

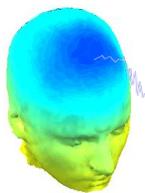


# **Simultaneous EEG/MEG analysis in EEGLAB**

EEGLAB Workshop XXII  
UCSD  
Day 3, 5:00



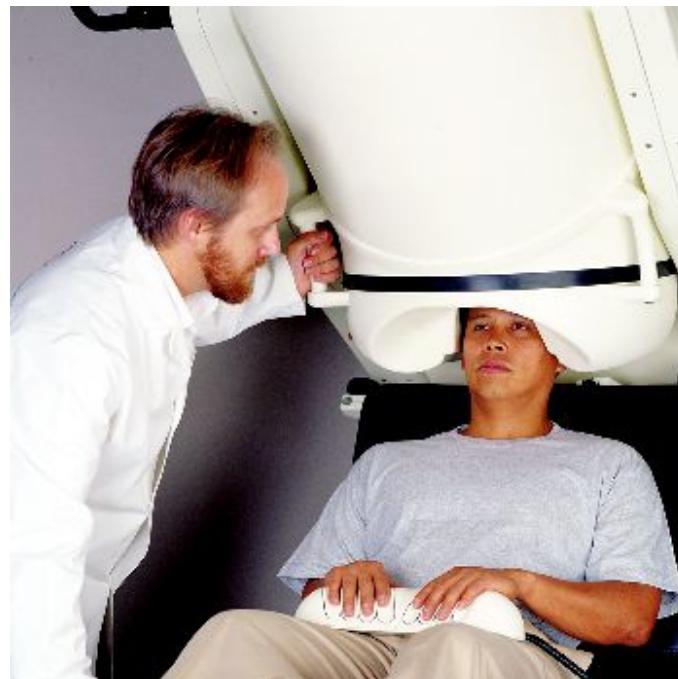
# Close cousins



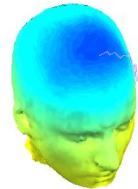
EEG



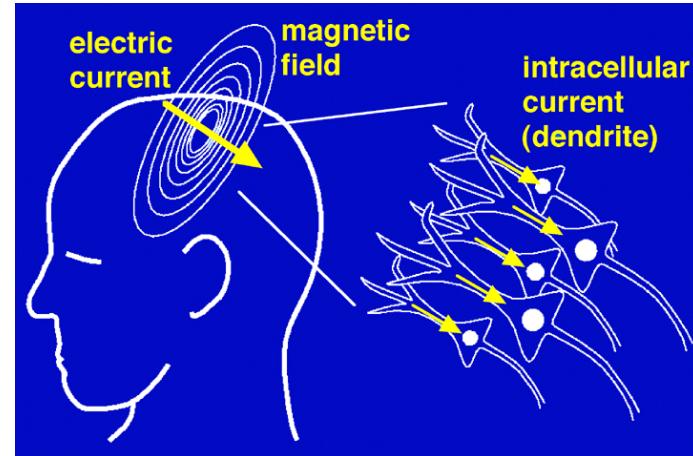
MEG



# MEG Basics



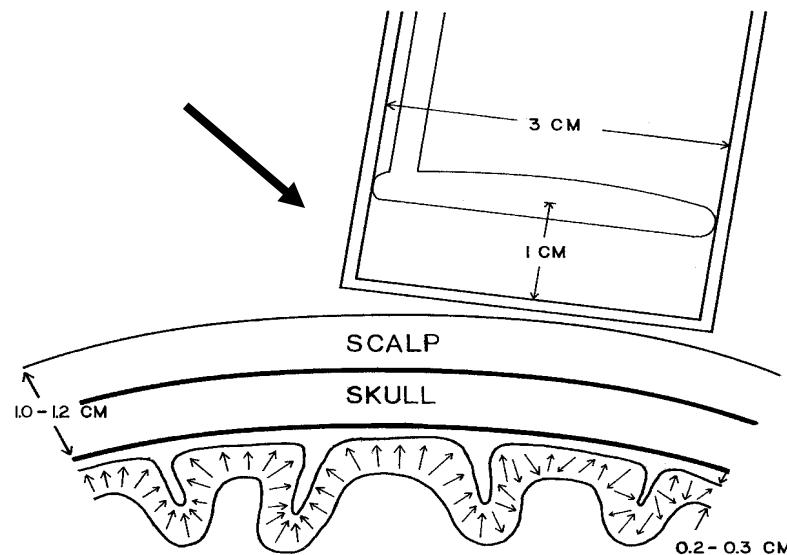
Measures magnetic fields induced by neural activity in cortex

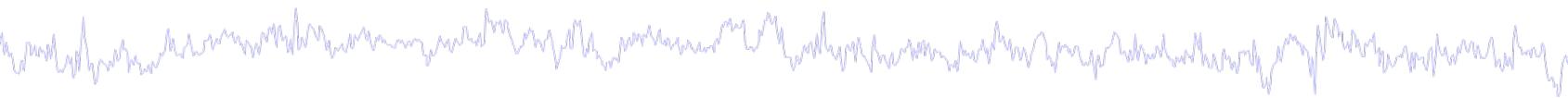
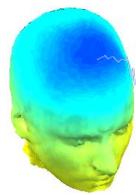


Technology: SQUIDs

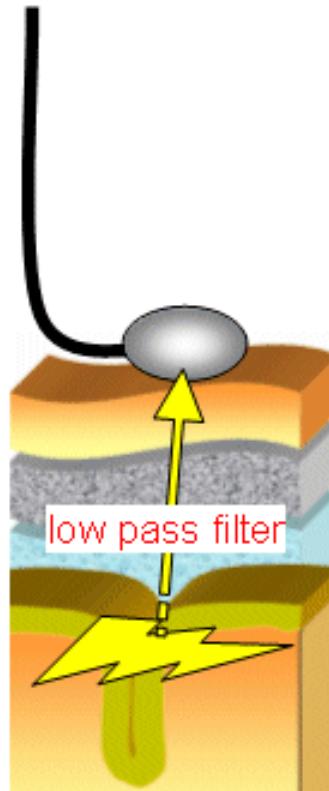
Magnetic field strengths:

