



Central European Institute of Technology  
BRNO | CZECH REPUBLIC

# Advanced methods for EEG data analysis

**Martin Lamoš**

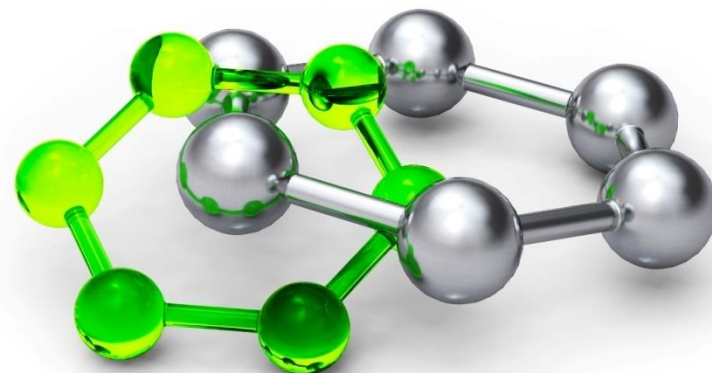
**Brno, November 15<sup>th</sup> 2016**



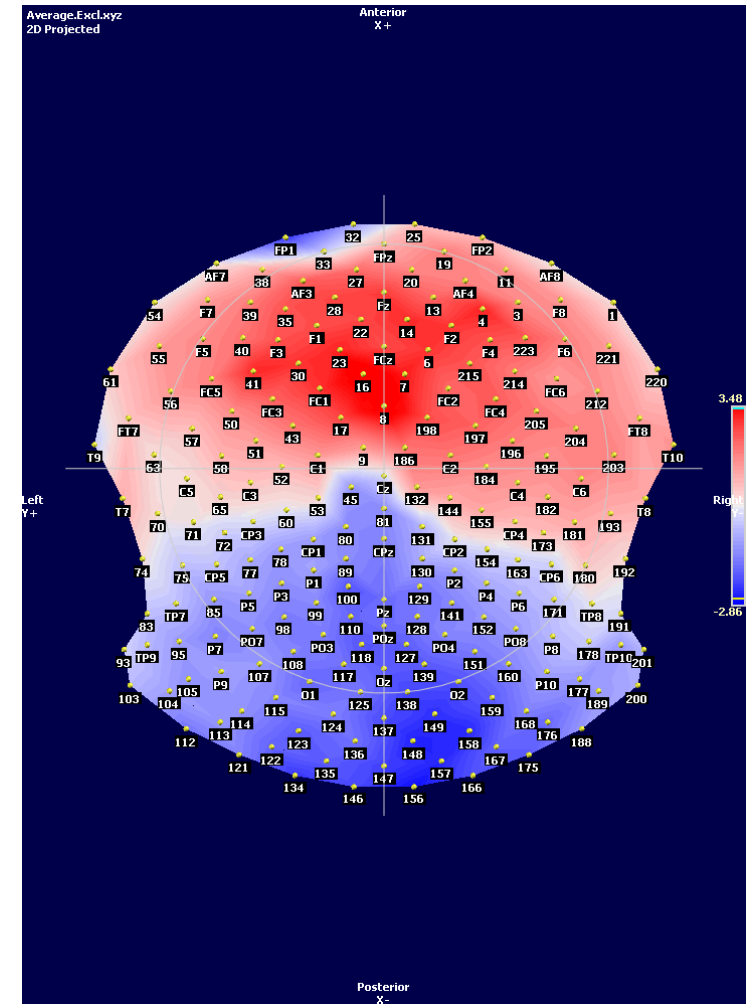
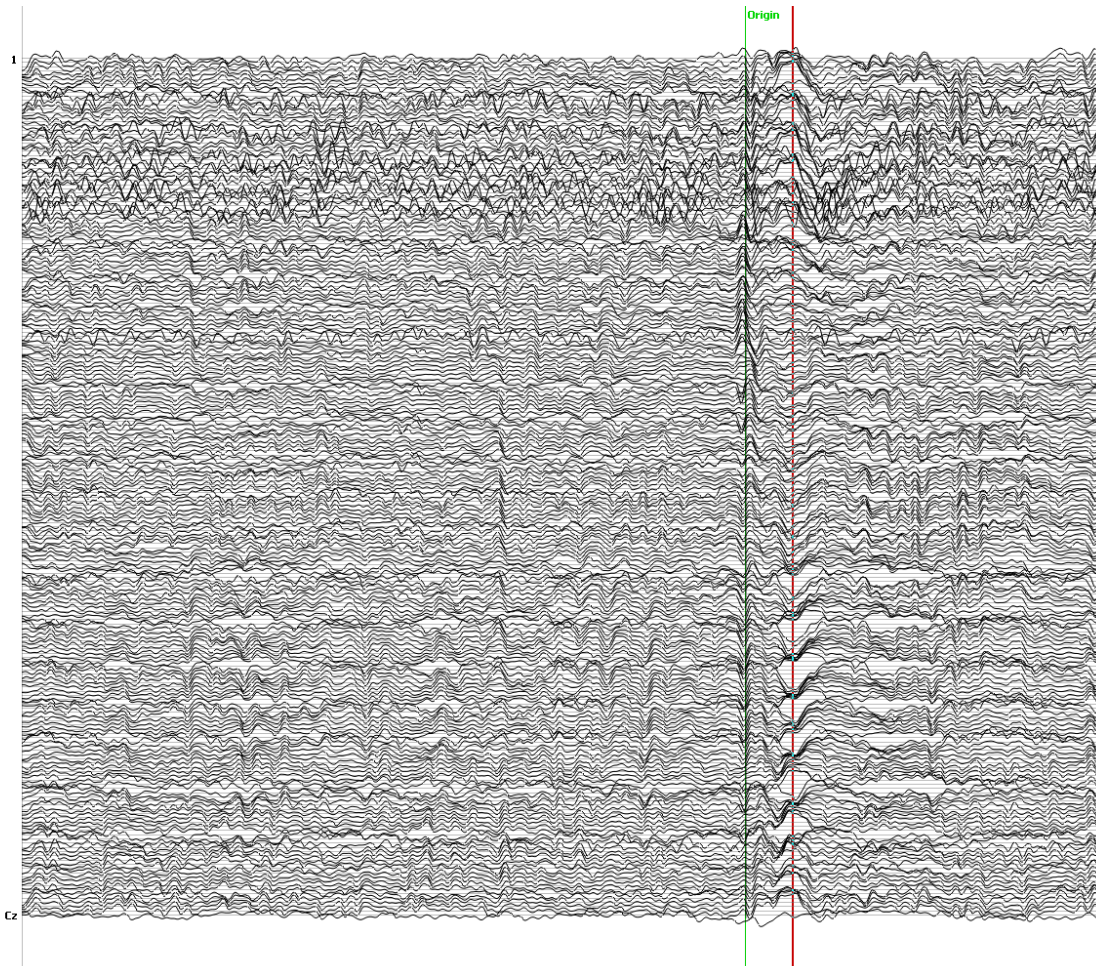
EUROPEAN UNION  
EUROPEAN REGIONAL DEVELOPMENT FUND  
INVESTING IN YOUR FUTURE



