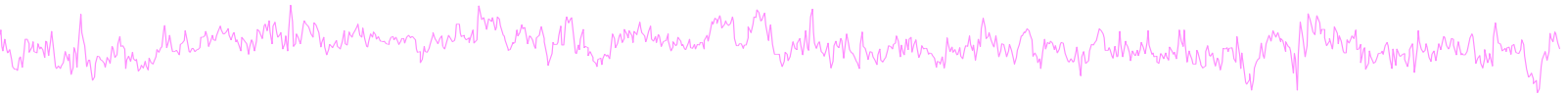
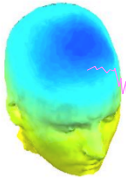


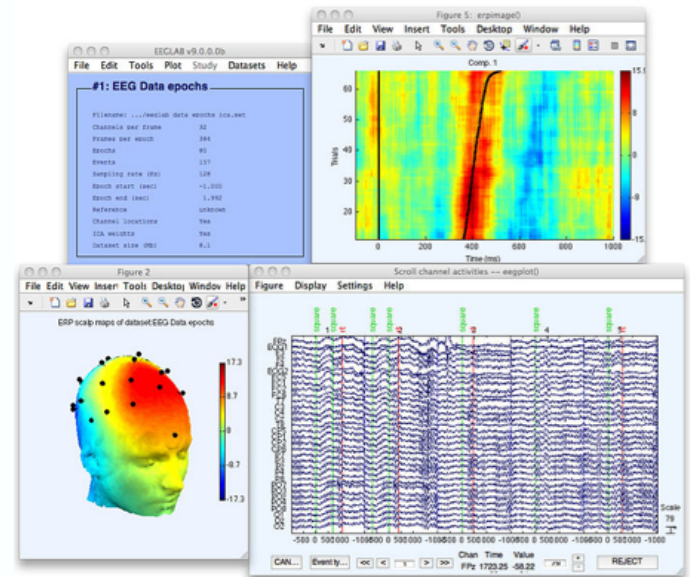
# EEGLAB overview



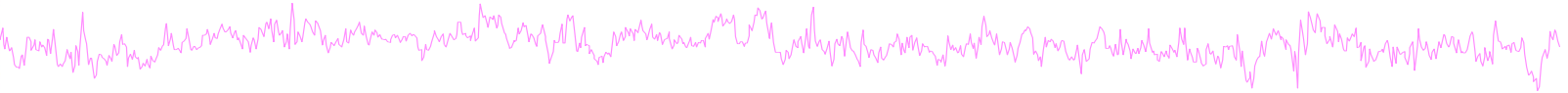
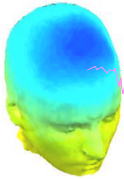
- Collection of about 600 functions (70 000 lines of code)
- About 100 000 download over the past 10 years
- About 6 500 users on the discussion list and 10 500 on the diffusion list
- NIH funding since 2003

<http://sccn.ucsd.edu/eeglab>

<http://sccn.ucsd.edu/wiki/eeglab>



# EEGLAB standard processing pipeline



## Single subject

1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
4. Extract epochs from data & reject artifactual epochs
5. Visualize data measures
6. Perform ICA decomposition
  - Perform source localization of components
  - Analyze components contribution to ERP
  - Analyze components contribution to spectrum

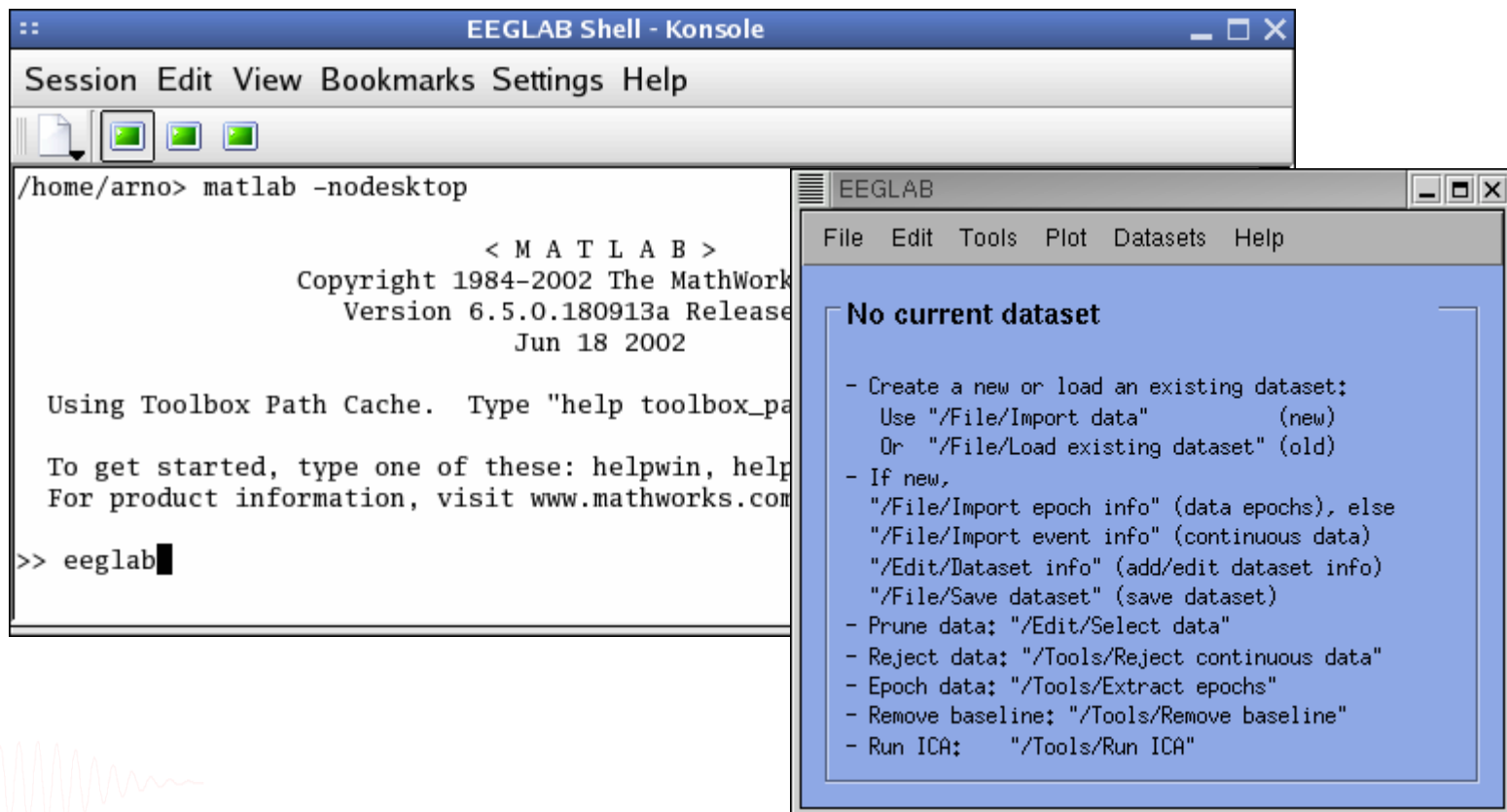
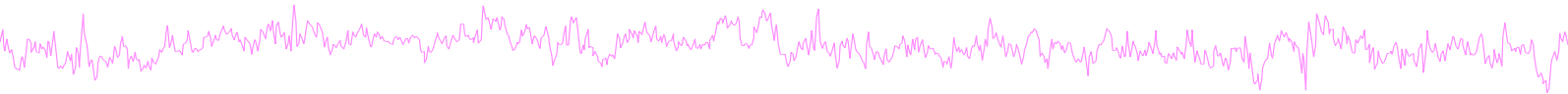
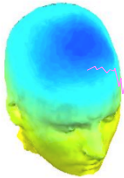
## Multi-subjects

1. Build study and STUDY design
2. Pre-compute measures
3. Cluster components
4. Analyze clusters

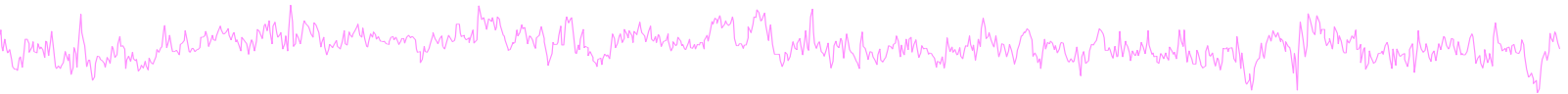
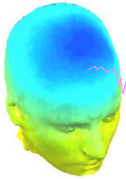


**Advanced analysis using scripting and EEGLAB command line functions**

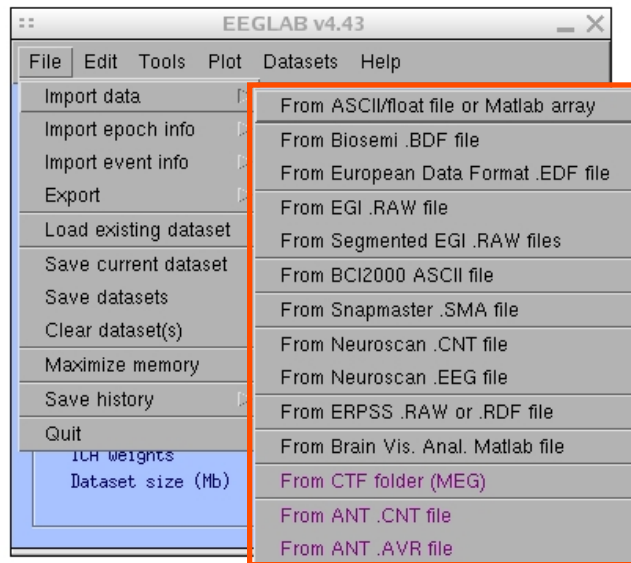
# The EEGLAB Matlab software



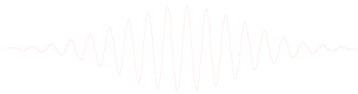
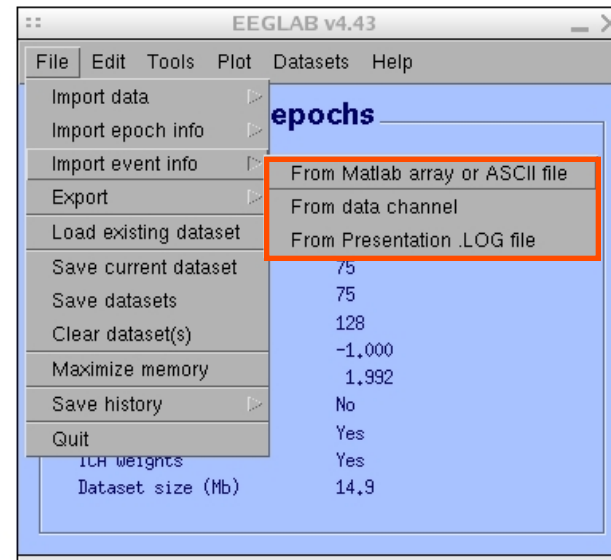
# 1. Importing data



## Import/load data

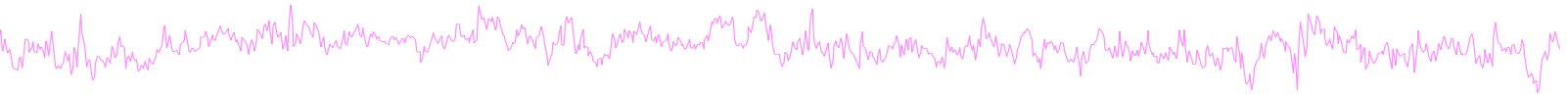
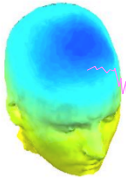


## Import events

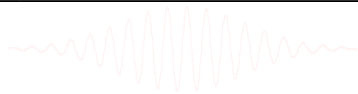
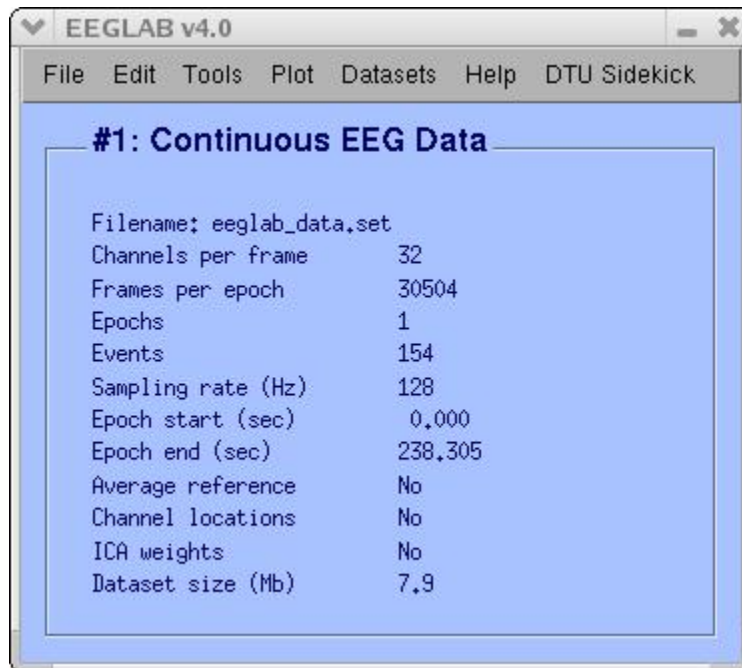




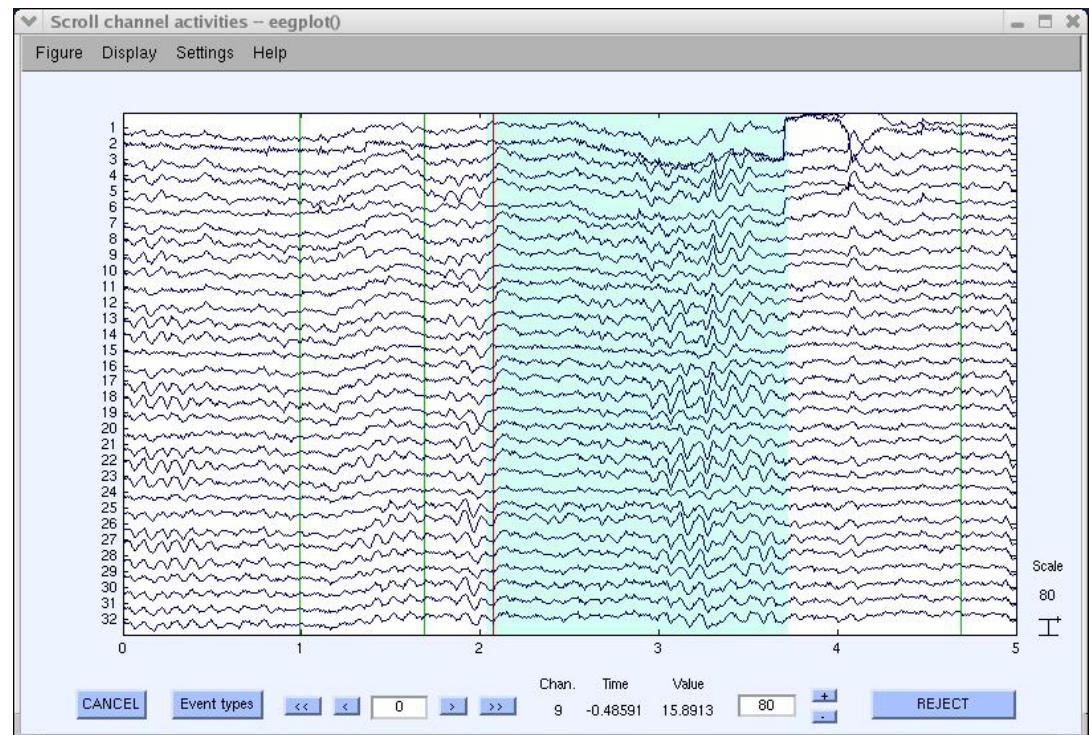
# 1. Importing data



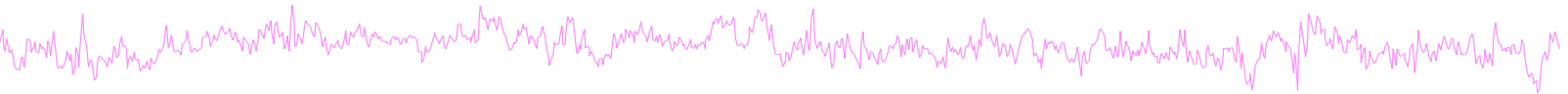
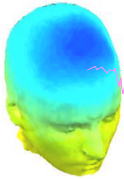
## Data info



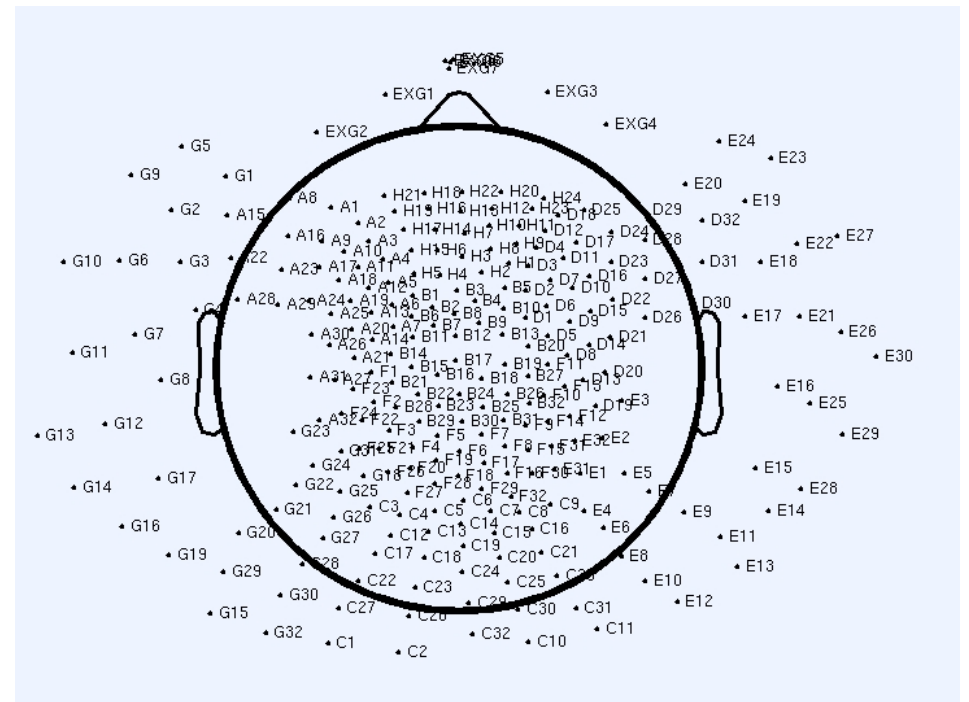
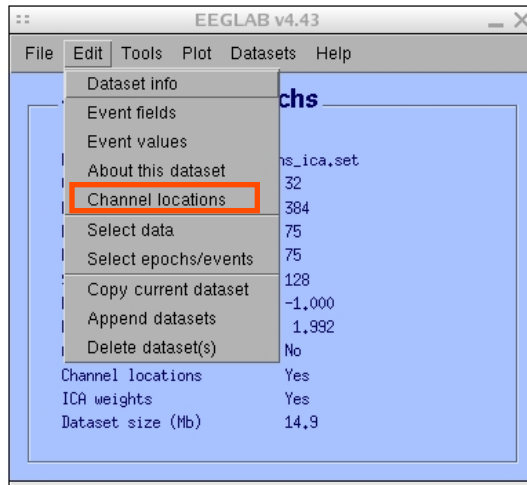
## Scrolling data



