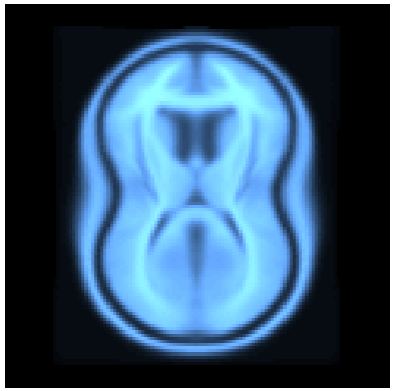
MEG and EEG analysis in SPM8



Vladimir Litvak

Wellcome Trust Centre for Neuroimaging
UCL Institute of Neurology

SPM M/EEG Course
Lyon, April 2012

“Classical” SPM

SPM

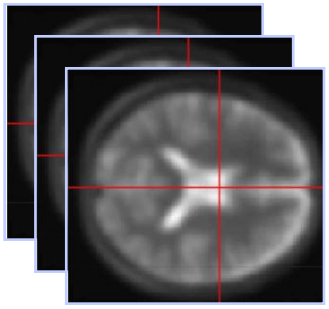
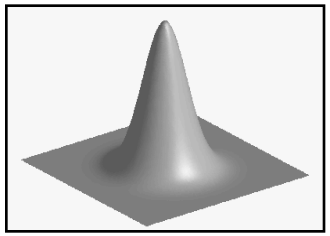
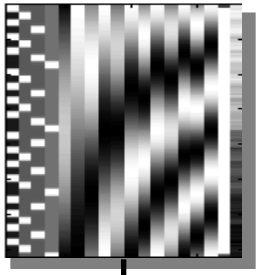


