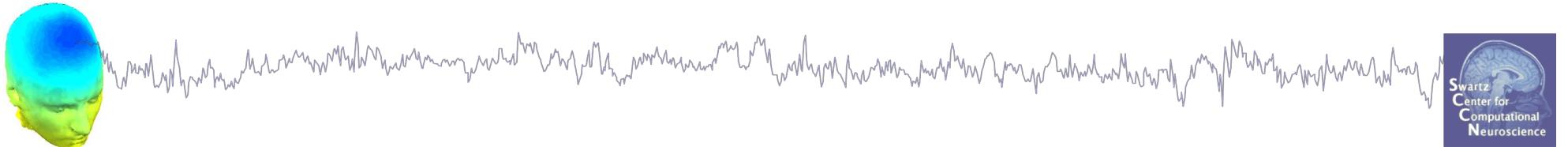


Simultaneous EEG/MEG analysis in EEGLAB

EEGLAB Workshop 2018
UCSD



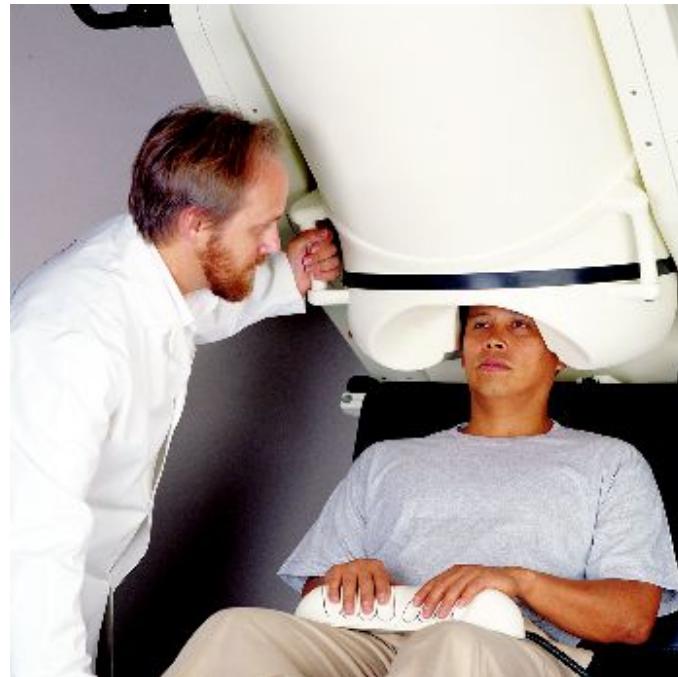
A tale of two cousins



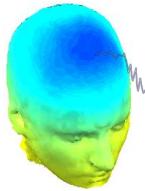
EEG



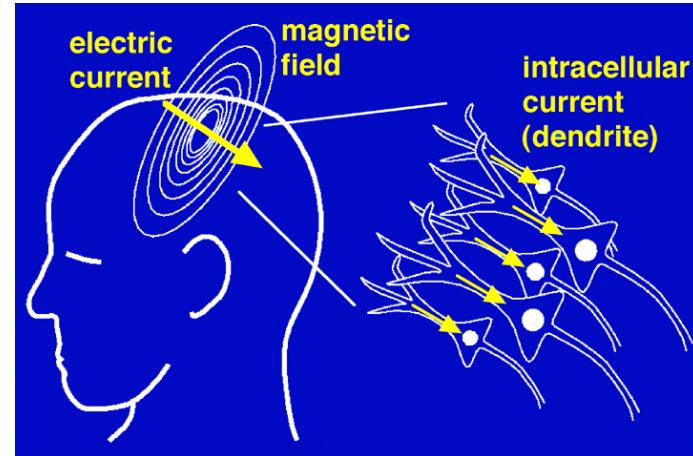
MEG



MEG Basics



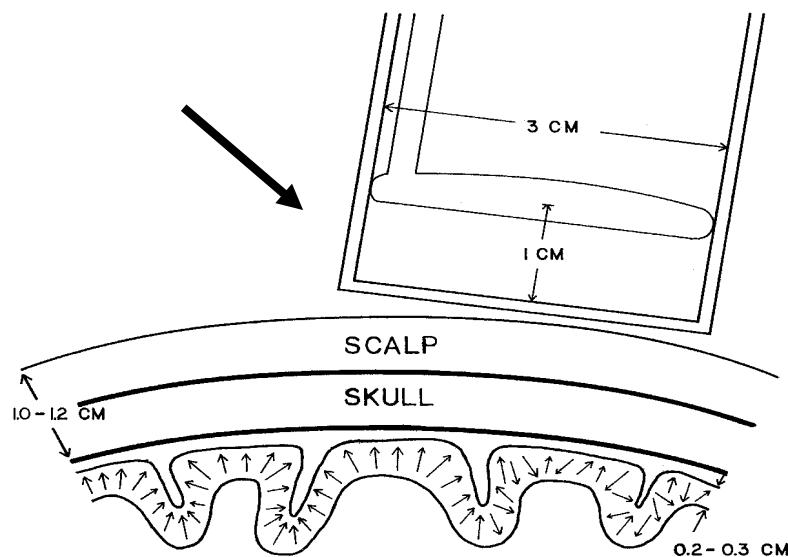
Measures magnetic fields induced by neural activity in cortex

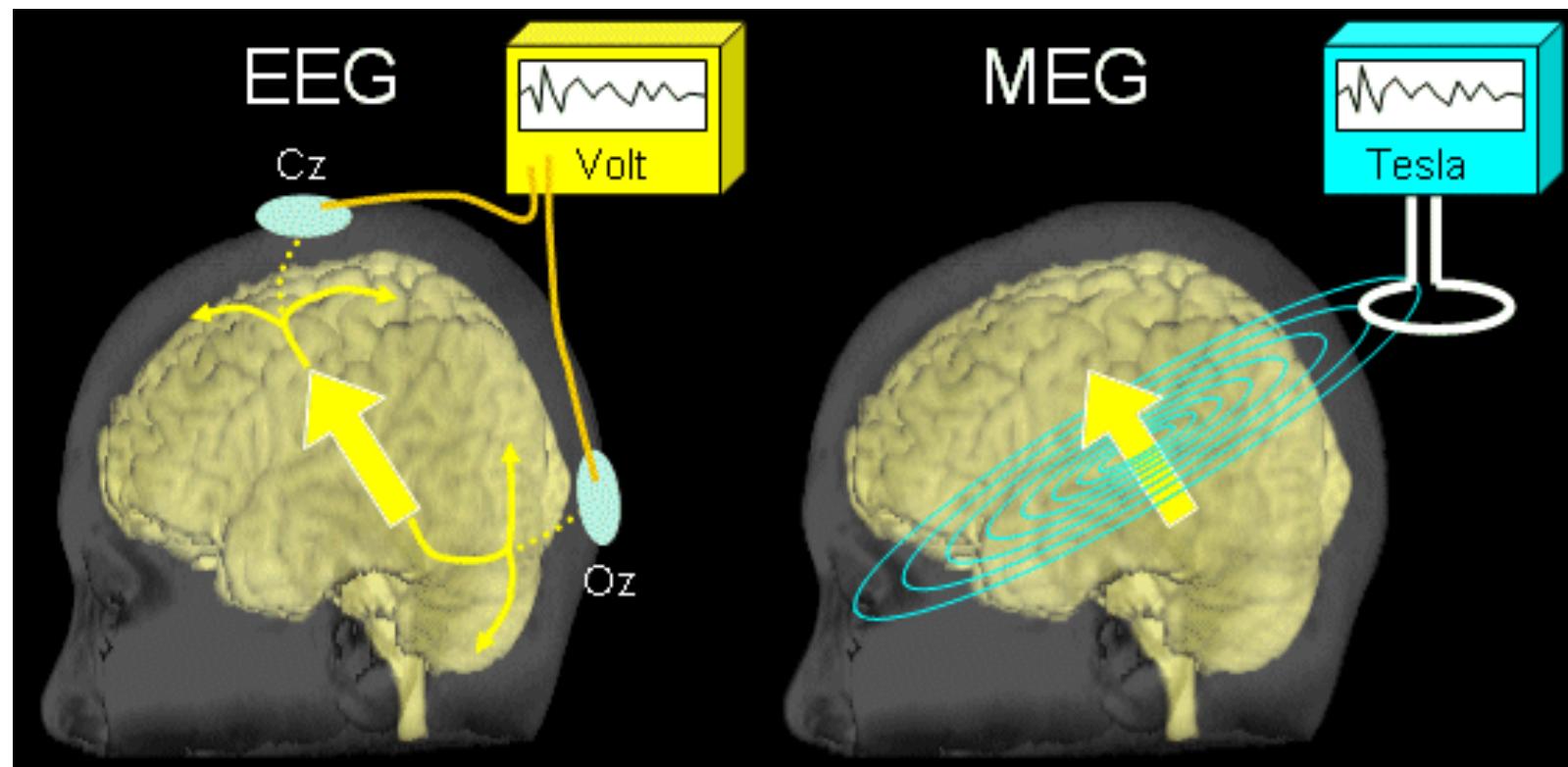
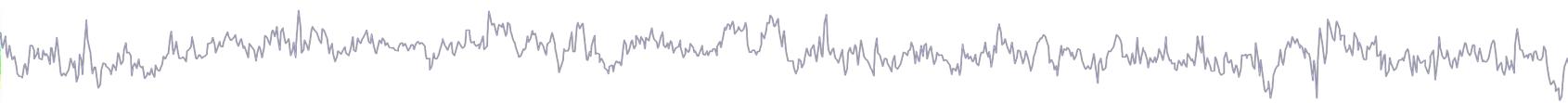
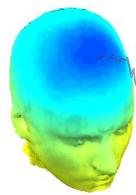


