Welcome!

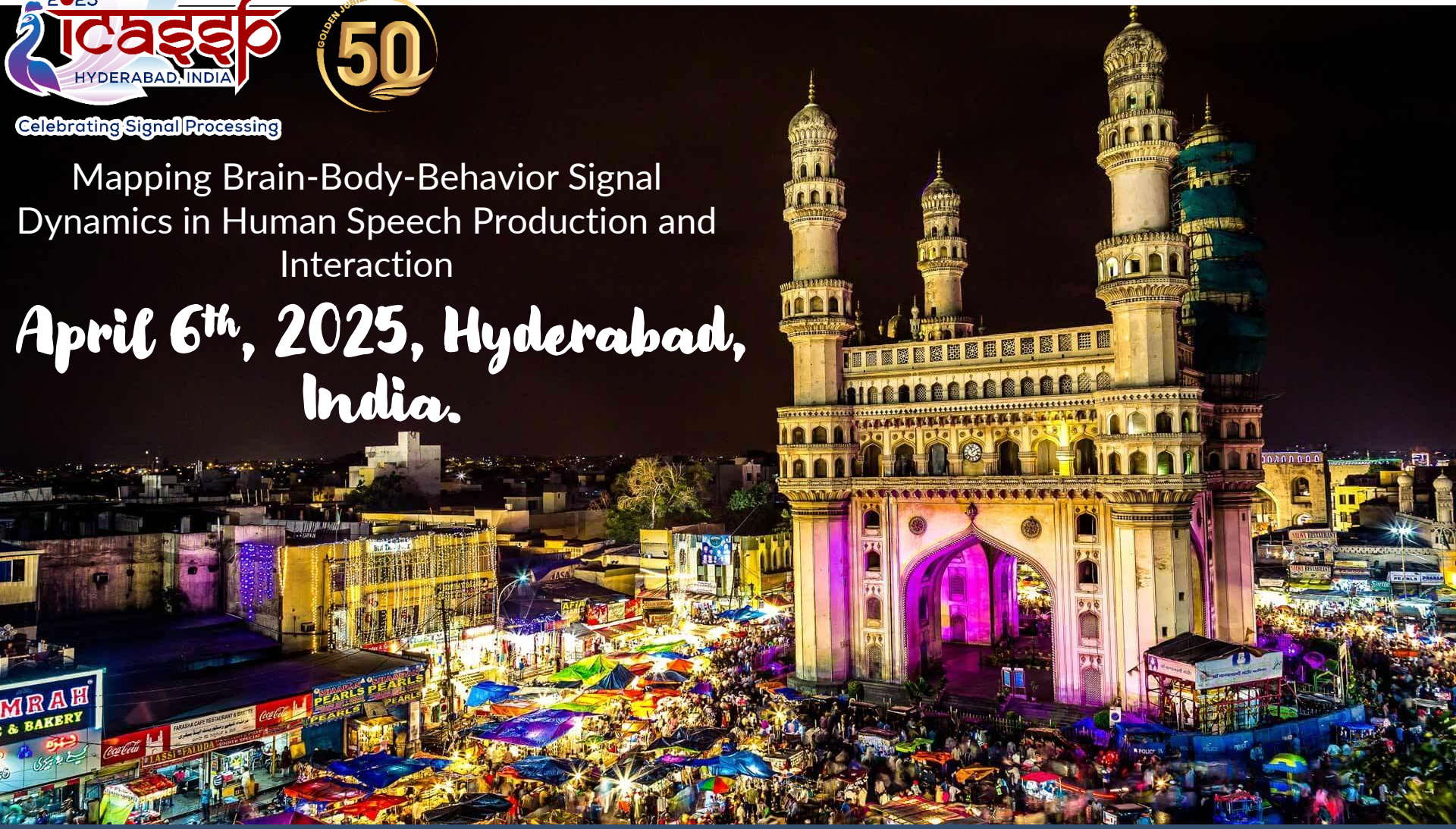
2025 icassp HYDERABAD, INDIA

GOLDEN JUBILEE 50

Celebrating Signal Processing

Mapping Brain-Body-Behavior Signal Dynamics in Human Speech Production and Interaction

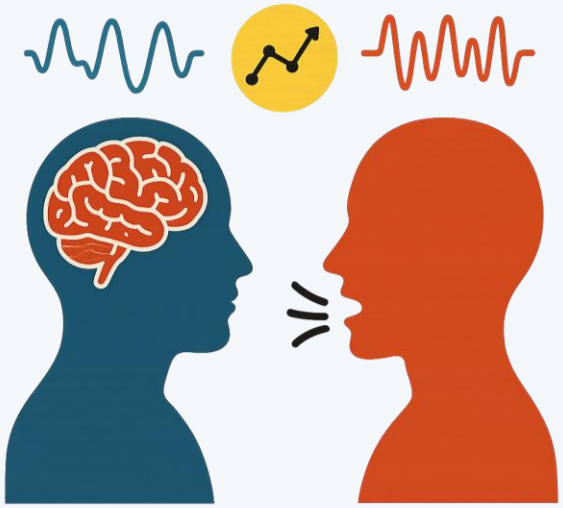
April 6th, 2025, Hyderabad, India.



Brainstorm

Welcome to WMB&SPI Workshop @ICASSP 2025!

Workshop on Mapping Brain-Body-Behavior Signal Dynamics in Human Speech Production and Interaction (WMB&SPI)



Satellite Workshop of the 2025 IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2025)

Our team

Hema A Murthy,
IIT Madras, India

Shri Narayanan,
USC, USA

Mriganka Sur,
MIT, USA

Rajeswari Aghoram,
JIPMER India

Richard Leahy,
USC, USA

Takfarinas Medani

Sudarsana Reddy Kadiri

Saish Jaiswal

Gowriprasad R

Kleanthis Avramidis
(PhD Student, USC)

Woojae Jeong
(PhD Student, USC)

Jihwan Lee
(PhD Student, USC)

Anand T
(PhD Student, IIT Madras)

Aditya Kommineni
(PhD Student, USC)

https://sites.google.com/view/wmbspi/team

Brainstorm

Agenda

Time	Event
09:30 a.m. – 09:35 a.m.	Welcome | Introduction to the Workshop
09:35 a.m. – 10:20 a.m.	Keynote 1: Shantala Hegde
10:20 a.m. – 11:05 a.m.	Keynote 2: Shalini Narayana
11:05 a.m. – 11:30 a.m.	Coffee Break
11:30 a.m. – 01:00 p.m.	Brainstorm Lecture and Demo
01:00 p.m. – 02:00 p.m.	Lunch
02:00 p.m. – 02:45 p.m.	Keynote 3: Tanja Schultz
02:45 p.m. – 03:30 p.m.	Poster Blitz + Presentations
03:30 p.m. – 04:00 p.m.	Coffee Break + Posters
04:00 p.m. – 04:45 p.m.	Keynote 4: Adolfo M. García
04:45 p.m. – 05:30 p.m.	Panel Discussion and Closing Notes

Invited Talks

Shantala Hegde | Additional Professor, Consultant Neuropsychologist
National Institute of Mental Health & Neuro Sciences, Bengaluru, India

Title: "Mapping brain-body-behaviour connection through understanding disconnection syndromes"

Shalini Narayana | Professor
The University of Tennessee Health Science Center

Title: "Neural Correlates of Speech and Language in Neurological Disorders: Lessons in Brain (Re)Organization"

Tanja Schultz | Professor
University of Bremen, Germany

Title: "Talk tells: Speech features-based prediction of cognitive change over the lifespan"

Adolfo M. García
Cognitive Neuroscience Center (Universidad de San Andrés, Argentina)
Global Brain Health Institute (GBHI), University of California, San Francisco
Departamento de Lingüística y Literatura, Facultad de Humanidades, Universidad de Santiago de Chile

Title: "Digital speech markers: The verbal blueprint of brain disorders"

Poster Presentations

- **"Impact Study of Meditation on Brain and Stress Using EEG Signals"**
  Authors: Siddharth Lotia (IIIT Bangalore), Harsh Verma (IIT Madras), and Saurav Kumar (IISc Bangalore)

- **"Investigating Listening-Related Fatigue: Development and Validation of an Auditory Psychomotor Vigilance Test using Behavioural and Electrophysiological Measures"**
  Authors: Sanjana M (Manipal Academy of Higher Education), Hari Prakash P (Manipal Academy of Higher Education), Kanaka G (Manipal Academy of Higher Education)

- **"EEG-Based Sentence-Level Speech Neuroprosthesis"**
  Authors: Sanjay B (SSN, Chennai), Themozhi J (SSN, Chennai), Vijayalakshmi P (SSN, Chennai)

- **"Brain Tumor-Induced Age-Dependent Reorganization of Speech and Language Networks Identified by Transcranial Magnetic Stimulation (TMS)"**
  Authors: Radha Kodali (UTHSC), Negar Noorizadeh (UTHSC, Le Bonheur Children's Hospital), Nitish Chourasia (UTHSC, Le Bonheur Children's Hospital), Amy McGregor (UTHSC, Le Bonheur Children's Hospital), Basanagoud Mudigoudar (UTHSC, Le Bonheur Children's Hospital), Amy Patterson (UTHSC, Le Bonheur Children's Hospital), Sarah Weatherspoon (UTHSC, Le Bonheur Children's Hospital), Paul Klimo (UTHSC, Le Bonheur Children's Hospital), Nir Shimony (UTHSC, Le Bonheur Children's Hospital), Federick Boop (UTHSC, Le Bonheur Children's Hospital), James W. Wheless (UTHSC, Le Bonheur Children's Hospital), Shalini Narayana (UTHSC, Le Bonheur Children's Hospital)

- **"Selective Target Speech Extraction Using Cross-Attention with EEG-Derived Embeddings"**
  Authors: Soham Karak (IIT Guwahati), Neeraj Sharma (IIT Guwahati)

- **"Deciphering Neural Correlates of Speech Across Indian Languages Using EEG: A Study on Subject-Specific and Linguistic Signatures"**
  Authors: Saish Jaiswal (IIT Madras), Hema Murthy (IIT Madras)

- **"Multimodal Neural and Biobehavioral Integration for Predicting Preconscious Responses in Mental Health Risk Assessment"**
  Authors: Takfarinas Medani (USC), Sudarsana Reddy Kadiri (USC), Woojae Jeong (USC), Aditya Kommineni (USC), Kleanthis Avramidis (USC), Colin McDaniel (USC), Myzelle Hughes (USC), Idan Blank (UCLA), Dany Byrd (USC), Elsi Kaiser (USC), Kristina Lerman (USC), Baruch Cahn (USC), Assal Habibi (USC), Richard Leahy (USC), Shrikanth Narayanan (USC)

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@PosterPresenters: Please provide your slides to the team by 2PM

ICASSP 2025

Brainstorm

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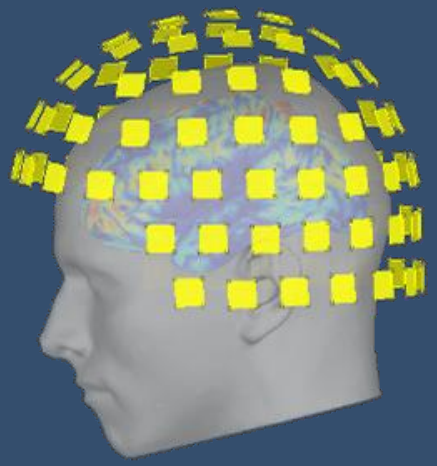
GOLDEN JUBILEE 50

USC University of Southern California



Brainstorm

http://neuroimage.usc.edu/brainstorm

Takfarinas MEDANI

Research Scientist

Brainstorm team (USC)

University of Southern California

USC UNIVERSITY OF SOUTHERN CALIFORNIA

McGill

neuro UTHealth

April 2025

let's start with a quick poll!

Brainstorm
http://neuroimage.usc.edu/brainstorm

- **Have you heard about the Brainstorm software?**
  - If Yes : Raise your hand

Agenda

- **Lecture (~45min)**
  - Overview of EEG/MEG & Electromagnetic Brain Mapping
  - Overview of the Brainstorm software
- **Demo with the Software (~45min)**
  - Introduction to the interface
  - Importing and processing anatomical data
  - Reviewing and processing EEG/MEG recordings
    - Sensor level analysis
    - Source level analysis
- **Objective:**
  - Demonstrating Brainstorm's features and how it can be used for multimodal e-phys data analysis.
  - Sensor and source level analysis

Agenda

- **Lecture (~45min)**
  - Overview of EEG/MEG & Electromagnetic Brain Mapping
  - Overview of the Brainstorm software
- **Demo with the Software (~45min) [Short Demo]**
  - Introduction to the interface
  - Importing and processing anatomical data
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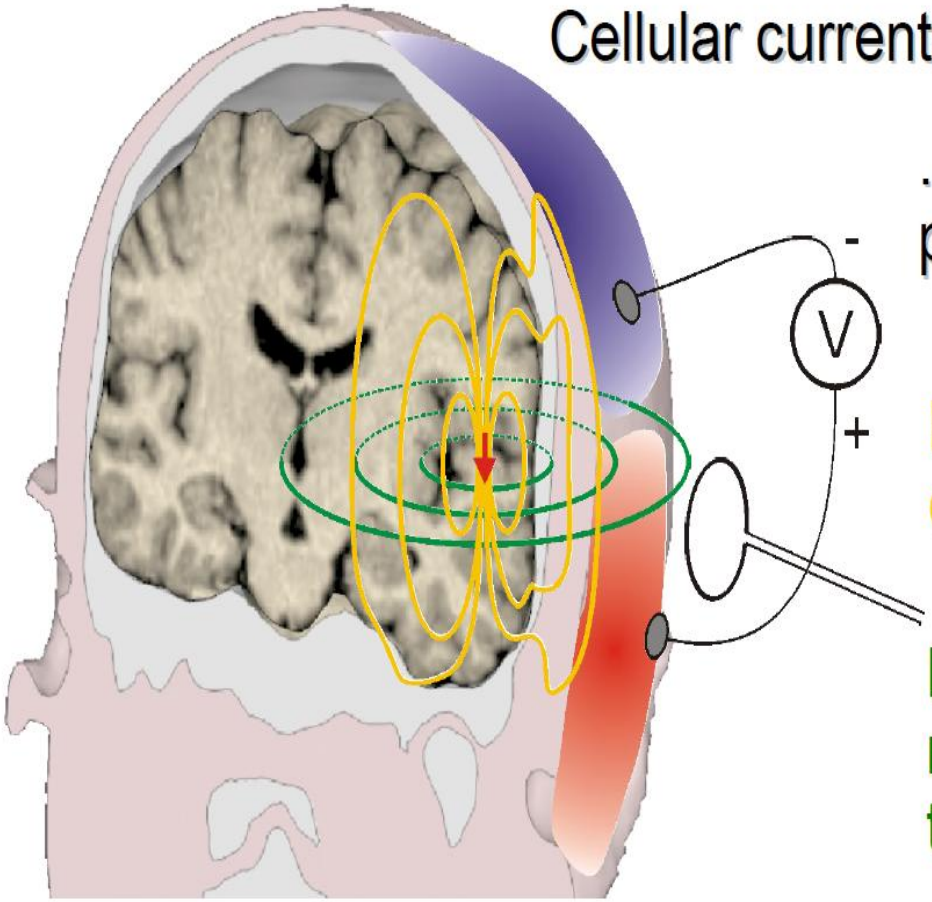
    - Sensor level analysis
    - Source level analysis
- **Objective:**
  - Demonstrating Brainstorm's features and how it can be used for multimodal e-phys data analysis.
  - Electromagnetic Brain Mapping
- **Scan QR and register (add email):**
  - To receive **the course materials** [slides and software]
  - Walkthrough to reproduce the Demo

https://docs.google.com/spreadsheets/d/1Lol_O5XTVMPvxkSZcvbfqsRW7as_UgeWFH5PSAnFFKU/edit?gid=986061177#gid=986061177

Electroencéphalographie (EEG) & Magnétoencéphalographie (MEG)



Cellular currents in an active neuron population...

... give rise to extracranial electric potentials and magnetic fields

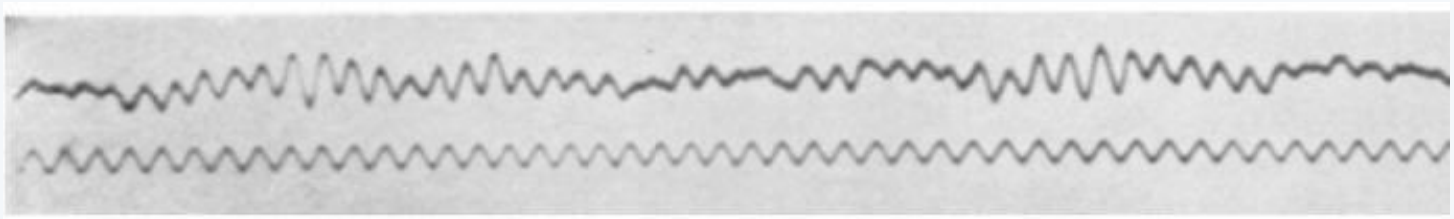
EEG = measuring the potential differences on the scalp

MEG = measuring neuromagnetic fields outside of the head

MEG and EEG track electric brain activity by measuring the electromagnetic fields generated by neurons

The first EEG measurement

- Hans Berger recorded the first human EEG
  - Alpha waves in 1924



  - *Upper trace: Human EEG*
  - *Lower trace: 10-Hz timing signal*

The first MEG measurement

- MEG became practical only after the SQUID (superconducting quantum interference device) sensor was invented

- David Cohen made the first MEG measurement with a SQUID in 1972 at MIT

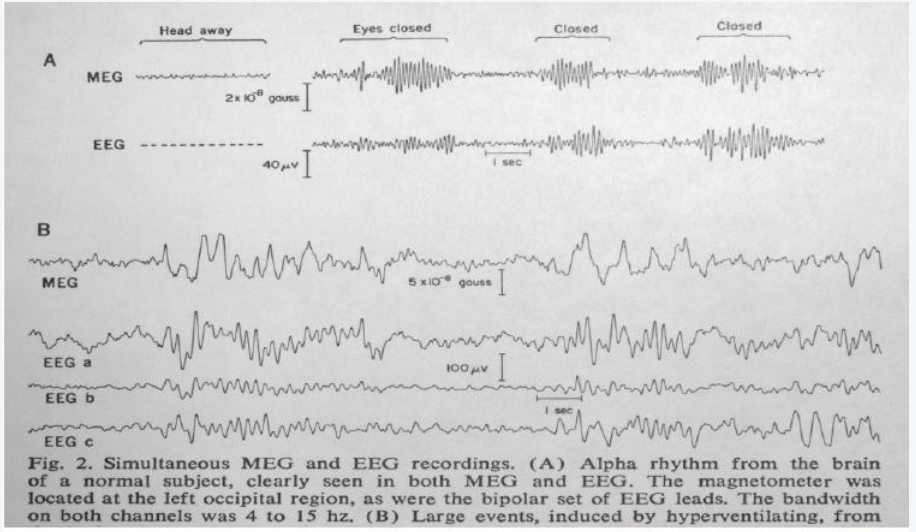
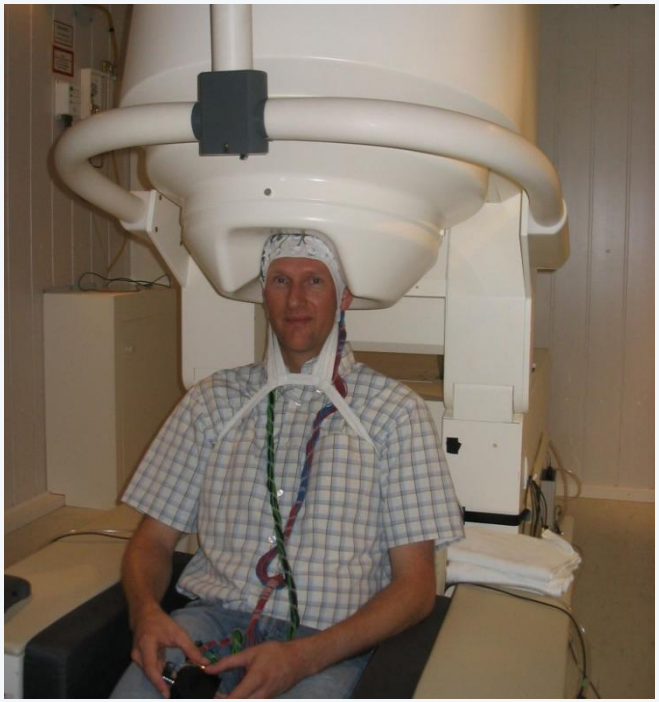


Fig. 2. Simultaneous MEG and EEG recordings. (A) Alpha rhythm from the brain of a normal subject, clearly seen in both MEG and EEG. The magnetometer was located at the left occipital region, as were the bipolar set of EEG leads. The bandwidth on both channels was 4 to 15 hz. (B) Large events, induced by hyperventilating, from

Cohen, Science 1972

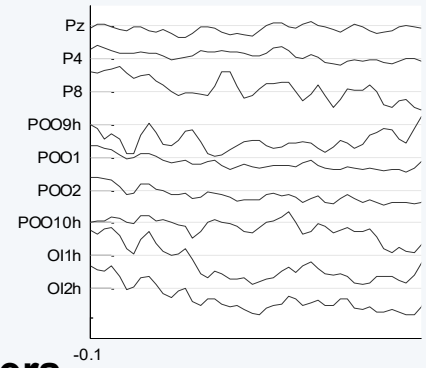
Electromagnetic Brain Mapping & Applications

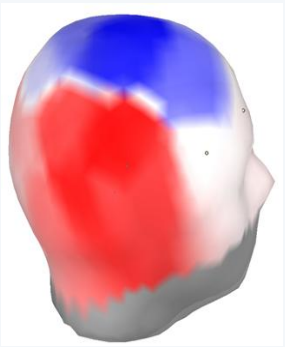


EEG

MEG

Data recording
EEG ~ uVolt
MEG~ fTesla



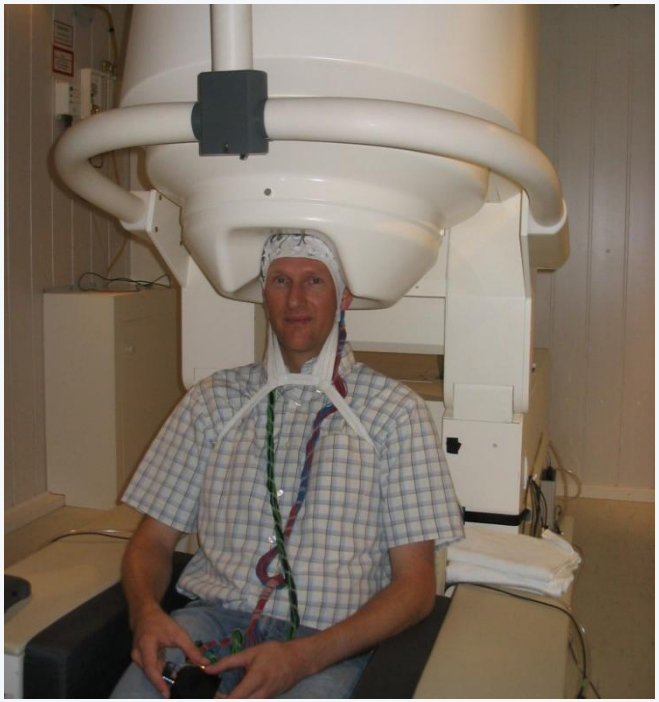


Sensor level analysis

- **Early Diagnosis of Neurological Disorders** (e.g., Parkinson's, Alzheimer's, Epilepsy)
- **Disorders of Consciousness / Brain States**
- **Brain Network Connectivity**
- **Mapping Behavior to Brain Activity**
- **High time resolution & Good spatial resolution**

Brainstorm

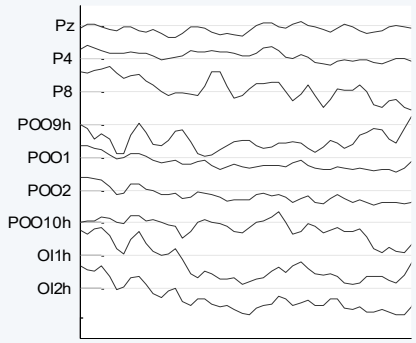
Electromagnetic Brain Mapping & Applications

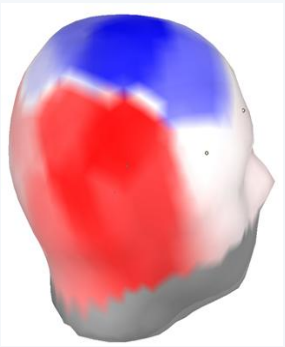


EEG

MEG

Data recording
EEG ~ uVolt
MEG~ fTesla





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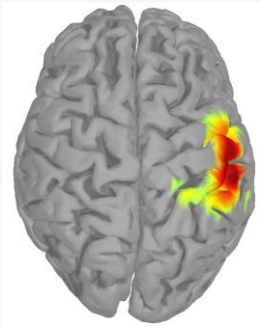

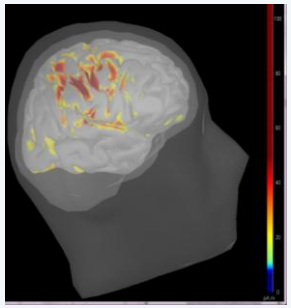

Source Level analysis

- **Early Diagnosis of Neurological Disorders** (e.g., Parkinson's, Alzheimer's, Epilepsy)
- **Disorders of Consciousness / Brain States**
- **Brain Network Connectivity**
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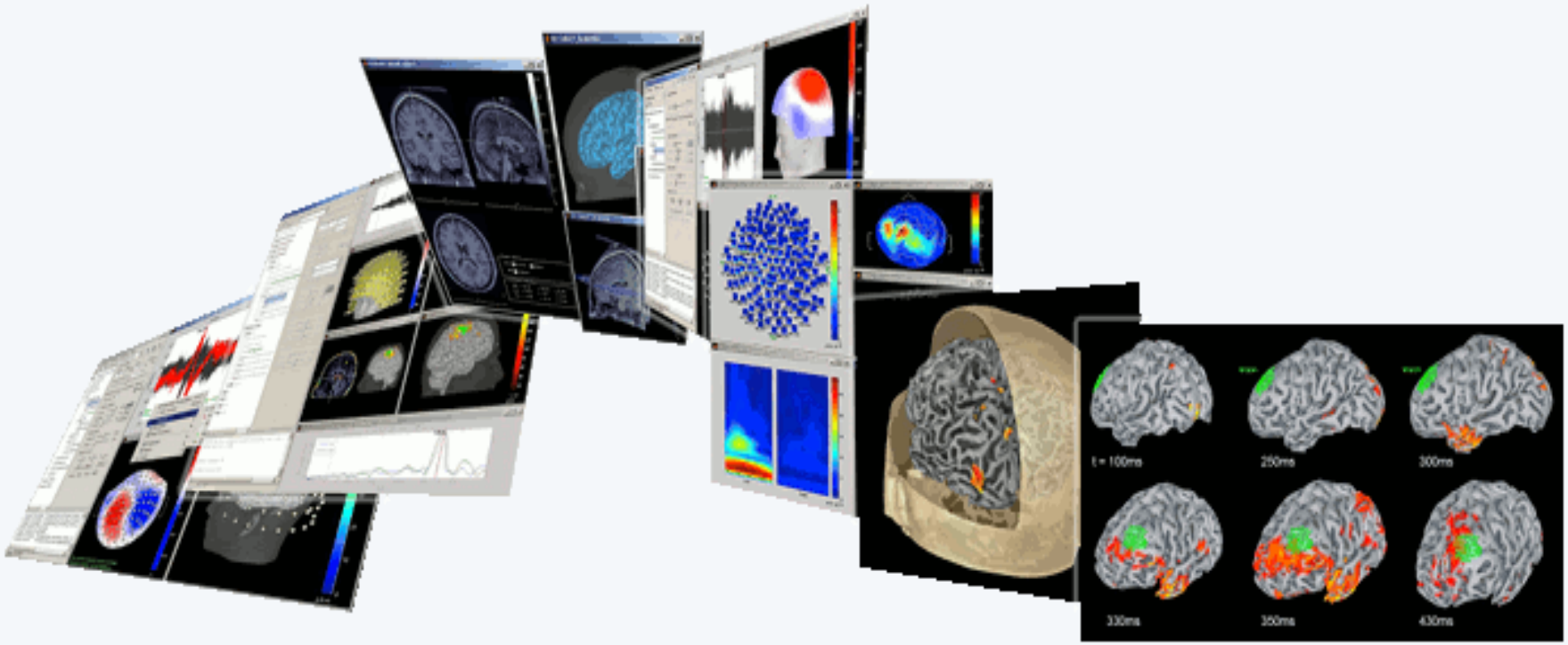
Overview of the Brainstorm Software



