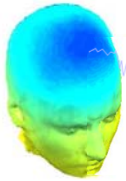


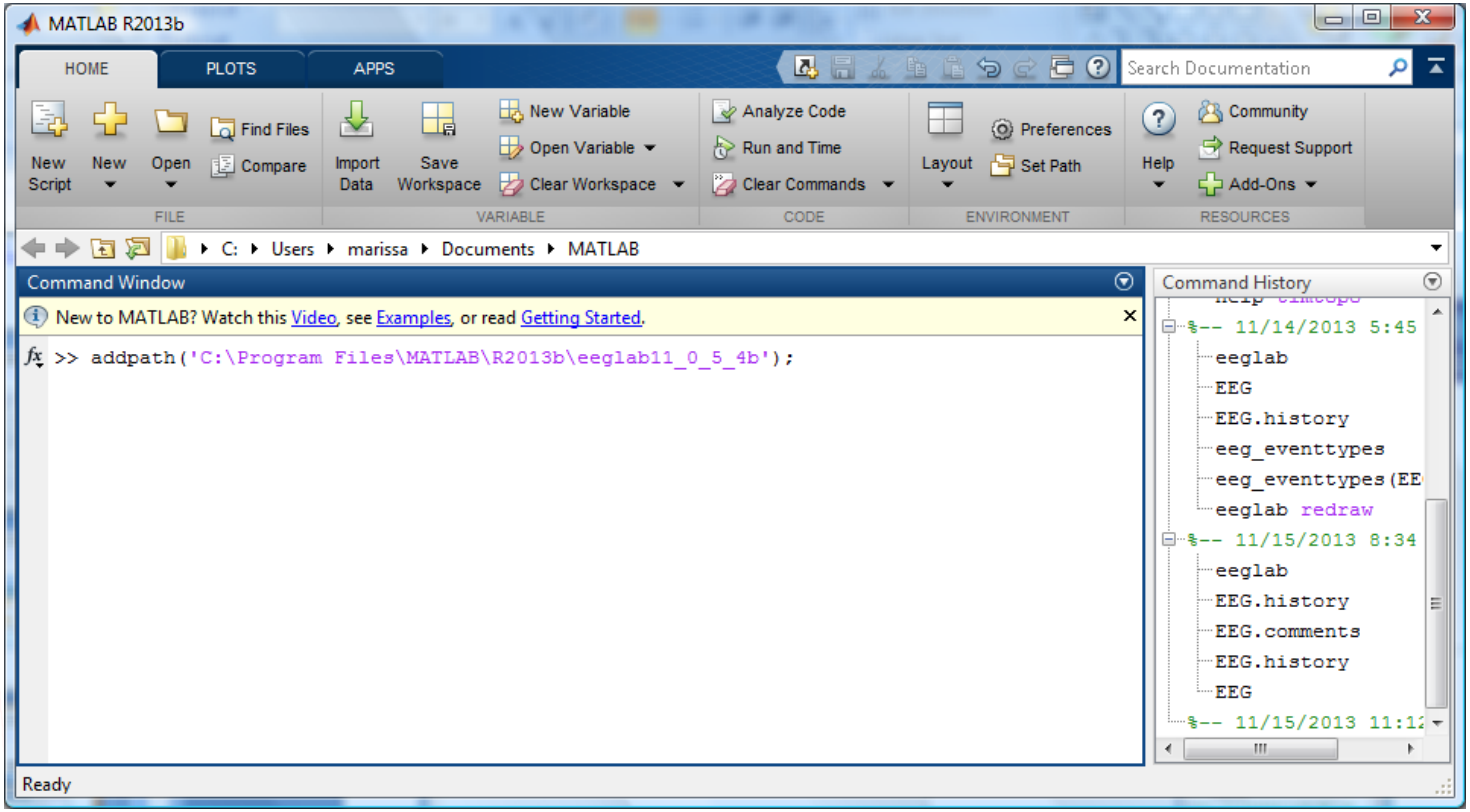
EEGLAB Processing

Data import

Basic ERP visualization

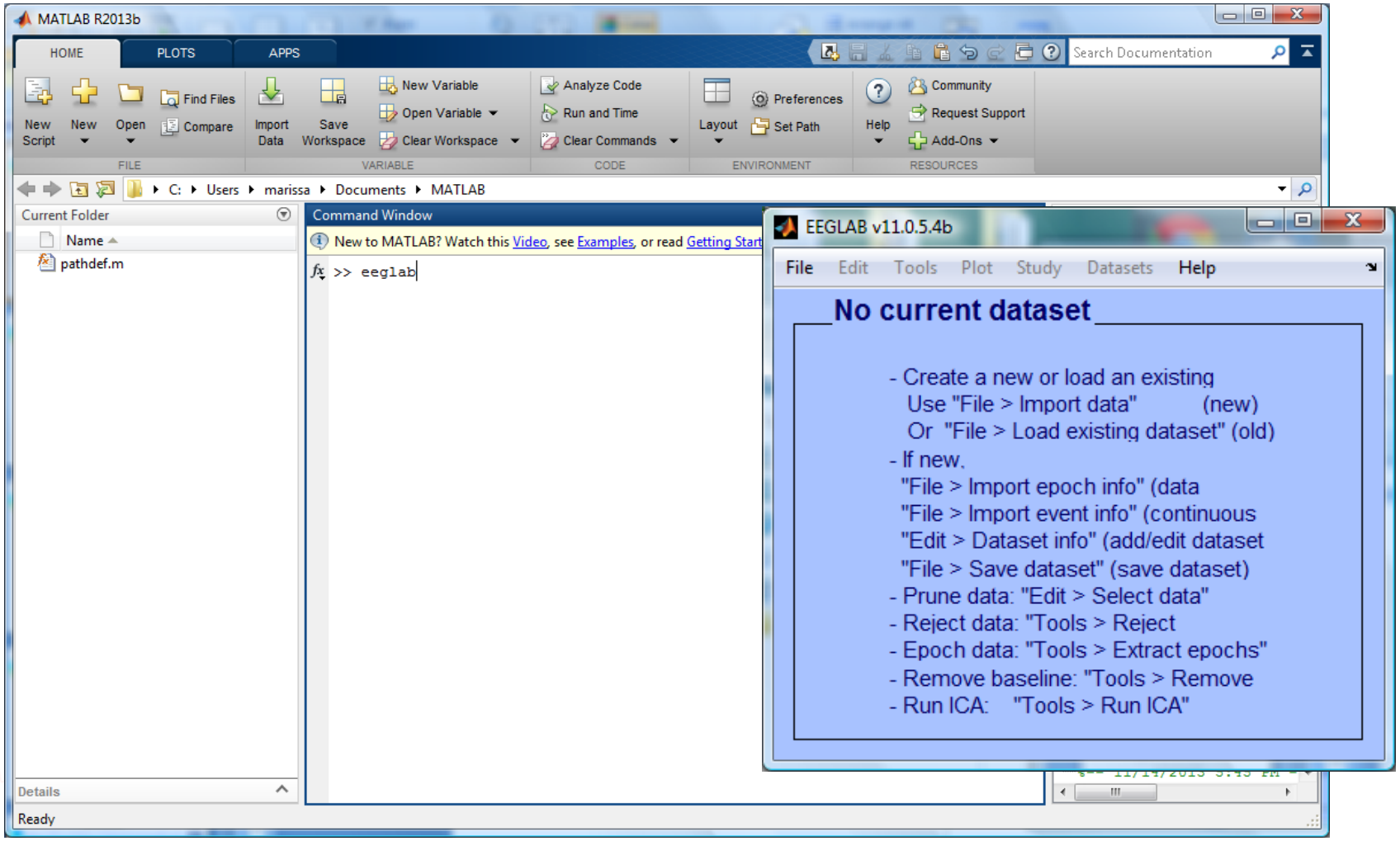
Installing EEGLAB and data folder

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

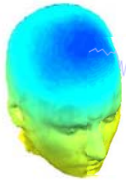


The EEGLAB Matlab software

main graphic interface



Pre-processing pipeline



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)

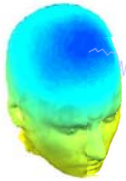
Examine raw data

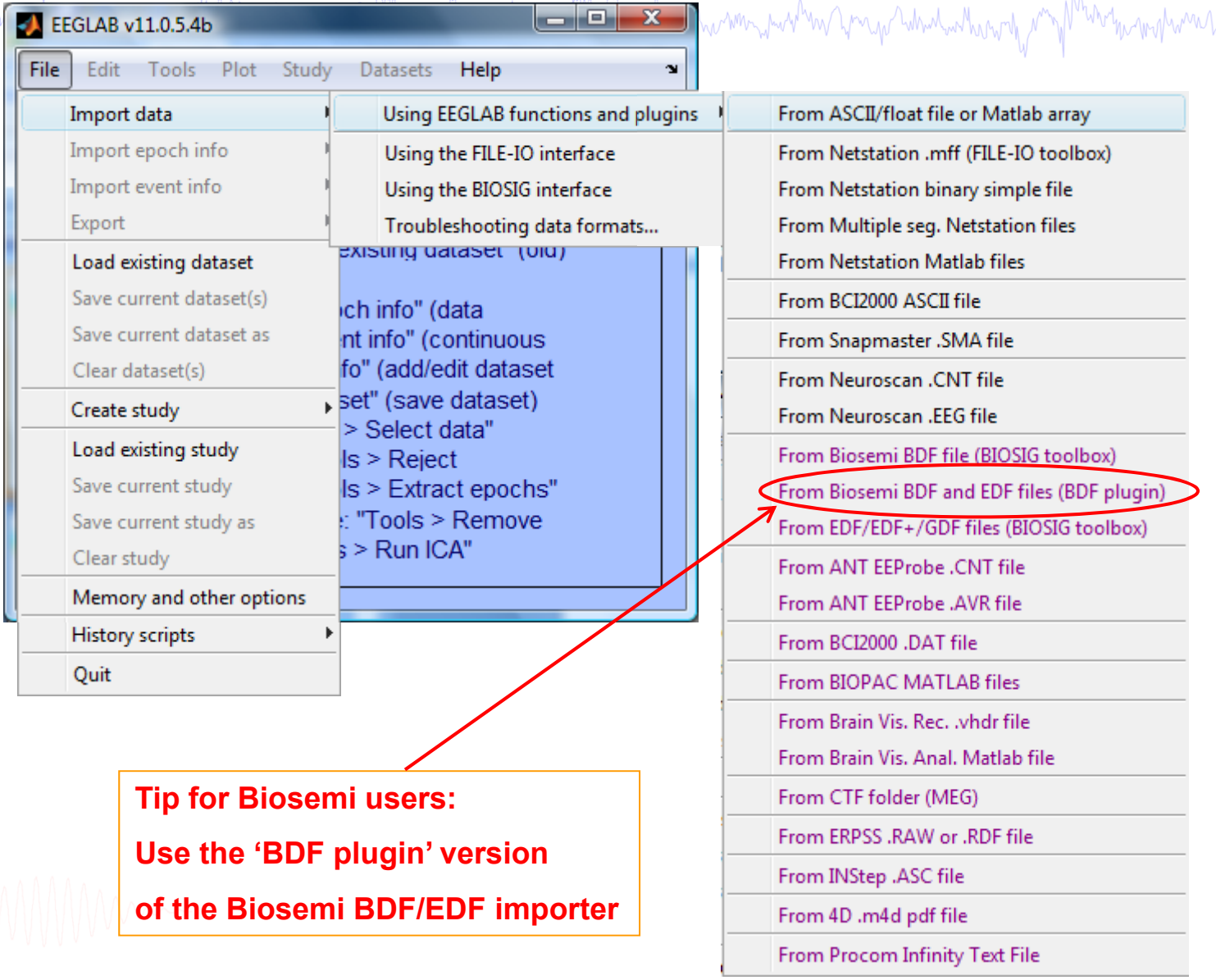
Identify/reject bad channels

Reject large artifact time points

Run ICA
(next talk)

Importing a dataset



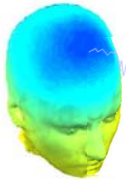


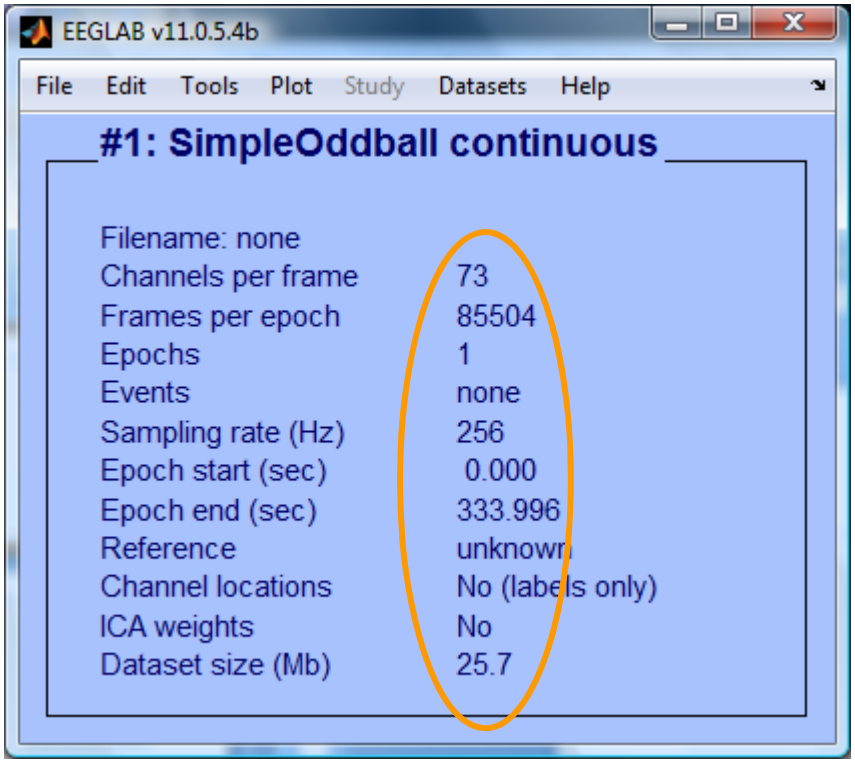
Tip for Biosemi users:

Use the 'BDF plugin' version

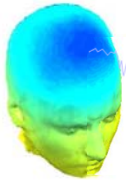
of the Biosemi BDF/EDF importer

Imported EEG data





Pre-processing pipeline



Collect high-density EEG data (>30 chan)

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Import event markers and channel locations

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High pass filter (~.5 – 1 Hz)

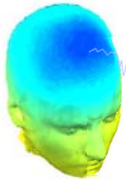
Remove line noise (if necessary)

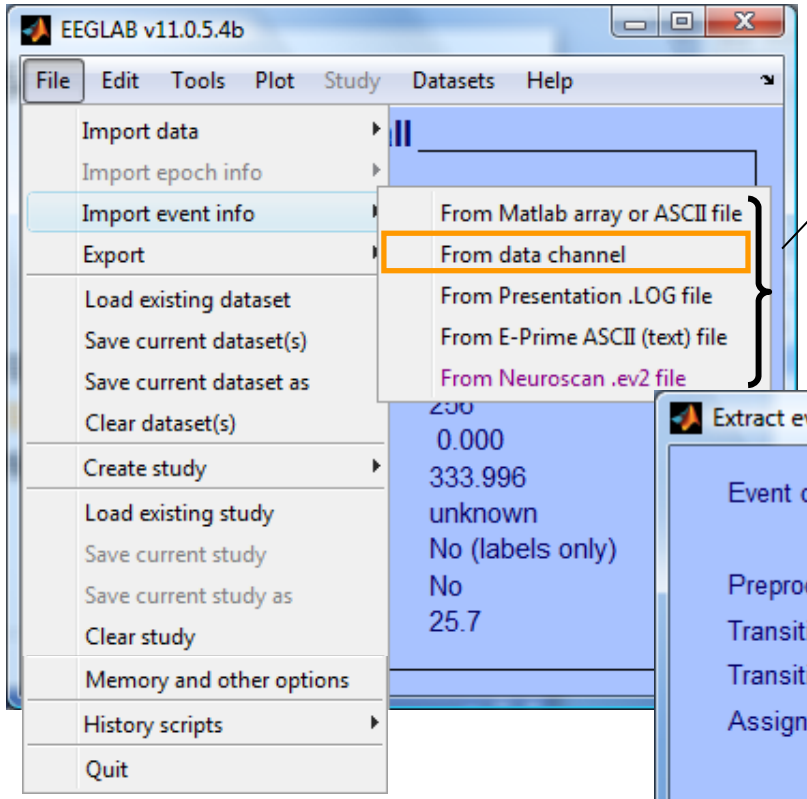
Identify/reject bad channels

Reject large artifact time points

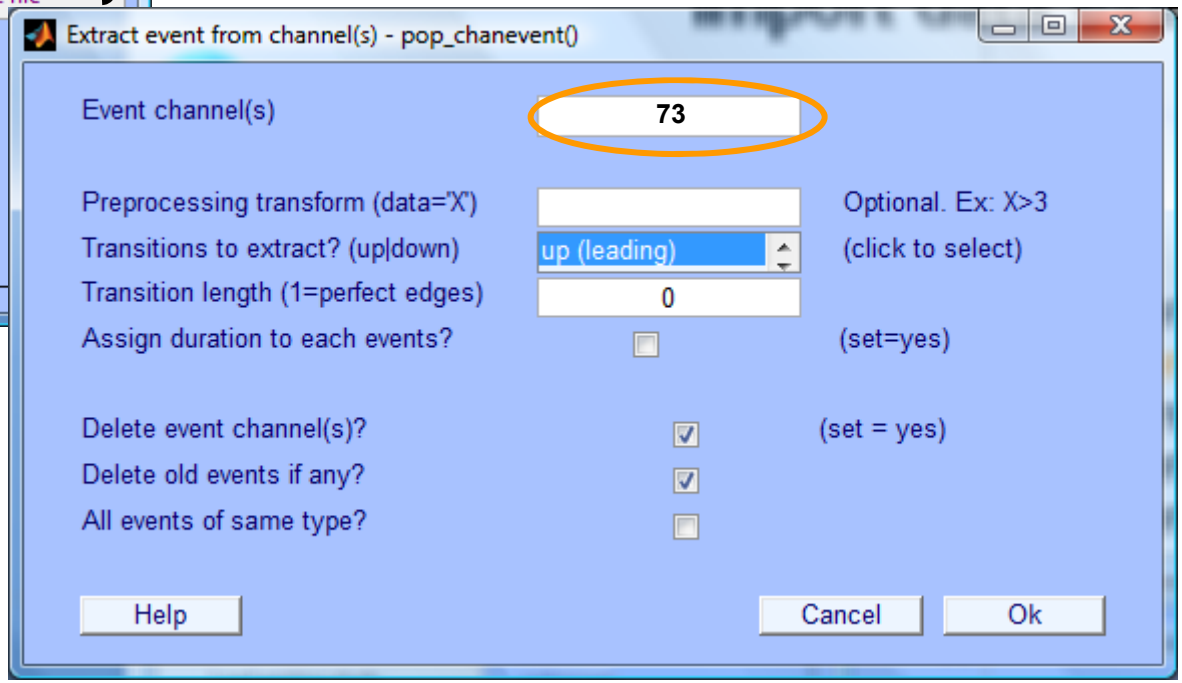
Run ICA
(next talk)

Import data events



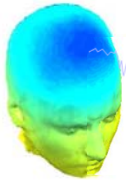


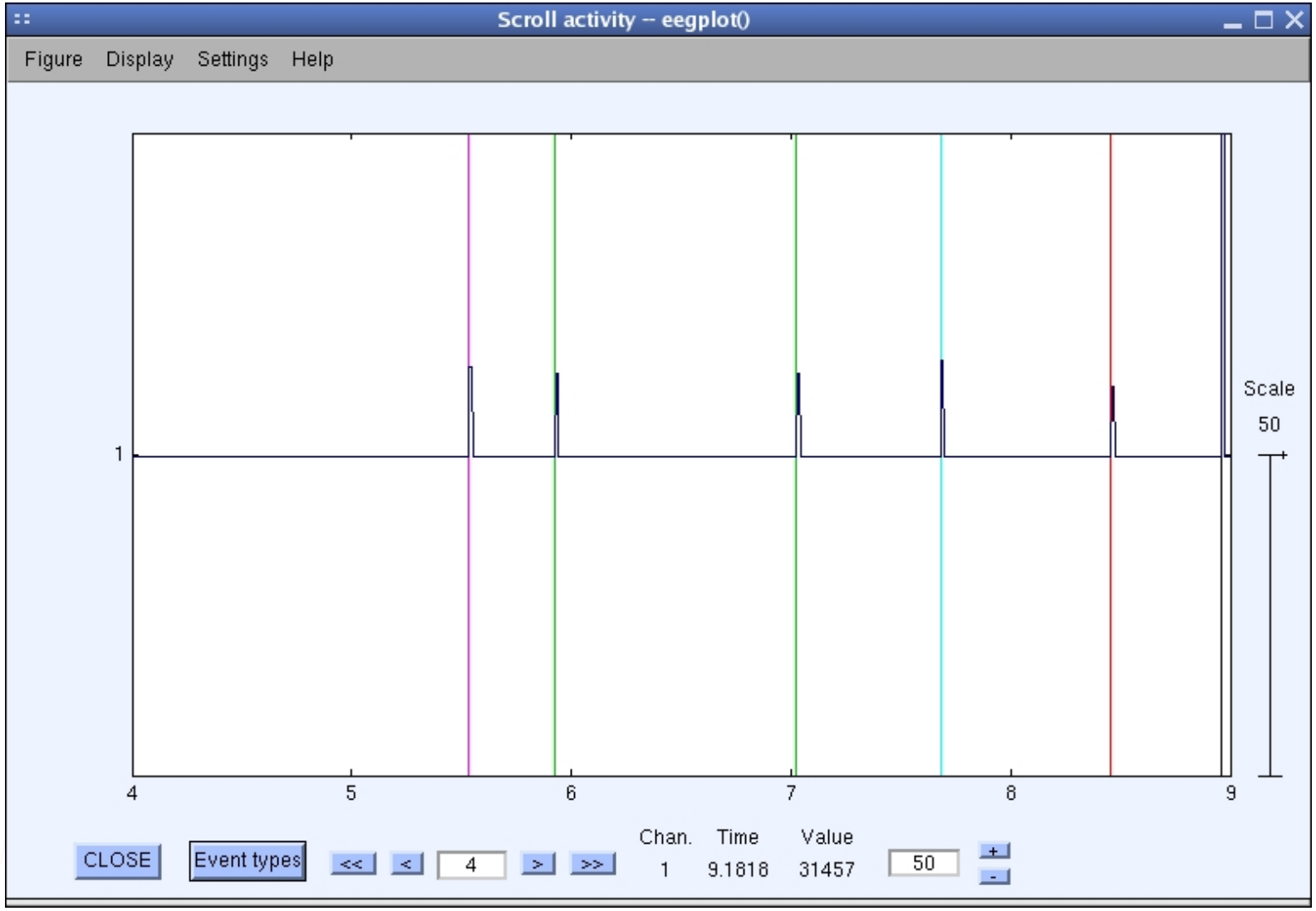
- Import events from Matlab array or ASCII file
- Import events from data channel
- Import from Presentation event file
- Import events from E-Prime event file
- Import events from Neuroscan event file



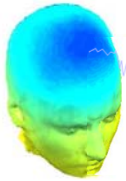
(Often imported automatically during data import)

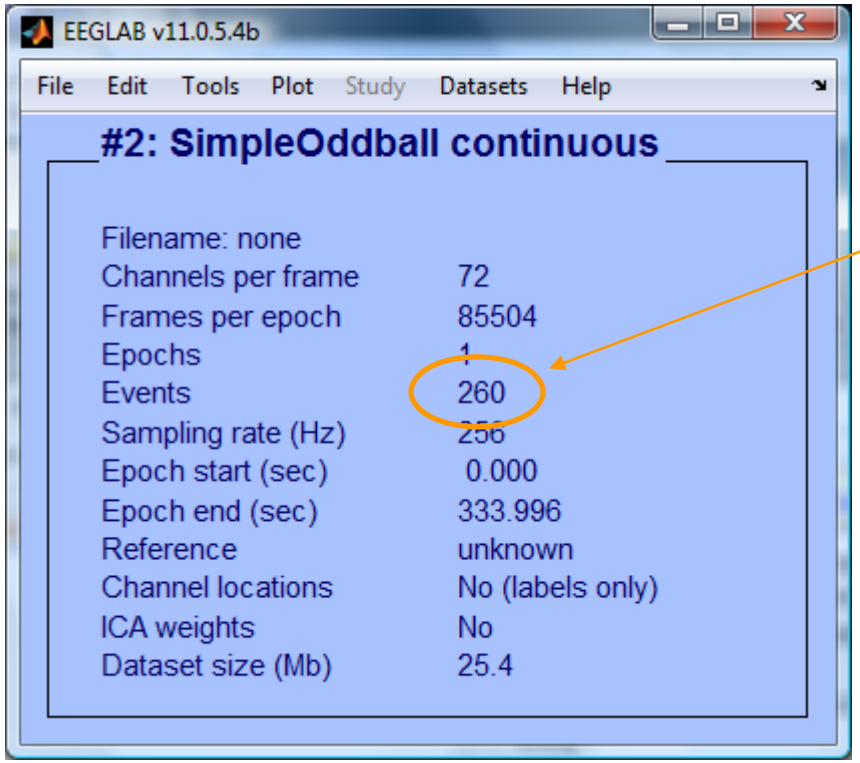
Appearance of an event channel in raw data





