INTRODUCTION
Primate MRI at ultra high field (UHF) requires individual Tx-coils for excitation of different body parts since the construction of one large body-coil is difficult [4]. If Primate functional MRI is the focus, volume Tx-coil limits the freedom for stimulation because the necessary fixation unit does not fit into commercial volume coils. The traveling-wave concept [1], offers the potential to overcome some of these restrictions: In volume RF-coils the usable B1+ -field is restricted to dimensions and geometry of the RF-coil itself, except the RF-coil is considered as a RF-resonator which can also overcome this restriction. Contrary to this, in the traveling-wave concept the usable B1+ -field is restricted to the dimensions of the waveguide (RF-shield) only. While standard transmit coils at 7T excite rather small volumes, the MR traveling-wave concept allows the excitation of larger volumes only depending on the length of the RF-shield. For an antenna with a frequency of 297.2 MHz the approximate wavelength is about 1m. Thus the RF-shield of the gradient coil (Fig. 1A) with a diameter of 64cm can be used as a waveguide. As our MRI-system has an extended gradient RF-shield with a length of 147.1cm the traveling-wave concept has the potential to work as a whole body coil.

MATERIALS AND METHODS
All measurements were performed on a 7T Siemens whole body scanner with SC72a gradient coil system (Siemens, Erlangen, Germany). If enclosing only air, the RF-shield has a cut-off frequency of 275 MHz for the propagating TE11 (H11) mode, which is below the proton Larmor frequency at 7T. The bigger diameter of the RF-shield of the 7T Siemens whole body scanner in comparison to other 7T systems [1] is an advantage. Thus, the wave propagates through the whole RF-shield without damping but a reflection of approx. 20% caused by the end of the RF-shield if no match is provided. The cut-off frequency decreases if the relative permittivity inside the bore increases. A patch antenna (Fig. 4A) was designed and constructed (Fig. 4B) by using field simulation software [3]. The antenna has a total diameter of 44 cm and a patch diameter of 24 cm. This 2 port patch antenna generates a circular polarized B1+ -field to achieve high excitation efficiency. The complete MRI-system was simulated after designing a CAD model to analyze the behavior of the transmitted field under different conditions e.g. different positions of the antenna (Fig. 1C). The simulations were evaluated by performing several experiments, in which the antenna was used for transmit and receive. For a better evaluation of the performance of this approach, the antenna was also only used to transmit RF-power while a 12-ch. phased array [2] Rx-coil and a 3-ch. phased array primate coil (Fig. 2A) we used for signal reception. To increase the directional characteristics of the patch antenna, additional tuning and matching capacitors were mounted to excite a 180° flip angle with lower transmit voltage to increase the RF-Energy efficiency inside the RF-shield. The designed 3-ch. phased array primate coil offers more space for auditory stimulation options in the primate MRI.

RESULTS
The field simulation software allowed optimizing the directivity of the designed patch antenna (Fig. 4A) inside the MRI system. (Fig. 3B) shows that the excitation by the designed patch antenna can achieve the same homogeneity as the Dual Helmholz CP coil (Tx) shown in Fig. 3B. The designed patch antenna can still be used for signal reception, but the signal-to-noise (SNR) is rather low since B1+ -filling factor for the patch antenna is insufficient for small objects like a grapefruit (Fig. 3B). With this designed patch antenna as Tx and the 3-ch. phased array primate coil for Rx the highest SNR can achieved under travelling-wave conditions because the B1+ -filling factor for a phased array coil is much better. The results of the 3-ch. phased array primate coil with Macaque as a subject show very high SNR in cover region of this coil (Fig. 2B). The anatomical MRI measurement was performed with the following sequence parameters: Turbo Spin Echo TR: 6000ms, TE: 240ms, matrix:256x256, FoV:140x140mm, slice thickness: 0.5mm, slice distance: 1mm, α=120° Ref. Amplitude = 310V (180°). Using an extra-long RF-shield as a wave guide, to avoid coupling between the antenna and the subject, the travelling-wave excitation opens the potential to act as an efficient body-coil under UHF conditions.

CONCLUSION
To apply the travelling-wave concept to act as an efficient body-coil some limitations need to be solved. The limited RF-power at standard 7T whole body MRI-Systems is 8 kW peak power in comparison to 25 kW peak power which are required for an internal 3T body-coil. 7T Radio Frequency Amplifier (RFPA) are much more expensive instead of 3T RFPA. In the present state the travelling-wave concept is capable to work as a body-coil at 7T for primates and opens the possibility to use only phased array coil for receive which increases the freedom for the stimulation in primate fMRI widely.

REFERENCES

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