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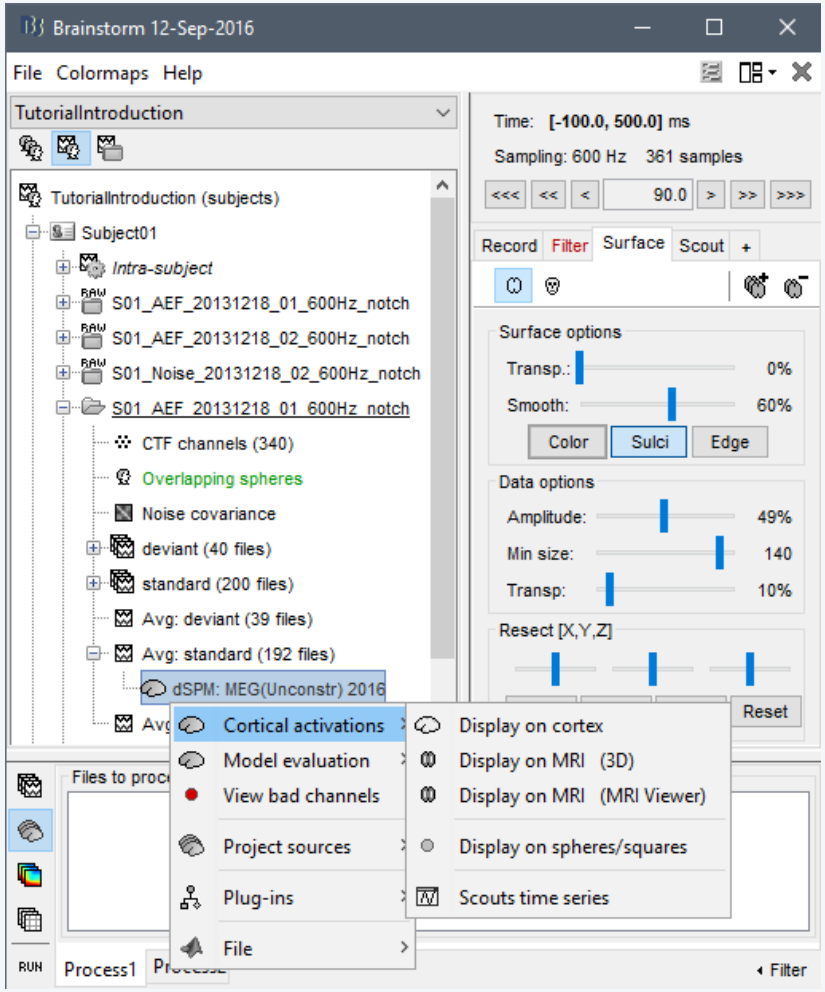
Overview of the Brainstorm Software

- Brainstorm Software
- Brainstorm User Interface
- Brainstorm Workflow
  - Review and Import Data
  - Data Co-registration
  - Data Analysis: Sensor and Source Level
  - Overview of the features/functionalities
- What's New?
- Today's demo

Brainstorm

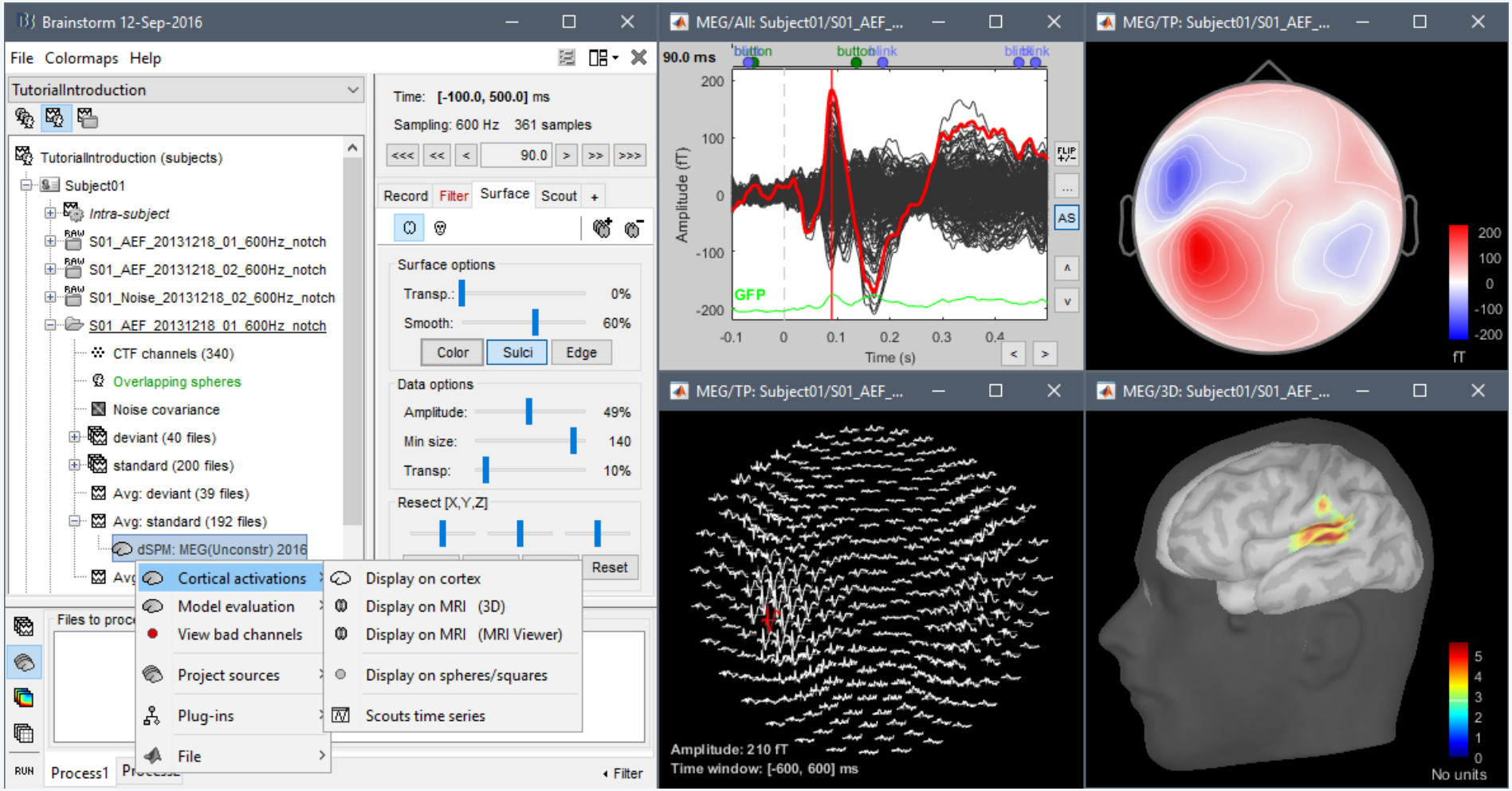
- The project started at the end of the 1990's
- A free and open-source application (GPL)
- Matlab & Java: Platform-independent
- Stand-alone version also available
- Interface-based: **click, drag, drop**
- No Matlab/coding experience required
- Supports most common file formats
- Daily updates of the software
- Educational resources & active users' community (~47k registered users) [Website, Forum, GitHub, …]

Graphic interface



Brainstorm

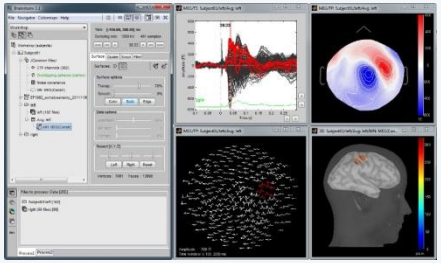
Graphic interface



Brainstorm

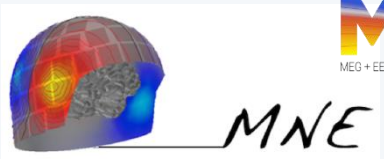
Software Tools for MEG/EEG

Brainstorm



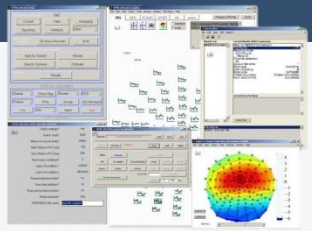
http://neuroimage.usc.edu/brainstorm/

MNE & MNE python



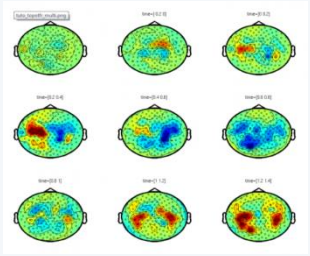
http://martinos.org/mne/stable/index.html

SPM



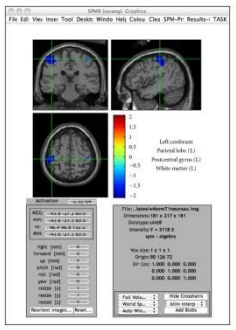
http://www.fil.ion.ucl.ac.uk/spm/software/

Fieldtrip



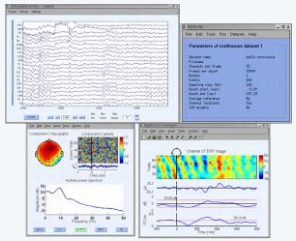
http://www.fieldtriptoolbox.org/

NutMEG



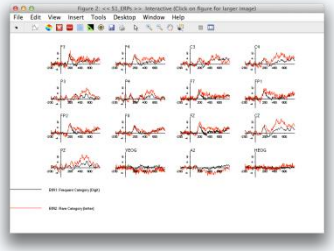
http://nutmeg.berkeley.edu/

EEGLAB



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

ERPLAB



http://erpinfo.org/erplab/

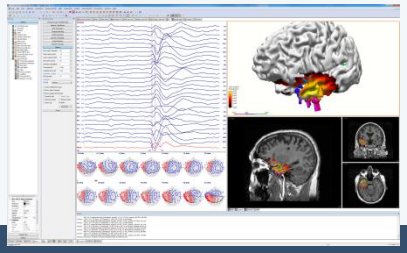
rtMEG: Real time MEG software interface
BCILAB: Open source Matlab toolbox for brain-computer interfaces
NFT: Neuroelectromagnetic forward head modeling
OpenMEEG: Neuroelectromagnetic BEM forward head modeling
DUNEuro: Neuroelectromagnetic FEM forward head modeling

Commercial Products

Vendor software

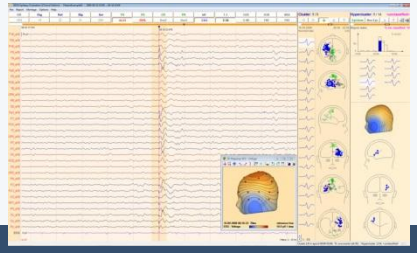
Elekta Neuromag
CTFMEG
EGI: Net Station 5
BioSemi

Curry



http://compumedicsneuroscan.com/

BESA



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Brainstorm

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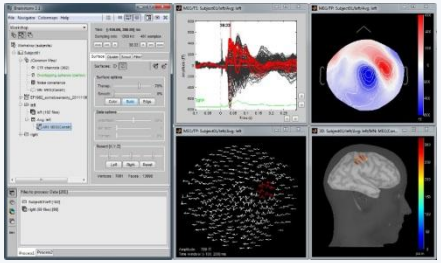

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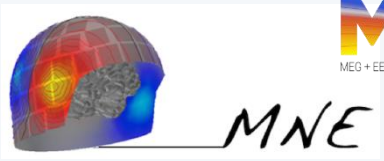
MNE & MNE python



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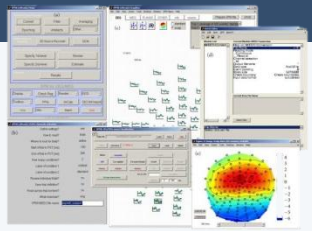
SPM



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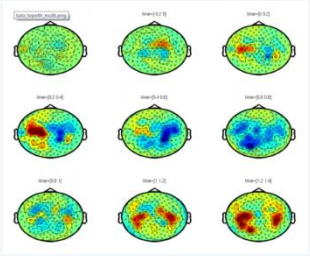

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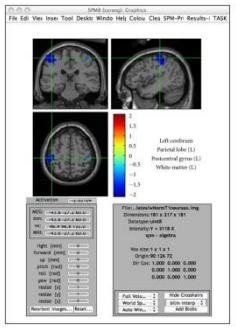
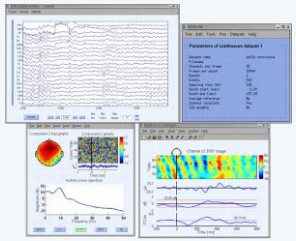
NutMEG



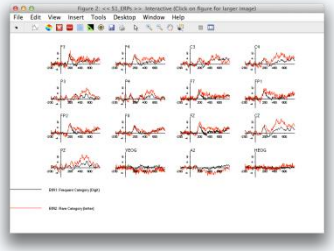
http://nutmeg.berkeley.edu/

EEGLAB



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

ERPLAB



http://erpinfo.org/erplab/

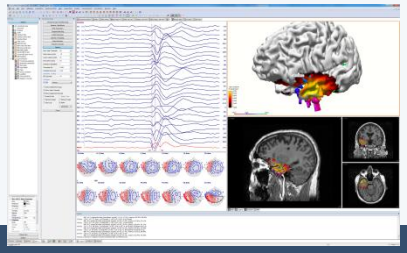
rtMEG: Real time MEG software interface
BCILAB: Open source Matlab toolbox for brain-computer interfaces
NFT: Neuroelectromagnetic forward head modeling
OpenMEEG: Neuroelectromagnetic BEM forward head modeling
DUNEuro: Neuroelectromagnetic FEM forward head modeling

Commercial Products

Vendor software

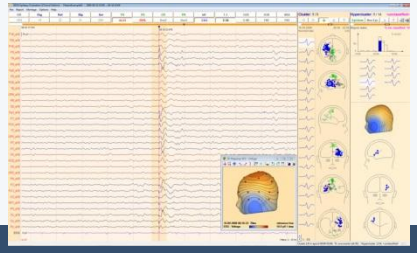
Elekta Neuromag
CTFMEG
EGI: Net Station 5
BioSemi

Curry



http://compumedicsneuroscan.com/

BESA

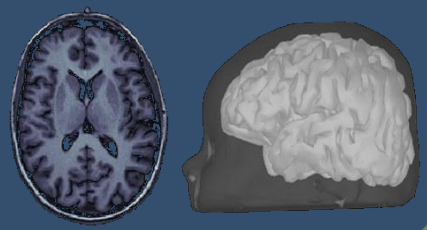


http://www.besa.de/

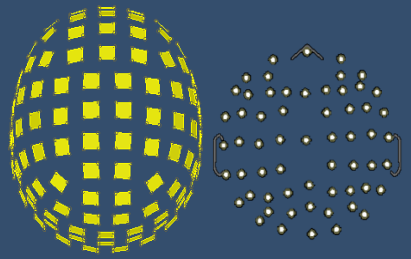
Brainstorm

Workflow

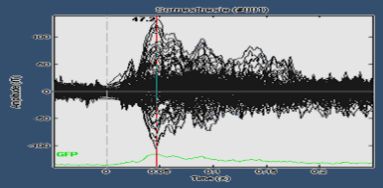
Anatomy



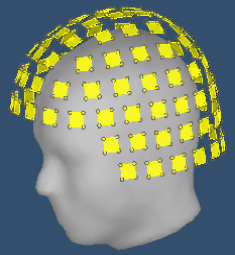
Sensors



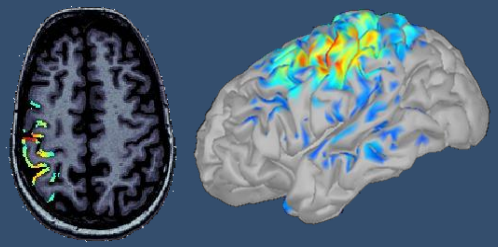
EPhys



Co-registration



Source estimation



Analysis

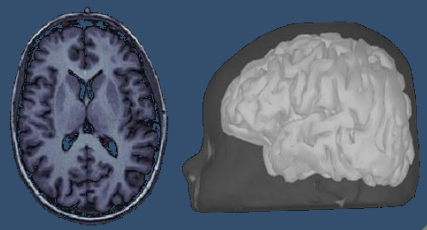
Averages
Statistics
Group analysis
Time-frequency
Connectivity
....

Workflow

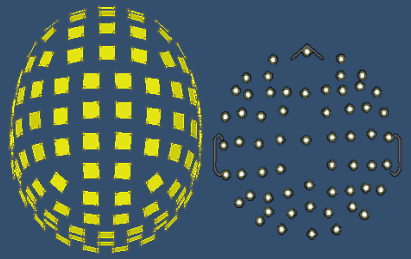
MRI, CT, DWI,

EEG, MEG, iEEG

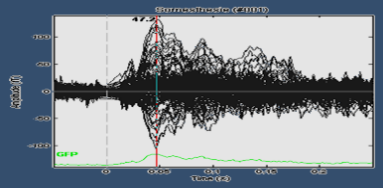
Anatomy



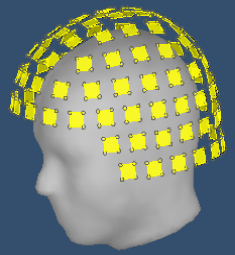
Sensors



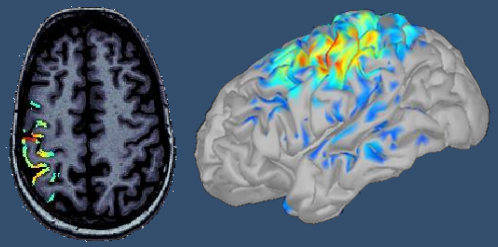
EPhys



Co-registration



Source estimation



Analysis

Averages
Statistics
Group analysis
Time-frequency
Connectivity
....

Single subject

Anatomy
Link recordings
MRI registration

Importing

PSD
Filters
Bad channels
Artifacts
Correction
Bad segments

Pre-processing

Events
Epoching
Averaging
Sources
Time-frequency

Analysis of the experimental data

Single subject → Group Analysis

Anatomy
Link recordings
MRI registration

Importing

PSD
Filters
Bad channels
Artifacts
Correction
Bad segments

Pre-processing

Events
Epoching
Averaging
Sources
Time-frequency

Analysis of the experimental data

Loop:
all acquisition runs
all subjects

Single subject → Group Analysis

Anatomy
Link recordings
MRI registration

Importing

PSD
Filters
Bad channels
Artifacts
Correction
Bad segments

Pre-processing

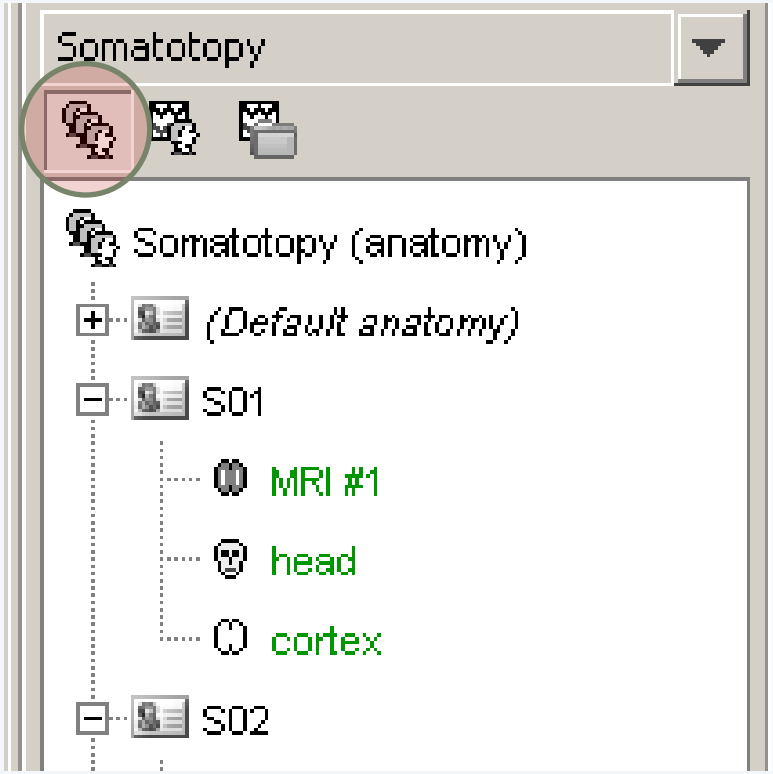
Events
Epoching
Averaging
Sources
Time-frequency

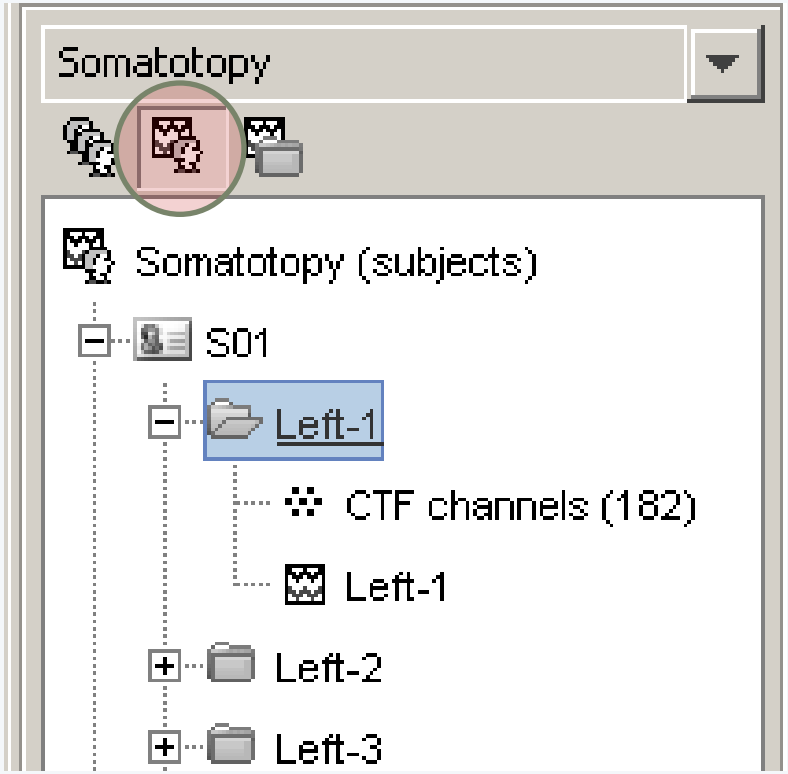
Analysis of the experimental data

Loop:
all acquisition runs
all subjects

Similar workflow for most modalities: EEG, MEG, sEEG, fNIRS, etc.

