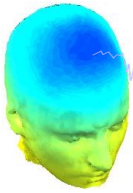
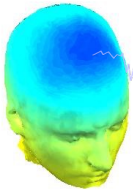
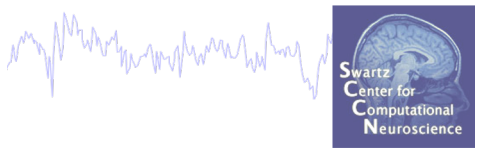


The DIPFIT and ROIconnect plug-ins

Arnaud Delorme



Source modeling



physiological source

electrical current

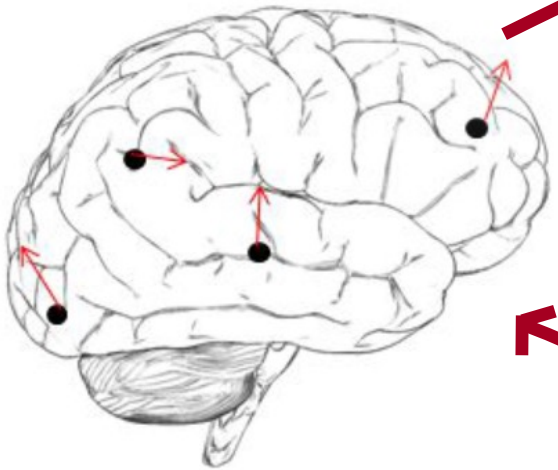
?

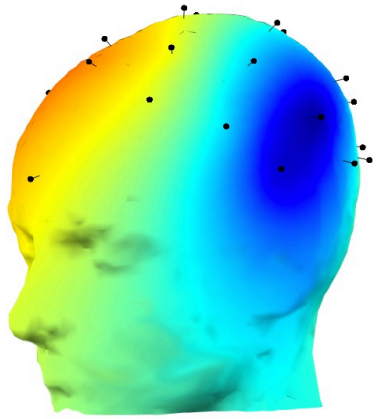
observed

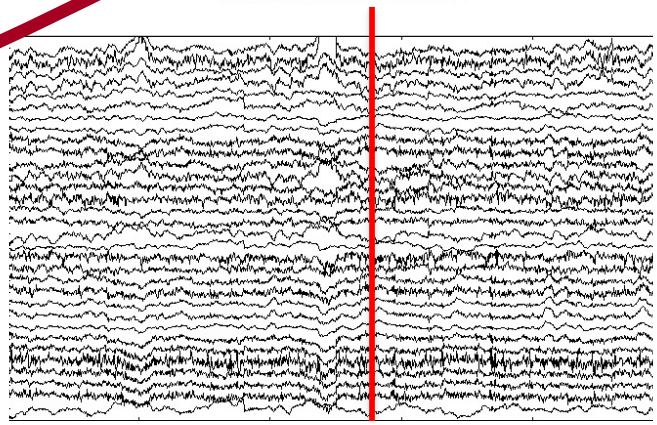
potential or field

Forward Problem

Inverse Problem







Forward Head Model Problem (well posed)

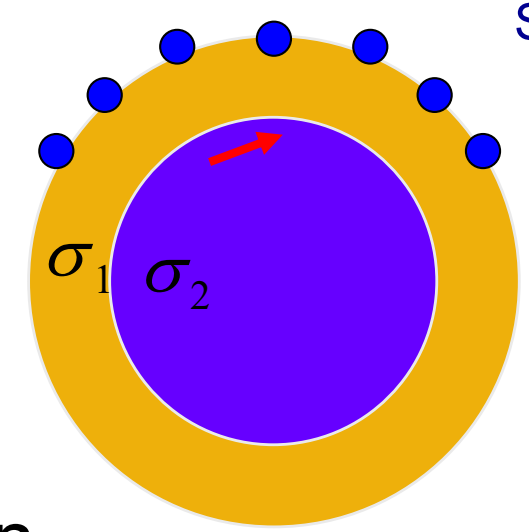
REQUIRES

→ Head Model
- Conductivity values
- Geometry

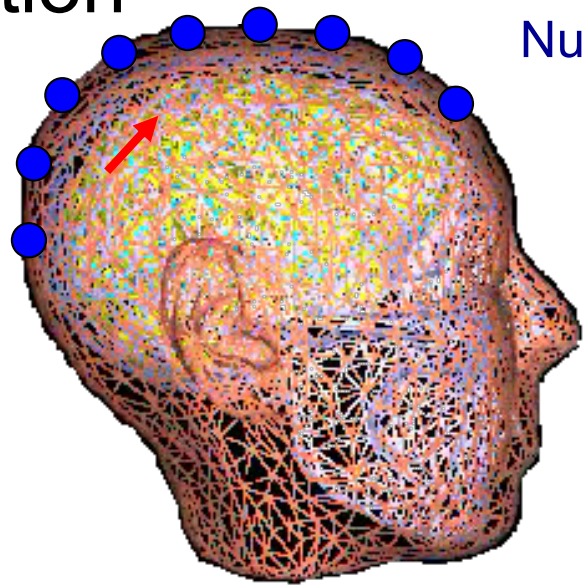
→ Sensor Locations

→ Possible source distribution
- Magnitudes
- Locations
- Directions

→ Solver

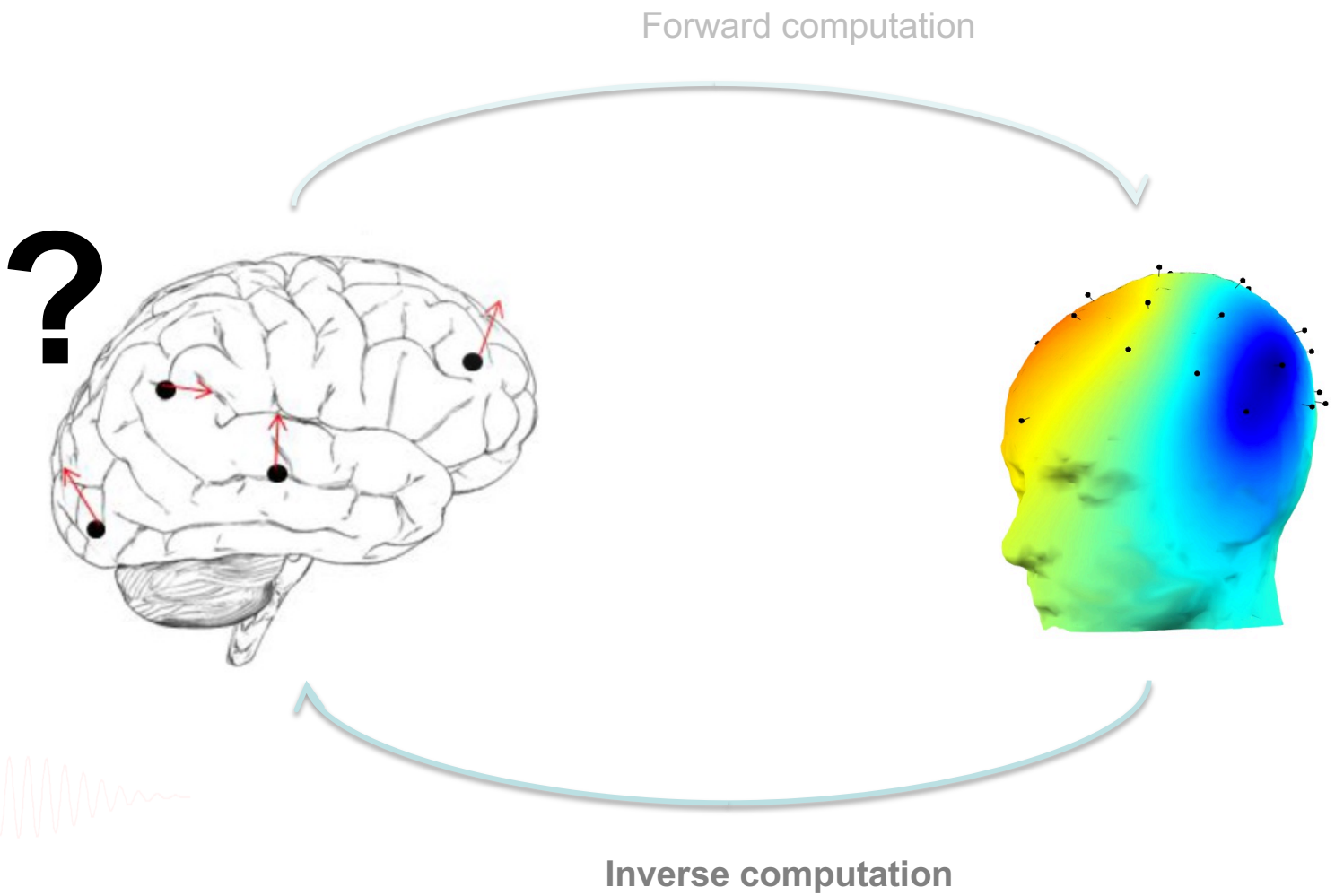


Spherical Model



Numerical Model

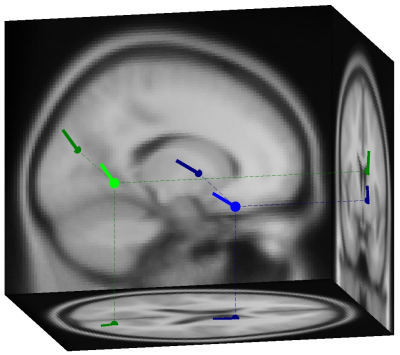
Since there is no unique solution the inverse problem is ill posed

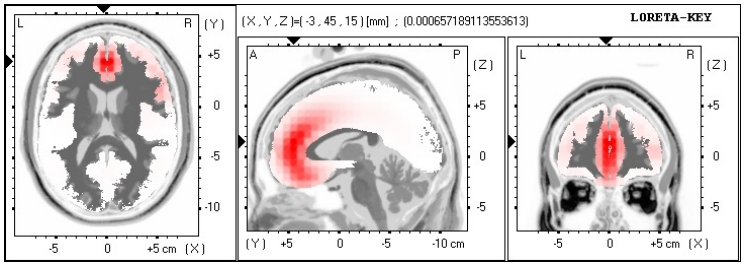


Inverse problem methods (ill posed)

Single and multiple dipole models

- Minimize error between model and measured potential/field





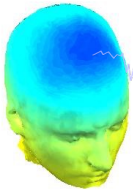
Distributed dipole models

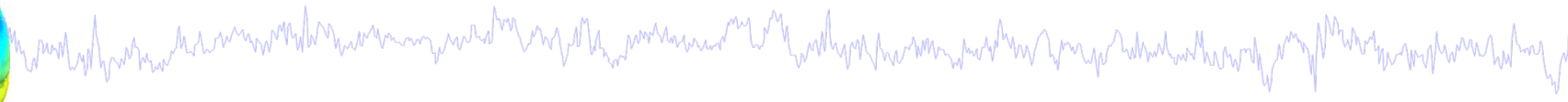
- Perfect fit of model to the measured potential/field
- Minimize an additional constraint on sources
  - LORETA (assume a smooth distribution)
  - Minimum Norm (L2, minimum power at the cortex)
  - Minimum Current (L1, minimum current in the cortex)

Solving the inverse problem

- **Spatial source filtering**
  - **Scan whole brain** with single dipole and compute the filter output at every location
    - MUSIC algorithm
    - *Beamforming* (e.g., LCMV, SAM, DICS)
  - **Perform ICA decomposition** (higher-order statistics)
    - ICA gives the projections of the sources to the scalp surface, i.e., **'simple' maps**!

