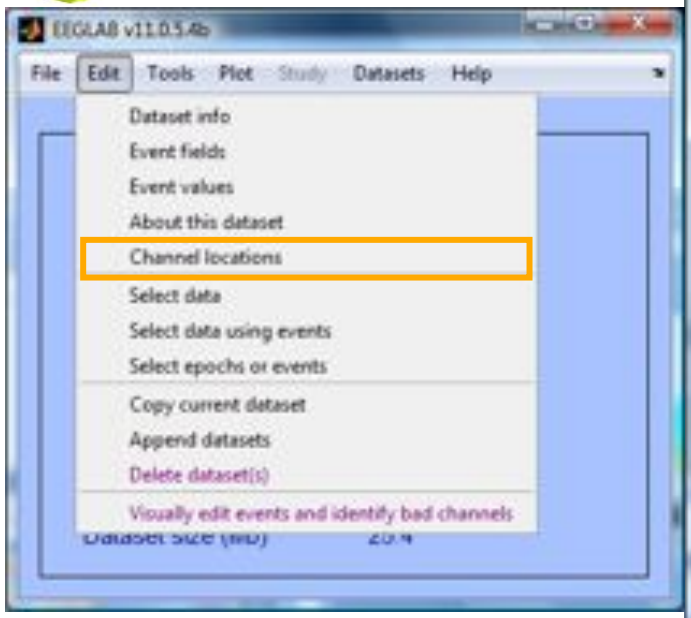
Review event values

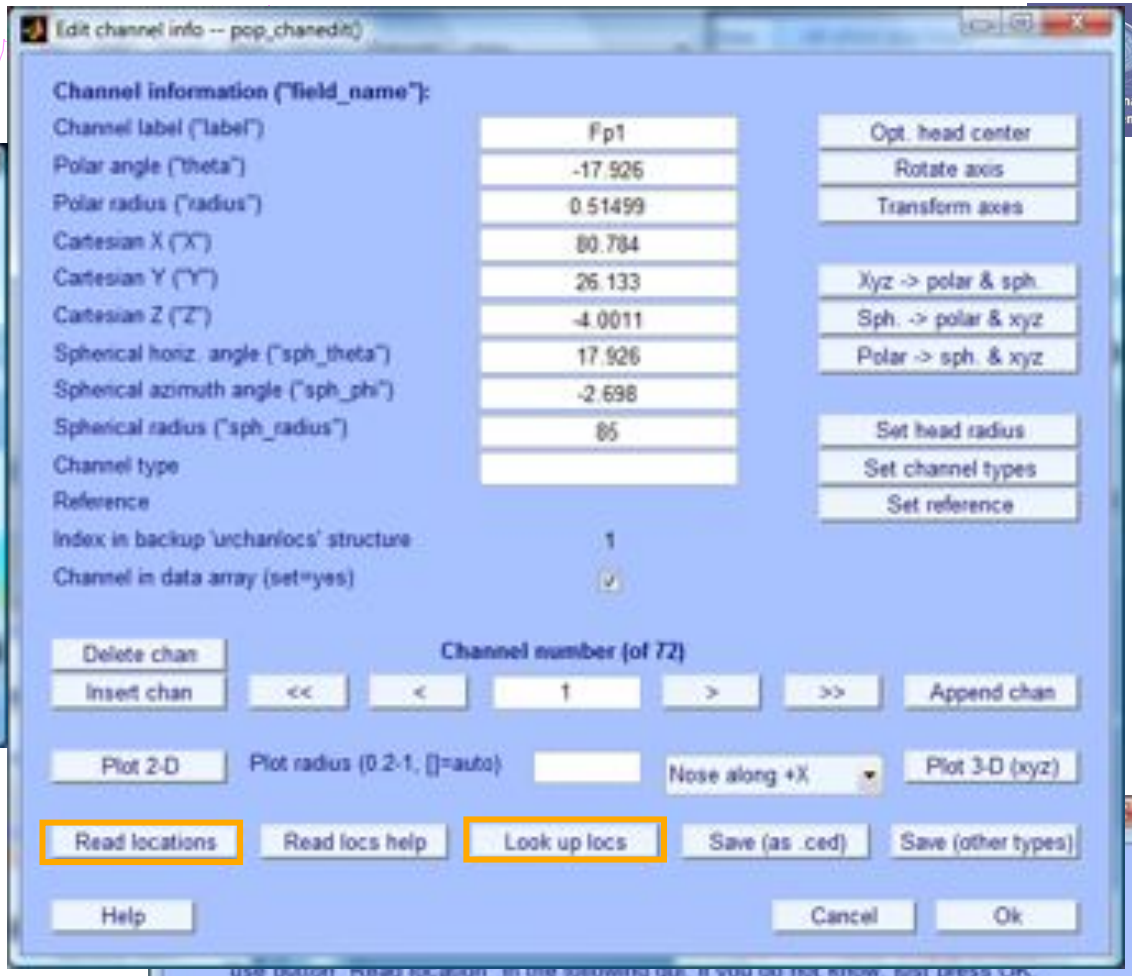


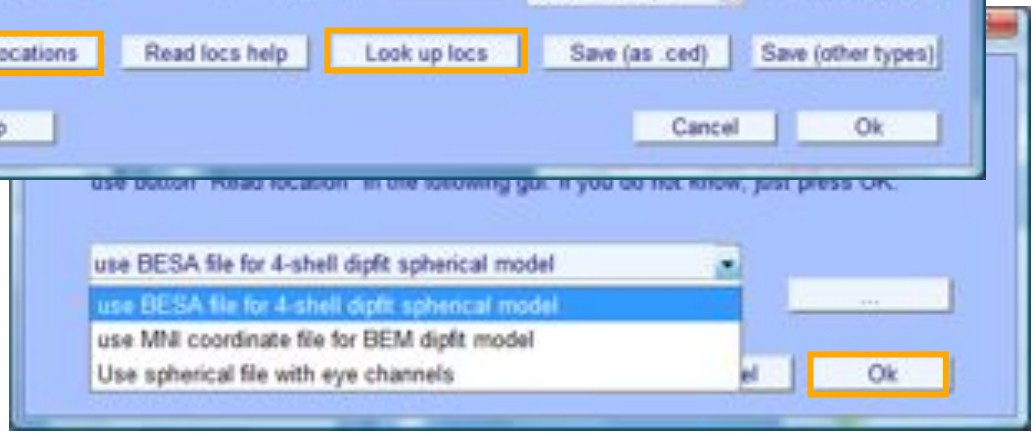


Import channel locations



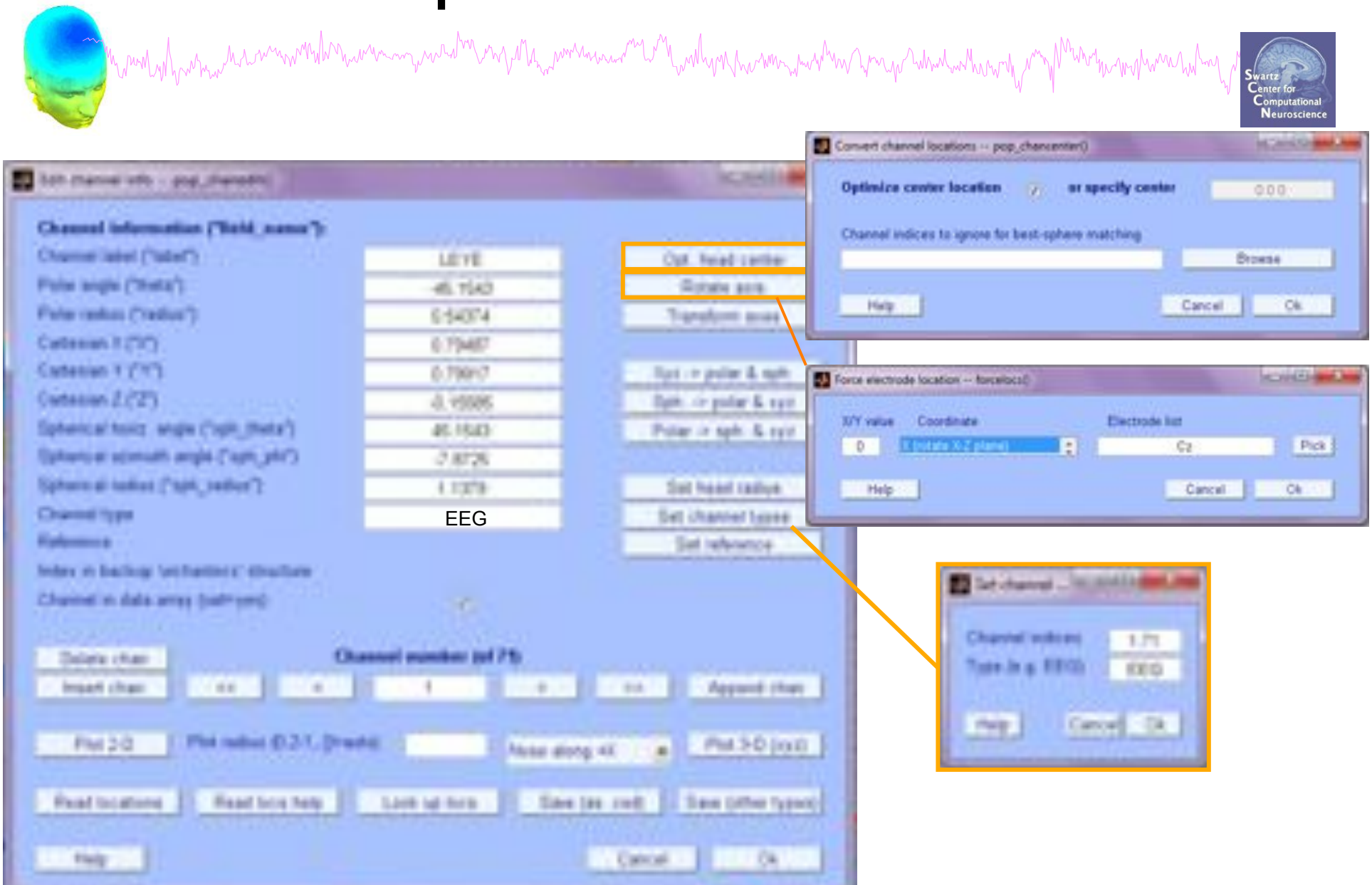


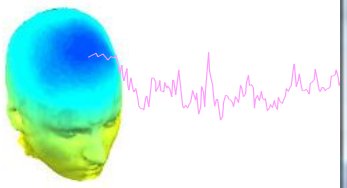


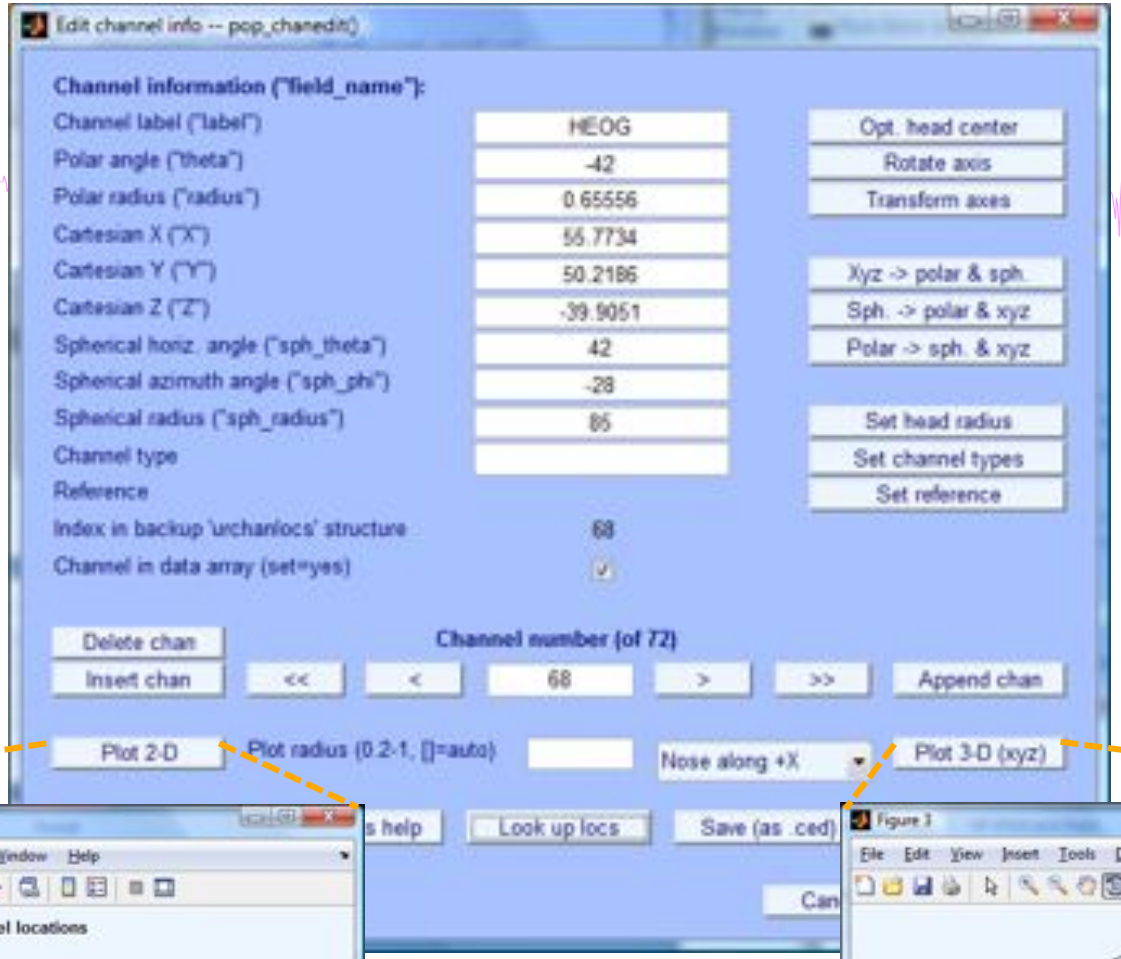


7 file formats supported (Polhemus, BESA, …)

Import channel locations






Edit channel info -- pop_chanedit()
Channel information ('field_name'):
Channel label ('label')
HEOG
Polar angle ('theta')
-42
Polar radius ('radius')
0.65556
Cartesian X ('X')
55.7734
Cartesian Y ('Y')
50.2186
Cartesian Z ('Z')
-39.9051
Spherical horiz. angle ('sph_theta')
42
Spherical azimuth angle ('sph_phi')
-28
Spherical radius ('sph_radius')
85
Channel type
Reference
Index in backup 'urchanlocs' structure
68
Channel in data array (set=yes)
Opt. head center
Rotate axis
Transform axes
Xyz -> polar & sph.
Sph. -> polar & xyz
Polar -> sph. & xyz
Set head radius
Set channel types
Set reference
Delete chan
Insert chan
Channel number (of 72)
<<
<
68
>
>>
Append chan
Plot 2-D
Plot radius (0.2-1, []=auto)
Nose along +X
Plot 3-D (xyz)
s help
Look up locs
Save (as .ced)

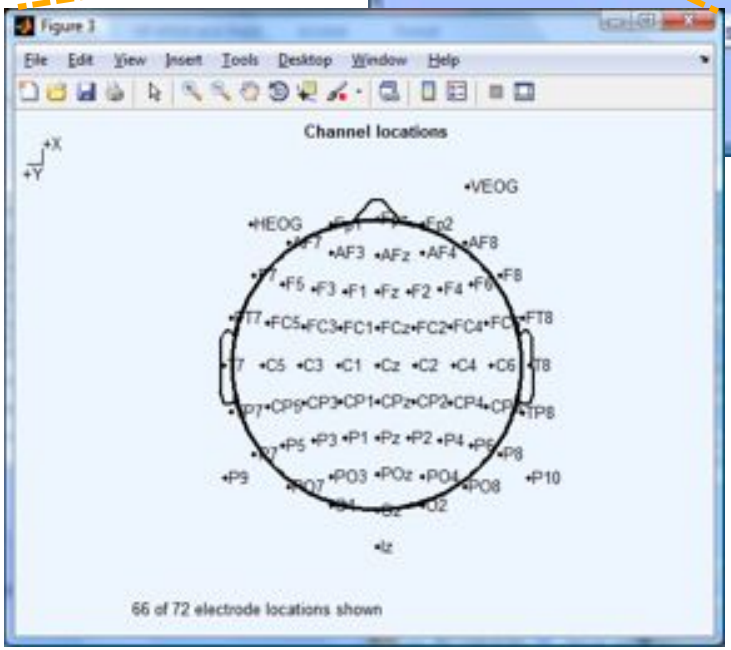


Figure 3
File Edit View Insert Tools Desktop Window Help
Channel locations
+X
+Y
66 of 72 electrode locations shown

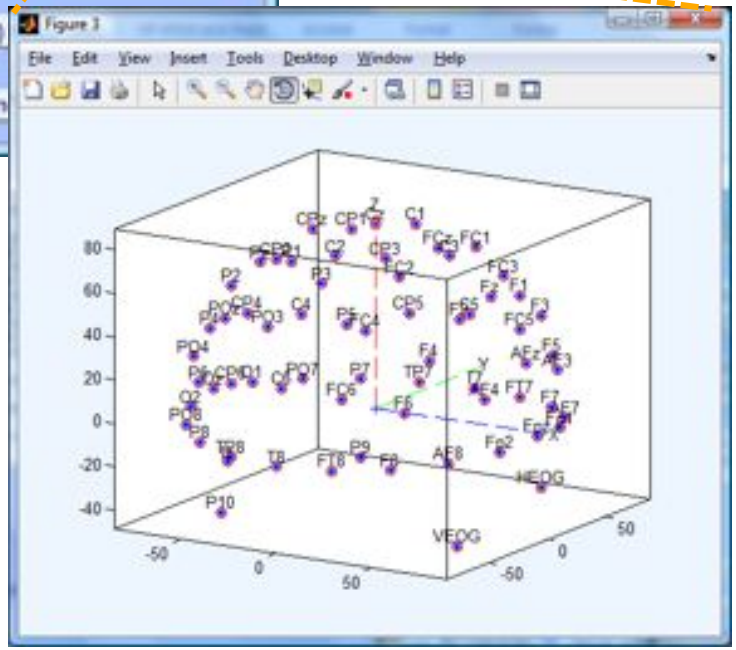
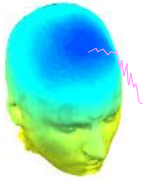
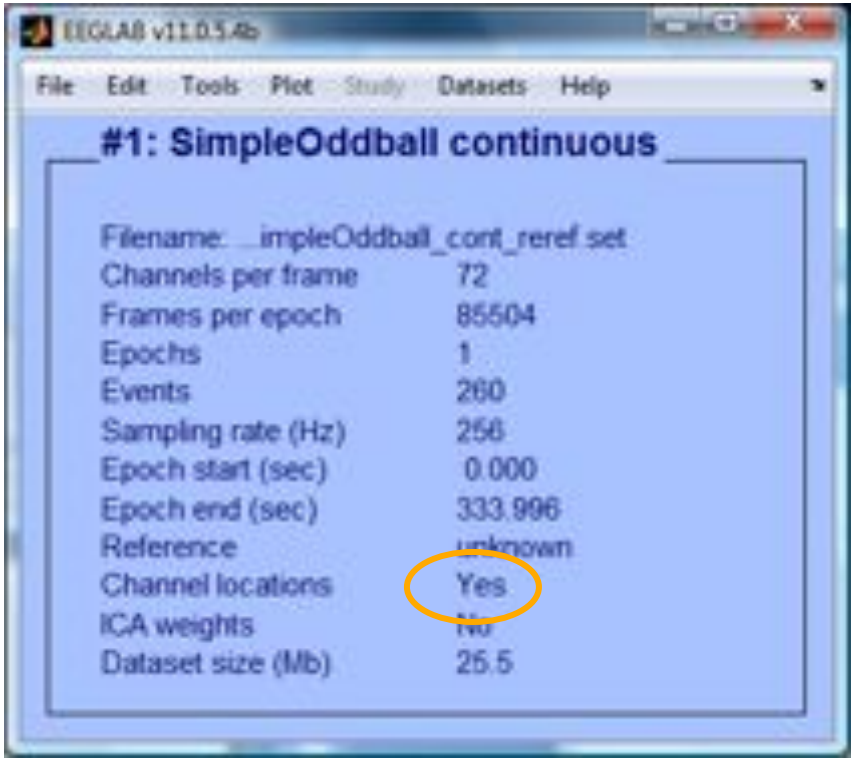


Figure 3
File Edit View Insert Tools Desktop Window Help

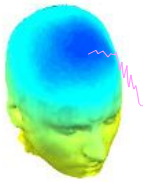

Swartz
Center for
Computational
Neuroscience

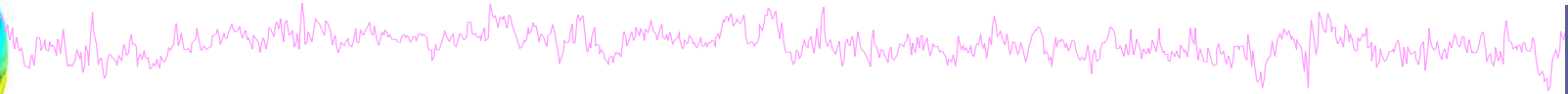
Imported channel locations





Pre-processing pipeline





Swartz Center for Computational Neuroscience

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

High pass filter (~.5 – 1 Hz)

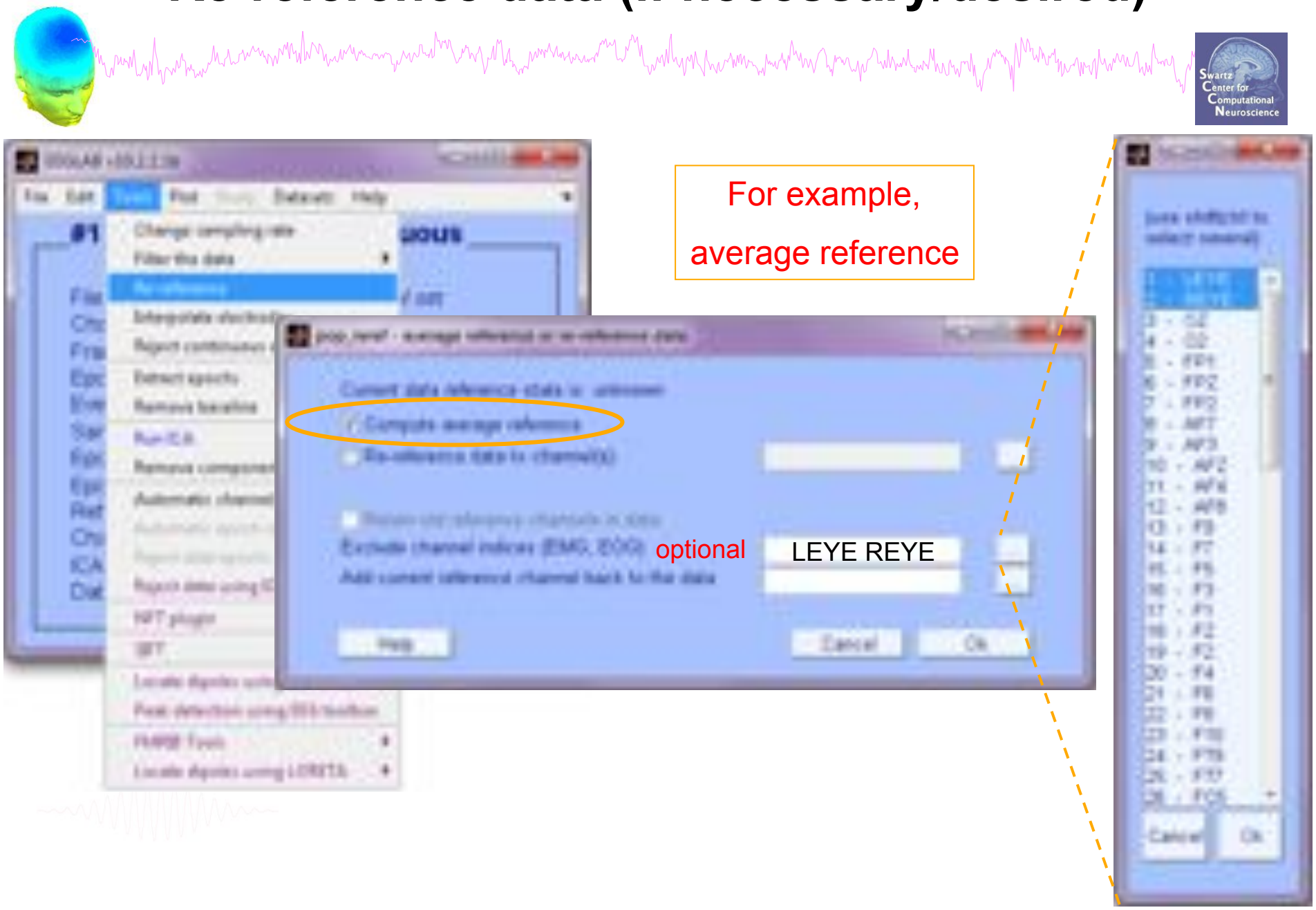
Remove line noise (if necessary)