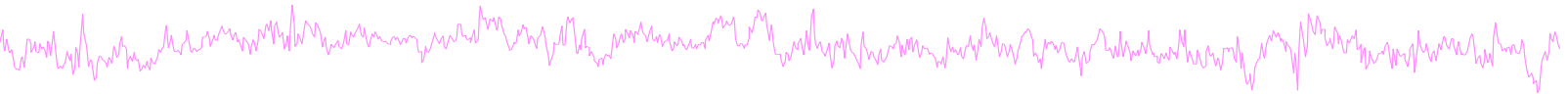
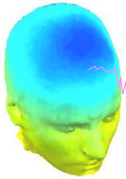
# 1. Importing channel location



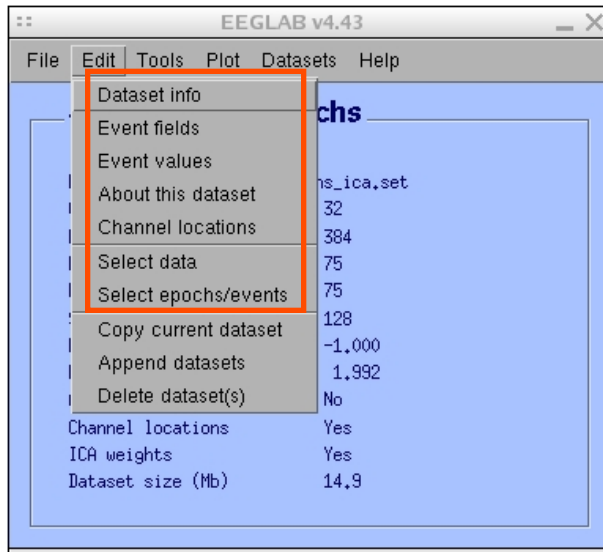
## Import channel location



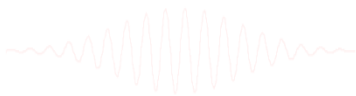
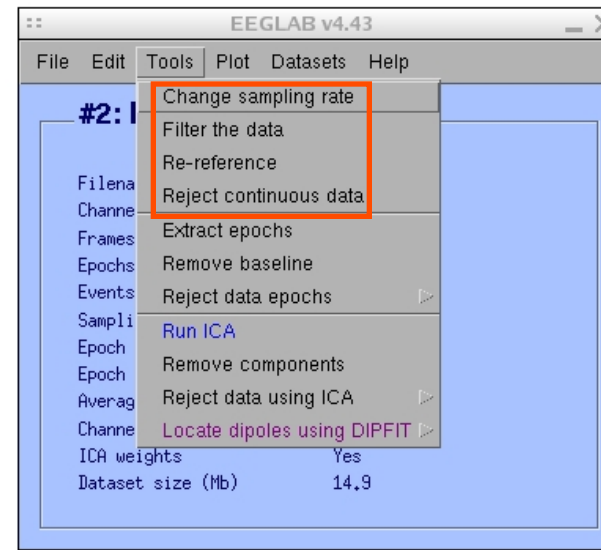
## 2. Edit, Re-reference, Resample, High pass filter data



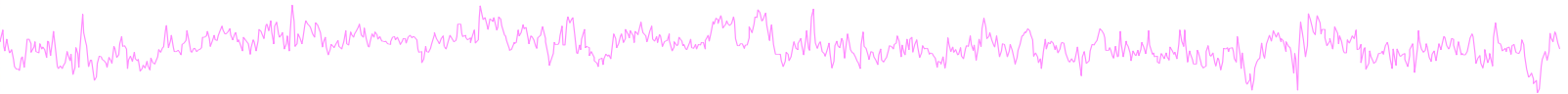
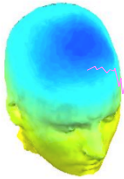
### Edit/select data



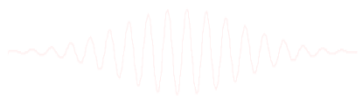
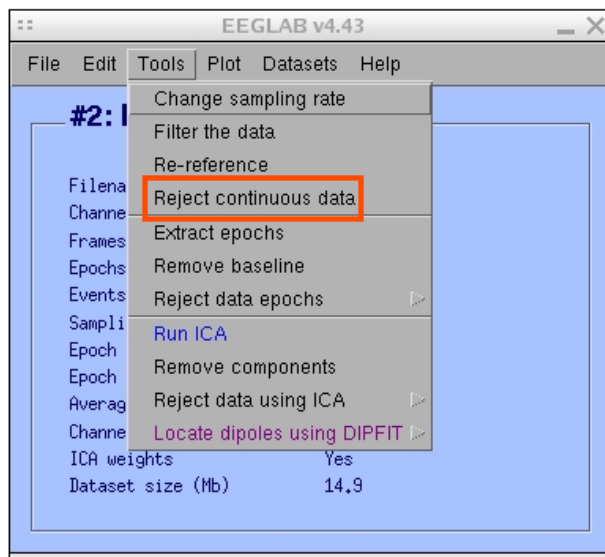
### Preprocessing data



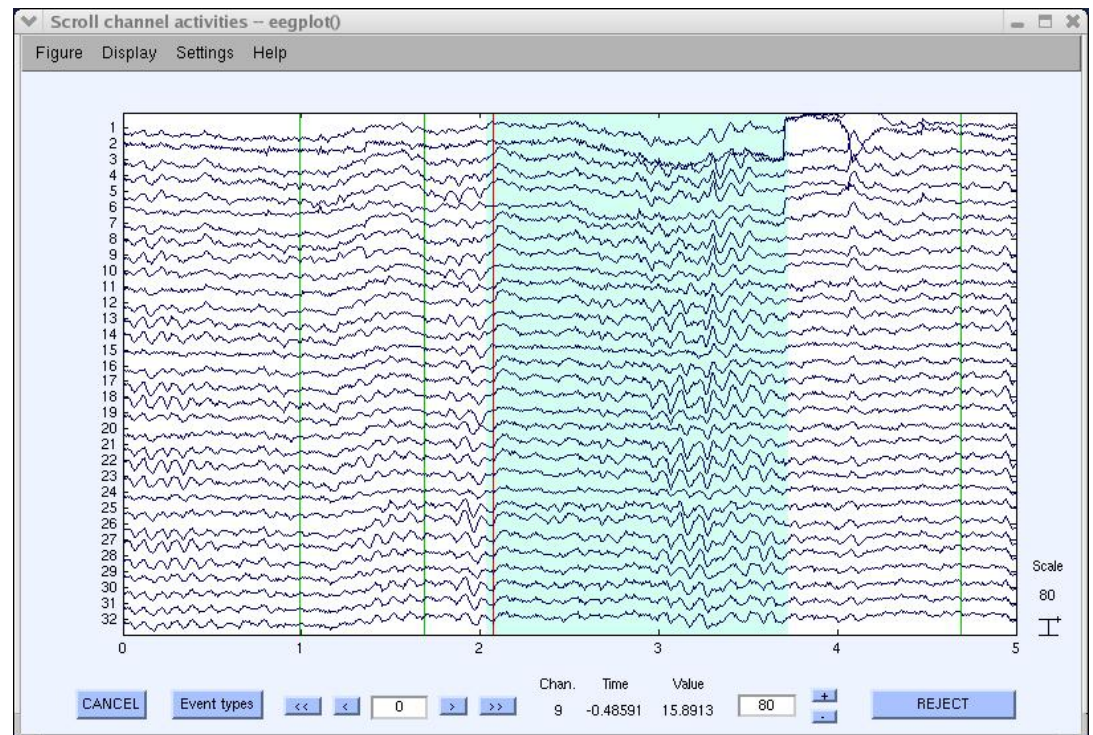
### 3. Reject artifacts in continuous data by visual inspection



#### Data info

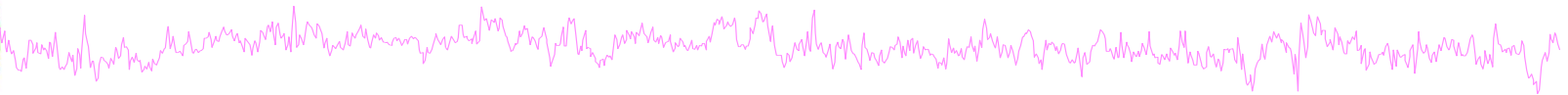
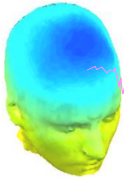


#### Reject portions of continuous data

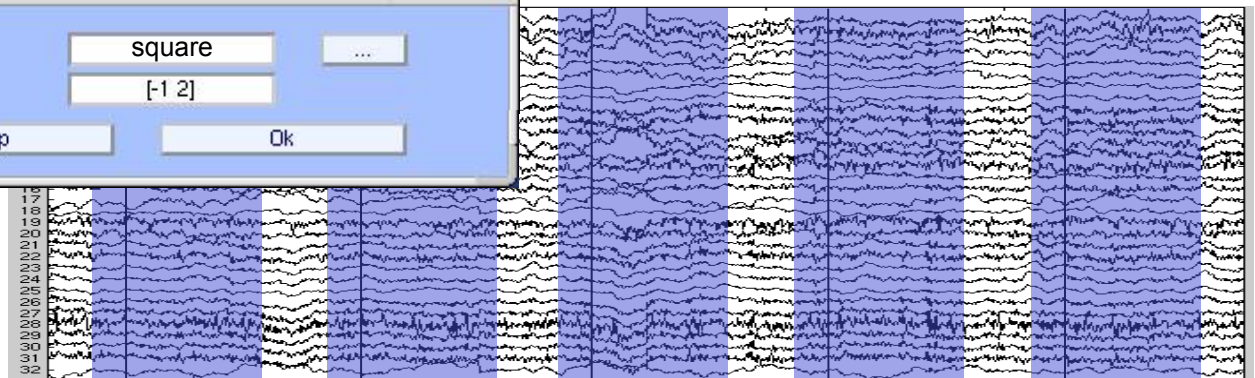
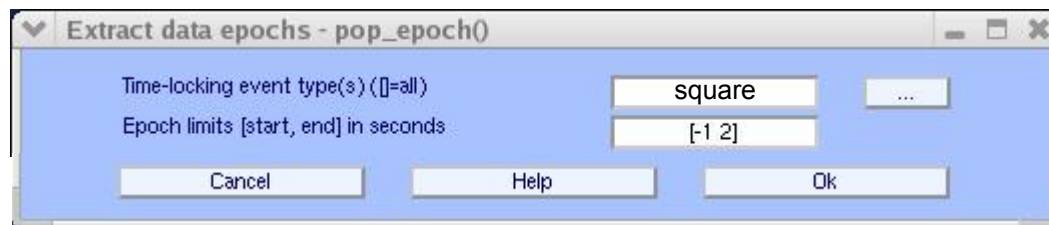
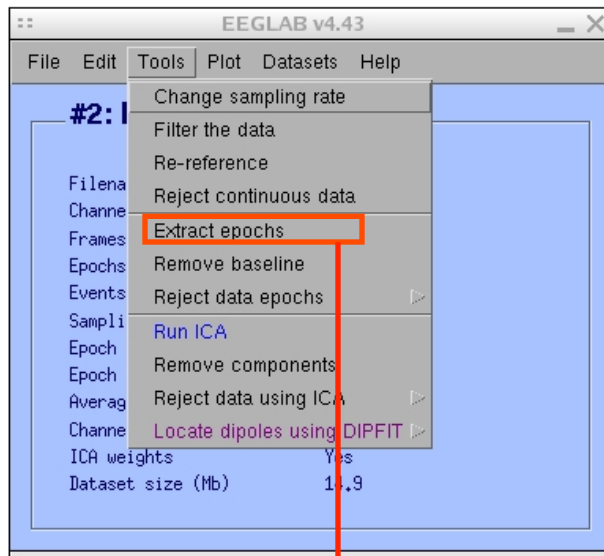




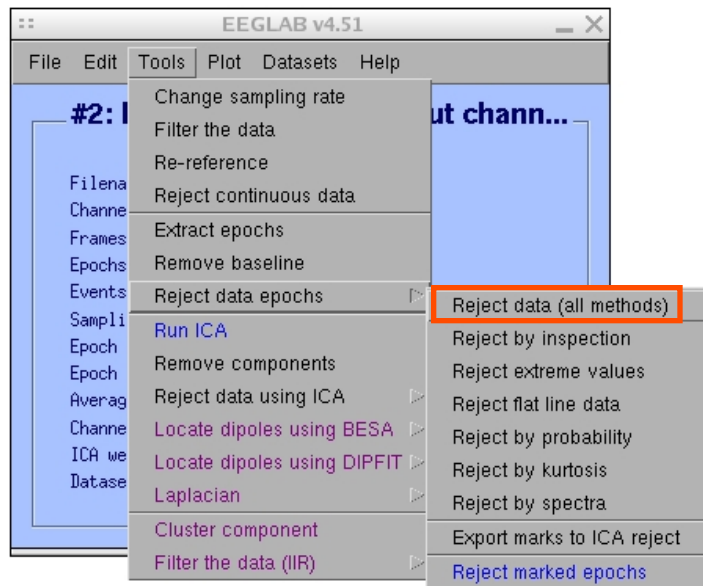
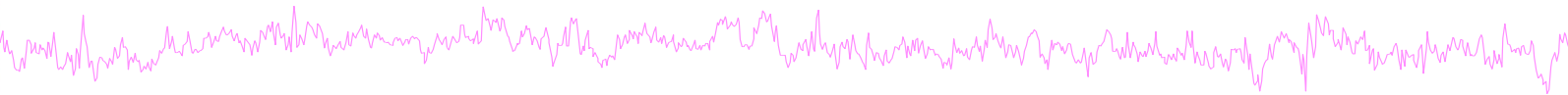
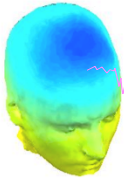
## 4. Extract epochs from data & reject artifactual epochs