Picotesla



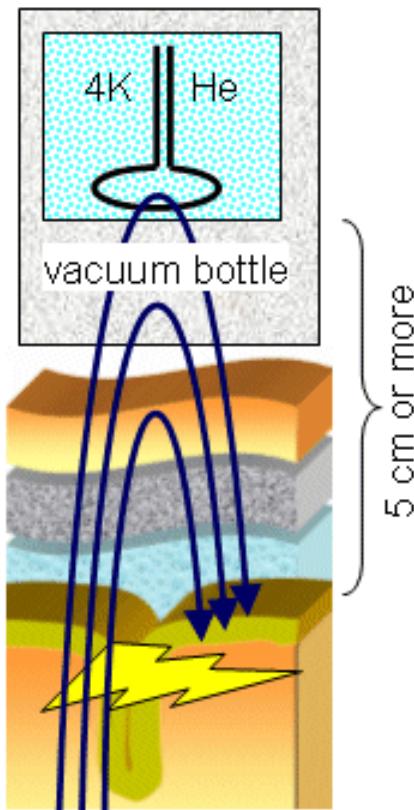


scalp EEG  $8\text{cm}^2$



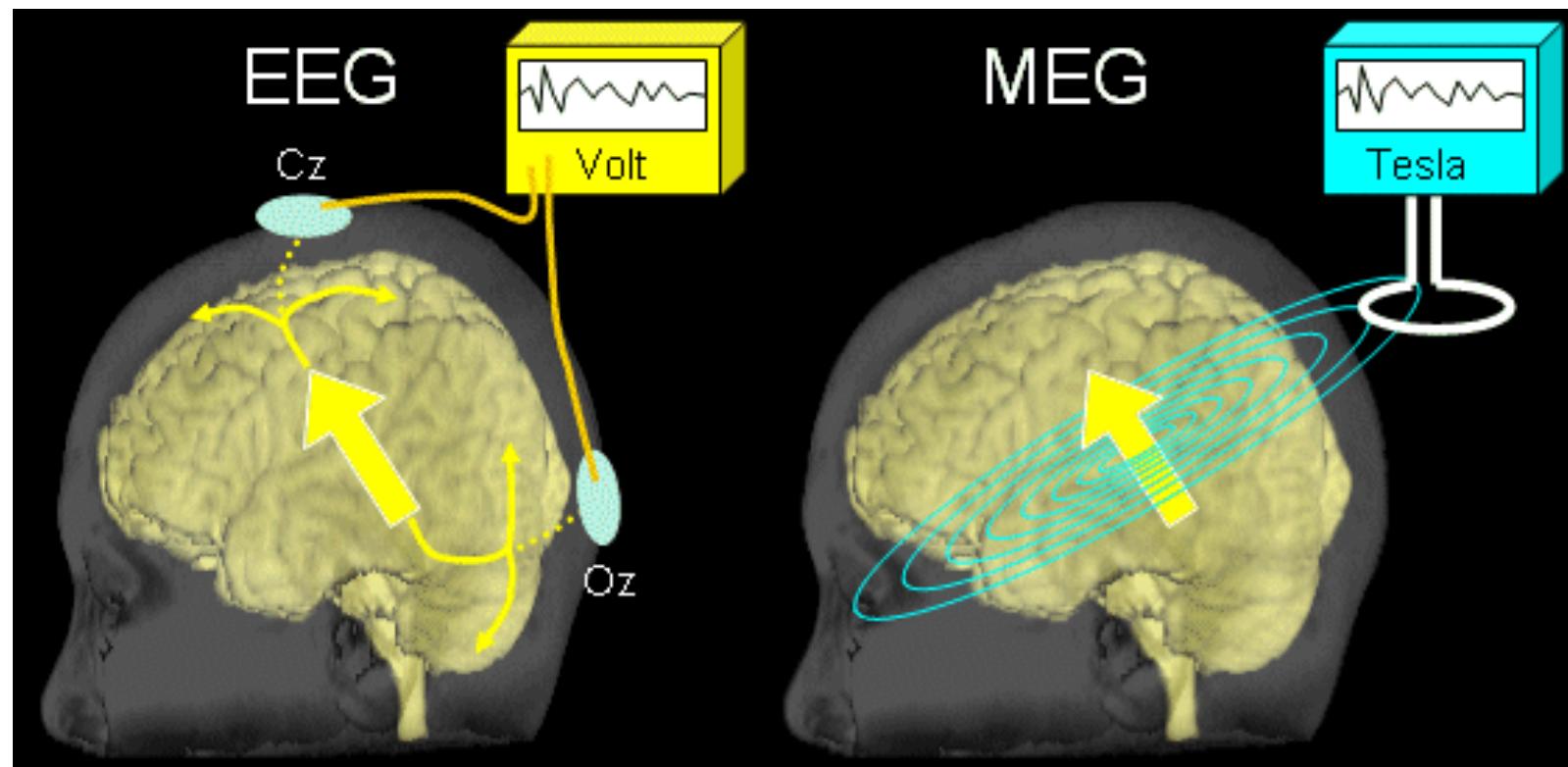
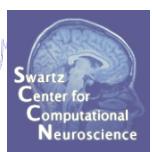
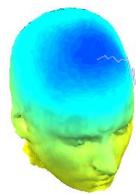
Signal decays  
through skull

MEG  $3\text{cm}^2$



Signal decays  
according to distance $^2$

scalp  
skull  
liquor space  
cortex  
white matter



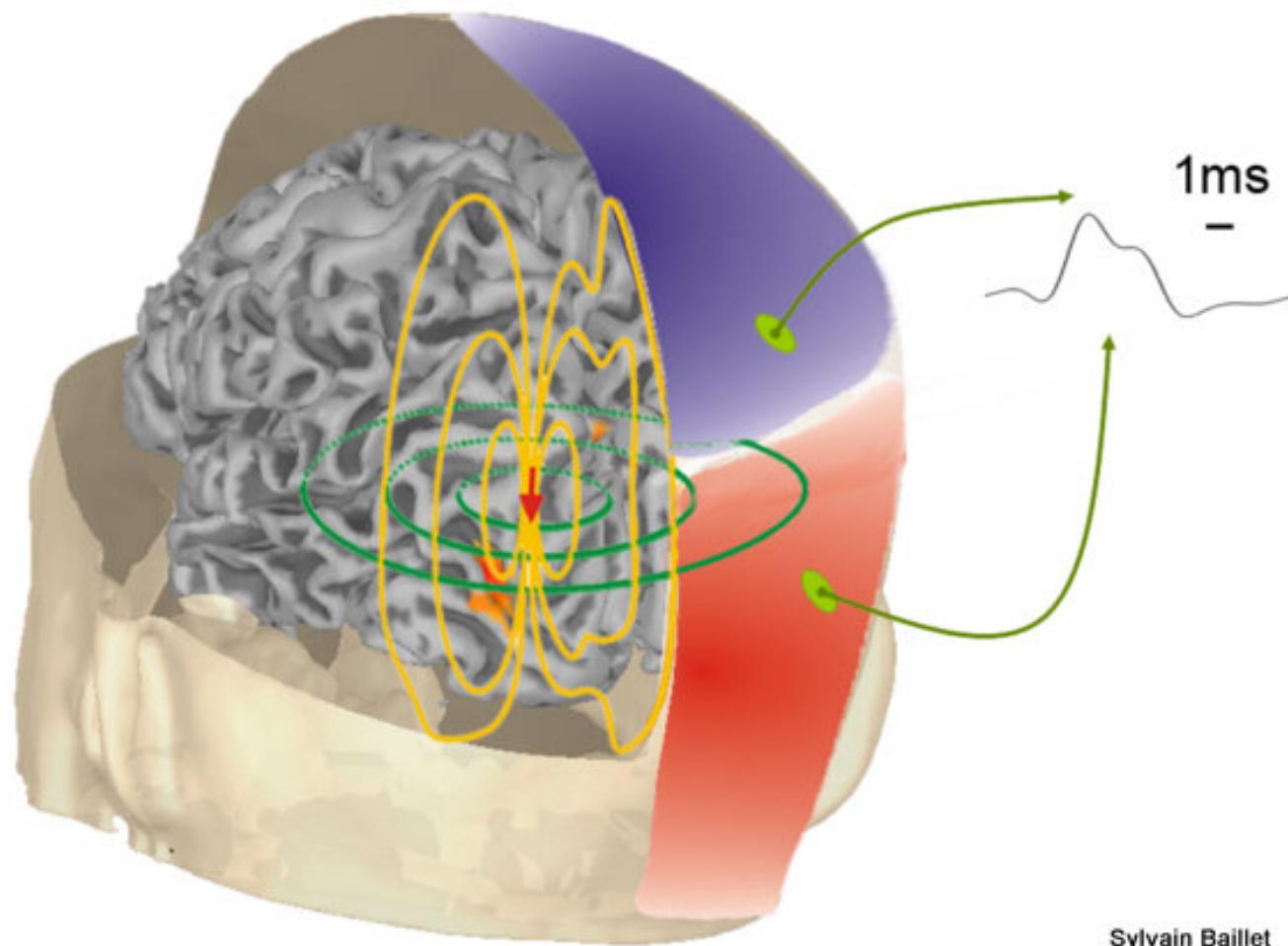
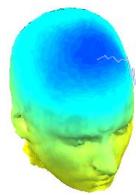
<http://meg.aalip.jp/vsEEG/vsEEGE.html>