Technology: SQUIDs

Magnetic field strengths:

Picotesla

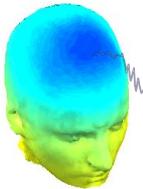




<http://meg.aalip.jp/vsEEG/vsEEGE.html>

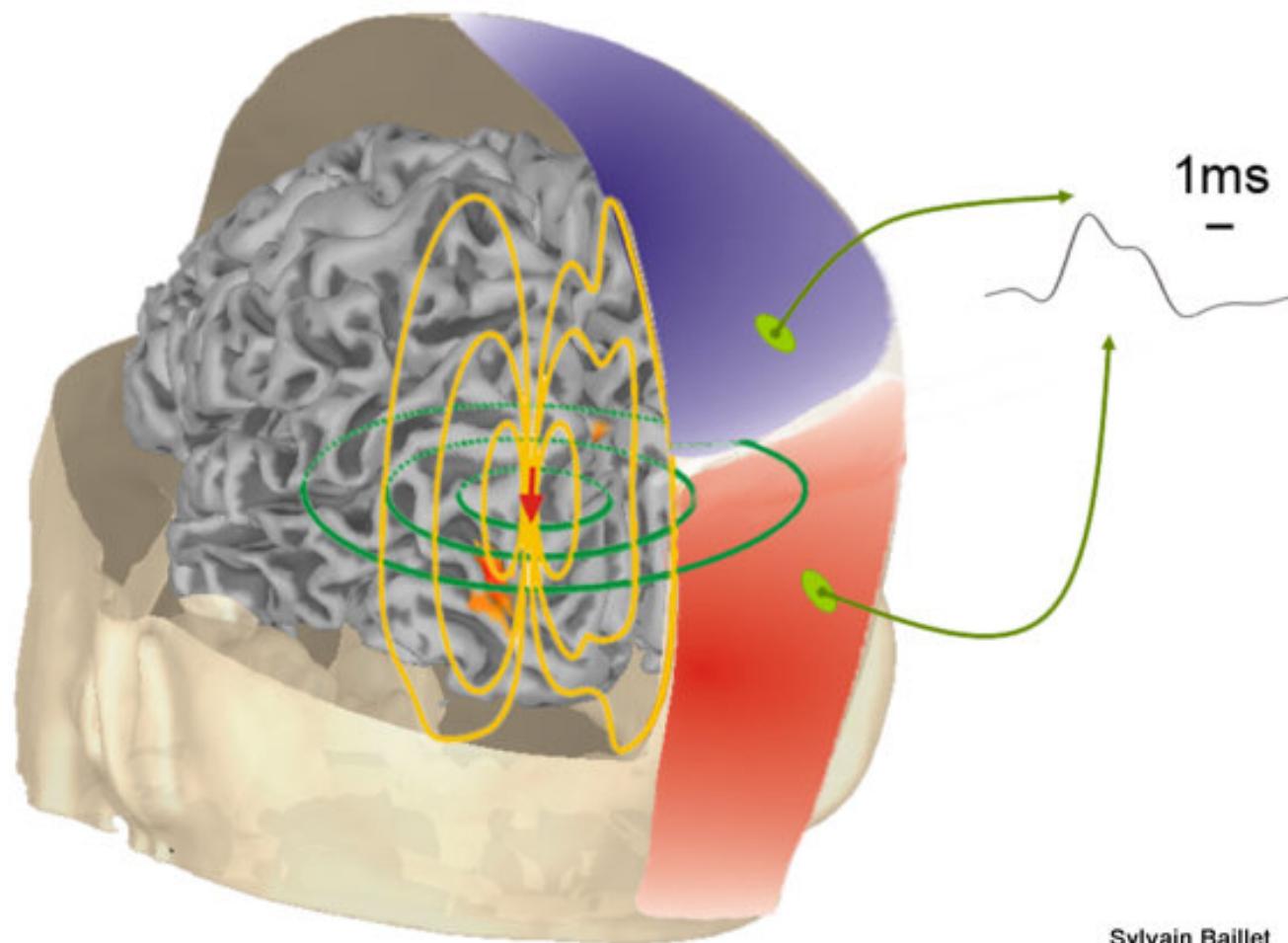
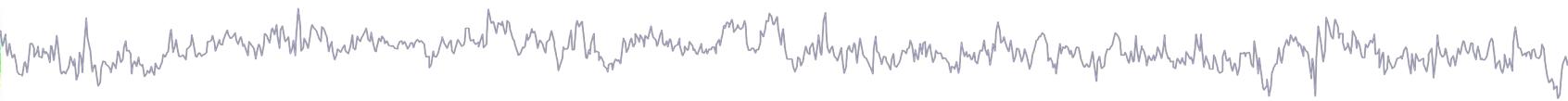
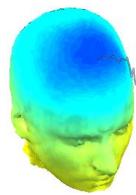


MEG vs. EEG



- Many arguments for superiority of one over the other
- Differences...
 - EEG is cheaper, and portable
 - MEG localization is not so sensitive to the details of the head model
 - MEG misses radial sources
 - MEG sensor locations vary run by run
 - MEG better for localizing auditory sources(?)
- Localization accuracy generally ~equivalent given good head model for EEG
- Scalp projections are orthogonal

