Welcome!

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

Brainstorm Workshop
19 March 2025, Toulouse, France.

"Quantitative SEEG analysis for epilepsy"

Agenda

- **AM Session: [10:00 to 12:30]**
  - **Lecture (~1h)**
    - Overview of the Brainstorm software
    - Background on sEEG modeling
    - Presentation of the case study
  - **Coffee Break (~15min)**
  - **Hands-on with the Software (~1h15)**
    - Introduction to the interface
    - Importing and processing anatomical data
    - sEEG contact localization and labeling
    - Reviewing and processing sEEG recordings
- **Lunch Break: [12:30 to 1:30]**
- **PM Session: [~1:30 to ~4:00] (~2h30)**
  - **Hands-on with the Software**
    - Importing a precomputed protocol
    - Analyzing sEEG data at the sensor level
    - Analyzing sEEG data at the source level
- **Objective:**
  - Demonstrating Brainstorm's features and how it can be used for SEEG analysis in epilepsy.

Brainstorm team today

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Event Organizer

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Concordia


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This software was generated primarily with support from the National Institutes of Health (**NIH**) under grants **R01-EB026299**, **2R01-EB009048**, **R01-EB009048**, **R01-EB002010** and **R01-EB000473**.

Brainstorm

UTH Collaborators (sEEG case study)

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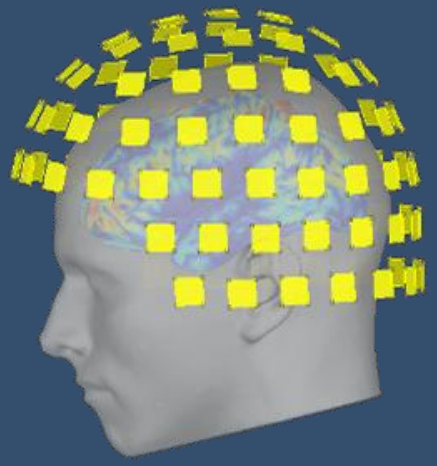
Brainstorm

Brainstorm

http://neuroimage.usc.edu/brainstorm



Takfarinas MEDANI

Research Scientist

Brainstorm team (USC)

University of Southern California

March 2025

let's start with a quick poll!

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

- **Are you currently using Brainstorm software?**
  - If Yes : Raise your hand

let's start with a quick poll!

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

- Are you currently using Brainstorm software?
  - If Yes : Raise your hand

- **For those who aren't using it… yet, are you aware of Brainstorm and its applications?“**
  - If Yes : Raise your hand

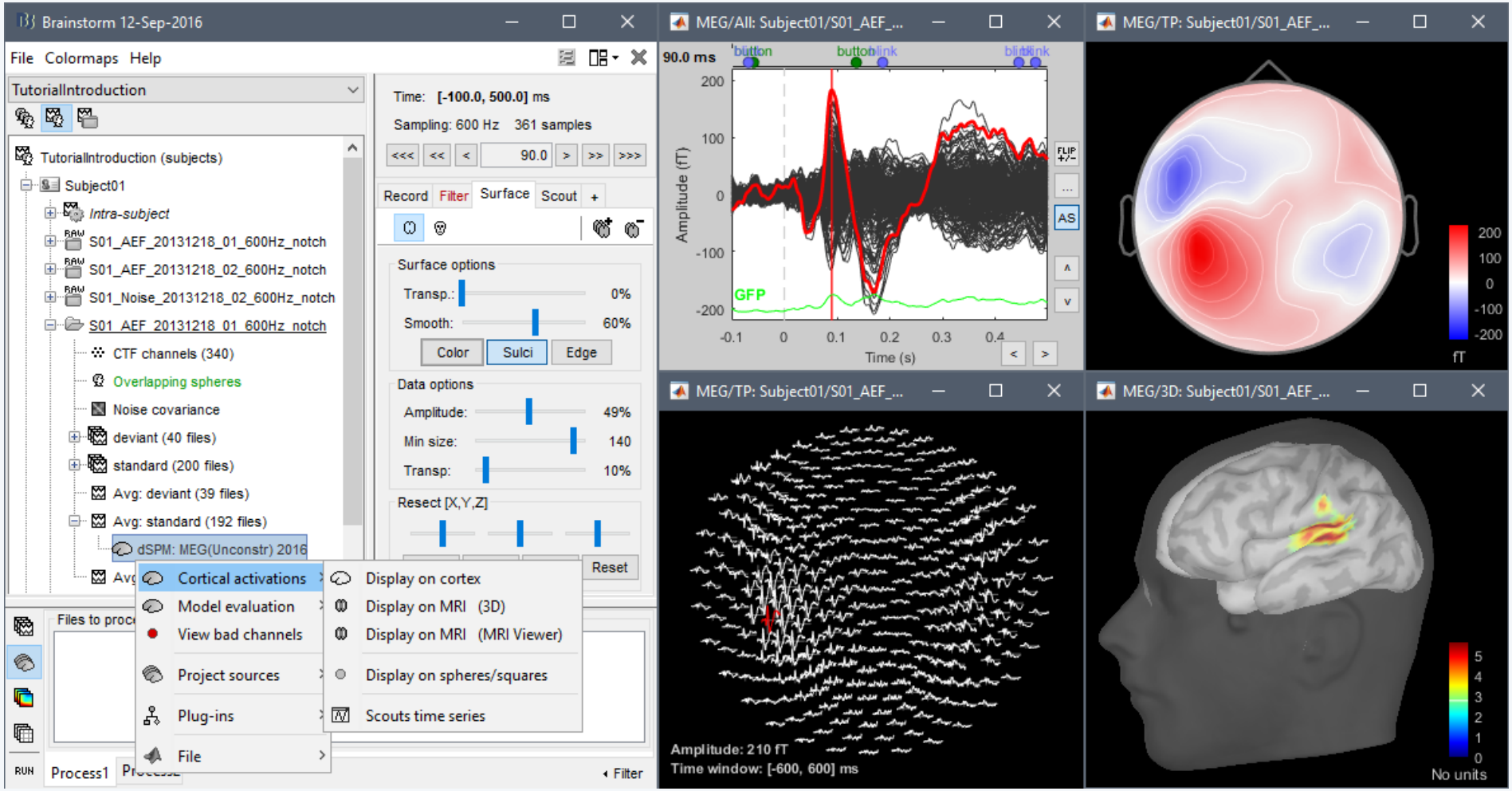
Outline

- 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 Workshop

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, …]

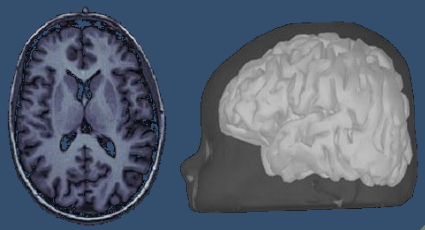
Graphic interface



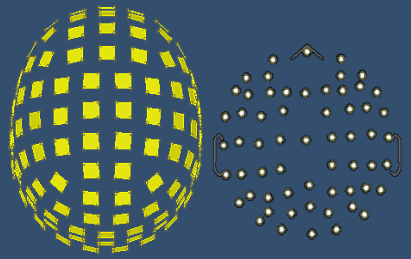
Brainstorm

Workflow

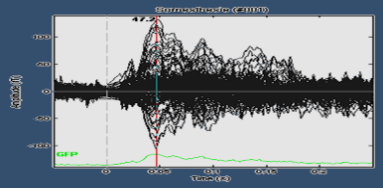
Anatomy



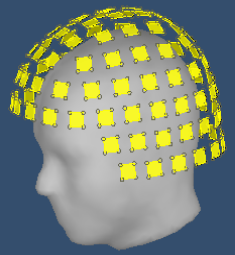
Sensors



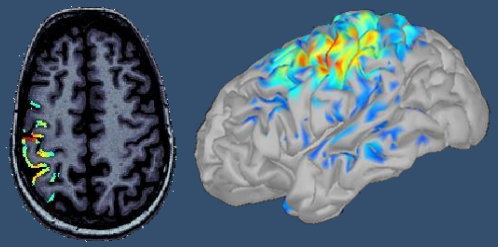
EPhys



Co-registration



Source estimation



Analysis

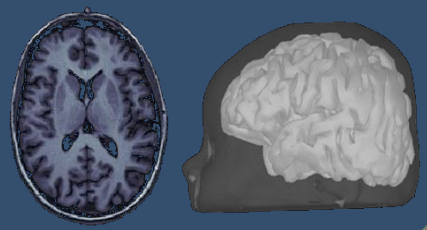
Averages
Statistics
Group analysis
Time-frequency
Connectivity
....

Workflow

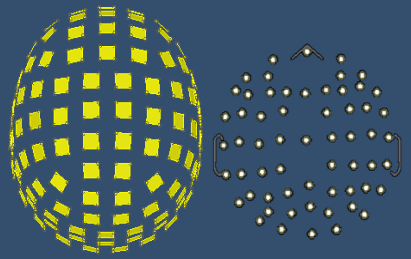
MRI, CT, DWI,

EEG, MEG, iEEG

Anatomy



Sensors



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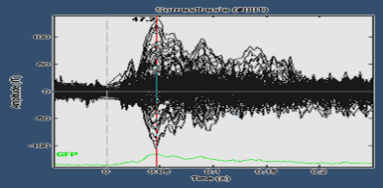
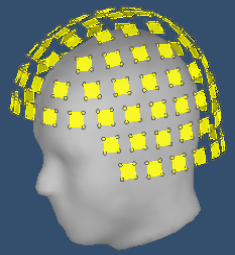
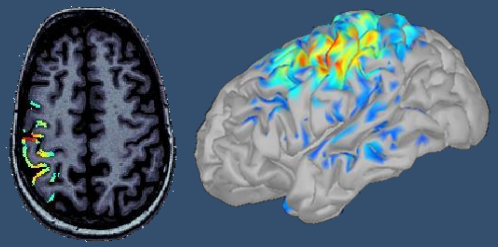


Co-registration



Source estimation



Analysis

Averages
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Connectivity
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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

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Analysis of the experimental data

Loop:
all acquisition runs
all subjects

Single subject → Group Analysis

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Analysis of the experimental data

Loop:
all acquisition runs
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Similar workflow for most modalities: EEG, MEG, sEEG, fNIRS, etc.

Single subject → Group Analysis

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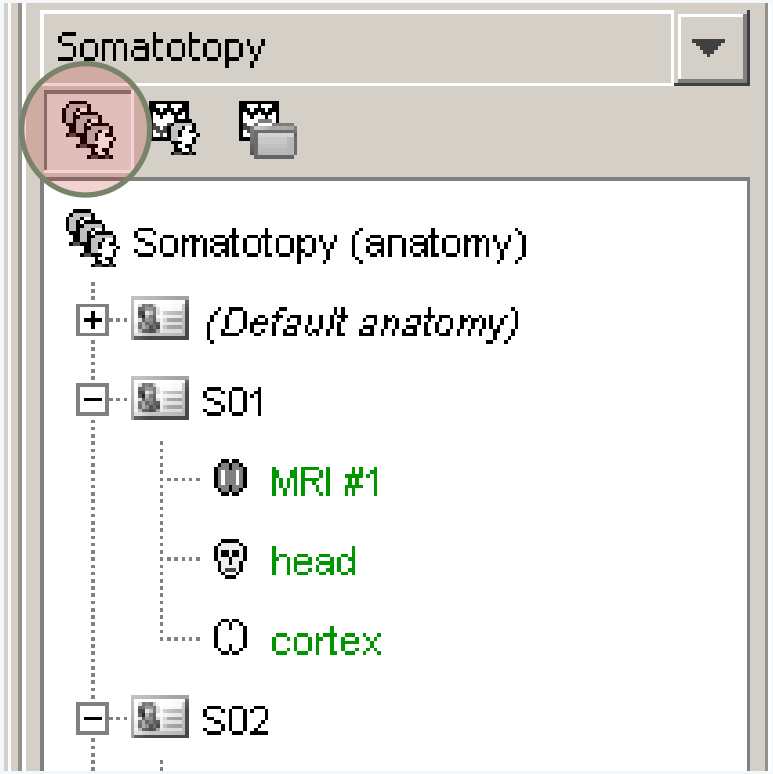
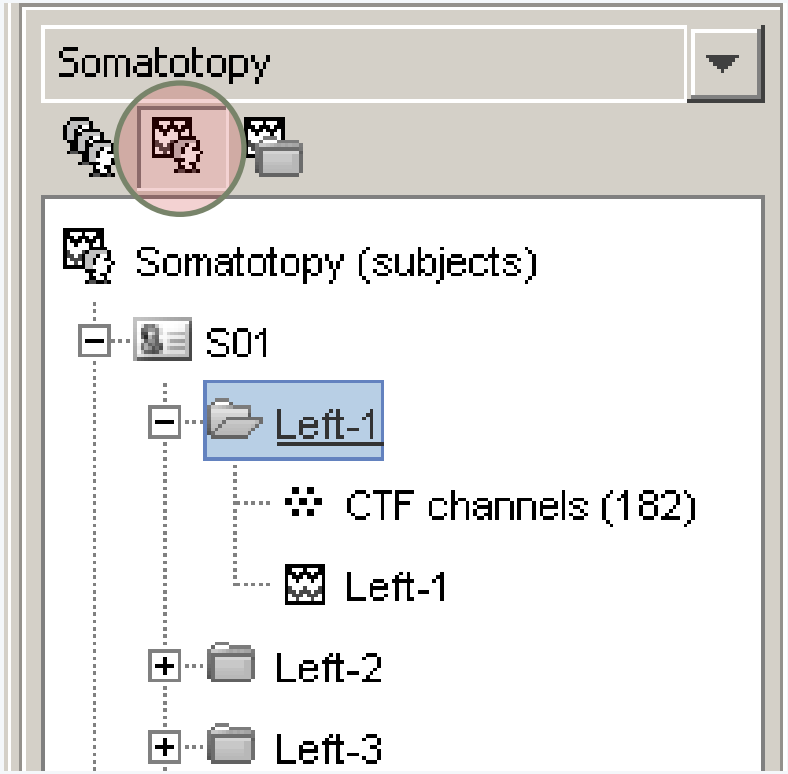
Similar workflow for most modalities: EEG, MEG, sEEG, fNIRS, etc.

Database





- Three levels:
  - Protocol
  - Subject
  - Condition

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

Import

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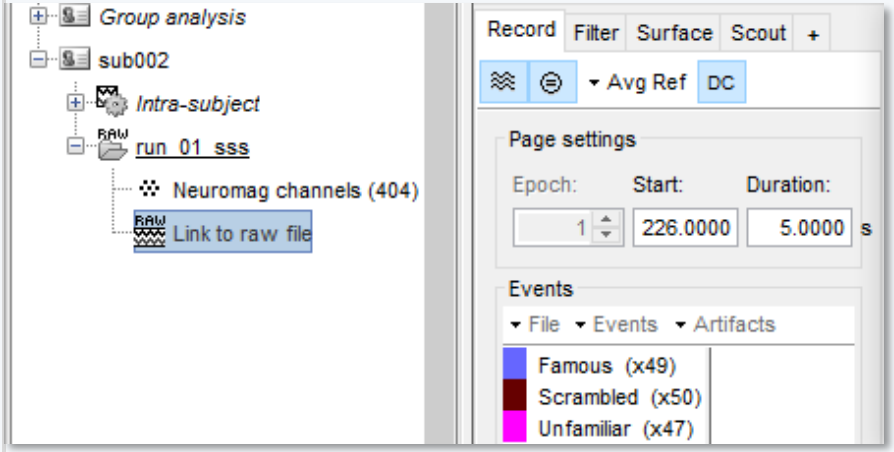
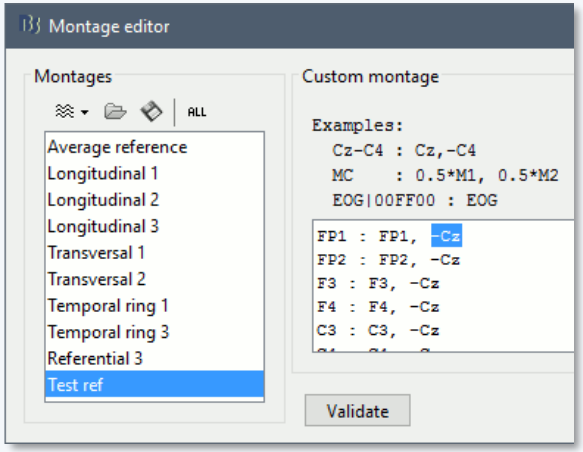
- One-click import of the T1 raw or segmentation: FreeSurfer, BrainSuite, BrainVISA, CIVET, CAT/SPM
- Import and place fiducials in the MRI

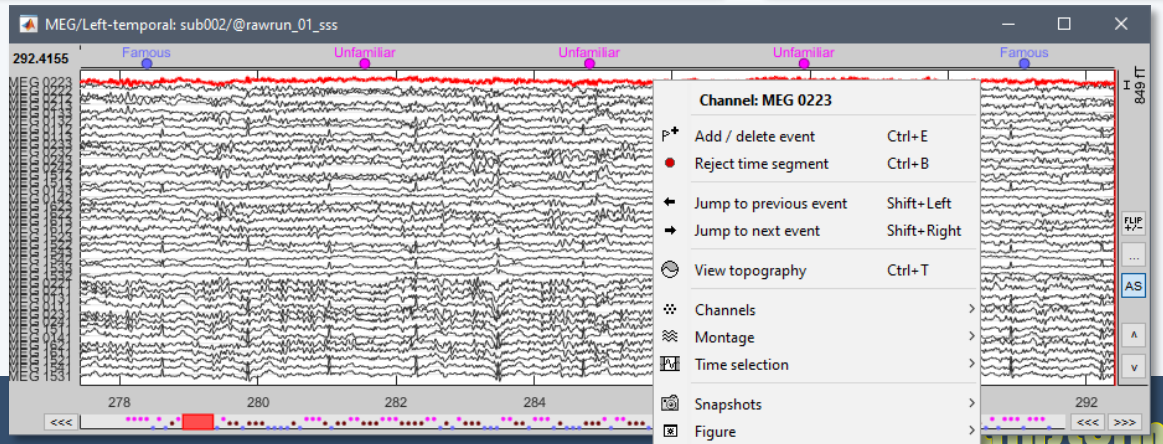
Brainstorm

Import

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

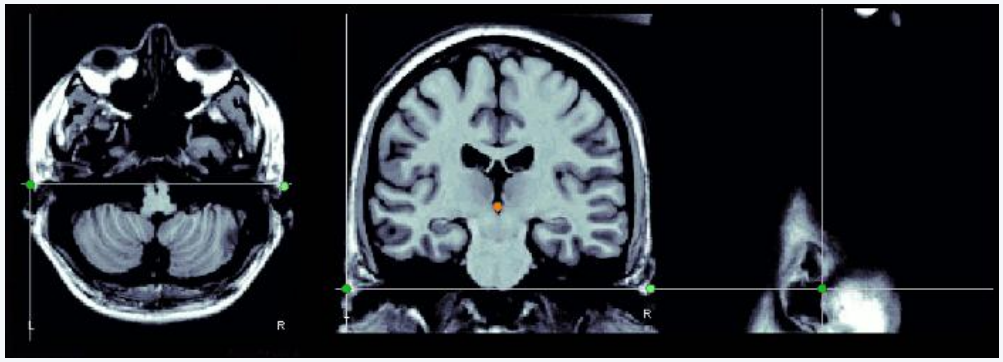






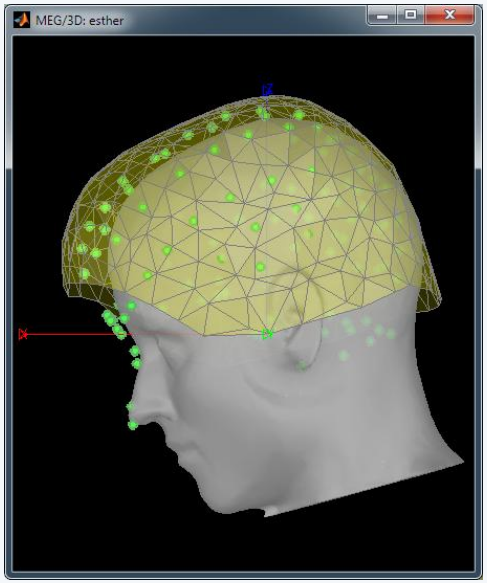
Co-registration MEEG / MRI (1)

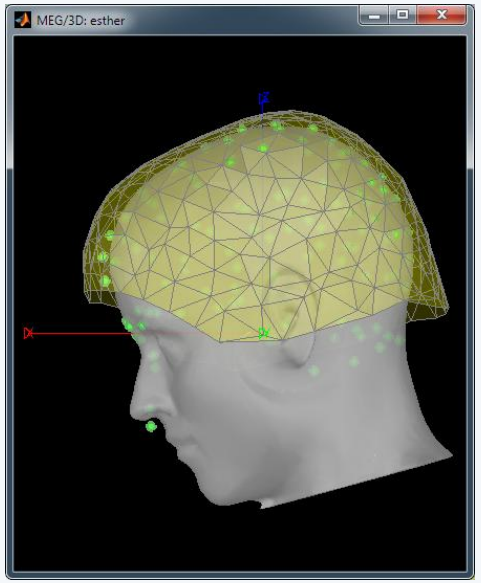
- Basic estimation based on three points:
  Nasion (NAS), Left ear (LPA), Right ear (RPA)
- MRI: Marked in the volume with the MRI Viewer
- MEEG: Obtained with a tracking system
  (Polhemus/FastTrack)