# MEG vs. EEG

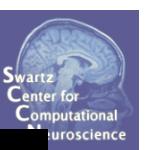
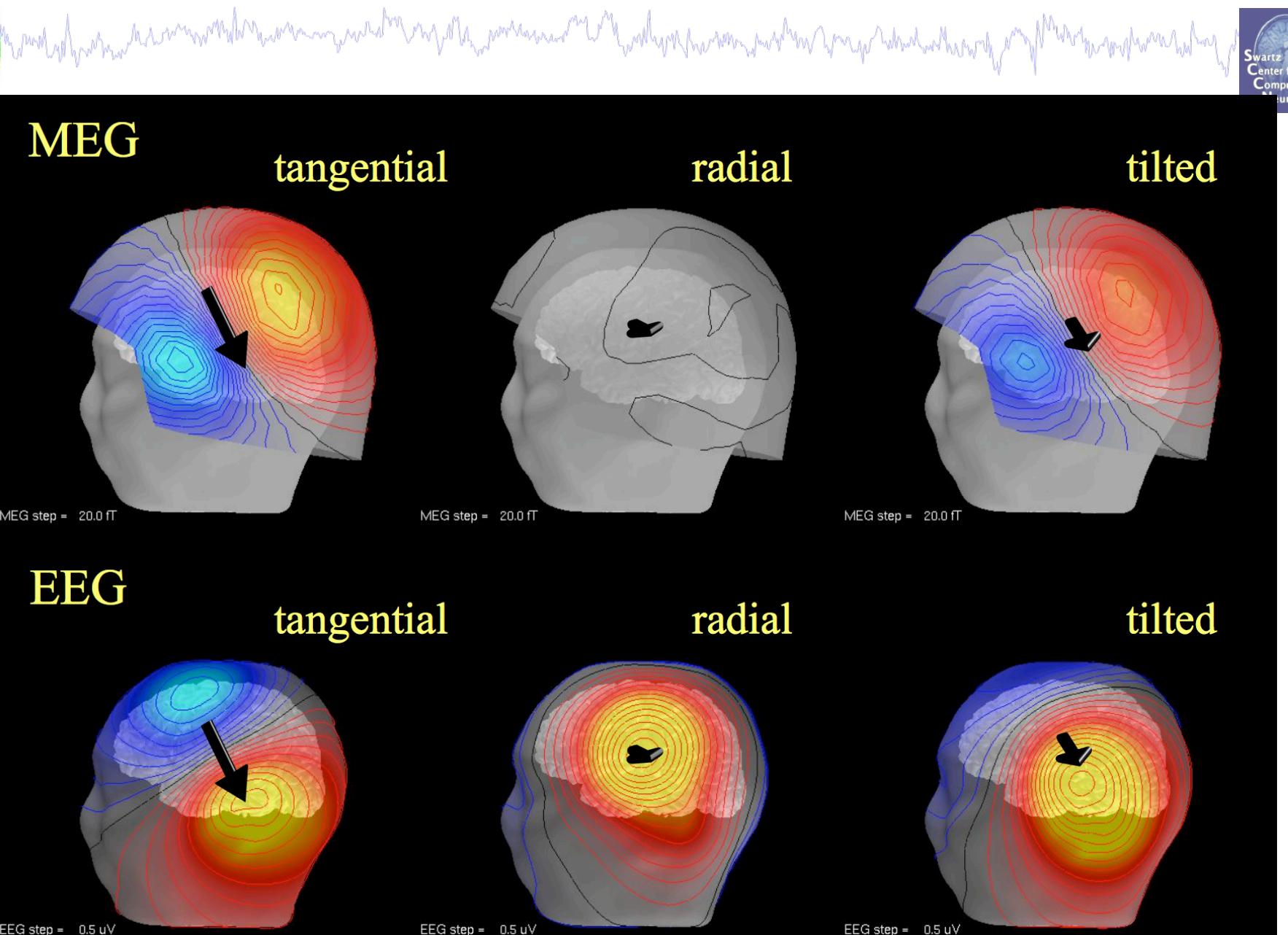
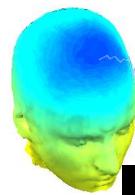


- Many arguments for superiority of one over the other
- Differences...
  - EEG is cheaper, and portable
  - MEG localization is not so sensitive to the details of the head model
  - MEG misses radial sources
  - MEG sensor locations vary run by run
  - MEG better for localizing auditory sources(?)
-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