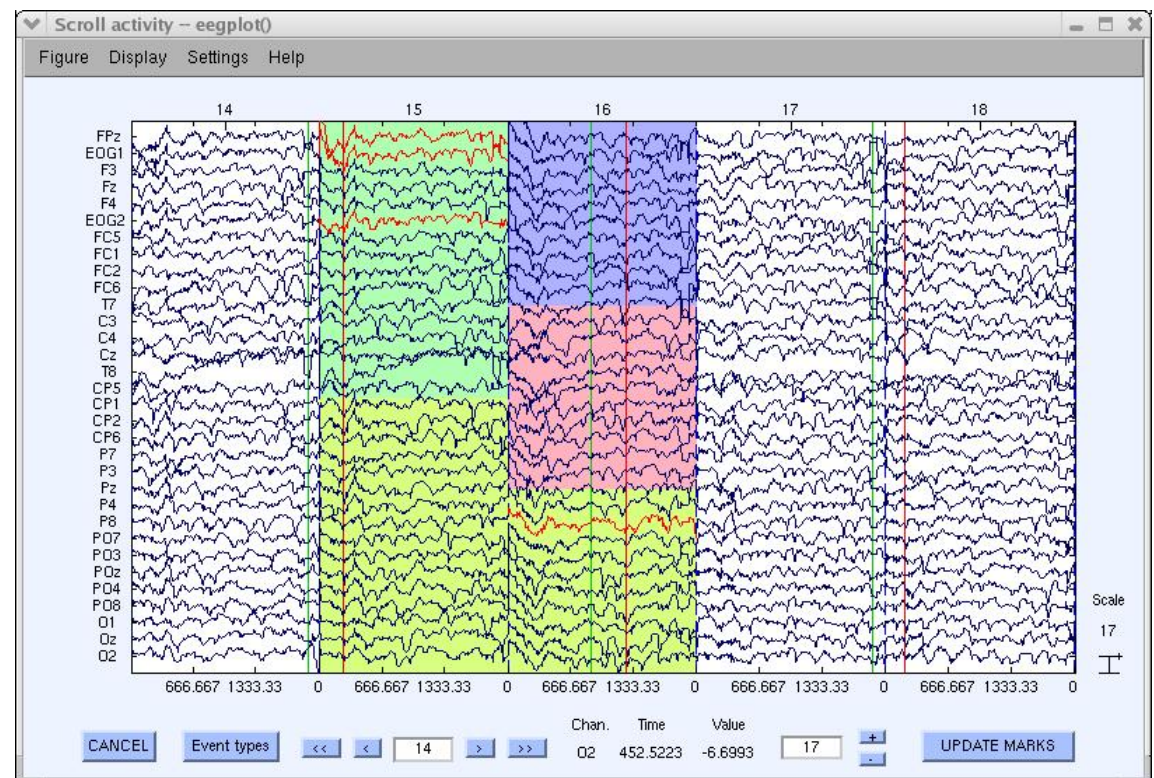
### Preprocessing data

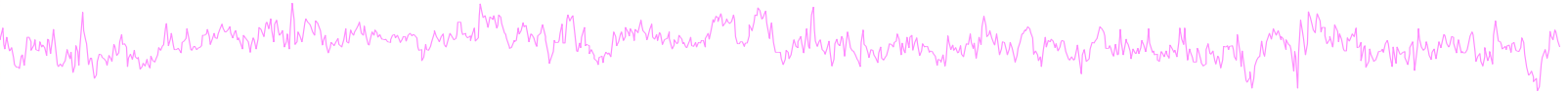


## 4. Extract epochs from data & reject artifactual epochs

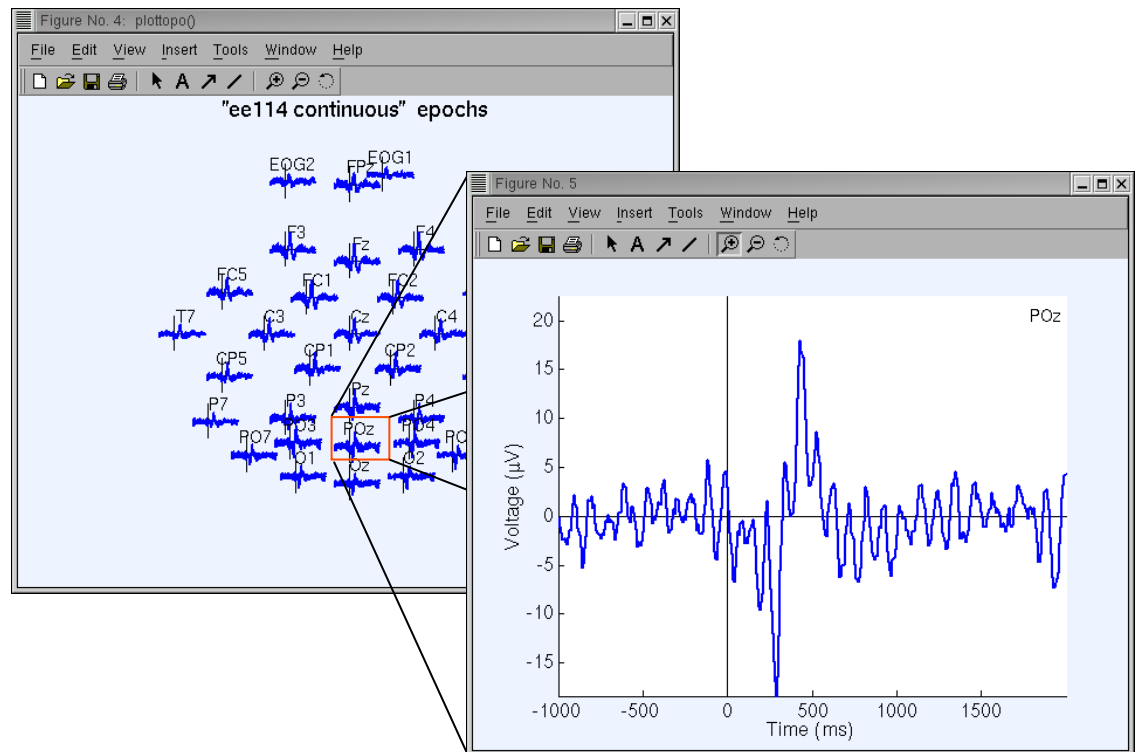


Different color = different rejection methods



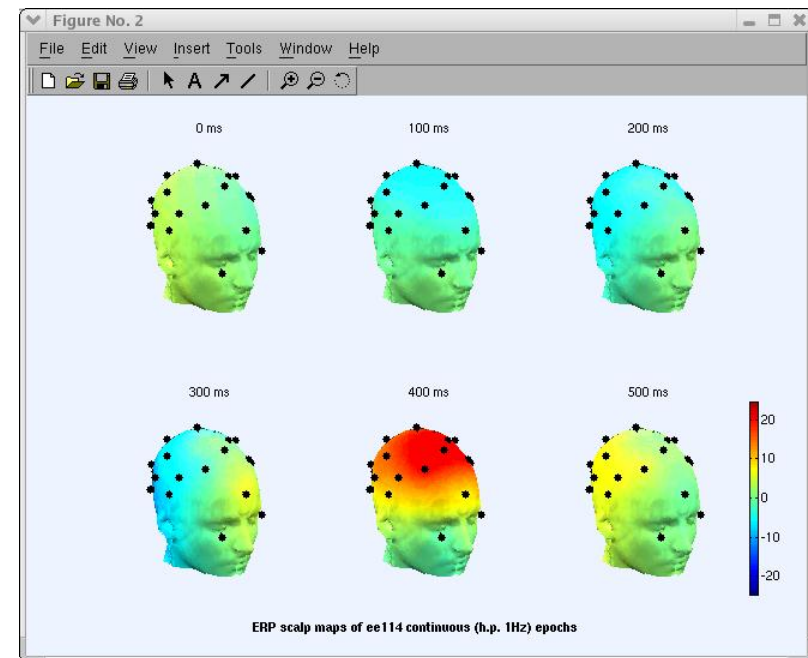
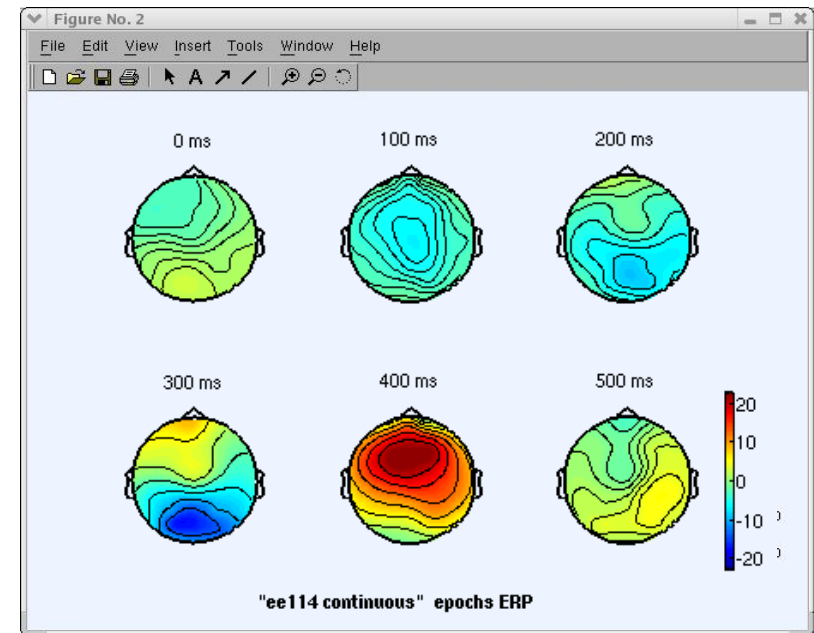
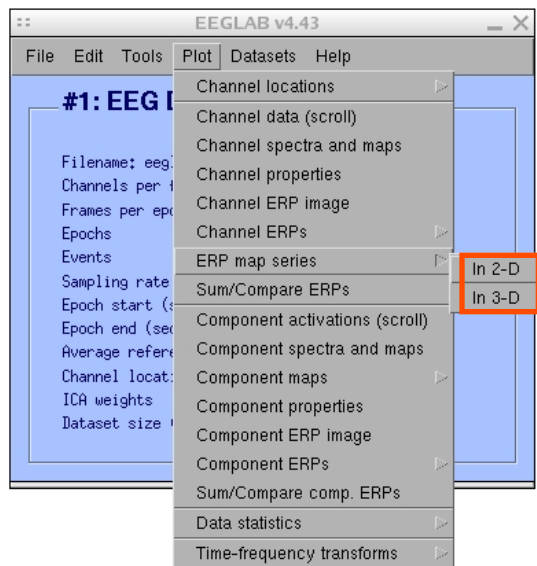


The screenshot shows the EEGLAB v4.33 software interface. The 'Plot' menu is open, displaying a list of plotting options. The option 'In scalp array' is highlighted with a red rectangular box. Other visible options include 'Channel locations', 'Channel data (scroll)', 'Channel spectra and maps', 'Channel properties', 'Channel ERP image', 'Channel ERPs', 'ERP map series', 'Sum/Compare ERPs', 'Component activations (scroll)', 'Component spectra and maps', 'Component maps', 'Component properties', 'Component ERP image', 'Component ERPs', 'Sum/Compare comp. ERPs', 'Data statistics', and 'Time-frequency transforms'. The background shows a portion of the main EEGLAB window with a blue header and various data fields.



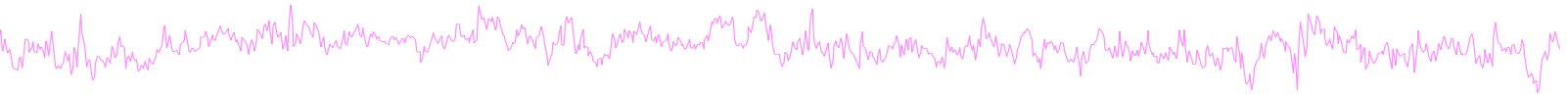
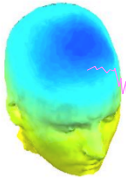
## 5. Visualize data measures

Plot ERP  
map series

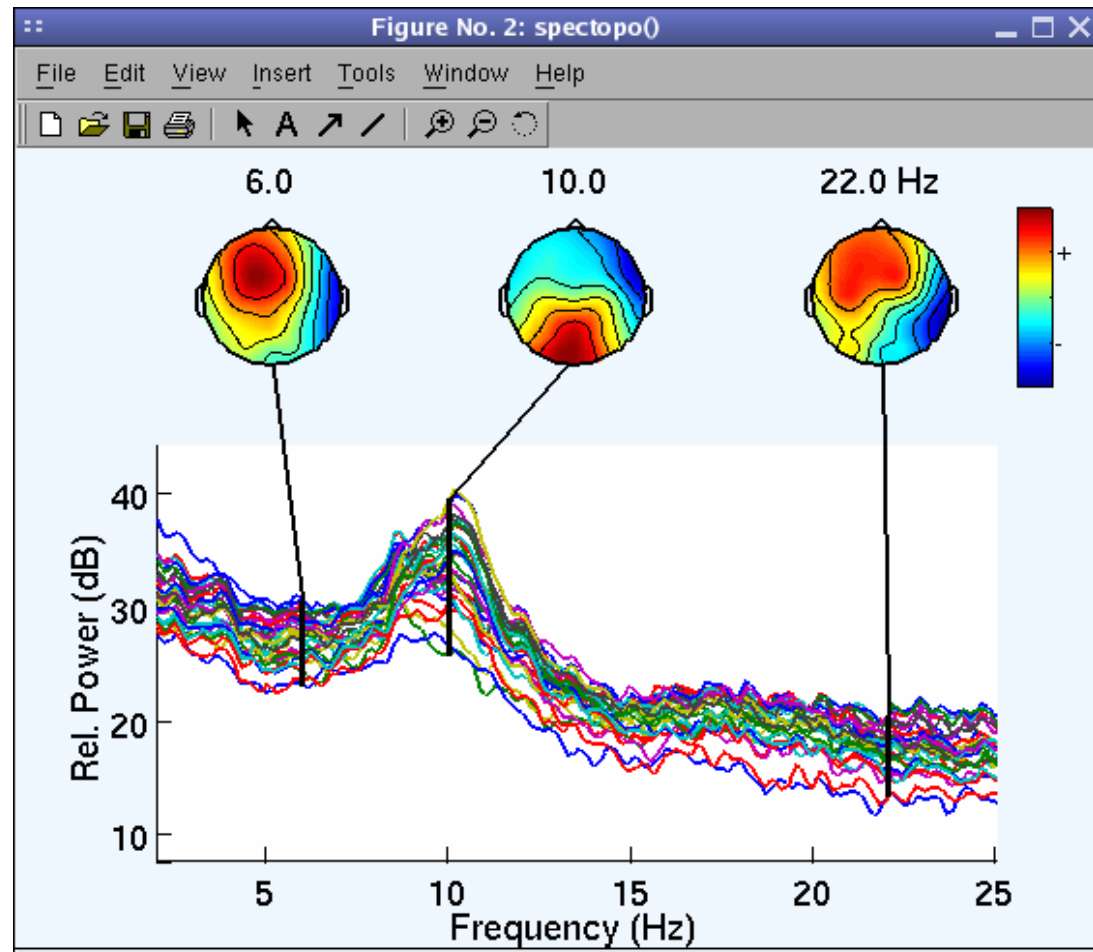
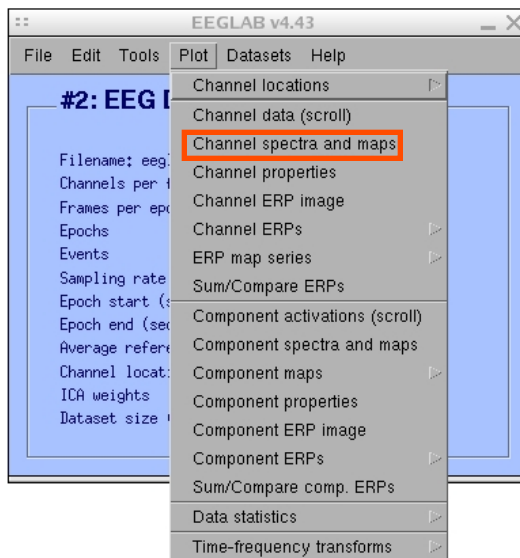




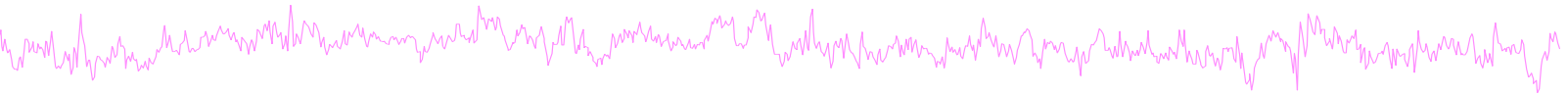
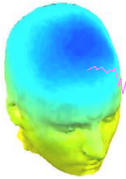
# 5. Visualize data measures



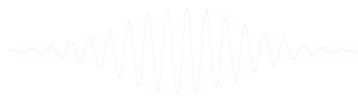
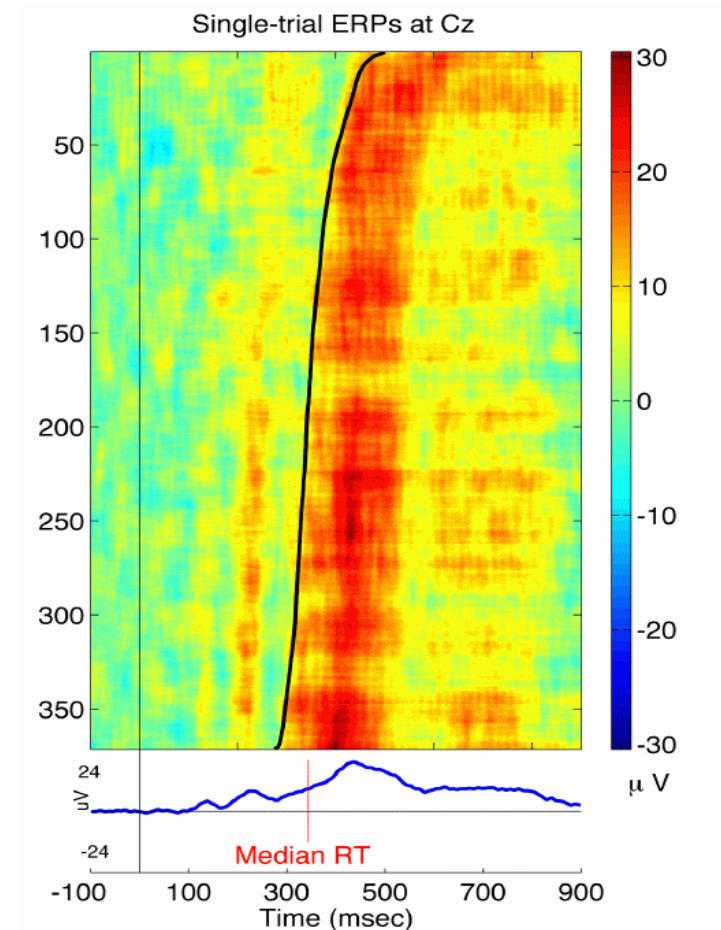
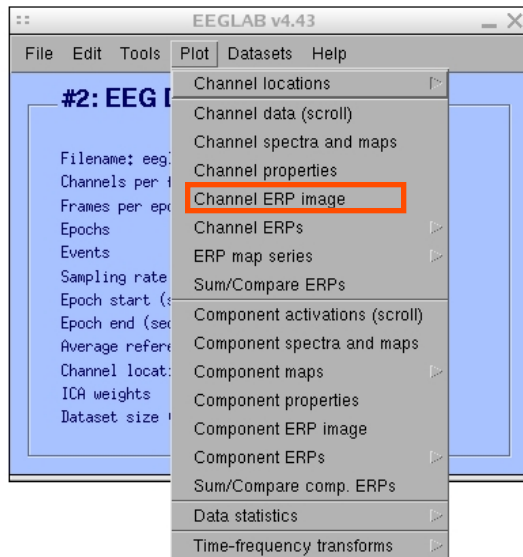
Plot data  
spectrum and  
maps



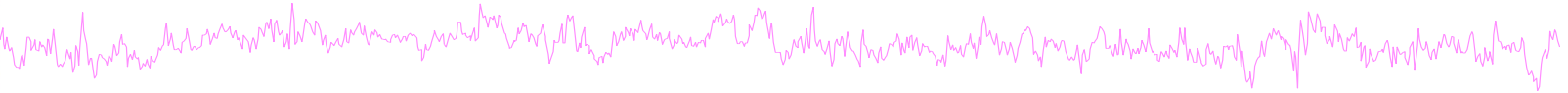
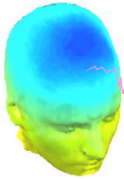
# 5. Visualize data measures



## Plot channel ERPimage



# EEGLAB standard processing pipeline



## Single subject

1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
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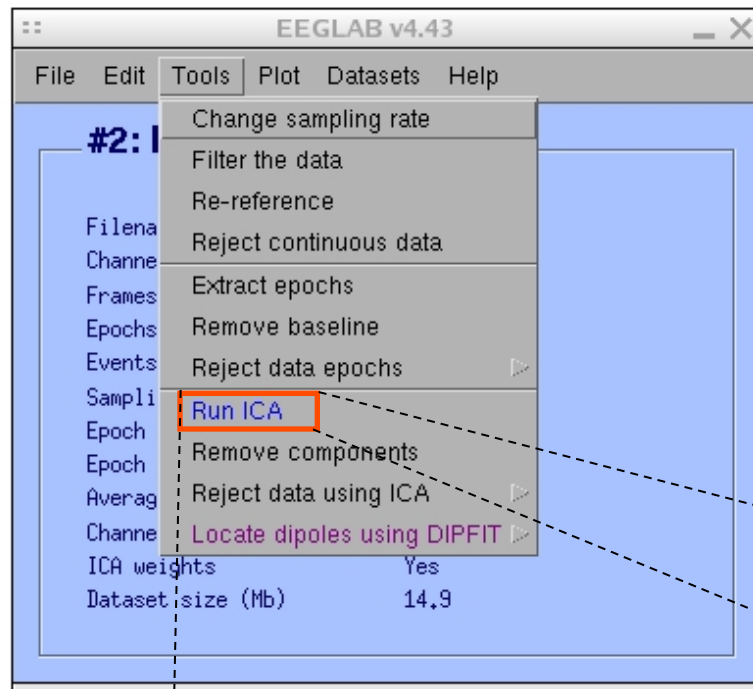
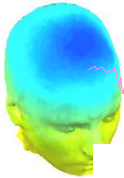
## Multi-subjects