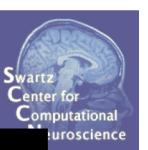
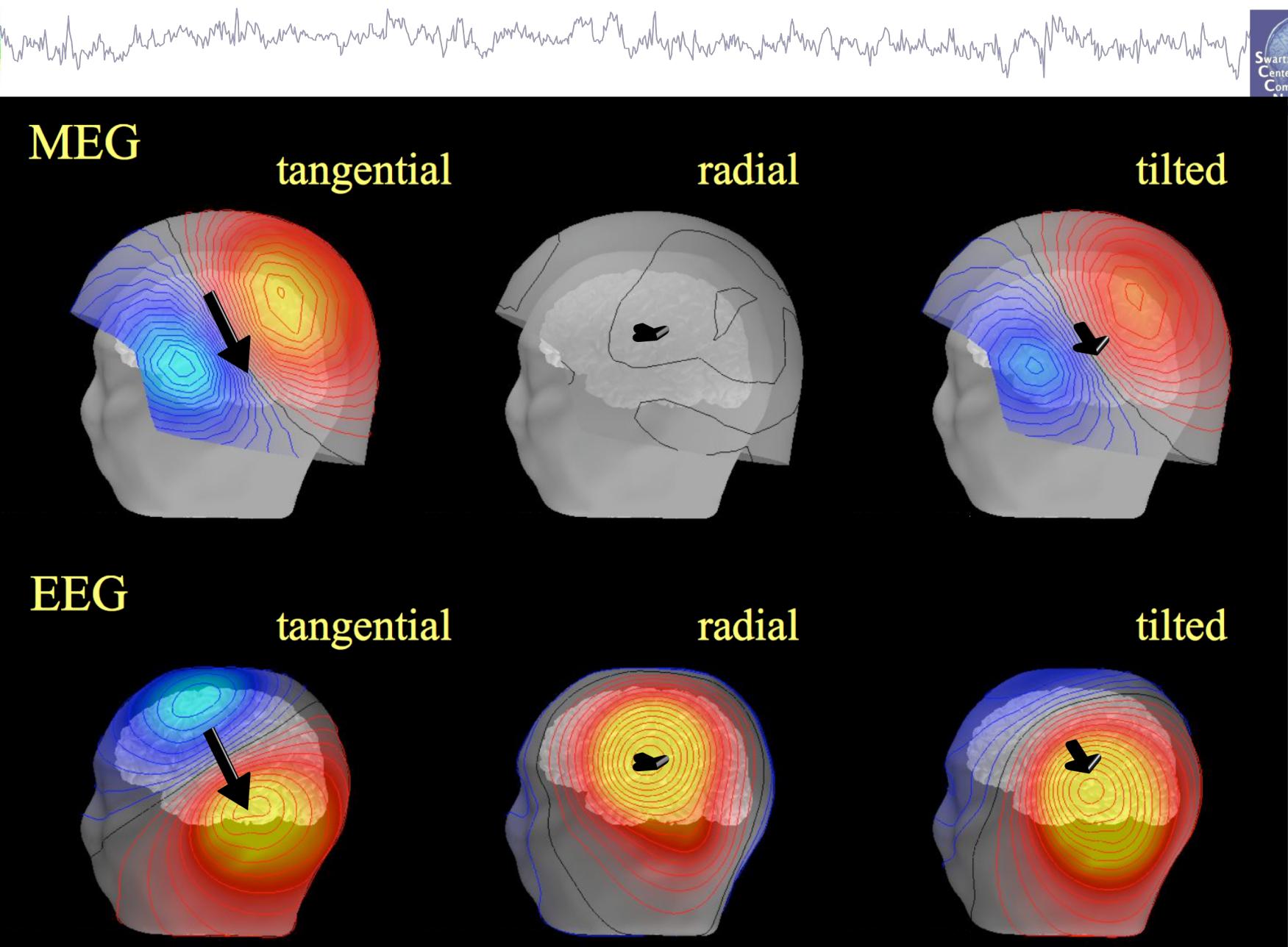
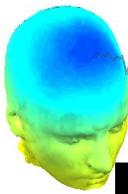




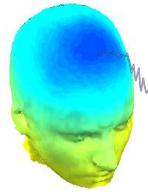
Sylvain Baillet



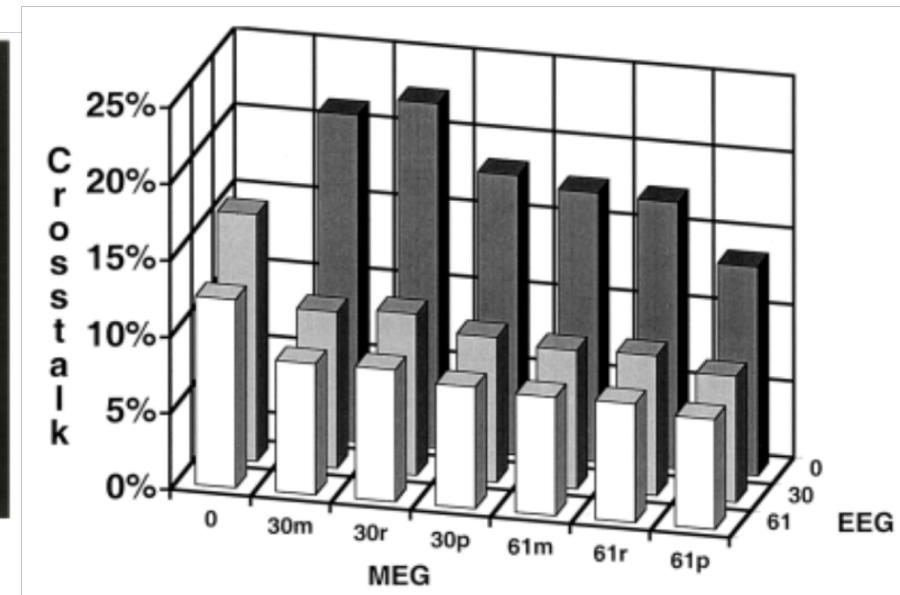
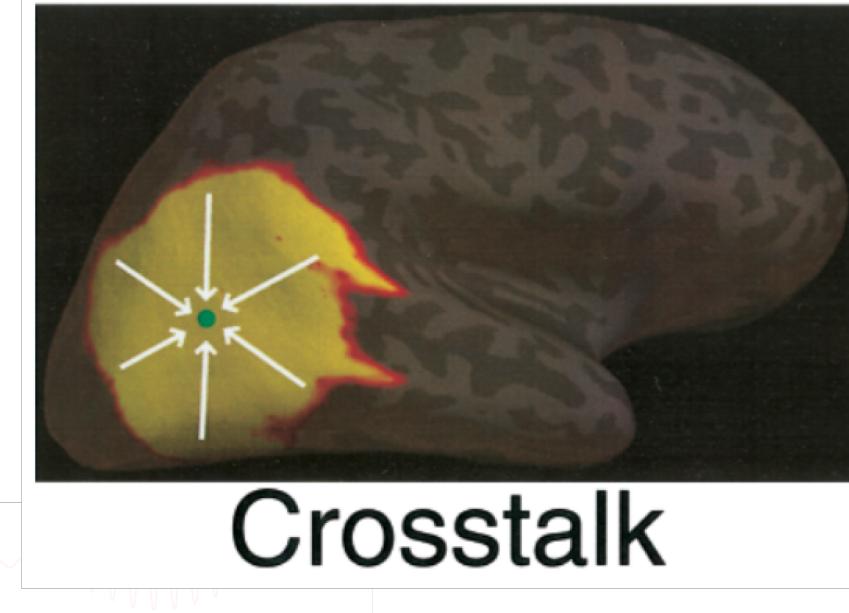
Orientation and Orthogonality



MEEG

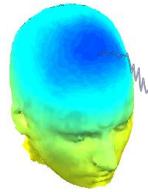


- Simultaneous MEG & EEG recording
 - Relatively rare
 - Adding even relatively few EEG/MEG channels to the other modality has *localization advantages*