**OP Research and  
Development for Innovation**

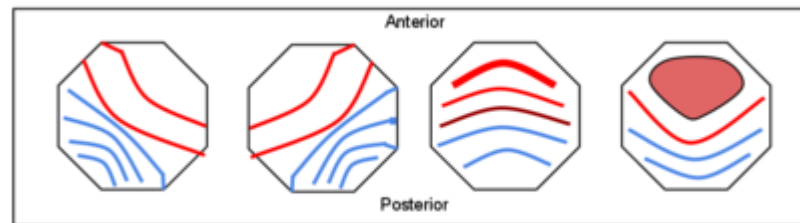
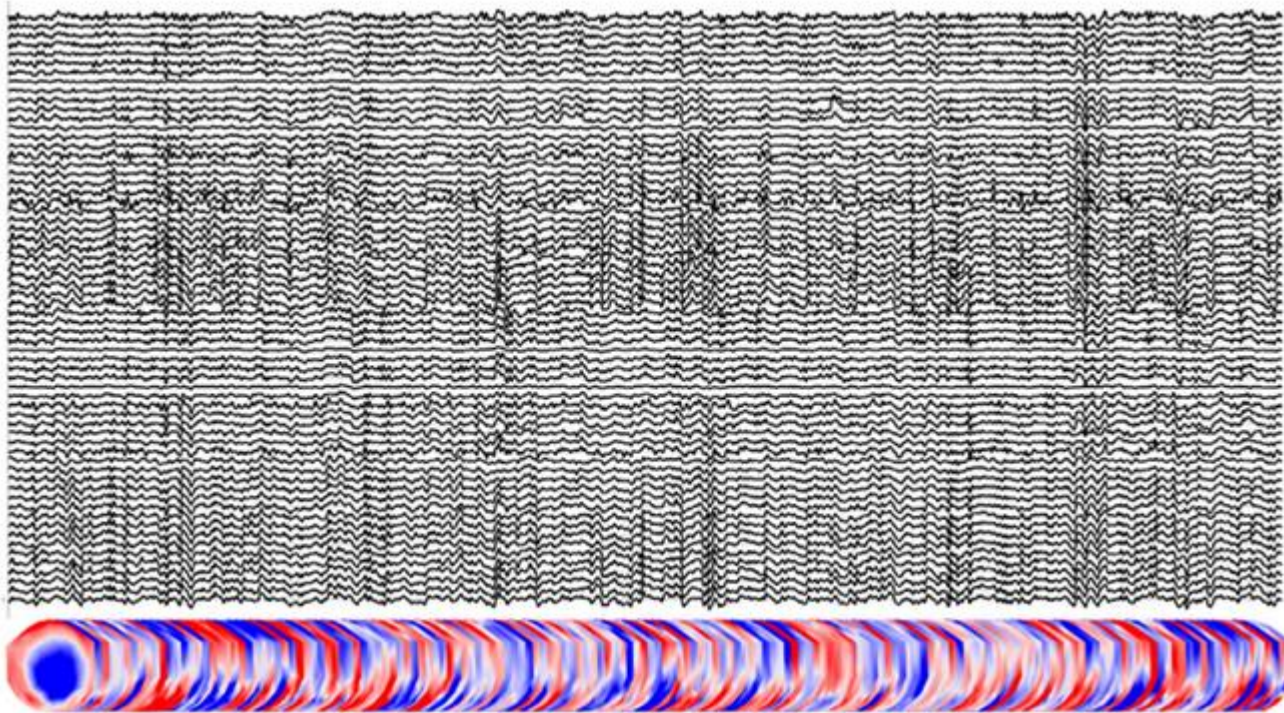


