

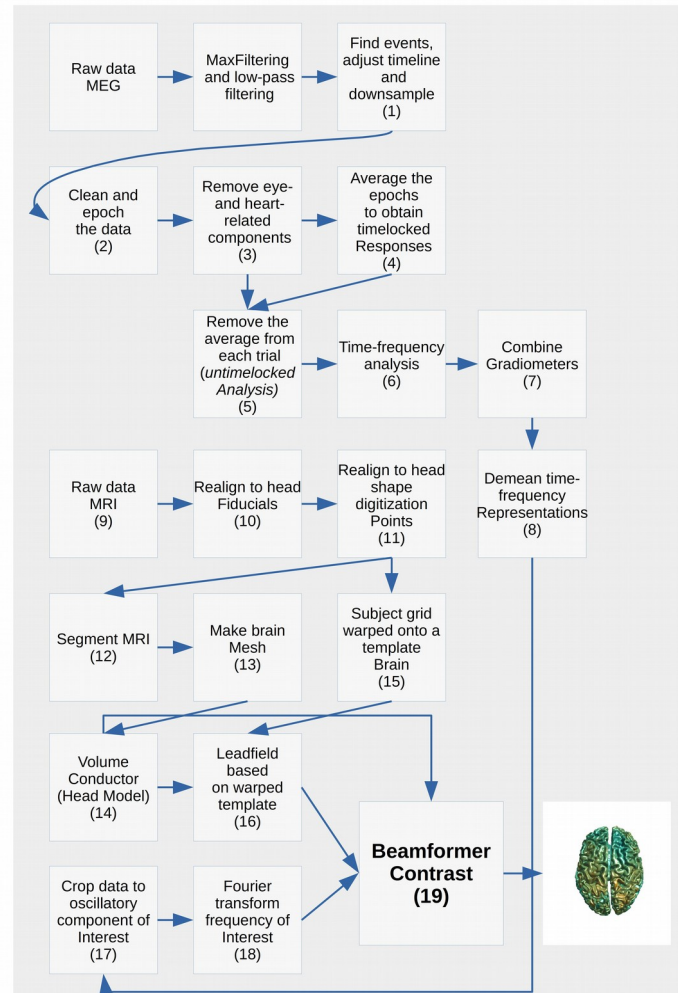


**Karolinska
Institutet**

From raw data to single subject source analysis

by: Lau M. Andersen and Mikkel Vinding

Single Subject Pipeline



Andersen, L.M., 2018. *Front. Neurosci.* 12.

Three sections

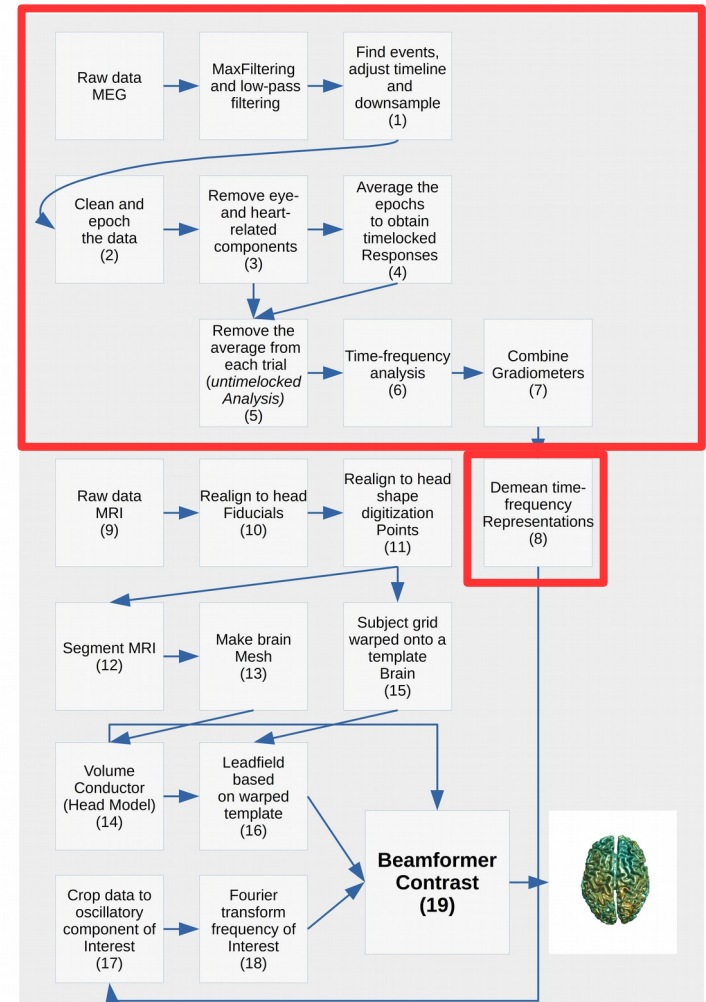
-
- ```
graph TD
 1[Raw data MEG] --> 2[Clean and epoch the data (2)]
 1 --> 3[MaxFiltering and low-pass filtering]
 3 --> 4[Average the epochs to obtain time-locked Responses (4)]
 2 --> 3
 4 --> 5[Remove the average from each trial (untimedlocked Analysis) (5)]
 5 --> 6[Time-frequency analysis (6)]
 6 --> 7[Combine Gradiometers (7)]
 7 --> 8[Demean time-frequency Representations (8)]
 8 --> 19[Beamformer Contrast (19)]
 9[Raw data MRI] --> 10[Realign to head Fiducials (10)]
 10 --> 11[Realign to head shape digitization Points (11)]
 11 --> 12[Segment MRI (12)]
 11 --> 13[Make brain Mesh (13)]
 11 --> 15[Subject grid warped onto a template Brain (15)]
 12 --> 13
 13 --> 14[Volume Conductor (Head Model) (14)]
 13 --> 16[Leadfield based on warped template (16)]
 13 --> 19
 14 --> 16
 15 --> 16
 15 --> 19
 16 --> 19
 17[Crop data to oscillatory component of Interest (17)]
 17 --> 18[Fourier transform frequency of Interest (18)]
 18 --> 19
 19 --> 20[Brain image]
```
- The flowchart illustrates the processing pipeline for MEG/EEG data, divided into two main sections: MEG processing (top) and MRI processing (bottom), both leading to a final Beamformer Contrast analysis (19).
- MEG Processing (Steps 1-8):**
- Raw data MEG
  - Clean and epoch the data (2)
  - MaxFiltering and low-pass filtering
  - Average the epochs to obtain time-locked Responses (4)
  - Remove the average from each trial (*untimedlocked Analysis*) (5)
  - Time-frequency analysis (6)
  - Combine Gradiometers (7)
  - Demean time-frequency Representations (8)
- MRI Processing (Steps 9-18):**
- Raw data MRI (9)
  - Realign to head Fiducials (10)
  - Realign to head shape digitization Points (11)
  - Segment MRI (12)
  - Make brain Mesh (13)
  - Subject grid warped onto a template Brain (15)
  - Volume Conductor (Head Model) (14)
  - Leadfield based on warped template (16)
  - Crop data to oscillatory component of Interest (17)
  - Fourier transform frequency of Interest (18)
- Final Analysis (Step 19):**
- Beamformer Contrast (19)
- The final result is visualized as a brain image showing the contrast results.

3

# Single Subject Pipeline

Three sections

- 1) **Preprocess MEG data**
- 2) *Preprocess MR data*
- 3) *Do source analysis (beamformer)*



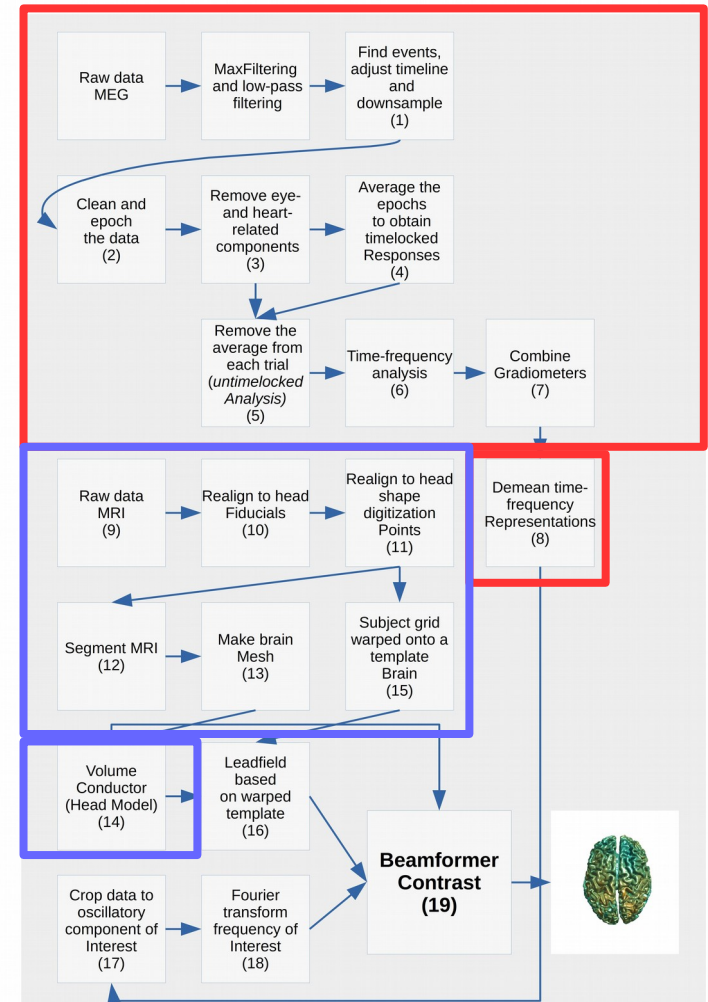
Adapted from: Andersen, L.M., 2018. *Front. Neurosci.* 12.

# Single Subject Pipeline

Three sections

- 1) **Preprocess MEG data**
- 2) **Preprocess MR data**
- 3) **Do source analysis (beamformer)**

(Note that warping (15-16) is only needed if you are preparing the subject to part of a group analysis)



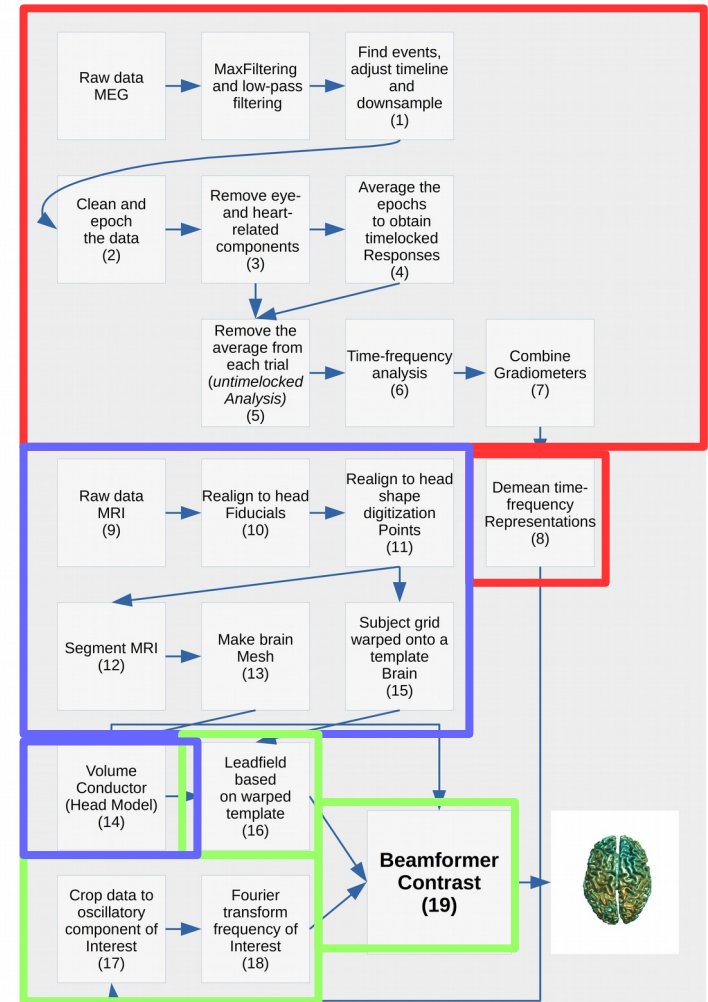
Adapted from: Andersen, L.M., 2018. *Front. Neurosci.* 12.

# Single Subject Pipeline

Three sections

- 1) **Preprocess MEG data**
- 2) **Preprocess MR data**
- 3) **Do source analysis (beamformer)**

(Note that warping (15-16) is only needed if you are preparing the subject to part of a group analysis)



Adapted from: Andersen, L.M., 2018. *Front. Neurosci.* 12.