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

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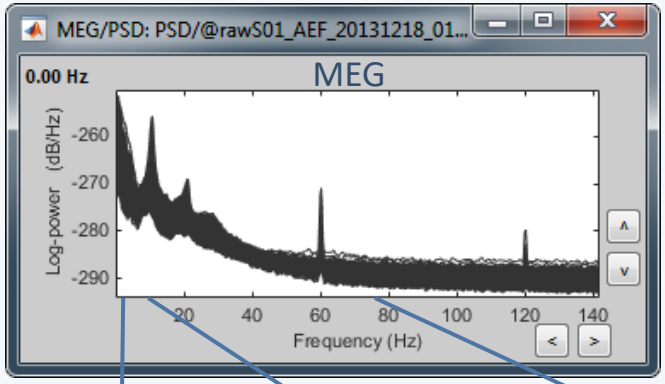
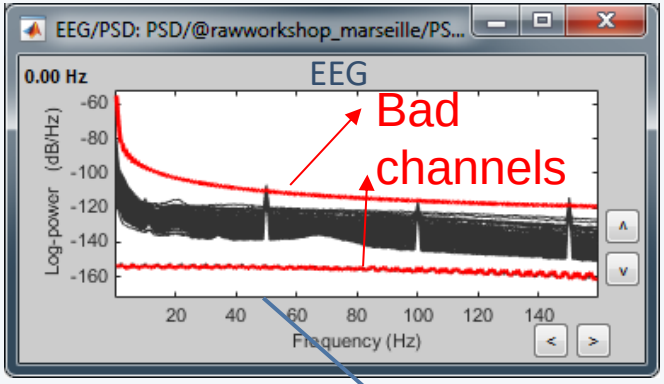
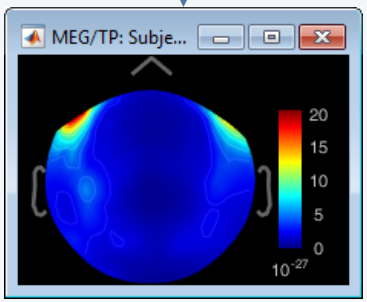
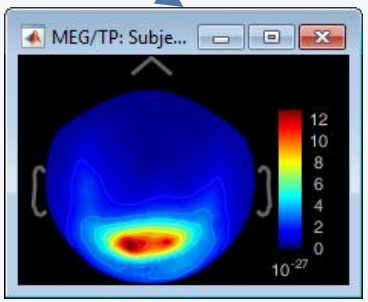
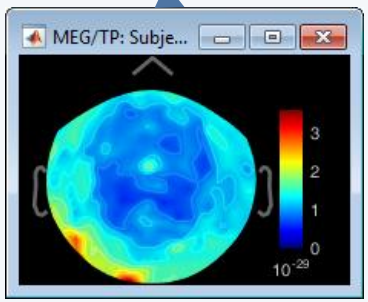
- Power spectrum density for quality control

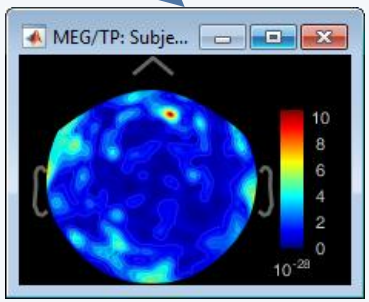












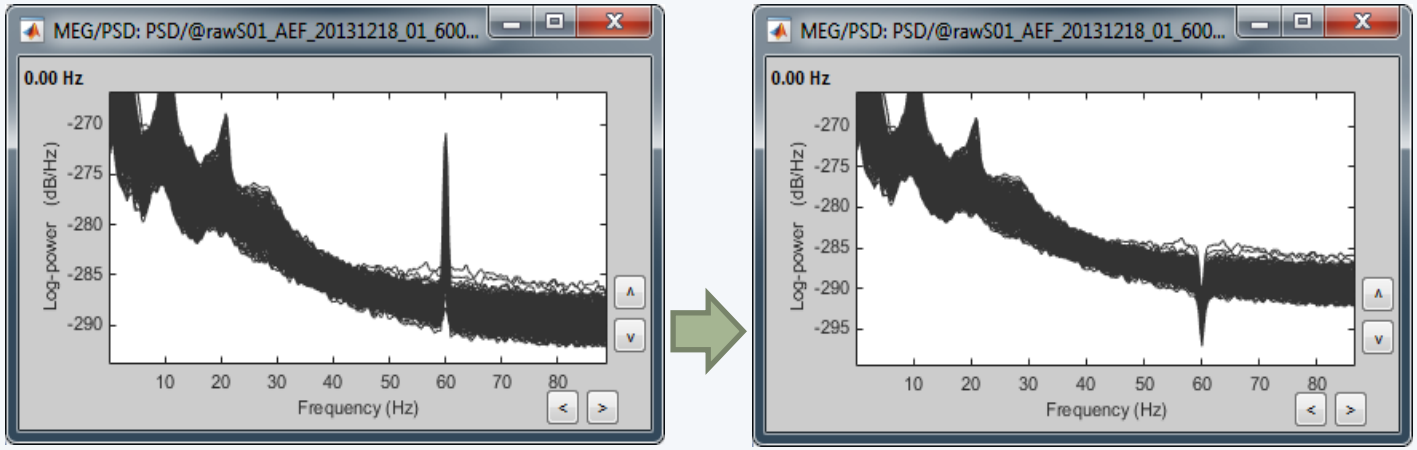
< 3Hz: Eyes | 10Hz: Alpha | > 40Hz: Muscle | 50/60Hz

Brainstorm

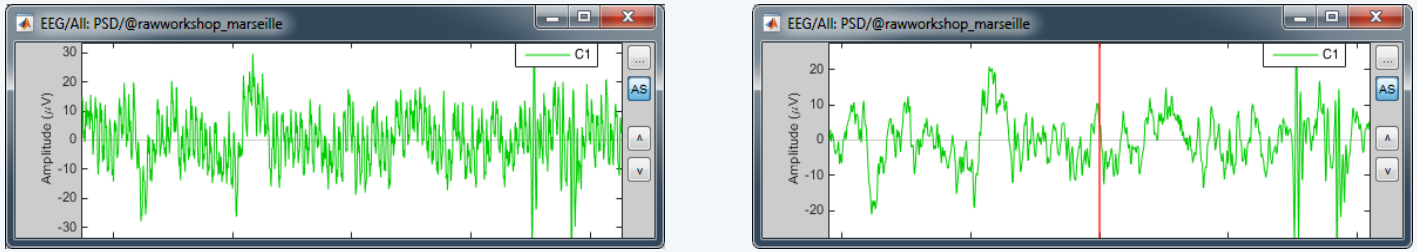
Pre-processing

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

PSD

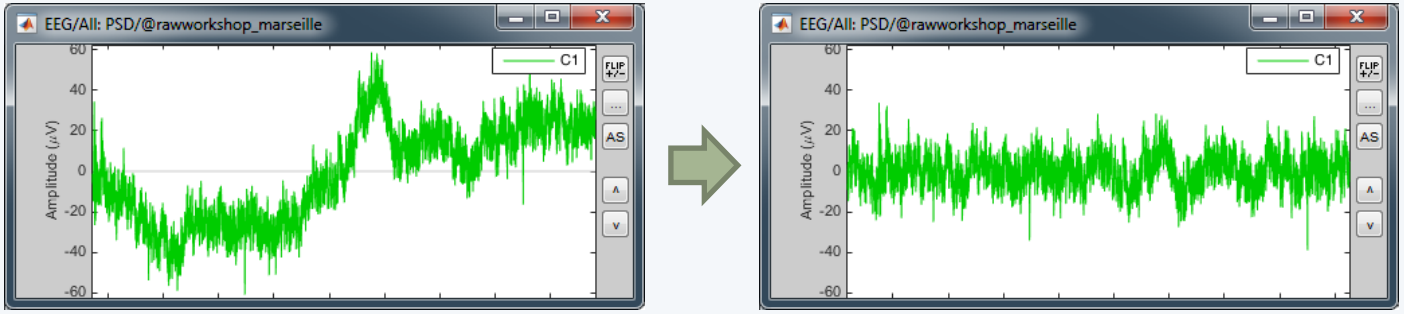


Signal

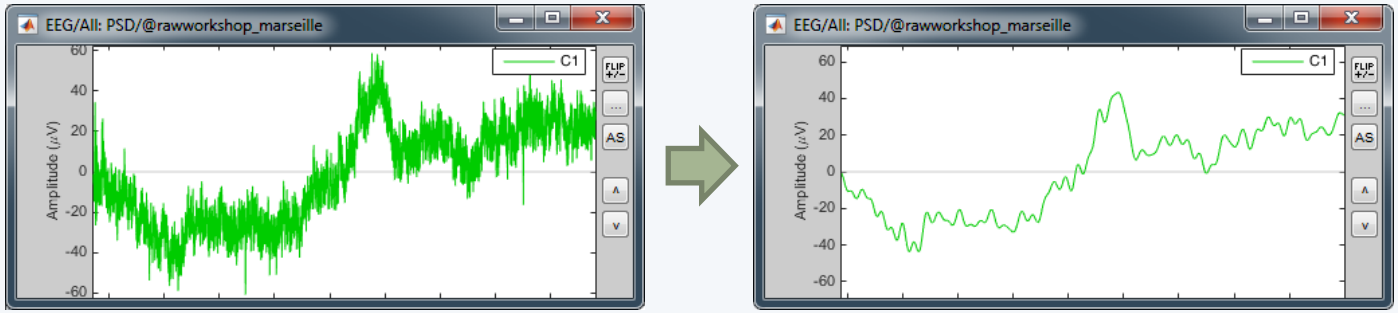


Pre-processing

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



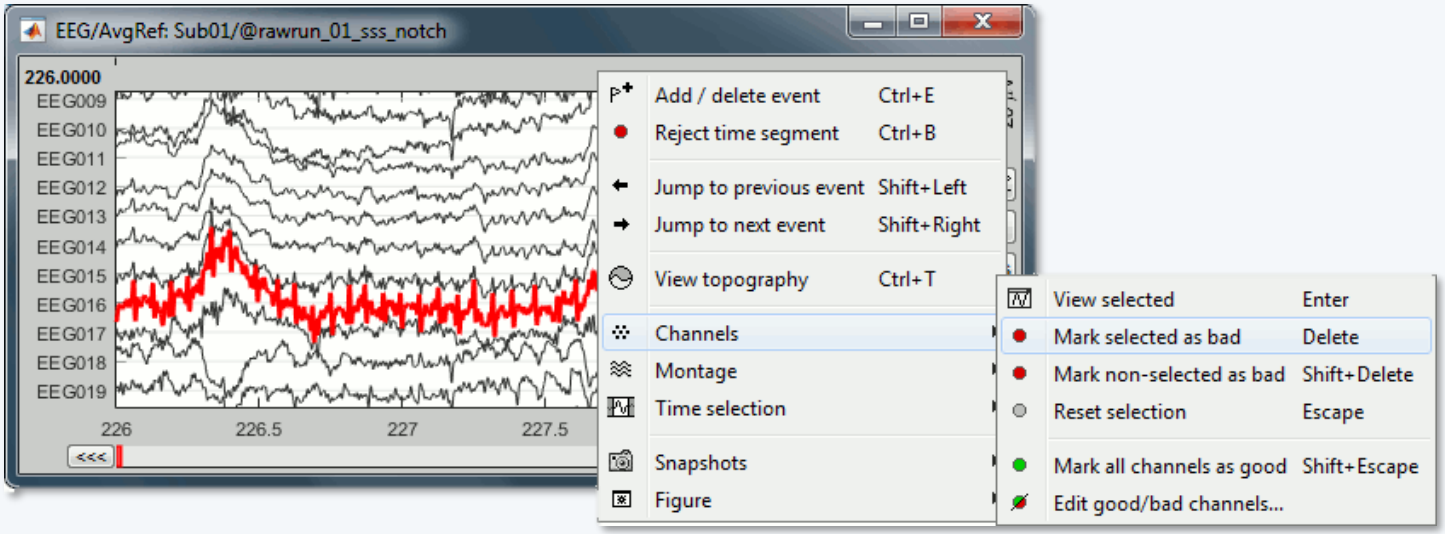
- **Low-pass filter**: Remove high-frequencies components



Brainstorm

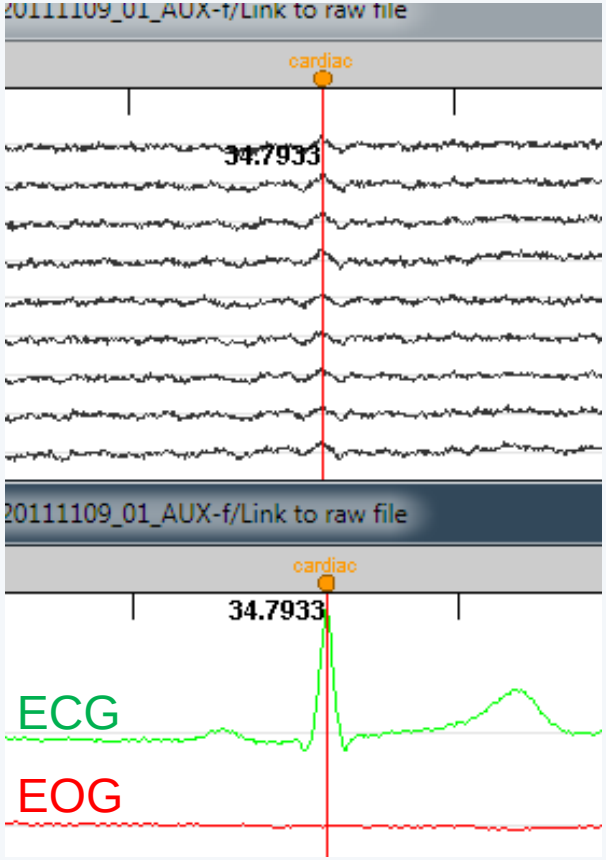
Pre-processing

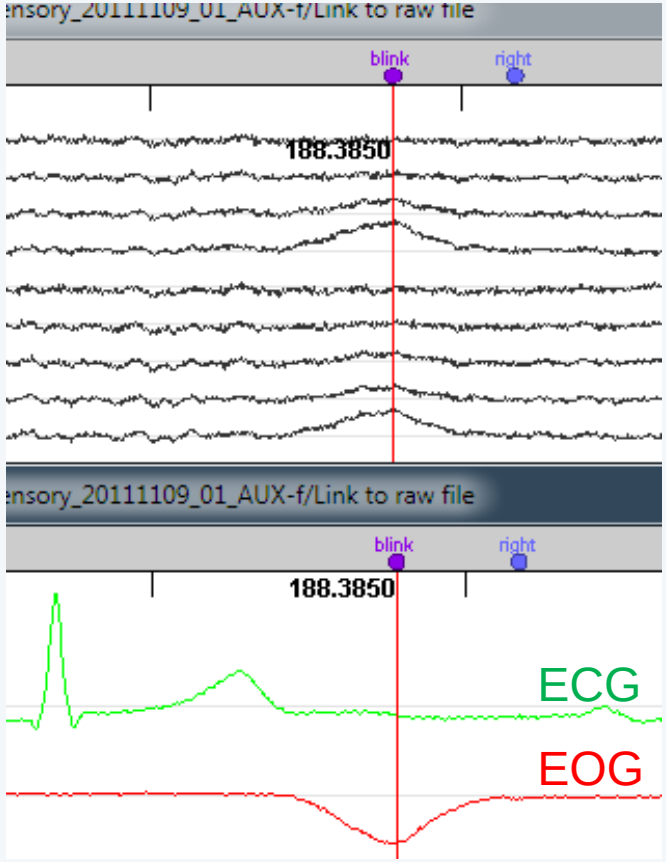
- Manual inspection of the recordings
- Interactive selection of bad channels
- Re-reference the EEG if necessary (Average ref)



Pre-processing

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





Brainstorm

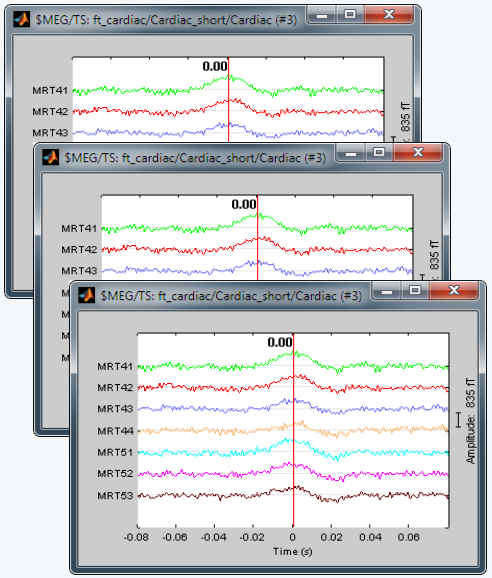
Artifact correction

- 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

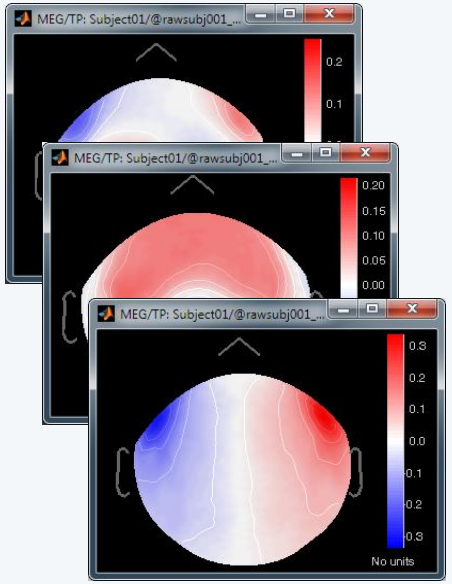
- Correction with Signal Space Projections (SSP)

Detect artifacts



PCA

Spatial components



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

Brainstorm

Pre-processing

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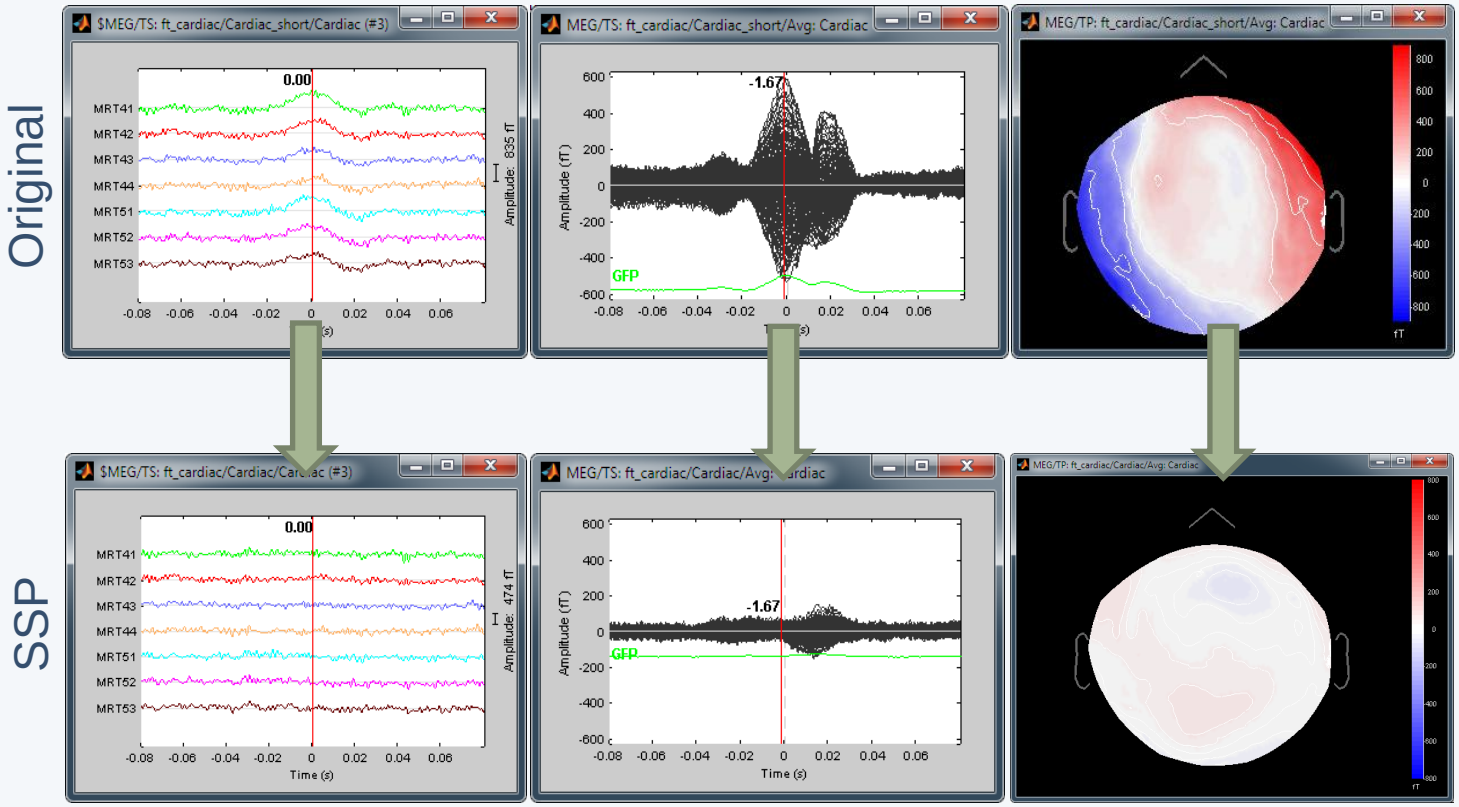
- Example: Cardiac artifact



