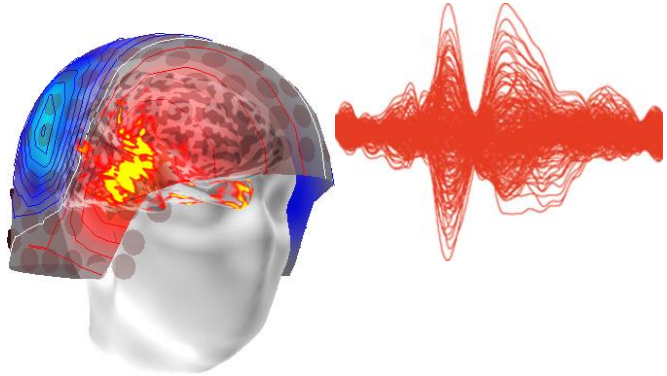

JÜLICH
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Investigating the spatio-temporal dynamics of neuromagnetic activity by using magnetoencephalography

Lukas Breuer[1,2]

[1]Institute of Neuroscience and Medicine (INM-4), Forschungszentrum Jülich, Germany
[2]Jülich Aachen Research Alliance (JARA) - Translational Brain Medicine, Jülich, Germany

http://www.fz-juelich.de/inm/inm-4

Content

(1) Properties of MEG

(2) System properties

(3) Signal generation

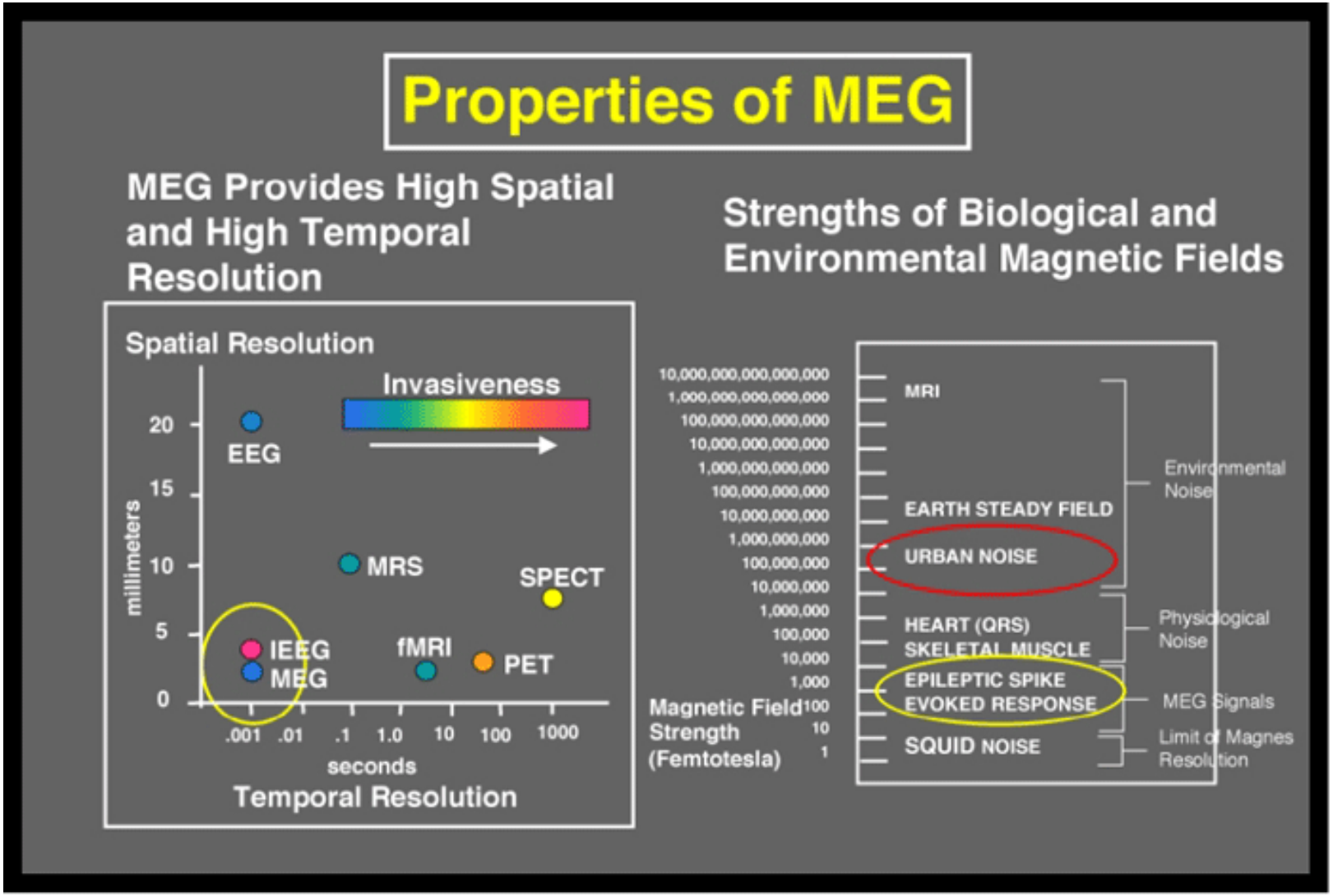
(4) Analysis of MEG signals

(5) Projects in Jülich

"What is MEG?"

"Applications & key technologies"

Properties of MEG



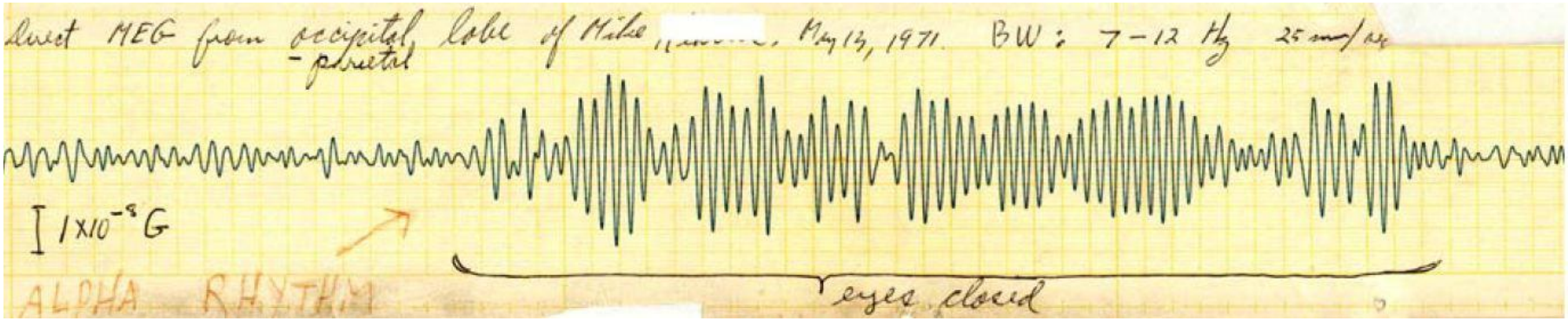
The early days

David Cohen

Martinos Center for Biomedical Imaging

First MCG in 1969

First MEG in 1971



MEG @ Jülich

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248 magnetometer whole-head MEG system (4D-Neuroimaging)

MEG @ Jülich

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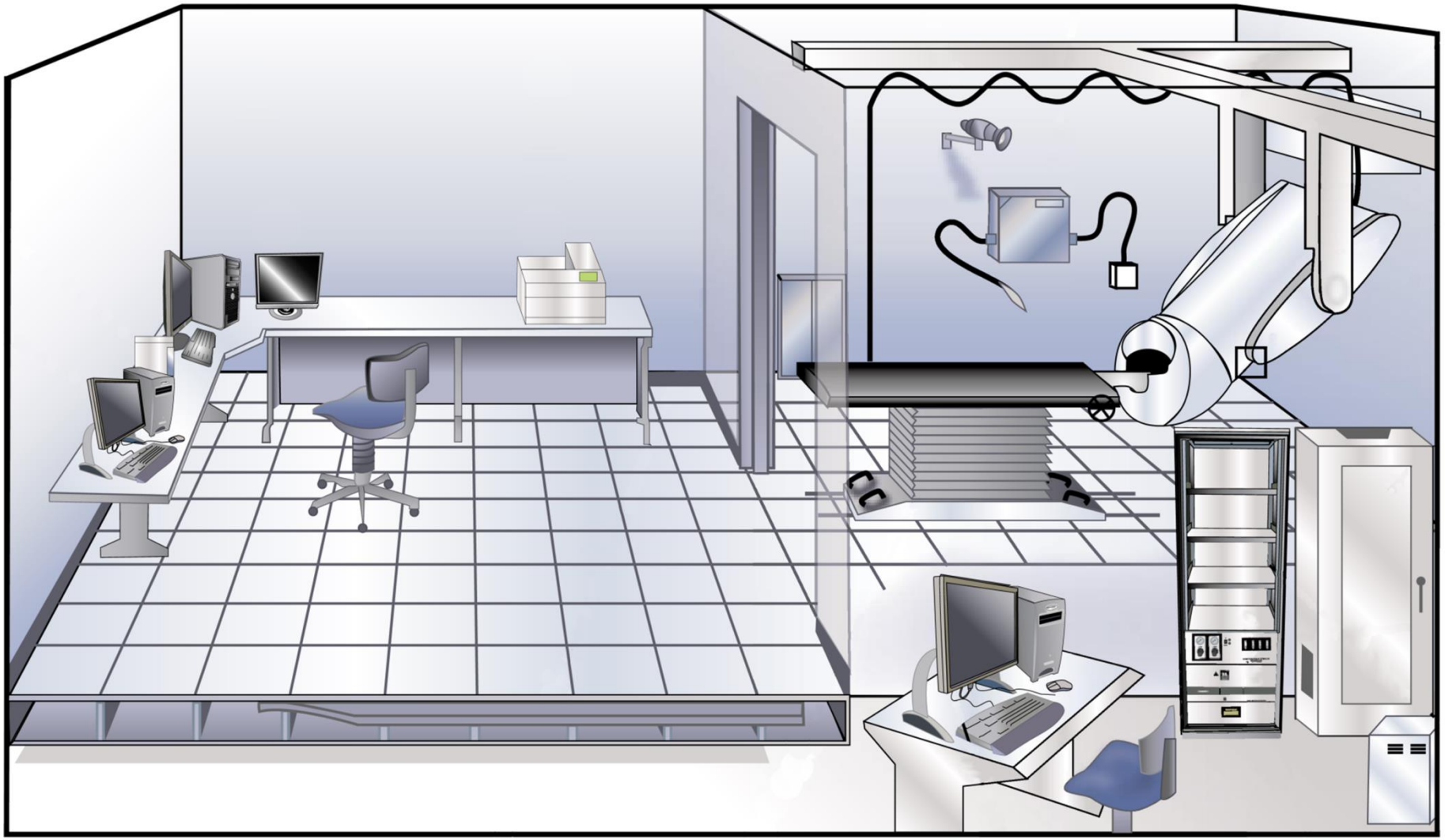
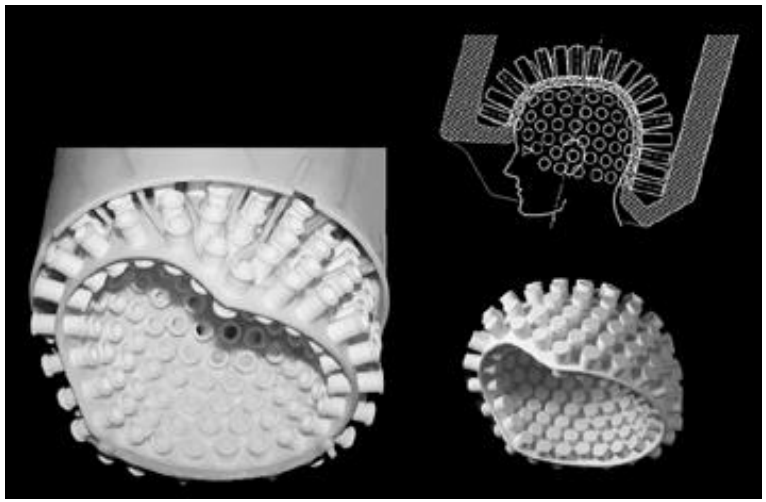
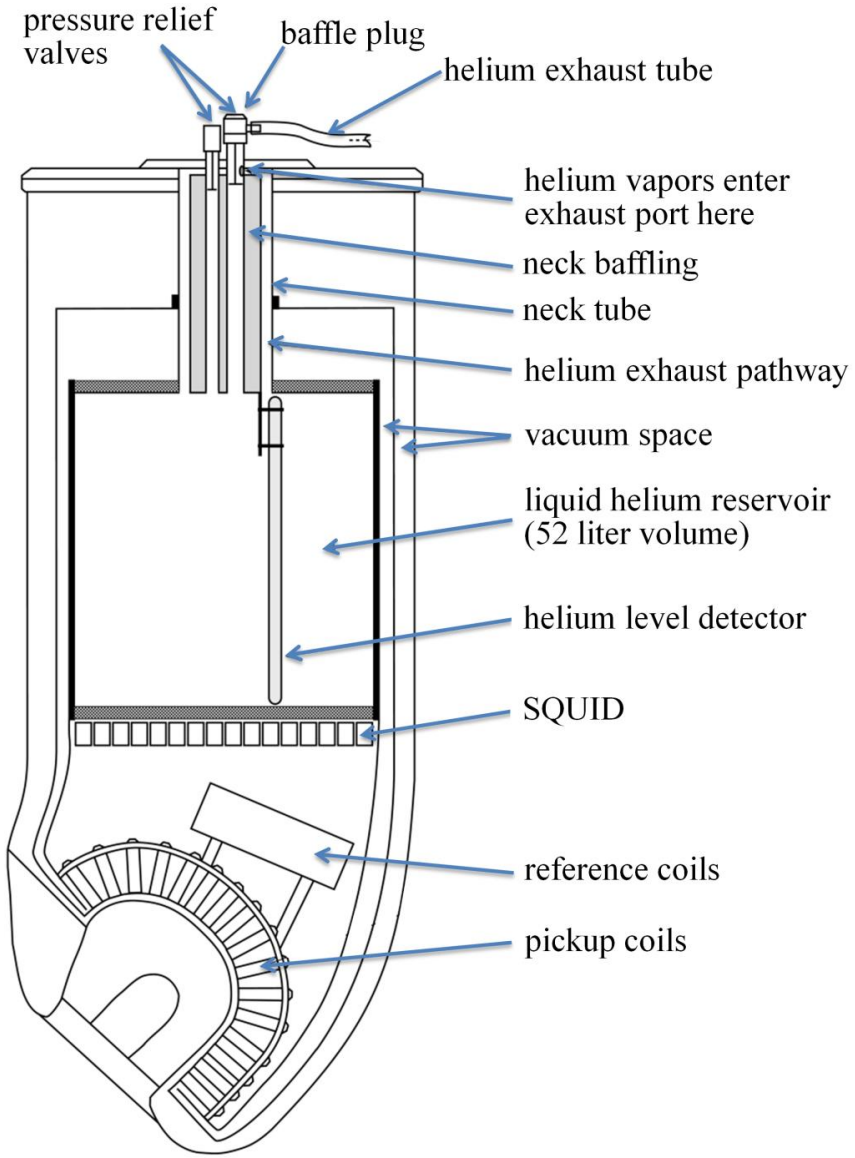