Identify/reject bad channels

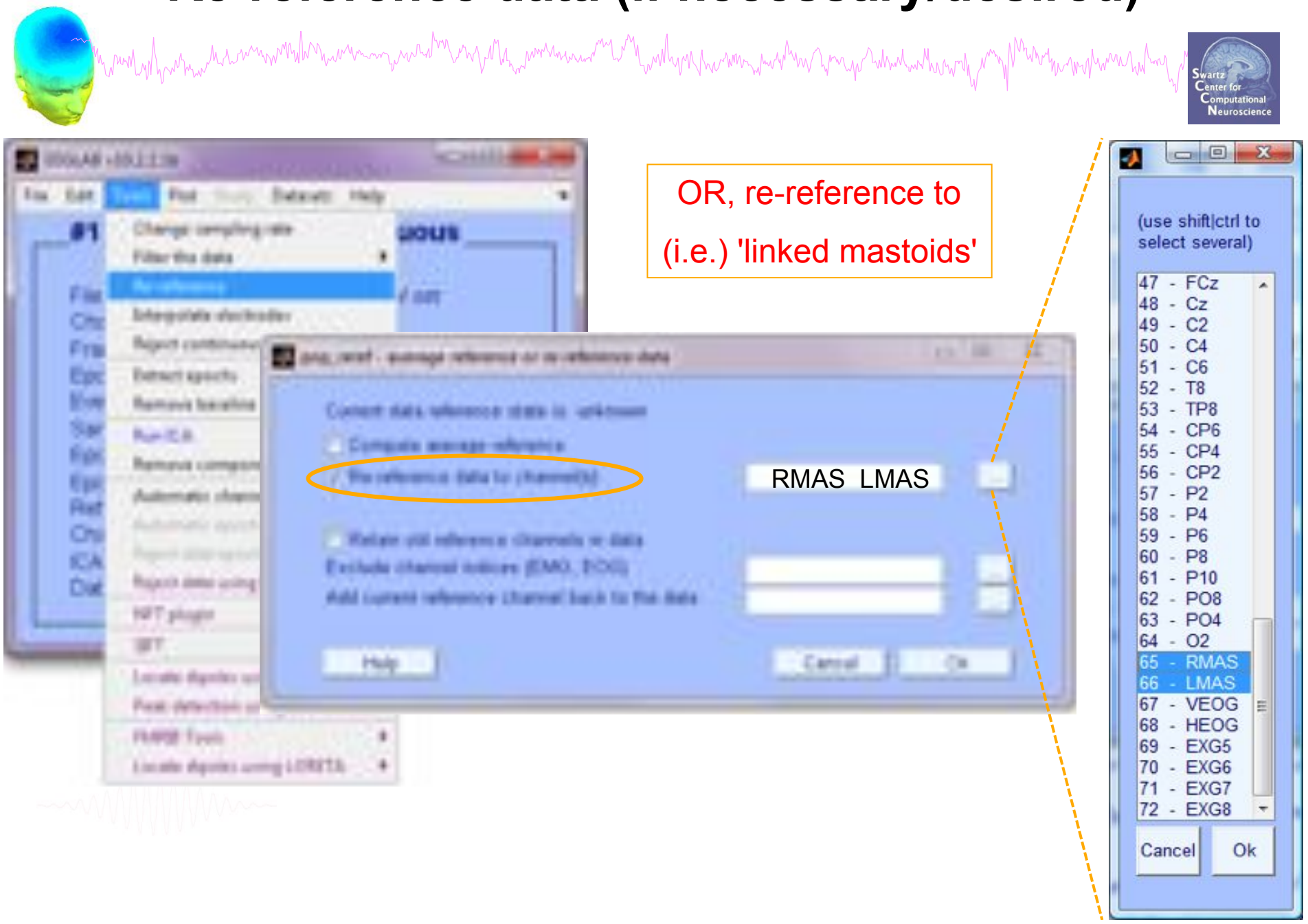
Reject large artifact time points

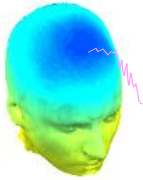
Run ICA

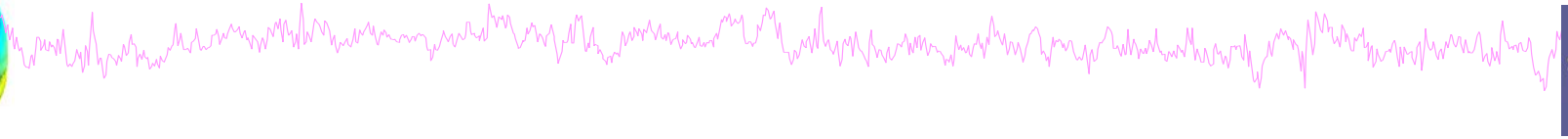
Re-reference data (if necessary/desired)

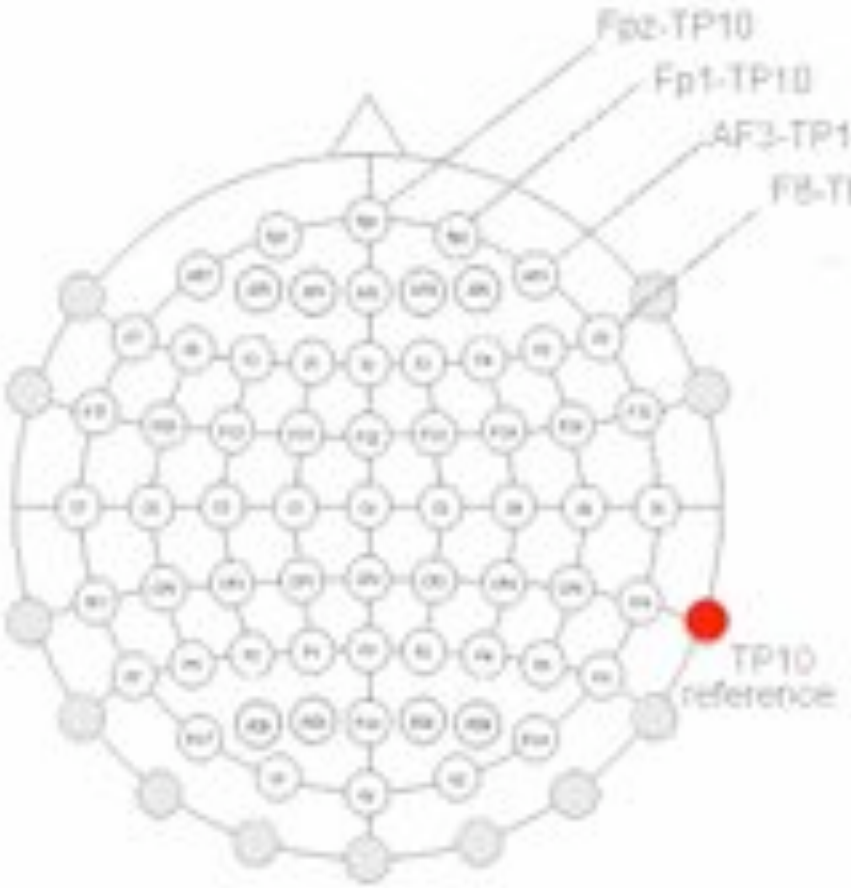


Re-reference data (if necessary/desired)









1. Average Reference assumption

   Fpz + Fp1 + AF3 + F8 + FT8 + ... + TP10 = 0

2. First recalculate the activity at reference TP10

   Sum of all electrode activity =

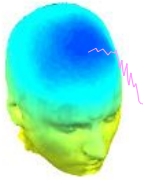
   Fpz + Fp1 + AF3 + F8 + ... - 64TP10

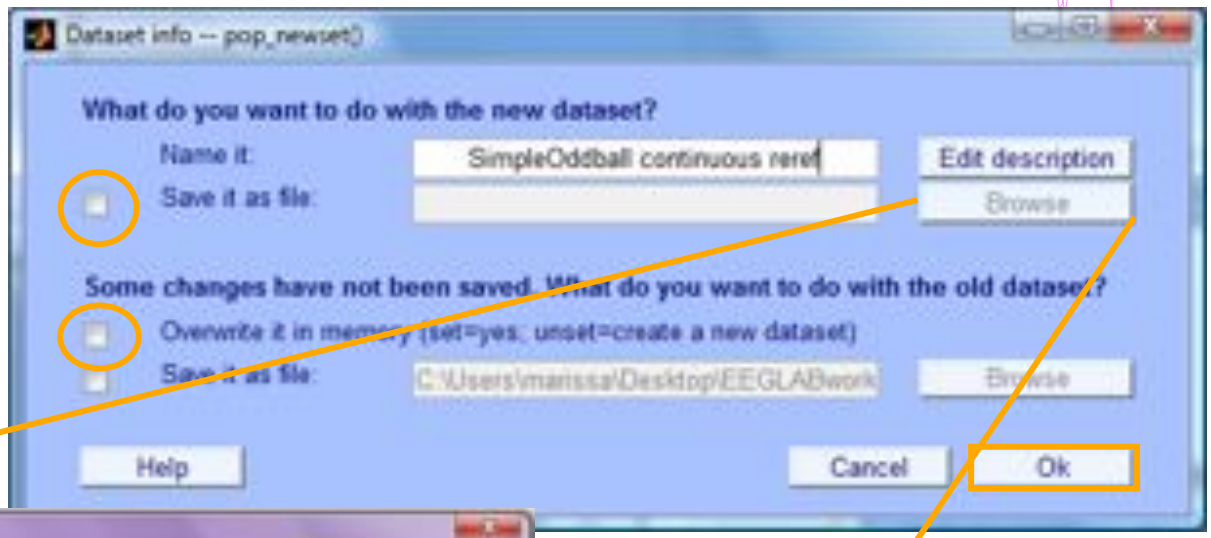
   minus Fpz + Fp1 + AF3 + F8 + ... + TP10 = 0

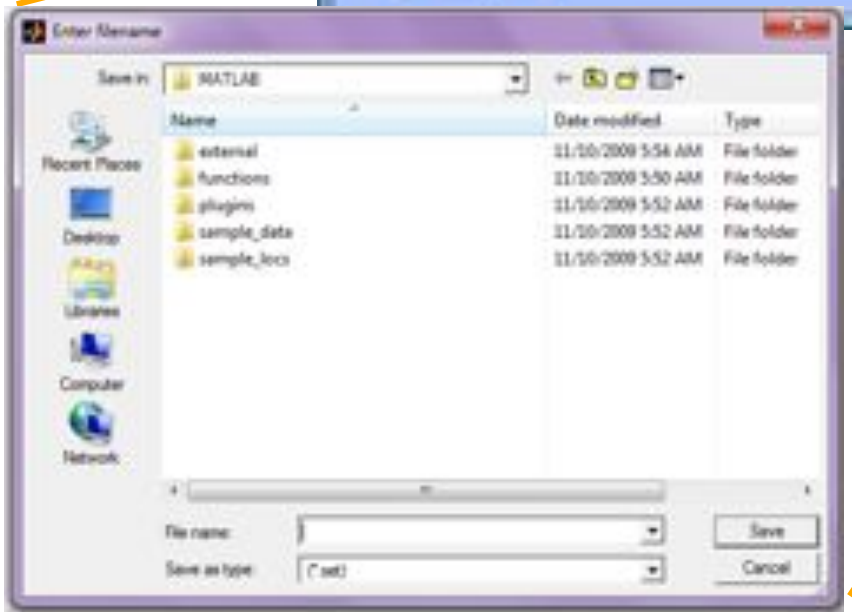
   TP10 = - (Sum of all electrode activity)/65

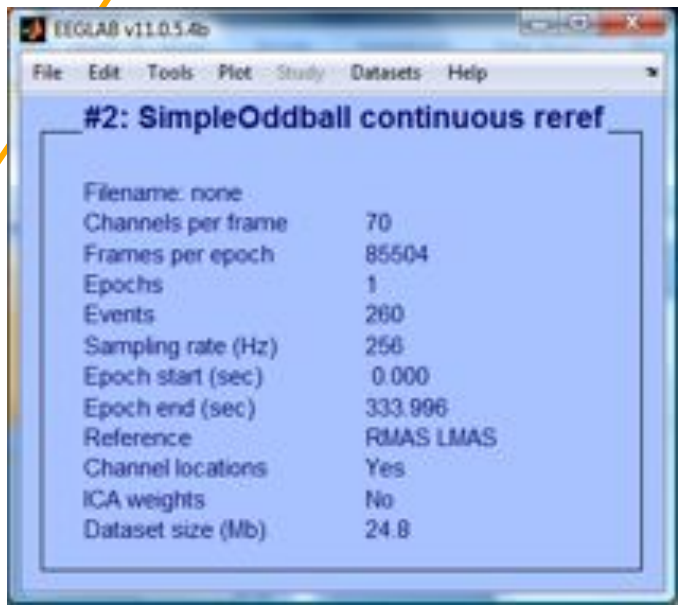
3. Add up the activity of TP10 to all channels

Save new dataset, keep old one

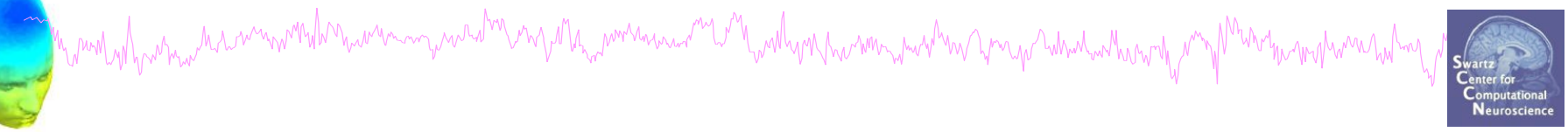


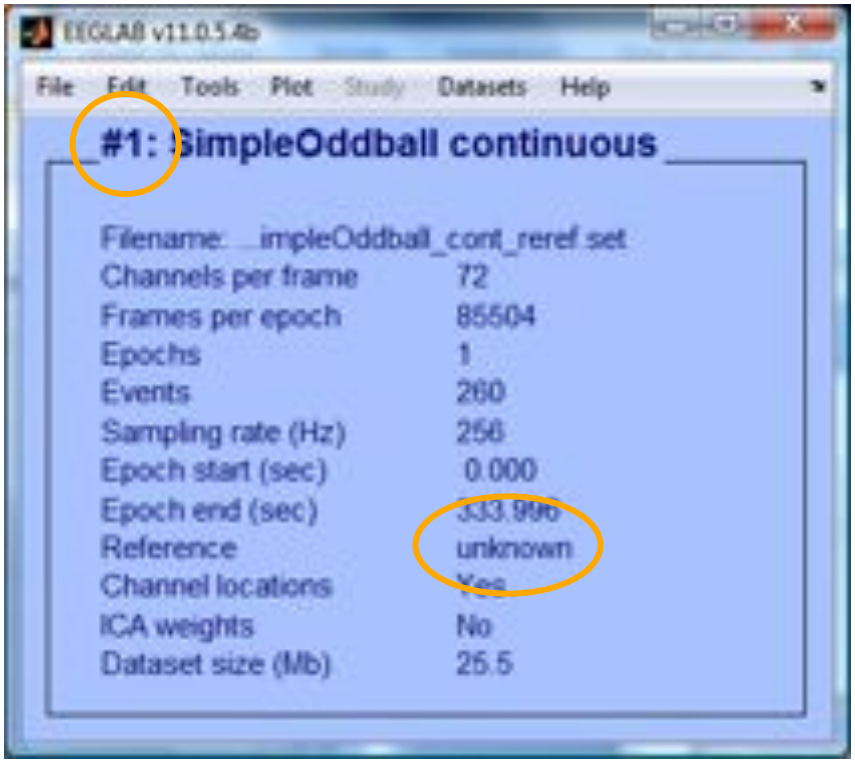


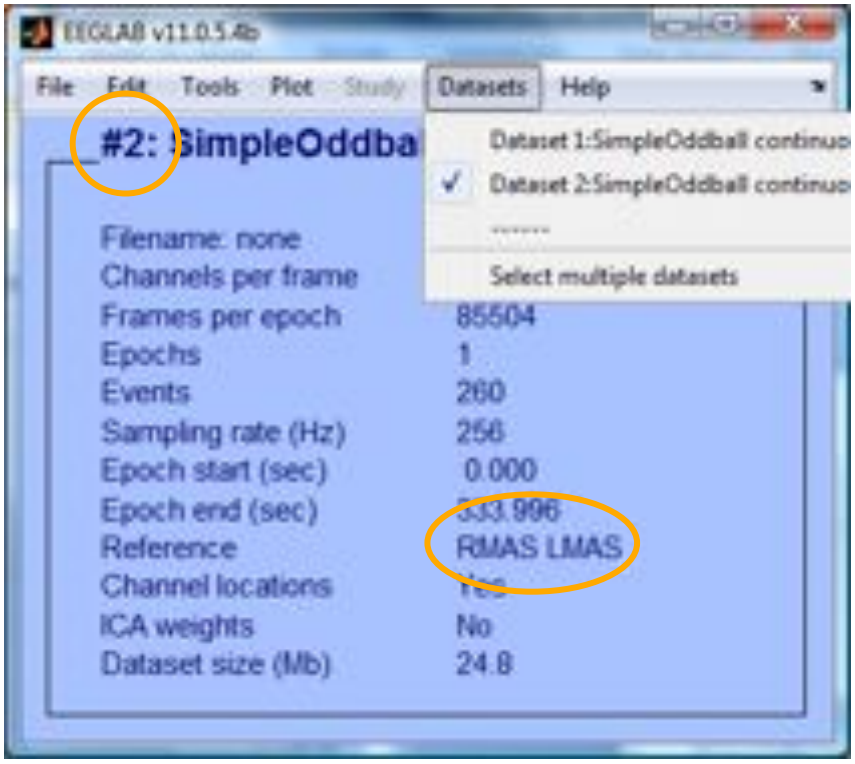




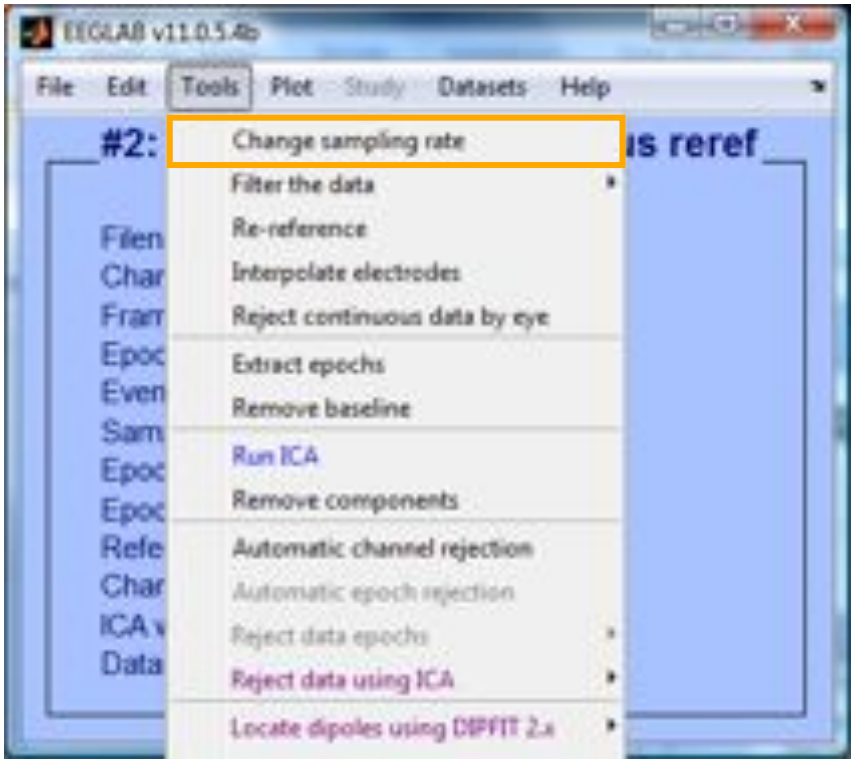
Multiple active datasets (ALLEEG)

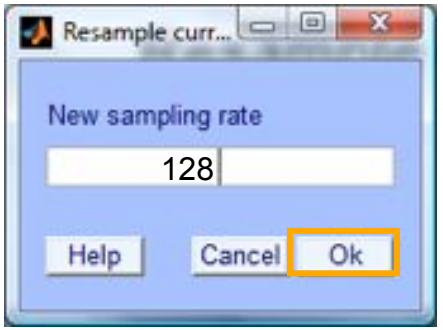




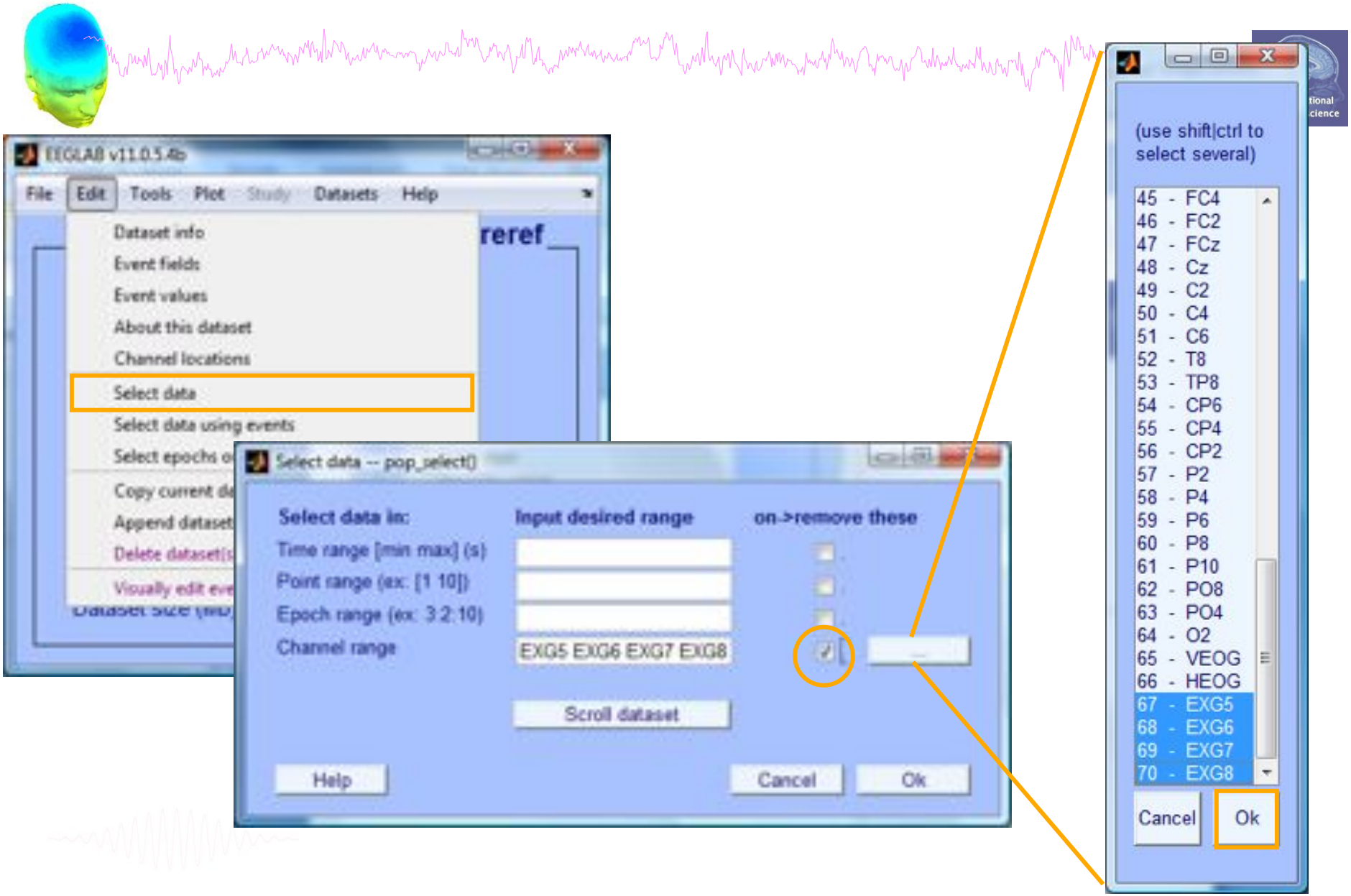


Resample data (if necessary)

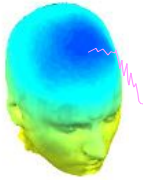


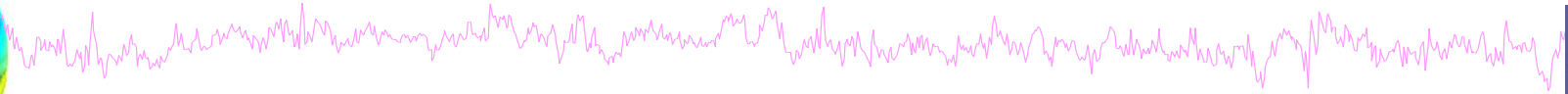


Remove unwanted channels



Pre-processing pipeline





Swartz Center for Computational Neuroscience

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

High pass filter (~.5 – 1 Hz)

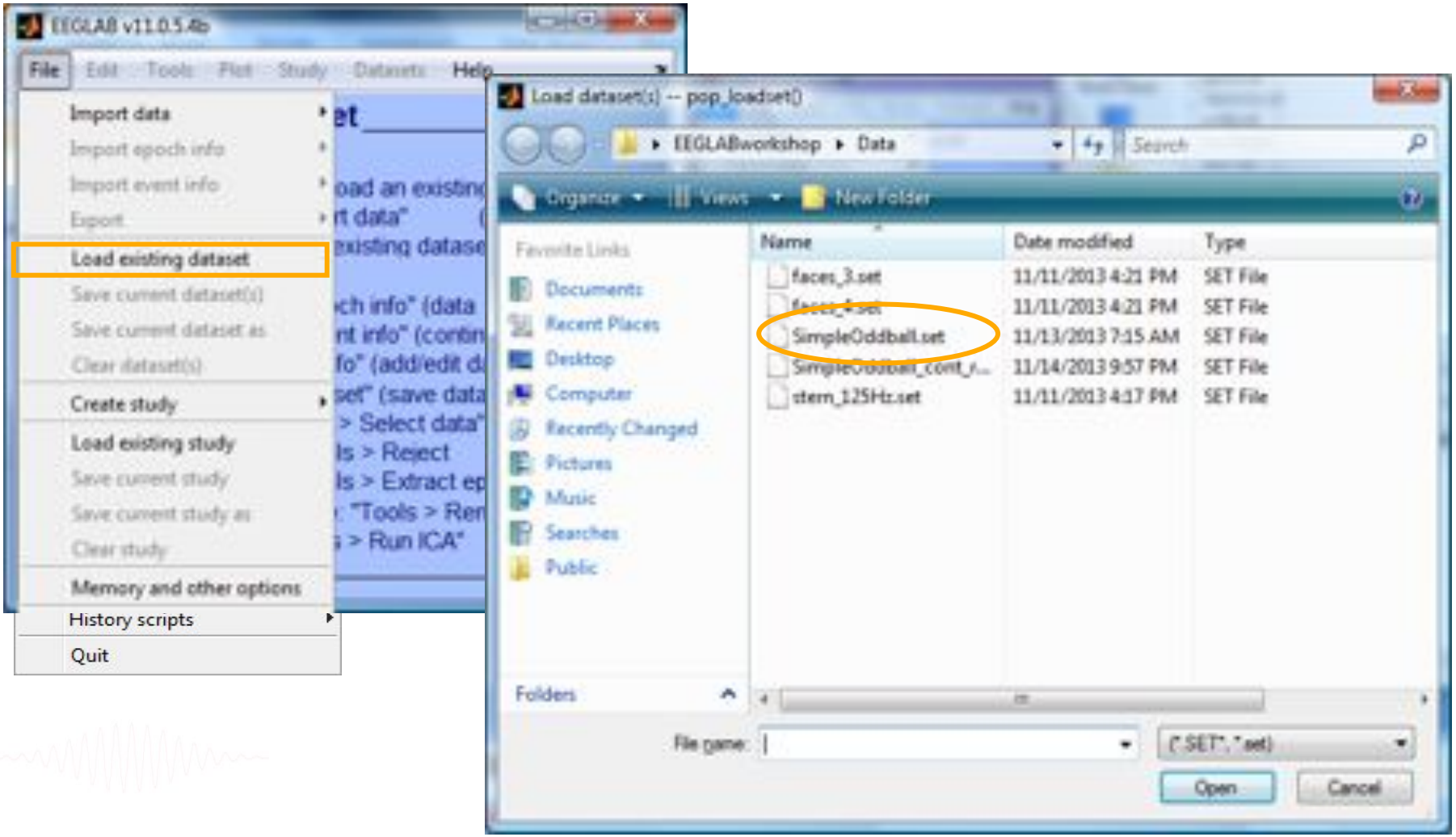
Remove line noise (if necessary)