Brainstorm

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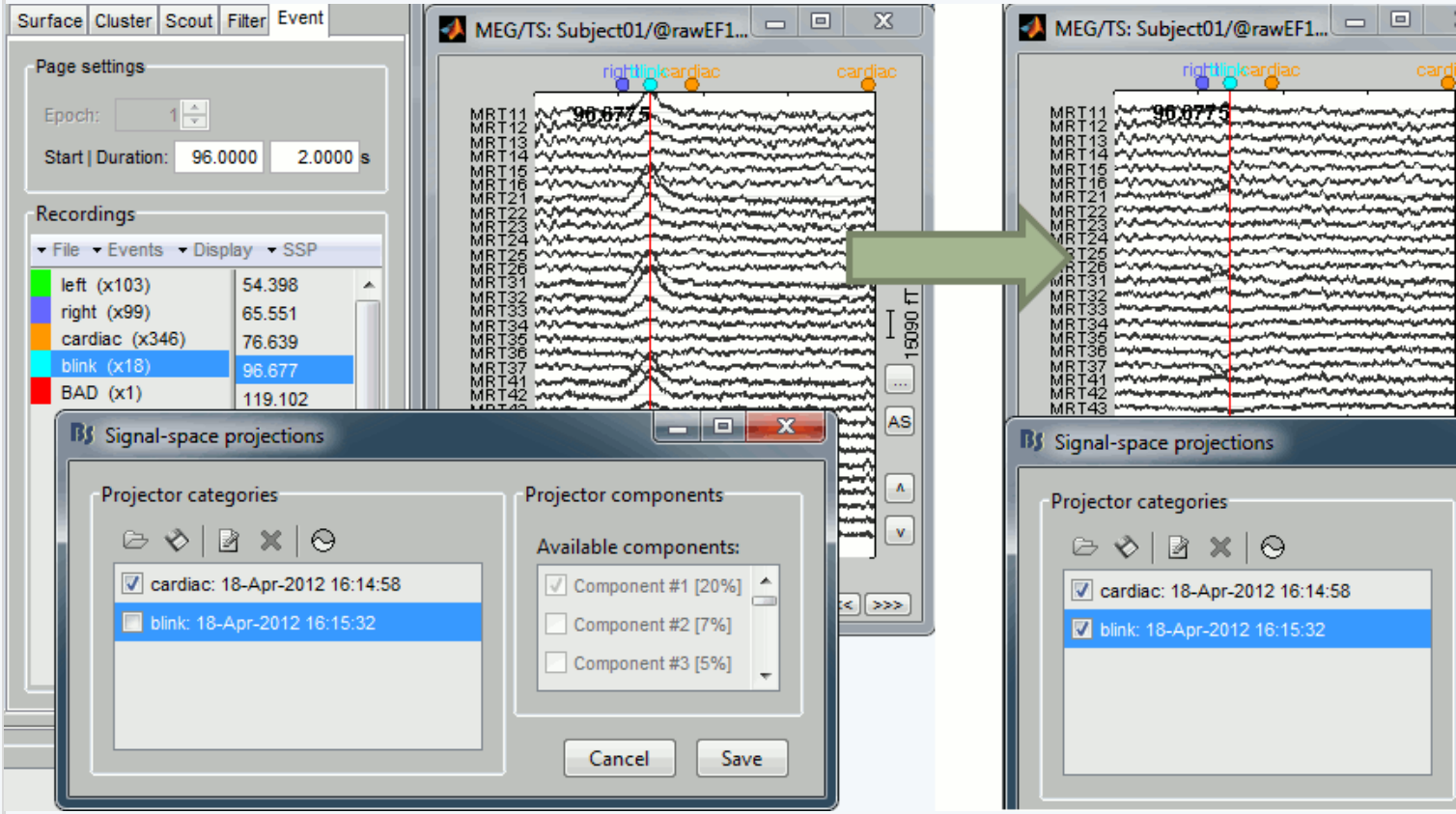
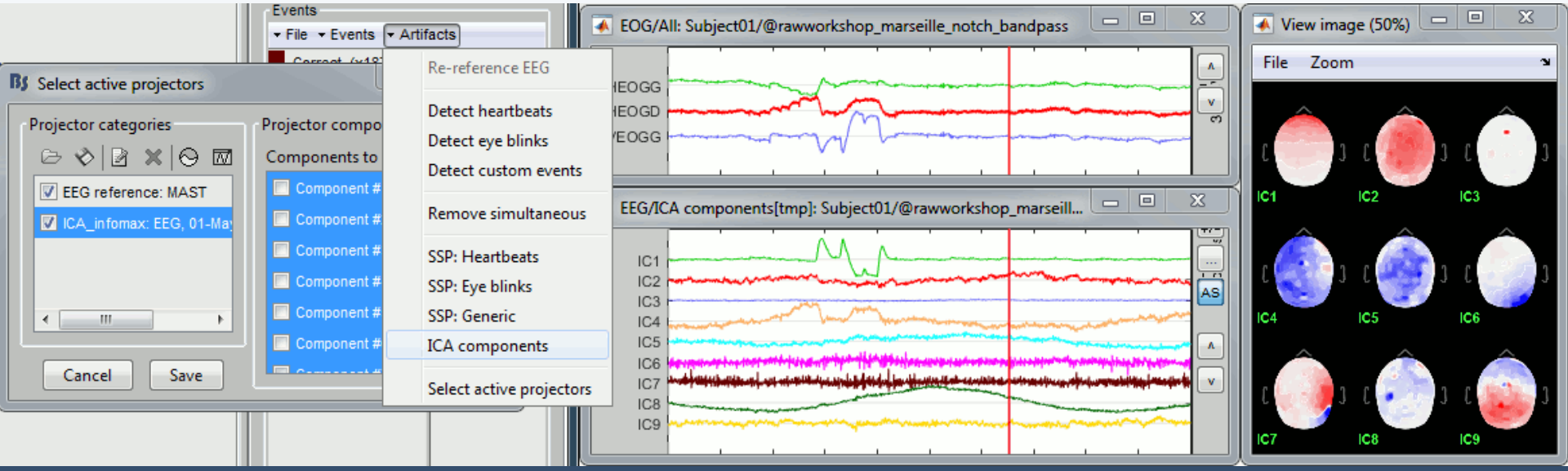
- Example: Blink



Brainstorm

Pre-processing

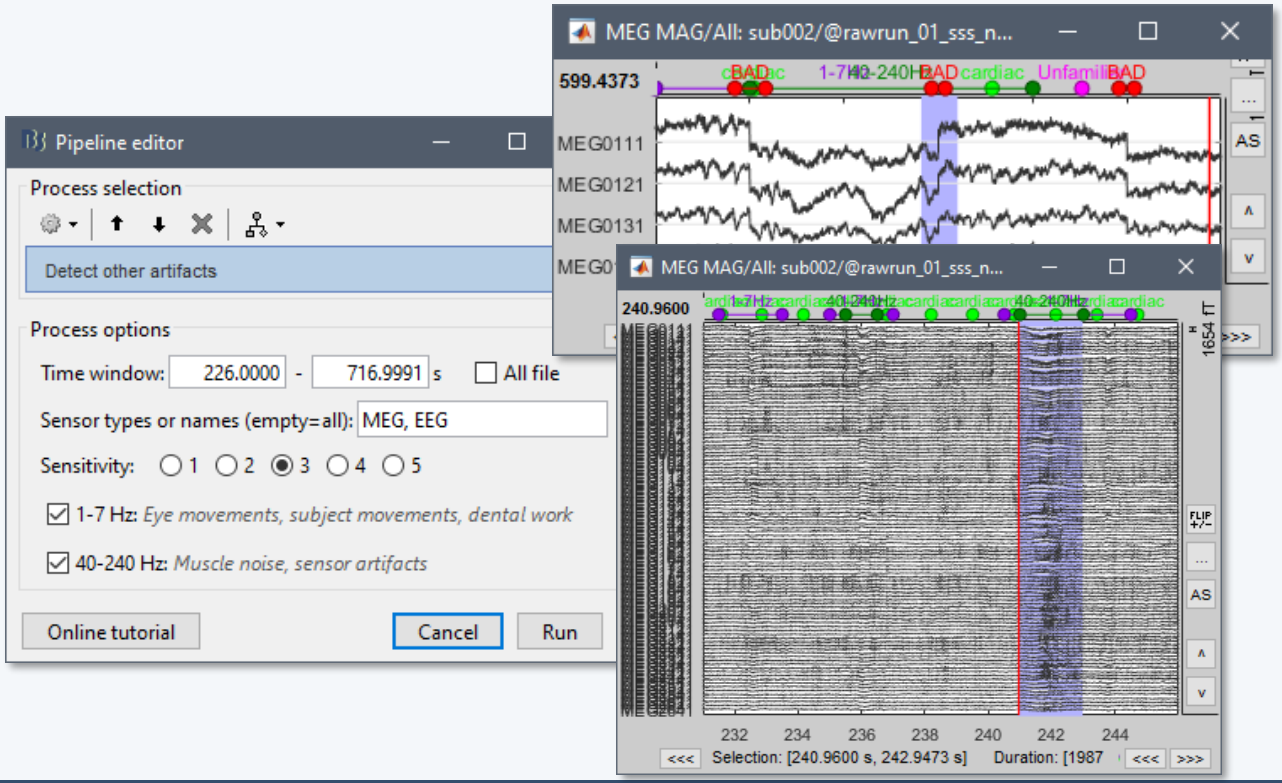
- Independent component analysis (ICA):
  - Popular in the EEG literature
  - Alternative to SSP for low number of sensors
  - Already implemented: Picard, FastICA, Infomax and JADE (EEGLAB)



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

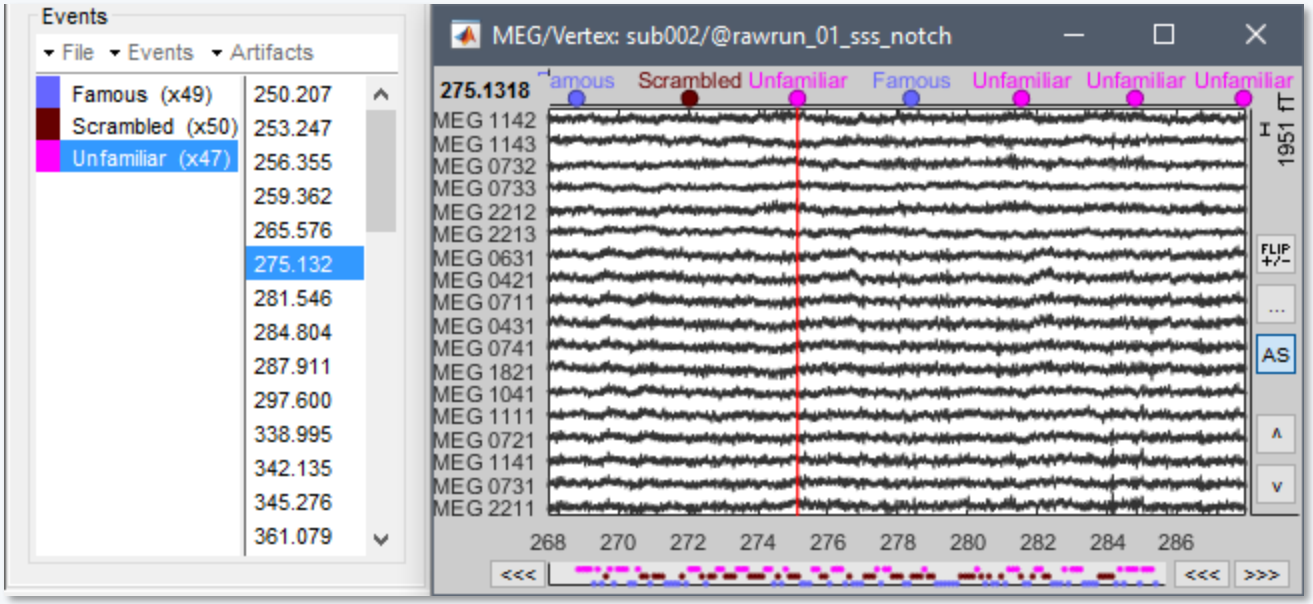


Brainstorm

Epoching

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

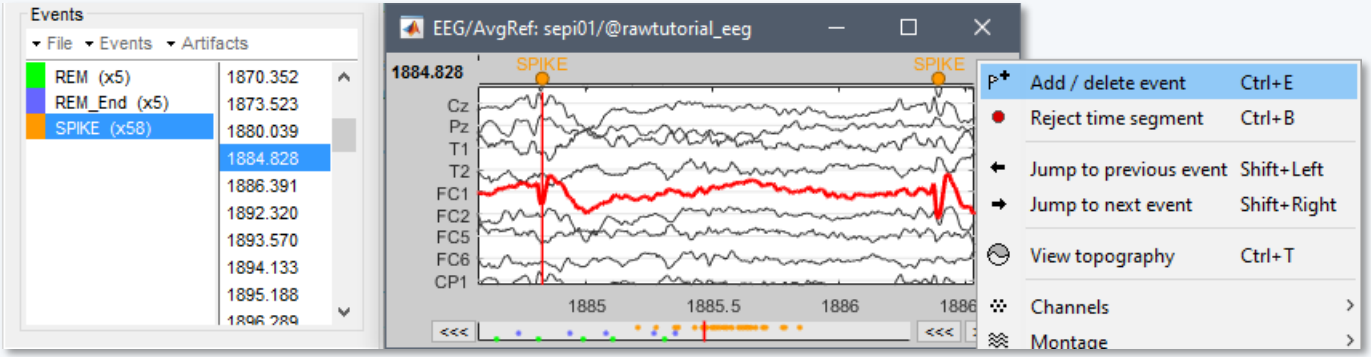
- How to get event markers in the recordings?



Brainstorm

Epoching

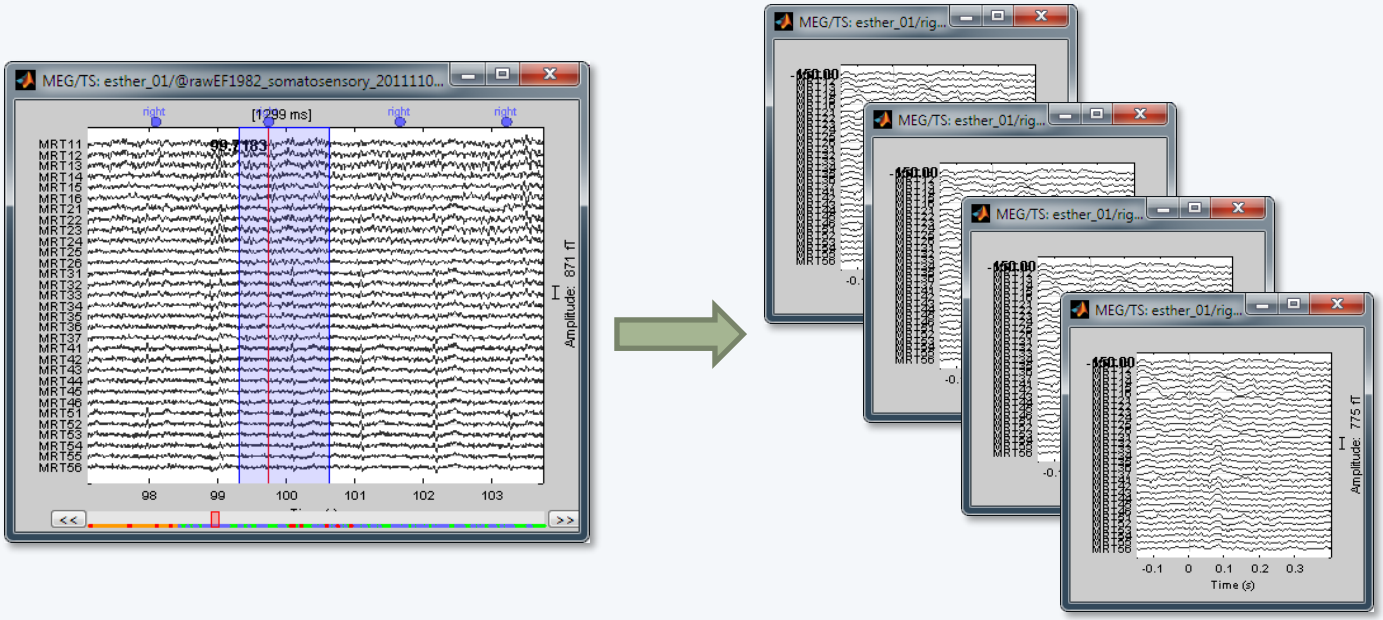
- Reading the triggers save by the presentation software
- Reading information recorded on the subject side (photodiode, microphone, response box)
- **Manual or automatic marking of biological or behavioral events, post-acquisition (*epileptic spikes, sleep spindles*, rat position in a box…)**
- ***Optimized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



Brainstorm

Epoching

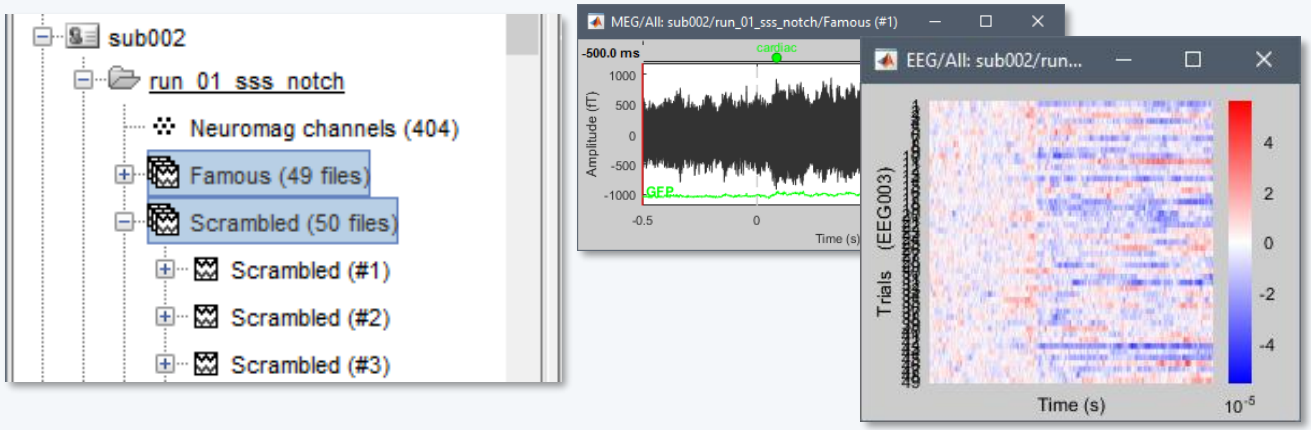
- Epochs = Trials = **Short blocks of recordings around an event of interest.**
- Epoching = Extracting epochs from the continuous recordings and saving them.



Brainstorm

Epoching

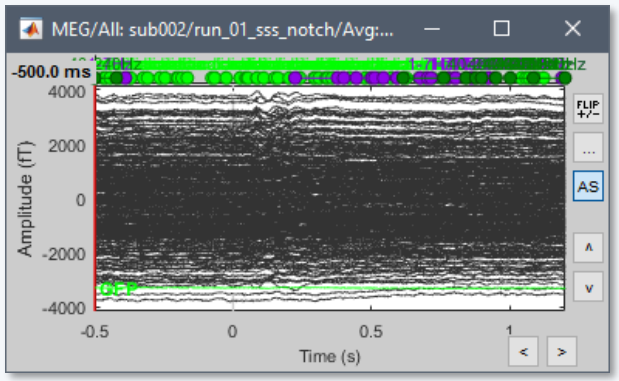
- In Brainstorm, each imported epoch is an independent file in the database.
- Accessible by event type or individually.

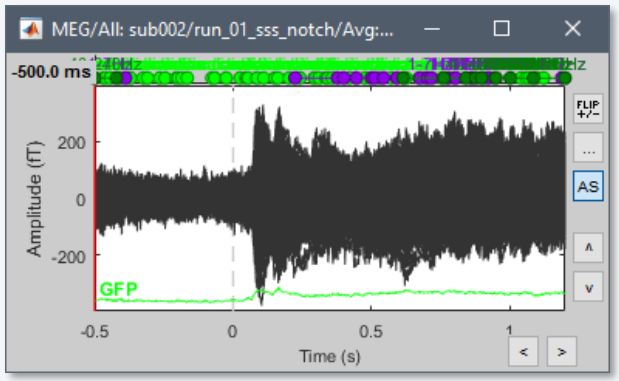


- In other programs, all the epochs from one run are saved in one single file (one file per event type, or one file with all the events).