# EEG microstates

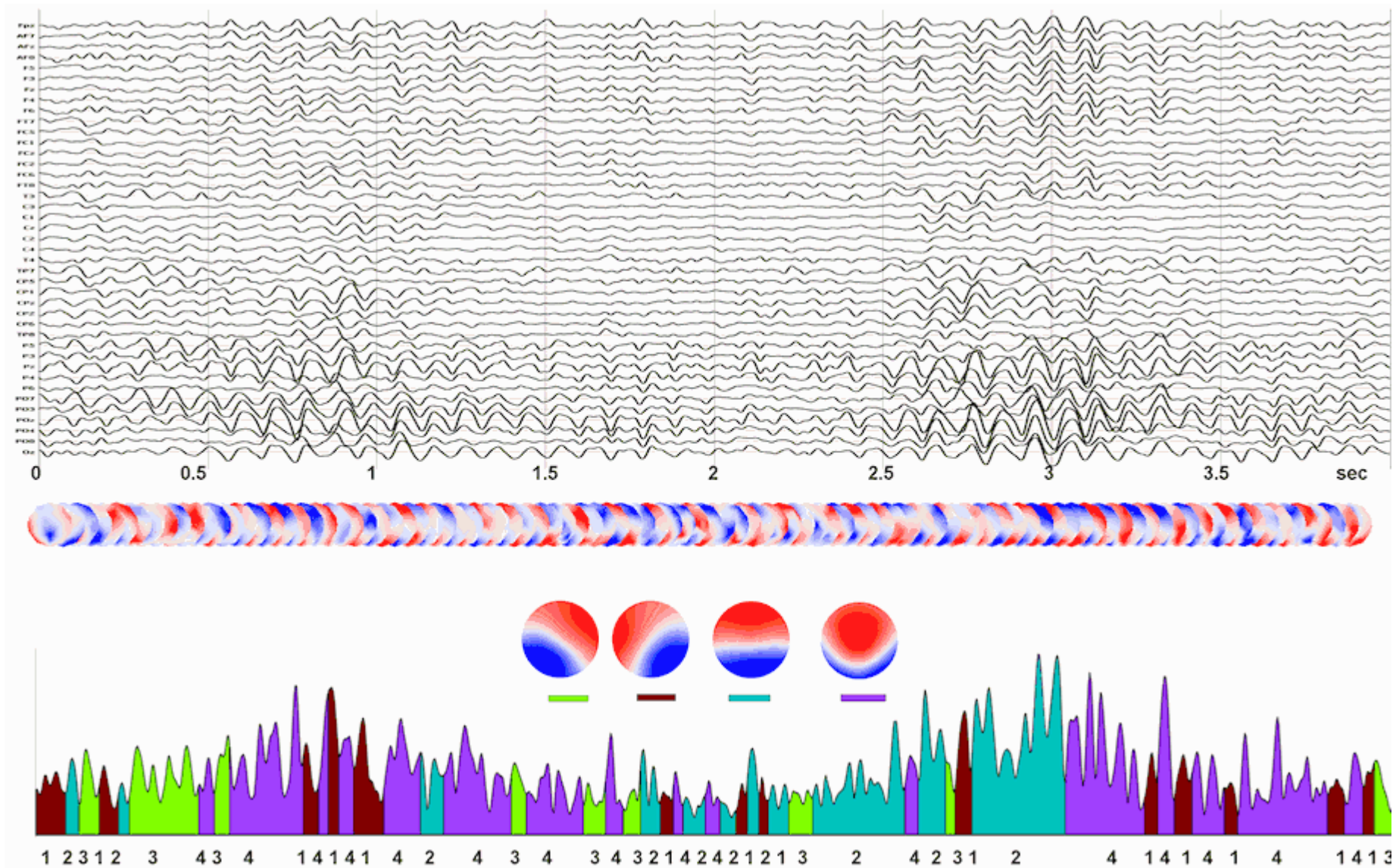




# EEG microstates

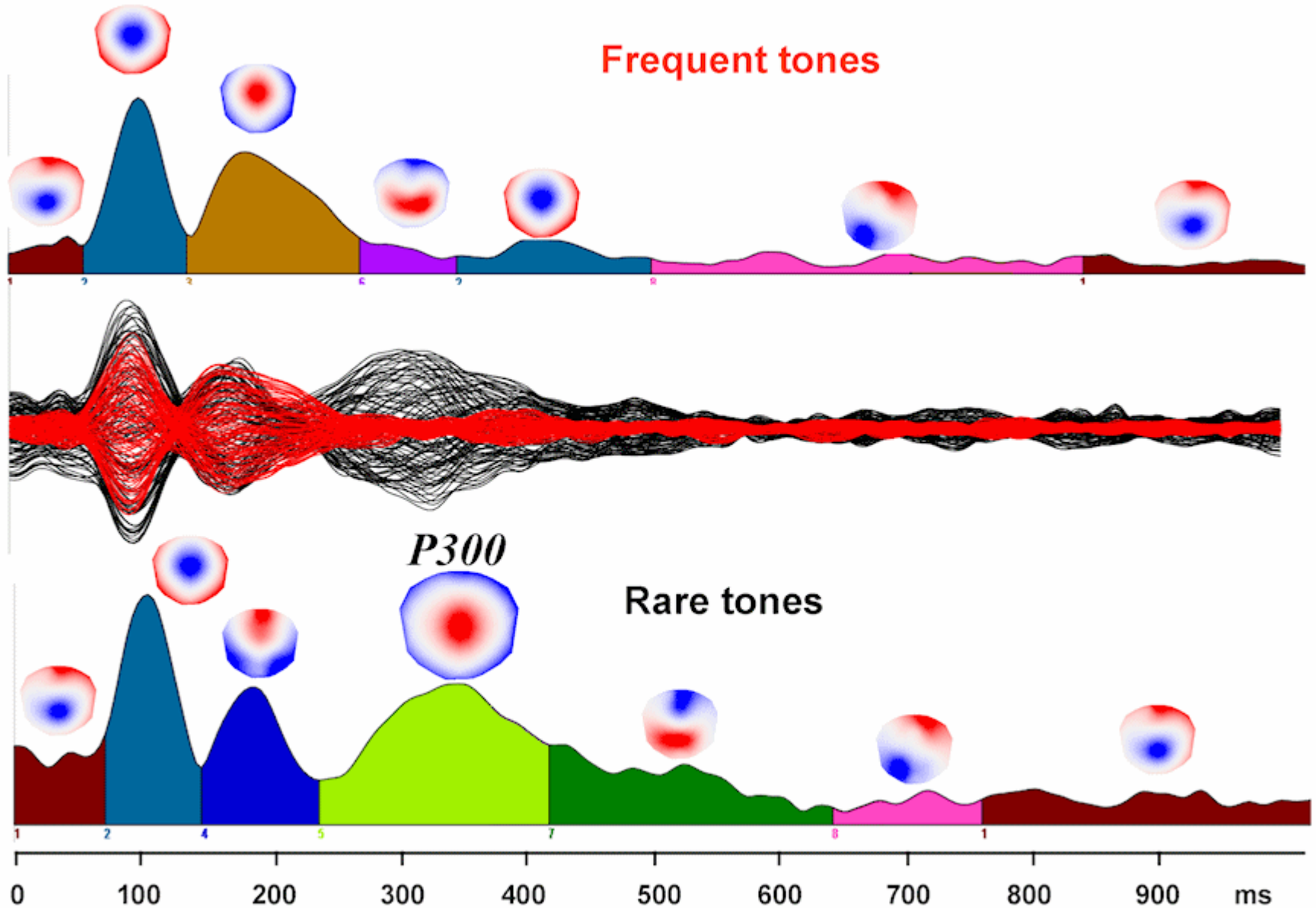


# EEG microstates



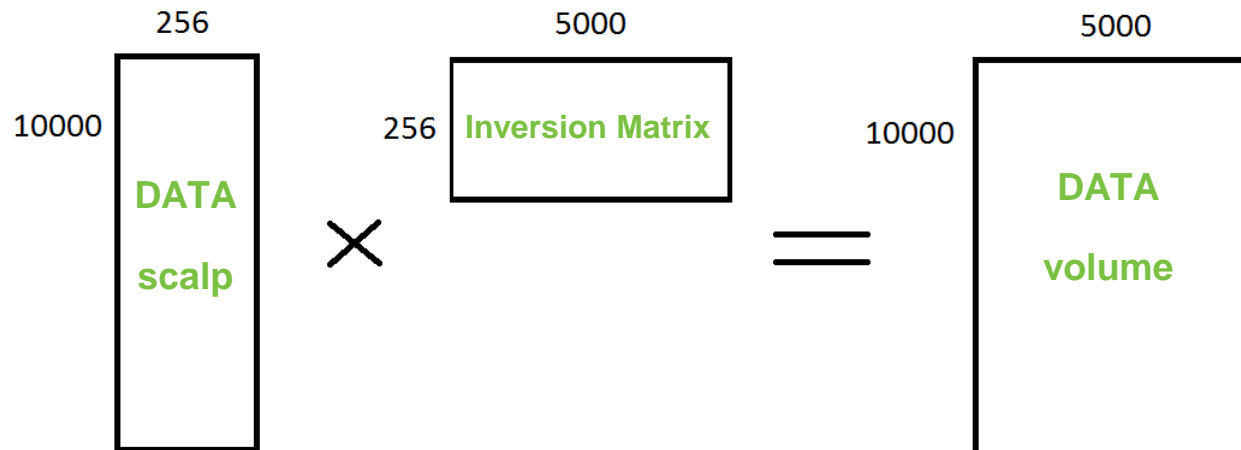


# EEG microstates



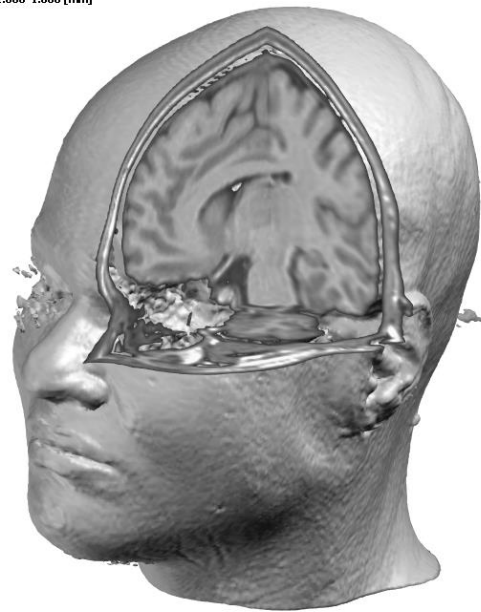
# Source Localization of Brain Activity

- Effort to reconstruct sources of the brain activity in the volume (3D) from the scalp EEG measurement (2D).
- Reconstructed signals are weaken and „blurred“ (distance and attenuation in the tissue)
- Many of necessary constants are not described or known well yet (conductance of skull)
- Mathematical and computation issues
- Practically – **fixed positions in the brain** (solution points - SP) and **inversion matrix** for the calculation from scalp data to signals localized in SP



# MRI

Full head  
Data are positive  
Volume size: 187 246 246 [Voxel]  
Content size: 160.0 237.0 226.0 [Voxel]  
Origin: 93.00 123.00 123.00 [Voxel]  
Voxel size: 1.000 1.000 1.000 [mm]

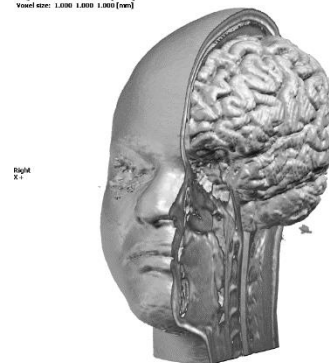


Segmented volume  
Data are positive  
Volume size: 187 246 246 [Voxel]  
Content size: 124.0 157.0 131.0 [Voxel]  
Origin: 93.00 123.00 123.00 [Voxel]  
Voxel size: 1.000 1.000 1.000 [mm]



- Noise Filtration
- Bias Field Correction
- Optimal orientation of the scan

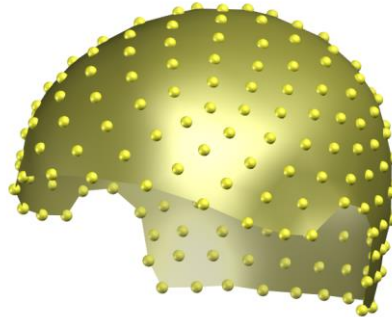