Identify/reject bad channels

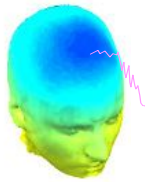
Reject large artifact time points

Run ICA

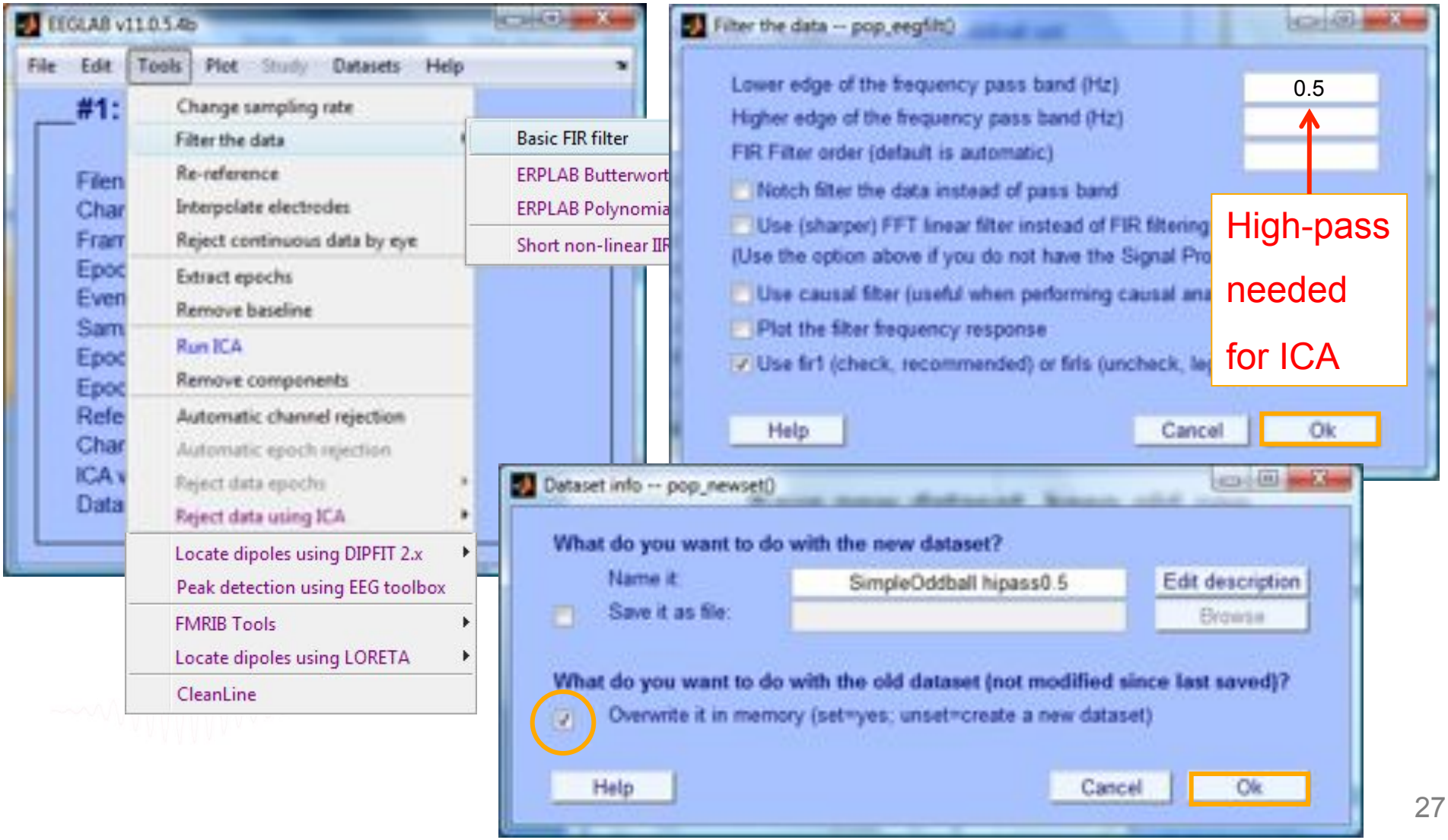
Load an existing dataset



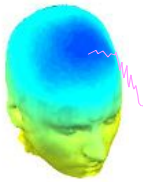
Filter the data (if necessary/desired)

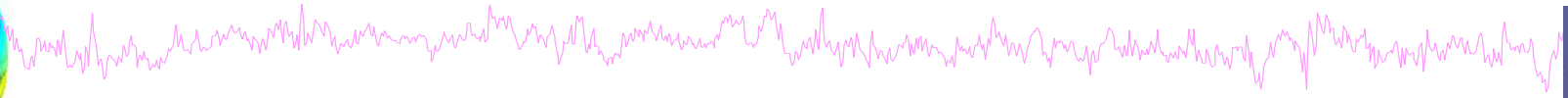


Lower cut off frequencies require longer stretches of continuous data



Pre-processing pipeline





Swartz Center for Computational Neuroscience

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

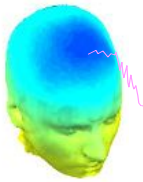
High pass filter (~.5 – 1 Hz)

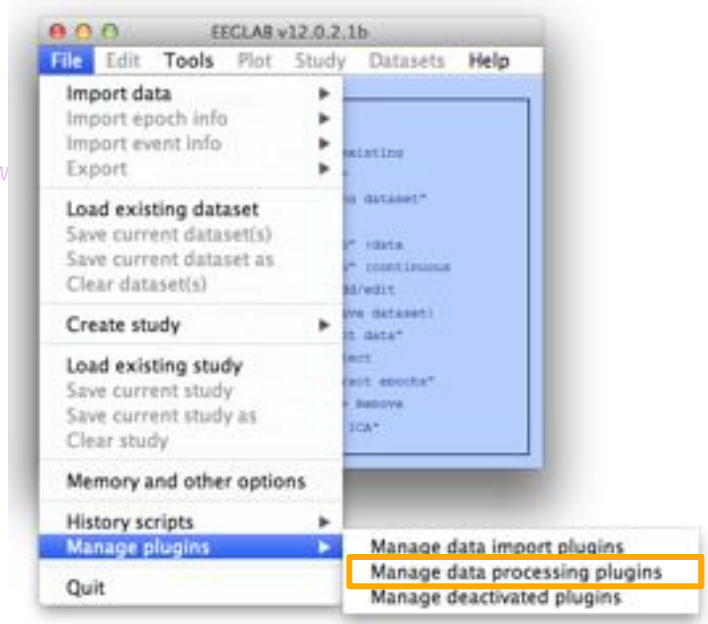
Remove line noise (if necessary)

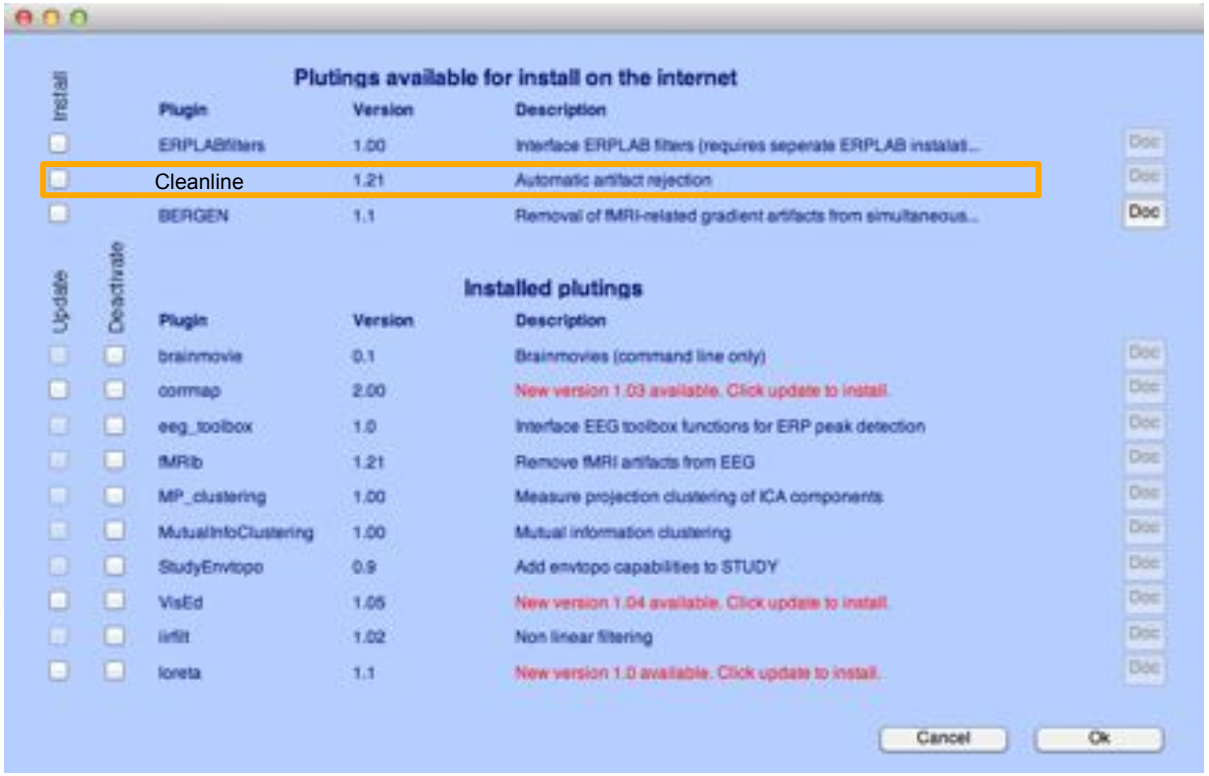
Identify/reject bad channels

Reject large artifact time points

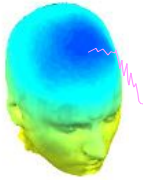
Run ICA

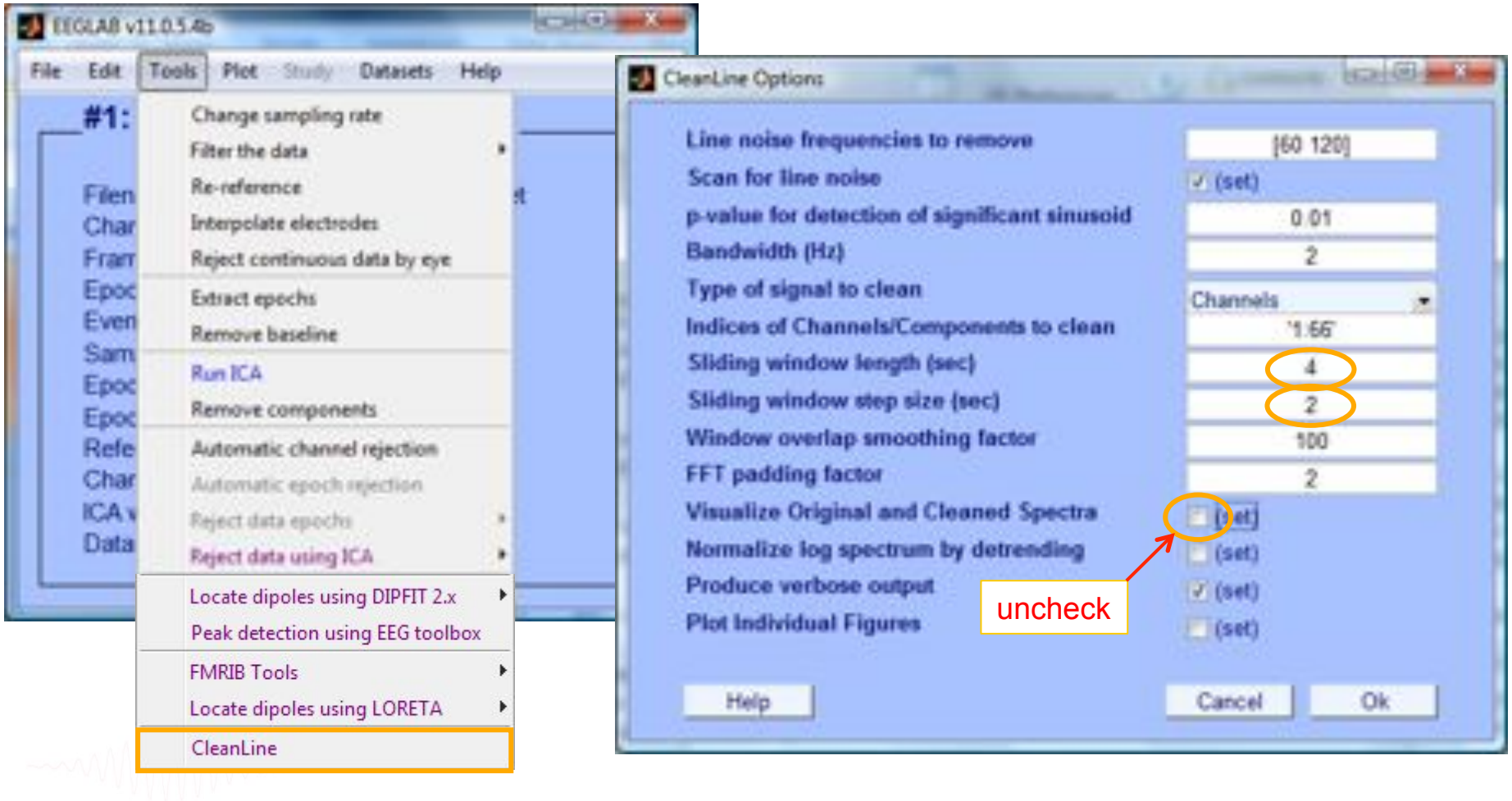



EEGLAB v12.0.2.1b
File
Edit
Tools
Plot
Study
Datasets
Help
Import data
Import epoch info
Import event info
Export
Load existing dataset
Save current dataset(s)
Save current dataset as
Clear dataset(s)
Create study
Load existing study
Save current study
Save current study as
Clear study
Memory and other options
History scripts
Manage plugins
Quit
Manage data import plugins
Manage data processing plugins
Manage deactivated plugins

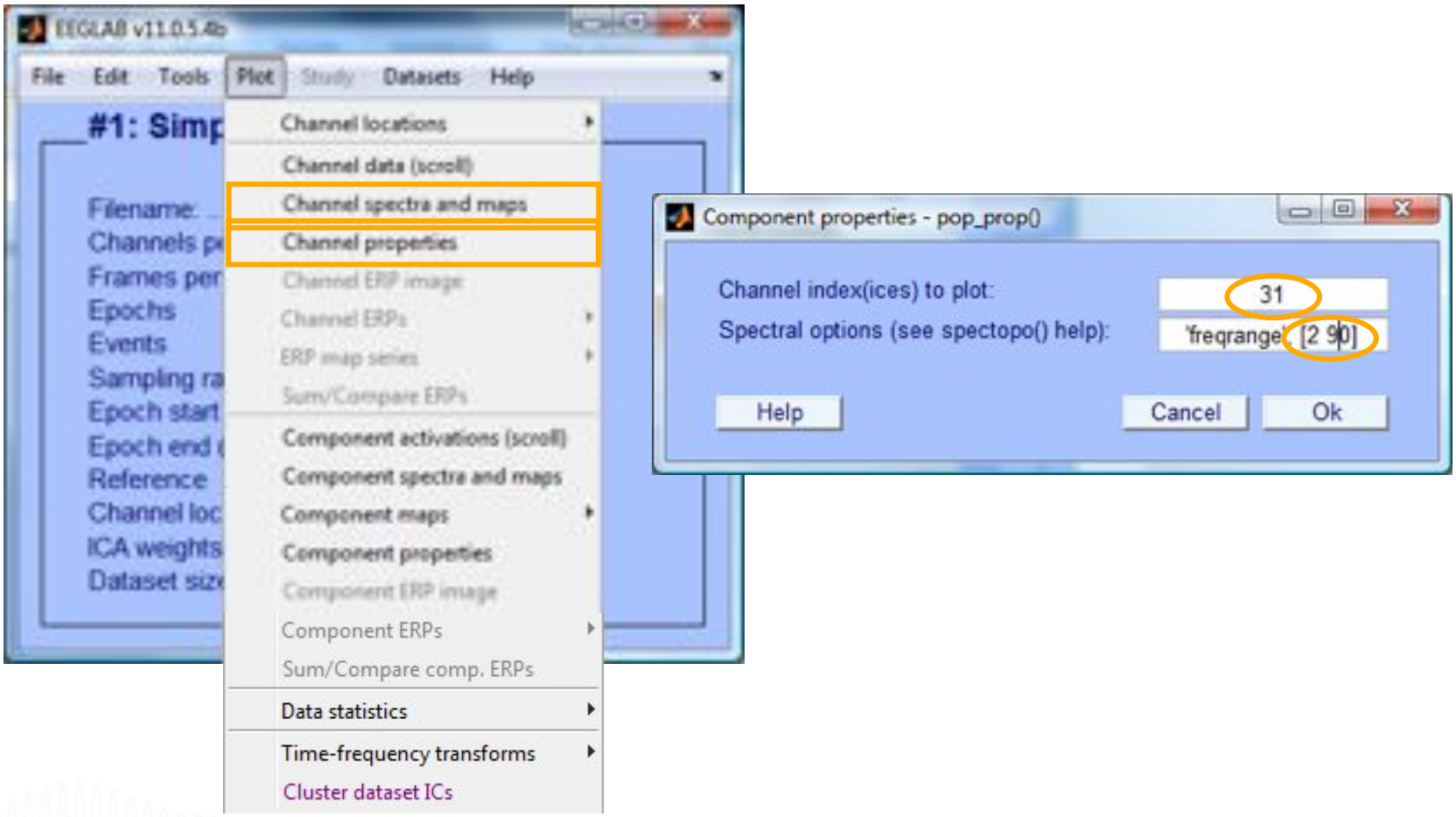

Plutings available for install on the internet
Install
Plugin
Version
Description
ERPLABfilters
1.00
Interface ERPLAB filters (requires seperate ERPLAB instalat...
Cleanline
1.21
Automatic artifact rejection
BERGEN
1.1
Removal of fMRI-related gradient artifacts from simultaneous...
Doc
Update
Deactivate
Installed plutings
brainmovie
0.1
Brainmovies (command line only)
commap
2.00
New version 1.03 available. Click update to install
eeg_toolbox
1.0
Interface EEG toolbox functions for ERP peak detection
fMRIb
1.21
Remove fMRI artifacts from EEG
MP_clustering
1.00
Measure projection clustering of ICA components
MutualInfoClustering
1.00
Mutual information clustering
StudyEnvtopo
0.9
Add envtopo capabilities to STUDY
VisEd
1.05
New version 1.04 available. Click update to install
iirfilt
1.02
Non linear filtering
loreta
1.1
New version 1.0 available. Click update to install
Cancel
Ok

Remove line noise (Cleanline)

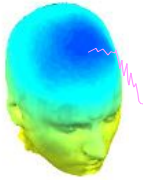


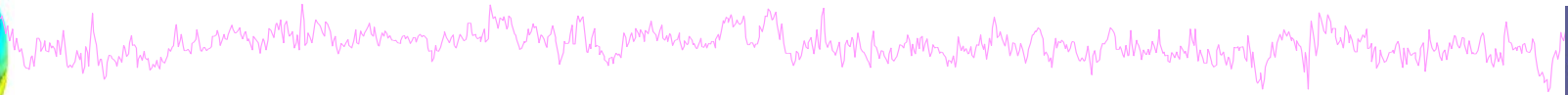


Plot channel spectra



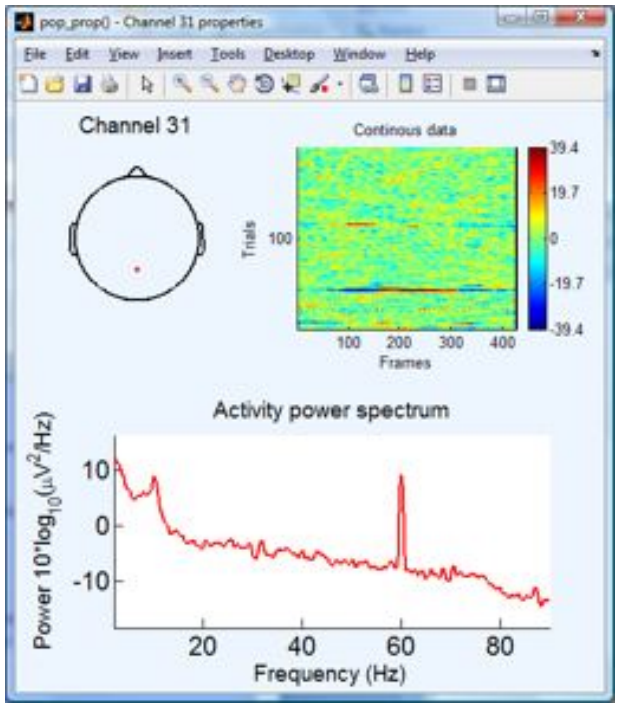
Filter comparisons



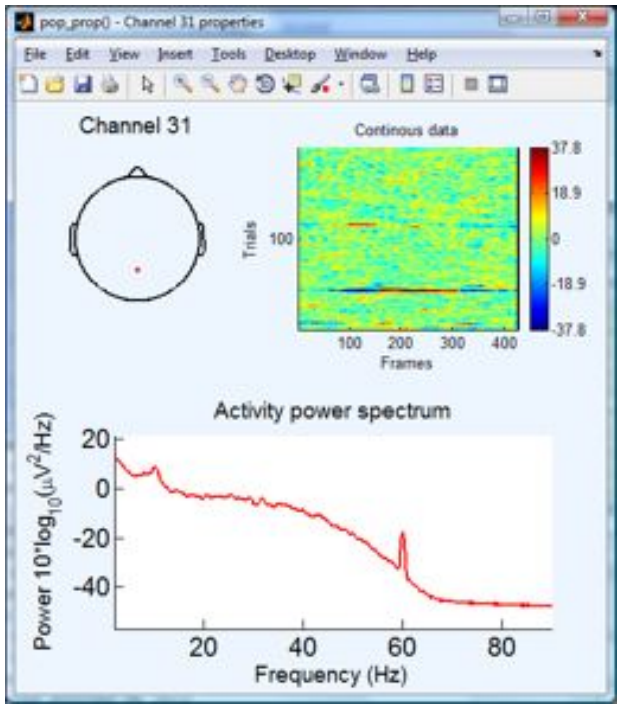


Swartz Center for Computational Neuroscience

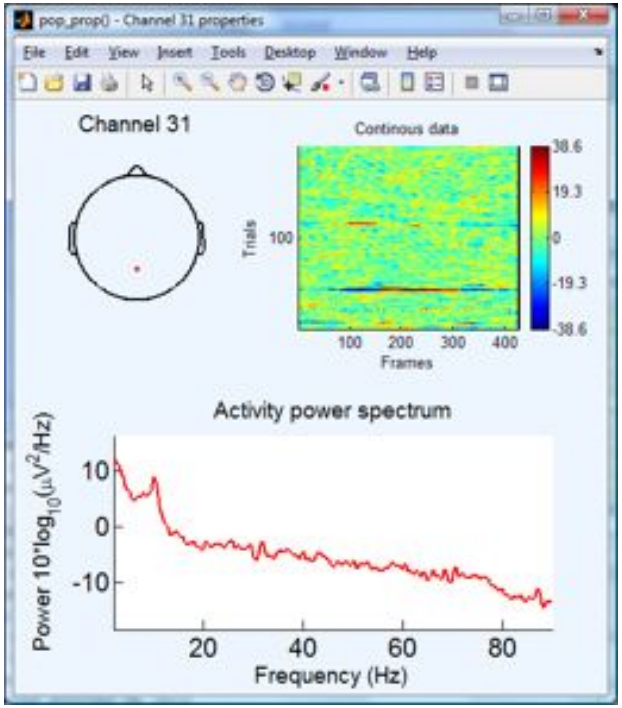
0.5 Hz high-pass filter



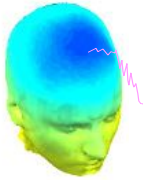
0.5 Hz high-pass filter
50 Hz low-pass filter



