# A high-performance head gradient coil for 7T systems

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## Introduction

7 Tesla in general allow for higher signal-to-noise (SNR) ratio and better spectral resolution. Main applications are therefore high resolution MRI, spectroscopy and SNR demanding imaging techniques such as diffusion imaging. In particular Diffusion Tensor Imaging (DTI) [1] and Diffusion Spectral Imaging (DSI) [2] require long duration gradient pulses for diffusion weighting. As the SNR increases with decreasing TE, shorter TE is therefore mandatory. This is only possible when using larger gradient pulses. However, the limits in using a whole body gradient coil with high gradient amplitudes, $G_{max}$, in combination with high slew rates, SR, are dictated by the peripheral nerve stimulations (PNS) [3] and the available current and voltage applied to the coil [4, 5]. To overcome the PNS limits, higher gradient performance can only be used when using smaller gradient coils, such as head sized coils. Reducing the radius r of such a coil also helps because the performance of a gradient coil scales with $r^5$ therefore allowing an increase in $G_{max}$ and SR.

## Design constraints

The new head gradient coil can be used either (a) in dedicated head scanners or (b) as add-ons to whole-body systems [6]. This poses certain constraints on size, shielding, force and torque compensation. The most demanding constraints were 400 mm inner bore to leave 20 mm radius for noise encapsulation and the small distance from shoulder to center of field-of-view. We use an asymmetric design wiht shoulder cut-outs to extend the gradient coil further without compromising ease of access. More details on design constraints and technical data were described in [7].

## Achieved Performance

We achieved a maximum gradient strength of 80 mT/m, sustained gradient strength of 50 mT/m, slew rate of 700 T/m/s, and shim strength of 14 mT/m². Due to the noise encapsulation, the noise level will under all circumstances be below 140 dB peak, typical sequences are much quieter. Figure 1 shows the installation in a dedicated 7 Tesla head scanner magnet with 680 mm patient bore. Figure 2 shows a first image example, a 3D reconstruction of a kiwi fruit, showing excellent image quality. The linearity of the gradient coil was measured with a phantom comprising of small spheres in 2 cm distance. Figure 3 shows a sagittal, coronal, and transversal slice through this phantom. One can clearly see the excellent linearity of the gradient coil; the field-of-view is limited in axial direction by the RF coil. Figure 4 shows the remaining concomitant fields after compensation of effects due to the asymmetric design of the gradient coil.

This information about this product is preliminary. The product is under development and not commercially available in the U.S., and its future availability cannot be ensured.

## References

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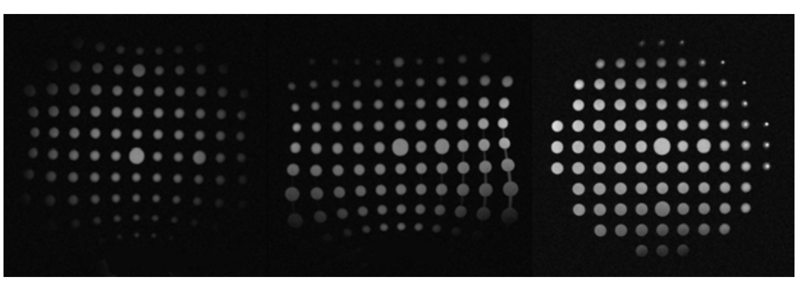

**Figure 3: Linearity**

**Figure 1: Installation**

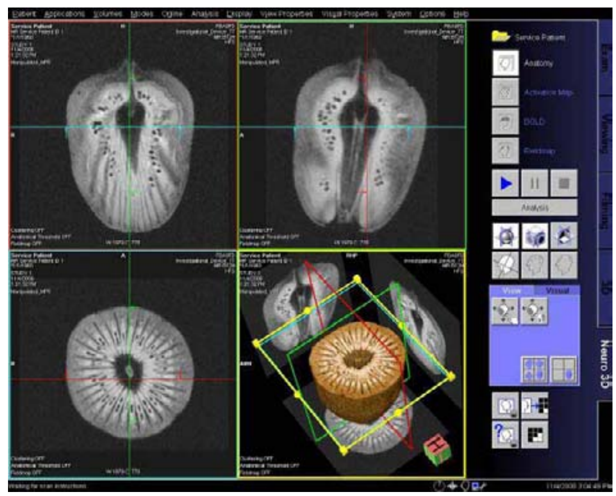

**Figure 2: First image of a kiwi fruit**

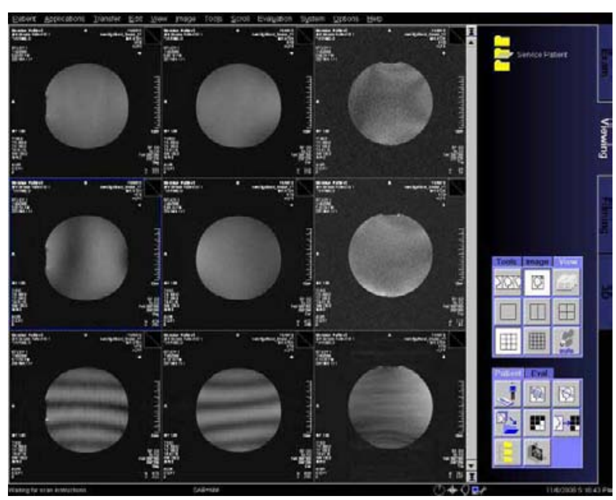

**Figure 4: Concomitant fields**