Full head  
Data are positive  
Volume size: 187 246 246 [Voxel]  
Content size: 160.0 237.0 226.0 [Voxel]  
Origin: 93.00 123.00 123.00 [Voxel]  
Voxel size: 1.000 1.000 1.000 [mm]



# Electrodes

204 electrodes, in 1 cluster(s)  
Surface Electrodes  
Data are 3D points  
3D Space  
Content size: 160.0 189.1 136.7 [mm]

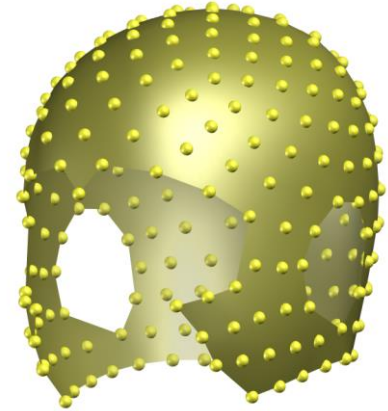
Superior  
Z+



Inferior  
Z-

257 electrodes, in 1 cluster(s)  
Surface Electrodes  
Data are 3D points  
3D Space  
Content size: 152.6 194.6 192.6 [mm]

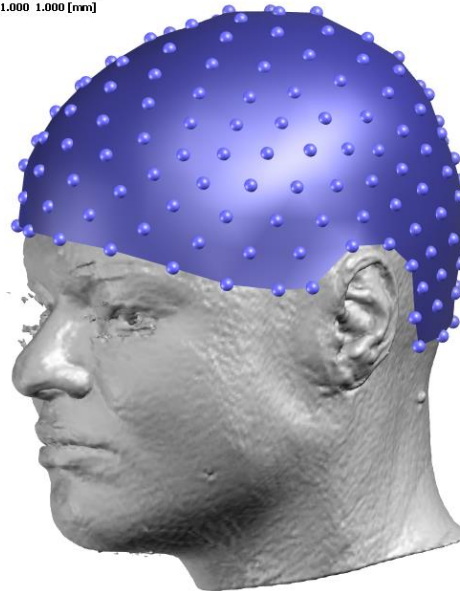
Superior  
Z+



Inferior  
Z-

Full head  
Data are positive  
Volume size: 171 251 247 [Voxel]  
Content size: 170.0 250.0 246.0 [Voxel]  
Origin: 87.00 139.00 161.00 [Voxel]  
Voxel size: 1.000 1.000 1.000 [mm]

Superior  
Z+



Anterior  
Y+

127

Posterior  
Y-

Inferior  
Z-

Registration of  
electrodes with  
MRI scan



# Solution Points

Segmented volume, Binary mask  
Data are positive  
Volume size: 187 246 246 [Voxel]  
Content size: 134.0 157.0 131.0 [Voxel]  
Origin: 93.00 123.00 123.00 [Voxel]  
Voxel size: 1.000 1.000 1.000 [mm]

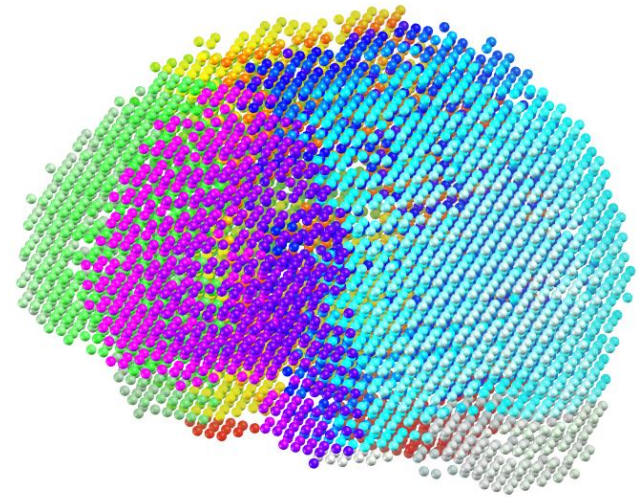
Superior  
Z+



Inferior  
Z-

5990 points  
Aligned Grid Solution Points  
Data are 3D points  
Content size: 159.7 185.1 139.6 [Voxel]