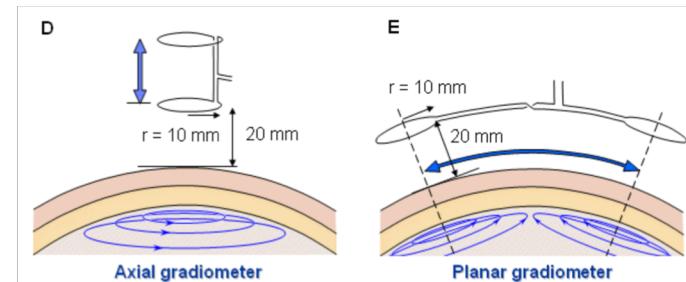


Liu et al. (2002) Human Brain Mapping 16:47– 62

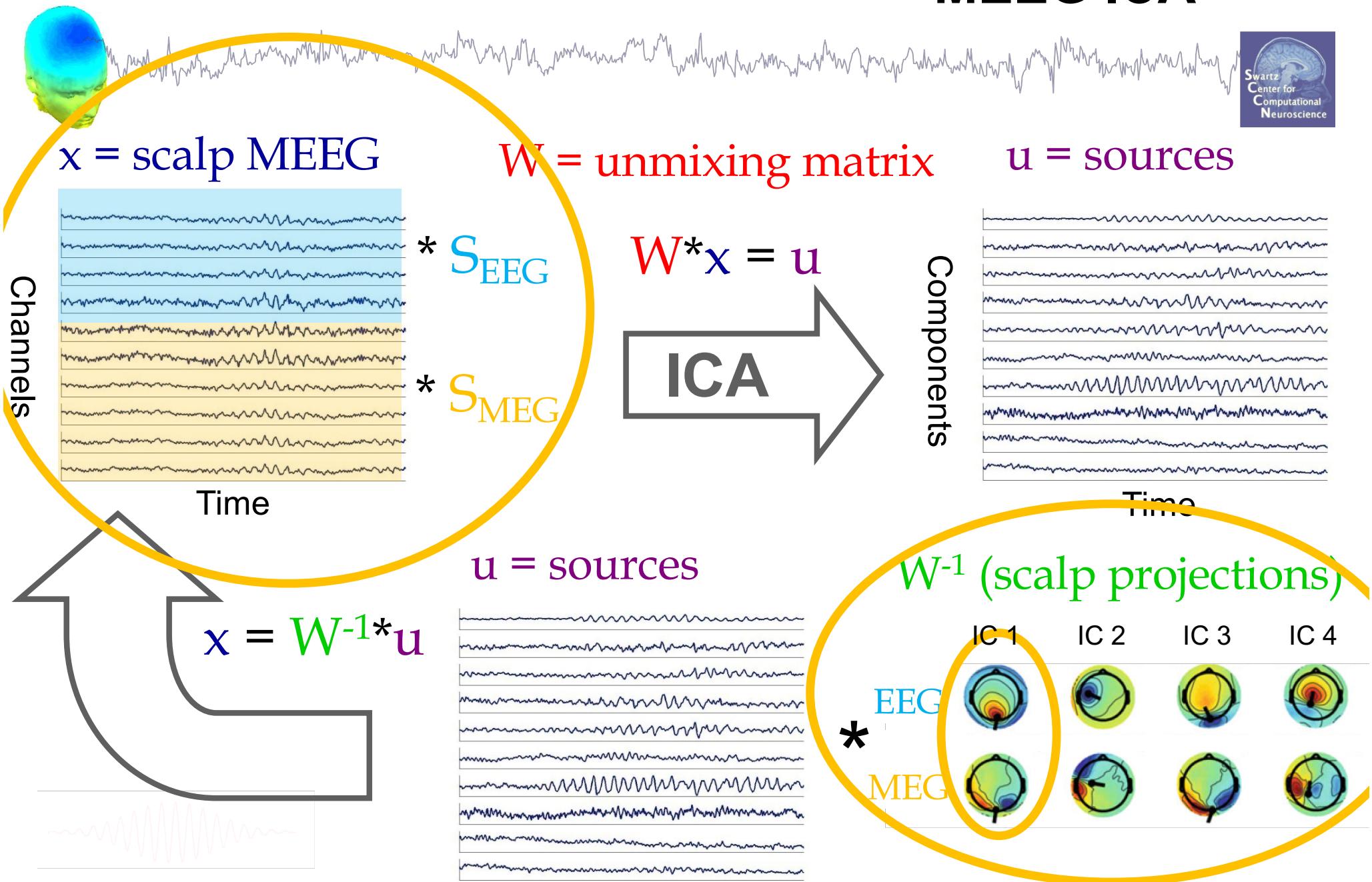
MEG in EEGLAB Considerations



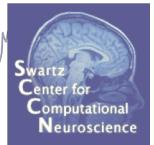
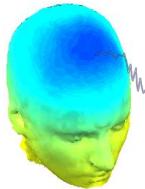
- Multiple MEG sensor types, some vector
 - Magnetometer (scalar)
 - Radial gradiometer (scalar)
 - Planar gradiometer (vector*)
- Dual head models, sensor specifications & lead fields
- Signal units and magnitudes are different
- How do ICA?



MEEG ICA



Plain English → MATLAB



Source activation = **unmixing** * Channel data

Channel data = **mixing (topo)** * Source activation

Prior to ICA: separately sphere **EEG** and **MEG** channels

```
EEG.icaact = (EEG.icaweights*EEG.icasphere) * EEG.data
```

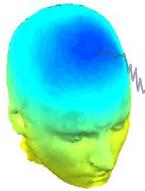
```
EEG.icasphere(:,echans) = EEG.icasphere(:, echans) * EEG/etc/meeg.Se
```

```
EEG.icasphere(:,mchans) = EEG.icasphere(:, mchans) * EEG/etc/meeg.Sm
```

```
EEG.data = EEG.icawinv * EEG.icaact
```



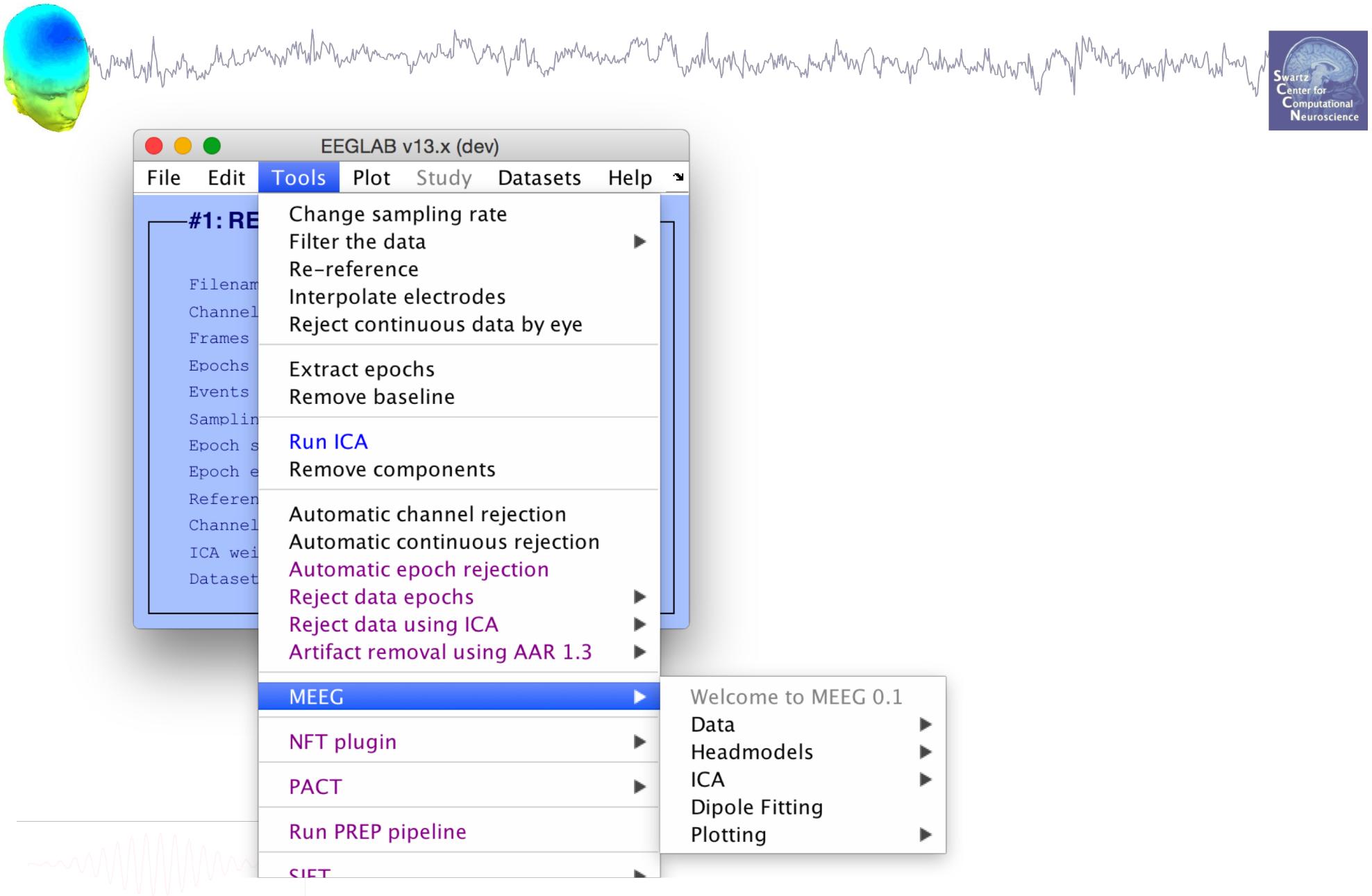
Implementation Details



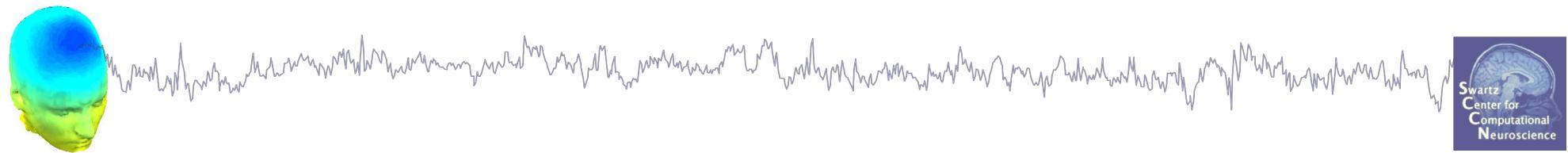
- Uses NFT & Fieldtrip 'under the hood'
 - Custom dipolefitting routines
 - Enhanced eeglab2fieldtrip and fieldtrip2eeglab
- Data
 - EEG.chanlocs.type = 'EEG' or 'MEG'
 - EEG/etc/meeg, EEG/etc/fieldtrip, EEG/etc/nft
- EEGLAB
 - Modified ICA-related functions
 - Replacements for plotting functions to handle two headmaps



