Large Spectral Bandwidth with Online Ramp Sampling Correction in Proton Echo Planar Spectroscopic Imaging of Human Brain at 4 Tesla

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Introduction:

Ramp sampling correction in high-speed spectroscopic imaging in human brain becomes necessary as spectral bandwidth and the relative proportion of ramp sampling increase. This is particularly important at high field to avoid contamination from peripheral lipids due to the point spread function. Here we explore the limits of spectral bandwidth and spatial resolution with Proton-Echo-Planar-Spectroscopic-Imaging (*PEPSI*) [1] at 4 Tesla.

Methods:

Measurements were performed on a healthy volunteer using a 4 Tesla Bruker MedSpec scanner, equipped with Sonata gradient system (maximum amplitude for short trapezoid gradients = 26 mT/m, maximum slew rate = 200 mT/m/ms) and quadrature head coil. PEPSI data were acquired from a para-axial slice at the upper edge of the ventricles with TR 2 s and short TE (14 ms), using 32x32 or 64x64 spatial matrix with minimum pixel size of 6 and 3 mm, respectively. The corresponding maximum spectral width after even/odd echo sorting [1] was 1.72 kHz at 6 mm resolution and 1.1 kHz at 3 mm resolution. Complete 8-slice outer volume suppression was applied along the perimeter of the brain (fig.1). Saturation pulse flip angles were optimized to minimize lipid contamination and 8-step phase cycling of the spin-echo pulses was employed. Ramp sampling correction was implemented as an ICE-Functor for online regridding of the time domain data. Even- and odd-echo data were reconstructed separately using a water reference scan for automatic phasing and frequency shift correction as described previously [1]. Spectra were quantified using LCModel fitting [2]. Absorption mode spectra from individual array coils were summed. Metabolic images were computed using relative concentration values from LCModel. Cramer-Rao lower bounds were mapped to assess regional differences in quality of fit.

Results:

Ramp sampling correction provided considerable improvement in spatial localization that was bandwidth dependent as shown in Fig.1-4. Lipid contamination at short TE was well controlled (Fig.4 and 5), which enables mapping of coupled resonances up to the edge of the volume of interest.

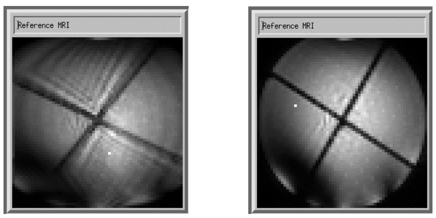

Fig.1: Spectroscopic images of un-suppressed water obtained without (left) and with (right) ramp sampling correction at 0.92 kHz bandwidth.

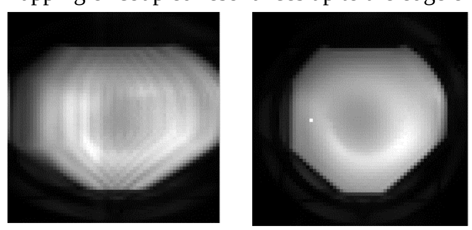

Fig.2: Spectroscopic images of un-suppressed water obtained without (left) and with (right) ramp sampling correction at 1.1 kHz bandwidth.

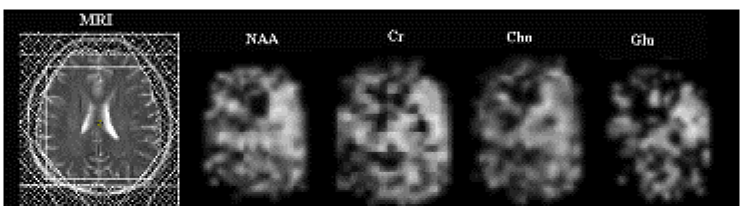

Fig. 3: Metabolite images at 4 Tesla without ramp sampling correction showing artifactual inhomogeneity (TE: 30 ms, 1.5 cm slice, 1 cm in-plane resolution, 8 minutes acquisition time).

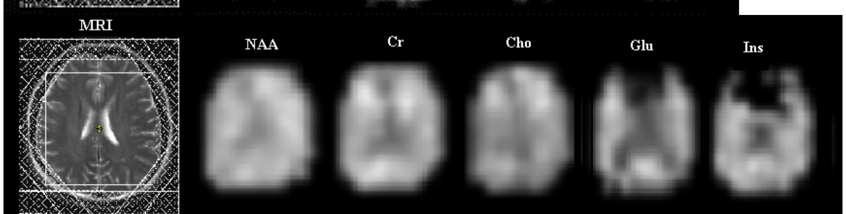

Fig.4: Metabolite images at 4 Tesla with ramp sampling correction (TE: 14 ms, 1.5 cm slice, 1 cm in-plane resolution, 8 minutes acquisition time). Cramer-Rao lower bounds: NAA - 3%, Cr - 5%, Cho - 5%, Glu - 9%, Ins - 11%

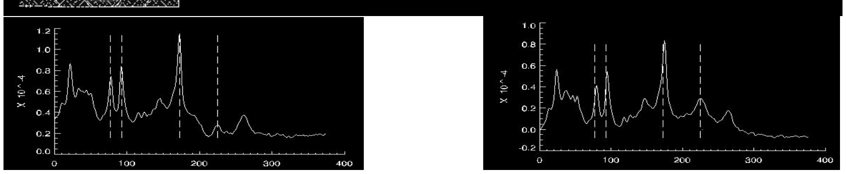

Fig.5: Examples of central and peripheral spectra from the data set in Fig.4, showing only minor lipid contamination.

Discussion:

Large spectral bandwidth up to 1.7 kHz for 6 mm voxel size is feasible when using the Sonata gradient system. However, ramp sampling reduces overall efficiency as compared to conventional phase encoding [3]. It is thus advantageous to use the smallest acceptable spectral width to minimize gradient ramps. Faster gradient slew rates provided by head gradient inserts are desirable as field strength increases, to limit ramp sampling.

Literature:

(1) Posse, S., et al., Magn Reson Med, 33, 34, 1995 (2) Provencher, S., Magn Reson Med 30:672, 1993. (3) Pohmann, R. et al. J. Magn Reson 129, 145, 1997

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