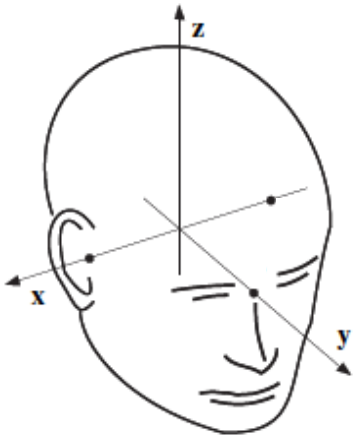
COORDINATE SYSTEMS MATCH

HEAD COORDINATE SYSTEM (HCS)



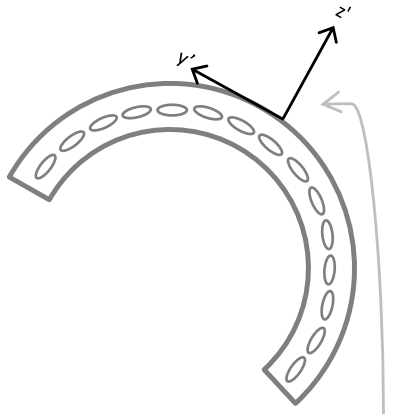
HPI COILS FIT PROCEDURE

- *Preparation*: define HPI coils position relative to HCS
- *Before each run*: current injection in HPI coils
- MEG detects HPI coils position relative to DCS
- Least squares fit find a suitable transformation

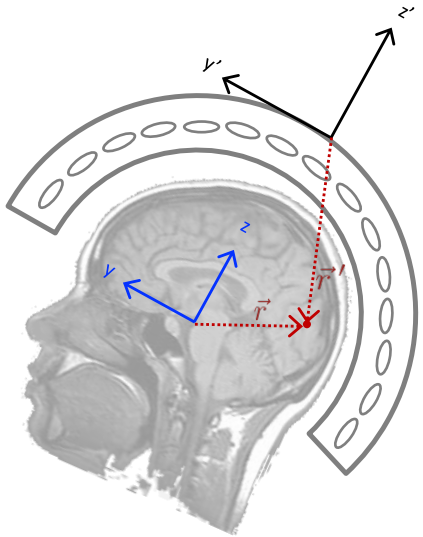
$$(R\,,\vec{T})$$

composed by a rotation matrix R and a traslation vector T

DEVICE COORDINATE SYSTEM (DCS)



Not here … just an example !

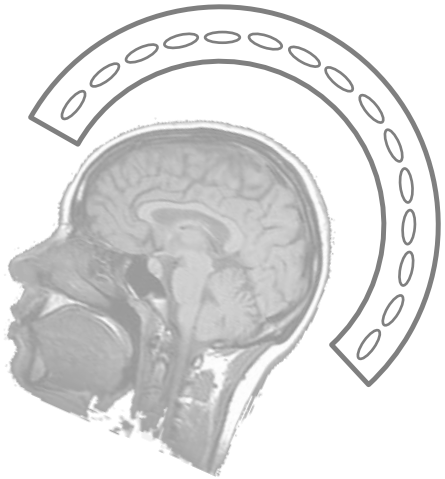


Any point in the brain can now be related also to sensors position

$$\vec{r} = R\,\vec{r}\,' + \vec{T}$$

Required for source reconstruction

HEAD POSITIONING PROBLEMS



NON OPTIMAL POSITIONING

Head too far from sensors

↓

Decrease in SNR of recorded brain activity

A sort of "optimal" position exists
(depends also on anatomy)

