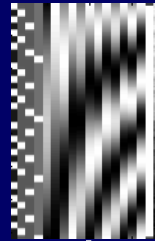
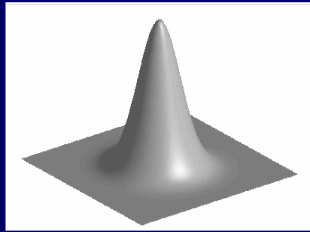
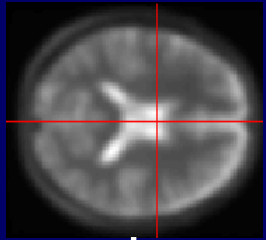


fMRI Data analysis

fMRI time-series

Kernel

Design matrix

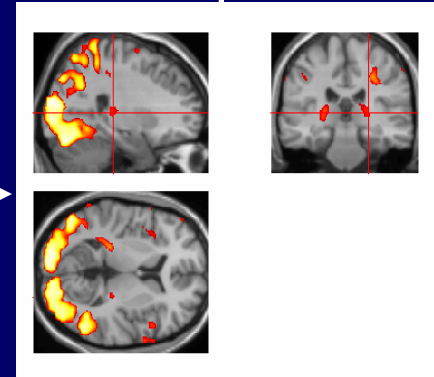


Realignment

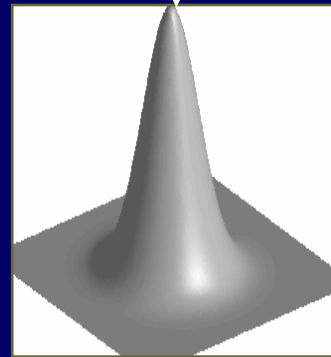
Smoothing

General linear model

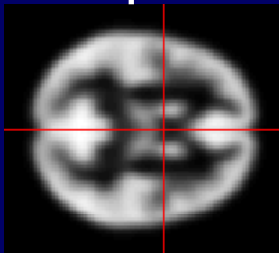
Inference with Gaussian field theory



Normalisation



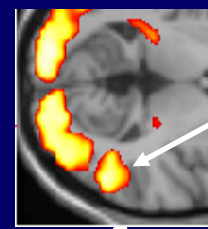
Adjusted regional data



Template

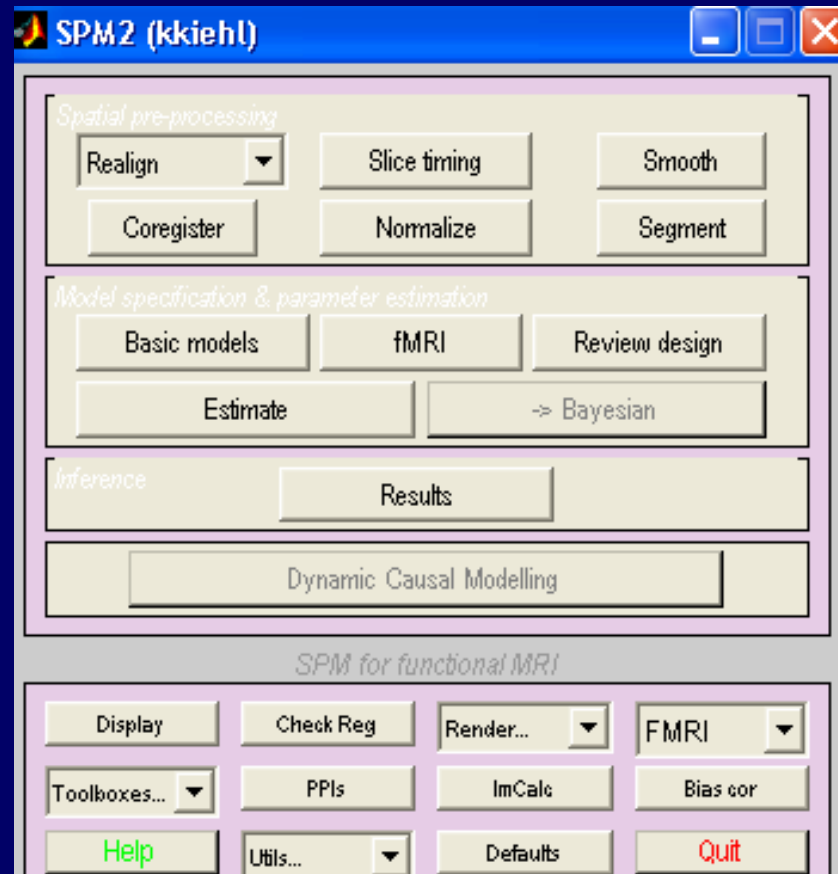
Parameter estimates

spatial modes and effective connectivity

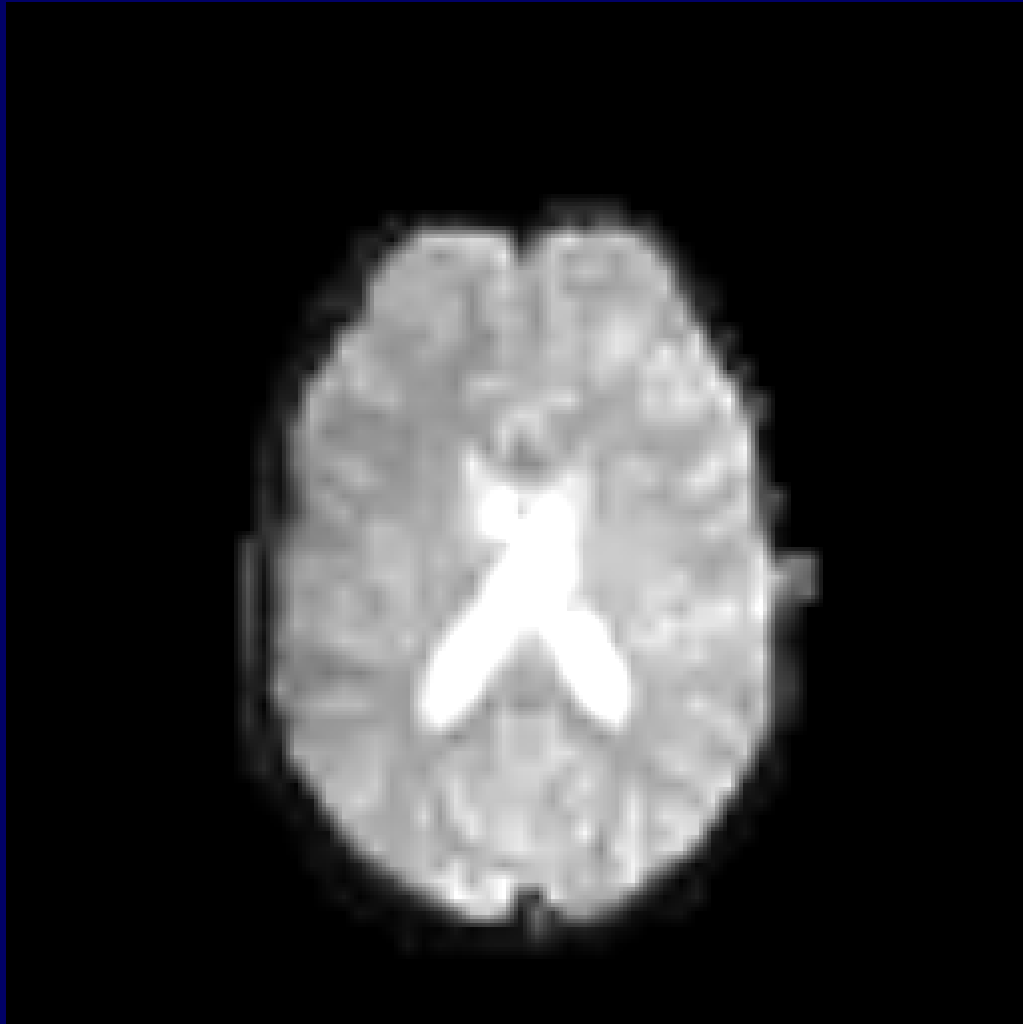


$p < 0.05$

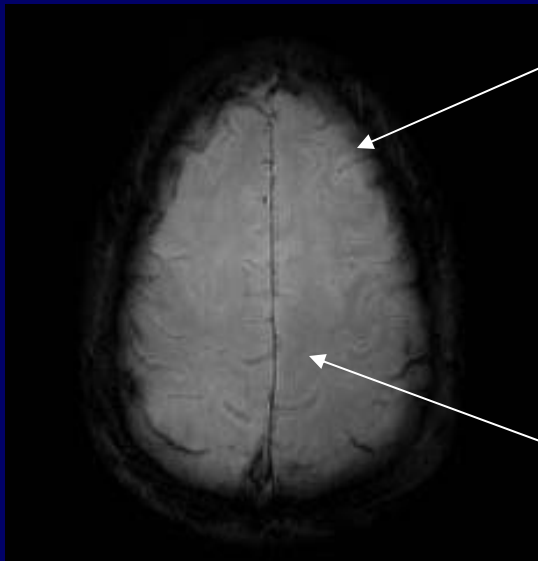
Realignment/Motion Estimation



Realign – Head Motion



How much motion is significant?



