# Skewed adiabatic pulses for outer volume suppression in single voxel spectroscopy

**F. Giove[1,2], F. Marcocci[1], F. Fasano[1,3], M. DiNuzzo[1], G. E. Hagberg[3], and B. Maraviglia[1,2]**
[1]Department of Physics, Sapienza University of Rome, Rome, RM, Italy, [2]MARBILab, Enrico Fermi Center, Rome, RM, Italy, [3]Neuroimaging Laboratory, Fondazione Santa Lucia IRCCS, Rome, RM, Italy

## *INTRODUCTION*

Commonly, the product spectroscopic sequences available on commercial scanners don't take full advantage of the scanner hardware. At an intermediate, now widely available field of 3T, issues like chemical shift displacement and contamination by external lipids become a problem, especially because of the low $\gamma$B1 and the slow prescribed gradients. In this context, detection of metabolites at low concentrations and with chemical shift near large lipid resonances (e.g. like lactate) is critical. Here we adopted an OVS suppression based on skewed asymmetric adiabatic pulses [Hwang1999], along with high performance dephasing gradients, in order to examine to what extent a substantial decrease of voxel signal contamination can be obtained on clinical scanners, without compromising water suppression efficiency.

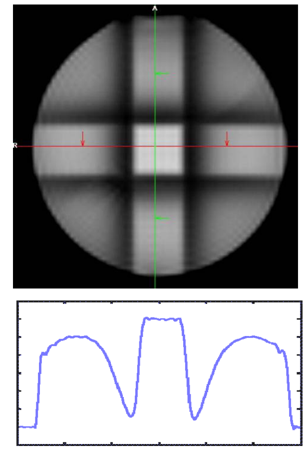


**Figure 1:** EPI axial image of a spherical phantom acquired after the OVS pulses, and profile averaged on the red line

## *METHODS*

All measurements were performed on an Allegra 3T Siemens head scanner, that features gradients capable of 40 mT/m and 400 mT/m/ms and a conventional birdcage transceiver coil. Spectra were preprocessed with JMRUI and quantified with LCModel.
Outer volume suppression was obtained with 3 consecutive OVS blocks (nominal thickness 30 mm), interleaved with water suppression, each including 6 saturation bands with variable distance from the voxel edge. Skewed pulses were used for RF excitation in non-adiabatic manner. The amplitudes of RF pulses corresponding to the second OVS block were modulated to compensate for B1 inhomogeneities. Selective excitation pulses were followed by crusher gradients with variable amplitude (between 16 and 30 mT/m) and short rise time (200us, corresponding to about 75% and 37% of the maximum gradients amplitude and slew rate, respectively).
Optimal distance between voxel and OVS bands was found using a two chambers, cubical phantom (with a solution of Creatine in the internal and Choline in the external chamber). An ordinary PRESS (TE 30 ms, TR 4 s) or low TE STEAM (TE 8 ms, TR 4 s). were used for the localized spectroscopy both in vitro and in 4 subjects (8 ml voxel placed in the visual cortex).
Two water suppression techniques were implemented: 4 pulses WET [Ogg1994] and VAPOR [Tkác1999], both based of repeated chemical shift selective pulses, the latter with 3T numerically optimized relaxation delays.

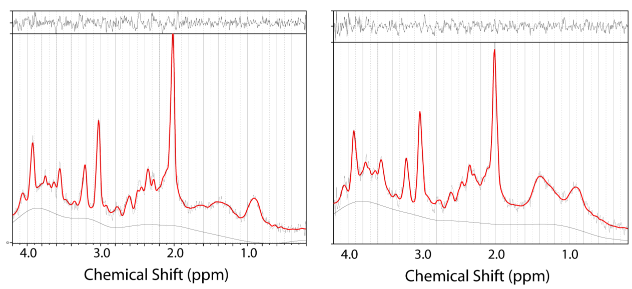
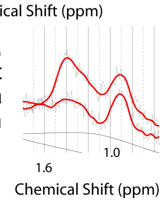



**Figure 2:** In vivo spectra (PRESS, 128 scans, TE 30ms) acquired with (top left) or without (top right) OVS pulses. In the bottom box a magnification of the spectra superimposed in the 1 ppm region (same scale) is shown.




## *RESULTS AND CONCLUSIONS*

The optimal distance between voxel and OVS bands, i.e. the one minimizing the contaminant signal and maximizing the internal signal, was found to be between 0 and 1 mm in the cubical phantom. The profile of magnetization measured by substituting the spectroscopic part with an EPI module matched the theoretical predictions and proved very good (Figure 1).
Suppression of extravoxel signal was found to be good or very good in all the investigated subjects. The most critical sequence was PRESS, because of inherently poorer selectivity of $\pi$ pulses. PRESS spectra showed some residual contamination, although selectivity was evidently improved (Figure 2).
The area of the residual water versus NAA peak area obtained in vivo with PRESS was 0.45±0.25 with 4 pulses WET and 0.25±0.15 with VAPOR, irrespectively of the OVS pulses played or not. Residual water signal with full VAPOR (including TM pulse) and STEAM was generally not measurable in the same conditions (Figure 3).
These results showed that the spectral quality can be substantially improved on clinical scanners including OVS pulses and optimal water suppression. The asymmetric adiabatic pulses [Hwang1999] proved especially suited for this application because the sharp selection profile on the voxel side allows the saturation bands to be prescribed adjacent to the voxel, while the poor selection of the far side of the band is not a concern.

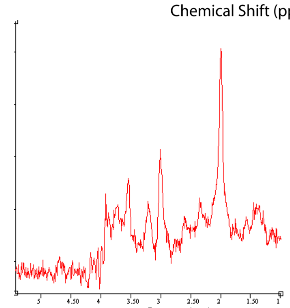


**Figure 3:** Full VAPOR water suppression is not affected by OVS pulses (STEAM, 16 scans, TE 8 ms)

## *REFERENCES*

Hwang TL, van Zijl PC, and Garwood M. Asymmetric adiabatic pulses for NH selection. J. Magn. Reson. **138:** 173-177 (1999)
Ogg RJ, Kingsley PB, and Taylor JS. WET, a T1- and B1-insensitive water-suppression method for in vivo localized 1H NMR spectroscopy. J Magn Reson B **104:** 1-10 (1994)
Tkác I et al. In vivo $^1$H NMR spectroscopy of rat brain at 1 ms echo time. Magn. Reson. Med. **41:** 649-656 (1999)