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

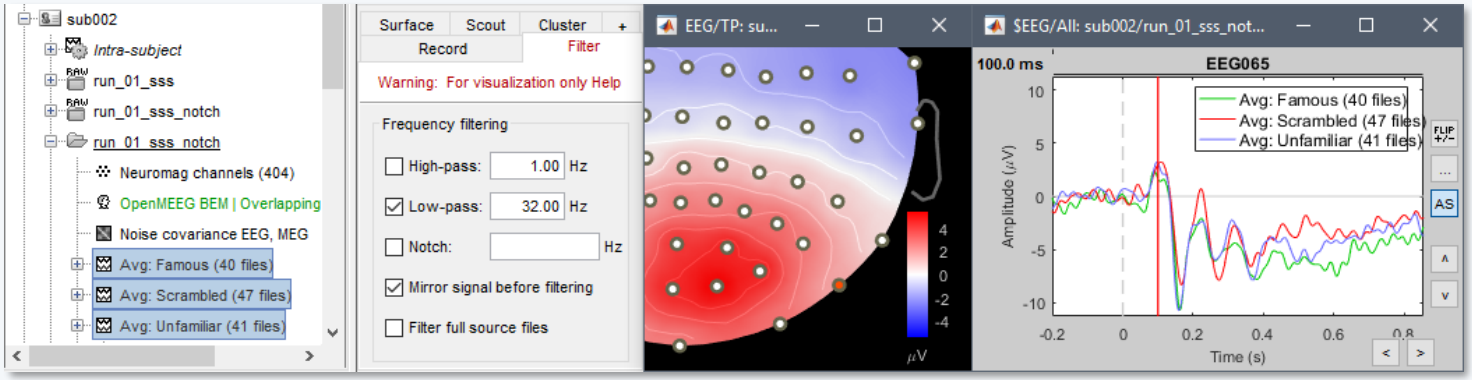
Sensor level analysis

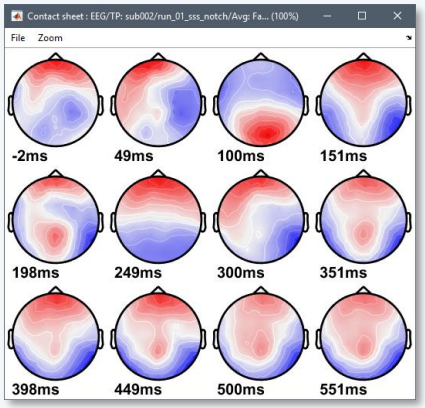
Anatomy
Link recordings
MRI registration

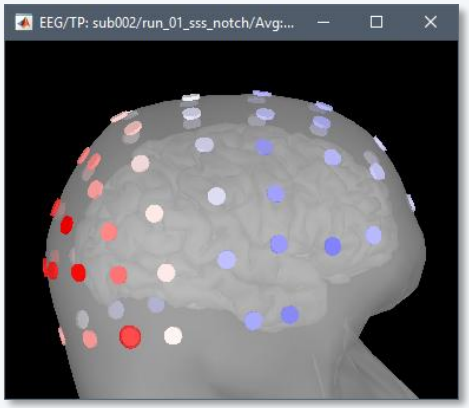
PSD
Filters
Bad channels
Artifacts
Correction
Bad segments

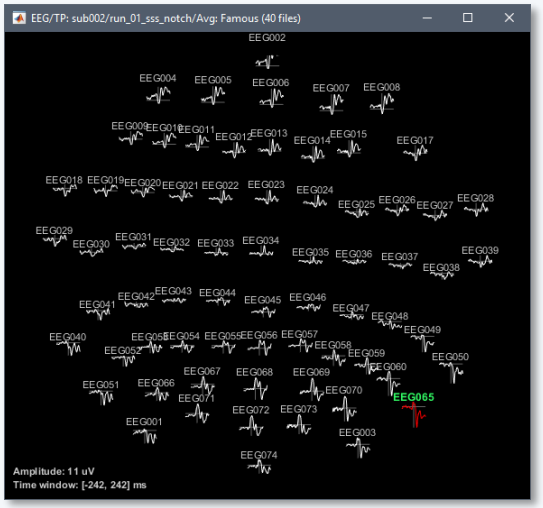
Markers
Epoching
Sensors
Sources
Time-frequency

- ERP & Sensor Cluster









Brainstorm

Sensor level analysis

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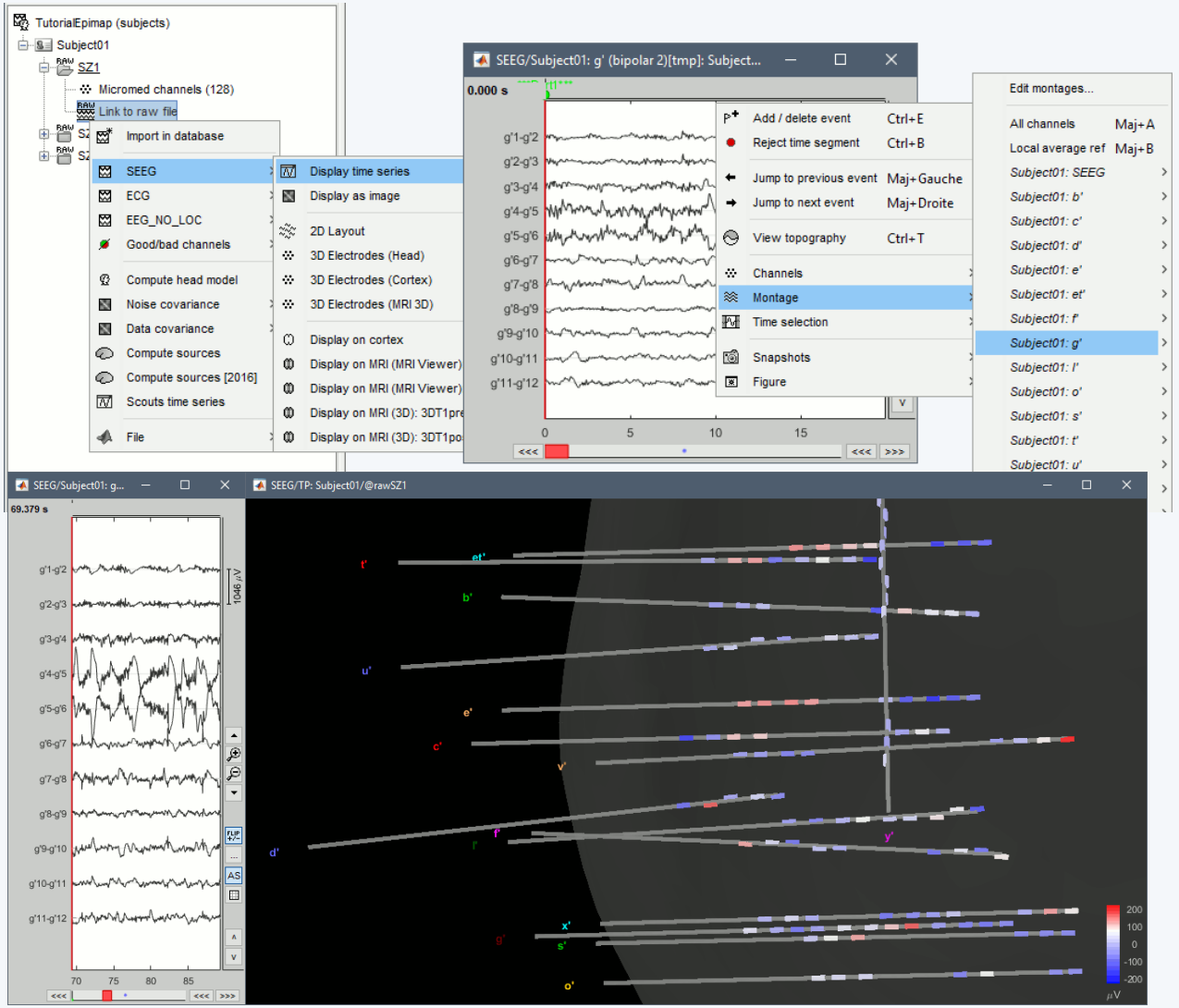
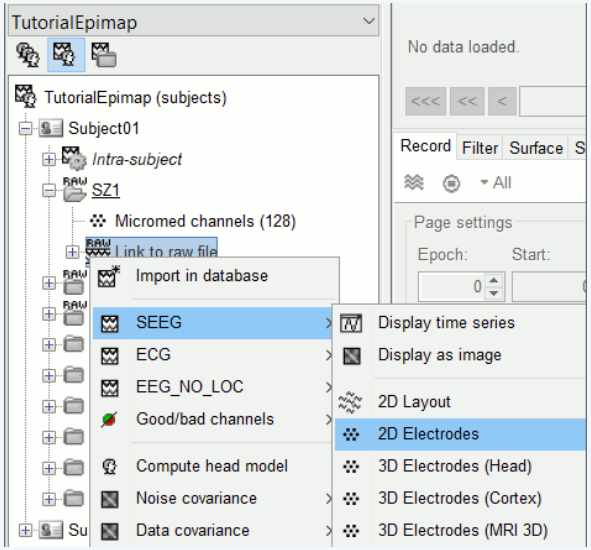
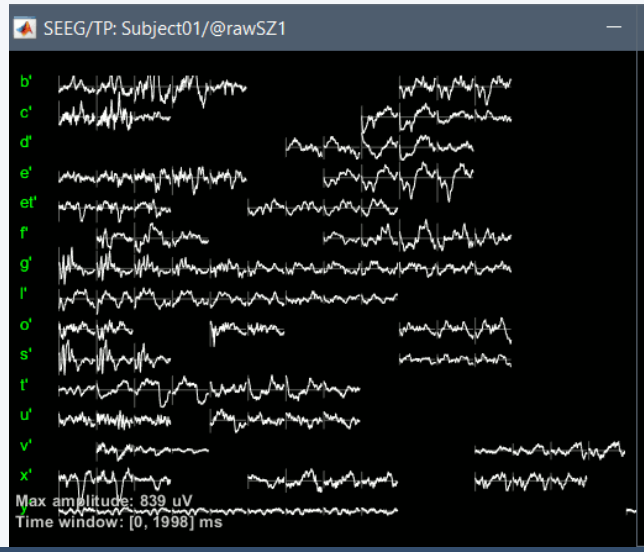
- SEEG time series & Montages

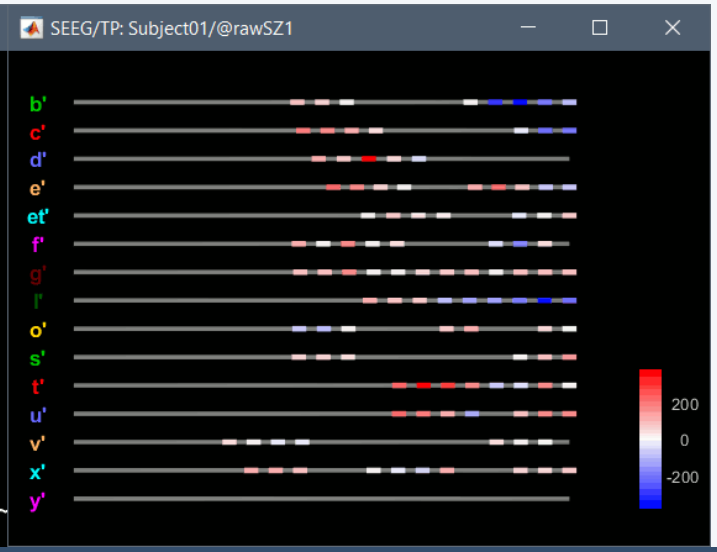


Sensor level analysis

- SEEG time series : 2D topography







Sensor level analysis

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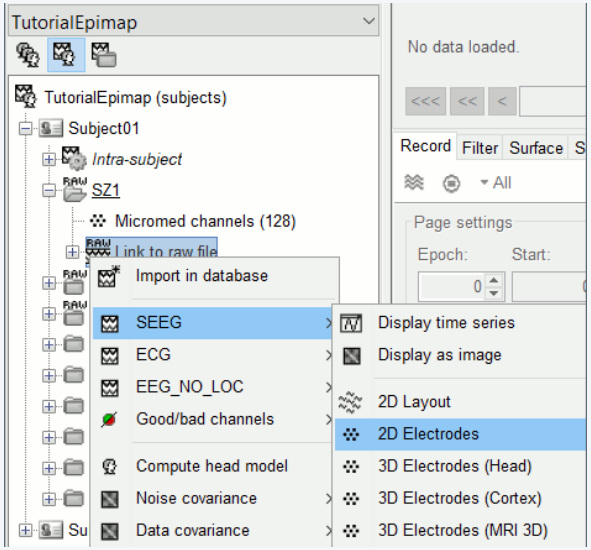
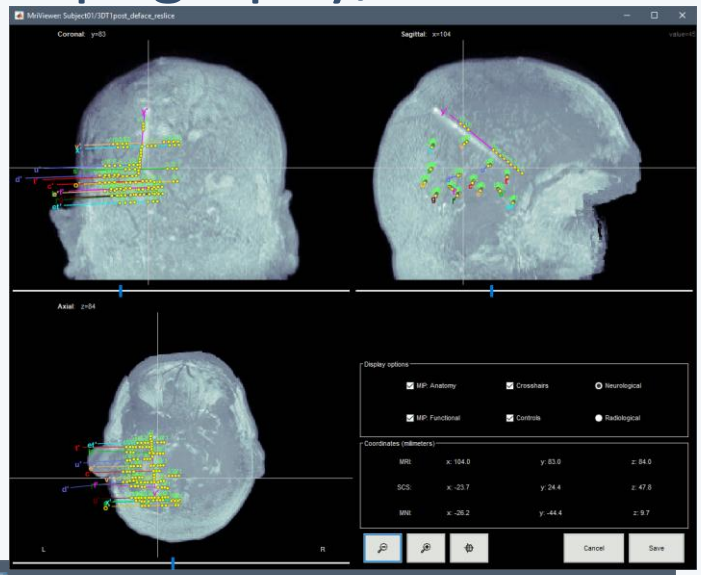
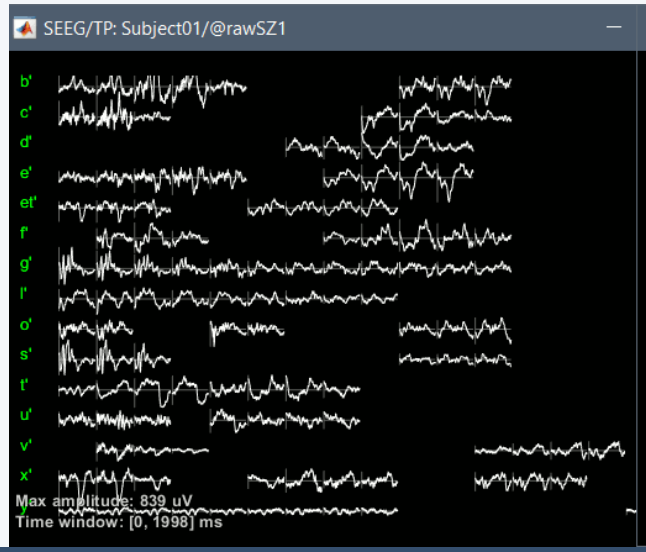
Sensors
Sources
Time-frequency

- SEEG time series : 2D topography/ 3D







Brainstorm

Some references

- Good Coverage is Important!

Epilepsy Research 128 (2016) 68–72

Contents lists available at www.sciencedirect.com

Epilepsy Research

journal homepage: www.elsevier.com/locate/epilepsyres

Short communication

Simultaneous SEEG-MEG-EEG recordings Overcome the SEEG limited spatial sampling

Martine Gavaret[a,b], Anne-Sophie Dubarry[a,c], Romain Carron[a,d], Fabrice Bartolomei[a,b], Agnès Trébuchon[a,b,1], Christian-George Bénar[a,*,1]

NeuroImage 260 (2022) 119438

Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/neuroimage

Advances in human intracranial electroencephalography research, guidelines and good practices

Manuel R. Mercier[a,*], Anne-Sophie Dubarry[b], François Tadel[c], Pietro Avanzini[d], Nikolai Axmacher[e,f], Dillan Cellier[g], Maria Del Vecchio[d], Liberty S. Hamilton[h,i,j], Dora Hermes[k], Michael J. Kahana[l], Robert T. Knight[m], Anais Llorens[n], Pierre Megevand[o], Lucia Melloni[p,q], Kai J. Miller[r], Vitória Piai[s,t], Aina Puce[u], Nick F Ramsey[v], Caspar M. Schwiedrzik[w,x], Sydney E. Smith[y], Arjen Stolk[s,z], Nicole C. Swann[aa], Mariska J Vansteensel[v], Bradley Voytek[g,y,ab,ac], Liang Wang[ad,ae], Jean-Philippe Lachaux[af,1], Robert Oostenveld[s,ag,1]

- Excellent Reference Paper on Good Practices

Brainstorm

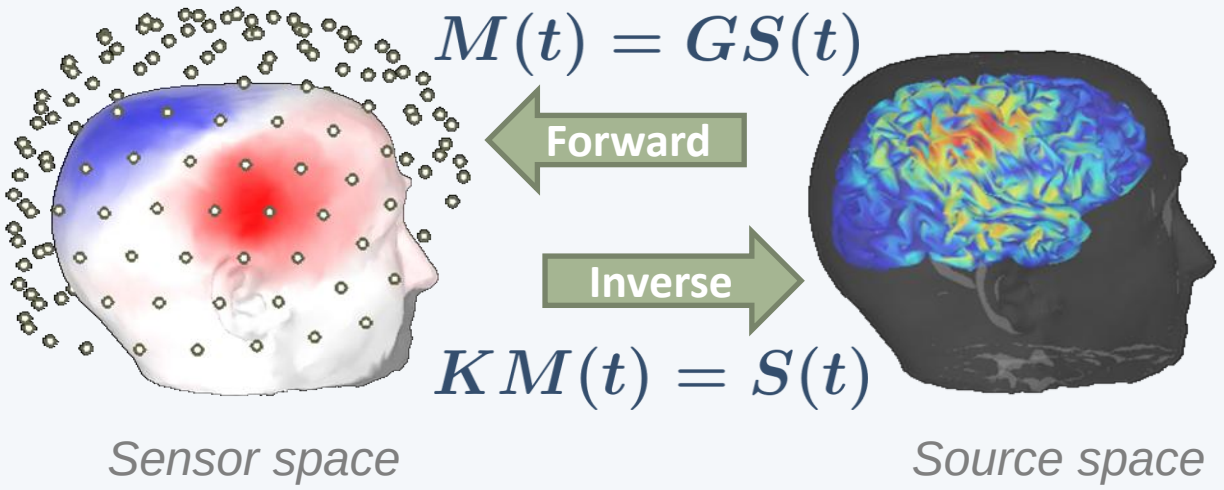
Source Reconstruction

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

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

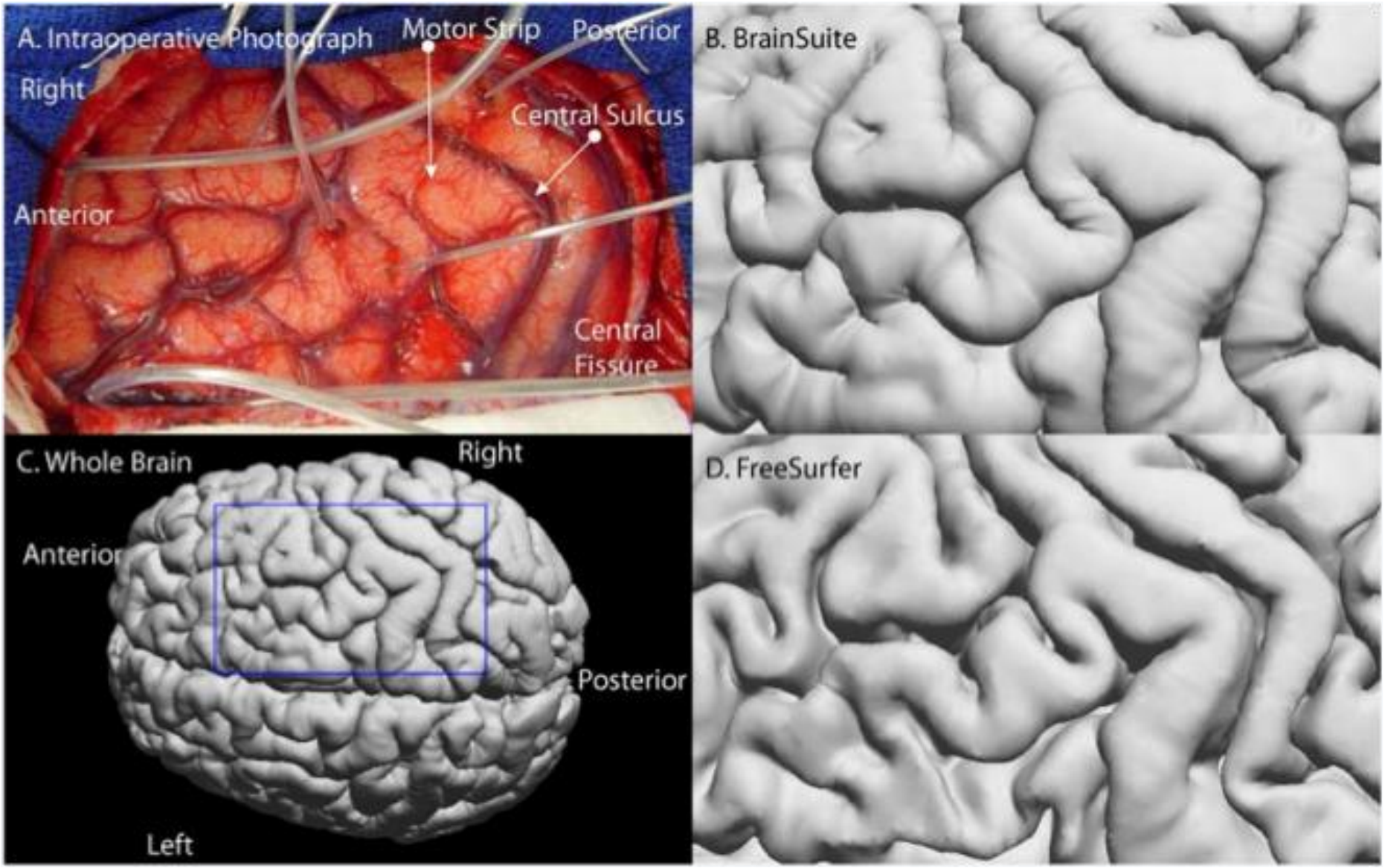
G Forward model: Overlapping spheres (MEG)
OpenMEEG BEM/DUNEuro FEM (EEG)