0.5 Hz high-pass filter
Cleanline



Other useful plugins



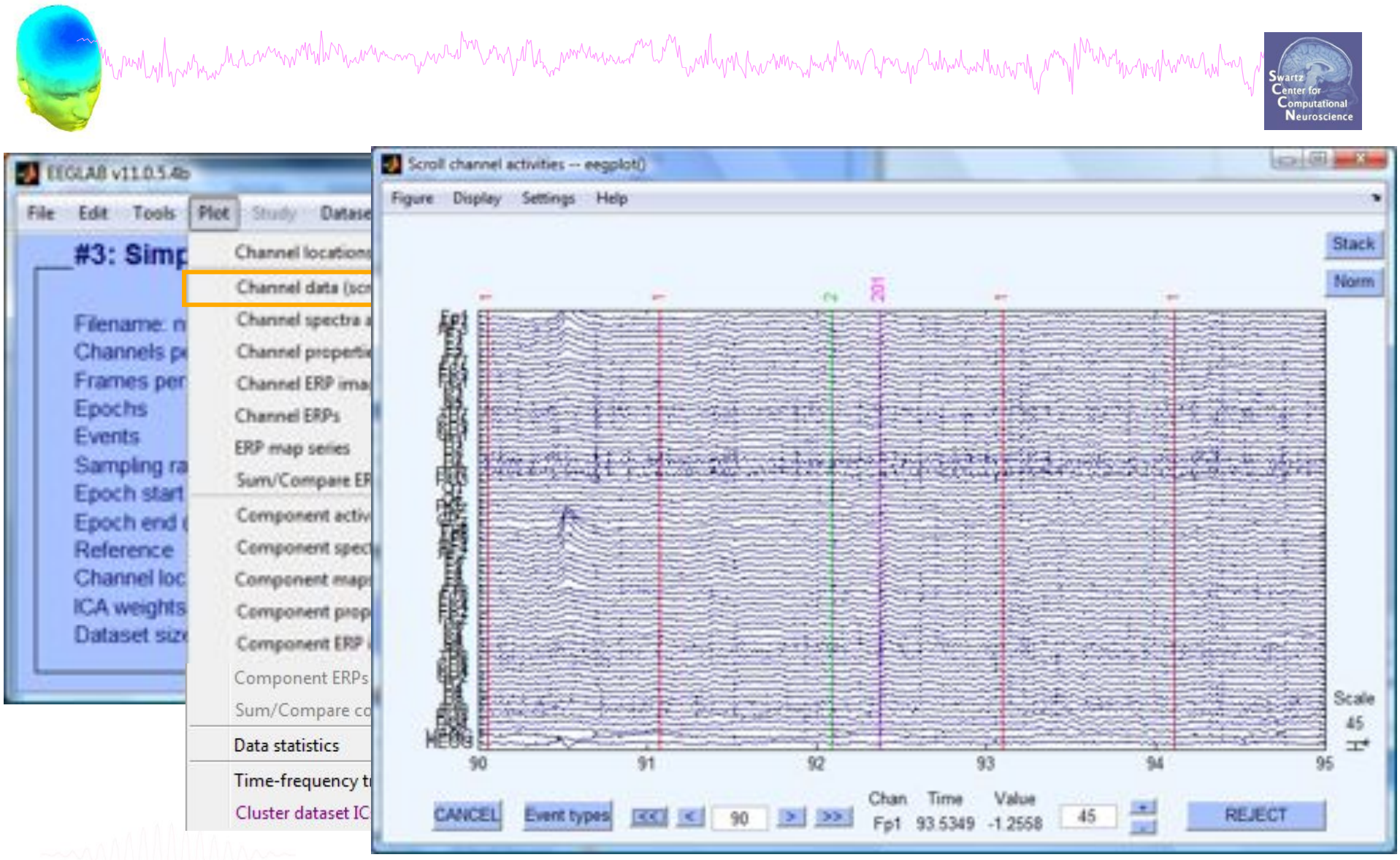
- Cleanline (developed by Tim Mullen)

  http://www.nitrc.org/projects/cleanline/

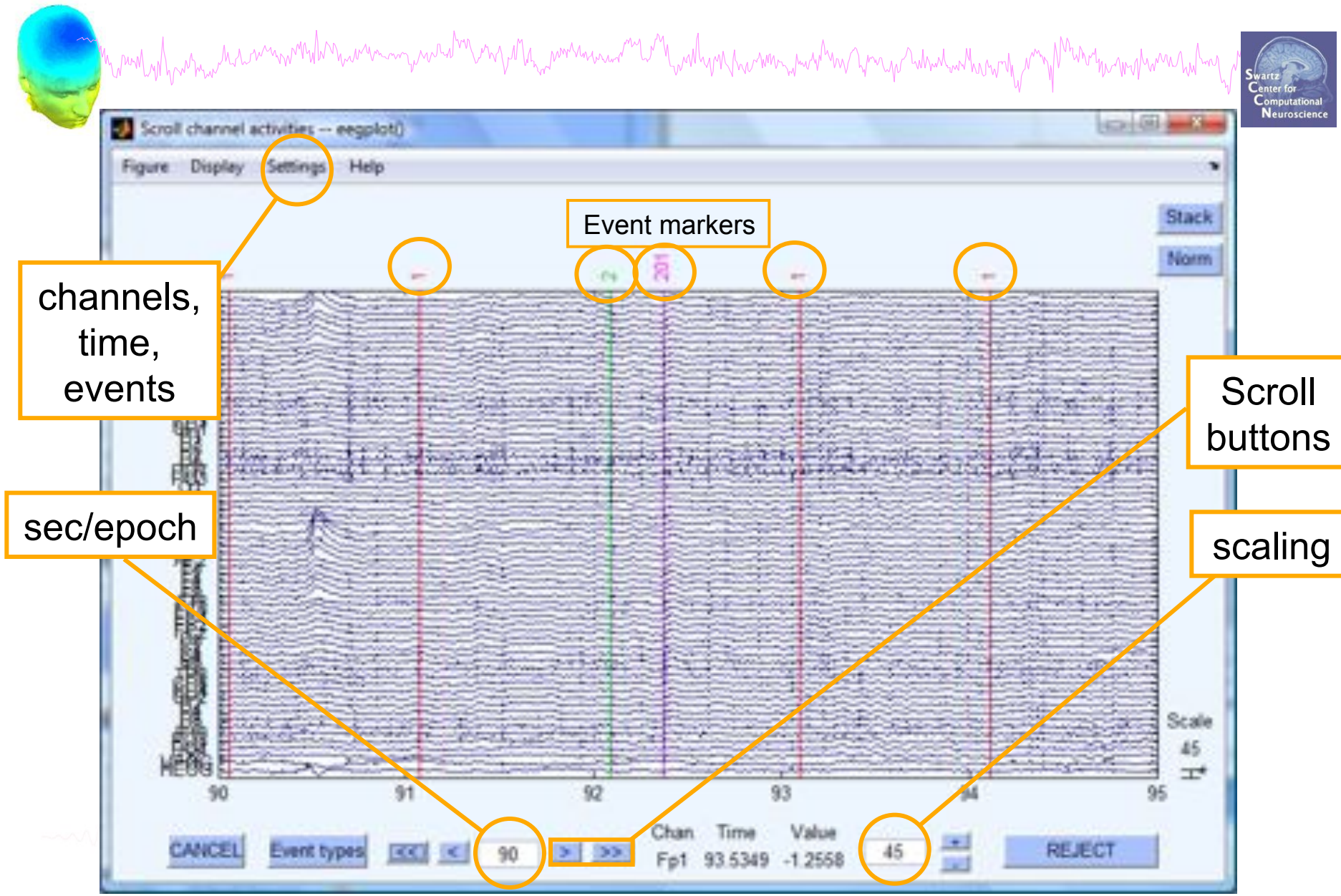
- ERPLAB Toolbox (developed by Steve Luck and Javier Lopez-Calderon at UC Davis)

  http://www.erpinfo.org/erplab/erplab-home/

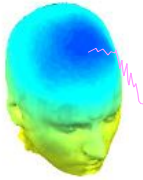
Scroll channel data

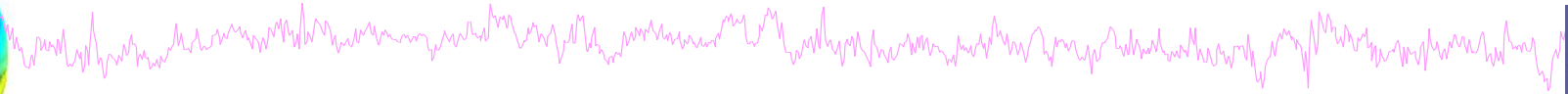


Scroll channel data



Pre-processing pipeline





Swartz Center for Computational Neuroscience

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

High pass filter (~.5 – 1 Hz)

Remove line noise (if necessary)

STOP!

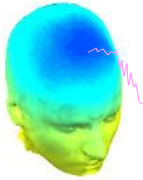
Save your dataset here; you will import ICA weights to this dataset later

Identify/reject bad channels

Reject large artifact time points

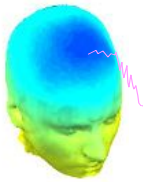
Run ICA

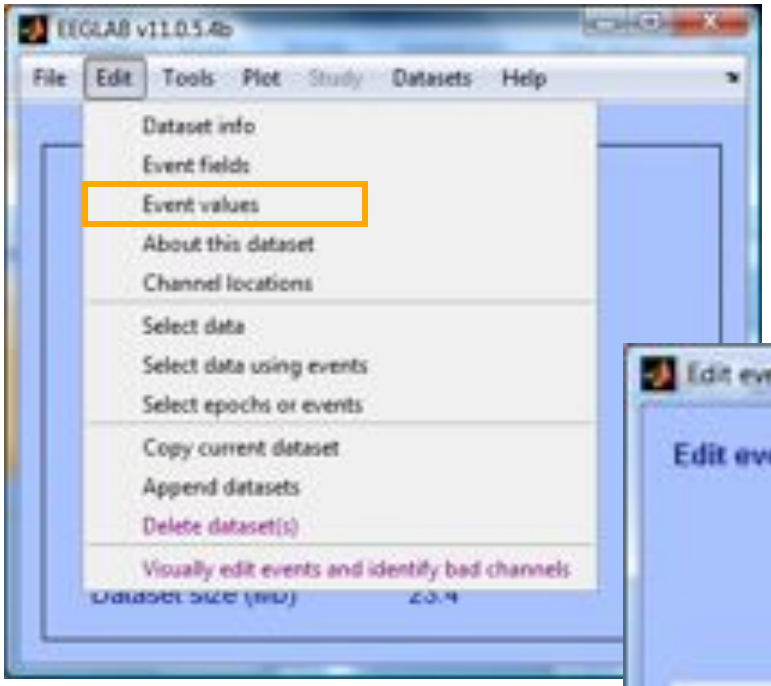
Visualizing ERPs



- Epoch data according to different event types
- Reject epochs containing artifact
- Various plot types (channel and scalp topography)

Review event values

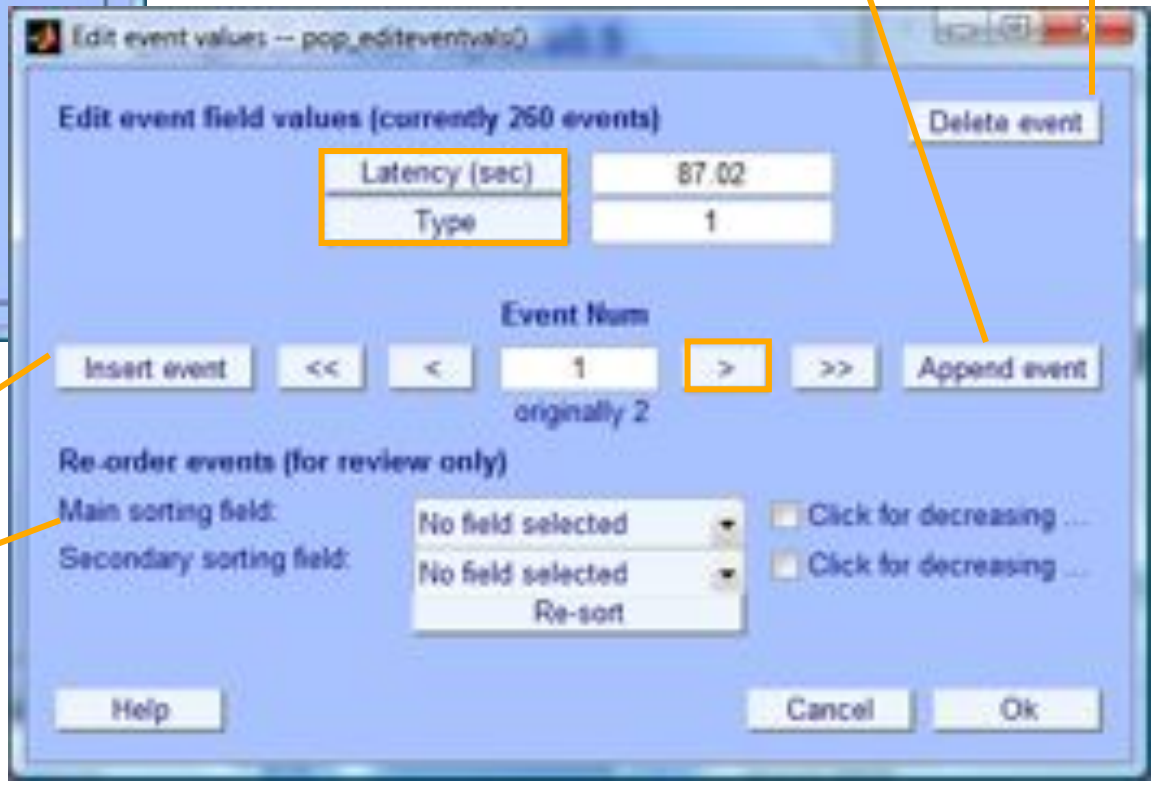




Event 'type' and 'latency' are recognized fields

Append event AFTER current event

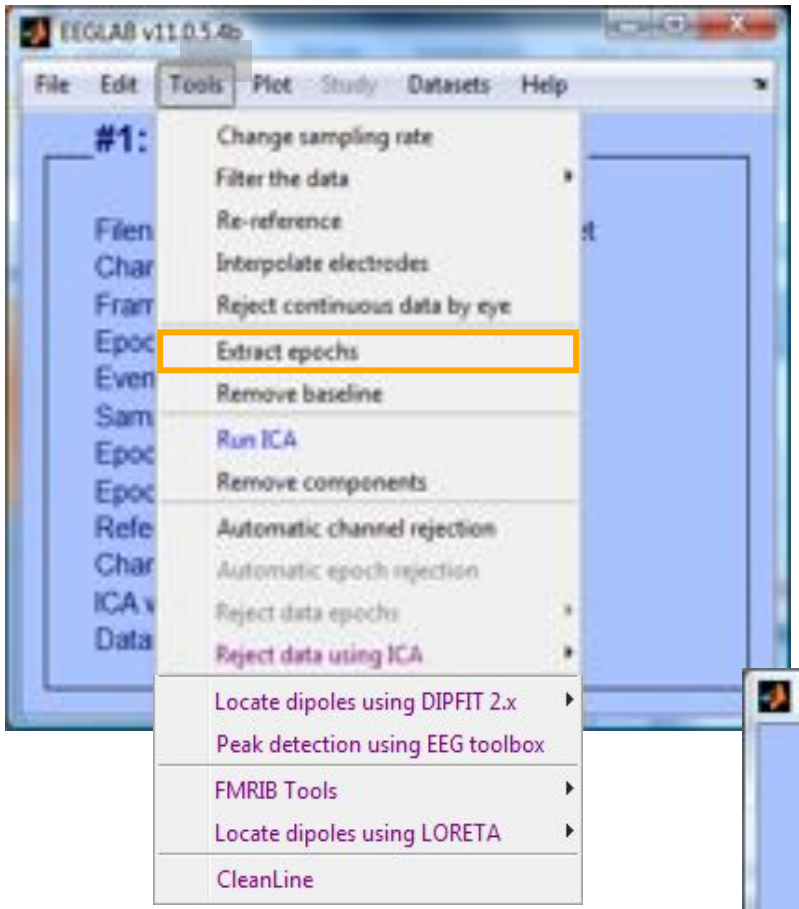
Delete CURRENT event



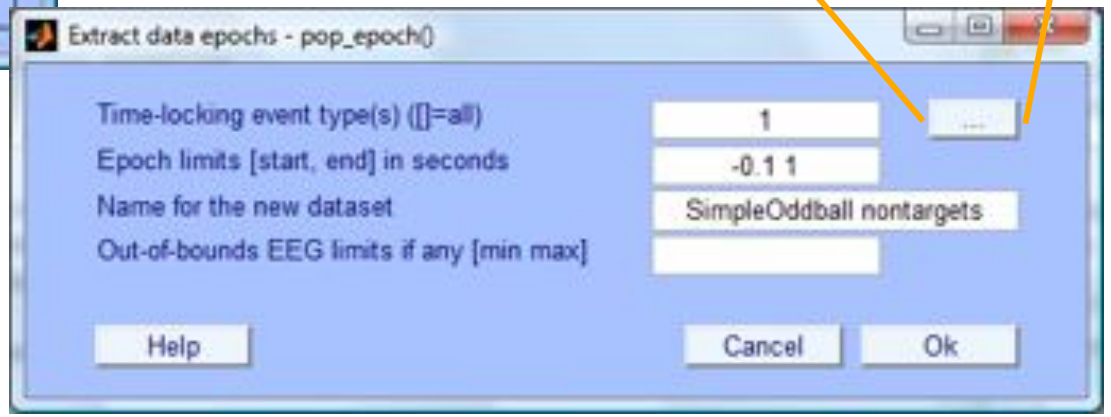
Insert event BEFORE current event

To resort: first select Main sorting field

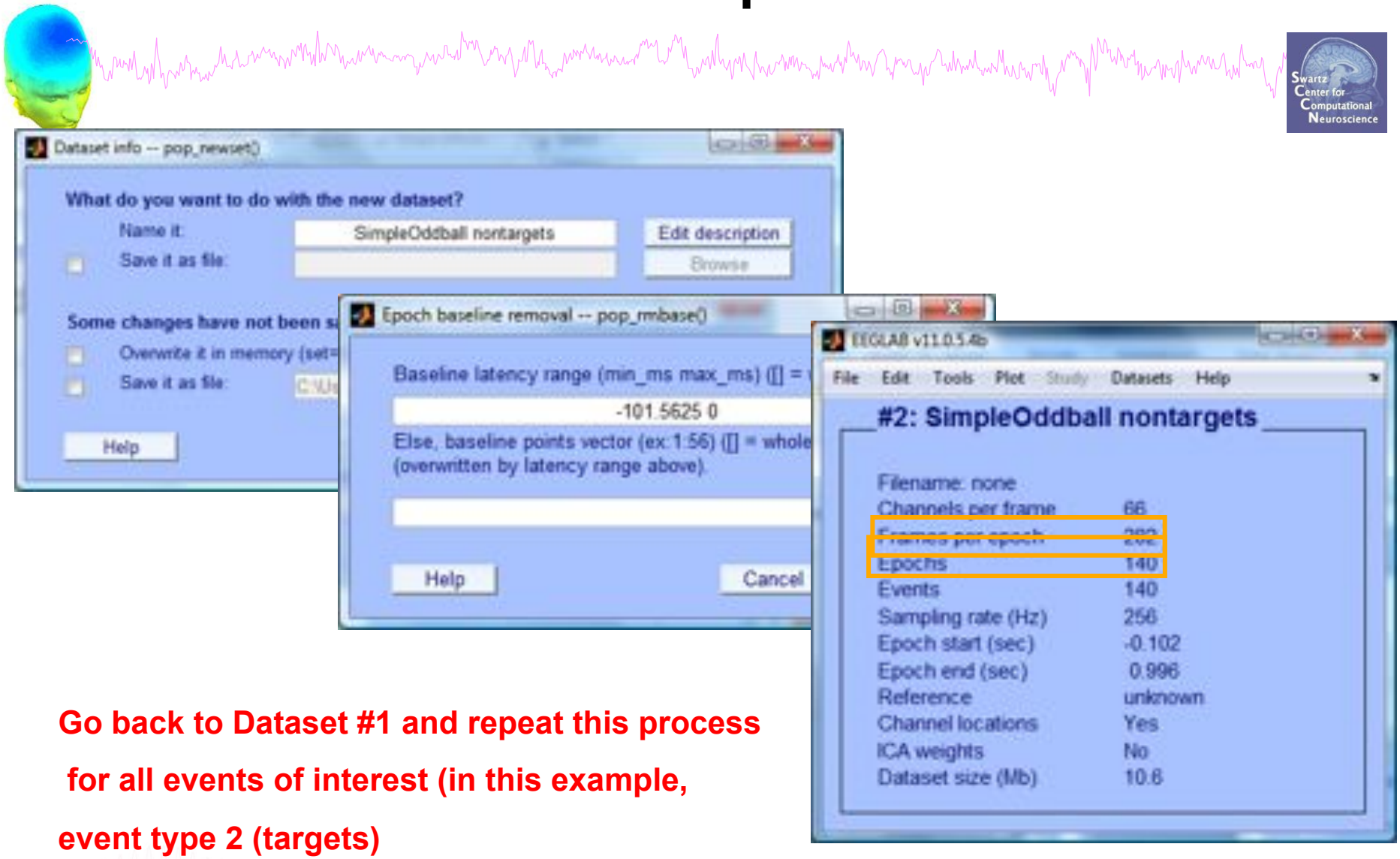
Extract epochs




```
>> eeg_eventtypes(EEG)
   1        140
   2        60
   201      60
```

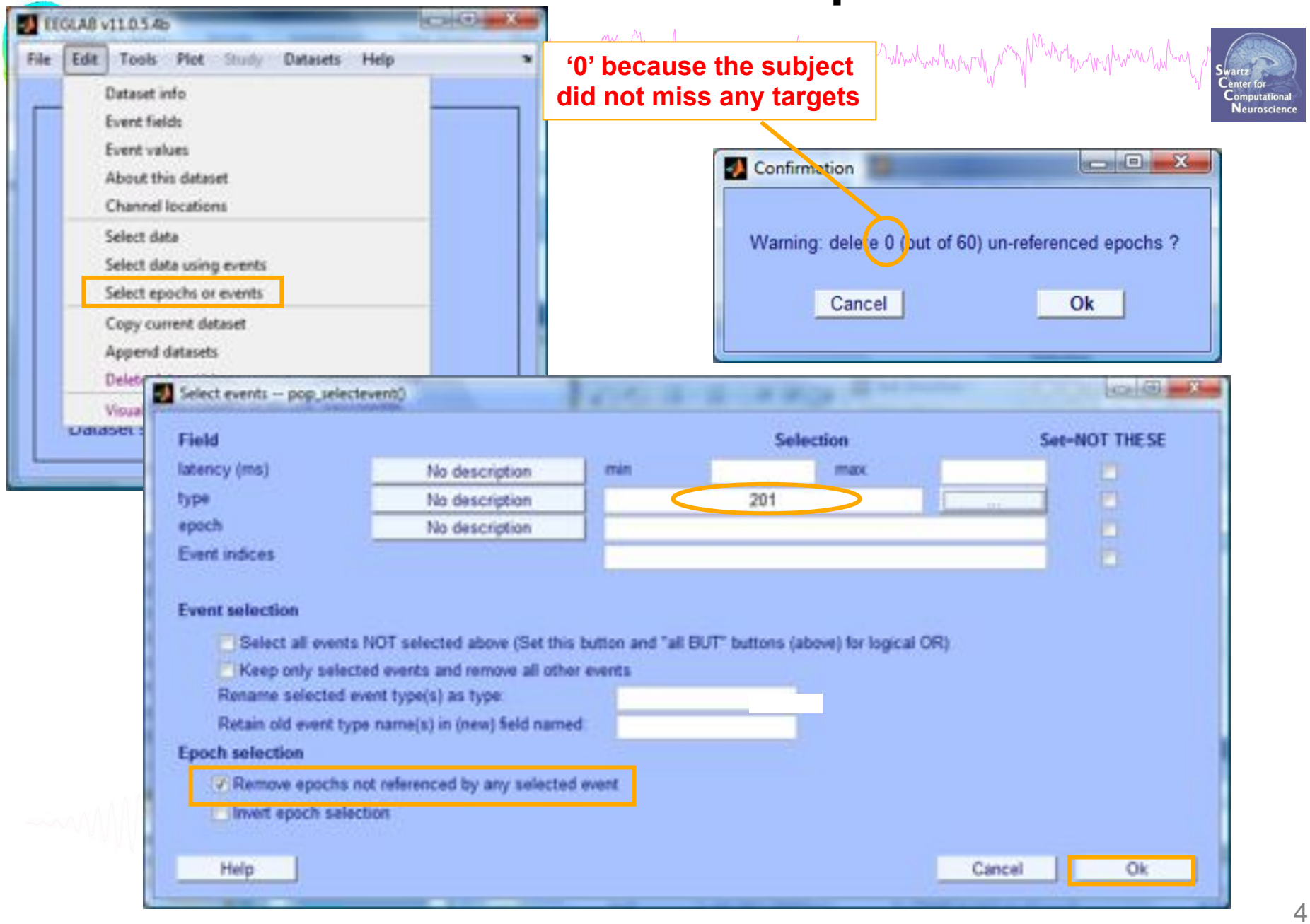


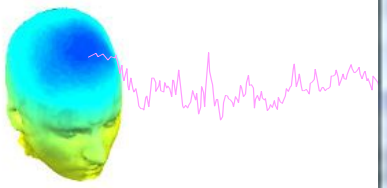
Extract epochs



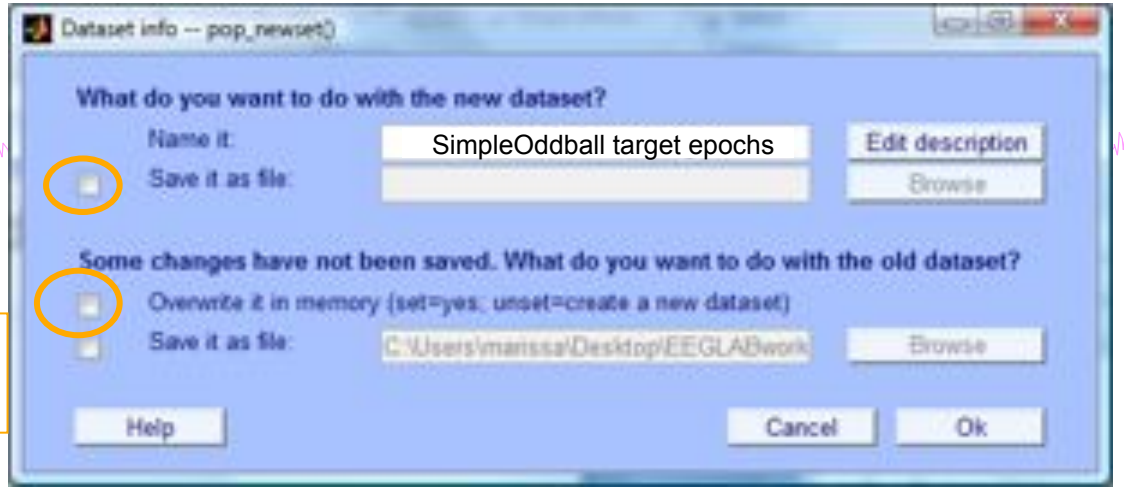
Go back to Dataset #1 and repeat this process for all events of interest (in this example, event type 2 (targets)

Select a subset of epochs

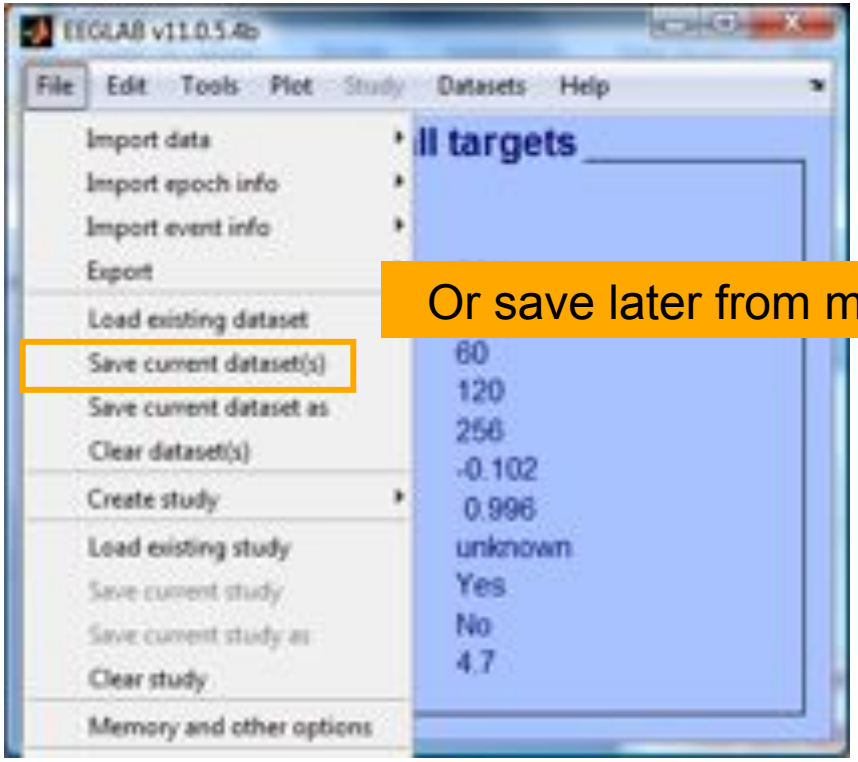




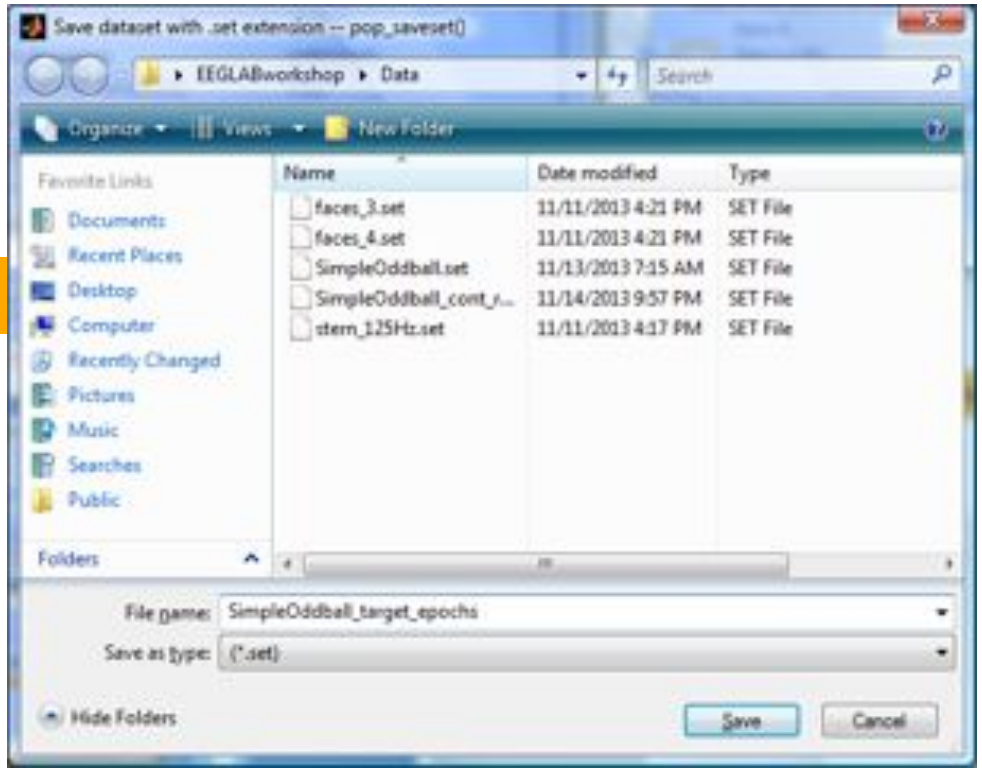
'Do not overwrite current dataset'