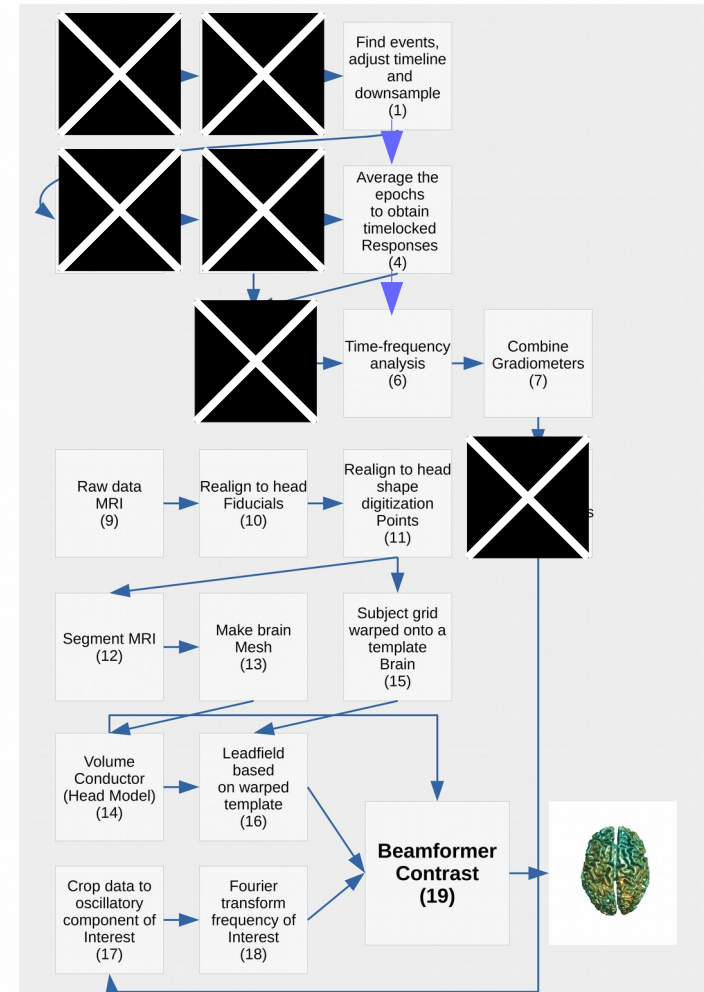
# Steps covered today

Find events,  
adjust timeline  
and  
downsample  
(1)

Average the  
epochs  
to obtain  
timelocked  
Responses  
(4)

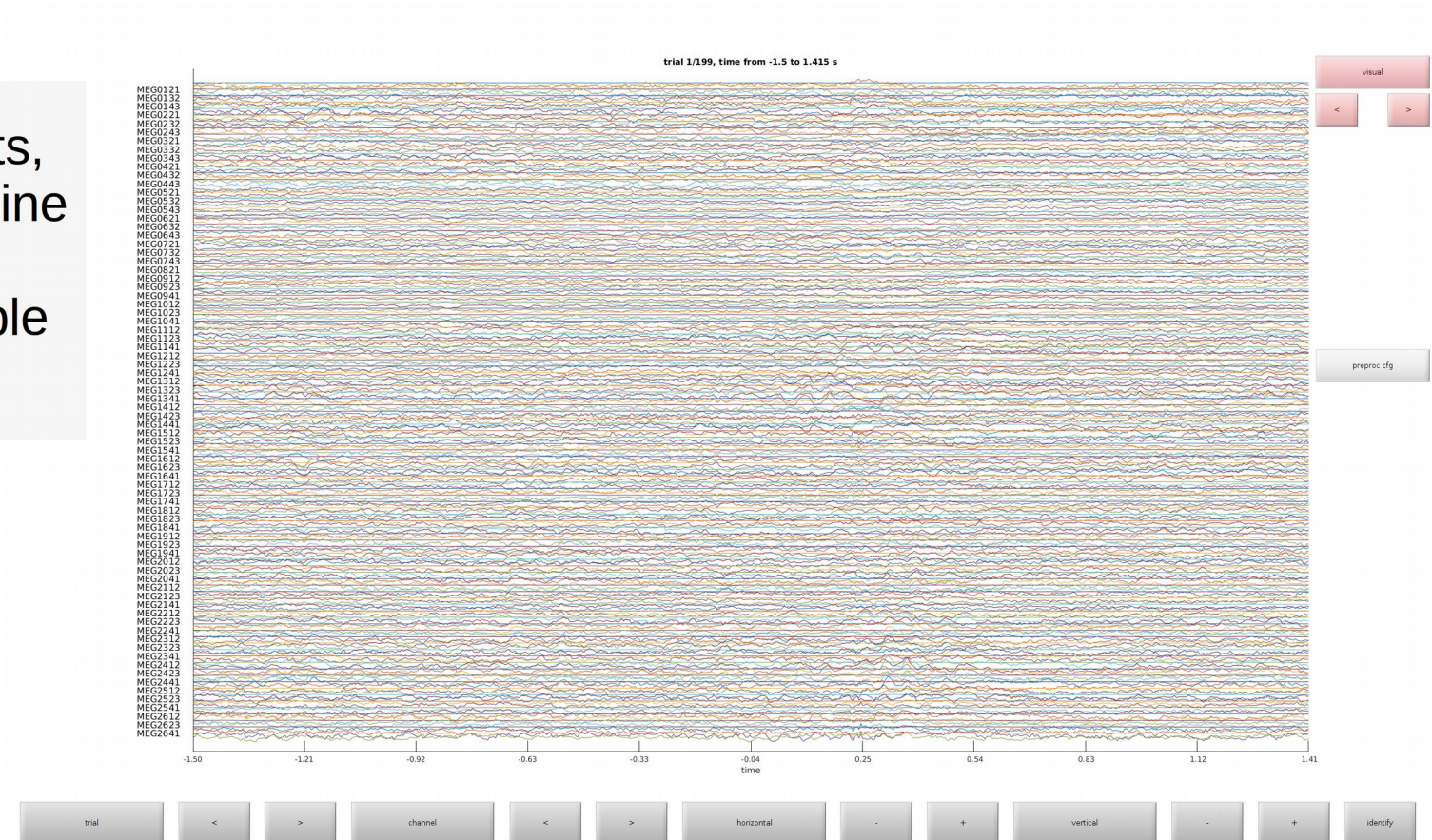
Time-frequency  
analysis  
(6)

Combine  
Gradiometers  
(7)

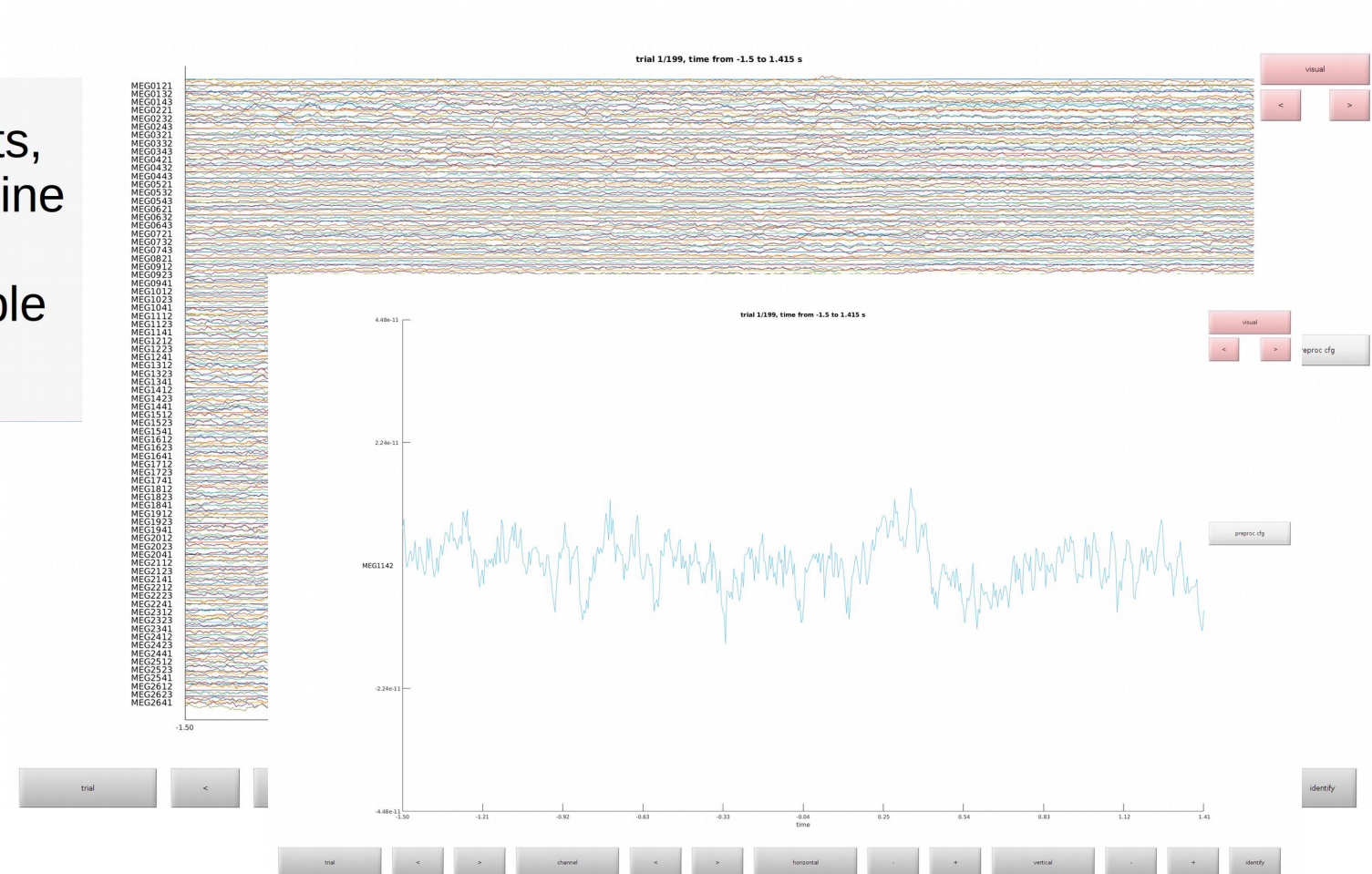




Find events,  
adjust timeline  
and  
downsample  
(1)



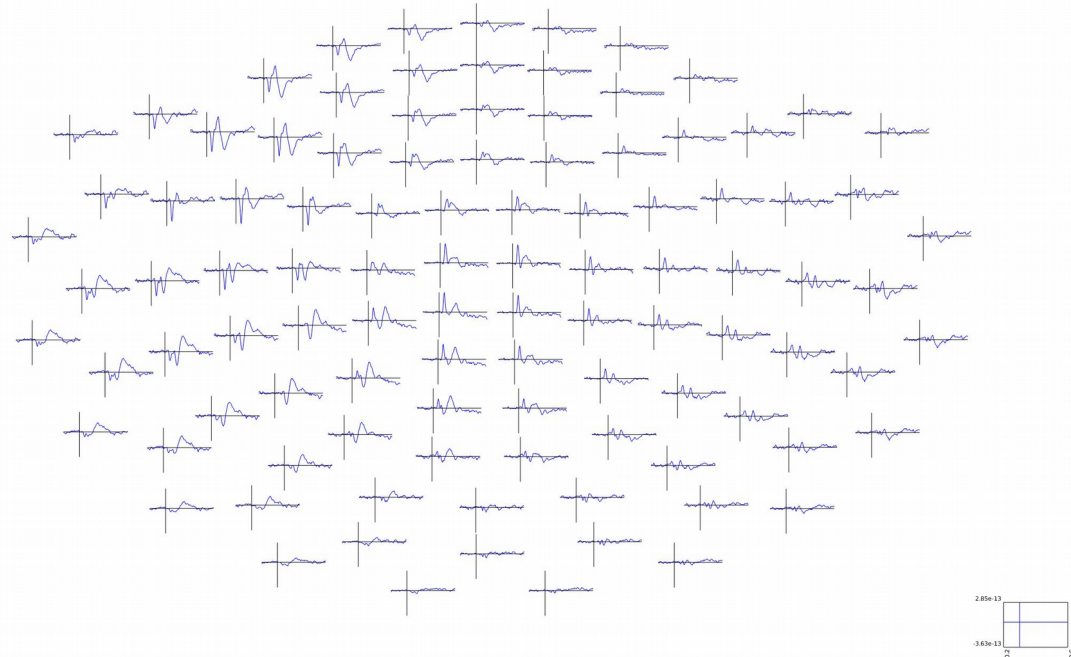
Find events,  
adjust timeline  
and  
downsample  
(1)





# 2D time courses

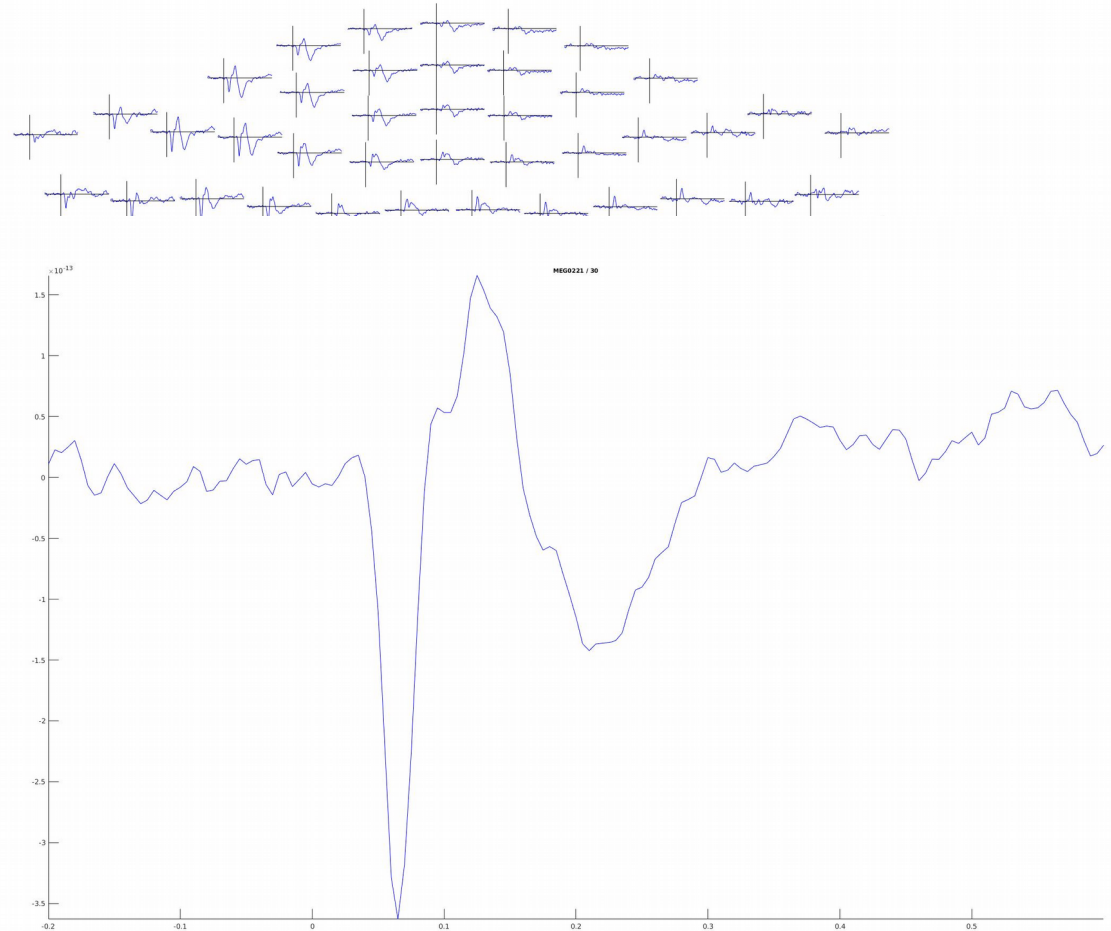
Average the  
epochs  
to obtain  
timelocked  
Responses  
(4)



