DOUBLE-SHOT CENTER-OUT ECHO PLANAR SPECTROSCOPIC IMAGING AT 3 TESLA

C. Labadie[1,2], S. Hetzer[1], T. Mildner[1], D. R. Amariei[3], M. Frécon[4], and H. E. Möller[1,2]
[1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [2]Faculty of Physics and Earth Science, University of Leipzig, Germany, [3]Servei de Ressonància Magnética Nuclear, Universitat Autònoma de Barcelona, Spain, [4]Laboratoire de Spectrométrie Ionique et Moléculaire, Université Claude Bernard Lyon 1, France

Introduction: In an echo planar spectroscopic imaging sequence, a gradient (typically G_x) is periodically cancelled at each spectral dwell-time enabling to recover spatial and spectroscopic information [1]. Varying two gradient directions permits a single-shot 2D spatial encoding within one spectral dwell-time [2]. At 3 Tesla, the spectral dwell-time limits the sampling of the phase encoding dimension (G_y). This work introduces a center-out phase-encoding sampling combined with a rewinder for coverage of one half of k-space. The second half is sampled during the following TR, and recombined with the corresponding first half after a template-based phase correction [3]. In order to mitigate effects of eddy currents, ADCs were acquired without ramp sampling (see Fig. 1).

Methods: A healthy volunteer (m 27y) was examined after informed consent on a TIM-Trio Siemens with a circularly polarized (CP) head coil: 4 OVS slabs positioned at the borders of a 101×101×17 mm^3 VOI (standard shim), TR 1.7 s, TE 33 ms, voxel size 17×17×17 mm^3 (4.91 mL), 12×12 matrix, 16 steps EXOR phase cycling, N_p 512 spectral points, 2 dummy double-shots, 160 double-shots separately stored. ADCs were progressively summed to study the effect of acquisition time. FFT was first applied along the readout dimension, and after a water template based phase correction along the phase encoding dimension. FIDs were processed with LCModel [4].

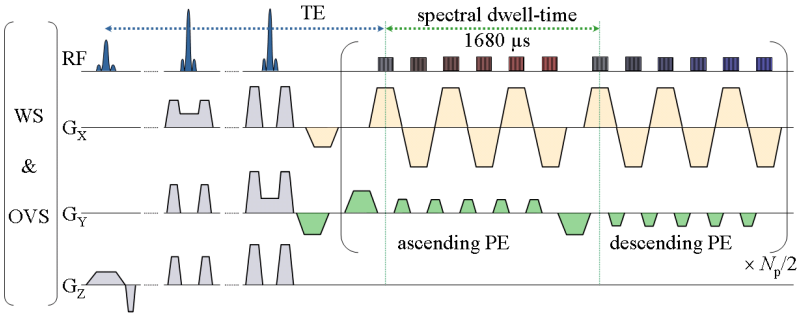

Fig. 1: Standard PRESS, with 3 WS and 2 OVS modules, selecting a VOI, followed by N_p center-out EPI modules returning periodically at each spectral dwell-time to the initial position in k-space. During the second shot, the sign of the green gradients is inversed to measure the second half of k-space of each spectral point. Furthermore, mechanical gradient resonances are avoided by alternating the center-out direction of consecutive spectral dwell-time, thus helping to keep the sequence away from forbidden gradient frequencies (an aspect that was independently controlled by a gradient spectral analysis). WS and green gradients are omitted during the water template acquisition. The spectral dwell-time of 1.68 ms yields a 4.83 ppm wide spectrum, which when centered at 2.8 ppm covers both the water (4.7 ppm) and fat peaks (methylene 1.3 ppm, methyl 0.9 ppm).

Results: The Table summarizes the standard error estimates (Cramer-Rao lower bounds) of the metabolite concentration as a function of the acquisition time. A 1:01 min long acquisition detects N-acetylaspartate (NAA), creatine (Cre), total choline (Ch), myo-inositol (mI) and glutamate (Glu). A baseline shape appears after 2:50 min acquisition. After 3:44 min acquisition, glutamine (Gln) is detected. The increased peak width with acquisition time may be related to movements.