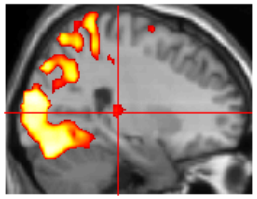
Image time-series

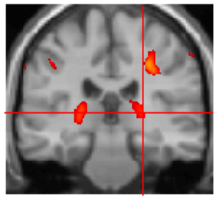


Spatial filter

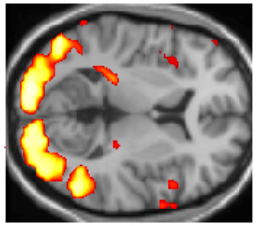


Design matrix



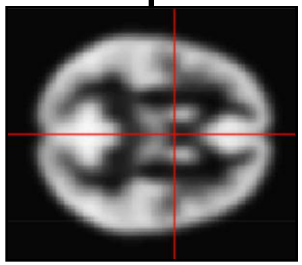


Statistical Parametric Map

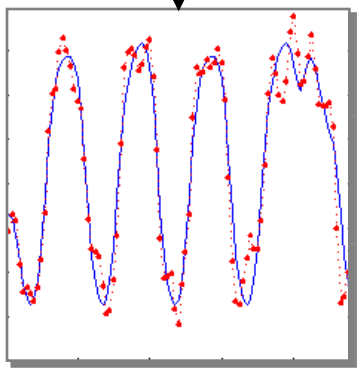


Realignment → Smoothing → General Linear Model →

Normalisation