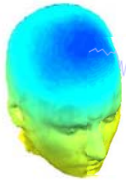
Imported data events





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

Sample data: basic P300 paradigm



File

SimpleOddball.set

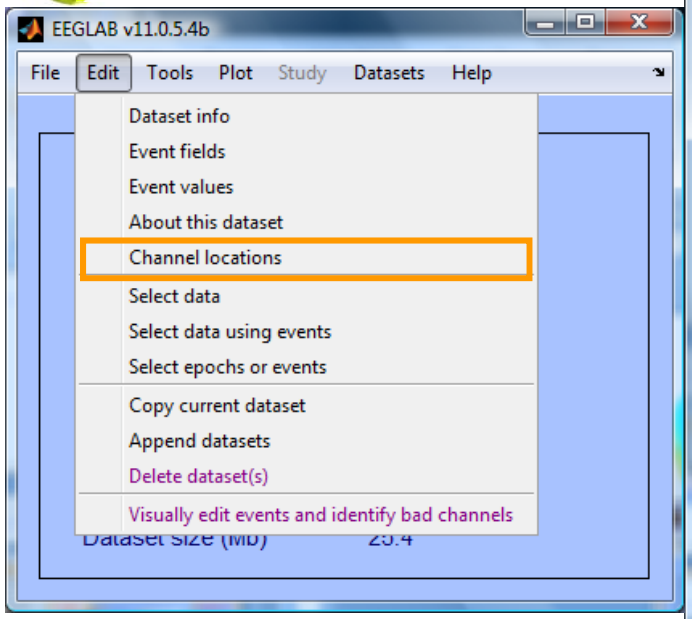
Data

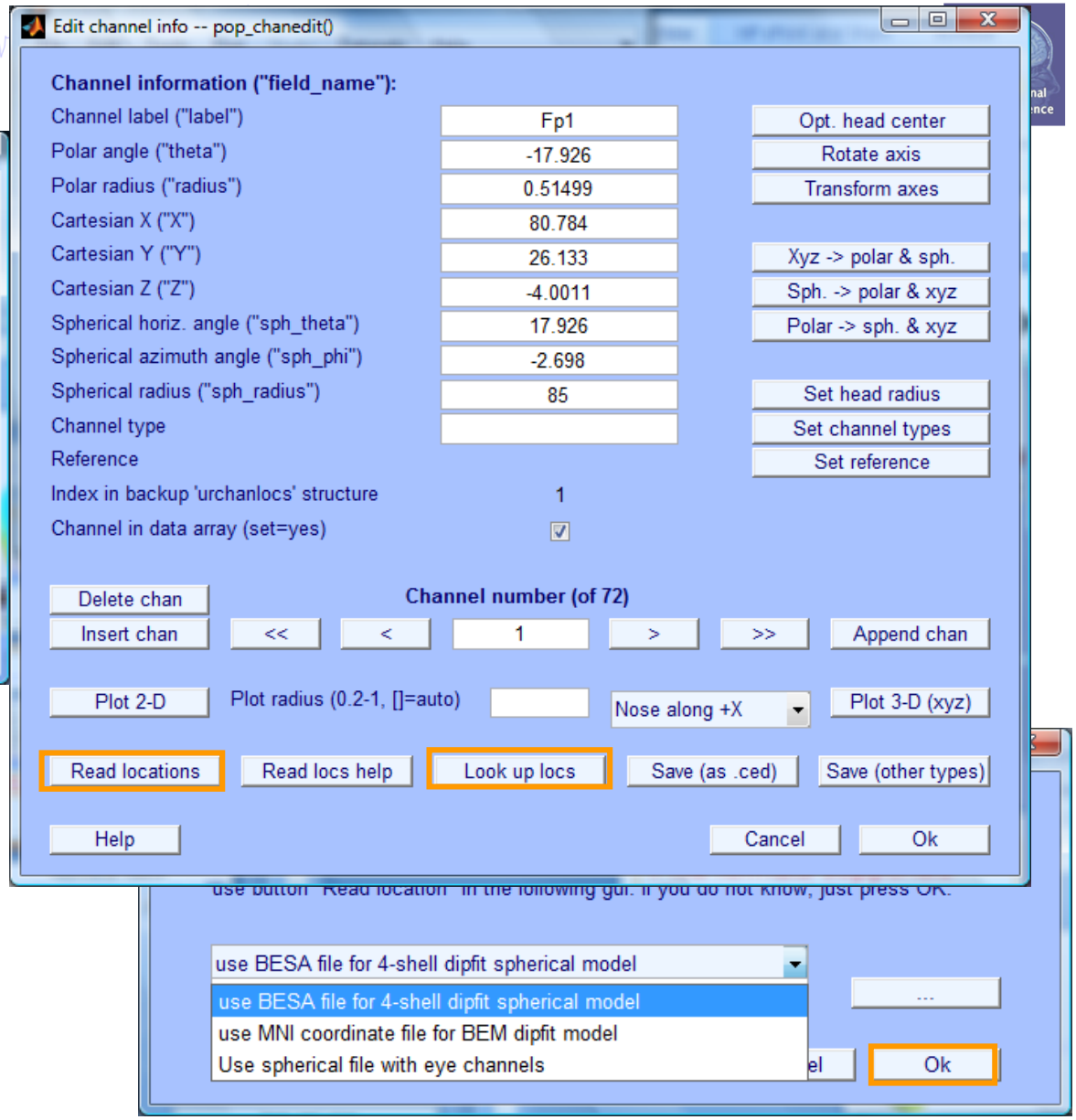
68 channel EEG, 256 Hz sampling rate, Biosemi system, re-referenced during import to averaged left and right mastoid electrodes

Task

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

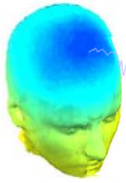
Import channel locations

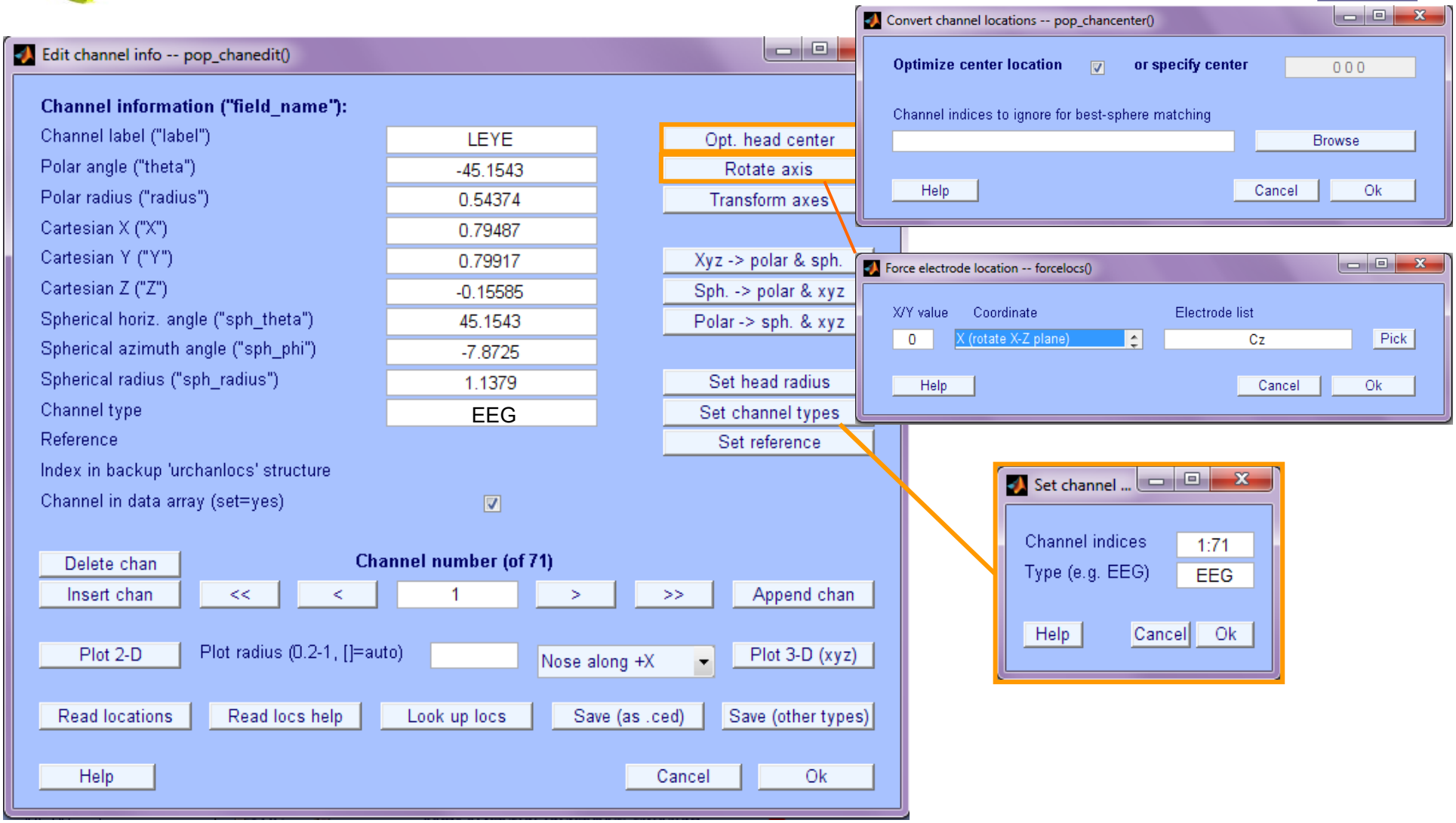


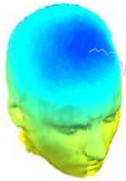


7 file formats supported (Polhemus, BESA, …)

Import channel locations







Edit channel info -- pop_chanedit()

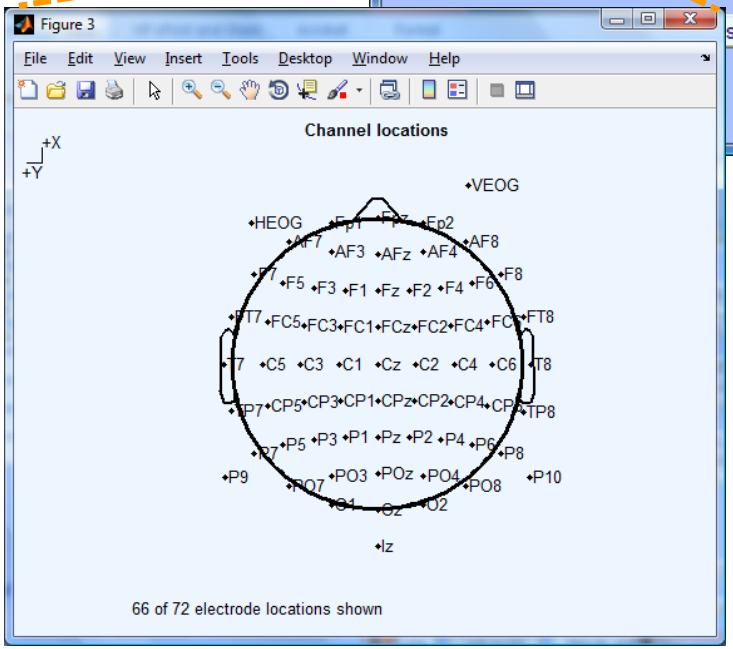
Channel information ("field_name"):

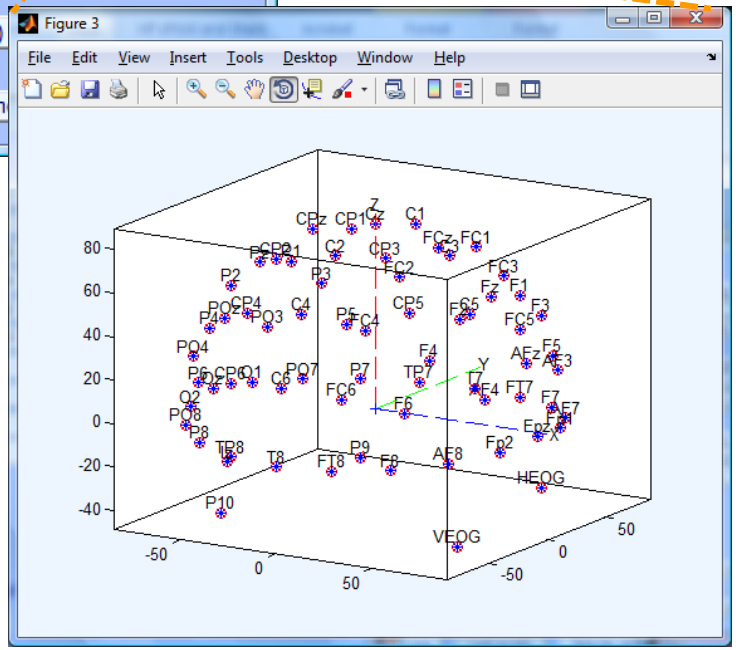
Channel label ("label")	HEOG	Opt. head center
Polar angle ("theta")	-42	Rotate axis
Polar radius ("radius")	0.65556	Transform axes
Cartesian X ("X")	55.7734	
Cartesian Y ("Y")	50.2186	Xyz -> polar & sph.
Cartesian Z ("Z")	-39.9051	Sph. -> polar & xyz
Spherical horiz. angle ("sph_theta")	42	Polar -> sph. & xyz
Spherical azimuth angle ("sph_phi")	-28	
Spherical radius ("sph_radius")	85	Set head radius
Channel type		Set channel types
Reference		Set reference
Index in backup 'urchanlocs' structure	68	
Channel in data array (set=yes)	☑	

Delete chan | Insert chan | **Channel number (of 72)** | << | < | 68 | > | >> | Append chan

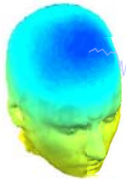
Plot 2-D | Plot radius (0.2-1, []=auto) | | Nose along +X | Plot 3-D (xyz)

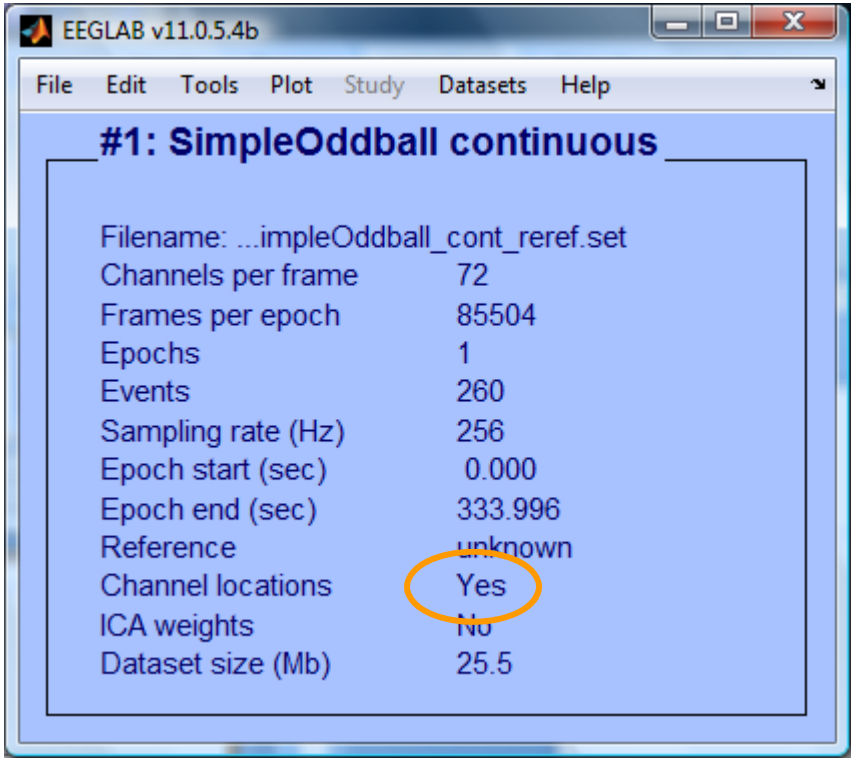
s help | Look up locs | Save (as .ced) | Can



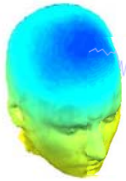


Imported channel locations





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)

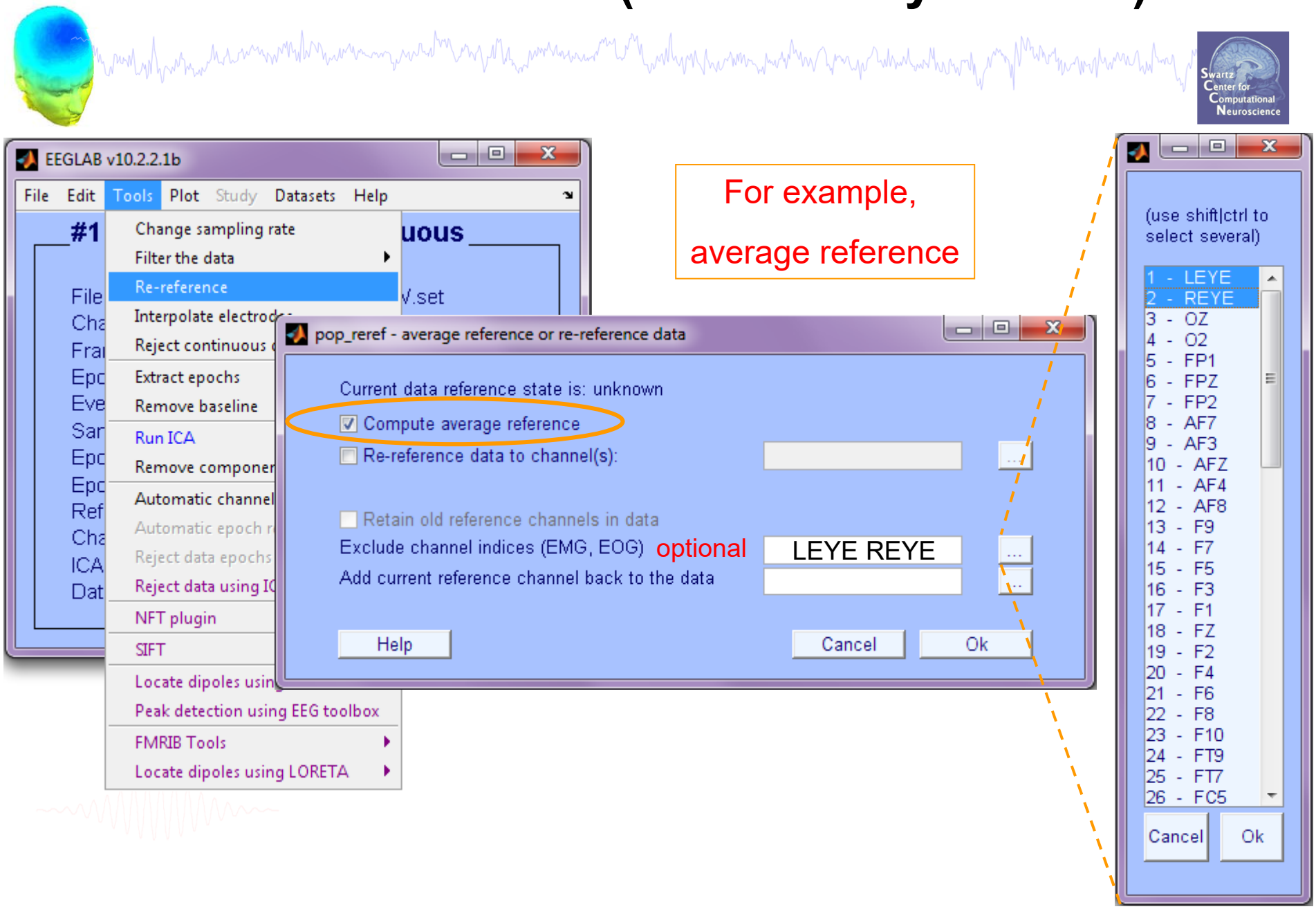
Remove line noise (if necessary)

Identify/reject bad channels

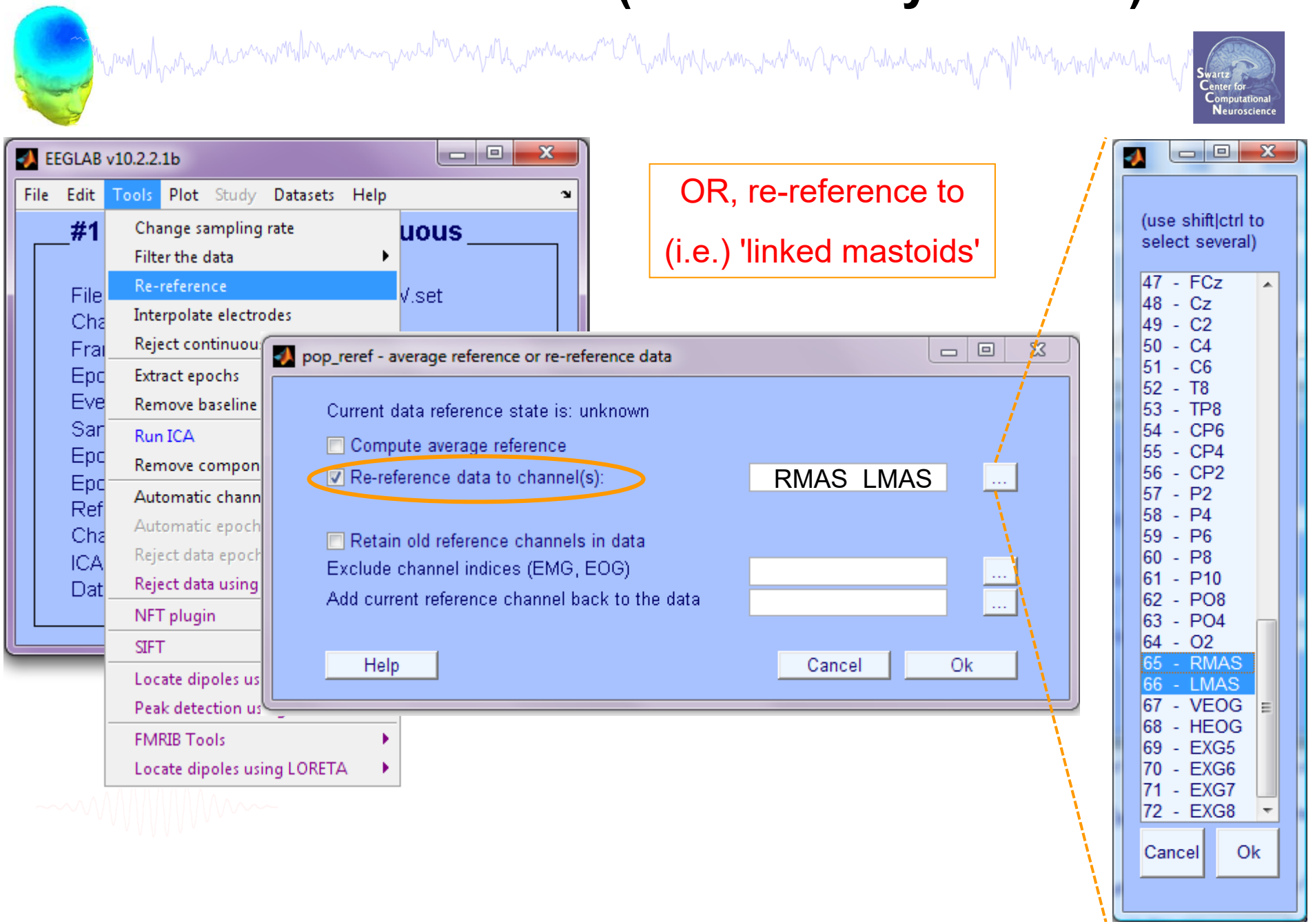
Reject large artifact time points

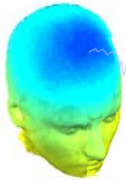
Run ICA
(next talk)

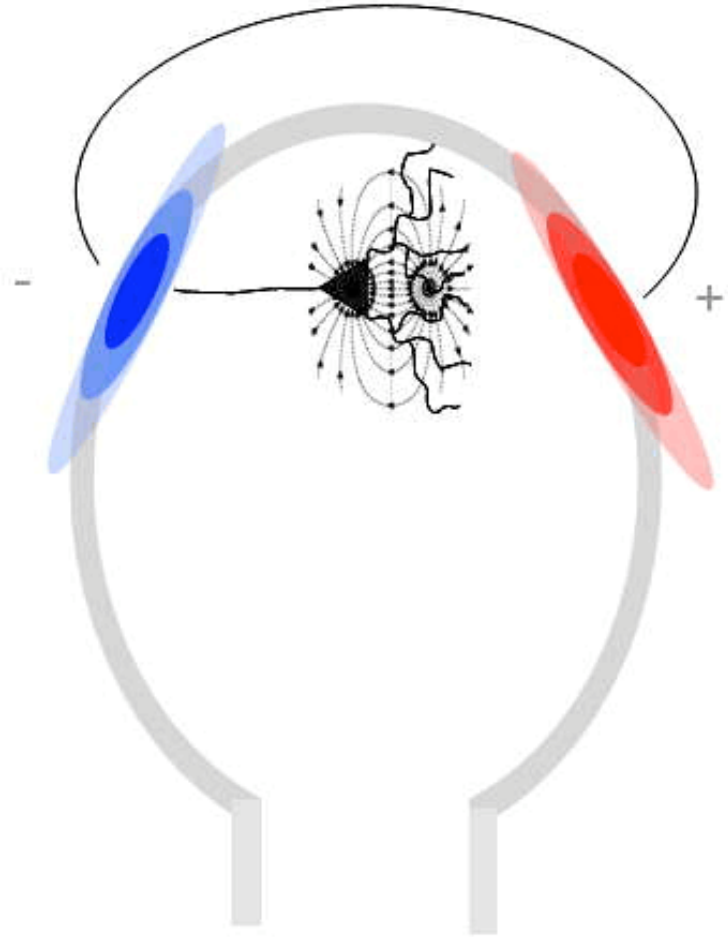
Re-reference data (if necessary/desired)



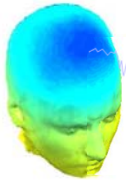
Re-reference data (if necessary/desired)

