

Partial spectroscopy of the human brain spontaneous activity

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Partial spectroscopy is the novel proposed methodology to study the human brain function.

This methodology is based on fact, that functional tomography method assigns to each frequency the spatial position of its source.

Object of the Research:

Spontaneous activity of the human brain

Goal of the research:

Identification of the spectral characteristics specific to the various compartments of the human brain

Partial spectra calculation workflow

- Registration of external magnetic field, produced by the human brain, using multichannel magnetic encephalograph.
- Calculation of the functional tomogram of the human brain, using frequency-pattern analysis of the magnetoencephalography data.
- Identification of the spatial boundaries of the anatomical compartments of the human brain, achieved by segmentation of the MRI.
- Calculation of voxel mask for individual compartments.
- Calculation of partial spectra, produced by sources, located in this compartments.

Calculation of the functional tomogram

1. Calculation of the Fourier transform of the multichannel signal. Transform is calculated on the full length of the signal.
2. Inverse Fourier transform at each frequency.
3. Application of the second order blind identification algorithm to each of the restored time-series in order to separate them to independent components.
4. Calculation of the normalized field patterns for each independent component.
5. Construction of the spatial grid with given accuracy. In each grid node set of test sources is placed. For each of such sources normalized field pattern is calculated. Such patterns are called “test patterns”.
6. Spatial distribution of the independent experimental patterns by means of minimization over test patterns array.

Segmentation of the MRI

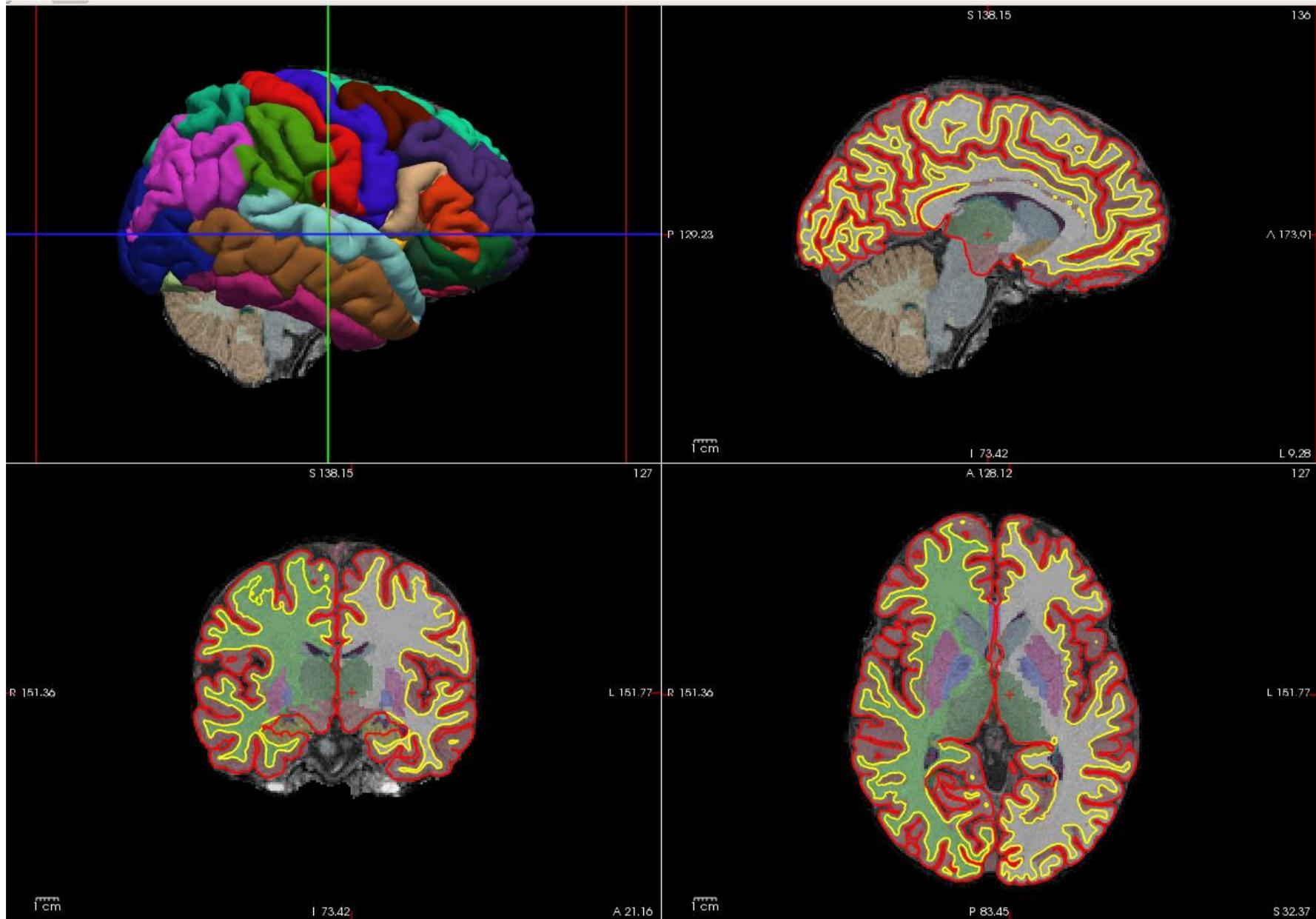
Segmentation of MRI - the division of the volume on the area occupied by the various departments and brain structures.