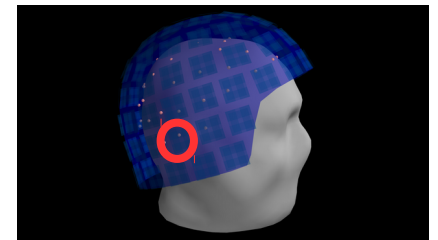
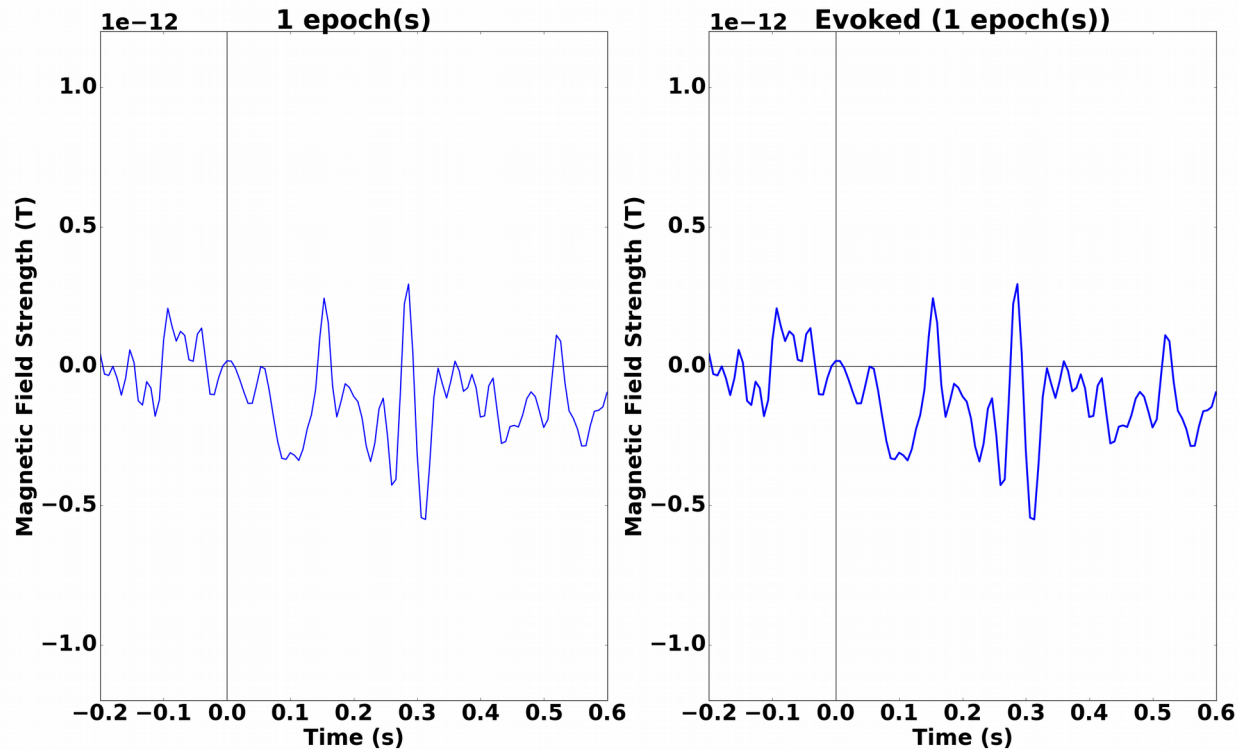


# 2D time courses

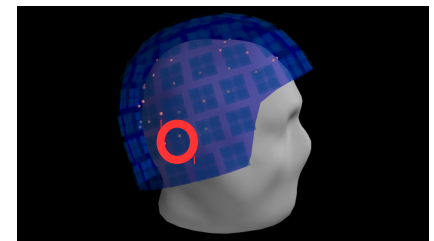
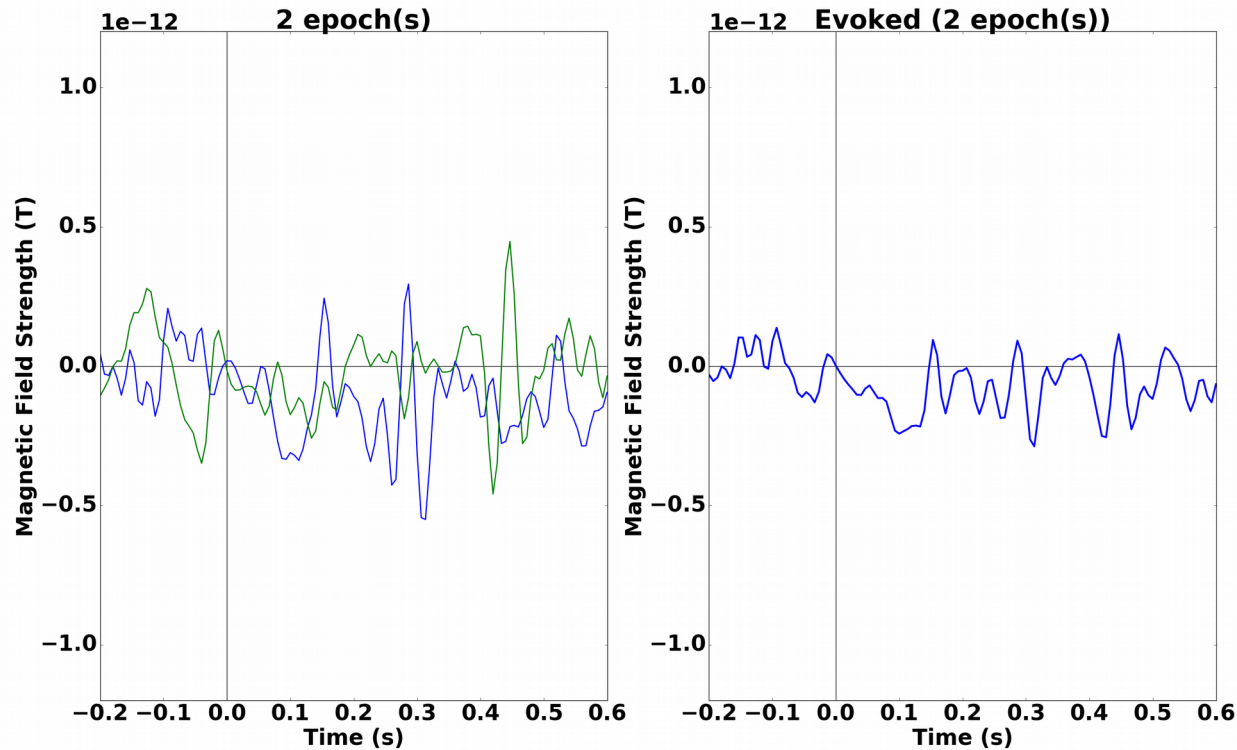
Average the  
epochs  
to obtain  
timelocked  
Responses  
(4)



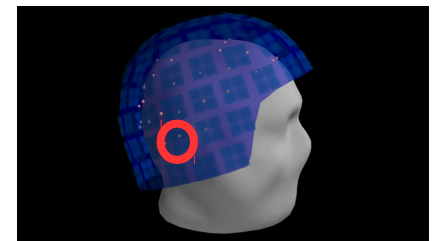
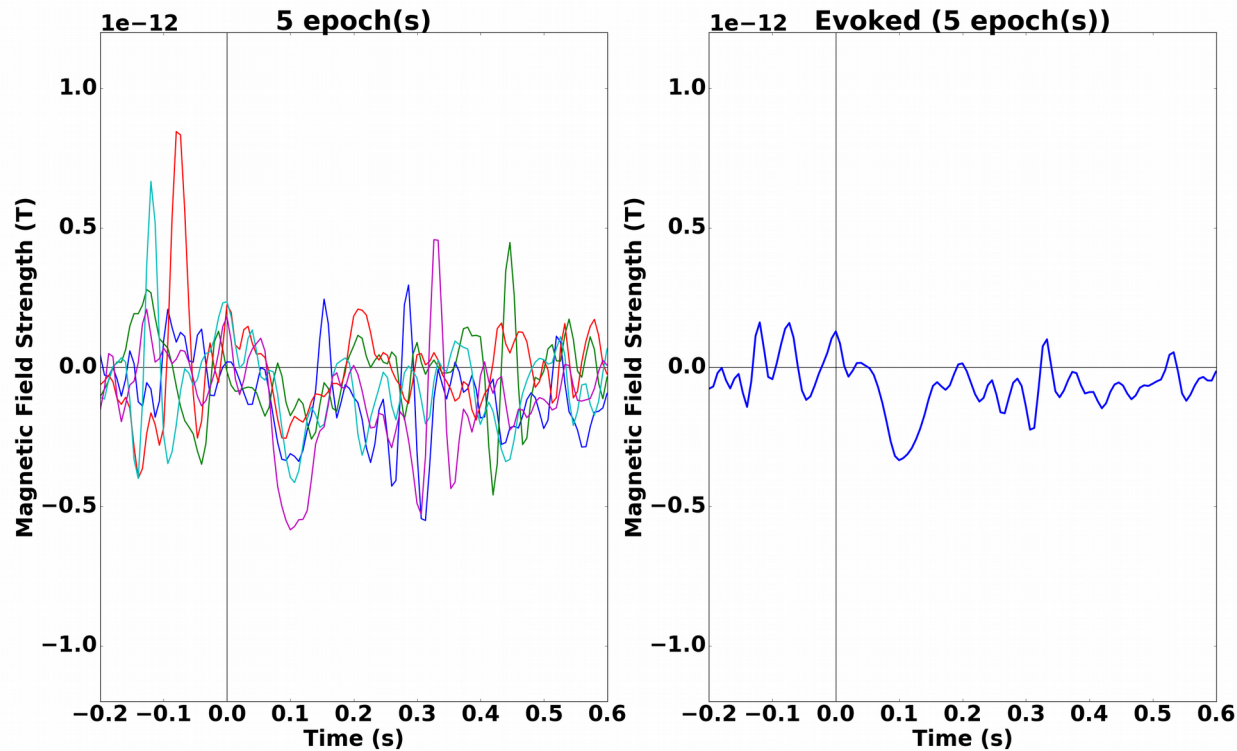
# Epochs and Evoked (MEG)



# Epochs and Evoked (MEG)

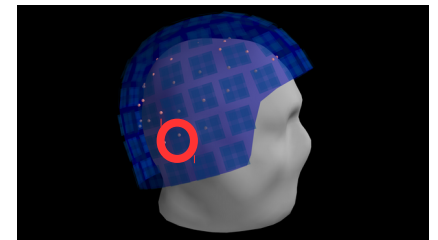
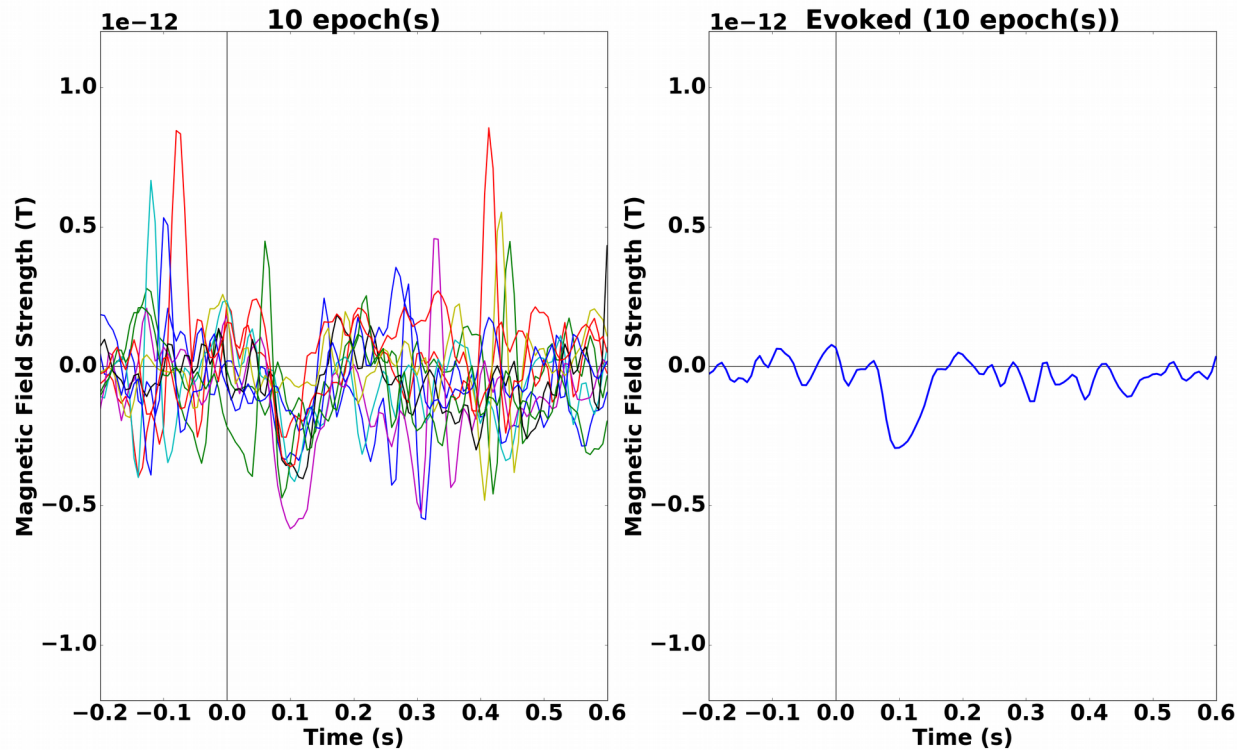