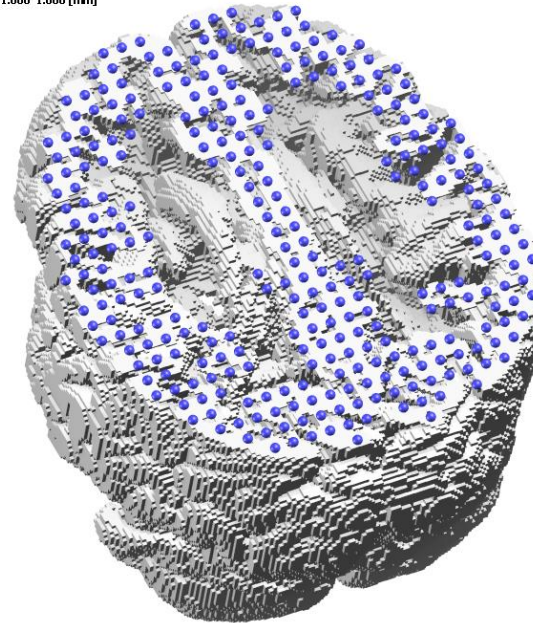
Superior  
Z+



1

Segmented volume, Binary mask  
Data are positive  
Volume size: 187 246 246 [Voxel]  
Content size: 134.0 157.0 131.0 [Voxel]  
Origin: 93.00 123.00 123.00 [Voxel]  
Voxel size: 1.000 1.000 1.000 [mm]

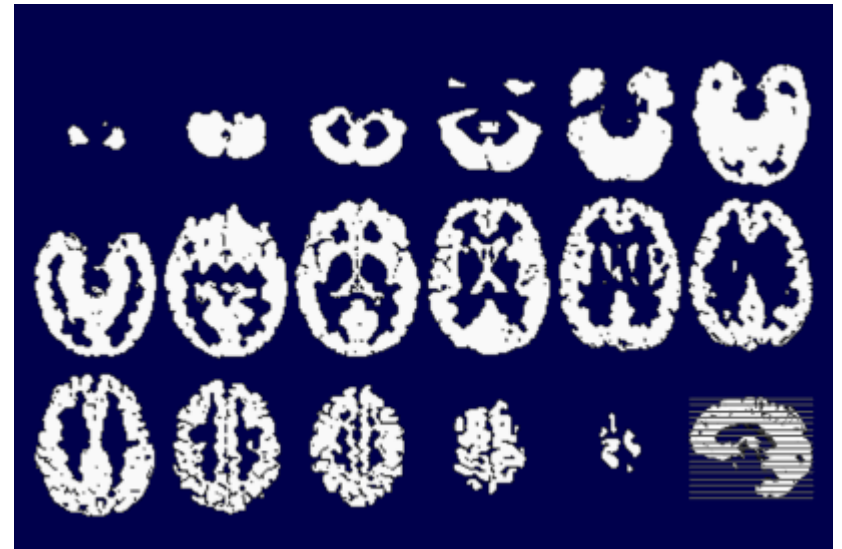
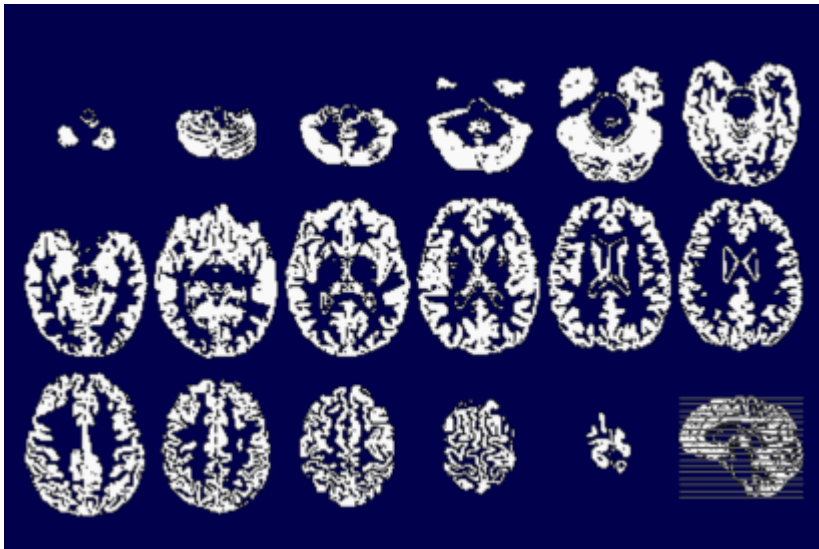
Left  
X-



Right  
X+

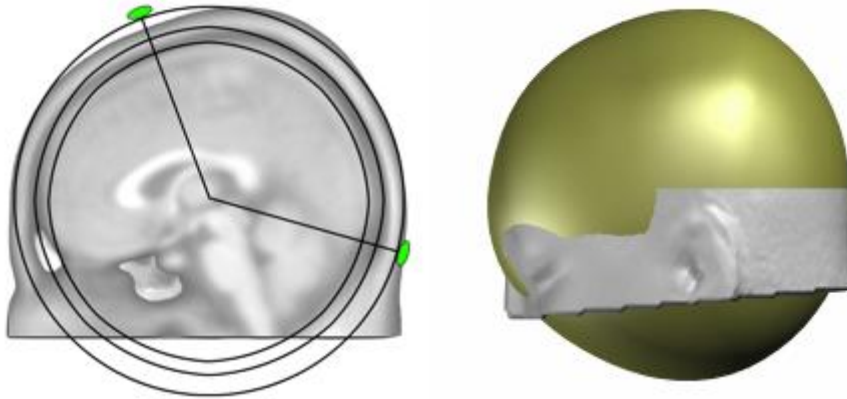


# Gray matter vs Mask of gray matter

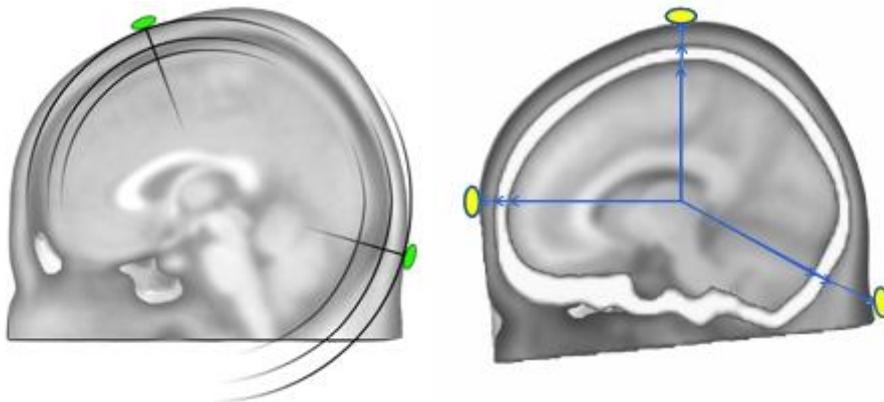


# Forward model

## SMAC - Spherical Model with Anatomical Constraints



## LSMAC - Locally Spherical Model with Anatomical Constraints



Full head  
Data are positive  
Volume size: 171 251 247 [Voxel]  
Content size: 170.0 250.0 246.0 [Voxel]  
Origin: 87.00 139.00 161.00 [Voxel]  
Voxel size: 1.000 1.000 1.000 [mm]