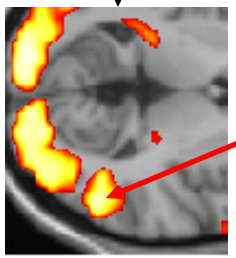


Anatomical reference

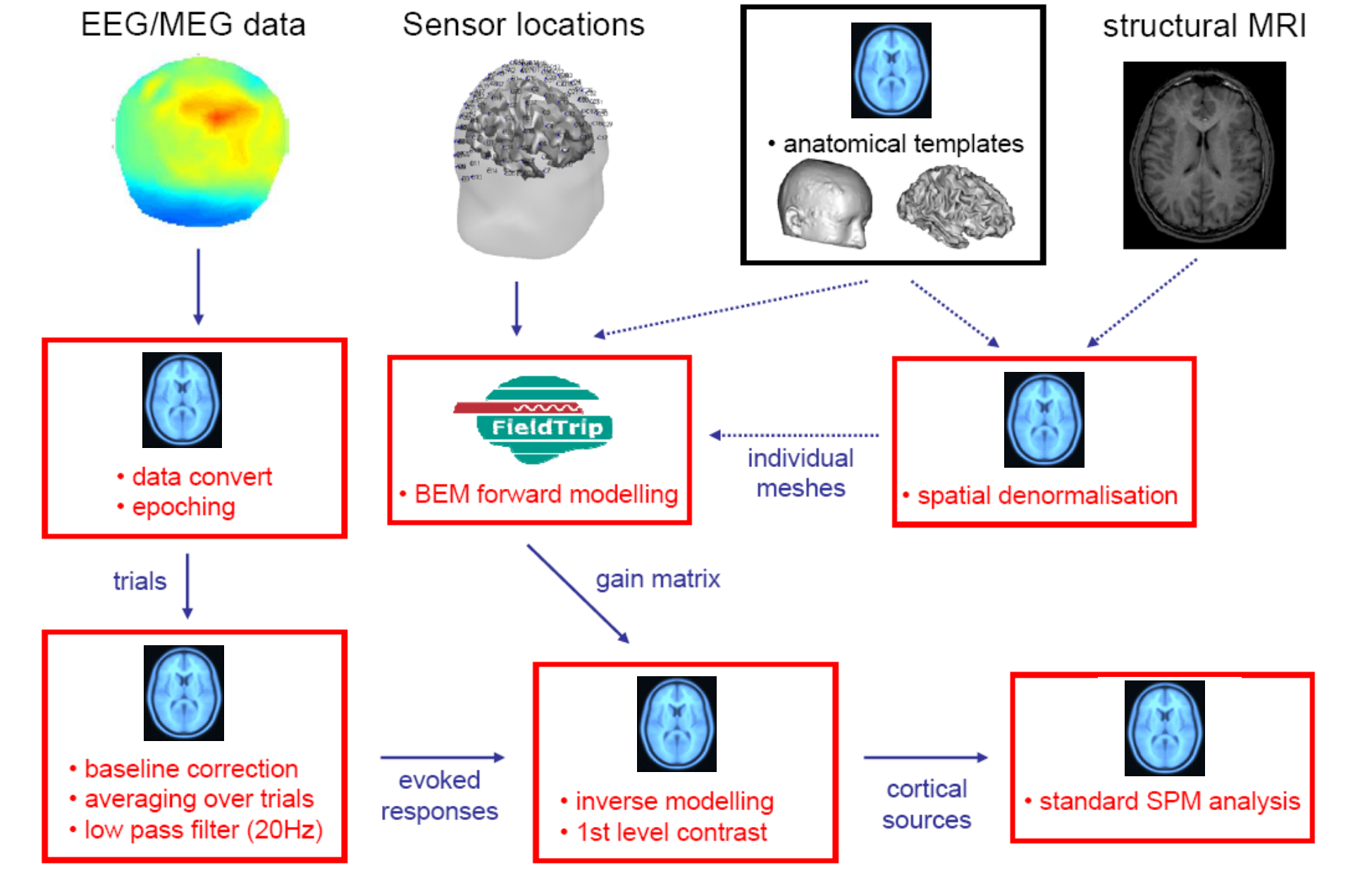


Parameter estimates

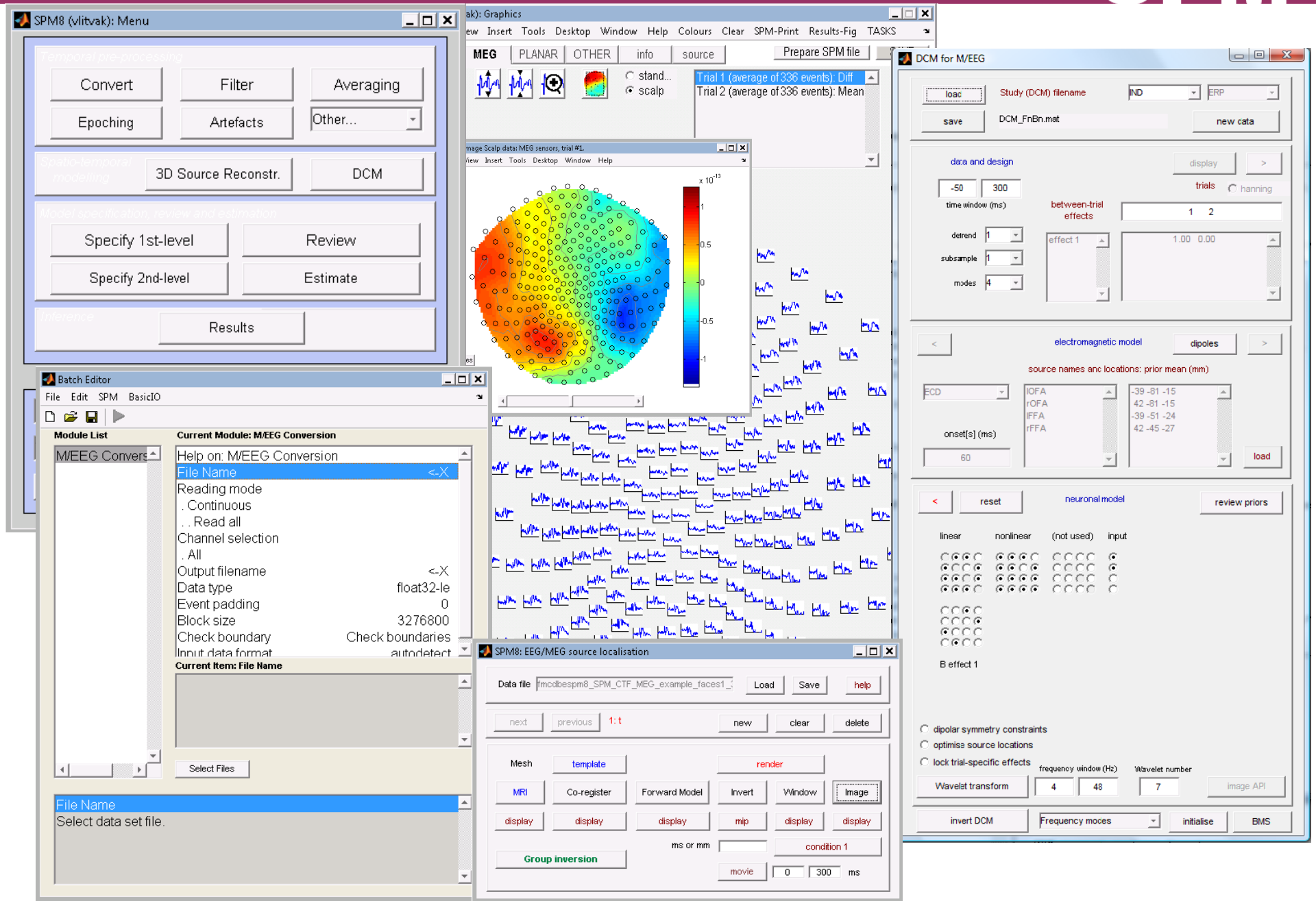
Statistical Inference ← RFT



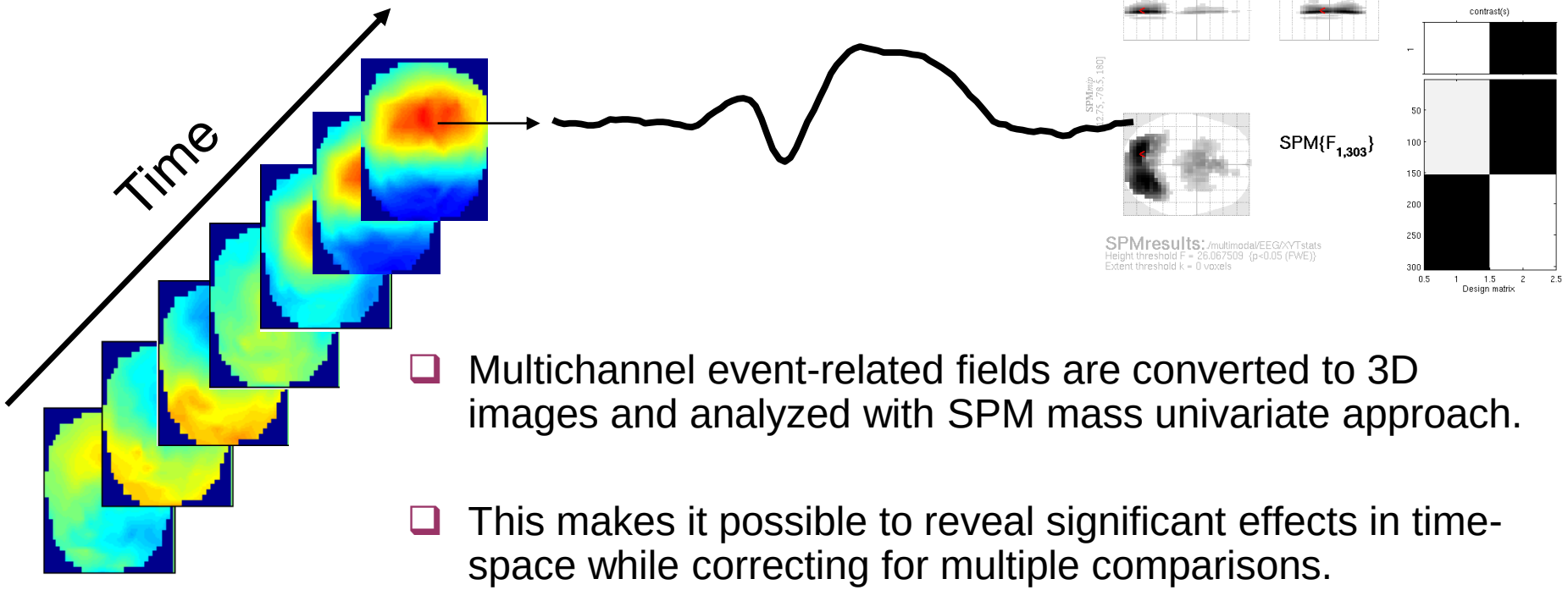
p <0.05


EEG/MEG data
Sensor locations
• anatomical templates
structural MRI
• data convert
• epoching
FieldTrip
• BEM forward modelling
individual meshes
• spatial denormalisation
trials
gain matrix
• baseline correction
• averaging over trials
• low pass filter (20Hz)
evoked responses
• inverse modelling
• 1st level contrast
cortical sources
• standard SPM analysis

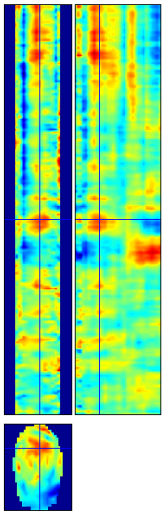
SPM M/EEG Interface



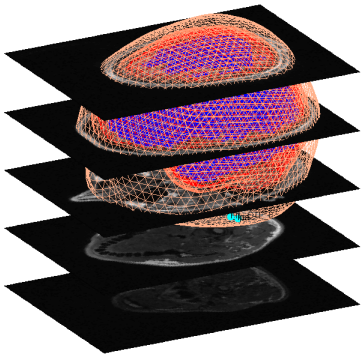
SPM M/EEG functionality: analysis of images