# Epochs and Evoked (MEG)

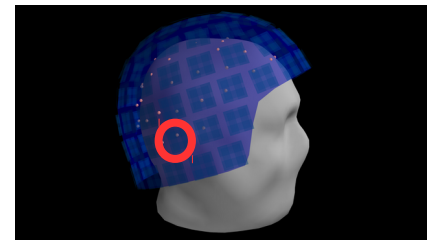
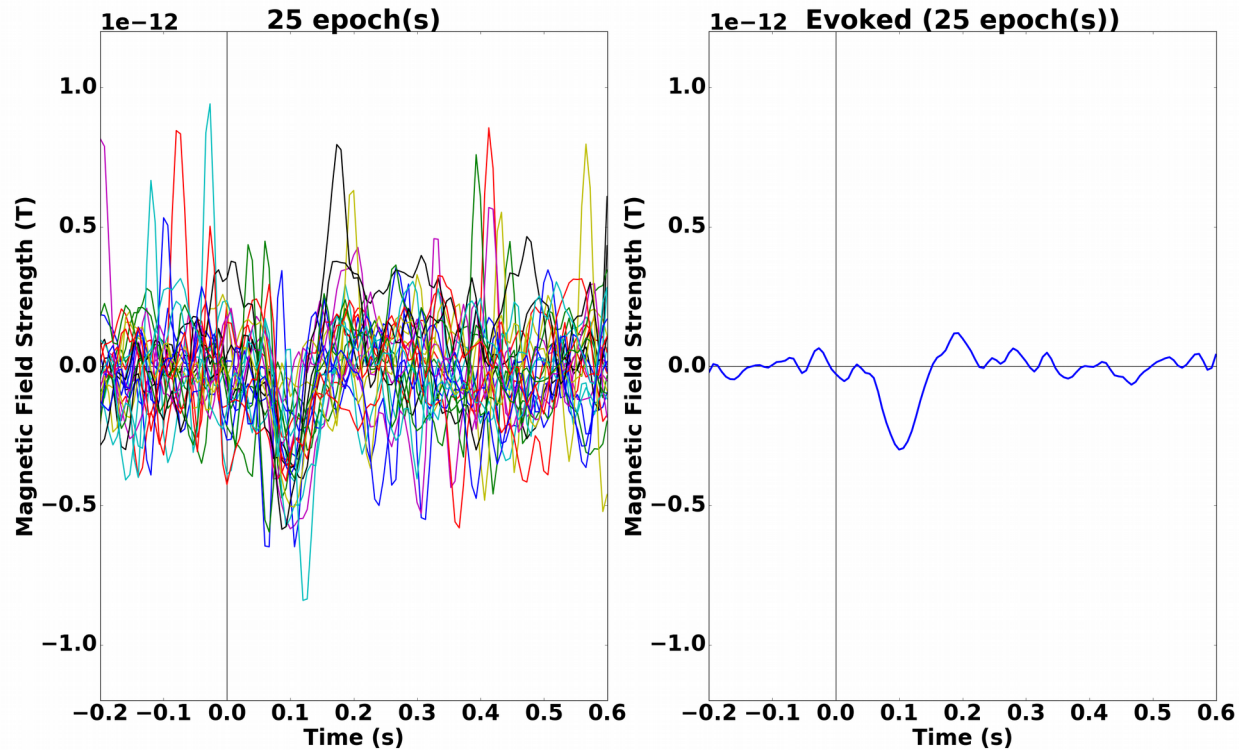




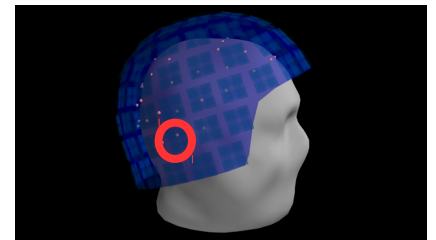
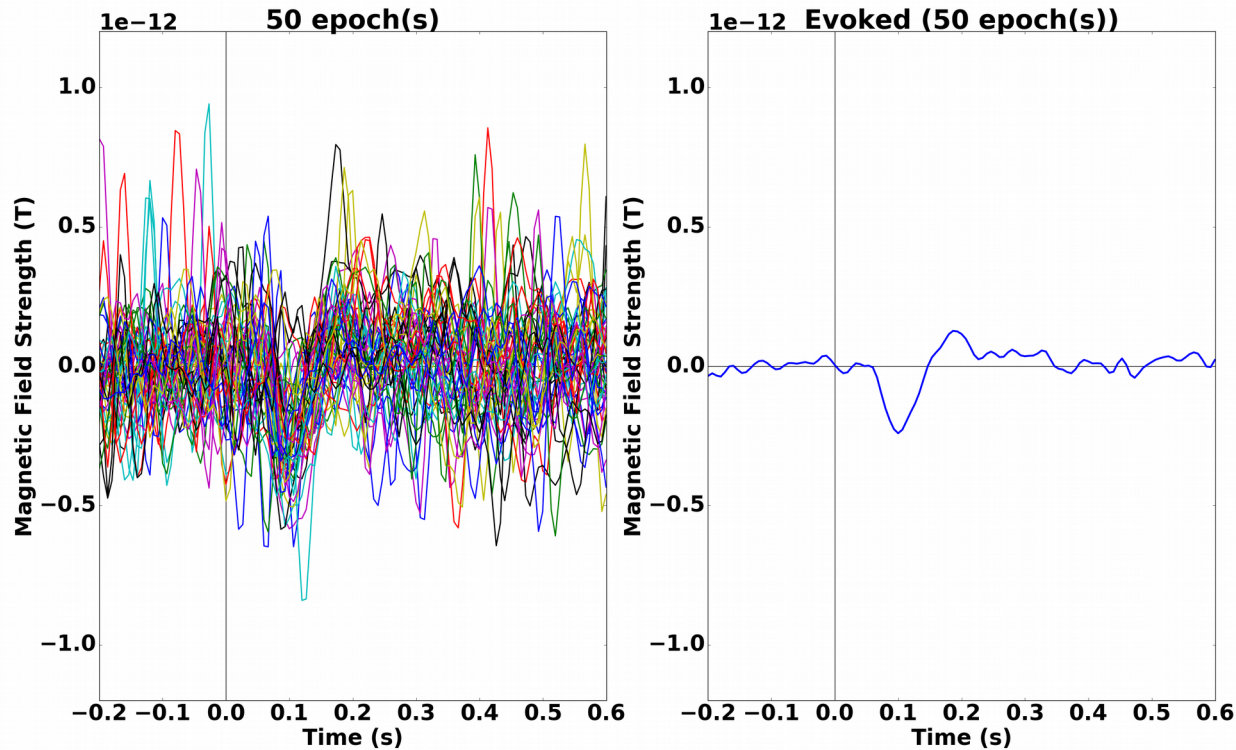
# Epochs and Evoked (MEG)



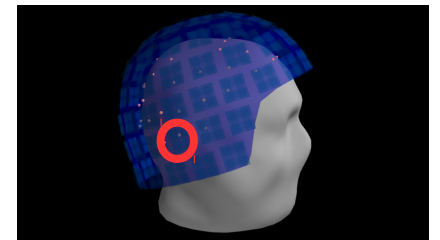
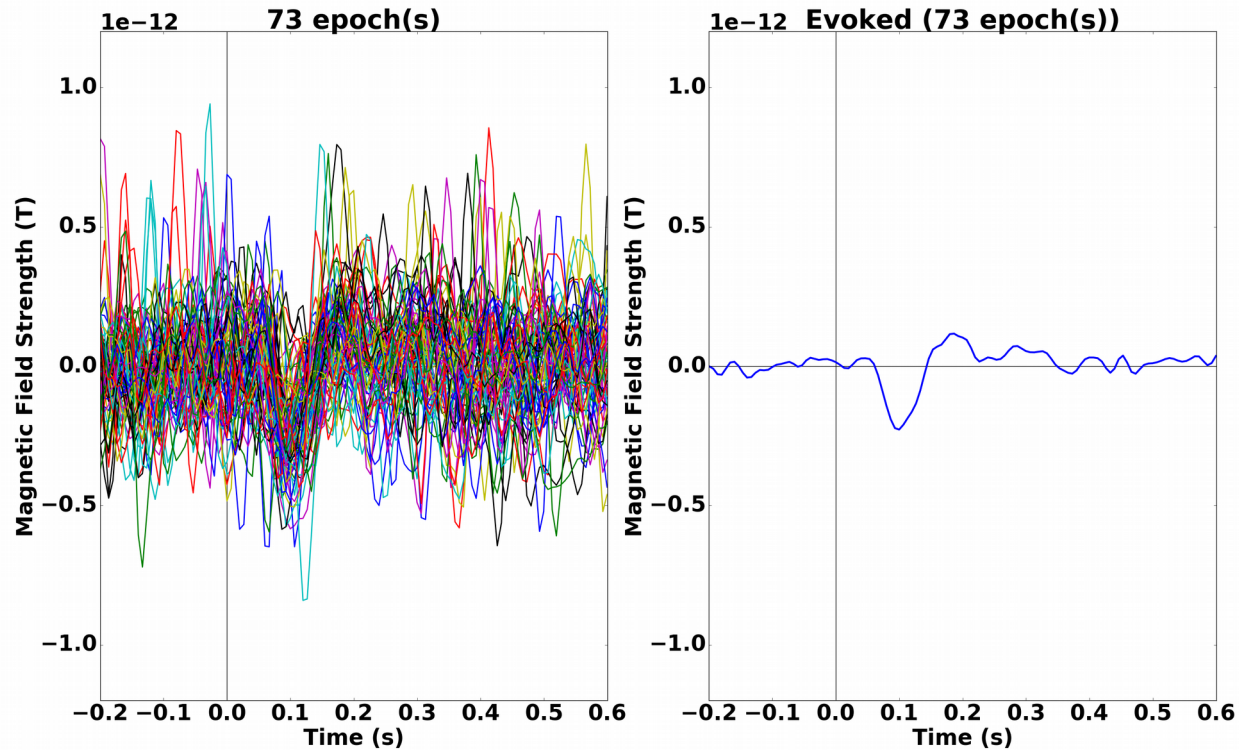
# Epochs and Evoked (MEG)



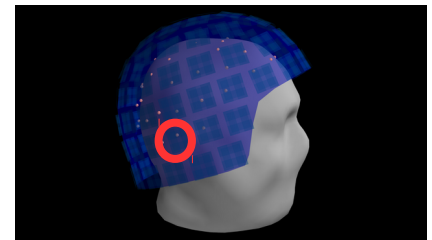
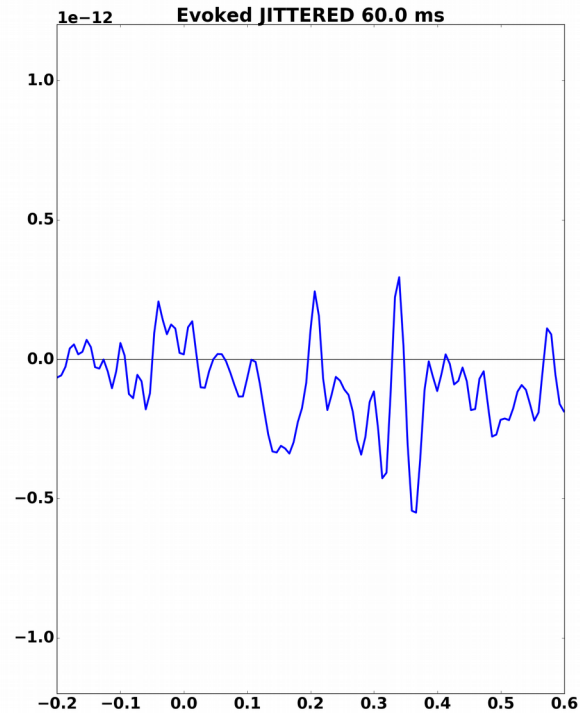
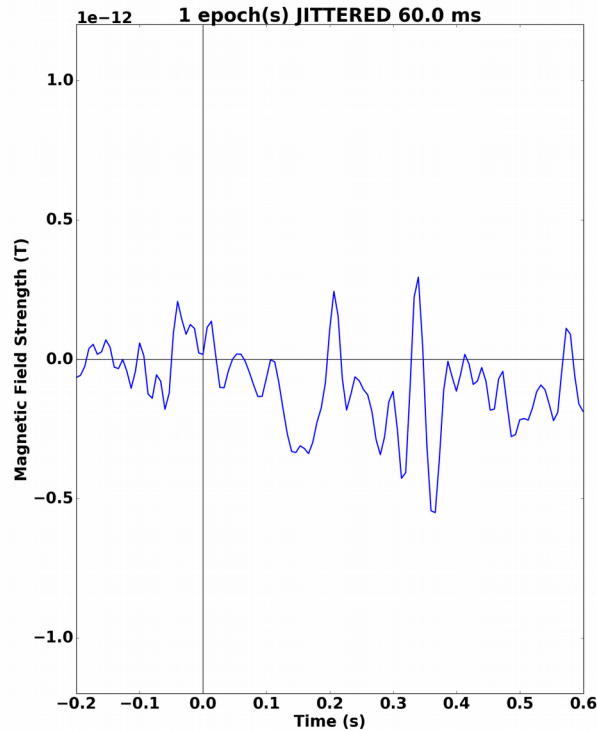
# Epochs and Evoked (MEG)