Edge:

$$\Delta S(x) \sim 70-90\%$$

$$0.05 \text{ pixel shift} \Rightarrow 3 - 5\% \Delta S$$

(187 μm)

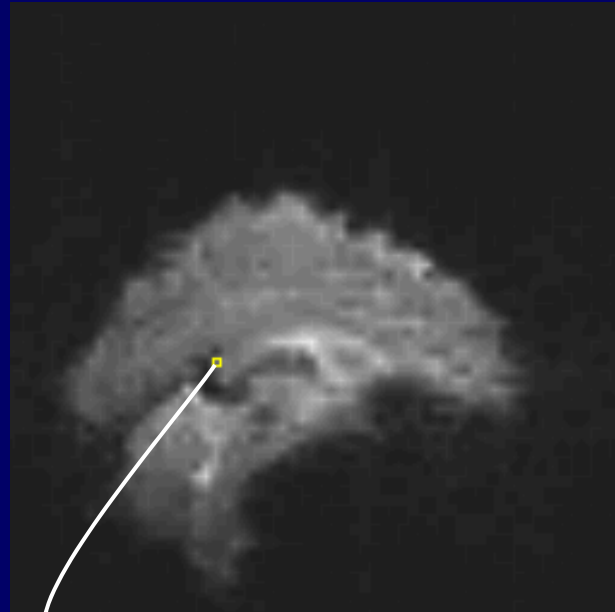
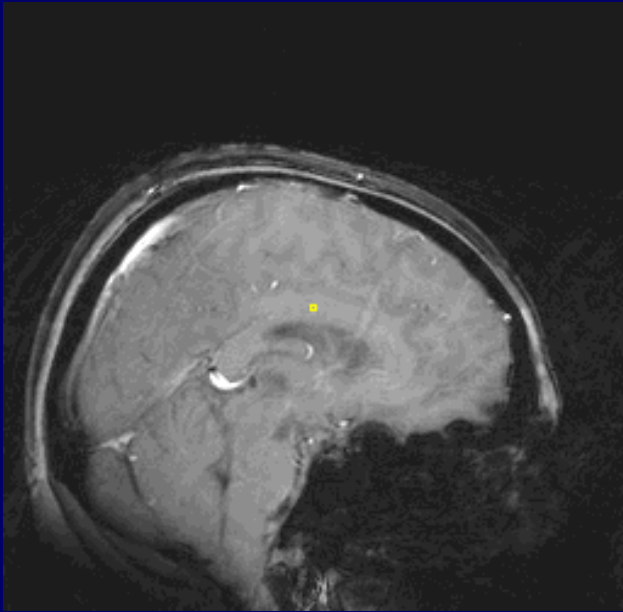
Inside:

$$\Delta S(x) \sim 10-20\%$$

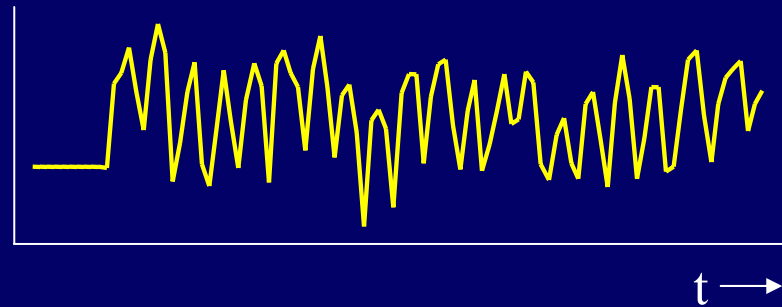
$$0.25 \text{ pixel shift} \Rightarrow 3 - 5\% \Delta S$$

(~1 mm)

Physiological artifacts

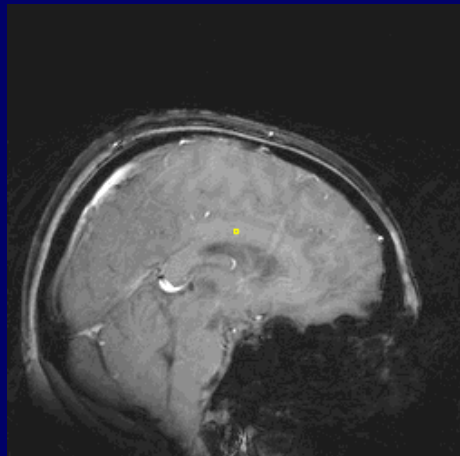


Oscillations in signal
due to respiration

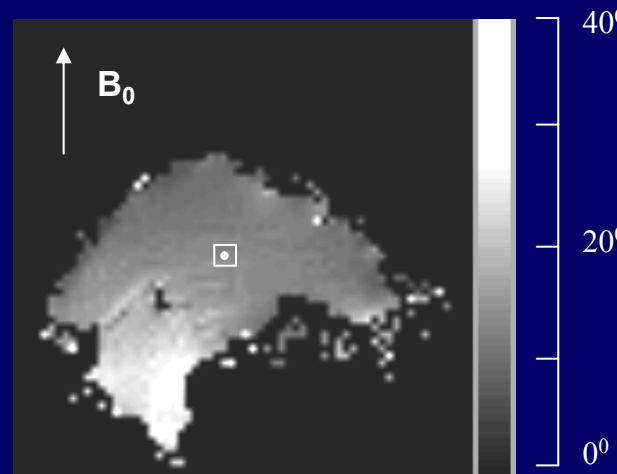


Physiological artifacts - sources

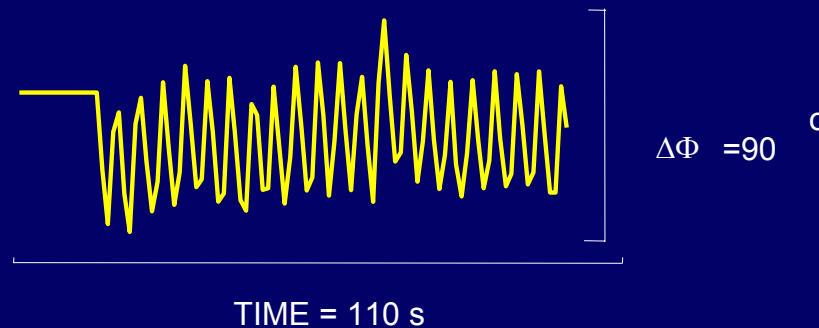
Signal changes result from motion and ΔB



