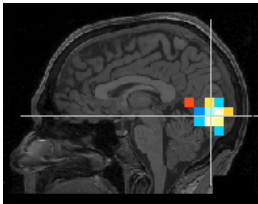
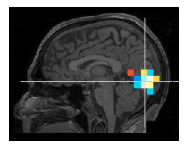


Introduction to beamforming using MNE-Python

Britta Westner, Chris Bailey, Sarang Dalal

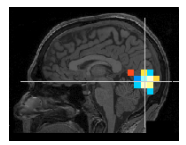
CFIN, December 11, 2017



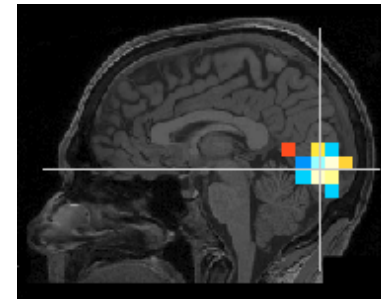
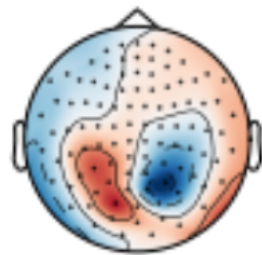


- What is source localization?
- Source reconstruction techniques
- What is a beamformer?
- Beamformer vs MNE
- How does it work?
- What is a forward model?
- Beamforming pipeline
- Hands-on session
- Discussion, open questions, etc

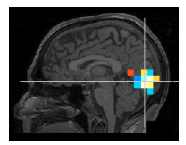
What is source reconstruction?



We want to estimate the source activity underlying our sensor-level measurements.



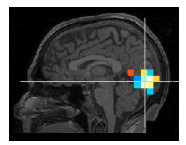
This is an ill-posed problem. We need tricks.



There are different algorithms that solve this ill-posed problem by making different *assumptions*:

- Dipole fitting (single and distributed dipole models)
- Minimum norm estimation
- Spatial filters = beamformers

What is a beamformer?

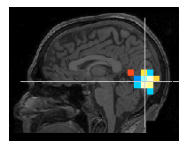


Beamformers are spatial filters.

The spatial filter (weights) describes the relationship between sensor- and source-space.

Different beamformer types:

- Linearly Constrained Minimum Variance beamformer - **LCMV**
time-domain
- Dynamical Imaging of Coherent Sources - **DICS**
frequency domain

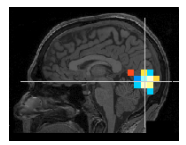


Minimum norm estimation

- assume activity everywhere
- estimate activity distribution across the brain (cortical sheet)

Beamforming

- assume that sources are uncorrelated
- estimate source activity at a given point



Beamformer formulas:

$$W = \frac{L^T C^{-1}}{L^T C^{-1} L}$$

L = forward model

C = covariance matrix

What do we do with this “W”?