MEEG Toolbox



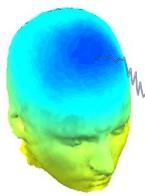
MEEG Toolbox



The image shows a software interface for the MEEG Toolbox. A vertical menu tree is displayed on the left side of the screen. The main menu items are Welcome to MEEG 0.1, Data, Headmodels, ICA, Dipole Fitting, and Plotting. The 'Data' menu is currently expanded, showing options: Load Merged MEEG, Load and Merge MEG & EEG, Merge MEG & EEG, Split MEEG, Load Fieldtrip, and Save Fieldtrip. The 'Headmodels' menu is also expanded, showing the 'Check' option. The 'ICA' menu is expanded, showing options: Run ICA and Load AMICA results. The 'Plotting' menu is expanded, showing options: Topoplot and ERPimage. In the bottom left corner, there is a small window displaying a red waveform plot.

- Welcome to MEEG 0.1
- **Data** ►
 - Load Merged MEEG
 - Load and Merge MEG & EEG
 - Merge MEG & EEG
 - Split MEEG
- Headmodels ►
 - Check
- ICA ►
 - Run ICA
 - Load AMICA results
- Dipole Fitting ►
- Plotting ►
 - Topoplot
 - ERPimage

Example Results



Iversen & Makeig (2014), **MEG/EEG Data Analysis Using EEGLAB**

in S. Supek and C. J. Aine (eds.), *Magnetoencephalography*, Springer-Verlag.



Bledowski C, Kaiser J, Wibral M, Yildiz-Erzberger K, Rahm B:
**Separable Neural Bases for Subprocesses of Recognition
in Working Memory.** *Cereb Cortex* 2012, **22**:1950–1958.

Data

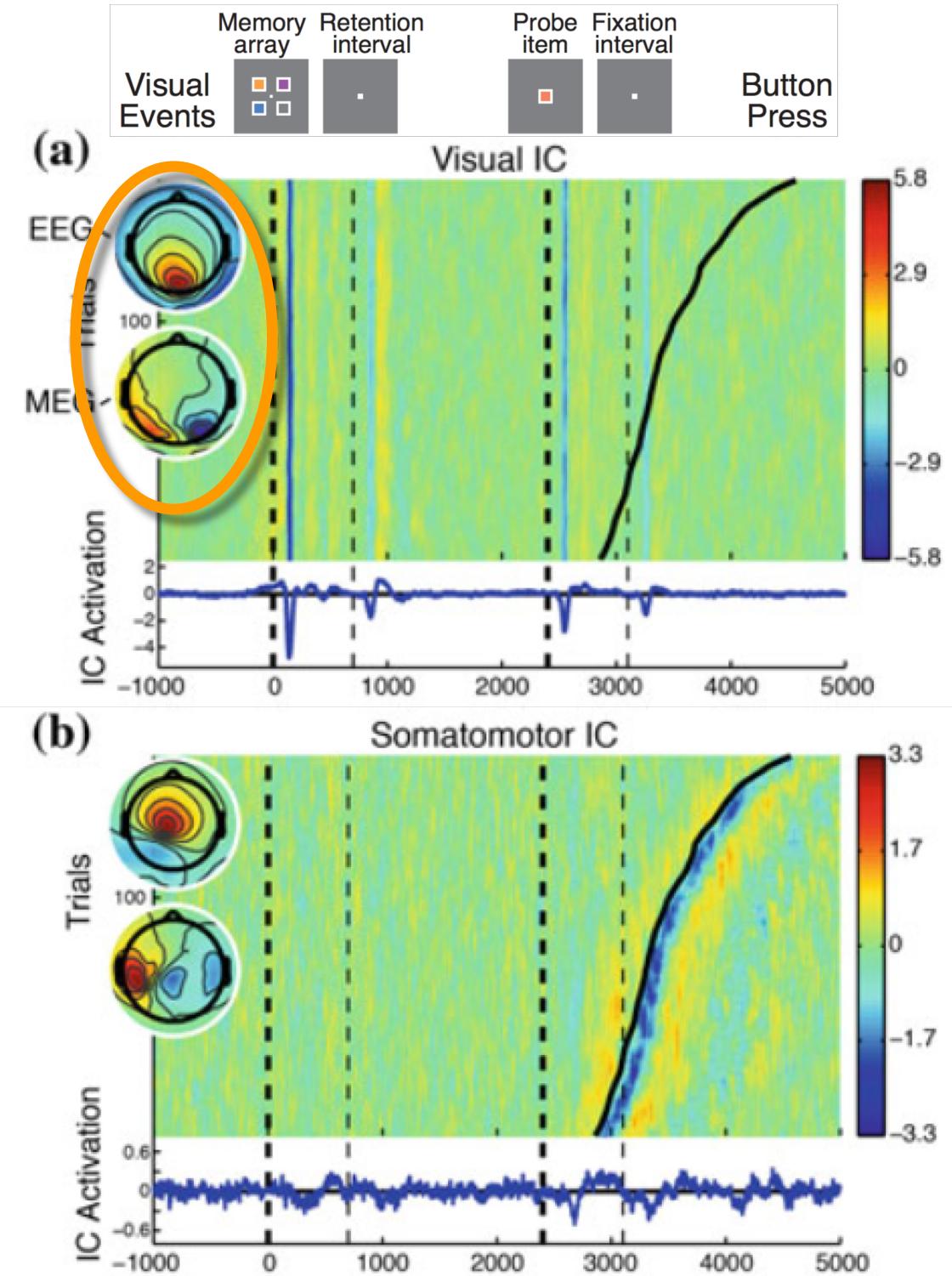
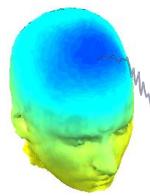
162 trials

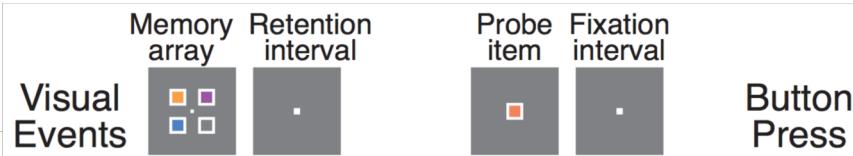
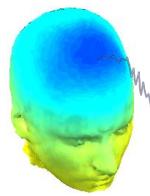
MEG: CTF (275 radial gradiometers)