Superior  
Z+

Anterior  
Y+

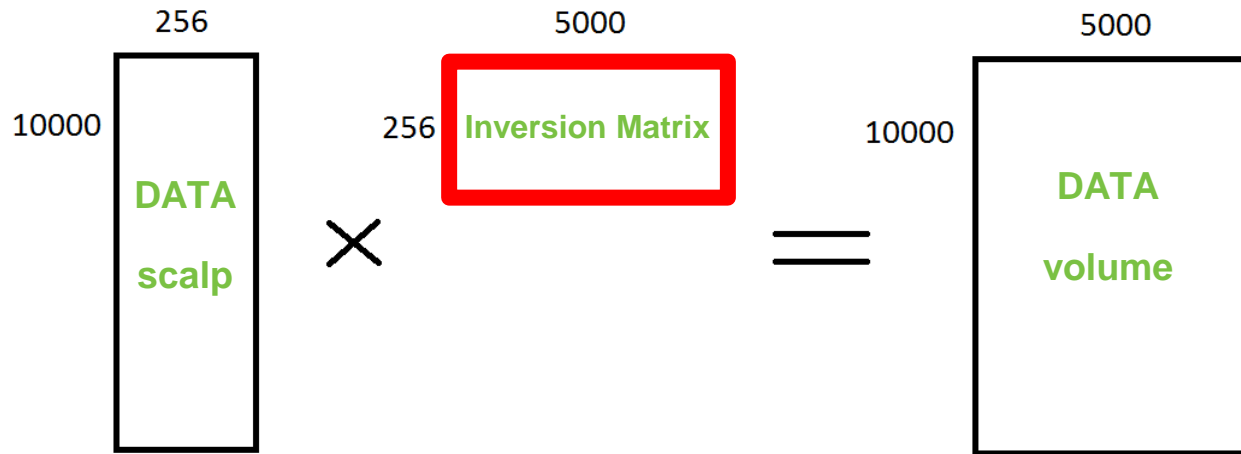
Inferior  
Z-

127  
Posterior  
Y-

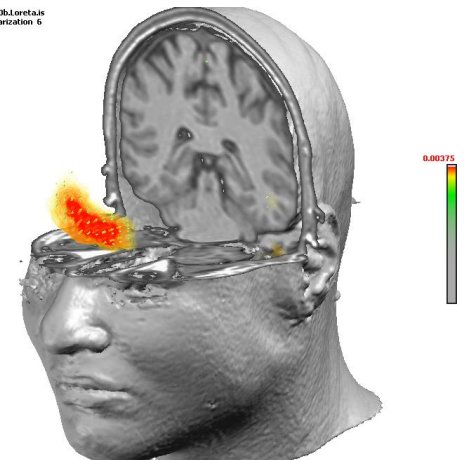


# Inverse solution

LORETA, LAURA, EPIFOCUS, ...



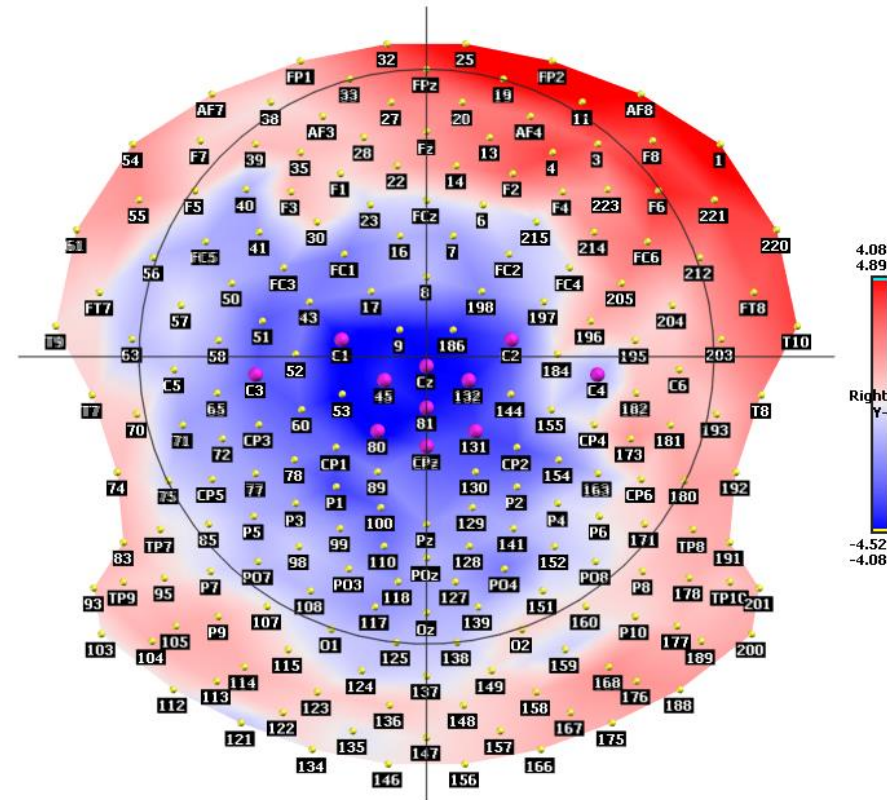
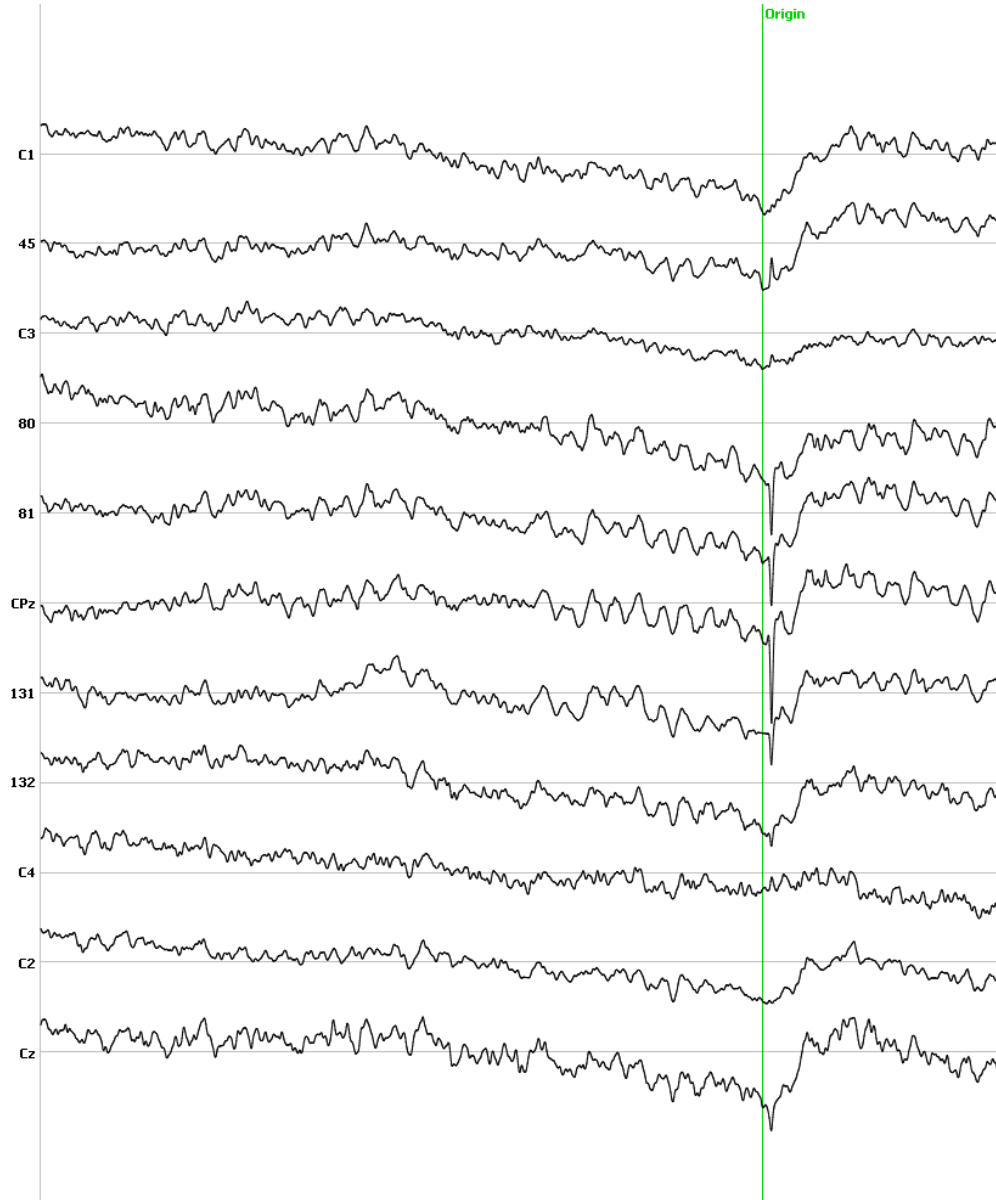
IS3000b.Loreta.js  
Regularization 6