Magnitude image

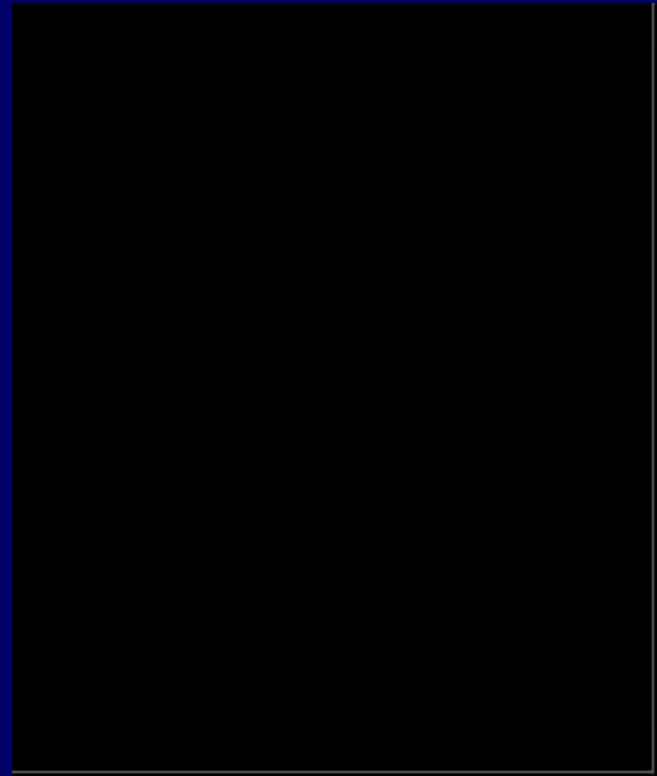


Field Map



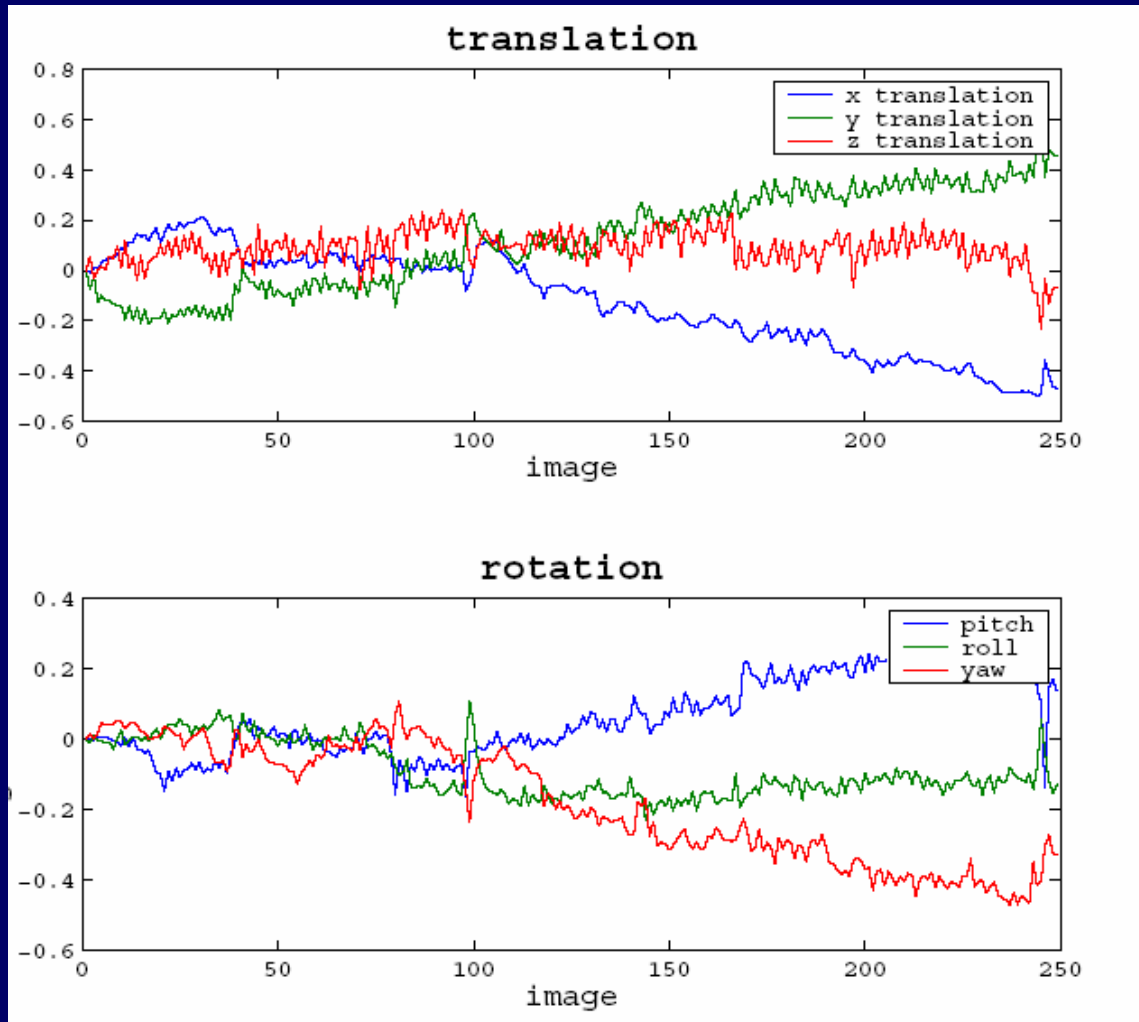
Summary

- Physiological artifacts
 - Filtering
 - Iterative subtraction
movie (i1-i2; i2-i3...)