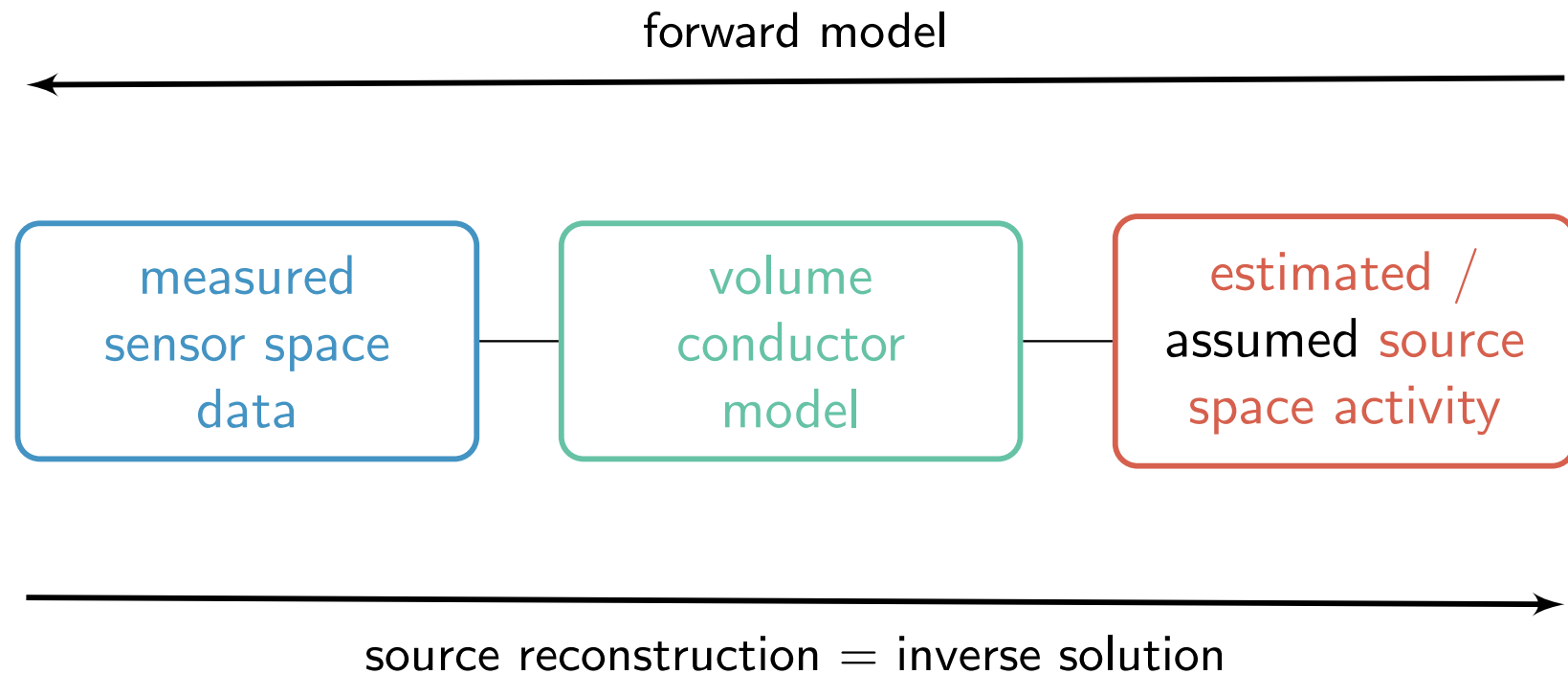
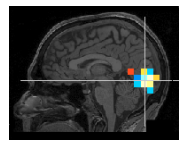
W = weights / spatial filter

$$\hat{s} = Wm$$

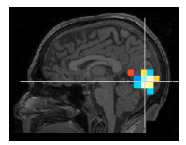
\hat{s} = estimated source activity

m = measured activity (sensor space)

How does it work? – Forward and inverse models

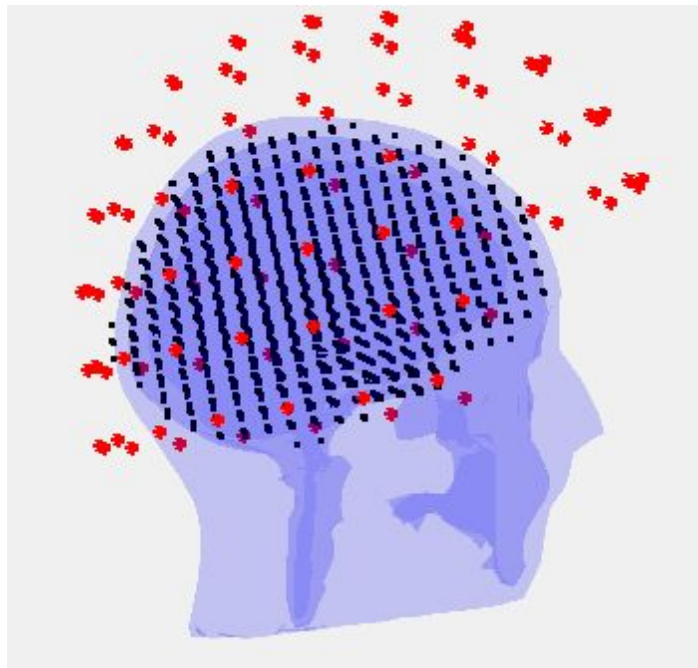


What is a forward model?



