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Spurious Phase Correction in Multi-Shot CSI

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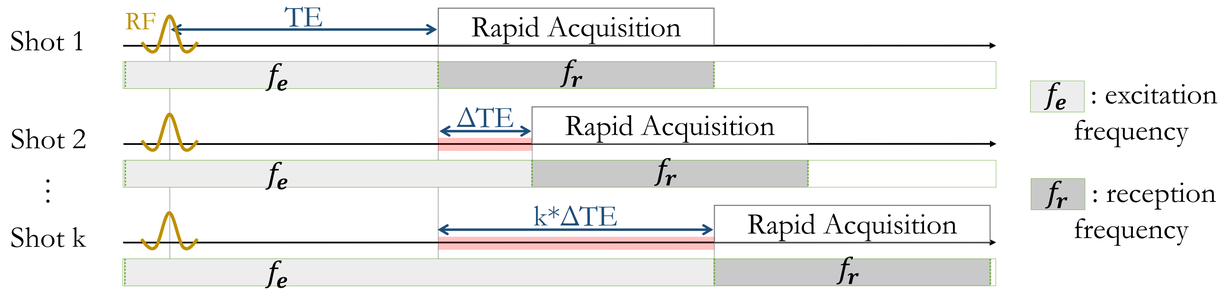
I. Introduction

- Multi-shot CSI : CS study during the TE increments (ΔTE) (refer to Fig1)
- Importance of maintaining a phase coherency during ΔTE
- Phase coherency's loss induces spectral distortion

Fig1: MRSI encoding scheme & frequency switching.



II. Problem

Slice Selection:

- Done with shifting the excitation frequency proportionally to the wanted position z: $\Delta f_e(z) = SW \times \frac{z}{FOV_z}$. Ergo, $\Delta f_e = 0$ for centred slice ($z = 0$)

However:

- Unwanted additional phase can be accumulated during ΔTEs leading to spectral distortion, hence improper images ➡ Correction is mandatory !

III. Two Proposed Solutions

1. Post-Processing Correction (**pP-C**). With S the acquired signal, k the number of shot:

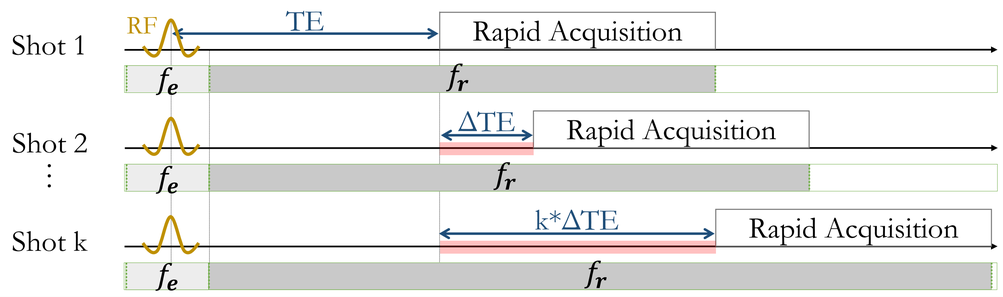
$$S_{corrected}(k,z) = S_{raw}(k,z) \times \exp(-i2\pi \times \Delta f_e(z) \times (k-1) \times \Delta TE)$$

2. Switching from the f_e to the f_r (dependent on the readout position and independent of z) after the excitation pulse (**RF-switch**) :

$$S_{corrected}(k) = S_{raw}(k) \times \exp(-i2\pi \times \Delta f_r \times (k-1) \times \Delta TE)$$

For non-Cartesian spatial encoding, readout is always centred. Ergo $\Delta f_r = 0$.

Fig2: MRSI encoding scheme with adjusted frequency switching -**RF-switch**.



IV. Application

Correction methods were applied on ^{13}C multi-shot CSI recorded with IDEAL SPIRAL [1] at a static magnetic field of 11.7 T.

Experimental Details:

- Phantom of four syringes containing ^{13}C-labelled Lactate (4 M, 182.2 ppm), Alanine (1.85 M, 175.8 ppm), Pyruvic acid (16.4 M, 174.5 ppm) and Urea (16.4 M, 162.5 ppm)
- Parameter optimisation through effective number of signal averages (NSA) [1] analysis : 7 shots and ΔTE = 0.86 ms
- For non hyperpolarized molecules: TR = 10 s, TE = 1.69 ms and a slice thickness of 15 mm
- Image resolution of $(0.78 \times 0.78 \times 15\ mm^3)$

1. doi 10.1002/mrm.23212

Fig3: ^{13}C metabolite maps of ^{13}C-labelled molecules, for a centred and a shifted slice, superimposed on a ^{1}H reference image.