# Epochs and Evoked (MEG)



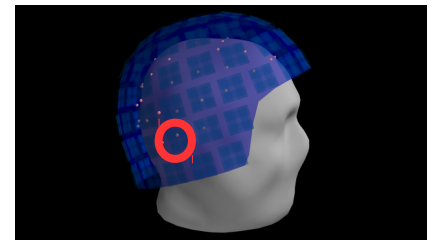
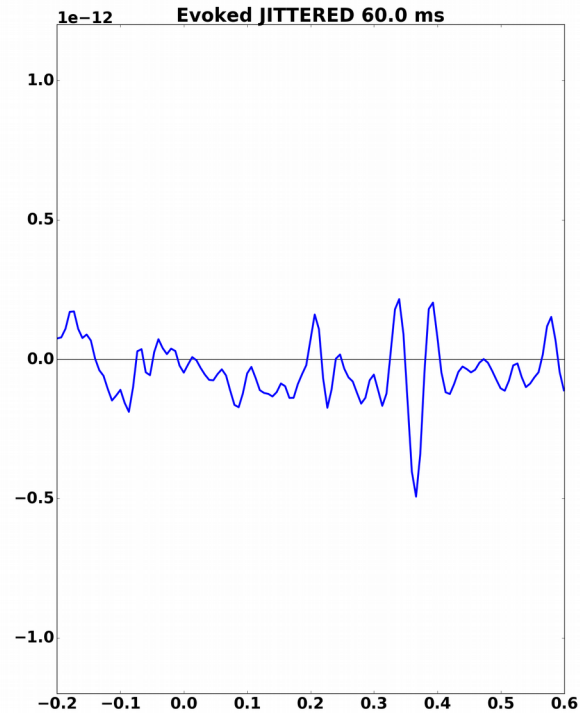
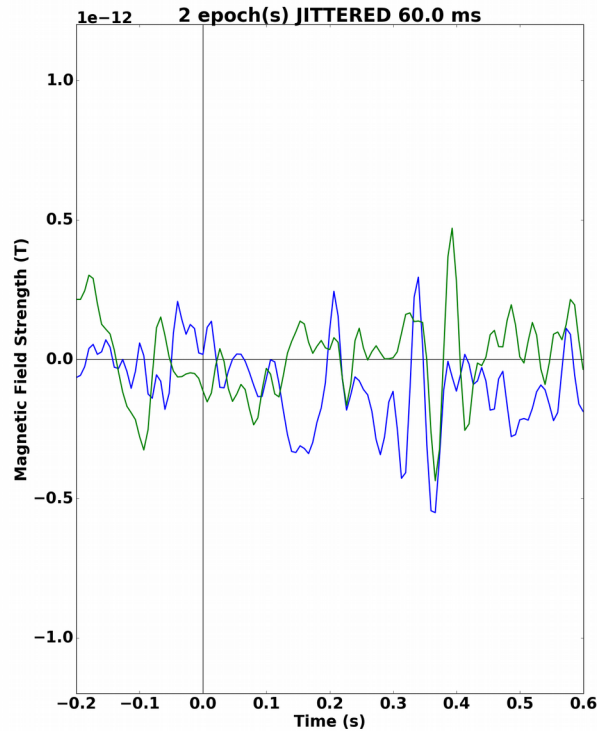
# Epochs and Evoked JITTERED 60 ms (MEG)





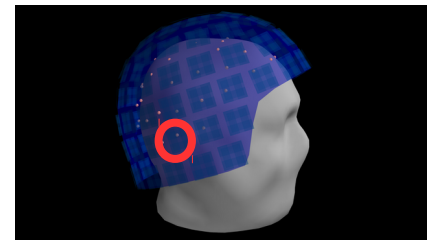
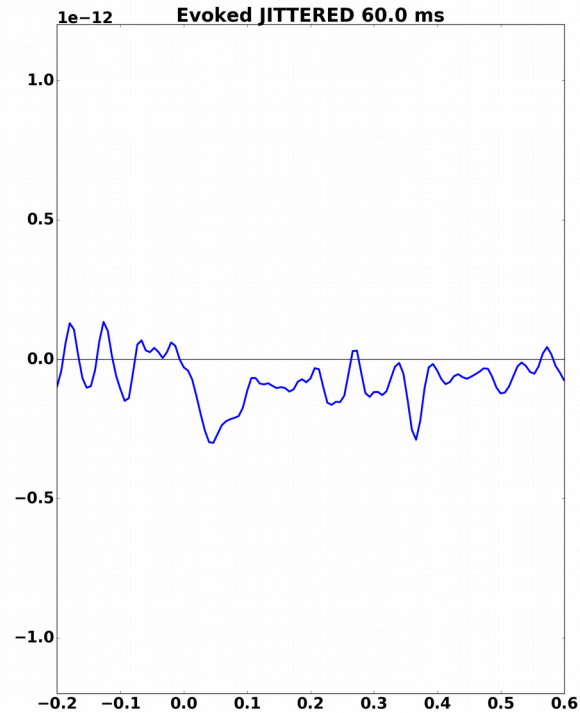
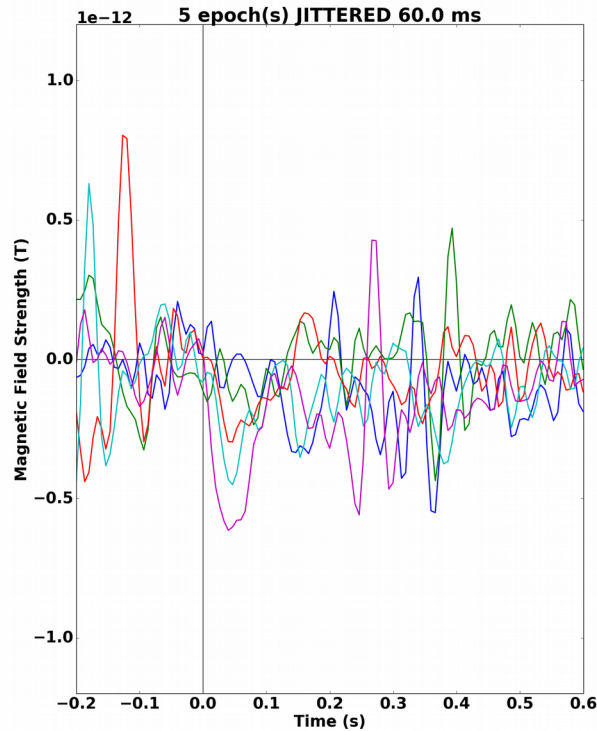
# Epochs and Evoked JITTERED

## 60 ms (MEG)



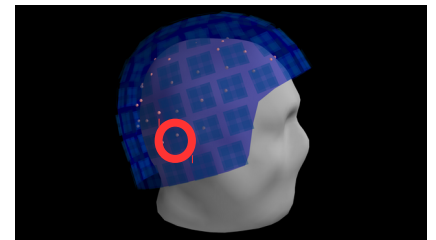
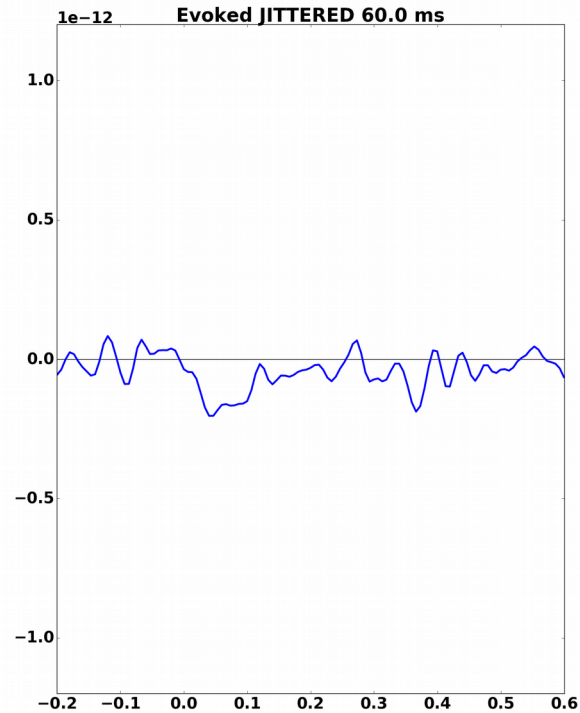
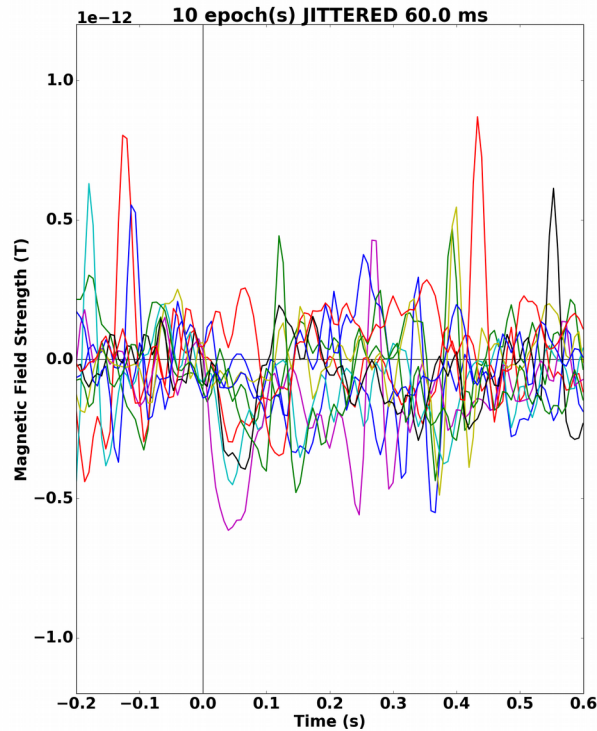
# Epochs and Evoked JITTERED

## 60 ms (MEG)



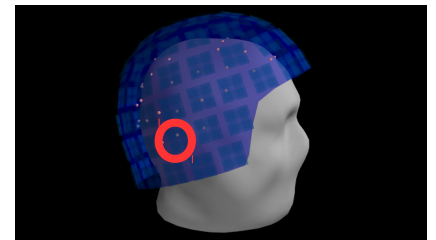
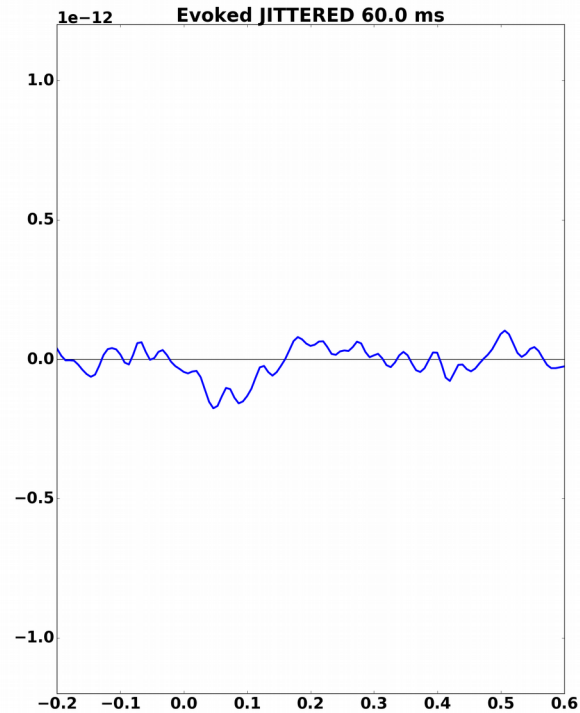
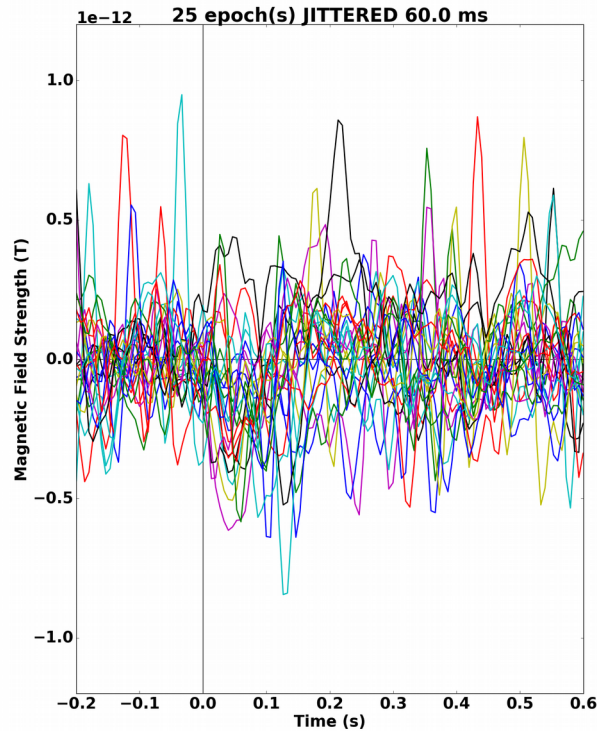
# Epochs and Evoked JITTERED