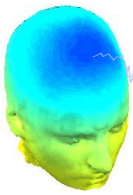
→ ICA solves 'the first half' of the inverse problem





DIPFIT and model co-registration

1. Co-register electrodes with model
2. Fit components



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) | Can

Figure 3

File Edit View Insert Tools Desktop Window Help

Channel locations

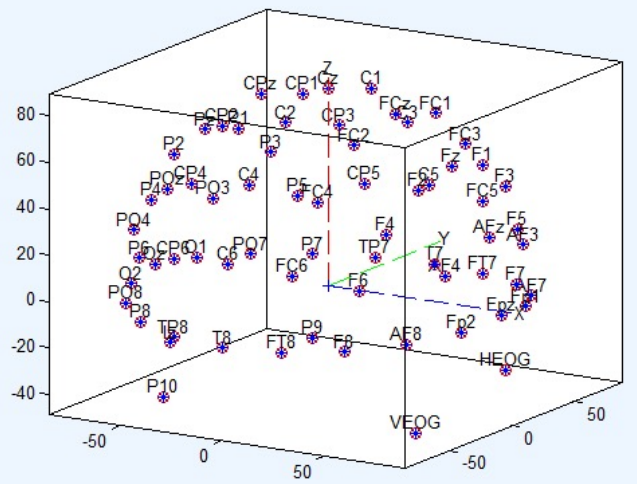
+X
+Y

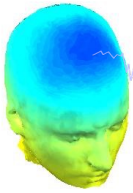
VEOG HEOG Fp1 Fp2 AF7 AF3 AFz AF4 AF8 F7 F5 F3 F1 Fz F2 F4 F6 F8 FT7 FC5 FC3 FC1 FCz FC2 FC4 FC6 FT8 T7 C5 C3 C1 Cz C2 C4 C6 T8 TP7 CP5 CP3 CP1 CPz CP2 CP4 CP6 TP8 P7 P5 P3 P1 Pz P2 P4 P6 P8 P9 PO7 PO3 POz PO4 PO8 P10 O1 Oz O2 Iz

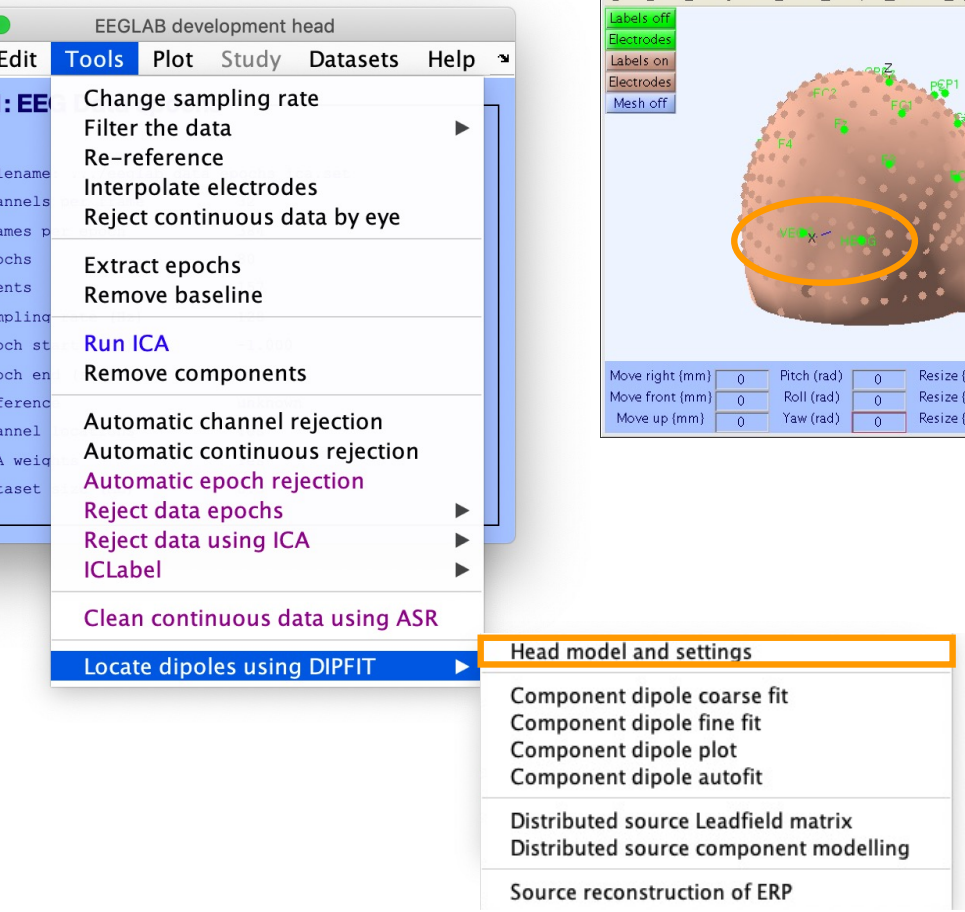
66 of 72 electrode locations shown

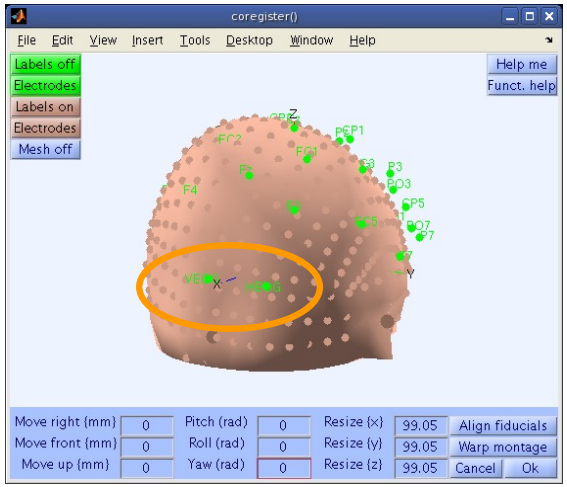
Figure 3

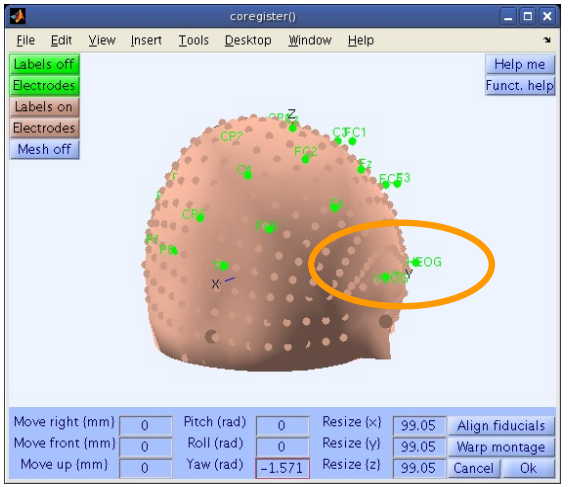
File Edit View Insert Tools Desktop Window Help



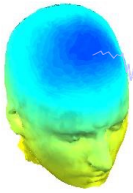



EEGLAB development head
File Edit Tools Plot Study Datasets Help
Change sampling rate
Filter the data
Re-reference
Interpolate electrodes
Reject continuous data by eye
Extract epochs
Remove baseline
Run ICA
Remove components
Automatic channel rejection
Automatic continuous rejection
Automatic epoch rejection
Reject data epochs
Reject data using ICA
ICLabel
Clean continuous data using ASR
Locate dipoles using DIPFIT
Head model and settings
Component dipole coarse fit
Component dipole fine fit
Component dipole plot
Component dipole autofit
Distributed source Leadfield matrix
Distributed source component modelling
Source reconstruction of ERP


coregister()
File Edit View Insert Tools Desktop Window Help
Labels off
Electrodes
Labels on
Electrodes
Mesh off
Help me
Funct. help
Move right (mm) 0
Move front (mm) 0
Move up (mm) 0
Pitch (rad) 0
Roll (rad) 0
Yaw (rad) 0
Resize (x) 99.05
Resize (y) 99.05
Resize (z) 99.05
Align fiducials
Warp montage
Cancel
Ok


coregister()
File Edit View Insert Tools Desktop Window Help
Labels off
Electrodes
Labels on
Electrodes
Mesh off
Help me
Funct. help
Move right (mm) 0
Move front (mm) 0
Move up (mm) 0
Pitch (rad) 0
Roll (rad) 0
Yaw (rad) -1.571
Resize (x) 99.05
Resize (y) 99.05
Resize (z) 99.05
Align fiducials
Warp montage
Cancel
Ok