TT min:sec	SNR	NAA %SD	Cre %SD	Ch %SD	mI %SD	Glu %SD	Gln %SD	FWHM ppm
1:01	6	6	6	9	12	10	30	0.033
1:56	8	5	5	7	10	11	22	0.033
2:50	10	4	4	6	9	12	20	0.033
3:44	10	4	4	6	9	14	17	0.038
4:39	11	4	4	6	9	14	19	0.038
5:33	11	3	4	6	9	12	17	0.047
6:28	12	3	3	5	8	10	18	0,052

Conclusion: The inherent advantage of the double-shot center-out EPI readout lies in a reduction of the spectral dwell-time that does not compromise k-space coverage. The resulting 4.83 ppm bandwidth provides a sufficient range to characterize the rest water and fat signals thus easing the determination of the macromolecular baseline found in short echo time spectra. Measurement with a multiple-channel array coil may provide an SNR sufficient for detection of further metabolites such as lactate.

References: [1] Matsui 1986 *JMR* 67:476; [2] Posse 2009 *MRM* 61:541; [3] Hetzer 2009 *Proc. ISMRM* 17:2663; [4] Provencher 1993 MRM 30:672

Acknowledgement: Funding by the European 6th Framework Programme MRTN-CT-2006-035801 contract of the FAST network.

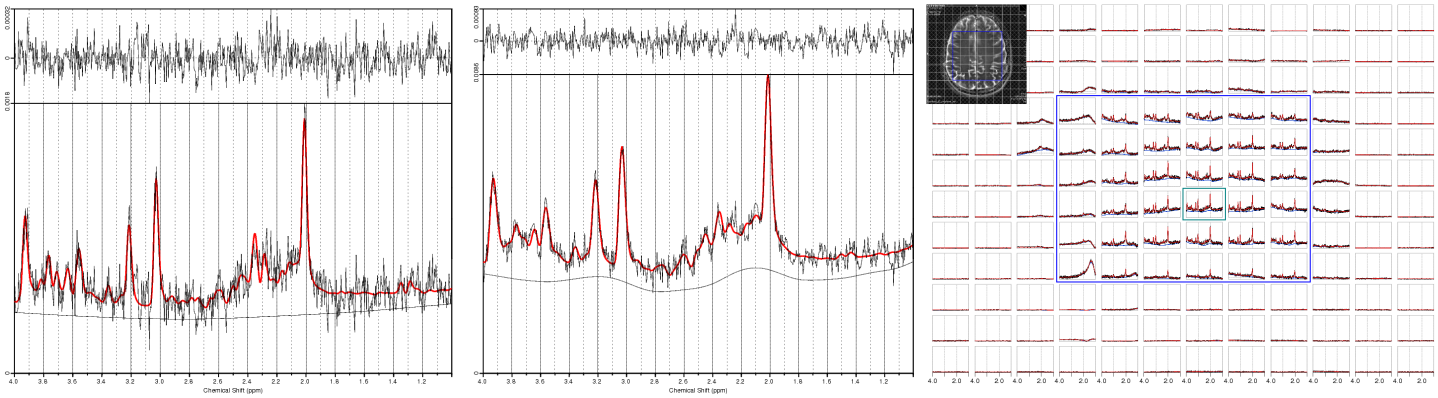

Fig. 2: (**left**) LCModel results of the first 1:01 min of acquisition for a center voxel (highlighted in green in the mosaic display); (**middle**) after a 5:33 min acquisition the macromolecular baseline displays more structure and the residuals are greatly improved; (**right**) mosaic display of the results obtained after 2:50 min acquisition; VOI selected by the PRESS excitation is highlighted in blue; rest fat signals are visible in the third and fourth columns that may be related to an insufficient outer volume suppression combined with a chemical shift displacement in the readout direction.