# Readiness potential

EGI 204.Geneva Average 13.10-10  
2D Projected

Anterior  
X+



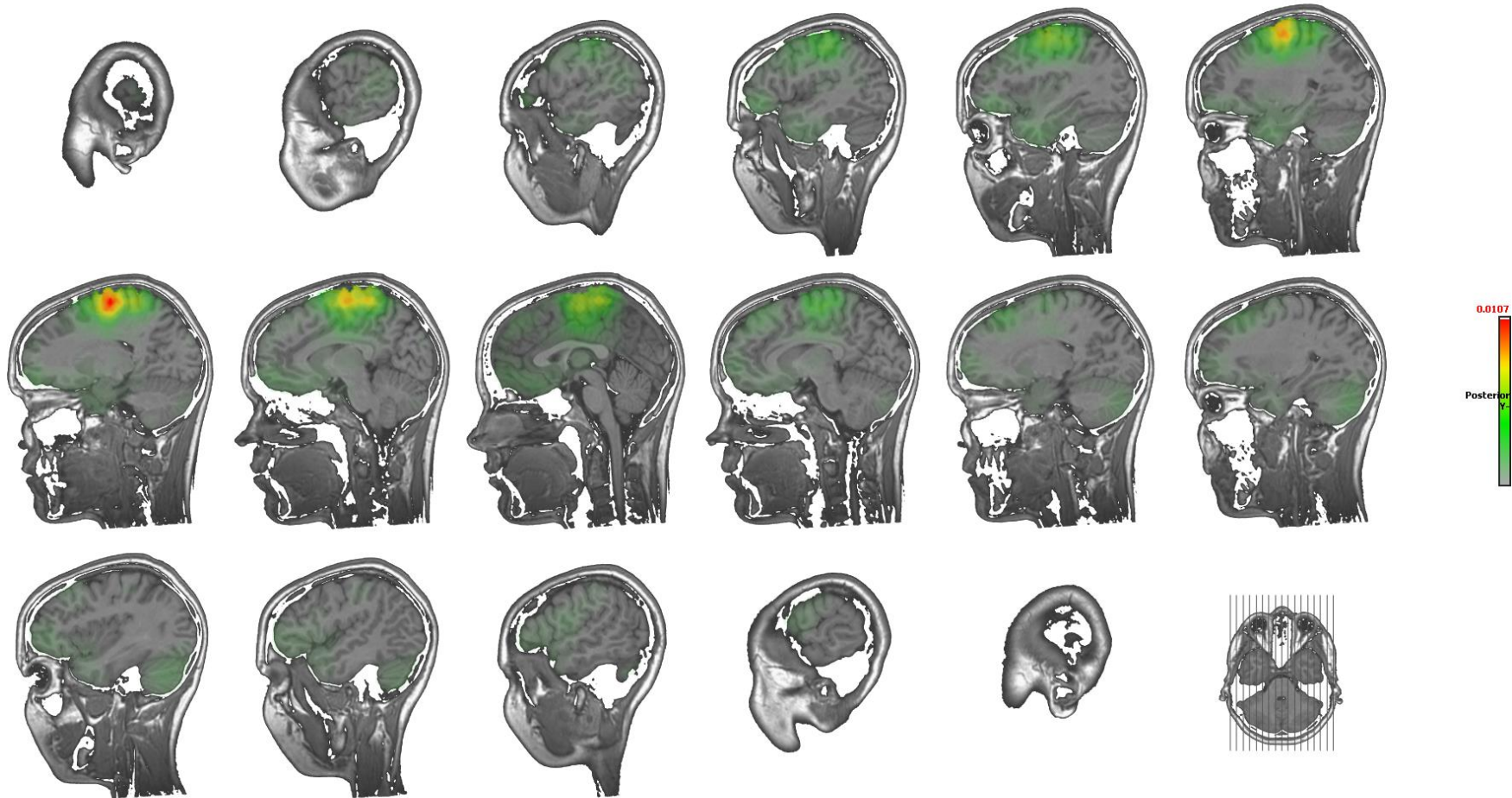
Posterior  
X-

# Readiness potential

155000\_dev2left.Laura  
Regularization 6

Superior  
Z+

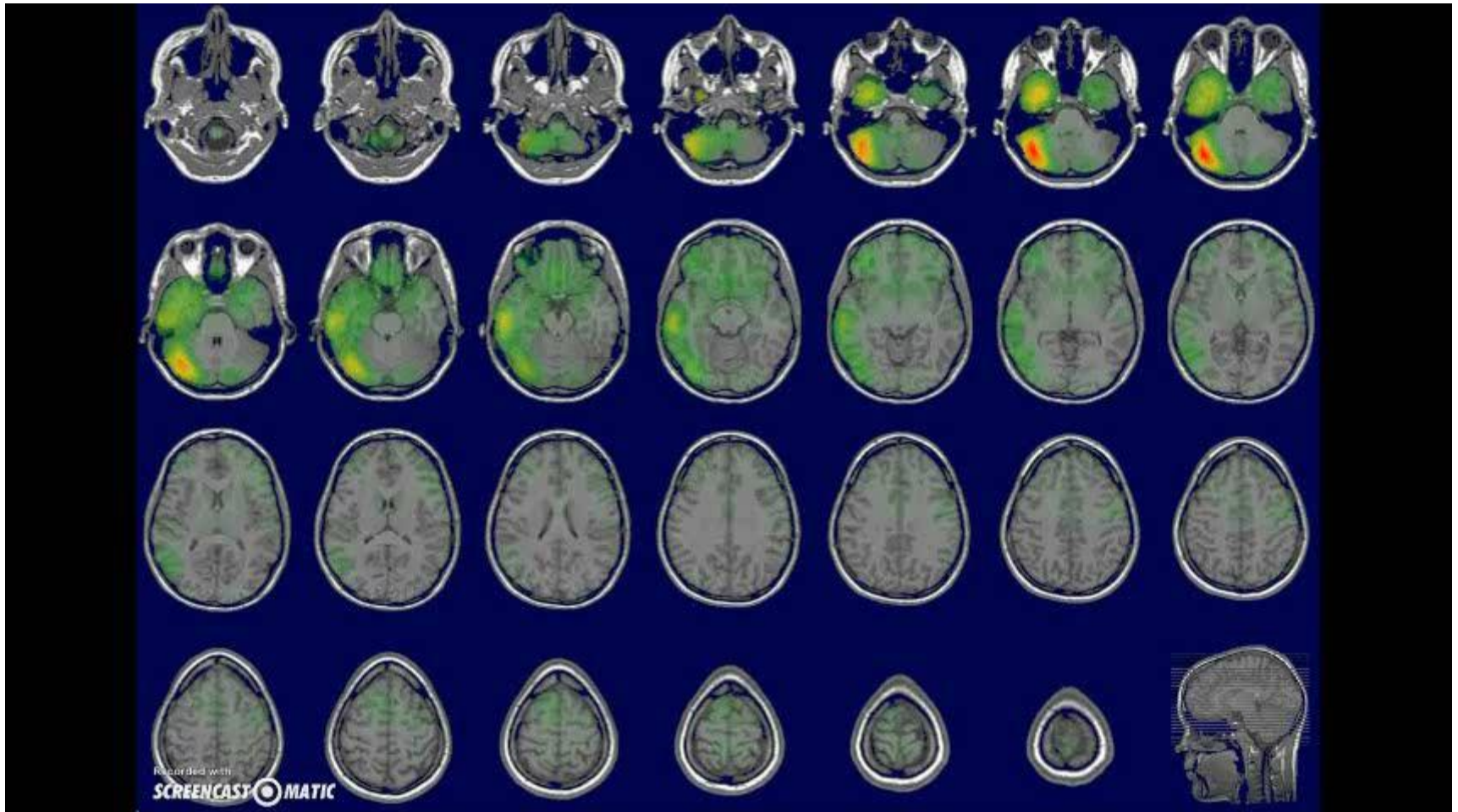
Anterior  
Y+



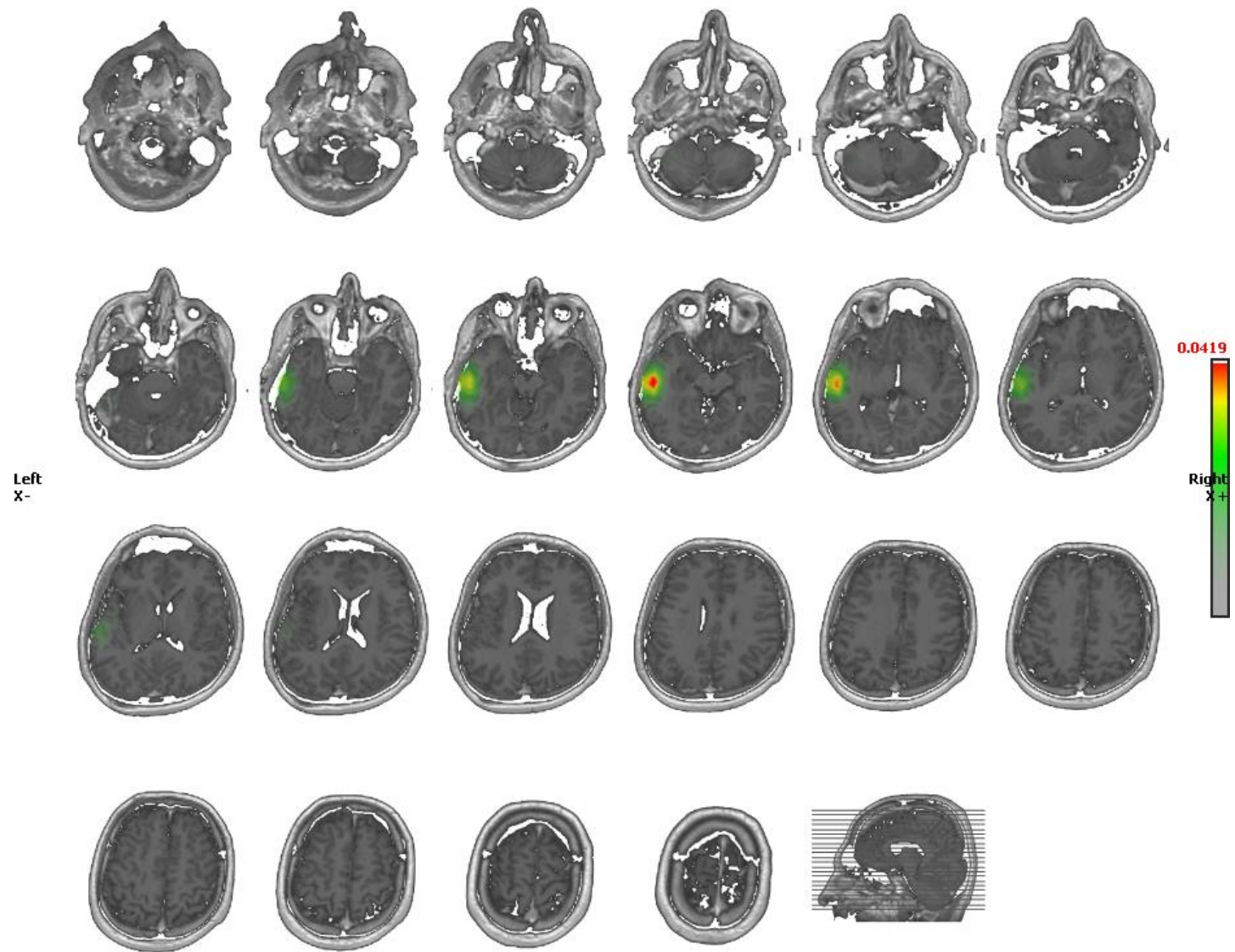
Inferior  
Z-



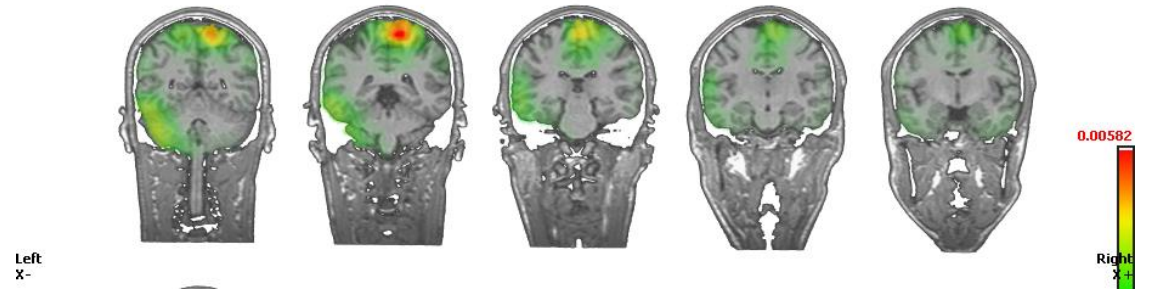
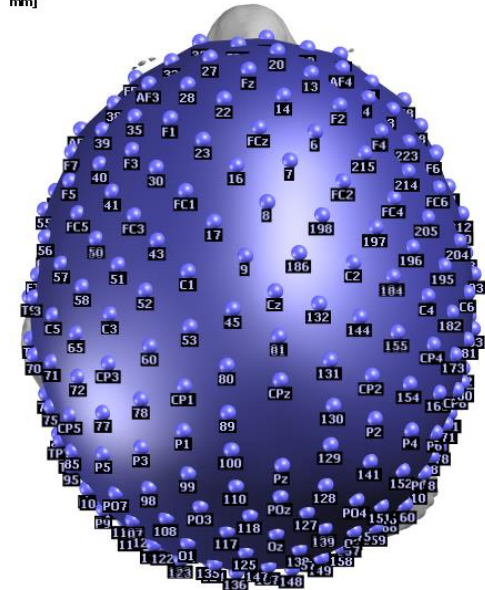
# Readiness potential



# Epilepsy focus localization

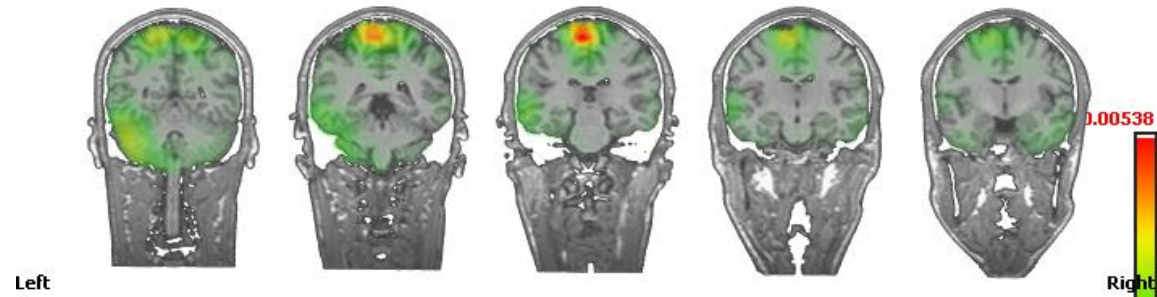
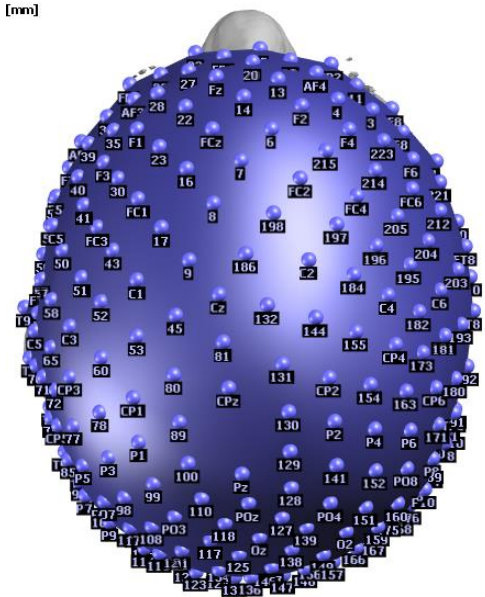


רחוק]



Left  
X-

[חזרה]