EEG.dipfit structure



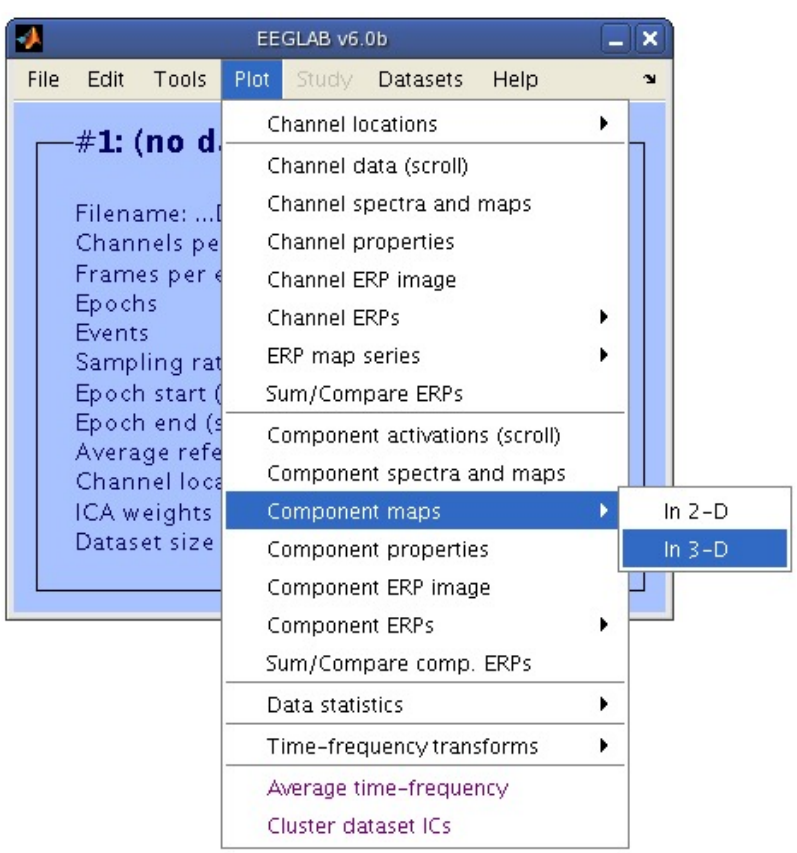
```
>> EEG.dipfit
ans =
            hdmfile: [1x76 char]
            mrifile: [1x71 char]
           chanfile: [1x83 char]
            chansel: [1x33 double]
         coordformat: 'spherical'
              model: [1x33 struct]
            current: 32
                vol: [1x1 struct]
          leadfield: []
     coord_transform: [0 0 -1.570796 100 76 90.87264 1 1 1]
```

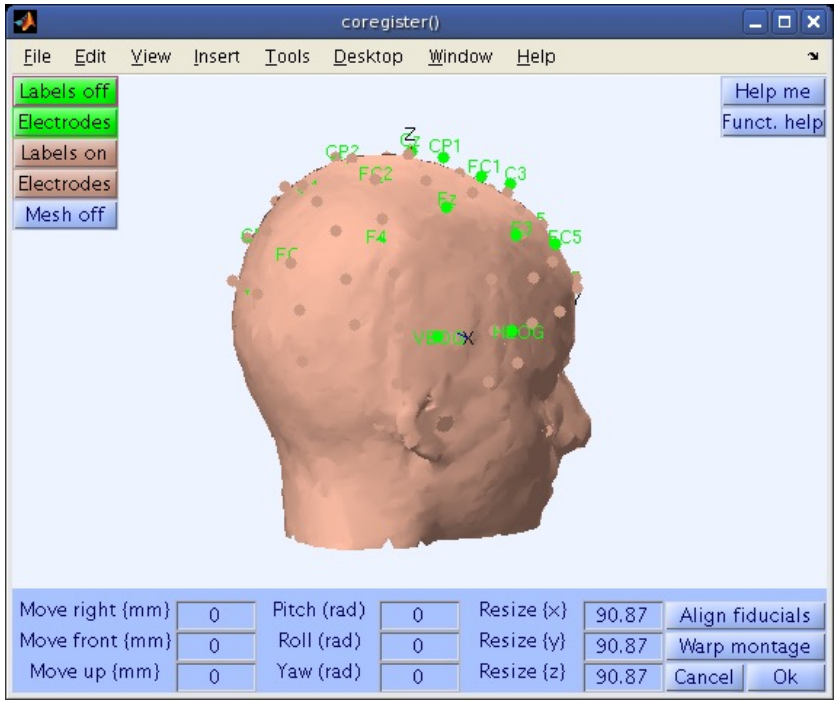
Rotation

Translation

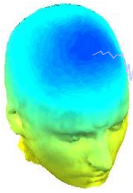
Scaling

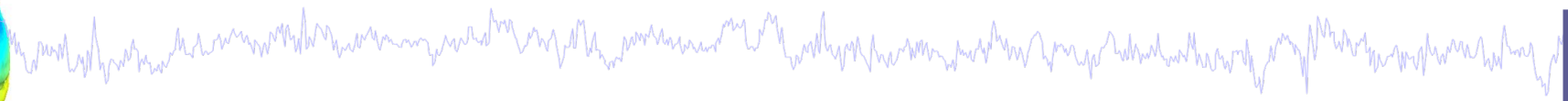
Plot scalp maps in 3D





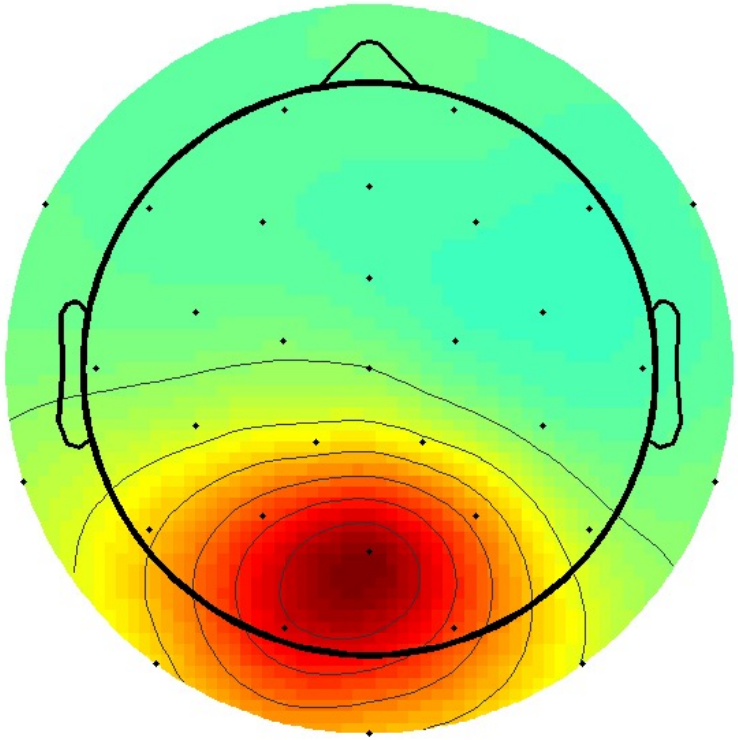
Go through co-registration in the same way as with dipfit co-registration



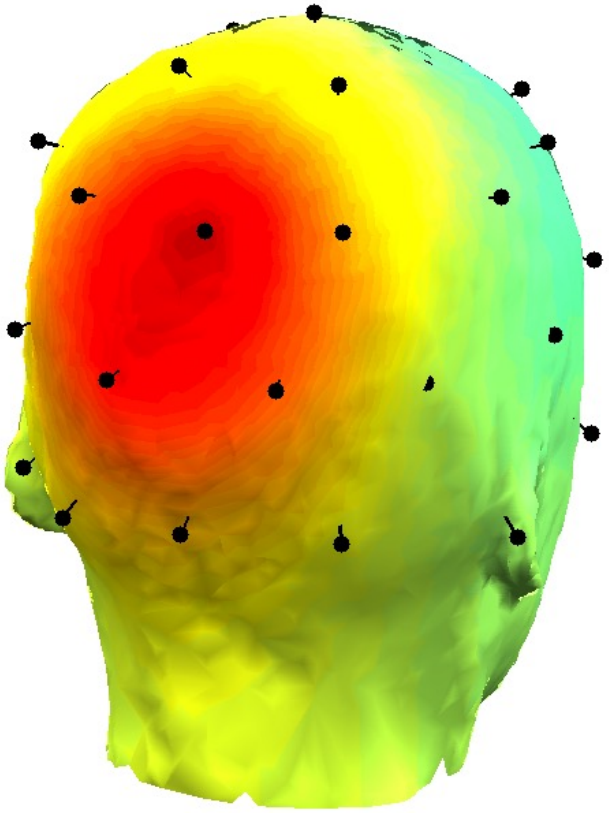


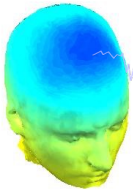
Swartz Center for Computational Neuroscience