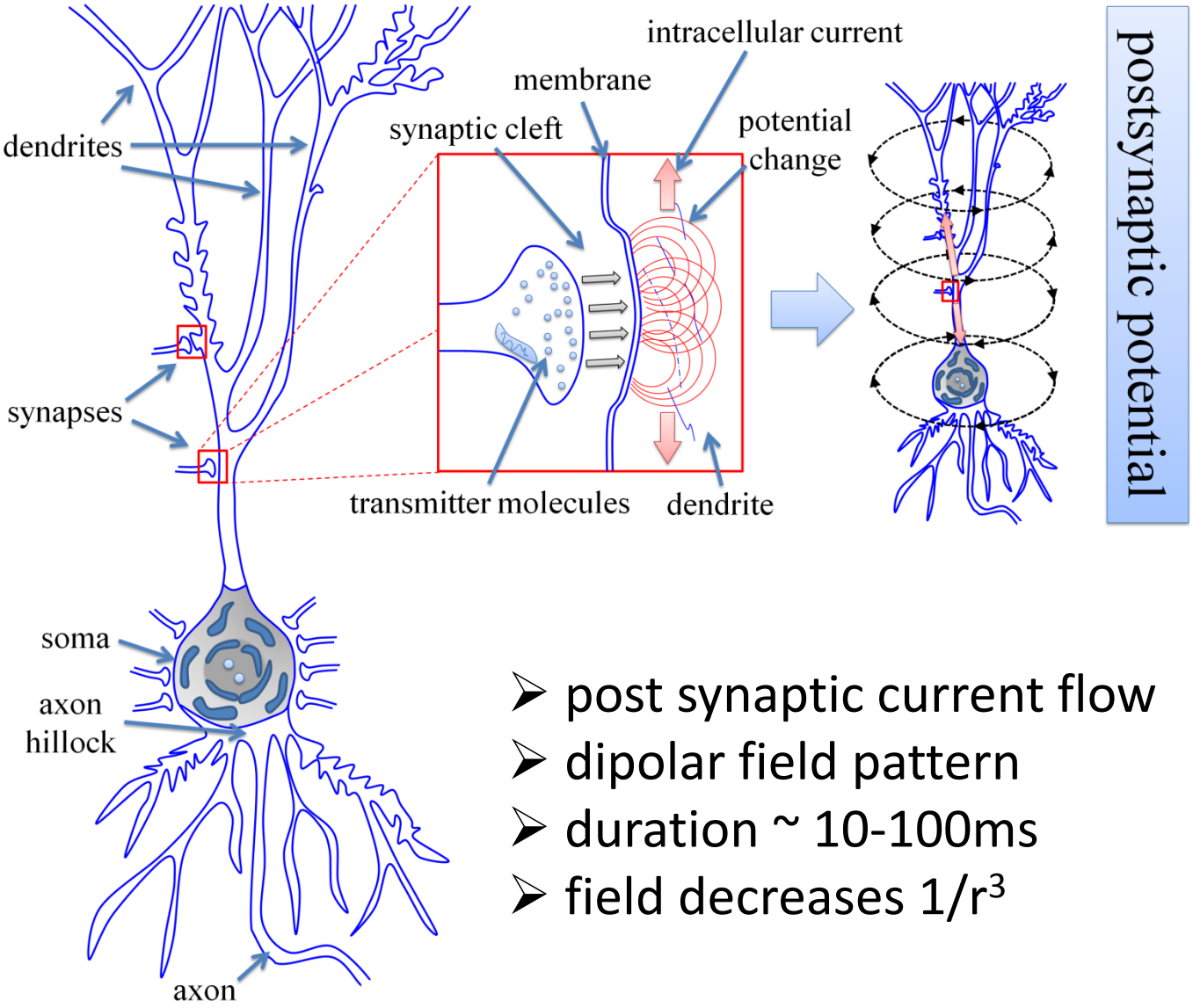
System properties



- non- invasive
- non-contact
- 248 high-sensitive detectors
- time resolution ms

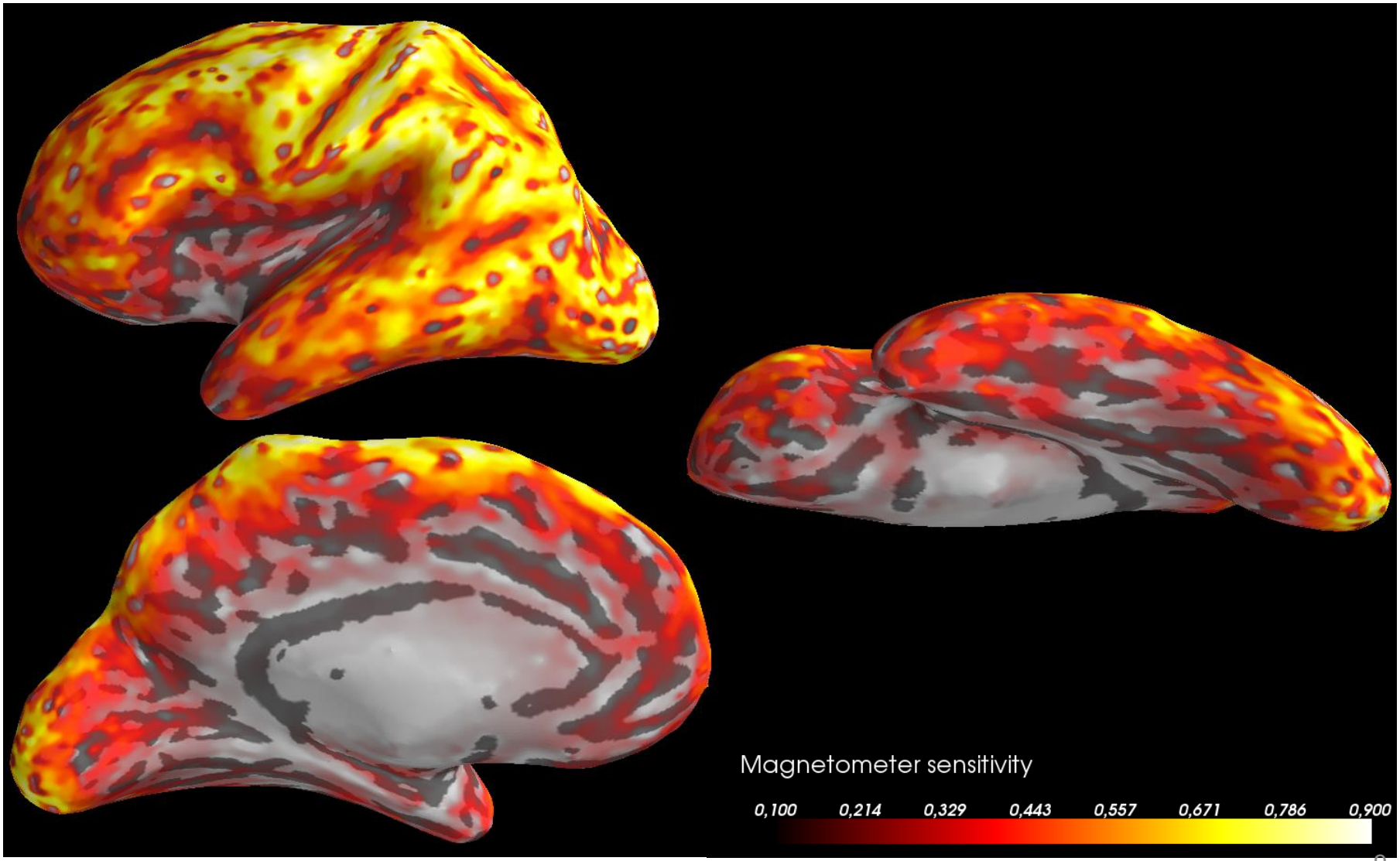


Signal generation



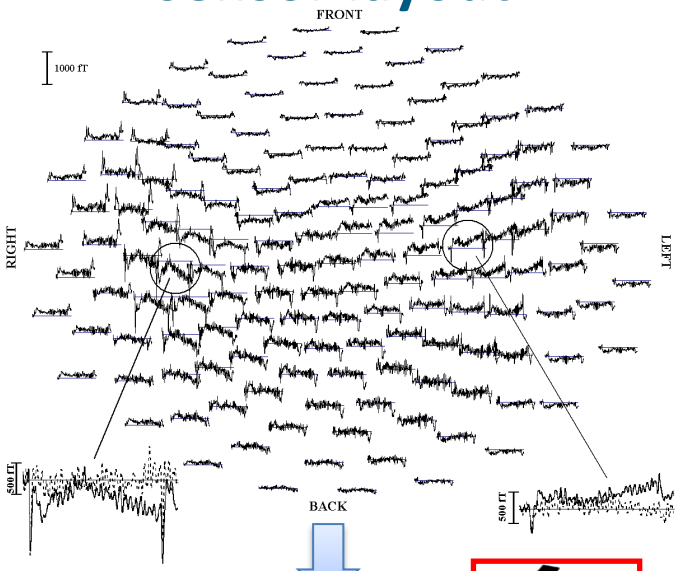
- post synaptic current flow
- dipolar field pattern
- duration ~ 10-100ms
- field decreases $1/r^3$

