In-vivo brain 3D RSI (Rosette Spectroscopic Imaging) with spherical/ellipsoidal encoding. Comparison to 3D RSI with cylindrical encoding and to ellipsoidal CSI.

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Background: With the increased SNR provided by high field (3T) scanners and high density array coils, the classical CSI encoding scheme is the main limitation in achieving moderately higher spatial resolution for *in*-vivo brain metabolites. Cartesian (EPSI) and non-Cartesian (spiral, rosettes, etc) sampling schemes have been demonstrated to speed up the data acquisition in spectroscopic imaging experiments. Here, we experimentally demonstrate - using the MRS braino phantom and *in*-vivo brain- Rosette Spectroscopic Imaging (RSI) with spherical encoding and compare its point spread function (PSF) to RSI with cylindrical encoding[1] and CSI with classical and ellipsoidal encoding [2].

Materials and Methods: Data was collected on a Tim Trio 3T scanner (Siemens, Erlangen, Germany) with SRmax=170mT/m/ms, using a 12-channel coil. The LASER excitation scheme [3] was used and the partitions in the Z-direction were encoded in a classical/Cartesian way; data in each partition was collected using rosette trajectories. Instead of collecting data on a disk of radius Kmax in each partition, the radius of the kx-ky disk sampled in each partition was calculated as $\sqrt{K_{max}^2 - K_z^2}$. Trajectories were designed for half of the kz partitions, according to the design described in [4]. A spectral width SW=1200Hz and FOV=16x16x8 cm^3 were used, for a nominal spatial resolution of 1cc. For partitions positioned at kz and –kz, equally distant from the center partition (kz=0), the same trajectories are used for data collection. The first partition is sampled by a single FID at the center of kx-ky space and 13/14/15/15/15/14/13 shots are used for the other partitions, for a total of 100 excitations. For comparison, the cylindrical K-space encoding requires 8*15shots=120shots. Complex data sampling rate was 10us, readout 320ms, 32K points sampled per FID. The region of interest (ROI) excited by LASER was either 12x8x4 cm^3 (phantom) or 10x10x4 cm^3 (in-vivo). Echo/repetition time were TE/TR=45/1000ms, for a scan time of 1:44 min:sec, including 4 equilibrium acquisitions. Data in each partition was gridded on a 3D (kx-ky-t) two-fold oversampled grid and FFT in all 4 directions performed. Channel recombination was done after reconstructing data in each channel. No spatial or spectral filters were used and images were zero-padded to 64x64x32 with 384 spectral points for each spatial location.

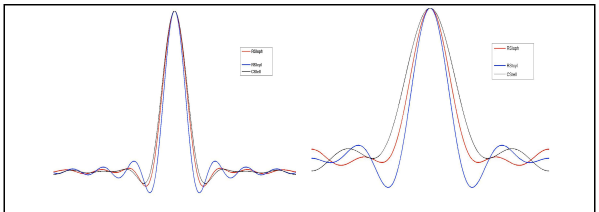

Fig 1:. *XY (left) and Z (right) PSFs for ylindrical and spherical RSI (*RSIcyl *in blue and* RSIsph *in red) and spherical/ellipsoidal CSI (*CSIell, *black).*

Results: While compared to the RSI with cylindrical encoding the effective resolution is slightly lower for the RSI with spherical encoding, the side lobes of the PSF are smaller in both xy- and z-direction (**Fig 1**), which reduces ringing artifacts. Both cylindrical (RSIcyl) and spherical/ellipsoidal RSI (RSIsph) have narrower FWHM (full width at half maximum) compared to the PSF for ellipsoidal CSI (CSIell). In fact, calculating the effective resolution as the product of the FWHMs in x,y and z directions, it was found that the effective voxel size/volume for RSI with spherical encoding is 3.9 smaller compared to ellipsoidal CSI. NAA maps for the phantom and in-vivo brain of a healthy volunteer are presented in **Fig 2**.

Sequence\FWHM	XY dir	Z dir
RSIsph	**1.15**	**1.17**
RSIcyl	**1.04**	**1**
CSIell	**1.73**	**3.53**

Table: *Relative FWHM in XY-direction and Z-dir for simulated PSFs with respect to classical CSI*

Discussion and Conclusions: RSI with spherical encoding uses rosette trajectories to sample a sphere in K-space rather than a cylinder, providing for isotropic resolution in this setting. A reduction in scan time of 15-30% (depending on resolution chosen) can be achieved compared to the cylindrical K-space RSI acquisition. Compared to ellipsoidal CSI, RSI with spherical encoding provides greater than a factor of 5 speedup in data acquisition and, at the same time, a 3.9 better effective spatial resolution. These benefits increase further for higher matrix sizes than the 16x16x8 used here.

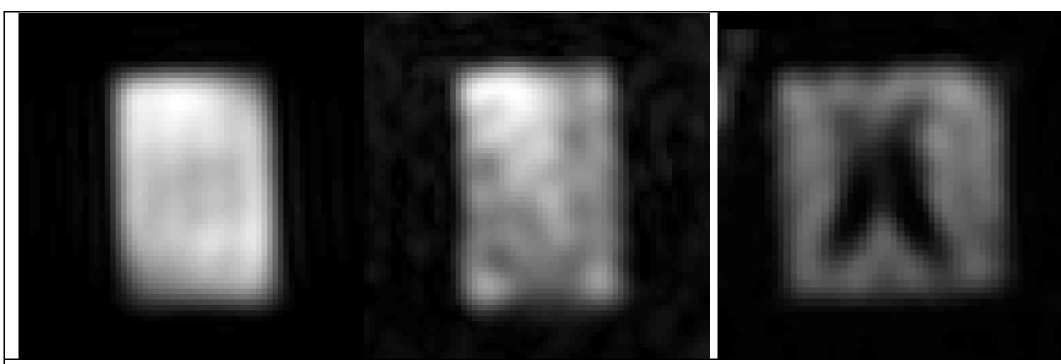

Fig 2. *4D reconstruction of K-t data acquired with RSI with spherical encoding: Braino MRS phantom, water (left) and NAA (center) resonances and in-vivo brain NAA map (right). Acquisition matrix 16x16x8, interpolated to 64x64x32.*

References: 1) Schirda et al, ISMRM 2011, p. 1425. 2) Maudsley et al. MRM 1994 3) Andronesi et al., JMR 2010 4) Schirda et al, JMRI 2009