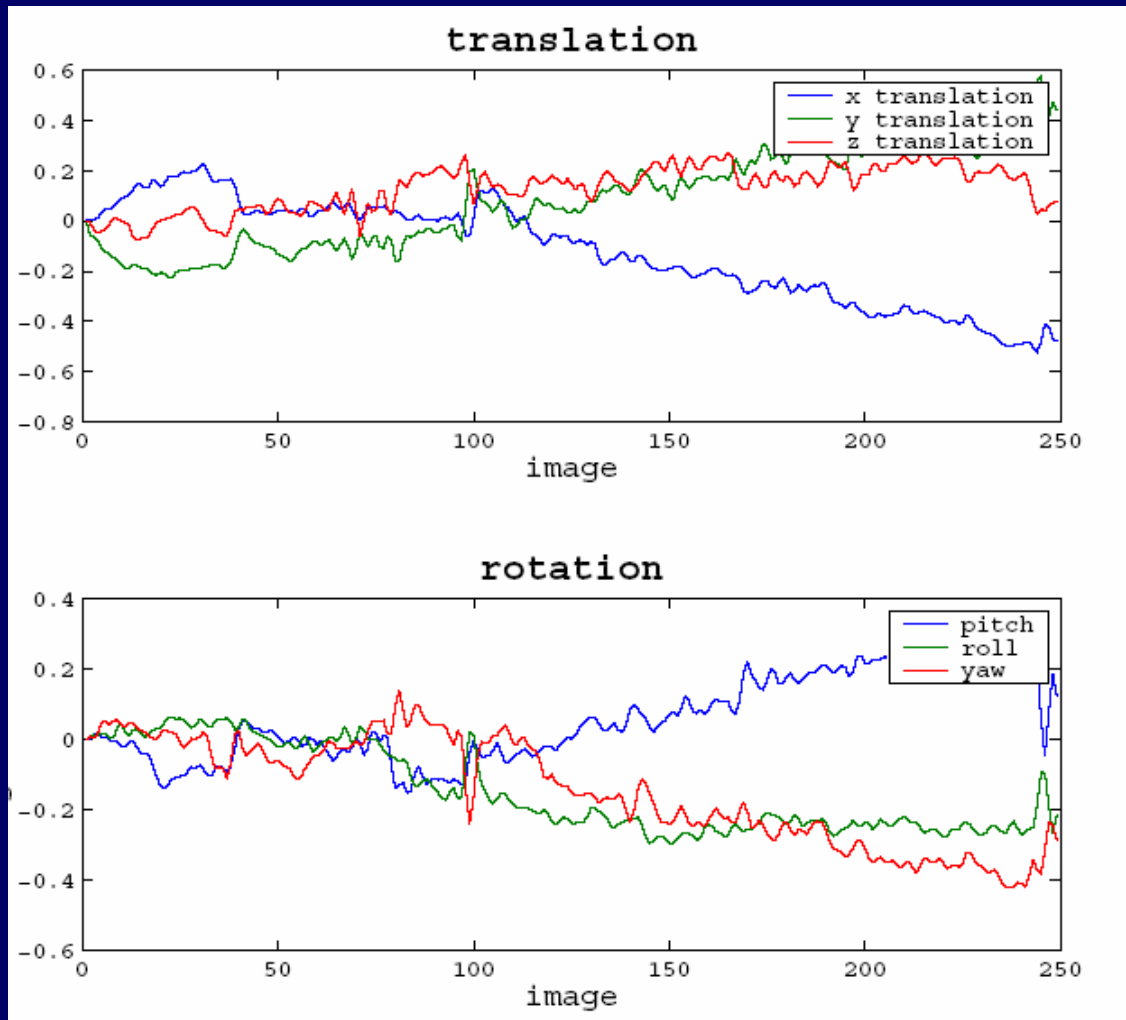
Summary

- Physiological artifacts
 - Filtering

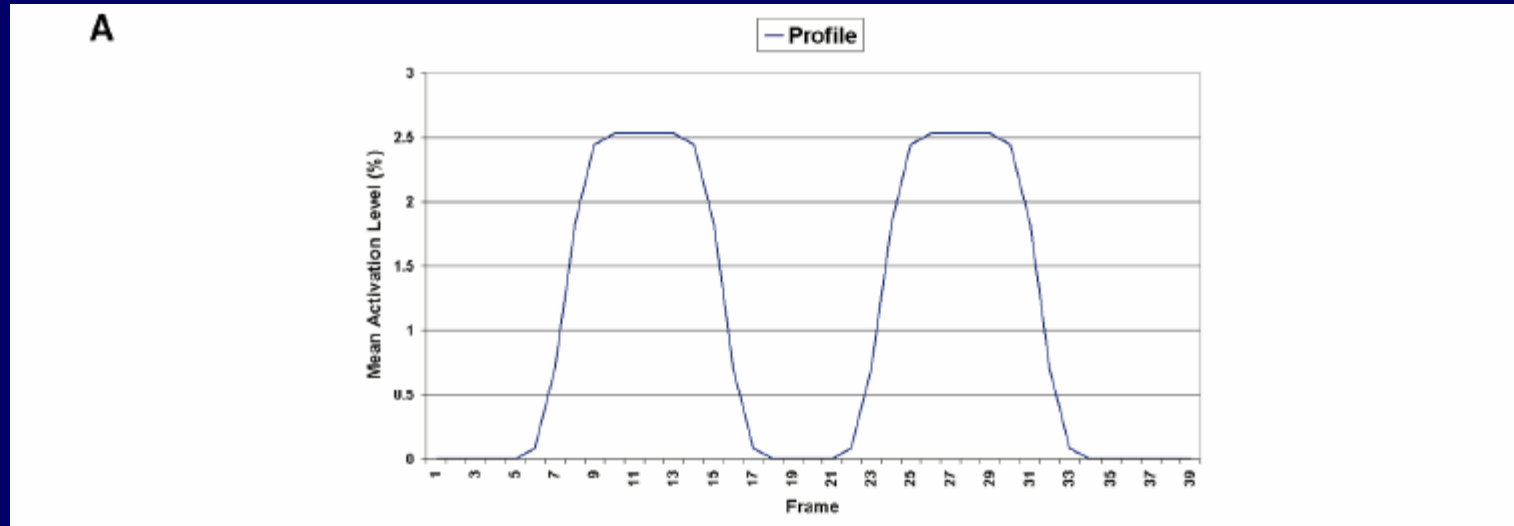


Summary

- Physiological artifacts
 - Filtering

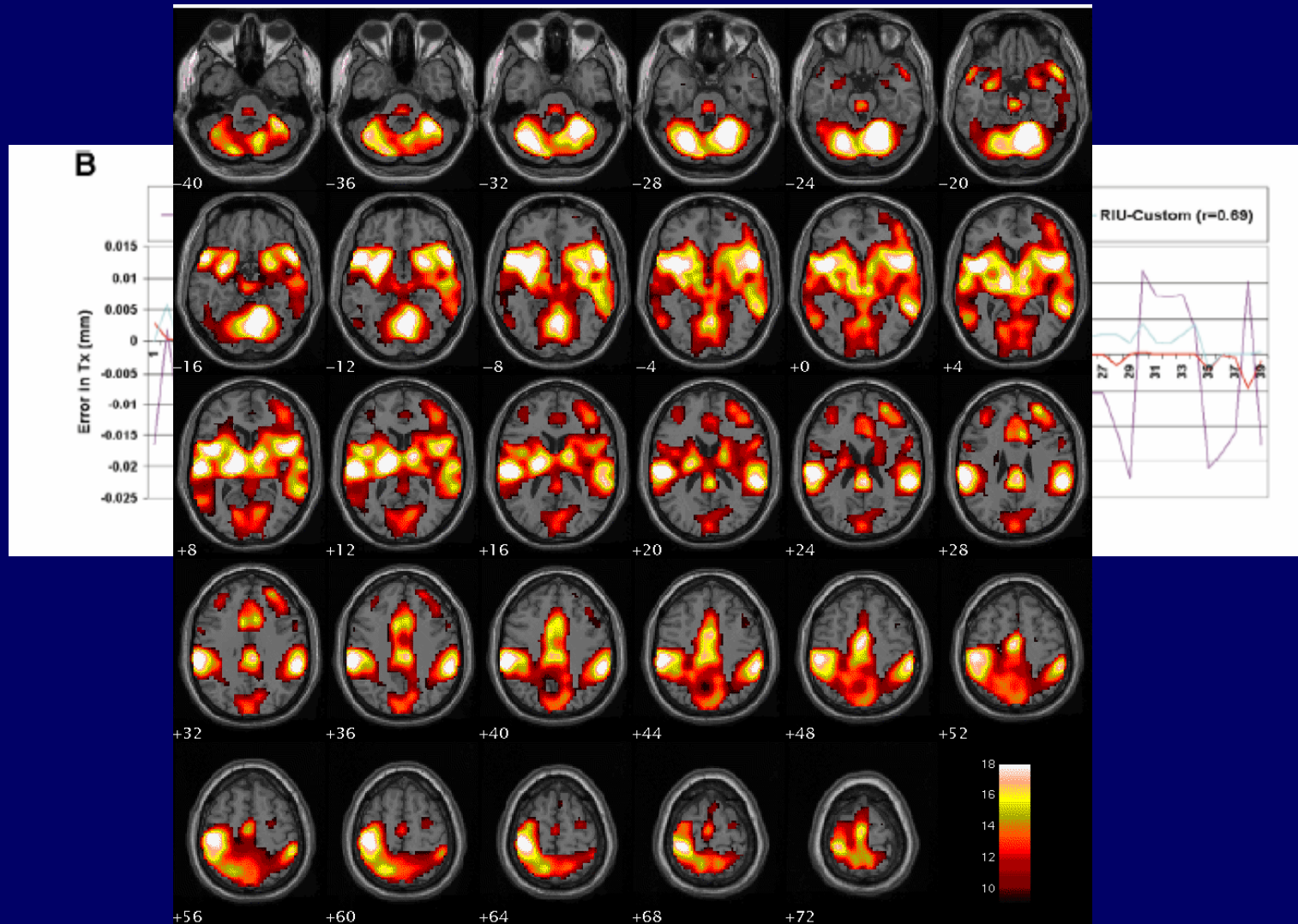


Can BOLD activity be 'estimated' as motion?



Can BOLD activity be 'estimated' as motion?