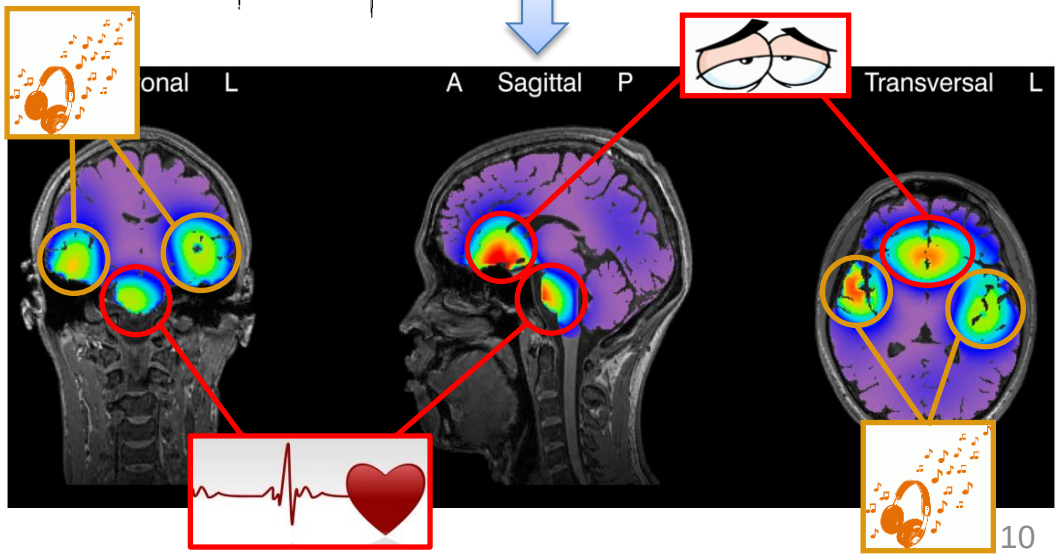
Sensitivity map



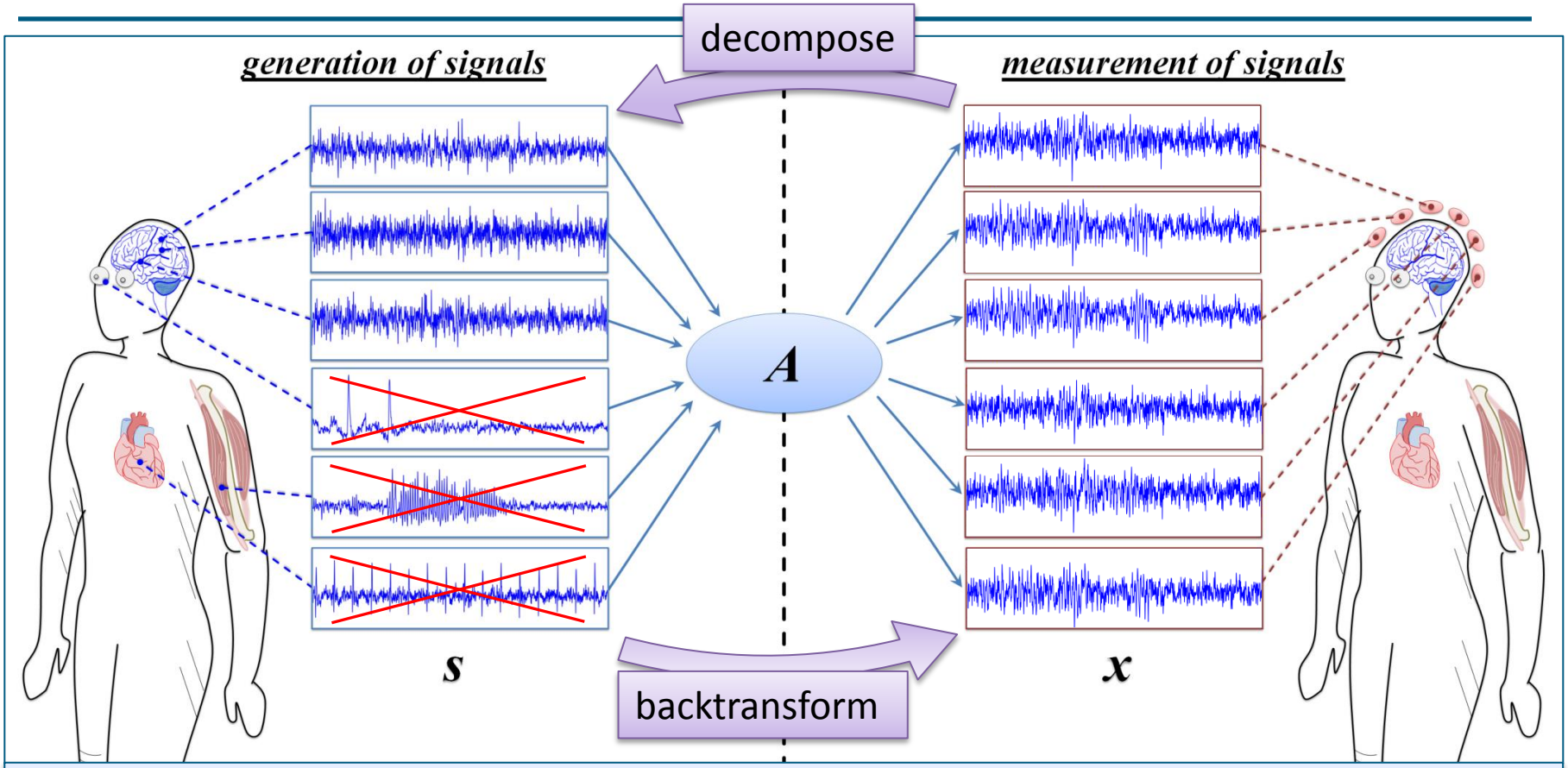
Artifact rejection

sensor layout





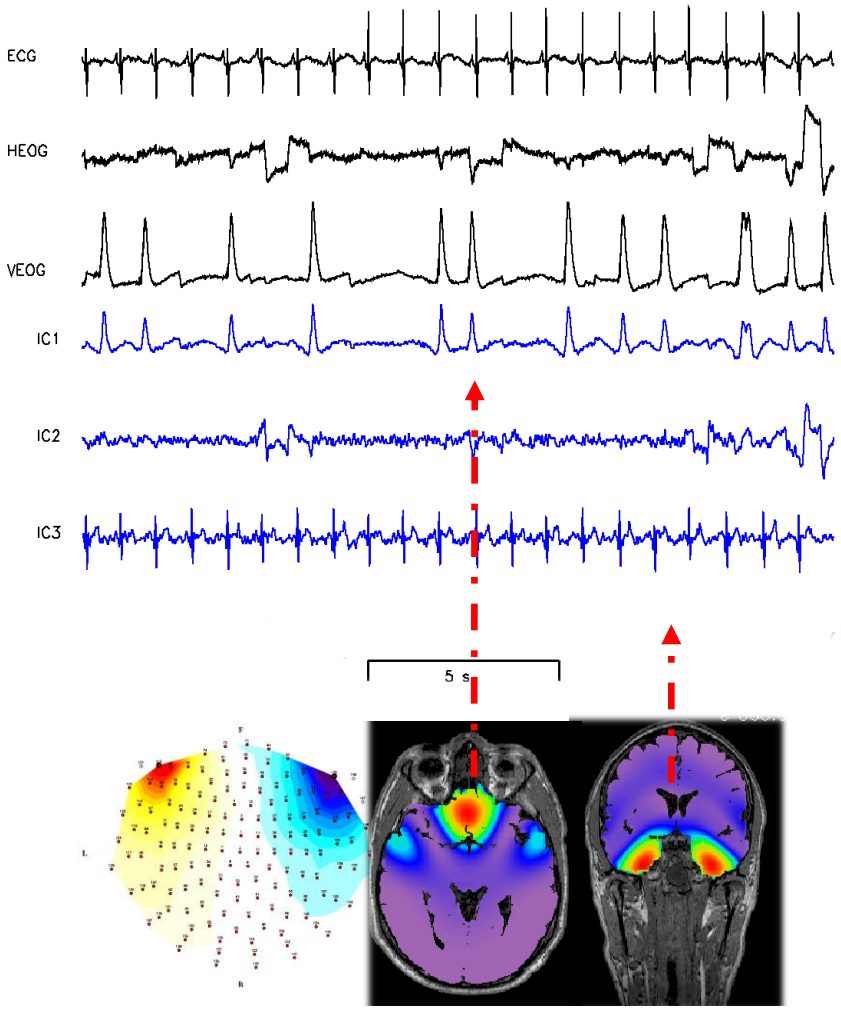
Artifact rejection

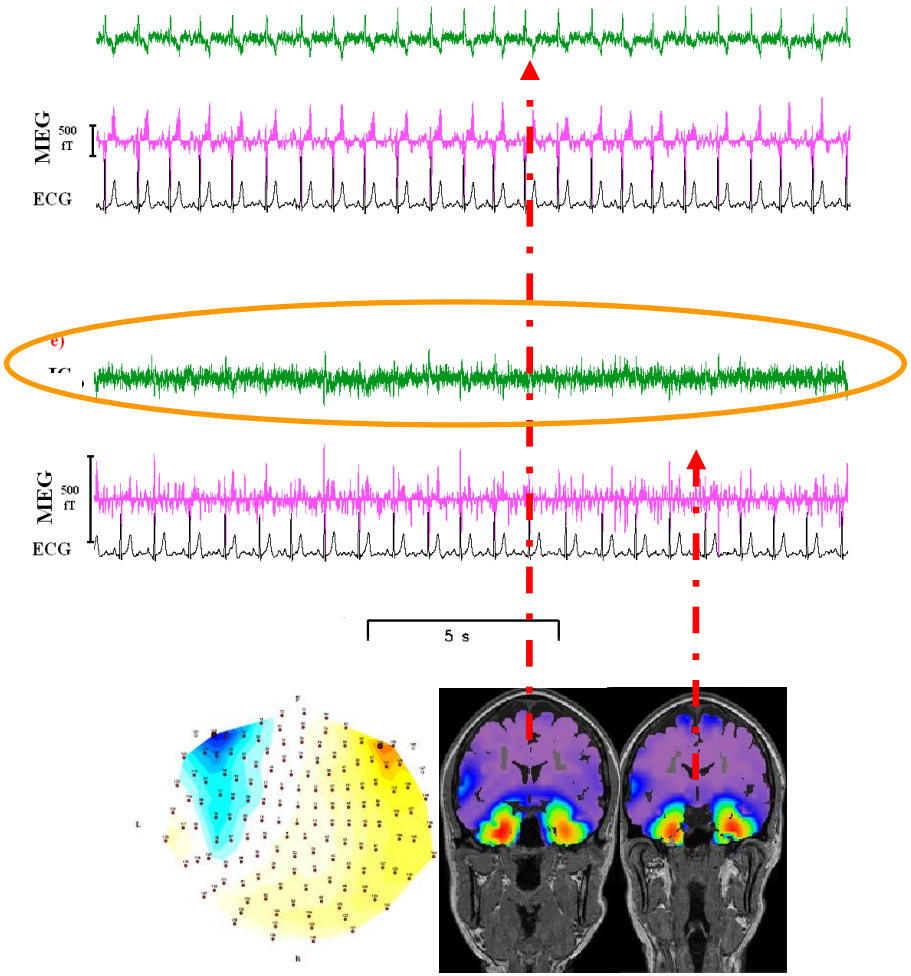


Independent Component Analysis (ICA):