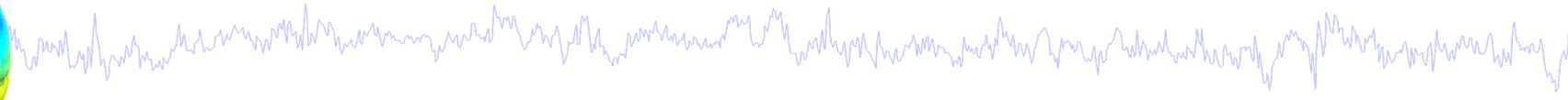
2D scalp map for IC 12



3D scalp map for IC 12

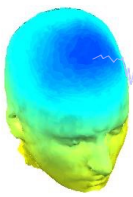




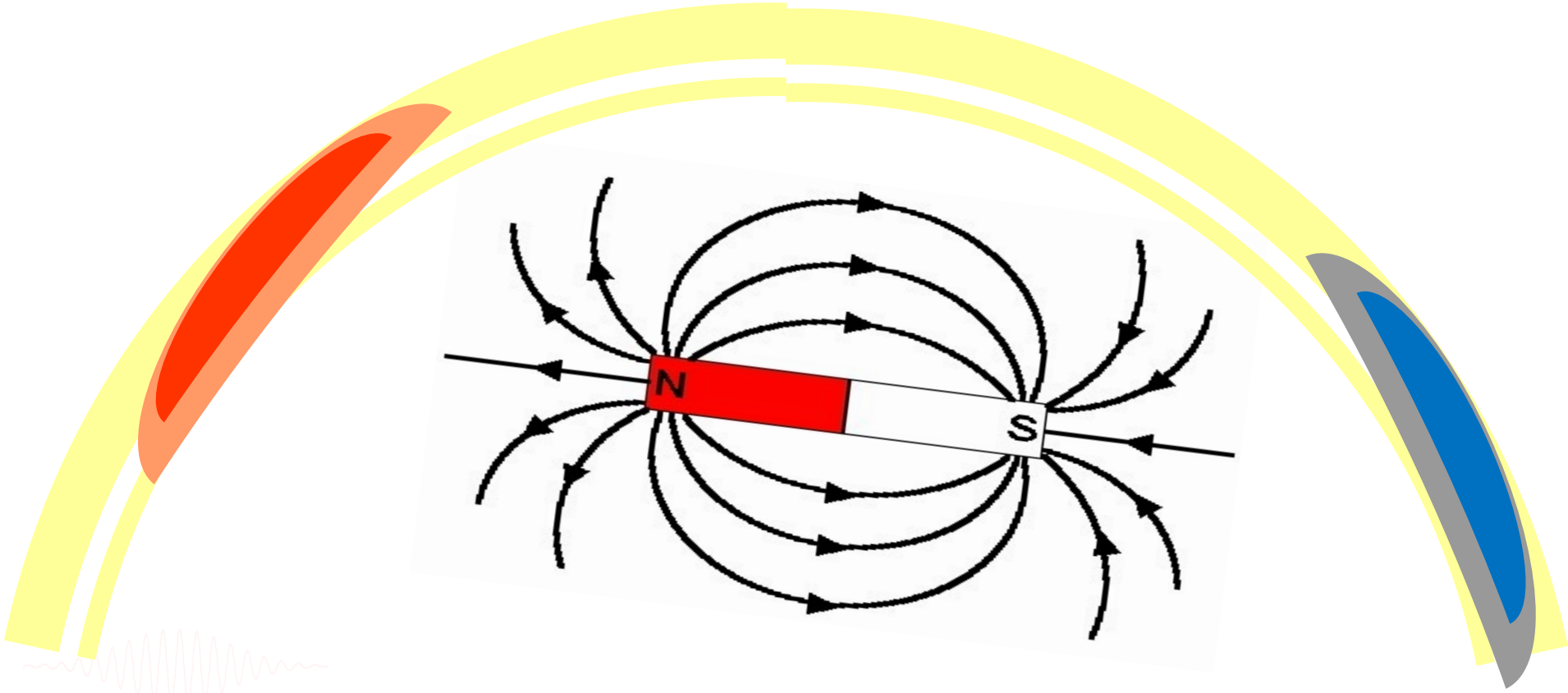


DIPFIT and model co-registration

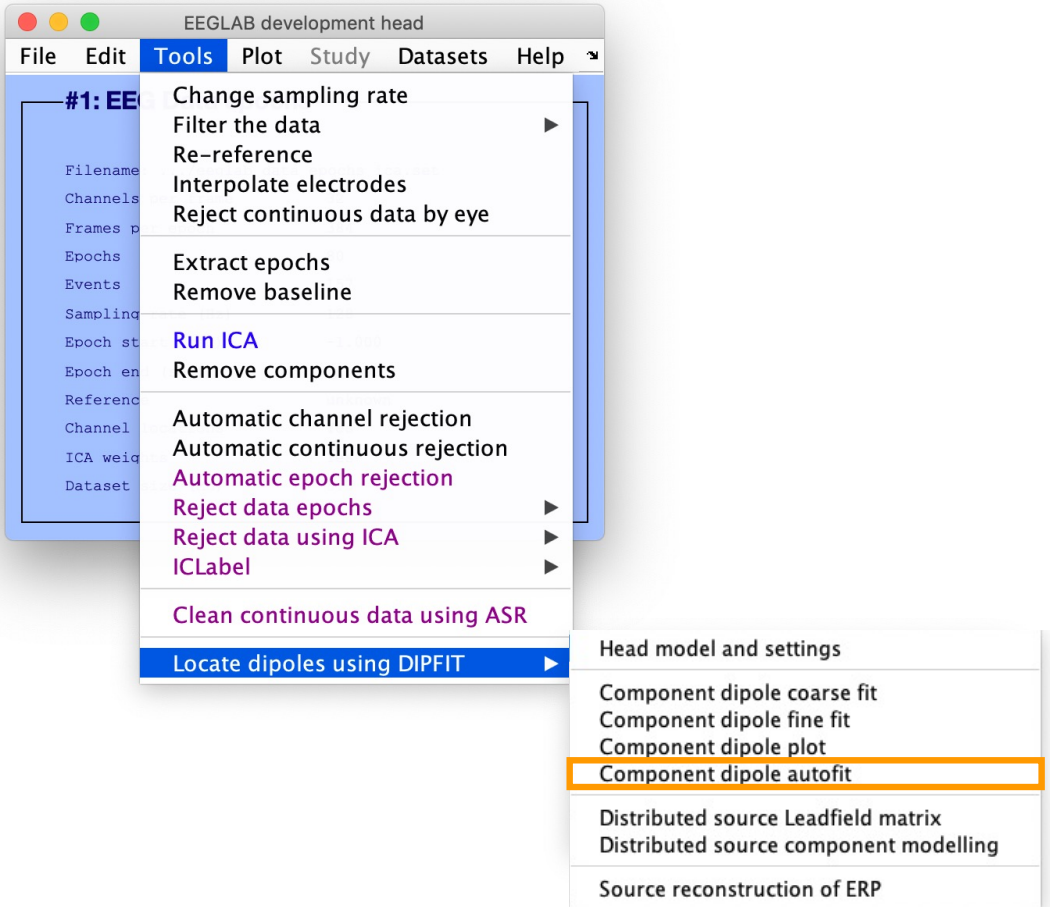
1. Co-register electrodes with model
2. Fit components