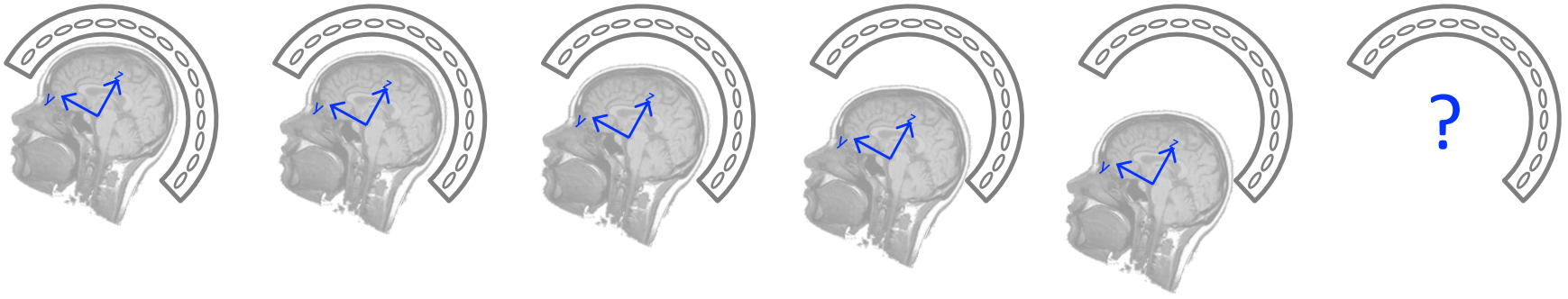
$(R\,,\vec{T})$ should be ideally close to:

$$\vec{T} = [0, 0, 40\,\mathrm{mm}]$$

$$R = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

HEAD MOVEMENTS

Subjects move during experiment → Different $(R\,,\vec{T})$ transformations are fitted accross runs → Unconsistency when concatenating data



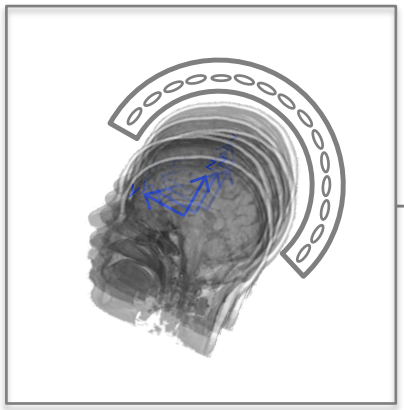
RUN #1 RUN #2 RUN #3 RUN #4 RUN #5 CONCATENATED

SOLUTIONS

IT IS IMPOSSIBLE TO COMPLETELY AVOID THIS PROBLEM

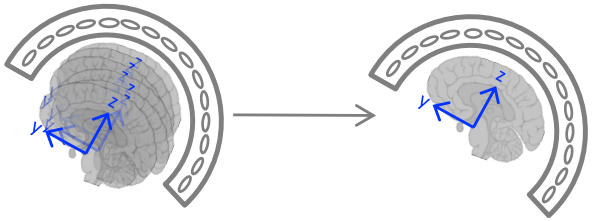
SOME OFFLINE PRE-PROCESSING IS ALWAYS REQUIRED

PIPELINE(S)



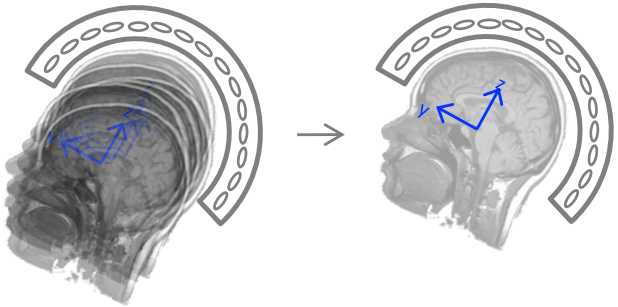
Inspection of head displacement during experimental session

SOURCE SPACE APPROACH (SUGGESTED)



Co-register each run on subject (or default) anatomy and analyze data in source space

SENSOR SPACE APPROACH



REALIGNMENT IN SENSOR SPACE

What do we need ?

- A reference head position (R,T) for realignment
- A method to transform sensors data as they had been recorded with head in reference position (Maxwell equations enter here …)

HEAD POSITION INSPECTION

HeadPositionHistory

A tool for offline checking participant head displacement.

Automatically suggest a reference.