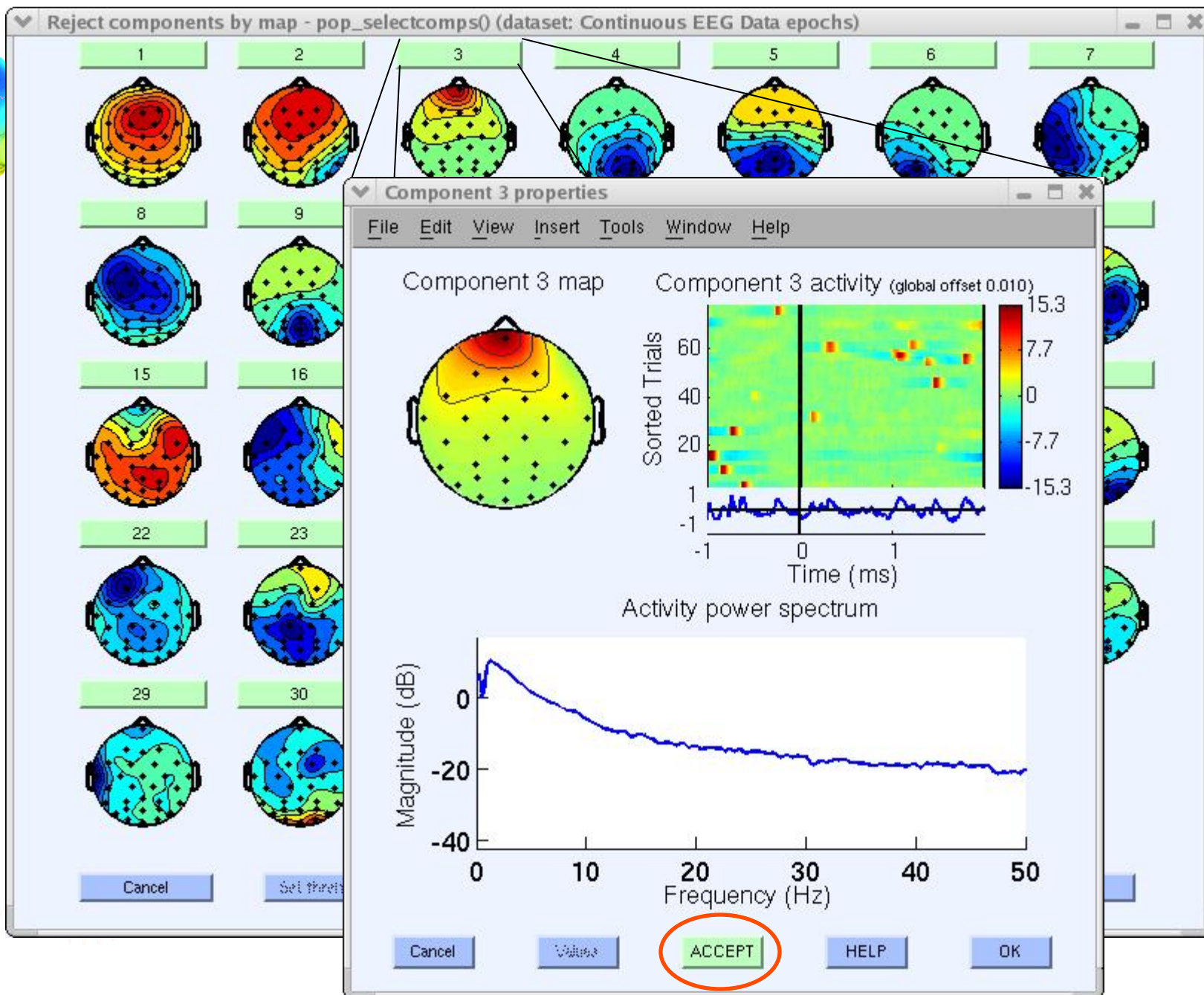
1. Build study
2. Pre-compute measures
3. Cluster components
4. Analyze clusters



**Advanced analysis using scripting and EEGLAB command line functions**

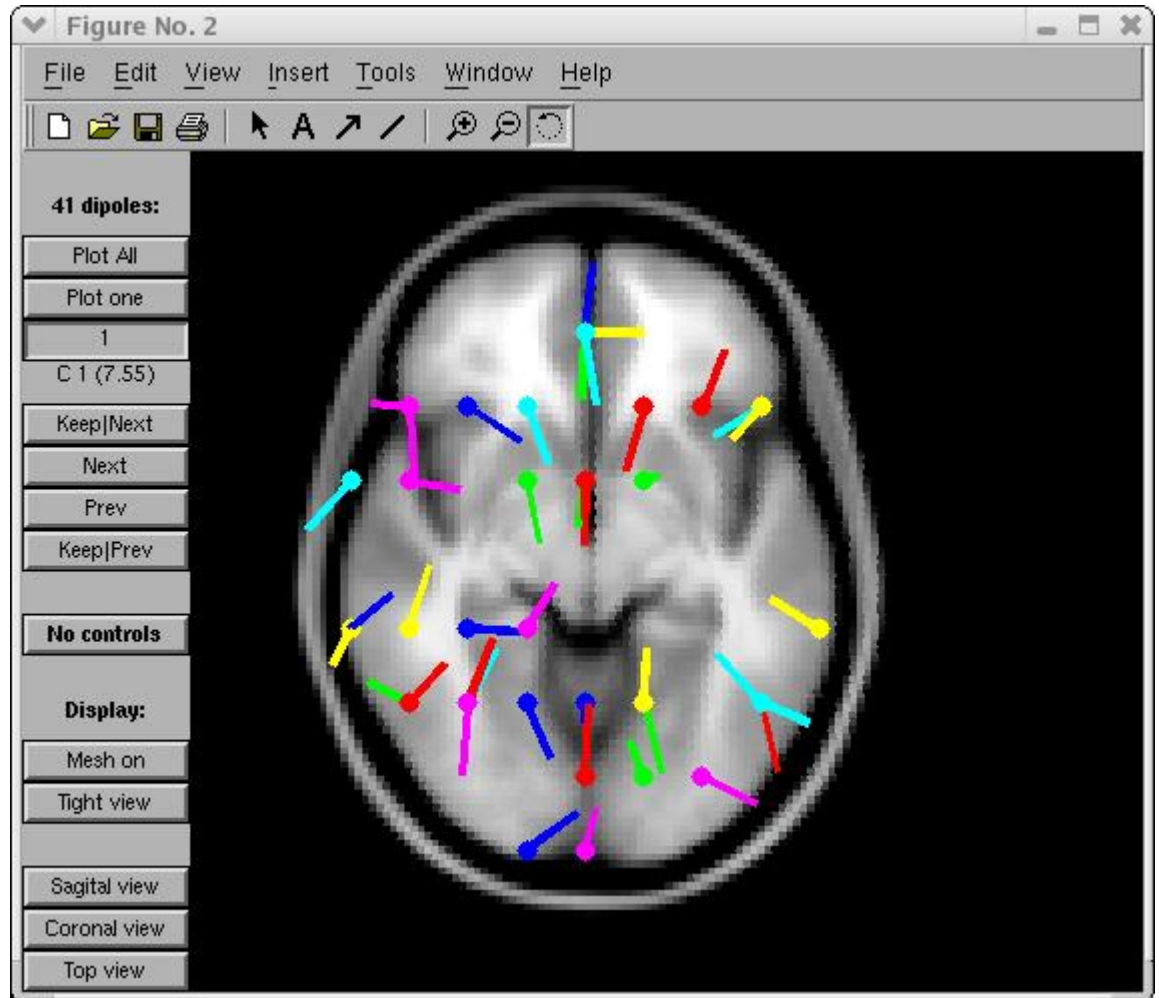
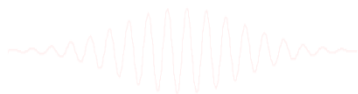
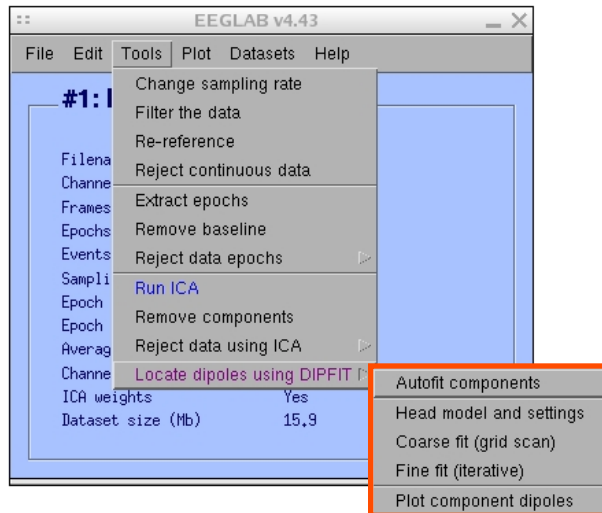
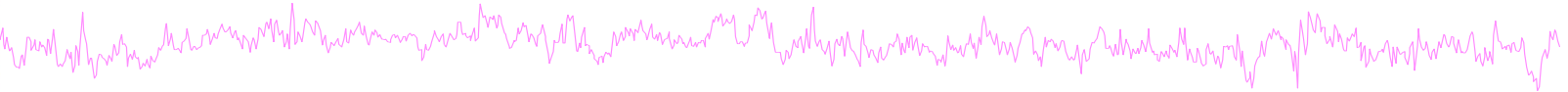
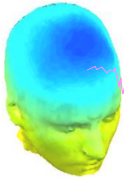
## 6. Perform ICA decomposition

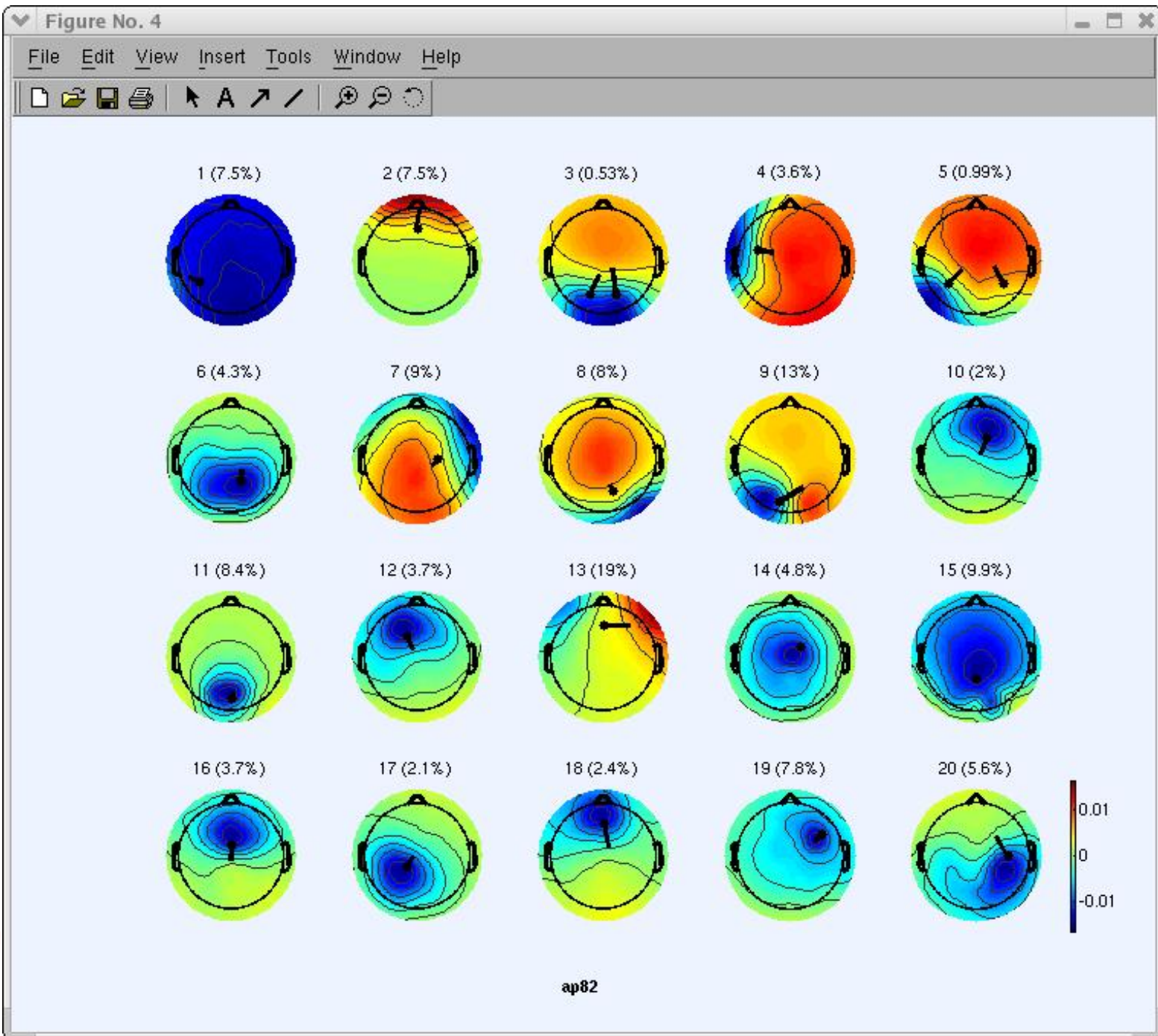




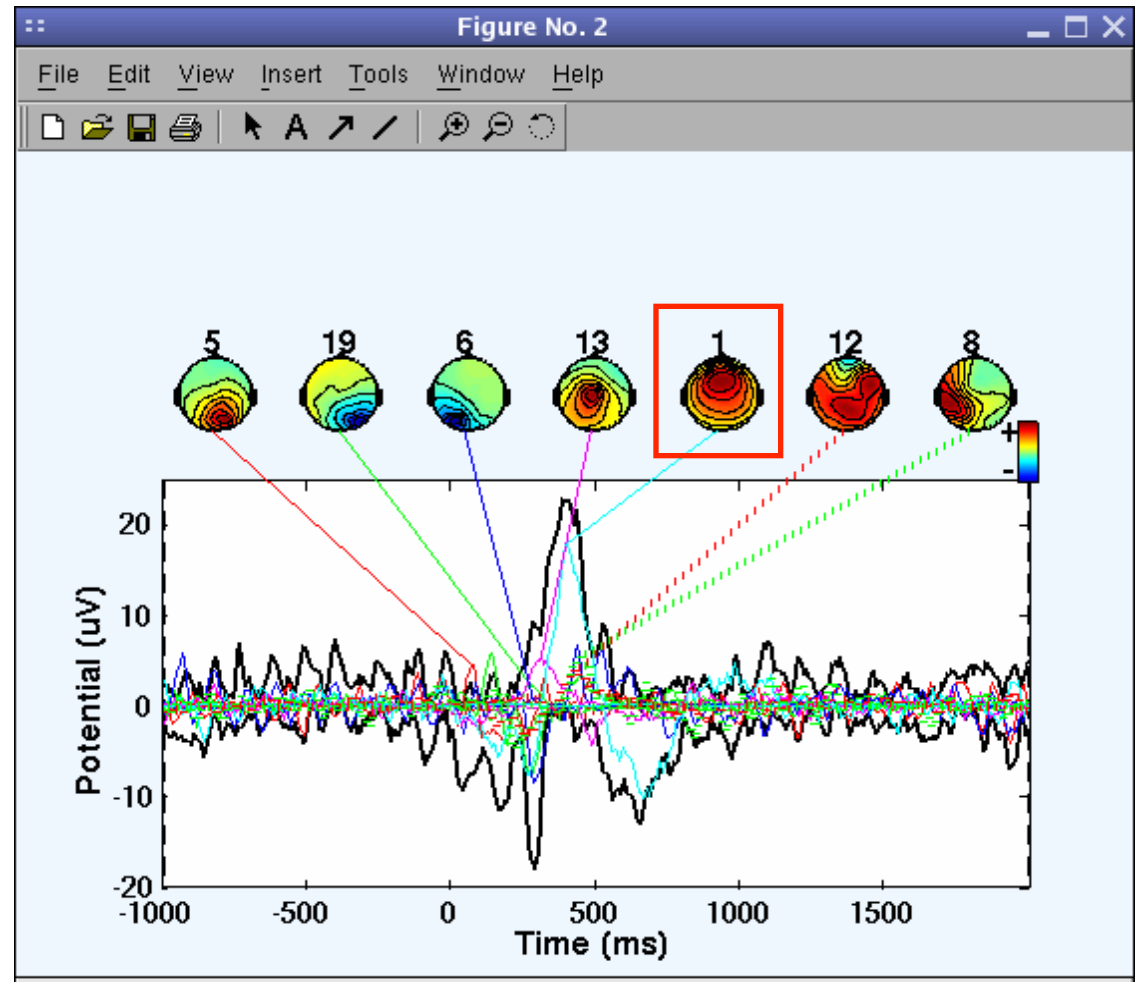
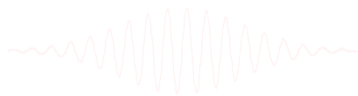
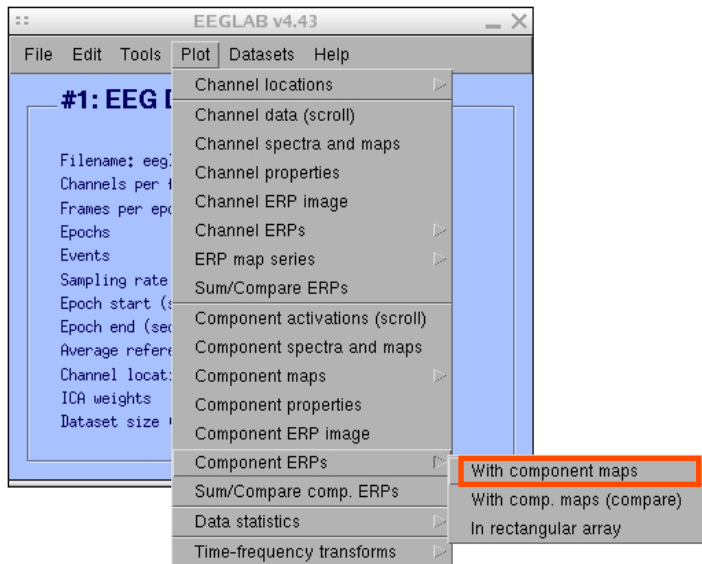
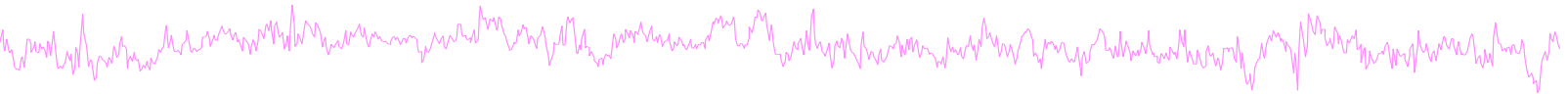
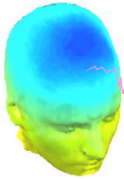