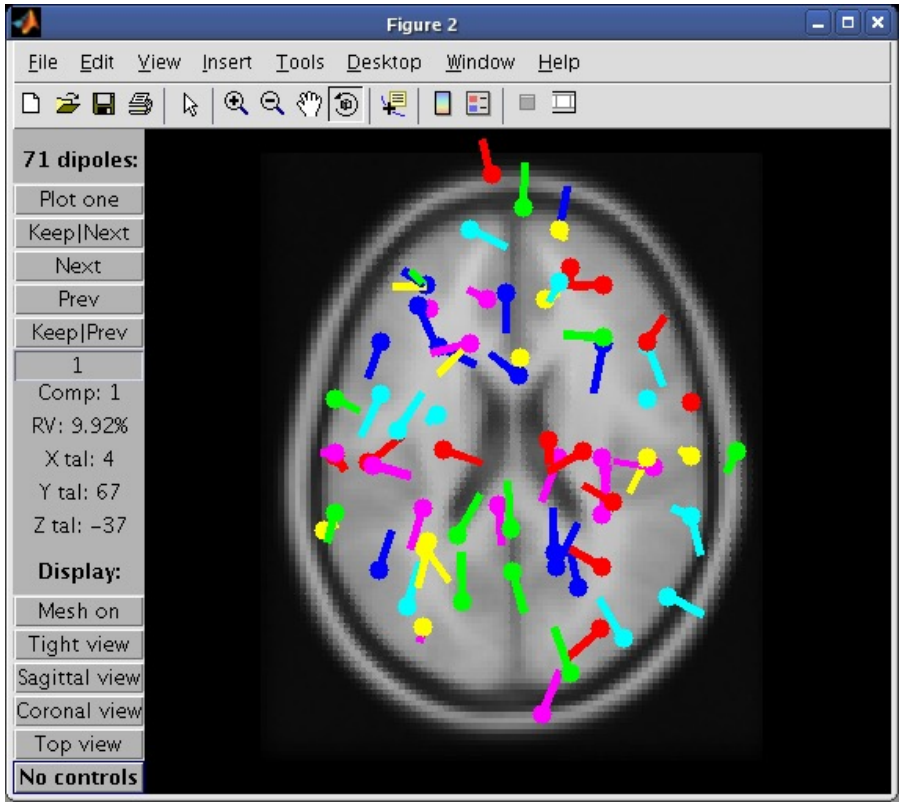


Patch of Cortex Acting as a Dipole

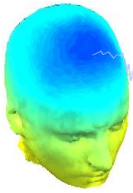


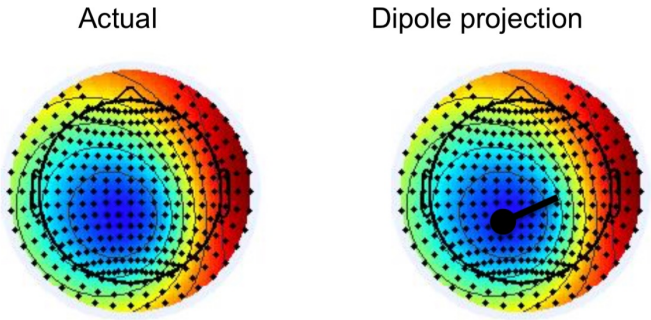
Fit equivalent dipoles



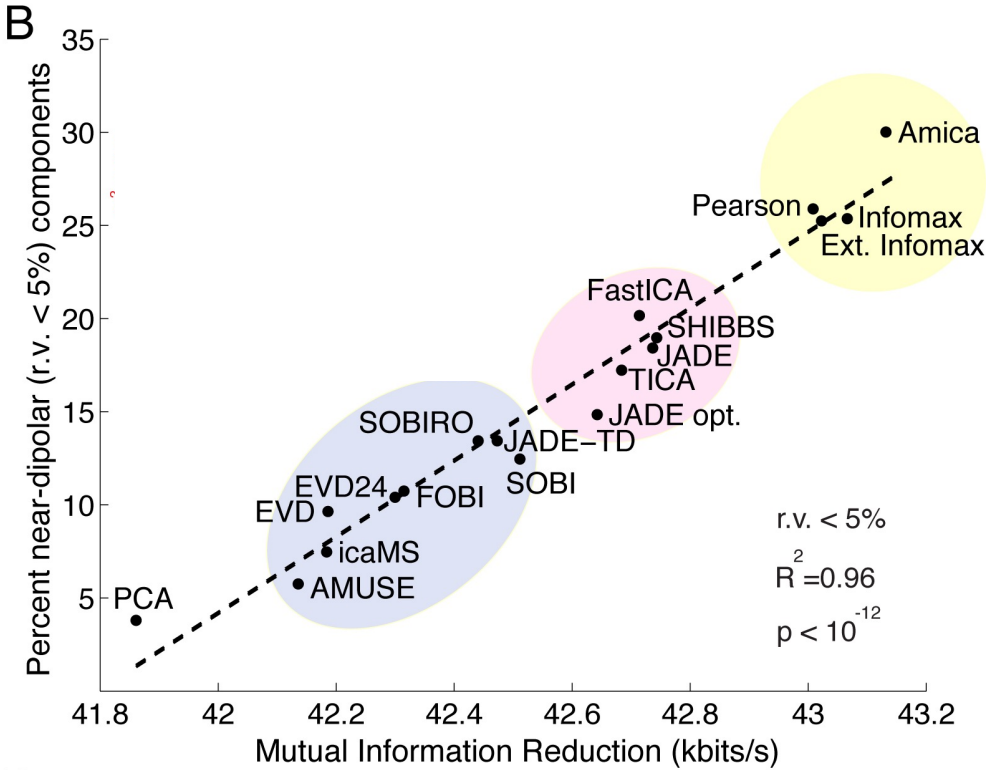


Computing residual variance



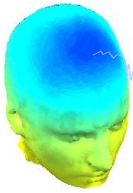


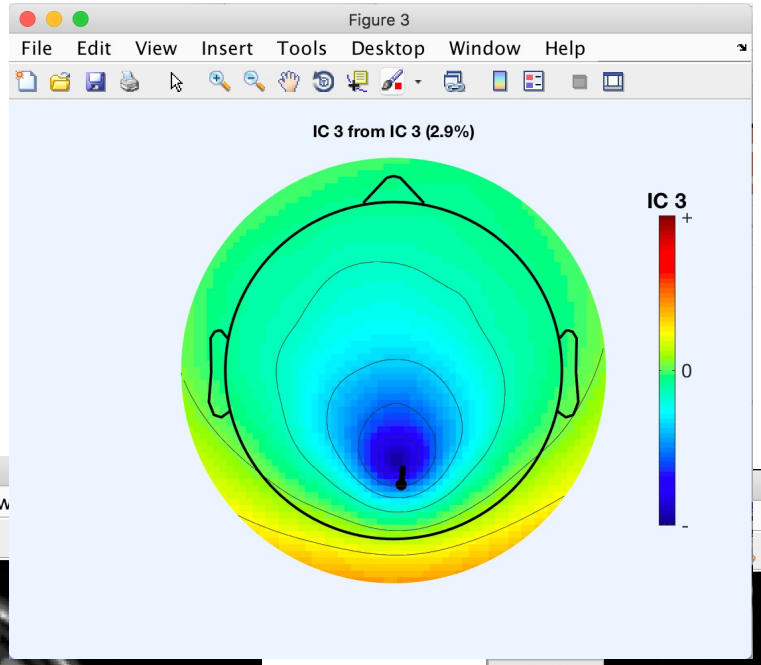
$$r = \Sigma(x_i - \tilde{x}_i)^2 / \Sigma x_i^2$$

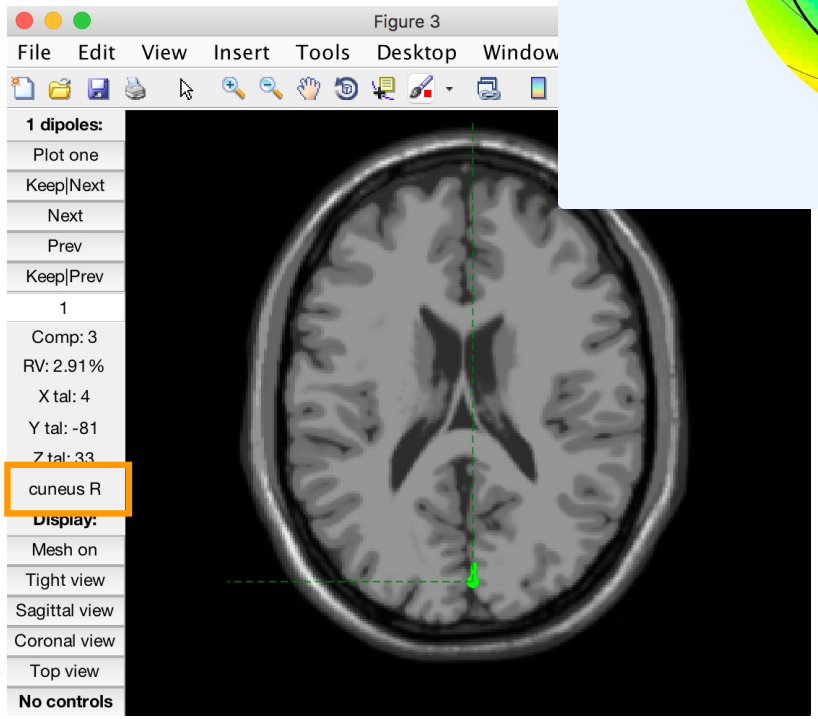


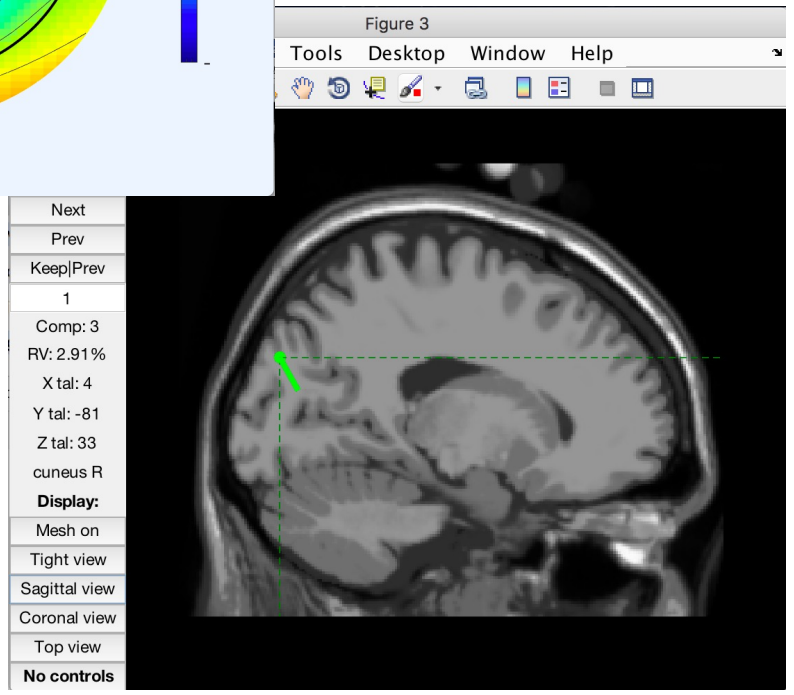
Delorme A, Palmer J, Onton J, Oostenveld R, Makeig S. Independent EEG sources are dipolar. PLoS One. 2012;7(2):e30135. doi: 10.1371/journal.pone.0030135. Epub 2012 Feb 15. PMID: 22355308; PMCID: PMC3280242.