Segmentation is performed on anatomical brain atlas. The result is an annotated three-dimensional map of the brain.

Following software may be used to segment the MRI

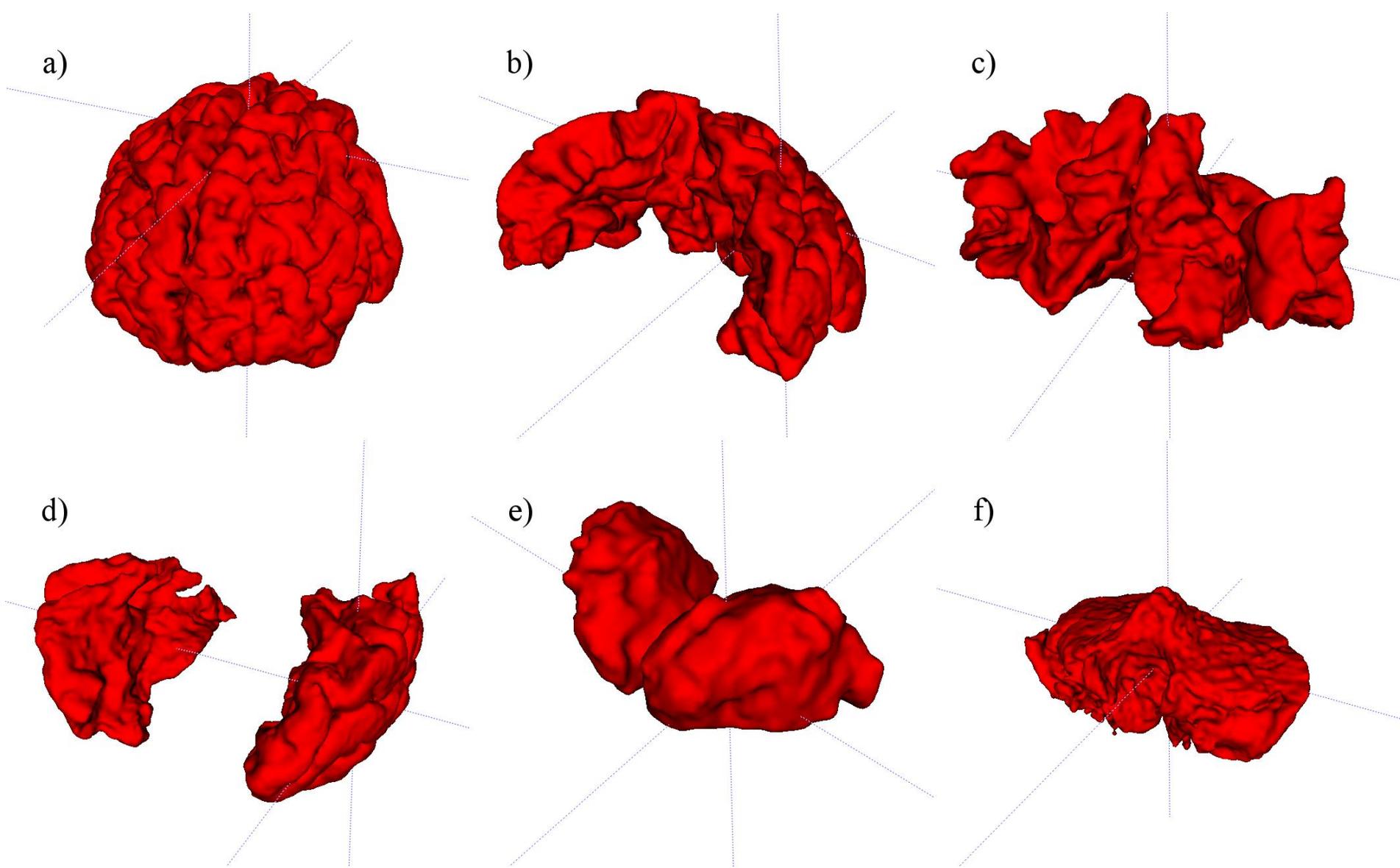
- Slicer3D
- FreeSurfer
- ITK-Snap

Result of MRI segmentation



Calculation of the individual compartment masks and partial spectra

- On the next step brain segmentation is divided into individual volumes of interest.
- Volumes are resampled to spatial resolution of functional tomogram.
- After that, overlapping volumes are calculated and removed from all of the volumes of interest. Resulting volumes are called voxel masks.
- To calculate partial spectra of individual compartments voxel masks are transformed to index form. Then elements with corresponding indexes are selected from the functional tomogram. Their frequencies and Fourier coefficients are forming the partial spectra.