Sylvain Baillet

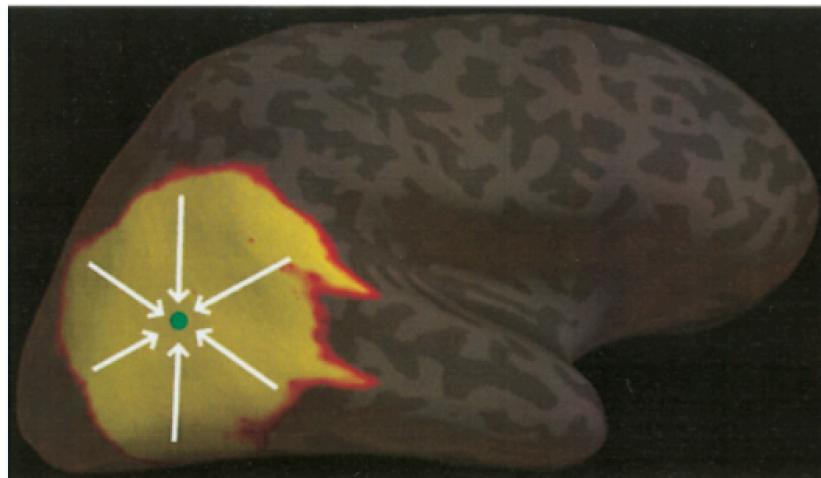
# Orientation and Orthogonality



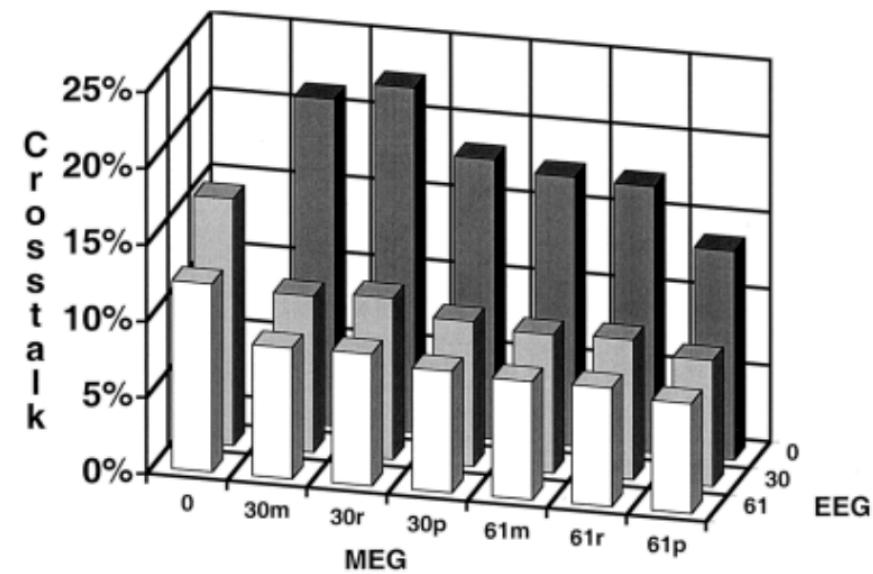
# MEEG



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



## Crosstalk

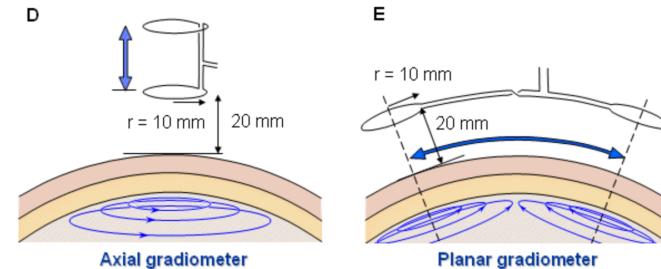


Liu et al. (2002) Human Brain Mapping 16:47– 62

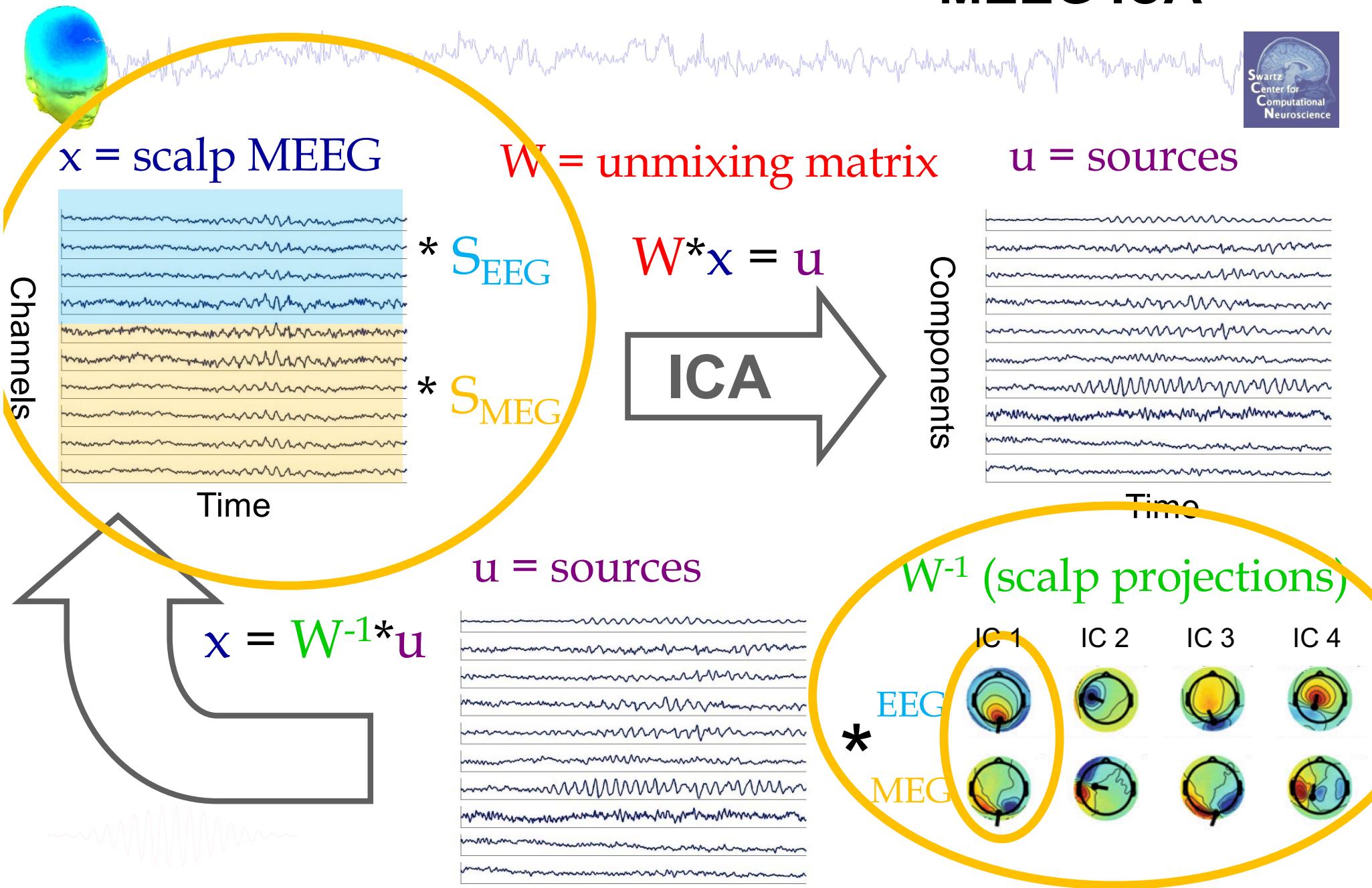
# MEG in EEGLAB Considerations



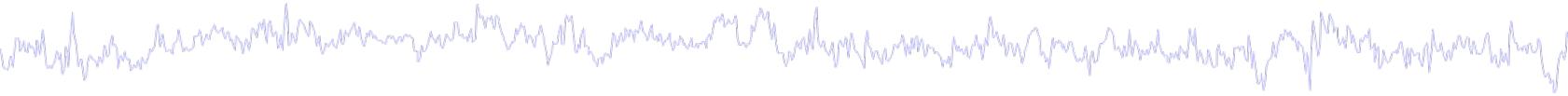
- Multiple MEG sensor types, some vector
  - Magnetometer (scalar)
  - Radial gradiometer (scalar)
  - Planar gradiometer (vector\*)
- Dual head models, sensor specifications & lead fields
- Signal units and magnitudes are different
- How do ICA?