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

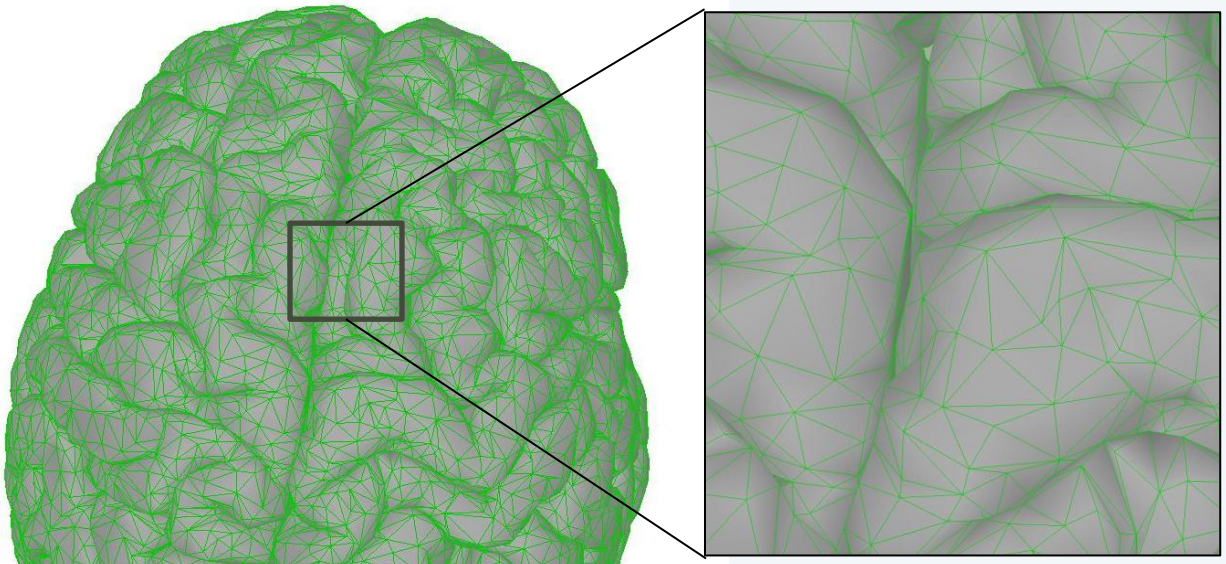


Brainstorm

Source Space: Cortical Surface (MRI Segmentation)



Cortical Surface: Modeling of sources



Thousands of triangles & vertices

~250k labeled vertices spanning 192,152 square mm

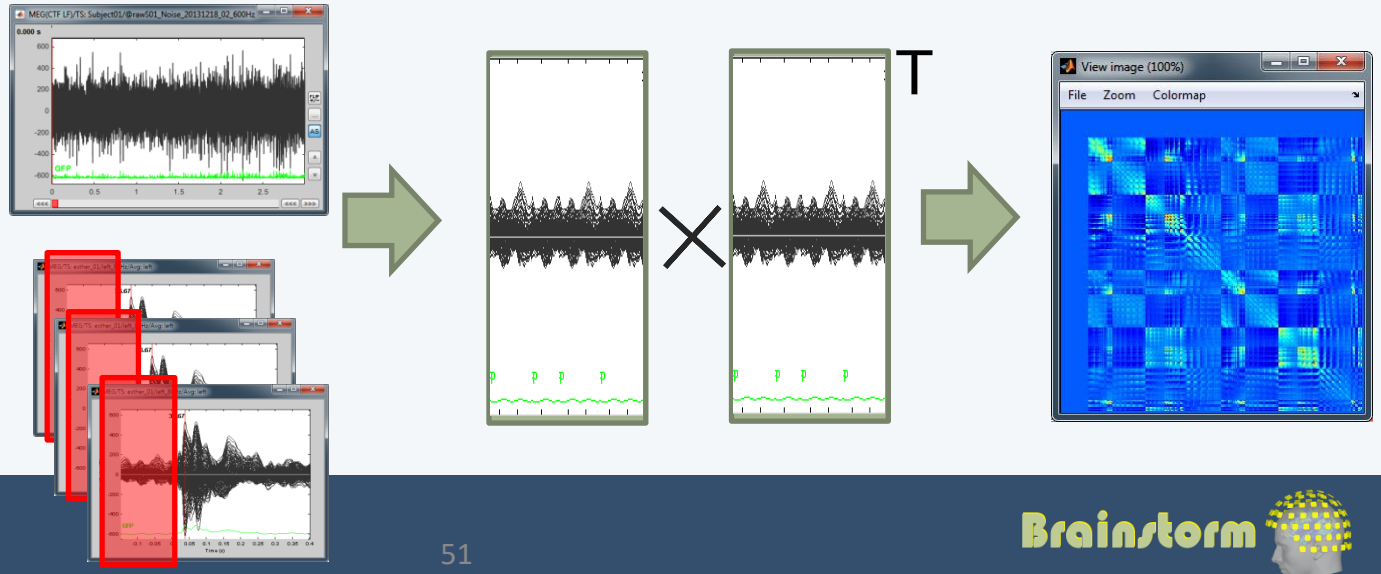
Brainstorm:
15,000 vertex for cortex model

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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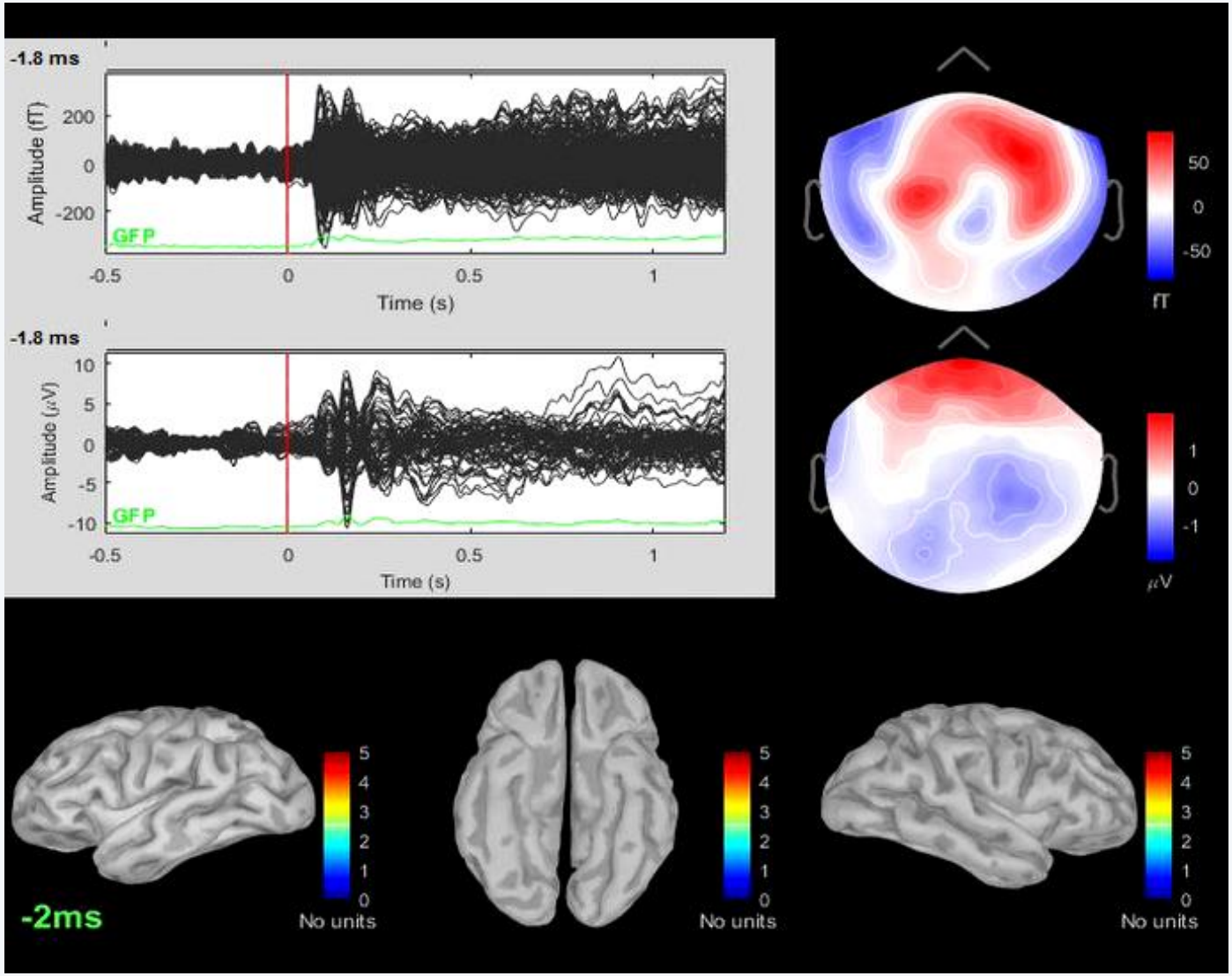
Correction
Bad segments

Markers
Epoching
Averaging
Sources
Time-frequency

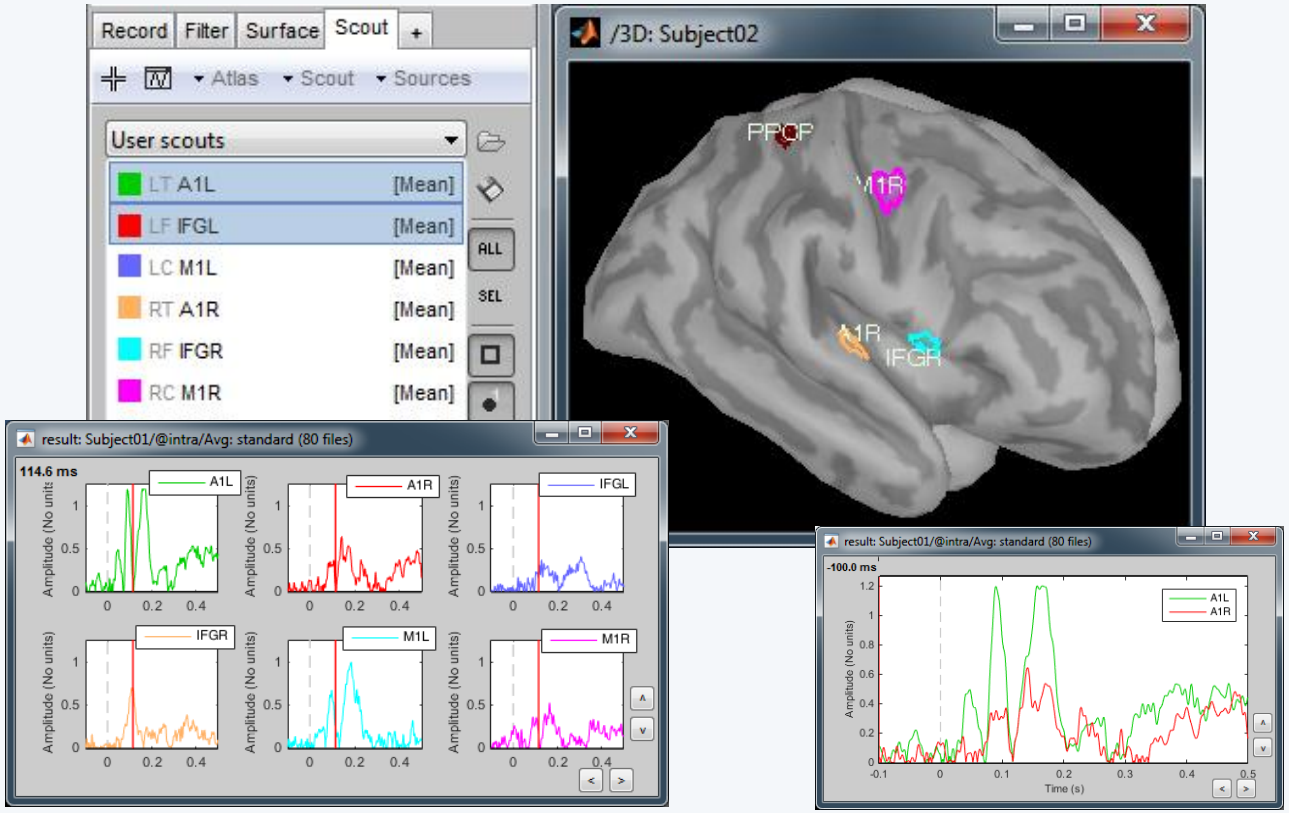
Example: Famous faces



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

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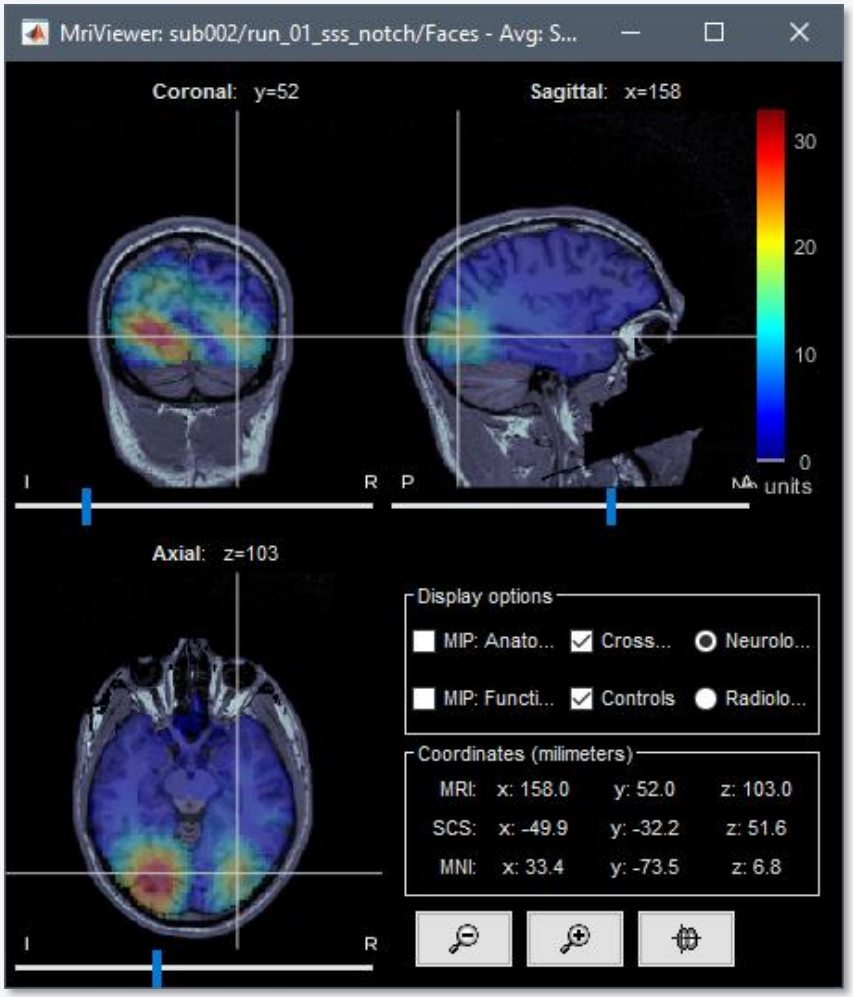
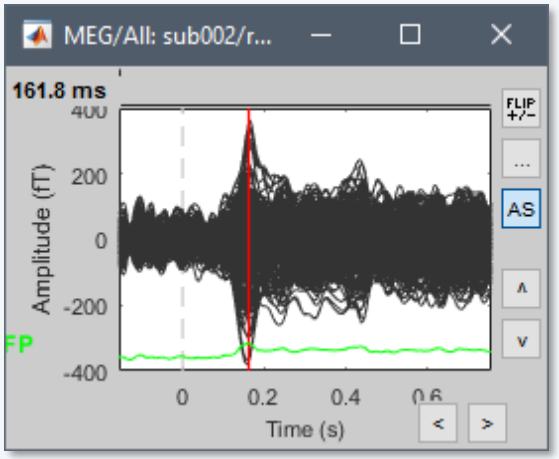
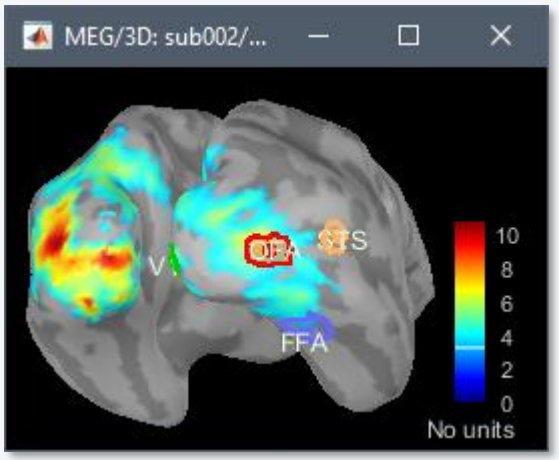
- Volume Source