- linear mixture: $x = A \cdot s$
- **goal**: find a linear transformation $W \approx A^{-1}$ that makes the output as independent as possible: $s = W \cdot x$
- *"different physical processes generate outputs that are independent of each other"*

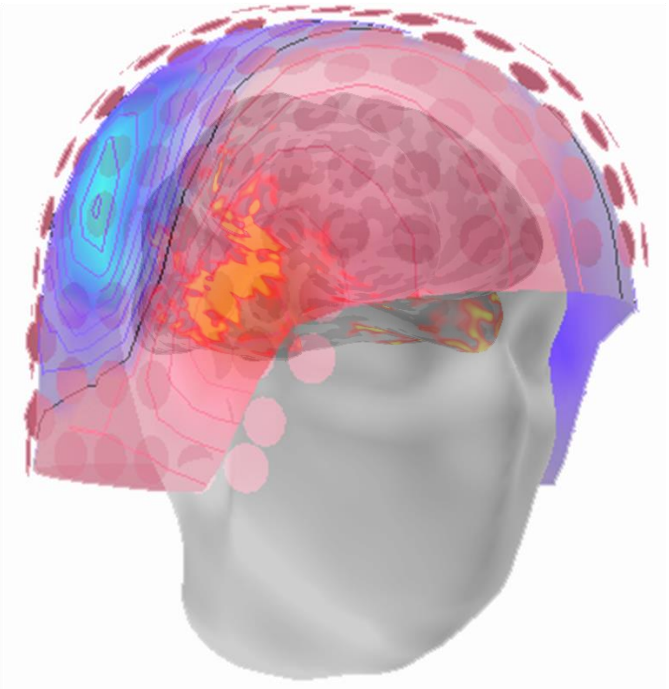
Artifact rejection



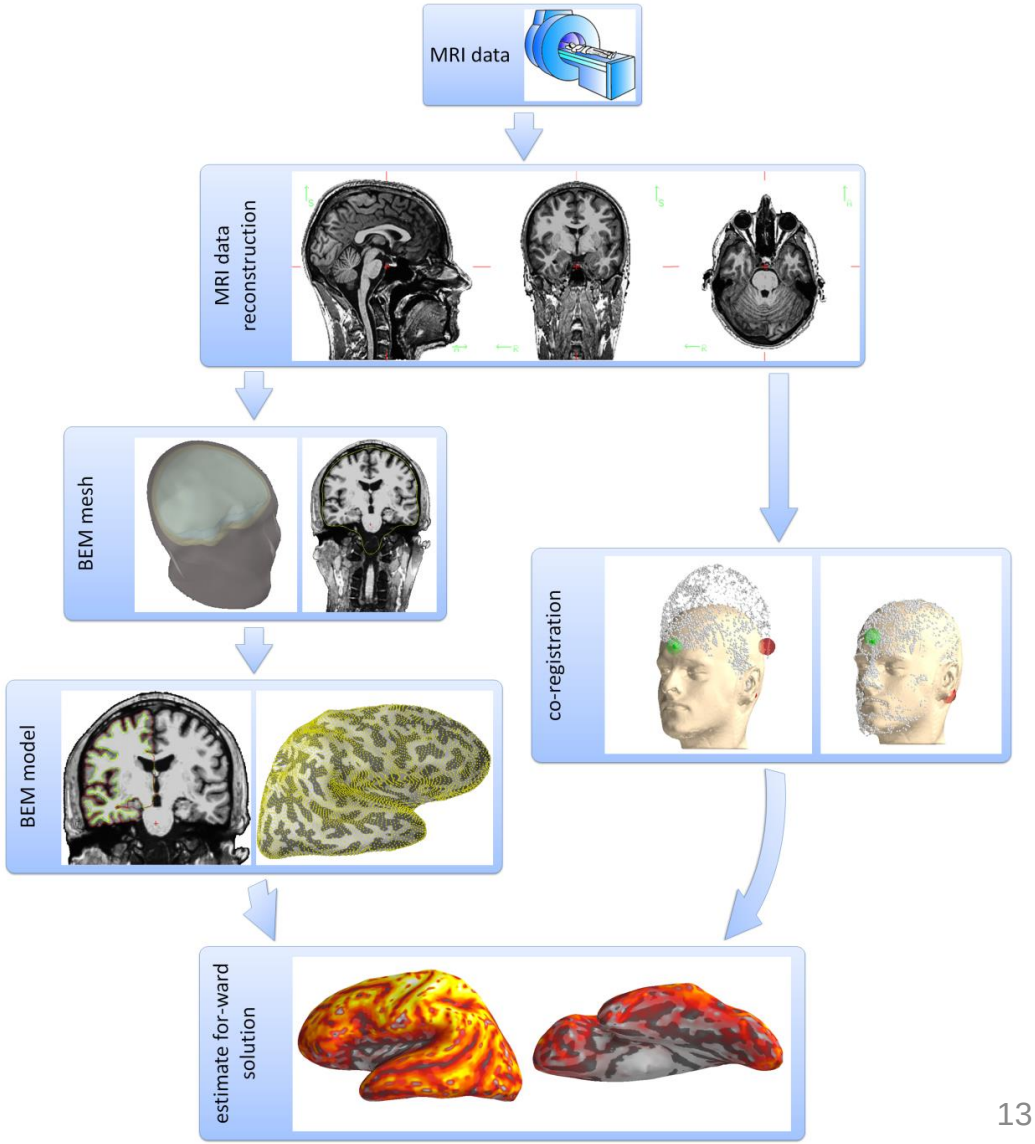


Dammers et al. (2008), *IEEE*

Source localization

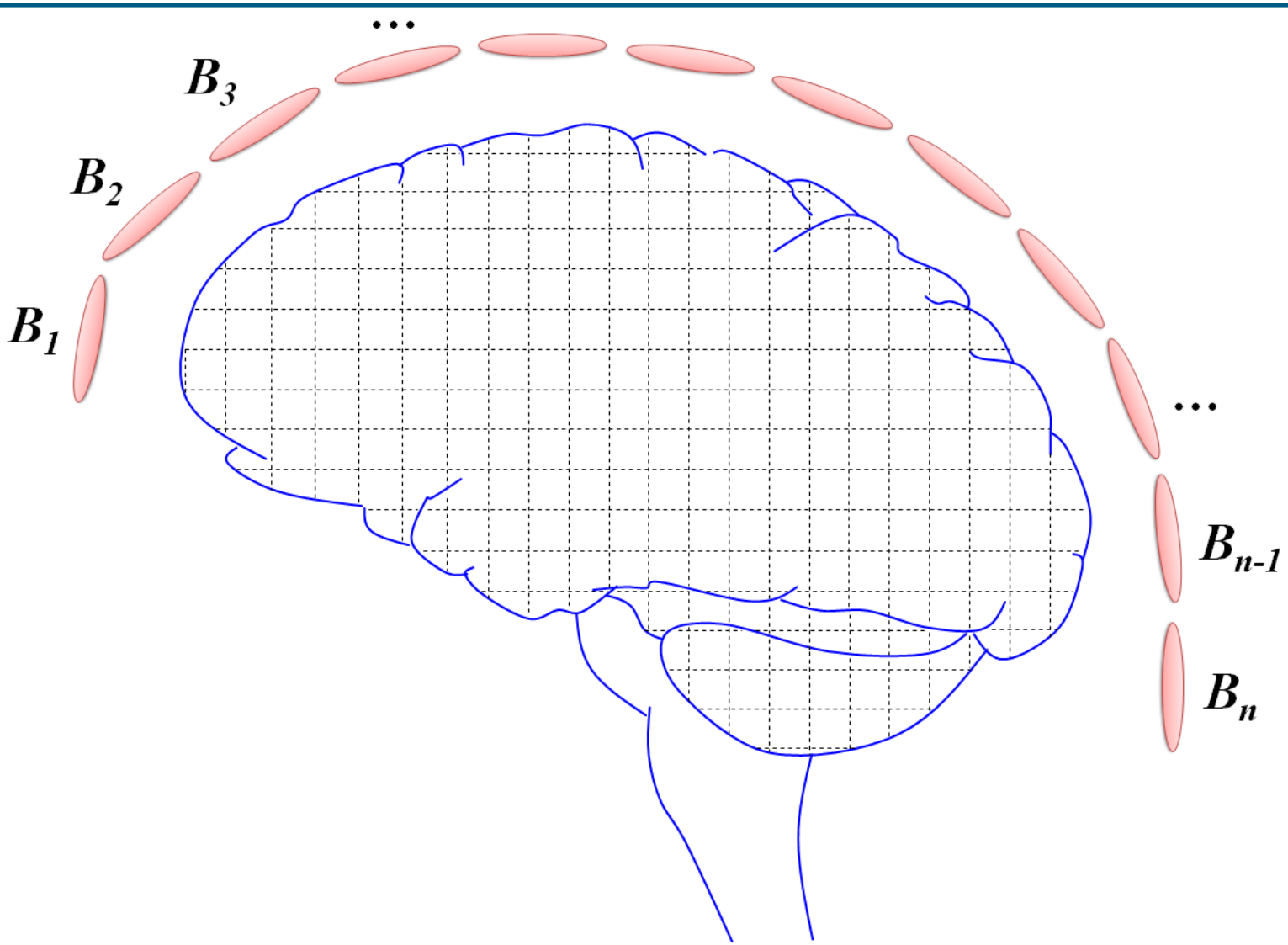


Gramfort et al. (2014), *NeuroImage*

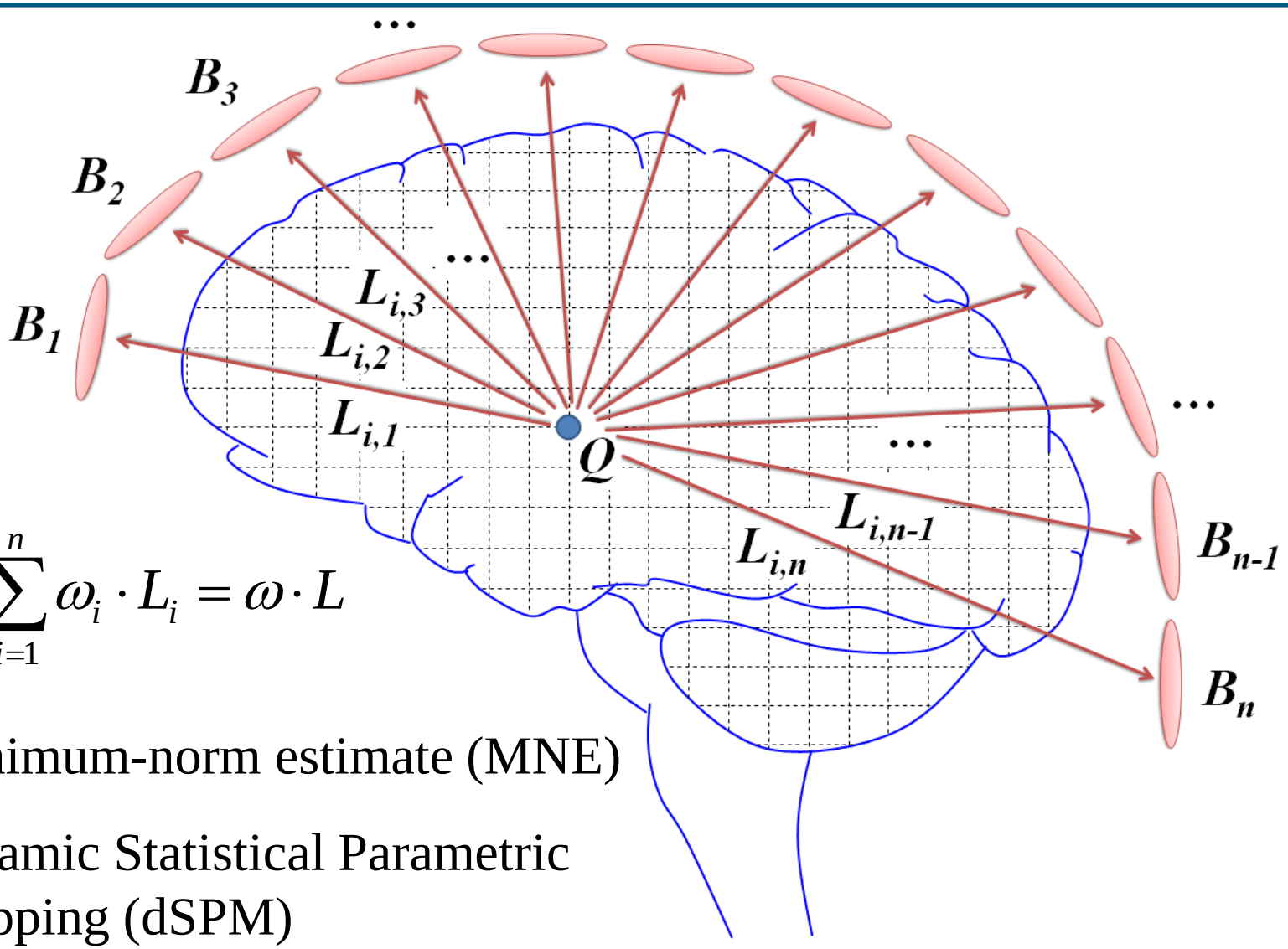