Database





- Three levels:
  - Protocol
  - Subject
  - Condition

- Popup menus
- All files saved in Matlab .mat
- Same architecture on the disk

Import

Anatomy
Link recordings
MRI registration

PSD
Filters
Bad channels
Artifacts
Correction
Bad segments

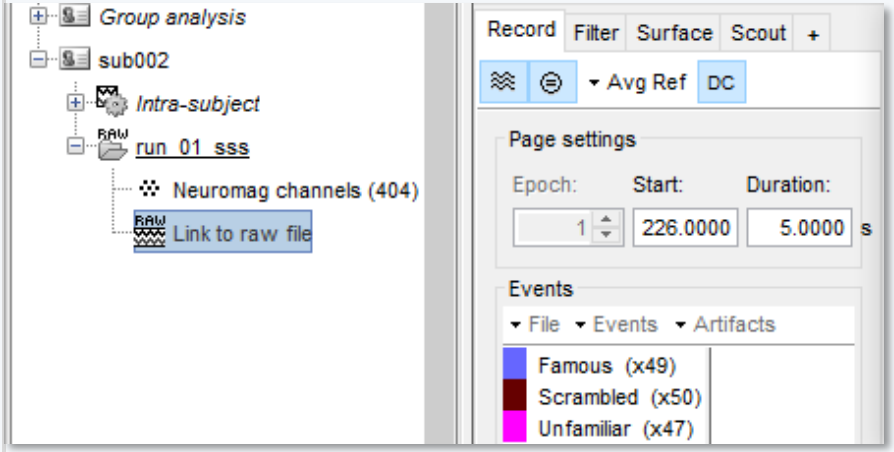
Markers
Epoching
Averaging
Sources
Time-frequency

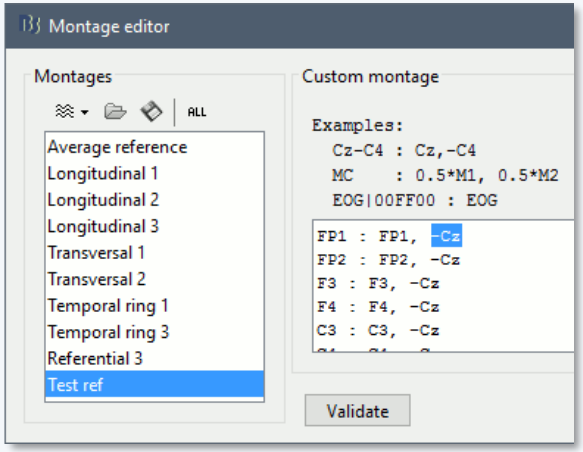
- One-click import of **the T1 raw or segmentation**: *FreeSurfer, BrainSuite, BrainVISA, CIVET, CAT/SPM*
- Import and place fiducials in the MRI

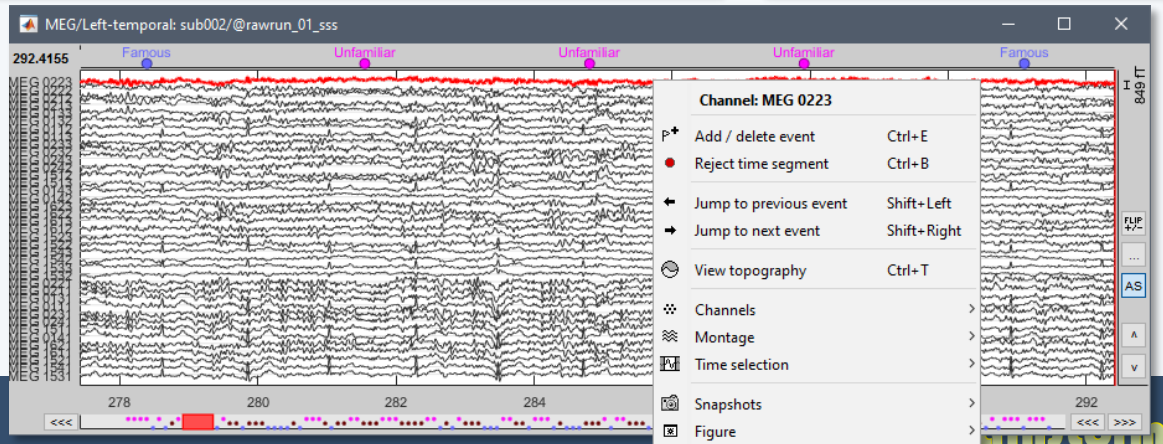
Brainstorm

Import

- Original files linked to the database (no copy)
- Rich data viewer with flexible montage editor
- Optimized reading functions

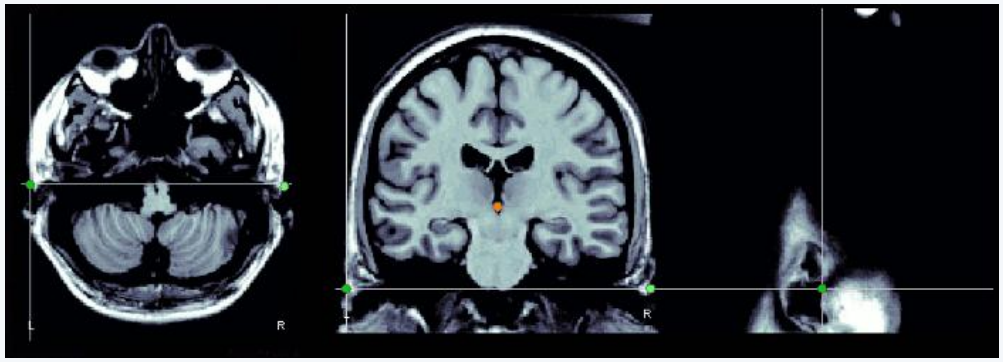






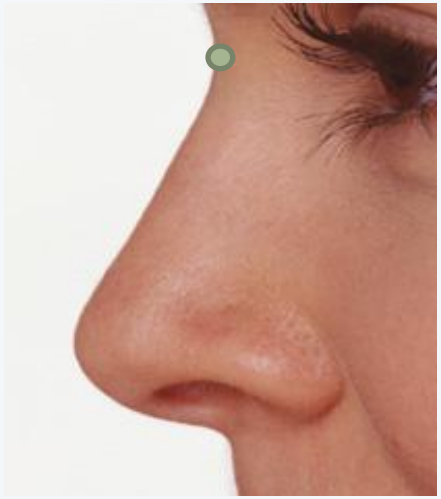
Co-registration MEEG / MRI (1)

- Basic estimation based on three points:
  Nasion (NAS), Left ear (LPA), Right ear (RPA)
- MRI: Marked in the volume with the MRI Viewer
- MEEG: Obtained with a tracking system
  (Polhemus/FastTrack)



Fiducial points

Nasion



Right preauricular

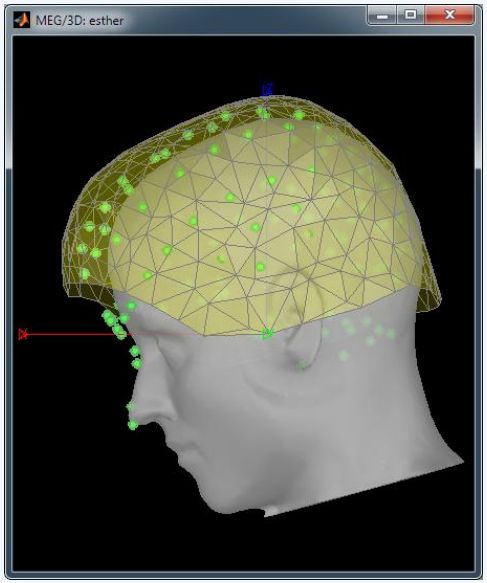
Left preauricular

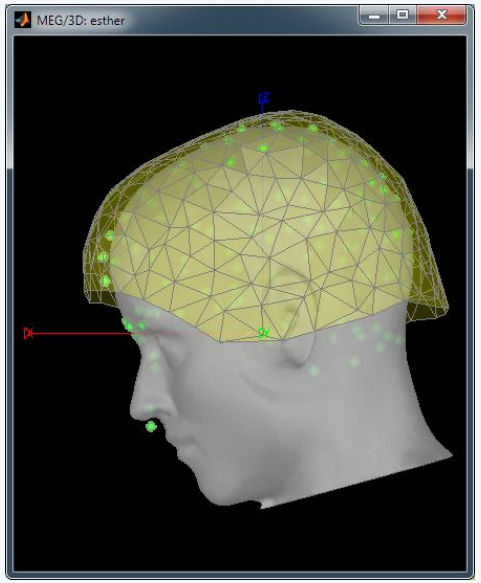
Nasion: The point in the nose with the deepest curvature.

Left/right preauricular: The top base of the tragus.

Co-registration MEEG / MRI (2)

- Automatic adjustment based on head shape: Fitting Polhemus points on the MRI head surface
- Final registration must be checked manually
- Polhemus/Fastrack interface included in Brainstorm





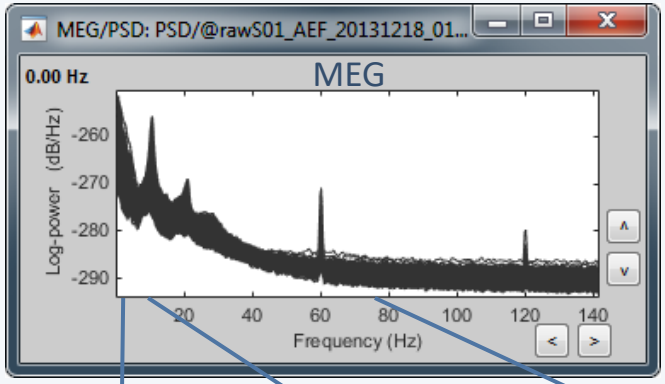
Quality control

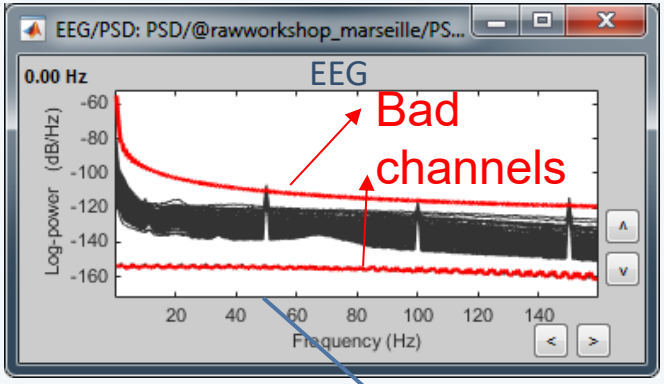
Anatomy
Link recordings
MRI registration

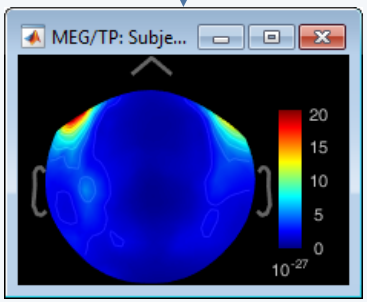
PSD
Filters
Bad channels
Artifacts
Correction
Bad segments

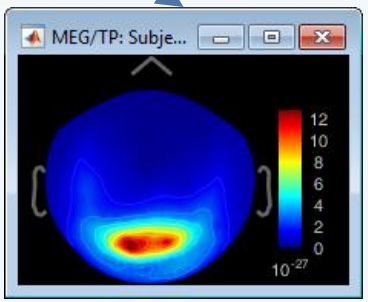
Markers
Epoching
Averaging
Sources
Time-frequency

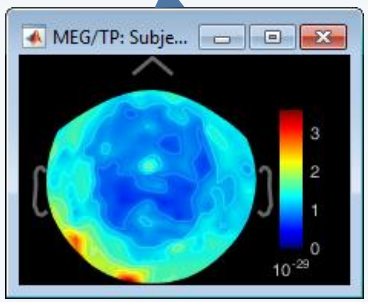
- Power spectrum density for quality control

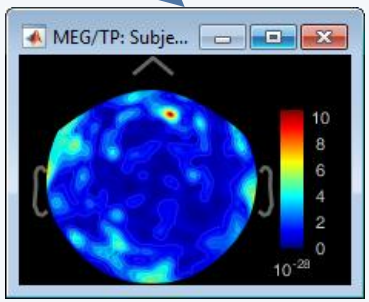












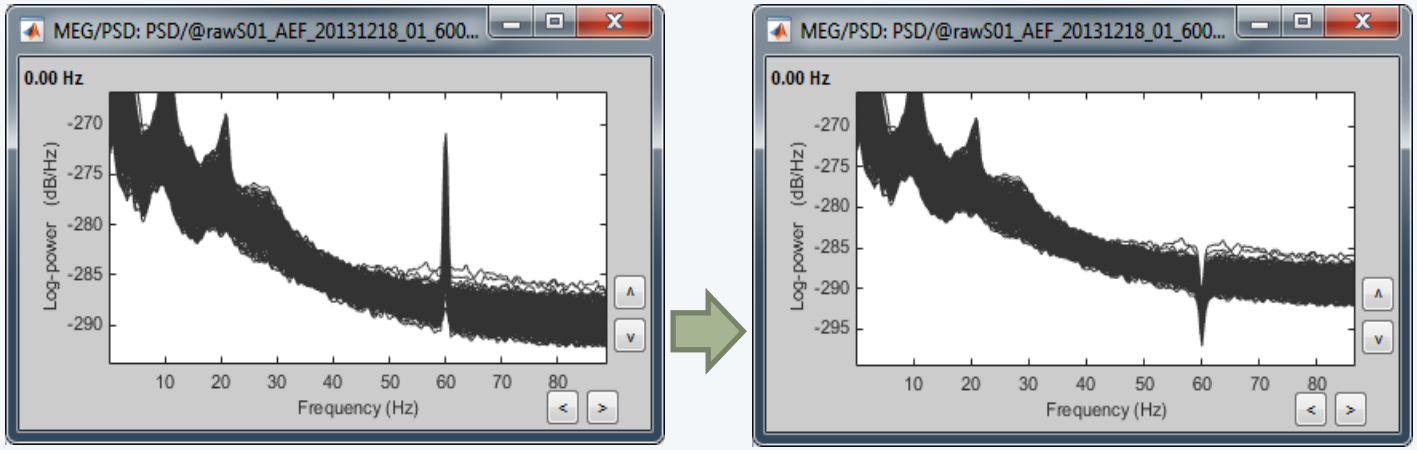
< 3Hz: Eyes | 10Hz: Alpha | > 40Hz: Muscle | 50/60Hz

Brainstorm

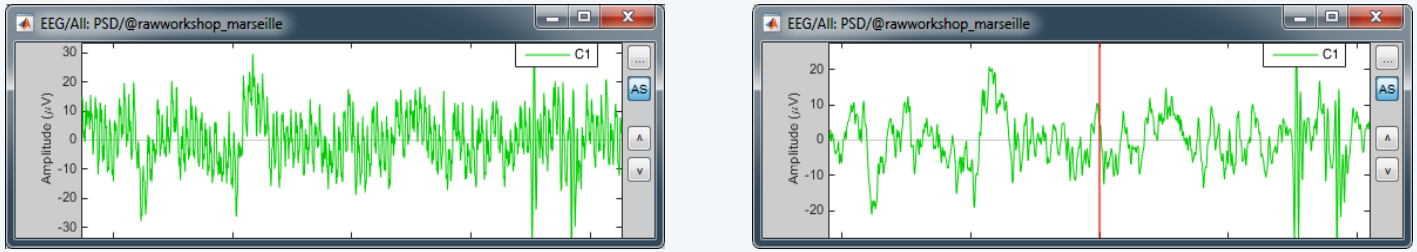
Pre-processing

- **Notch filter**: Removes 50Hz/60Hz power line noise (and harmonics)

PSD

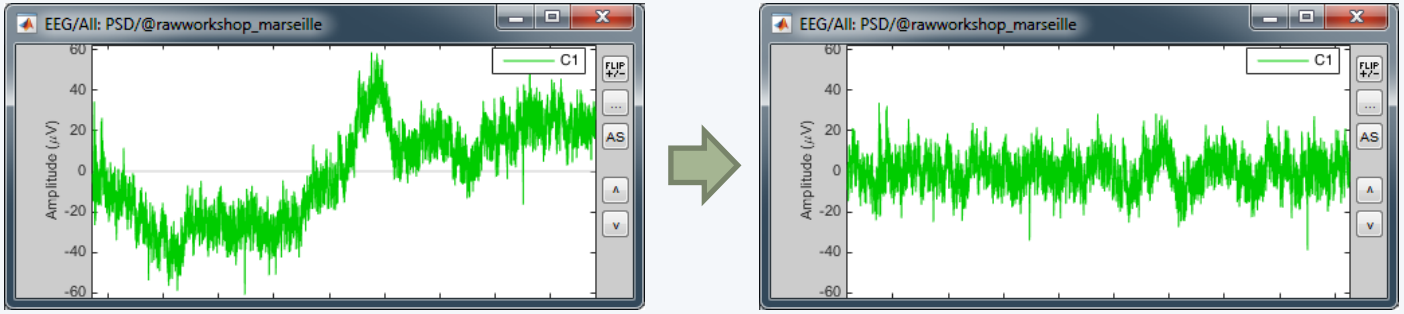


Signal

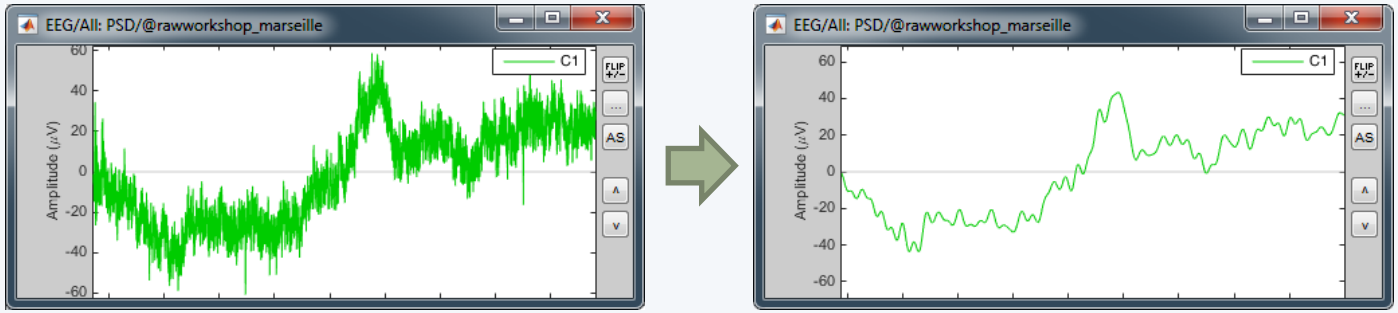


Pre-processing

- **High-pass filter**: Removes slow components (eye movements, breathing, sensor drifts…)



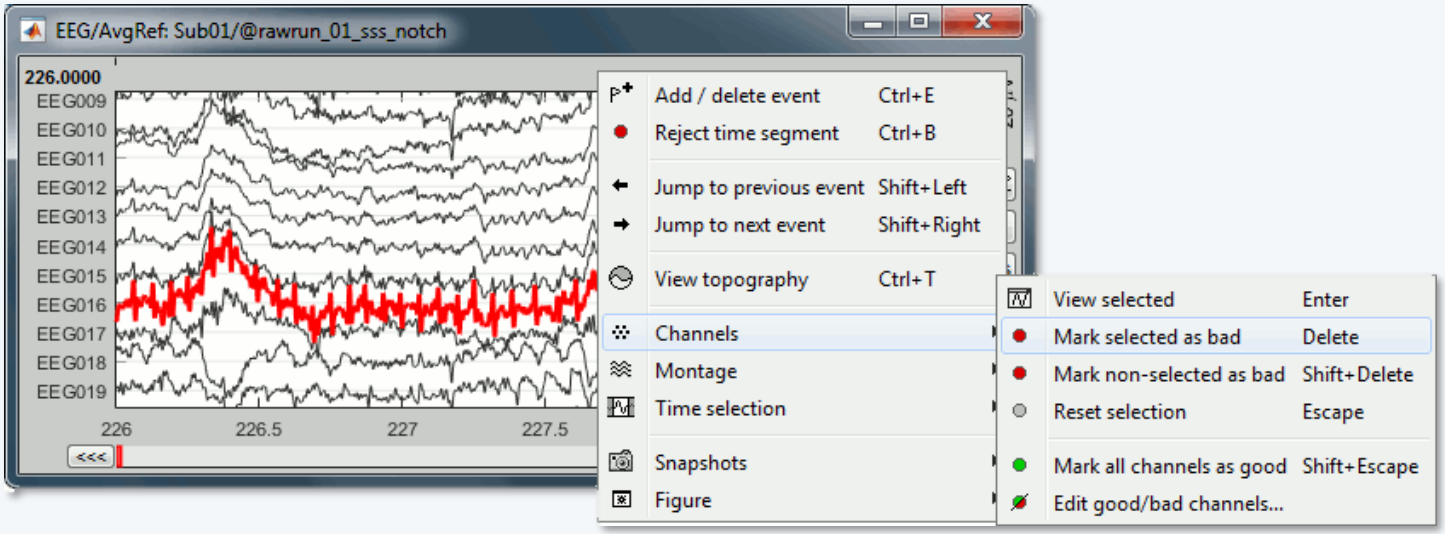
- **Low-pass filter**: Remove high-frequencies components



Brainstorm

Pre-processing

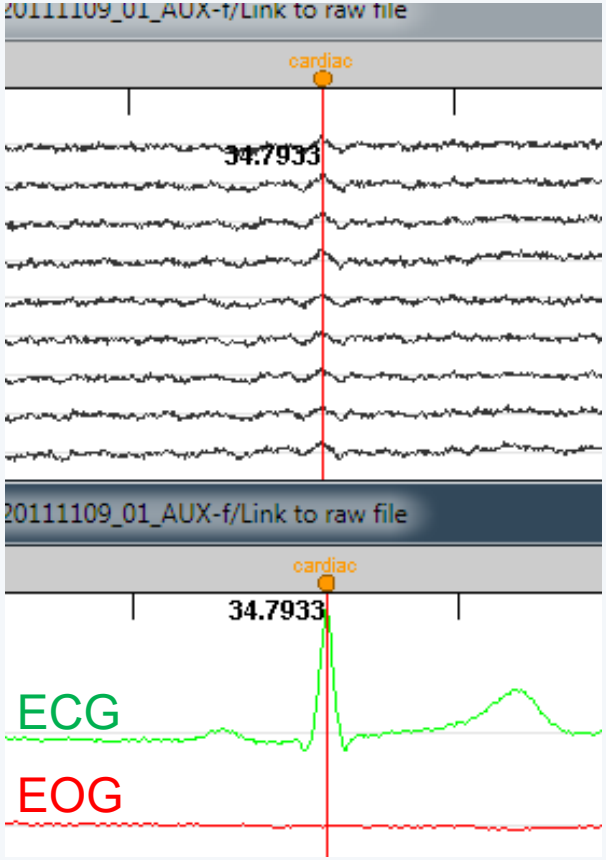
- Manual inspection of the recordings
- Interactive selection of bad channels
- Re-reference the EEG if necessary (Average ref)

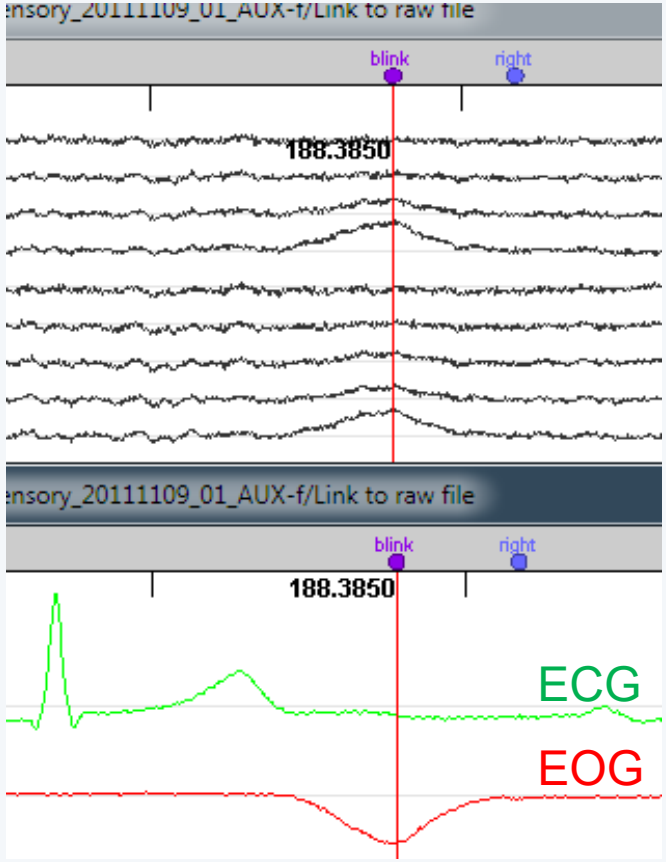


Brainstorm

Pre-processing

- Automatic detection of blinks and heartbeats (peak detection, or explicit amplitude threshold)





Brainstorm

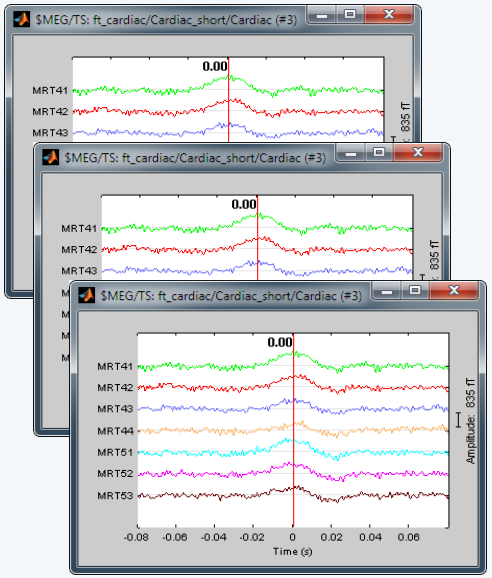
Artifact correction

- Two categories of artifacts:
  - Well-defined, reproducible, short, frequent:
    - Heartbeats, eye blinks, eye movements, some stimulators
    - Unavoidable and frequent: we cannot just ignore them
    - **Can be modeled and removed from the signal efficiently**
      - **ICA, SSP**
  - All the other events that can alter the recordings:
    - Movements, building vibrations, metro nearby…
    - Too complex or not repeated enough to be modeled
    - **Safer to mark them as bad segments, and ignore them**

Pre-processing

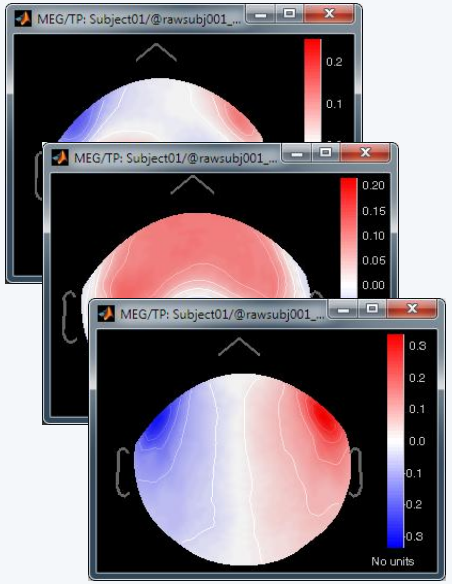
- Correction with Signal Space Projections (SSP)

Detect artifacts



PCA

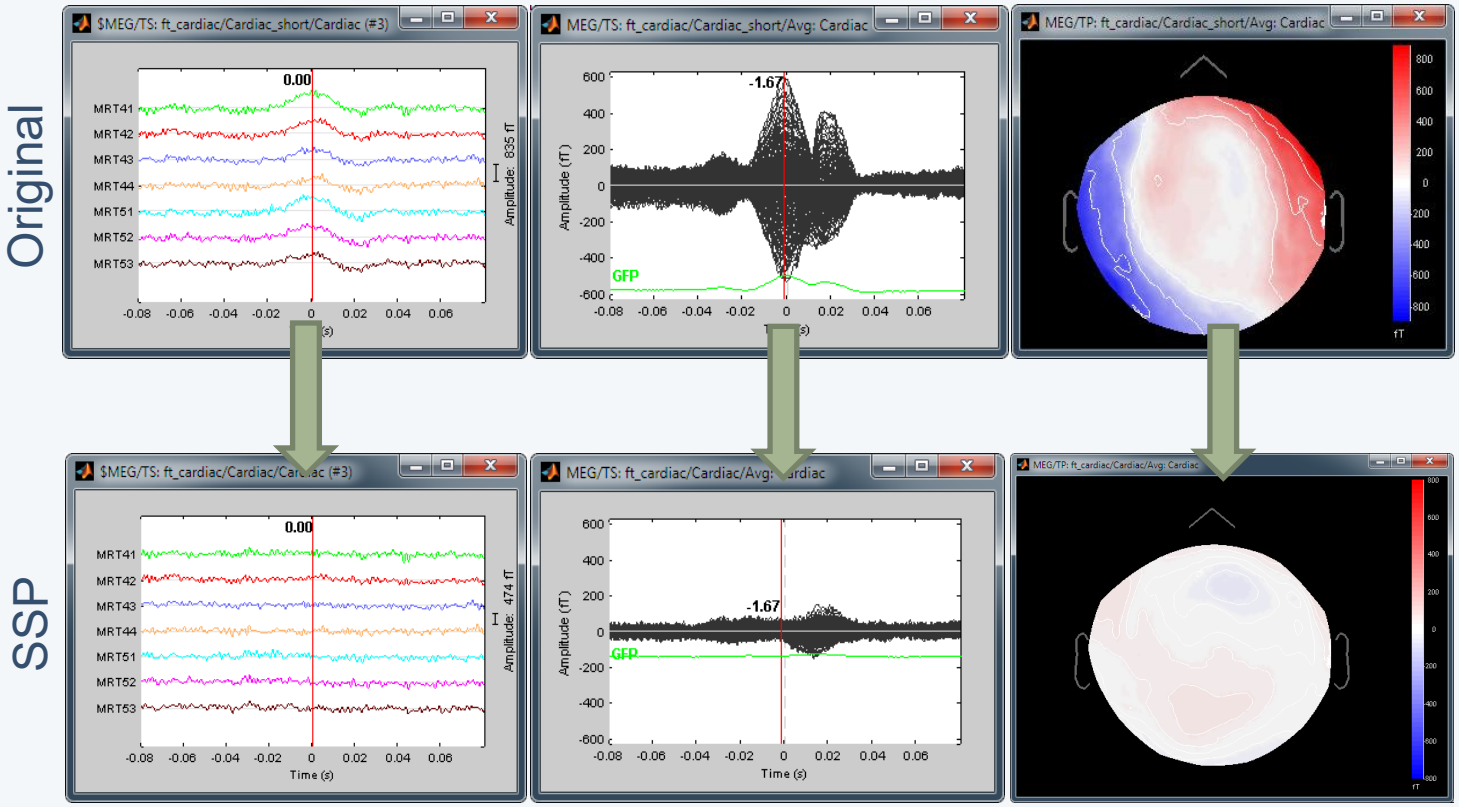
Spatial components



Select components and compute a linear projector to remove their contribution from the recordings