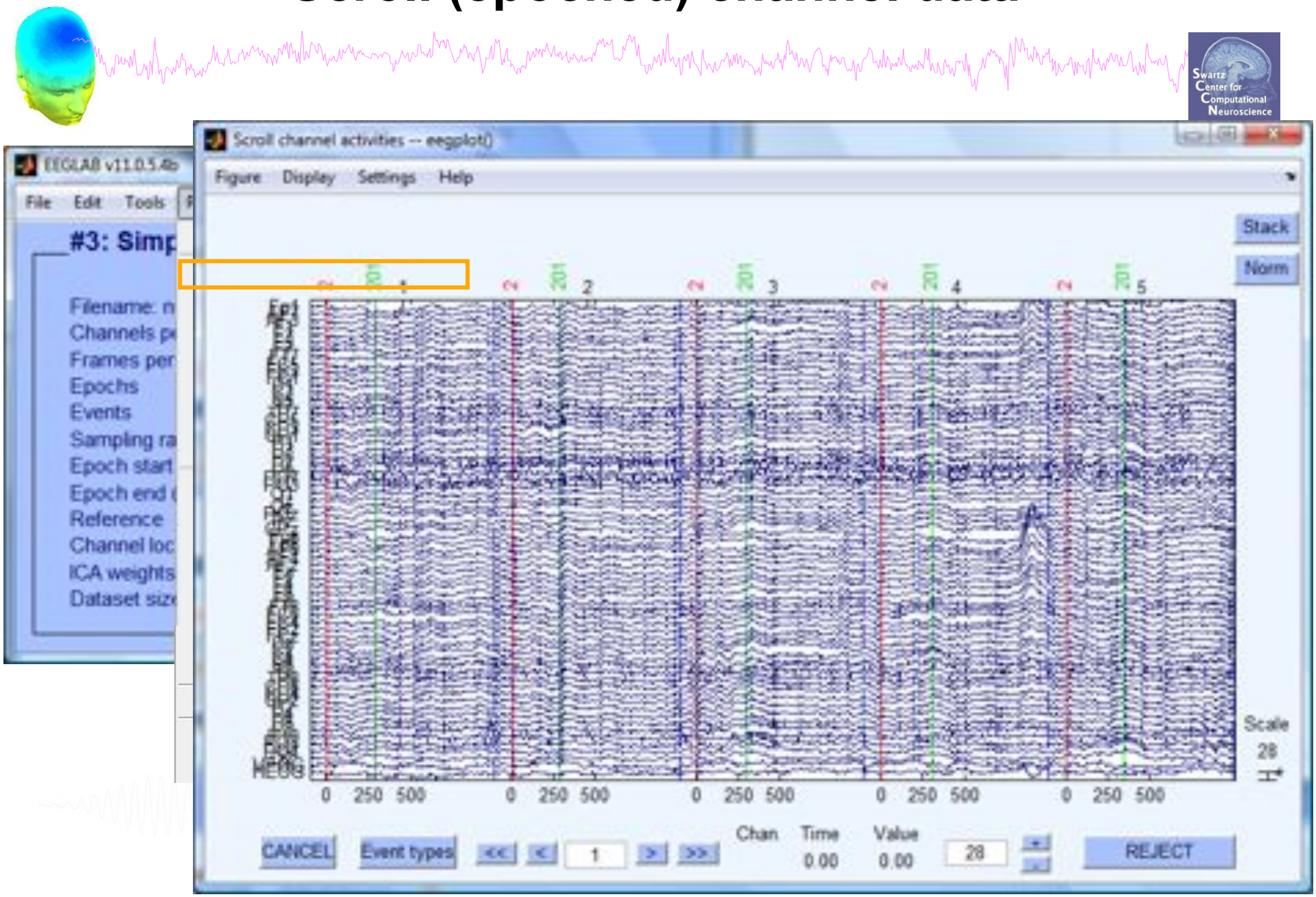
Save dataset (optional)



Or save later from menu

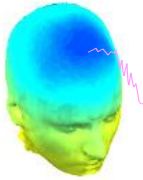


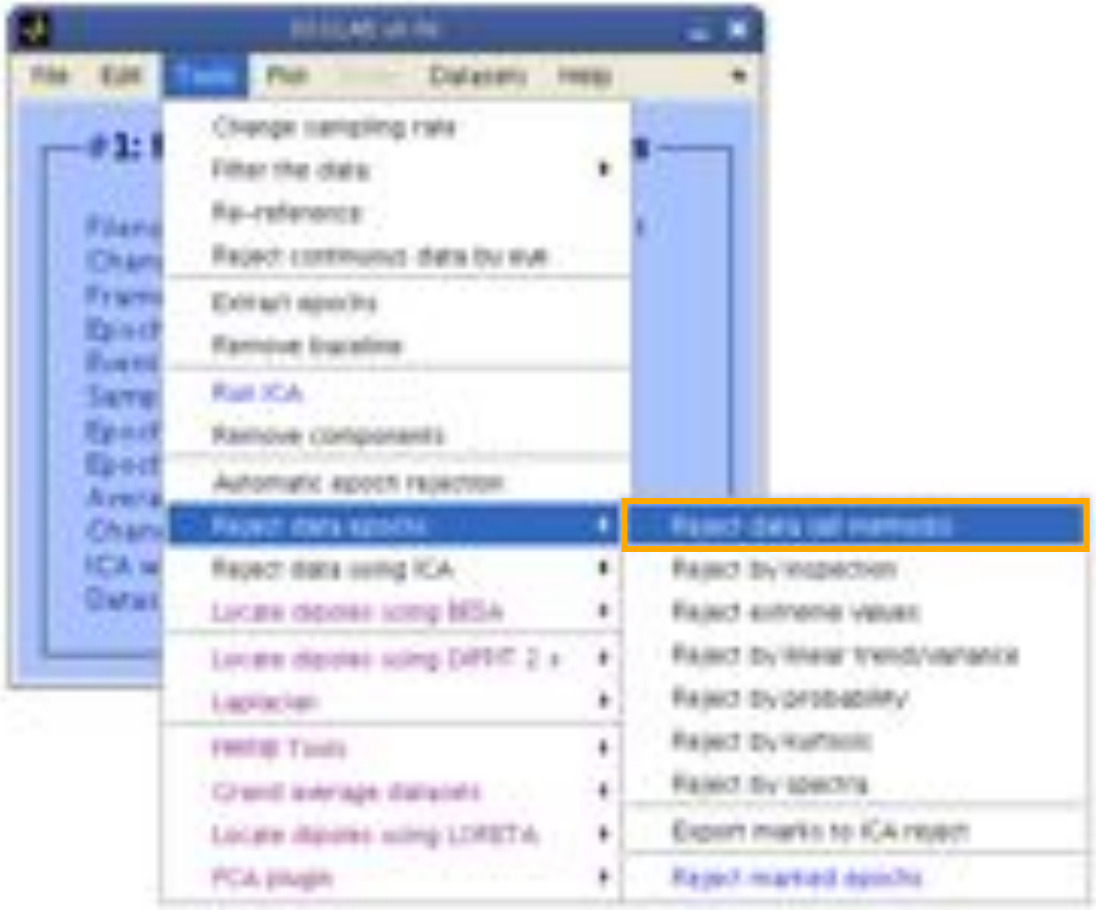
Scroll (epoched) channel data



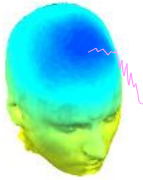
Reject epochs with artifact

Reject data epochs





Reject data epochs



visual inspection

probability

Reject trials using data statistics - pop_rejmenu()

Mark trials by appearance

Scroll Data | Marked trials 0

Find abnormal values

Upper limit(s) (uV)	25	Lower limit(s) (uV)	-25
Start time(s) (ms)	-1000	Ending time(s) (ms)	1996
Electrode(s)	1:31	Currently marked trials	0

Calc / Plot | Help

Find abnormal trends

Max slope (uV/epoch)	50	R-squared limit (0 to 1)	0.3
Electrode(s)	1:31	Currently marked trials	0

Calc / Plot | Help

Find improbable data

Single-channel limit (std. dev.)	5	All channels limit (std. dev.)	5
Electrode(s)	1:31	Currently marked trials	0

Calculate | Scroll Data | Plot | Help

Find abnormal distributions

Single-channel limit (std. dev.)	5	All channels limit (std. dev.)	5
Electrode(s)	1:31	Currently marked trials	0

Calculate | Scroll Data | Plot | Help

Find abnormal spectra (slow)

Upper limit(s) (dB)	25	Lower limit(s) (dB)	-25
Low frequency(s) (Hz)	0	High frequency(s) (Hz)	50
Electrode(s)	1:31	Currently marked trials	0

Calc / Plot | Help

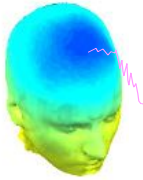
Plotting options

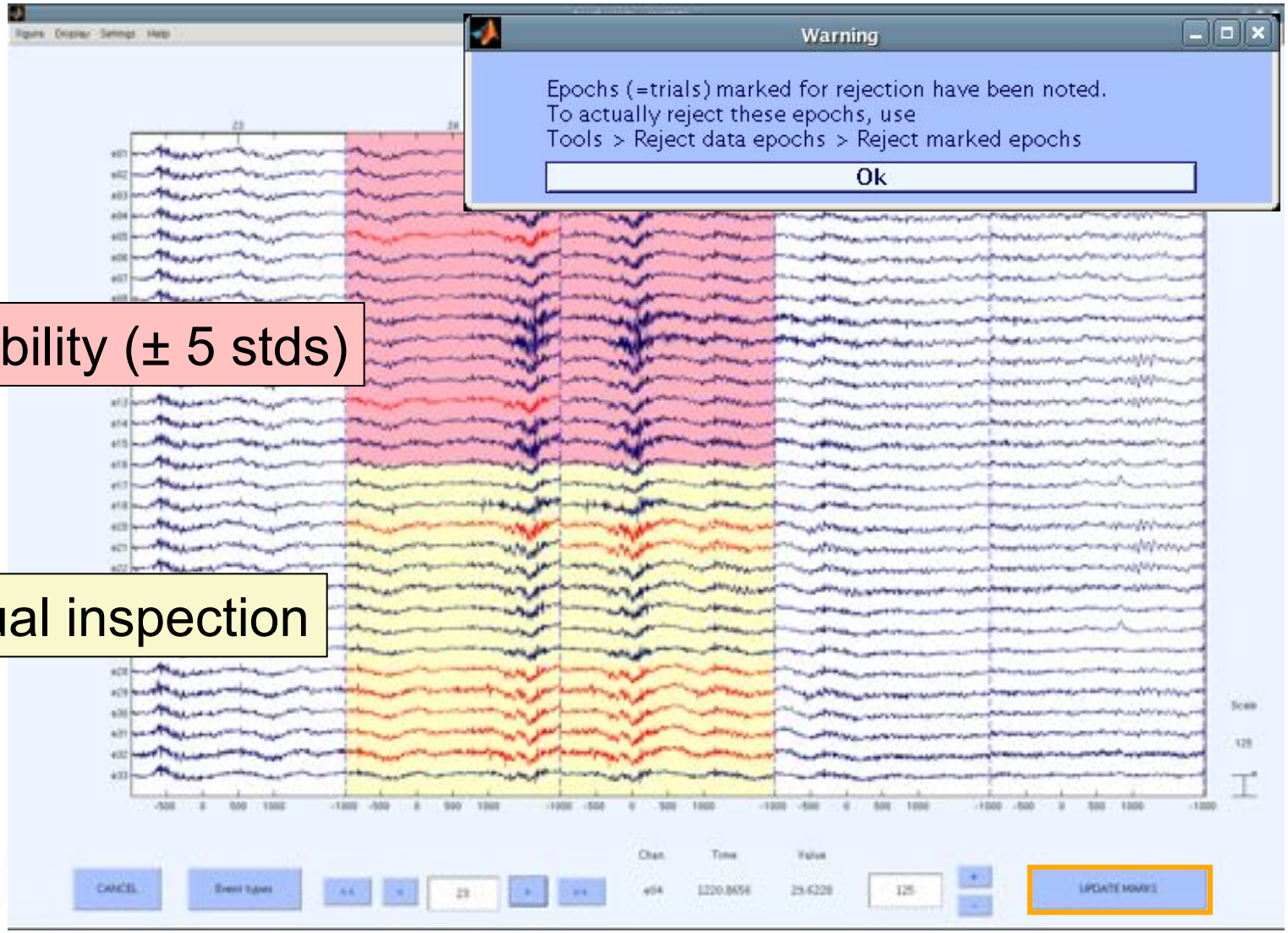
Show all trials marked for rejection by the measure selected above or checked below

- ☑ Abnormal appearance
- ☑ Improbable epochs
- ☑ Abnormal values
- ☑ Abnormal distributions
- ☑ Abnormal trends
- ☑ Abnormal spectra

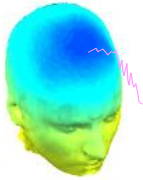
Close (keep marks) | Clear all marks | Reject marked trials

