# 4T Actively-Detunable Double-Tuned 1H/31P TEM Head Volume Coil and Four-Channel 31P Phased Array for Human Brain Spectroscopy

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**Introduction:** Although the $^{31}$P spectroscopy is often limited by the available SNR, there are few reports of the use of $^{31}$P phased arrays to increase sensitivity for brain studies. Although receive-only $^{31}$P phased arrays in combination with larger transmit-only surface coils have been reported (1,2); to our knowledge their use with homogeneous transmit volume coils, has not been reported. To provide high-resolution anatomical imaging and shimming with a homogeneous coil without removal of the coil or patient from the magnet, double-tuning of the volume transmit coil and active detuning of the volume coil and array is required. In this work we describe the design and construction of a $^{31}$P/$^{1}$H double-tuned TEM transmit-receive volume coil/ $^{31}$P receive-only phased array for $^{31}$P spectroscopic imaging (SI) of the human brain at 4T.

**Methods:** A double-tuned $^{31}$P/$^{1}$H (69MHz/ 170 MHz) TEM head coil was built using 24 coaxial resonant elements (3) with alternate elements tuned to the two frequencies ($^{31}$P and $^{1}$H). The coil measured 23.9 cm in length with an RF shield o.d. of 38 cm and an element i.d. of 31.8 cm. The coil was driven in quadrature using two-port drives (Fig.1A). Active detuning of the volume coil at both frequencies was provided using PIN diodes (4,5). To improve decoupling the PIN diodes across each element were connected in series with inductances to form resonant tank circuits (6). Additionally, the PIN diodes were placed at the coil entrance where TEM elements were adjusted to tune the tank circuits. Elements near the back wall were used to tune the TEM coil. A $^{31}$P phased array circumscribing a head was built using 6.4mm wide copper tape and consisted of four 9 x 10 cm surface coils as shown in Fig. 1B. After additional inductive decoupling the coupling between surface coils loaded with a head or a phantom was less than -20 dB. Triaxial baluns, used to prevent shield currents, were constructed to provide high resistive impedance both at 69 and 170 MHz. For that purpose the cable length was chosen slightly longer than the quarter wavelength at 170 MHz (~30cm) and a series resonant circuit was connected between the two shields. This circuit was adjusted to obtain high resistive impedance at both frequencies. All images and spectroscopic data were acquired on a Varian INOVA 4T whole-body system. Spectroscopic images were acquired using a non-selective excitation pulse and 13x13x13 spherical encoding over a FOV of 24x24x24cm$^3$. The data was acquired using 6 averages and a TR of 0.5s for an acquisition time of 48 minutes.

**Figure 1**
A) Back and B) front views of $^{1}$H/$^{31}$P actively detunable TEM volume coil with the $^{31}$P array inside

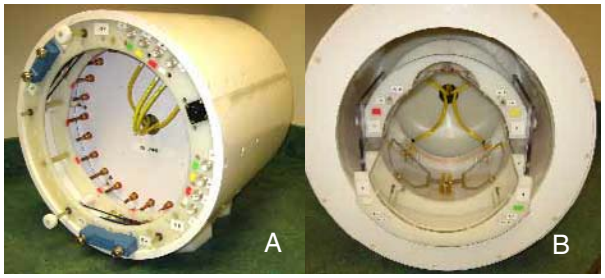
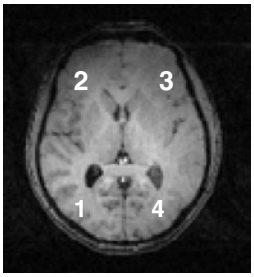
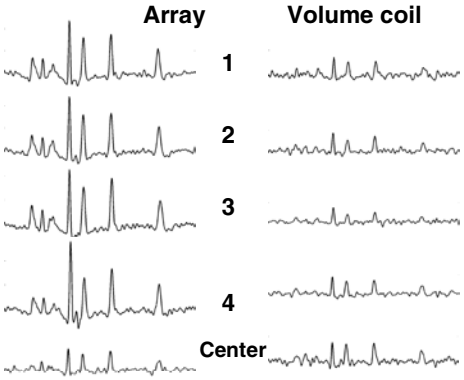



**Figure 2**
$^{31}$P Spectroscopic data




**Results and Discussion:** Figure 2 displays spectroscopic imaging data acquired using the four-channel $^{31}$P phased array and the TEM volume coil for reception. In both cases the TEM volume coil was used for transmission. In comparison to the TEM volume coil the SNR of the $^{31}$P phased array improved 3-fold in the periphery of the brain near the surface coils and provided similar sensitivity in the center of the brain. Since the volume coil can also be used for reception at the proton frequency, high quality anatomical images from the entire brain can also be acquired in the same setting without the need for patient repositioning or changes in hardware configuration.

**Conclusion:** An actively detunable $^{31}$P/$^{1}$H double-tuned TEM volume transmit/ four-channel $^{31}$P array receive RF system has been developed for 4T MRSI of the human brain. It can be used either in volume-transmit/array-receive mode or in TEM transmit/receive mode with the array detuned.

**References:** 1) Hardy CJ et al, MRM 1992;28:54-64. 2) Lee RF et al, MRM 2000;43:269-277. 3) Vaughan JT et al, MRM 1994;32:206-218. 4) Vaughan JT et al, MRM 2002;47:990-1000. 5) Avdievich NI et al, MRM 2004;52:1459-1464. 6) Edelstein WA et al, JMR 1986;67:156-161.