Synonyms: *lead field*, *gain matrix*

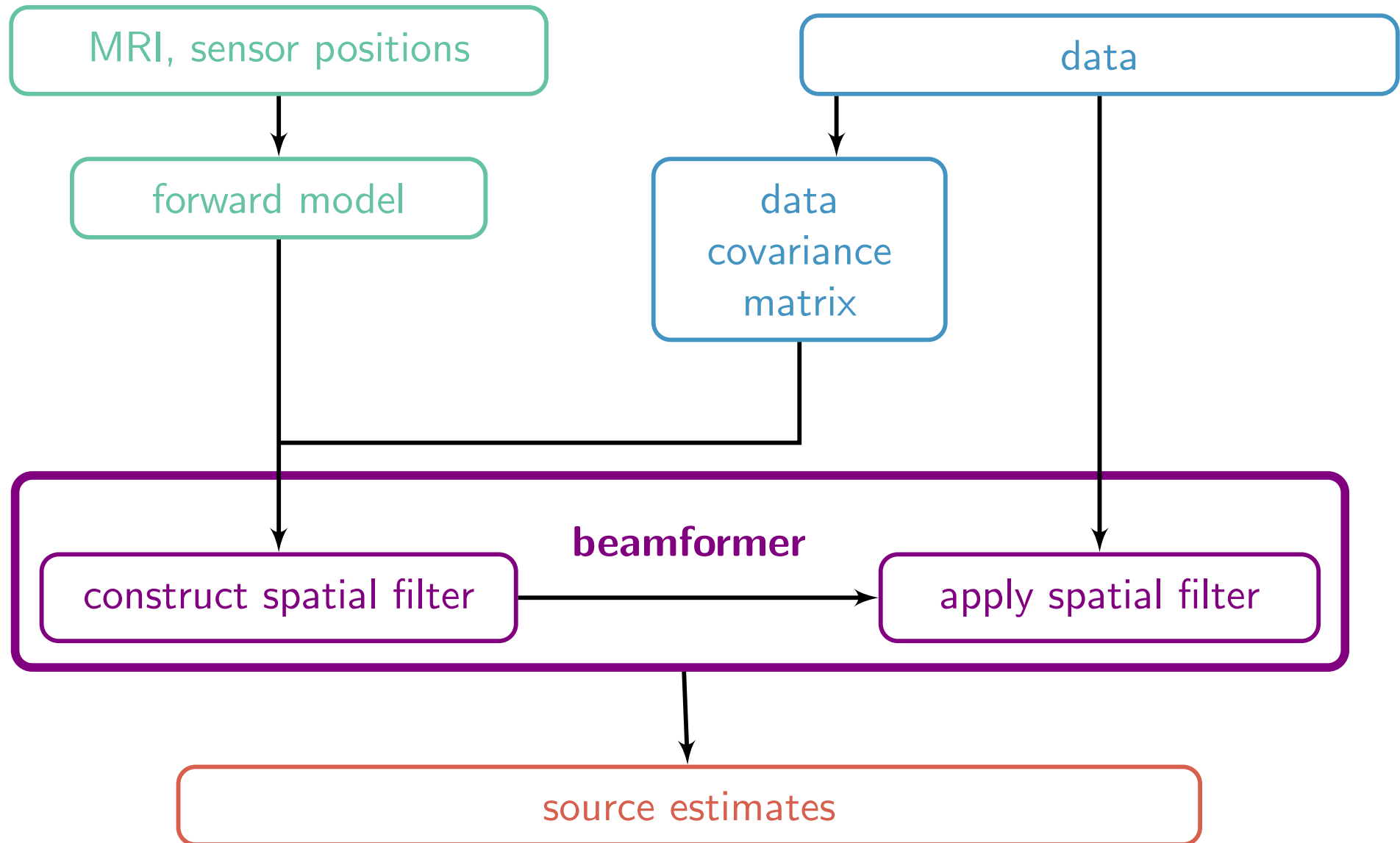
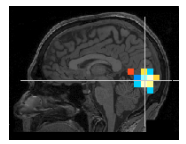
specifies the (mathematical) relations between given source points and the sensors.



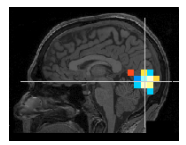
This needs information about:

- the sources
- the anatomical properties of the conductor
- the sensor positions

Beamforming pipeline



Let's try that on real data!



Hands-on session

Source-reconstructing brain activity following full-field flashes.