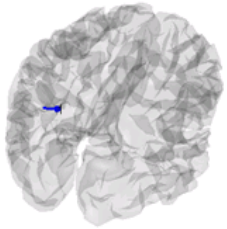


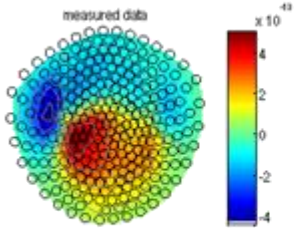
- Multichannel event-related fields are converted to 3D images and analyzed with SPM mass univariate approach.
- This makes it possible to reveal significant effects in time-space while correcting for multiple comparisons.
- Complex parametric models can be tested.
- Time-frequency matrices, results of source reconstruction and other data types representable as 2D or 3D images can be analyzed in a similar way.

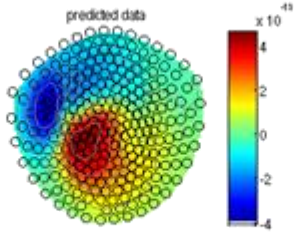


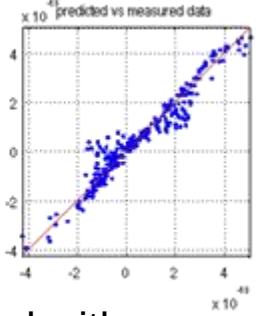
SPM M/EEG functionality: source analysis