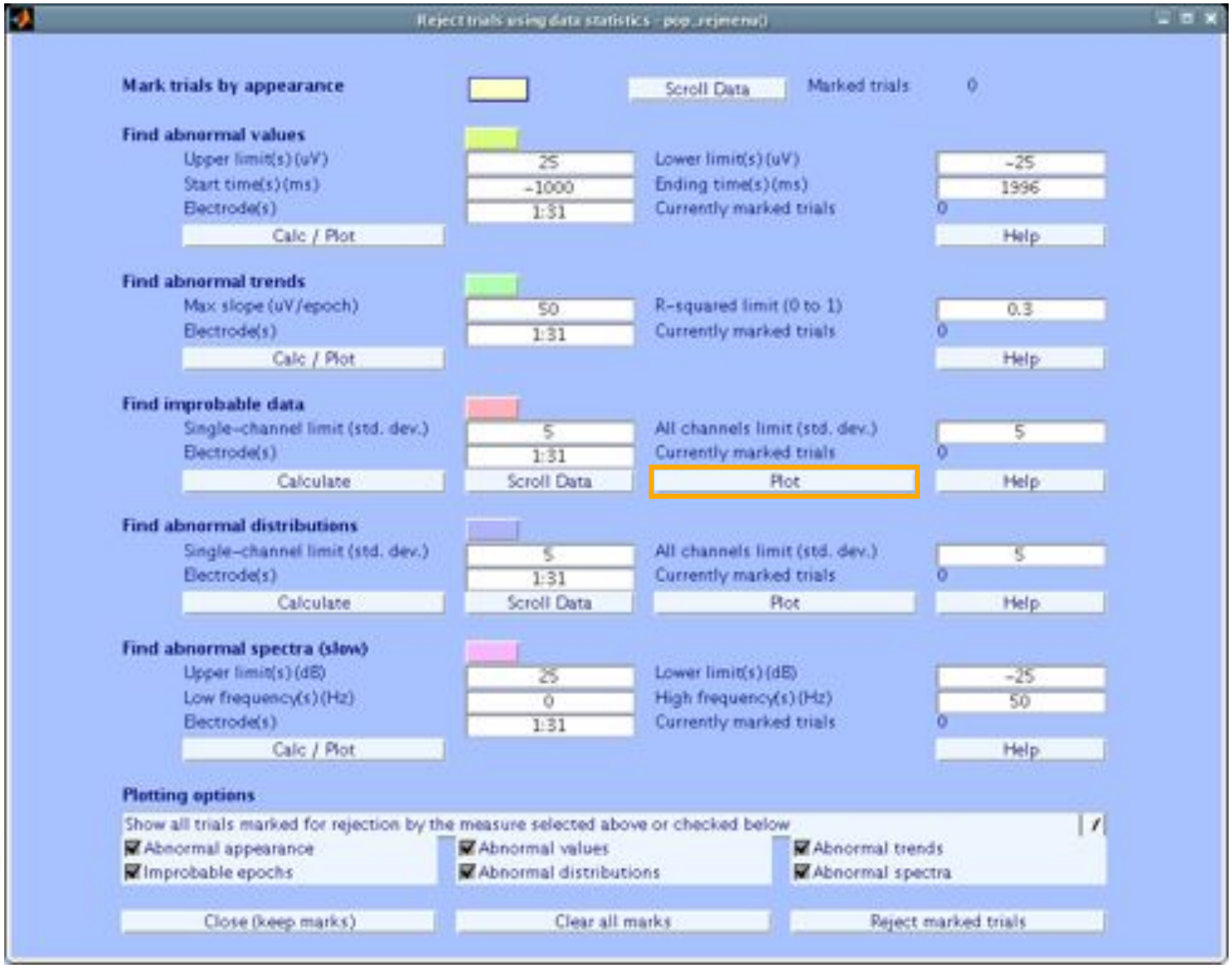
Reject data epochs



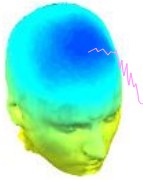


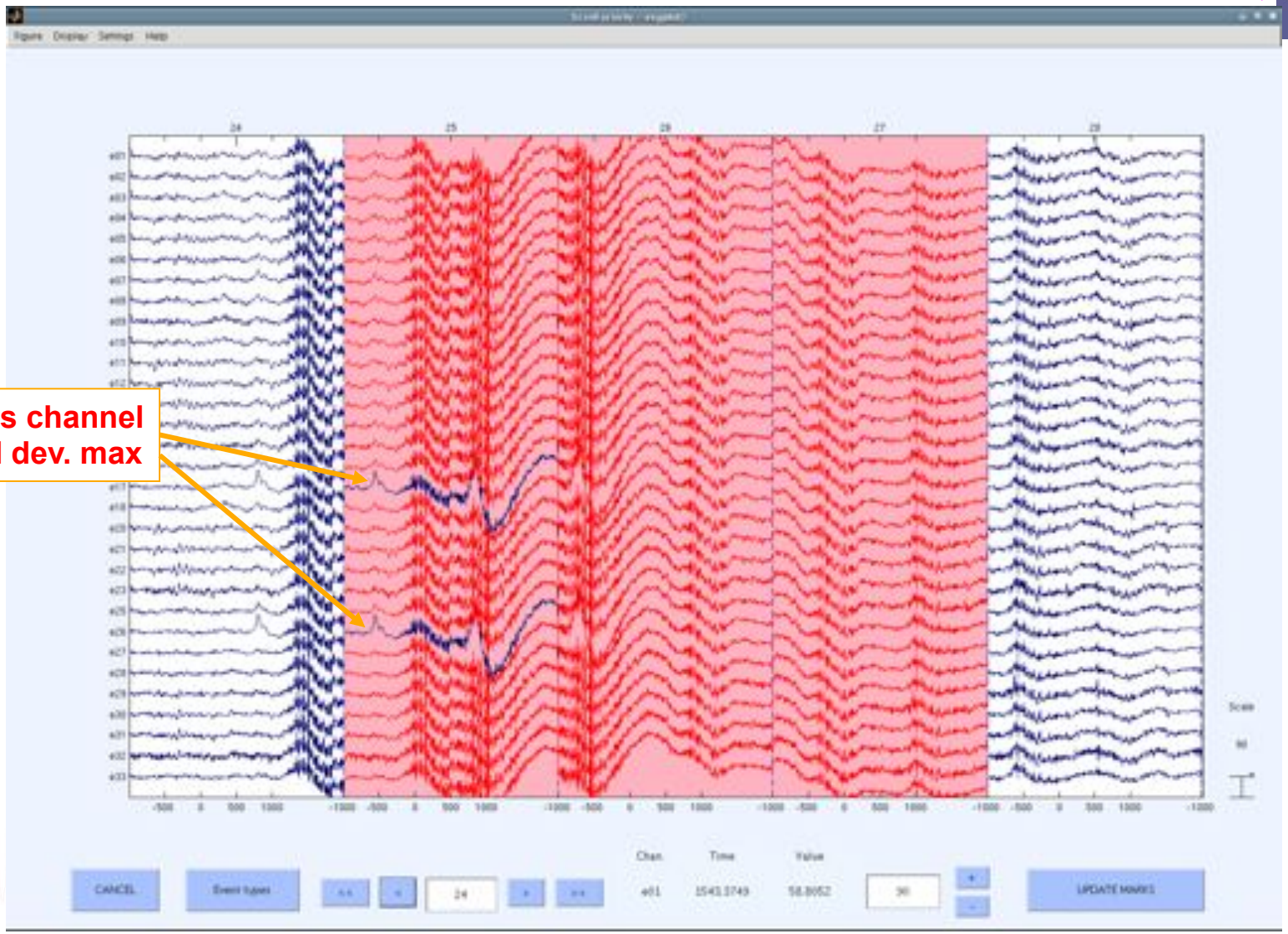
Plot channel measures over time



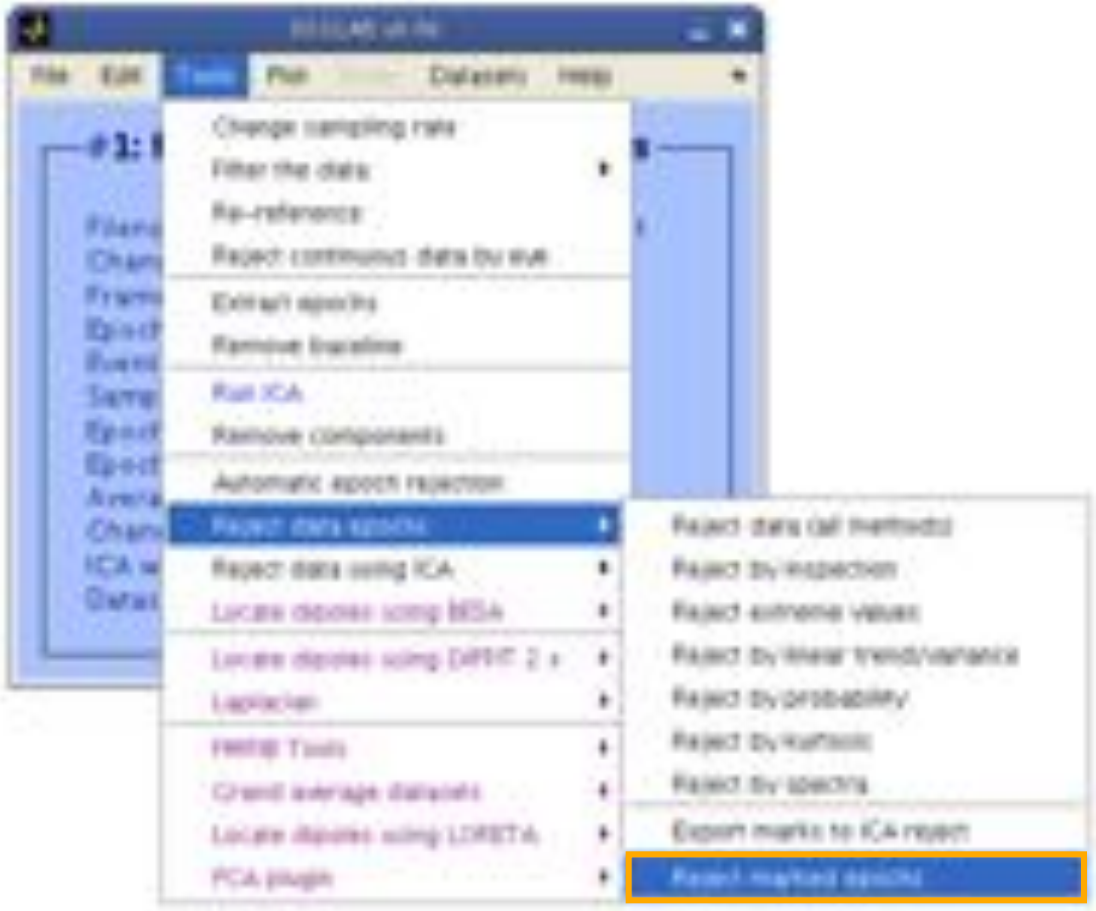


Reject data epochs

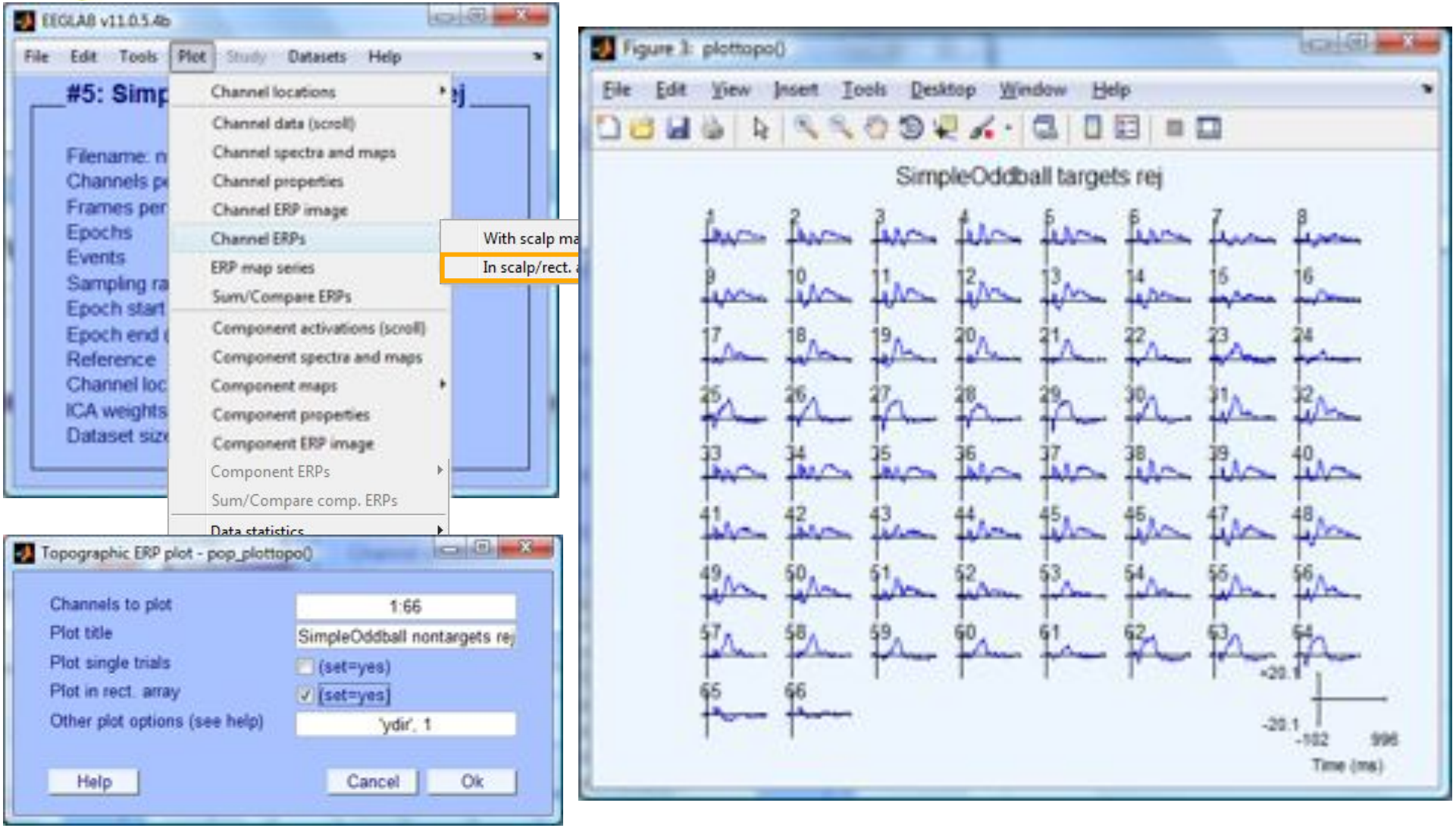




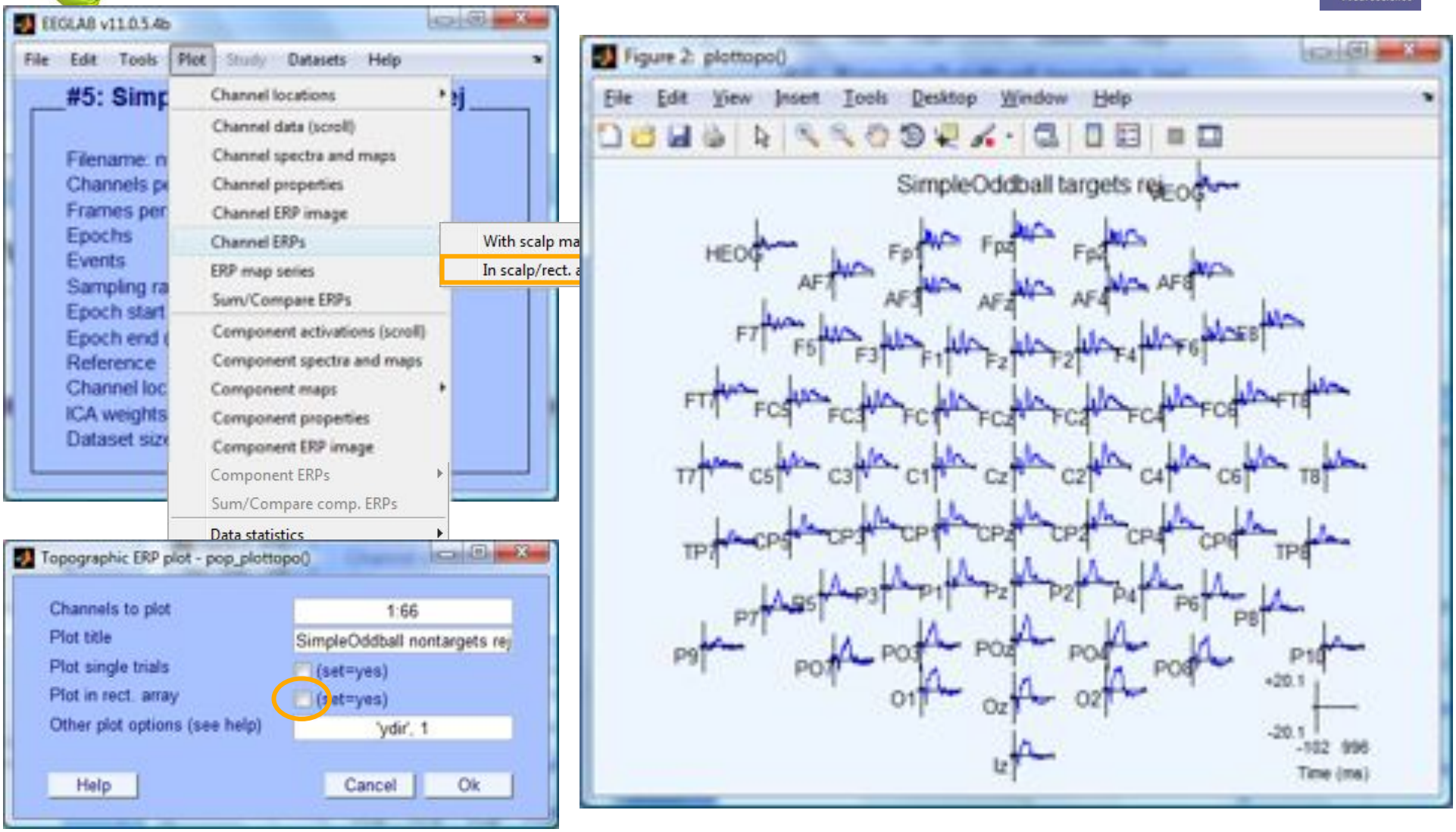
Reject data epochs



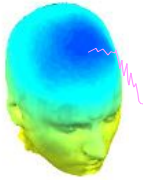
Visualize ERP in rectangular array

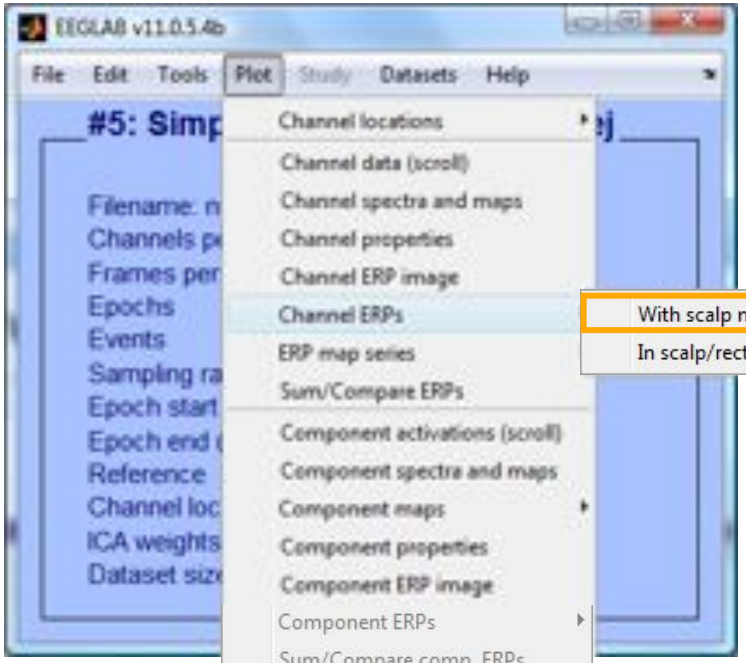


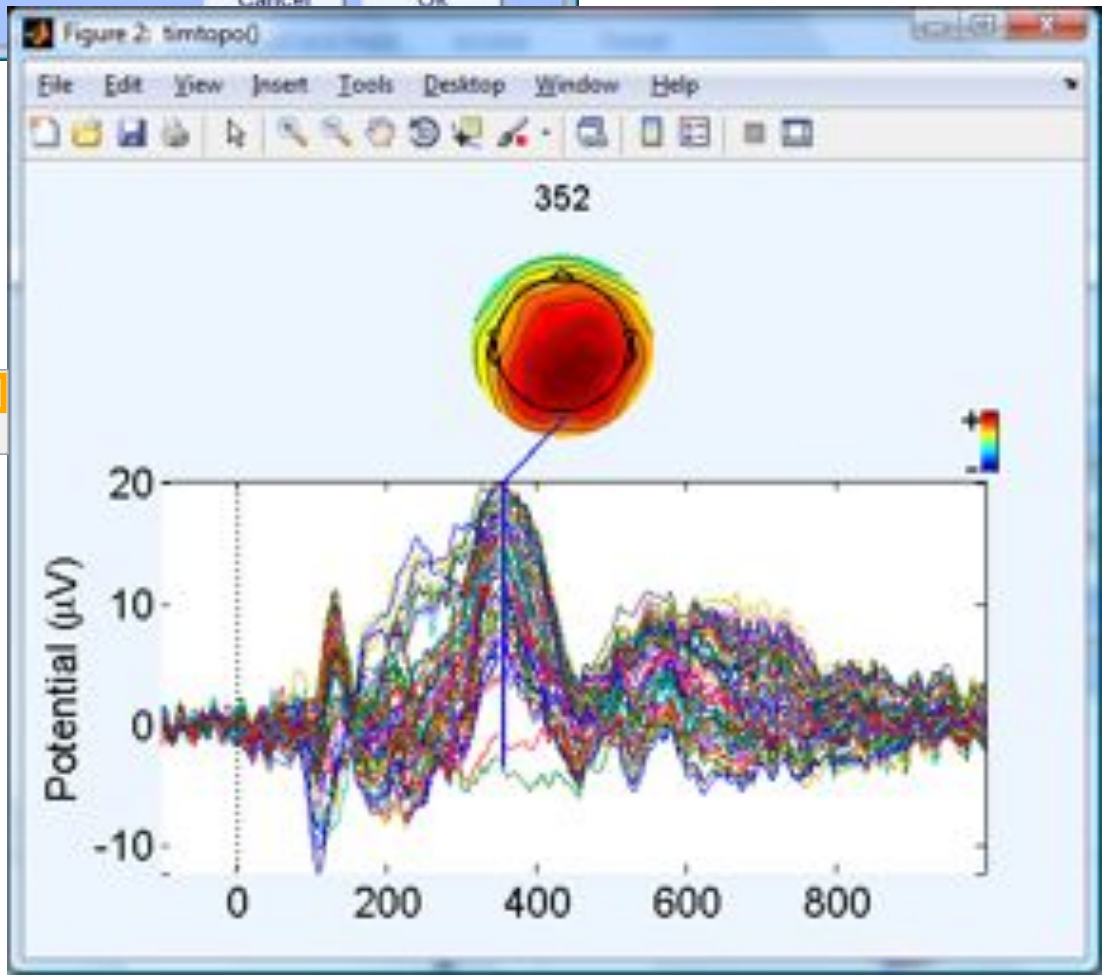
Visualize ERP in topographic array



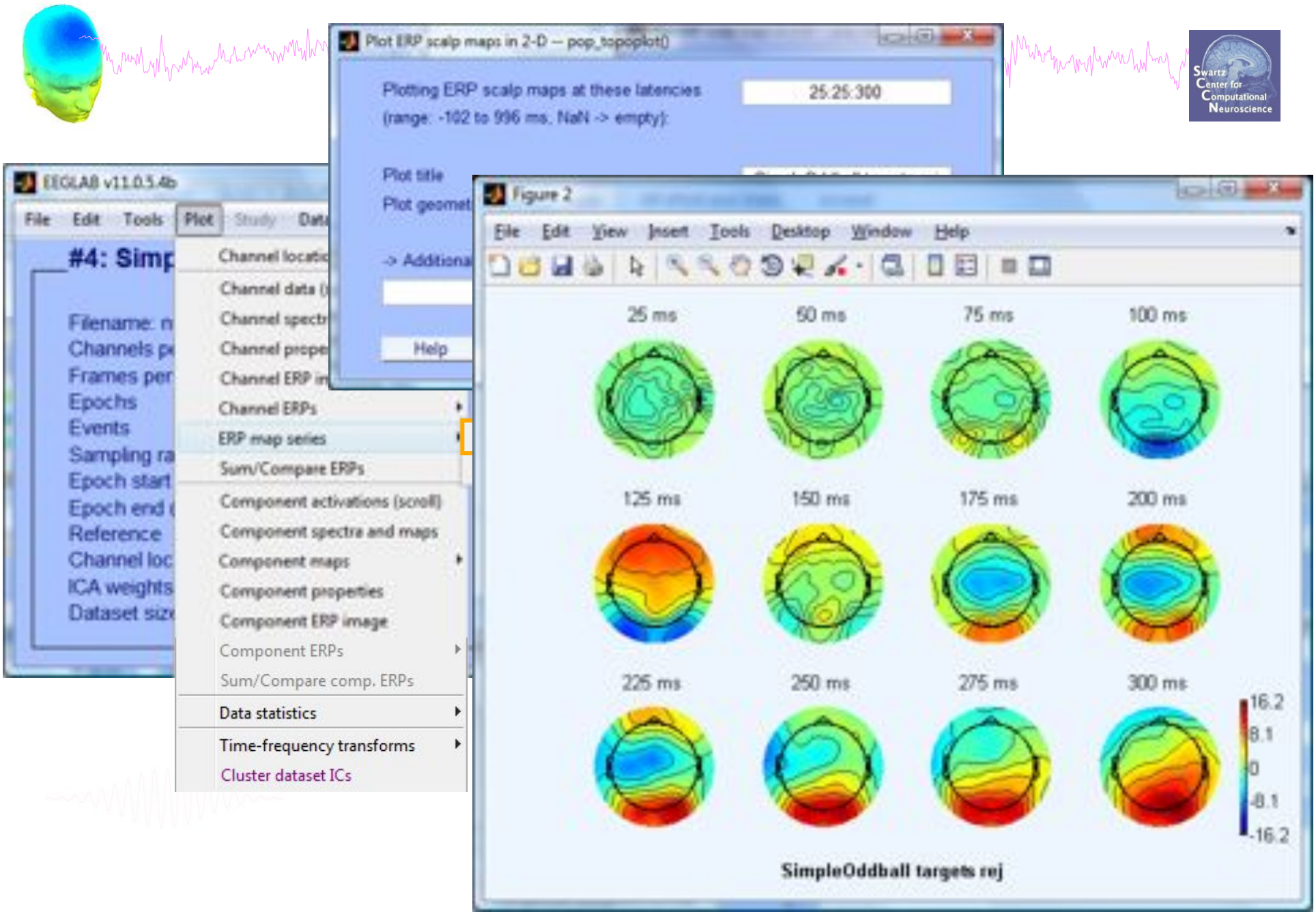
Visualize ERP scalp distribution



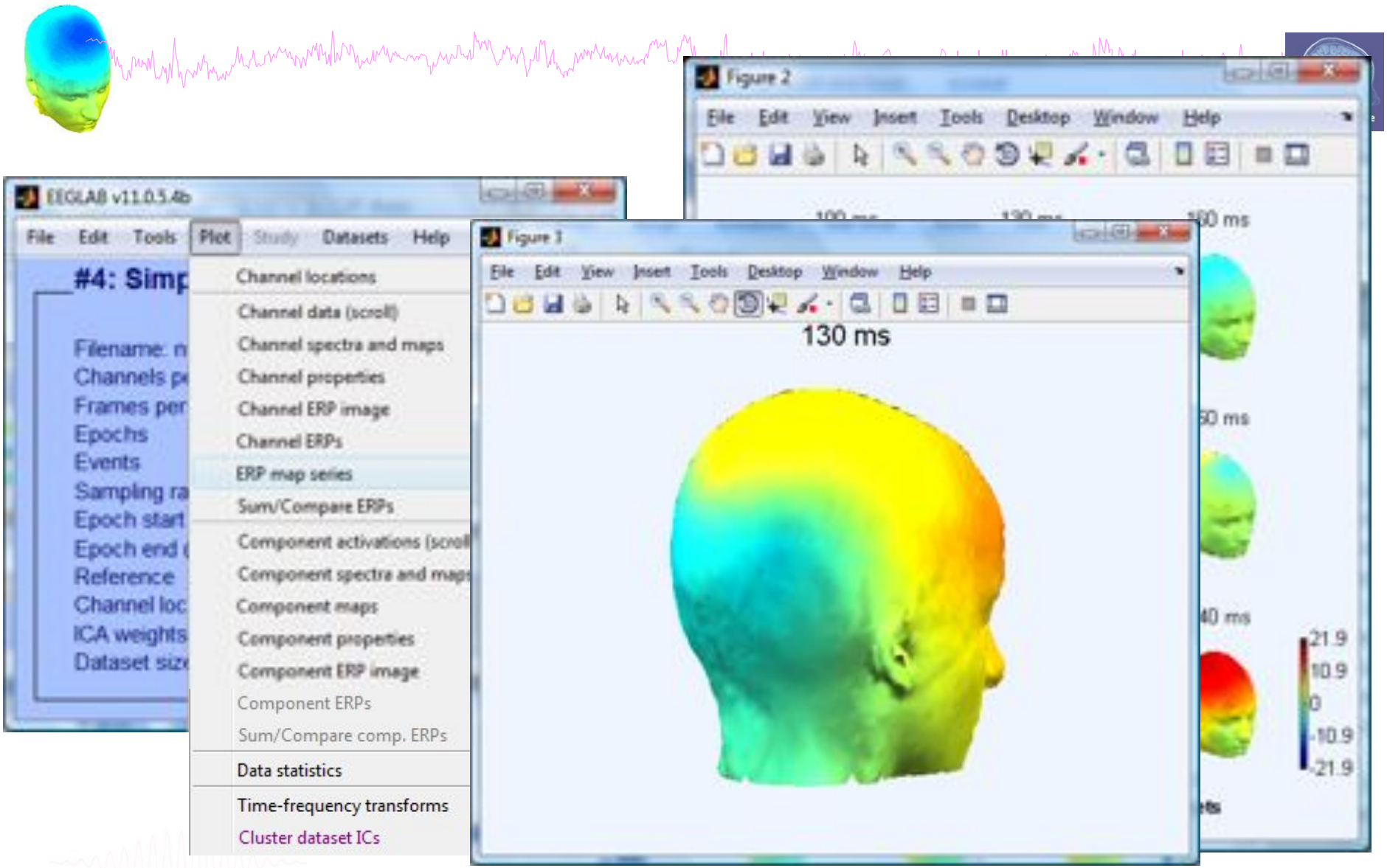




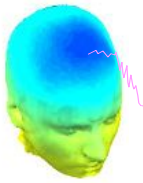
Visualize channel ERPs in 2D



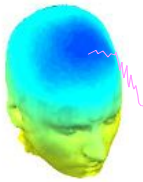
Visualize channel ERPs in 3D



Exercises



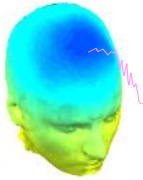
- Load SimpleOddball.set
- Rereference data to average reference
- Hi-pass filter the continuous data, then save
- Epoch the data on circles (event type 1) and stars (event type 2)
- Scroll the epoched data and perform visual rejection of epochs
- Explore the automated artifact rejection tools
- Save ‘clean’ epoched datasets for circles and stars

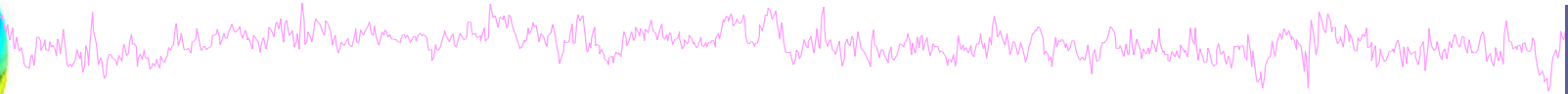


EEGLAB Processing

Data cleaning for ICA

Pre-processing pipeline





Swartz Center for Computational Neuroscience

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

High pass filter (~.5 – 1 Hz)

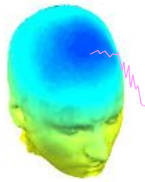
Remove line noise (if necessary)

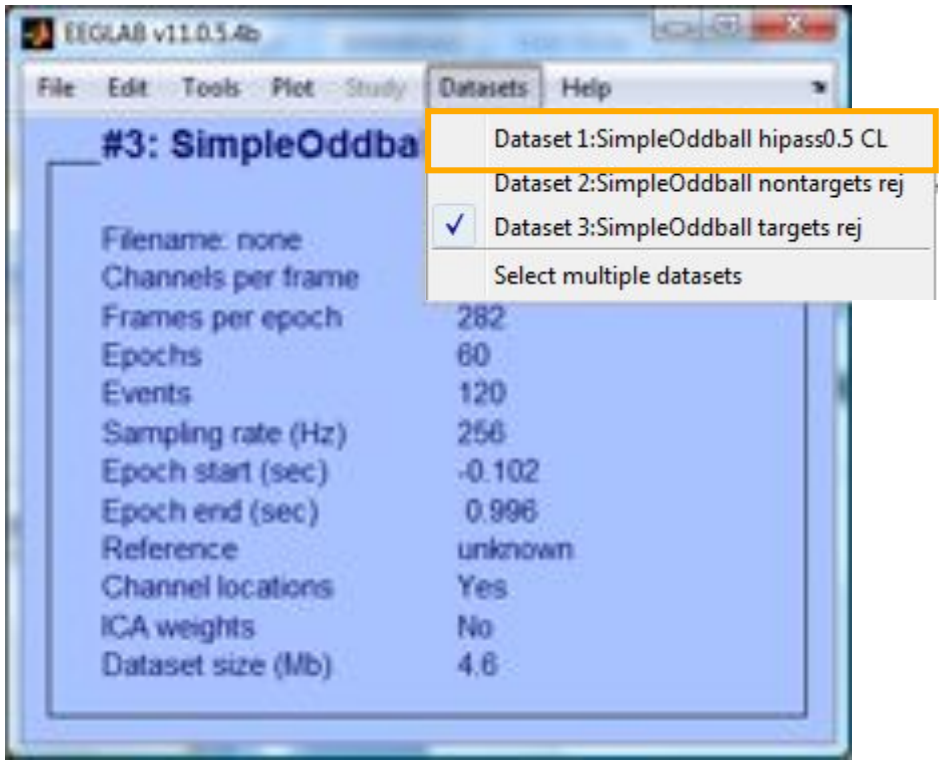
Identify/reject bad channels

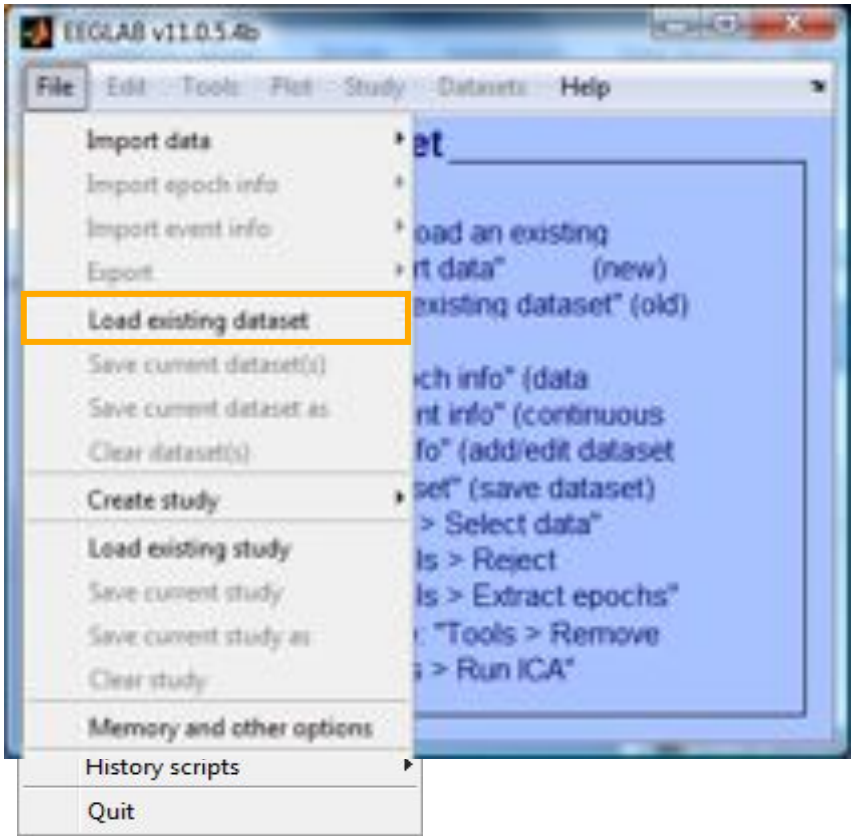
Reject large artifact time points

Run ICA

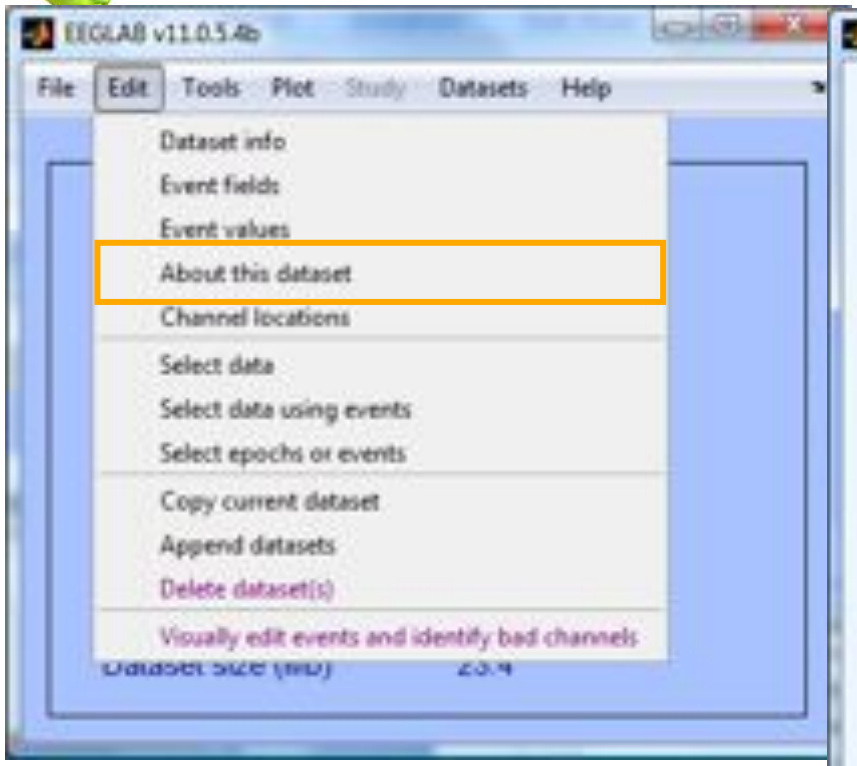
Retrieve or reload continuous EEG dataset