# Localizing components

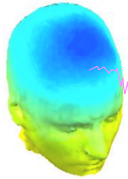




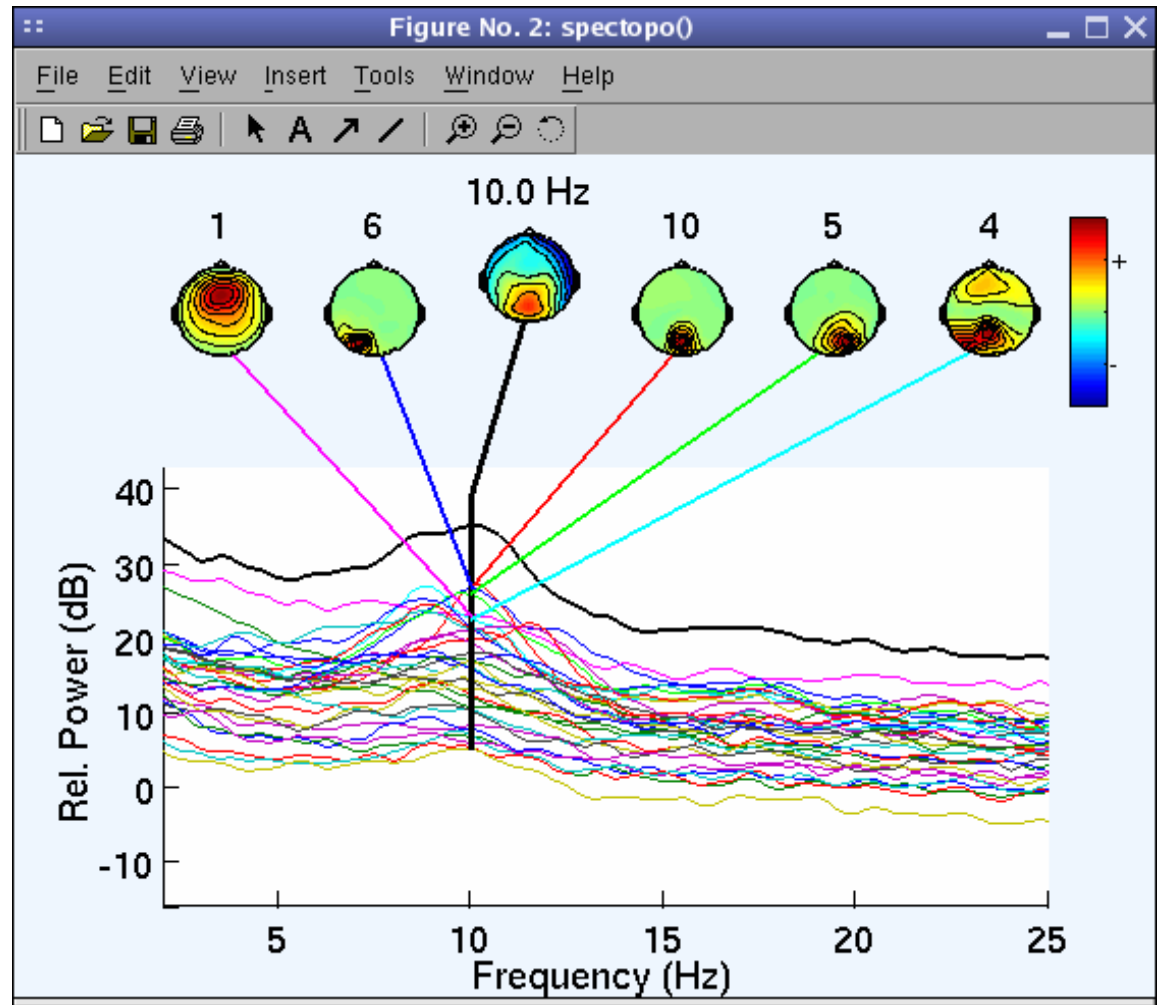
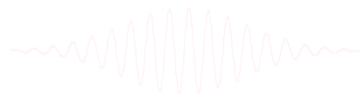
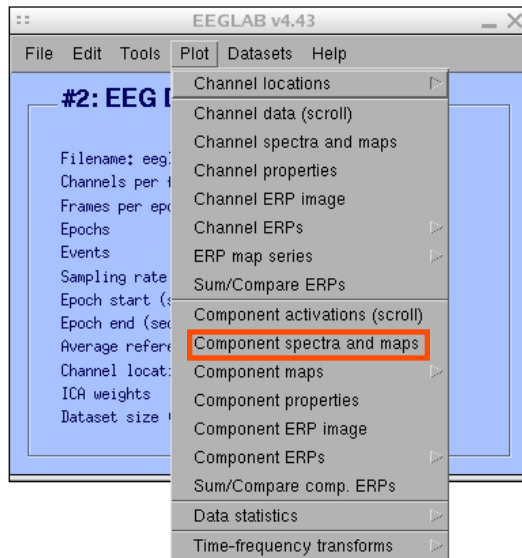
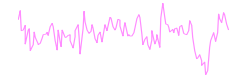
# Component contribution to the ERP



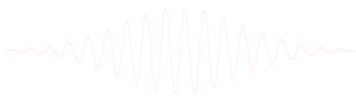
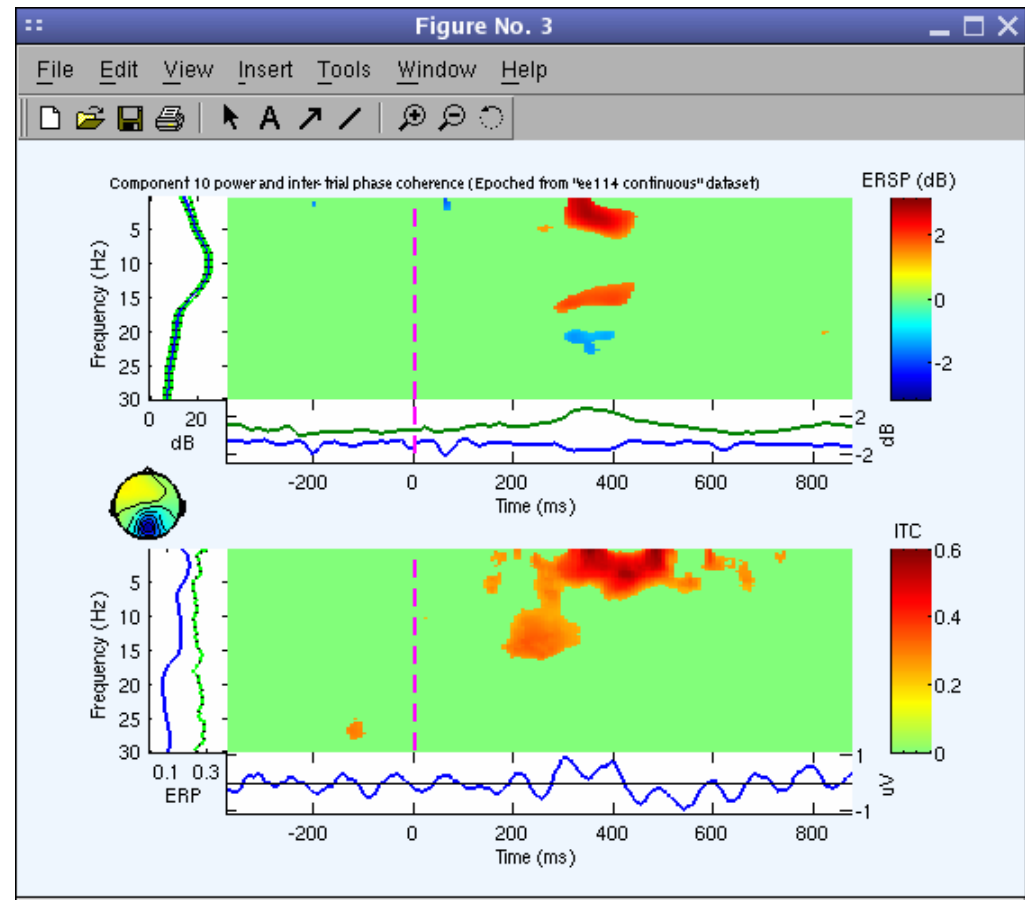
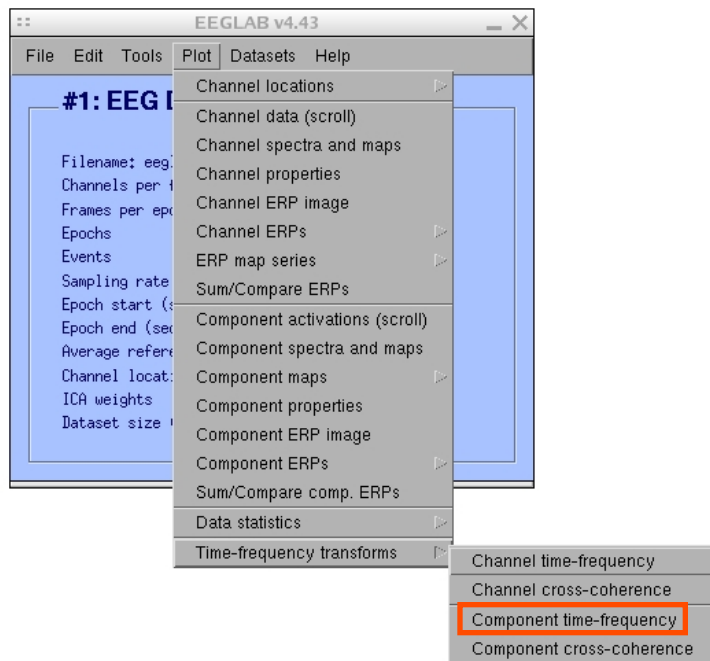
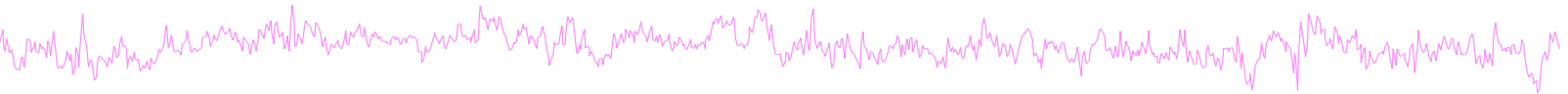
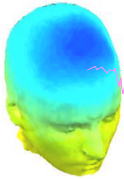




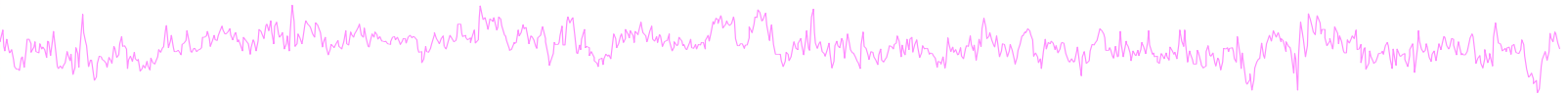
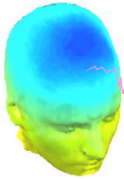
# Component contribution to the EEG spectrum



# Component time-frequency



# EEGLAB standard processing pipeline



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  - Perform source localization of components
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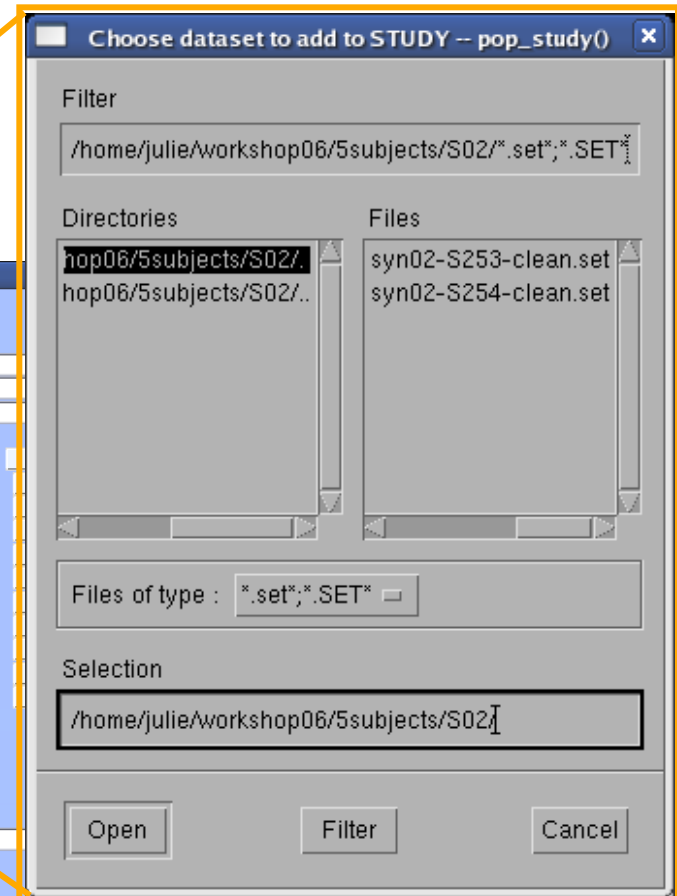
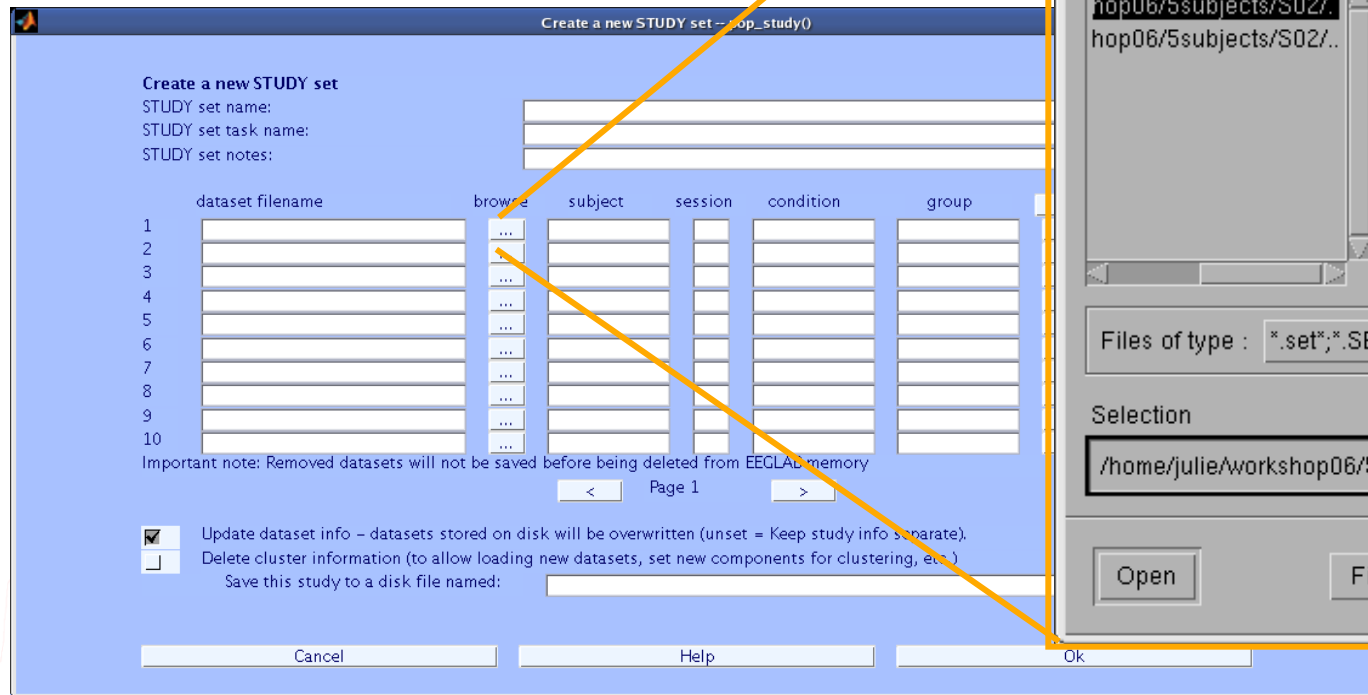
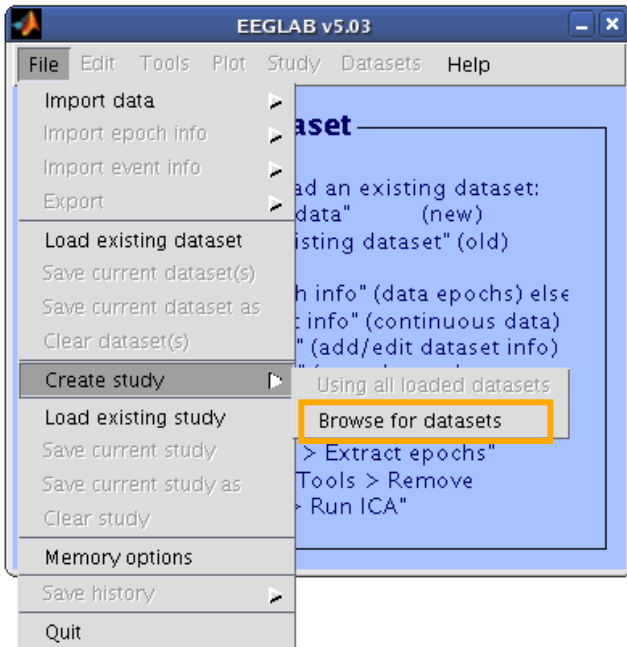
## Multi-subjects

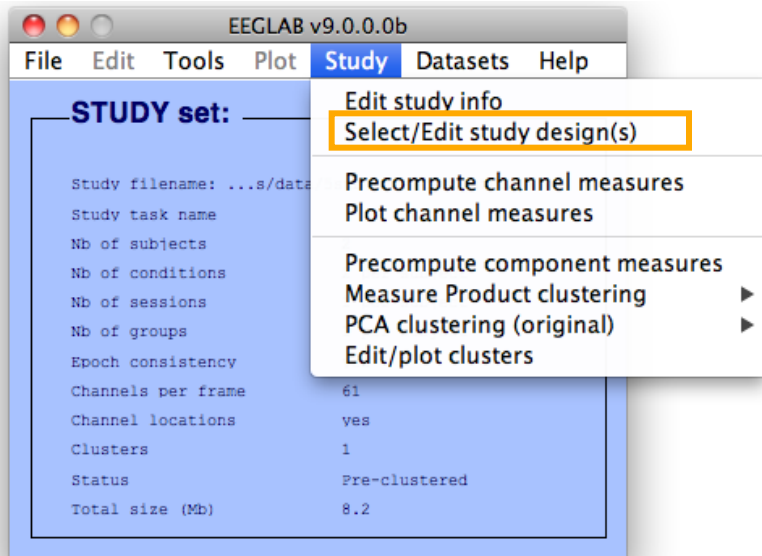
1. Build study and STUDY design
2. Pre-compute measures
3. Cluster components
4. Analyze clusters