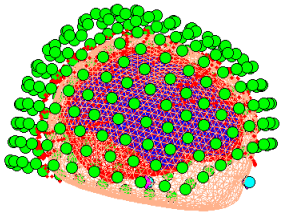


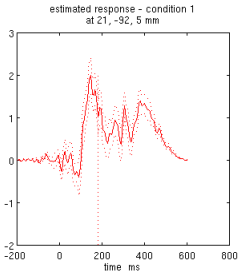


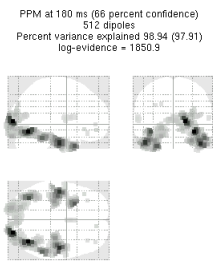






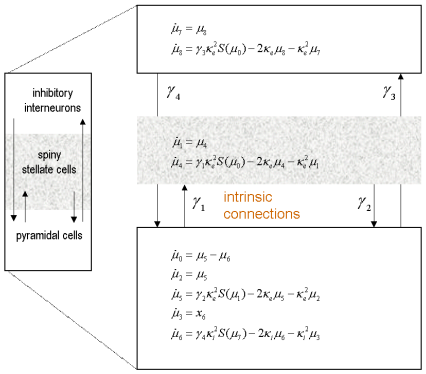


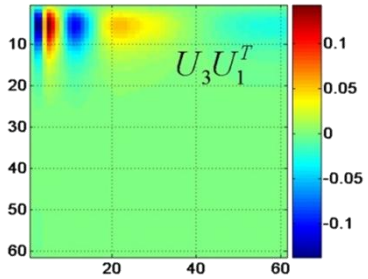


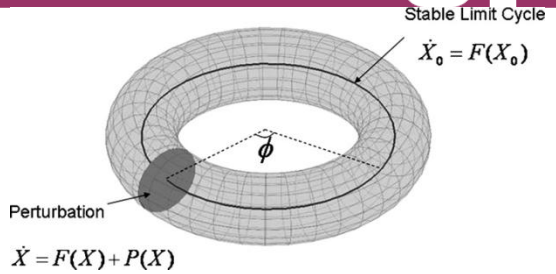


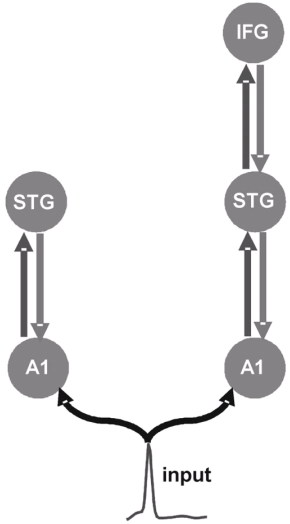
- Several kinds of MEG forward models can be generated with or without using individual MRI and/or head shape measurement.
- Bayesian imaging source reconstruction makes it possible to
  - incorporate prior knowledge (e.g. fMRI)
  - constrain the solutions to be similar across a group of subjects
  - perform multimodal fusion (EEG+MEG, planar gradiometers+magnetometers+EEG in Neuromag)
- Both evoked and induced activity can be reconstructed.
- There is also equivalent current dipole -based tool that makes it possible to compare dipole solutions using Bayesian model evidence (including selecting the optimal number of dipoles).

SPM M/EEG functionality: Dynamic Causal Modelling



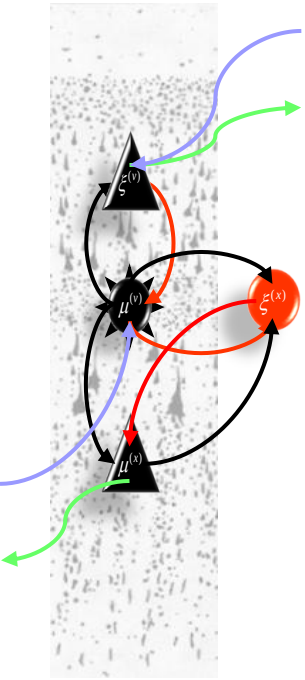






- Dynamic Causal Modelling (DCM) is a novel approach that combines data analysis and neural modelling.
- DCM makes it possible to directly test predictions of theoretical models against the data, estimate physiologically meaningful model parameters and compare different models using Bayesian model comparison.
- DCM can serve as the basis for a new integrative approach in neuroscience where different experiments are used to inform and refine the same model.
- DCM is presently available for evoked responses, induced responses, phase coupling and steady state responses (power spectra and cross spectra).

New features in SPM8/SPM12



- DCM for steady state responses has been extended to complex spectra (Friston et al., Neuroimage 2012).
- More sophisticated model comparison strategies.
- DCM for neural fields makes it possible to asses spatial properties of active cortical patches (Pinotsis et al., Neuroimage 2012)
- GLM application for analysis of continuous time-frequency data to better characterise induced responses to temporally overlapping events.

- Multivariate tests for sensor- and source- level data.
- Support for fusion of sensor types in VB-ECD and DCM.
- Physiologically realistic DCMs for time-varying spectra (epileptic seizures, induced responses, phase coupling).

SPM

FieldTrip

FieldTrip

http://fieldtrip.fcdonders.nl/

BrainGain

What is FieldTrip?

A MATLAB toolbox for electrophysiological data analysis

Features: high-level functions for electrophysiological data analysis

- Data reading
  - all commercial MEG systems, many different EEG systems
- Preprocessing
  - filtering, segmenting
- Time-locked ERF analysis
- Frequency and time-frequency analysis
  - multitapers, wavelets, welch, hilbert, parametric spectral estimates