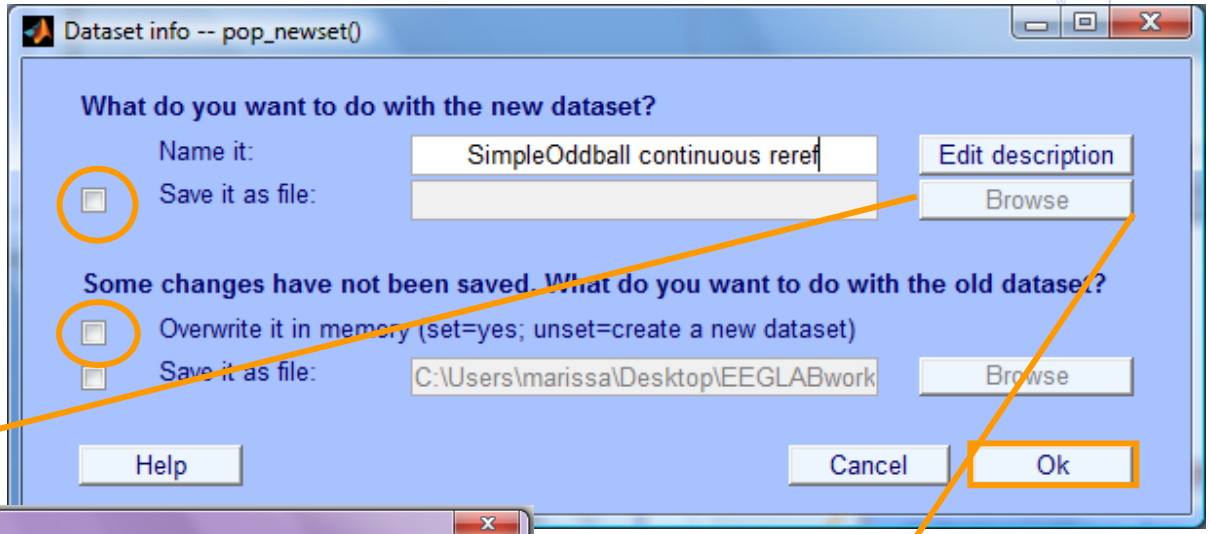


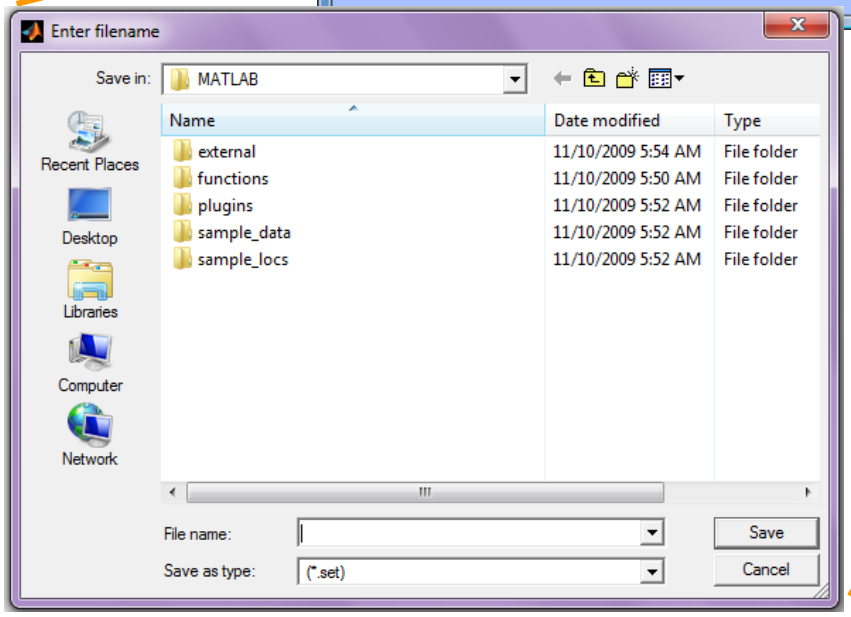


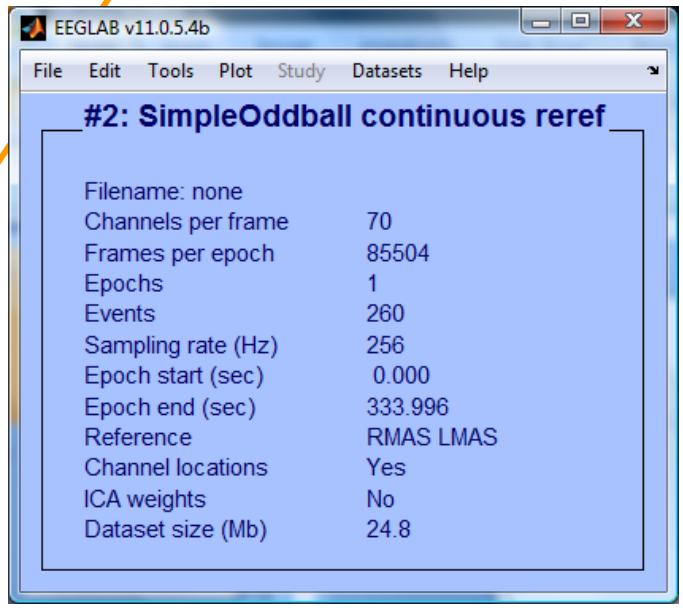


Save new dataset, keep old one

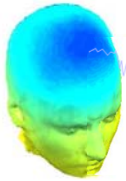


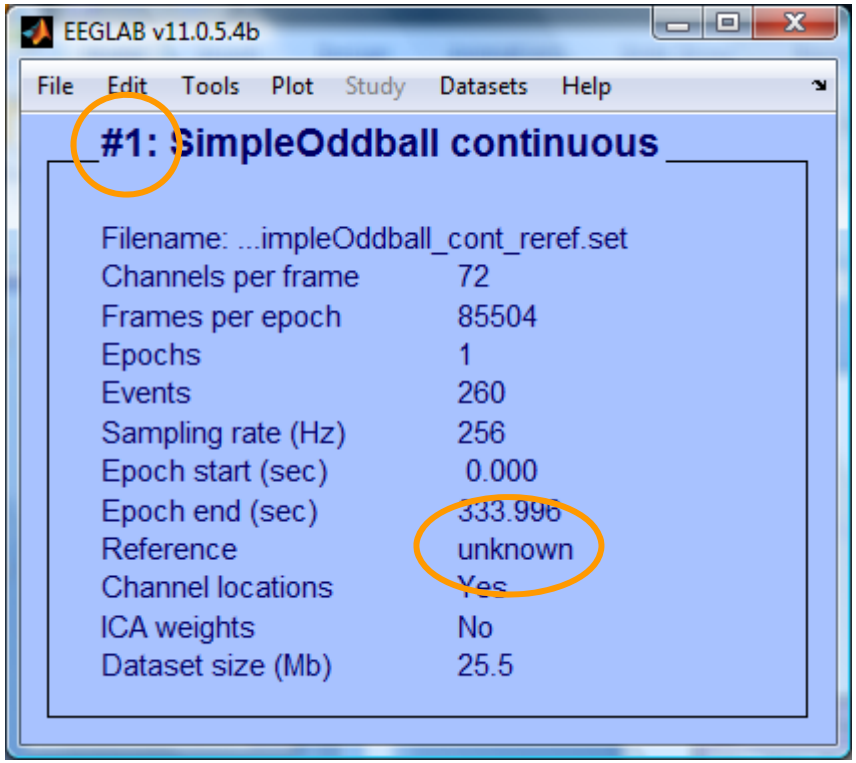


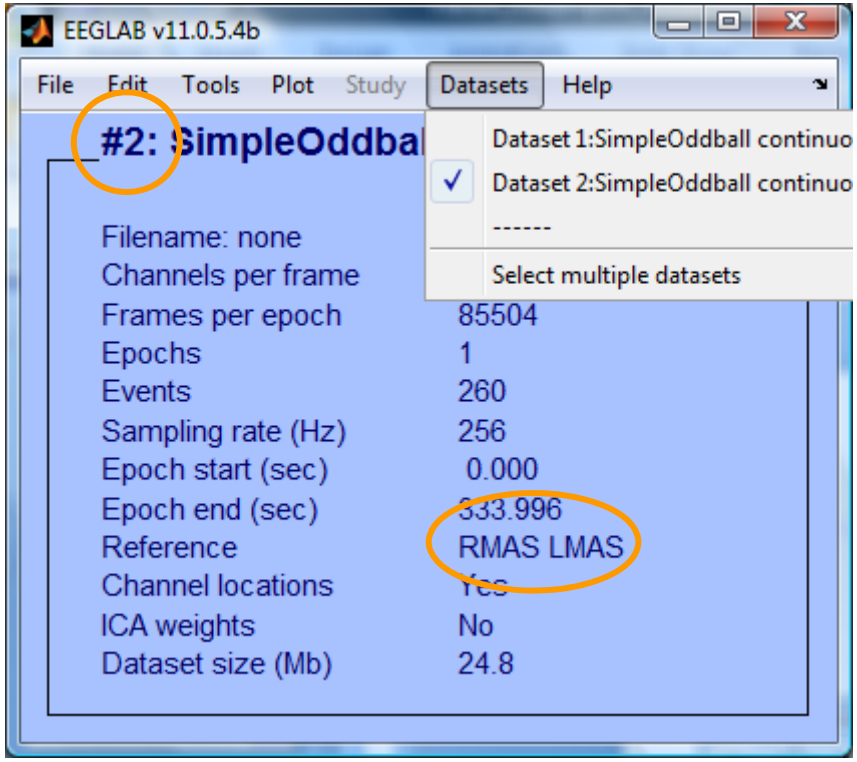




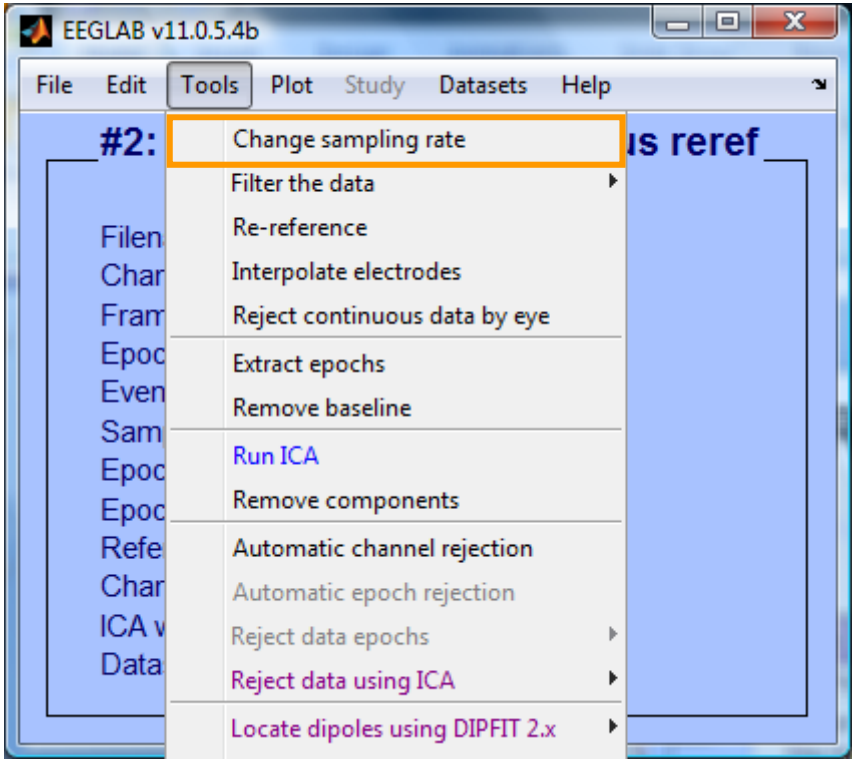
Multiple active datasets (ALLEEG)

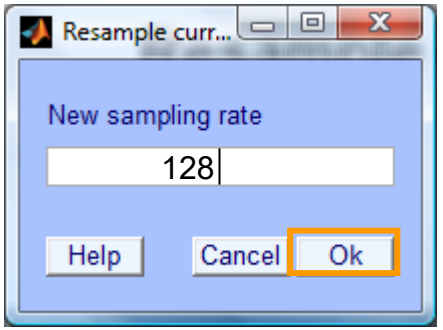




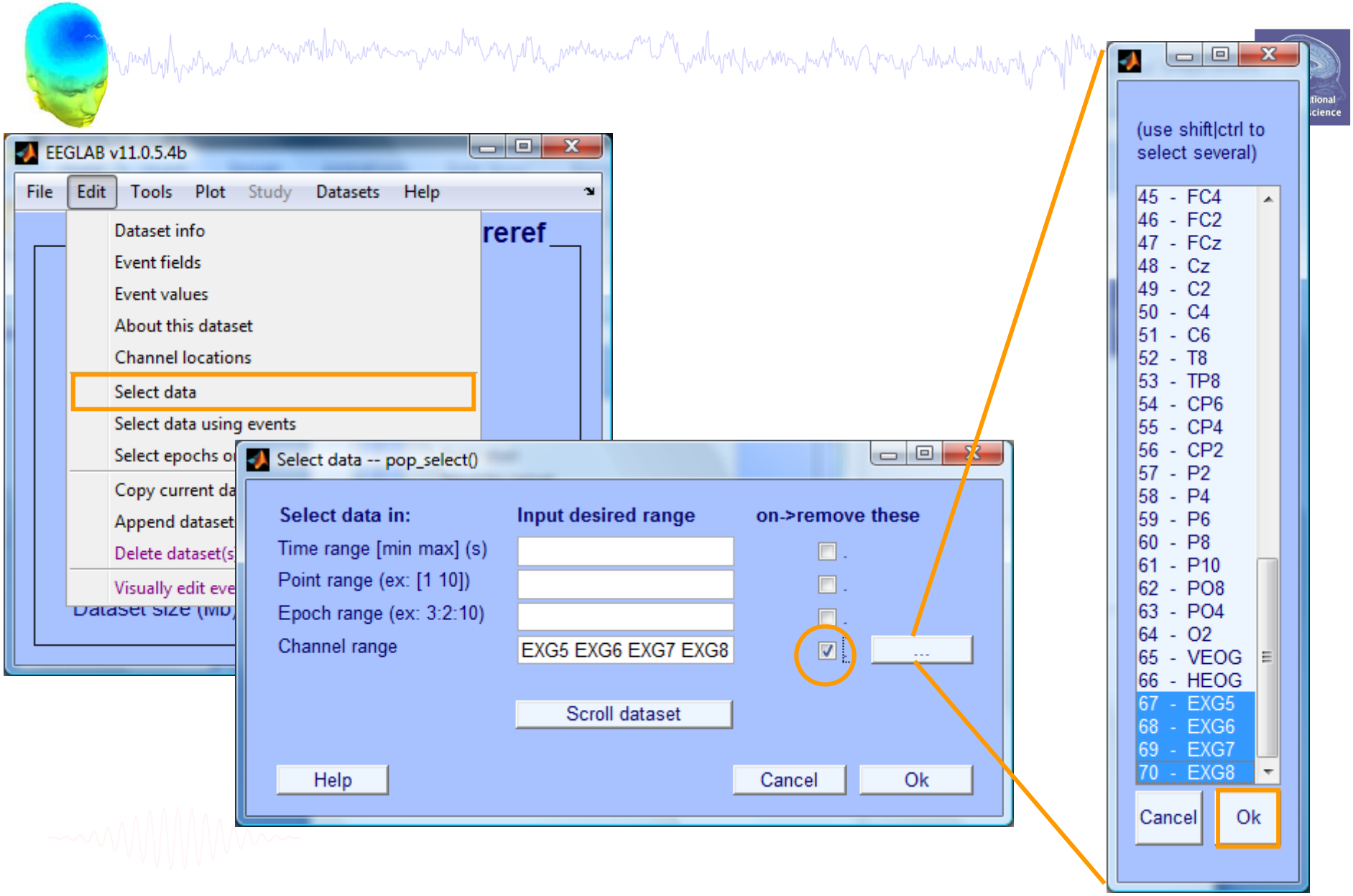


Resample data (if necessary)

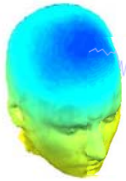




Remove unwanted channels



Pre-processing pipeline



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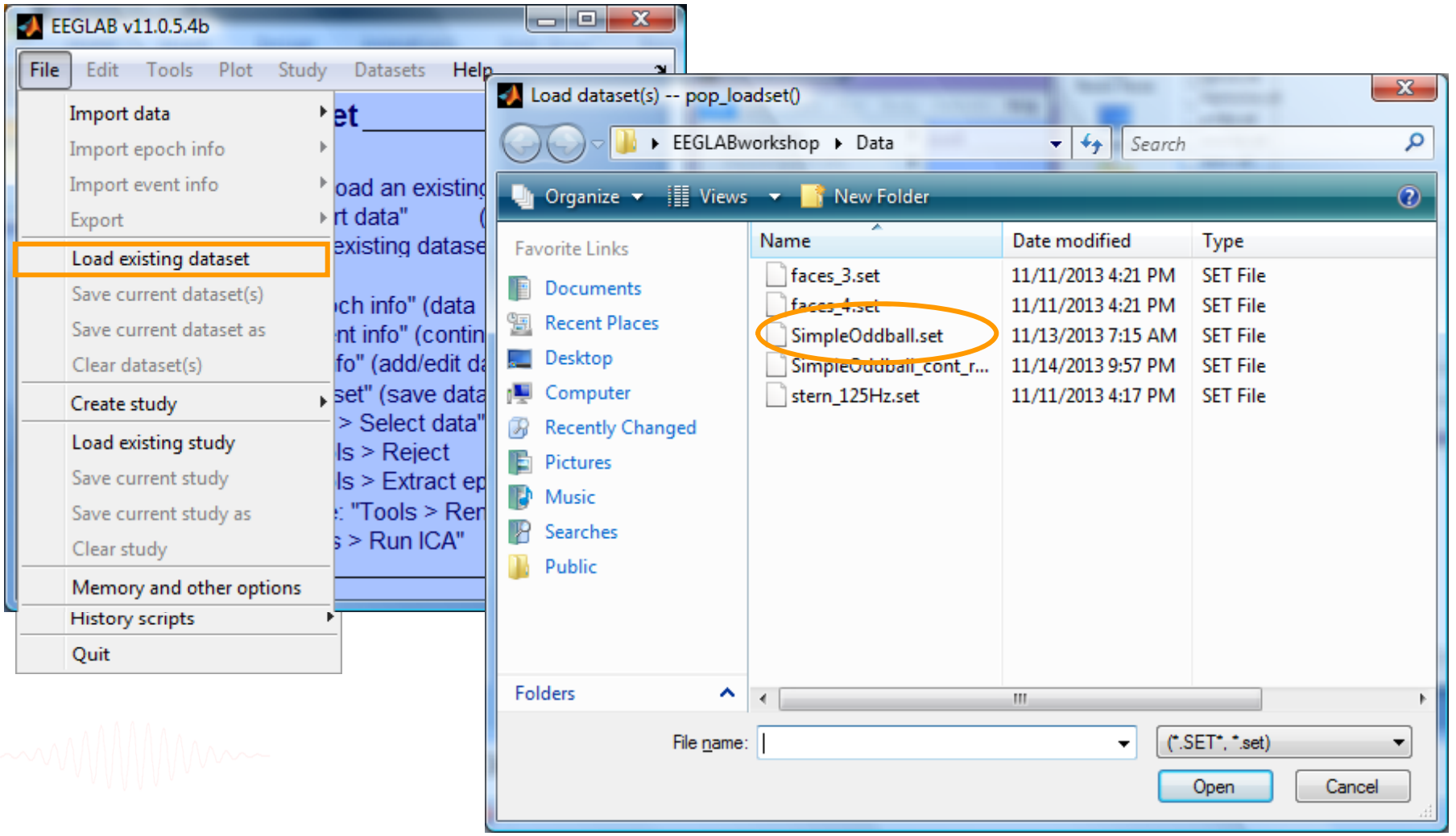
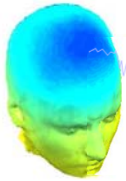
Run ICA
(next talk)

Load an existing dataset



Filter the data (if necessary/desired)



Lower cut off frequencies require longer stretches of continuous data

EEGLAB v14.x (dev)

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
Locate dipoles using DIPFIT 2.x

Basic FIR filter
Windowed sin
Parks-McClell
Moving averag
Basic FIR filter

Filter the data -- pop_eegfilt()

Lower edge of the frequency pass band (Hz) 0.5
Higher edge of the frequency pass band (Hz)
FIR Filter order (default is automatic)
Notch filter the data instead of pass band
Use (sharper) FFT linear filter instead of FIR filtering
(Use the option above if you do not have the Signal Pro
Use causal filter (useful when performing causal ana
Plot the filter frequency response
Use fir1 (check, recommended) or firls (uncheck, le

High-pass needed for ICA

Help Cancel Ok

Dataset info -- pop_newset()

What do you want to do with the new dataset?

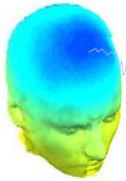
Name it: SimpleOddball hipass0.5 Edit description
Save it as file: Browse

What do you want to do with the old dataset (not modified since last saved)?

Overwrite it in memory (set=yes; unset=create a new dataset)

Help Cancel Ok

Pre-processing pipeline



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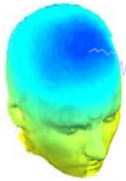
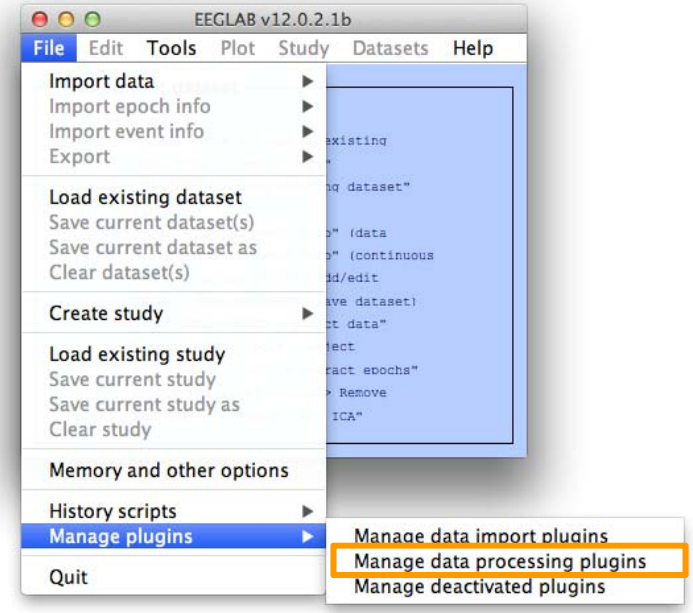
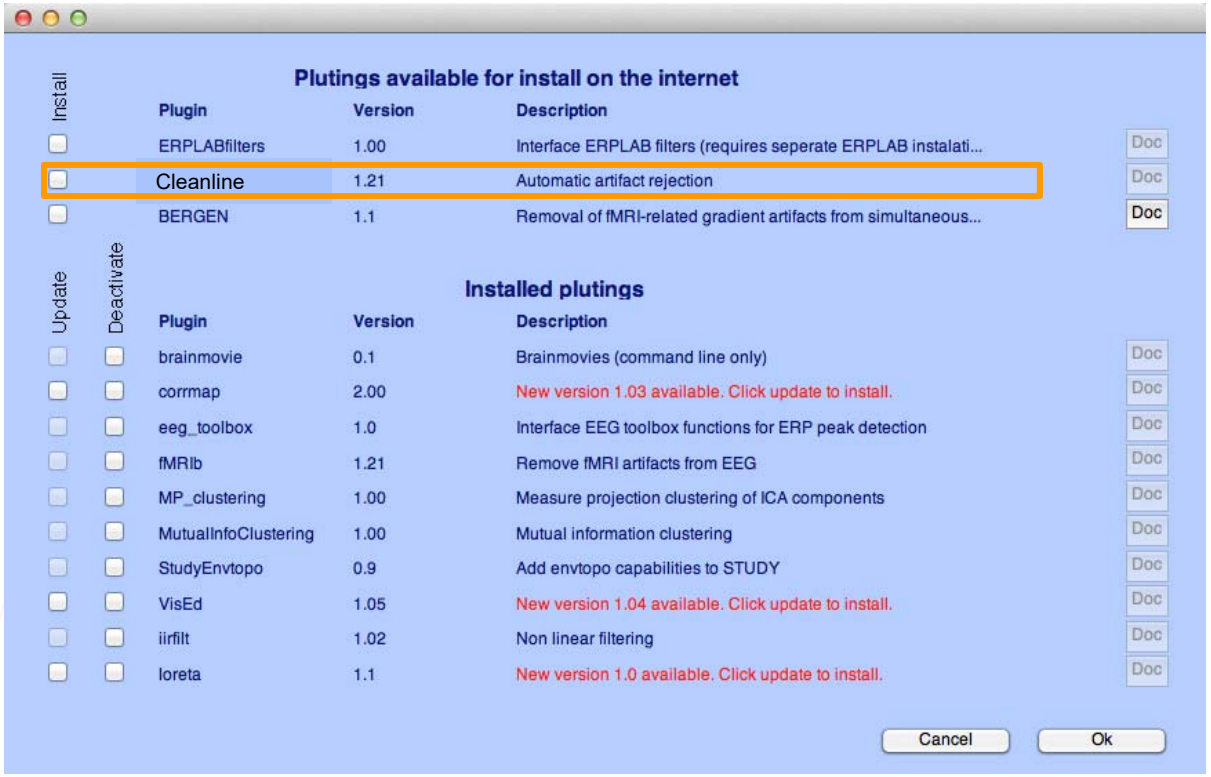
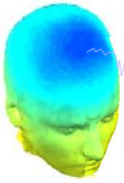
Run ICA
(next talk)

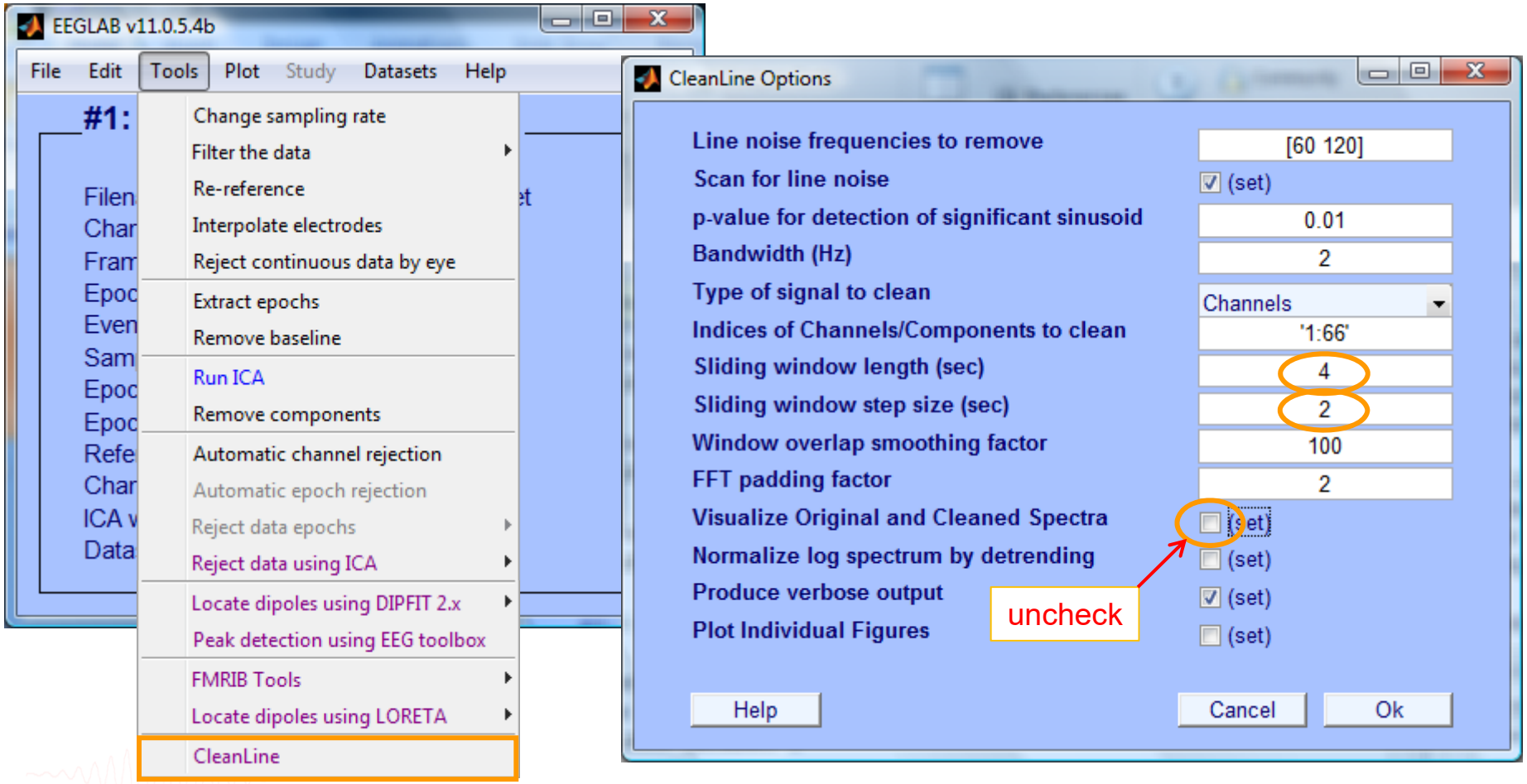



EEGLAB v12.0.2.1b
File
Edit
Tools
Plot
Study
Datasets
Help
Import data
Import epoch info
Import event info
Export
Load existing dataset
Save current dataset(s)
Save current dataset as
Clear dataset(s)
Create study
Load existing study
Save current study
Save current study as
Clear study
Memory and other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