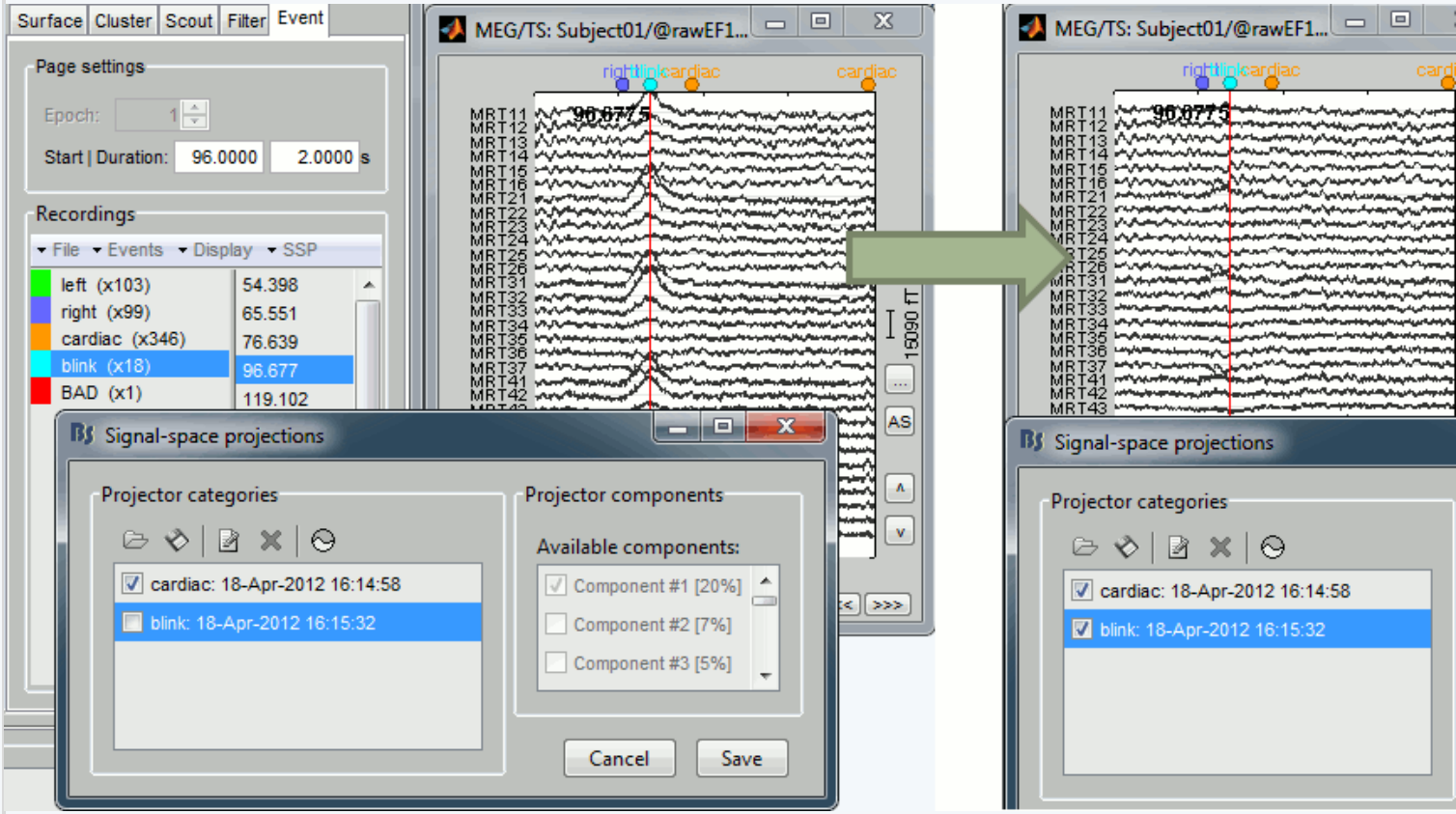
Brainstorm

- Example: Cardiac artifact



Pre-processing

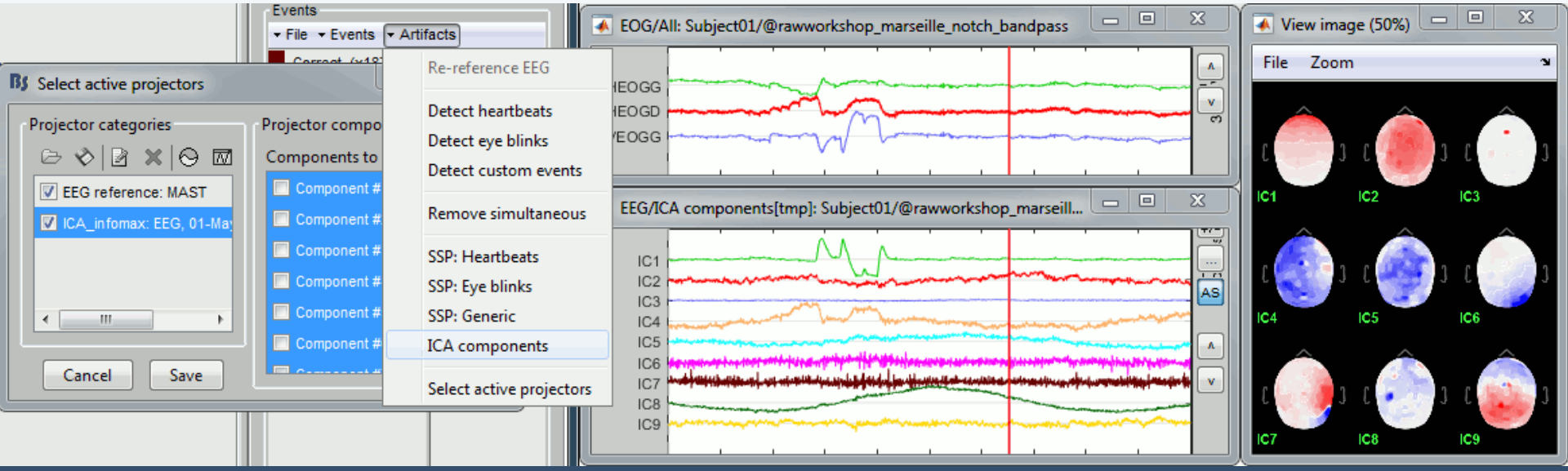
- Example: Blink



Brainstorm

Pre-processing

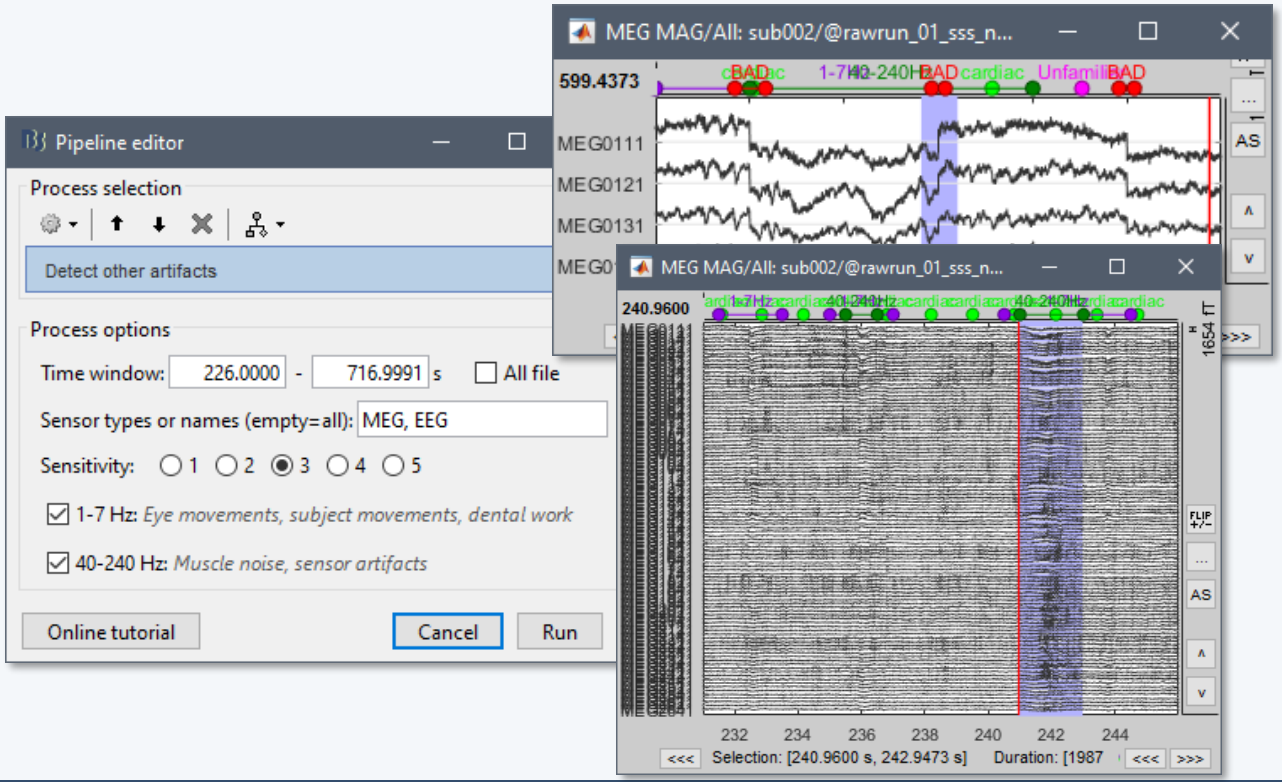
- Independent component analysis (ICA):
  - Popular in the EEG literature
  - Alternative to SSP for low number of sensors
  - Already implemented: Picard, FastICA, Infomax and JADE (EEGLAB)



Brainstorm

Pre-processing

- Automatic detection of artifacts (RMS-based)
- Manual screening of all the recordings is advised (scroll all the sensors by pages of 10-20s)
- Exclude: Blinks, movements, SQUID jumps

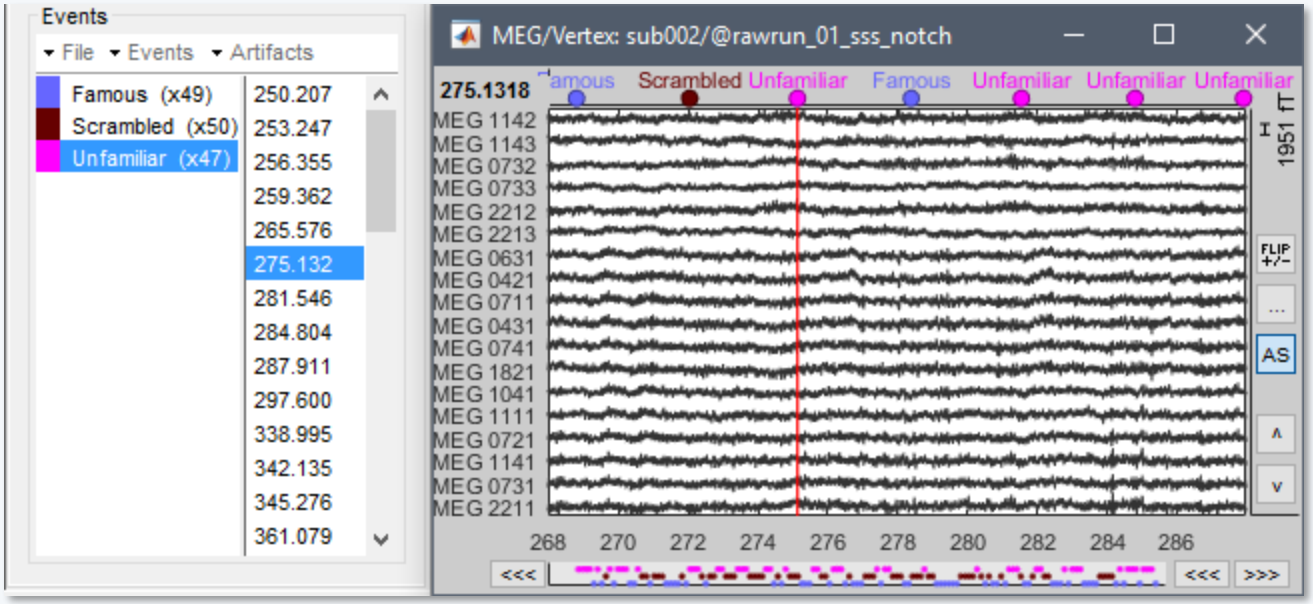


Brainstorm

Epoching

- Two types of experiments:
  - Steady-state or resting-state (ongoing activity)
  - Event-based (stimulus, response, spike…)

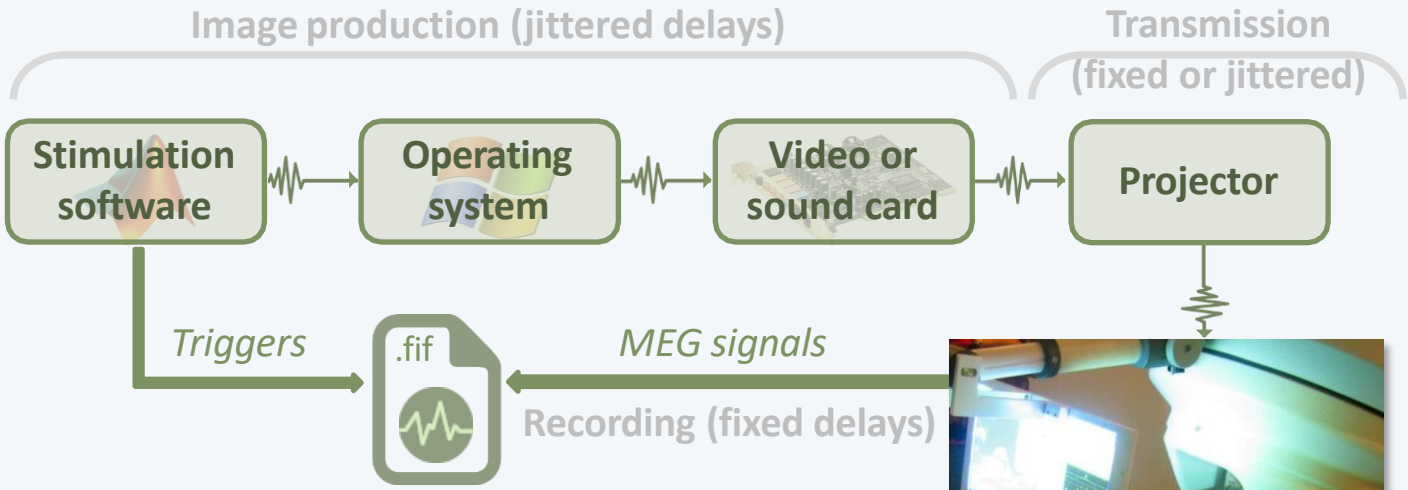
- How to get event markers in the recordings?

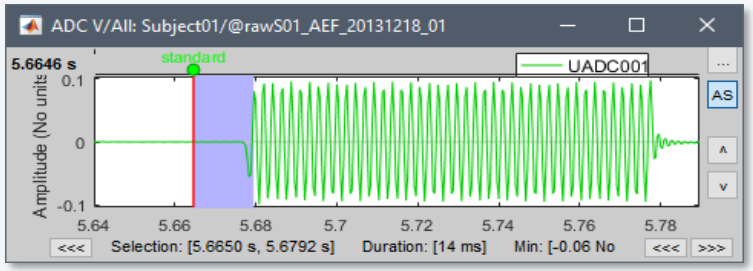


Brainstorm

Epoching

- **Reading the triggers saved by the presentation software (includes jittered OS delays)**

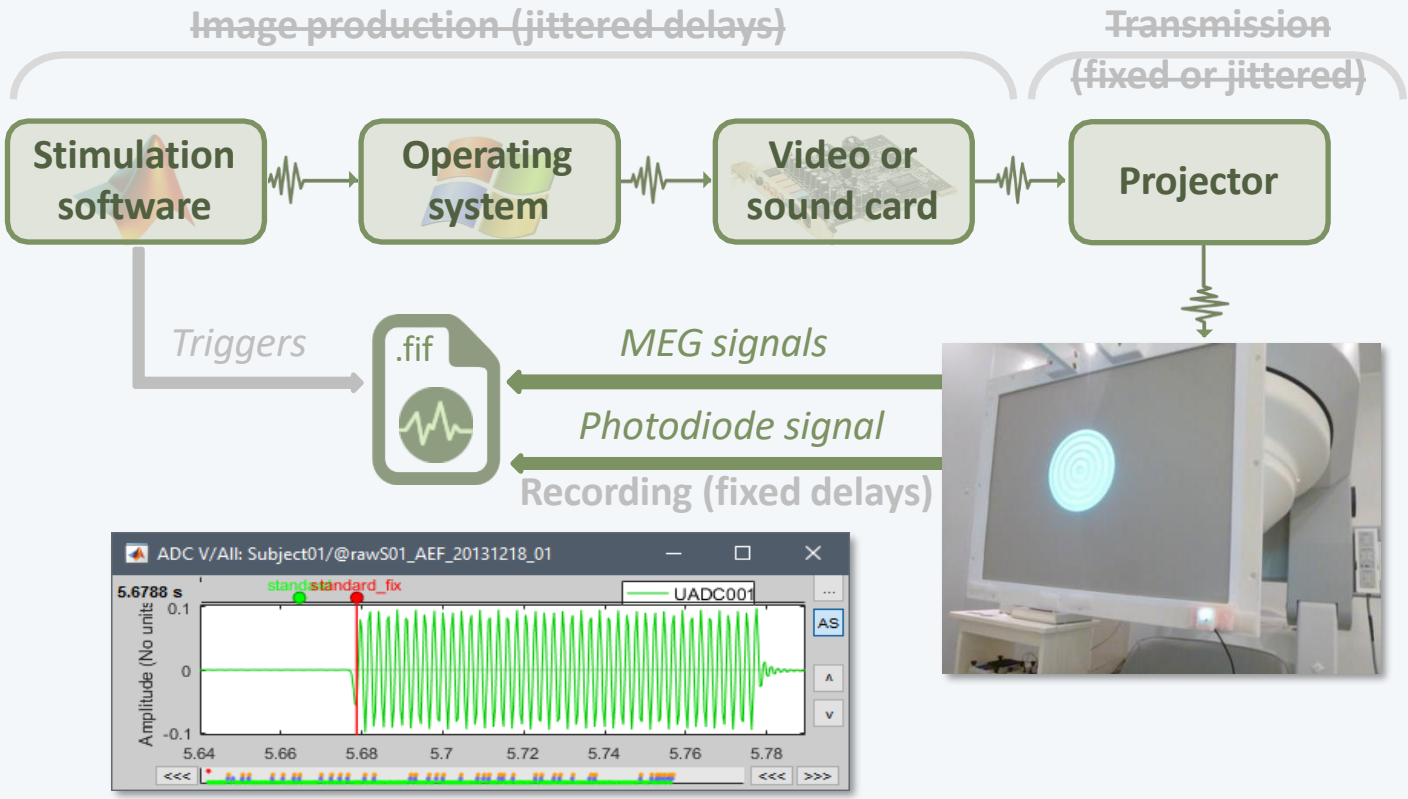




- File triggers are never aligned with the real stim

Epoching

- **Reading information recorded on the subject side (photodiode, microphone, response box…)**

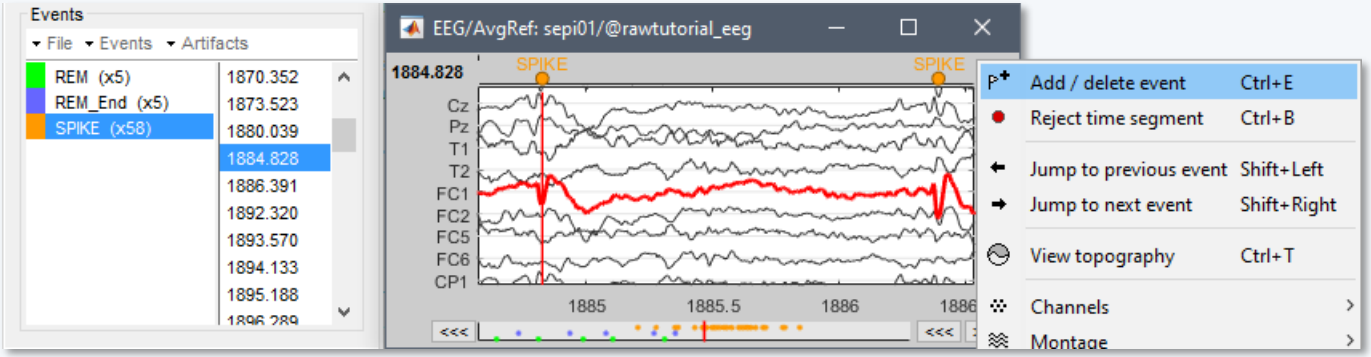


- Avoids most uncontrollable jittered delays

Brainstorm

Epoching

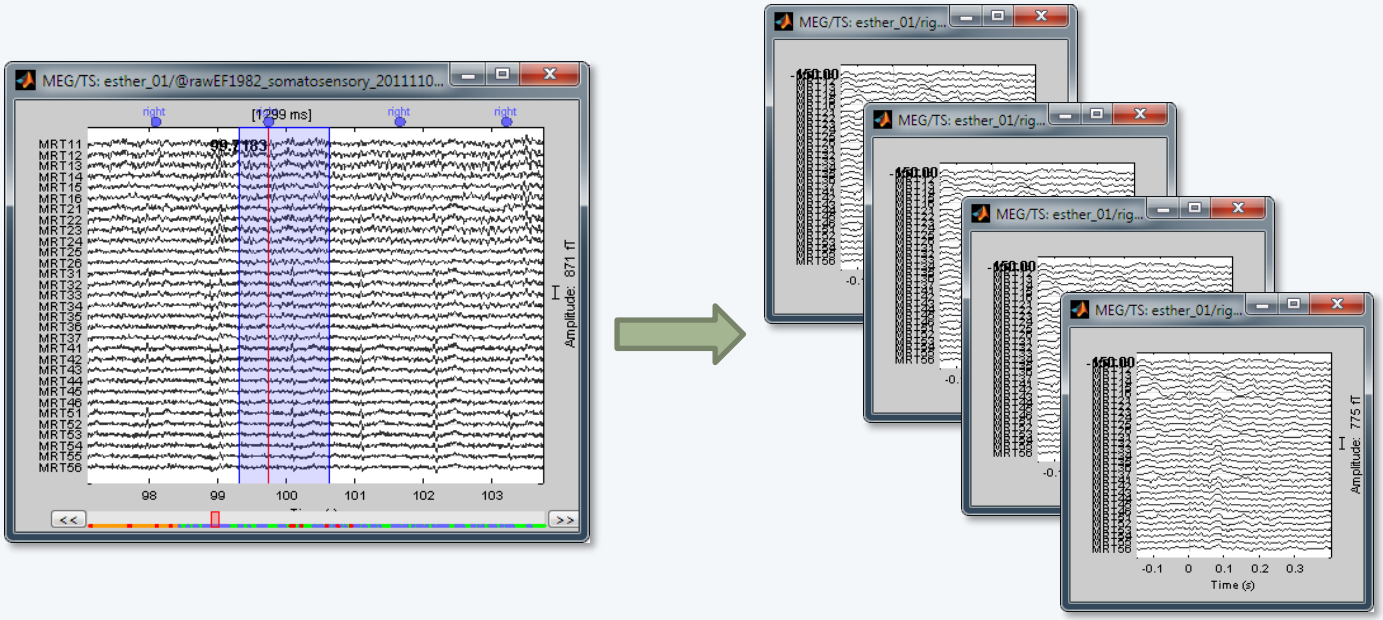
- Reading the triggers save by the presentation software
- Reading information recorded on the subject side (photodiode, microphone, response box)
- **Manual or automatic marking of biological or behavioral events, post-acquisition (*epileptic spikes, sleep spindles*, rat position in a box…)**
- ***Optimized workflow for clinicians***
  (keyboard and mouse shortcuts, workspace…)



Brainstorm

Epoching

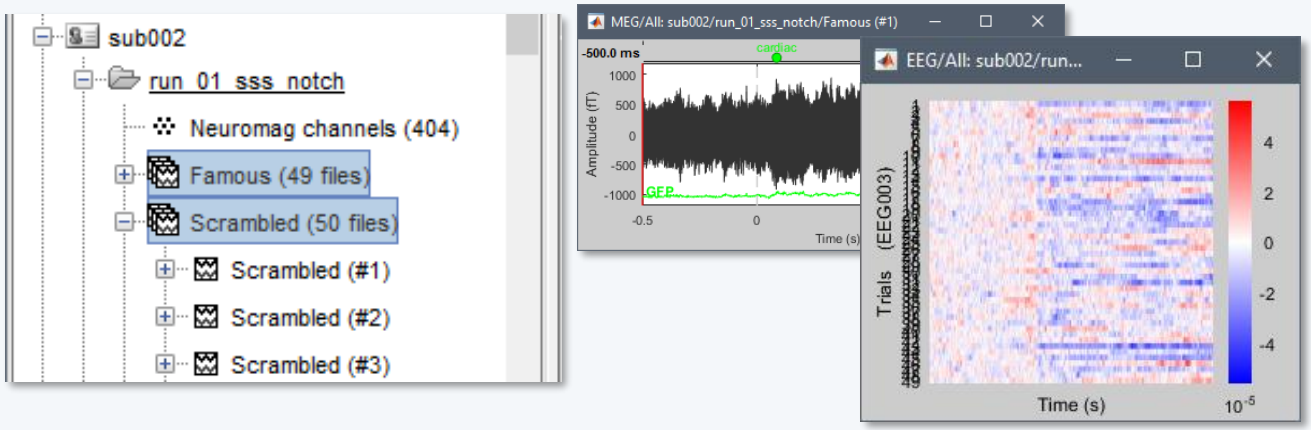
- Epochs = Trials = Short blocks of recordings around an event of interest.
- Epoching = Extracting epochs from the continuous recordings and saving them.



