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## Spurious phase correction in multi-shot CSI

Nour El Sabbagh, Carine Chassain, H el ene Ratiney, Guilhem Pag es, J.-M.  
Bonny

► **To cite this version:**

Nour El Sabbagh, Carine Chassain, H el ene Ratiney, Guilhem Pag es, J.-M. Bonny. Spurious phase correction in multi-shot CSI. ESMRMB 2020 - 37th annual meeting, Sep 2020, Inconnu, France. hal-03238472

**HAL Id: hal-03238472**

**<https://hal.inrae.fr/hal-03238472>**

Submitted on 27 May 2021

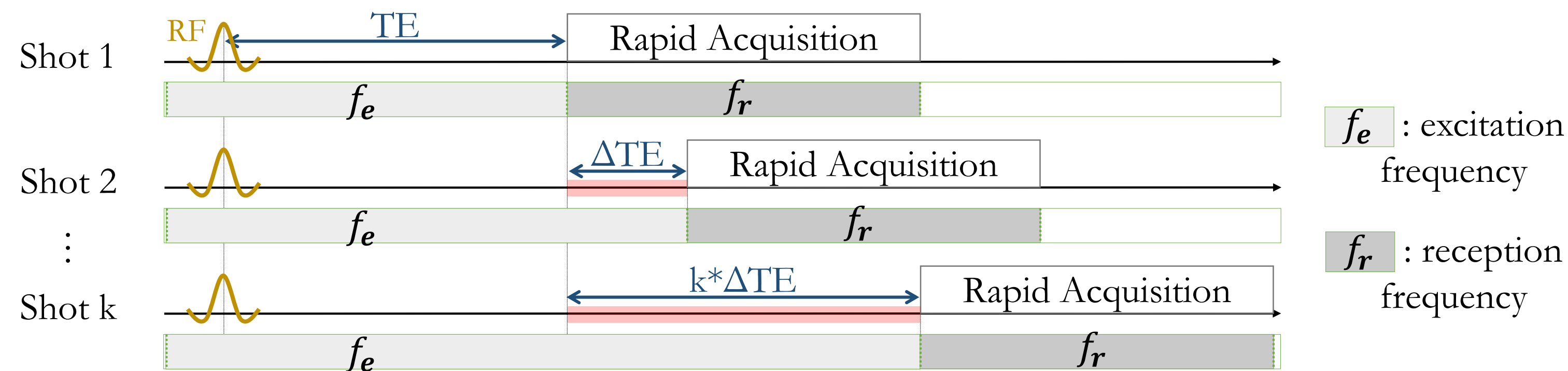
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## I. Introduction

- Multi-shot CSI : CS study during the TE increments ( $\Delta TE$ ) (refer to Fig1)
- Importance of maintaining a phase coherency during  $\Delta TE$
- 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  $\Delta TE$ s leading to spectral distortion, hence improper images  $\rightarrow$  Correction is mandatory !

## III. Two Proposed Solutions

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

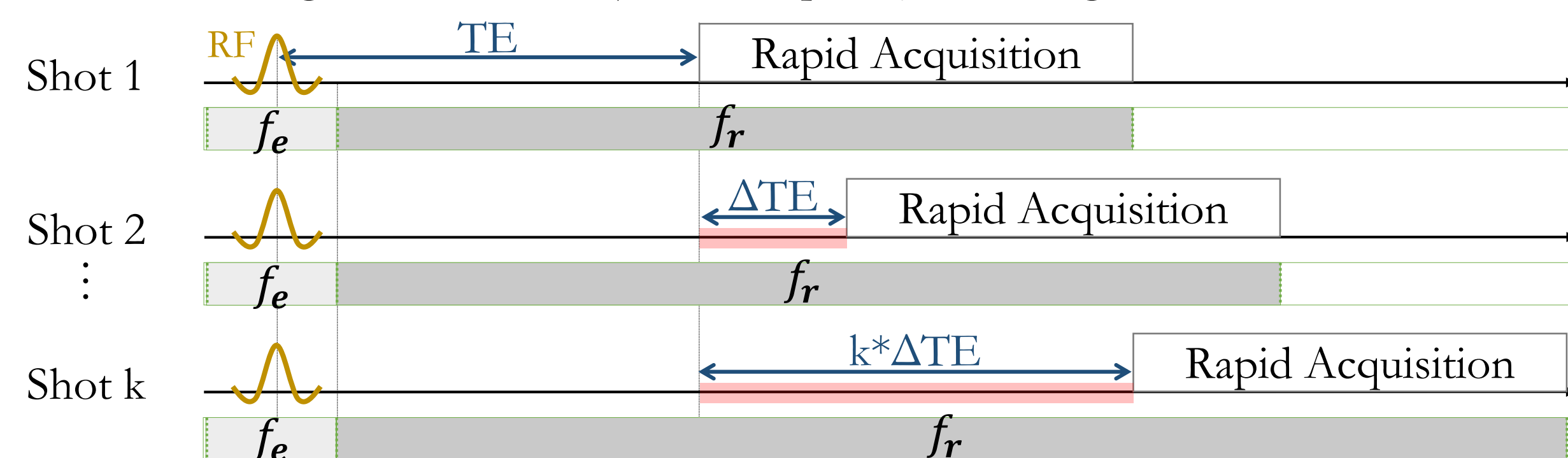
$$S_{corrected}(k, z) = S_{raw}(k, z) \times \exp(-i2\pi \times \Delta f_e(z) \times (k - 1) \times \Delta TE)$$

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  $\Delta TE = 0.86$  ms
- For non hyperpolarized molecules: TR = 10 s, TE = 1.69 ms and a slice thickness of 15 mm
- Image resolution of  $(0.78 \times 0.78 \times 15 \text{ mm}^3)$

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  $^1H$  reference image.