**Left**

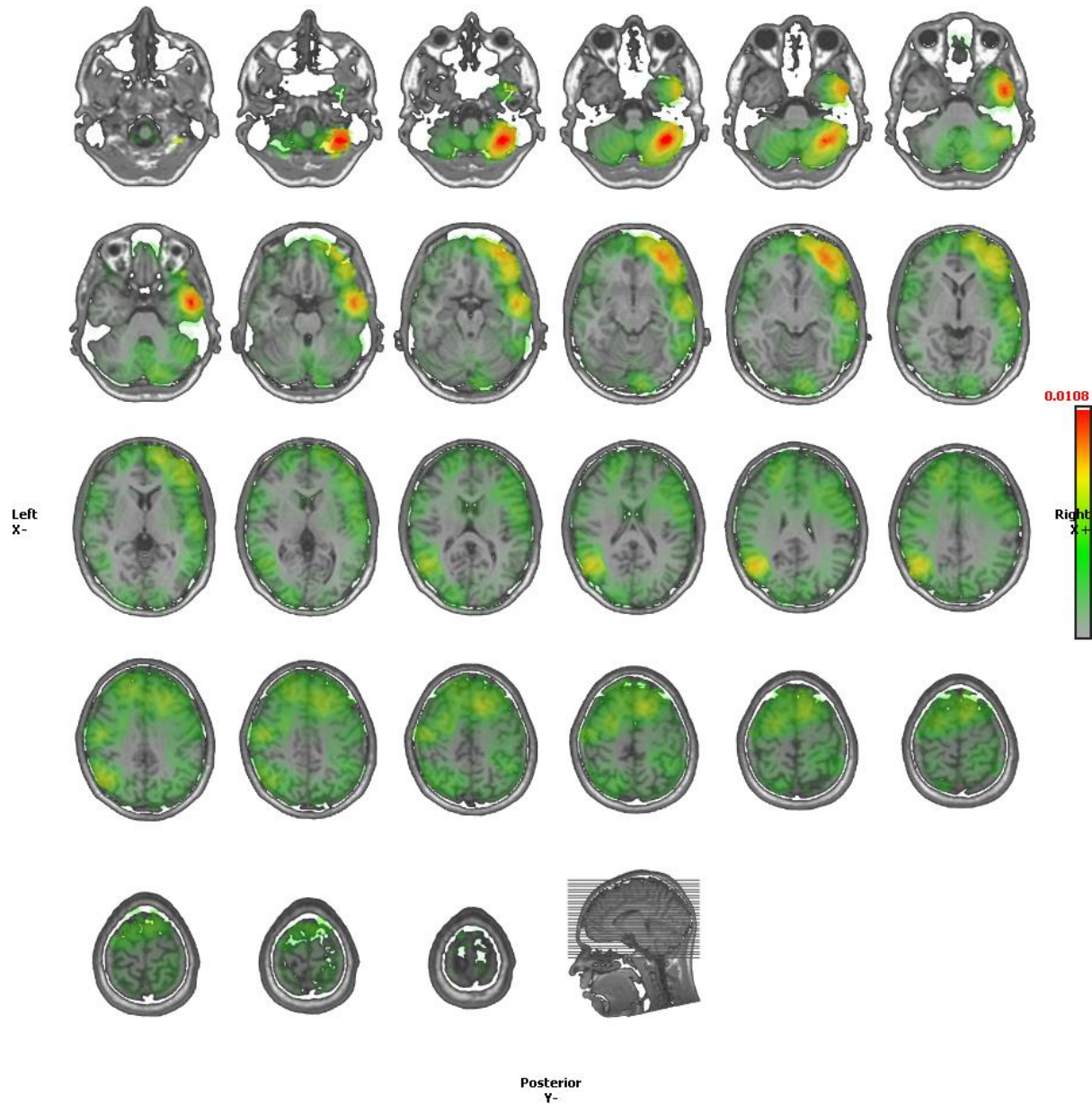
11



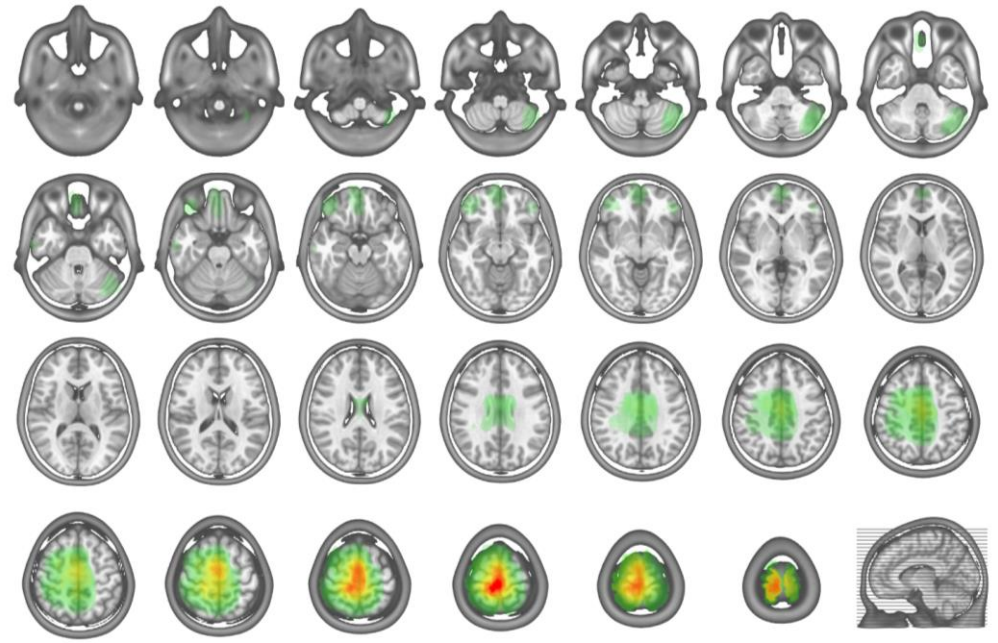
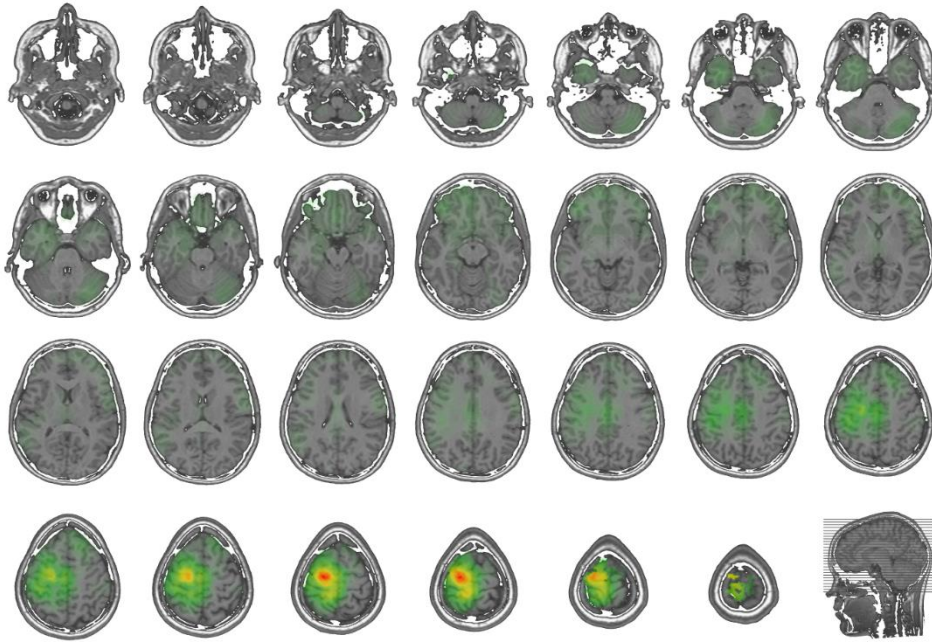
# Data Quality

IS.Loreta[R6].average.Export204.interp1.interp2.interp3

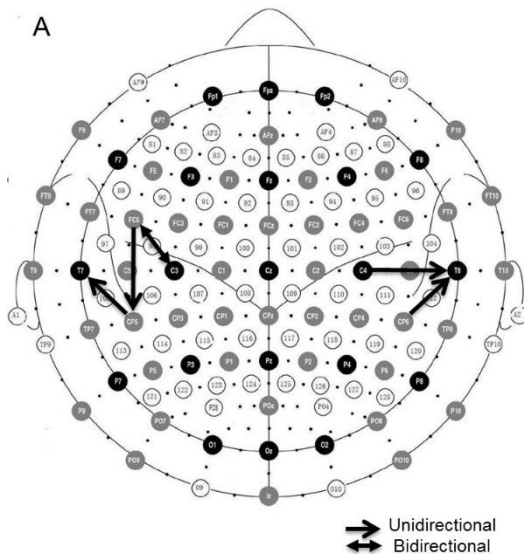
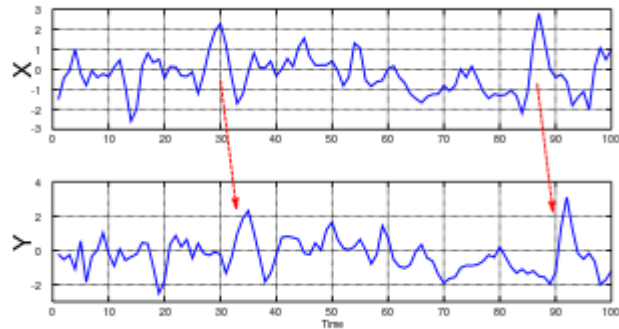
Anterior  
Y+



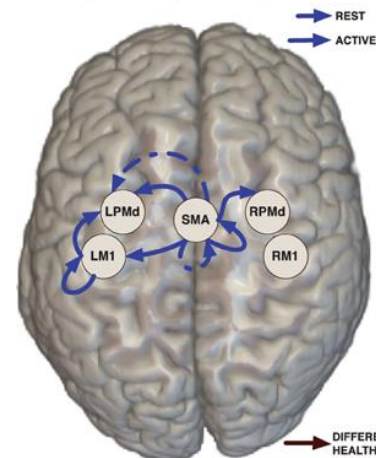
# Forward model - MRI vs MNI template



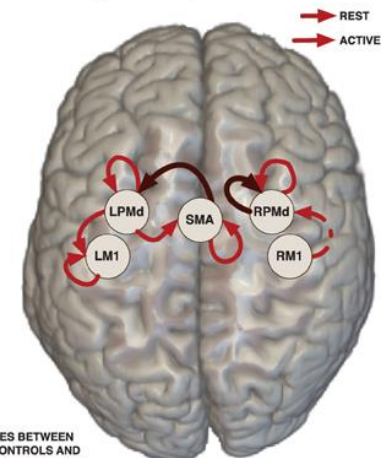
# Effective Connectivity – Granger Causality



Granger Causality for Healthy Controls



Granger Causality for Stroke Patients



DIFFERENCES BETWEEN HEALTHY CONTROLS AND STROKE PATIENTS DURING ACTIVE



# Thank you for your attention



Central European Institute of Technology  
c/o Masaryk University  
Žerotínovo nám. 9  
601 77 Brno, Czech Republic

[www.ceitec.eu](http://www.ceitec.eu) | [info@ceitec.cz](mailto:info@ceitec.cz)



EUROPEAN UNION  
EUROPEAN REGIONAL DEVELOPMENT FUND  
INVESTING IN YOUR FUTURE



**OP Research and  
Development for Innovation**