Brainstorm

Epoching

- In Brainstorm, each imported epoch is an independent file in the database.
- Accessible by event type or individually.

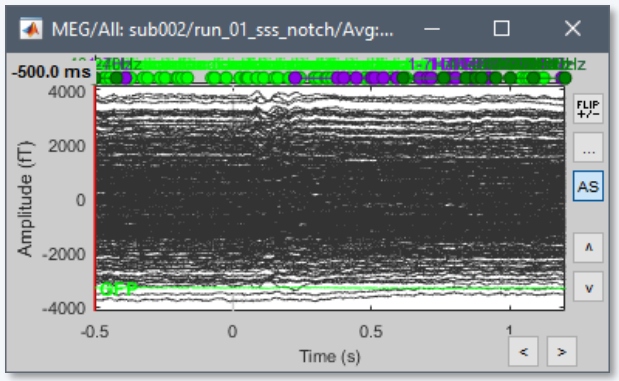


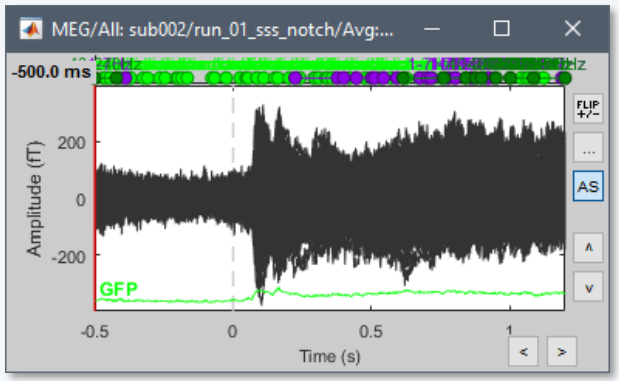
- In other programs, all the epochs from one run are saved in one single file (one file per event type, or one file with all the events).

Brainstorm

Epoching

- Processing steps that can be applied on epochs:
  - **DC offset correction**: Subtract the average estimated over a baseline period
  - **Detrending**: Subtract a linear trend estimated over a reference period
  - **Resampling**: Decrease the sampling rate
- This dataset: DC correction, baseline=[-500,0]ms



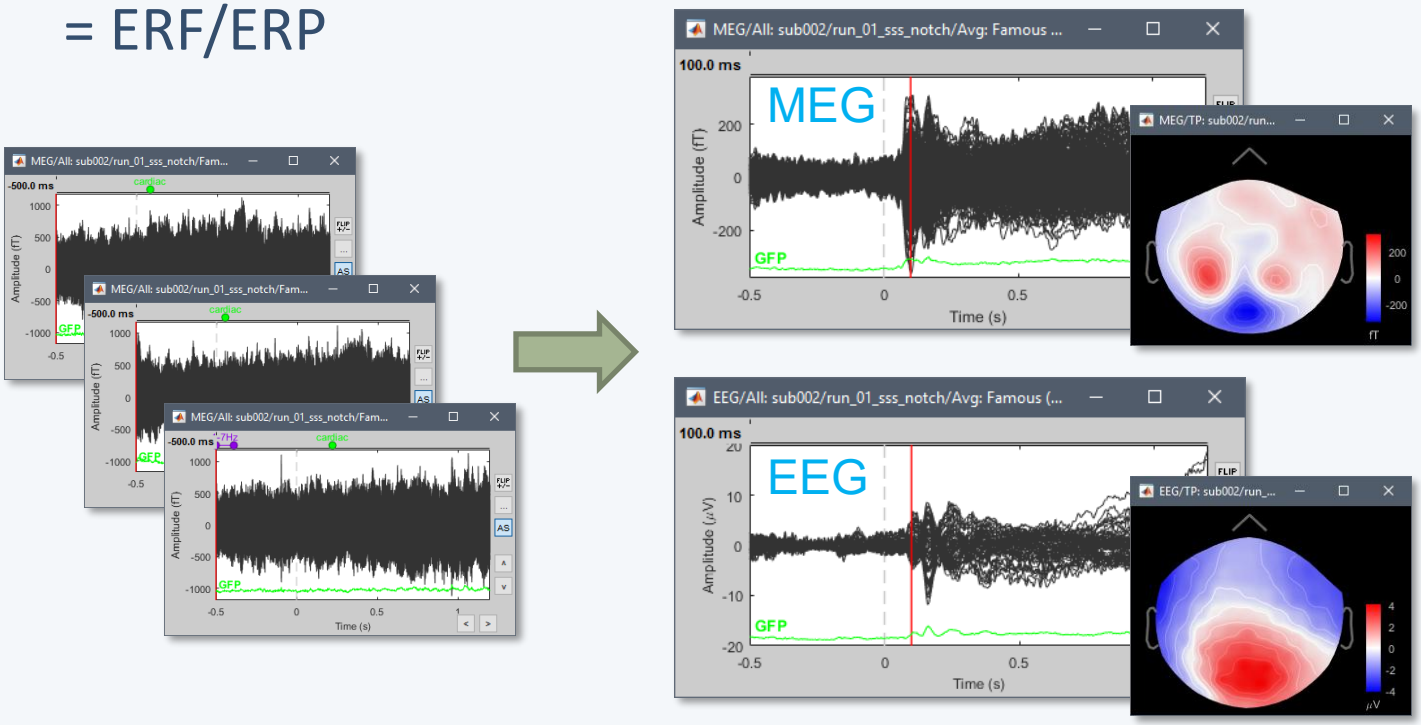


Brainstorm

Averaging

- Averaging the trials: Reveals the features of the signals that are locked in time to a given event

  = Event-related field / potential
  = Evoked response
  = ERF/ERP

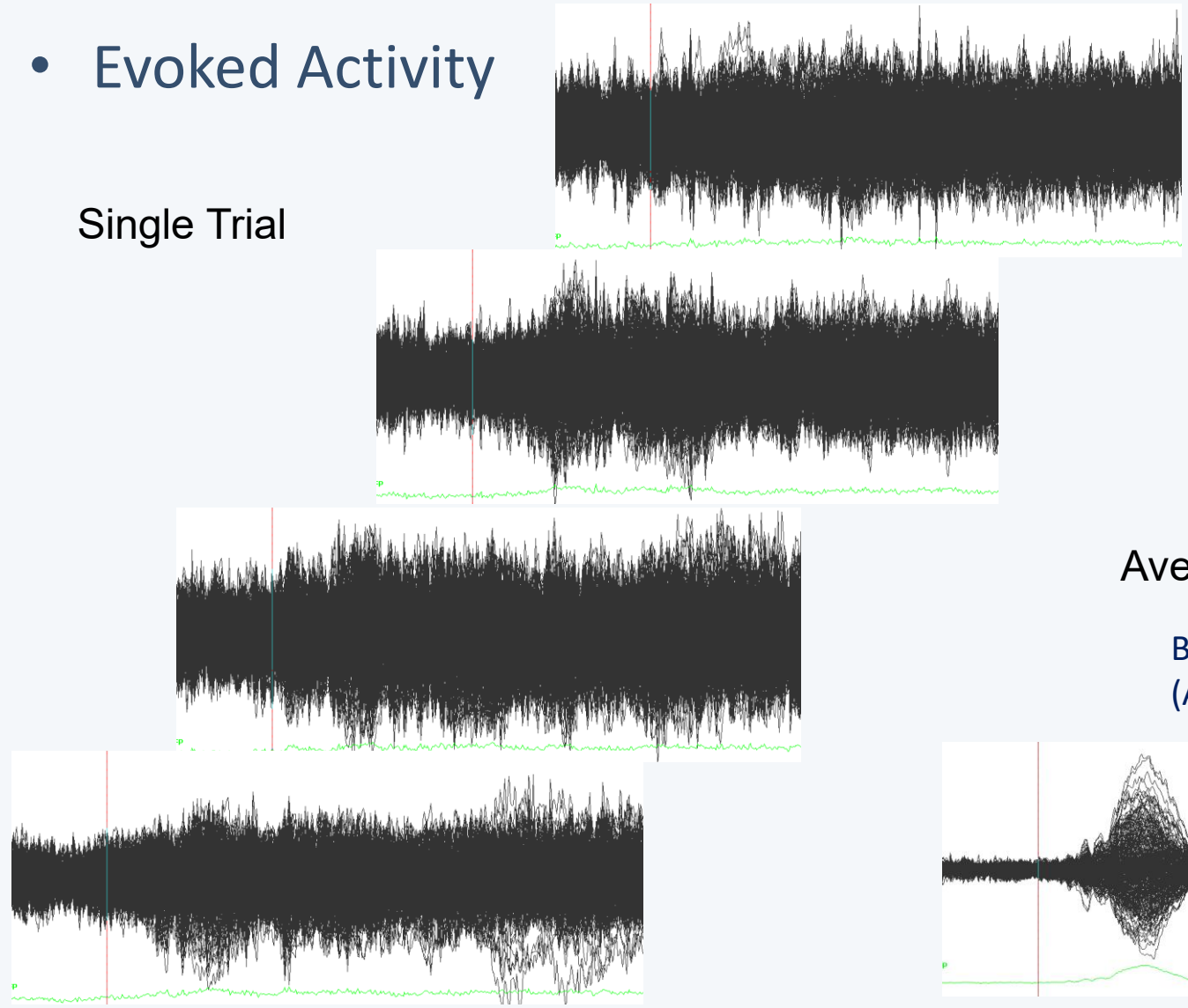


Brainstorm

Evoked Activity

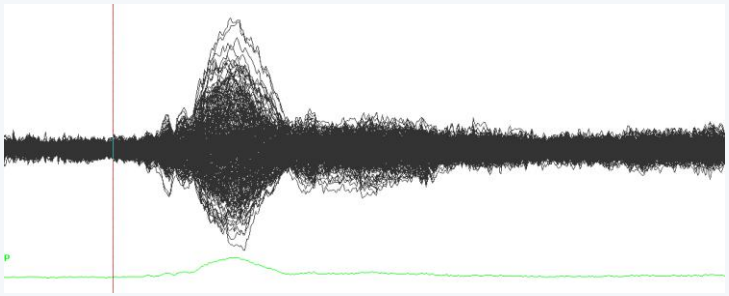
- Evoked Activity

Single Trial



Averaging

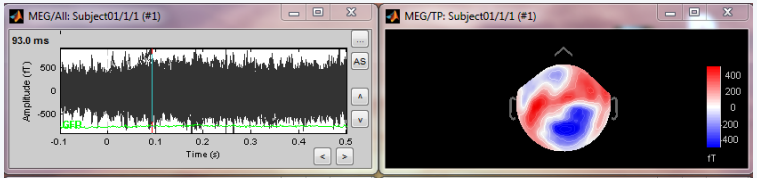
Brain auditory response
(Average of 100 trials)



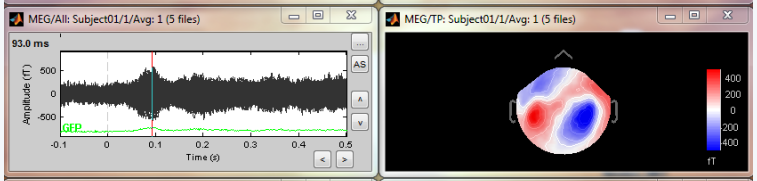
How many trials?

- Brain auditory response
  - MEG data

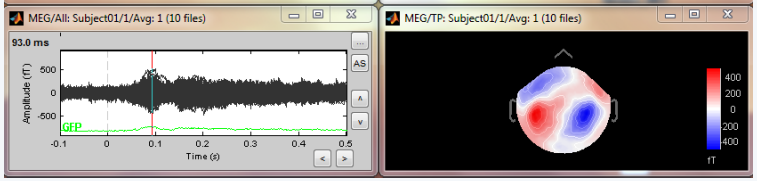
1 trial



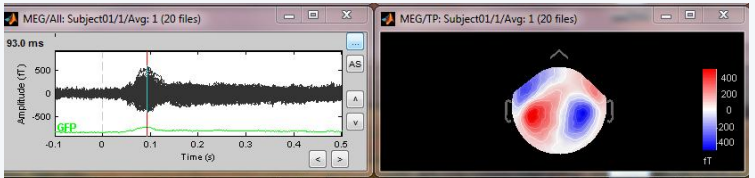
5 trials



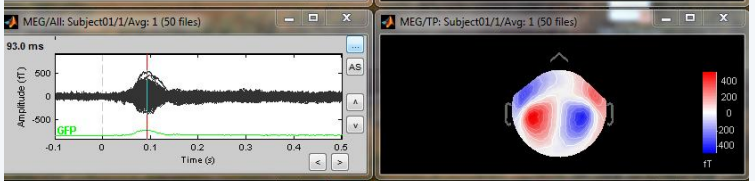
10 trials



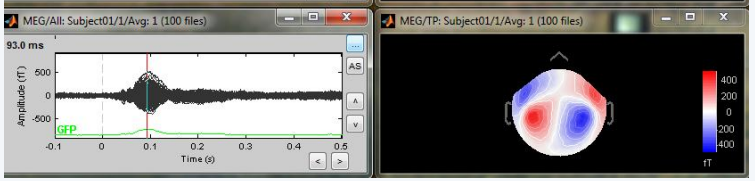
20 trial



50 trials



100 trials



Brainstorm

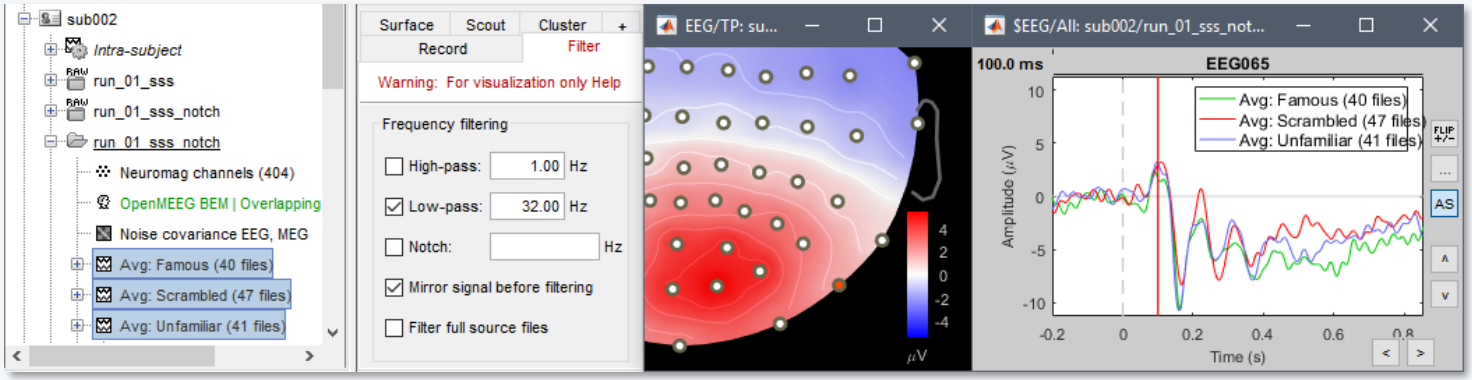
Sensor level analysis

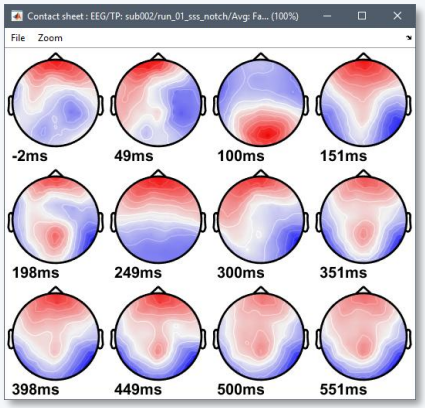
Anatomy
Link recordings
MRI registration

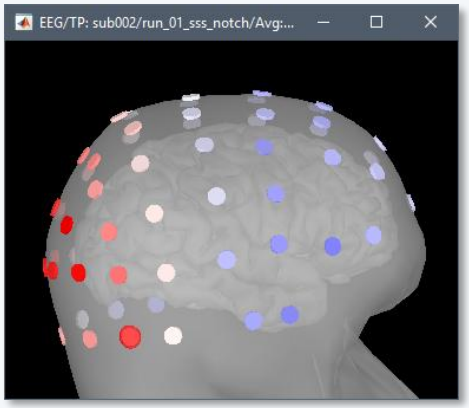
PSD
Filters
Bad channels
Artifacts
Correction
Bad segments

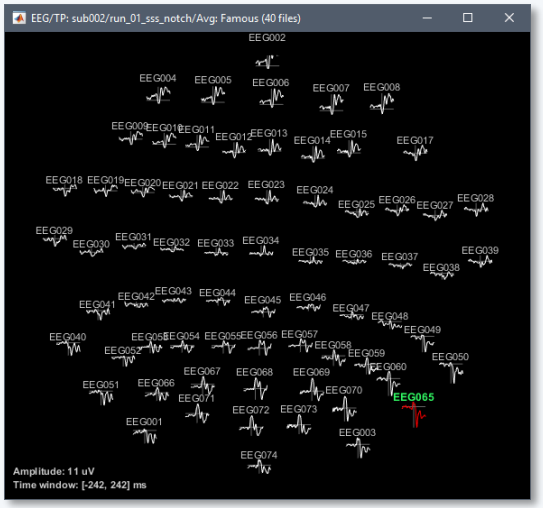
Markers
Epoching
Sensors
Sources
Time-frequency

- ERP & Sensor Cluster









Brainstorm

Sensor level analysis

Anatomy
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MRI registration

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Bad channels
Artifacts
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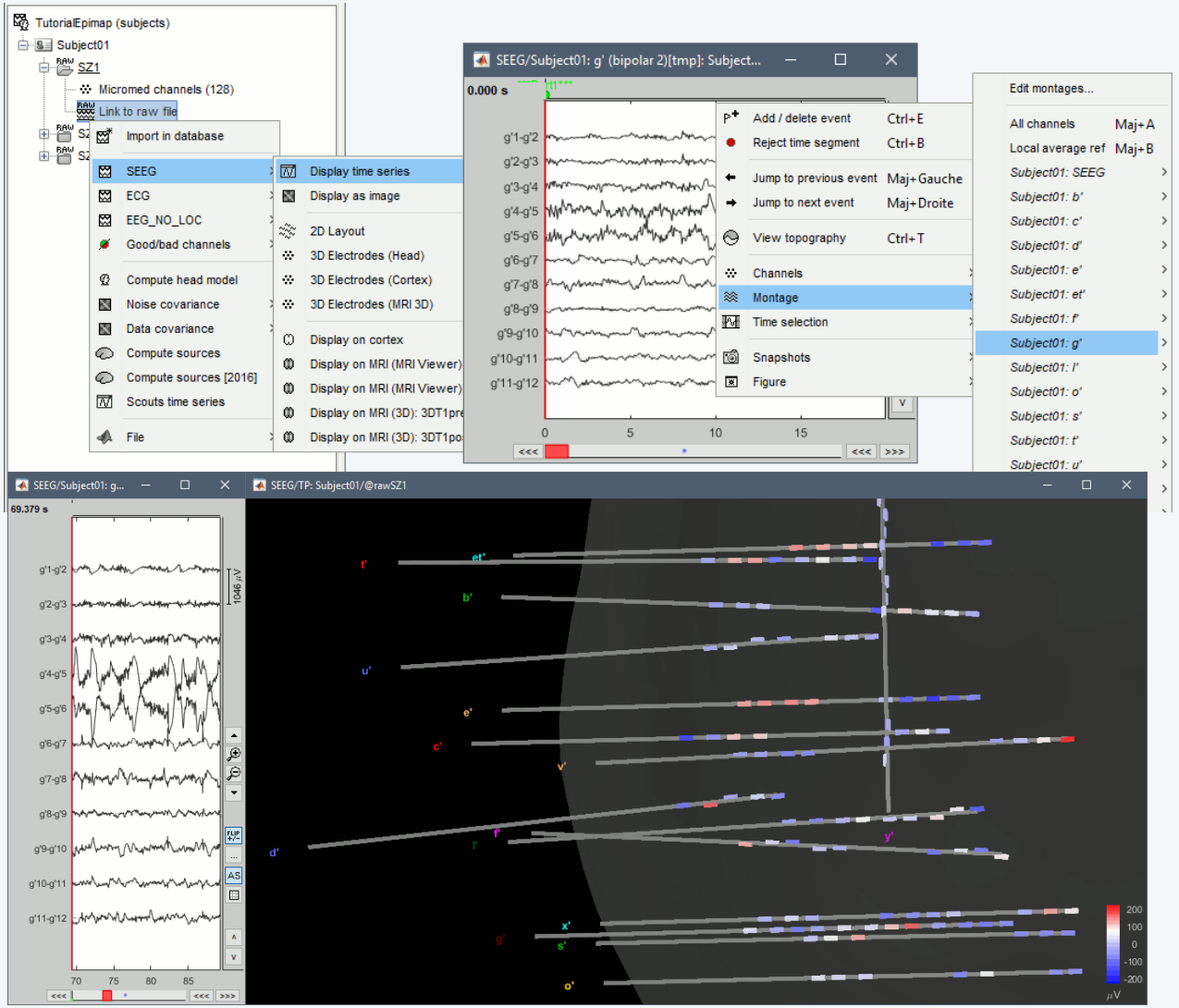
Bad segments

Markers
Epoching
Sensors
Sources
Time-frequency

- SEEG time series & Montages



Sensor level analysis

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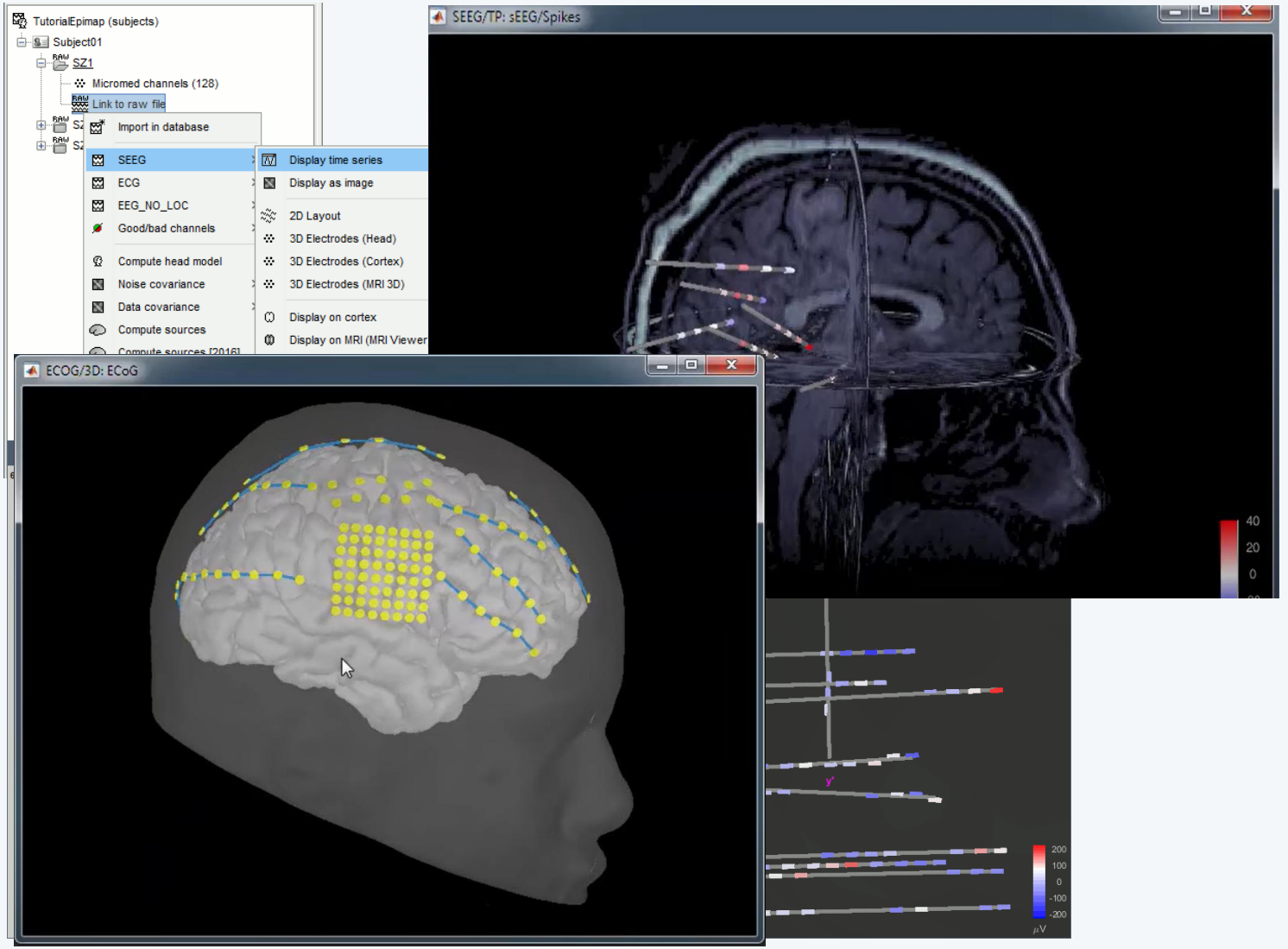
Sensors
Sources
Time-frequency