Scroll through dipoles

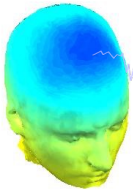


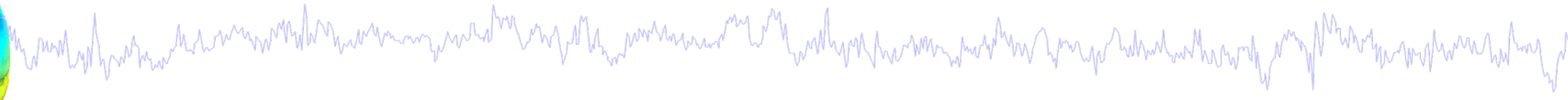




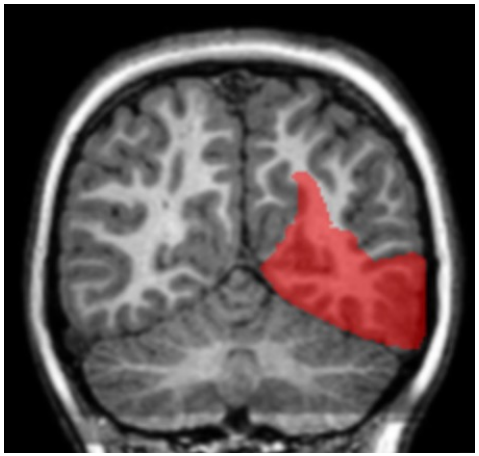


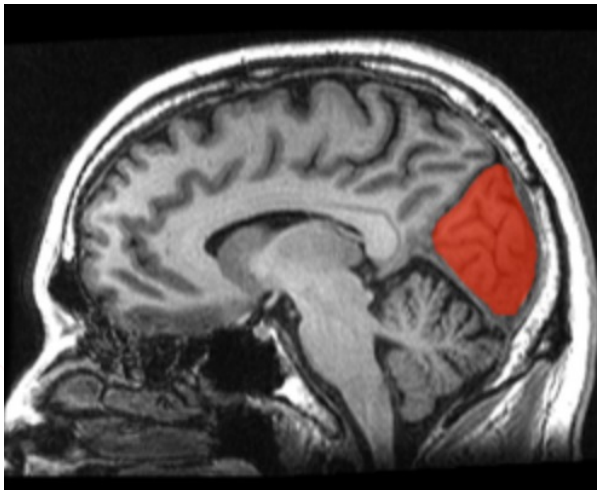
Desikan-Killiany Atlas



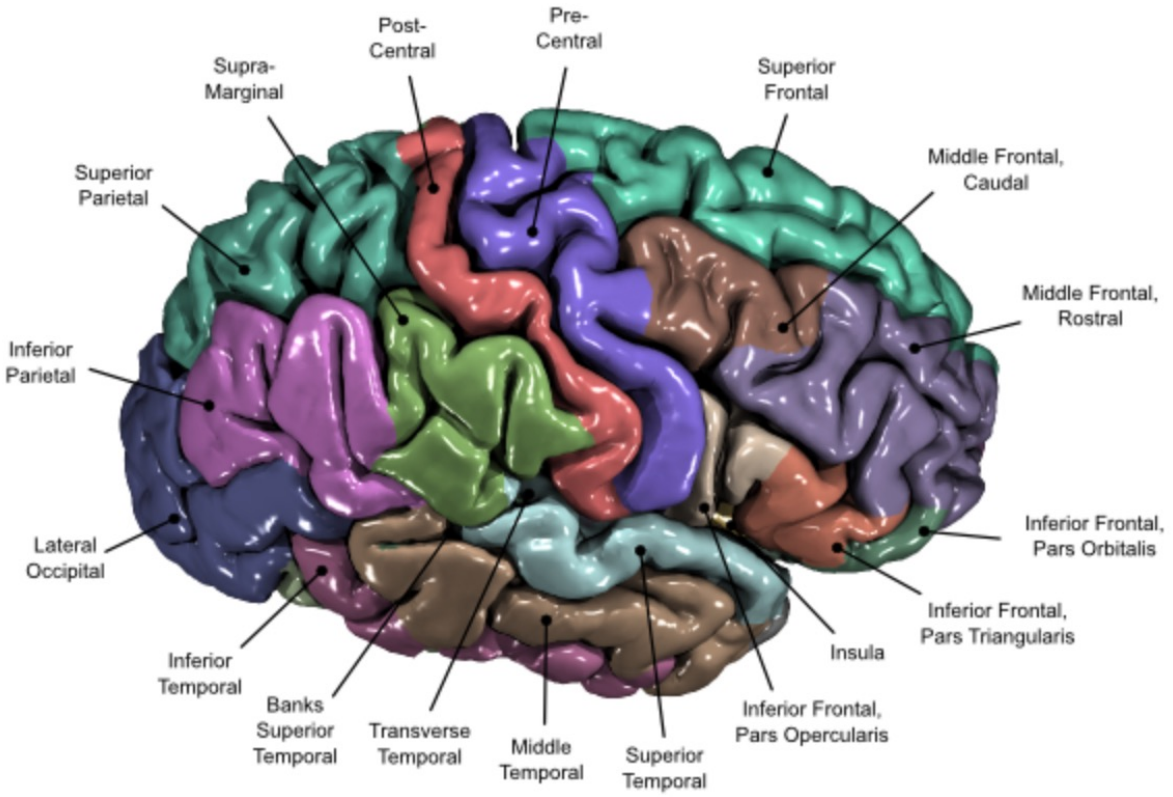


Right Cuneus

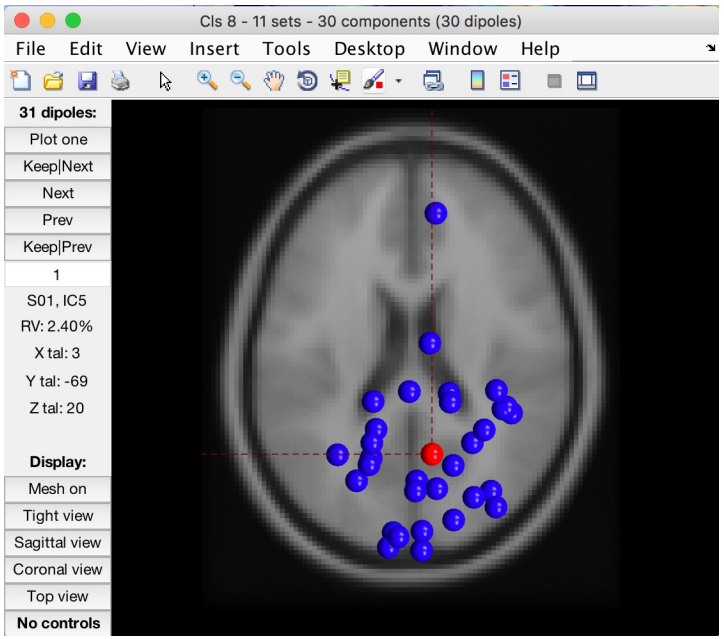


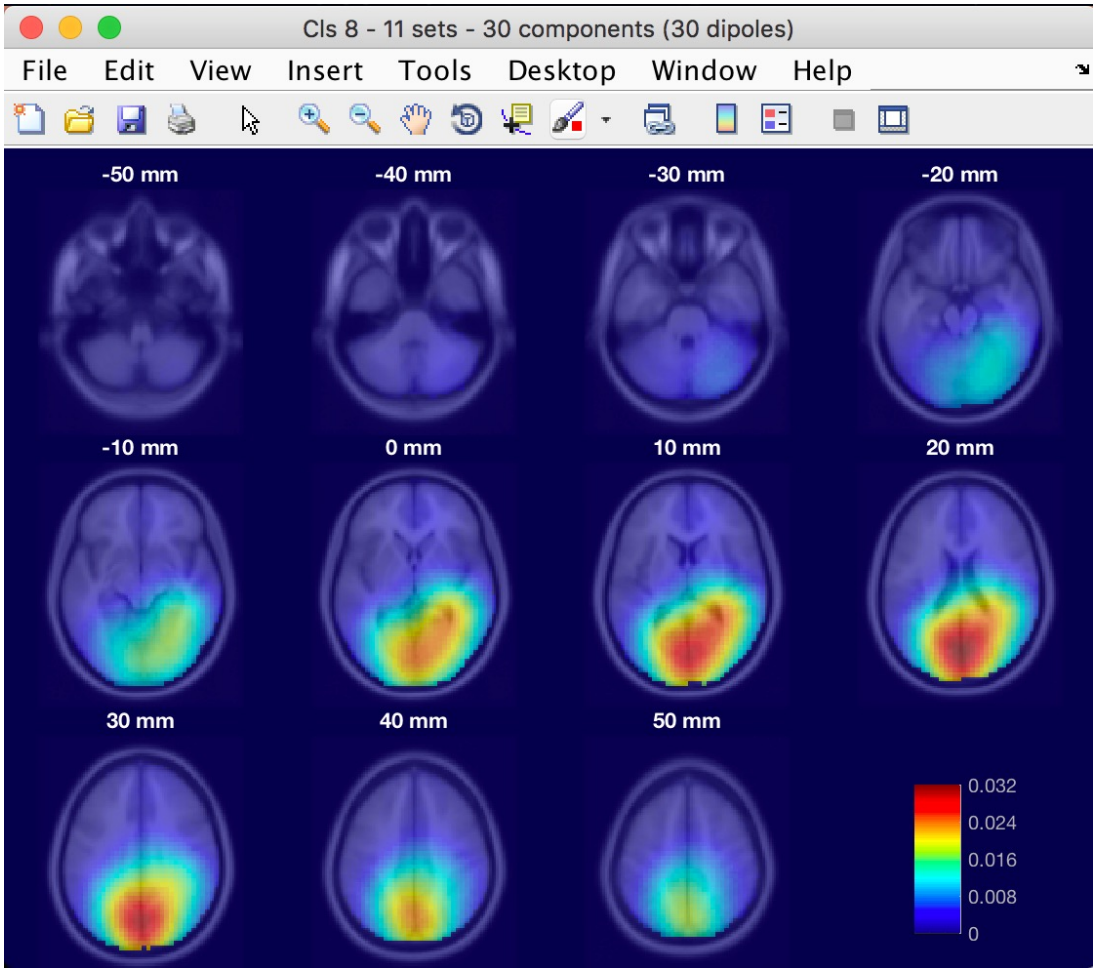


68 brain areas

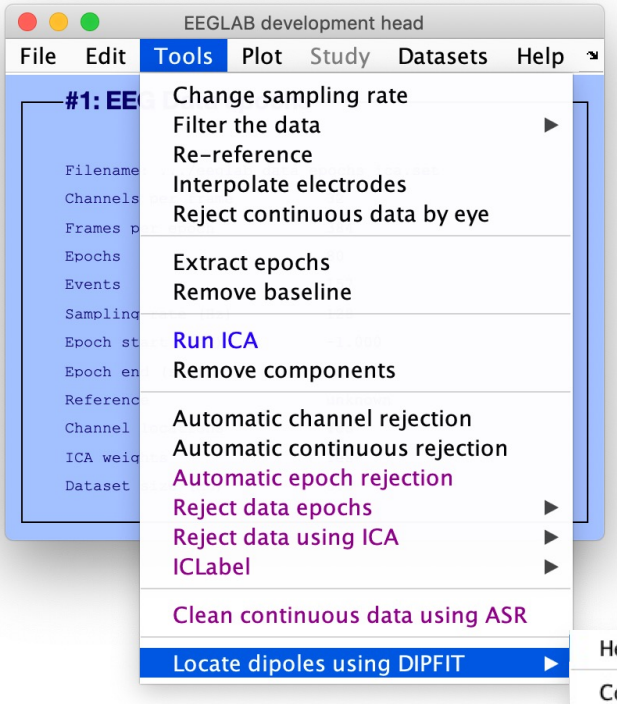


Visualizing ICA component clusters

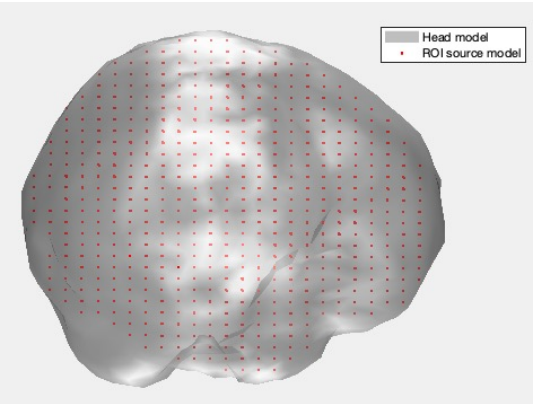




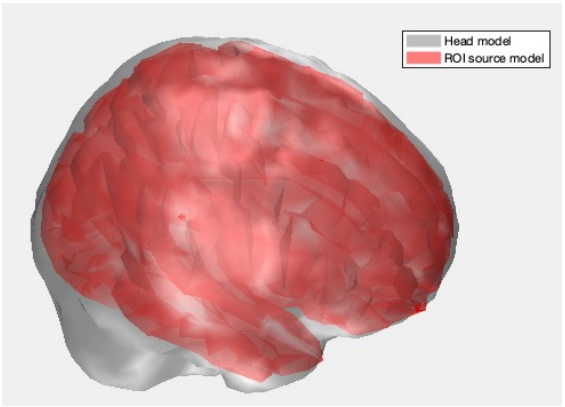
Distributed source localization in DIPFIT



