Explorations into Ultrahigh Field Magnetic Resonance
Where Physics, Mathematics, Biology and Medicine Meet

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The development of ultrahigh field magnetic resonance (UHF-MR) is moving forward at an amazing speed that is breaking through technical barriers almost as fast as they appear. UHF-MR has a staggering number of potential uses in neuroscience, neurology, radiology, cardiology, internal medicine, physiology, oncology, nephrology, ophthalmology and other related clinical fields. With almost 40,000 MR examinations already performed at 7.0 Tesla, the reasons for moving UHF-MR into clinical applications are more compelling than ever. The value UHF-MR has already proven itself many times over at lower field strengths; now 7.0 T has opened a window on tissues, organs, and (patho)physiological processes that have been largely inaccessible in the past. Images from these instruments have revealed new aspects of the anatomy, functions and physio-metabolic characteristics of the brain, heart, joints, kidneys, liver, eye, and other organs/tissues, at an unparalleled quality. 40,000 sounds like a large number, but in fact we have barely cracked open the door and have yet to truly assess what lies on the other side. To this end this presentation documents advances in UHF-MR with the goal to but **also highlights the potential for collaboration between imaging scientists and mathematicians along with the opportunities for post processing. In this light opportunities for mutually beneficial collaboration are proposed.** To meet this goal the traits, challenges and opportunities for discovery of human UHF-MRI will be surveyed. The considerations run from technical advances to early clinical applications. Examples of UHF-MR strategies are demonstrated. Their added value over the kindred counterparts at lower fields is explored along with an outline of research promises. Encouraging developments into enabling multiple channel radiofrequency (RF) antennae concepts (Figure 1) are reviewed. Frontier applications of MR at 7T are surveyed including cardiac imaging (Figure 1), ophthalmic MRI and high spatial resolution MRI of the brain. Heteronuclear UHF-MR applications are explored with a focus on sodium MRI (Figure 1). Current trends in UHF-MR are considered together with their clinical implications. A concluding section ventures a glance beyond the horizon including explorations into Extreme Field MR (EF-MR) which envisions human MR at 20 Tesla, which is an important leap of the imagination because it aims to fill a crucial "resolution gap" in our understanding of human biology (39, 40). It is the speakers hope that this presentation will convey the seeds of this vision and inspire the audience to become pioneers in these amazingly promising new areas of biomedical research: ultrahigh field and extreme field MR.

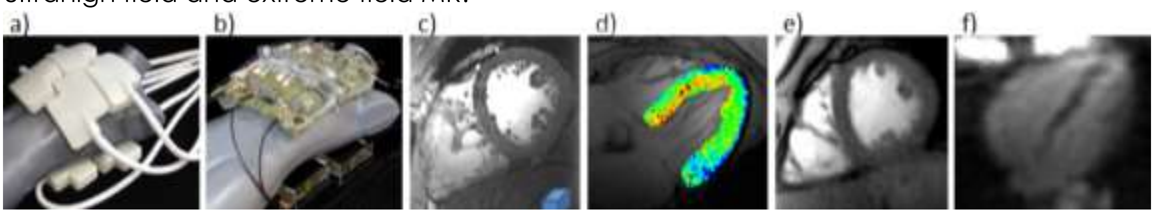

Figure 1: a, b) Examples of multi-channel transceiver arrays tailored for cardiac MR at 7.0 T including a) a 32 channel loop array configuration and b) a 16 channel bow tie antenna array. c) Short axis view of the heart (spatial resolution=0.8 x 0.8 x 2.5mm^3). d) High resolution myocardial T_2* colour map (four chamber view of the heart, spatial resolution=(1.5 x 1.5 x 2.5) mm^3) obtained at 7.0 T. e) Short axis view of the heart derived from free breathing real time imaging. f) Sodium image of a four chamber view of the heart acquired with a density-adapted 3D radial technique.