- **Inverse Problem**

Source localization



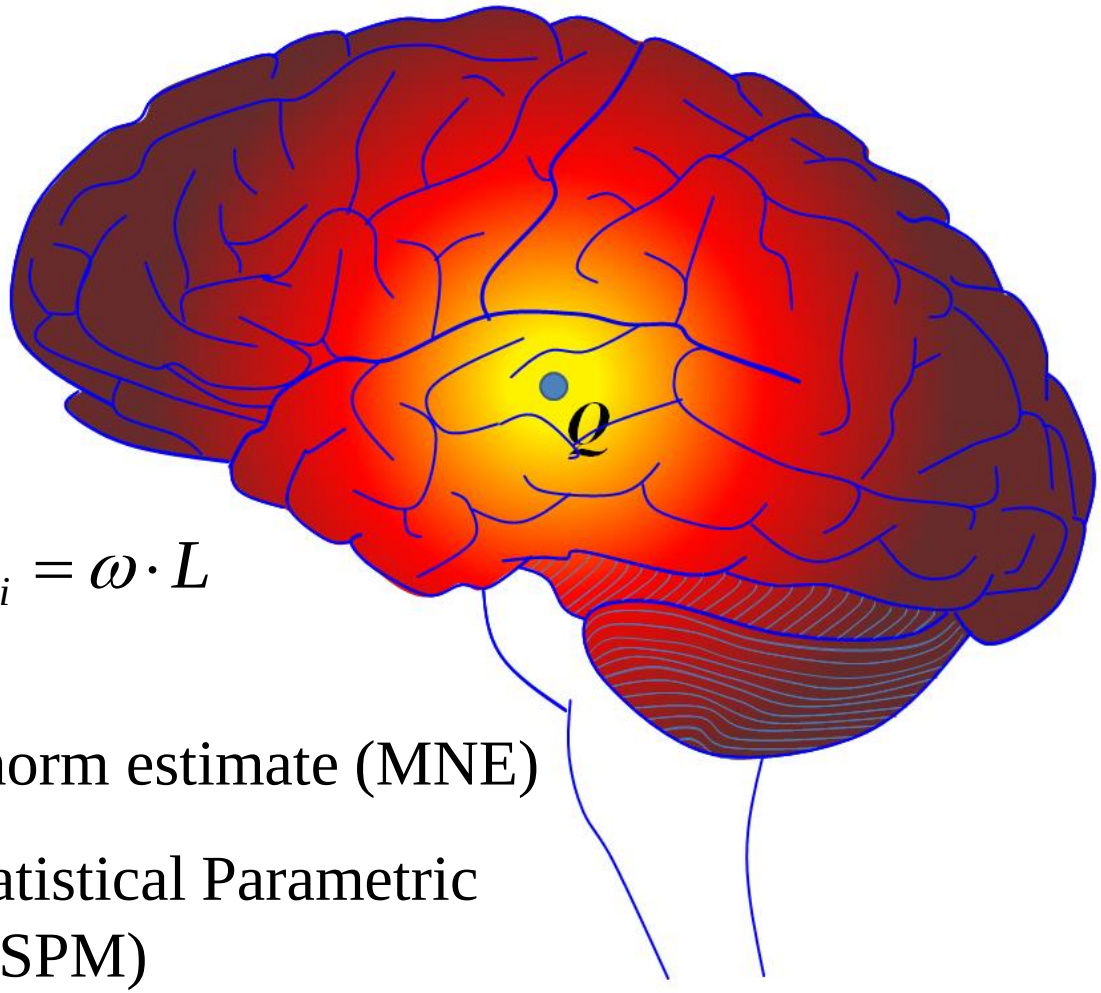
Source localization



$$J = \sum_{i=1}^{n} \omega_i \cdot L_i = \omega \cdot L$$

- Minimum-norm estimate (MNE)
- dynamic Statistical Parametric Mapping (dSPM)

Source localization

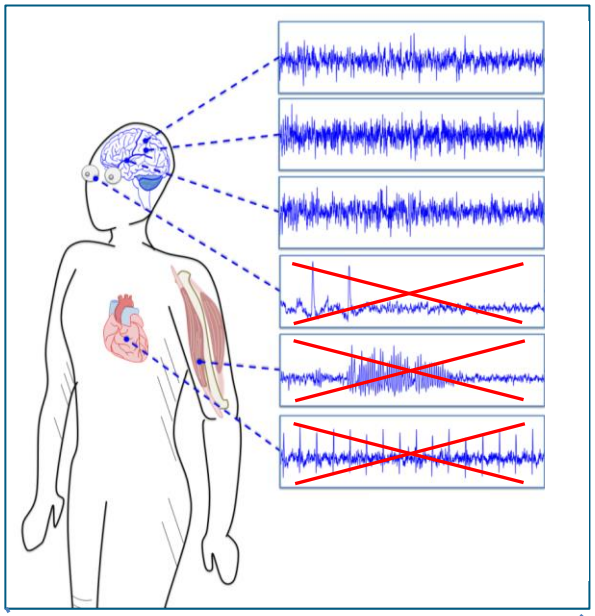


$$J = \sum_{i=1}^{n} \omega_i \cdot L_i = \omega \cdot L$$

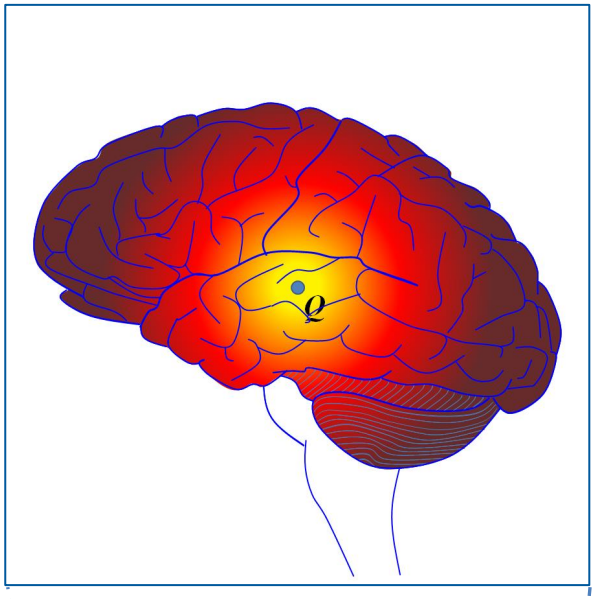
- Minimum-norm estimate (MNE)
- dynamic Statistical Parametric Mapping (dSPM)