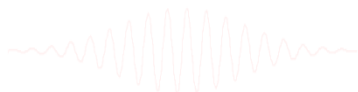
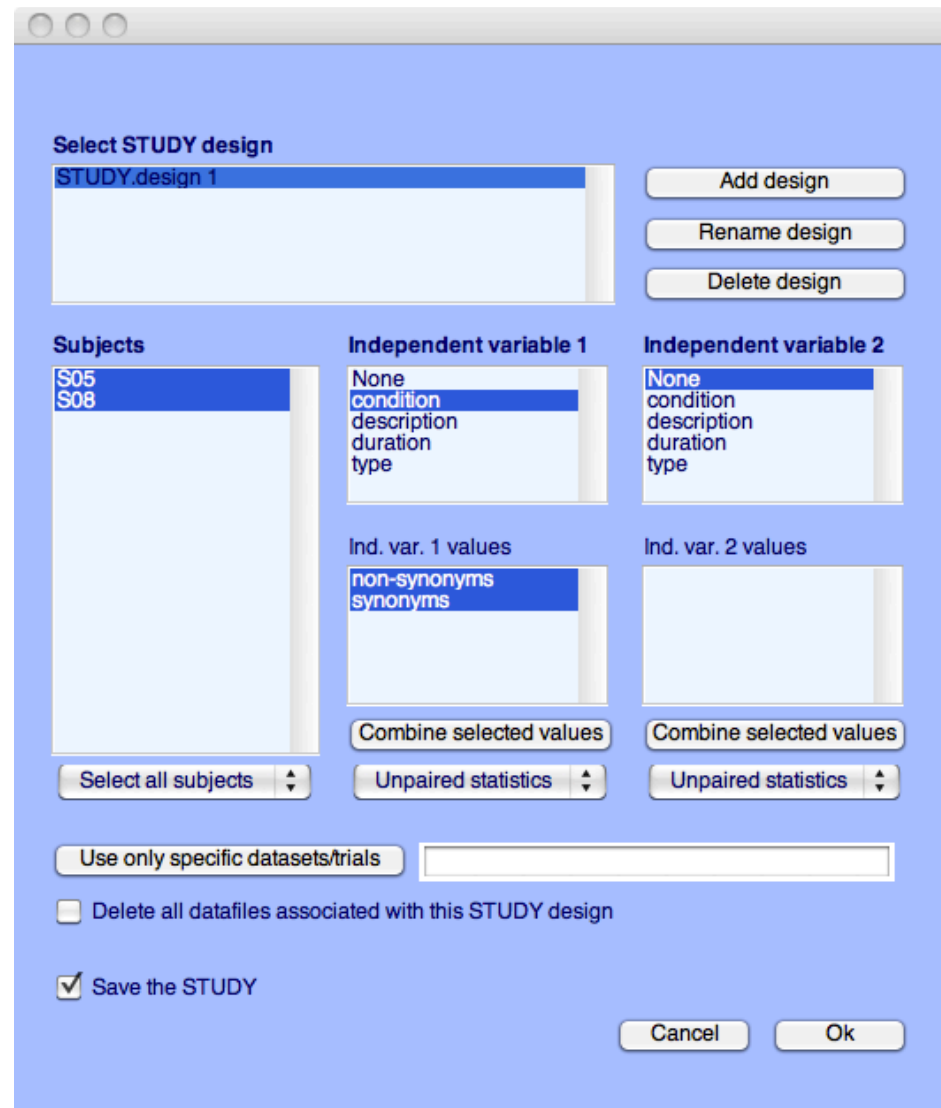
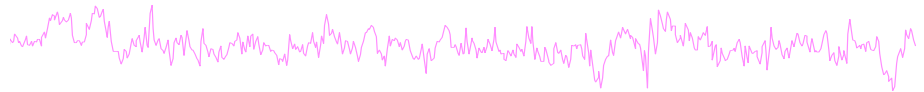
**Advanced analysis using scripting and EEGLAB command line functions**

# 1. Build a STUDY

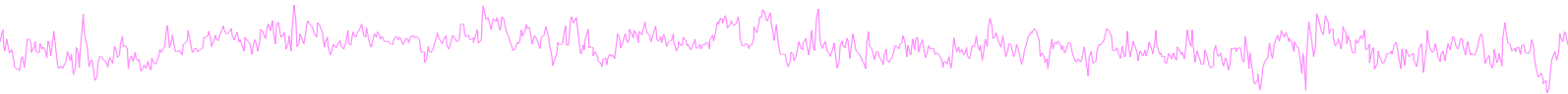
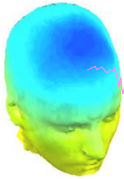




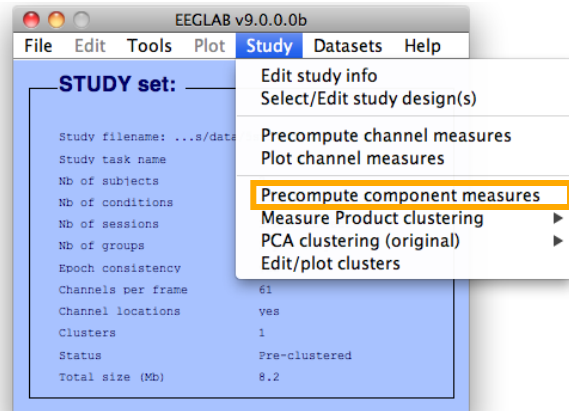
# Edit STUDY design



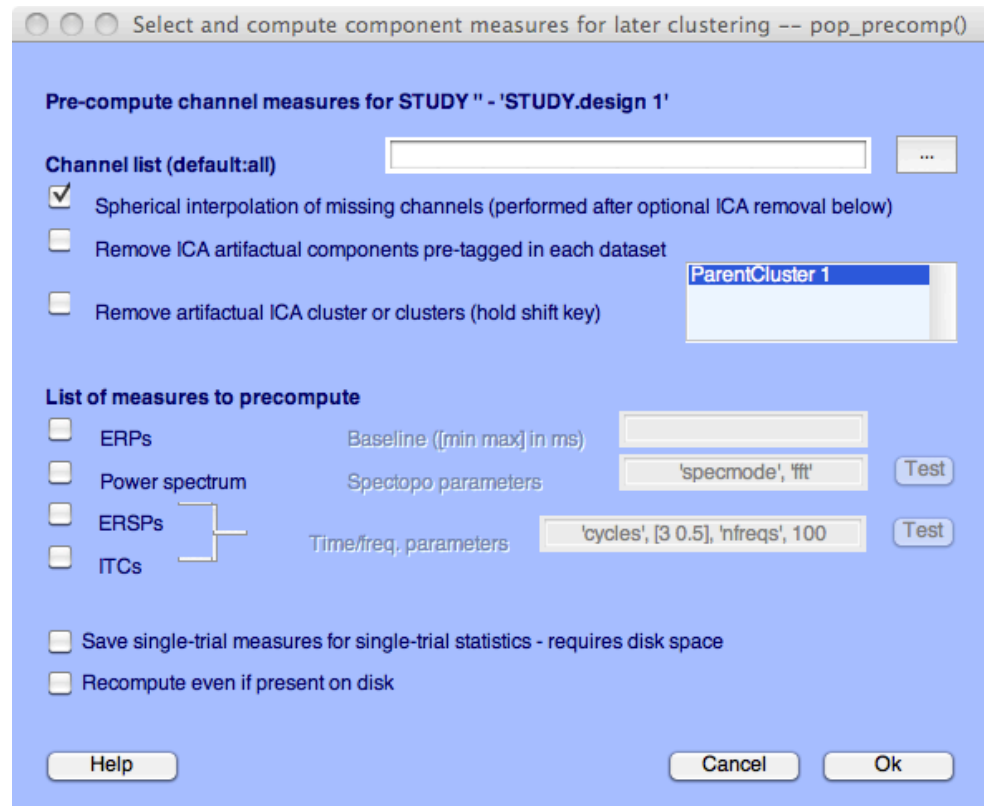
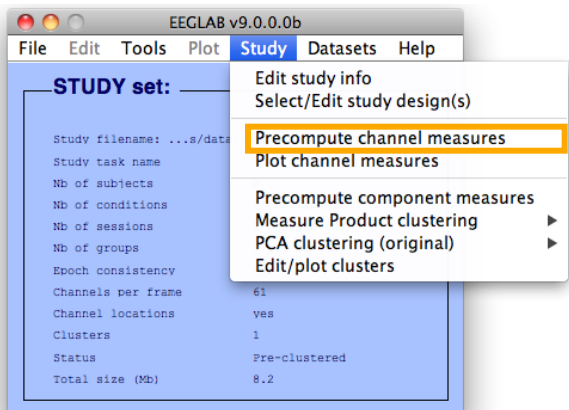
## 2. Pre-compute measures

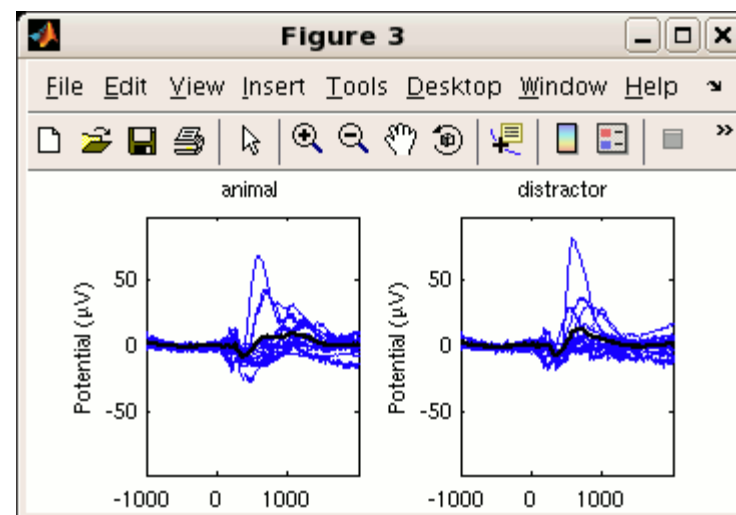
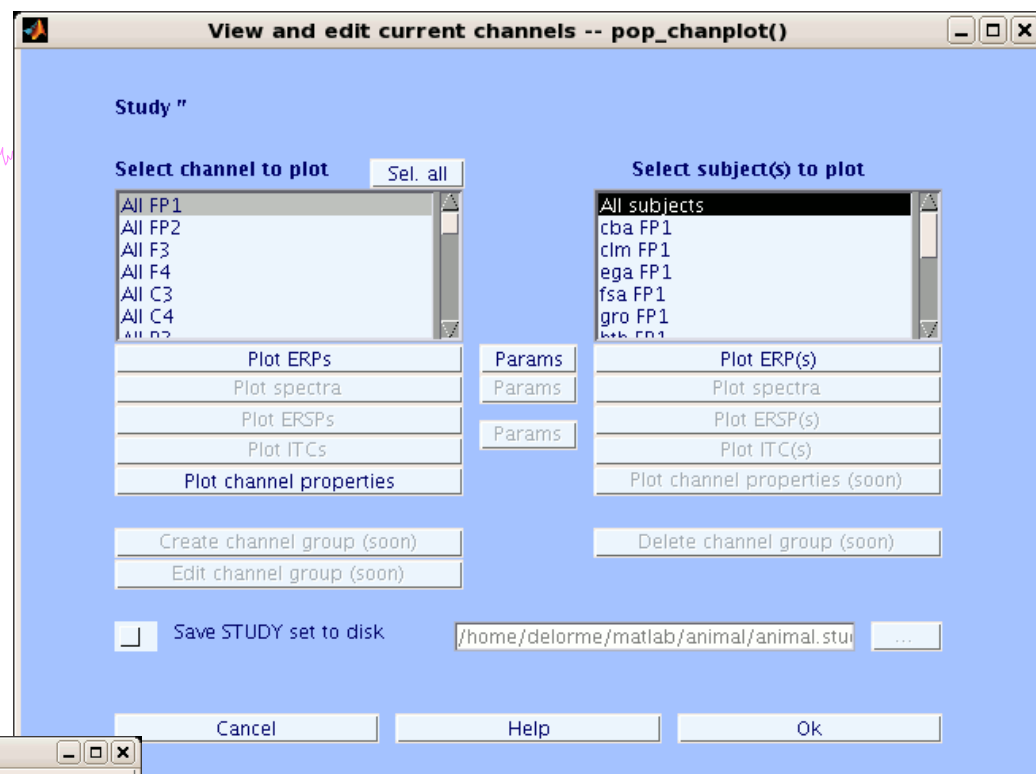
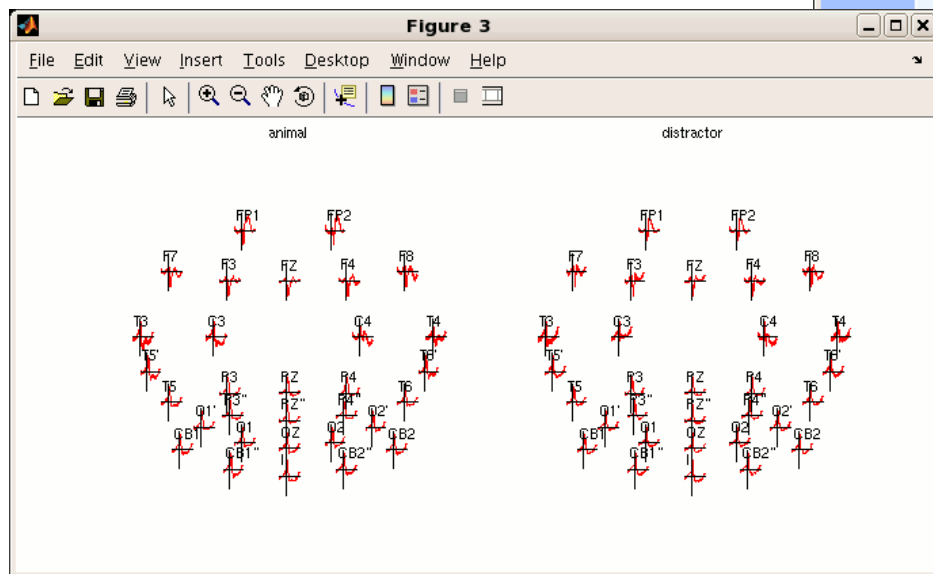
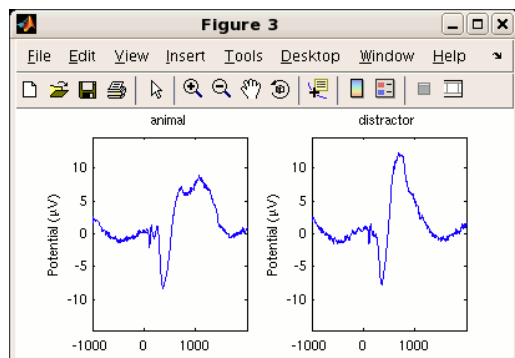


Components

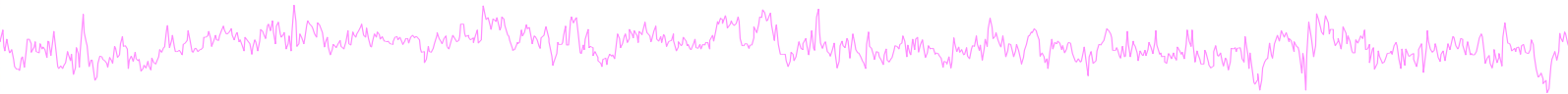
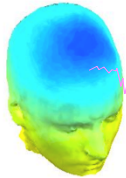


Channels





# 3. Cluster components



EEGLAB v6.0b

File Edit Tools Plot **Study** Datasets Help

**STUDY set: Attention**

Study filename:  
Study task name  
Nb of subjects  
Nb of conditions  
Nb of sessions  
Nb of groups  
Epoch consistency yes  
Channels per frame 31  
Channel locations yes  
Clusters 1  
Status Pre-clustered  
Total size (Mb) 32.4

Edit study info  
Precompute channel measures  
Plot channel measures  
Precompute component measures  
**Build preclustering array**  
Cluster components  
Edit/plot clusters

Select and compute component measures for later clustering -- pop\_preclust()

**Build pre-clustering matrix for STUDY 'Attention'**  
Select the cluster to refine during sub-clustering (any existing sub-hierarchy will be overwritten)

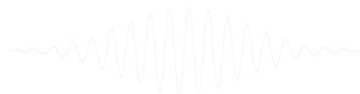
ParentCluster 1 (181 ICs)

(note: only measures that have been precomputed may be used)

Load	Dims.	Norm.	Rel. Wt.	
<input checked="" type="checkbox"/> spectra	10	<input checked="" type="checkbox"/>	1	Freq. range [Hz] 3 25
<input checked="" type="checkbox"/> ERPs	10	<input checked="" type="checkbox"/>	1	Time range [ms] 0 600
<input checked="" type="checkbox"/> dipoles	3	<input checked="" type="checkbox"/>	10	
<input type="checkbox"/> scalp maps	10	<input checked="" type="checkbox"/>	1	Use channel values <input checked="" type="checkbox"/> Absolute values
<input checked="" type="checkbox"/> ERSPs	20	<input checked="" type="checkbox"/>	1	Time range [ms] 0 1500 Freq. range [Hz] 3 45
<input checked="" type="checkbox"/> ITCs	10	<input checked="" type="checkbox"/>	1	Time range [ms] 0 600 Freq. range [Hz] 2 30
<input type="checkbox"/> Final dimensions	10			

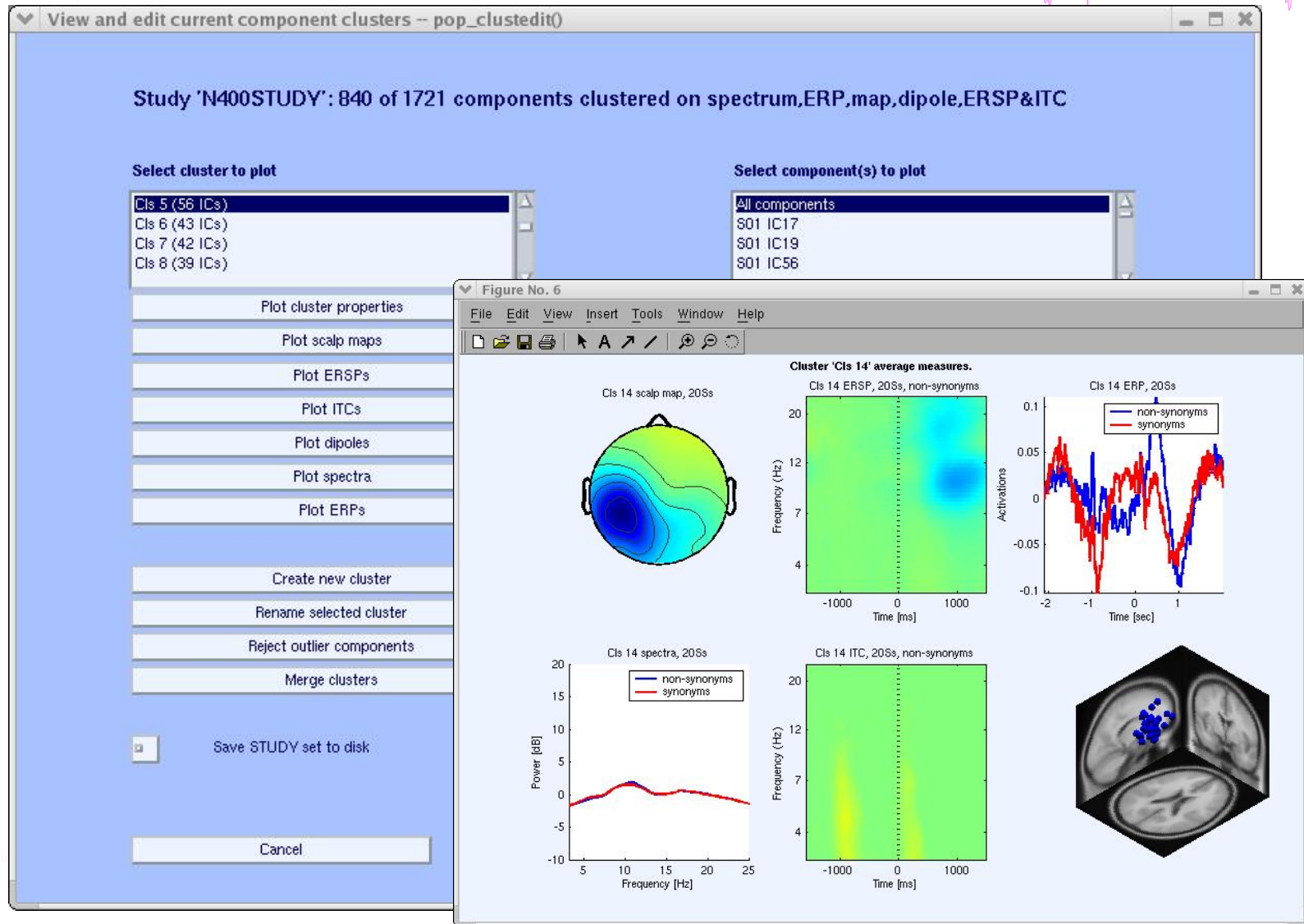
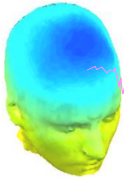
☐ Save STUDY to file /home/julie/WorkshopSD2007/STUDY/attention.study ...

