Functional SVS in the human brain at 9.4T

So far established:
- metabolite cycled STEAM (left) with optimized RF pulses (top: optimization of the metabolite inversion pulse) for shot by shot frequency and phase alignment to correct for frequency fluctuations due to physiological motion and to enable constructive averaging
- RF coil dedicated to the visual cortex
- compatible fMRI stimulation setup
- raw data readin and processing pipeline

Work in progress:
- motion correction based on optical tracking
- optimization of the substraction based analysis approach for functional 1H MRS
- functional MRS under visual stimulation
- functional MRS under pharmacological challenge

18 brain metabolites by JPRESS / ProFit @ 3T

- J-resolved PRESS spreads the spectral information along two spectral axes (chemical shift and J-coupling constants) and reduces the spectral overlap (left: 2D JPRESS from the human brain (2x2x2 cm³))
- ProFit V2 is an iterative spectral fitting approach for J-resolved spectra that (i) utilizes simulated baseline spectra of 18 metabolites
- (ii) considers a macromolecular and a spline baseline
- (iii) uses a spline line shape model extracted by self-deconvolution to account for line shape distortions introduced by B₀ inhomogeneity and frequency fluctuation over time
- (iv) allows for flexible handling of prior knowledge throughout the iterations
- (v) includes parameters modelling frequency offsets, phase offsets, T₂ relaxation times and concentrations
- the combination of JPRESS & ProFit is the only method that allows for simultaneous detection of 18 brain metabolites at 3T
- it's accuracy and precision has been extensively validated on simulated and in vivo data
- it is our current work horse for many clinical studies investigating disease and pharmacological effects
- got distributed to 80 sites

Validation of accuracy based on simulated "inter-subject" data with in vivo quality regarding 0 SNR, line shapes and baseline (left) and precision analysis on intra-subject in vivo data (right)

Spinal Cord SVS at 3T

Technical challenges and solutions:
- low SNR: small size and deep location
- dedicated close fitting receive array
- ultra-high field
- susceptibility borders
- 2nd order ECG triggered FASTERMAP B₀ shimming
- voxel positioning
- lipid contamination
- pulsatile CSF flow
- inner volume saturation
- ECG triggering
- flow compensation
- non-water suppressed metabolite cycled MRS for frequency and phase alignment

respiratory gating

navigator based prospective motion correction during calibration phases and acquisition

Results:
- Characteristic changes in the spinal cord metabolic finger print in multiple sclerosis and intramedullary tumors

EREITC for absolute quantification

Electric RFerence To access In vivo Concentrations:
- artificially synthesized NMR-like signal
- optical transmission line for signal stability
- inductively coupled into T/R coil
- scales with coil load
- phase, frequency and amplitude adjustable via the MRI console
- Voigt line shape – line width is also adjustable
- preparation phase for eddy current pre-distortion and phase correction to make resulting suitable for standard processing and spectral fitting pipelines
- artificial phase encoding for MRSI – free choice of voxel position
- requires one time calibration against high precision phantoms (i.e. T₂ relaxometry)
- high short and long term stability after warm up
- at high field a receive sensivity correction is necessary
- compatible with proton decoupling in 31P and 13C

EREITC includes parameters modelling frequency offsets, phase offsets, T₂ relaxation times and concentrations
- subject dependent, subject specific, subject variability
- very robust and easy to use
- applicable in a wide range of field strengths

EREITC scales with coil load

EREITC vs. internal water reference

EREITC enables reliable quantification of mM metabolite concentrations independent of internal reference standards that might alter in case of pathologies or not be present in case of ¹³C and ³¹P MRS