# 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
```

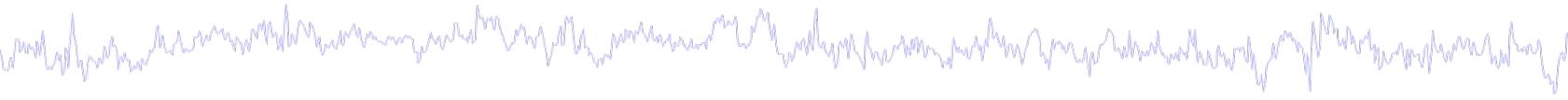
```
EEG.icasphere(:,echans) = EEG.icasphere(:, echans) * EEG/etc/meeg.Se
```

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

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



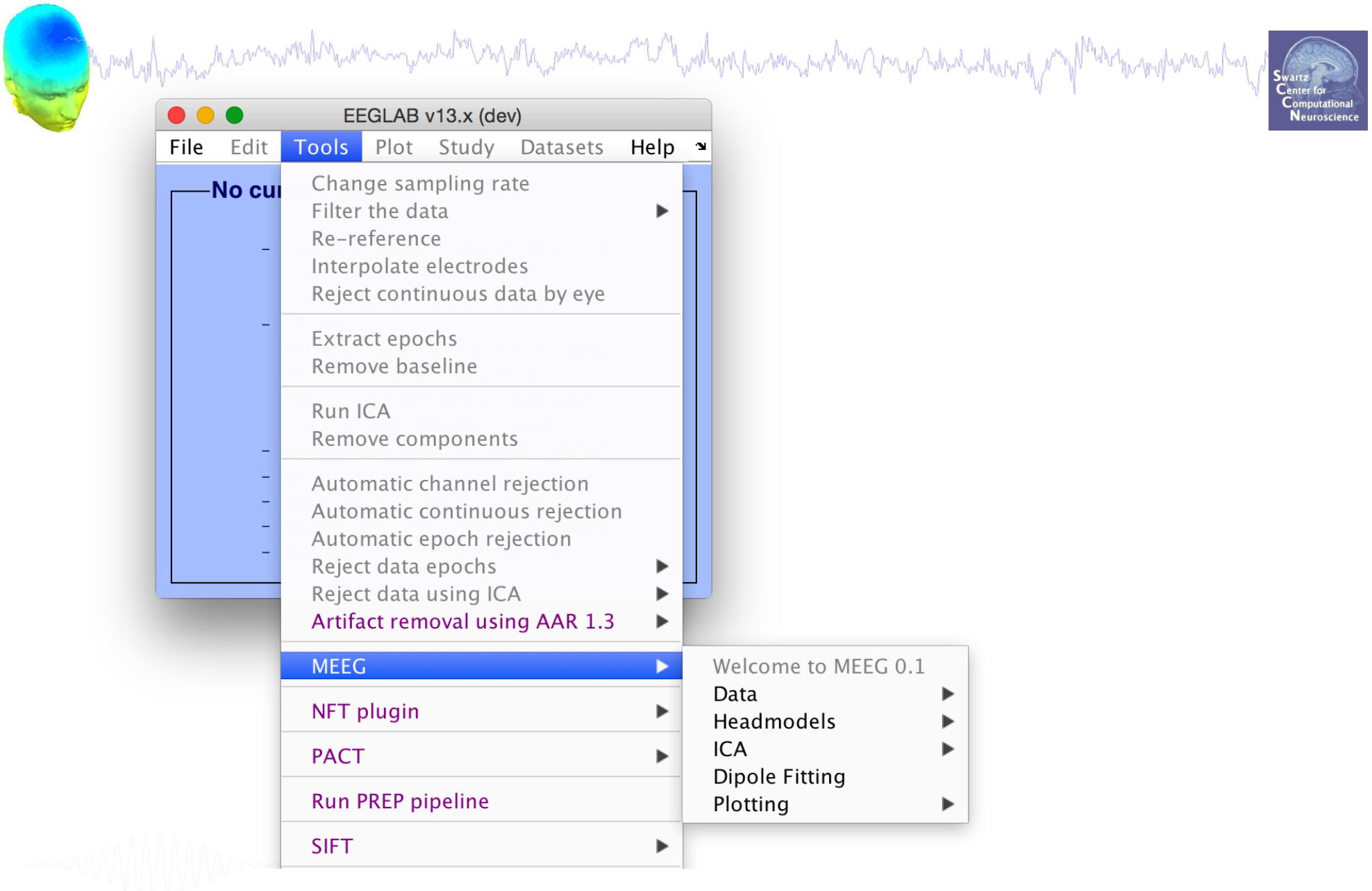
# Implementation Details



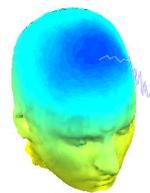
- Uses NFT & Fieldtrip 'under the hood'
  - Custom dipolefitting routines
  - Enhanced eeglab2fieldtrip and fieldtrip2eeglab
- Data
  - EEG.chanlocs.type = 'EEG' or 'MEG'
  - EEG/etc/meeg, EEG/etc/fieldtrip, EEG/etc/nft
- EEGLAB
  - Modified ICA-related functions