Features: high-level functions for electrophysiological data analysis

Functional connectivity analysis

- coherence, phase locking value, granger causality, and many more

Source reconstruction

- beamformers, dipole fitting, linear estimation

Statistical analysis

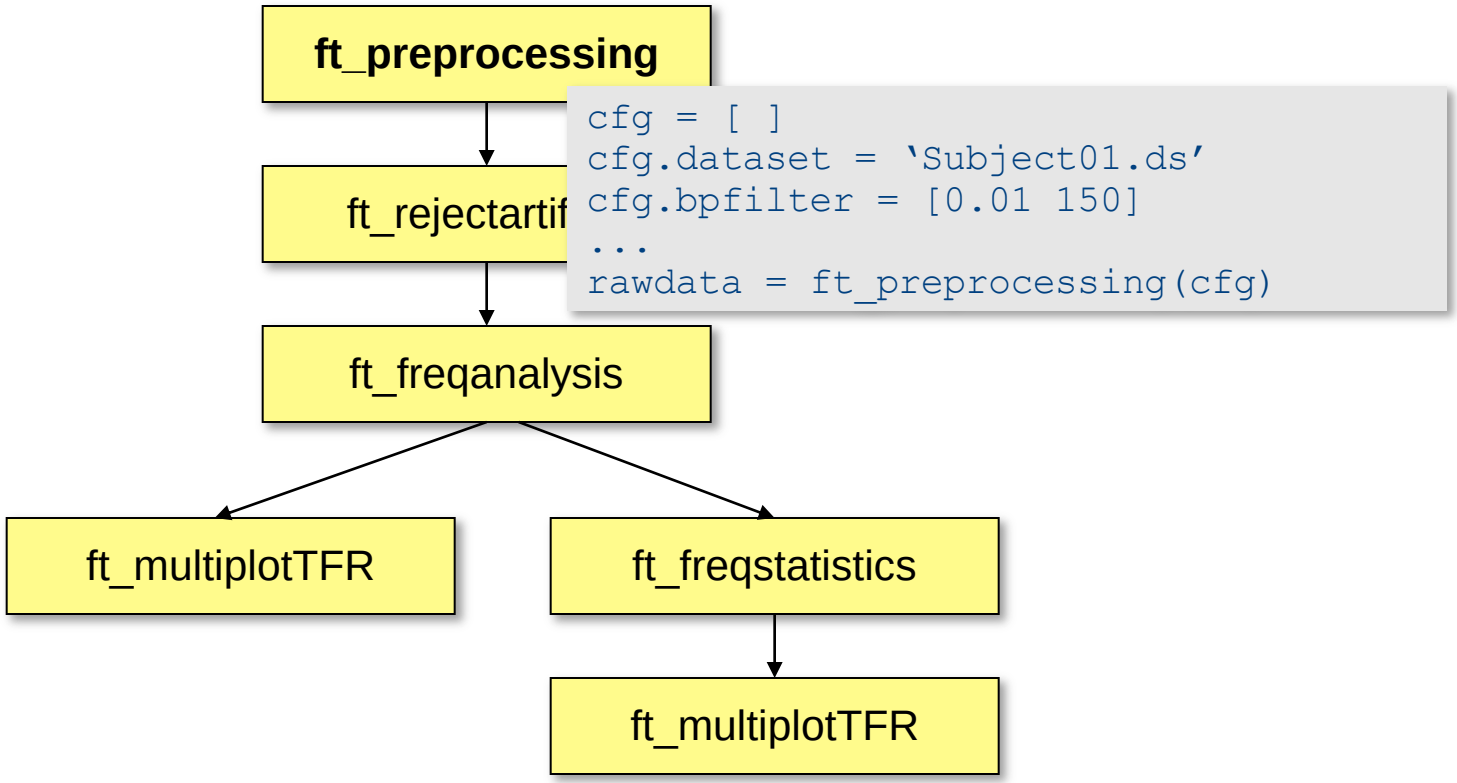
- parametric, non-parametric, channel and source level