Volume

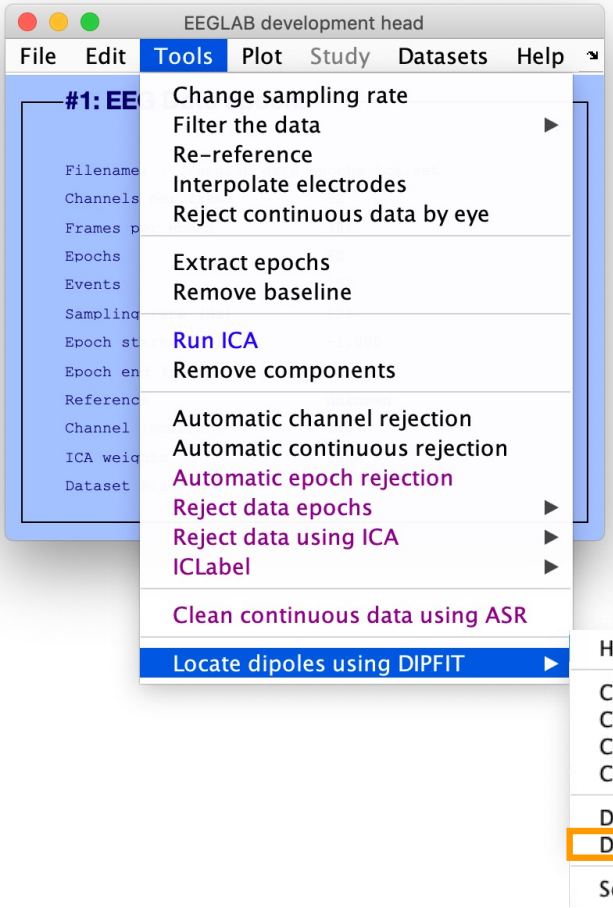


Surface

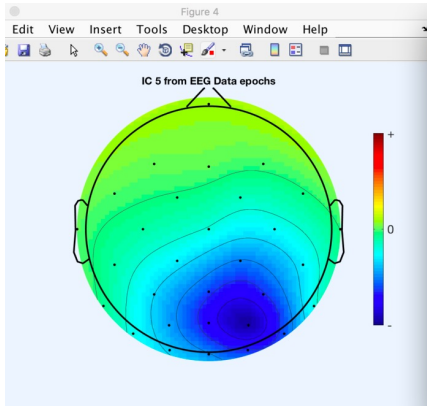


Distributed source localization

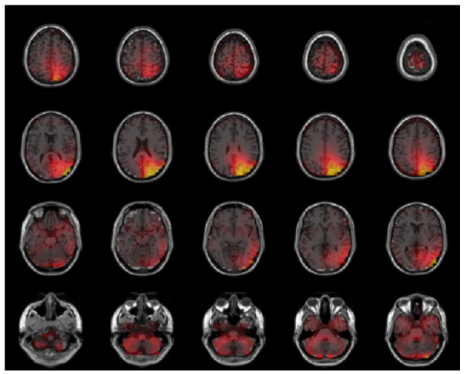
(eloreta or LCMV beamforming)



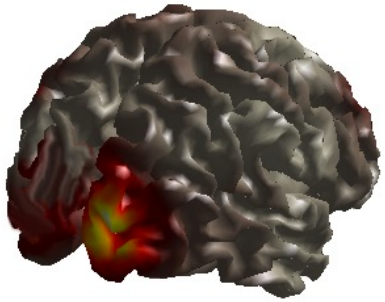
IC scalp topo

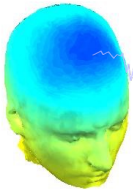


Volume



Surface

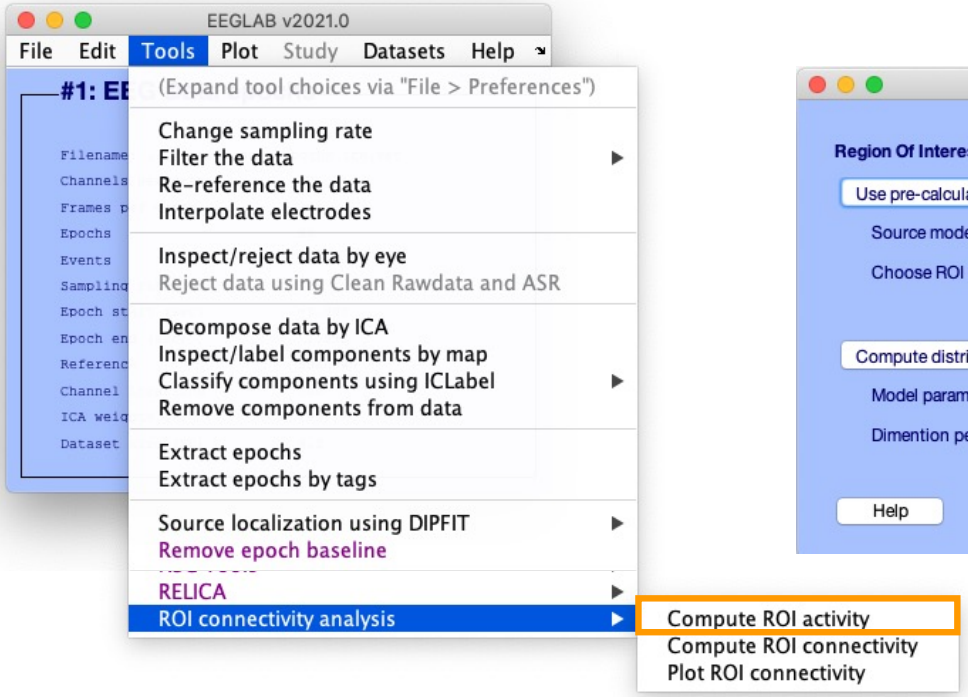


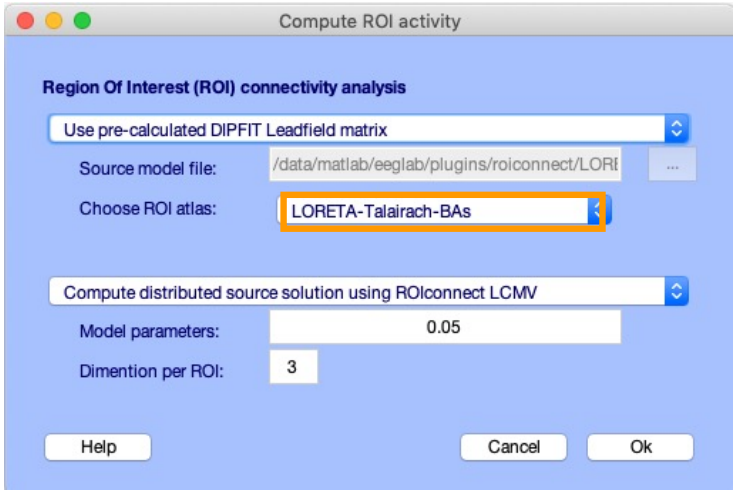


Swartz Center for Computational Neuroscience

ROIconnect plugin

Stefan Hauffe



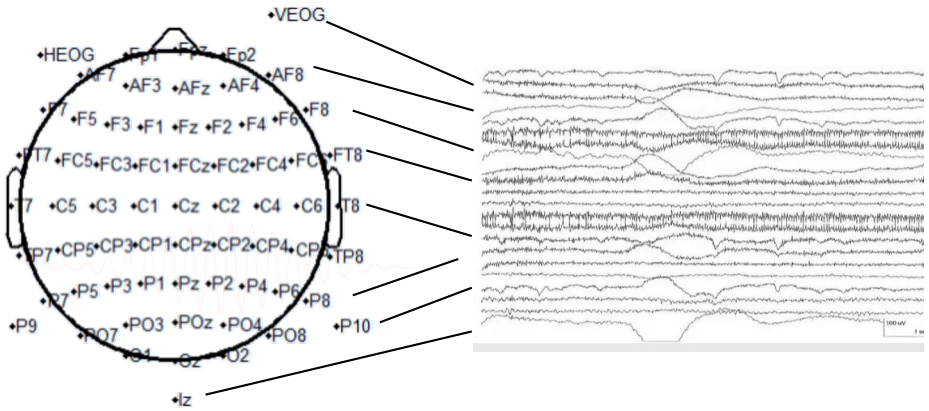


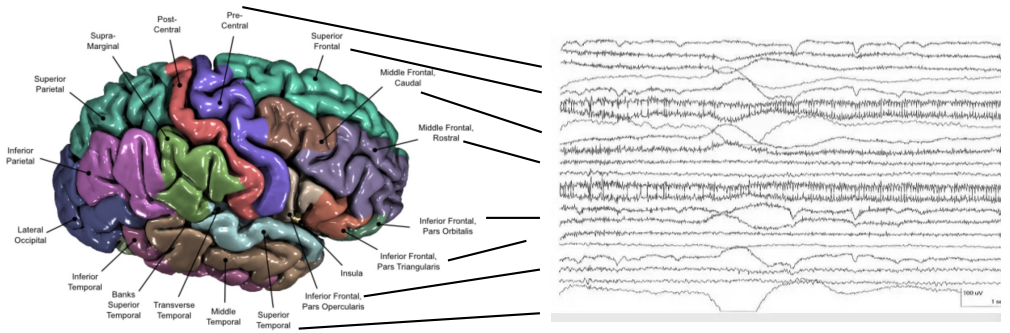
→ Leadfield matrix

→ Atlas for ROIs

→ Method

Channel space → **ROI space**



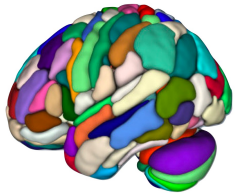


Connectivity analysis using ROIconnect

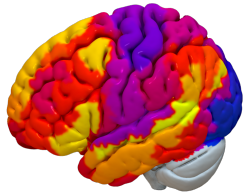
Volumetric atlases

AFNI MNI

Brainnetome

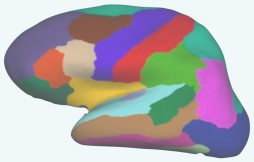


Schaefer 2018

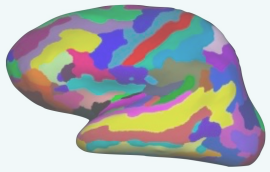


Surface atlases

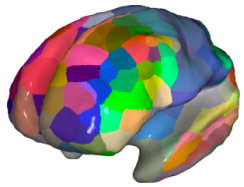
Desikan Kiliany



Destrieux

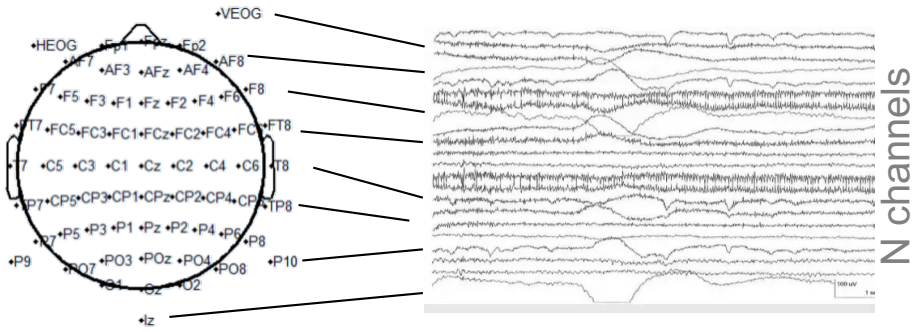


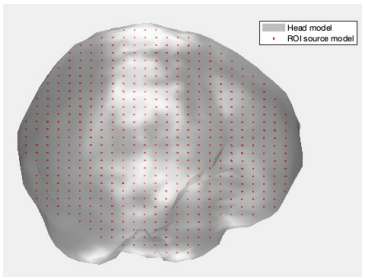
PrAGMATiC

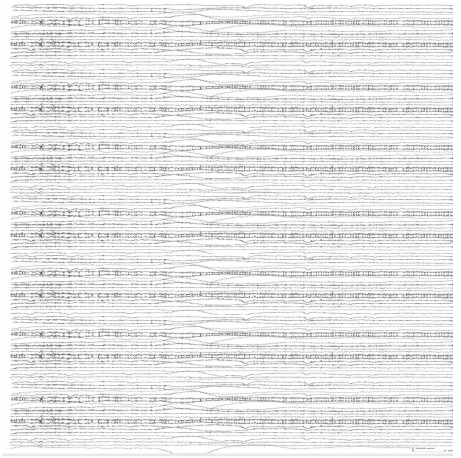


Channel space (~100 dim)