  - Replacements for plotting functions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



# MEEG Toolbox



# MEEG Toolbox



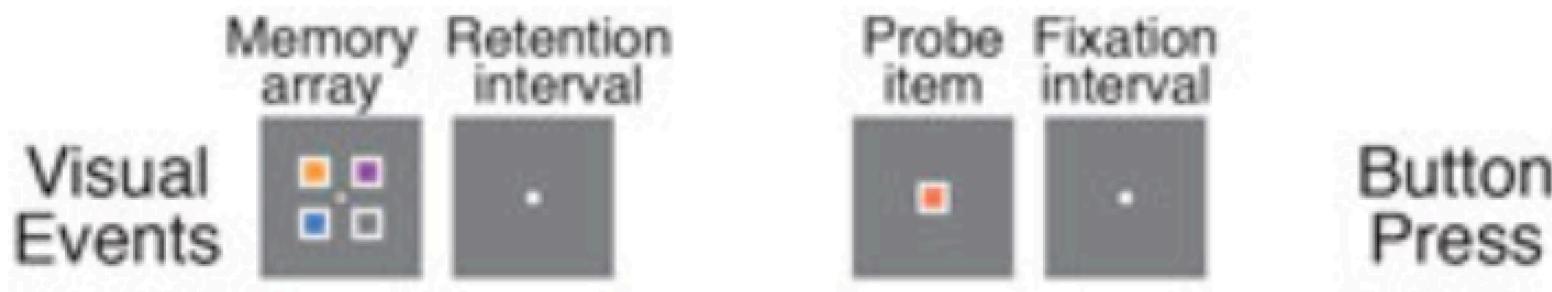
The image shows the MEEG Toolbox interface with several open menus:

- Main Menu (Top Left):** Welcome to MEEG 0.1, Data, Headmodels, ICA, Dipole Fitting, Plotting.
- Data Submenu:** Load Merged MEEG, Load and Merge MEG & EEG, Merge MEG & EEG, Split MEEG, Load Fieldtrip, Save Fieldtrip.
- ICA Submenu:** Welcome to MEEG 0.1, Data, Headmodels, ICA, Dipole Fitting, Plotting.
- Headmodels Submenu:** Welcome to MEEG 0.1, Data, Headmodels, ICA, Dipole Fitting, Plotting. A "Check" button is visible.