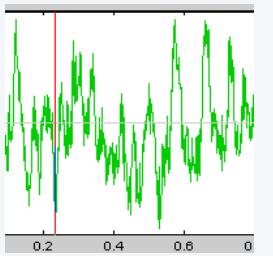


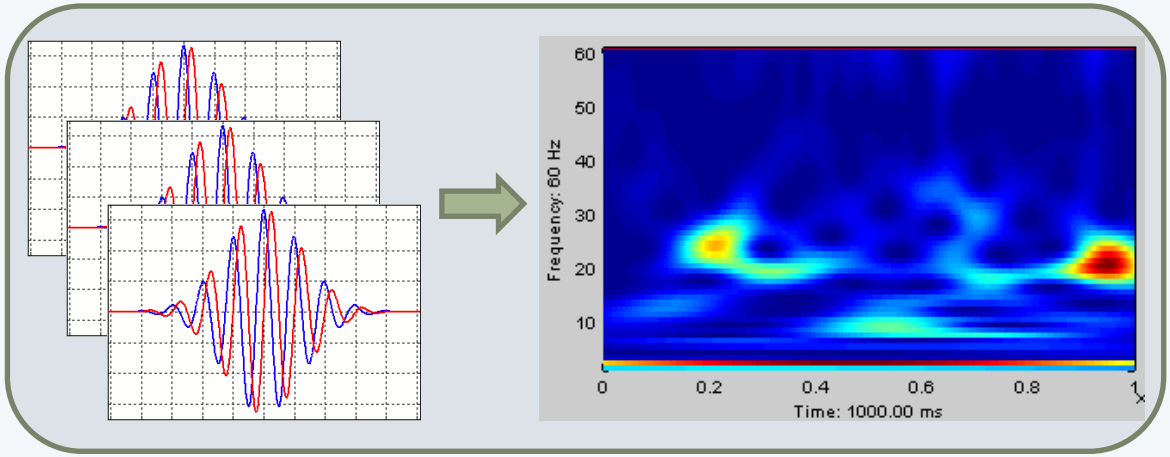


Brainstorm

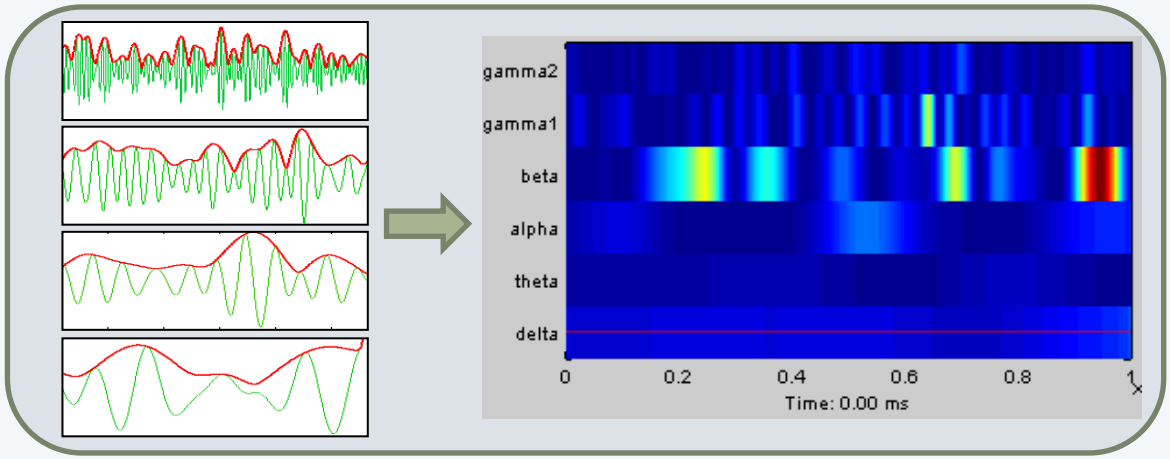
Time-frequency

Morlet wavelets



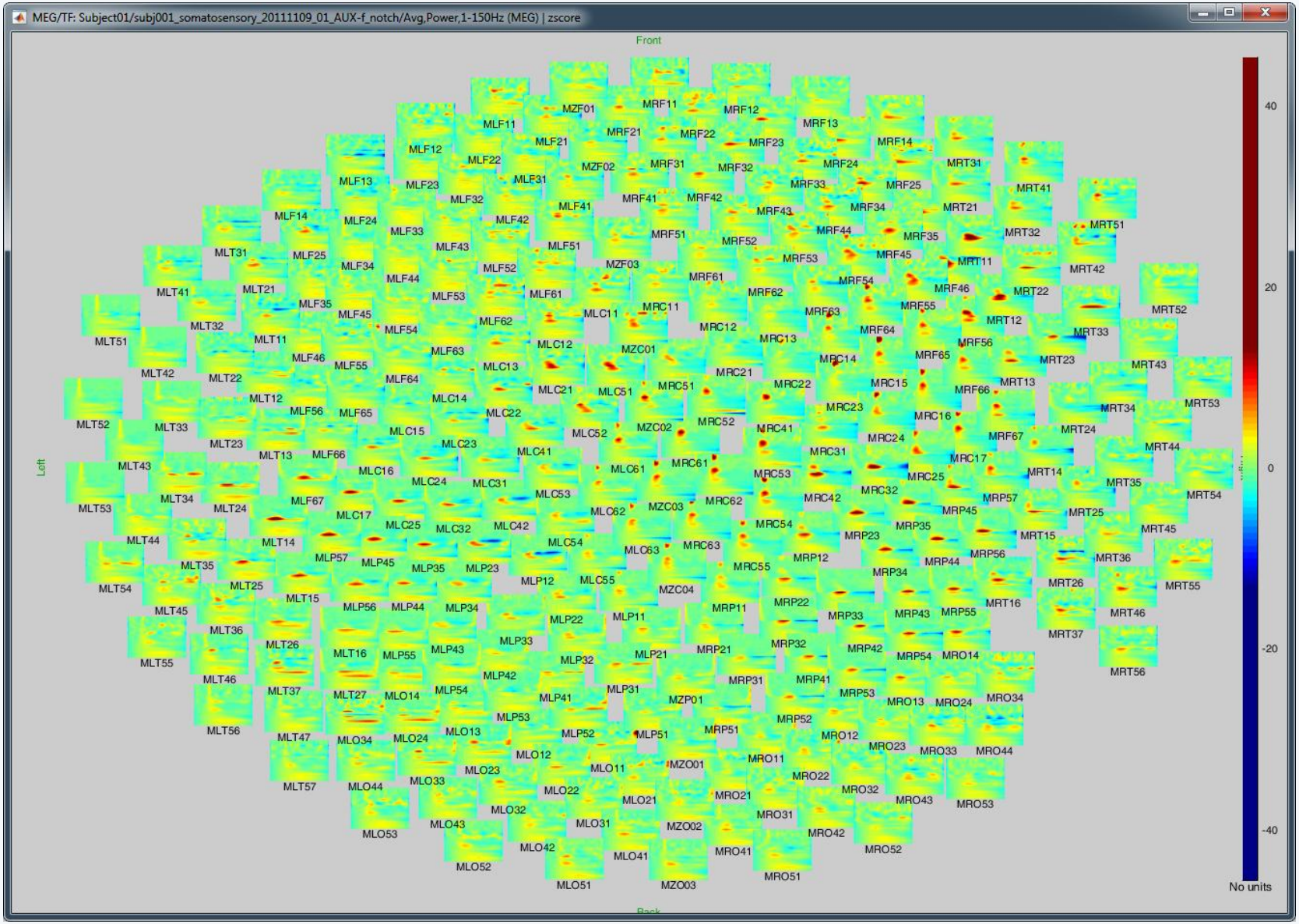


Hilbert transform + band-pass filter



Brainstorm

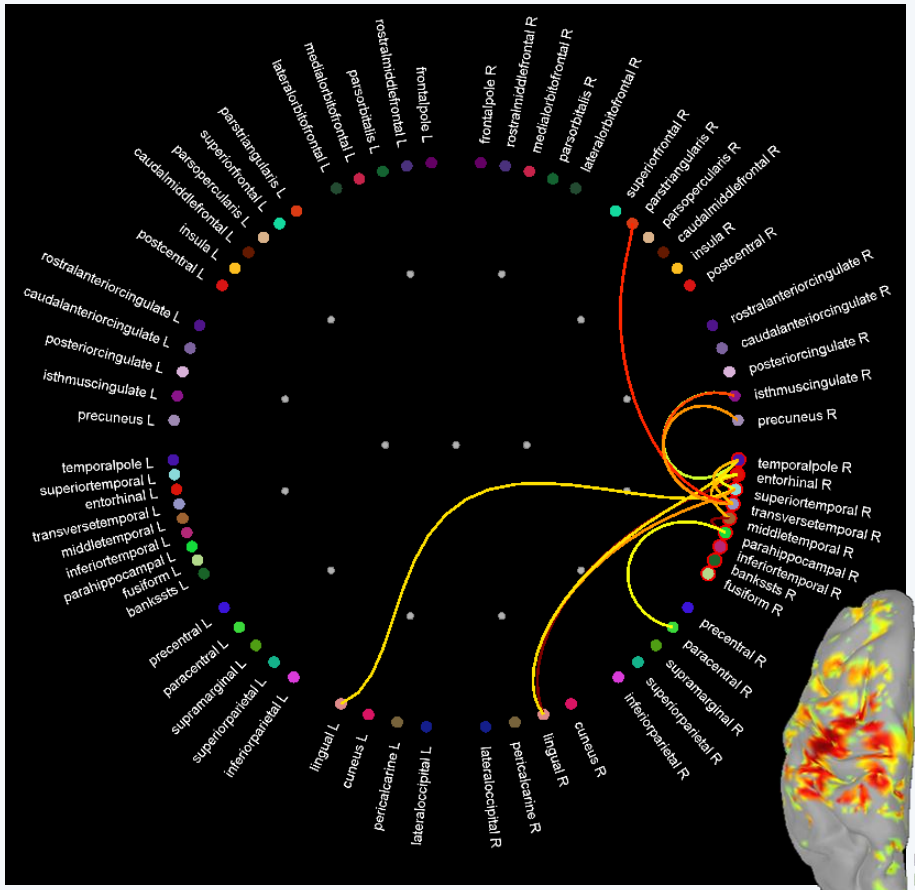
Time-frequency



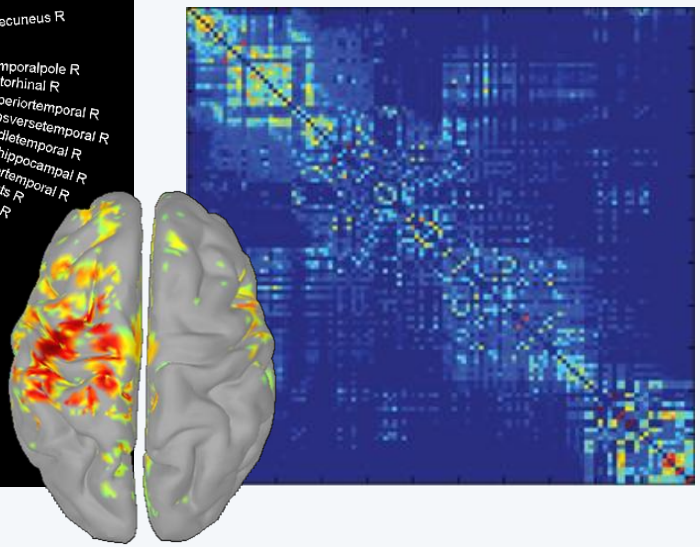
Brainstorm

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

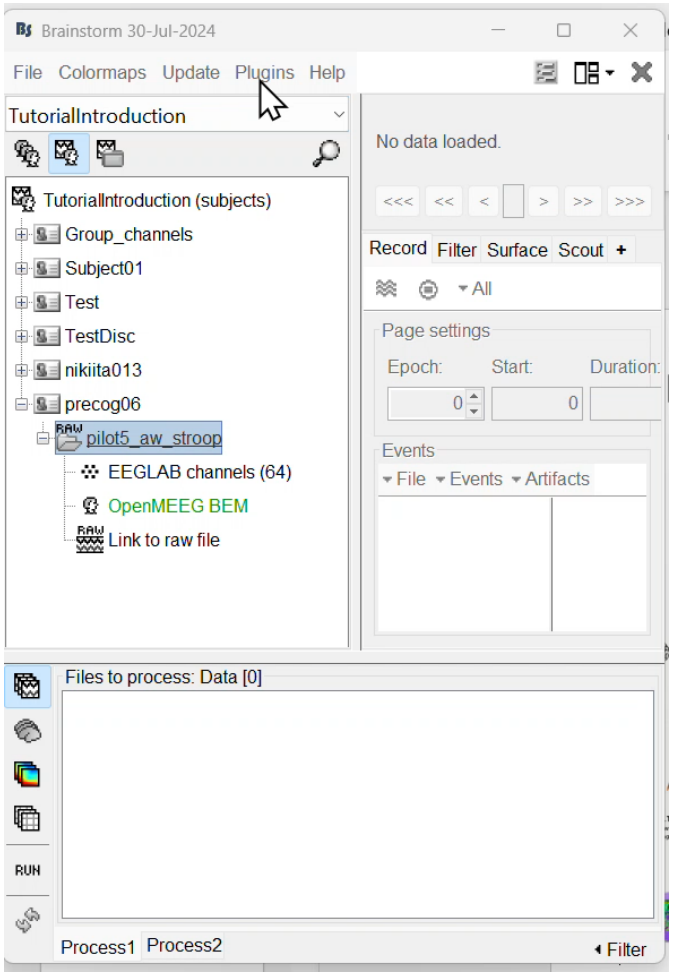
Tutorial 28: Scripting

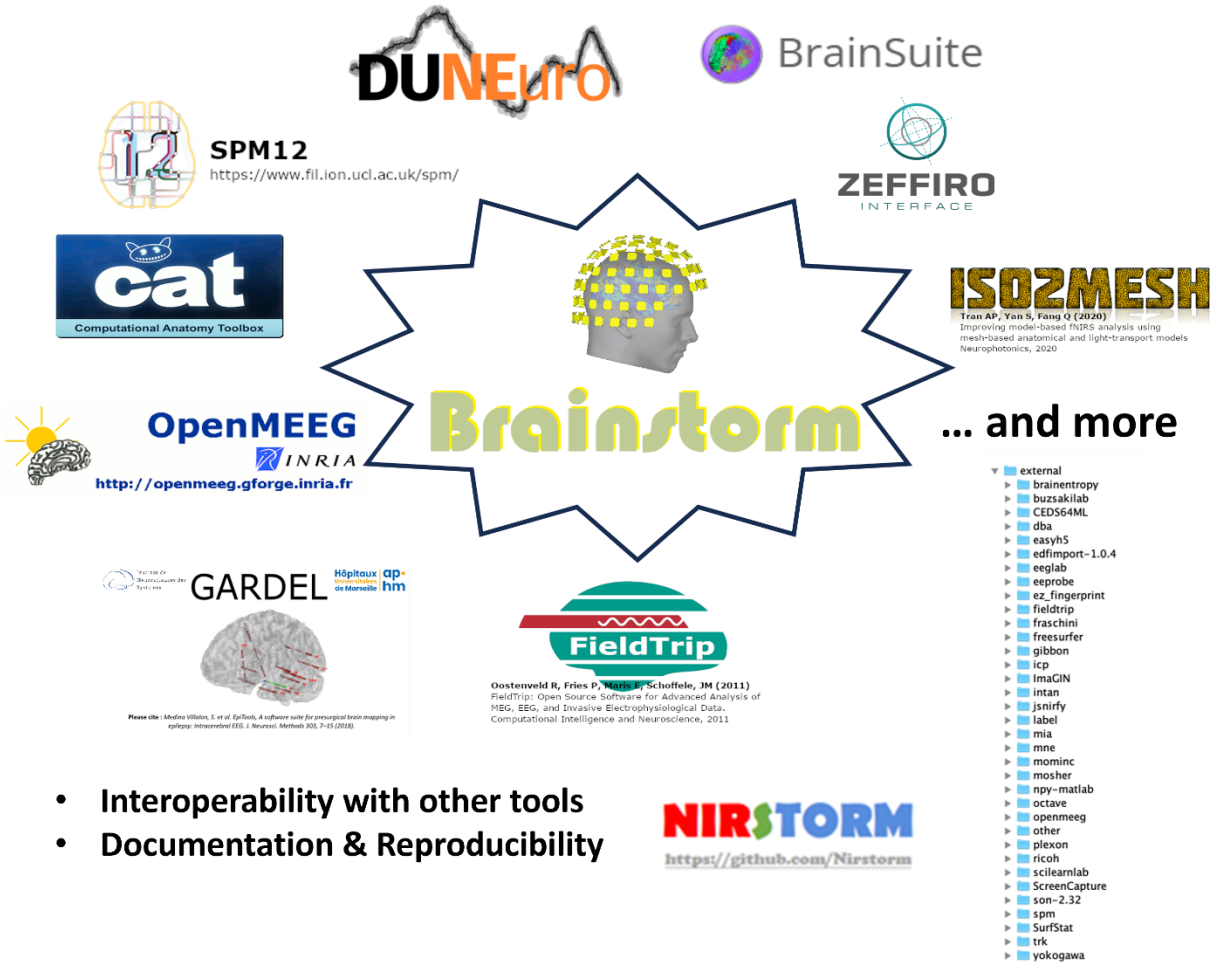
Authors: Francois Tadel, Elizabeth Bock, Matthias Sure, Sylvain Baillet

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!**





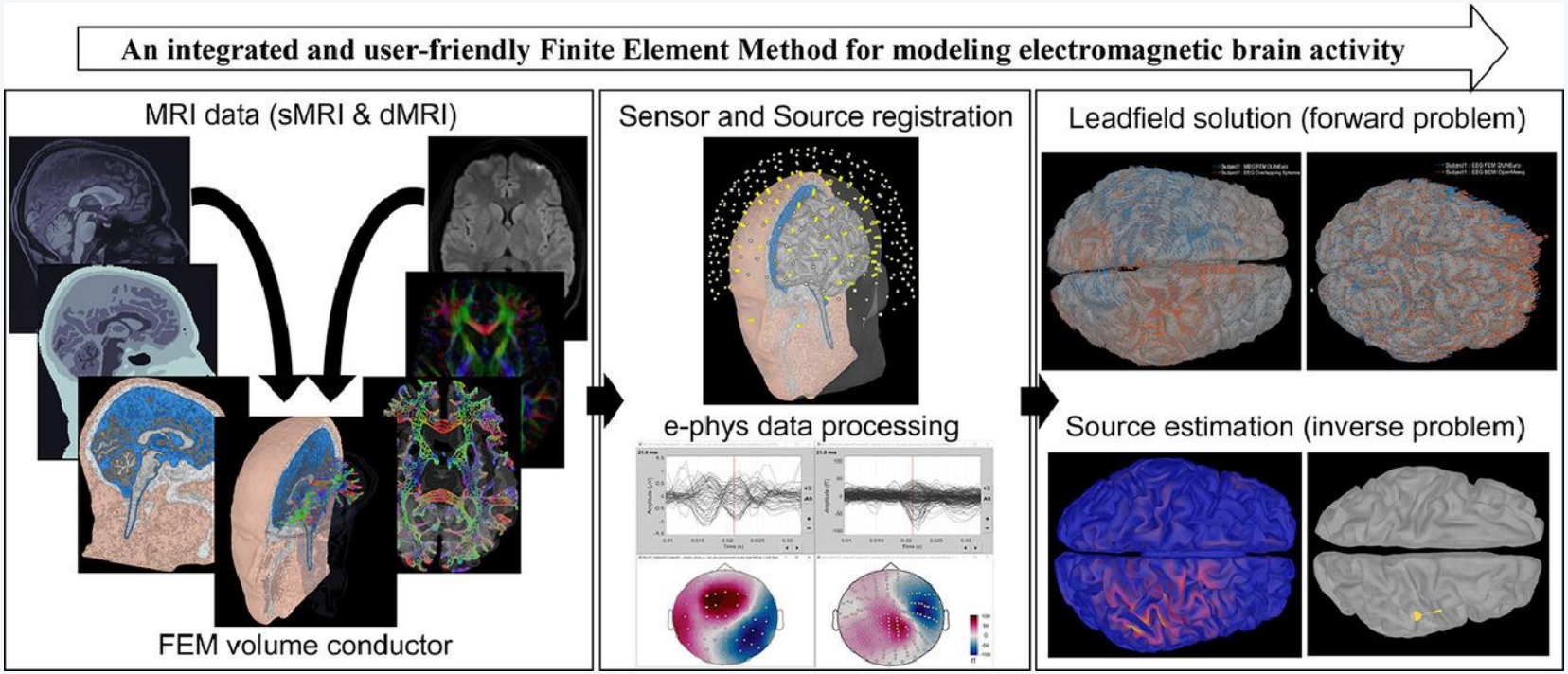
- **Interoperability with other tools**
- **Documentation & Reproducibility**

NIRSTORM
https://github.com/Nirstorm

Brainstorm

What's New?

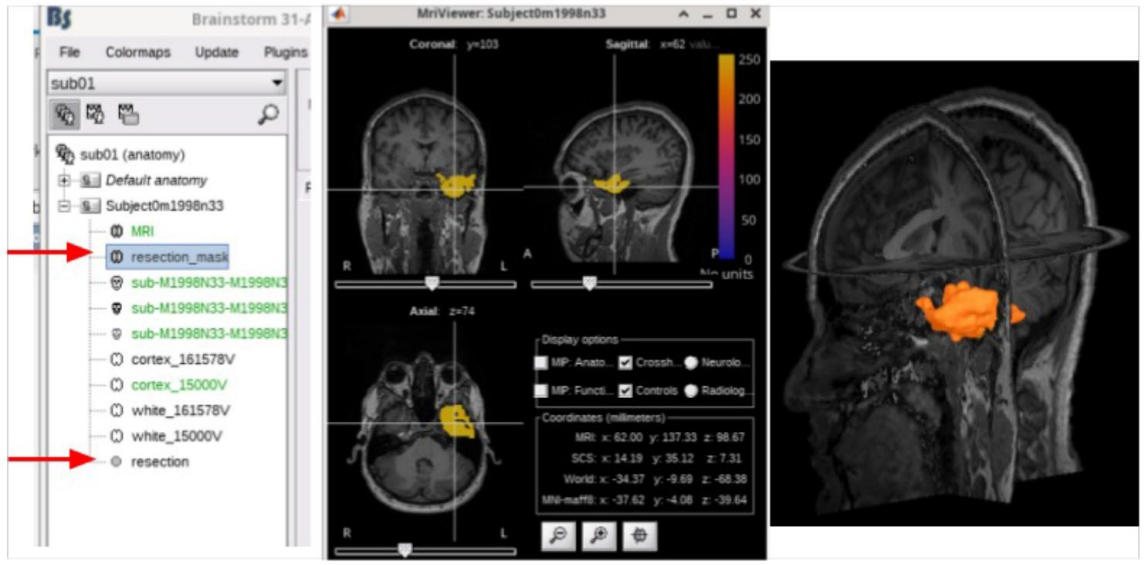
- **Brainstorm - DUNEuro: An integrated and user-friendly Finite Element Method for modeling electromagnetic brain activity**



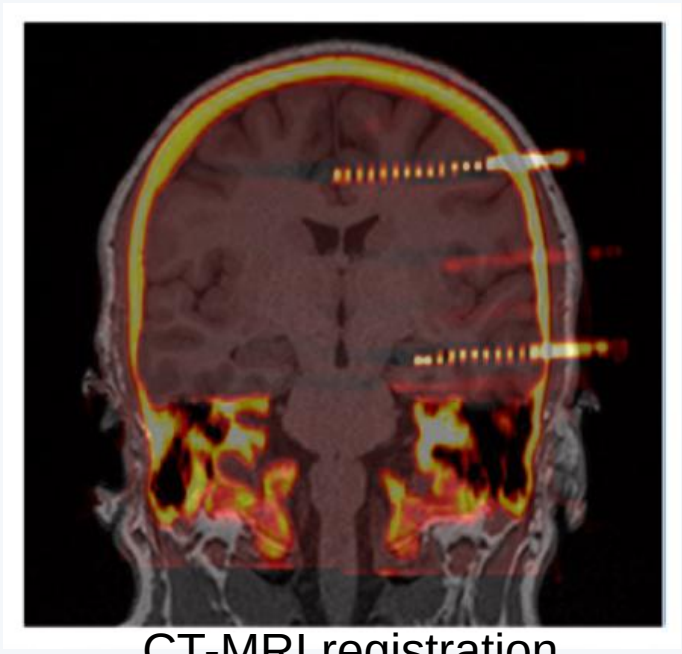
Takfarinas Medani, Juan Garcia-Prieto, Francois Tadel, Marios Antonakakis, Tim Erdbrügger, Malte Höltershinken, Wayne Mead, Sophie Schrader, Anand Joshi, Christian Engwer, Carsten H. Wolters, John C. Mosher, Richard M. Leahy
(https://doi.org/10.1016/j.neuroimage.2022.119851)

What's New?