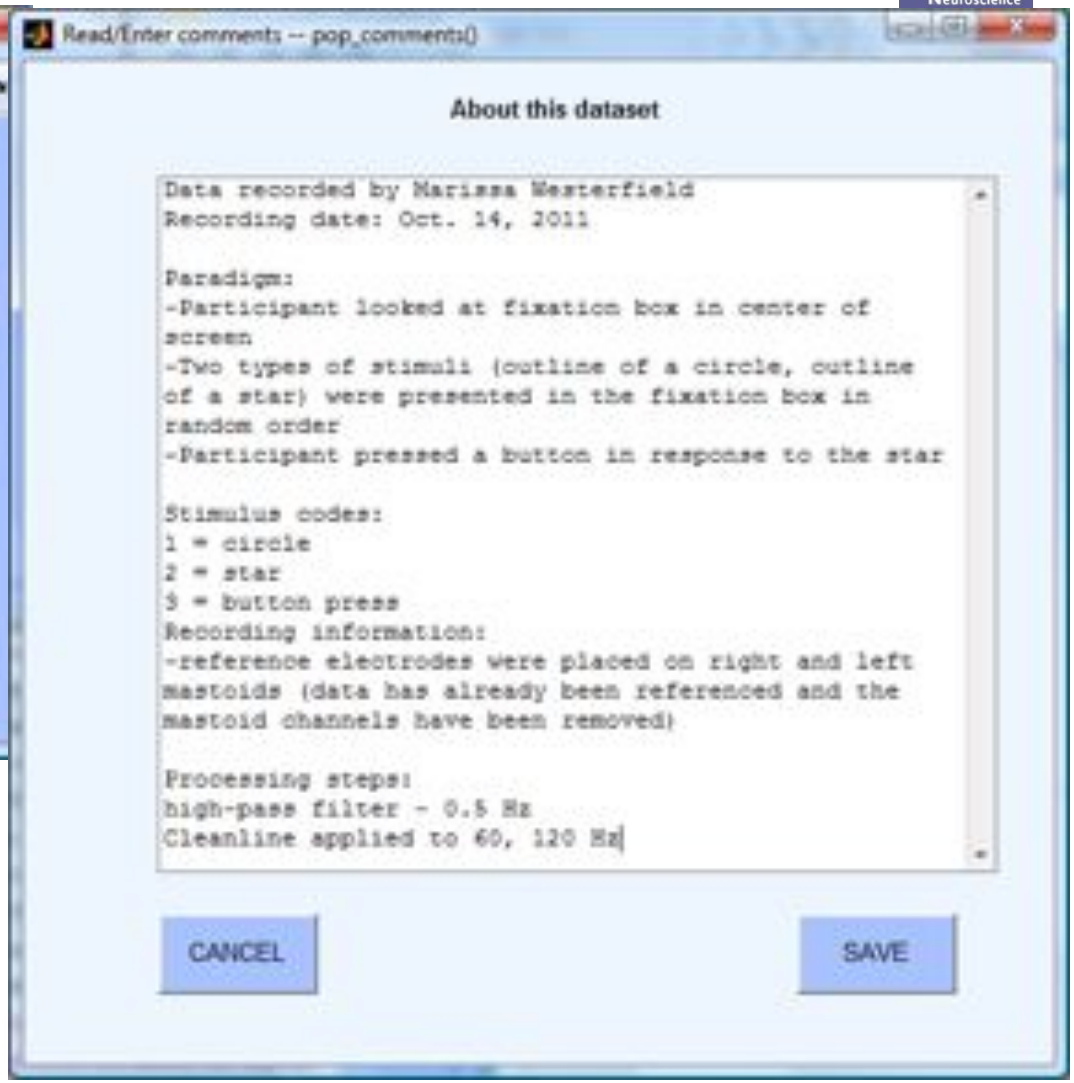






Comments and dataset history

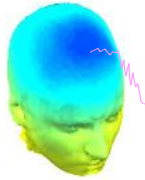


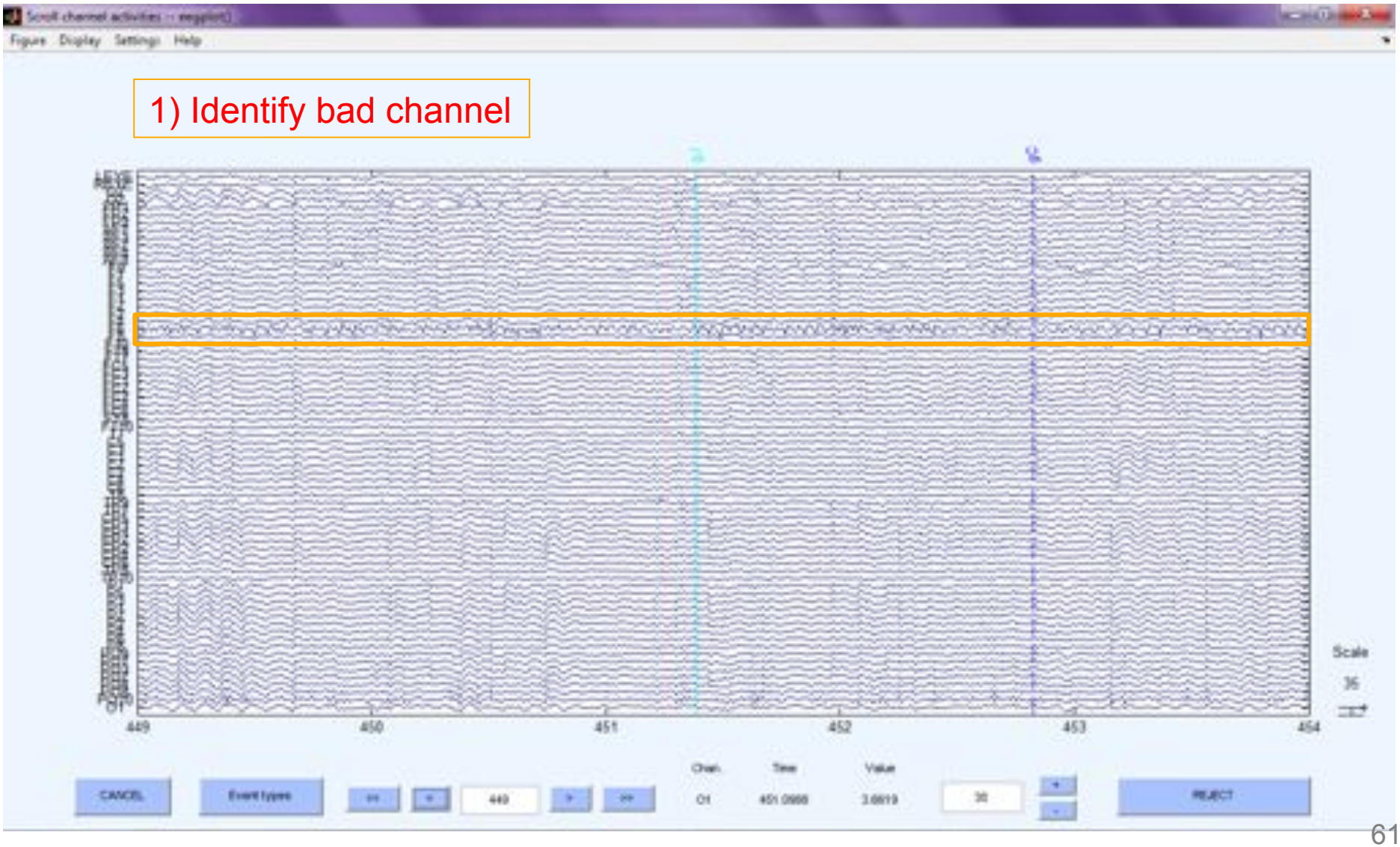


Also:
>> EEG.comments

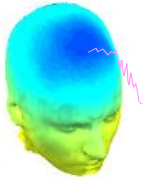
or
>> EEG.history

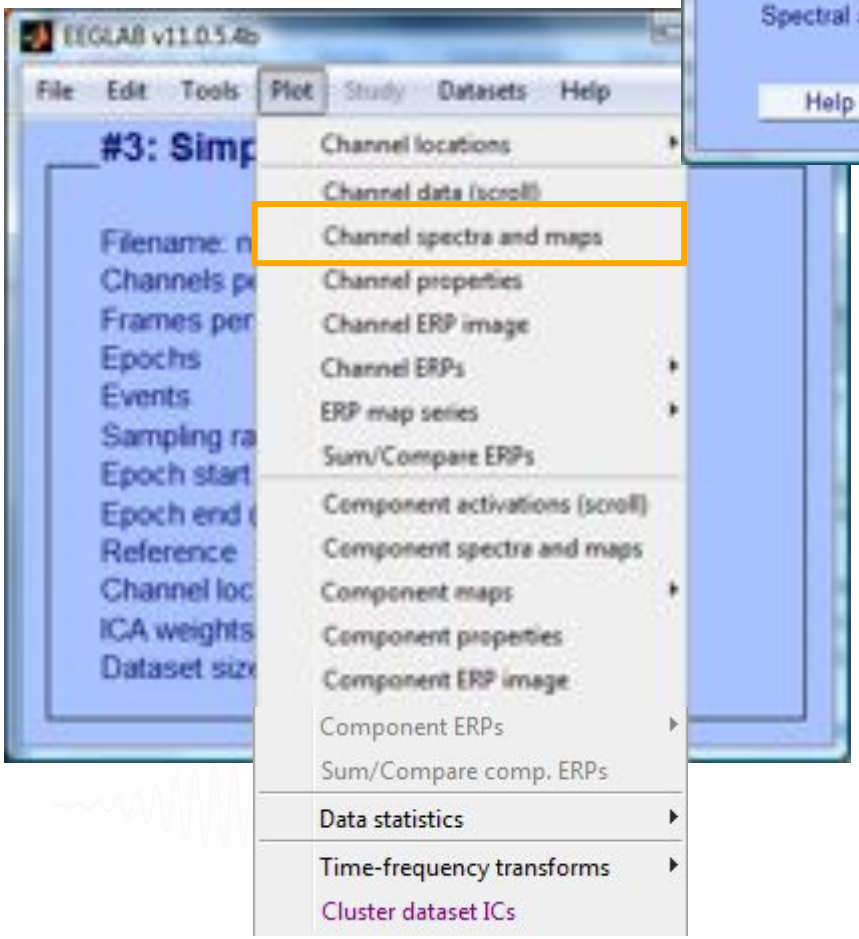
Manually identifying bad channels

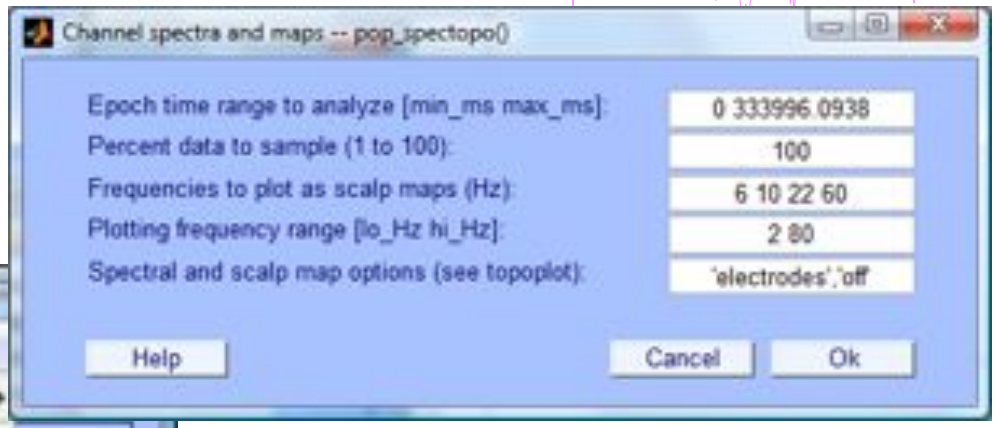


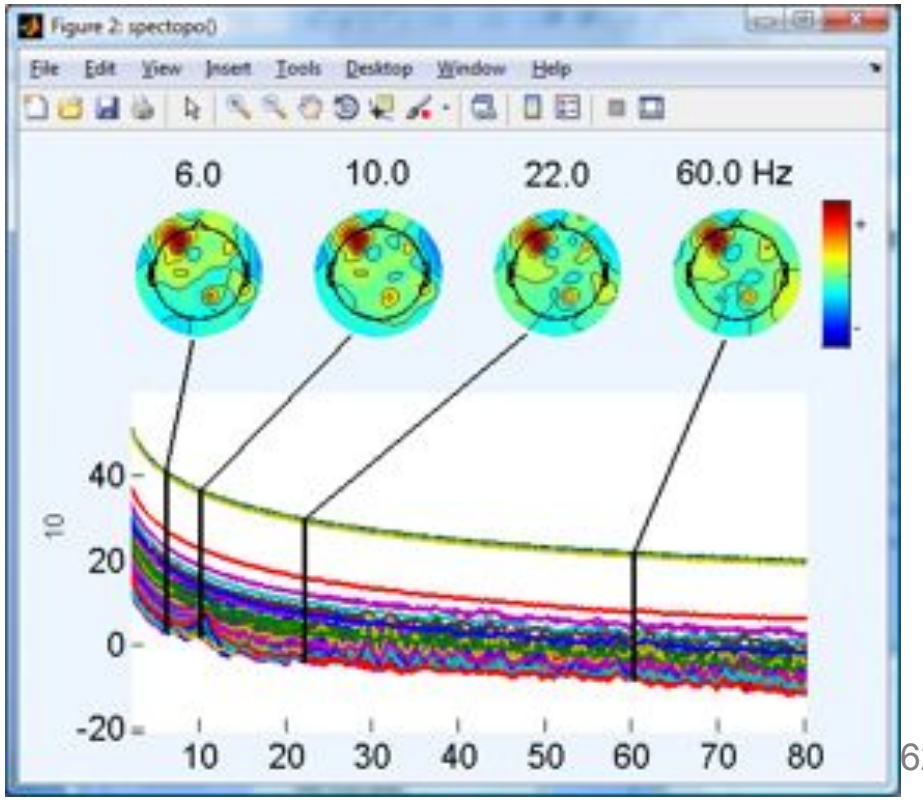


Manually identifying bad channels

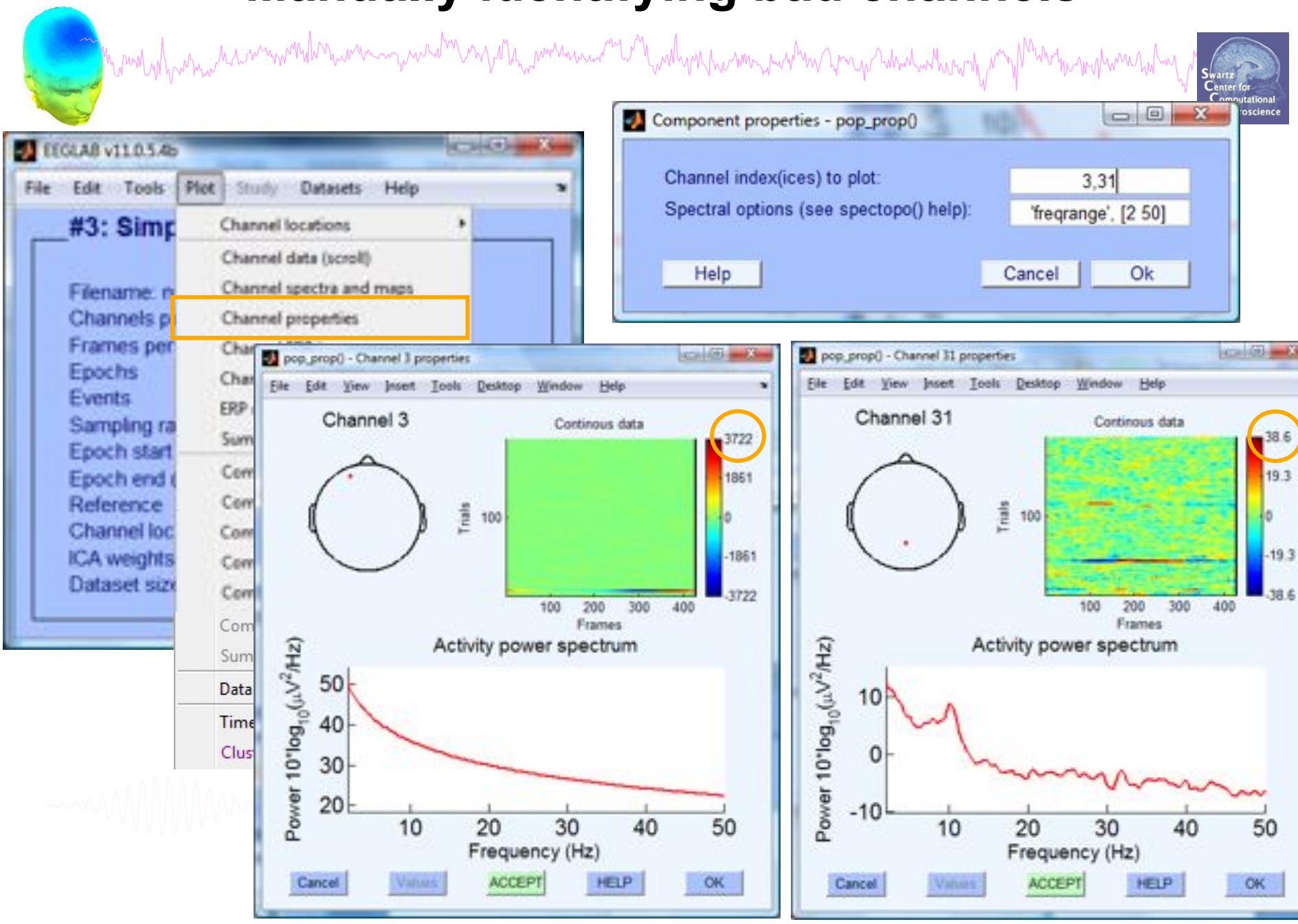






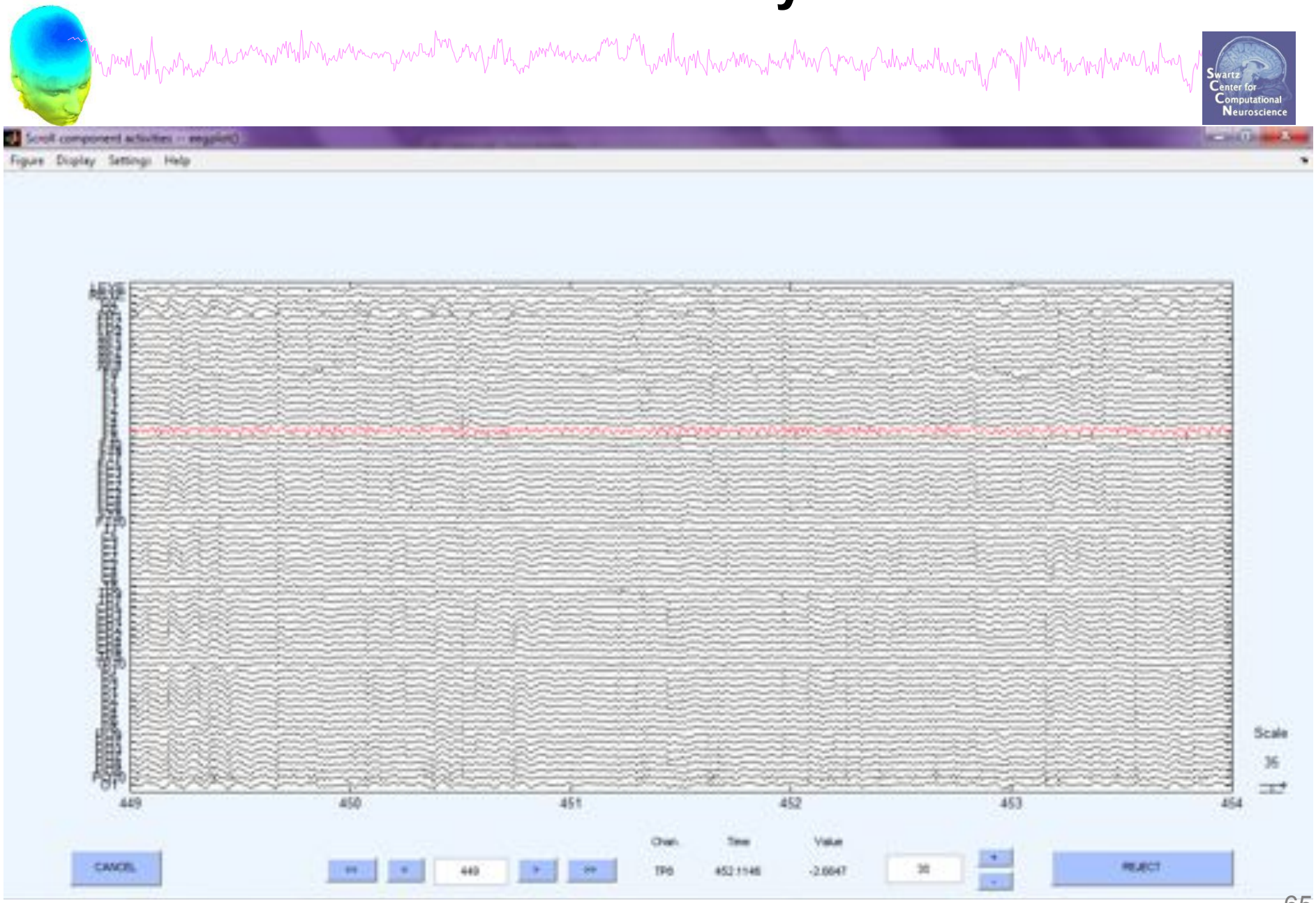


Manually identifying bad channels

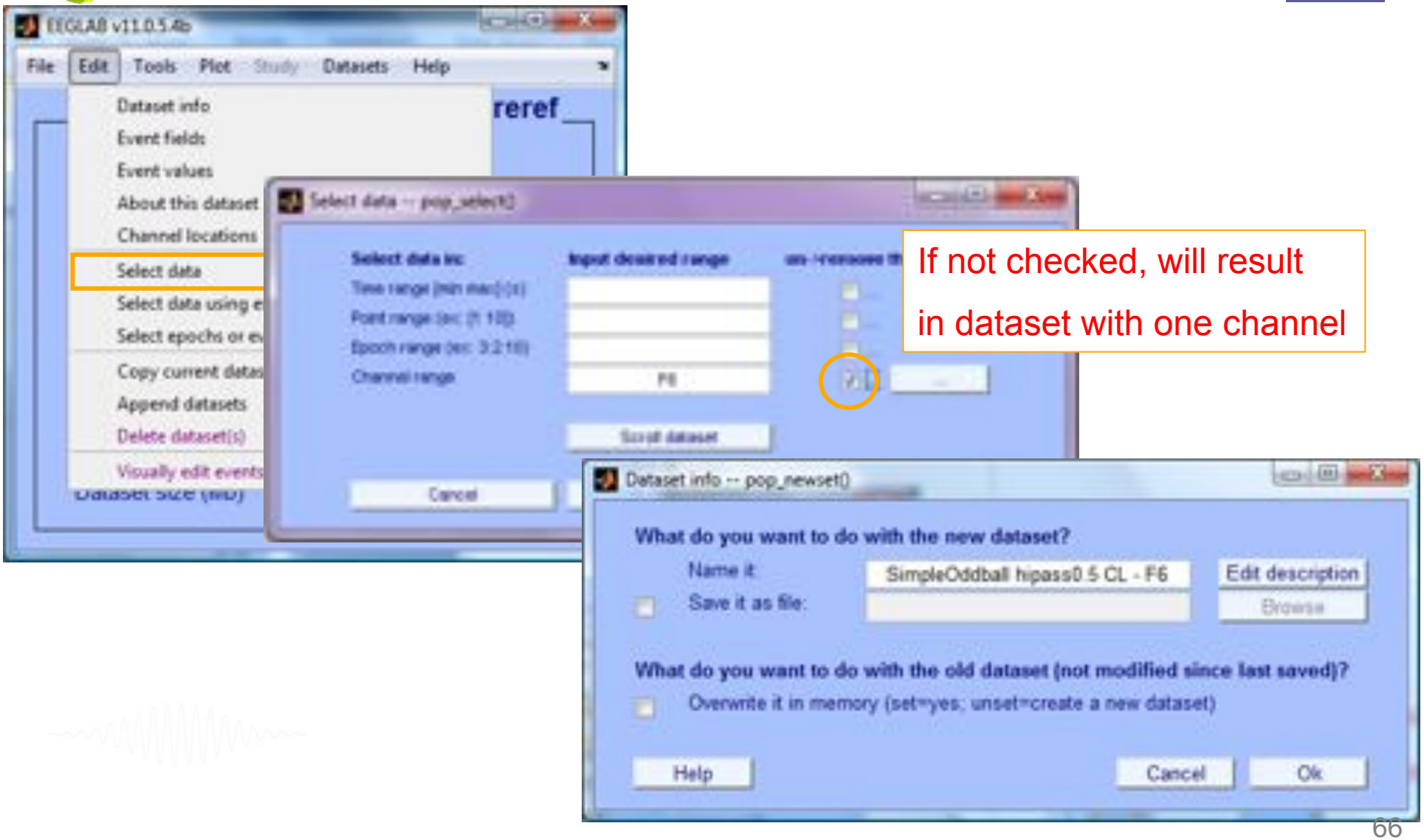


Auto-detection of noisy channels

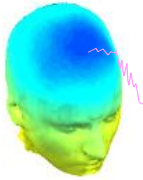
Auto-detected noisy channel



Removing channel(s)

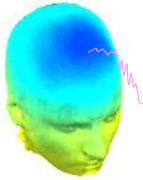


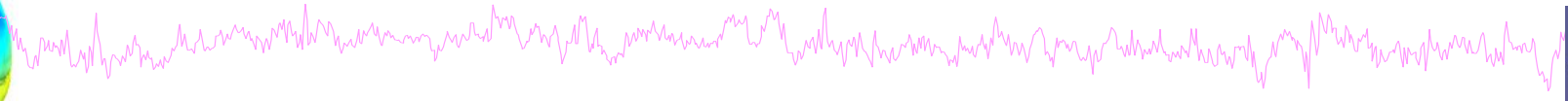
Removing channel(s)



- You may prefer to interpolate bad channels rather than remove them altogether
- The loss in dimensionality will affect the ICA decomposition
- Usual solution:
  - Delete the bad channels before running ICA
  - STUDY tools will do much of this automatically (interpolate missing channels, etc)

Pre-processing pipeline





Swartz Center for Computational Neuroscience

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

High pass filter (~.5 – 1 Hz)

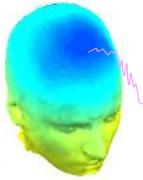
Remove line noise (if necessary)