## 60 ms (MEG)

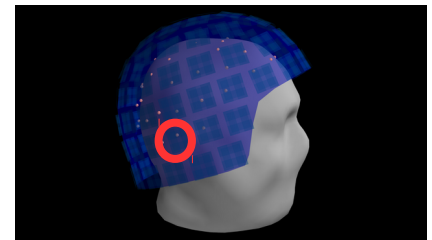
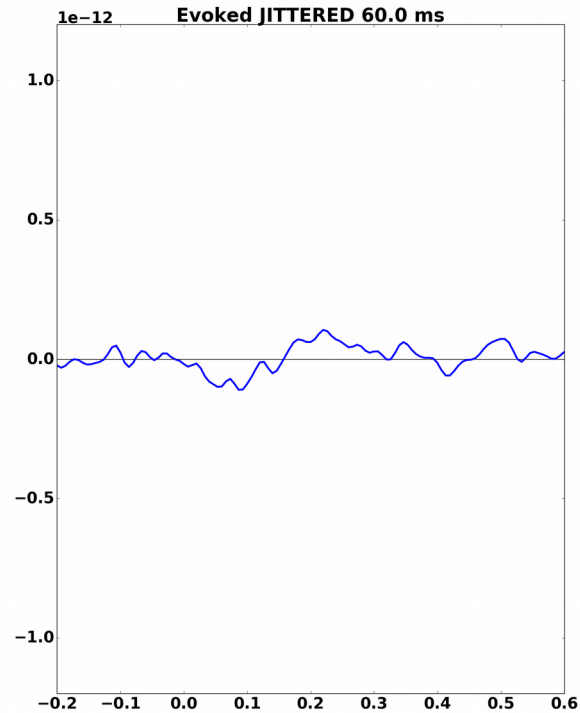
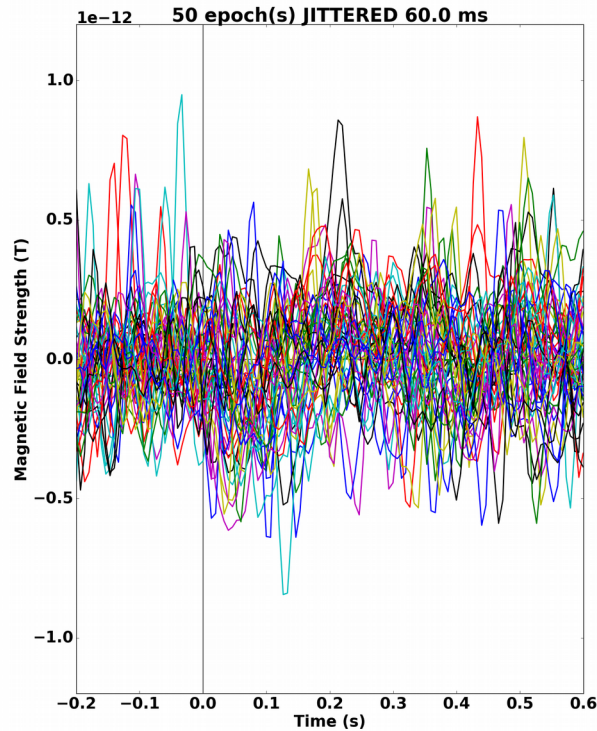


# Epochs and Evoked JITTERED

## 60 ms (MEG)



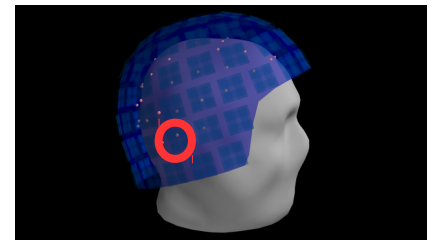
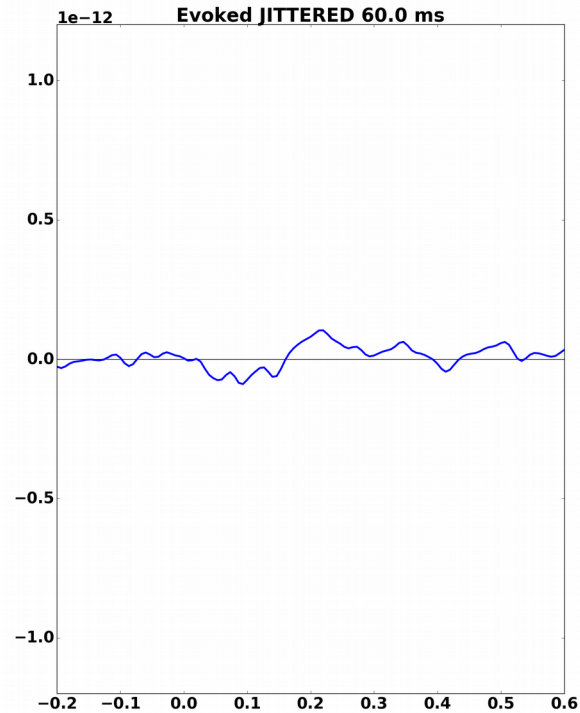
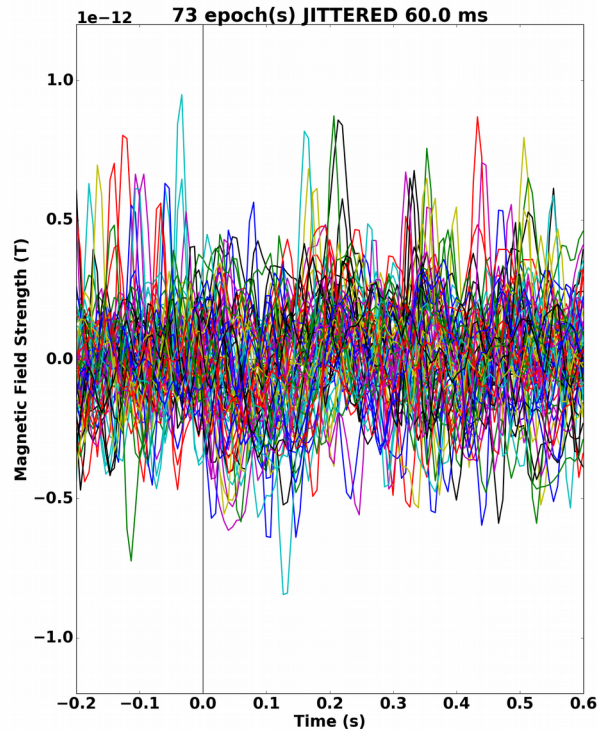
# Epochs and Evoked JITTERED 60 ms (MEG)



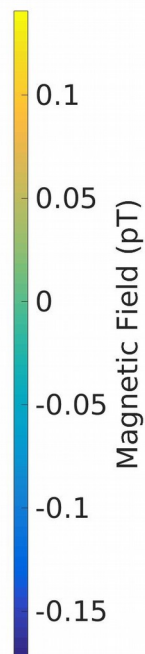
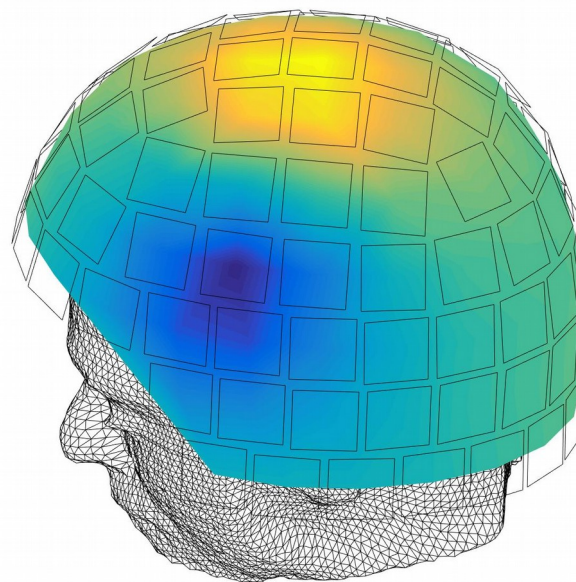


# Epochs and Evoked JITTERED

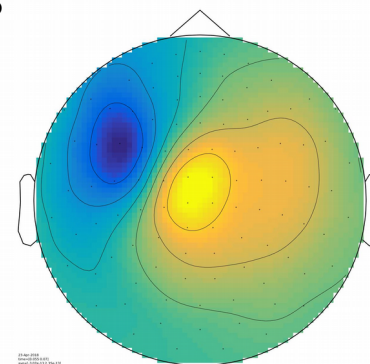
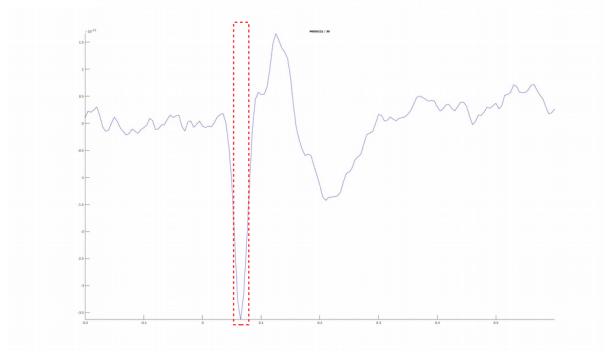
## 60 ms (MEG)



# Topographies

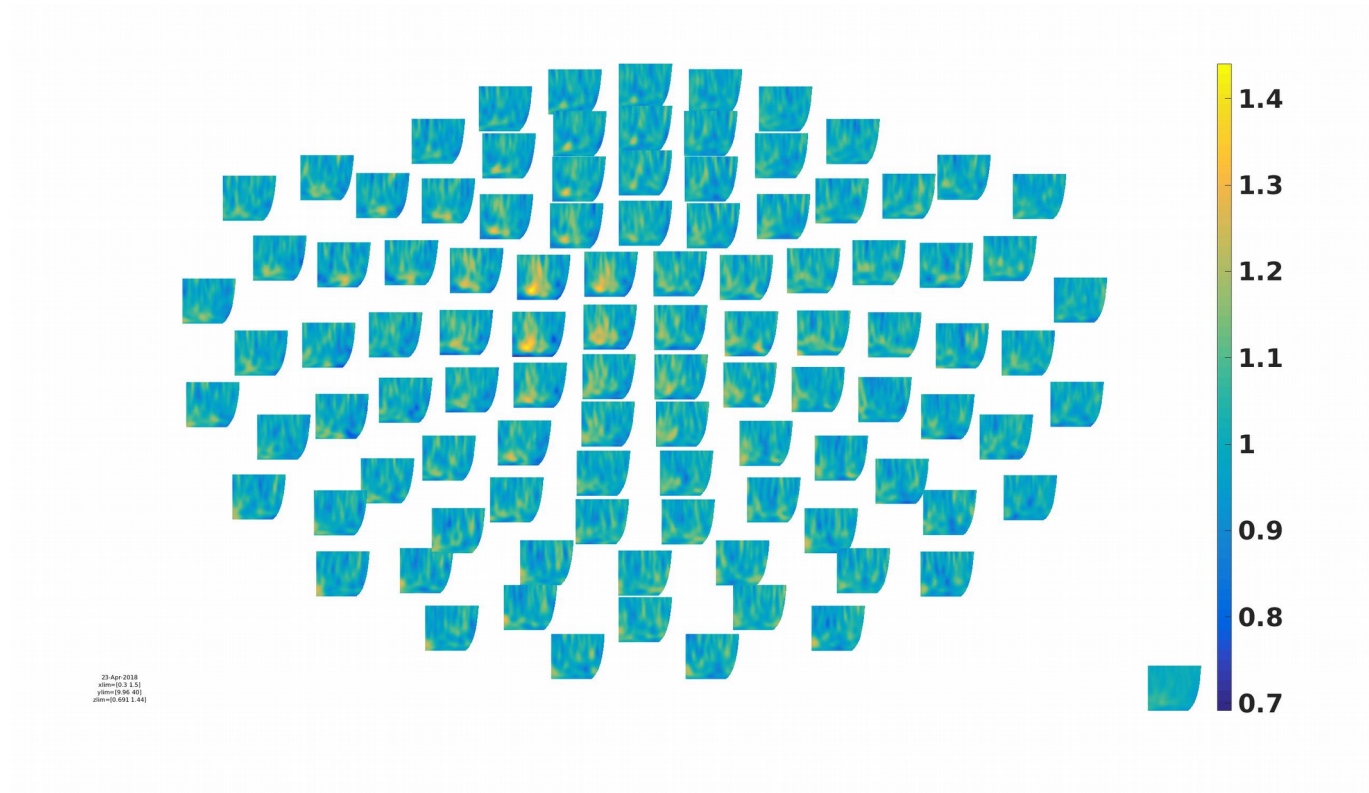


55 ms



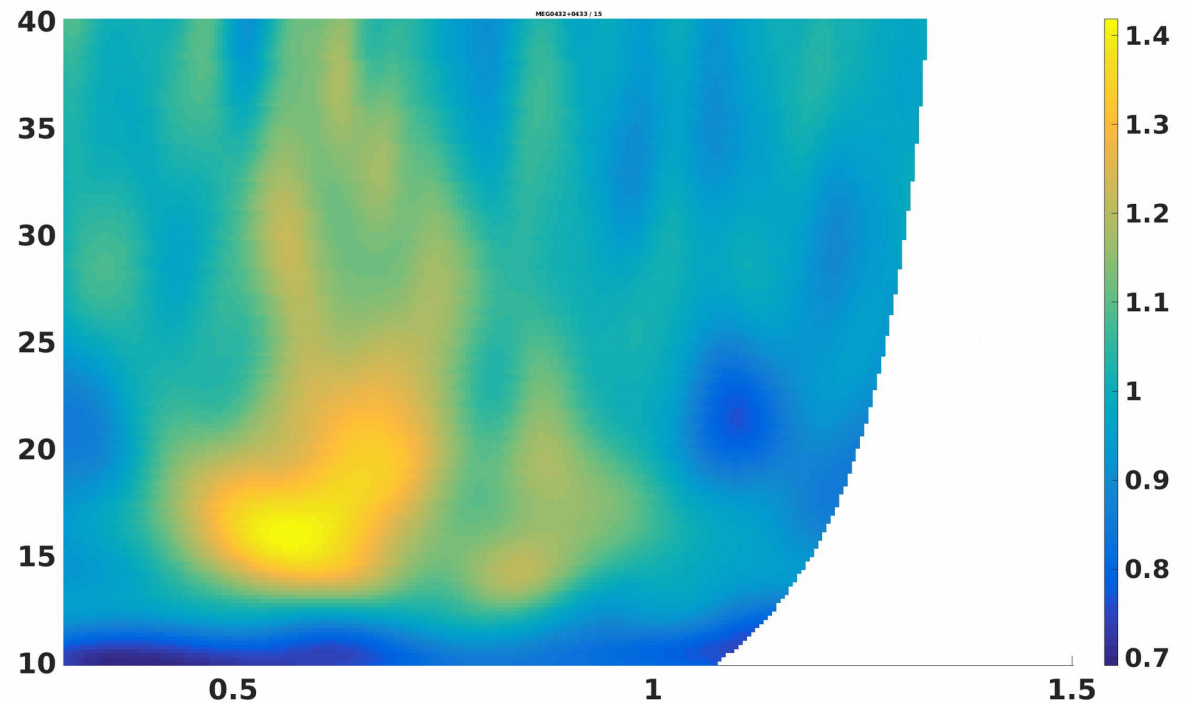
## Time-frequency analysis (6)