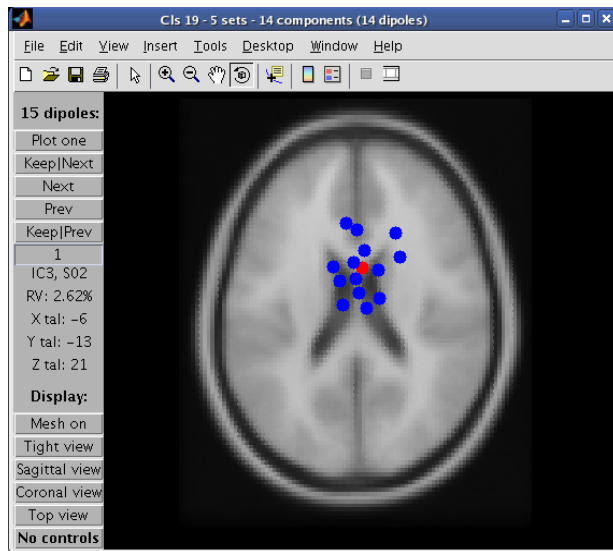
Cancel Help Ok





# 4. Analyze clusters





View and edit current

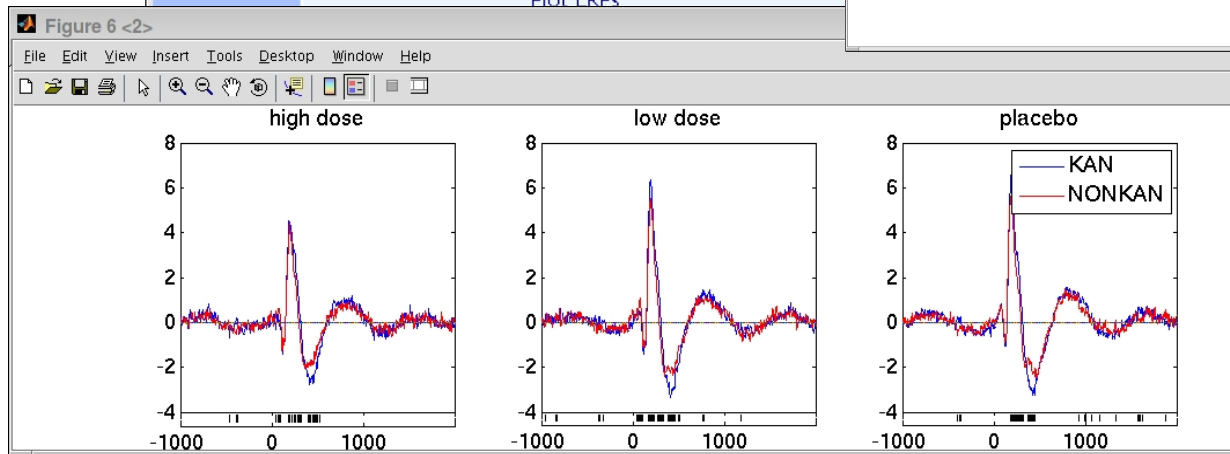
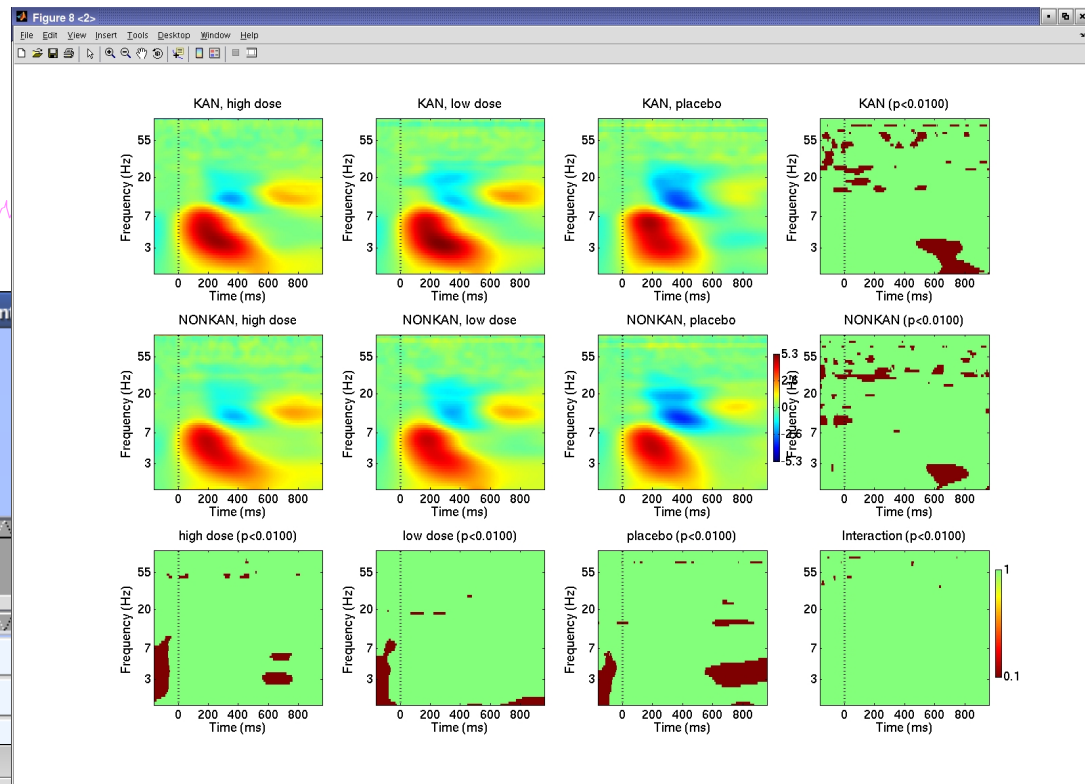
nts clustered

Clis 17 (8 ICs)  
Clis 18 (14 ICs)  
Clis 19 (14 ICs)  
Outliers Clis 17 20 (1 ICs)

Plot scalp maps

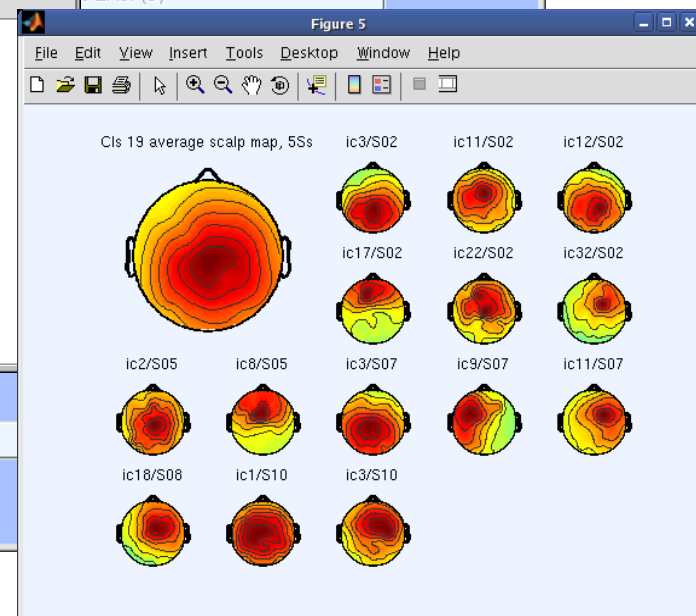
Plot dipoles

Plot ERPs

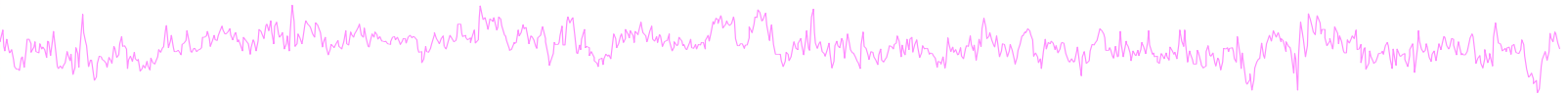
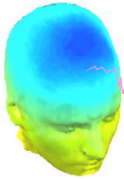


Cancel

Help



# EEGLAB standard processing pipeline



## Single subject

1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
4. Extract epochs from data & reject artifactual epochs
5. Visualize data measures
6. Perform ICA decomposition
  - Perform source localization of components
  - Analyze components contribution to ERP
  - Analyze components contribution to spectrum

## Multi-subjects

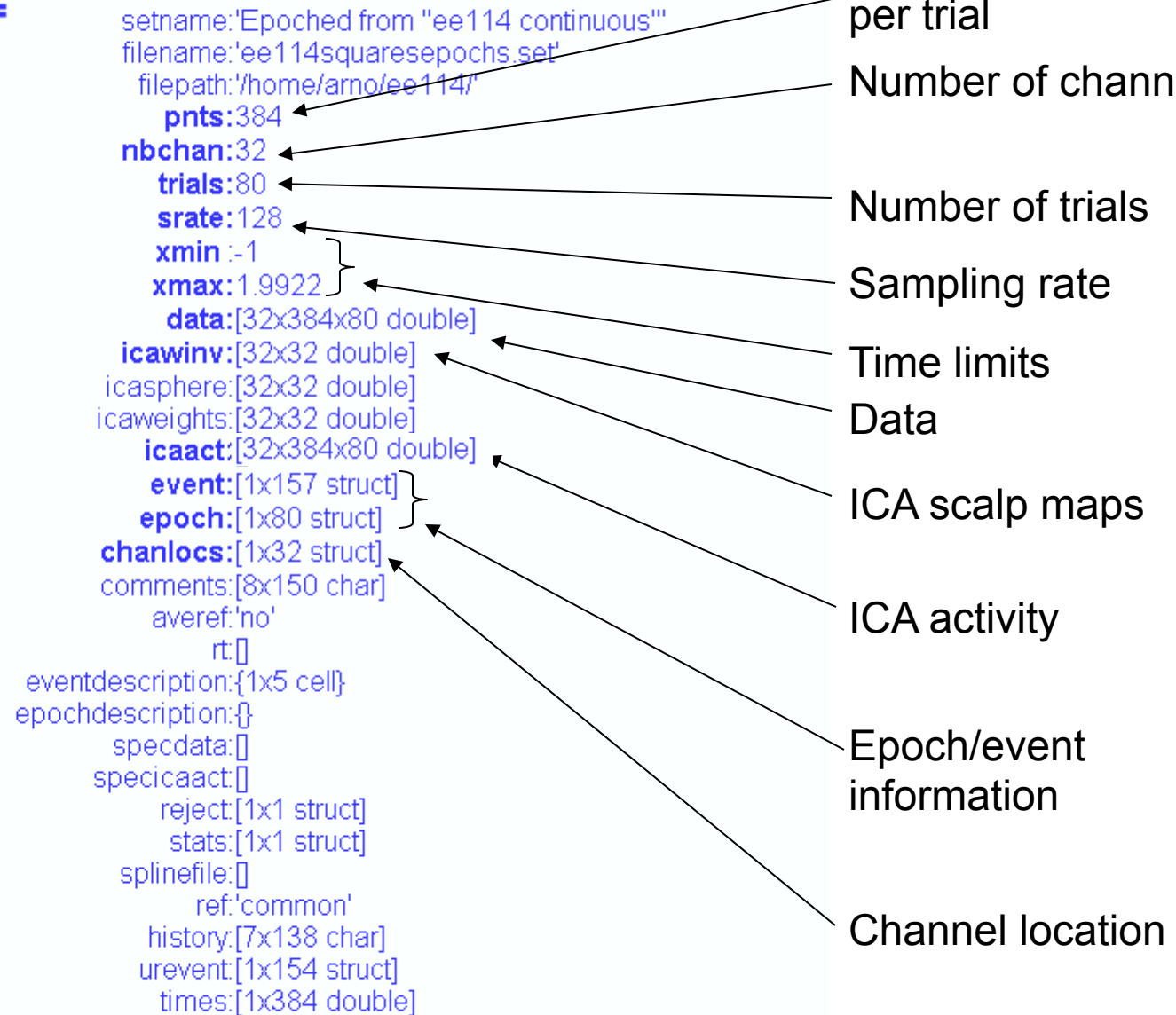
1. Build study and design
2. Pre-compute measures
3. Cluster components
4. Analyze clusters



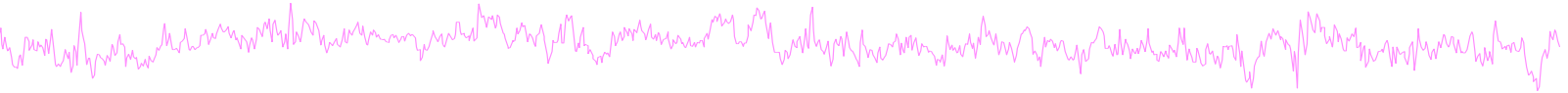
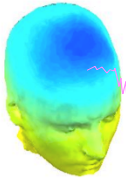
**Advanced analysis using scripting and EEGLAB command line functions**

# EEG structure

EEG =



# 3 levels of functions



Administrative functions: handle EEG and ALLEEG structures

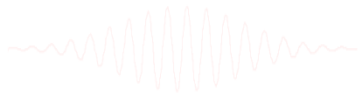
`eeglab()`, `eeg_checkset()`, `pop_delset()`, ...

Pop functions: interactive functions using EEG structure

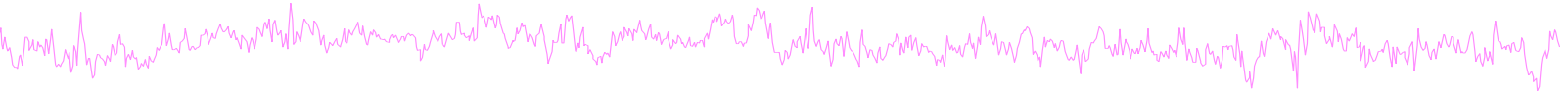
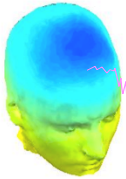
`pop_erpimage()`, `pop_topoplot()`, `pop_envtopo()`, ...

Signal processing functions: perform signal processing

`erpimage()`, `topoplot()`, `envtopo()`, ...

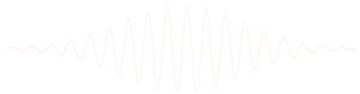


# Command line tools

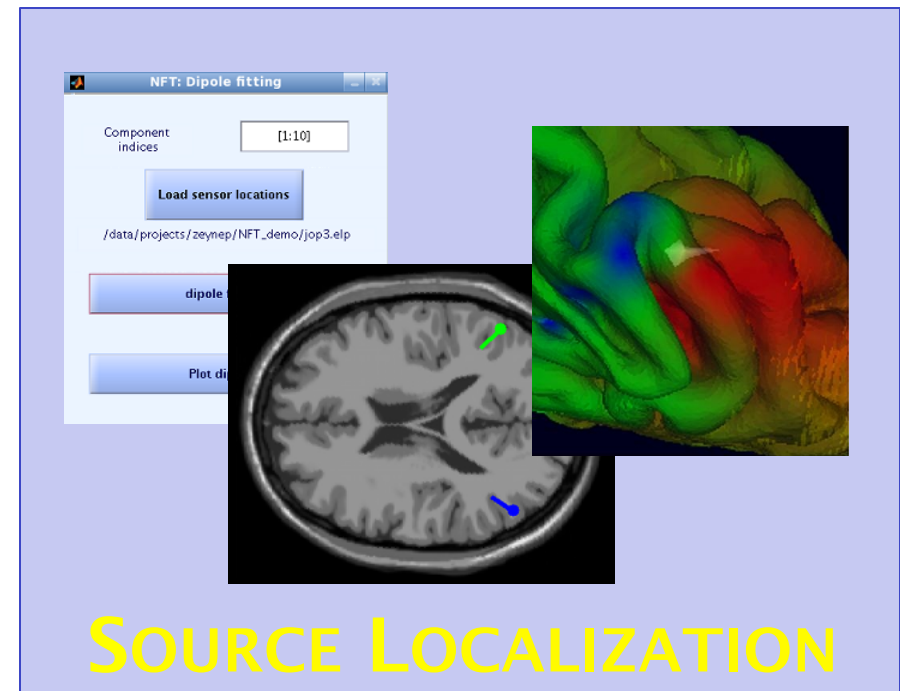
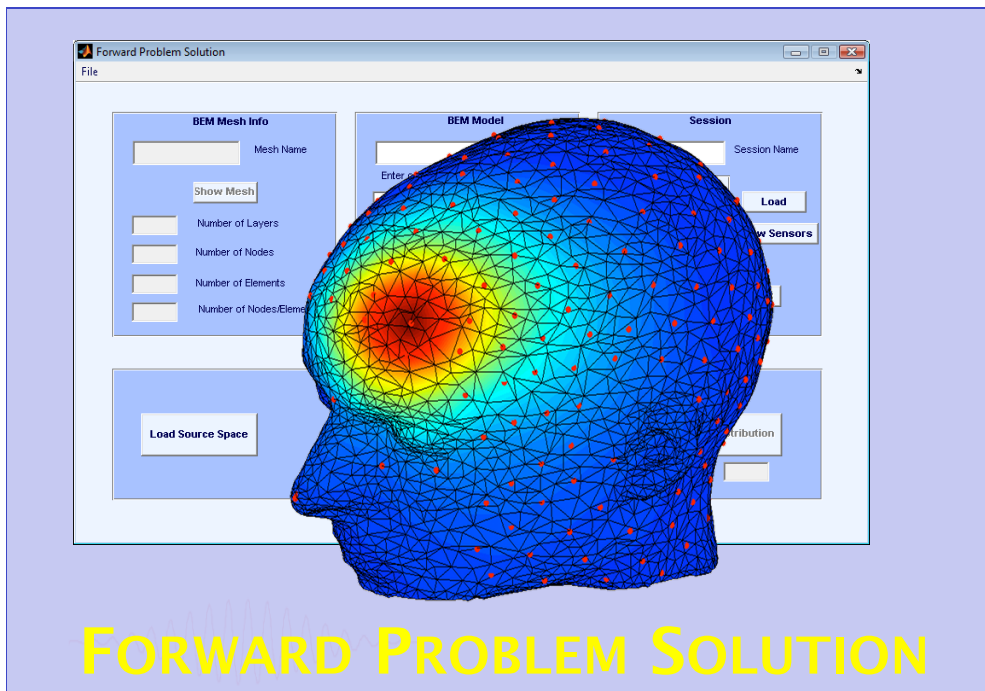
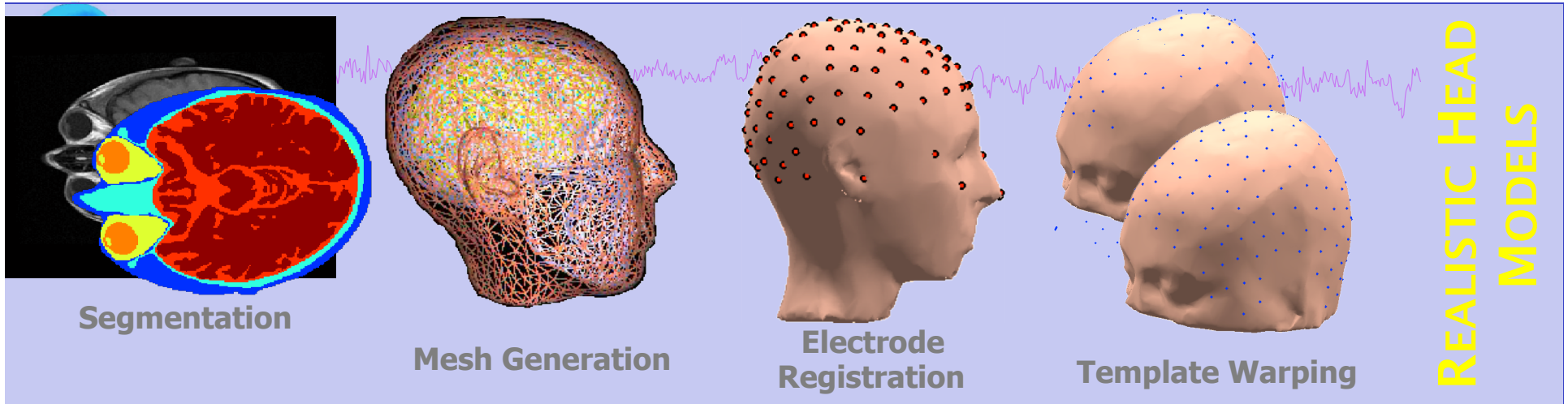


(“eegh” Menus write both dataset and global history)

- Automated processing on groups of subjects (possibly on several processors).
- Richer options for plotting and processing functions (time-frequency decompositions, ...)
- Custom processing...