- **CT-MRI volume co-registration and Resection labeling**



pre/post op resection volume detection



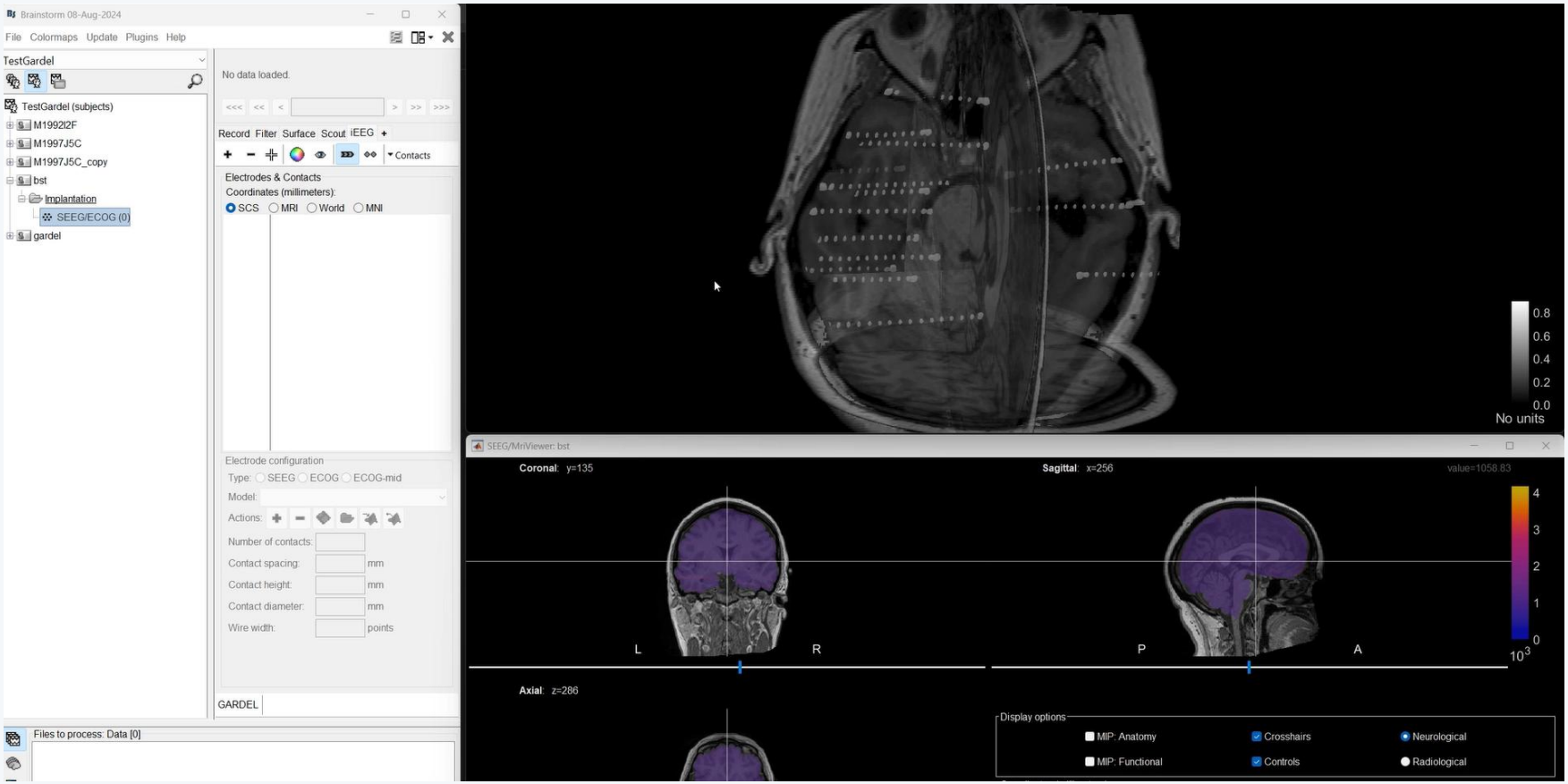
CT-MRI registration

A Joshi, Chinara, T. Medani and brainstorm team
https://neuroimage.usc.edu/brainstorm/Tutorials/SegBrainSuite?highlight=%28resection%29#Resection_labeling

Brainstorm

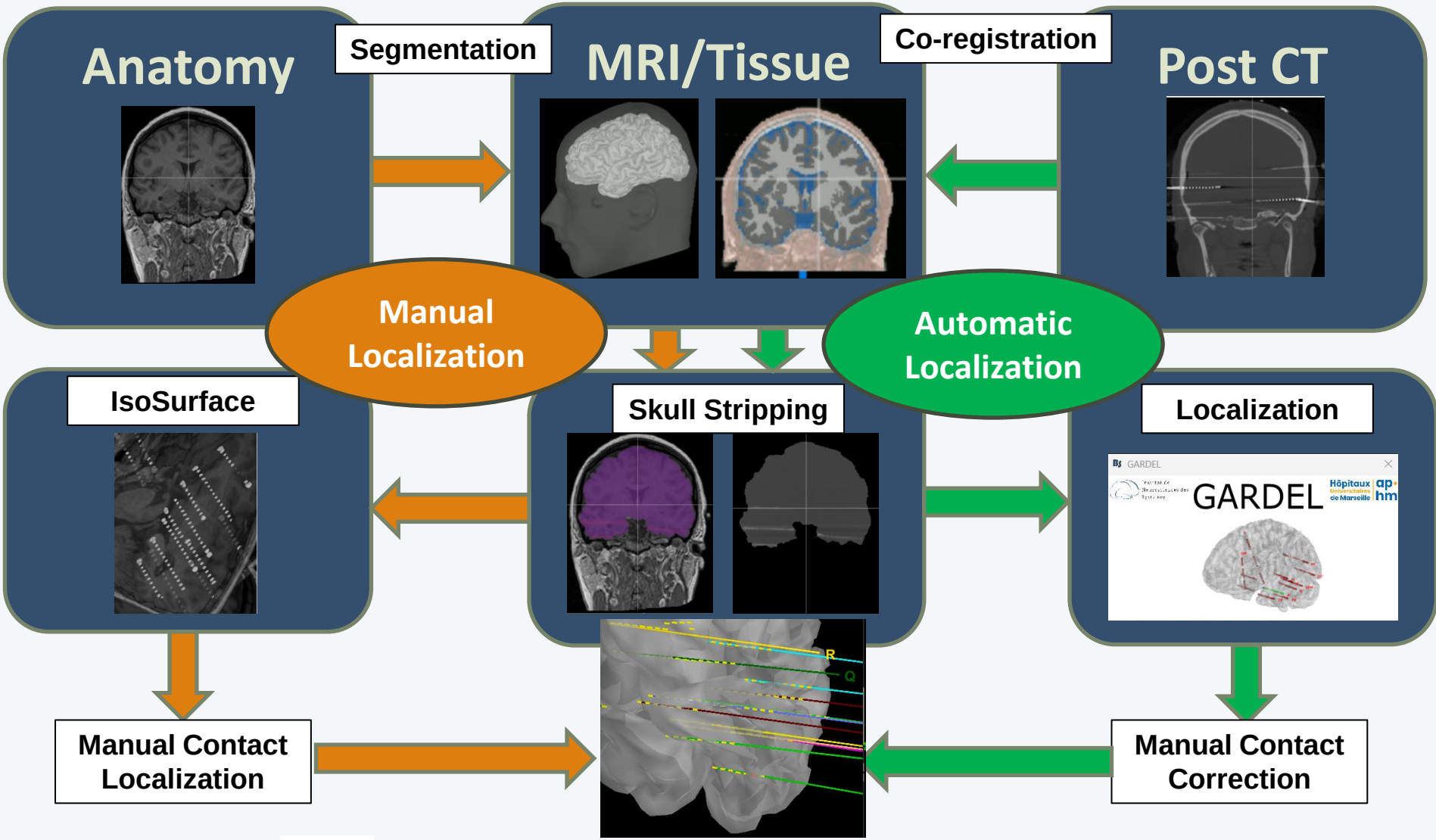
What's New?

- **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

sEEG : Co-registration & contact localization

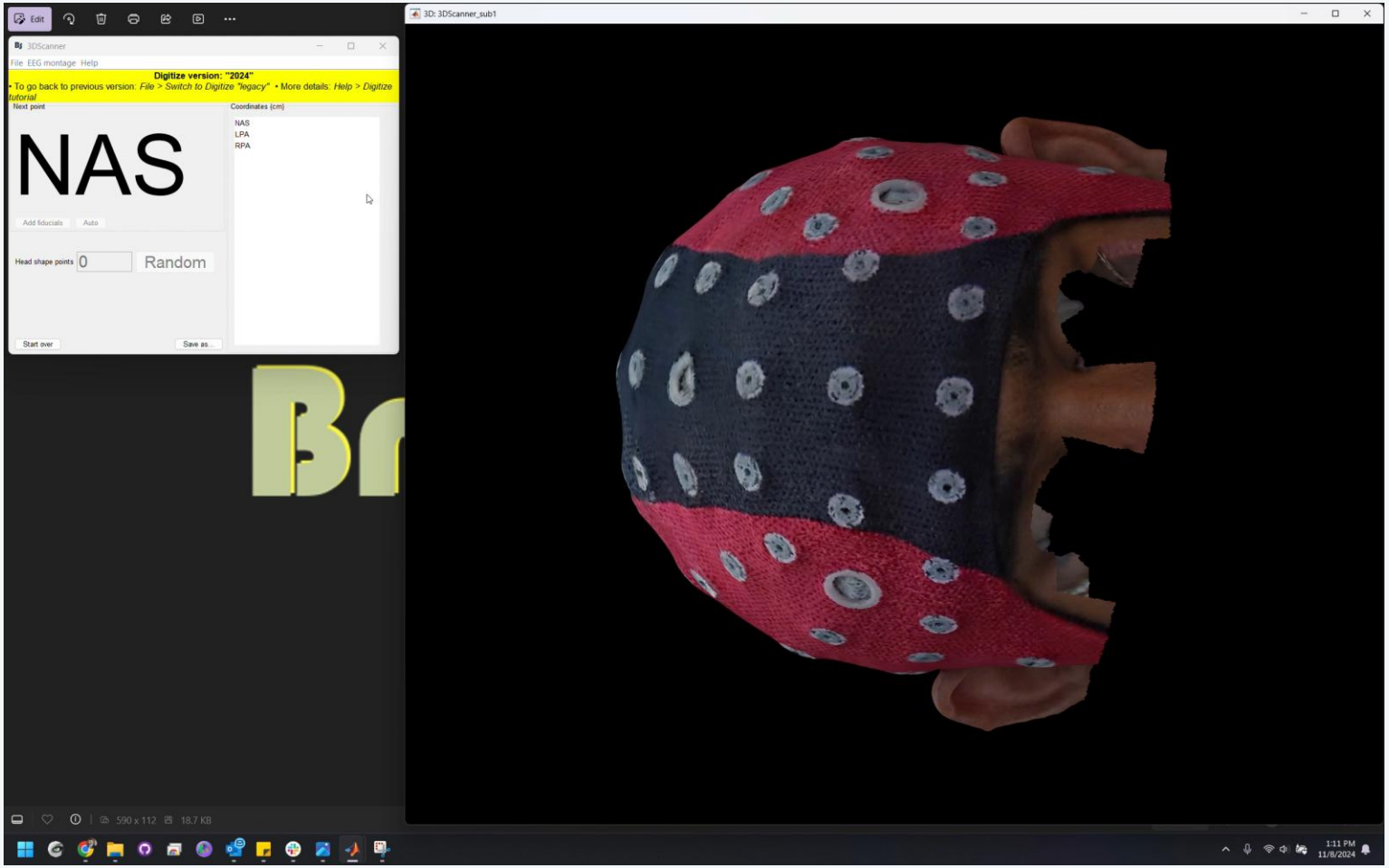


Chinara, S.Medina, A Joshi, C-G Bénar, T.Medani and brainstorm team: https://neuroimage.usc.edu/brainstorm/Tutorials/IeegContactLocalization
Medina Villalon et al. EpiTools, 2018 doi: 10.1016/j.jneumeth.2018.03.018

Brainstorm

What's New?

- **Automated EEG Electrode Localization and Labeling**

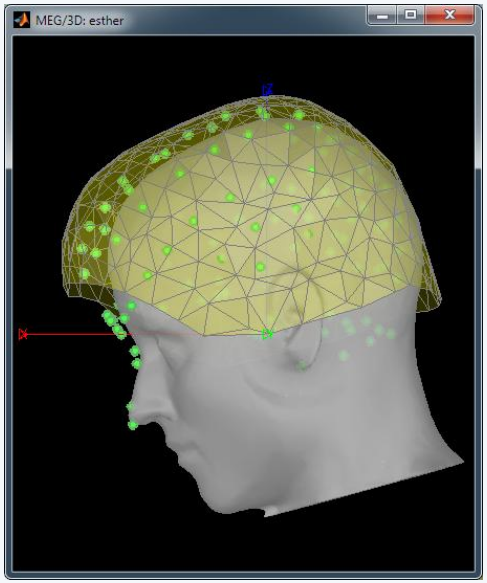


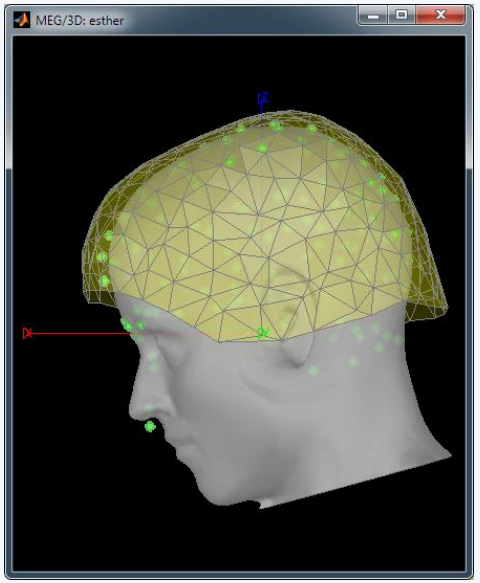
Chinara, A Joshi, Vakilna, Medani, and brainstorm team: https://neuroimage.usc.edu/brainstorm/Tutorials/TutDigitize3dScanner

Brainstorm

Co-registration MEEG / MRI (2)

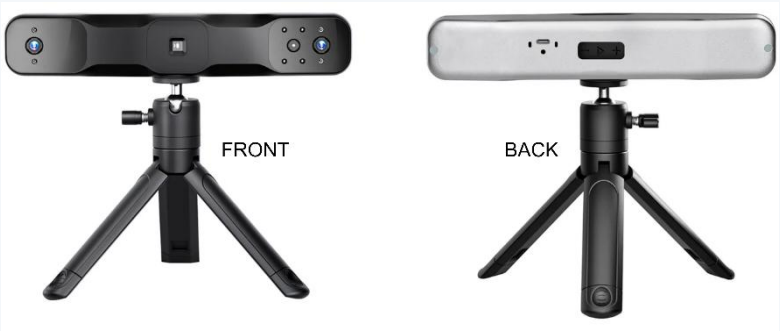
- Automatic adjustment based on head shape: Fitting Polhemus points on the MRI head surface
- Final registration must be checked manually
- Polhemus driver included in Brainstorm

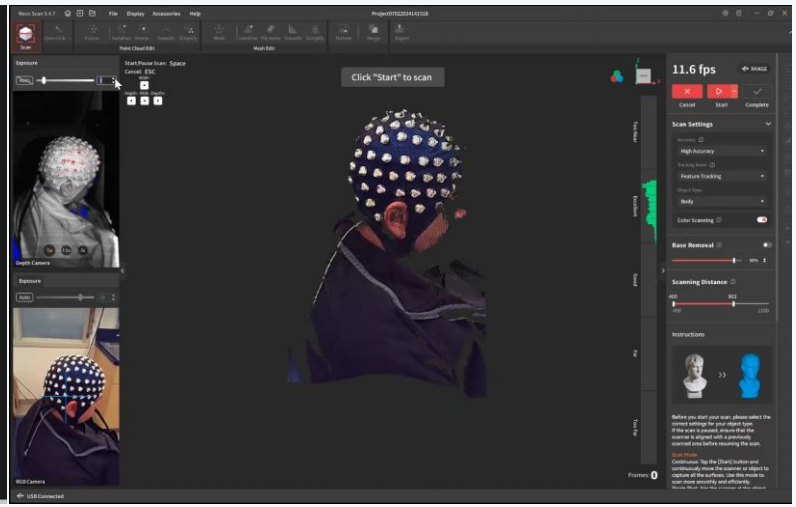




Co-registration EEG / MRI (3)

- 3D for scanning EEG scalp electrode

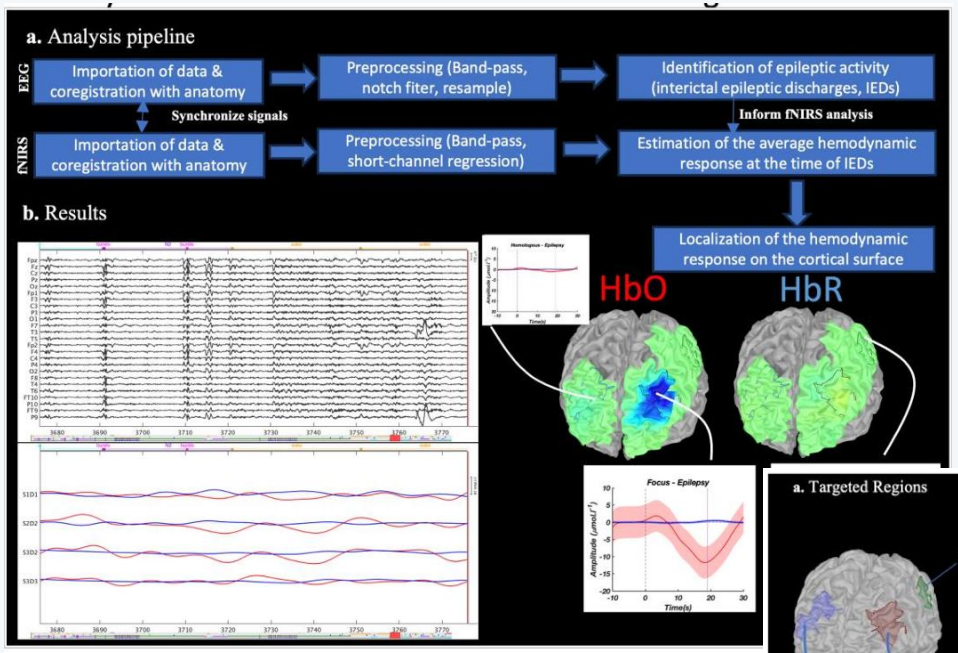


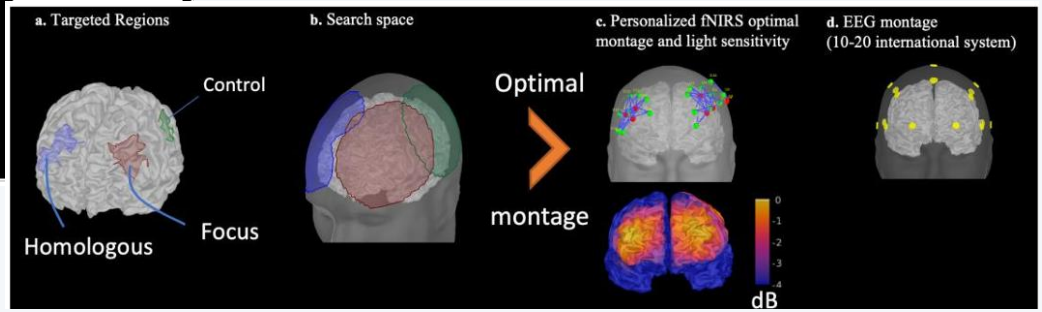


https://neuroimage.usc.edu/brainstorm/Tutorials/TutDigitize3dScanner

What's New?

- **NIRSTORM: a Brainstorm extension dedicated to functional Near Infrared Spectroscopy (fNIRS) data analysis, advanced 3D reconstructions, and optimal probe design**





Édouard Delaire, Thomas Vincent, Zhengchen Cai, Alexis Machado, Laurent Hugueville, Denis Schwartz, Francois Tadel, Raymundo Cassani, Louis Bherer, Jean-Marc Lina, Mélanie Pélégrini-Issac, Christophe Grova (https://www.biorxiv.org/content/10.1101/2024.09.05.611463v1)

What's New?

And more...!!