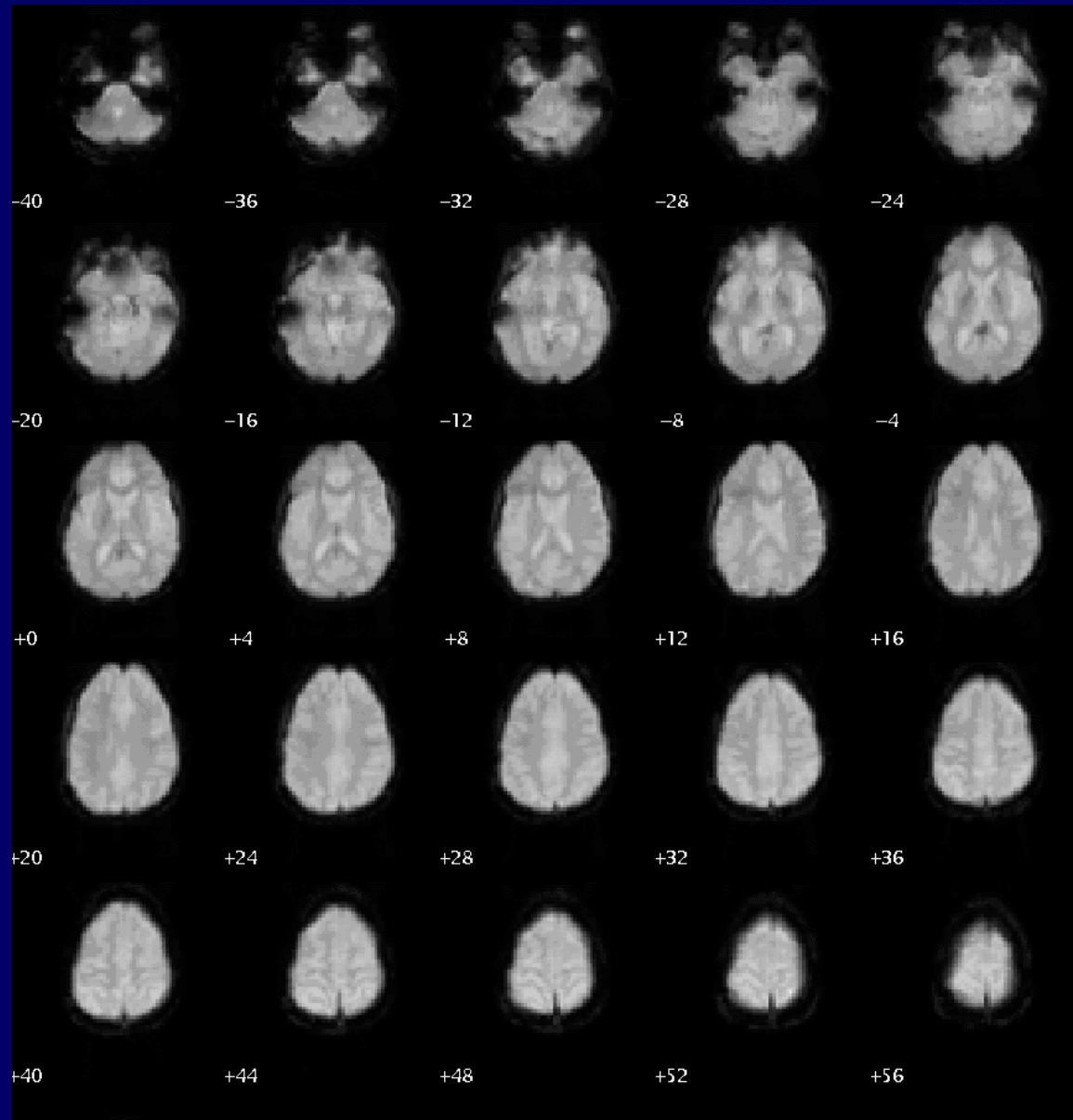
YES. In some circumstances



References

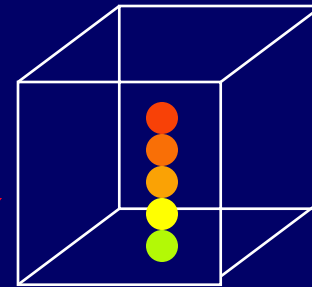
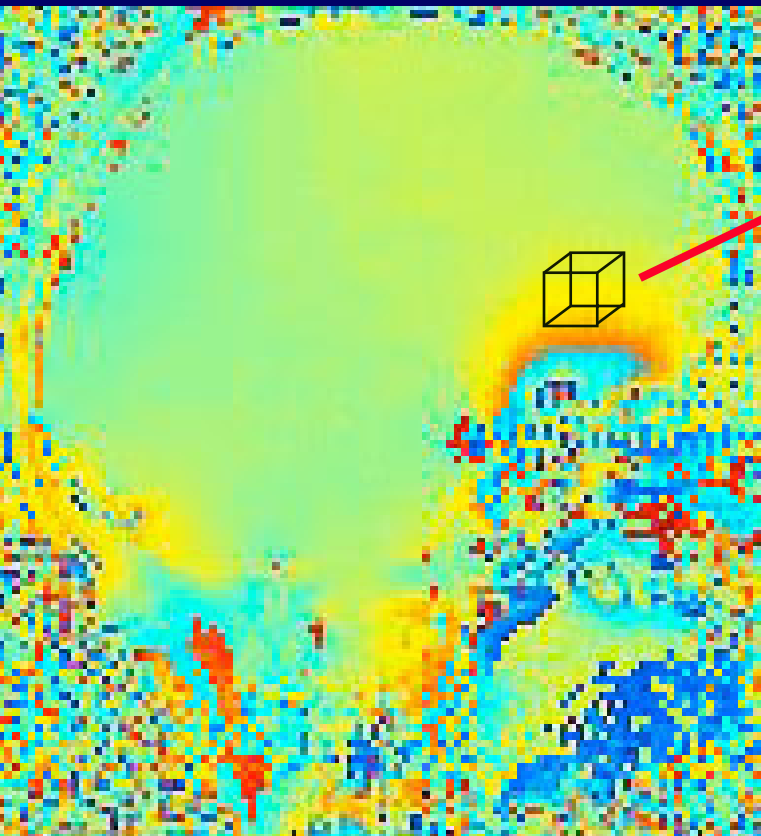
- L. Freire, A. Roche and J.-Fr. Mangin. *What is the best similarity measure for motion correction in fMRI?* **IEEE Transactions in Medical Imaging** **21**, p. 470-484, 2002.
- L. Freire and J.-F. Mangin. *Motion correction algorithms may create spurious brain activations in the absence of subject motion.* **Neuroimage** **14(3)**, p. 709-722, september 2001.
- P.J. Rousseeuw and A.M. Leroy. **Robust Regression and Outlier Detection.** Wiley Series in Probability and Mathematical Statistics. 1987.