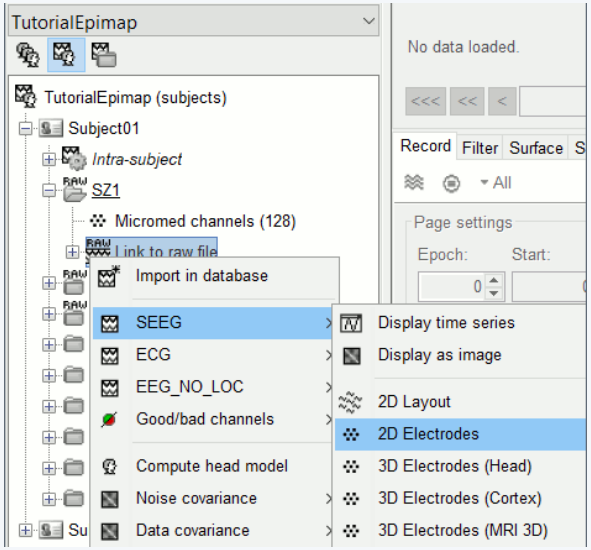
- SEEG time series & Montages

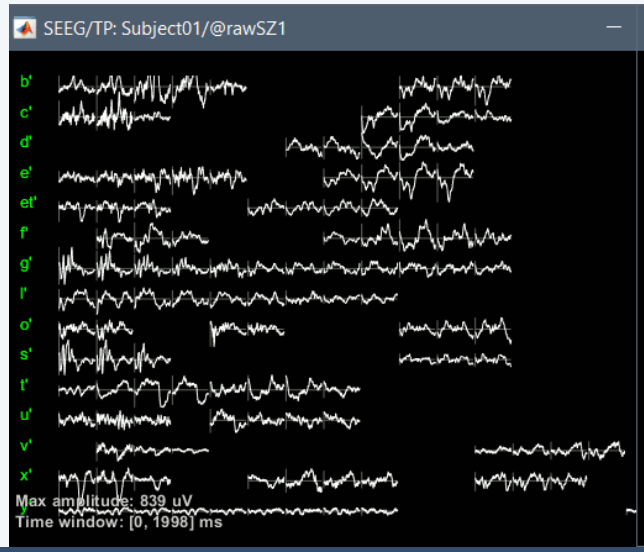


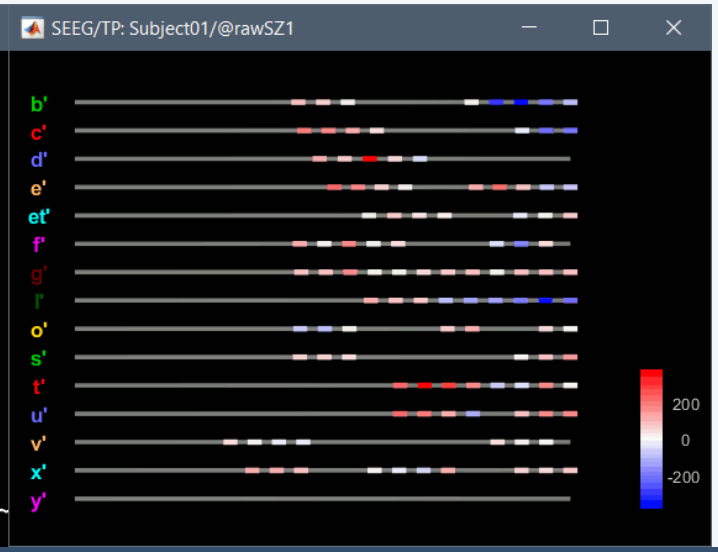
Brainstorm

Sensor level analysis

- SEEG time series : 2D topography







Sensor level analysis

Anatomy
Link recordings
MRI registration

PSD
Filters
Bad channels
Artifacts
Correction
Bad segments

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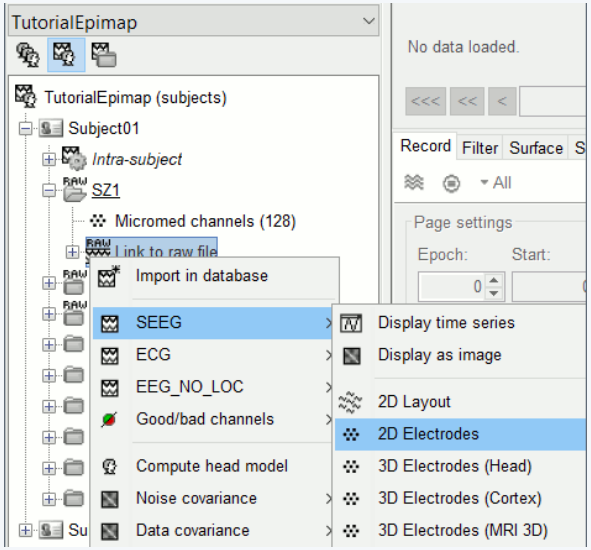
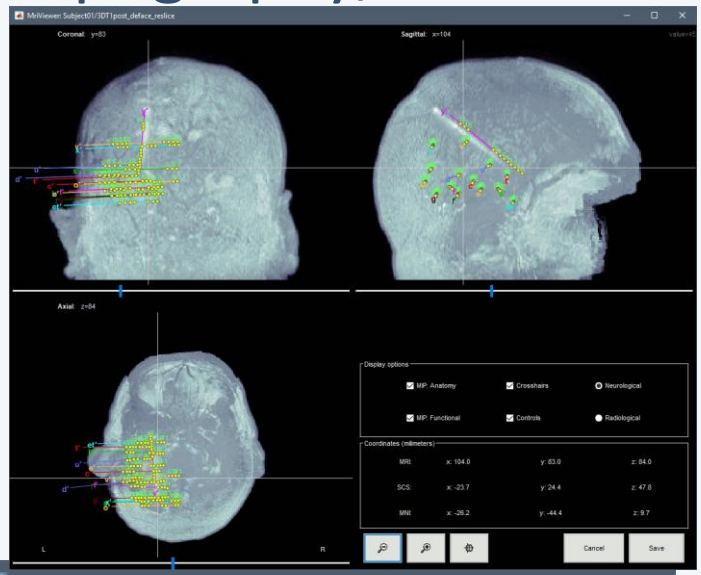
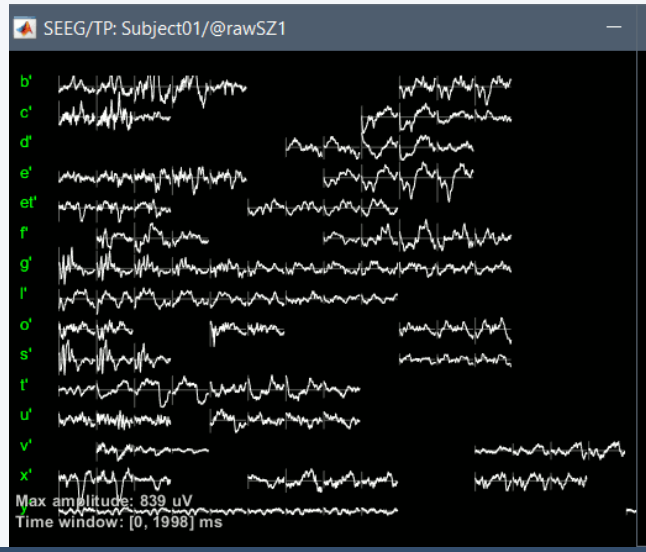
Epoching
Sensors
Sources
Time-frequency

- SEEG time series : 2D topography/ 3D







Brainstorm

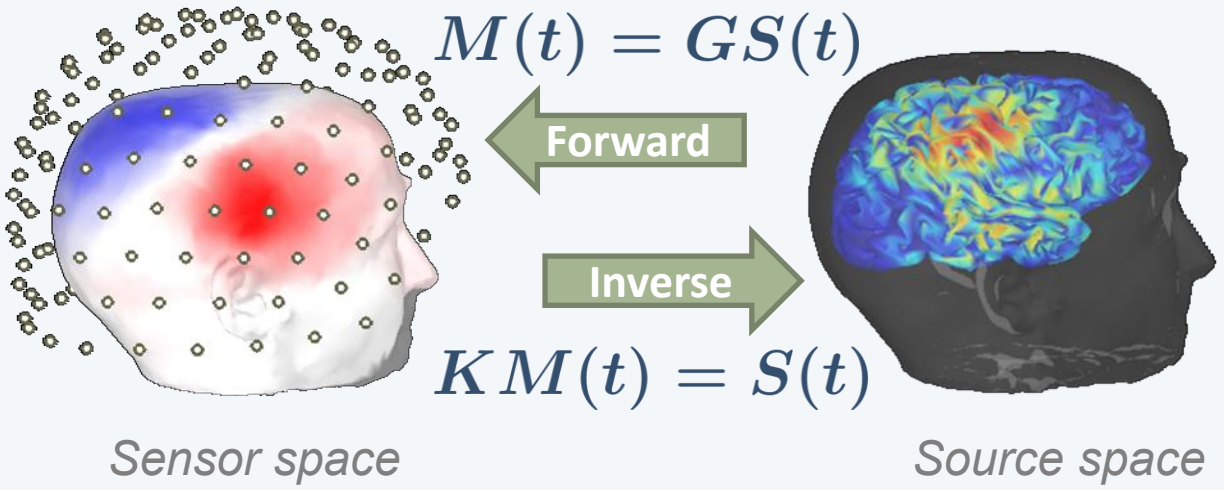
Source Reconstruction

$M(t)$ Sensor space: EEG or MEG sensors

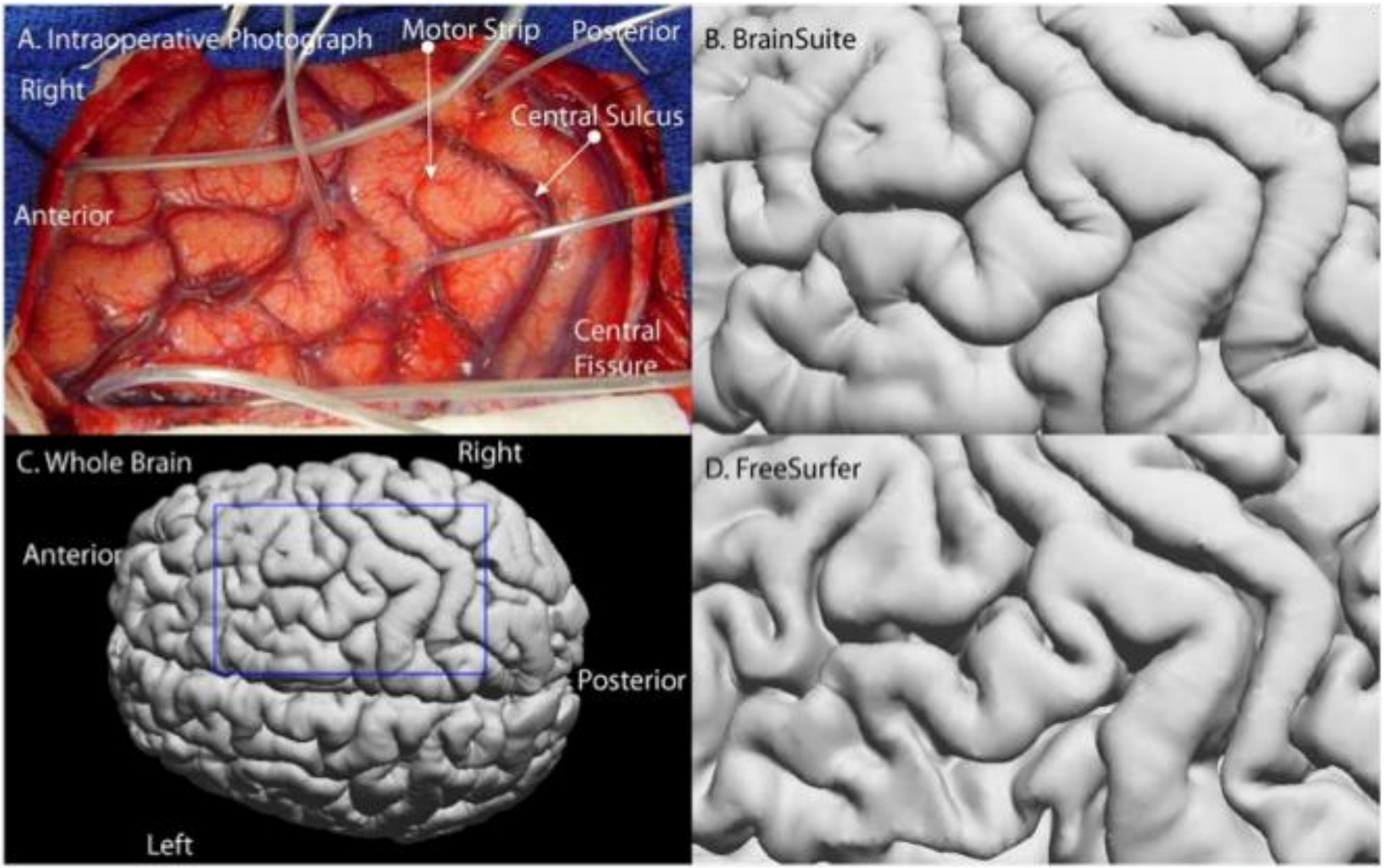
$S(t)$ Source space: Cortex or full head volume

G Forward model: Overlapping spheres (MEG)
OpenMEEG BEM/DUNEuro FEM (EEG)

K Inverse model: **Minimum norm estimates**
Beamformers

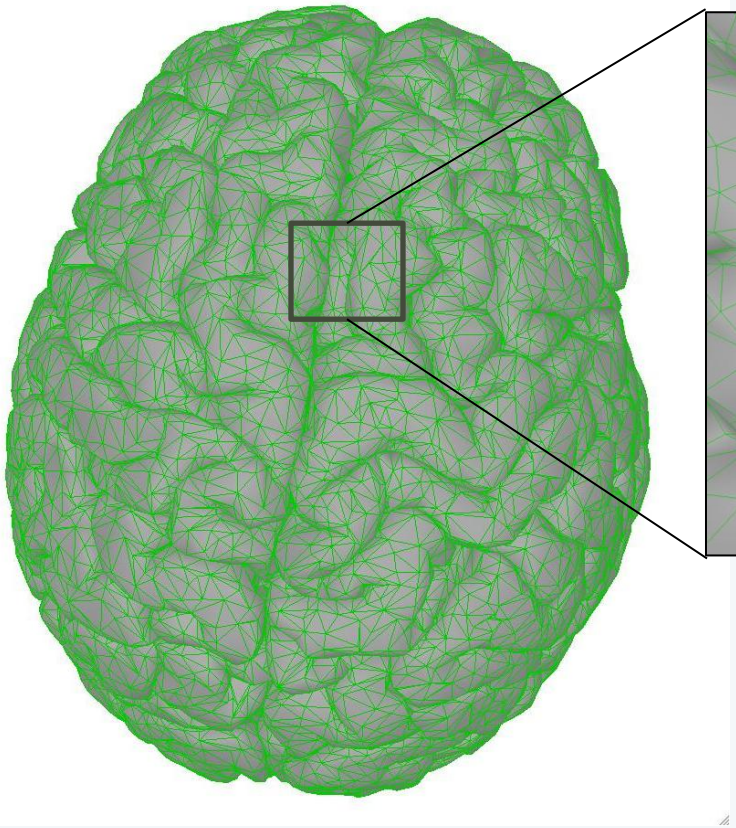


Source Space: Cortical Surface (MRI Segmentation)



Brainstorm

Cortical Surface: Modeling of sources



Thousands of triangles & vertices

~250k labeled vertices spanning 192,152 square mm

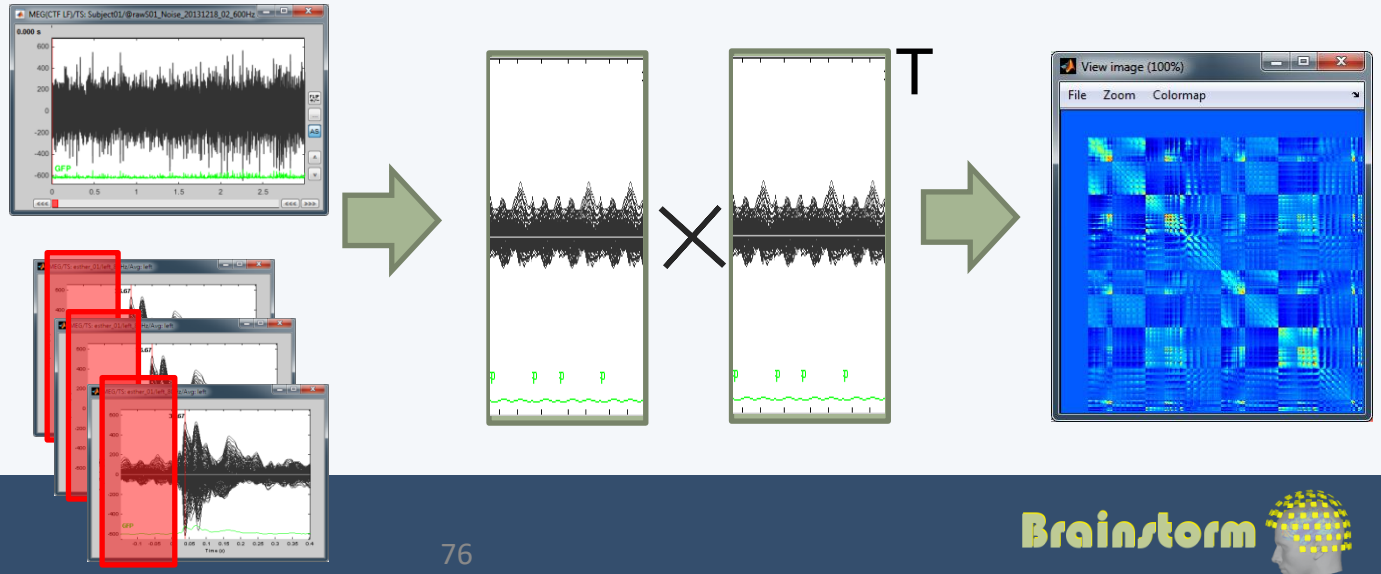
Brainstorm:
15,000 vertex for cortex model

Each Vertex Models an ~1 square mm Cortical Column

Columns are nominally radial (gyri), tangential (sulci), or some combination.

Noise covariance

- The MNE model requires an estimation of the level of noise of the sensors
- Noise covariance matrix = covariance of segments that do not contain any “meaningful” data
- Empty room, pre-stim baseline, resting, …



Brainstorm

Source level analysis

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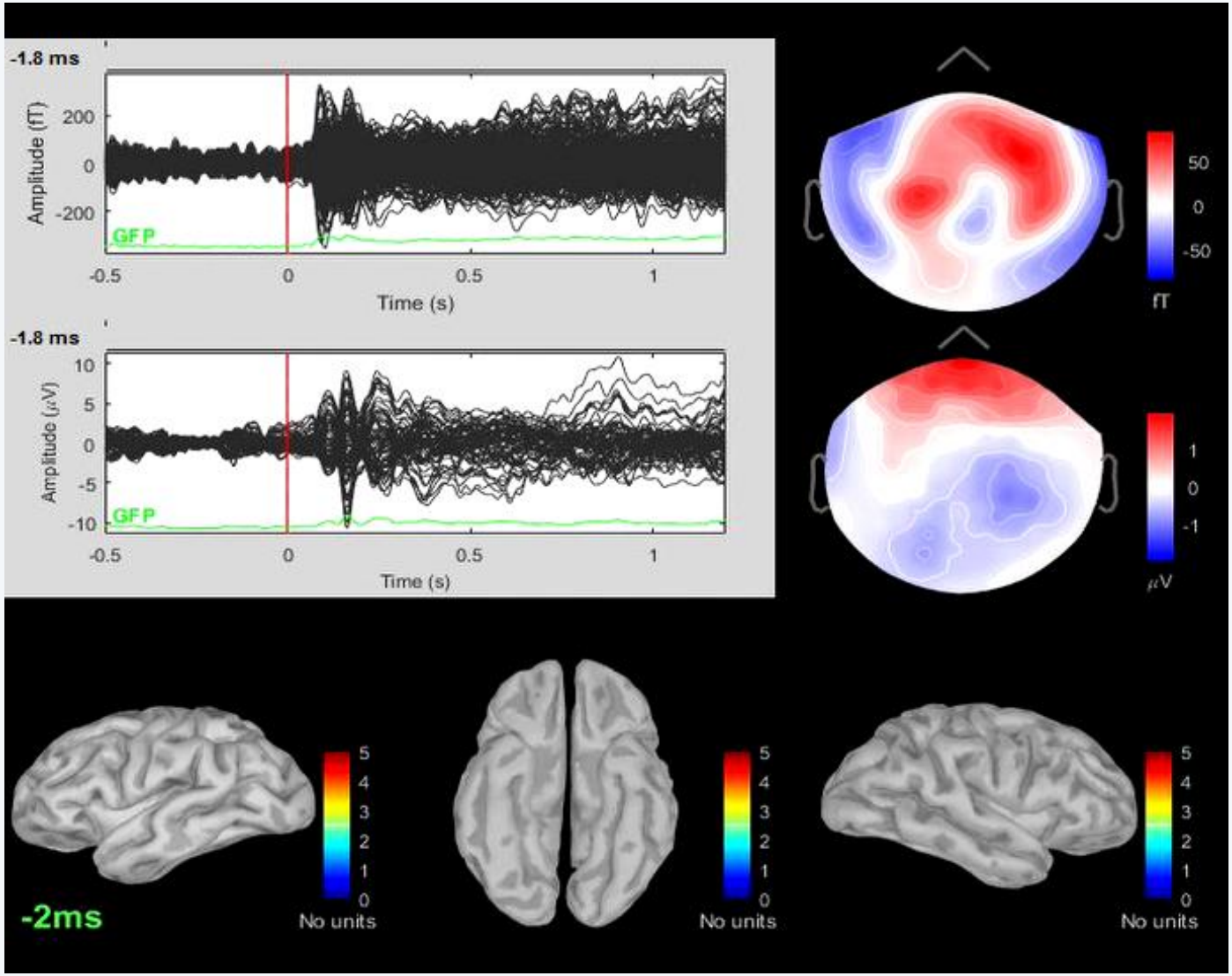
Bad segments

Markers
Epoching
Averaging
Sources
Time-frequency

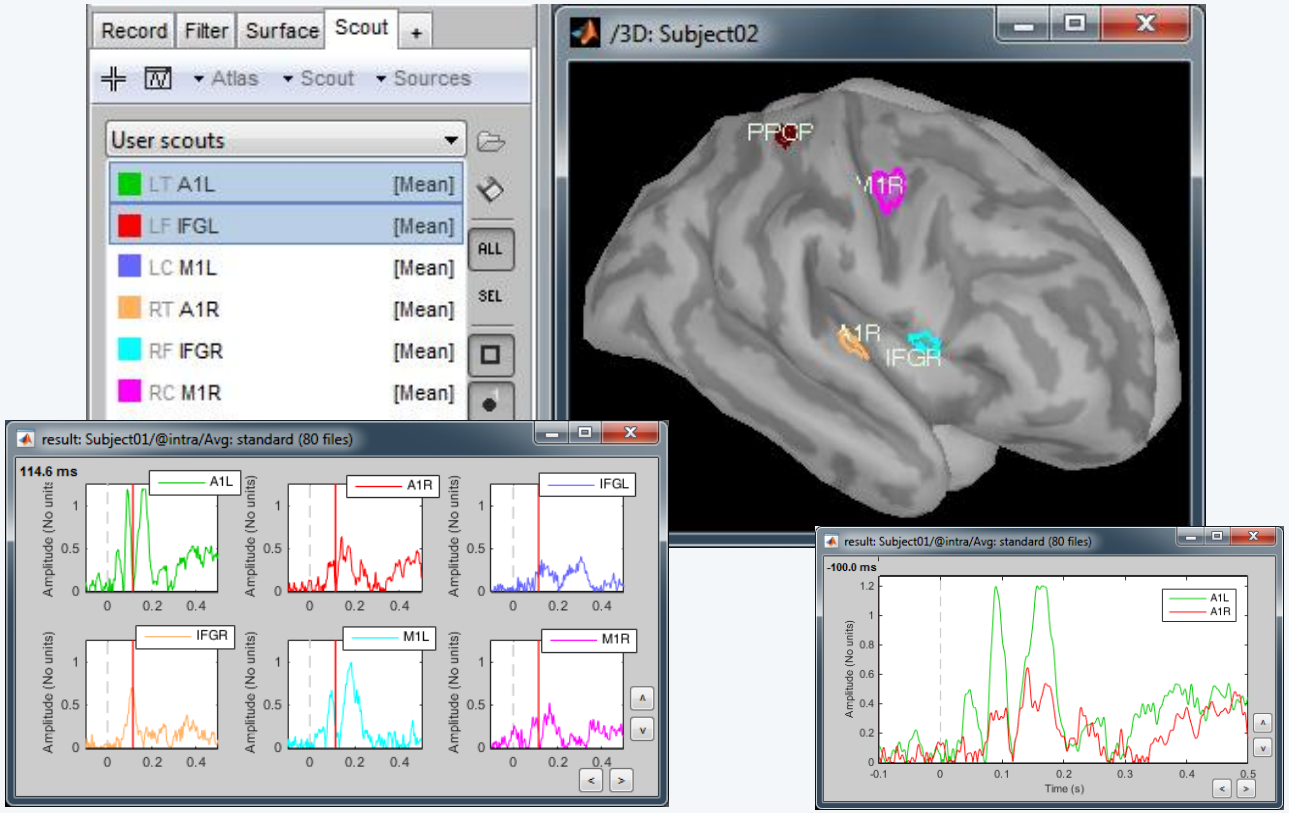
Example: Famous faces



Brainstorm

Source level analysis

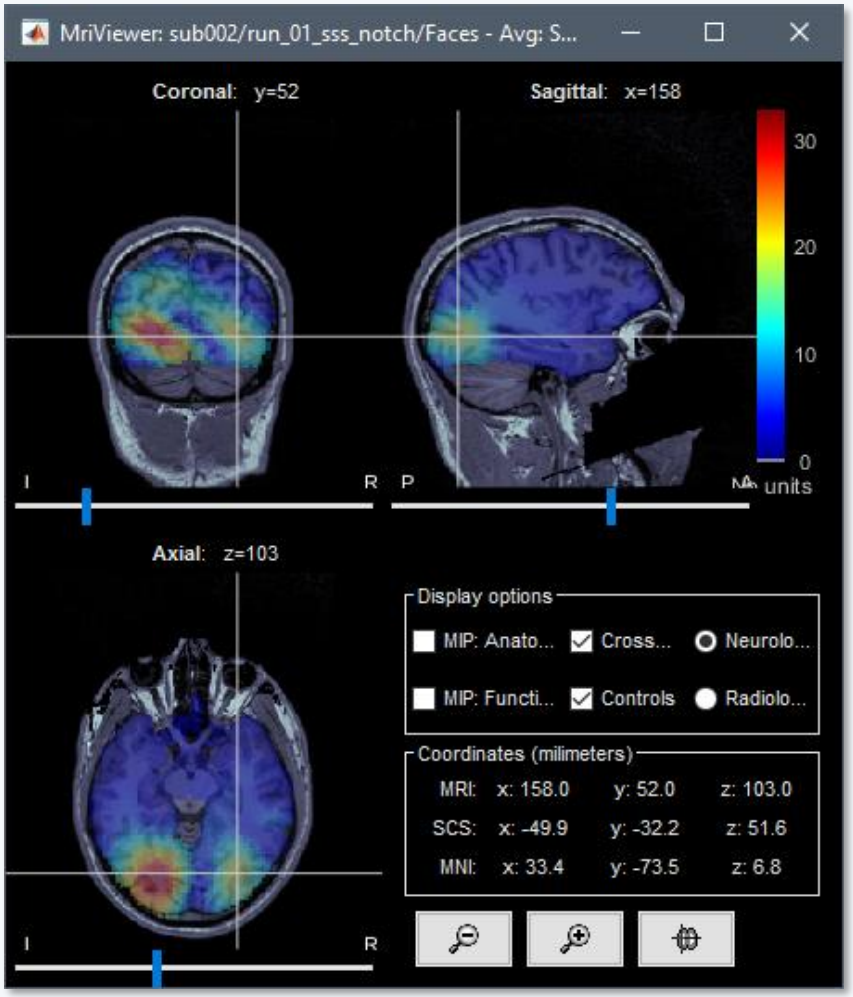
- Regions of interest at cortical level (**scouts**)
  = Subset of a few dipoles in the brain
  = Group of vertices of the cortex surface