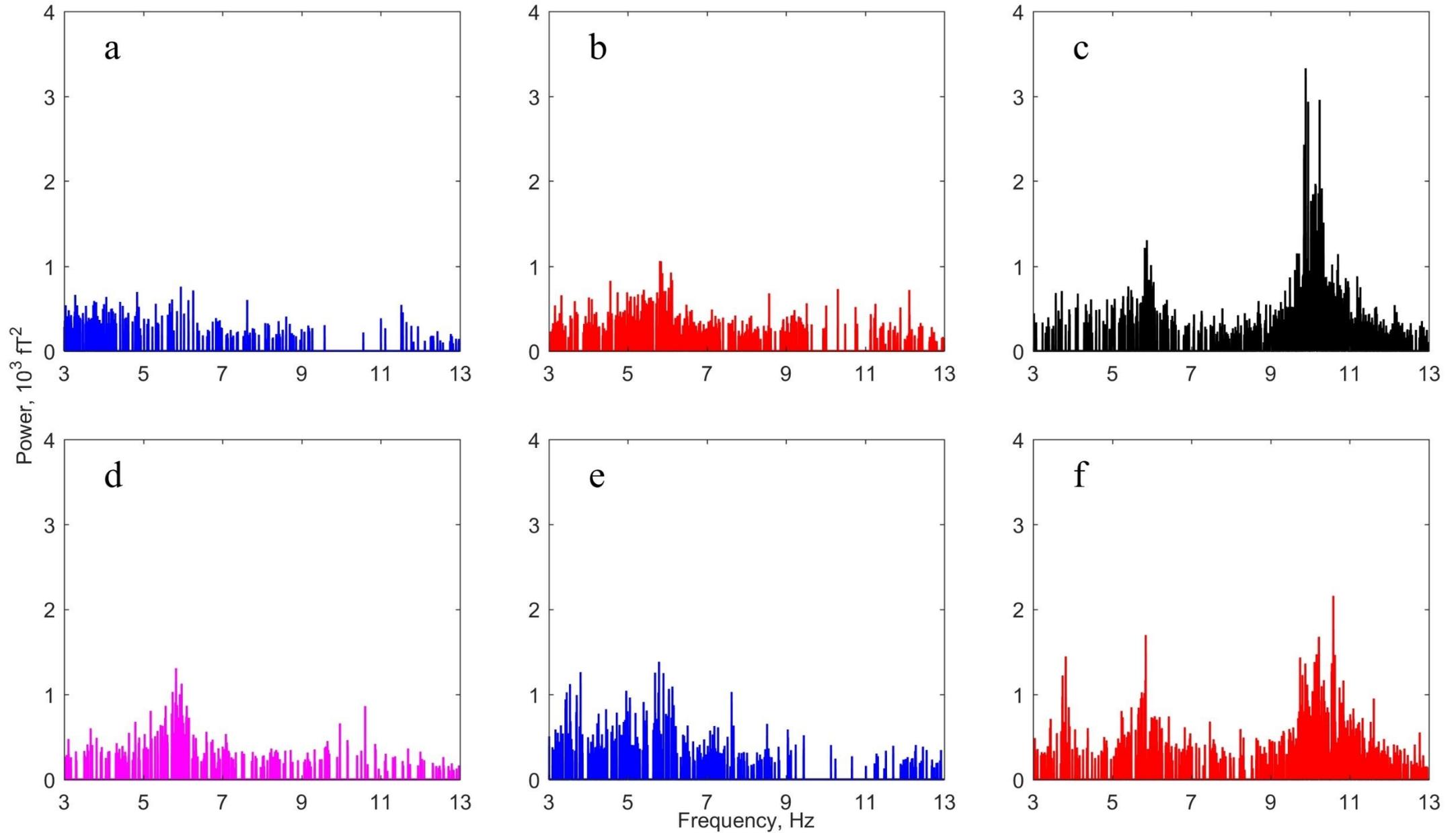


Voxel masks of the brain compartments. a) Frontal lobe b) Parietal lobe c) Occipital lobe; d) Temporal lobes; e) Thalamus d) Cerebellum