- Plotting Submenu:** Welcome to MEEG 0.1, Data, Headmodels, ICA, Dipole Fitting, Plotting. A "Topoplot" and "ERPimage" button is visible.

# Example Results

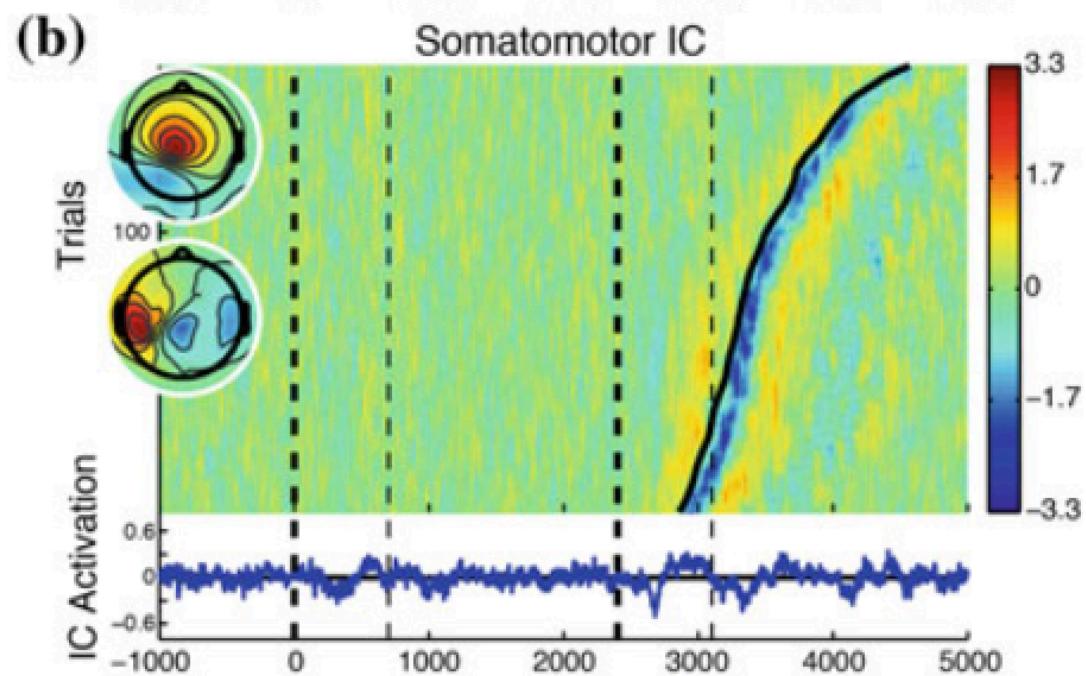
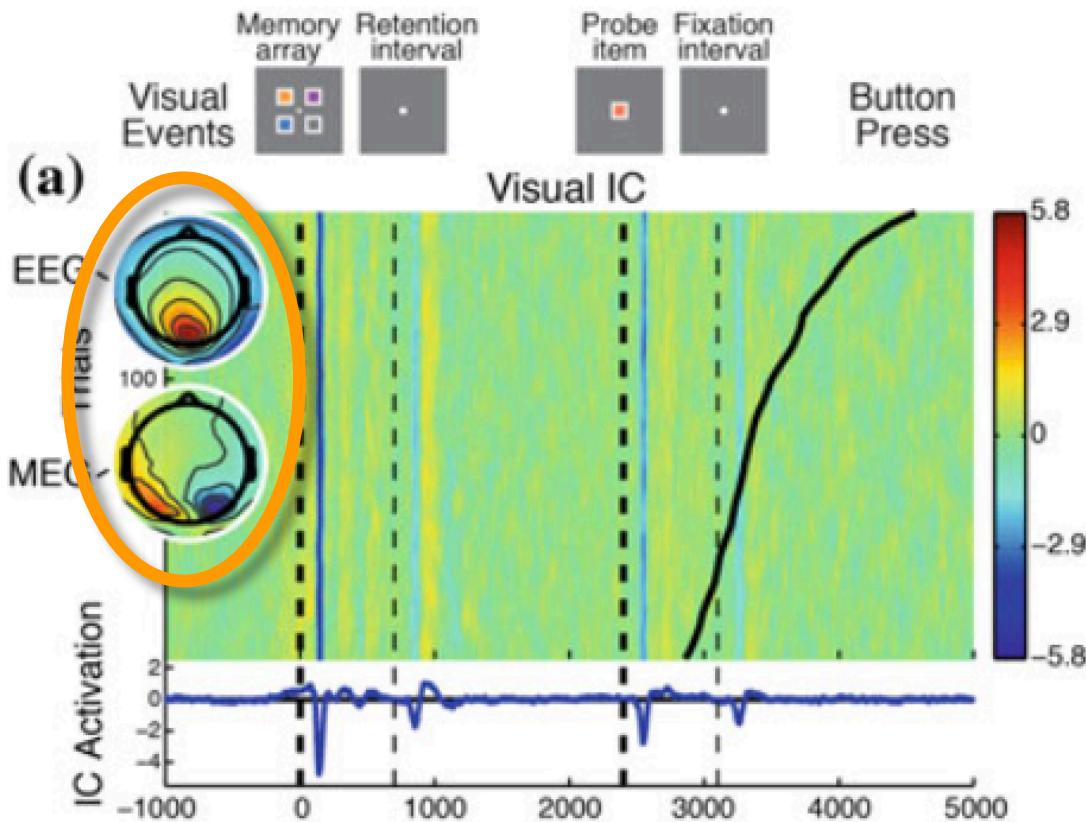


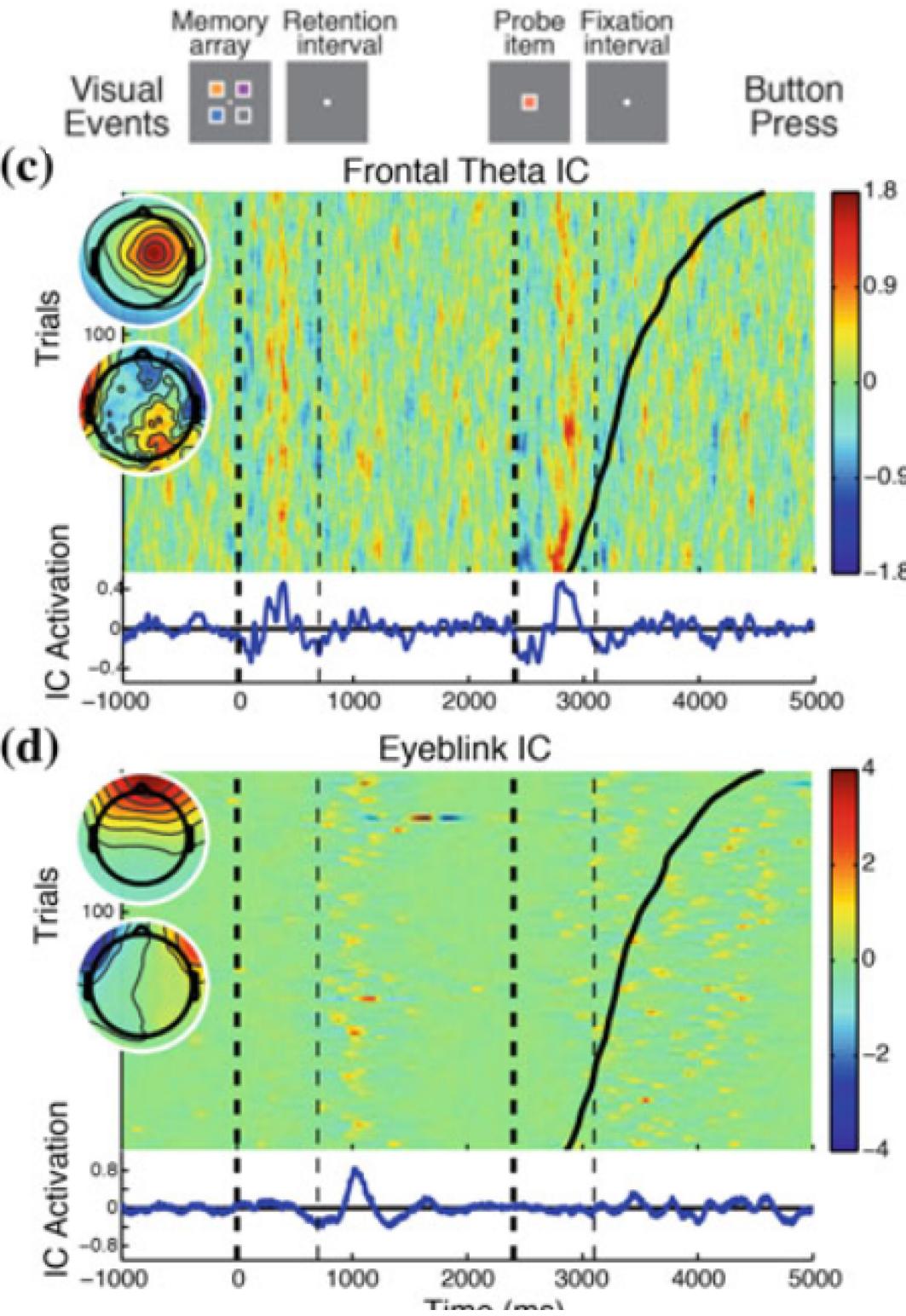
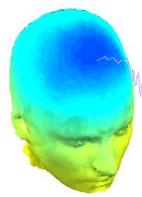
Iversen & Makeig (2014), MEG/EEG Data Analysis Using EEGLAB  
in S. Supek and C. J. Aine (eds.), *Magnetoencephalography*, Springer-Verlag.



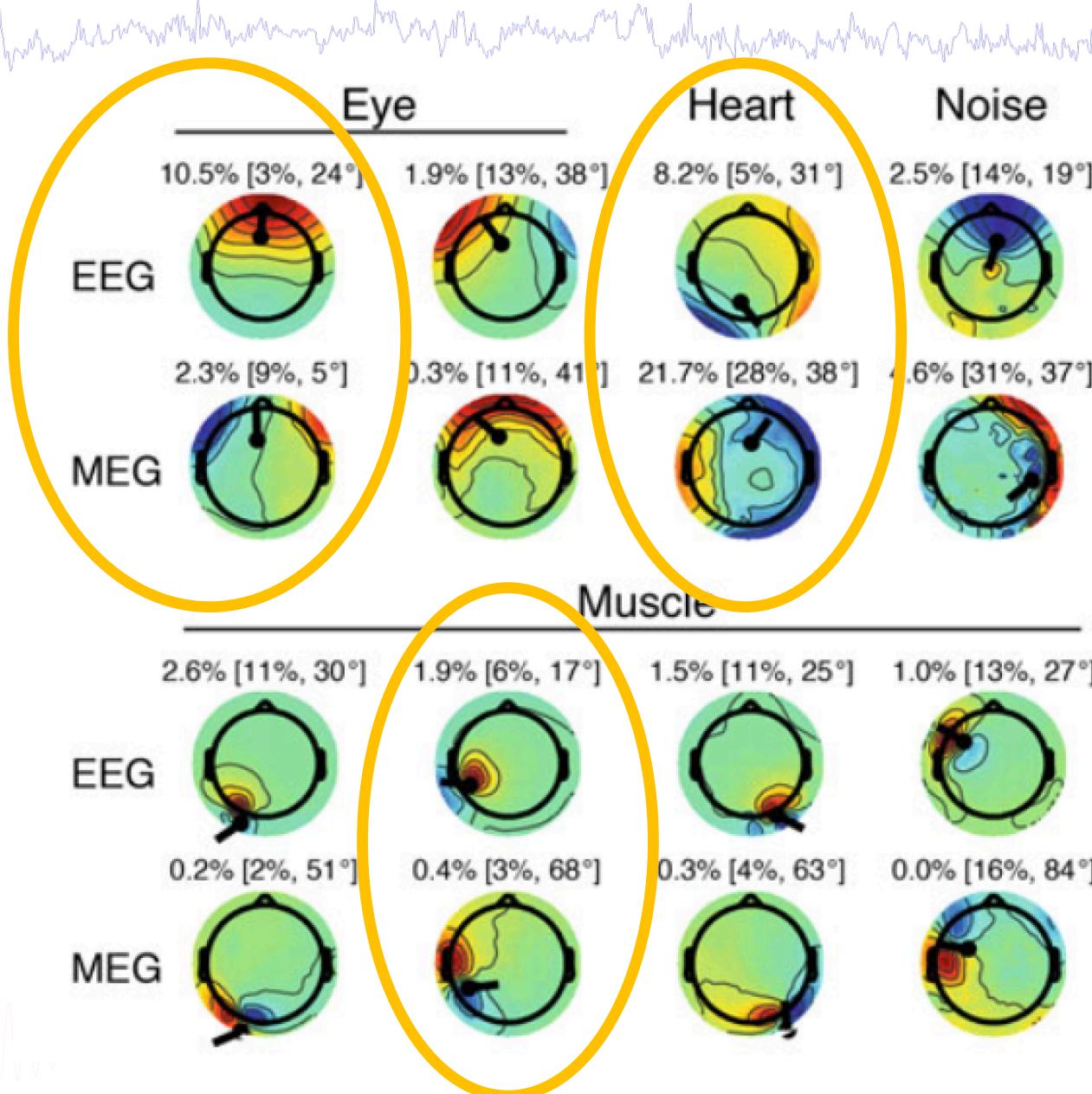
Bledowski C, Kaiser J, Wibral M, Yildiz-Erzberger K, Rahm B: **Separable Neural Bases for Subprocesses of Recognition in Working Memory**. *Cereb Cortex* 2012, **22**:1950–1958.