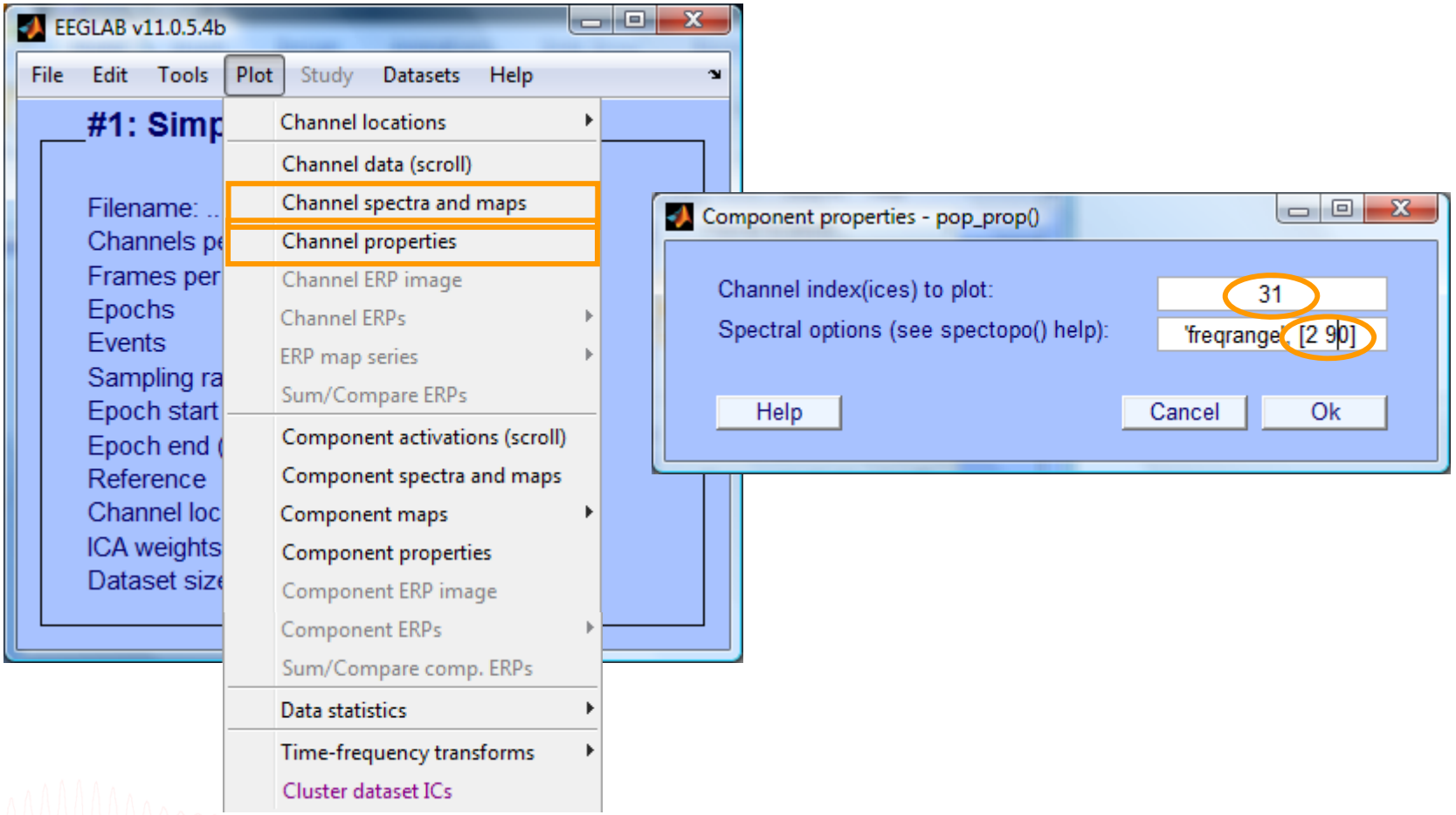

Plutings available for install on the internet
Install
Plugin
Version
Description
ERPLABfilters
1.00
Interface ERPLAB filters (requires seperate ERPLAB instalati...
Doc
Cleanline
1.21
Automatic artifact rejection
Doc
BERGEN
1.1
Removal of fMRI-related gradient artifacts from simultaneous...
Doc
Installed plutings
Update
Deactivate
Plugin
Version
Description
brainmovie
0.1
Brainmovies (command line only)
corrmap
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)

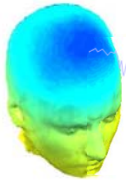




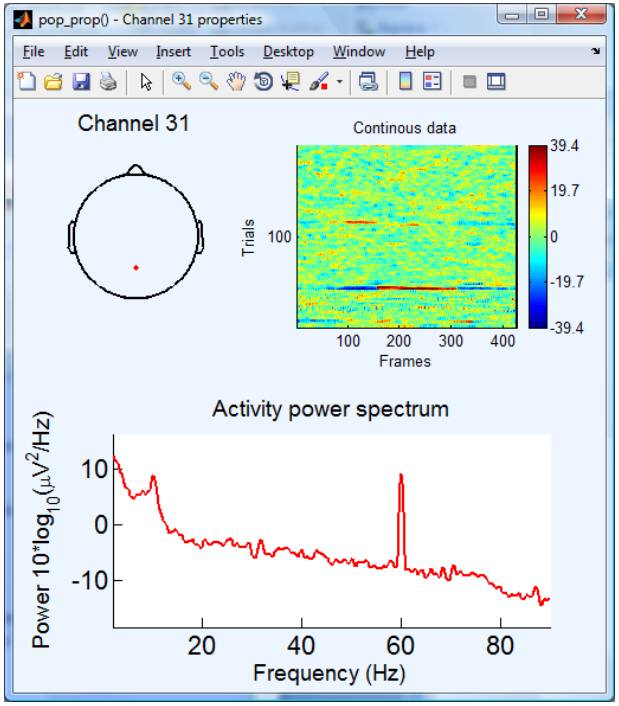
Plot channel spectra



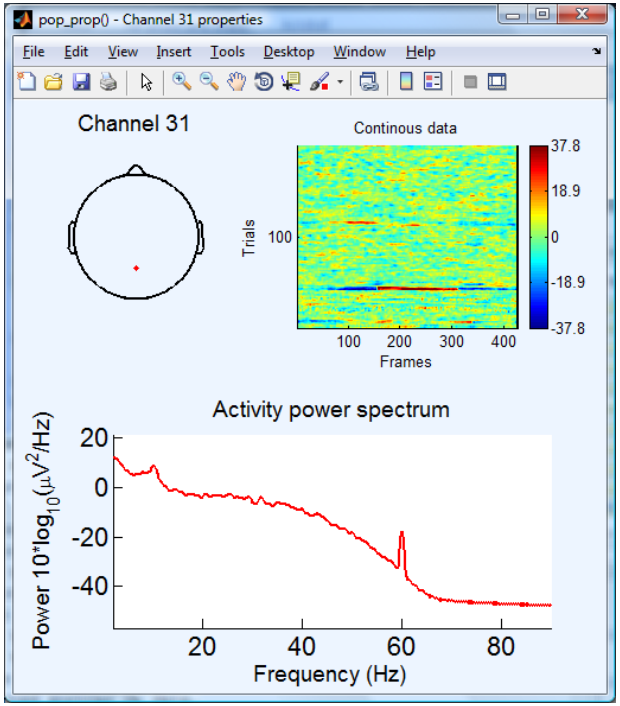
Filter comparisons



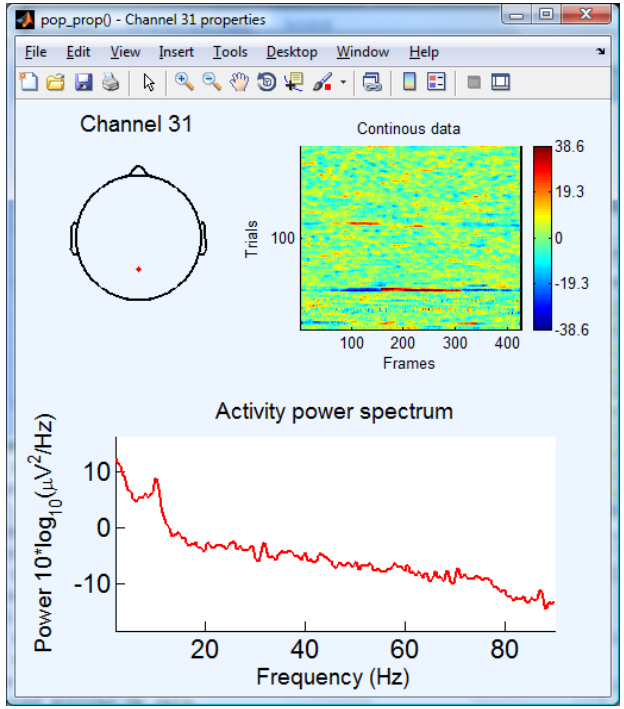
0.5 Hz high-pass filter



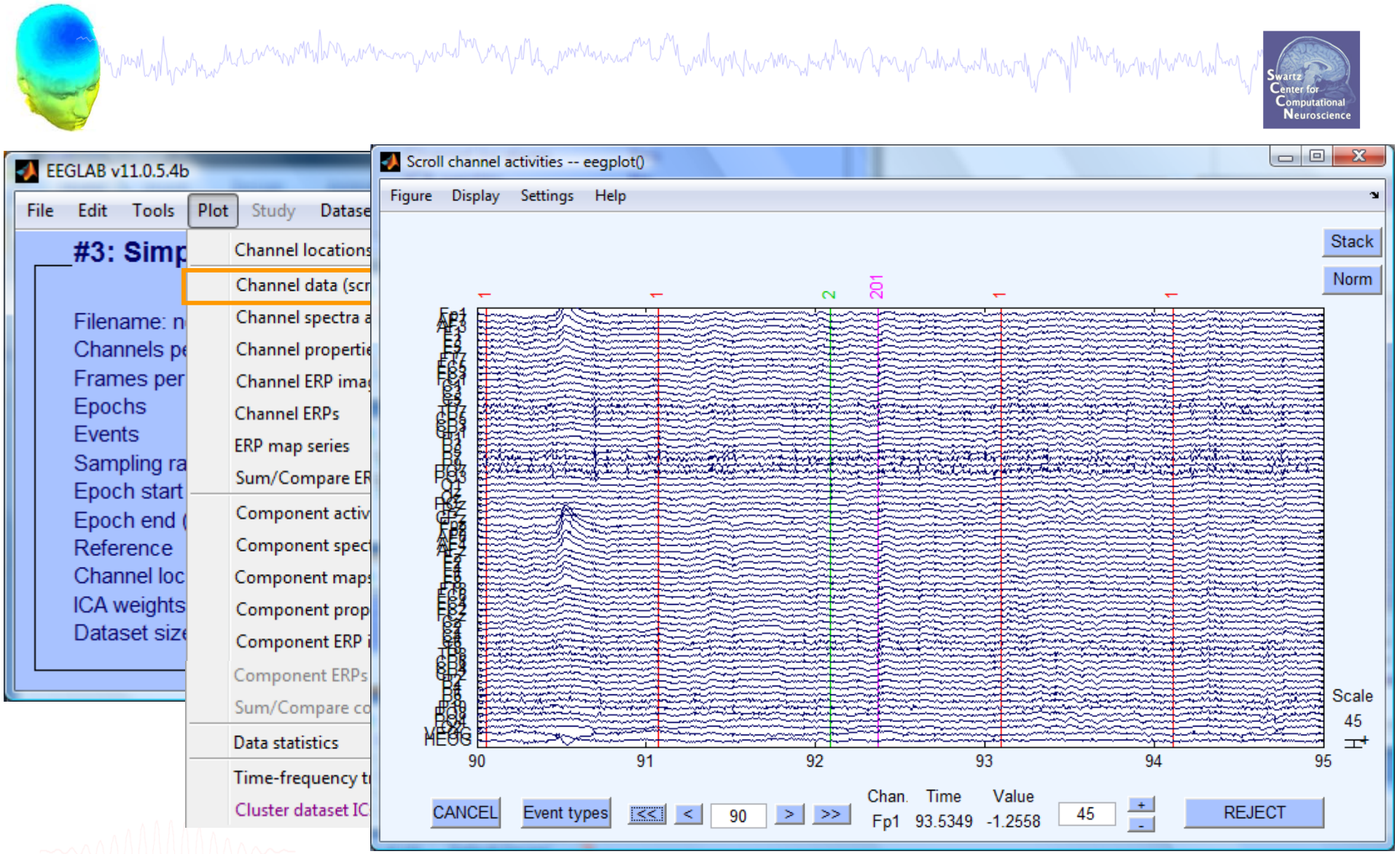
0.5 Hz high-pass filter
50 Hz low-pass filter



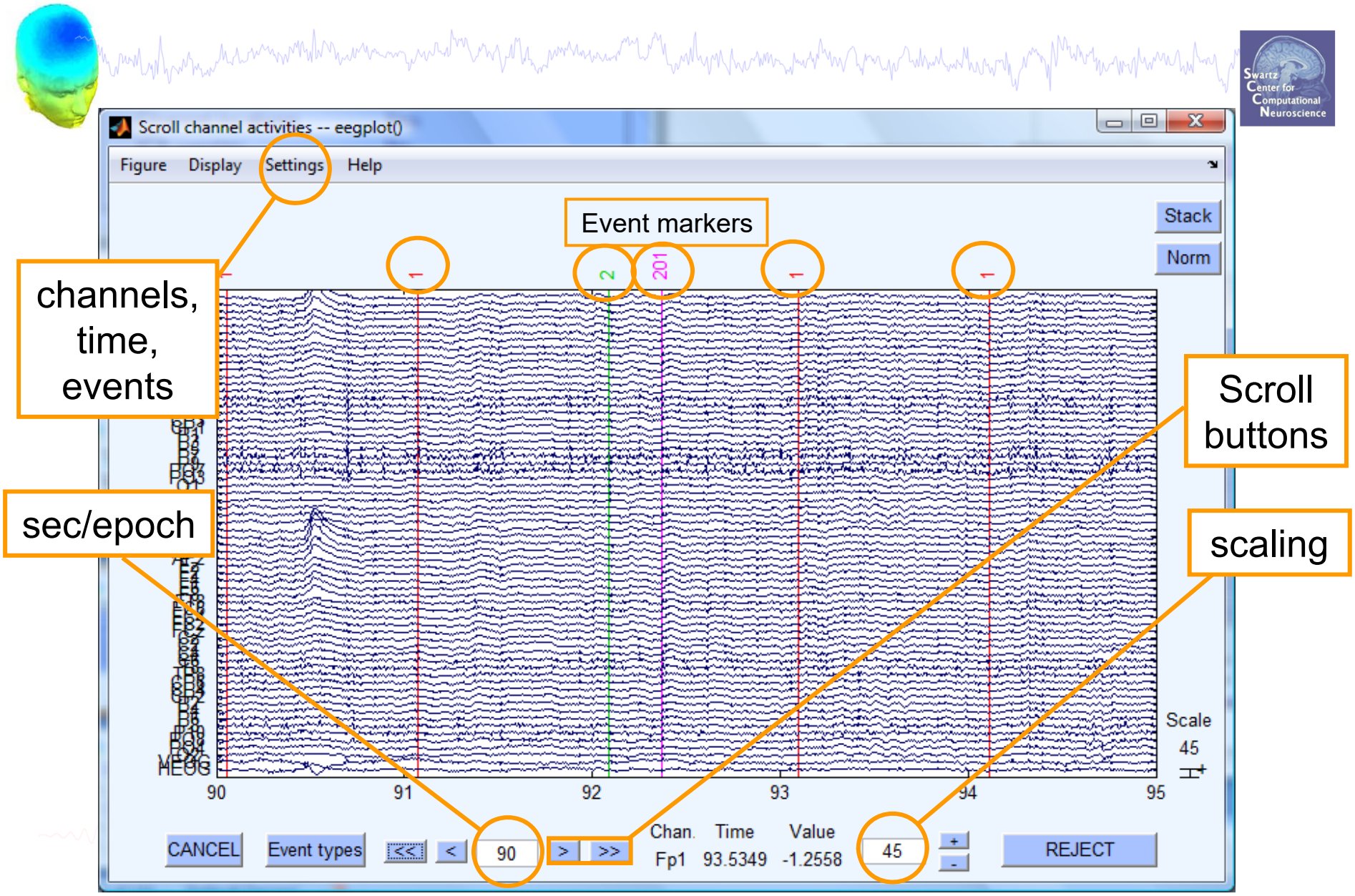
0.5 Hz high-pass filter
Cleanline



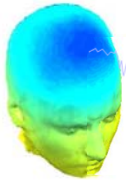
Scroll channel data



Scroll channel data



Pre-processing pipeline



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!

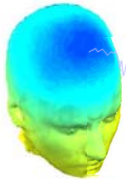
Save your dataset here; you will import ICA weights to this dataset later

Identify/reject bad channels

Reject large artifact time points

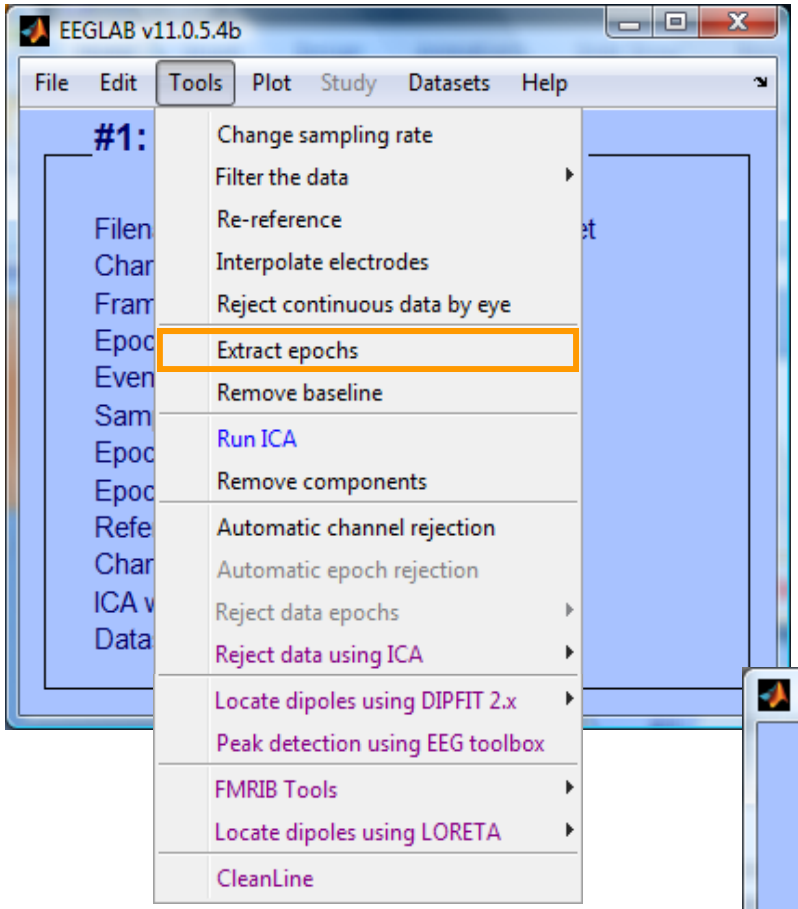
Run ICA
(next talk)

Visualizing ERPs

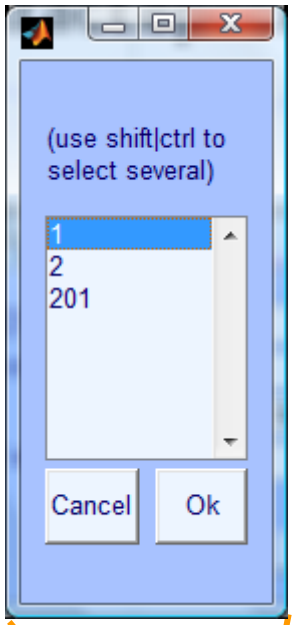


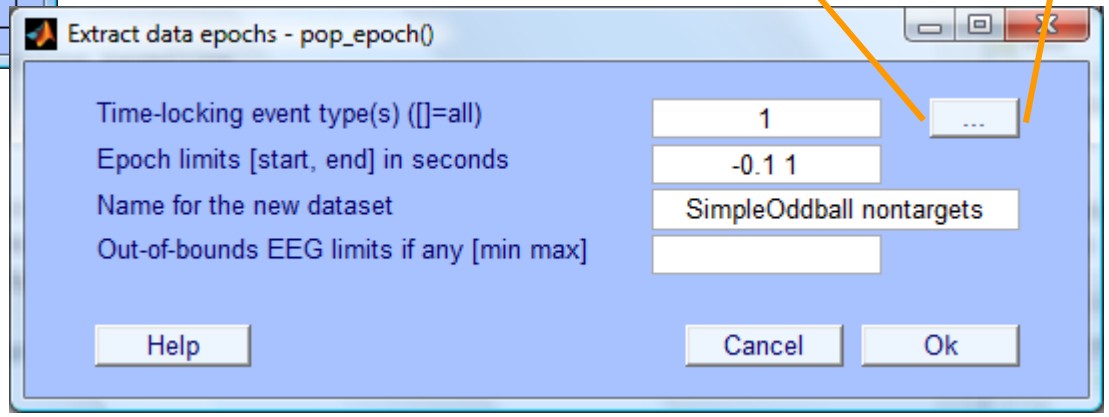
- Epoch data according to different event types
- Reject epochs containing artifact
- Various plot types (channel and scalp topography)

Extract epochs

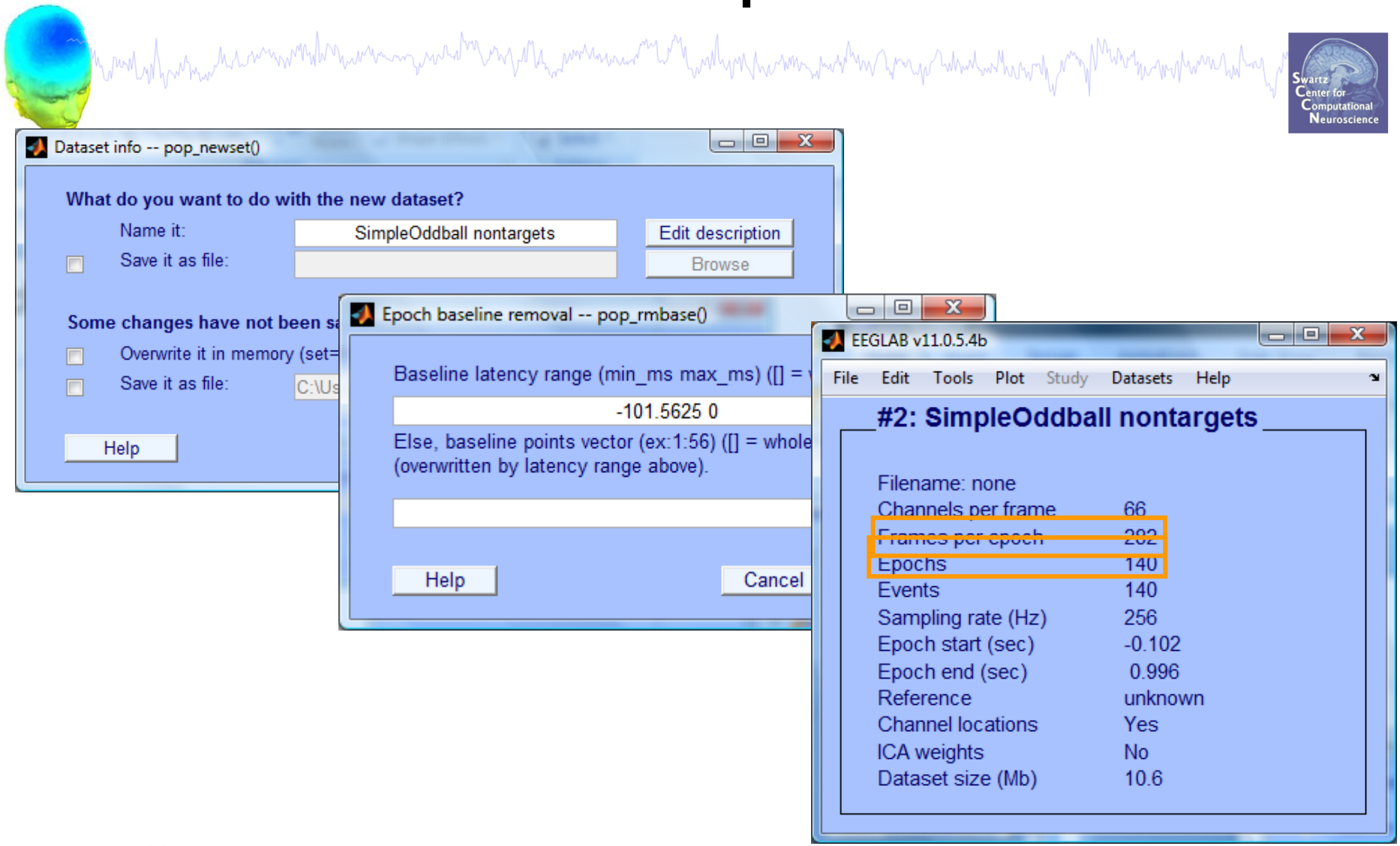



```
>> eeg_eventtypes(EEG)
   1       140
   2       60
   201     60
```