Typical Functional Image Volume

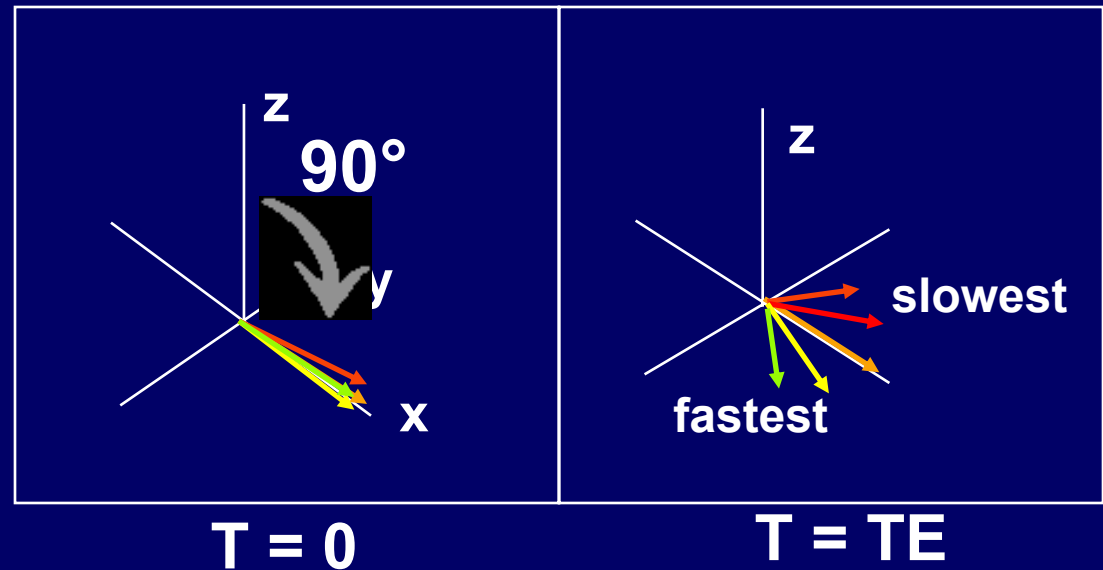


1) Non-uniform Local Field Causes Local Dephasing

Sagittal B_0 field map at 3T



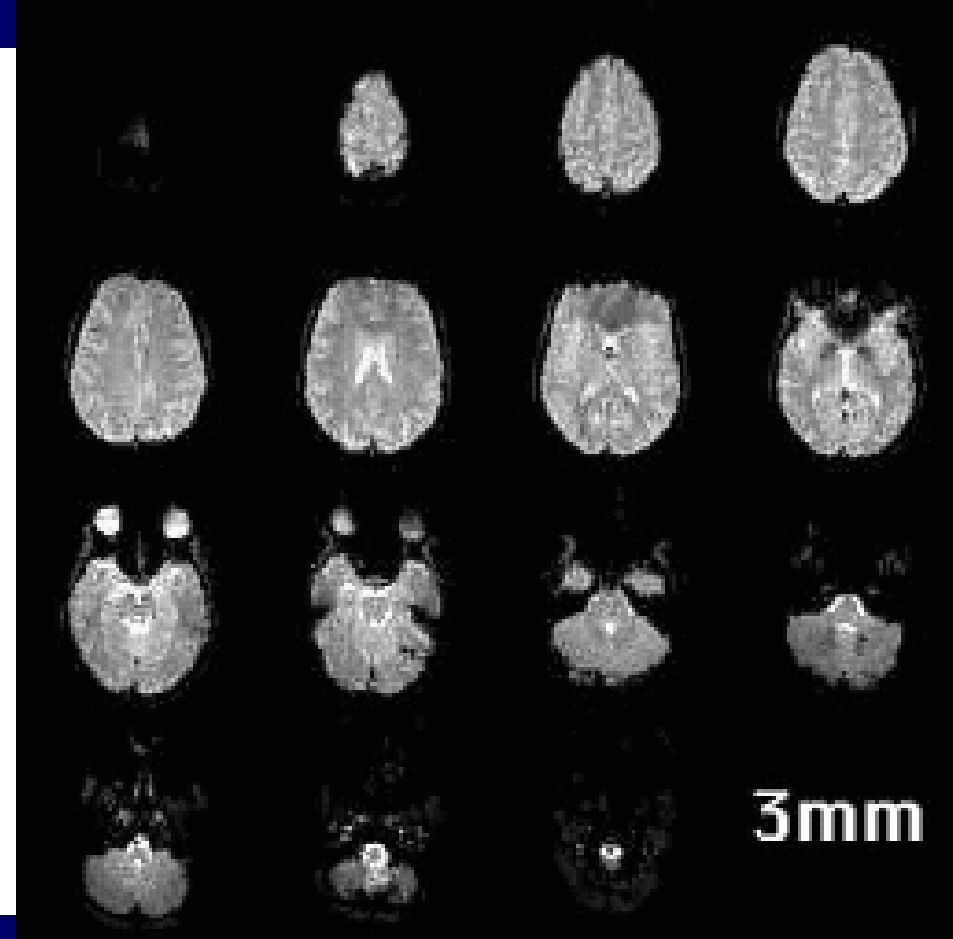
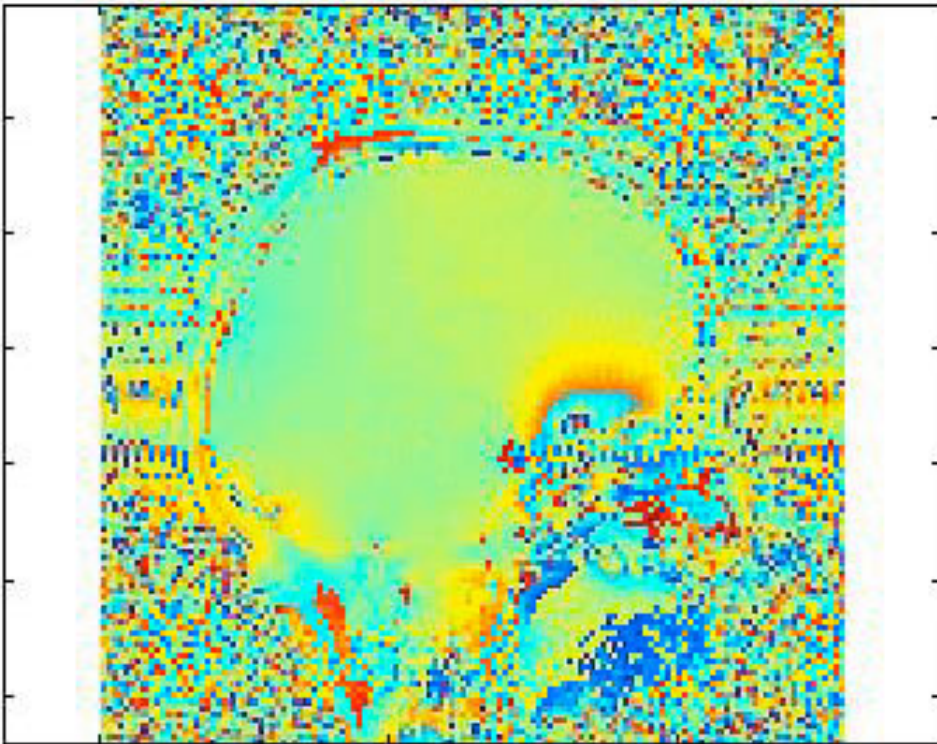
5 water protons in different parts of the voxel...



Local susceptibility gradients: thru-plane dephasing

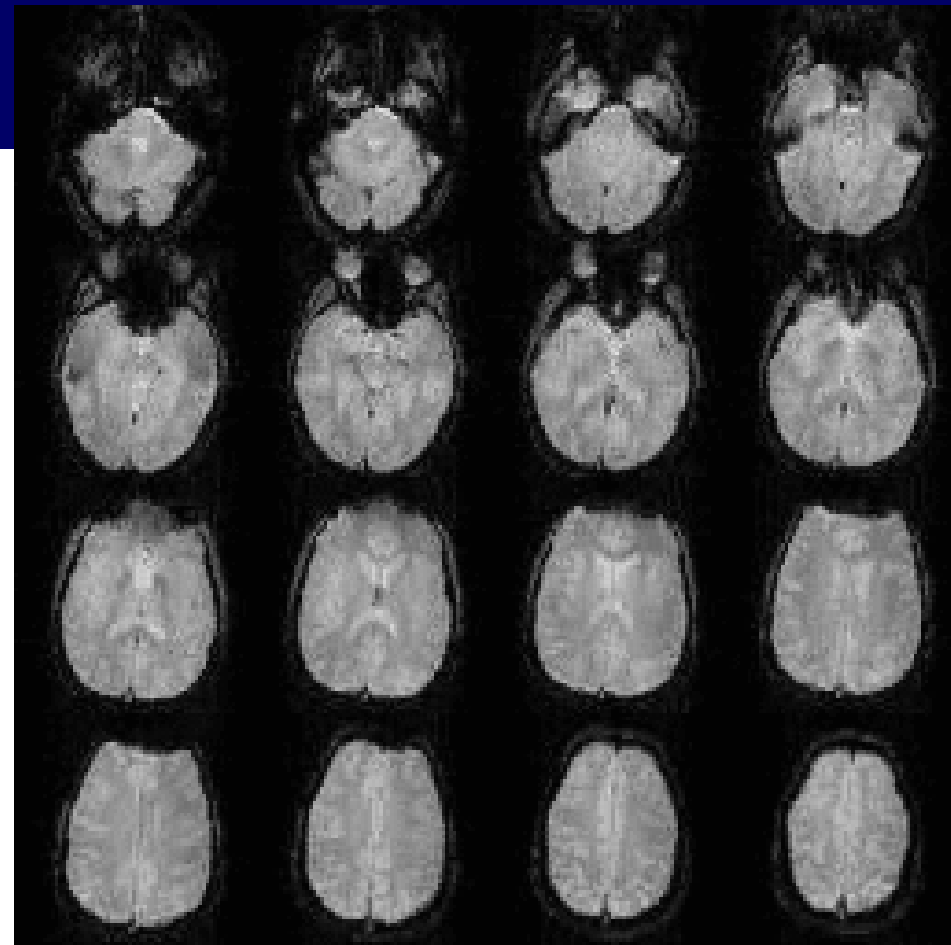
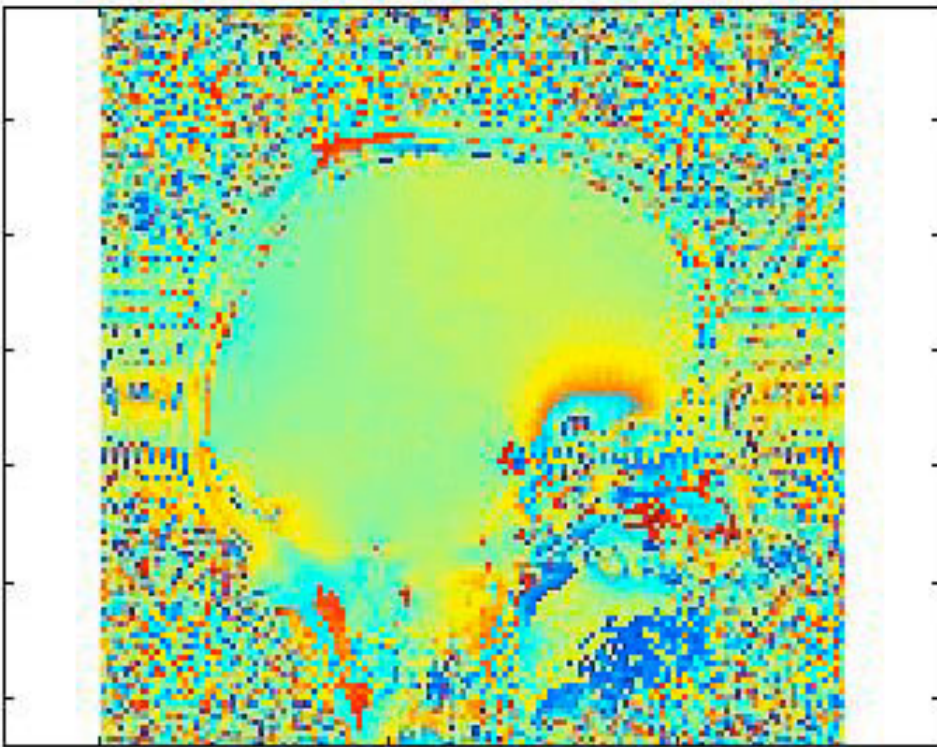
Bad for thick slice above frontal sinus...

