System Characterization for VP-PROPELLER MRA

N. R. Zwart[1], and J. G. Pipe[1]
[1]Keller Center for Imaging Innovation, Barrow Neurological Institute, Phoenix, AZ, United States

Introduction

VPPROP MRA is a 2D-3D hybrid sequence that employs frequency swept 'chirp' rf pulses to acquire thick-overlapping-slabs as a 2D acquisition (ie. there are no phase encodes for the slice direction). The parabolic phase induced by the chirp rf pulse (Fig1:c,g) can be reconstructed to obtain prescribed slice thickness with similar SNR benefits to a 3D sequence (Fig1:b,d,e). The in-plane trajectory is a PROPELLER-GRE with asymmetrically sampled blades which reduce the first moment in the readout direction to compensate for dephasing due to in-plane flow. The blades are rotated 360^{O} which provides critically supported high frequency k-space and a highly oversampled center of k-space for PROPELLER motion correction in MRA. Blood contrast is ostensibly attained through flow related enhancement and is further augmented by partially refocusing G_z[1]. Flow artifacts caused by through plane motion are mitigated by partially refocusing G_z which reduces the first moment in K_z, just as the in-plane TE is shortened by collecting asymmetric blades. When combined with parabolic encoding, the partially refocused G_z shifts the parabolic vertex towards an edge of an excited slab, based on the direction of the RF frequency sweep (Fig1:c,k). This has the effect of expressing the blood flowing into the slab edge closest to the parabolic vertex and suppressing blood entering the opposing edge, without the need for a preceding saturation pulse. The additional SNR increase provided by the parabolic phase encoding works to improve upon signal losses due to slow or tortuous flow.

The focus of this work is to characterize the system response of the chirp rf pulse and partially-refocused-chirp rf pulse.

Procedure

A thin slice phantom (Fig1:a) is scanned in the direction normal to the slice, to simulate a delta function in K_z. The range of frequencies to be swept over can be deduced by considering the bandwidth of one slice is:

$$\Delta_\omega = \gamma \, G_z \, \Delta_z \qquad (1)$$

It follows that exciting 'M' number of slices:

$$\Delta_\omega = M \, \gamma \, G_z \, \Delta_z \qquad (2)$$

$$M = \Delta_\omega \, / \, \gamma \, G_z \, \Delta_z \qquad (3)$$

Rearranging equation (2) reveals M to be a time-bandwidth product, which determines the width of the parabolic phase[2]. Successive slabs overlap by M-1 slices. This infers that a fully supported slice will have to be the center of a volume with at least 2M+1 acquired slabs.

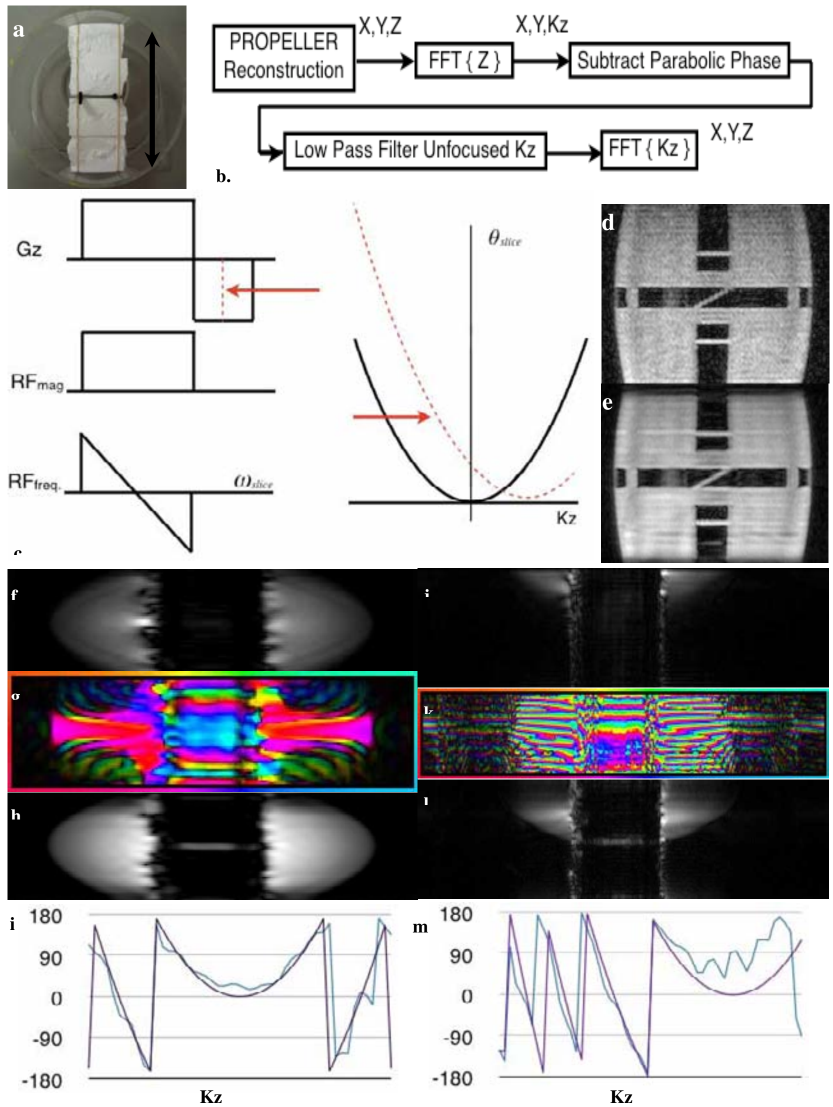

Fig1: a) (delta-phantom) A column of polystyrene is separated by 4mm of space to simulate a single slice normal to the direction of the arrow. b) Reconstruction order for VPPROP. c) Partially refocusing G_z will shift the vertex of the parabolic phase towards one edge of the slice. The sampling window in K_z then contains higher freq. which will increase resolution. d) Resolution phantom, M=0; e) M=24, $SNR_{gain}=\sqrt{M}$. f) Cross section of axial scan using delta phantom M=24: X-Z with dispersed energy; g) X-K_z phase map. parabolic phase is evident down the center of K_z corresponding to the single slice in the delta-phantom; h) X-reconstructed Z; i) Applied and measured phase in degrees. j,k,l,m) Same as f,g,h,i, with 25% G_z refocusing and M=24.

[1] Pipe.J, MRM 41:309 99'; [2] Pipe.J, MRM 36:137 96'