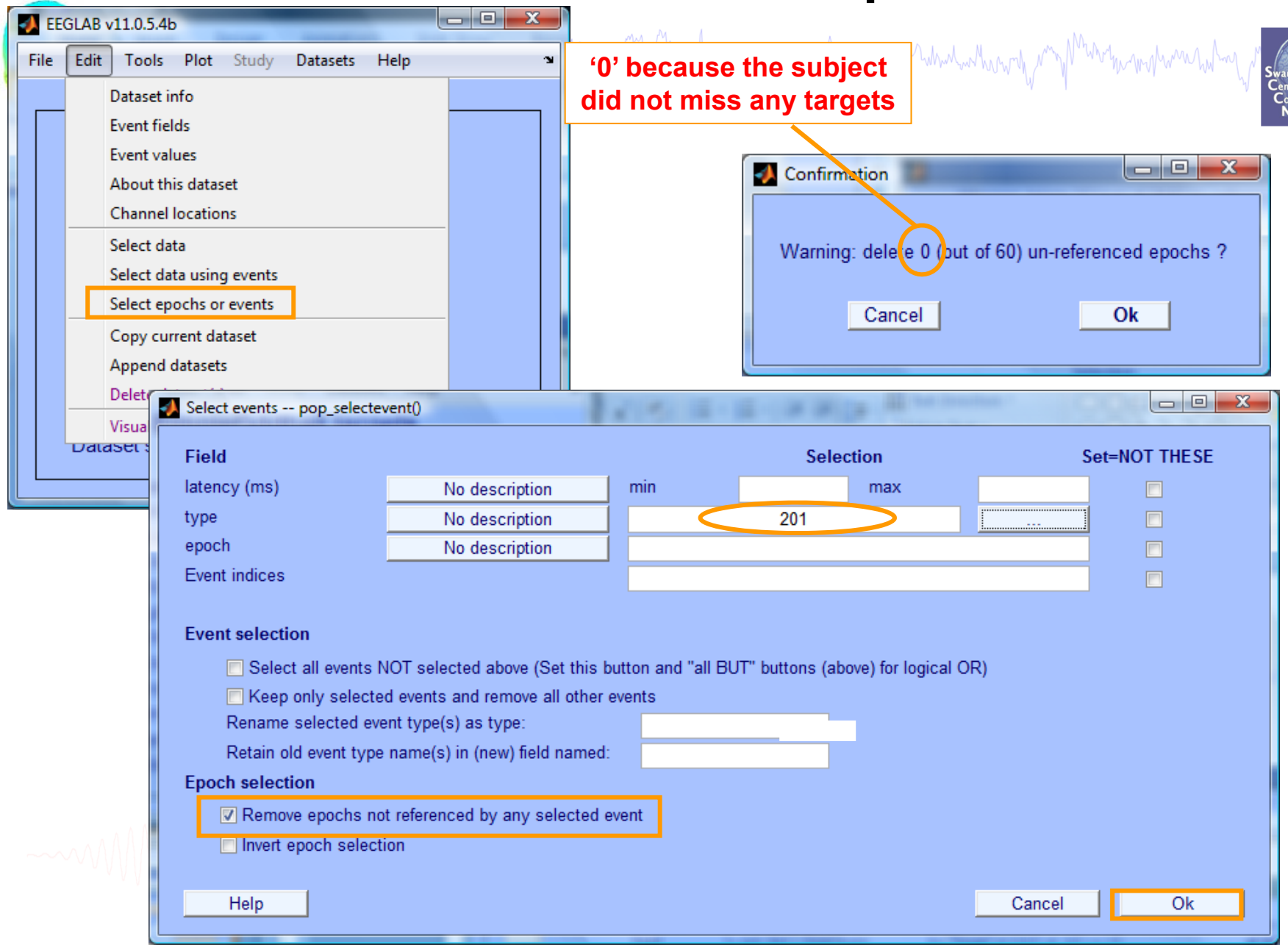


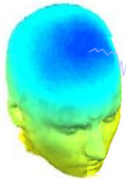


Extract epochs

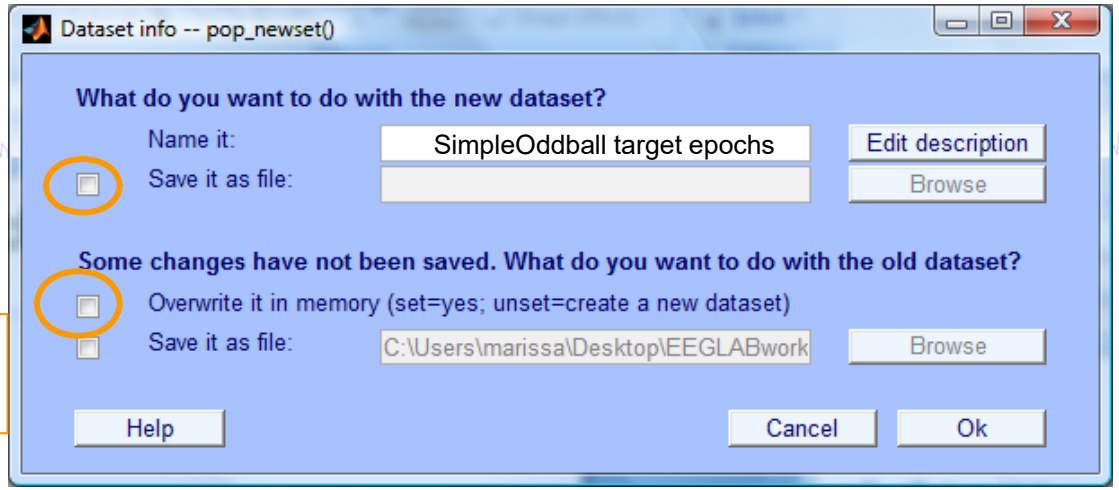


Select a subset of epochs

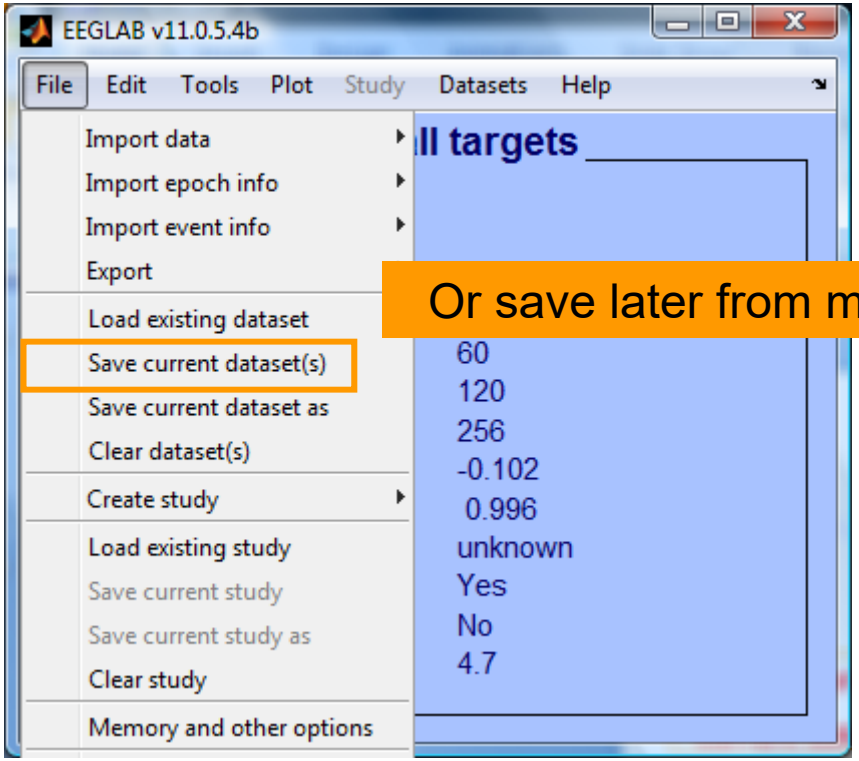




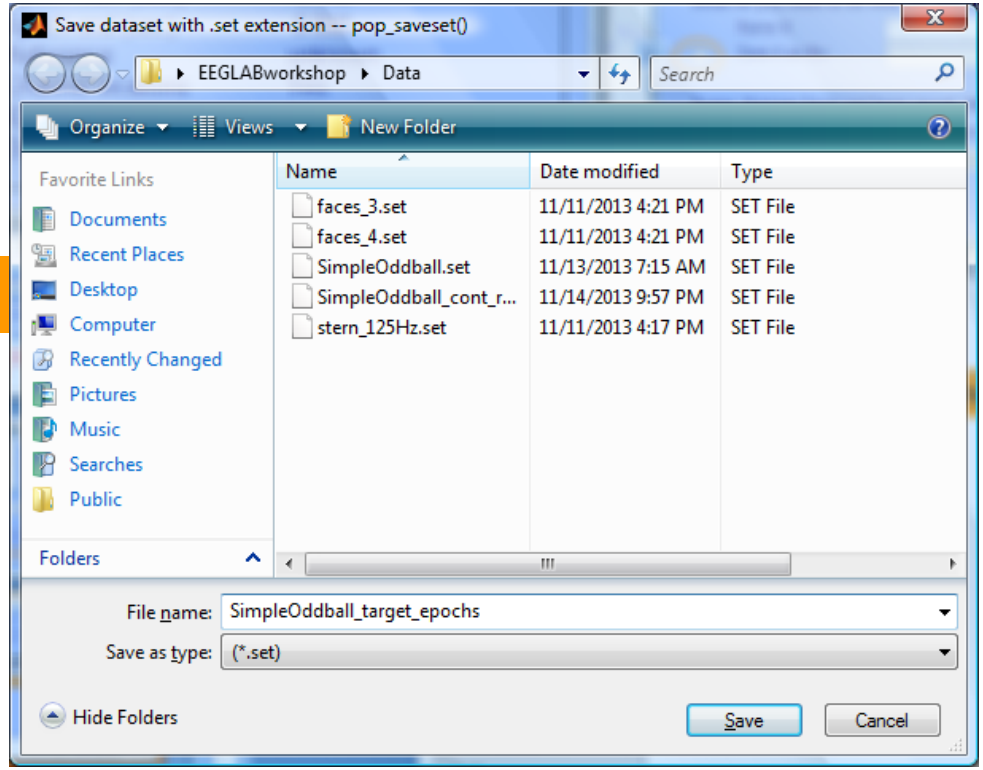
'Do not overwrite current dataset'



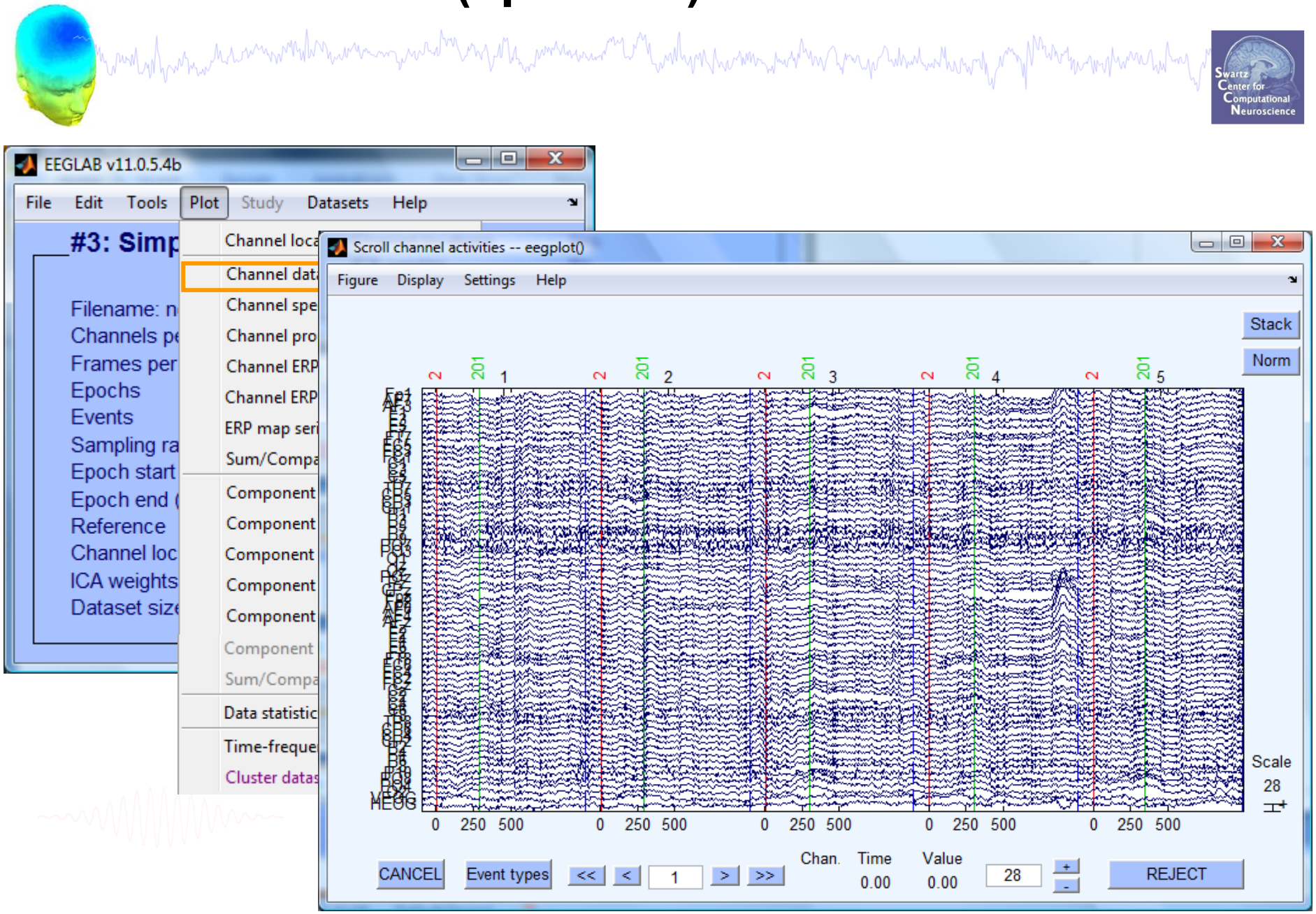
Save dataset (optional)



