

## Design Optimization of a 32-Channel Head Coil at 7T

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**Introduction:** Recent advances in high field MR scanners (7T) provide us with systems up to 32 channel receivers [1,2]. The development of phased array coils with an increasing number of elements places increasingly constraints on the arrangement of the components, including preamplifier, cables and cable traps. For maximum spatial efficiency and reduced losses, most of the components (esp. the preamp) needed to be placed adjacent to the corresponding coil loop. Reduced interaction with the transmit coil requires a sparse configuration of conductors, well isolated through cable traps. Stability consideration requires the sparse configuration to be solidly mounted. In this study we developed and tested a 32-channel array using a coil-adjacent component design, densely packed around the helmet former, but sparse in conductive material which multiple small cable traps in the coaxial lines on the output of the preamplifiers. The array is designed to fit into a head gradient insert at 7T. The design was compared to a previous 32-channel design, where preamps are mounted in a stack behind the head and connected to the elements by coaxial cables.

**Material and Methods:** The phased-array and birdcage Tx coil were developed and tested on a 32-channel 7T MRI scanner (Siemens Healthcare, Erlangen, Germany) using a 40cm dia head AC84 gradient insert. The elements were arranged on a close-fitting fiberglass helmet (Fig.1). The layout of the coil elements consists of an overlapped arrangement of hexagonal and pentagonal tiling pattern [3]. A 16awg tin-plated copper wire was used for all coil loops. Conductor crossings of nearest neighboring elements are realized by bridges. The hexagon and pentagon elements consist of 6 and 5 tuning capacitors respectively. Preamplifiers (Siemens Healthcare, Erlangen, Germany) are connected directly to the elements via a daughter board. Thus, no connecting cable is needed. This allows the preamp to be driven in a balanced condition (two GaAs-FETs on the first stage). The daughter board includes an active and passive detuning circuit (crossed passive diode) and RF fuses. At the coil drive point the capacitance value was split, which causes a virtual ground between the two divided capacitors. A series capacitor provides the required source impedance for the preamplifier under loading conditions. Nearest neighbor elements were decoupled using geometrical overlap (slightly bending the wire bridges). Next-nearest neighboring coil elements were decoupled using preamplifier decoupling, where the series matching capacitor transforms the preamp impedance to an inductance at the coil terminal. The transformed inductance

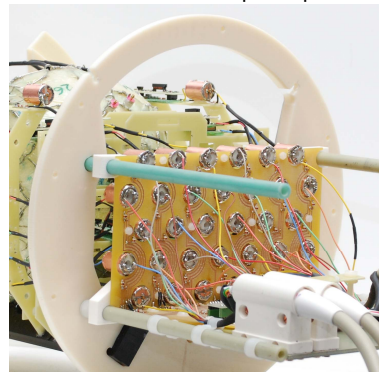


Fig. 2. Back-end of the phased-array with incorporated cable trap rack.

resonates with the tuning capacitor at the coil drive point, which results in a high impedance at the coil terminal. The active detuning circuit was placed away from the drive point on one of the tuning capacitors using a hand-wound inductor and PIN diode. Fuses with a rating of 570mA were added as an additional safety feature as well as a passive detuning circuit. Preamplifiers were mechanically mounted on a dedicated rack around the helmet (Fig.1). Behind each preamp one or two shielded cable traps were placed to suppress common mode currents induced by the RF transmitter system. Immediately behind the Tx coil a cable trap shelf was constructed (Fig.2). To keep the RF continuity inside the cables, special attention was paid to incorporate all the needed cable traps without any additional breakpoint and solder joints. The Tx CP birdcage coil with a diameter of 28 cm consists of 16 rungs and is designed as a bandpass circuit. The drive points were placed at the leg and eight PIN-diodes on one ending provide active tuning during transmit.



Fig. 4. Sagittal brain slice obtained from an MPRAGE (1mm isotropic).

**Results:** The coil shows  $S_{12}$  decoupling between nearest neighbors of -17 dB and a very strong preamplifier decoupling of -35 dB, which drops down to approximately -28dB under loading. The unloaded-to-loaded Q ratio for the receive coils are 10 and 8 for large (hexagonal) and small (pentagonal) coils respectively. Fig. 3 shows a SNR comparison of the array to our previous design [1], where the preamps were placed distal to the end of the coil. The new constructed coil gains 25% in averaged SNR. The averaged G-Factor maps show similar results for both coils (Fig. 4). The voltage necessary to achieve a 180° excitation pulse was reduced from 331V to 252 V. The variation of peak-to-peak stability of the EPI time series was under 0.4%.

**Conclusion:** A new generation of a 32-channel coil at 7T was constructed, tested, and compared to a previous 32-channel design. Substantial changes have been implemented to achieve better SNR, increased stability, lower transmit power.

**Acknowledgment:** Grant P41 (P41RR14075) **References:** [1] G.C. Wiggins et al.; Proc. ISMRM 2006 p.414; [2] P.Ledden et al.; Proc. ISMRM 2009 p.242 [3] G.C. Wiggins et al. MRM 2006, 56:216-23, [4] Kellmann et al. MRM 2005 54(6):1439-1447; [5] R.M. Weisskoff MRM 1996 36:643-655.

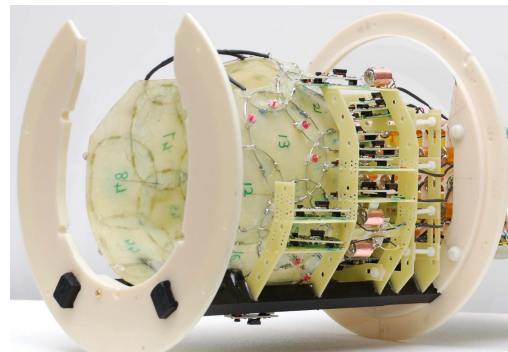


Fig. 1. Receive array with adjacent preamplifier setup.

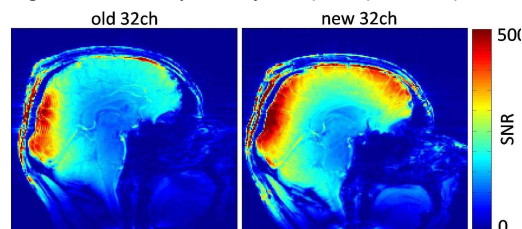


Fig. 3. Opt. SNR maps of the previous and the new coil.

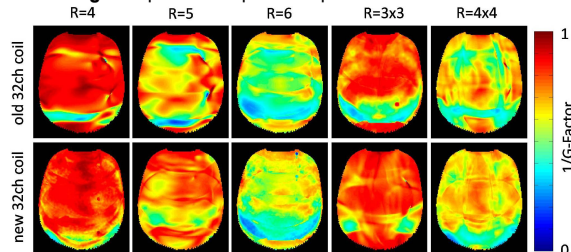


Fig. 4. 1/G-Factor maps of the previous and the new coil.