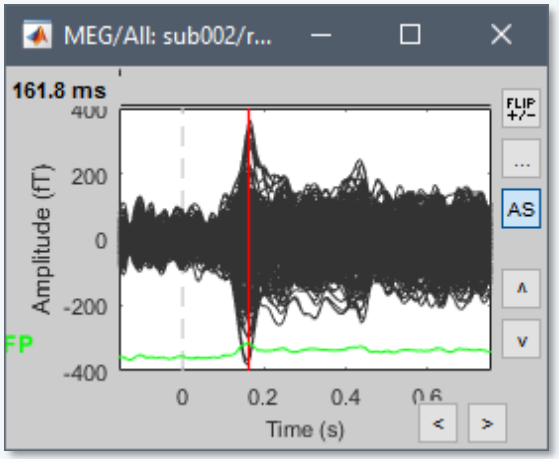


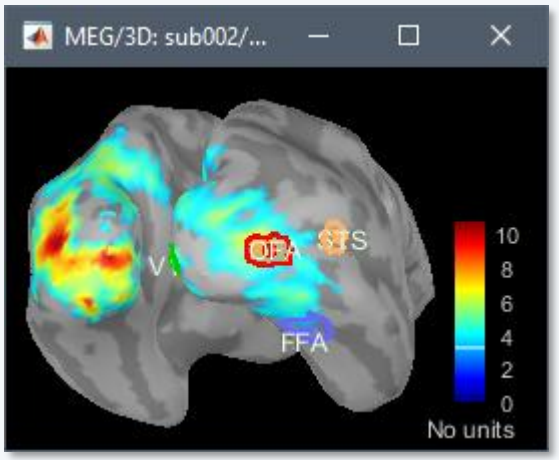
Brainstorm

Source level analysis

- Volume Source



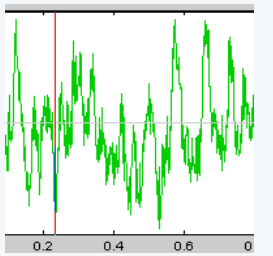


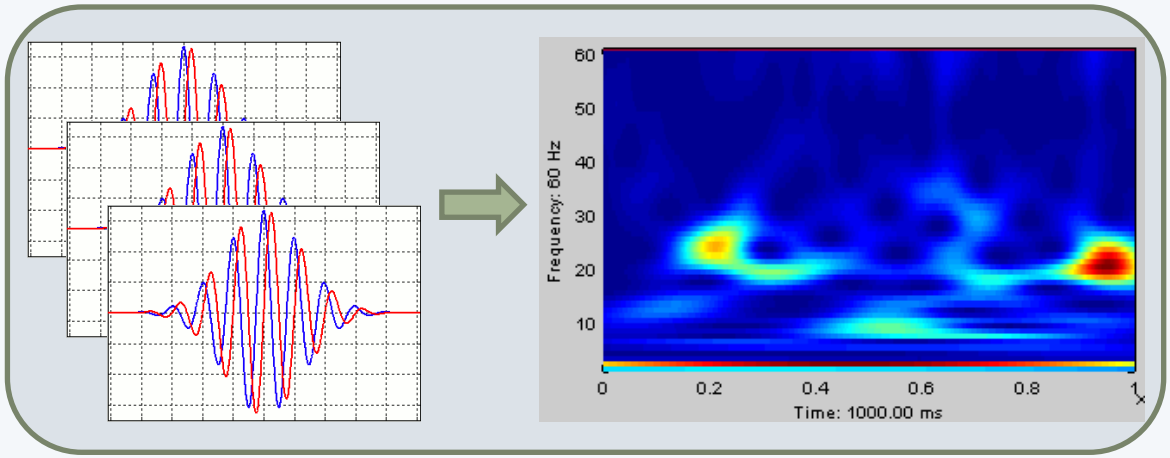


Brainstorm

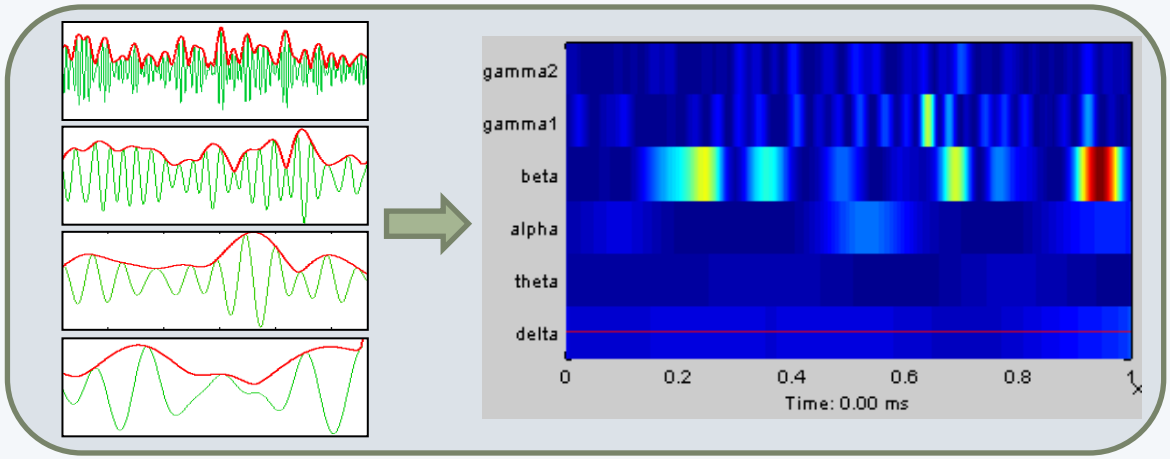
Time-frequency

Morlet wavelets



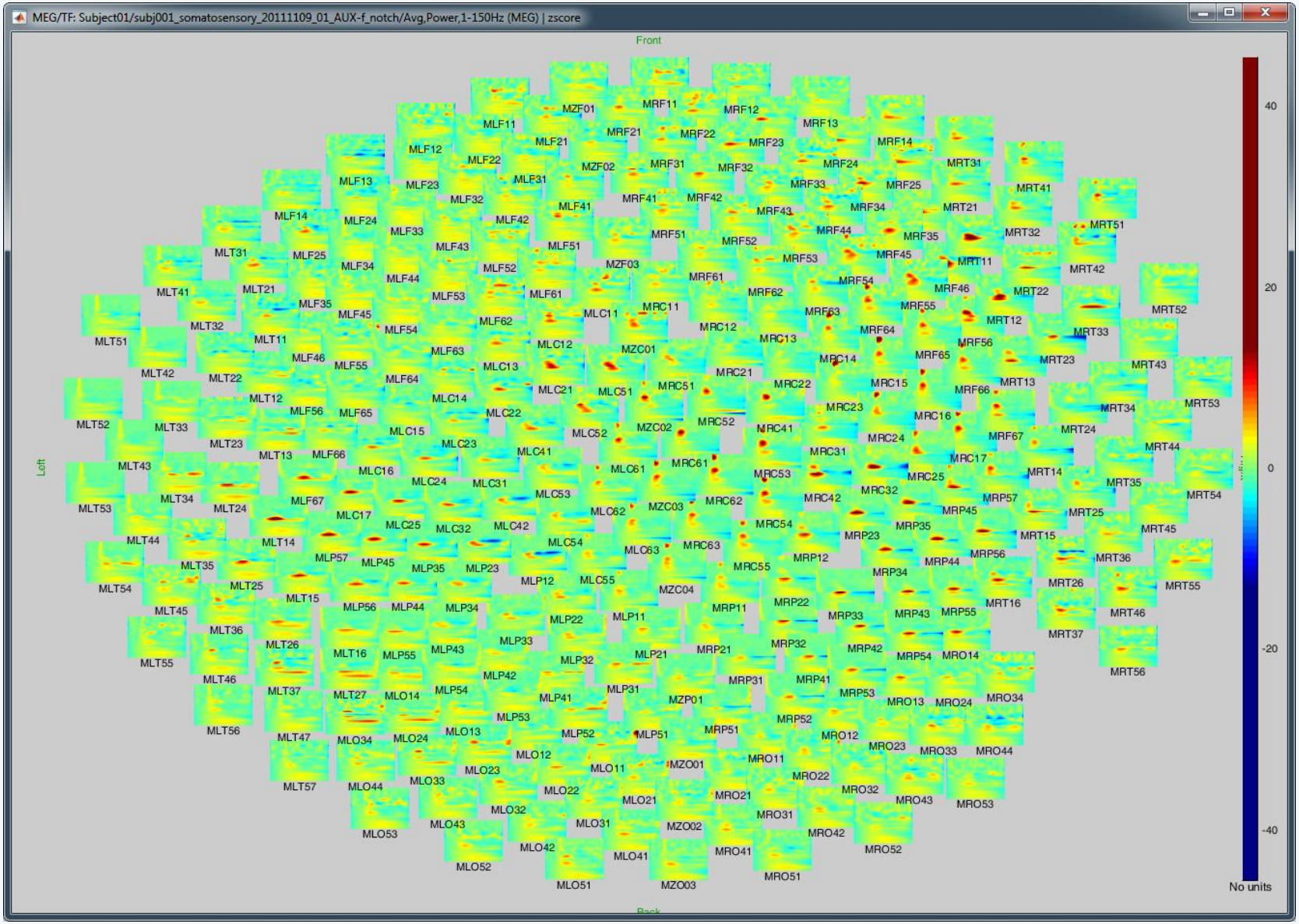


Hilbert transform + band-pass filter



Brainstorm

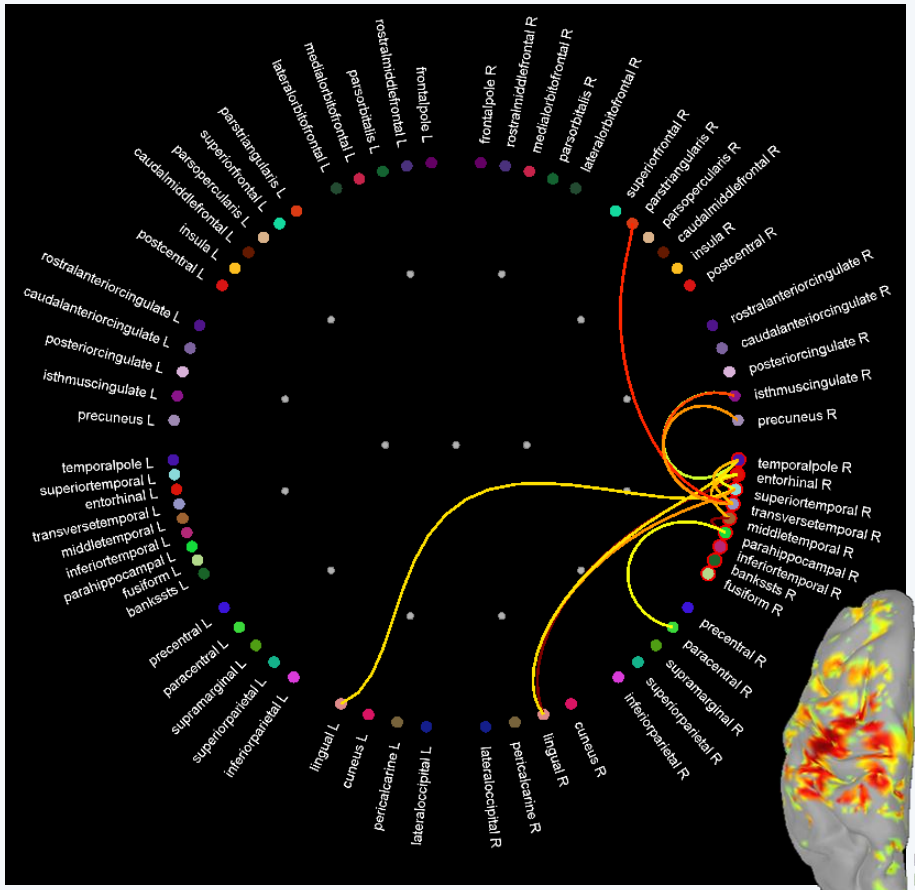
Time-frequency



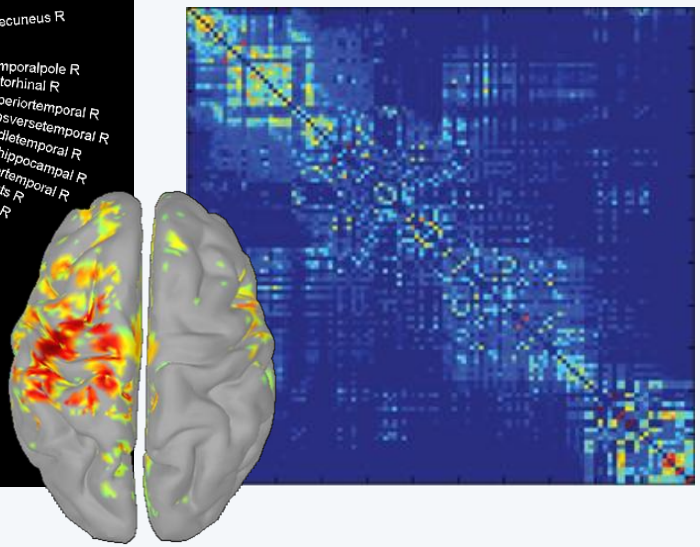
Brainstorm

Other measures

- Connectivity measures



- Correlation
- Coherence
- Phase locking value
- Granger causality



Brainstorm

Other measures

- And more …

Source modeling

- Volume source estimation
- Deep cerebral structures
- Realistic head model: BEM with OpenMEEG
- Dipoles: Scanning and displaying
- Dipoles: FieldTrip dipole fitting
- Maximum entropy on the mean (MEM)
- Other beamforming methods
- Simulations

Finite Element Modeling

- Realistic head model: FEM with DUNEuro
- FEM mesh generation
- FEM tensors estimation
- FEM median nerve example

Signal processing

- Machine learning: Decoding / MVPA
- Phase-amplitude coupling: Method
- Phase-amplitude coupling: Example
- Partial Least Squares (PLS)
- Epileptogenic Zone Fingerprint
- FOOOF: Fitting Oscillations & One-Over-F
- SPRiNT: Spectral Param. Resolved in Time

Connectivity

- Functional connectivity
- Corticomuscular coherence
- Connectivity graphs
- Virtual fibers for connectivity
- Granger causality

Brain-fingerprinting

- Brain-fingerprinting

https://neuroimage.usc.edu/brainstorm/Tutorials

Add your code to Brainstorm

- Direct manipulation of the files in Matlab
- Use the menu “Run Matlab command”
- Write a plugin:
  - Well documented API
  - Lots of example (170 functions written as plugins)
  - Open-source GitHub repository
- Write your Brainstorm scripts

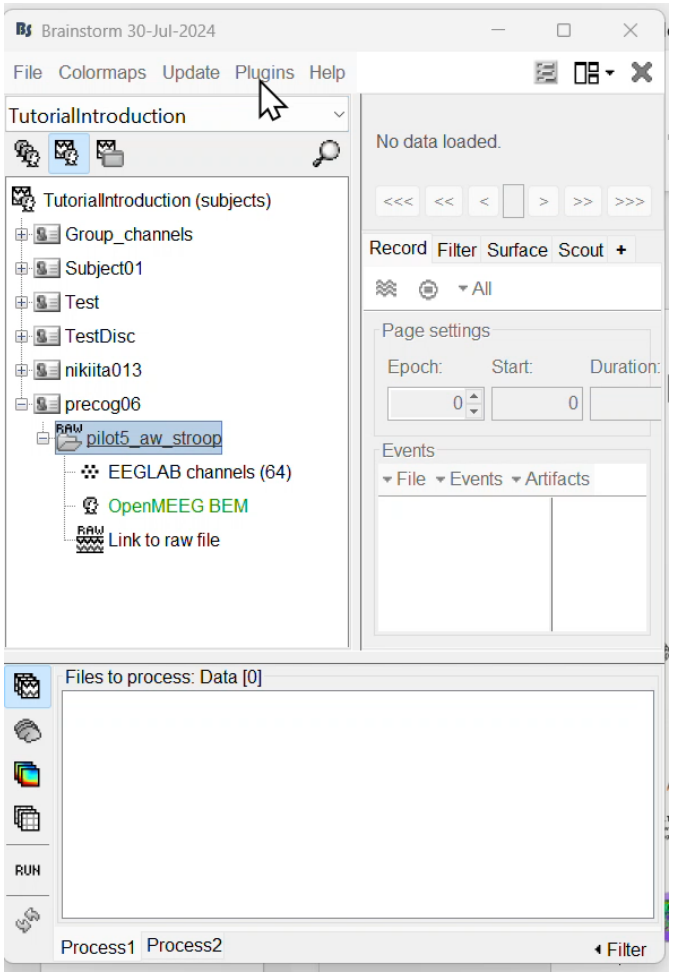
Tutorial 28: Scripting

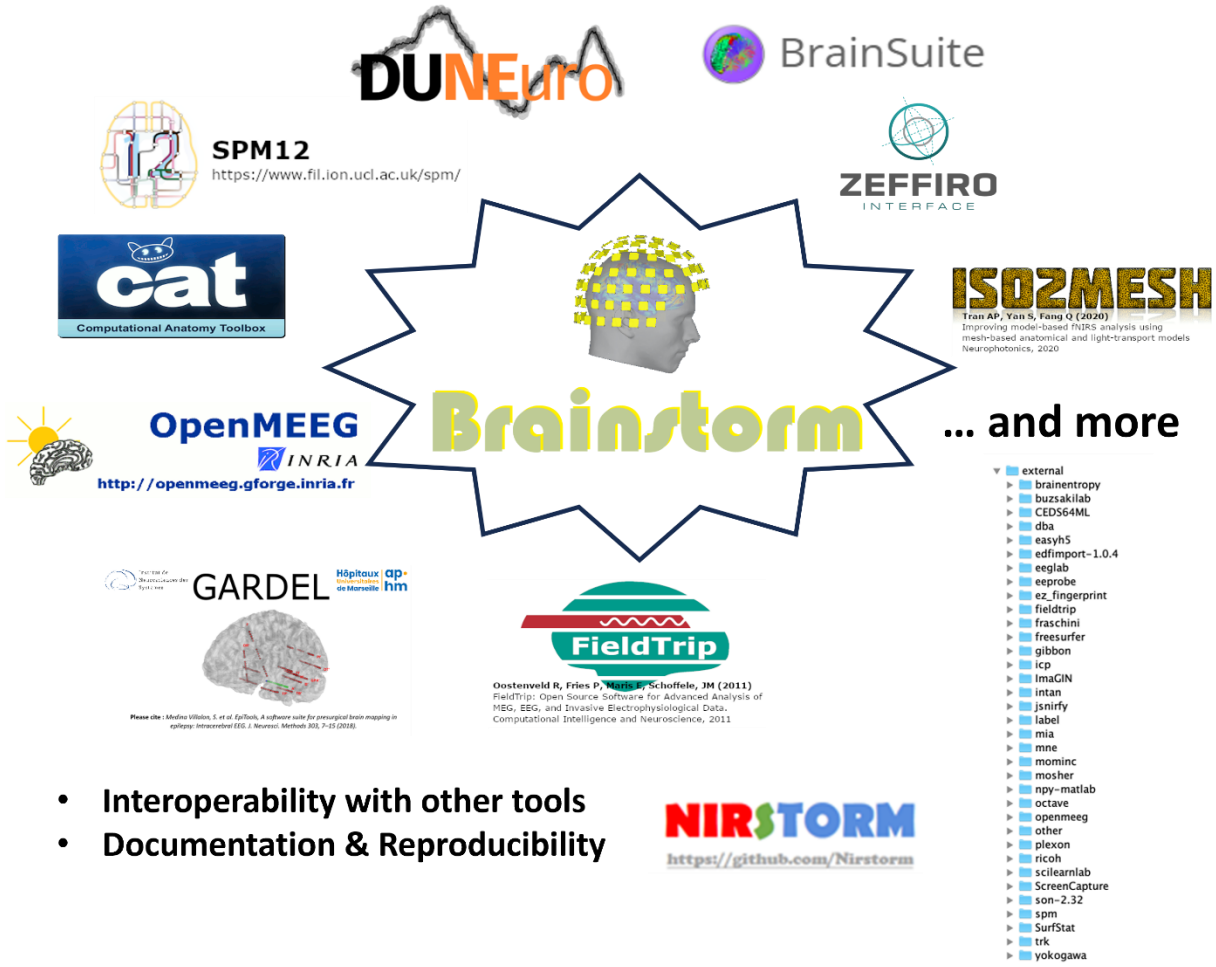
Authors: Francois Tadel, Elizabeth Bock, Matthias Sure, Sylvain Baillet

The previous tutorials explained how to use Brainstorm in an interactive way to process one subject with two acquisition runs. In the context of a typical neuroimaging study, you may have tens or hundreds of subjects to process in the same way, it is unrealistic to do everything manually. Some parts of the analysis can be processed in batches with no direct supervision, others require more attention. This tutorial introduces tools and tricks that will help you assemble an efficient analysis pipeline.

What's New?

- **Brainstorm Plugin Manager: Brainstorm as a hub!**





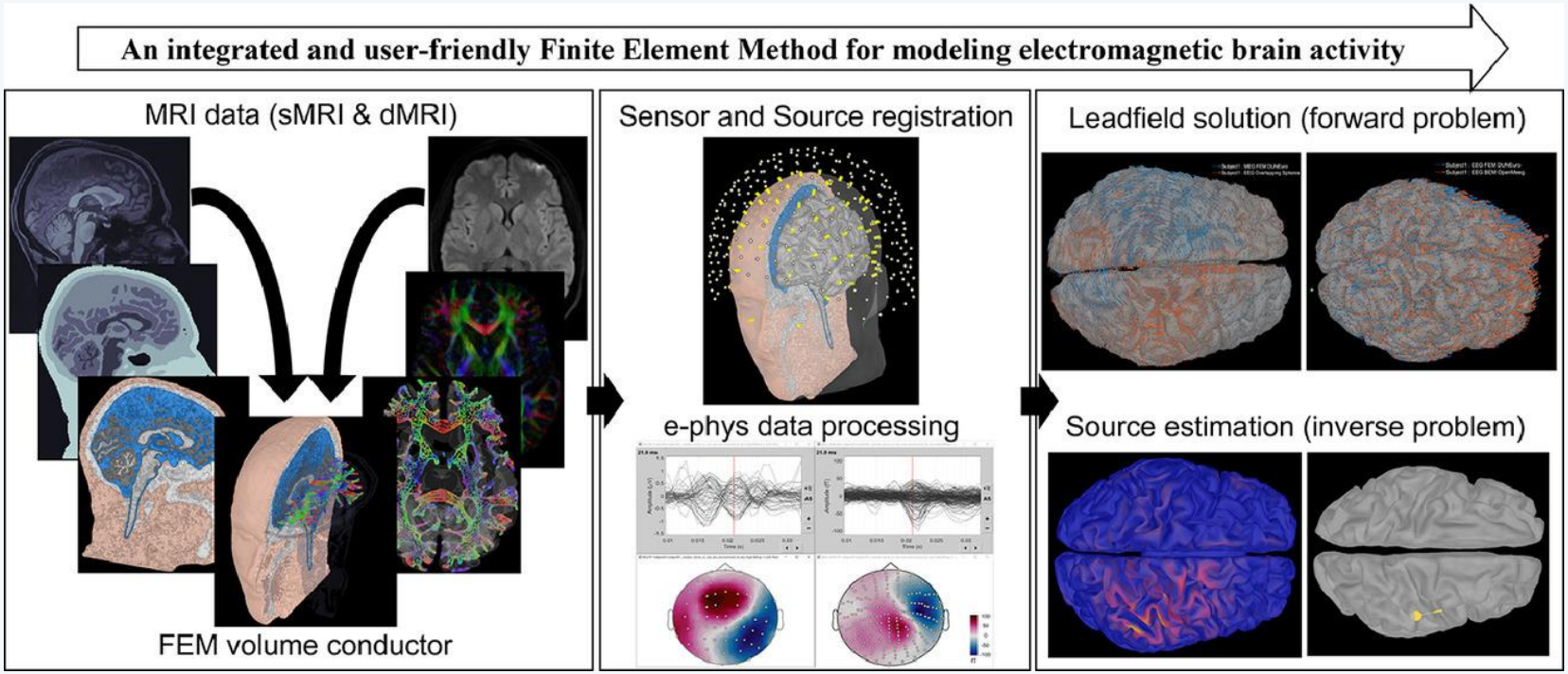
- **Interoperability with other tools**
- **Documentation & Reproducibility**

NIRSTORM
https://github.com/Nirstorm

Brainstorm

What's New?

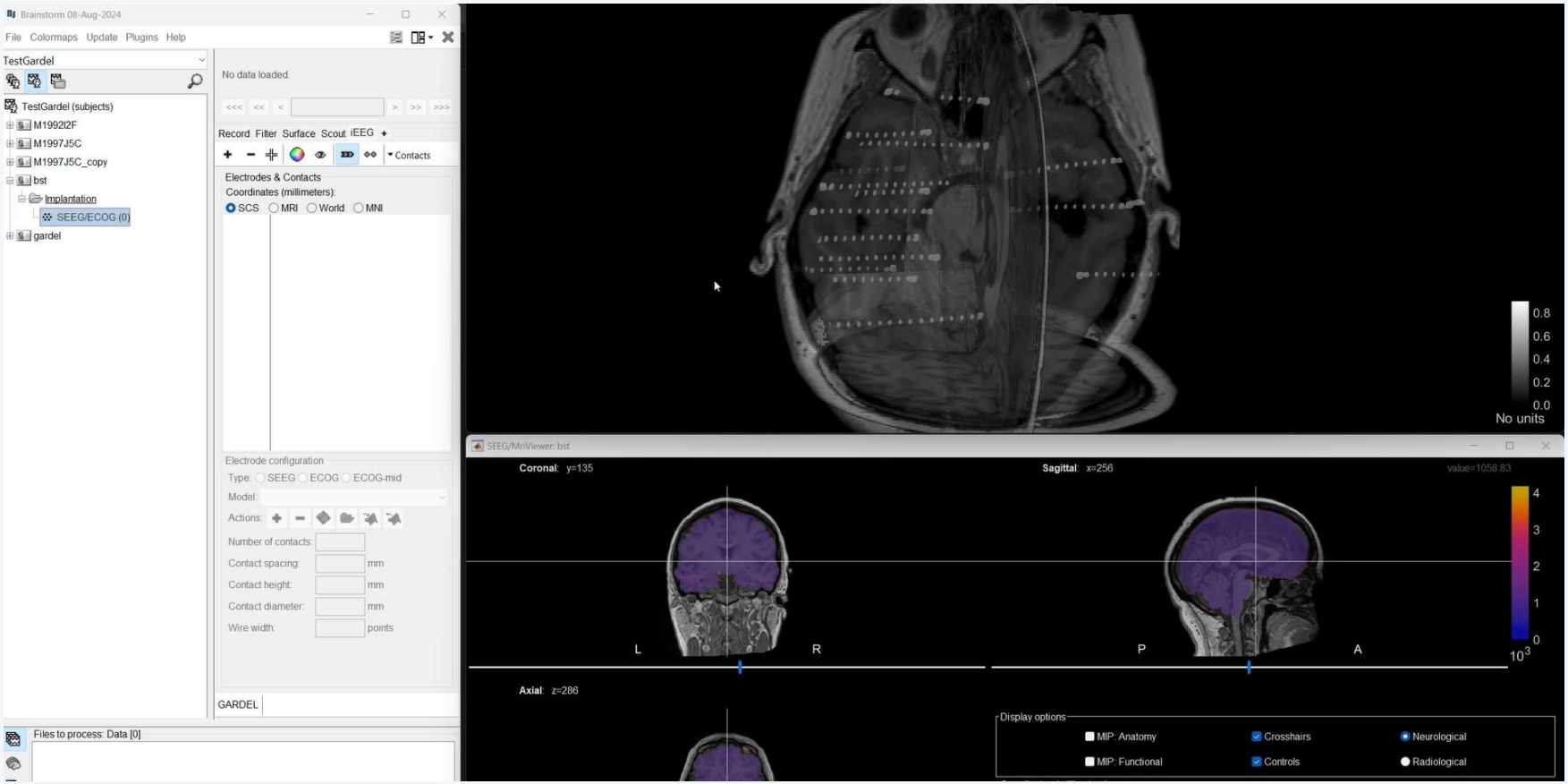
- **Brainstorm - DUNEuro: An integrated and user-friendly Finite Element Method for modeling electromagnetic brain activity**



Takfarinas Medani, Juan Garcia-Prieto, Francois Tadel, Marios Antonakakis, Tim Erdbrügger, Malte Höltershinken, Wayne Mead, Sophie Schrader, Anand Joshi, Christian Engwer, Carsten H. Wolters, John C. Mosher, Richard M. Leahy
(https://doi.org/10.1016/j.neuroimage.2022.119851)

What's New?