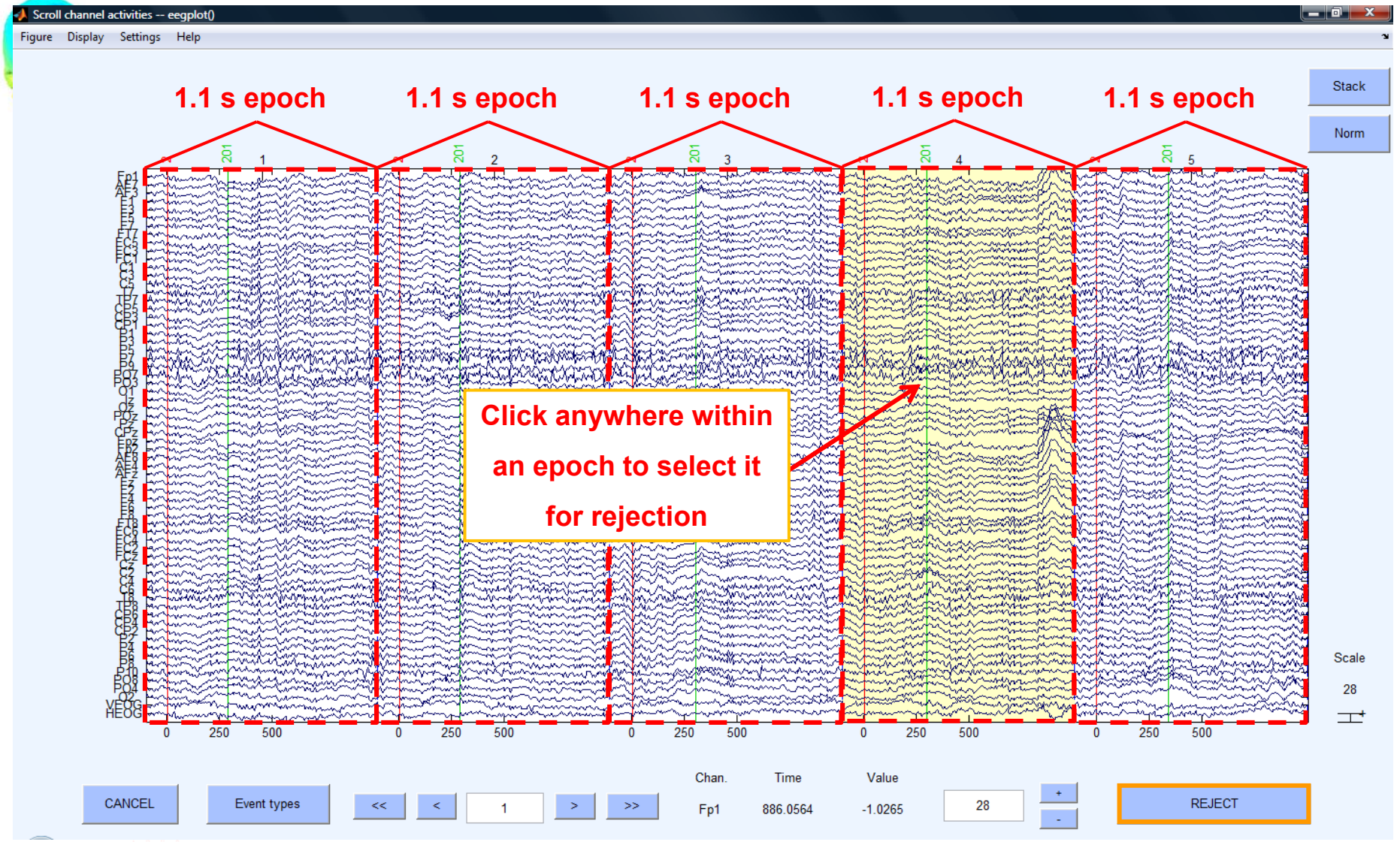
Or save later from menu



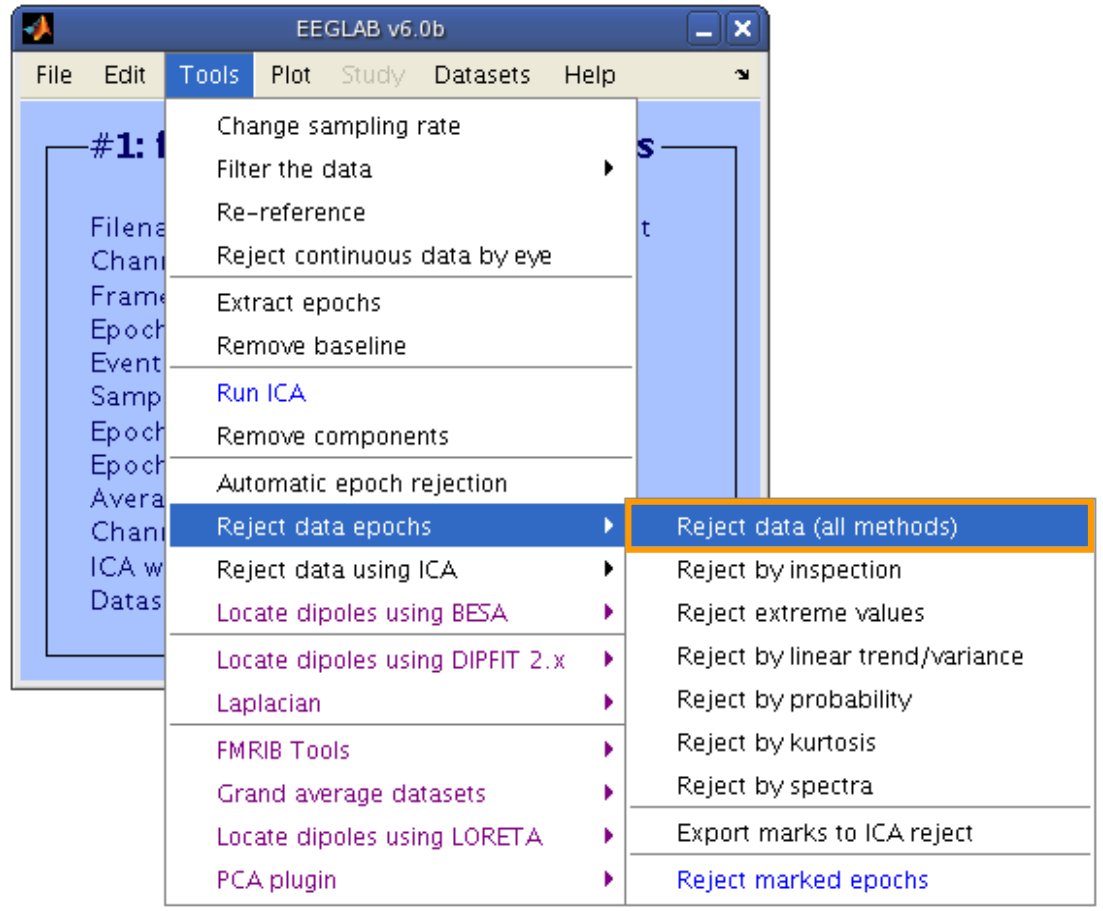
Scroll (epoched) channel data



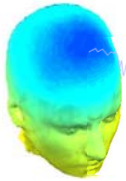
Reject epochs with artifact

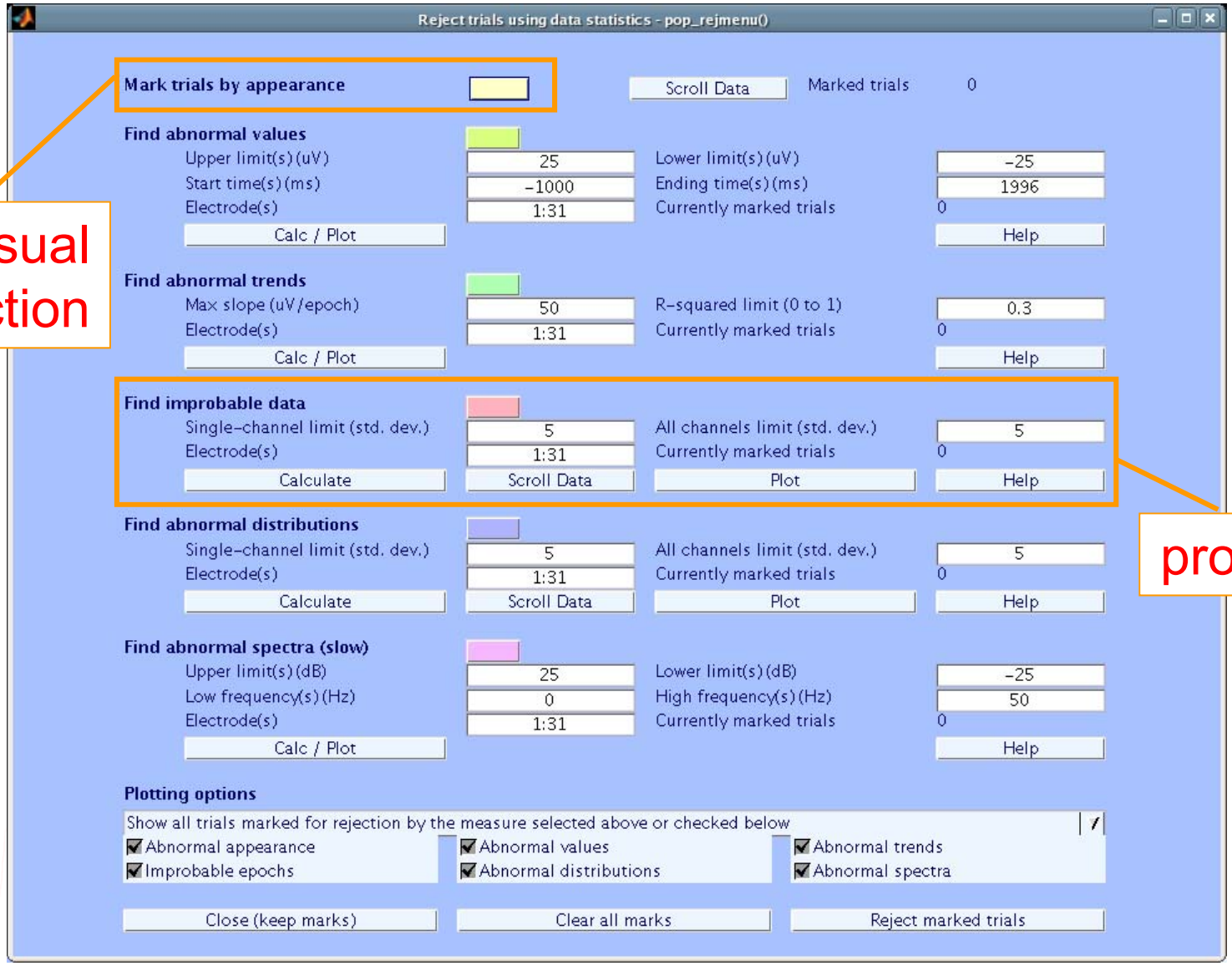


Reject data epochs



Reject data epochs

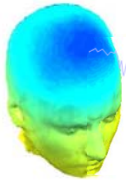


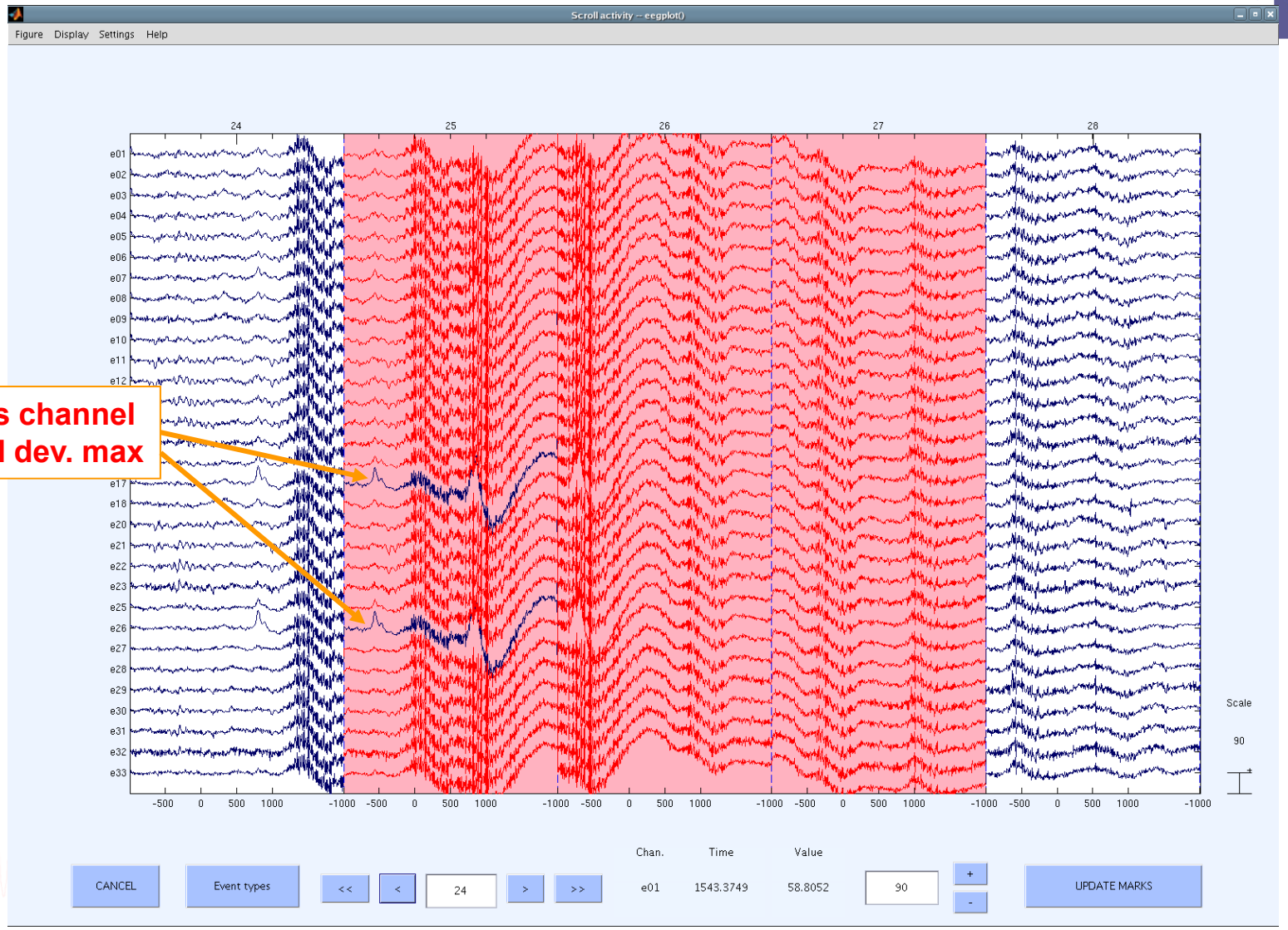


visual inspection

probability

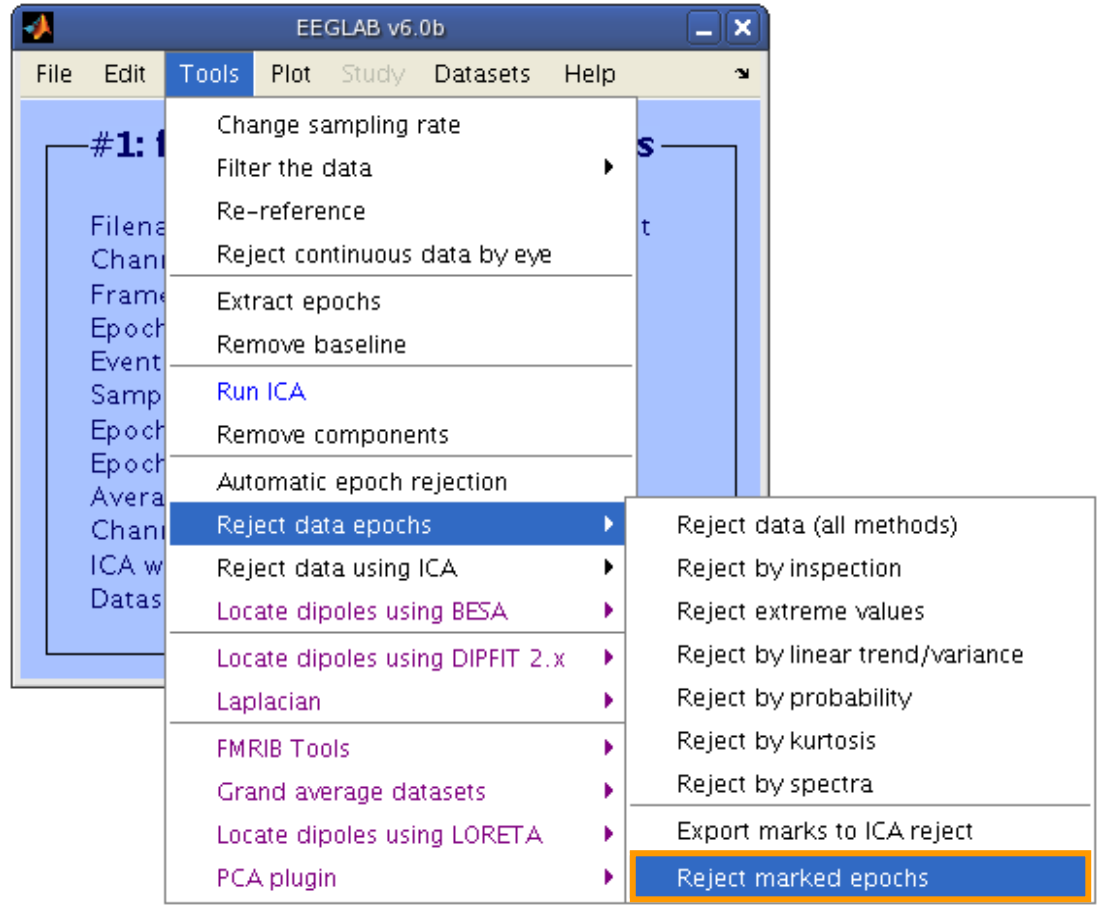
Reject data epochs



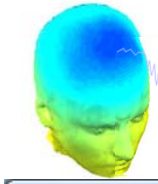


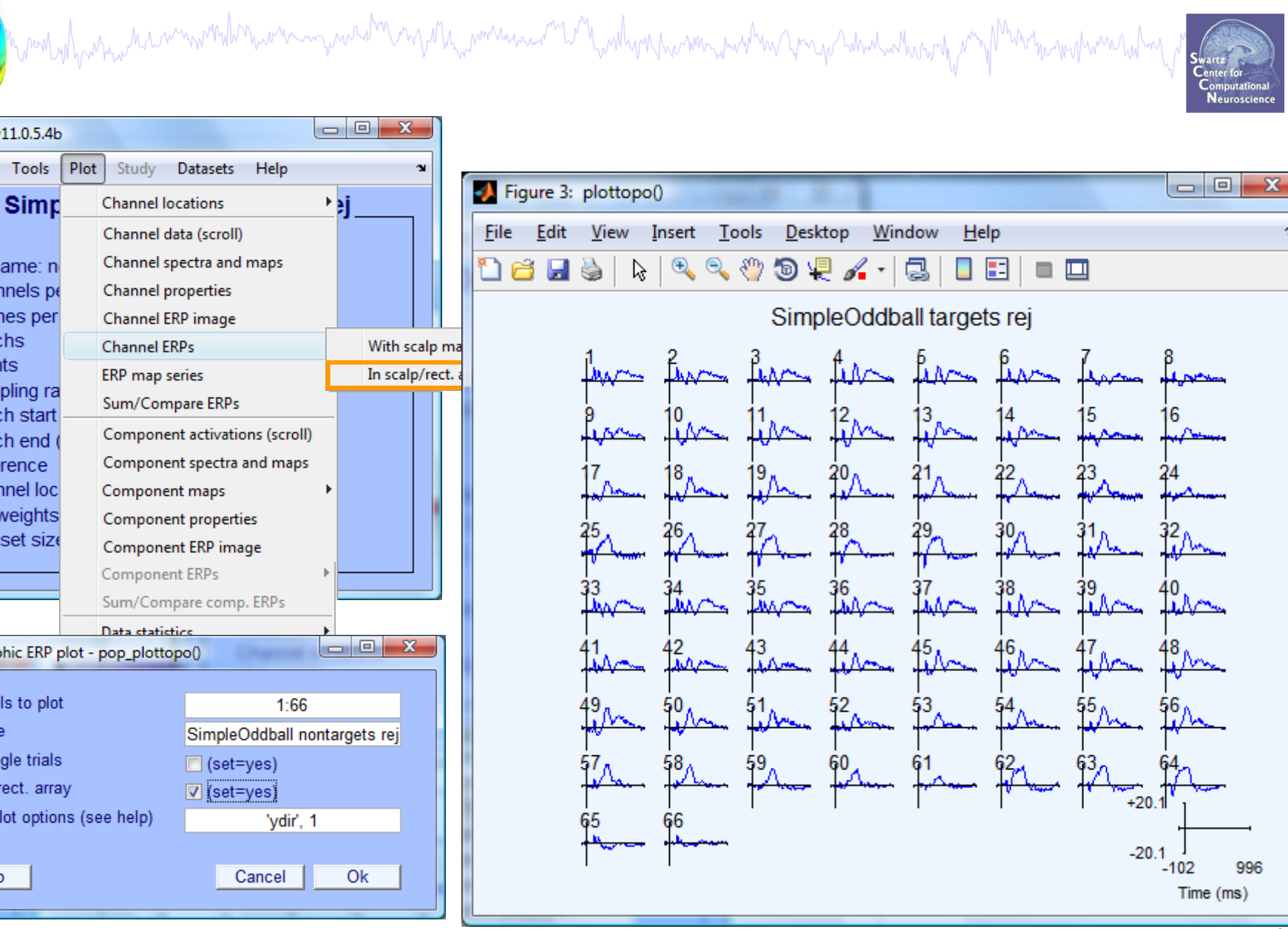
Exceeds channel standard dev. max

Reject data epochs

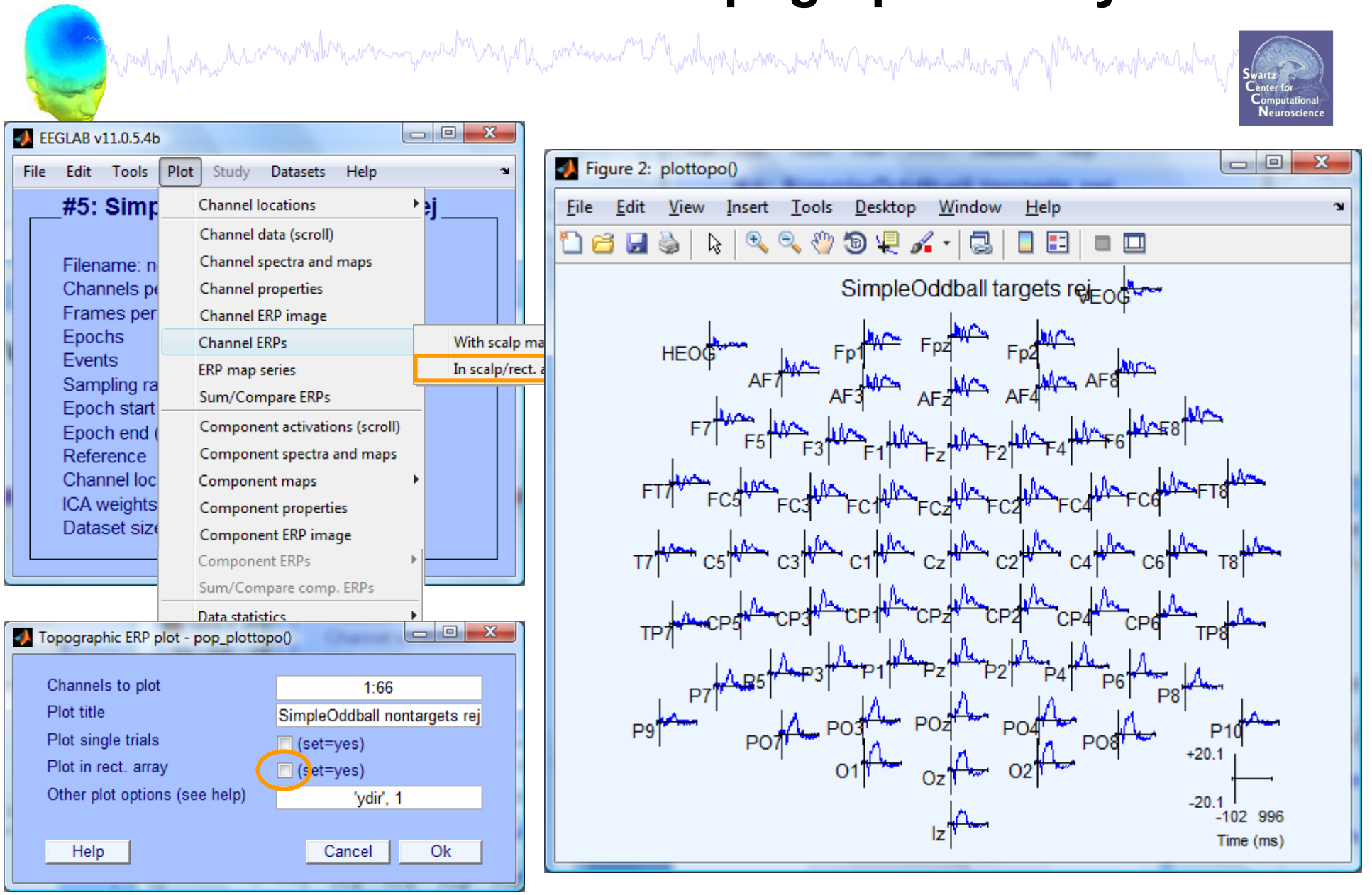


Visualize ERP in rectangular array

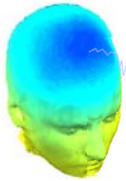


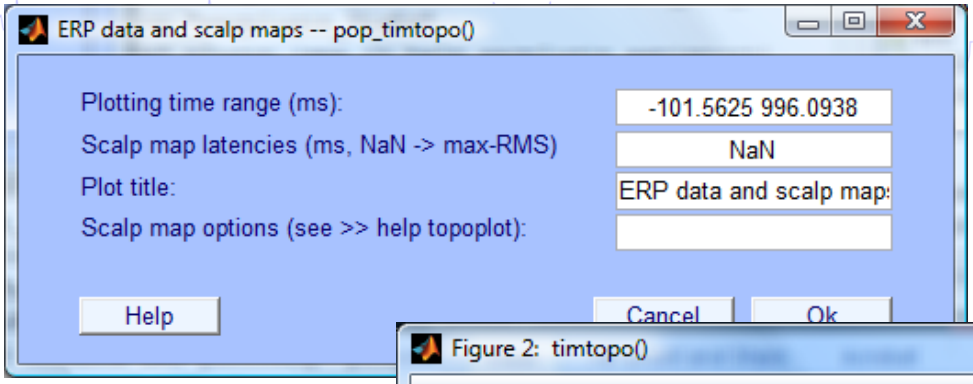


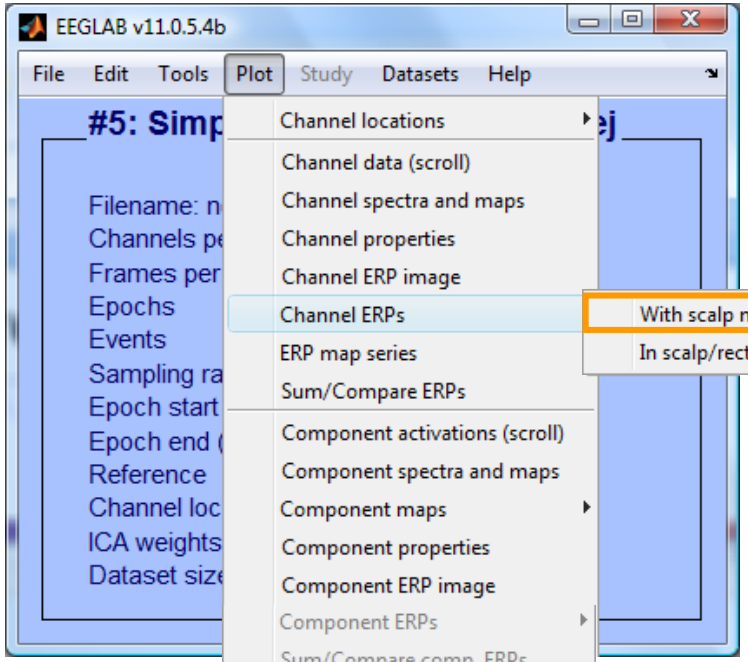
Visualize ERP in topographic array

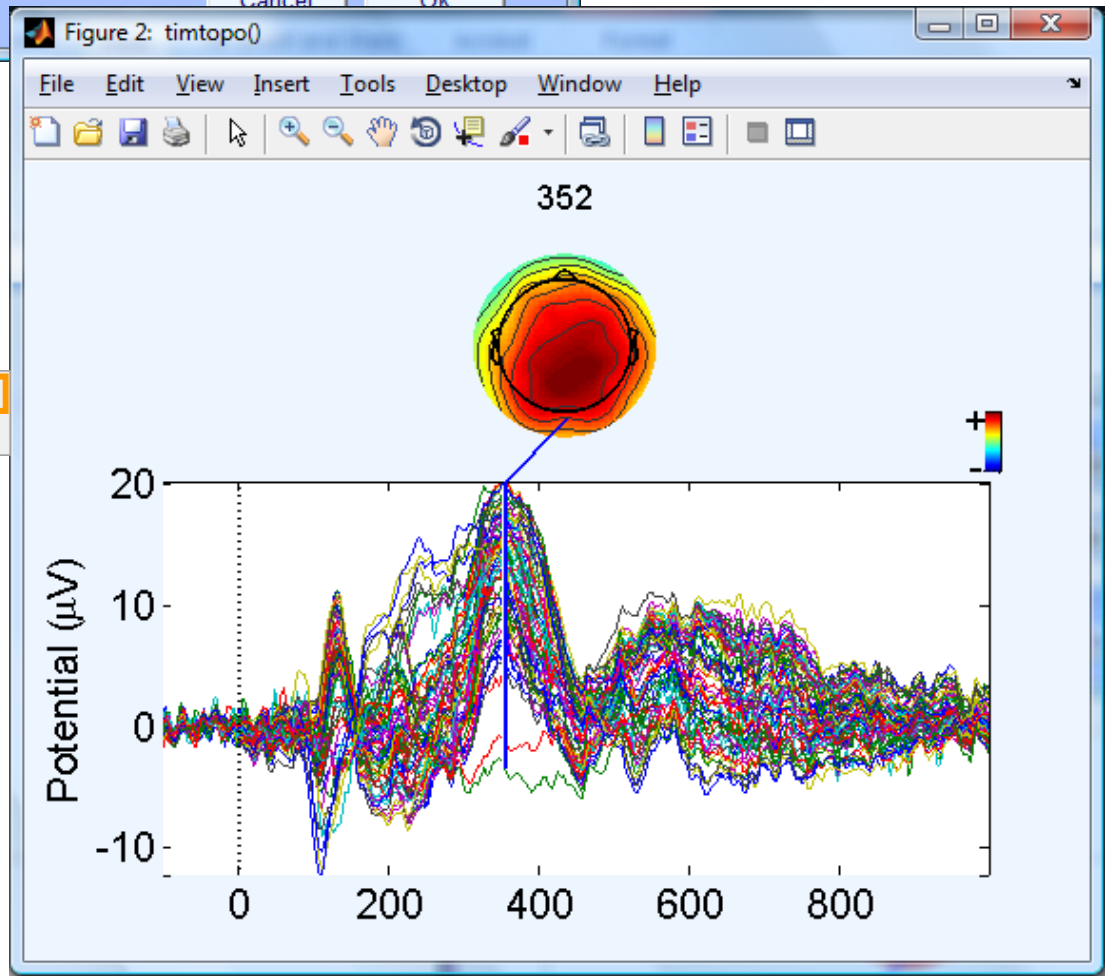


Visualize ERP scalp distribution

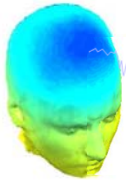


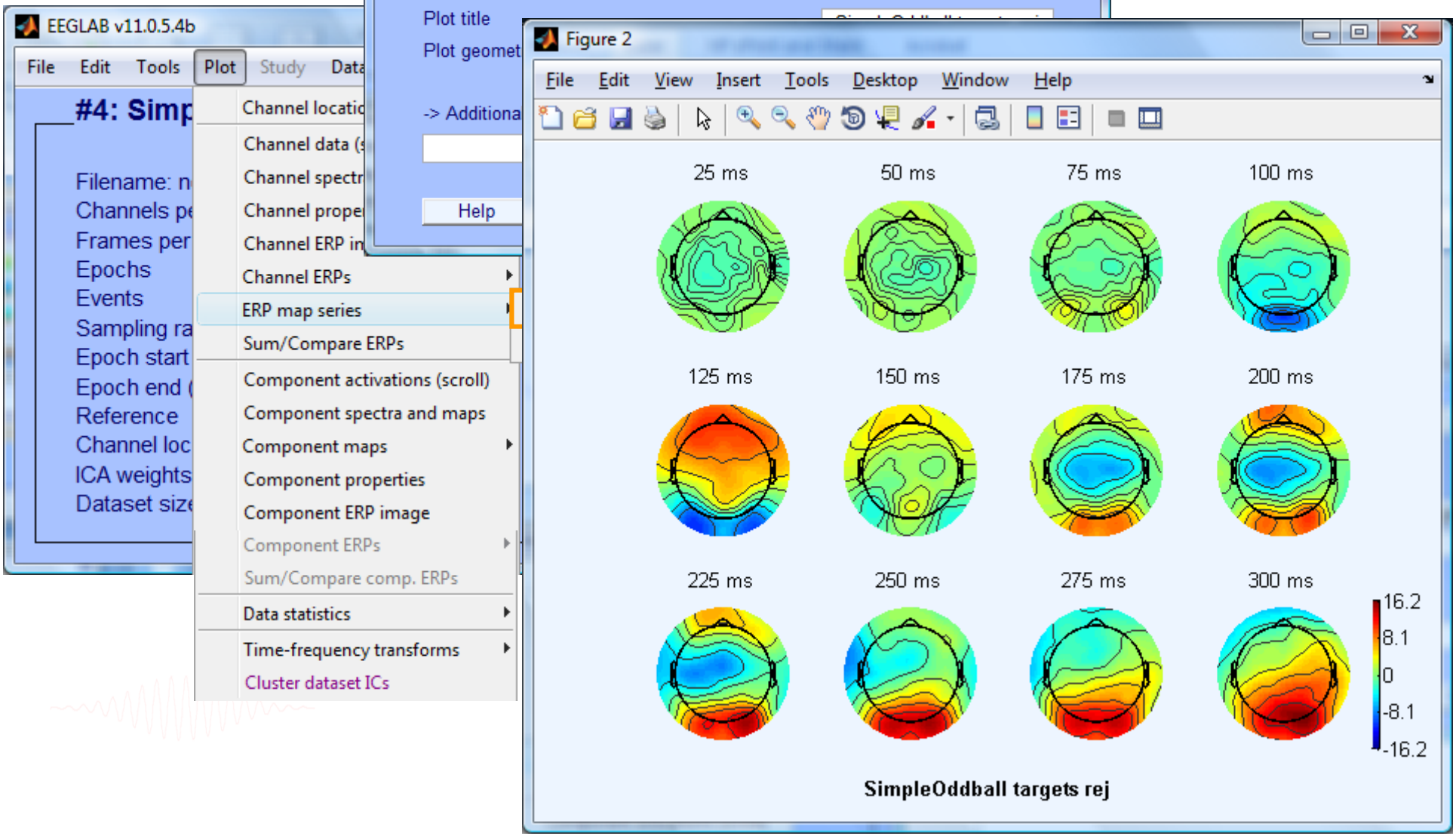




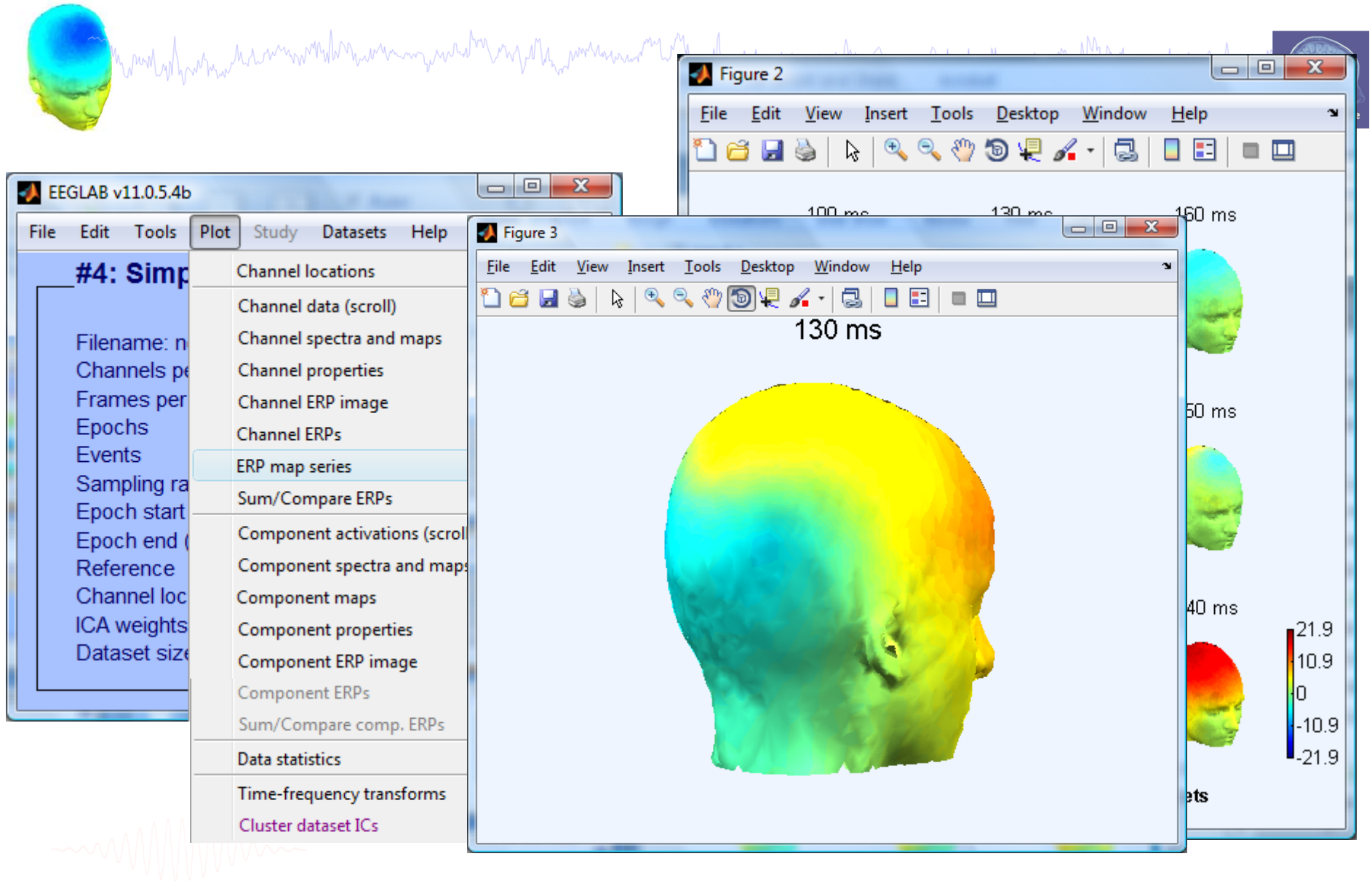


Visualize channel ERPs in 2D

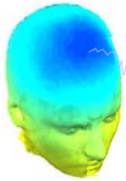




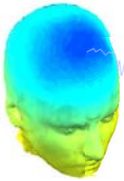
Visualize channel ERPs in 3D



Exercises (continuous data)



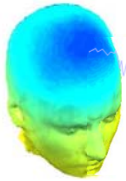
- Load SimpleOddball.set
- Rereference data to average reference
- Hi-pass filter the continuous data, then save
- Epoch the data on circles (event type 1) and stars (event type 2)
- Scroll the epoched data and perform visual rejection of epochs
- Explore the automated artifact rejection tools
- Save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



EEGLAB Processing

Data cleaning for ICA

Pre-processing pipeline



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)

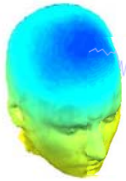
Remove line noise (if necessary)

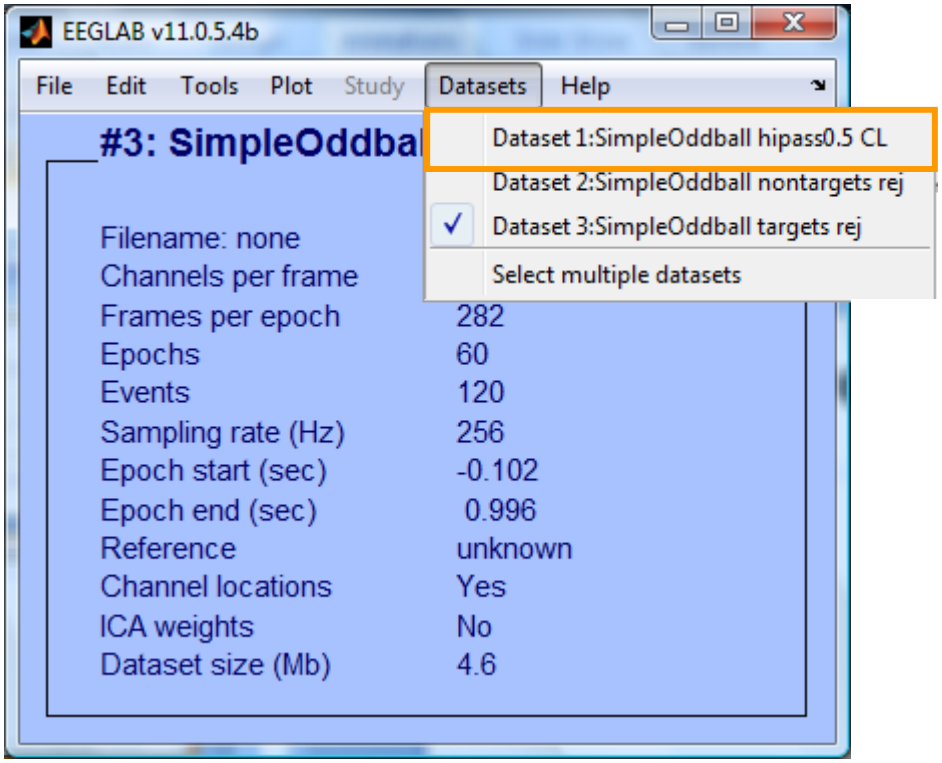
Identify/reject bad channels

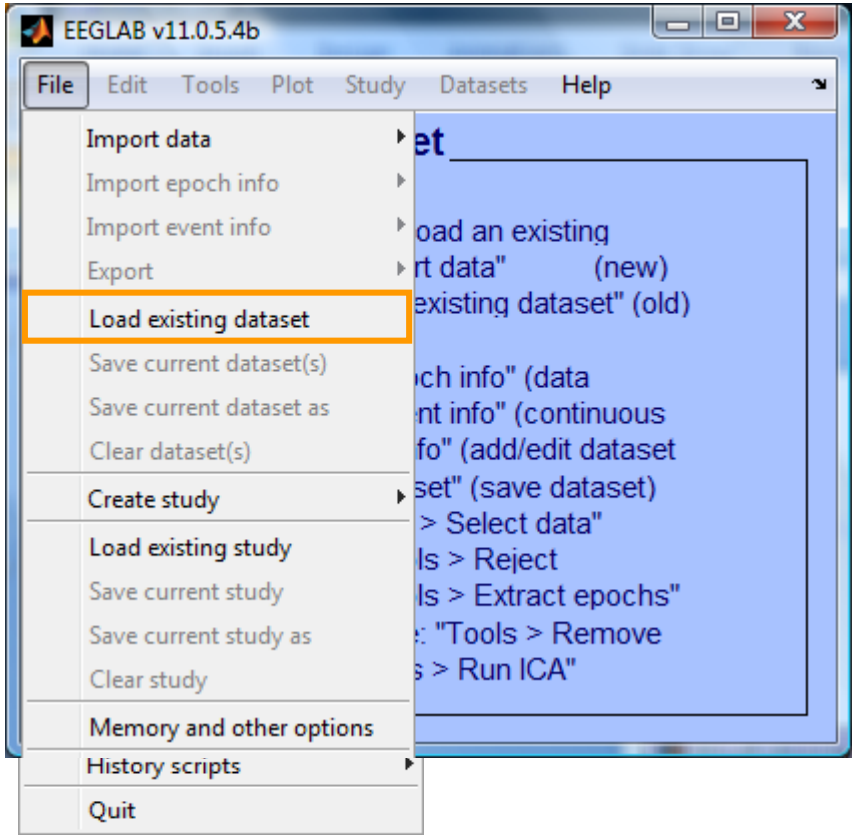
Reject large artifact time points

Run ICA
(next talk)