## Combine Gradiometers (7)



Time-frequency  
analysis  
(6)

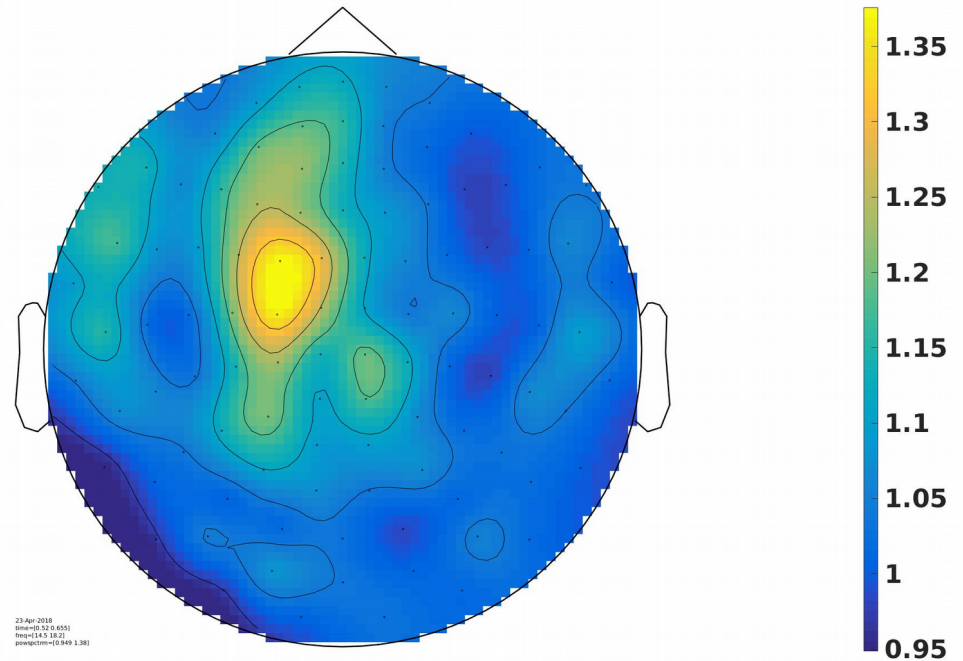
Combine  
Gradiometers  
(7)



Time: 500-600 ms  
Frequency: 14-18 Hz

Time-frequency  
analysis  
(6)

Combine  
Gradiometers  
(7)

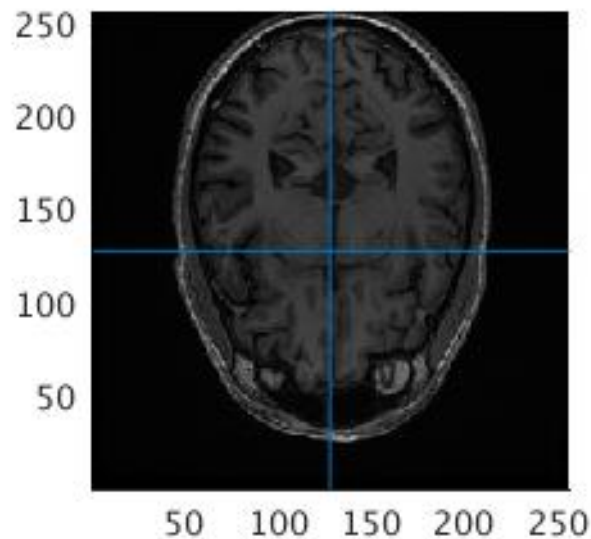
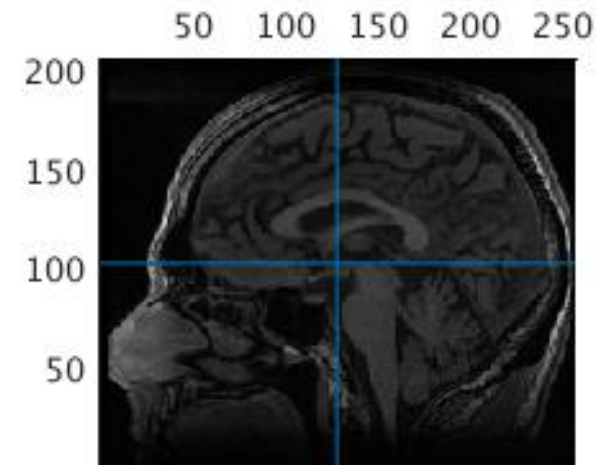
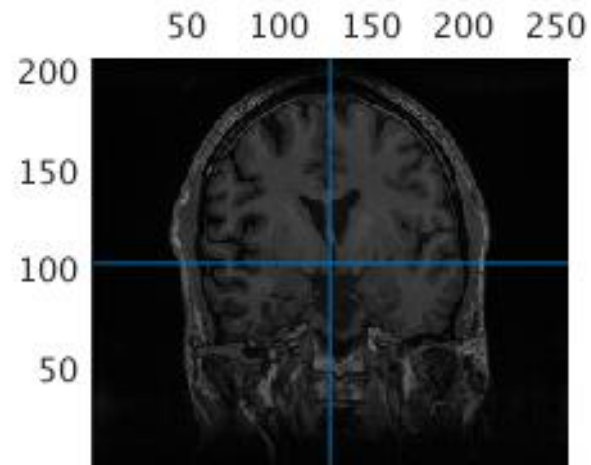




# Preprocess MR data



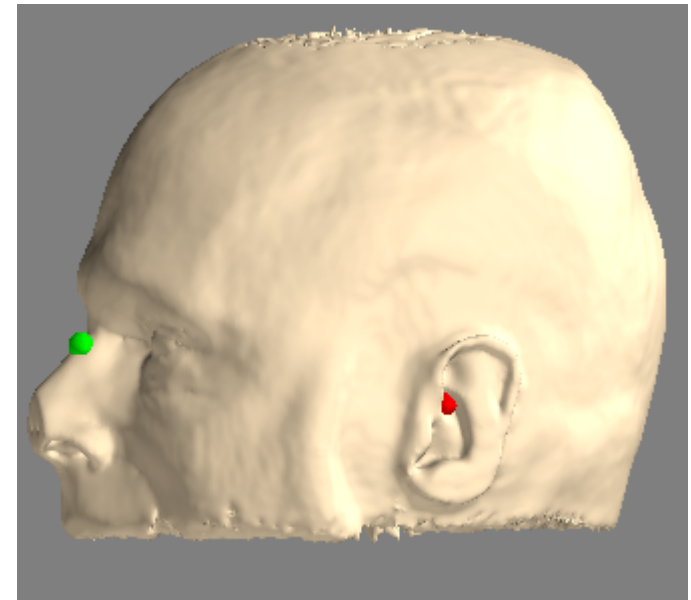
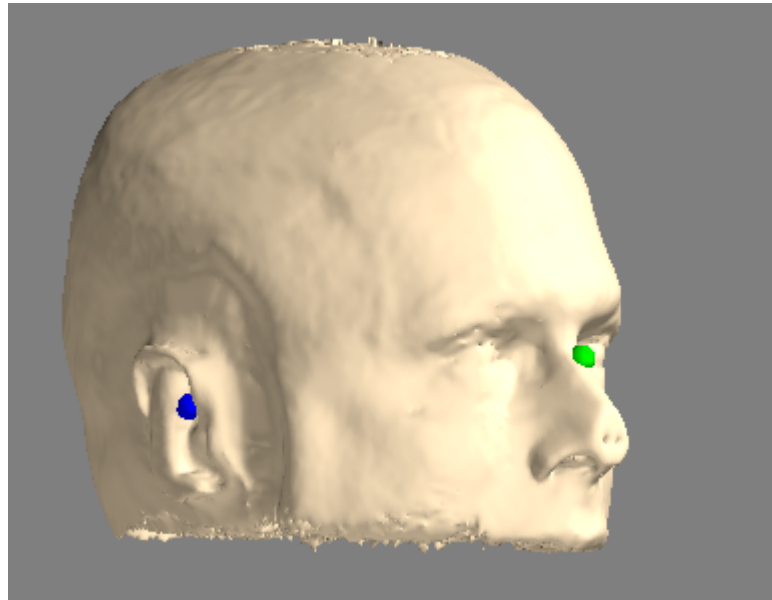
# Raw data MRI (9)



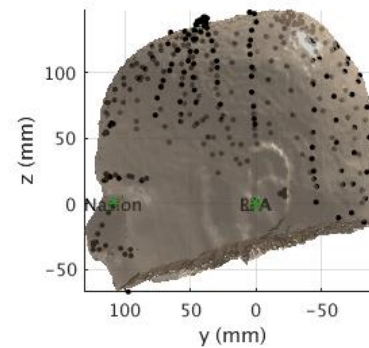
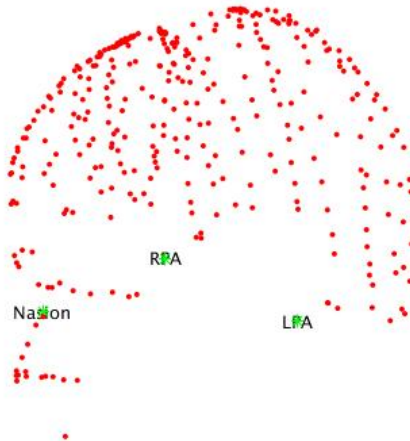
voxel 6717312, indices [128 128 103]  
acpc coordinates [2.2 46.2 -1.0] mm

atlas label: NA

## Realign to head Fiducials (10)



# Realign to head shape digitization Points (11)



|        |   |   |   |
|--------|---|---|---|
| rotate | 0 | 0 | 0 |
| scale  | 1 | 1 | 1 |
| transl | 0 | 0 | 0 |

left ▾

alpha 0.6

redisplay

apply

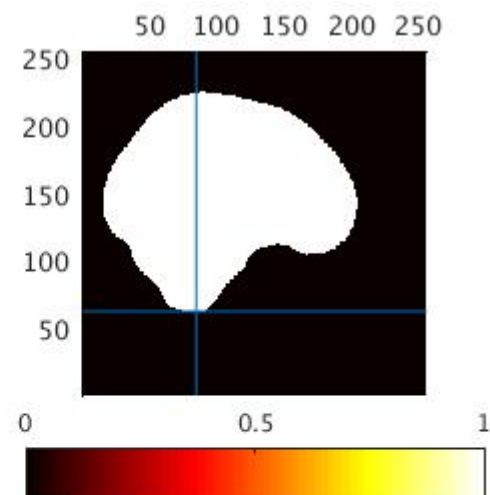
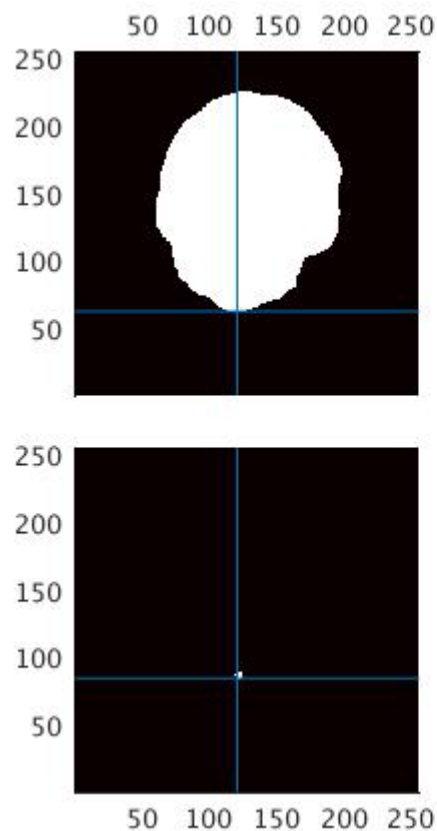
toggle label

toggle axes

toggle grid

quit

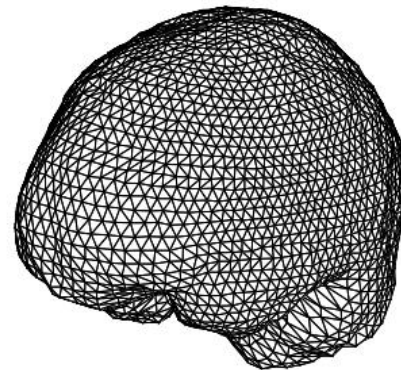
## Segment MRI (12)



voxel 4084857, indices [121 85 63]  
neuromag coordinates [-7.5 -13.5 -25.5]  
value 1.000000

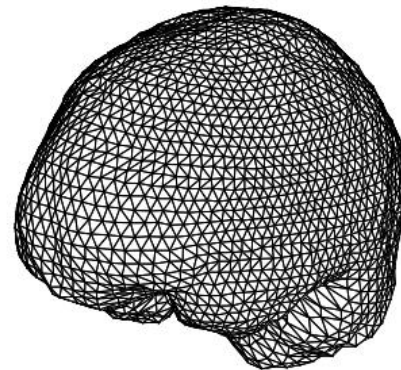
atlas label: NA

Make brain  
Mesh  
(13)



This specifies how the electric currents spread throughout the conductor (the brain compartment inside the skull).