Orbitofrontal susceptibility region



Thru-plane dephasing: worse at long TE

Orbitofrontal susceptibility region

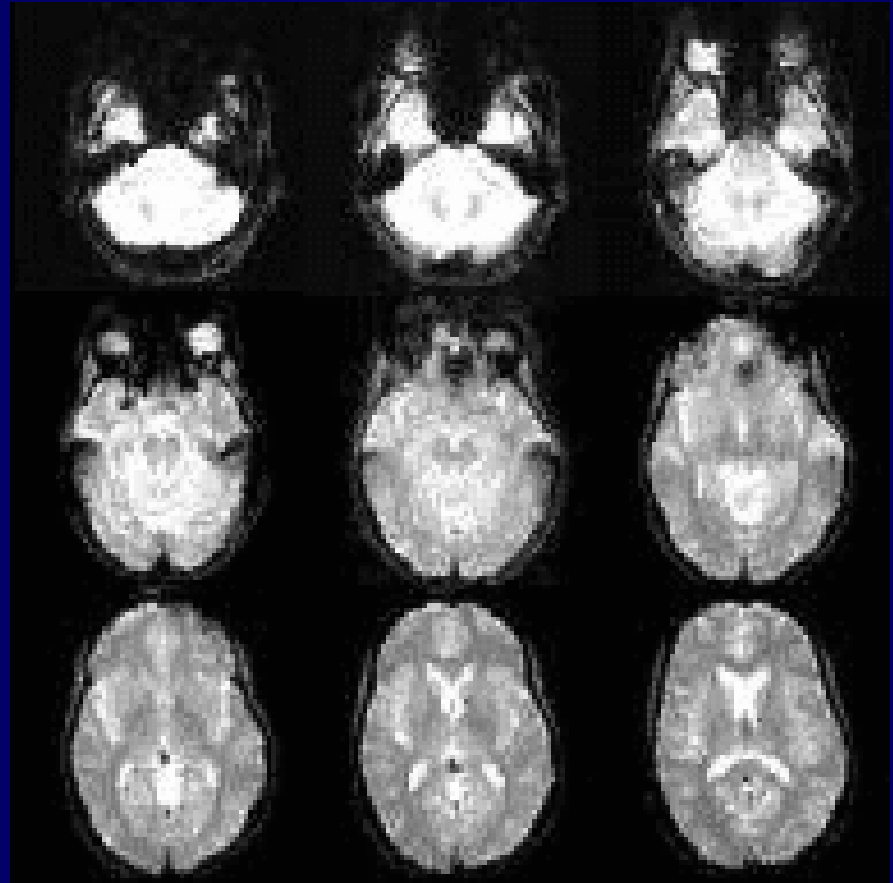


3T, TE = 21, 30, 40, 50, 60ms

Susceptibility in EPI can give either a compression or expansion

Altering the direction kspace is transversed causes either local compression or expansion.

choose your poison...