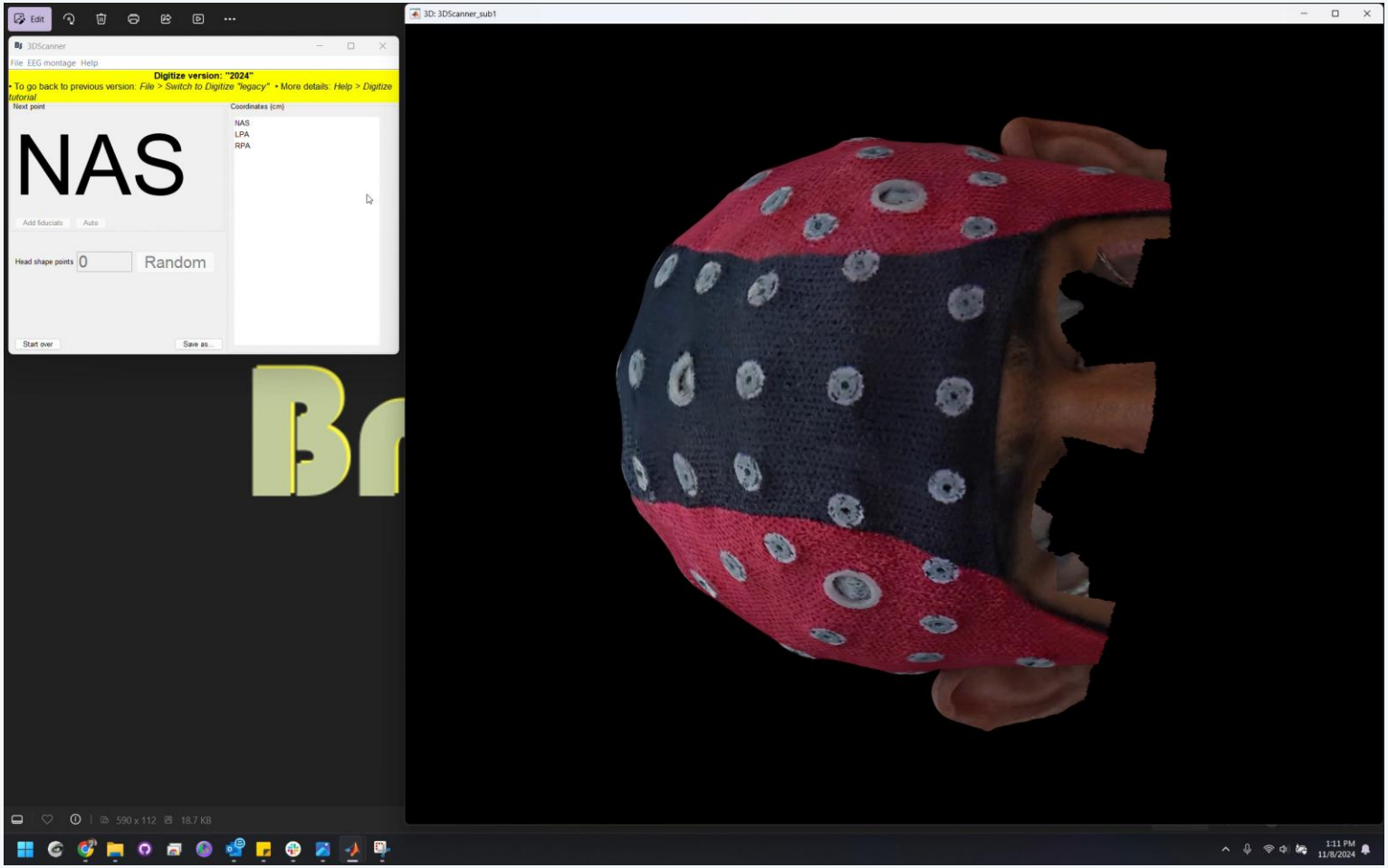
- **Automated sEEG Electrode Localization and Labeling**



Chinara, S.Medina, A Joshi, C-G Bénar , T.Medani and brainstorm team: https://neuroimage.usc.edu/brainstorm/Tutorials/IeegContactLocalization
Medina Villalon et al. EpiTools, 2018 doi: 10.1016/j.jneumeth.2018.03.018

What's New?

- **Automated EEG Electrode Localization and Labeling**



Chinara, A Joshi, Vakilna, Medani, and brainstorm team: https://neuroimage.usc.edu/brainstorm/Tutorials/TutDigitize3dScanner

Brainstorm

What's New?

And more...!!

Brainstorm

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Development

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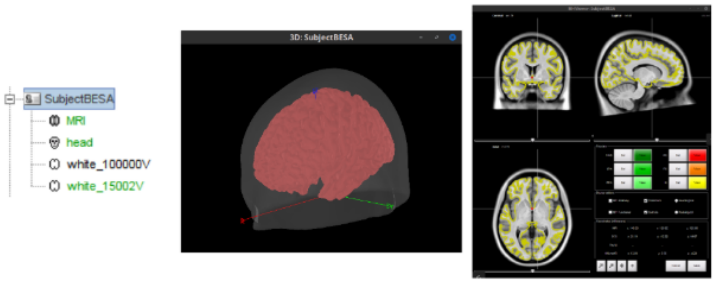
What's new

Brainstorm is in a very active development state: small or major bug fixes and improvements almost everyday. To update your version of the software easily: Install and update.
See also the full list of updates: brainstorm3/doc/updates.txt | All GitHub commits

February 2025

Anatomy

- Import volumes and surfaces from **MRI BESA**



- Export surfaces as (ASCII and binary) **STL files**

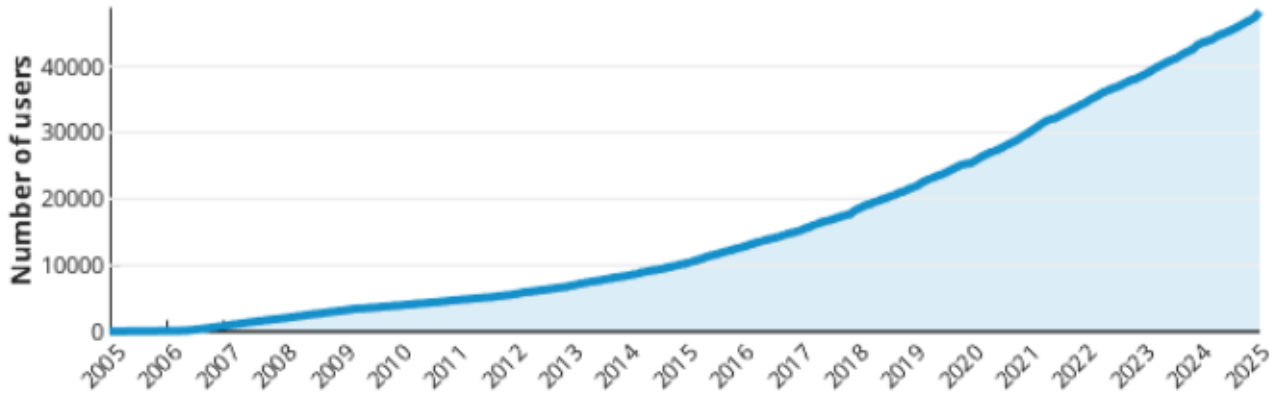
Processes

https://neuroimage.usc.edu/brainstorm/News

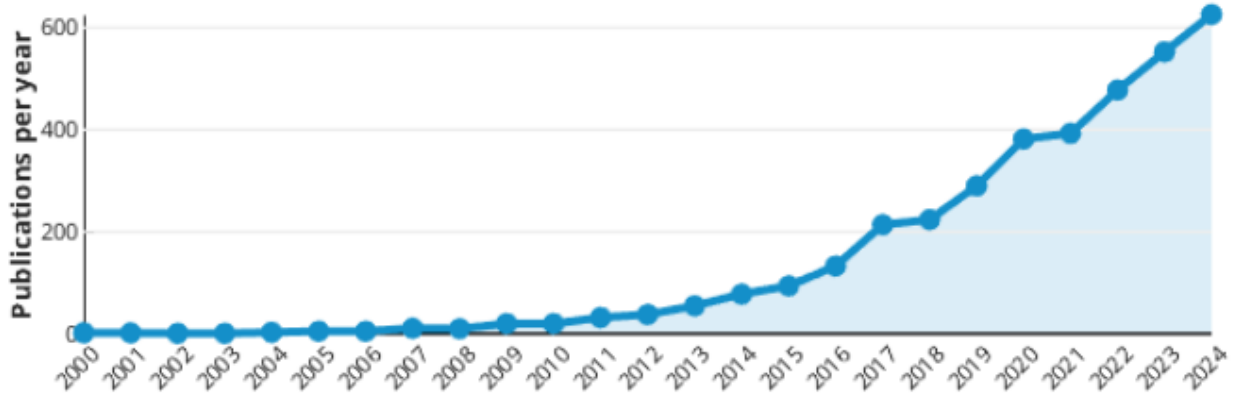
Brainstorm

Software statistics: April 2025

Number of user accounts registered on the website: **48,255**

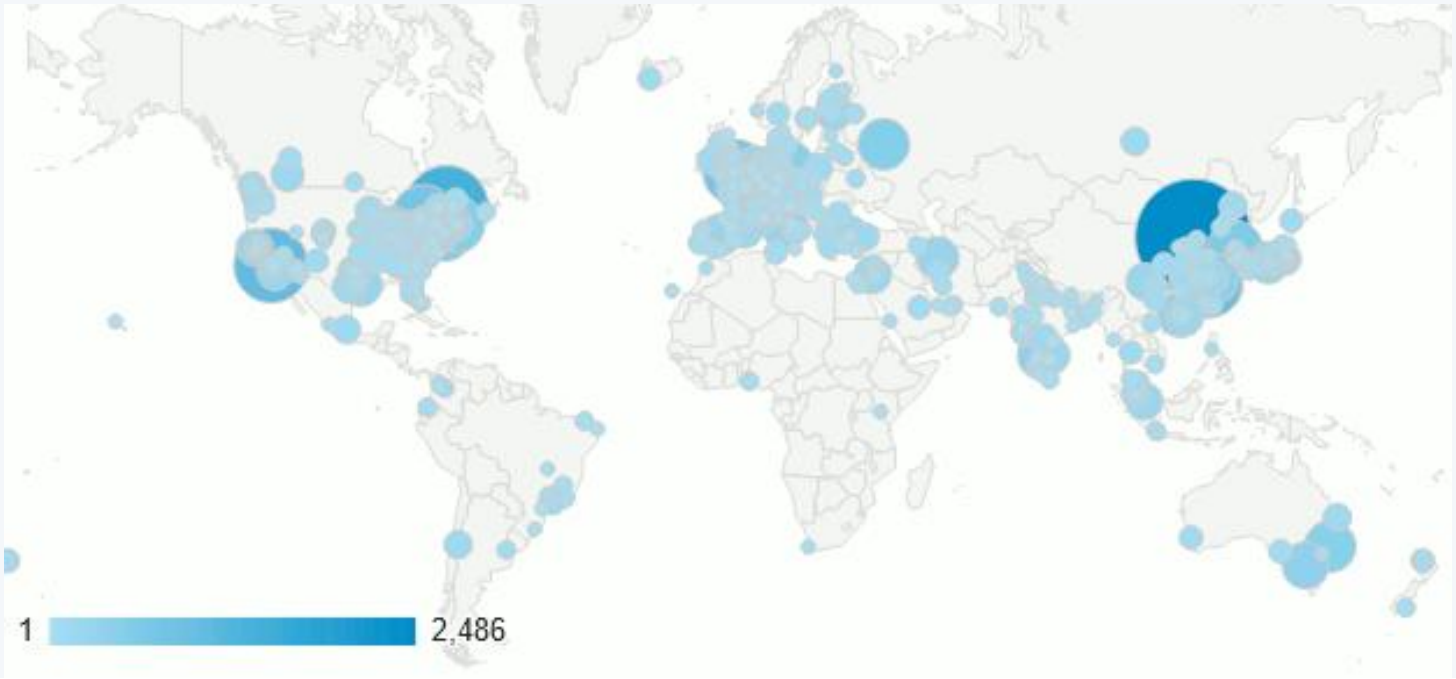


Number of peer-reviewed articles and book chapters published using Brainstorm: **3846**
(Up to March 2025)



User community (2025)

- >48,000+ users registered on the website



Find users next to you

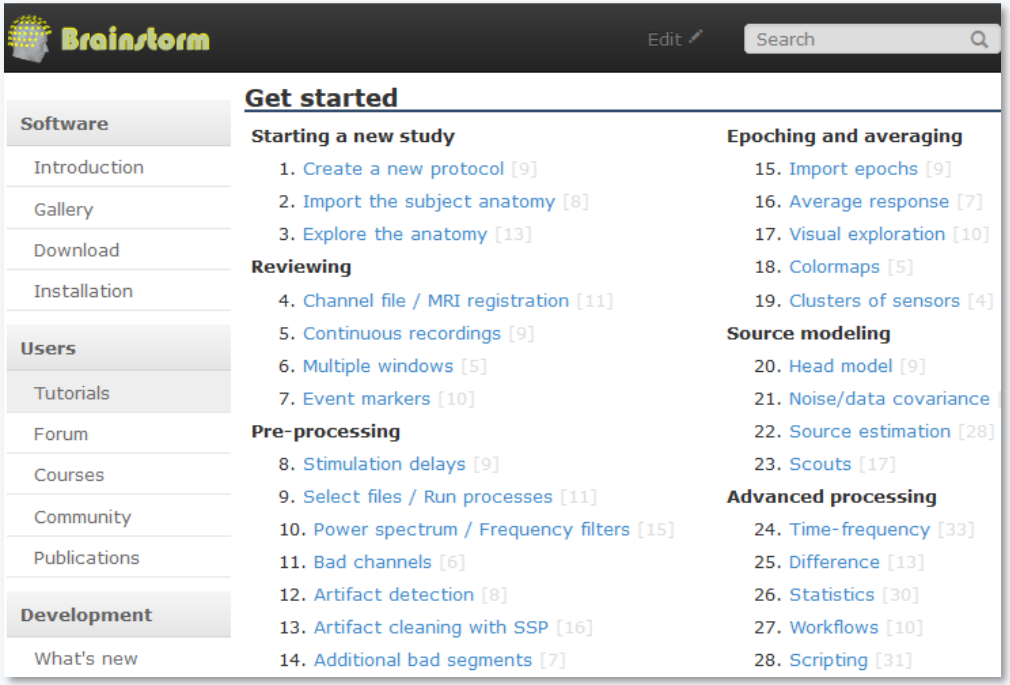
Location: montreal

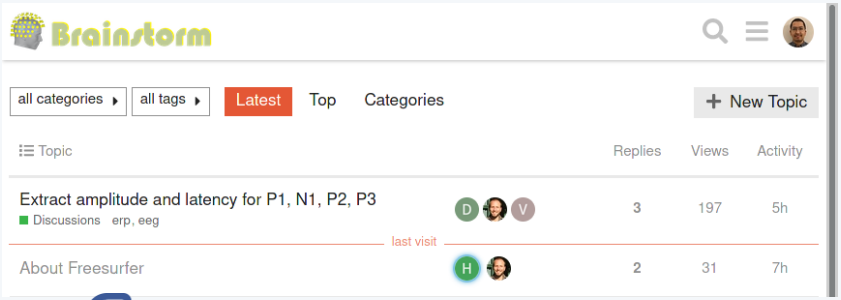
Users found: 847

Brainstorm

User support

- Online tutorials: 30-hour self-training program
- Active user forum: 150 posts/month
- Daily updates: 1500 downloads/month





@BrainstormSoftware

@brainstorm2day

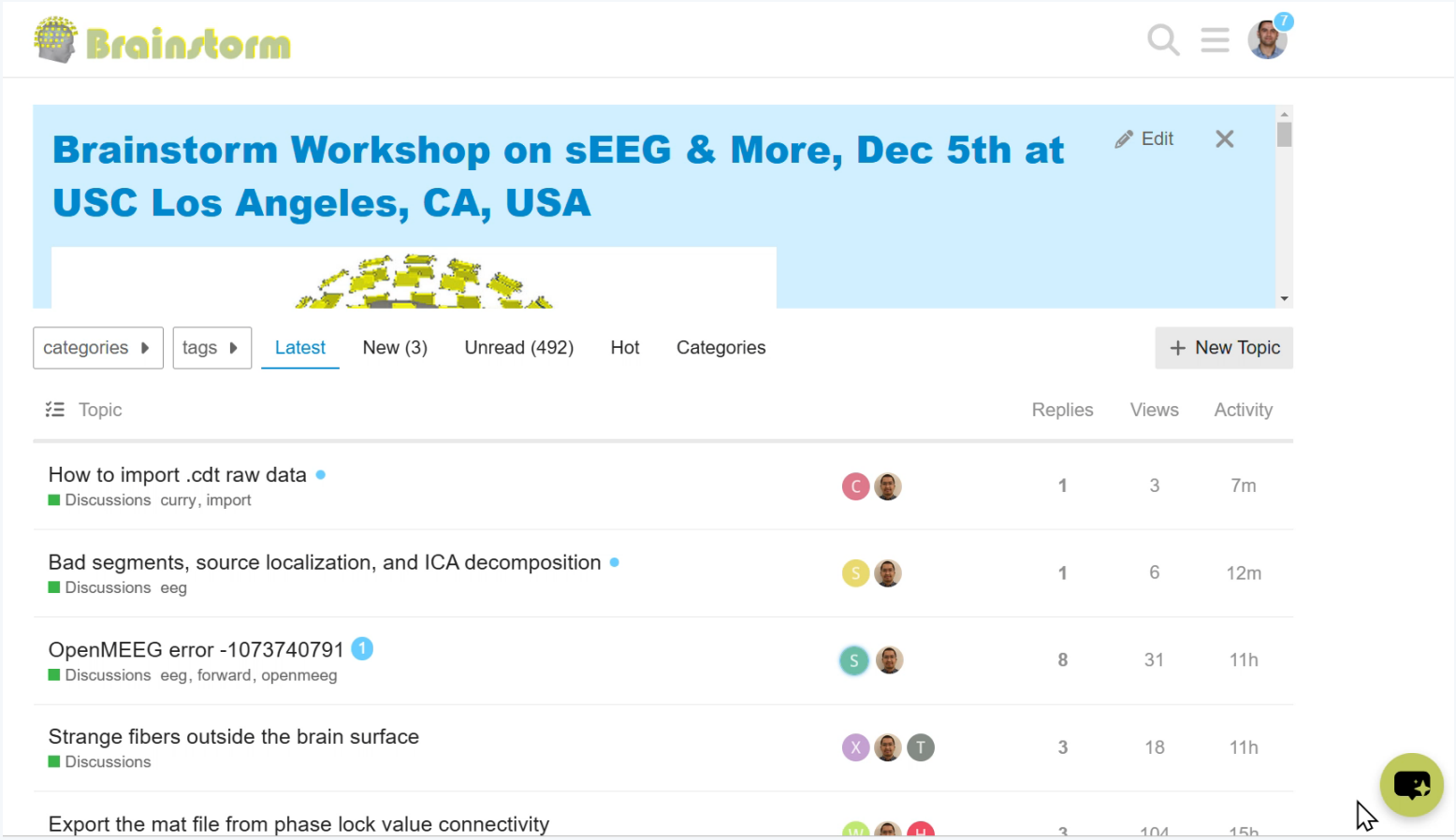
@brainstorm-tools

@ brainstorm-neuroimage

Brainstorm

User support

- Forum Brainstorm Chabot



https://neuroimage.usc.edu/forums/

Upcoming Brainstorm Events

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📍 **Toulouse, France,**

Date: March 19, 2025

Focus: Advanced training in Brainstorm's features for stereotactic EEG (sEEG) analysis.

Part of the MicMac2025

https://micmac-workshop.org

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📍 **Hyderabad, India**

Date: April 6, 2025

Focus: Brainstorm overview presentation and demo on EEG and MEG analysis.

Part of the International Conference on Acoustics, Speech, and Signal Processing (ICASSP).

Program & Registration: https://lnkd.in/diVwMDRz

==========

📍 **Aix-en-Provence, France**

Date: October 27–31, 2025

Focus: Brainstorm overview presentation and handson on EEG and MEG analysis.

Part of *PracticalMEEG events*

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📍 **Brisbane, Australia**

Date: June 24-28, 2025

Focus: Software Demo.

Part of *OHBM 2025*

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👩‍🏫 **Host a Workshop**

Looking to organize a tailored Brainstorm workshop for your lab, university, or team? Whether you need to advance your knowledge or stay at the forefront of cutting-edge methods, we're here to help!

📧 DM us here or Contact us at brainstorm-l@maillist.usc.edu to discuss your needs.

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Antoine Ducorps
Denis Schwartz
…

NIRSTORM


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Concordia

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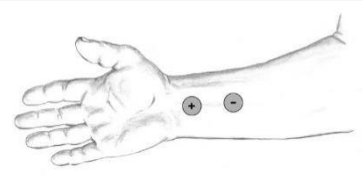
Brainstorm

TODAY

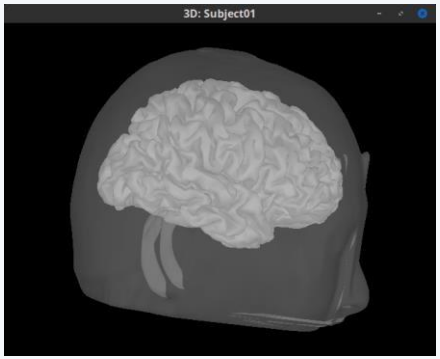
Median nerve stimulation

- Right arm stimulation: monophasic square-wave duration 0.3 ms
- 1 participant / 1 run / 336 stimuli

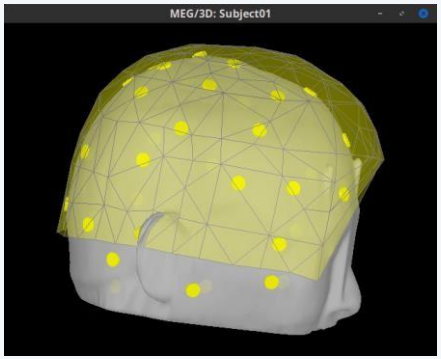
- Individual MRI, processed with CAT12
- MEG: Yokogawa 160 axial gradiometers @ 2000 Hz
- EEG: Nihon Kohden 41 electrodes @ 2000 Hz



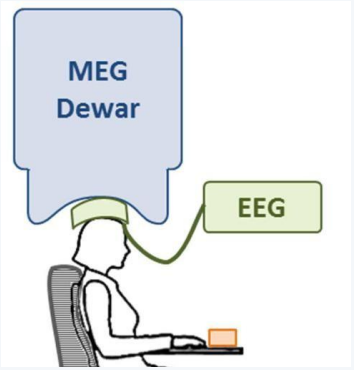
Median nerve percutaneous stimulation



Scalp and cortical surface



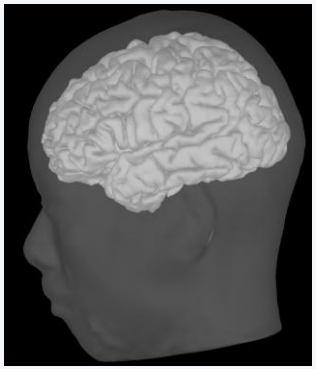
EEG electrodes and MEG helmet



Simultaneous MEG and EEG acquisition

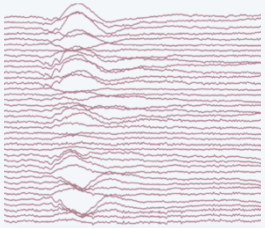
Demo Overview

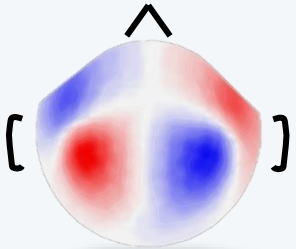
Importing anatomy



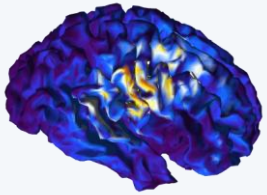
Preprocessing and artifact removal

Signals at sensor level





Signals at source level
(forward and inverse models)



Other topics: statistics, scripting, etc

```
% Process: High-pass:500Hz
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    'sensortypes', 'MEG, EEG', ...
    'highpass',    500, ...
    'lowpass',     0, ...
    'tranband',    0, ...
    'attenuation', 'strict', ...  % 60dB
    'ver',         '2019', ...  % 2019
    'mirror',      0, ...
    'read_all',    1);
```

Register to receive today's material

- Register to receive course/demo materials
  - [We don't have time to cover all items]
- Add your feedback about Brainstorm and shape future sessions—share your thoughts!

https://docs.google.com/spreadsheets/d/1Lol_O5XTVMPvxkSZcvbfqsRW7as_UgeWFH5PSAnFFKU/edit?usp=sharing