EEG: 64 Channels

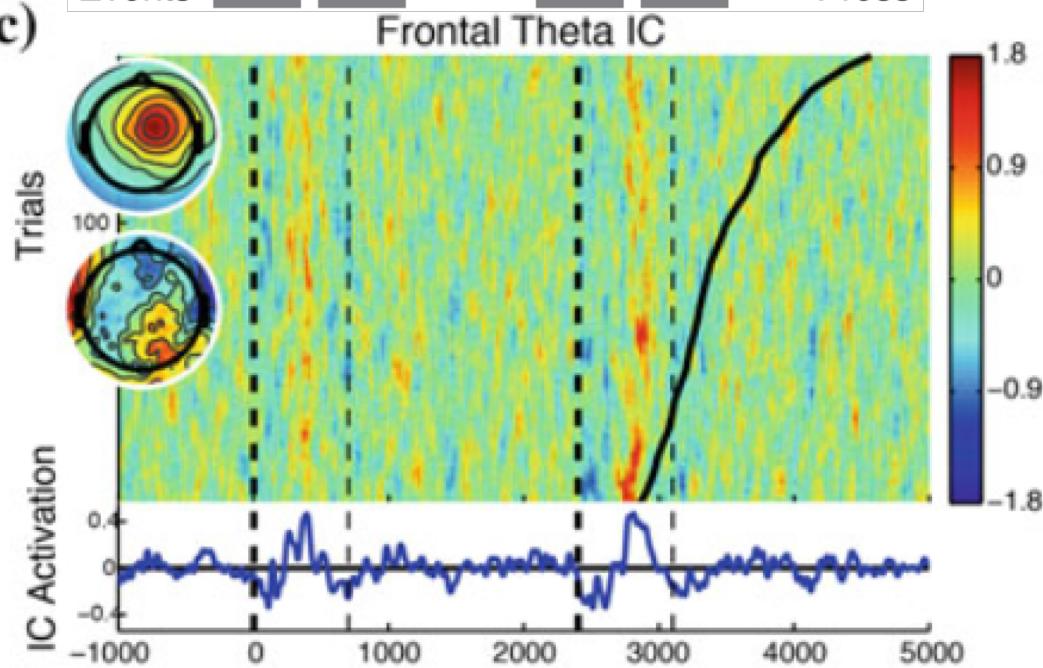
Head Model: digitized headshape & electrode locations
(warped template head model)



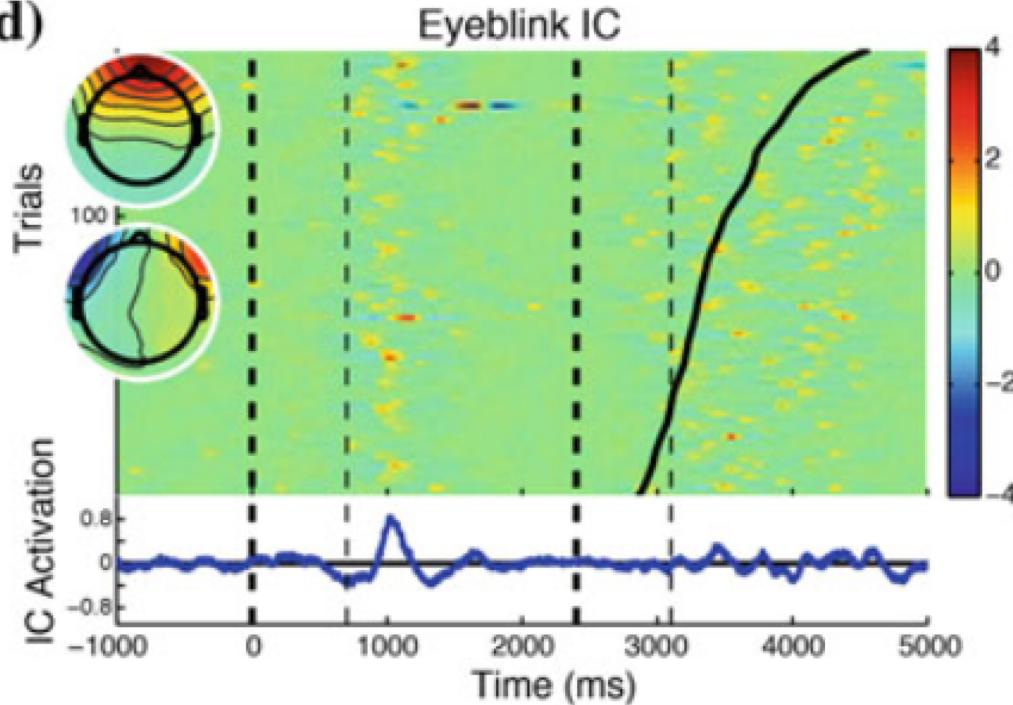




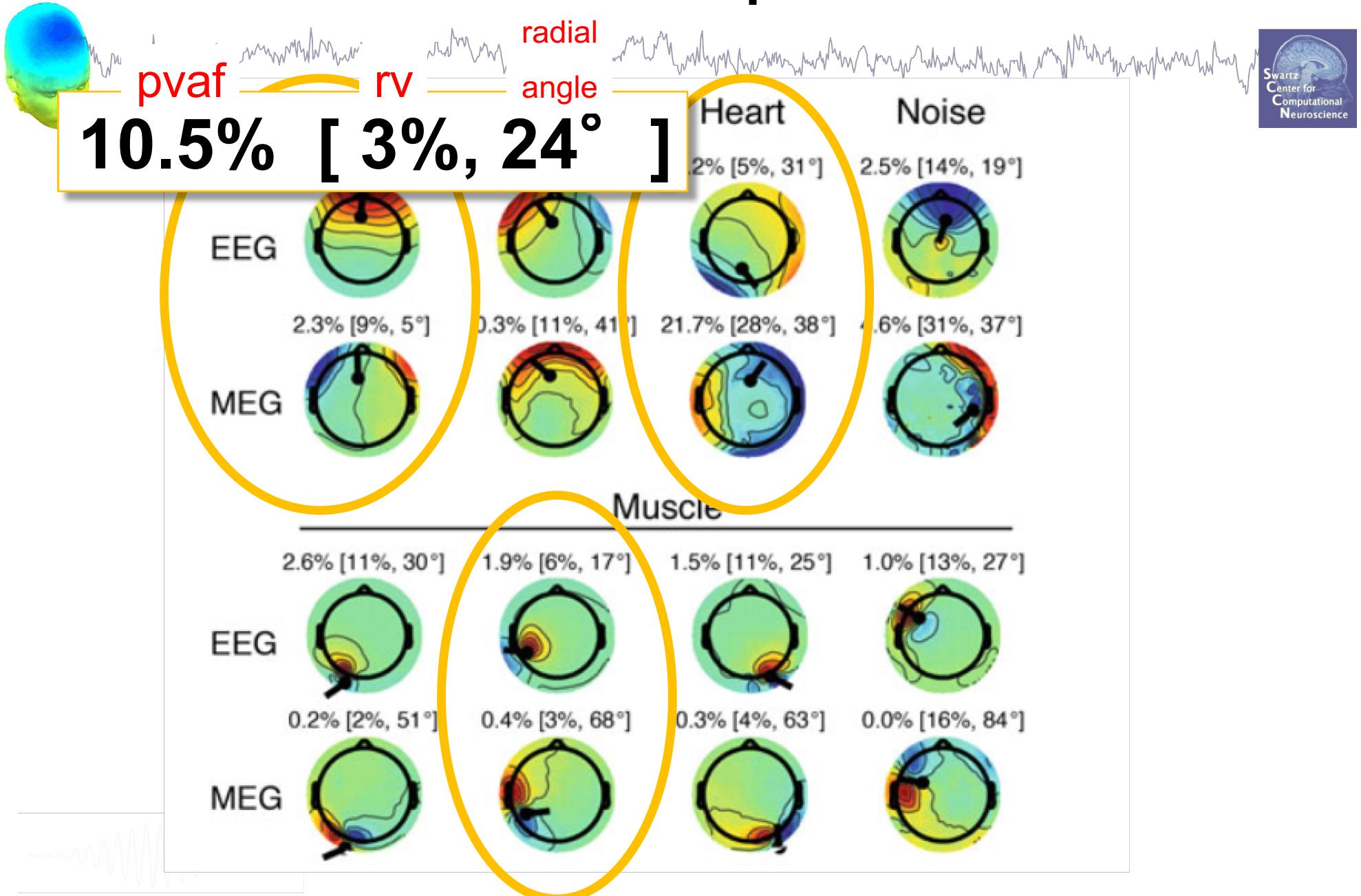
(c)