Summary preprocessing

filtering



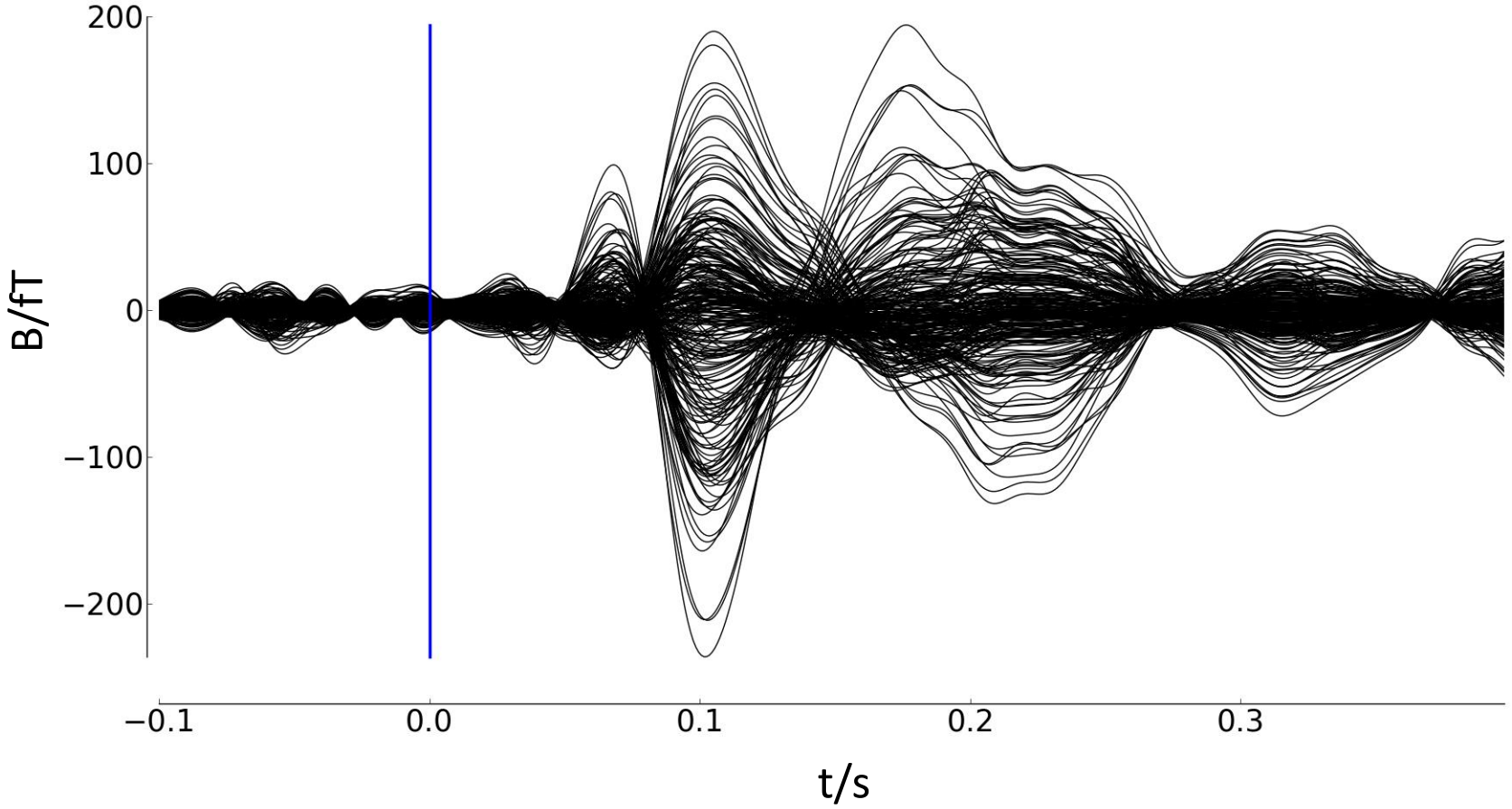
signal cleaning



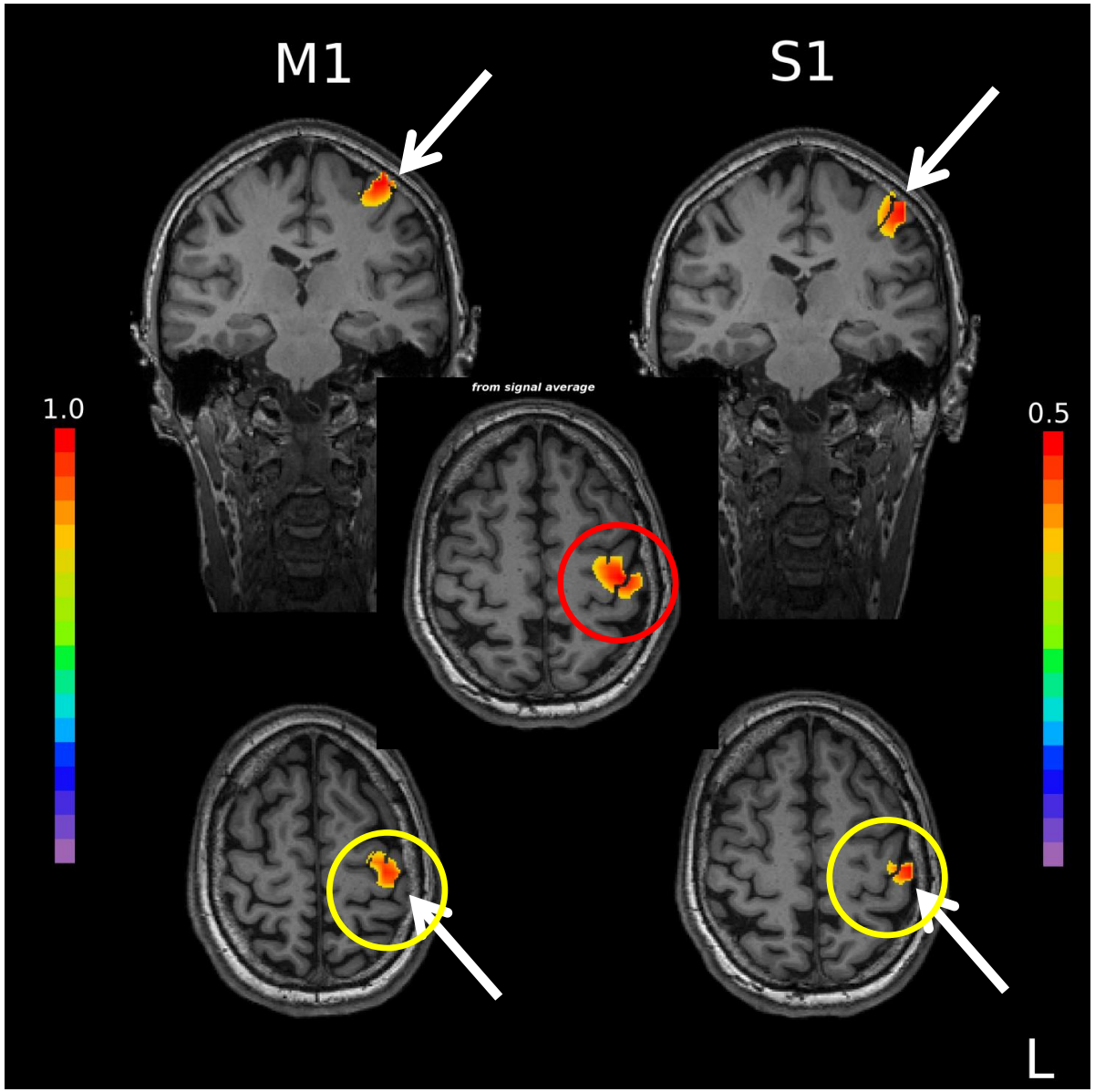
source localization

Results

Auditory cued finger tapping



Results



Content

(1) *Properties of MEG*

(2) *System properties*

(3) *Signal generation*

(4) *Analysis of MEG signals*

(5) *Projects in Jülich*

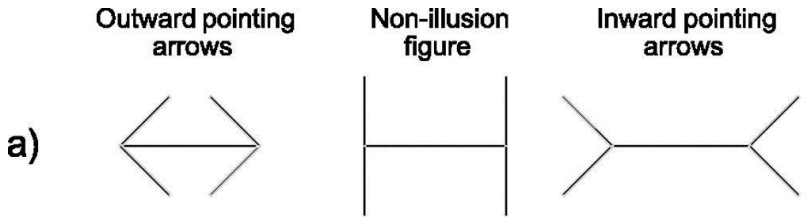
"What is MEG?"

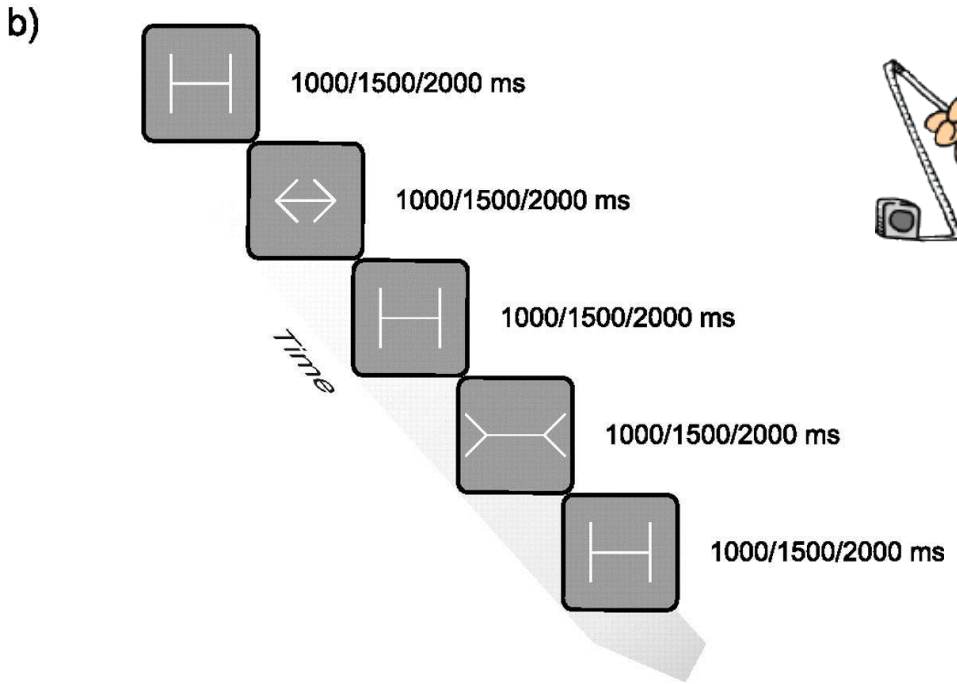
- high-temporal resolution
- good to moderate spatial resolution
- completely non-invasive

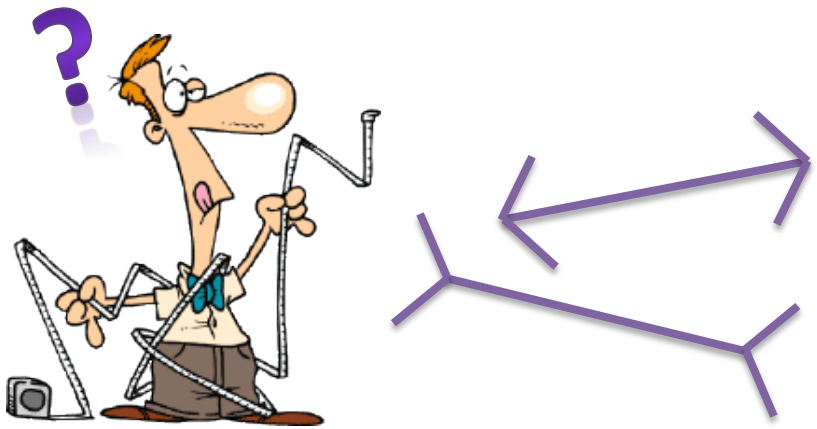
"Applications & key technologies"

APPLICATIONS

(a) Müller-Lyer figures used in the experiment.