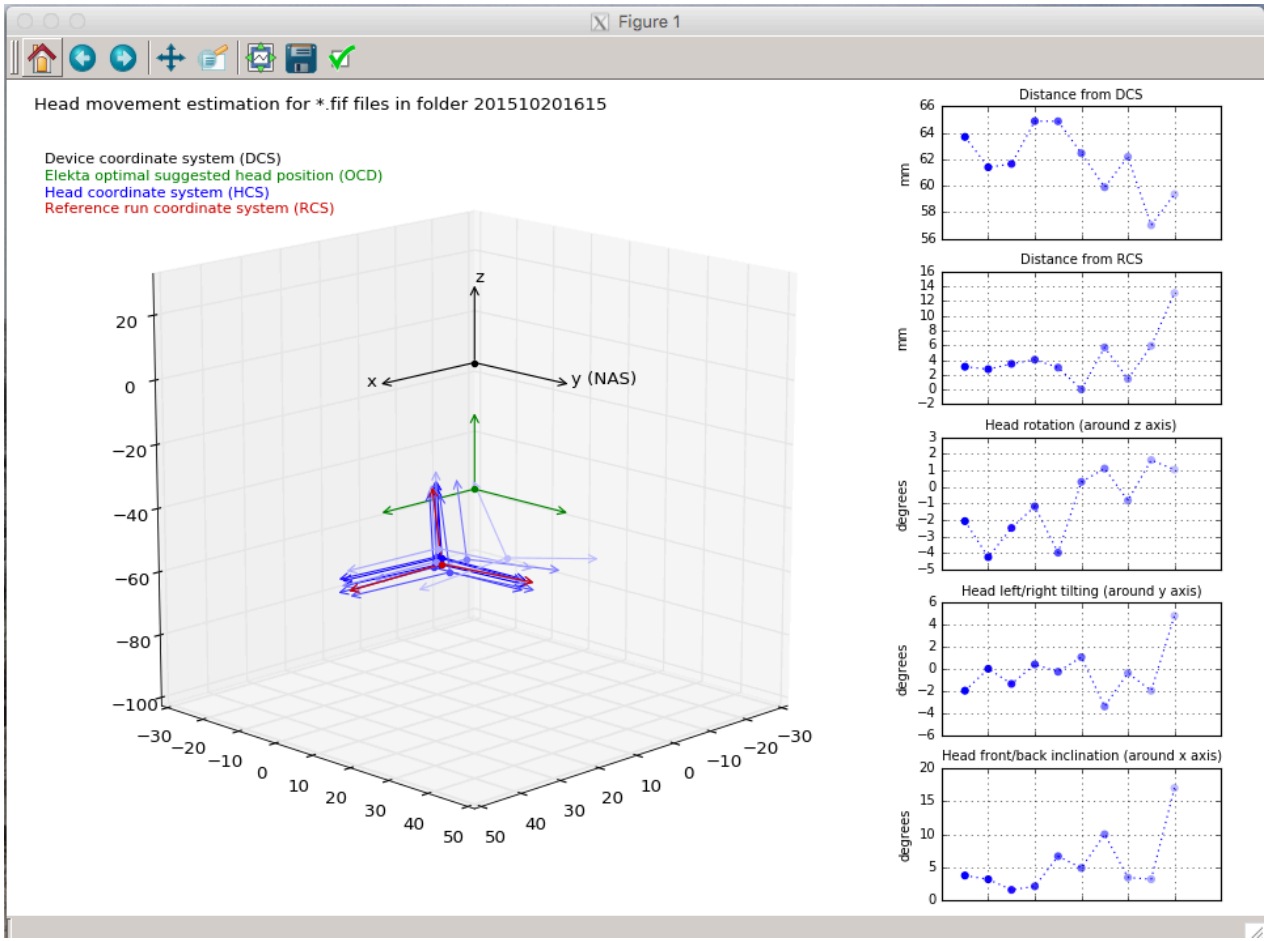
Command line syntax:

```
HeadPositionHistory FOLDER_WITH_FIFF_FILES [REFERENCE_FIF_FILE]
```

```
Filenames ordered according to acquisition time:

        # 1    19930324RBTR_201510201615_2012036_S22run01.fif
        # 2    19930324RBTR_201510201615_2012036_S22run02.fif
        # 3    19930324RBTR_201510201615_2012036_S22run03.fif
        # 4    19930324RBTR_201510201615_2012036_S22run04.fif
        # 5    19930324RBTR_201510201615_2012036_S22run05.fif
        # 6    19930324RBTR_201510201615_2012036_S22run06.fif
        # 7    19930324RBTR_201510201615_2012036_S22run07.fif
        # 8    19930324RBTR_201510201615_2012036_S22run08.fif
        # 9    19930324RBTR_201510201615_2012036_S22run09.fif
        # 10   19930324RBTR_201510201615_2012036_S22run10.fif


Suggested (computed) reference for MaxMove realignment:

        #6     19930324RBTR_201510201615_2012036_S22run06.fif
```