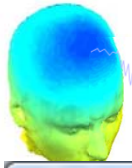
Retrieve or reload continuous EEG dataset

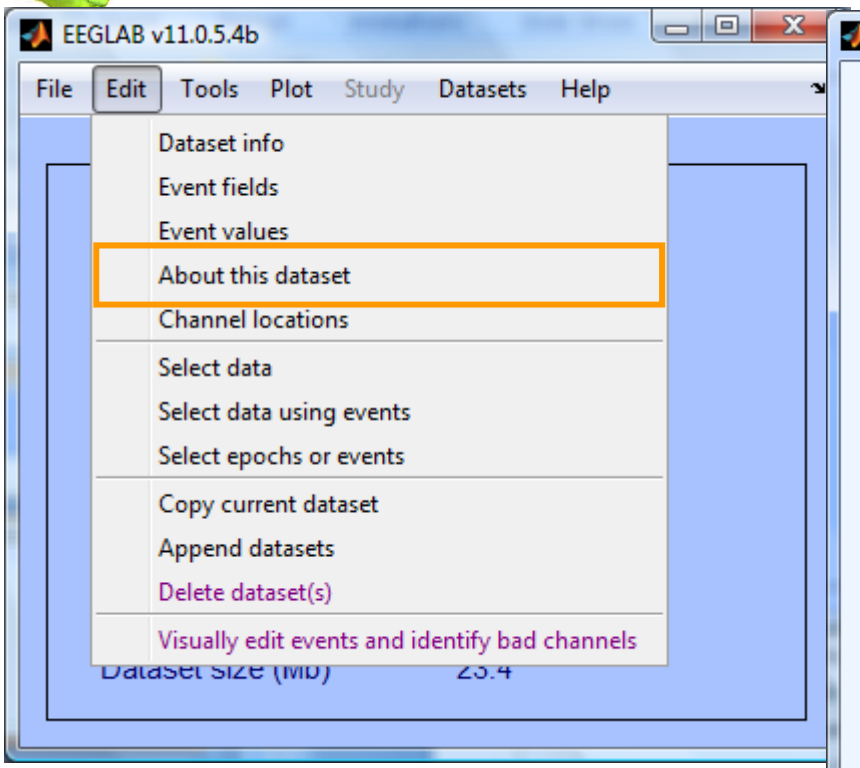


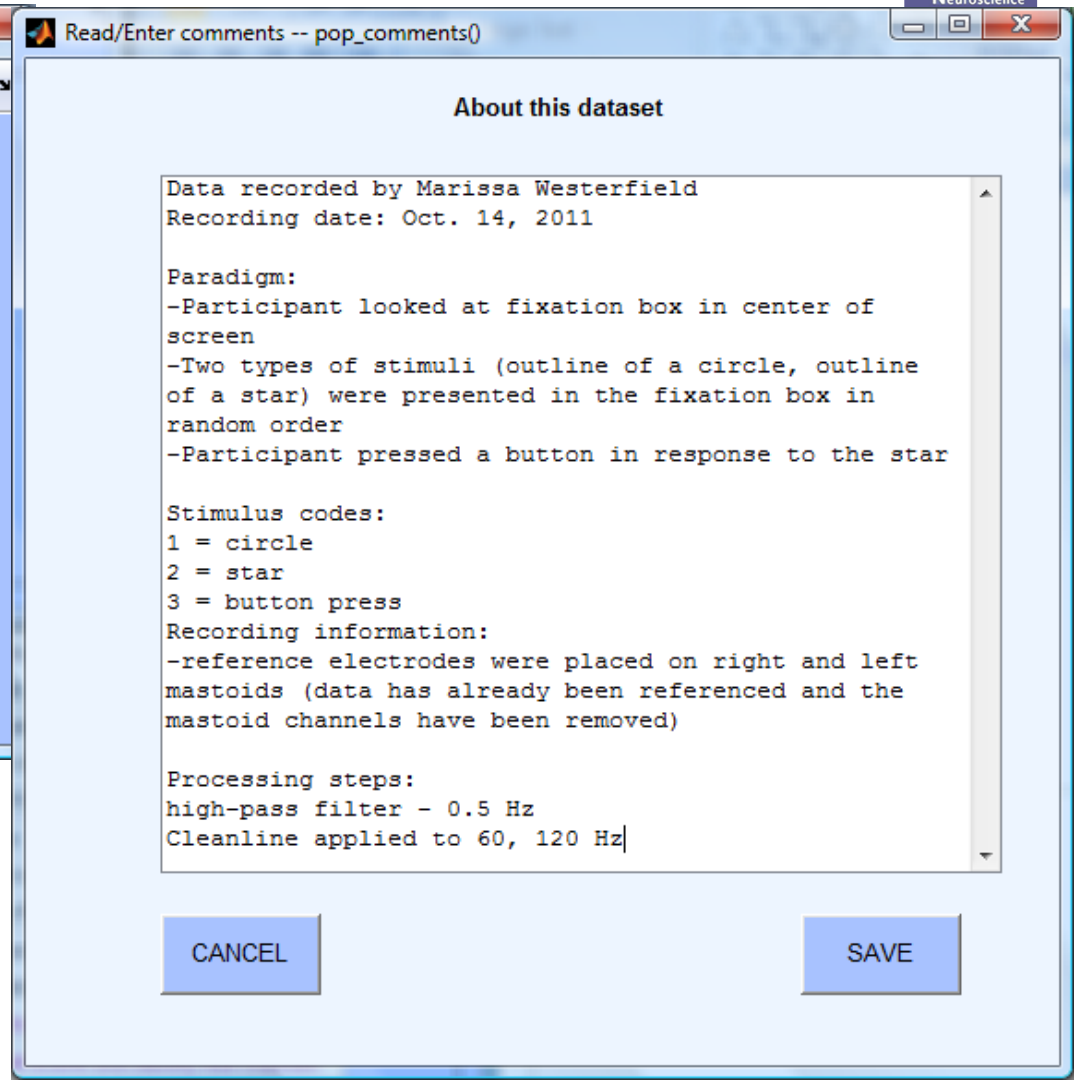




Comments and dataset history



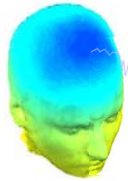




Also:
>> EEG.comments

or
>> EEG.history

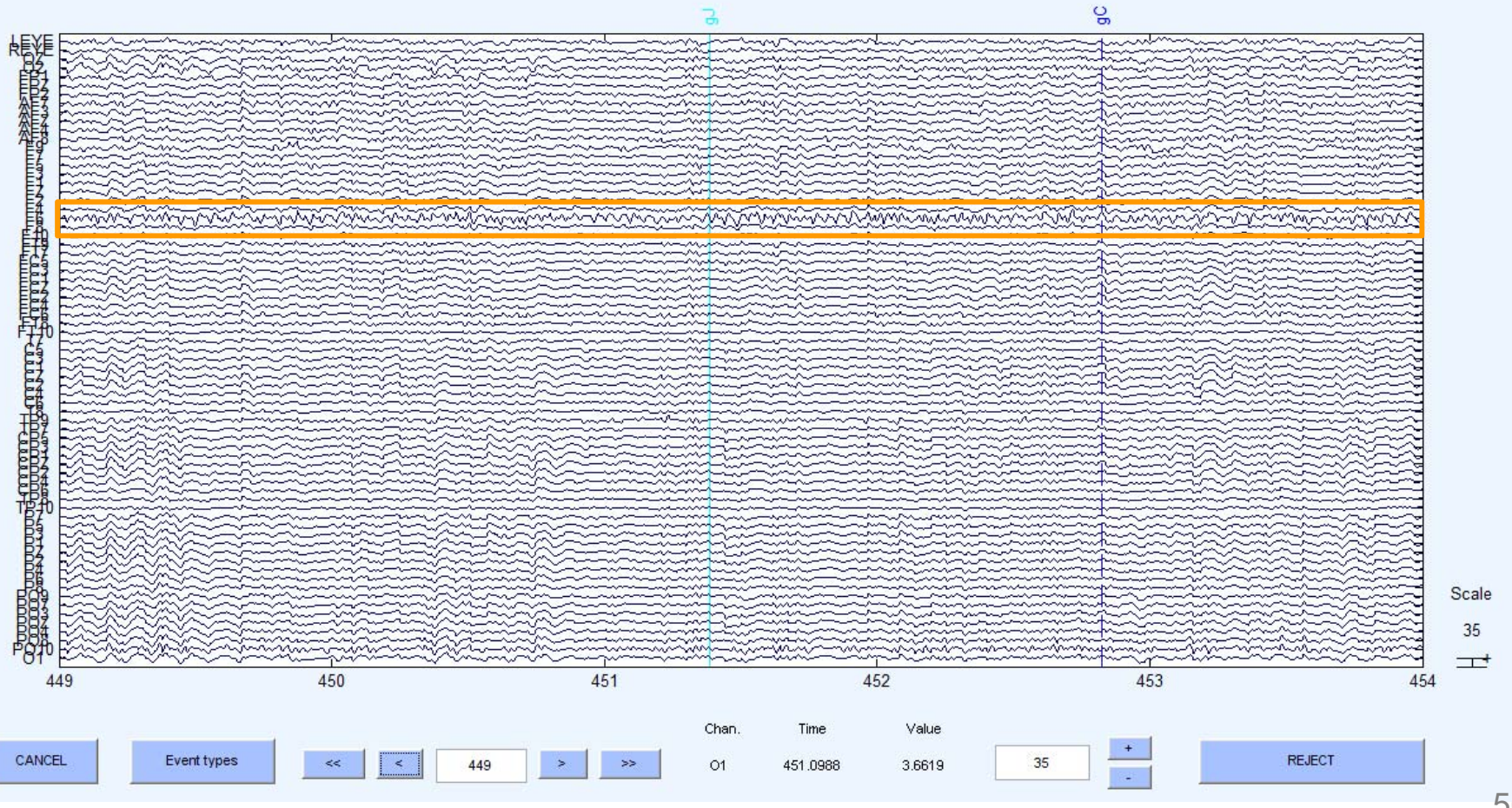
Manually identifying bad channels



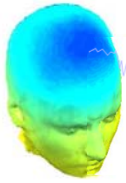
Scroll channel activities -- eegplot()