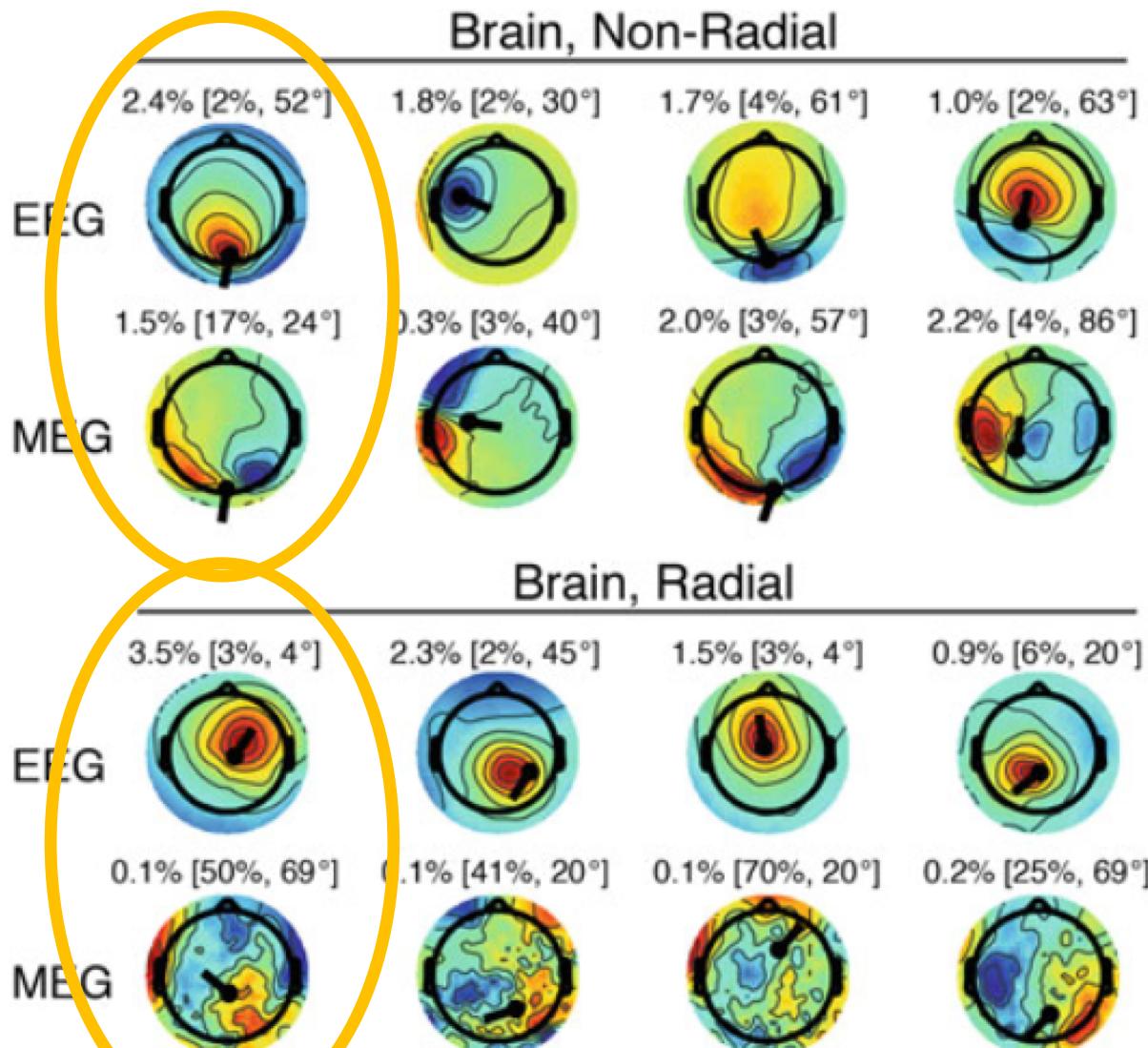
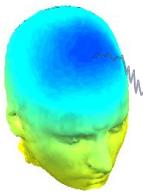
(d)



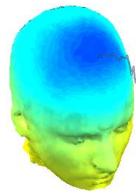
Artifact Components



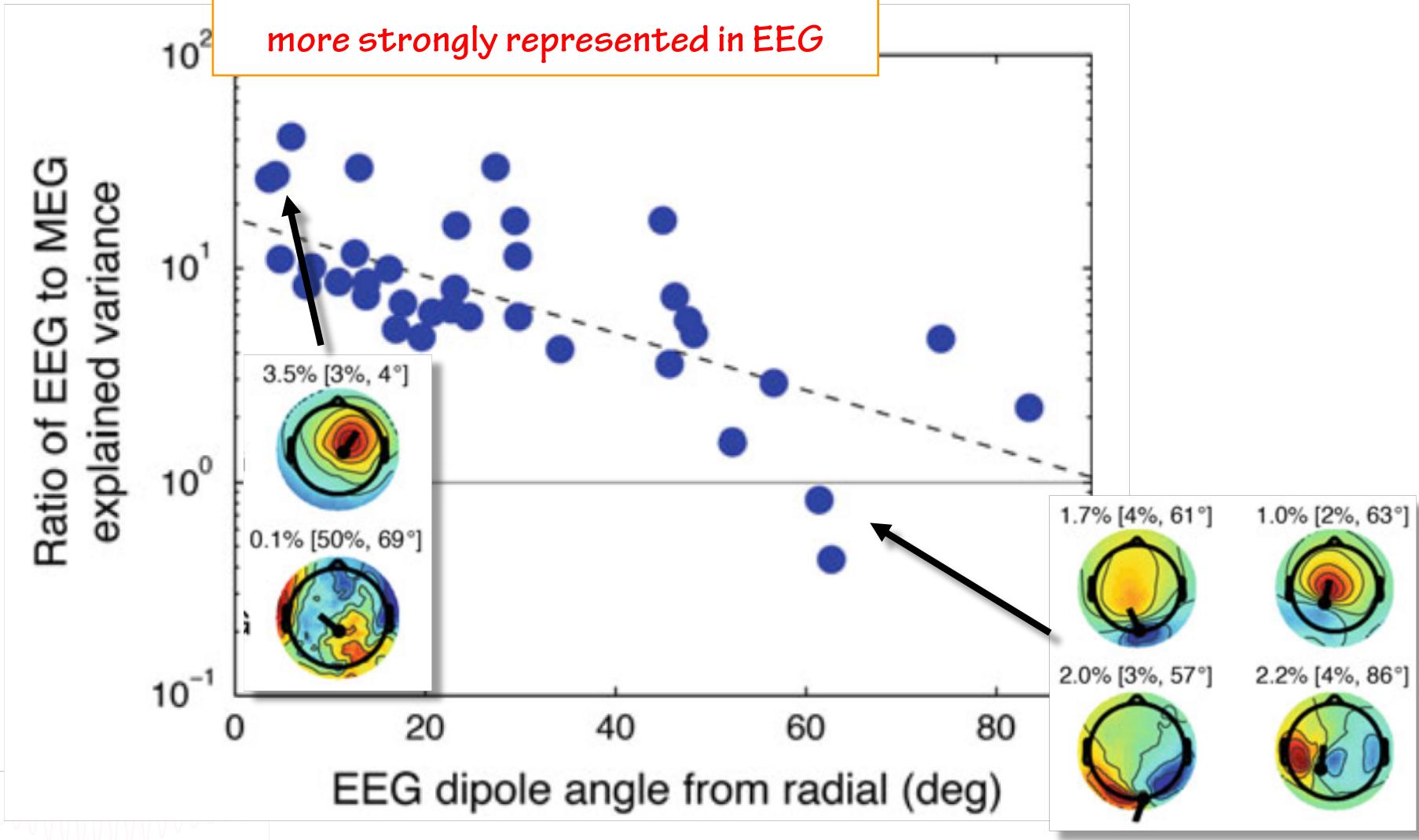
Brain Components



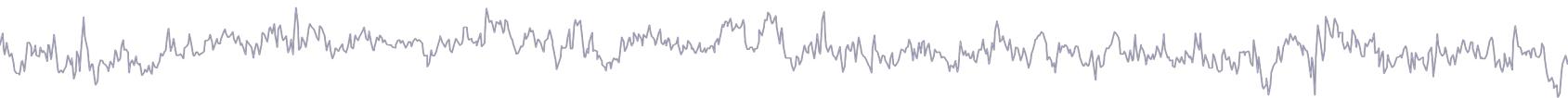
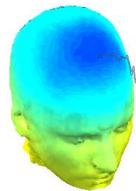
Experimental validation of radial angle dependence