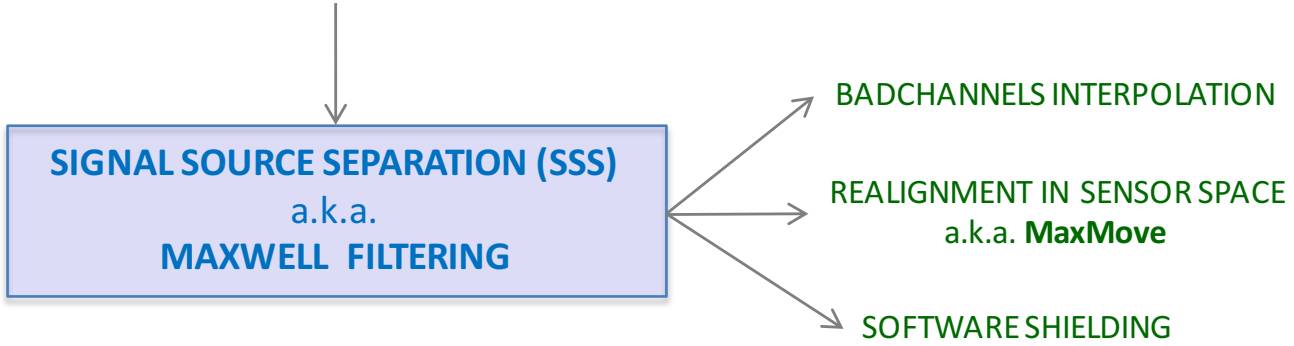
SUGGESTED REFERENCE

$$(R\,,\vec{T}) \longrightarrow \vec{T} = \min_{\vec{T}_i} \sum_{j \neq i} \|\vec{T}_j - \vec{T}_i\|^2$$



SIGNAL SOURCE SEPARATION

Well, we have a reference now, but **how to transform all sensors data** as they had been recorded with the participant head in the reference position ?



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Presentation of electromagnetic multichannel data: The signal space separation method

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(Received 6 August 2004; accepted 22 April 2005; published online 21 June 2005)

Measurement of external magnetic fields provides information on electric current distribution inside an object. For example, in magnetoencephalography modern measurement devices sample the magnetic field produced by the brain in several hundred distinct locations around the head. The signal space separation (SSS) method creates a fundamental linear basis for all measurable multichannel signal vectors of magnetic origin. The SSS basis is based on the fact that the magnetic field can be expressed as a combination of two separate and rapidly converging expansions of harmonic functions with one expansion for signals arising from inside of the measurement volume of the sensor array and another for signals arising from outside of this volume. The separation is based on the different convergence volumes of the two expansions and on the fact that the sensors are located in a source current-free volume between the interesting and interfering sources.

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Applications of the Signal Space Separation Method

Samu Taulu, Juha Simola, and Matti Kajola

***Abstract*—The reliability of biomagnetic measurements is traditionally challenged by external interference signals, movement artifacts, and comparison problems caused by different positions of the subjects or different sensor configurations. The Signal Space Separation method (SSS) idealizes magnetic multichannel signals** surement sessions, even from the same subject, as the head usually cannot be fixed to the device. Furthermore, grand averages across different subjects may be biased because the subjects are not necessarily at the same position with respect to the device.

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Spatiotemporal signal space separation method for rejecting nearby interference in MEG measurements

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Abstract
Limitations of traditional magnetoencephalography (MEG) exclude some important patient groups from MEG examinations, such as epilepsy patients