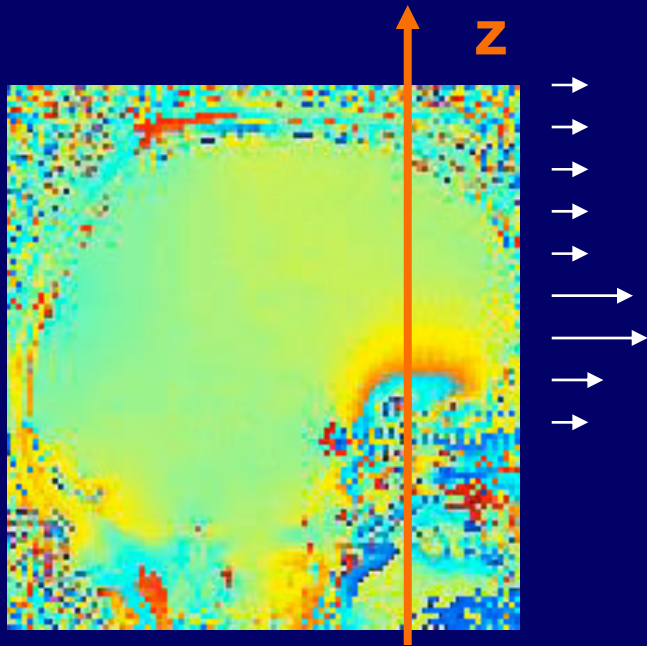


3T whole body gradients

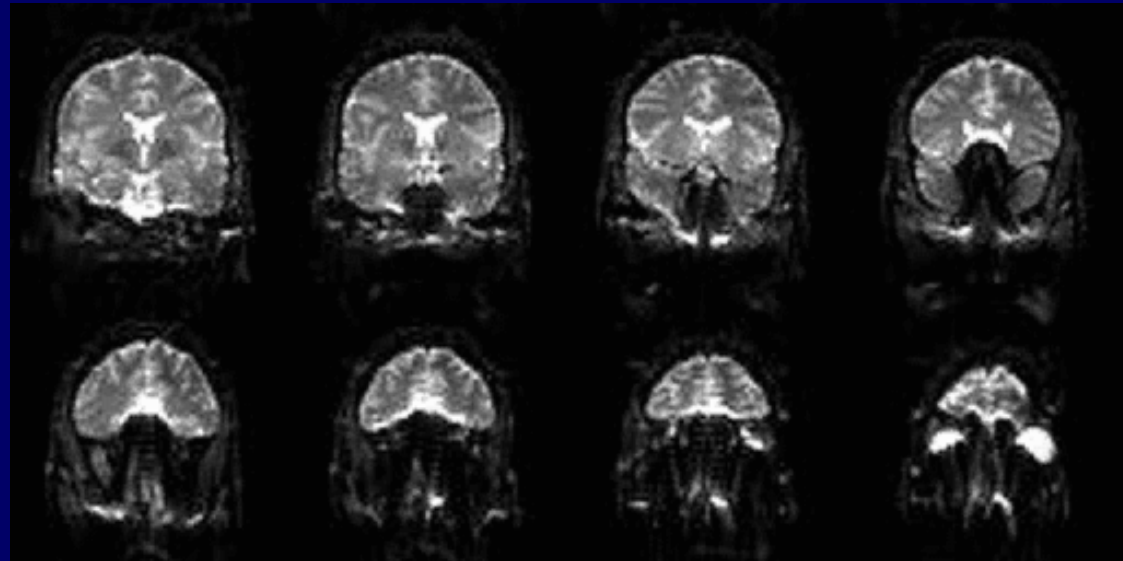
Susceptibility Causes Image Distortion

Use shortest possible encoding

Echoplanar Image,
 $\Delta\theta \propto \text{encode time} \propto 1/\text{BW}$



Field near sinus



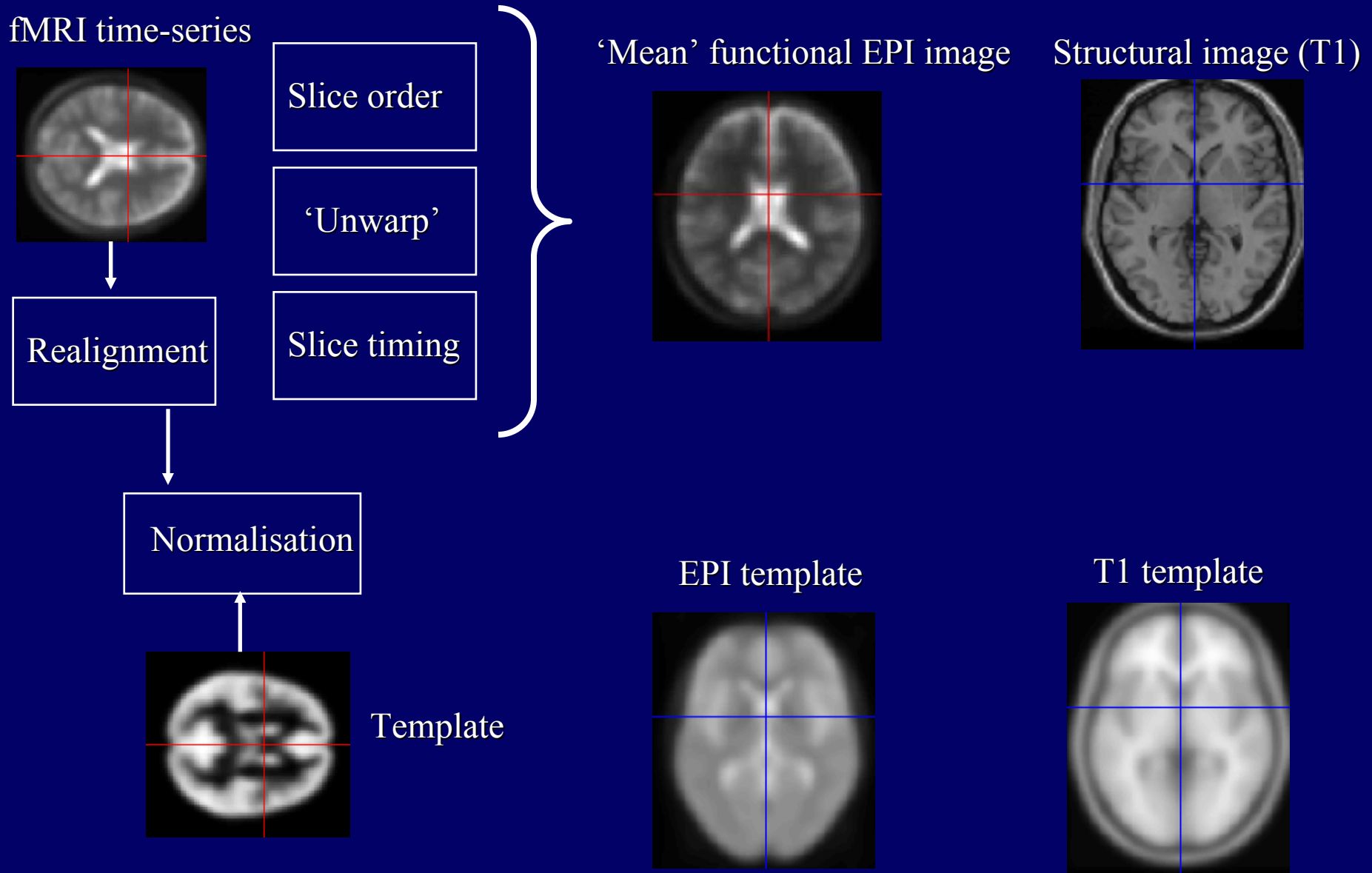
3T head gradients

Encode time = 34, 26, 22, 17ms

Talairach space

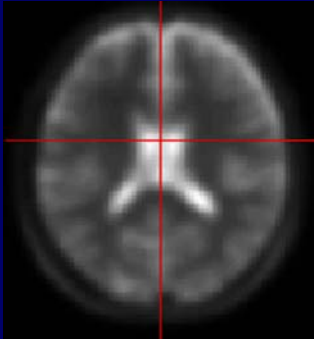
- Revised in spm96 using MNI brain
 - Montreal Neurological Institute
 - Based on 304 normal subjects
 - More representative of population
 - 10-15% larger than Talairach space
- Much confusion in the literature
 - Must convert to ‘Talairach’ to ‘MNI’ space
 - Meta-analyses
 - Planning studies, regions of interest
 - Different groups/software use different methods
 - Manuscripts must specify the ‘actual space’ used

Spatial Normalization



Spatial Normalization

'Mean' functional image

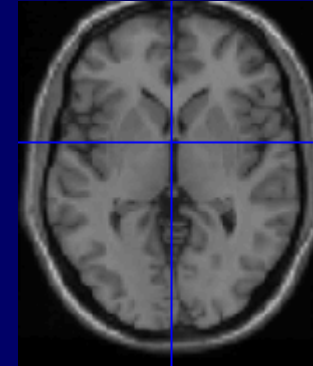


Coregister subject's 'mean EPI'
to 'structural T1 image'

Problems:

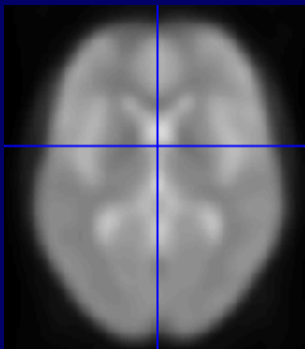
- coreg is linear operation –
 - EPI warping and
 - EPI distortion not accounted
- Unless you have:
 - 'field map correction'
 - issues – slow acquisition

Structural image (T1)

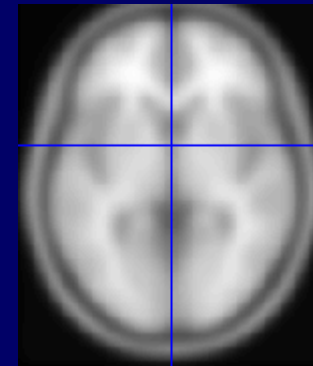


Normalize T1
to T1 Template

EPI template

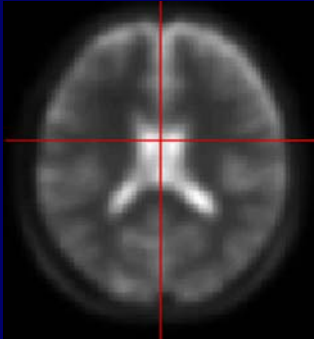


T1 template

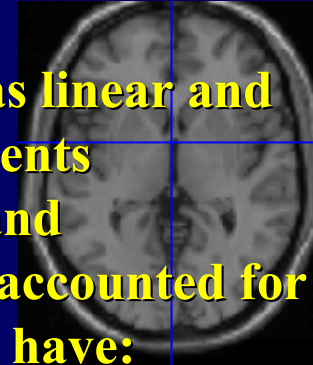


Spatial Normalization

'Mean' functional image



Structural image (T1)

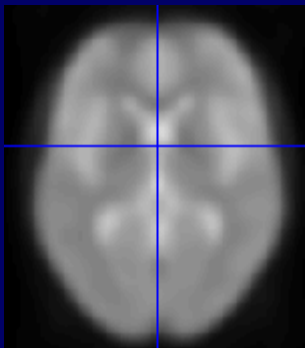


Good:

- normalization has linear and nonlinear components
 - EPI warping and
 - EPI distortion accounted for
- Even better if you have:
'field map correction'
-issues – slow acquisition

Normalize
'mean EPI' to
EPI Template

EPI template



Bad – If 'mean EPI' is different from 'EPI template' T1 template normalization can go wrong

- tune normalization
- customize basis functions
- create 'site' template