Source space (~10,000)

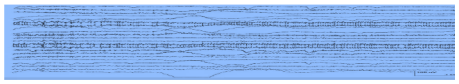


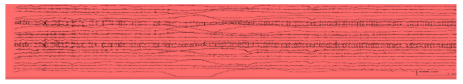


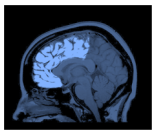


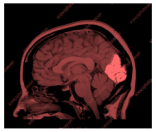
First ROI

Second ROI









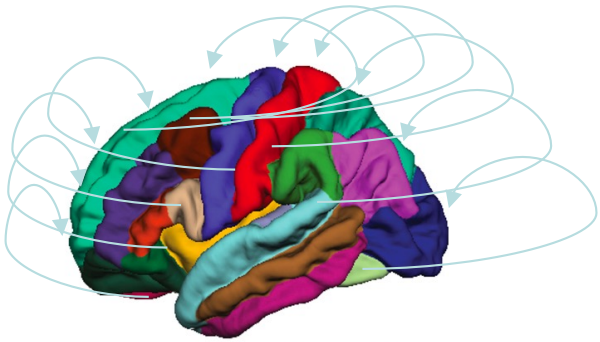
PCA

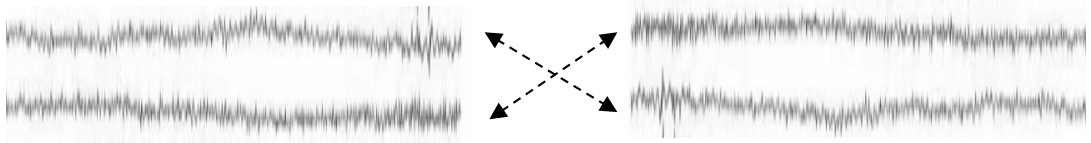
PCA

Dim ~ 2 to 4

Dim ~ 2 to 4

Compute connectivity between all ROI pairs

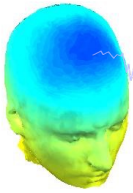




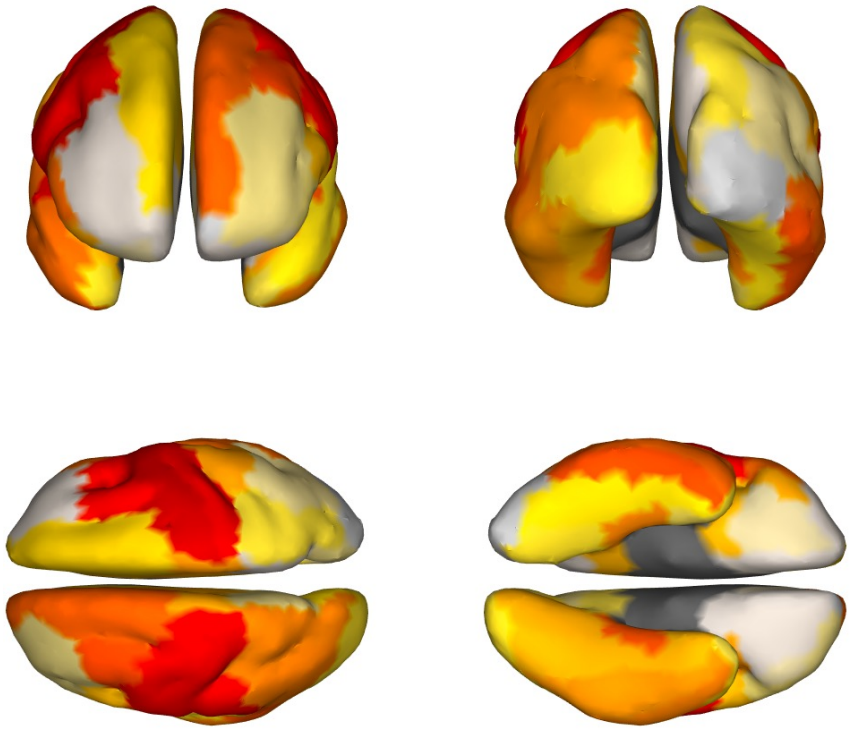
Pairwise connectivity

TRGC, GC, TRPDC,

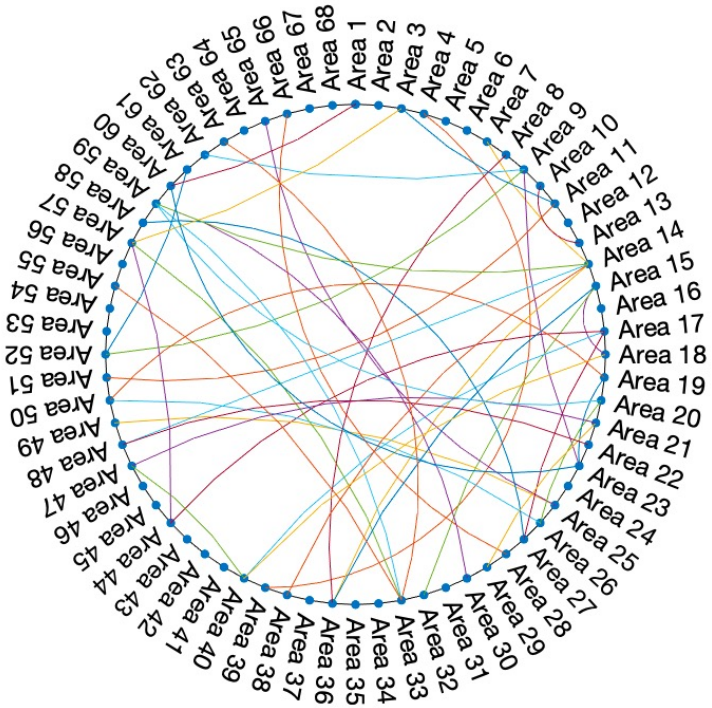
PDC, TRDTF, DTF and CS



Red regions are highly interacting



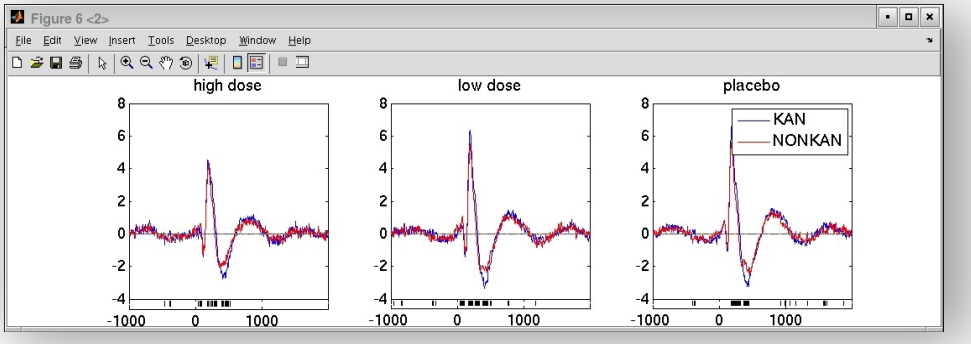
Connectivity matrix between 68 ROIs

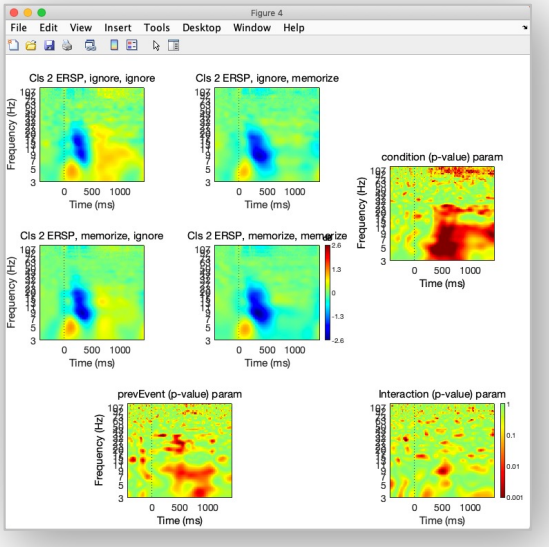


https://github.com/arnodelorme/roiconnect

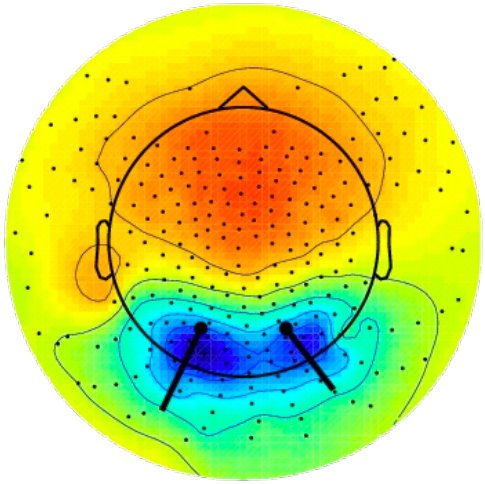
ROIconnect future

- Export ROI activity





- More atlases
- Comparison with ICA
- Validation of head models with different resolutions



The END