All other operations that are required around it

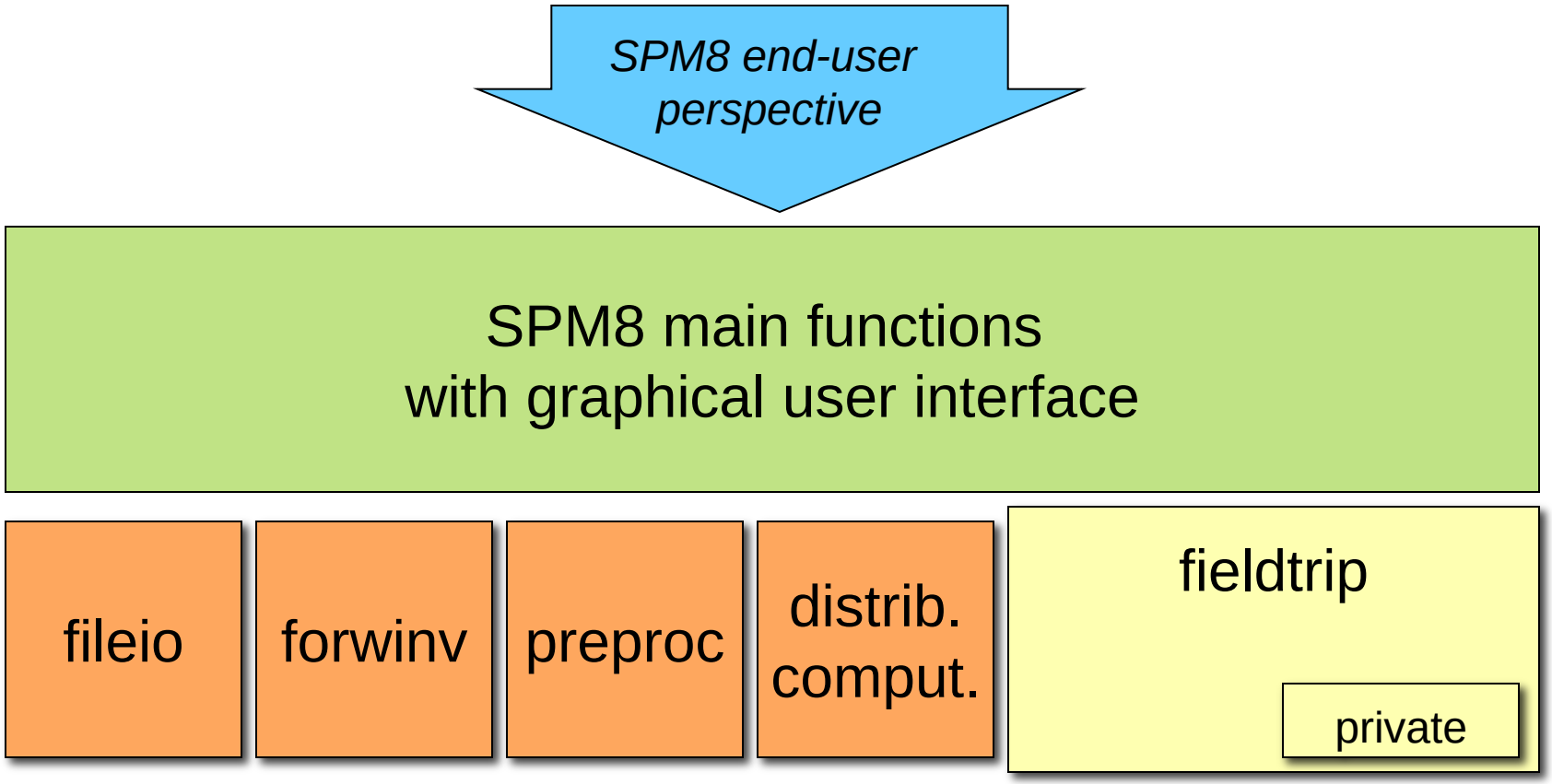
But…

Features

Analysis steps are incorporated in functions



FieldTrip toolbox - code reused in SPM8



- SPM8 provides complete analysis toolkit for M/EEG that can be easily applied to common experimental paradigms using GUI.

- Although there is complex theoretical background behind some of the methods implemented in SPM, the application of the methods is straightforward and does not necessarily require mathematical training or programming skills.

- DCM is a novel method different from all other available M/EEG analysis methods because it allows making inferences not about data features but about the underlying hidden causes.

- SPM8 developers have a formal collaborations with the developers of Fieldtrip toolbox and a fully functional version of Fieldtrip is included in SPM8. SPM and Fieldtrip functionality can be combined to create powerful custom analysis tools.