Volume  
Conductor  
(Head Model)  
(14)

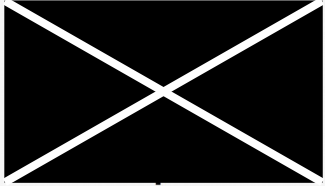




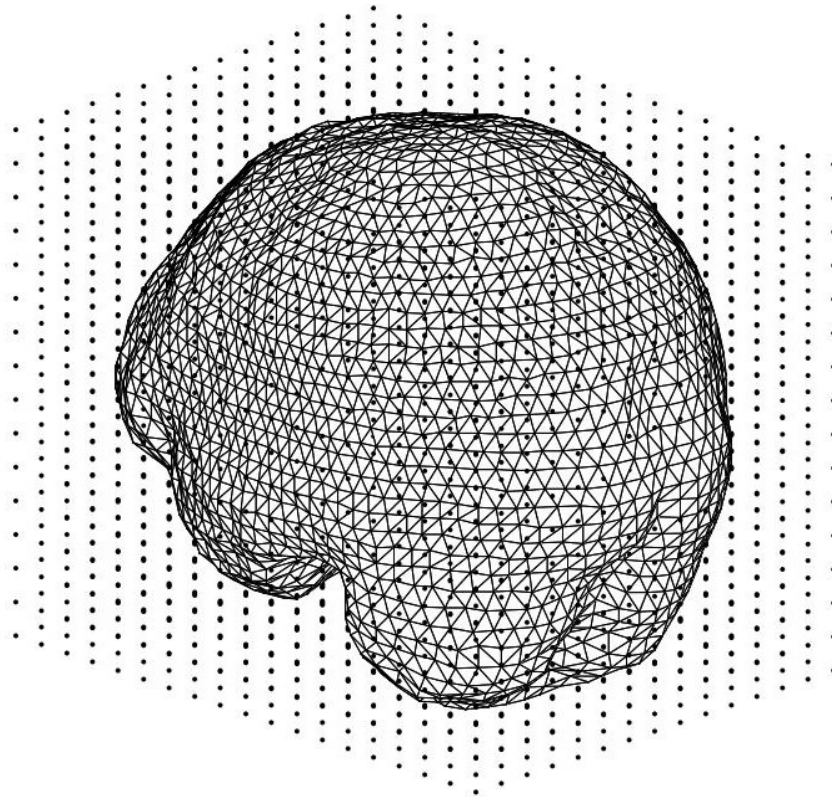
# Source analysis (beamformer)

Leadfield  
based  
on warped  
template  
(16)

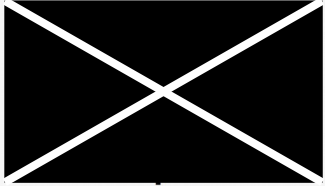
Leadfield



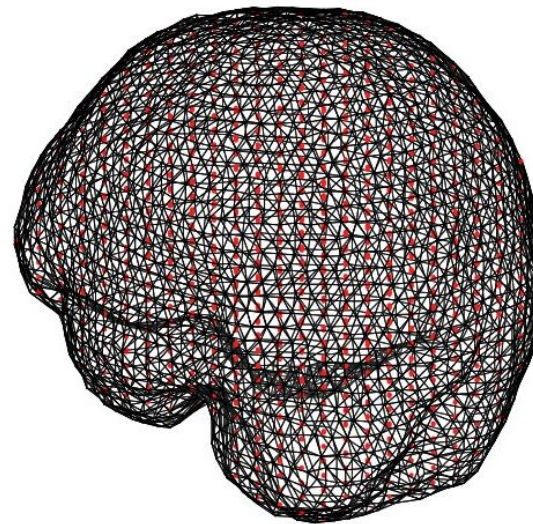
(16)

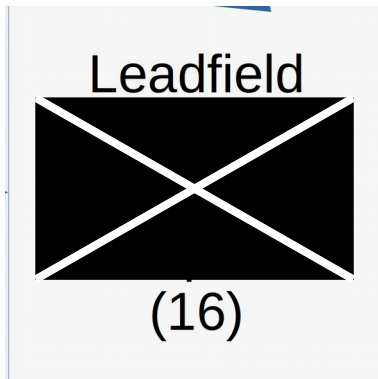


Leadfield

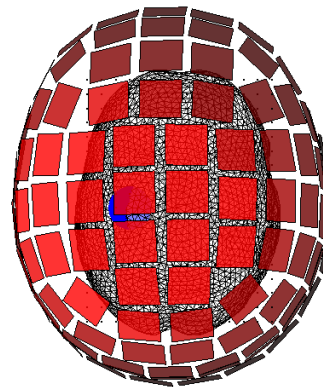


(16)

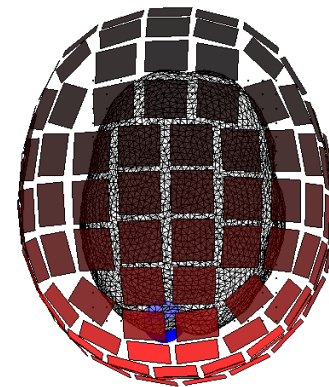




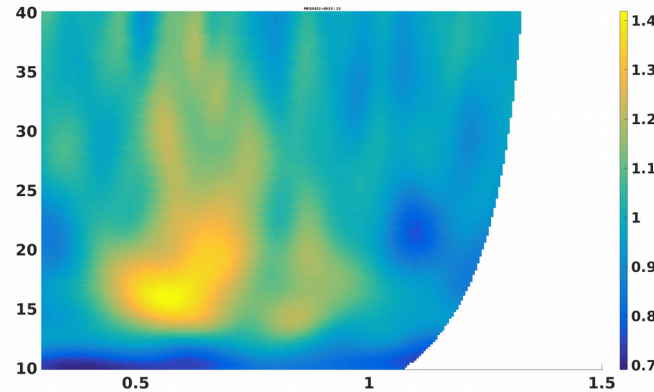
"Tactile source"



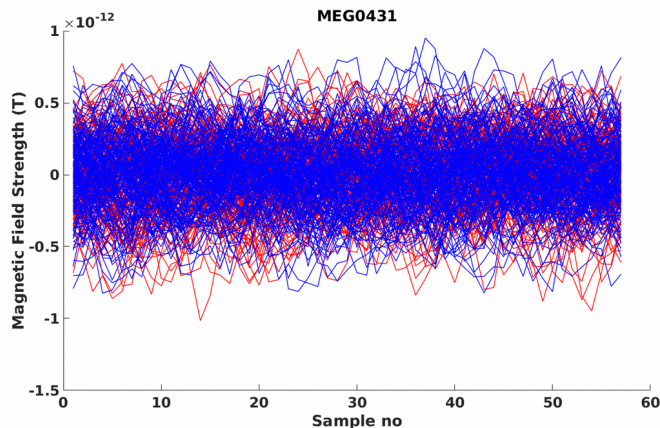
"Occipital" source



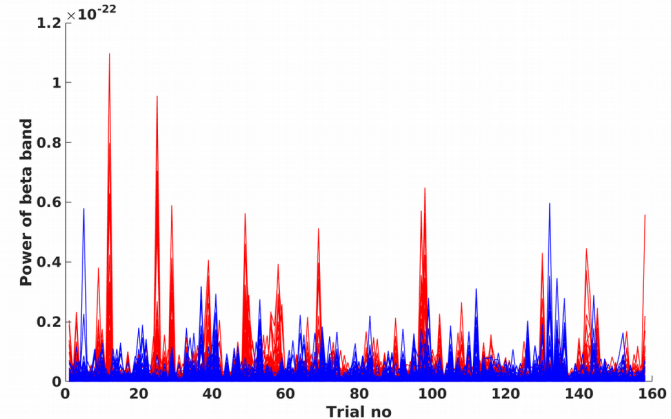
Crop data to  
oscillatory  
component of  
Interest  
(17)



Timelocked (average  
per sample)



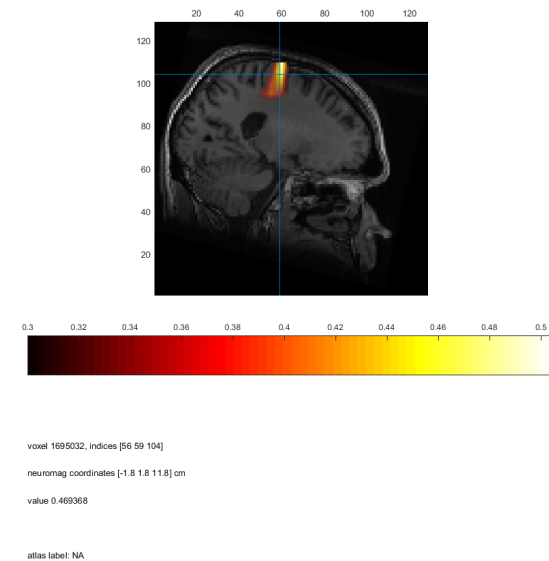
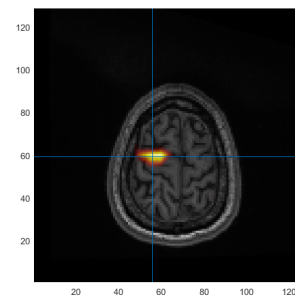
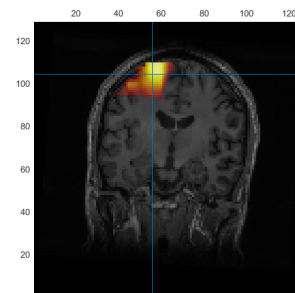
Power in the beta band  
(estimate per trial)



RED: rebound  
BLUE: baseline

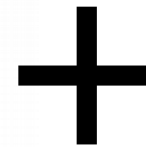
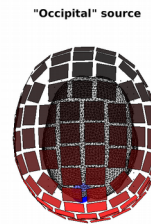
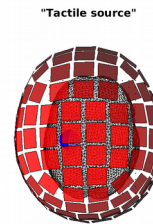
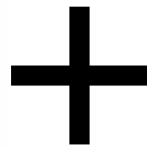
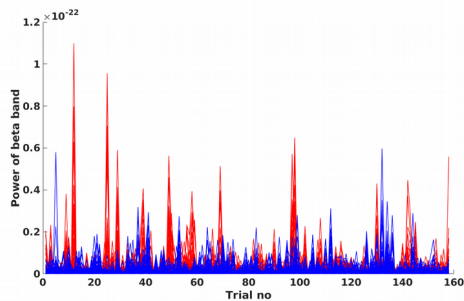


# Beamformer Contrast (19)



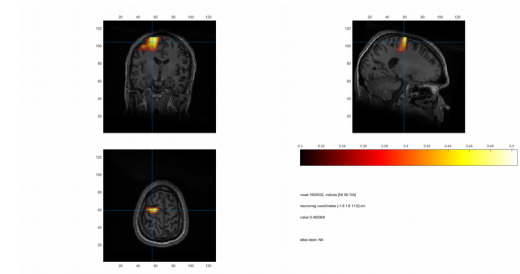
Frequency power estimates

Leadfield  
(Linking all sources to all sensors)



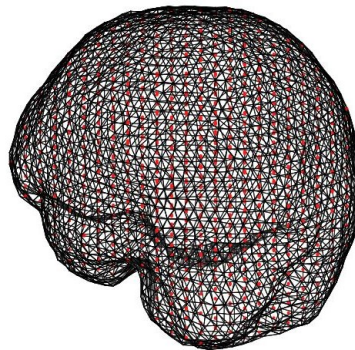
*MATH*

Beamformer power estimation



## Beamformer details

For each source a  
spatial filter is  
constructed



## Beamformer details

For each source a  
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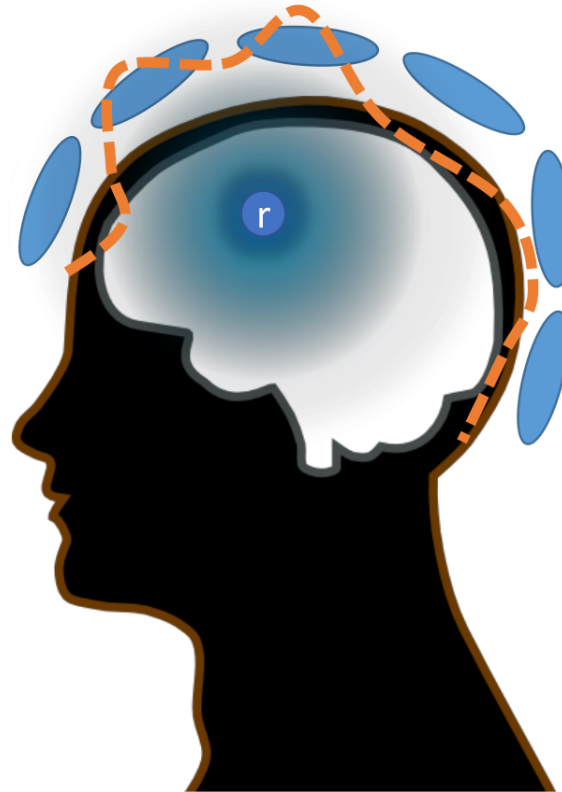


## Beamformer details

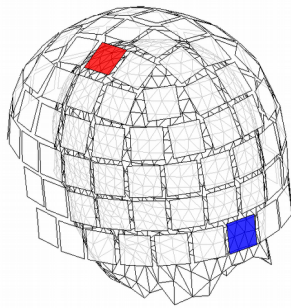
For each source a spatial filter is constructed

That filter maximizes input from sensors to which the source is most heavily linked and attenuates input from all other sensors. The filter weights the leadfield

This is subject to the unit-gain constraint

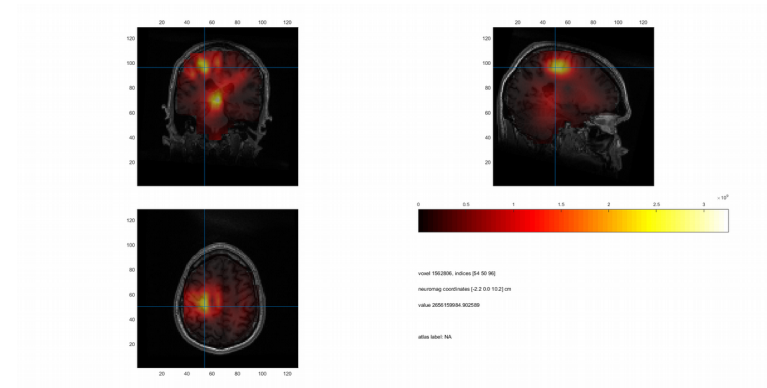


## Examples of spatial filters



Centre of the head bias is visible here (due to the unit gain constraint)

### Red channel



### Blue channel