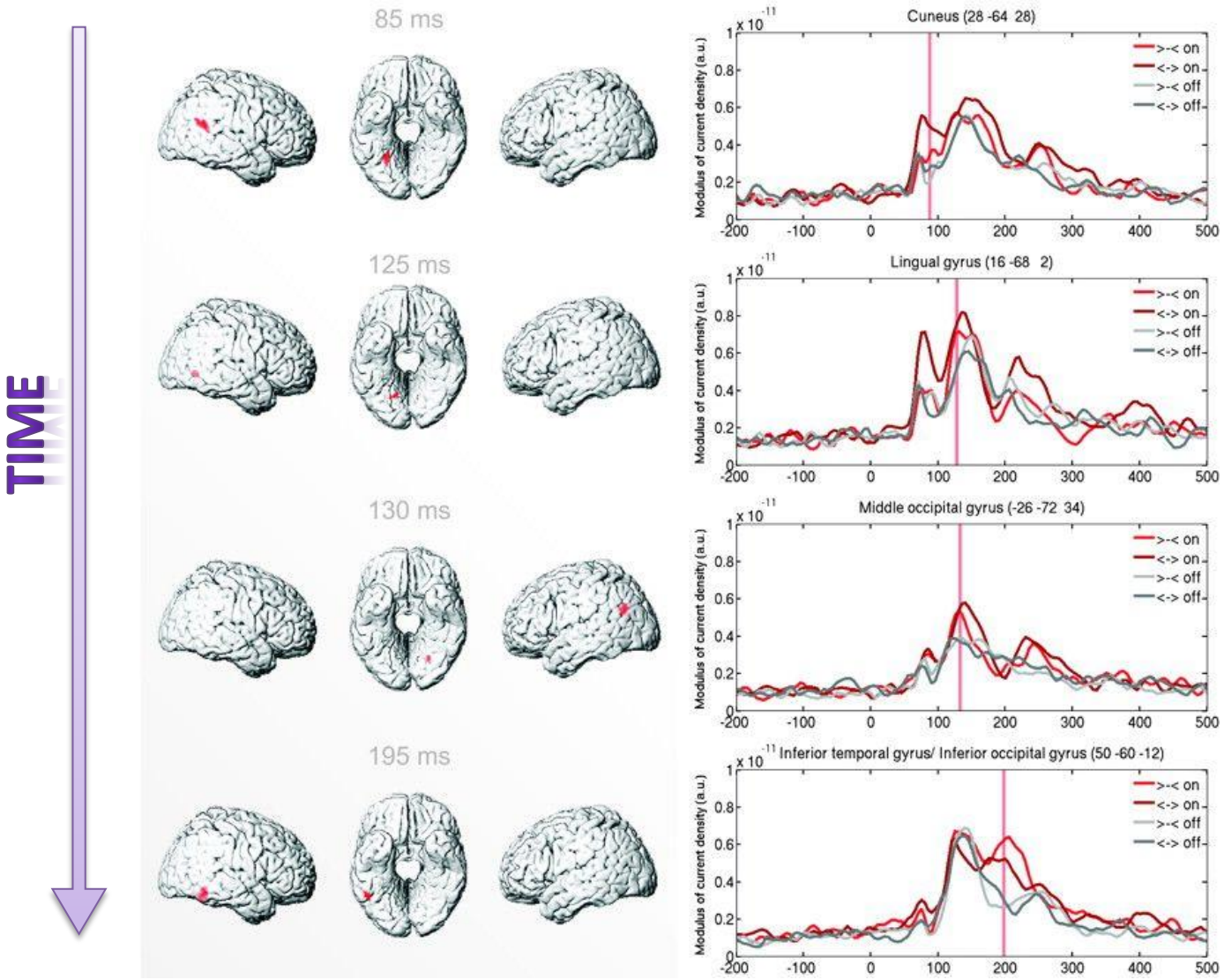






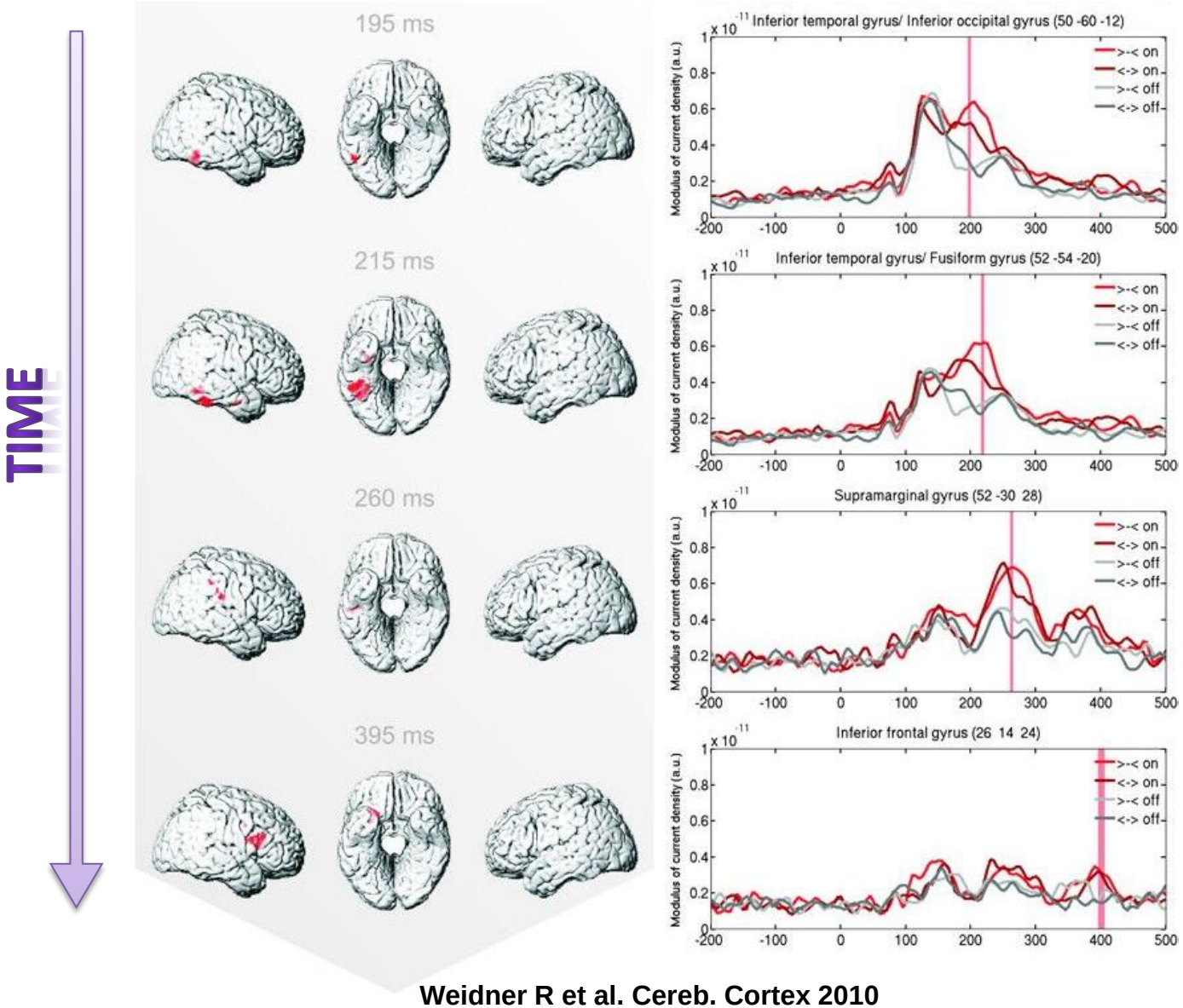
Weidner R et al. Cereb. Cortex 2010

APPLICATIONS



Weidner R et al. Cereb. Cortex 2010

APPLICATIONS



Weidner R et al. Cereb. Cortex 2010

CTPS BASED CAUSALITY ANALYSIS

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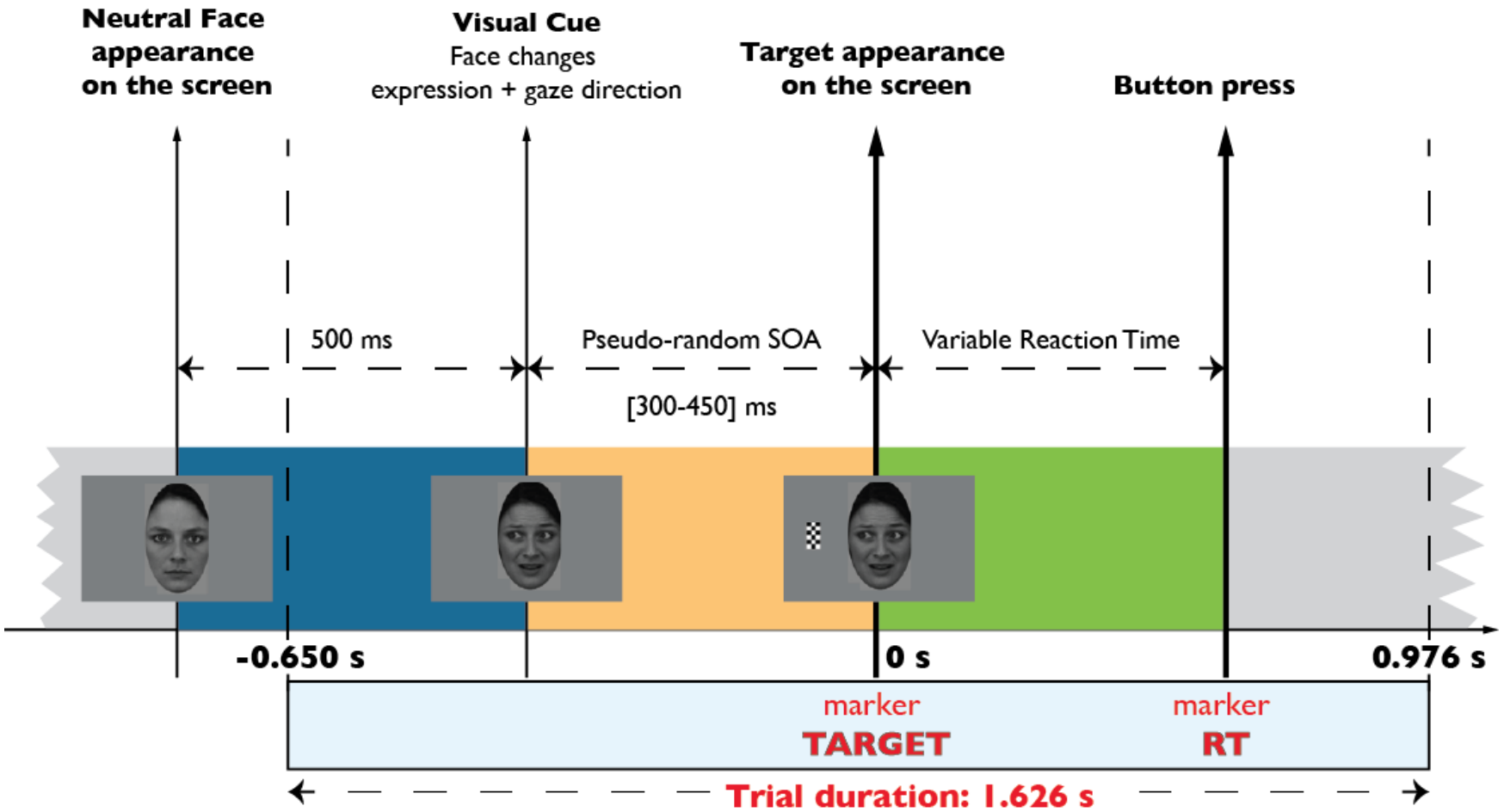
Application to a gaze cueing MEG study