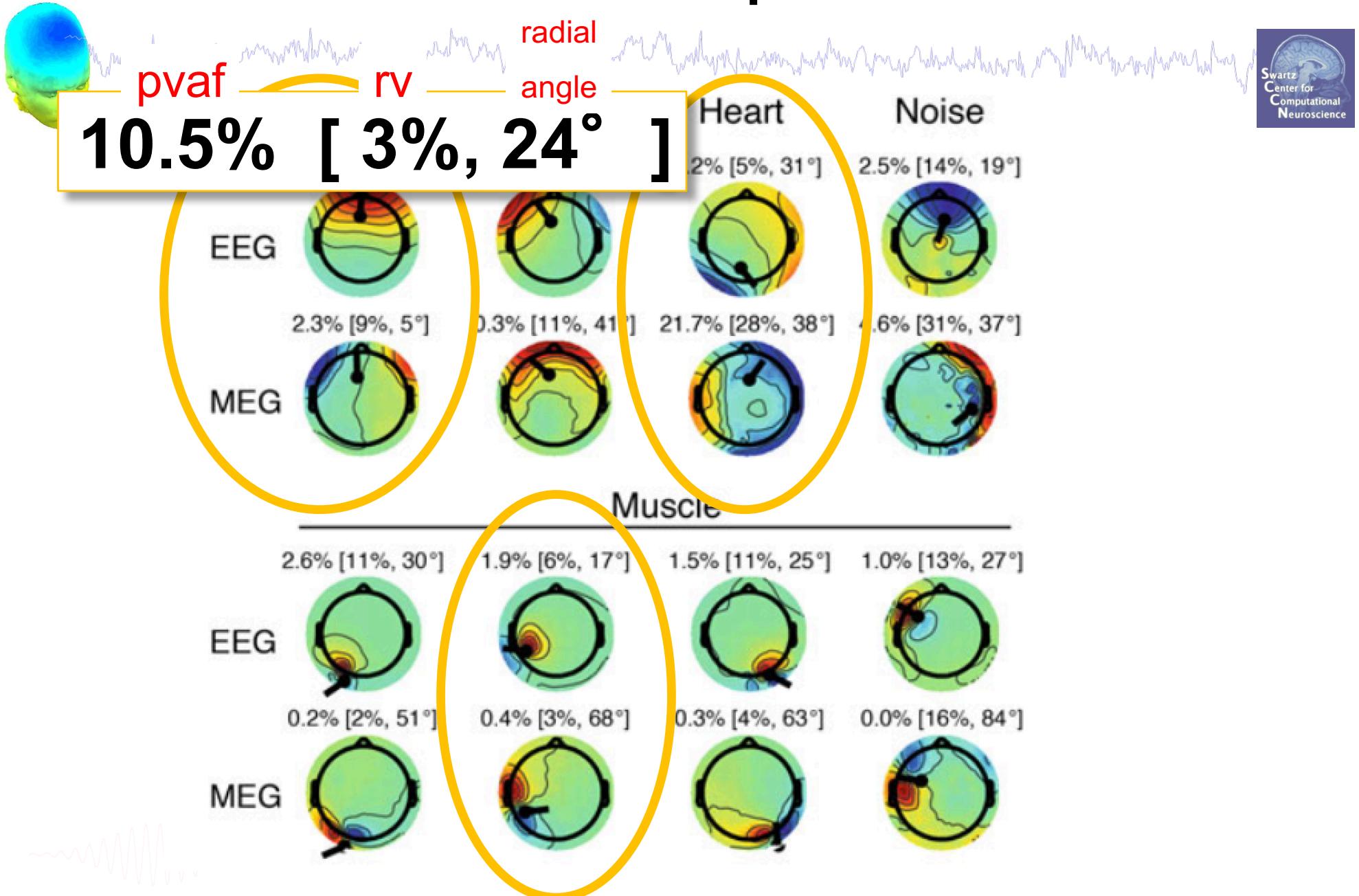




# Artifact Components



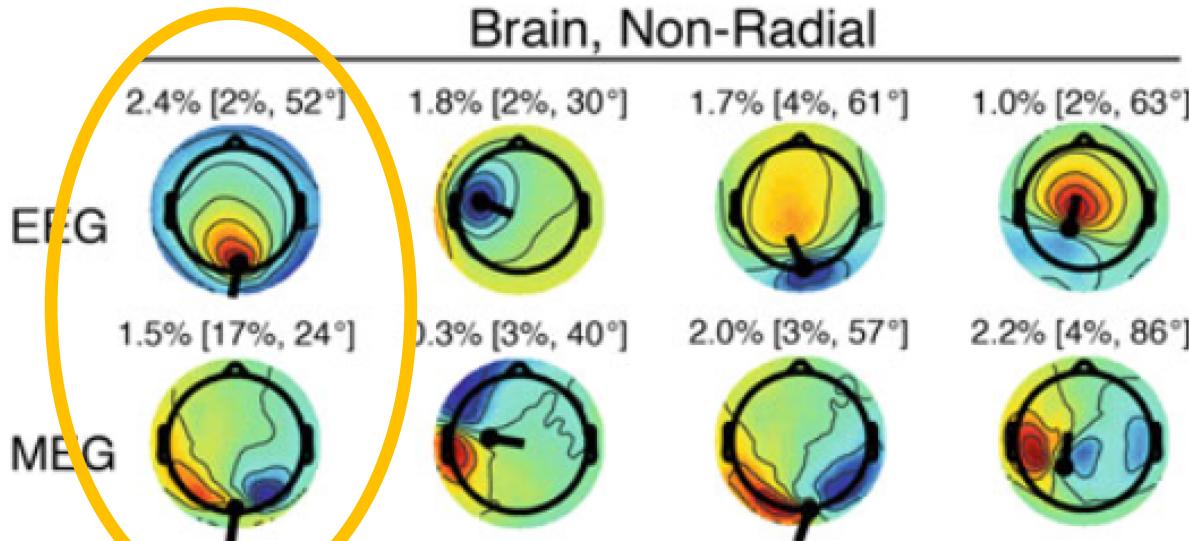
# Artifact Components



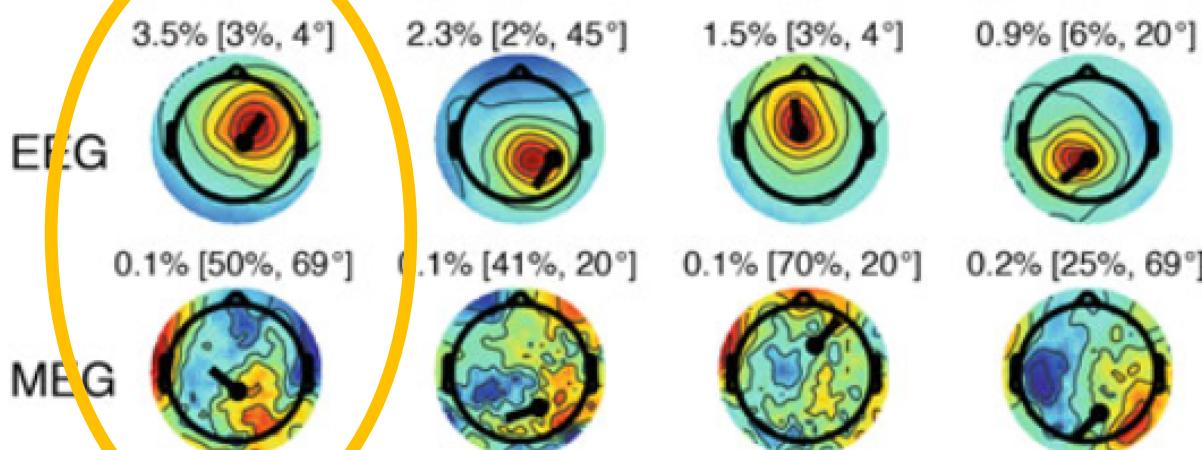
# Brain Components



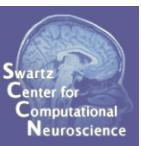
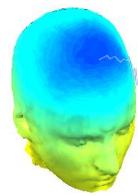
Brain, Non-Radial



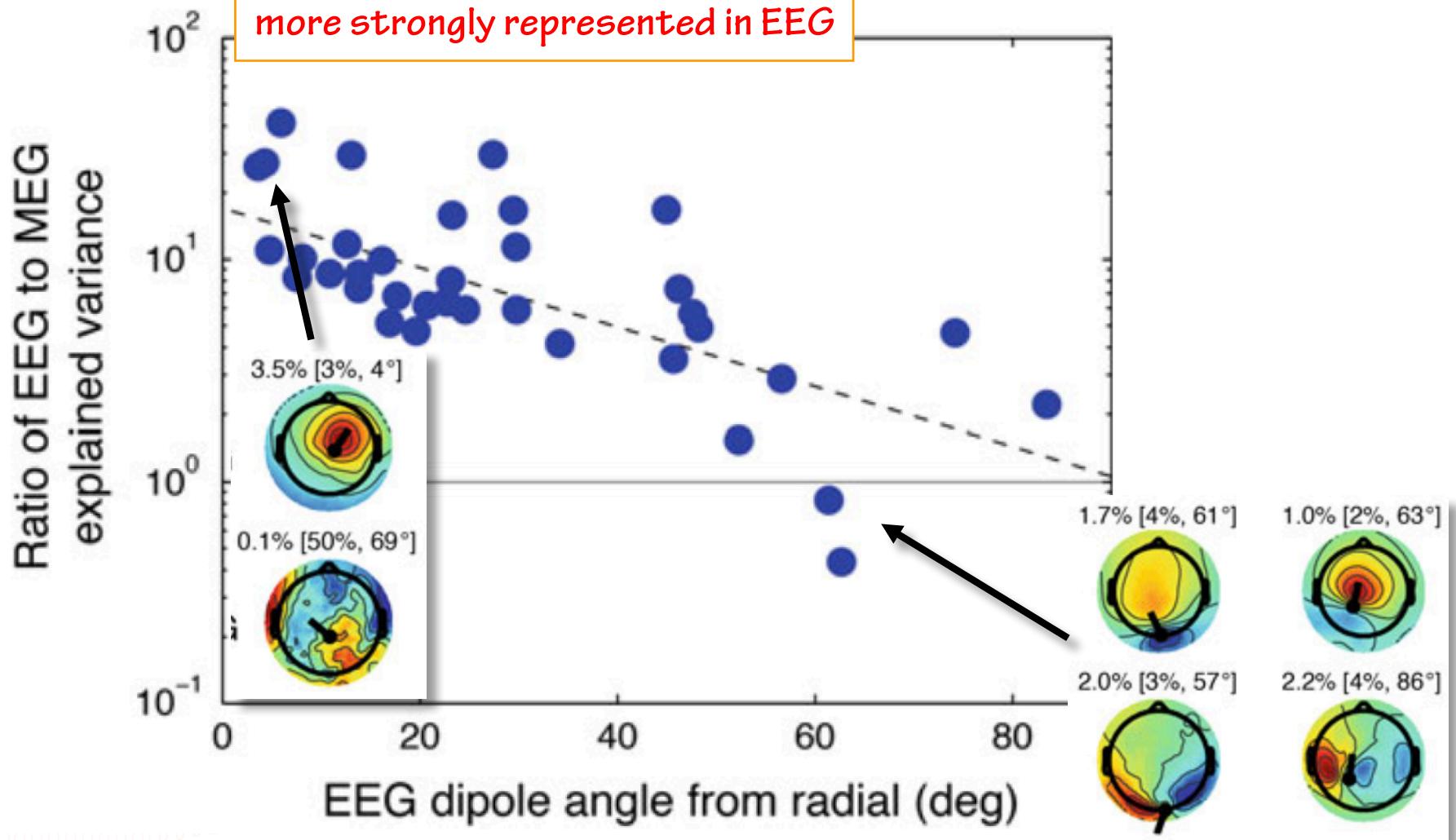
Brain, Radial



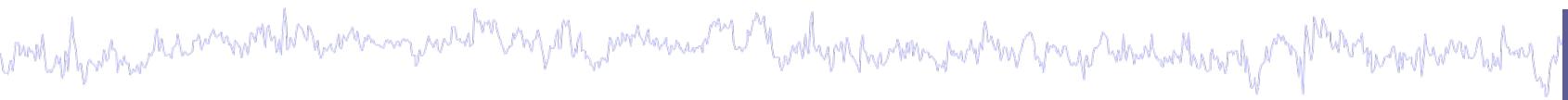
# Experimental validation of radial angle dependence



Radially-oriented sources are  
more strongly represented in EEG



# Thanks



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