Brainstorm

Edit

Search

Software

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Users

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- Courses
- Community
- Publications

Development

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- Contribute

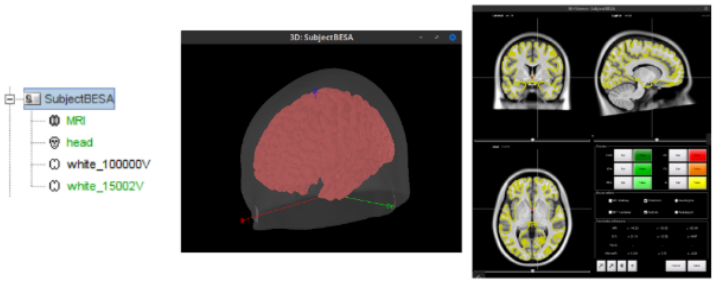
What's new

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**

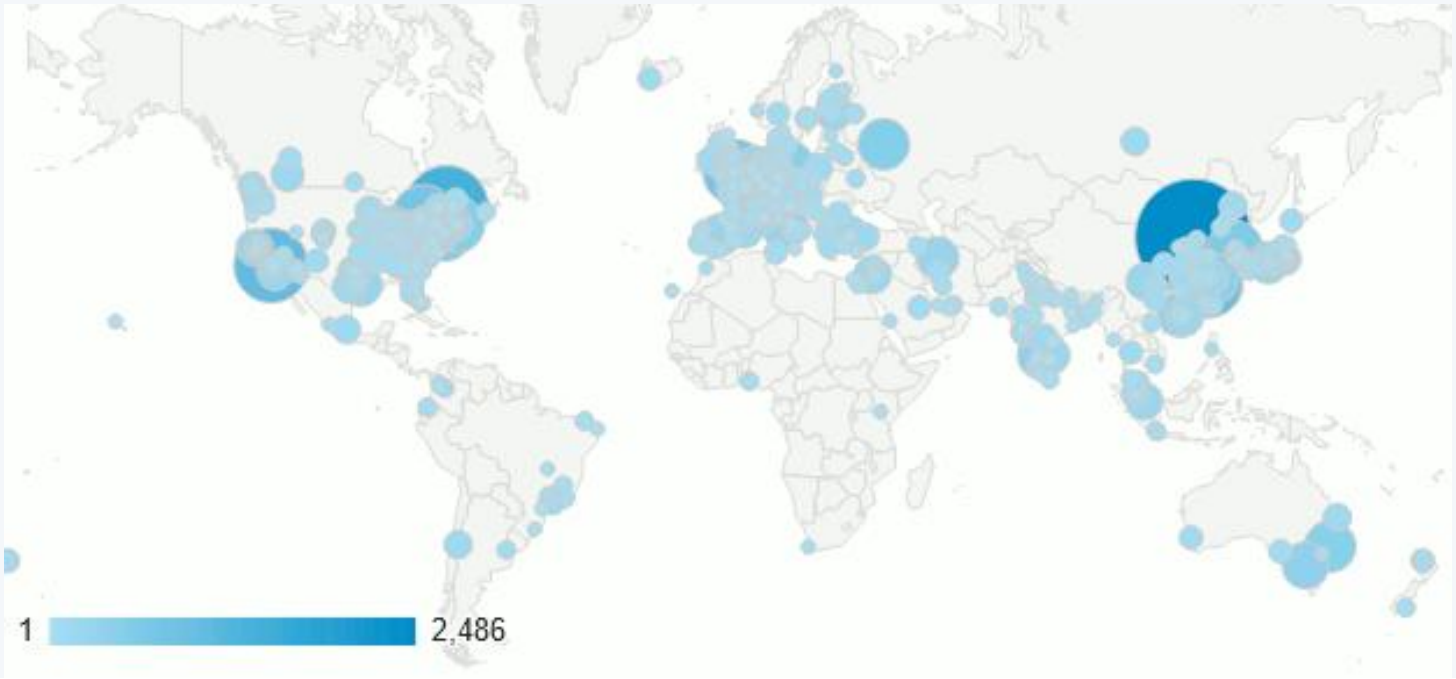
Processes

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

Brainstorm

User community (2025)

- >47,000+ users registered on the website



Find users next to you

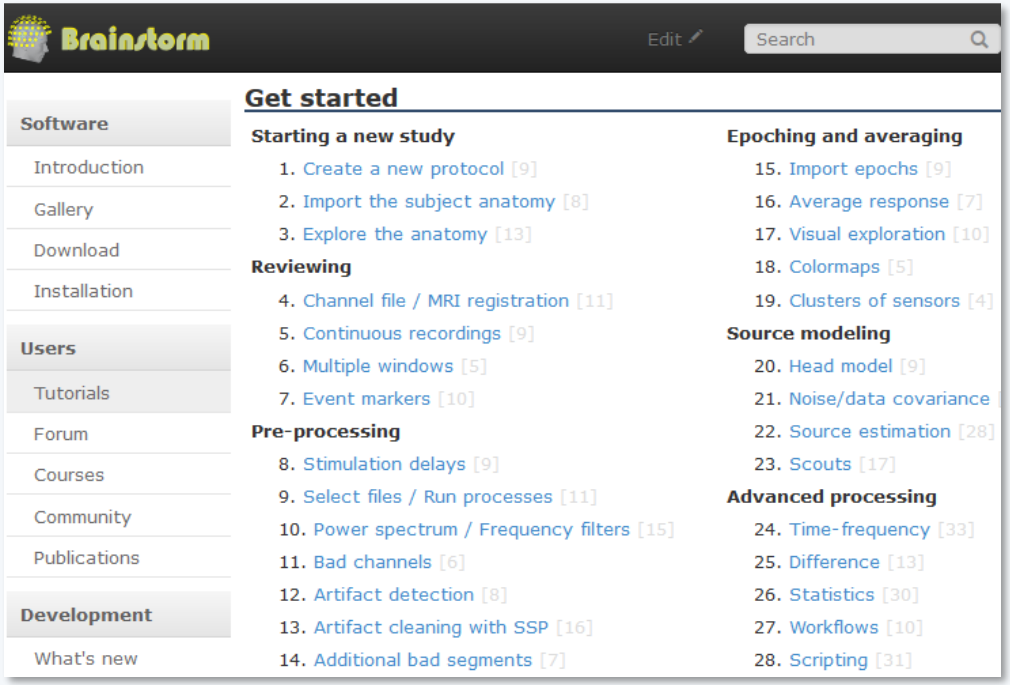
Location: montreal

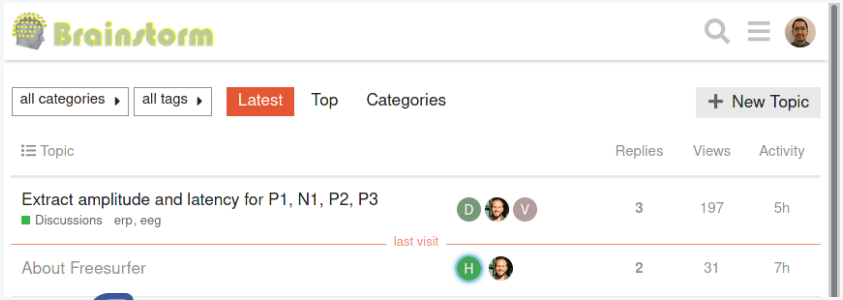
Users found: 847

Brainstorm

User support

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





@BrainstormSoftware

@brainstorm2day

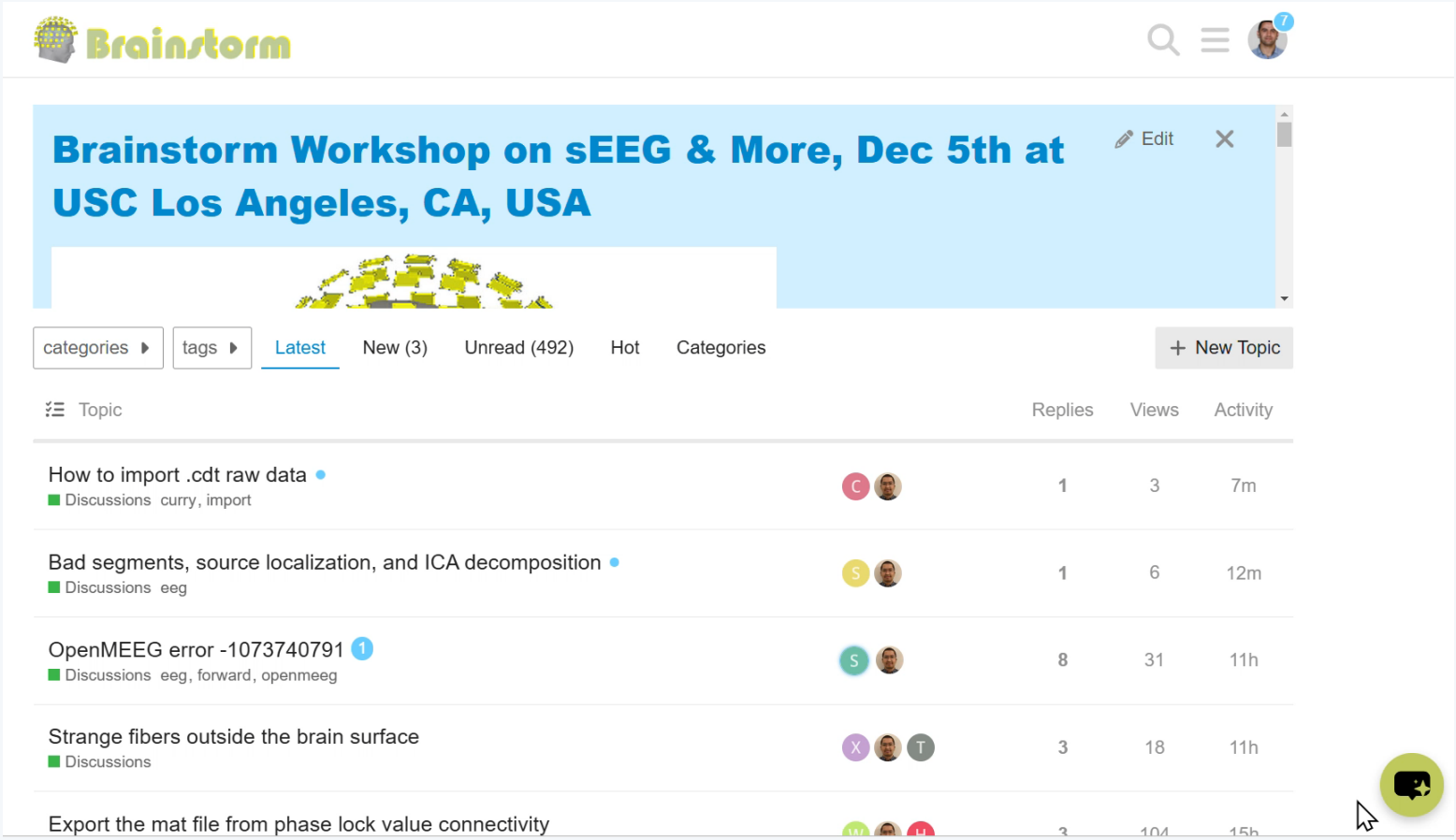
@brainstorm-tools

@ brainstorm-neuroimage

Brainstorm

User support

- Forum Brainstorm Chabot



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

Upcoming Brainstorm Events

==========

📍 **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

==========

📍 **Aix-en-Provence, France**

Date: October 27–31, 2025

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

Part of *PracticalMEEG events*

==========

📍 **Hyderabad, India**

Date: April 7, 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

==========

📍 **Brisbane, Australia**

Date: June 24-28, 2025

Focus: Software Demo.

Part of *OHBM 2025*

==========

👩‍🏫 **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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This software was generated primarily with support from the National Institutes of Health (**NIH**) under grants **R01-EB026299**, **2R01-EB009048**, **R01-EB009048**, **R01-EB002010** and **R01-EB000473**.

Brainstorm

UTH Collaborators (sEEG case study)

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The University of Texas Health Science Center at Houston

Texas Institute for Restorative Neurotechnologies

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Dr. John C. Mosher
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Co-PI, Brainstorm

Dr. Samden Lhatoo
Co-Director, Texas Institute for Restorative Neurotechnologies

Johnson Hampson, MSBME
Biomedical Engineering Manager

TODAY

Today's event!

- Hands-on Session for Quantitative sEEG Analysis
  - **Prerequisites:** Ensure you have installed and tested the software and obtained a dataset copy.
  - **Walkthrough Guide**: Access the step-by-step guide online: https://neuroimage.usc.edu/brainstorm/WorkshopToulouse2025
- **Topics Covered:**
  - Introduction to the software and its features
  - Performing end-to-end sEEG analysis using Brainstorm
  - Importing, exploring, and processing anatomical data (MRIs)
  - Importing, post-processing, and analyzing sEEG data
  - Sensor- and source-level analysis
    - Highlights the Epileptogenic Zone 'fingerprint'.

The Epileptogenic Zone 'fingerprint' (sensor)

JOURNAL ARTICLE

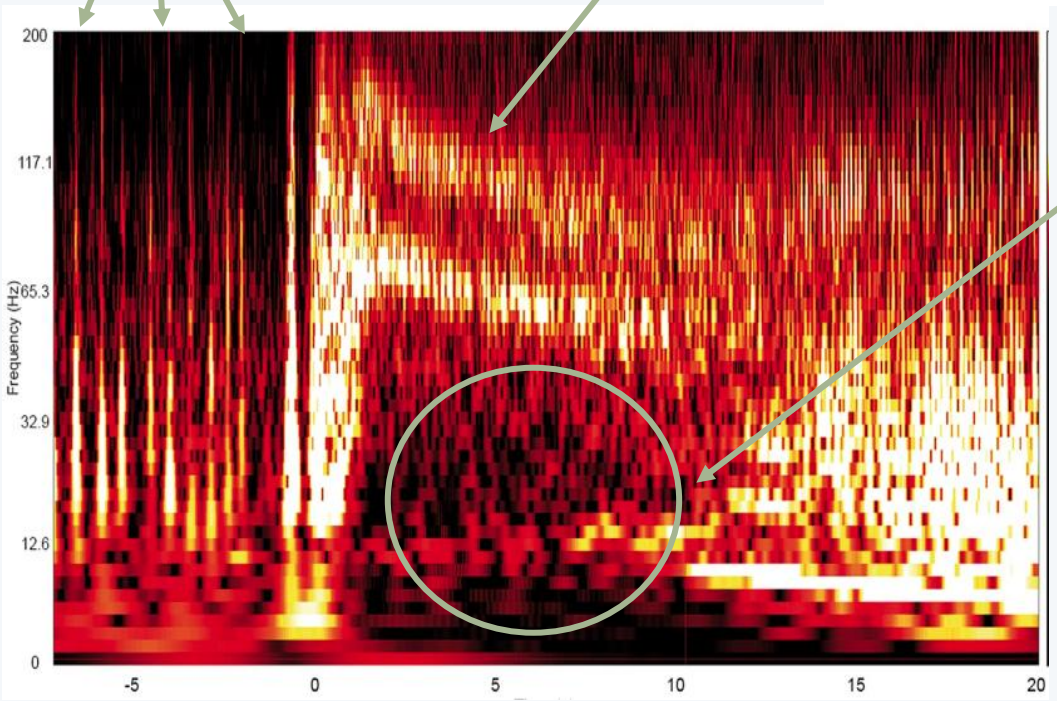
A fingerprint of the epileptogenic zone in human epilepsies

Olesya Grinenko, Jian Li, John C Mosher, Irene Z Wang, Juan C Bulacio, Jorge Gonzalez-Martinez, Dileep Nair, Imad Najm, Richard M Leahy, Patrick Chauvel
Author Notes

Brain, Volume 141, Issue 1, January 2018, Pages 117–131,
https://doi.org/10.1093/brain/awx306
Published: 20 December 2017 **Article history**

Pre-ictal spikes

Narrow band of fast activity (Chirp)



Suppression of slow pre-ictal frequencies

Brainstorm

The Epileptogenic Zone 'fingerprint' [source]

zenodo Search records... Communities My dashboard

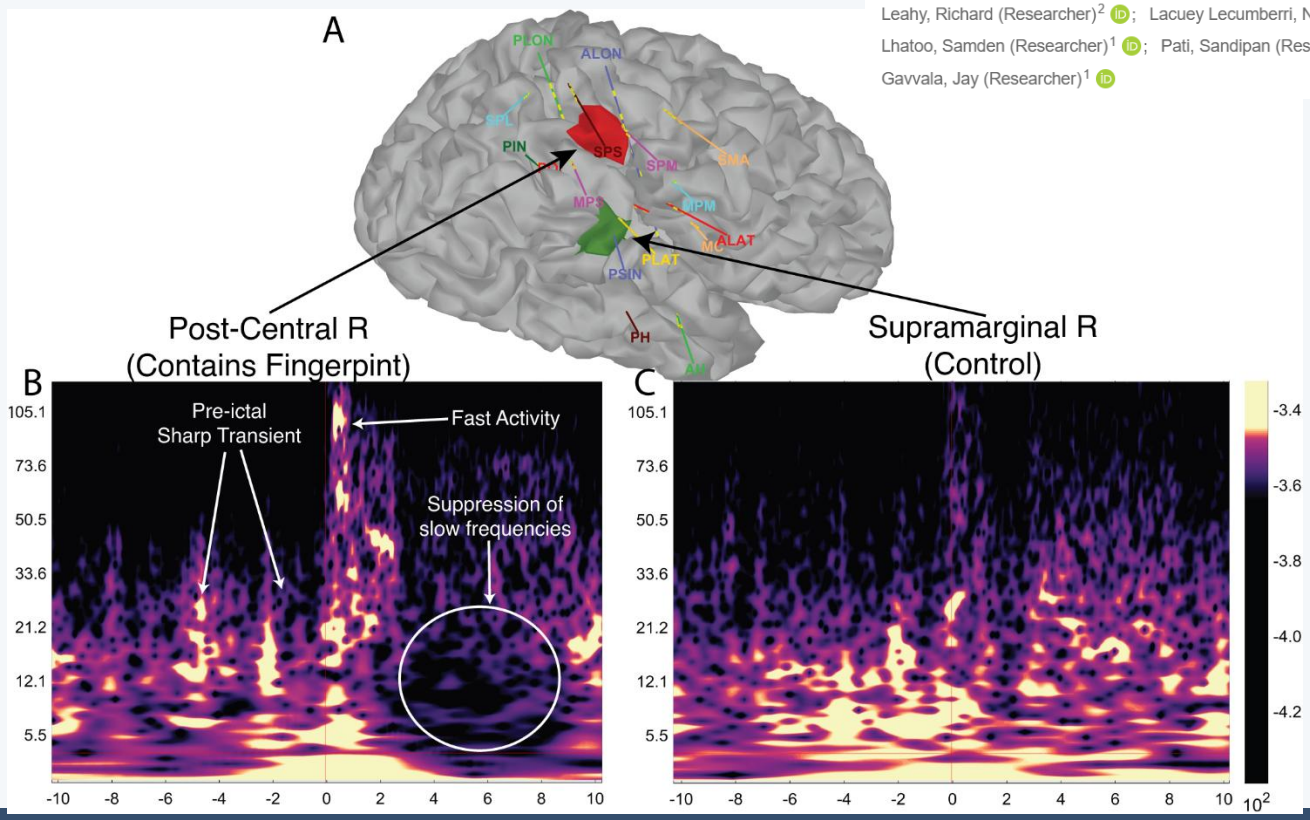
Published February 5, 2025 | Version v1

Preprint Open

Time-Frequency Fingerprint Analysis in SEEG Source-Space to Identify the Epileptogenic Zone

Vakilna, Yash Shashank (Researcher)[1]; Atilgan, Deniz (Researcher)[1]; Hampson, Johnson P (Researcher)[1]; Medani, Takfarinas (Researcher)[2]; Leahy, Richard (Researcher)[2]; Lacuey Lecumberri, Nuria (Researcher)[1]; Lhatoo, Samden (Researcher)[1]; Pati, Sandipan (Researcher)[3]; Mosher, John (Researcher)[1]; Gavvala, Jay (Researcher)[1]

Show affiliations



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Sample Data

- Patient with known drug-resistant epilepsy (@UTH Houston)
- PT has PMG (polymicrogyria) in the right perirolandic (central lobe) region, ➔suspected seizure onset site
- PT underwent SEEG lead implantation predominantly targeting the anatomical abnormality.
  - 17 devices (‘electrodes’) implanted, comprising about 250 (‘channels,’ ‘contacts’).
  - Depth electrodes: model **PMT**2102-14-091/2102-16-101
  - SEEG signals were recorded on a Nihon Kohden (Irvine, CA) EEG machine with a 2kHz SR
- The visual analysis of SEEG demonstrated seizure onset patterns
  - sEEG data was evaluated and marked by a neurologist/epileptologist
  - Multiple data recordings were provided (baseline, ictal and interictal, and LVFA)

Analysis approach

- Patient anatomy:
  - T1 MRI raw
  - T1 MRI pre-implantation, processed with Freesurfer
  - CT Scan post-implantation
  - Registered on the pre-implantation image with Brainstorm (&SPM)
  - Used to get 3D positions for the SEEG contacts
- Patient sEEG Data analysis
  - sEEG data processing (events markers, filters, …)
  - Forward and inverse model computation
  - Interictal spike: 2D sensor layout display
  - Interictal spike source level: sLORETA
  - Seizure onset with ictal wave source level: sLORETA
  - Ictal onset with LVFA: sensor level EZ fingerprint
  - Ictal onset with LVFA: source level EZ fingerprint
  - Ictal onset with repetitive spiking: filtered sLORETA

Reference: Vakilna YS, Atilgan D, Hampson JP, Medani T, Leahy R, Lacuey Lecumberri N, et al. Time-Frequency Fingerprint Analysis in SEEG Source-Space to Identify the Epileptogenic Zone. Zenodo; 2025. https://doi.org/10.5281/zenodo.14807262

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Feedback Brainstorm software & workshop

- Your feedback helps improve Brainstorm workshops and shape future sessions—share your thoughts!