Processing of target presentation in a gaze cuing paradigm



Lachat et al., *PLoS One*, 2012

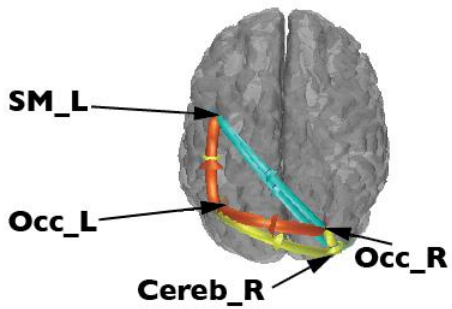
CTPS BASED CAUSALITY ANALYSIS

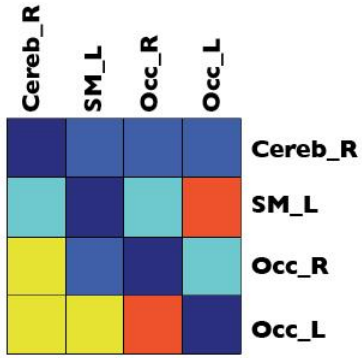
JÜLICH FORSCHUNGSZENTRUM

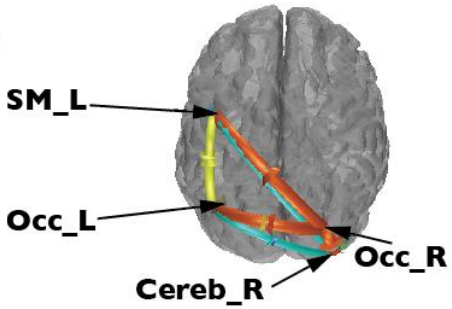
Theta band
3 – 7 Hz

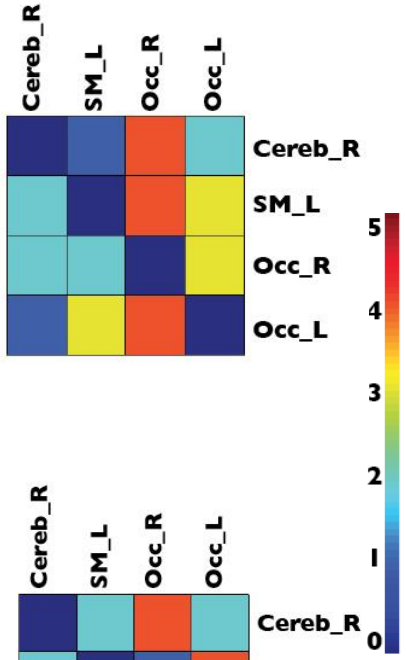
Alpha band
8 – 12 Hz

Target

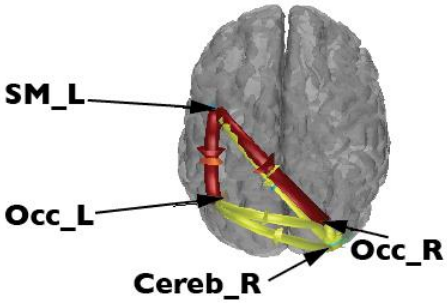


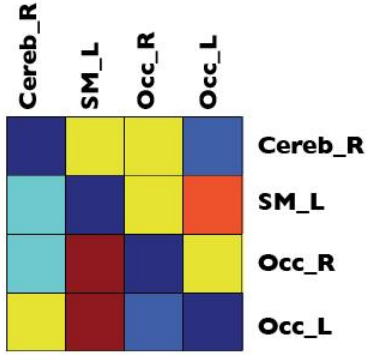


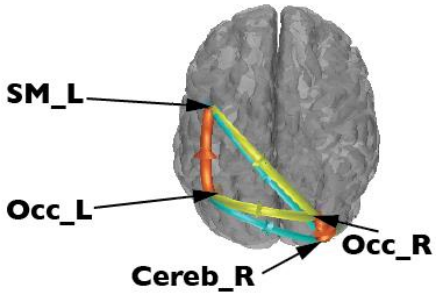




RT





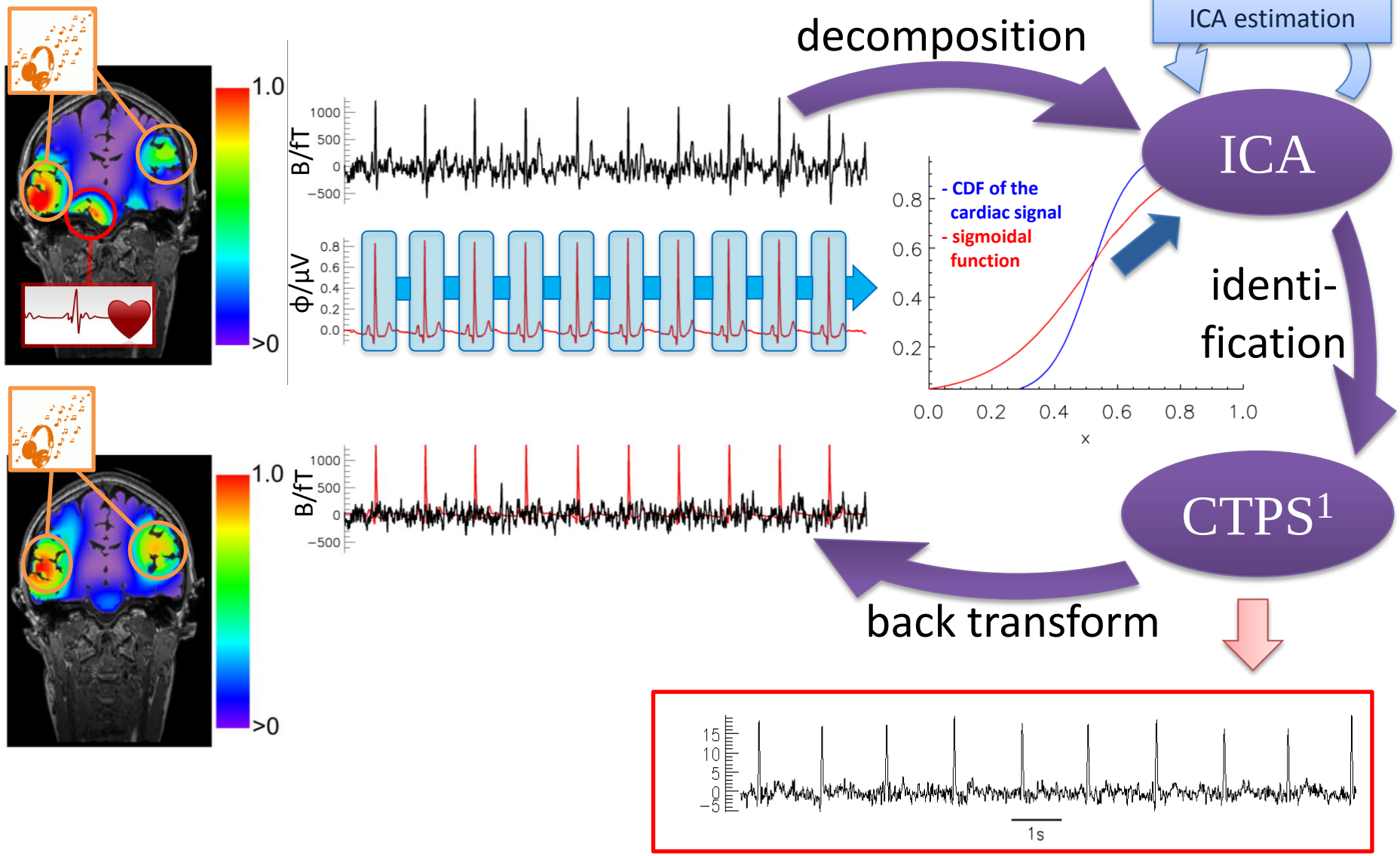


Dammers & Fasoula et al., *NeuroImage*, under review

MEG 2.0

- REAL-TIME MEG
- HIGH-Tc SQUID for MEG

REAL-TIME MEG



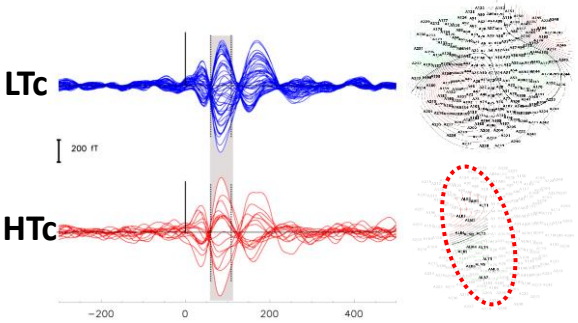
[1]Dammers et al. (2008), *IEEE* Breuer, Dammers, … , Shah (2014), *IEEE*

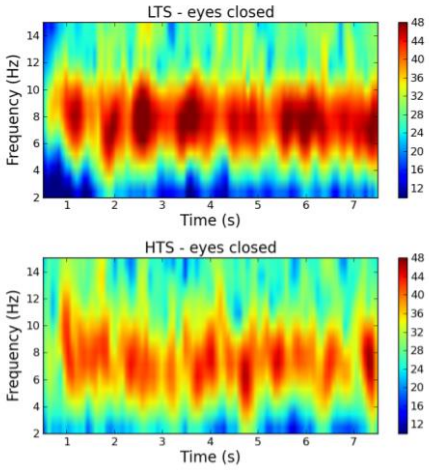
HIGH-Tc SQUID for MEG

Liquid nitrogen

- (almost) unlimited availability
- inexpensive
- easy handling
- long time between refills

Averaged auditory signals (300 trials)





Can we reproduce results of the low-Tc system?

- MEG signals ✓
- time-frequency ✓
- source localization ✓

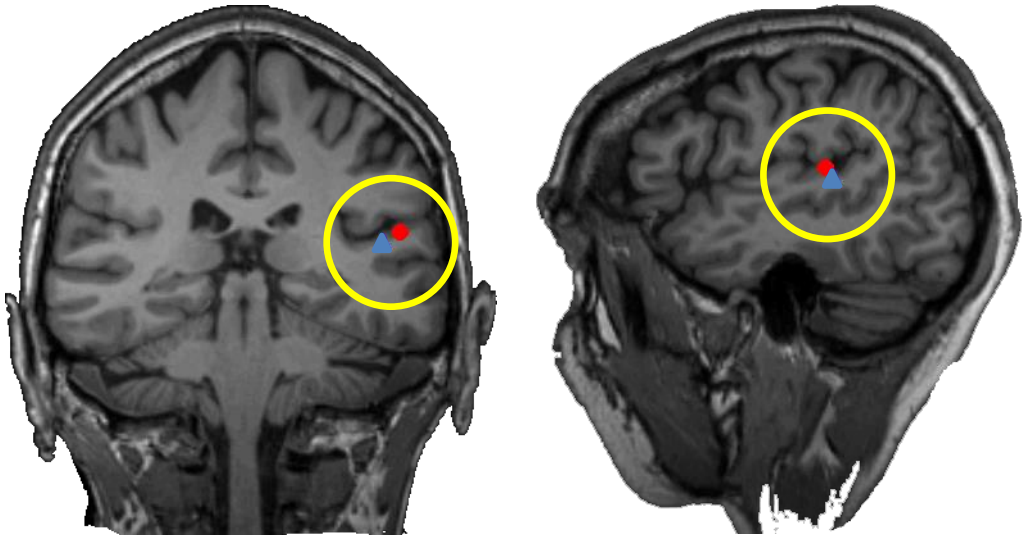
Displacement

⇨ **7.1 mm**

[mm]	X	Y	Z
LTc	-2.0	54.9	618
HTc	-4.4	57.4	55.6
Distance	2.4	-2.5	6.2

▲ LTc

● HTc



Dammers, … , Shah (2014), *Applied Phys. Let.*

Summary

Magnetoenzephalographie (MEG)

… to take away …

studying the temporal dynamics of neuromagnetic activity with…

- ***high temporal resolution***
- ***good to moderate spatial resolution***
- ***completely non-invasive***

Many Thanks for your Attention!

INM-4

- N. Jon Shah
- Jürgen Dammers
- Frank Boers
- Harald Chocholacs
- Qunxi Dong
- Eberhard Eich
- Andrea Muren
- Praveen Sripad
- Nadine Rosen

Children‘s Hospital of Philadelphia

- Timothy P.L. Roberts
- John W. Dell
- J. Chris Edgar
- Rachel L. Golembski
- Peter V. Lam