Identify/reject bad channels

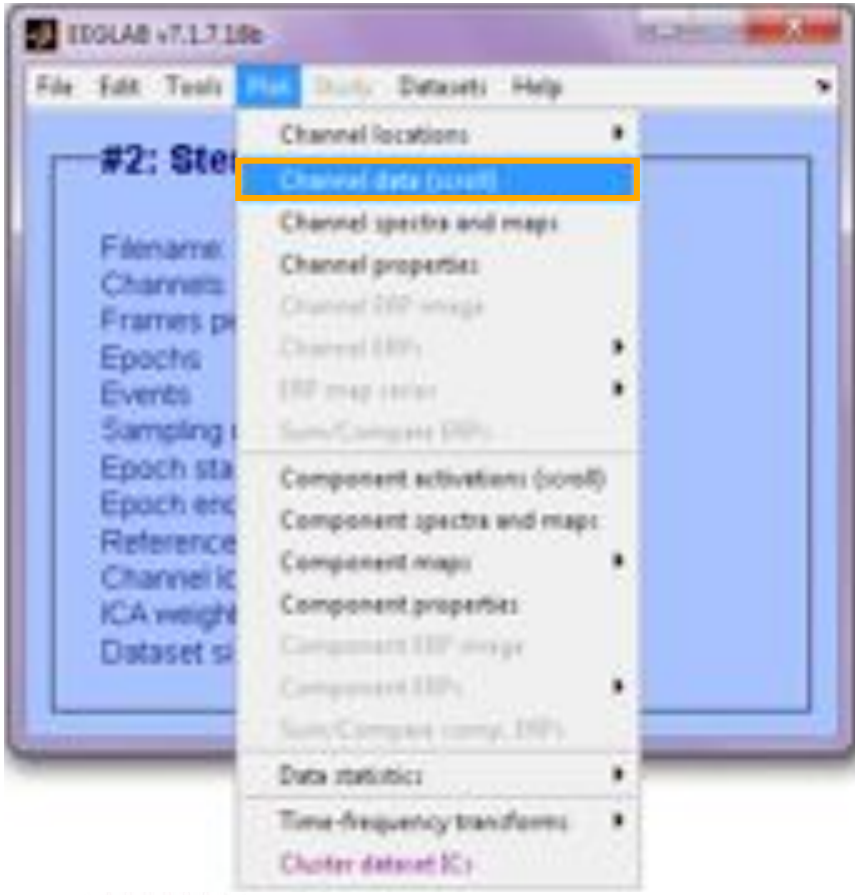
Reject large artifact time points

Run ICA

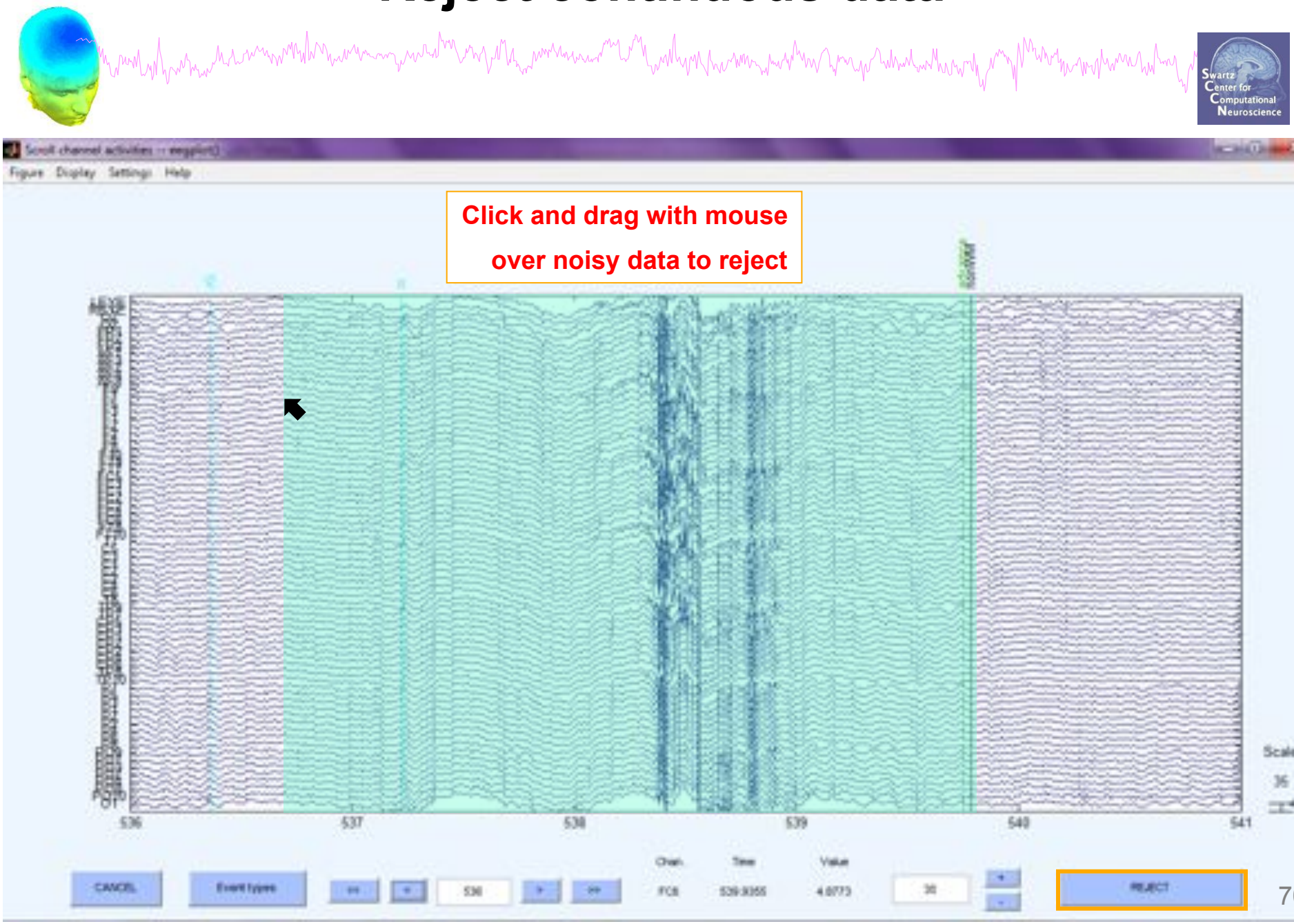
Reject continuous data



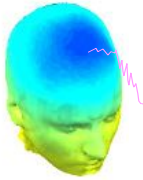
Equivalent

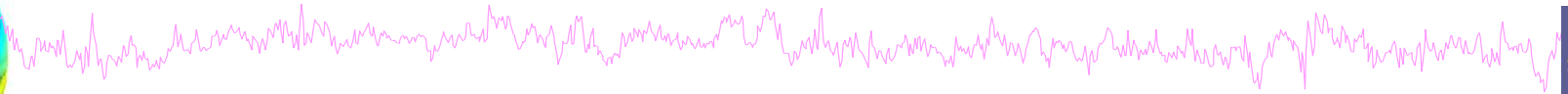


Reject continuous data



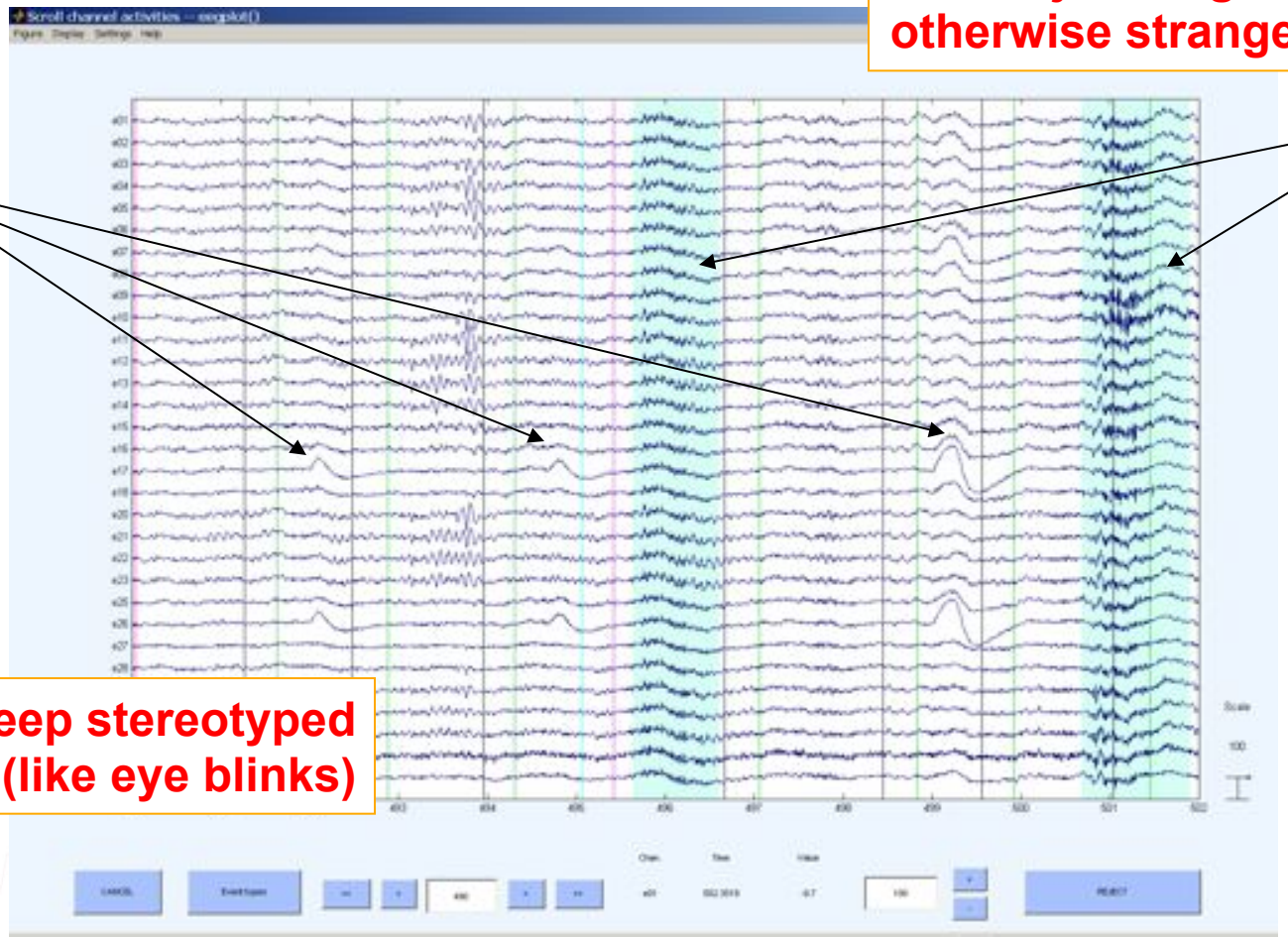
Rejecting data for ICA





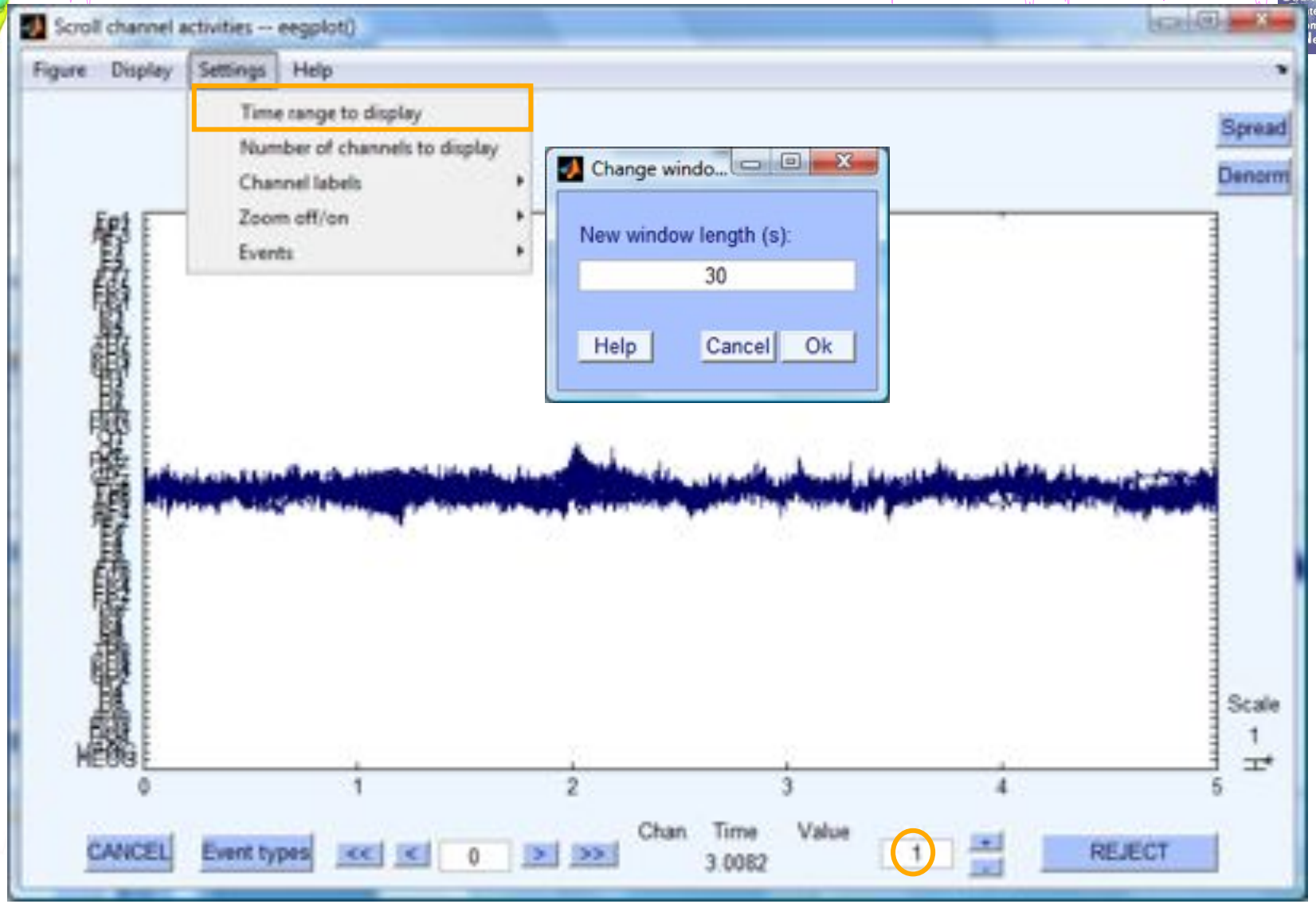
To prepare data for ICA:

Reject large muscle or otherwise strange events...

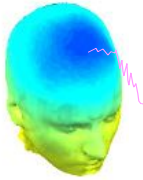


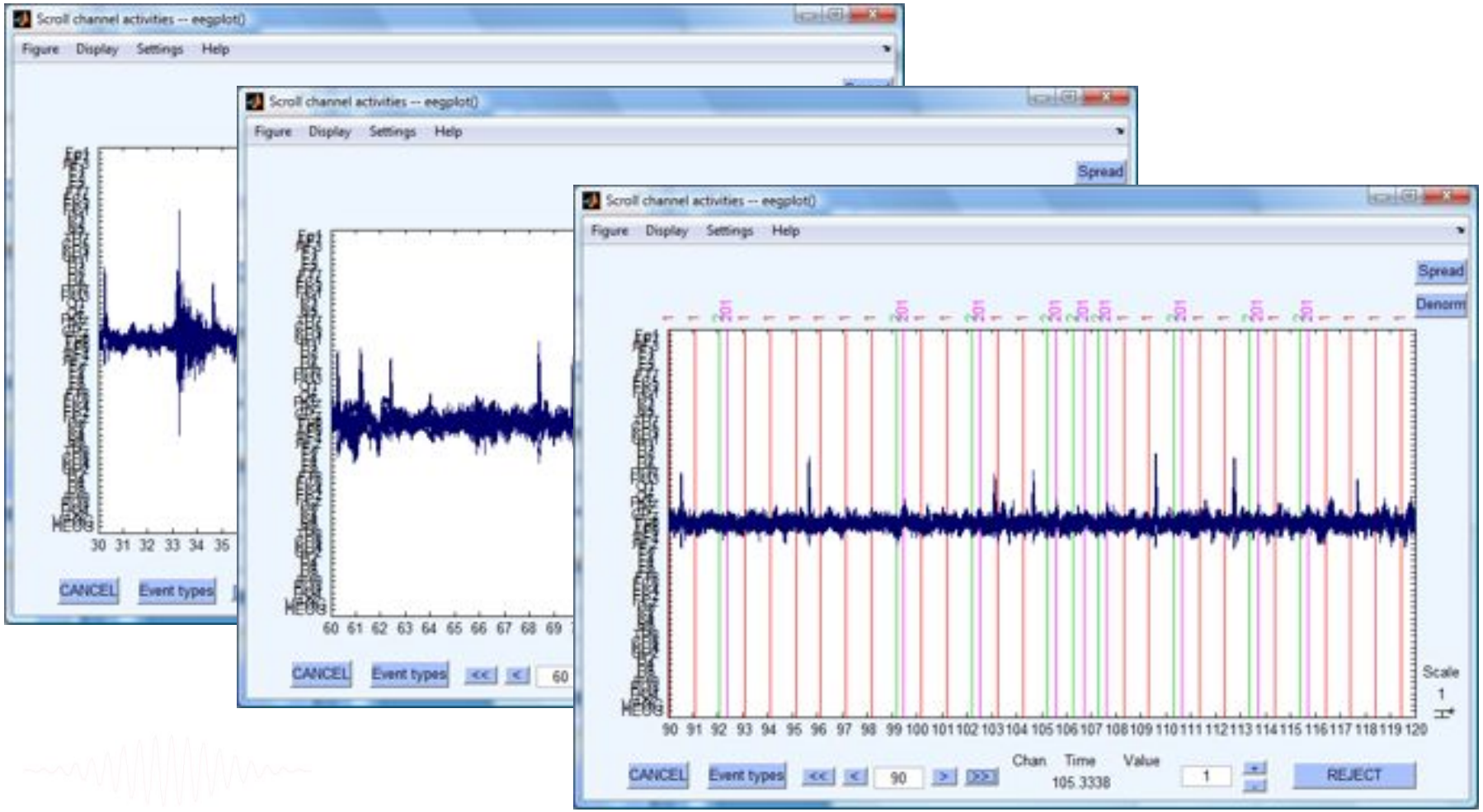
... but keep stereotyped artifacts (like eye blinks)

Fast (but sloppy) artifact rejection

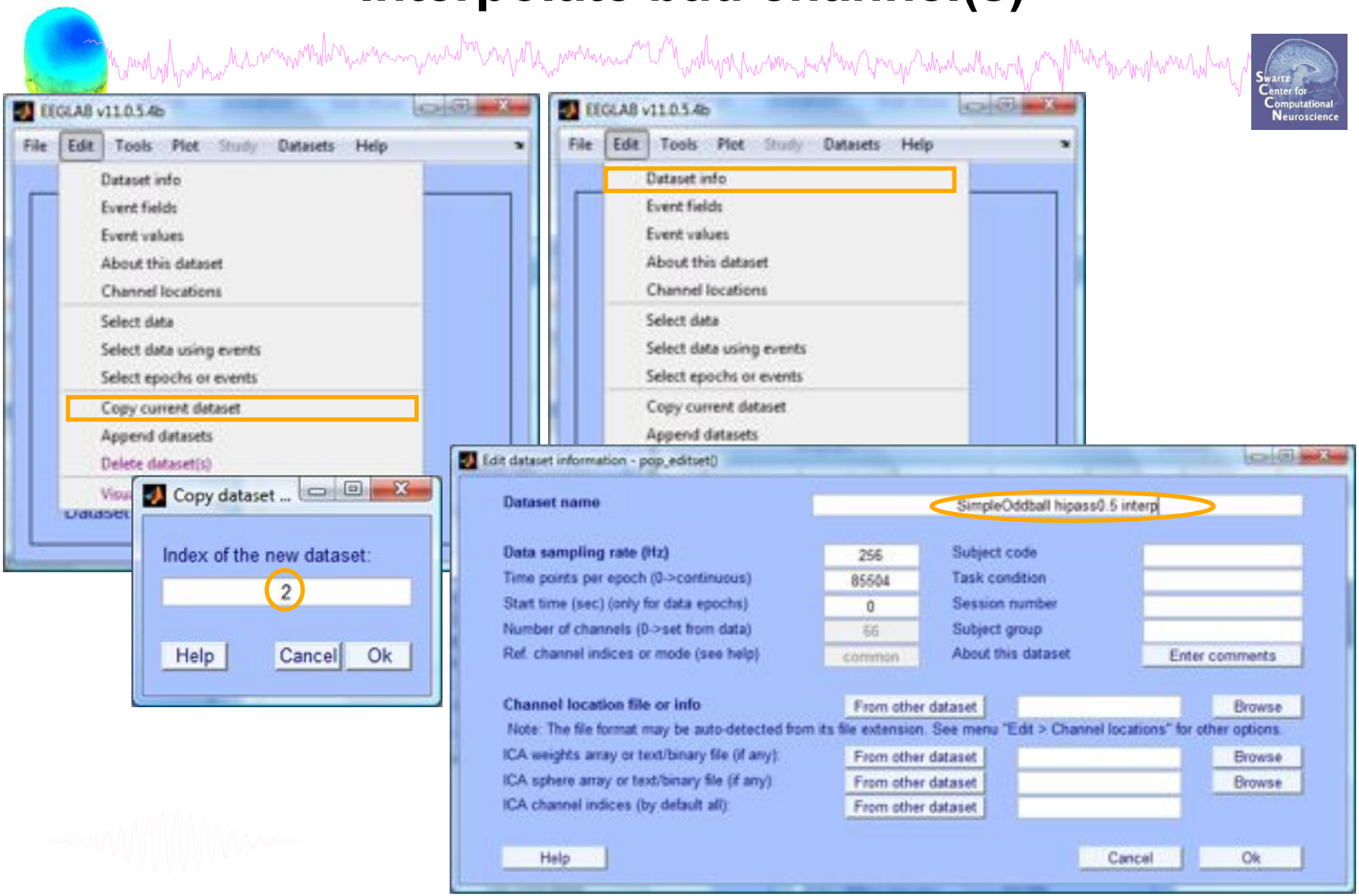


Fast (but sometimes sloppy) artifact rejection

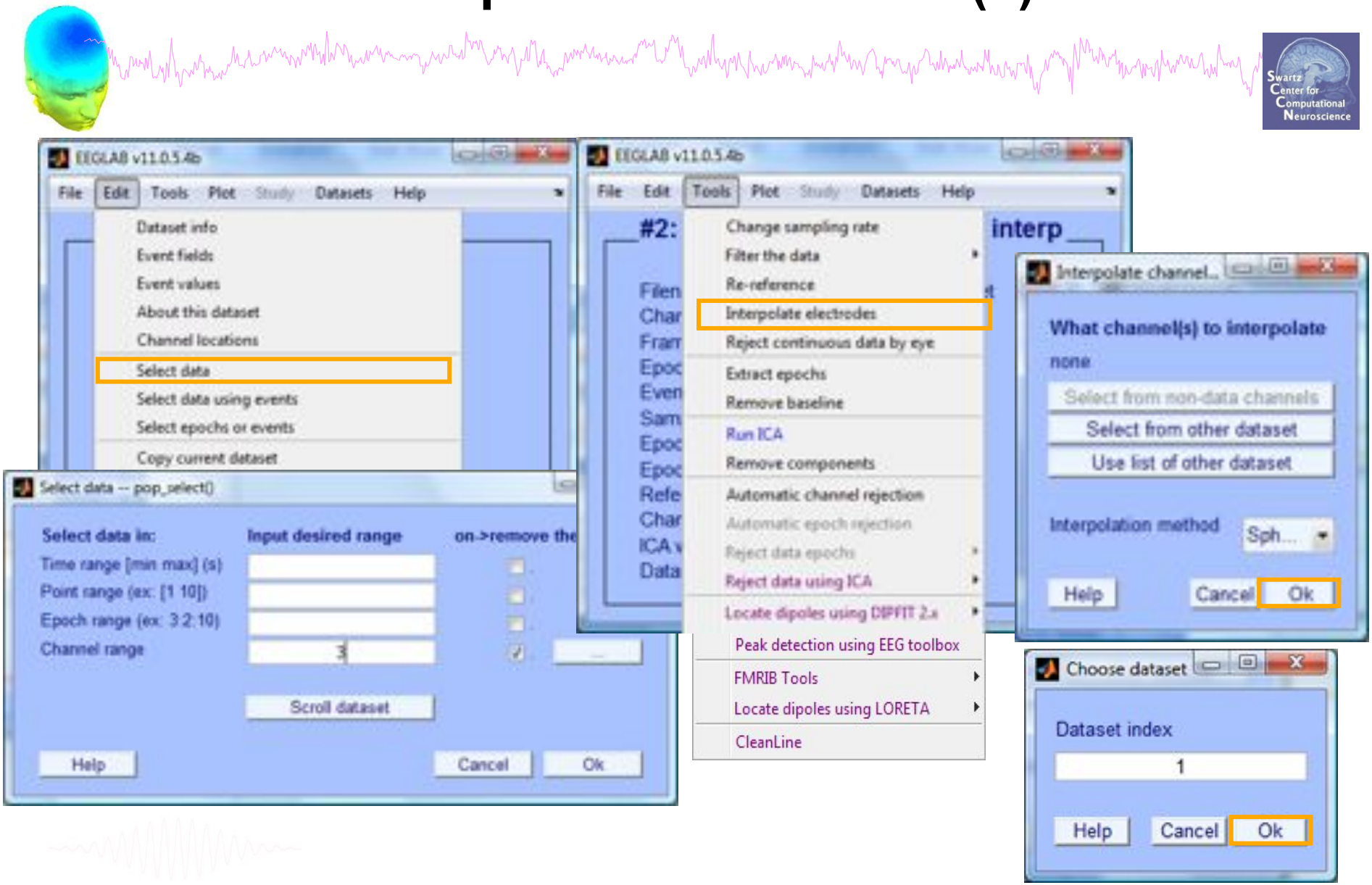




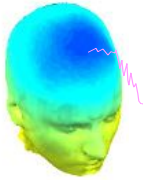
Interpolate bad channel(s)



Interpolate bad channel(s)

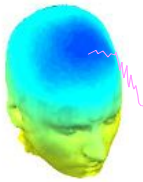


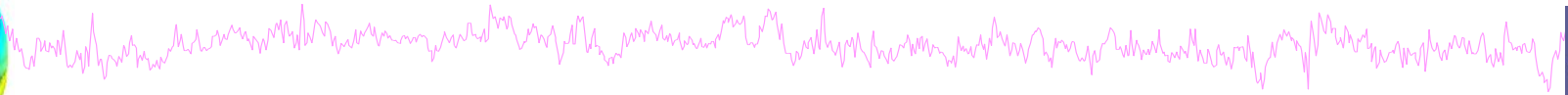
Exercises



- Load a previously filtered version of SimpleOddball.set
- Identify bad channel(s) using auto-detection tool; plot channel properties of flagged channels
- Identify and remove non-task portions of continuous data; see if the previously flagged channels are still identified as bad
- Scroll the epoched data and perform visual rejection of epochs
- Explore the automated artifact rejection tools

Pre-processing pipeline





Swartz Center for Computational Neuroscience

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

High pass filter (~.5 – 1 Hz)

Remove line noise (if necessary)

Identify/reject bad channels

Reject large artifact time points

Run ICA