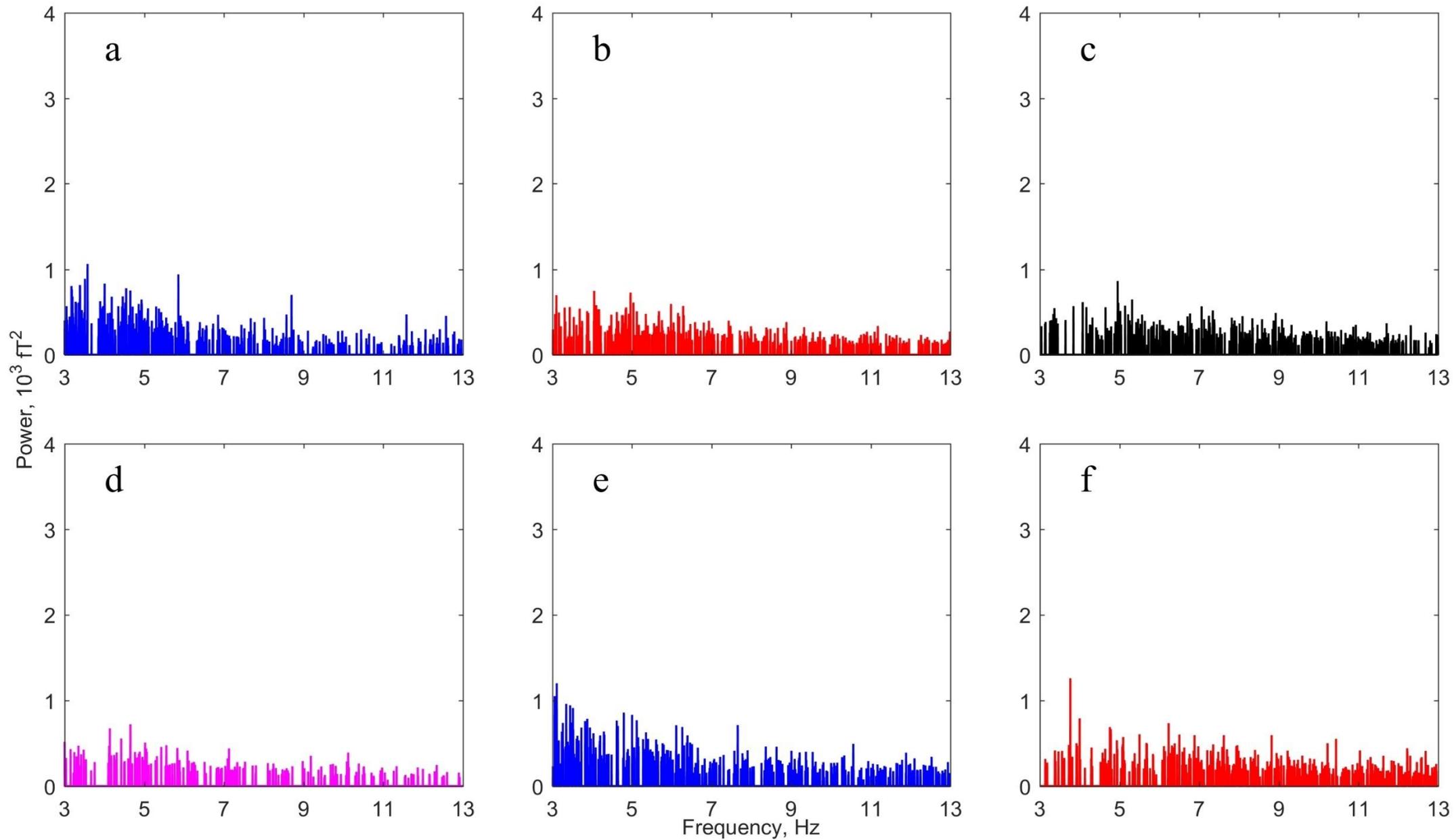
Partial spectra of the spontaneous activity

- The alpha-rhythm was selected for this study since it is the dominant oscillation in the resting brain spontaneous activity.
- MEG recordings were acquired from 10 healthy adults. MEG recordings were implemented at the New York University School of Medicine Center for Neuromagnetism (CNM). The subjects were asked to relax but stay awake during each 7-min recording period. Recordings were made during both “eyes closed” and “eyes open” conditions.
- Frequency band from 3 to 13 Hz was selected for further analysis.
- For each subject individual MRI was segmented using Freesurfer software. Mask for 6 compartments of interest were calculated: 1. frontal lobe; 2. parietal lobe; 3. occipital lobe; 4. temporal lobes; 5. thalamus; 6. cerebellum;
- Partial spectra were calculated for these compartments in both conditions “eyes closed” and “eyes open”.

Partial spectra, eyes closed



Partial spectra, eyes opened



Possible applications of method

- Proposed methodology allows the identifications of spectral characteristics specific to the various compartments of the human brain
- Partial spectra atlas will be used in the fundamental and diagnostic studies of the human brain
- Such atlas may be used not only in MEG studies, but also in the EEG studies, due to identity of the field sources.

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