Radially-oriented sources are 10-50x
more strongly represented in EEG

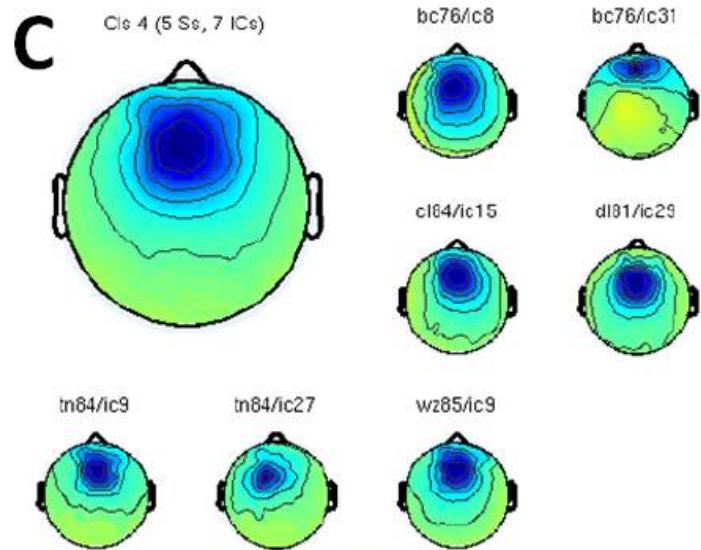


MEG Data (Rhythm perception)

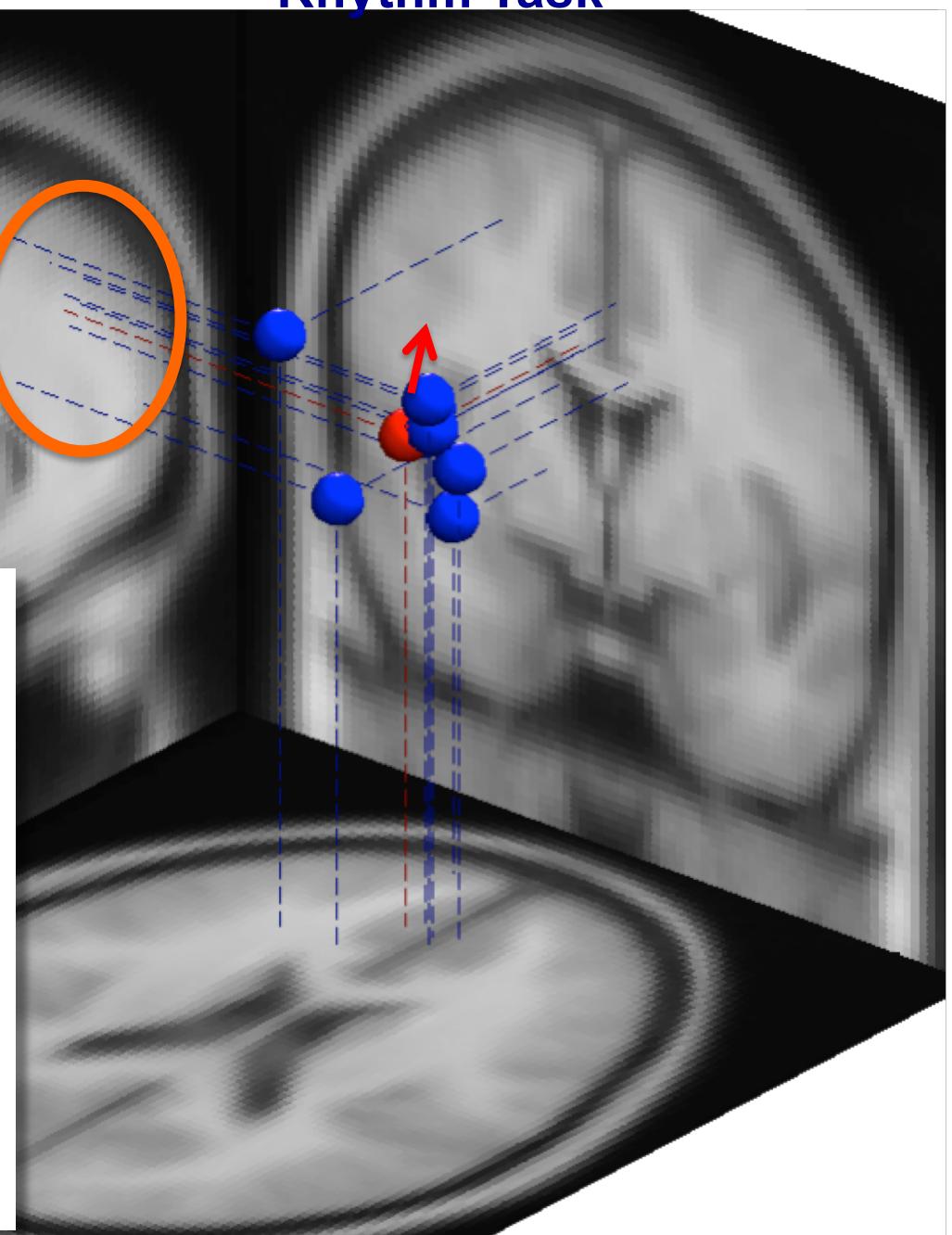
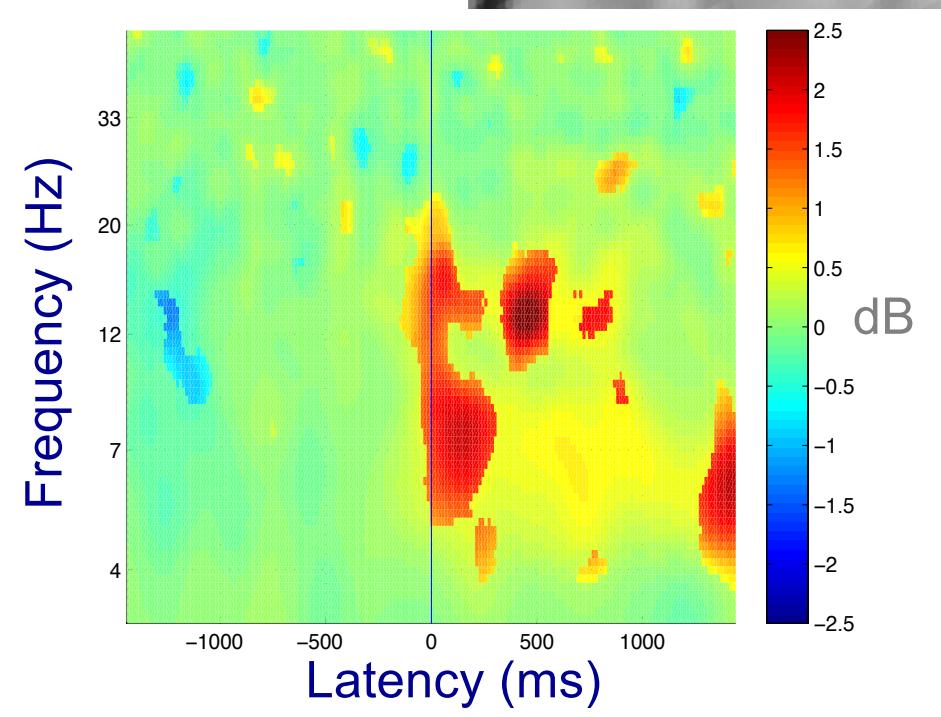


Iversen (2009; in prep)

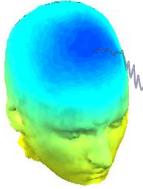
EEG IC Source Cluster 4 (Frontal Midline)



Rhythm Task



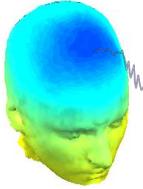
Conclusions



- A new method for fusing EEG & MEG data to find unified sources
 - Expect localization accuracy to benefit
- Verified the theoretical prediction of *MEG-blindness to radial sources*
- Provides argument for repeating MEG experiments using EEG...



Thanks



- Seeking beta testers with MEEG datasets!
 - Contact me: jiversen@ucsd.edu
- Acknowledgements
 - Jason Palmer
 - Michael Wibral
 - Zeynep Akalin Acar