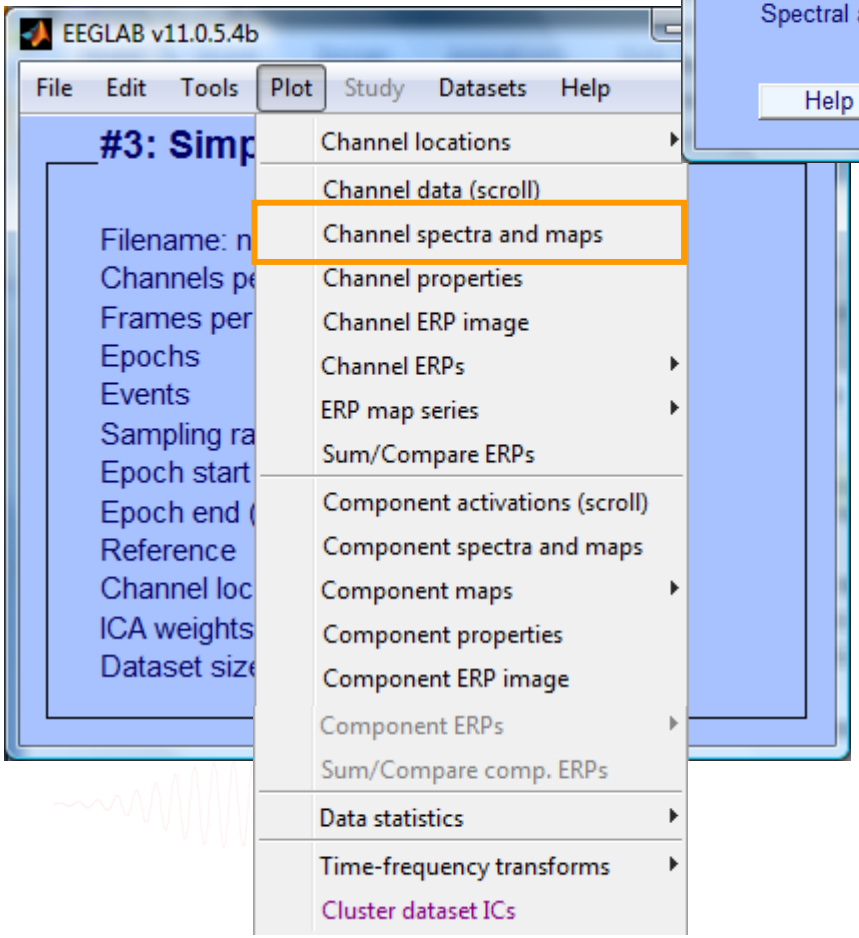
Figure Display Settings Help

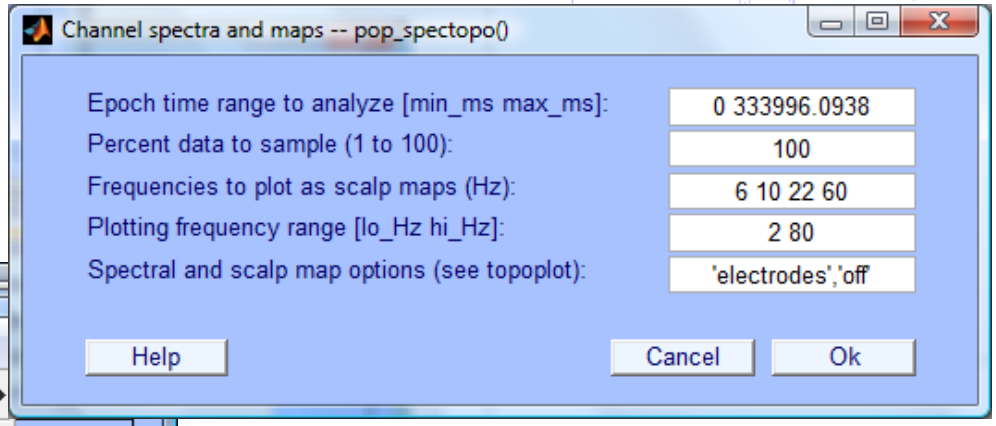
1) Identify bad channel

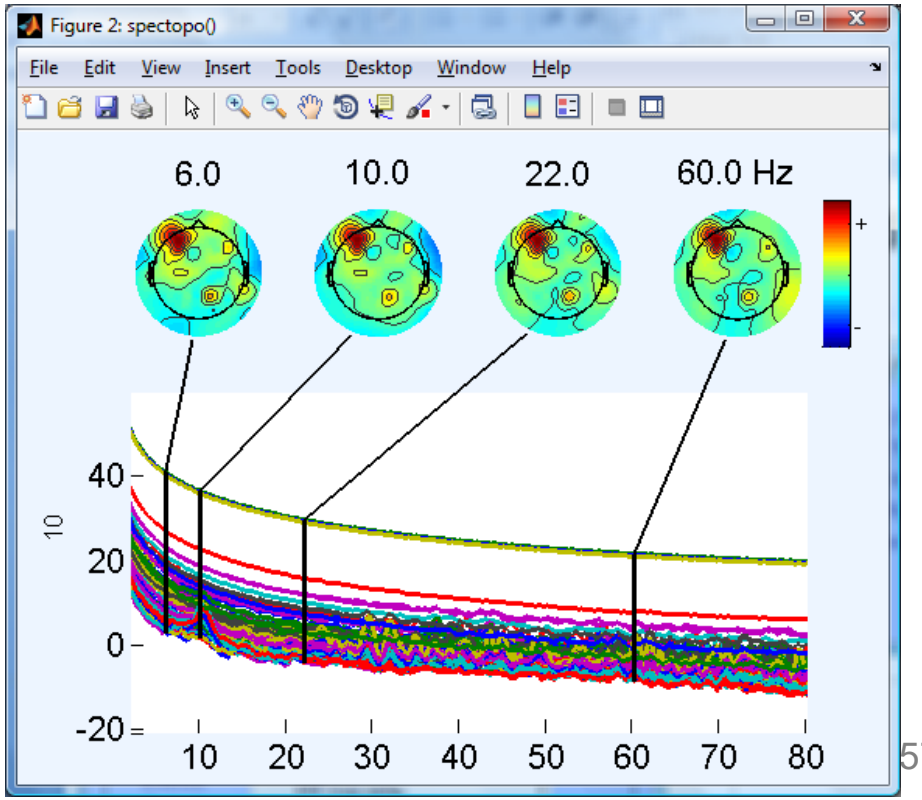


Manually identifying bad channels

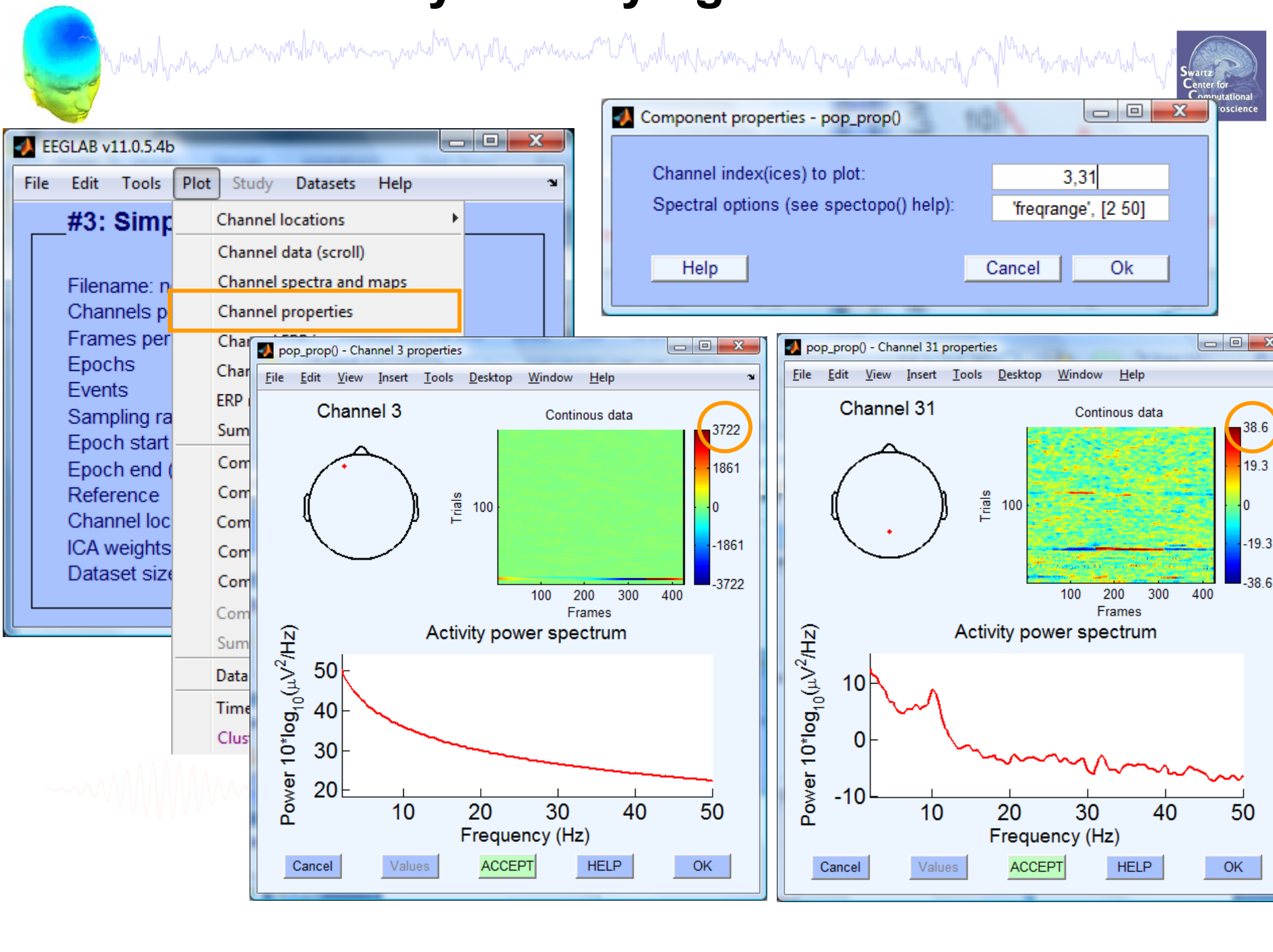




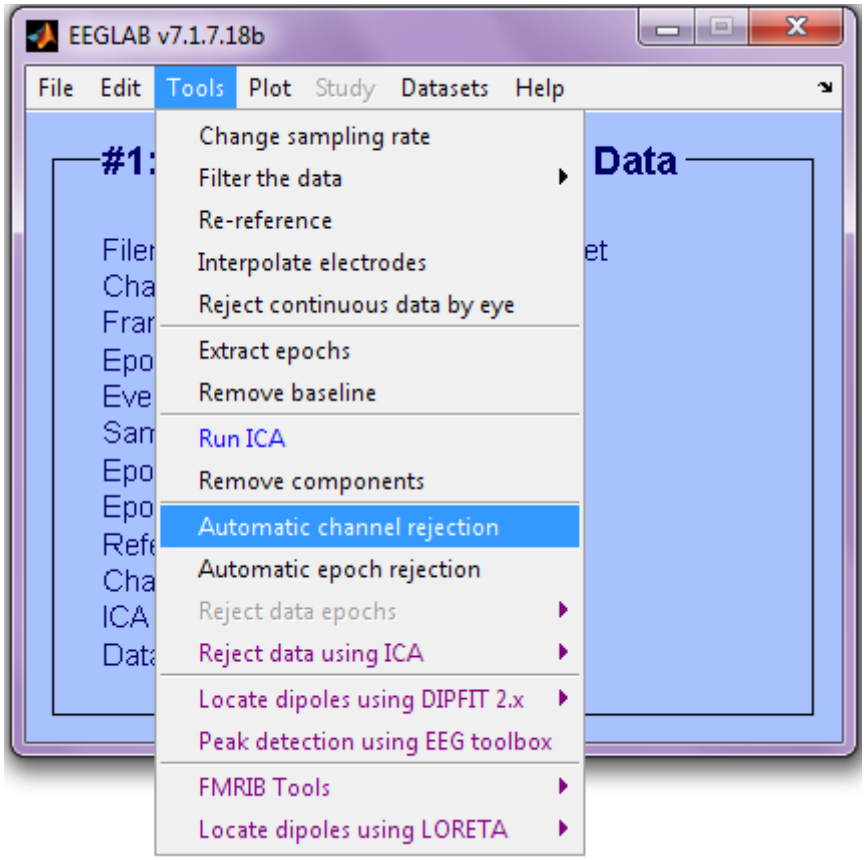


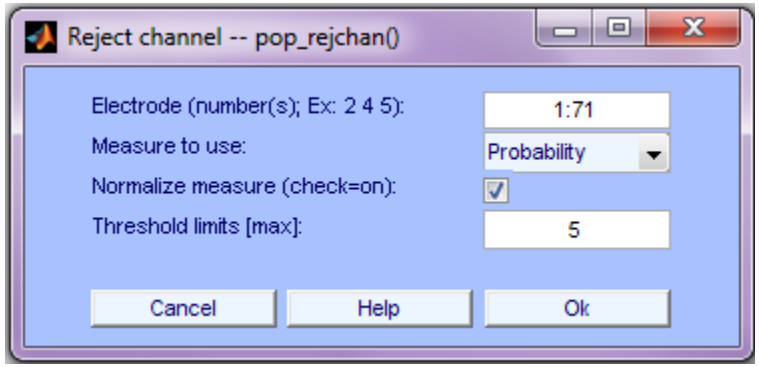


Manually identifying bad channels

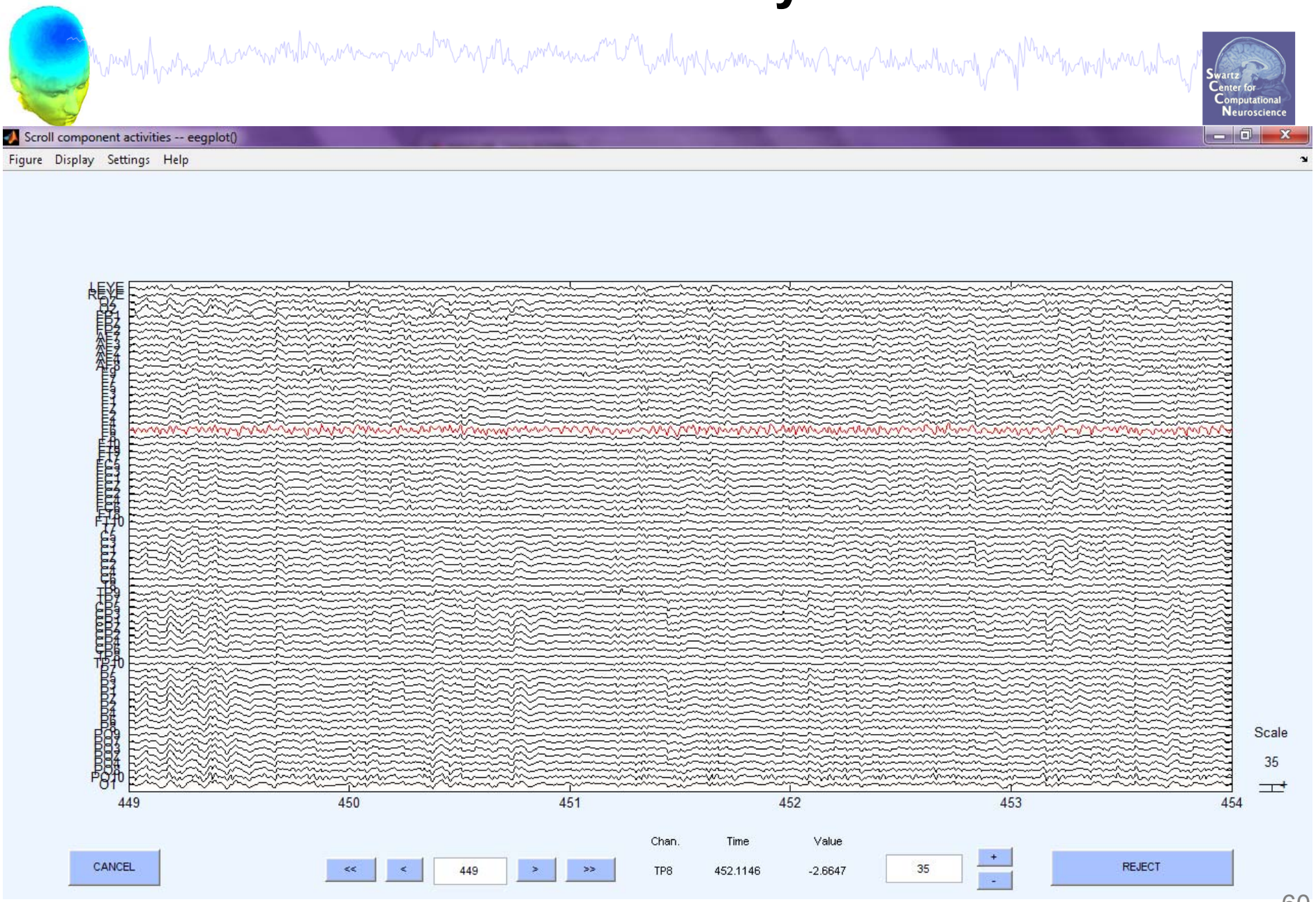


Auto-detection of noisy channels

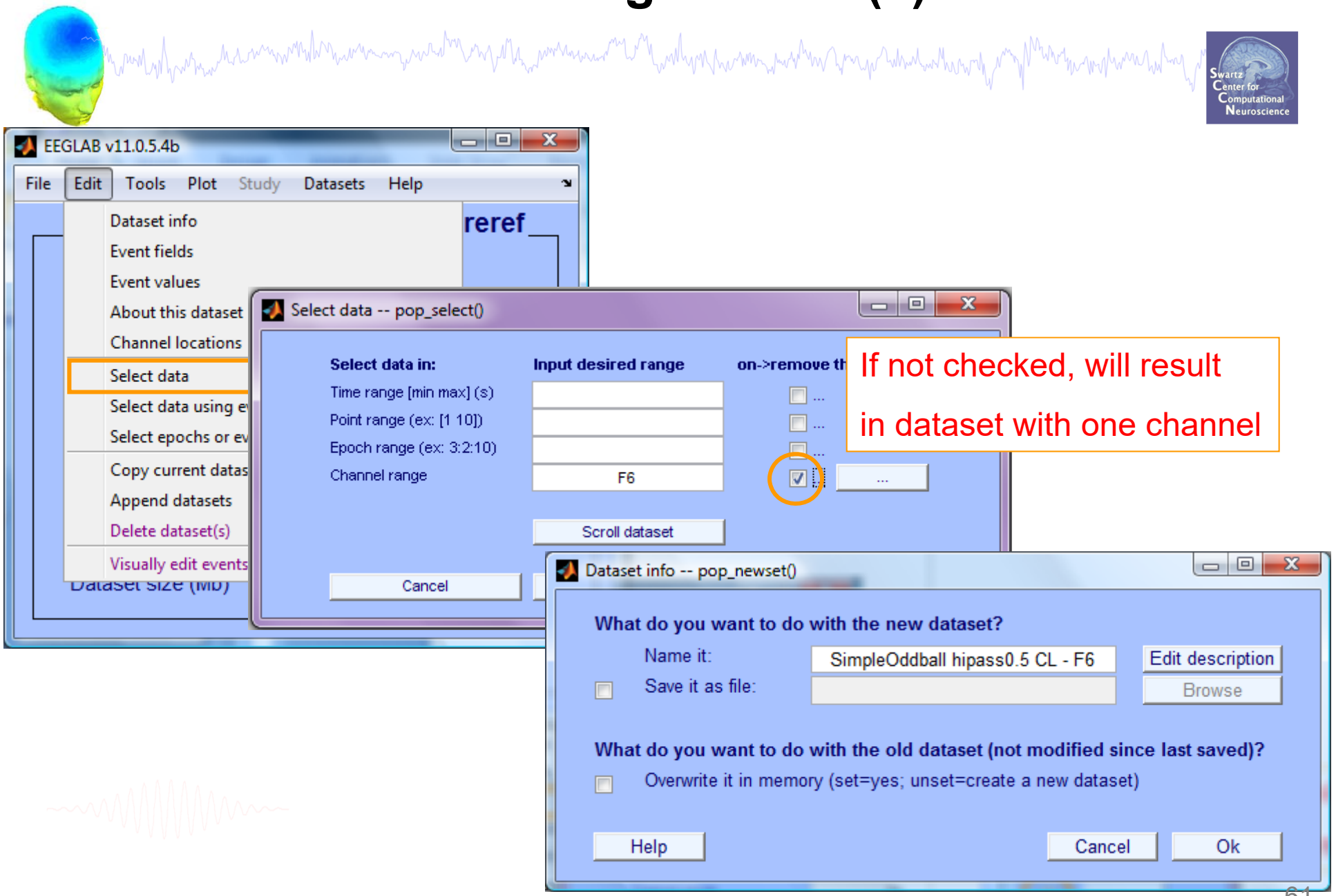




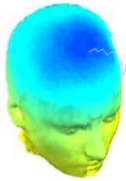
Auto-detected noisy channel



Removing channel(s)

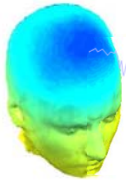


Removing channel(s)



- 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



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)

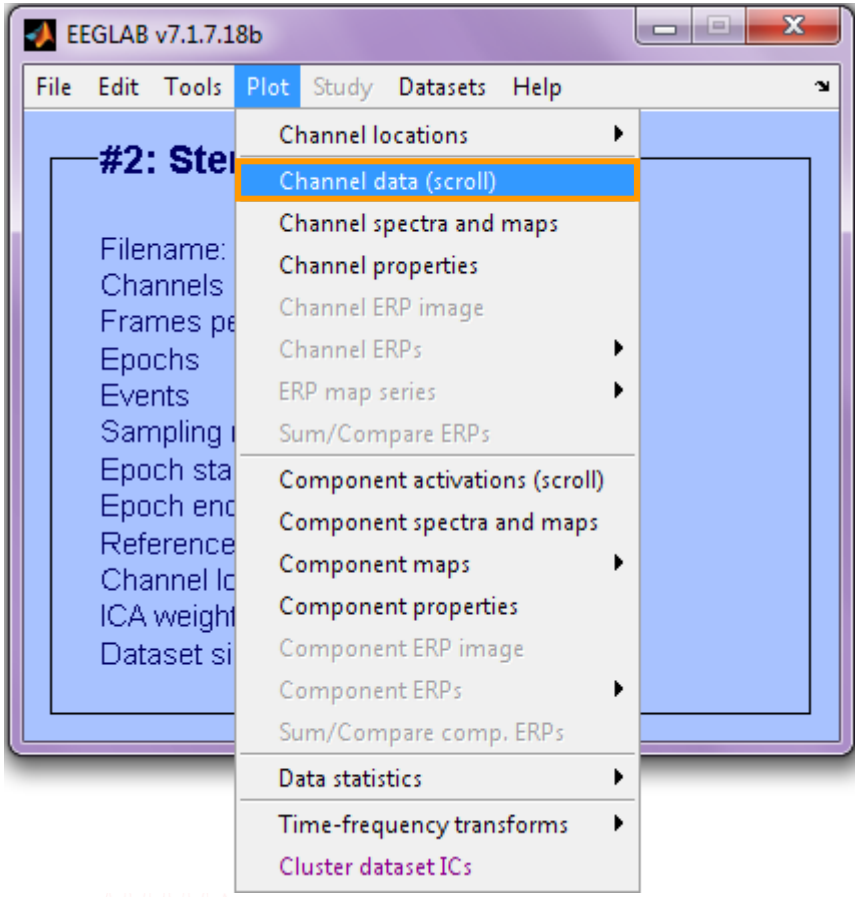
Identify/reject bad channels

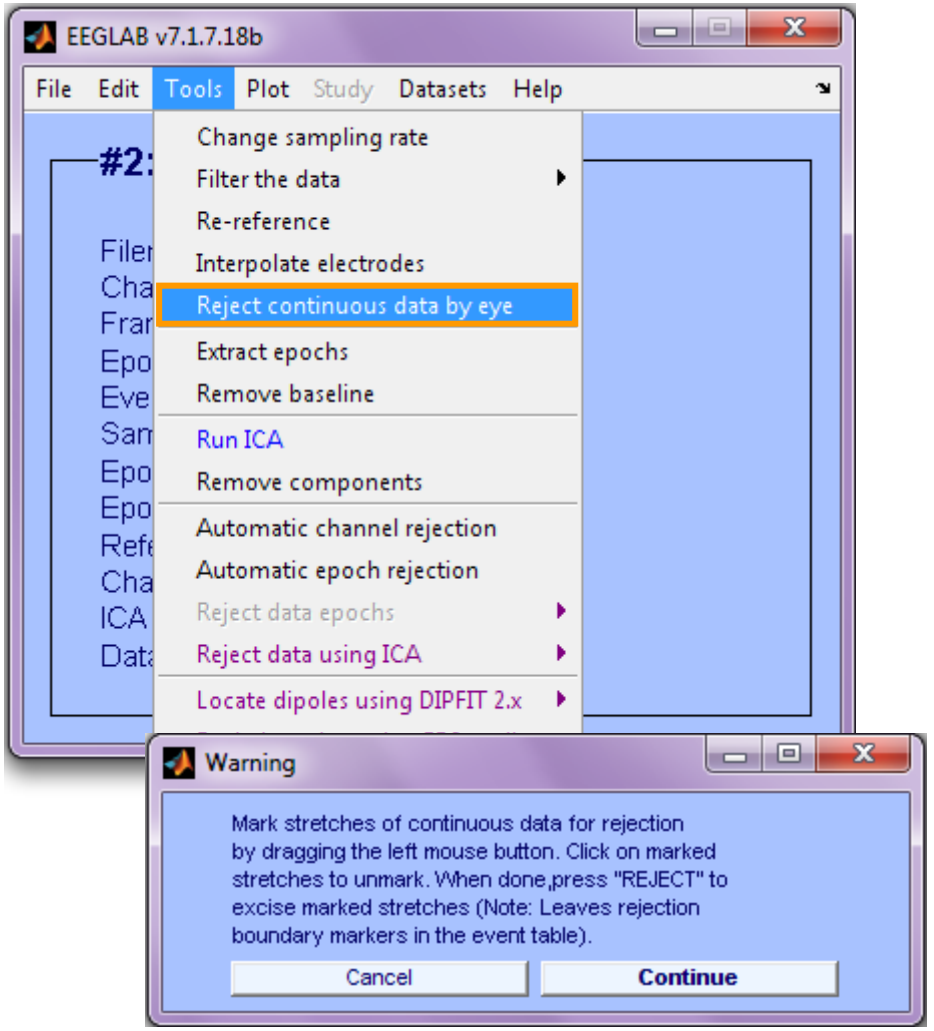
Reject large artifact time points

Run ICA
(next talk)

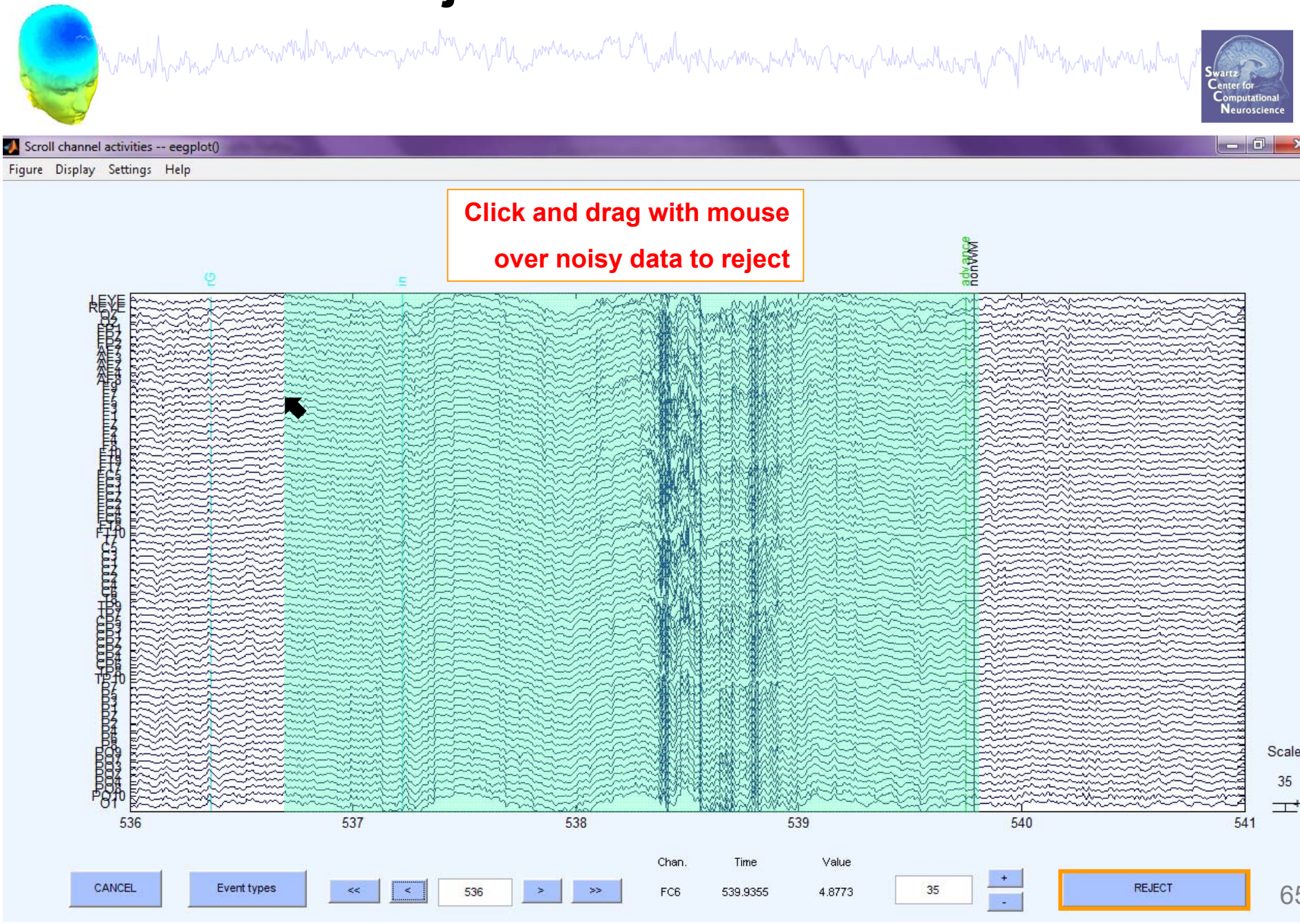
Reject continuous data

Equivalent

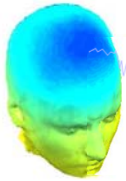




Reject continuous data

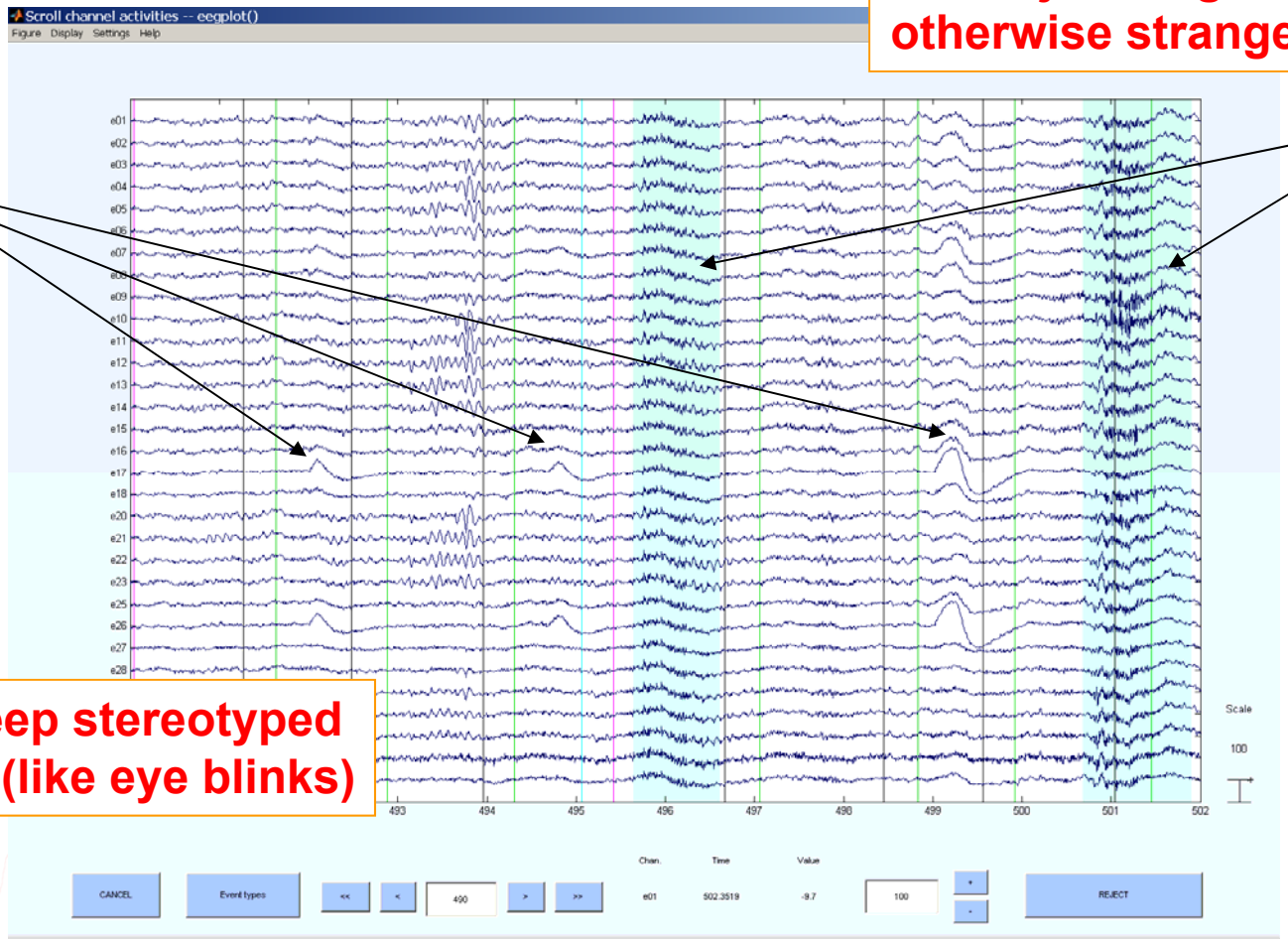


Rejecting data for ICA



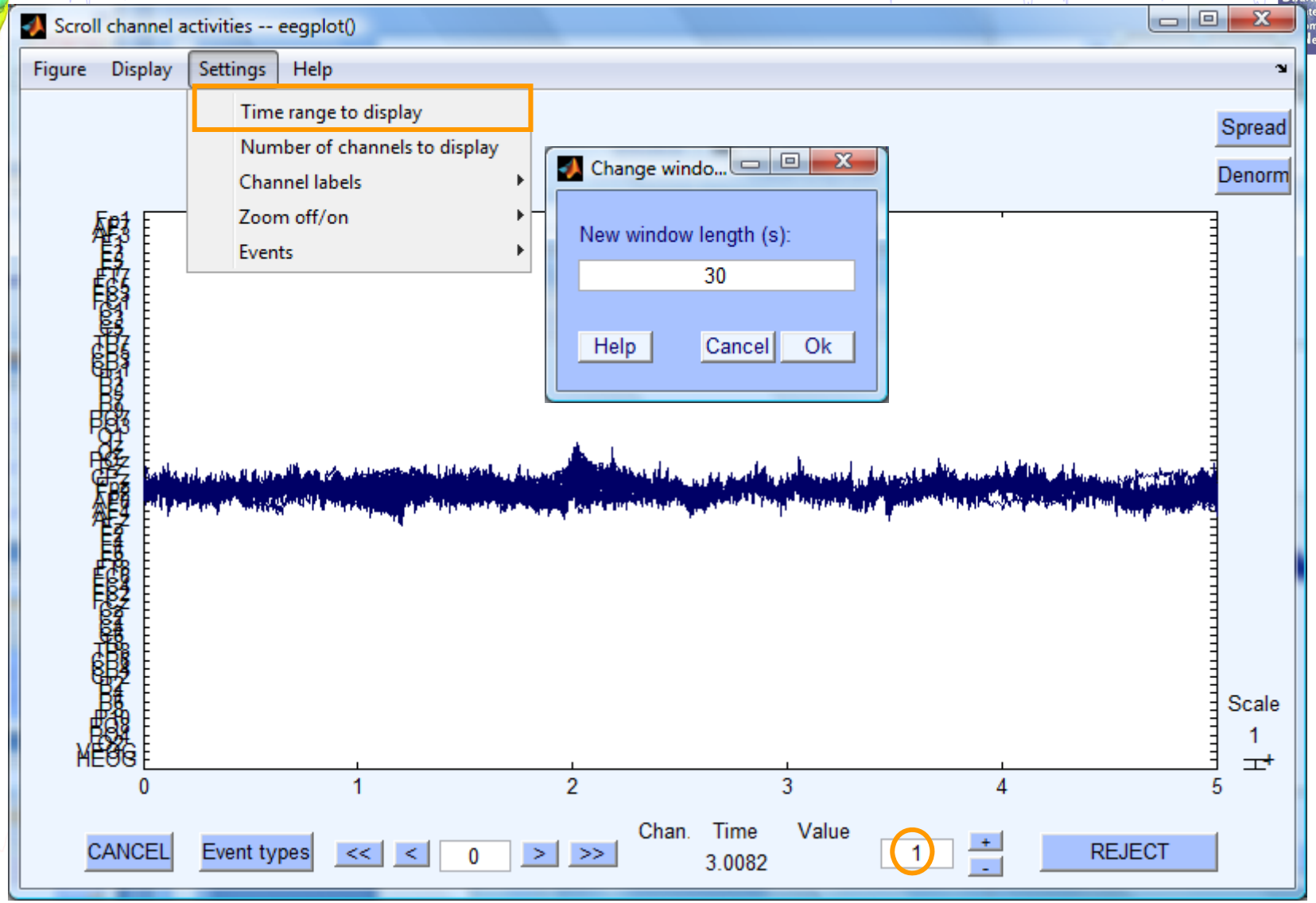
To prepare data for ICA:

Reject large muscle or otherwise strange events...

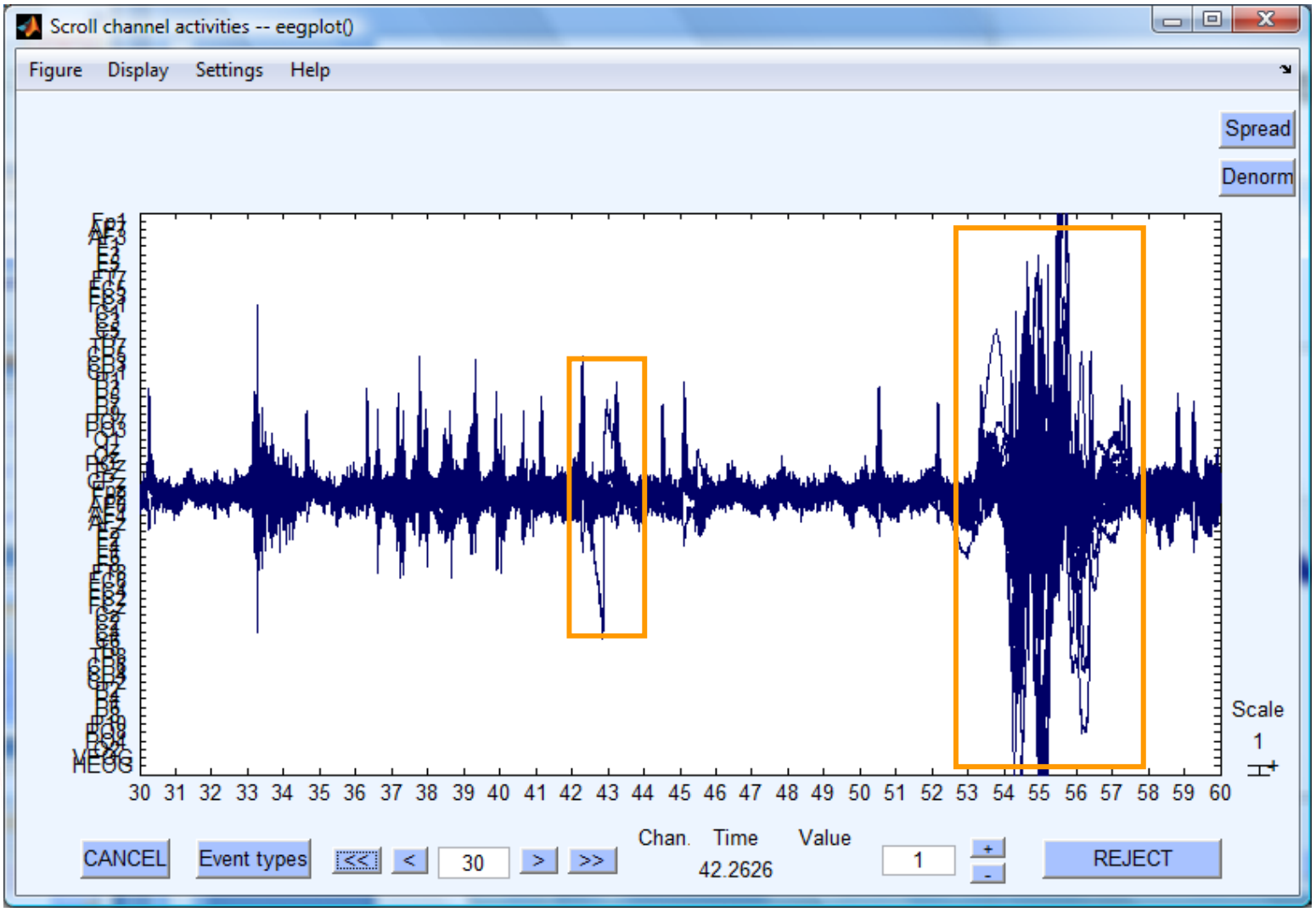


... but keep stereotyped artifacts (like eye blinks)

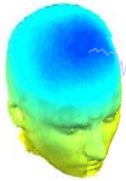
Fast (but sloppy) artifact rejection



Fast (but sometimes sloppy) artifact rejection



Pre-processing pipeline



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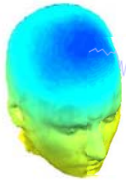
(next talk)

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