Strip-MAMBA: Combined Step Field and Gradient 2D Planar Encoding

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Synopsis
A new method of collecting ultra-fast 2D images, known as strip-MAMBA, has been demonstrated experimentally. The images have conventional resolution in the frequency encode direction but orthogonal in-plane resolution dependent on the number of coils in a B_0 step field array, which encodes through a priori knowledge of the coil location. A single unidirectional readout gradient is used to encode one dimension whilst the second in-plane dimension is encoded without conventional switched phase encoding in a single shot. The method has been tested on phantoms yielding very rapid 2D image frame rates.

Introduction
Auxiliary B_0 step coils can be used to produce unique magnetic field strengths at discrete locations, thereby allowing simultaneous imaging of a plane without imaging gradients [1]. Step fields can also be used to image parallel slices simultaneously without aliasing using a conventional imaging process [2]. Although 2D MAMBA allows virtually instantaneous imaging, a limitation is poor in-plane resolution, the pixel size being similar to the dimensions of the auxiliary coils creating the field. An alternative trade-off is to use strip-MAMBA [3], which combines MAMBA parallel step field imaging in one in-plane direction with the resolution obtained by gradient encoding in the other direction. The field steps modify both the frequency and phase of the signal so that together with the frequency encode gradient each pixel within the 2d plane is encoded uniquely within a single data acquisition. The data set is 1D transformed and can then be reorganised into a 2D image using a priori knowledge of the coil positions. This sequence allows ultra-short TE single acquisition, single shot imaging of a thin plane of spins contained within the MAMBA coils with high resolution along one direction.

Methods
An array of six circular 25 mm diameter coils with increasing number of turns was constructed to produce a stepped B_0 field in the x (conventionally the phase encoding) direction and located in the head coil of a 1.5T MR (Eclipse, Philips Medical) as shown in figure 1. MR marker capsules were located at the centre of each coil. To demonstrate the method, a conventional 2D axial spin echo sequence was collected without phase encoding in the presence of the MAMBA field (7 slices, TR=200ms,TE=16ms, FOV = 60mm, SLT = 5mm, 128x256, effective NEX = 128) with standard 2DFT reconstruction. Images with and without the MAMBA current (500mA) applied were added together to show the frequency/phase shifts due to the coils. Further processing of the raw data set allowed time resolved 2D images to be calculated for all 128 excitations.

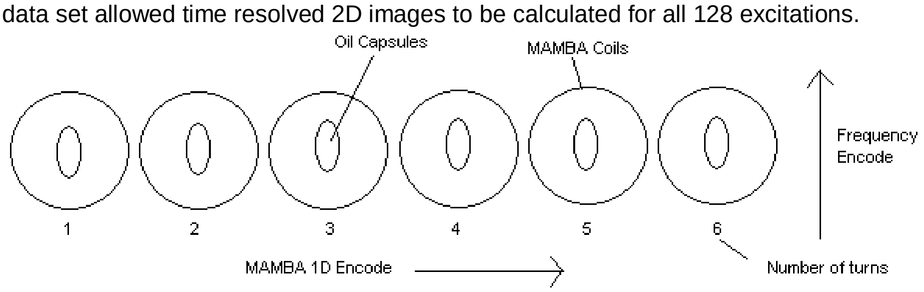

Figure 1. Schematic of 1D MAMBA array and marker capsules. B_0 is perpendicular to this plane.

Results
Without the current applied, all the projections of the oil capsules collapsed into a single line at zero phase (Figure 1 left arrow) Projections from each of the six coils were clearly visualised when the current was switched into the array Figure 1 right arrow). The projections were shifted in both the frequency and phase directions in proportion to the current in each coil. Separation could be increased by increasing the current in the B_0 array.

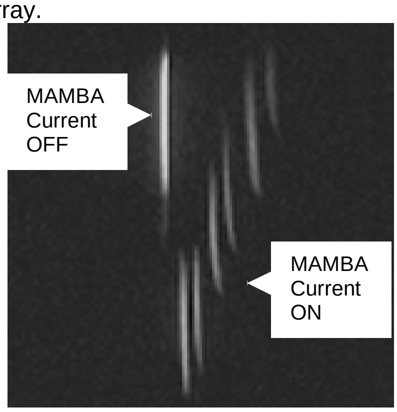

Figure 2 Six spatially resolved projections are seen with I=500mA and NO switched phase encoding. The figure shows the sum of images acquired without (single projection) and with (six projections) current applied to illustrate the frequency and phase shifts produced by the MAMBA 1D array.

Discussion
A 6x256 resolution image was acquired with each frequency encode gradient application. This method enables very high time resolution imaging without the need for reversing switched gradients as used in EPI. The resolution in one direction is governed by the number of coils in the 1D MAMBA array and could be made much higher than presented here using target field coil design (3). Strip-MAMBA may be useful for very high temporal resolution 2D imaging of thin planes of spins e.g. material in an industrial planar flow process or for superficial structures where high time resolution is required such as in studies of direct neuronal firing using MR detection.

References
(1). Lee KJ *et al*. Magn Reson Imaging 2002;20:119-25 (2). Paley MNJ et al. MRM, In Press, Dec 2002. (3). Lee KJ *et al*. Proc. 8th Meeting BCISMRM, Sheffield 2002.