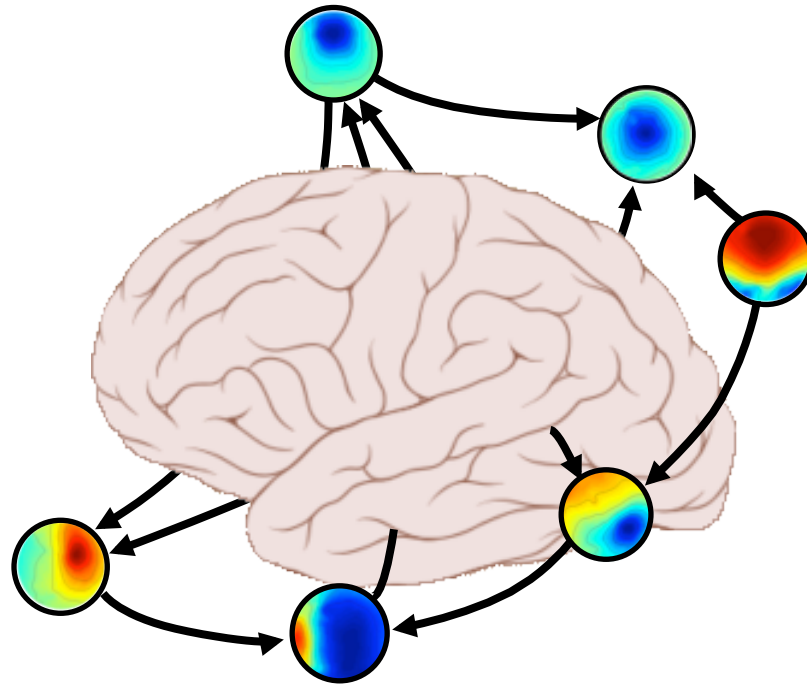


# NFT: Neuroelectromagnetic Forward Head Modeling Toolbox



<http://sccn.ucsd.edu/nft>

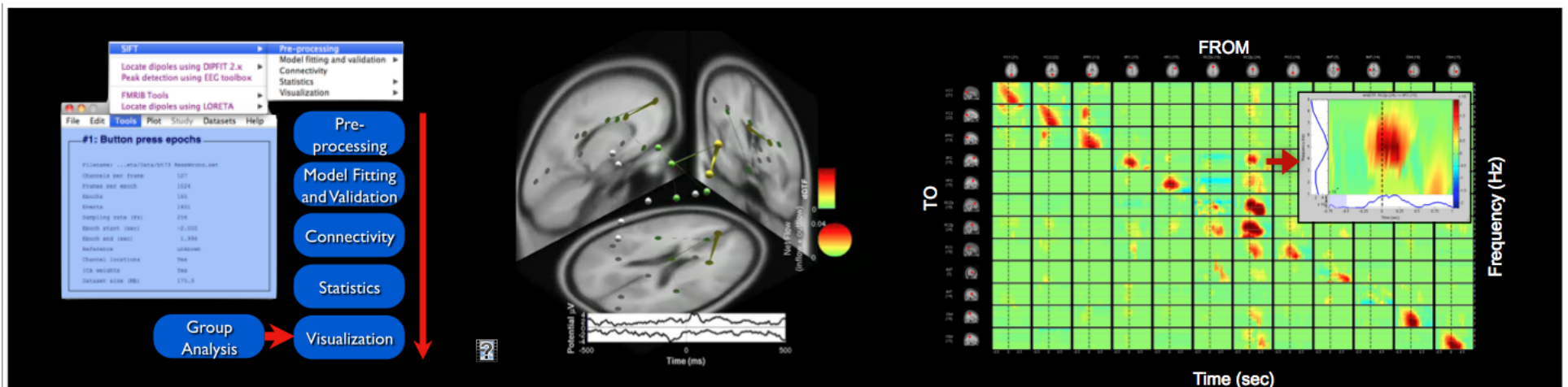




# SIFT

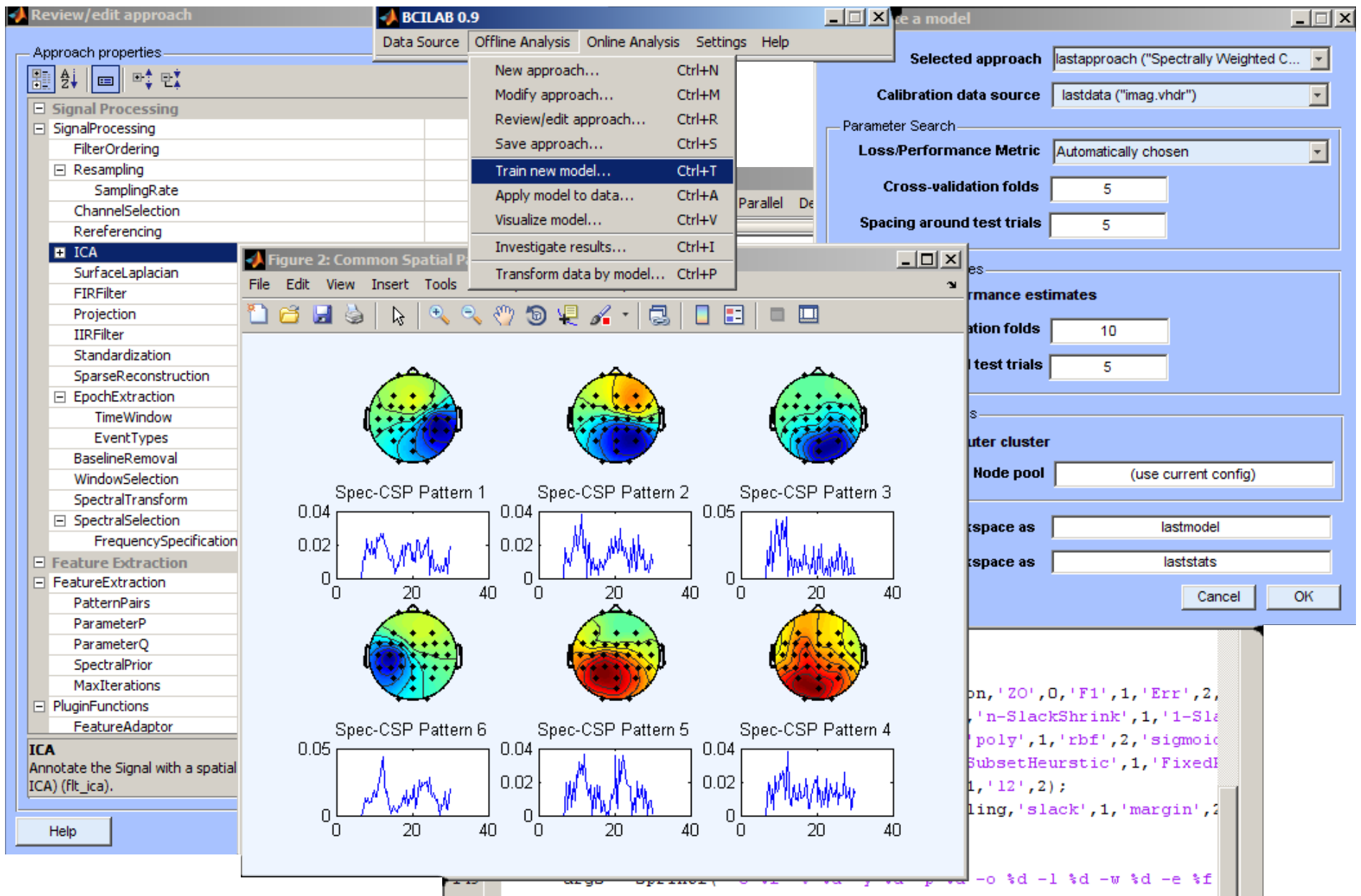
Source Information Flow Toolbox

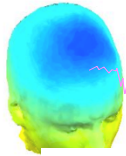
*"It makes you cool"*



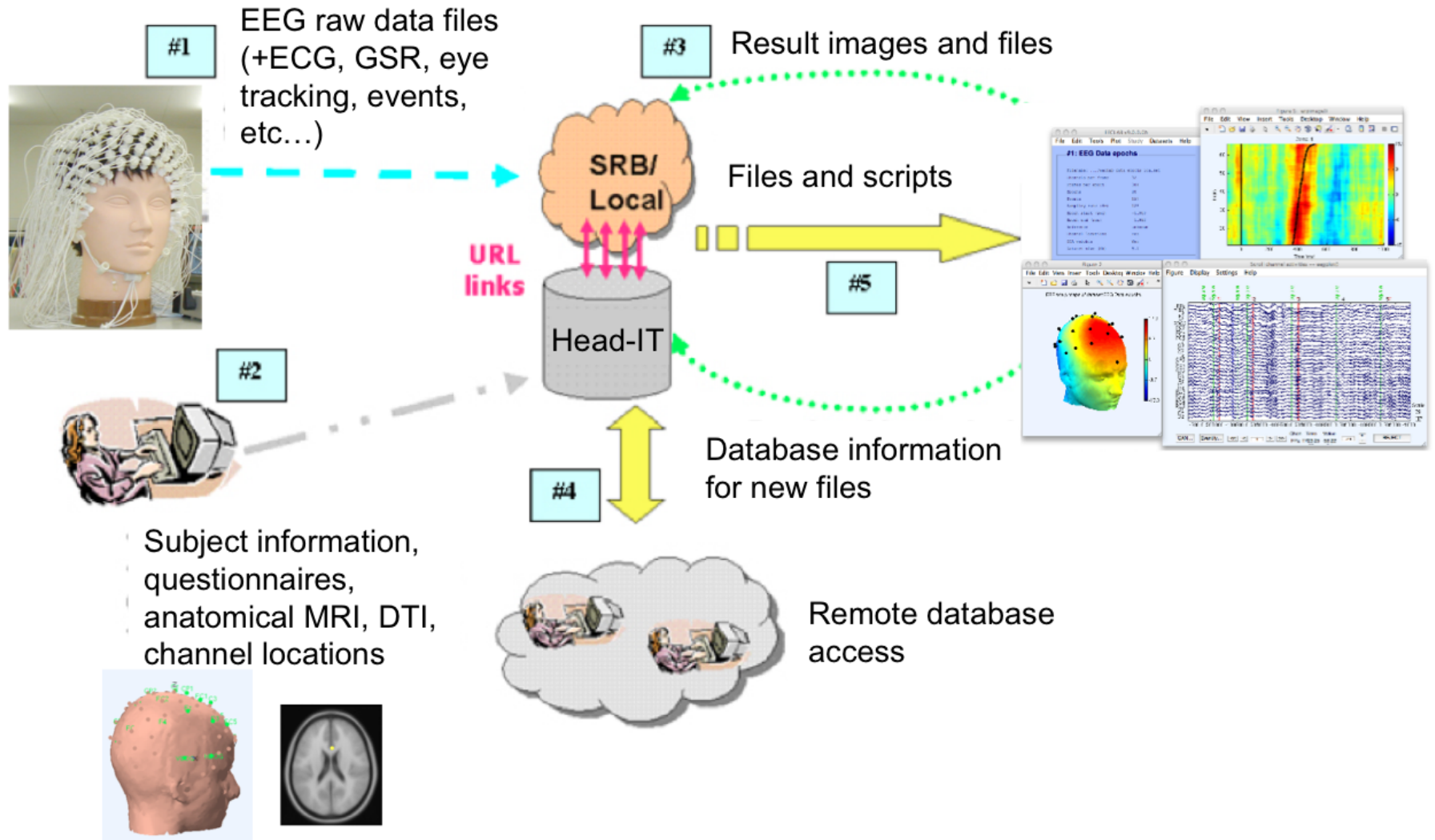


# BCILAB - C. Kothe

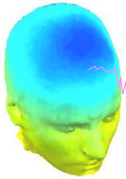




# EEG database: HEAD-IT framework



# Pros/Cons of Matlab based open source



- Pros
  - Easy to program, highly modular and extendable
  - Not dependent on any platform (64-bit)
  - Large community of users (latest development in signal processing research)
  - Cannot imagine more powerful scripting capabilities
- Cons
  - Matlab required for which you have to pay
  - Large memory requirements
  - Matlab bugs, possible version differences, cross-platform compatibility problems

# Beijing Workshop Program

Purple lettering = lecture, Orange lettering = tutorial

## Saturday, June 16

7:30 - 8:30 Breakfast

### Overview and ICA Theory/Practice

8:30 – 9:30 -- Mining event-related brain dynamics I (Scott Makeig)

9:30 – 10:00 -- EEGLAB overview (Arnaud Delorme)

-- Break--

10:30 – 11:15 -- ICA theory (Tzyy-Ping Jung)

11:15 – 12:00 -- Data import, artifact rejection and ICA decomposition (Julie Onton)

12:00-13:00 Lunch

### ICA, time-frequency and information flow

13:00 – 14:00 -- Evaluating ICA components (Julie Onton)

14:00 – 15:00 -- Time-Frequency decompositions and practicum (Tim Mullen)

--Break--

15:30 – 16:30 -- SIFT toolbox: Source information flow and granger causality tools (T. Mullen)

16:30 – 17:30 -- Using the SIFT toolbox (Tim Mullen)

17:30 – 19:00 -- Data and helpers available

19:00 Dinner

## Sunday, June 17th

7:30 - 8:30 Breakfast

### Source Localization

8:30 – 9:00 -- Forward and inverse EEG source modeling - (Scott Makeig)

9:00 – 9:30 -- Using the NFT and Dipfit plug-ins (Julie Onton)

9:30 – 10:00 -- Why and how to cluster independent EEG component processes (Scott Makeig)

-- Break--

### Component Clustering

10:30 – 11:00 -- Creating EEGLAB studies and study designs (Arnaud Delorme)

11:00 – 12:00 -- Independent Component Clustering (Arnaud Delorme)

12:00-13:00 Lunch

### Processing multiple subjects using STUDY tools

13:00 – 13:30 -- Trial-by-trial data visualization and scripting (Julie Onton)

13:30 – 14:30 -- Plotting measures and computing statistics for EEGLAB studies (Arnaud Delorme)

14:30 – 15:30 -- Scripting for EEGLAB studies (Arnaud Delorme)

15:30 – 19:00-- Practicum on datasets and results presentation

19:00 Dinner

## Monday, June 18th

7:30-8:30 -- Breakfast

8:30 – 9:00 -- Mining event-related brain dynamics II (Scott Makeig)

9:00 – 9:30 -- The near future of wireless EEG and mobile brain/body imaging (Tzyy Ping Jung)

9:30 – 10:00 -- Building and publishing EEGLAB plug-ins (Arnaud Delorme)

-- Break--

10:30 – 11:30 -- Brain-computer interface (BCI) design: Theory and practice (Christian Kothe)

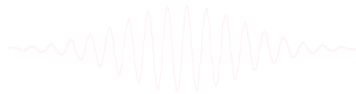
11:30 – 12:30 -- Using BCILAB (Christian Kothe)

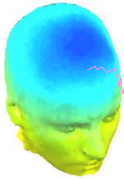
12:30 - 13:30 Lunch

14:00 – 17:30 Excursion

17:30 – 18:30 -- Final discussion (Makeig, Jung, Delorme and all)

18:30 workshop ends





# EEGLAB articles

Delorme, A., Makeig, S. (2004) EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, 134(1), 9-21.

Makeig, S., Debener, S., Onton, J., Delorme, A. (2004) Mining event related dynamics. *Trends in cognitive Neuroscience*, 8(5), 204-210.

Delorme, A., Kothe, C., Bigdely, N., Vankov, A., Oostenveld, R., Makeig, S. Matlab Tools for BCI Research? In "human-computer interaction and brain-computer interfaces". Editors : Tan, D. and Nijholt, A. To appear in 2010. Springer Publishing.

Delorme, A., Mullen, T., Kothe, C., Bigdely-Shamlo, N., Akalin, Z., Vankov, A., Makeig, S. EEGLAB, MPT, NetSIFT, NFT, BCILAB, and ERICA: New tools for advanced EEG/MEG processing. *Computational Intelligence*, accepted.

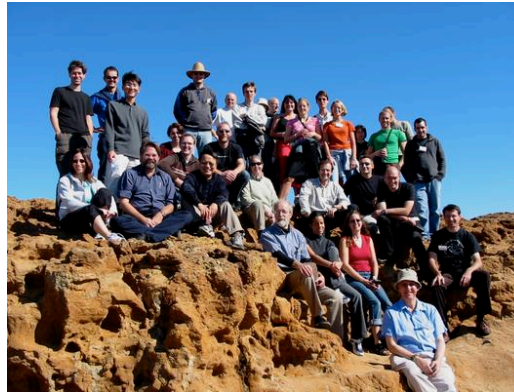
Delorme, A., Makeig, S. Open Source Programming for Interpreted Language: Graphic Interface and Macro Bridging Interface. IEEE International Conference on Signal Image Technology and Internet Based Systems. In press.



# Workshops

## **First EEGLAB Workshop**

University of CA San Diego  
La Jolla, California,  
Oct. 28-30, 2004  
following the Society for  
Neuroscience meeting  
in San Diego



## **Third EEGLAB Workshop**

Singapore, Nov. 15-18, 2006



## **Second EEGLAB Workshop**

Porto, Portugal, Sept. 17-19, 2005  
preceeding the SPR meeting in Lisbon



## **Fourth EEGLAB Workshop**

Aspet (pyrénées), France, June 26-29, 2007



## **.... 12<sup>th</sup> EEGLAB Workshop**

UCSD, San Diego, Nov 18-22, 2010